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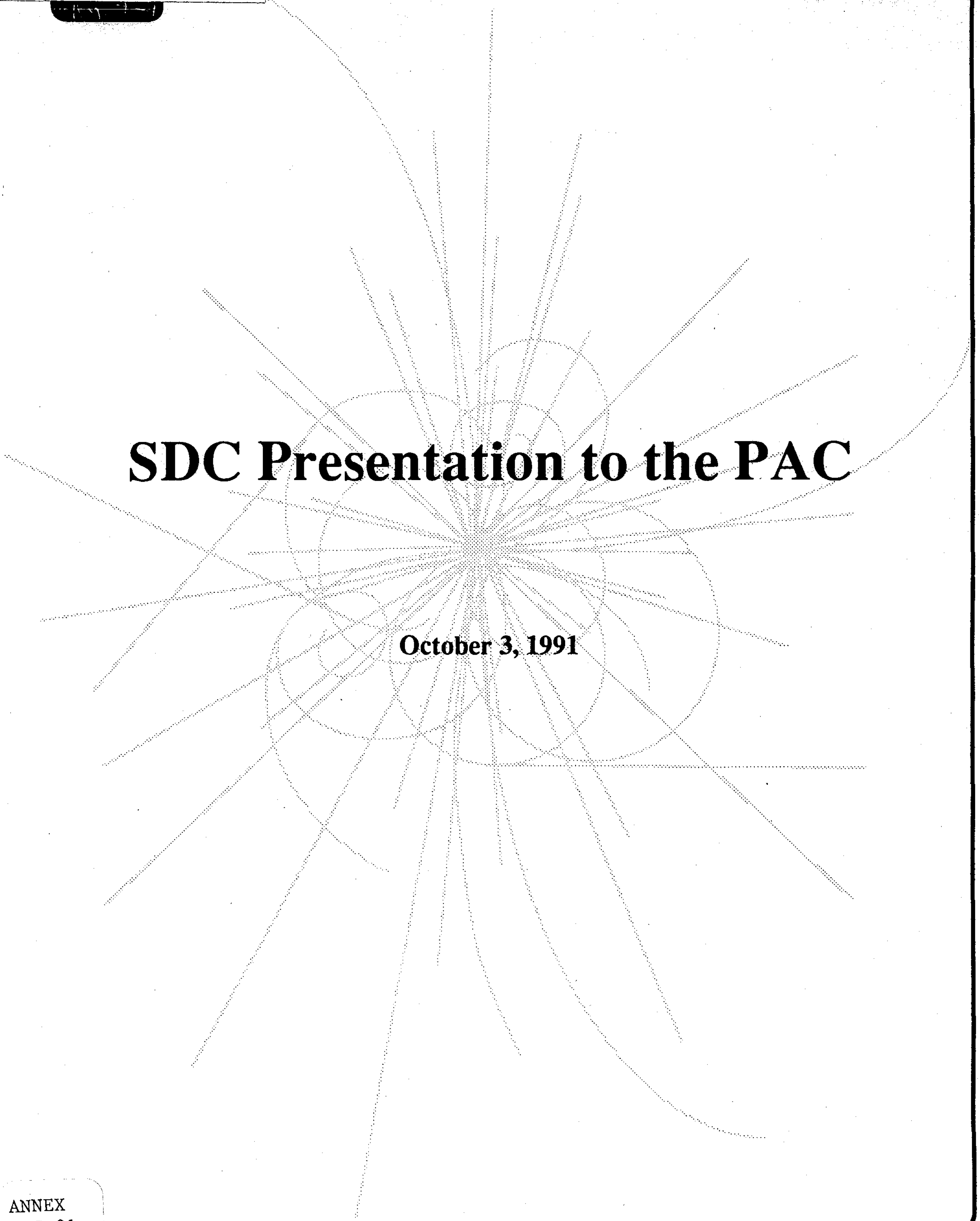
SDC-91-111

SDC Presentation to the PAC



October 3, 1991

ANNEX
ADC-91-
111

SDC PRESENTATION TO PAC
October 3, 1991

General remarks on SDC status including non-US participation. Calorimetry and tracking volume decisions.	G. Trilling
Scope and cost estimate of detector.	M. Gilchriese
Subsystem status and R&D (including test-beam program).	
Calorimetry,	D. Green
Tracking,	A. Seiden
Muon Systems,	J. Bensinger
Electronics.	A. Lankford
Installation studies.	D. Bintinger
Preparation for Technical Proposal and summary.	M. Gilchriese

George Trilling

PAC Meeting
October 3-4, 1991

COLLABORATION INSTITUTIONAL MEMBERSHIP

U.S.A.	49 institutions including 6 national labs
Canada	6 institutions including 1 national lab
China	2 institutions
Japan	17 institutions including 1 national lab
Western Europe	7 institutions including 2 national labs
U.S.S.R.	7 institutions including 1 international lab
Eastern Europe	4 institutions
Israel	1 institution

NEW COLLABORATION APPLICANTS

LAFEX (Lab de Fisica Exp. de Altas Energias)
Rio de Janeiro, Brazil

INSTITUTE OF NUCLEAR PHYSICS
Krakow, Poland

UNIVERSITE DE MONTREAL
Montreal, Canada

UNIVERSITY OF OKLAHOMA
Norman, Oklahoma

NON-US CONTRIBUTIONS TO SDC
Recent Developments

Brazilian group from Rio de Janeiro has applied to join SDC.

Italian collaborators made presentation to INFN Board for Accelerator Experiments. Accepted as PSDC (Proposal for SDC), financed for R&D efforts related to SDC proposal. Full INFN commitment to be discussed in about a year. SDC meeting in Pisa January 8 - 11, 1991.

Canadian Federal Government has offered support for KAON at the level of $240M. Impact on Canadian support for SDC unclear.

The IZHORA steel plant in St. Petersburg has been officially requested by JINR (Dubna) to provide a dollar cost estimate for fabrication of the barrel muon toroids.

IHEP (Serpukhov) physicists are participating in SDC meetings, and are expected to provide parts of muon system. Production work may require US dollar infusion.

SDC DETECTOR SUMMARY

SOLENOID MAGNET
Tracking Volume: 3.4 m diameter by 8m long

CENTRAL TRACKING AND HIGH RESOLUTION VERTEX DETECTION (COVERING $|\eta| < 2.5$)
Inner Silicon Strip and Pixel Systems
Outer Gas/Wire or Scintillating-Fiber System
Gas/Microstrip for Intermediate-Angle Region

PRECISION HERMETIC CALORIMETRY(COVERING $|\eta| < 3$)
Scintillating Tile with Fiber Readout with Lead/Iron Absorber
High Spatial Resolution EM Shower Max Scintillation Detector

FORWARD CALORIMETRY(COVERING $3 < |\eta| < 5$)

MUON SYSTEM WITH IRON MAGNETIC TOROIDS (covering $|\eta| < 2.5$)
Tracking Chambers, Scintillation and Cerenkov Counters

ID & PRECISION ENERGY MEASUREMENT OF ELECTRONS/MUONS
Electrons: Central Tracking Plus Calorimetry
Muons : Central Tracking Plus Muon System

TRACKING VOLUME COMPARISON

COMPARE THE TWO TRACKING VOLUMES:

$R \times L/2 = 1.7 \times 4.0\ m^2$ vs. $1.5 \times 3.0\ m^2$

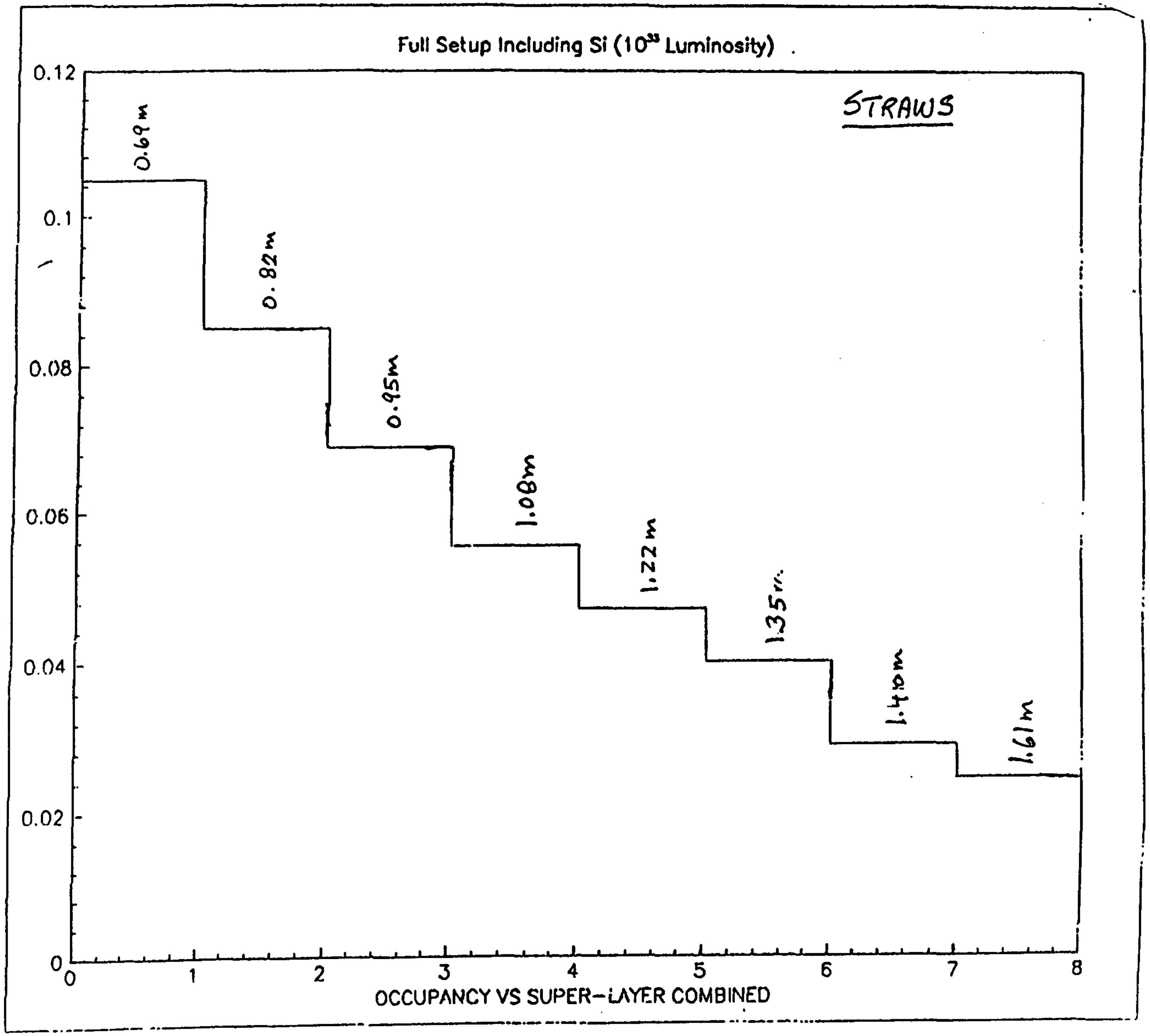
ISSUES:

Tracker occupancy
Momentum resolution
Impact on solenoid development
Impact on radiation doses
Cost consequences
General considerations

COST IMPACT OF LARGER VOLUME

Outer tracker (straws)	4M
Solenoid	8M
Central calorimeter	4M
Muon system	5M
TOTAL	21M

OCCUPANCY OF STRAW TUBES AT 10^{33}



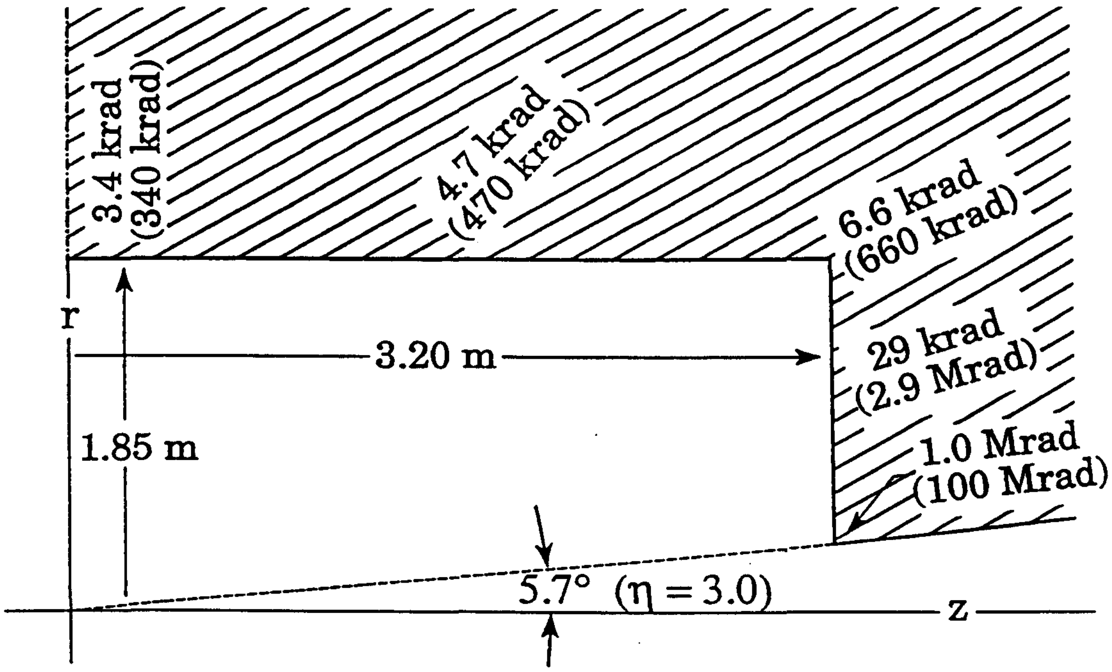
IMPACT ON RADIATION DOSES

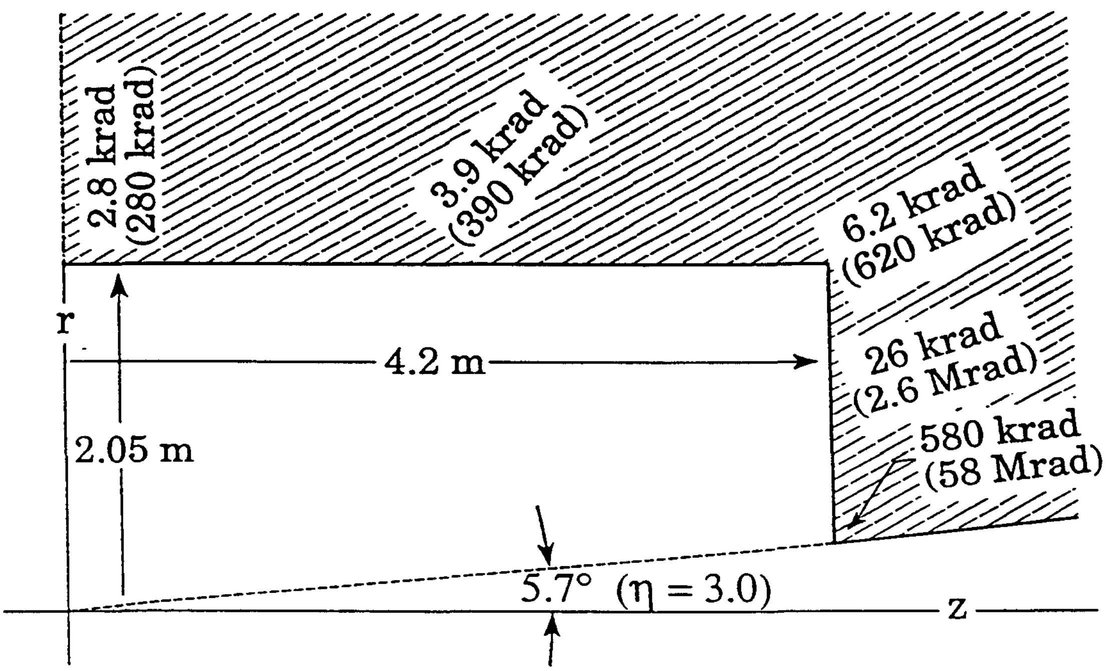
Increase in dose at EM shower max for smaller volume.

Increase in neutron fluence:

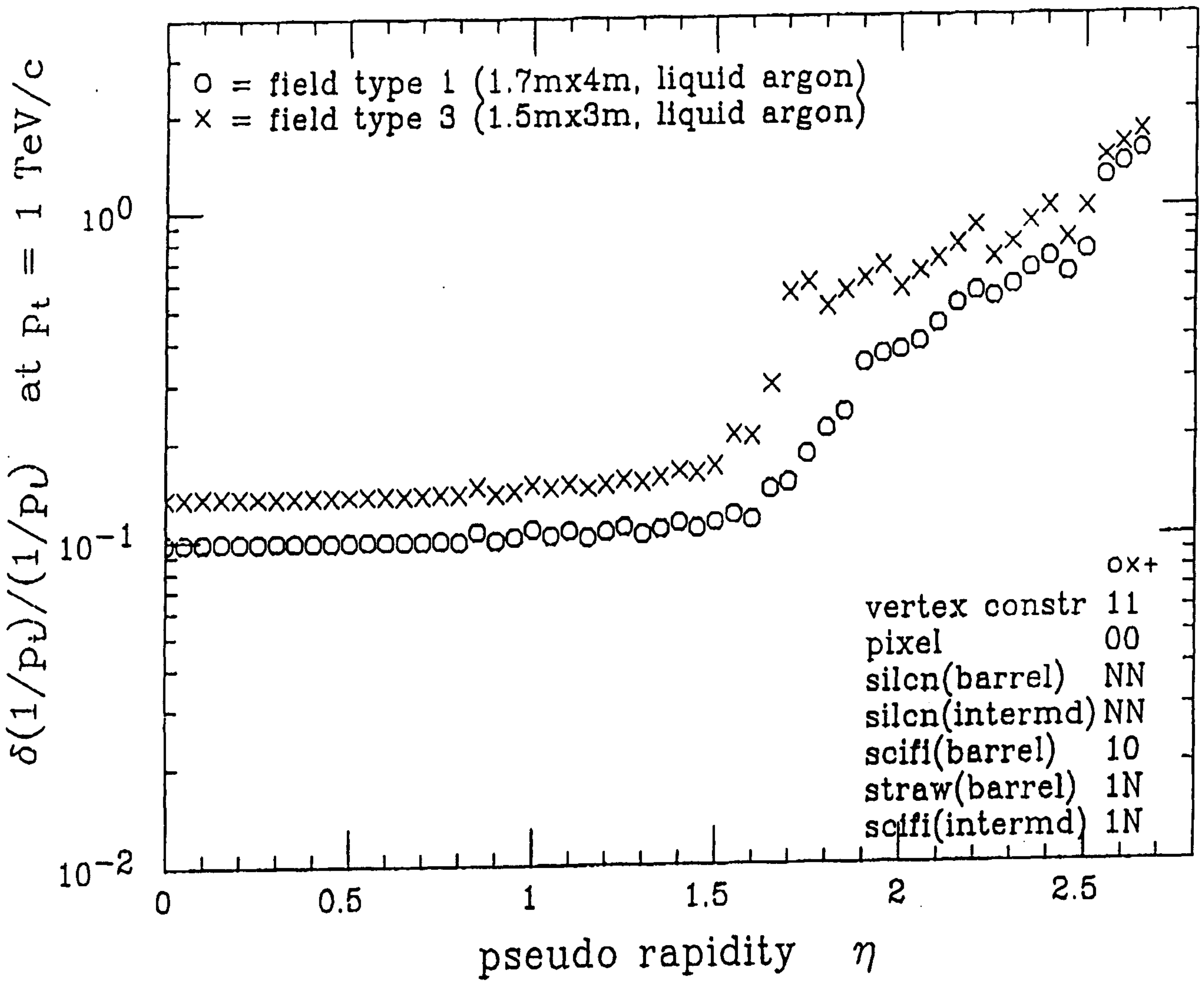
z position (m)	fluence (n / m^2 / SSC year) Vol = 1.7 x 4	Vol = 1.5 x 3
0	3.6×10^{11}	5.4×10^{11}
1.0	3.8×10^{11}	6.1×10^{11}
2.5	6.0×10^{11}	1.8×10^{12}

DOSES AT EM SHOWER MAX
1 year at design luminosity
100 years at design luminosity (parentheses)





1.7mx4m vs 1.5mx3m



IMPACT ON SOLENOID DEVELOPMENT

Conductor has been optimized for a 1.7 x 4 m^2 coil.

Engineering calculations have been done at KEK/FNAL/Toshiba for the present dimensions. Several months of lost effort if they have to be redone for new dimensions. There would be delay in development of prototype.

SOME GENERAL ARGUMENTS
(against changing tracking volume)

Tracking volume change, once implemented, is irreversible.

It is not clear that any straw layers can be at $R < 1$ m.
70 cm of radial space is more comfortable for pattern recognition 50 cm.

There is considerable momentum in magnet development. It would be unfortunate to slow it down.

If silicon remains the same, the geometry of the intermediate tracker becomes more awkward in the smaller volume.

SDC DECISION ON TRACKING VOLUME

Retain tracking volume radius at its present baseline value of 1.7 m.

The tracking volume length is to be specified in the range 3.5 - 4.0 m, after further study of where the optimum lies. It will be specified by the November collaboration meeting.

SDC CENTRAL CALORIMETRY
History

May 1990 (EoI)	4 technological options	
November 1990 (LoI)	2 options	a) Pb/La b) Scint. tile with WLS fiber (Pb/Fe for hadronic absorb.)
August 1991	Extensive review Requirements document LA Conceptual Design Report	
September 1991	Scint. tile Conceptual Design Report	
Sept. 12-14, 1991	Technical Board Meeting Calorimeter presentations and discussion Impact on other systems, costs, integration Technical Board recommendations	
Sept. 26, 1991	Report to Collaboration	

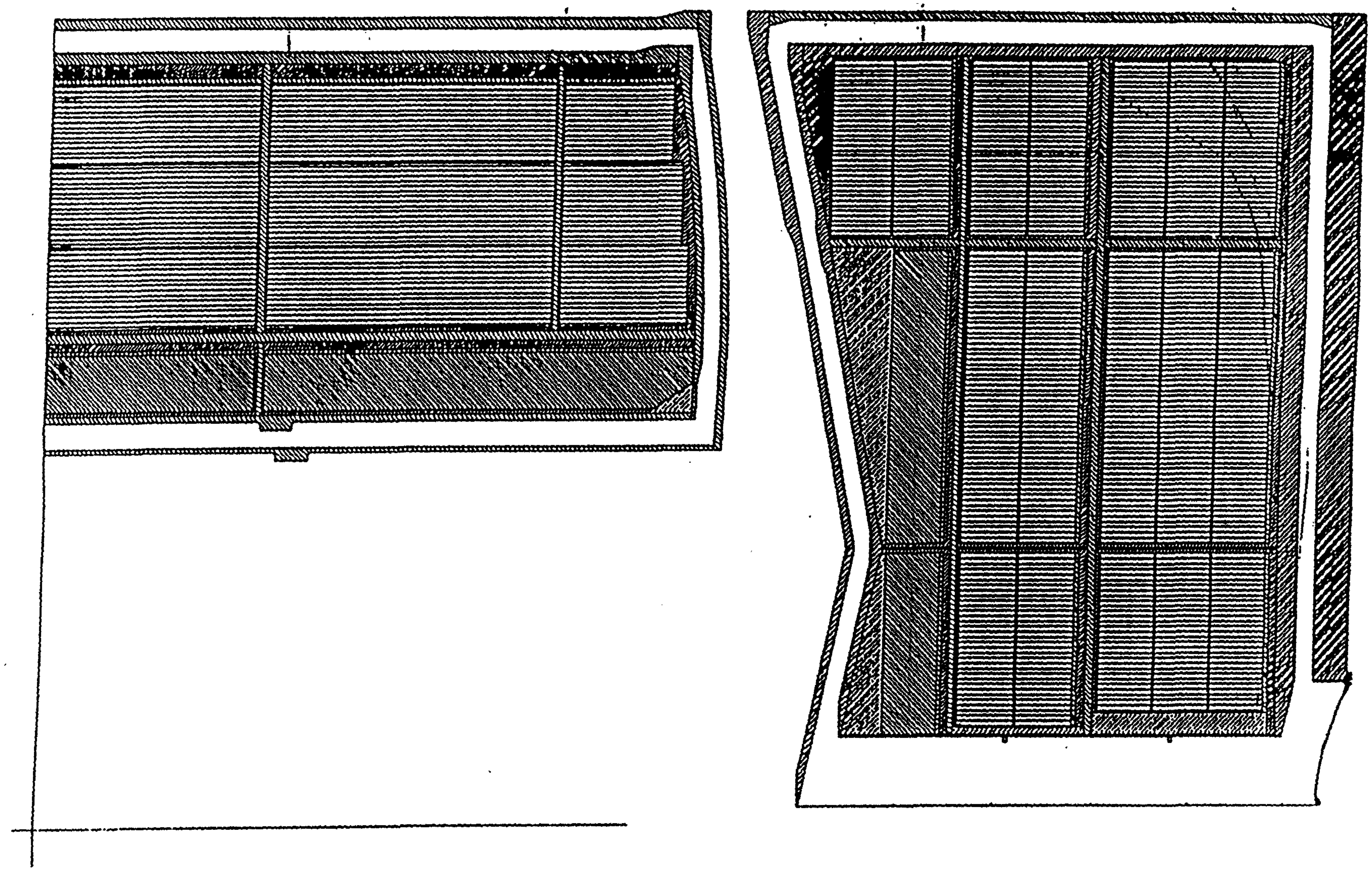
CALORIMETER CONFIGURATIONS

	LAR	Mod A	Mod B
Total depth ($\eta=0$)	9 λ	9 λ	9 λ
Total depth ($\eta=3$)	11 λ	11 λ	12 λ
BARREL EM			
Longitudinal segments	2	1	1
Transverse segmentation	0.05	0.05	0.05
Pb thickness (mm)	4	3.2	4
LAR/Scint thickness (mm)	4	2.5	2.5
Depth (X0)	25	22	22
BARREL HAD1			
Longitudinal segments	1	1	1
Transverse segmentation	0.05	0.05	0.1
Pb/Fe thickness (mm)	14(Pb)	25(Fe)	21(Pb)
LAR/Scint thickness (mm)	2	2.5	2.5
BARREL HAD2			
Longitudinal segments	1	1	1
Transverse segmentation	0.05	0.1	0.1
Pb/Fe thickness (mm)	14(Pb)	51(Fe)	46(Fe)
LAR/Scint thickness (mm)	2	2.5	2.5

CALORIMETER CONFIGURATIONS (cont.)

	LAR	Mod A	Mod B
ENDCAP EM			
Longitudinal segments	2	2	2
Transverse segmentation	0.05	0.05	0.05
Pb thickness (mm)	4	6.3	8
LAR/Scint thickness (mm)	4	2.5	2.5
Depth (X0)	25	22	22
ENDCAP HAD1			
Longitudinal segments	1	1	1
Transverse segmentation	0.05	0.05	0.1
Pb/Fe thickness (mm)	14(Pb)	51(Fe)	31(Pb)
LAR/Scint thickness (mm)	2	2.5	2.5
ENDCAP HAD2			
Longitudinal segments	1	1	1
Transverse segmentation	0.05	0.1	0.1
Pb/Fe thickness (mm)	14(Pb)	102(Fe)	67(Fe)
LAR/Scint thickness (mm)	2	2.5	2.5
SHOWER MAX			
$\Delta\phi$ layer & $\Delta\eta$ layer	0.05/6	0.05/8	0.05/8
MASSLESS GAP	Yes	Wt layr1	Wt layr1

Liquid Argon Calorimeter



Scintillator Calorimeter (Model A)
Iron-dominated Had 1

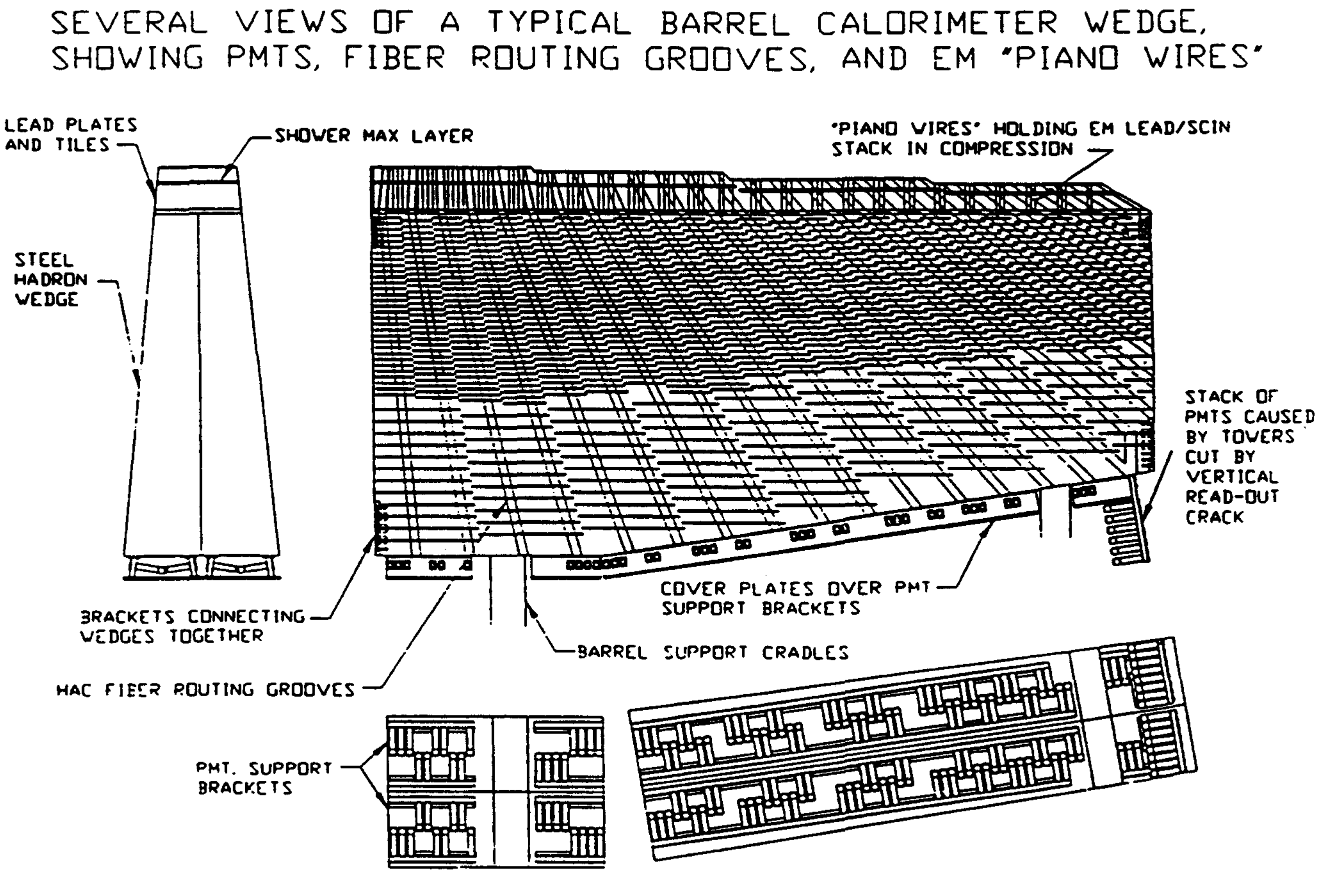


Figure 3.1(c) - Several views of a typical barrel calorimeter wedge, showing PMTs, fiber routing grooves, and EM "Piano Wires".

Scintillator Calorimeter (Model B)
Lead Had 1

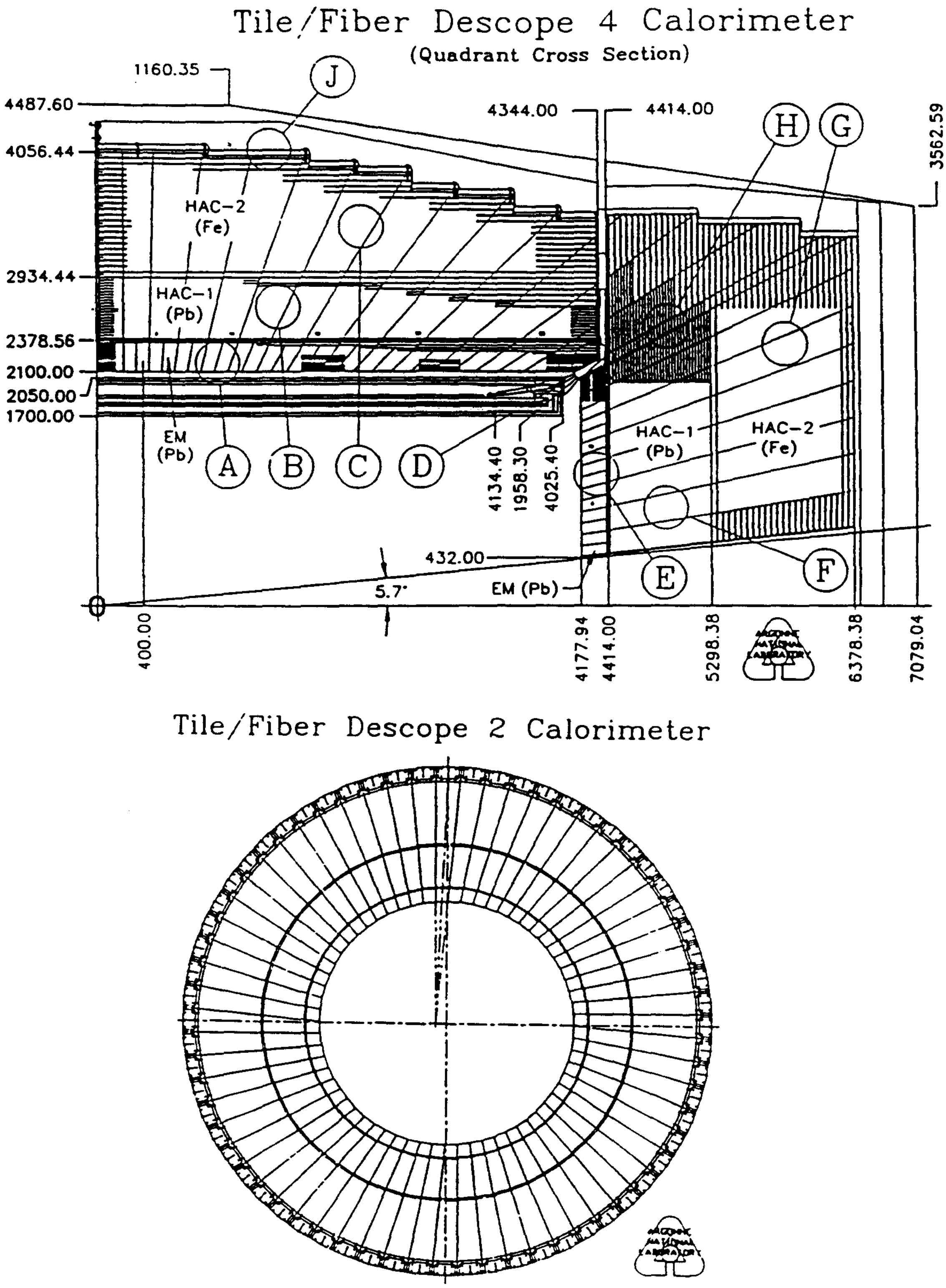
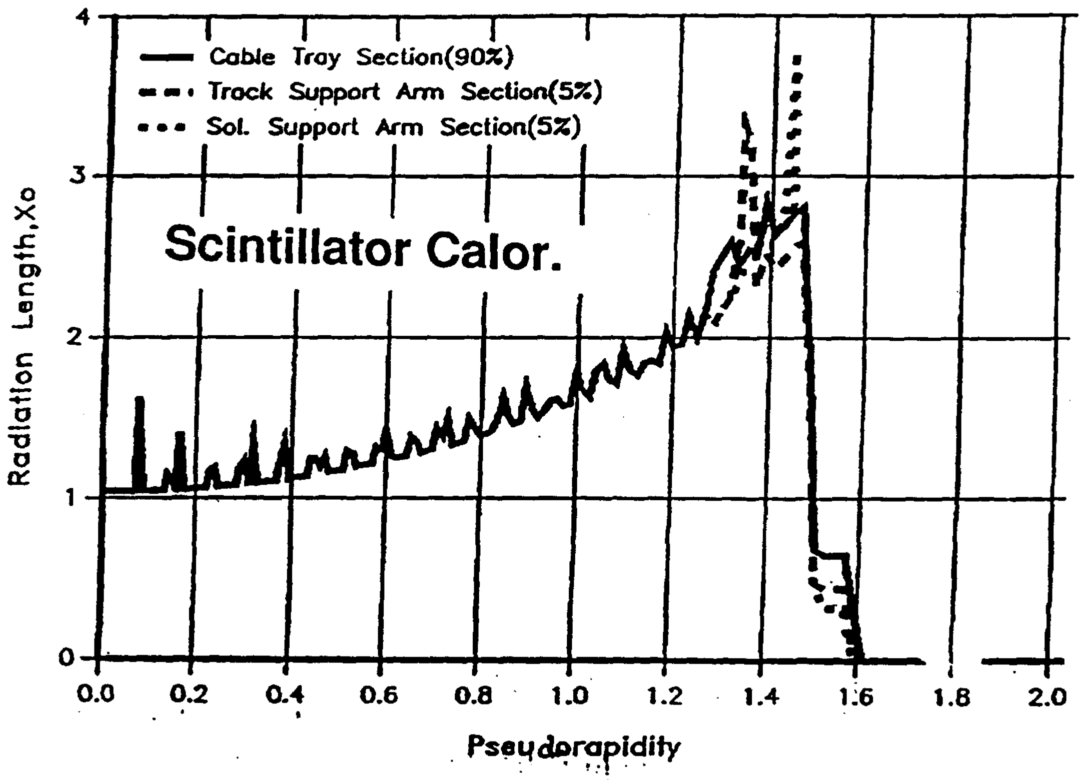


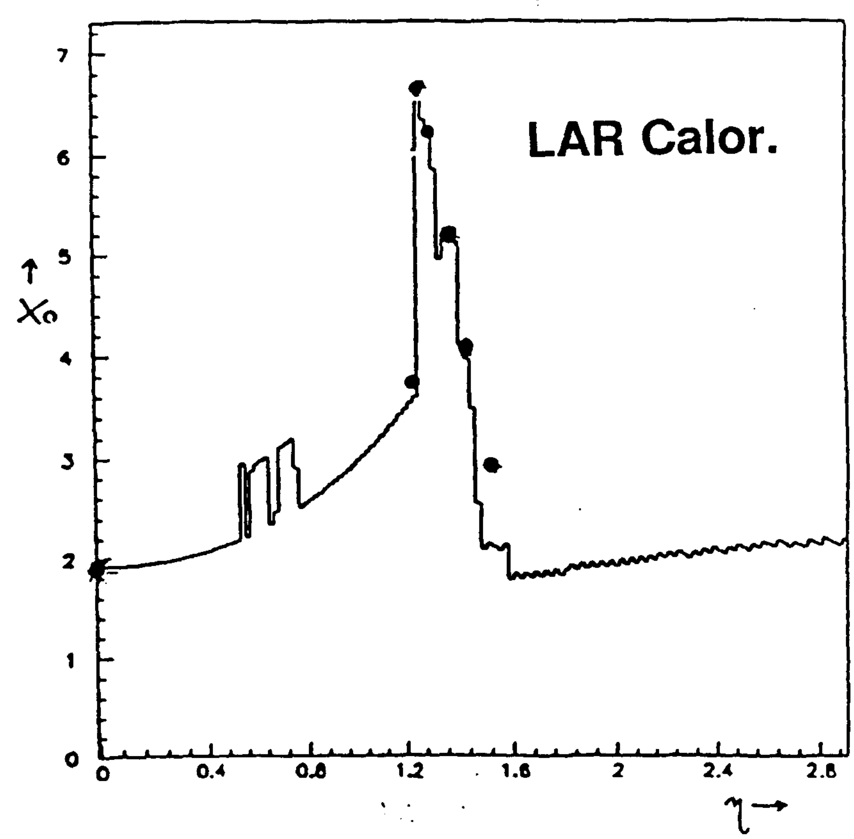
Figure 4.1 a)MODEL B Quadrant Cross section, b) End Section

Comparison of the liquid argon (LAR) and scintillator (SCINT) calorimeter options.

	LAR	SCINT
Electron acceptance		x
EM resolution-stochastic	very	close
EM constant term	x	
Electron, γ ID, isolation		x
Hadronic resolution-stochastic	very	close
Hadronic constant term, e/h		x
Hadronic transverse segmentation	x	
Missing E_T measurements		x
Cost (including impact on other systems)		x
Schedule	very	close
Magnetic field uniformity		x
Integration		x
Safety		x
Impact on electronics, DAQ, trigger		x
Muon system performance		x
Neutrons, albedo in cavity		x
Flexibility, upgrade		x
High $\mathcal{L}$ performance		x
Maturity of design	x	
Radiation resistance	x	
Ease of calibration	x	

Radiation Lengths V.S. Pseudorapidity





Noise/ Pileup in LAR Calor.

Section	N_{amp}	per Preamp										per Channel				
		N_{gap}	$<r>$ cm	C_D pF	C_s pF	C_{tot} pF	n	t_{peak} ns	ENC fC	ENE MeV	ENE MeV	Pileup MeV	Total MeV	Mip MeV	Mip S/N	σ_t ns
EM1	1	5	236	970	340	1310	5	60	1.7	27	27	30	40	32	0.8	< 1
EM2	1	26	255	5680	460	6140	11	60	4.9	75	75	54	92	161	1.7	< 1
HAD1	2	18	314	3100	1030	4130	9	100	2.8	194	274	44	278	662	6.3	2.8
								200	2.0	80	113	63	129		5.1	2.6
HAD2	2	27	387	7070	1530	8600	13	100	4.9	337	477	3	477	993	2.1	4.8
								200	3.5	139	197	4	197		5.0	3.9

The total noise in the EM section of the calorimeter is essentially constant with peaking time in the range 60 .le. tpeak .le. 100 ns (variation is +/- 2.5%). The peaking time is selected to be 60 ns to provide better pileup supression for higher luminosity running. For a luminosity increase from 10**33 to 10**34, the total noise in EM1 plus EM2 will increase from 115 MeV to 278 MeV (i.e., proportional to Lum**0.38). This value of tpeak depends on the pileup calculation in section 7.3; a more detailed calculation will be required to finally select the shaping time. The use of variable shaping time shapers (Section 7.3.1) will enable the optimization to be based on observed backgrounds. Note, however, that a variation of +/-30% in energy deposited per crossing corresponds to a variation in the total EM noise of 10%.

Noise/ Pileup in LAR Calor.

SUMMARY

- Fast LAr risetime preserved by electrode structure

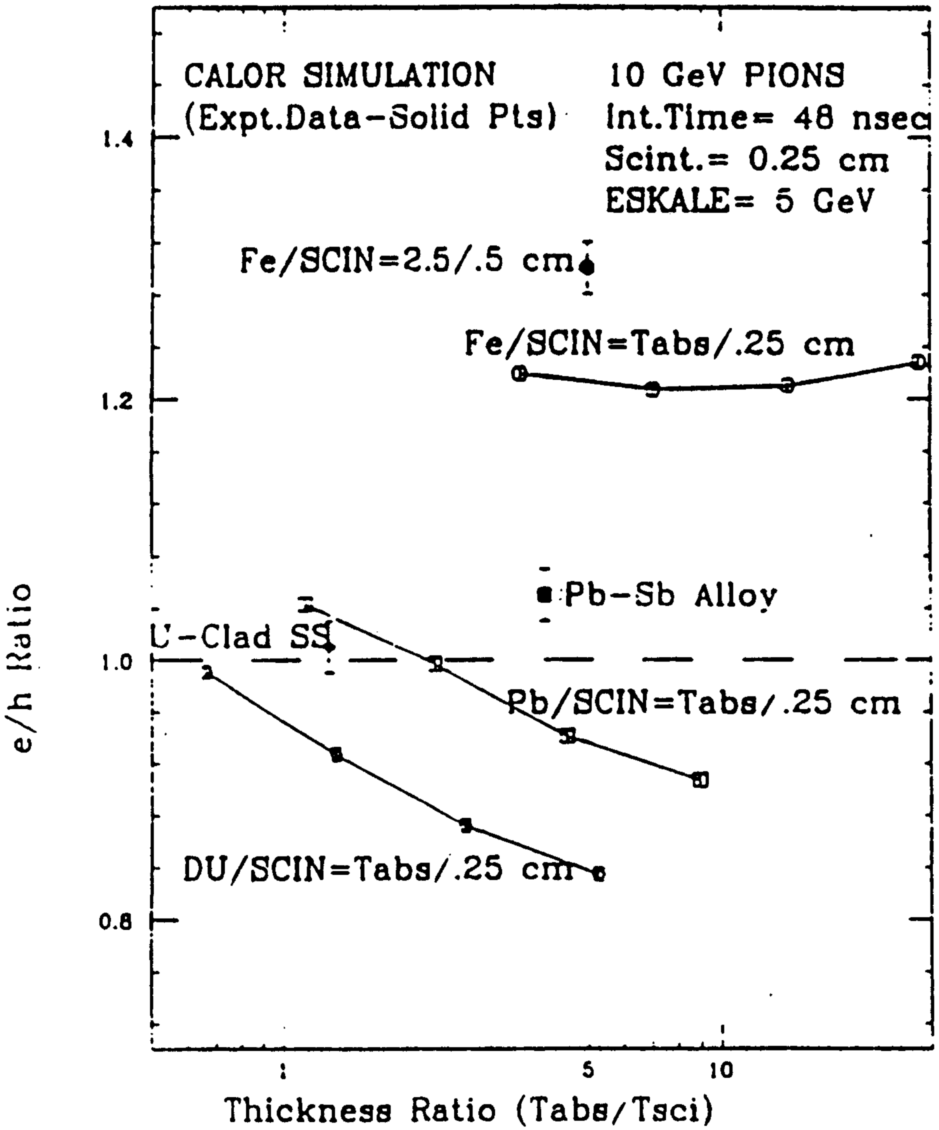
- $\sigma t < 4$ ns for >2 GeV in EM tower
  $\sigma t < 4$ ns for >80 GeV jet
  (both are better in endcap)

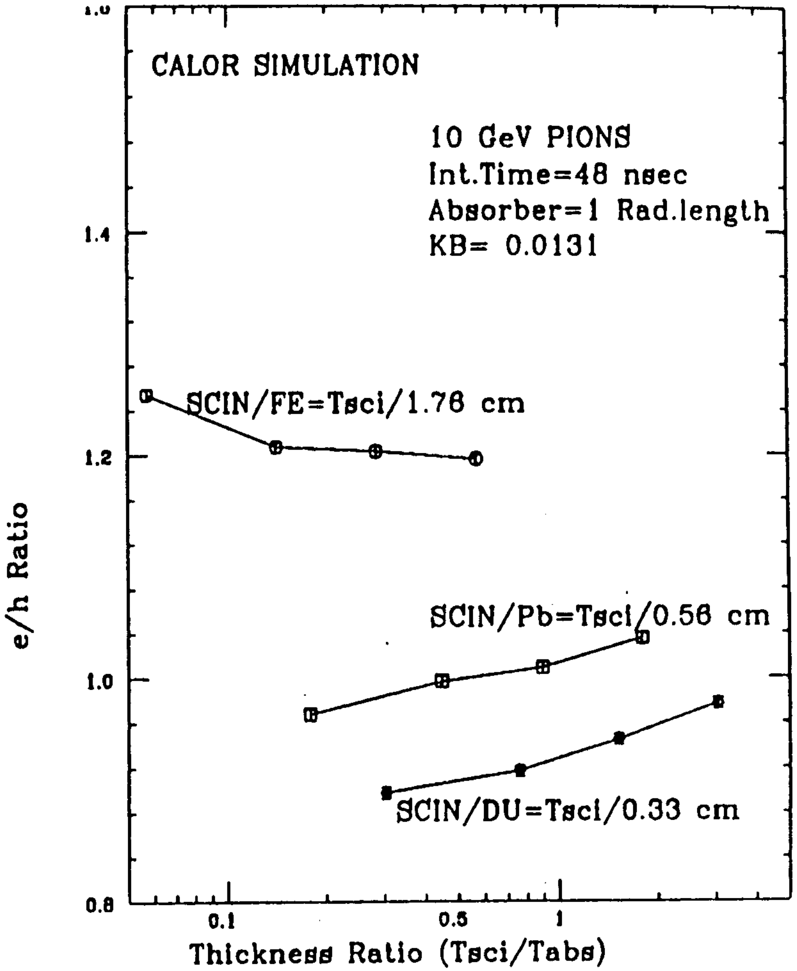
- Effect of noise and pileup on EM resolution:
  $$\frac{\sigma}{Et} = \frac{0.13}{\sqrt{Et}} \oplus \frac{0.22}{Et} \quad @ \; 10^{**}33$$

- H --> $\gamma\gamma$ efficiencies
  - single γ efficiency reduced 1% [4%]
  - mass resolution worse by 5% [20%]
  - event efficiency 0.58 (fast) --> 0.56 (LAr)
    0.60 (fast) --> 0.52 (LAr)

- H --> WW --> eν + jets; isolated e- efficiency 0.92 [10**33] --> 0.72 [10**34] (tighter cuts)

e/h Ratio from Simulation





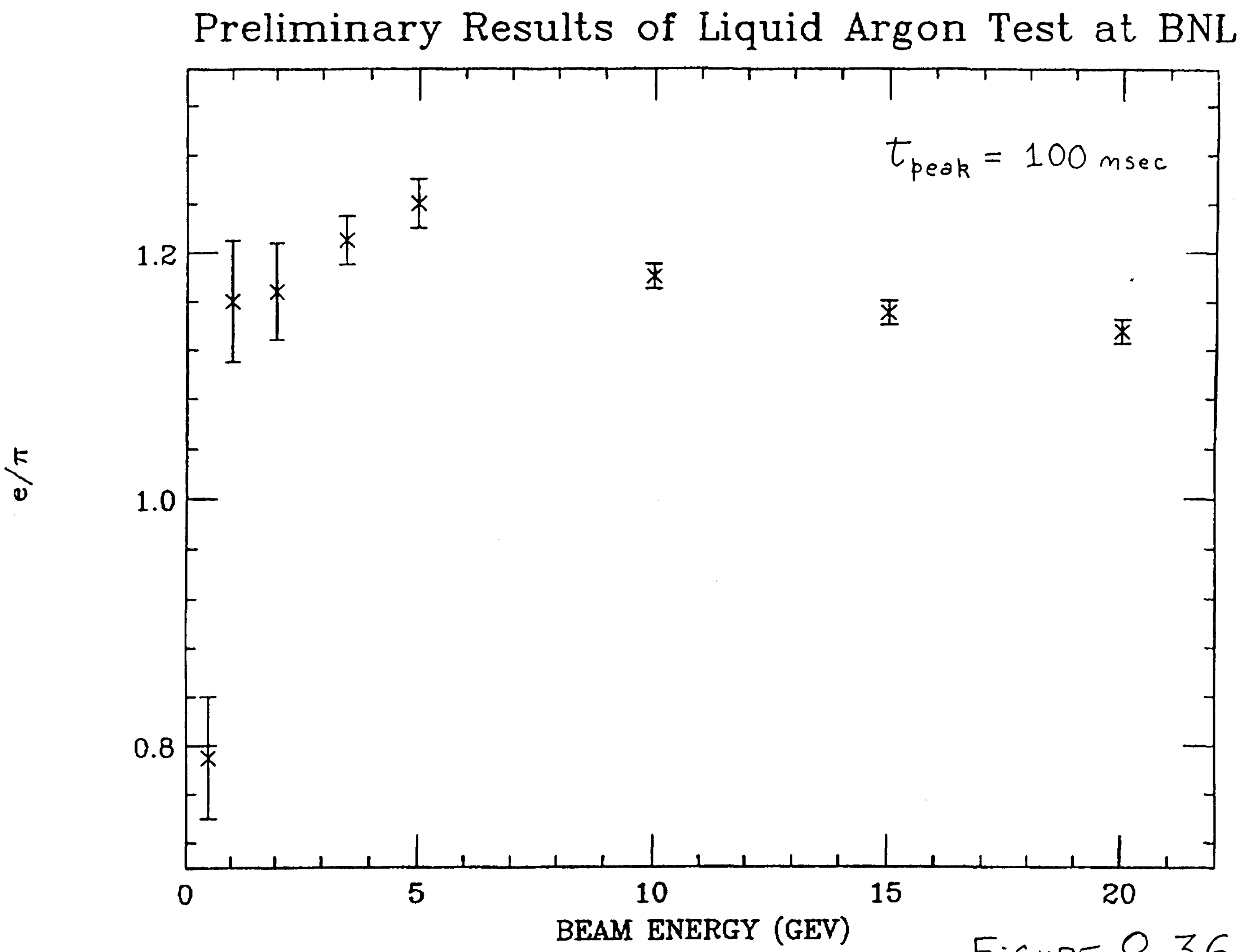
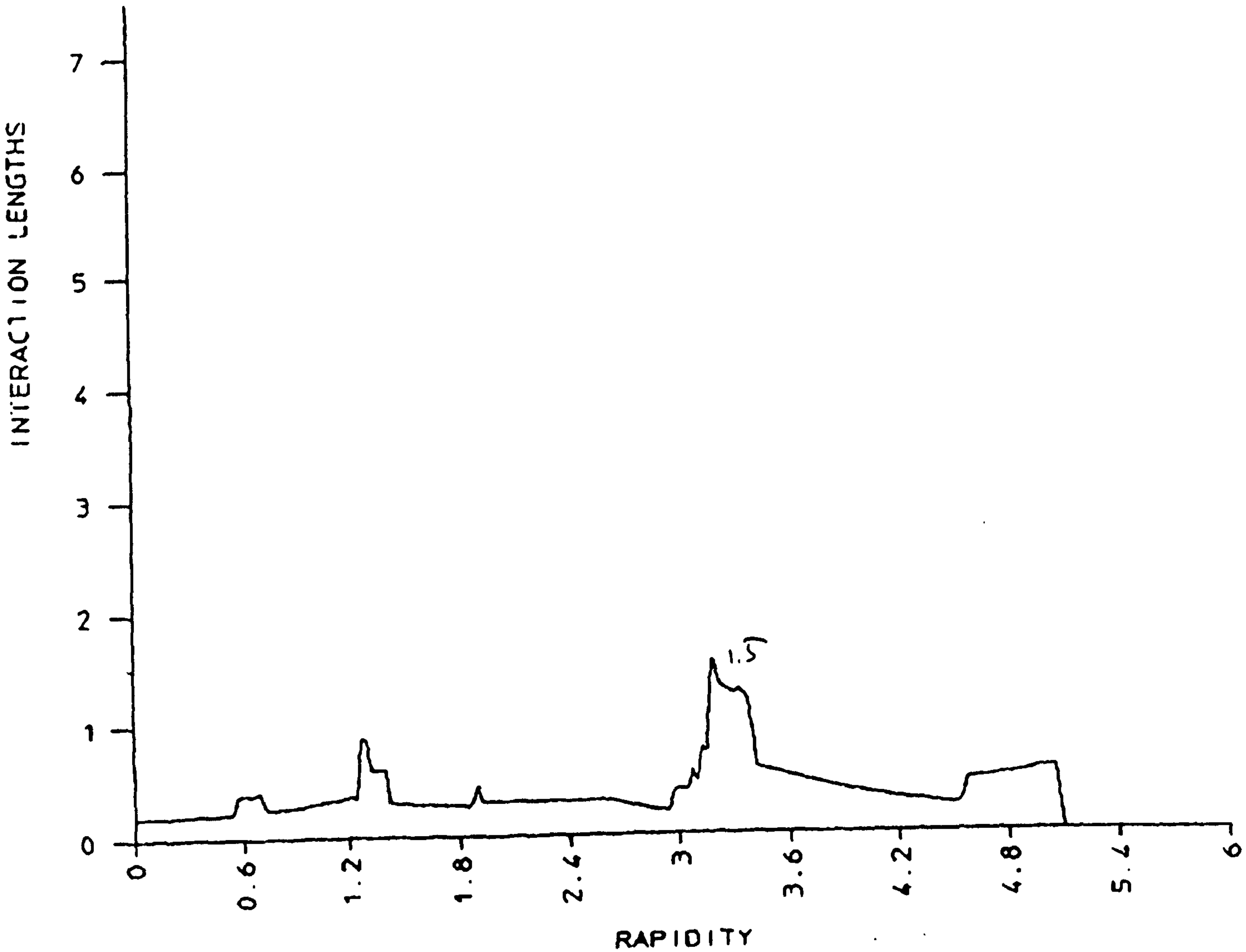

Preliminary Results of Liquid Argon Test at BNL
t_{peak} = 100 nsec
e/π
1.2
1.0
0.8
0
5
10
15
20
BEAM ENERGY (GEV)

FIGURE 8.36

Interaction Lengths vs. η in LAR Calorimeter



COST COMPARISON

Liquid Argon minus Scintillator

Calorimeter cost	+9 M
Electronics	+7 M
R&D	- 2 M
Prototypes	+1 M
Installation	+1 M
Underground hall	+3 M
Muon system	+10M
Total cost difference	+29 M

Giving the scintillator calorimeter 2 EM depth segments in the barrel, and 0.05x0.05 granularity in HAC1 to make it the same as the LA design would add about 14 M to the scintillator calorimeter cost.

