SDC-90-00088

SDC
SOLENOIDAL DETECTOR NOTES

SDC COLLABORATION MEETING,
SUPERCONDUCTING SUPERCOLLIDER LABORATORY

September 18-21, 1990

SDC-90-00008

SDC Collaboration Meeting

Superconducting Supercollider Laboratory

September 18-21, 1990

LOI INPUT : TRACKING GROUP

1) "CHARGE":

LOI AUTHORS

INCORPORATE DESCOPING CHANGES

INTERMEDIATE TRACKING

>> MORE WORK NEEDED

>> RADIAL WIRE REPORT (J. DAUNTON)

VERIFY DESCOPE RESOLUTIONS

2) "LIASONS":

1993 TEST BEAM — INTEGRATED TRACKING SYSTEM TEST

>> NEED TEST GOALS SUMMARIZED FOR EACH SUBSYSTEM

>> CONTACTS:

SILICON : SADROZINSKI

STRAWS : RUST

SCI.FI. : MARGULIES

HYBRID : ROBERTSON

LIASON WITH MUON GROUP: _____

J. MATTHEWS

SEPT 22, 1990.

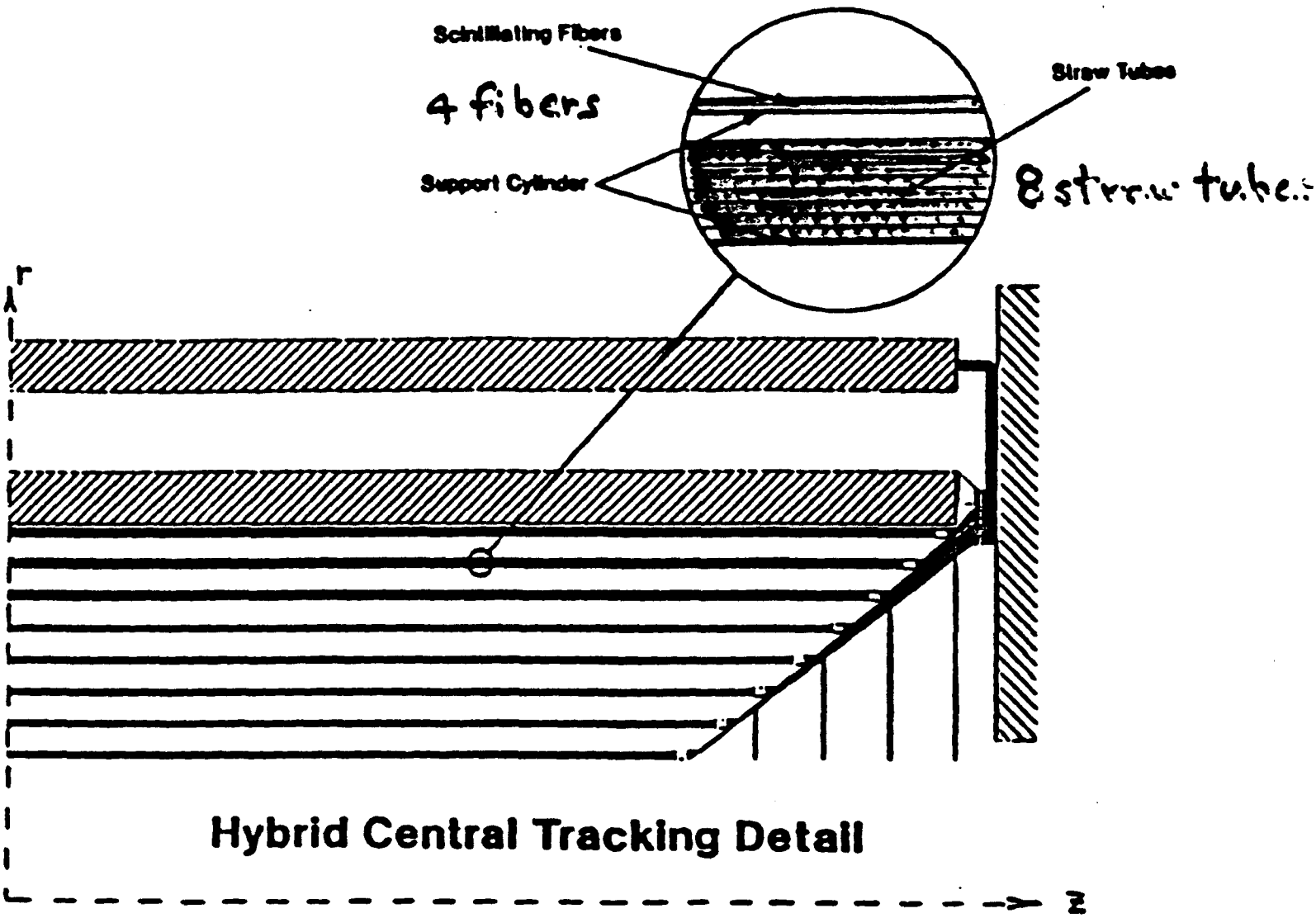


Figure 1 Cutaway view of one quarter section of a HCTC detector, with eight straw tube superlayers (z wires) and three outer scintillating fiber superlayers (stereo, u-v fibers).

1) L.O.I.: (4 pages tracking + _ overview & design goals)

>> AUTHOR/EDITOR – J. MATTHEWS

– DRAFT IN ≤ 2 WEEKS

– OFFICIAL SCHEDULE:

DRAFT: OCT 18

REVISED: NOV 1

FINAL (CAL NTG): NOV 7

>> FORMAT:

a) GOAL IS A <u>UNIFIED</u> TRACKING SYSTEM PROVIDING:

i) TRIGGER INPUT

ii) PATTERN RECOGNITION (& EFFICIENT TRACK RECONSTRUCTION)

iii) MOMENTUM (& IMPACT PARAMETER) RESOLUTION

b) GOAL IS TO PROVIDE "UNIFORM" TRACKING PERFORMANCE FOR $|\eta| \leq 2.5$ (AS MOTIVATED E.G. BY STANDARD MODEL PHYSICS)

a), b) ACHIEVED BY:

i) TRACKING SUPERLAYERS

- USED IN MOST MODERN TRACKING SYSTEMS AND FOUND TO BE EFFECTIVE (cf CDF)
- SUPPORTS TRACK FINDING ALGORITHMS THAT COMBINE TRACK SEGMENTS FROM DIFFERENT TRACKING SUBSYSTEMS.
- UNIFIED TRACK FINDING MEANS FEWER TOTAL TRACKING LAYERS, AND TOLERATES DIFFERENT TRACKING TECHNOLOGIES.

ii) TRACKING SUBSYSTEMS (vs R, Z):

- PIXELS
- SILICON: { 2 SIDED MICRO-STRIPS, MINI STRIPS } — SMALL "R"
- AXIAL LARGE RADIUS: { STRAWS, FIBERS, HYBRID }
- INTERMEDIATE: { RADIAL WIRES, FIBERS, ⋮ } — LARGE "R"

iii) DECISION PATH (LARGE "R" TRACKING):

- PREFERENCE IS TO BUILD A SYSTEM THAT CAN OPERATE AT $10^{34}\ cm^{-2} sec^{-1}$ ≡ "FIBERS"
- COST (OR TECHNOLOGY LIMITATIONS) WILL RESULT IN SYSTEM THAT CAN ACHIEVE $\gtrsim 10^{33}\ cm^{-2} sec$ ≡ "WIRES" OR "HYBRID"

>> PAGE ALLOCATIONS:

a) DESIGN PHILOSOPHY, OPTIONS, DECISION PATH ..... 2 PAGES

b) "DESCOPED" TRACKING SYSTEM:

i) TECHNICAL DETAILS:

PIXELS :	_____
SILICON :	SEIDEN
STRAWS :	FORD, HANSON
SCI.FI. :	RUCHTI
HYBRID :	GOSHAW
RADIAL WIRES:	DAUNTON

UPDATED TABLE FROM EDI ..... 1/2 PAGE

ii) FIGURES:

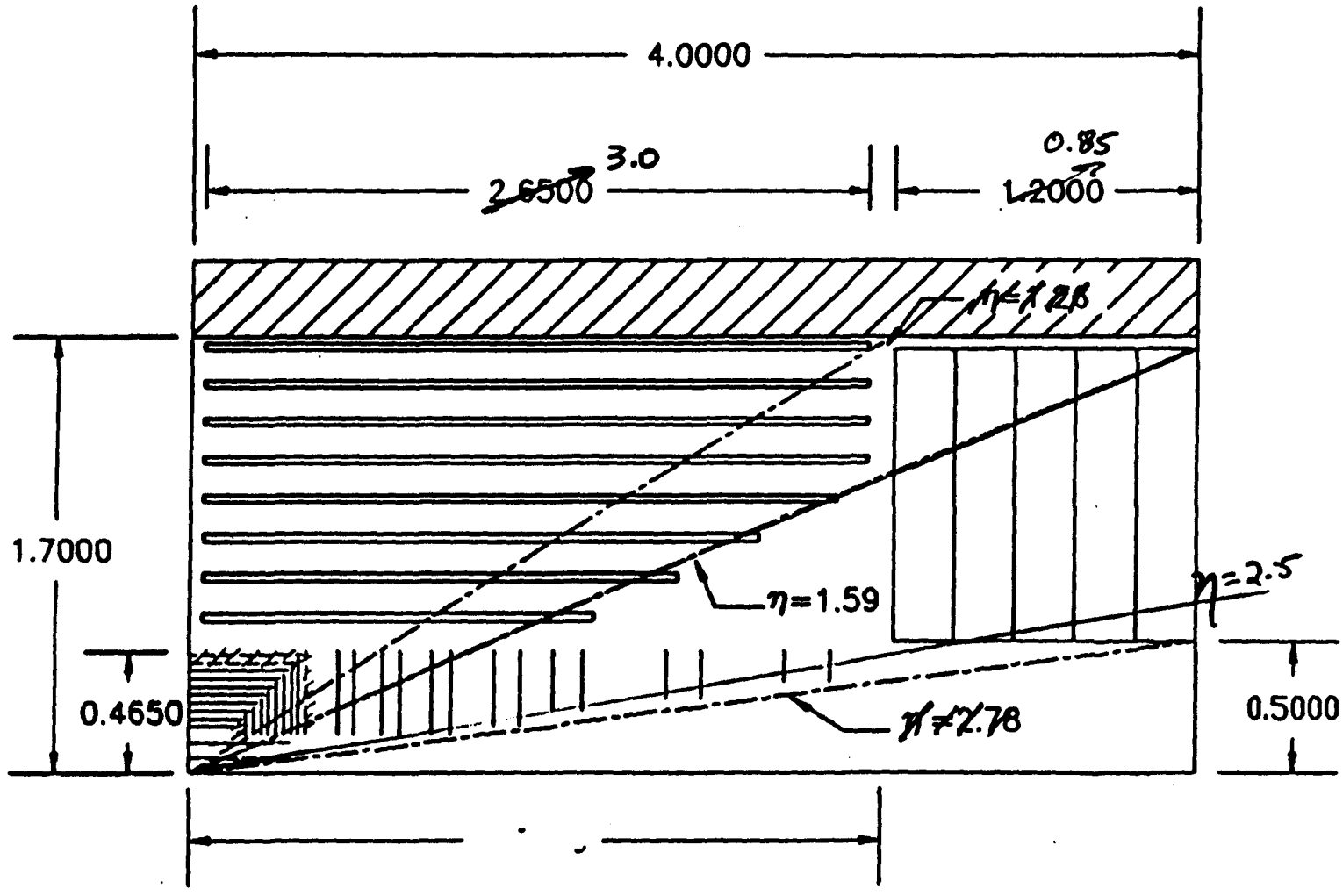
MOMENTUM RESOLUTION vs η (HYLEN)

TRACKING LAYOUT(S) ← ≈ SAME AS EDI (FORD)

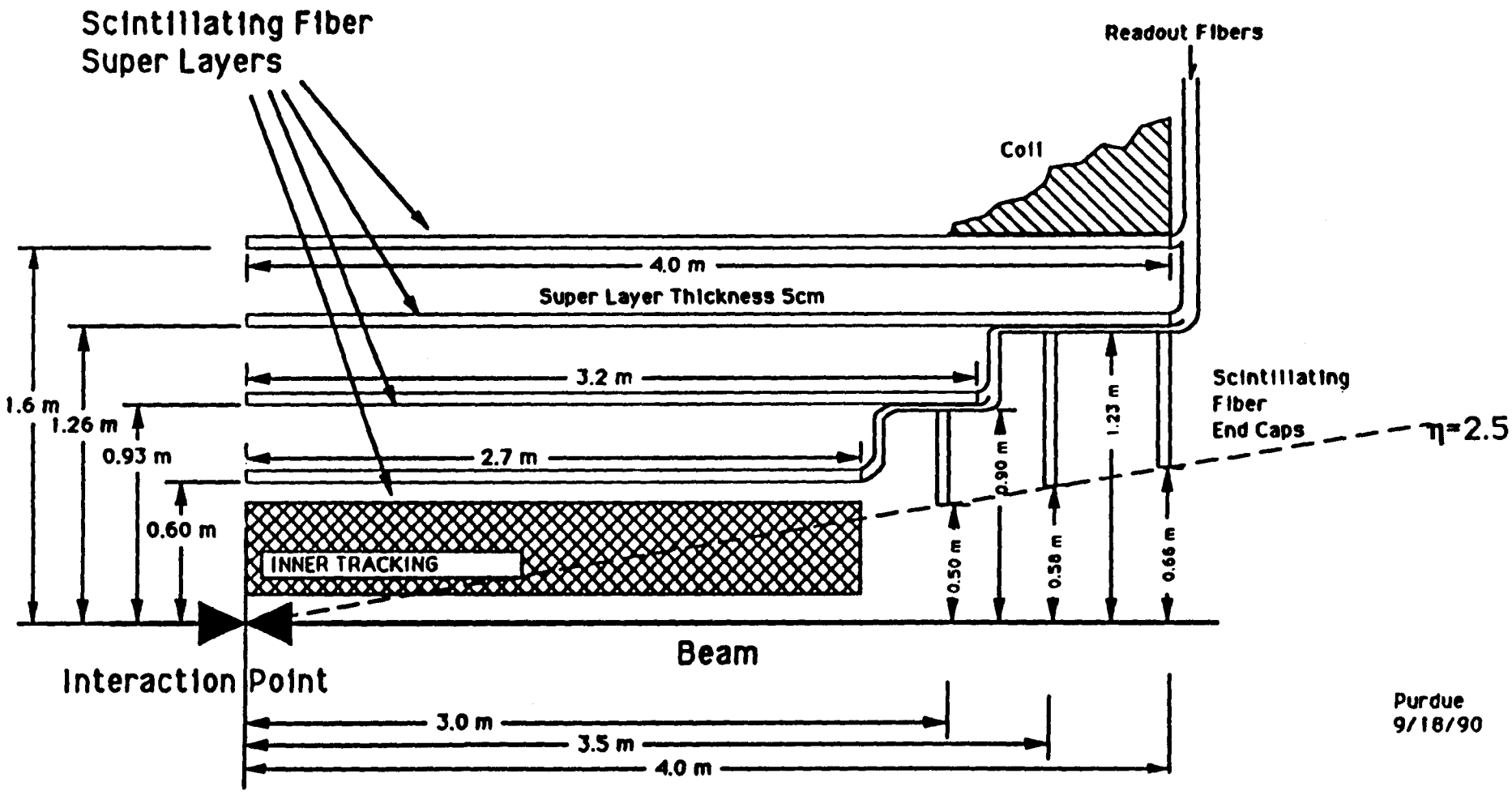
DETAILS OF SILICON LAYOUT ← TO ADDRESS CONFUSION IN NUMBER OF LAYERS,... (ZIOCR)

TOTAL FIGURE BUDGET ..... 1 PAGE

iii) BRIEF DISCUSSION OF IMPACT OF REDUCED TRACKING VOLUME, AND CHANNEL COUNTS ..... 1/2 PAGE



E


Scintillating Fiber
Super Layers
Readout Fibers
Coil
4.0 m
Super Layer Thickness 5cm
3.2 m
2.7 m
1.6 m
1.26 m
0.93 m
0.60 m
INNER TRACKING
Scintillating
Fiber
End Caps
η=2.5
0.50 m
0.90 m
0.58 m
1.23 m
0.66 m
Beam
Interaction Point
3.0 m
3.5 m
4.0 m
Purdue
9/18/90

2) SUPPORT DOCUMENTS:

i) SDC NOTES:

(ESPECIALLY FROM FORT WORTH PRESENTATIONS AND FROM RECENT SUBSYSTEM PROPOSALS.)

ii) TRACKING DESIGN "DECISION PATH":

BRIEF (≤2 PAGES/SUBSYSTEM) LIST OF MAJOR GOALS/TIMETABLE FOR EACH SUBSYSTEM (FOR NEXT ~2 YEARS) ⇒ SDC NOTE?

iii) SIMULATIONS:

- CONSISTENT EVALUATION OF DETECTOR "OCCUPANCY" VS DETECTOR RADIAL DISTANCE FROM BEAM (FOR SILICON, STRAWS, FIBERS, INTERMEDIATE TRACKING) — ASAI. (CONTACT T. KONDO)

- PROOF OF PRINCIPLE OF INTEGRATED TRACKING (eg HIGGS → ZZ → $4\ell^{\pm}$) — HUBBARD, ADAMS, CORDON, PALOUNEK, ...

  MAY NOT BE POSSIBLE IN TIME FOR LOI IF USE FULL <u>GEANT</u> BASED SIMULATION

- TRIGGER SIMULATION OF "INTERMEDIATE" SILICON TRACKING — LEWIS, _____

L. Price

PHYSICS & DETECTOR PERF. UPDATE

9/22/90

1. LoI Writing

- New work on $Z' \to$ leptons (G. Eppley)
- Physics section authors

  Overview: Einsweiler, Price

  a. Higgs: Einsweiler

  b. Top: Goltieri/Palounek, Sinervo/Holleback, Barnett

  c. $Z, Z' \to jj$: Price

  d. $Z' \to \ell\ell$: Siegrist
- Video meeting Mon, 1 Oct., 12:00 noon CDT/10:00 am PDT
- Draft LoI section 5 October

2. Simulation Framework
(with Computing & Software)

- Work reported on by S. Kunori, I. Gaines, K. Einsweiler, A. Palounek (+ R. Blair & A. White in August)
- Timescale: basics by January
- Working group established
  D. Adams, K. Einsweiler, I. Gaines, S. Kunori (chair), A. Palounek, L. Price, H. Trost, A. White

  Need to add: SSC person, Subsystem liaisons, Japanese, ...
- Video meeting Wed. 26 Sept. 3:00 pm CDT
- Continued discussion this afternoon

SDC Simulation Framework

S. Kunori, Univ. of Maryland

21-Sept-1990

Purpose: Share many programs easily
- integrated program
- well debagged code

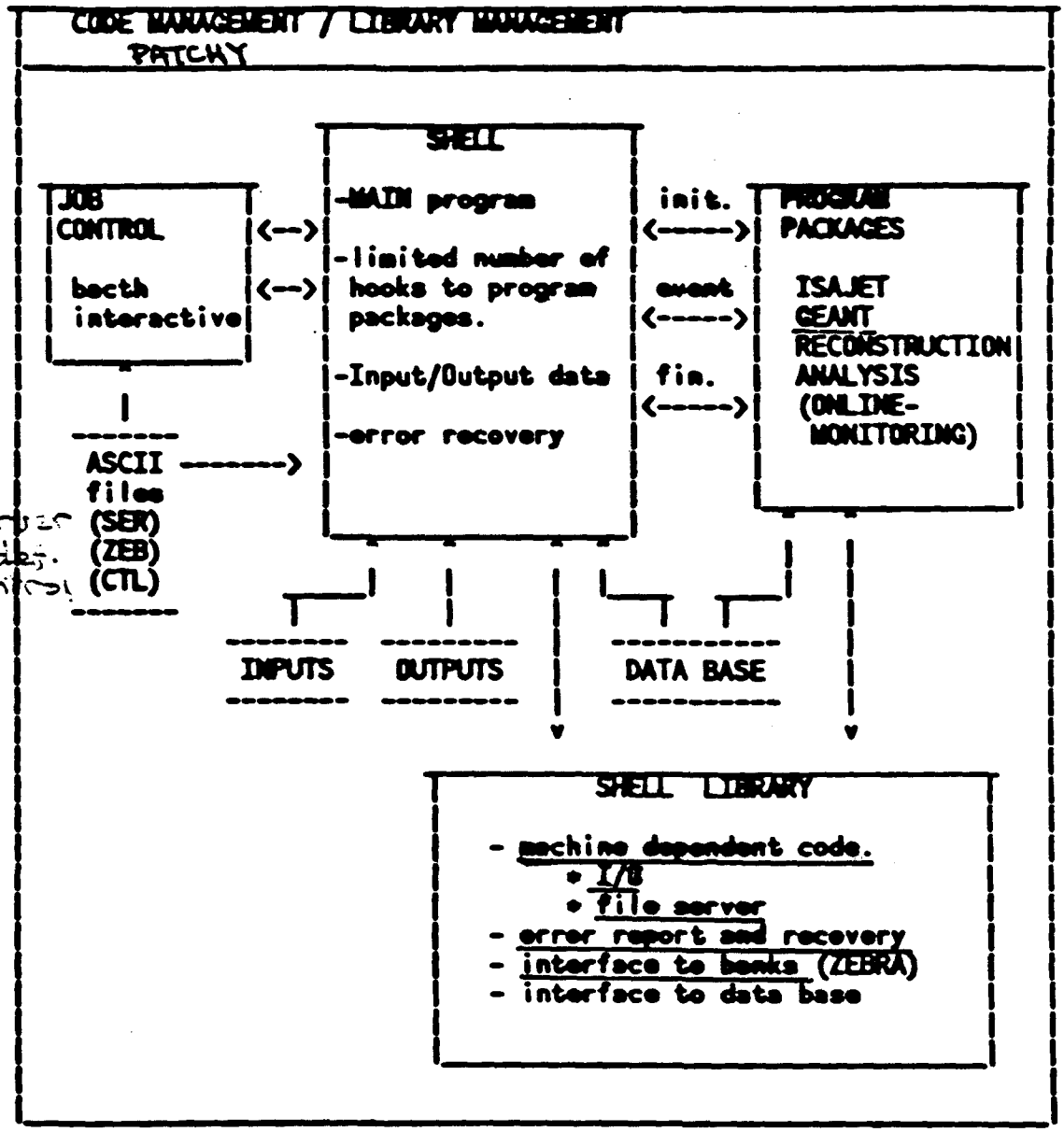
→ detailed detector design as quick as possible for proposal.

How: Common framework for all programs.
- machine independent code
- job control on various machines.

- SHELL: general framework
- GEANT-framework

Goal: to have SHELL + GEANT by the end of this year.

Fig.1 SHELL structure



[2.2] Choices for the SHELL system.

LANGUAGE: Fortran 77 with minimum extensions.

subroutine names: maximum 7 characters.
common block names: maximum 7 characters. } → 6 ?

Following extensions are allowed.
- use of DO, ENDDO
- use of DO, WHILE
- use of IMPLICIT NONE with patchy switch.

H-J. Trost: more strict! (CRAY, ...)

Following are NOT allowed.

- direct call of OPEN and CLOSE (except inside of the I/O package) | - do not call STOP.

CODE MANAGEMENT: PATCHY ⟶ CMZ in future?

Following Patchy commands are allowd.

- use of PATCH, DECK structure.
- use of TITEL, KEEP, SEQ.
- use of ADD,REP,DEL in correction set.

Follwoing are not allowd.

- use of PATCH switches, i.e.,
  +SELF,xxxxx.
  a=b
  +SELF.
  with exception. Allowed PATCHY switches are listed in [3.2].

DATA STRUCTURE: ZEBRA with interface routines

All of users have to call SHELL routines to store/retreive data to/from ZEBRA banks. NO EXCEPTION.

RUN CONTROL FILE

```
*-----------------------------------------------------------------------
*    (( example of CTL file ))
* key-words
*-----------------------------------------------------------------------
TITLE  THE SDC SHELL JOB      ! title
RUNS   000001 999999                          ! range of run numbers.
NEVENTS   400                                 ! total number of events
*                                               to be processed.
*
IN   DISK SDC$DAT:DATA_FILE1.DAT EVENTS=100     ! read 100 events from file
IN   TAPE FILE1                  EVENTS=100     ! read 100 events from tape
IN   8MM  FILE1                  EVENTS=100     ! read 100 events from 8mm
OUT  DISK OUTFILE1.DAT           BYTES=140M     ! write data up to 140 Mbytes
OUT  DISK OUTFILE2.DAT           BYTES=140M     !   :
*
CPUTOTAL 1000.                                ! total CPU time
CPULEFT    10.                                ! CPU time reserved for
*                                               finalizing program.
*
HBOOKFILE RUN0001.HBK   (or NONE)             ! HBOOK output file name.
HBOOKPRINT ON   ( or OFF )                    ! HBOOK print out.
*
END
*-----------------------------------------------------------------------
```

[3.5] SHELL: Data structure

3.5.1 Data tree structure

The internal data structure is five levels as shown below.

```
level 1      2      3      4      5

   [HEAD]                                  ! event header
     |
    1|-----[RAW]                           ! raw data header
     |
    2|-----[RECO]                          ! reconstruction header
     |
    3|-----[SIMU]                          ! simulation header
     |      1|-----[HPAR]                  ! particle header
     |       |      1|-----[PVTX]>         ! vertex banks
     |       |             1|-----[PART]>  ! particle banks
     |       |
     |      2|-----[HTRK]                  ! tracking detector header
     |       |       |-----[????]>           (not yet defined)
     |       |
     |      3|-----[HCAL]                  ! calorimeter header
     |       |       |-----[????]>           (not yet defined)
     |       |
     |      4|-----[HMUO]                  ! muon detector header
     |               |-----[????]>           (not yet defined)
     |               |-----[    ]>
     |
    4|-----[GENE]>                         ! event generation header
     |      1|-----[HHEP]*                 ! HEP event header
     |              1|-----[HEPE]>         ! HEP particle banks
     |
    5|-----[USER]
```

The user accesses only to 4th and 5th level bank using access routines that are descrived in 3.4.3. The bank structure can be expanded to many banks but never exceeds this five level structure. The bank structure is defined in a ZEB file described in 3.4.2.

The data banks at level 3-5 will be defined by users or program packages and be described in ZEBRA_BANKS.DOC.

```
[HHEP]
  |----[HEPV]>
        |----[HEPE]>
```

Layered approach:

I. Gaines

1) SW distribution layer
   Source codes & proc files

2) Standard I/O structure layer

Event generation → Events

Detector Simulation → Raw Data

Physics Analysis → track/jet banks

3) Cooperating packages layer
   Common simulation framework

4) Full analysis control

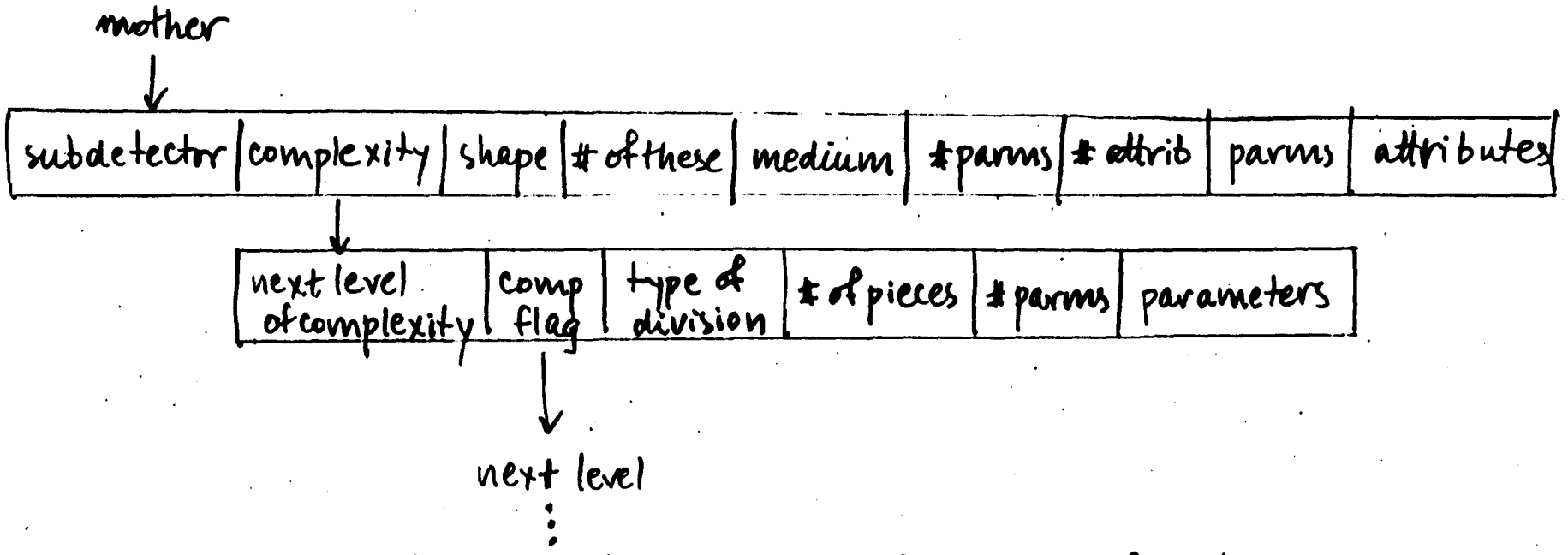
Standard tools used at all layers

APT Palounek
21 Sept 1990

PROPOSED GEOMETRY DEFINITION DATA STRUCTURE

GOALS:

- simple, easy to use
- should be stored (as used) with every simulation run so can completely reconstruct detector simulated (GEANT structure not always sufficient)
- mimics JVOLU closely so correspondence close and translation as easy as possible (⇒ [illegible])
- try to keep correspondence only as long as useful (no contortions)
- must be able to choose and distinguish between different versions of same level of complexity.
- local plumbing, electronics included in subdetector; global plumbing/electronics its own volume



shape can be user shape, though GEANT preferred

complexity flag chooses which of several possibilities at next level to take

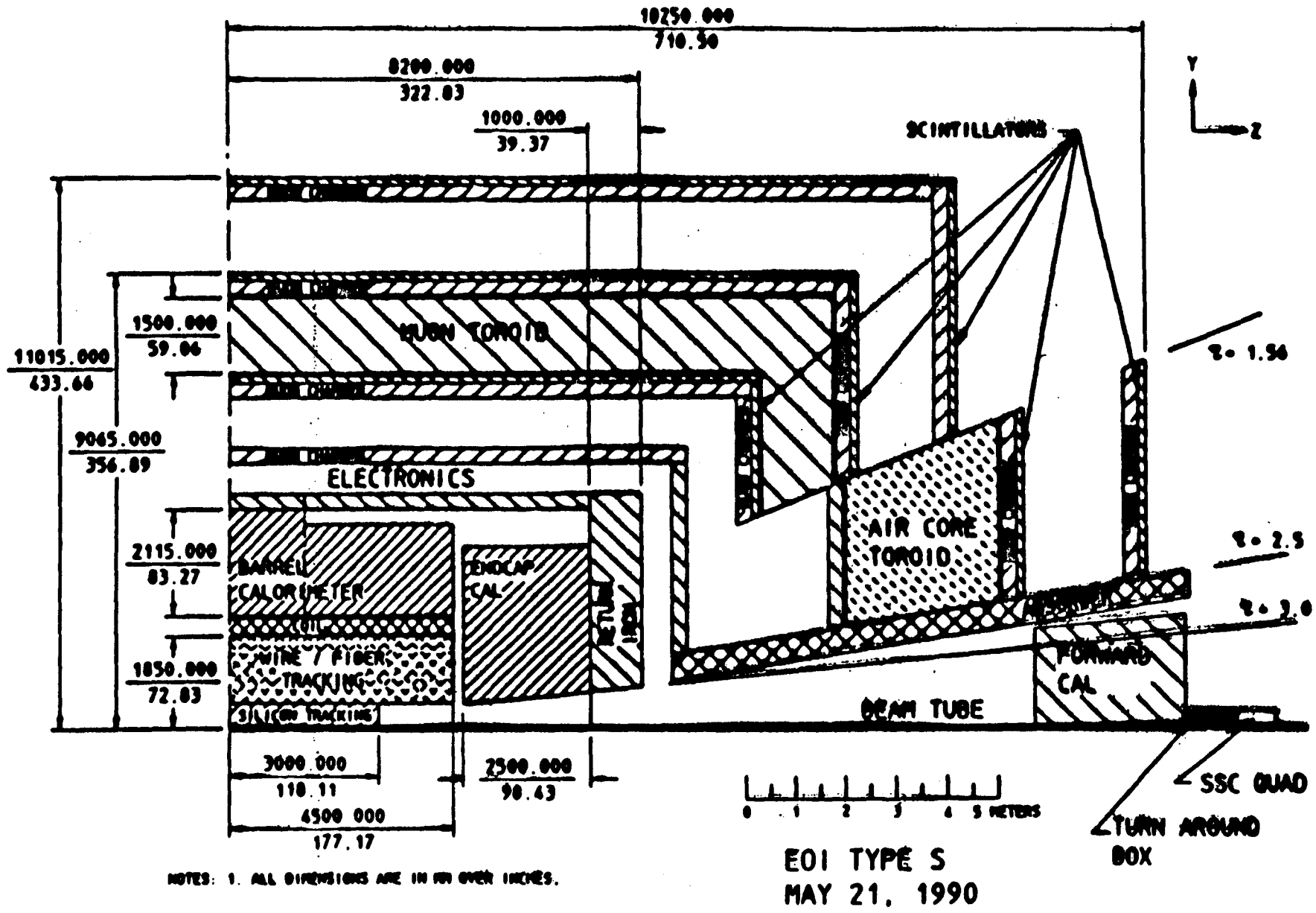
attributes include how deep to go

Report of Muon Group

1. ACT Task Force Report

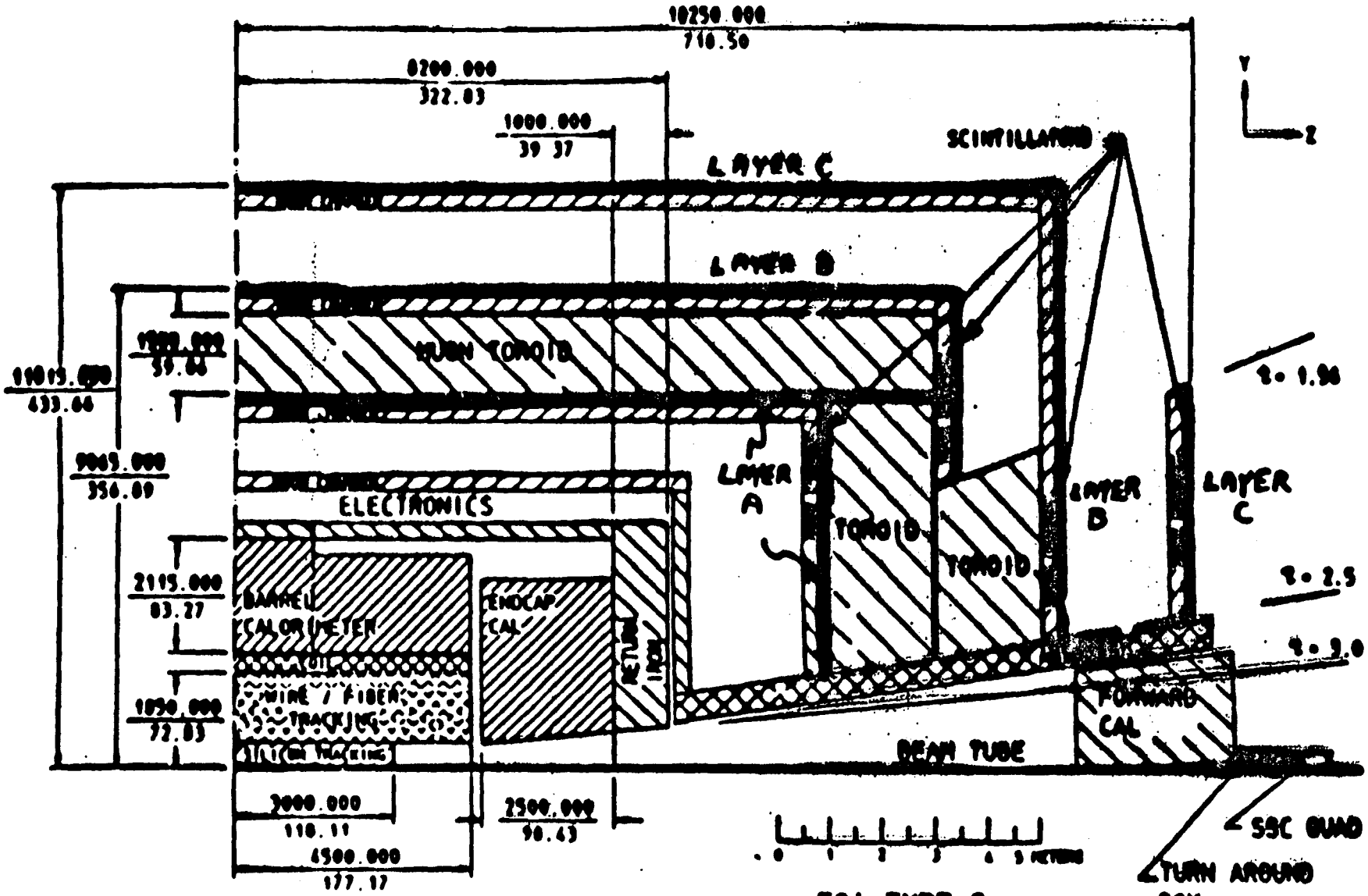
2. Relayout of Muon System Components

G. Felaman
SSCL
Sept. 22, 1990



NOTES: 1. ALL DIMENSIONS ARE IN MM OVER INCHES.

FIG. 3. Quadrant plan view of the detector with the short, or Type-S, solenoid, also shown in Fig. 1. In this version we have shown air-core toroids for muon momentum analysis at intermediate angles.



NOTES: 1. ALL DIMENSIONS ARE IN MM OVER INCHES.

FIG 1 VERSION WITH FORWARD IRON TOROIDS

R. THUN
17 AUG 90

W

Physics: ACT vs. Iron toroids

The basic justification for the air-core toroids was to have uniform resolution for muons over the full rapidity range. The mass resolution for typical Z's would be comparable. figure

Example: Z production (Erredde)

Region		σ_{m_Z} (GeV/c²)	
		Air-core	Iron
C-C	22.8%	0.6	0.6
C-I	17.8%	0.7	1.4
I-I	6.4%	1.2	3.0
≥ 1 F	53.0%	-	-

The air-core toroids clearly give better resolution, but we were unable to find any process for which their existence made the difference between doing a piece of physics and not doing it.

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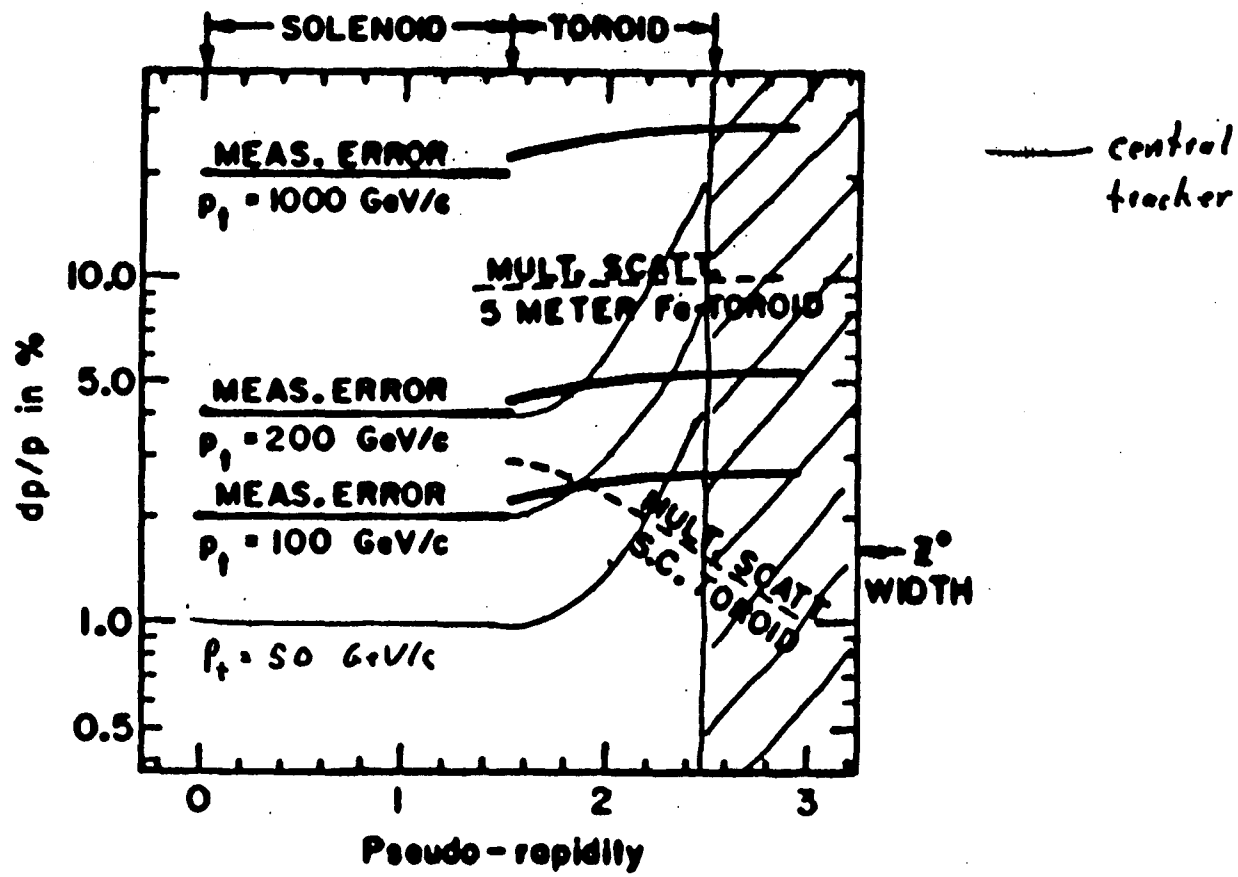


FIG. 23. Comparison of the muon momentum resolution from the central tracker with that of the intermediate-angle superconducting air-core toroid system. The solid lines show the resolutions $\delta p_t/p_t^2 = 0.2\ (\mathrm{TeV}/c)^{-1}$ for the central tracker and $0.25\ (\mathrm{TeV}/c)^{-1}\ \cos\theta$ for the air-core toroids. The dashed lines show multiple-scattering contributions to the resolution of an air-core toroid and an intermediate-angle toroid of magnetised iron. Also shown is the resolution required to reconstruct the $Z(\rightarrow \mu\mu)$ mass with an error equal to the natural width of the Z.

There are several reasons for this:

1. Most μ's come from W decay, where there is a missing ν.

2. Low p_t processes usually have high rates, making forward regions less important.

3. High p_t processes tend to be central and/or have high p_t, where $\sigma_{iron} \approx \sigma_{air\text{-}core}$.

Example: 800 GeV/c² Higgs $\rightarrow ZZ \rightarrow 4\mu$ (Einrode)

Region		σ_{m_H} (%) ACT	σ_{m_H} (%) FeT	σ_{m_H} (%) stand-alone ACT	σ_{m_H} (%) stand-alone FeT
C-C + C-C	30%	2.2	2.2	6.2	6.2
C-C + C-I	20%	2.0	2.3	5.0	5.5
C-I + C-I	12%	2.1	2.5	5.8	6.0
other	?	1.8	2.7	3.8	5.4

Costs

	EOI	Purcell	Hitachi
Stored energy	280 MJ	300 MJ	280 MJ
Coils		continuous	32 discrete
Cooling		bath	indirect
Cost*	40 M$	19 M$	80 M$ (11 G¥)

+ 5.2 M for cryo support

Iron toroids ~ 13 M$

Air core vs. Iron toroids

Air core	Iron
Higher resolution	Lower cost
$100 < p_t < 400$ GeV/c for $\eta \gtrsim 2$	No η gap
	Better shielding
	Less technological risk

Access: a problem in either case

Conclusion: Elimination of the ACT's is one of the better ways to downscope.

Goals of the muon system

1) Provide a level 1 trigger

   simple and fast – get to kHz range

2) Provide a level 2 trigger

   sharpen the p_t definition

3) Identify muons.

   redundant momentum measurement

4) Improve p measurement at high momentum

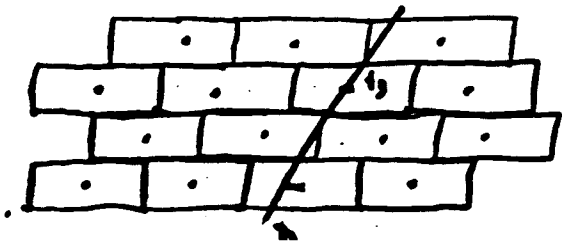
5) Provide some capability of stand-alone operation at $\mathcal{L} > 10^{33}\ cm^{-2}\ sec^{-1}$

Level 1 trigger:

- Must make a fast decision running at 60 MHz
- Only need to get to kHz range, and this can be done locally.

Solution: (Chapman) Arrange the hardware to make the trigger easy: projective wires in ϕ. Use Δt to 2 projective wires (CDF method).

Basic solution requires 4 planes:



$\Delta t = t_3 - t_1$

More restrictive solution requires 6 planes.

Typical values for 20 GeV/c p_t:

Toroidal bend	40 mr
Multiple scattering	10 mr
Longitudinal vertex position	6 mr
Measurement error (10cm lever arm)	3 mr

Level 1 requirements: (Central and End)

6 $\mathcal{U}$ layers in the last superlayer
4 $\mathcal{U}$ layers in the next-to-last superlayer

2 layers of scintillator
1 layer of Cherenkov counters in the end region

Level 2 trigger:

Purpose is to sharpen p_t trigger. In the central region, the φ direction provides the sharpest resolution. Therefore, use projective φ layers and connect with stub in central tracker.

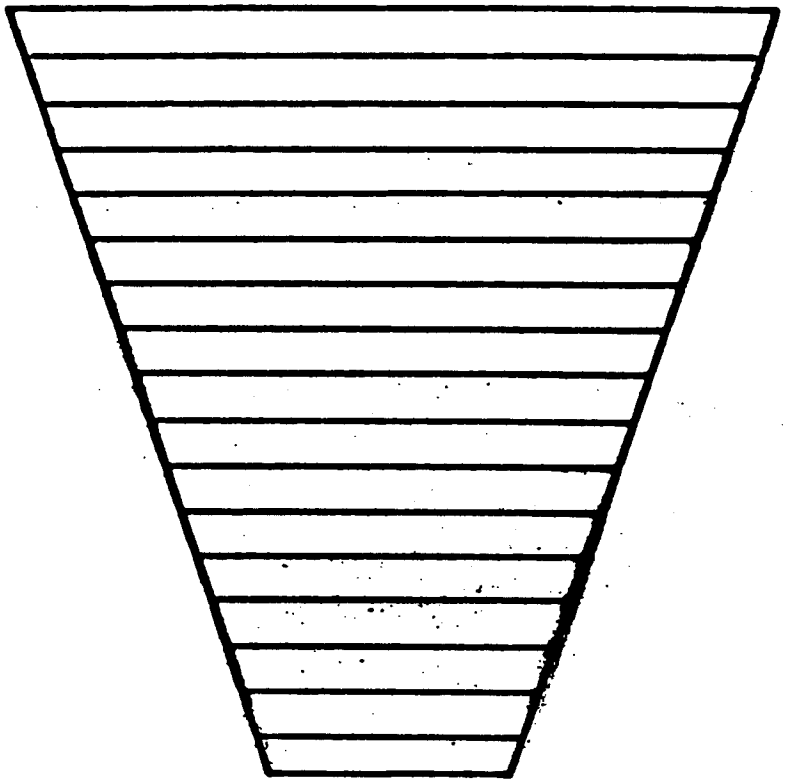
In the end region, provide an angle-angle measurement by putting v planes in the first two superlayers.

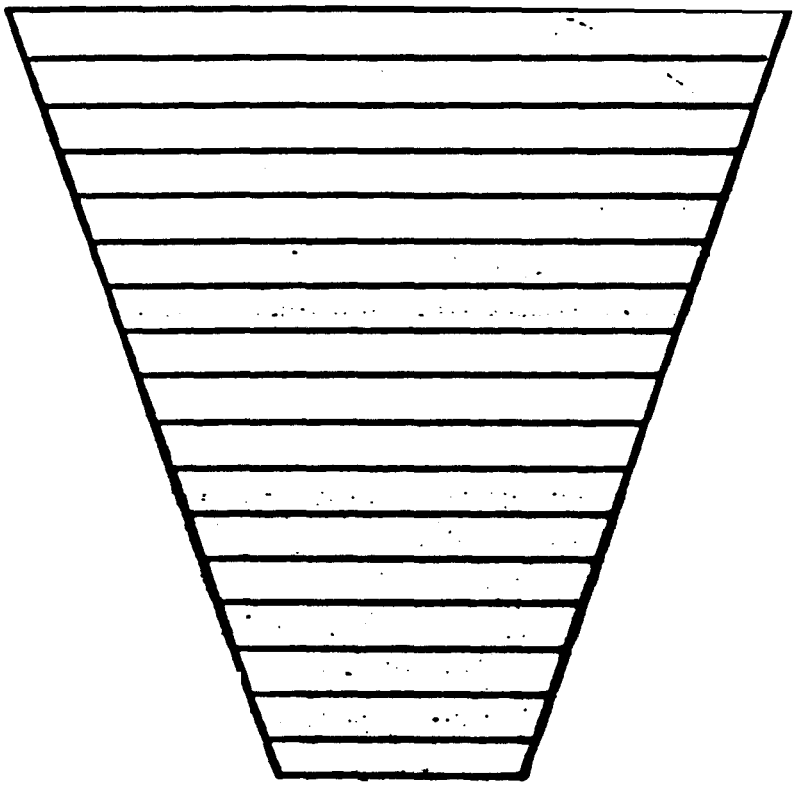
Level 2 additional requirements:

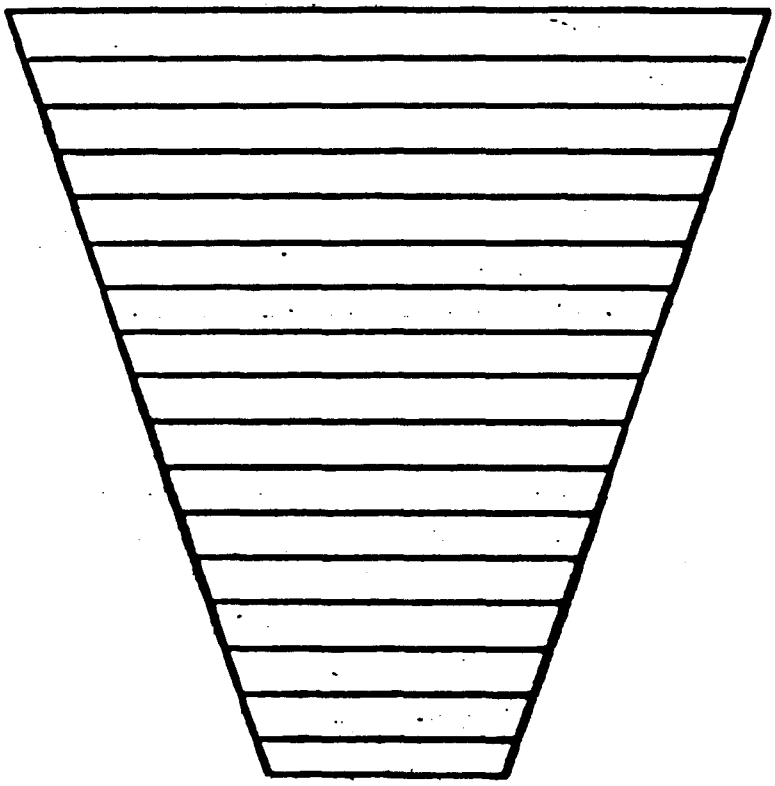
Central: 4 layers of φ at 2nd and 4th superlayers

End: 4 layers of v at 1st and 2nd superlayers

End cap scheme







Identify muons:

1) Tie ϑ and φ together:

Central: 2 stereo layers at superlayers 2 and 4

End: 2 sets of 2 stereo layers at superlayers 2 and 4 or 5

figure

2) Provide redundant momentum measurement

Central: 6 ϑ measurements at superlayer 2

End: no additional requirement

Improve p measurement at high momentum

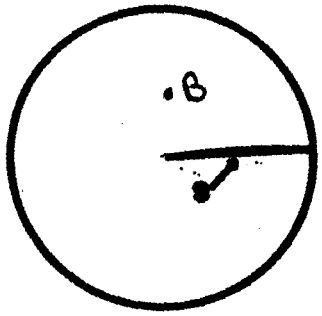
φ measurements in central region give larger sagitta.

figure.

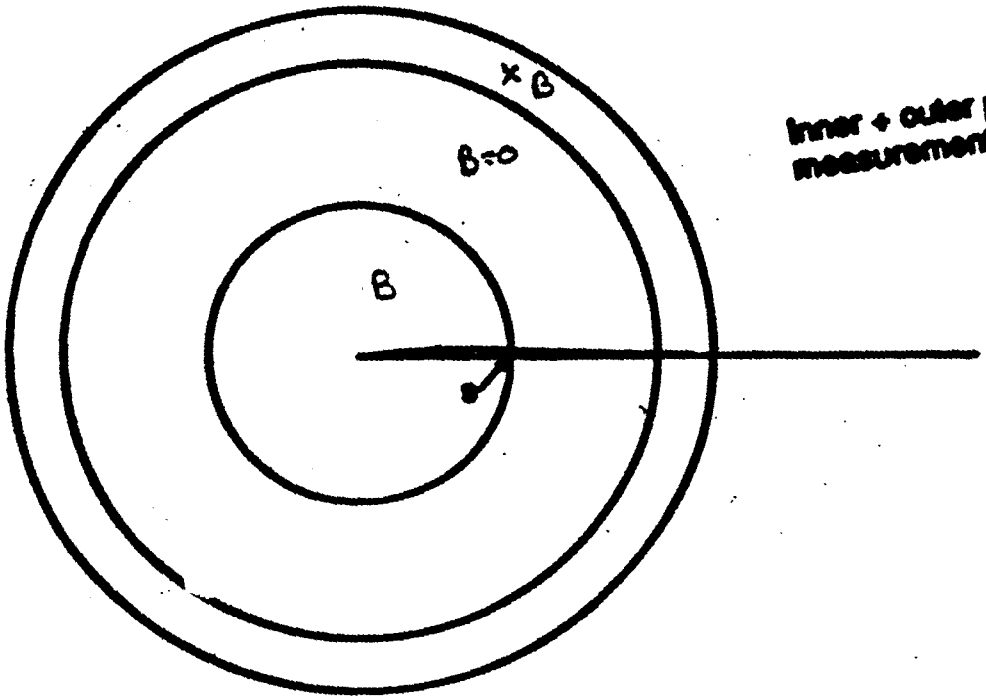
Requires no additional chambers.

Provide stand-alone capability for $\mathcal{L} > 10^{33}$

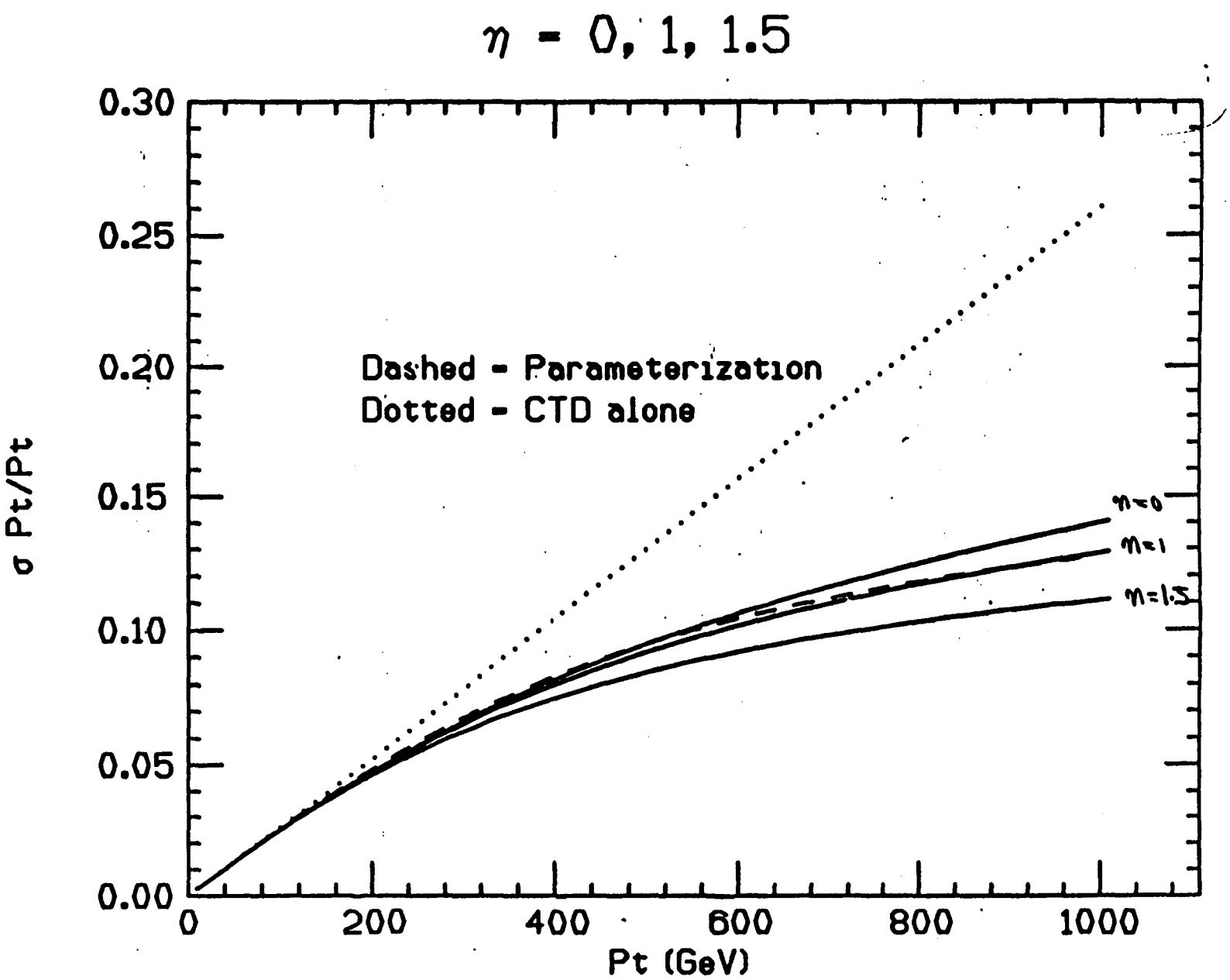
Requires no additional chambers



Inner only



Inner + outer phi measurements


η = 0, 1, 1.5
Dashed - Parameterization
Dotted - CTD alone
η=0
η=1
η=1.5
σ Pt/Pt
Pt (GeV)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
200
400
600
800
1000

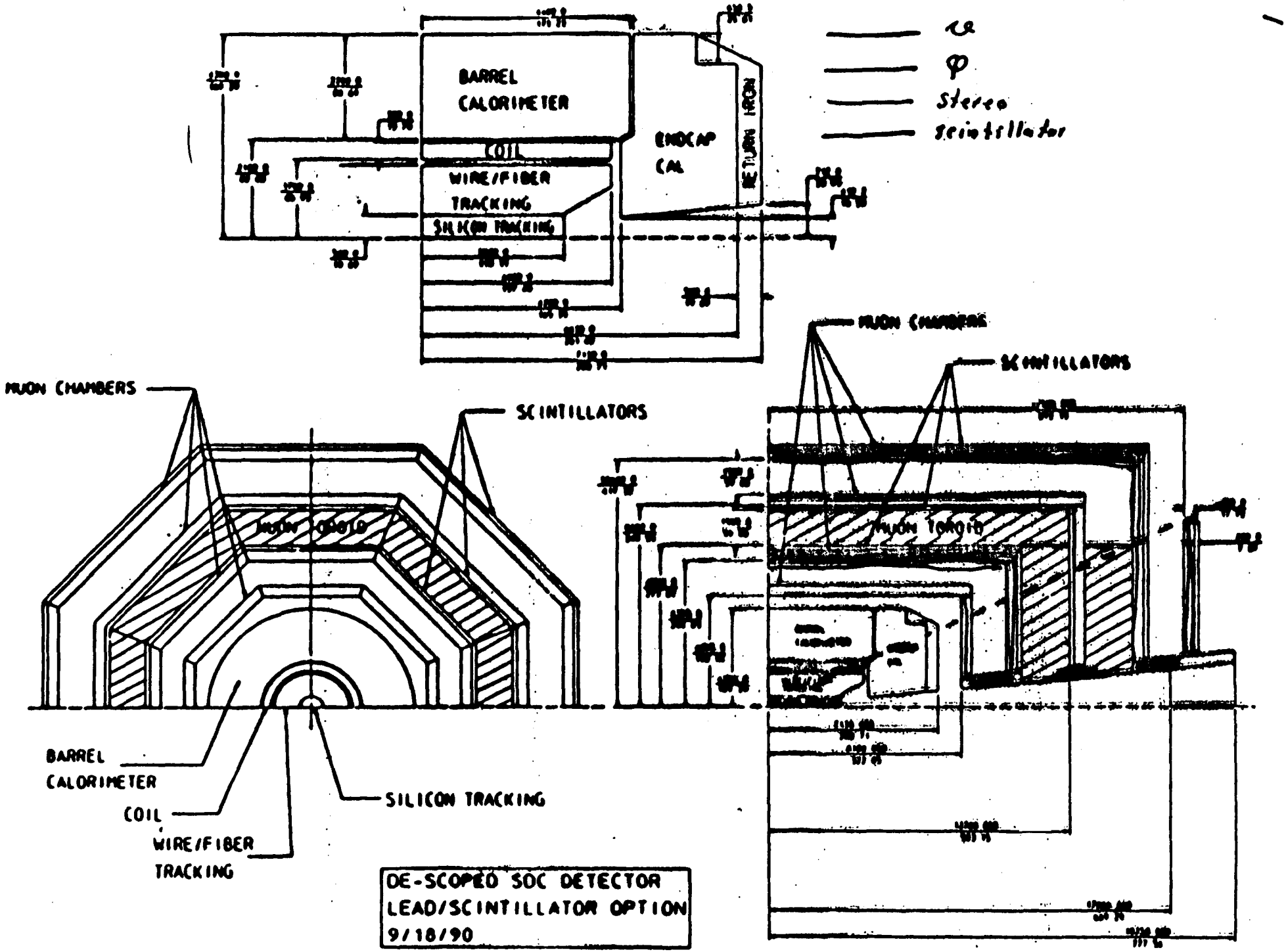
Barrel CTD & $\mu 2 \rightarrow \mu 4$ Φ

$$\left(\frac{\sigma(P_\perp)}{P_\perp}\right)^{-2} = \frac{1}{(5.3 \times 10^{-3})^2 + (2.6 \times 10^{-4}\ P_\perp)^2}$$

$$+\frac{1}{(.136)^2 + (5.45 \times 10^{-5}\ P_\perp)^2}$$

- Varies by $< 10\%$ from $0 < |\eta| < 1$
- $P_\perp$ in GeV

$$\Rightarrow \frac{\sigma_p}{p} = 16.5\% \quad @ \quad p_t = 2\ \text{TeV}$$


BARREL CALORIMETER
COIL
WIRE/FIBER TRACKING
SILICON TRACKING
ENDCAP CAL
RETURN IRON
θ
φ
Stereo
scintillator
MUON CHAMBERS
SCINTILLATORS
MUON TOROID
BARREL CALORIMETER
COIL
WIRE/FIBER TRACKING
SILICON TRACKING
DE-SCOPED SDC DETECTOR
LEAD/SCINTILLATOR OPTION
9/18/90

Summary of chamber planes

Super. layer	Central ϑ	Central φ	Central s	End ϑ	End s_1	End s_2
1	-	-	-	4	-	-
2	6	4	2	4	2	2
3	4	-	-	4	-	-
4	6	4	2	6	2	2
Total	28			76		
EOI	32			32		

Channel count: 111,216 EOI 100k

Future activities:

Oct 27 Fermilab Chamber design

A SUPERCONDUCTING TOROIDAL MAGNET
for the
ARGONNE NATIONAL LABORATORY
SUPERCONDUCTING SUPER COLLIDER DETECTOR

PARAMETER LIST

1.	Minimum radius	2.3 meter
2.	Maximum radius	5.95 meter
3.	Length	3 meter
4.	Peak field	2.7 tesla
5.	Front end plate thickness at I.D., total	9.78 cm
6.	Rear end plate thickness at O.D., total	5.26 cm
7.	Torus internal volume, carbon	0.02%
8.	Stored energy	≈300 MJ
9.	Operating current	7,000 amps
10.	Conductor	Al stabilized NbTi
11.	Conductor size	0.39 cm x 2 cm
12.	Current density	9,000 A/cm²
13.	Type of stabilization	Bath cooled
14.	Ampere turns	34 x 10⁶
15.	Conductor length (@ 7,000 amps)	51,000 meters
16.	Conductor weight	26,300 lbs.
17.	Cold weight including conductor	135,600 lbs.
18.	Warm weight	37,500 lbs.
19.	Total weight	172,900 lbs.
20.	Liquid helium volume	15,000 liters

COST ESTIMATE
FOR THE
SSC DETECTOR TOROIDAL COILS

The cost for the toroidal coils of the SSC detector has been estimated based on the conceptual design by Advanced Cryo Magnetics Inc. Labor cost is assumed to be $80.00 per hour.

The cost is shown below:

1.	Engineering		$500,000
2.	First of a kind costs Prototype scale model Forms and tooling Manufacturing engineering Shop travelers and procedures Inspection procedures and hold points		$500,000
3.	*Materials		
	Toroid former	$504,000	
	Helium vessel	$230,000	
	Inner/outer cone and end beams	$541,000	
	Vacuum can	$370,000	
	Rings	$180,000	
	Insulation	$120,000	
	Carbon loops	$500,000	
	Miscellaneous	$489,000	
	Subtotal		$2,934,000
	Contingency, 25%		$733,000
4.	On Site Labor		
	Vessel forming	$620,000	
	Welding	$300,000	
	Coil Winding	$1,020,000	
	Inspection and testing	$90,000	
	Rework	$366,000	
	Subtotal		$2,196,000
	Contingency, 20%		$439,000
5.	**Conductor		
	51000 # of 7000 amp		$2,700,000
GRAND TOTAL			$10,002,000

* Material costs include off-site fabrication labor

** Conductor costs are based on a Siemens quote of $52/meter. TGC has quoted $31/meter for the same conductor.

From: Jnet%"MORIS@JANKEKVX"
To: JNET%"gary@slacvm"
CC:
Subj: Cost estimate for ACTs

Received: From SLACVM(GARY) by HUHEPL with Jnet id 3217
for FELDMAN@HUHEPL; Sun, 16 Sep 90 23:59 EDT
Date: Mon, 17 Sep 90 12:11 V
From: <MORIS@JANKEKVX>
Subject: Cost estimate for ACTs
To: gary@slacvm
Original_To: JNET%"gary@slacvm"

September 17, 1990

Dear Gary:

Unfortunately I cannot attend September meetings at Dallas. A. Maki, KEK will bring some results of our studies on the SDC muon system which include the ACT system. We have asked Hitachi to make a cost estimate for the ACTs with very similar characteristics to those in the EoI. A rather crude estimate by Hitachi is given below:

Coil parameters	
Stored energy	280 MJ/set
Number of discrete coils	32 /set
Current	8000 A
Inductance	8.75 H/set
Cooling method	Indirect
Estimated cost:	
Total (two sets)	11,000,000,000 +-20% Yen (about 80 M$)

I hope this information will be useful for our decision.

Sincerely yours, Shigeki Mori

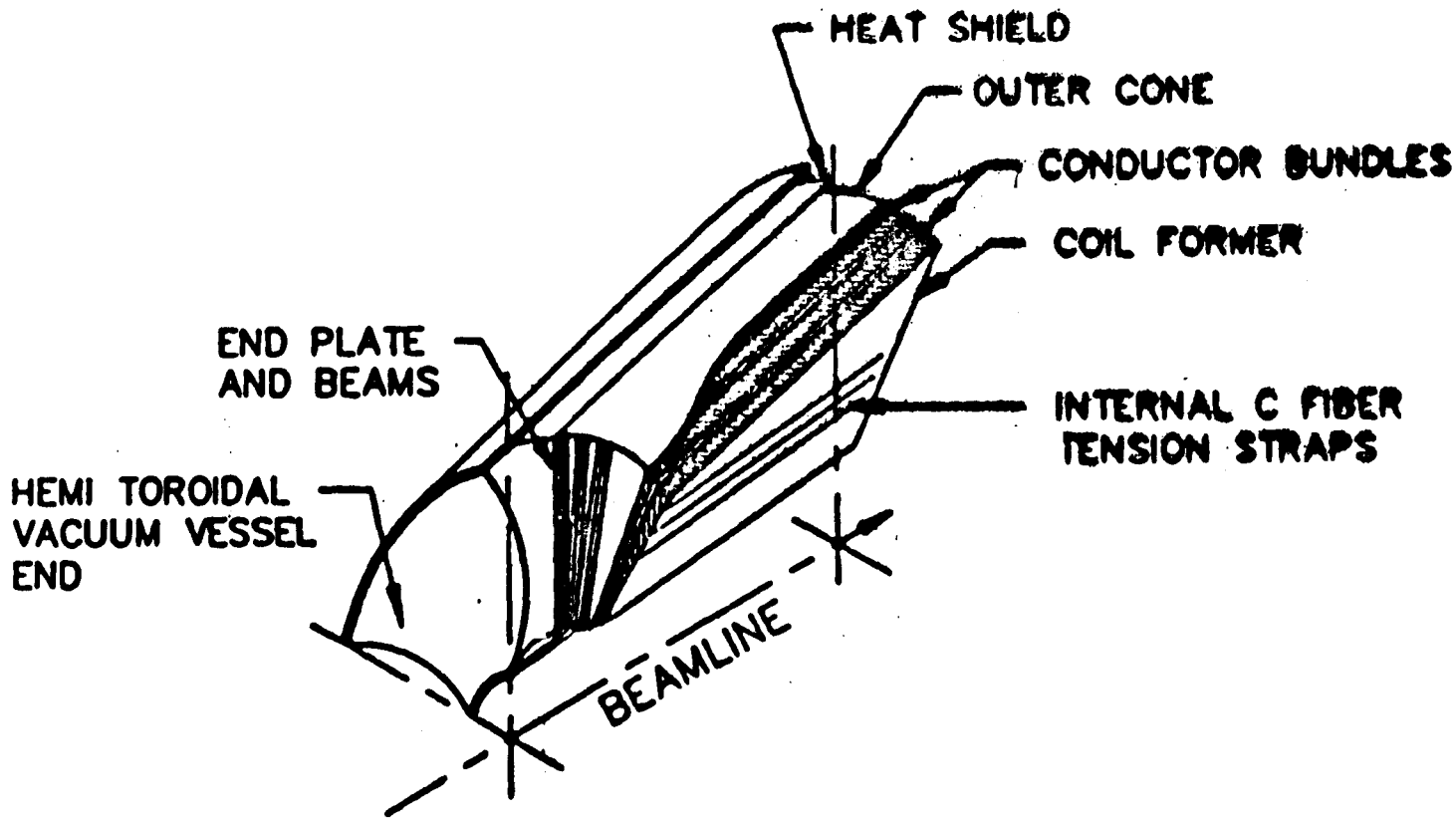


FIG. 24. Continuous winding air-core toroid, from a preliminary design (April 1990) by Advanced CryoMagnetics, Inc.

NOVEMBER CALORIMETER REVIEW

CAL. TECH. COMM. CHARGED TO RANK OPTIONS

→ TWO TO HAVE SUBSTATIAL ENGINEERING SUPPORT

NONUNIFORM INITAL RESPONSE

→ STANDARD FORM

CALL FOR QUESTIONS/CRITIQUE OF "OTHER" OPTIONS (EMAIL BY 9/28)

WRITTEN (E-MAIL) FORMS/REPLY DUE 11/1

PRESENTATIONS @ LBL

DELIBERATION @ LBL

→ REPORT

not be reasonably provided by Nov. 1 if we can agree on a version at the Dallas meeting. Comments please!

CHARACTERIZATION OF SDC CALORIMETER OPTION _____

EM RESOLUTION STOCHASTIC _____%/(sqrt(E) (E in GeV)
CONSTANT _____%
NOISE 0.1x0.1 _____ GeV
Nonuniformity only constant ('good') _____%

HAD RESOLUTION e/h _____
STOCHASTIC _____%/sqrt(E) (E in GeV)
CONSTANT _____%
NOISE cone r=0.6 _____ GeV
Nonunifority only constant (jet<|2.4|) _____%

HERMETICITY GOOD e ACCEPTANCE _____%
EM RES. NOMINAL, AVERAGE, WORST (to 2.9) _____%, _____%, _____%
HAD RES. NOMINAL, AVERAGE, WORST (to 2.4) _____%, _____%, _____%
(Note: resolutions should be for 50 GeV Et electrons and 50 GeV Et jets. The Wormsley parameterization is sufficient.)

ELECTRON ID & TRIGGER
EM SHOWER POSITION RES. _____ mm
NOISE IN A CONE OF 0.15 _____ GEV
CHARACTERISTIC INTEGRATION TIME _____ ns
EM TRIGGER RESOLUTION _____%/SQRT(E), _____%, _____GeV, _____GeV
HAD TRIGGER RESOLUTION _____%/SQRT(E), _____%, _____GeV, _____GeV
(Note: that is stochastic, constant, electronic noise and pileup at 10**33 in 0.1x0.1.)

LINEARITY (Uncorrected) EM _____ %/100 GeV
HAD (pion) _____ %/100 GeV
Comment _____

RADIATION SURVIVAL (best guess presently available)
(Note: this refers to plastic, electronics and everything. Two cases: 10 years at 10**33 and 5 years at 10**34 where one year is 10**7 sec on. Unaffected is defined as less than 1% change in EM resolution as online corrected. Degradation in absolute %, not fraction change or the number.)
UNAFFECTED PHASE SPACE |ETA| < _____, _____
DEGRADATION OF EM RESOLUTION, AVERAGE (in R) AFFECTED _____%, _____%
DEGRADATION OF EM RESOLUTION, WORST CASE _____%, _____%
REPLACEMENTS/FIXES ASSUMED ABOVE AND FEREQUENCY _____
(Note: include level of disassembly required.)

SAFETY ISSUES: LIST _____
IMPLICATIONS FOR ACCESS _____
IMPLICATIONS FOR THE REST OF THE DETECTOR AND HALL _____

CALIBRATION/MAINTAINANCE
STABILITY IN NORMAL OPERATION +/- _____% TYPICAL CHANNEL
WORST RAW CHANGE IN GAIN/MONTH @10**34 _____%
TESTBEAM REQUIREMENTS:

_____ TOWERS CALIBRATED
_____ TOWERS MAPPED IN DETAIL
_____ EXTRA MODULES FOR STUDY: DESCRIBE:

_____

LIST OPREATIONAL PROCEEDURES: _____

_____

COST AND SCHEDULE (CURRENT BEST GUESS, NO CONTINGENCY, '90$)

CHANNEL COUNT _____ \
TOTAL WEIGHT _____ > APPEND DETAILS
DENSITY _____ /
BOTTOM LINE (APPEND ESTIMATE) _____M$
MINIMUM DURATION FROM SERIOUS FUNDING TO COMPLETION
(APPEND SCHEDULE) _____ YEARS
OUTER RADIOUS FOR ACCESS / OTHER DETECTORS _____ m

APPEND DRAWINGS:

SIDE VIEW
END VIEW
RADIATION LENGTHS VS ETA (AND PHI AS NEEDED) LIVE AND DEAD THROUGH 30.
ABSORPTION LENGTHS VS ETA (AND PHI AS NEEDED) LIVE AND DEAD
SCHEME FOR MECHANICAL SUPPORT (ROUGH)

NOTE: Material in support of the above is restricted to a total of 25 pages total, in order to facilitate wide distribution. As much as possible should be in electronic form.

Prepared by _____ Date_____

THE FOLLOWING IS A SAMPLE (FAKED) OF WHAT ANSWERS MIGHT LOOK LIKE:
OPTION: imaginary
EM RESOLUTION: 17, 1.5, 0.03, 1.4
HAD: 1.05, 60, 3, 0.4, 2
HERM: 94, 2.5, 2.6. 3.1, 9, 10, 12
E, TRIG: 2, 0.1, 32, 20, 2, 0.1, 0.1, 70, 4, 0.2, 0.1
LIN: 1, 2.5, both correctable to <0.2% up to 1 TeV
RAD: 2.4, 2.2, 1.5, 2.2, 2, 4, eta > 2.6 replaced every 2x10**41, not needed if better plastic. Same as access to tracking end, 50 ton crane. No need for complete disassembly to get at electronics.
SAFETY: high voltage, sources, access: falling, ventilation, monkey bars on doorlike muon chambers, sources internally housed, HV encapsulated, fans at opening to space between muon chambers, multiple exits in muon system
CALIB: <0.5, 0.2, 250, 250, 2, two central wedges and two end sectors, peds, charge injection, light flashers, mobile sources
COST AND SCHEDULE: 4x 10.8k towers, 250x256 mult. prerad, 25000T, 9 g/cc, 80, 4, 4.1
J. Fred Muggs, 9/5/90
(Note that answers should be directly editted into the blanks!)

END OF JOB

ANHEP0::LJN

JOB 911

DALAGENDA

Owner UIC:	[C5031400,LJN]
Account:	C5031400

Priority:	100
Submit queue:	H220
Submitted:	18-SEP-1990 15:25
Printer queue:	H220
Printer device:	LTA220
Started:	18-SEP-1990 15:25
Finished:	18-SEP-1990 15:27

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Sheets printed:	3

Digital Equipment Corporation
VAX/VMS Version V5.3-1

ScriptPrinter LN03R
ScriptPrinter Software V2.1

DATE		TASK / MILESTONE
~ JAN 94		Begin FINAL FAB
Summer 93	▲	detailed design review (whole Detector) [ALL problems 'SOLVED']
FALL 92 ~~Summer 92~~ - EARLY 93		**design VALIDATION** ~~Prototype~~ beam test
JAN 92		Begin FULL Preliminary design - Final MODULE
FALL 91	▲	PROPOSAL DUE
JAN 92 ~~August 91~~	▲	MAKE Technology choice R & D completed - remaining problems 'just' engineering
Summer ~~90~~		**Then begin FAB**
~~Spring~~ 91		Test beam MODULE design review, ~~The begin FAB~~
NOV 90	▲	Technical REVIEW - WPO for simulation
FALL 90 - Spring 91		Test beam MODULE design - prototype + Preliminary calorimeter design (rough)

END OF JOB

ANHEP0::LJN

JOB 914

FORMO

Owner UIC:	[C5031400,LJN]
Account:	C5031400

Priority:	100
Submit queue:	H220
Submitted:	18-SEP-1990 15:26
Printer queue:	H220
Printer device:	LTA220
Started:	18-SEP-1990 15:29
Finished:	18-SEP-1990 15:30

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Sheets printed:	3

Digital Equipment Corporation
VAX/VMS Version V5.3-1

ScriptPrinter LN03R
ScriptPrinter Software V2.1

PRESENTATIONS TODAY

UPDATES ON

PLATES
SPAGHETTI
LIQUID ARGON
PREADATORS

FRIDAY

AM BRIEF ORGANIZATION
OPTION MEETINGS

PM JOINT CAL GROUP

PHYSICS CALCULATIONS FOR THE LOI

Solenoidal Detector Collaboration Meeting

L. E. Price
September 20, 1990

b. Assume a top quark with a mass of 250 GeV.

- How is it discovered in your detector?
- How accurately could the mass be measured?
- Can its decay properties be determined? For example, if the top decays to a charged Higgs with a mass of 150 GeV, at what branching ratio level can this process be detected?

b. Assume a top quark with a mass of 250 GeV.

- How is it discovered in your detector?
- How accurately could the mass be measured?
- Can its decay properties be determined? For example, if the top decays to a charged Higgs with a mass of 150 GeV, at what branching ratio level can this process be detected?

Methods

Isolated electron, isolated muon (EOI)

Isolated lepton and jets (EOI)

*Isolated lepton (from top decay), non-isolated lepton of opposite sign (from b-decay from same top) (PAC response)

$t \rightarrow H^+ b$

$H^+ \rightarrow \tau\nu$ (PAC Response)

*$H^+ \rightarrow c\bar{s}$ (New)

People

M. Barnett, L. Galtieri, B., Hollebeek, B. Hubbard, A. Palounek, P. Sinervo, A. Bay, J. Gunion, H.-J. Trost

Backup Material

SDC-30

SDC notes in preparation

Methods

Isolated electron, isolated muon (EOI)

Isolated lepton and jets (EOI)

*Isolated lepton (from top decay), non-isolated lepton of opposite sign (from b-decay from same top) (PAC response)

$t \rightarrow H^+ b$

$H^+ \rightarrow \tau\nu$ (PAC Response)

*$H^+ \rightarrow c\bar{s}$ (New)

People

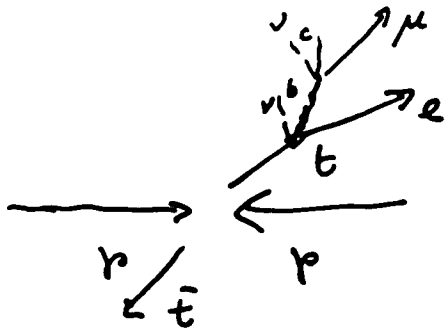
M. Barnett, L. Galtieri, B., Hollebeek, B. Hubbard, A. Palounek, P. Sinervo

Backup Material

SDC notes in preparation

Top Mass determination

A. Bay, A. Geltieri, A. Palounek



topology

$t \to e\, b\, \nu$ isolated e

$\hookrightarrow \mu\, c\, \nu$ non-isolated μ

$M(e-\mu) \propto M_{top}$

- Trigger

$E_T(e) > 35$ GeV

Full efficient at $E_T = 40$ GeV

- Require

isolated e $E_\perp(e) > 40$ GeV

non-isolated μ $P_\perp(\mu) > 20$ GeV

$P_\perp(e\mu) > 120$ GeV/c

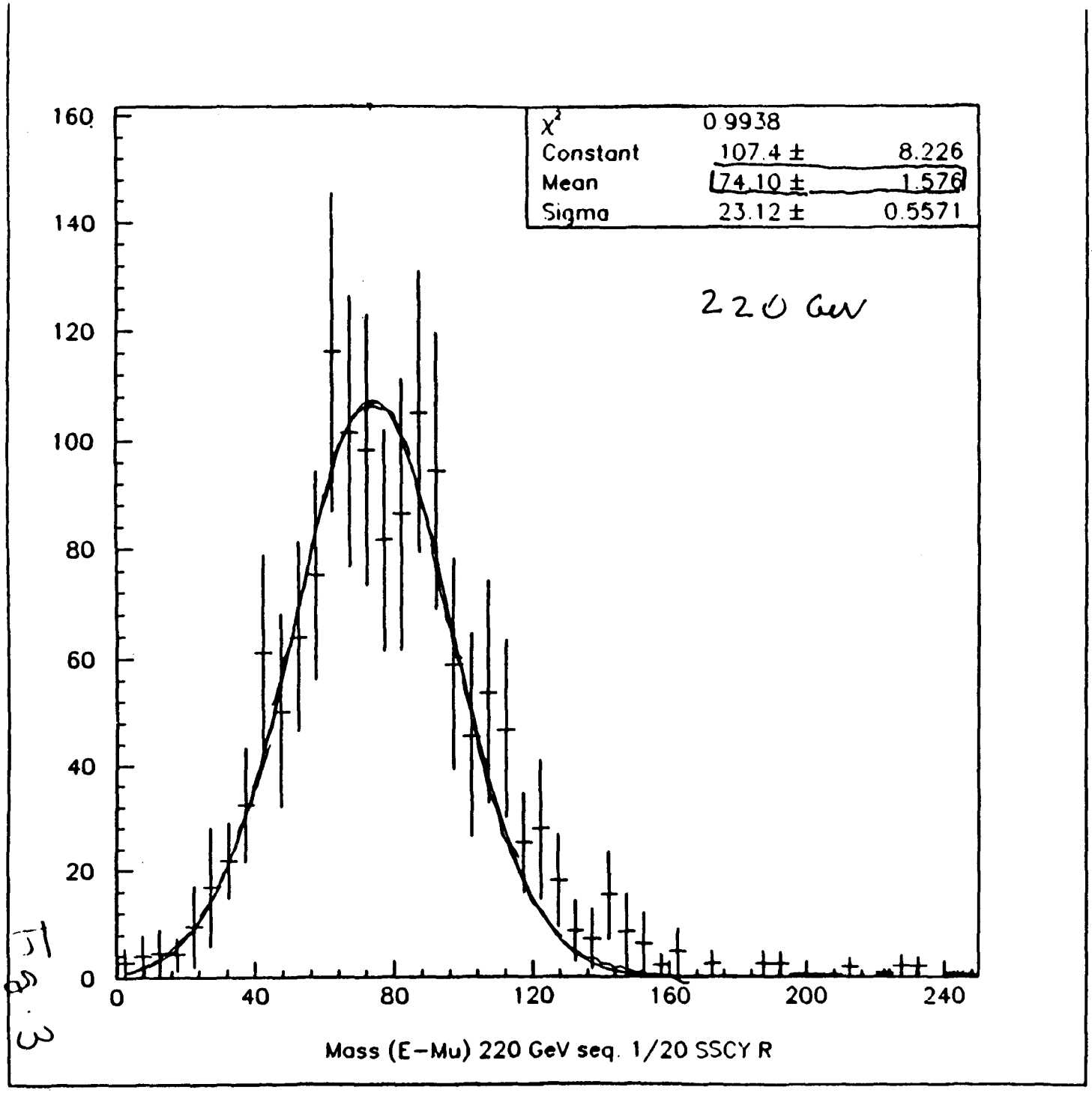
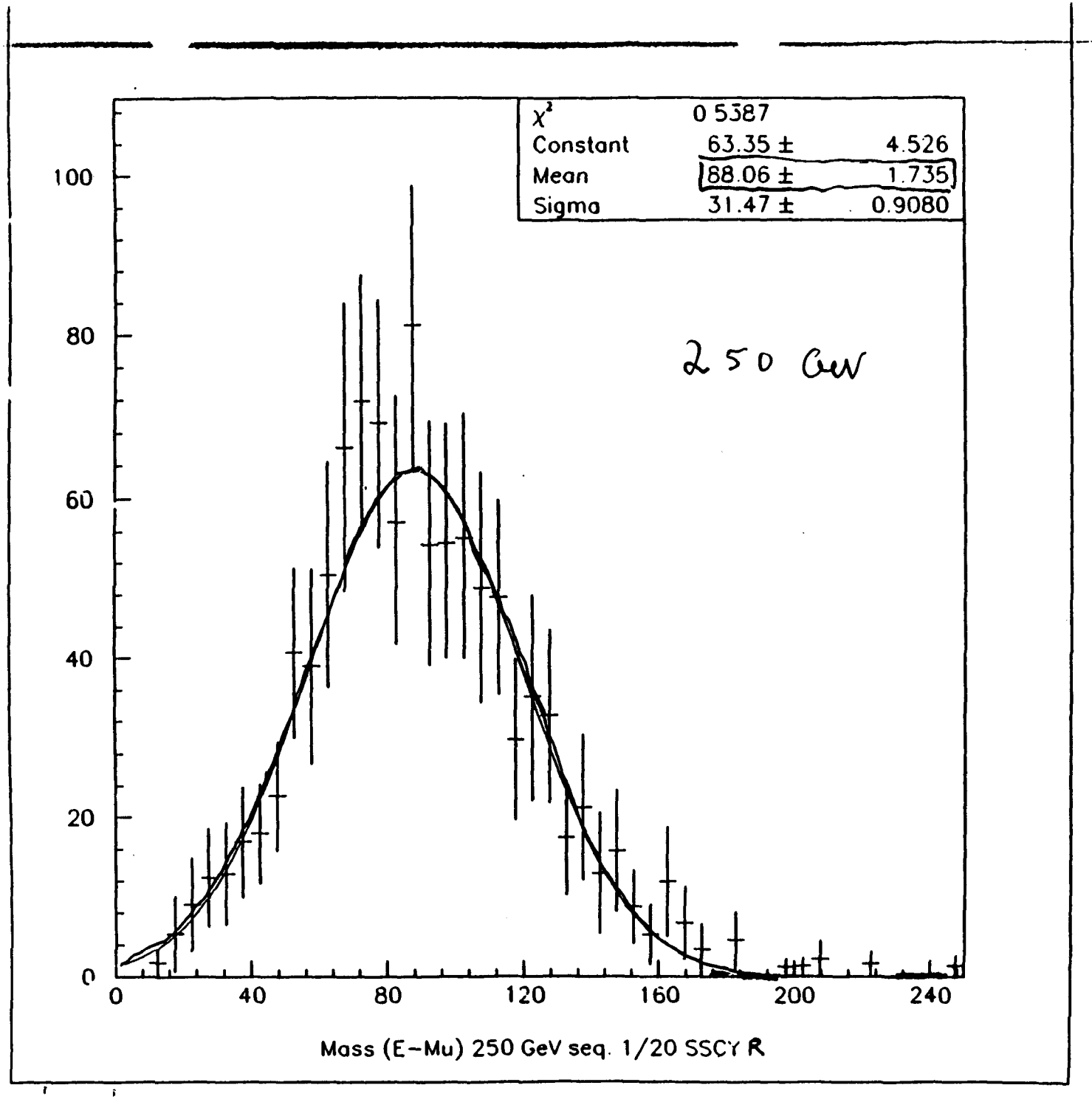


Fig. 3

Sum

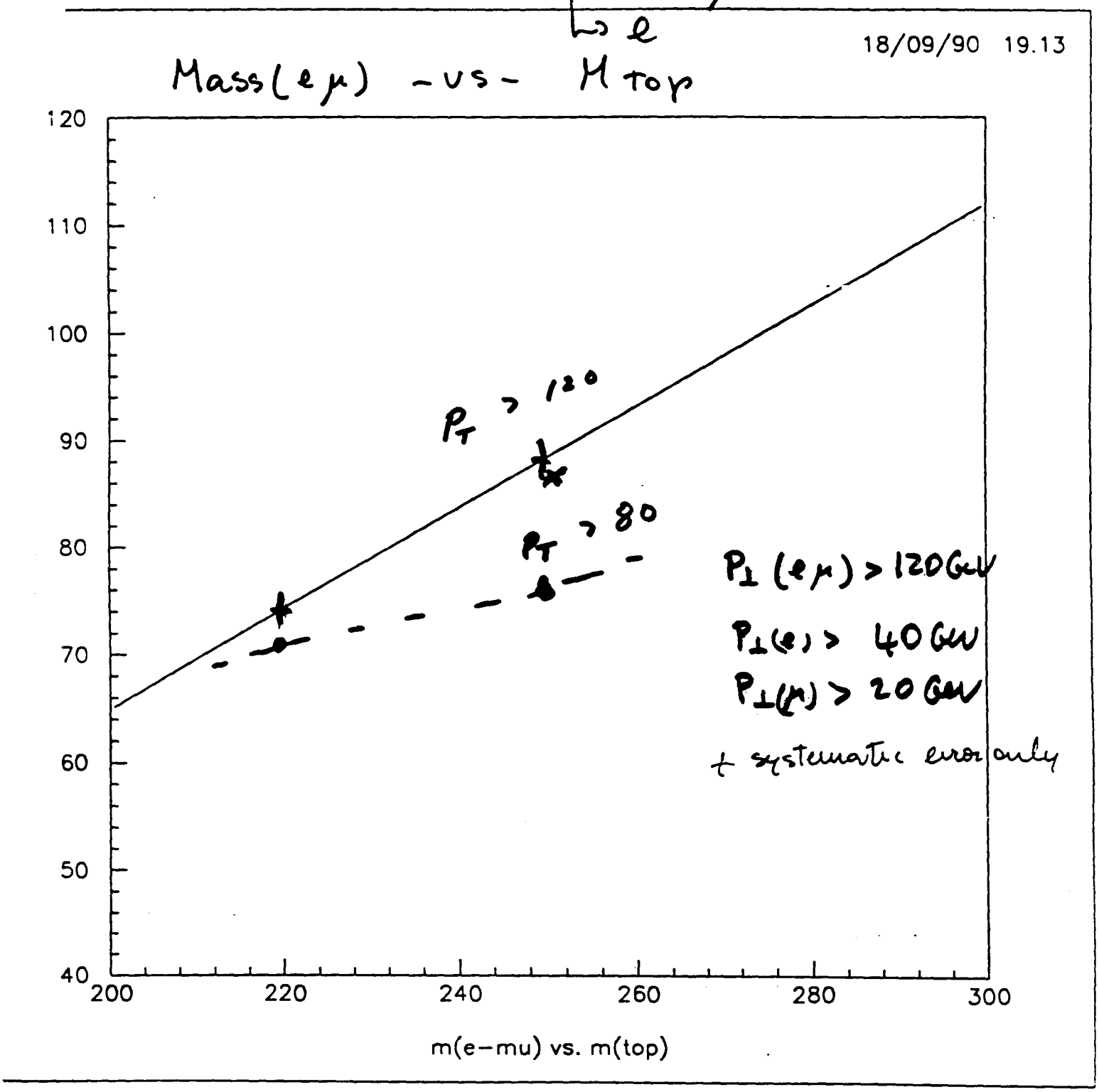
251K events

Sum



336K events

$pp \to t\bar{t}$, $t \to W b$, $W \to e$, $b \to \mu$



- $dM(e\mu) = (.47 \pm .08)\, dM_{top}$

  this gives $\frac{dM}{M}(top) = 1.5\%$ statistics

- systematics error

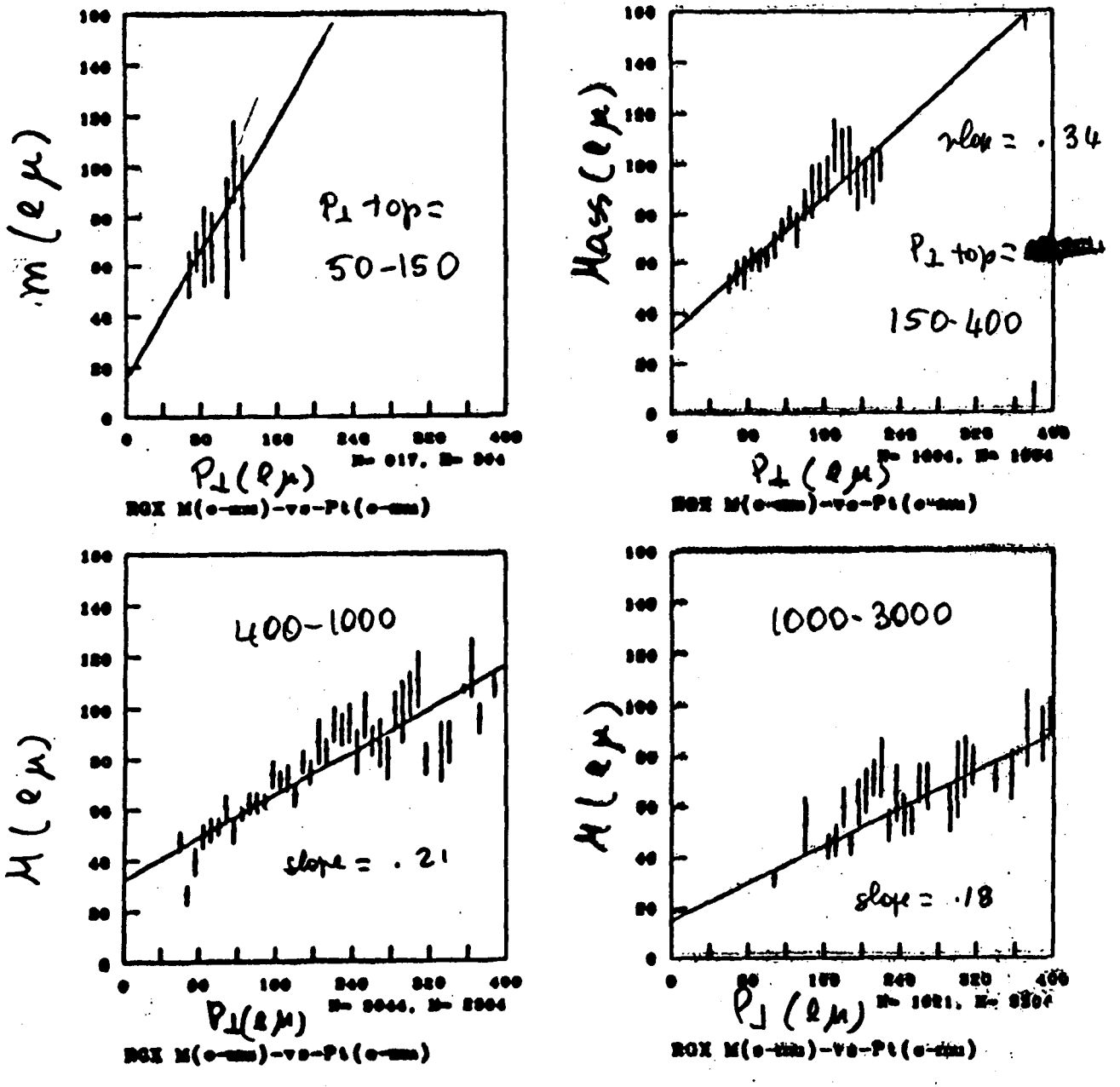
  1. Fragmentation both top + bottom
     they will be better known by then
     - tried varying a parameter in Peterson form
       $\varepsilon = \frac{d}{m_t}$, very little change.

	d	
$M(e\mu)$	.5	88.2 ± 1.8
	.2	86.1 ± 1.8

  2. Top production model
     most can be tuned in Montecarlo
     so that data are reproduced

  3. Smearing due to resolution
     E_{Te} cut
     $P_{\perp\mu}$ cut
     $P_{\perp}(e\mu)$ cut.

Mtop=250 GeV RUN F PTe)40,Ptmu)20 SMEAR, 1/20SSCY



Conclusions:

- even with $\frac{1}{20}$ SSCY of data one can obtain the top mass within a few %
- Systematics errors from physics come from
  a. b fragmentation uncertainty
     (tried one case, error quite small)
  b. Top $p_\perp$ distribution
     studying $M(e-\mu)$ -vs- $P_\perp(e-\mu)$ and tuning the Montecarlo, it is possible to reduce this systematic error.
- Systematics from E_T, $P_\perp \mu$ resolution
- another analysis of this channel has been done by Nodulman, using the ISAJET detector routine
- Smearing functions defined in the EOI have been used for this analysis.

ST...:

9/10/90 B. Hubbard UCS
(with Barnett, Gunion.

PAC Question: t decay to H^+b

$m_t = 250$ GeV/c^2
$m_{H^+} = 150$ GeV/c^2

Two methods:

- τ excess
- hadronic decays (to $c\bar{s}$)

Note in progress ...

