GEM TN-93-267

Physics Simulation Group Meeting - SSCL

January 13, 1993

Abstract:

Agenda, attendees, and presentations of the GEM Physics Simulation Group Meeting held at the SSC Laboratory on January 13, 1993.

Agenda for Physics/Simulation meeting Jan 13/k

1. Status of GEM physics simulations – B. Zhou

2. Status of gamfast – T. Skwarnicki
   – muons – T. Wenaus

3. Status Reports on Chapter 2 sections

   As listed: ~~1 – FE Paige / T. Skwarnicki~~

   2 – Higgs ϕ ~~R.Y. Zhu~~ H Yamamoto

   ~~3 – Top/heavy flavor – Chiaki Yanagisawa~~

   ~~4 – Jet ϕ – Rob Carey~~

   ~~5 – Ultra high $\mathcal{L}$ – Lane, Zhou~~

   6 – $\not{E}_T$ – FE Paige

~~4. Overview – K. Lane~~

5. Other business – Visualization ~~– L. Villasenor~~

   – ~~Muon simulation – T. Wenaus~~

Physics Simulation Meeting 1/13/93

Name	Ins.	Email
HENK Uijterwaal	SSCL	HENK@PDSF.SSC.GOV
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TOMASZ SKWARNICKI	SMU	TOMASZ@SSCVX1
Frank Paige	SSC	paige@SSCVX1.SSC.gov
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Ken McFarlane	SSC	mcfarlan@SSCVX1
Barry Barish	Caltech	Barish@SSCVX1

gem

γeμ

Presentation by:

Bing Zhou

Boston Sub-detector Simulation Meeting Report

Bing Zhou / BU / Jan. 13, 93

- Boston meeting time : Jan. 8-9, 93
- Simulators attending the Boston meeting :

Tomosz	Skwarnicki	(SMU)	--- GEMFAST
Shown	Mckee	(Michigan)	--- Central Tracker
Hong	Ma	(BNL)	--- EM/HCAL (LAr)
Mike	Shupe	(Arizona)	--- F/B Calorimeter
Rob	Carey	(B.U.)	--- TC/FC (jets)
K.	Shmakov	(ORNL)	--- TC/HCAL ($\not{E}_T$)
A.	Savin	(ORNL)	--- TC/HCAL ($\Delta E/E$)
Yu.	Efremenko	(ORNL)	--- TC/HCAL (ΔE_μ)
Henk	Uijterwaal	(SSCL)	--- TR/DAQ
Steve	Ahlen	(B.U.)	--- meeting observer
Ken	Lane	(B.U.)	---- phys. simu. leader
Bing	Zhou	(B.U.)	--- meeting organizer
Jim	Miller	(B.U.)	--- FC
B.	Moore	(Mississipi)	---
Terre	Wenzus	(LLNL)	--- muon (absent due to flu)

Meeting purpose : prepare TDR phys. studies

1> Understand the current detector simulation status

2> Identify the problems

3> Clarify further work responsibilities

Meeting format :

Sub-detector simulation leaders present.

— Detector perfomance assumptions : σ, t, ...

