GEM TN-91-21

GEM Collaboration Council Meeting at the SSCL

October 2, 1991

Abstract:

Transparencies from the GEM Council Meeting at the SSCL on October 2, 1991 are presented.

******GEM******
Collaboration Council Meeting
October 2, 1991
SSCL 9:00 AM
Building 4 Auditorium

Agenda

9:00 am	General Business (Barish and Willis)
9:30 am	Discussion of Detector Decisions
	- -Magnet (Stroynowski)
	- -Muons (Taylor/Ahlen)
	- -Calorimeters (Brau/Adair)
	- -Inner Tracking (Morgan/Baltay/Musser)
	- -Electronics-DAQ (Shaevita/Marlow)
11:00	LOI Physics Questions (Paige/Lane)
12:00	Lunch
1:00	LOI plans (Barish, Yost)
1:30	Engineering/Costing (Sanders/Marx)
2:30	Adjourn

B. Barish

GEM

Collaboration Council Meeting

Oct 2, 1991

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SSCL 9 AM
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2:30	Adjourn

After 3pm there will be a meeting of the Executive Committee.
Some of the subsystems groups will be having meetings in breakout rooms
After the Executive Committee meeting there will be a practice session or PAC presentations

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Thursday October 3
Morning Session will be in the Auditorium and will be open.
GEM presentations will be from 9:30 - 12:00
All are welcome and encouraged to attend.

Afternoon sessions will be closed or involve a small number of GEM representatives (eg. Exec Committee and Spokesmen)

In addition to the Council meeting and the PAC meeting, the following sub-group meetings are currently scheduled:

Calorimetry	Oct 1	Auditorium
Muons	Oct 1	Cafetorium
Computing	Oct 4	Cafetorium
DAQ/Trigger	Oct 4	Strategy Room (in center section of B4)
Tracking	Oct 3	B18 Large Conf Rm.

These room assignments are tentative. Please check the sign at the User Office for possible changes.

PROPOSED PLAN

JULY 91
PAC

JUNE 91 - Collaboration Forms

JULY 91 - Submit EOI

Name Detector
Define Detector
Choose Technologies
} DECISIONS!

Nov 91 - Submit LOI

R+D
Engineering
Test Beams
(April 92 - Report for Hall Title II.)

Nov 92 - Submit Eng/Design Report

This schedule stays on critical path!

- Hall kept on schedule
- Single Coil SC Magnet
- Needs R+D ; Engineering Support

Status / News

(September)

- Decisions / Defining GEM Detector
- Magnet Panel Review 1 + 2
- Begin Engineering Integration
- R+D + Engineering Support

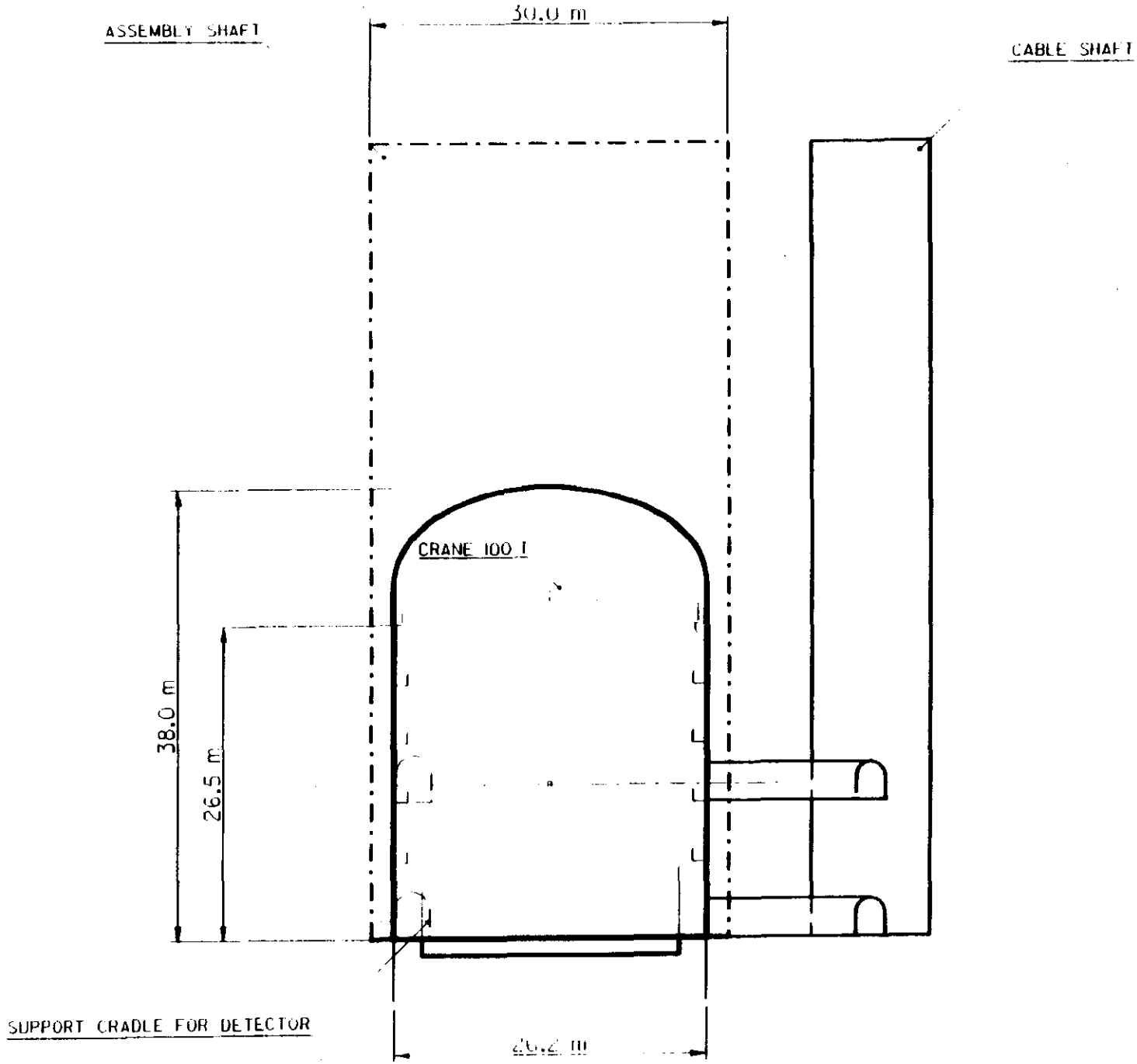
→ EOI 14M
Now ~17M (Subgroup estimates)
[Magnet 2.7M → 6M]

(October)

- Trip to Russia (Barish, Willis, Sanders, Marx)
- Corpus Christi
- Develop R+D Plan (Baltay...)
- 1st Draft LOI - Nov 4

Before November
- Collab Council Mtg -

RIGHT VIEW


ASSEMBLY SHAFT
30.0 m
CABLE SHAFT
CRANE 100 T
38.0 m
26.5 m
SUPPORT CRADLE FOR DETECTOR
20.2 m

July 91
PAC

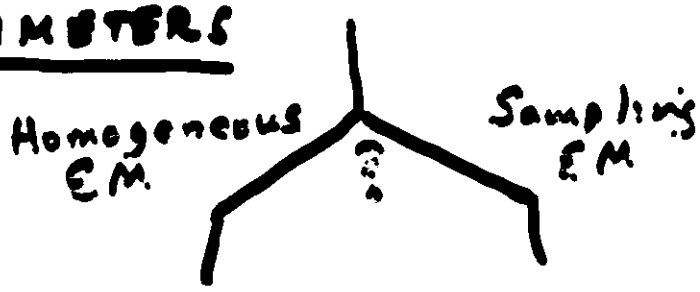
Decisions before LOI

1) **HALL** to keep on schedule

2) **MAGNET** to proceed with Engineering Design.

3) **MUONS** - design tracking system
- pursue ≤ 2 technologies for FY92

4) **CALORIMETERS**



- pursue ≤ 2 techologies for calorimeter subsystems

- design, location, techologies for Forward Calorimeters

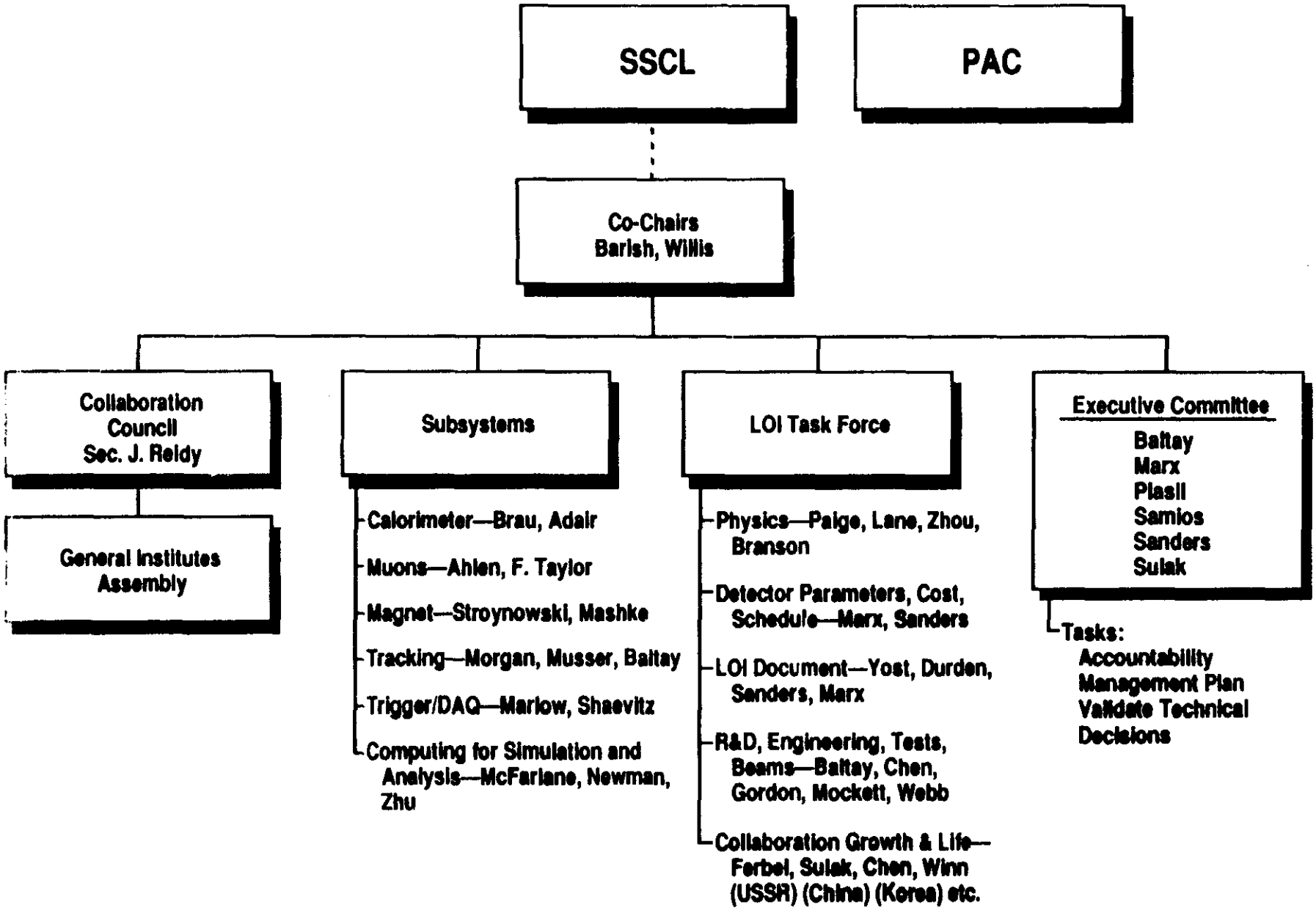
5) **TRACKER**
- goals
- technologies to pursue.

JULY 91
PAC

FY92 - Engineering's > Requests
R + D

Item	Engineering	R & D
Integration,Coordination,Costing	1.25	
Magnet	1.25	1.5
Muon System	.5	2.0
Calorimetry	.5	3.0
Tracking	.5	2.0
Trigger/ACQ		0.5
Reserve		1.0
Total	4.0	10.0

Assumes ability to <u>redistribute</u>
R+D toward 'chosen' systems
for FY92 !


SSCL
PAC
Co-Chairs
Barish, Willis
Collaboration Council
Sec. J. Reidy
General Institutes Assembly
Subsystems
Calorimeter—Brau, Adair
Muons—Ahlen, F. Taylor
Magnet—Stroynowski, Mashke
Tracking—Morgan, Musser, Baltay
Trigger/DAQ—Marlow, Shaevitz
Computing for Simulation and Analysis—McFarlane, Newman, Zhu
LOI Task Force
Physics—Paige, Lane, Zhou, Branson
Detector Parameters, Cost, Schedule—Marx, Sanders
LOI Document—Yost, Durden, Sanders, Marx
R&D, Engineering, Tests, Beams—Baltay, Chen, Gordon, Mockett, Webb
Collaboration Growth & Life—Ferbel, Sulak, Chen, Winn (USSR) (China) (Korea) etc.
Executive Committee
Baltay
Marx
Plasil
Samios
Sanders
Sulak
Tasks:
Accountability
Management Plan
Validate Technical Decisions
hd/7-17-91

MAGNET

R. STRUZNOWSKI
10/2/91

DESIGN TEAM
MIT, LLNL, NHMFL, SSCL + MAGNET TECHNICAL PANEL

INITIALLY 3 OPTIONS: UNSHIELDED MAGNET
SHIELDED MAGNET
a) DOUBLE COIL OPTION
b) Fe SHIELD

ISSUES: COST, FEASIBILITY, RISKS, SCHEDULE

VISIT TO MIT PLASMA FUSION LABORATORY

MAGNET DESIGN PARAMETERS

	Single	Double Coil
Centeral induction (T)	0.8	0.8
Inner radius, cryostat ("free bore") (m)	8.3	8.3
Outer radius, overall (m)	9.5	12
Inner length, door to door(m)	29	29
Measurement lever arm (m)	3.8	3.8
Mass of windings (t)	440	500/700*
Mass of cold structure (t)	330	450
Mass of cryostat vessel (t)	550	845
Mass of iron poles (each) (t)	2950	7000
Radial pressure on windings (kPa)	260	390/-110*
Stored energy (GJ)	1.8	4.1
Inductance (H)	1.5	3.3

**outer-coil/inner-coil*

MILLER 012 9.3.91

1) The Decision Group approved the recommendations of the Magnet Technical Panel to proceed with the single superconductiong coil option for the LOI. This option is significantly less expensive then either the two-coil system or the iron-shielded system. It also presents minimal technical risks. The unshielded coil can be used without violating any existing enviromental or safety regulations. It will produce a fringe field of up to about 35 gauss at the surface above the experimental hall with the area of about 180 by 200 m where field will exceed 10 gauss. Such area can be marked by fence or hedge. Higher fringe fields are expected in the experimental hall, where local shielding of sensitive equipment and special handling of ferromagnetic tools will be necessary. There are ample examples of facilities operating with substantial fringe fields. These range from MRI hospital installations, through Bubble Chamber's magnets to magnetic fusion confinement devices (MFTF, HFTF and FENIX at LLNL, ALCATOR C-MOD at MIT Plasma Fusion Laboratory and others). Proof of existance of equipment working in such fringe field is available.

) The base-line design for the LOI will consist of the central coil with straight poles. It has been recognised that the field integral in the forward direction is too small. Ideas for improvement of the field at small angles exist, but the engineering work on such options will be postponed for later part of this year. This decision is motivated by the limited funds and time available and by desire to produce properly eng neered and costed base-line design for the LOI.

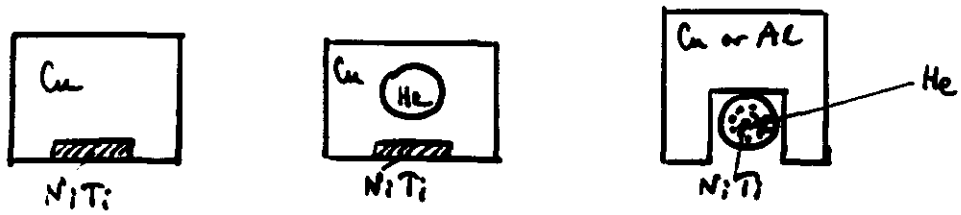
Single coil option allowes for future upgrades of the muon system by placing additional chambers outside the coil. No work is planned on such option for the LOI.

For the LOI, the base-line design will be optimized for the cost, size and field value producing the same muon measurements resolution.

OTHER DESIGN ISSUES

- COOLING
  - NATURAL CONVECTIVE FLOW (THERMAL SYPHON)
  - CRYOGENIC SYSTEM MAY BE COUPLED/PATTERNED ON THE ACCELERATOR CRYO SYSTEM

- CONDUCTOR - CLOSELY COUPLED TO THE MANUFACTURING PROCESS

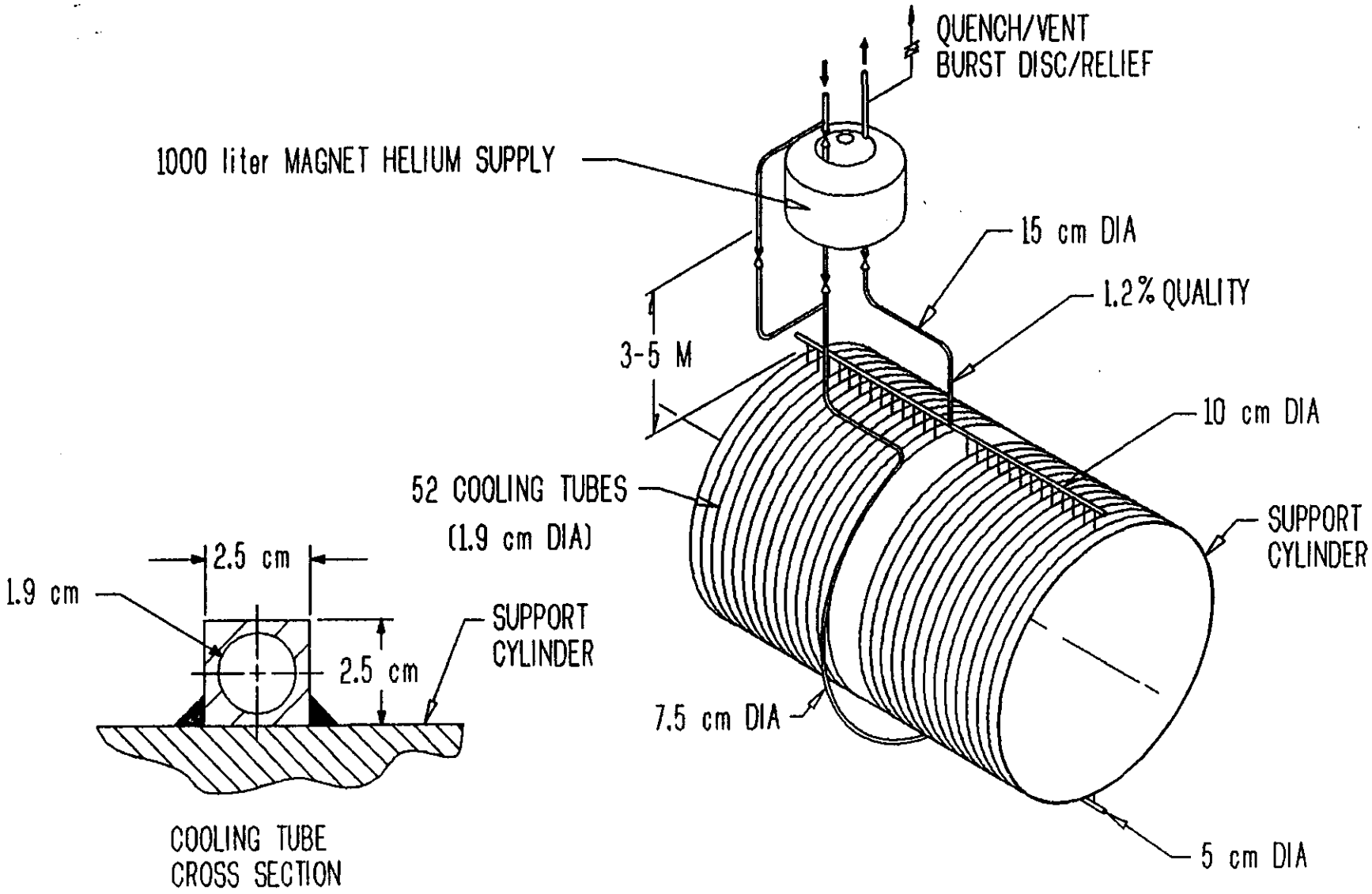


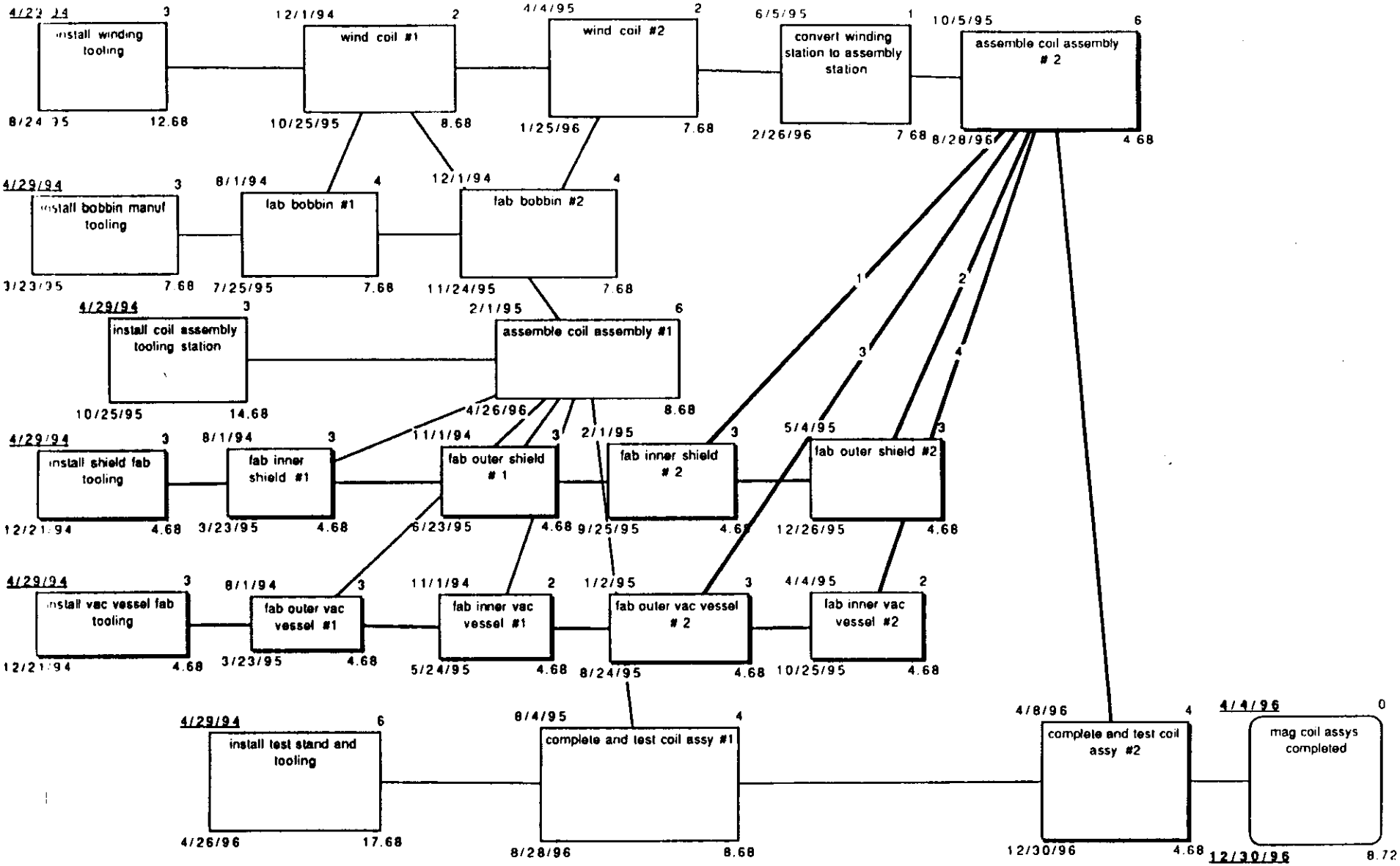
  - MANY OPTIONS WOULD WORK
  - SAFETY MARGIN LARGEST FOR "ROPE-IN-CONDUIT"
  - STRONG RECOMMENDATION FOR R&D

- SCHEDULE
  - DEPENDS ON MANUFACTURING SCHEMES AND PROCUREMENT PLANS
  - INCREASED NUMBER OF PARALLEL PATHS AND PREFABRICATED COMPONENTS
  - WINDING IN SECTIONS
  - NO FIELD TESTING AT THE SURFACE
  - COMPLETON 10/96

FIGURE I

MAGNET NATURAL CONVECTION (THERMAL SYPHON) LOOP

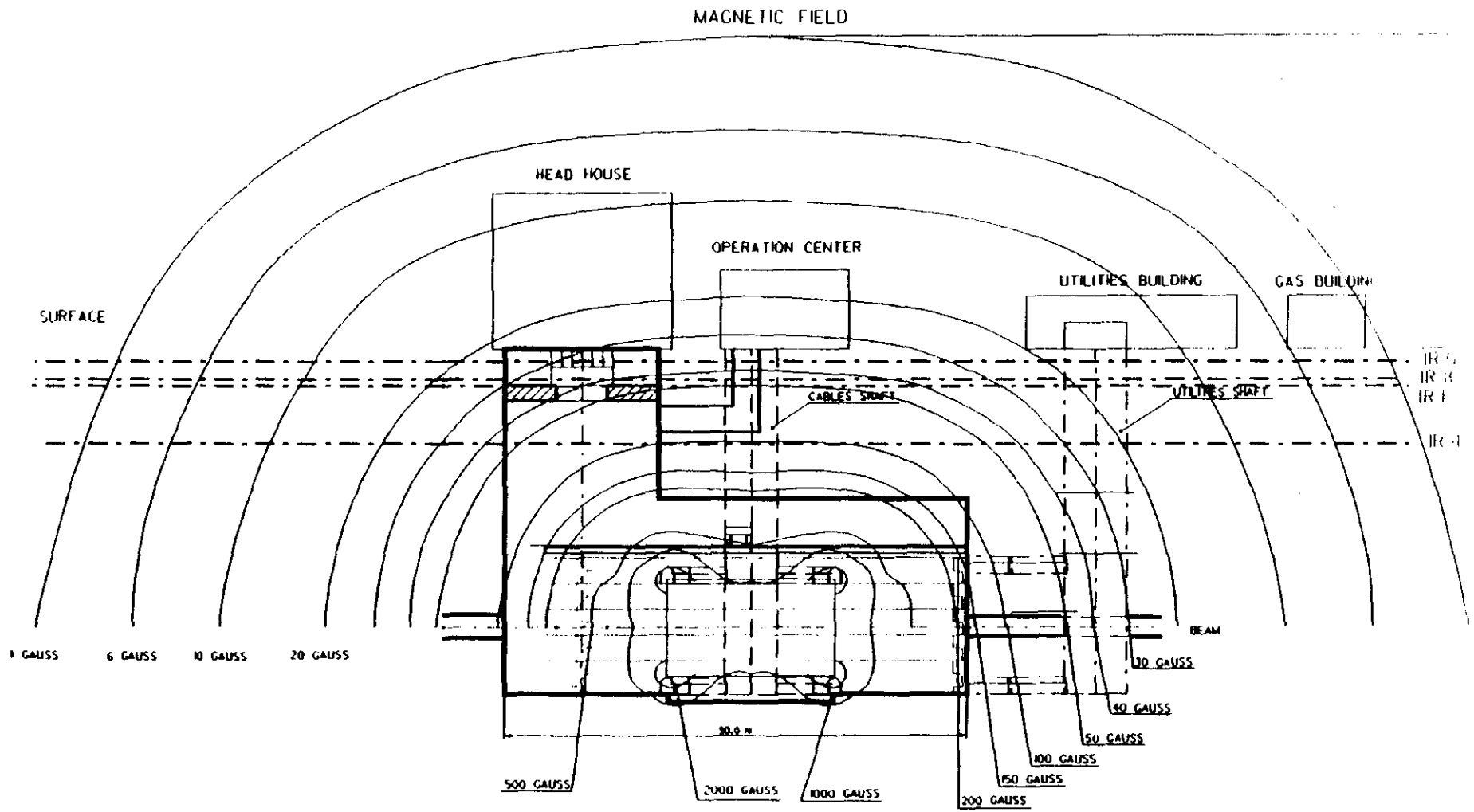




Earliest Start — Duration

GEM Magnet Assembly Schedule CVJ III 8/27/91

Latest Finish — Slack


MAGNETIC FIELD
HEAD HOUSE
OPERATION CENTER
UTILITIES BUILDING
GAS BUILDING
SURFACE
CABLES SHAFT
UTILITIES SHAFT
BEAM
1 GAUSS
6 GAUSS
10 GAUSS
20 GAUSS
30 GAUSS
40 GAUSS
50 GAUSS
100 GAUSS
150 GAUSS
200 GAUSS
500 GAUSS
2000 GAUSS
1000 GAUSS

- [illegible] FIELD AT THE SURFACE

  - AREA WITH FIELD >10 GAUSS APPROXIMATELY 200 x 200 m

    [illegible] DEPEND [illegible] AND [illegible]

    [illegible] FIELD ABOVE [illegible]

    [illegible] OTHER EXISTING OPEN FIELD FACILITIES

    HFTF, MFTF, FENIX AT LLNL

    ALCATOR C-MOD AT MIT

    15' BUBBLE CHAMBER AT FNAL

    LCT AT OAK RIDGE NL

    MRI FACILITIES AT HOSPITALS

  - FIELD ~1 GAUSS AT HIGHT OF ~60 m
  - NO OBVIOUS OTHER HEALTH HAZARDS

- OPTIONS UNDER STUDY
  - FENCE AROUND 5 GAUSS PERIMETER
  - RESTRICTED ACCESS FOR PEOPLE WITH PACEMAKERS
  - SHIELDING OF THE COUNTING HOUSE (~$150k)

  - SHIELDING OF SURFACE WITH IRON PLATES

    [illegible]

    (BACKUP OPTION, CAN BE PUT IN LATER)

  - BUILD A HILL ~50 m HIGH

- FORCE FIELD IN THE HALL

LARGE 1 ÷ 2 KGAUSS NEAR THE DETECTOR
200 ÷ 300 GAUSS NEAR LOWER COUNTING HOUSE

OPERATIONAL ISSUES ADDRESSED/SOLVED IN OTHER FACILITIES

PERSONNEL PROTECTION SYSTEM HAS TO BE IN PLACE
NO GENERAL ACCESS WITH FIELD ON
PERSONNEL TRAINING MAY BE NEEDED

SENSITIVE EQUIPMENT HAS TO BE SHIELDED
MOTORS, FANS, PUMPS, ...

FERROMAGNETIC OBJECTS HAVE TO BE SECURED
BeCu TOOLS FOR WORK IN THE FIELD

5. ASSESSMENT OF GEM MAGNET ADVISORY PANEL

- MAGNET - FEASIBLE
- RISKS - ACCEPTABLE

} STATE OF THE ART MAGN
WITH SUBSTANTIAL
ENGINEERING CHALLENGE

- TIME SCHEDULE - TIGHT BUT POSSIBLE
  STRONGLY DEPENDS ON PROCUREMENT AND MANUFACTURING SCHEME

- COST - $ 94.1 M INCLUDING 25% CONTINGENCY

Current Magnet Cost Estimate

	Tech Panel Mods
Subsystem Design	11.7
Coil Forms	7.0
Conductor	7.7
Winding (incl tooling)	12.0
Thermal radiation shields	2.3
Vacuum vessels	8.2
Cold mass supports	7.4
Coil assembly	6.4
Poles	11.1
Power/protection system	5.7
Cryogenics & vacuum	11.2
Installation	2.1
Management/integration	1.3
Total	$94.1M

25% CONTINGENCY INCLUDED

6. FORWARD DIRECTION - POSSIBLE IMPROVEMENTS

- RESOLUTION AS PROPOSED NOW [illegible]% AT $\gamma = 2.[illegible]$
- ISSUE PUT ON BACK BURNER DUE TO LACK OF TIME AND MONEY FOR WELL ENGINEERED SOLUTION
- IDEAS EXIST

  BENT POLE

  ADD-ON SOLENOID
- WILL COST $> \$5$ M PER END

F.E. Taylor 10/2/91

Definition of GEM Muon System

Function:

- Muon identification
  Track outside 10 to 12 λ calorimeter
  (< 366 Xo if Pb)

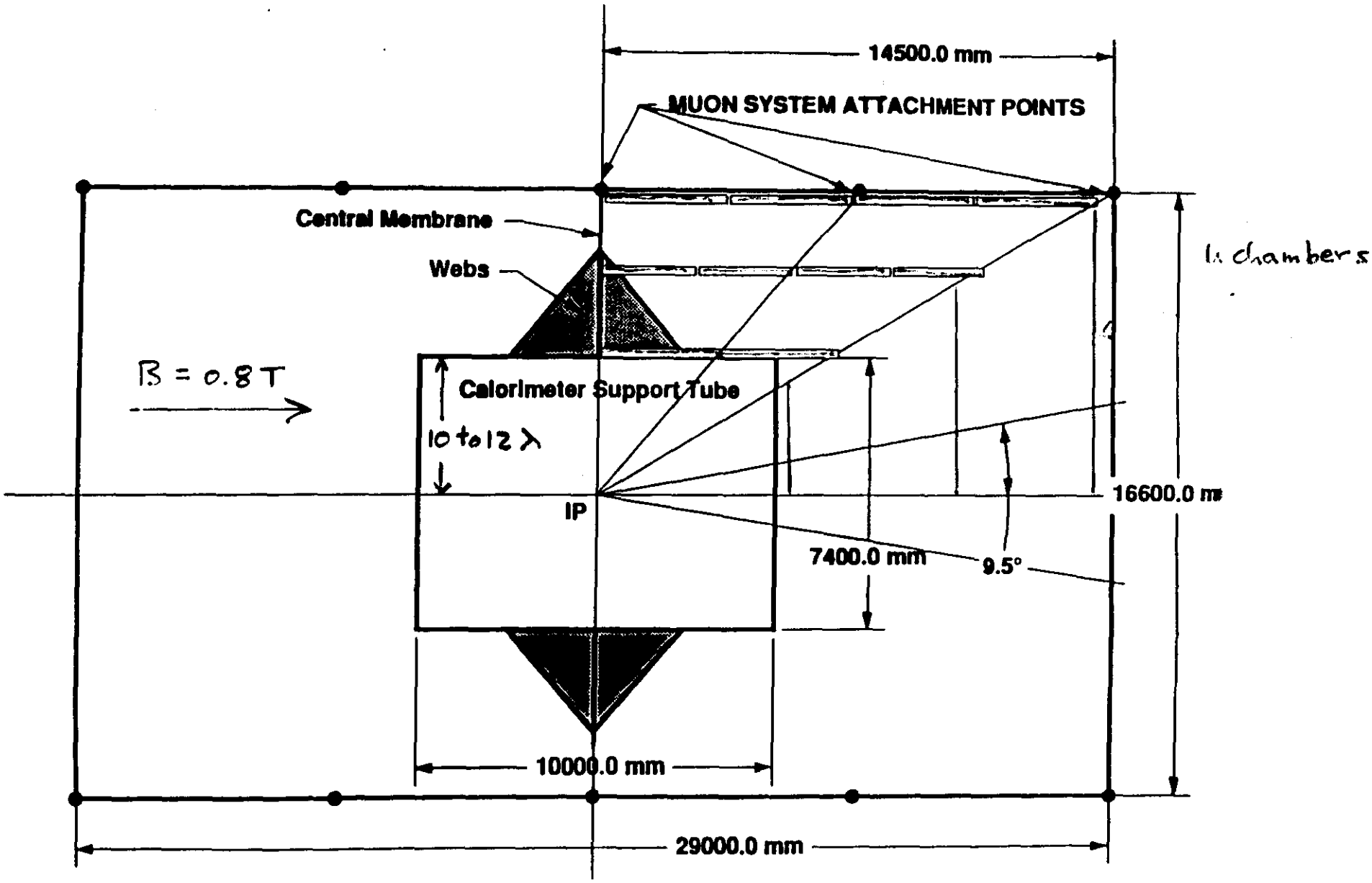
- Muon charge assignment

- P_t trigger (P_t > 50 GeV/c)

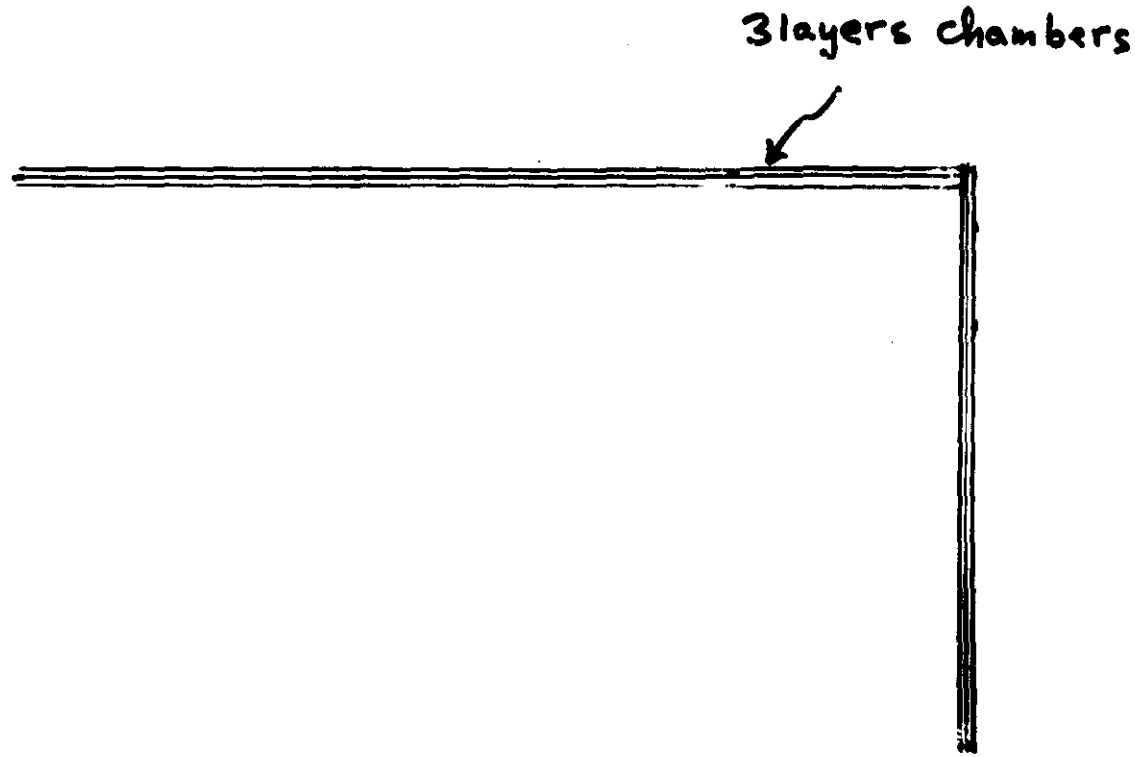
Segmentation:	3 cm barrel
	3 mm endcaps
Rates - Level 1:	10^4 to 10^5 Hz/10^{34}
Rates - Level 2:	10^2 to 10^3 Hz/10^{34}

- Beam crossing tag: (τ < 5 ns)

- P_μ resolution:
  $\delta P_\mu / P_\mu \approx 5$ %
  for 500 GeV/c $\eta \approx 0$ (90 degrees)



Elevation of Muon System Volume (Shaded Area)


3layers chambers

Physics that Muon System addresses:

Process:	Resol'n required
H --> Zo* Zo --> 4 μ	* *
Zo* --> 2 μ	* * *
Heavy onium states --> 2 μ ($\sigma \approx 1/M^2$ and $\Gamma \approx M^5$)	hard to do
$t\bar{t}$ --> e^{+-} μ^{-+}	*
W W and W Zo* scattering	* *
SUSY	* *

Good resolution: $\delta P\mu/P\mu < 5$ % at 500 GeV/c

* Good resolution helps
** Good resolution needed
*** Good resolution absolutely necessary

from: F. Dydak

- Need to evaluate performance / reaction as muon system evolves.