(1) magnetic field contour of B_z

Type 1, (r,z/2)=(1.7m,4.0m), liquid argon

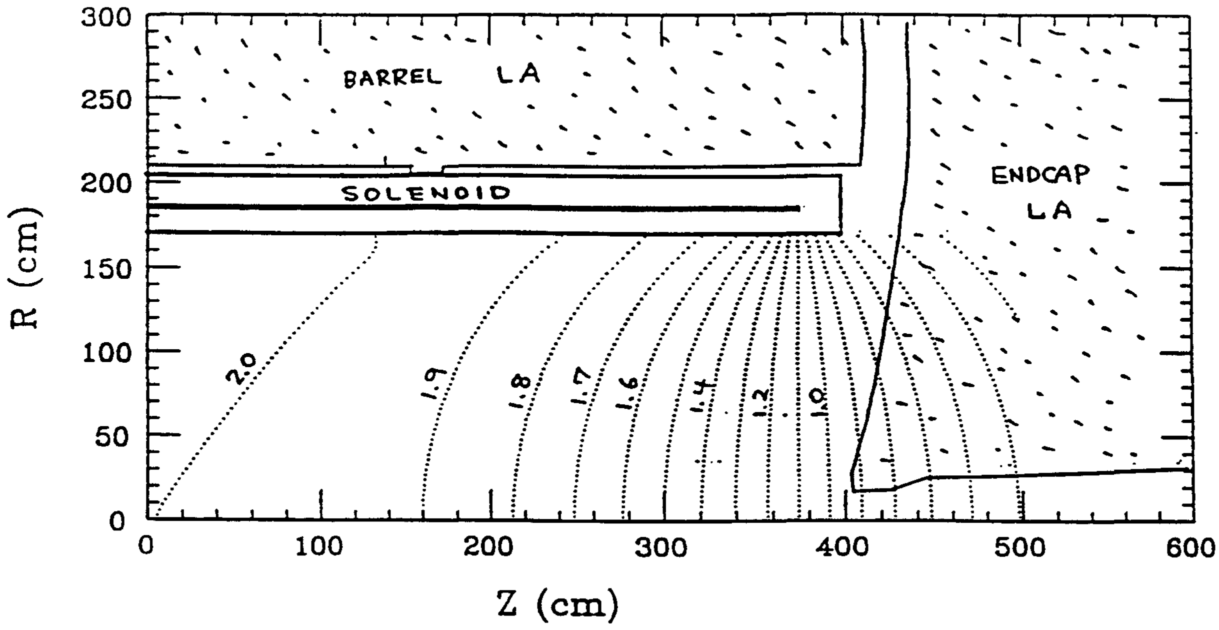


Fig. 1

(4) magnetic field contour of B_z

Type 4, (r,z/2)=(1.7m,4.0m), Tile–fiber, EM(Pb), Had(all Fe)

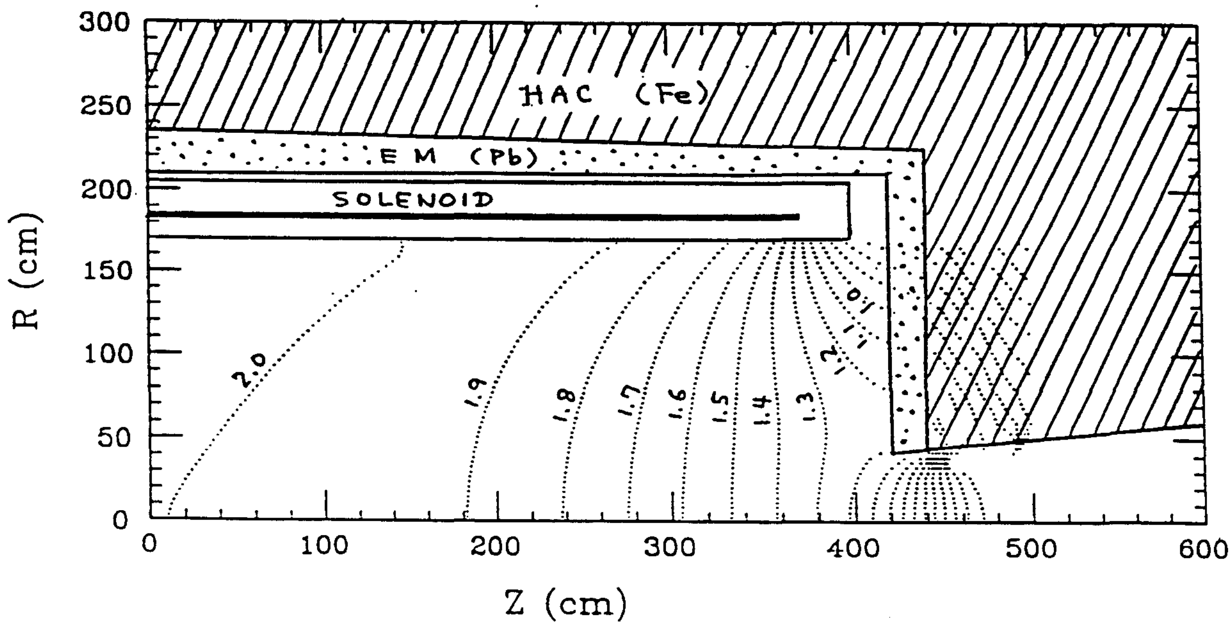
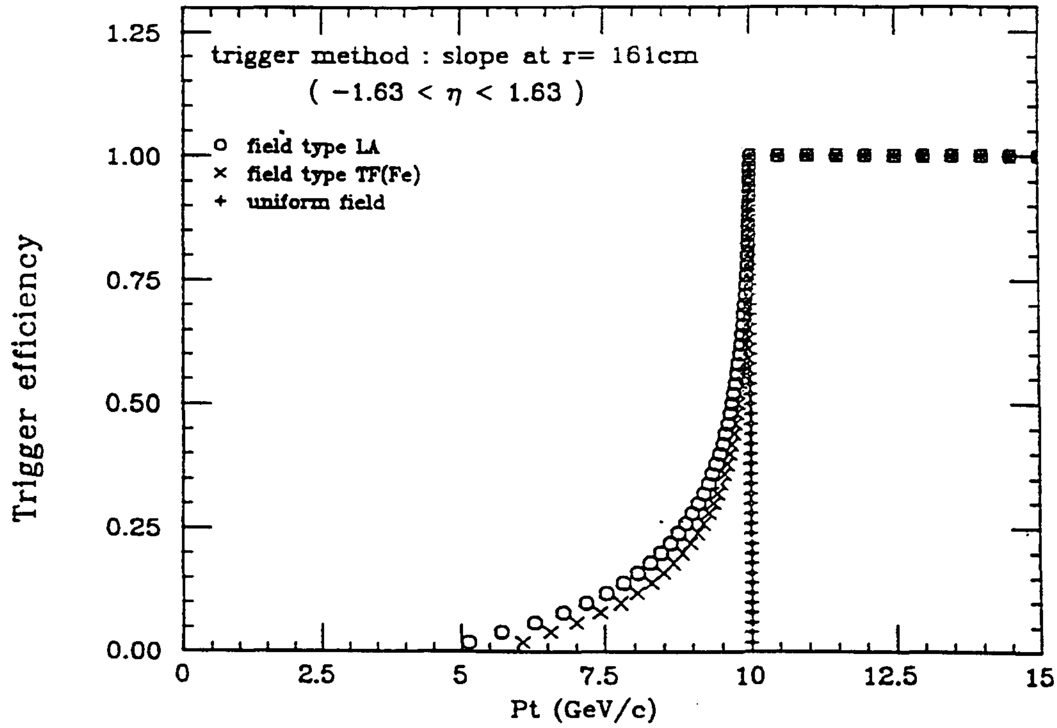
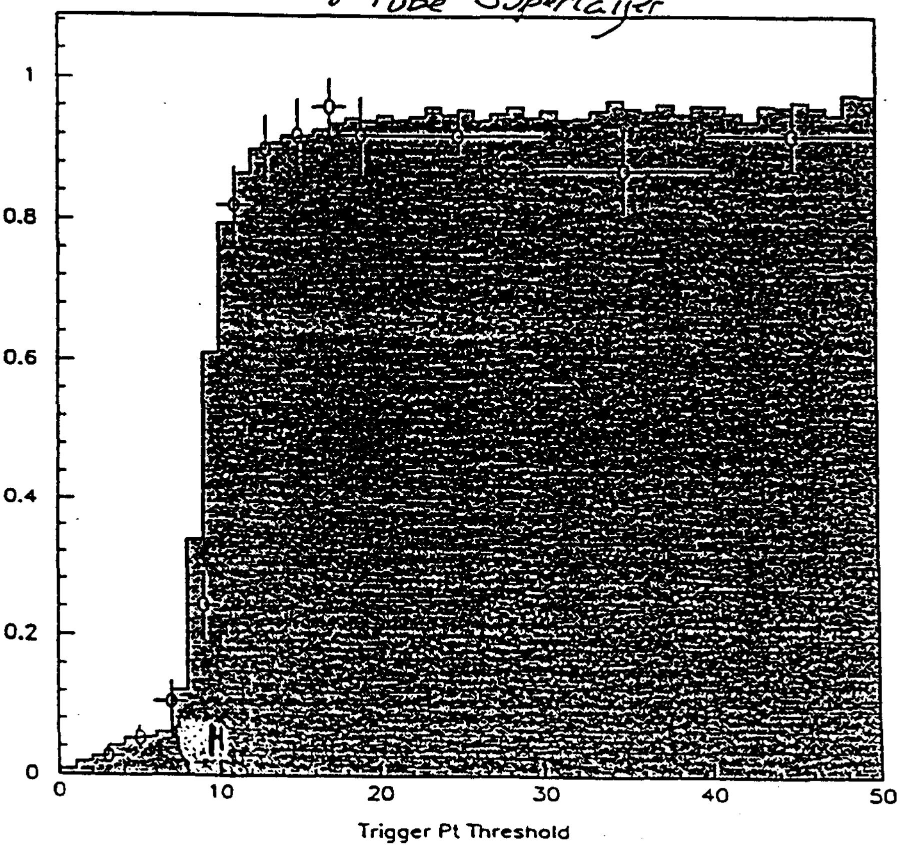


Fig. 2

field non-uniformity effects on track triggering



8-Tube Superlayer



IMPACT ON TRACKING

I. Magnetic field non-uniformity (Task Force).
(Note: Field non-uniform in all designs presented,
least non-uniform in Fe/scint. hadronic calorimeter design,
could be fully uniform with reentrant EM section).

1. Reduced trajectory bend angle at large z,
   Softens trigger threshold.
2. Modified time-distance relation at large z,
   Greater tolerance on synchronizer--softens threshold.
3. Pattern recognition,
   Depends on detailed pattern recognition procedure.
4. Momentum resolution,
   Very small effect for designs presented.

II. Neutron fluence in tracking cavity reduced by scintillator.
Reduction factor is 3.

IMPACT ON MAGNET

Flux return far from current sheet (Pb/LA, Pb/Scint. for HAC1).
- Large compressive stresses(~1700 tonnes) on conductor.
- Small magnetic decentering forces (< coil weight).
- Non-uniform field.

Flux return near current sheet (Fe/Scint. for HAC1, reentrant EC).
- Reduced compressive stresses.
- Larger magnetic decentering forces (> coil weight).
- More uniform field.

For the designs presented, the compressive forces varied from 1700 to 1100 tonnes. It is possible to have forces down to 100 tonnes with reentrant EC and Fe/Scint. HAC1. This requires further study to understand the impact of reentrant EM geometry.

IMPACT ON ELECTRONICS

From point of view of electronics performance, there are no significant differences between LA and Scintillator technologies.

Undesirable environmental consequences for LA:

- Detector electronics crates sit in 0.1 T magnetic field.
  - Precludes commercial power supplies, fans, etc.
  - Servicing and trouble-shooting more awkward.

IMPACT ON MUON SYSTEM

1. Effect of multiple scattering in calorimeter absorber on level 1 trigger threshold:

Calorimeter design	(Bend angle)/(Scattering angle)
All lead HAC (LA)	2.8
All iron HAC (Scint.)	3.9
Lead/Iron HAC (Scint.)	3.2

For fixed threshold, level 1 trigger rate is increased by Pb.

2. LA calorimeter is larger ($\Delta R = 0.4$ m, $\Delta L/2 = 1.6$ m).
   Hence larger muon system is required,
   (included in cost comparison).

Radiation Hardness Test Beam Module

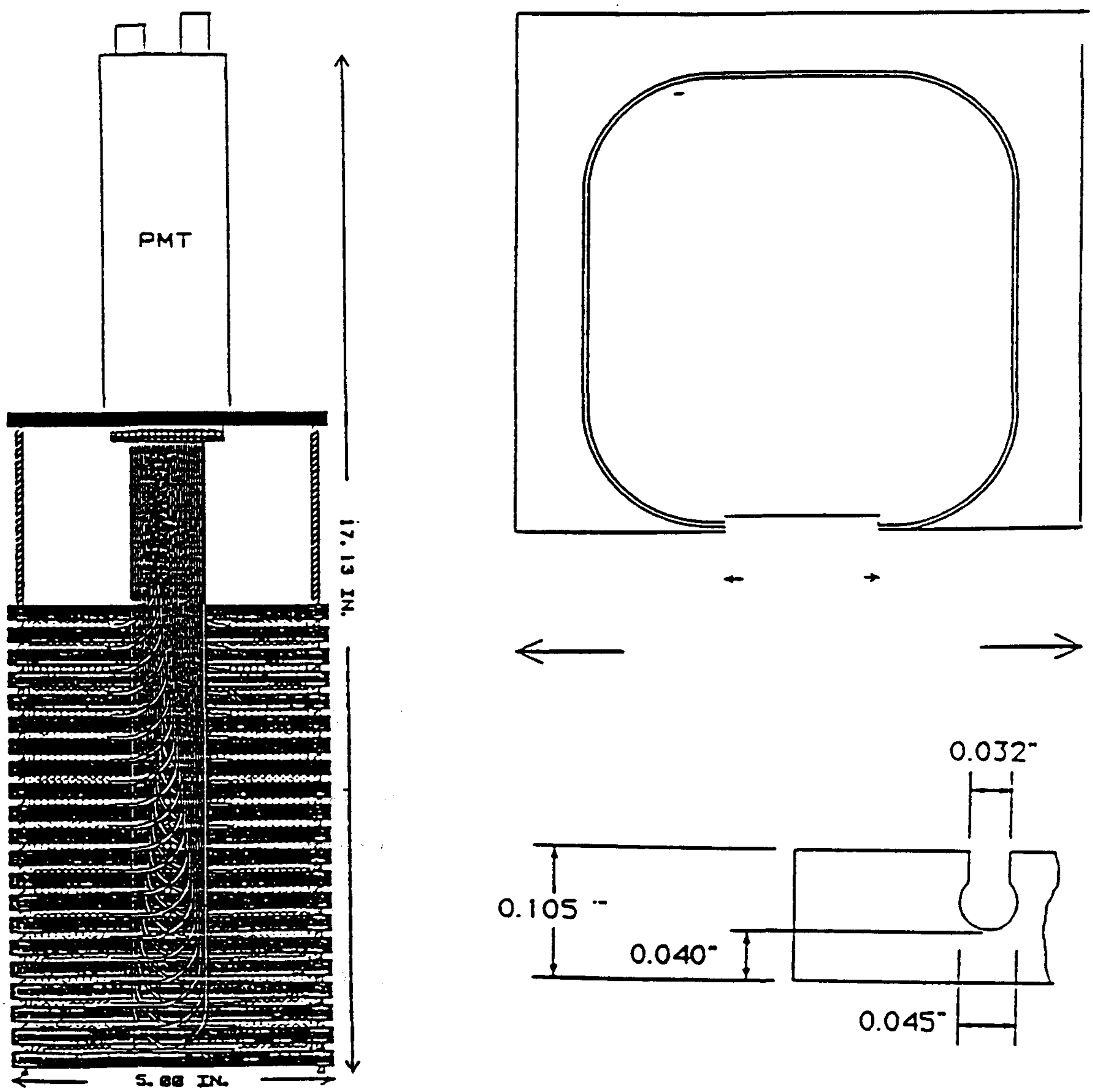


Figure 8.2 Radiation hardness test beam module.

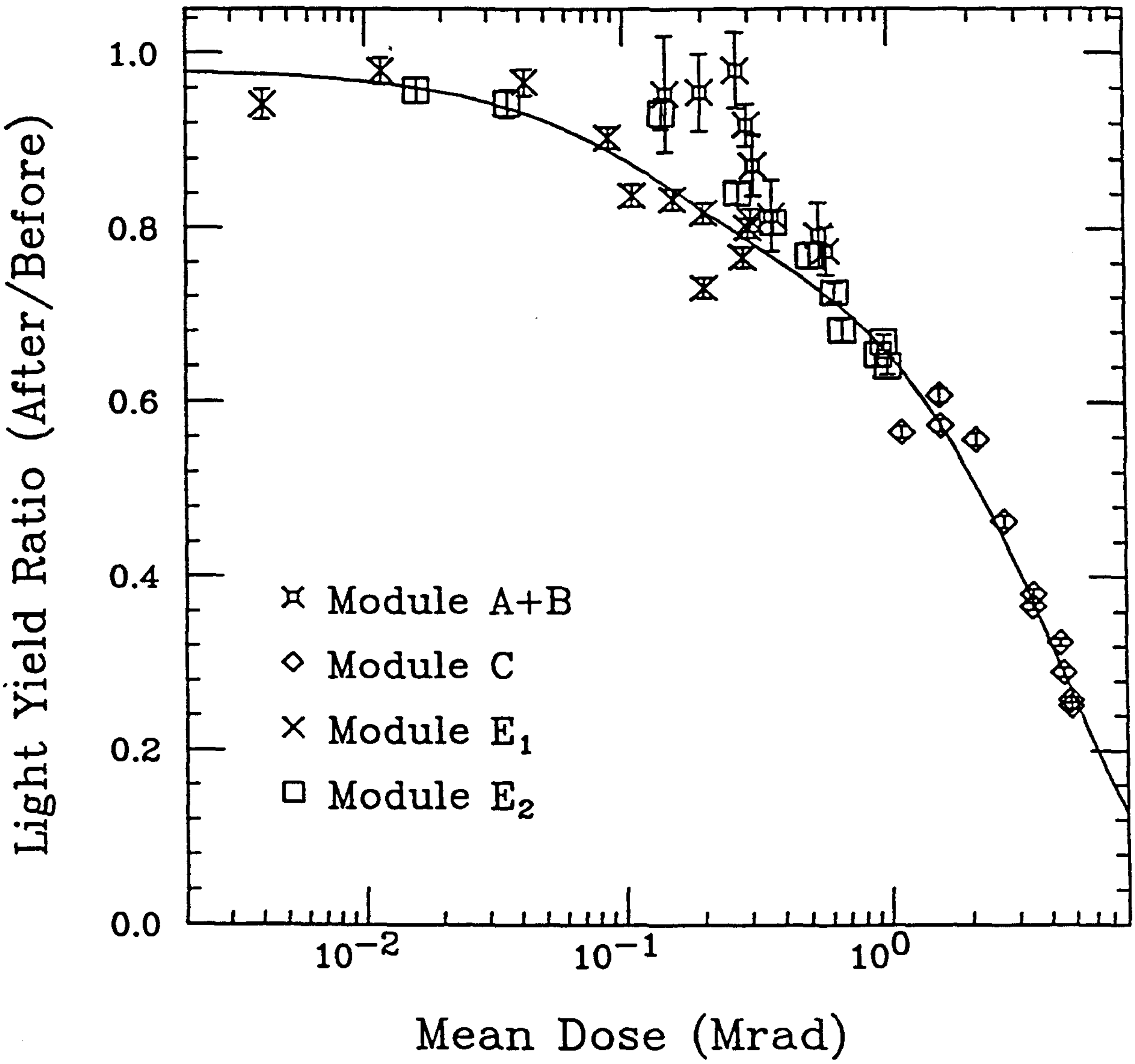


Figure 16: The 2.5-GeV electron shower induced damage as a function of the mean dose, measured with electron beam (in square-crosses) and with a ^{106}Ru source (in squares, diamonds and crosses). The curve is a fit given by Eq. (2).

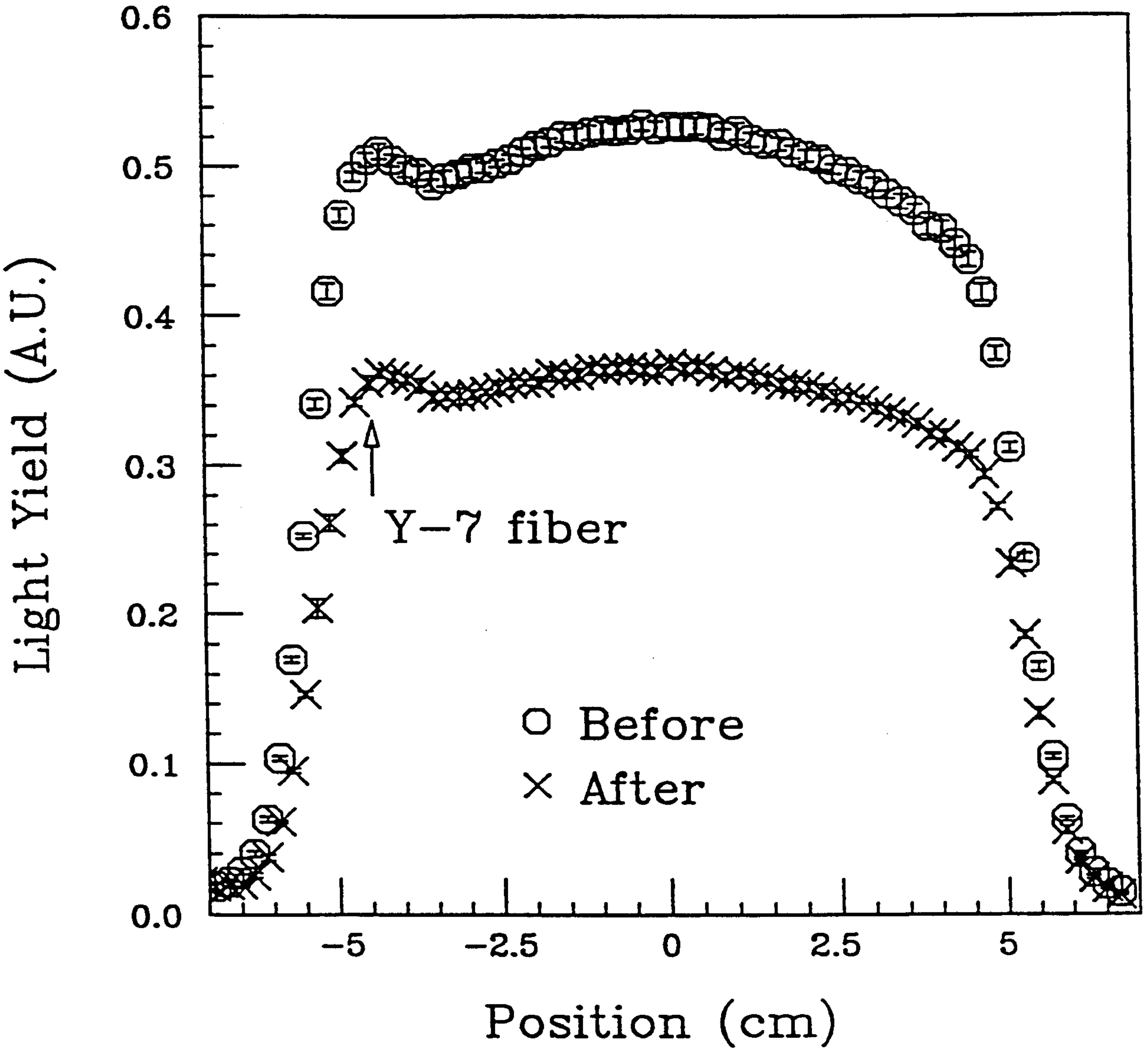


Figure 15: Response map of a tile/fiber assembly measured by scanning with a ^{106}Ru source. This assembly was non-uniformly exposed to ^{60}Co with a dose distribution of 0.62 Mrad at the center and 0.20 Mrad at the edge.

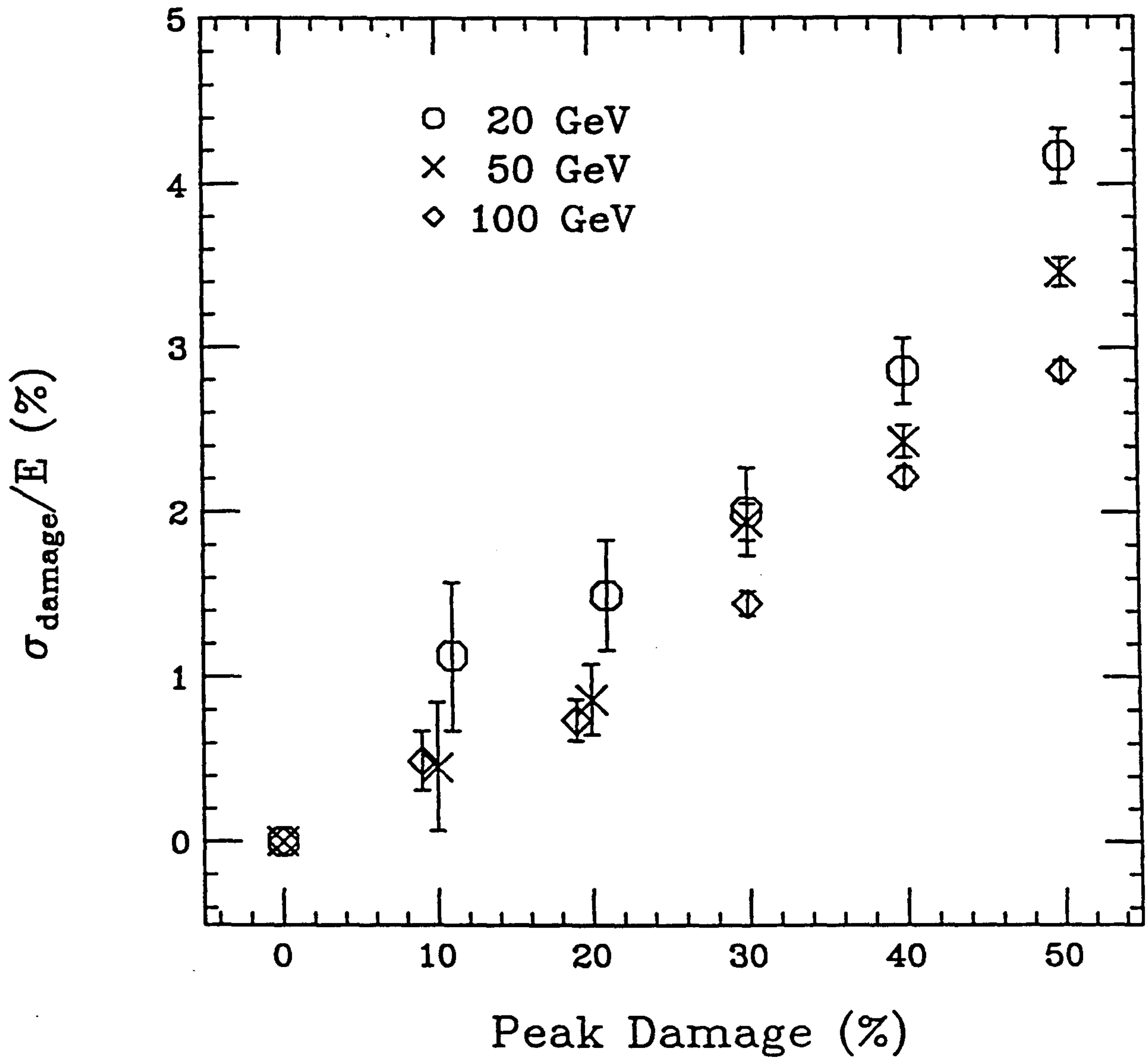
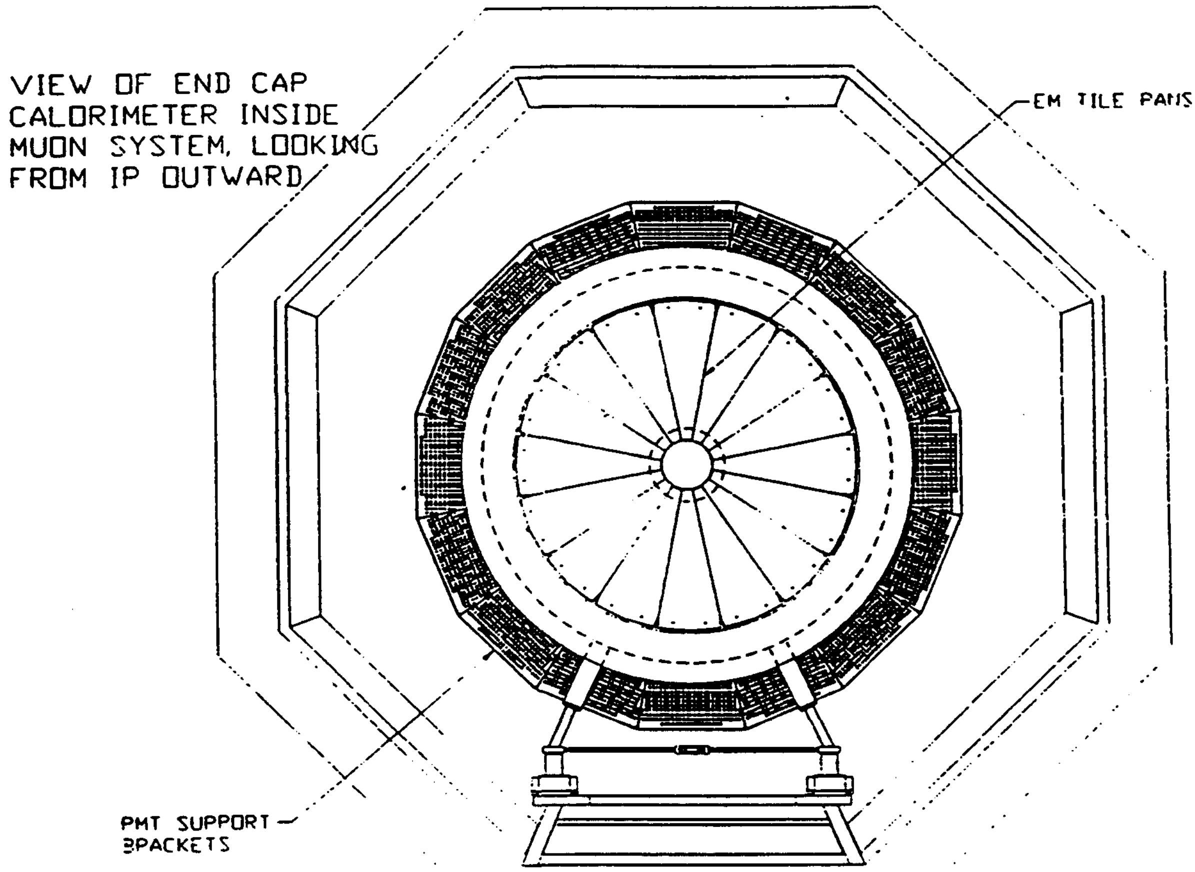
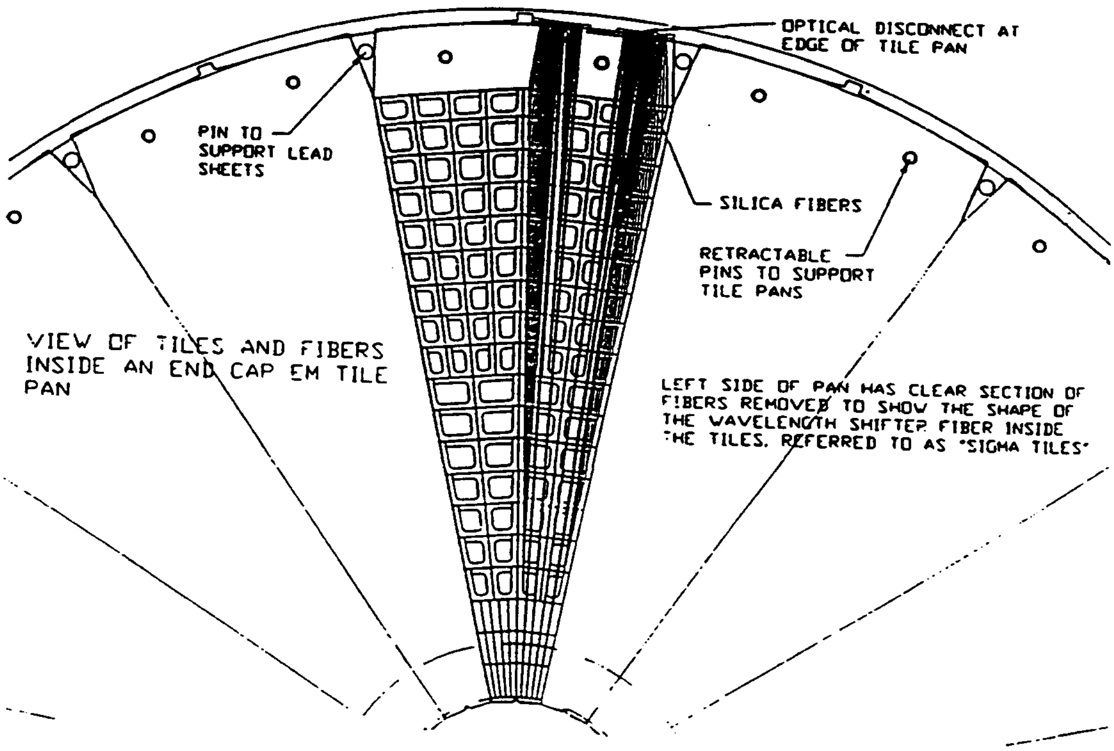


Figure 21: Damage-induced error to resolution as a function of the peak damage for energies of 20, 50 and 100 GeV.


VIEW OF END CAP
CALORIMETER INSIDE
MUON SYSTEM, LOOKING
FROM IP OUTWARD
EM TILE PANS
PMT SUPPORT
BRACKETS


OPTICAL DISCONNECT AT
EDGE OF TILE PAN
PIN TO
SUPPORT LEAD
SHEETS
SILICA FIBERS
RETRACTABLE
PINS TO SUPPORT
TILE PANS
VIEW OF TILES AND FIBERS
INSIDE AN END CAP EM TILE
PAN
LEFT SIDE OF PAN HAS CLEAR SECTION OF
FIBERS REMOVED TO SHOW THE SHAPE OF
THE WAVELENGTH SHIFTER FIBER INSIDE
THE TILES, REFERRED TO AS "SIGMA TILES"

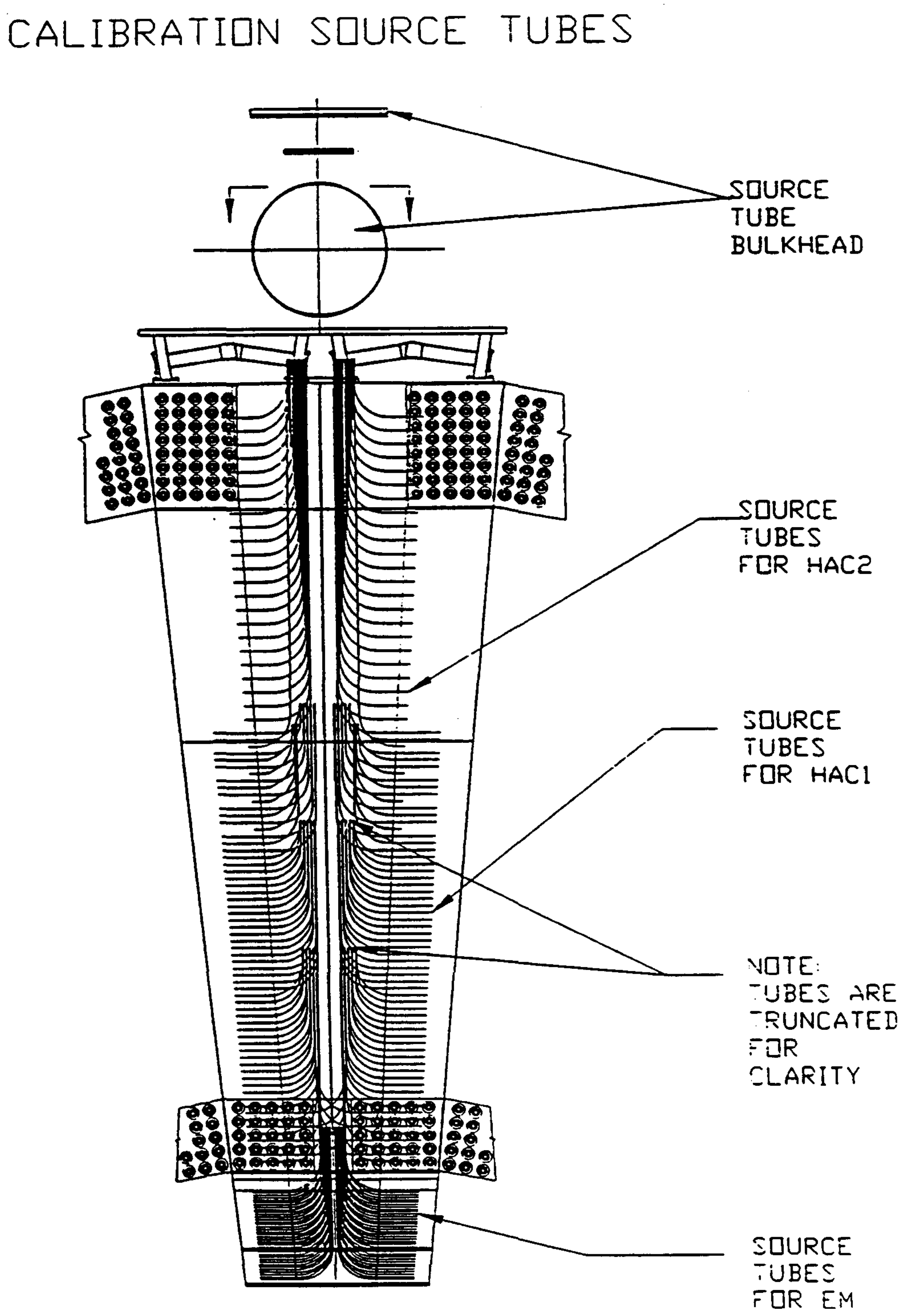
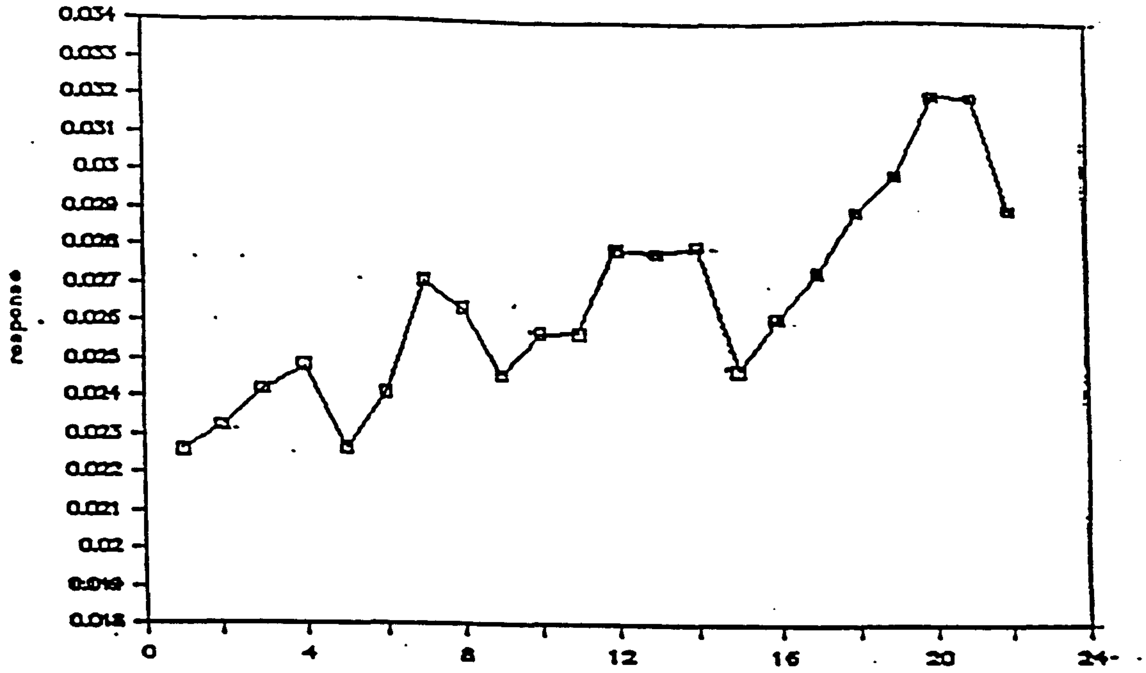


Figure 9.2 Layout of the source tubes for a single barrel wedge. Two basic tyubes fan out to the 2 towers of the wedge. Each tile in the wedge is scanned transversely.

LONGITUDINAL MASKING



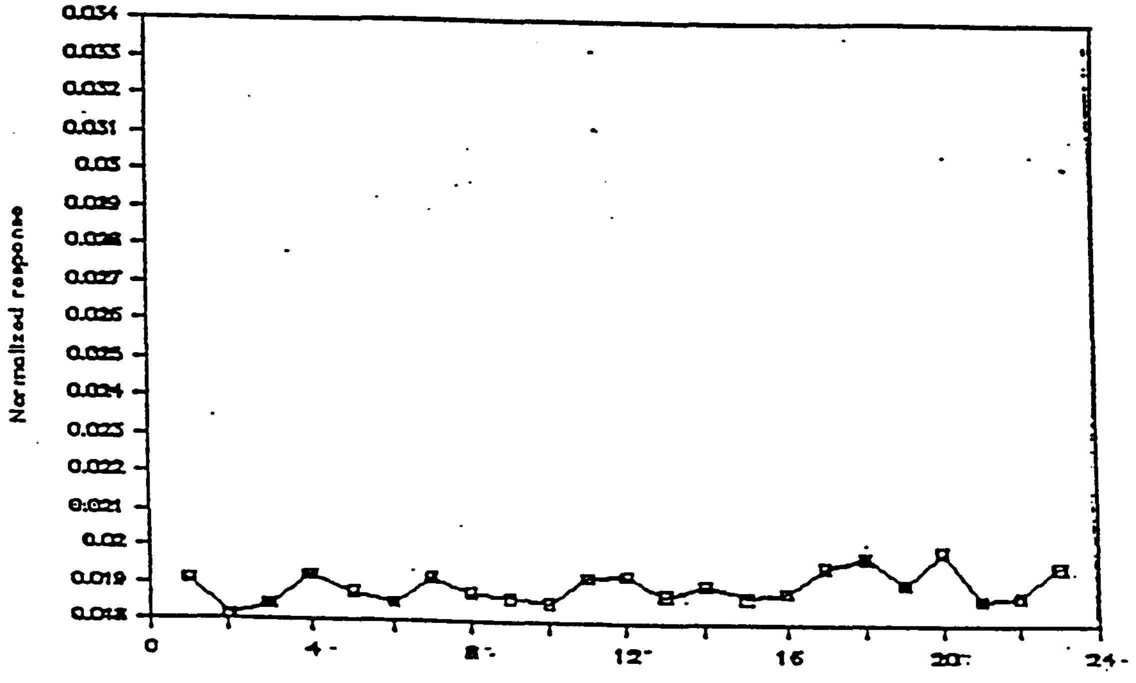


Figure 6.17 a) The longitudinal response of tiles in a tower. The hortizontal scale is tile number ranging from 1 (front) to 23 (back). The vertical scale is relative light yield. The RMS variation is 11.5%.

b) The same tower as in (a), after longitudinal masking. The RMS variation is now 2.6%.

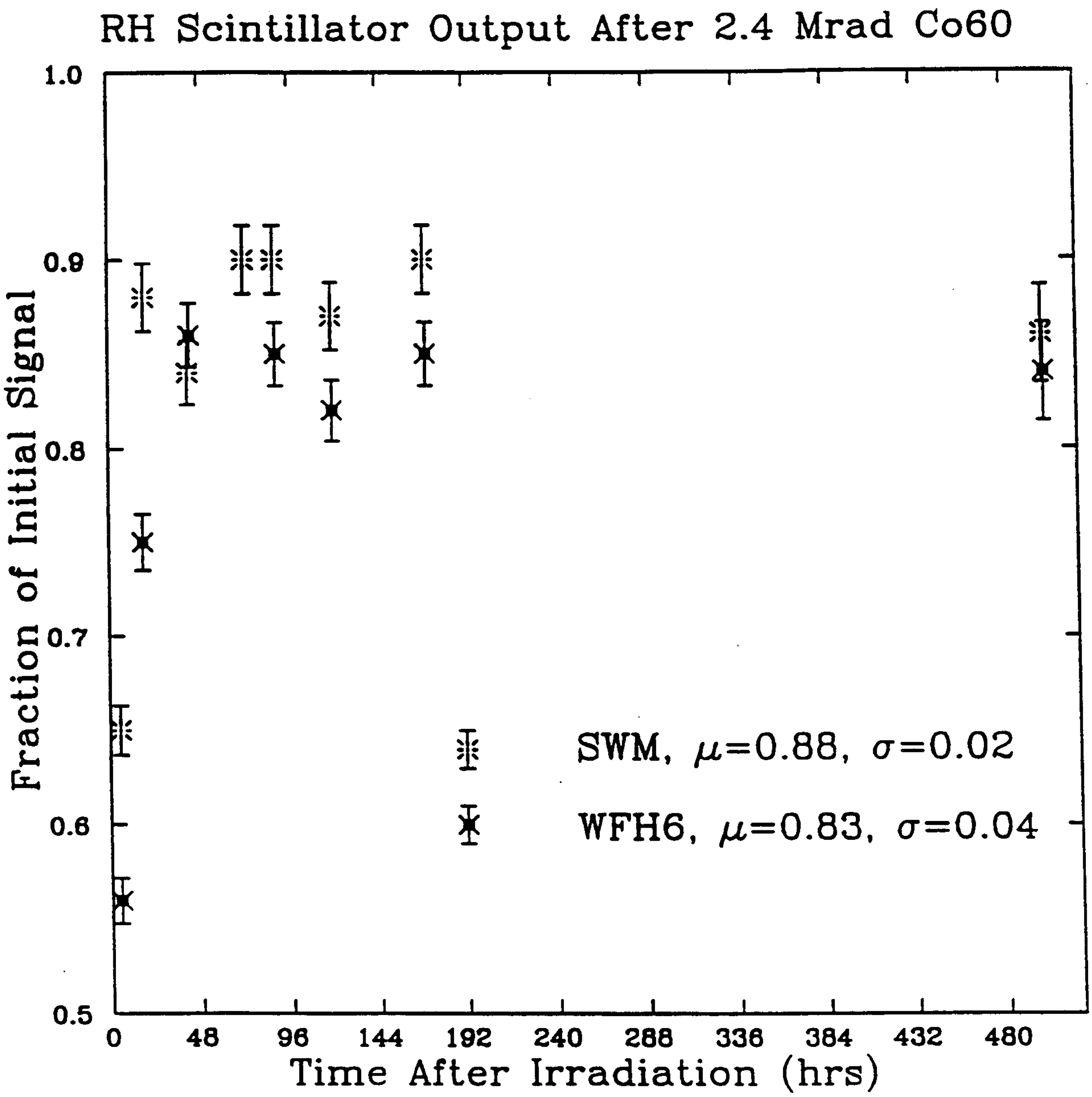


Figure 8.12 Average light output from 3 disks of 2 inches diameter read out using 2 wraps of 1 mm BCF91A.

CALIBRATION & RADIATION DAMAGE

CALIBRATION

Source tubes allow irradiation of each individual tile.
Information can be used to correct for damage through longitudinal masking.
Z --> ee occur at rate of 10^4/tower for 1 Mr at shower max.

BARREL DAMAGE EXPECTATIONS

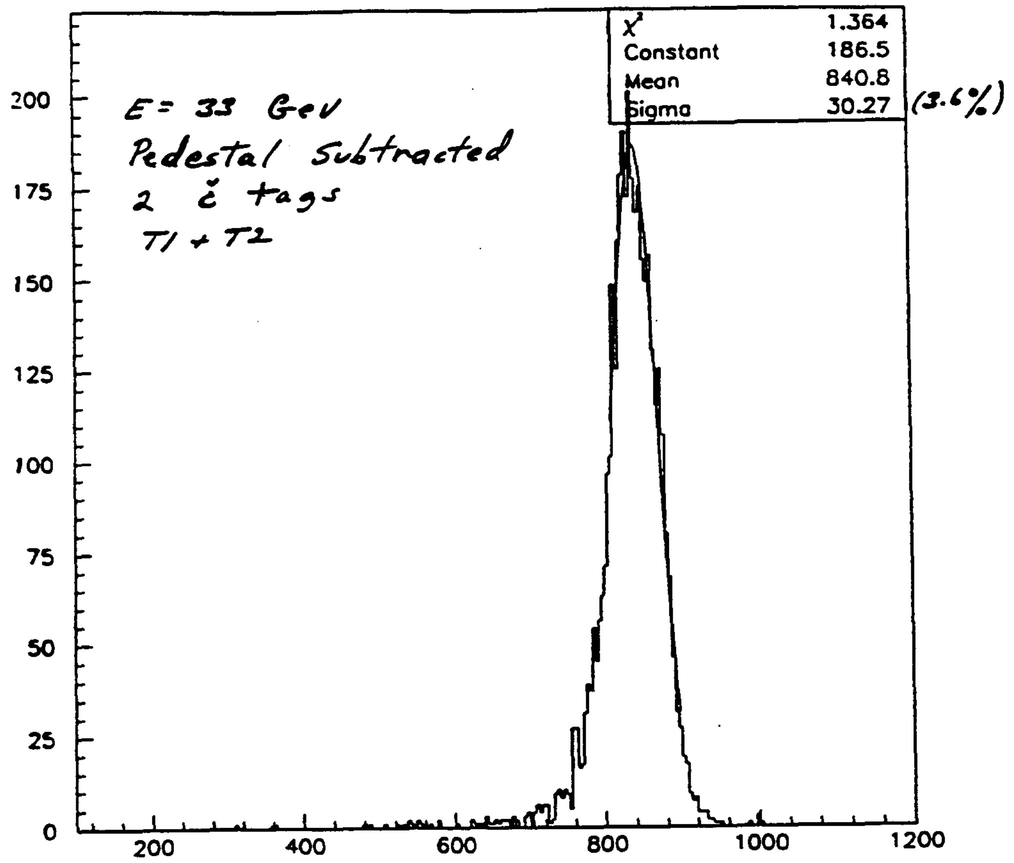
With existing scint., expect < 20% light loss at EM shower max for 100 years at design luminosity ==> $\Delta\sigma/E < 1\%$.

ENDCAP DAMAGE EXPECTATIONS

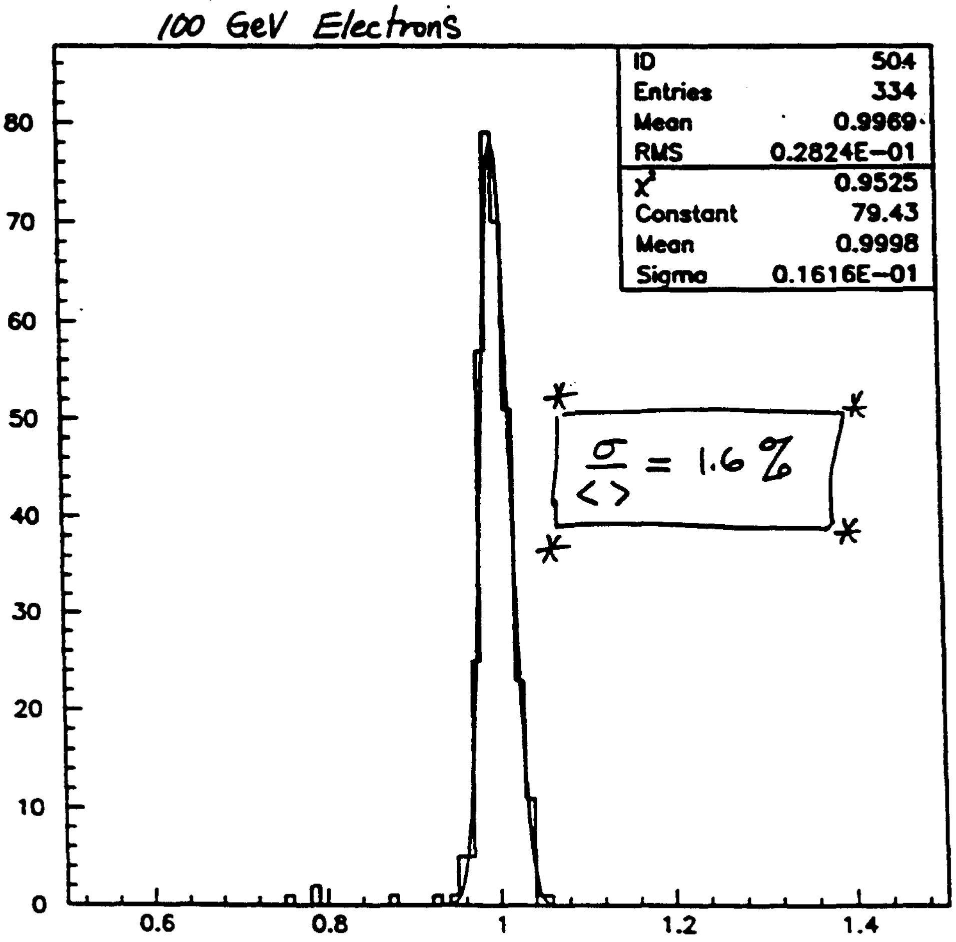
With modest scint. improvement (~2), damage factor: $e^{-D/10\ Mr}$.
This implies at $|\eta|=3$, $L=10^{33}$, 50% damage after ~12 years.
With 2 long. EM sections, this loss can be corrected event by event to $\Delta\sigma/E = 1\%$.
Longitudinal masking can also be used to greatly reduce damage effects.

ESTIMATES ON REPLACEMENT OF ALL EM SCINT. IN ENDCAP

1 - 1.5 months with one shift.