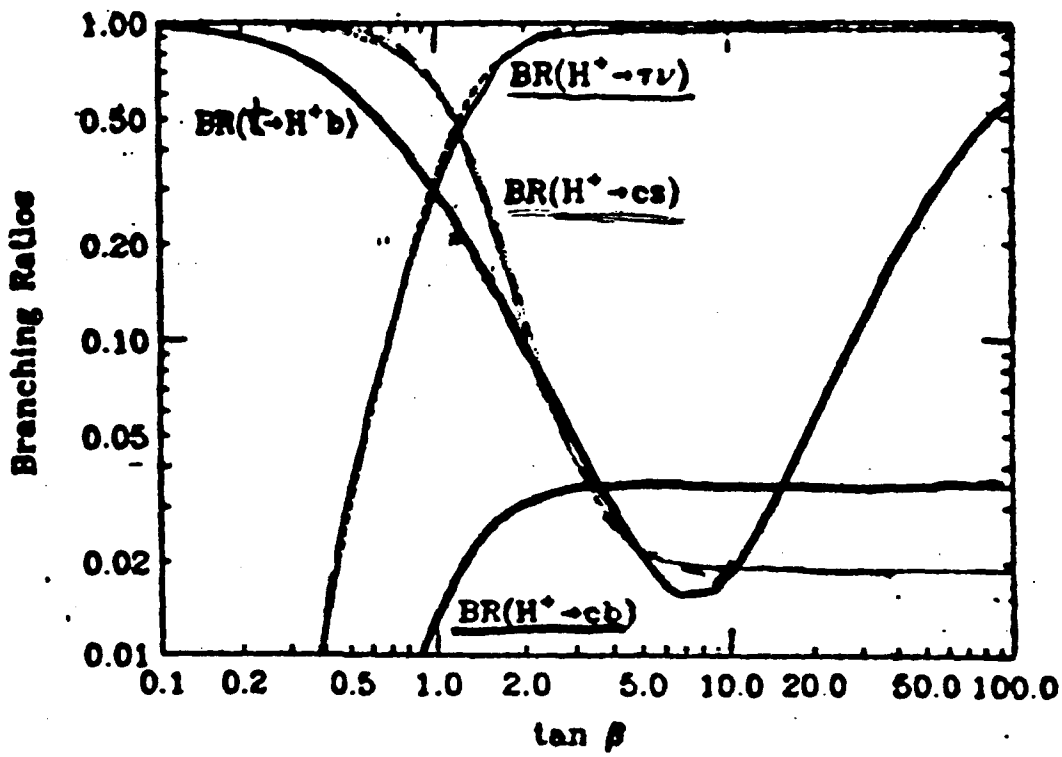


FIG. 14. Branching fractions for the reactions $t \to H^+b$ and $H^+ \to \tau\nu$, $c\bar{s}$ and $c\bar{b}$ as a function of the parameter $\tan\beta$ [9].

considered is to search for an excess of τ's in $t\bar{t}$ events. The number of τ's produced in t decays may be enhanced if the top quark can decay into $H^\pm b$, since the charged Higgs can have a very large branching ratio to $\tau\nu$. Thus, our strategy will be to look for events in which one top quark decays semi-leptonically via a $W^\pm$, and the other top quark decays [illegible] we use only the decay to $\tau\nu$ and look

Method 1: τ decays

$B(H^+ \to \tau^+\nu) > 50\%$ for $\tan\beta > 1$

(but $B(t \to H^+ b) < 25\%$)

Require: lepton (e, μ) $P_T > 40$ GeV/c

(A) isolated $(E_T / E_T(.4)) > 0.8)$

central $|\eta| < 2.5$

(B) Two tagged b jets, $P_T > 30$ GeV/c

$|\eta| < 2.$

Assume 50 % tag efficiency / jet

Selects events from:

$t\bar{t} \to W^+W^-b\bar{b}$ "WW events"

$W^+H^-b\bar{b}$ "WH events"

Background from non-top should be "small".

"Jet" is cluster of final state particles (excluding ν's) from Isajet

- clustered within $R < 0.7$
- $|\eta| < 2.5$, $P_T > 20$ GeV/c

Calorimeter not simulated in detail

Resolution imposed with JET_SMEAR routine

τ criteria:

look for decay $\tau^- \to \pi^- \nu$ or $K^- \nu$

high P_T single charged hadron,

isolated $P_T / \sum E_T(.4) > 0.8$

Compare ~~Normalize~~ to di-lepton rate (assuming universality) to eliminate uncertainty on $\sigma_{t\bar{t}}$

$$R_{predicted} = \frac{N_{t\bar{t}}\, e_{trig}\, e_{tag}\, \frac{4}{81}\, B(\tau \to \pi\nu)\, e_{\pi}^{WW}(P_T)}{N_{t\bar{t}}\, e_{tag}\, e_{\ell 2}(P_T) + \mathcal{O}(10\%)}$$

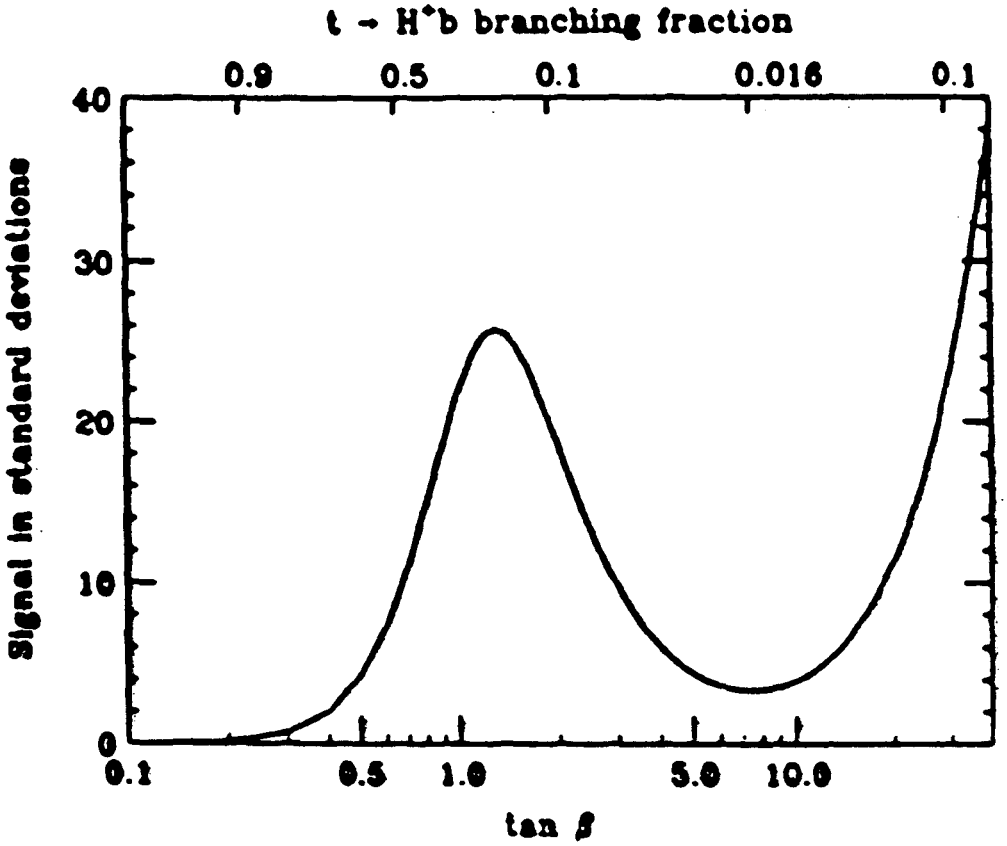
from Isajet, $e_{trig} \sim .49$

$e_{tag} \sim .122$

$$\frac{N_{obs}}{N_{pred}} \simeq \frac{(1-B_H)^2 + 2B(1-B)\frac{2}{9}\frac{e_{\pi}^{WH}}{e_{\pi}^{WW}}}{(1-B_H)^2} = \frac{N^{WW} + N^{WH}}{N^{WW}}$$

* sigma excess is $\dfrac{N^{WH}}{\sqrt{N^{WW}}}$

Figure from E.I
New numbers are being calculated for significance of $H^+ \to \tau\nu$



events per year to roughly 1000 events per year, where a p_t cut of 100 GeV/c has been imposed on the pion.

To judge the significance of this excess, we consider the number of 1-prong decays with $p_t > 100$ GeV/c. The number of standard deviations above expectations from lepton universality, as a function of the branching fraction $t \to H^+b$, is shown in Fig. 15. Requiring a five sigma effect, after one year we could detect $t \to H^+b$ and measure its branching ratio if that branching ratio lies between 3 and 60%, corresponding to $\tan\beta = 0.5$–4.5 or $\tan\beta > 12$.

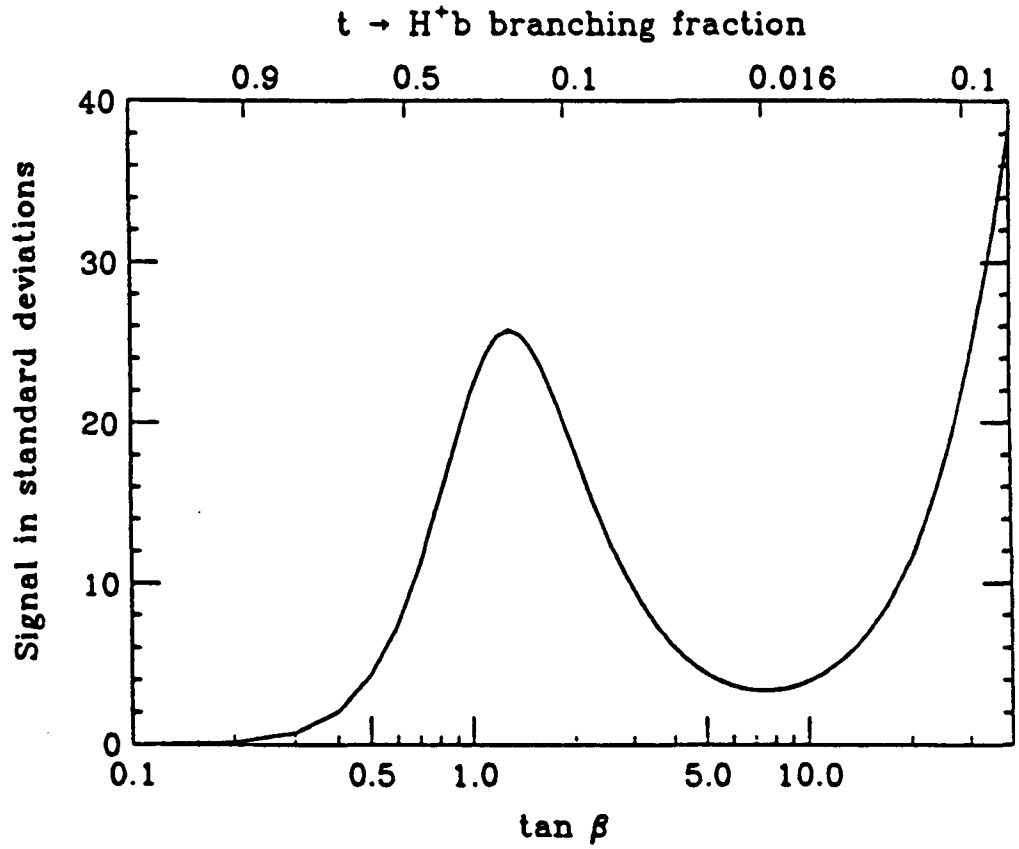


FIG. 15. Significance of the excess of isolated pions due to $t \to H^+b$, $H^+ \to \tau\nu$, and $\tau \to \pi\nu$ relative to expectations for $t \to W^+b$ (assuming lepton universality) as a function of $\tan\beta$ (bottom labels). The pion is required to have $p_t^\pi > 100$ GeV/c and is produced in association with an isolated lepton with $p_t > 40$ GeV/c. The upper labels give the $t \to H^+b$ branching ratio, which reaches a minimum at $\tan\beta \approx 8$ (see. Fig. 14).

This method is not sensitive to $t \to H^+b$ branching fractions greater than 60% because the branching ratio $H \to \tau\nu$ becomes too small (see Fig. 14). In this case we must search for the $c\bar{s}$ decay of the H^+. We do this by using the second method described above to detect top decays. We search for events of the type $t\bar{t} \to WbH\bar{b} \to \ell\nu b\bar{c}s\bar{b}$ by looking for events with an isolated lepton with $p_t > 40$ GeV/c, two tagged b jets and two additional jets. This work is in progress, but we expect that the invariant mass of the dijet system consisting of non-b jets will show a peak at the charged Higgs mass as well as at the W mass.

Method II. uses $H^+ \to c\bar{s}$ decays

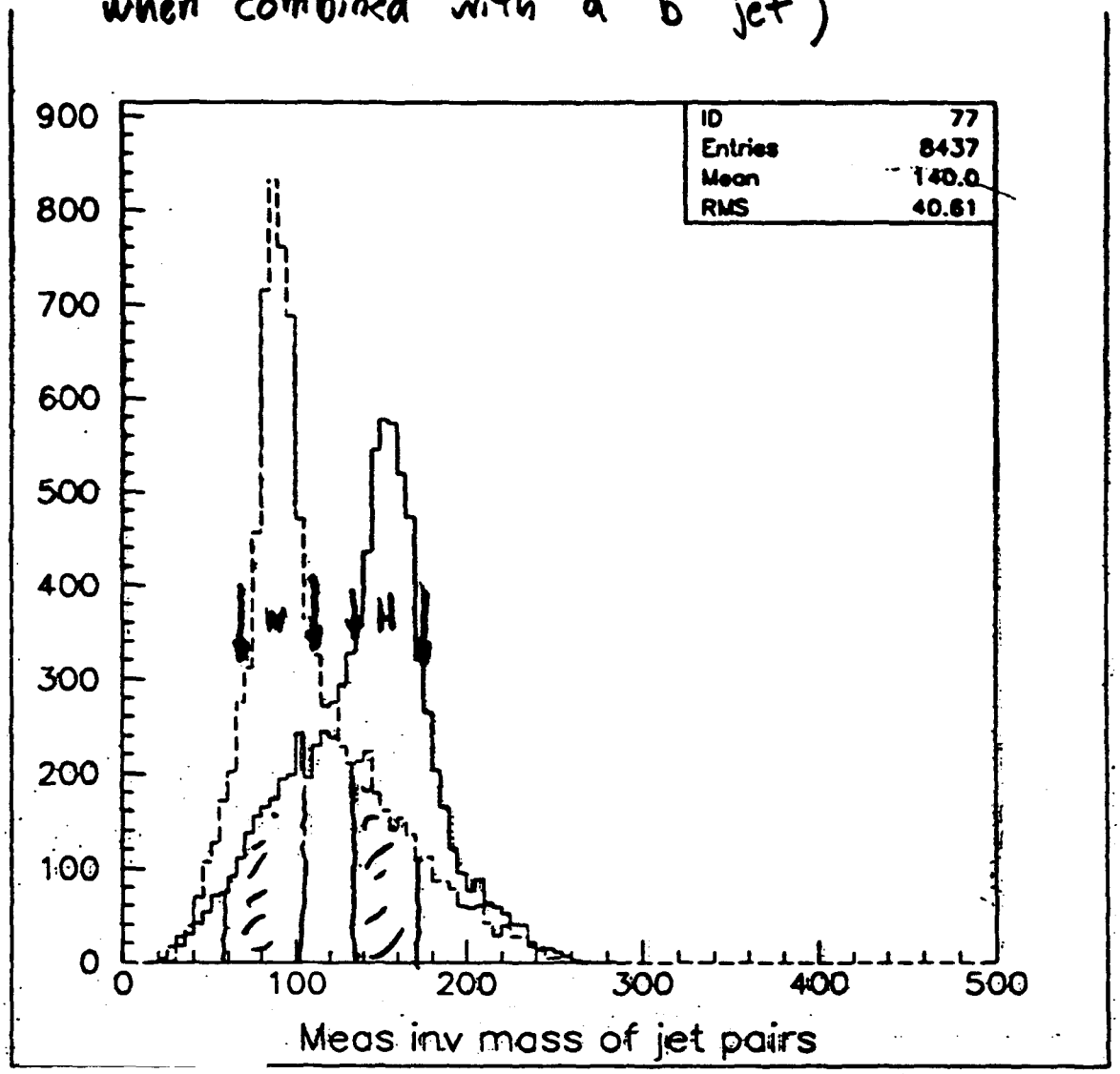
- plot invariant masses of jet pairs (not including tagged b's)

- to reduce combinatoric background, first require consistancy with t mass:

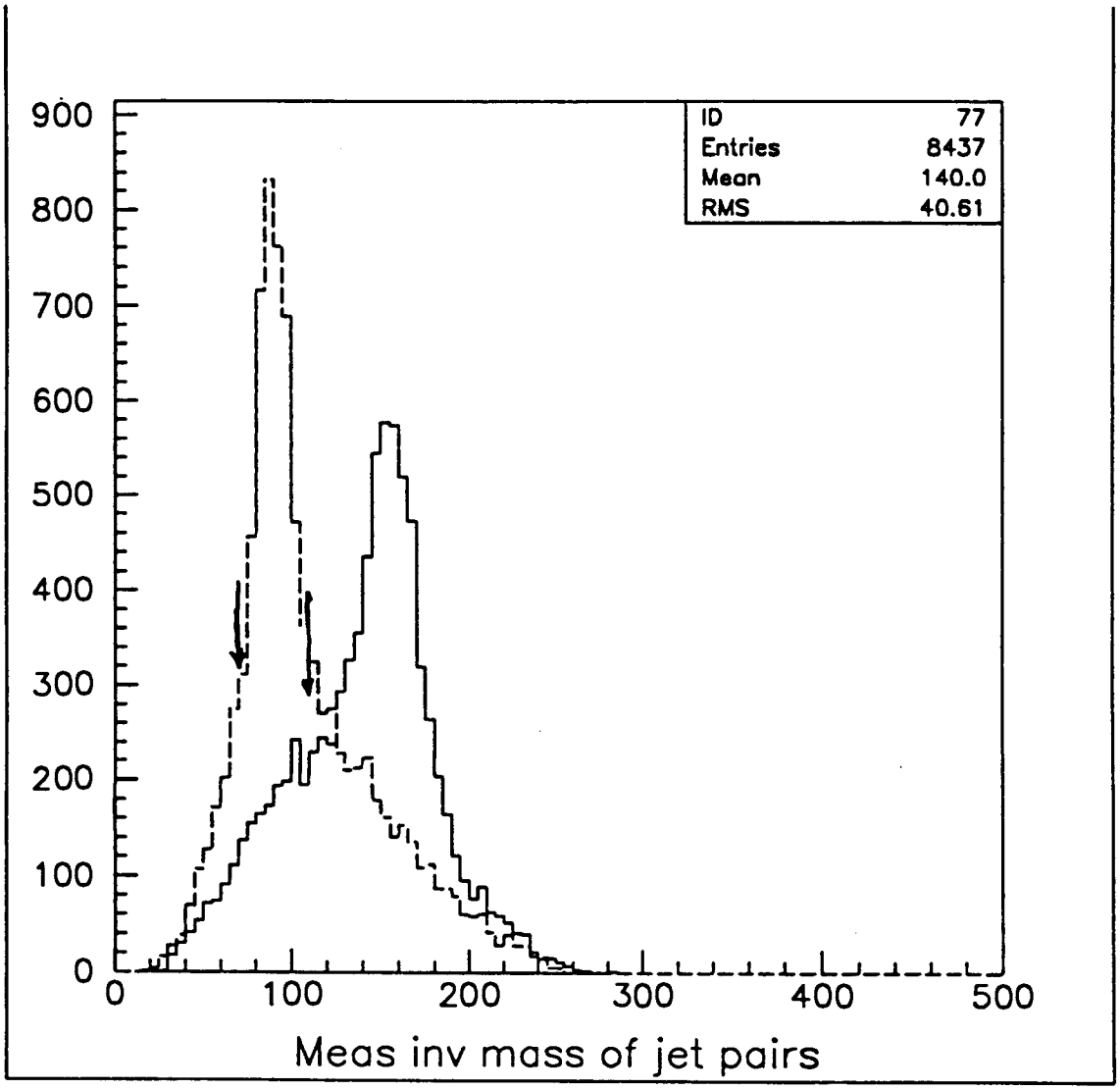
$$IM(j_1 + j_2 + b_{1 \text{ or } 2}) < 300 \text{ GeV}/c^2$$

- then pick two highest P_T jets satisfying above criterion

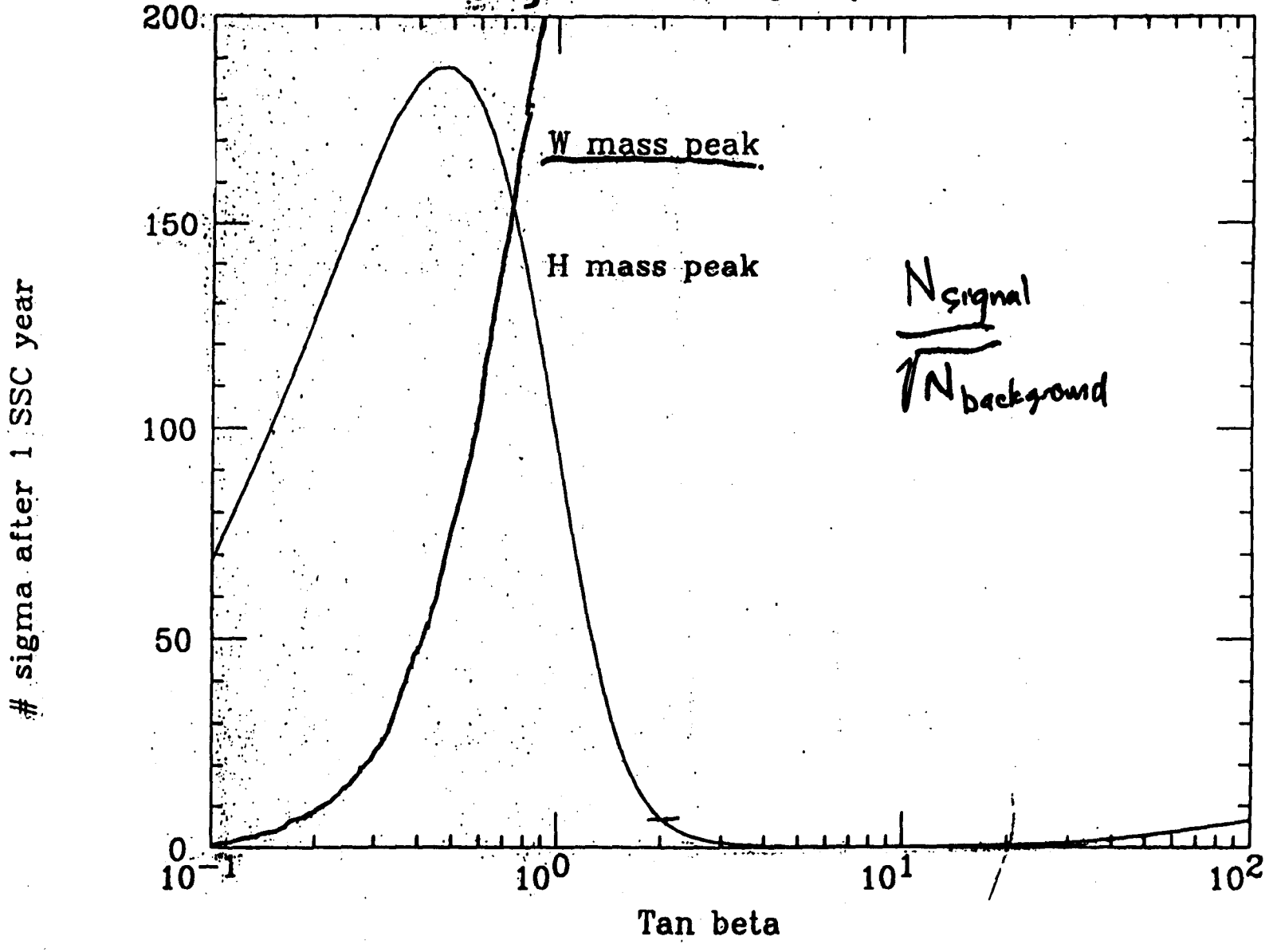
- plot 'best' combination of two jets (2 highest p_T jets consistent with t mass when combined with a b jet)

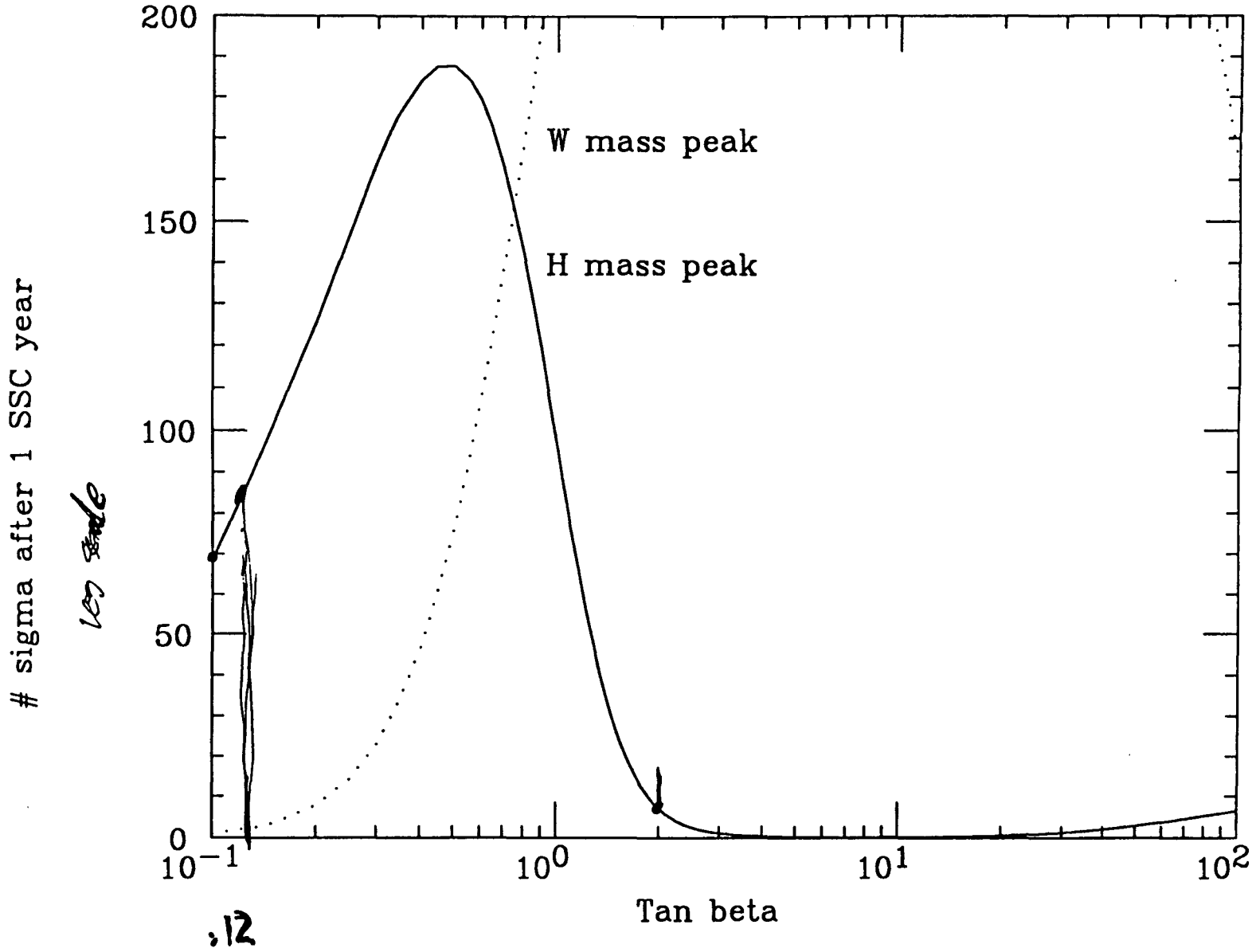


Assume background shape is the same, ~~reasonable~~ estimate signal + background in two intervals


ID 77
Entries 8437
Mean 140.0
RMS 40.61
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
500
Meas inv mass of jet pairs

Significance of Mass Peak from $H \to c\bar{c}$




200
150
100
50
0
sigma after 1 SSC year
W mass peak
H mass peak
10^{-1}
10^{0}
10^{1}
10^{2}
Tan beta

c. Demonstrate the jet energy and resolution of your proposed detector by studying decays

$$Z \rightarrow \text{jet} + \text{jet}$$

$$Z' \rightarrow \text{jet} + \text{jet}, \; M_{Z'} = 1TeV$$

c. Demonstrate the jet energy and resolution of your proposed detector by studying decays

$$Z \rightarrow \text{jet} + \text{jet}$$

$$Z' \rightarrow \text{jet} + \text{jet}, \; M_{Z'} = 1TeV$$

Methods

Generate Z, Z' in p_T ranges around 0, 50, 500 GeV

Pass through detector simulation with ANLSIM or SSCSIM

Aim to understand origin of mass resolution

Magnetic Field, Shower size, Calorimeter Resolution, Calorimeter Segmentation, Cracks

People

A. Beretvas, R. Blair, K. Denisenko, N. Denisenko, A. Para, L. Price, B. Wicklund, W. Wu, G. P. Yeh

Backup Material

SDC Note(s) to be written

Methods

Generate Z, Z' in p_T ranges around 0, 50, 500 GeV

Pass through detector simulation with ANLSIM or SSCSIM

Aim to understand origin of mass resolution

Magnetic Field, Shower size, Calorimeter Resolution, Calorimeter Segmentation, Cracks

People

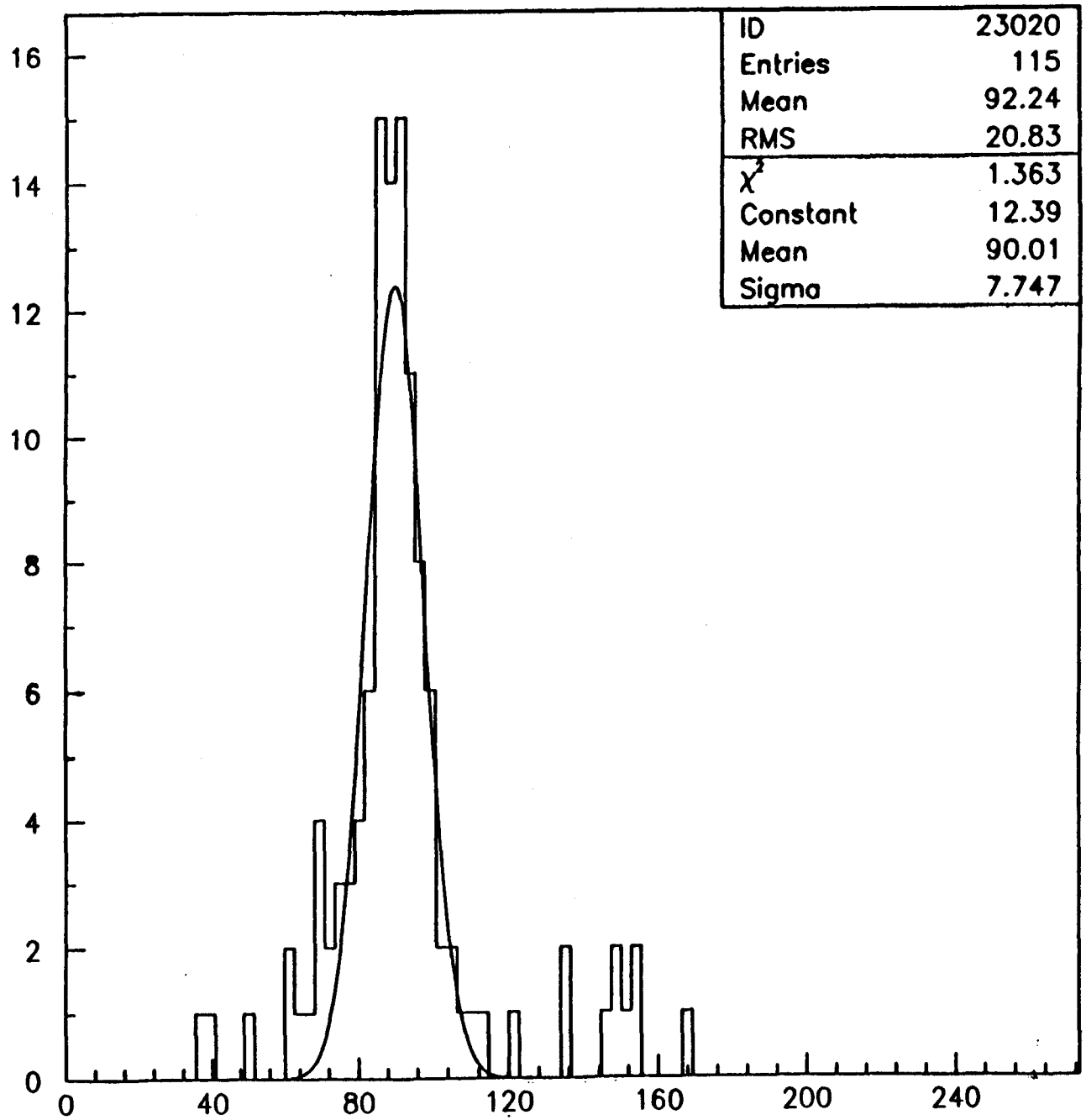
A. Beretvas, R. Blair, K. Denisenko, N. Denisenko, A. Para, L. Price, B. Wicklund, W. Wu, G. P. Yeh

Backup Material

SDC Note(s) to be written

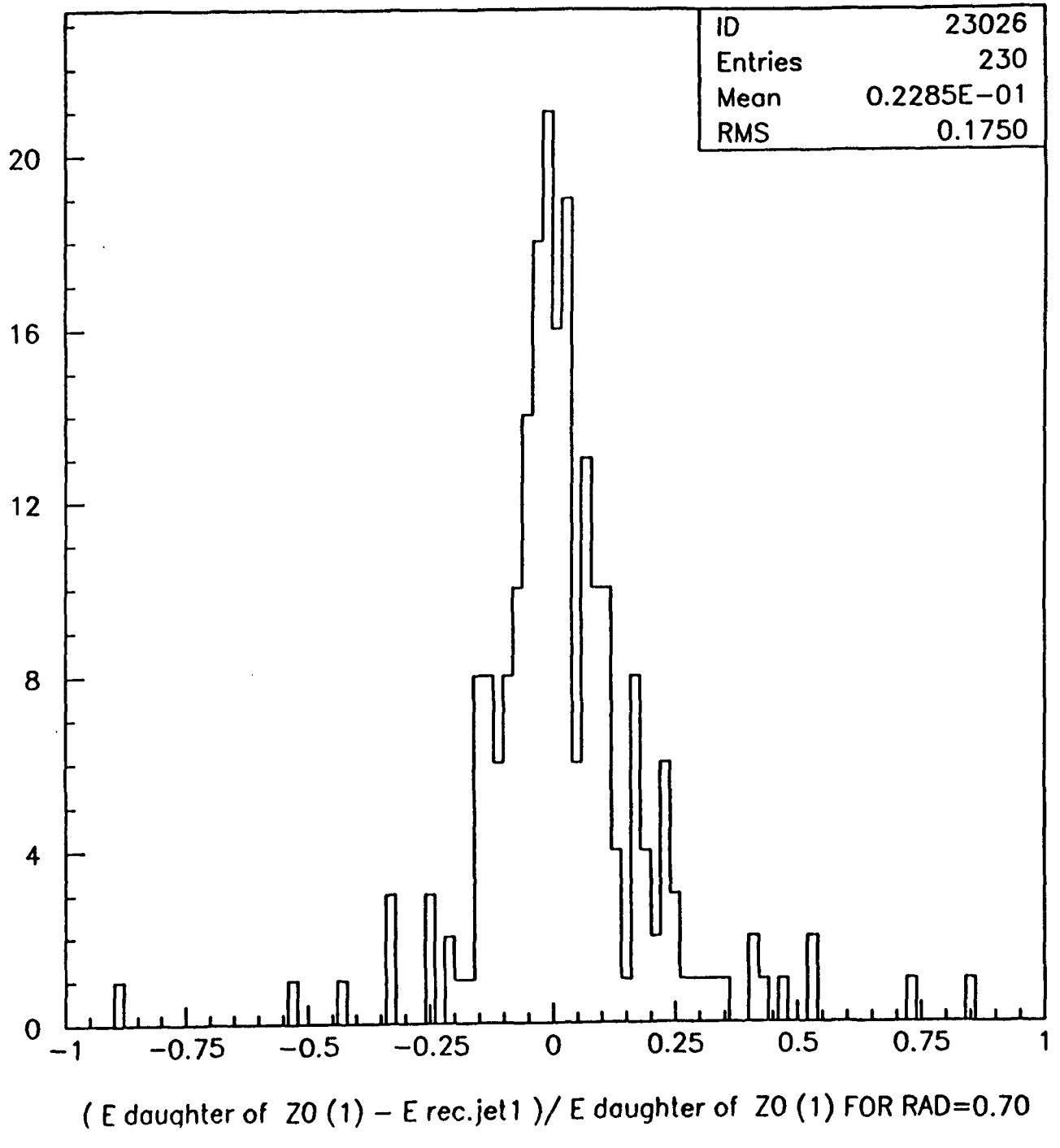
No B field, low p_T Z $\Delta\eta = \Delta\phi = .05$

$\left(\frac{\Delta E}{E}\right)_{had} = \frac{0.5}{\sqrt{E}} \oplus 0.03$

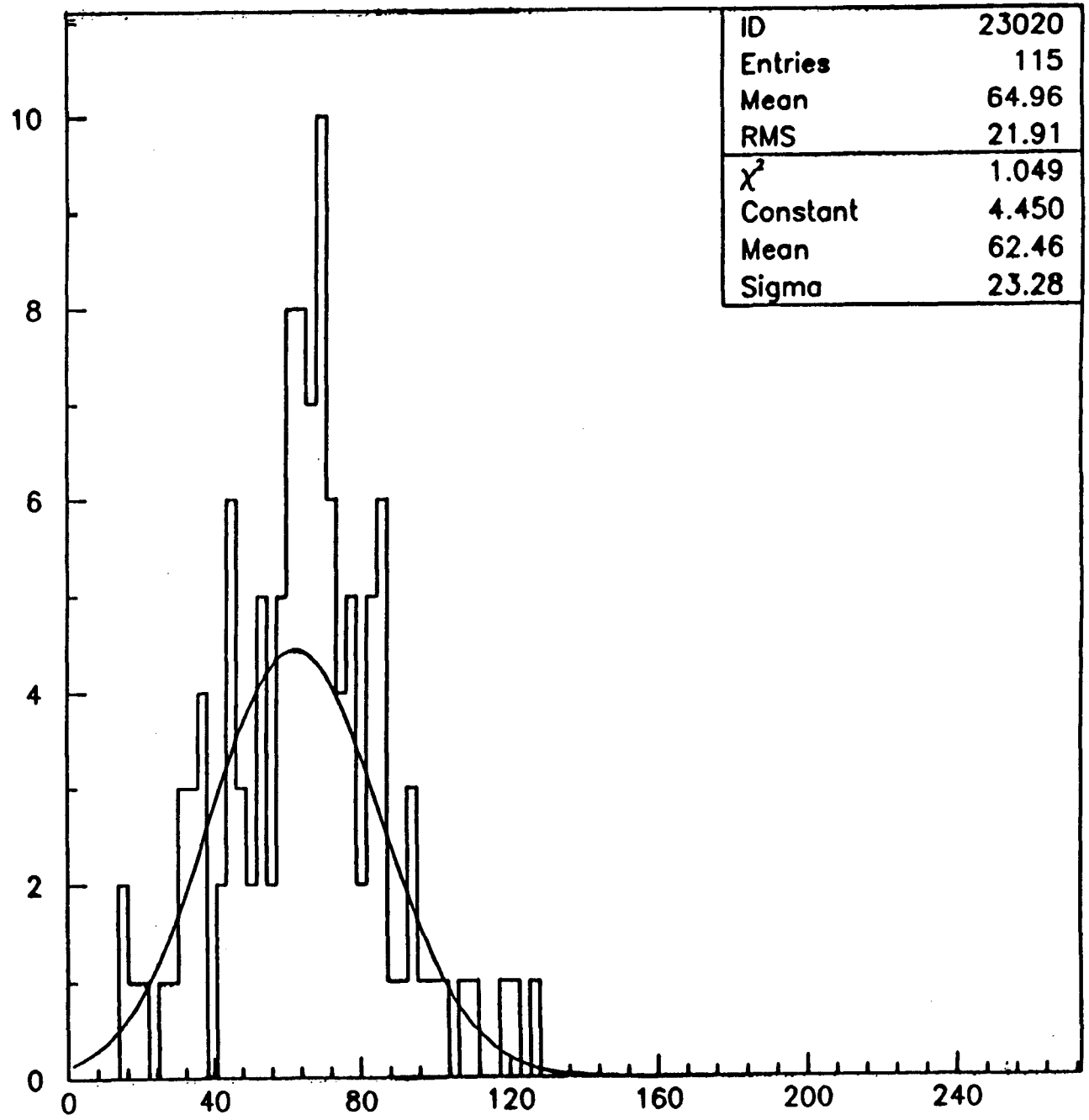


JET–JET RECONSTRUCTED M. S FOR Z0 FOR RAD=0.70

No B field, low p_T Z

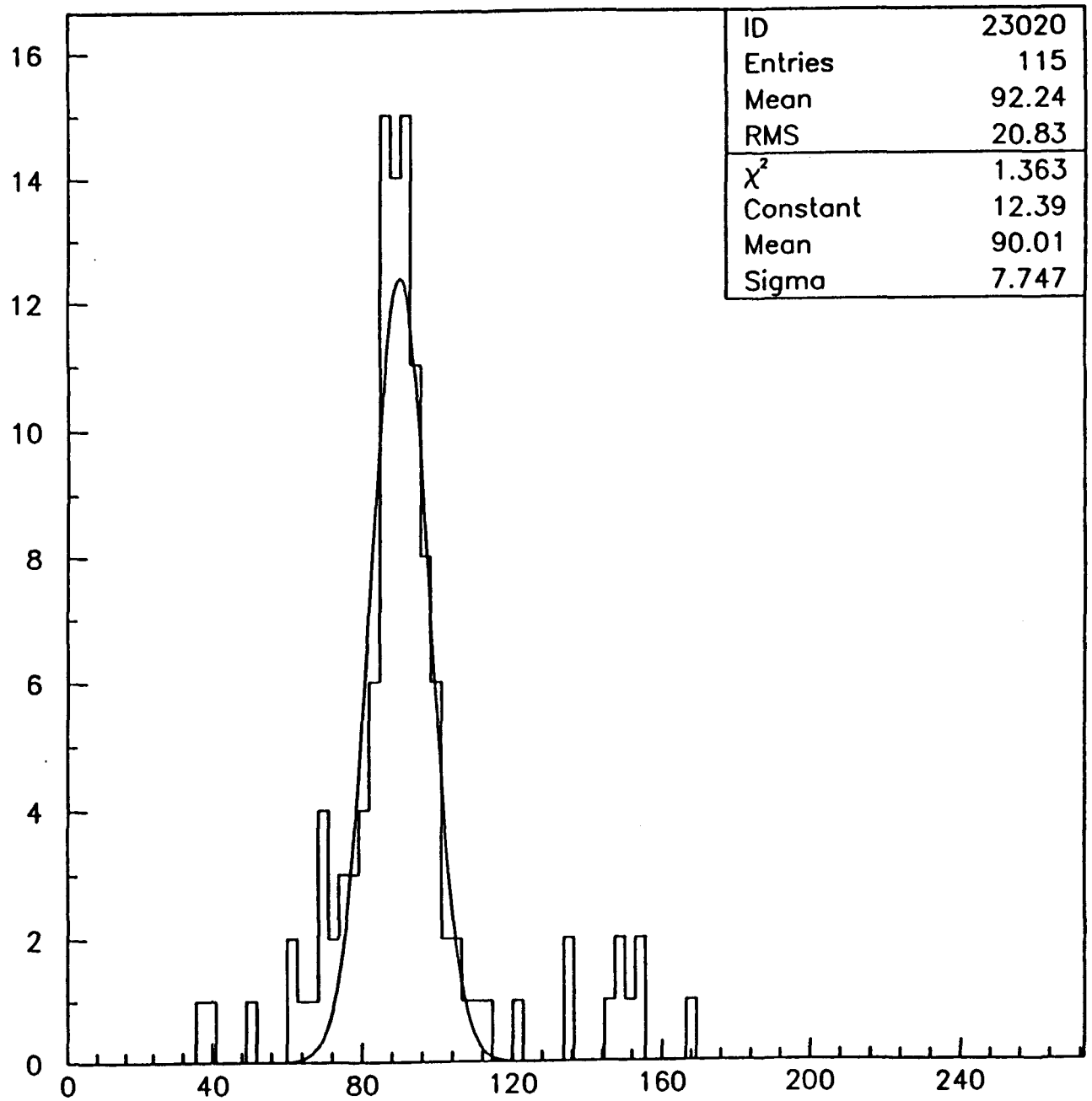


low p_T Z, $\Delta\eta = \Delta\phi = 0.05$, $\left(\frac{\Delta E}{E}\right)_{had} = \frac{0.5}{\sqrt{E}} \oplus 0.03$



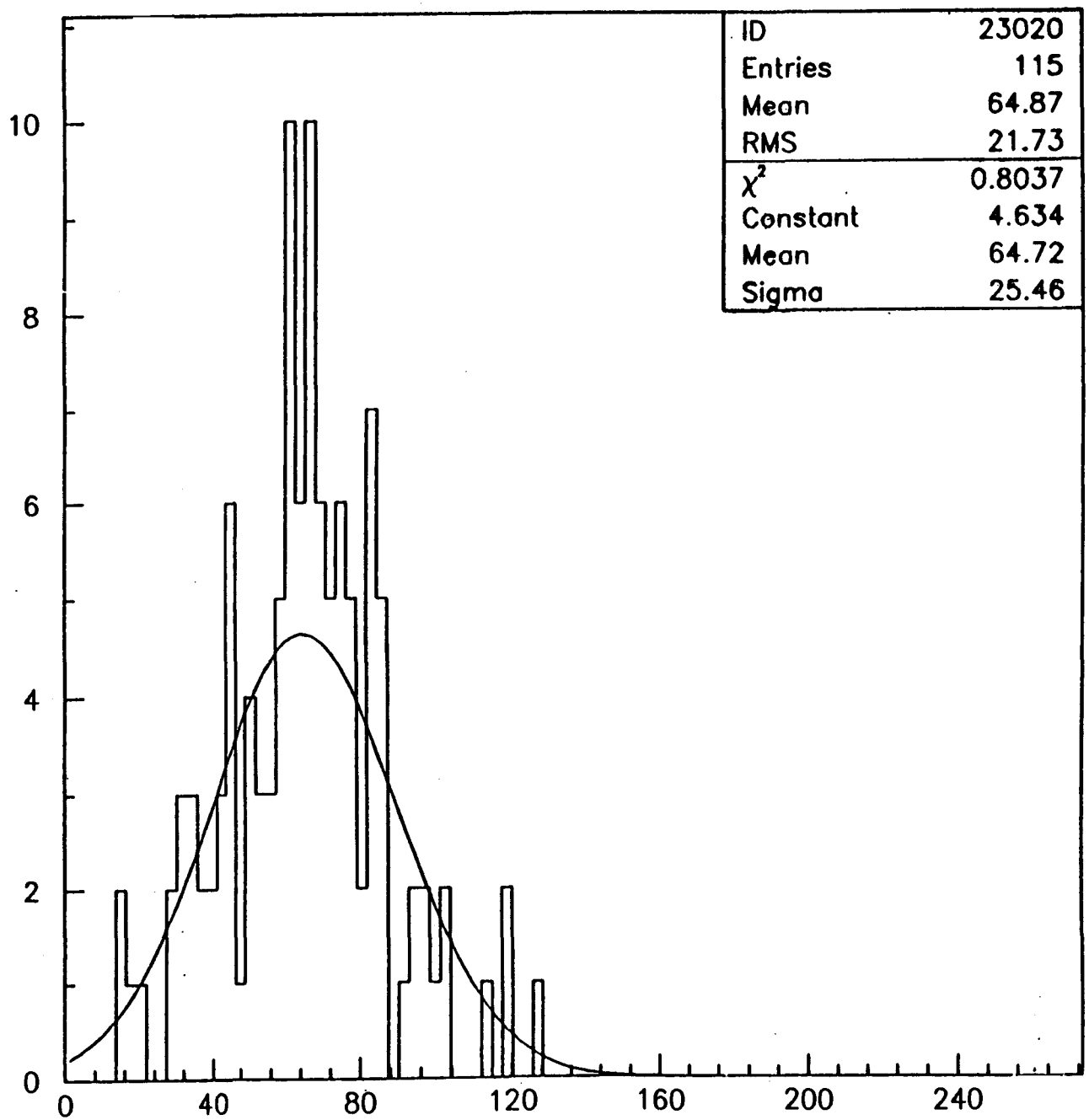
JET–JET RECONSTRUCTEL .ASS FOR Z0 FOR RAD=0.70

No B field, low p_T Z



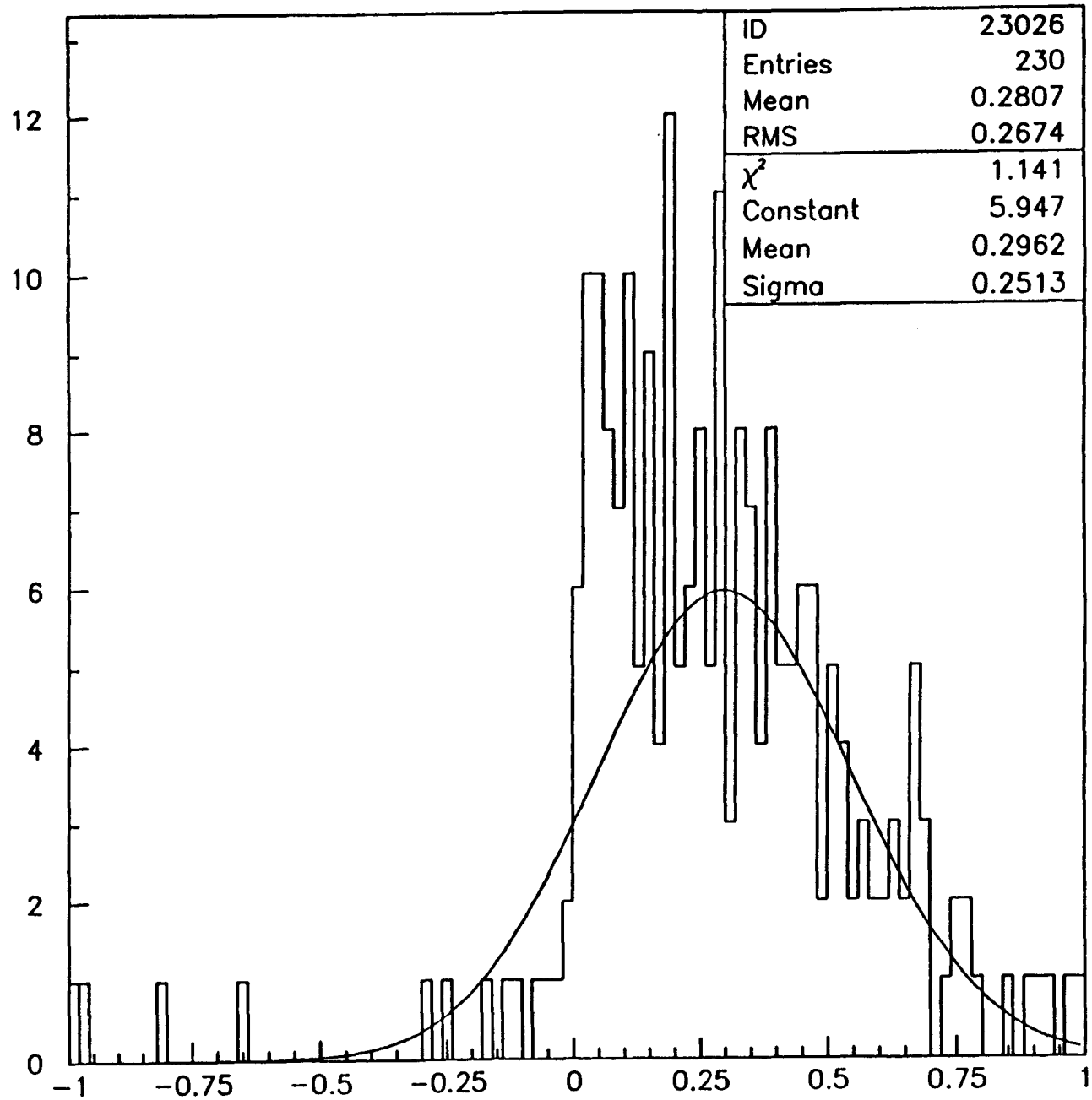
JET–JET RECONSTRUCTED MASS FOR Z0 FOR RAD=0.70

$(\Delta E/E)_{had} = \frac{.3}{\sqrt{E}} \oplus 2\%$ low p_T 2



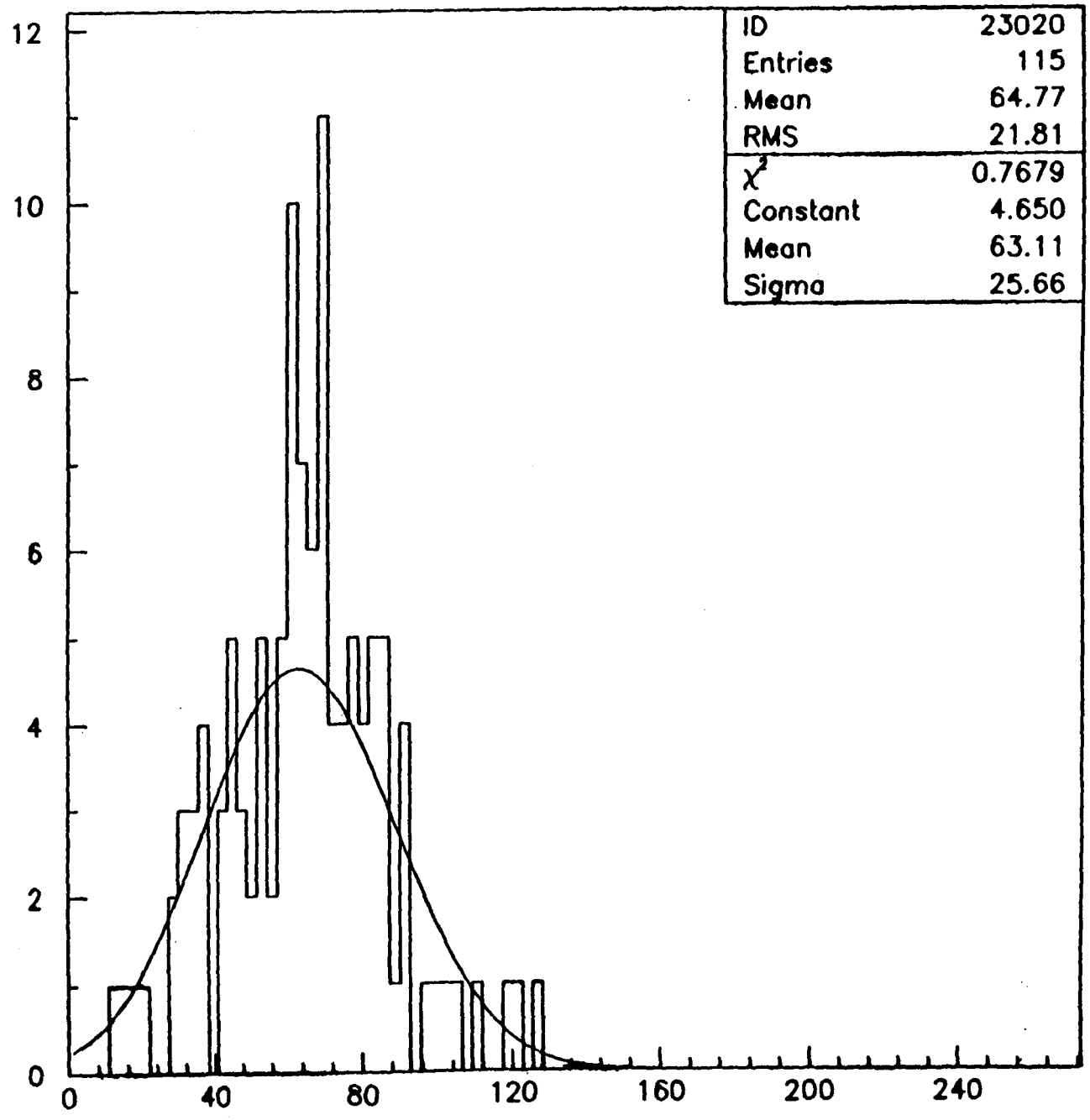
JET-JET RECONSTRUCTED M. .S FOR Z0 FOR RAD=0.70

$(\Delta E/E)_{had} = \frac{.3}{\sqrt{E}} \oplus 2\%$ low p_T 2



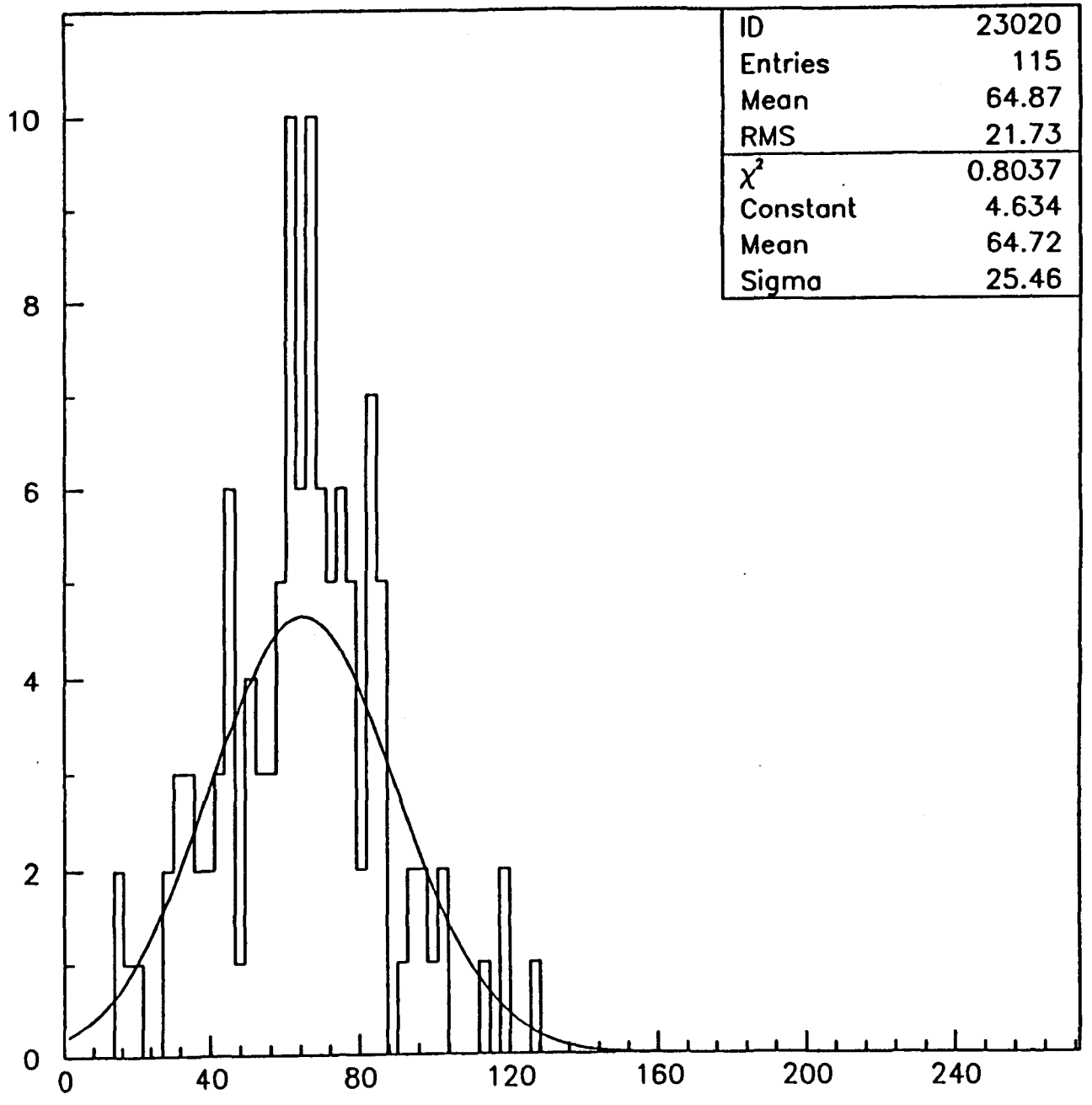
(E daughter of Z0 (1) − E rec.jet1)/ E daughter of Z0 (1) FOR RAD=0.70

$\Delta\eta = \Delta\phi = .03$ low p_T 2



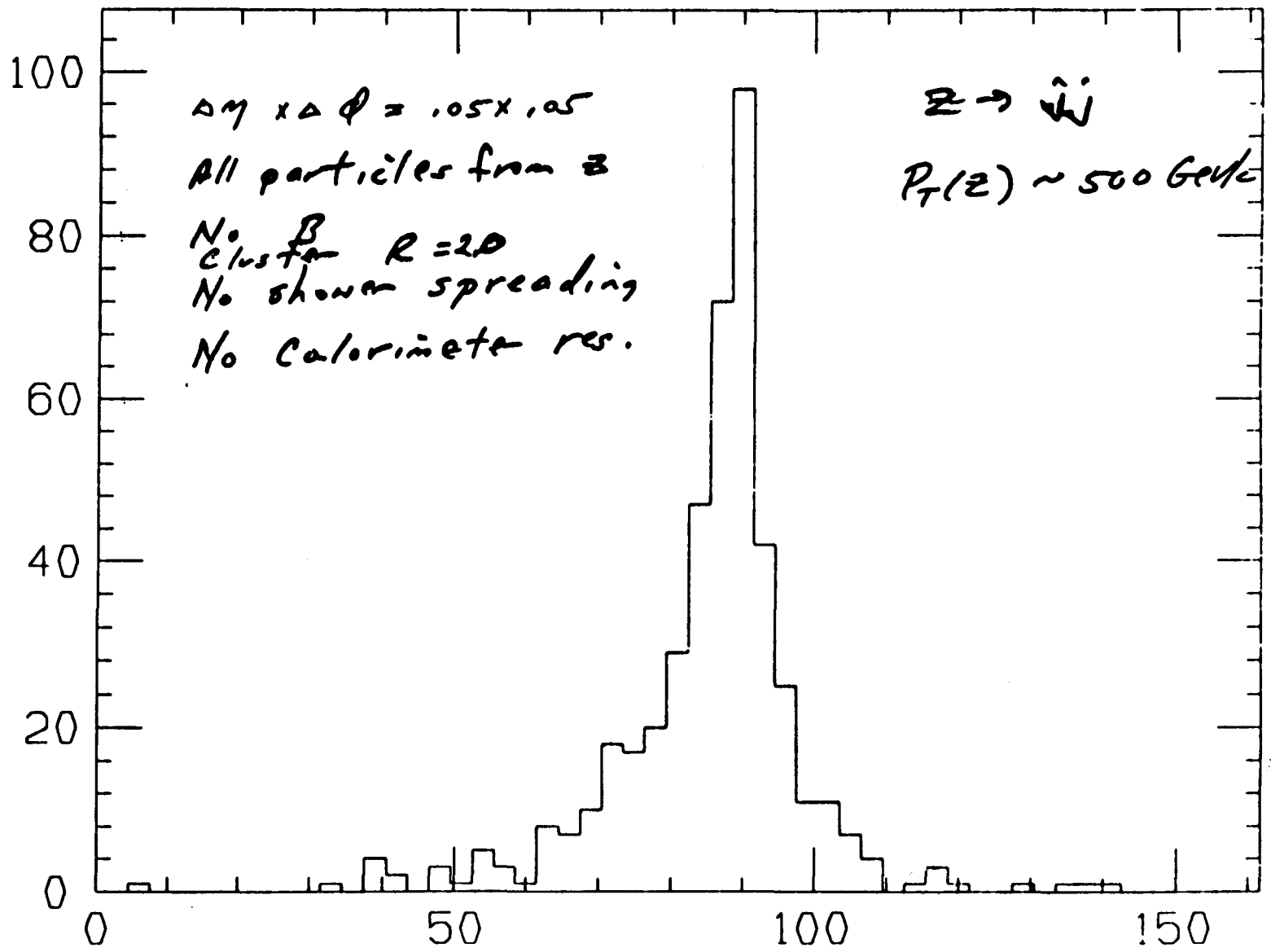
JET RECONSTRUCTED MASS FOR 70 FOR RAD=0.70

$(\Delta E/E)_{hal} = \frac{.3}{\sqrt{E}} \oplus 2\%$ low p_T 2

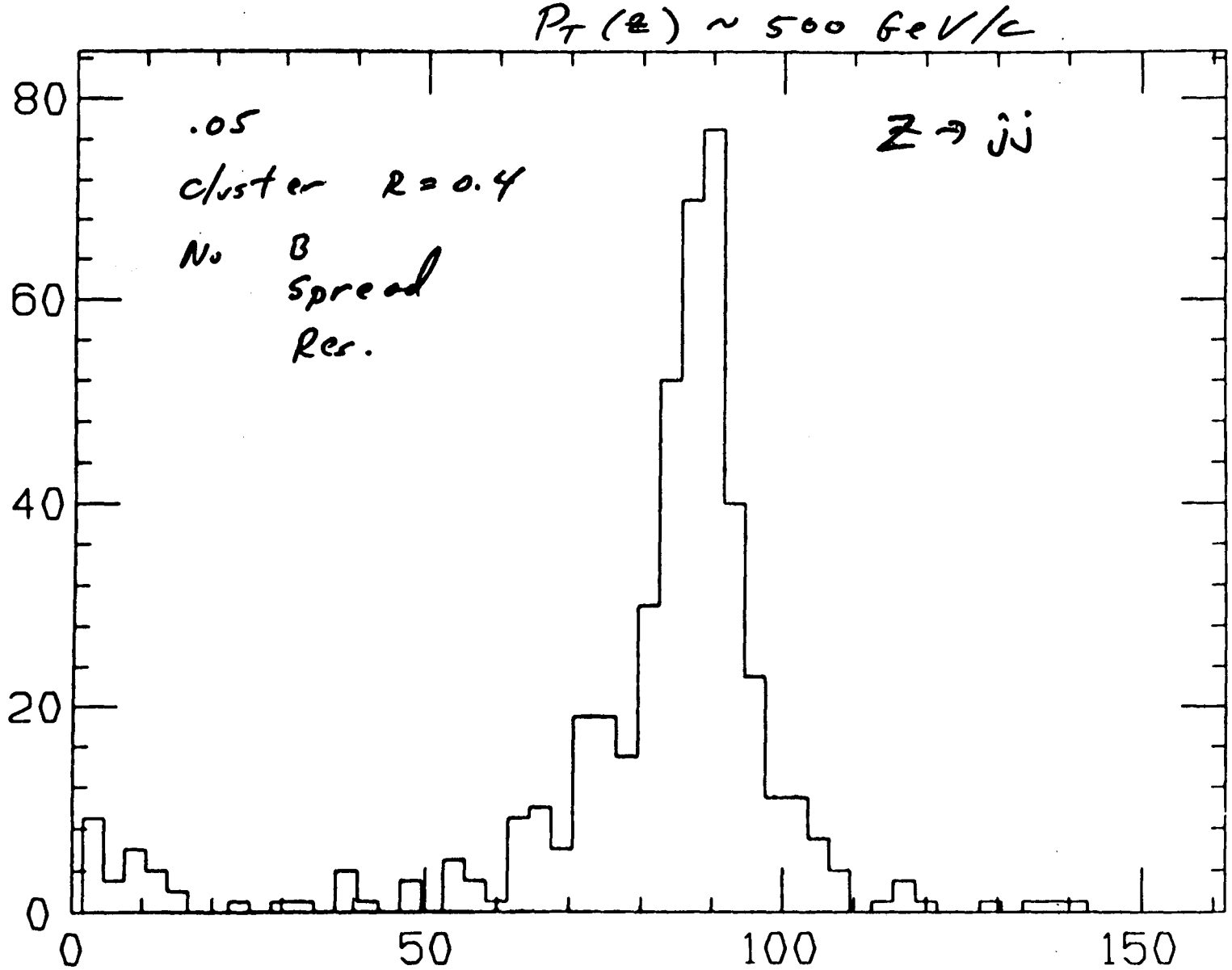


JET–JET RECONSTRUCTED MASS FOR Z0 FOR RAD=0.70

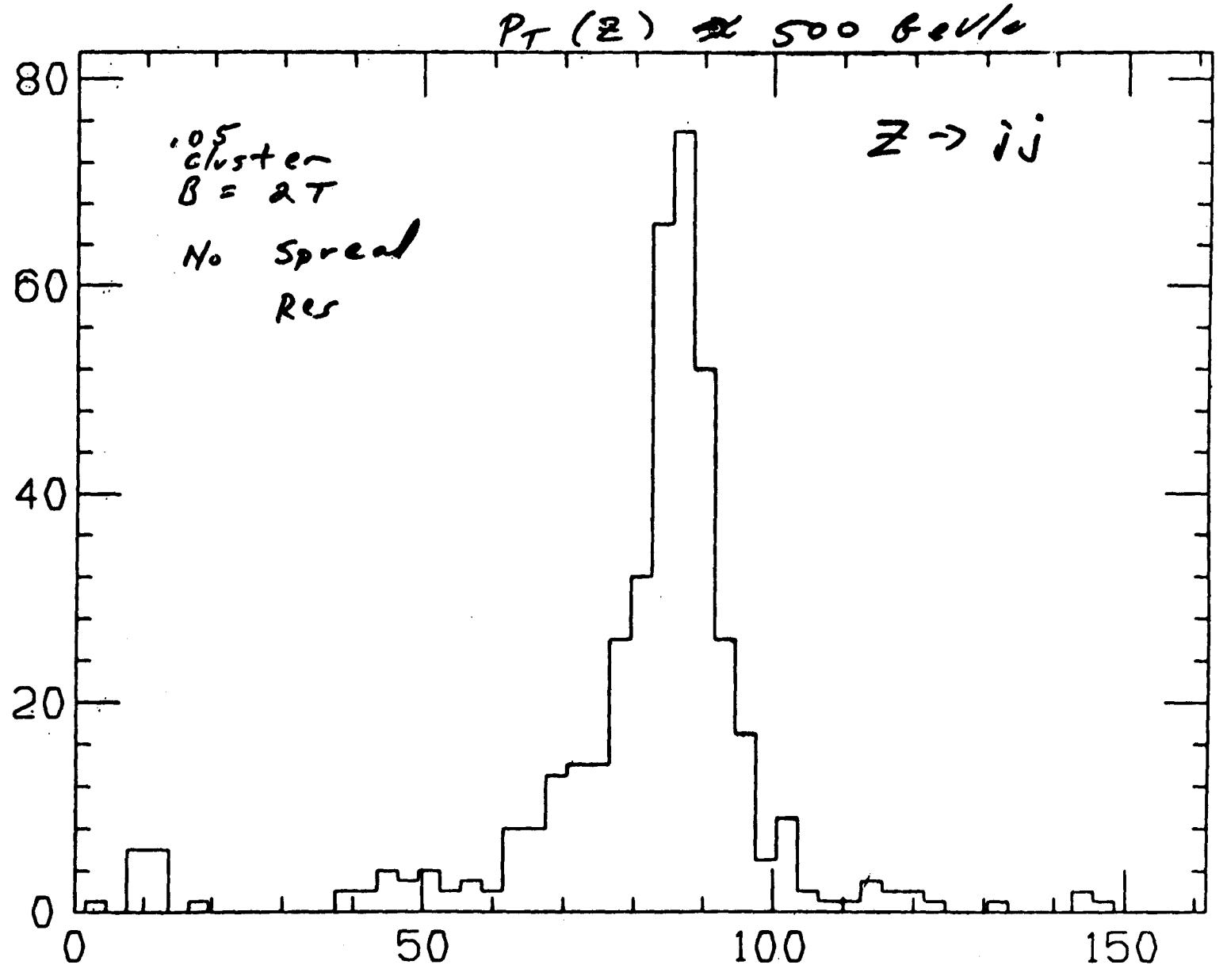
NO SHOWER, NO RESOL., NO B, NO CLUST., Z



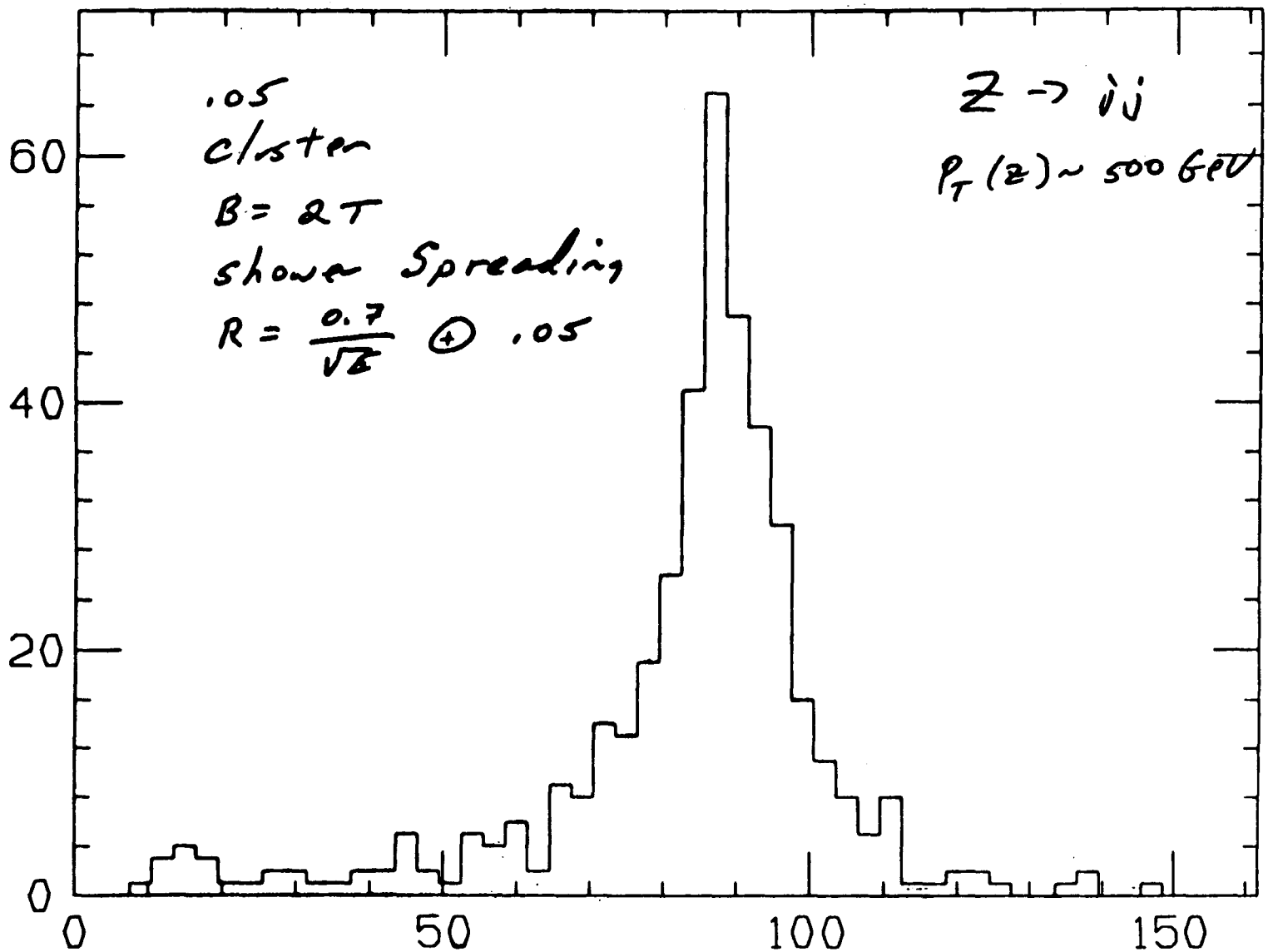
NO SHOWER, NO RESOL., NO B ONLY Z DAUGH



!5X.087 NO SHOWER SPREAD NO RESOL. ONLY



Z --> ONE OR TWO JETS AH=.7 CH=.05



4 CALORIMETER OPTIONS

LIQUID ARGON, WARM LIQUID, PLATES, & SPAGHETTI

NOVEMBER MEETING

⇒ ANNOINT 2 FOR ENGINEERING (ORDERED LIST, REPORT COMMISSION)

PLATE NEWS:

COST/DESIGN FOR LOI DEFAULT

PRELIMINARY CDF TESTBEAM RESULTS

→ PLAN FOR RAD DEVELOPMENT

SPAGHETTI NEWS:

DESIGNING

PRELIMINARY CDF TESTBEAM STUDY

LIQUID ARGON NEWS:

WORK ON COST, DESCOPE, DIMENSIONS

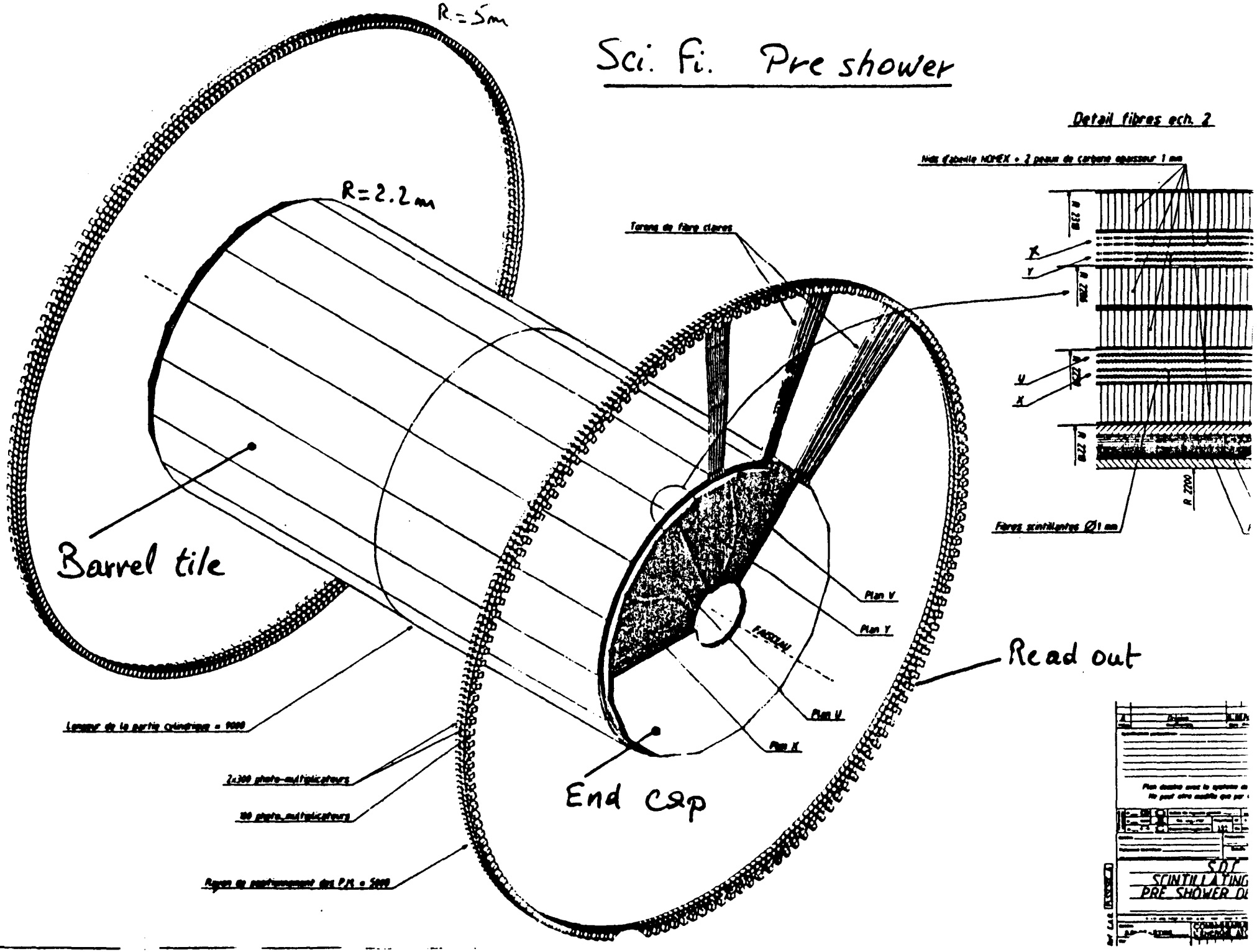
UPCOMING TESTS

NO WARM LIQUID NEWS

Where do we(LAC) go?

	Savings
(0) $savings with present design accurate cost estimation	40M$?
(1) G10 readout -> tile Capacitance/noise, Sampling ratio, Inductance of HV cap., e/μ (+0.05up?), Beam test required, EM tile?	308mm
(2) 3 div. -> 2 div. Where separation, EM/HAD, (EM+HAD)/HAD Mechnical analysis	130mm
(3) Cal/Yoke space 0.3 -> 0.05 Feedthrus on the heads (enough area?)	250mm
(4) Iron inside the cryostat Force, No iron Barrel-Endcap	500mm
(5) 6 λ LAC + 3 λ Scinti-Yoke Do we like it? Cold mass support	500-αmm
(6) 8 λ at 90° Scinti also can reduce to this...	218mm
(7) Pb -> Uranium Cost high? Who handles?	475mm
(8) Electronics space	500 mm

Sci. Fi. Pre shower



CHARGE FOR NOVEMBER

1) Beat down channel count

2) Cost estimate for read out & Front end electronics

3) Integration issues:

coil vs calorimeter support
Space
neutron absorption

4) Simulations:

Preshower vs Shower max

Effective resolution

t (250 and 150) non isolated $e^{\pm}$

$WH \longrightarrow \mu\nu\, \gamma\gamma$ isolated γ

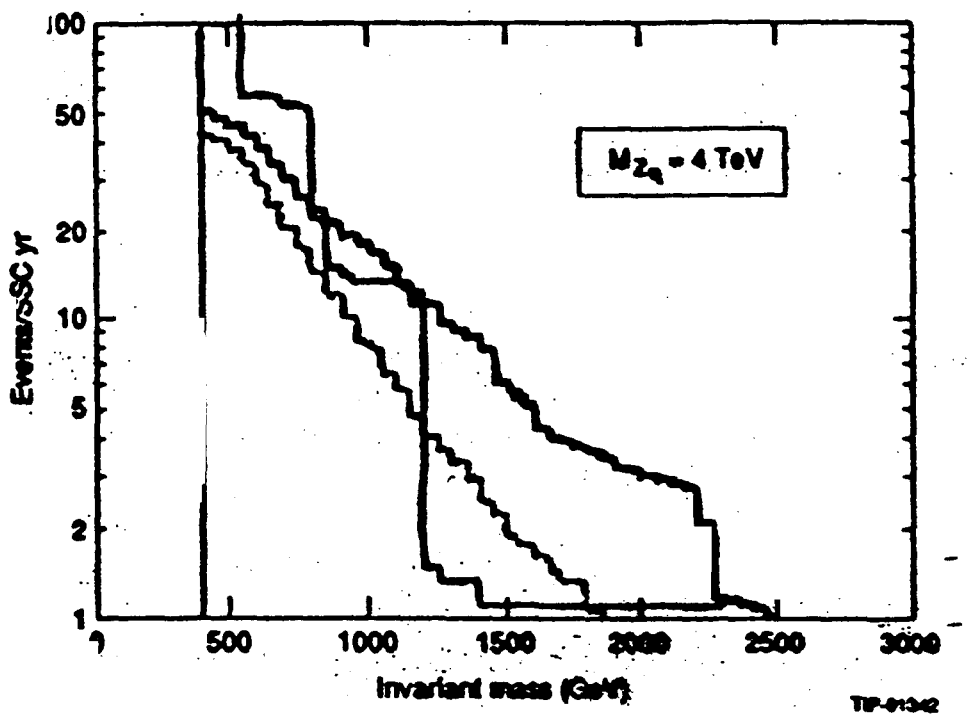
hadron calor. calibration isolated $\pi^{\pm}$

ANYONE WITH QUESTIONS/CONCERNS
ABOUT ANY OPTION, E-MAIL
TO "LJN@ANCHEP" BY 9/29
⇒ COLLECTION WILL BE DISTRIBUTED
BEFORE REVIEW MATERIAL IS DUE

LOI TEXT DRAFT INITIATED BY
A. MAKI

TEST BEAM LIAISONS
JIM FREEMAN
BILL FOSTER
GERRY ABRAMS

— Signal
— $t\bar{t}$
— DY



Excess of events, $M > 1300$ ⇒

test of universality

For τ : $e\mu$, $e(\mu)\pi$, or $\pi\pi$

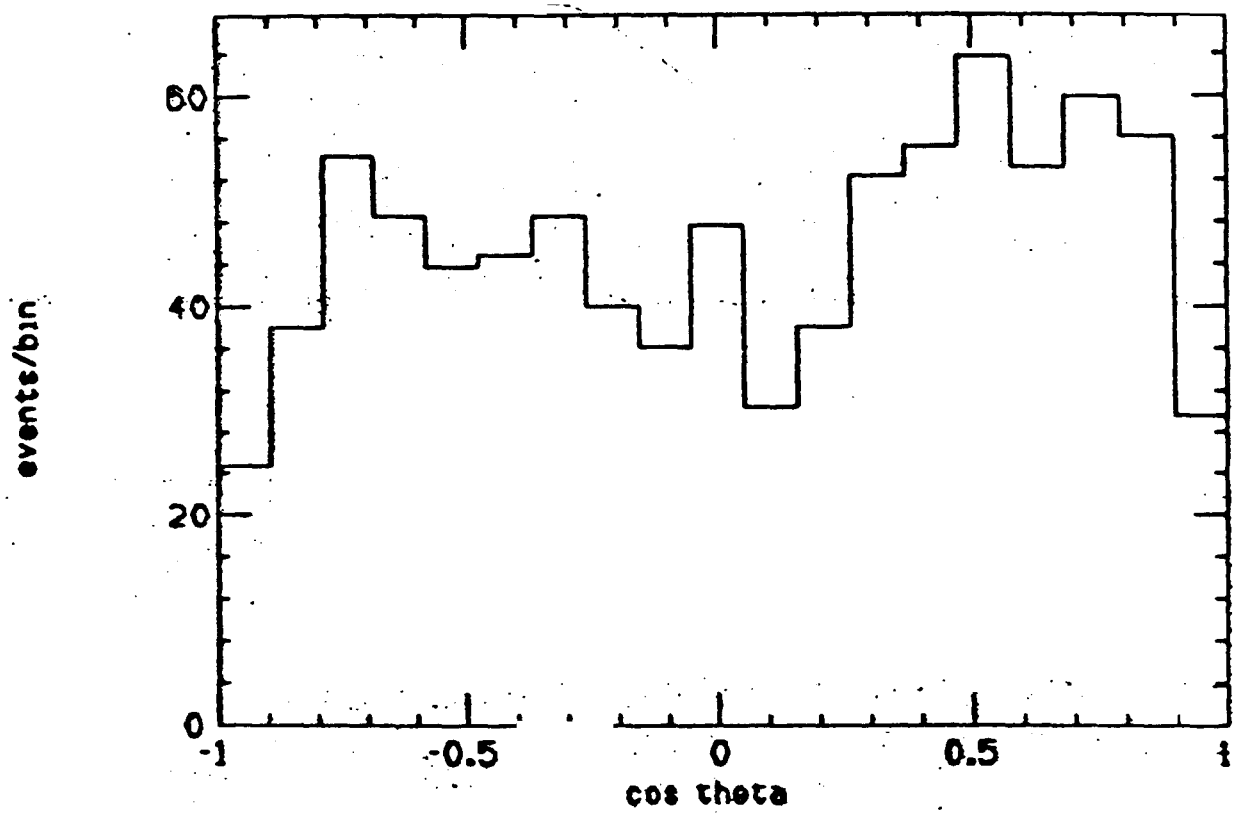
BKGND : DY

$t\bar{t}$
$\hookrightarrow W + x$
$\hookrightarrow \tau\nu$

- reduce top background:

Tracks have large P_t	> 200 gev
Large inv. mass	> 400 gev
back-back in ϕ	30°
$\Delta\phi$ ($\not{E}_t$, tracks) small	$\pm 30^\circ$, either track,
tracks isolated	$\not{E}_t > 100$ gev
	< 5 GeV, $\Delta R > .4$

angle electrons



Outline For this Section (5 pages)

↳ 3

Figures: Fit to width

Fit to $\cos\theta$ distn.

Content: As before +

- quote a number on A & error
- width measurement

Long Notes (due Oct. 15)

SDC-36 + New Appendix with 'descoped' resolutions; redo with new couplings

$\tau\tau$ modes Siegrist et al.

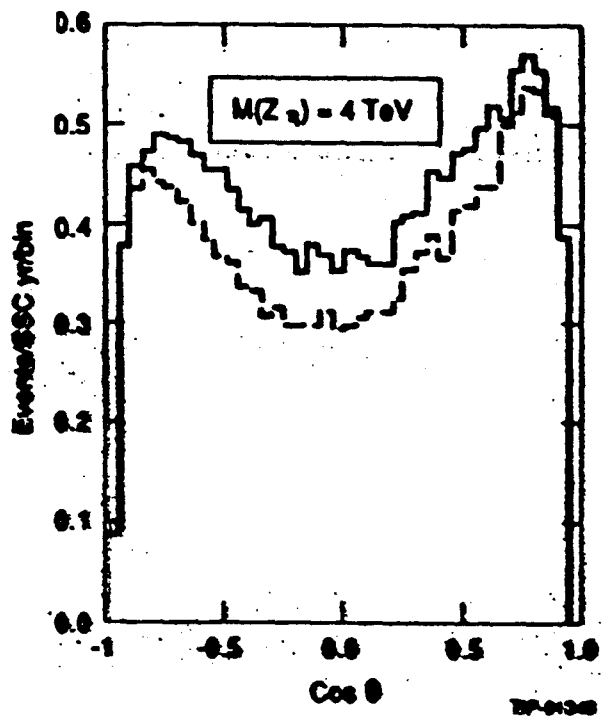
Section 5.3 EOI

∡ Distn. cut in MASS ± 1 TeV

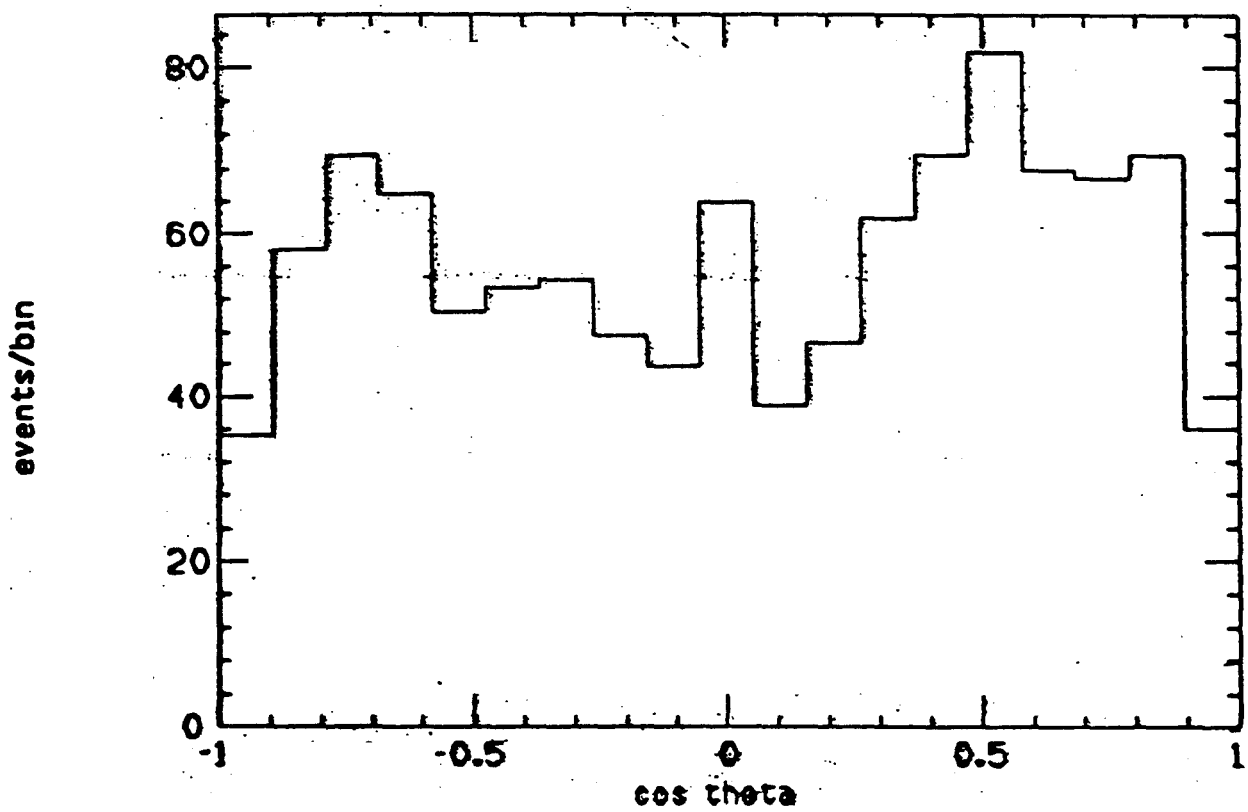
$P_z(Z') > 1$ TeV

$$A = \frac{\int_0^{\pi/2} dN/d\cos\theta - \int_{\pi/2}^{\pi} dN/d\cos\theta}{+ \quad ''}$$

$\theta \equiv$ Positive Lepton direction



angle perfect

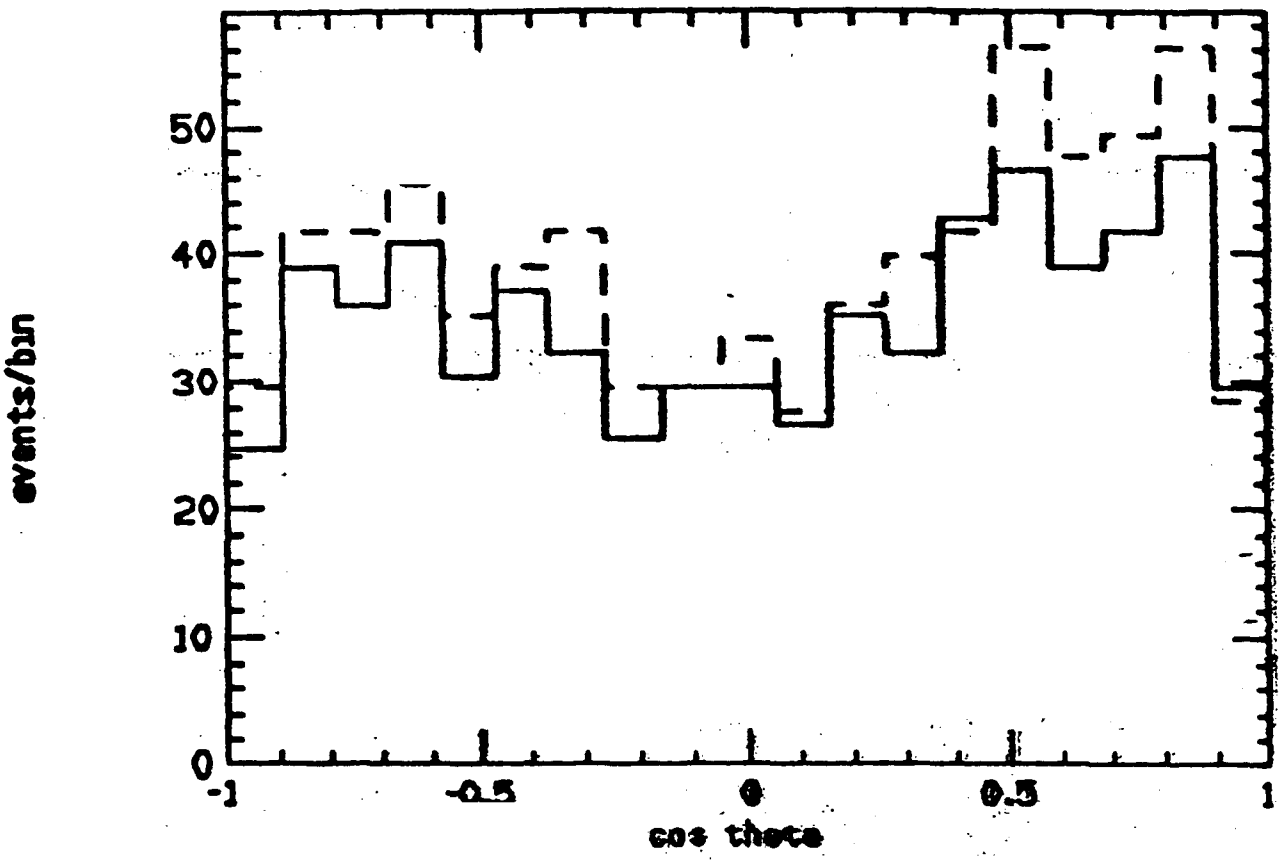


Siegrist

effect of descope on 4 Tev

(I H)

ngle muons solid (dashed) is LOI (EOI) resolution



H

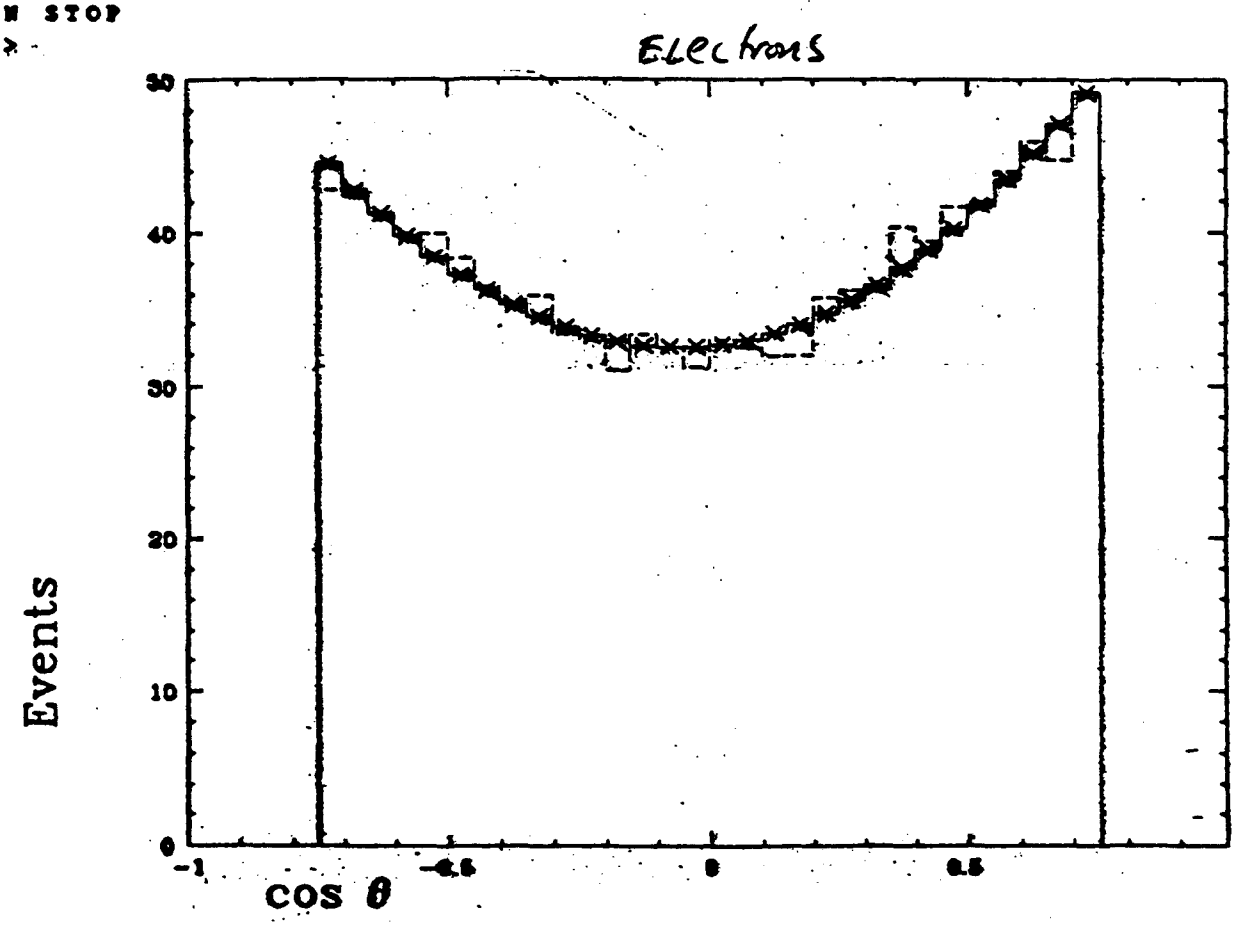
Loss of sign determination

FAKED Fit

$|\cos\theta| < .75$ region

$$\frac{dN}{d\cos\theta} = a + b\cos\theta + c\cos^2\theta$$

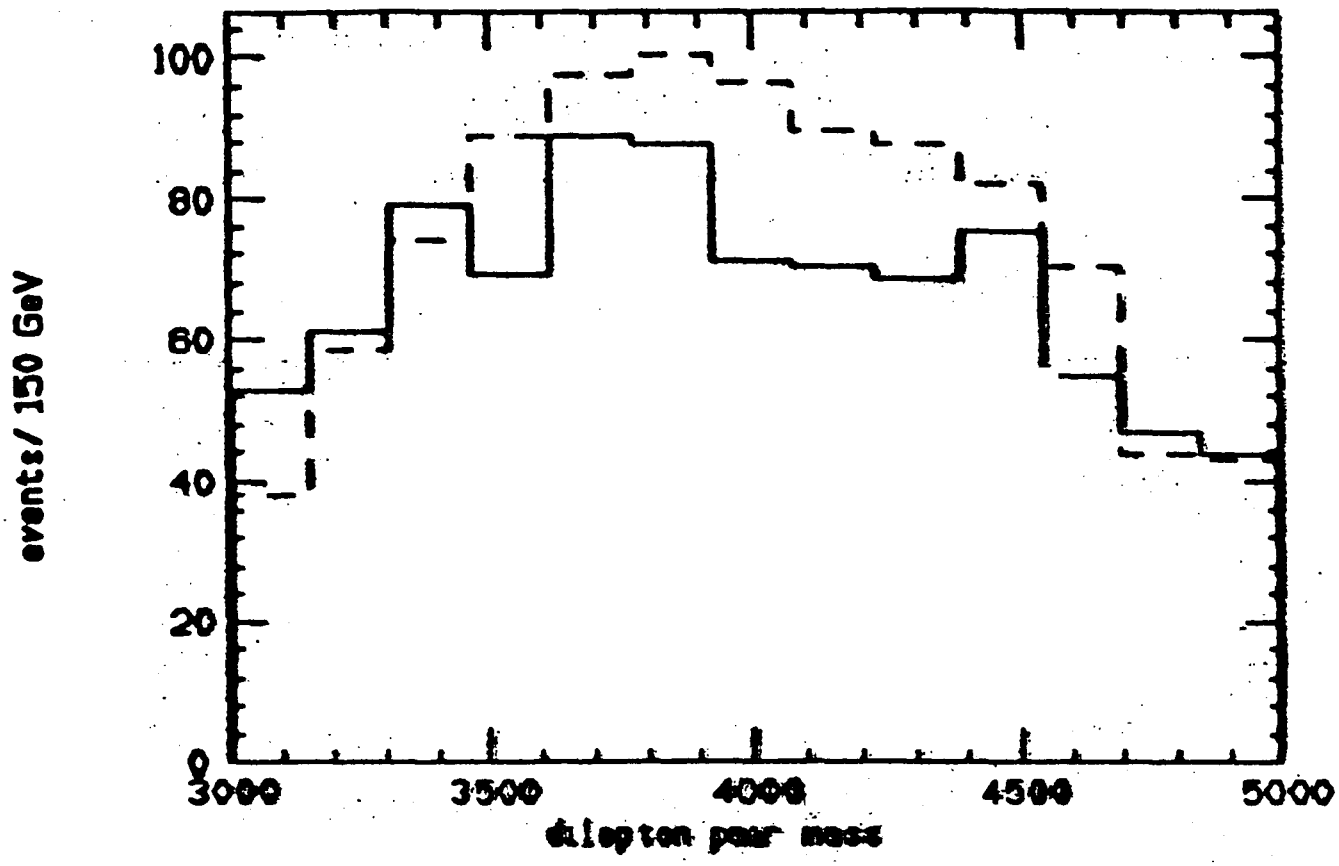
)RTRAN STOP
:CVX1>



resolution effects ?