Progress since last GEM Meeting 9/5/91:

(1) GEM Muon Group meeting 9/6/91:
- Discussed technologies pros & cons
- Agreed that Ahlen/Nimblett/Taylor would formulate a recommendation of technologies to retain for LOI and R&D up to Proposal.

(2) Decision Group at CIT 9/19/91 to 9/21/91:
- Technologies as proposed accepted.

(3) GEM Muon Group notified of technology choices 9/23/91

(4) Engineering Coordination meeting 9/26/91requested:
- Develop specifications of system
  - o function
  - o channel count
  - o resolution, etc.
- Determine the mechanical specs.
- Rough out services needed (HV, gas, etc.)

(5) SSCL Decision Group meeting 9/27/91
- Harden the specifications of each system for PAC presentation 10/3/91.

(6) GEM Muon Group meeting 10/1/91:
- Present specifications for LOI systems
- Develop a coordinated R&D program

TASK: develop a muon system by summer '92 for GEM Proposal

Proposed Technologies for LOI

(a) Momentum Determination and Trigger:

Central Region: $\theta > 30^0$ $(0 < \eta < 1.3)$

Pressurized Drift Tubes (PDT)

Limited Steamer Drift Tubes (LSDT)

Level 2 trig.

Endcaps: $9.5^0 < \theta < 30^0$ $(1.3 < \eta < 2.5)$

Cathode Strip Chambers (CSC)

(LSDT as backup)

(b) Beam Crossing Tag:

Central region:

Resistive Plate Chambers (RPC)

(Scintillators as backup)

Level 1 trig.

Endcaps:

Cathode Strip Chambers

(c) Second Coordinate Determination:

Central region:

Resistive Plate Chambers for PDT option (Q division)

Limited Streamer Drift Chambers (Q division/strips)

Endcap region:

Cathode Strip Chambers

From EOI to CIT Meeting considered:

L* Chambers

Demanding technology all wires in common gas volume. Lorentz angle effects large.

LSDT made of plastic (Iarocci tubes)

Mechanical design difficult to align tubes to desired accuracy.

Straw Tubes

Hard to construct long tubes which can be pressurized.

All options could be made to work. Decisions based on ease of construction, operational robustness, effort to achieve resolution.

Performance/Cost

For Barrel P_μ & Level 2 Trigger

Pressurized Drift Tubes (Al or Fe)

Advantages:

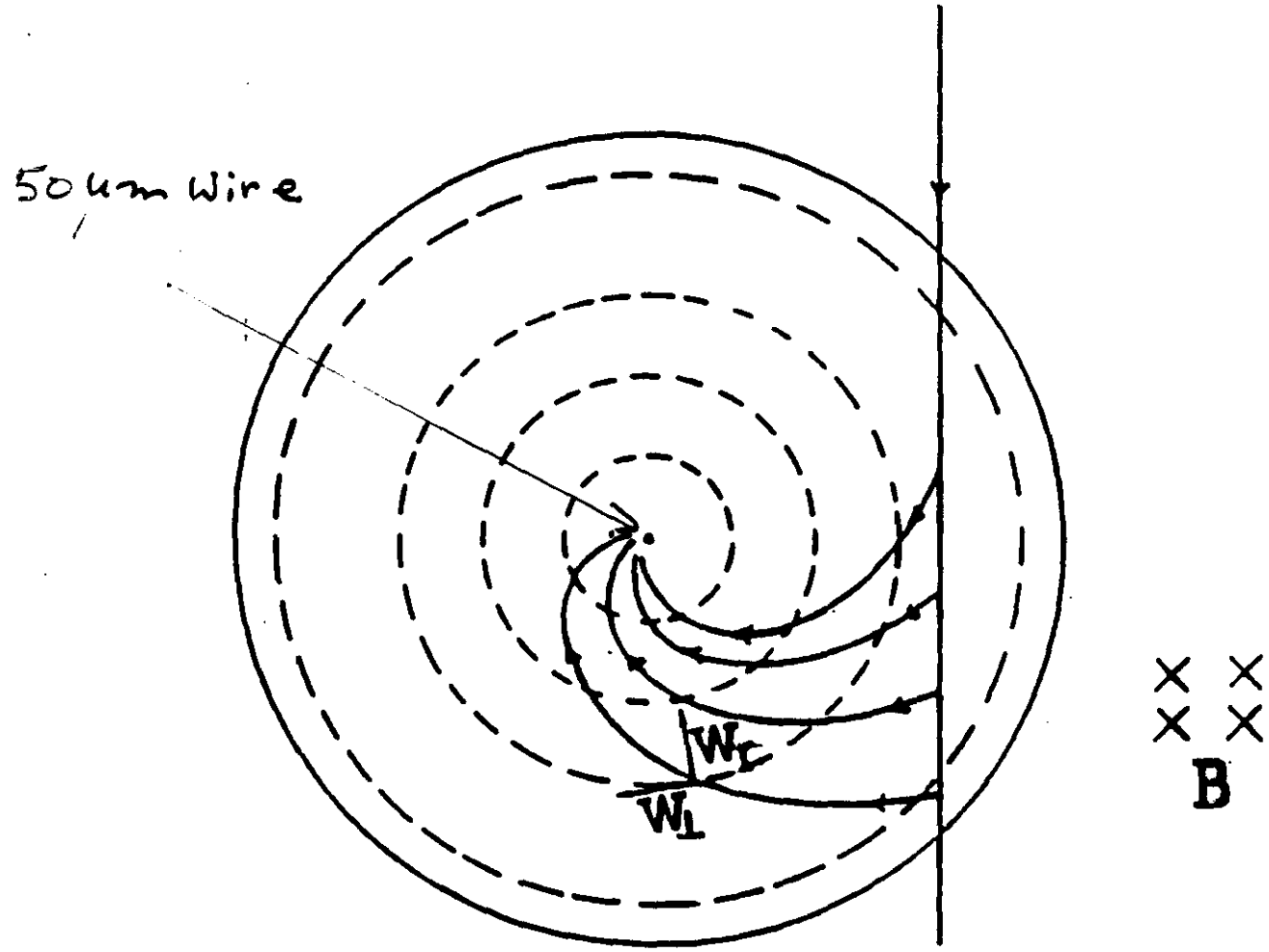
- Used in B-fields (HRS and CDF) Exam
- Can pressurize: $\sigma x \approx 1/P^{1/3}$
- Modular construction
- Not sensitive to angle of incidence (cyl-sym)

Disadvantages:

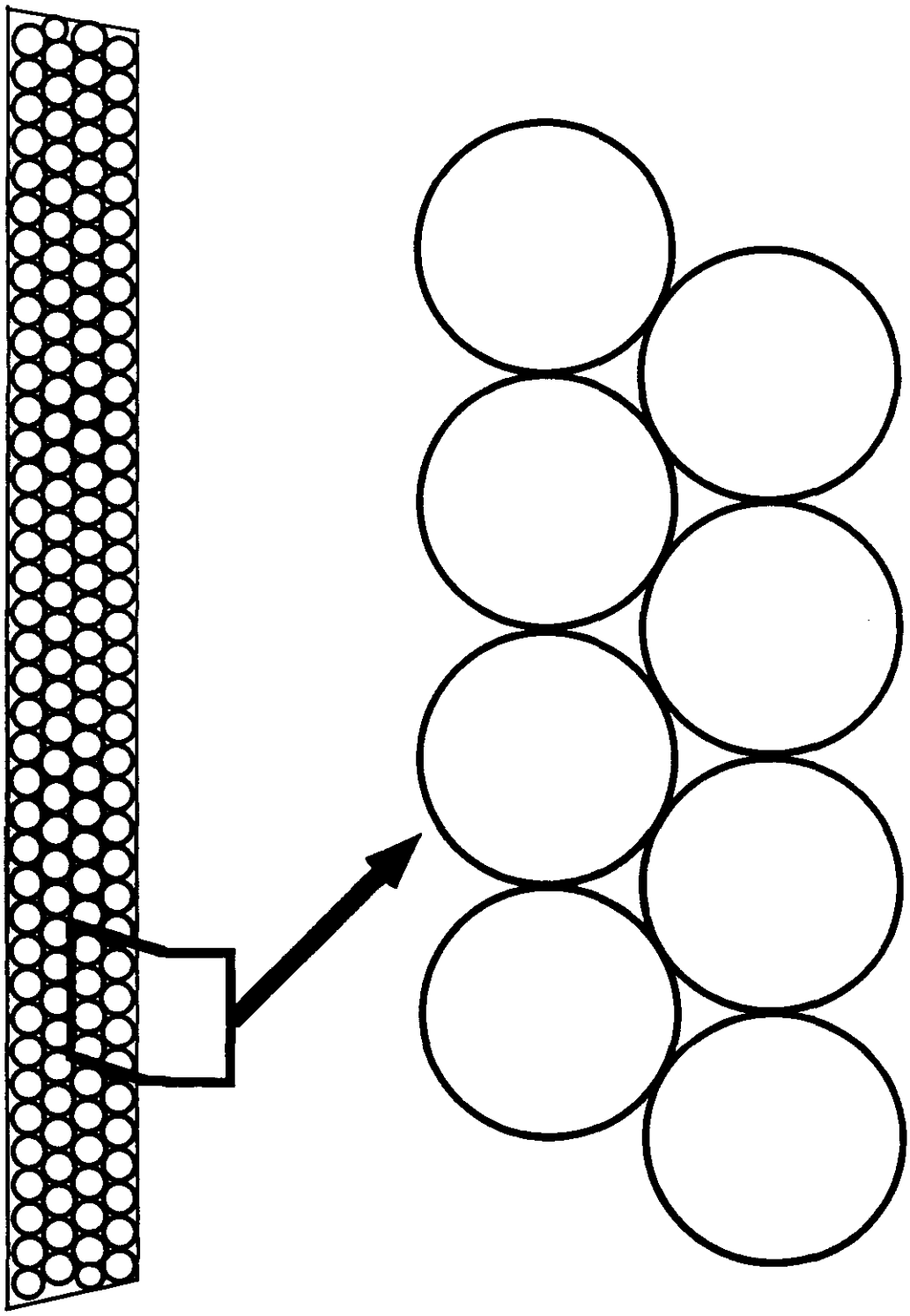
- Second coordinate by charge division
  (rate limited?)
- Hard to support wire (sag must be understood)
- Gas seals at high pressure must be robust

PDTubes

$\sigma_{resol'n} \sim 34\mu m$ to $200\mu m$
depending on gas, pressure



Drift Trajectories For Electron Swarm Centroids



For P, θ Level 2 trigger barrel

Limited Streamer Drift Tubes

Advantages:

- Fast risetime and large pulses of Limited Streamer
- Second coordinate possible by orthogonal strips
- Modular construction
- Open profile for mass production wire stringing

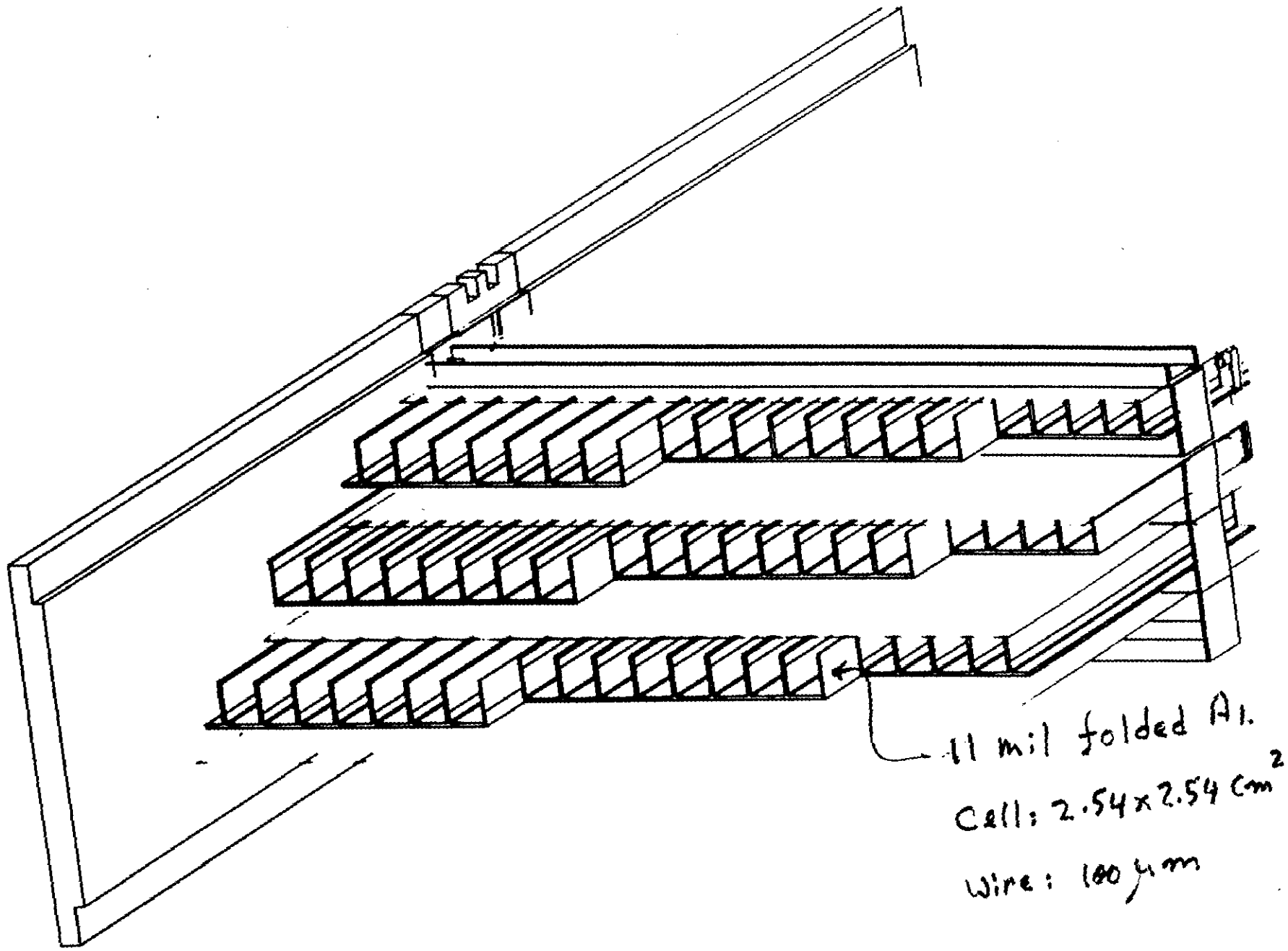
Disadvantages:

- Precision resolution in B-field to be demonstrated
- Rate effects of Limited Streamer mode to be understood
- Radiation hardness of Limited Streamer mode

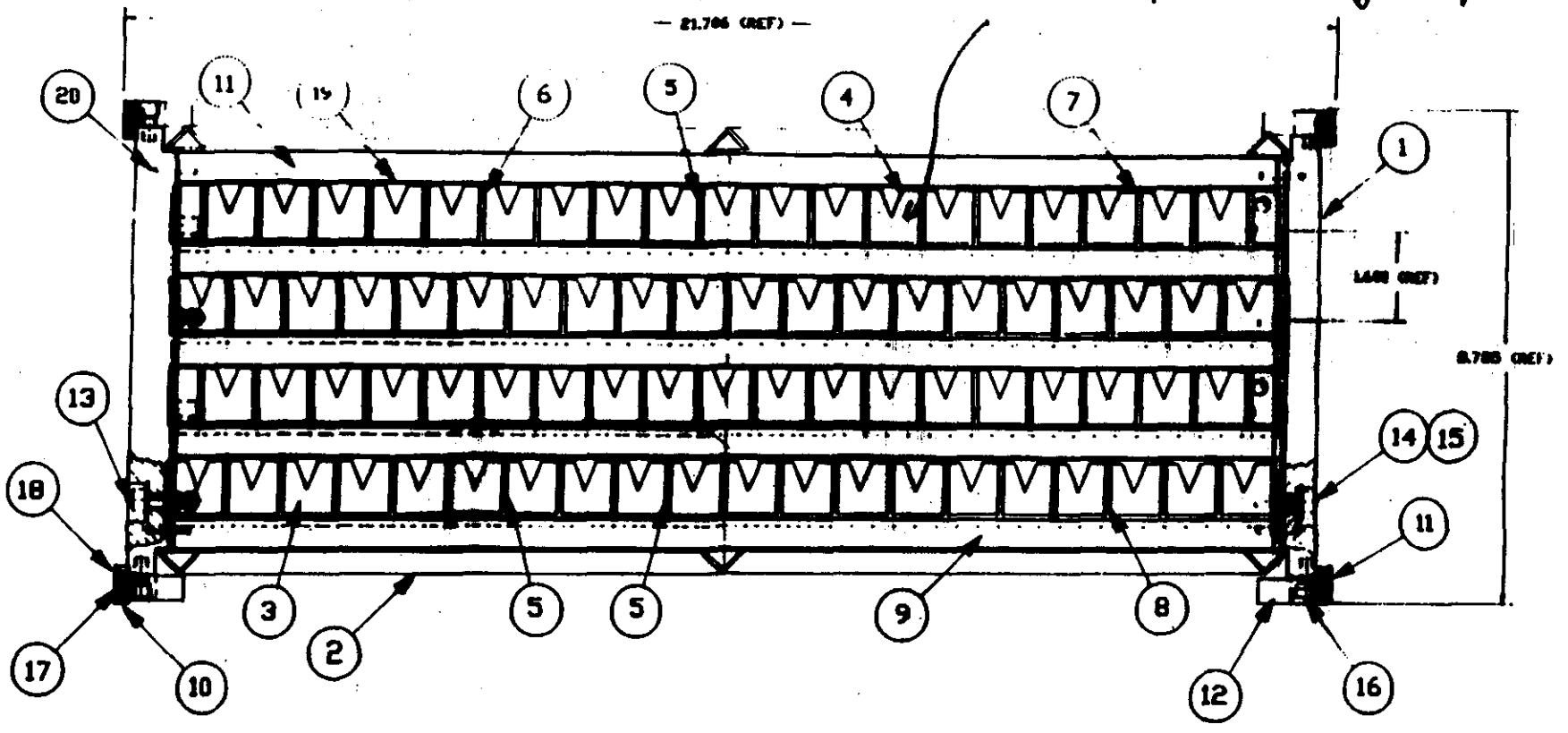
Muon beam (0.5 TeV/c at FNAL) no B-field

$\sigma_{drift} \simeq 120\ \mu m$ L.S. mode: Safe gas $\left[\begin{matrix} C_4H_{10} : CF_4 : CO_2 \\ 11 : 69 : 20 \end{matrix}\right]$

$\sigma_{strip} \approx 96\ \mu m$ Sat. prop. mode $\left[\begin{matrix} A : C_4H_{10} \\ 1 : 3 \end{matrix}\right]$


11 mil folded Al.
Cell: 2.54 x 2.54 cm²
Wire: 100 μm

Wires supported by bridge



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PROTOTYPE MUON CHAMBI
PARTIAL SECTION
END VIEW

D CSC91-04

For P, θ, Level 1 trigger in endcaps

Cathode Strip Chambers

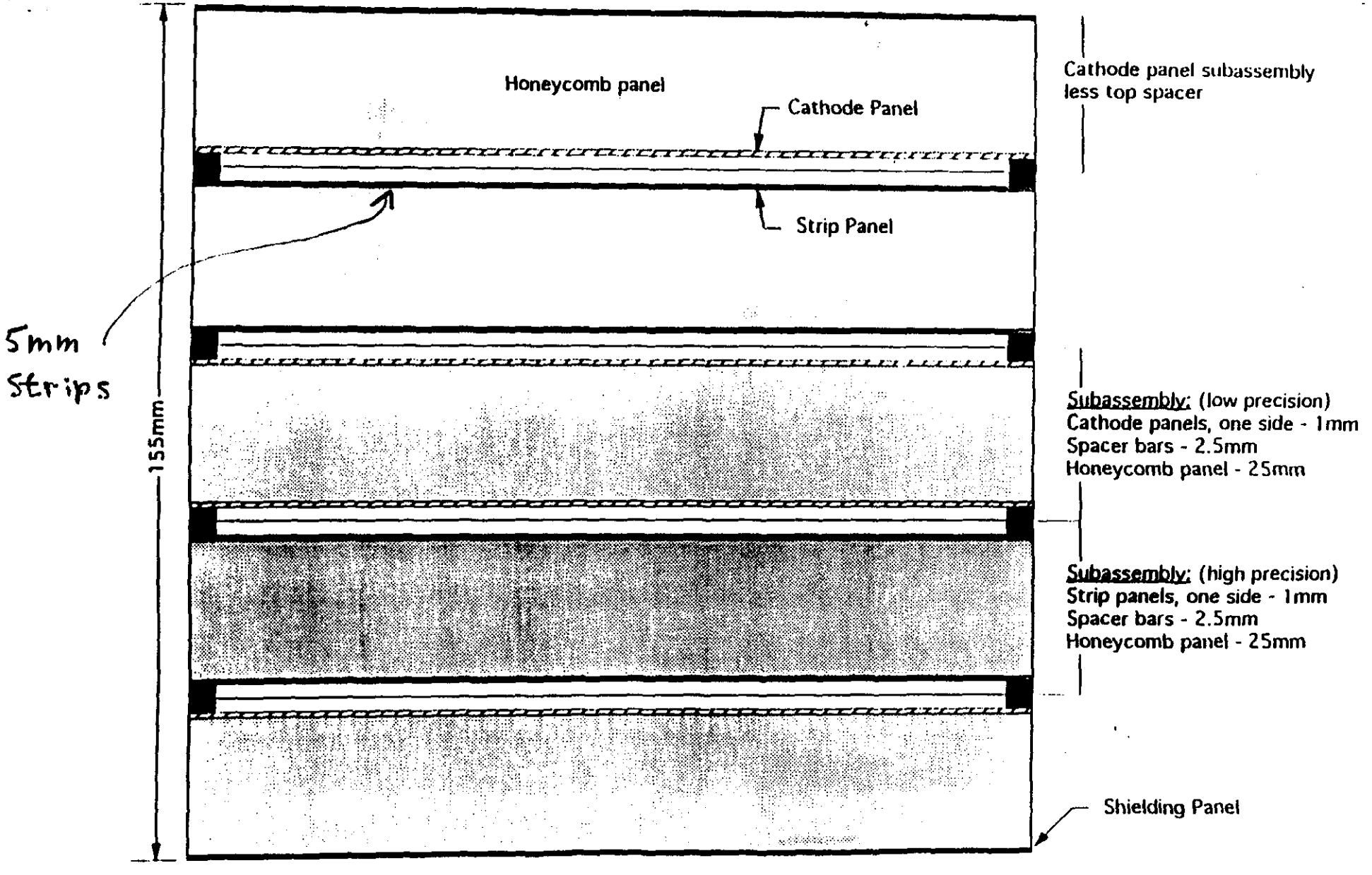
Advantages:

- Good pattern recognition (3-d with pads)
- Fast response for beam tagging
- Flexible mechanical design for endcap geometry
- Position resolution insensitive to gas, HV, etc.
- Full functionality in one technology:
  triggering, beam cross tagging, P, Z

Disadvantages:

- Channel count high (300 k for endcaps)
- Precision operation in B-field to be demonstrated
- Electronics plant nontrival (1% channel-to-channel)
- Few planes ==> sensitive to background (δ-rays)

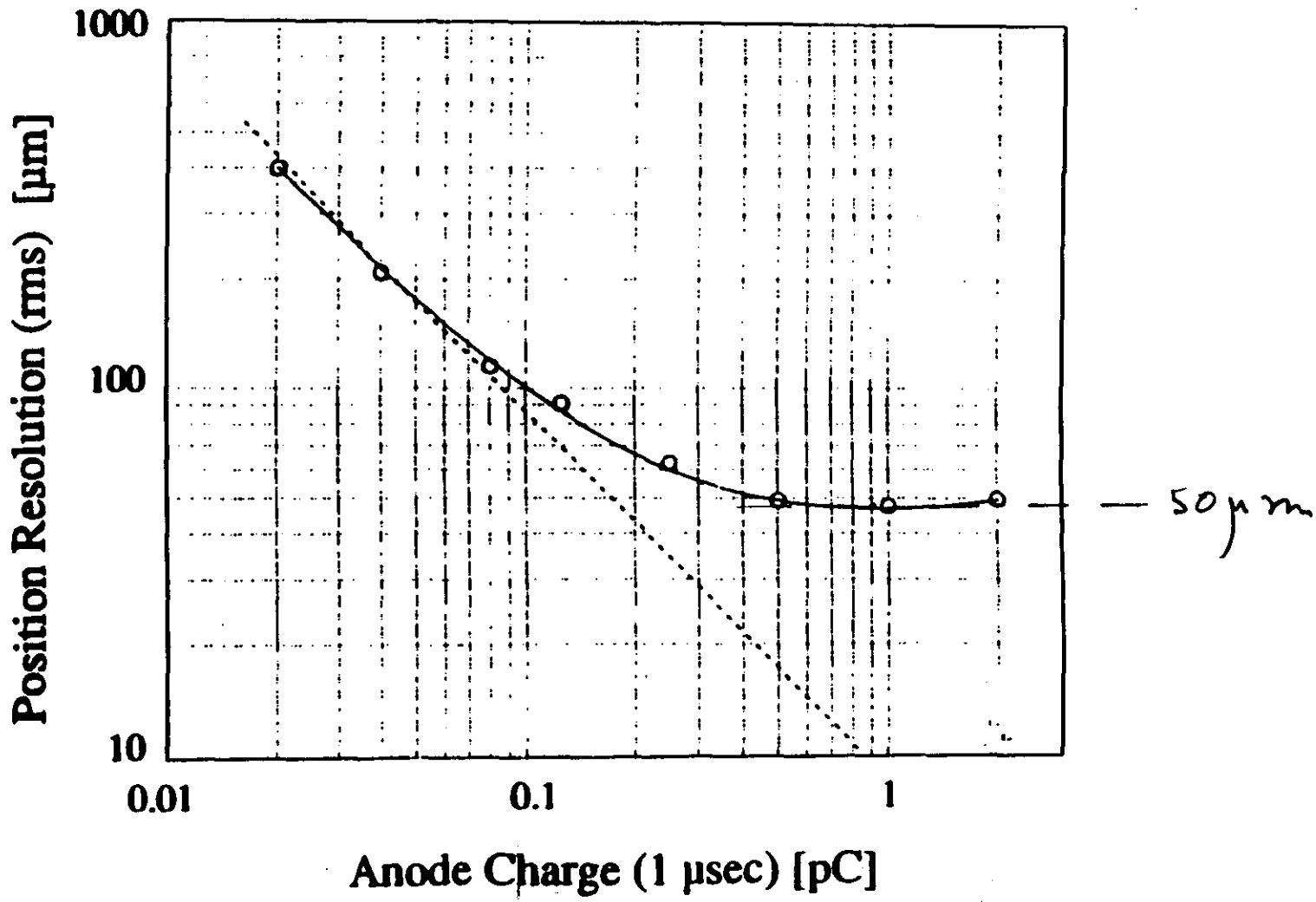
$\sigma_{strip} \simeq 50\,\mu m$ to $100\,\mu m$ (strip width, L-angle amps. stability.)



Gas Pad Chambers Study.2
C. Grinnell 09.08.91 page 1/2

Position Resolution vs. Anode Charge
for a Single Chevron Cathode

(5.4 keV X-rays, 12mm readout spacing, 50% Ar + 50% C_2H_6 gas mixture)



For ② & Level 1 trigger in barrel

Resistive Plate Chambers

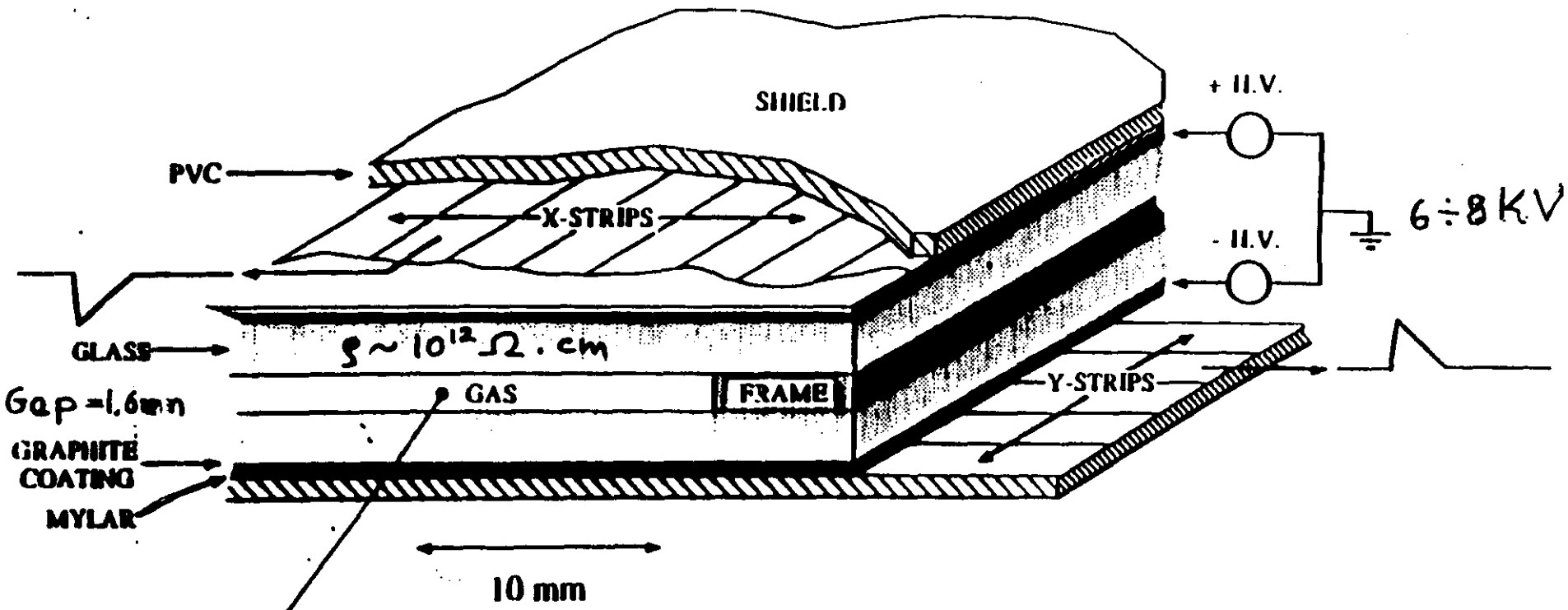
Advantages:

- Fast and large pulses for beam cross tagging
- High pattern recognition capability
  - Z-coordinate (needed for PDT option)
  - Pμ - trigger
- Simple and inexpensive construction (glass?)

Disadvantages:

- Noise characteristics to be understood
  - interference with other systems?
  - how many planes needed for clean trigger?
- Rate limitations to be understood
- Operation in B-field ?