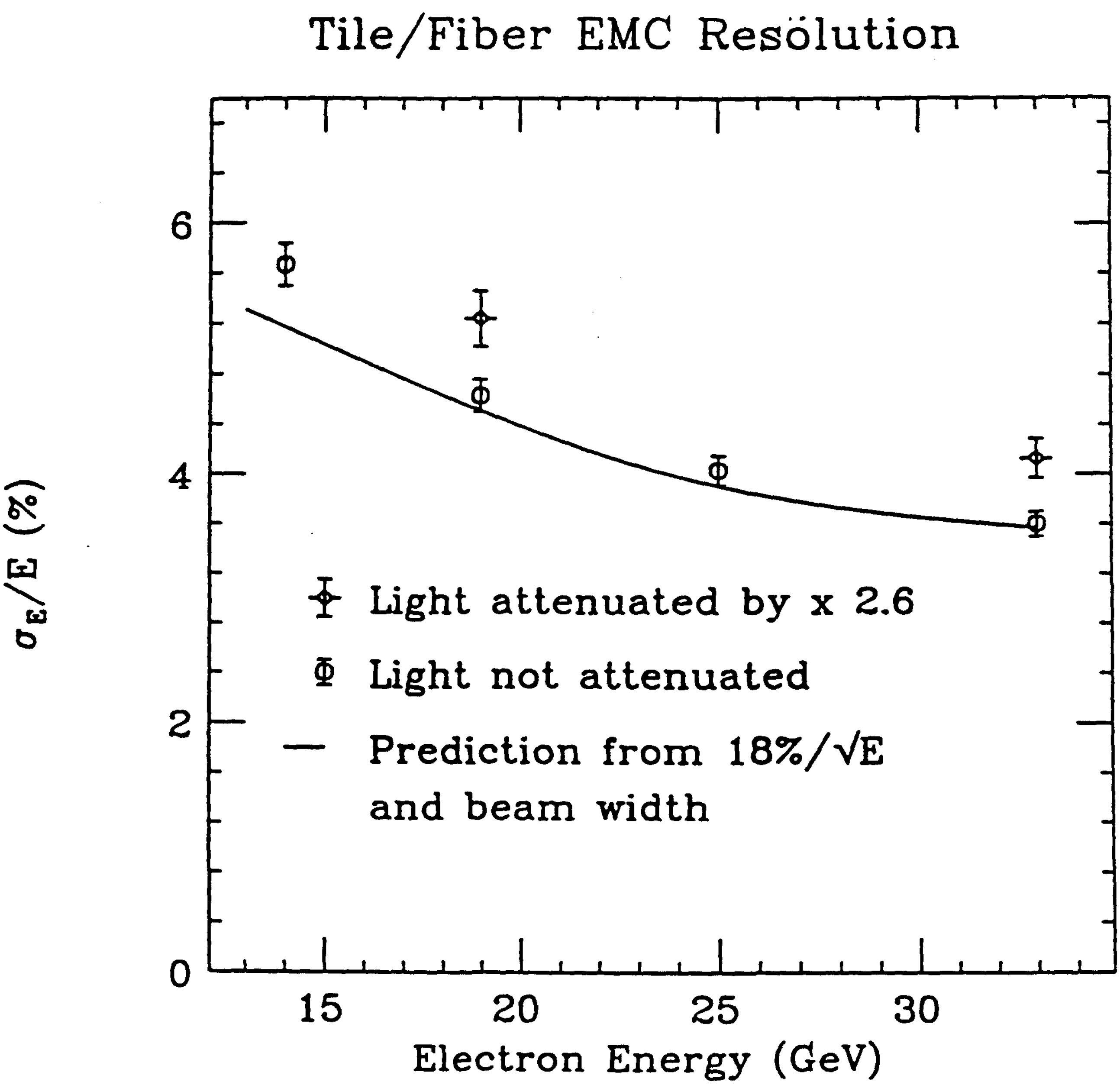


SDC
CAST PB
MODULE



CDF
MODULE

TEST OF PHOTOELECTRON STATISTICS



E	σ_E/E Unatten.	Atten.	σ_N/σ_0	Unattenuated photoelectrons	P.E./E
33 ~~19~~ GeV	3.6%	4.1	0.4	3905	118 ± 24 /GeV
19 ~~33~~	4.6	5.2	0.4	2657	139 ± 35 / GeV

PRELIMINARY BEAM TEST RESULTS

Liquid Argon (Brookhaven)

EM module	6 mm Pb plates	
$\sigma/E = 18\%/\sqrt{E}$		
Hadronic module	12 mm Pb plates	
$\sigma/E = 64\%/\sqrt{E}$		

From fit to e/π data, e/h = 1.23 => 3.2% constant term

Scintillator tile / fiber (Fermilab)

ANL EM module	5 mm Pb	2.5 mm Scint.
$\sigma/E = 18\%/\sqrt{E}$		
CDF EM module	4.8 mm Pb	4 mm Scint.
σ/E = 1.6% for 100 GeV e		
CDF hadronic	5 cm Fe	4 mm Scint.
σ/E = 8% for 150 GeV π		

EM Photoelectron yields scaled to SCSN81 and SDC tile/Pb

ANL	80 Pe/GeV
CDF	150 Pe/GeV
(Uncomfortably low?	increase SDC tile to 4 mm for EM)

CONCLUSIONS

The SDC has adopted scintillating tile with WLS fiber as the technology for the central calorimetry.

The choice of hadronic absorber in HAC1, and its geometrical relation to the current sheet in the magnet still have to be determined. A committee is being set up, and it is expected that this decision can be made by the SDC November meeting.

There is still much R&D to be done to ensure that radiation damage effects do not degrade performance, and that an adequate calibration/monitoring system is implemented.

With the choice of a single calorimeter technology, it is essential to bring together the efforts from ALL the groups which were working on central calorimetry to ensure that adequate intellectual and technical power is brought to bear on the design of the SDC central calorimeter.

TECHNICAL REVIEWS/COMMITTEES

Review of Front-End Electronics Status (Sept. 9 - 11)
Review committee:
- Electronics/DAQ/Trigger Steering Committee
- Eight other experts from SDC (engineers & physicists)
- Five non-SDC experts

Muon tracking chamber review committee
- Recommend choice of muon chamber design (Feb. 1, 1992).
- Chairpersons: A. Maki, R. Thun

Hadronic absorber evaluation committee
- Evaluate calorimetric impact of various absorber configurations (November SDC meeting).
- Chairperson: J. Siegrist

Central tracking review committee
- Recommend configuration(s) contained in tech. proposal (Feb. 1, 1992)
- Chairperson: T. Kondo

M. Gilchriese

PAC Meeting
October 3-4, 1991

Decisions and Major Reviews

Past

- Tracking volume
- Central calorimetry

Future

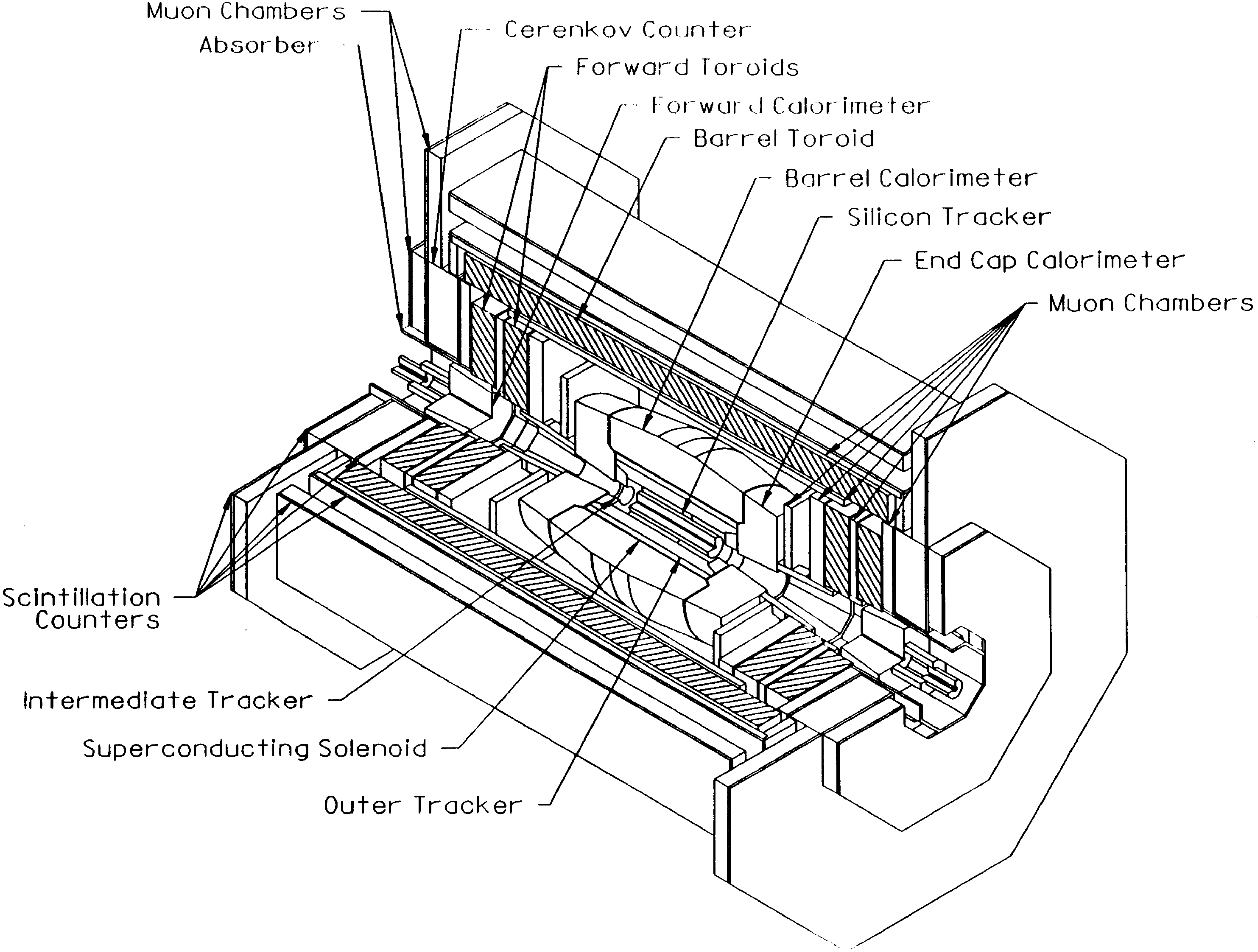
• Forward calorimeter review - what is supported in FY92	Nov. 1
• Central calorimeter absorber configuration	Nov. 17
• Radius of muon system barrel toroid	Nov. 17
• Tracking system review	Nov. 17
• Tracking system option(s) selected	Feb. 1
• Barrel muon chamber design selected	Feb. 1

Detector Dimensions and Parameters

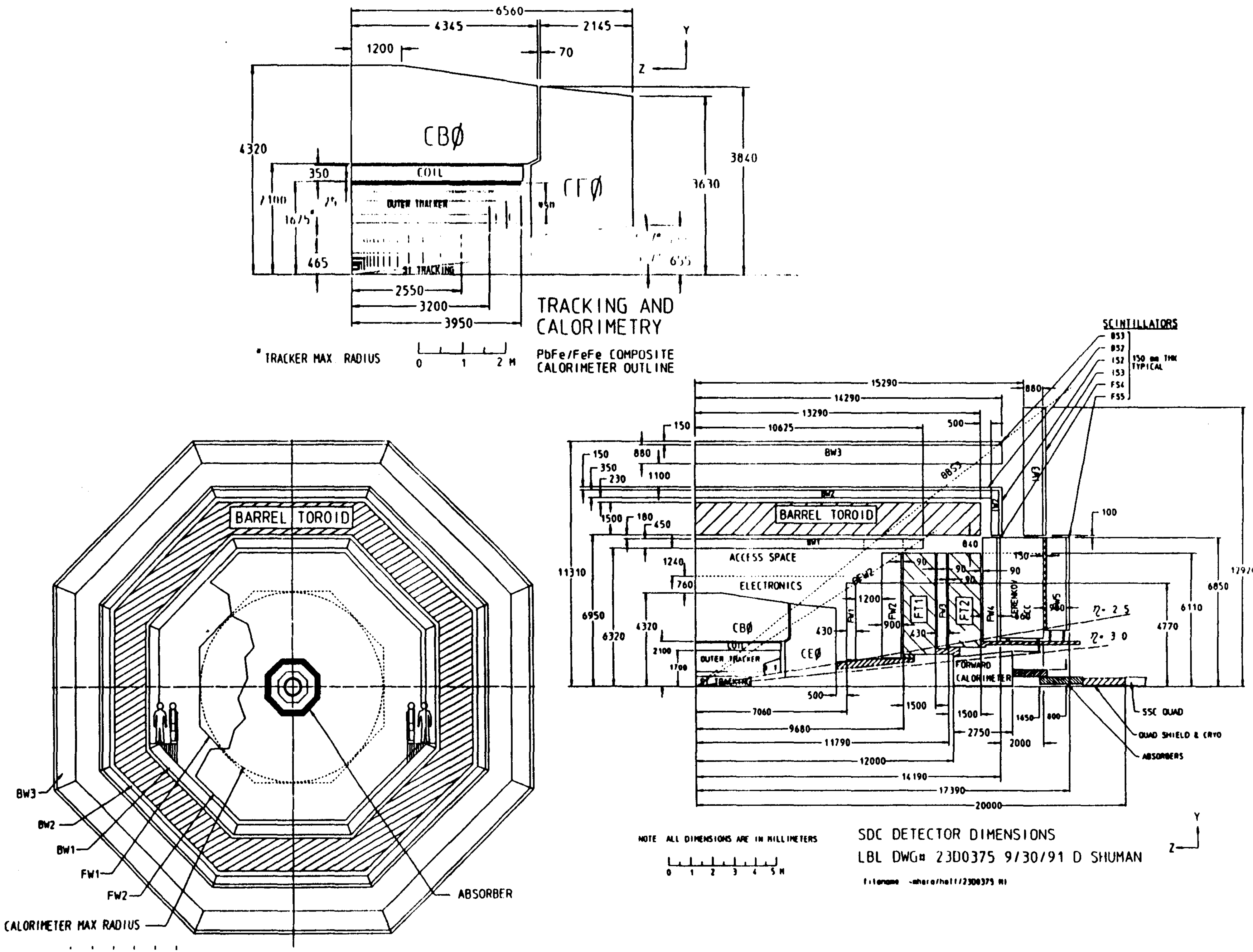
Progress since July PAC meeting

- Tracking volume decision
- Calorimeter decision - precise dimensions of calorimeter remain to be determined. Next step is absorber choice by mid- November
- Electronics and access space on back of calorimeter and associated cable plant. Preliminary study complete. Finalize in mid-November.
- Muon system layout. Particularly thickness of barrel toroid and of inner muon chamber(BW1)

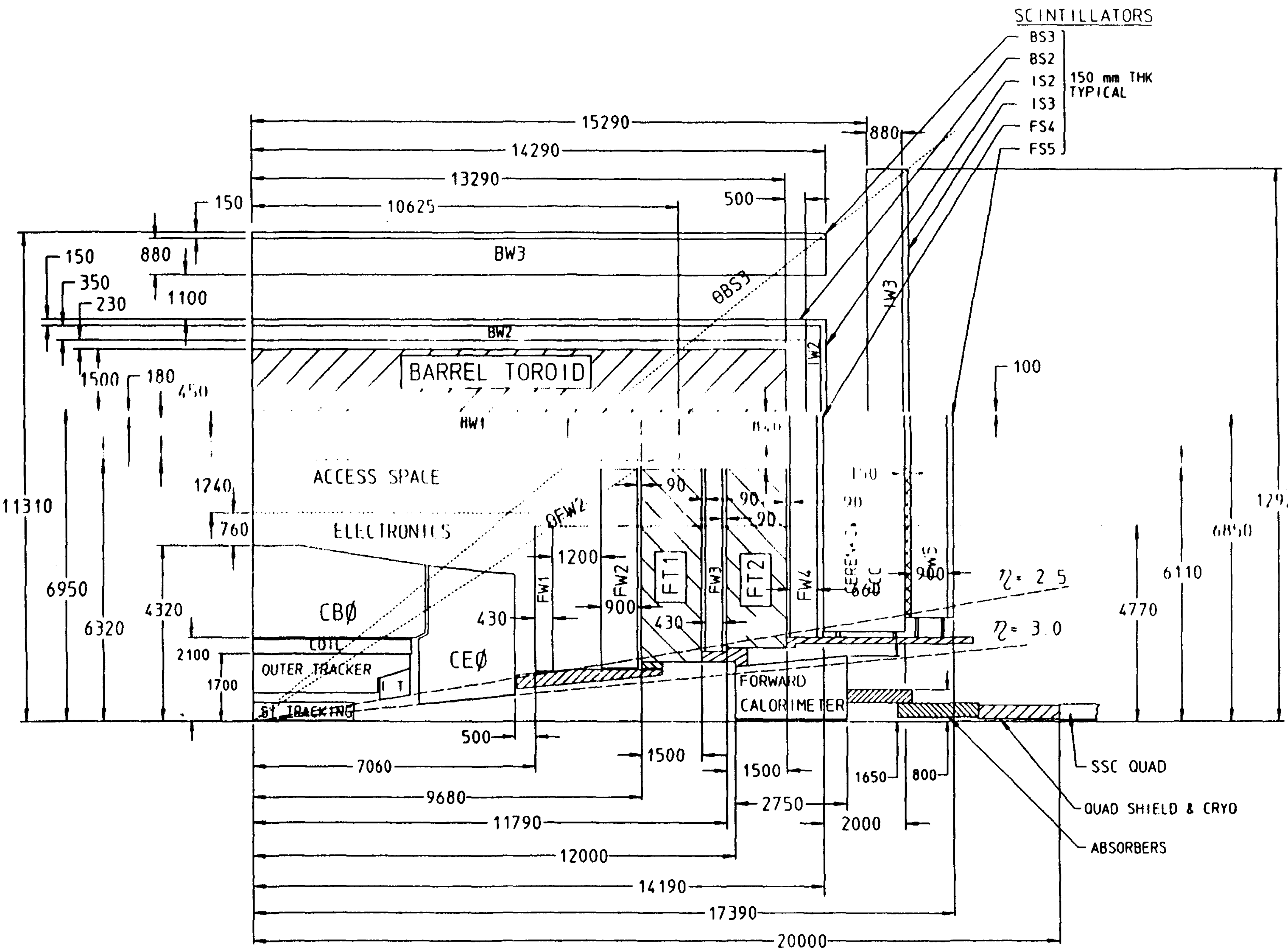
Next major iteration by November 17. Freeze dimensions of muon system and envelope of central calorimeter for Technical Proposal.



The SDC Detector



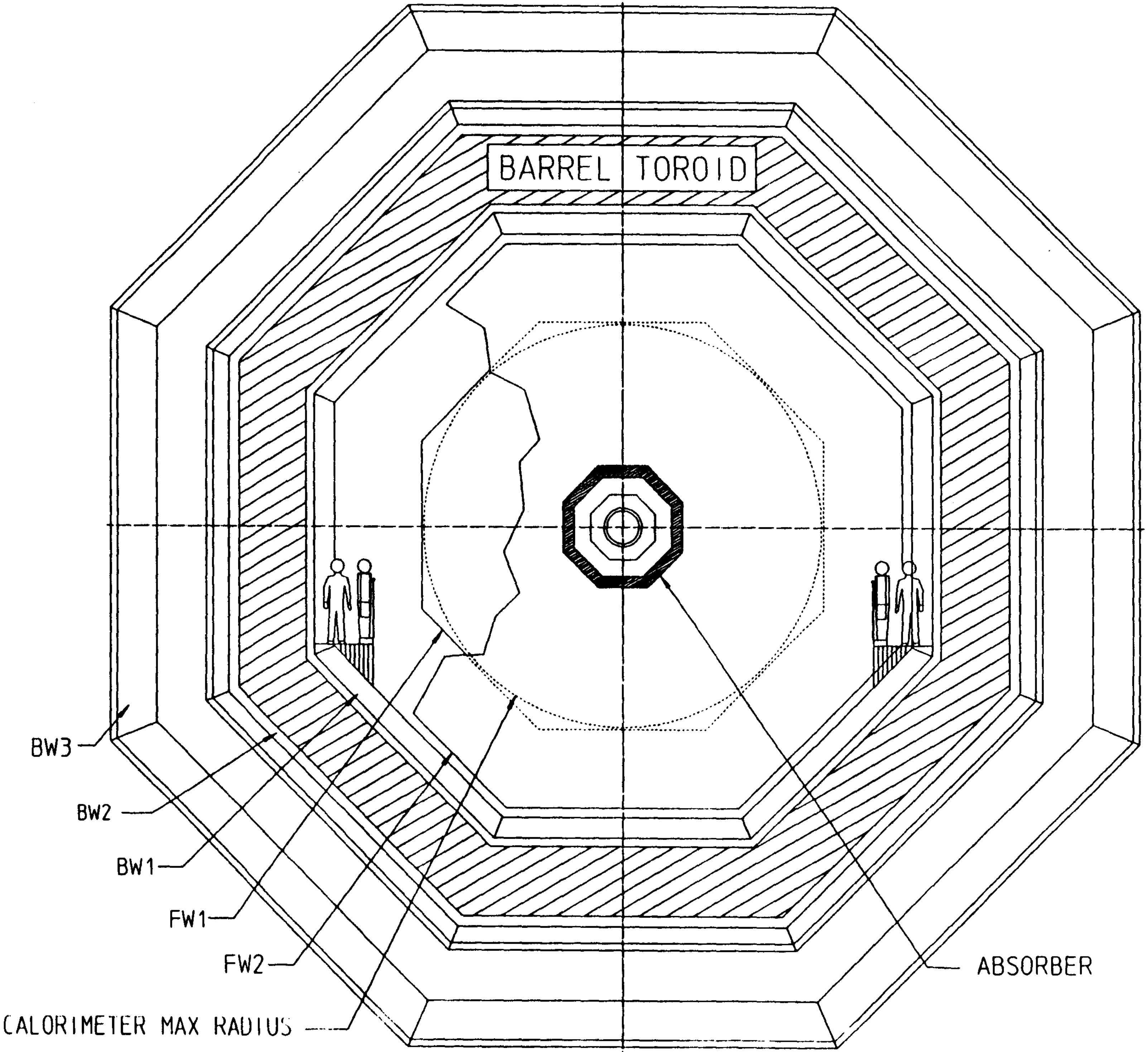
6560
4345
2145
1200
70
Y
Z
4320
3840
3630
CBØ
COIL
CEØ
OUTER TRACKER
SI TRACKING
350
2100
1675*
465
655
2550
3200
3950
TRACKING AND
CALORIMETRY
* TRACKER MAX. RADIUS
0 1 2 M
PbFe/FeFe COMPOSITE
CALORIMETER OUTLINE
SCINTILLATORS
BS3
BS2
FS2
FS3
FS4
FS5
150 mm THK TYPICAL
15290
14290
13290
10625
880
500
BW3
BW2
BW1
BARREL TOROID
ACCESS SPACE
ELECTRONICS
11310
6950
6320
4320
2100
1700
FW1
FW2
FW3
FW4
FW5
FT1
FT2
CERENKOV
FORWARD
CALORIMETER
η = 2.5
η = 3.0
17970
6850
6110
4770
7060
9680
11790
12000
14190
17390
20000
SSC QUAD
QUAD SHIELD & CRYO
ABSORBERS
BW3
BW2
BW1
FW1
FW2
CALORIMETER MAX RADIUS
ABSORBER
NOTE ALL DIMENSIONS ARE IN MILLIMETERS
0 1 2 3 4 5 M
SDC DETECTOR DIMENSIONS
LBL DWG# 23D0375 9/30/91 D SHUMAN

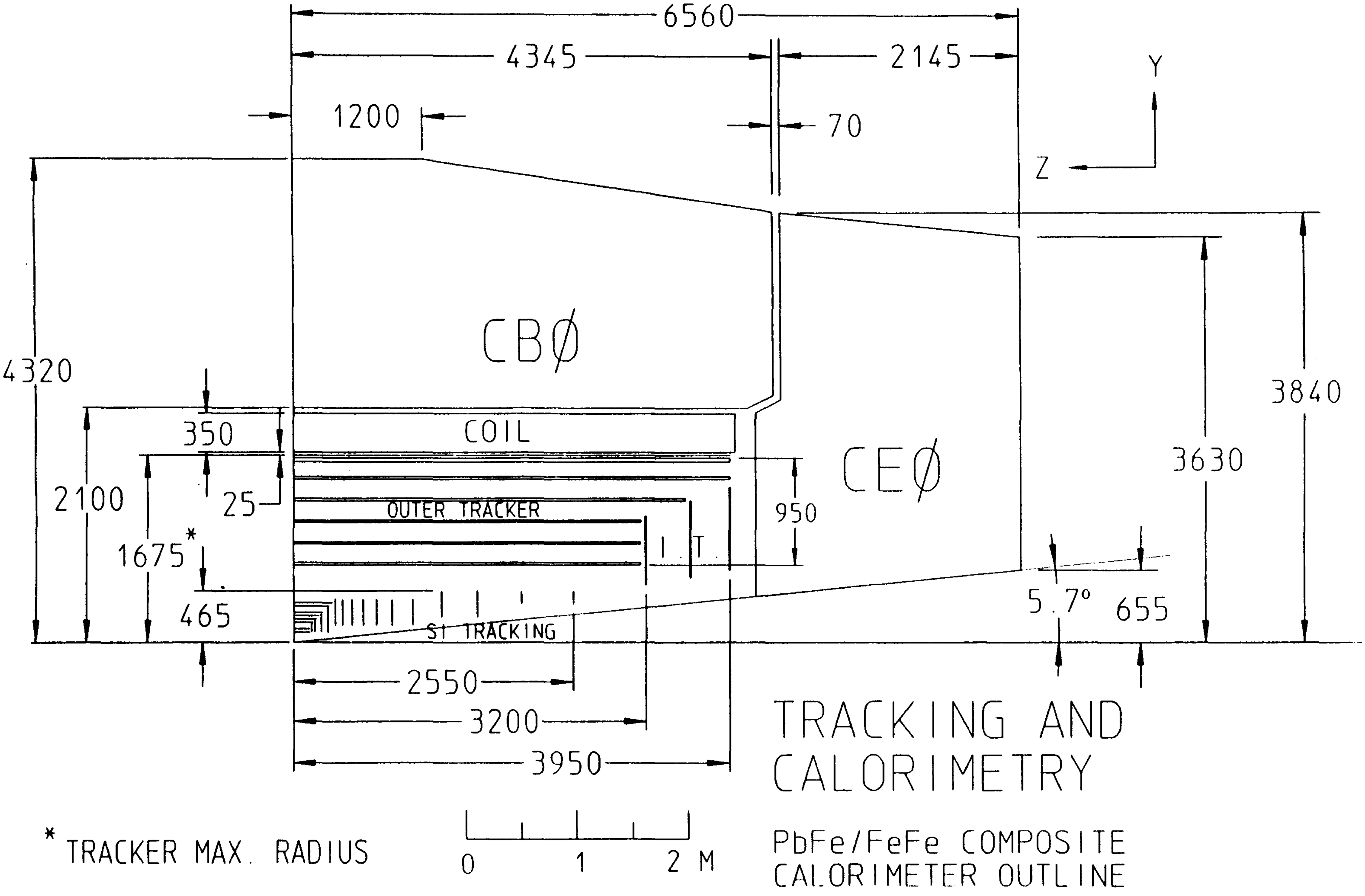


NOTE. ALL DIMENSIONS ARE IN MILLIMETERS.

SDC DETECTOR DIMENSIONS

LBL DWG# 23D0375 9/30/91 D. SHUMAN


BARREL TOROID
BW3
BW2
BW1
FW1
FW2
CALORIMETER MAX RADIUS
ABSORBER


6560
4345
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Y
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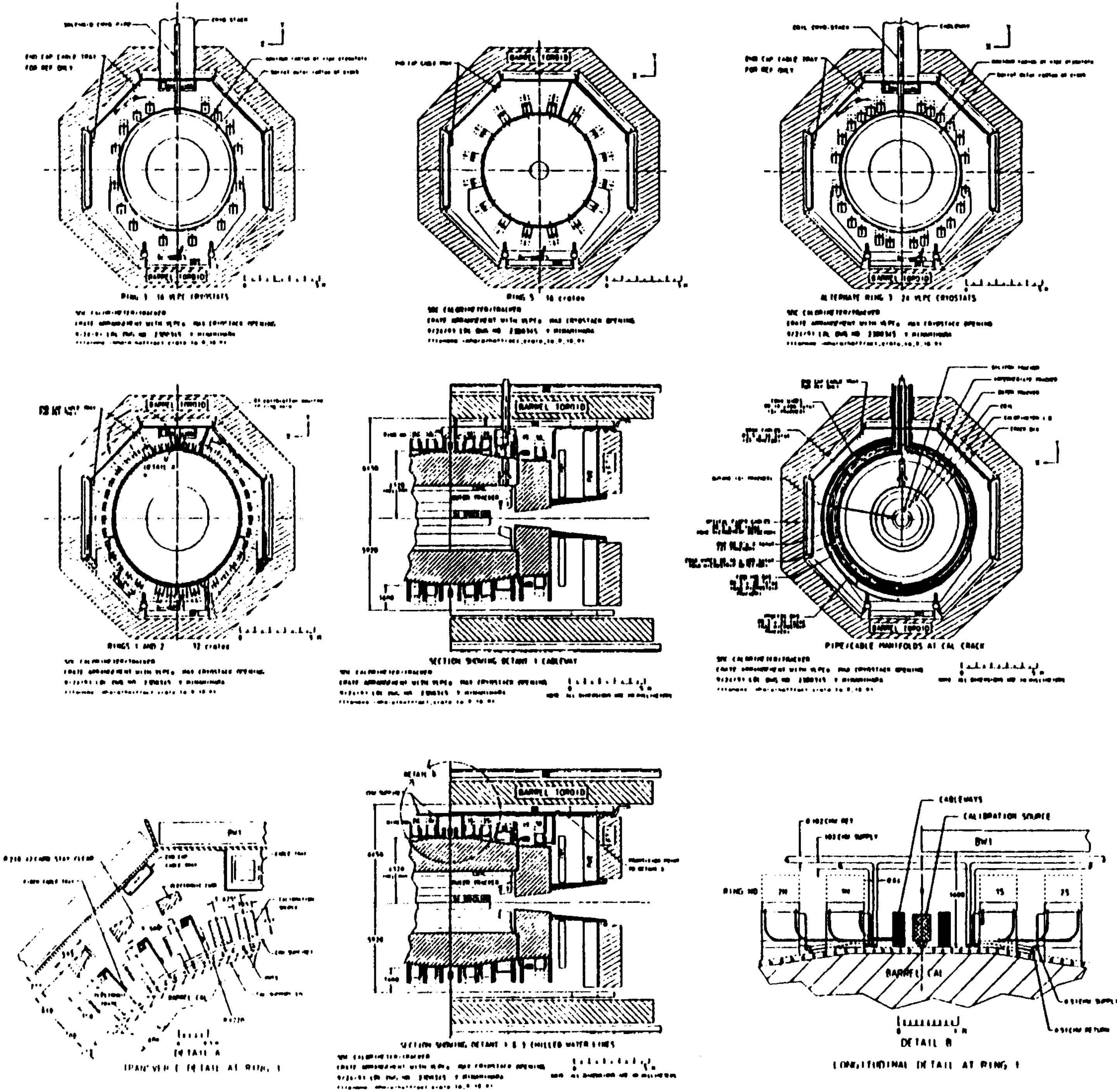
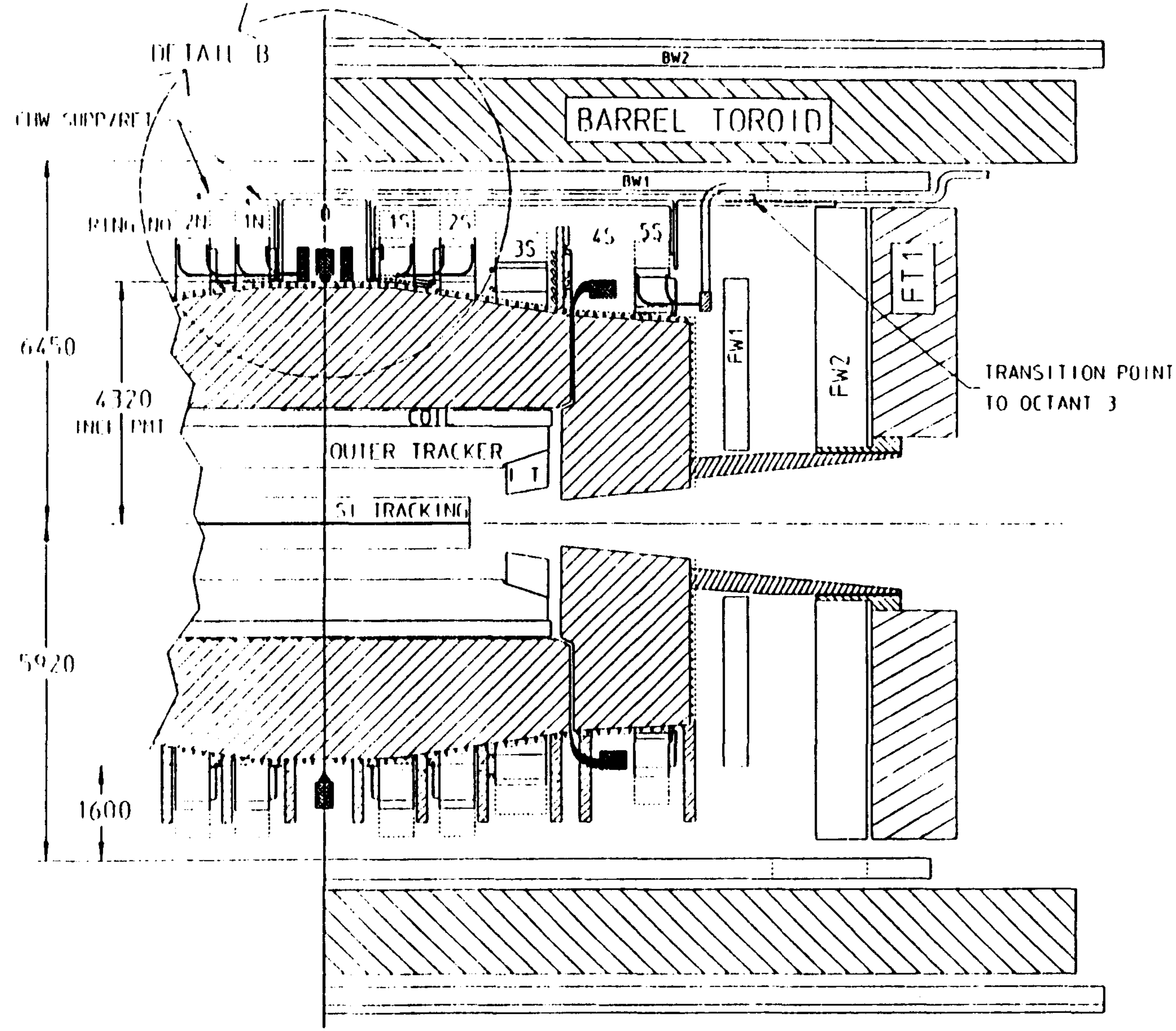
4320
CBØ
CEØ
COIL
350
25
2100
1675*
465
OUTER TRACKER
I.T.
SI TRACKING
950
3630
3840
5.7°
655
2550
3200
3950
0
1
2 M
* TRACKER MAX. RADIUS
TRACKING AND CALORIMETRY
PbFe/FeFe COMPOSITE CALORIMETER OUTLINE



LBL SDC 0051
9/23/91



SECTION SHOWING OCTANT 1 & 3 CHILLED WATER LINES

SDC CALORIMETER/TRACKER

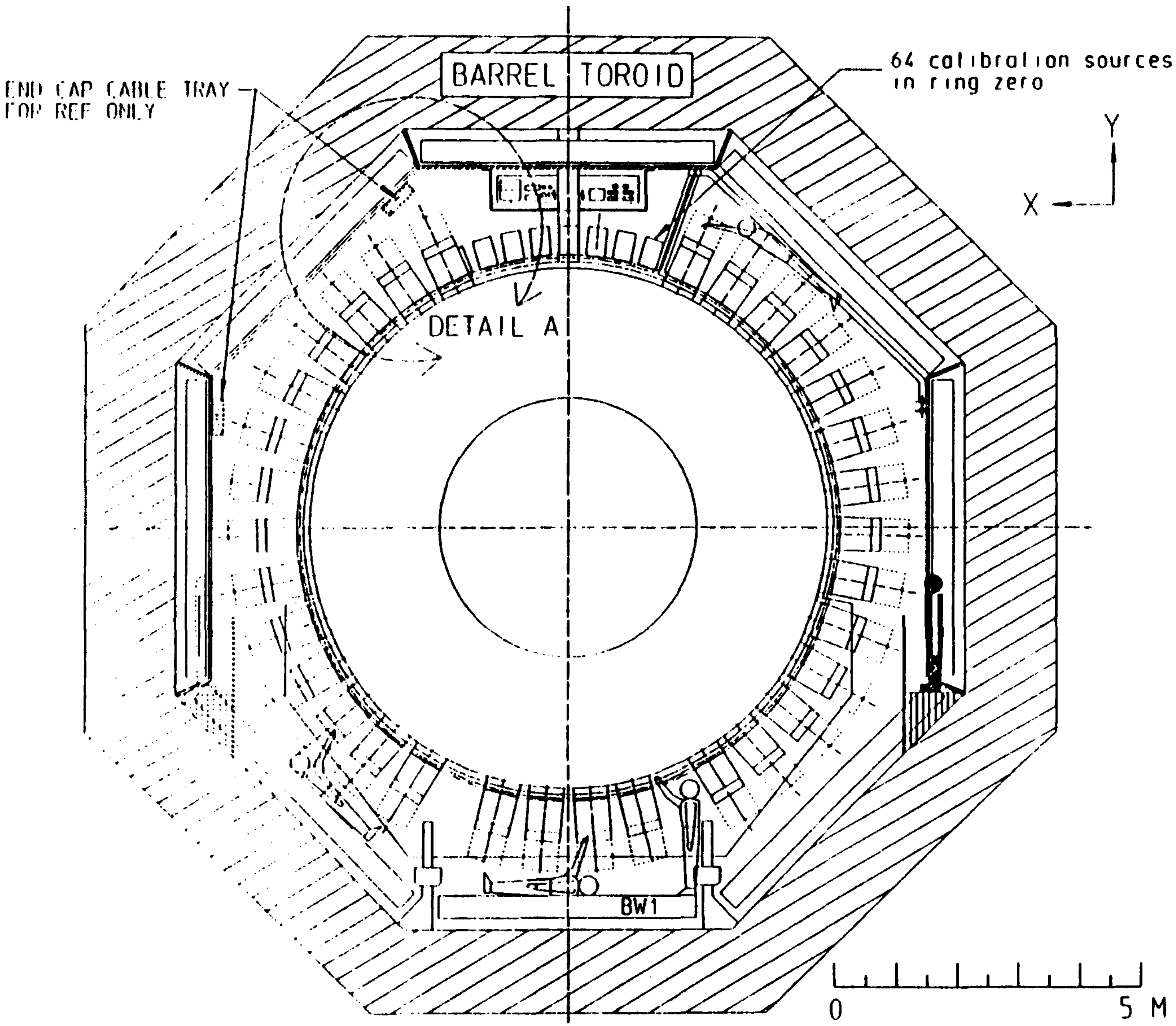
CRATE ARRANGEMENT WITH VLPCs, MAX CRYOSTACK OPENING

9/24/91 LBL DWG NO 23D0345 Y MINAMIHARA

Filename mhara/hoff/scr crate lo_9_18_91

0 5 M

NOTE ALL DIMENSIONS ARE IN MILLIMETERS.

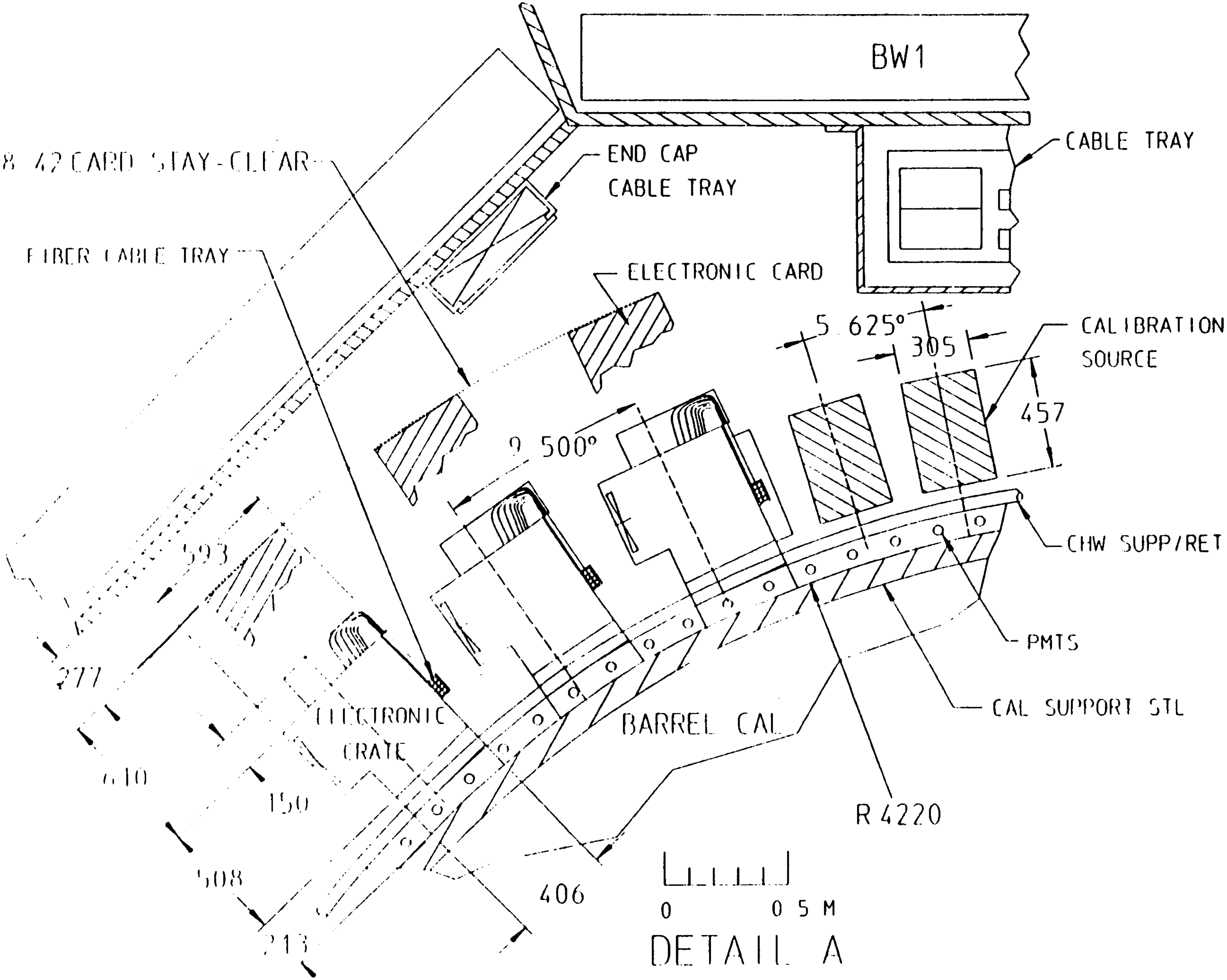


RINGS 1 AND 2 32 crates

SDC CALORIMETER/TRACKER

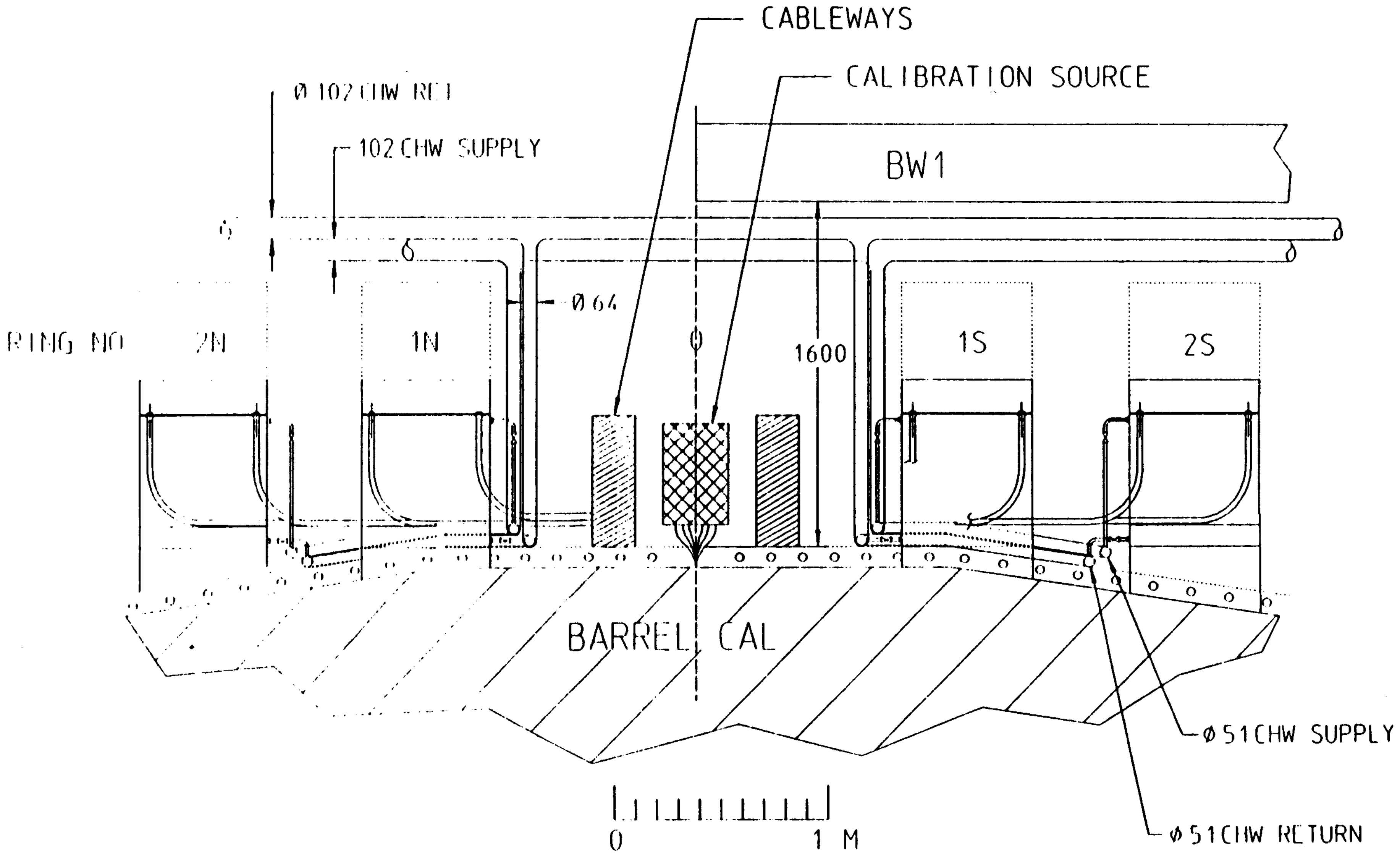
CRATE ARRANGEMENT WITH VLPCs, MAX CRYOSTACK OPENING

9/24/91 LBL DWG NO 23D0345 Y MINAMIHARA



DETAIL A

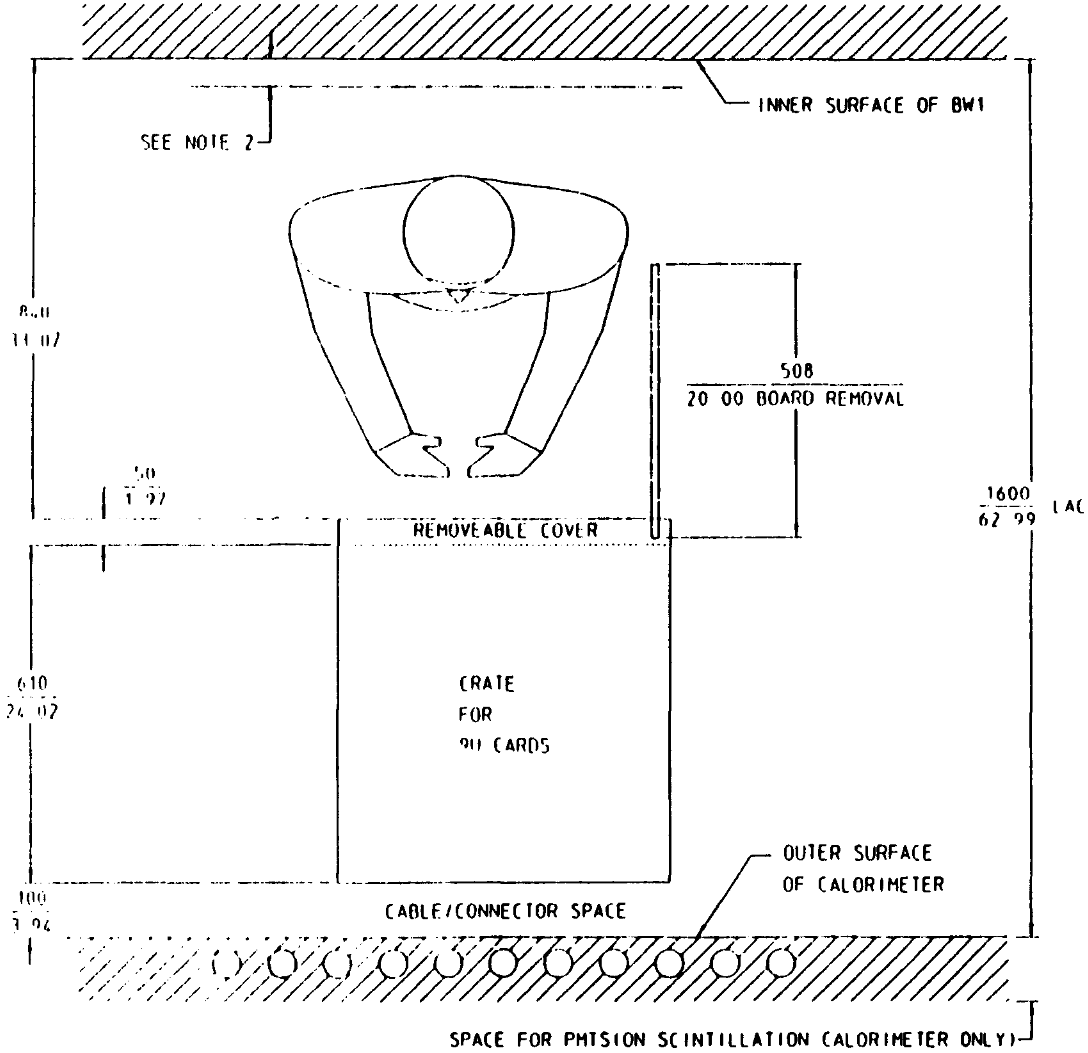
TRANSVERSE DETAIL AT RING 1



DETAIL B

LONGITUDINAL DETAIL AT RING 1

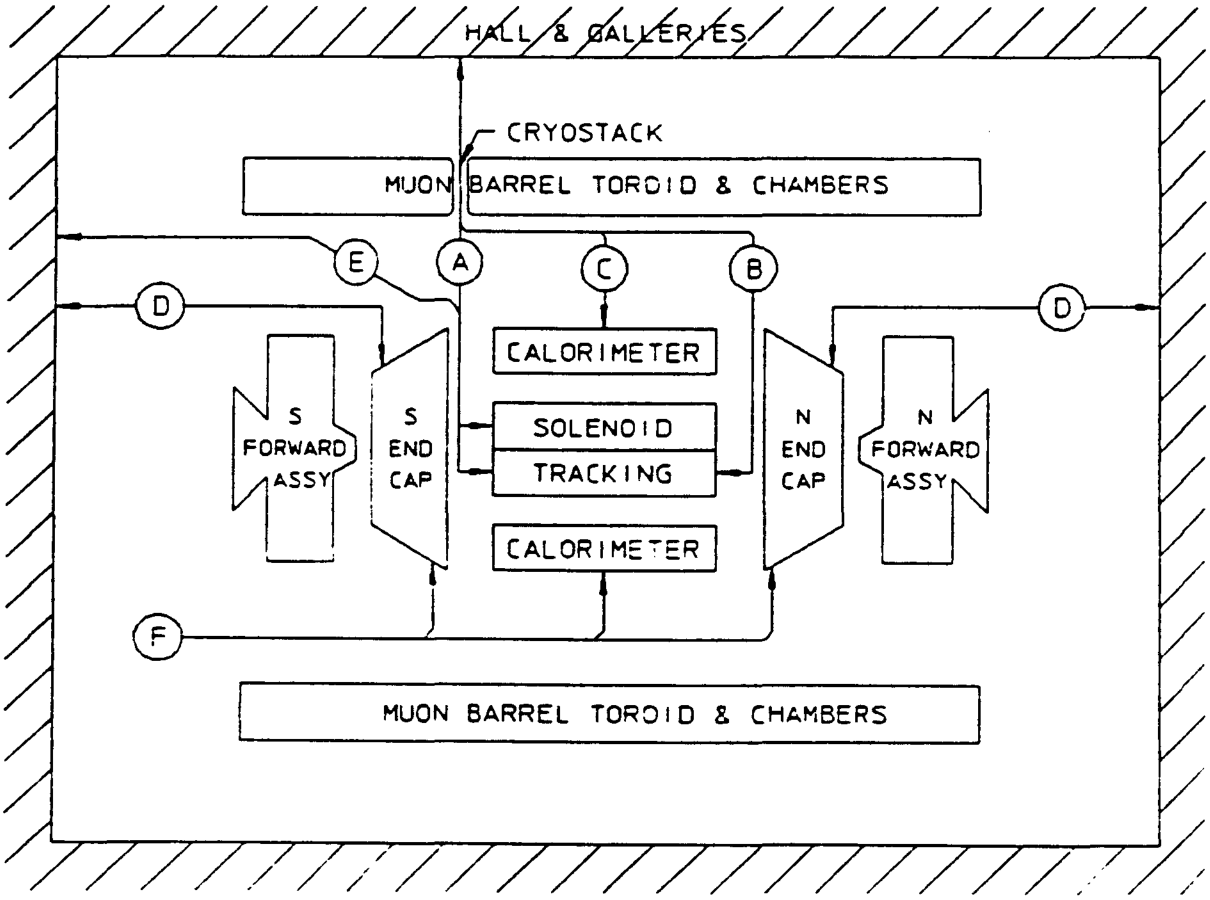
A4: CRATE & ACCESS RADIAL SPACE



NOTE 1 ALL DIMENSIONS ARE IN MM OVER INCHES

2 AT SOME LOCATIONS SOME PIPES/CABLES & SUPPORTS WILL REDUCE THIS CLEARANCE

LBL SDC 0051
9/23/91



A1: SCHEMATIC DIAGRAM OF CABLE & PIPING ROUTES
(with maximum use of the cryostack)