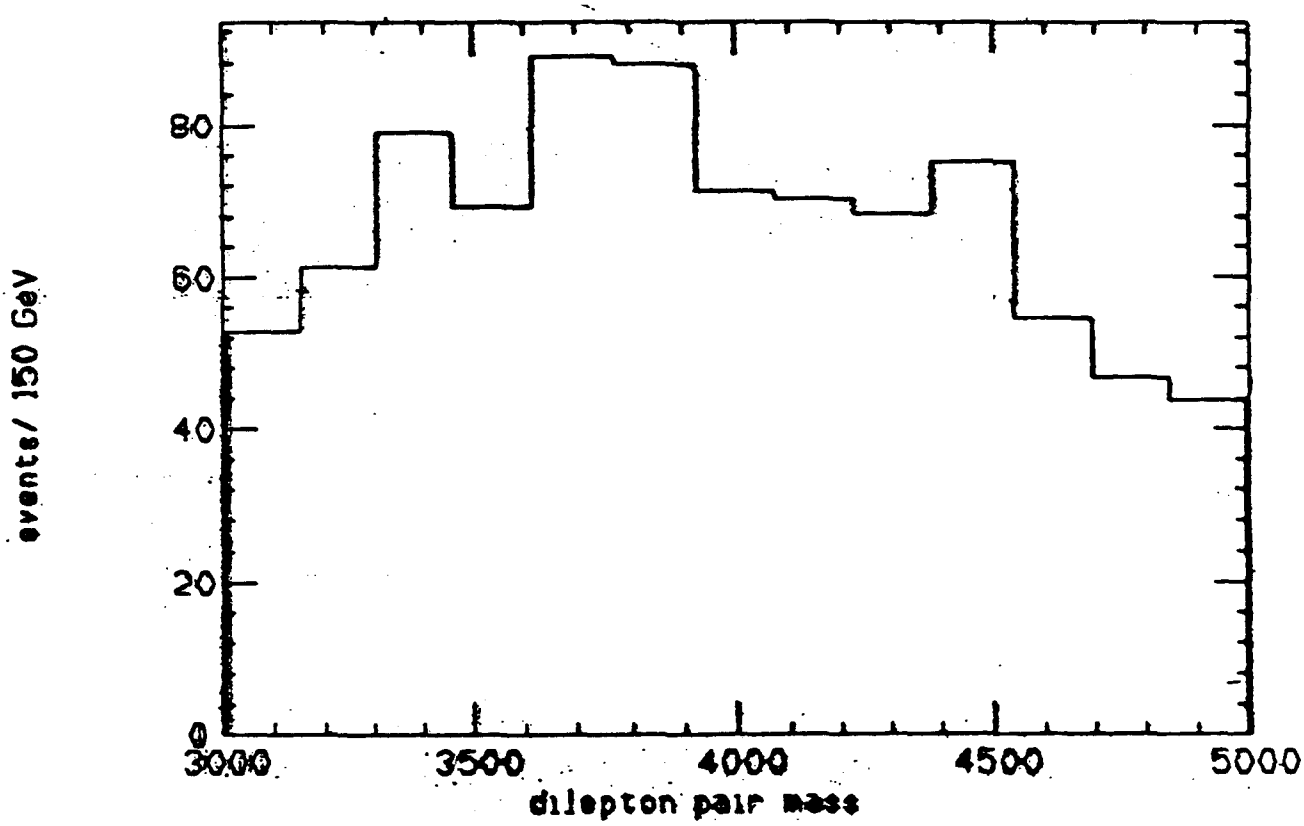
(IH)

inv muons solid (dashed) is LOI (EOI) resolution

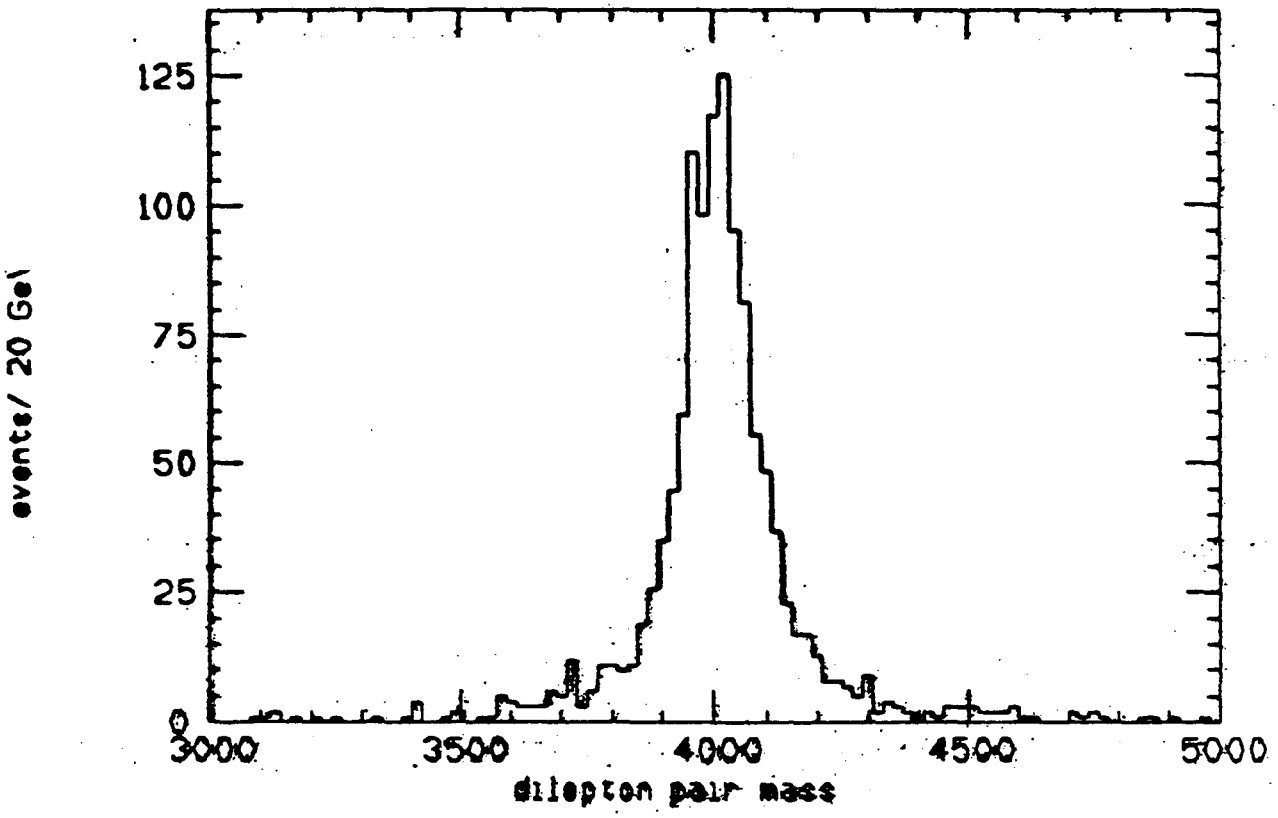


13 years' running!

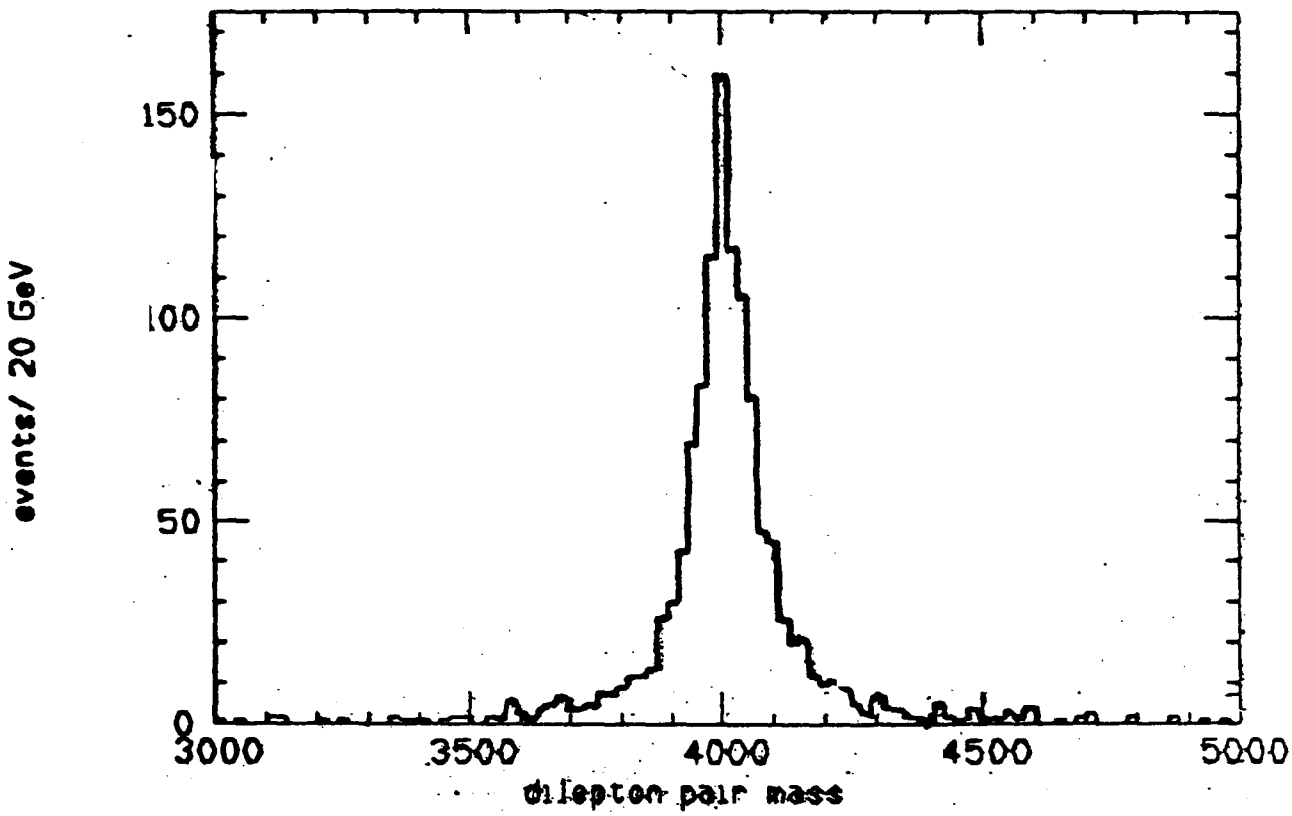
Inv muons



inv electrons

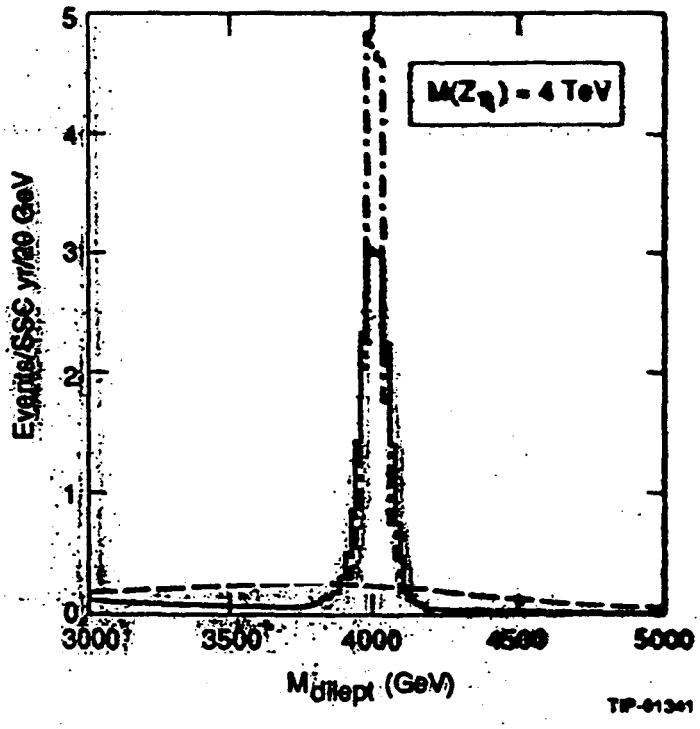


inv mass perfect



Select 2 leptons, plot Z' + DY bkgnd.

EOI plot - width will go up, we will fit for width ....



LOI Question (d)

Demonstrate the acceptance and resolution of your lepton detector by a study of a Z' with a mass of 4 TeV. Show a measurement of the mass and asymmetry for 1000 produced events each of $Z' \to ee, \mu\mu, \tau\tau$

SDC: Assume standard model couplings, $10^{33}\mathcal{L}$

$\Rightarrow$ 13 years running to collect 1000 events

~ 50 years for model in EOI

Outline For this Section (3 pages)

Figures: $H \to ZZ^*$ 120 .... GEV (Einsweiler)

repeat 800 GEV plots (reduced)

$WH \to \ell^\pm \gamma\gamma$ plot (Mangano)

Content: As before, INCLUDE Comments on $H \to b\bar{b}$, $\tau\tau$

Long Notes - Backup material due Oct. 15

$H \to 4\ell$ (Hinchliffe, Einsweiler, Barnett, Siegrist)

$WH \to \ell\nu\gamma\gamma$ (Mangano)

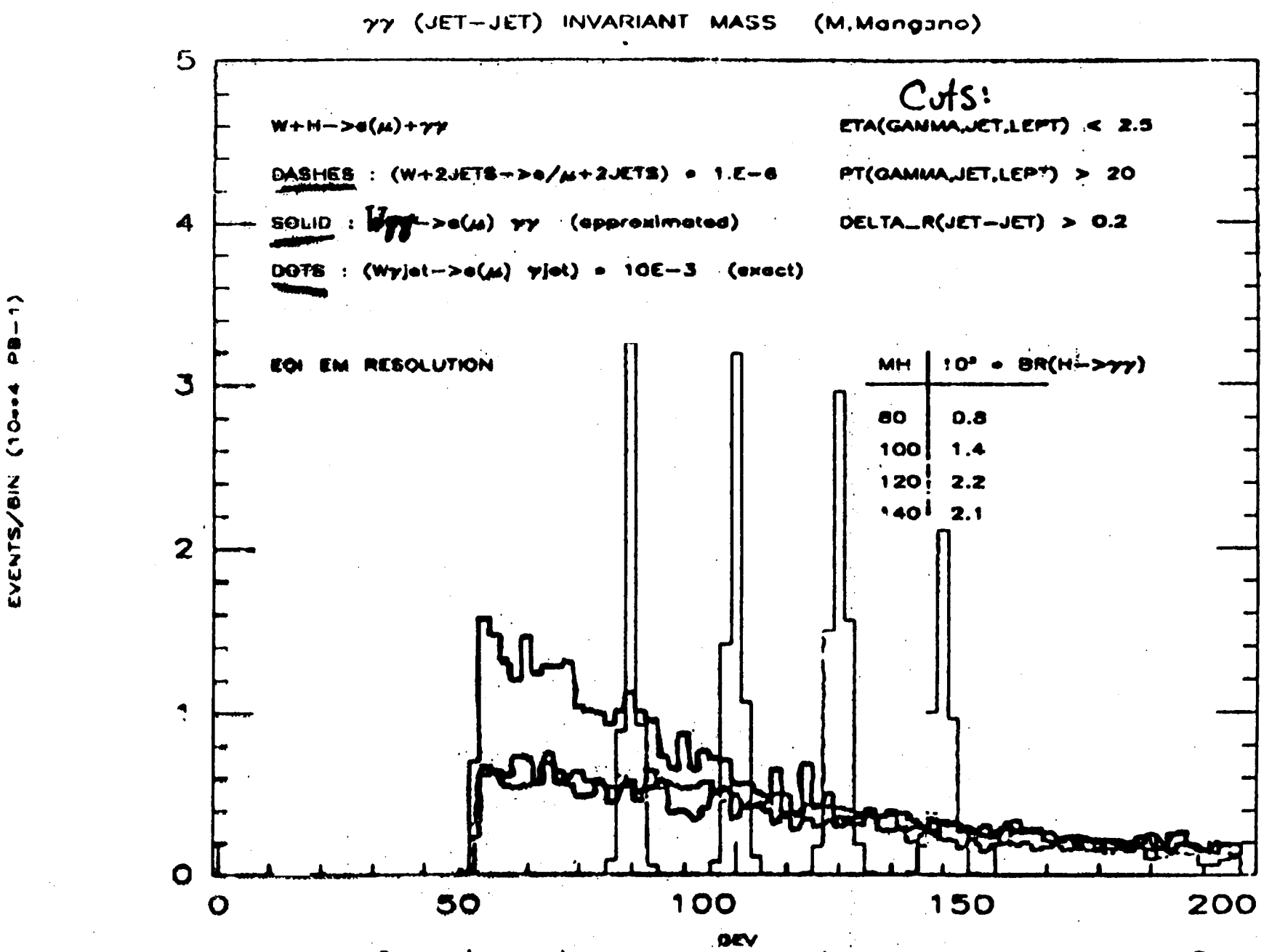
$WH \to \ell\nu b\bar{b}$ (Price et al)

H+jets + ZZ+jets (Hinchliffe)

Section 5.3, EOI

Question 1, PAC response

+ SDC-3, SDC-9, SDC-33, SDC-48



Event Rate Low, but all important mass range is covered...

Throw price, show 3 years' data...

$WH \to e(\mu) + \gamma\gamma$

- less stringent resolution requirements compared to the classic case $H \to \gamma\gamma$ – reduced background

- residual backgrounds:

  $W\gamma\gamma$

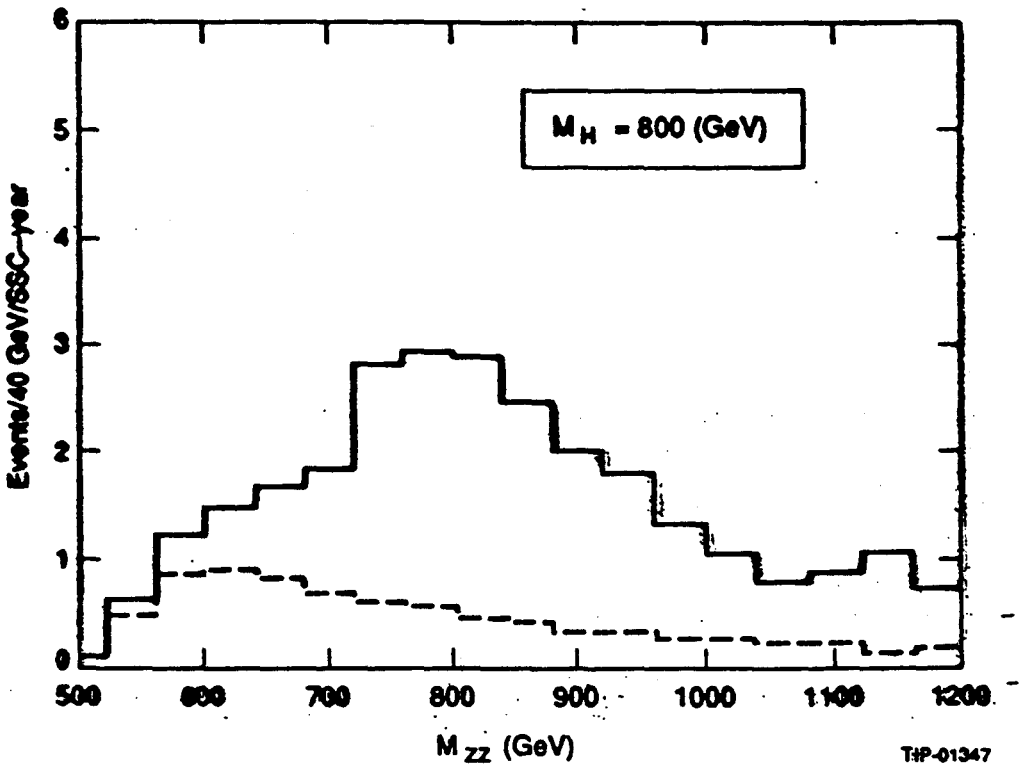
  $W + \gamma + \text{jets}$
  $\hookrightarrow$ fake γ (estimate 10^{-3}/jet)

  $W + \text{jets}$
  $\hookrightarrow$ fake $\gamma\gamma$

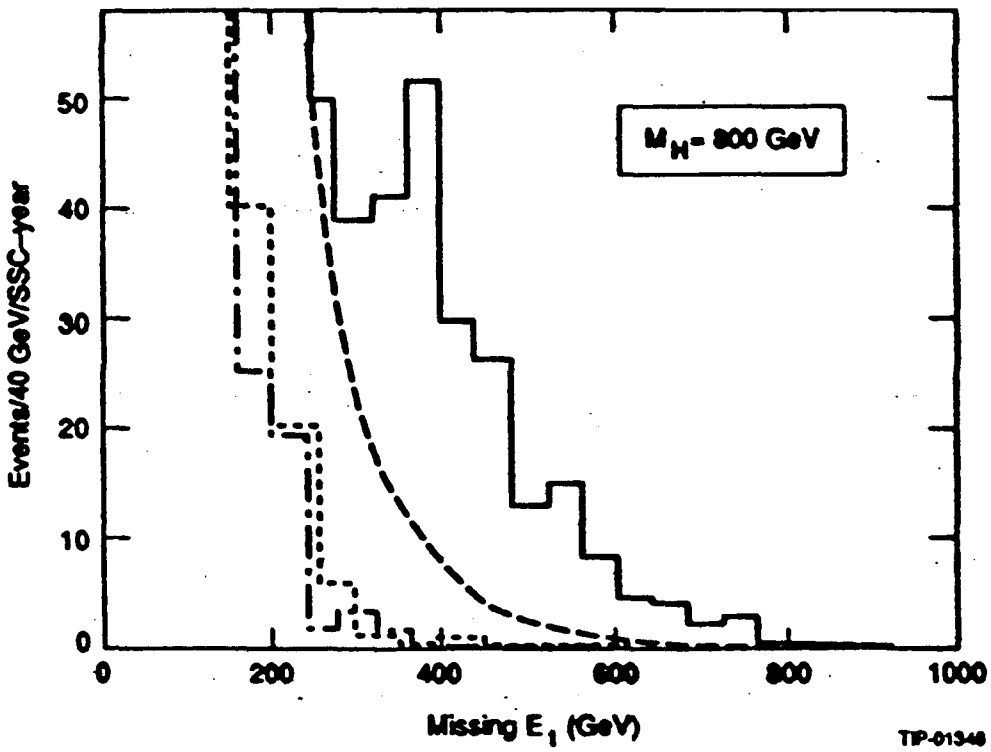
Require $P_t > 250$ GeV on ONE Z

Gives significant signal,

but NO rate left

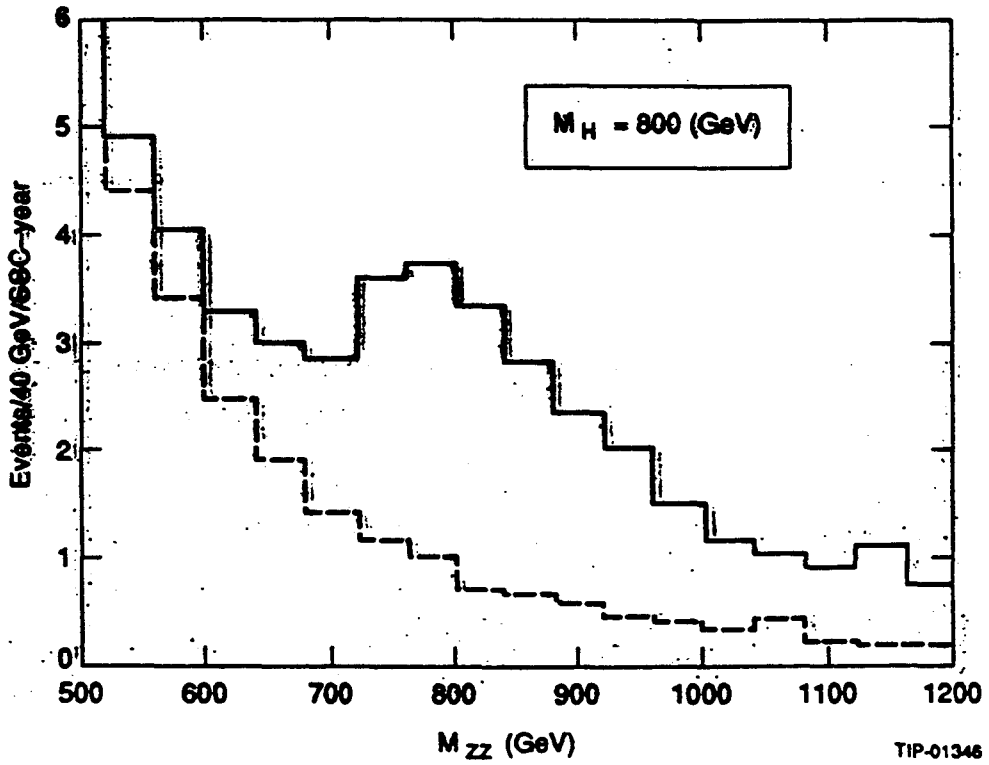


Instead, use ee ($\mu\mu$) + $\not{p}_t$ to pick up $H \to ZZ \to \nu\bar{\nu}\, \ell^+\ell^-$



Excess of events at hi $\not{p}_t$ will establish signal (determine distn. at low $\not{p}_t$)

Hi mass Higgs => NO signal



Relevant decay modes (PAC response)

$H \to ZZ \quad (ZZ^*)$ $\qquad 125 < m_H < 800$ GEV

$\hookrightarrow 4\ell$

$WH \to e(\mu) + \gamma\gamma$ $\qquad 80 < m_H < 140$ GEV

Other modes under study:

$WH \to e(\mu)\ b\bar{b}$

$H + \text{jets} \to ZZ + \text{jets}$

LOI Question (a):

Describe the CAPABILITIES of your proposed detector for searching for a STANDARD MODEL Higgs in the following mass regions:

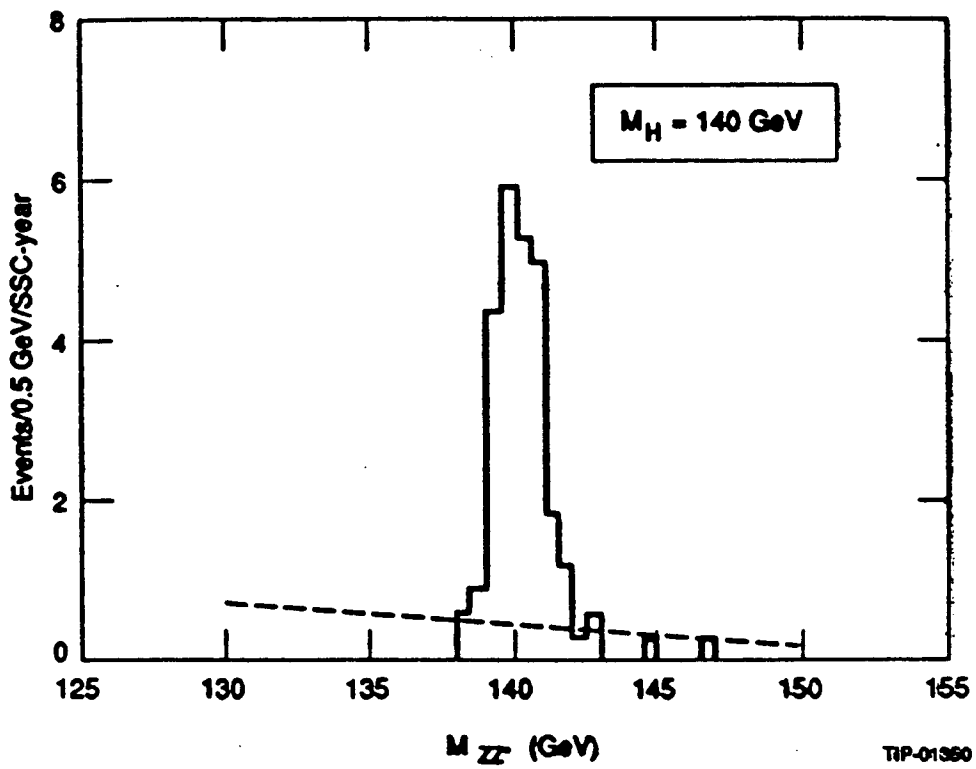
$80 < M_H < 180$ GEV

$M_H \sim 200$ GeV

~ 400 GeV

~ 800 GeV

Show masses 125 - 400 on as few plots as possible



Four Lepton Selection Criteria :

- ≥ 2 leptons, $p_t > 20$ GEV
  $|\eta| < 2.5$ (trigger)

- Isolation cuts to reduce $Z\tau\bar{\tau}$ & $Zb\bar{b}$ background (All 4 leptons)
  ≤ 2 GEV inside ΔR of .2

- For $M_H > 200$ gev, reconstruct two Z's $\pm$ 20 gev

Geometrical Acceptance ~ 60% SDC-3

Reconstruction ϵ ~ 80% / pair SDC-35

~ 40% overall ϵ
@ $m_H \sim 400$ GEV

LOI question (a):

Describe the capabilities of your proposed detector for searching for a standard model Higgs in the following mass regions:

$80 < M_H < 180$ GeV

$M_H \sim 200$ GeV

~ 400 GeV

~ 800 GeV

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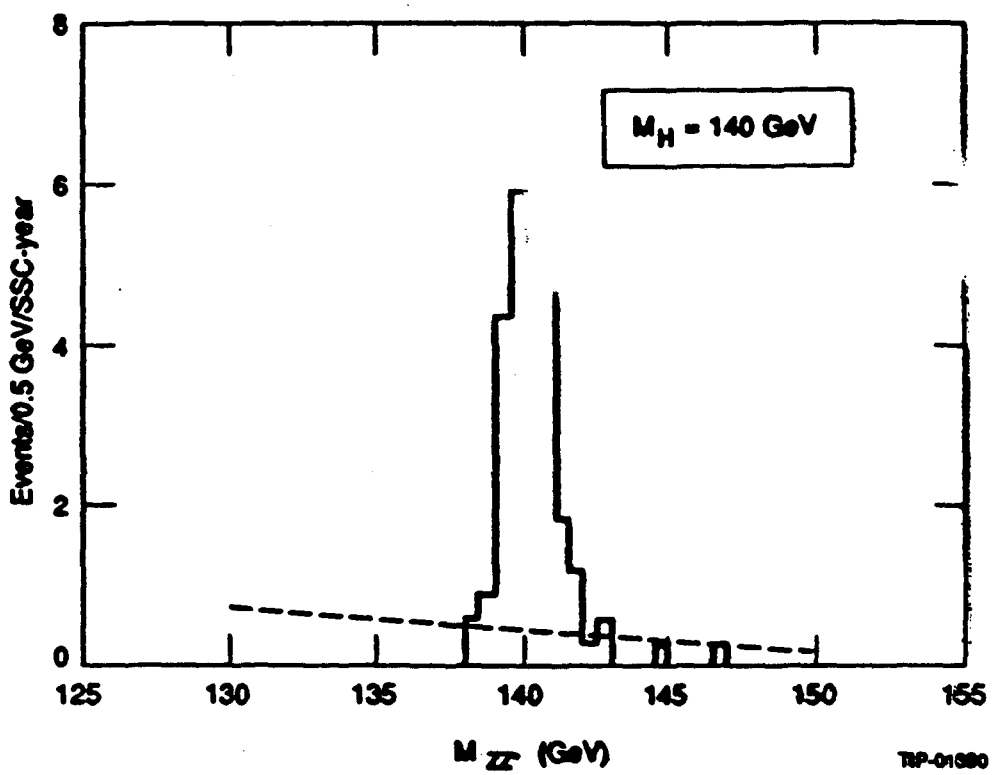

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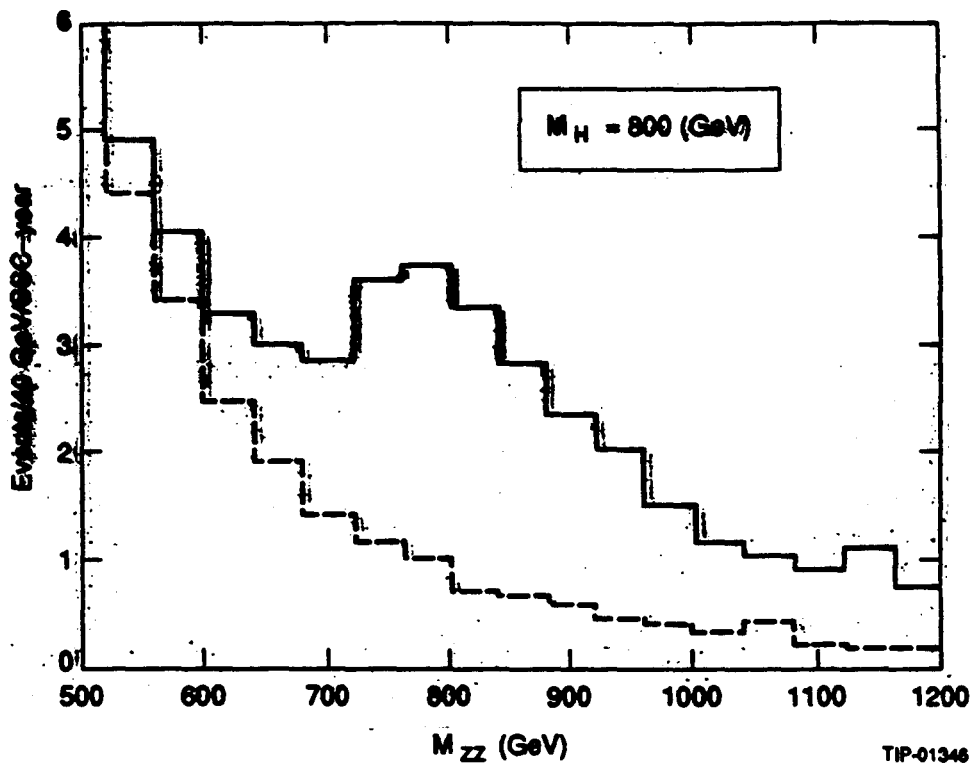

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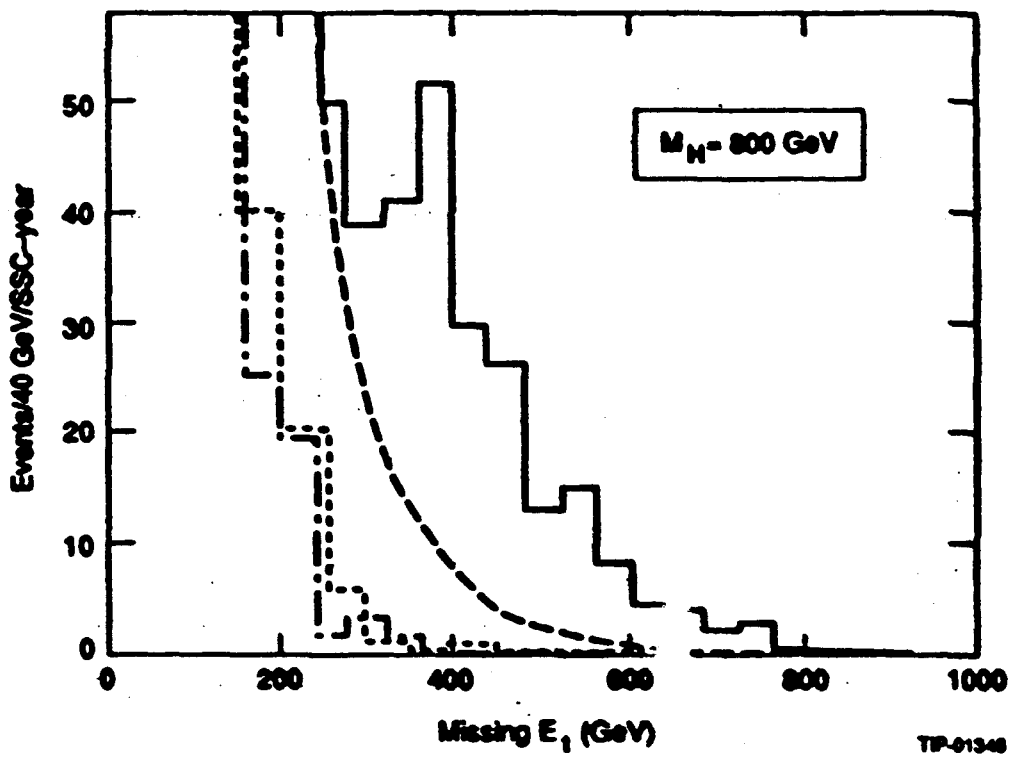

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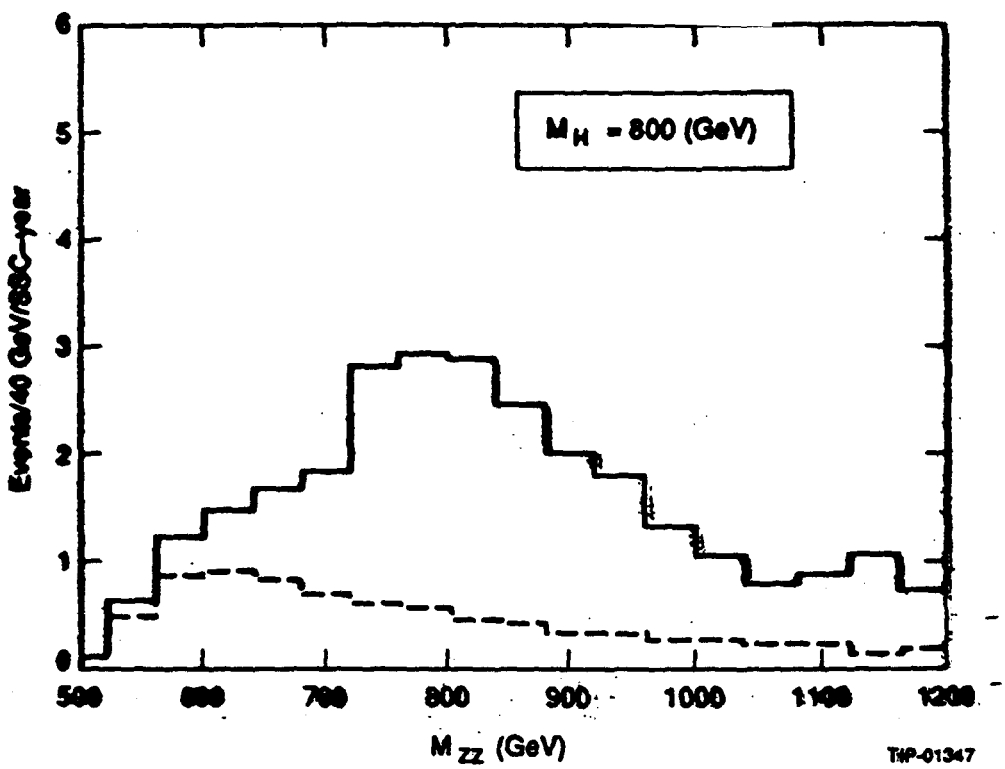

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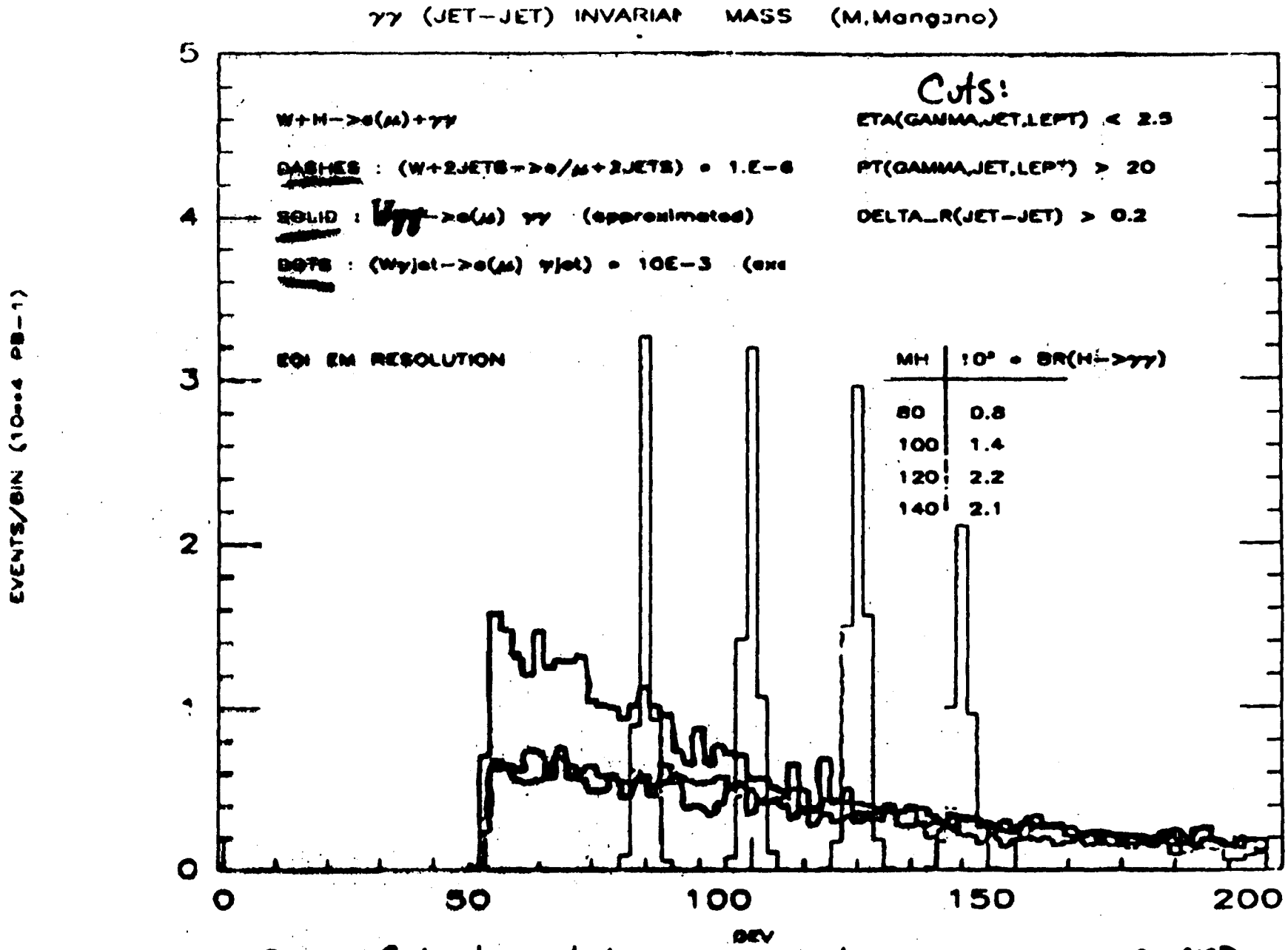

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Section 5.3, EOI

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+ SDC-3, SDC-9, SDC-33, SDC-48

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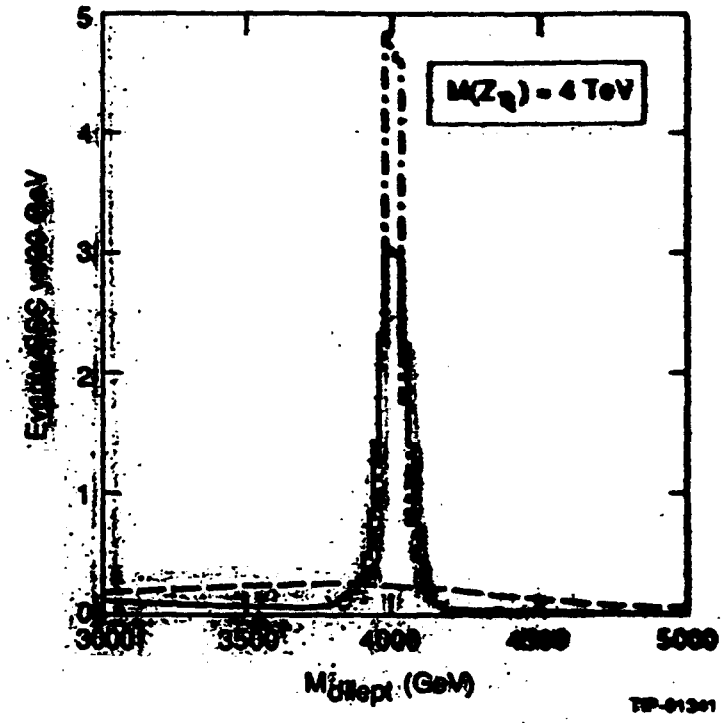
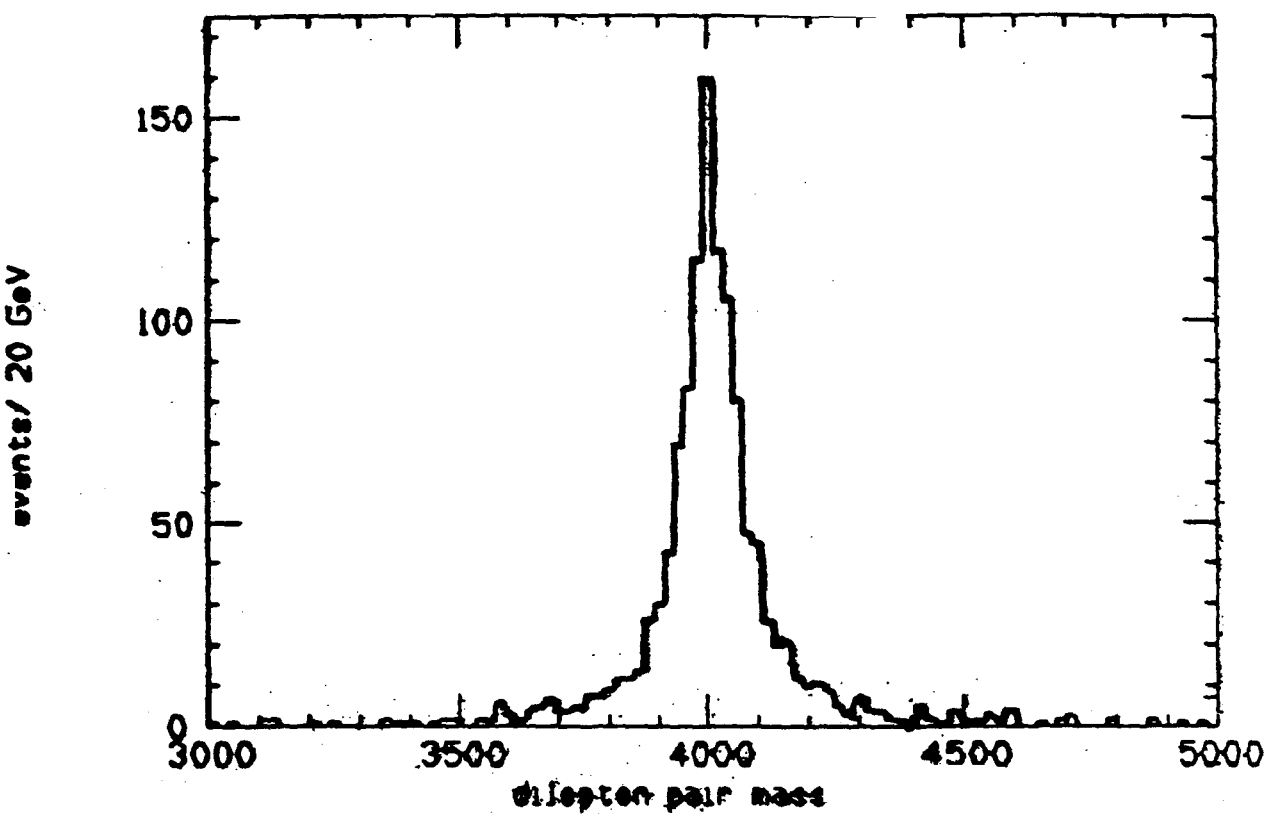
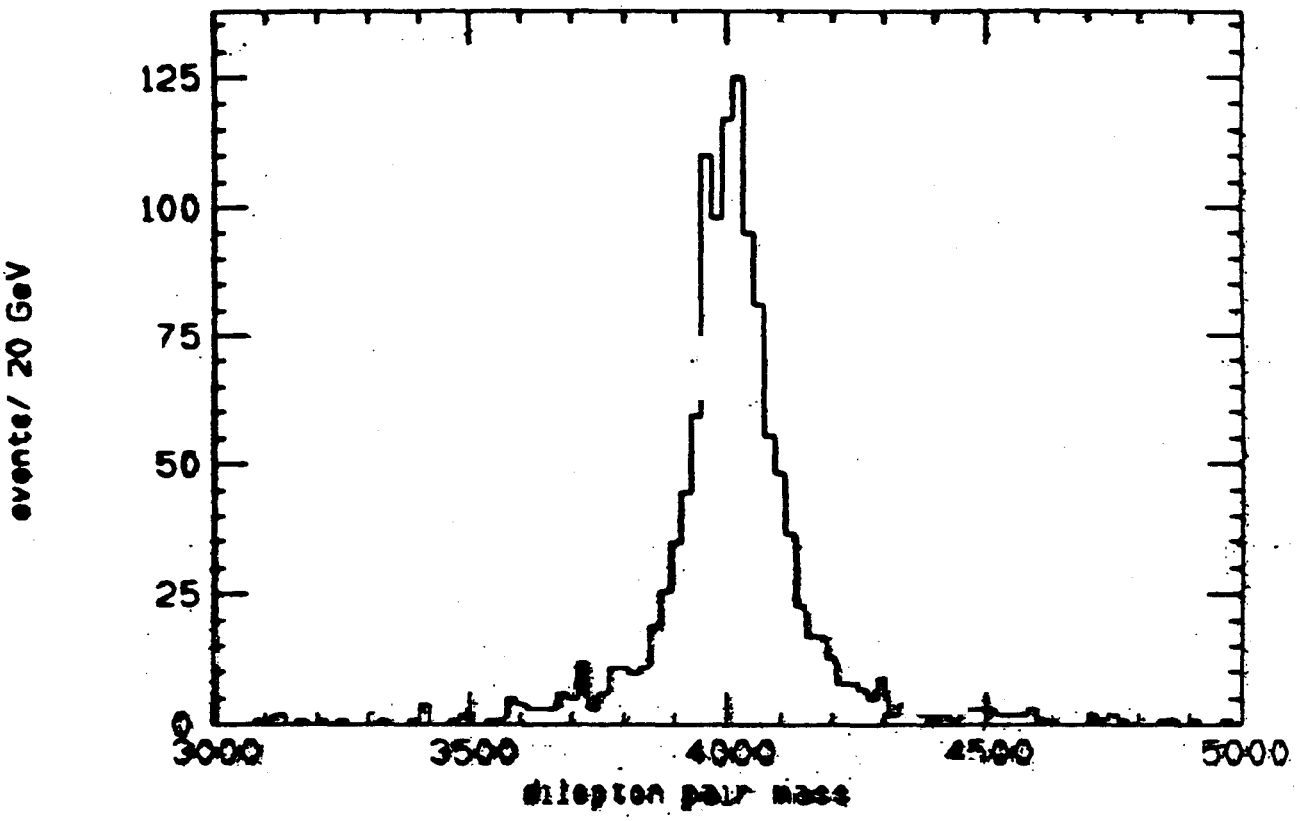
EOI plot - width will go up, we will fit for width ....



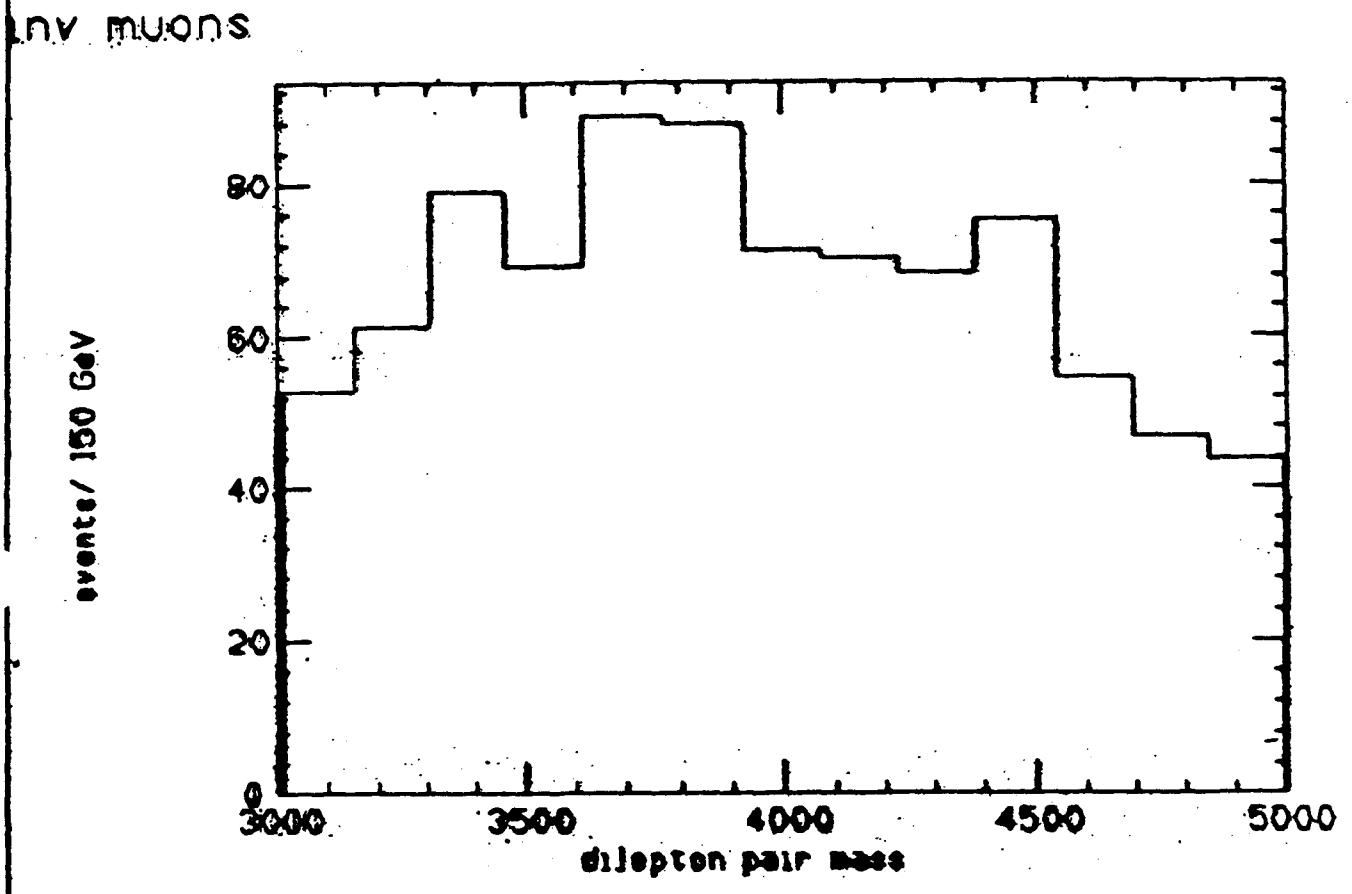
inv mass perfect



inv electrons

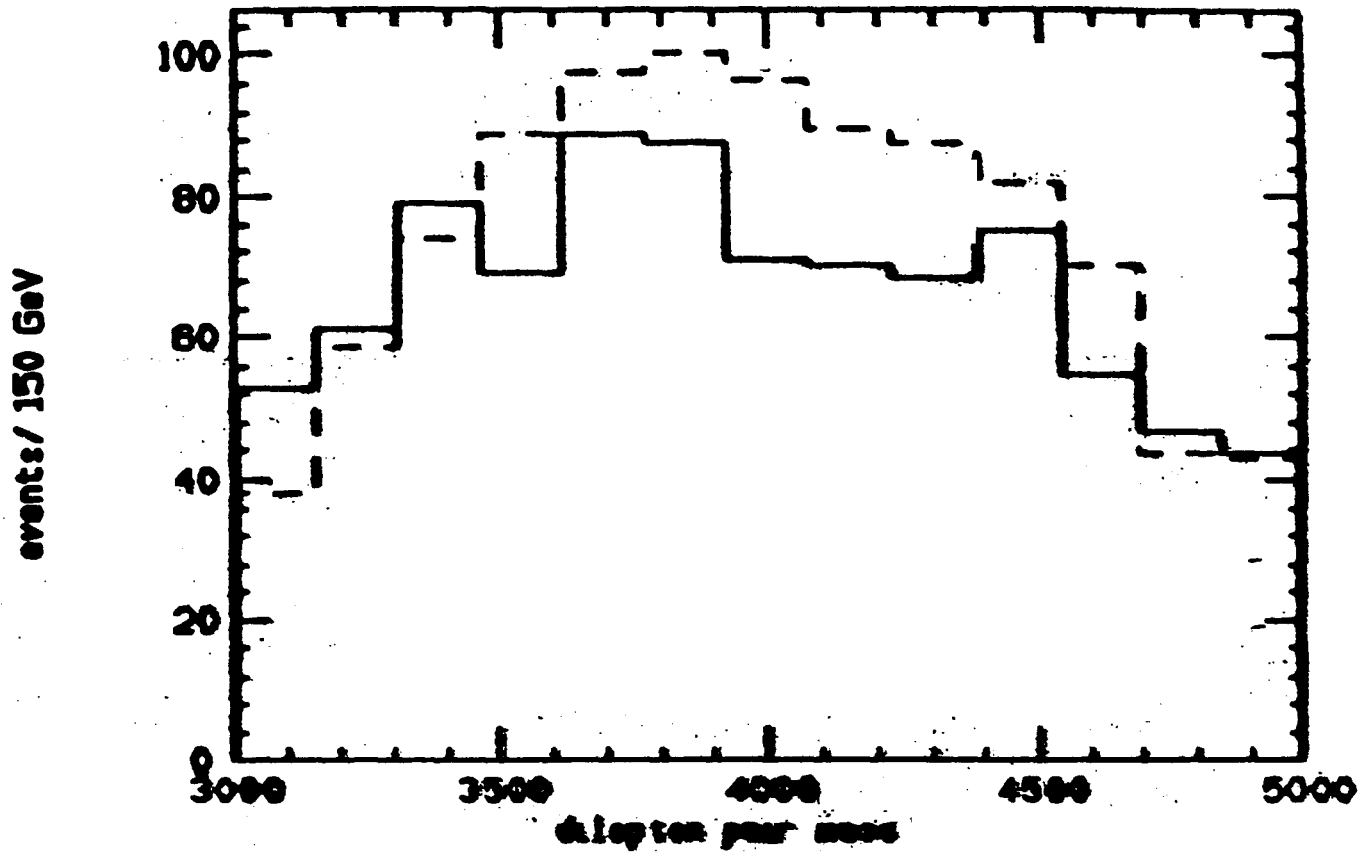


13 years' running!



(IV)

inv muons solid (dashed) is LOI (EOI) resolution

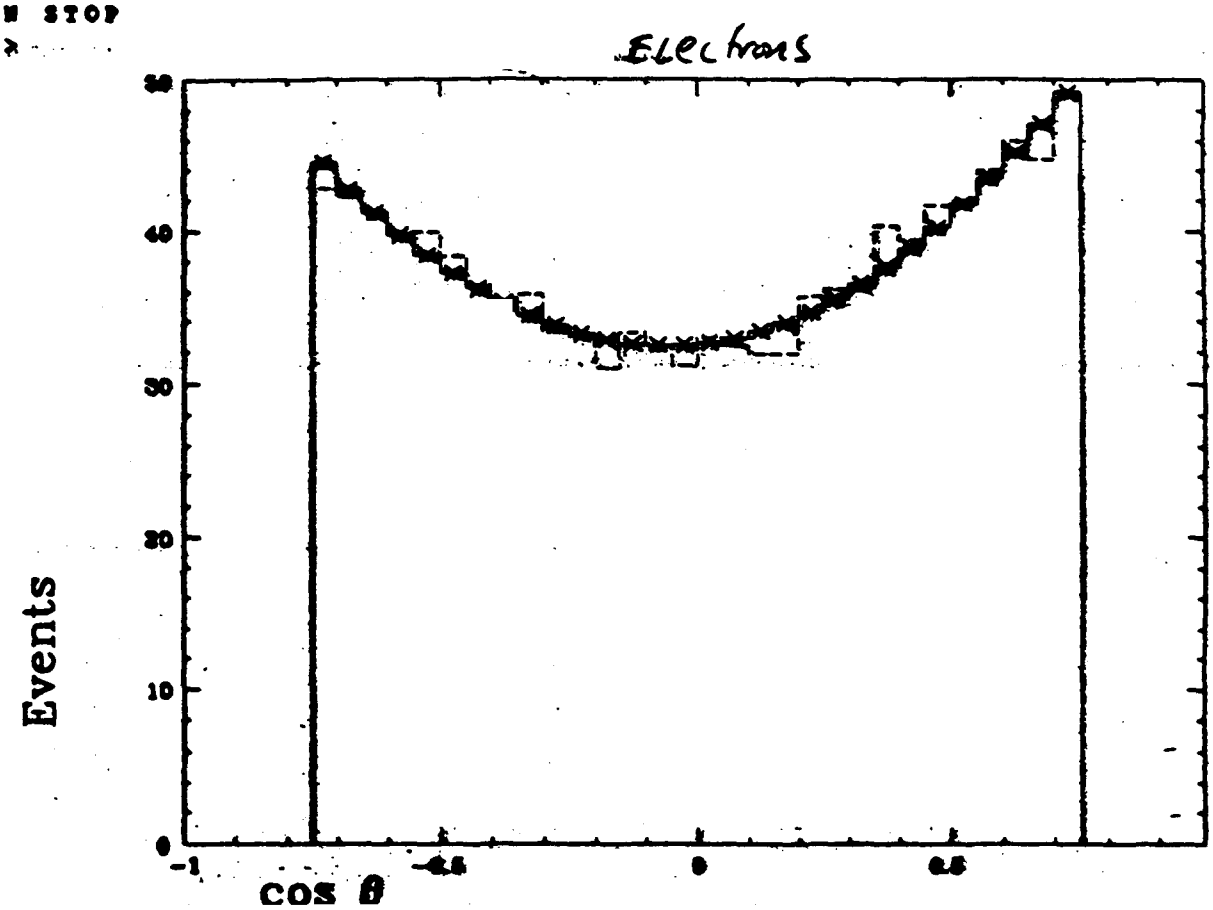


FAKED Fit

$|\cos\theta| < .75$ region

$$\frac{dN}{d\cos\theta} = a + b\cos\theta + c\cos^2\theta$$

)RTRAN STOP
:CVX1>



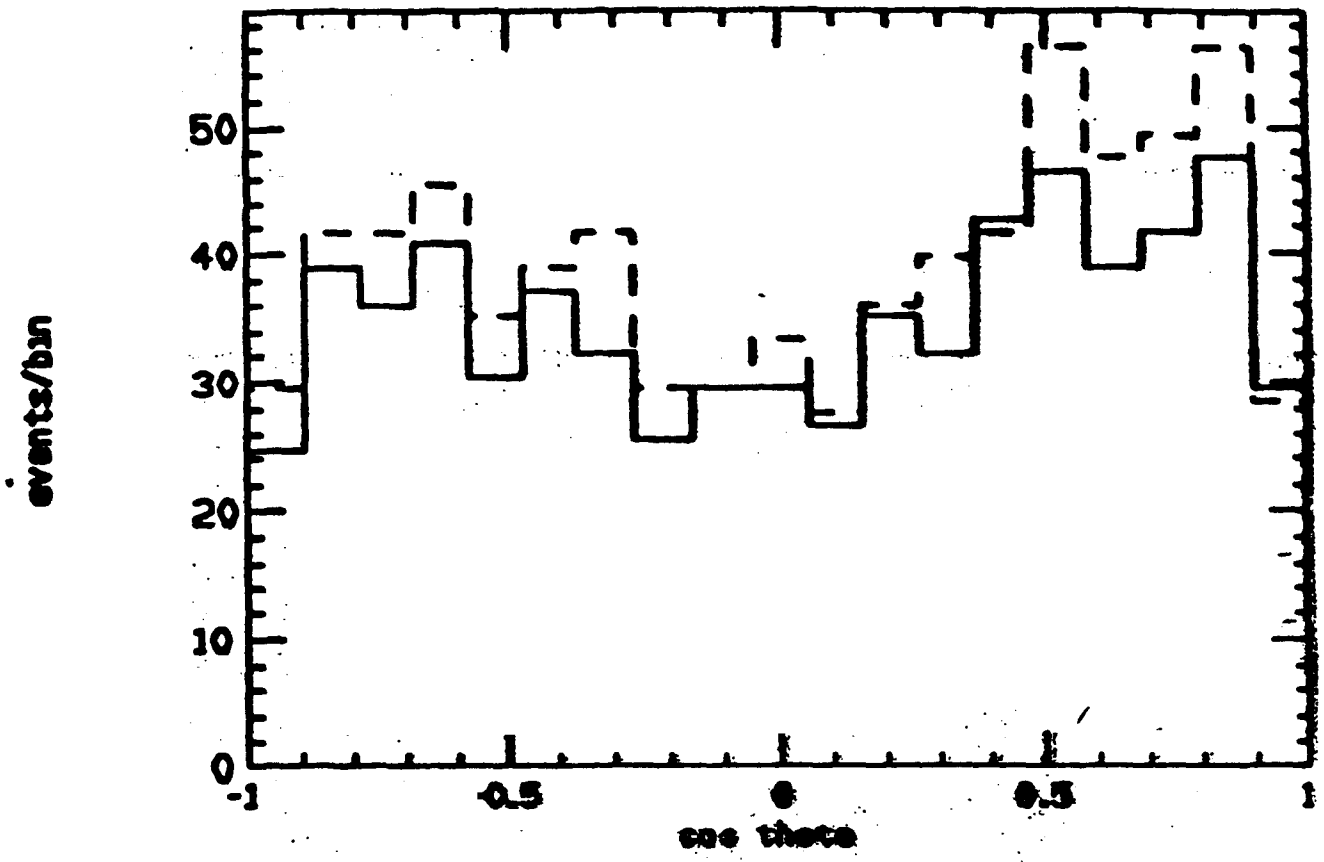
resolution effects ?

Siegrist

effect of descope on 4 Tev

(I H)

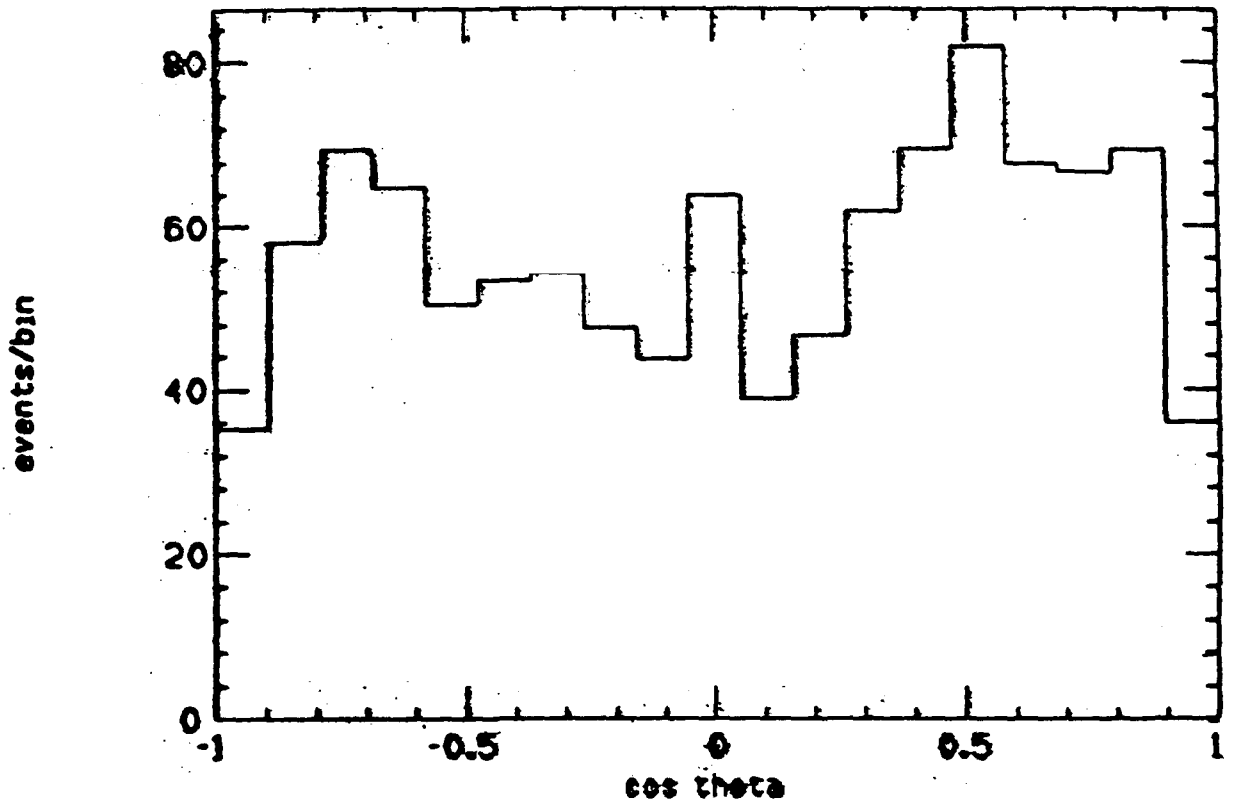
ngle muons solid (dashed) is LOI (EOI) resolution



H

Loss of sign determination

angle perfect

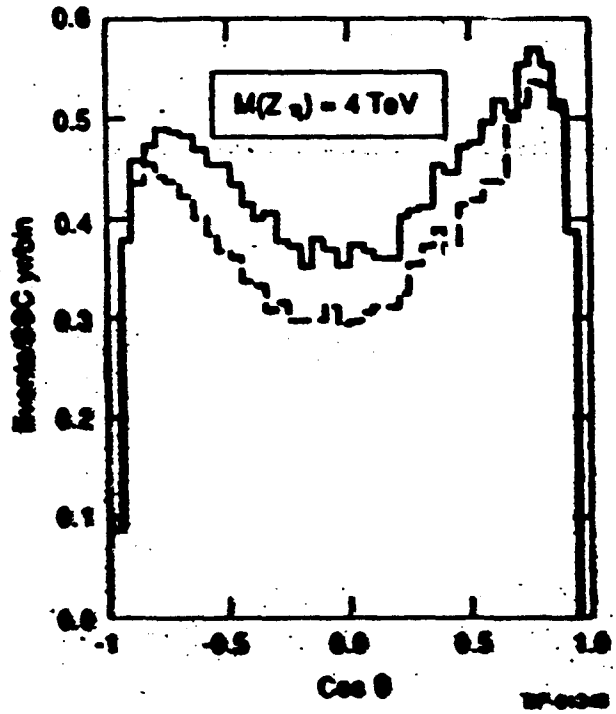


∡ Distn. cut in MASS ± 1 TeV

$P_z(Z') > 1$ TeV

$$A = \frac{\int_0^{\pi/2} dN/d\cos\theta - \int_{\pi/2}^{\pi} dN/d\cos\theta}{\text{"} \quad + \quad \text{"}}$$

$\theta \equiv$ Positive Lepton direction



Outline For this Section (5 pages)
↳ 3

Figures: Fit to width

Fit to $\cos\theta$ distn.

Content: As before +

- quote a number on A & error
- width measurement

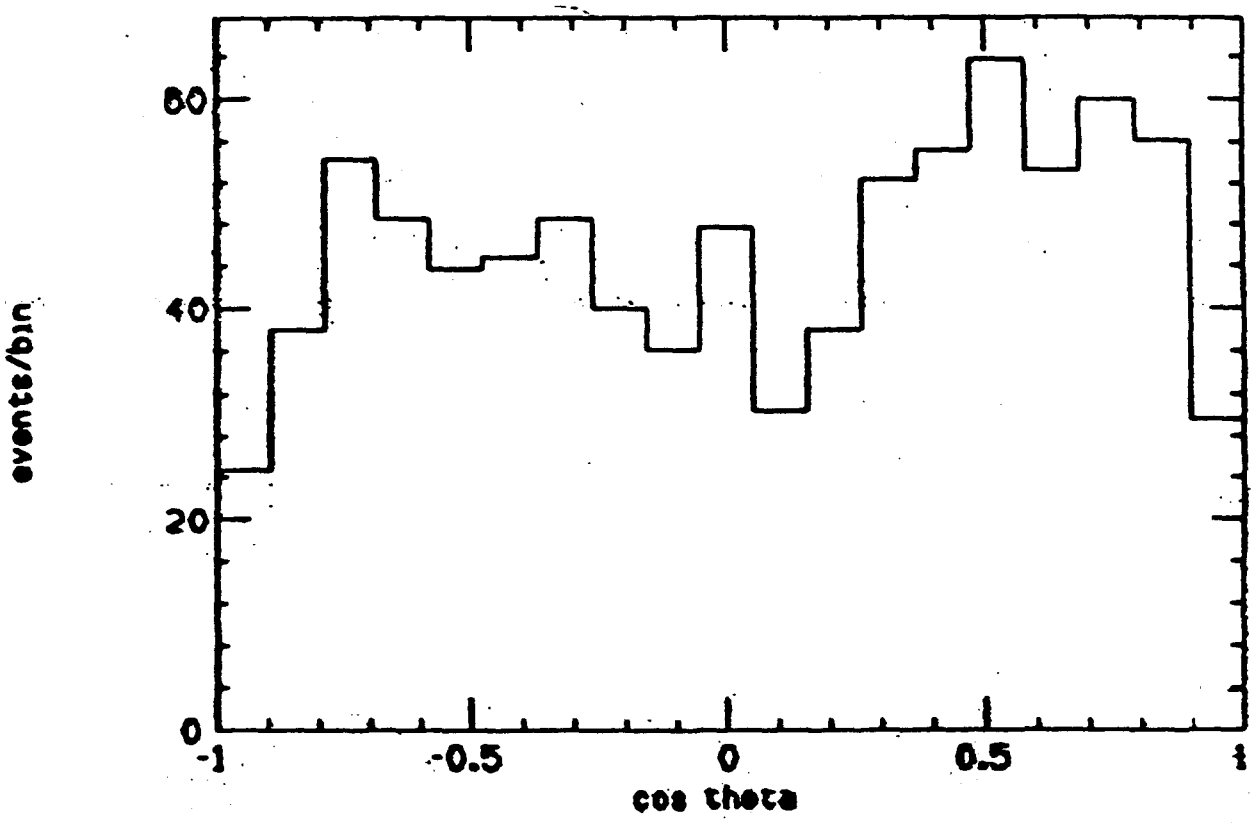
Long Notes (due Oct. 5)

SDC-36 + New Appendix with 'descoped' resolutions; redo with new couplings

?? modes Siegrist et. al.

Section 5.4 EOI

angle electrons



For τ : $e\mu$, $e(\mu)\pi$, or $\pi\pi$

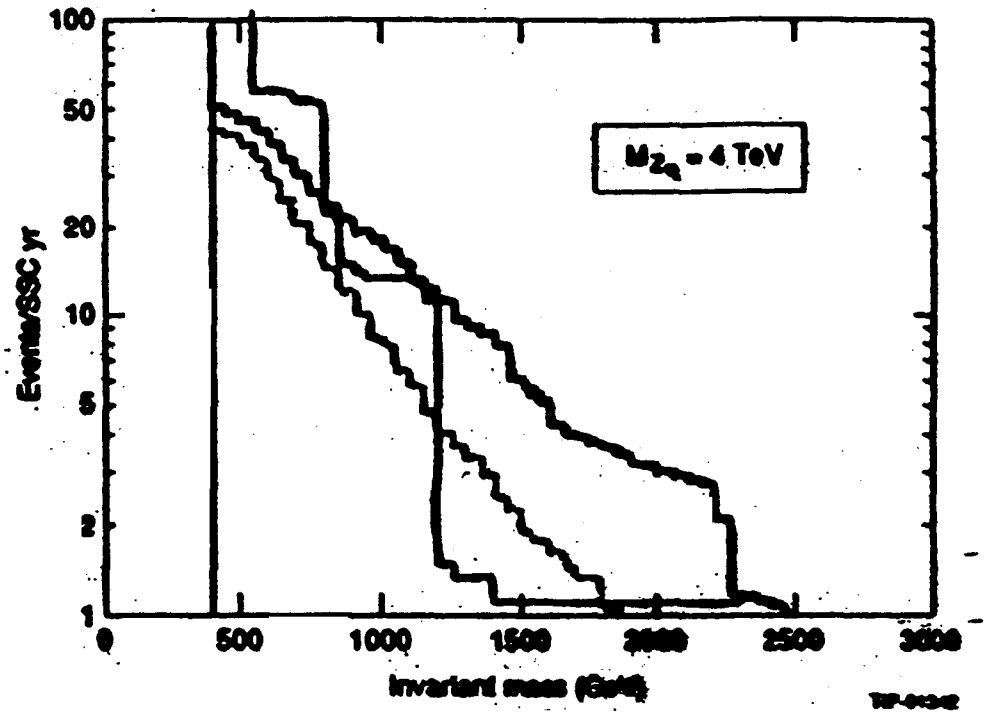
BKGND : DY

$t\bar{t}$
$\hookrightarrow W + x$
$\hookrightarrow \tau\nu$

- reduce top background:

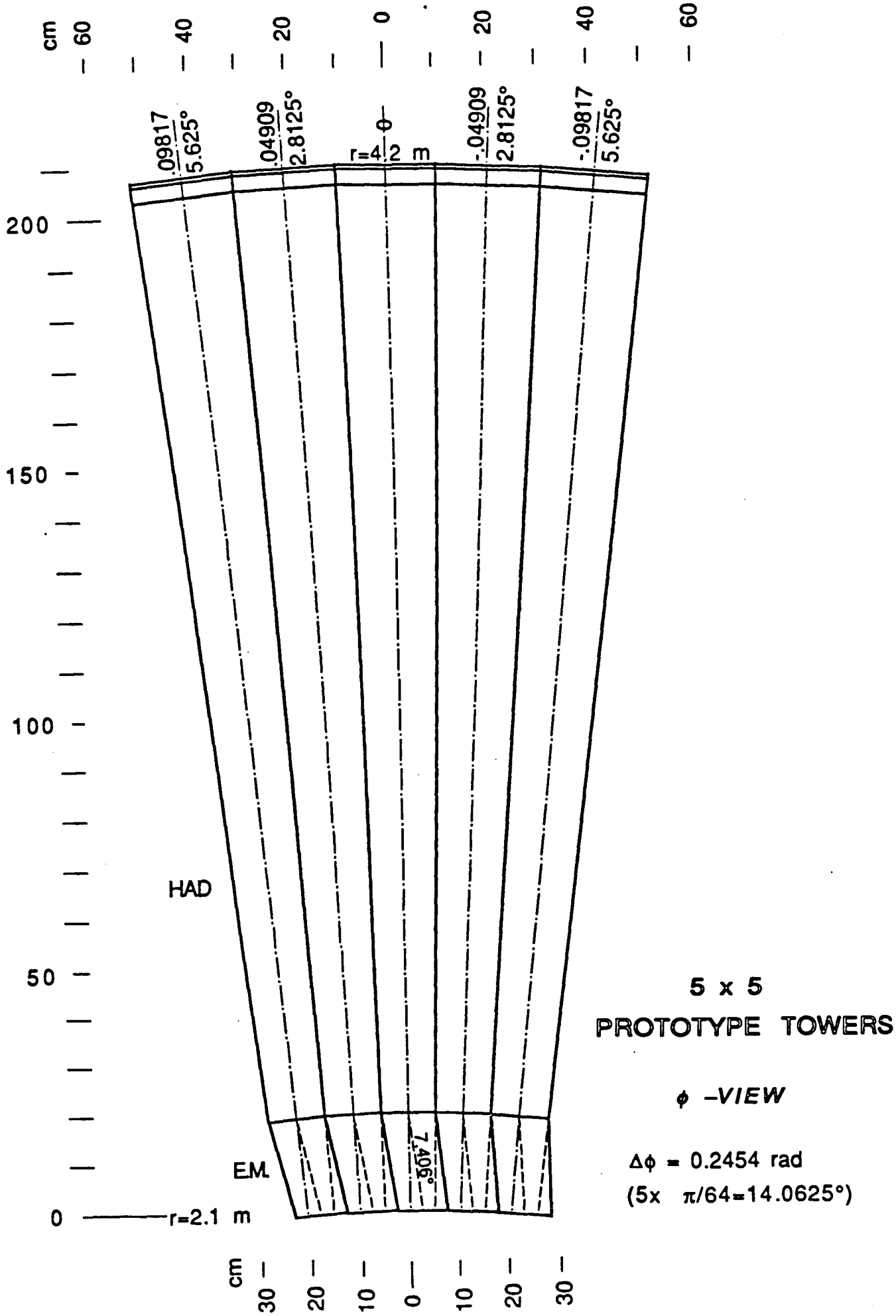
Tracks have large P_t	> 200 gev
Large inv. mass	> 400 gev
back-back in ϕ	30°
$\Delta\phi$ ($\not{E}_t$, tracks) small	$\pm 30^\circ$, either track,
tracks isolated	$\not{E}_t > 100$ gev
	< 5 GeV, $\Delta R > .4$

— Signal
— $t\bar{t}$
— DY



Excess of events, $M > 1300$ ⇒

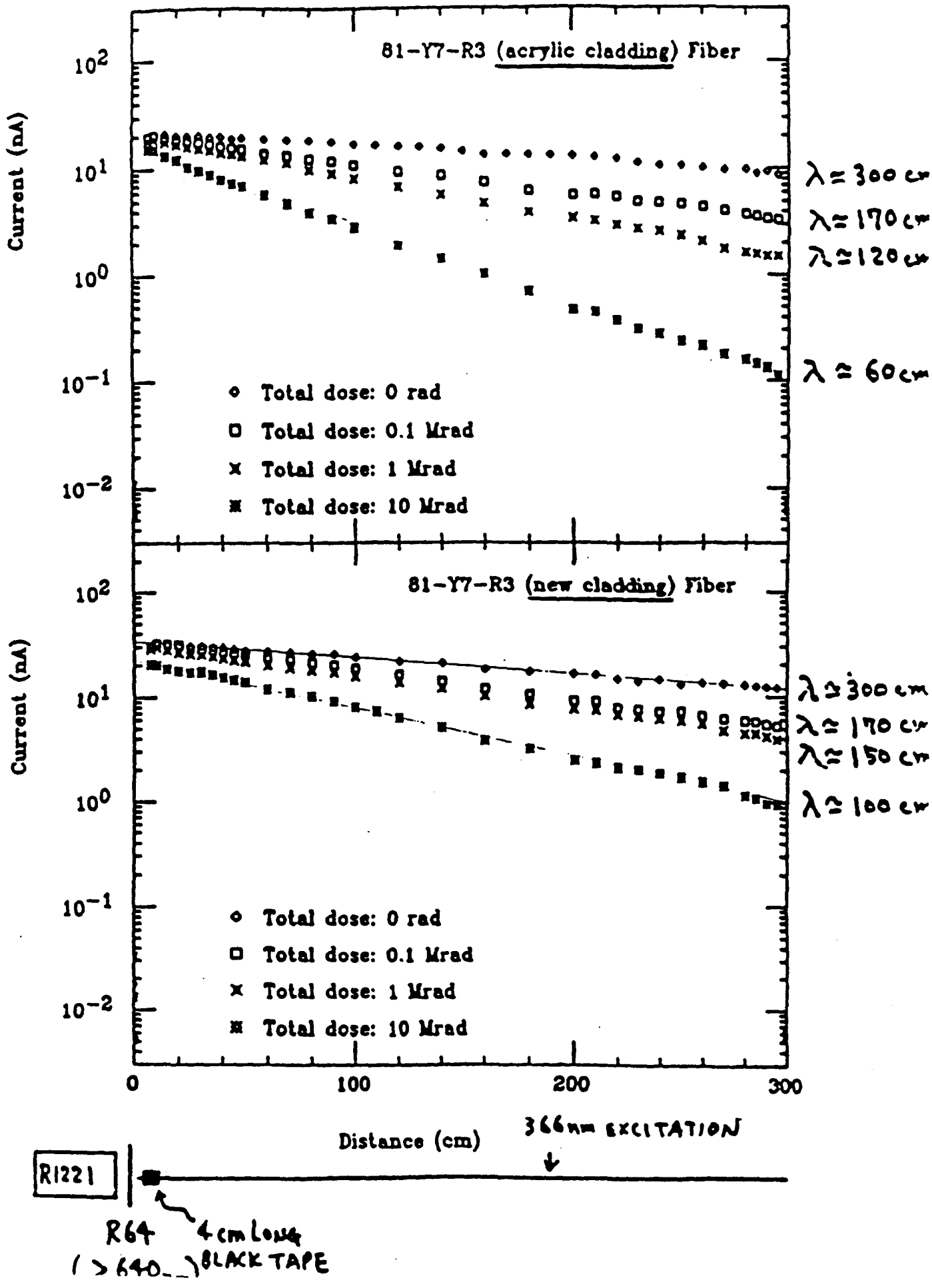
test of universality

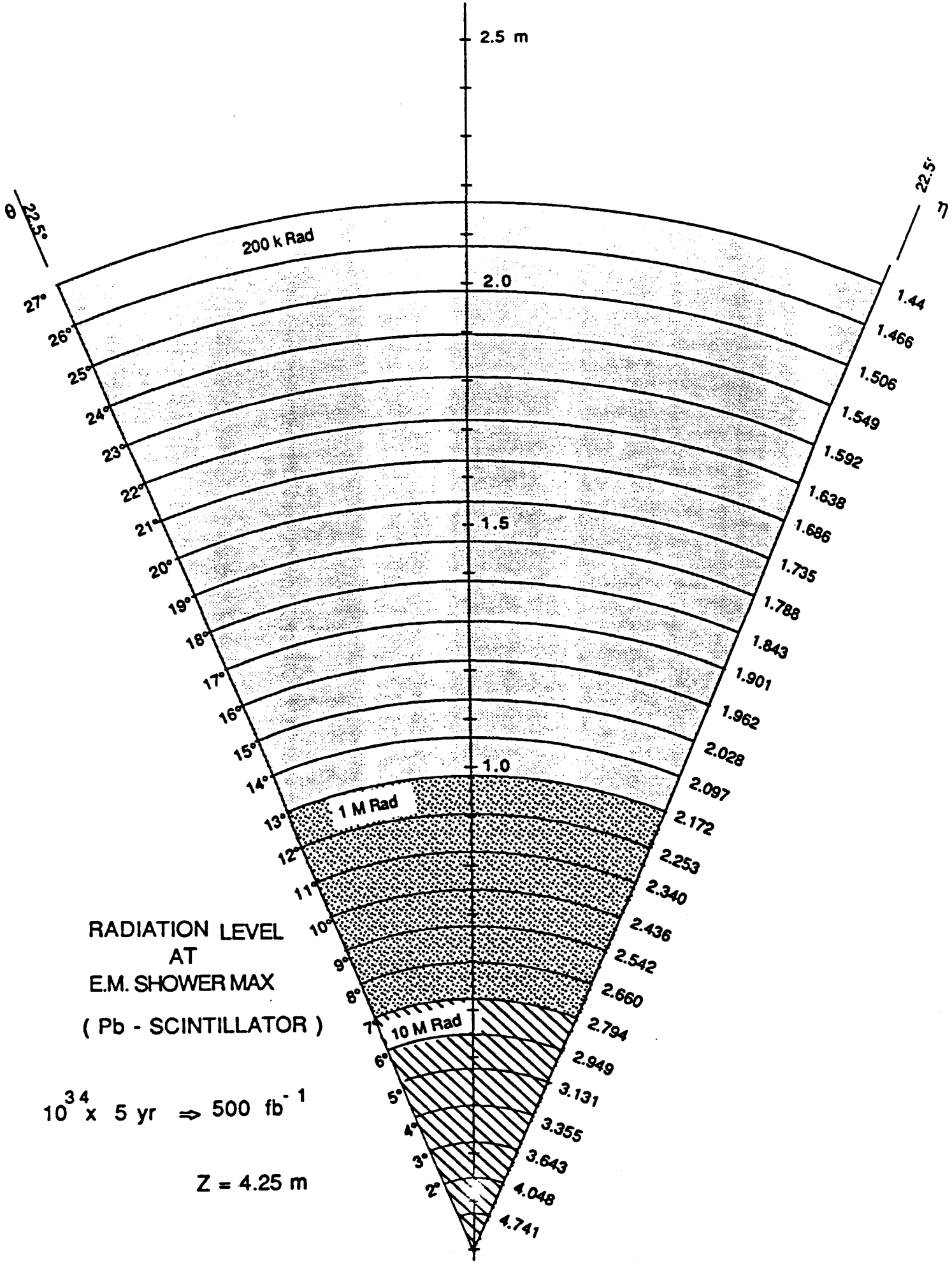

cm
60
40
20
0
20
40
60
.09817
5.625°
.04909
2.8125°
r=4.2 m
-.04909
2.8125°
-.09817
5.625°
200
150
100
50
0
HAD
EM
7.405°
r=2.1 m
cm
30
20
10
0
10
20
30
5 x 5
PROTOTYPE TOWERS
φ -VIEW
Δφ = 0.2454 rad
(5x π/64=14.0625°)

NEAR FUTURE PROGRAM

Nov 1990	: One protoype module (0.05 x 0.0491 x 12.1 m)	
	Assembly	
	Optical/radioactive source test	
	Assembly procedure design/cost estimate	
	Overall structure design	
Jan 1991	: Four prototype modules	
	Assembly	
	Beam test	
Mar 1991	: 5 x 5 prototype modules	- Complete
	Assembly	
	Beam test	
Aug 1991	: 5 E.M. module radiation damage test	- Complete
Oct 1991	: Assembly procedure design/cost estimate	- Complete
	Overall structure design	- Complete

Radiation Damage (SCSF 81 + Y1 + K5) RED LIGHT



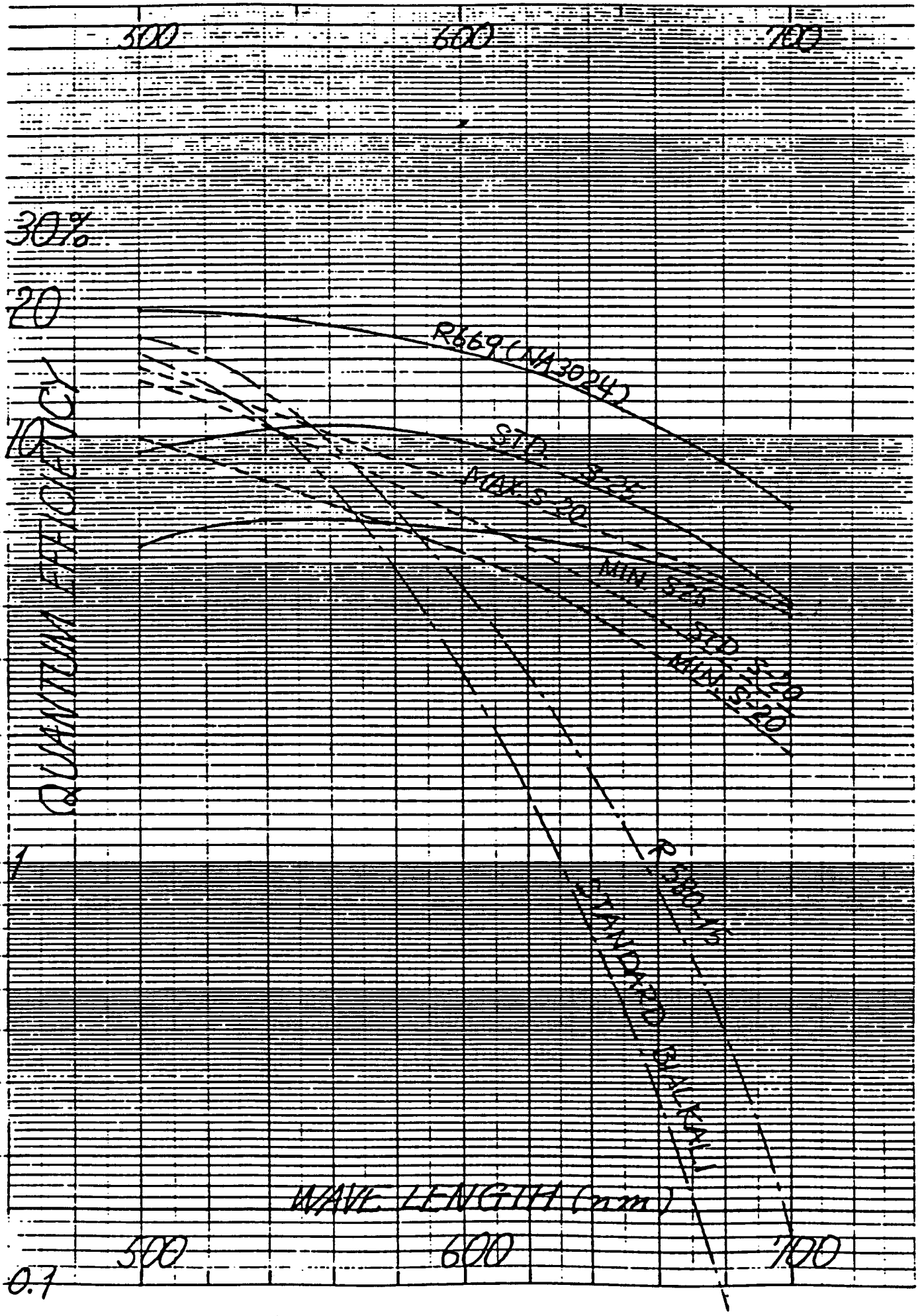

2.5 m
2.0
1.5
1.0
θ 22.5°
η 22.5°
200 k Rad
1 M Rad
10 M Rad
27°
26°
25°
24°
23°
22°
21°
20°
19°
18°
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1.44
1.466
1.506
1.549
1.592
1.638
1.686
1.735
1.788
1.843
1.901
1.962
2.028
2.097
2.172
2.253
2.340
2.436
2.542
2.660
2.794
2.949
3.131
3.355
3.643
4.048
4.741
RADIATION LEVEL
AT
E.M. SHOWER MAX
(Pb - SCINTILLATOR)
10^{34} x 5 yr ⇒ 500 fb^{-1}
Z = 4.25 m

Phototube

HAD	7,168 ch x 3 inch PM	==>	$1.08 M $150/PM
EM	7,168 ch x 2 inch PM	==>	$ .93 M $130/PM

Acrylic diffuser

HAD	7,168 x "3 inch"	==>	$ .22 M $30/piece
EM	7,168 x "2 inch"	==>	$.14 M $20/piece