— Simulated Detector geometry set-up

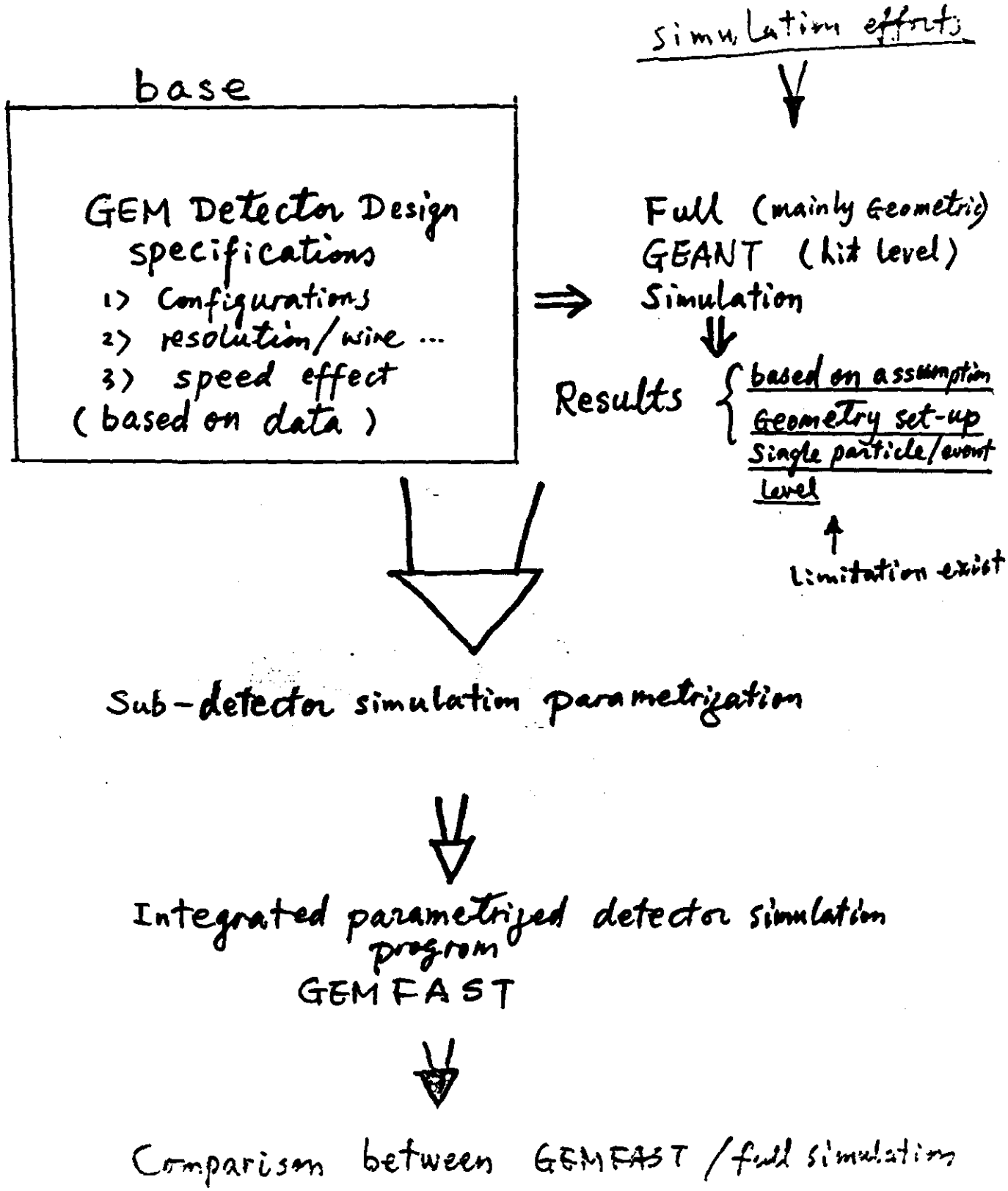
— detailed simulation results

— parametrization → GEMFAST

— output from GEMFAST comparing with full simulation results

Meeting Records :

All transparencies are put together as CDN note


simulation efforts
base
GEM Detector Design specifications
1) Configurations
2) resolution/wire ...
3) speed effect
(based on data)
Full (mainly Geometric)
GEANT (hit level)
Simulation
Results
based on assumption
Geometry set-up
Single particle/event level
Limitation exist
Sub-detector simulation parametrization
Integrated parametrized detector simulation program
GEMFAST
Comparison between GEMFAST/full simulation

Central Tracker Simulation

Assumptions : Silicon Tracker, 10μ/layer (50μ pitch)
Remark : $50\mu/\sqrt{12} = 14.4\mu$
pad chamber, 50μ/layer (30ns int. T)
Remark : 50μ achieved with 200 int. Timing and B-field = 0

GEANT simulation: Complete material Geometry set-up
— good for γ-conversion, δ-rays
— good for acceptance
— Needed for full event simulation

Current full simulation status :

At single particle level ($P_T > 1.0$ GeV)
— $\Delta P_T/P_T$ vs. η (average in φ)
— σ_z, $\delta_{r-\varphi}$ vs. η (average in φ)
— Charge determination for electron / μ vs. η
— photon conversion prob. (to be finish soon)
— track reconstruction efficiency (Geometry only limit)

$\Rightarrow$ All above information would be good for isolated charged particles

Q: What is the criteria of a isolated track?