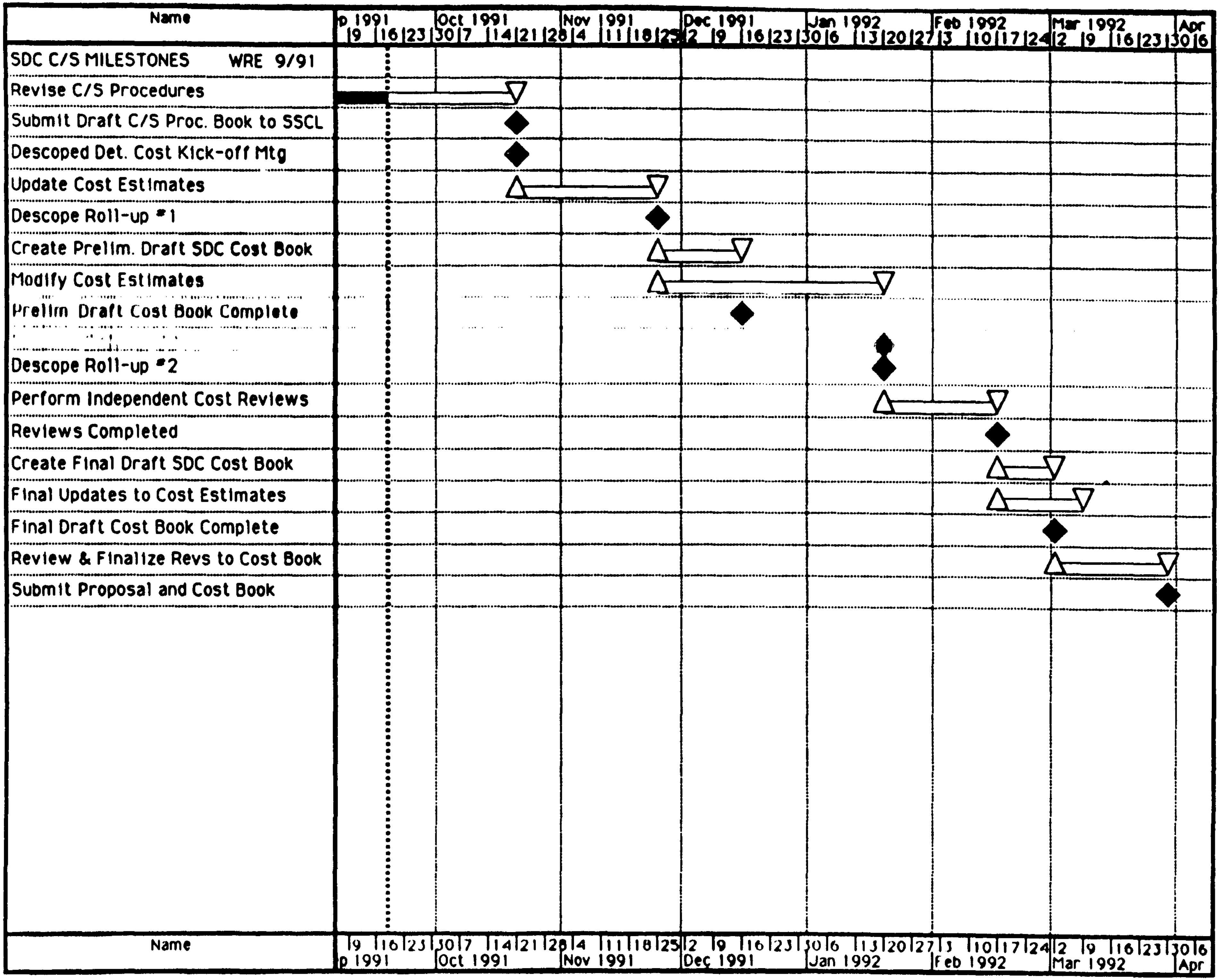
Route	Via Octant	Description of services
A	1, cryostack	Solenoid, all services. Silicon tracker, all except butane pipe (see E). Straw or Fiber tracker, all services. Gas microstrip, all services.
B	1, cryostack	Same as A except no solenoid services.
C	1, cryostack	Calorimeter and internal crate services, except cooling water (see F
D	7, South	South endcap, all services except cooling water (see F).
	8, North	North endcap, all services except cooling water (see F).
E	7, South	Butane for silicon tracker.
F	3, South	Cooling water for all crates

Cost

- Use existing database to aid in technology selections and scope definition
- Improve mechanics of estimating/scheduling
- Plan for cost/schedule estimate to be included with Technical Proposal
  - see schedule of events
- Present estimate - total cost including contingency

System	Cost(FY91 M$)
Tracking systems†	95
Calorimeter systems	160
Superconducting solenoid	35
Muon system	120
Electronics systems	100
On-line computing	10
Conventional systems	10
Installation and test	30
Project management	20
TOTAL	580

† Includes silicon front-end electronics


Name
p 1991
Oct 1991
Nov 1991
Dec 1991
Jan 1992
Feb 1992
Mar 1992
Apr
9 16 23 30 7 14 21 28 4 11 18 25 2 9 16 23 30 6 13 20 27 3 10 17 24 2 9 16 23 30 6
SDC C/S MILESTONES WRE 9/91
Revise C/S Procedures
Submit Draft C/S Proc. Book to SSCL
Descoped Det. Cost Kick-off Mtg
Update Cost Estimates
Descope Roll-up #1
Create Prelim. Draft SDC Cost Book
Modify Cost Estimates
Prelim Draft Cost Book Complete
Descope Roll-up #2
Perform Independent Cost Reviews
Reviews Completed
Create Final Draft SDC Cost Book
Final Updates to Cost Estimates
Final Draft Cost Book Complete
Review & Finalize Revs to Cost Book
Submit Proposal and Cost Book

D. Green

PAC Meeting
October 3-4, 1991

SDC CALORIMETRY

1) WHAT HAVE WE DONE?

a) REQUIREMENTS } DESCOPE
COR-LA, COR-TF } SIMULTANEOUSLY
CHOICE *

b) FY91 R+D

OPTICS, CALIBRATION, RADIATION DAMAGE, ETC. (KEK, BEIJI[NG], ORSA[Y])

CULMINATING IN BEAM TESTS

MP: ANL/WSTC, SM/PS
MT: FNAL HANGING FILE
CDF UPGRADE

2) WHERE ARE WE GOING?

a) Fe/Pb CHOICE — NOV, DEC

b) FY92 PLAN — RETAIN ALL INTERESTED PARTIES

c) DESIGN REPORT

CALORIMETER CONCEPTUAL DESIGN
TILE/FIBER SCINTILLATOR OPTION

Volume I

September 3, 1991

SDC Tile/Fiber Calorimeter Group

2 TILE/FIBER: Fe/Pb

MODEL A

HAC1 - Fe

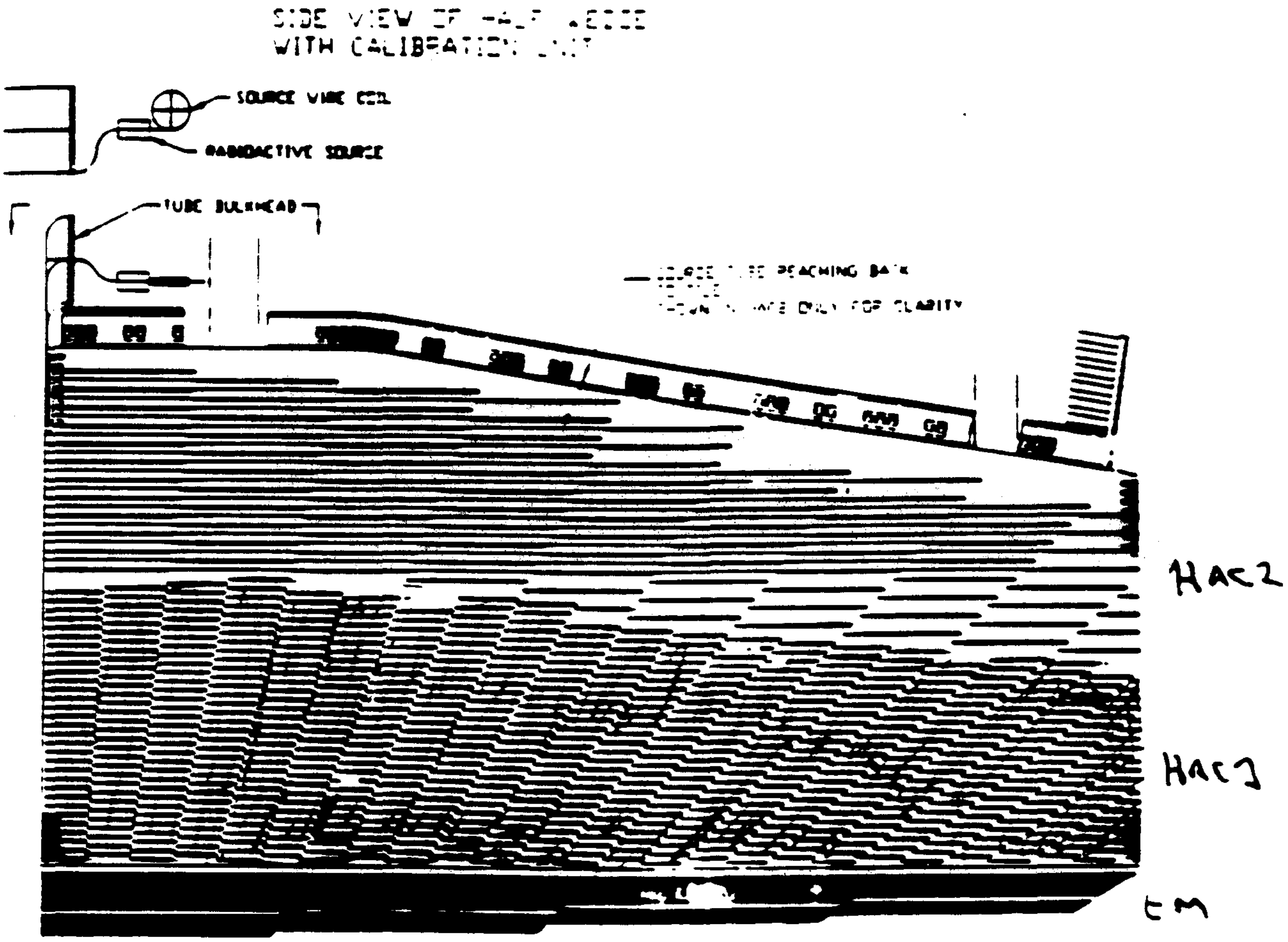
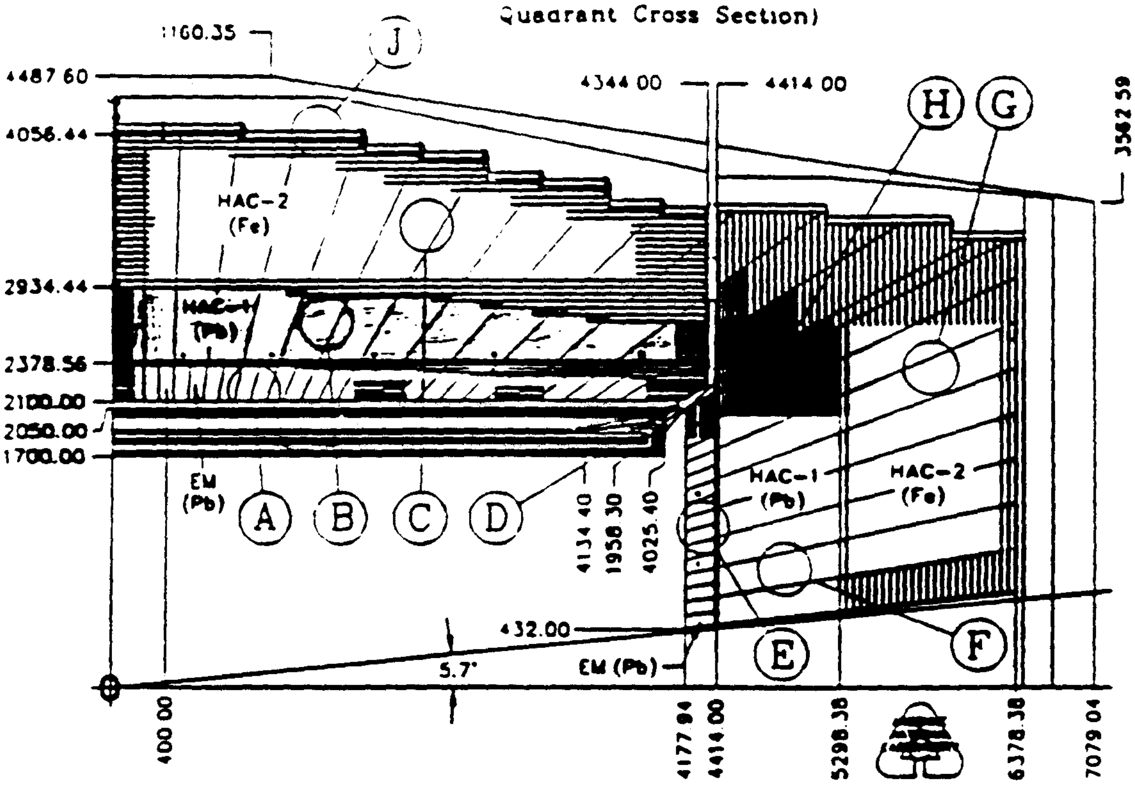


Figure 3.1(d) - Side views of a typical barrel calorimeter wedge, showing pattern of staggered slots in the iron calorimeter, PMTs, and source drives.

MODEL 3 - HAC2 Pb

Tile/Fiber Descope 4 Calorimeter

(Quadrant Cross Section)



Tile/Fiber Descope 2 Calorimeter

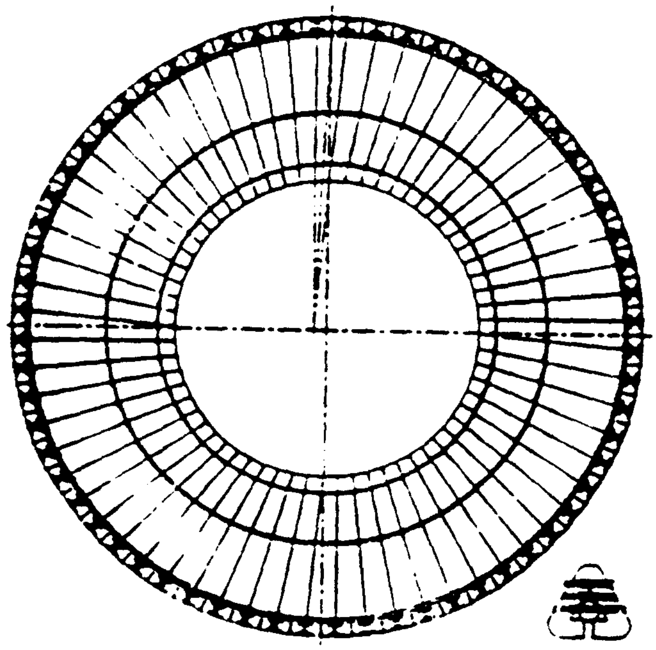


Figure 4.1 a)MODEL B Quadrant Cross section, b) End Section

MP TEST BEAM

EM CAST Pb — ANL/WSTC

How good are the pieces?

- Absorber Thickness

  $\sigma = 1\%$

- Optical System

  Testing system

  Light Yield 3 p.e./mip-layer

  Transverse uniformity $\sigma \sim 1\%$

  Longitudinal uniformity $\sigma = 8\%$

  Scintillator thickness $\sigma = 3.6\%$

  Fibers + splices $\sigma = 3.8\%$

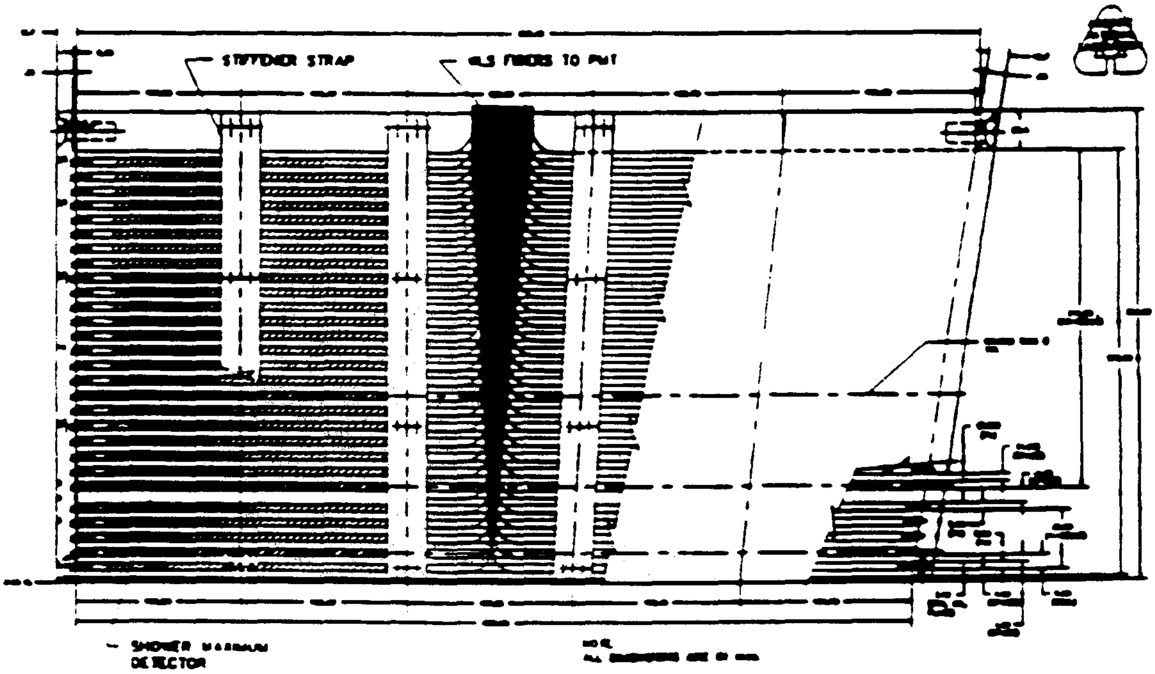
  May want to mask *

QC FINAL PASS

2%

SDC TILE/FIBER CALORIMETER

Truncated EMC Module for Testbeam



FIBER ROUTING

CAST Pb IN Fe BULKHEAD

Figure 4.12 Truncated EM Test Module Design

M.P

How good is the whole calorimeter?

- Testbeam measurements

  September 1-6, 1991

  3 towers instrumented

- Beamline setup

  Momentum tagging to $\sigma = 1.5\%$

  2 gas Cerenkov counters to tag electrons

  Beam 30-50% electrons

  Tunable 15-35 GeV. Can go to 100-150 GeV but rarely

  Data at (15), 19, 25, 33 Ge

  PWC's

- Resolution

  Matches calculation of $18\%\sqrt{E}$ *

  No evidence of constant term

- Uniformity

  Undersize scintillator emphasizes dip at bulkhead

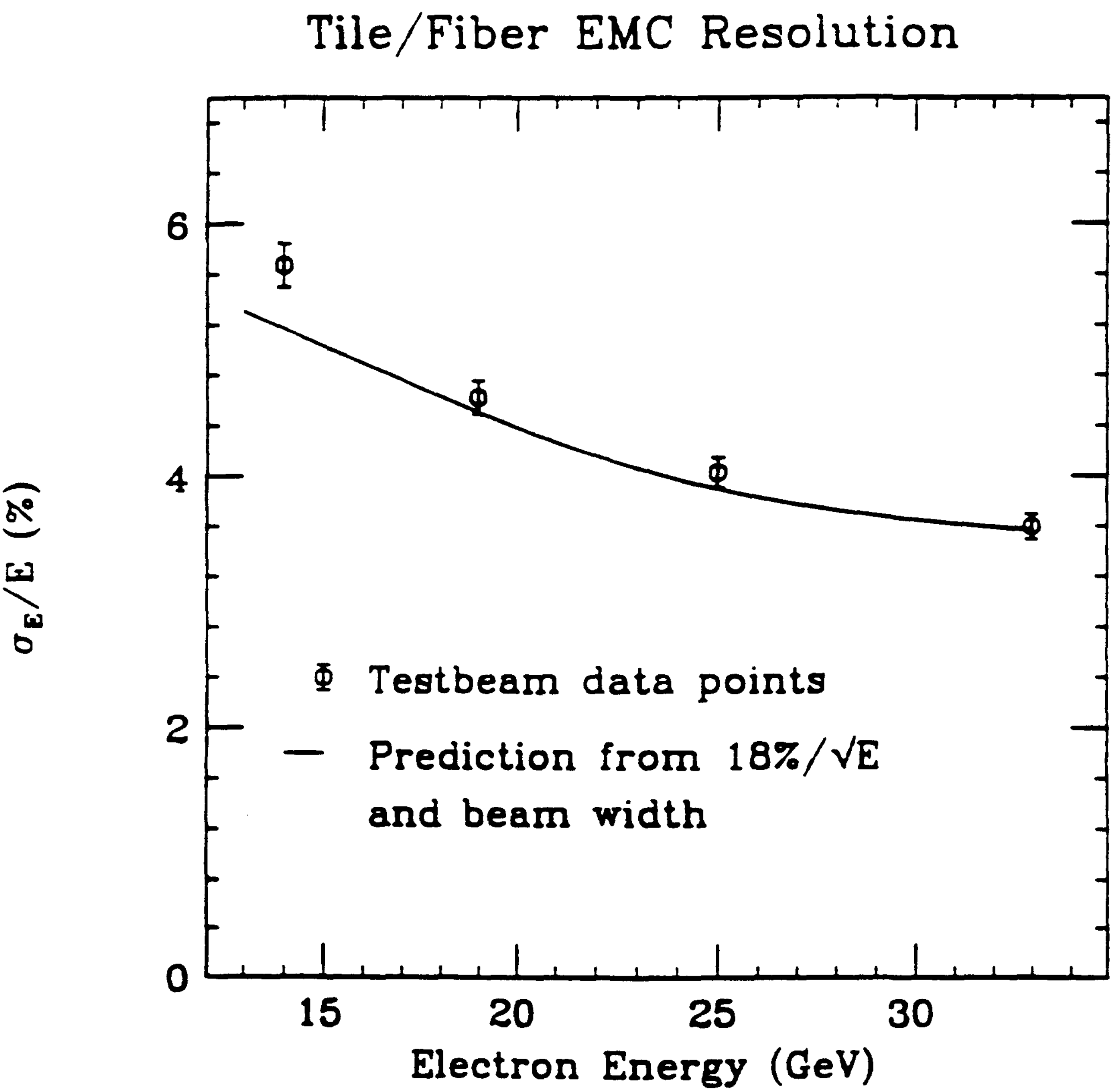
  ...Which is mostly correctable

- Light yield

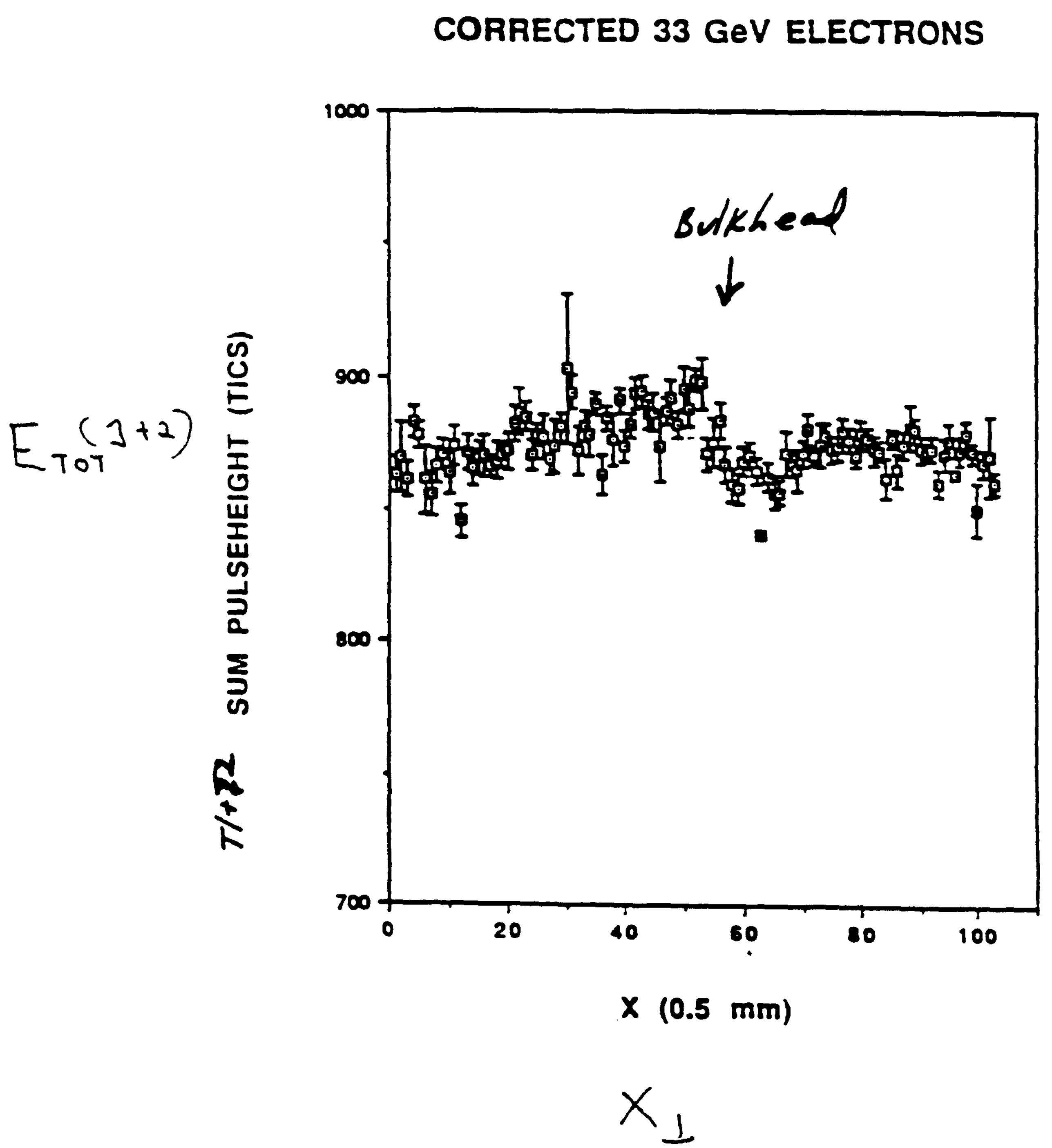
  Light to Tower 1 attenuated by neutral density filter

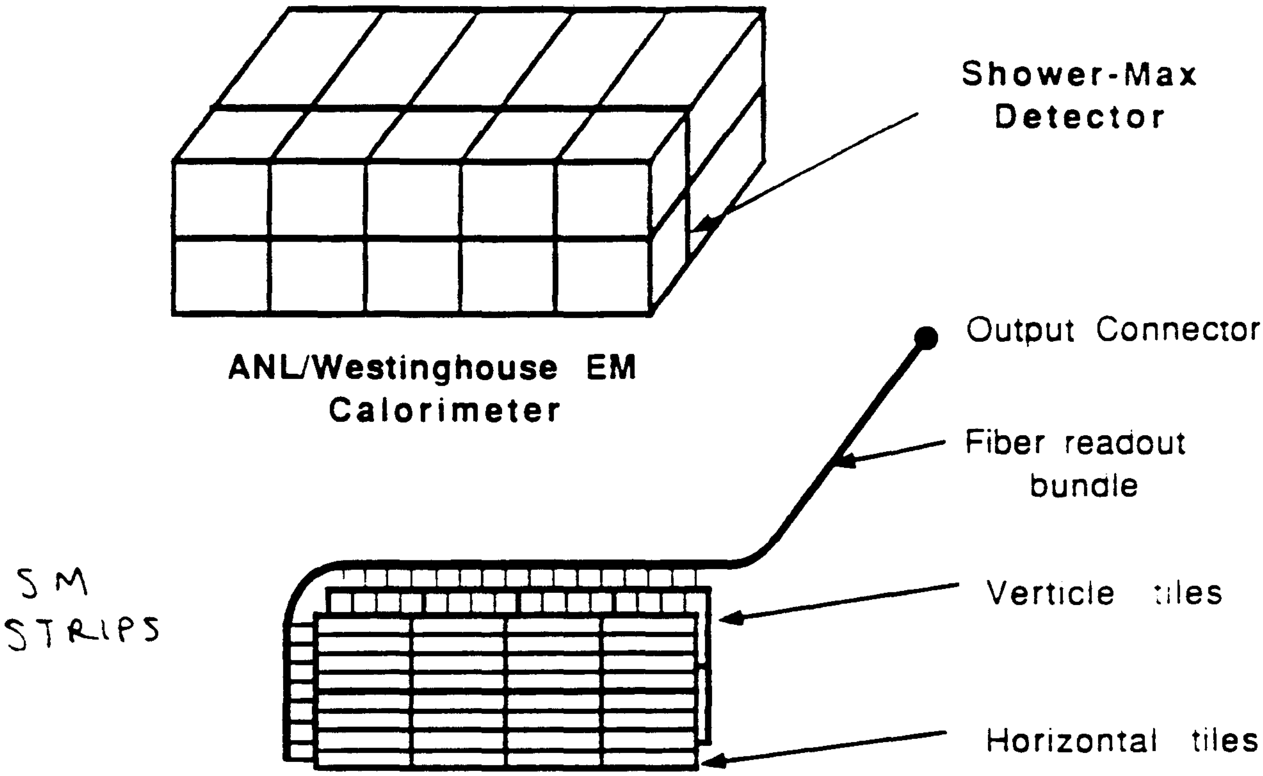
MP

EM RESOLUTION

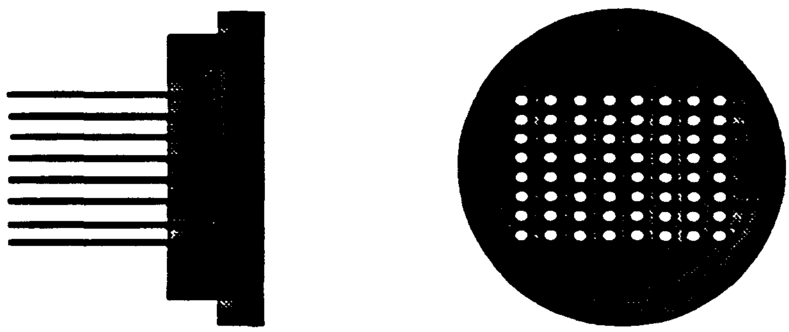


MP: SCAN ACROSS TOWER BOUNDARY





We are equiping 8 out of the 10 towers of both calorimeters with 4 x 4 arrays of tiles read out with wavelength-shifting fibers. In both calorimeters the fibers go to a 64 channel connector.



64 Channel Fiber connector to connect to APD and MCPMT readout.

- Identify practical combinations of

    materials
    thicknesses
    sampling fractions
    gate time

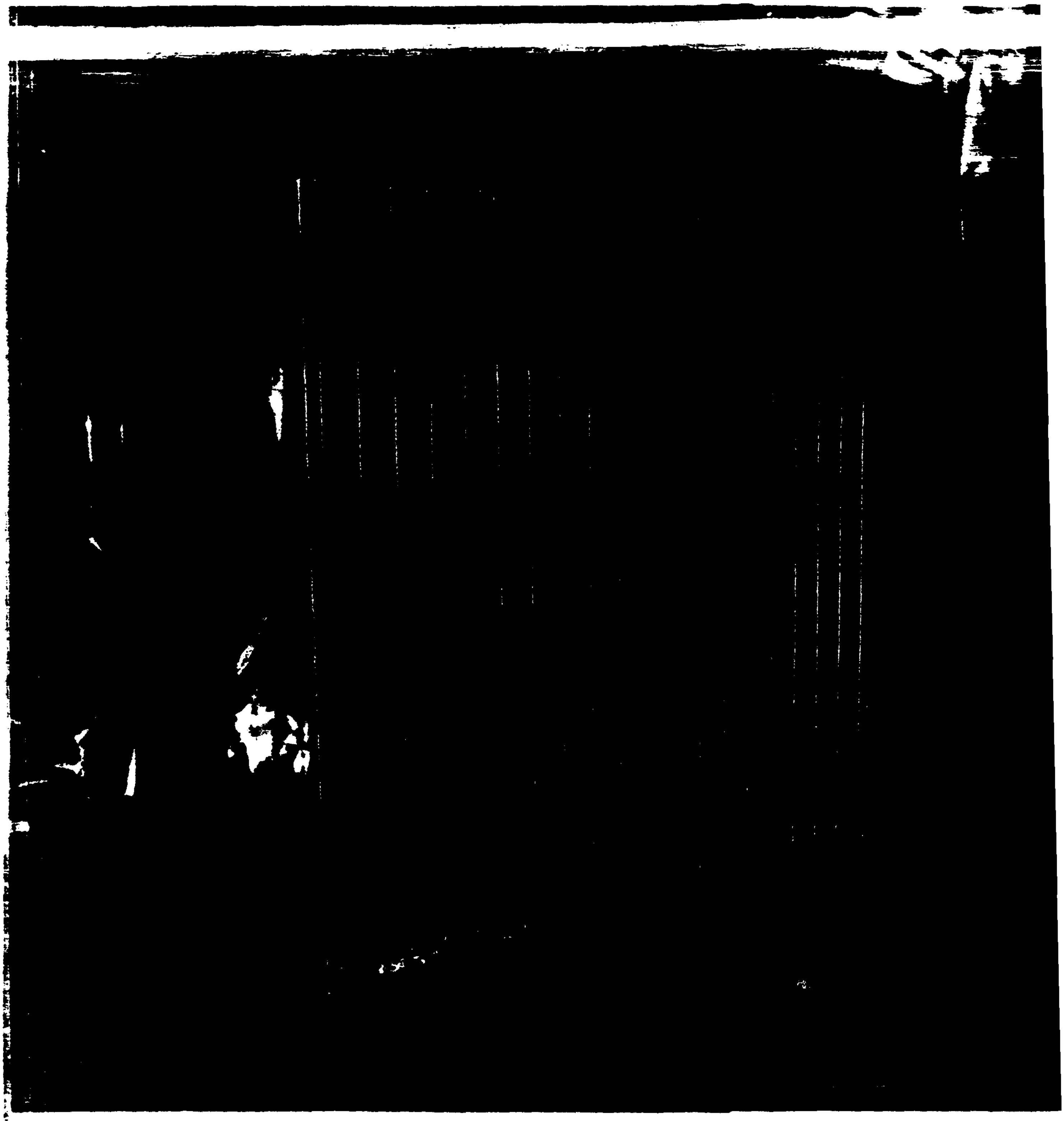
  which will give good resolution
  and $|1 - e/h| < 0.1$

- Provide data with variety of absorbers
  in consistent set of experimental con
  to use to turn up hadronic cascade Monte Carlo

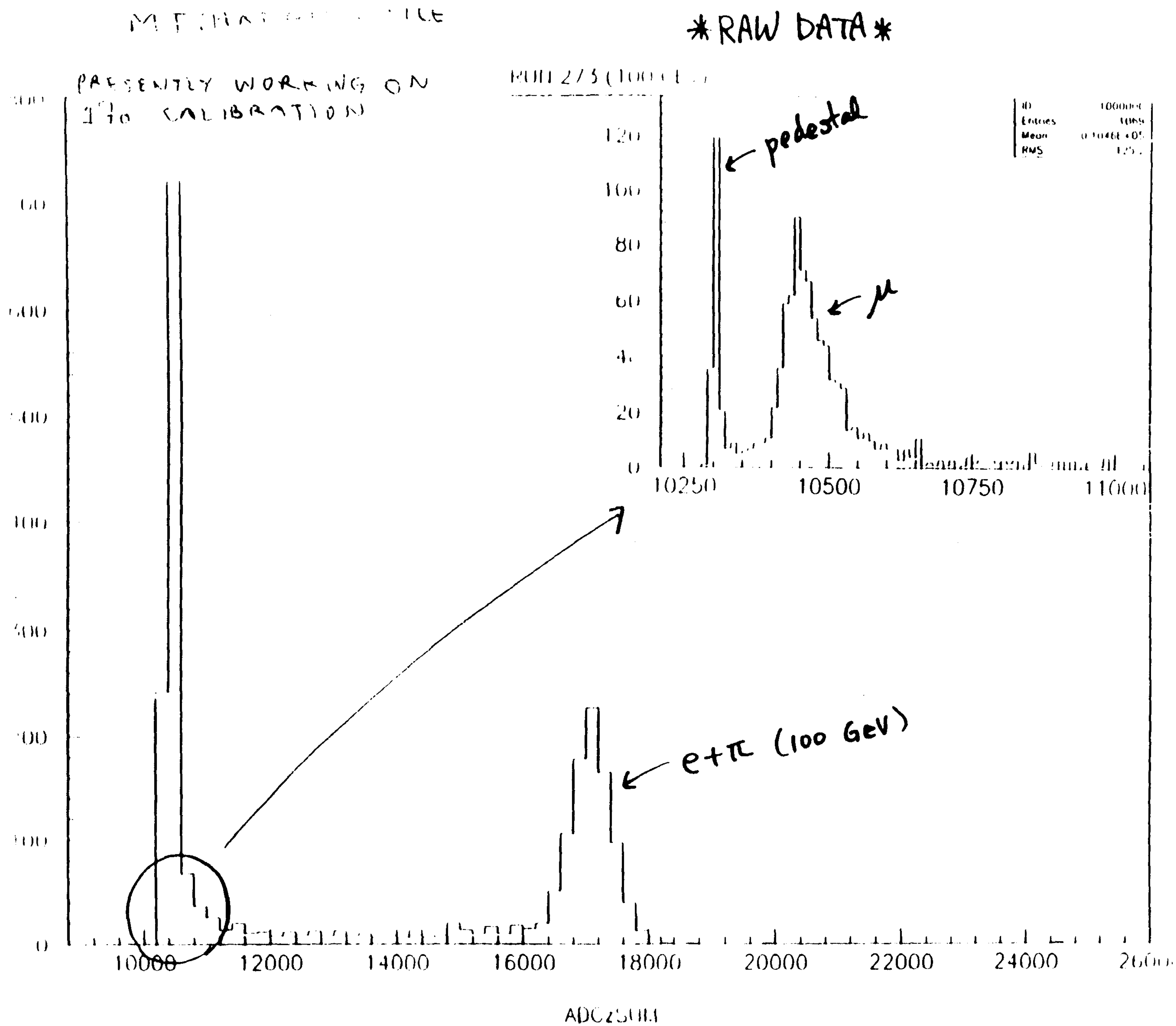
ALL BUILT & INSTALLED

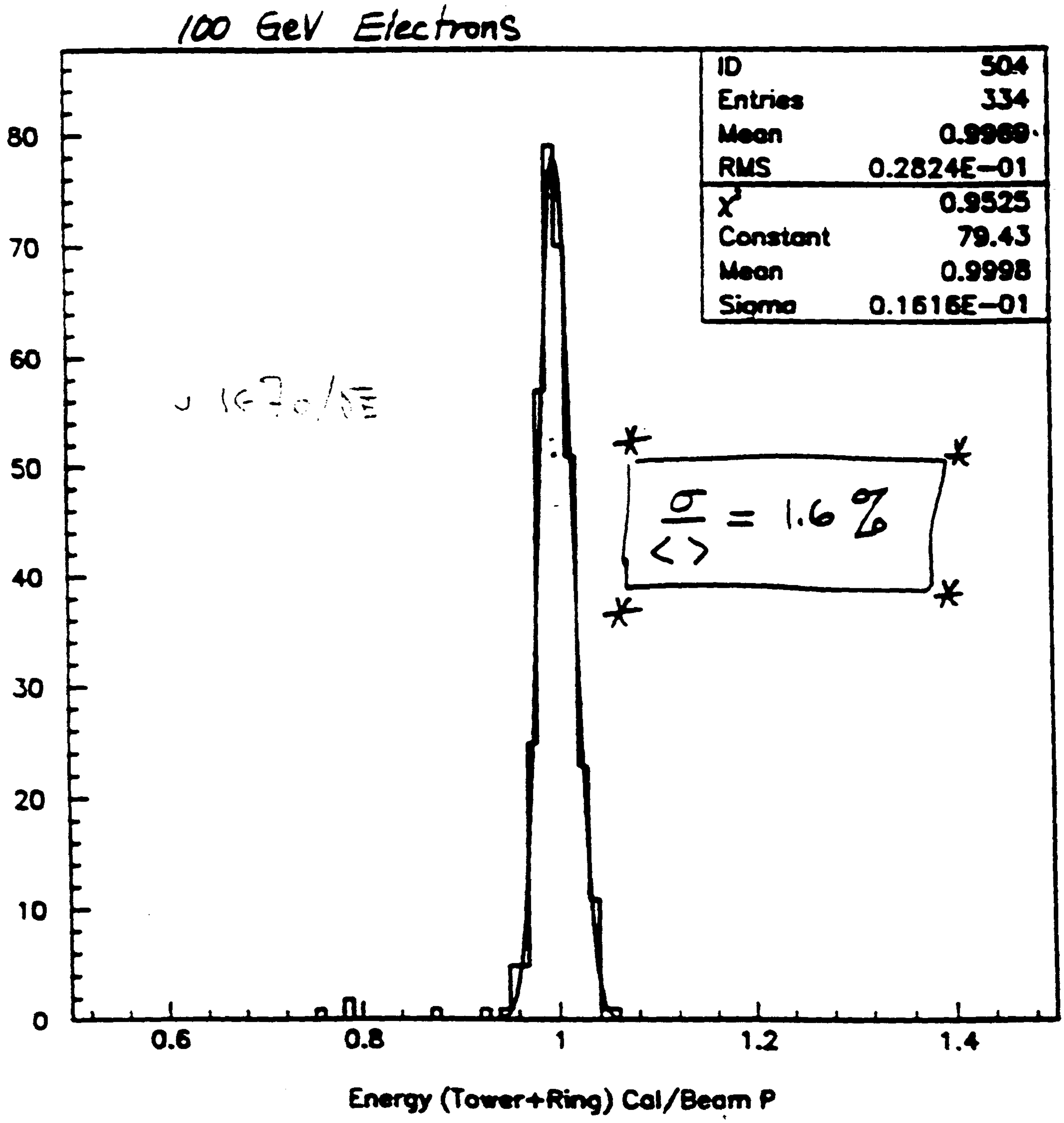
- 1 MONTH Check out run
  3 MONTH beam data

TESTS OF Al, G10, Fe, Pb
"STACKS"

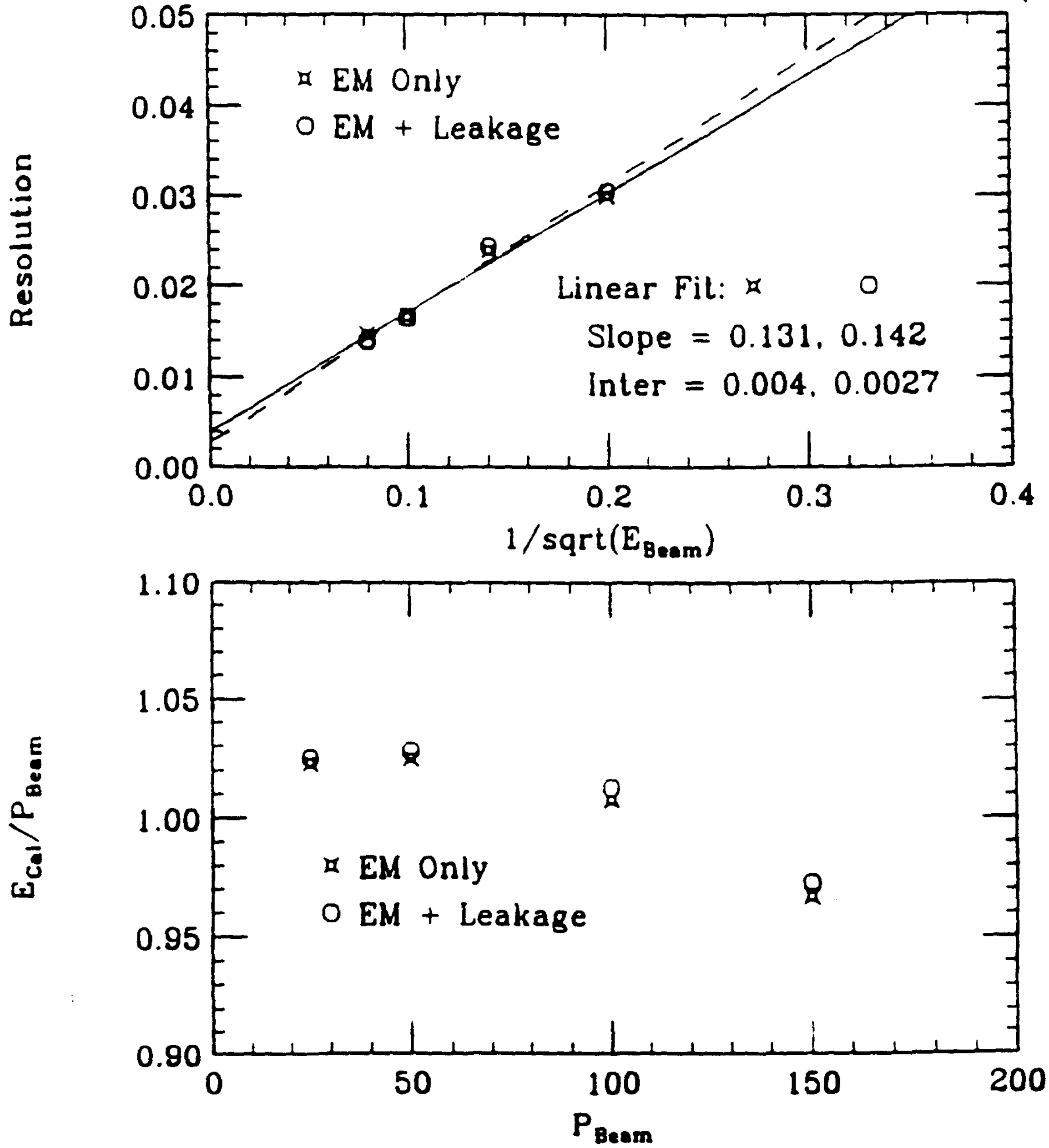


RAW DATA


PRESENTLY WORKING ON
1% CALIBRATION
pedestal
μ
e+π (100 GeV)
0
20
60
80
120
10250
10500
10750
11000
10000
12000
14000
16000
18000
20000
22000
24000
Entries
Mean
RMS



100 GeV Electrons
ID 504
Entries 334
Mean 0.9969
RMS 0.2824E-01
χ² 0.9525
Constant 79.43
Mean 0.9998
Sigma 0.1616E-01
σ/<> = 1.6 %
0
10
20
30
40
50
60
70
80
0.6
0.8
1
1.2
1.4
Energy (Tower+Ring) Cal/Beam P



EM Only
EM + Leakage
Linear Fit:
Slope = 0.131, 0.142
Inter = 0.004, 0.0027
Resolution
1/sqrt(E_Beam)
0.00
0.01
0.02
0.03
0.04
0.05
0.0
0.1
0.2
0.3
0.4
EM Only
EM + Leakage
E_Cal/P_Beam
P_Beam
0.90
0.95
1.00
1.05
1.10
0
50
100
150
200

FY92 SDC CALORIMETER BUDGET

TASK	BUDGET (K$)	COMMENTS
SCINT R+D	1400	
DEVELOPMENT	400	DEFER SOME BASIC R+D
RAD DAMAGE	300	Co + C BEAM + LONG TERM
OPTICS	400	OPTIMIZATION
CALIBRATION	200	DEFER ENGINEERING
PMT/HV	100	DEFER SPEC
SIMULATIONS	—	NO SUPPORT
SM	200	MAPMT - NO OPTIONS
FCAL	200	REQUIREMENTS AND RADDAM NO ENGINEERING
CAL ENGINEERING	1700	NO PREPRODUCTION PROTOTYPE
SM ENGINEERING	100	CAL INTEGRATION
CONTINGENCY/ RESERVE	200	
	3800	CRITICAL ISSUES OF RADIATION DAMAGE AND CALIBRATION ADDRESSED. DOES NOT COVER ENGINEERING TO PROTOTYPE

From: [illegible] -OCT-1991 13:56:44.27
To: PLAVALLIE
CC: DGREEN
Subj: please send out to the SDC_CALOR.DIS as soon as possible. Thanks. Dan

THE RADDAM TASK FOR SDC CALORIMETER FY92 R&D

Dear Colleagues,
The note I sent you on task responsibilities within the FY92 budget did not spell out the boundaries of the tasks. In particular, the tasks for scintillator development, raddam, and optics development logically overlap. Below please find a definition of the boundaries between these tasks.

1. SCINTILLATOR DEVELOPMENT

a. fund R&D on basic research on plastics.
b. fund R&D on basic research on scintillator and wavelength shifter fluors (e.g. red/green)
c. fund R&D on scintillator fabrication process (e.g. injection molding)
d. develop a predictive model for long term aging.

....

z. preliminary radiation tests with Co of small samples. pass screened candidates on to Task #2.

2. RADDAM

a. cut and groove any new plastics produced in Task #1
b. screen complete tile/fiber assemblies with Co irradiation, 1,2,4,8 Mrad evaluate w.r.t a SCSC81+BCF91 standard. DOCUMENT the results.
c. setup long term, low dose rate tests and perform them. DOCUMENT the results.
d. make sets of 20 tiles and fibers for any candidiates for e beam tests.
e. help take the data at IHEP/Beijing
f. collate and DOCUMENT and DISSEMINATE the e beam test results.

3. OPTICS

a. evaluate the optical properties of any new candidates from Task #2.
b. evaluate any candidates for endcap/barrel "baseline" plastics for light output, and uniformity (e.g. many fiber system)
c. setup a standard light output setup. define a standard SCSC81+BCF91 light output vs time for Phillips XP enhanced green readout. measure all samples from b, compare to the standard, and DOCUMENT and DISSEMINATE the results.
d. evaluate candidiates for the baseline WLS deployment (e.g. sigma tile and its two fiber equivalent.) Document light yield , uniformity and time stability in the mechanical configurations expected to be used in the EM and HAC calorimeters.

...

... specifications for the Design Report.

Please let me know if your institution wishes to take responsibility for 1 or more of these RADDAM tasks. I need to know what resources you will bring to bear on that task, what support you need to accomplish the task, and how you plan to define/supply the "deliverables" associated with the task.

I need your responses ASAP. We will present a first cut to Gil on Oct 8. I would like to distribute a draft allocation by E-mail somewhat prior to that meeting, so that your feedback may be addressed. Please get back to me on the RADDAM task so that I can factor your wishes/responsibilities into the budget.

Cheers, Dan Green

A. Seiden

PAC Meeting
October 3-4, 1991

SDC Tracking System

October 3

PAC Subcommittee Meeting

Tracking is one of the most challenging areas for an SSC detector.

Example: For standard luminosity, dosage of about 0.25 megarad per year at a radius of 15 cm.

Occupancy of about 10% at a radius of 80 cm in a 4 mm diameter straw tube covering 1.5 units of rapidity.

In addition, the physics is very demanding:

(1) $H^0 \to Z^0 Z^0 \to 4$ charged leptons requires very large rapidity coverage, $|\eta| \leq 2.5$.

and

High efficiency for track reconstruction and lepton identification since event reconstruction $\sim$ (track efficiency)^4.

(2) Detailed study of $t\bar{t}$ events requires:

Lepton identification within jets, and

B vertex tagging

These requirements lead to systems which are a significant extension over present tracking systems.

They require:

(1) Very large, very precise, low mass mechanical structure.

(2) Very fast readout.

(3) For straw tubes and silicon detectors, very low power per channel because of the large number of closely spaced channels.

(4) Simultaneous, high speed, data collection and readout to avoid deadtime. Leads to complicated system issues in areas such as cross talk.

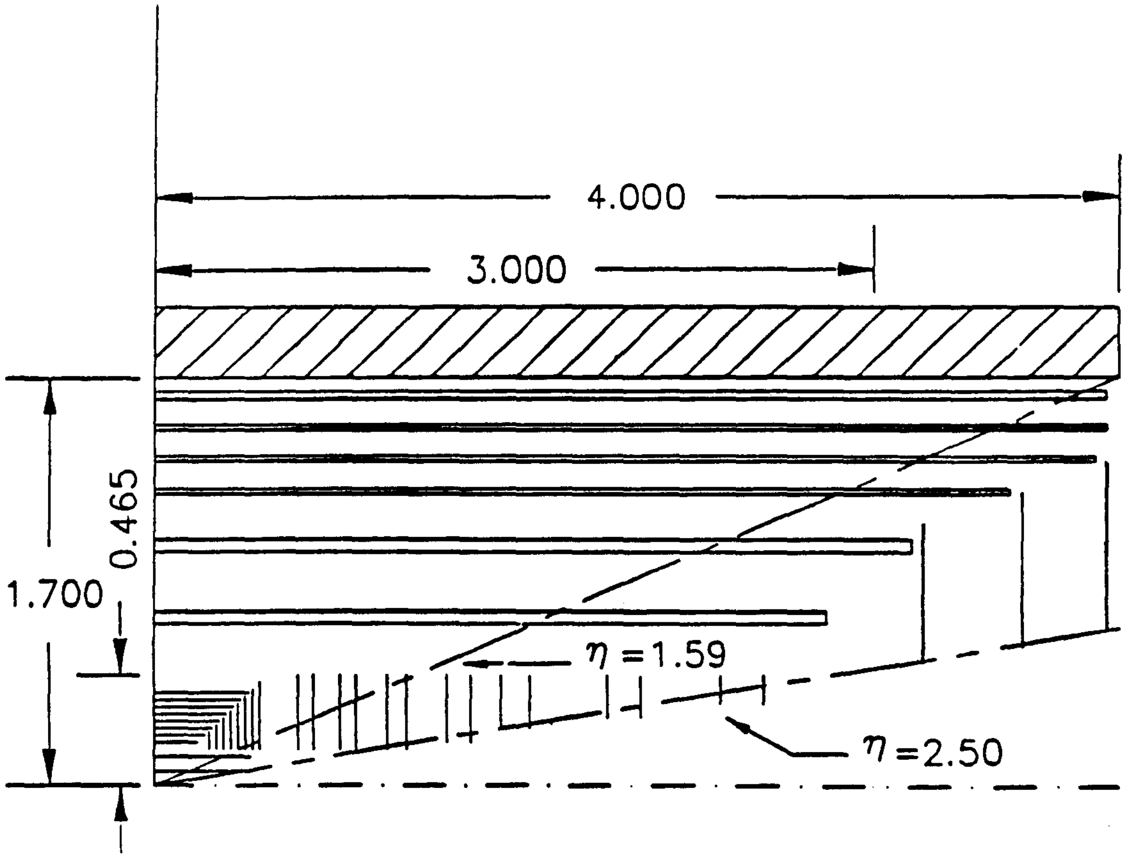


Fig. II-1. A section through one quadrant of the tracking system of the baseline design.

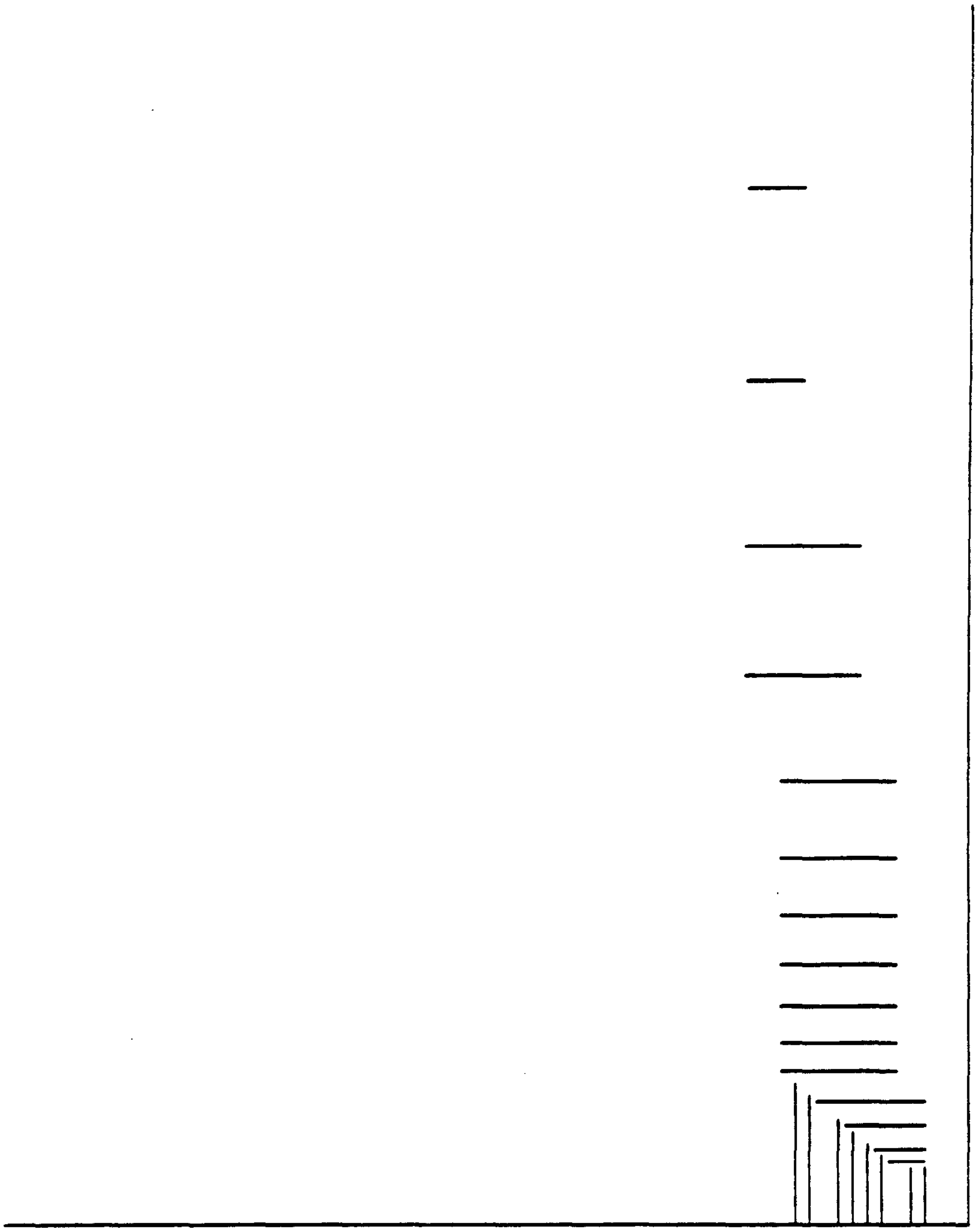
The tracking system has been descoped significantly.