K+E SEMI-LOGARITHMIC 3 CYCLES × 180 DIVISIONS KEUFFEL & ESSER CO.
46 5810

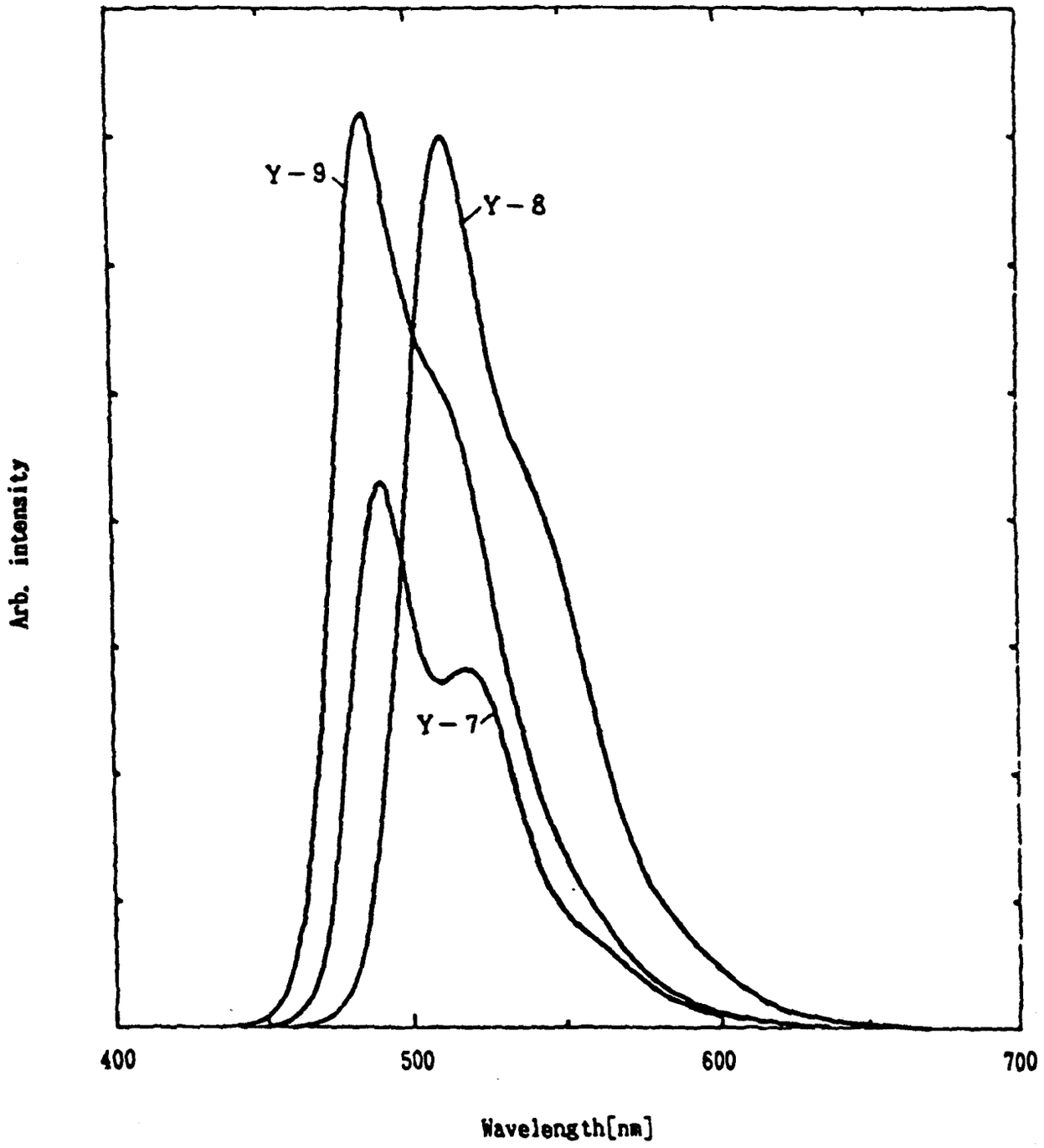
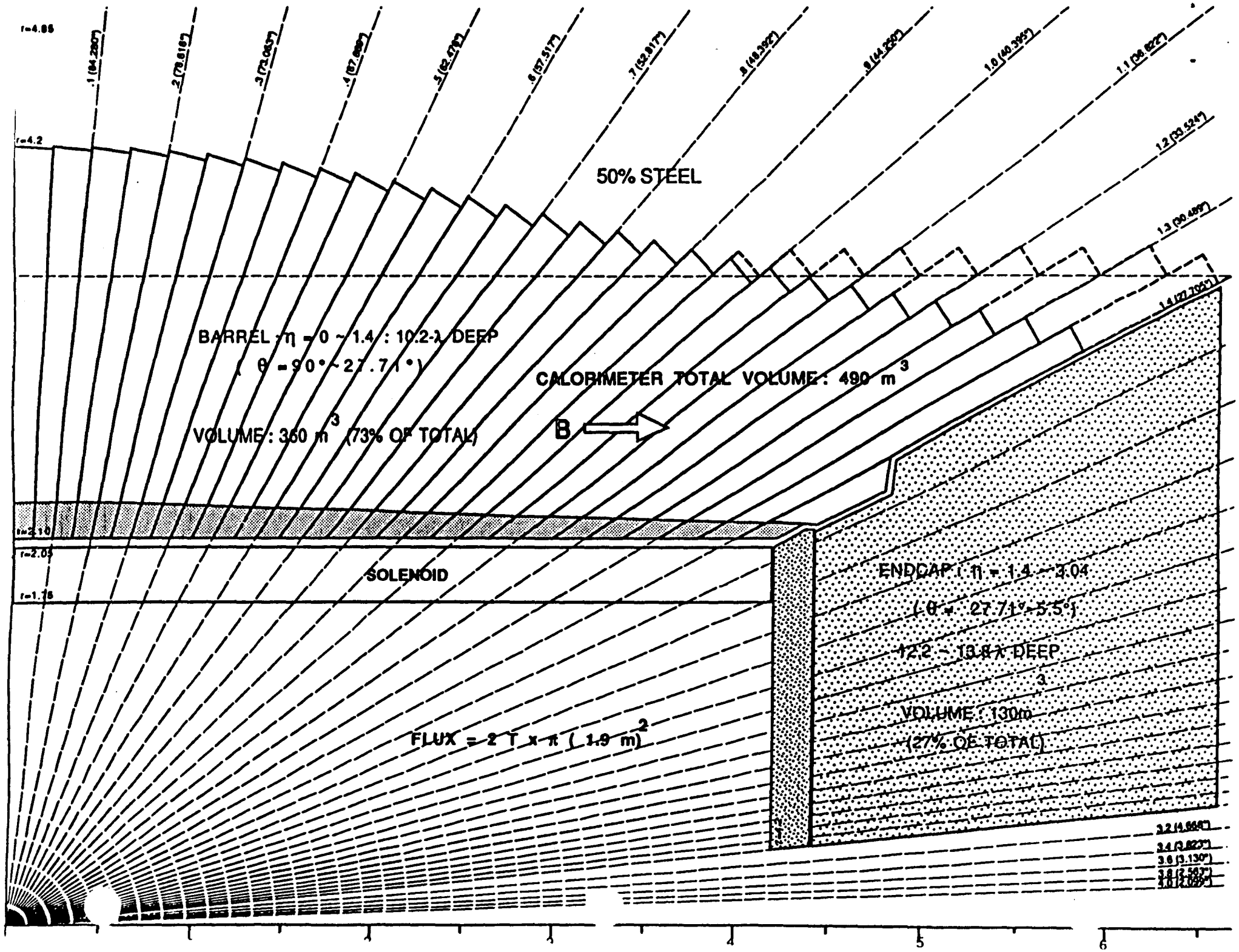
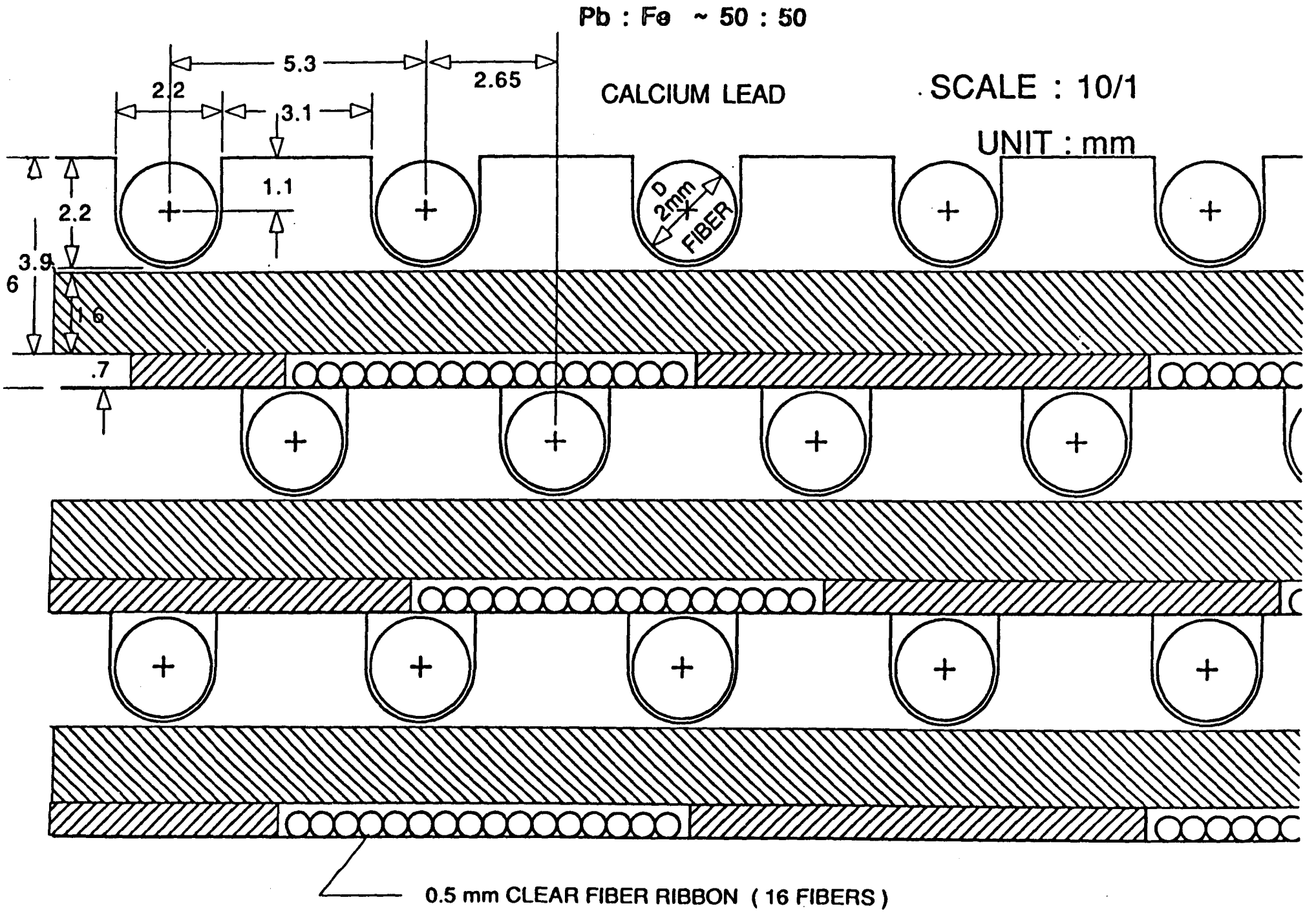
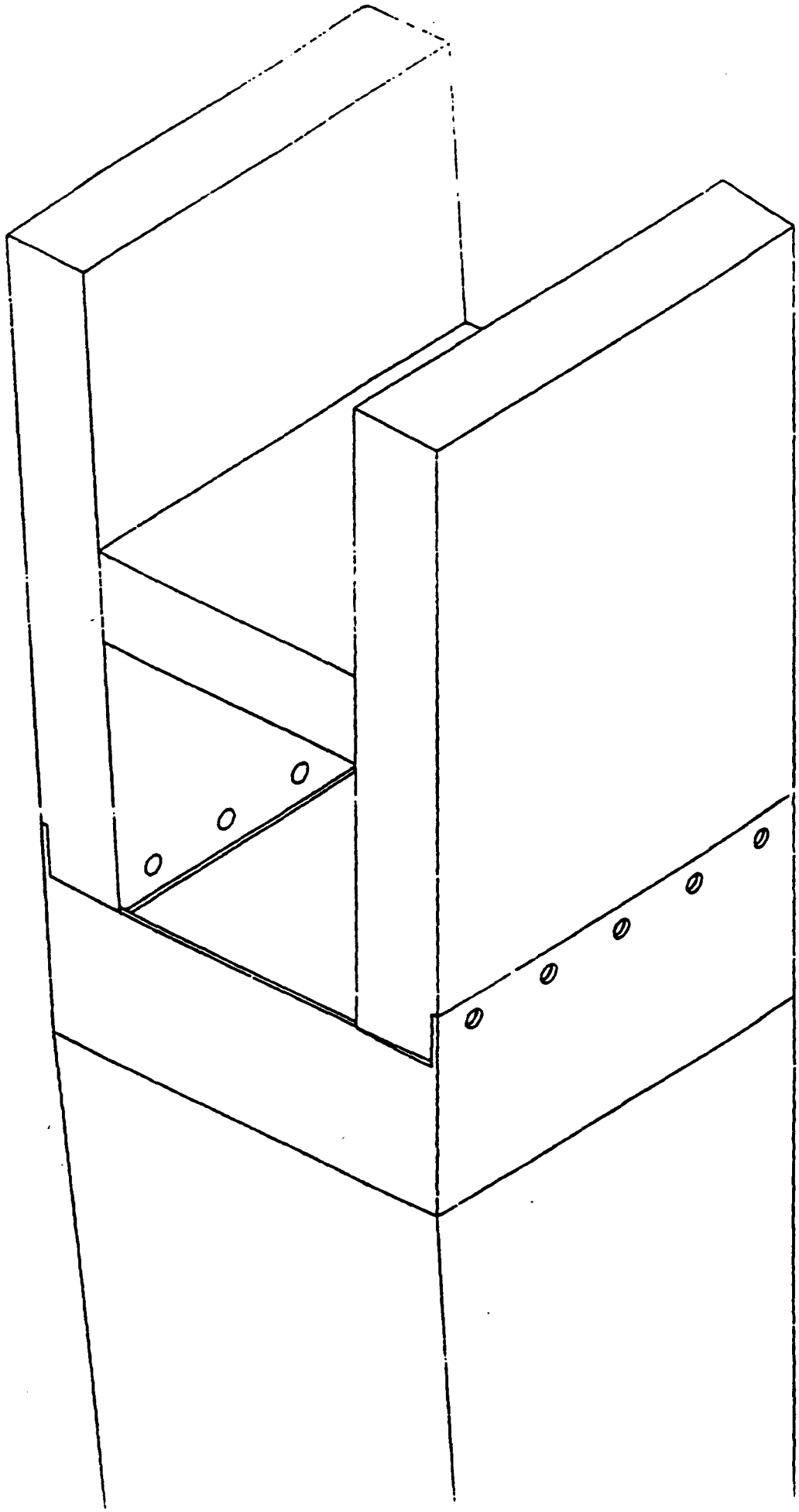
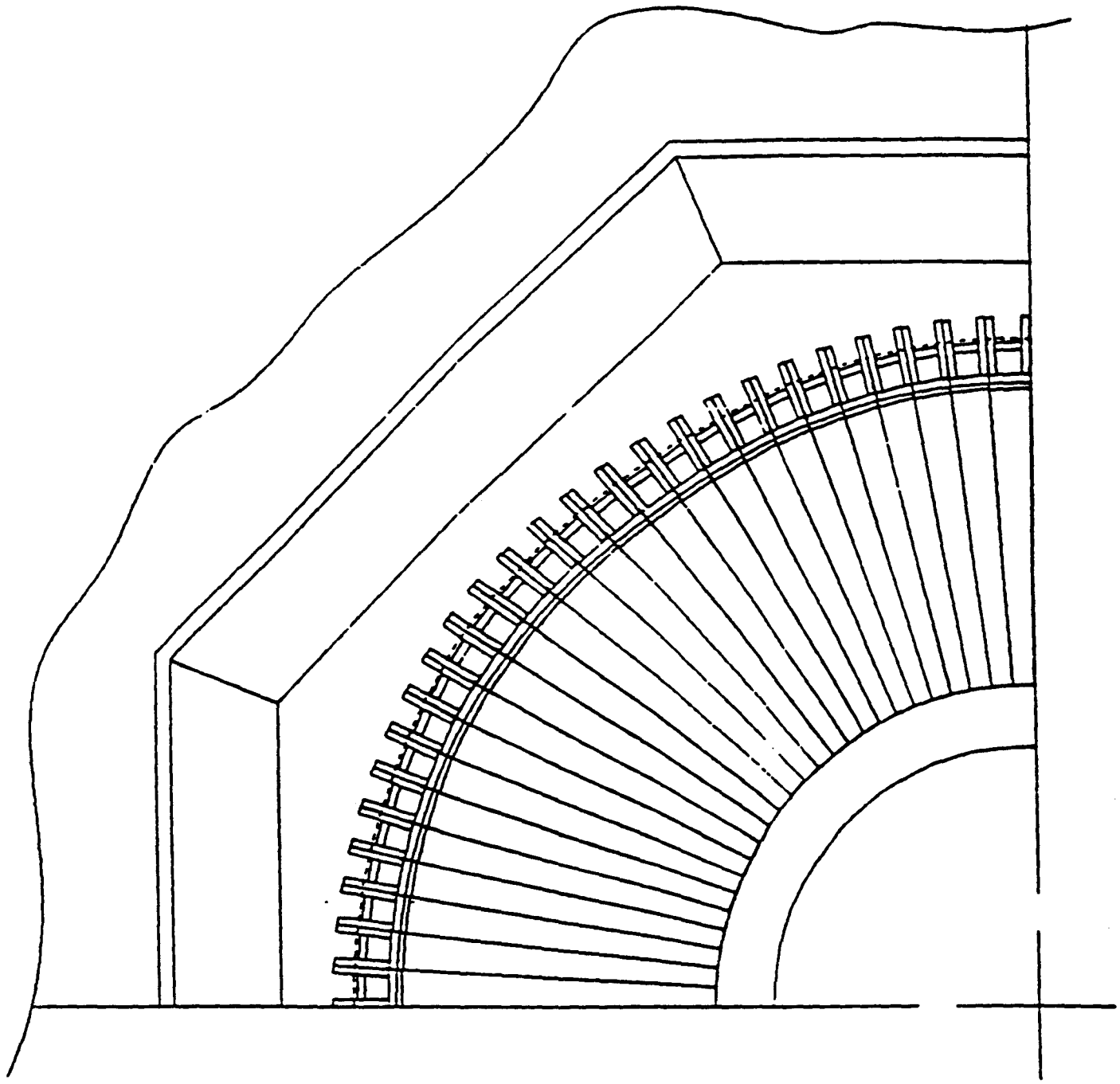


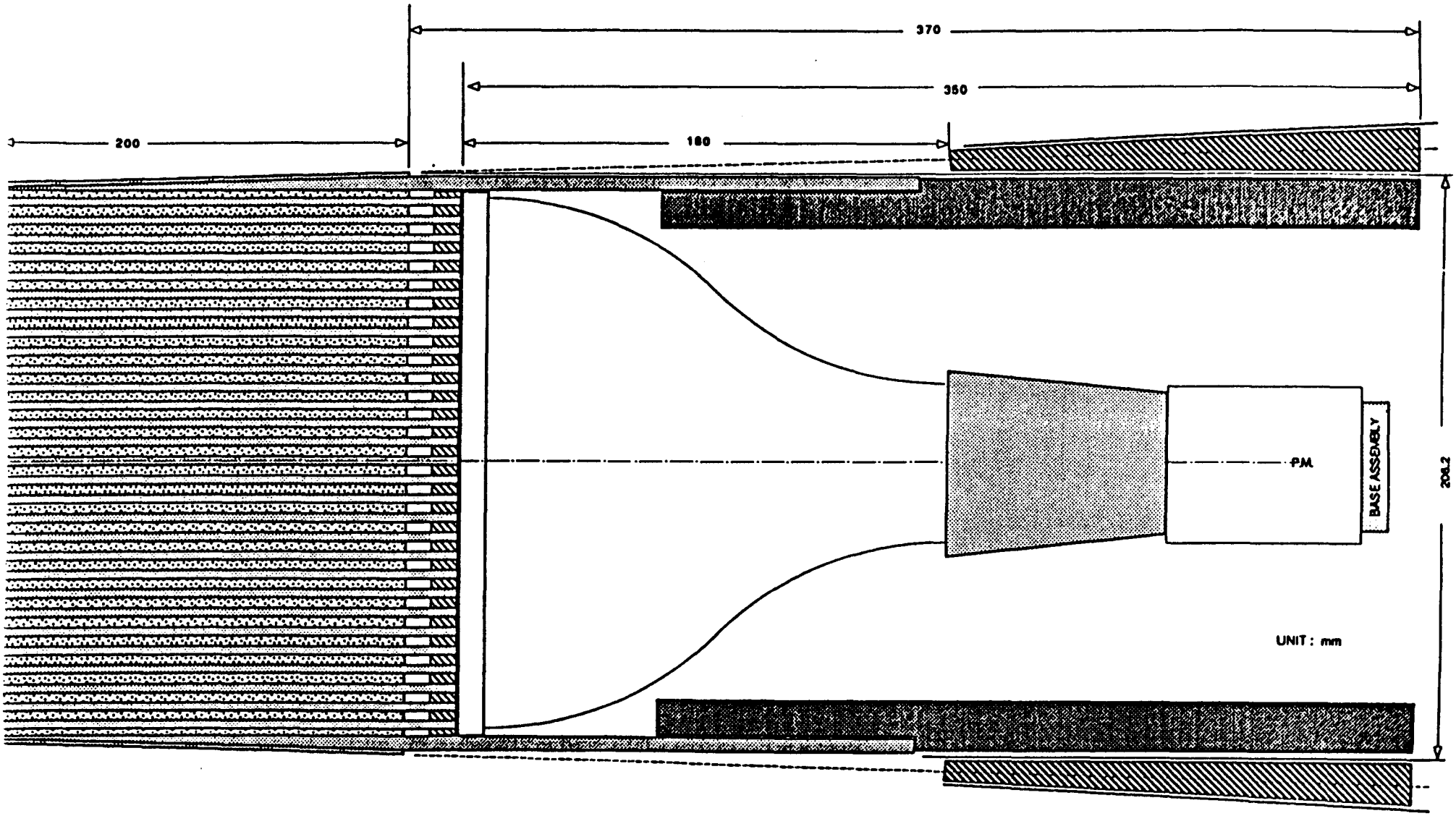
Fig.3 Emission spectra
Concentration: 5.2 ppm in
St monomer in 1x1cm cell
Ex.waveleng. : 440 nm (Y-7,Y-8,Y-9)
Em.Peak : 480 nm (Y-7),511 nm (Y-8)
485 nm (Y-9)

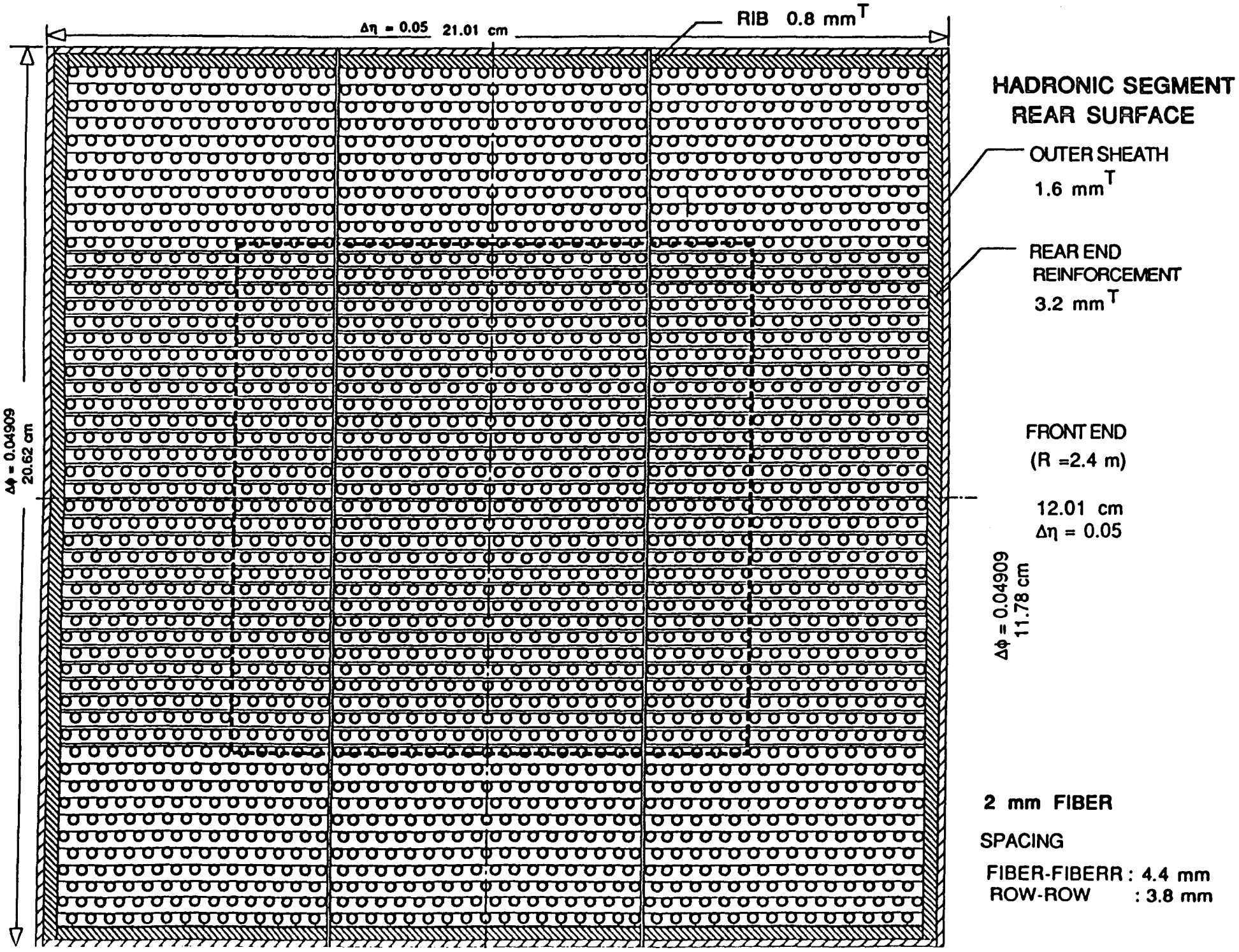

50% STEEL
BARREL η = 0 ~ 1.4 : 10.2-λ DEEP
(θ = 90° ~ 27.71°)
VOLUME: 360 m³ (73% OF TOTAL)
CALORIMETER TOTAL VOLUME: 490 m³
B
SOLENOID
ENDCAP (η = 1.4 ~ 3.04
(θ = 27.71° ~ 5.5°)
12.2 ~ 13.8 λ DEEP
VOLUME: 130 m³
(27% OF TOTAL)
FLUX = 2 T × π (1.9 m)²

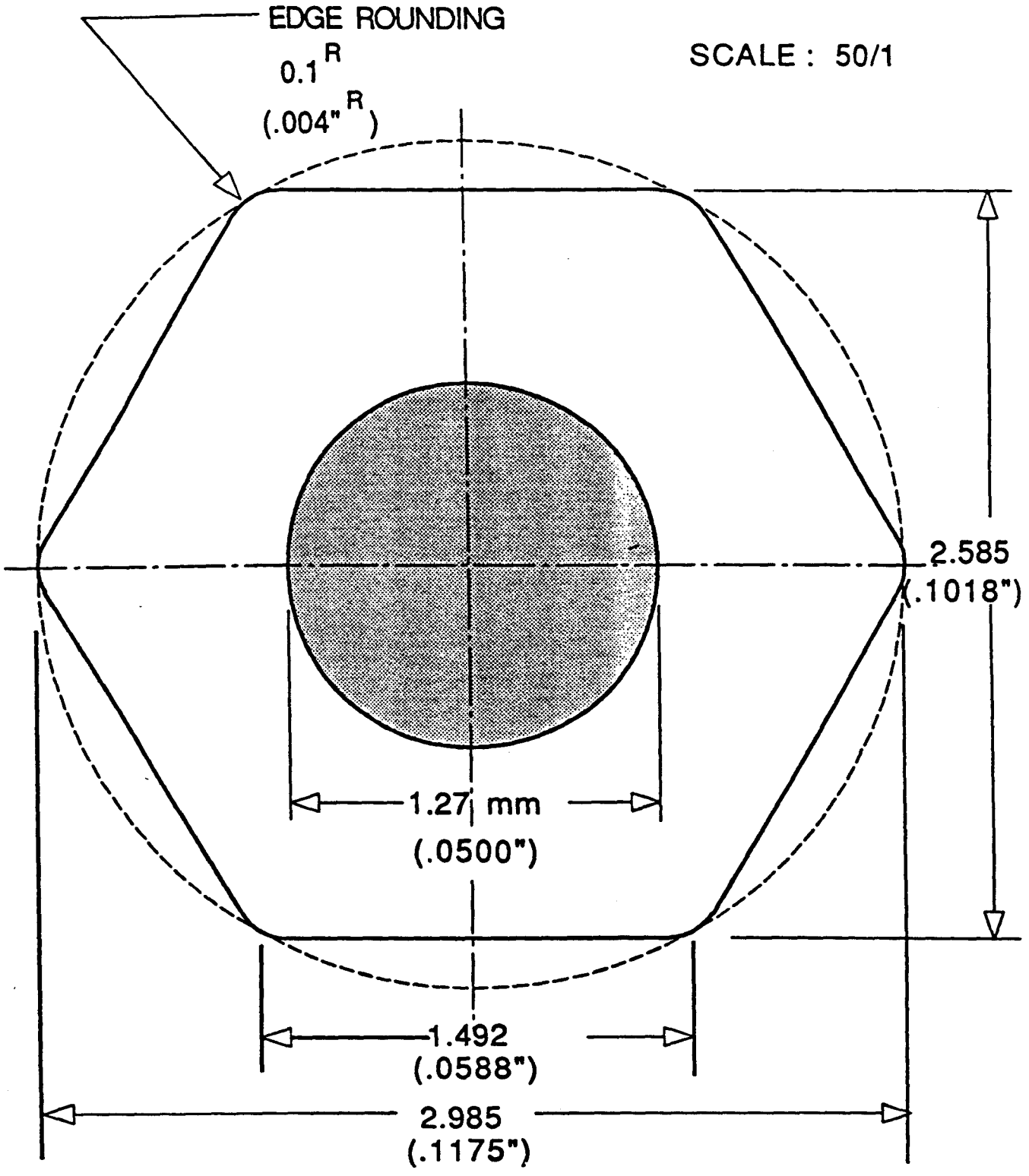

Pb : Fe ~ 50 : 50
5.3
2.65
2.2
3.1
CALCIUM LEAD
SCALE : 10/1
UNIT : mm
1.1
2.2
3.9
6
1.6
.7
D
2mm
FIBER
0.5 mm CLEAR FIBER RIBBON (16 FIBERS)






370
350
200
180
PM
BASE ASSEMBLY
204.2
UNIT : mm


Δη = 0.05 21.01 cm
RIB 0.8 mm^T
HADRONIC SEGMENT
REAR SURFACE
OUTER SHEATH
1.6 mm^T
REAR END
REINFORCEMENT
3.2 mm^T
Δφ = 0.04909
20.62 cm
FRONT END
(R =2.4 m)
12.01 cm
Δη = 0.05
Δφ = 0.04909
11.78 cm
2 mm FIBER
SPACING
FIBER-FIBERR : 4.4 mm
ROW-ROW : 3.8 mm



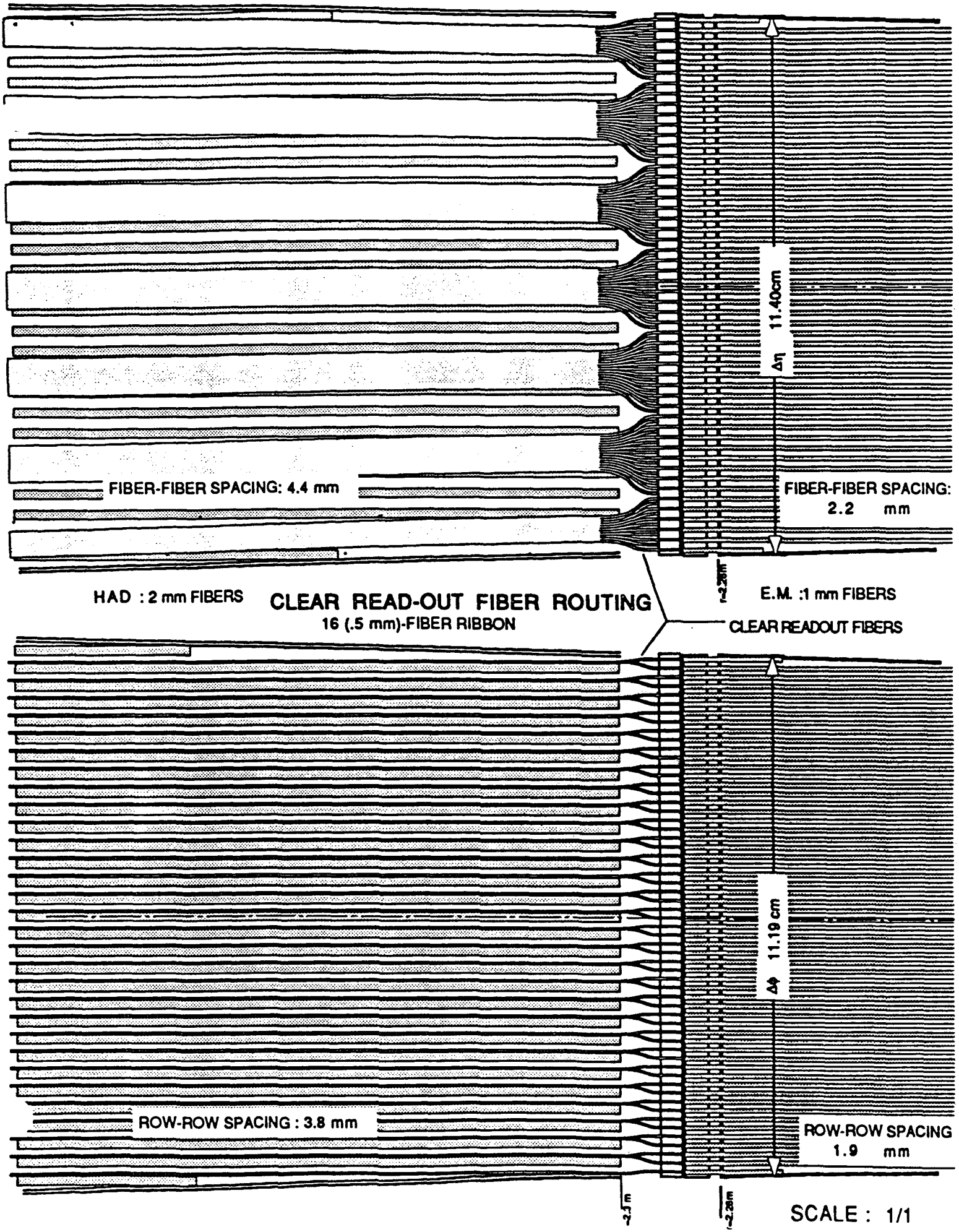
HEXAGONAL LEAD TUBING

: Antimony-Lead
2 ~ 3 %

D
(1.2 mm Fiber)

s=2.585mm = .1018"

h=2.238mm = .0881"


FIBER-FIBER SPACING: 4.4 mm
Δη 11.40cm
FIBER-FIBER SPACING:
2.2 mm
HAD : 2 mm FIBERS
CLEAR READ-OUT FIBER ROUTING
16 (.5 mm)-FIBER RIBBON
E.M. :1 mm FIBERS
CLEAR READOUT FIBERS
Δφ 11.19 cm
ROW-ROW SPACING : 3.8 mm
ROW-ROW SPACING
1.9 mm
SCALE : 1/1

E.M. SEGMENT REAR VIEW

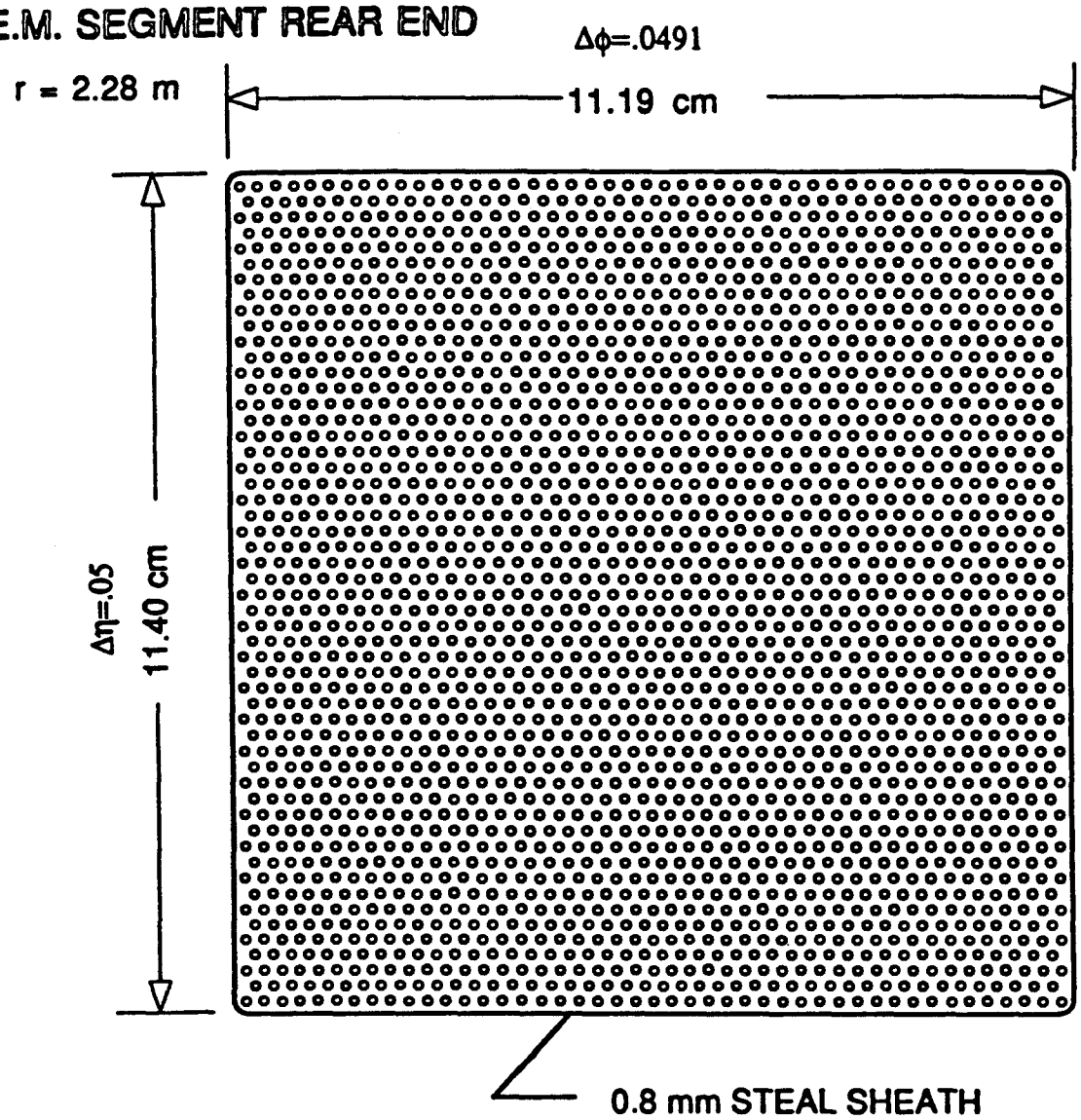
TOWER AT $\eta = 0 \sim 0.05$

$(\theta = 90° \sim 87.1364°)$

$\Delta\eta \times \Delta\phi = 0.05 \times 0.04909$

$(\pi/64 = 2.8125°)$

E.M. SEGMENT REAR END



1 mm FIBER

25 X_0 TOTAL

SPACING : FIBER-TO-FIBER = 2.2 mm

ROW-TO-ROW = 1.9 mm

* Lead : Calcium Loaded Lead (Doe Run Lead Co. SJM-610 or Equivalent)

		SJM-610	Lead-6% Antimony
Chemical Composition :	Calcium	0.065 %	
	Tin	0.7 %	
	Silver etc.	10 ppm or smaller	
Density		11.35 g/cm^3	10.88 g/cm^3
Melting Point(Solidus)		327°C(621°F)	252°C(486°F) (Rolled)
Ultimate Tensile Strength	(kg/cm^2)	632.8(9,000psi)	309.4(4,400psi)
Yield Strength(0.2% Offset)	(kg/cm^2)	597.6(8,500psi)	196.9(2,800psi)
Elongation (%)		10	40
Stress Rupture(Hrs to rupture			
@Stress of 281.2 kg/cm^2(4000psi)		50	Nil
@Stress of 210.9 kg/cm^2(3000psi)		500	2

*The properties of wrought lead-calcium(-tin) alloys are directional and all properties shown are in the longitudinal ditrection. Transverse properties are somewhat lower.

1) E.M. Segment : Scintillation Fiber - Lead Composit (1 : 4 in volume)

Density : 9.29 g/cm^3

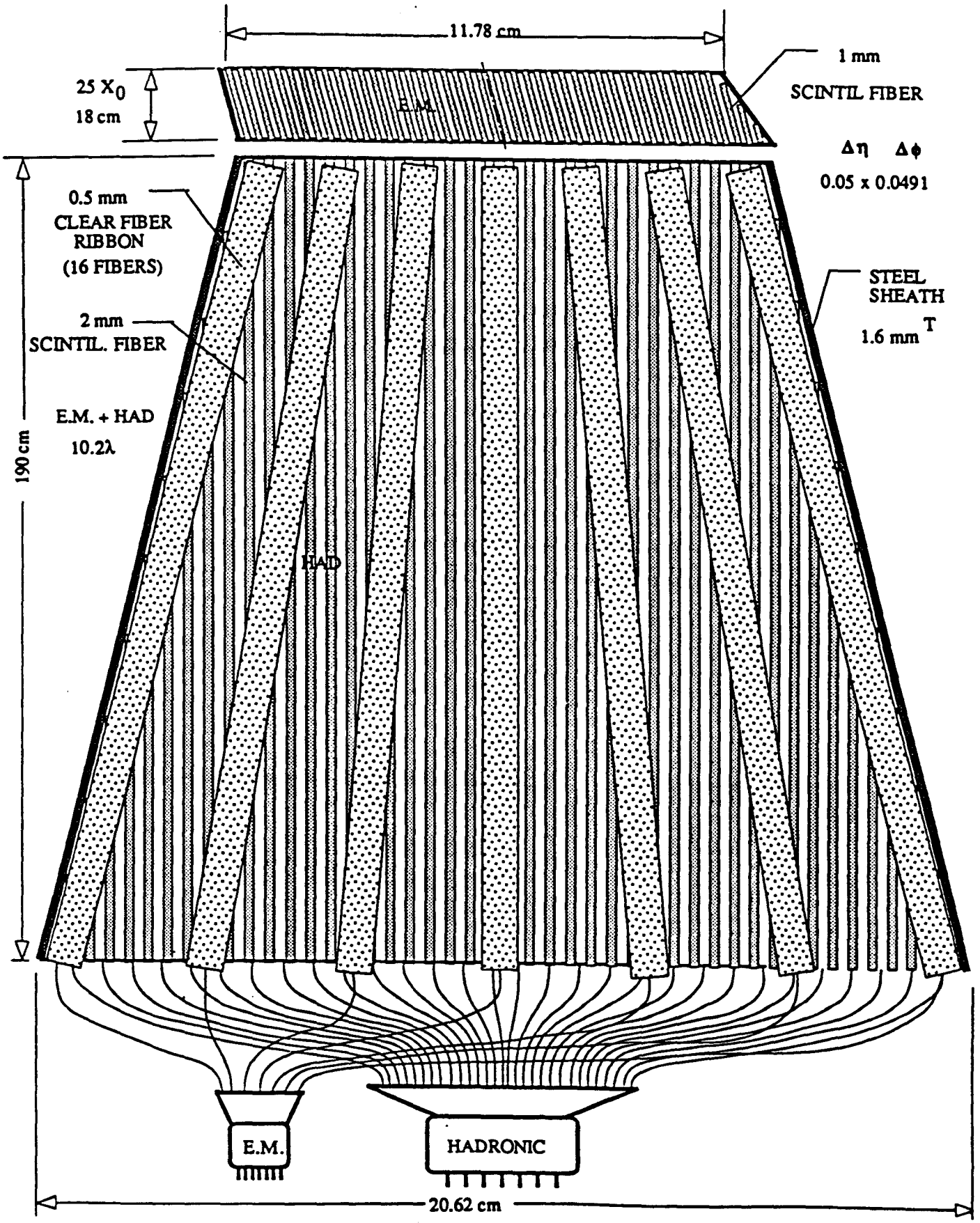
X_0 : 7.0 mm

λ^N_{int} : 20.3 cm

2) Hadronic segment : Scintillation Fiber - Lead - Iron Composit (2 : 5 : 5 in volume)

Density : 8.18 g/cm^3

λ^N_{int} : 19.5 cm



LONGITUDINALLY SEGMENTED SCINTILLATION FIBER CALORIMETER

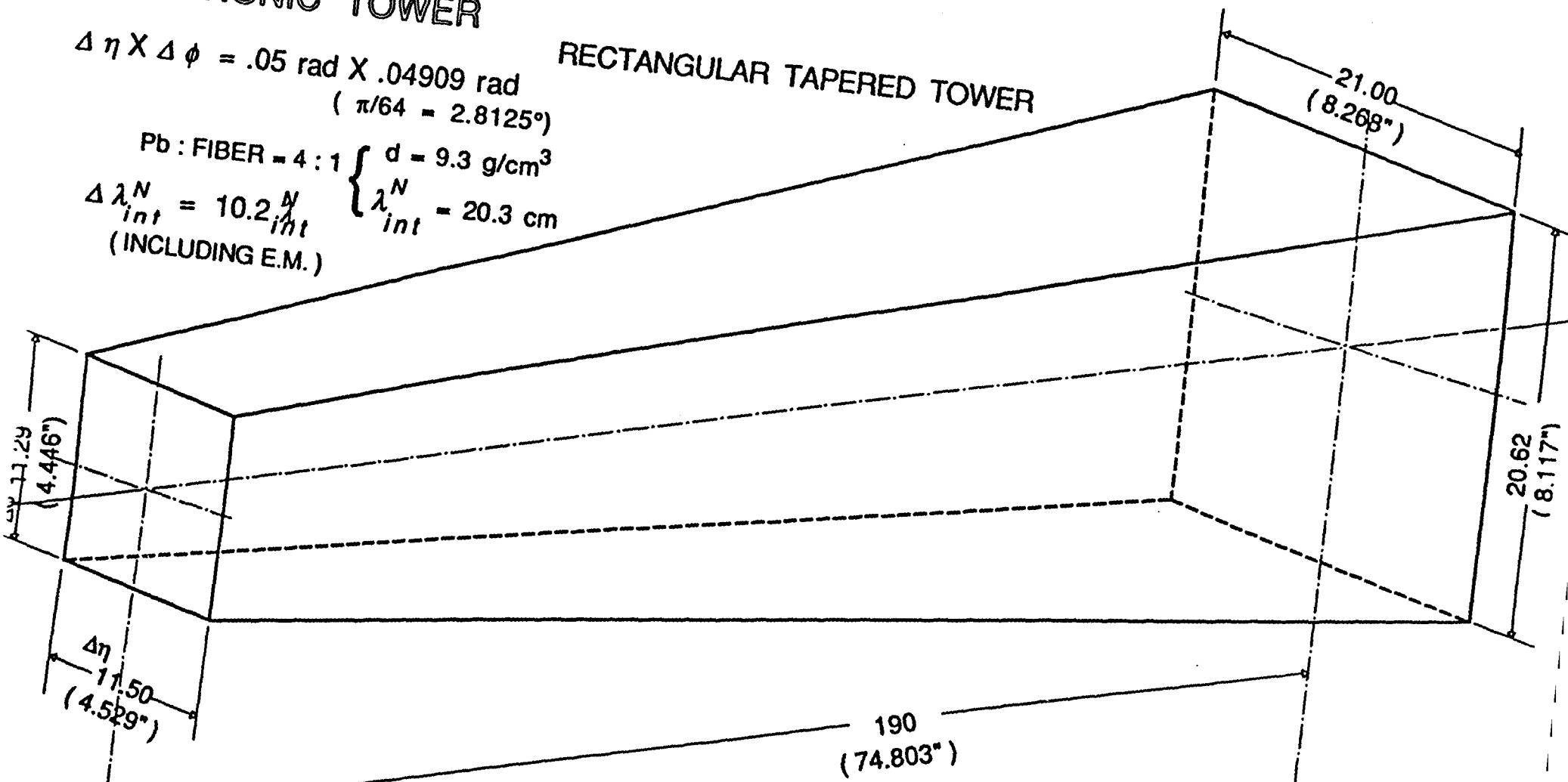
HADRONIC TOWER

$\Delta\eta \times \Delta\phi$ = .05 rad X .04909 rad
($\pi/64$ = 2.8125°)

Pb : FIBER = 4 : 1 $\begin{cases} d = 9.3\ g/cm^3 \\ \lambda^N_{int} = 20.3\ cm \end{cases}$

$\Delta\lambda^N_{int} = 10.2\lambda^N_{int}$
(INCLUDING E.M.)

RECTANGULAR TAPERED TOWER



VOLUME = $\frac{1}{3}$ ($R^3_{REAR} - R^3_{FRONT}$) x $\Delta\eta$ x $\Delta\phi$
= 5.07 x 10^4 cm^3

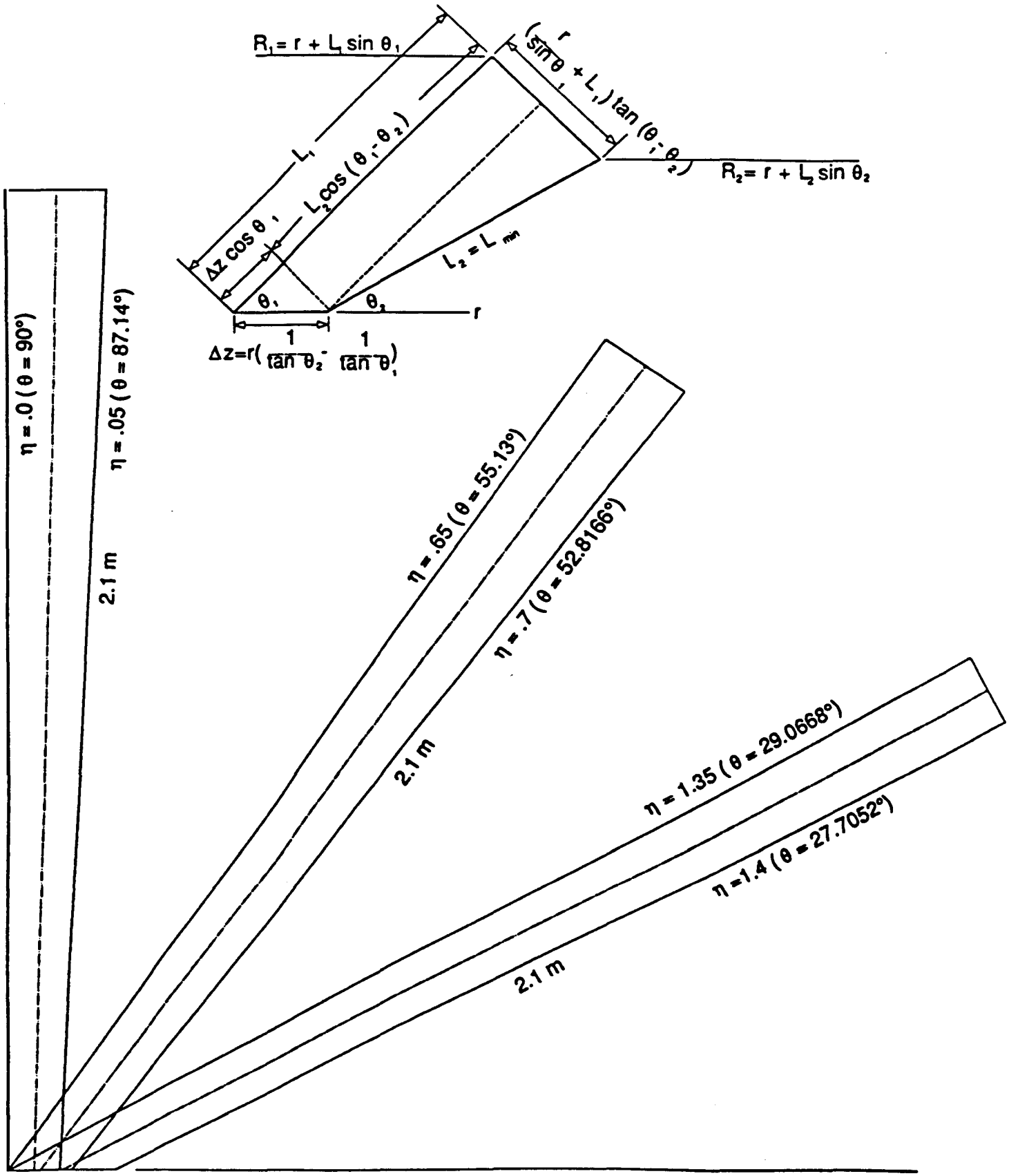
WEIGHT = VOLUME x 9.3 g/cm^3
= 471 kg
= 1039 LBS

R = 2.3 m
(R^{EM}_{FRONT} = 1.7+0.4=2.1meter)

R = 4.2 m
(R_{REAR} = 4.2 meter)

UNIT : CM

Rev : S

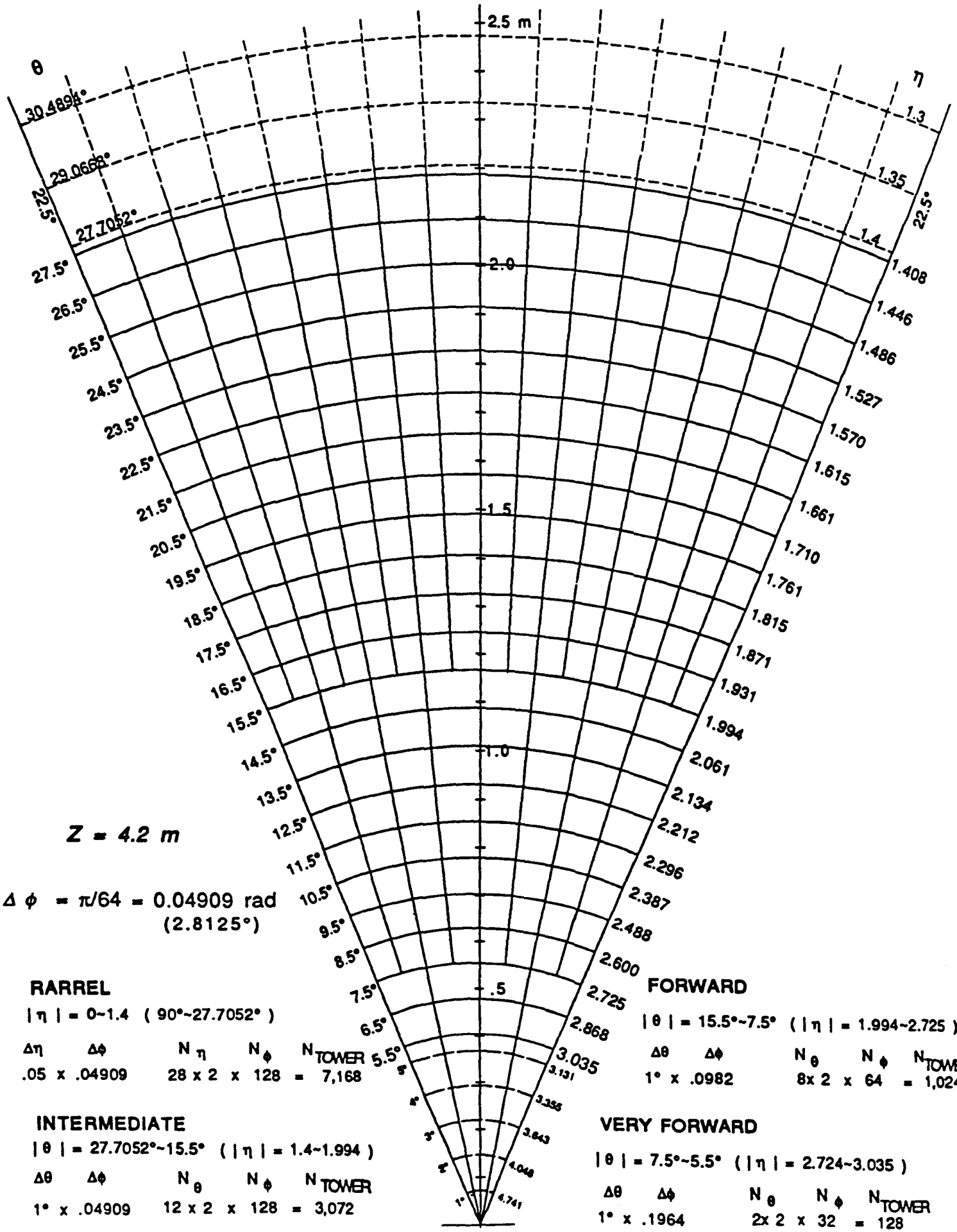

R₁ = r + L₁ sin θ₁
(r/sin θ₁ + L₁) tan (θ₁ - θ₂)
R₂ = r + L₂ sin θ₂
L₁
L₂ cos (θ₁ - θ₂)
ΔZ cos θ₁
L₂ = L min
θ₁
θ₂
r
Δz = r(1/tan θ₂ - 1/tan θ₁)
η = .0 (θ = 90°)
η = .05 (θ = 87.14°)
2.1 m
η = .65 (θ = 55.13°)
η = .7 (θ = 52.8166°)
2.1 m
η = 1.35 (θ = 29.0668°)
η = 1.4 (θ = 27.7052°)
2.1 m

END CAP SEGMENTATION

	η	θ
26)	1.3	30.4894°
27)	1.335	29.5°
28)	1.371	28.5°
29)	1.408	27.5°
30)	1.446	26.5
31)	1.486	25.5°
32)	1.527	24.5°
33)	1.570	23.5°
34)	1.615	22.5°
35)	1.661	21.5°
36)	1.710	20.5°
37)	1.761	19.5°
38)	1.815	18.5°
39)	1.871	17.5°
40)	1.931	16.5°
41)	1.994	15.5°
42)	2.061	14.5°
43)	2.134	13.5°
44)	2.212	12.5°
45)	2.296	11.5°
46)	2.387	10.5°
47)	2.488	9.5°
48)	2.600	8.5°
49)	2.725	7.5°
50)	2.868	6.5°
51)	3.035	5.5°

BARREL SEGMENTATION

	η	θ	Z (r=210)	Z (r=212)	d (r=210)
0)	0	90°	0 cm	0 cm	210 cm
1)	.05	87.1364°	10.504	10.604	210.26
2)	.1	84.2799°	21.035	21.236	211.05
3)	.15	81.4377°	31.618	31.919	212.37
4)	.2	78.6165°	42.280	42.683	214.21
5)	.25	75.8230°	53.048	53.554	216.60
6)	.3	73.0634°	63.949	64.558	219.52
7)	.35	70.3438°	75.010	75.724	222.99
8)	.4	67.6695°	86.258	87.079	227.03
9)	.45	65.0455°	97.722	98.652	231.62
10)	.5	62.4762°	109.430	110.472	236.80
11)	.55	59.9656°	121.411	127.193	242.57
12)	.6	57.5170°	133.697	134.970	248.95
13)	.65	55.1332°	146.317	147.711	255.95
14)	.7	52.8166°	159.303	160.820	263.59
15)	.75	50.5690°	172.686	174.331	271.88
16)	.8	48.3915°	186.502	188.279	280.86
17)	.85	46.2852°	200.784	202.696	290.54
18)	.9	44.2503°	215.569	217.622	300.95
19)	.95	42.2871°	230.891	233.090	312.11
20)	1.0	40.3951°	246.792	249.142	324.05
21)	1.05	38.5737°	263.310	265.818	336.80
22)	1.1	36.8222°	280.486	283.157	350.39
23)	1.15	35.1394°	298.363	301.205	364.86
24)	1.2	33.5240°	316.987	320.006	380.24
25)	1.25	31.9745°	336.403	339.607	396.57
26)	1.3	30.4894°	356.660	360.057	413.89
27)	1.35	29.0668°	377.811	381.409	432.25
28)	1.4	27.7052°	399.903	403.711	451.69



$Z = 4.2\ m$

$\Delta\phi = \pi/64 = 0.04909$ rad
(2.8125°)

RARREL

$|\eta| = 0\sim1.4$ (90°~27.7052°)

$\Delta\eta$	$\Delta\phi$	N_η	N_ϕ	N_{TOWER}
.05 x	.04909	28 x 2 x	128 =	7,168

INTERMEDIATE

$|\theta| = 27.7052°\sim15.5°$ ($|\eta| = 1.4\sim1.994$)

$\Delta\theta$	$\Delta\phi$	N_θ	N_ϕ	N_{TOWER}
1° x	.04909	12 x 2 x	128 =	3,072

FORWARD

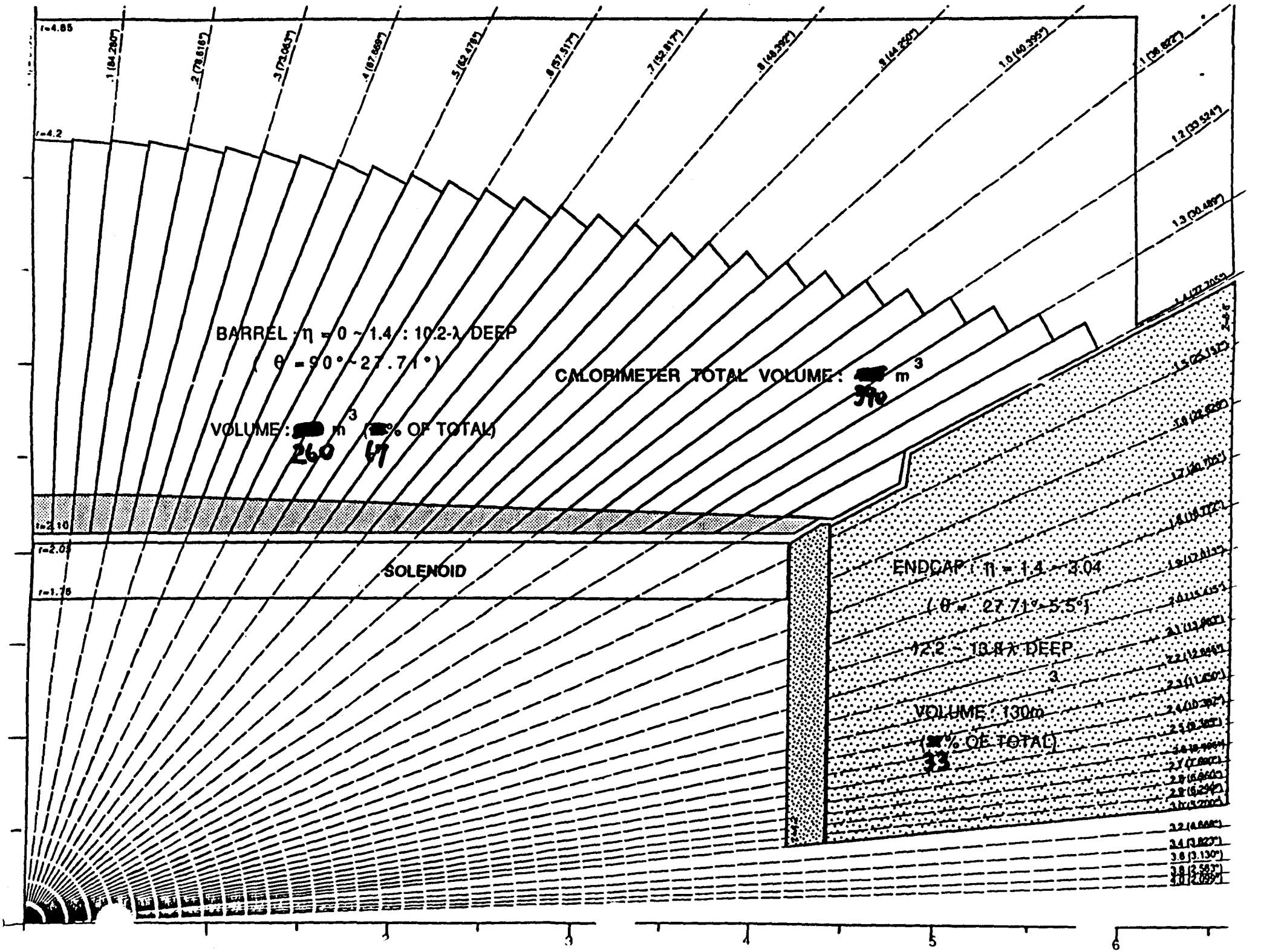
$|\theta| = 15.5°\sim7.5°$ ($|\eta| = 1.994\sim2.725$)

$\Delta\theta$	$\Delta\phi$	N_θ	N_ϕ	N_{TOWER}
1° x	.0982	8x 2 x	64 =	1,024

VERY FORWARD

$|\theta| = 7.5°\sim5.5°$ ($|\eta| = 2.724\sim3.035$)

$\Delta\theta$	$\Delta\phi$	N_θ	N_ϕ	N_{TOWER}
1° x	.1964	2x 2 x	32 =	128


r=4.85
r=4.2
r=2.10
r=2.03
r=1.75
BARREL η = 0 ~ 1.4 : 10.2-λ DEEP
(θ = 90° ~ 27.71°)
VOLUME: [redacted] m3 ([redacted]% OF TOTAL)
260 47
CALORIMETER TOTAL VOLUME: [redacted] m3
SOLENOID
ENDCAP η = 1.4 ~ 3.04
(θ = 27.71° ~ 5.5°)
12.2 ~ 13.8λ DEEP
VOLUME: 130m3
([redacted]% OF TOTAL)
33
3
4
5
6

LONGITUDINALLY SEGMENTED SCINTILLATION FIBER CALORIMETER

Sept 19, 1990

GEOMETRY

Inner radius of barrel : r=2.1 m
Endcap front face : z=4.2 m
Depth of calorimeter : 2.1 m minimum along projective line
=> 10.2 int. l.
BARREL : eta = 0 ~ 1.4 (theta = 90° ~ 27.705°)
ENDCAP : theta =27.705°~ 5.5° (eta = 1.4 ~ 3.035)

Projective towers
BARREL : d(eta) x d (phi) = 0.05 x 0.04909
($\pi/64$ = 2.8125°)
ENDCAP : d(theta) = 1°

MATERIAL

BARREL : Pb + scintillation fiber : 4 : 1 (Volume)
(If magnetic flux is returned through calorimeter
Pb + Fe + scintillation fiber : ~5 : ~ 5 : 2)
ENDCAP : Pb + Fe + scintillation fiber : ~5 : ~5 : 2

SEGMENTATION

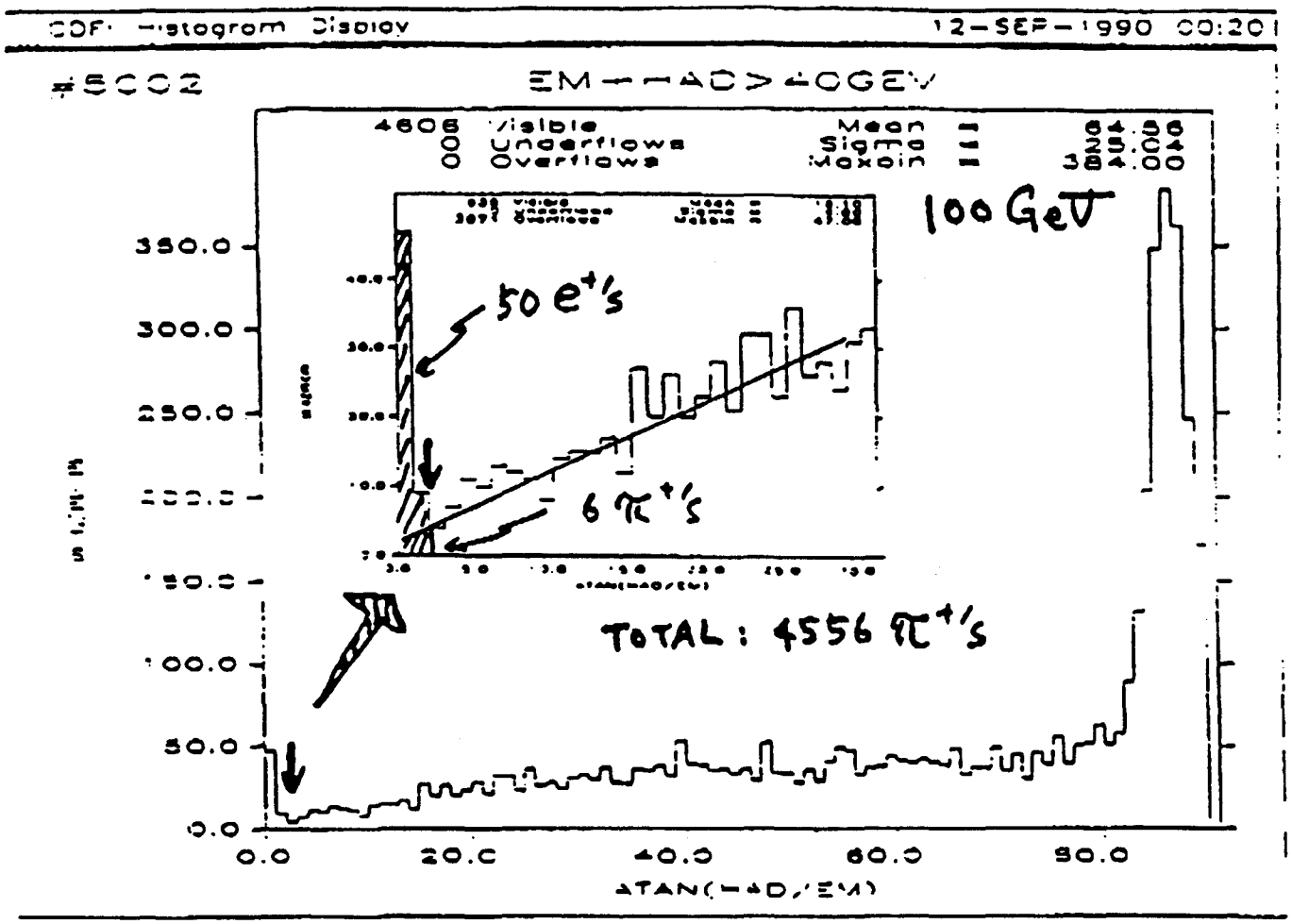
a) Pre-radiator + position measuring layer
~ 3 rad. l. , ~ 2cm deep.
(1.4 rad. l. of the solenoid coil material is counted within this thickness. Therefore as the material thickness of the coil increases with the polar angle, the added material thickness has to be adjusted accordingly.

b) Main electromagnetic segment
Pb : fiber = 4 :1
density = 9.3 g/cm**3
rad. l. =7 mm
nuclear int. l. = 20.3 cm
toatal depth = 22 rad. l. = 15.4 cm

*Toatl depth of electromagnetic section
solenoid coil + pre-radiator + main e.m. = 25 rad. l.

19/21

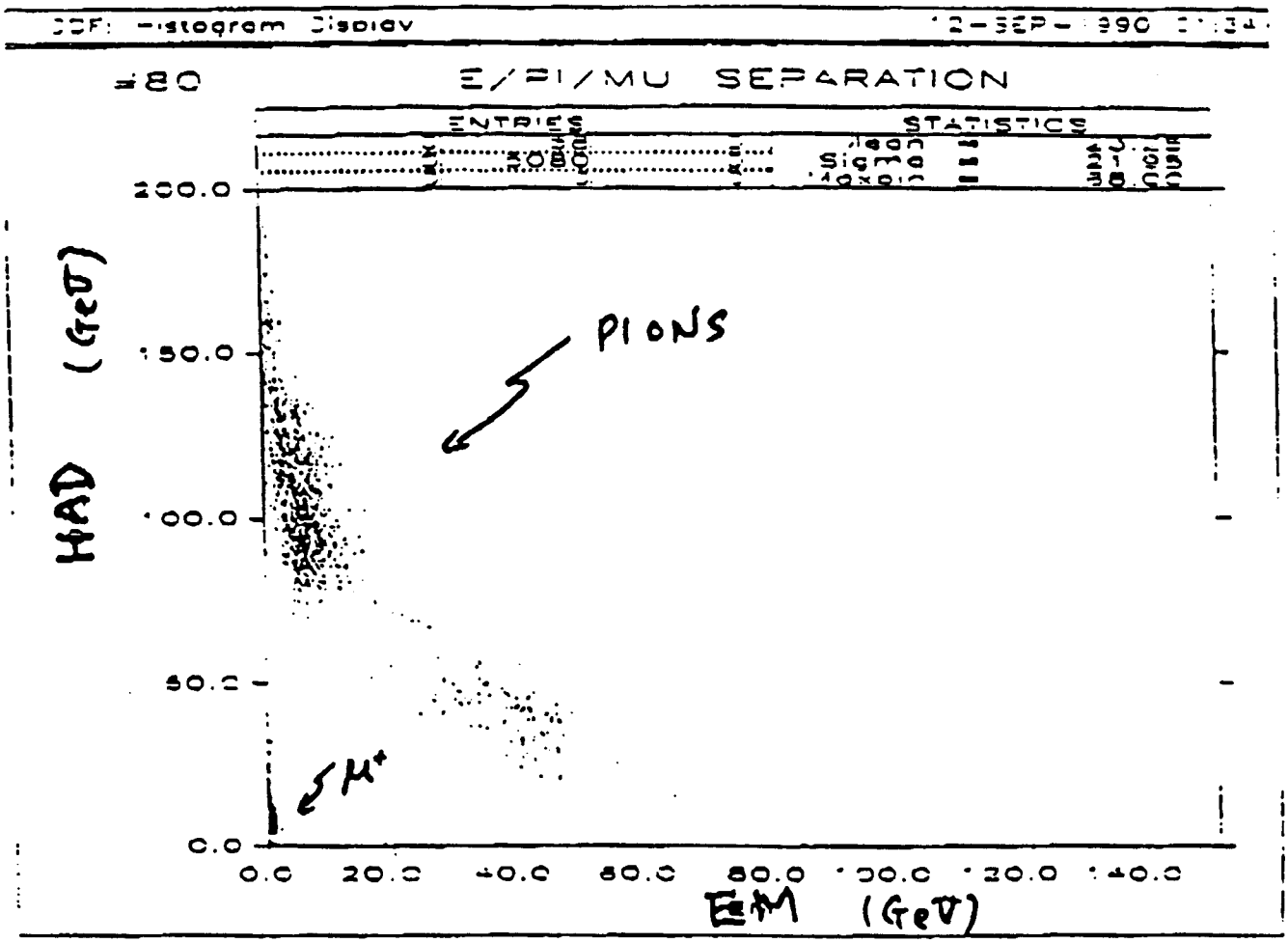
e/π SEPARATION



p (GeV/c)	e+ Efficiency	π+ Rejection
25	97%	≈1/100
50	97%	≈1/620
→ 100	97%	≈1/760
150	97%	≈1/1000

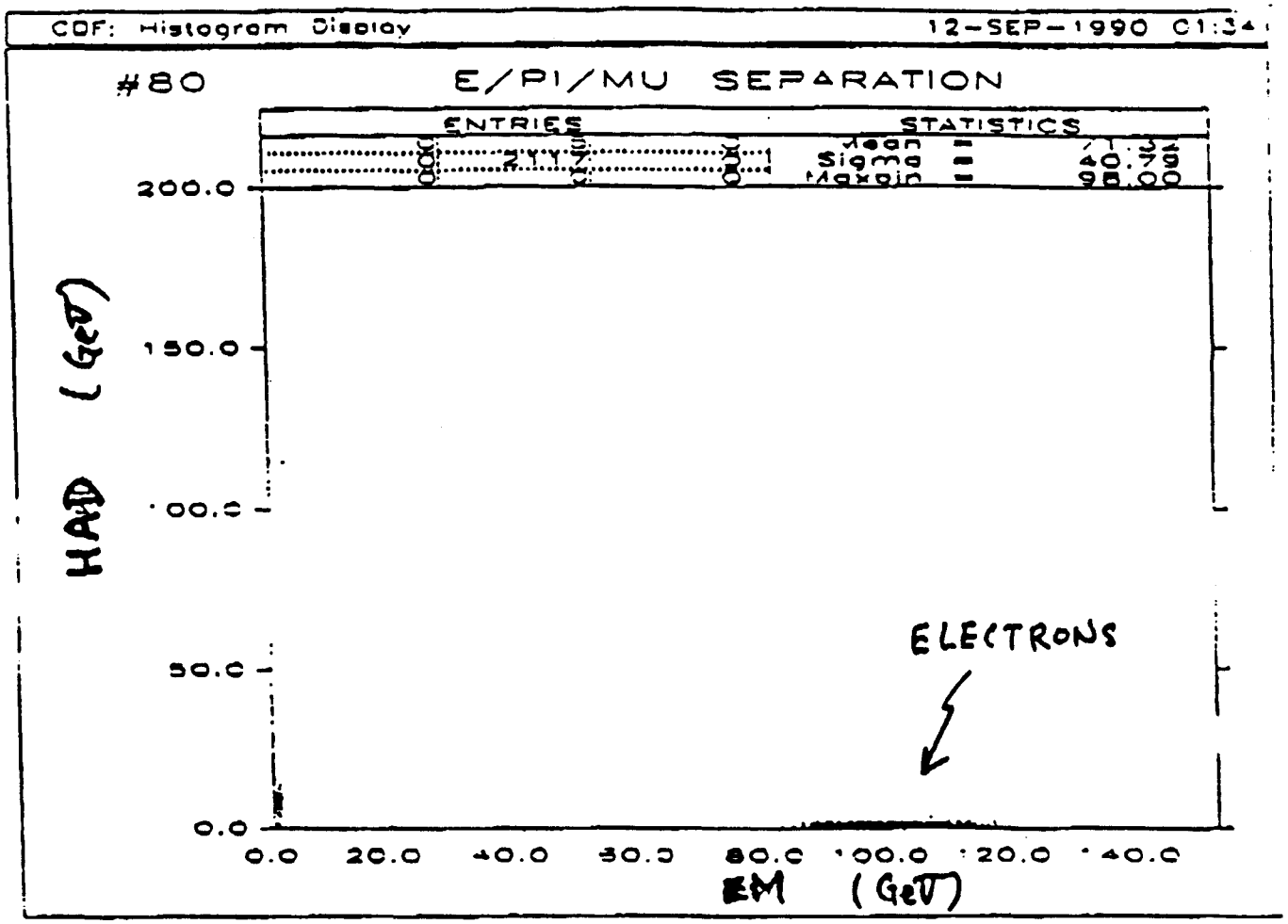
8/21

100 GeV PIONS

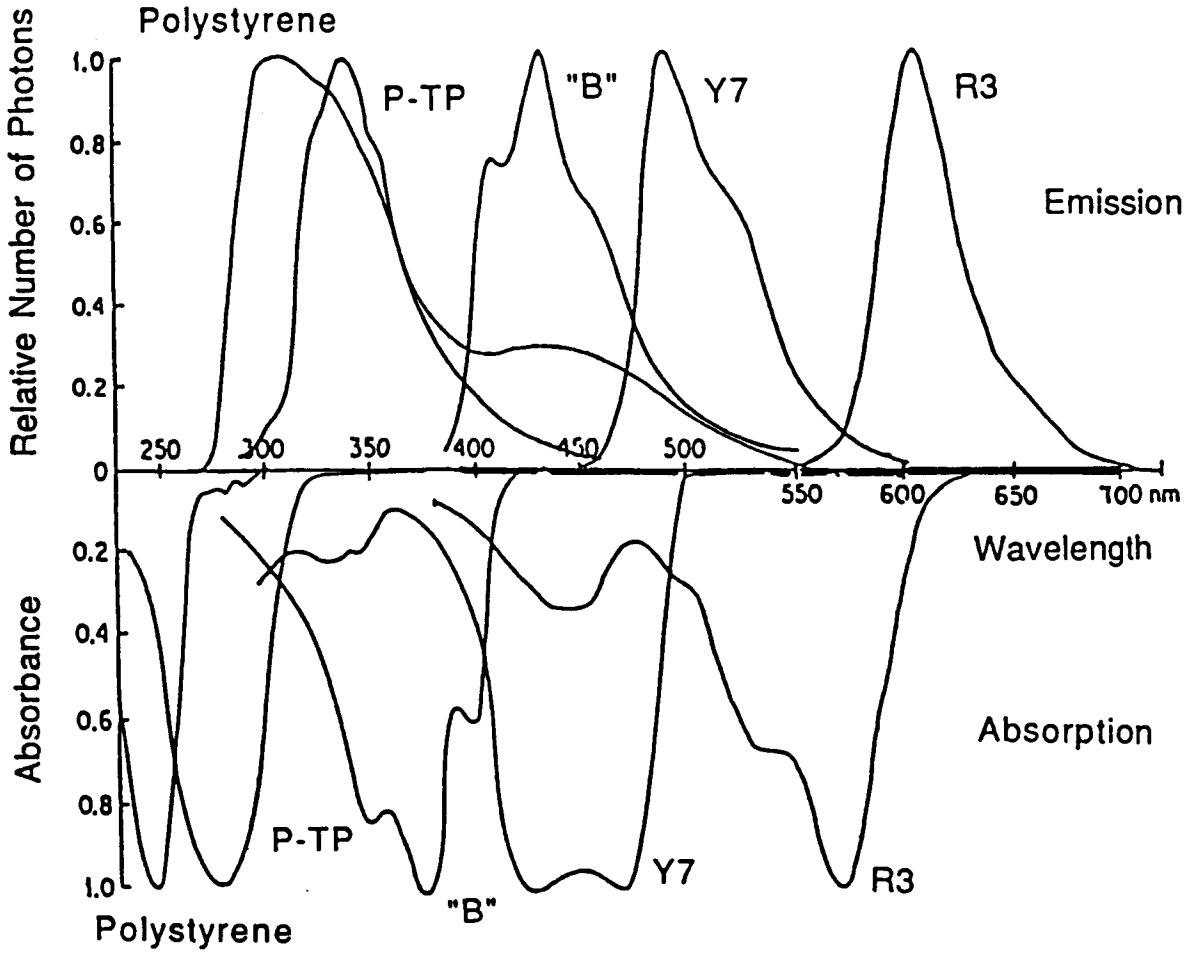


7/21

100 GeV ELECTRONS



ABSORPTION AND EMISSION SPECTRA



KURARAY

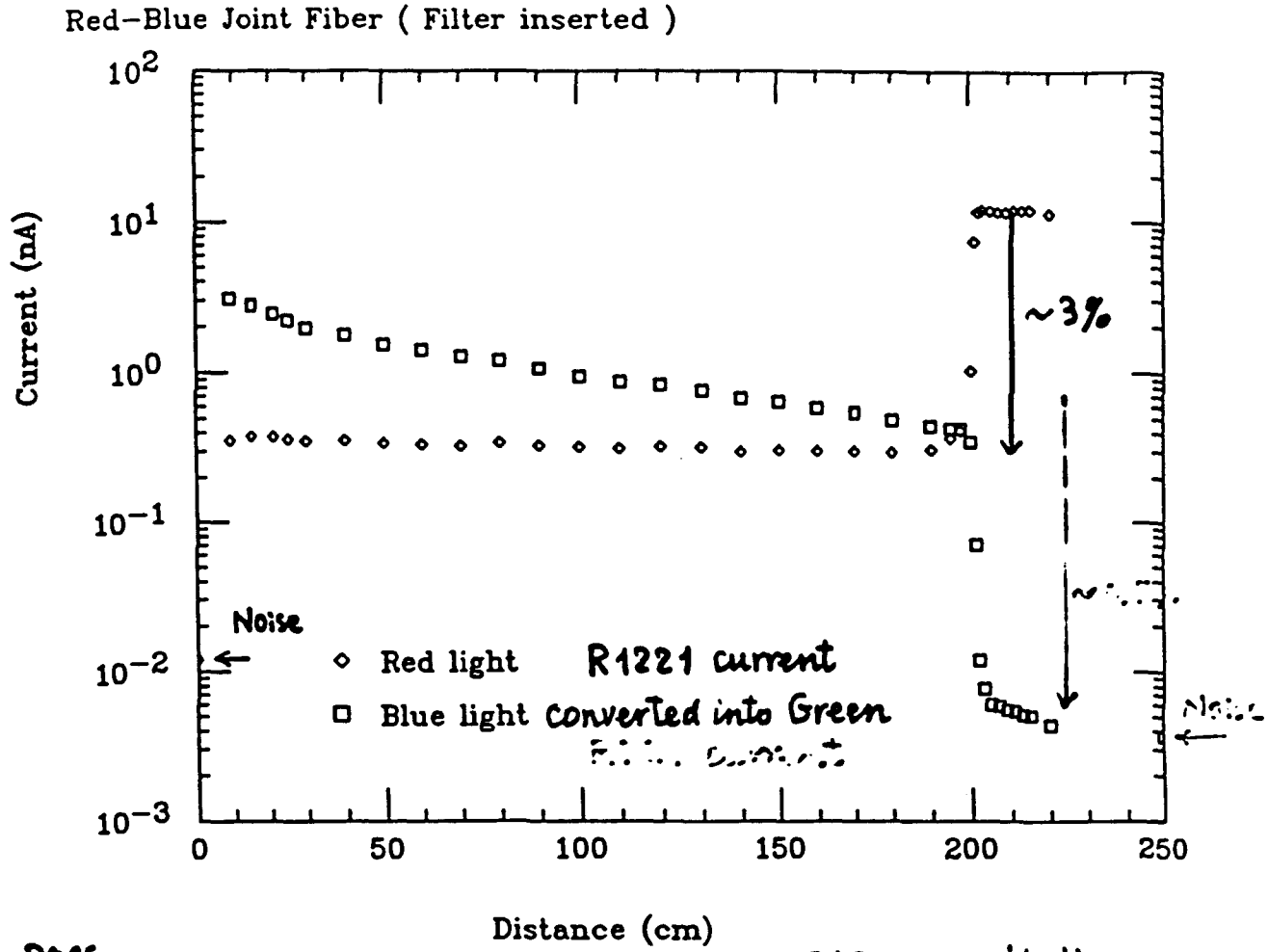
Figure 1

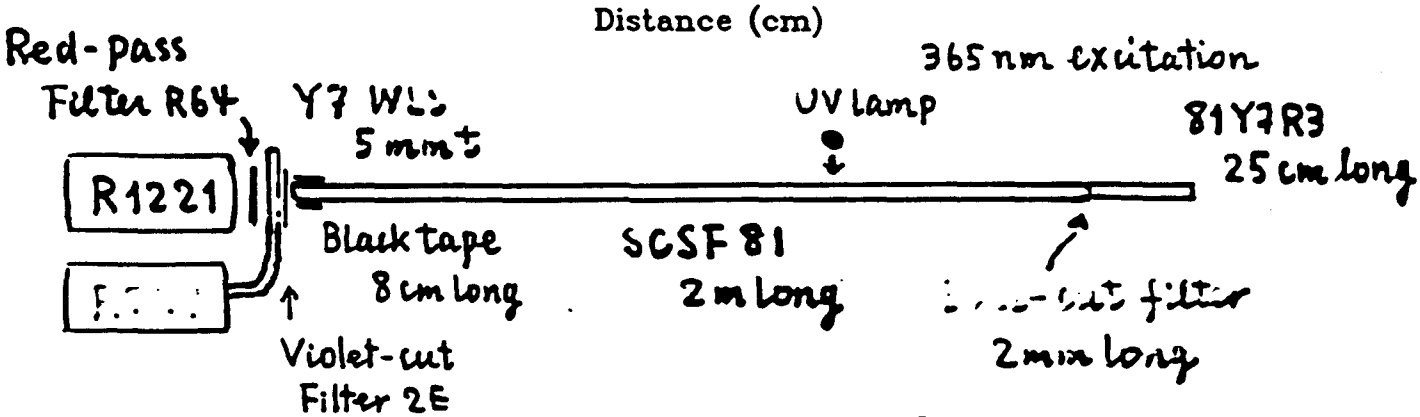
SCSN81 = PS + p-TP + "B" Red sinti. R3 = SCSN81 + Y7 + R3

- R3 emission spectrum is completely separated from SCSN81 and Y7 absorption spectra.
- Overlap of Y7 green light and R3 red light is small.

COLOR MIXING ?

IT IS A SMALL EFFECT AND CAN BE CORRECTED



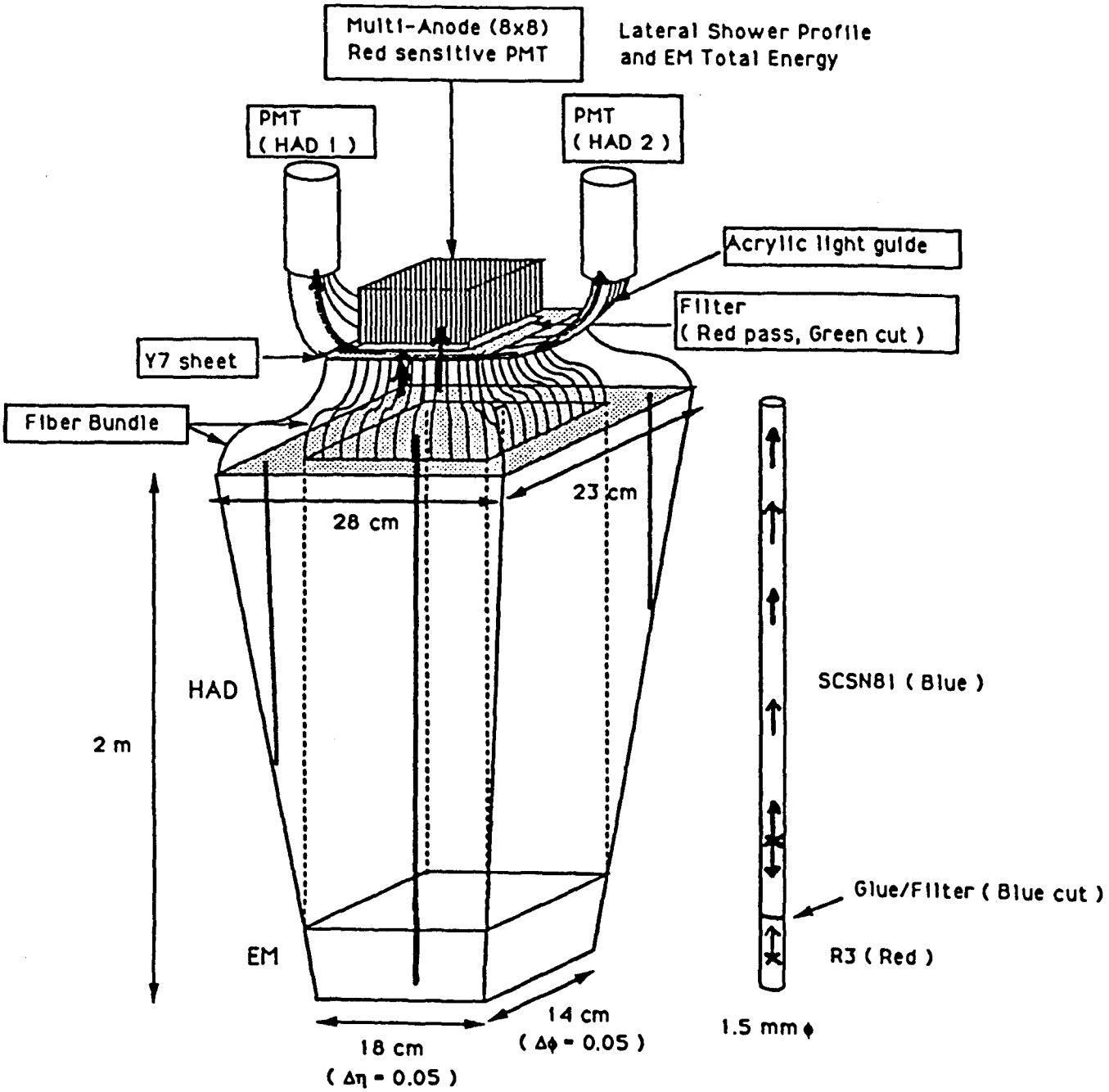


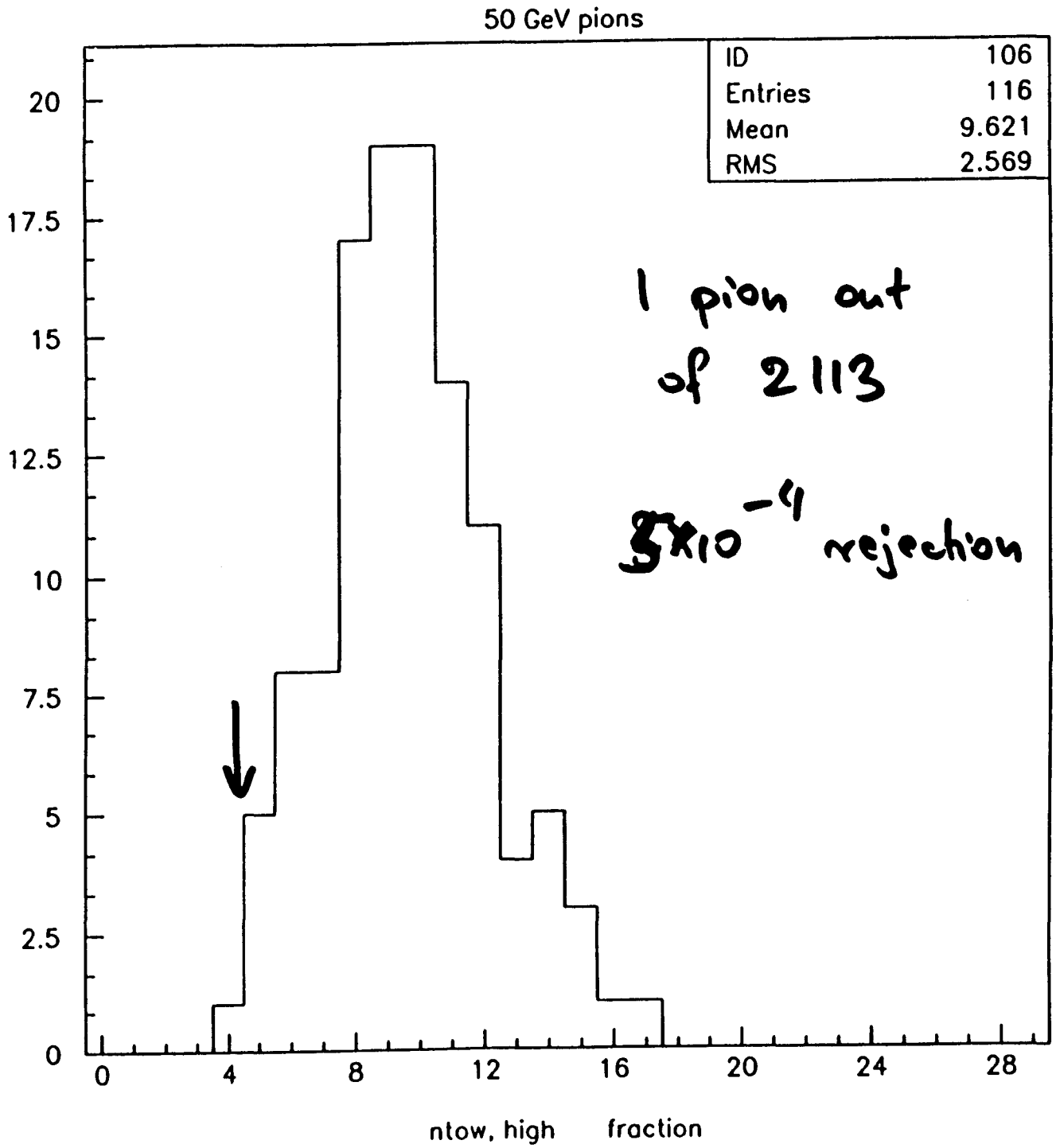
$$R = C_R \left[\int_{R3} E\,dx + (\sim 3\%) \int_{81} E\,dx \right]$$

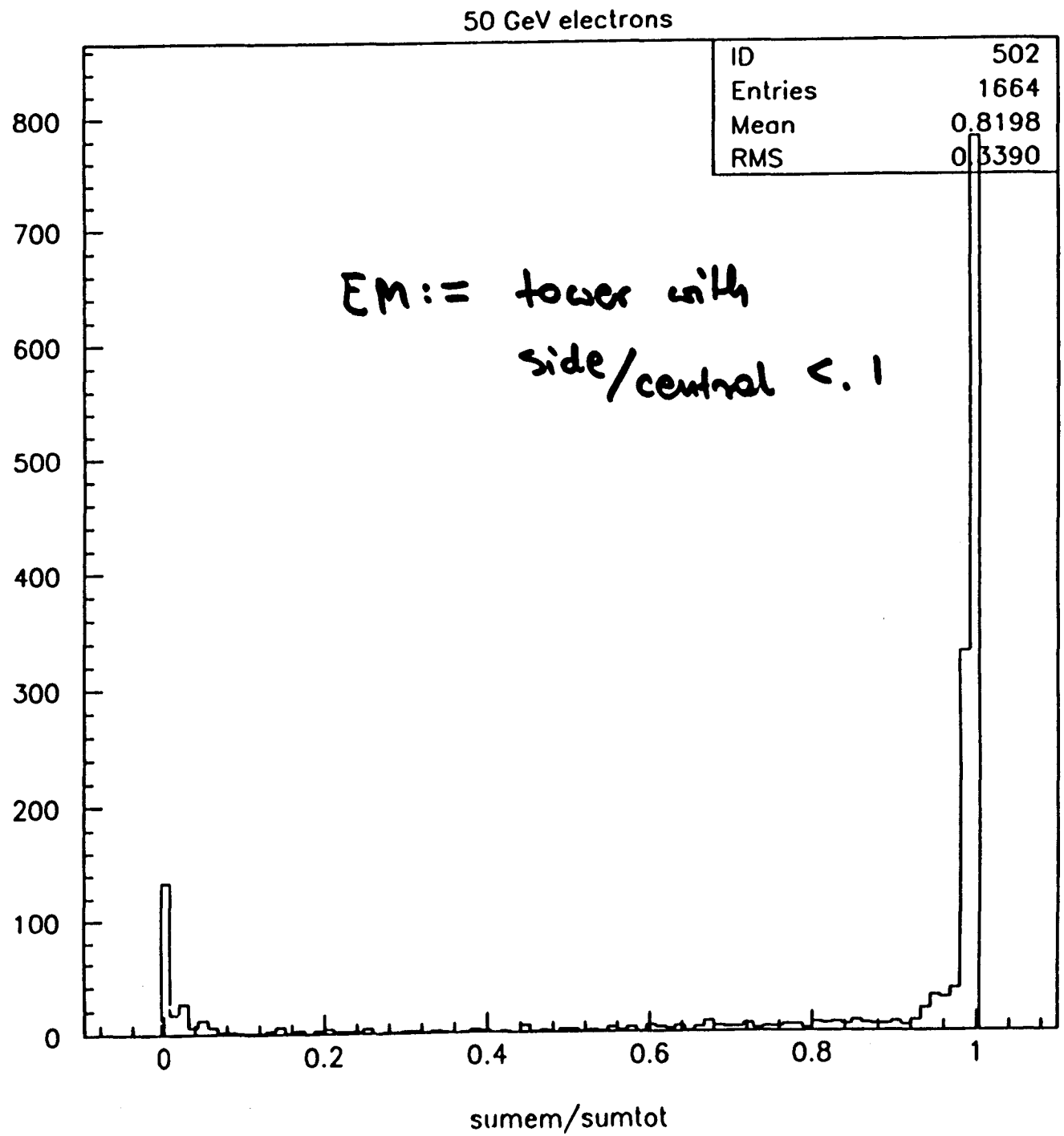
$$G = C_G \left[\int_{81} E\,dx + (\sim 0.5\%) \int_{R3} E\,dx \right]$$

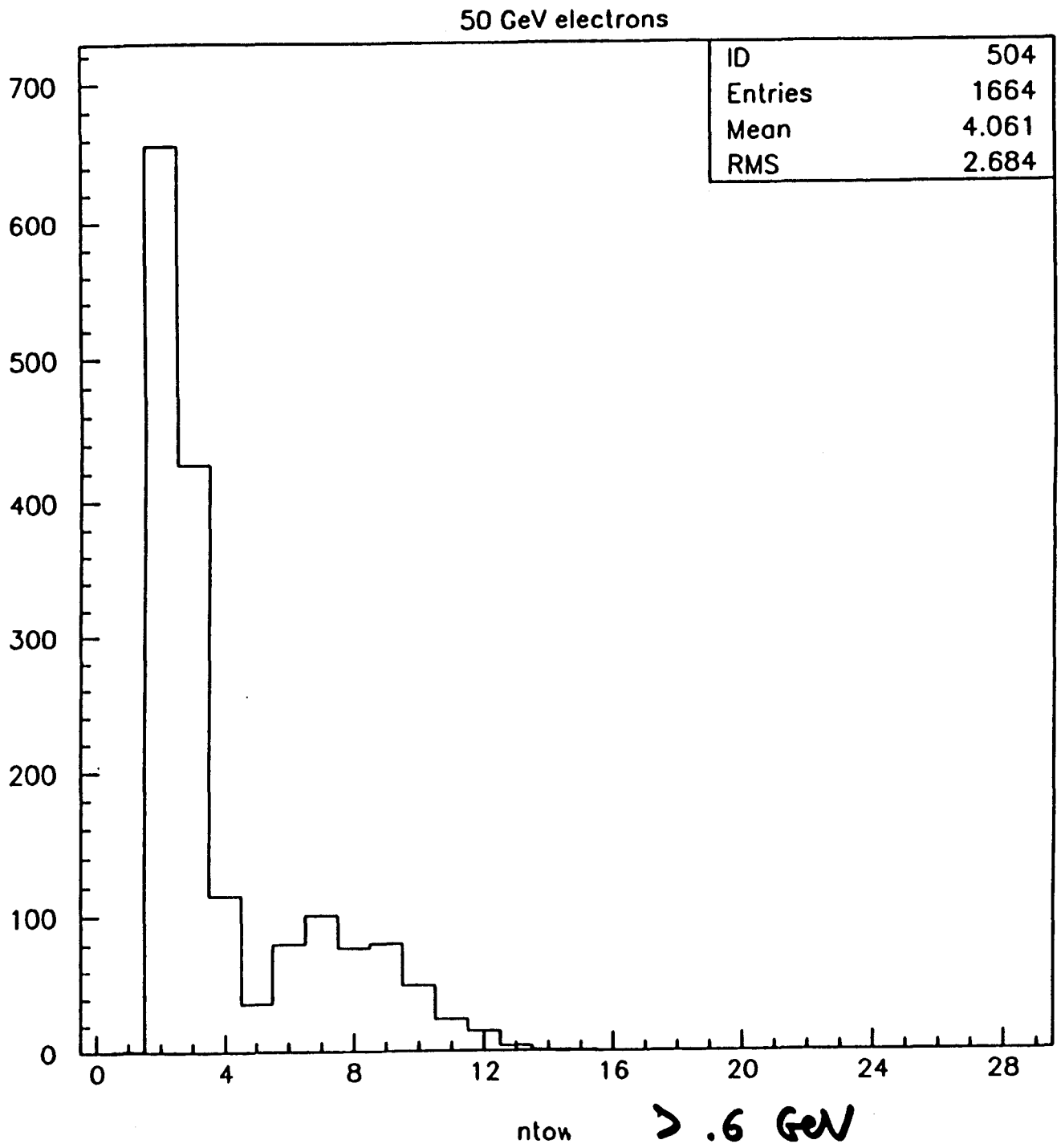
$$\Rightarrow \quad EM \equiv \int_{R3} E\,dx = \frac{R}{C_R} - (\sim 3\%)\frac{G}{C_G}$$