Glass Spark Counter *



Ar/Iso/Freon = 60/38/2

* R&D project for a new version of large gap parallel plate counters (GLASS)

	System	Layer Config.	Weight	# of channels	X_0 mid layer	Type
L2 & P barrel	PDT/barrel	8:8:4 P_μ	60 Tons	100.3 k	10%	A_L tubes 14 mil 3.81 cm dia.
	LSDT/barrel	8:16:8 P_μ	97 tons	225.3 k		A_L folded 11 mils
		2:4:2 θ_μ		25 k	44%	2.54 cm cell 1 cm strips
L1 Trigger, P, θ in endcaps						
	CSC/endcaps	4:4:3 P_μ	29 to 53 Tons	231 k		5 mm gap 2.5 mm pitch
		2:2:2 θ_μ		21 k	8%	5 mm strips
L1 Trigger & θ in barrel						
	RPC/barrel	2:2:2 P_μ	25 tons (glass)	28 k		3 cm strips 2 mm gap
		2:2:2 θ_μ		7.5 k	3.5%	

Engineering Program:

(1) Technology non-specific:

(a) Alignment **system** (superlayer-to-superlayer)

(b) Support structure for superlayers

(c) System aspects: gas, power, cabling

(d) Access (scaffolding)

(e) Electronics layout - high end

(f) Test rig ~~in Boston~~ at SSCL to evaluate technologies

(g) Evaluate B-fields/ muon system performance

(2) Technology Specific:

(a) Large scale **prototypes** of PDT, LSDT, CSC, RPC

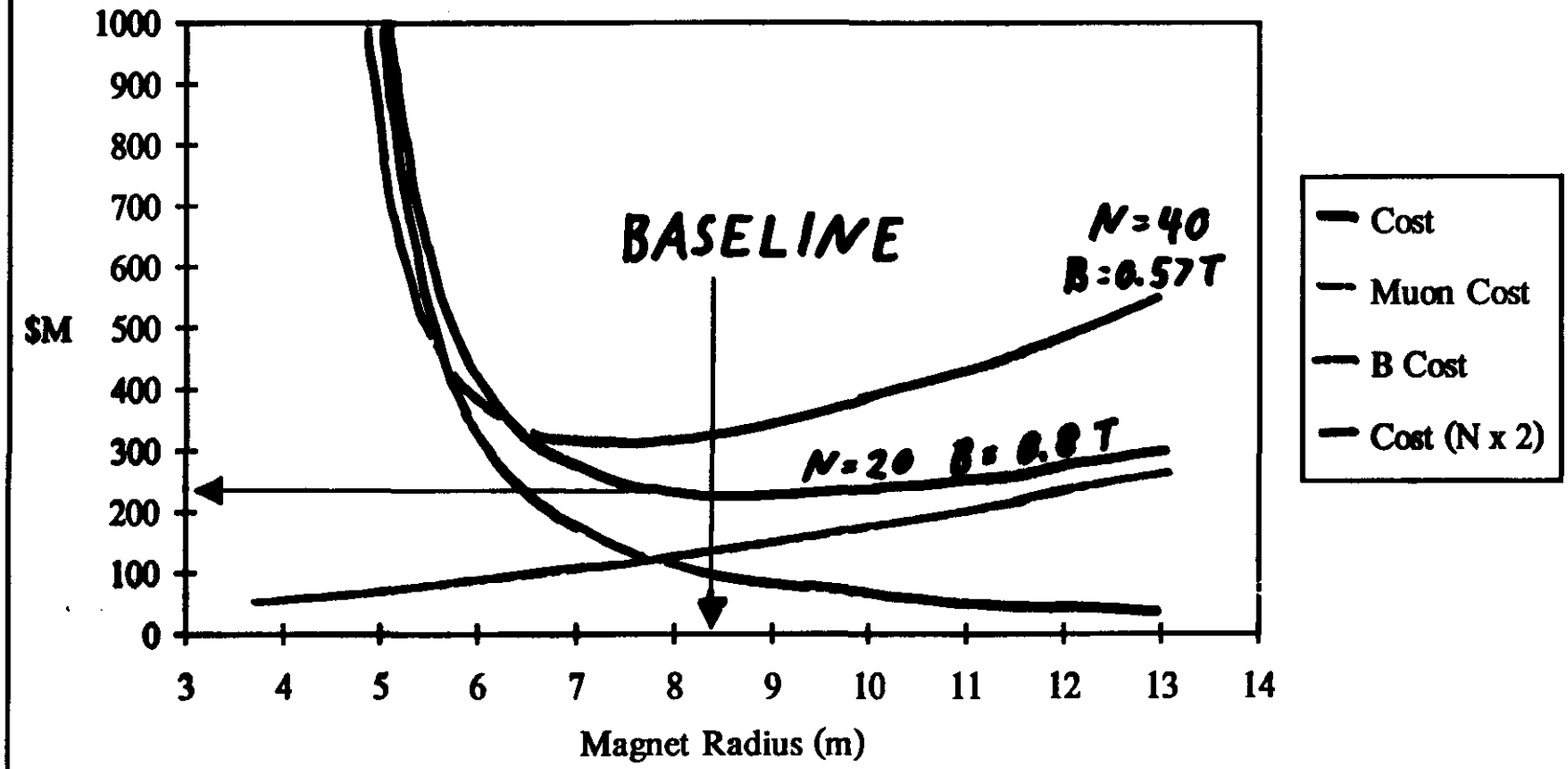
(b) Develop internal alignment system

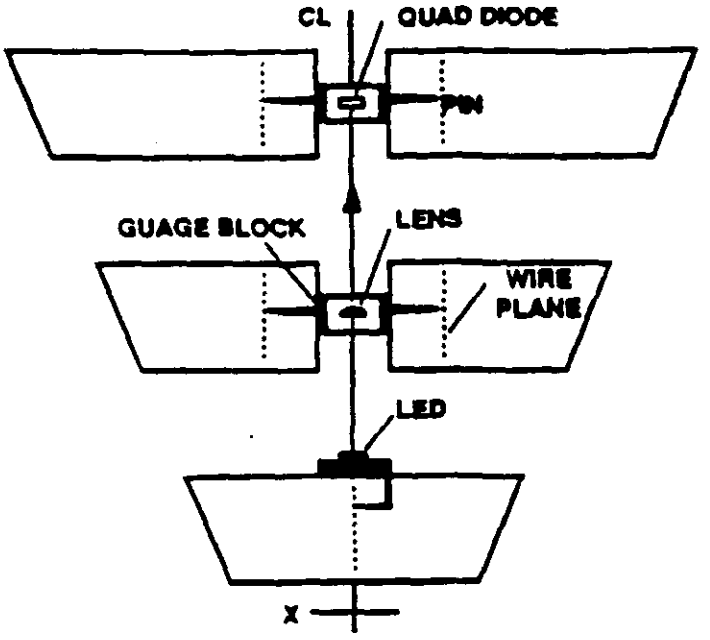
(c) Test rig for Lorentz angle measurements

(d) Develop electronics for chamber readout, triggering, and beam cross tagging.

Cost estimates: $(\underbrace{34}_{\text{Chambers}} + \underbrace{53}_{\text{in hall const.}}) \times \underbrace{1.2}_{\text{contingency}} \times \underbrace{1.25}_{\text{Theriot}} = \$130\,M$

Cost Model: N = 8:8:4 in barrel; N = 4:4:3 in endcap; endcap muon cost = 1/2 of barrel muon cost; muon cost proportional to chamber area; magnet cost proportional to (stored energy)^(2/3); resolution = 5% at 90 degrees at 500 GeV

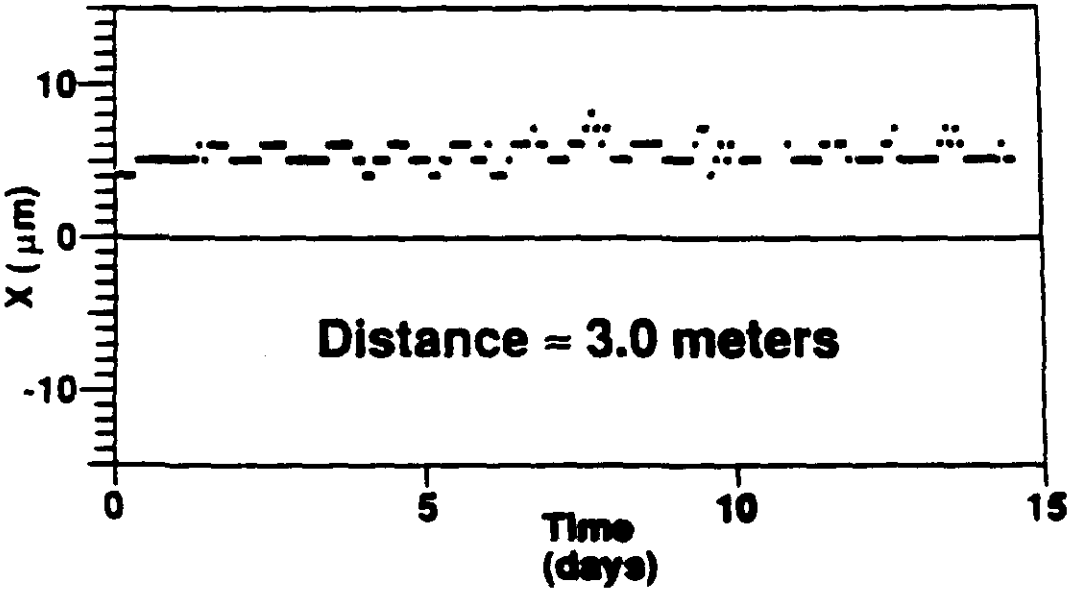


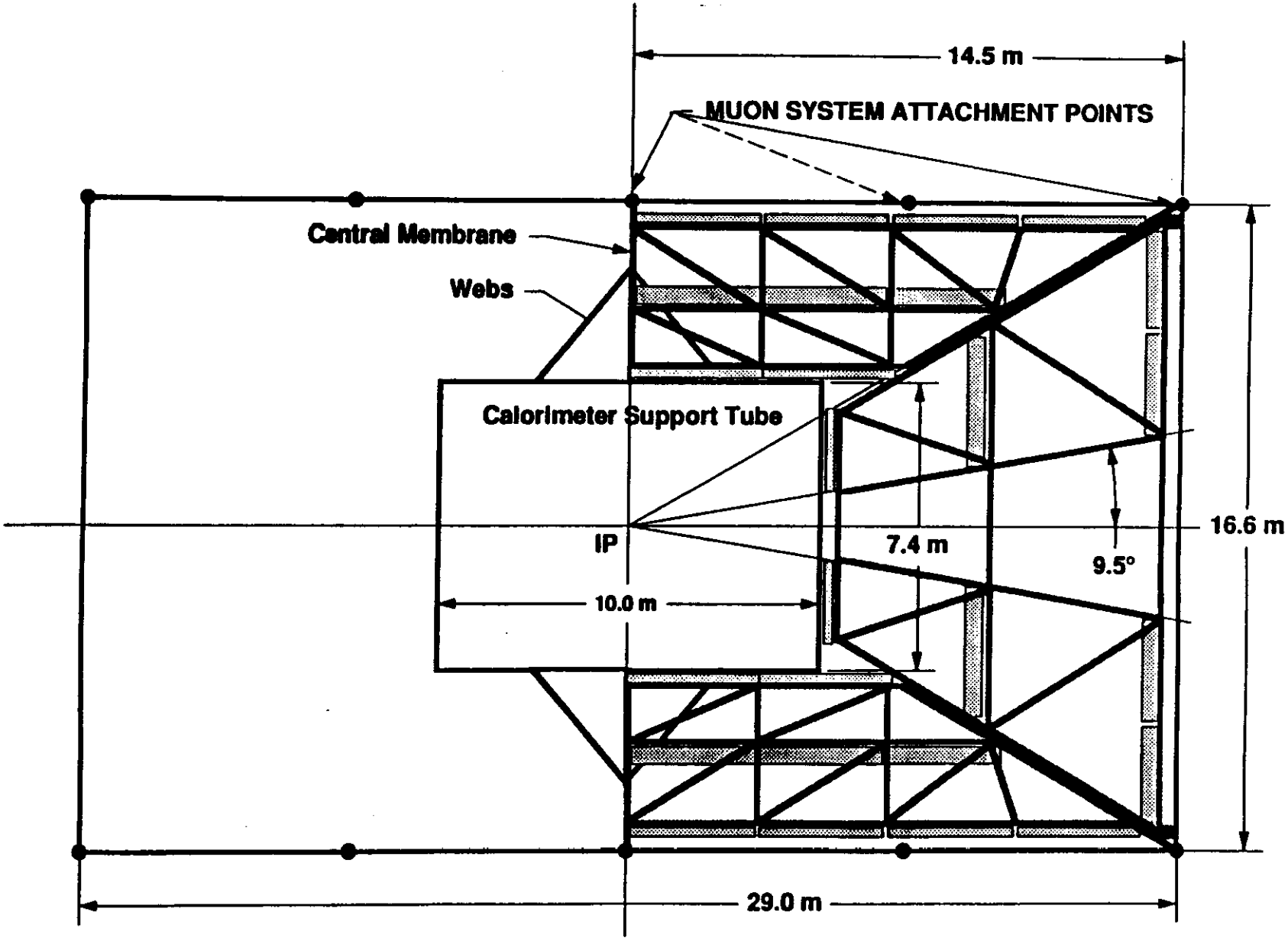


Stability of L3 Alignment for 3 Layers of Chambers

4μm

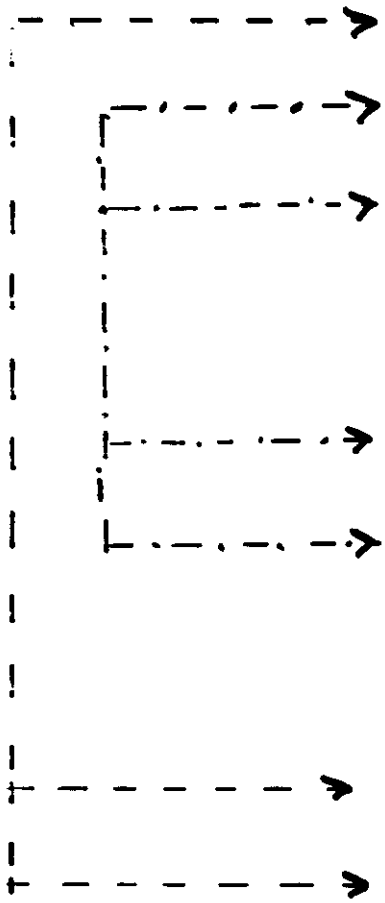
Reproduces after 1 Year





ELEVATION OF PDT MUON SYSTEM

F. Nimblett
21 August 1991



R & D

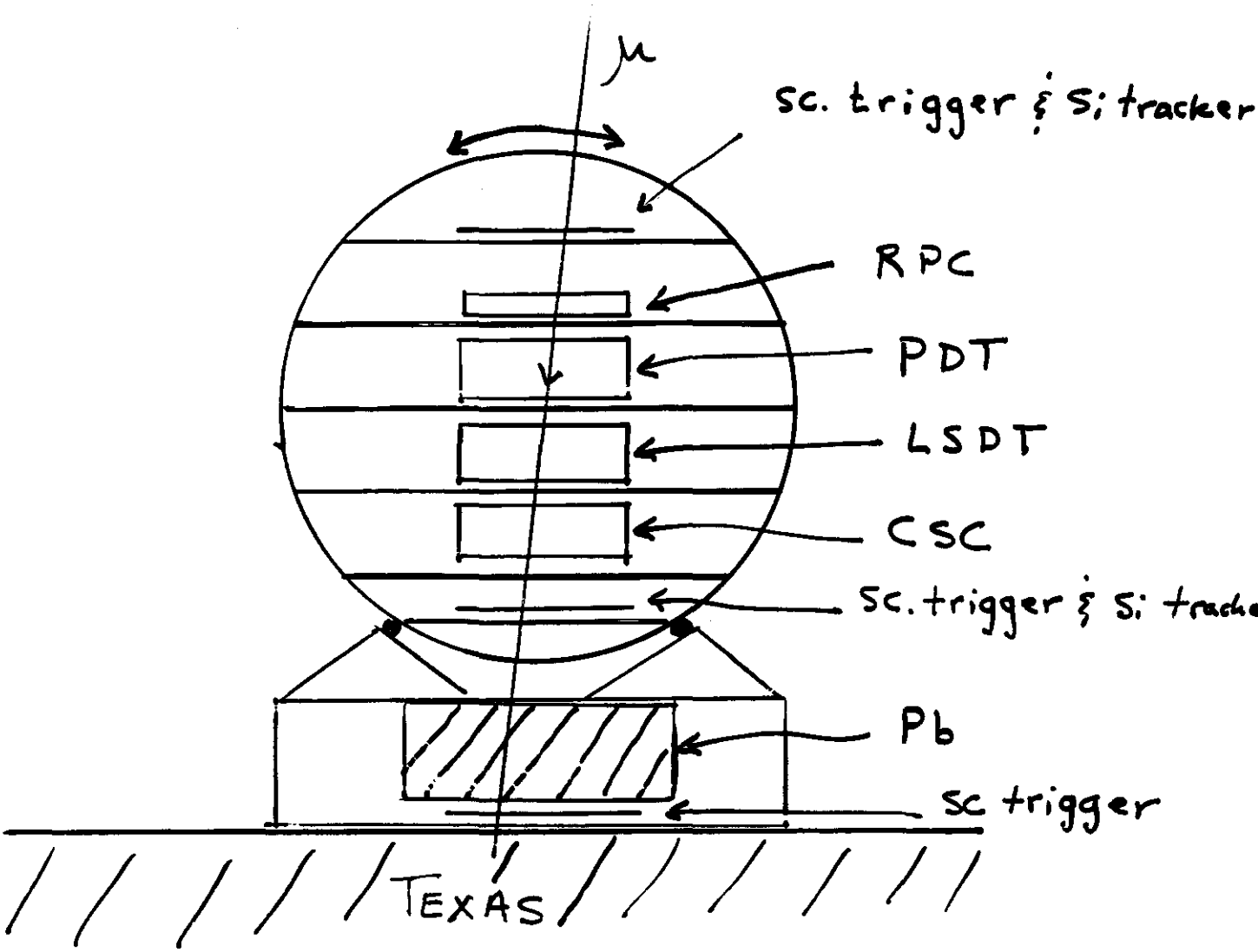
- Tasks:

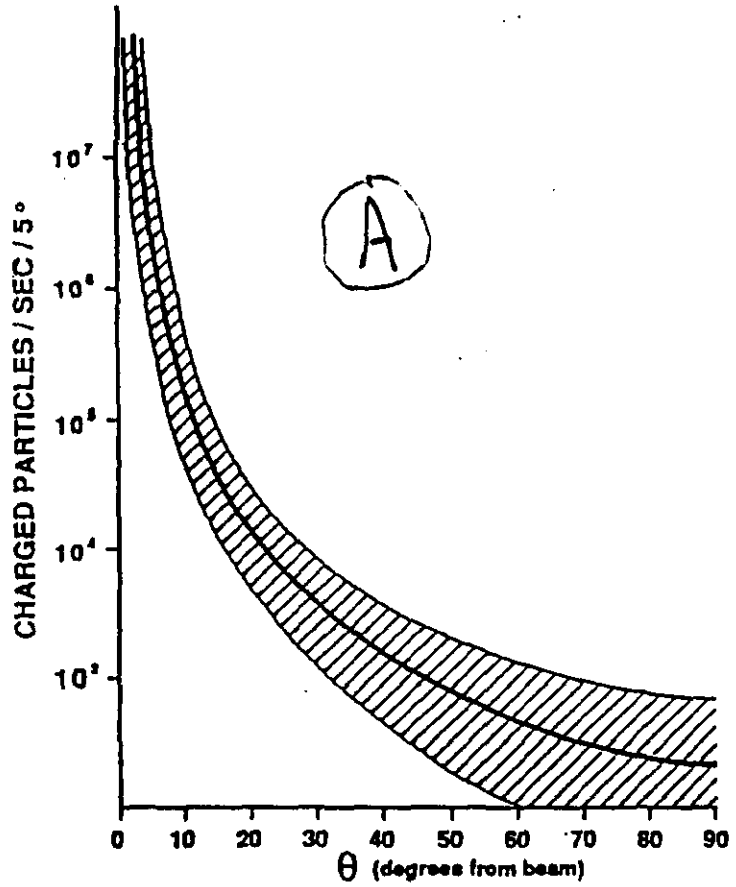
(1) Develop drift tube concept	
(a) PDT option	\$430k
(b) LSDT option	177k
(c) Houston factory	450k
	198k
(2) Develop CSC concept	
(a) "Classical" pads	597k
(b) "Dubna" option	95k
(3) Develop RPCs	
(a) LLNL resistive glass	200k
(b) MIT RPC lab	395k
(4) Develop Support & alignment	900k
(5) Build Test lab at SSCL	
	\$3.4 m

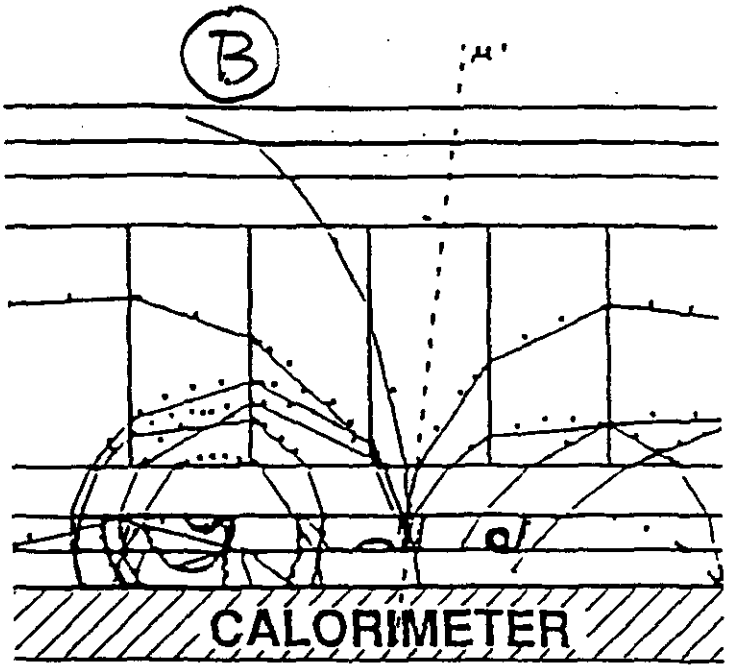
- Each task asked to submit detailed schedule & job list by Oct. 15th

- Formed a simulations group to study μ-system

Test rig


μ
sc. trigger & Si tracker
RPC
PDT
LSDT
CSC
sc. trigger & Si tracke
Pb
sc trigger
TEXAS





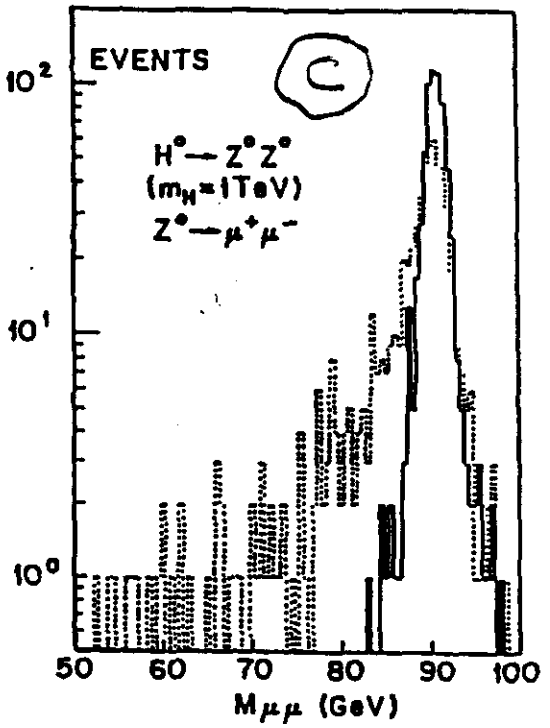
δ-rays, Punch through

Pattern recognition

Charged particle rate

Segmentation of trigger

& P - Z readout



$\delta(\Delta E_\mu)$ in Calorimeter

Calorimeter: λ, segmentation

resol'n

Baseline performance:

Sagitta measurement:

Barrel region ($\theta > 30^0$):

$$S = 0.3\ B\ \Delta R^2\ /\ 8P\mu\ \sin\theta$$

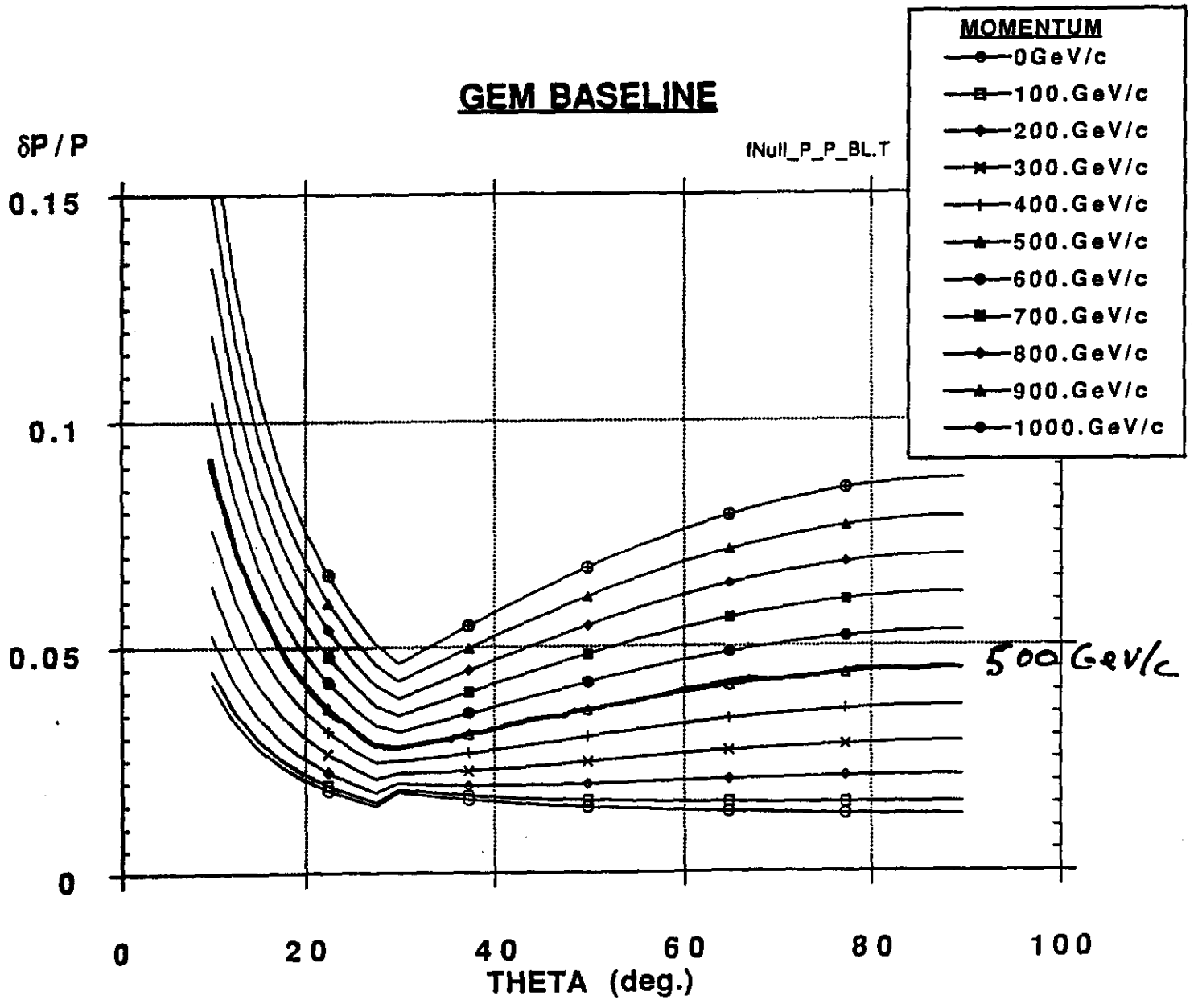
Endcap region ($30^0 > \theta > 9.5^0$):

$$S = 0.3\ B\ \Delta Z^2\ \tan\theta /\ 8P\mu\ \cos\theta$$

Momentum resolution depends on:

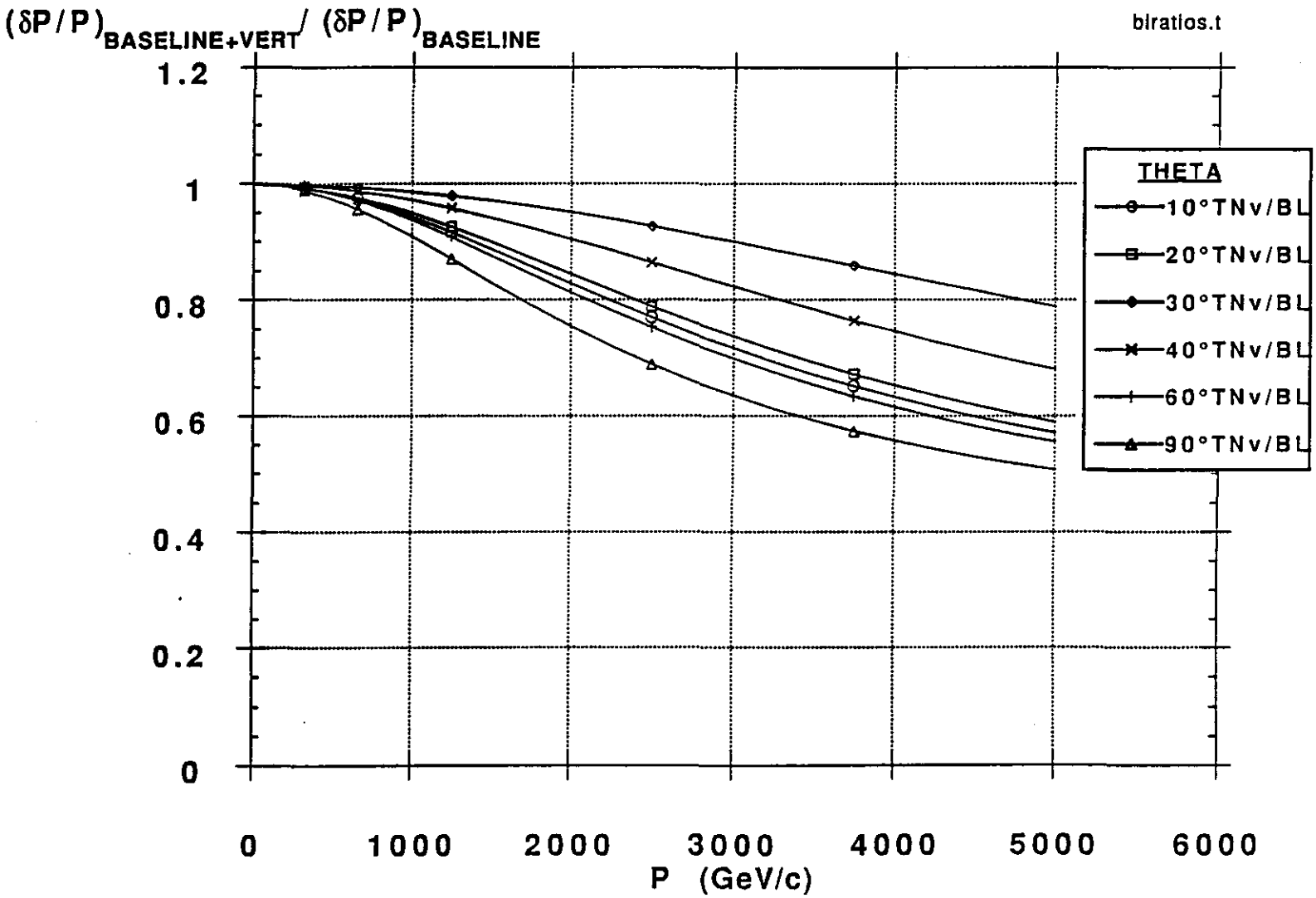
$P\mu$, $\theta\mu$	$\longrightarrow$	given
$B\ L^2$	$\longrightarrow$	wants to be large
ΔS	$\longrightarrow$	hit resolution alignment errors multiple scattering $\delta(\Delta E\mu)$ calorimeter

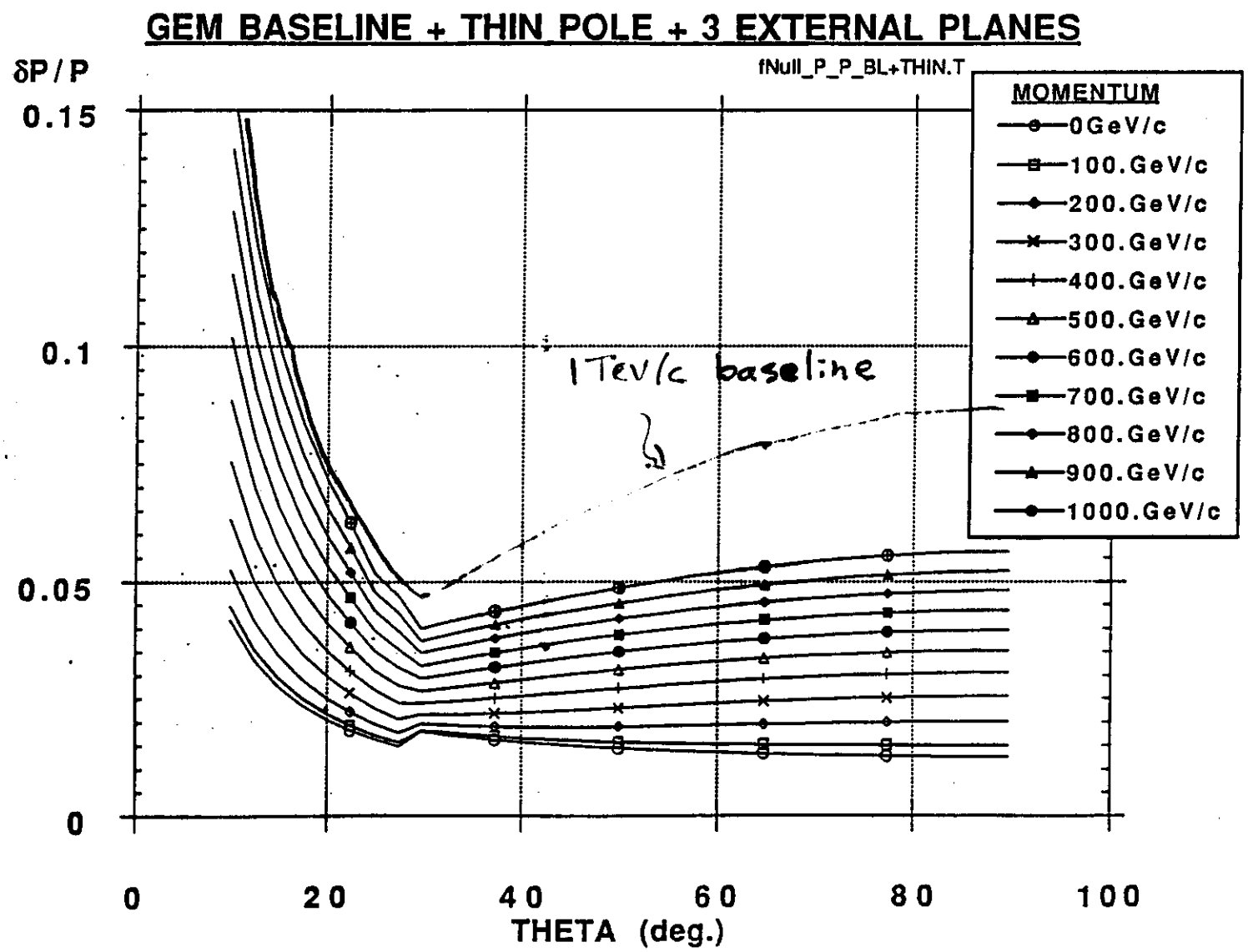
L. Rosenson MIT



L. Rosenson MIT

RATIO OF MOMEMTUM RESOLUTION : BASELINE + VERTEX CONSTRAINT/BASELINE




GEM BASELINE + THIN POLE + 3 EXTERNAL PLANES
δP / P
fNull_P_P_BL+THIN.T
0.15
0.1
0.05
0
0
20
40
60
80
100
THETA (deg.)
MOMENTUM
0GeV/c
100.GeV/c
200.GeV/c
300.GeV/c
400.GeV/c
500.GeV/c
600.GeV/c
700.GeV/c
800.GeV/c
900.GeV/c
1000.GeV/c
1Tev/c baseline

Possible improvements to baseline resol'n:

(a) Constrain the primary vertex in trajectory fit:

For σ vertex = 100 μm:

$\delta P\mu/P\mu$ at 5 TeV/c improves by factor of 0.5 to 0.8.
Less improvement at lower momentum.

(b) Adding planes external to coil:

For 3 planes at ΔR = 3 m and ΔZ = 5 m:

$\delta P\mu/P\mu$ improves at 1 TeV/c by factor of 0.65 at 90^0.
Less improvement at lower momentum and angle.

