GEM TN-92-89

# GEM Detector for the SSC: U.S. - Republic of Korea Working Group Meeting

Gary Sanders
SSC Laboratory

April 14, 1992

Abstract:

Transparencies of the presentations at the April 14, 1992 Republic of Korea Working Group Meeting.

GEM Project Department

U.S. - Republic of Korea Working Group Meeting

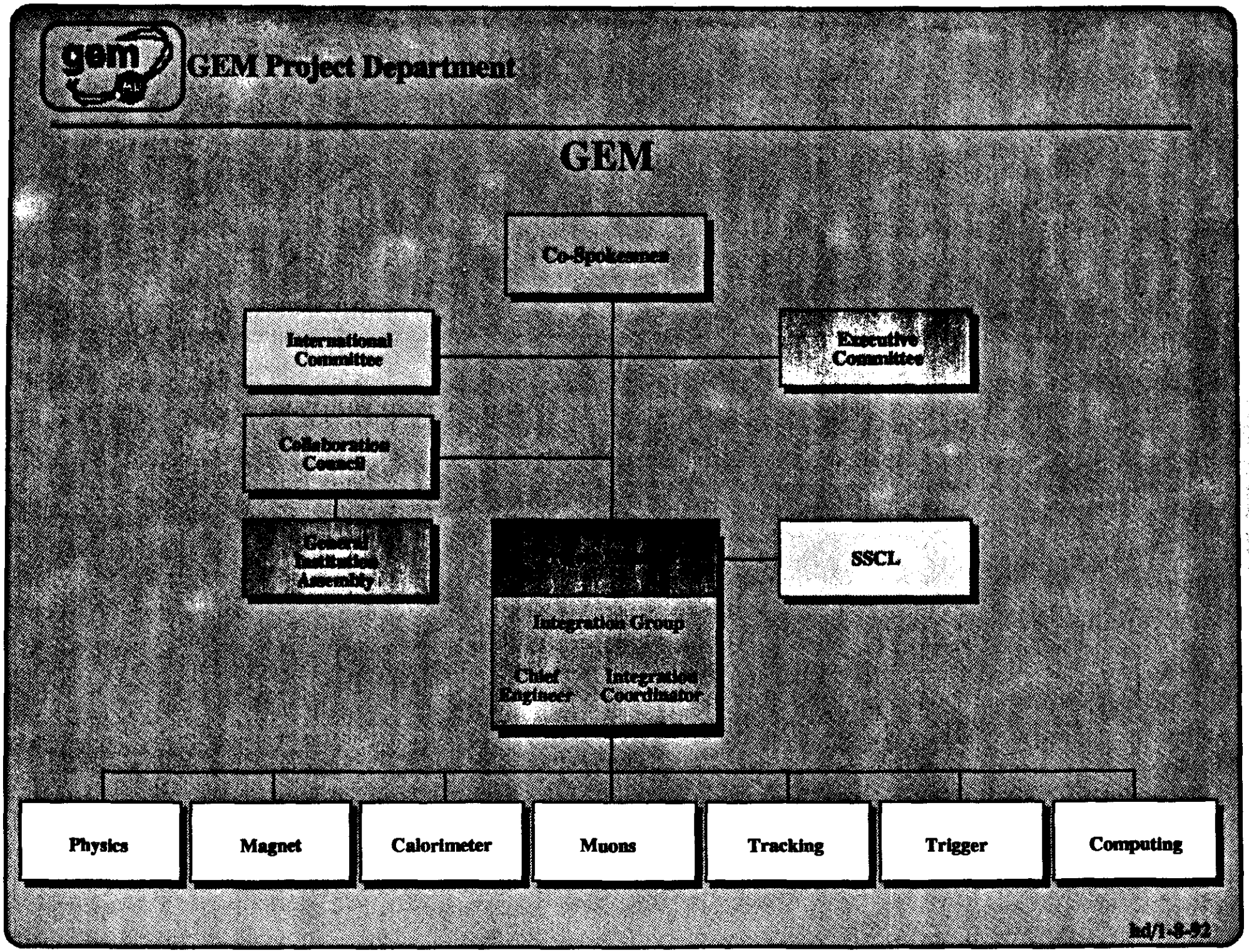
# The GEM Detector for the SSC

Gary Sanders

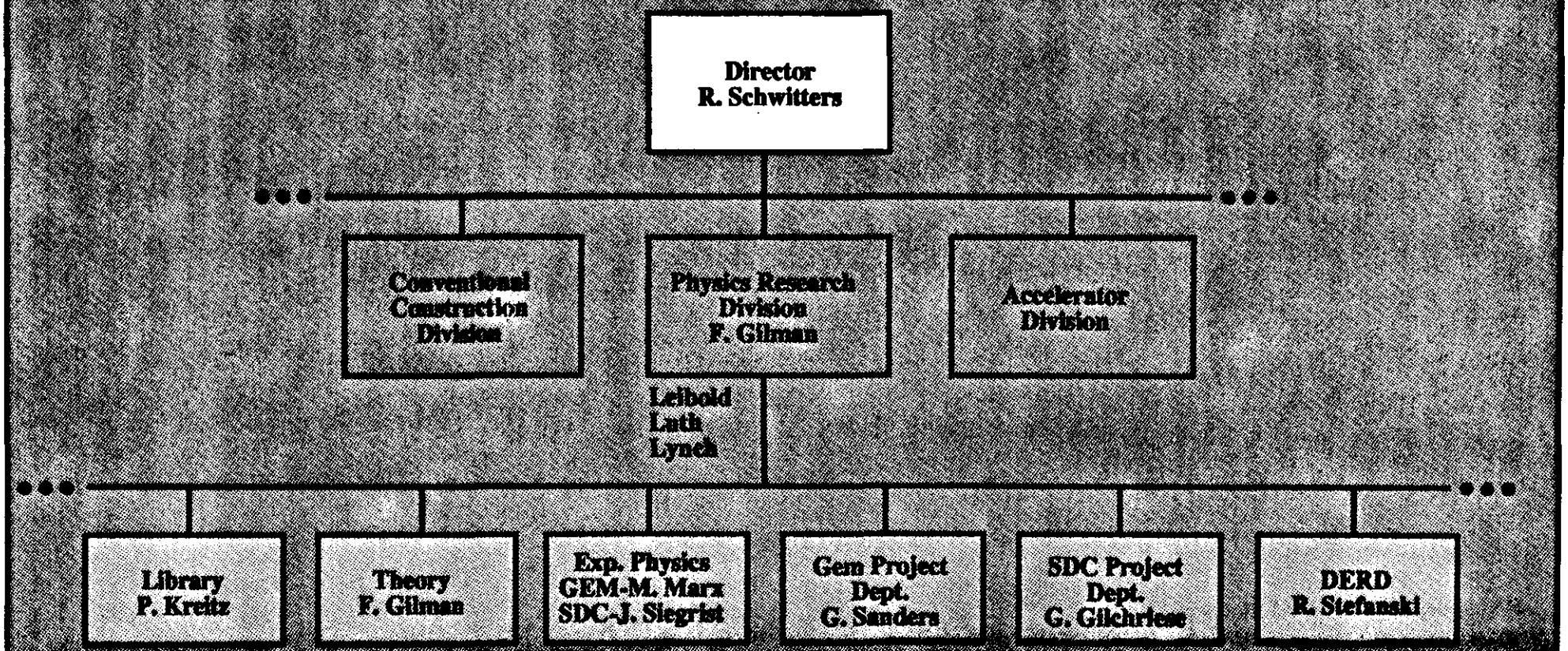
April 14, 1992

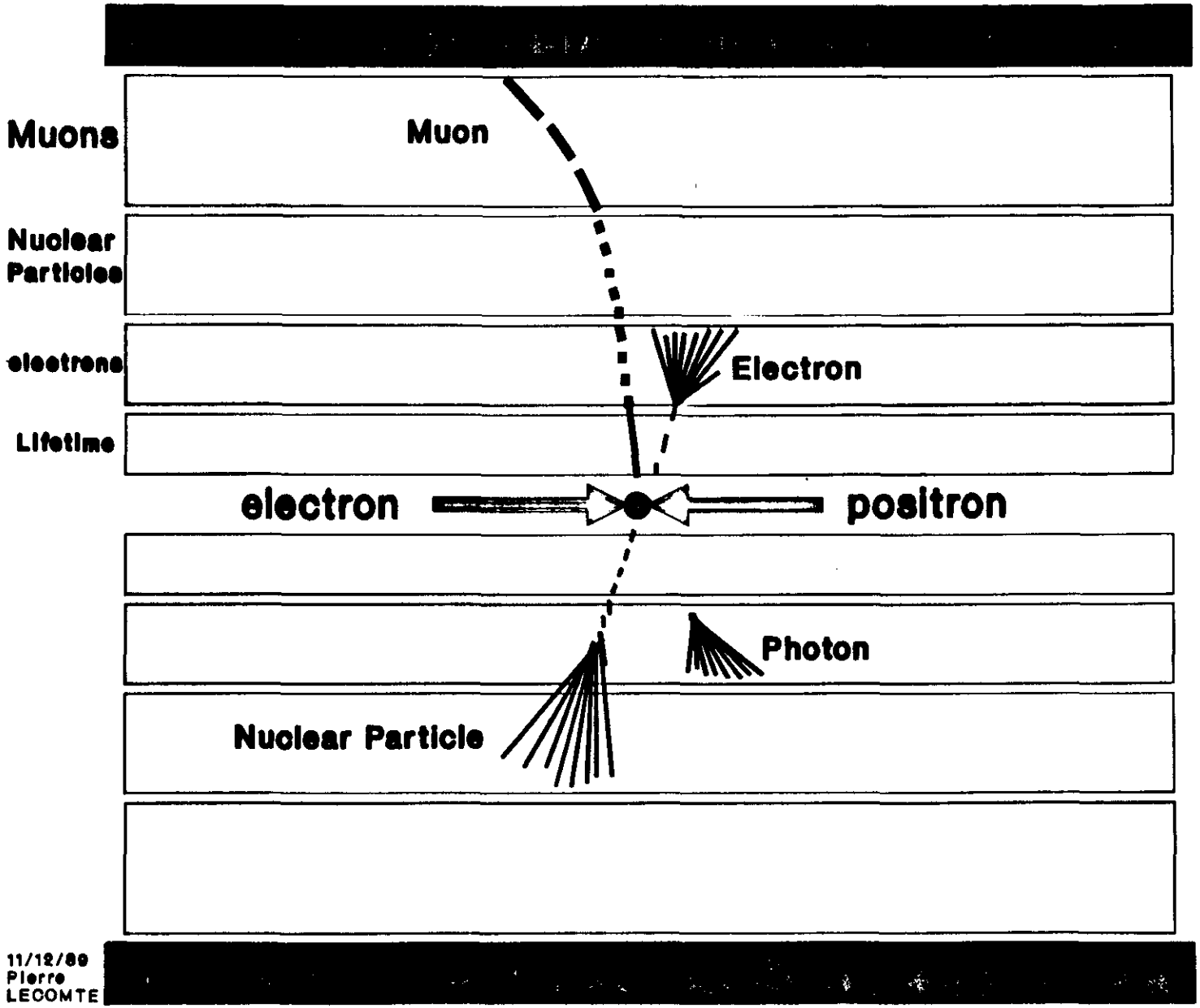
- GEM is an international scientific collaboration
  - 650 scientists and engineers
  - 85 institutions
  - 16 nations

| | | | |
|---|---|---|---|
| Belorus | Georgia | Italy | Romania |
| Brazil | Germany | Japan | Russia |
| China | India | Korea | Taiwan |
| Colombia | Israel | Mexico | USA |

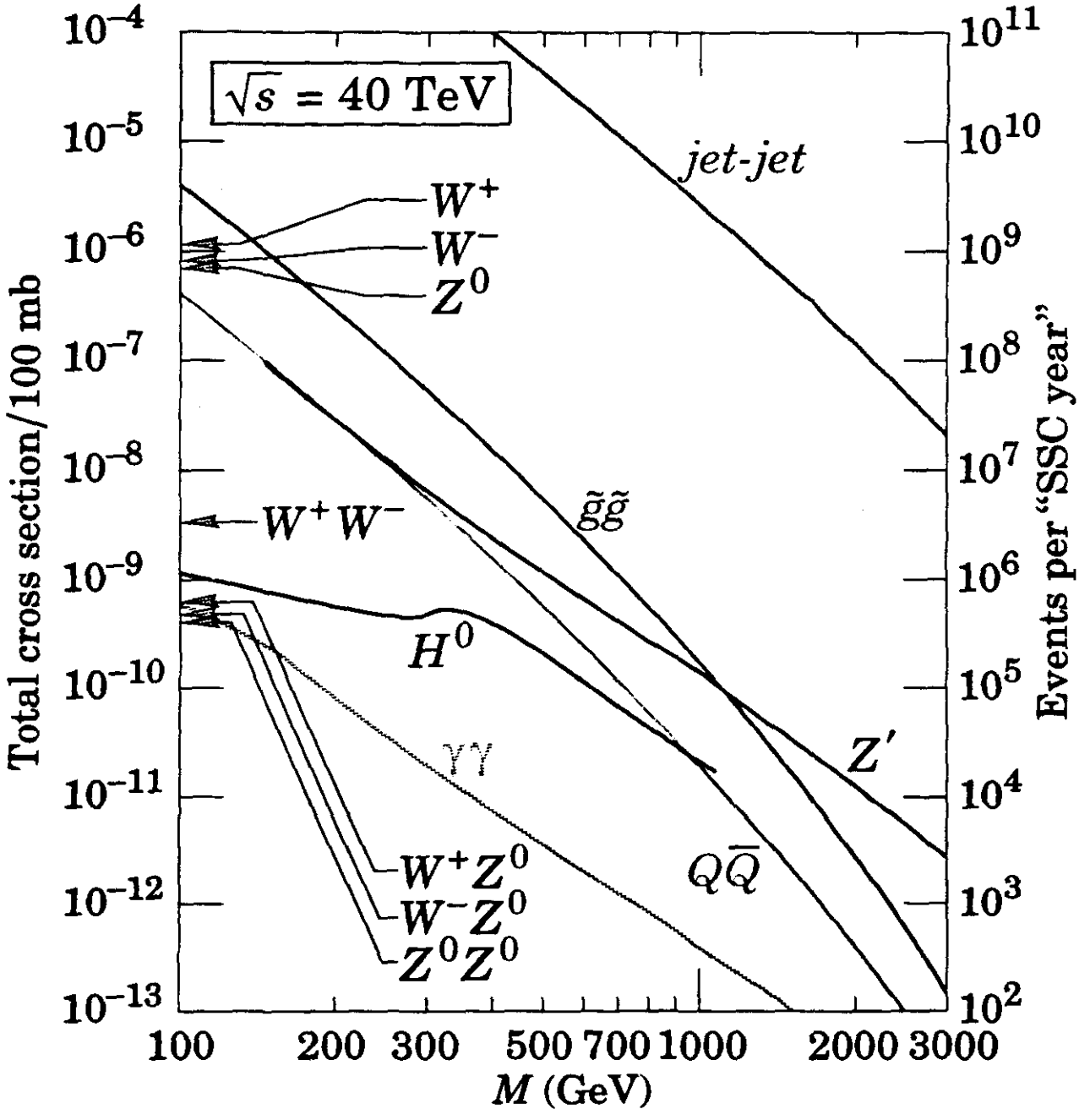

GEM Project Department
GEM
Co-Spokesmen
International Committee
Executive Committee
Collaboration Council
General Institution Assembly
SSCL
Integration Group
Chief Engineer
Integration Coordinator
Physics
Magnet
Calorimeter
Muons
Tracking
Trigger
Computing
hd/1-8-92