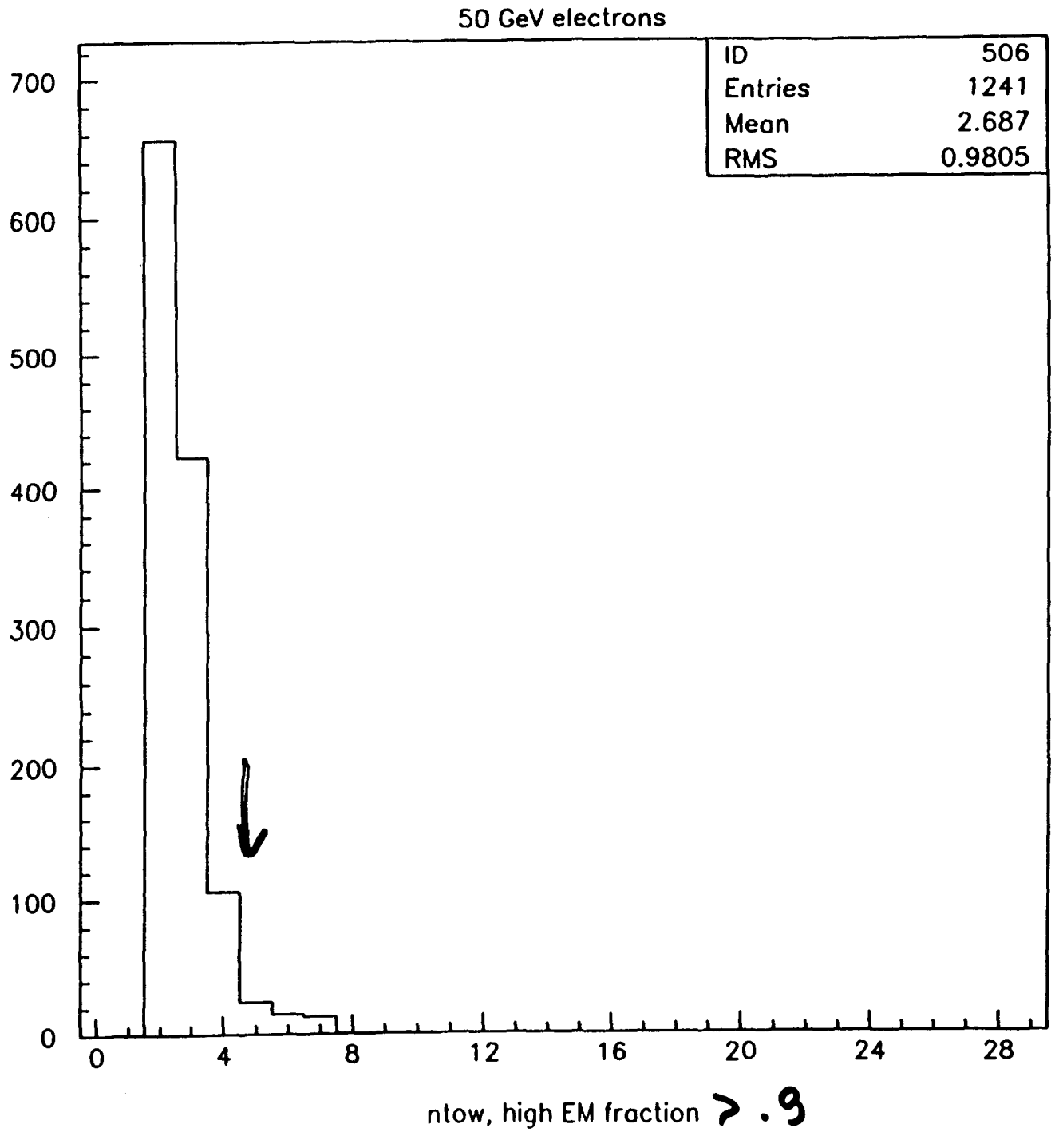
SCHEMATIC DIAGRAM OF THE RGB CALORIMETER

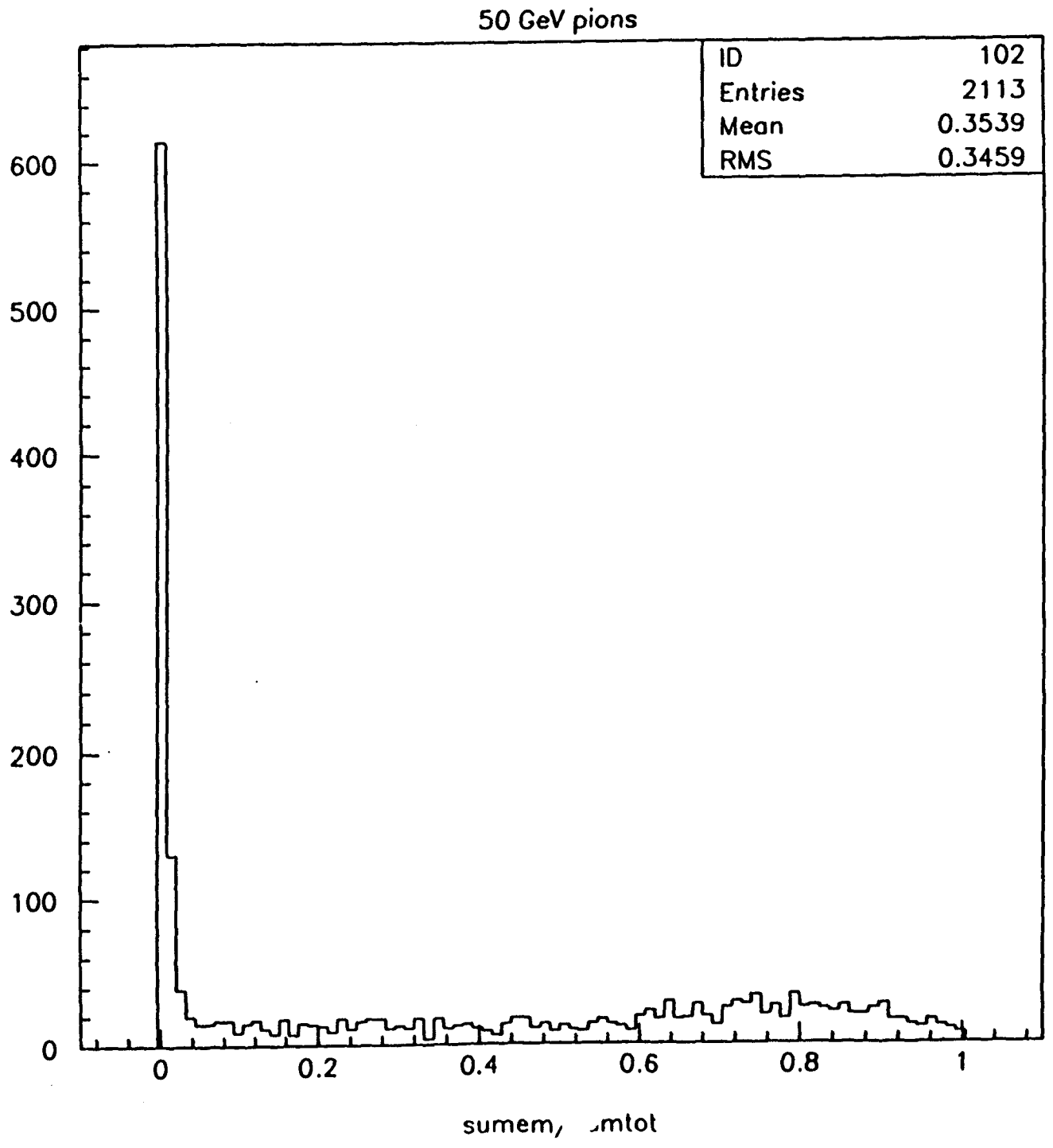


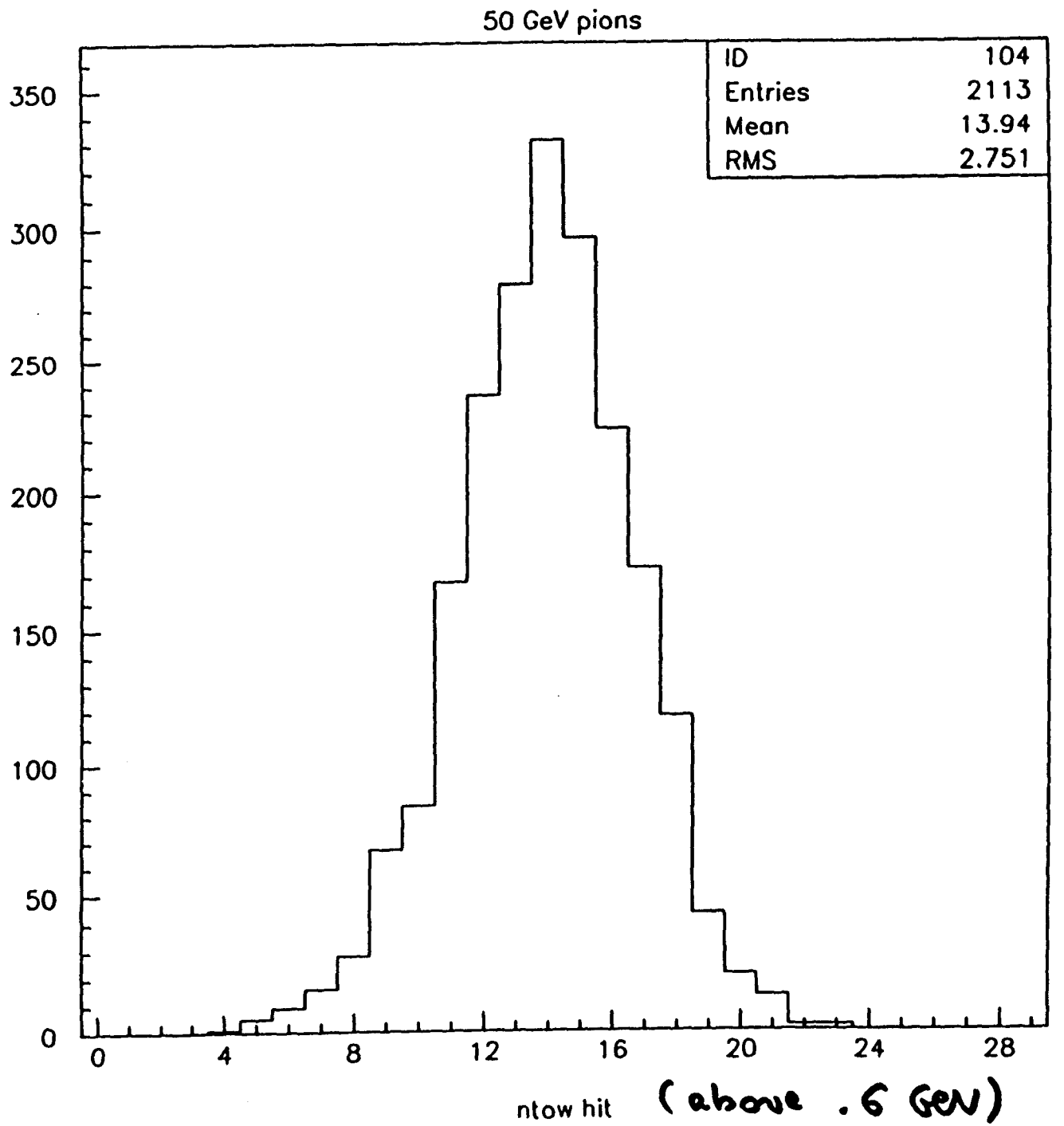

50 GeV pions
ID 106
Entries 116
Mean 9.621
RMS 2.569
1 pion out of 2113
5x10^-4 rejection
20
17.5
15
12.5
10
7.5
5
2.5
0
0
4
8
12
16
20
24
28
ntow, high fraction

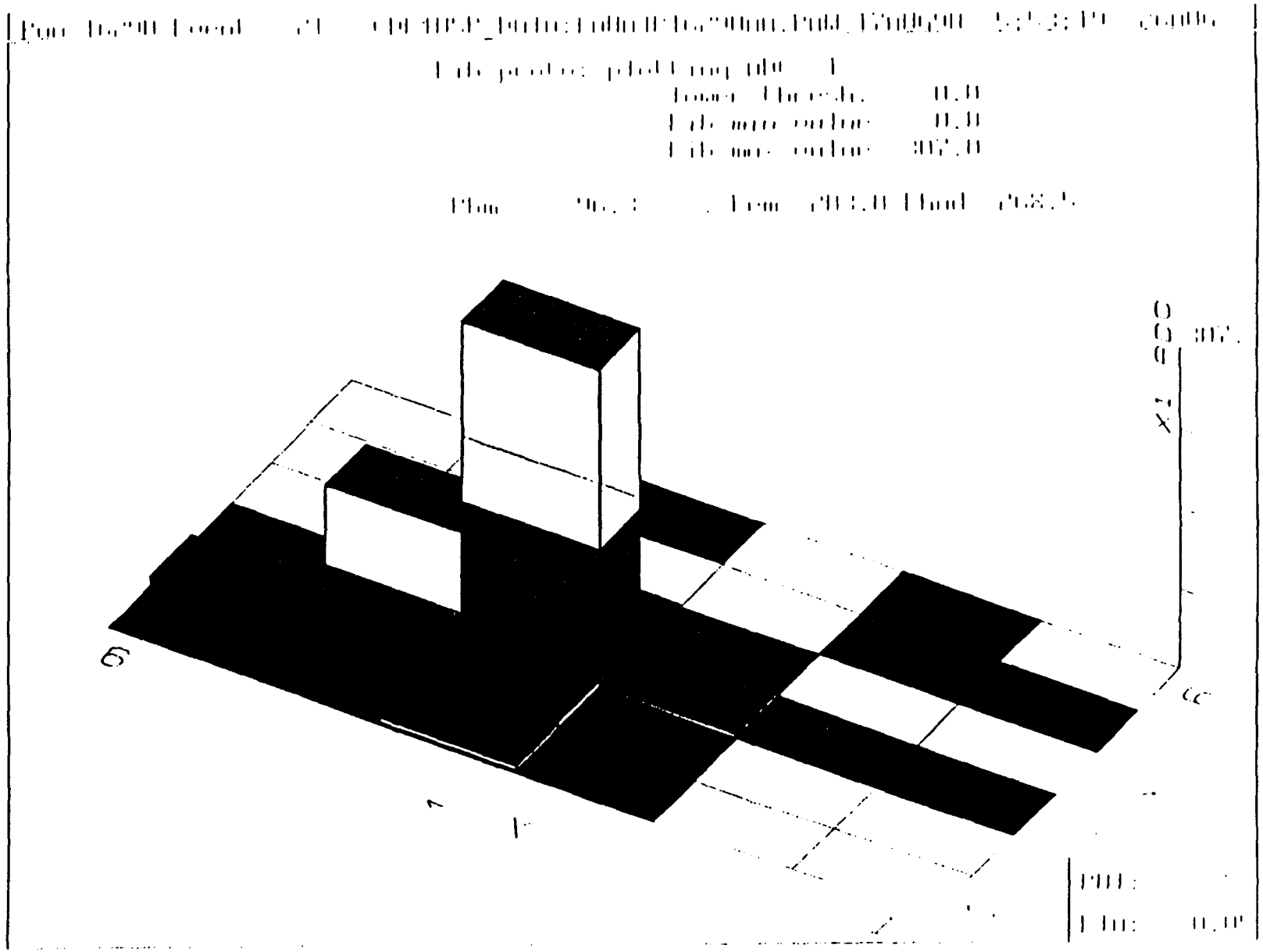

50 GeV electrons
ID 502
Entries 1664
Mean 0.8198
RMS 0.3390
EM := tower with
side/central < .1
800
700
600
500
400
300
200
100
0
0
0.2
0.4
0.6
0.8
1
sumem/sumtot

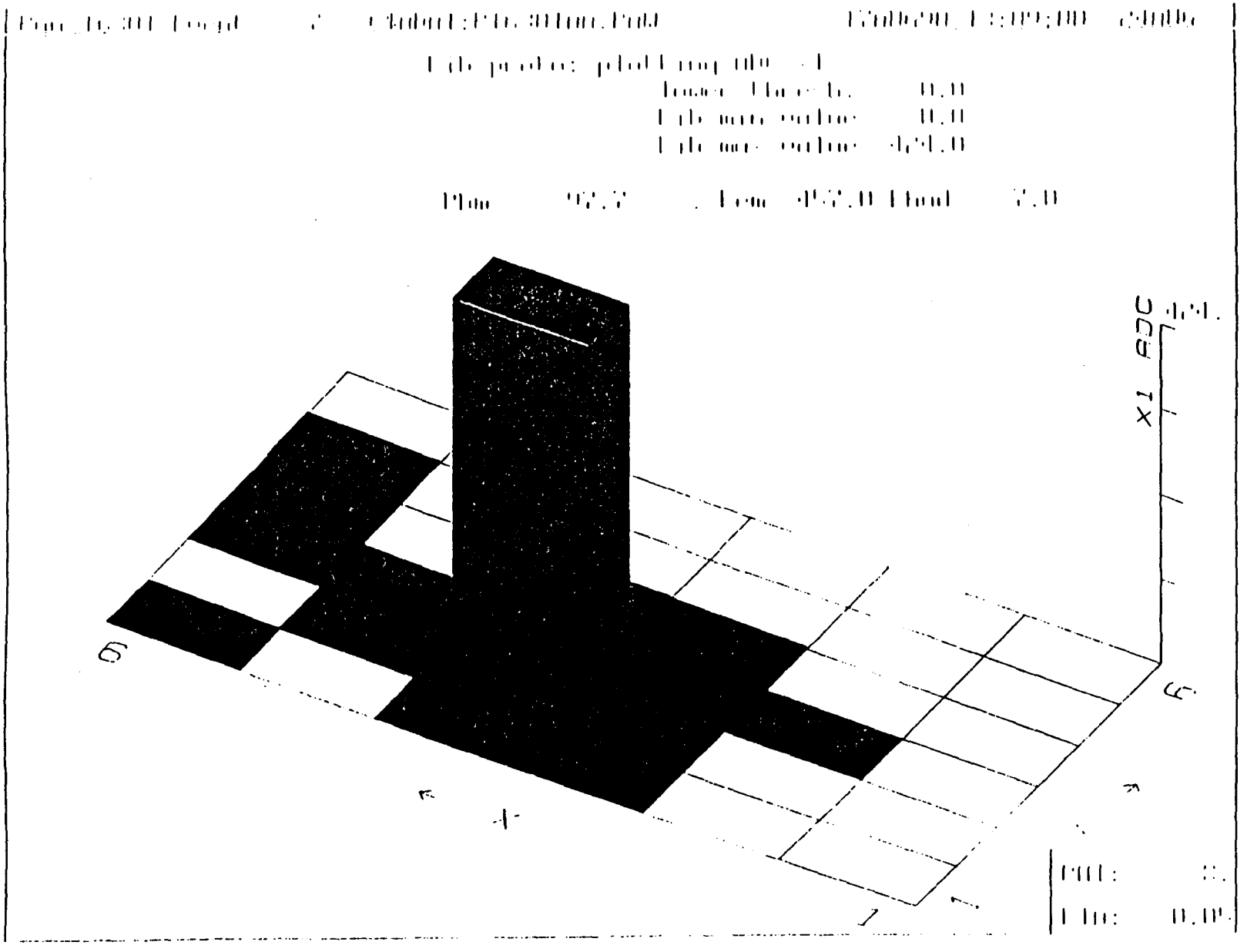

50 GeV electrons
ID 504
Entries 1664
Mean 4.061
RMS 2.684
700
600
500
400
300
200
100
0
0
4
8
12
16
20
24
28
ntow
> .6 GeV

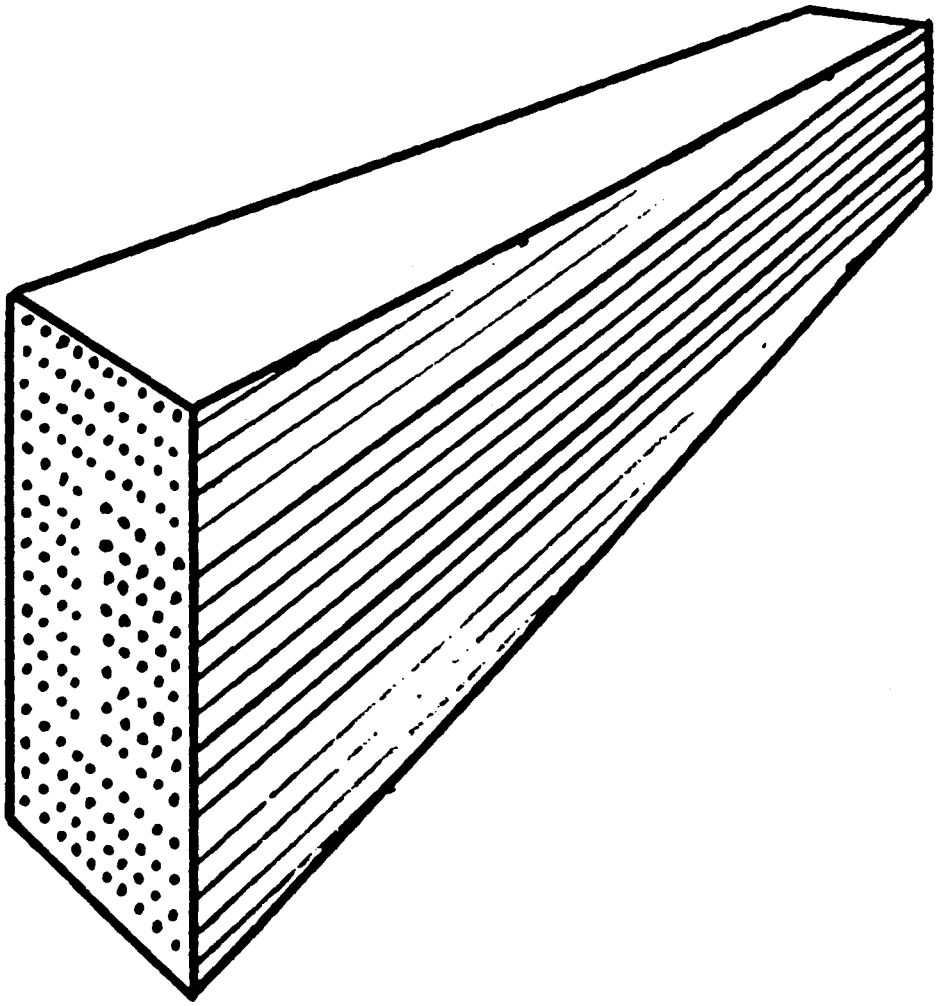

50 GeV electrons
ID 506
Entries 1241
Mean 2.687
RMS 0.9805
700
600
500
400
300
200
100
0
0
4
8
12
16
20
24
28
ntow, high EM fraction > .9


50 GeV pions
ID 102
Entries 2113
Mean 0.3539
RMS 0.3459
600
500
400
300
200
100
0
0
0.2
0.4
0.6
0.8
1
sumem/ ,mtot


50 GeV pions
ID 104
Entries 2113
Mean 13.94
RMS 2.751
350
300
250
200
150
100
50
0
0
4
8
12
16
20
24
28
ntow hit
(above .6 GeV)




X1 ADC
6
6
1
1



RADIATION DAMAGE TEST

USING REALISTIC E.M. MODULE

2.5 GeV Injector Liniac at KEK TRISTAN & PHOTON FACTORY

PLANS

* Total dose = 10 M rad
* Over 6 months
* 5 different fibers
  - Blue fiber
  - Green fiber
  - Orange fiber
  - Blue with fluorinated polymer cladding
  - Green with fluorinated polymer cladding

* Jan ~ July, 1991

MAJAOR EFFORT

* Optimal module design

  ==> Best possible performance
  Practicality
  material
  Labor
  Cost

* Support structure

* Better understanding of performance
  Basic characteristics
  Overall performance
  ===> Monte Carlo
  Beam test

ISSUES

* Fiber quality control

* Splicing

* Radiation damage

* Module assembly

* Structure

PROTOTYPING - BEAM TEST

A) SINGLE COMPARTMENT DESIGN (A. Par. et al.)

6 X 5 TOWERS

* Front face : 6 cm x 6 cm (0.03 rad X 0.03rad at r=2 m)
  Rear face: 12 cm x 12 cm
* 2 m long (10 int. l.)
* Pb : Fe : Fiber = 40% : 45 % : 15 %)
* Total weight = 5 tons
* 2 PM / tower (central~ "e.m." + side ~"had")
* 2700 fibers / tower x 30 towers = 81,000 fibers

B) RGB DESIGN

1 TOWRE

* Front face: 18 cm x 14 cm (0.05 rad x 0.039 at r= 3.6 m)
  Rear face: 28 cm x 23 cm
* 2 m long (10 int. l.)
* Pb : Fiber = 4 : 1
* 0.7 tons
* 3 PM / tower (2 Green = "had + 1 Red = " e.m. ")

EXPERIENCE

A) Assembly procedures

* **Grooved Pb plate fabrication**
* **Assembly procedure**
* **Handling of large number of fibers**

B) Splicing of large number of fibers

C) e/π separation (Preliminary)

* **Longitudinal segmentation : 1 E.M. + 1 HAD**
  ==> 1/ 760 @ 100 GeV (e eff = 97%)
  1/1000 200 GeV " " " "
* **Lateral shower spread**
  ==> 1/2,000 @ 50 GeV (e eff > 95%)

LONGITUDINALLY SEGMENTED SCINTILLATION FIBER CALORIMETER

FEATURES

Longitudinal segmentation : E.M. + HAD

Clean e/π separation
Trigger signals at earliest level
Software
Independent optimization

E.M. : 4 % in volume
* Good energy resolution
* Good hermeticity (0.9 int.l.)
* Possible smaller lateral segmentation
* Possible faster timing
* Needs to avoid channeling

===> Better homogeneity
1mm fiber
Pb + fiber
>6° tilt
Possible special method of fabrication

HAD : 96 % in volume
* Coarser energy resolution
* Behind 0.9 int. l.
* Good economy
* Compensation by neutrons
* No channeling
* Long module

===> Coarser homogeneity
2 mm fiber
Pb only or Pb + Fe
No tilt
Better attenuation length
Simpler/economical assembly procedures

Independent minimum ionizing signals for μ identification
Possible weighting of E.M. and HAD signals
==> Better energy resolution for jets
Better e/h
Better attenuation length

LONGITUDINALLY SEGMENTED SCINTILLATIN FIBER CALORIMETER

R & D

SDC

FERMILAB	: A. Para, M. Mishina D. Goloskie, N. Bosek (Engineer)
Michigan	: C. Bromberg, J. Huston, R. Miller
UCSD	: M. Sivertz
Texas A & M	: T. Kamon
Tsukuba	: K. Takikawa, S. Kim, K. Yasuoka, H. Funayama

OUTSIDE

Boston	: W. Worstell, R. Carey, L. Roberts

INDUSTRY

Martin Marietta	: G. Guetenberg, J. Pohlen, ???

Regular Meeting at Fermilab
on
Every Other Monday

Physics Tags

Isolated $e^{\pm}$ Vs. $\pi^{\pm}$ $\quad H \to Z Z^*$

Preshower	$R_\pi \times 4$	test beam
	$R_\pi \times 15$	simple M.C.
Shower max	?	

Isolated γ Vs. π^0 $\quad WH \to \mu\nu\,\gamma\gamma$

Preshower	$E_\gamma < 75$ GeV	Barrel
	$E_\gamma < 100$ GeV	Ends
Shower max	$E_\gamma < 20$ GeV	useless

Isolated $\pi^{\pm}$ Vs. $\pi^{\pm}\pi^0$ $\quad \tau^+ \to \pi^+ \nu$

Preshower	Any $M(\pi^+\pi^0)$	Consistent with $E = P$
Shower max	$M(\pi^+\pi^0) \gtrsim 0.5$ GeV	

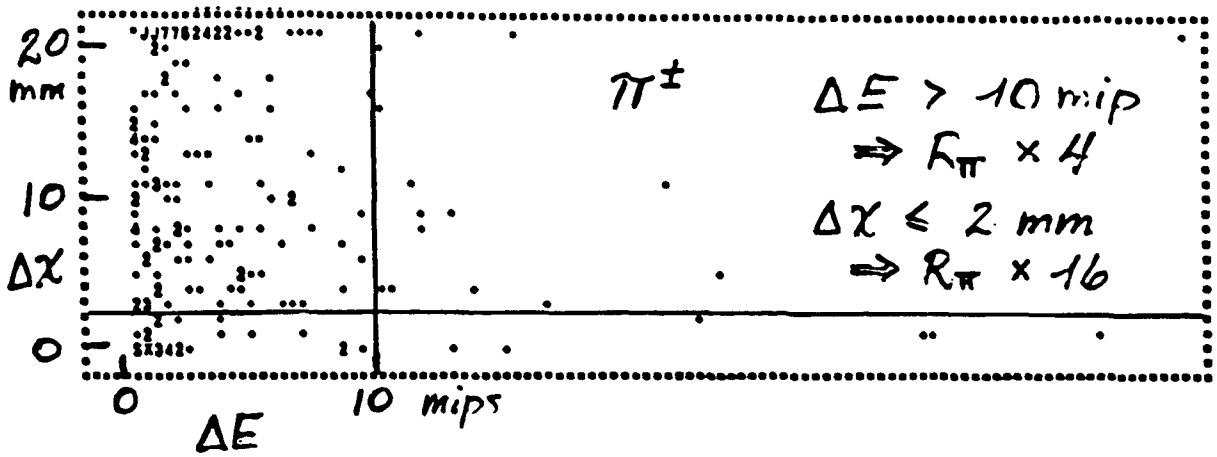
Preshower better for in-situ hadron calib ?

Non-isolated $e^{\pm}$ $\quad t \to b \to c\,e\,\nu$

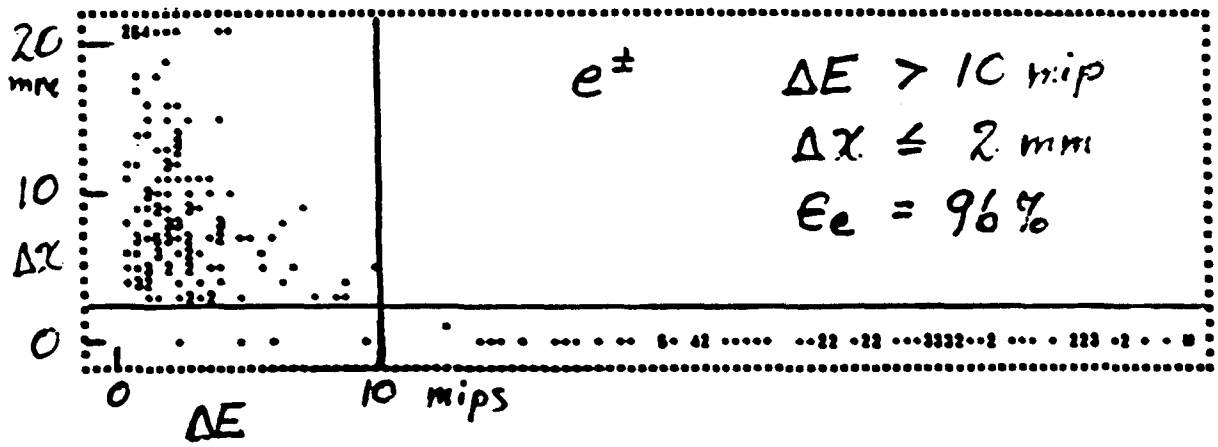
Fragmentation functions

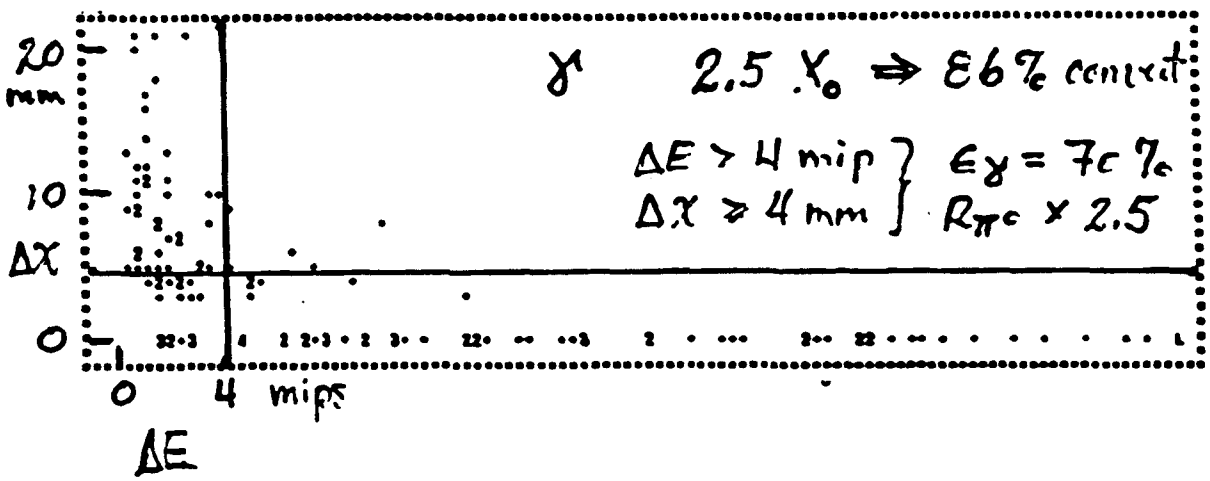
Preshower	$\epsilon_e = 50\%$	$R_\pi \times 50$	With min. ion.
	$\epsilon_e = 70\%$	$R_\pi \times 7$	No min. ion. signal
Shower max	$\epsilon_e = 75\%$	$R_\pi \times 11$	O.K.

Preshower Clusters : Δx Vs. ΔE



Test beam





READOUT OPTIONS.

wire chamber / strip chamber option.

1cm. strips 1m. long readout at both ends.

20,000 channels at $125 ea = $2.5M.

occupancy 5×10^3 cm^{-2} s^{-1}.

Rate in 1m × 1cm strip 0.5MHz.

2.5 mm gap ⇒ 50 nsec charge collection time.

⇒ 2.5% occupancy.

not including shower spreading & albedo.

factor of 3 or more.

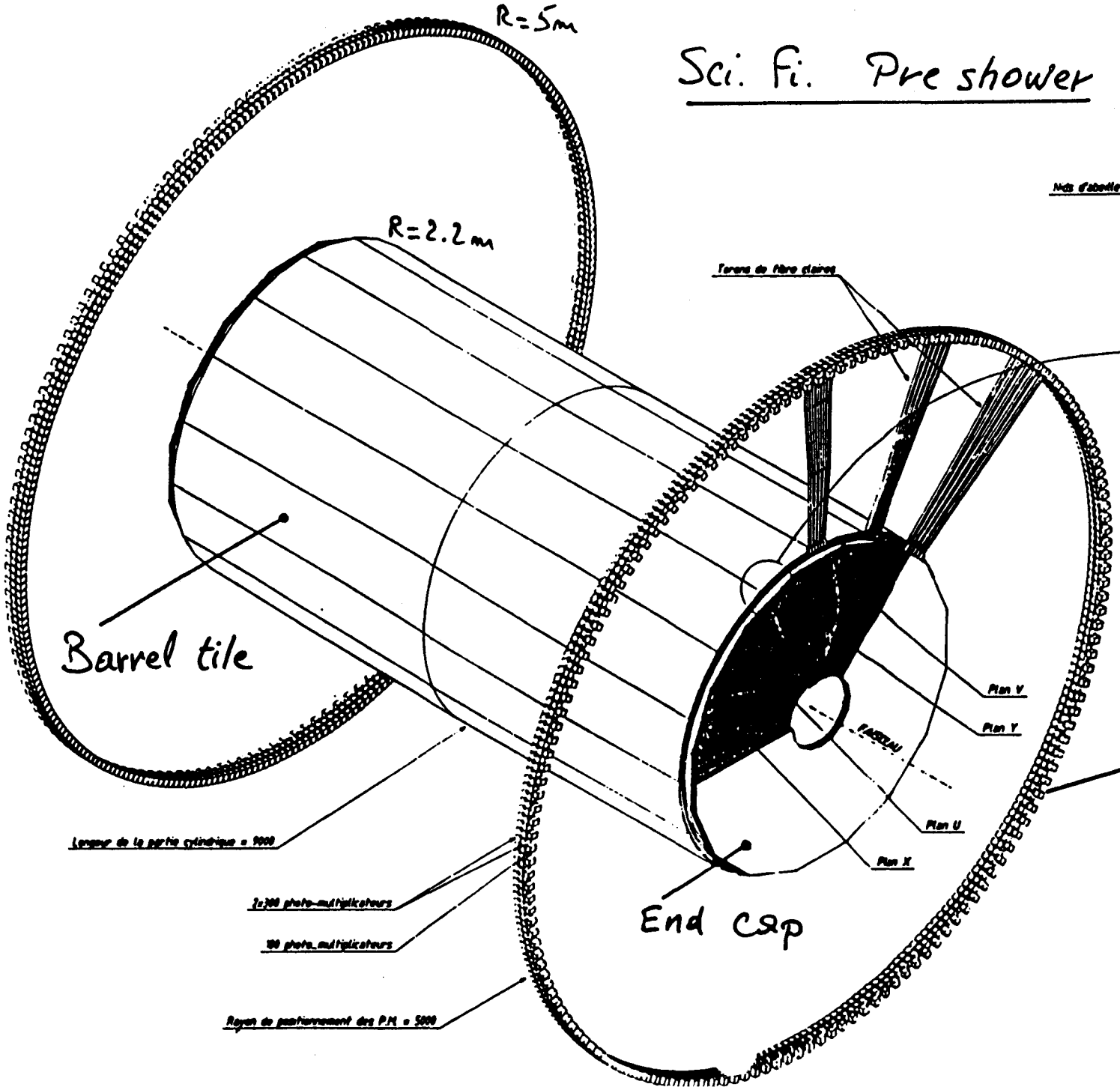
Readout options for fine granularity

Detector option currently considered; FIBER / TILE.

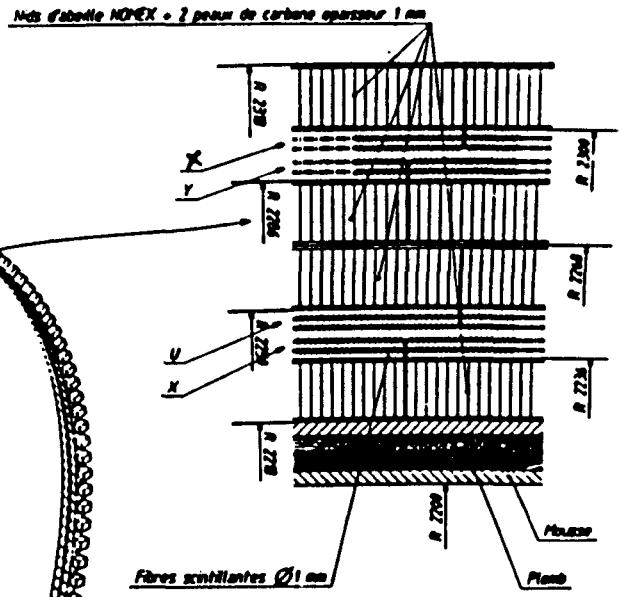
READOUT SCHEMES UNDER STUDY

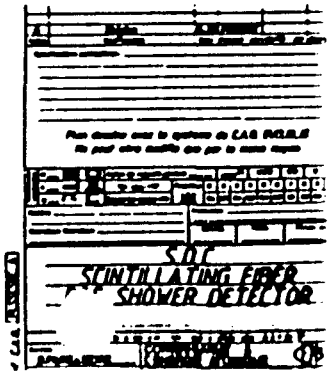
		Advantages	Disadvantages.
MAPMT.	- cross grid anode. 29×8 = 232 fibers 29+8 = 37 r.o. channels.	Focusts	B-field sensitive Ghosts in x-y Cross-Talk. Low gain.
APD -	Simple economic readout ~$20 per channel. - 8 bit resolution.	Known Technology. not effected by B fields. unambiguous readout.	8-bit resolution Power consumption Not min-I sensi
Hybrid Pixel image tube.	- LBL pixel detector with SMART RO. INSIDE an image-tube.	High fiber # per tube.	Novel technolo occupancy limited.

Sci. Fi. Pre shower



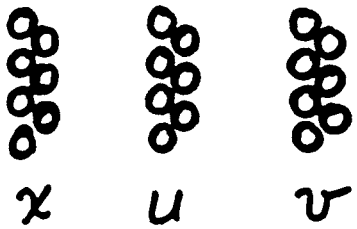
Detail fibres ech. 2





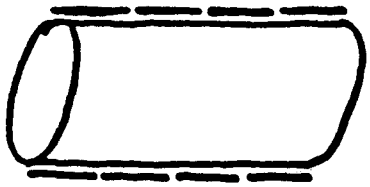
Preshower / Shower Max

Preshower



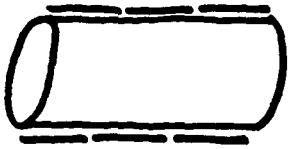
1.5 mm fibers
1.0 mm step
Stereo ± 30° ?

$\eta = 0$ 1.3 X_0 Al + 1.2 X_0 Pb
$\eta = 1.6$ 2.5 X_0 Al / 2.5 X_0 Pb in Ends



R = 2.2 m 4 × 2.25 m

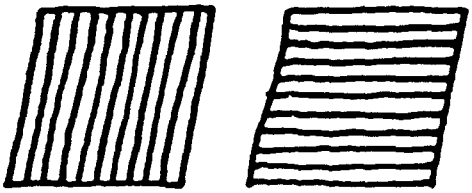
Barrel: 150 k channels
Ends: 43 k channels



R = 1.7 m 3 × 2.33 m

Barrel: 90 k channels
Ends: 33 k channels

Shower Max



2 × 10 channels / tower

Barrel: 154 k channel
Ends: 60 k channel

Descope: channels × $\frac{1}{2}$

Preshower / Shower max

Rockefeller: Giokaris, Goulianos, Mélèse, Rusack, White

Saclay: Bonamy, Ehnwein, Le Dû, Hubbard, Pansart

Design	Ehnwein
Read-out	Rusack, Pansart
Trigger	Le Dû
Beam Tests	Rusack
Physics Evaluation	Pansart, Hubbard
Simulation	Bonamy
Radiation Hardness	Ehnwein

Subsystem Collaborators:

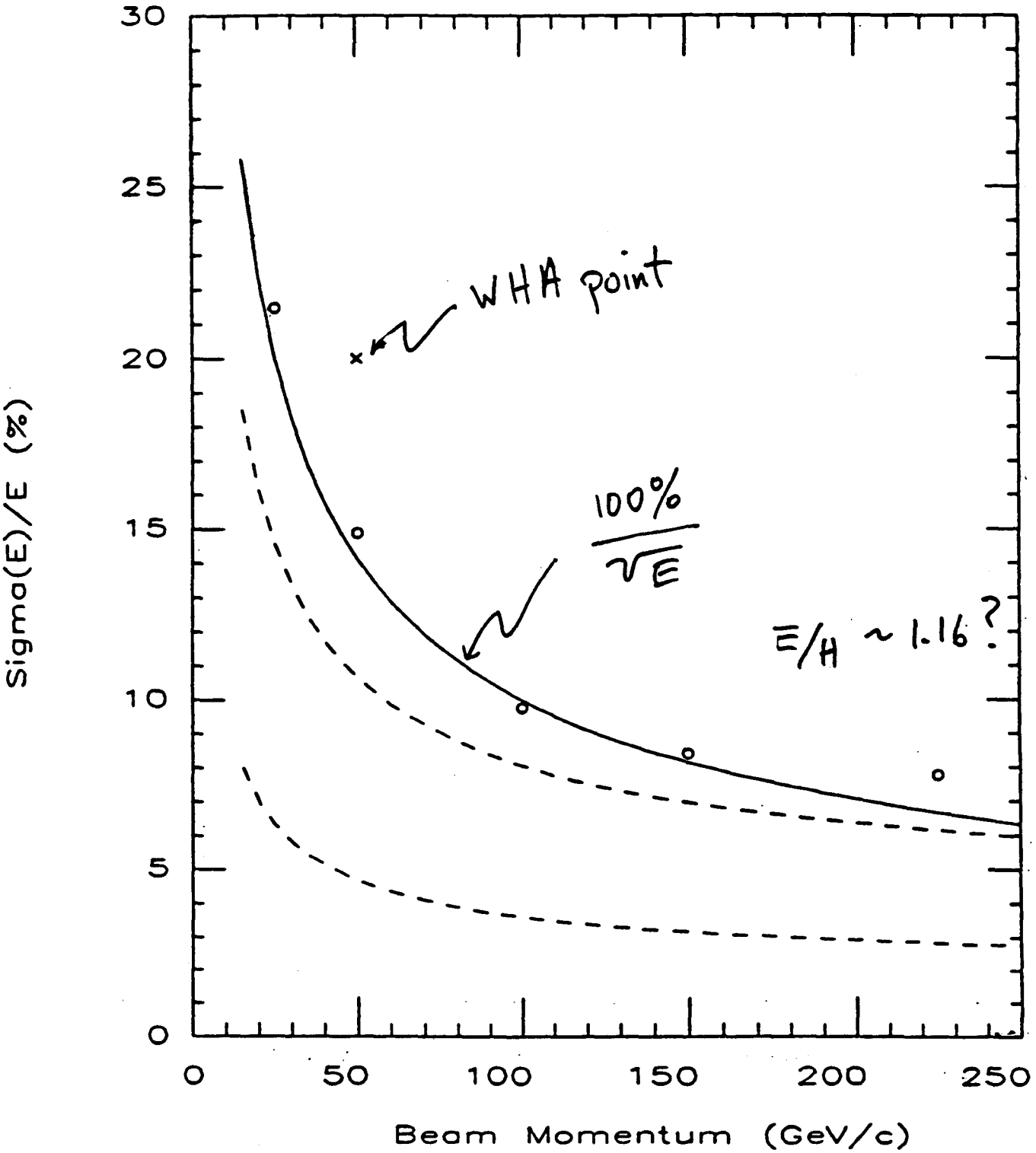
Northeastern	TEXAS → EMPACT
Tel Aviv	
U. South Carolina	EMPACT
Yale	EMPACT / BCD

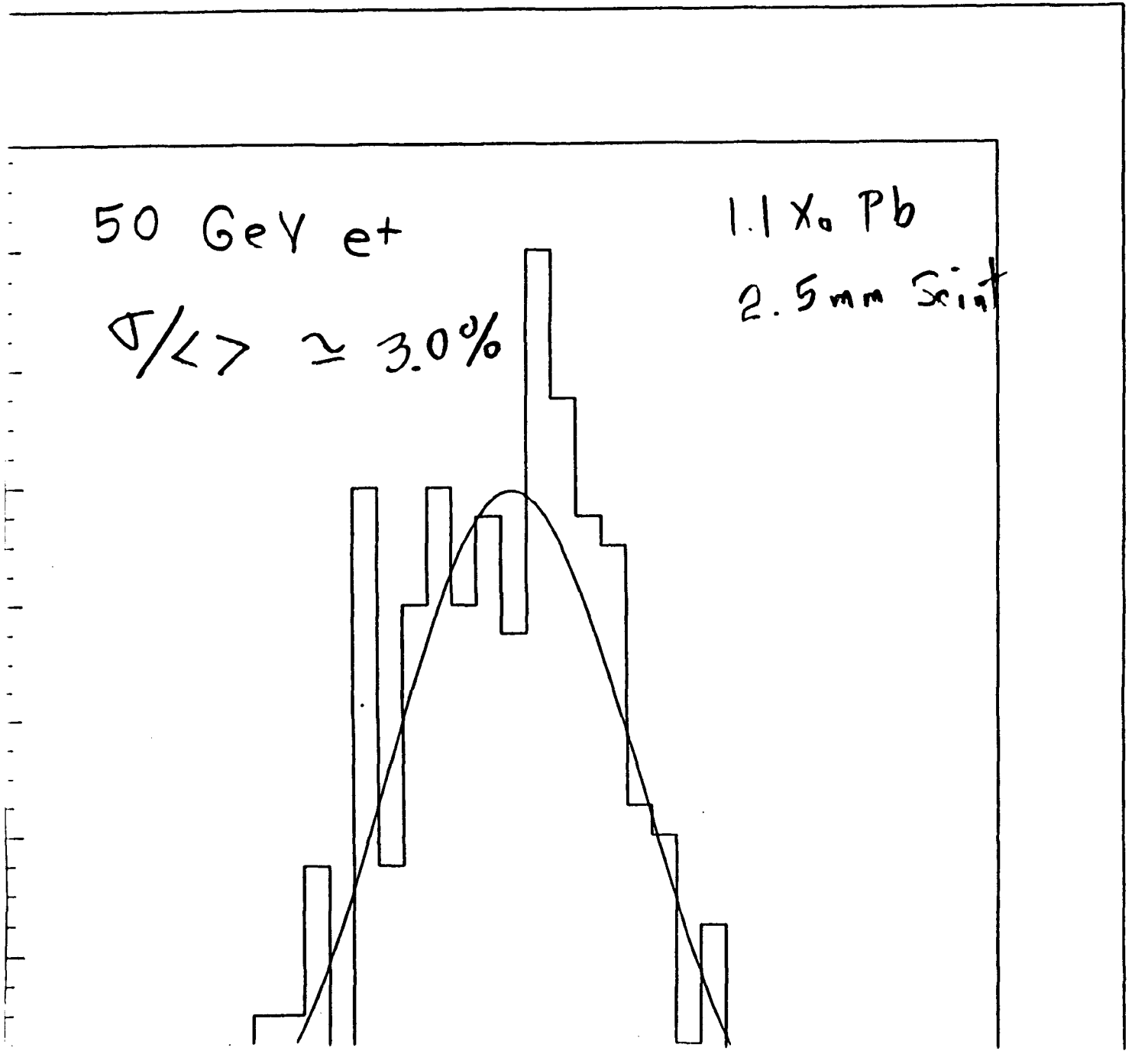
Spokespersons: Rusack (SDC)
Cushman (EMPACT)

Associated with Foster / Fraudfoot tile calorimeter
Discussions with Para spaghetti calorimeter
Need closer collaboration with WALIC, LAC.

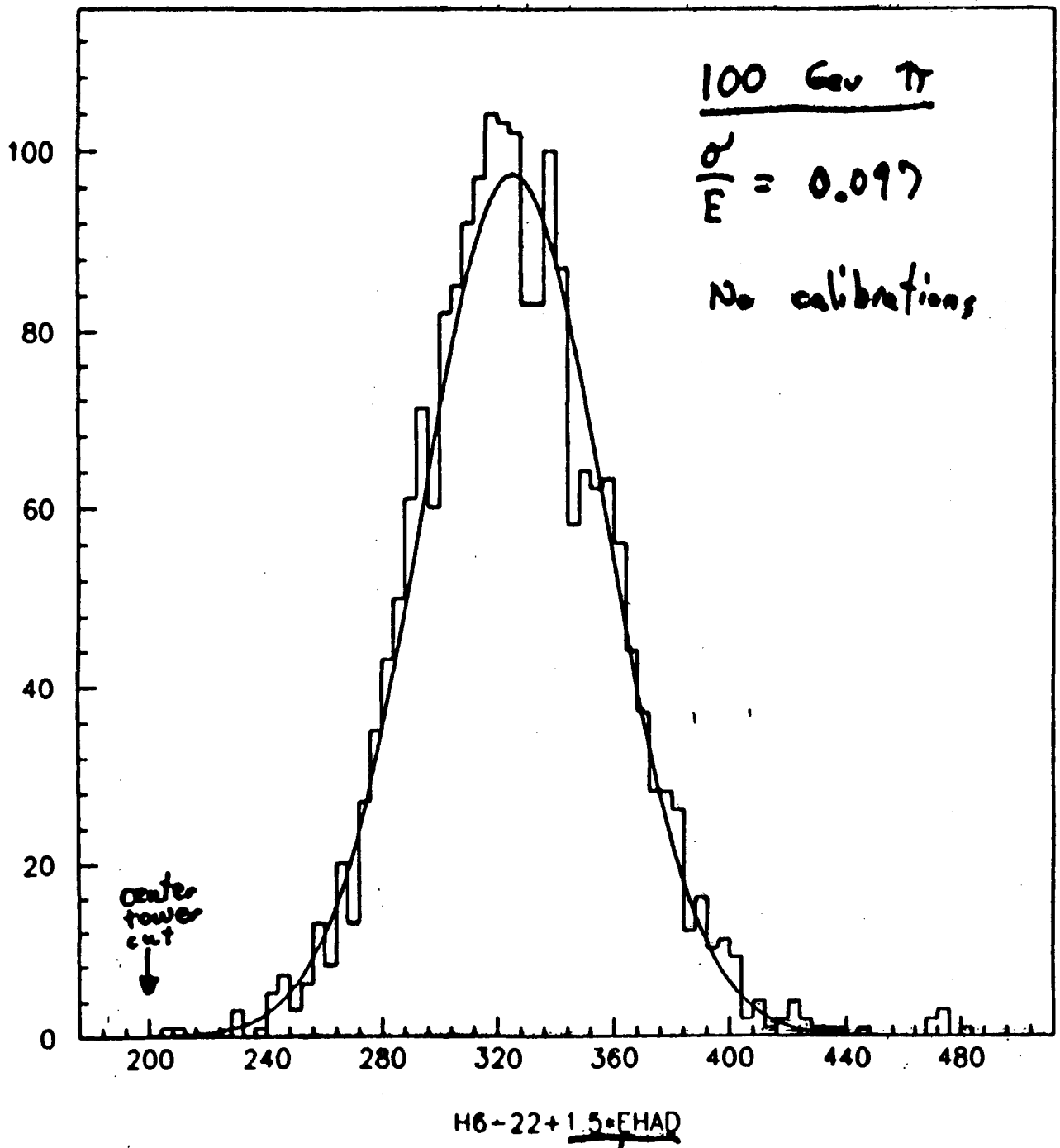
hadron prototype

5-Lambda Hadron Cal Resolution



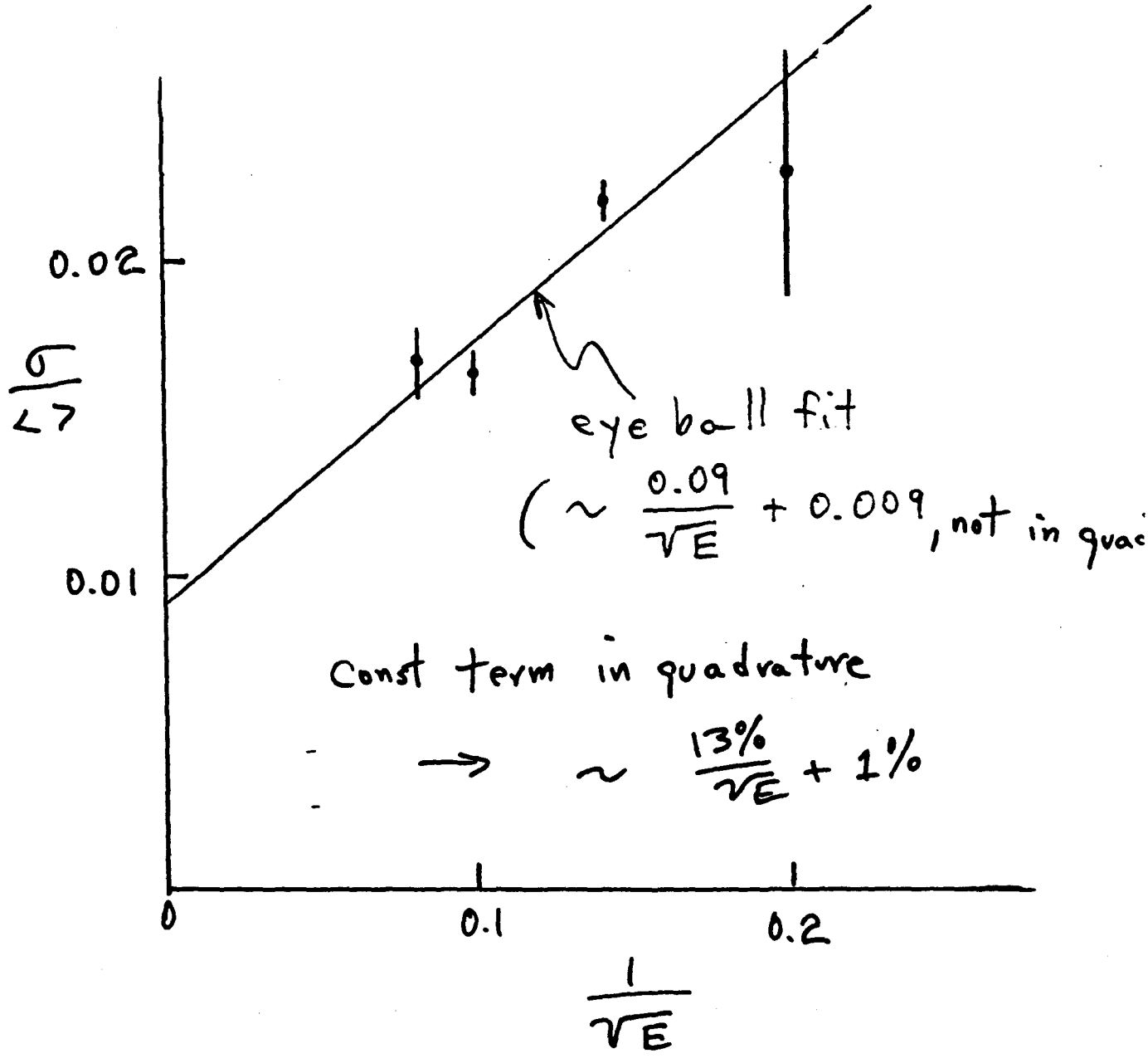

50 GeV e+
σ/<> ≃ 3.0%
1.1 X₀ Pb
2.5mm Scint

Hadron Tile Prototype



1 tower EM prototype

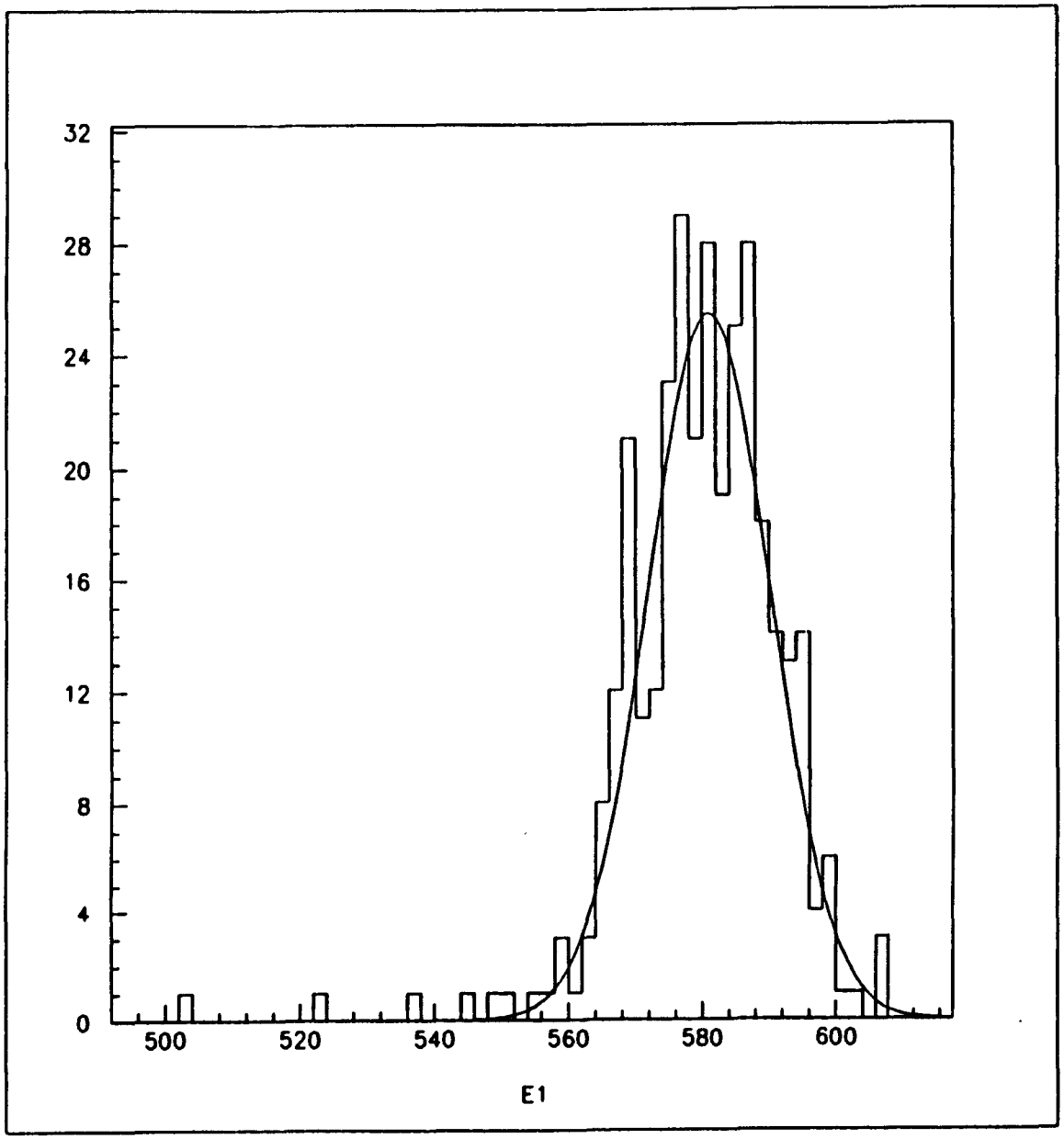
Energy Resolution



$\langle 581 \rangle$

$\sigma = 9.24$

$\sigma / \langle \rangle = 1.6\%$

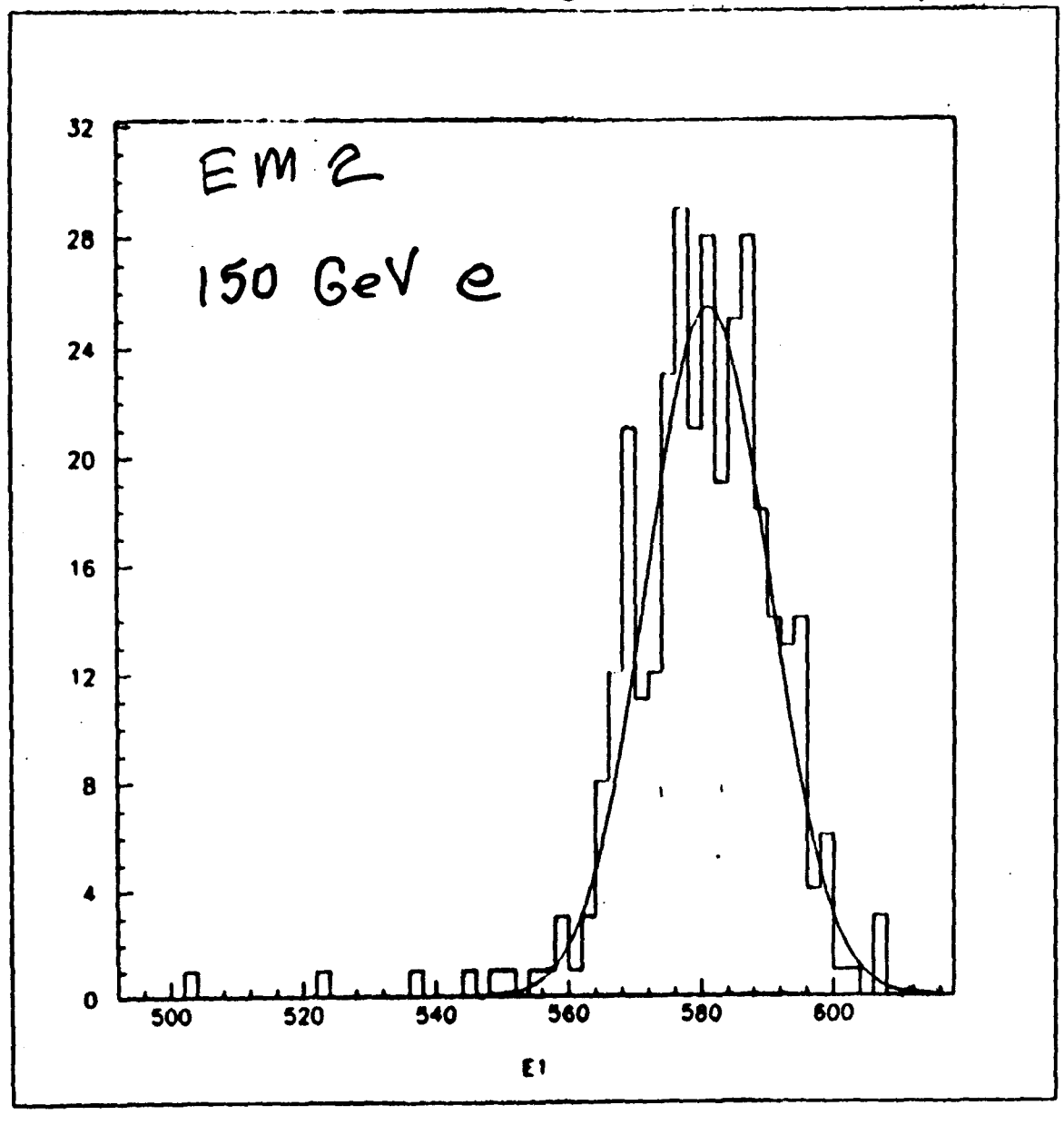


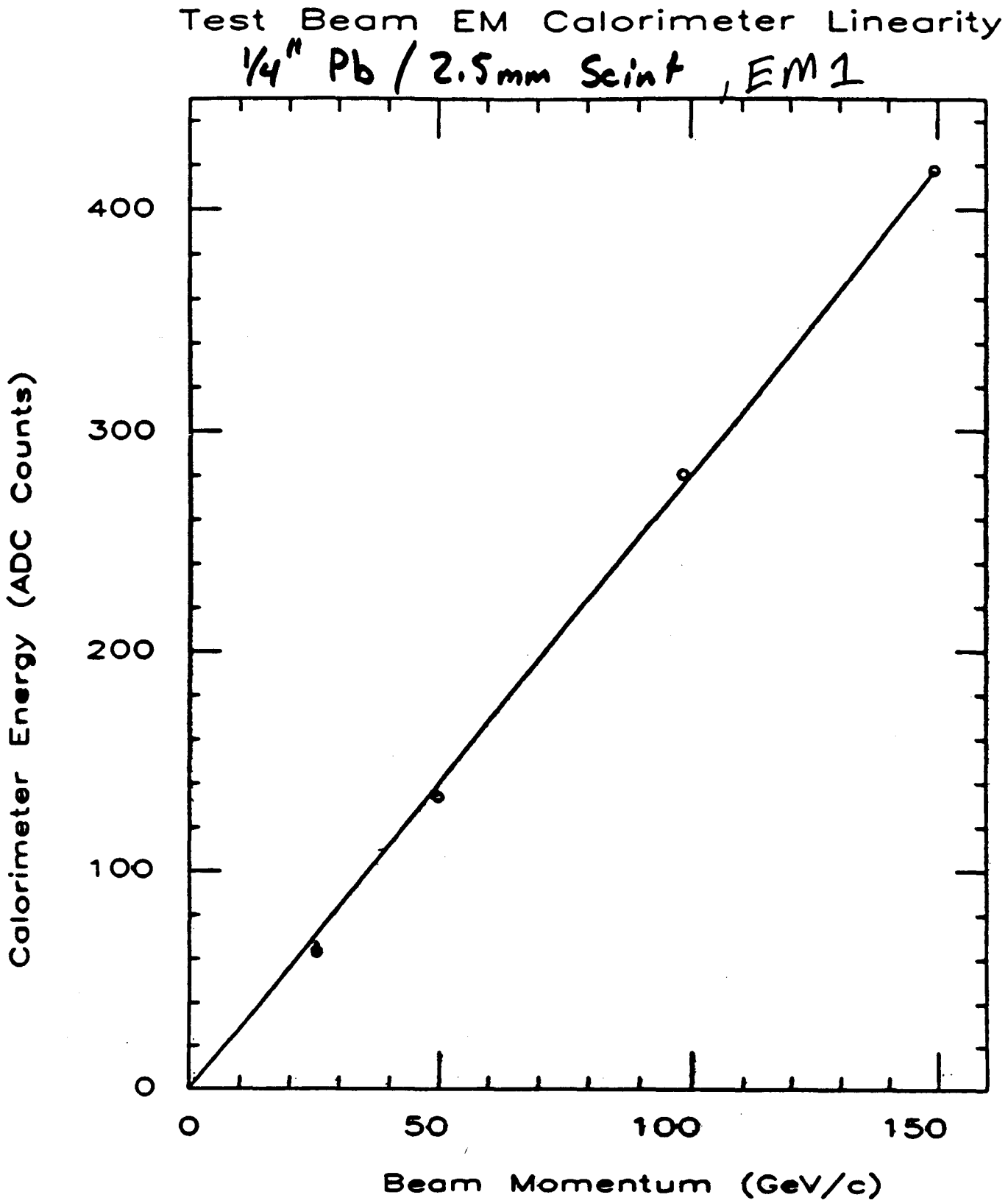
raw energy dist, no P beam corr.

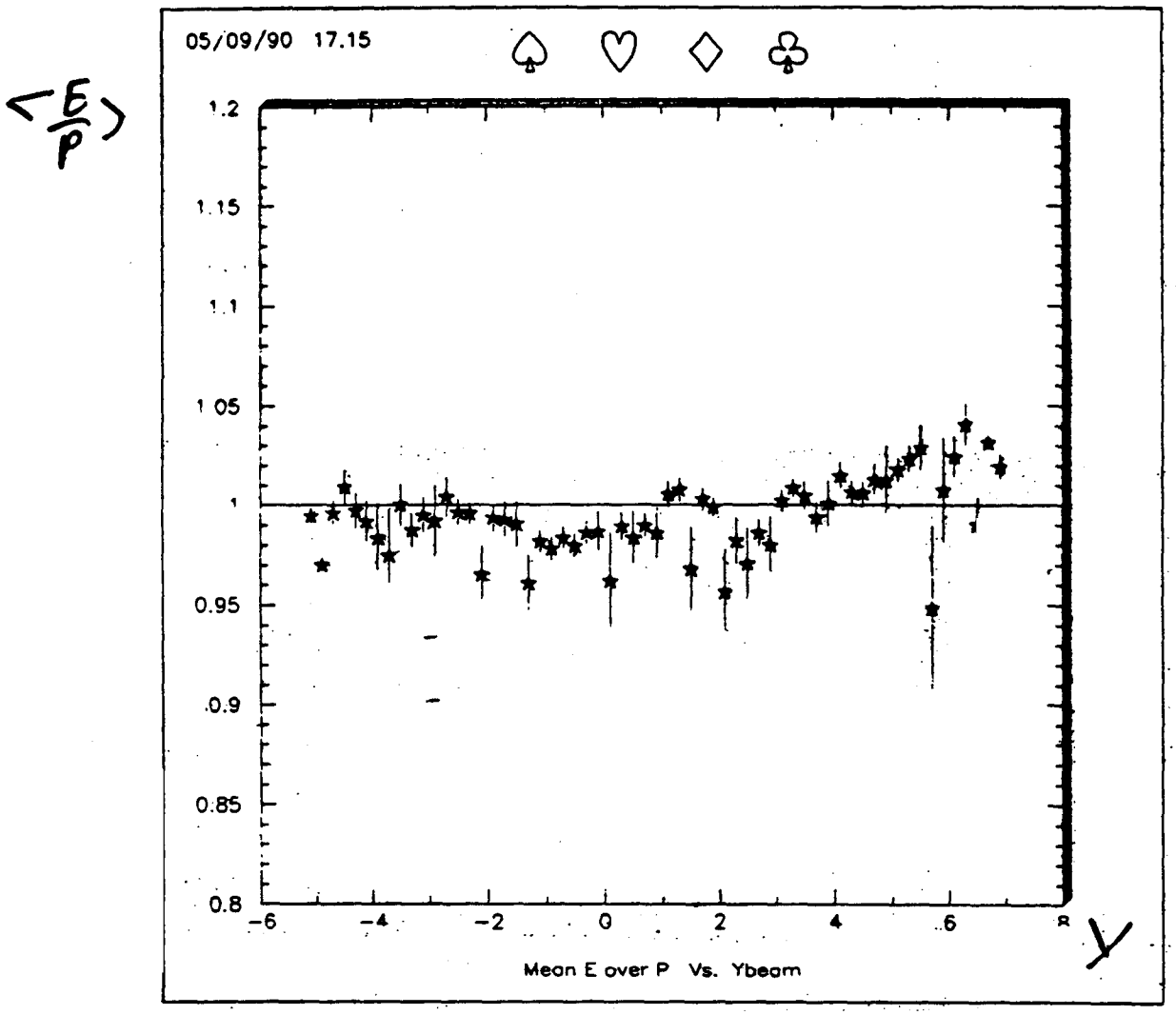
$\langle 581 \rangle$

$\sigma = 9.24$

$\sigma / \langle \rangle = 1.6\%$

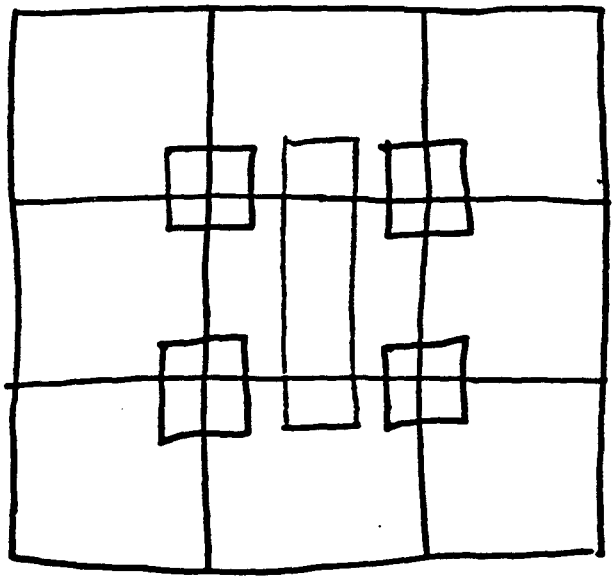



Test Beam EM Calorimeter Linearity
1/4" Pb / 2.5mm Scint , EM1
Calorimeter Energy (ADC Counts)
0
100
200
300
400
0
50
100
150
Beam Momentum (GeV/c)



UNIFORM WITHIN 2%.

Uniformity



integrate over scan region
(tracking not yet understood)

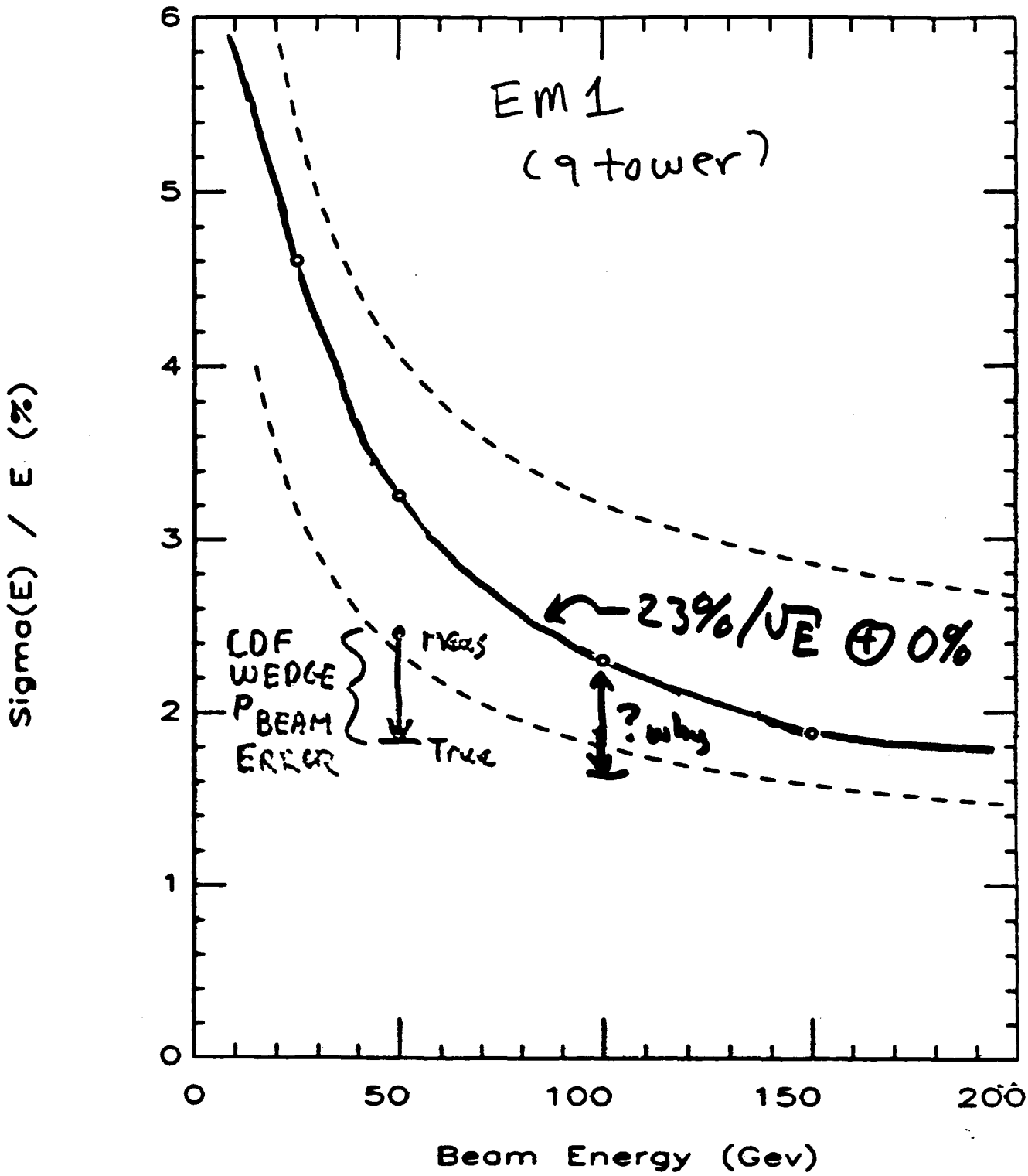
100 GeV e

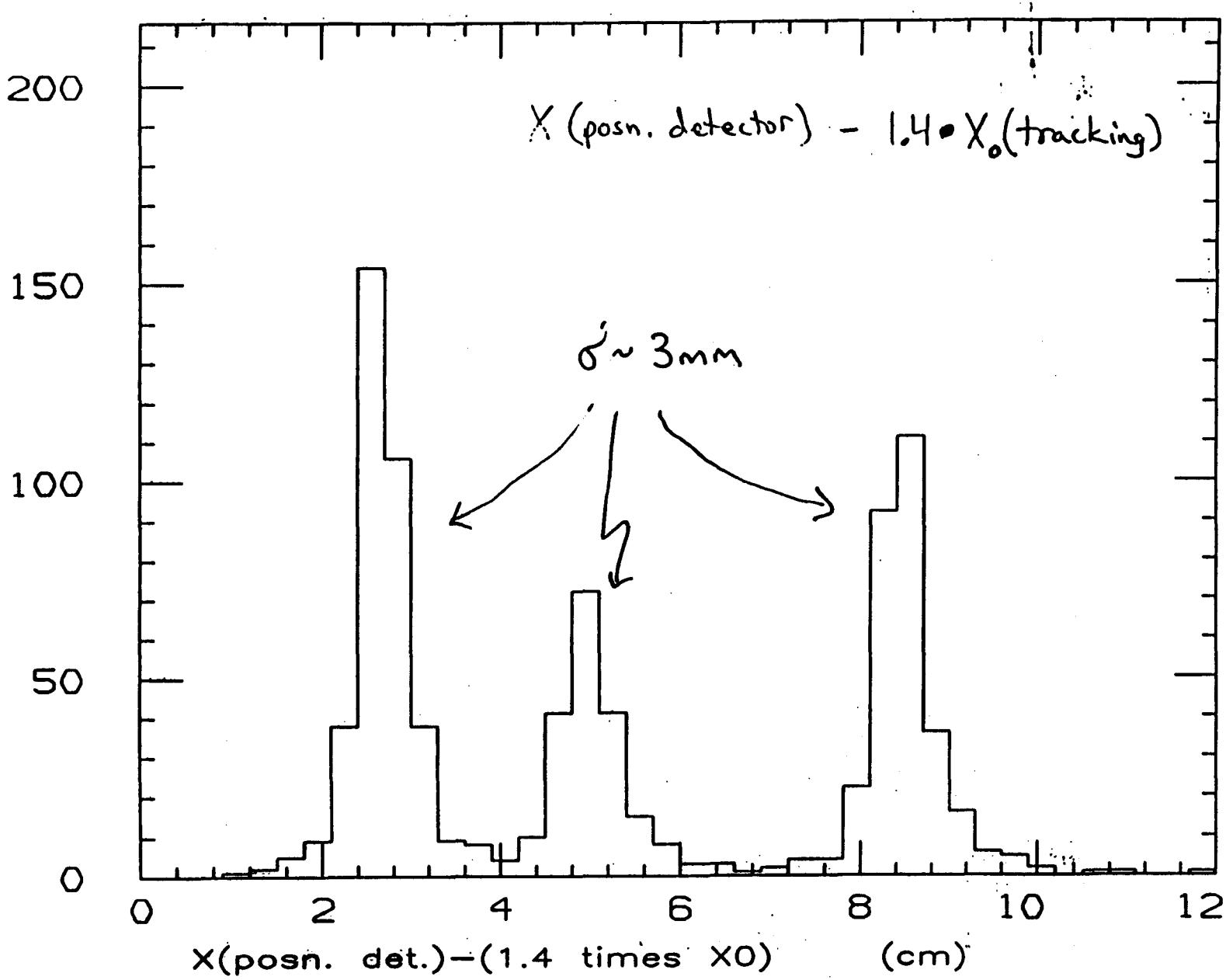
green region: 2.3% width → ~3%

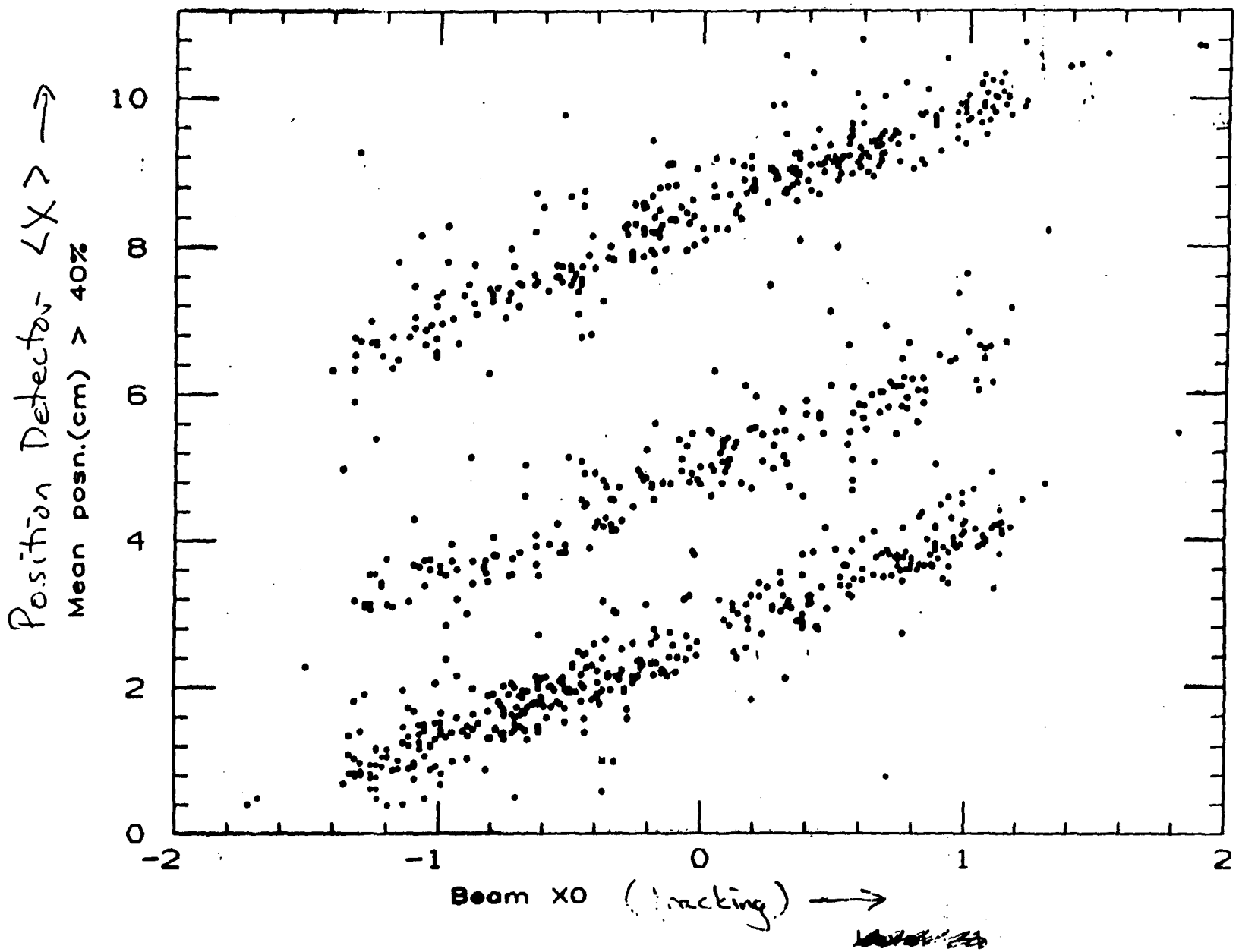
blue region: 2.3% → ~4%

Warning! calibrations not yet finished

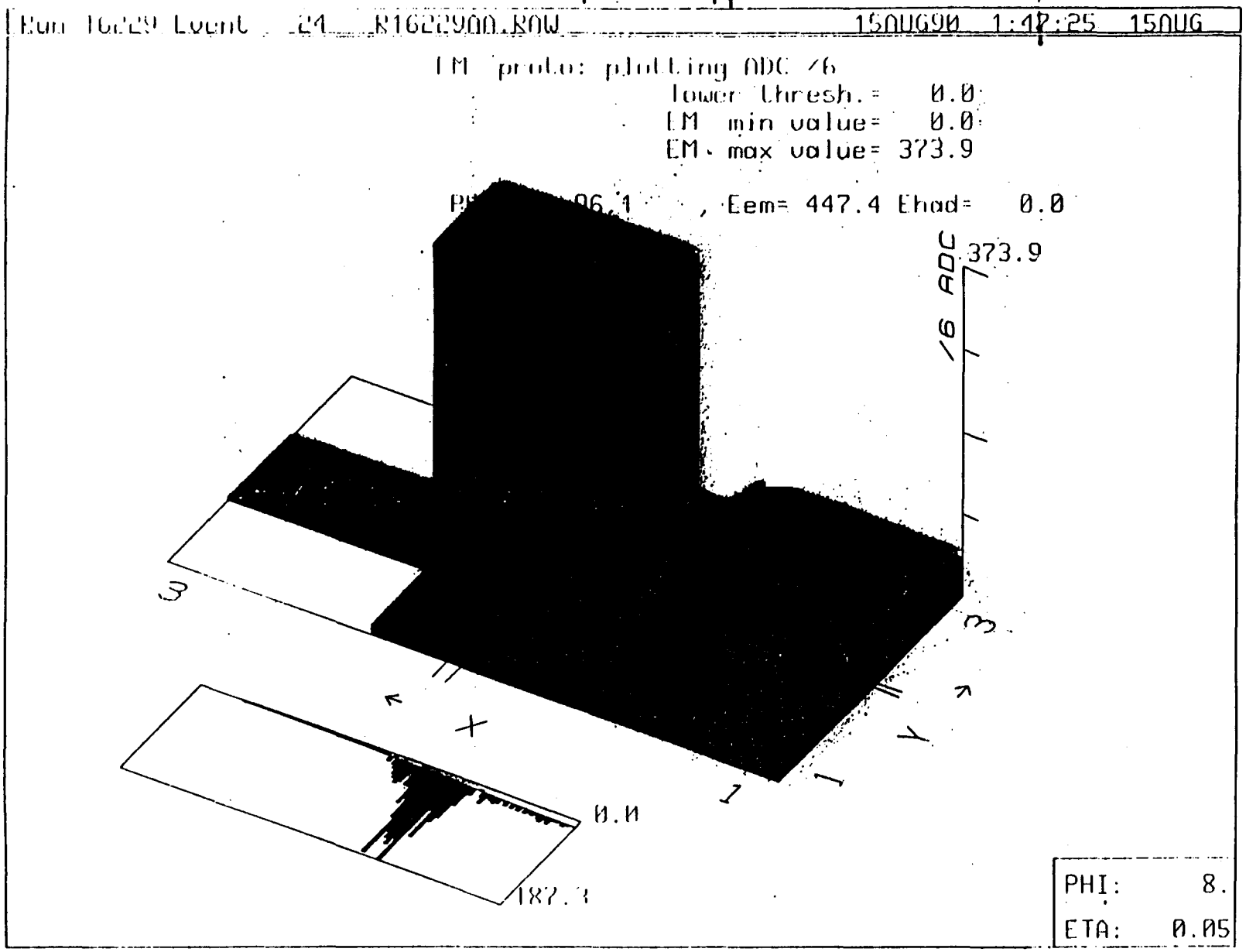
Test Beam EM Calorimeter Resolution




X (posn. detector) - 1.4 • X0(tracking)
σ ~ 3mm
200
150
100
50
0
0
2
4
6
8
10
12
X(posn. det.)-(1.4 times X0) (cm)


Position Detector <X> →
Mean posn.(cm) > 40%
10
8
6
4
2
0
-2
-1
0
1
2
Beam XO (tracking) →

9 tower prototype



Tile light yield

EM 1 tiles

$\langle\ \rangle \simeq 260$ counts

$\sigma \simeq 10$ counts

$\frac{\sigma}{\langle\ \rangle} \simeq 3\%$

~1000 tiles built

→ good cost estimate

→ feed into T. Kirk costing

Hadron Prototypes

D. 16 towers (6" x 6") (352 tiles)

2' x 2' x 5 λ thick

2" Fe

2.5 mm thick plastic, 0.7mm fibers

(assembled in hall → problems)

D'. same as D, assembled in modules in lab 6. (384 tiles)

$\sigma/E \simeq \frac{115\%}{\sqrt{E}}$ (low light yield)

(2X lower than D, trimm

D''. replace central tower with

1/4" thick plates, 1mm fibers

→ very high light yield

→ σ/E for electrons $\sim \frac{35-40\%}{\sqrt{E}}$

EM prototypes

A. 9 tower (6 cm X 6 cm)

0.7 mm fiber, 1 X_0 pb, 24 X_0

B. 1 tower (12 cm X 12 cm)

1.0 mm fiber, 0.5 and 1 X_0 pb, 20 X_0

C. Shower Position Detector

112 fiber plane of 2mm ø scint. fibers read out by multi-anode pmts

embedded at 2X_0 or 5X_0 in

EM prototype A.

Tile / Fiber News (J. Freeman)

- merging of "Argonne" and "FNAL" subsystem groups

  → $\gtrsim$ 100 people

  → explore Pb, Fe, composite calorimeters

- test beam results from prototypes (ANL, FNAL, Purdue, Rochester, Rockefeller, UCLA)

- CDF adopted tile/fiber option for calorimeter upgrade

Wire chamber channel count

arrel: E o I: 2 (ends) × 8 (superlayers) × 8 (straw layers/sl)
(a possible choice)

$\downarrow$ 7 $\qquad$ $\downarrow$ 6 (9 for outer layer)

1) Remove inner superlayer (r_{first} 73 → 88 cm)
   (x u v x u v x stereo configuration)
2) New slayers 1-6 have 6 layers
3) " slayer 7 has 9 layers (trigger)

N_{chan} 250,880 → 191,520 (-24%)

(If R_{coil} 1.85 m → 1.70 m, area → 1 − 16%, so layer pruning would be milder than above)

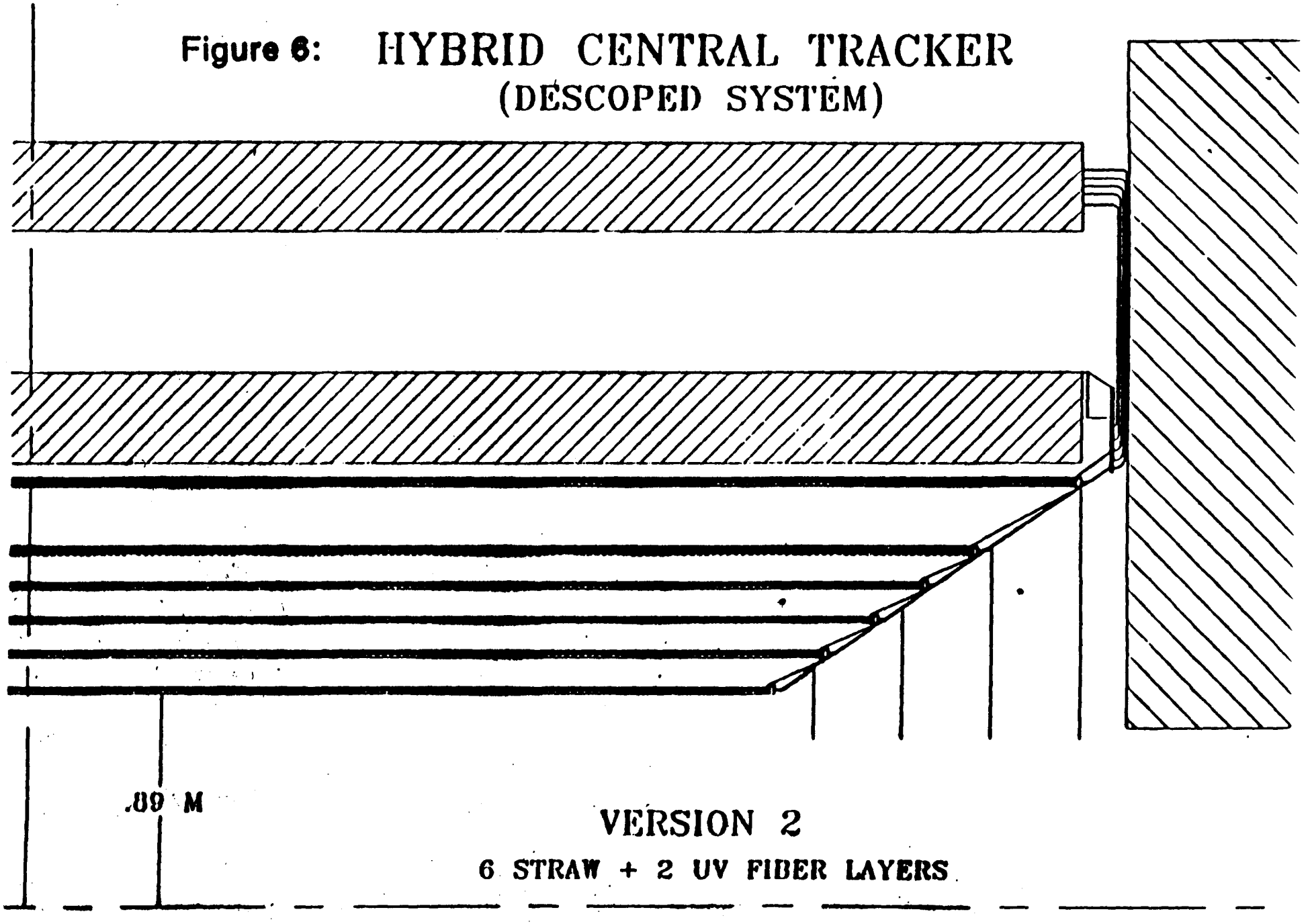
Intermediate: E o I: 2 (ends) × 6 (planes)

$\downarrow$ 5

N_{chan} 60,000 → 50,000 (-17%)

All wire channels
310,880 → 241,520 (-22%)

Figure 6: HYBRID CENTRAL TRACKER
(DESCOPED SYSTEM)



VERSION 2

6 STRAW + 2 UV FIBER LAYERS

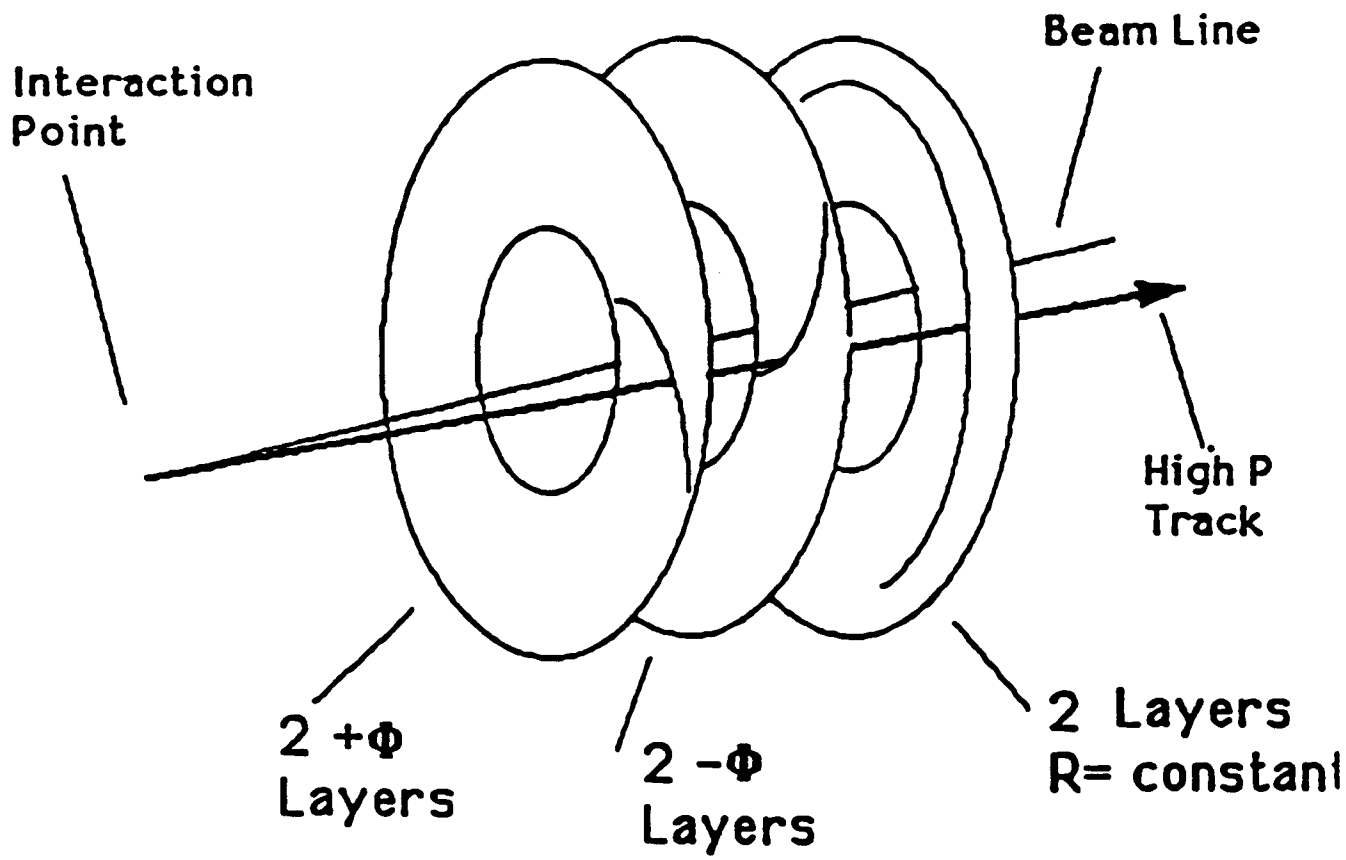
Table 1 summarizes some features of these HCTC versions. An estimate of the momentum resolution was made assuming 150 μm point setting error in the straw tubes and 15 micron in the scilicon strip inner tracker. This result is tabulated in Table 1 and plotted in Figure 10. Obviuously the real question about the various tracking versions is not momentum resolution but the ability to carry out pattern recognition in the SSC operating environment. A detailed study of these problems is being carried out at Florida State University (SCRI) by Martyn Corden and Mike Mermikides.