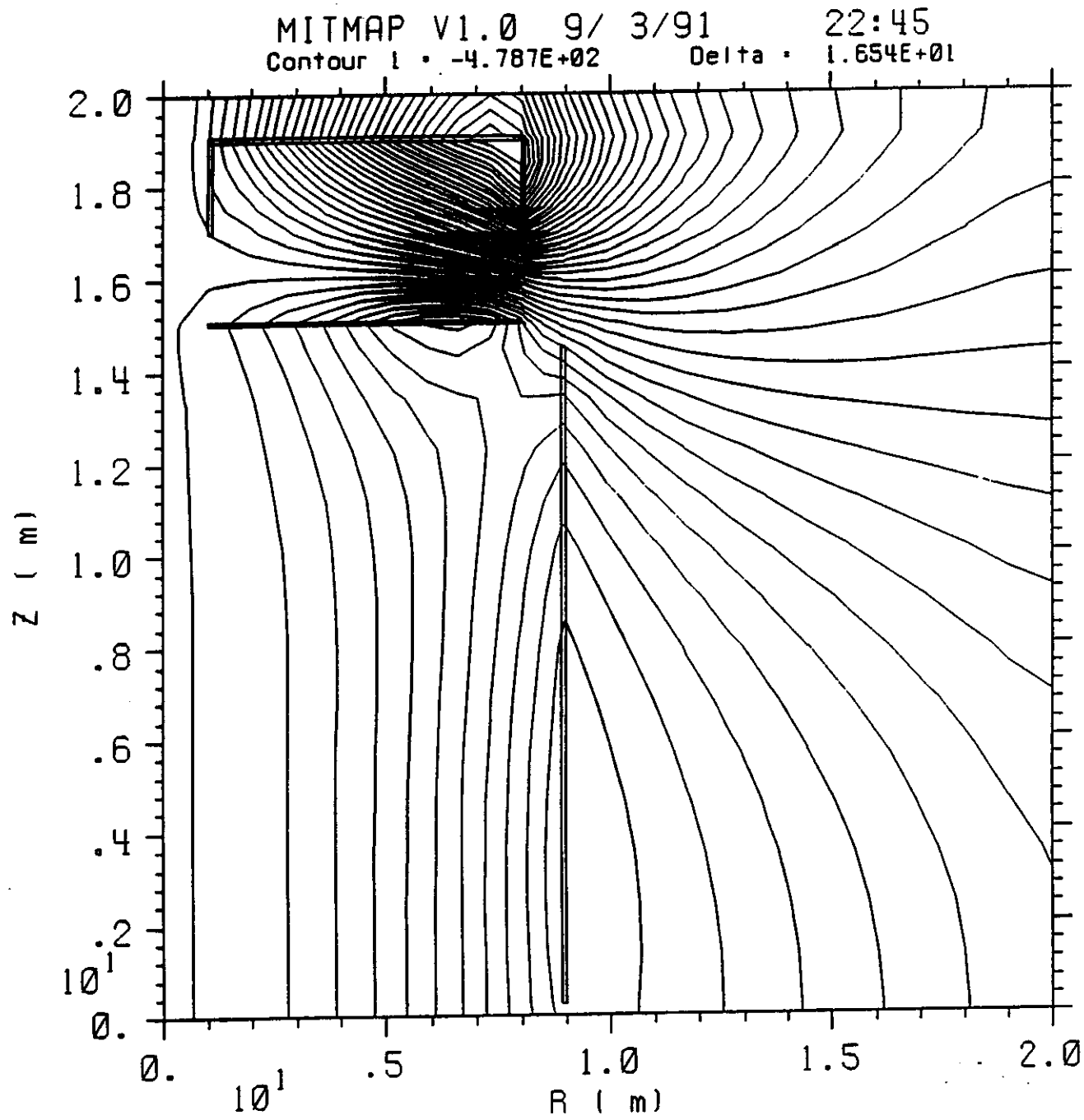
(c) B-field shaping at forward angles:

(Cusp) option improves $\delta P\mu/P\mu$ by 0.5 at η = 2.5

Note: Thin Pole versus Thick Pole:

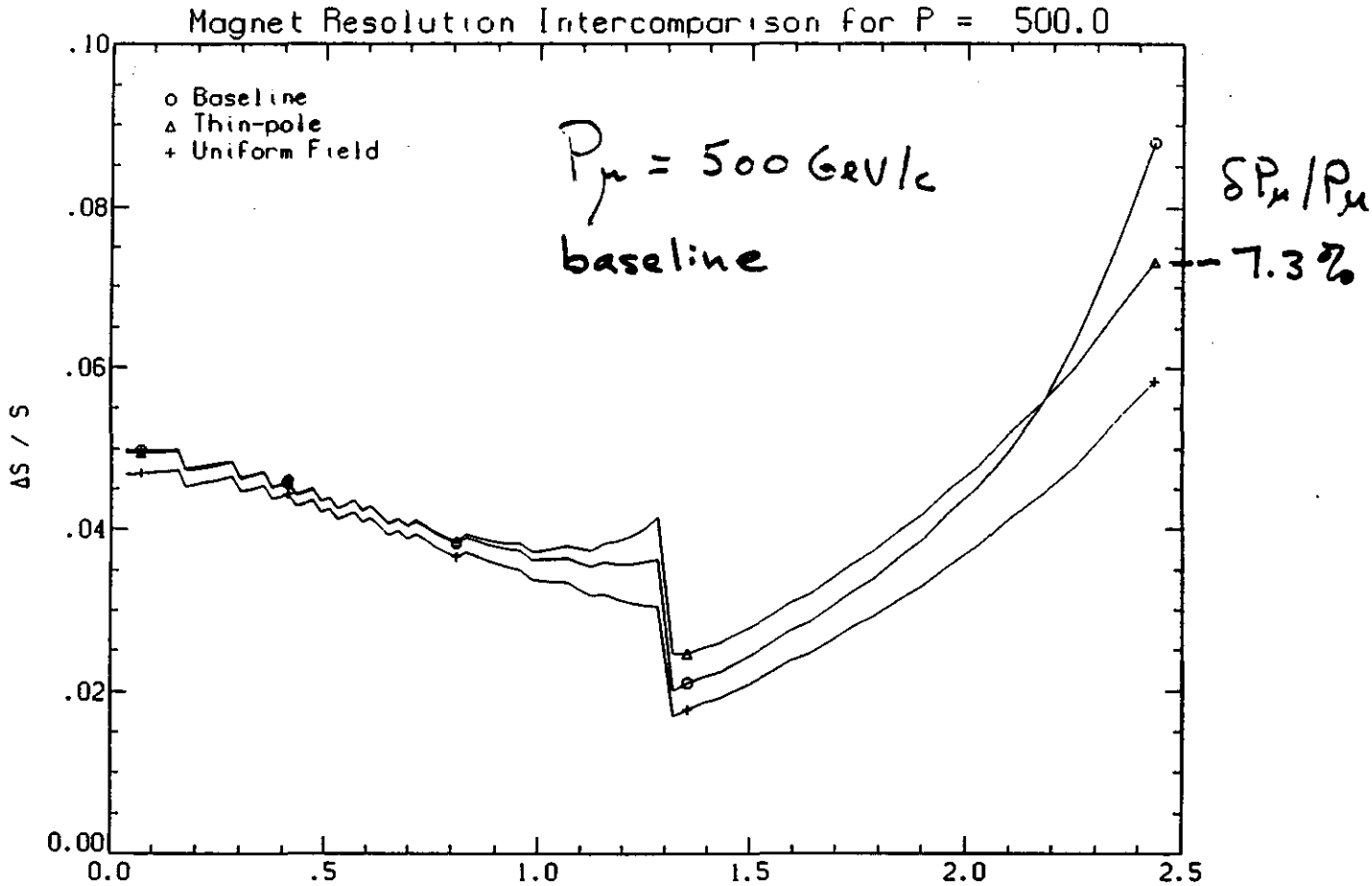
$\Delta(\delta P\mu/P\mu)$ < 20 % between options

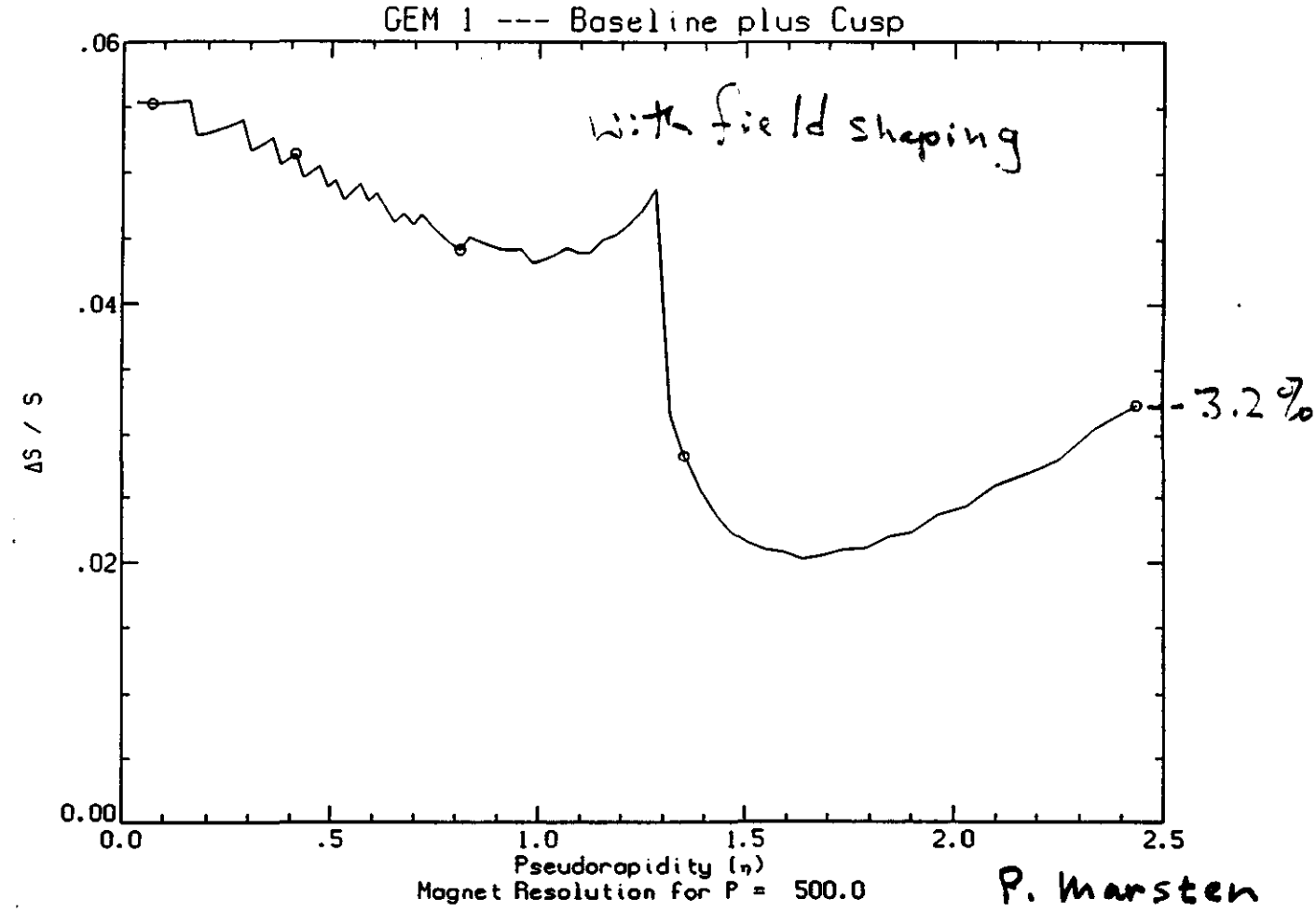
GEM 1 --- Baseline plus Cusp



CONTOURS OF CONSTANT FLUX

Possible Field Shaping

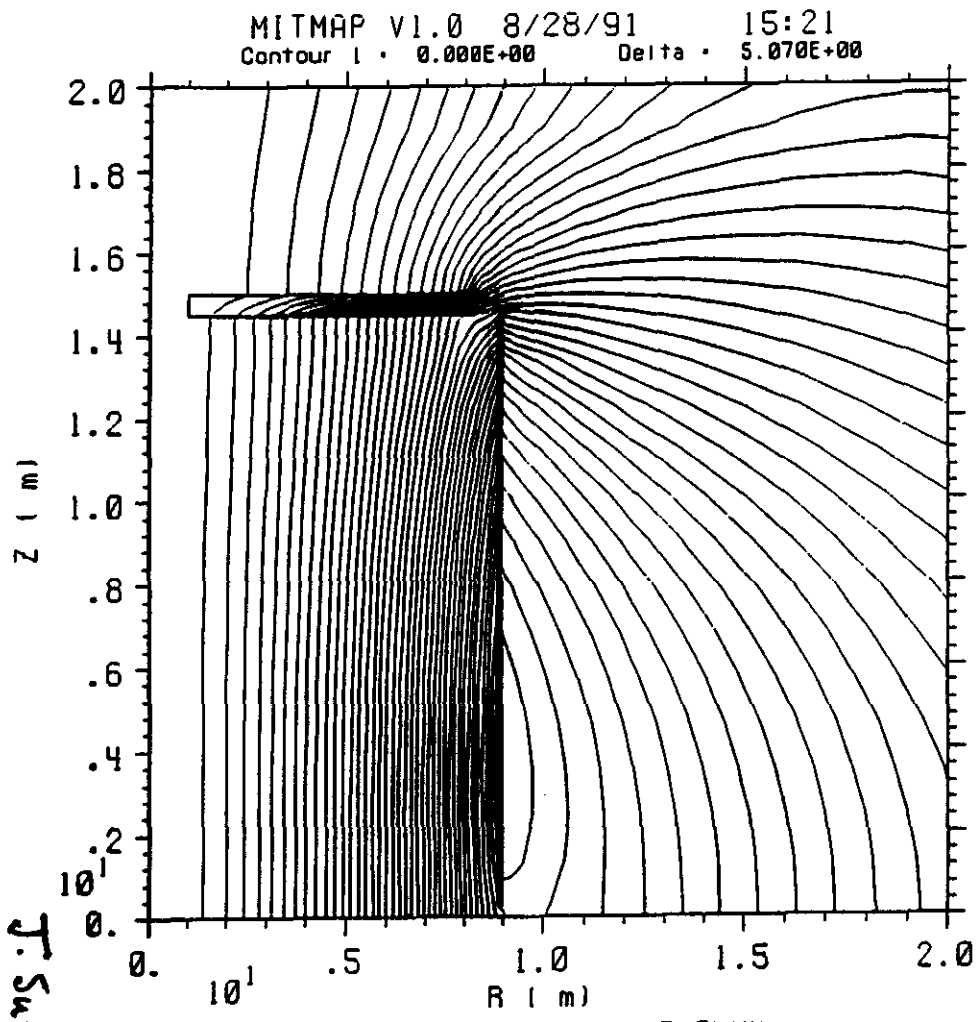




P. Marsten
J. Sullivan

Thin Pole

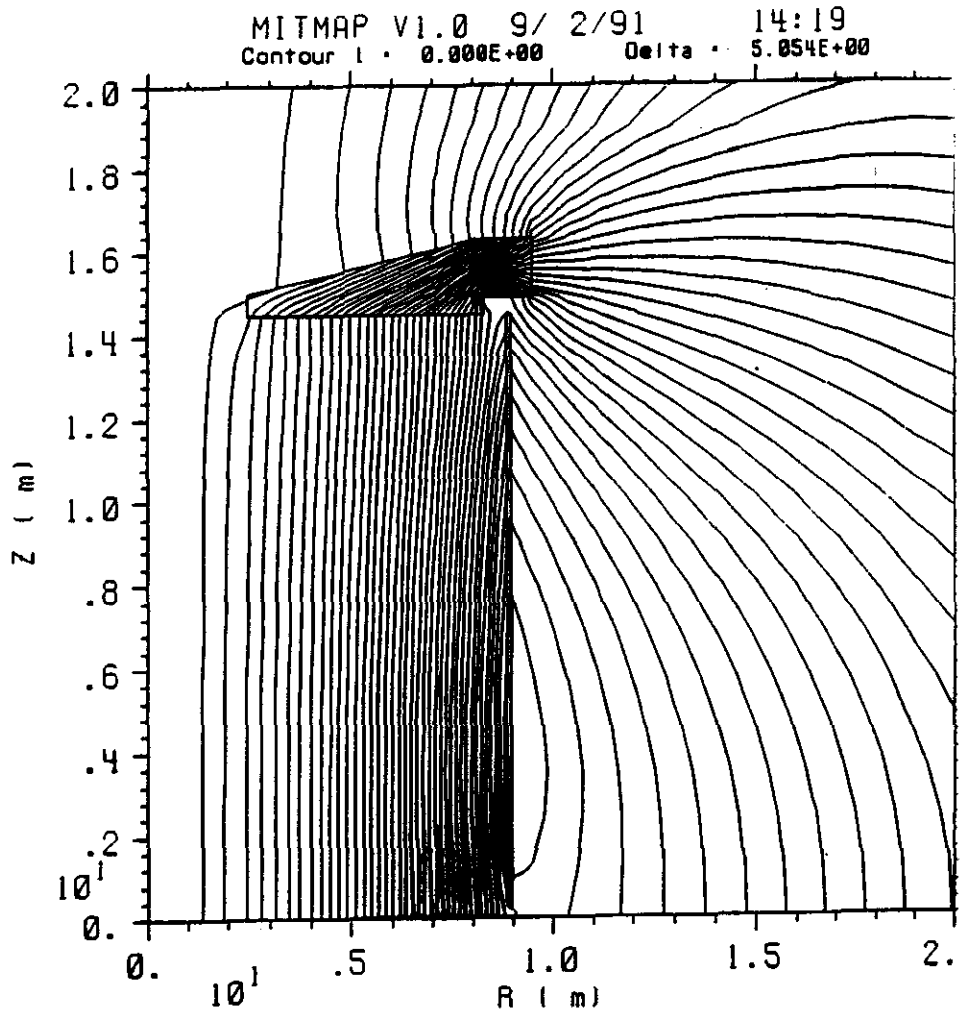
GEM --- Thin Pole Options: Case 3



CONTOURS OF CONSTANT FLUX

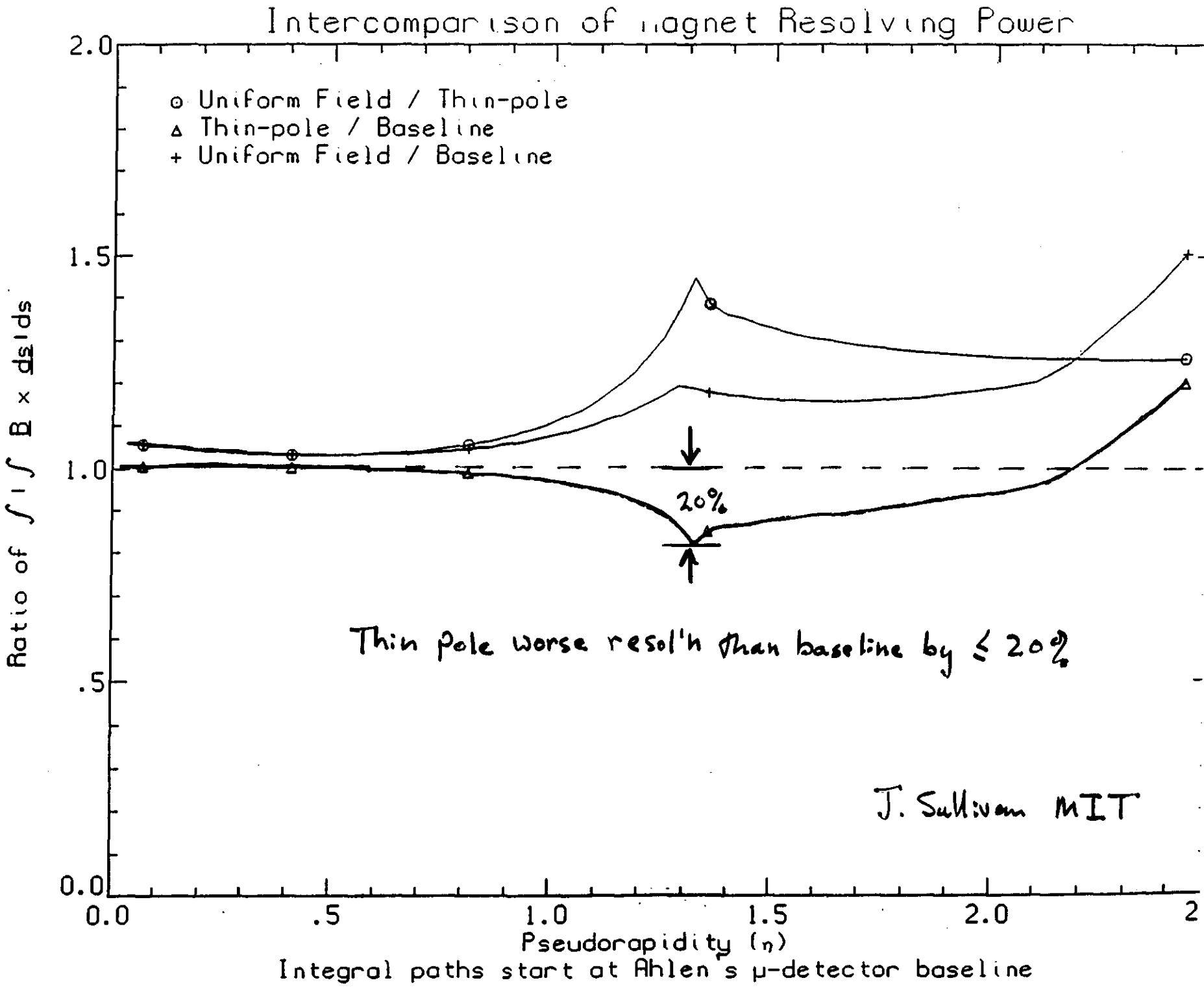
Baseline
Pole

GEM 1 --- Baseline with Full Pole



CONTOURS OF CONSTANT FLUX

J. Sullivan et al.


Intercomparison of Magnet Resolving Power
Uniform Field / Thin-pole
Thin-pole / Baseline
Uniform Field / Baseline
Ratio of ∫|∫ B × ds|ds
2.0
1.5
1.0
.5
0.0
0.0
.5
1.0
1.5
2.0
2
Pseudorapidity (η)
Integral paths start at Ahlen's μ-detector baseline
20%
Thin pole worse resol'n than baseline by ≲ 20%
J. Sullivan MIT

Summary:

Made selections of technologies for further R&D

Developing an R&D program for ultimate technology selections by summer 1992

Studying cost models of magnet/muon system

Considering (inexpensive) extensions of baseline design to improve resolution.

In the next few months:

- o Need to start full-scale engineering
- o Need to setup machinery to evaluate muon system performance as design of detector evolves.
  - Energy loss fluctuations in calorimeter
  - Muon system resolution versus design
  - Pattern recognition versus design
  - Trigger rates versus design
- o Contribute to global integration of GEM detector

J. Brau

September 13, 1991

TO: Barry Barish and Bill Willis
FROM: Bob Adair and Jim Brau
SUBJECT: Calorimeter Group Consensus

The GEM Calorimeter Group met at the SSC Laboratory September 4th and 6th to review the GEM calorimeter options. During this meeting the group developed a clear consensus on its recommendation to the GEM Collaboration for next year's R&D plan. This consensus is summarized in the following statement:

> The GEM Calorimeter Group wishes to continue R&D on two calorimeter systems during the next year. These two systems include one with a very high resolution electromagnetic section, which the group finds highly desirable, if feasible, and one which offers a conservative approach, but also with a high resolution electromagnetic section.
>
> With this end in mind we wish to continue R&D on
>
> * BaF2 EM
> * Scintillator Hadron Calorimetry
>
> * Liquid Argon
> * Xe/Kr Sandr for the barrel and LXe for the endcap
>
> The choice of scintillator technology (liquid or spaghetti) is being reviewed and will be chosen soon, no later than the LoI.
>
> We also wish to pursue R&D on forward calorimetry and have a coordinated research plan with liquid argon and liquid scintillator options.
>
> Finally we are reviewing the physics arguments and performance potentials for a preradiator. We will attempt to develop a consensus on a direction for this subsystem as soon as possible.

This consensus developed following a thorough review of each technology in which the proponents of each were asked to answer in writing and orally the questions and concerns expressed by others in the group. These reports are contained in the GEM Technical Report, GEM TN-91-00009.

GEM

A PRECISION LEPTON-PHOTON DETECTOR FOR THE SSC

- CALORIMETRY GOALS:
  DRIVEN By PHYSICS
  - The Highest Resolution Calorimetry System for Leptons and Photons
  - Within Budget and Schedule
  - Radiation Hard
  - Complementary to SDC

GEM

PHYSICS GOALS LEAD To TWO SYSTEM APPROACHES

- LOWER RISK SOLUTION EXISTS; NEEDS HIGHER EM RESOLUTION:
  - ⇒ LIQUID ARGON With Fine Sampling Accordion EM
- HIGHER RISK SYSTEM, With POTENTIAL LARGE PERFORMANCE GAIN:
  - ⇒ BaF_2 CRYSTAL EM, With SCINTILLATOR HCAL
    - NOTE: Radiation Hard Production Not Yet Achieved
      - Requires One Year of R&D
      - Expert Review Panel

GEM

TWO COMPLEMENTARY APPROACHES

RESULTING IN THE HIGHEST FEASIBLE RESOLUTION

- **LIQUID ARGON With ACCORDION EM; Liquid Krypton Option**
  - **Intrinsic Stability**
    $\Rightarrow$ Ease of Calibration
  - **Tested in Large Systems (With Plates)**
    $\Rightarrow$ Small Systematics
  - **Radiation Resistant**
  - **Uniform**
- **BaF_2 CRYSTAL EM, With SCINTILLATOR HCAL**
  - **Intrinsic Higher EM Resolution**
  - **Higher HCAL Speed:**
    $\Rightarrow$ Lower Noise in Isolation Cone
  - **Effective Compensation:**
    $\Rightarrow$ Small Constant Term for Jets
    With HCAL $e/\pi \approx 1$
  - **More λ for a Given Radius**

GEM CALORIMETRY

- **COMPLEMENTARY STRENGTHS:**

  INTRINSIC RESOL'N and SPEED $\Longleftrightarrow$ **LOWER RISK TECHNOLOGY**

- **COMPLEMENTARY TASKS for EM:**

  $\sigma_E/E = (a/\sqrt{E} \oplus b)\%$

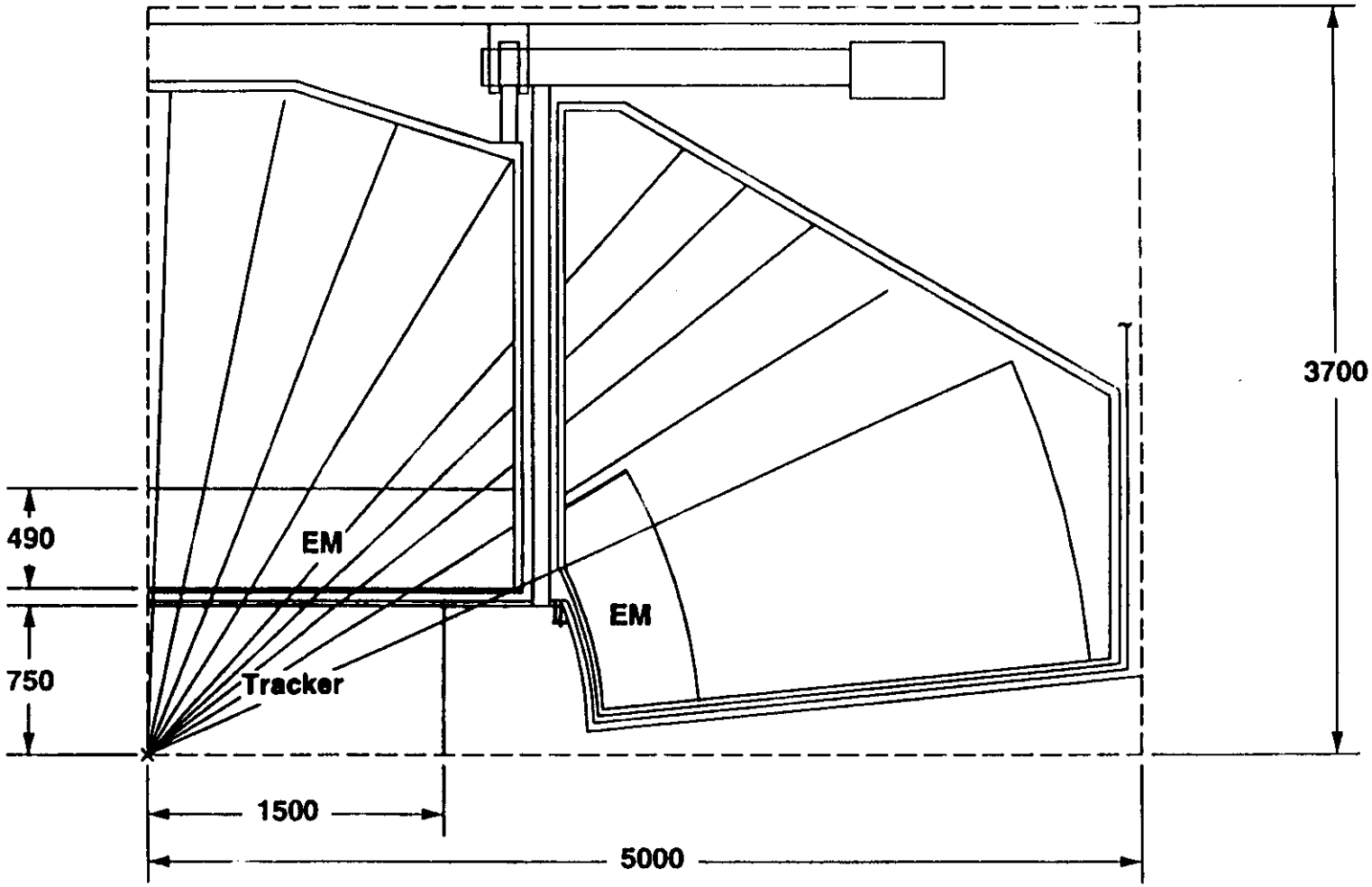
  BaF_2 + SCINT. HCAL $\Longleftrightarrow$ **LIQUID ARGON**

  Reduce b $\leq$ 0.5% — **Reduce a $\leq$ 7%**

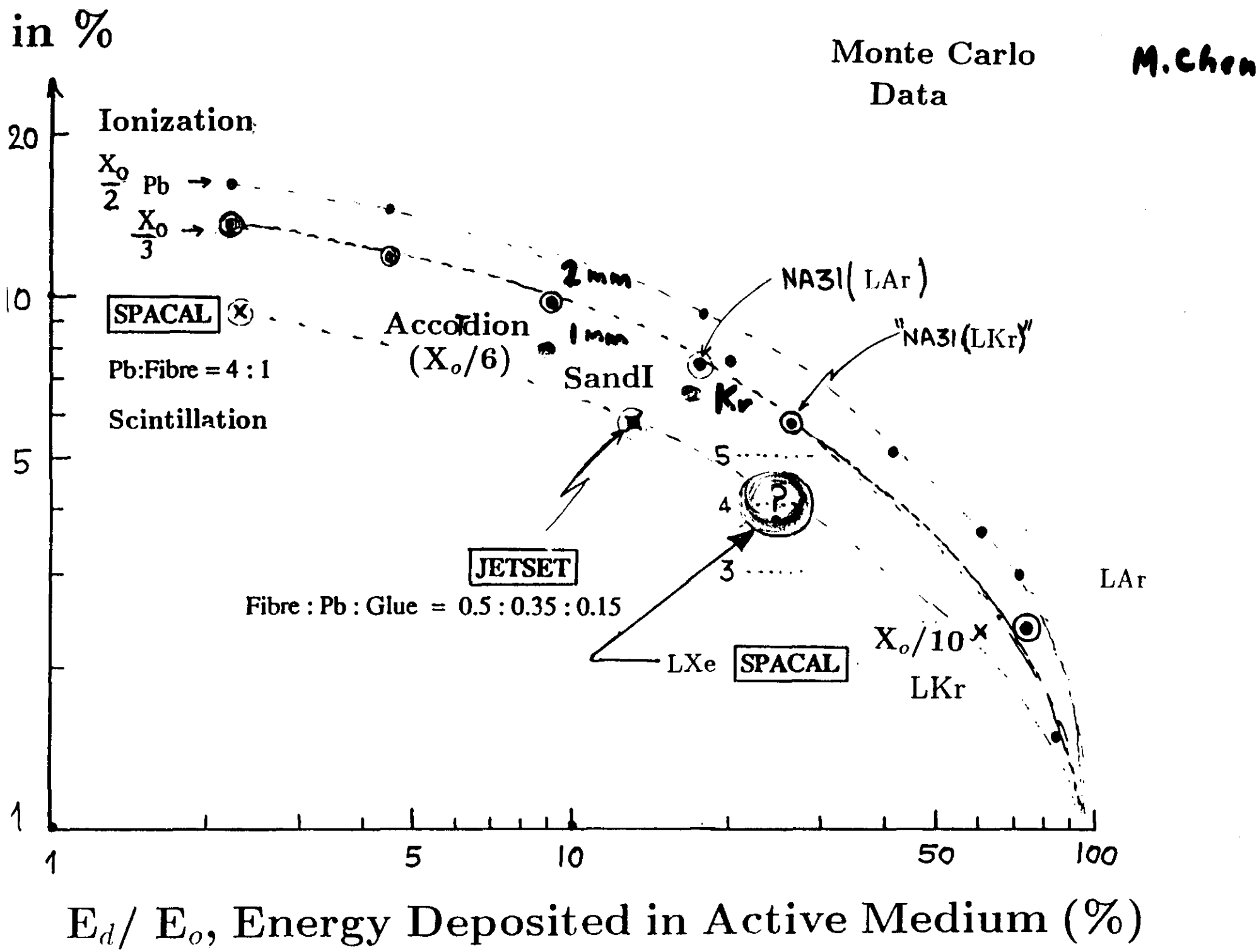
  ↑

  → DESIGN and SIMULATE AS a SUBDETECTOR of GEM

GEM Medium Barrel Configuration



MARTIN MARIETTA


in %
Monte Carlo
Data
M.Chen
Ionization
$\frac{X_0}{2}$ Pb
$\frac{X_0}{3}$
SPACAL
Pb:Fibre = 4 : 1
Scintillation
Accordion
($X_o/6$)
2mm
1mm
SandI
NA31(LAr)
"NA31(LKr)"
Kr
JETSET
Fibre : Pb : Glue = 0.5 : 0.35 : 0.15
LXe
SPACAL
$X_o/10$
LKr
LAr
20
10
5
1
1
5
10
50
100
E_d/ E_o, Energy Deposited in Active Medium (%)

BaF_2 + CALORIMETER SYSTEM:
Scintillating Fiber (SF) or
Liquid Scintillator (LS);
Liquid Argon Study

Choice of One Scintillator HCAL By Early November

HCAL SUBSYSTEM GOALS:

- Complement the BaF_2:
  $\Delta\eta \times \Delta\phi \approx 0.08 \times 0.08$

  $\Rightarrow$ Good Jet Resolution

  $\Rightarrow$ Missing E_T Resolution, (With Forward HCAL)