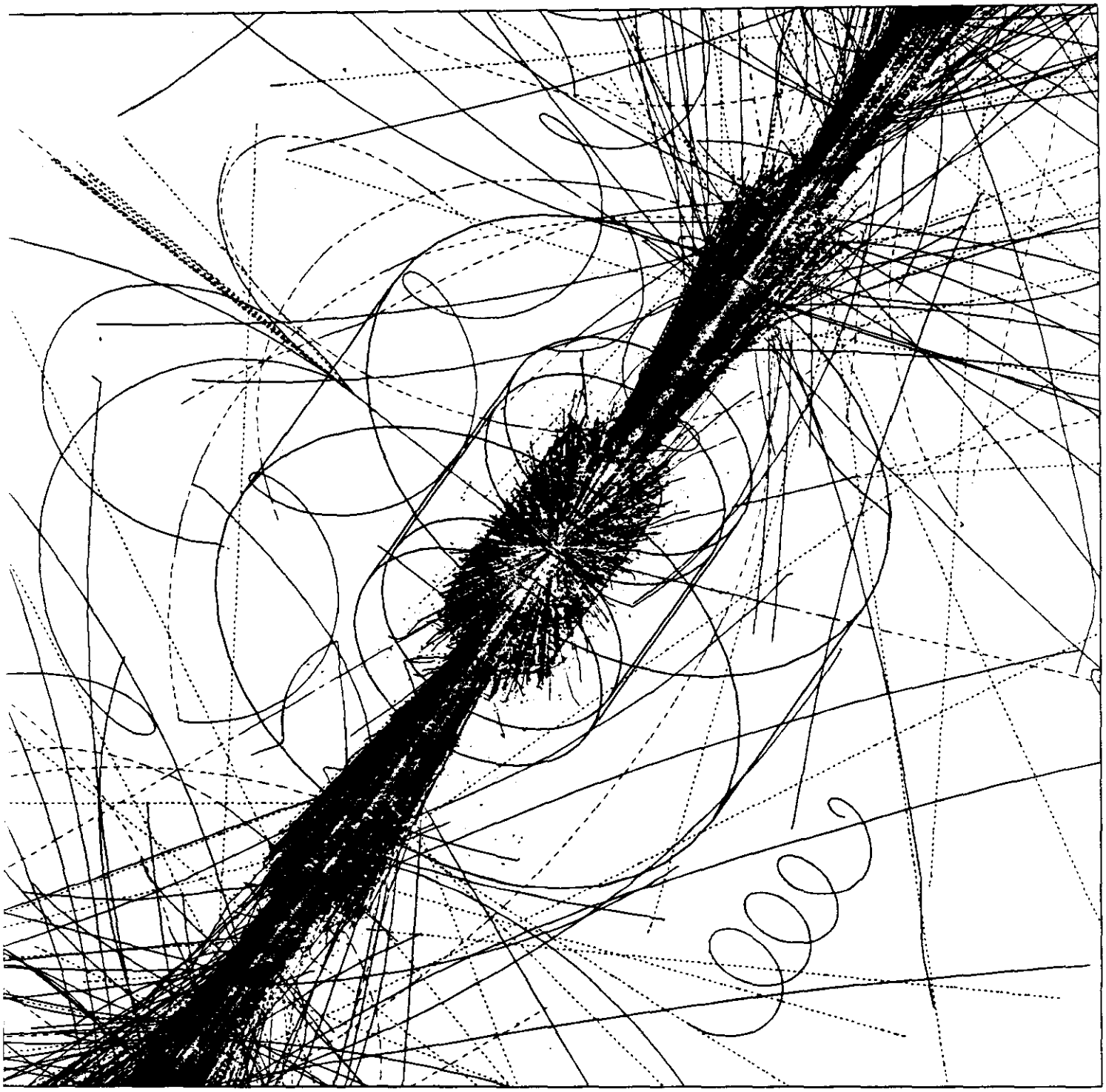
# GEM Project Department in SSCL






11/12/89
Pierre
LECOMTE

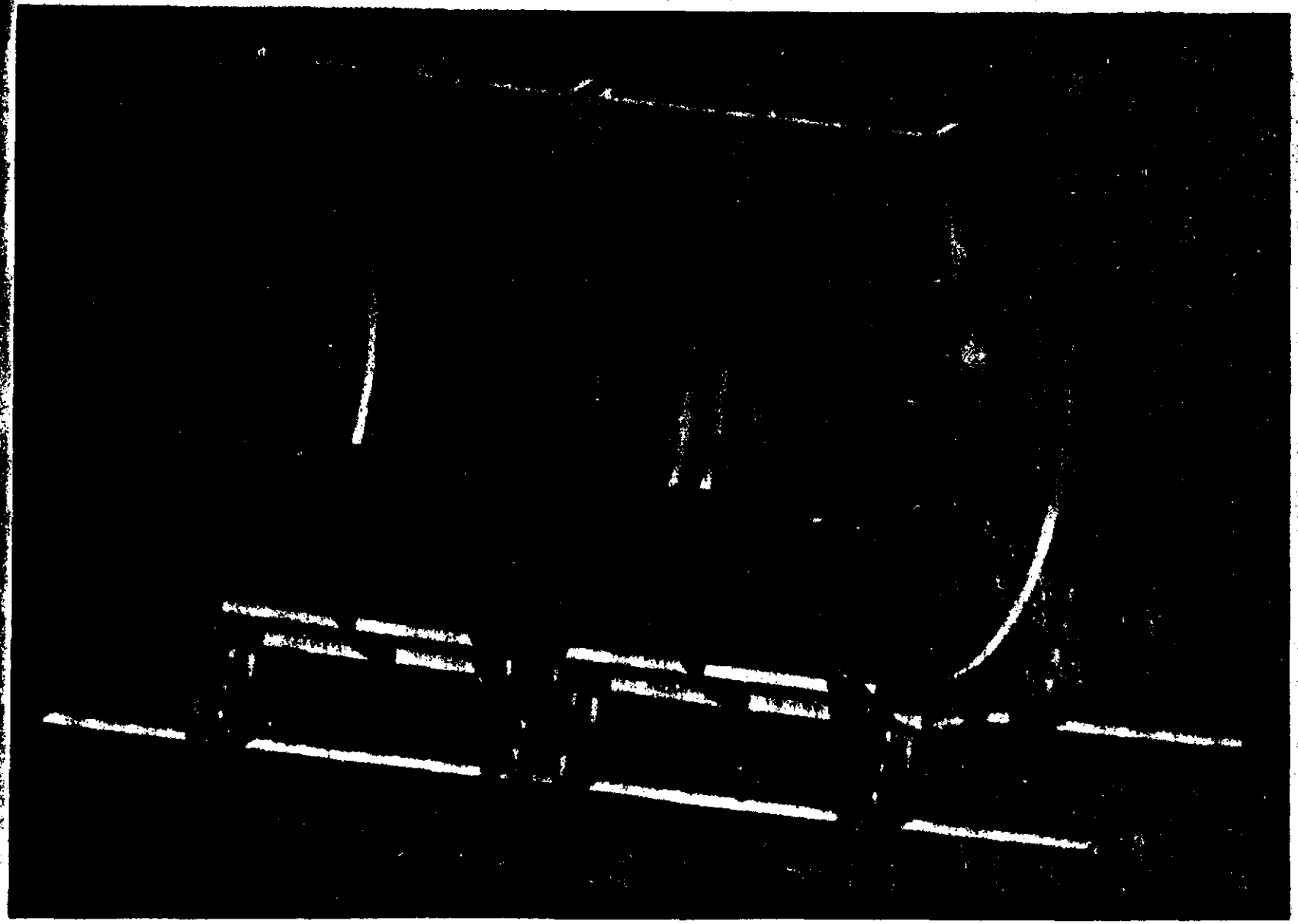

$\sqrt{s}$ = 40 TeV
jet-jet
$W^+$
$W^-$
$Z^0$
$W^+W^-$
$\tilde{g}\tilde{g}$
$H^0$
$\gamma\gamma$
$Z'$
$Q\bar{Q}$
$W^+Z^0$
$W^-Z^0$
$Z^0Z^0$
Total cross section/100 mb
Events per "SSC year"
$M$ (GeV)
$10^{-4}$
$10^{-5}$
$10^{-6}$
$10^{-7}$
$10^{-8}$
$10^{-9}$
$10^{-10}$
$10^{-11}$
$10^{-12}$
$10^{-13}$
$10^{11}$
$10^{10}$
$10^{9}$
$10^{8}$
$10^{7}$
$10^{6}$
$10^{5}$
$10^{4}$
$10^{3}$
$10^{2}$
100
200
300
500
700
1000
2000
3000



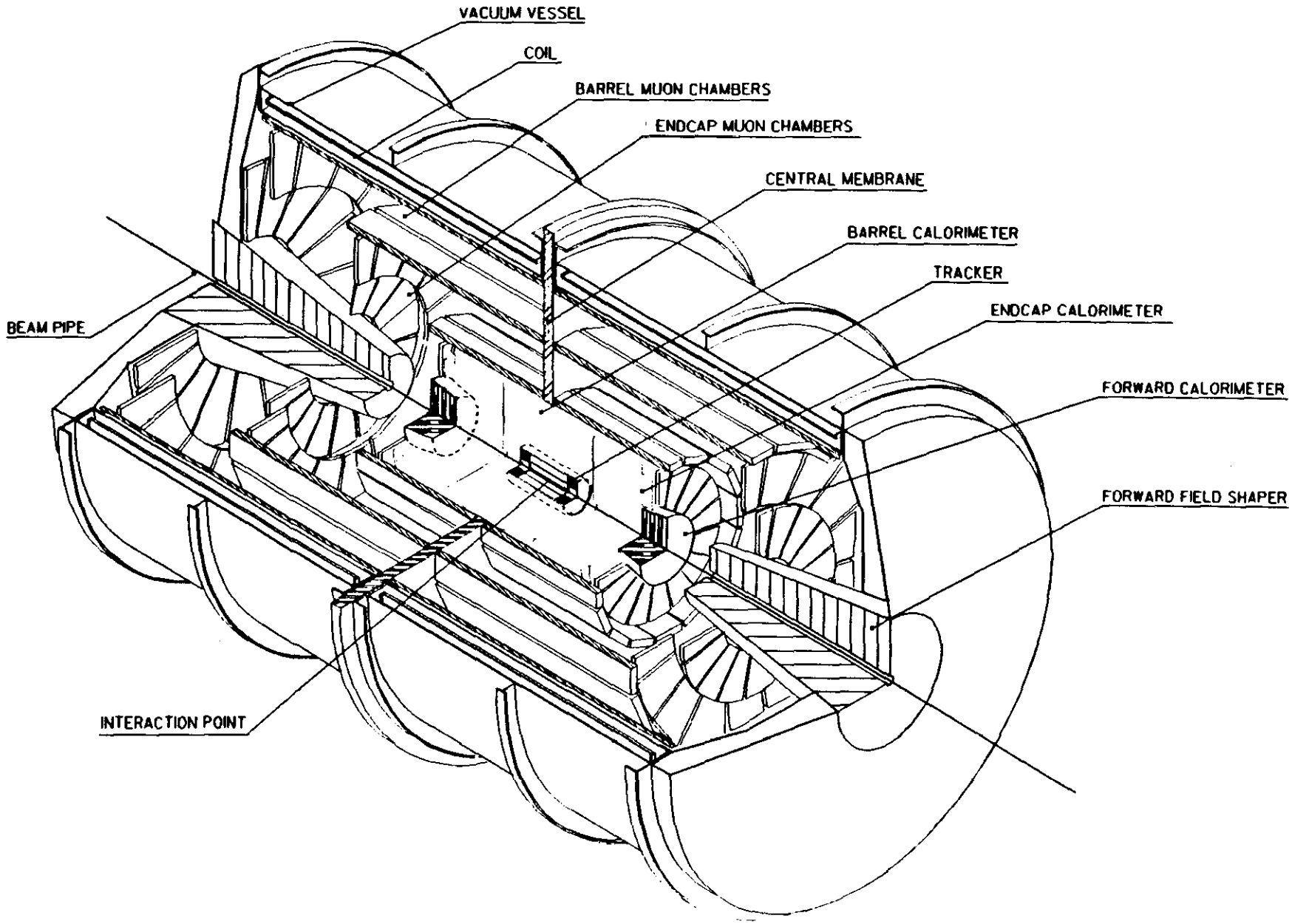
# EMPHASIS IN GEM

- Very precise measurement of muon momenta using only the outer muon spectrometer in an open magnetic volume
- Very precise measurement of electron and photon energies using a precision electromagnetic calorimeter with no coil in front of the calorimeter
- Hermetic calorimetry and good jet resolution
- Central tracker emphasis on ensuring clean measurement of physics signals without requiring full pattern recognition
- High luminosity

# Superconducting Solenoids

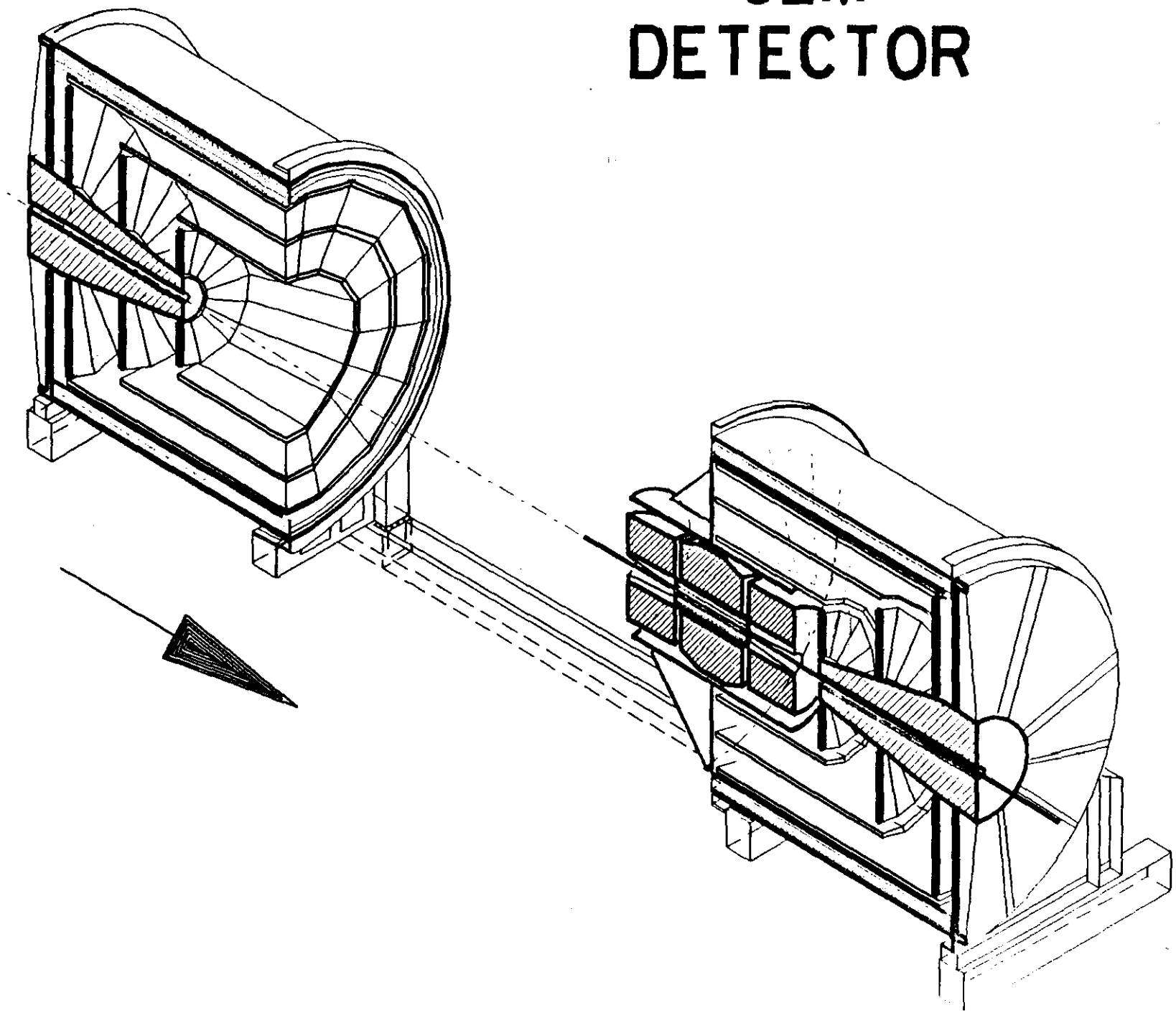


# GEM DETECTOR




(ISOMETRIC GEM920305. ZC)

# GEM DETECTOR



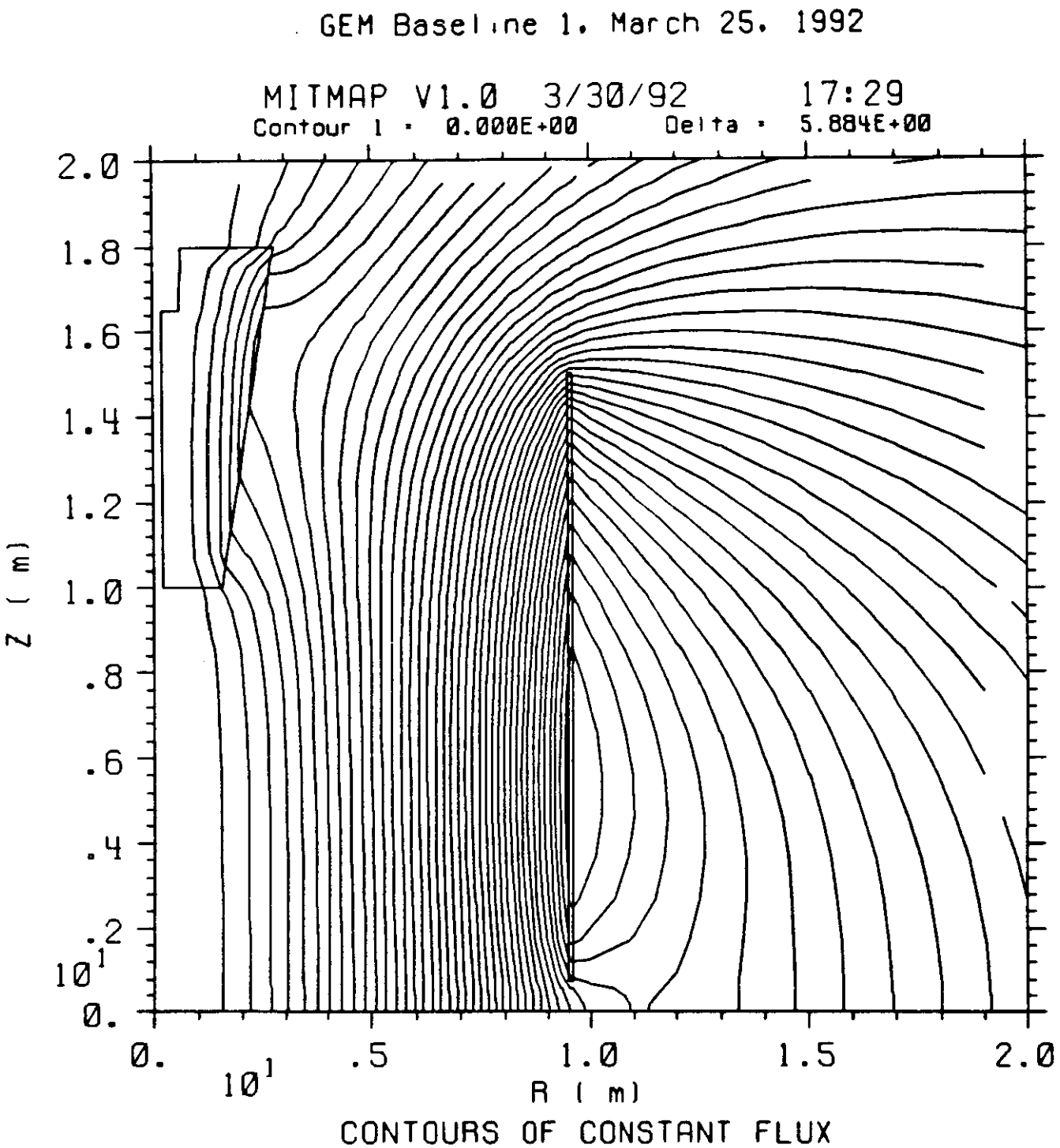



Figure 3: Lines of magnetic flux (field lines) in a meridional half-plane; the figure is rotationally symmetric about the horizontal axis and has mirror symmetry about $Z = 0$. Note: the beam axis, $Z$, is vertical while the transverse axis, $R$ is horizontal. Both axes extend from 0 to 20 m and the field is in gauss. A sketch of the superconducting winding and the forward flux concentrator (field shaper) is also shown.