Motivation: reduce cost and reduce the total amount of material within the tracking volume.

Systems presently under study:

7 to 8	layers of silicon within a radius of 50 cm covering the full η range.
4 to 5	superlayers of straws or fibers from 70 cm to 170 cm covering $\lvert\eta\rvert \leq 1.8$.

The region of $\lvert\eta\rvert > 1.8$ and radius of > 50 cm is very difficult. Present focus: Gas microstrips, since performance is well matched to requirements.



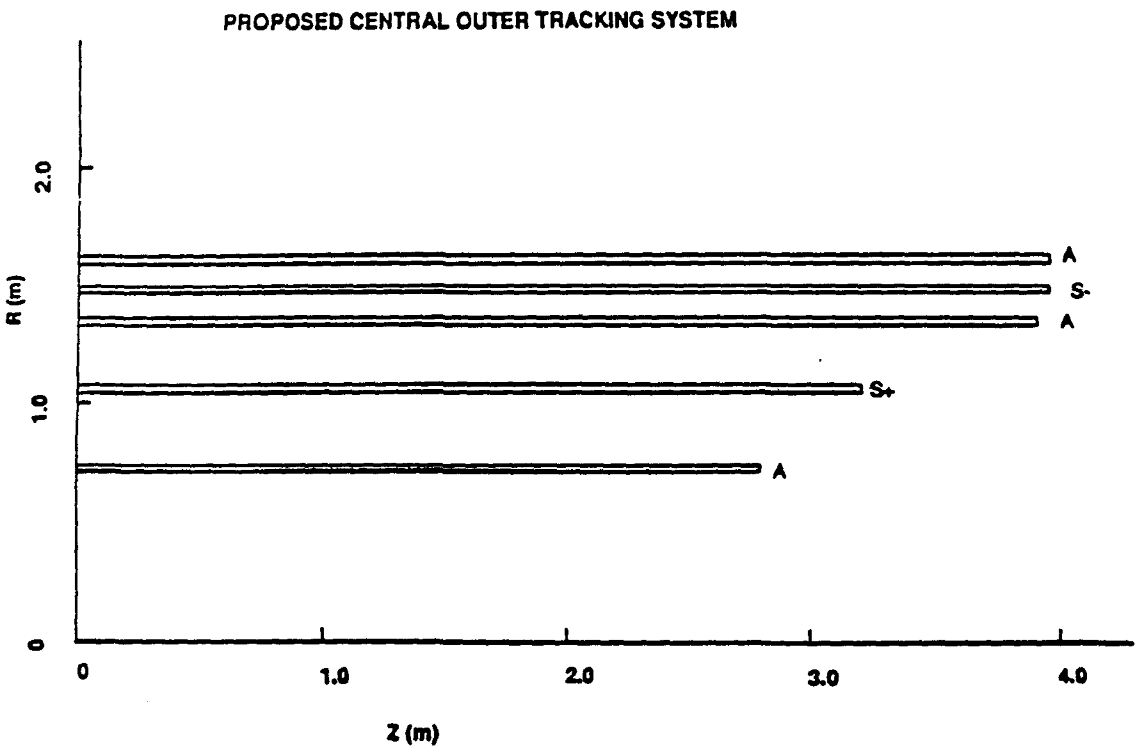
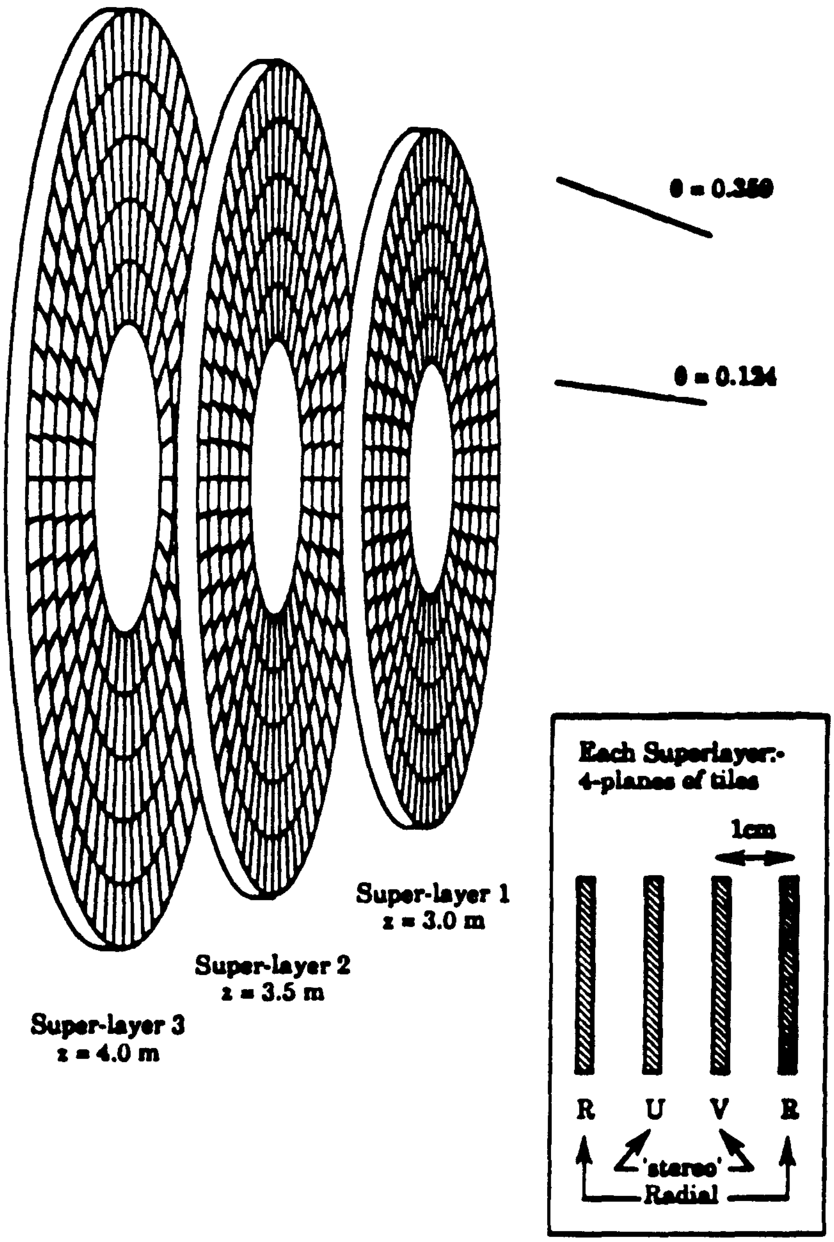


Fig. II-2. A section through one quadrant of the descoped all-straw central outer tracking system.

SDC 91-00061

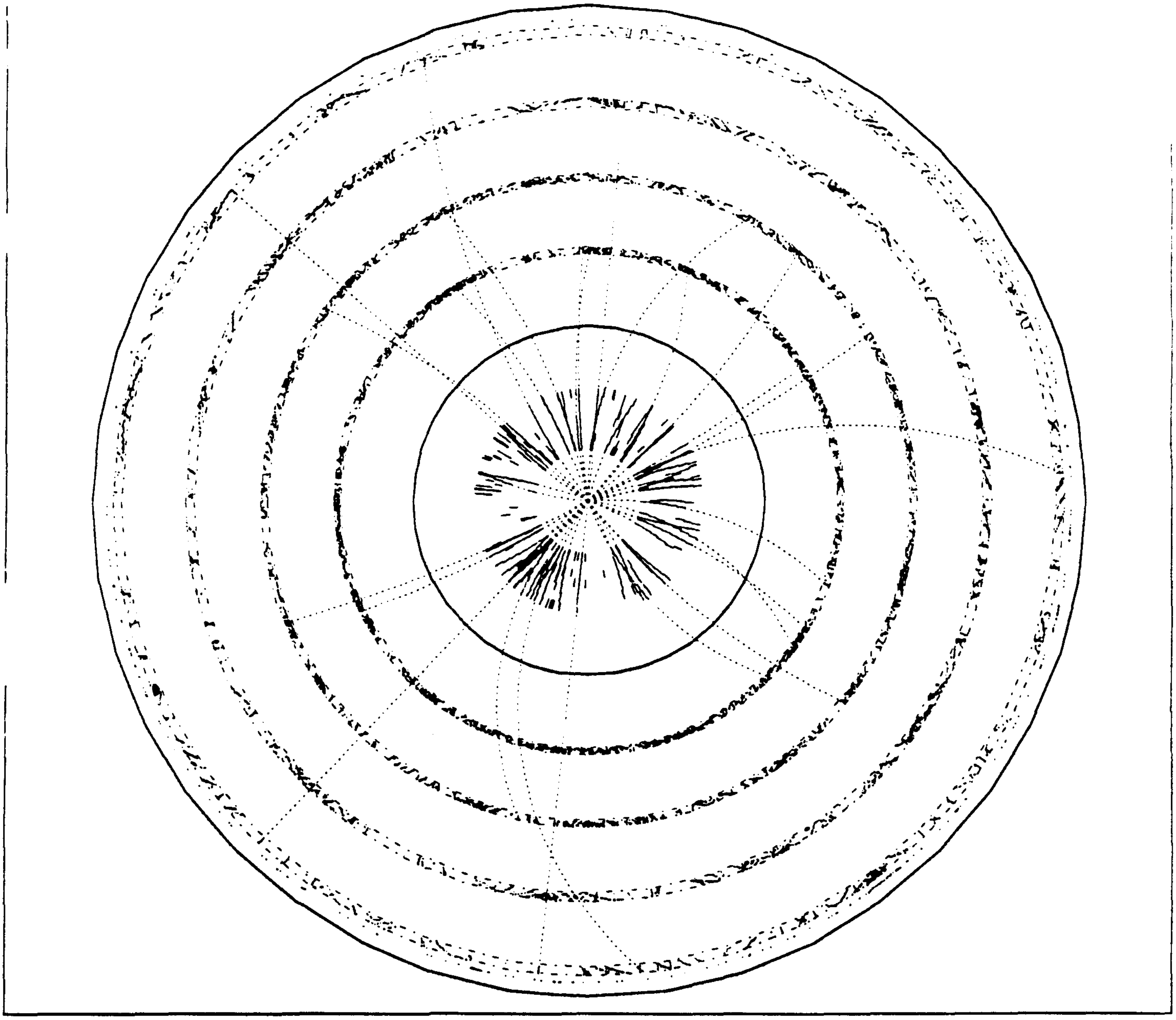
ITD


θ = 0.350
θ = 0.124
Super-layer 1
z = 3.0 m
Super-layer 2
z = 3.5 m
Super-layer 3
z = 4.0 m
Each Superlayer:-
4-planes of tiles
1cm
R U V R
'stereo'
Radial

Have appointed a committee, chaired by T. Kondo to finalize tracking choices for the technical proposal.

Unlikely to be able to make choice between straws and fibers this year. Systems are not mature enough. Try to quantify, given present knowledge, for the two choices: Expected performance, cost, risk, as well as optimize the full tracking geometry.

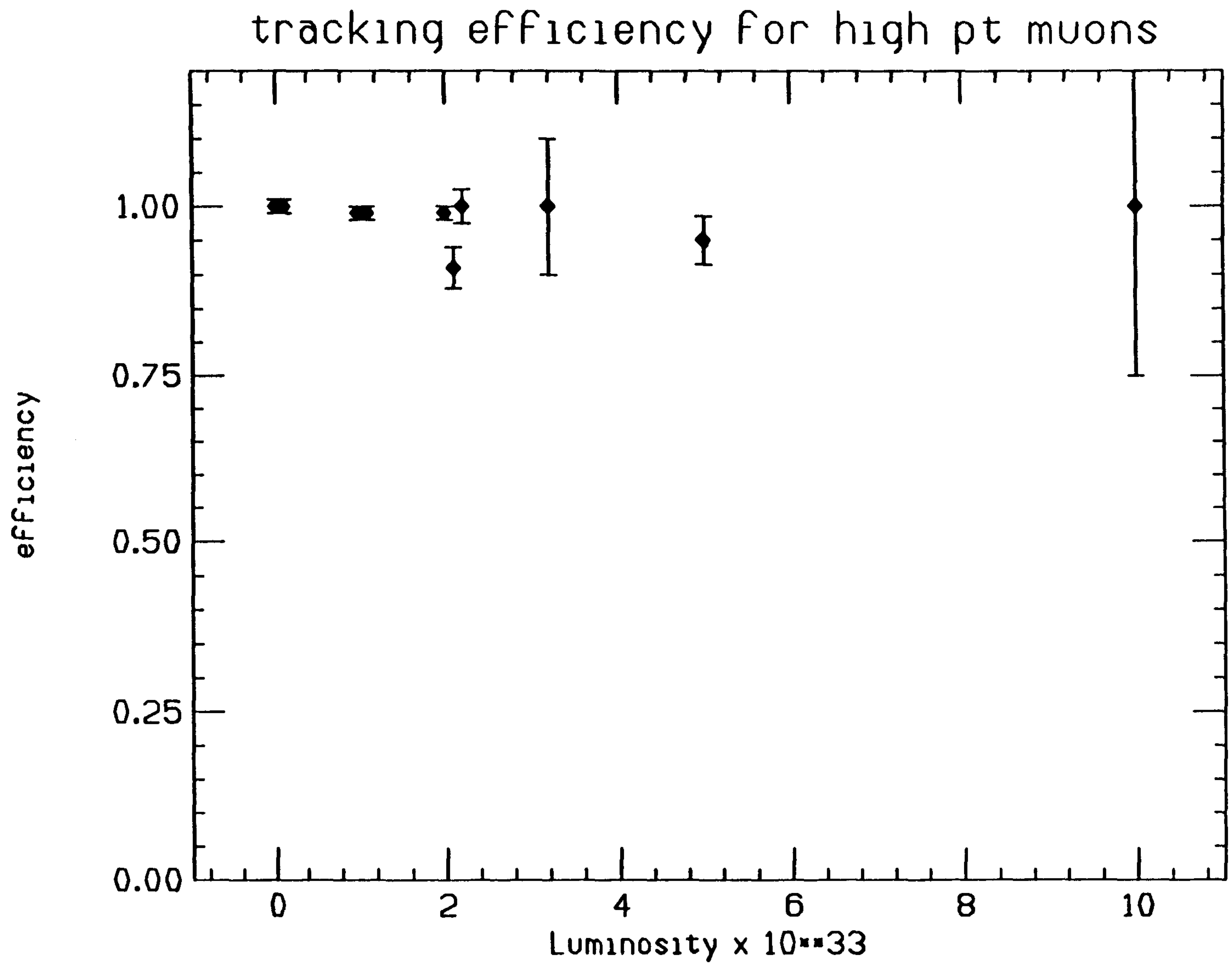
For studying the geometry and physics performance: SDC has mounted a significant effort to generate simulation tools to look at the tracking performance. Includes silicon plus straws or fibers and a realistic simulation of the geometry and effects of material in the tracking volume. Just beginning to get first results.



♦ – 200 GeV/c μ + min. bias bg. (8 silicon barrel layers)

♦ $H \rightarrow 4\mu$ + min bias "

♦ 200 GeV/c μ + min bias, (4 silicon barrel layers).



Silicon Strip R&D Accomplishments in FY 1991

Work on the silicon system is proceeding in a large number of areas, all of which are critical to achieving a system with adequate performance. These areas include: low-power, low-noise, radiation-hard electronics; low-mass, ultra-stable, mechanical structures; low-mass, vibration-free, cooling systems; the development of maximally radiation-hard detectors; and the development of data acquisition and triggering schemes using the silicon.

Major accomplishments to date have included:

1. Demonstration that double-sided silicon detectors will function properly up to doses of 10^{14} particles cm^{-2}, implying 20 years of lifetime at a radius of 15 cm for the SSC design luminosity.
2. Demonstration that bipolar and radiation hardened CMOS electronics will function for the same fluences as listed above for the detectors.
3. Design, fabrication and testing of a fast analog front-end chip with power consumption of less than 1 mW/channel.
4. Construction of a prototype wick-cooling ring demonstrating the removal of heat for hours by a fully passive system (i.e., without pumps).
5. Finite element calculations for the major mechanical elements of the detector satisfying our dimensional tolerance goals.
6. Demonstration of the basic mechanical structure of a detector module, with sufficient rigidity and ruggedness.
7. A first critical path decision choosing 12 cm detector units with a two-chip set (bipolar preamplifier and discriminator plus CMOS data storage chip) as the basic detector module.
8. Completion of a detailed construction schedule and cost estimate for an SSC silicon tracker.
9. Distribution of work among institutions aimed at the production of an SSC Detector.

Pixel R&D Accomplishments in FY 1991

Progress in FY1991 was made in several areas. A complete architectural design was established by Hughes that incorporated the following performance features:

1. x-y storage of smart pixel hits in 32-deep pattern registers;
2. Time stamping of hits in 32-deep content addressable memory;
3. Sparse readout of valid hits in a selected time slice;
4. On-chip rejection of ghost hits;
5. On-pixel storage of analog information;
6. Non-redundant readout of neighbors option;
7. Programmable microcontroller

Two test IC's with pixel size of $50 \times 150\ \mu$m, were fabricated by Hughes to determine behavior of single pixel cells and two-dimensional arrays of pixel cells.

At LBL, an advanced pixel cell design has been pursued. This design incorporates RC-CR shaping, peak sample and hold, DC servos to stabilize operating points, and autonomous operation, requiring no resets or initialization. The design incorporates principles that maximize radiation hardness.

Straw-Tracking R&D Progress in FY 1991

Straw R&D

- Attenuation lengths have been measured and values greater than 7 m can be attained.
- Deterioration in radiation environments much greater than 10 years at SSC design luminosity is not a problem with proper choice of materials (copper on kapton is best).

Resolution and Positioning

- Construction of 60 channel 2.7 meter-long superlayer. Using the chamber achieve a resolution measurement of 120 microns.
- Development of a technique to measure wire position using collimated SR90 source (accuracy: better than 70 microns).
- Wires can be positioned to accuracy of $\sim$ 25 μm by enclosing $\sim$ 200 straws in modules with carbon fiber shells.

Construction: Two choices under evaluation– modules placed on cylinders or straws directly on cylinders

- Construction of 7 meter-long chamber consisting of 6 straw tubes. There are 8 wire support inside.
- Construction of 100 channel shell-less module.

- Development of the technique of wire tension relieving method.
- Design and construction of 3 meter-long straw placing machine.
- Six 30 cm-long 64-straw modules have been built and are under test at 5 institutions.
- A 1-meter module is under construction using a shell design of carbon fiber and Roha cell foam sandwich.
- A 4-meter shell has been designed and will be completed by the end of 1991.

Large-Scale Structures

- A conceptual design for a support cylinder, also of carbon fiber foam sandwich, has been achieved.
- A conceptual design for a space frame to support the cylinders has been studied.
- This system has very little material–3.5% Xo for 4 superlayers–including straws, shells, and supports.

Front-End and Triggering Electronics

- Designs for the front-end electronics and trigger have reached at least conceptual stage.
- Prototypes of the preamp/shaper and TMC have been tested.

Fiber Tracking R&D Accomplishments in FY 1991

To realize the potential of fiber tracking technology, a challenging R&D program has been initiated which includes major development effort in the following areas: (1) high efficiency, low-loss, and radiation resistant fiber scintillators and waveguides; (2) high quantum efficiency, visible light sensitive photon counters (VLPC's) based upon the existing Rockwell Solid State Photomultiplier (SSPM) and incorporating associated front end electronics; (3) first-level trigger electronics based on ASIC (Application Specific Integration Circuitry) technology; and (4) simulation packages capable of characterizing fiber tracking designs. Major accomplishments to date are:

- A number of promising prototype fluorescent dyes which were synthesized in FY90 funding year have now been incorporated into scintillating fibers for studies of fiber efficiency and attenuation length and for manufacture of prototype fiber ribbons. When read out with Visible Light Photon Counters (VLPC-I), these fibers and ribbons provide excellent photon yields. Additional new fluorescent materials have been developed during FY91, and their incorporation into polystyrene have indicated high scintillation efficiency and excellent radiation resistance characteristics.
- The development of the Visible Light Photon Counter (VLPC) has been underway at Rockwell International Science Center. The development has proceeded in two steps. In Step 1 the devices were optimized for visible wavelength response yielding a measured quantum efficiency of ~85% at a wavelength of 565nm. These have been produced in linear arrays, and have been delivered in significant quantities (hundred channels) to the UCLA group. Highly successful preliminary studies have been performed with these devices coupled to individual fiber elements or to 16 element arrays of fiber ribbons. Step 2 is to optimize the devices for speed and to minimize the infrared response. Fabrication of the first lot of these new devices is in progress.
- A study of cryogenic preamplifiers for use with VLPC/SSPM devices has been initiated in consultation with Honeywell, and studies continue within the collaboration on the development and use of the room temperature preamplifier option.
- Limited engineering studies sufficient for a preliminary fiber tracking system costing have been carried out in collaboration with Oak Ridge National Laboratory.

- A beam test facility (T839) has been developed at Fermilab in the New Muon laboratory, equipped with a remotely operable transporter to position fiber ribbons and superlayers at various angles relative to the beam. Initial beam studies are beginning now using fiber ribbons and multianode photo-tubes for light detection, until such time as VLPC-II devices are available for beam tests.
- Highly successful initial tests of individual scintillating fibers and waveguides and arrays of ribbons of these structures have been performed using VLPC-I as the photo-detectors in laboratory-based tests. Fibers and waveguides are of 830μm diameter, with scintillator lengths of 4m and waveguide lengths of 3m or 4m depending upon the test configuration. When spliced together to form actual fiber detection elements, the total fiber lengths are 7-8m. The mean detected photo-electron yield at the VLPC when the far end of the scintillation fiber is excited by cosmic rays has been observed to be $\sim$6 photoelectrons when the far end of the fiber is mirrored.

Fermilab Beam Tests

The physics Section and the Research Division at Fermilab have provided resources to install T839, Scintillating Fiber Tracking Studies, in the New Muon hall. Commissioning has been completed on a darkbox and its transporter, which has been designed to scan parallel arrays of 3 m long fiber ribbons across the beam and rotate the ribbons through 70 degrees to simulate inclined tracks. Mechanical mounts and the electronics required to operate a 64-channel photo-multiplier tube have also been prepared, and the detector assembly has been connected to the T839 data acquisition system. Orders have been placed for a second photo-tube, which has a fiber optic faceplate to reduce optical cross-talk.

The transporter includes a fiber ribbon suspension system which provides stability of $\pm 25 \mu m$ in relative alignment of four layers of ribbons. It has remote motion control via stepping motors, and position and angle readback have been provided with local displays and analog voltages to be sent to the data acquisition system. The darkbox has been made to accomodate three types of detectors for reading out the fibers: (1) Visible Light Photon Counters; (2) multi-channel photo-multiplier tubes; and (3) avalanche photo-diodes. The transporter was recently modified to accomodate a separate darkbox brought from Purdue University.

A high voltage divider, 64 channels of analog amplifiers and delay cabling were built for the multi-channel phototube. A mechanical mount for the tube and electronics incorporates an adjustable interface plate for aligning the optical fibers with respect to the tube pixels. Noise spectra have been recorded for all 64 channels of the system. Detailed studies with a radioactive source have demonstrated the single photo-electron resolution capability of the tube.

Next year's R&D aims at:

(1) Finishing proof of principle for remaining unique areas critical to tracking system.

(2) Work needed to complete the design to allow further cost estimation and confidence that our contingency estimates are correct.

(3) Work needed to remain on schedule for 1999 installation. This is already very difficult!

TABLE 2 : FY 1992 SILICON TRACKER R + D COSTS

TASK	GOALS	PROTOTYPES/TESTS		COST $K	
			LABOR	MATERIALS	TOTAL
TECHNICAL MANAGEMENT	O PREPARE PROPOSALS, BUDGETS & OVERSEE SCHEDULE		$30	$0	
MECH. ENG. MANAGEMENT	O PREPARE PROPOSALS, BUDGETS & OVERSEE SCHEDULE		$60	$0	
PROPOSAL SUPPORT	O ELABORATION OF DESIGN FOR PROPOSAL		$100	$0	
		SUBTOTAL (PROJECT MANAGEMENT):	$190	$0	$190
DOUBLE SIDED DETECTOR	O FABRICATE DOUBLE SIDED DETECTORS WITH FIELD	O COMPARE CAPACITANCE & RADIATION RESISTANCE	$0	$60	
DEVELOPEMENT	PLATE ISOLATION	OF FIELD PLATE AND P-IMPLANT ISOLATION			
DETECTOR MODULE	O COMBINE DETECTORS & FRONT END ELECTRONICS	O TEST RADIATION HARDNESS & CROSSTALK	$170	$50	
	TO INDIVIDUALLY TESTABLE MODULES	O TEST DIFFERENT SHIELDING TECHNIQUES			
CABLES	O DEVELOPE LOW-MASS CABLES	O TEST NOISE ISOLATION CABLES	$40	$40	
	O LAY OUT CABLING PLAN	O TEST POWER BYPASSING			
BIPOLAR FRONT END CHIP	O DESIGN, FABRICATE & TEST CIRCUIT BLOCKS	O TEST RADIATION HARDNESS, NOISE, TIME WALK,	$270	$125	
	O DESIGN, FABRICATE & TEST FULL MULTICHANNEL	POWER CONSUMPTION, & DEAD TIME			
	ARRAY				
CMOS DATA STORAGE CHIP	O DESIGN, FABRICATE & TEST TEST CIRCUITS (MOSIS)	O TEST RADIATION HARDNESS	$230	$115	
	O DESIGN & FABRICATE FULL SIZE RAD HARD CHIP	O TEST DIGITAL TIME STAMPING & DATA BUFFERING			
		O TEST SPARSE SCAN READOUT			
		SUBTOTAL (DETECTORS/FRONT END ELECTRONICS):	$710	$390	$1,100

TABLE 2 : FY 1992 SILICON TRACKER R + D COSTS

TASK	GOALS	PROTOTYPES/TESTS		COST $K	
cont.			LABOR	MATERIALS	TOTAL
COOLING RING PROTOTYPE	O DEMONSTRATE FABRICABILITY	O TOOLING PROTOTYPE-COMPRESION MOLDS	$160	$95	
DEVELOPMENT	WITH 120 DEG. ARC SEGMENT	O G/E RING PROTOTYPES			
	O ACHIEVE THERMAL CONDUCTIVITY	O MATERIAL PHYSICAL SPECIMENS TESTS			
	ENHANCEMENTS FOR ELIMINATING	O FULL RING ASSEMBLY (120 DEG. SEGMENTS)			
	EXCESSIVE THERMAL GRADIENTS				
	O ACHIEVE TAILORED G/E MATERIAL				
	PROPERTIES - LOW MOISTURE ABSORPTION				
SILICON DETECTOR	O DEMONSTRATE CONSTRUCTION OF EDGE-	O TOOLING PROTOTYPE-VACUUM CHUCK	$160	$90	
MODULE	BONDED SILICON LADDER ASSEMBLY	HOLDING FIXTURE			
	O DEMONSTRATE STRUCTURAL INTEGRITY OF	O THERMAL BEHAVIOR OF ADHESIVE UV CURING			
	MODULE USING ROOM TEMP. CURING	PRODUCTS			
	ADHESIVE FOR FACILITATING HIGH	O STRUCTURAL COMPONENT TEST			
	PRODUCTION RATES AND MINIMIZING	O MODULE RADIATION/MATERIAL			
	INTERNAL RESIDUAL STRESSES	COMPATIBILITY TESTS			
	O DEMONSTRATE MATERIAL COMPATIBILITY				
	USING ACTIVE STRIP DETECTOR				
	O PRODUCE SUFFICIENT MODULES FOR 120 DEG.				
	ARC SILICON SHELL AND FULL SILICON				
	PROTOTYPE SHELL				
WICK DEVELOPMENT	O COMPLETE INVESTIGATION OF	O TEST VARIOUS POLYSTYRENE WICK THICKNESSES/	$200	$80	
	POLYSTYRENE	GEOMETRICAL SHAPES			
	- THERMAL RESISTANCE MEASUREMENTS	O 120 DEG. ARC WICK SEGMENT			
	- TRANSIENT BEHAVIOR	TOOLING PROTOTYPE			
	O PRODUCE 120 DEG. ARC SEGMENT WICK	O CONDUCT 120 DEG. ARC COOLING RING TESTS			
	W/ARTERY	O CONDUCT 120 DEG. ARC SILICON SHELL			
	O UPGRADE WICK FACILITY TEST TO	PROTOTYPE TESTS			
	ENCOMPASS TEST OF FULL SILICON SHELL				
	PROTOTYPES				
ALIGNMENT/STABILITY	O DEVELOP ALIGNMENT/ASSEMBLY CONCEPT	O OPTICAL ALIGNMENT UNIT COMPATIBLE	$250	$100	
MEASUREMENTS	FOR PLACEMENT/BONDING SILICON	WITH OPERATOR CONTROLLED MECHANICAL			
	DETECTOR MODULES ONTO 120 DEG. ARC SHELL	ASSEMBLY			
	AND/OR FULL SHELL PROTOTYPE	O METROLOGY-LIKE MEASUREMENTS			
	O DEVELOP MEANS OF MEASURING SILICON	DETERMINING STABILITY OF SILICON			
	STRUCTURE STABILITY TO <5 MICRONS	STRUCTURES AND COMPONENT MATERIAL			
	O DEVELOP ALIGNMENT/STABILITY MEASURING	PROPERTIES			
	TECHNIQUES SUITED TO ANY GEOMETRY, NOT	O ENVIRONMENTAL CONTROL CHAMBER FOR			
	"RESTRICTED TO SILICON BARREL" GEOMETRY	COMPONENT TESTS AND MATERIAL TESTS			

TABLE 2 : FY 1992 SILICON TRACKER R + D COSTS

TASK	GOALS	PROTOTYPES/TESTS	COST $K		
cont.			LABOR	MATERIALS	TOTAL
CENTRAL REGION	O DEVELOP OPERATOR-CONTROLLED	O PROTOTYPE TESTS OF OPERATOR CONTROLLED	$116	$75	
PROTOTYPE	MECHANICAL ASSEMBLY UNIT FOR SILICON	MECHANICAL ASSEMBLY UNIT FOR SILICON			
	DETECTOR MODULE	MODULES			
	O ASSEMBLE 120 DEG. ARC SILICON SHELL UNIT	O COOLING TEST OF 120 DEG. ARC SHELL ASSEMBLY			
	O DEVELOP KINEMATIC MOUNT SUPPORT	O PROTOTYPE LOW-MASS, LOW-Z KINEMATIC	$124	$20	
	FOR COOLING RING/SILICON SHELL	MOUNT			
	STRUCTURE				
	O BUILD COMPLETE SILICON SHELL MODULE	O CONDUCT STATIC STABILITY TESTS	$130	$55	
	O DEMONSTRATE SILICON DETECTOR MODULE	O FRAGILITY TESTS OF PARTIAL SILICON SHELL			
	PLACEMENT TO 25 MICRONS	ASSEMBLY			
		SUBTOTAL (MECHANICAL):	$1,140	$515	$1,655
		GRAND TOTAL:	$2,040	$905	$2,945

FY92 STRAW R&D

TASK	GOALS	PROTOTYPES/TESTS		COST ($K)	
			LABOR (MY)	MATERIALS	TOTAL
Drift Cell R&D	•Develop wire support	Wire supports	2.00	35.60	132.80
	•Develop resistive	Resistive terminators			
	termination	Straw bundles			
	•Develop fabrication				
	techniques				
Endplate and Electronics	•Develop crosstalk-free	Endplates	0.50	24.80	49.10
Interface R&D	connection from wires to	Wire connectors			
	electronics				
Straw Placement	•Establish feasibility of	4 meter nontrigger module	2.00	100.00	197.20
Structure R&D, Alignmer	precise straw placement	4 meter trigger module			
	structure	or			
	•Establish alignment	8 meter straw placement			
	techniques				
	•Establish fabrication				
	technique and cost				
Detector and Electronics	•Establish operating	Test prototype straw	0.50	105.00	129.30
Evaluation	condition with electronics	structures with prototype			
	prototypes	electronics			
Aging and Radiation	•Determine lifetime of	Test prototype straw		37.00	37.00
Damage Studies	tracking system at SSC	structures with radiation			
	•Choose materials	and/or high currents, rates			
Travel	•Attend meetings		1.54		75.00
Totals			6.54	302.40	620.40

Fiber Tracking R&D FY92

	Cost ($K)	Total
Scintillating Fiber Development		
dyes	50	
polymerization	25	
claddings	25	
preforms	50	
fiber drawing	50	
radiation and environmental studies	50	
measuring facility	50	
		300
Ribbon Fabrication		
winding, laying structures	75	
adhesives, material studies	25	
splicing techniques	75	
measuring facility	50	
		225
Mechanical Engineering		
Engineering liaison	50	
Environmental controls, light tightening techniques	50	
		100
Trigger/ASIC		120
Readout R&D		
VLPC refinements: Removal of IR sensitivity, Improvement of speed, Preamplifier Integration		245
Readout Engineering		
VLPC cassette/canister	250	
Bench test of VLPC	80	
Preamps for 1000 channels	80	
Cryo preamp R&D	80	
Cryo system issues	50	
		540
Grand Total		**1,530**

FY92 Mechanical Engineering Funding Profile		Sept. 25,1991
For Outer Barrel Tracker (Iteration 4)		A.T. Goshaw
Catagory 1: Proof of Principle		
Task	**Reccomended SDC budget (K$)**	**Comments**
support cylinder design	60	
tests of composite structures, cylinder prototype	150	Use an existing mandrel.
alignment methods	75	
module development or straw placement machine	60	Assumes only one straw placement procedure.
fiber placement	70	Assumes both straw and fiber R&D in FY92.
Catagory 2: For SDC Proposal		
Task	**Reccomended SDC budget (K$)**	
assembly and manufacturing concepts	75	One design for proposal.
support structure design/analysis	90	
structural flange design	50	
tooling and fixture design	60	
end plate and utilities	50	Need to clarify overlap with integration fundin
summation of catagories 1 and 2	740	
costing and project management for proposal	150	This assumes the mechanical engineering
		budget must support cost and schedule
total mechanical engineering for FY 92	890	preparation for the proposal.
Comments:		
This budget is based upon information provided by David Vandergriff and Roger Swensrud		
In response to the first iteration circulated on Sept. 9 and a second iteration circulated on Sept.19.		
In addition it was reviewed by the outer tracking mechanical engineering subgroup on Sept. 25.		

Conclusions

(**1**) Excellent progress is being made on the relevant tracking technologies.

(**2**) Time left for R&D is about two years, so must during this time finish design, including very sophisticated engineering, and construct modest-sized system to refine concepts, check performance, and demonstrate robustness on the system level. Extremely tight schedule.

(**3**) Need significant financial support to complete the critical R&D and move forward to construction.

J. Bensinger

PAC Meeting
October 3-4, 1991

Goals for the SDC Muon System

1. Good resolution, redundant measurement at low Pt and primary measurement at high Pt.
2. Good track pair resolution.
3. Accept particles at large angles without loss of resolution.
4. Wire spans of distance up to 9 m.
5. Chamber pairs have wires that accurately project to the interaction point.
6. There should be a minimum of dead space.
7. Robust design.
8. Easily industrialized.
9. Relatively inexpensive.

FY92 R&D Plans for the SDC Muon Program

1) Concentrate on the "critical path" items. Engineer systems - building meaningful prototypes in FY93.

- Complete full length prototypes and choose chamber design by February 1992.
- Proof of Principle - Design Super Tower Prototype
- Development of Global Alignment System

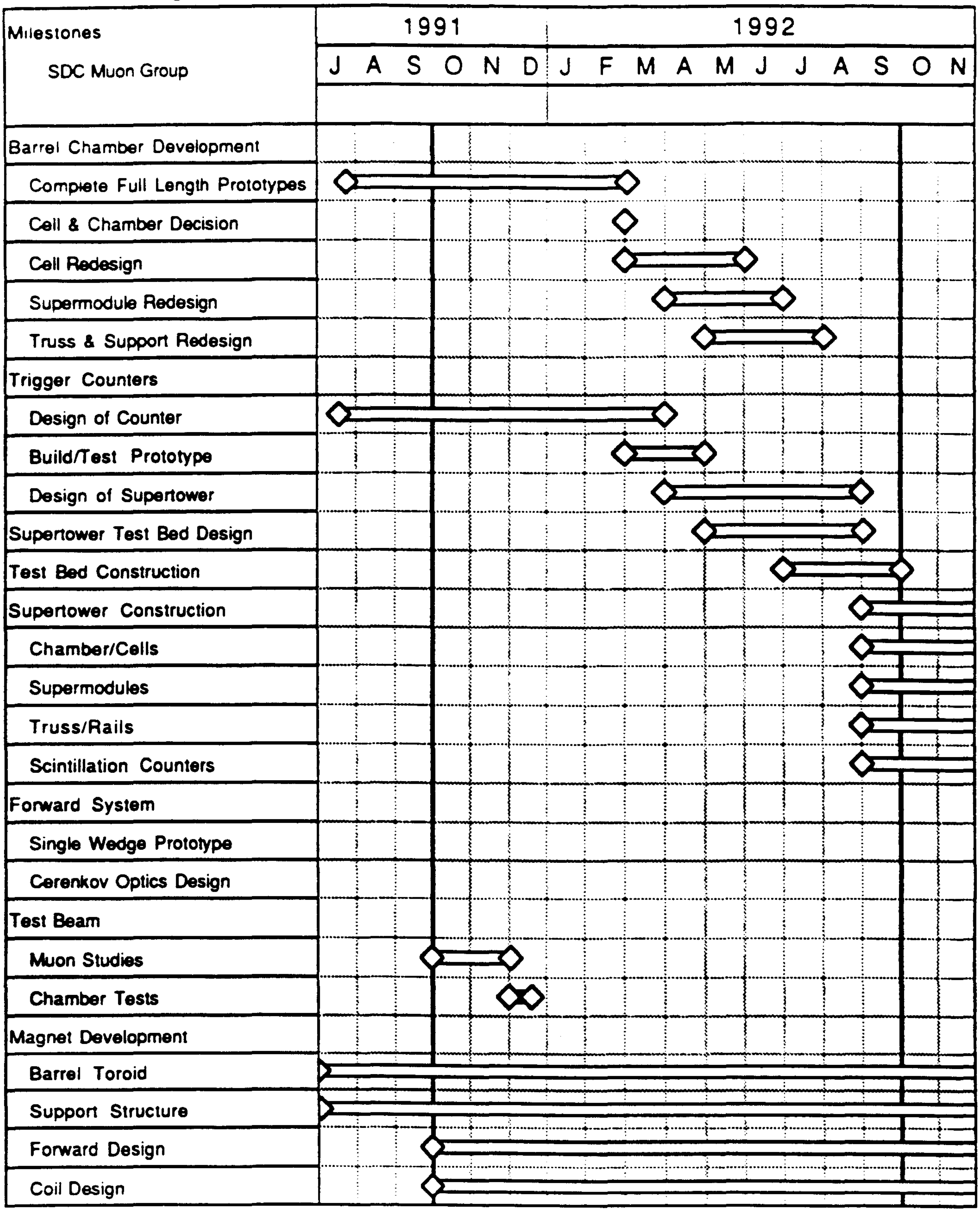
2) Secondary Goals - Limited Effort

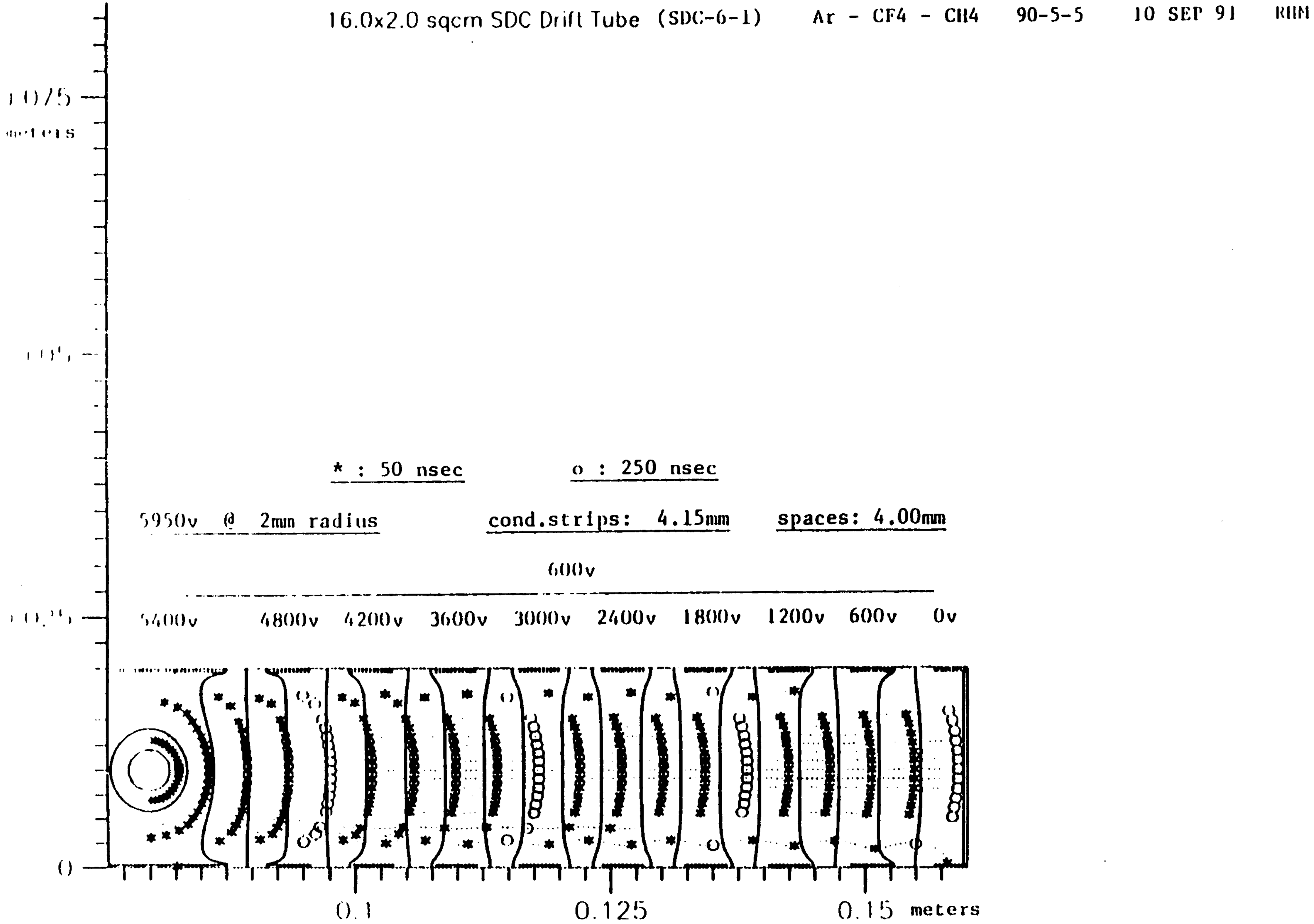
- Forward Region
- Trigger Systems
- Readout Electronics
- Develop Installation Tooling and Techniques
- Plan for Chamber Production and Assembly
- Develop Facilities Plans

3) Toroid Magnet Design

- Barrel Toroid Design
- Magnet support system
- Forward Toroid System
- Coil Design

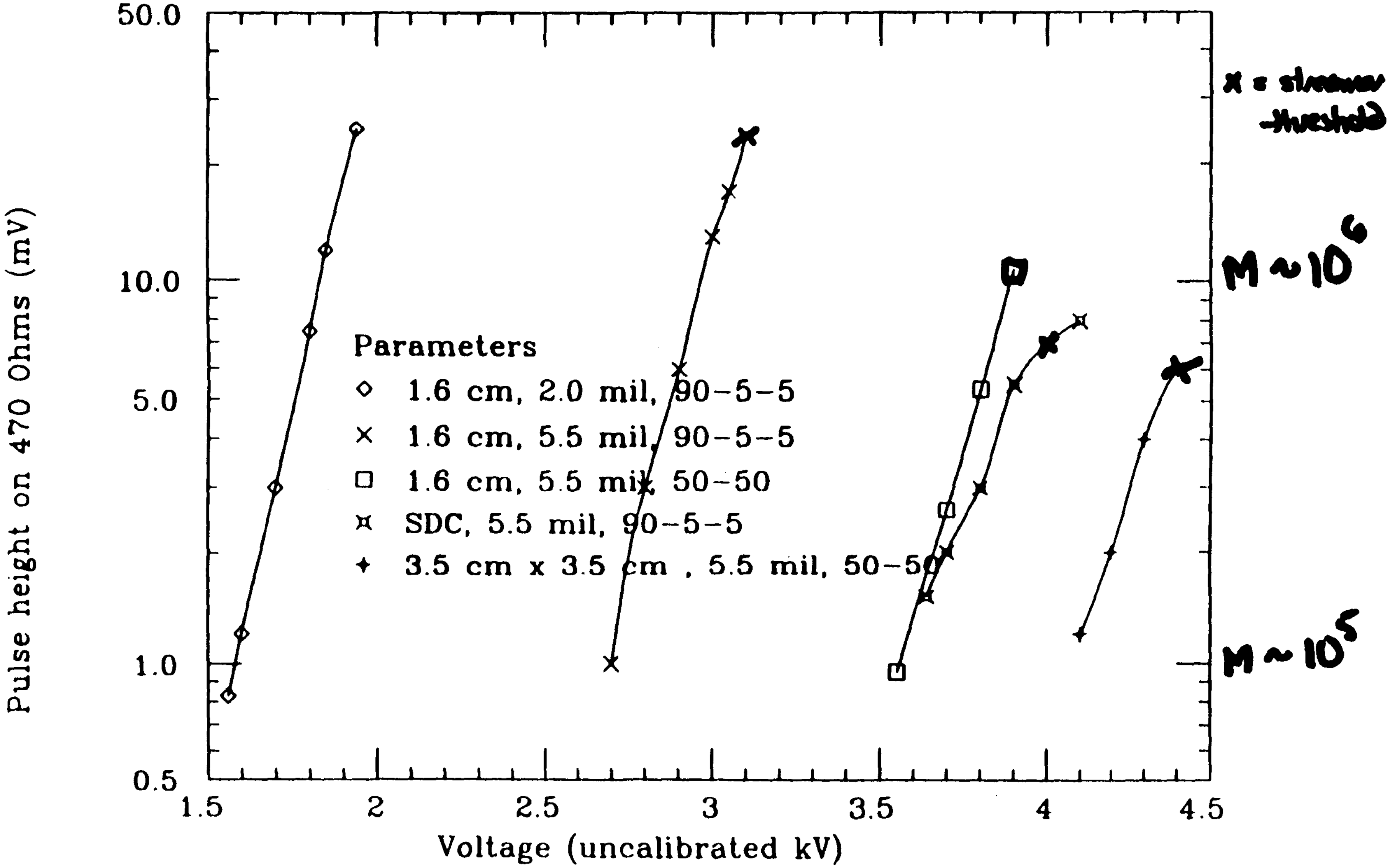
1992 R&D Progam for the SDC Muon Group





16.0x2.0 sqcm SDC Drift Tube (SDC-6-1) Ar - CF4 - CH4 90-5-5 10 SEP 91 RHM
* : 50 nsec
o : 250 nsec
5950v @ 2mm radius
cond.strips: 4.15mm
spaces: 4.00mm
600v
5400v
4800v
4200v
3600v
3000v
2400v
1800v
1200v
600v
0v
0.1
0.125
0.15
meters
0
meters

Fe source signals

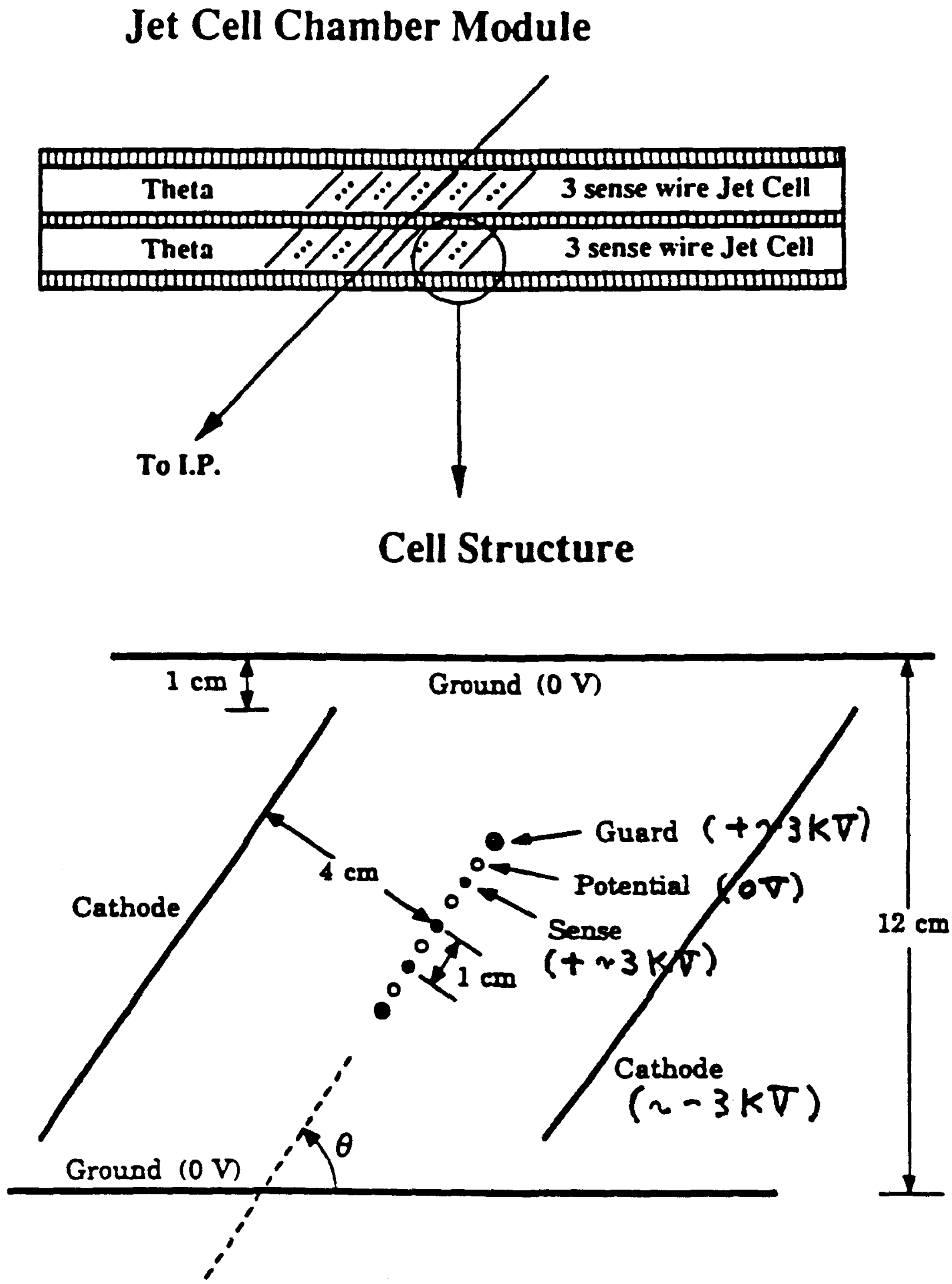


$$M = \frac{I(\text{source on}) - I(\text{source off})}{[R(\text{on}) - R(\text{off})] \times 226 \frac{e}{\text{x-ray}}}$$