  $\Rightarrow$ Improved Lepton ID and Measurement

- Rapid Development: Ready for GEM System Choice By Design Report

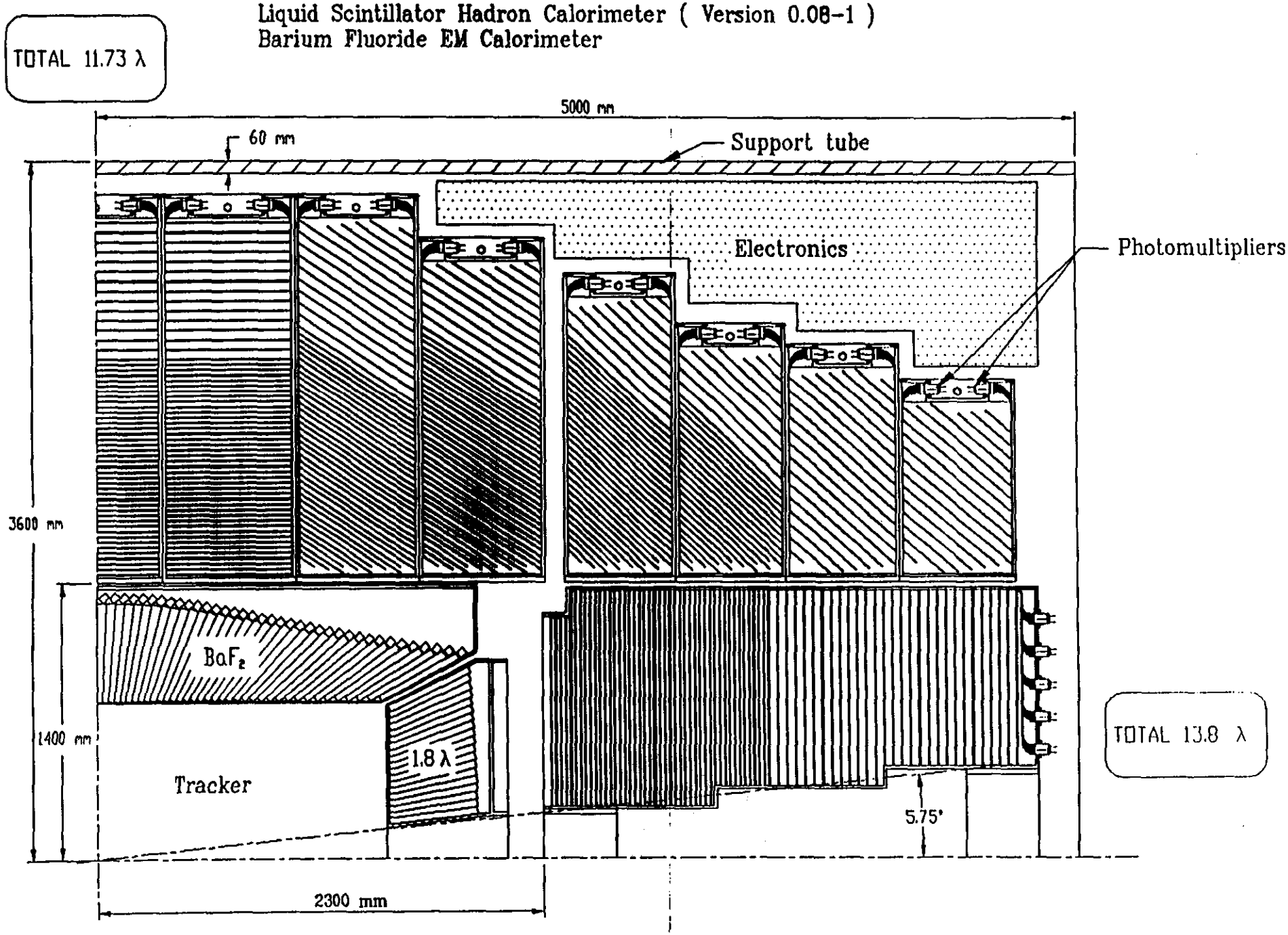
  $\Rightarrow$ Beam Test By Summer 1992

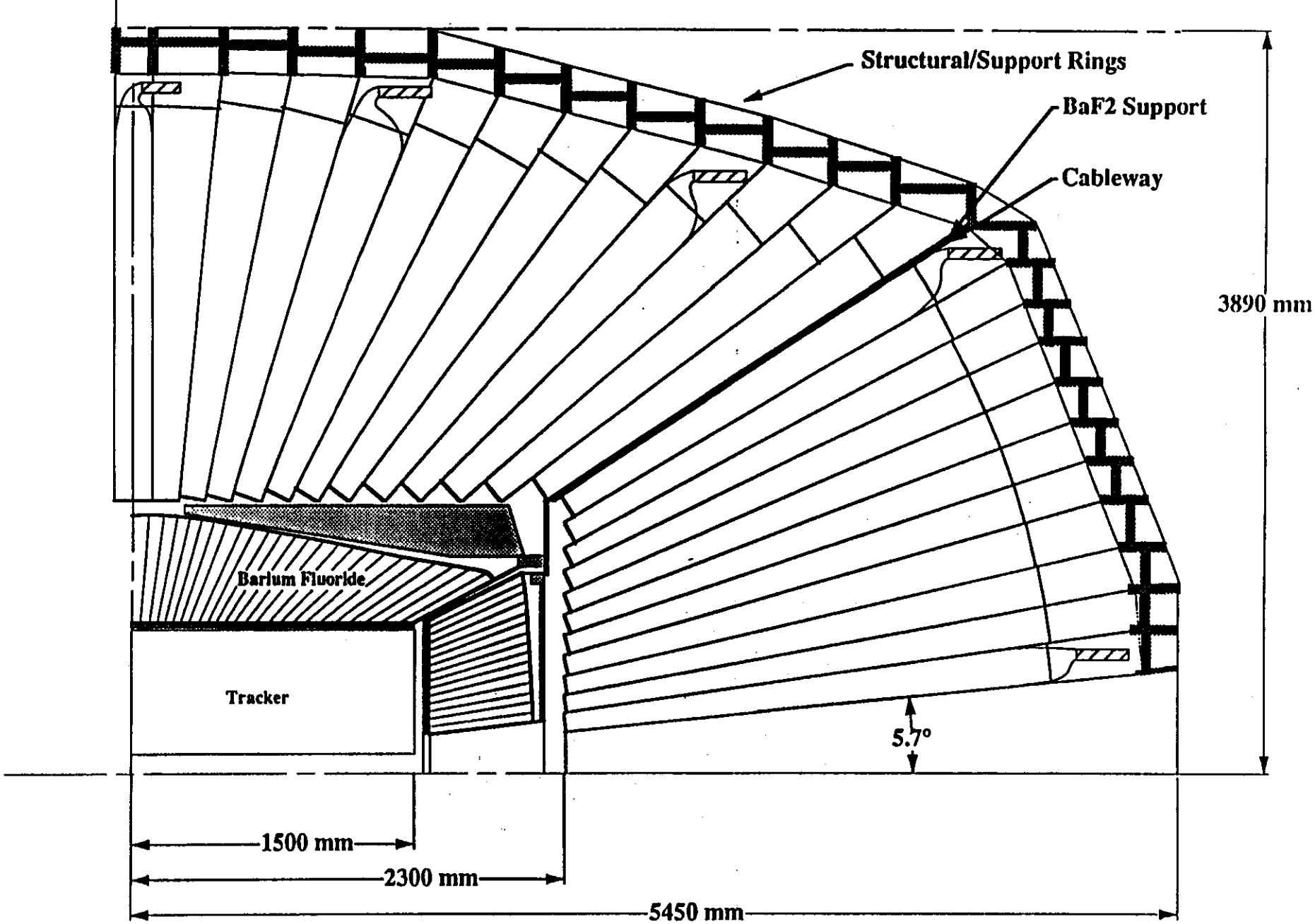
- Maximize GEM's Physics Capability

BaF_2 + HCAL CHOICE: GENERAL QUESTIONS: Answers In October

- **Conceptual Design Layouts With Dimensions:**
  - ⇒ **LS: Module, Layer Structure, Fiber Readout**
  - ⇒ **SF: Module Structure, Fiber Readout**
  - ⇒ **LAr: Segmentation, Cryostat, Readout**
  - ⇒ **ALL: Mechanical Structures and Supports; Access/Assembly/Disassembly Scheme**
- **HCAL Depth (λ); Dead Spaces**

Liquid Scintillator Hadron Calorimeter (Version 0.08-1)
Barium Fluoride EM Calorimeter

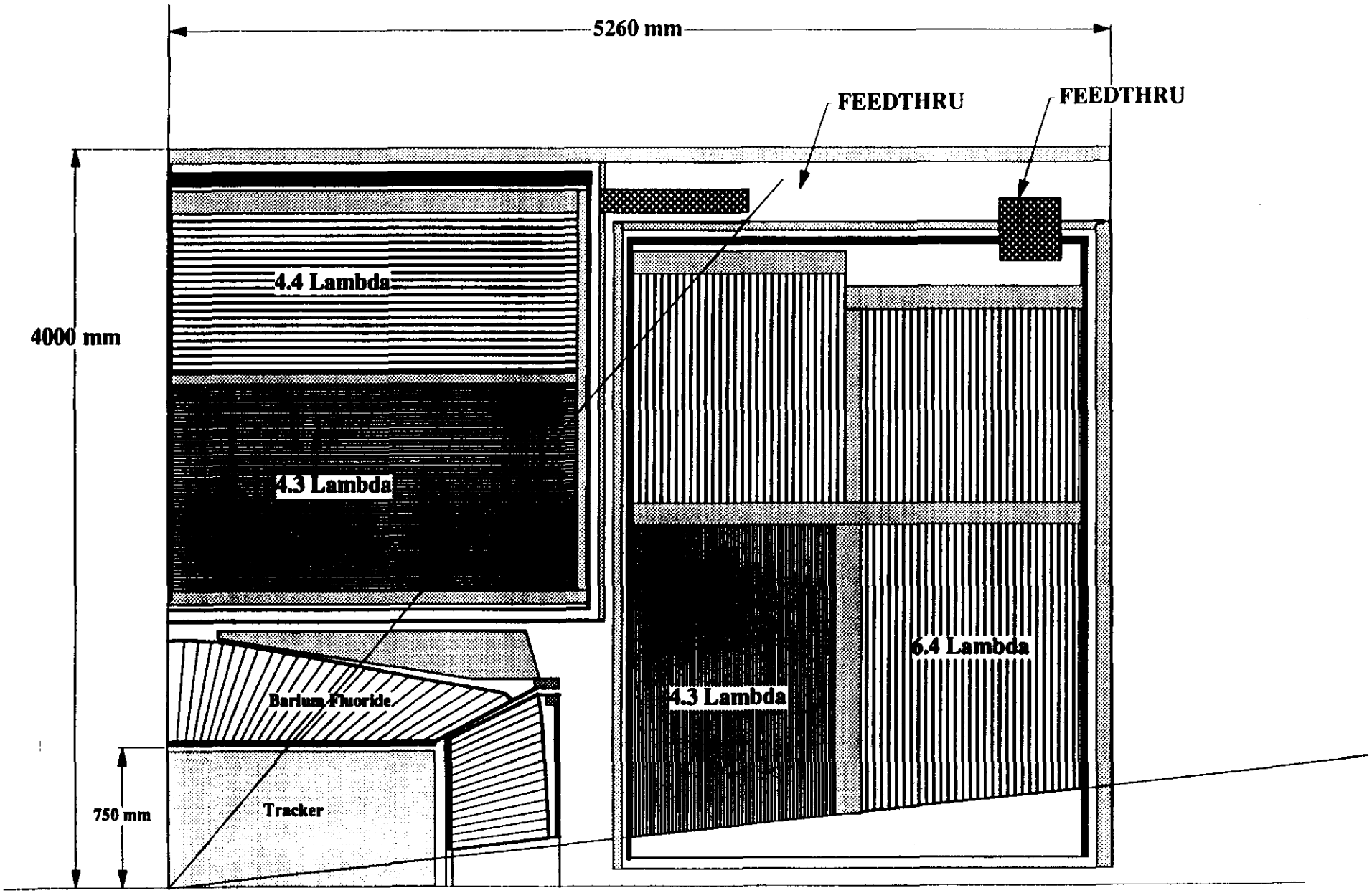




Spaghetti Hadron Calorimeter
Lead Shot Filled/ 0.10 Segmentation
Barium Fluoride EM Calorimeter

G.03.SC.00038

Rennich



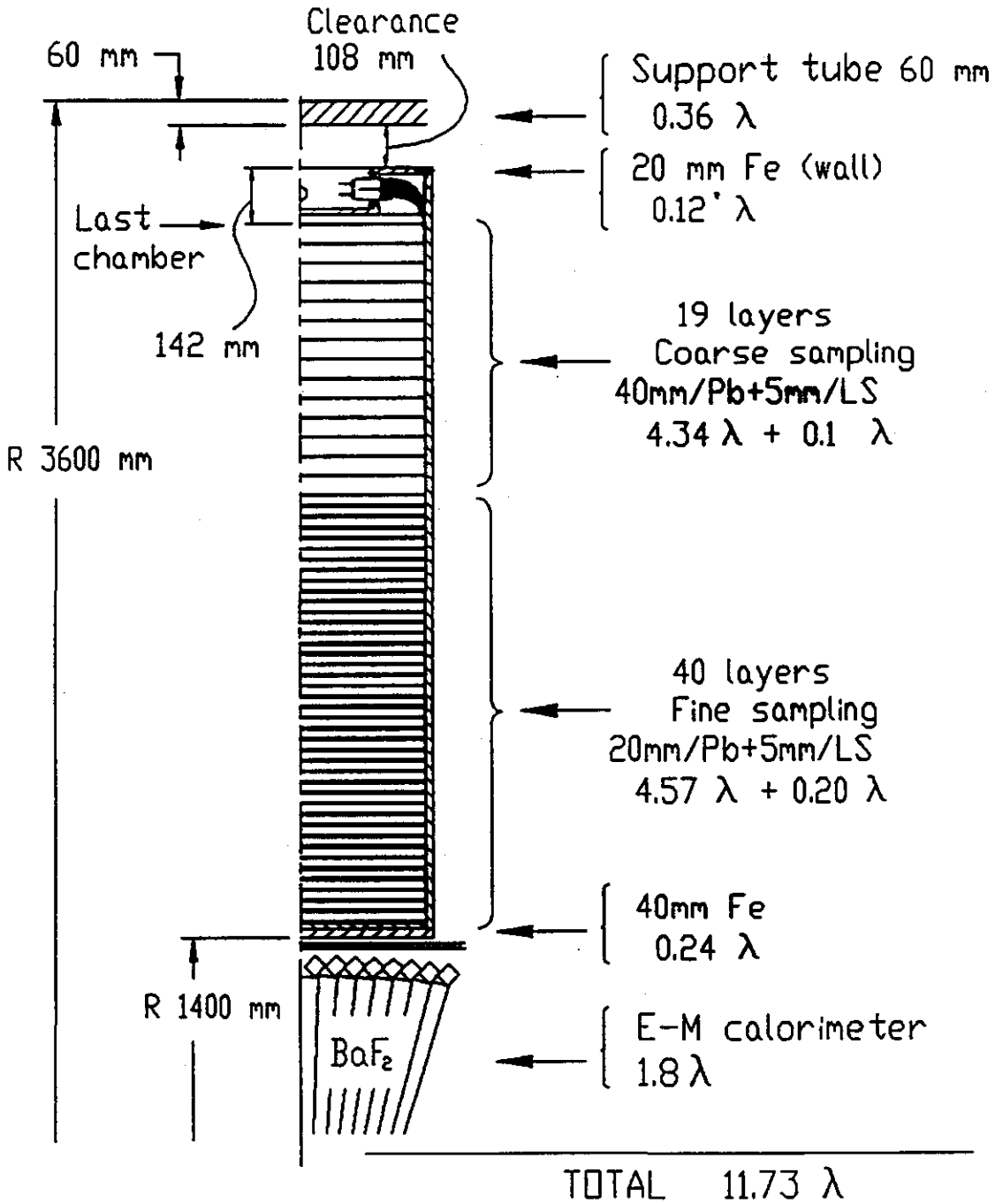
Total Thickness: 11 Lambda

G.03 LA 00019

GEM
Liquid Argon Calorimeter
Barium Fluoride EM Section

Incomplete
Incomplete
Incomplete

Liquid Scintillator Hadron Calorimeter
Sampling structure scheme



λ_{Pb} = 175 mm

λ_{Fe} = 168 mm

λ_{Scl} = 1000 mm

BaF_2 + HCAL CHOICE: PHYSICS QUESTIONS

SIMULATION STUDY COMPLETED By NOVEMBER:

- **Energy Resolution, Behind BaF_2** for 20, 100, 500, 1000, ... GeV Jets
  - Performance For Typical, Mostly-EM, and Mostly-Hadronic Jets:
    - ⇒ Reconstructed Energy Distribution
    - ⇒ Missing E_T Distribution
- Can Longitudinal Segmentation in the HCAL Improve the Muon Resolution ?
- Can Longitudinal Segmentation in the HCAL Improve the BaF_2 Electron and γ Resol'n ?
- NUMBER of $\lambda \Leftrightarrow$ Performance

BaF_2 + HCAL CHOICE: ASSOCIATED EFFECTS and ISSUES

- **Systematic Effects:**
  - ⇒ Magnetic Field (0.8 Tesla)
  - ⇒ Non-Uniformities in Cells or Towers
  - ⇒ Fiber Attentuation Length, Non-Uniformity
  - ⇒ Mechanical Structure, Walls, and Typical 'Dead Regions'
- **Effective Compensation: Hydrogenous, Compensating or Overcompensating HCAL.** *
- **Resolution as Function of e/h in EM Section, With Varying Reconstruction Algorithm.**
- **Transverse Segmentation Required by Physics**

* GEANT vs. HETC Study:

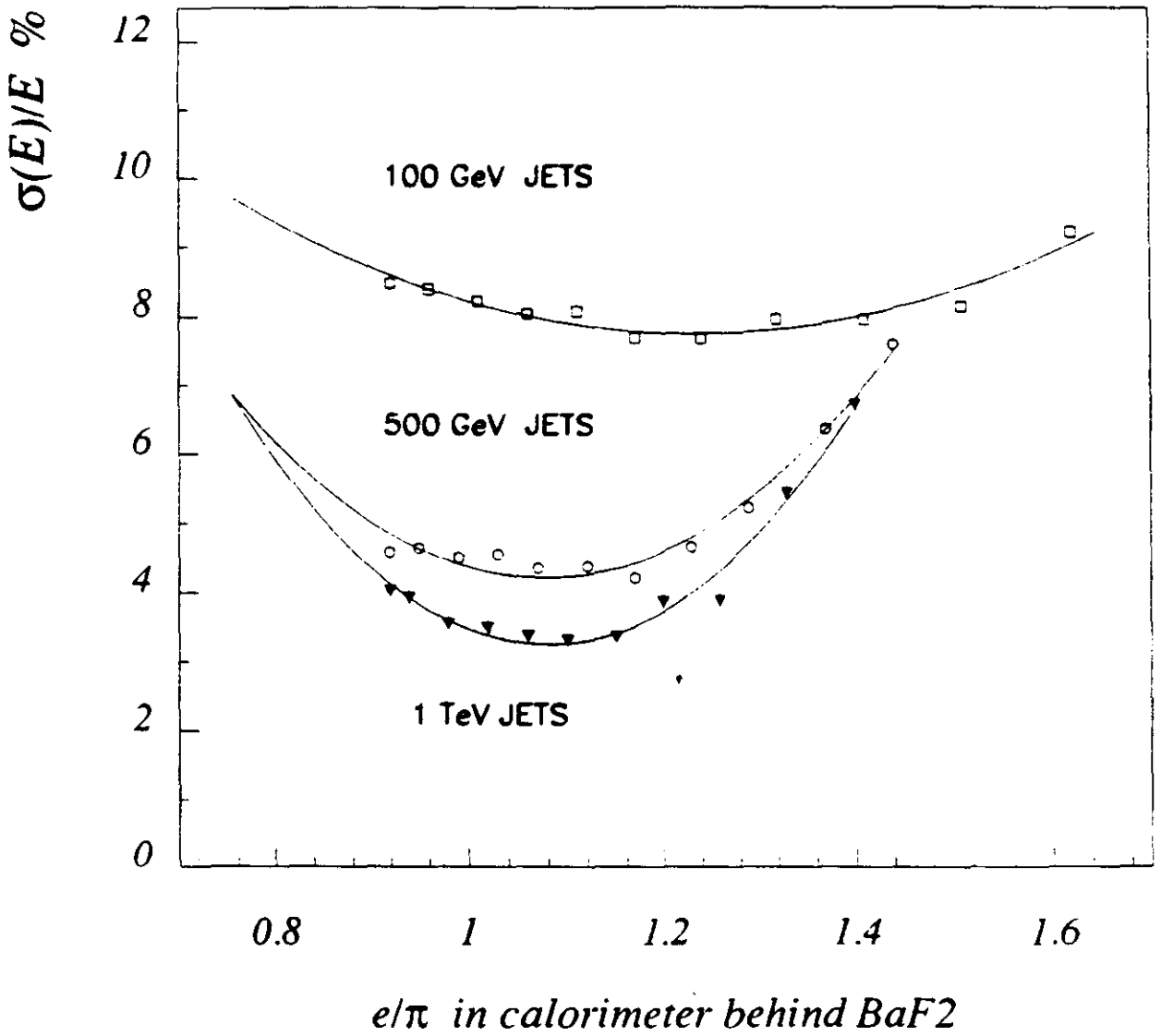
- Preliminary Results (ORNL)

Y.K.

GEANT3 - JET RESOLUTION for BaF2+scint.HADRON calorimeter

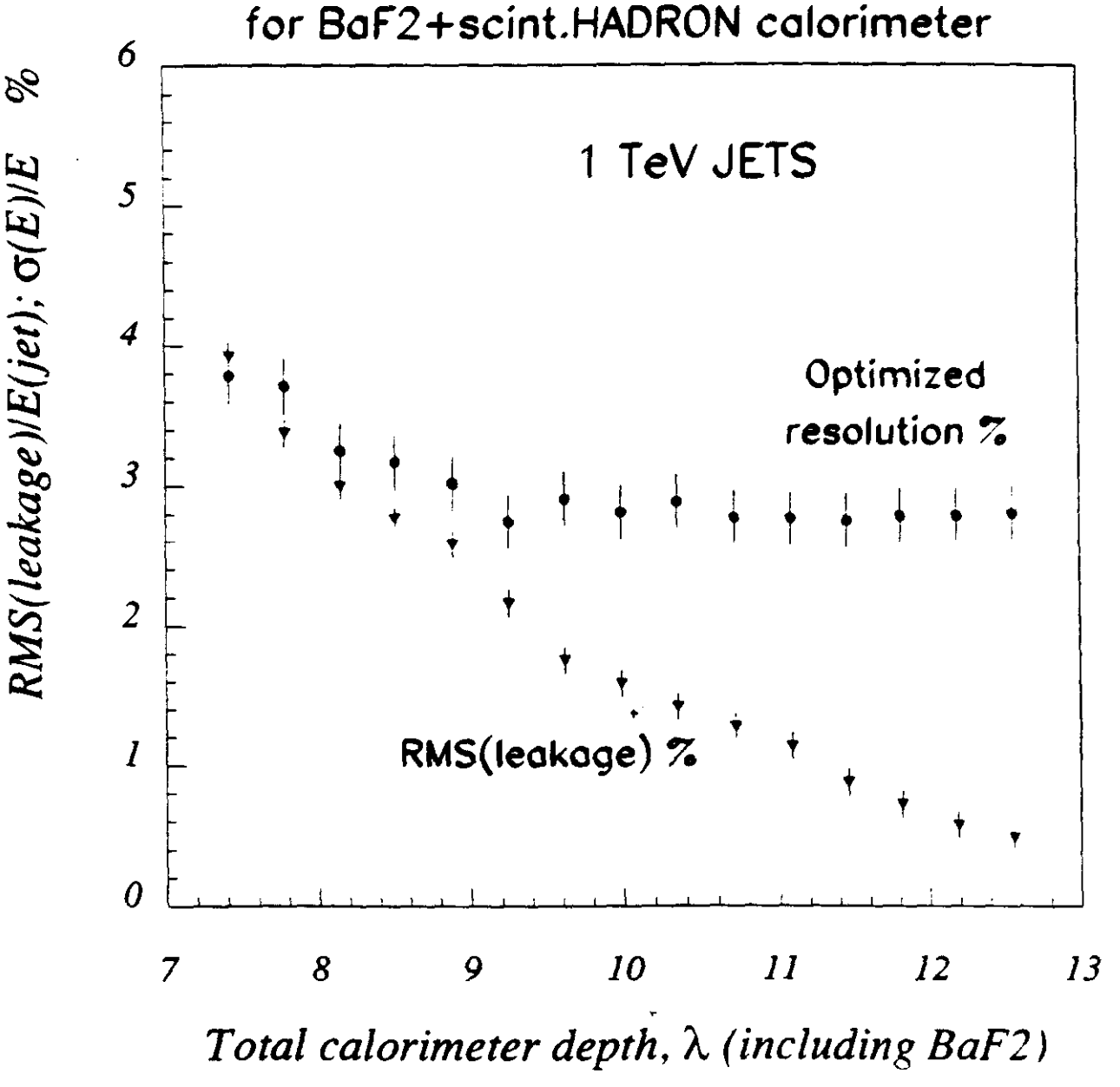
here BaF2 <e/π> = 1.7

After optimisation for α*BaF2 + β*HC



Y.K.

LEAKAGE FLUCTUATIONS IN CALORIMETER



Y.K.

Thickness of Calorimeter

1. Punchthrough of π and K simulates μ

   $L_{tot} > 10.5\,\lambda$ @ 90°

2. Leakage fluctuations should not contribute to constant term of hadronic resolution

   $L_{tot} > 9.5\,\lambda$ @ 90°

CALORIMETER GROUP POSITION ON PRE-RADIATOR

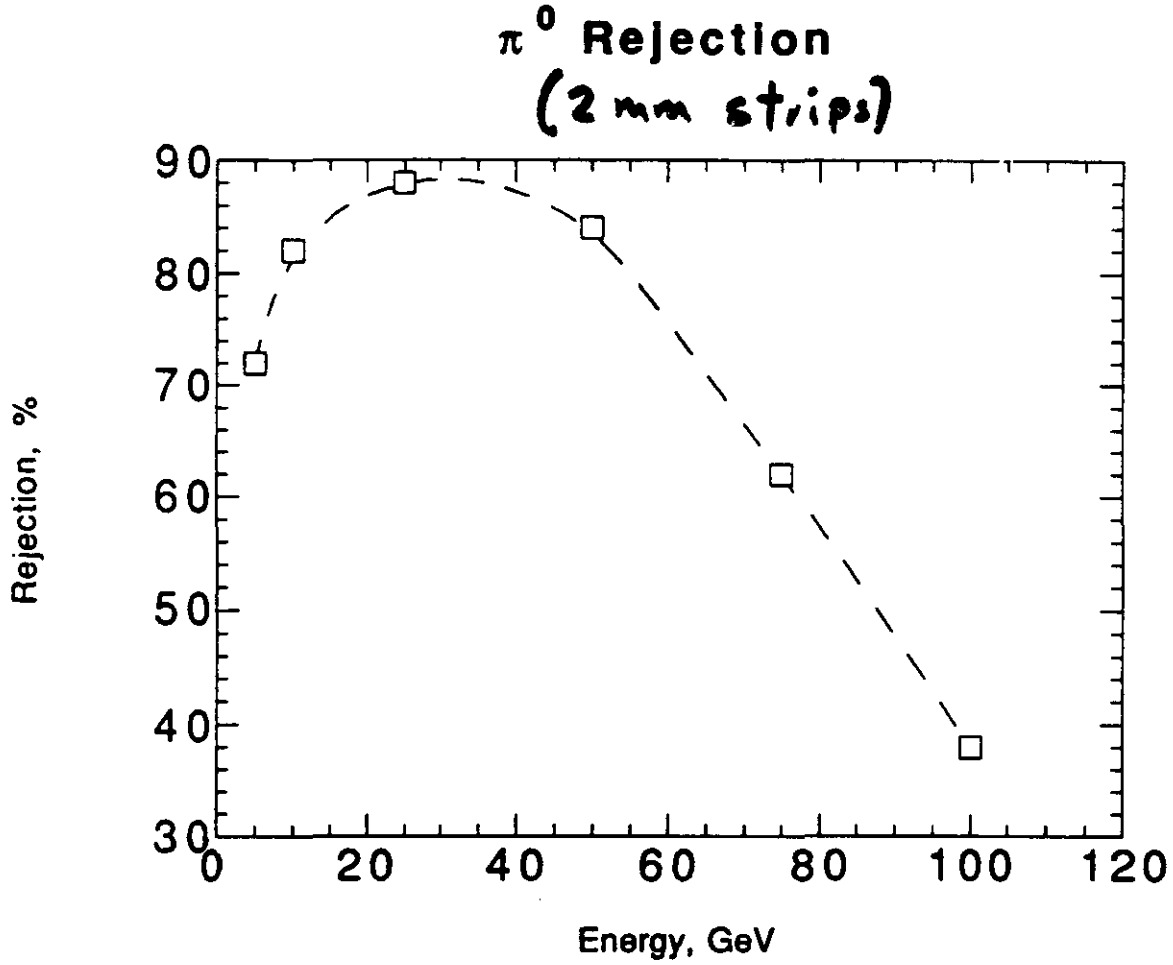
- A PRE-RADIATOR SHOWS PROMISE FOR ADDING TO PHYSICS PERFORMANCE
- CHOICE OF PRE-RADIATOR COUPLED TO CALORIMETER CHOICE
- RECOMMEND MODEST ENGINEERING AND R+D SUPPORT FOR PRE-RAD.

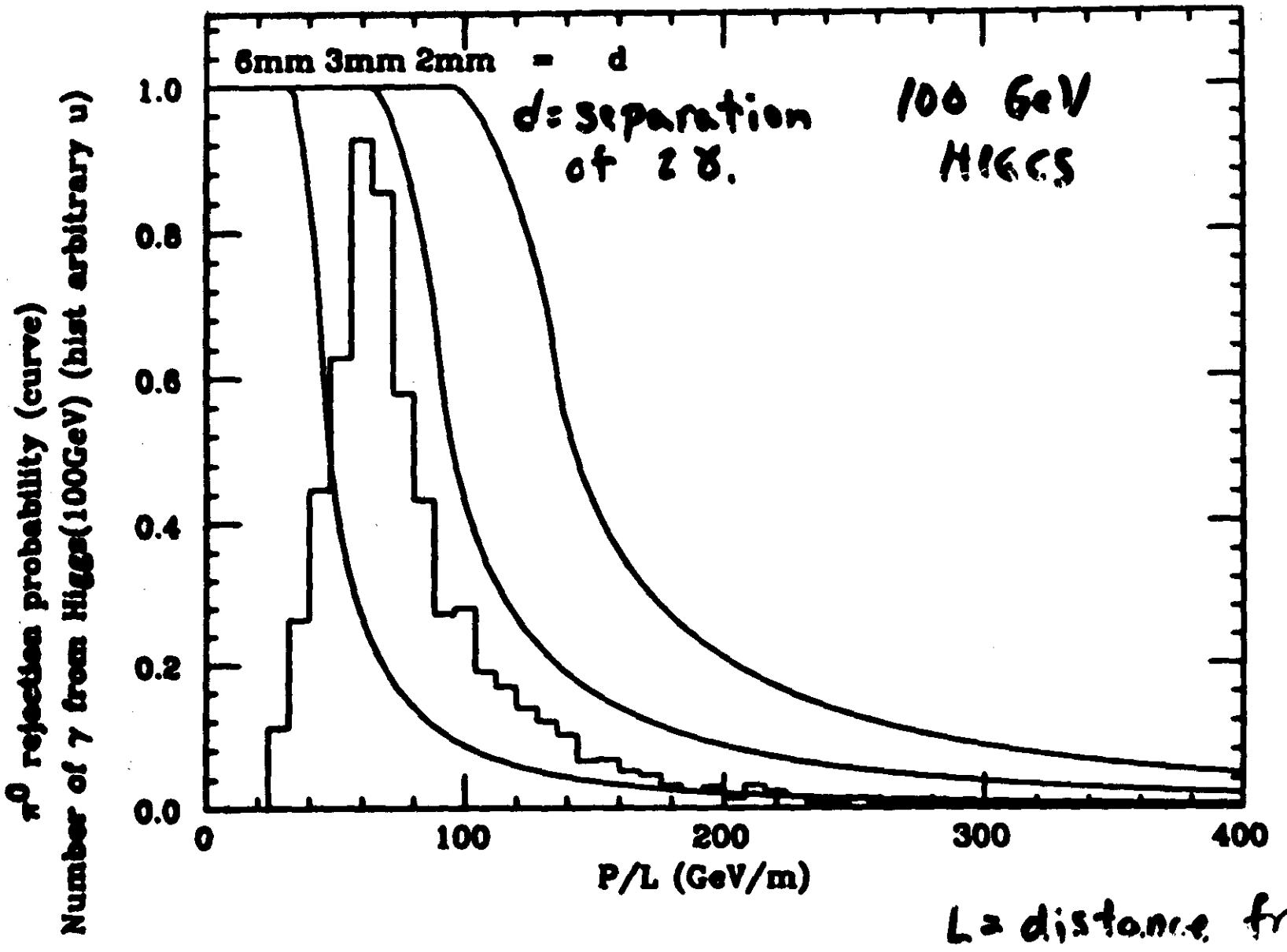
FAVORED TECHNIQUES

SILICON STRIPS
SILICON DRIFT (RAD HARD?)
LIQ. ARGON READOUT STRIPS

THIS POSITION SUPPORTED BY M.C. WORK OF P. CUSHMAN, M. CLEMEN, P. MOCKETT, & K. FURUNO et al.

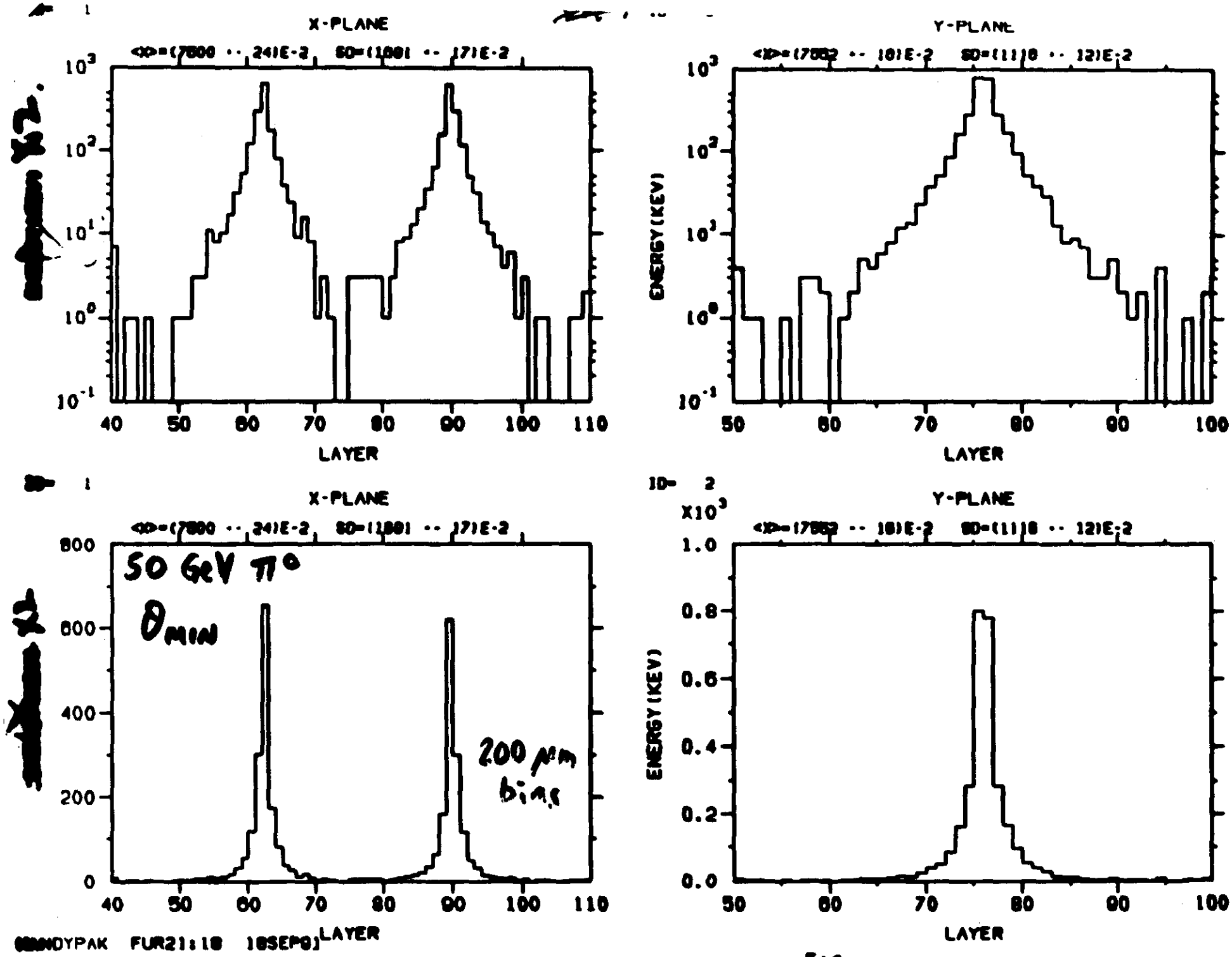
P. Mockett etal





L = distance from interaction to P.R.