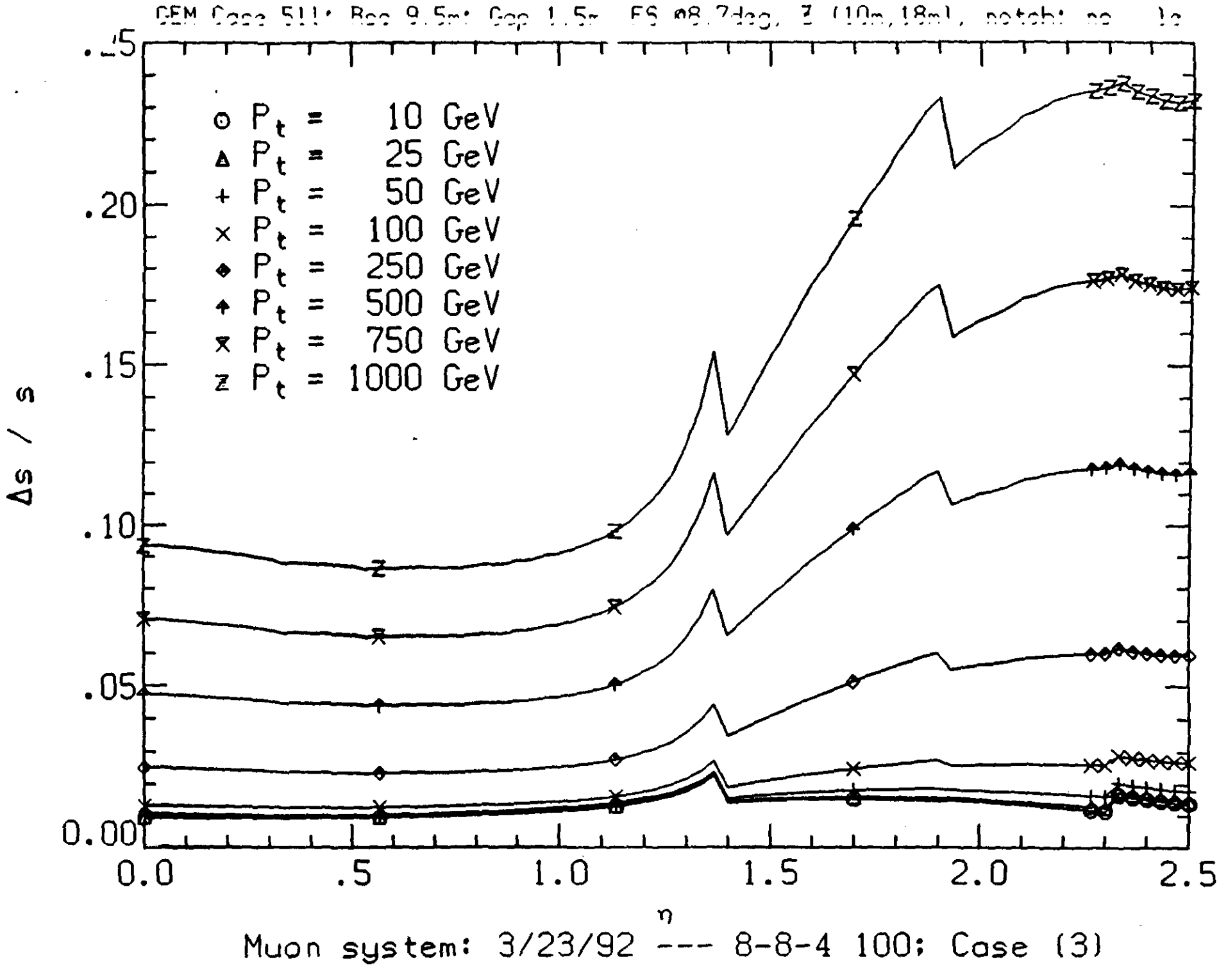
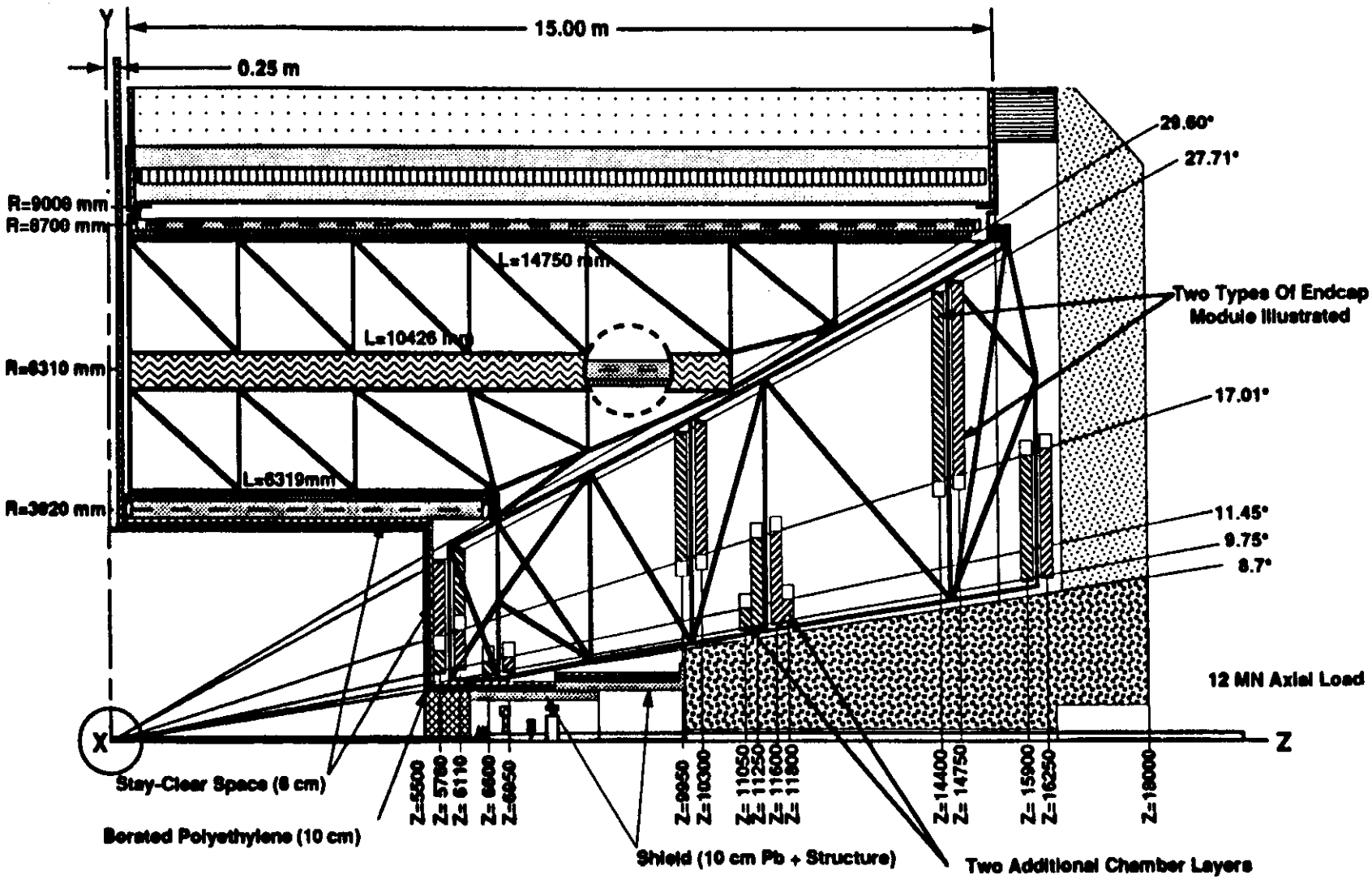

GEM Case 511: Rec 9.5m: Gap 1.5m FS 08.7deg, Z (10m,18m), notch: no
.25
.20
.15
.10
.05
0.00
Δs / s
0.0
.5
1.0
1.5
2.0
2.5
η
⊙ $P_t$ = 10 GeV
▲ $P_t$ = 25 GeV
+ $P_t$ = 50 GeV
× $P_t$ = 100 GeV
◆ $P_t$ = 250 GeV
♦ $P_t$ = 500 GeV
⧖ $P_t$ = 750 GeV
z $P_t$ = 1000 GeV
Muon system: 3/23/92 --- 8-8-4 100; Case (3)

Fig. 4.1.1




# GEM MUON SYSTEM (BASELINE)

## (4/8/4 layers for Theta = 9.75° to 11.45°)

| Draper Laboratory | |
|---|---|
| GEM Muon System (BASELINE)<br>4/8/4 Layers 9.75° to 11.45° | |
| Drawn By: F. Nimblett | Rev (-) |
| Dwg. No: GMU0009 | 3/27/92 |
| Approved by: | |

Fig. 3.1

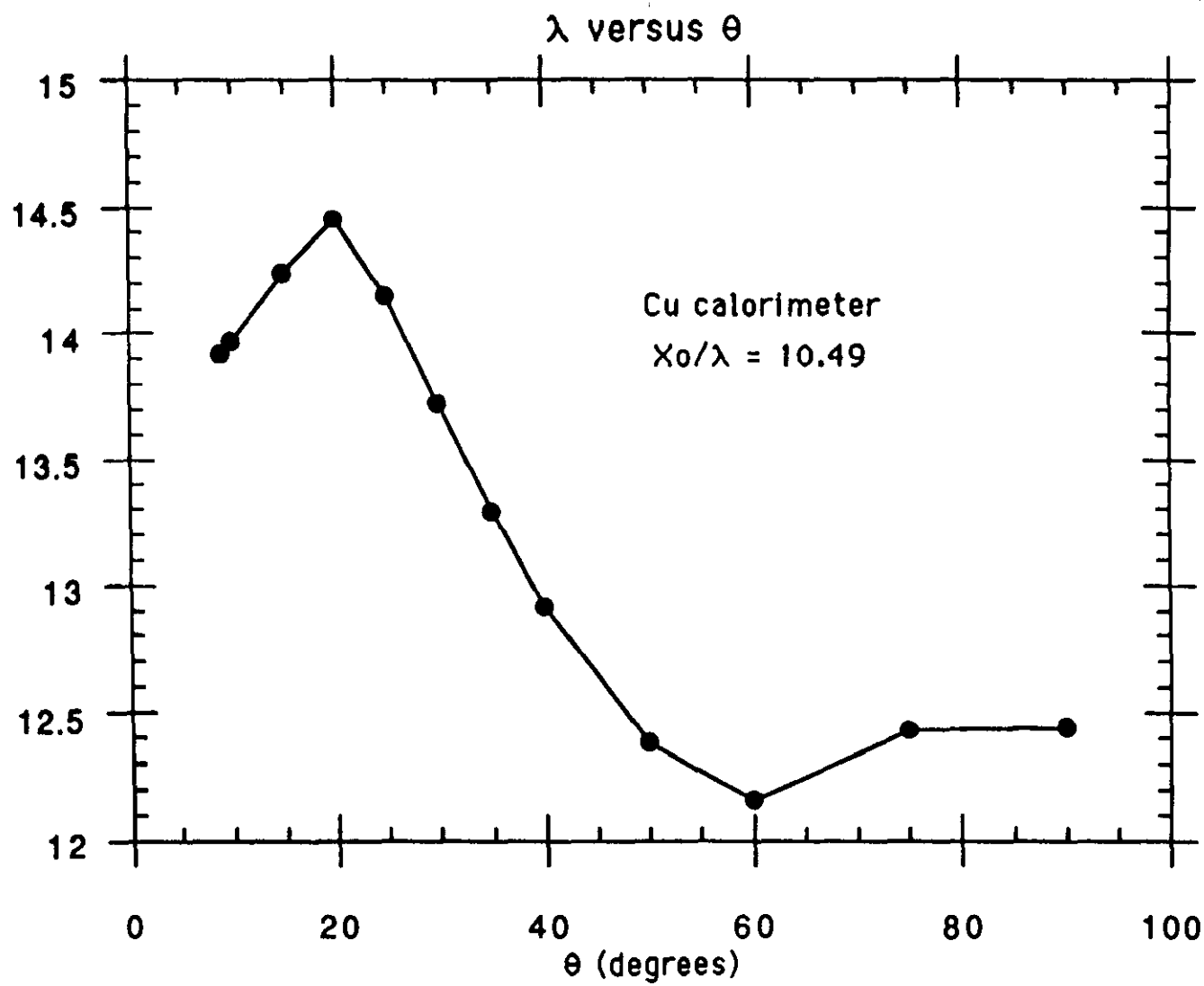

λ versus θ
15
14.5
14
13.5
13
12.5
12
0
20
40
60
80
100
θ (degrees)
Cu calorimeter
Xo/λ = 10.49

Fig. 4.2.1

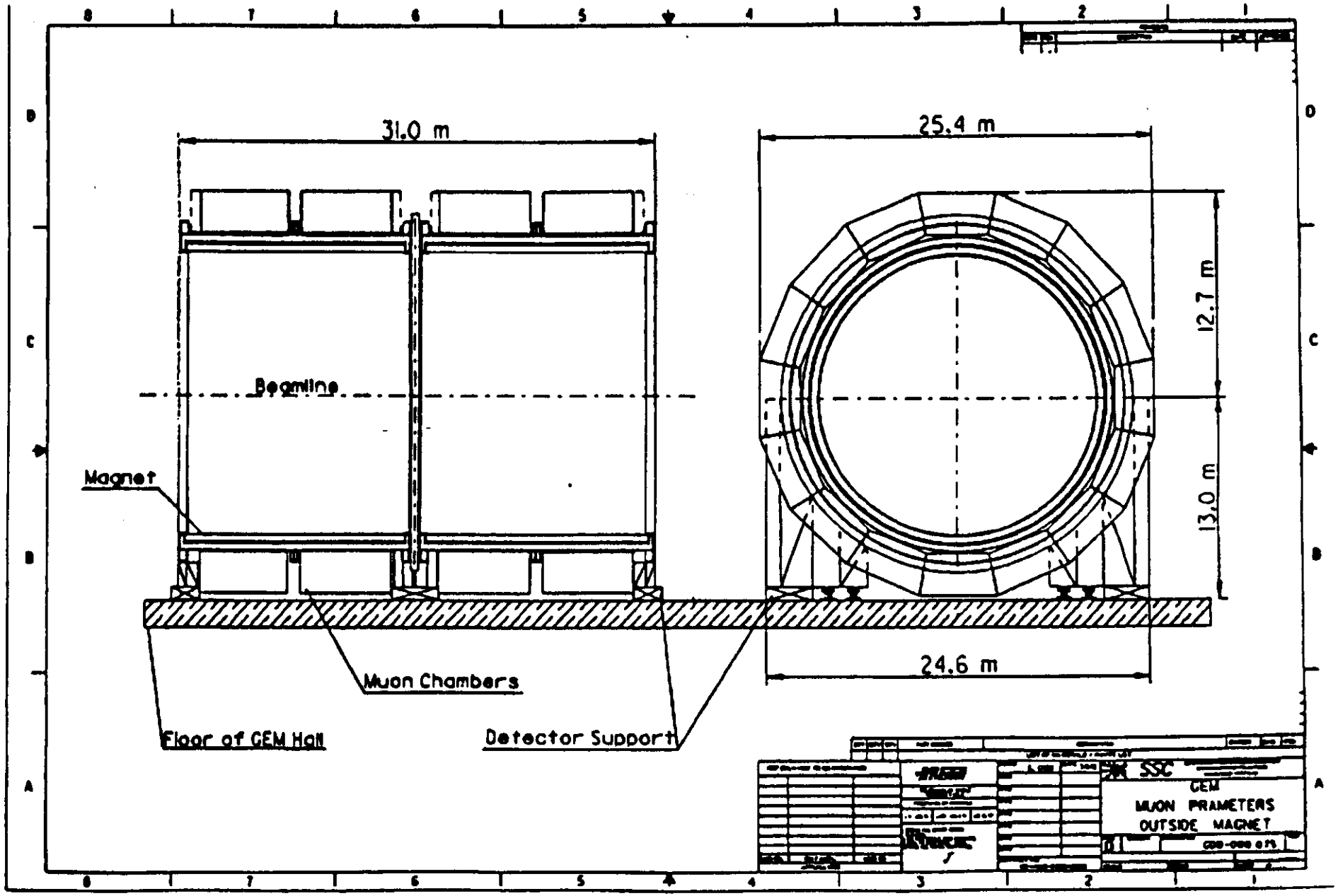

31.0 m
25.4 m
12.7 m
13.0 m
24.6 m
Beamline
Magnet
Muon Chambers
Floor of GEM Hall
Detector Support
SSC
GEM
MUON PRAMETERS
OUTSIDE MAGNET

Fig. 7.1

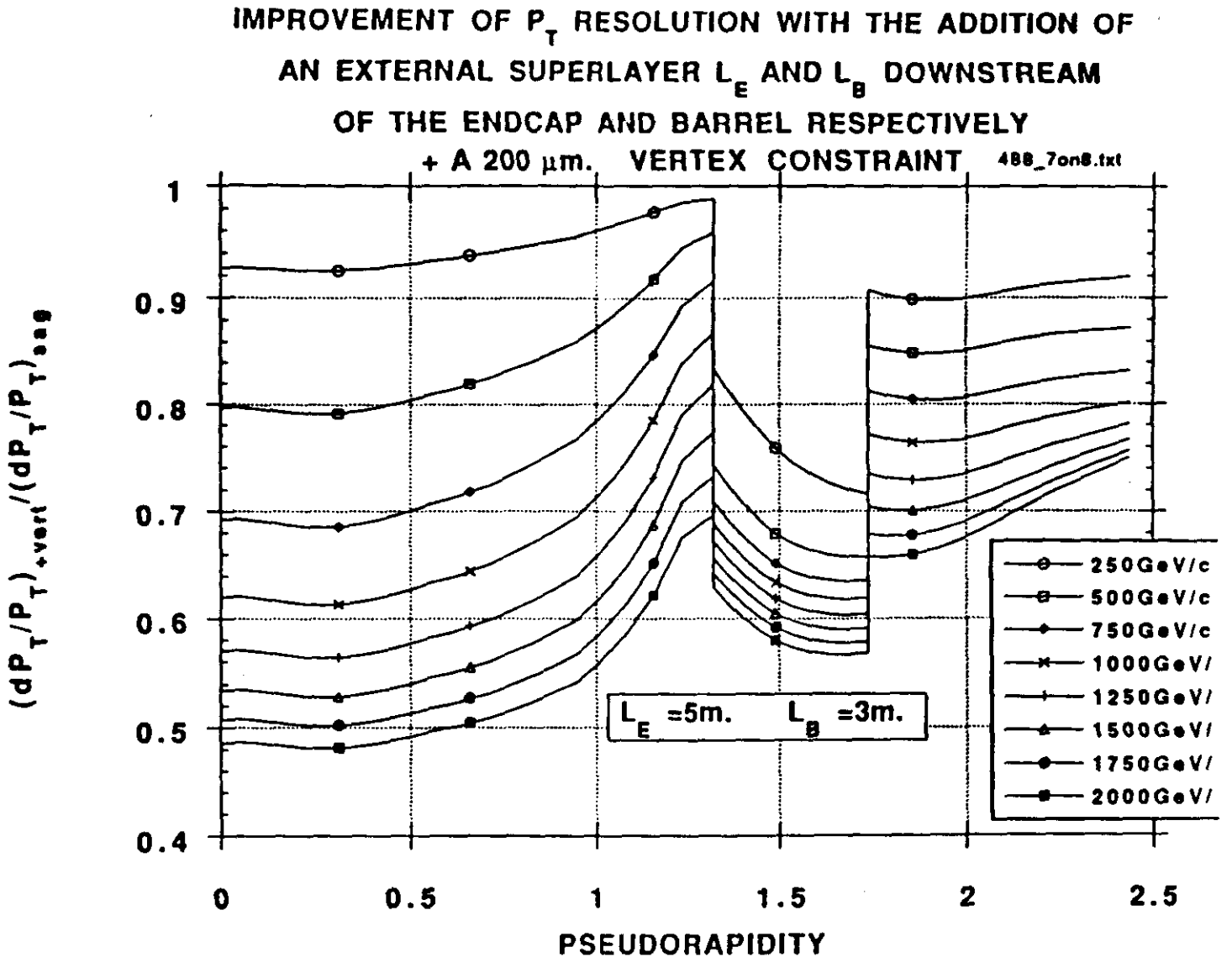
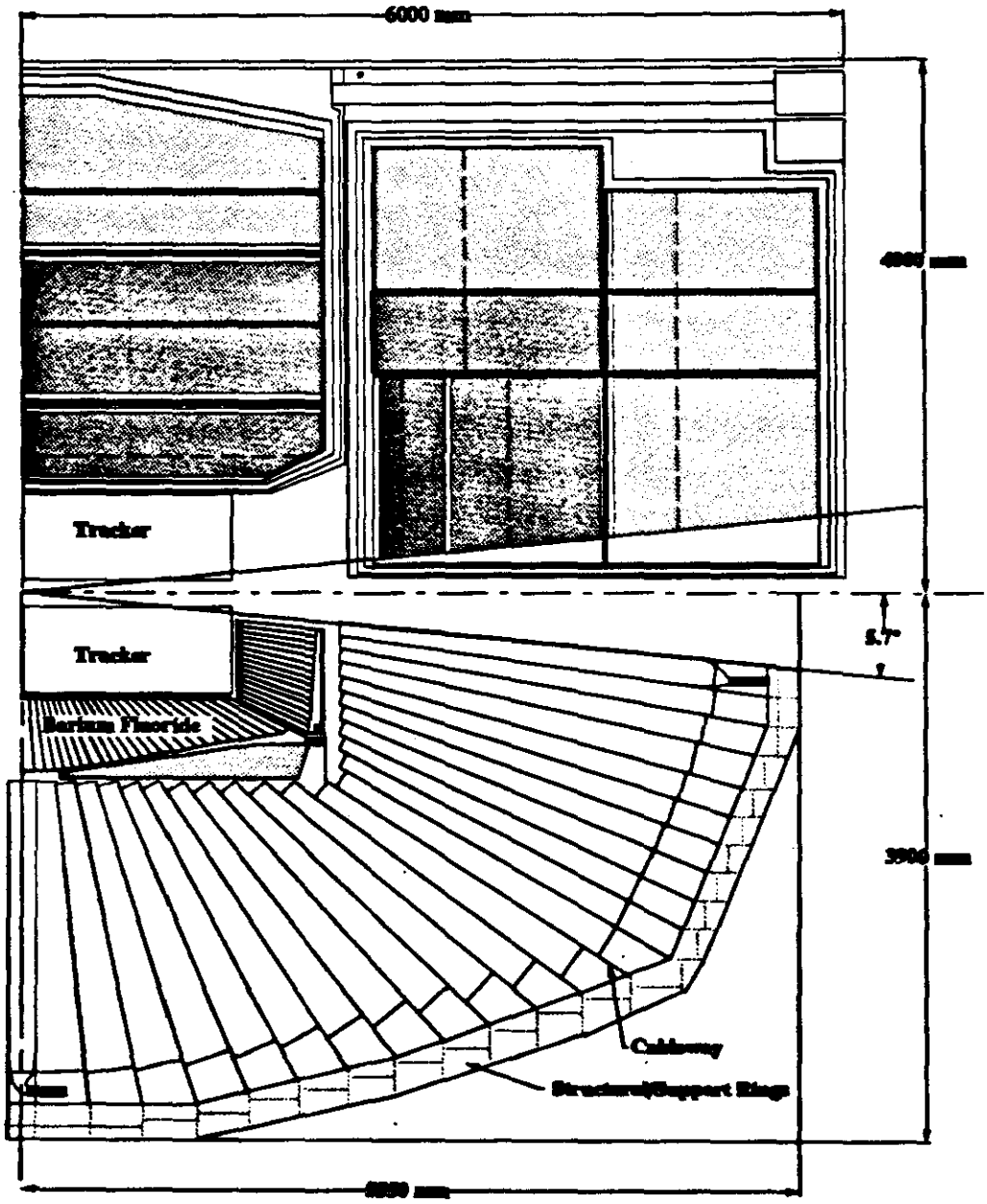