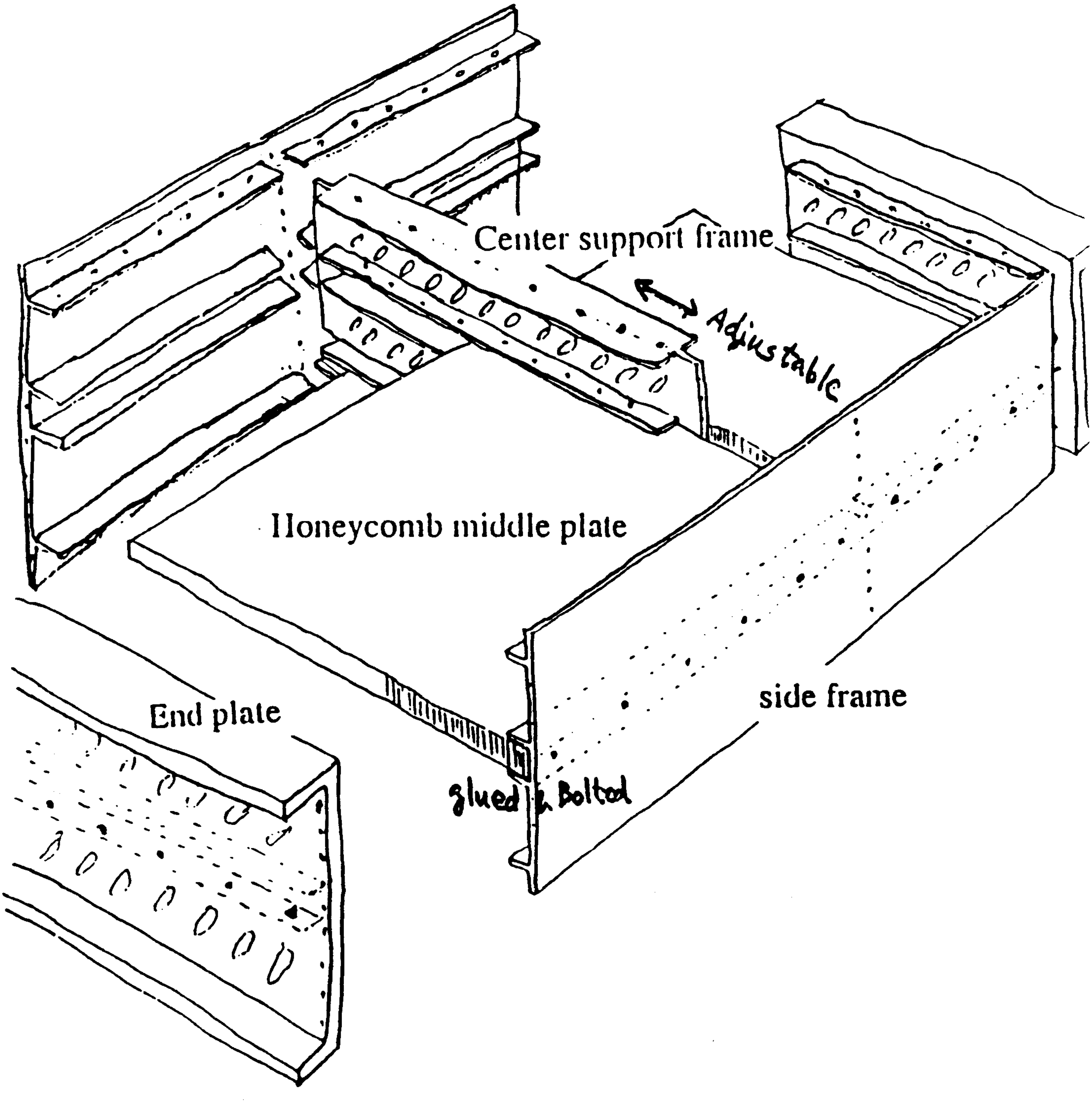
I = HV supply current

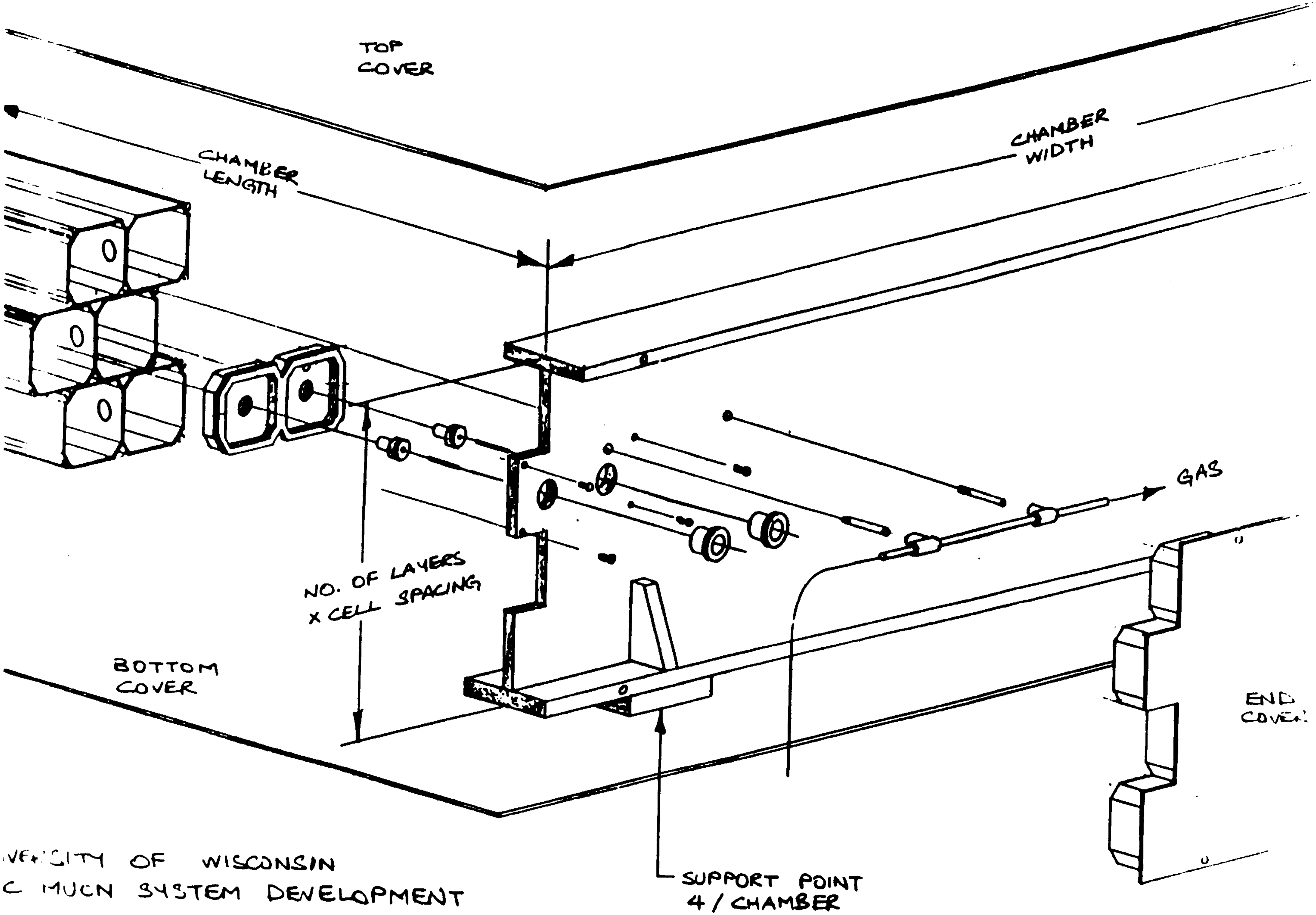
R = scope trigger rate

Slanted Jet cell partitioned with stiff cathode plates placed in a rigid box frame



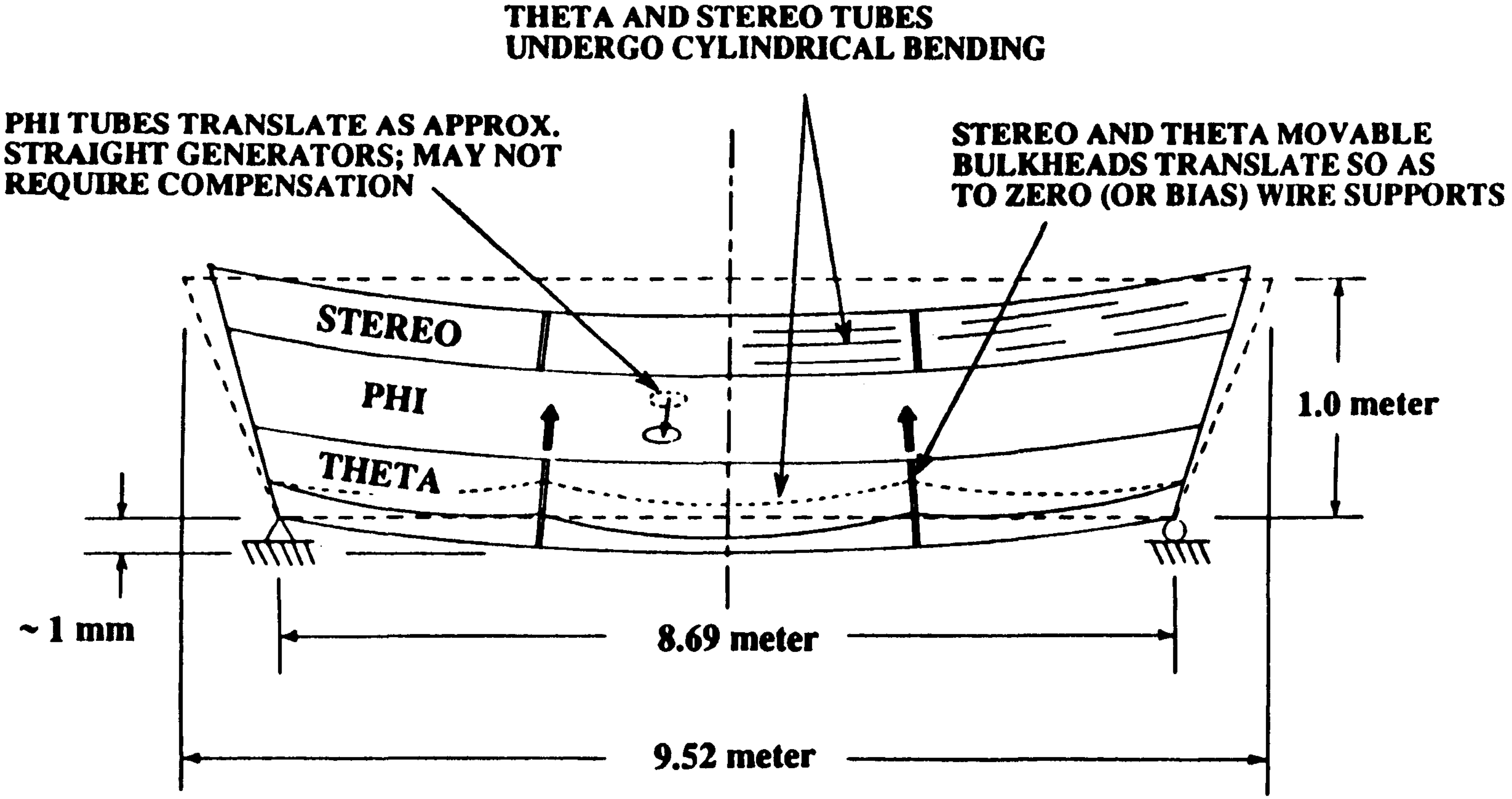
■ Frame structure and assembly procedure:





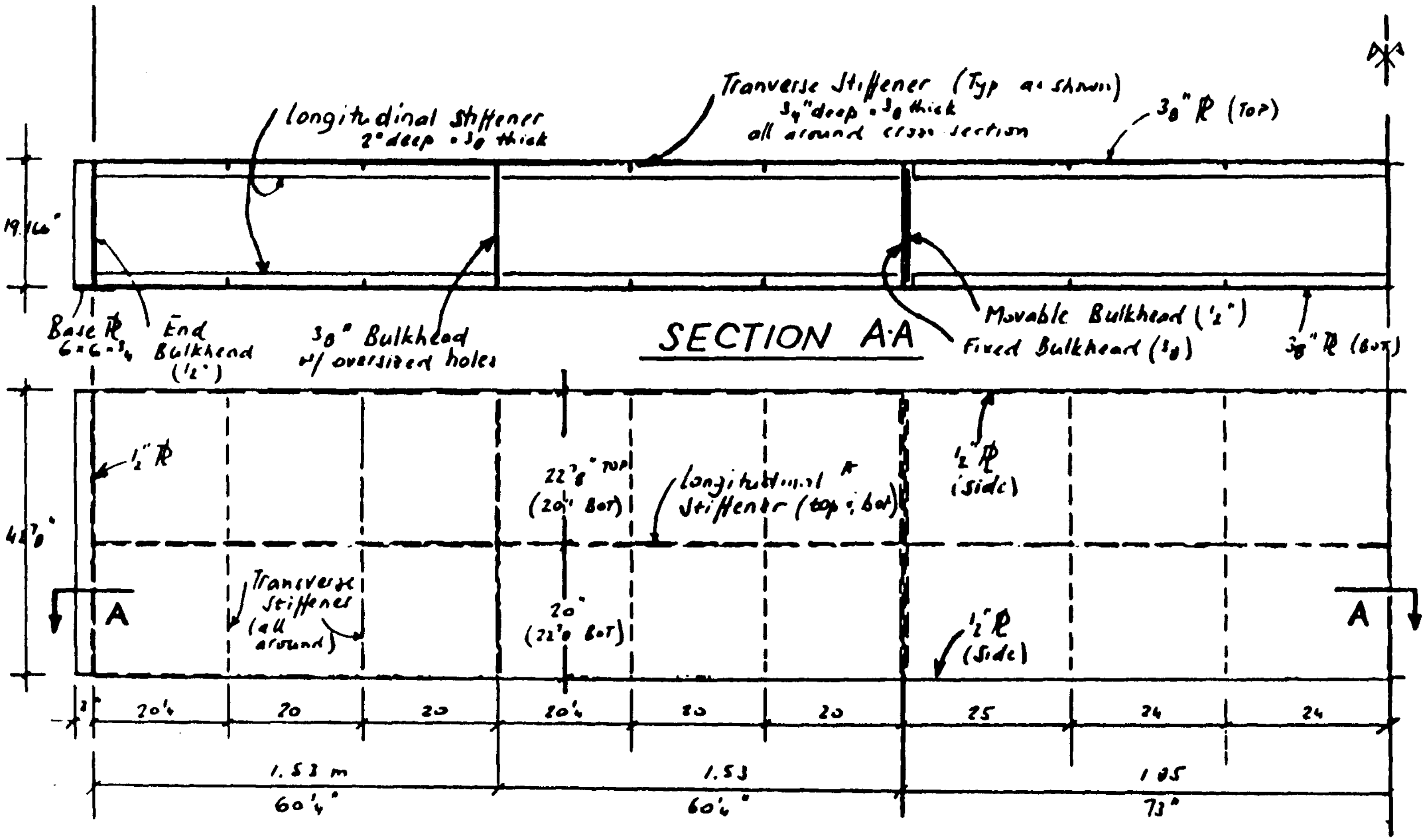
VERSITY OF WISCONSIN
C MUON SYSTEM DEVELOPMENT
ON CHAMBER CONCEPT
/ /91 FF

SUPERMODULE COMPENSATION CONCEPT



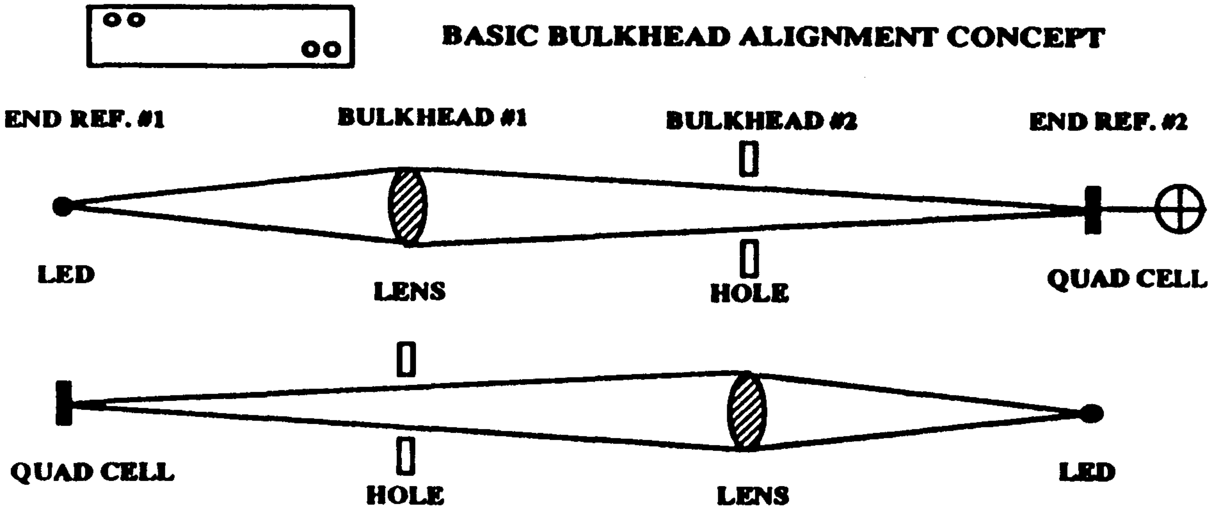
BW3 GEOMETRY

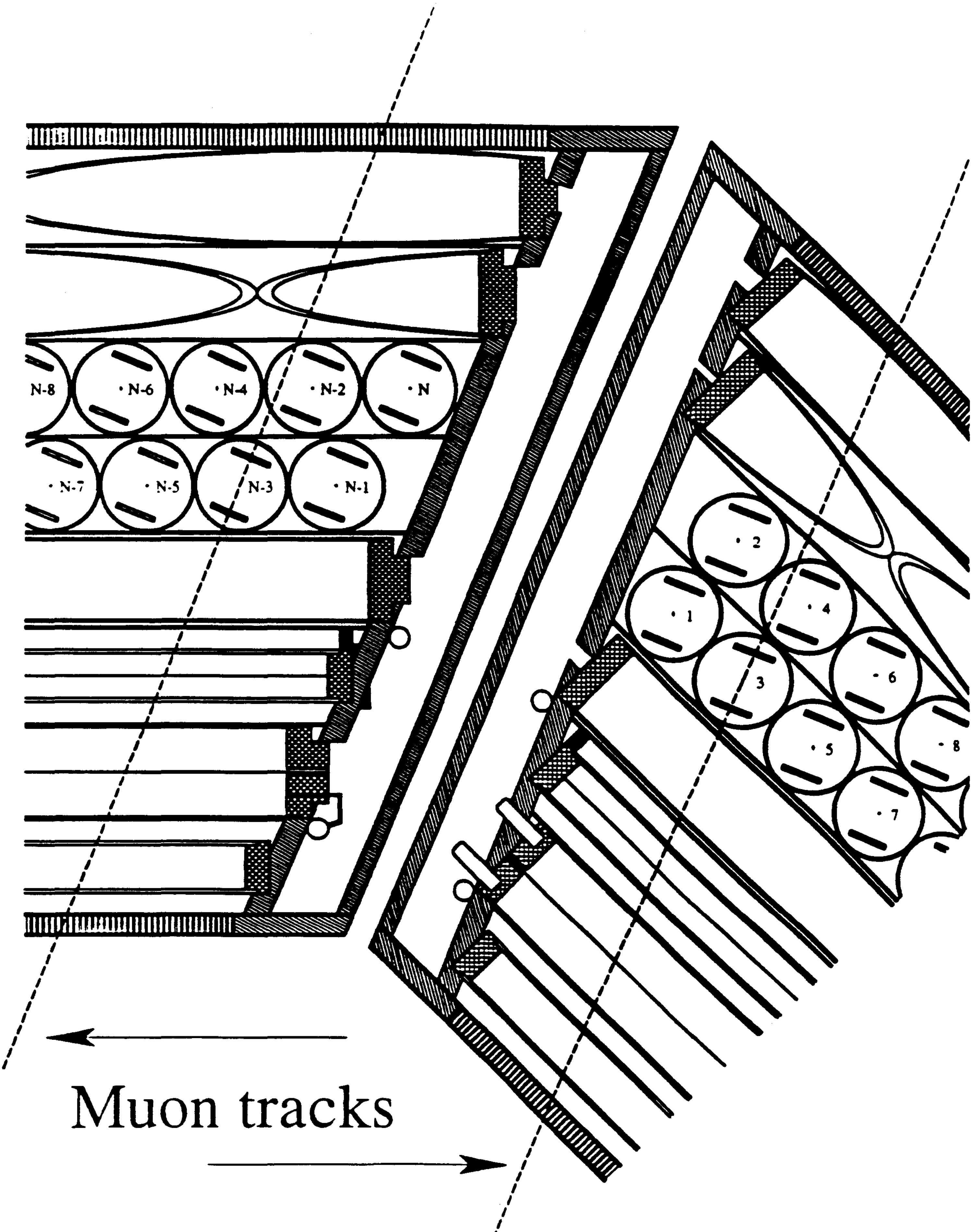
PROTOTYPE BOSTON CHAMBER DESIGN



SUMMARY OF ALIGNMENT SYSTEM CHARACTERISTICS

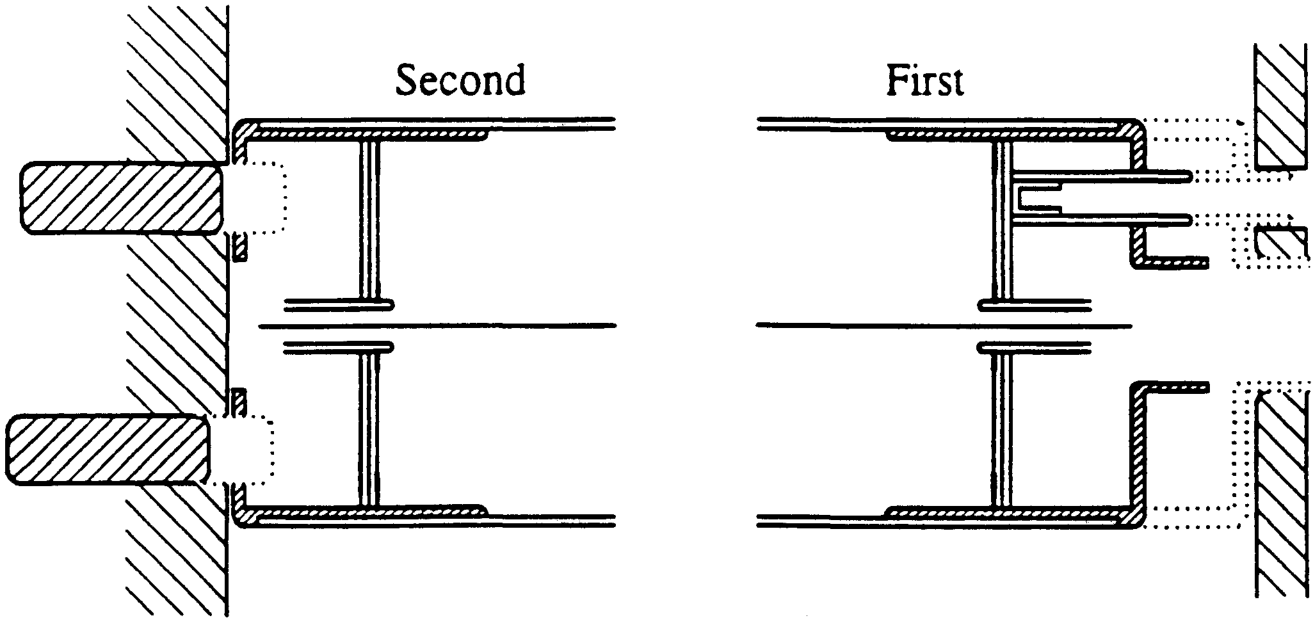
- REQUIREMENTS: SIMPLICITY, RELIABILITY, ACCURACY, COST
- SOLUTION:
  - NULLING CONCEPT USING LED/LENS/DETECTOR TO ALIGN TWO BULKHEADS W.R.T. END PLATES.
  - ASSUMES THAT BOTH SOURCE AND DETECTOR POSITIONS ARE USED AS REFERENCE.



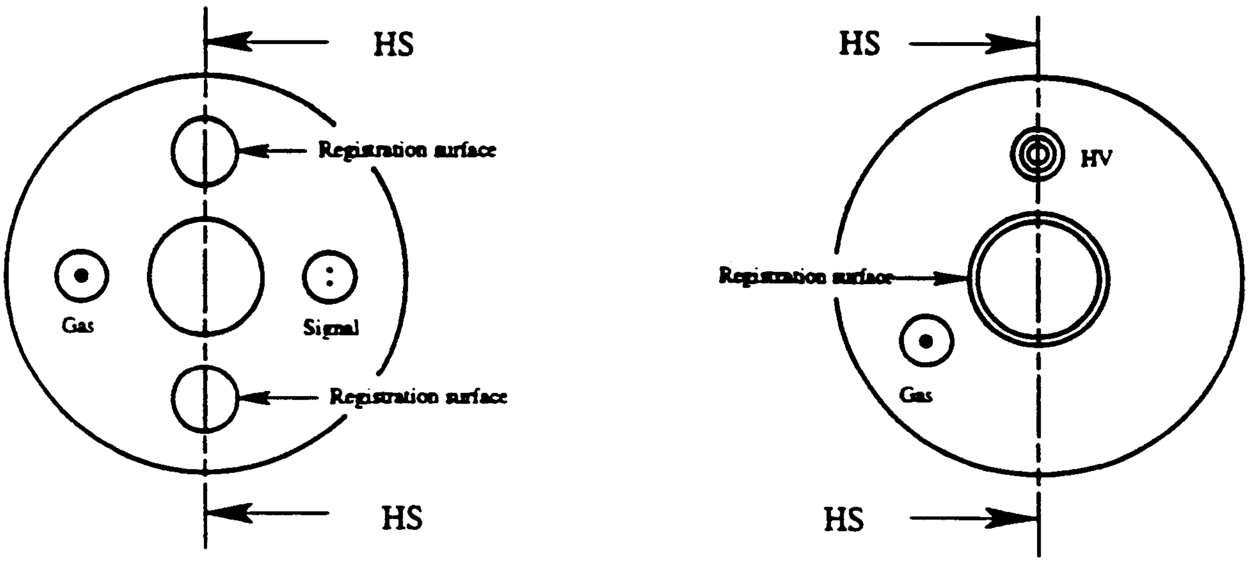


N-8
N-6
N-4
N-2
N
N-7
N-5
N-3
N-1
2
1
4
3
6
5
8
7
Muon tracks

Assembly
sequence

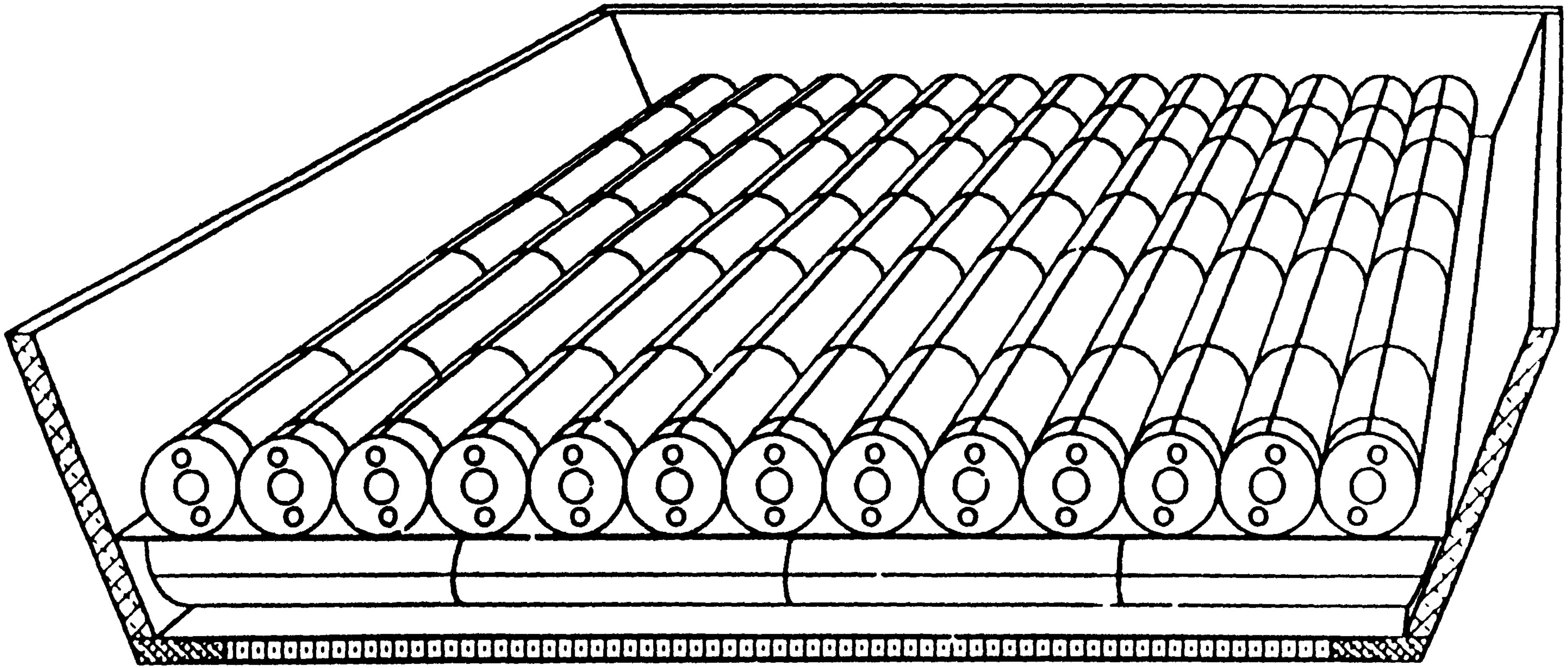


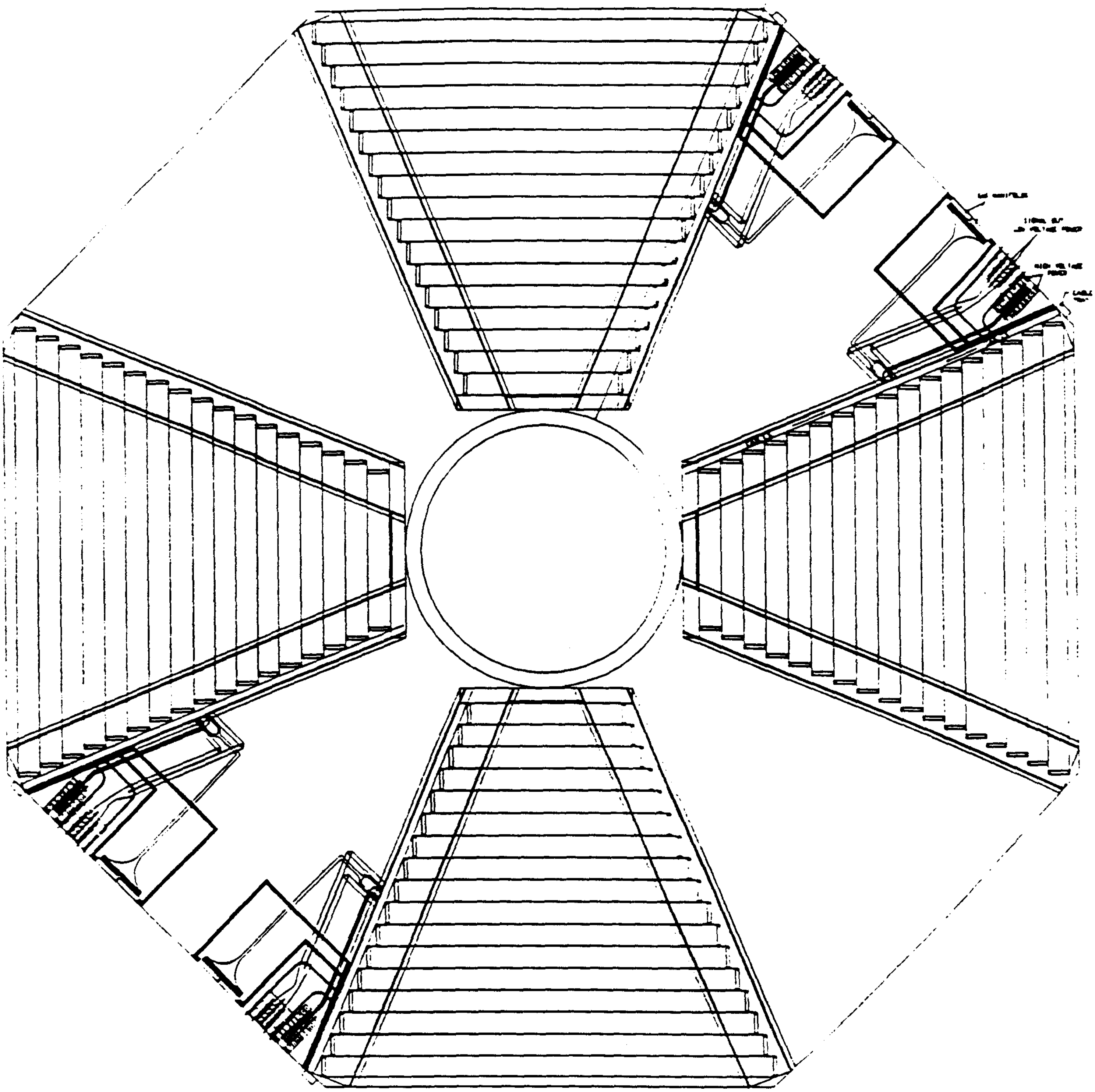
Horizontal Section



End views

Prototype to test mechanical issues



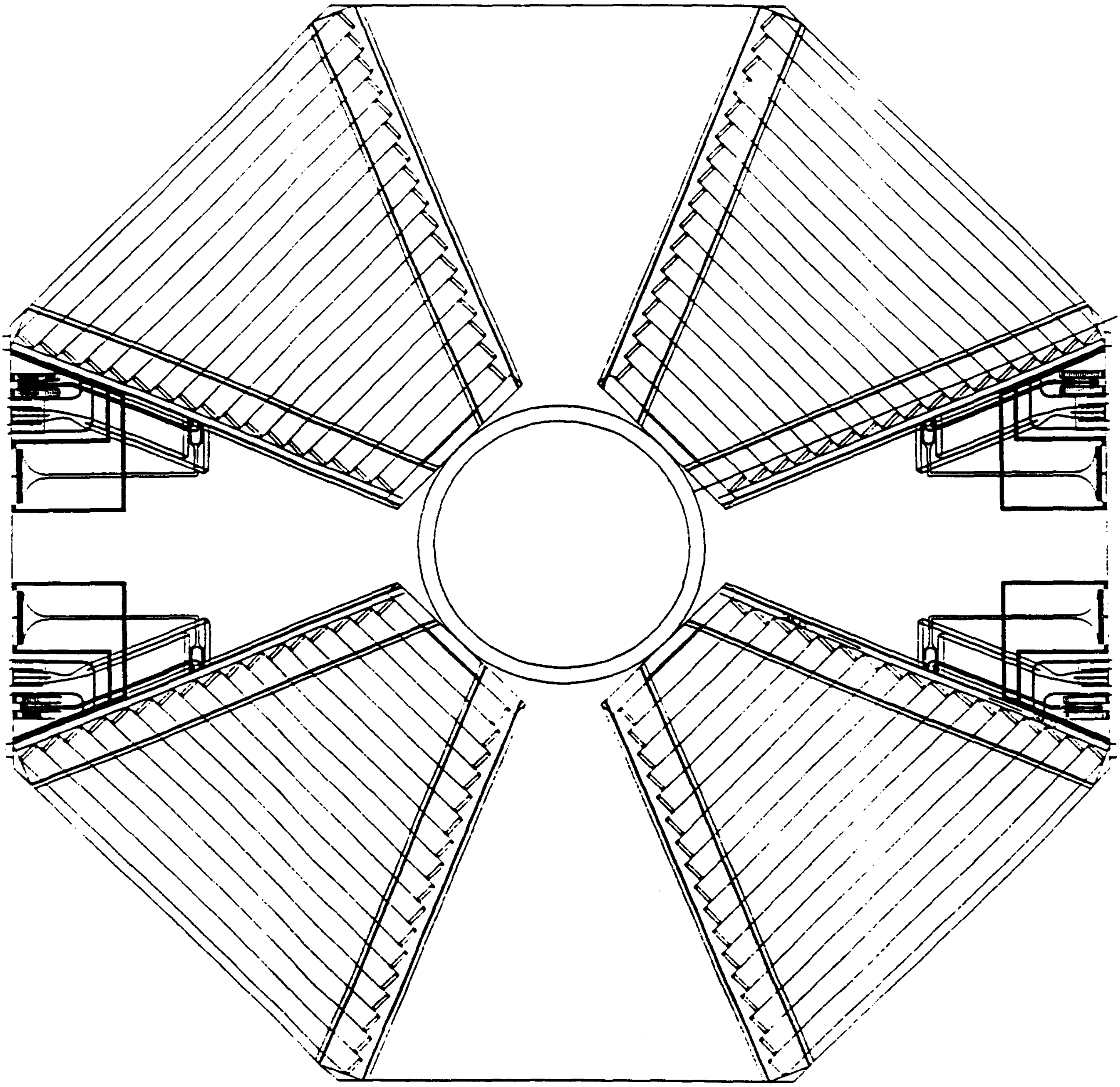


48 FRONT LAYER

Dept. of Physics and Astronomy

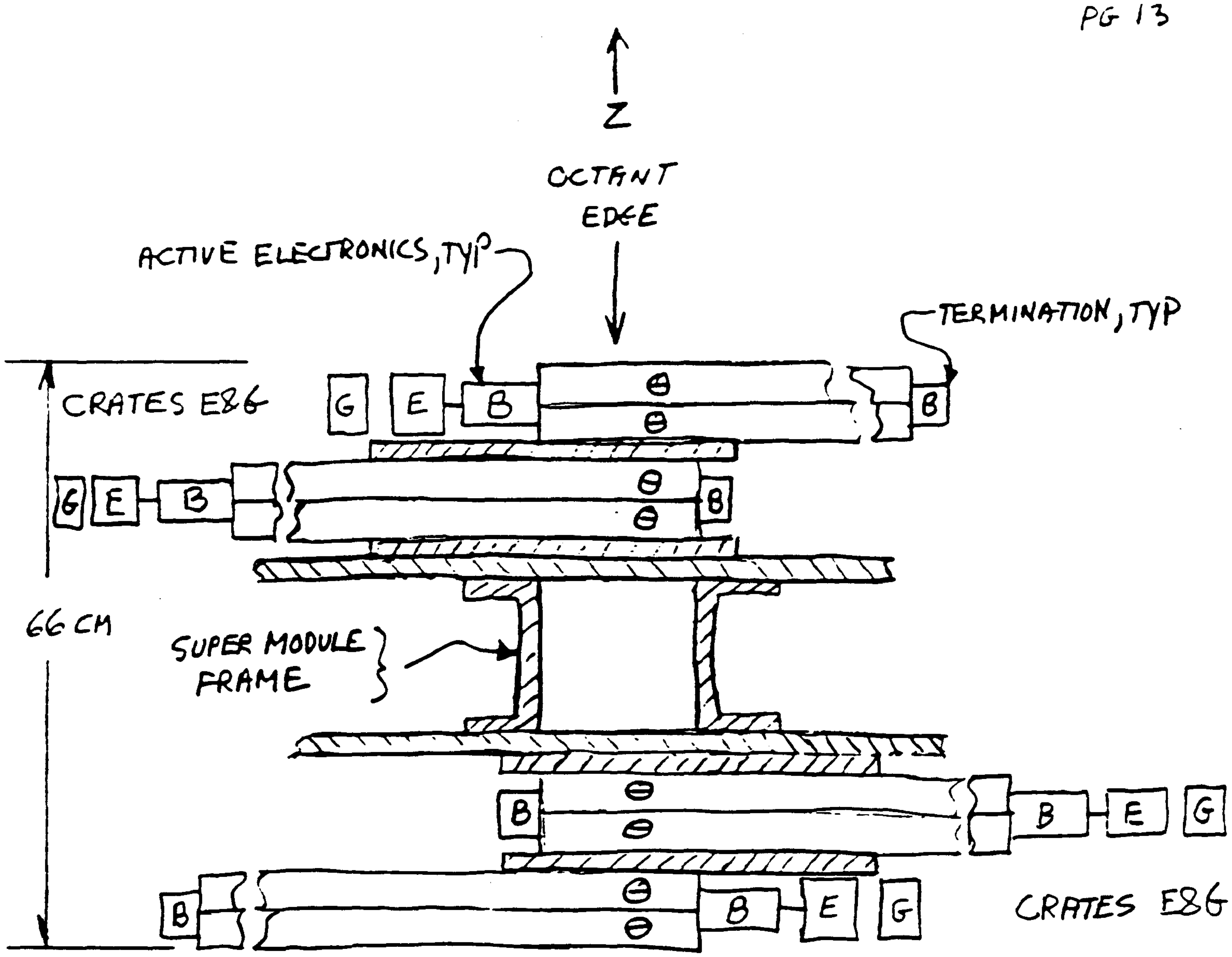
High Energy Physics

Drawing Number



45 BACK LAYER

UNIVERSITY OF MARYLAND
Dept. of Physics and Astronomy
High Energy Physics
[illegible] Forward Muon Chambers
Drawing Number
By Mike Murrbach Date 09.18.[illegible]
Revision [illegible] Rev. Date 09.24.[illegible]
Revision by Mike Murrbach
ACAD FILE [illegible] SCALE NOT TO SCALE



B = BOARDS
E = ELEC CABLES
G = GAS LINES

FIGURE 7b - STATION N FW4
4 CM CHAMBERS

Test Beam Program

1) Study of debris associated with muons in an absorber.

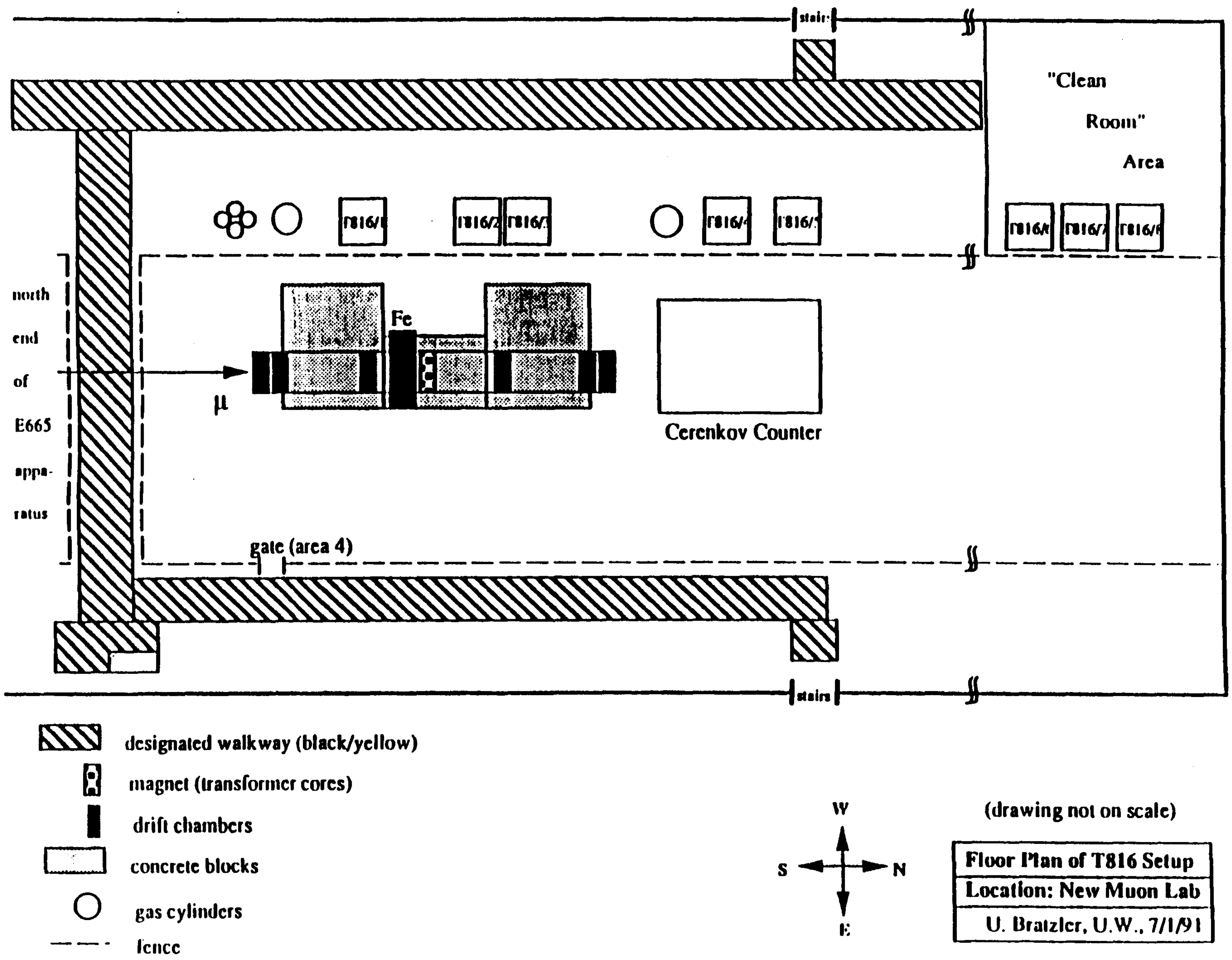
- Dependence on muon energy.
- Dependence on material.

2) Measurement of neutrons produced in a calorimeter.

3) Determine the effect of accompanying debris on track reconstruction and resolution.

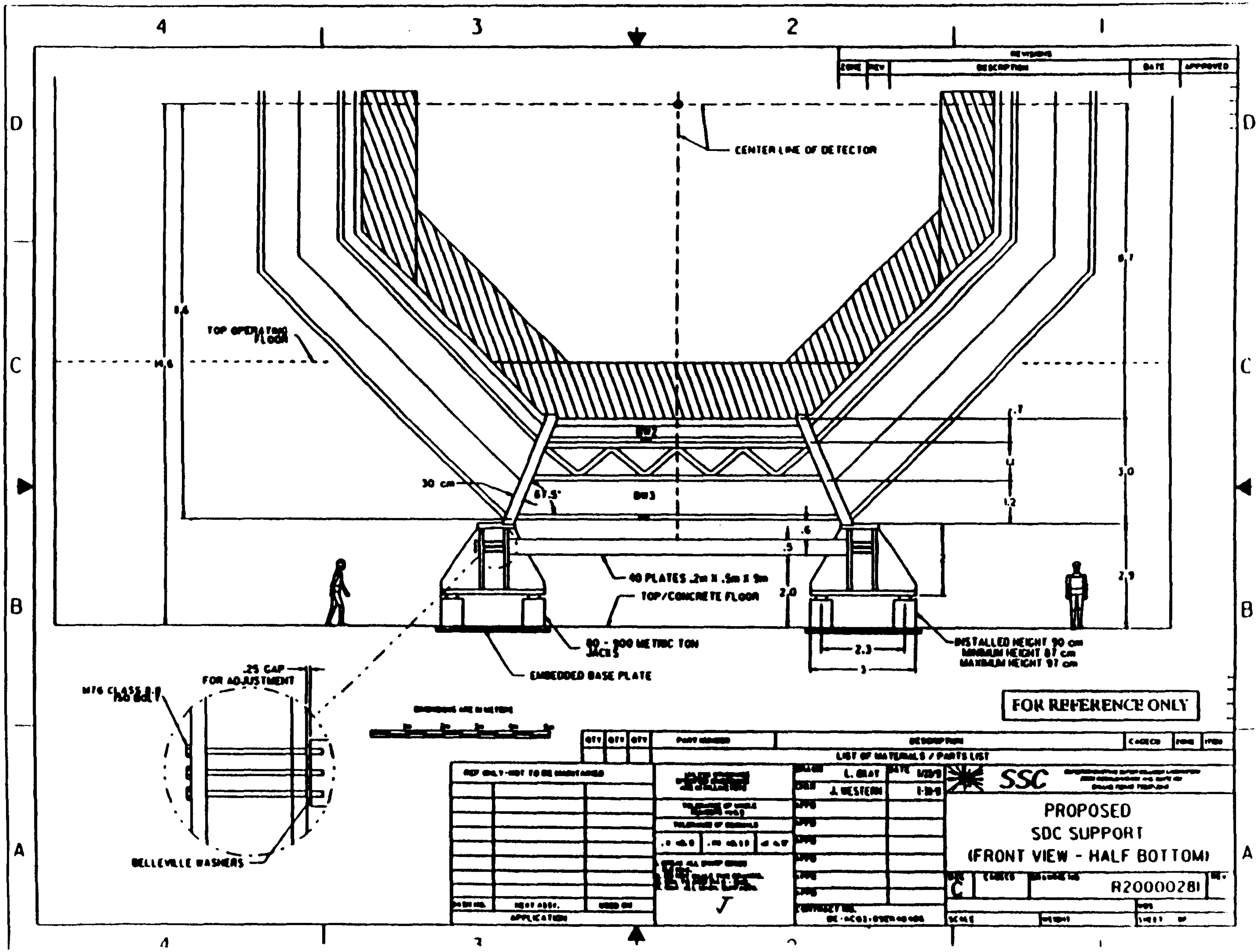
4) Cerenkov counter test.

5) First data run - October 3, 1991.

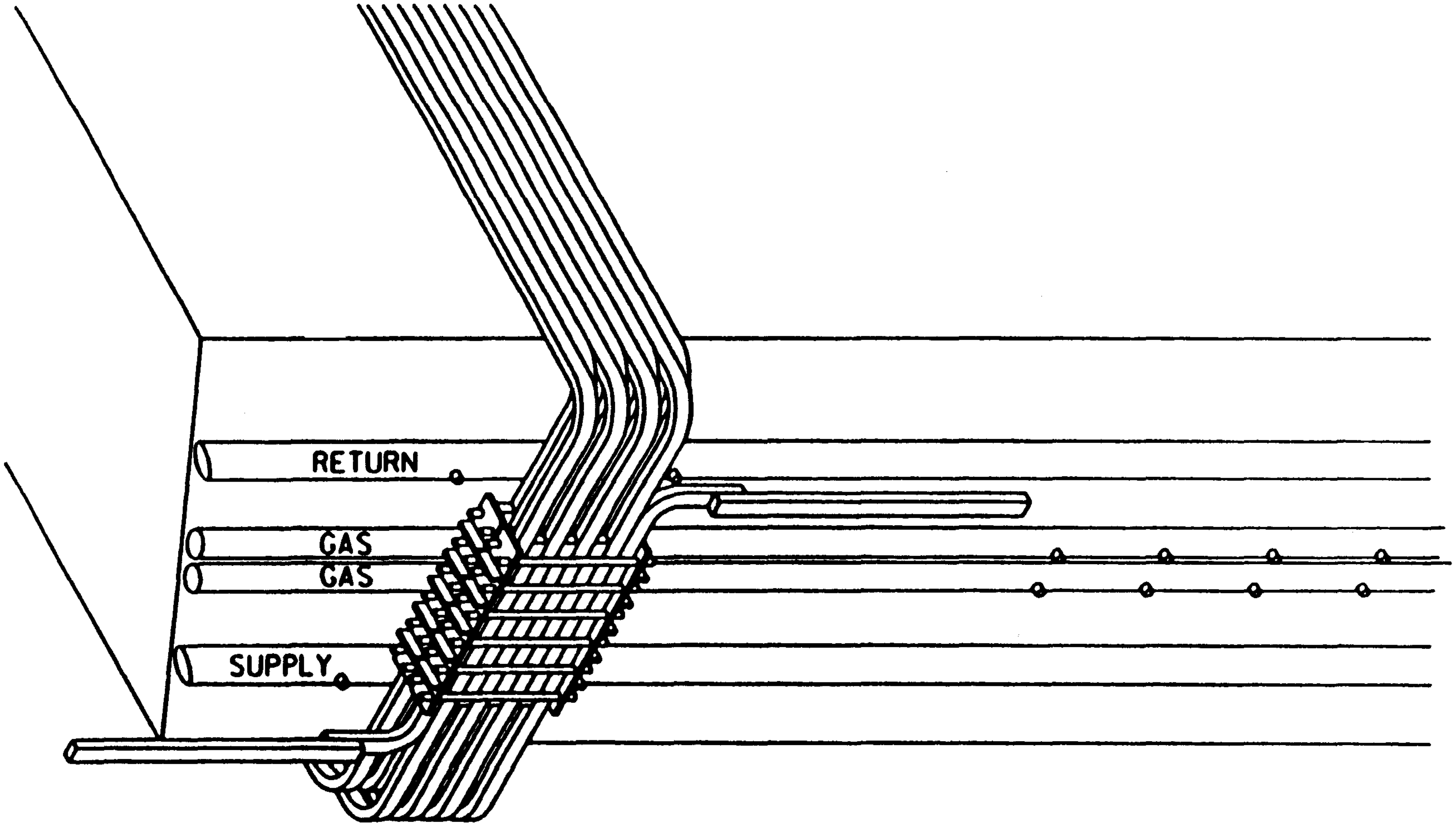

stairs
"Clean
Room"
Area
T816/1
T816/2
T816/3
T816/4
T816/5
T816/6
T816/7
T816/8
north
end
of
E665
appa-
ratus
Fe
μ
Cerenkov Counter
gate (area 4)
stairs
designated walkway (black/yellow)
magnet (transformer cores)
drift chambers
concrete blocks
gas cylinders
fence
W
S
N
E
(drawing not on scale)
Floor Plan of T816 Setup
Location: New Muon Lab
U. Bratzler, U.W., 7/1/91

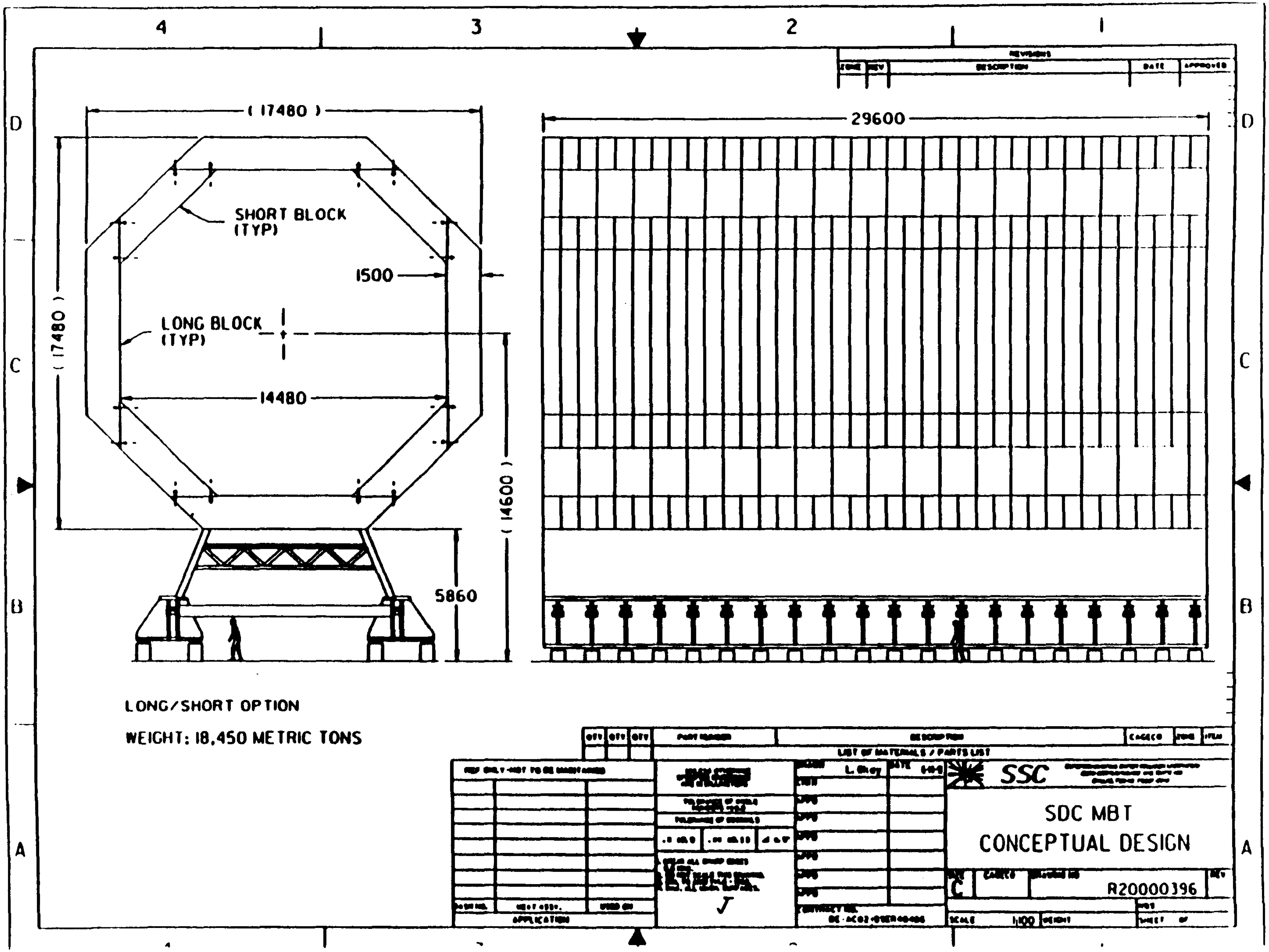
T816 Tests of Prototype Muon Chambers

- Overall Efficiency
- Effy vs. Drift Distance
- Drift Distance vs Time - How Linear?
- Spatial Resolution
- Spatial Resolution vs. Drift Distance
- Hit Multiplicities ($\delta-$rays)
- Two/Multi-hit Spatial Resolution
- Noise Immunity/Stability/Reliability
- Angle Effect(s)
- Performance vs. Gas Type(s)
- Wire Aging vs Gas Type(s)



CENTER LINE OF DETECTOR
TOP OPERATING FLOOR
30 cm
87.5°
40 PLATES .2m X .5m X 9m
TOP/CONCRETE FLOOR
80 - 900 METRIC TON JACKS
EMBEDDED BASE PLATE
INSTALLED HEIGHT 90 cm
MINIMUM HEIGHT 87 cm
MAXIMUM HEIGHT 97 cm
.25 GAP FOR ADJUSTMENT
BELLEVILLE WASHERS
FOR REFERENCE ONLY
LIST OF MATERIALS / PARTS LIST
L. GRAY
J. WESTERN
SSC
PROPOSED
SDC SUPPORT
(FRONT VIEW - HALF BOTTOM)
C
R20000281
APPLICATION


RETURN
GAS
GAS
SUPPLY



(17480)
SHORT BLOCK (TYP)
1500
LONG BLOCK (TYP)
(17480)
14480
(14600)
5860
29600
LONG/SHORT OPTION
WEIGHT: 18,450 METRIC TONS
SSC
SDC MBT
CONCEPTUAL DESIGN
C
R20000396
1:100

A. Lankford

PAC Meeting
October 3-4, 1991

SDC FRONT-END ELECTRONICS: OVERVIEW OF STATUS AND R&D PRIORITIES

Status:

Development of critical custom IC's proceeding well,
but no complete proof-of-principle yet.
Significant work remains.
Preliminary conceptual design reports exist, and have been reviewed, for nearly every front-end system.