Figure V.2


X-PLANE
Y-PLANE
LAYER
ENERGY(KEV)
X-PLANE
Y-PLANE
50 GeV π°
θ MIN
200 μm bins
LAYER
ENERGY(KEV)
LAYER
I+4

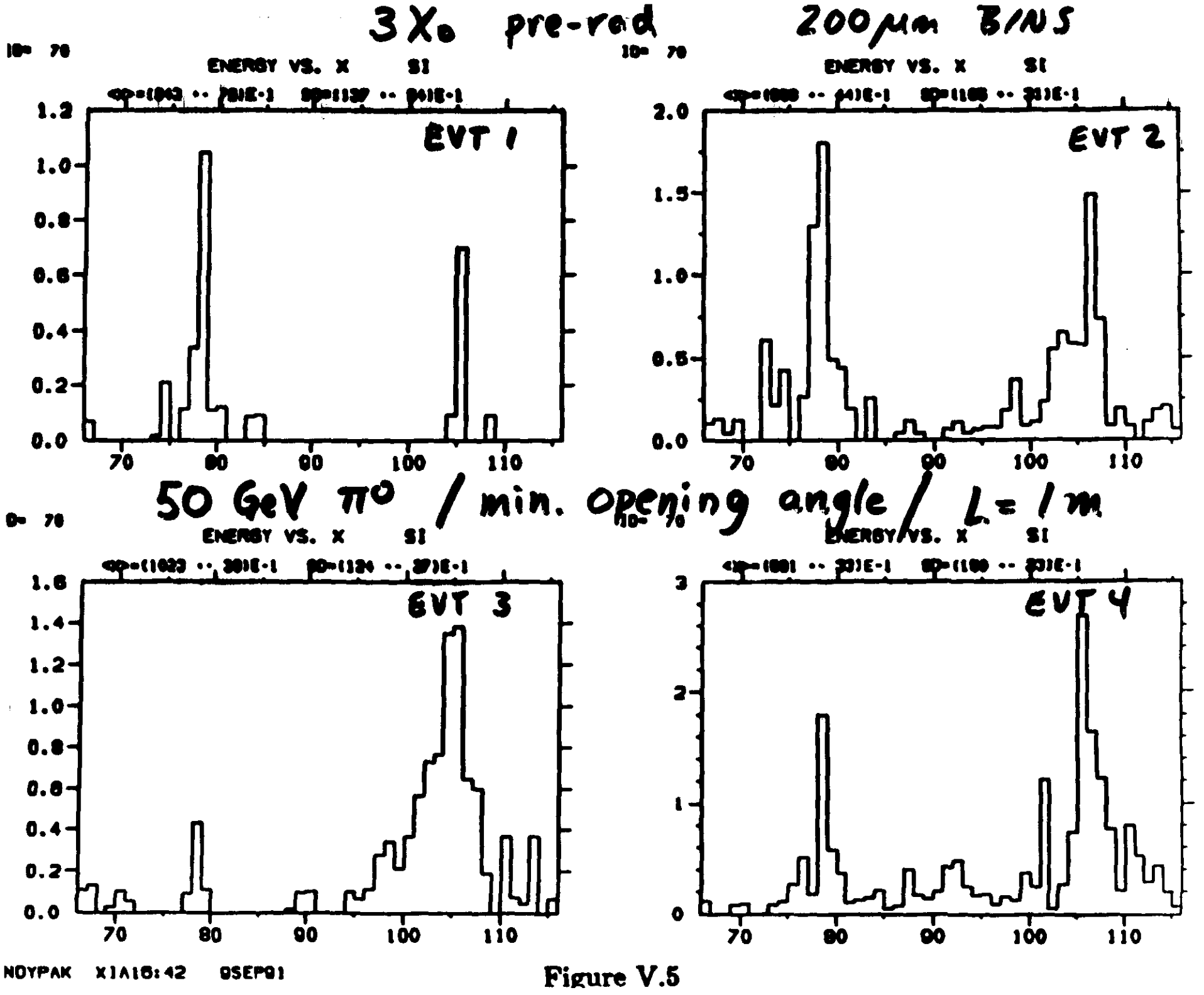
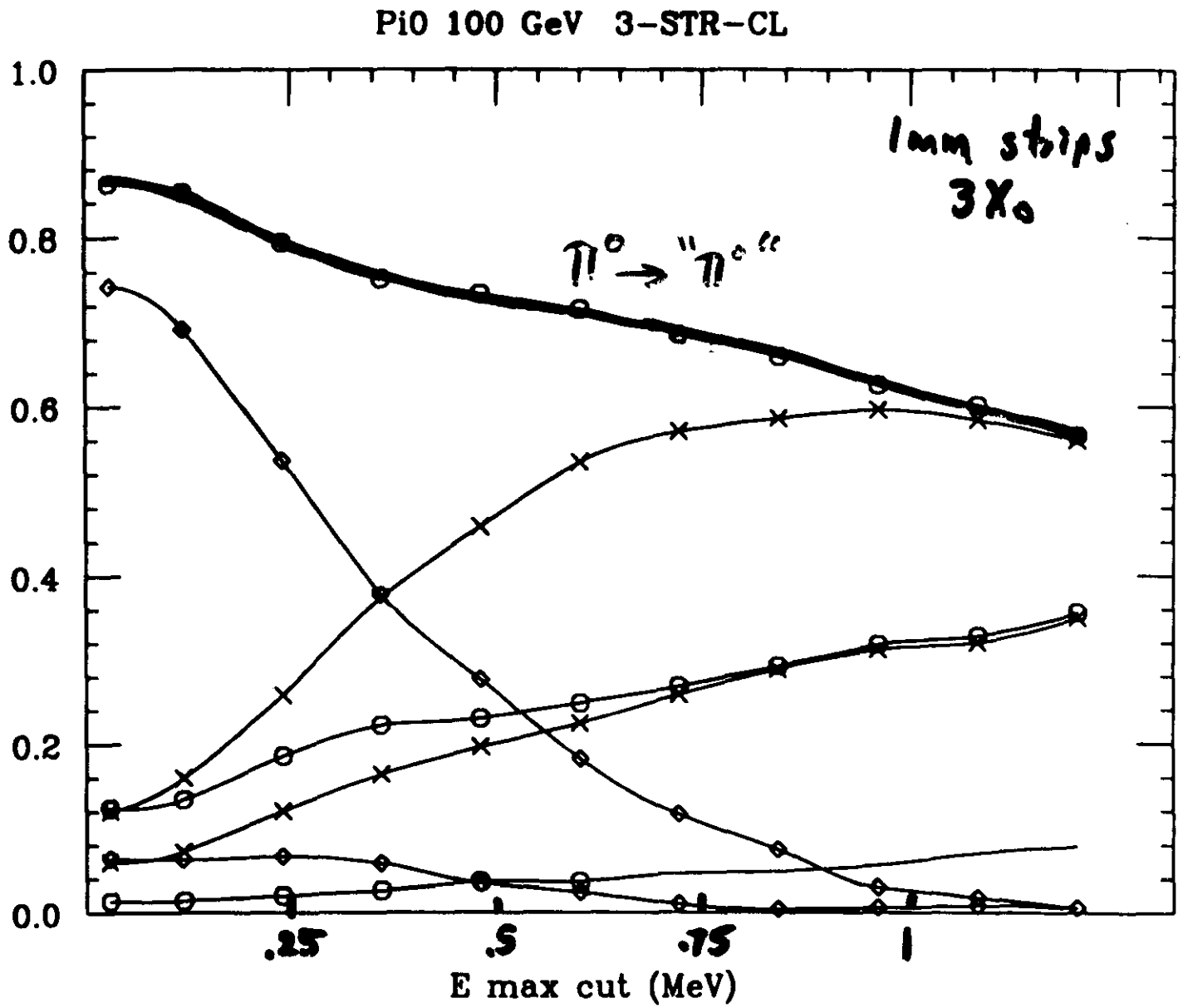
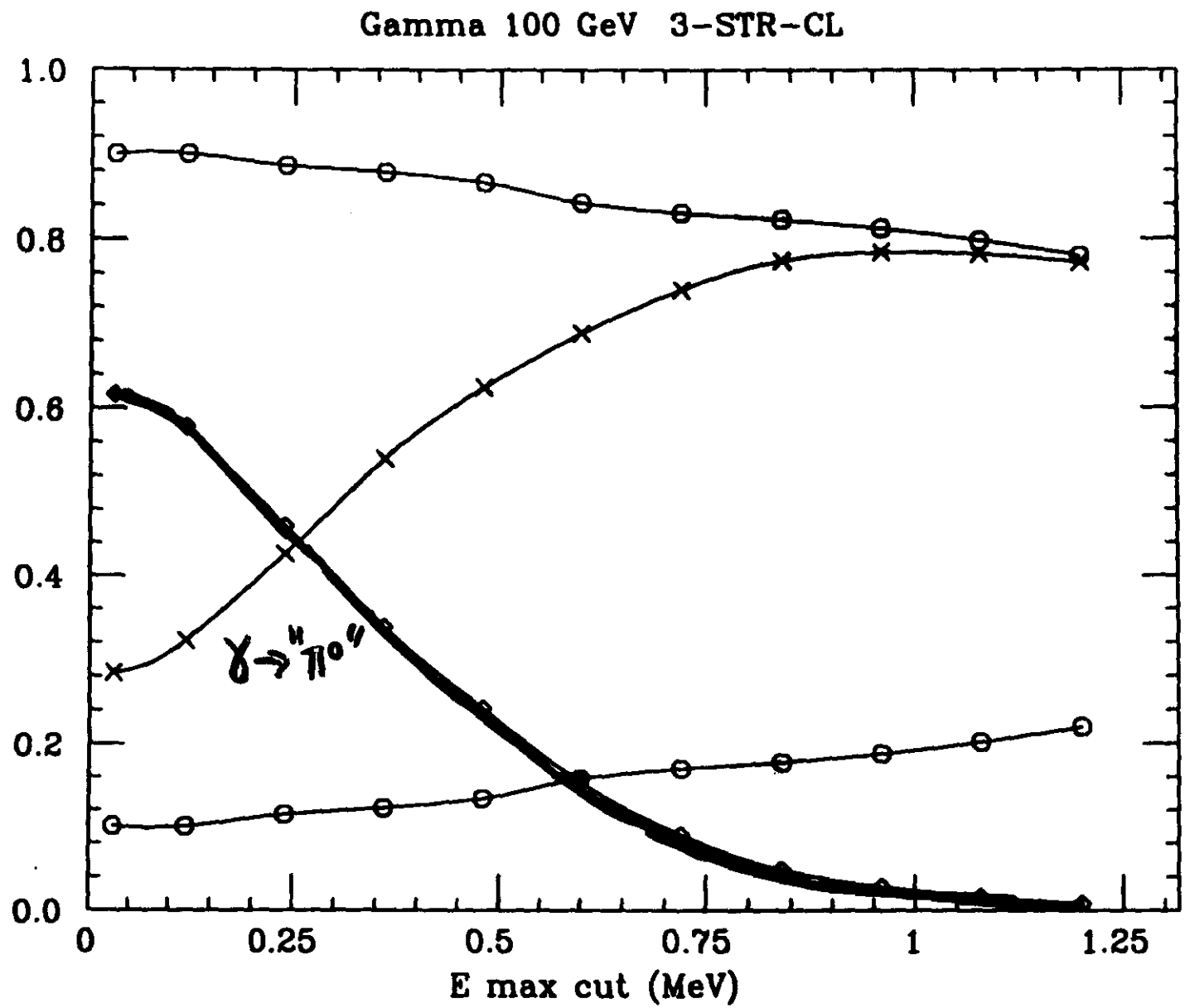

3X₀ pre-rad
200μm BINS
ID= 70
ENERGY VS. X SI
EVT 1
EVT 2
50 GeV π⁰ / min. opening angle / L = 1 m
EVT 3
EVT 4
NOYPAK X1A16:42 05SEP91

Figure V.5

K. FURUN

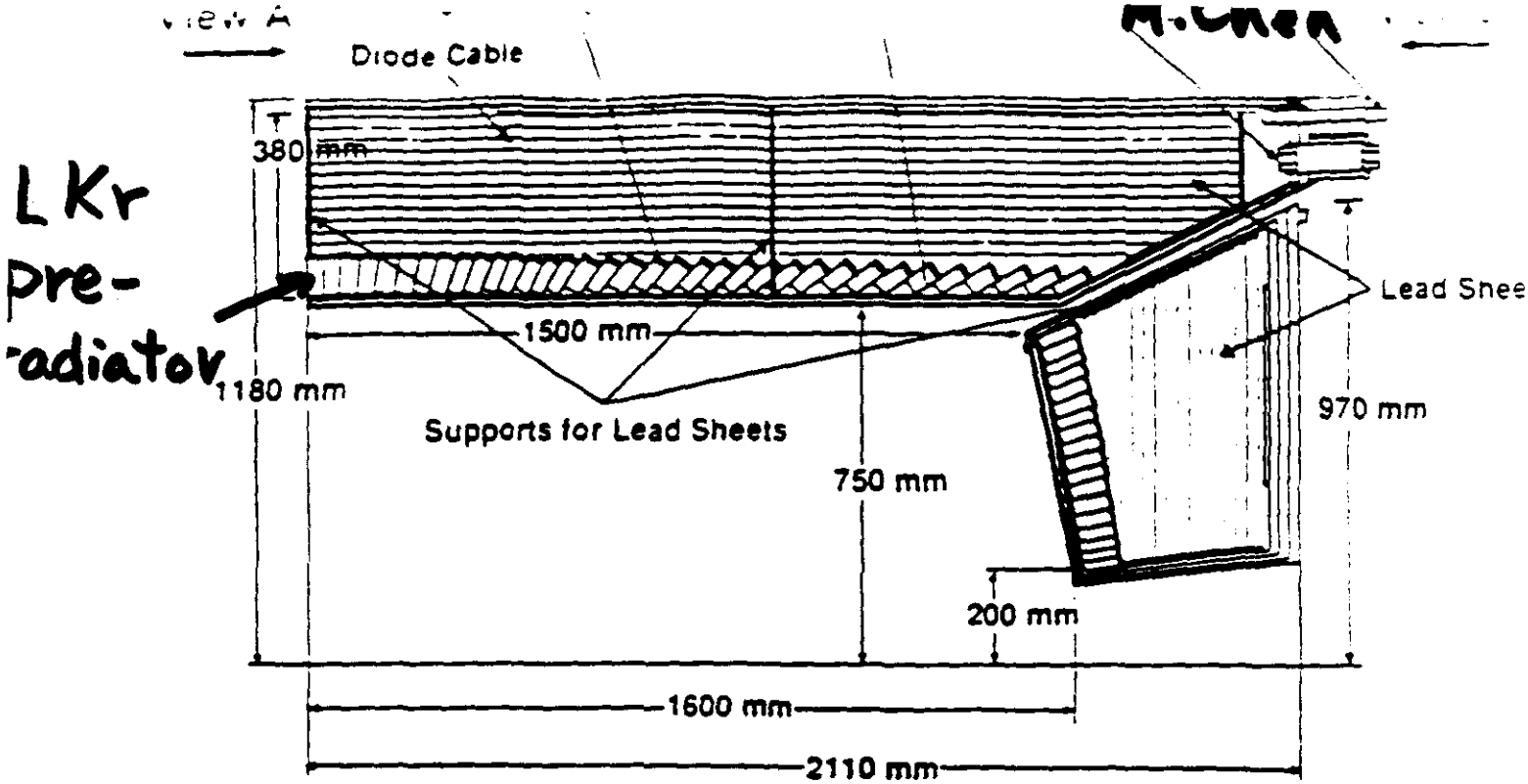


cluster finding


Gamma 100 GeV 3-STR-CL
1.0
0.8
0.6
0.4
0.2
0.0
0
0.25
0.5
0.75
1
1.25
E max cut (MeV)
γ→"π0"

CONCLUSION

Pre-radiator with 1mm strips ~~panels~~ in X **AND** Y can improve significance of Higgs signal by a factor of 1.4 → 2.4



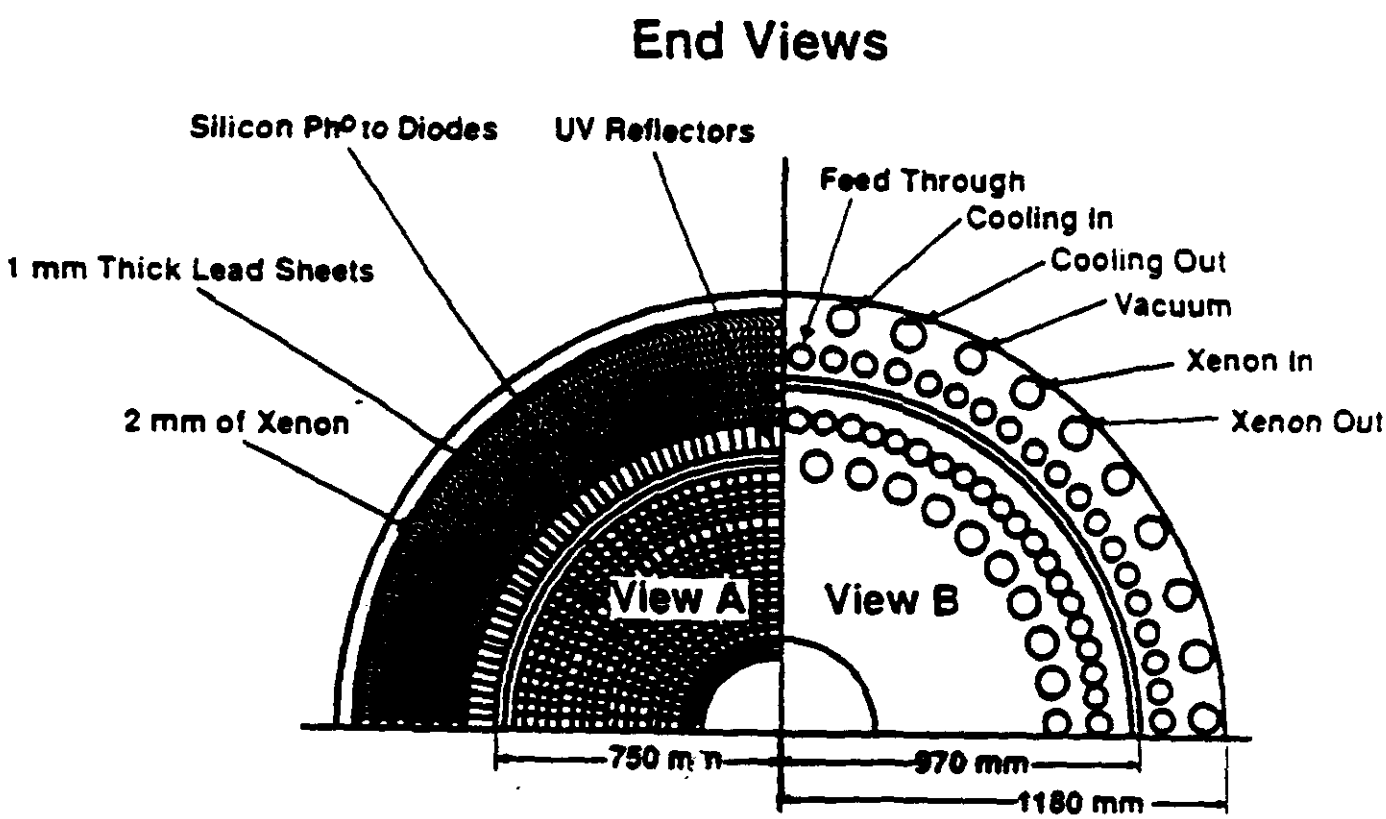


Figure 21: Side and end views of one quadrant of SandI electromagnetic detector using LKr + 5% LXe. SandI has a homogeneous section in the front, with a UV diode collecting scintillation light from the first 10 cm of the homogeneous noble liquid; followed by a drift diode to detect the positions of showers; and a sampling ionization calorimeter in the back (e.g. Accordion).

M. SHUPE
UNIV. OF ARIZONA
OCT, 1991

DESIGN CRITERIA FOR FORWARD CALORIMETER.

- PHYSICS:
  1. $\not{E}_T$ COVERAGE TO $\sim |\eta| = 5.0$, WITH RESOLUTION UP TO ν IMPOSED LIMIT.
  2. JET RESOLUTION $\Rightarrow$ p_T RESOLUTION
- RADIATION HARDNESS:
  TO IONIZING RADIATION NEAR e SHOWER MAX. AND NEUTRON FLUX.
- INTEGRATE INTO FORWARD REGION DESIGN.
- HIGH RATE CAPABILITY:
  (FOR LIQUID ARGON)
  1. USE SHORT SHAPING TIMES, AND SMALL GAPS.
  2. CALCULATE AND MEASURE + ION PILEUP.
- COST
  (FOR PROPOSED DESIGN)
  1. COST OF TUNGSTEN
  2. CHANNEL COUNT

etc..

Physics Requiring a Forward Calorimeter

Missing E_T

Higgs

$$H \rightarrow ZZ \rightarrow \ell^+\ell^-\nu\bar{\nu}$$
$$H \rightarrow ZZ \rightarrow \ell^+\ell^-\tau\bar{\tau}$$

New heavy quarks

SUSY

Technicolor

$$\rho_{TC}^{\pm} \rightarrow W^{\pm}Z^{o} \rightarrow \ell^{\pm}\nu\ell^+\ell^-$$

Leptoquarks $gg \rightarrow P_3P_3 \rightarrow b\tau\bar{b}\bar{\tau}$

New Gauge Bosons

$$W'^{\pm} \rightarrow \ell^{\pm}\nu$$

Other sources of boson pairs

$$W^{\pm}Z^{o} \rightarrow \ell^{\pm}\nu\ell^+\ell^-$$
$$W^{\pm}W^{\pm} \rightarrow \ell^{\pm}\nu\ell^{\pm}\nu$$
$$W^+W^- \rightarrow \ell^+\nu\ell^-\nu \text{ if separable from } t\bar{t}$$

Forward Jets

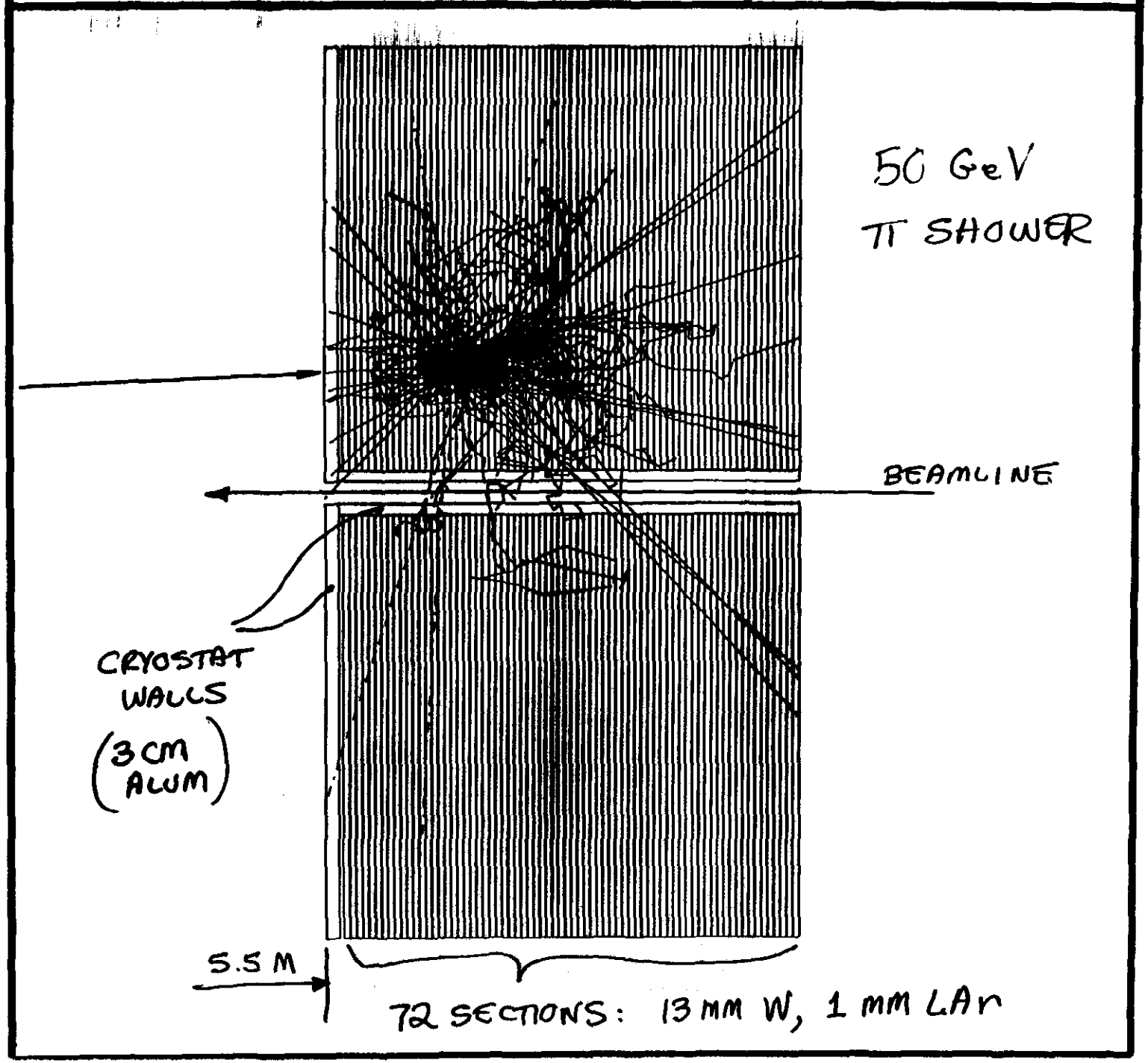
VV scattering with forward jet tagging

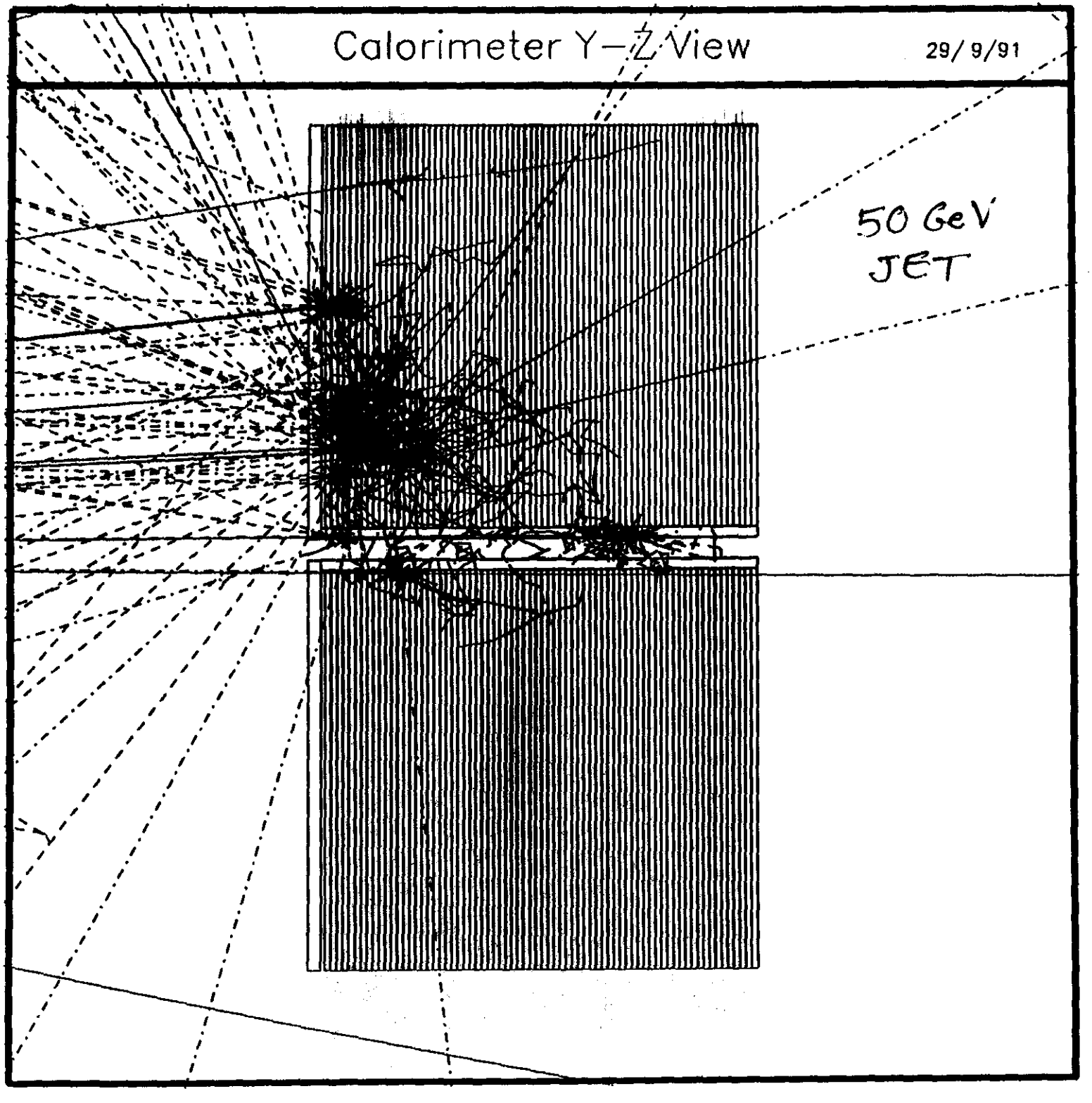
Low x physics via forward di-jets

π 50GeV

Calorimeter Y–Z View

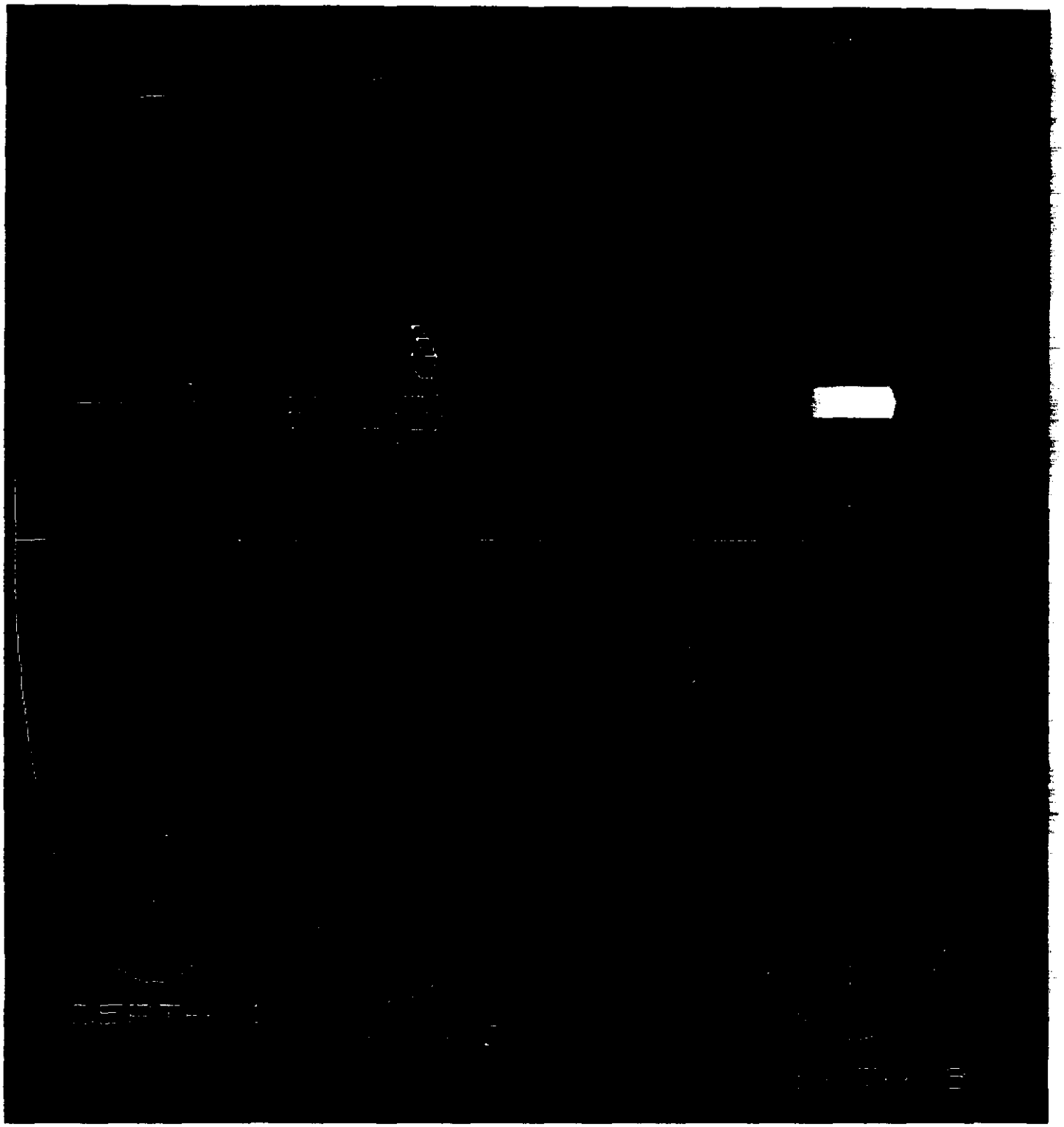
24/9/91




Calorimeter Y–Z View
29/ 9/91
50 GeV
JET

ENERGY IN DEPTHS

3 GANGED DEPTHS IN FCAL



$20X_\phi$ DEEP

5λ DEEP
$(-20X_\phi)$

5λ DEEP

LAr-TUNGSTEN FCAL OPTION FOR GEM

SUMMARY

- MANY BASIC DESIGN PARAMETERS TO BE DETERMINED BY INTEGRATION INTO GEM (FCAL SOMEWHAT FLEXIBLE)

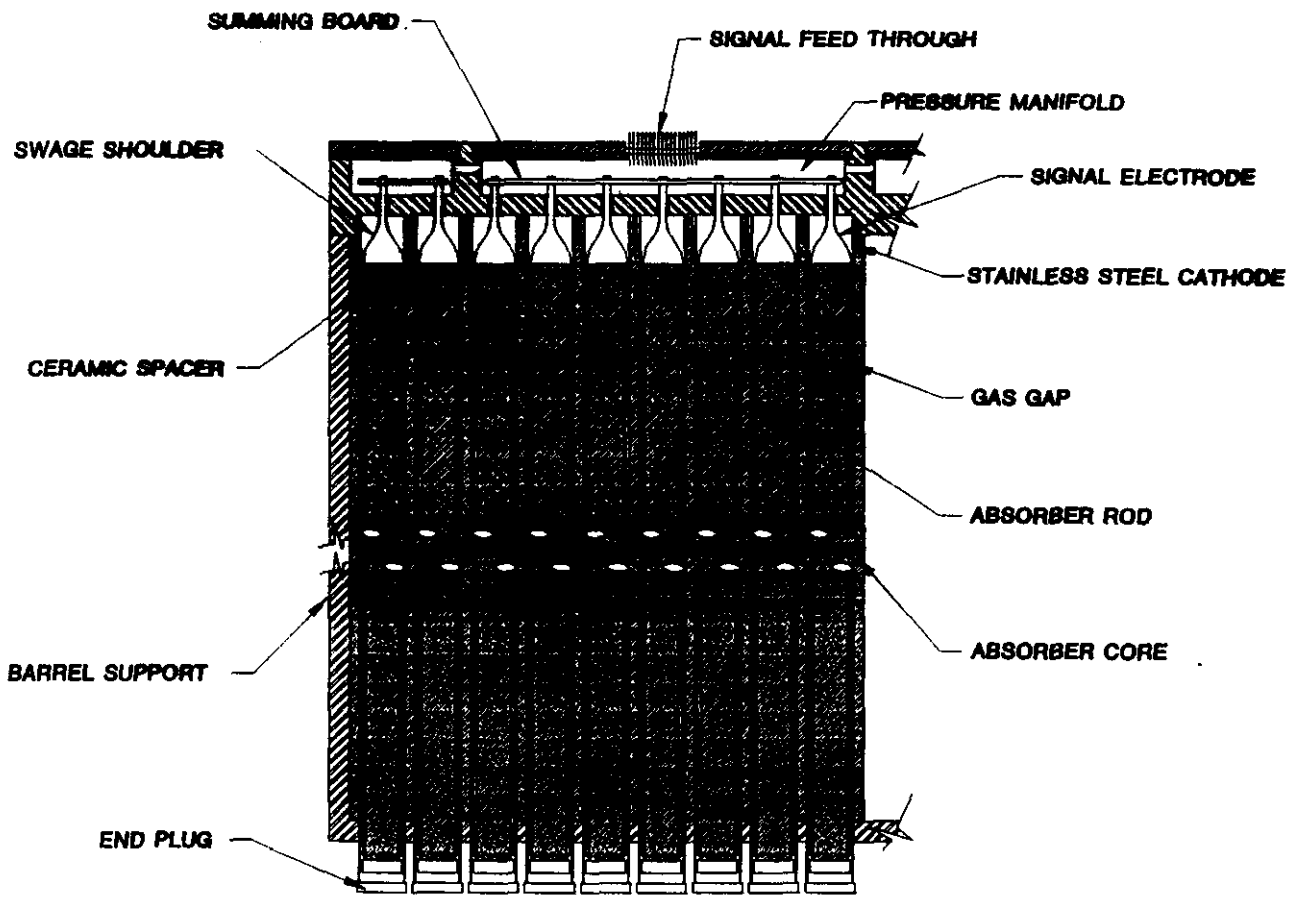
- SMALL DETECTOR ⇒ SMALL RAW MATERIAL COSTS AND CHANNEL COUNTS

- EXPECT RAD. HARDNESS OF LAr. CARE TAKEN WITH ANY OTHER MATERIALS NEAR BEAMPIPE.