IMPROVEMENT OF $P_T$ RESOLUTION WITH THE ADDITION OF
AN EXTERNAL SUPERLAYER $L_E$ AND $L_B$ DOWNSTREAM
OF THE ENDCAP AND BARREL RESPECTIVELY
+ A 200 μm. VERTEX CONSTRAINT
488_7on8.txt
$(dP_T/P_T)_{+vert}/(dP_T/P_T)_{sag}$
1
0.9
0.8
0.7
0.6
0.5
0.4
0
0.5
1
1.5
2
2.5
PSEUDORAPIDITY
$L_E$ =5m. $L_B$ =3m.
250GeV/c
500GeV/c
750GeV/c
1000GeV/
1250GeV/
1500GeV/
1750GeV/
2000GeV/

Fig. 7.2

**Liquid Argon Calorimeter**




**BaF2 EM with Scintillating Fiber Hadron Calorimeter**

**Table 2.4-1 Effect of Energy Resolution: a and b**

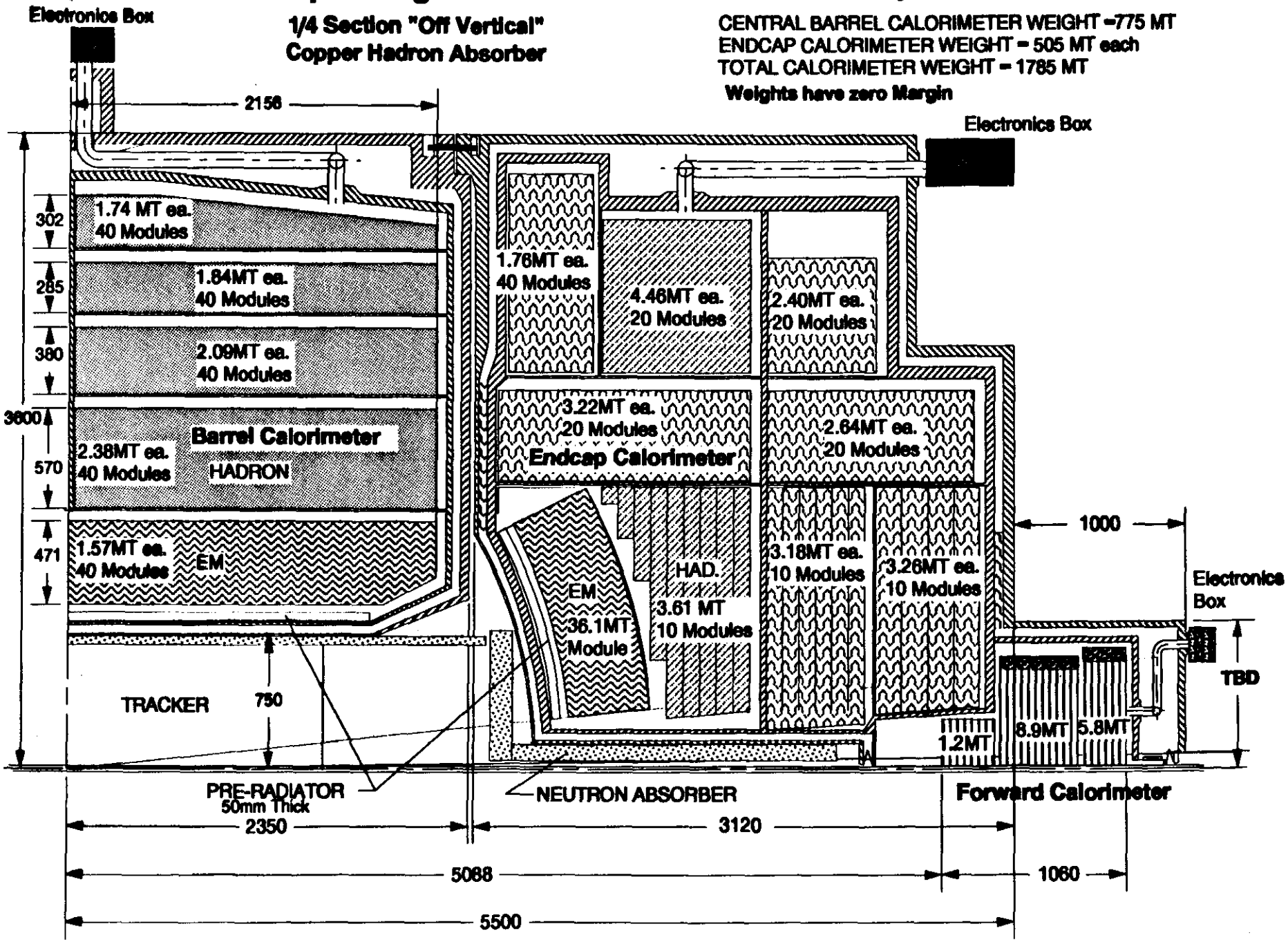
| a = | 2.0 | 5.0 | 7.5 | 10 | 15 |
|---|---|---|---|---|---|
| b = .25 | 0.63 | 1.2 | 1.7 | 2.2 | 3.3 |
| b = 0.5 | 1.0 | 1.4 | 1.8 | 2.3 | 3.4 |
| b = .75 | 1.4 | 1.7 | 2.1 | 2.6 | 3.6 |
| b = 1.0 | 1.8 | 2.1 | 2.4 | 2.9 | 3.7 |

# GEM Liquid Argon Calorimeter

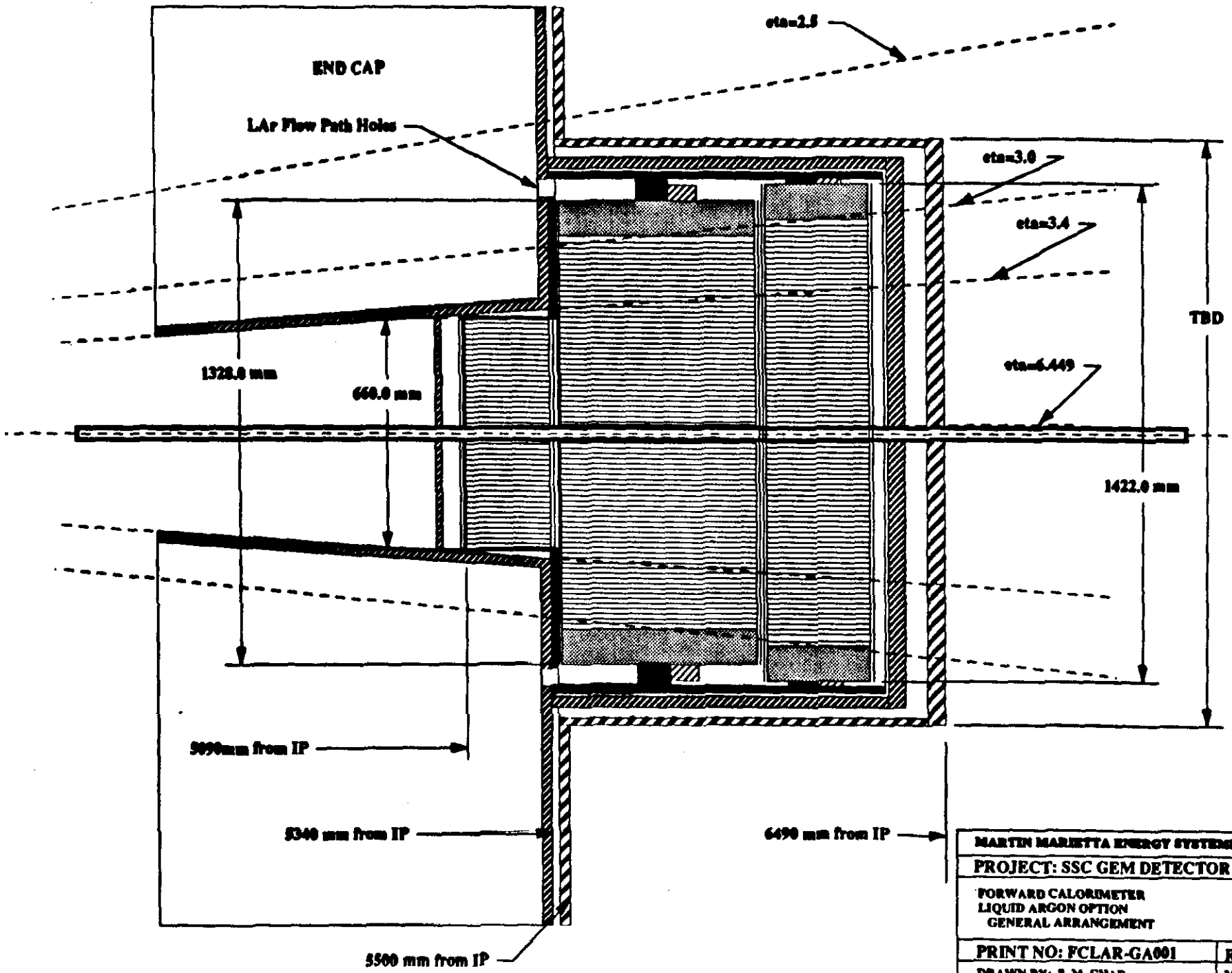
**1/4 Section "Off Vertical"**
**Copper Hadron Absorber**

Shows General Configuration with Electronic feed throughs

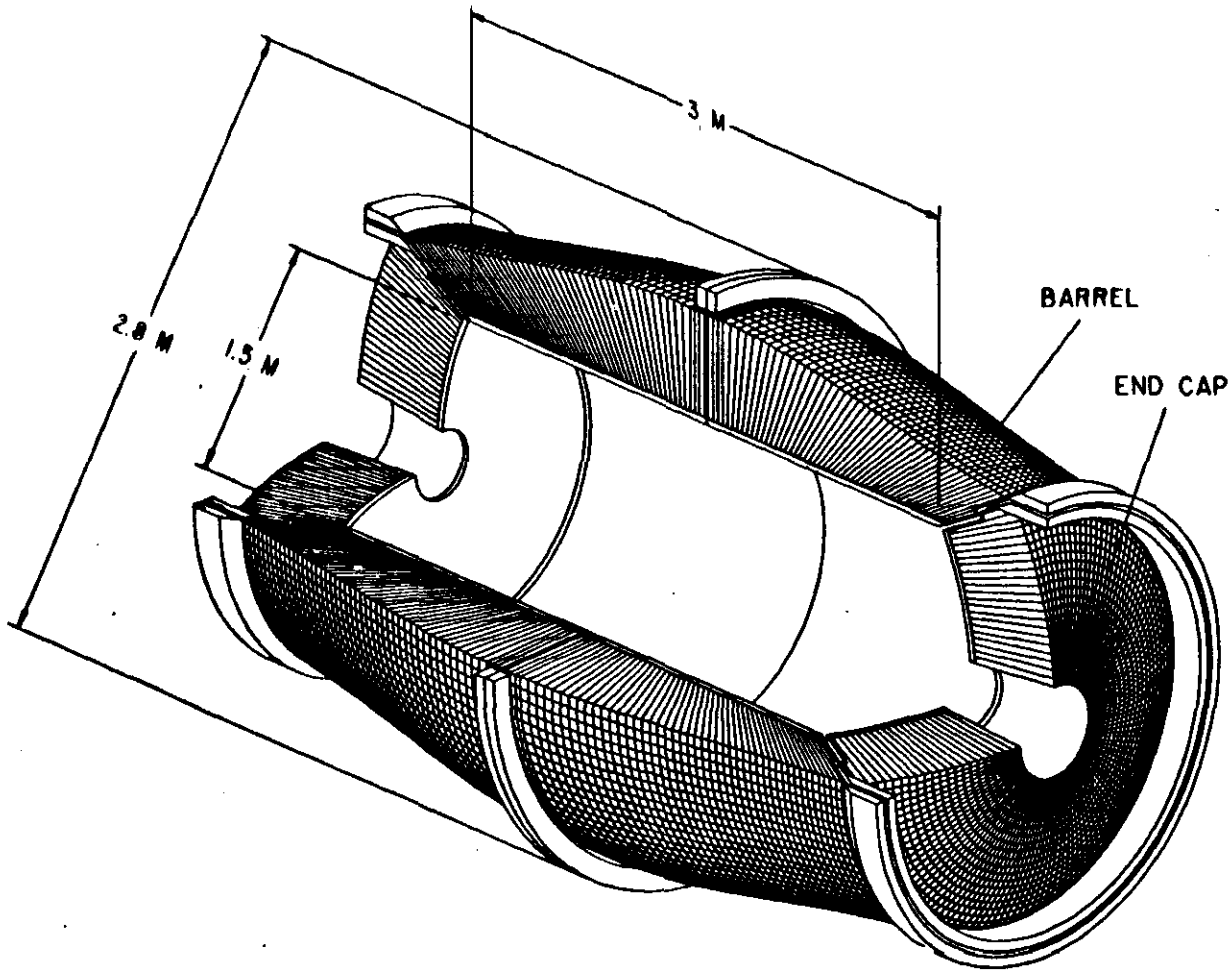
CENTRAL BARREL CALORIMETER WEIGHT =775 MT
ENDCAP CALORIMETER WEIGHT = 505 MT each
TOTAL CALORIMETER WEIGHT = 1785 MT
**Weights have zero Margin**

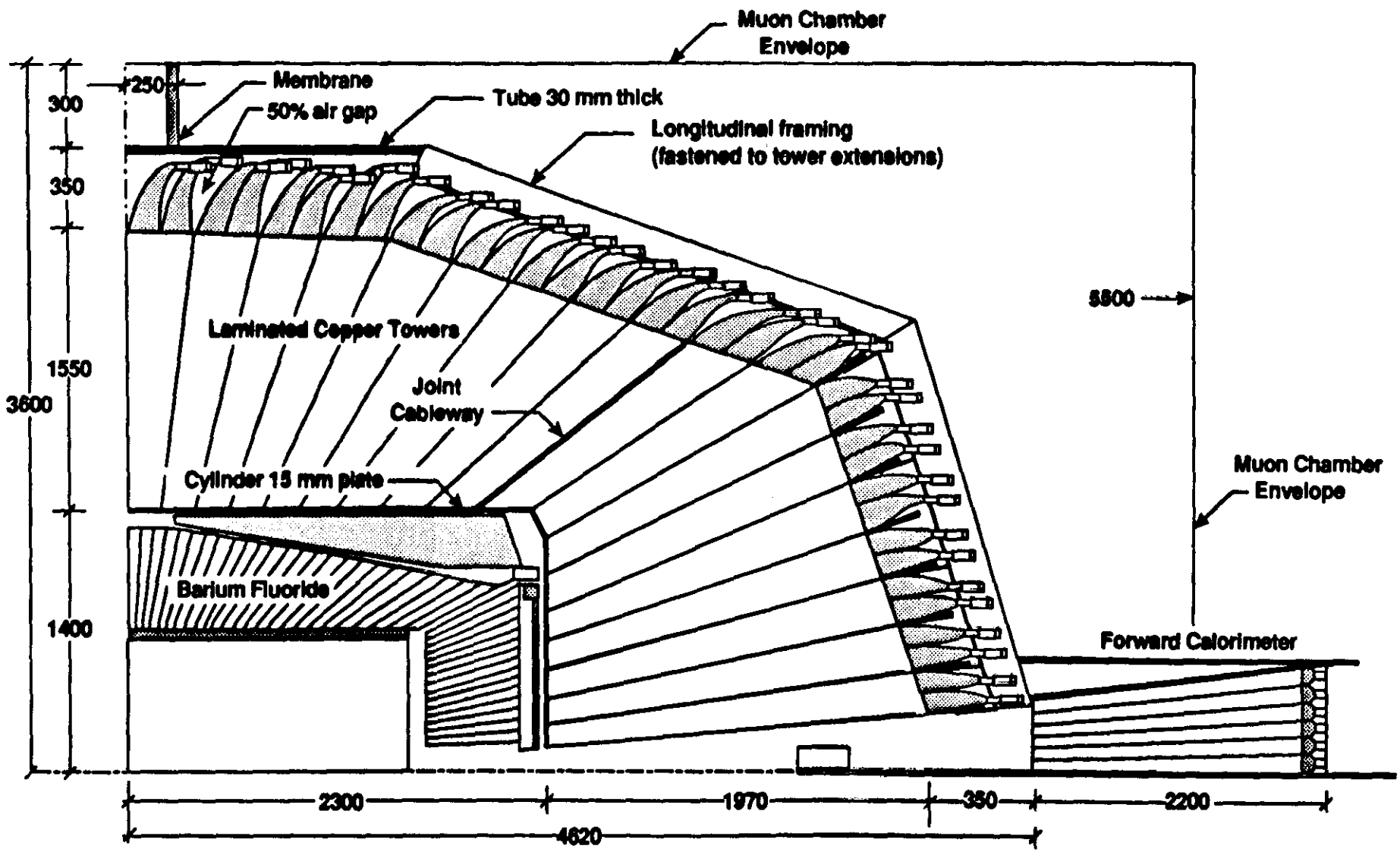



LLMason 3/23/92




| | |
|---|---|
| MARTIN MARIETTA ENERGY SYSTEMS | |
| PROJECT: SSC GEM DETECTOR | |
| FORWARD CALORIMETER<br>LIQUID ARGON OPTION<br>GENERAL ARRANGEMENT | |
| PRINT NO: FCLAR-GA001 | REV 3 |
| DRAWN BY: S. M. CHAE | 3/25/92 |
| CHECKED & APPROVED BY: | |