FY92 R&D Priorities:

Complete proof-of-principle of critical IC's
for each detector subsystem.
Perform system tests
to demonstrate requisite performance,
particularly in face of digital/analog crosstalk
in a many channel system.
Complete conceptual designs of all systems.
Initiate development of support IC's
common to several of all systems,
such as programmable delays, data collection,
clock drivers, etc.

Impact of budget:

Proof-of-principle for some critical IC's will be delayed.
Full system tests will not be performed this year.
No funding for support IC's.

SDC STRAW TRACKER READOUT
(Penn, KEK)

Overview:

Preamp, shaper, discriminator, data buffering, formation of trigger primitives, and data collection circuits are all mounted on chamber endplate. Packaging of this electronics is challenging.

FY92 R&D Tasks:

- Preamp/shaper/discriminator:
  - Integrate preamp/shaper with discriminator.
  - Layout and fabricate 8-channel ASD.
- Data storage and readout:
  - Convert TMC to rad hard process if necessary.
  - Extend TMC pipeline
  - Complete development of TMC/AMU prototype.
  - Conceptual design of
    - Level 2 Buffer (L2B)
    - Data Collection Circuit (DCC)
- System:
  - System tests for digital/analog crosstalk.
  - Study packaging for mounting on chamber,
    - e.g.: hybrids, silicon-on-substrate
  - Refine system conceptual design.
- Support chamber tests with ASD's.

Impact of budget:

- Slow ASD development.
- Eliminate support for TMC/AMU.
- Limited support for system tests.

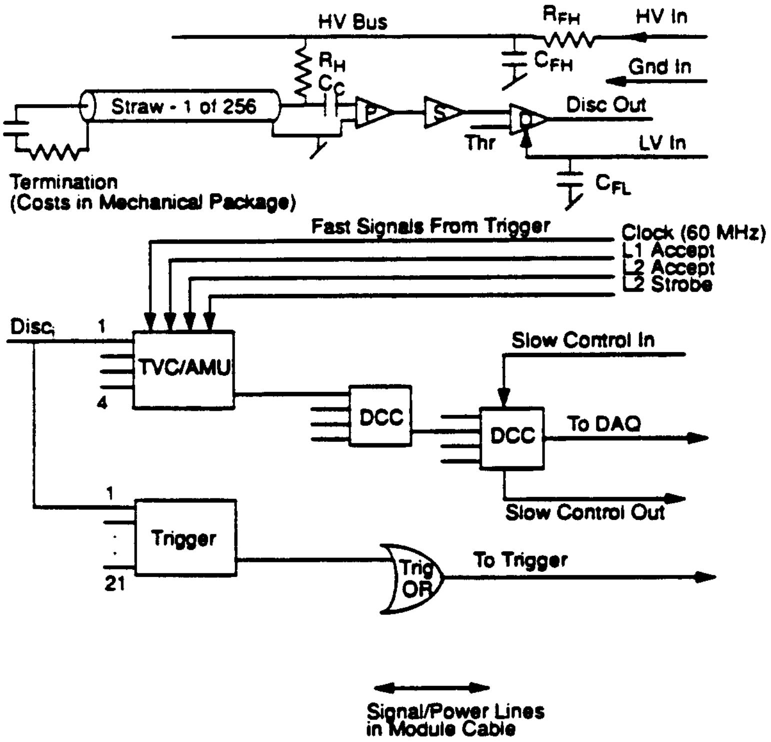


Figure 28: Block Schematic of a Straw Readout Module. Note that in this case we are describing a system with the straw anode at positive HV, it is also possible to operate the anode at ground (or near ground) potential and use a negative HV on the cathode. The negative HV scheme has some advantages in terms of the number of required HV capacitors per module but may have some disadvantages in terms of increased sensitivity to breakdown. Until further work is completed on both possibilities, we have chosen to describe the positive HV scheme both because it is somewhat more conservative and because it is, perhaps, a trifle more obvious to the reader.

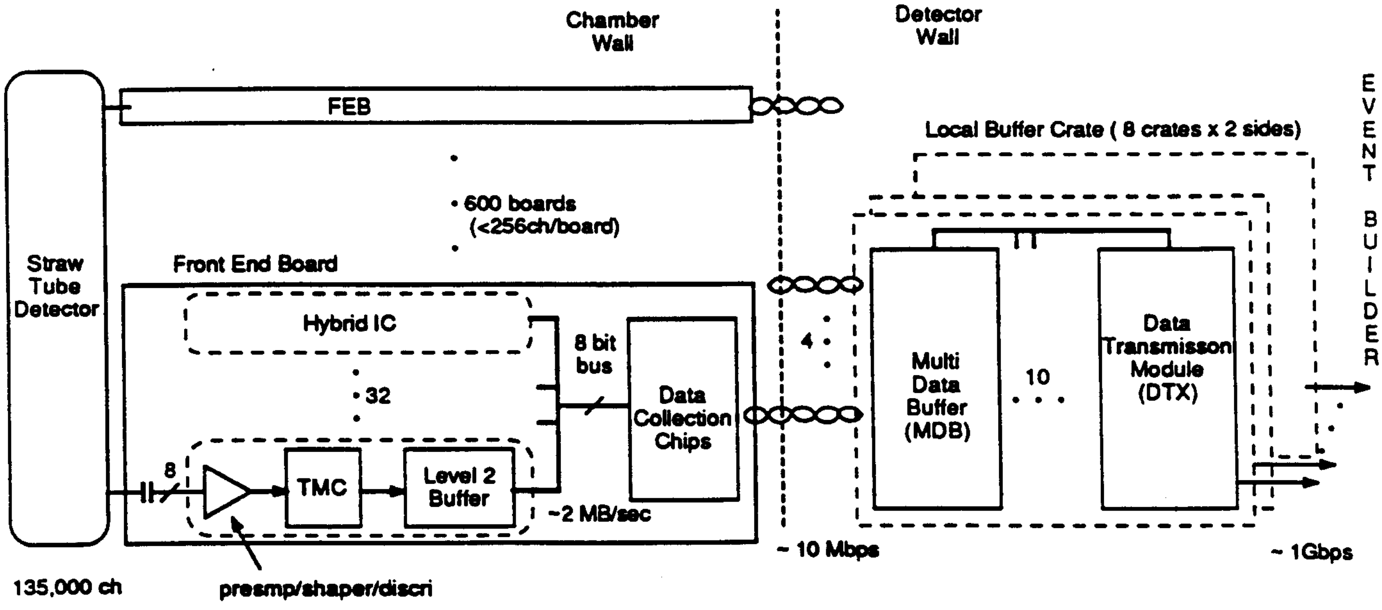


Fig.1 Data Flow Diagram of the Straw Tube

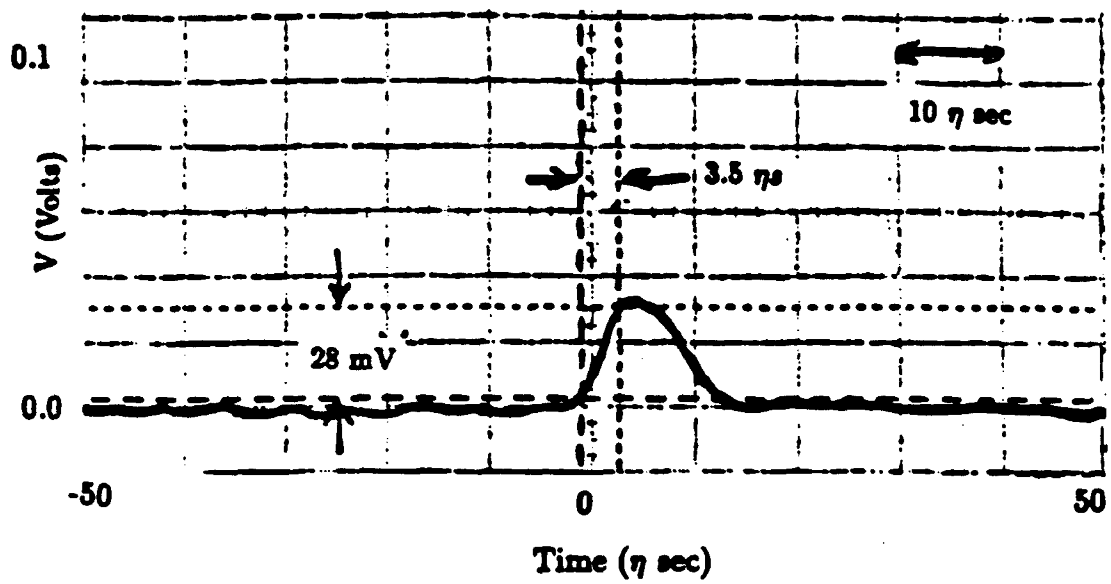


Figure 10: Signal from 2 meter straw tube filled with CF_4 The waveform shows the output of the prototype amplifier attached to a detector tail cancellation circuit.

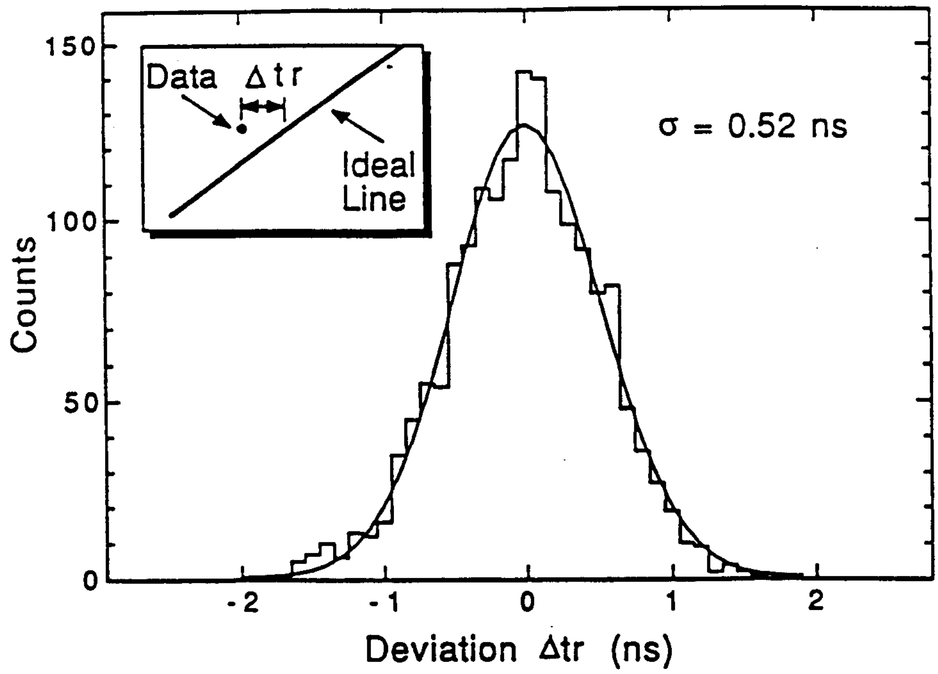


Fig. 11 Time resolution measurement. The deviation from ideal line includes both the digitization error and the TMC error.

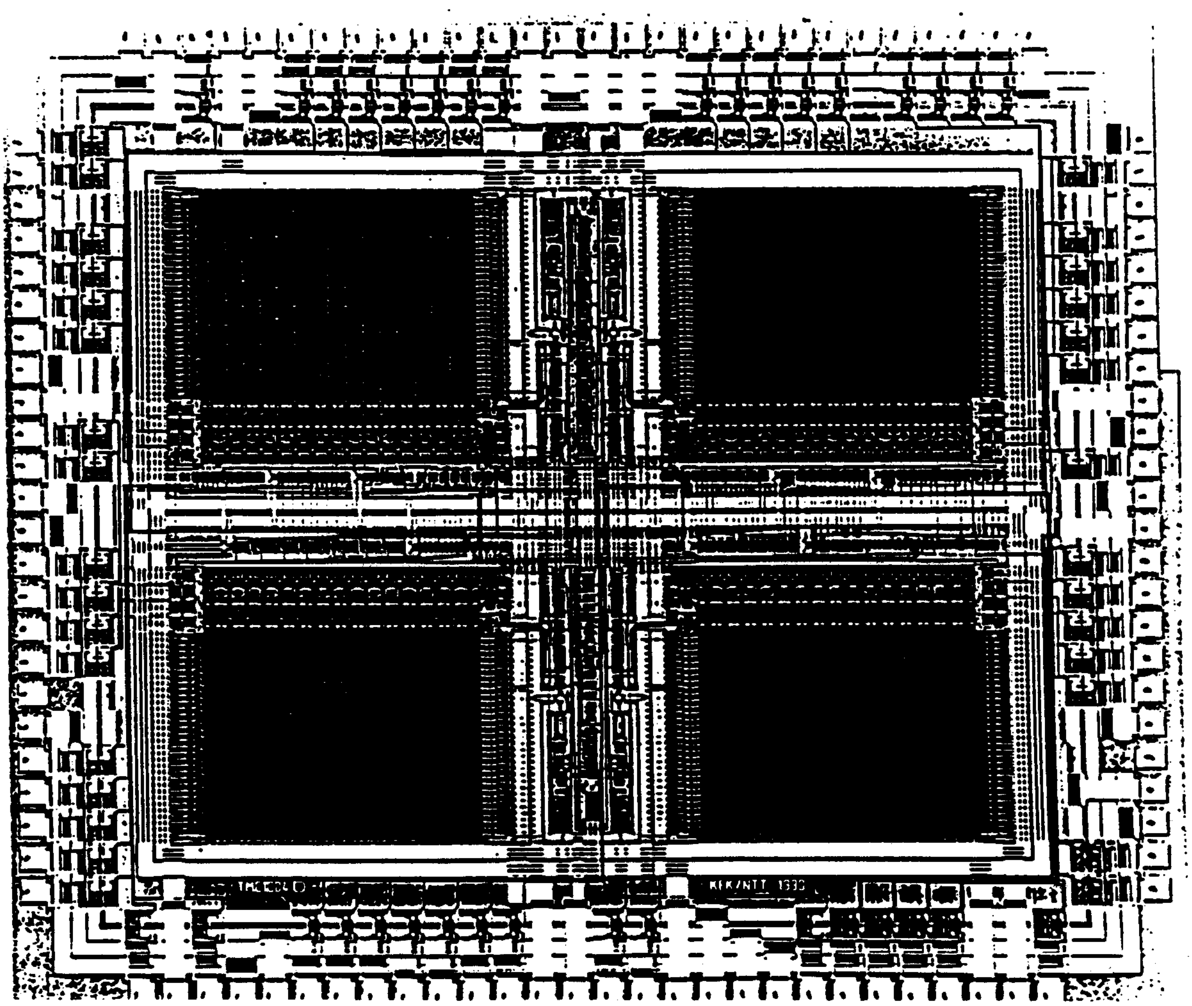


Fig. 12. Photograph of the TMC1004 chip.

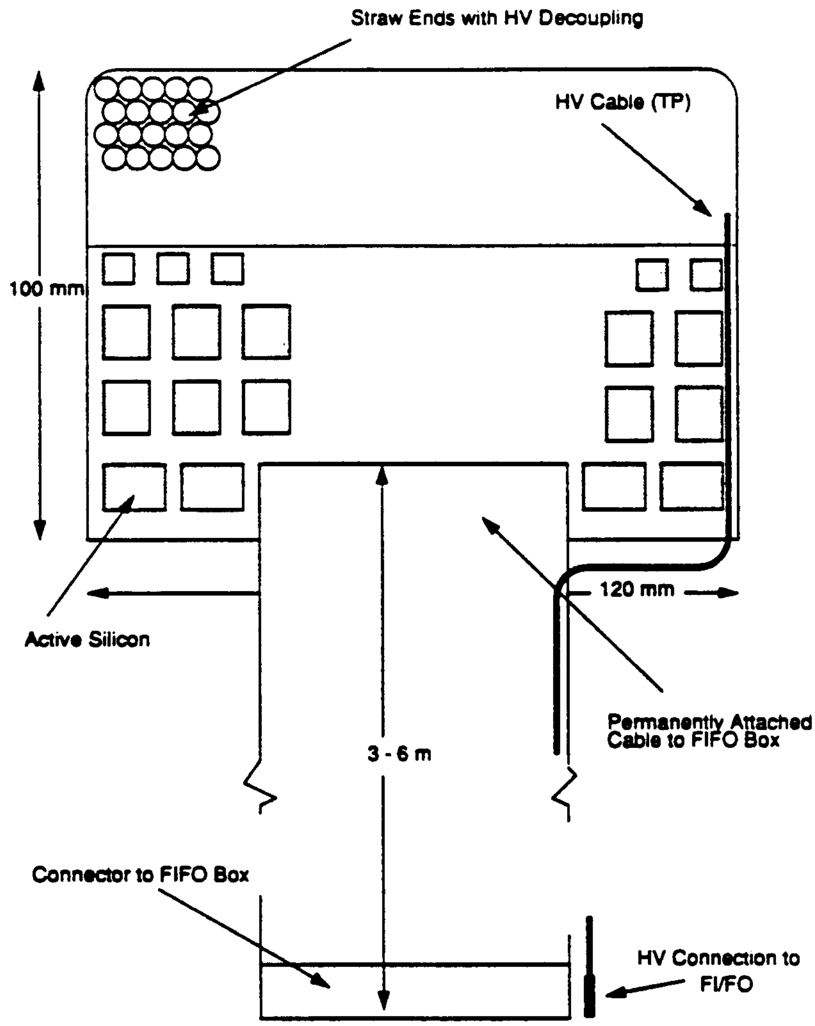


Figure 29: Approximate layout of the electronics module and attached cable.

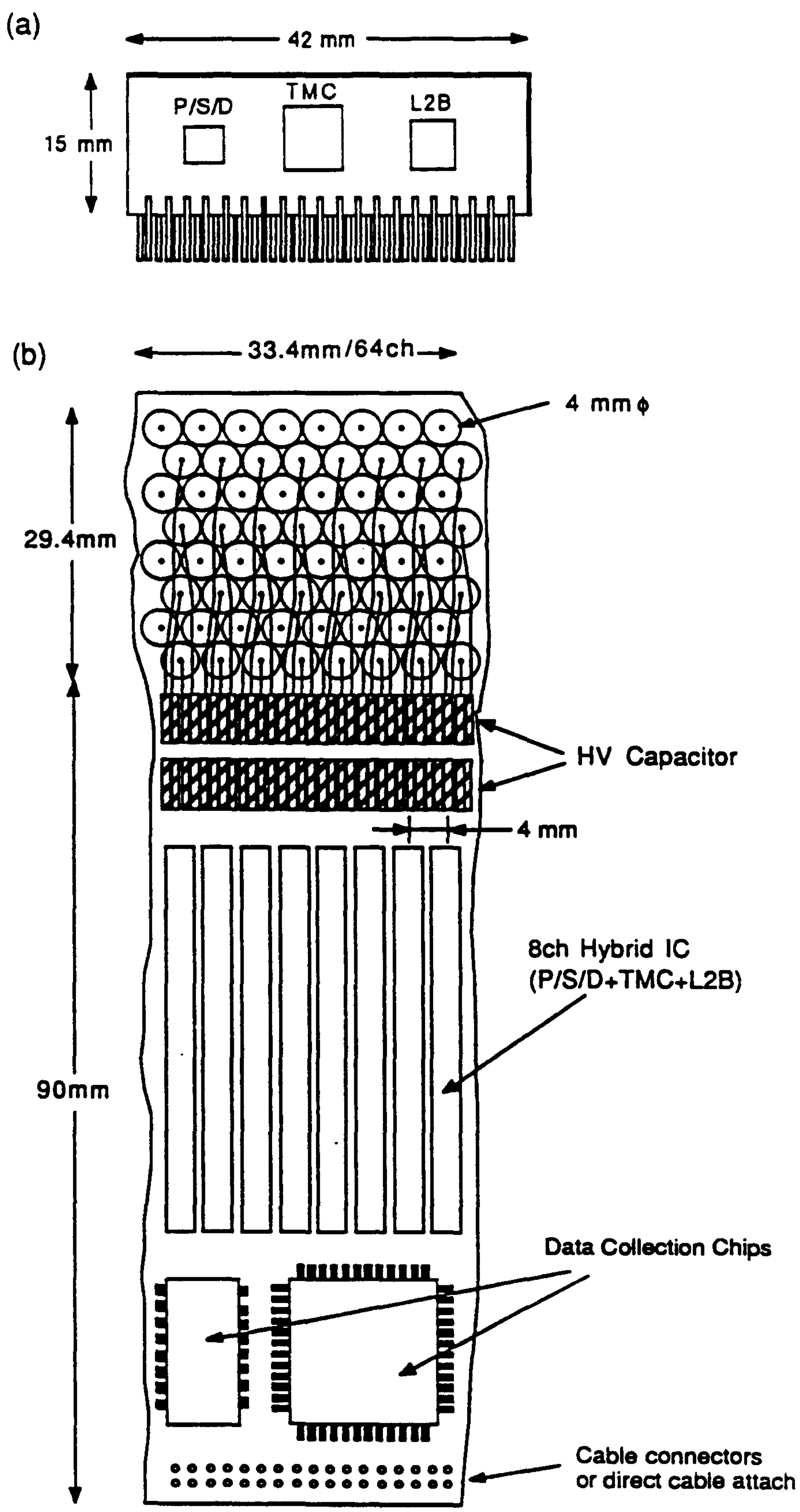


Fig. 12 Mounting Example of (a) the Hybrid IC and (b) the Front-End Board.

Fermilab SDC

Sci-Fi Tracker Electronics Current Status

VLPC Readout:

1) Working with Rockwell to specify signal levels, pulse shaping and cryostat design
2) Approximately 256 channels of prototype amplifier/shaper/discriminators of various designs, including a GAs cryogenic version.
3) Crosstalk measurements of amplifiers and cables underway.
4) Conceptual design of L1, L2, storage and track finding ASIC's.
5) Conceptual design of tracking readout board and trigger interfaces.
6) Mechanical, cooling, power design for tracking crate and VLPC cryostat proceeding.

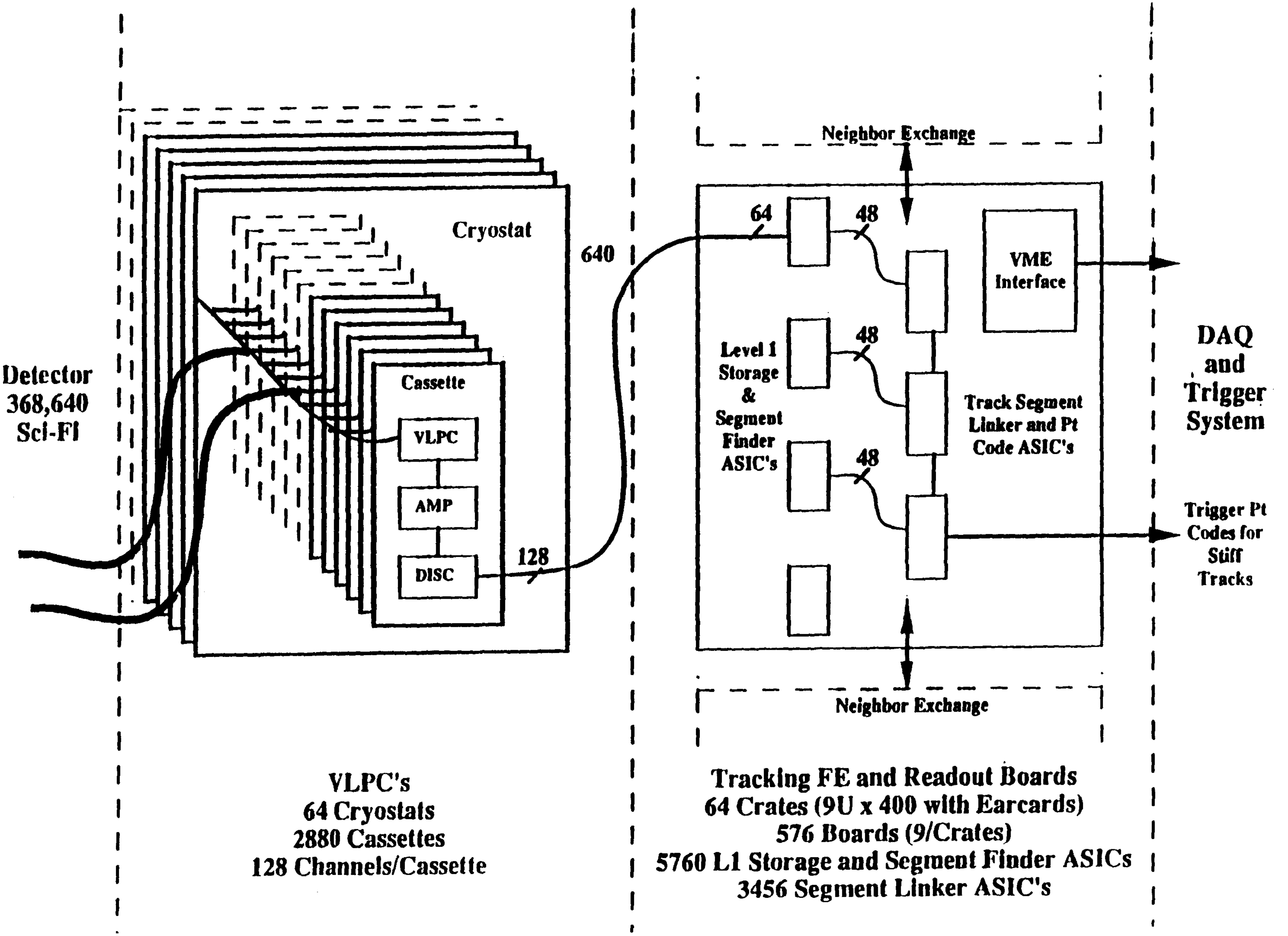
Test Beam:

1) 128 Channel fiber tracking readout board with L1 buffer and track segment finding included, being fabricated. This will be used to study tracking algorithms.
2) 128 Channel test data source at 60 Mhz being fabricated for test fixture.

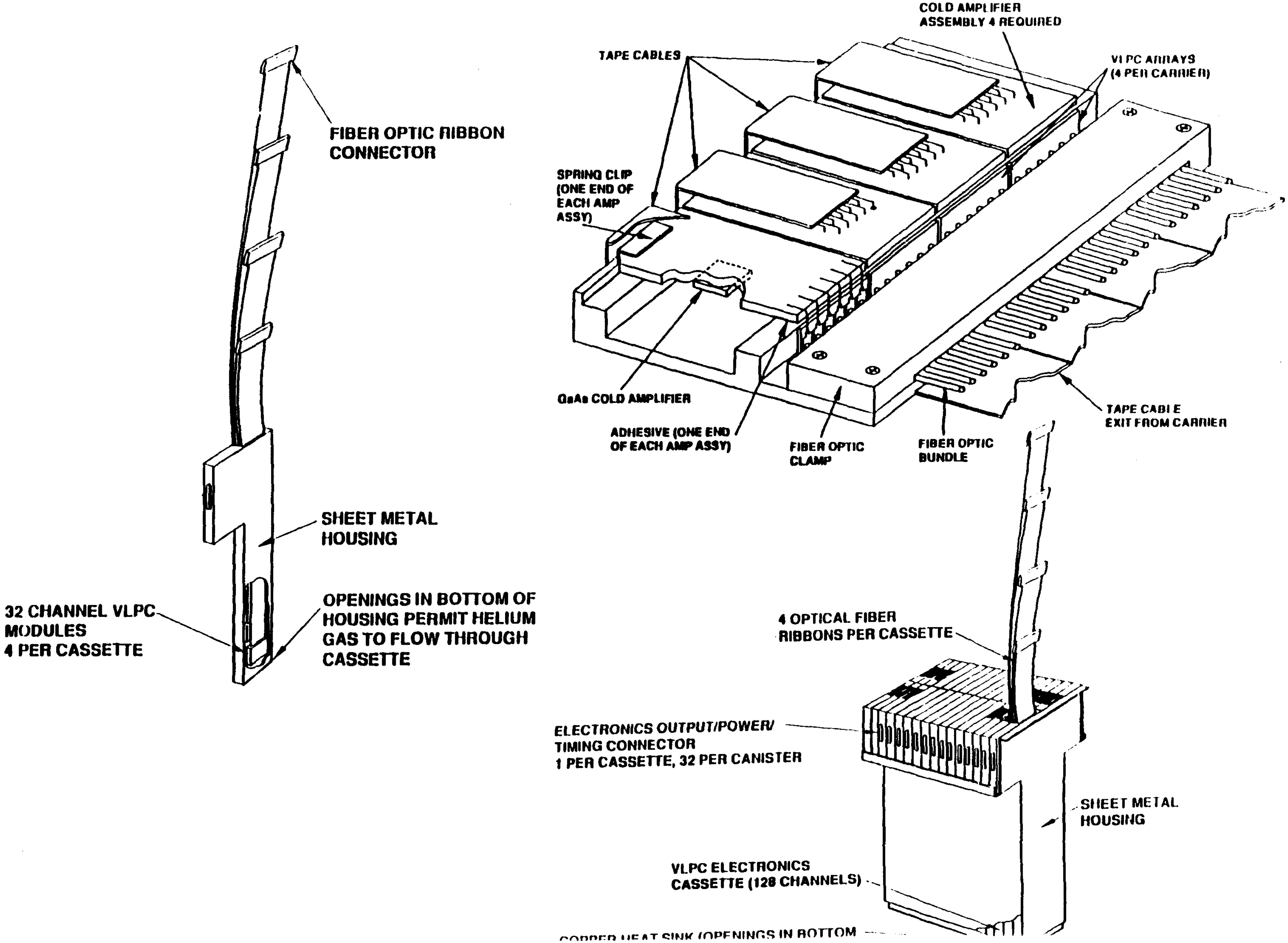
Triggering:

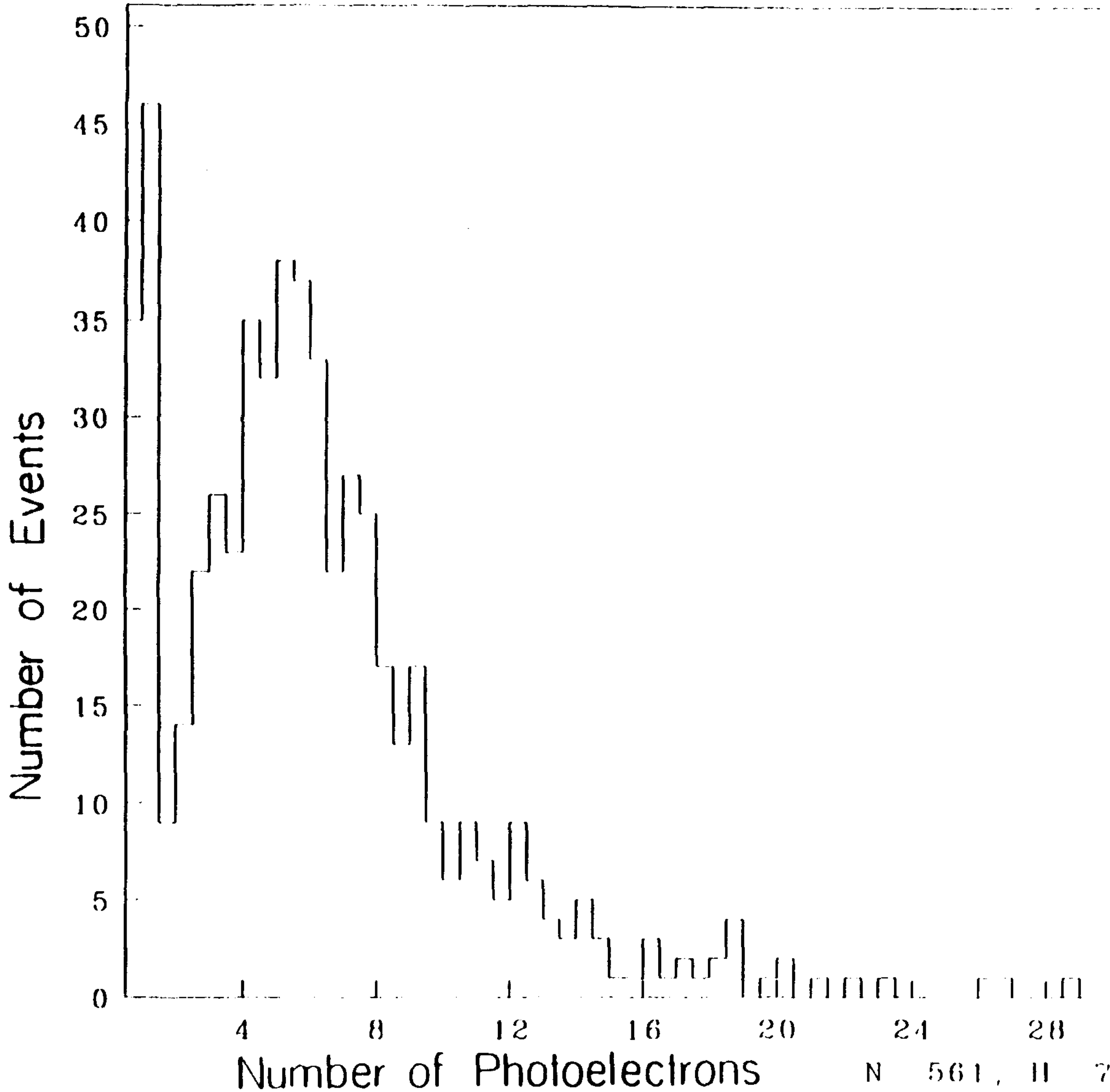
1) Segment finding test of algorithms in test beam.
2) Simulations of trigger with various super layer structures to study efficiencies.

SDC Barrel Fiber Tracker Block Diagram



SUPERCONDUCTING SUPERCOLLIDER (SSC)





3rd Layer triggered by 1&4 layers
CF 3m SF=3.5m

Fermilab SDC

Scintillating Tile - Digital Calorimeter Current Status

PMT's:

1) Studying candidate PMT's, evaluating performance,gain, MTBF, etc.
2) 128 Channel test data source at 60 Mhz being fabricated for test fixture.

Charge Pump Base:

1) Prototyping tube bases to study noise issues associated with charge pump base.
2) Designing sinusoidal charge pump base.
3) Investigating manufacturing techniques to decrease cost of PMT bases.

ASIC Design:

1) Current spiltter ASIC, prototyping underway at Orbit Semi. Tests will be completed to see if this fabrication is adequate for our needs. First pass chips due in any day.
2) Gated integrator is in conceptual design and will eventually be part of same ASIC as the current splitter. Parts of circuit have been tested.
3) FADC tests have been made with an 8 bit FADC operating on the same circuit as the fast amplifier with noise at less than 1 bit (6000 electrons).
4) Adder ASIC, design underway with test submissions to Orbit and partially functioning chips returned.
5) Calibration look-up and L1 storage ASIC, conceptual design underway with layout of some custom cells already complete for testing.

Test Beam:

1) Proof of principle Adder tree board is being constructed which will have 16 inputs each having an 8 bit mantissa and 4 bit exponent.
2) L1 storage, a prototype board is being assembled which will provide digital pipeline storage for 16 PMT's.

Impact of budget on digital calorimeter readout:

Support only for development of current splitter/integrator IC.

Impact of budget on sci-fi tracker readout:

Support only:

- Refinements to VLPC
- Conceptual design of analog and digital electronics.

SDC CALORIMETER READOUT with SWITCHED CAPACITOR ARRAY

(LBL)

Overview:

It is contemplated that a single front-end board will contain all the following functions:

- signal amplification, storage pending L1/L2 decisions,
- sums and primatives for the L1 trigger,
- control, clocks and time synchronization,
- calibration, and high-speed readout.

We especially need to demonstrate the analog store concept in the noisy environment of a circuit card with a large number of channels.

The performance of the IC's will continue to improve with the available technology, and we intend to continue iterating on the current designs in order to acheive the fundamental limits and fully exploit the limits of this technology.

FY92 R&D Tasks:

- System conceptual design and engineering.
- Design and simulation of amplifiers:
  - preamp, delay-line shaper, split-scale drivers.
- Continued development of architecture chip (ALP).
- Improvements to SCA:
  - linearity, op amp, input protection, receivers, continued refinement.
- Completion of ADC:
  - improvement, multichannel version, integrate w/ SCA.
- Board/system tests.

Impact of budget:

- Reduction in technical support (chip testing, technician).
- Defer work on amplifiers.
- Slow down SCA and ADC work.

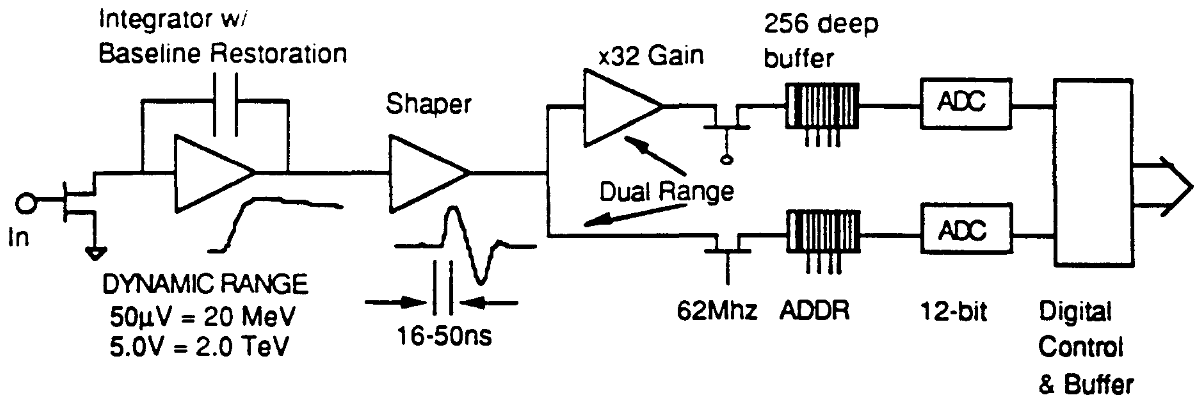
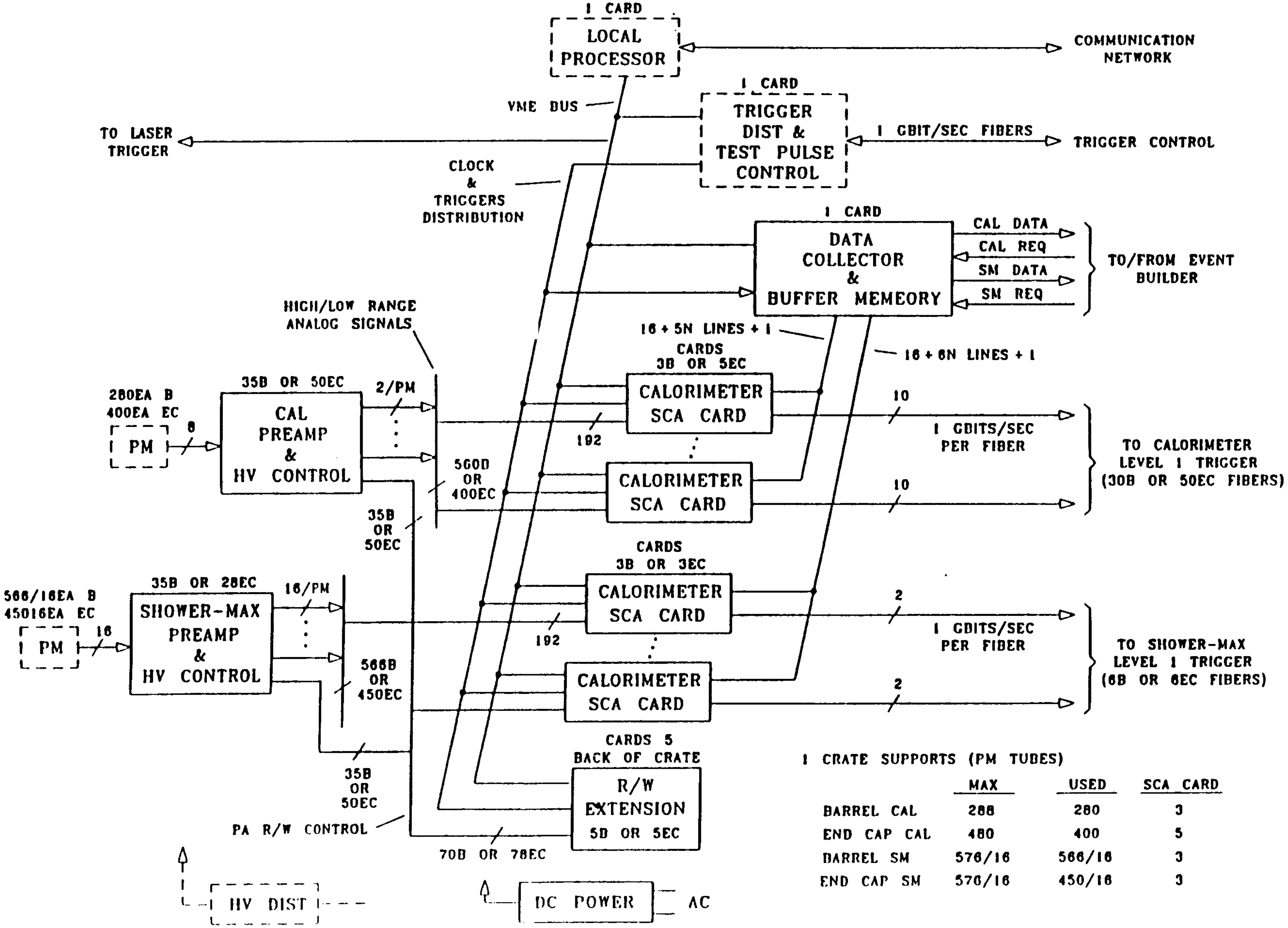


Fig. 1.4. Shown in the figure is a conceptual design for an SSC calorimeter front end electronics architecture. Signals are preamplified, shaped, split into high and low-range channels, and then stored during the level 1/2 trigger decision in an analog memory. After a Level 2 accept analog data are digitized and readout.

FRONT END CRATE FOR CALORIMETER AND SHOWER-MAX
(1 OF 96 CRATES SHOWN 64B AND 32EC)

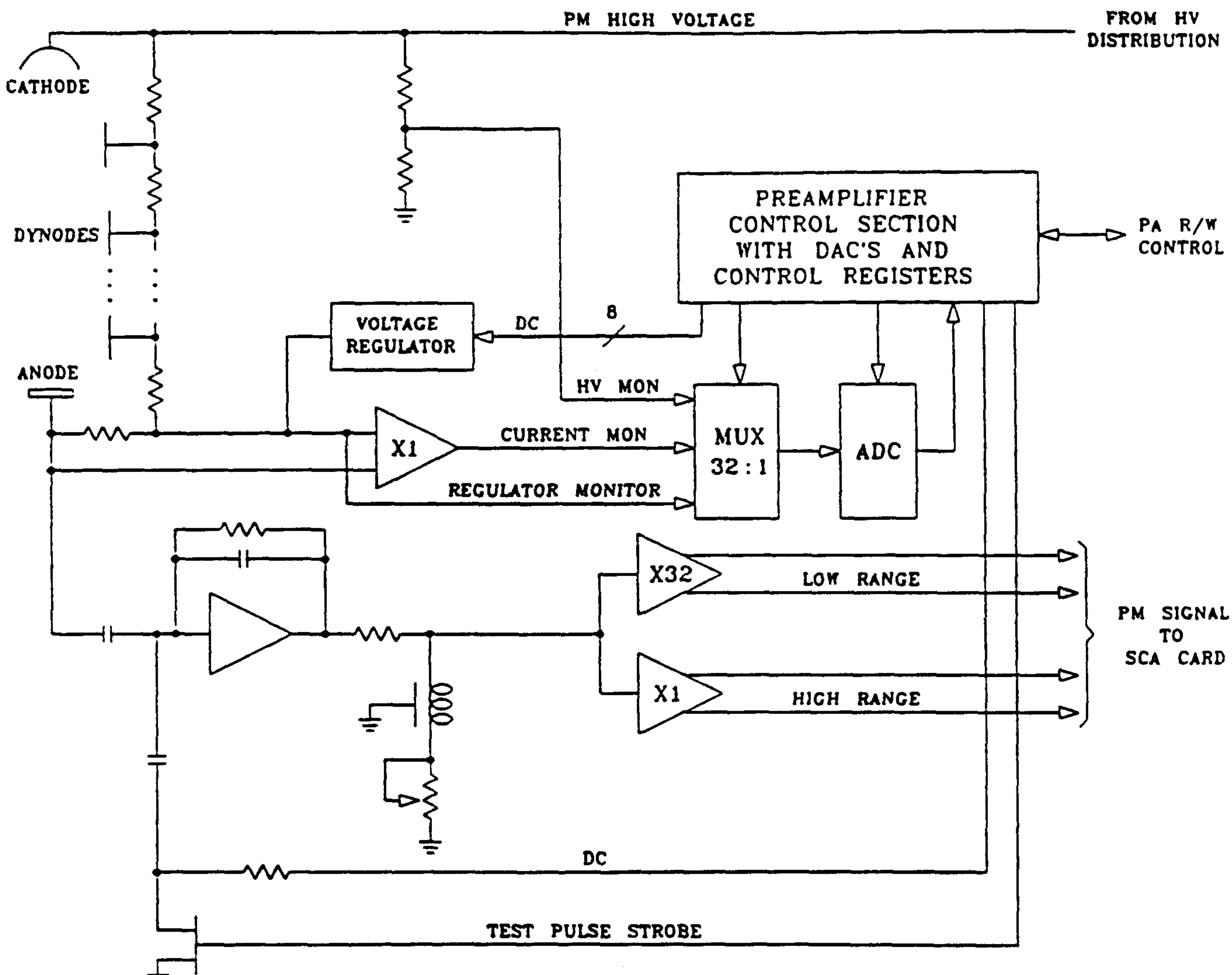


1 CRATE SUPPORTS (PM TUBES)

	MAX	USED	SCA CARD
BARREL CAL	288	280	3
END CAP CAL	480	400	5
BARREL SM	576/16	566/16	3
END CAP SM	576/16	450/16	3

Figure 4.3

CALORIMETER PREAMP AND HV CONTROL CARD



1 OF 8 PM'S, HV REGULATORS AND PREAMPLIFIERS SHOWN

Figure 4.4a

CALORIMETER
SCA CARD

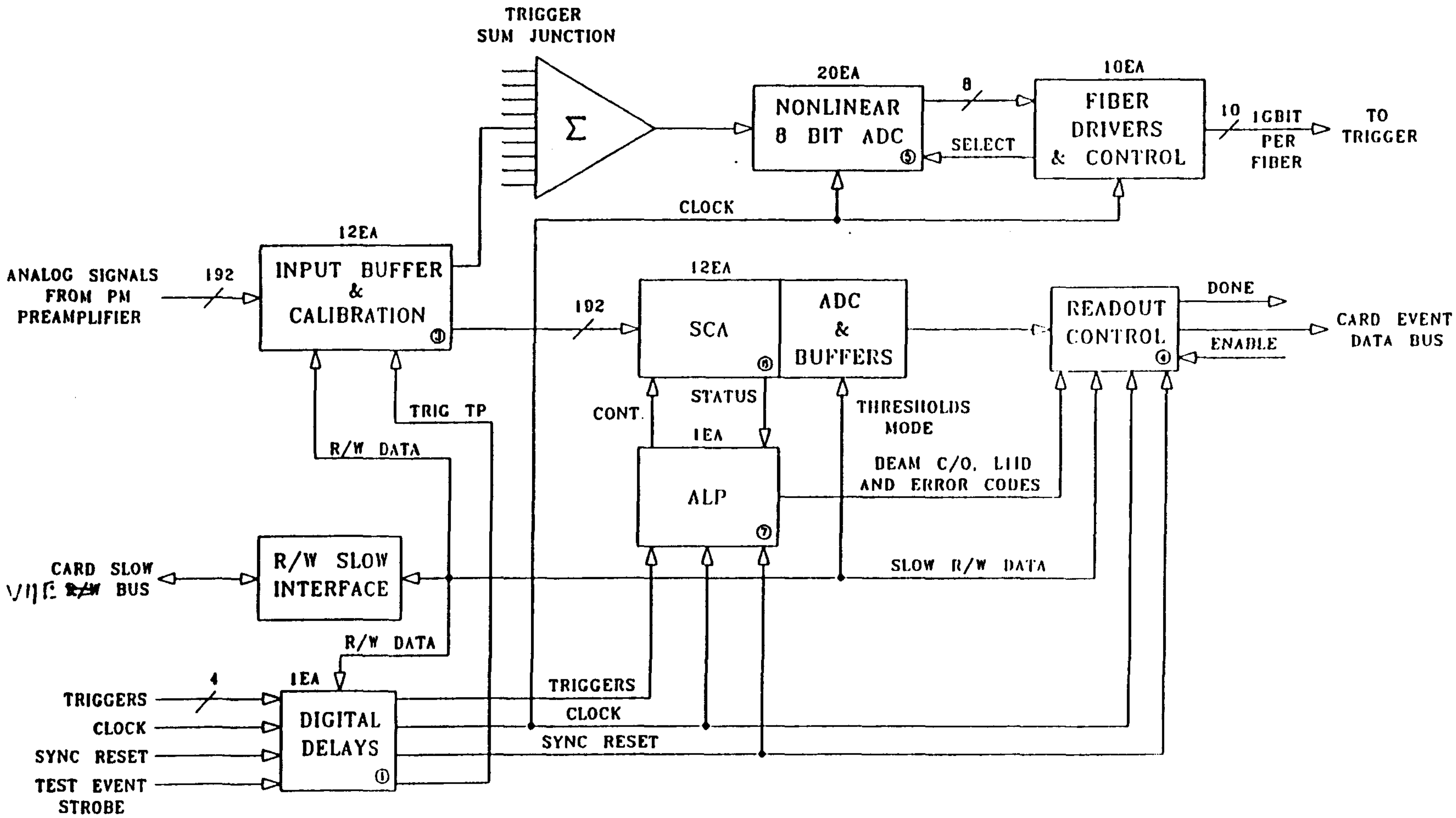


Figure 4.5a

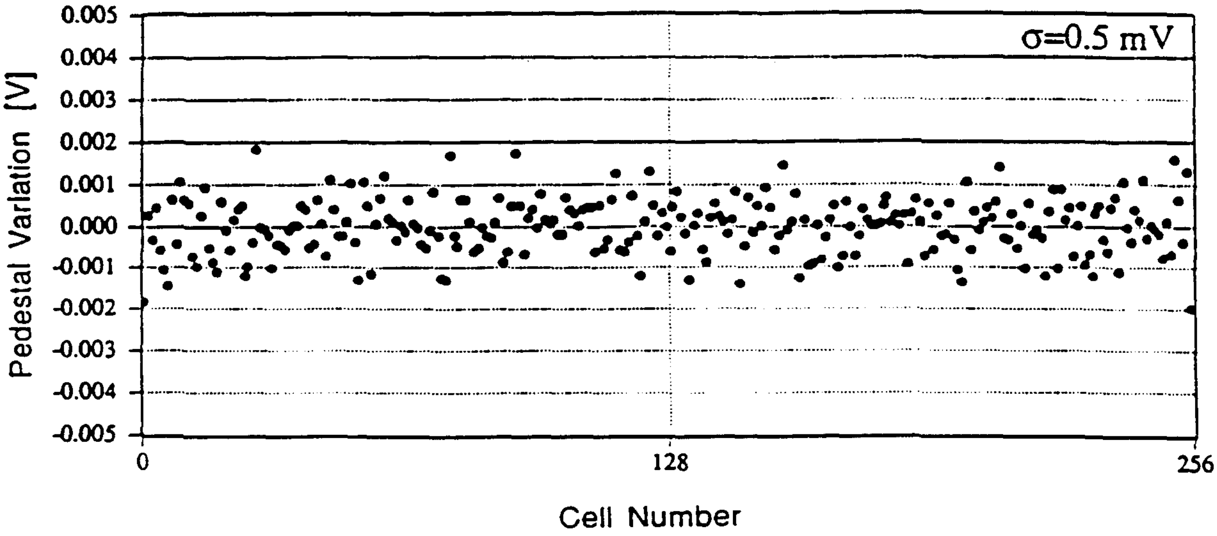


Fig. 3.6. Cell-to-cell pedestal variation as a function of cell number across a single channel. The small pedestal variation will permit large dynamic range operation of the circuit without corrections.

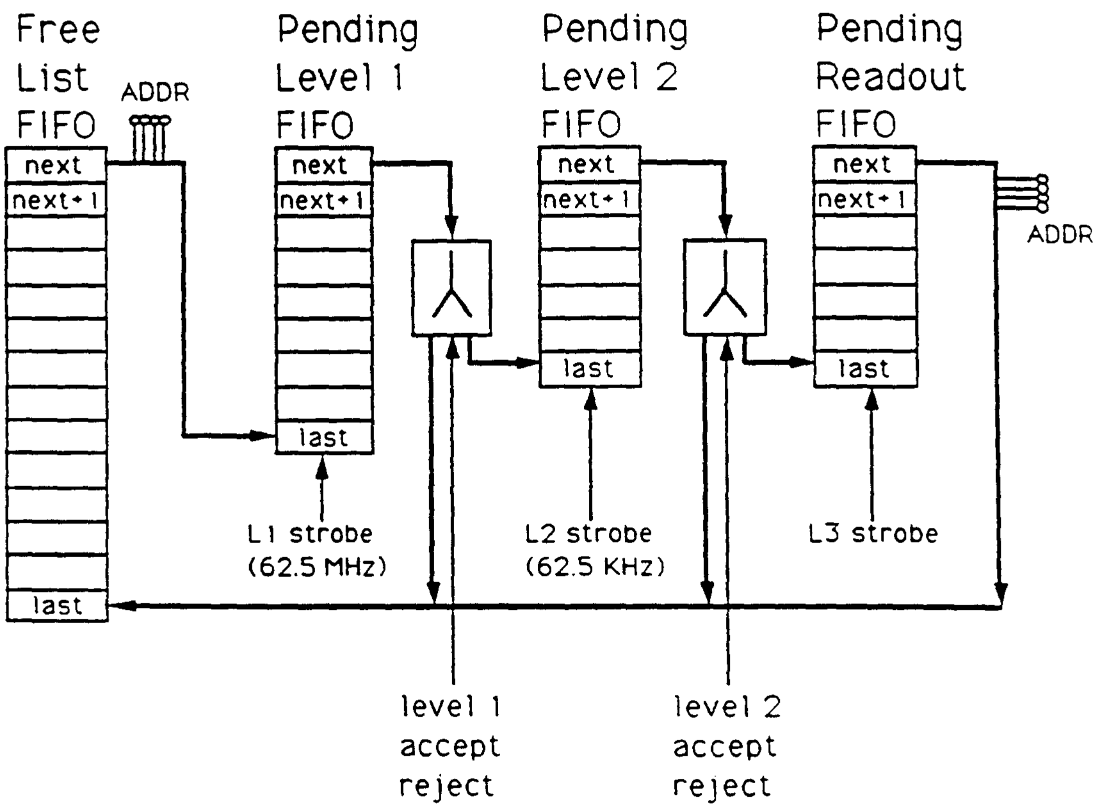


Fig. 5.1. Block diagram of the address list processor, showing the four FIFO memories for the address pointer lists for: empty cells, pending Level 1, pending Level 2, and pending read-out.