Limitations (now)
1) Isolated Track ($P_T > 1$ GeV) can use the above info.
2) V_z, $\bar{c}$ is needed $\Rightarrow$ need reconstruction eff. at event level
3) only at 10^{33} Lumi case.

LKr EM Calorimeter Simulation

Assumptions

1) Sampling material LKr / Lead, $25 X_0$, 1.5λ
2) Shaping time 20-40 ns
3) Noise (at 10^{33}) 20-25 MeV/tower
4) $4 X_0$, 4.7 mm strip towers in front of LKr

GEANT simulation: 6 x 6 tower matrix (barrel)
Full structure (endcap)

Current status: $\Delta E/E = 5.6\%/\sqrt{E} + 0.4\%$ (barrel)
$8.5\%/\sqrt{E} + 0.4\%$ (endcap)

pointing: $\left(\frac{40}{\sqrt{E}} + 0.5\right)$ mrad (B)
$\left(\frac{50}{\sqrt{E}} + 0.5\right)$ mrad (endcap)

π^0 rejection: $90 \rightarrow 40$
for E_{π^0} from 10-80 GeV

- parametrization in GEMFAST need to be tuned (E, shower shape) or to be put in: pointing, π^0 rejection

Limits:

- Shower profile infomation in GEMFAST is not accurate
- TeV e/γ energy leakage need to be checked out. ⇒ if leak is large, need add up HCAL energy for e/γ
- electron ID efficiency may not accurate (lower)

HCAL (L.Ar/Cu) Simulation

Assumption:
1) Segment 0.08 x 0.08 ($\Delta\varphi \times \Delta\eta$)
2) Shaping time 50 - 200 ns
3) Noise (10^{33}) 75(1λ) → 135 MeV/tower
5) dynamic range 50 MeV → 5 TeV
6) 4.8 λ; (9 mm Pb / 2 mm LKr)/plat

GEANT simulation:
1) Material put in Geant as plat
→ No transverse tower structure
2) Weighting procedure applied to jet
↓
Single π resolution:
$$\frac{\Delta E}{E} = \frac{51\%}{\sqrt{E}} + 6.8\% \rightarrow (6.3\%)$$
Jet resolution:
$$\Delta E/E = \frac{57.3\%}{\sqrt{E}} + 4.3\% \rightarrow (3.3\%)$$

Current status: in GEMFAST:
1) jet resolution $\frac{60\%}{\sqrt{E}} + 2\%$
2) e/h = 1 (Assuming there is a weighting way to correct it)
3) Longitudinal shower profile need to be tuned to agree to full simu

Limits:
1) No transverse / Longitudinal shower profile
⇒ effect to the isolation cuts ?
2) Jet E, angular resolution need to be understood.

F/B Calorimeter

Assumption

1) Mixture : W/ LAr
2) Cylindrical Module

Full Geant Simulation: with simplified geometry

— Angular resolution dominate
— $\Delta E/E = 100\%/\sqrt{E}$ is ok

Current Status:

- Energy resolution
  Angular resolution $\Rightarrow$ coded in GEMFAST
- pile-up effect need to be workout

Limits:

- only use it for $\not{E}_T$ measurent.
- not for jet analysis

Tail Catching Calorimeter

(or call μ-filter)

ssumption: In front of TC ① 25 X_0 EM
3 seq. L. ← (1.4 mm Pb / 5.7 mm LKr)
② 4.8 λ HCAL
3 seq. L. ← (9 mm Pb / 2 mm LKr)
③ TC
10 Layers: 57 mm Cu / 3.5 mm sc.