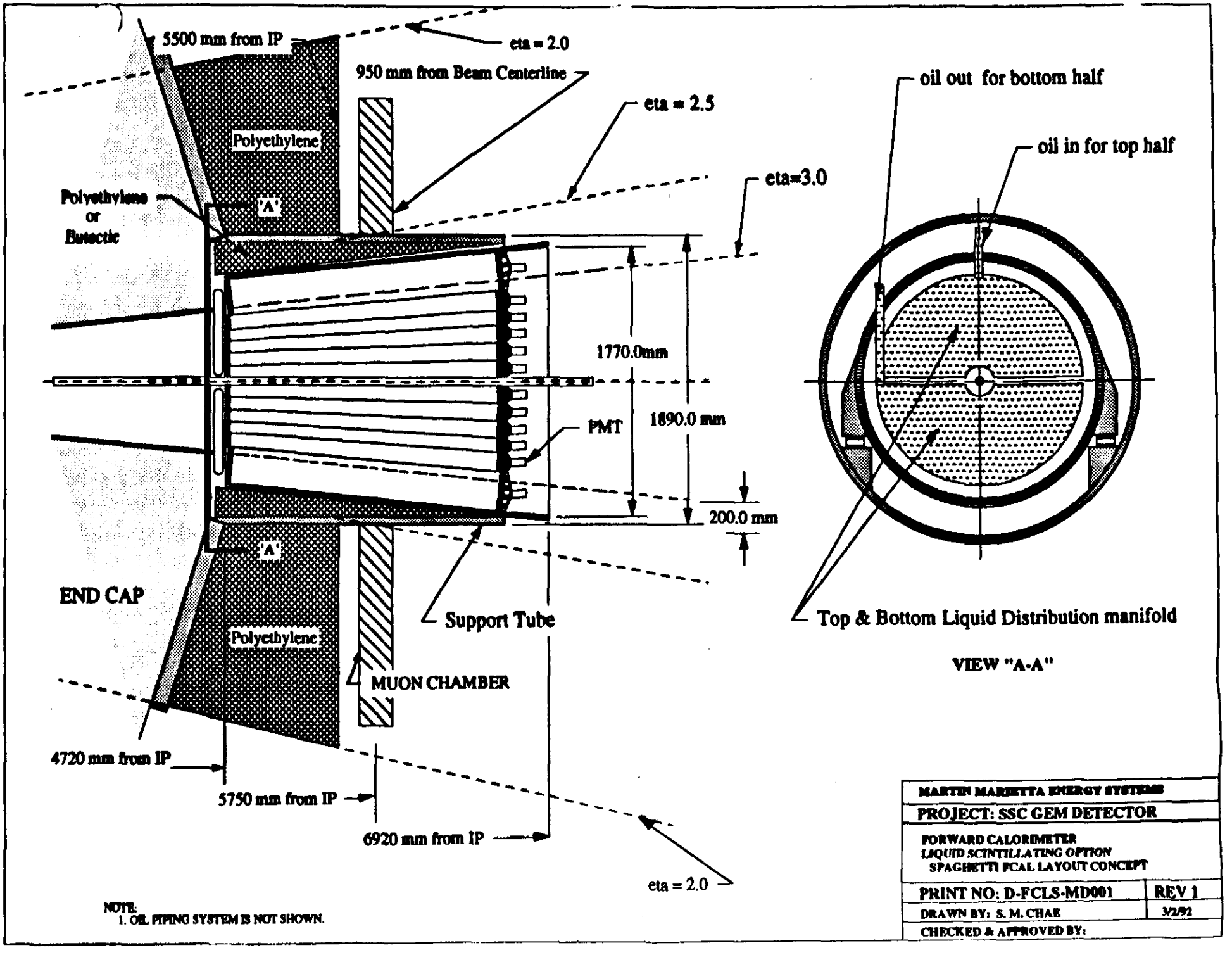

3 M
2.8 M
1.5 M
BARREL
END CAP

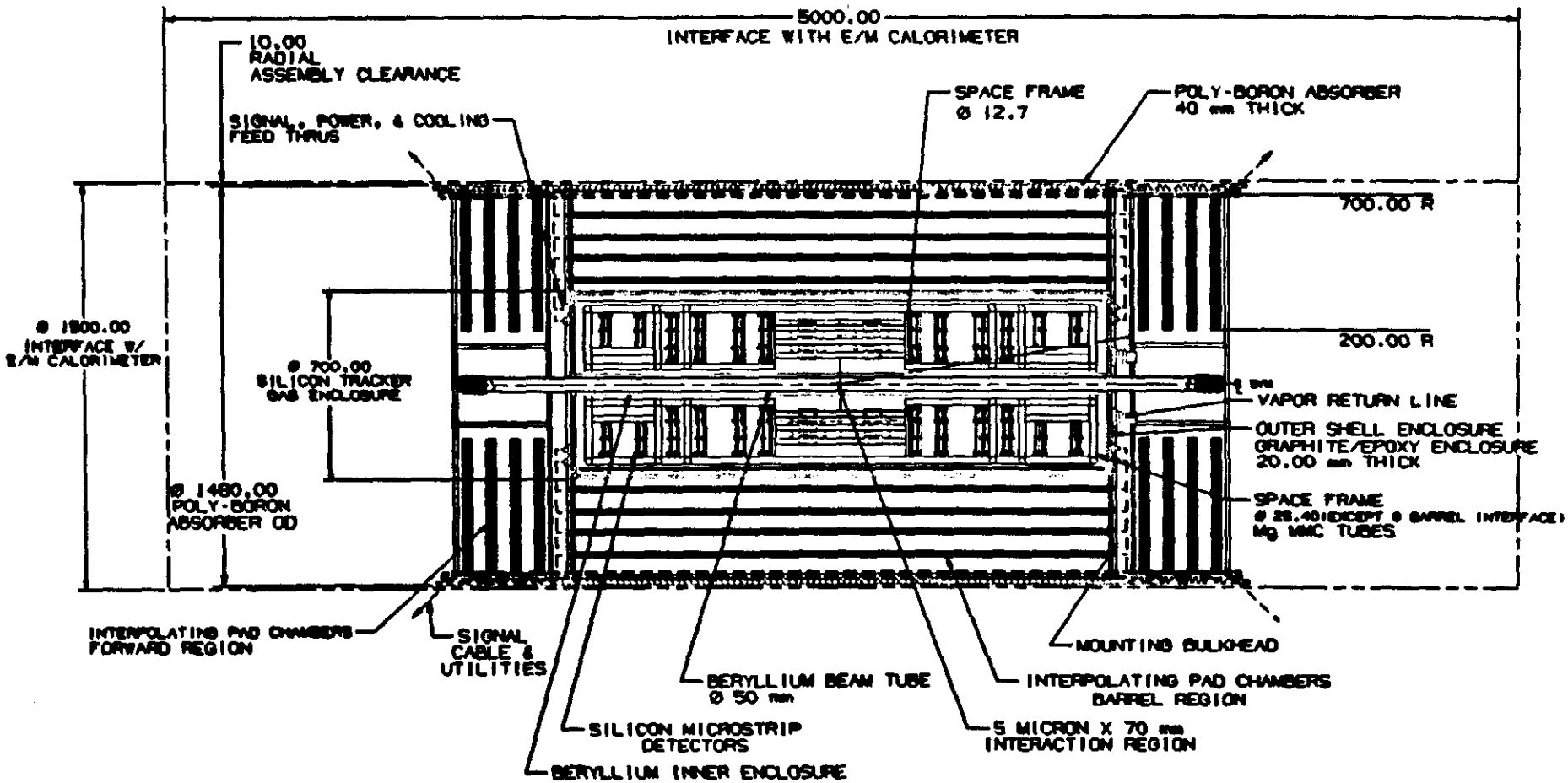



Dimensions in millimeters

# GEM Scintillator Calorimeter System

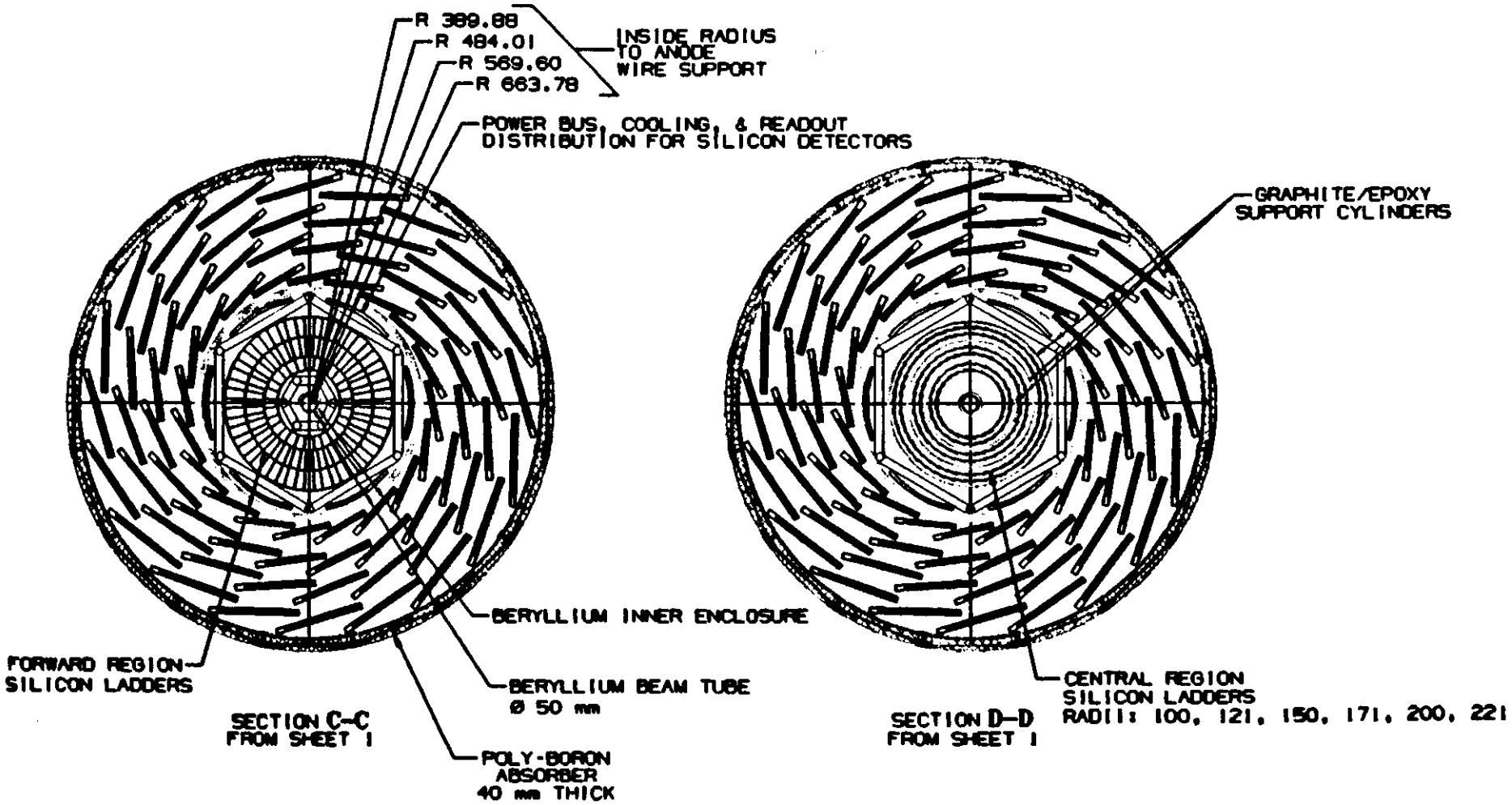
F. Ayer 92030276


5500 mm from IP
eta = 2.0
950 mm from Beam Centerline
eta = 2.5
eta=3.0
Polyethylene
Polyethylene or Eutectic
'A'
1770.0mm
1890.0 mm
PMT
200.0 mm
'A'
END CAP
Support Tube
Polyethylene
MUON CHAMBER
4720 mm from IP
5750 mm from IP
6920 mm from IP
eta = 2.0
oil out for bottom half
oil in for top half
Top & Bottom Liquid Distribution manifold
VIEW "A-A"
NOTE:
1. OIL PIPING SYSTEM IS NOT SHOWN.
MARTIN MARIETTA ENERGY SYSTEMS
PROJECT: SSC GEM DETECTOR
FORWARD CALORIMETER
LIQUID SCINTILLATING OPTION
SPAGHETTI FCAL LAYOUT CONCEPT
PRINT NO: D-FCLS-MD001
REV 1
DRAWN BY: S. M. CHAE
3/2/92
CHECKED & APPROVED BY:

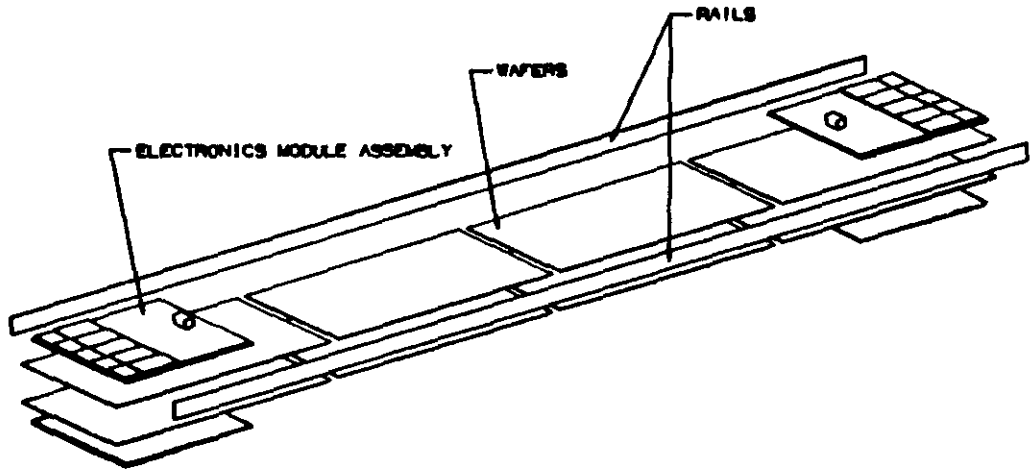



# GEM CENTRAL TRACKER

GEMV8-126-JV




GEMVG-1098-JV 3-23-92




PRELIMINARY
NOT TO BE USED FOR FABRICATION

METRIC
THIRD ANGLE PROJECTION

Los Alamos

GEM SILICON TRACKER
EXPLODED LADDER ASSY

A1 SK-GEM12-02E 1

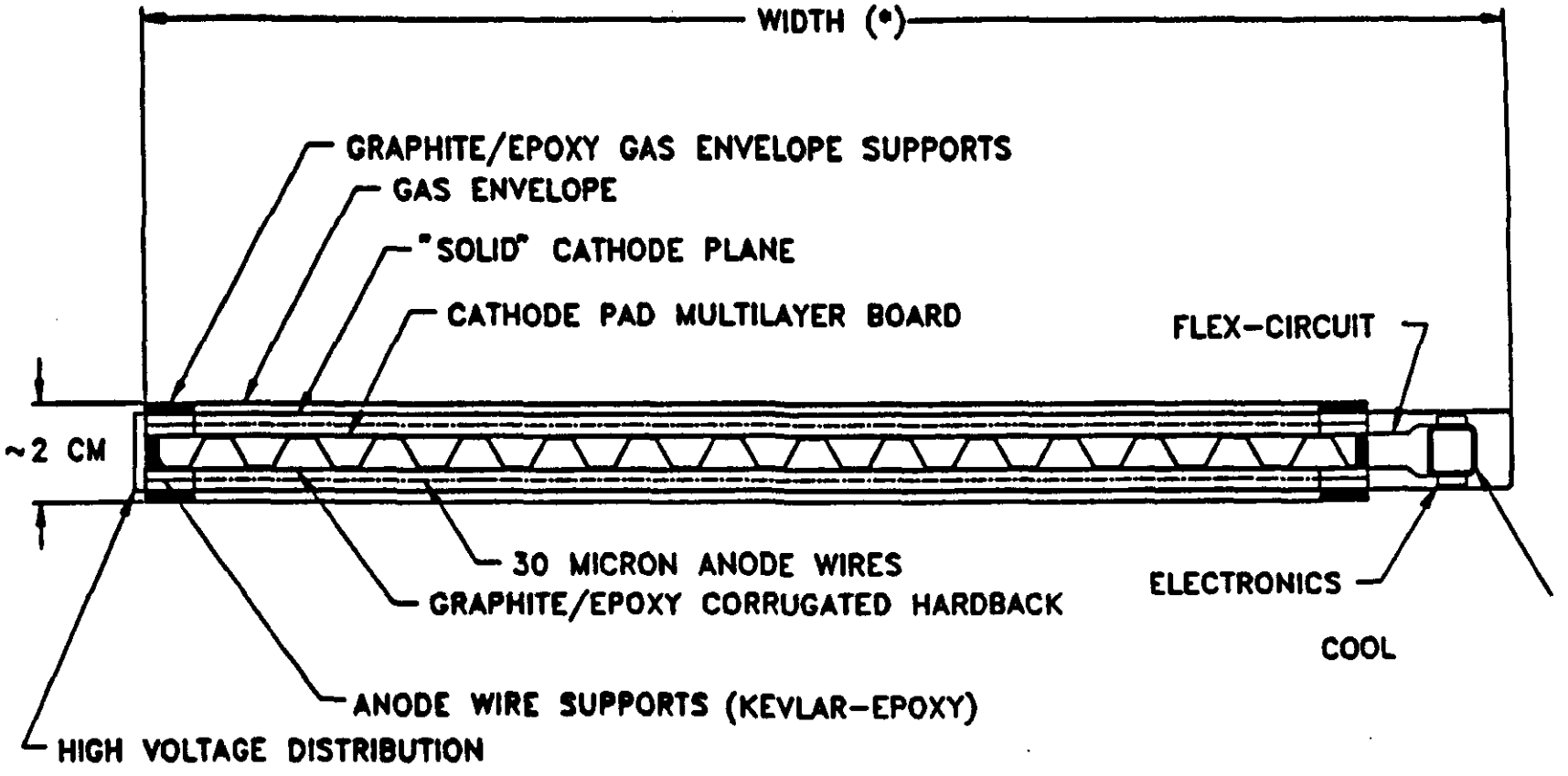



FIGURE 4:

# GEM TRACKING IPC SUPERLAYER

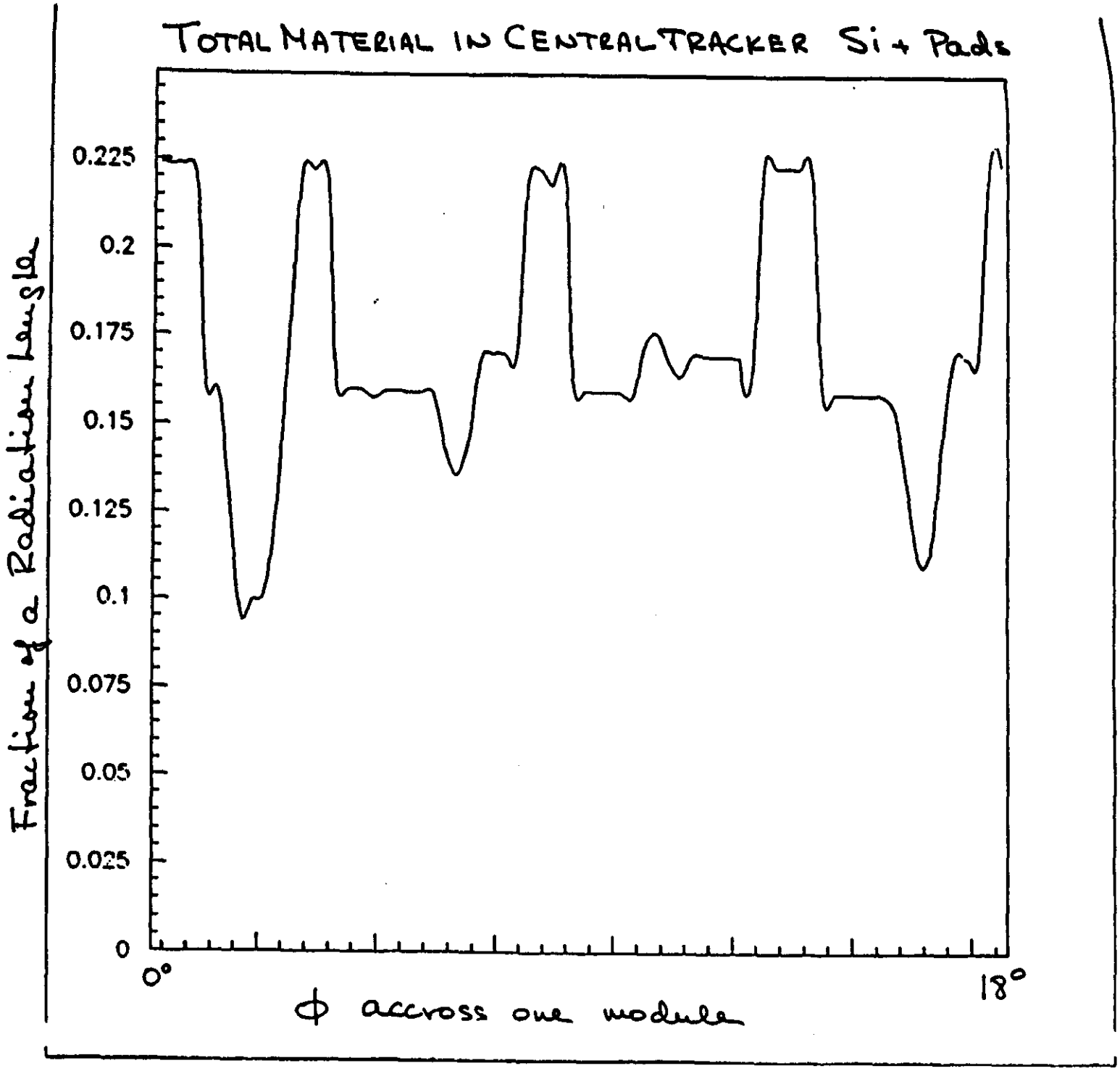
## SECTIONAL OF TYPICAL BARREL MODULE

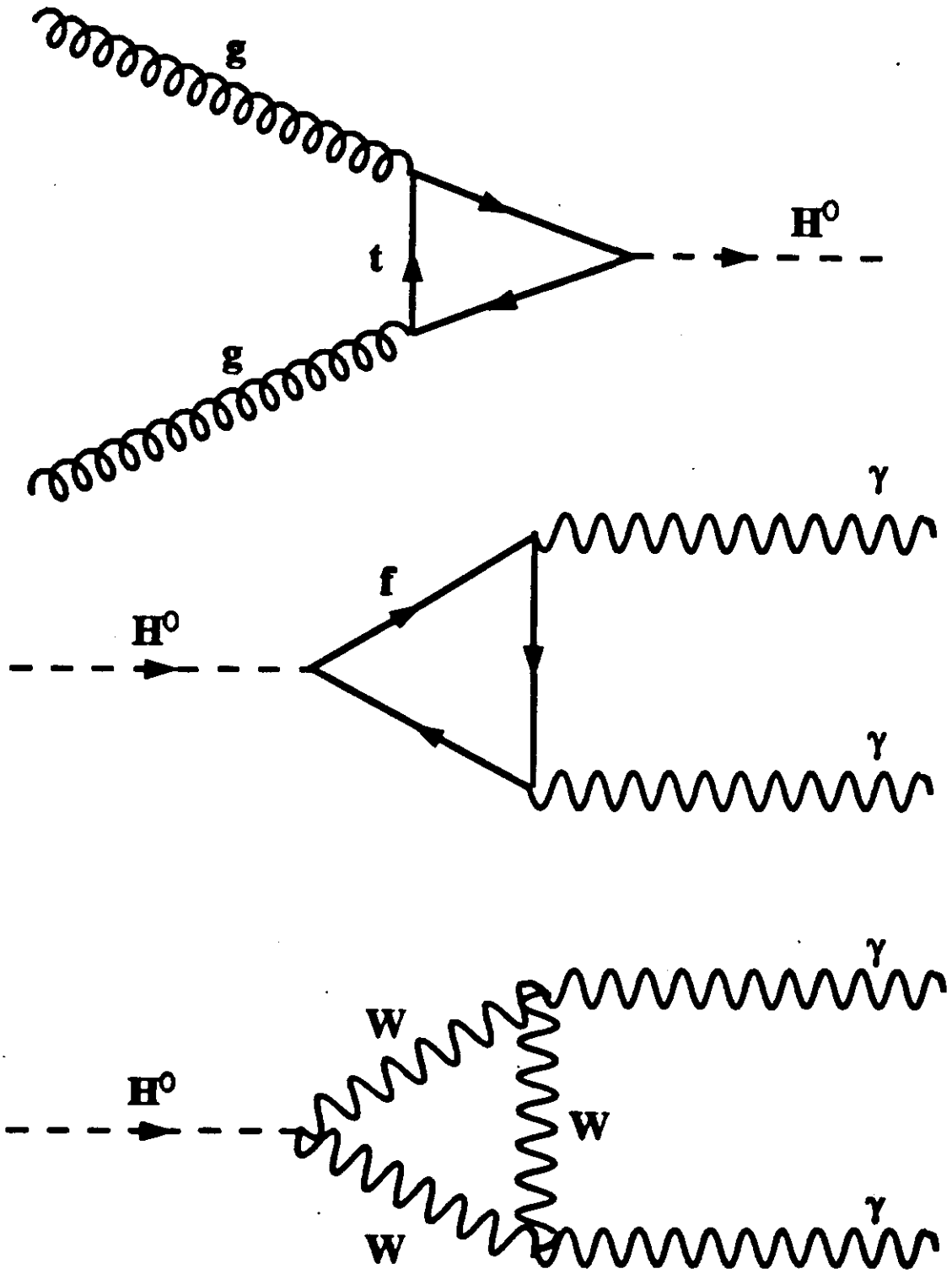
*NOTE: LEVEL I = 18 CM
LEVEL II = 21.8 CM
LEVEL III = 24.5 CM
LEVEL IV = 27.4 CM
(SUBTRACT 5 CM FOR ACTIVE WIDTH)

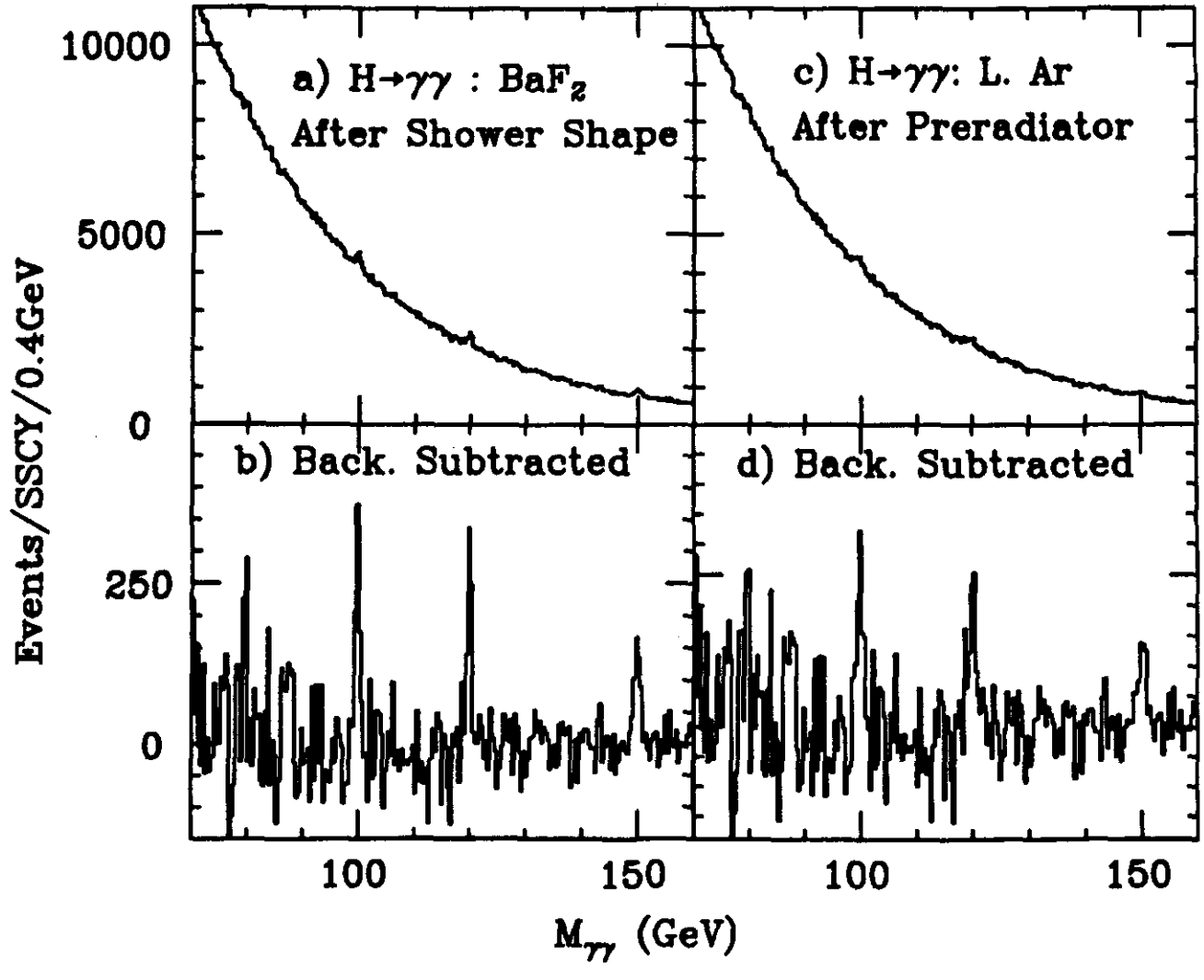
W. EMMET
TALE PPG 22-JAN-19

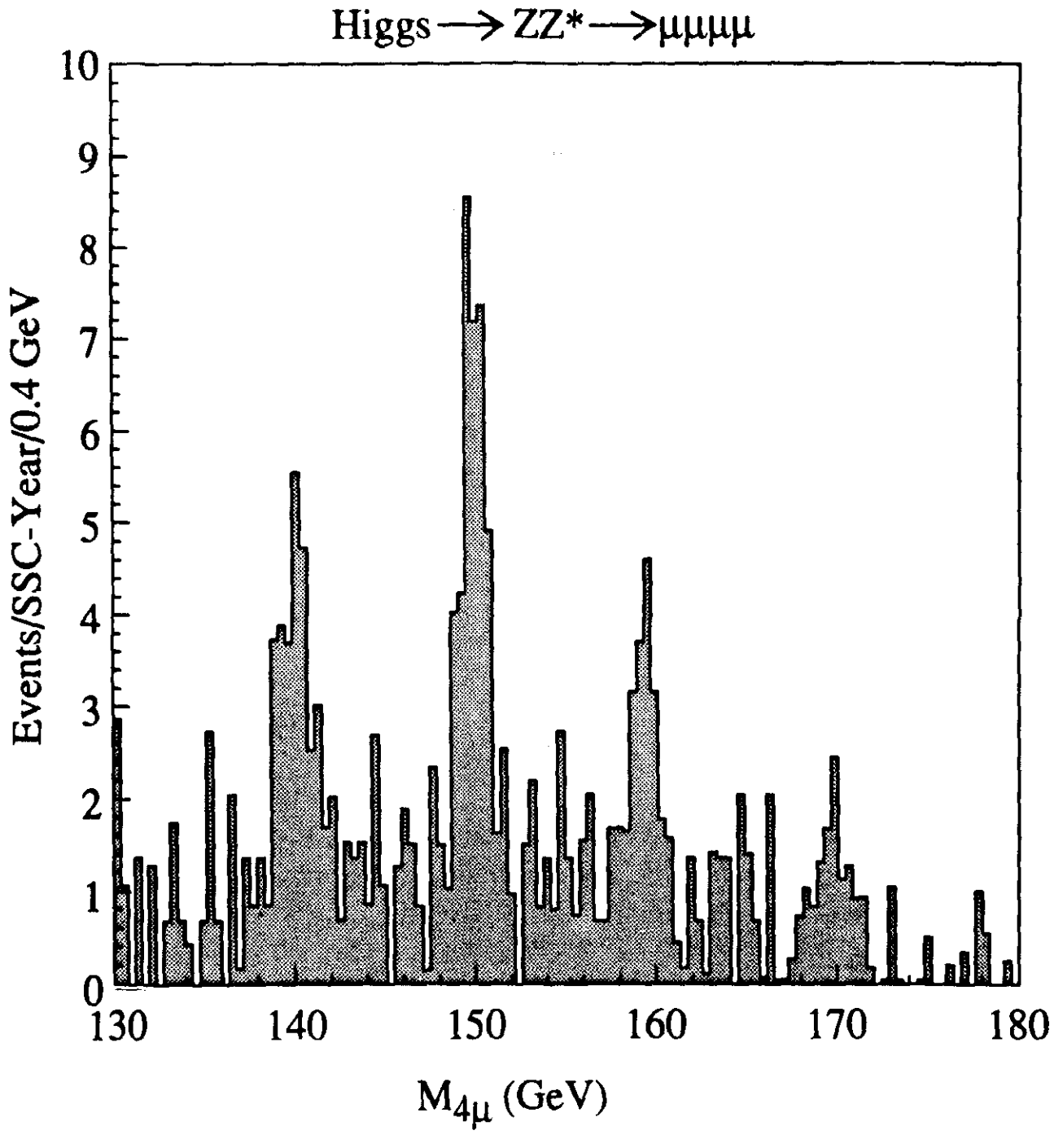
| Physics Processes | Id. Primary Vertex | $e/\gamma$ Separation | $e, \mu, \gamma$ Isolation Cuts | $e/h$ Separation | Muon Momentum Check | $e\pm$ Sign Separation | Secondary Vertex | Low Momentum Track | Full Event Reconstr. |
|---|---|---|---|---|---|---|---|---|---|
| $H^0 \to \gamma + \gamma$ | X | X | X | | | | | | |
| $H^0 \to e^+e^-l^+l^-, e^+e^-\nu\bar{\nu}, e^+e^-$ *jetjet* | X | X | X | X | | X | | | |
| $H^0 \to \mu^+\mu^-l^+l^-, \mu^+\mu^-\nu\bar{\nu}, \mu^+\mu^-$ *jetjet* | X | | X | | X | | | | |
| Gluino Pair Prod $\tilde{g}\tilde{g} \to e^\pm e^\pm, \mu^\pm e^\pm$ | X | X | X | X | X | X | | | |
| Techni eta $\eta_T \to b + \bar{b}$ or $t + \bar{t}$ | X | | X | | | | X | | |
| WW Scattering $W^\pm W^\pm \to e^\pm e^\pm, \mu^\pm e^\pm$ | X | X | X | X | X | X | | | |
| $Z^1 \to e^+e^-$ Asymmetry | X | X | X | X | | X | | | |
| B Physics, e.g. $B \to \Psi$, etc. | X | | | | | | X | X | X |
| Top Physics $t \to W + b$, etc. | X | | X | | | | X | X | X |

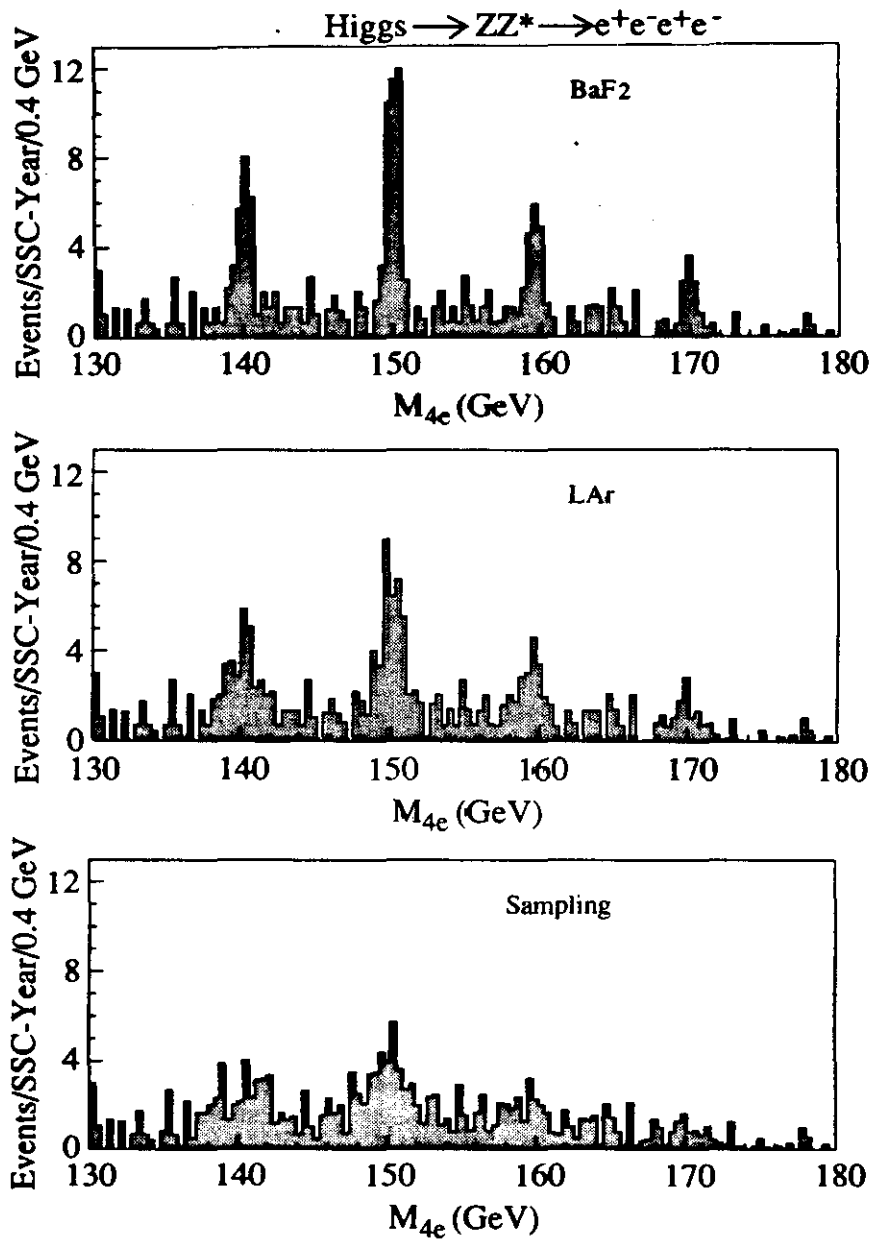
CENTRAL TRACKER PHYSICS STUDIES

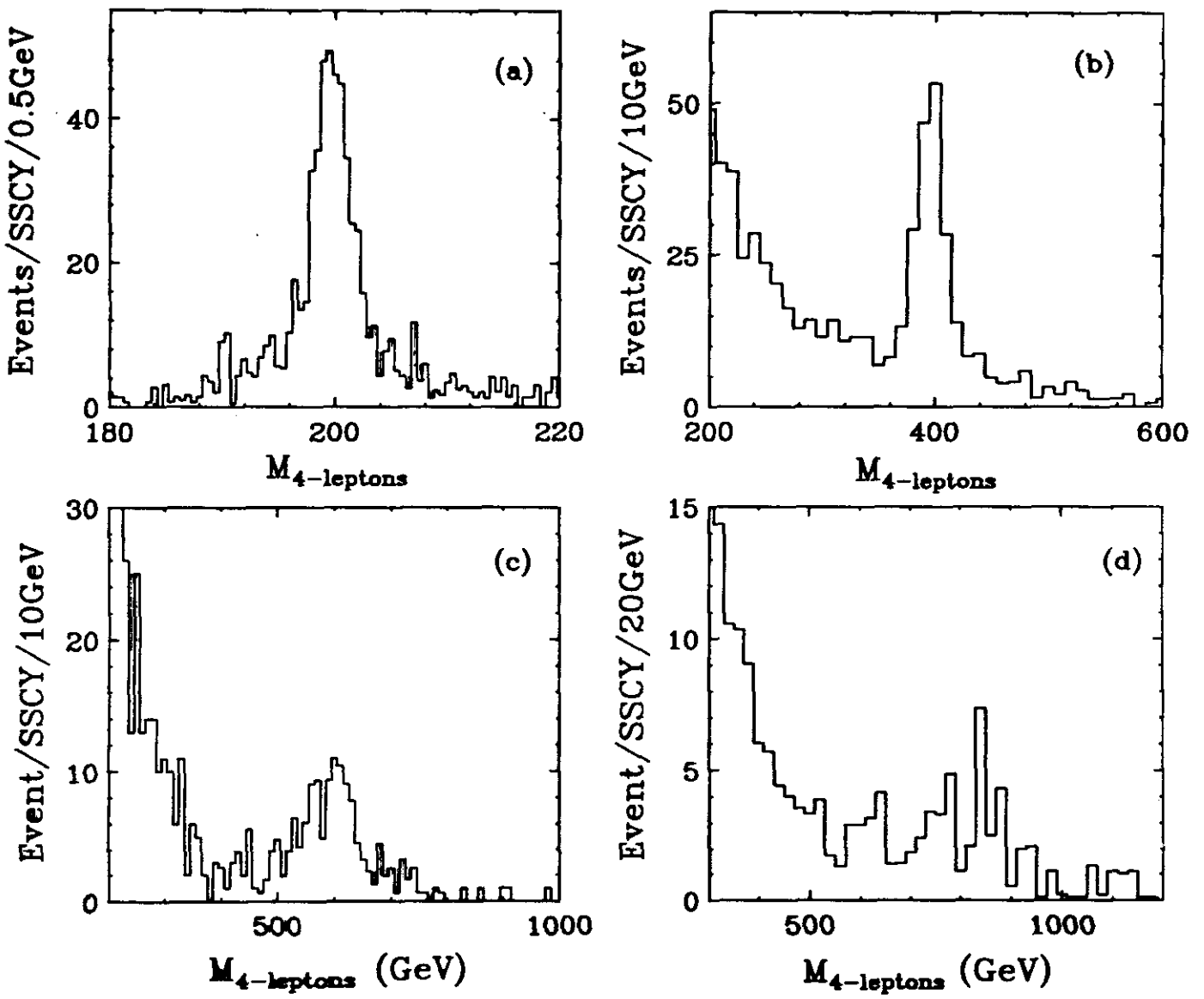

TOTAL MATERIAL IN CENTRAL TRACKER Si + Pads
Fraction of a Radiation Length
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
0°
18°
φ accross one module