Why pursue two approaches to calorimeter readout?

Technical challenge:
- 17-bit dynamic range (1:100,000)
- simultaneous read/write operation ("deadtimeless")
- cost for large systems

Neither approach has been fully demonstrated.
Each has different uncertainties.

- switched capacitor approach
  - proof-of-principle nearly complete
- splitter/integrator approach
  - potentially more robust

Potentially different system costs.

Next review of alternatives will take place in December 91 or January 92. A choice will be made at that time if appropriate.

SDC MUON FRONT-END ELECTRONICS
(Harvard, Michigan)

Overview:

Chamber-mounted and base-mounted electronics provide amplified and discriminated signals to nearby crates which buffer and collect data for readout and which form trigger primitives. Design will likely use ASD's & storage IC's developed for straw readout. The organization of the readout is strongly influenced by the trigger requirement of combining information from counters and multiple chamber planes at Level 1.

FY92 R&D Tasks:

Develop complete conceptual design of subsystem.
Evaluate existing preamp and amp/shaper/disc chips.
Prototype card with Penn ASD chip.
Design and fab CMOS test pulse chip for calibration.
Design and fab low-power CMOS cable driver
  to link ASD cards to trigger/readout crates.
Support chamber tests
  with ASD cards and high voltage distribution.
Conceptual design of trigger/readout crate.

Impact of budget:

Slow down development of analog electronics.

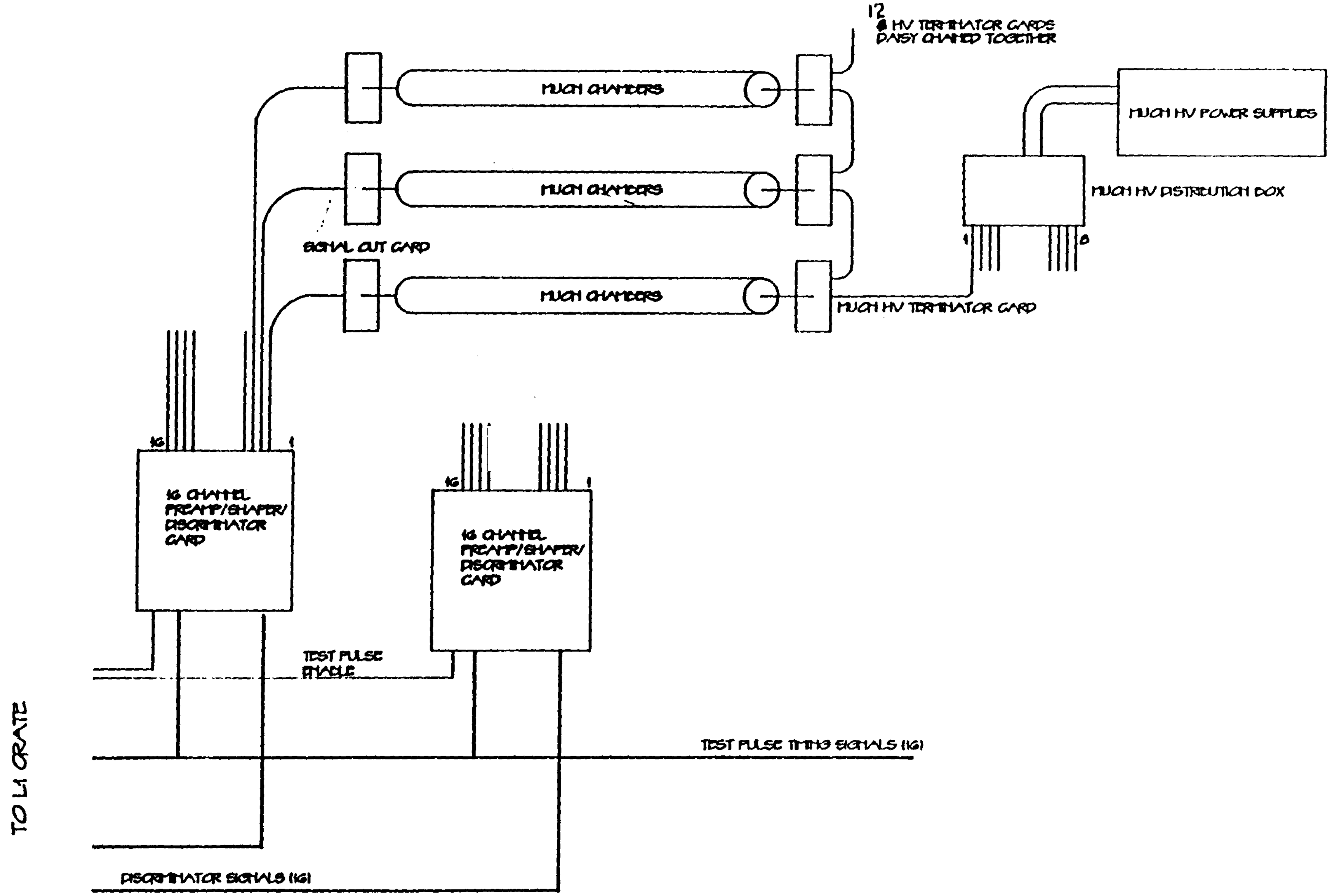

12
HV TERMINATOR CARDS
DAISY CHAINED TOGETHER
MUCH CHAMBERS
MUCH CHAMBERS
MUCH CHAMBERS
MUCH HV POWER SUPPLIES
MUCH HV DISTRIBUTION BOX
SIGNAL OUT CARD
MUCH HV TERMINATOR CARD
16 CHANNEL PREAMP/SHAPER/ DISCRIMINATOR CARD
16 CHANNEL PREAMP/SHAPER/ DISCRIMINATOR CARD
TEST PULSE ENABLE
TO L1 CRATE
TEST PULSE TIMING SIGNALS (16)
DISCRIMINATOR SIGNALS (16)

Fig 1.

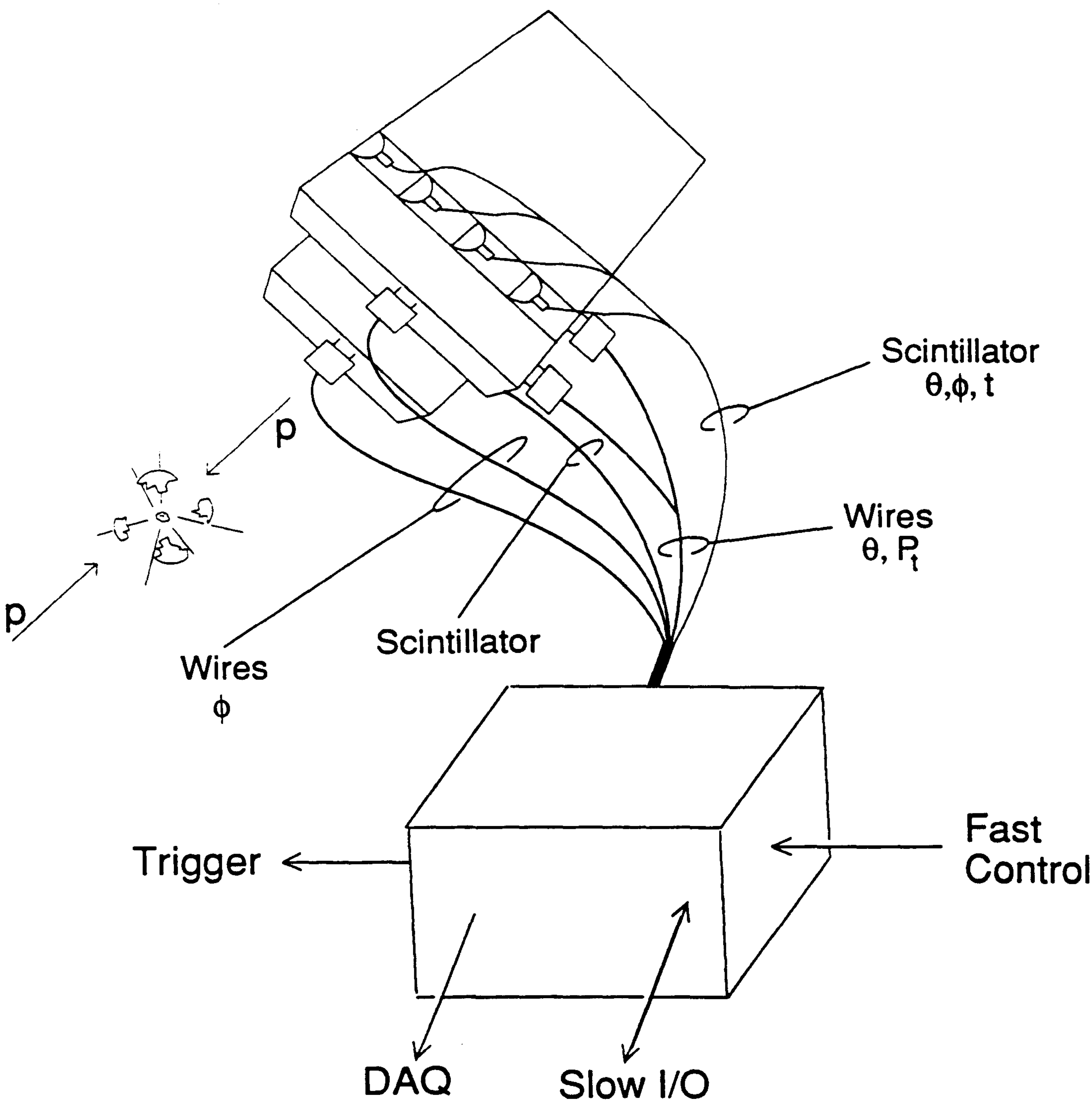


FIG. 2. An octant section from the barrel portion of the SDC muon system beyond the toroid for the option that includes two scintillator stations radially.

SDC TRIGGER:
OVERVIEW OF STATUS AND R&D PRIORITIES

The highest priority goal at present is definition of a credible trigger system design and of critical path components.

Conceptual design tasks require strong engineering support

Status:

Ongoing studies
of pipeline length and front-end control.
Physics simulations underway.
Preliminary conceptual design complete for Level 1.
Many key components under study or in proto state.

FY92 R&D Priorities:

Simulation; define conceptual design.
Complete conceptual design; define building blocks.
Launch development of key components.
Define inputs from subsystems, data paths, control.

Impact of budget:

This important area will not be able to accelerate its progress as needed.

Development of key components will be slowed.

No resources are available to support development of a complete conceptual design or key components at Level 2 once Level 2 requirements are defined.

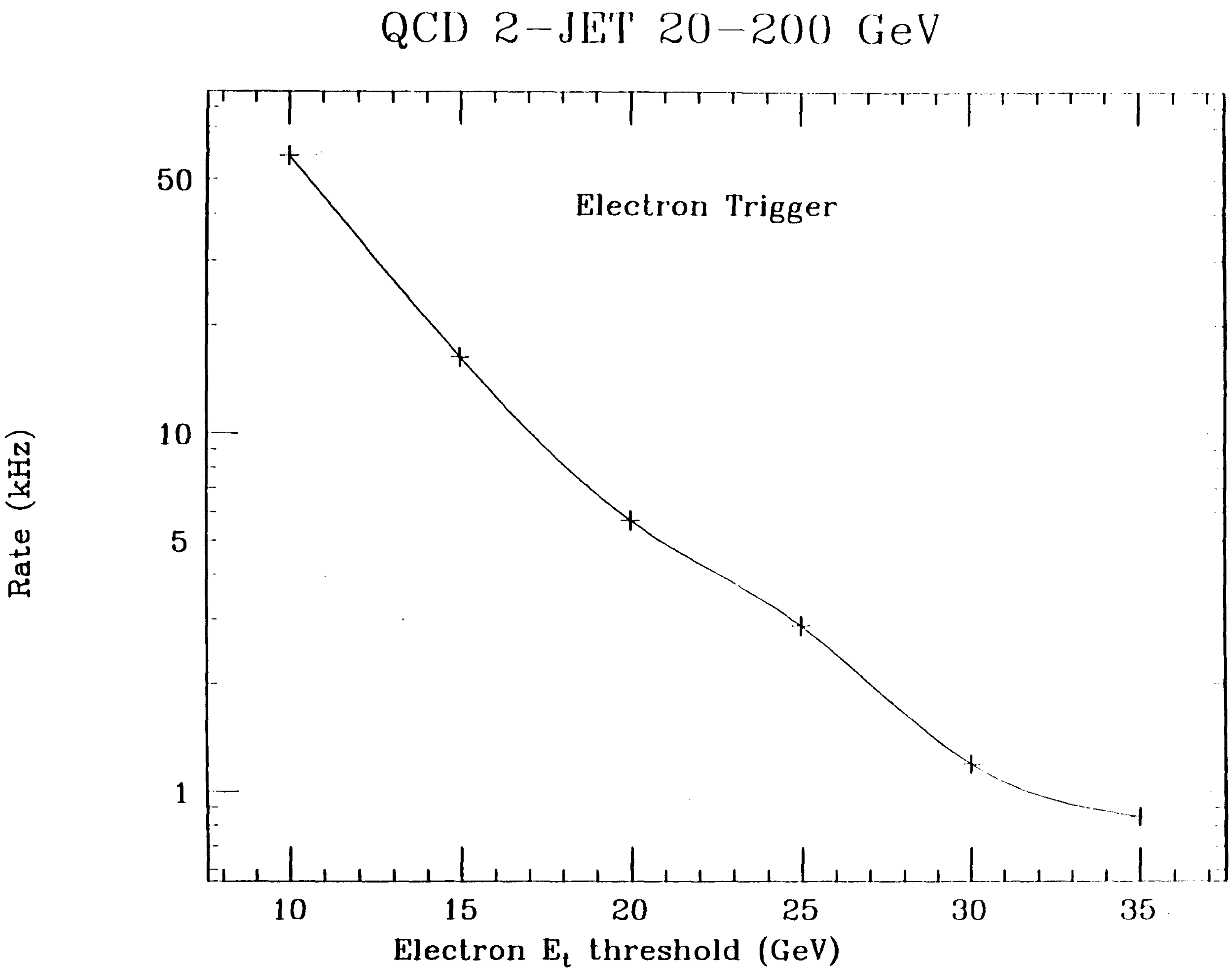

QCD 2-JET 20-200 GeV
Electron Trigger
Rate (kHz)
50
10
5
1
10
15
20
25
30
35
Electron E_t threshold (GeV)

Figure 23

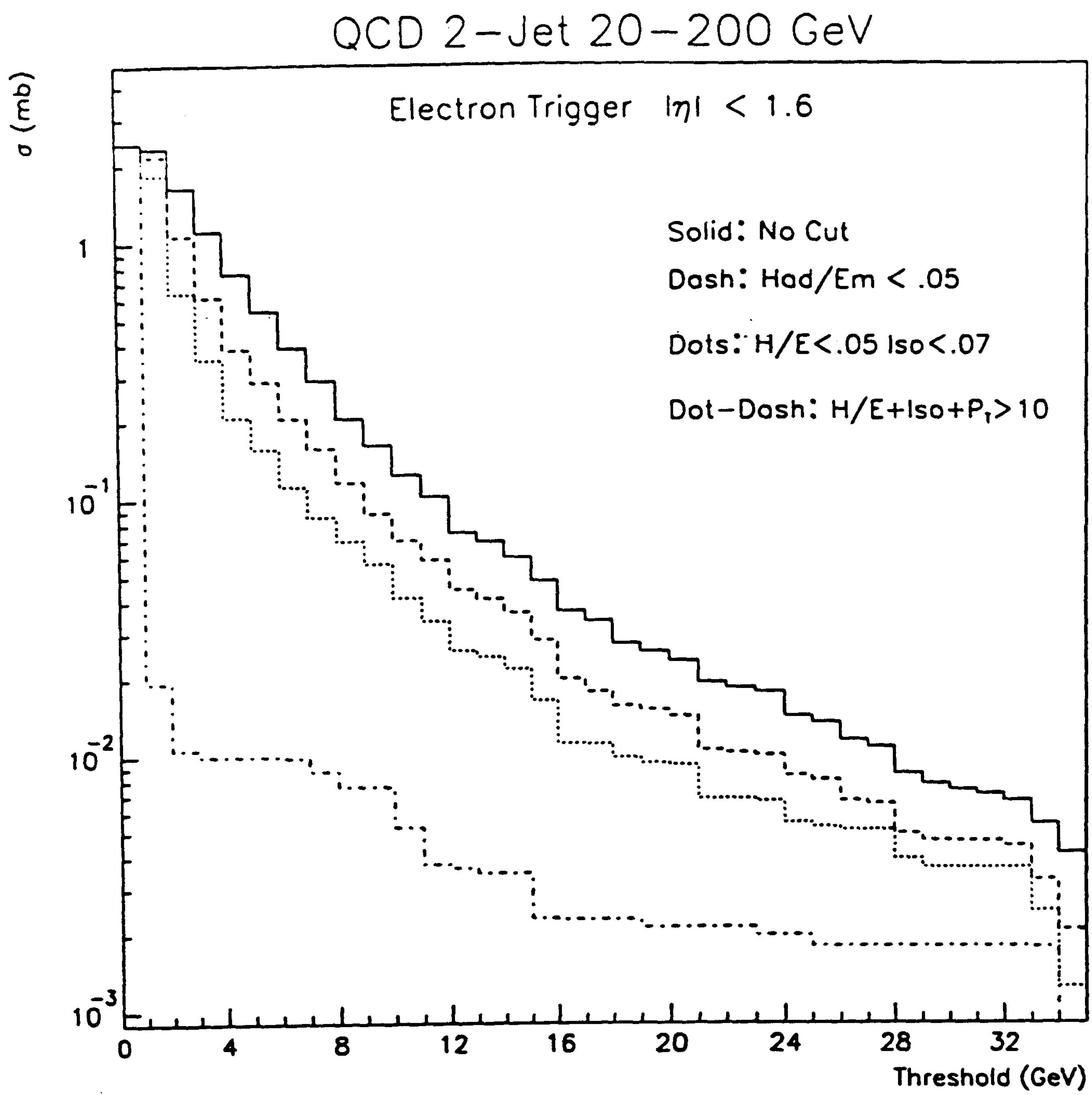


Figure 3: The level 1 inclusive electron trigger rate in the barrel calorimeter versus the E_T threshold for no cut (solid), Had/Em cut (dashed), Had/Em and isolation (dot), and finally adding the requirement of a track match in ϕ with the tower (dot-dash).

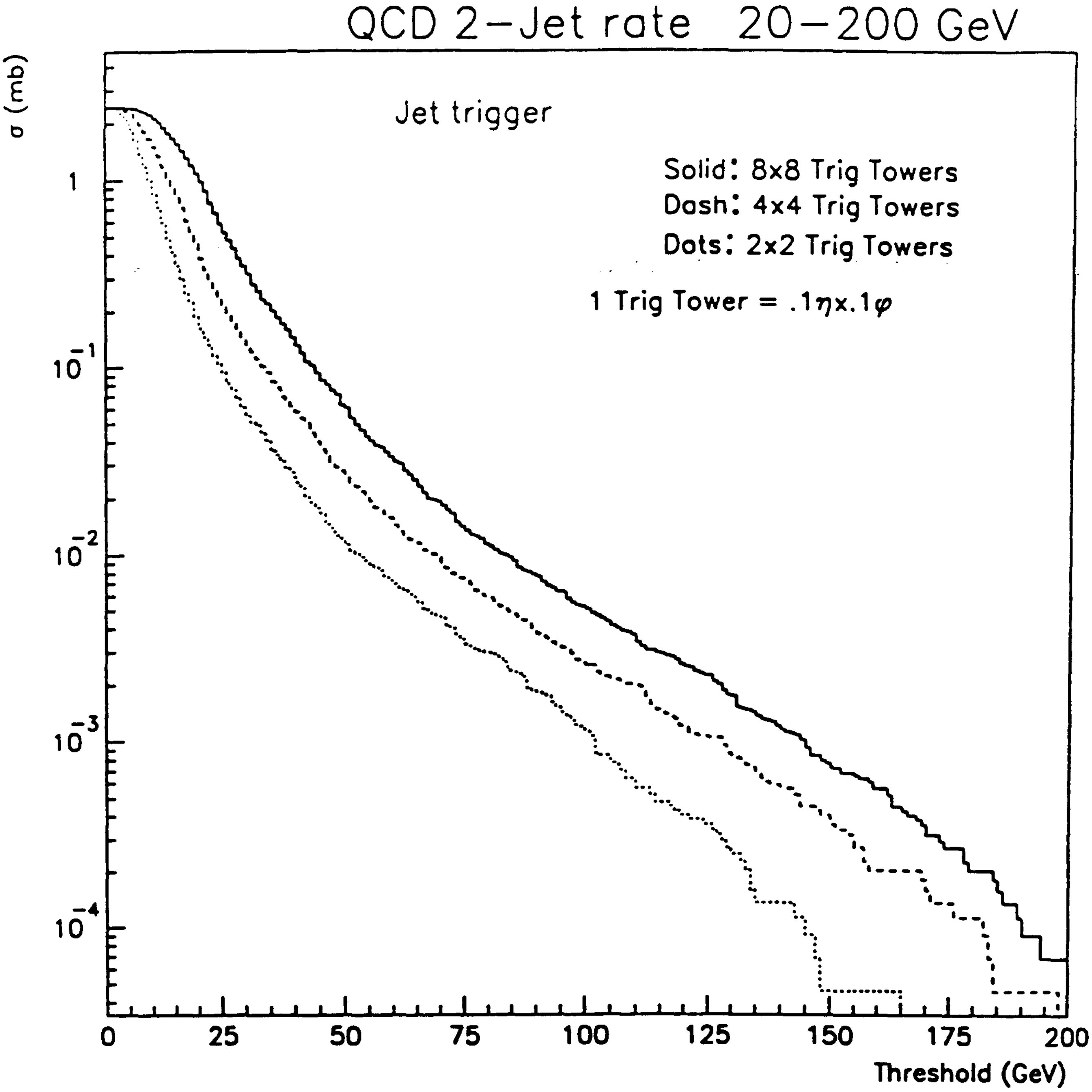


Figure 2: The level 1 inclusive jet trigger rate versus the E_T threshold for various tower sizes.

SDC TRIGGER SYSTEM ENGINEERING

(Chicago, Wisconsin, others)

Overview:

A preliminary conceptual design of the trigger system has been prepared. This includes a summary of the trigger requirements, overall architecture and data flow, design of the level 1 and level 2 trigger systems, technology of data transmission, design of clock and control systems, timing of trigger decisions, and cost information.

FY92 R&D Tasks:

- Conceptual design:
  - Refine requirements definition:
    - performance, protocols, functions, interfaces.
  - Define data from each subsystem to each level.
  - Explore architecture and hardware layout.
  - Integrate system design with subsystem designs.
  - Complete baseline conceptual design.
- Timing:
  - Develop protocol of timing synchronization.
  - Design and build proto clock/control module to support tests of front ends.

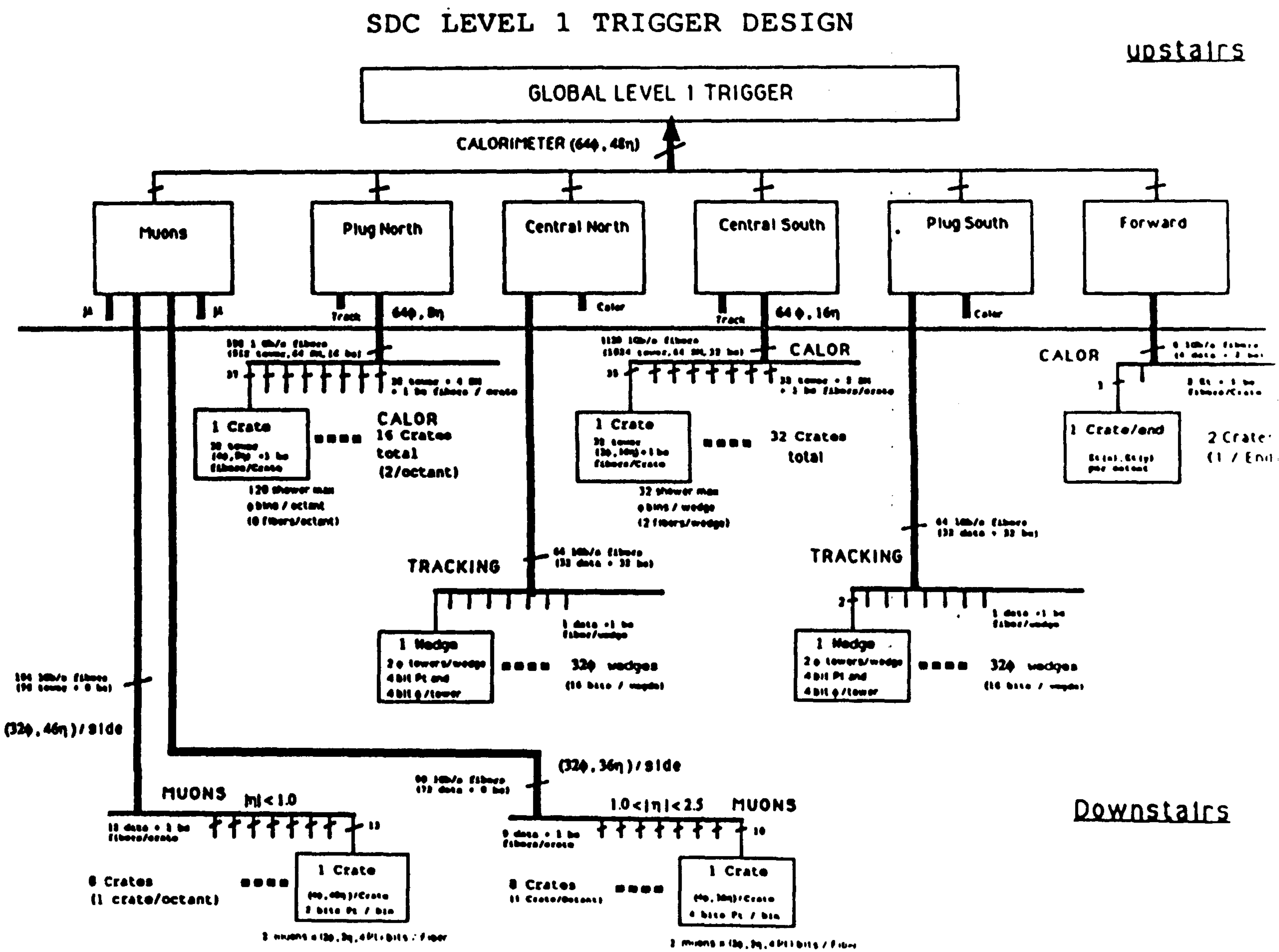


Figure 4: One possible implementation for the SDC level 1 trigger.

SDC STRAW TRACKER TRIGGER

(Michigan)

Overview:

A stiff track segment finder (synchronizer) is constructed from digital delay chains configured as mean timers. Maximum drift time and momentum cuts are programmable. Segments can be linked to form tracks. A prototype one-channel synchronizer is undergoing detailed tests.

FY92 R&D Tasks:

Multichannel version of synchronizer.
Prototype tests with array of straws.
Simulation of performance,
acceptance, efficiency, rejection.

SDC FIBER TRACKER TRIGGER
(FNAL)

Overview:

Stiff track segments are found in superlayers by lookup techniques. Track segments are also linked using lookups. Digital ASIC's provide trigger functionality.

FY92 R&D Tasks:

- Simulation of trigger using test beam data.
- Preliminary design of logic:
  - Segment Finder ASIC
  - Segment Linker ASIC
  - P_t code and exchange.

SDC CALORIMETER TRIGGER
(FNAL, LBL, Chicago, Wisconsin)

Overview:

The calorimeter trigger is based on digital data from trigger towers provided at 62 MHz. Energies are summed and electrons are identified by patterns of enegy deposition.

FY92 R&D Tasks:

Develop adder tree.
Develop design of electron pattern logic.
Develop electron sorter logic.

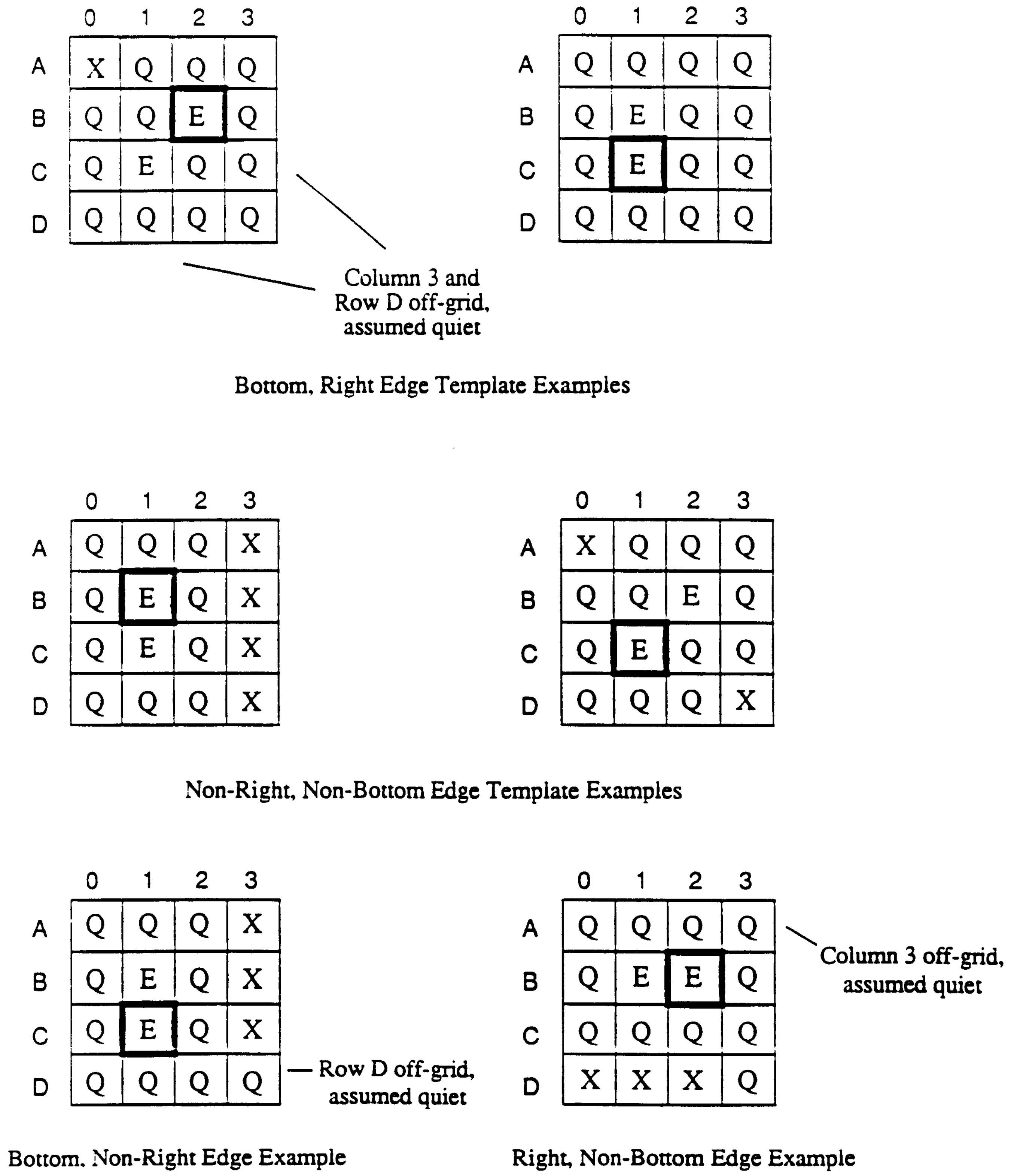


Figure 8. Examples of Isolated Electron Assignments to Towers. Isolated Electrons are assigned to Towers with bold outline.

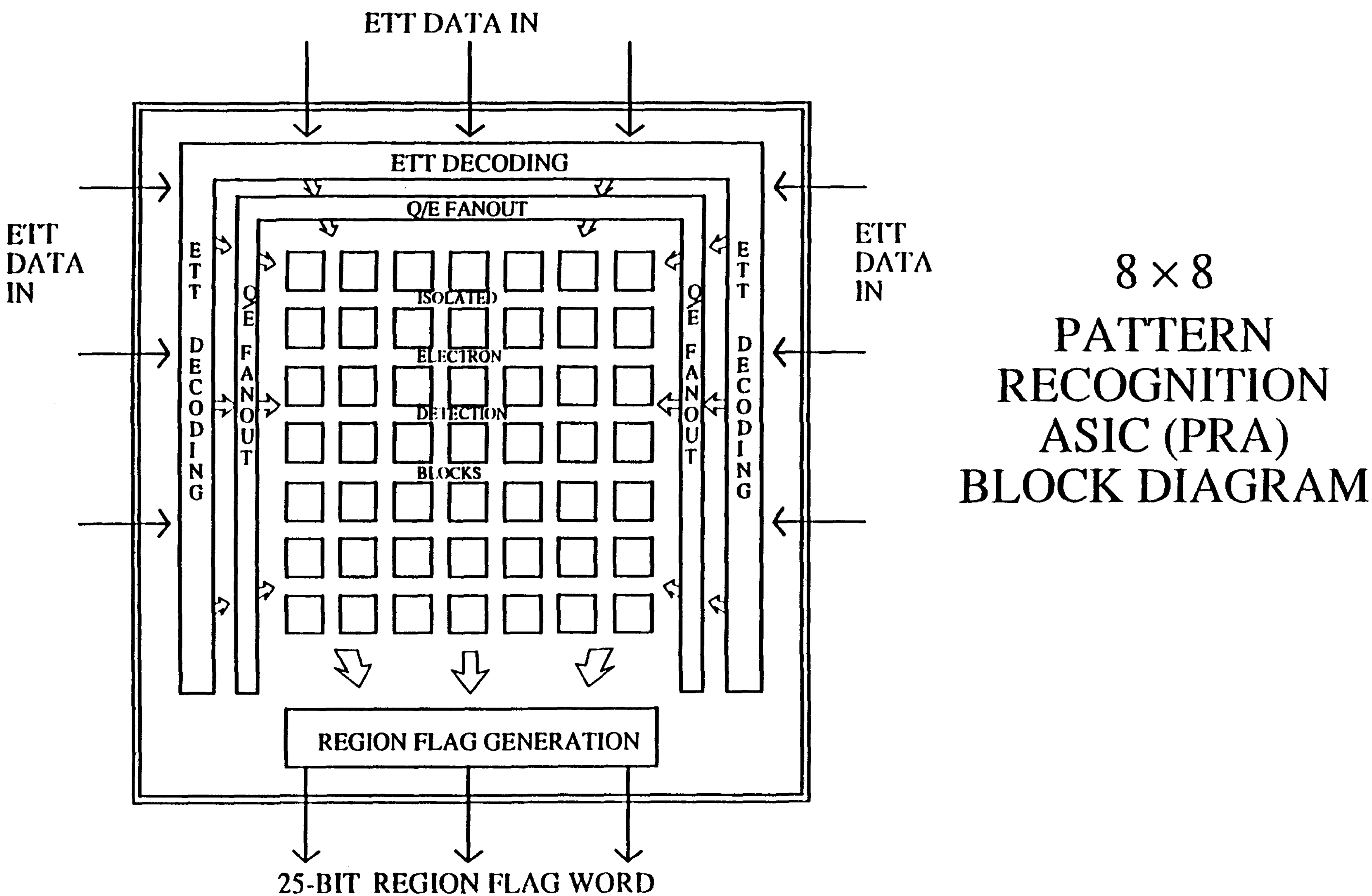


Figure 3. PRA Block Diagram

SDC MUON TRIGGER
(Michigan)

Overview:

Stiff muon track segments are identified from scintillator and chamber hits using mean timers and coincidences. Combining information from counters and multiple chamber layers poses particular difficulties to the layout of the trigger system.

FY92 R&D Tasks:

Conceptual design of primitives generation.
Prototype ASIC's for wire/counter correlation.
Prototype circuit design
for generating and multiplexing trigger primitives.

SDC DATA ACQUISITION:
OVERVIEW OF STATUS AND R&D PRIORITIES

The current focus is a baseline conceptual design which provides a credible solution to the problems of high bandwidth and "deadtimeless" operation. The architecture should allow advantageous use of future progress in communications and computing technology. It should also allow scaling performance to very high levels. Challenges are formidable. Development of certain key components should be initiated.

Status:

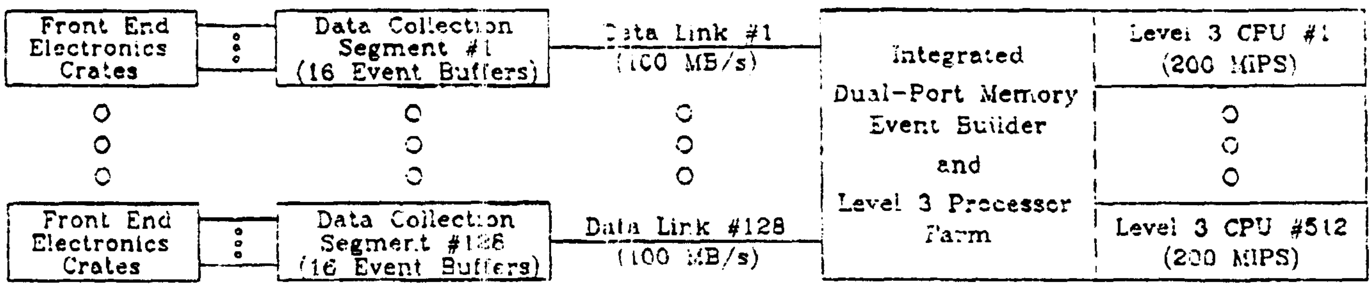
Preliminary conceptual design being reviewed.
Architectural modelling proceeding.
Prototype barrel-shifter event builder complete.

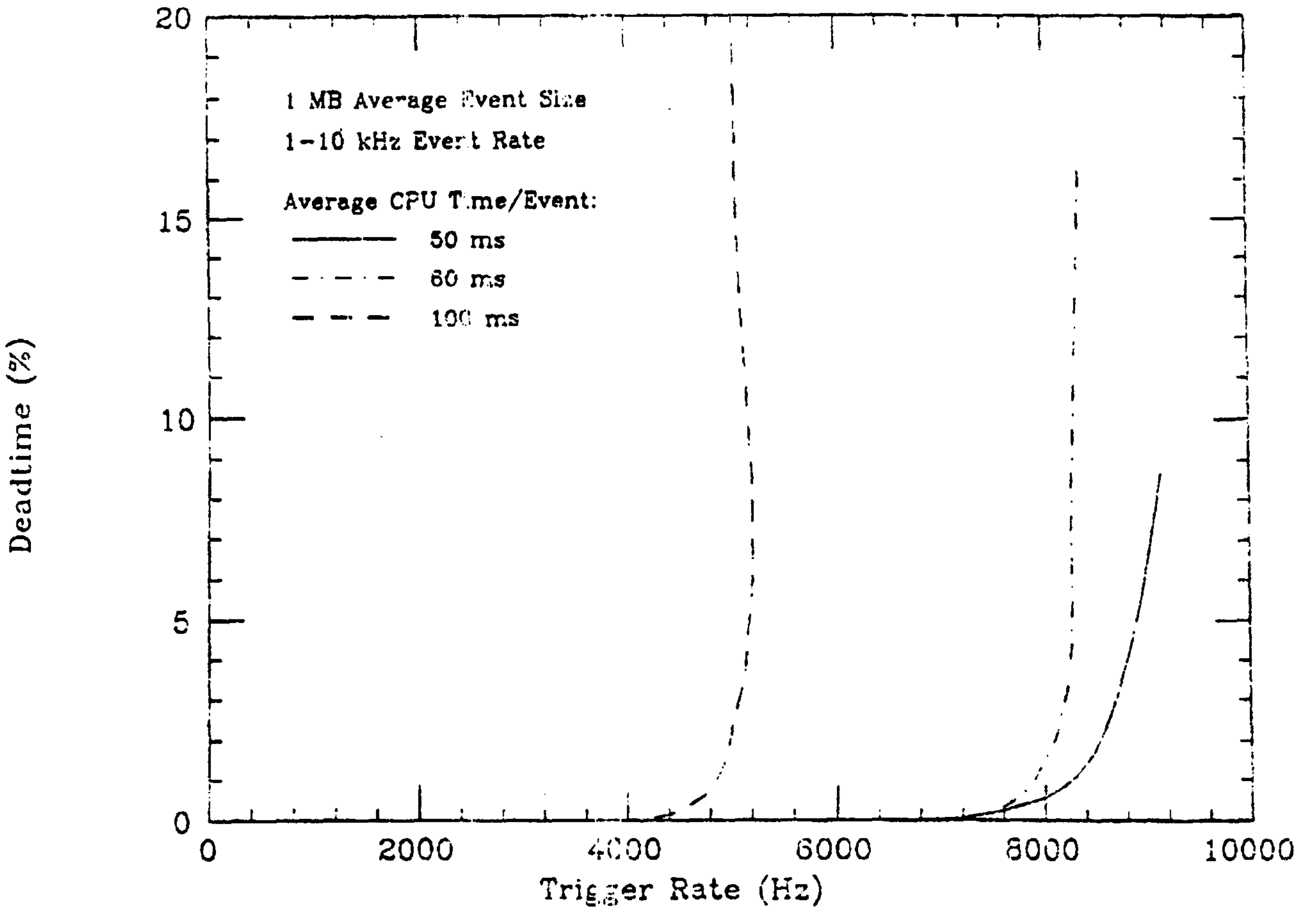
FY92 R&D Priorities:

Evolve conceptual design; initiate system engineering.
Construct comprehensive architectural model,
    in lieu of prototype.
Refine definition of f.e. interface and data collection;
    initiate design of data collection circuits.
Define control mechanism and network.
Begin to understand issues of reliability & redundancy.
Industrial collab on issues of large system design.
Technology studies/tracking:
    data transmission, event builder(KEK), farm(KEK)
Initiate development of portable DAQ system.

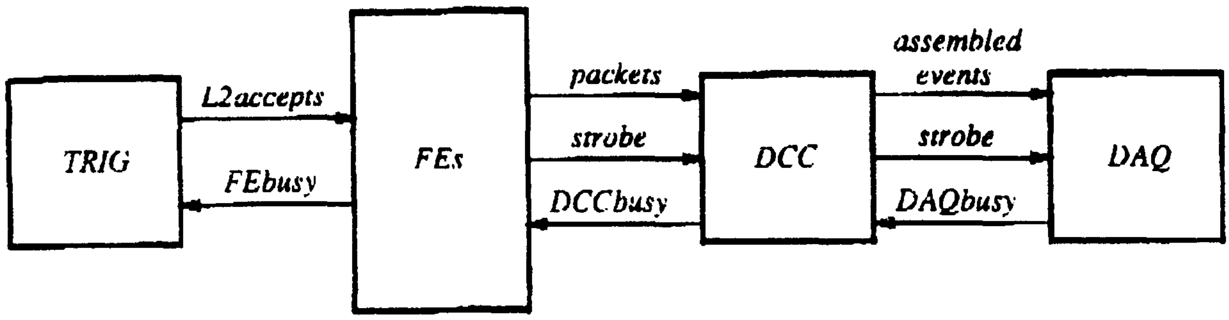
Impact of budget:

No significant growth of activity in this important area.
Support only:
    conceptual design, modelling, and a small effort on interface to front-end.
No support for:
    technology studies, reliability studies, portable DAQ, control mechanisms, or system engineering.

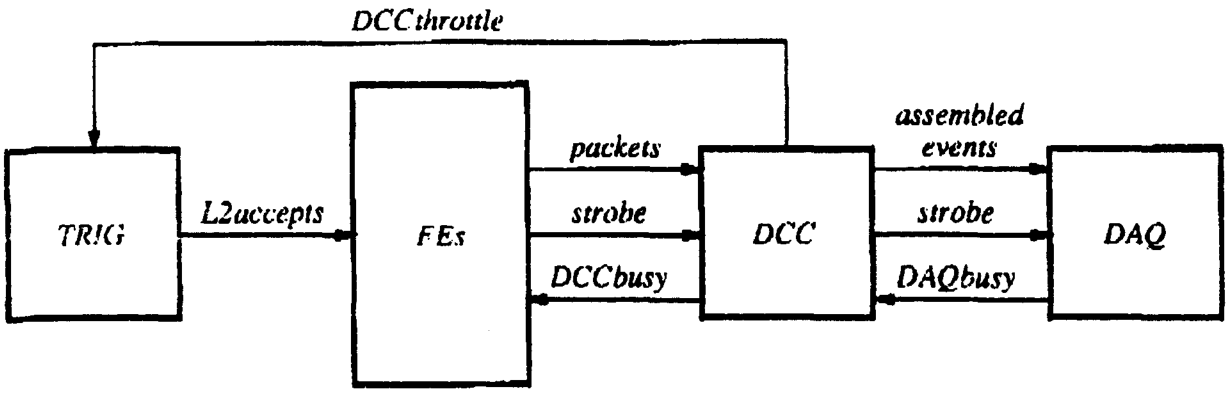

Front End Electronics Crates
Data Collection Segment #1 (16 Event Buffers)
Data Link #1 (100 MB/s)
Integrated Dual-Port Memory Event Builder and Level 3 Processor Farm
Level 3 CPU #1 (200 MIPS)
Front End Electronics Crates
Data Collection Segment #128 (16 Event Buffers)
Data Link #128 (100 MB/s)
Level 3 CPU #512 (200 MIPS)


1 MB Average Event Size
1-10 kHz Event Rate
Average CPU Time/Event:
50 ms
60 ms
100 ms
Deadtime (%)
Trigger Rate (Hz)
0
5
10
15
20
0
2000
4000
6000
8000
10000

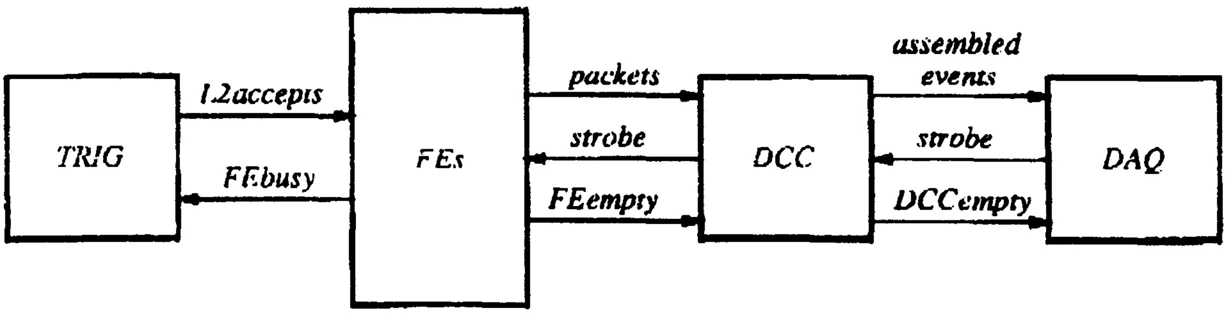
(a) Backup throttling



(b) Direct throttling



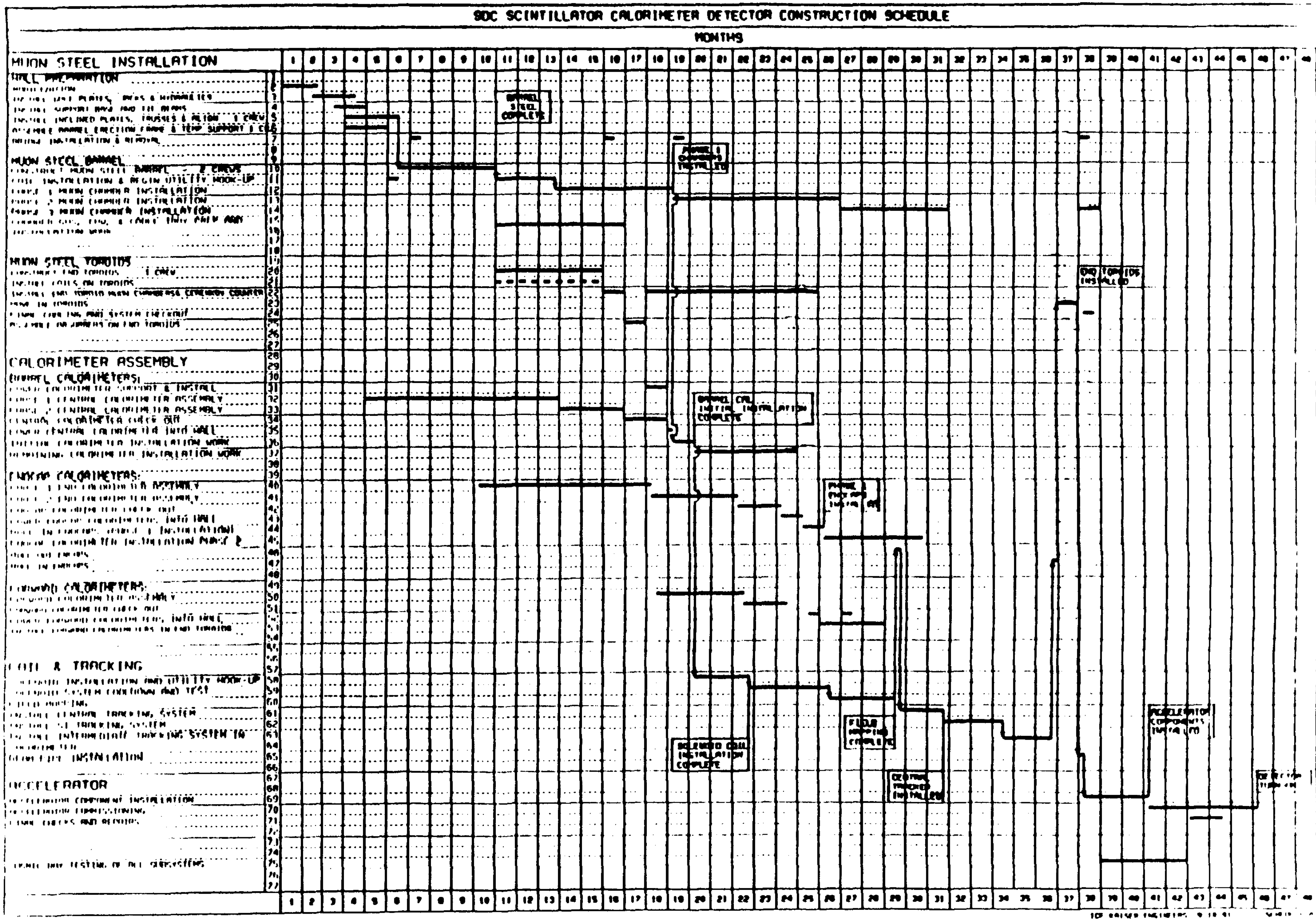
(c) Pull architecture



Model architectures for deadtime studies

D. Bintinger

PAC Meeting
October 3-4, 1991



SDC SCINTILLATOR CALORIMETER DETECTOR CONSTRUCTION SCHEDULE
MONTHS
MUON STEEL INSTALLATION
MUON STEEL BARREL
MUON STEEL TOROIDS
CALORIMETER ASSEMBLY
COIL & TRACKING
ACCELERATOR
BARREL STEEL COMPLETE
PHASE 1 CHAMBERS INSTALLED
END TOROIDS INSTALLED
BARREL CAL INITIAL INSTALLATION COMPLETE
SOLENOID COIL INSTALLATION COMPLETE
FIELD MAPPING COMPLETE
CENTRAL TRACKER INSTALLED
ACCELERATOR COMPONENTS INSTALLED

M. Gilchriese

PAC Meeting
October 3-4, 1991

Technical Proposal Production

Overall editors: D. Groom, W. Chinowsky, G. Trilling and M. Gilchriese

The SDC Technical Proposal - Coordinating Editors

1. Introduction - G. Trilling
2. Overview of the Detector - M. Gilchriese
3. Physics Performance - K. Einsweiler
4. Central Tracking System - A. Seiden
5. Superconducting Solenoid - A. Yamamoto
6. Calorimeter System - L. Nodulman
7. Muon System - G. Feldman
8. Electronics, Data Acquisition,Trigger and Control Systems - F. Kirsten
9. On-line Computing - A. Fry
10. Off-line Computing - L. Price
11. Safety - J. Elias
12. Experimental Facilities - T. Thurston
13. Installation and Commissioning - M. Harris
14. Test Beam Program - J. Siegrist
15. Cost and Schedule Summary - M. Gilchriese

Technical Proposal Schedule

October 1	Assign coordinating editors
November 13	Detailed outline + final writing assignments and/or draft text
December 13	Zeroth draft submitted to chapter editors(and overall editors for comments)
January 3	Submit first draft to overall editors
January 31	Submit second draft to overall editors
February 21	Deliver final draft to SSCL for duplication of 150 copies
February 26-29	Review of final draft by collaboration and editors
March 23	Final printout of text with figures
March 25	Assemble, print and bind 40 copies
April 1	Submit 40 copies to SSCL

Other Documents Related to Technical Proposal

- Cost/schedule book. Coordinators: W. Edwards, D. Etherton.
- SDC Project Management Plan and related documents: Coordinators: T. Elioff, T. Kirk
- Preliminary hazards analysis. Coordinator: J. Elias

Budget Process and Schedule

- Established targets for subystem groups
- First round with subsystem groups complete by end of next week. Attempt to meet target and identify items to receive support if additional funds become available
- Compile first draft of detailed(by institution) budget summary by October 21
- Revise R&D and Engineering Plan by end of October.
- Finalize institutional agreements and budget assignments as soon as possible and "append" to overall plan.
- Reserve some funds or plan on redirecting funds as choices are made

FY92 Budget Request($K)

System	Original Request	Budget Targets	Minimum Required
Tracking systems	8575	3700	6200
Calorimeter systems	5800	3800	4800
Muon system	4300	2700	3200
Superconducting Sol.	800	500	600
Electronics systems	4050	1800	2300
Project Management	2500	2500	2800
Totals	26025	15000	19900

Major Consequences of Reduced Budget

Tracking Systems

- Drop all work on pixel detectors
- Postpone work on forward silicon disks
- Force premature selection of outer barrel tracking technology
- Even with such a selection
    - delay "proof-of-principle" prototype section of silicon tracker
    - delay "proof-of-principle" for selected barrel technology
    - no support in US of intermediate tracker

Muon System

- Defer construction of prototype supertower

Major Consequences of Reduced Budget cont.

Calorimeter Systems

- Defer most R&D on improved scintillator
- Defer most work on calibration system
- Eliminate engineering for forward calorimeter
- Defer prototype barrel wedge construction
- Slow down significantly engineering ramp up to move into detailed design

Electronics Systems

- Defer proof-of-principle of critical front-end components
- Delay prototype systems tests of front-ends
- No growth in DAQ or trigger area
- No prototype development in DAQ and trigger

Conclusions

- The SDC is on track to produce a Technical Proposal, the related cost/schedule and other required documents by April 1, 1992.

- The present FY92 budget allocation will force a premature technology choice of the tracking system. The time to design, build, install and operate the tracking system before replacement or upgrade is about 15 years. We should make the correct choice.

- The present FY92 budget allocation will also cause substantial delays in prototypes for all systems and not allow an adequate build up of engineering resources

- We cannot pretend that the SDC will remain on schedule to be ready by 1999 with the present FY92 budget.

CONCLUSIONS
(CONTINUED)

The SDC needs to understand in much more detail what in-kind contributions will be available from its non-U.S. members, to define more clearly the actual level of U.S. funds needed.
With a sound detector concept, it should be able to maximize the overall non-U.S. contribution level.

The SDC and its detector will, for many years, be a crucial link which allows the ambitious performance goals of the SSC to be translated into potential for dramatic discovery. This is why such a large group is working on this enterprise; and why, in spite of base program commitments, that group has built up so much momentum. It is the opinion of both the U.S. and non-U.S. members of the SDC that if indeed~$600M are needed, the extra funding involved is sufficiently modest on the scale of the SSC enterprise that it will be found in the totality of countries involved.