- (+) ION MOBILITY MEASUREMENT CRITICAL FOR HIGHEST η

- R+D EFFORT COMBINABLE WITH OTHER FCAL AND LAr WORK.

D. Makowiecki



HIGH PRESSURE IONIZATION CHAMBER

(CROSS SECTION)

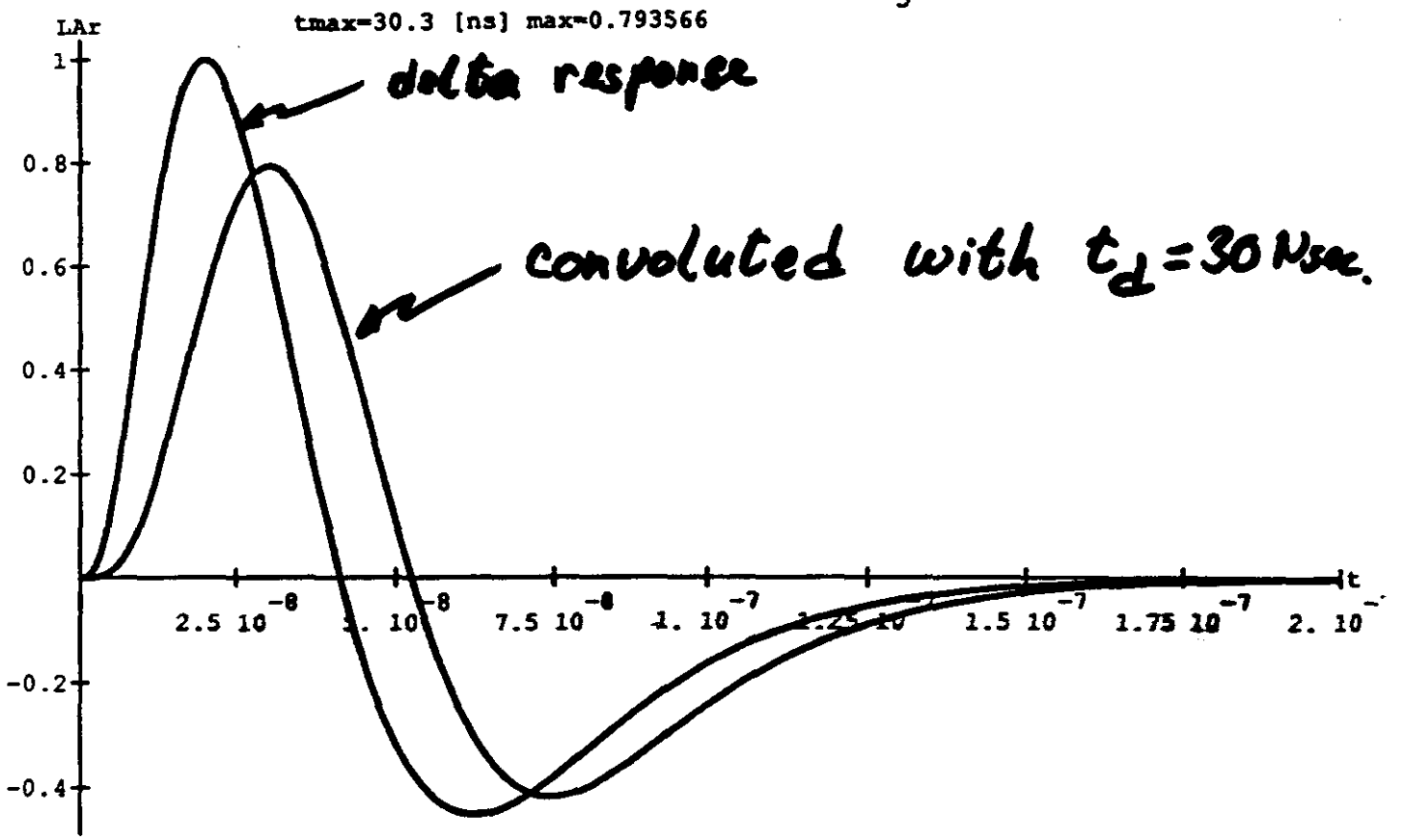
bnl

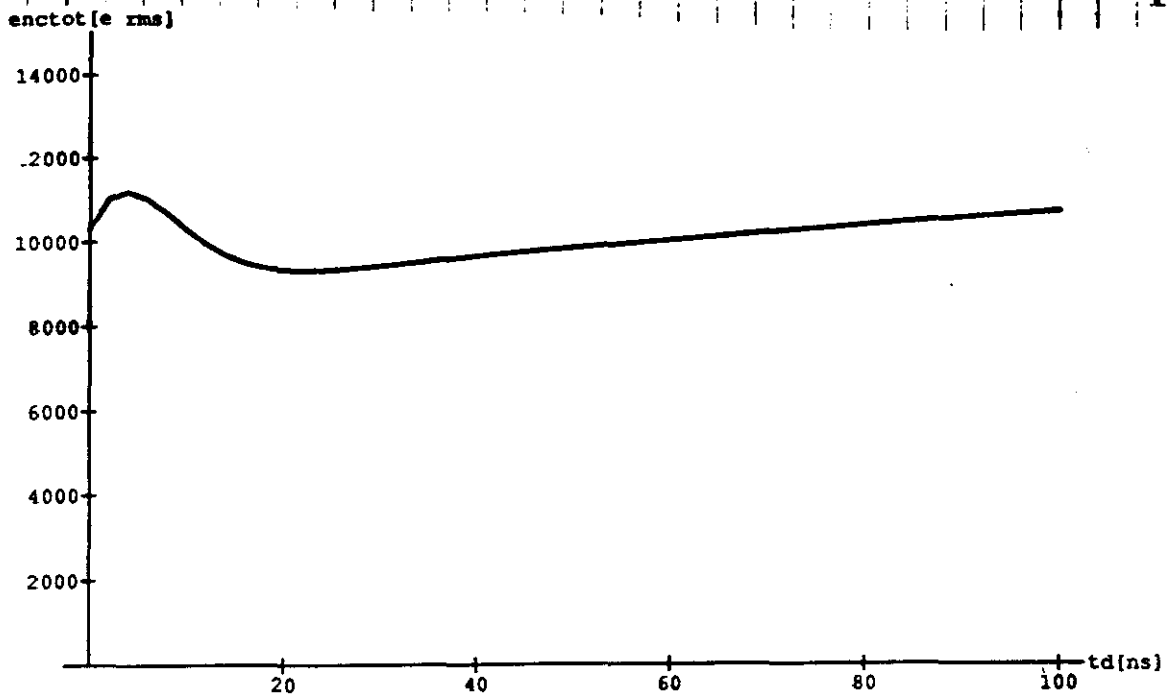
[redacted] response normalized to unity delta response

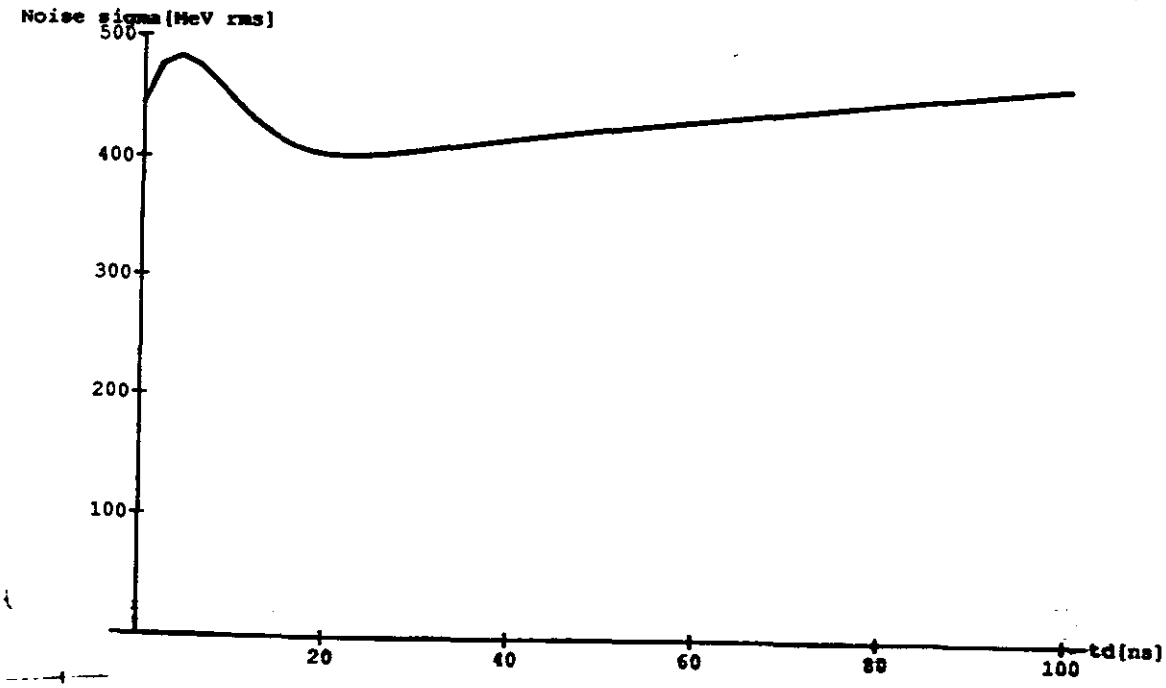
$$\{H[s]=, \frac{7.396\ 10^{-17}\ s^{2}}{(1. + 8.6\ 10^{-9}\ s)^{4}\ (1. + 2.\ 10^{-8}\ s)}\}$$

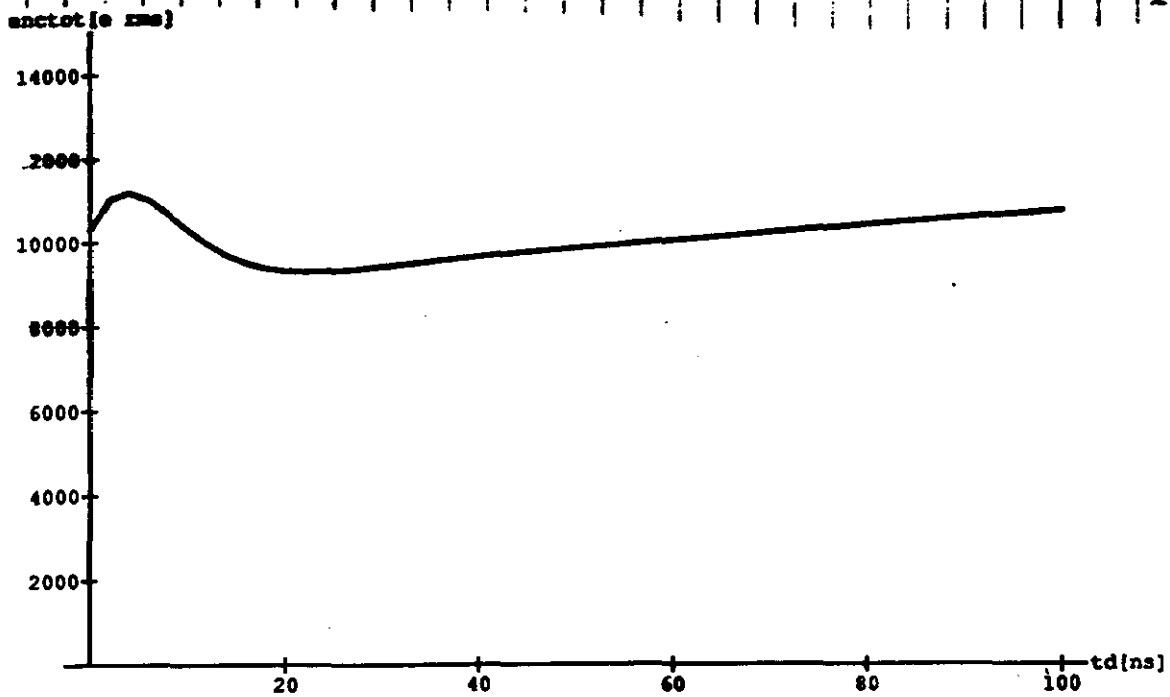
zo=50[ohm] Cd=400[pF] tauw=20[ns] taush=$\frac{43}{5}$[ns] td=30[ns]

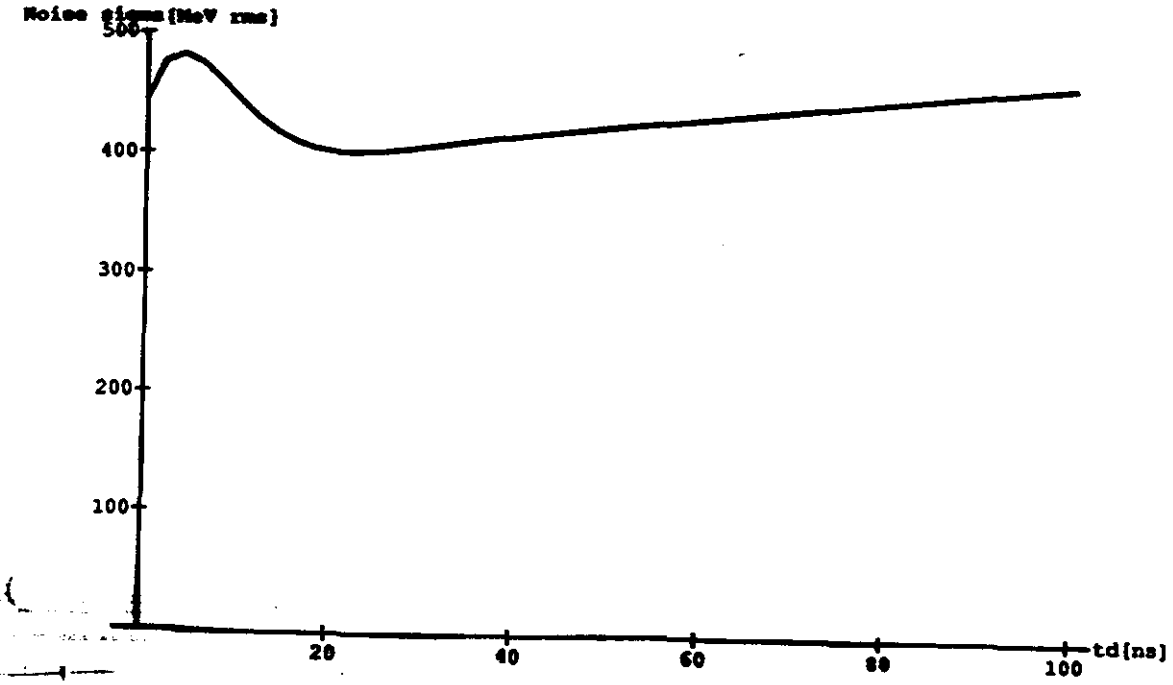
tmax=30.3 [ns] max=0.793566




enctot[e rms]
14000
12000
10000
8000
6000
4000
2000
20
40
60
80
100
td[ns]


Noise sigma[MeV rms]
500
400
300
200
100
20
40
60
80
100
td[ns]


anctot[e rms]
14000
12000
10000
8000
6000
4000
2000
20
40
60
80
100
td[ns]


Noise sigma[MeV rms]
500
400
300
200
100
20
40
60
80
100
td[ns]

Frank Dwige 10/2/91

STATUS OF SIMULATIONS FOR THE LOI

Simulations effort is behind schedule. We need

- Who is doing what?
- Who is too burdened to fulfill assigned tasks.
- Regular communication between people doing calculations and those "in charge" of it.

Final calculations, with write-ups, needed by $\sim$ October 25; first LOI draft by November 4!

Subsystem Parameters:

Too little input from subsystem leaders – especially:

- *Central Tracker:*

  Specifications received are skimpy!

  Discussion of central tracker appears *nowhere* in simulations done so far.

  → Use in answer the PAC's questions 1 – 4 (Higgs, top, $\not{E}_T$, jets)?

  → Will the tracker work at $\mathcal{L} \simeq 10^{34}$ to distinguish $e^{\pm}$ from γ?

- *Trigger:*

  Question 1 (Higgs) specifically asks us to discuss triggering startegies. What are they?

- *Magnet / Muon System:*

Do simulators know *all* the options they should be considering?

- *Calorimetry:*

  Careful $H^0 \rightarrow \gamma\gamma$ background study for LAr urgently needed.

  What do we do about F/B calorimetry ($3 < \eta < 5$)?

PAC Questions:

We need people to be *responsible* for each of the PAC questions, to direct / oversee the work and to guarantee delivery by $\sim$ October 25.

- *Higgs Physics* – Bing Zhou

$\rightarrow$ Complete the analysis of $H^0 \rightarrow \gamma\gamma$ background, especially the QCD background for BaF_2 and LAr.

$\rightarrow$ Are we doing $t\bar{t}H^0 \rightarrow$ isolated leptons + jets + $\gamma\gamma$?

$\rightarrow$ Redo analysis of $H^0 \rightarrow Z^0 Z^0 \rightarrow \ell_1^+\ell_1^-\ell_2^+\ell_2^-$, $\ell^+\ell^-\nu\bar{\nu}$, $\ell^+\ell^- jj$. F/B calorimetry? Calorimetry for $H^0 \rightarrow \ell^+\ell^- jj$?

- *Top Physics* – Serban Protopopescu

  → Calculations so far are primitive. Should reuse programs from before.

  → Need $t \to H^+ b$ analysis.

  → Need more help here.

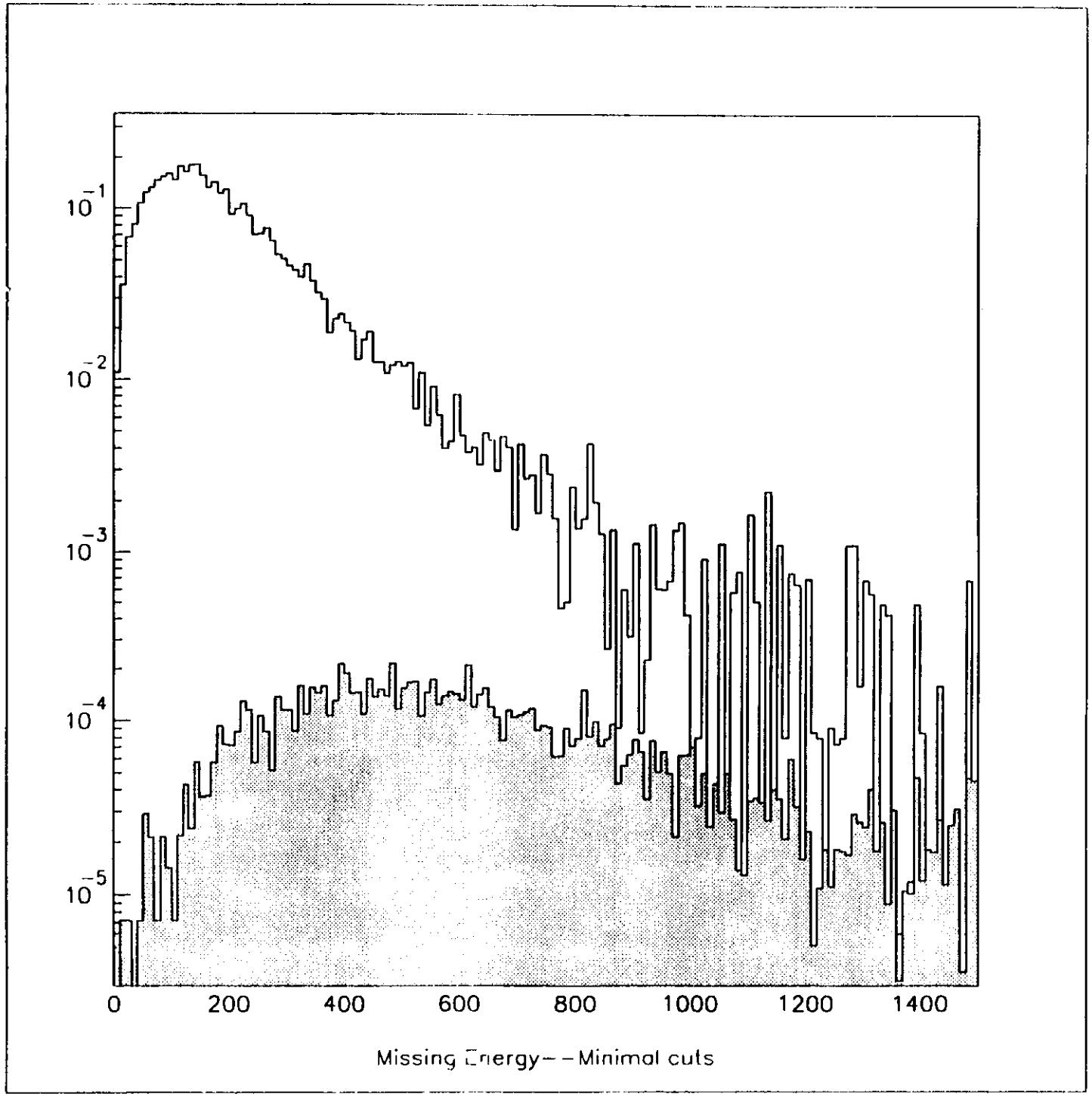
- *$\not{E}_T$ Physics* – Frank Paige

  → 300 GeV Gluino – Physics backgrounds started. Need detector backgrounds for $\eta_{\max} = 3, 4, 5$. Need same-sign dilepton ($\ell_1^\pm \ell_2^\pm + X$) signals and backgrounds. (Steve Kahn)

  → 400 GeV $t' \to W^+ b$: Need to redo old analyses for GEM (Vanyashin).

- *Jet Energy Measurement* – Ray Frey

  → $Z^0 \to jj$ (from $H^0 \to Z^0 Z^0$, H. Ma) and $Z' \to jj$ (R. Frey)


10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
200
400
600
800
1000
1200
1400
Missing Energy--Minimal cuts

Analyses are still primitive. Need better calorimeter simulation.

- *Complementarity to SDC* – Ken Lane

→ *No* guidance on how we are complementary to SDC, nor even what SDC is! Assume:

→ Better EM calorimetry.

→ More precise, "robust" muon system – useable at $\mathcal{L} \simeq 10^{34}$.

Tentative list of processes where we should be better than SDC:

H^0 (and h_{susy}, π_T^0) → $\gamma\gamma$. (Zhu; Yamamoto)

$t\bar{t}H^0$ → isolated leptons + jets + $\gamma\gamma$. (Zhu, Yamamoto)

$H^0 \to ZZ^* \to \ell_1^+\ell_1^-\ell_2^+\ell_2^-$. (Zhou)

Heavy $H^0 \to Z^0Z^0 \to \mu^+\mu^-\mu^+\mu^-$, at 10^{34} if necessary. (Zhou)

Heavy $H^0 \to Z^0 Z^0 \to \ell^+\ell^- jj$ – relies on $|M_{\ell^+\ell^-} - M_Z| < 2$ GeV. (Zhou, Ma)

Tagging b (hence $t \to W^+ b$) by $\mu^\pm$ buried in b-decay jet $\to$ access to flavor physics, charged Higgses, technipions,...

$Z' \to e^+e^-$ precision mass and width at $\mathcal{L} = 10^{34}$ – does EMC, tracker work?? (Lane)

$Z' \to \mu^+\mu^-$ asymmetry at $\mathcal{L} = 10^{34}$ Possibly also $W'^\pm \to \mu^\pm \nu$. (Lane)

Similar studies of quark / lepton substructure in the Drell-Yan process. (Lane)

$\tilde{\mathcal{G}}\tilde{\mathcal{G}} \to \ell_1^\pm \ell_2^\pm + X$. (Paige)

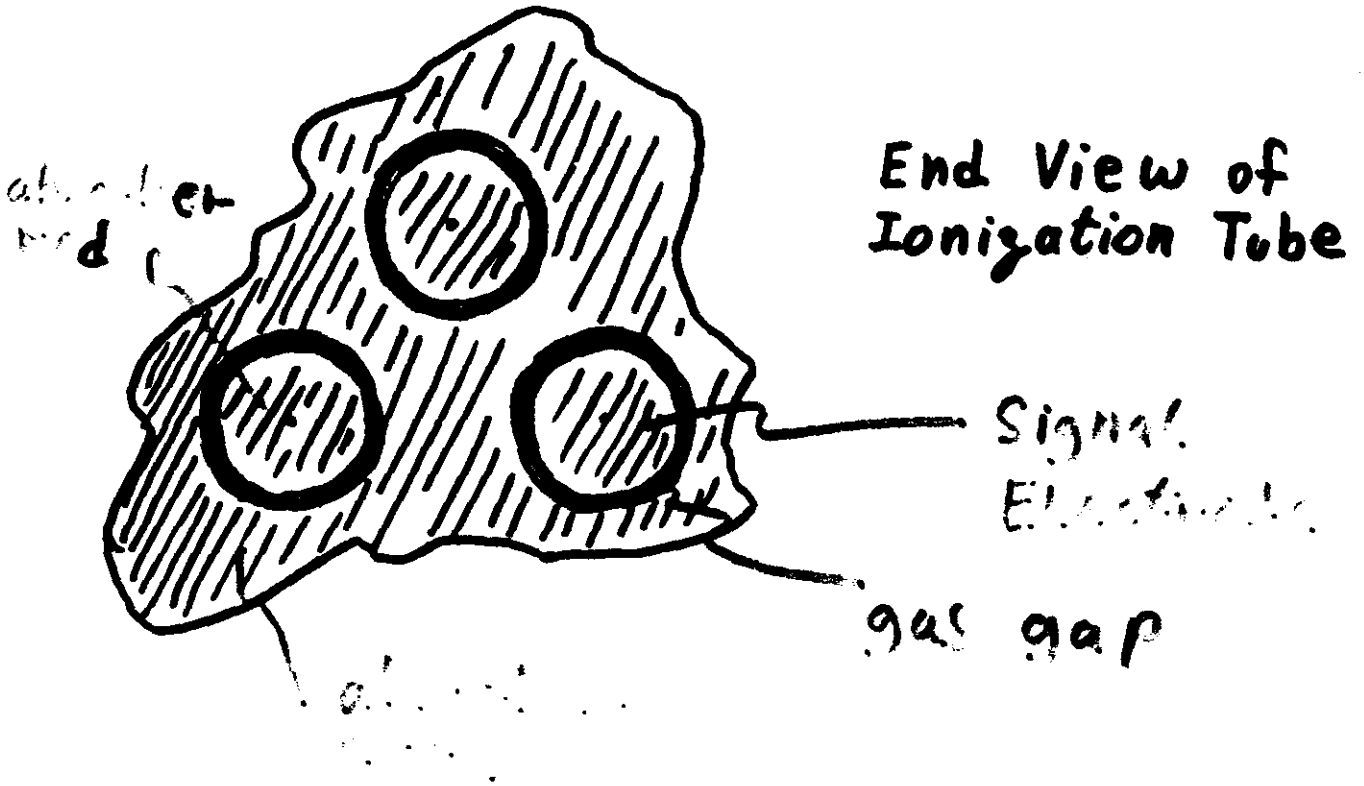
We wil also mention, but not calculate such processes as ρ_T production (leptons at 10^{34}).

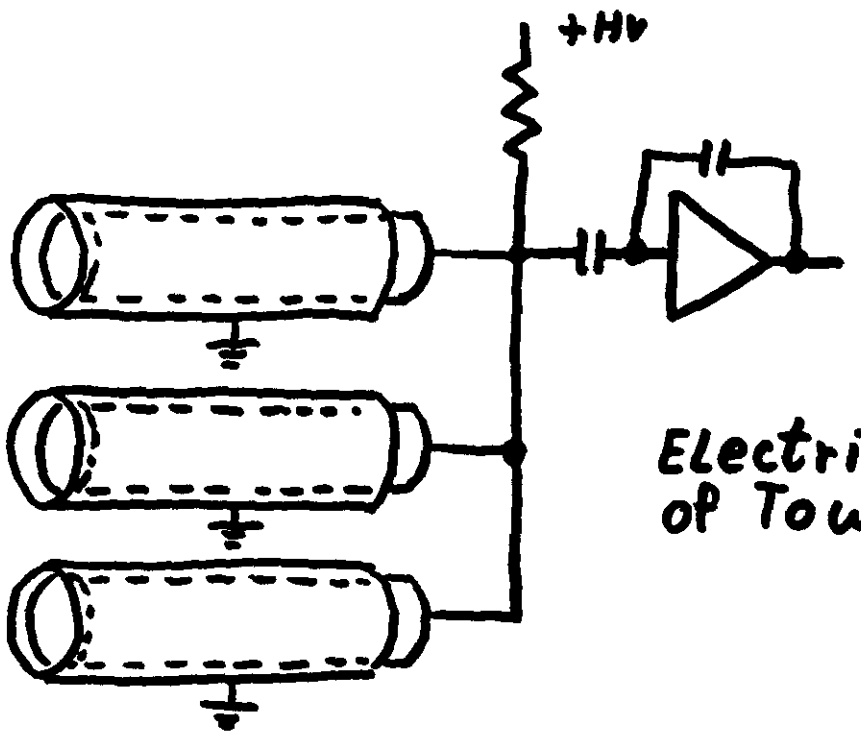
E. Kistenev
S. Rescia
D. Makowiecki

HIGH PRESSURE GASEOUS IONIZATION TUBES

ADVANTAGES:

- ABILITY TO HANDLE HIGH RATES
- DRIFT TIME FASTER THAN IN LIQUIDS
- SPACE CHARGE EFFECT REDUCED
- UNIFORMITY
- EASE OF CALIBRATION
- RADIATION HARD





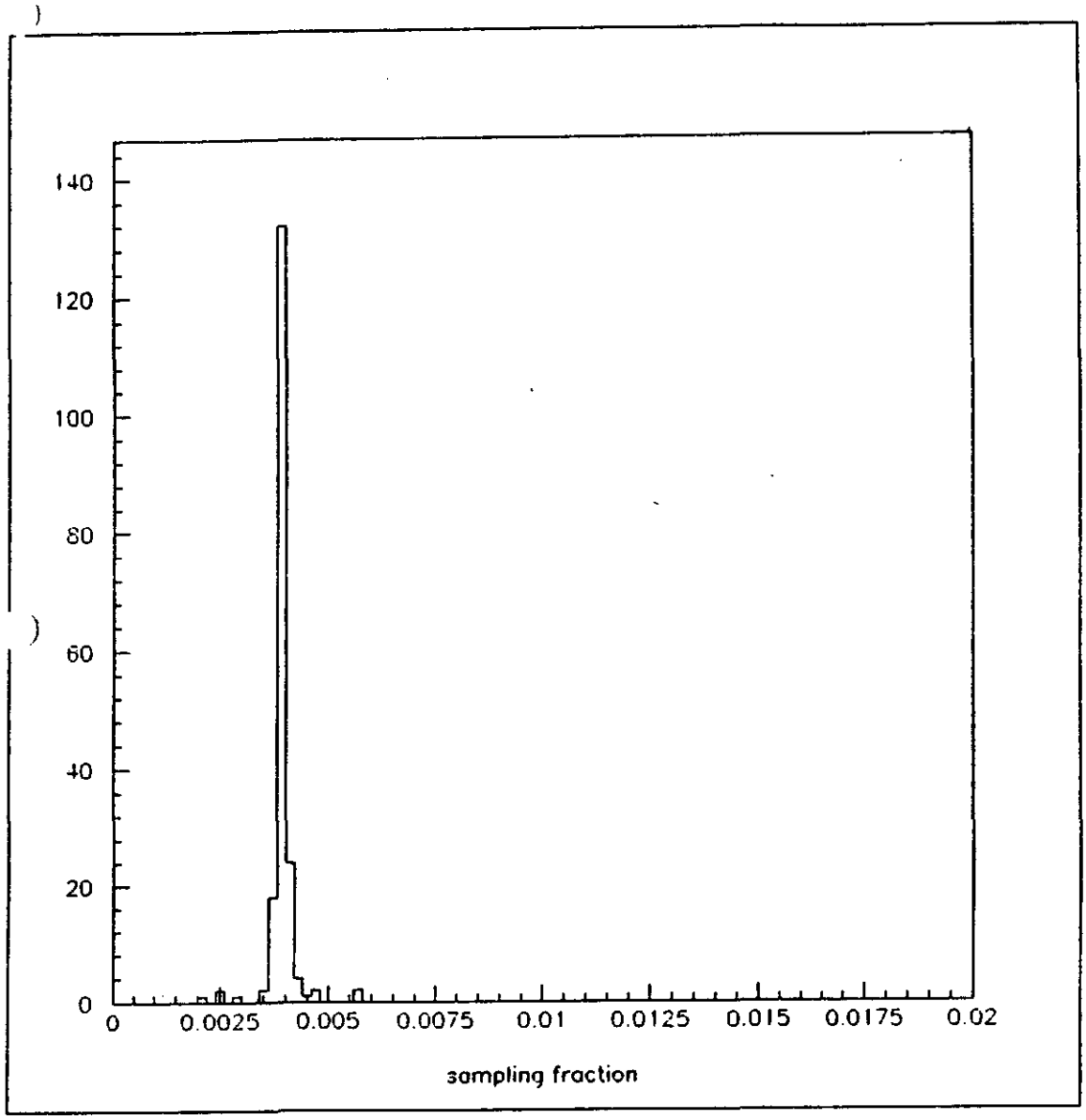
Electrical Schematic
of Towers

absorber core: Pb, W

absorber rod: Pb, W, DU

The sampling fraction for a tube calorimeter computed along the random path perpendicular to the tube axis is equal to _

• ext t. diam [mm]	10	10	20	20	10	10
• gap [mm]	1	2	1	2	1	2
• p [atm]	50					
• absorber	Pb	Pb	Pb	Pb	W	W
• sensitive Volume [%]	24	44	13	24	24	44
• sampl. frac. [%]	.39	.92	.18	.39	.25	.60


140
120
100
80
60
40
20
0
0
0.0025
0.005
0.0075
0.01
0.0125
0.015
0.0175
0.02
sampling fraction