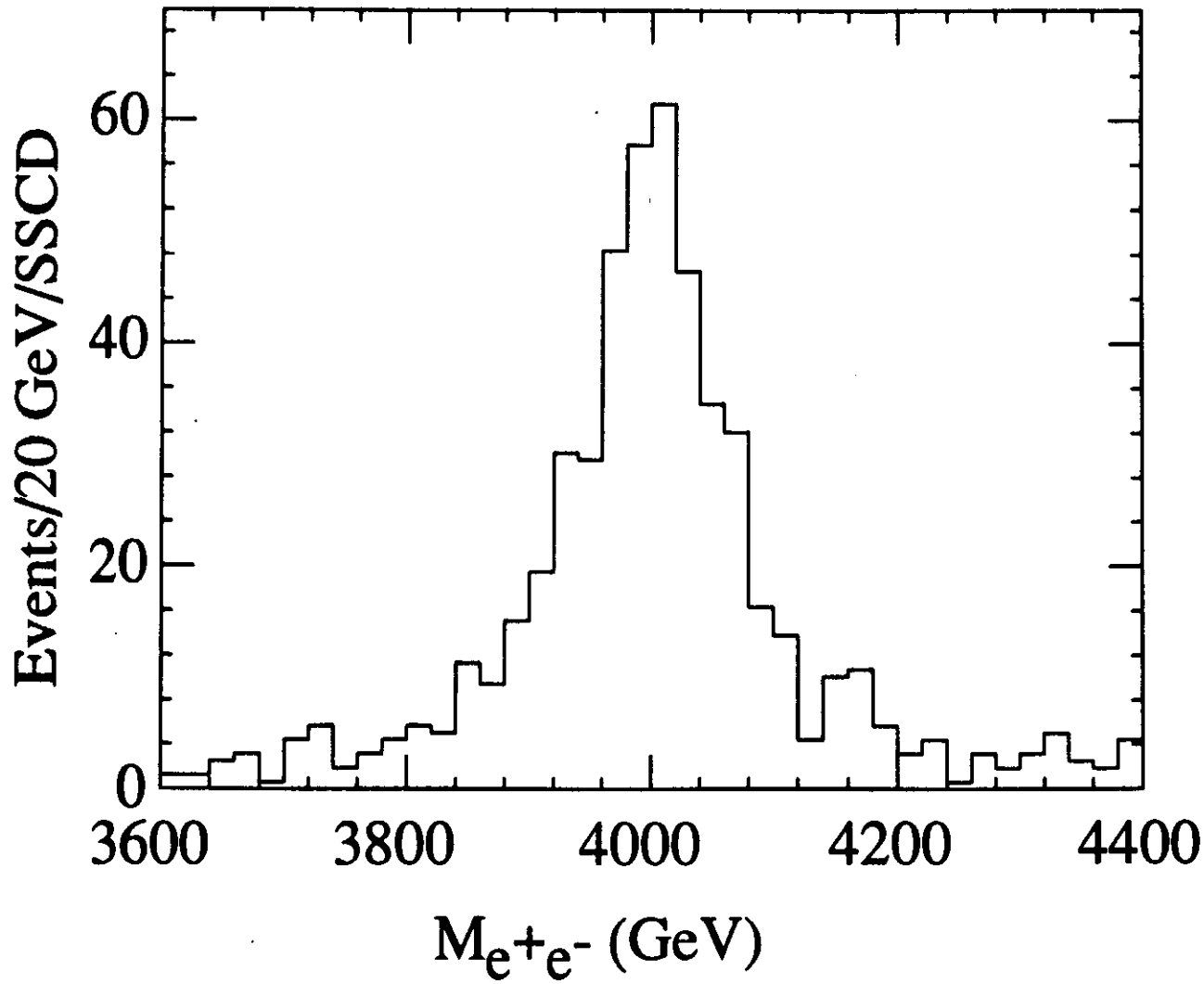

g
t
g
H°
γ
f
H°
γ
γ
W
H°
W
W
γ

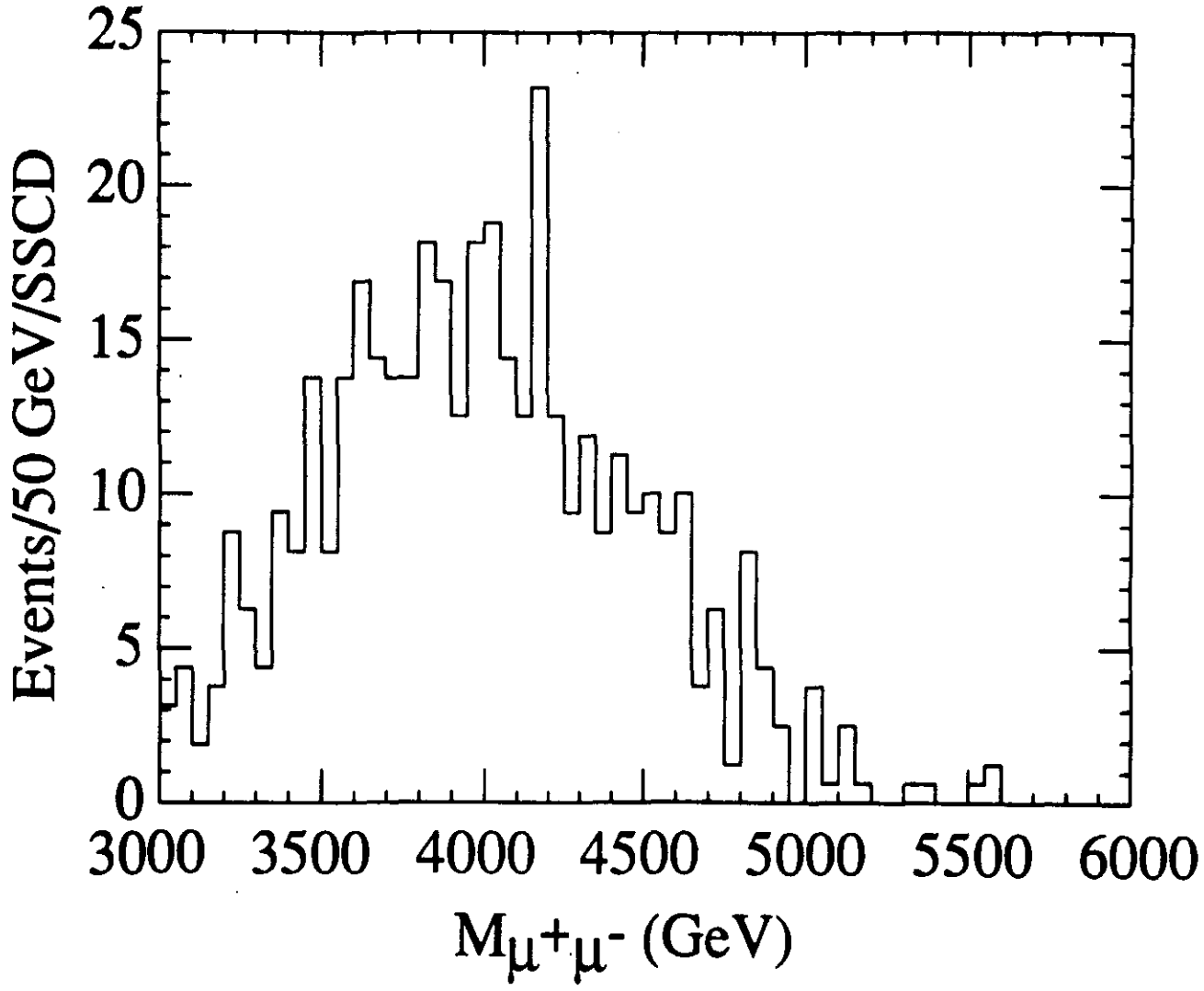

a) H→γγ : BaF2
After Shower Shape
c) H→γγ: L. Ar
After Preradiator
b) Back. Subtracted
d) Back. Subtracted
10000
5000
0
250
0
100
150
100
150
Events/SSCY/0.4GeV
Mγγ (GeV)


Higgs → ZZ* → μμμμ
Events/SSC-Year/0.4 GeV
0
1
2
3
4
5
6
7
8
9
10
130
140
150
160
170
180
M4μ (GeV)

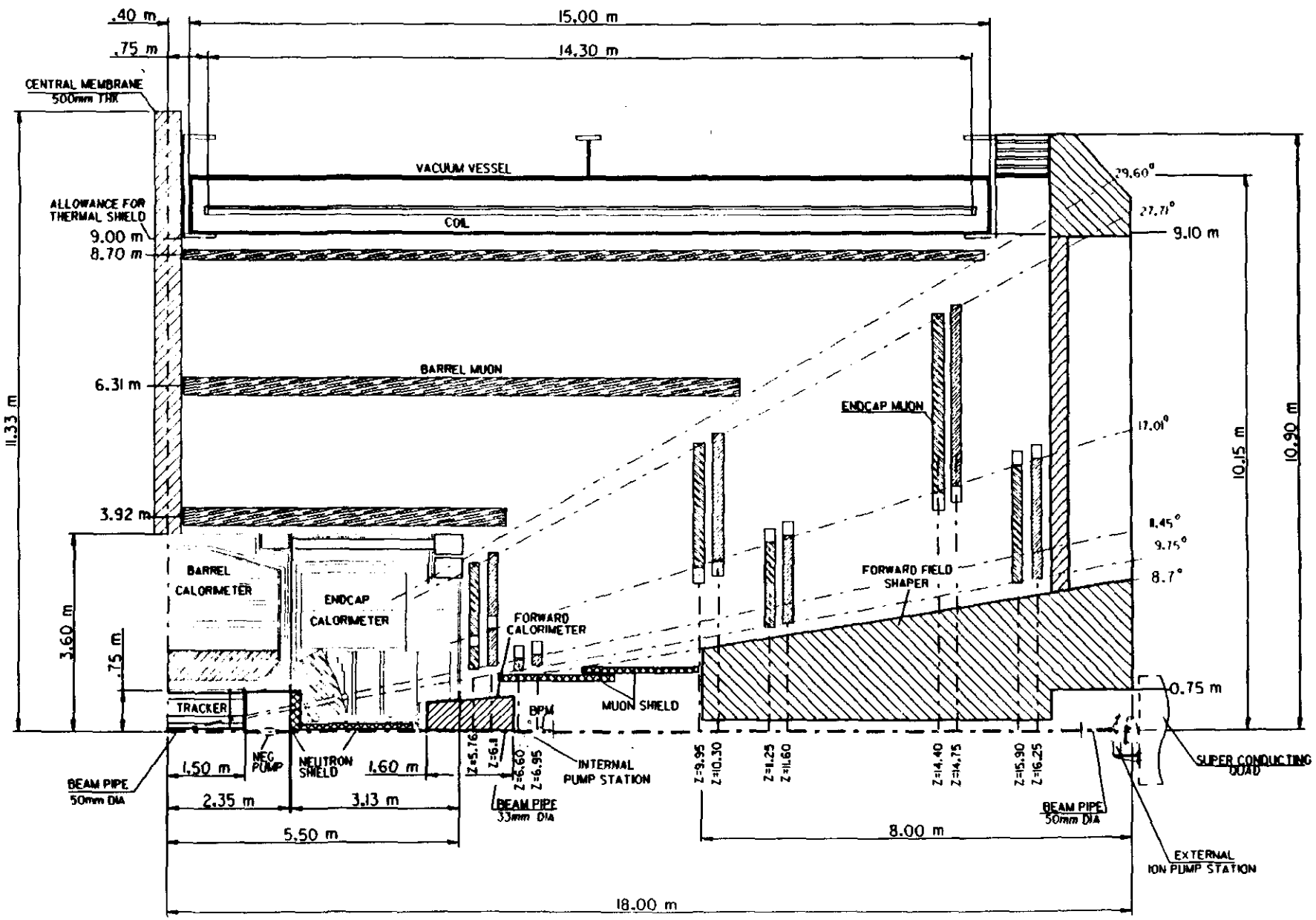

Higgs → ZZ* → e+e-e+e-
BaF2
LAr
Sampling
Events/SSC-Year/0.4 GeV
M4e (GeV)
0
4
8
12
130
140
150
160
170
180

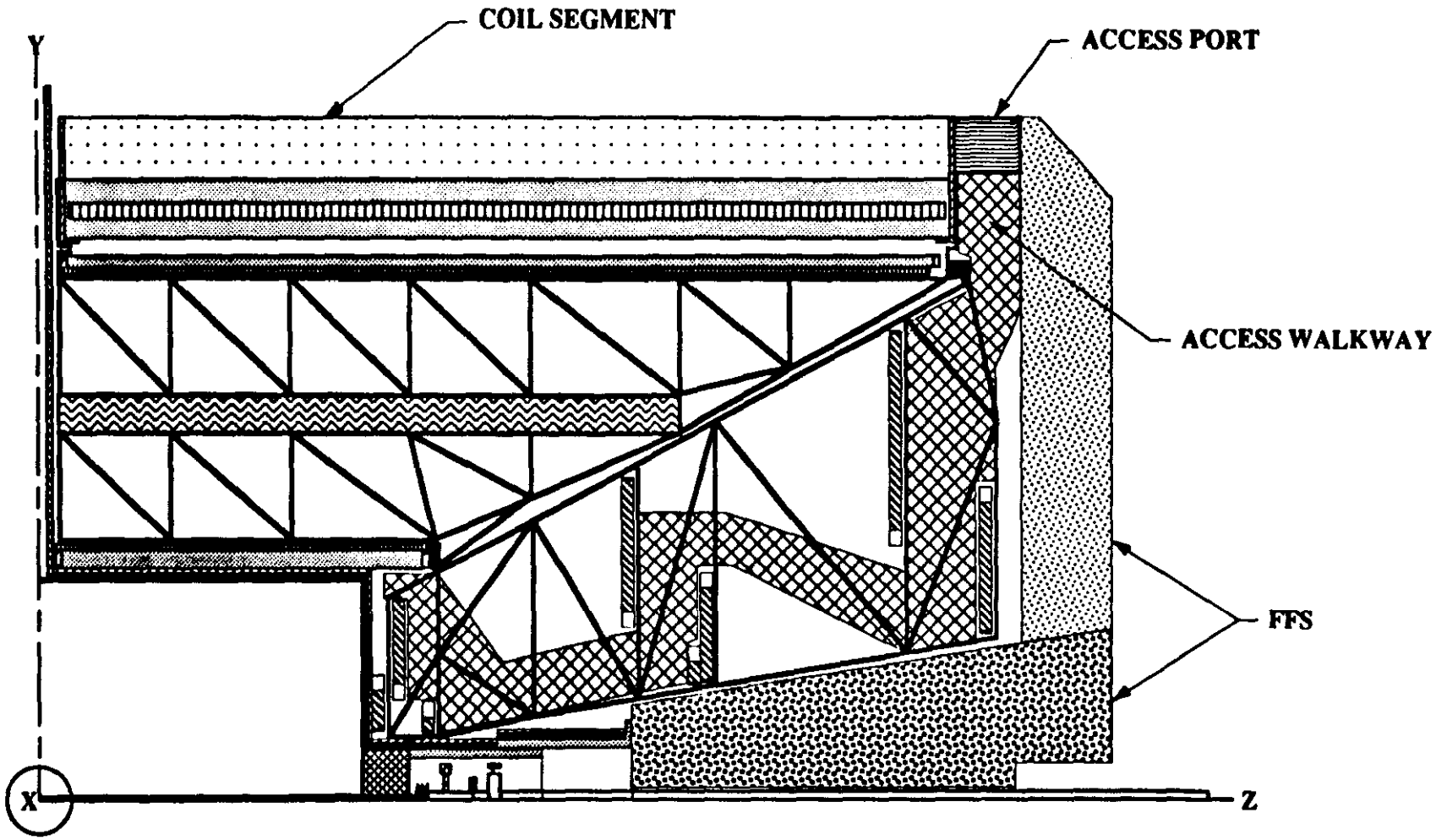

(a)
Events/SSCY/0.5GeV
0
20
40
180
200
220
$M_{4-leptons}$
(b)
Events/SSCY/10GeV
0
25
50
200
400
600
$M_{4-leptons}$
(c)
Event/SSCY/10GeV
0
10
20
30
500
1000
$M_{4-leptons}$ (GeV)
(d)
Event/SSCY/20GeV
0
5
10
15
500
1000
$M_{4-leptons}$ (GeV)


Events/20 GeV/SSCD
60
40
20
0
3600
3800
4000
4200
4400
$M_{e^+e^-}$ (GeV)


Events/50 GeV/SSCD
25
20
15
10
5
0
3000
3500
4000
4500
5000
5500
6000
$M_{\mu^+\mu^-}$ (GeV)