EANT Simulation: Simple plat material set up
↓
- $\Delta E/E$ (π, jet)
- ΔE_μ
- $\not{E}_T$

Conclusion:
- for $\Delta E/E$, ΔE_μ no readout is needed !!!
- It is not clear for $\not{E}_T$ case

urrent status: In GEMFAST:
- All hadrons E smearing based on $A\%/\sqrt{E} + B$
- No fluctuation of E leakage in TC
- Very few (TeV) μ will loss large amount of E in TC
  ⇒ effect to the Acceptance for very high μ detection

→ Limit

Suggestions for Physics Simulations

Physics study $\Rightarrow$ find out detector sensitivity

$$J \equiv \frac{N_{signal}}{\sqrt{N_{background}}}$$

- Generator (PYTHIA, ISAJET)

  give signal/background cross sections

  $N_0 = \mathcal{L} \cdot \sigma$

- Detector simulation

  We also need information for simulations

  $N_{Accepted} = N_0 \cdot \underline{\varepsilon_{trigger}} \cdot \underline{\varepsilon_{selection}} \cdot \underline{\varepsilon_{Geom}}$

- <u>GEMFAST used to obtain</u>
  - ε_{Geom}
  - $\varepsilon_{selection}$ (with limitations)

Be careful about the signal/background selection efficiencies for

γ

e

μ

by using GEMFAST

Why?

in e/γ ID :

Transverse / Longitudinal shower profile is a powerful tool, However :

GEM EM CAL:		GEMFAST
3 Longitudinal seg.	$\not\Leftrightarrow$	1 Long. seg.
0.026×0.026 $\Delta\varphi \times \Delta\eta$		3x3 is hard to tuned to be corr.

e/γ ID procedure using GEMFAST will be

1) findout "Isolated" EM bumps
2) apply the HCAL Veto
3) Apply $\pi^0/\pi^\pm$ rejection (as function of E)
   { signal eff. for certain rejection is needed
   { background rejection cuts should be optimized

$\Rightarrow$ Now existing a curve for π^0 rejection, but one must pay the price of signal efficiency of <u>90%</u> $\Rightarrow$ for 4e case ε_{signal} for ID only can be 64% !!

$\Rightarrow$ different physics process may require dif. rejection power

$\Rightarrow$ tuning the cuts is not easy in GEMFAST

μ - ID

→ find tracks in μ-chamber

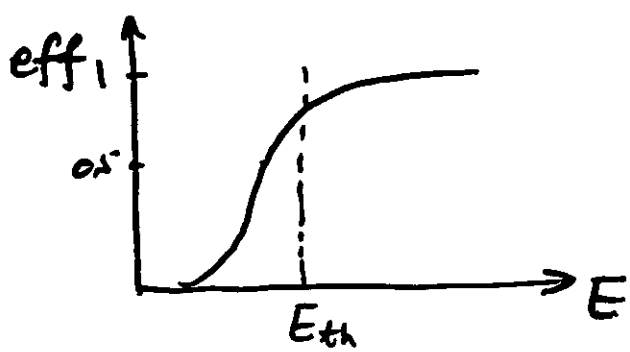
→ trace the tracks into vertex
cut on tracks far from vertex

→ P_μ vs. P_{CT} (comparison)

But it is not clear the vertex reconstruction in GEMFAST

<u>Trigger issue :</u>

We need trigger threshould curves



vs. η

both for μ, e, γ for different final state ; 1μ, 2μ, 4μ, $1e$, $2e$, $4e$, 2γ, ...

gem

γeμ

Presentation by:

Tomasz Skwarnicki

TOMASZ SKWARNICKI / SMU
Jan 13, 93

gemfast
PROGRESS REPORT

very significant improvements in the simulation code:

- momentum-charge and impact parameter resolutions in CT — Shawn McKee, Melynda Bu
- gflash for shower development in the central region calorimeters — Tomasz S., Hong Ma
- momentum resolution and ~~reconstruction~~ geometrical efficiency in MU — Torre Wenaus
- new energy loss for muons — Peter Dingus
- Baseline-II FC resolution tables — Mike Shupe
- Trigger code — Henk Uijterwaal

previously announced improvements relatively to Baseline-I version:

- new approach to geometrical acceptance in CT (# of intersected layers) — Tomasz S., Shawn McKee
- naive primary vertex reconstruction code — Tomasz S.
- realistic segmentation in endcap calorimeter — Tomasz S.