Table 1: Various HCTC Detector Configurations

Configuration	Straw Tube Channels	Scifi Channels	Relative Cost	Momentum Resolution*
full system (see Figure 5)	244,700	165,600	1.0	9 %
descoped detector (see Figures 6,7)	187,000	110,400	0.75	10 %
reduce r and L by 10% (see Figure 8)	220,200	144,000	0.91	11 %
high luminosity upgrade (see Figure 9)	179,100	360,000	----	9 %

* sigma of the distribution of p_t error/p_t using1 TeV particles(see Fig. 10)

Super Sublayer of the Intermediate Tracker



Fiber Equations for Super Sublayers:

$$\phi-\phi_0=\pm\left[\sqrt{\left(\frac{r}{r_0}\right)^2-1}\ -Cos^{-1}\left(\frac{r_0}{r}\right)\right]$$

R=Constant

All "ϕ" Fibers= 1mm

All R=Constant *Fibers=500μm*

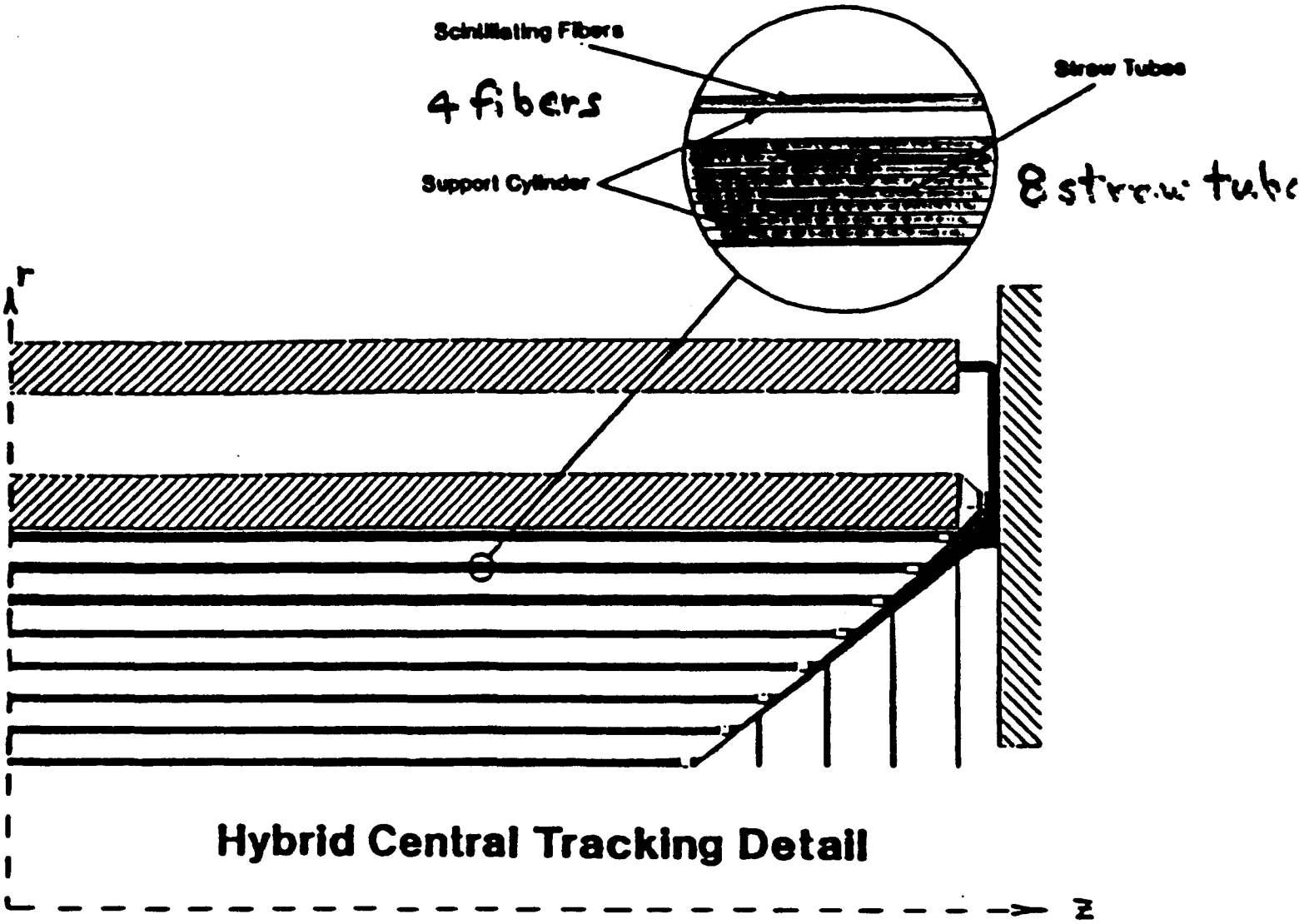
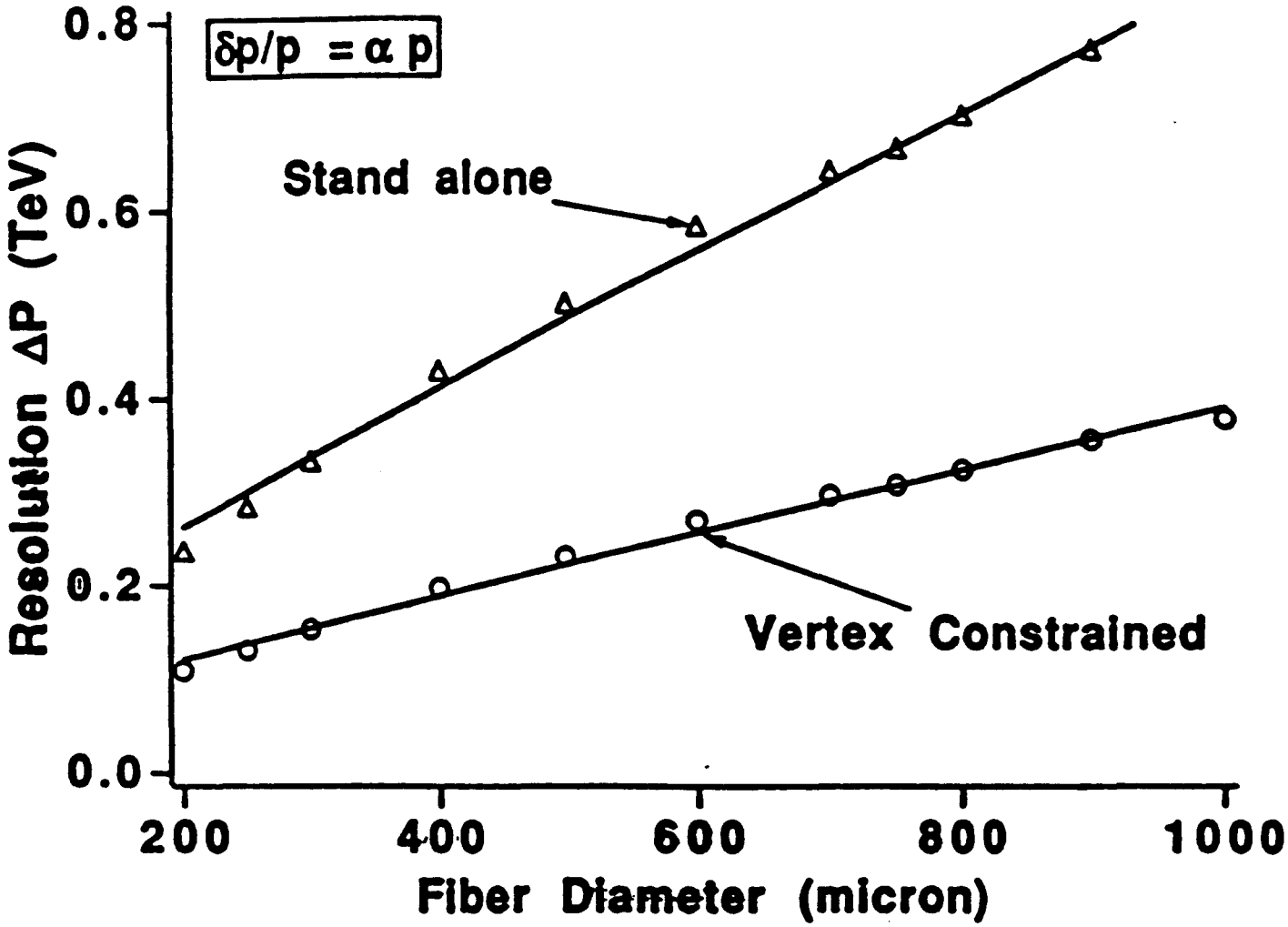


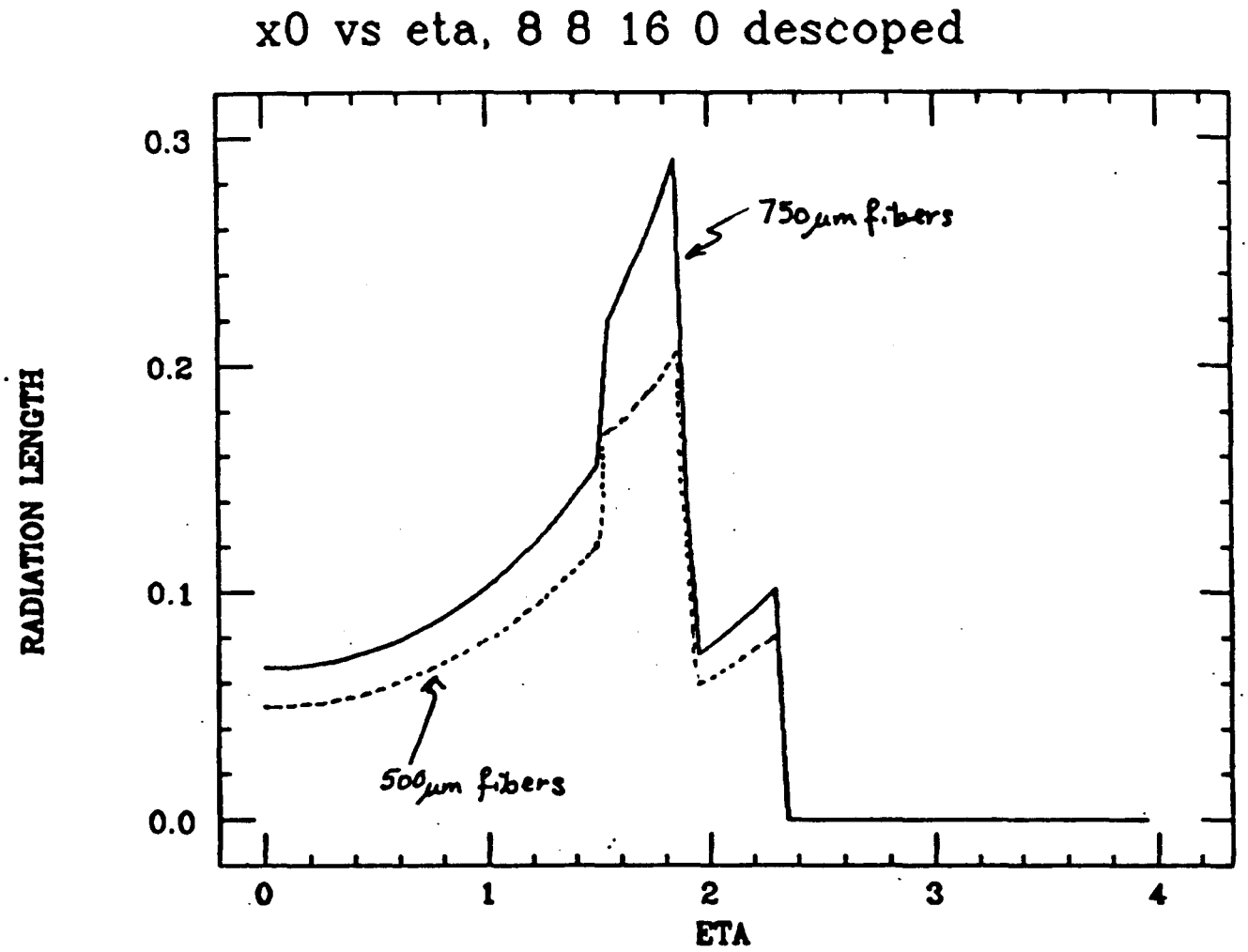
Figure 1 Cutaway view of one quarter section of a HCTC detector, with eight straw tube superlayers (z wires) and three outer scintillating fiber superlayers (stereo, u-v fibers).

CHANNEL COUNTS VS. FIBER DIAMETER
(BARREL REGION)

$\langle R \rangle$	N_{meas}	500μm	650μm	750μm	850μm
62.5	8	62,832	48,332	41,888	36,960
96	8	96,510	74,238	64,340	56,771
129	16	259,370	199,516	172,913	152,570
162.5	16	326,726	251,328	217,817	192,192
TOTAL (per half)		745,438	573,414	496,958	438,493
TOTAL		1.49M	1.15 M	0.99 M	0.88M


δp/p = α p
Stand alone
Vertex Constrained
Resolution ΔP (TeV)
0.0
0.2
0.4
0.6
0.8
200
400
600
800
1000
Fiber Diameter (micron)

750μm fibers



IMPACT OF DESCOPING PROPOSAL ON SCINTILLATING FIBER TRACKING.

1. Radius Reduction

2. Fiber Diameter Increase

   500μm (previous) ⟶ $\gtrsim$ 750μm

3. Occupancy (still ok up to $\mathcal{L} \sim 10^{34}\ cm^{-2}s^{-1}$)
   (inner ~13%), (outer ~0.8%)

4. Radiation Resistance (still "ok" up to $\mathcal{L} \sim 10^{34}\ cm^{-2}s^{-1}$)
   (inner layer has 1 Megarad in 10 yrs)

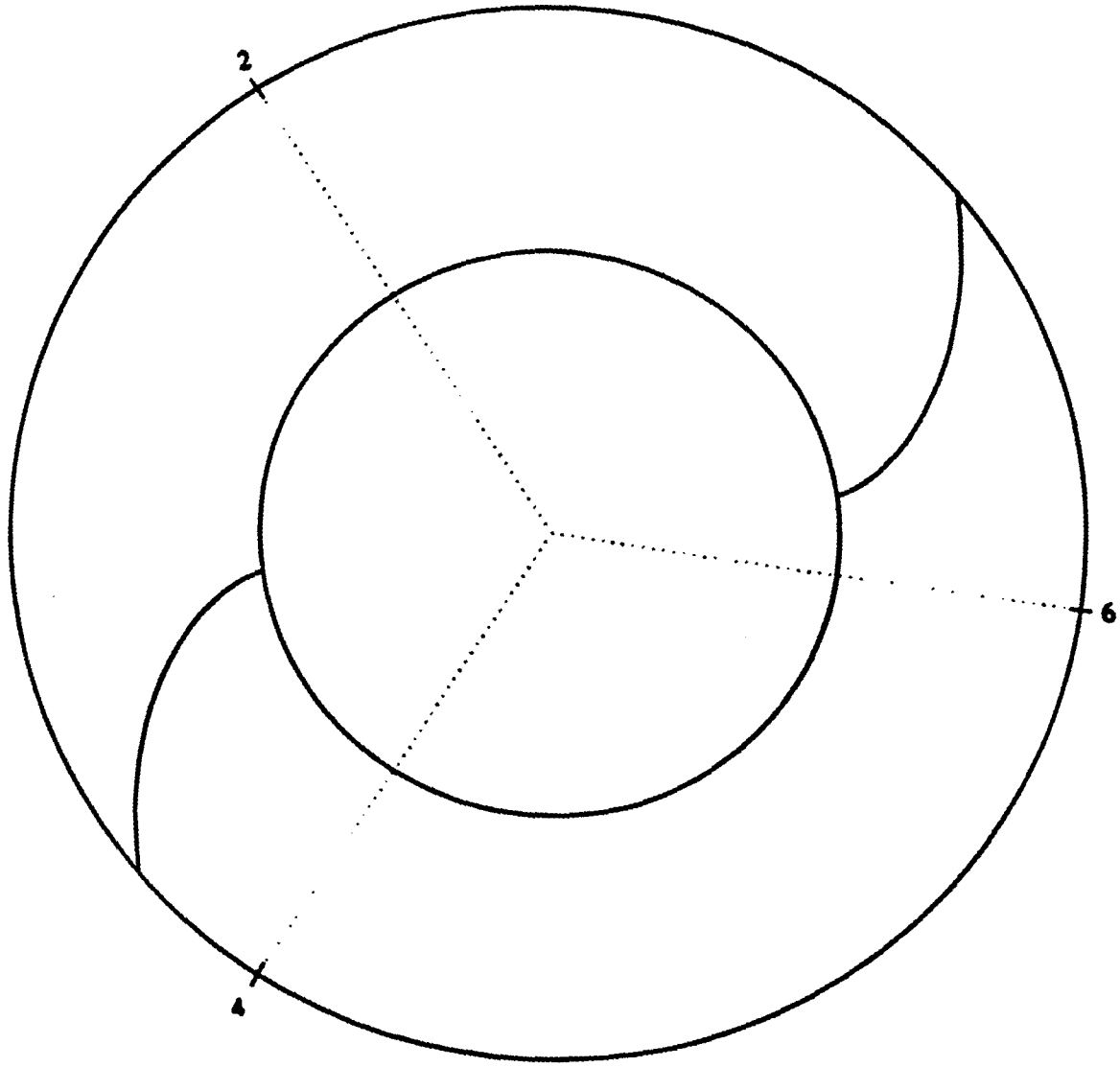
CONSEQUENCES:

1,2 $\frac{\sigma_{p_T}}{p_T}$ will increase by a factor × 1.8 (STAND ALONE ONLY)

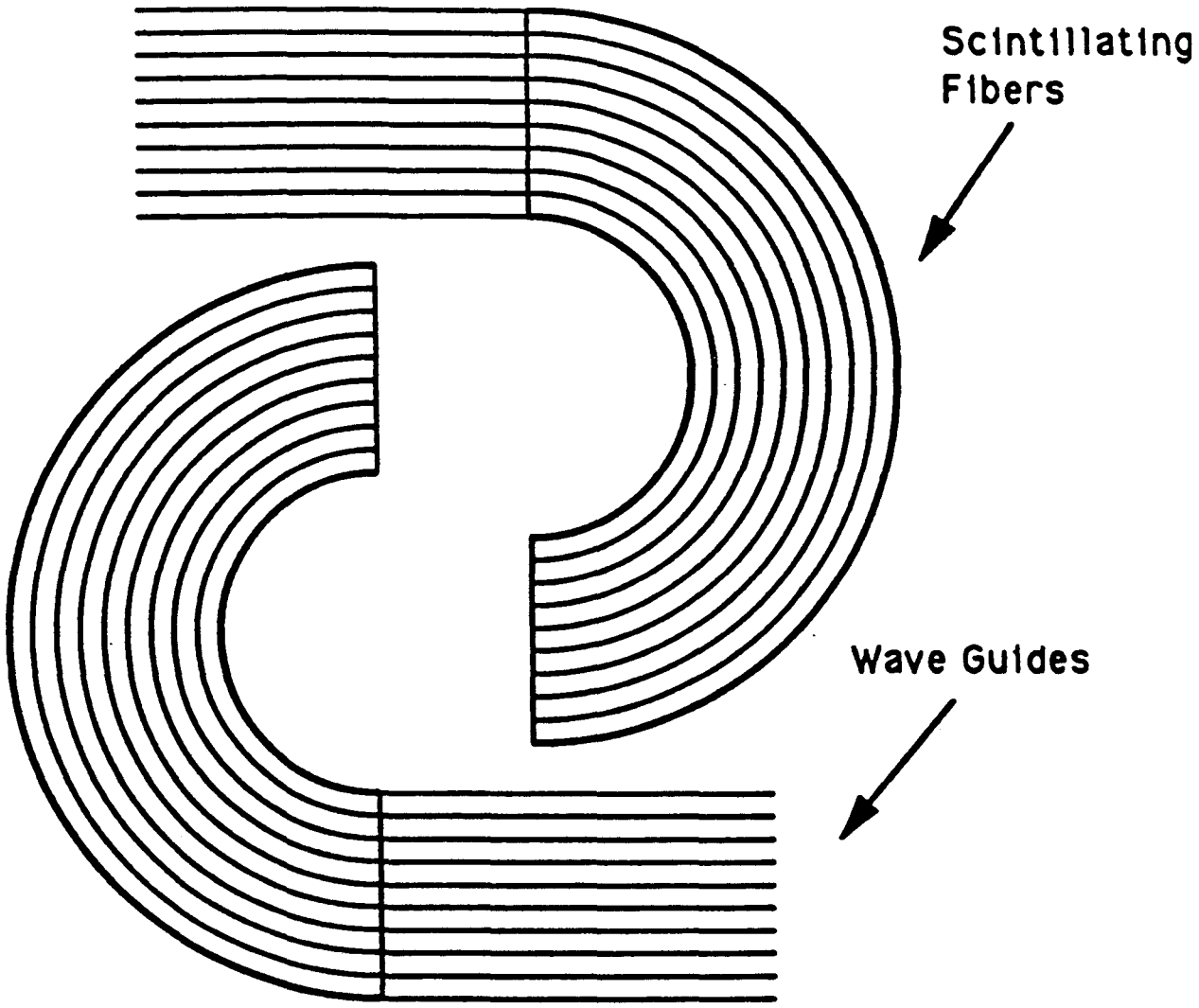
Material thickness (X_0) increases. × 1.4

3,4 Tracker should still work well to the highest luminosities.

Trigger capability at level 1 still intact.


2
6
4

Intermediate Tracker R=const. Layer



9/20/90

Tracking at reduced scope

Ex. 1) Keep EoI dimensions, reduce channel/area count by 23%

Ex. 2) Scale down volume by 10%

R 1.8 m → 1.6 m

$\frac{1}{2}L$ 4.5 m → 4.0 m

Ex. 3) Decrease length by 15%

$\frac{1}{2}L$ 4.5 → 3.8 m

$500M proposal (≈ all of above)

channel count (area) → 1 - 25%

R_{coil} 1.85 m → 1.70 m

$\frac{1}{2}L$ 4.5 m → 4.0 m

Some generic consequences

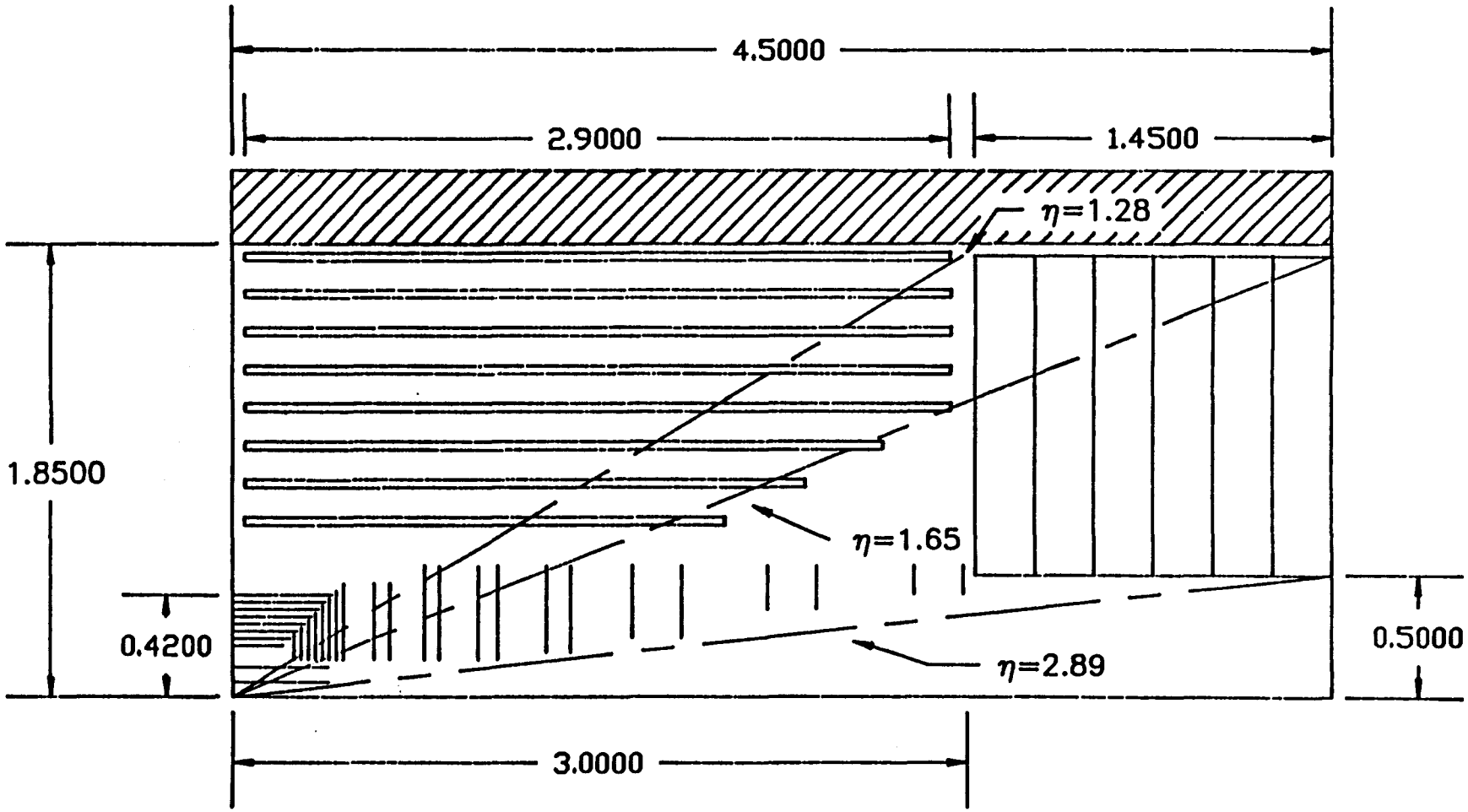
$\sigma(p_\perp)/p_\perp \propto 1/R^2$ → ~ 20% worse

η cutoff for good $\sigma(p_\perp)$ 1.65 → 1.60 → 1.50

$\sigma(p_\perp)/p_\perp \propto 1/\sqrt{N_{meas}}$

Redundancy for pattern recognition

From EoI



Track extrapolation resolution

ansatz: [How good is this assumption? (1)]
Pattern recognition in Si pixel/strips
finds all interesting tracks

How reliably can outer hits be linked to these?

Construct 5-parameter error matrix for track

$$r\phi = [b + \phi_0 r + \tfrac{1}{2}\kappa r^2]\cos\theta_s + [z_0 + \cot\theta\, r]\sin\theta_s$$

stereo angle

EoI configuration:

2×2 layers pixels : $\sigma(r\phi) = 10\mu m$, $\sigma(z) = 100\mu m$
8×2 " strips : $\sigma(r\phi) = 15\mu m$, $\theta_s = \pm 5$ mrad
8×8 " straws : $\sigma(r\phi) = 100\mu m$ ($/\sqrt{8}$ for sl) $= 35\mu m$, $\theta_s = \pm 3°$
2×2 + 2×4 " scifi : $\sigma(r\phi) = 500\mu m/\sqrt{12}/\sqrt{4} = 72\mu m$, $\theta_s = -4.5°, +$

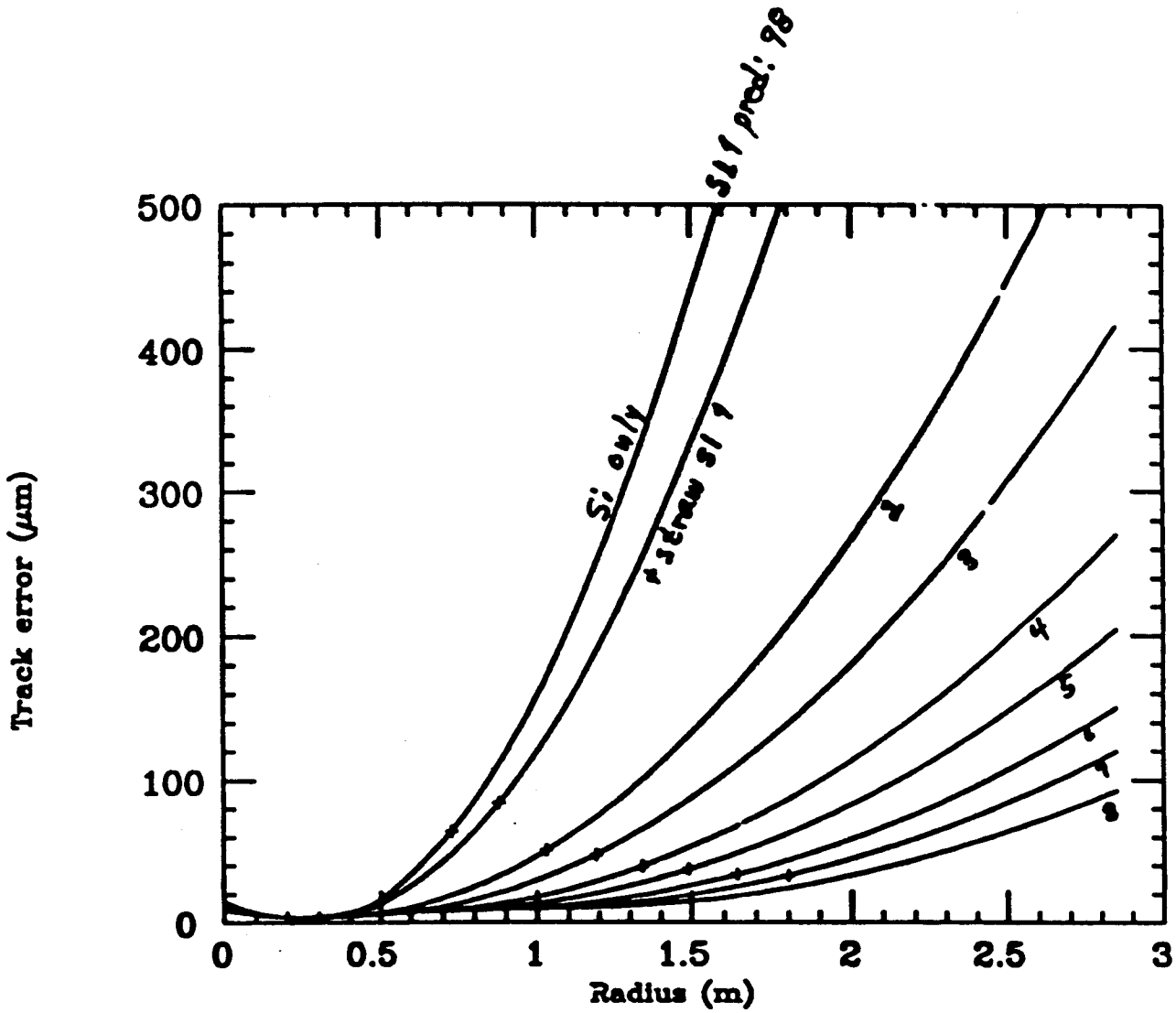
NO multiple scattering

Plot $\sigma(r\phi)$ vs r, as outer tracker layers added.

Conclusions

1) Pixels contribute a lot
2) Avoid big gap between Si, outer layers
3) Probably 1st outer slayer should be axial
   (last one also, for trigger)
4) This should work well, <u>if</u> (1), and
   superlayer efficiencies are high

EoI configuration, pix + strips + straws



For full system:

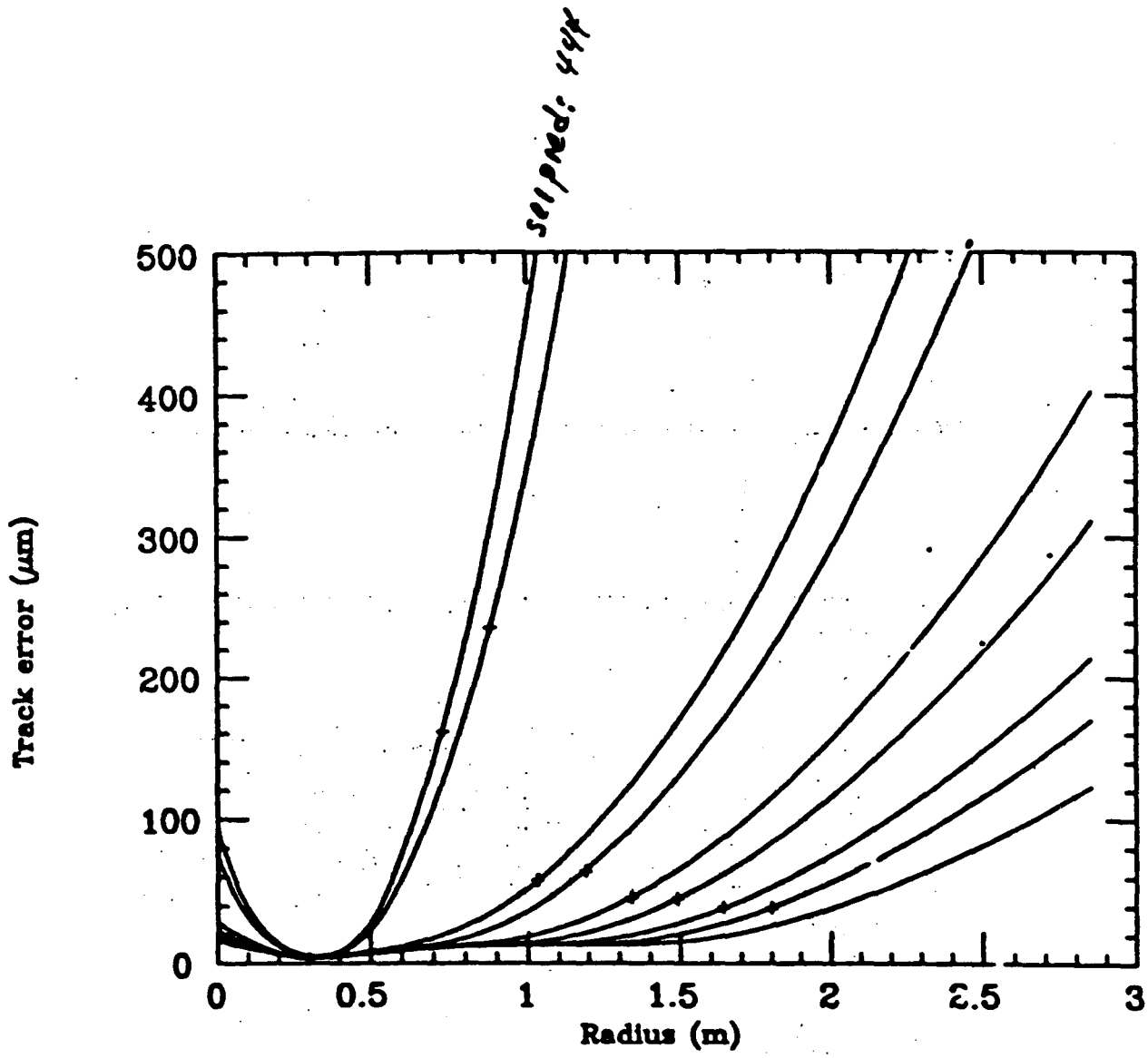
$\sigma(p_\perp)/p_\perp\big|_{1\,TeV} \simeq 0.072$

$\sigma(b) \simeq 8.5\,\mu m$

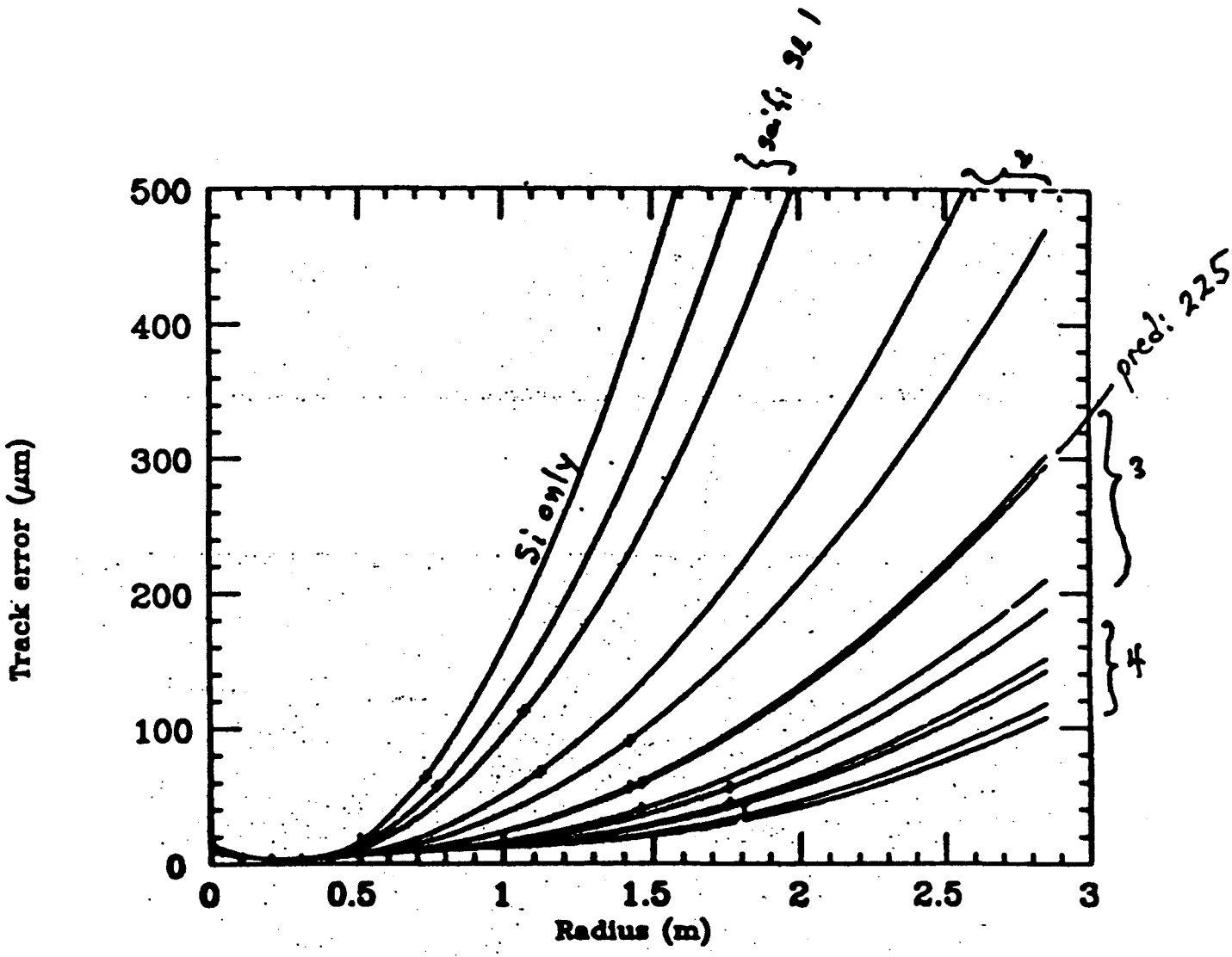
$\sigma(r\phi)\big|_{r=2.85m} \simeq 92.5\,\mu m$

$\sigma(z)\big|_{r=2.85m} \simeq 0.8\ mm$

EoI, less pixels



EoI configuration, pix + strips + scifi



For full system:

$\sigma(p_\perp)/p_\perp|_{1TeV} = 0.079$

$\sigma(b) = 9.0\ \mu m$

$\sigma(r\varphi)|_{r=2.85m} = 108\ \mu m$

$\sigma(z)|_{r=2.85m} = 1.0\ mm$

Occupancy calc. for 4 mm diam. straws

Isajet ("TWOJET", $p_\perp > 4.5$ GeV)
(i.e., $\ni \sigma_{jj} \simeq \sigma_{inel} \approx 100$ mb)

E.I geometry

Stable charged particle $\vec{p}$-vectors, trace helix to superlayer

Assume two turns for average looper.

" 40 ns livetime → 2.6 bunch crossings

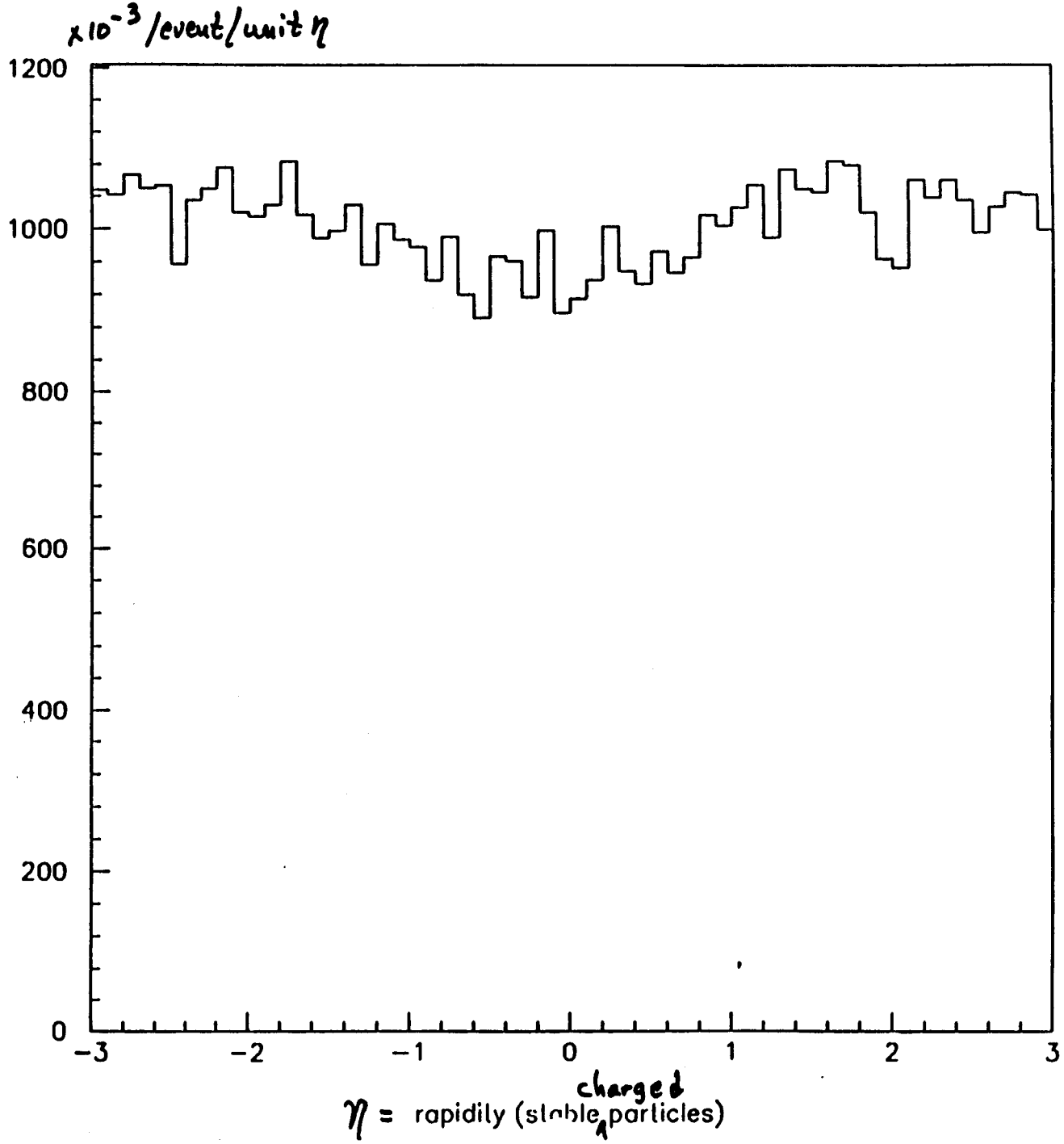
" $\mathcal{L} = 10^{33}$ → 1.6 int./crossing

→ 4.2 interactions/gate

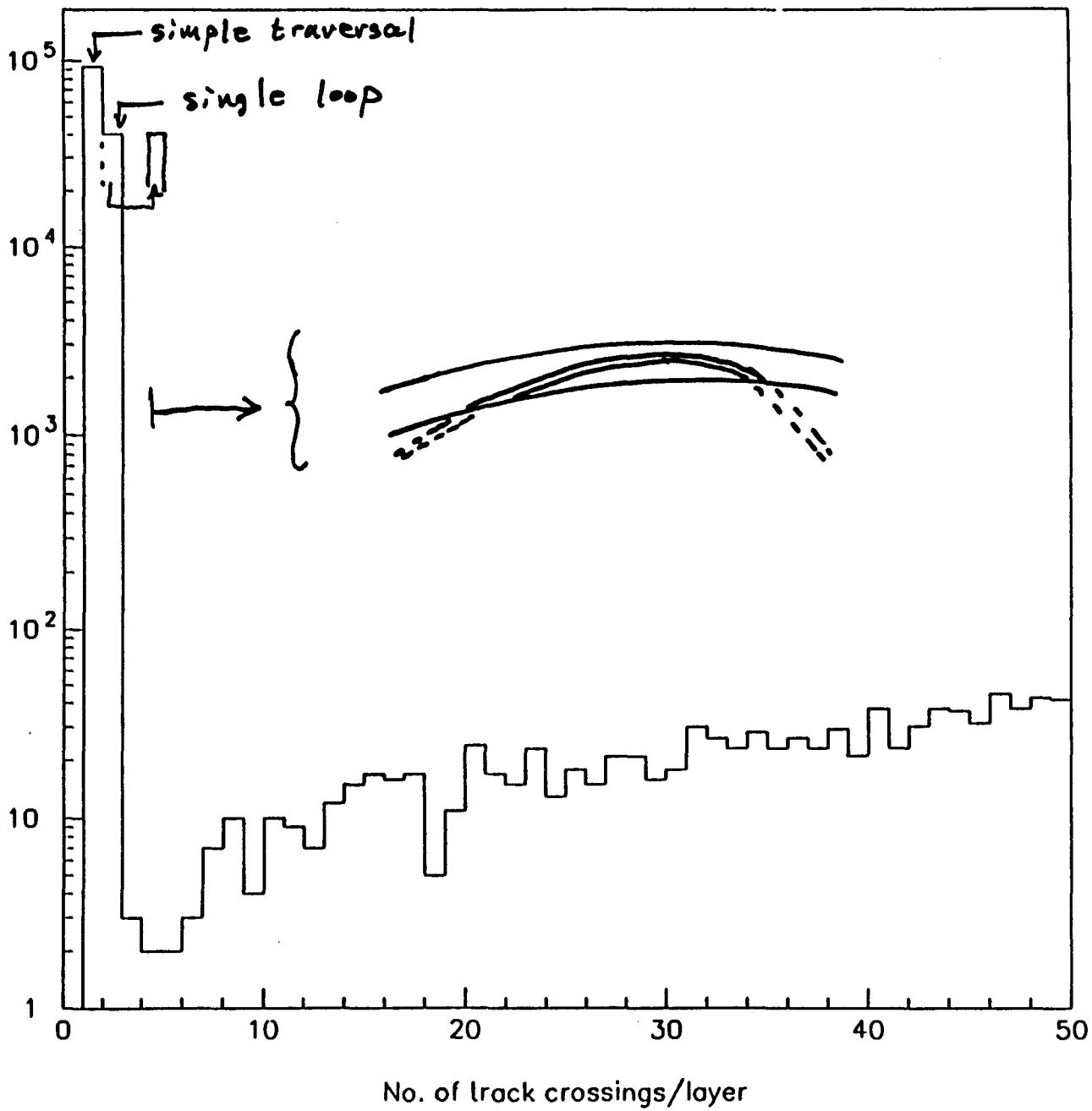
Compare with M. Asai, SSC-SDE-28
(scaled by 4/5 for straw diam.)

- Pythia/Geant (5 mm straws)
- Occ.(with secondary interactions)/Occ.(without) $\simeq 1.9$ @ $r = 1$ m.
- This calc/Asai (no sec. int.) $\simeq 0.8$ at $r = 1$ m.

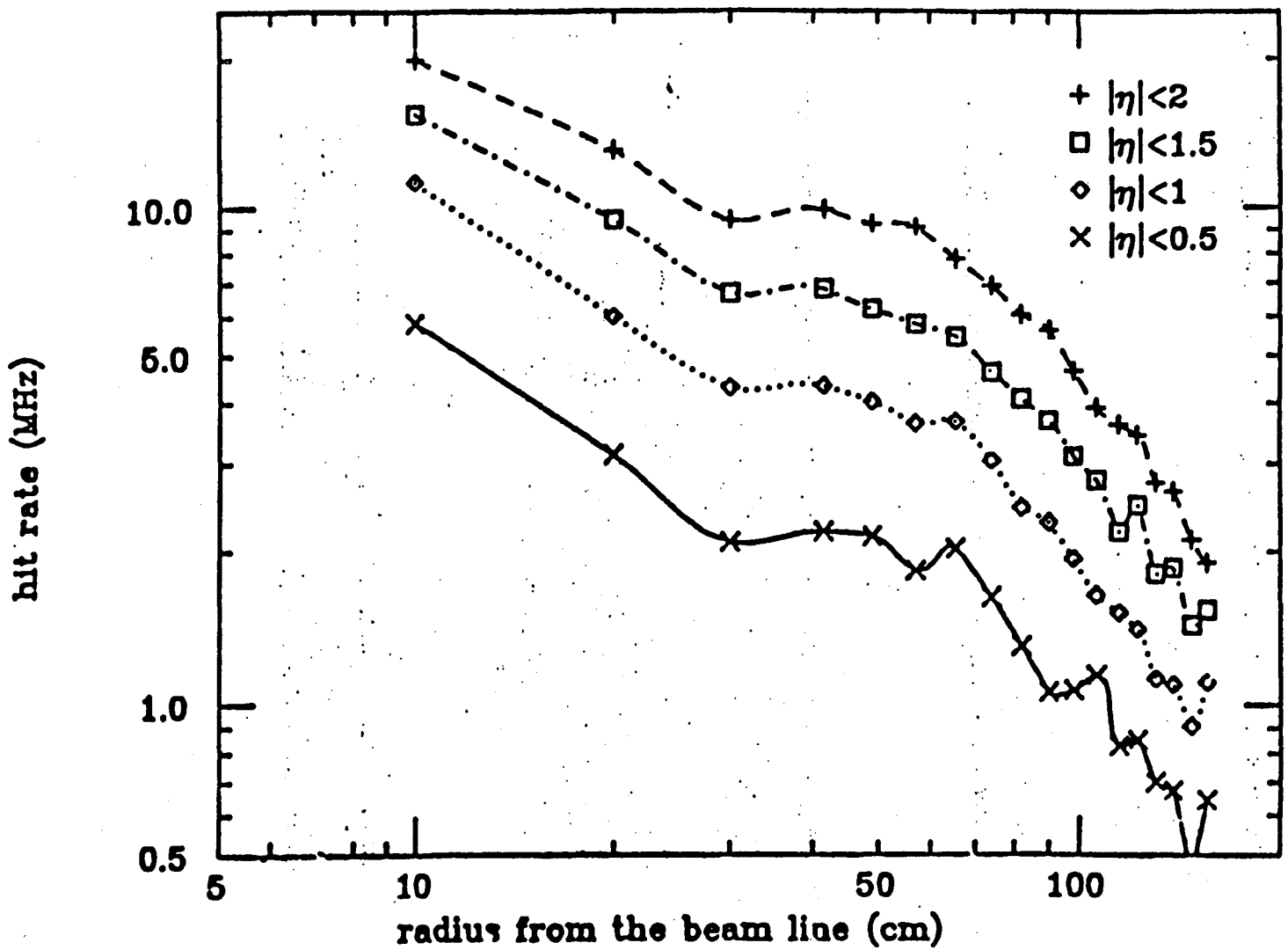
Isajet (TWOJET, $p_\perp > 4.5$ GeV)



Multiple crossings of superlayer by a track



Field 2 Tesla 5 mmϕ straw



From M. Asai, SSC-SDE-28

F. 1a

Field 2 Tesla primary particle only

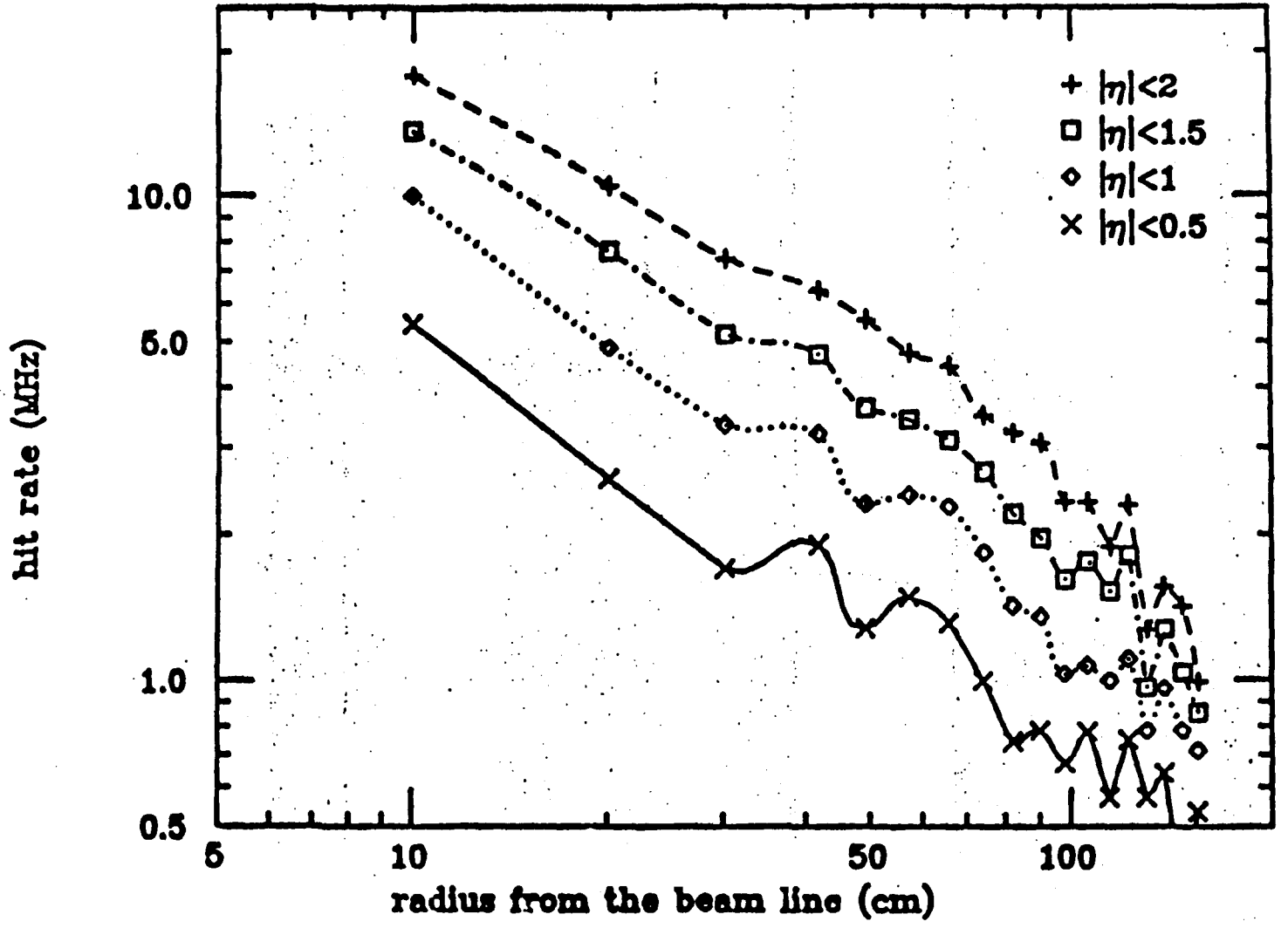
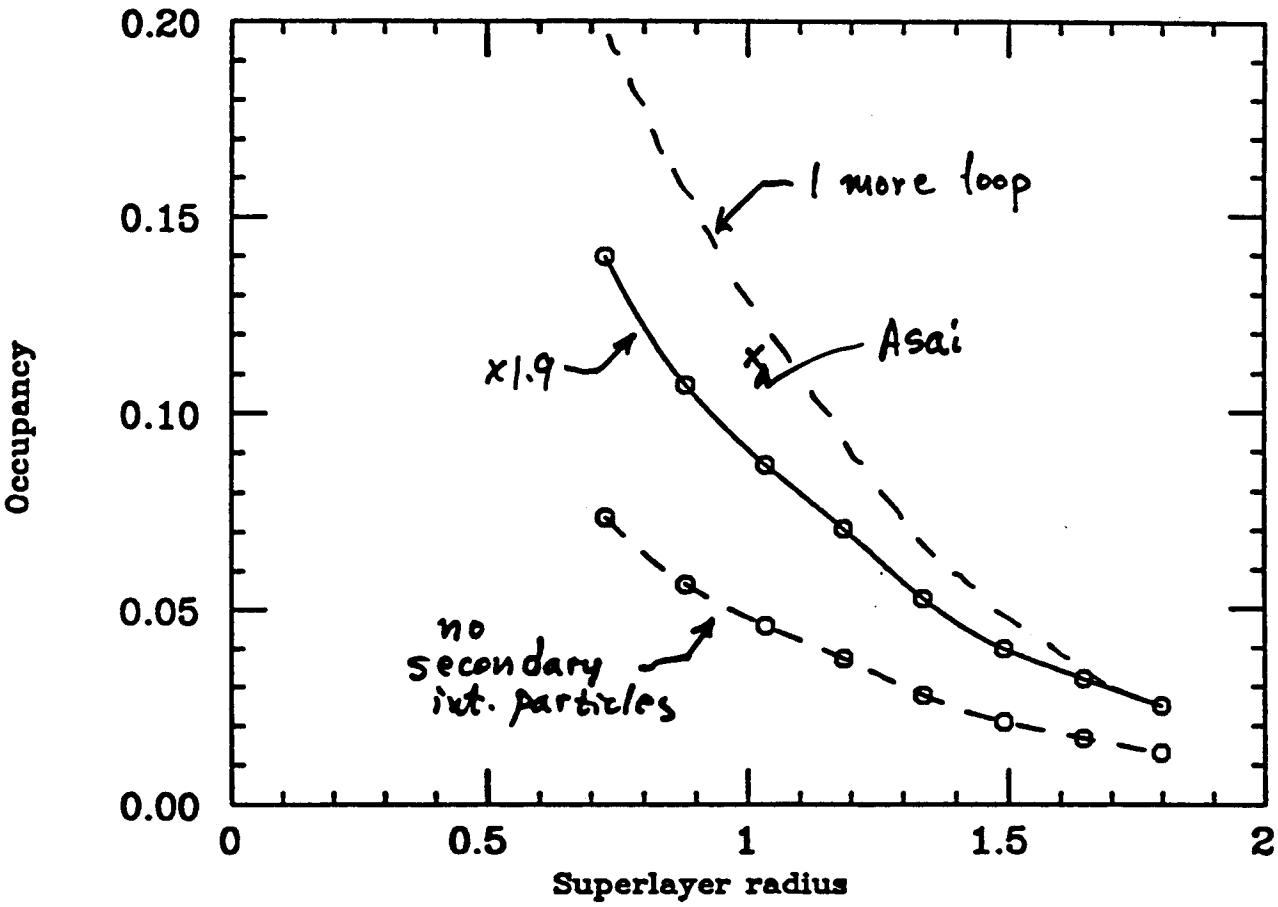


Fig 5a

Occupancy vs radius

$\mathcal{L} = 10^{33}$



Solid curve includes scale factor for secondaries a la Asai.

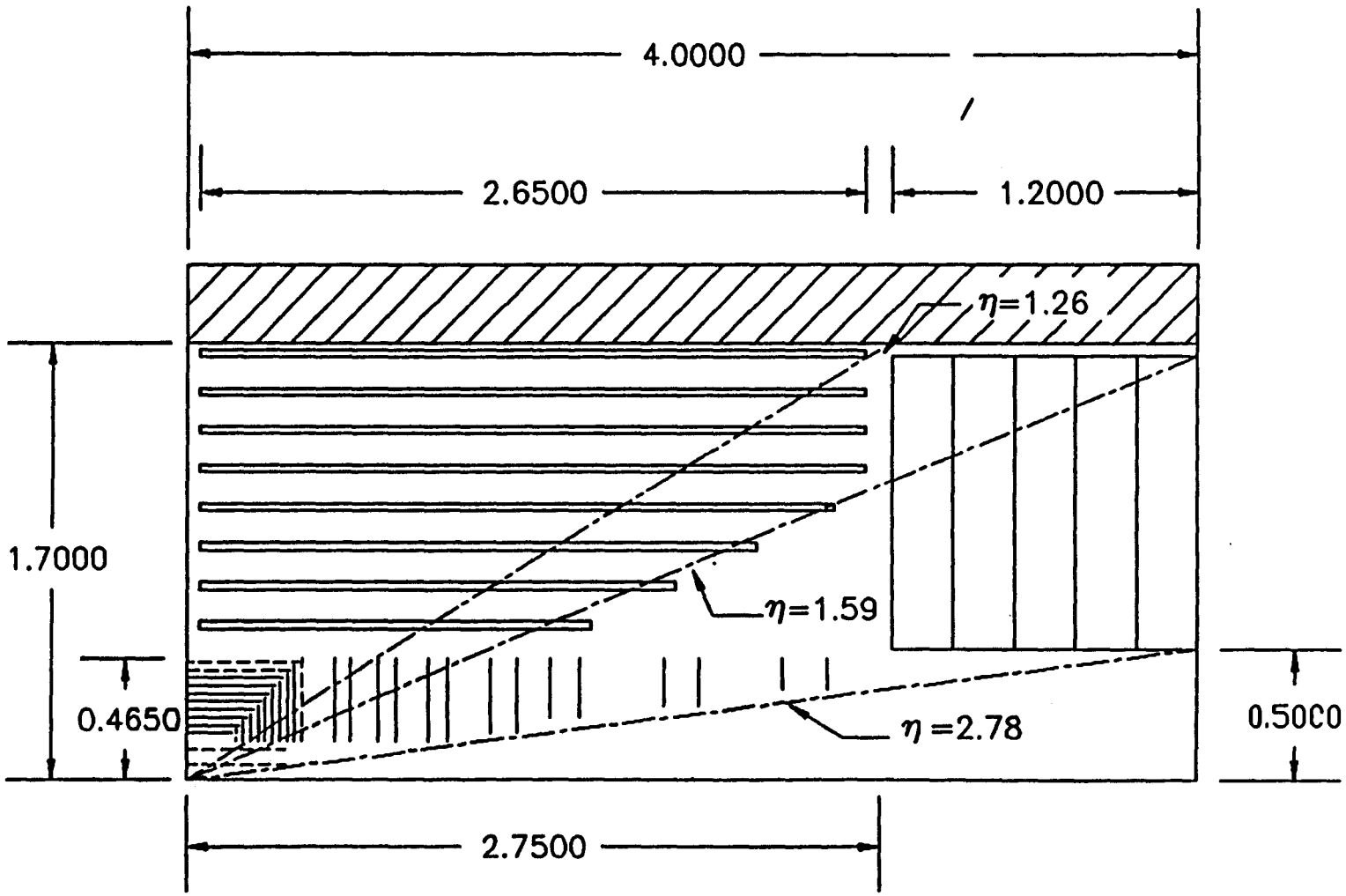
Silicon strip scope reduction

Phase 1: Keep no. of layers, reduce lever arm forward

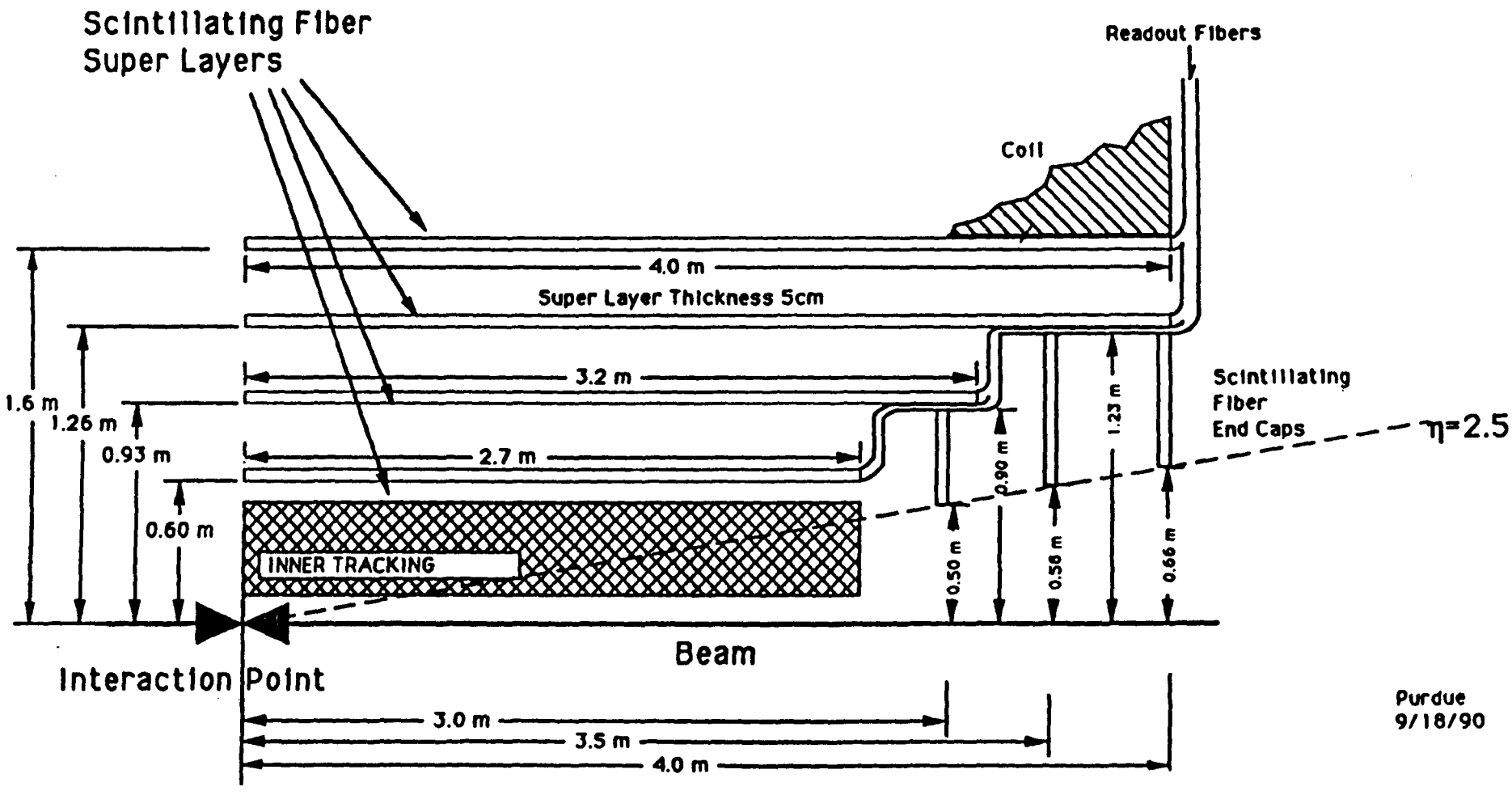
Phase 2: Make 20% of layers single-sided

Net reduction: 23%

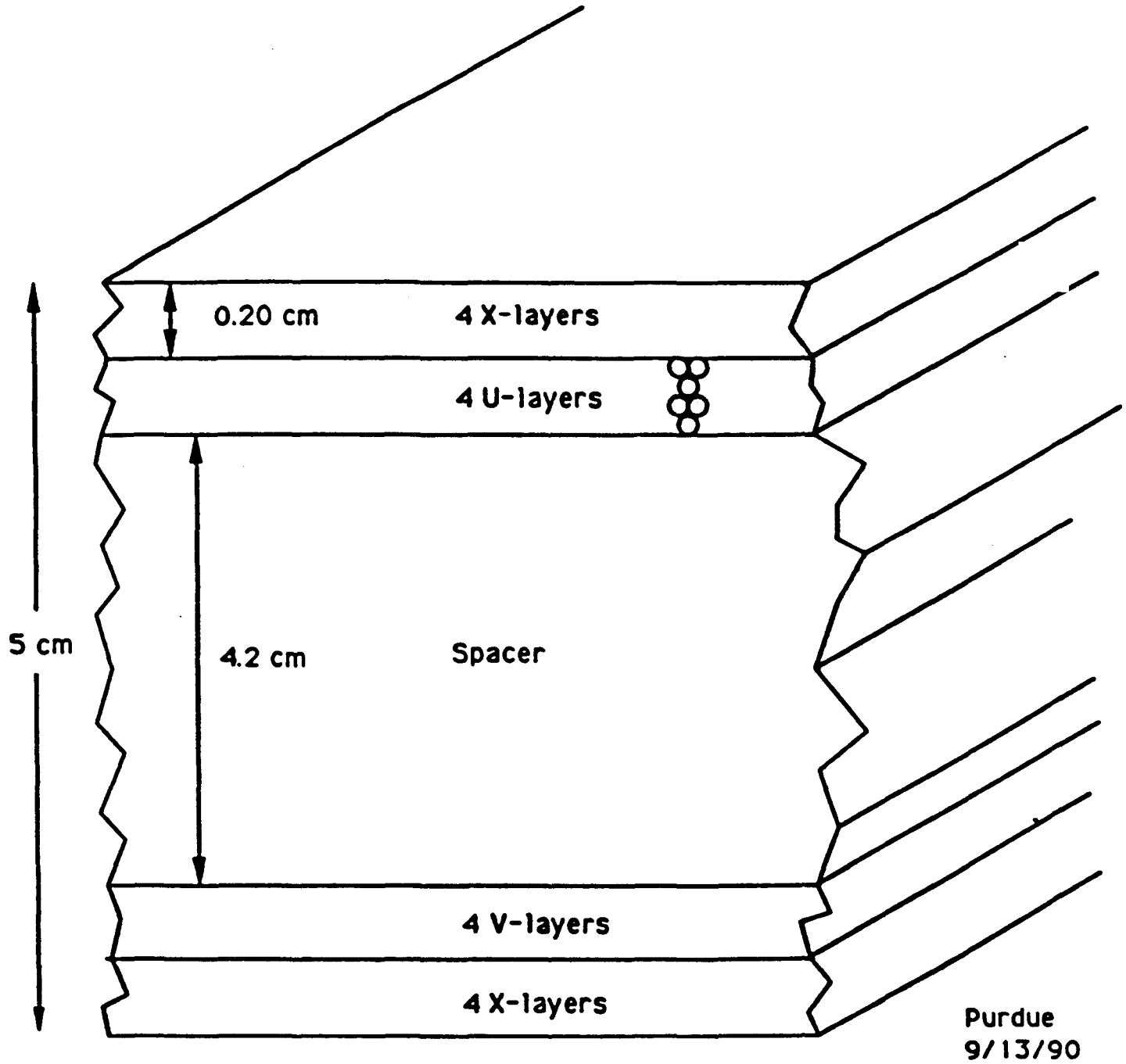
$500M proposal of 9/11/90



E


Scintillating Fiber
Super Layers
Readout Fibers
Coil
4.0 m
Super Layer Thickness 5cm
3.2 m
2.7 m
1.6 m
1.26 m
0.93 m
0.60 m
INNER TRACKING
0.50 m
0.90 m
0.58 m
1.23 m
0.66 m
Scintillating
Fiber
End Caps
η=2.5
Beam
Interaction Point
3.0 m
3.5 m
4.0 m
Purdue
9/18/90

Cross-section of a Super layer



$$\frac{\#\text{fibers}}{\text{super layer}} = \#\text{ layers} \times 2\pi R_{\text{average}} \frac{1}{d_{\text{fiber}}} \qquad (d_{\text{fiber}} = .075\text{cm})$$

Superlayer	ave. Radius (cm)	# of Layers	No. of fibers
1	62.5	8	41,890
2	96	8	64,340
3	129	16	172,920
4	162.5	16	217,790
			496,940

Total no. of fibers =2 halves x 496,940= 993,880

L Nodulman 9/20

NOVEMBER CALORIMETER REVIEW

CAL. TECH. COMM. CHARGED TO RANK OPTIONS

⇒ TWO TO HAVE SUBSTATIAL ENGINEERING SUPPORT

NONUNIFORM INITAL RESPONSE

→ STANDARD FORM

CALL FOR QUESTIONS/CRITIQUE OF "OTHER" OPTIONS (EMAIL BY 9/28)

WRITTEN (E-MAIL) FORMS/REPLY DUE 11/1

PRESENTATIONS @ LBL

DELIBERATION @ LBL

→ REPORT

to our last call for information. It reflects the charge (and subsequent comments) from Gil. I do not think there is anything requested which could not be reasonably provided by Nov. 1 if we can agree on a version at the Dallas meeting. Comments please!

CHARACTERIZATION OF SDC CALORIMETER OPTION _____

EM RESOLUTION STOCHASTIC _____%/(sqrt(E) (E in GeV)
CONSTANT _____%
NOISE 0.1x0.1 _____ GeV
Nonuniformity only constant ('good') _____%

HAD RESOLUTION e/h _____
STOCHASTIC _____%/sqrt(E) (E in GeV)
CONSTANT _____%
NOISE cone r=0.6 _____ GeV
Nonunifority only constant (jet<|2.4|) _____%

HERMETICITY GOOD e ACCEPTANCE _____%
EM RES. NOMINAL, AVERAGE, WORST (to 2.9) _____%, _____%, _____%
HAD RES. NOMINAL, AVERAGE, WORST (to 2.4) _____%, _____%, _____%
(Note: resolutions should be for 50 GeV Et electrons and 50 GeV Et jets. The Wormsley parameterization is sufficient.)

ELECTRON ID & TRIGGER
EM SHOWER POSITION RES. _____ mm
NOISE IN A CONE OF 0.15 _____ GEV
CHARACTERISTIC INTEGRATION TIME _____ ns
EM TRIGGER RESOLUTION _____%/SQRT(E), _____%, _____GeV, _____GeV
HAD TRIGGER RESOLUTION _____%/SQRT(E), _____%, _____GeV, _____GeV
(Note: that is stochastic, constant, electronic noise and pileup at 10**33 in 0.1x0.1.)

LINEARITY (Uncorrected) EM _____ %/100 GeV
HAD (pion) _____ %/100 GeV
Comment _____
_____

RADIATION SURVIVAL (best guess presently available)
(Note: this refers to plastic, electronics and everything. Two cases: 10 years at 10**33 and 5 years at 10**34 where one year is 10**7 sec on. Unaffected is defined as less than 1% change in EM resolution as online corrected. Degradation in absolute %, not fraction change or the number.)
UNAFFECTED PHASE SPACE |ETA| < _____, _____
DEGRADATION OF EM RESOLUTION, AVERAGE (in R) AFFECTED _____%, _____%
DEGRADATION OF EM RESOLUTION, WORST CASE _____%, _____%
REPLACEMENTS/FIXES ASSUMED ABOVE AND FEREQUENCY _____
_____
_____
(Note: include level of disassembly required.)

SAFETY ISSUES: LIST _____
IMPLICATIONS FOR ACCESS _____
_____
IMPLICATIONS FOR THE REST OF THE DETECTOR AND HALL _____
_____

CALIBRATION/MAINTAINANCE
STABILITY IN NORMAL OPERATION +/- _____% TYPICAL CHANNEL
WORST RAW CHANGE IN GAIN/MONTH @10**34 _____%
TESTBEAM REQUIREMENTS:

_____ TOWERS CALIBRATED
_____ TOWERS MAPPED IN DETAIL
_____ EXTRA MODULES FOR STUDY: DESCRIBE:

_____

LIST OPREATIONAL PROCEEDURES: _____

_____

COST AND SCHEDULE (CURRENT BEST GUESS, NO CONTINGENCY, '90$)

CHANNEL COUNT _____
TOTAL WEIGHT _____ > APPEND DETAILS
DENSITY _____
BOTTOM LINE (APPEND ESTIMATE) _____M$
MINIMUM DURATION FROM SERIOUS FUNDING TO COMPLETION
(APPEND SCHEDULE) _____ YEARS
OUTER RADIOUS FOR ACCESS / OTHER DETECTORS _____ m

APPEND DRAWINGS:

SIDE VIEW
END VIEW
RADIATION LENGTHS VS ETA (AND PHI AS NEEDED) LIVE AND DEAD THROUGH 30.
ABSORPTION LENGTHS VS ETA (AND PHI AS NEEDED) LIVE AND DEAD
SCHEME FOR MECHANICAL SUPPORT (ROUGH)

NOTE: Material in support of the above is restricted to a total of 25 pages total, in order to facilitate wide distribution. As much as possible should be in electronic form.

Prepared by _____ Date_____

THE FOLLOWING IS A SAMPLE (FAKED) OF WHAT ANSWERS MIGHT LOOK LIKE:
OPTION: imaginary
EM RESOLUTION: 17, 1.5, 0.03, 1.4
HAD: 1.05, 60, 3, 0.4, 2
HERM: 94, 2.5, 2.6. 3.1, 9, 10, 12
E, TRIG: 2, 0.1, 32, 20, 2, 0.1, 0.1, 70, 4, 0.2, 0.1
LIN: 1, 2.5, both correctable to <0.2% up to 1 TeV
RAD: 2.4, 2.2, 1.5, 2.2, 2, 4, eta > 2.6 replaced every 2x10**41, not needed if better plastic. Same as access to tracking end, 50 ton crane. No need for complete disassembly to get at electronics.
SAFETY: high voltage, sources, access: falling, ventilation, monkey bars on doorlike muon chambers, sources internally housed, HV encapsulated, fans at opening to space between muon chambers, multiple exits in muon system
CALIB: <0.5, 0.2, 250, 250, 2, two central wedges and two end sectors, peds, charge injection, light flashers, mobile sources
COST AND SCHEDULE: 4x 10.8k towers, 250x256 mult. prerad, 25000T, 9 g/cc, 80, 4, 4.1
J. Fred Muggs, 9/5/90
(Note that answers should be directly editted into the blanks!)

DATE		TASK / MILESTONE
~ JAN 94		Begin FINAL FAB
Summer 93	▲	detailed design review (whole detector) [ALL problems 'solved']
FALL 92 ~~Summer 92~~ - Early 93		design VALIDATION ~~Prototype~~ beam test
JAN 92		Begin Full Preliminary design - Final module
FALL 91	▲	PROPOSAL DUE
JAN 92 ~~August 91~~	▲	MAKE Technology choice R & D completed - remaining problems 'just' engineering
SUMMER ~~SO FAR~~		Then begin FAB
~~Spring~~ 91		Test beam MODULE design review, ~~The begin FAB~~
NOV 90	▲	Technical REVIEW - LOI for simulation
FALL 90 - Spring 91		Test beam MODULE design - prototype + Preliminary calorimeter design (rough)

PRESENTATIONS TODAY

UPDATES ON

PLATES
SPAGHETTI
LIQUID ARGON
PREADATORS

FRIDAY

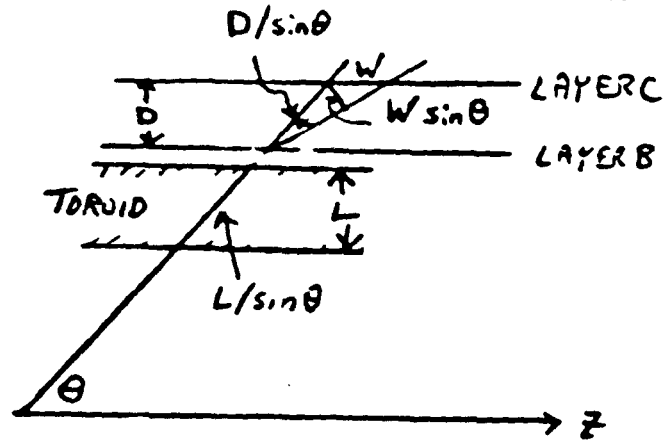
AM BRIEF ORGANIZATION
OPTION MEETINGS

PM JOINT CAL GROUP

FIG 6

Scintillator Segmentation for Uniform $P_\perp$ Thresholds

Naively:



1.) CENTRAL REGION

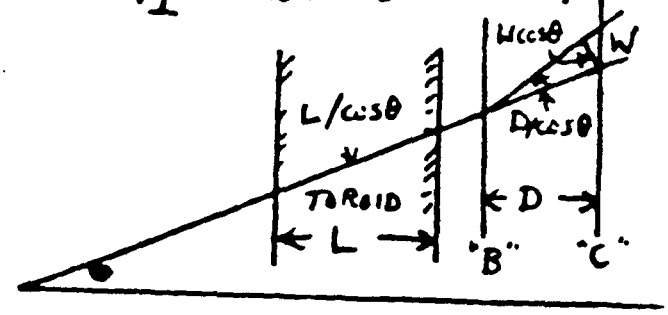
Counter width W defines a bend-angle

$$\alpha \approx \frac{W\sin\theta}{D/\sin\theta} = \frac{W}{D}\sin^2\theta$$

$$P_\perp = p\sin\theta \approx \frac{0.3B\frac{L}{\sin\theta}}{\alpha}\sin\theta = \frac{0.3BLD}{W\sin^2\theta}$$

so want $$\boxed{W \approx \frac{0.3BLD}{P_\perp \sin^2\theta}}$$

In the Monte Carlo $W = \frac{\text{const}}{\sin^2\theta}$ does give uniform $P_\perp$ thresholds vs θ.



2.) FORWARD REGION

$$\alpha \approx \frac{W\cos\theta}{D/\cos\theta} = \frac{W}{D}\cos^2\theta$$

$$P_\perp = p\sin\theta \approx \frac{0.3B\frac{L}{\cos\theta}}{\frac{W}{D}\cos^2\theta}\sin\theta = \frac{0.3BLD}{W}\frac{\sin\theta}{\cos^3\theta}$$

or $$\boxed{W \approx \frac{0.3BLD}{P_\perp}\frac{\sin\theta}{\cos^3\theta}}$$

In the Monte Carlo, this gives a somewhat non-uniform response. Empirically $W \approx [\sin\theta]^{1.35}$ works OK.

R. THUN
9 SEP 90

FIG 4 POSSIBLE COUNTER SEGMENTATION

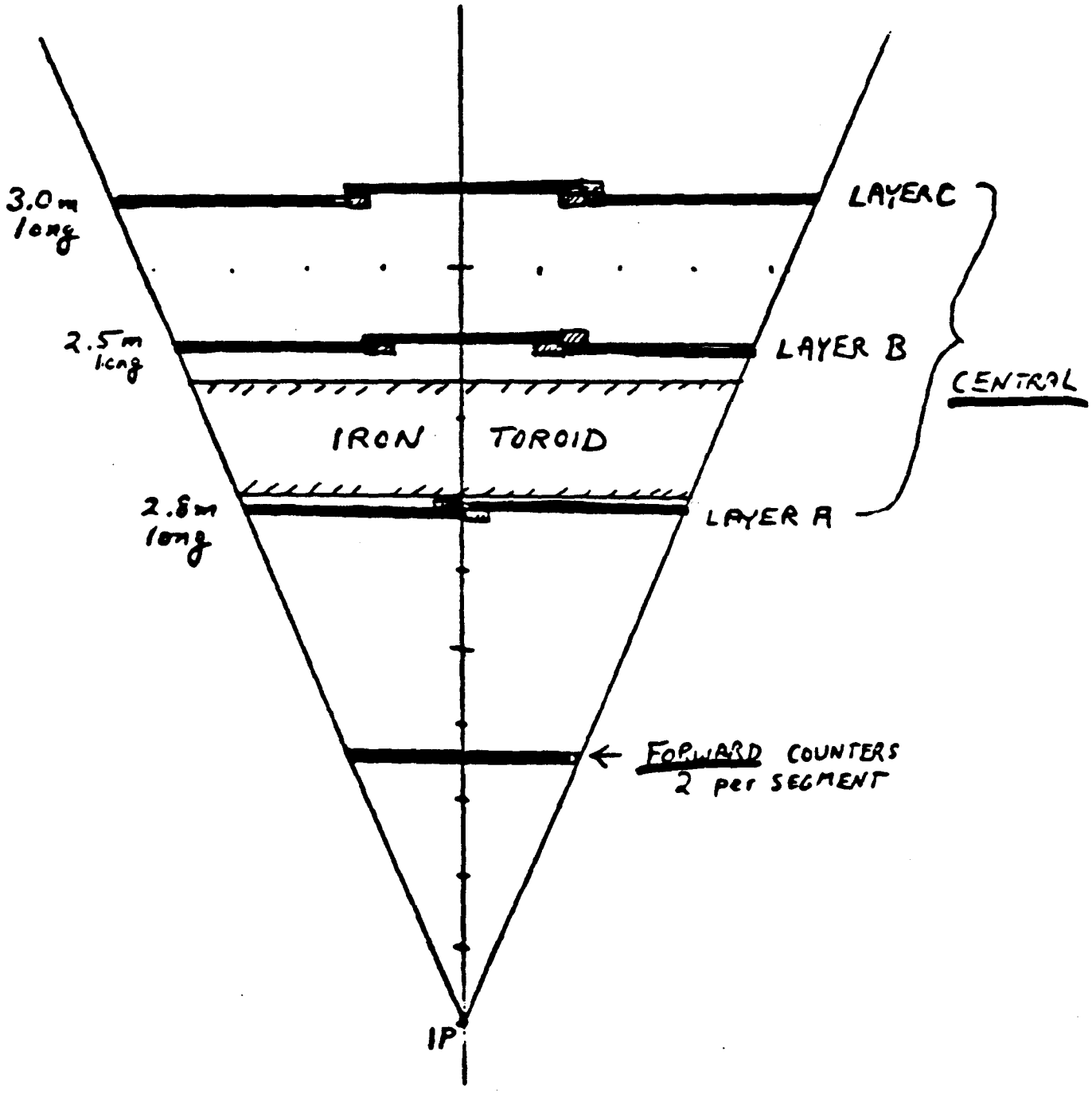


FIG. 7

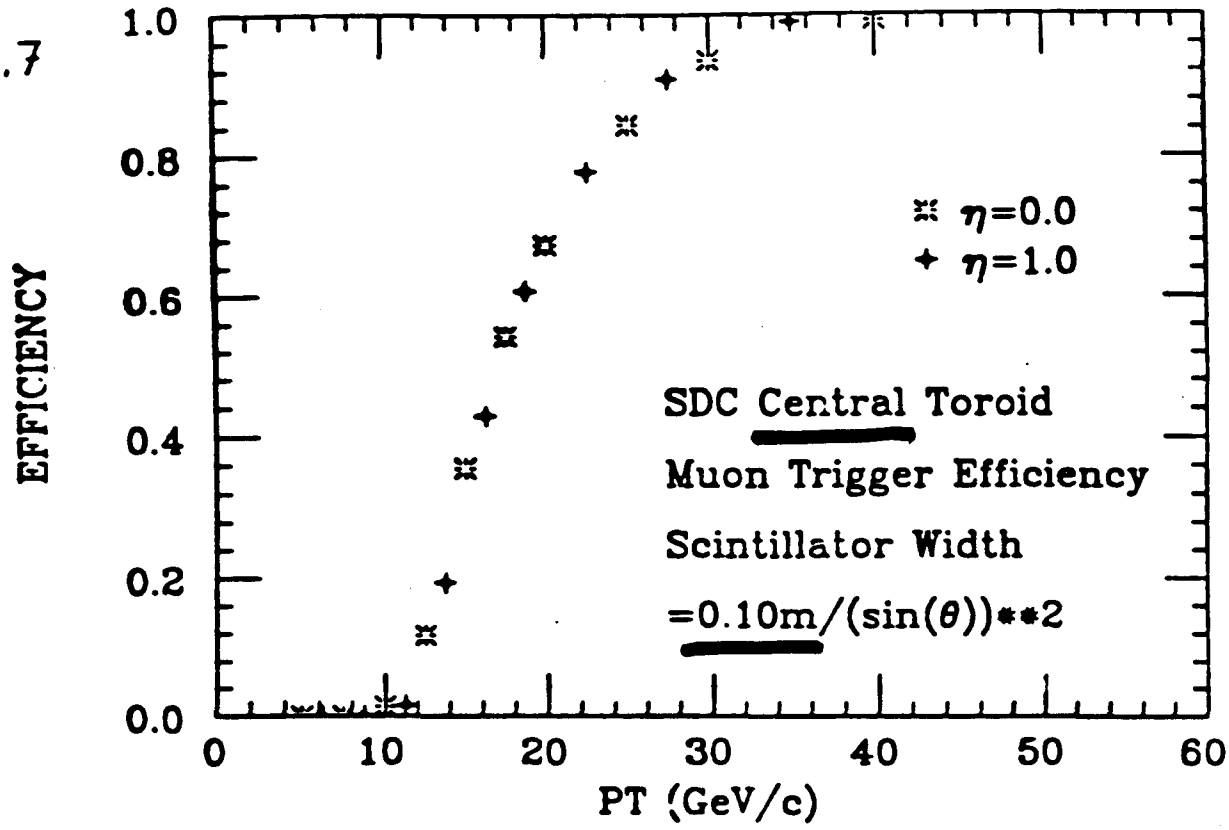

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=0.0
η=1.0
SDC Central Toroid
Muon Trigger Efficiency
Scintillator Width
=0.10m/(sin(θ))**2

FIG. 8

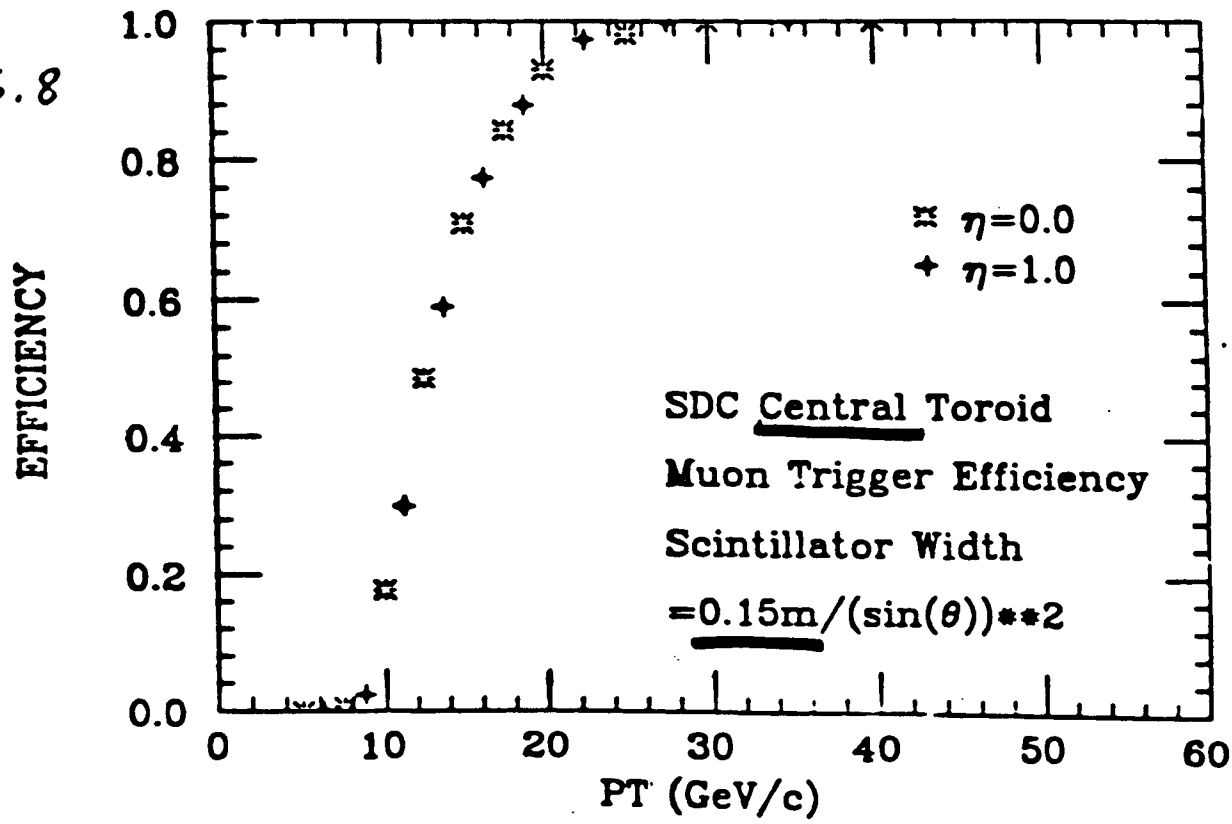

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=0.0
η=1.0
SDC Central Toroid
Muon Trigger Efficiency
Scintillator Width
=0.15m/(sin(θ))**2

FIG 9

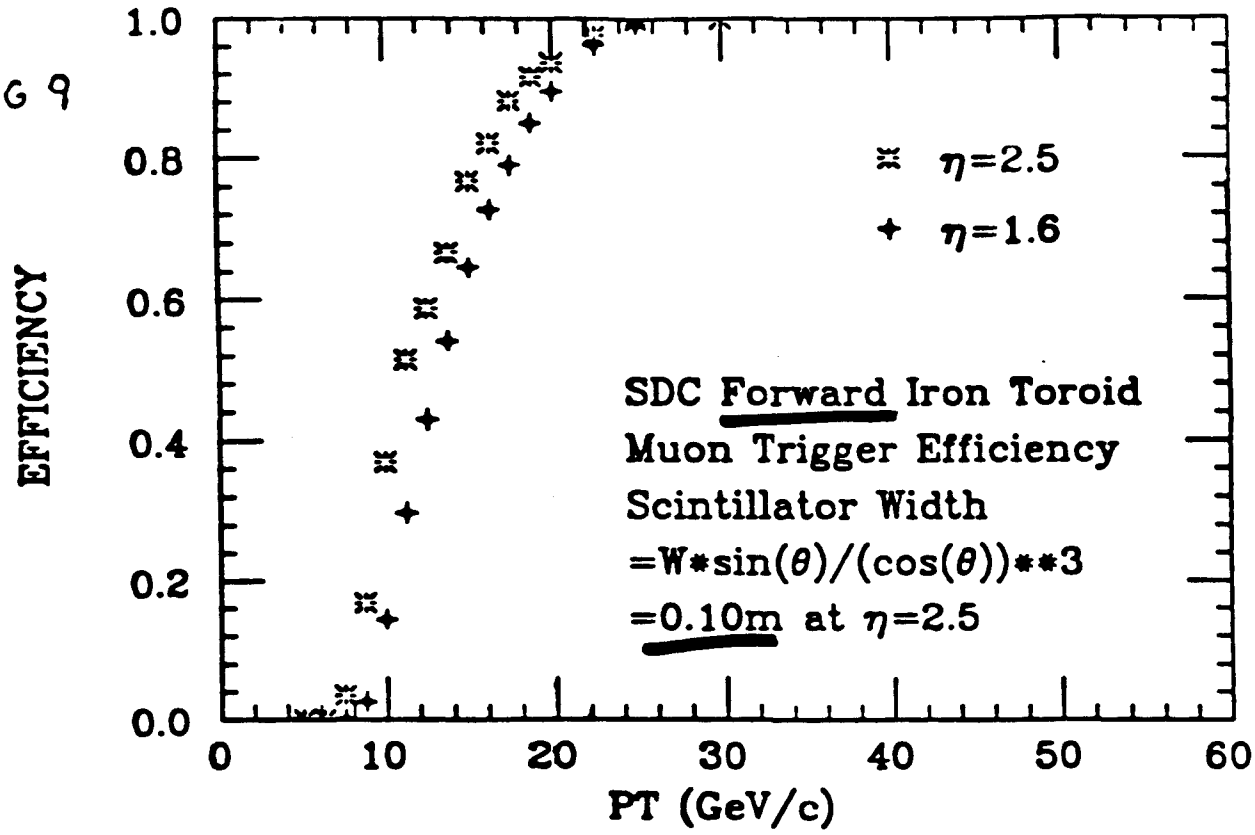

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*sin(θ)/(cos(θ))**3
=0.10m at η=2.5

FIG 10

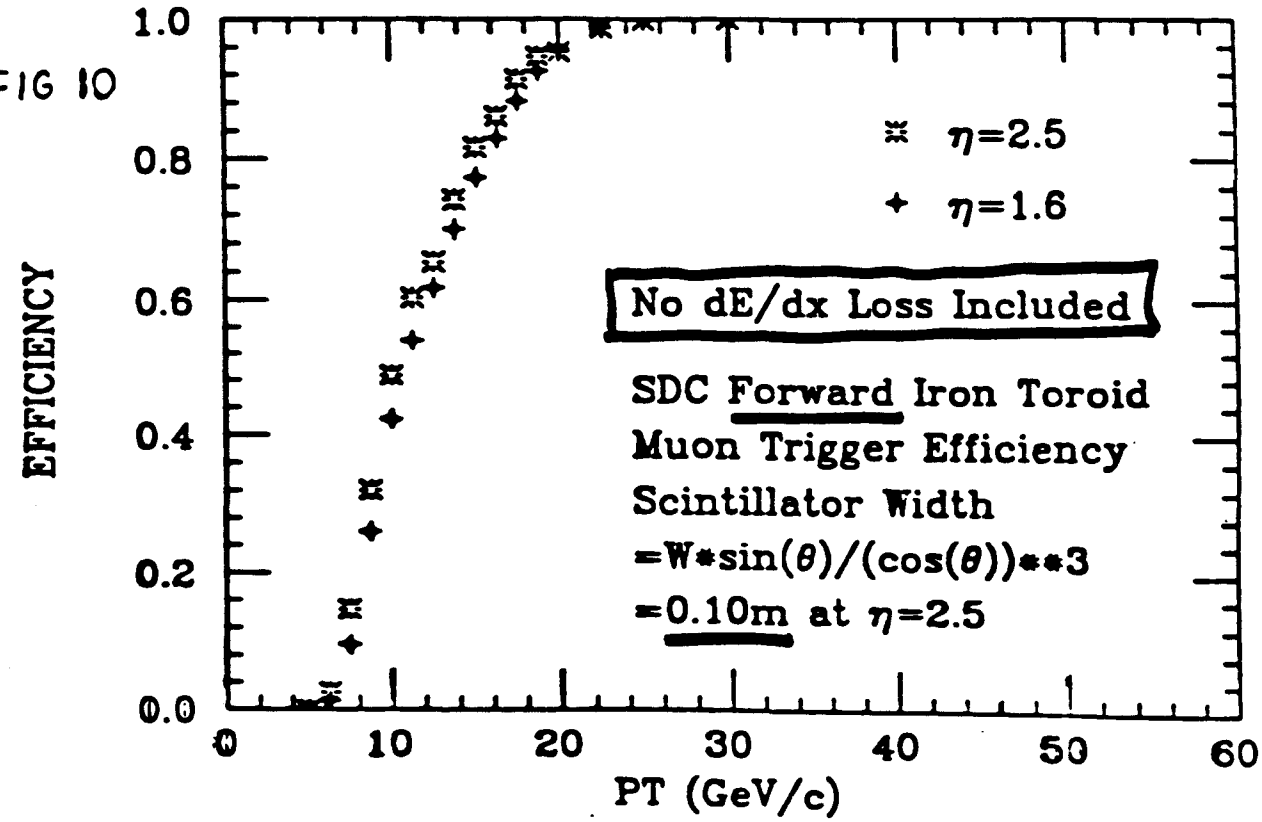

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
No dE/dx Loss Included
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*sin(θ)/(cos(θ))**3
=0.10m at η=2.5

FIG. 11

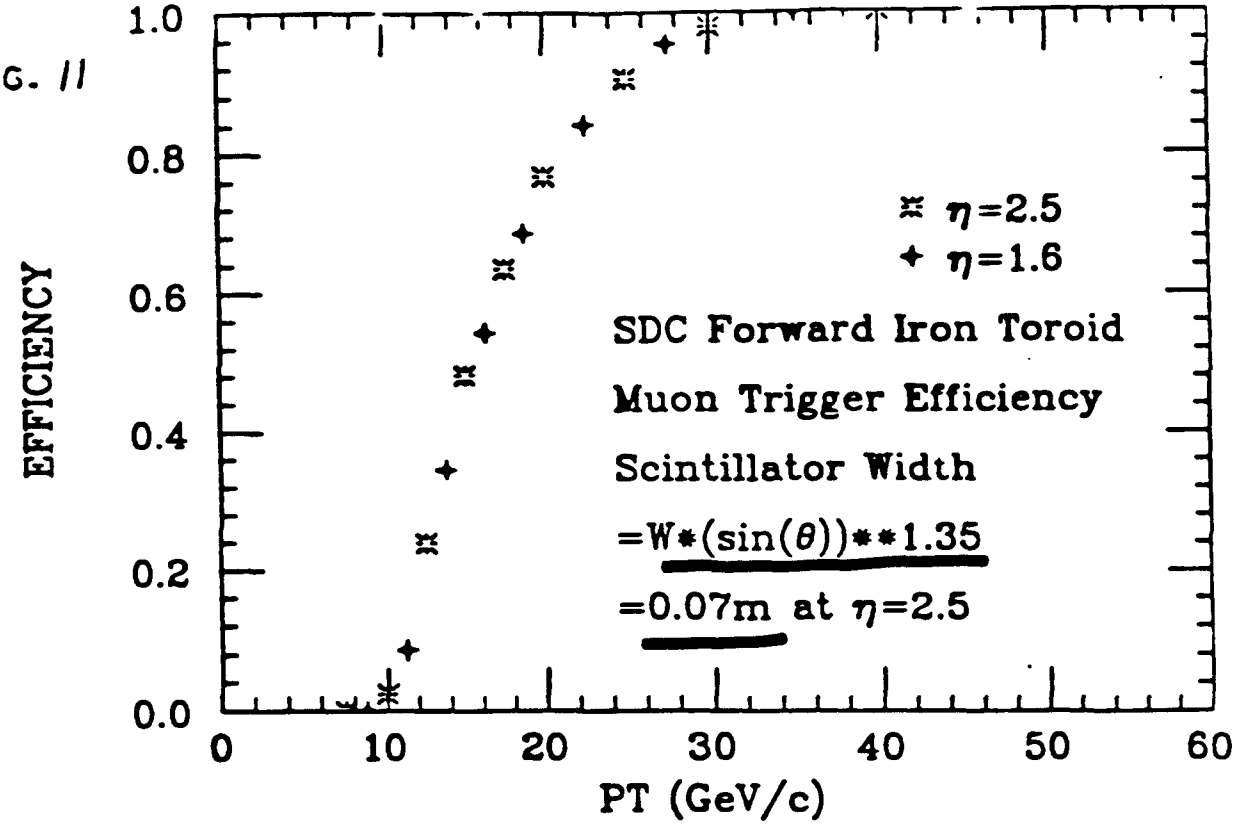
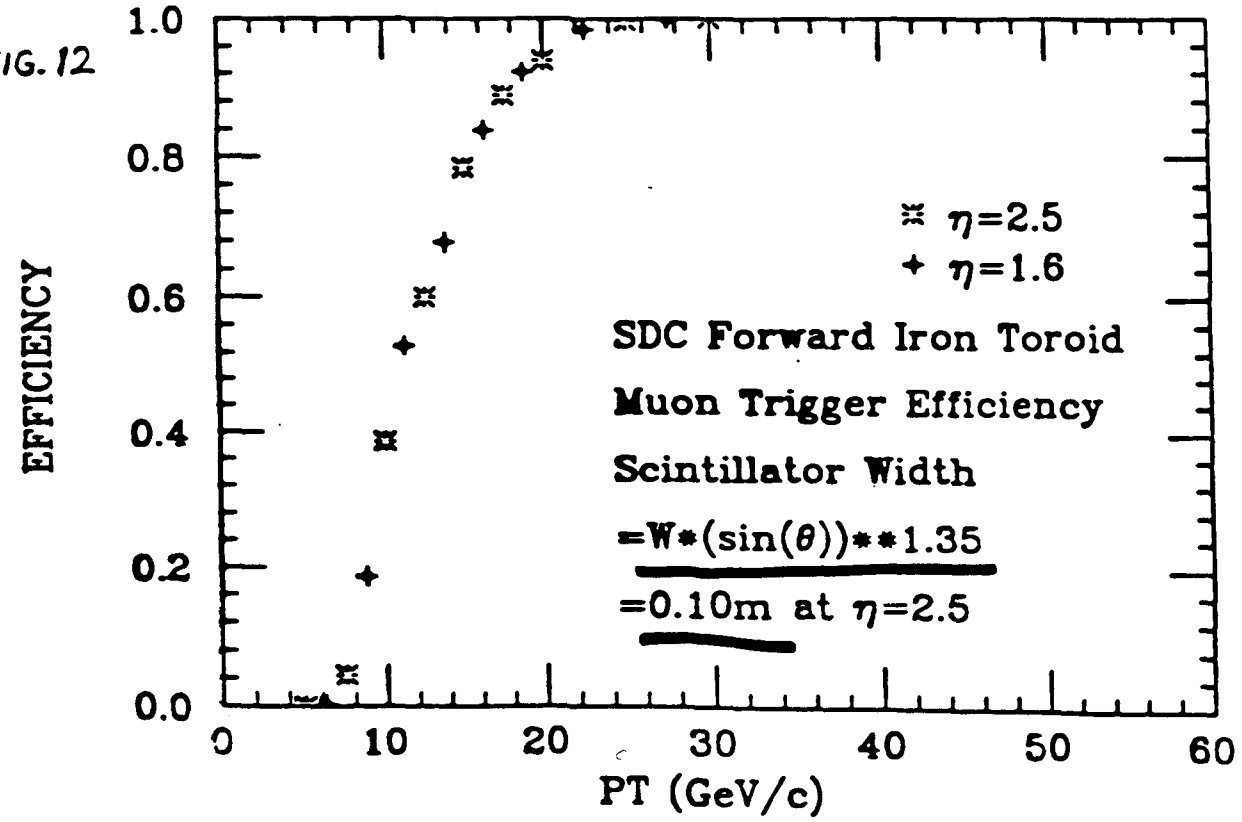

1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*(sin(θ))**1.35
=0.07m at η=2.5

FIG. 12


1.0
0.8
0.6
0.4
0.2
0.0
EFFICIENCY
0
10
20
30
40
50
60
PT (GeV/c)
η=2.5
η=1.6
SDC Forward Iron Toroid
Muon Trigger Efficiency
Scintillator Width
=W*(sin(θ))**1.35
=0.10m at η=2.5

09/15/90

SDC MUON SCINTILLATOR TRIGGER RATES DUE TO COSMIC MUONS.