# GEM DETECTOR ELEVATION

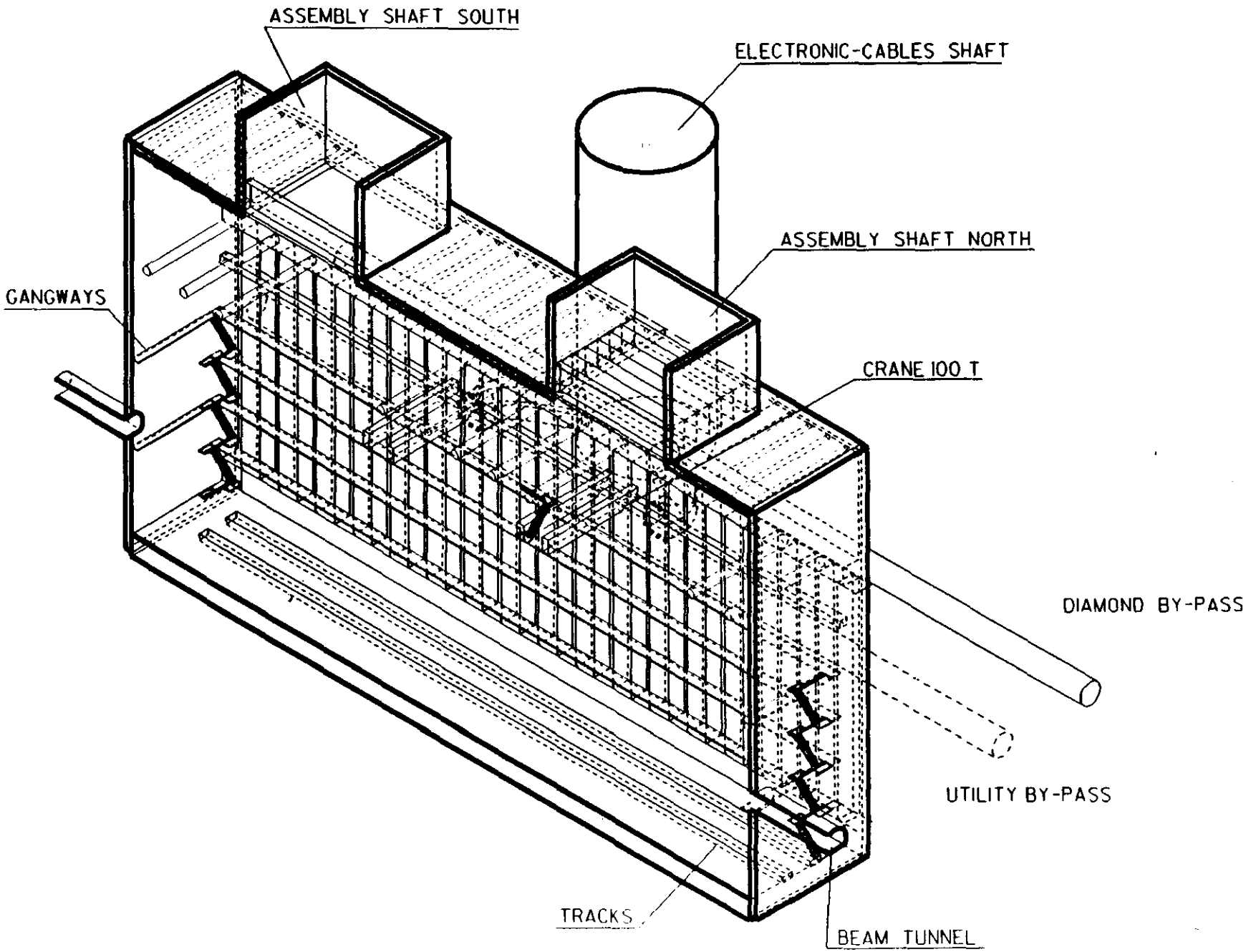


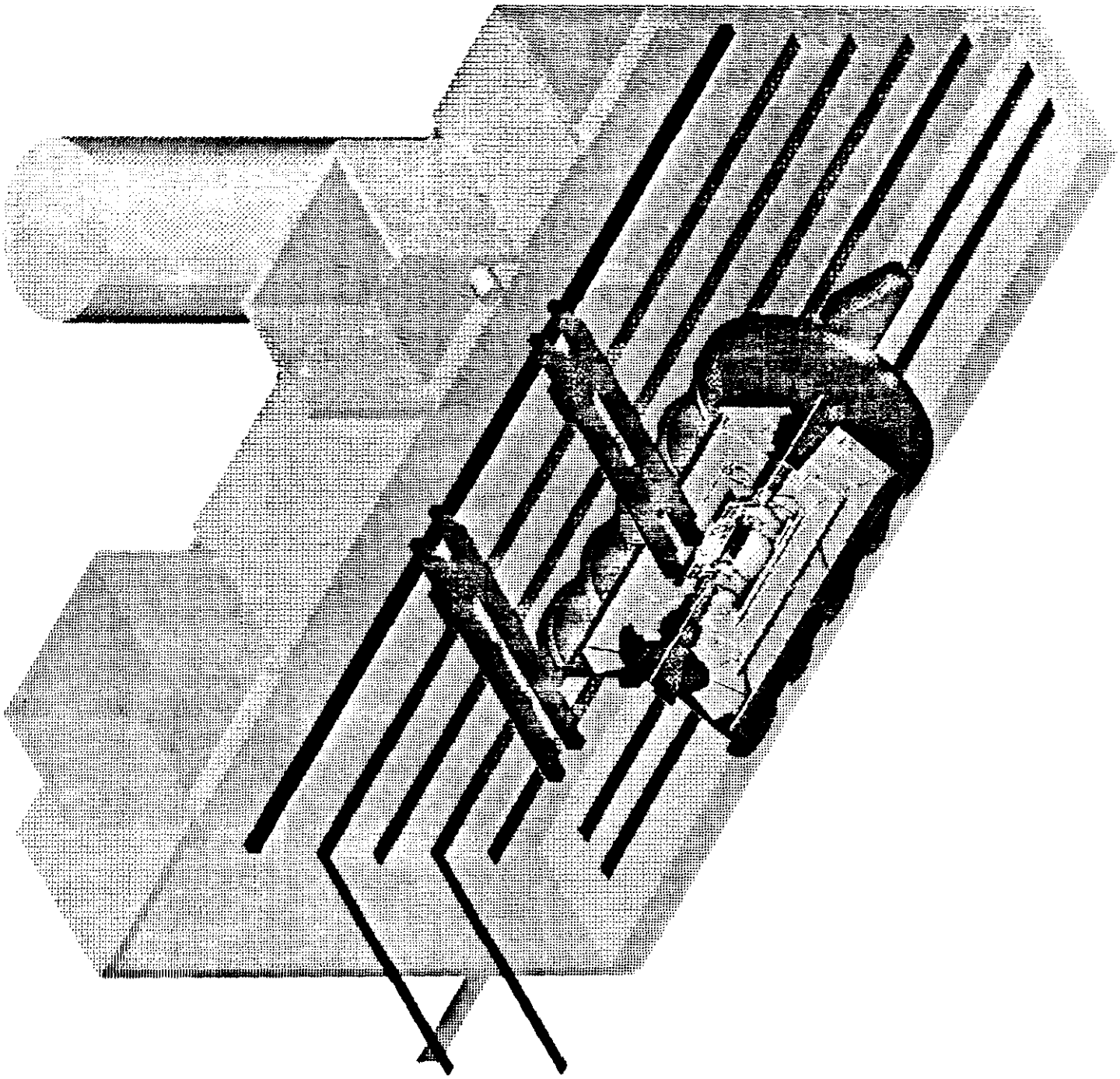



# GEM MUON SYSTEM
## ACCESS WALKWAY ILLUSTRATED
## (PLAN VIEW)

| Draper Laboratory | |
|---|---|
| | |
| Drawn By: F. Nimblett | Rev (-) |
| Dwg. No: | 3/30/92 |
| Approved by: | |

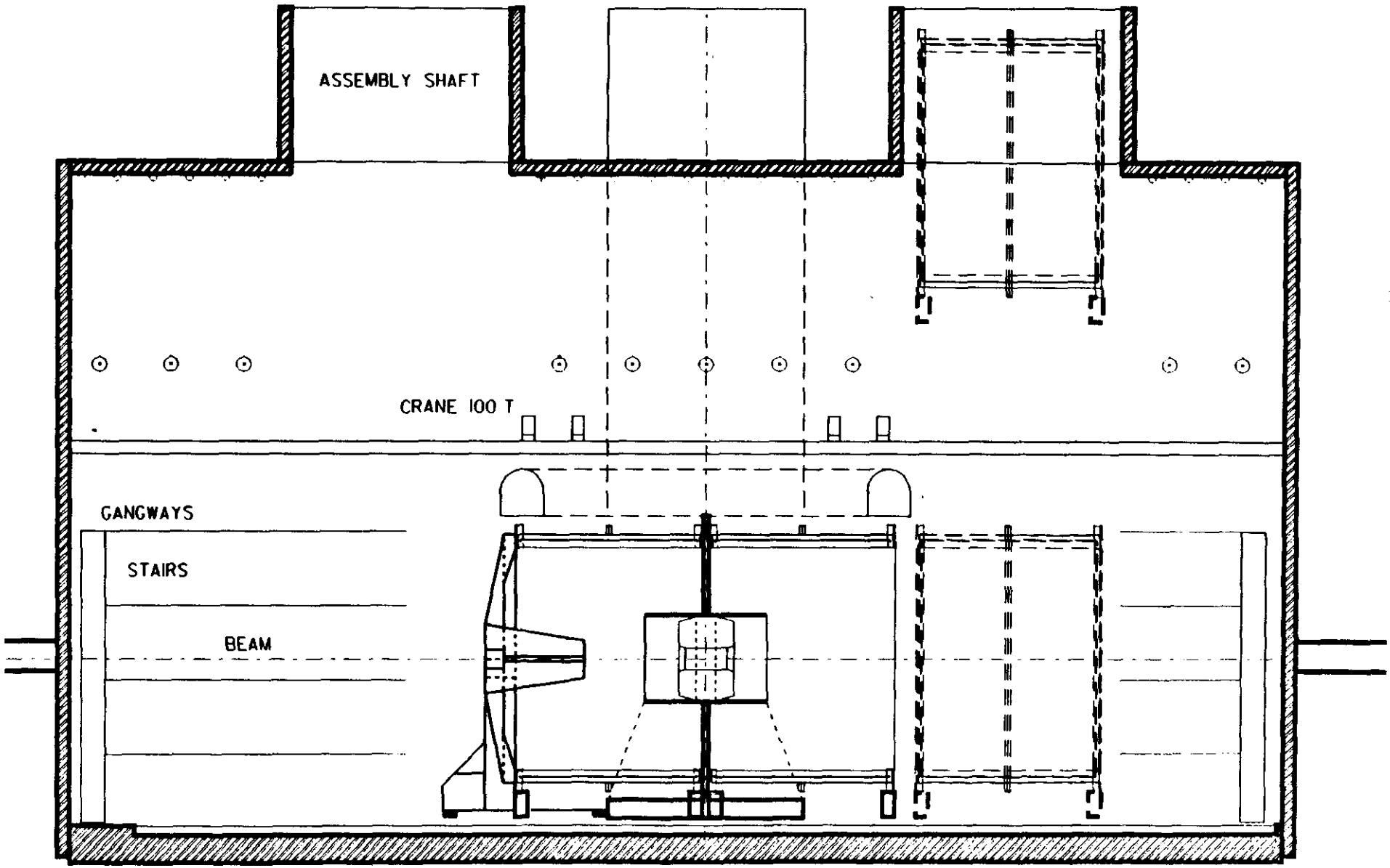
# GEM EXPERIMENTAL HALL





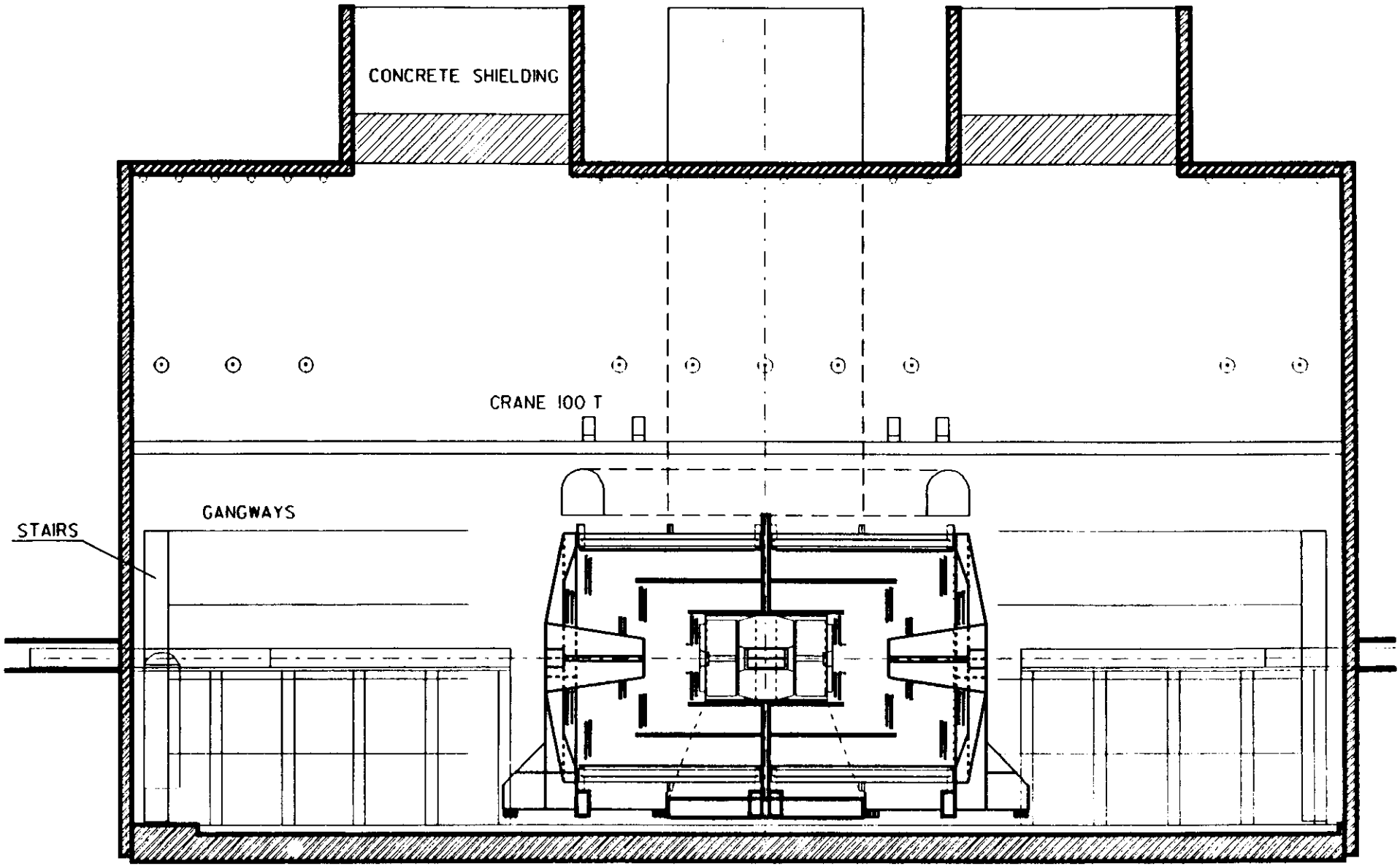
# PHASE 7

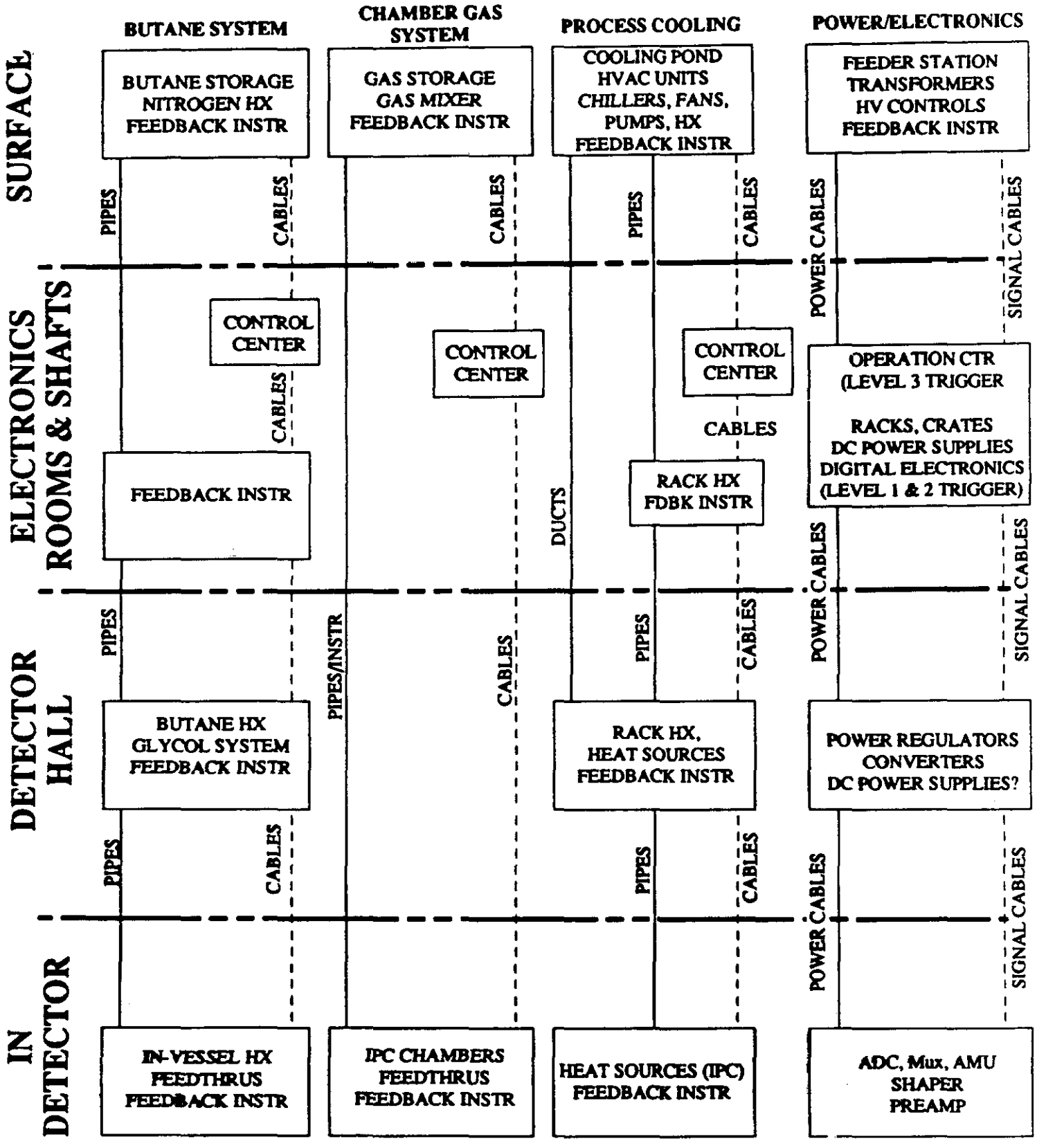
## INSTALL MAGNET HALF COIL _NORTH_ - JUNE 1996



# PHASE 21 -22 - 23

COMPLETE TESTS AND CHECKOUTS - MARCH 1999
COMMISSION COLLIDER - APRIL 1999
DETECTOR READY FOR PHYSICS - OCTOBER 1999






# *GEM* TRACKER SUBSYSTEM UTILITIES LAYOUT

EBERLE 03/30/92

# GEM MILESTONES

| | |
|---|---|
| July 1991 | Expression of Interest |
| Nov 1991 | Letter of Intent |
| Dec 1991 | Approval to proceed to Technical Design Report |
| Apr 1992 | GEM Detector Baseline Established |
| Jul 1992 | Program Advisory Committee review of GEM and GEM Magnet |
| Aug 1992 | GEM magnet contract offered |
| Sept 1992 | GEM Magnet reviewed by DOE |
| Nov 1992 | Technical Design Report review period |