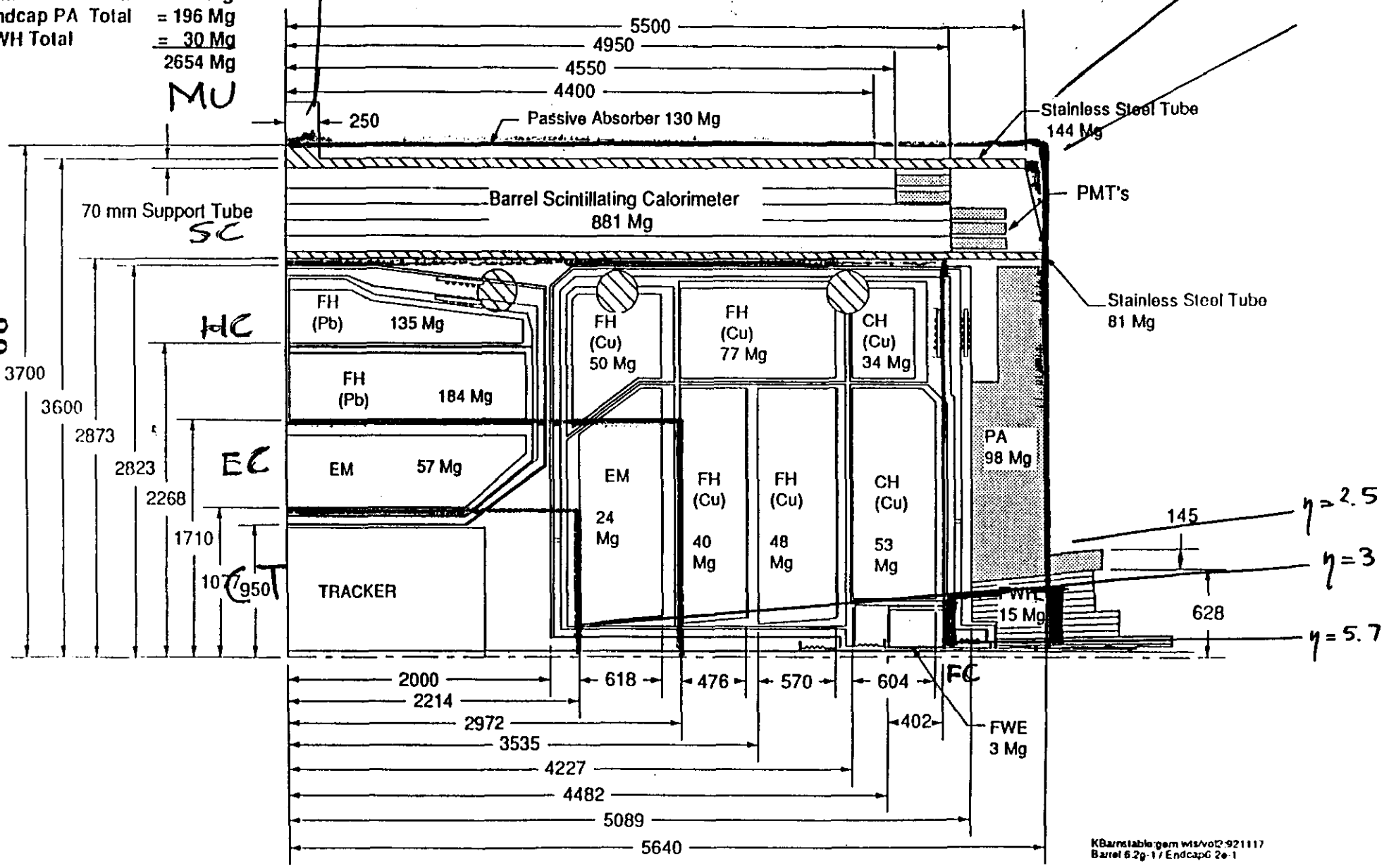
work is not completed yet but we had very productive meeting in Boston last week

GEM Calorimeter

	Weight	Volume
Barrel Calorimeter	= 433 Mg	24135 L. LKr
2 Endcap Total	= 759 Mg	38475 L. LAr
Scint. Cal. & St. St.	= 1236 Mg	
2 Endcap PA Total	= 196 Mg	
2 FWH Total	= 30 Mg	
	2654 Mg	

MU

gaps in MU acceptance



KBarrstable:gem wts/vol2:921117
Barrel 6.2g-1 / Endcap6 2e-1

Status of CT

- New parametrization approach to CT single particle resolution parameters
  - Melynda Brooks – GEANT simulation results
  - Shawn McKee – parametrization algorithms and code