Seong. Hong

MICH :: HONG

HONG @ UMIPHYS

o. Cosmic muon flux - empirical formula (1 GeV ~ 100 TeV)

$$I(h,\theta_M) = \frac{174}{h\cos\theta_M + 400}(h + 10\sec\theta_M)^{-1.53}\,\frac{h+75}{h+50+25\cdot\sec\theta_M}$$

$$\times\; e^{-8.0\times10^{-4}(h+10\sec\theta_M)}$$

where h : depth in hg/m^2

θ_M : angle with respect to the vertical direction

At shallow depths

$$I(h,\theta_M) = I(h,0)\cos^n\theta_M \qquad n = 1.53 + 8.0\times10^{-4}\,h$$

where

$$I(h,0) = \frac{174}{h+400}(h+10)^{-1.53}\,e^{-8.0\times10^{-4}h}$$

Our case

$$h = \underset{\text{air}}{10.3} + \underset{\substack{100\text{ ft}\\ \text{of dirt}}}{80.3} = 90.6\ hg/m^2$$

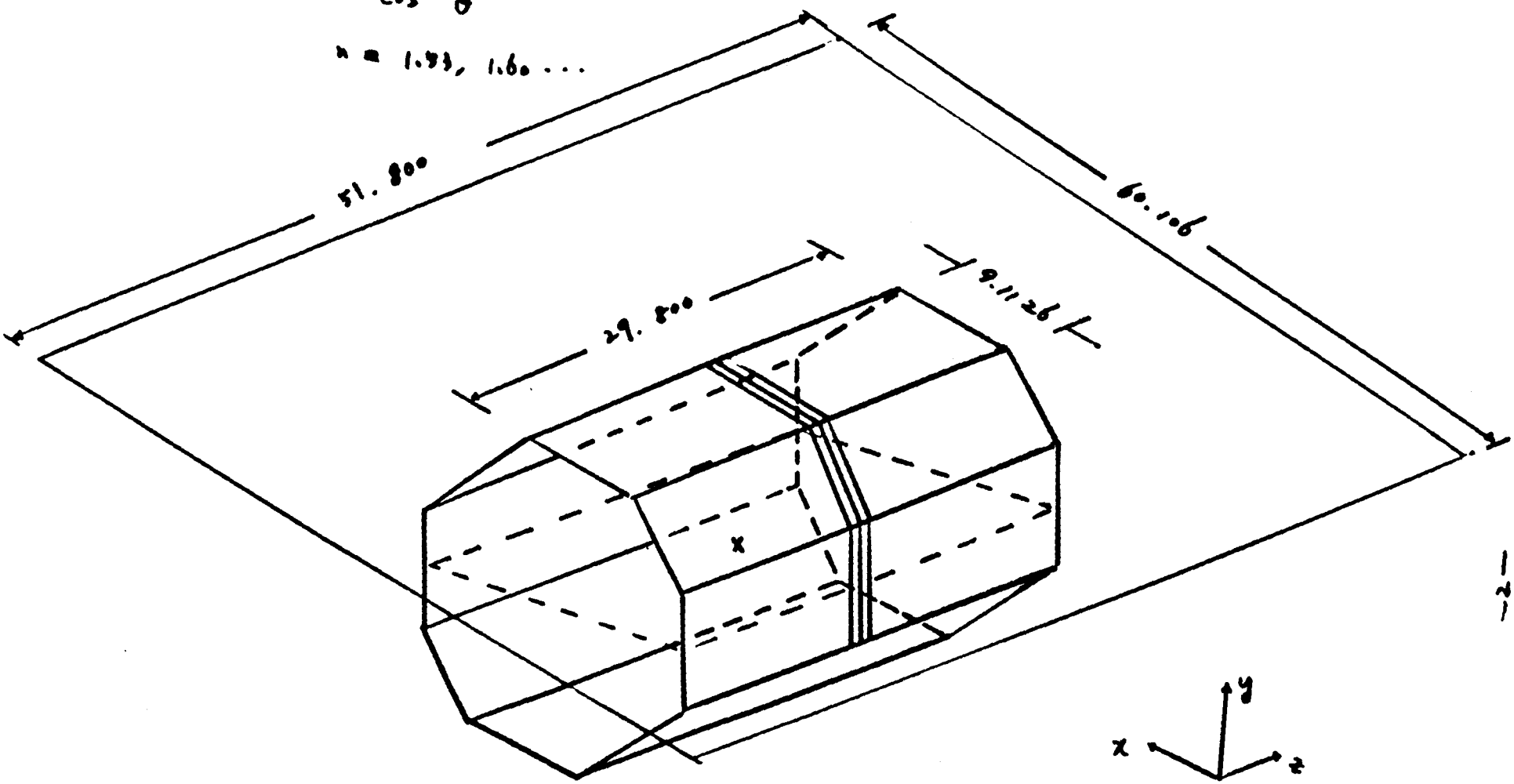
$$\int_{\theta_M=0}^{\pi/2}\int_{\varphi=0}^{2\pi} I(h,\theta_M)\,d\Omega = \underline{12\ /m^2\cdot sec.}$$

• Generate cosmic muons on a plane ($y = 11.000$ m).

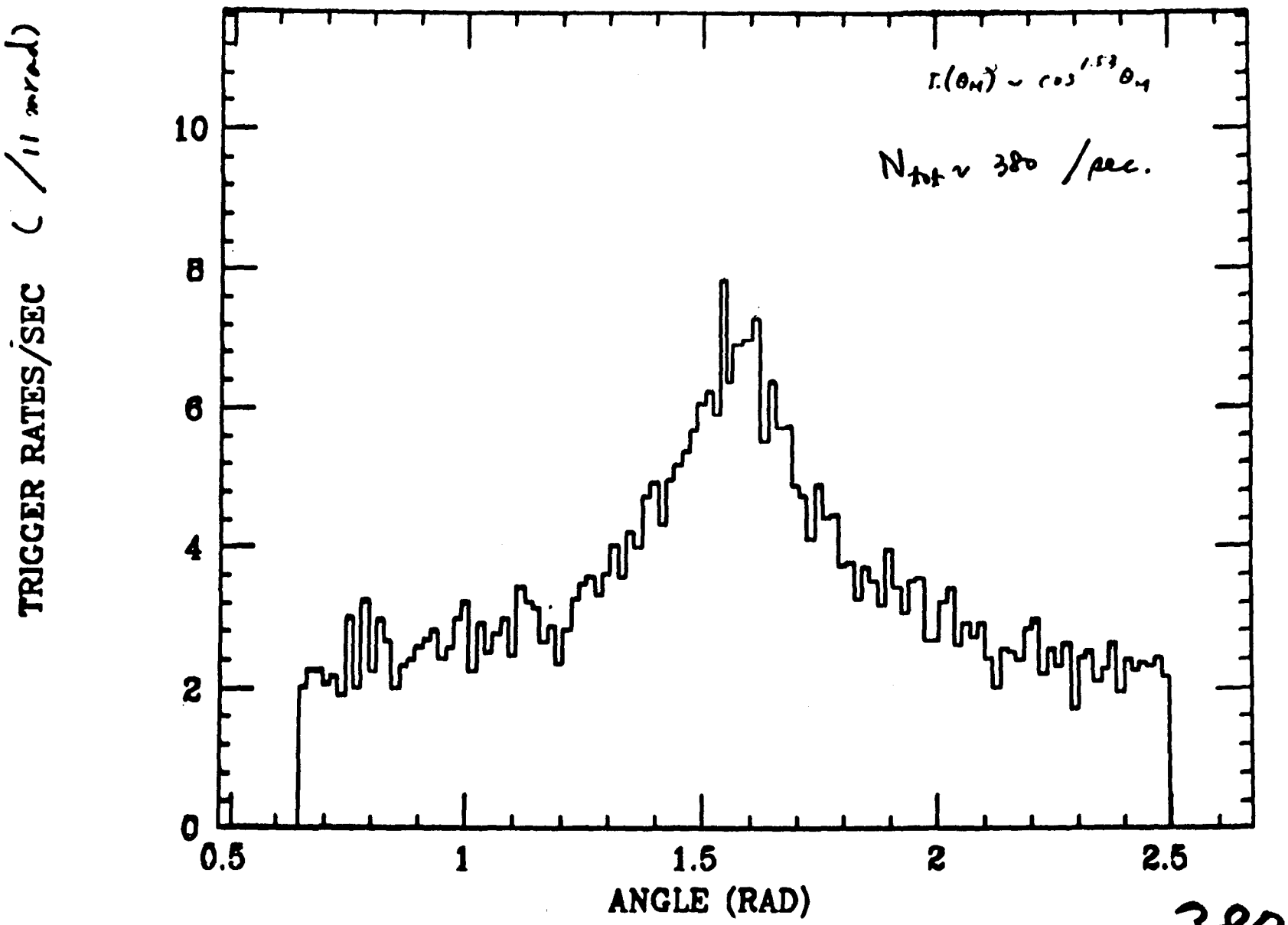
x_M, z_M, φ_M : flat distributions

$\theta_M \sim \cos^n \theta$

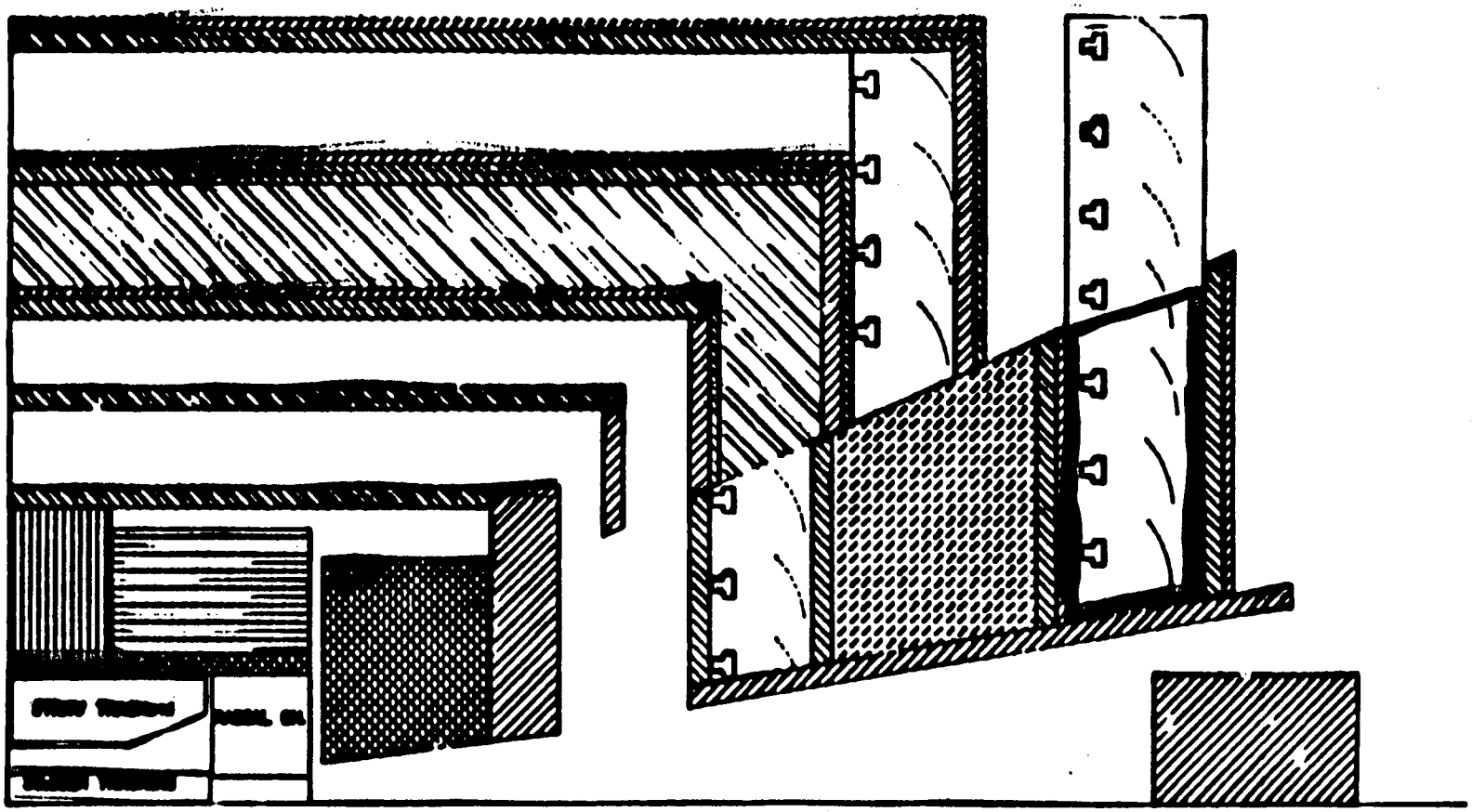
$n = 1.93, 1.60 \ldots$



SDC MUON SCINTILLATOR TRIGGER RATES



TOTAL CENTRAL COSMIC RAY RATE = $\frac{380}{sec}$



U. NAUENBERG : ČERENKOV TRIGGER

1 phototube / m^2

ADVANTAGES

1) Singles rates only due to muons with

$$P_t \gtrsim 10\ GeV/c$$

Reduces singles by $\sim 10^{-3} - 10^{-4}$

2) Not sensitive to low energy neutrons

3) Greatly reduced sensitivity to ~~low~~ cosmic rays

BUT

4) Need to understand effect of delta ray electrons.

Beam test Fermilab Nov 1990-[illegible]
Feb-March [illegible]

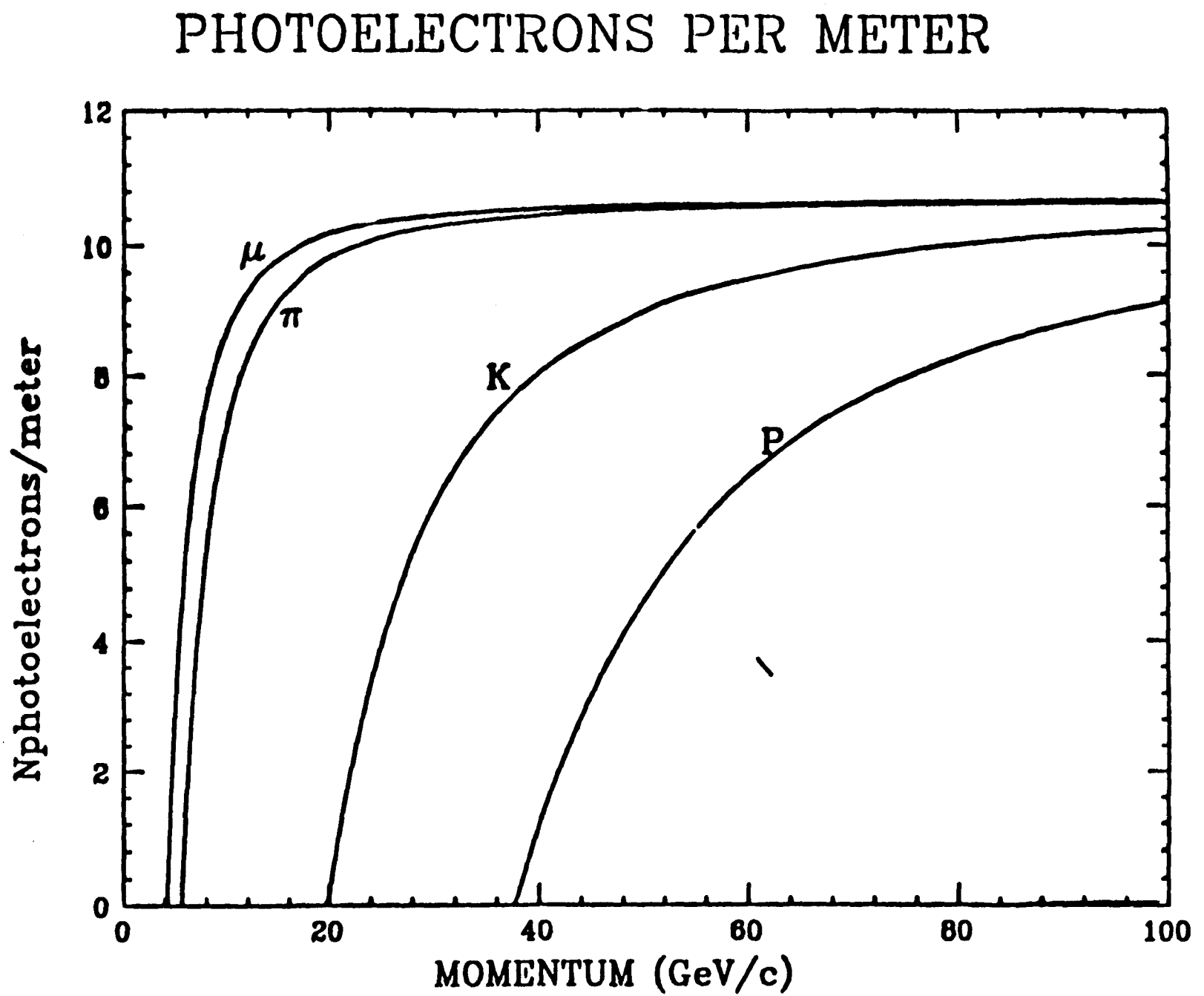

PHOTOELECTRONS PER METER
Nphotoelectrons/meter
MOMENTUM (GeV/c)
μ
π
K
P
0
2
4
6
8
10
12
0
20
40
60
80
100

FIG. 2

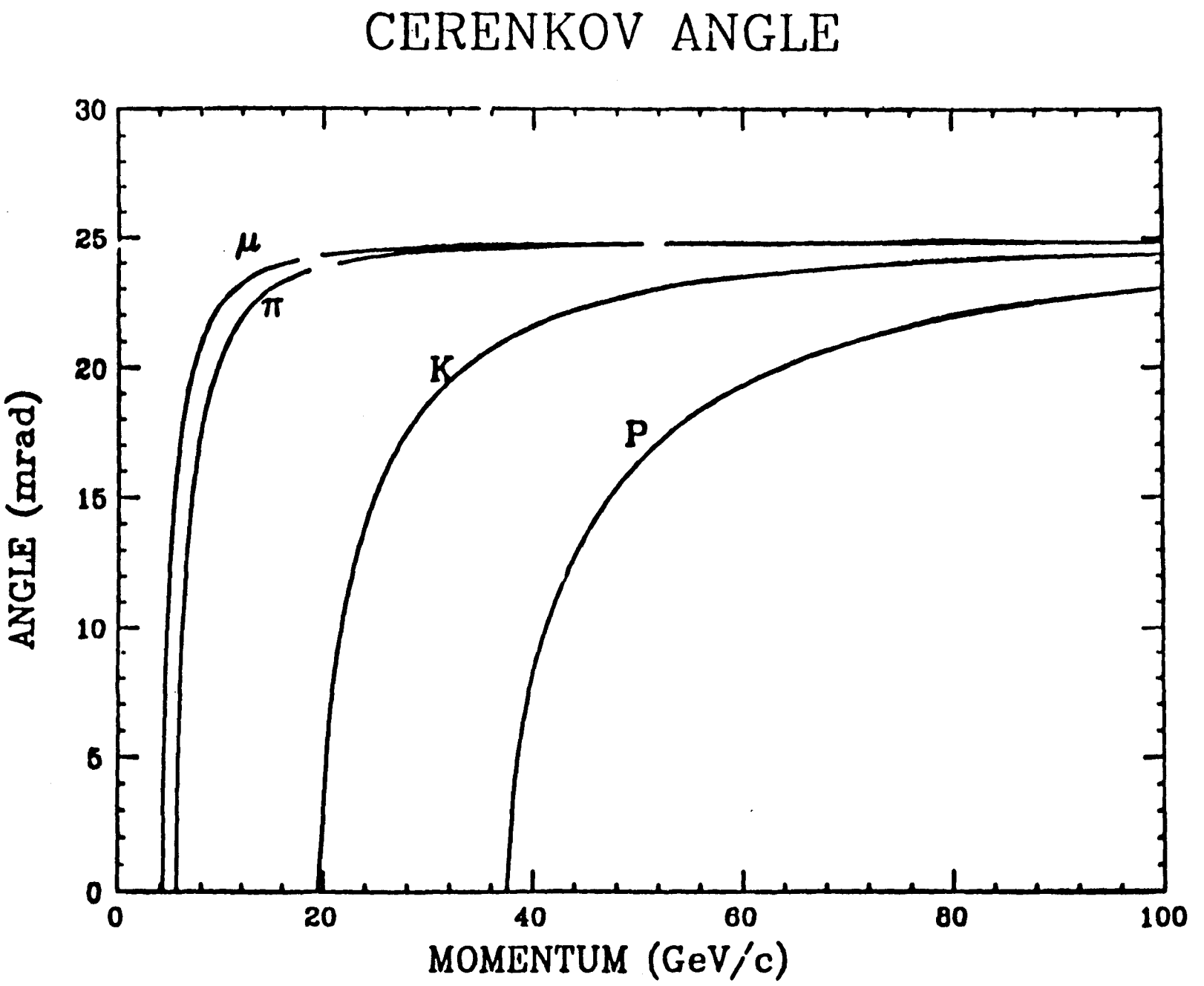

CERENKOV ANGLE
ANGLE (mrad)
MOMENTUM (GeV/c)
μ
π
K
P
0
5
10
15
20
25
30
0
20
40
60
80
100

FIG. 1

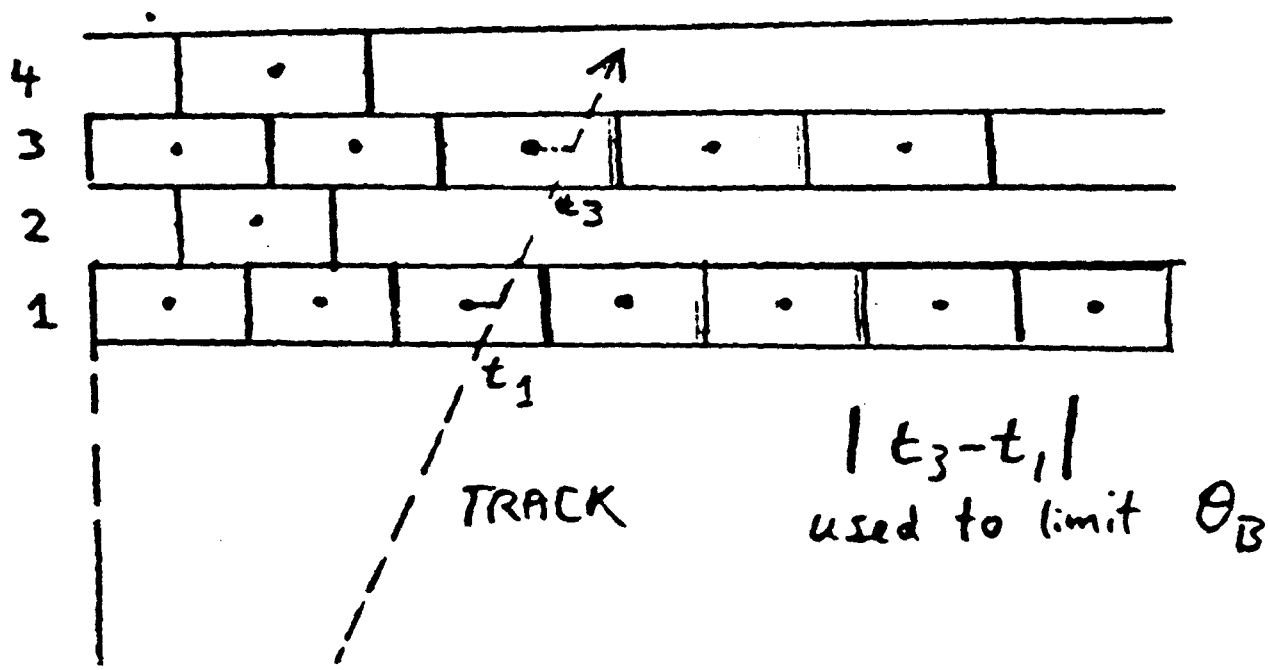
WIRE CHAMBER TRIGGER (J. Chapman)

1.) VERY DIFFICULT TO DO NON-LOCAL 1st LEVEL TRIGGERS

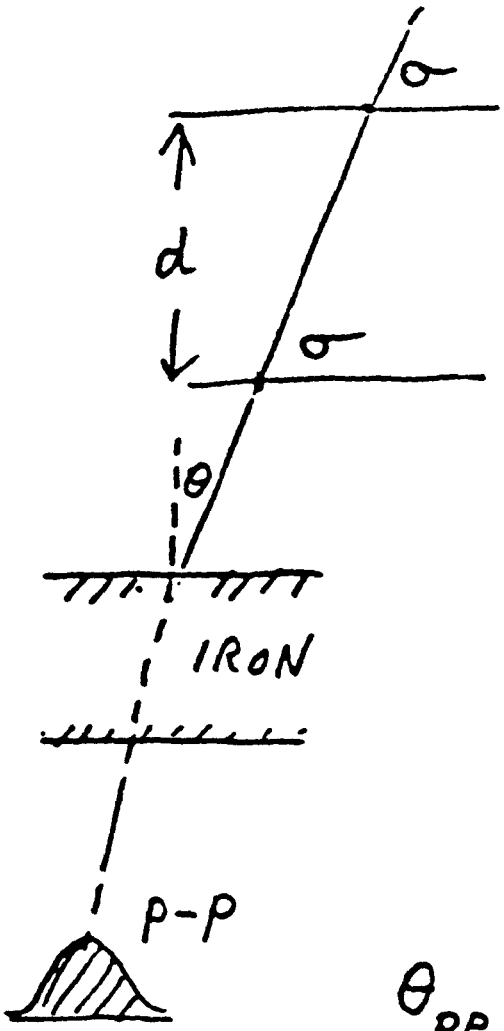
2.) LOOK AT LOCAL TRIGGERS BASED ON DRIFT-TIME DIFFERENCES (A LA CDF).

→ REQUIRES PROJECTIVE GEOMETRY

CAN BE IMPLEMENTED WITH CELLS WHOSE WIDTH VARIES SLIGHTLY WITH LAYER:



MUON WIRE CHAMBER TRIGGER



$$\boxed{\theta = \frac{810\ \text{mr}}{p}}$$

$$\theta_{ms} \approx \frac{.014}{p}\sqrt{200 X_0}$$

$$\approx \frac{200\ \text{mr}}{p}$$

$$\theta_{int} \approx \frac{\sqrt{2}\sigma}{d} \approx \frac{1.4\ \ 250\mu m}{10\,cm}$$

$$= 3.5\ \text{mr}$$

$$\theta_{pp} \approx \frac{5\,cm}{900\,cm} \approx 5.5\ \text{mr}$$

at $\boxed{p = 20\ \text{GeV}}$ $\quad \delta\theta = \sqrt{(10)^2 + (3.5)^2 + (5.5)^2}$

$$\boxed{\begin{array}{l} \delta\theta = 12\ \text{mr} \\ \theta = 40.5\ \text{mr} \end{array}}$$

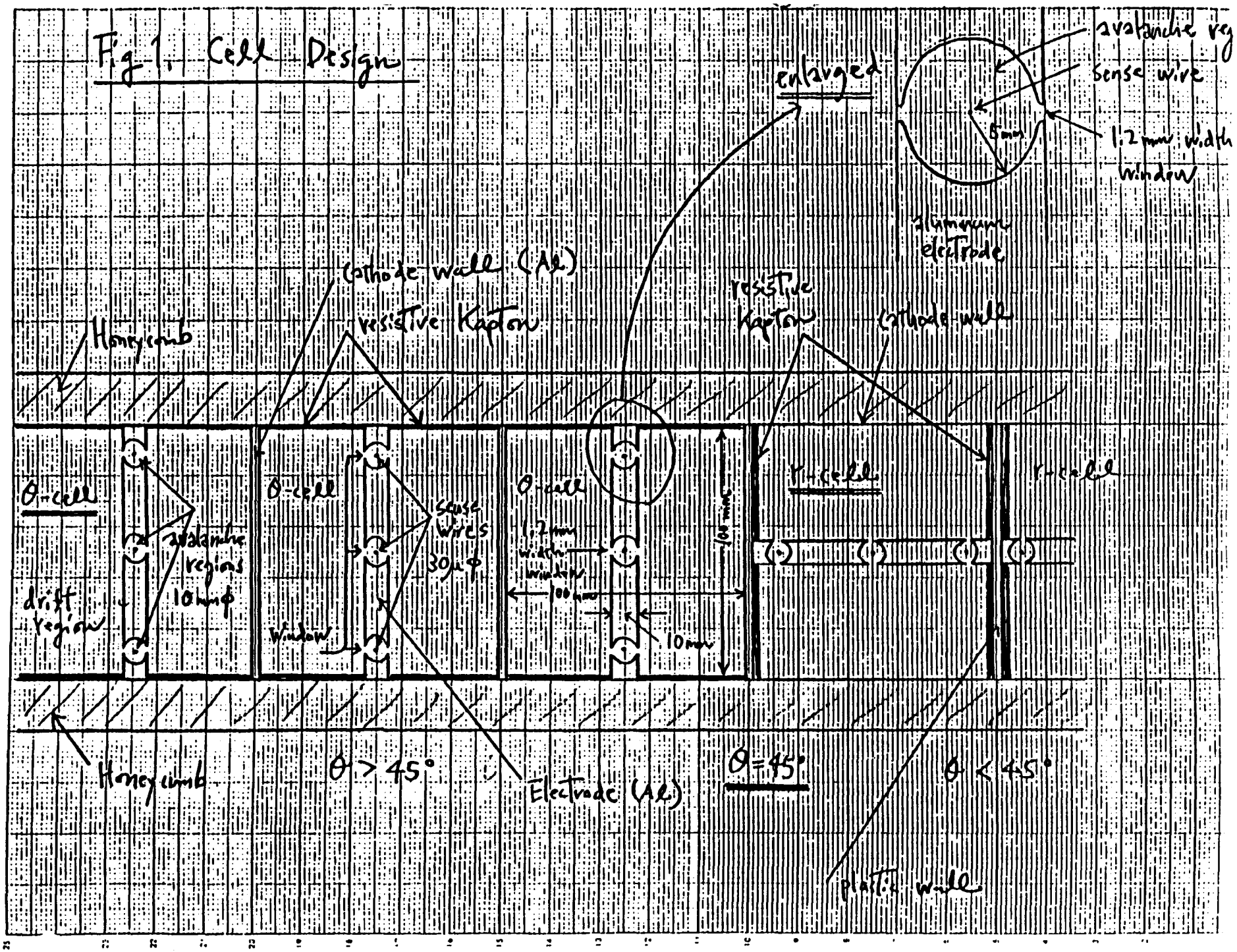
vs

at $\boxed{p = 40\ \text{GeV}}$ $\quad \delta\theta = \sqrt{(5)^2 + (3.5)^2 + (5.5)^2}$

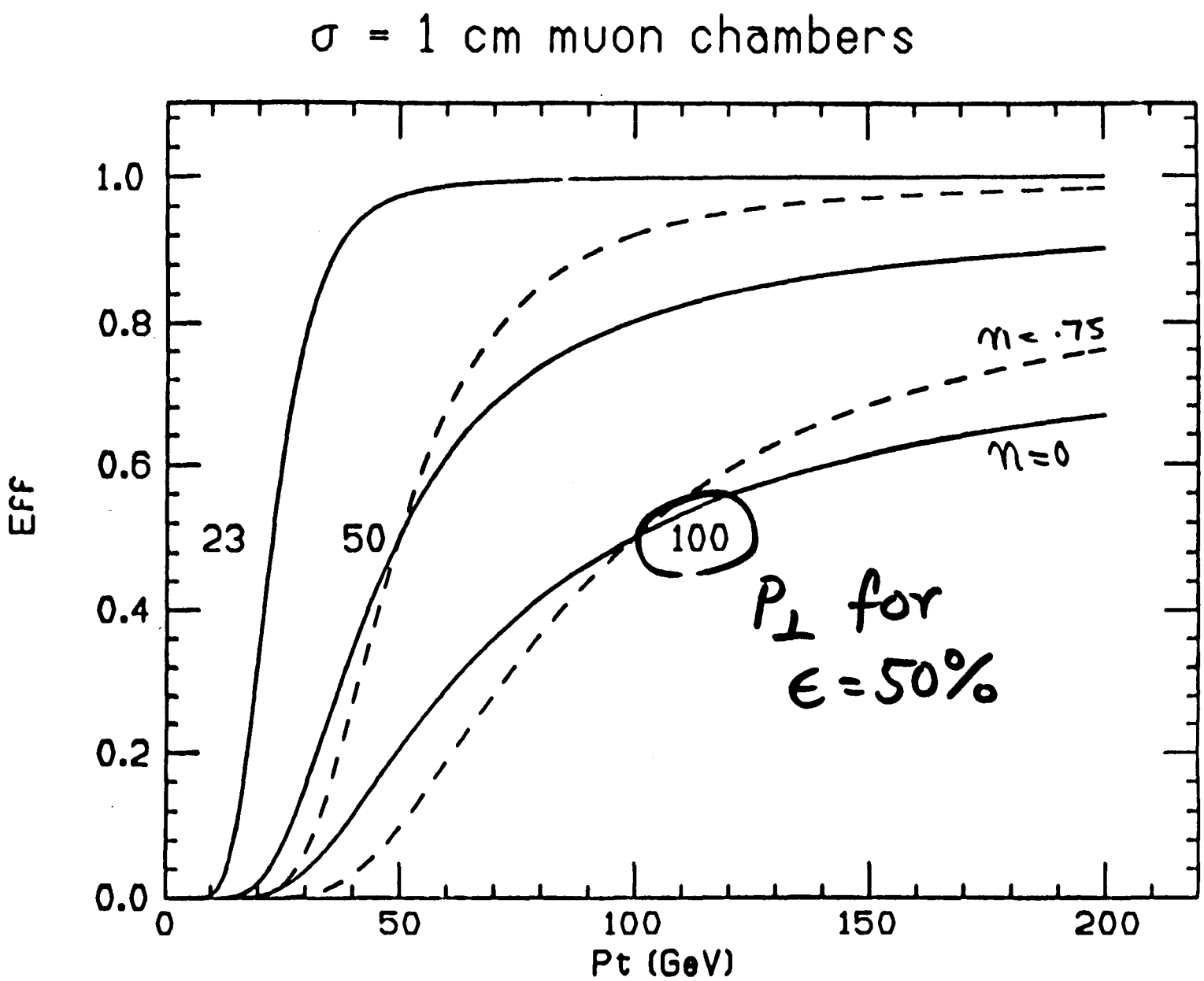
$$\boxed{\begin{array}{l} \delta\theta = 8.2\ \text{mr} \\ \theta = 20.3\ \text{mr} \end{array}}$$

vs

Fig 1. Cell Design



TERAMOTO



J. WISS : TRIGGER RESOLUTION STUDIES

MAGNET TASK FORCE STATUS

SEPTEMBER 20, 1990
DALLAS, TX
T. KIRK

GOOD NEWS!

THE TASK FORCE HAS (DRAFT) RECOMMENDATIONS

BAD NEWS!

THEY HAVEN'T BEEN SEEN BY ALL TF MEMBERS;
THE REPORT IS NOT FINAL
(SIGH---)

#KIRK

①

SOLENOID MAGNET TASK FORCE

PURPOSE: ASSEMBLE TECHNICAL & COST DATA AND FORMULATE A REPORT TO ALLOW A CHOICE TO BE MADE ON THE SOLENOID MAGNET GEOMETRY. THE IMPACTS ON TRACKING, CALORIMETRY & TRIGGERING WILL BE TAKEN INTO ACCOUNT.

TIME SCALE:
FIRST MEETING – JULY 6, SNOWMASS
OPEN MEETING* – AUG 16, ANL
FINAL REPORT – SEPT ~~26~~ 28, DALLAS

TASK FORCE:
✓ T. KIRK – CHAIRMAN, ANL
✓ G. FOSTER, FNAL
– R. HOLLEBEEK, PENN
✓ R. KEPHART, FNAL
✓ T. KONDO, KEK
– S. MORI, TSUKUBA
✓ H. OGREN, INDIANA
✓ J. PROUDFOOT, ANL
– Y. SAKAI, KEK
– A. YAMAMOTO, KEK

/⇔ AGREE ON DRAFT

* INPUT TO THE TASK FORCE CAN BE IN THE FORM OF SUBMISSIONS TO MEMBERS OR <u>SCHEDULED</u> ORAL PRESENTATIONS TO THE OPEN MEETING ON AUGUST 16. THE TF WILL ALSO, OF COURSE, ACTIVELY SEEK INFORMATION

METHODOLOGY
T. Kirk

✓ 1. Review & accept the Charge to the Task Force

2. Schedule to do the Work:
   - ✓ July 6 – MTF Organiz. Meeting
   - ✓ Aug. 15 – MTF Progress Meeting
   - ✓ Aug. 16 – Open Presentation Meeting
   - X Sept. 7 – Draft Written Report
   - DRAFT Sept. 18 – Final Written Report
   - ✓ Sept. 20 – Oral Presentation to SDC

3. Organize & Carry Out the Work:
   - ✓ Draft Outline – July 6
   - ? Final Outline – Aug. 15
   - X Draft Text – Sept. ~~7~~ 19
   - Final Text – Sept. ~~18~~ 28

   Task Force members are organized in subgroups to assemble the information needed for the report from SDC Steering Subgroups (or other relevant sources)

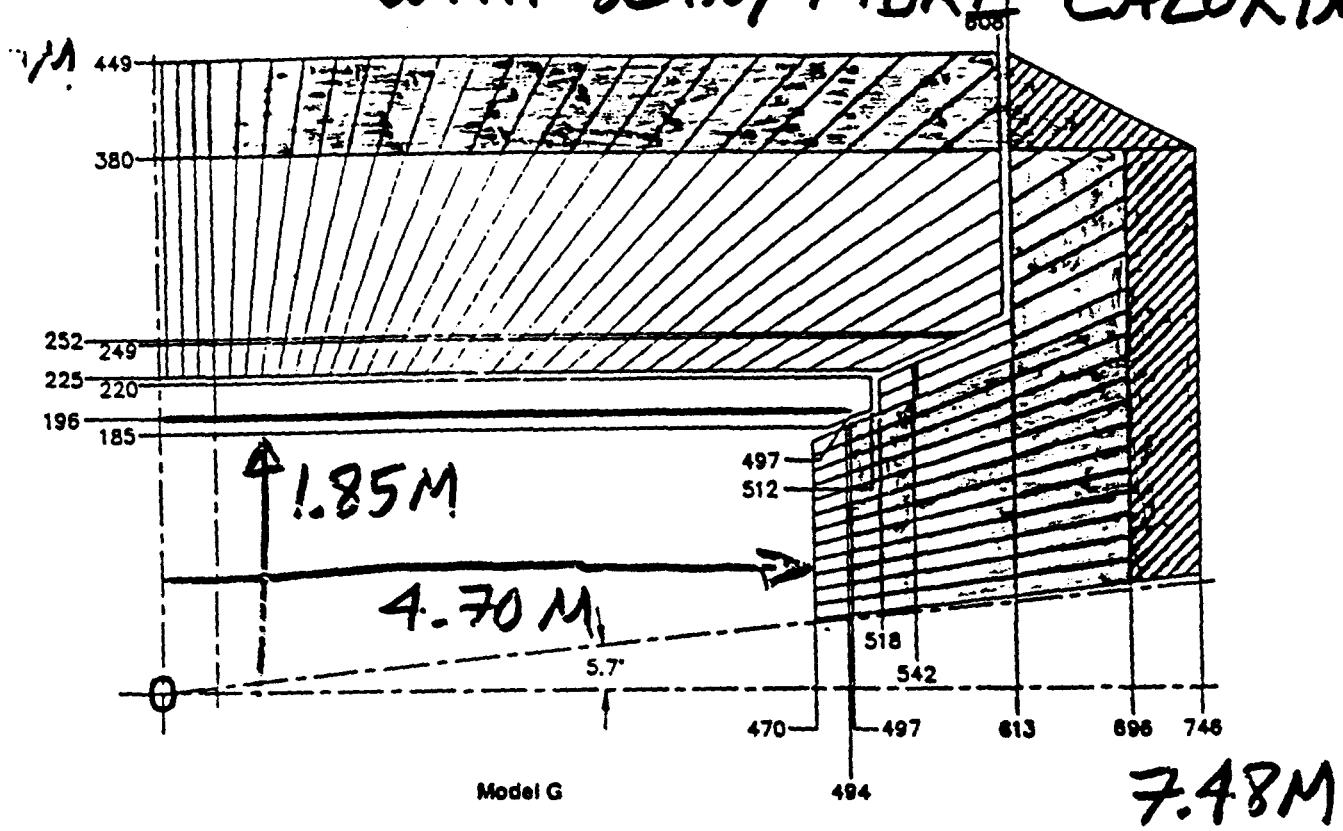
4. Final Report requires some detailed review by the whole TF plus some cost information. We believe we [illegible]

DRAFT Recommendations
SDC Magnet Task Force
Version: September 20, 1990

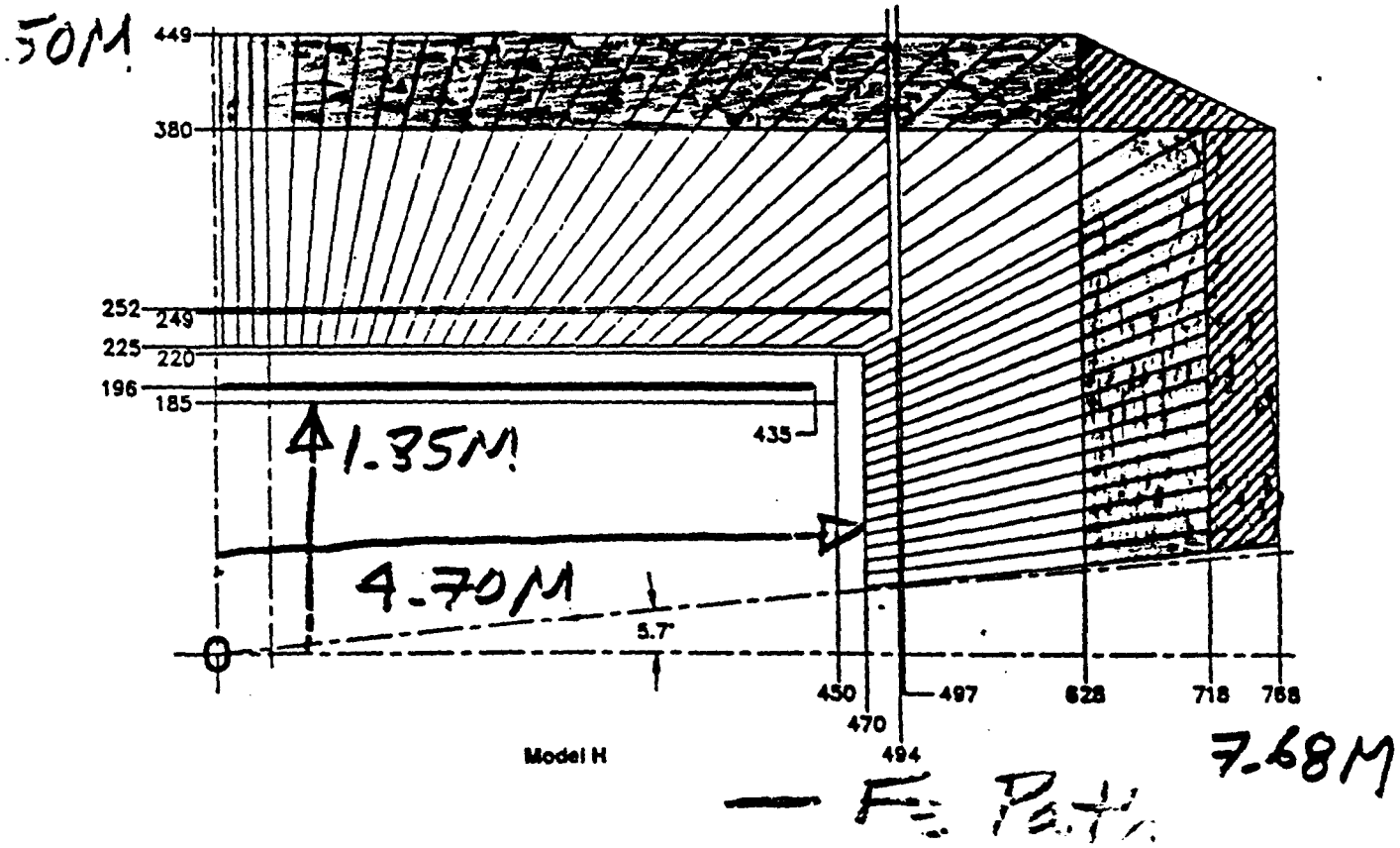
1. We recommend that the Type-S and Type-I coil options be combined in a unified coil design concept (Type-U) and that the resulting Type-U design be the focus of future engineering design and magnet R&D activities.

2. We recommend that the Type-L coil option with the coil extending to a solid iron return yoke be dropped from further consideration.

EXAMPLE OF TYPE-U COIL WITH SCIN/FIBRE CALORIM



Model G



Model H

Figure 1.1 - SDC Calorimeter Models

Model G above has ferromagnetic hadron calorimetry in the endcap, hence maintains nearly uniform field in the solenoid volume; Model H has non-ferromagnetic hadron calorimeter sections behind the EM section, hence has a large fringe field

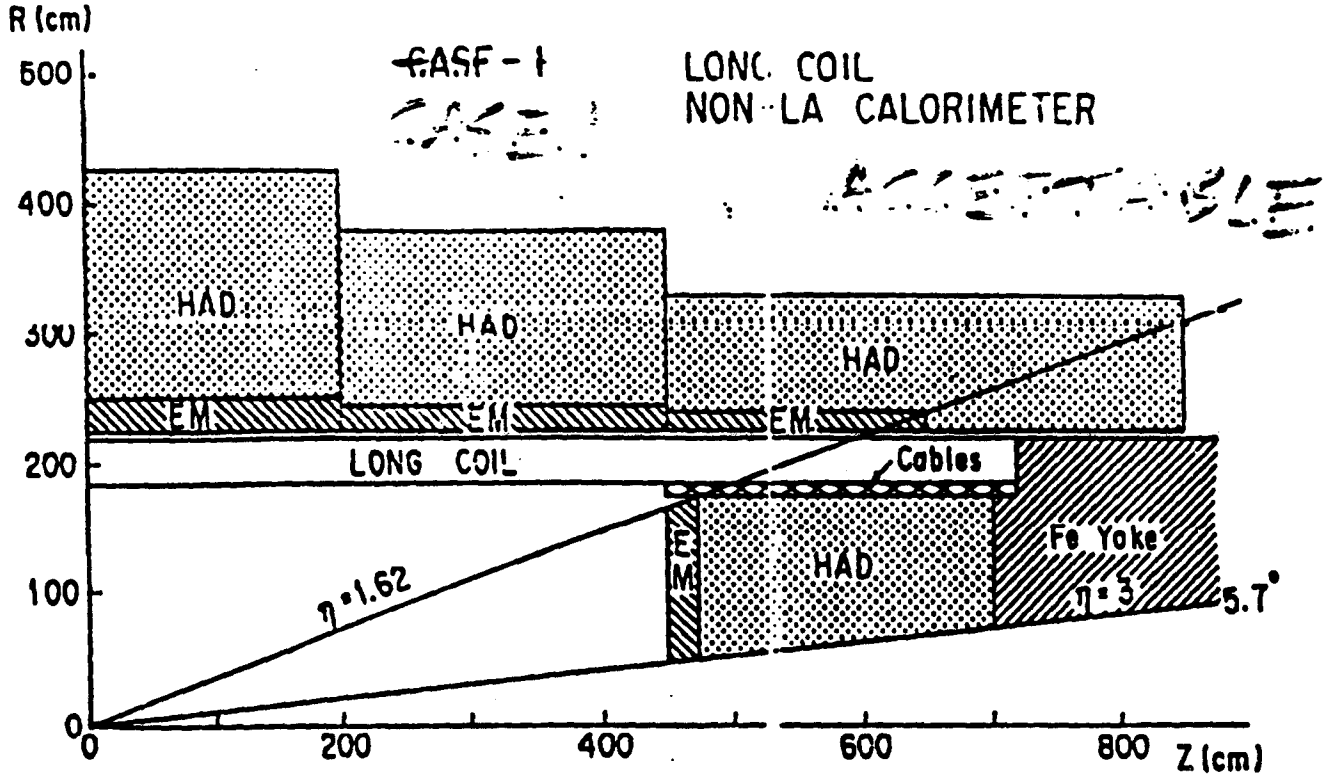


Fig.2.1 Configuration case-1 : long coil and non-liquid argon calorimeter.

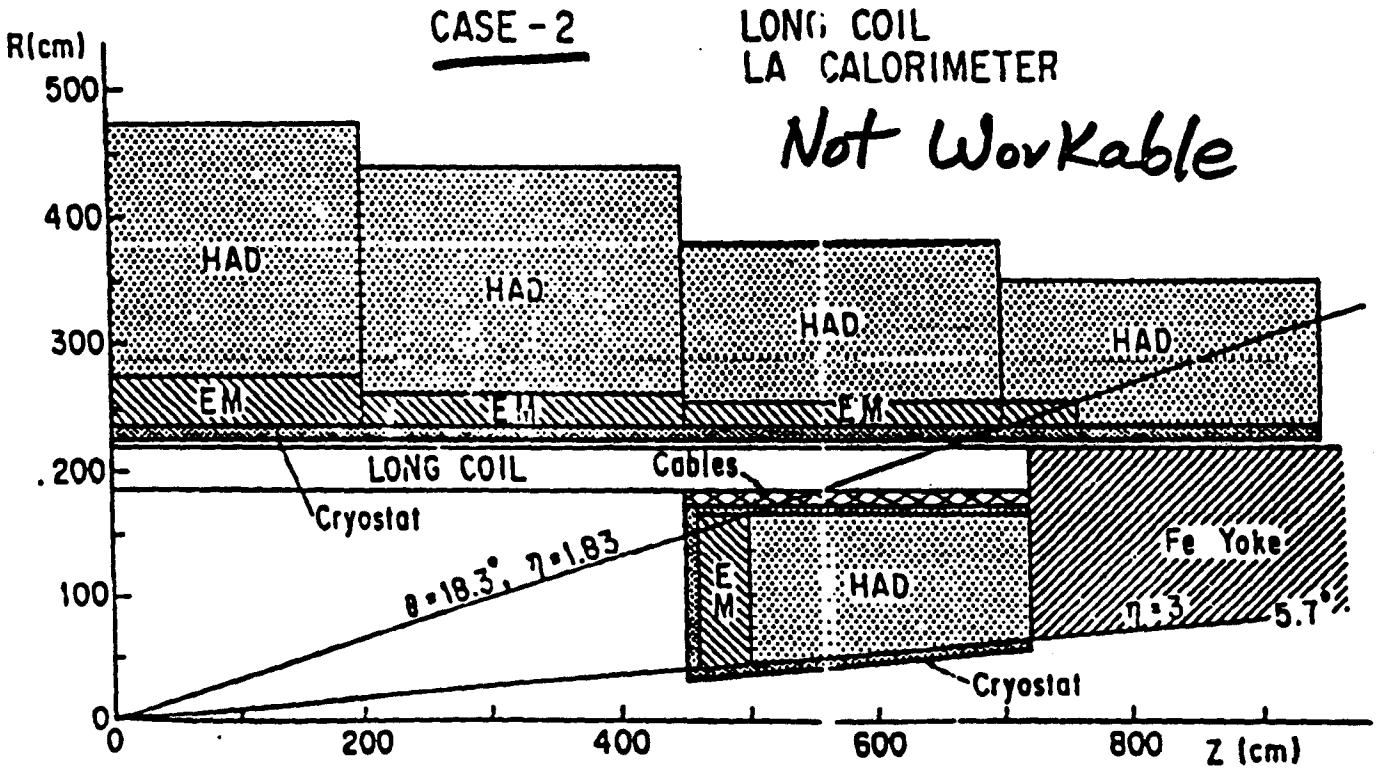


Fig.2.2 Configuration case-2 : long coil and liquid argon calorimeter.

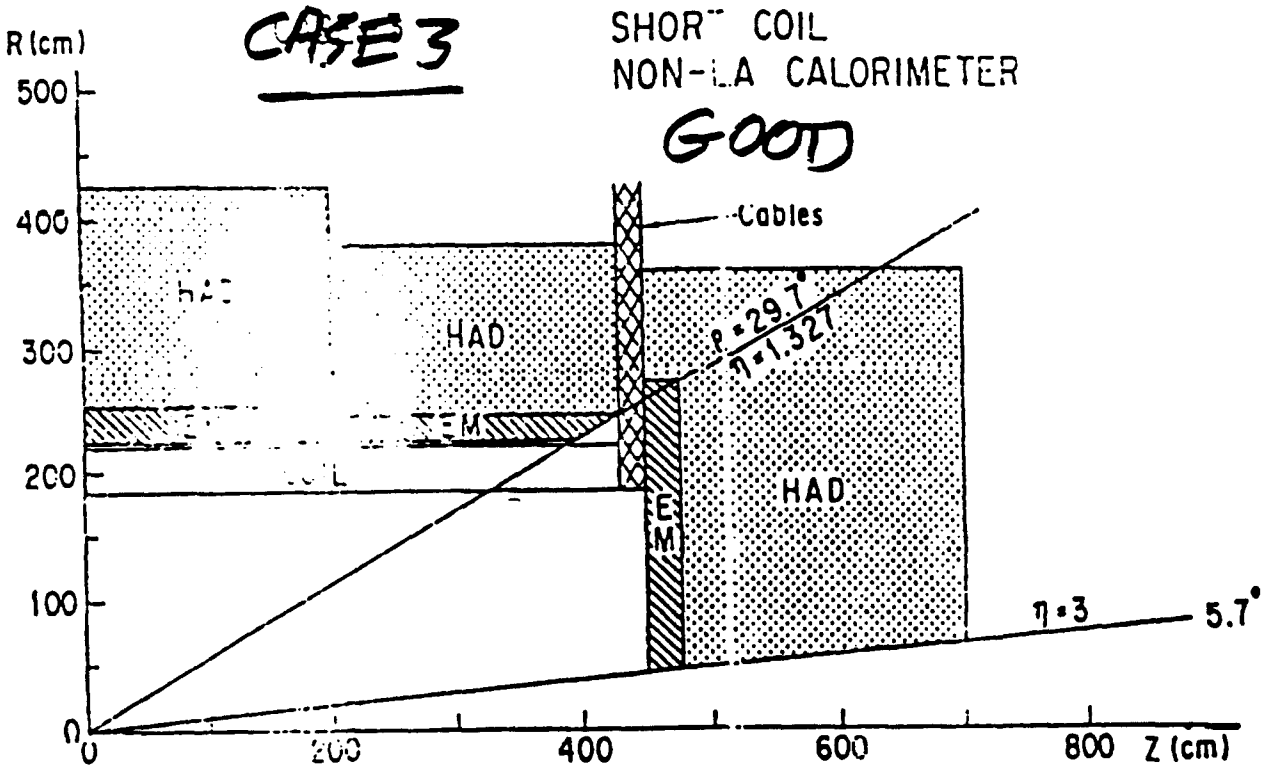
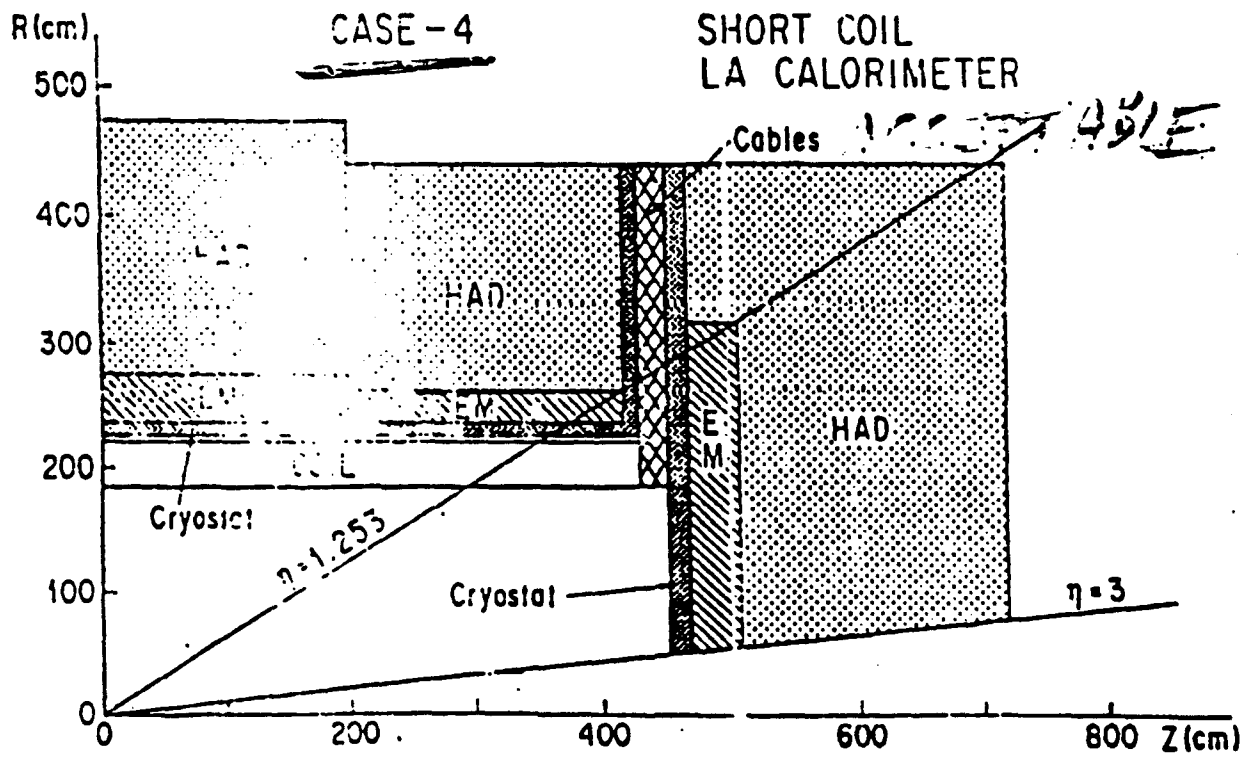


Fig.2.3 Configuration case-3 : short coil and non-liquid argon calorimeter.



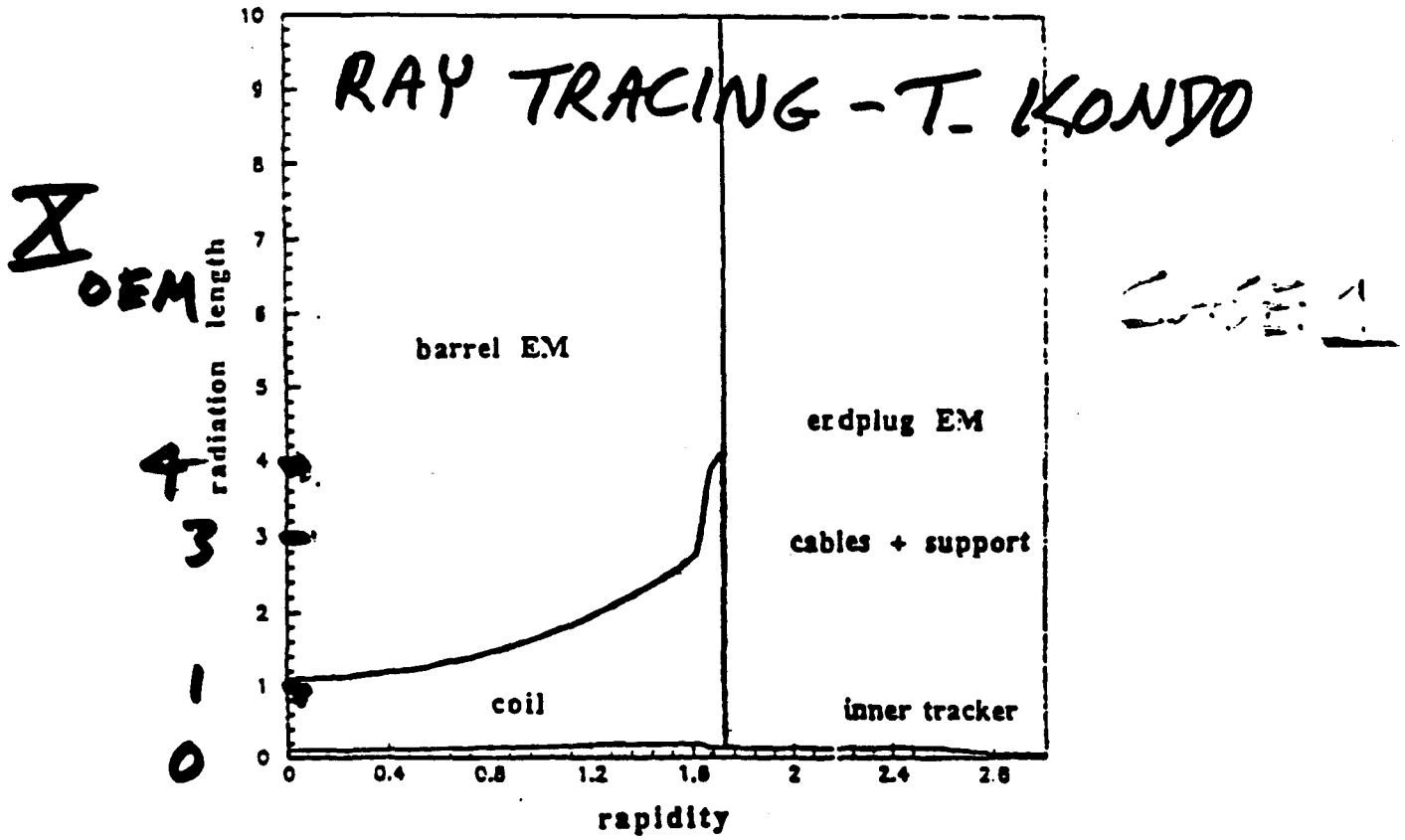


Fig.2.5 Rapidity dependence of radiation length for case-1.

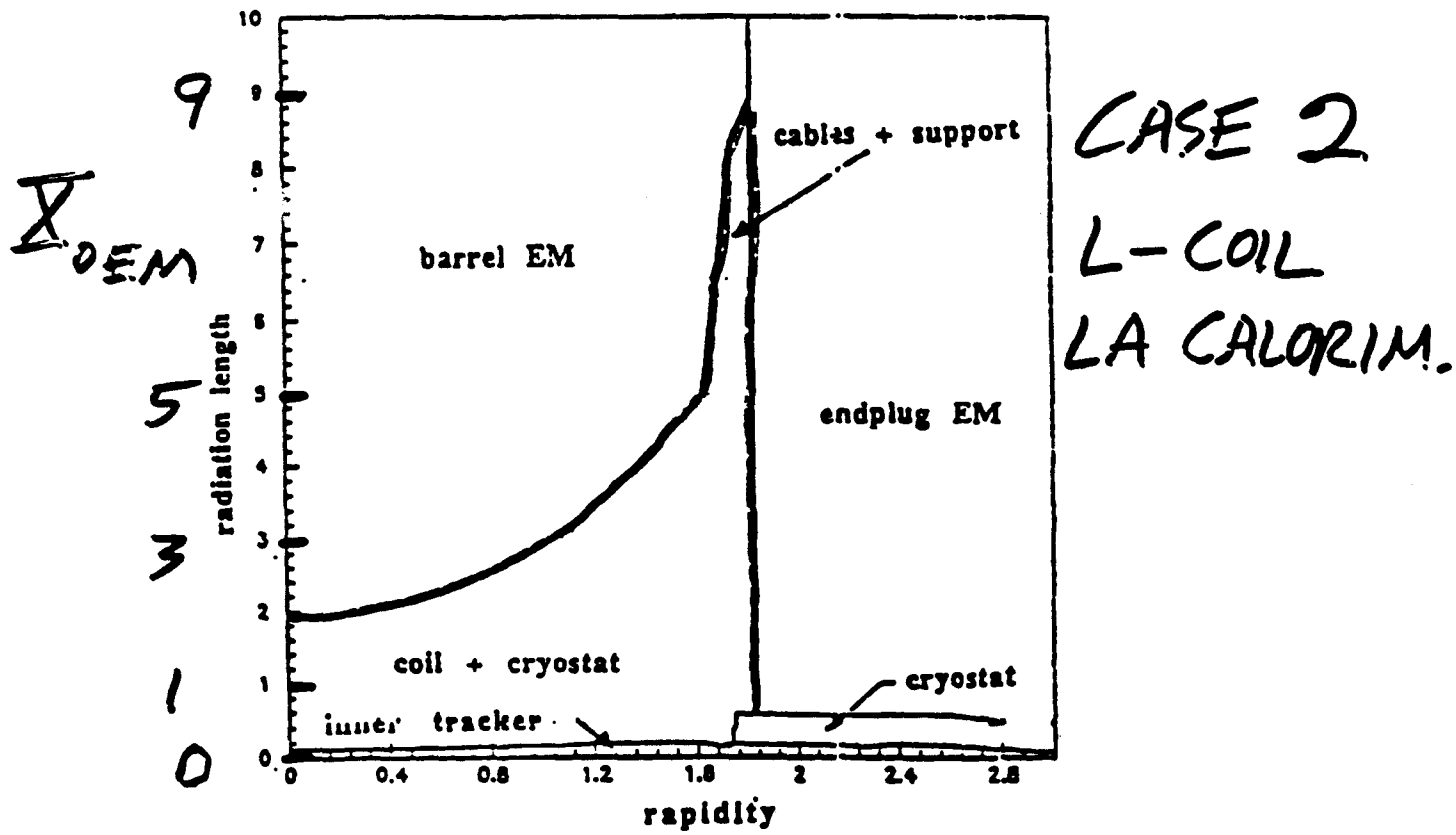


Fig.2.6 Rapidity dependence of radiation length for case-2.

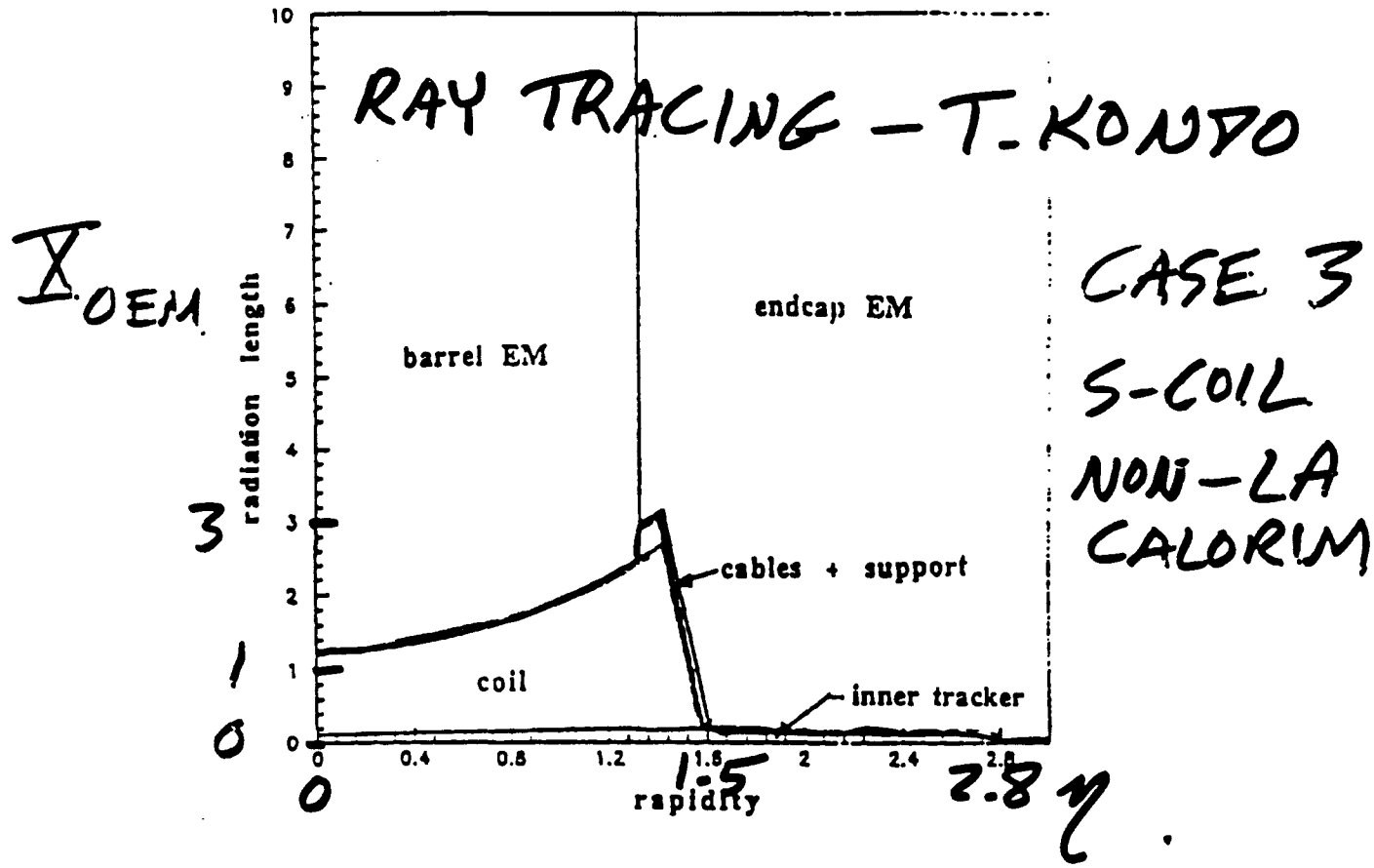


Fig.2.7 Rapidity dependence of radiation length for case-3.

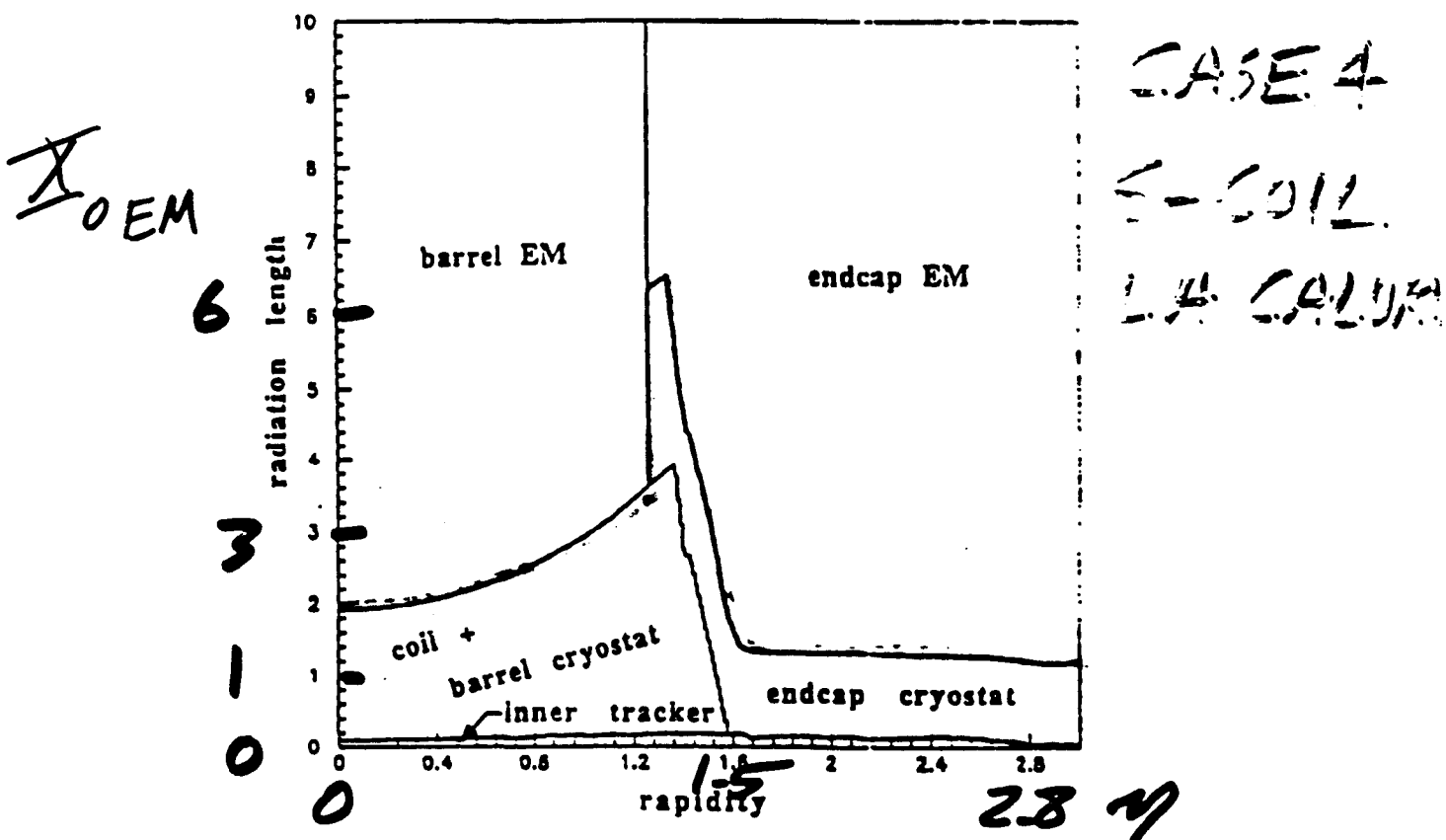
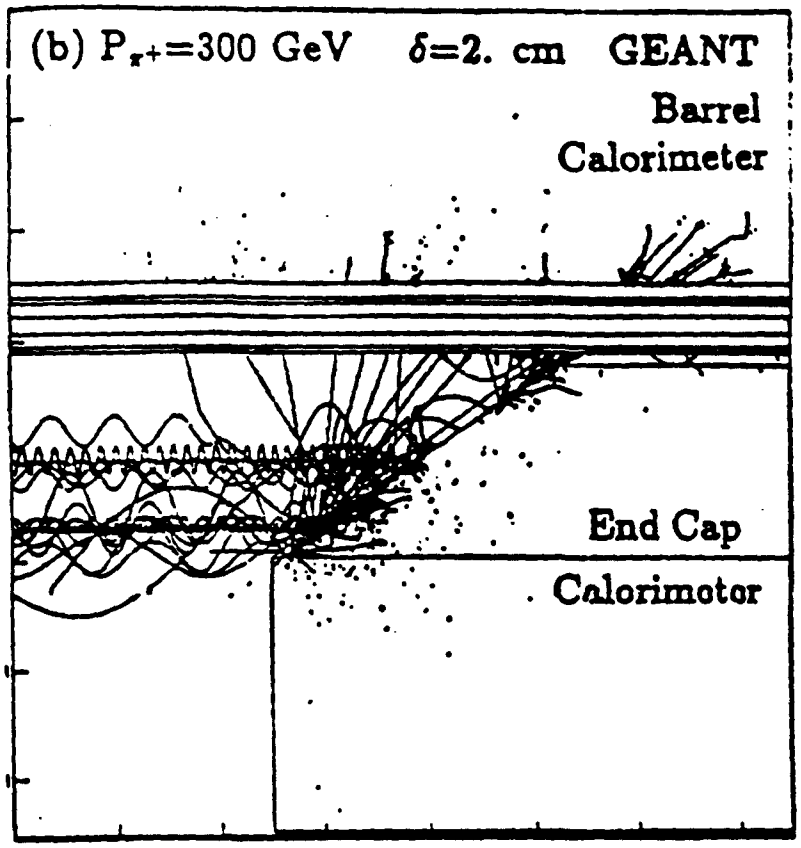


Fig.2.8 Rapidity dependence of radiation length for case-4.



300 GeV π
strikes
ENDCAP
near pole
bevel...

S-COIL B FIELD

Fig.2.15 A Geant event with 300 GeV incident pion striking near the bevel.

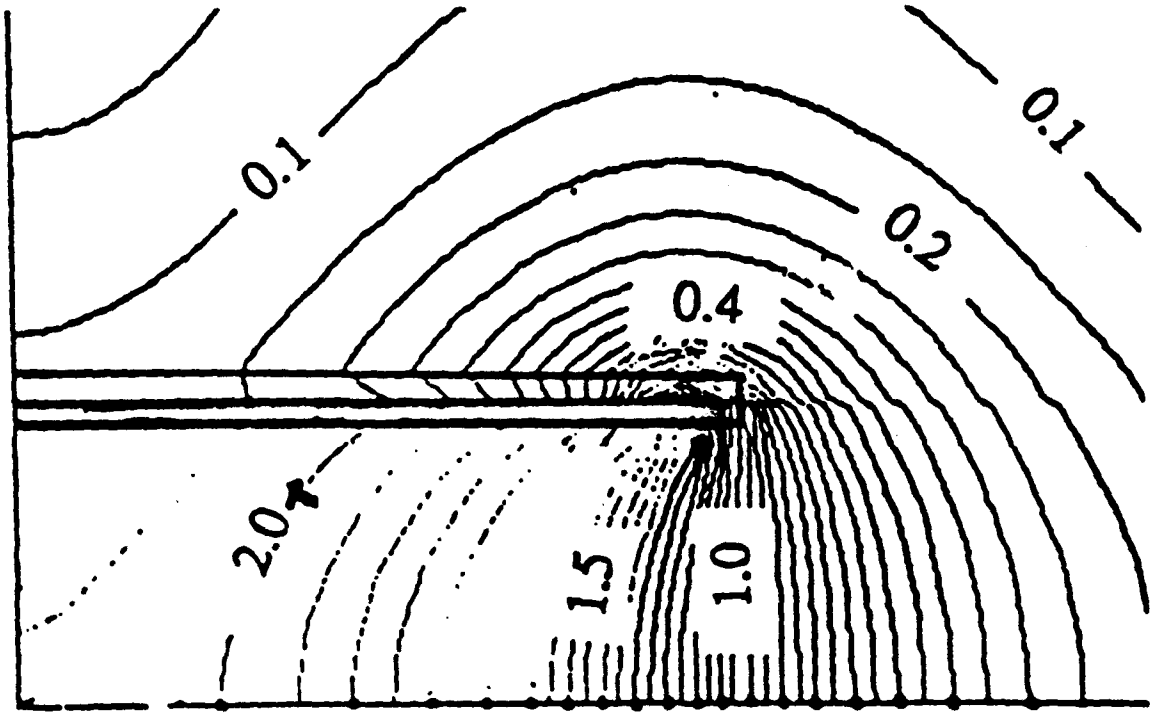


Fig.2.16 Magnetic field map of the Type-S.

RELATIVE TRACKING RESOLUTION OF S, I COIL FIELDS

— Y. SAKAI / H. OGREN

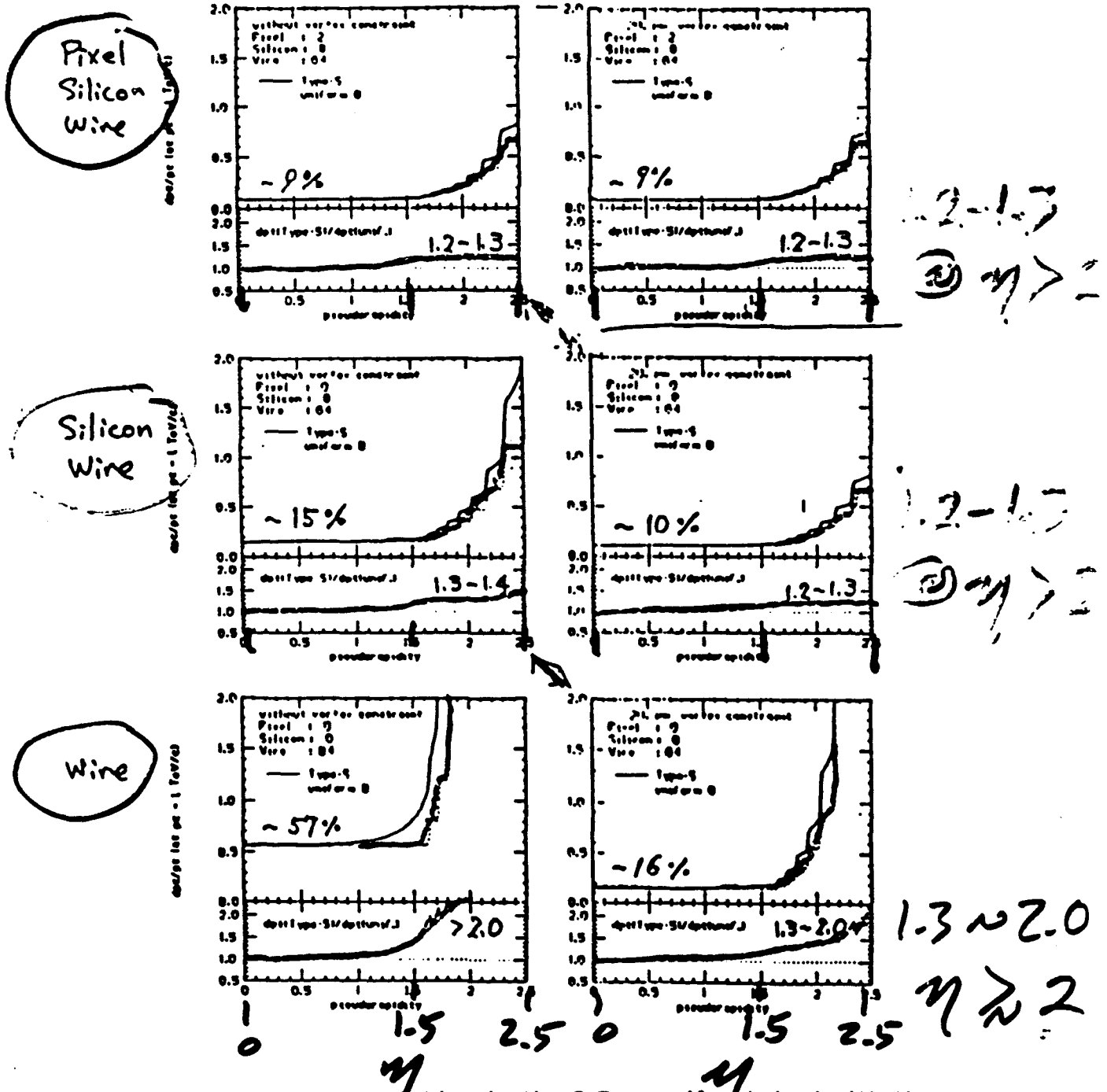


Fig. 2.3.1-3 The momentum resolution in the S-Type coil obtained with three different tracking configurations. The vertex constrained fits are on the right. The lower plot in each figure compares the resolution to that obtained in the L-type coil.

TRACKING RESOLUTION

Element	Vertex Constraint	dp/p2 (%/TeV) (|h| >1.5)	Type-S/Uni...
Pixel/Silicon/wire	No	9- 63	1.2-1.3
Silicon/wire	No	15-120	1.3-1.4
Wire only	No	57-200	> 2.0
Pixel/Silicon/wire	20 mm	9- 60	1.2-1.3
Silicon/wire	20mm	10- 64	1.2-1.3
Wire only	20 mm	16-200	1.3-2.0

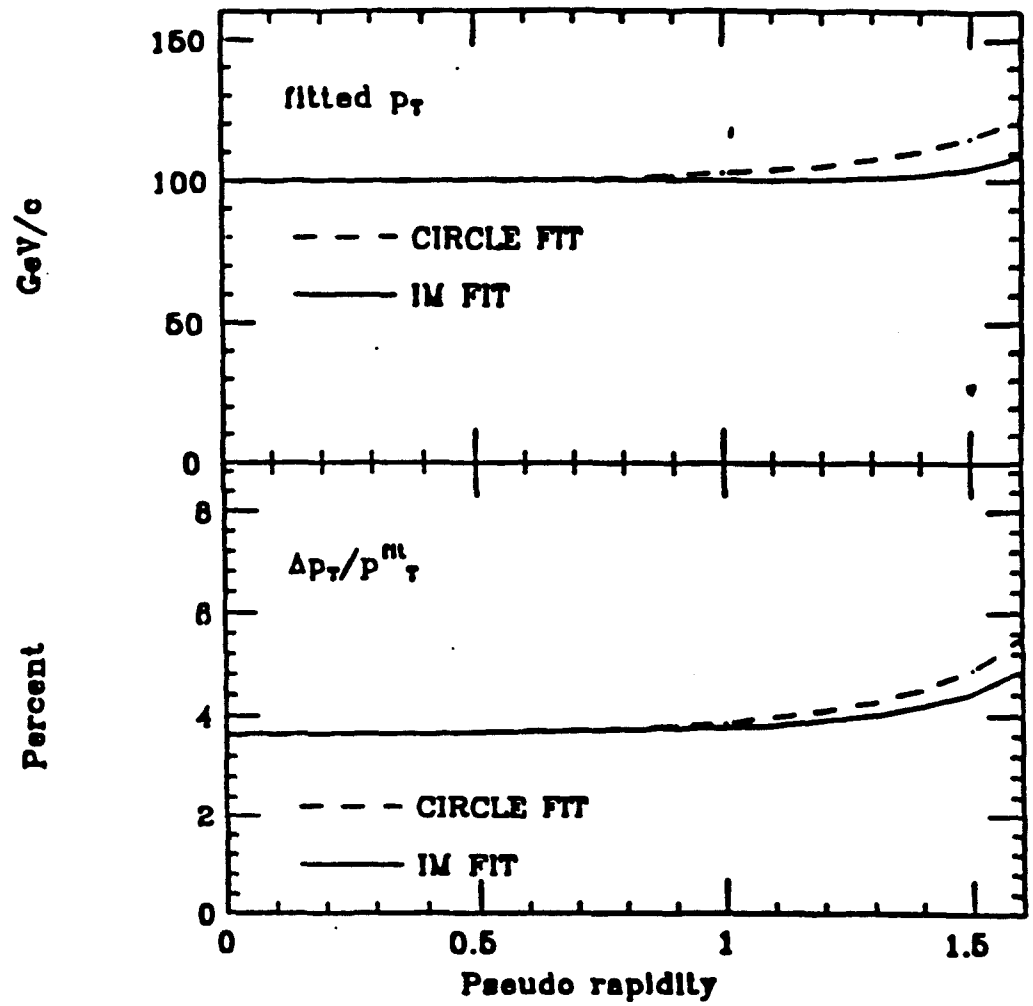


Fig. 2.3.1-1 The difference between a simple circular fit and the IMFIT result. The dashed line is the circle fit.

LA CALORIM – Fe XFORMERS

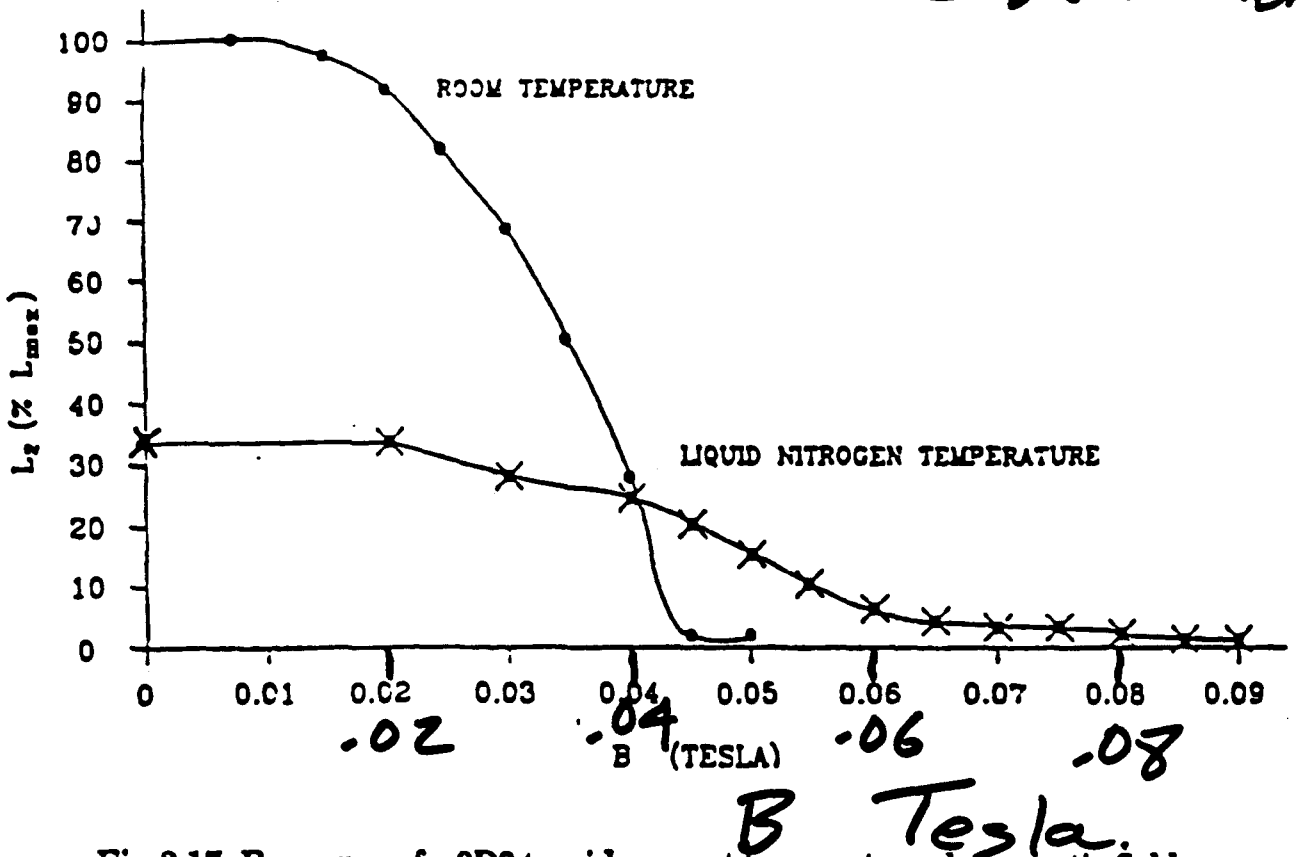
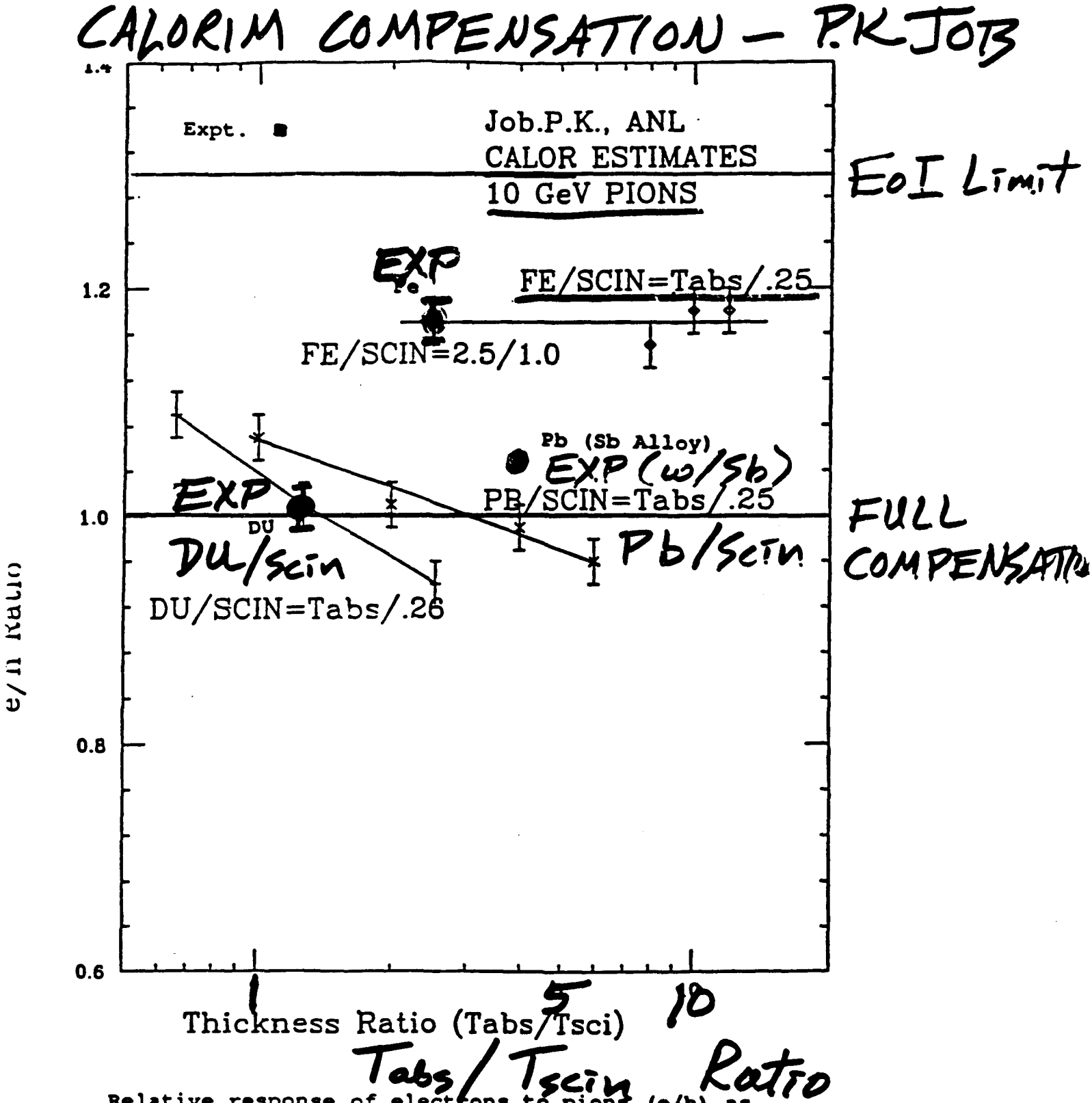


Fig.2.17 Response of a 3D3 toroid magnet to an external magnetic field lying in the plane of the torus.

⇒ use ESTs...



Relative response of electrons to pions (e/h) as a function of absorber thickness and composition for a fixed scintillator thickness of 0.25 cm.