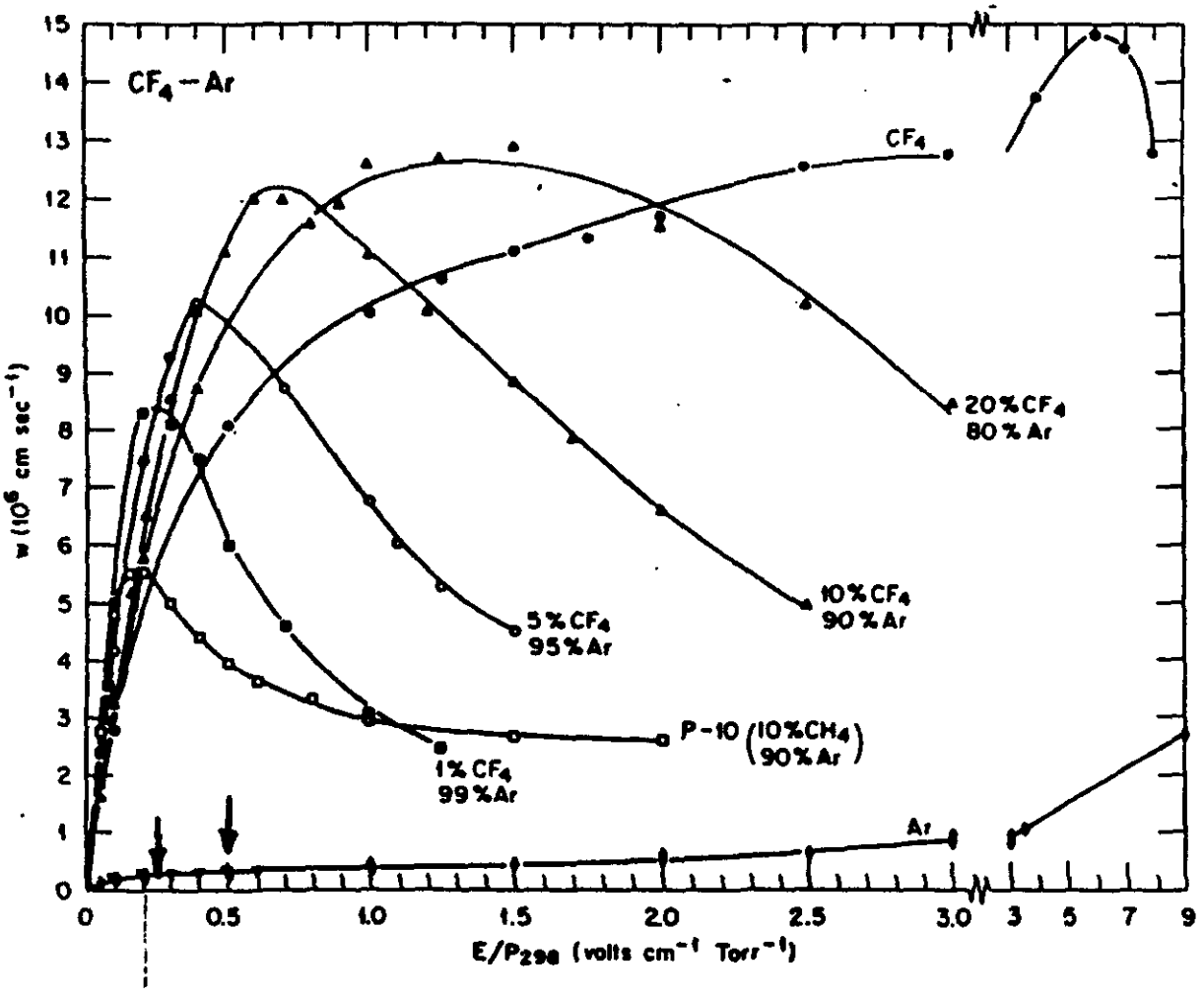
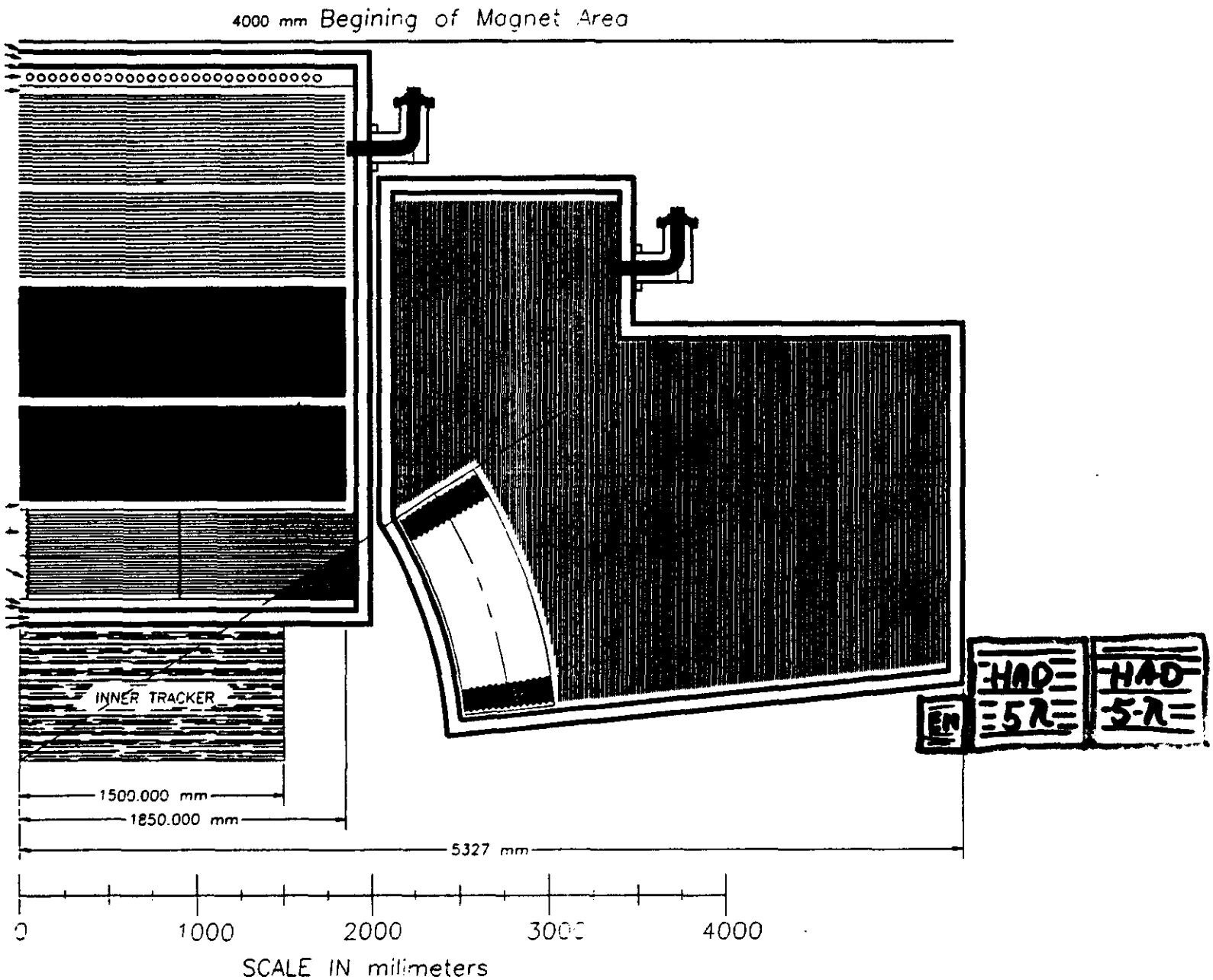


Fig. 125 Christophorou et al. (1979)

→ 19KV/cm @ 50 atm.

→ 9.5KV/cm @ 50 atm.


4000 mm Begining of Magnet Area
INNER TRACKER
1500.000 mm
1850.000 mm
5327 mm
EM
HAD
5λ
HAD
5λ
0
1000
2000
3000
4000
SCALE IN milimeters

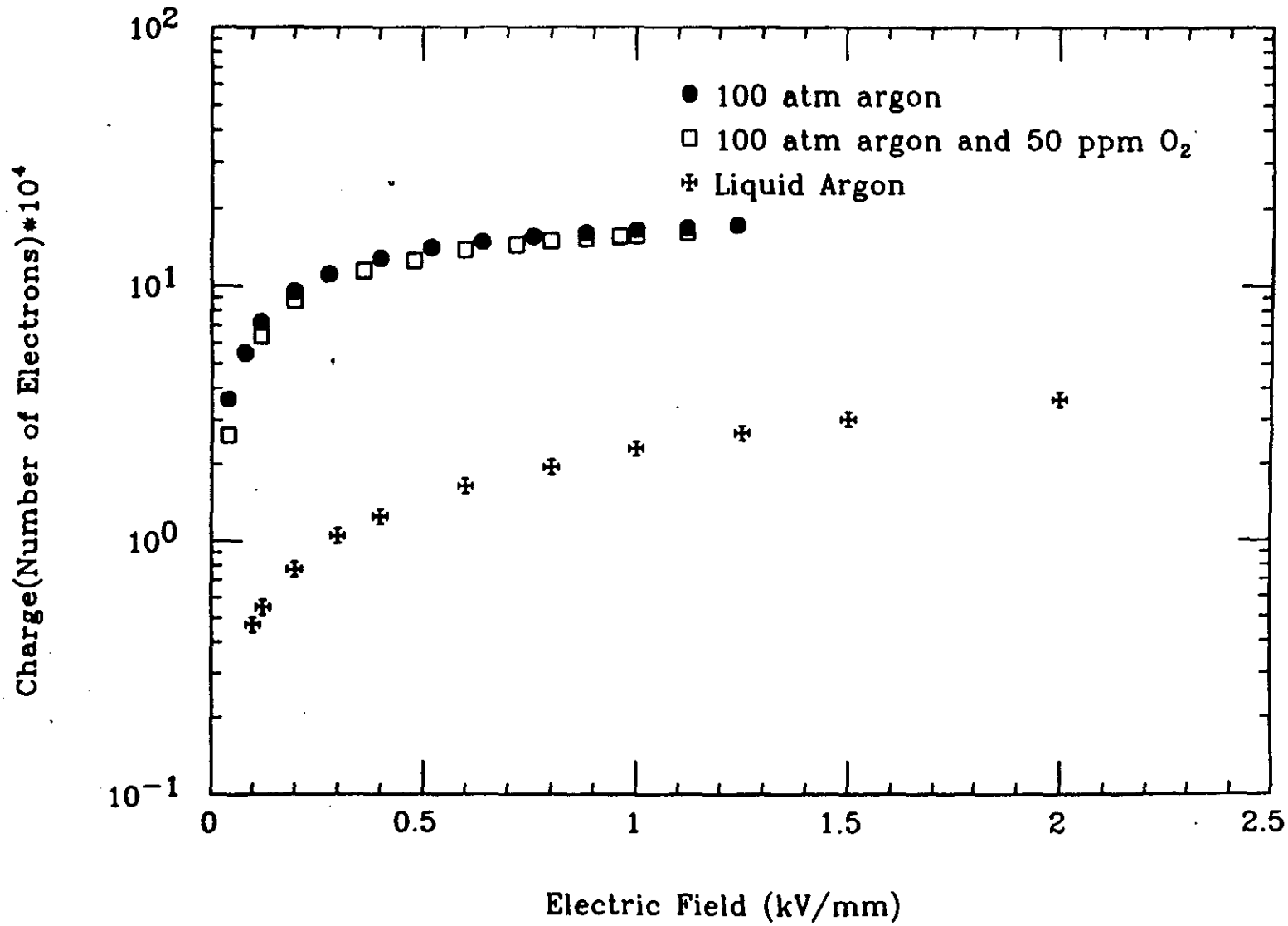

100 atm argon
100 atm argon and 50 ppm O_2
Liquid Argon
Charge(Number of Electrons)*10^4
10^2
10^1
10^0
10^{-1}
0
0.5
1
1.5
2
2.5
Electric Field (kV/mm)

Figure 2

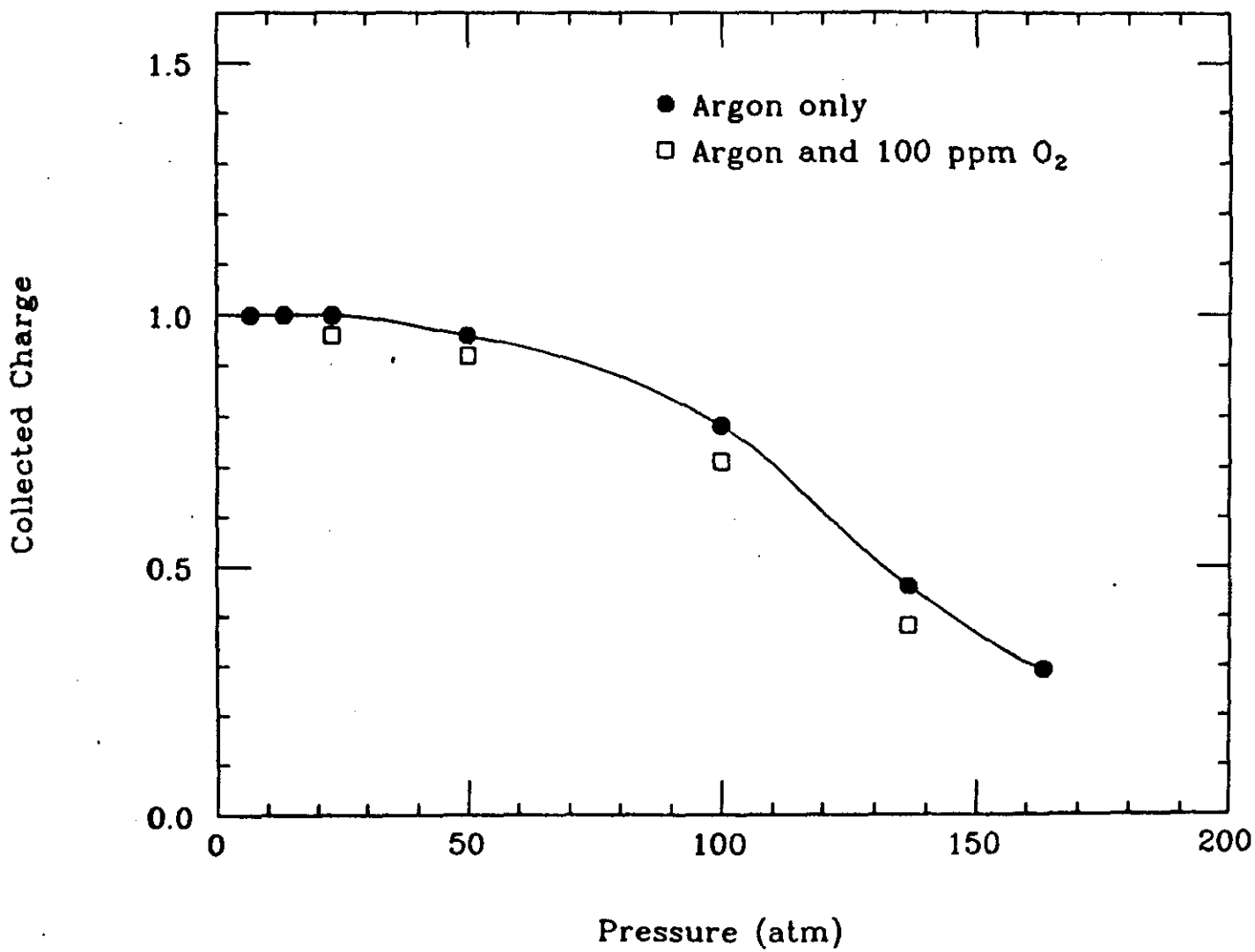
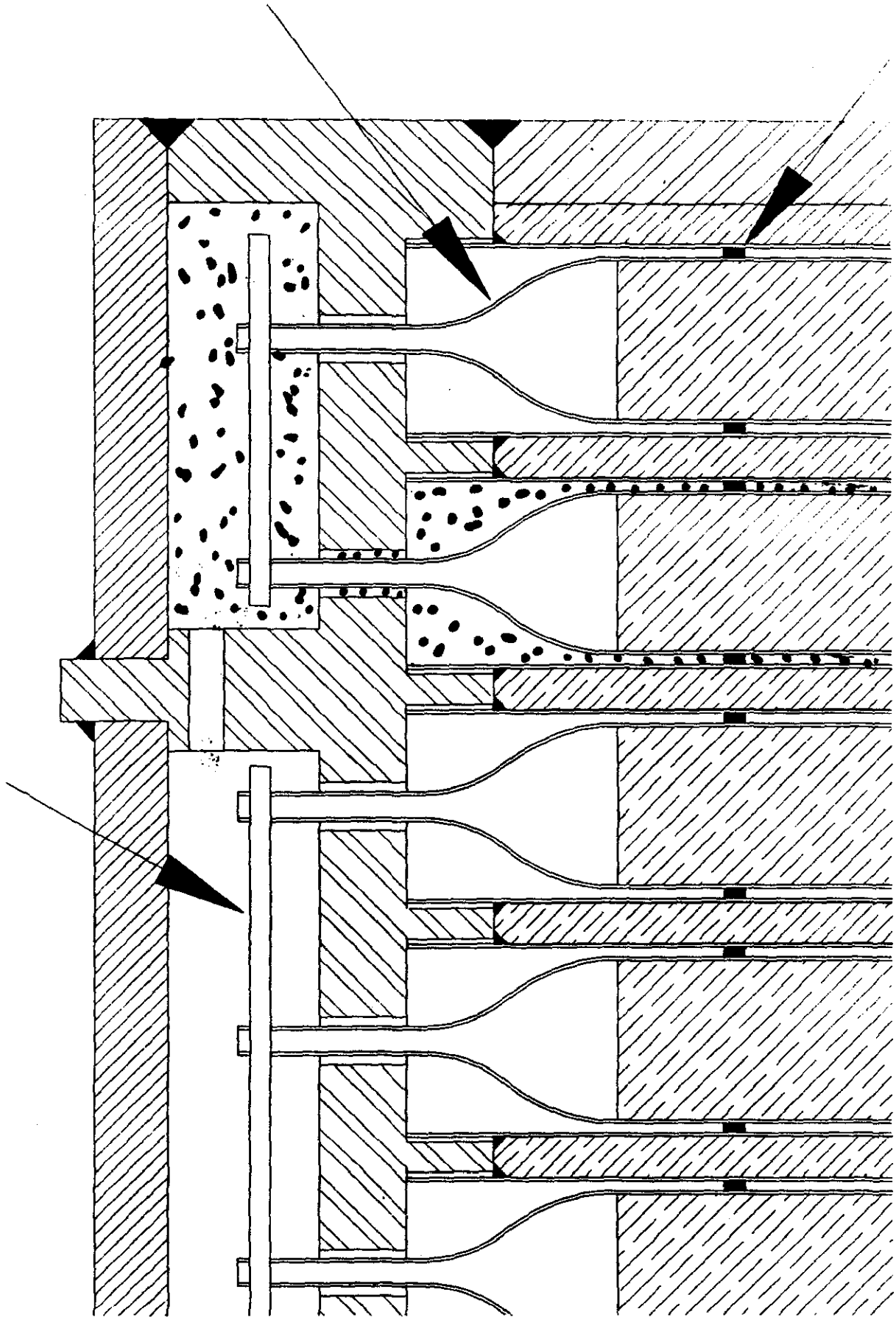
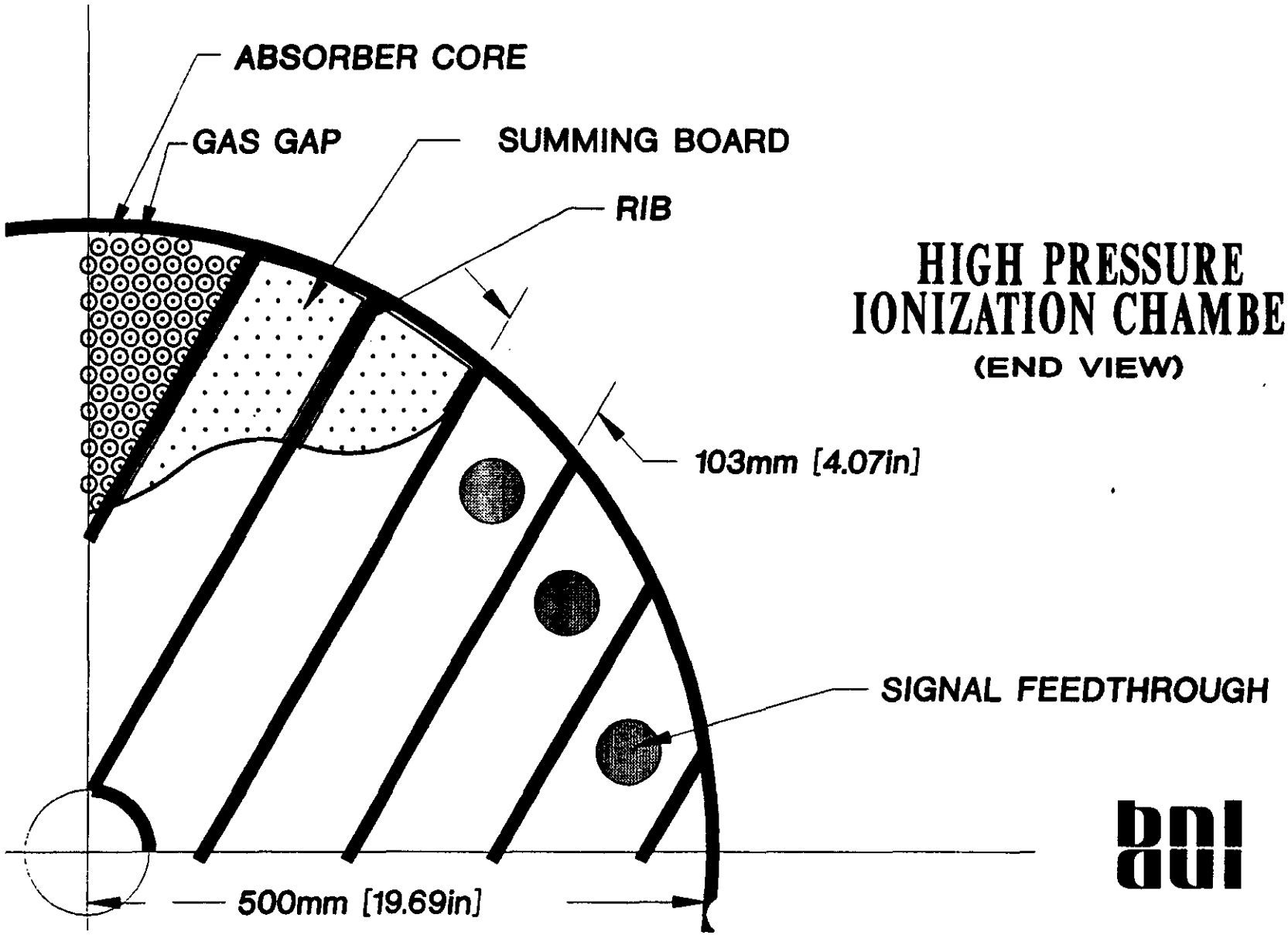

Argon only
Argon and 100 ppm O_2
Collected Charge
1.5
1.0
0.5
0.0
0
50
100
150
200
Pressure (atm)

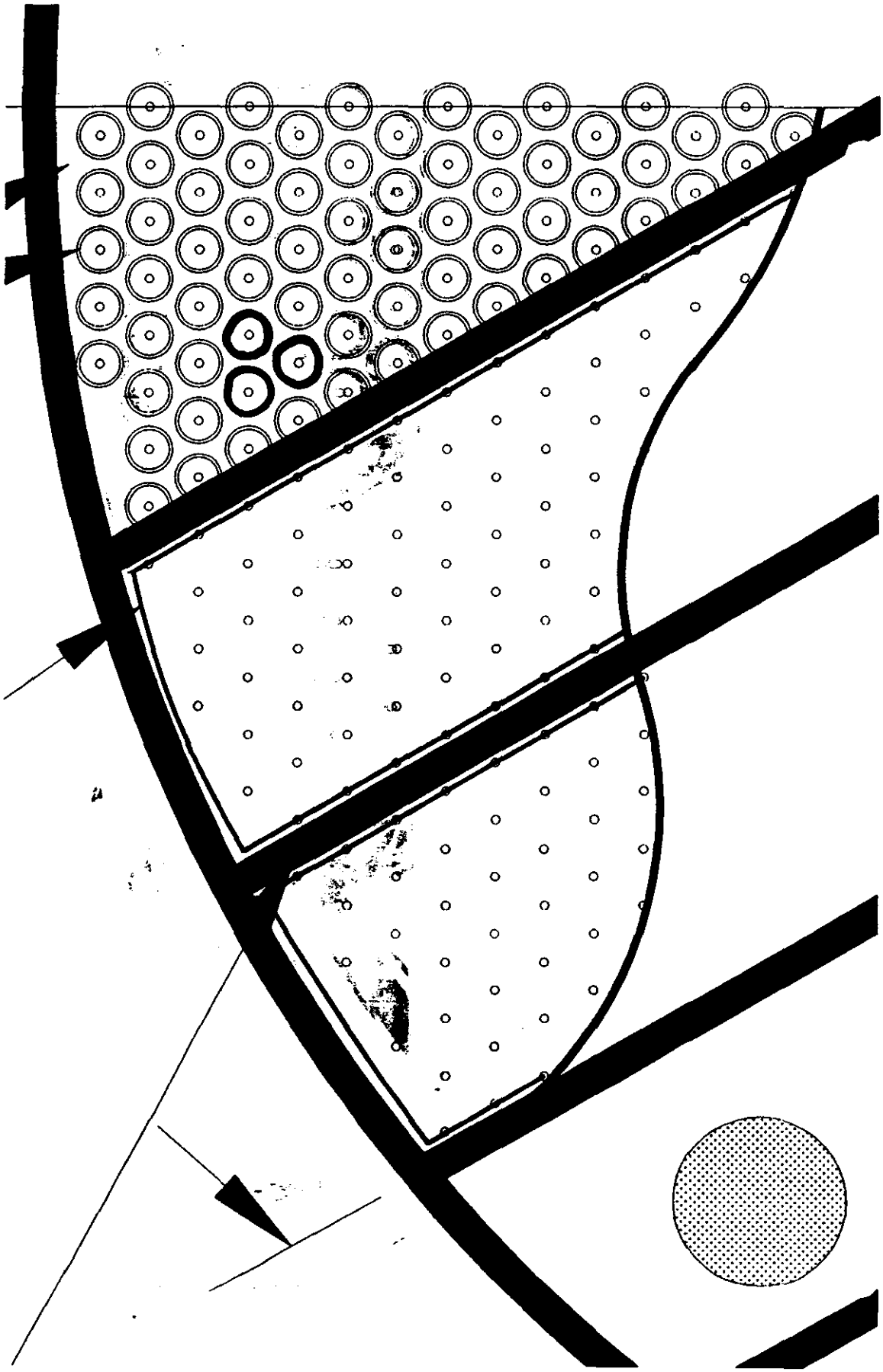
Figure 3

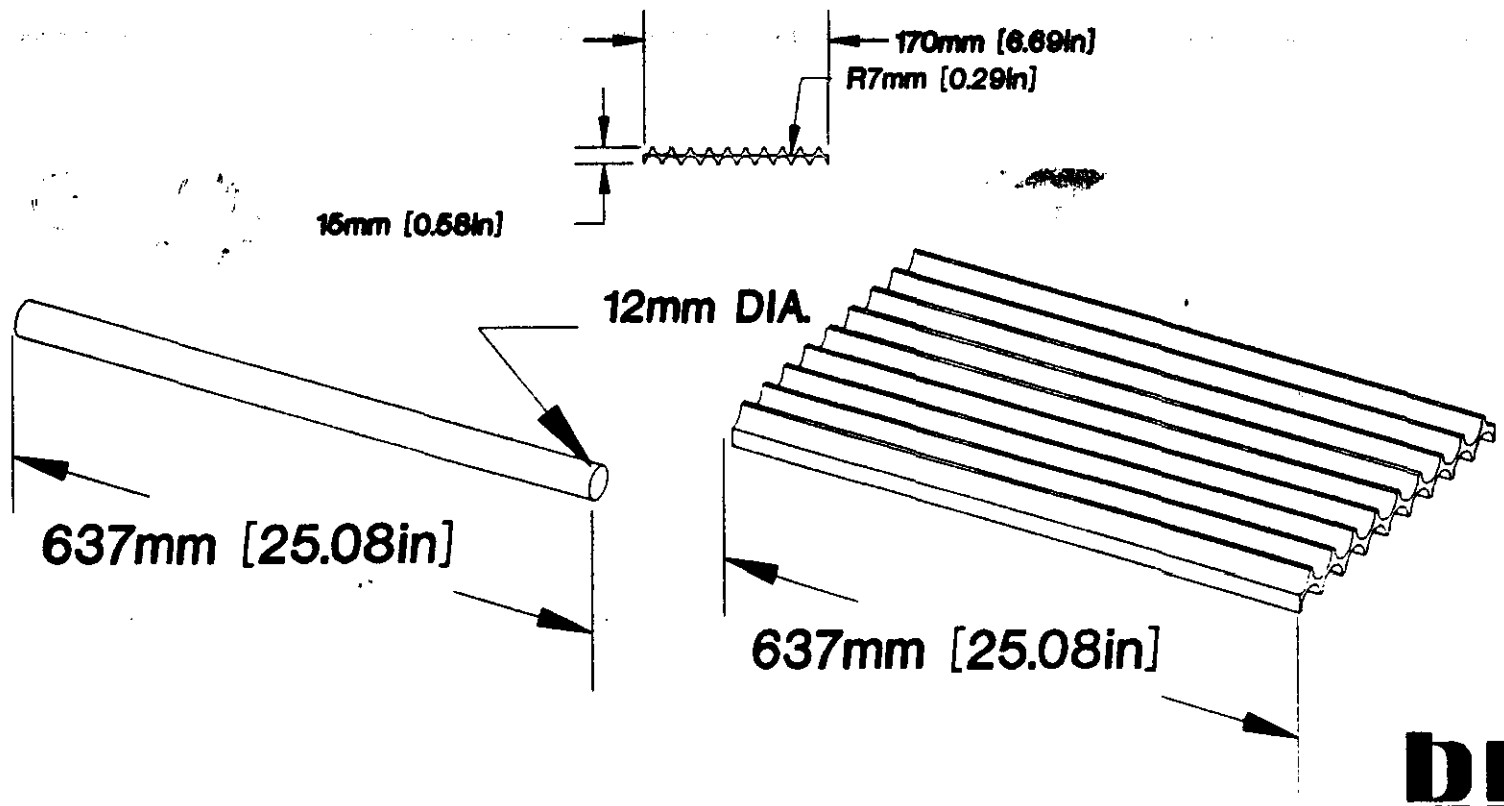




HIGH PRESSURE IONIZATION CHAMBER

(END VIEW)




170mm [6.69in]
R7mm [0.29in]
15mm [0.58in]
12mm DIA.
637mm [25.08in]
637mm [25.08in]

THE LOI

MEMBERS

I. INTRO & OVERVIEW

II. GEM DETECTOR

2.1 Hall & Surface facilities

2.2 Magnet

2.3 Muons

2.4 Calorimetry

2.5 Tracking

2.6 Trigger/DAQ

2.7 Computing

III. PHYSICS

IV. COST & SCHEDULE

V. COLLABORATION ORGANIZATION

VI. PLAN & R&D

PRODUCING THE LOI

M-SOFT WORD

DOUBLE COLUMN, 12-PT (10-PT??)

MOST FIGURES FIT IN 1 COLUMN
(50 PAGE LIMIT)

DRAFTS TO SSC IN

PLUS HARDCOPY { WORD
TEX (VANILLA FLAVOR)

AFTER TYPESETTING, SOME
EDITING, THEN → [GEMLIB]
(RTF, ASCII)

NEED A SINGLE POINT OF
CONTACT FOR EACH SECTION

ALL COMMENTS, CHANGES TO THIS
PERSON, WHO WILL FORWARD
COLLECTED & APPROVED EDITS
TO SSC VIA MARKED-UP FAX
OR CLEAR E-MAIL OR PHONE

DATES

NOV 4 – GOOD DRAFT TO SSC

NOV 11 – BACK TO CONTACT PEOPLE
FOR FINAL REVISIONS

NOV 18 – FINAL DRAFTS TO SSC

FRIDAY, NOV 22 – TO PRINTER

NOV 30 – TO PAC

NEED SOME DRAFTS EARLIER
TO GET STARTED.

EDITORS @ SSC: BARISH, MARX,
SANDERS, YOST
+ A TEAM OF PROOFREADERS

E-MAIL TEXT TO
SSCVX1::OURDEN

OTHER COMMUNICATIONS TO
SSCVX1::YOST
SSCVX1::SANDERS / SSCVX1::
MARX

10/2/91

SYSTEM INTEGRATION

- OPTIMIZE EXPERIMENT (NOT SUBSYSTEMS)
- IDENTIFY SUBSYSTEM INTERACTIONS
- ITERATE PHYSICAL/COST BOUNDARIES
- SUBSYSTEM SPECS + SERVICES
  Power, Cooling, Fluids, Alignment
  Safety, ...
- IDENTIFY FACILITY REQUIREMENTS
- INTERACTIONS WITH SSC
  - Beam Pipe, Quads, Schedule
- SYSTEM ACCESS REQUIREMENTS

→ TECHNICAL REPORT SYSTEM SPEC

→ CHANGE CONTROL

Key Issues Now:

1) Underground + Surface Facilities

2) Access Philosophy
   8-12 mo to service tracker?

   Trade Access ⟷ "Hermicity"
   Efficiency

   Cost vs Risk

3) Calorimeter Technology
   2 Independent Designs?
   Speify Baseline Volumes?

4) Forward Calorimeter/Field Shaping

C. DALTAY OCT. 1991

GEM R&D - Possible Sequence of Events

1. Sept 15 1991 due date for FY 1991 Progress Reports
   Due date for FY92 R&D proposals for large detectors delayed until R&D plans prepared.

2. The GEM Collaboration should submit a single coherent R&D proposal by the delayed due date
   a) GEM to make decisions narrowing down the technologies to be supported for each subsystem to a few by Oct 3,4
   b) PAC to (hopefully) bless the GEM decisions on Oct 3,4 meeting
   c) GEM Subsystems to generate plan for the engineering and R&D needed to support the technologies of choice
   d) GEM management to provide subsystems with guidelines for engineering and R&D funds available to each subsystem

e) Subsystems to write their section of the R&D Proposal

i) Motivation and importance of work
ii) Technical Description
iii) Timetable
iv) Budget
v) Institutions involved (approx)

Nov 4

f) GEM R&D Committee to assemble proposal and submit to the SSC Lab.

3. The SSC R&D Panel (Brig Williams etal) will review the proposal for technical correctness and hopefully recommend approval

4. Overlaps and possible collaboration with SDC on common R&D problems to be worked out

5. GEM Subsystems should generate a more detailed plan for the R&D

a) Institutions involved, with the scientists and engineers named, specifying fraction of time spent on this work

b) Detailed role and responsibility of each institution

c) Timetable for work at each institution

d) Budget at each institution, specifying support from all sources

- GEM R&D funds
- TNRLC funds
- Operating funds and manpower at that institution
- Other ?

6. Based on the above detailed plan, MOU's to be written between each institution, GEM, and the SSC Lab.

7. Members of the GEM Collaboration may wish to submit to the SSC Lab proposals to complete R&D work on technologies not selected to be supported by GEM. These proposals should be negotiated with the SSC Lab independently of the above frame work for GEM R&D. These proposals are still due Sept 15!

October 2, 1991

Engineering and R&D Plan

The Next Step

GEM Subsystems to generate Plan for Engineering and R&D needed to support the technologies of choice

1. This is for FY92 Funds - Oct 91 to Oct 92
2. Include Engineering and R&D for each subsystem
3. A few pages per subsystem
   a) A few paragraphs describing work, why necessary etc
   b) Funds needed in FY92
      - Available from other sources
      - Requested from GEM funds
4. Get Plan to R&D Committee by October 14, 1991

To: C. Baltay, Phys Dept. Yale Univ.
Fax (203) 432-6125

Subsystems to formulate FY92 Engineering and R&D Plan

1. System Integration — G. Sanders, M. Marx
2. Magnet — R. Stroynowski, A. Maschke
3. Calorimetry — J. Brau, R. Adair
4. Central Tracking — K. Morgan, J. Musser, K. Batta
5. DAQ & Trigger — D. Harlowe, H. Schalewitz
6. Computing — K. McFarlane, H. Newman, R. Zhu
7. Muon System — S. Ahlen, F. Taylor

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