Figure 2.20

DAN GREEN

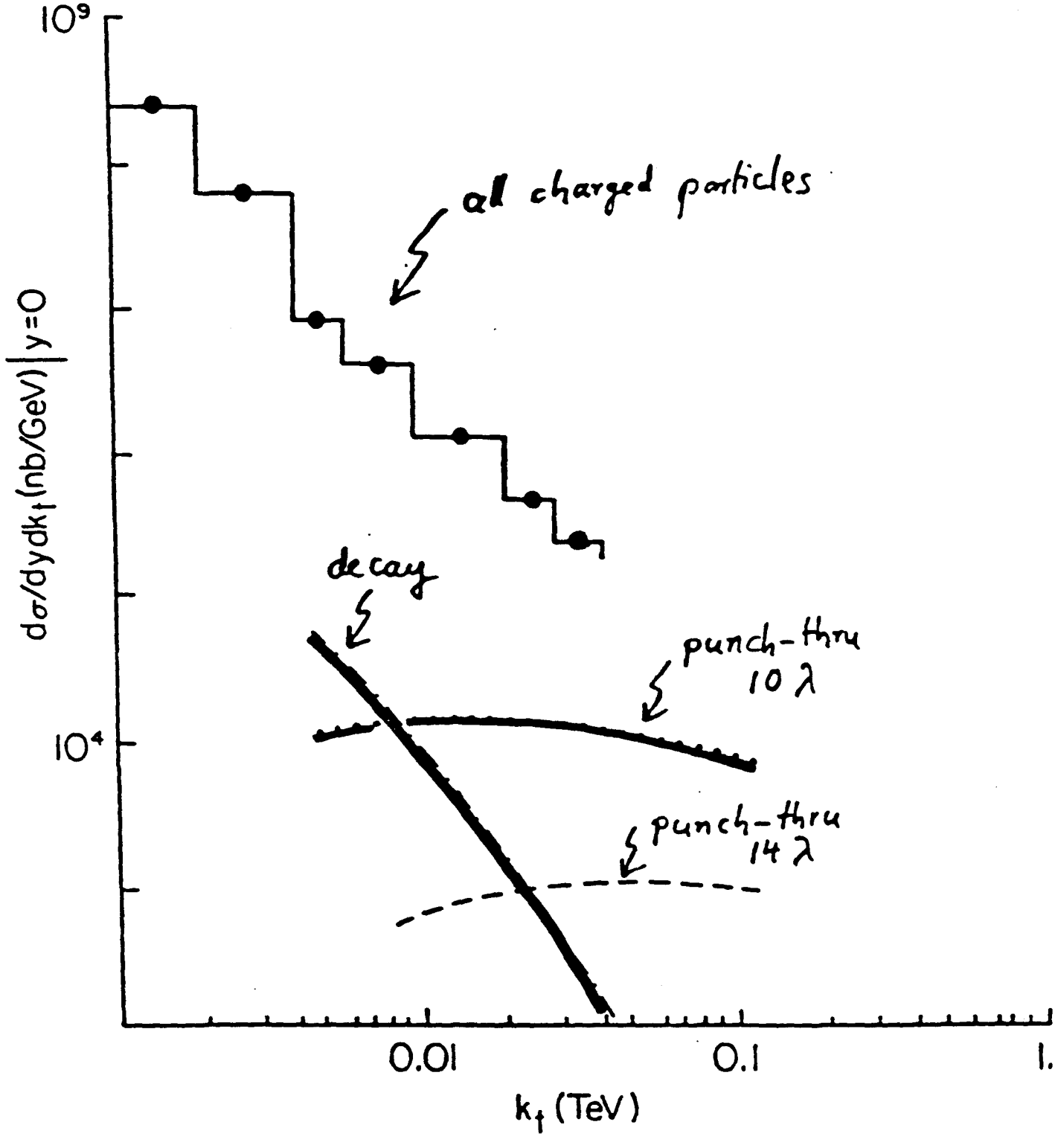


Figure 1

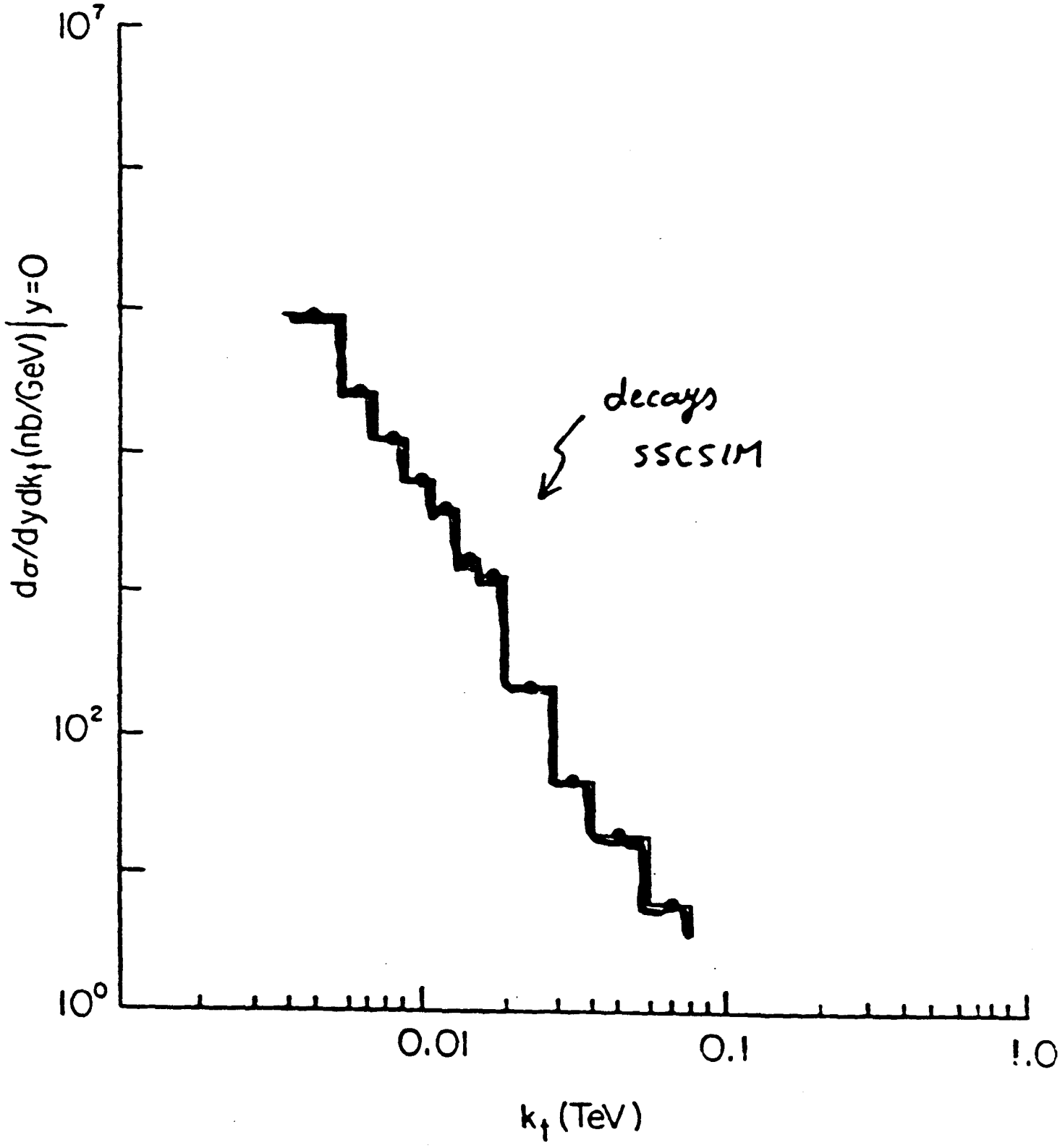

10^7
10^2
10^0
$d\sigma/dy\,dk_t\,(nb/GeV)\big|_{y=0}$
decays
SSCSIM
0.01
0.1
1.0
k_t (TeV)

Figure 2

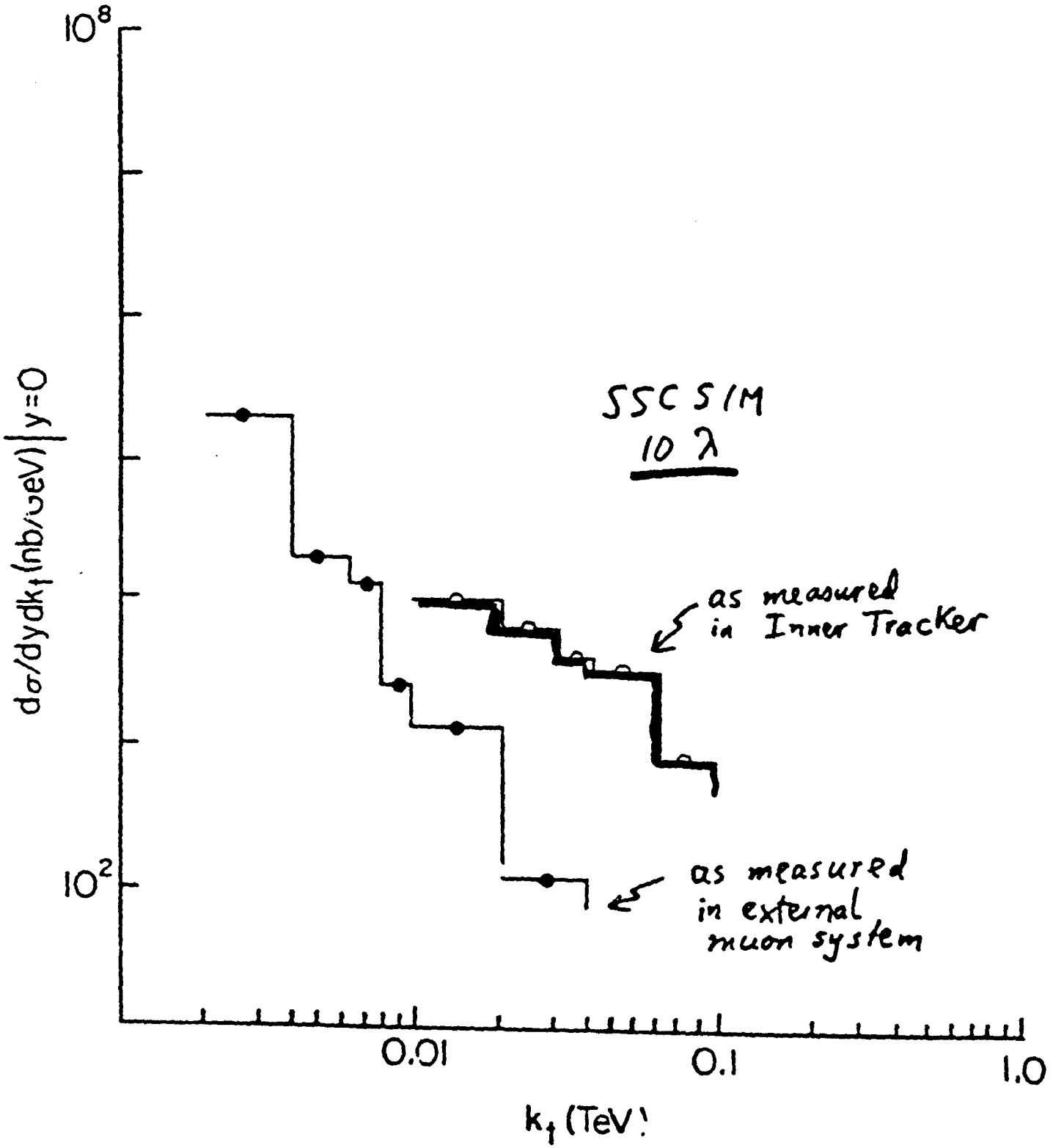


Figure 4

Figure 3

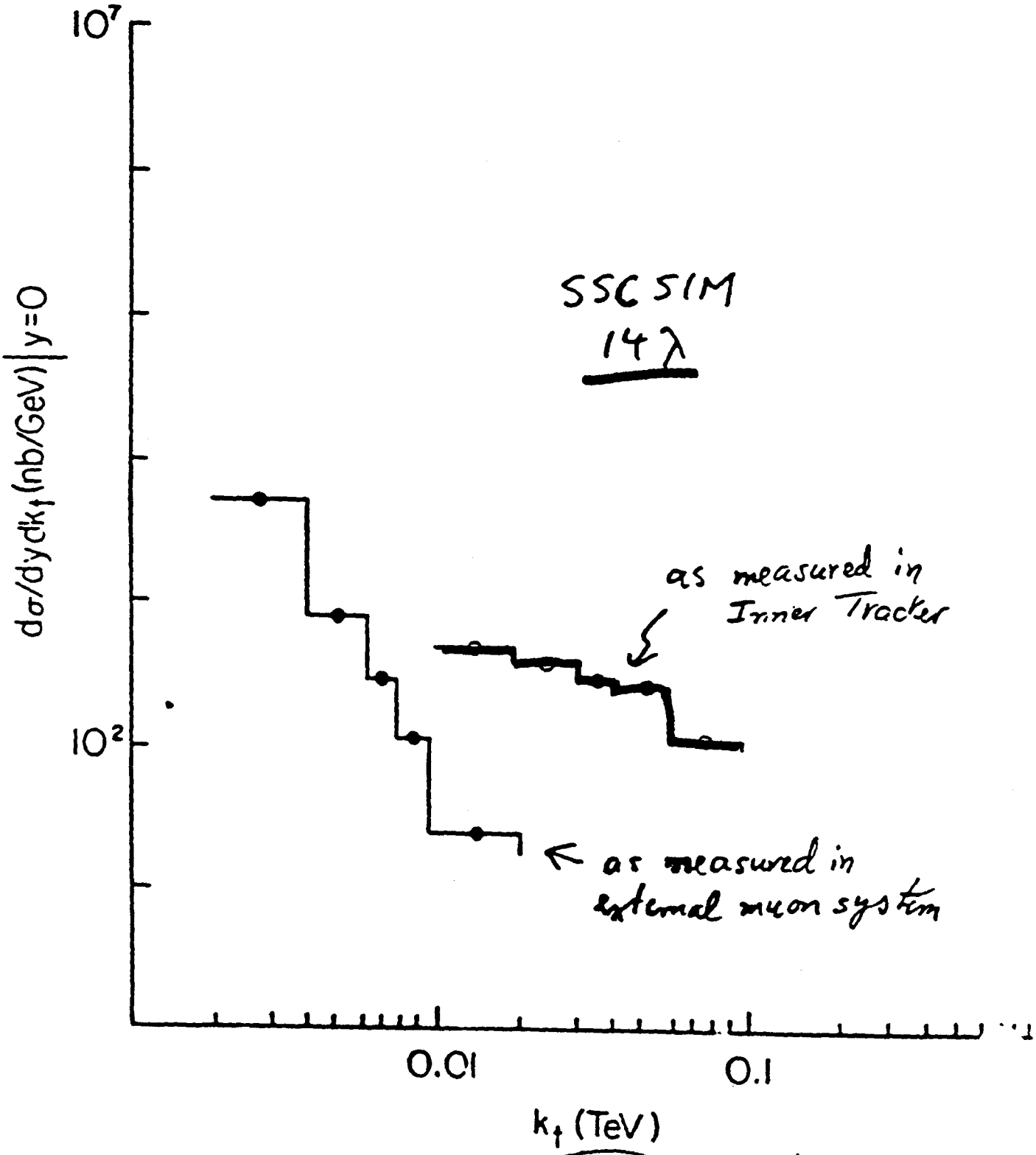


Figure 3

Fig 4

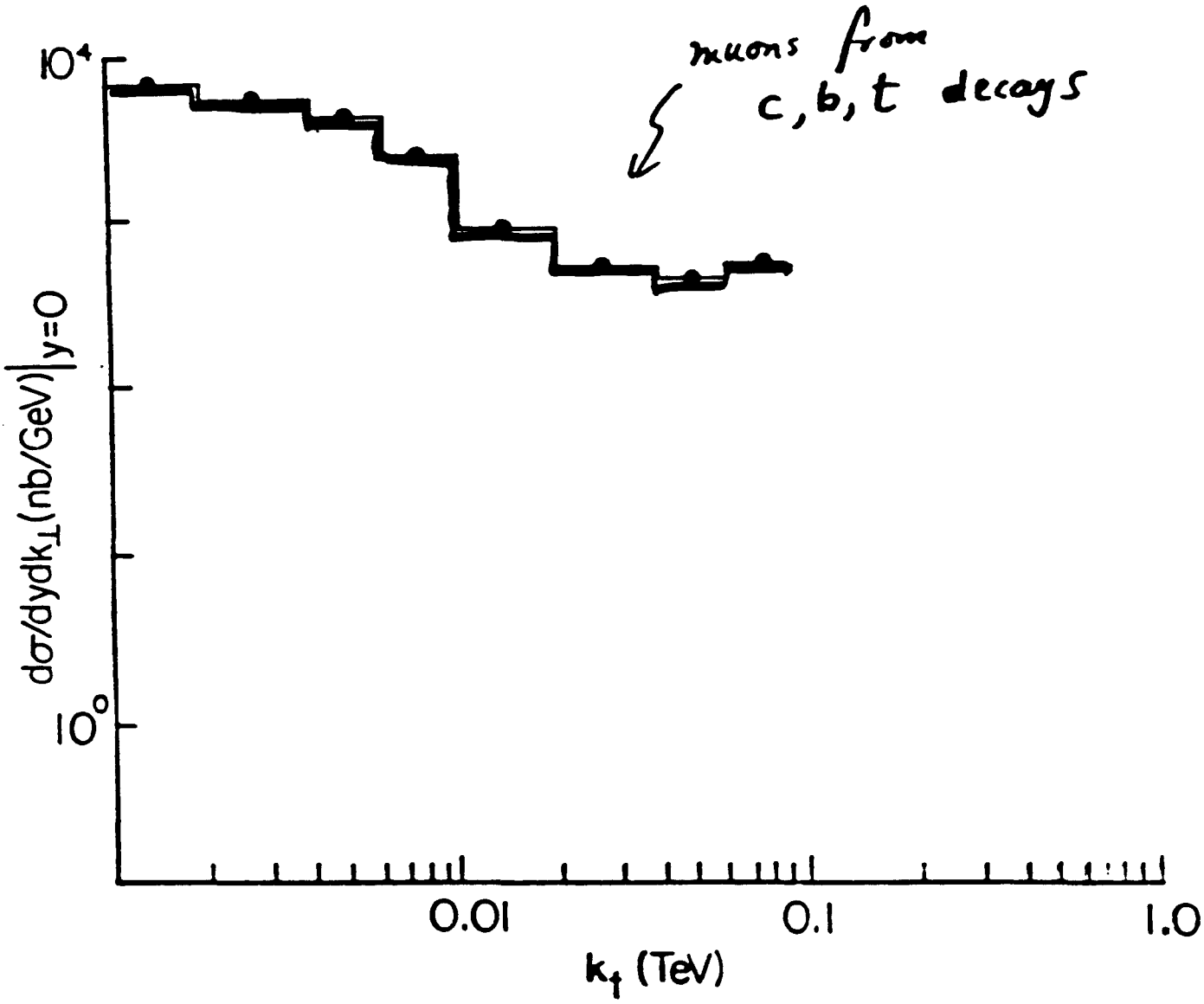
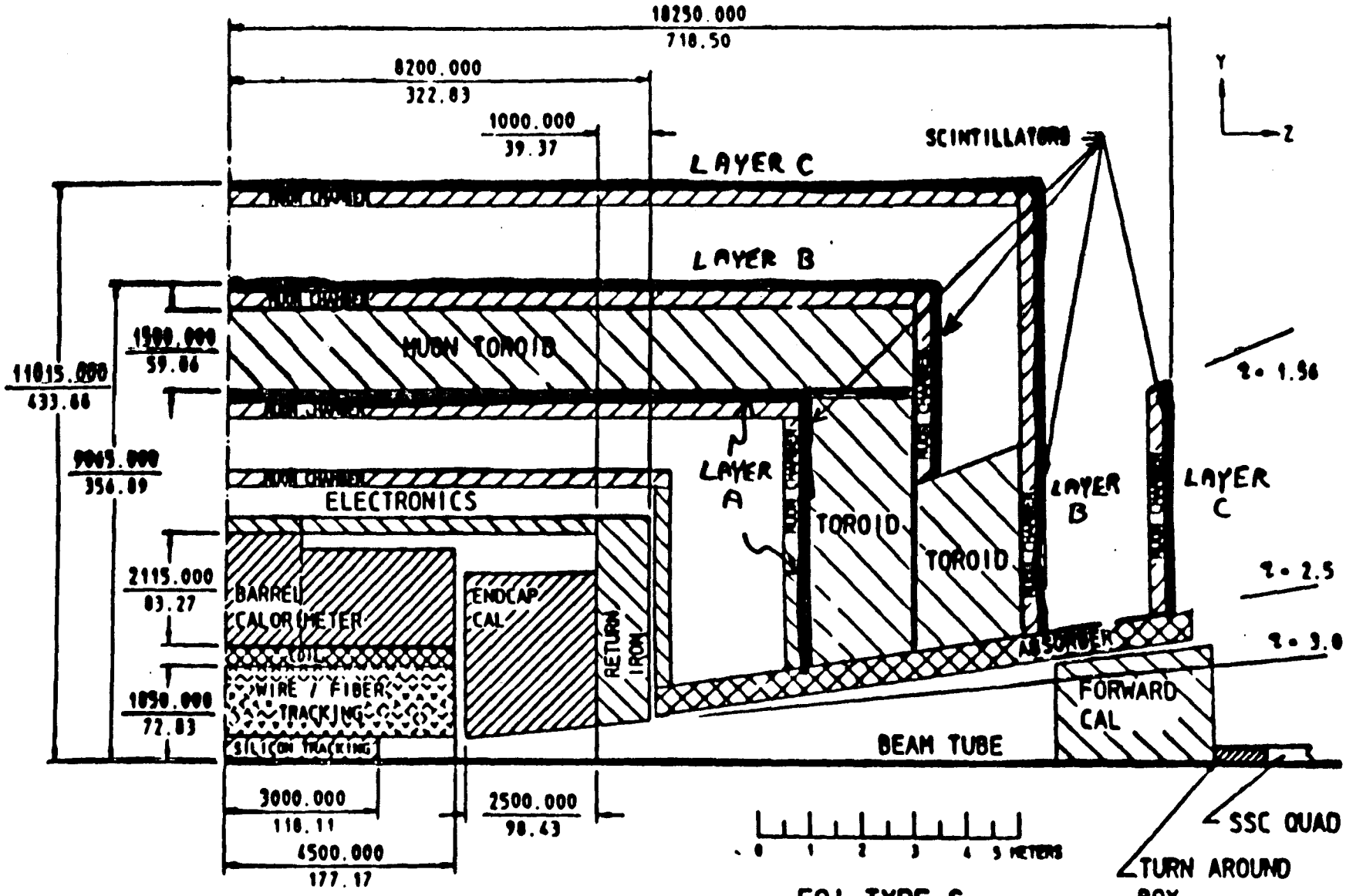

muons from
c, b, t decays
10^4
10^0
$d\sigma/dydk_\perp$ (nb/GeV)$|_{y=0}$
0.01
0.1
1.0
k_t (TeV)

Figure 6



NOTES: 1. ALL DIMENSIONS ARE IN MM OVER INCHES.

FIG 1 VERSION WITH FORWARD IRON TOROIDS

R. THUN
17 AUG 90

W

6 SEP 90
R. THUN

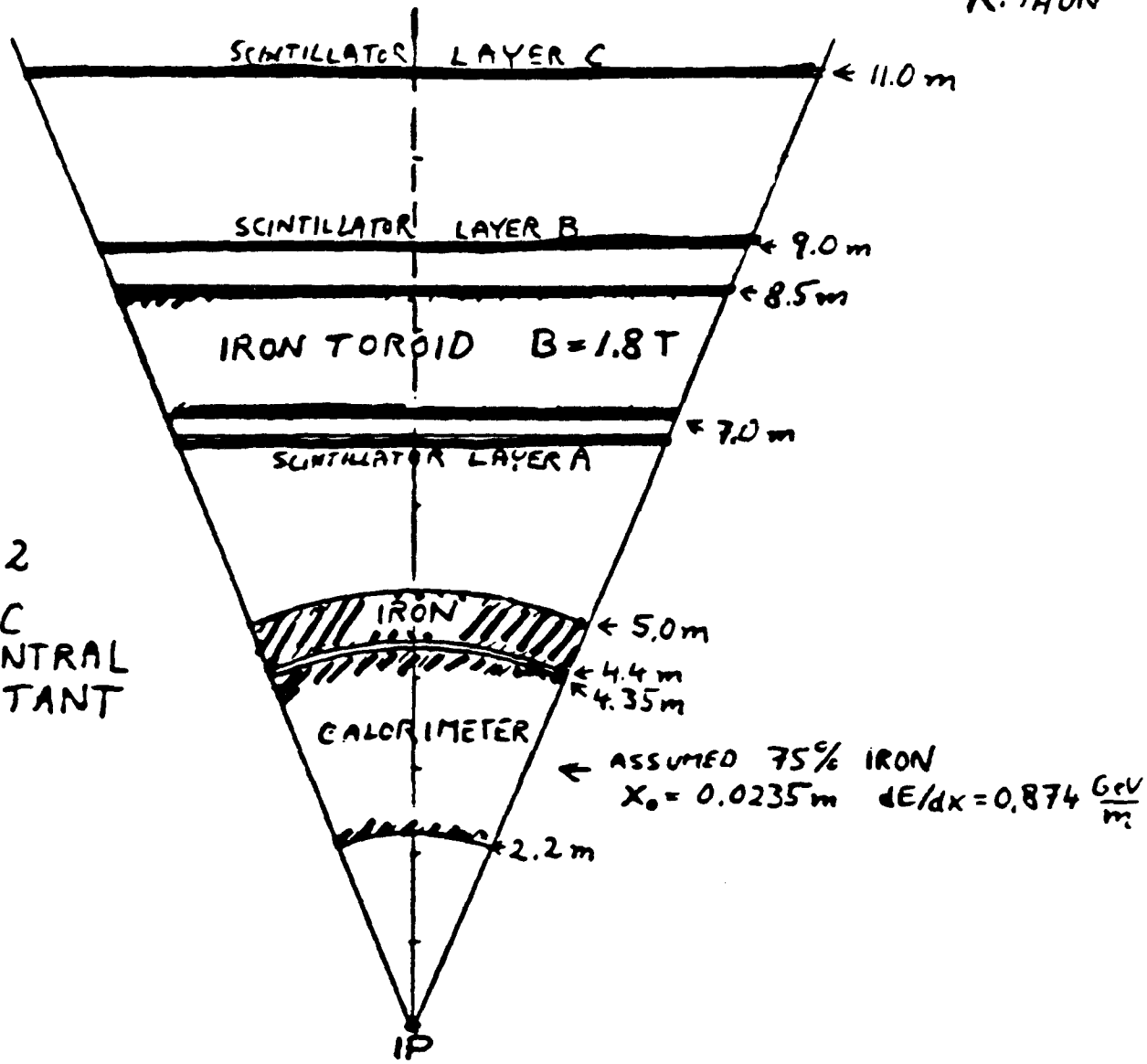
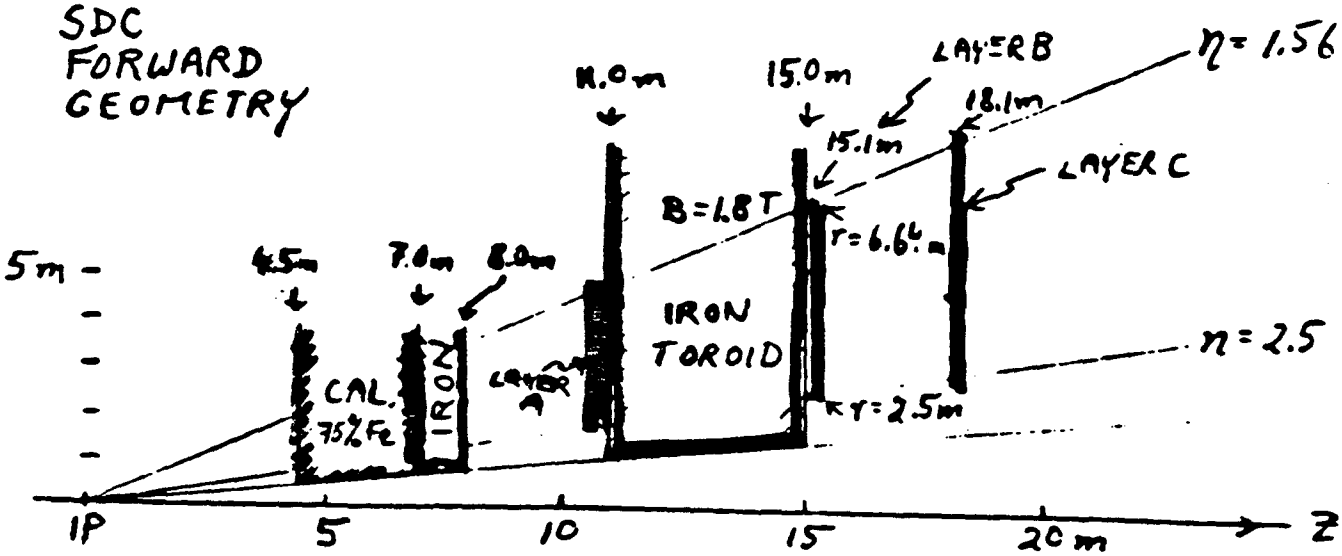


FIG 2

SDC CENTRAL OCTANT

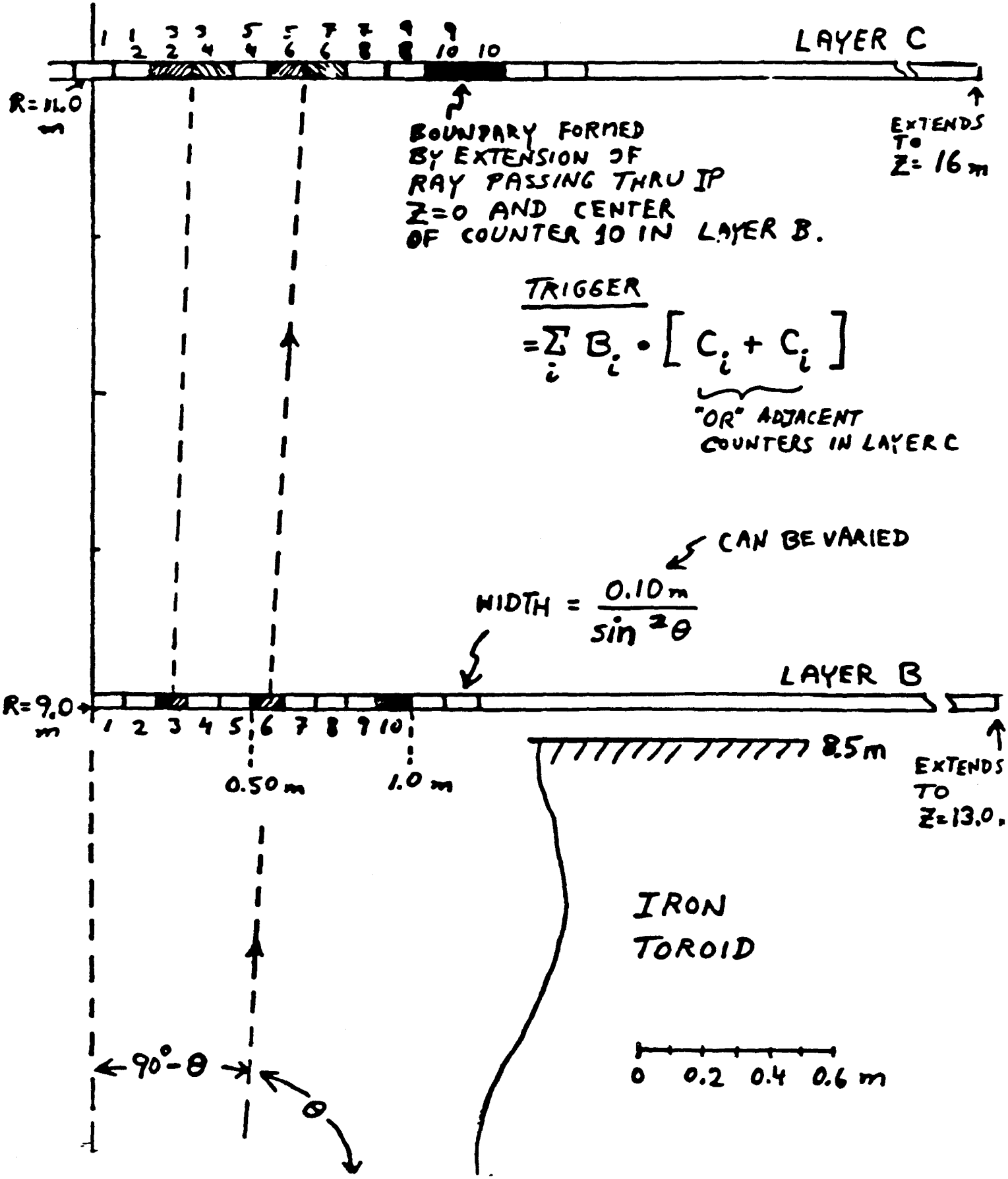
FIG 3

SDC FORWARD GEOMETRY



20 JUN 90
R. Thun

FIG 5 CENTRAL MUON TRIGGER SCINTILLATORS
(FORWARD LAYOUT IS SIMILAR)



R. THUN

20 Sep 90

UPDATE FROM MUON GROUP

1.) TRIGGER

→ meeting at Fermilab 15 Sep 90

2.) AGENDA for DALLAS

→ AIR-CORE vs IRON

→ CHAMBER DESIGN

→ LOI INPUT

MUON TRIGGER MEETING

SEP 15 FERMILAB

1.) D. GREEN – RATES
2.) R. THUN – SCINT. TRIGGER
3.) U. NAUENBERG – Č TRIGGER
4.) J. WISS – TRIGGER RESOLUTION
5.) M. HANEY – TRIGGER SIMULATION
6.) K. JOHNS, M. FORTNER – DØ TRIGGER
7.) S. ERREDE – CDF TRIGGER
8.) S. HONG – COSMIC RAY RATES
9.) J. CHAPMAN, G. FELDMAN – SDC CHAMBER TRIGGER

SDC MUON SYSTEM NOTES AND DOCUMENTS (last updated: ~~25 July~~ 18 Sep 1990)
(This list contains some non-SDC publications of particular interest)

TITLE	AUTHOR(s)	DATE	COMMENTS
Muon Rates at the SDC	D. Green, D. Hedin	?	
Fast Non-Explosive Gases for Drift Chambers, FNAL TM-1523	D. Green et al.	May 88	
Central Muon Trigger Resolution for the Solenoidal Detector	D. Carlsmith	9 Jan 90	
Iron-Scintillator Configurations for Muon Triggers	R. Thun	11 Jan 90	
Muon Momentum Accuracy-Matching the Forward Toroid to the Central System	T. Fields	31 Jan 90	
SSC Detector Muon Sub-System Beam Tests	D. Carlsmith et al.	31 Jan 90	
Comparison of Muon Momentum Resolution for the Solenoidal Detector versus Muon Momentum Resolution for External-Only Systems	S. Errede	8 Mar 90	
Computation of Coil Parameters for RTK Baseline Muon Toroid	J. Bensinger	28 Mar 90	
Impact of Various Magnet Options on Higgs Physics	R. Thun	12 Apr 90	
Tracking Muons at SSC	T. Zhao	30 May 90	
Comments on the Muon-Detector Performance at High Luminosity	Y. Asano	July 90	
A Note on the Drift Modules for SSC	Y. Asano	21 July 90	
Momentum Resolution for Muons Using the Full Tracking System of SDC	S. Odaka	Aug 90	
A Cell Design for SDC Central Muon Chambers	Y. Teramoto	3 Sep 90	
A Note on Chamber Size and Readout Electronics for SDC Muon Chambers	Y. Teramoto	6 Sep 90	
A Note on Number of Planes per Super-Layer in SDC Muon Chambers Based on Trigger Considerations	Y. Teramoto	10 Sep 90	
Iron-Scintillator Configurations for SDC Muon Triggers SDC-90-00077	R. Thun	7 Sep 90	
Muon Rates for Triggers	D. Green	Aug 90	

Angle Dependence of Forward Muon Momentum Resolution	J. Wiss	12 Sep 90
Particle Rates and Punch-thru Rates for the SDC Detector	Y. Asano	Sep 90

J. Bensinger
9/20/90

Toroid Steel Construction

RTK effort

Jorge Brown
Les Dittert
Alan Nunez
Jim Bensinger
David Bintinger
Richard Kadel

SSC Lab

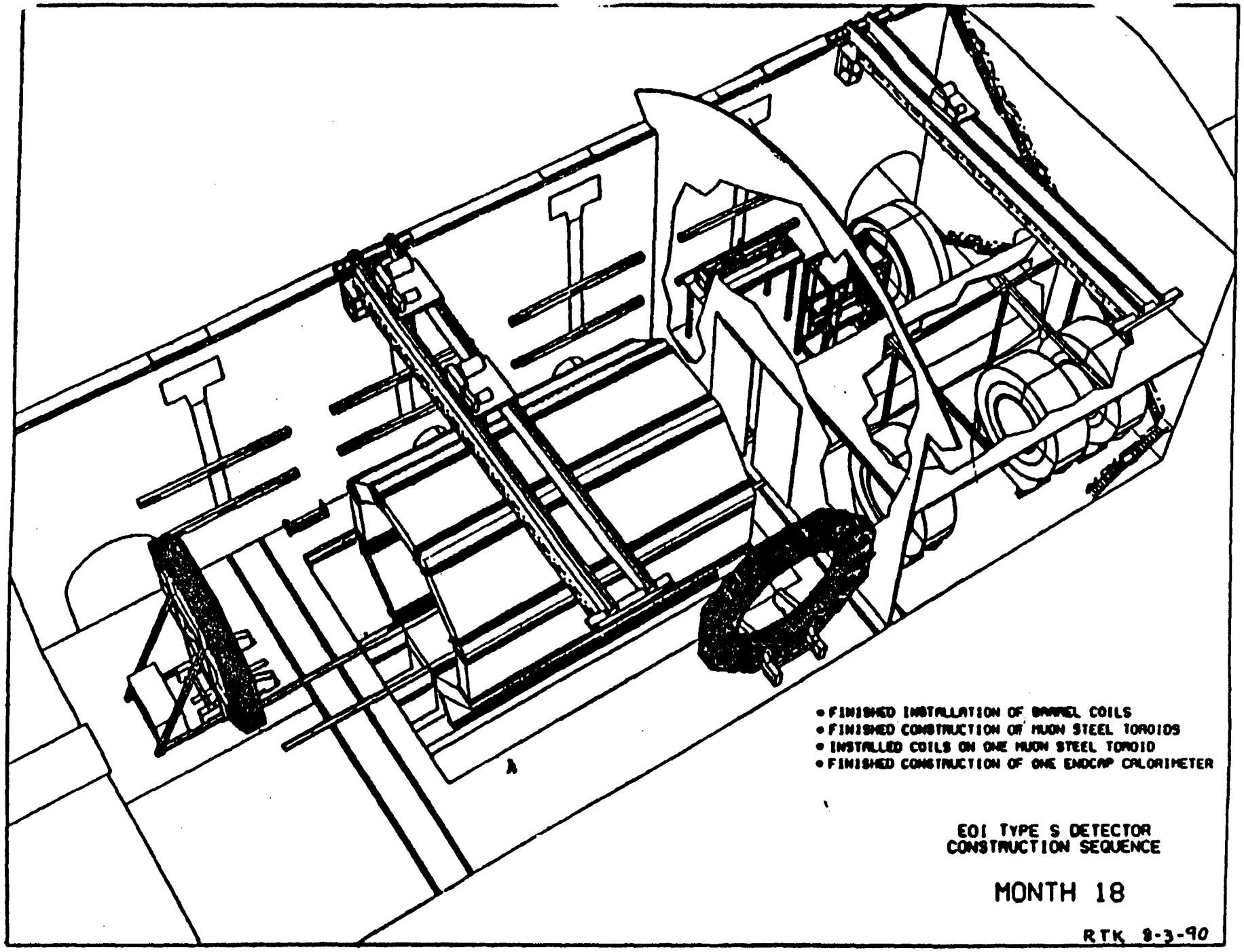
Tim Thurston

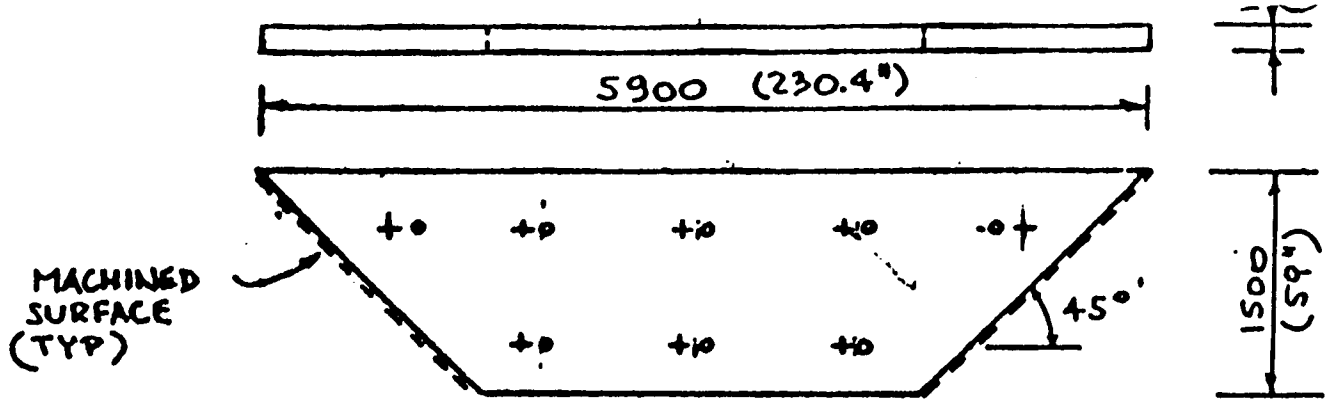
PSL - Wisconsin

Jeff Cherwinka

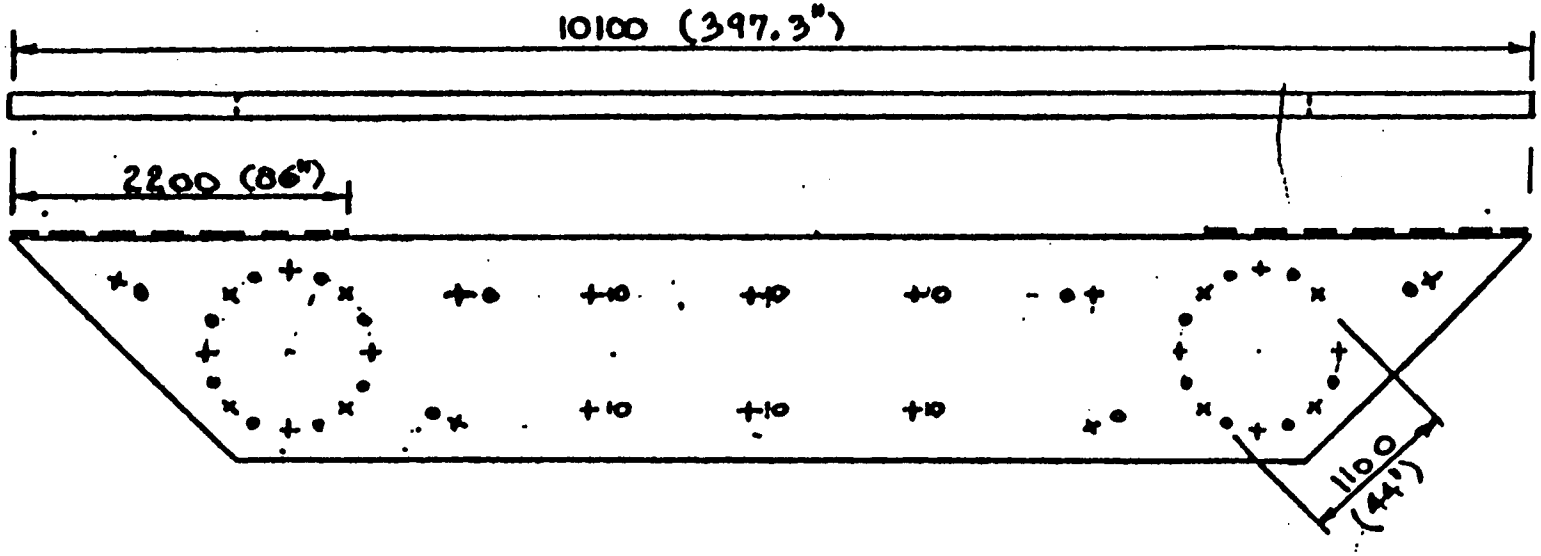
Japan

A. Maki
S. Terada
S. Mori
T. Shinkawa


• FINISHED INSTALLATION OF BARREL COILS
• FINISHED CONSTRUCTION OF MUON STEEL TOROIDS
• INSTALLED COILS ON ONE MUON STEEL TOROID
• FINISHED CONSTRUCTION OF ONE ENDCAP CALORIMETER
EOI TYPE S DETECTOR
CONSTRUCTION SEQUENCE
MONTH 18
RTK 8-3-90



ELEVATION OF "SHORT" PLATES

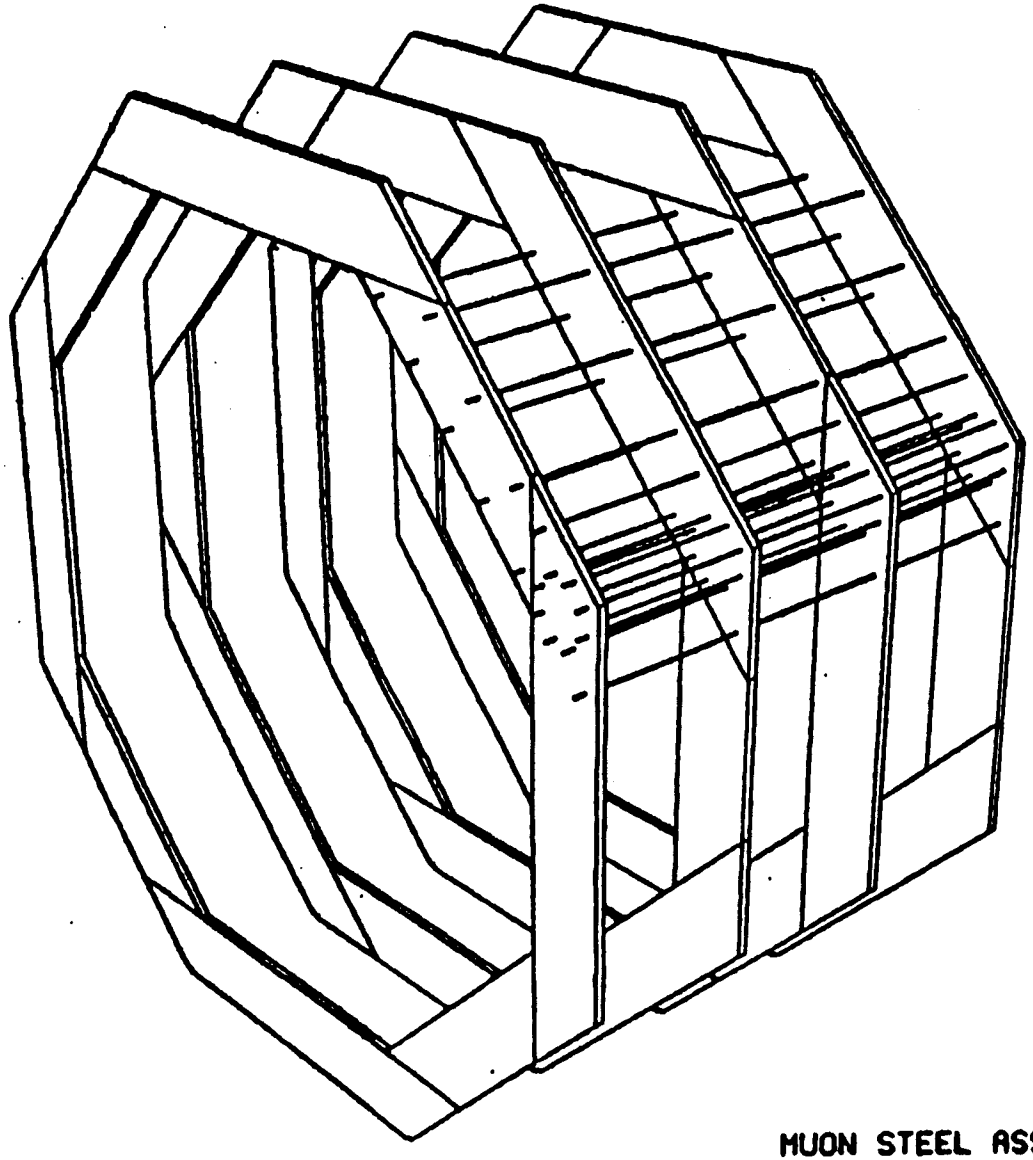


ELEVATION OF "LONG" PLATES

NOTE: 12% OF THE PLATES WILL BE DRILLED WITH RECESSED 2"ϕ HOLES SHOWN THUS: + AND o
44% OF THE PLATES WILL BE DRILLED WITH STANDARD 2"ϕ HOLES SHOWN THUS: + , AND THE REMAING 44% WITH STANDARD 2"ϕ HOLES SHOWN THUS: o

EO1 TYPE S SOLENOID
MUON STEEL PLATES

SK* 1

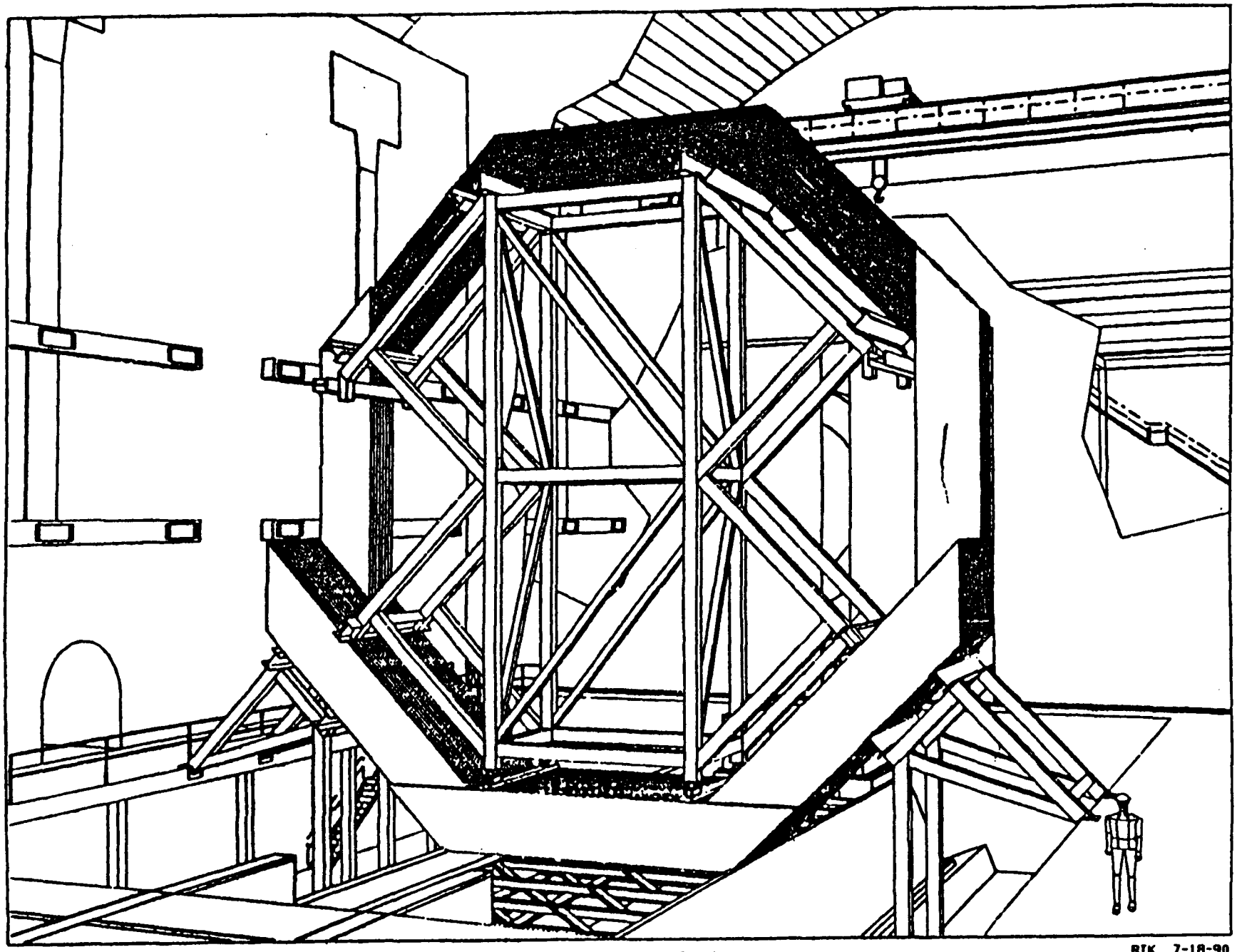


MUON STEEL ASSEMBLY

RTK 7-18-90

EOI TYPE 5 SOLENOID
MUON STEEL PLATES

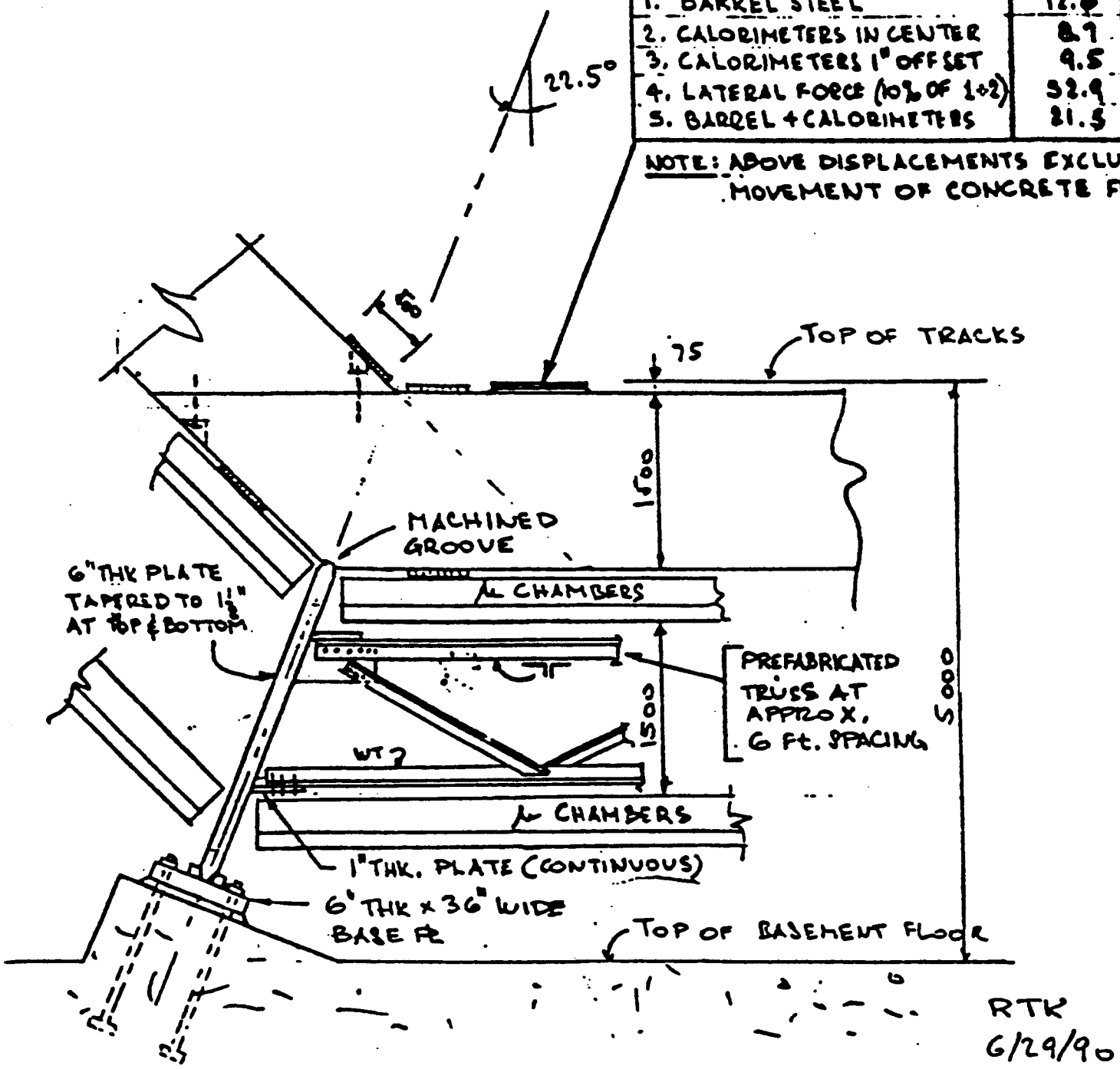
SK* 2



MONTH 5.9

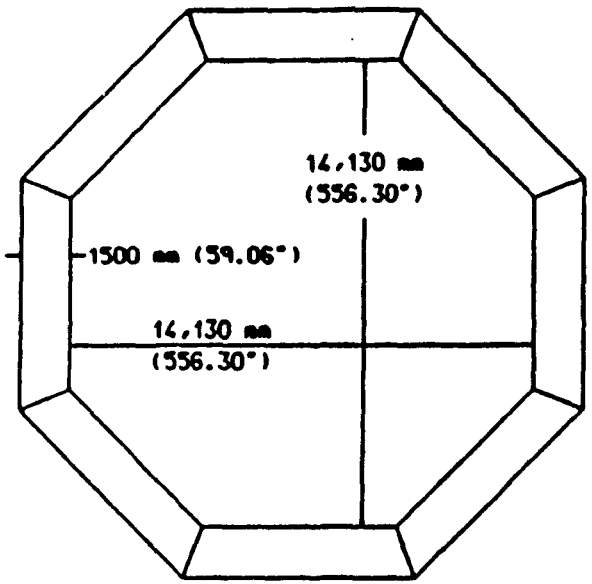
MOVEMENT OF TRACK DUE TO WEIGHT OF	MOVEMENT (MI VERTICAL	HOR
1. BARREL STEEL	12.8	0.7
2. CALORIMETERS IN CENTER	8.7	0.3
3. CALORIMETERS 1" OFFSET	9.5	2.
4. LATERAL FORCE (10% OF 1+2)	52.9	13(
5. BARREL + CALORIMETERS	21.5	1

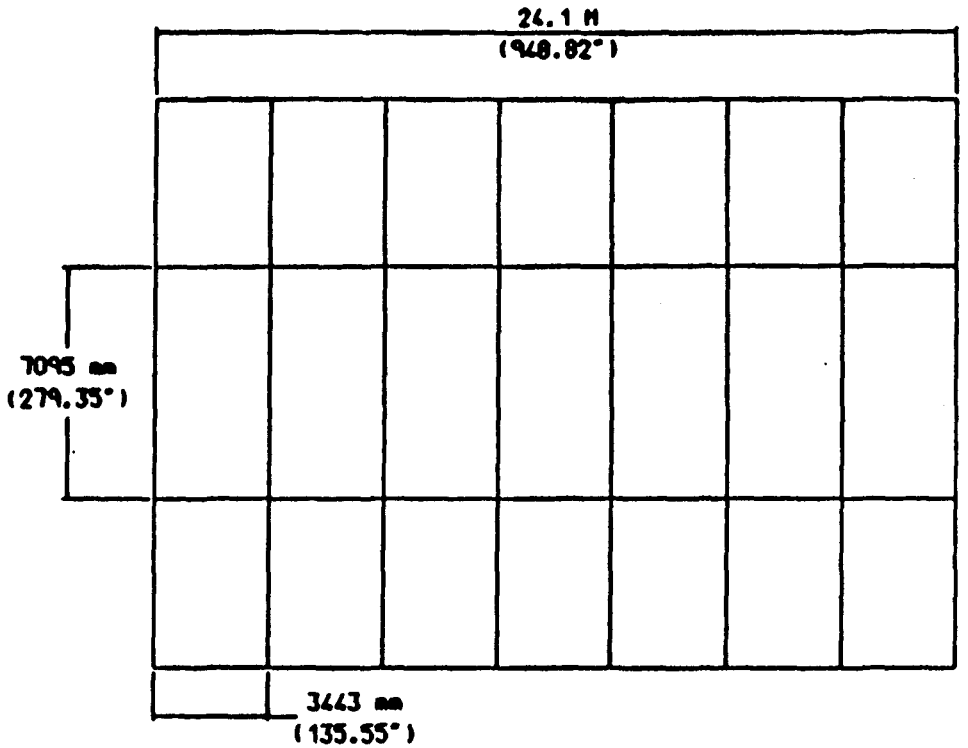
NOTE: ABOVE DISPLACEMENTS EXCLUDE MOVEMENT OF CONCRETE FLOOR



SDC – TYPE S DETECTOR

INCLINED PLATE BARREL SUPPORT





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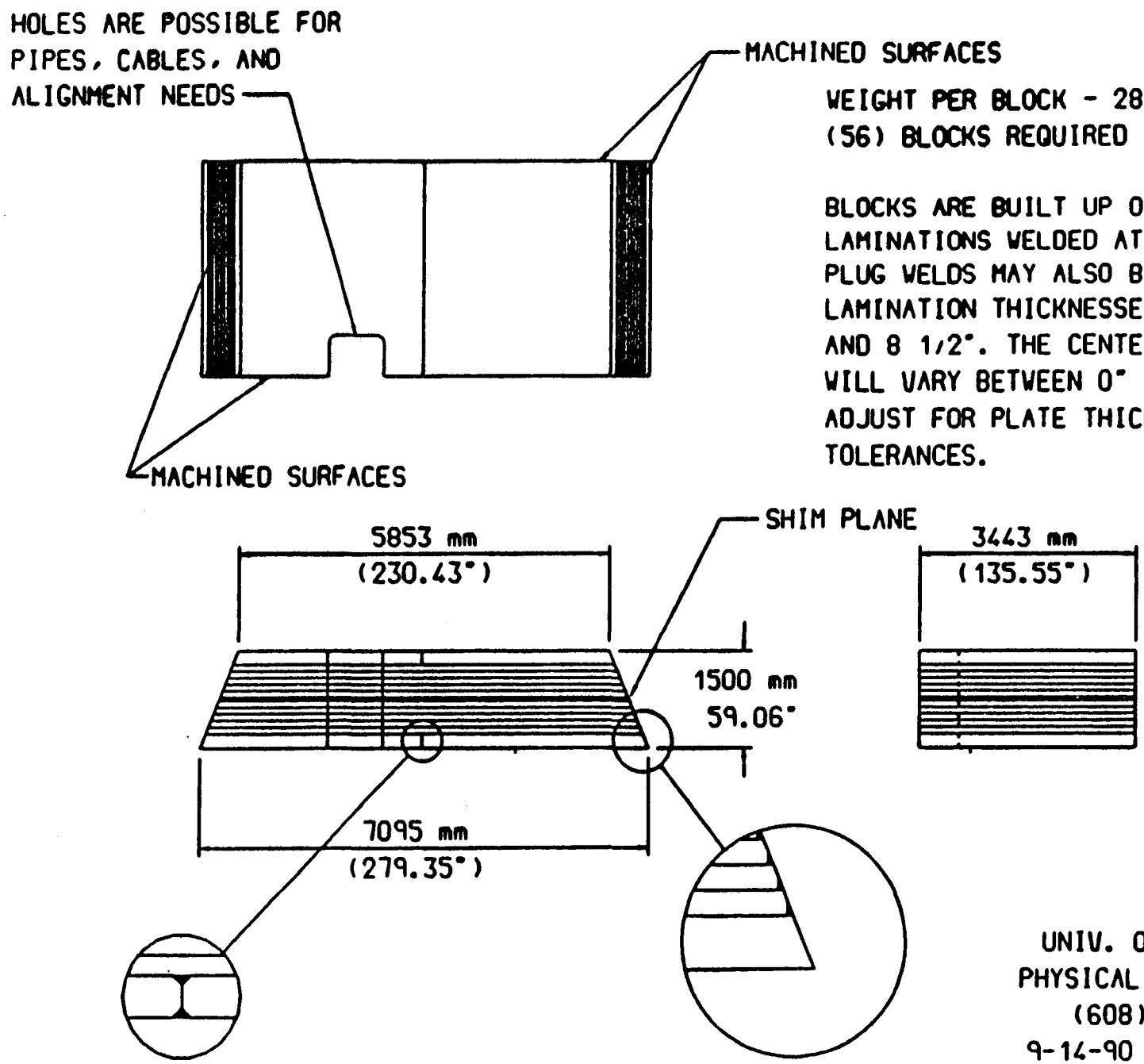
PHYSICAL SCIENCES LAB
(608) 873-6651
9-14-90 1/48 SCALE

PROJECTED BY AMR DRAWING FILENAME OCT



WEIGHT PER BLOCK - 289.5 TONS
(56) BLOCKS REQUIRED

BLOCKS ARE BUILT UP OF PLATE LAMINATIONS WELDED AT EDGES. PLUG WELDS MAY ALSO BE NEEDED. LAMINATION THICKNESSES ARE 4" AND 8 1/2". THE CENTER LAMINATION WILL VARY BETWEEN 0" AND 2" TO ADJUST FOR PLATE THICKNESS TOLERANCES.

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9-14-90 1/40 SCALE

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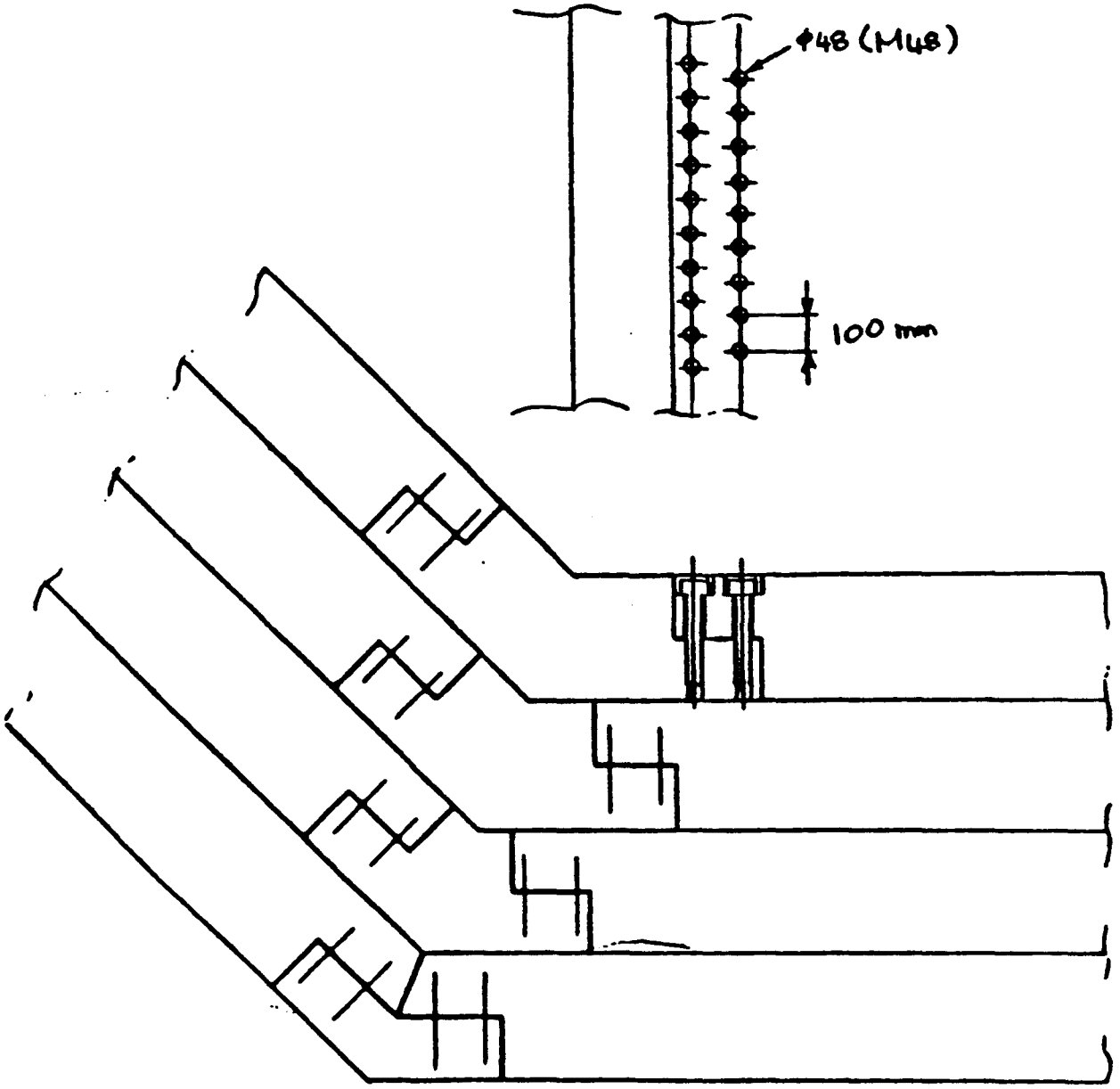
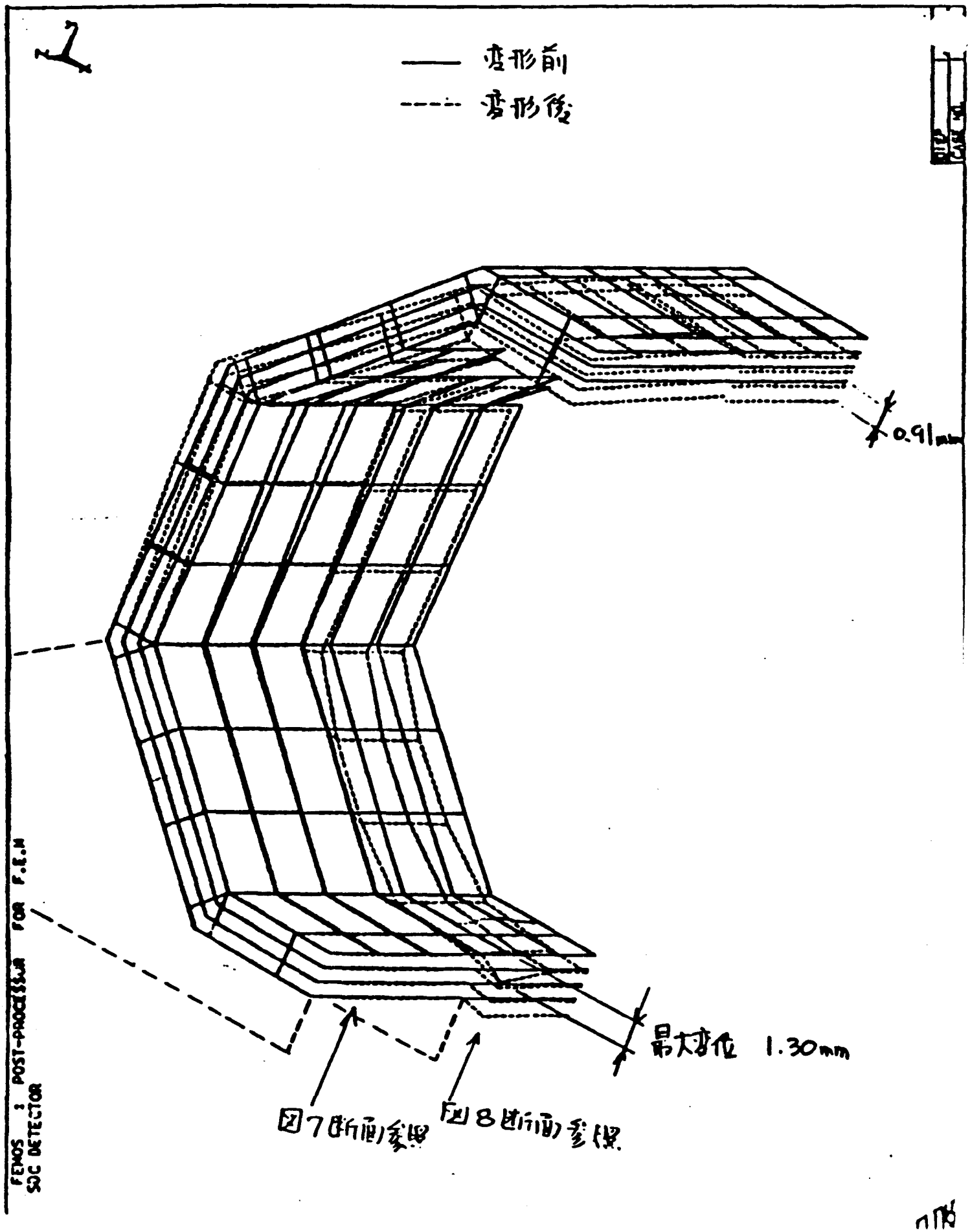
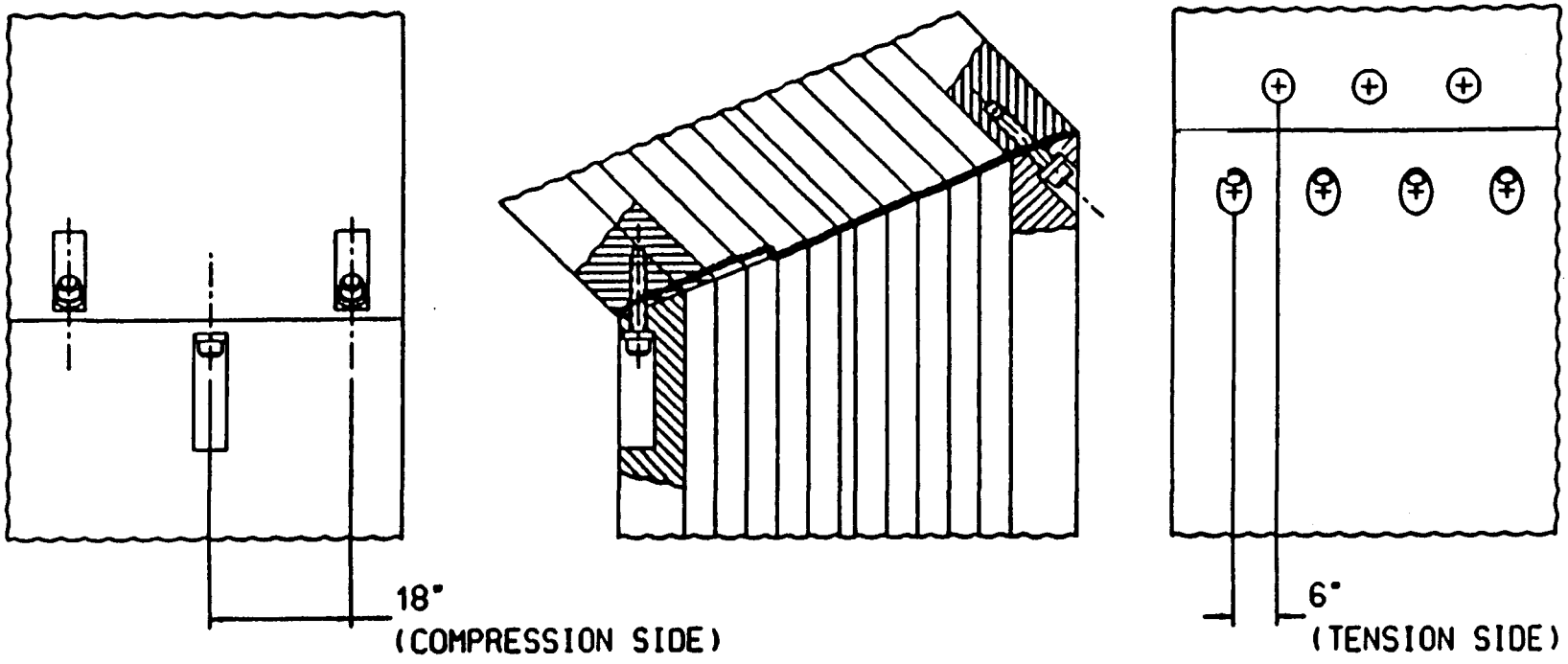
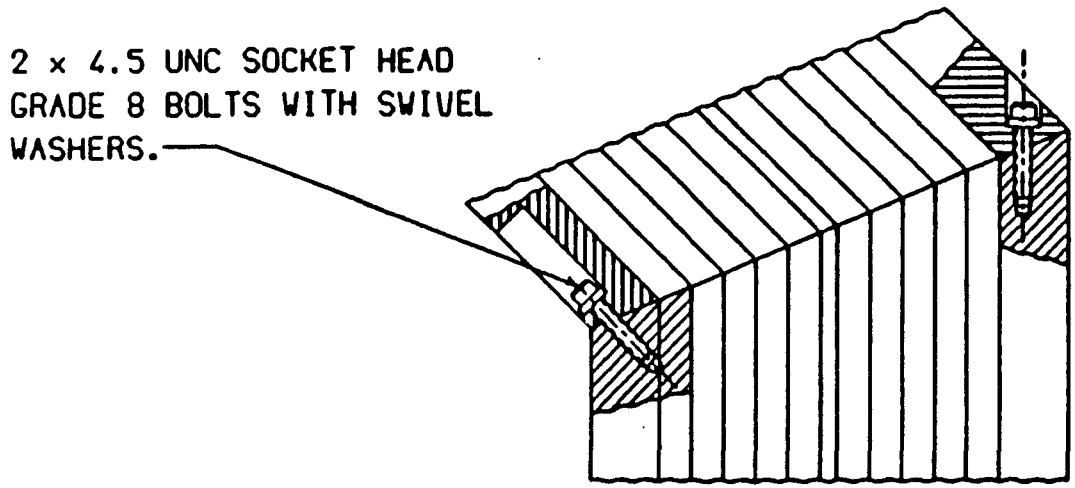

φ48 (M48)
100 mm


変形前
変形後
0.91mm
最大変位 1.30mm
図7断面参照
図8断面参照
FEMOS 1 POST-PROCESSOR FOR F.E.M
SDC DETECTOR





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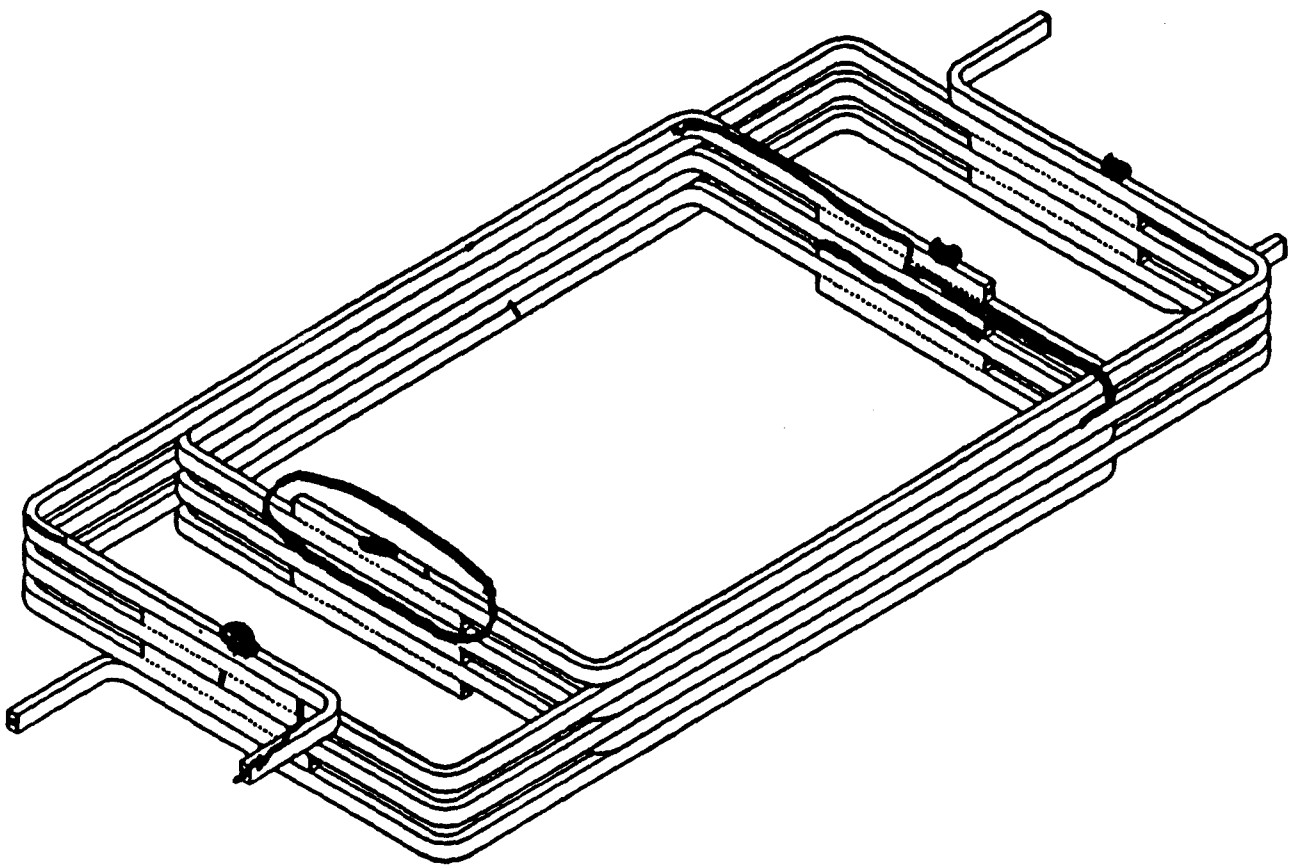

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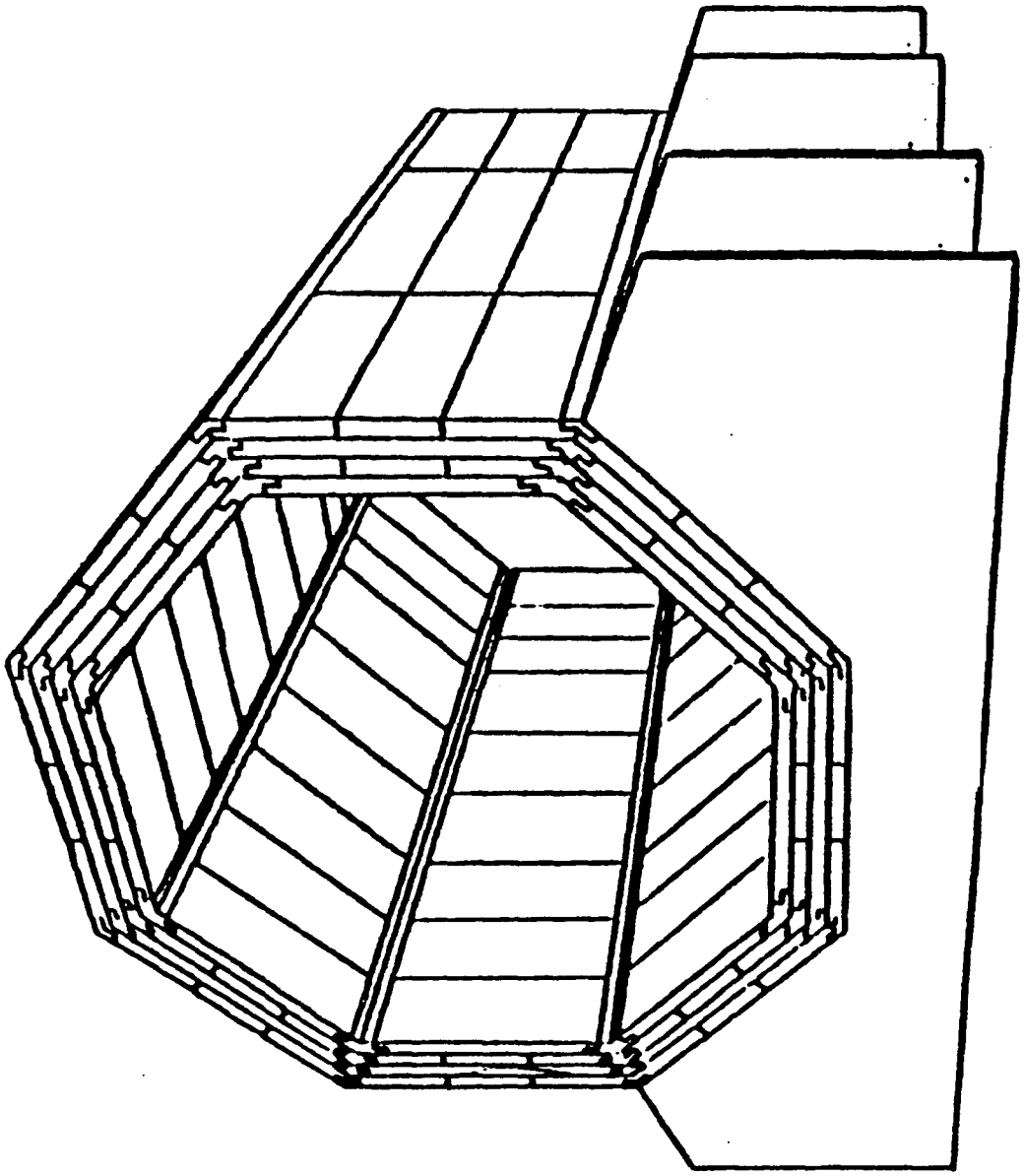
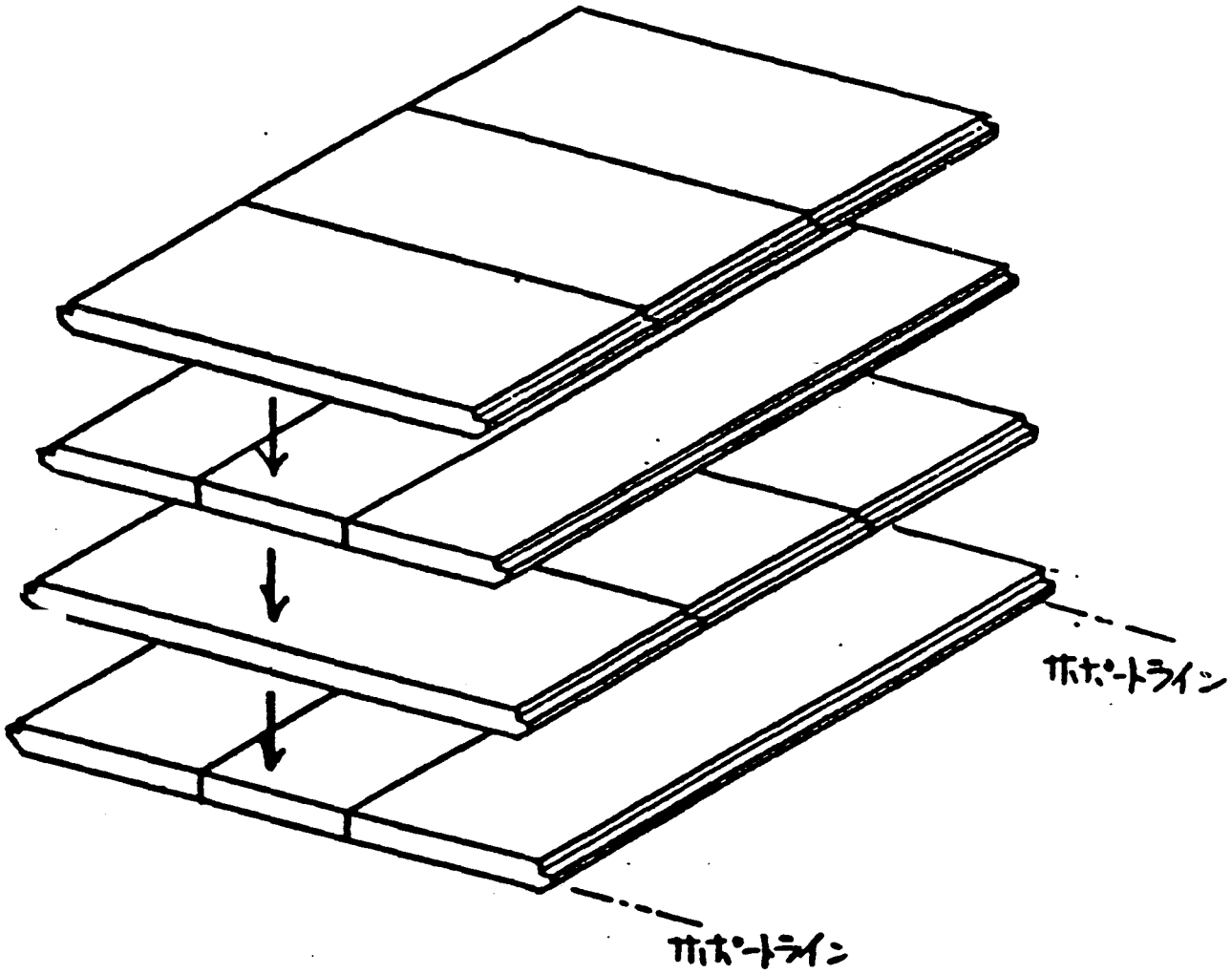
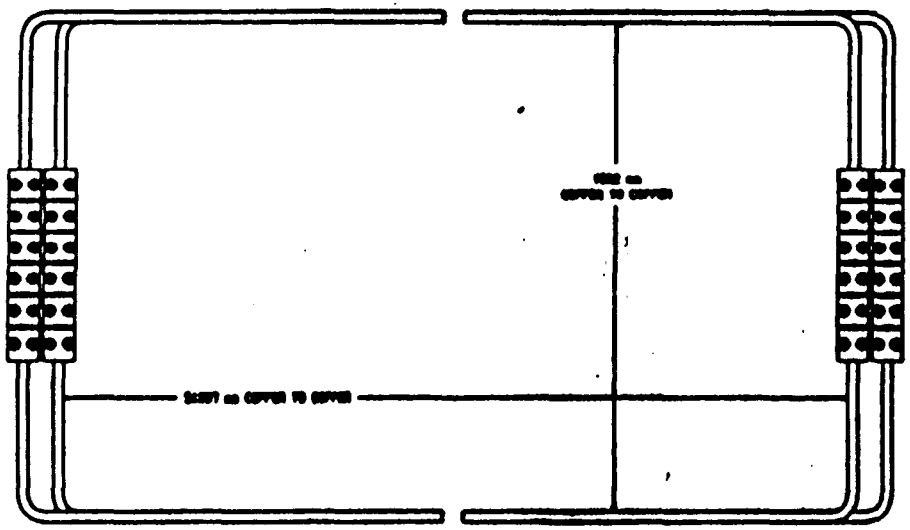
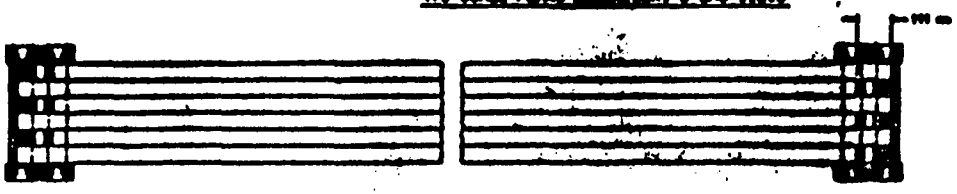




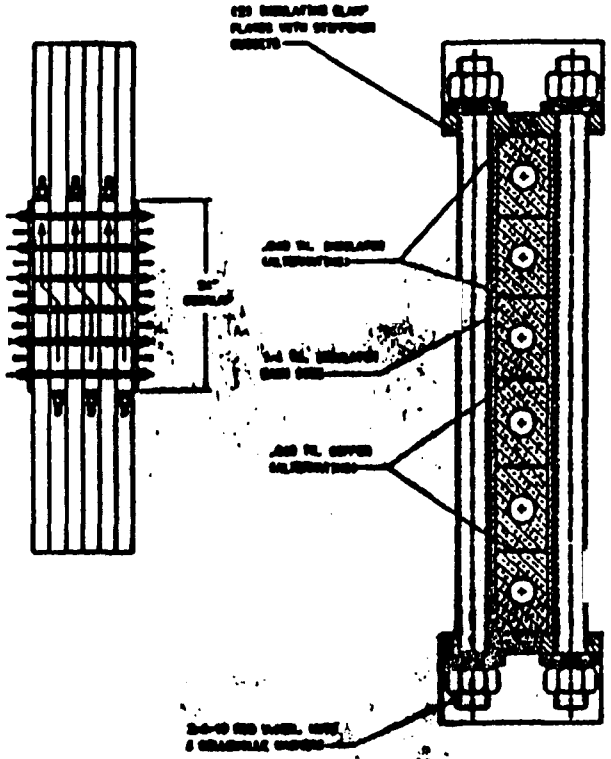
トロイド積層方法



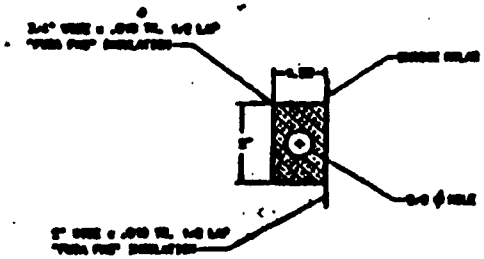
1/3 SCALE PLAN, [illegible], & END VIEW



1/48 SCALE PLAN VIEW OF COILS



[illegible] CLAMP PLATES
FULL SCALE



[illegible]
FULL SCALE

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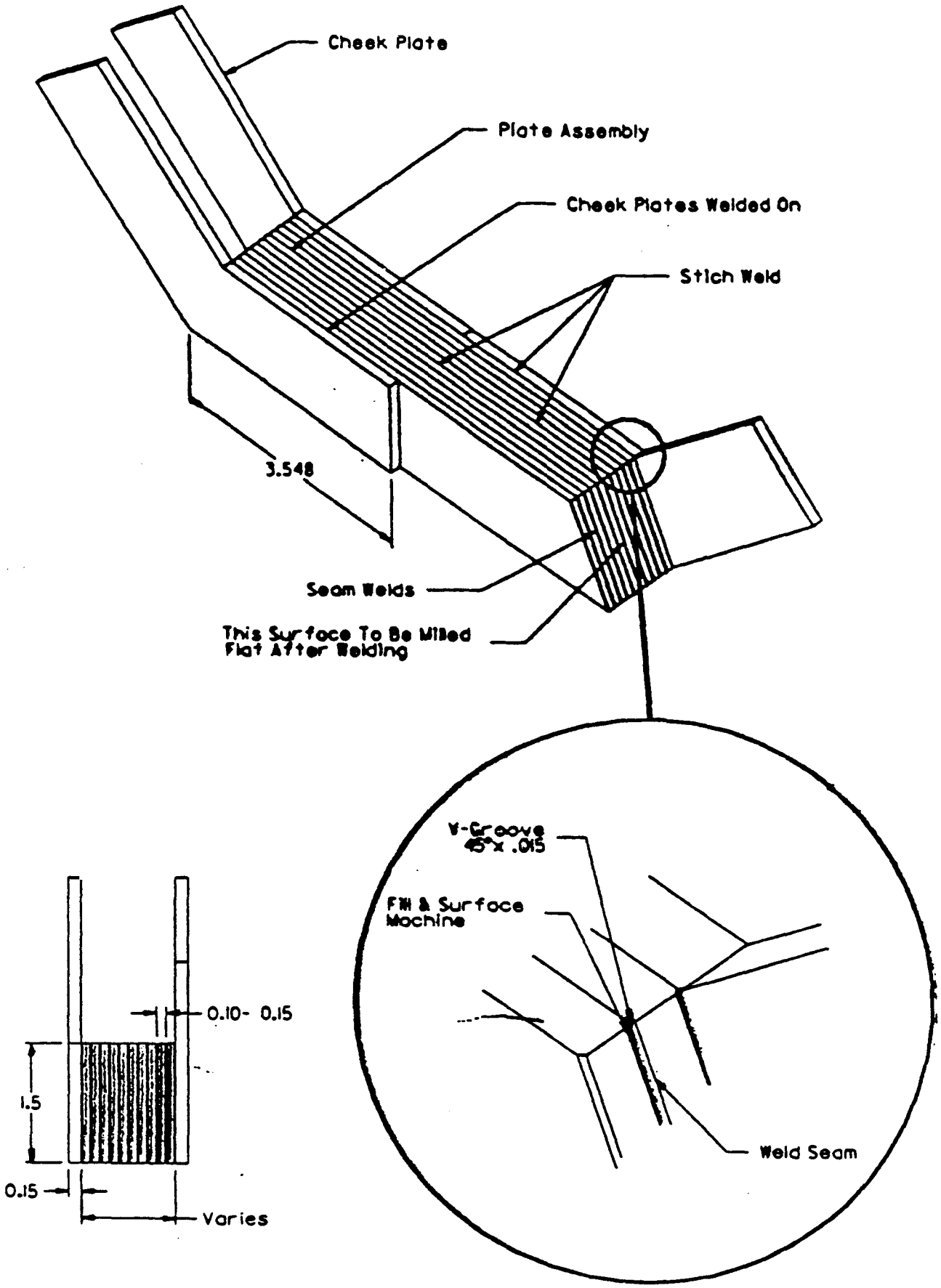
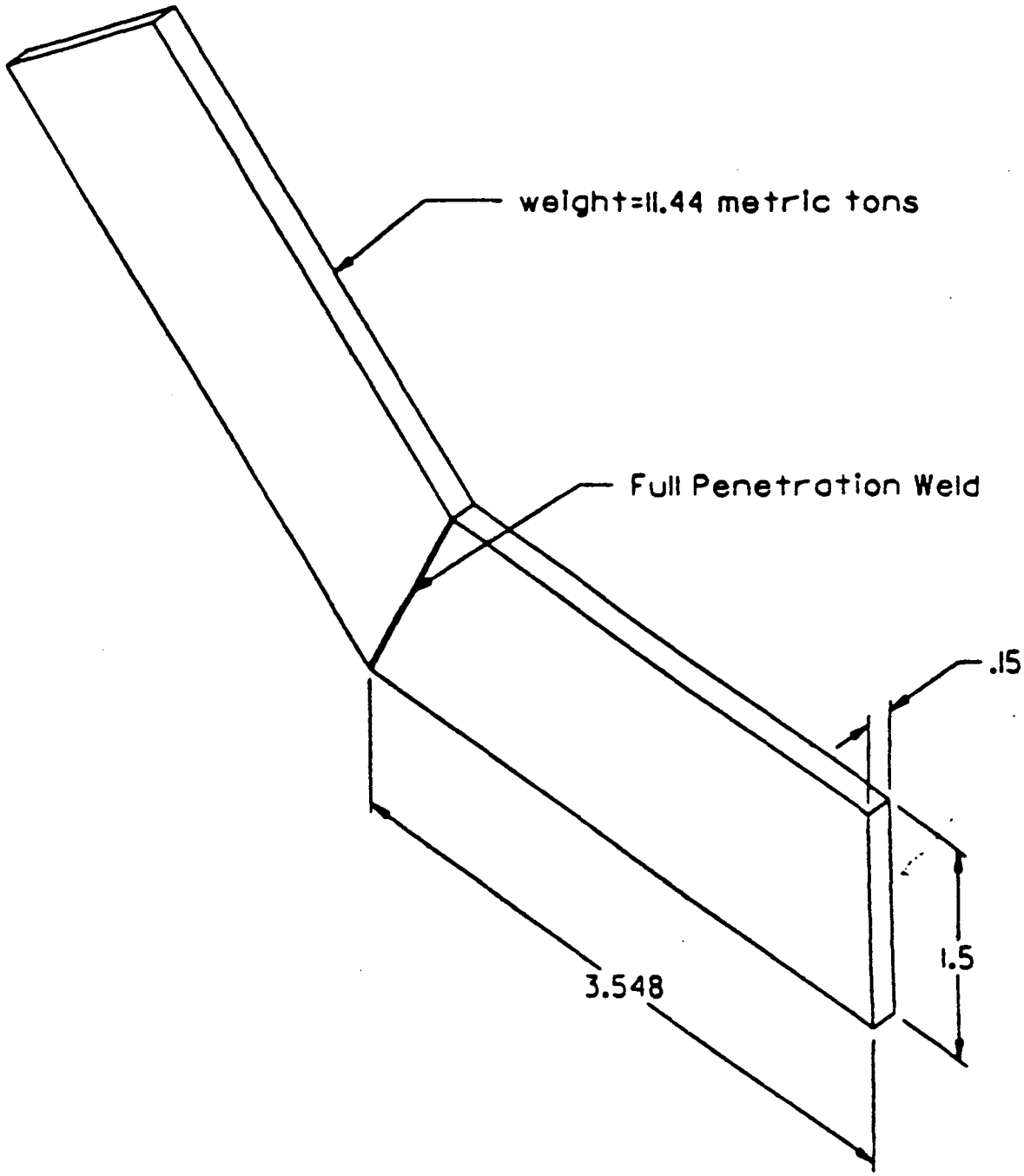
(608) 873-[illegible]
9-14-70 SCALE IS NOTED

DESIGN PACKAGE *2

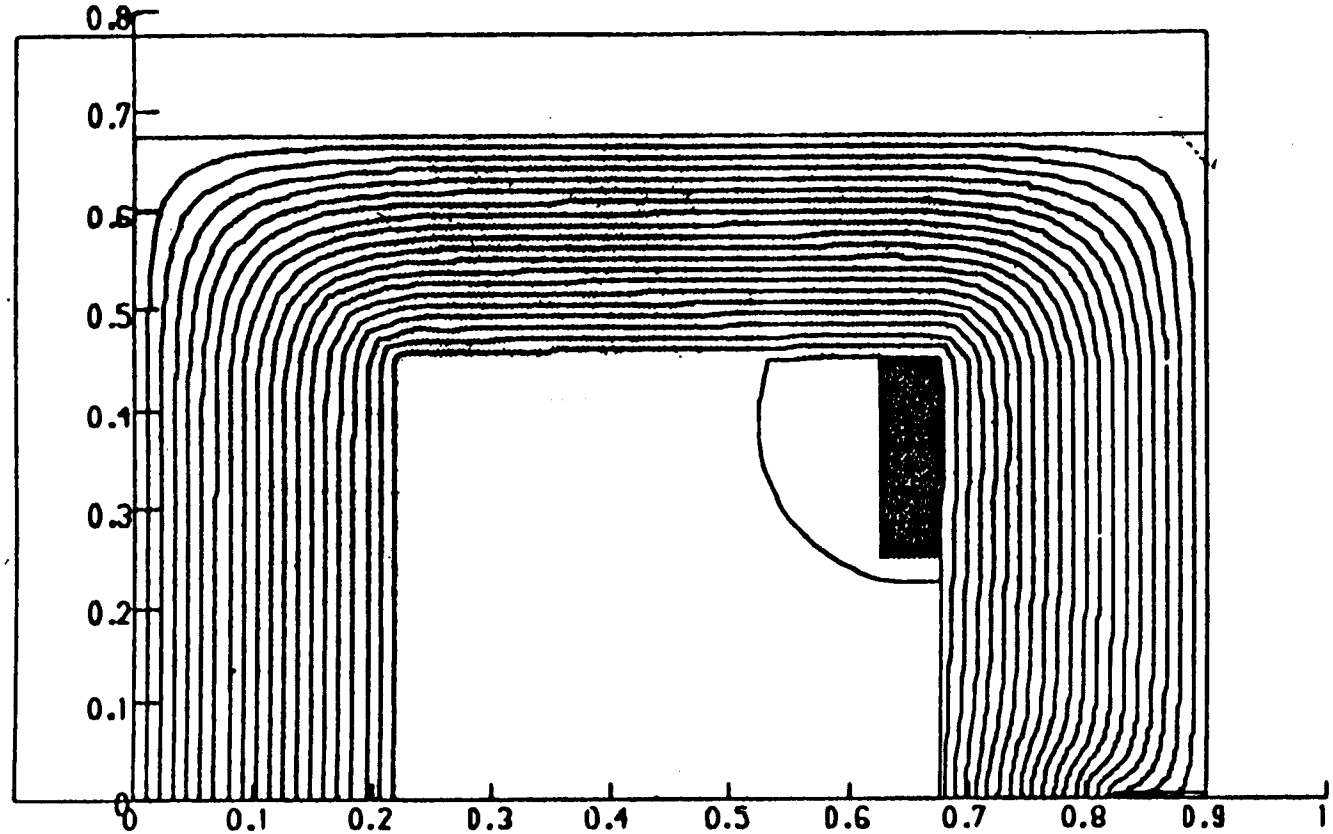


DIMENSIONS ARE IN METERS



Cheek Plate Detail

ROID_GA .RES
/Sep/90 11:57:04 Page 3 : RECO 0 1 0 .8 -LABE +FILL AXES=REDR



Component: POT
Minimum: 0, Maximum: 0.4, Interval: 0.02

ELEM=LINE SYMM=XY SOLN=AT FIEL=MAGN
Static Solution Mesh 1350 Elements 7 Regions

VF/PE2D.8