- electrons are done now separately due to the effects of Bremmstrahlung
  (Bremmstrahlung γ's not explicitely generated)
- right correlations between measured momentum and charge
- better interpolation code
  (right high momentum limit, parametrizations may be unstable below $P_t = 1$ GeV)
- latest Baseline-II design

PICTURES

- Geometrical acceptance
  - # of intersected layers ICLCT in fsi-fascom.inc
    - FSI-CTSLAY
      - Tomasz S. – algorithm
      - Shawn McKee – geometry

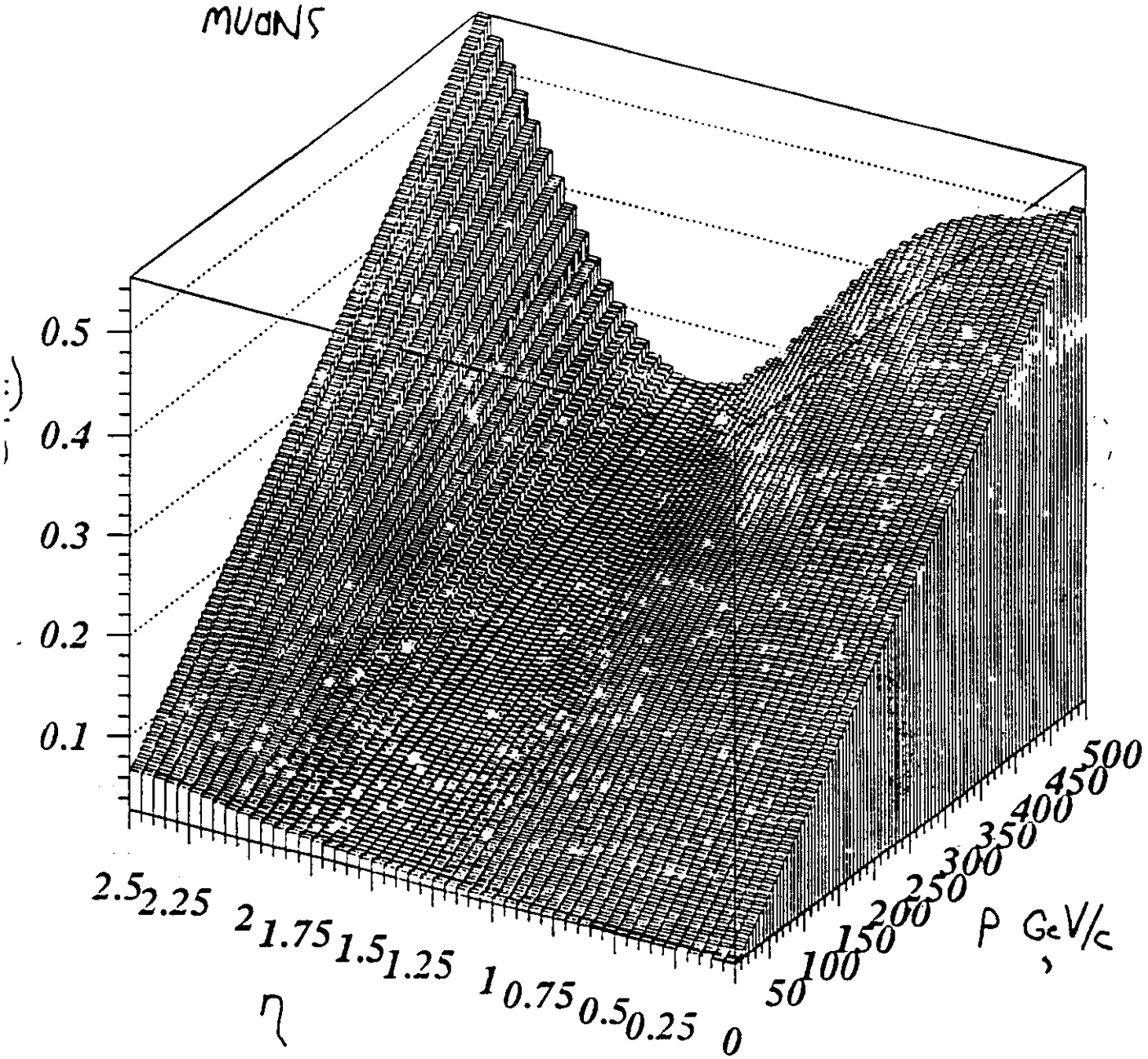
PICTURES

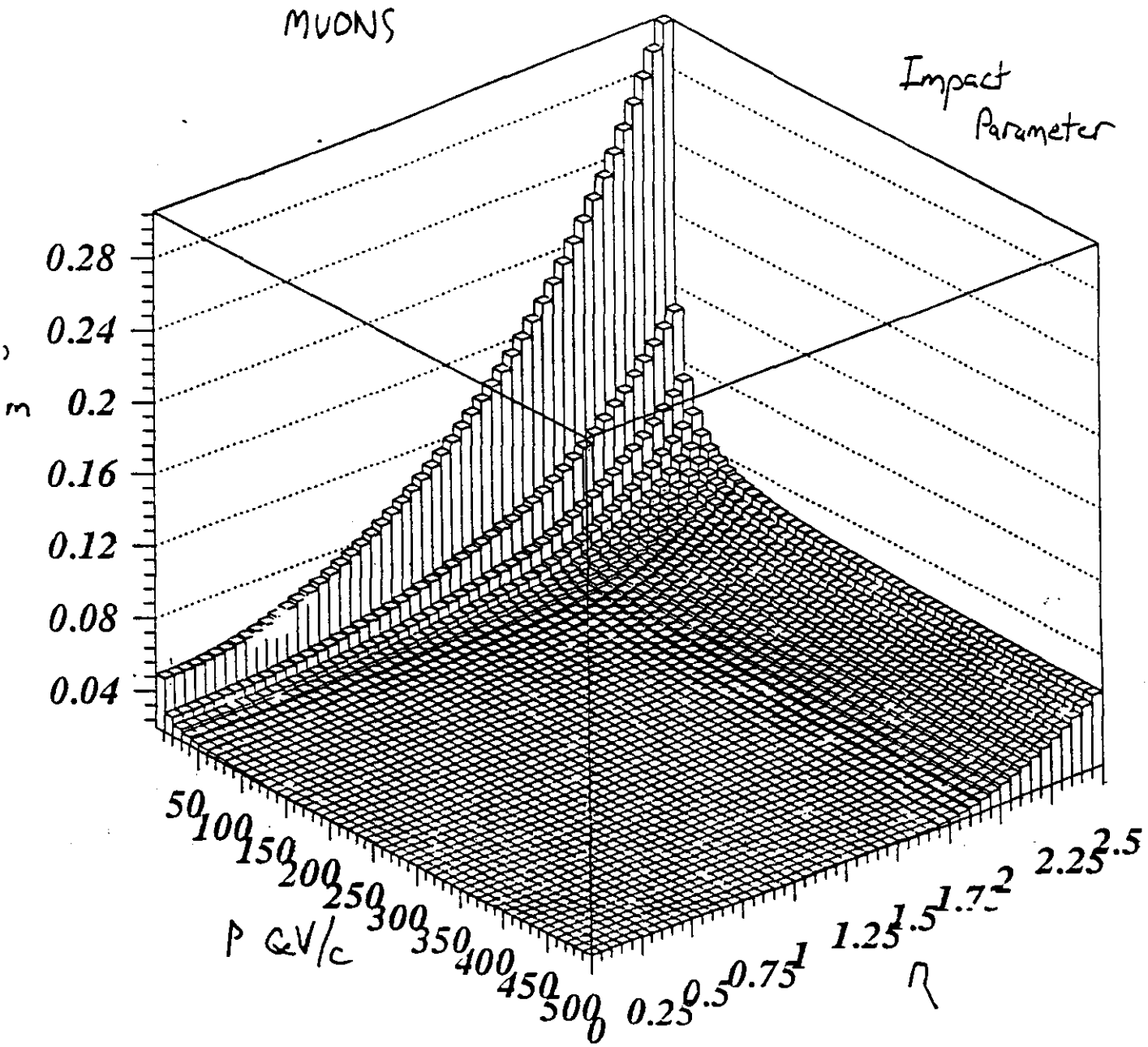
- geometrical reconstruction efficiency EFFCT in fsi-fascom.inc

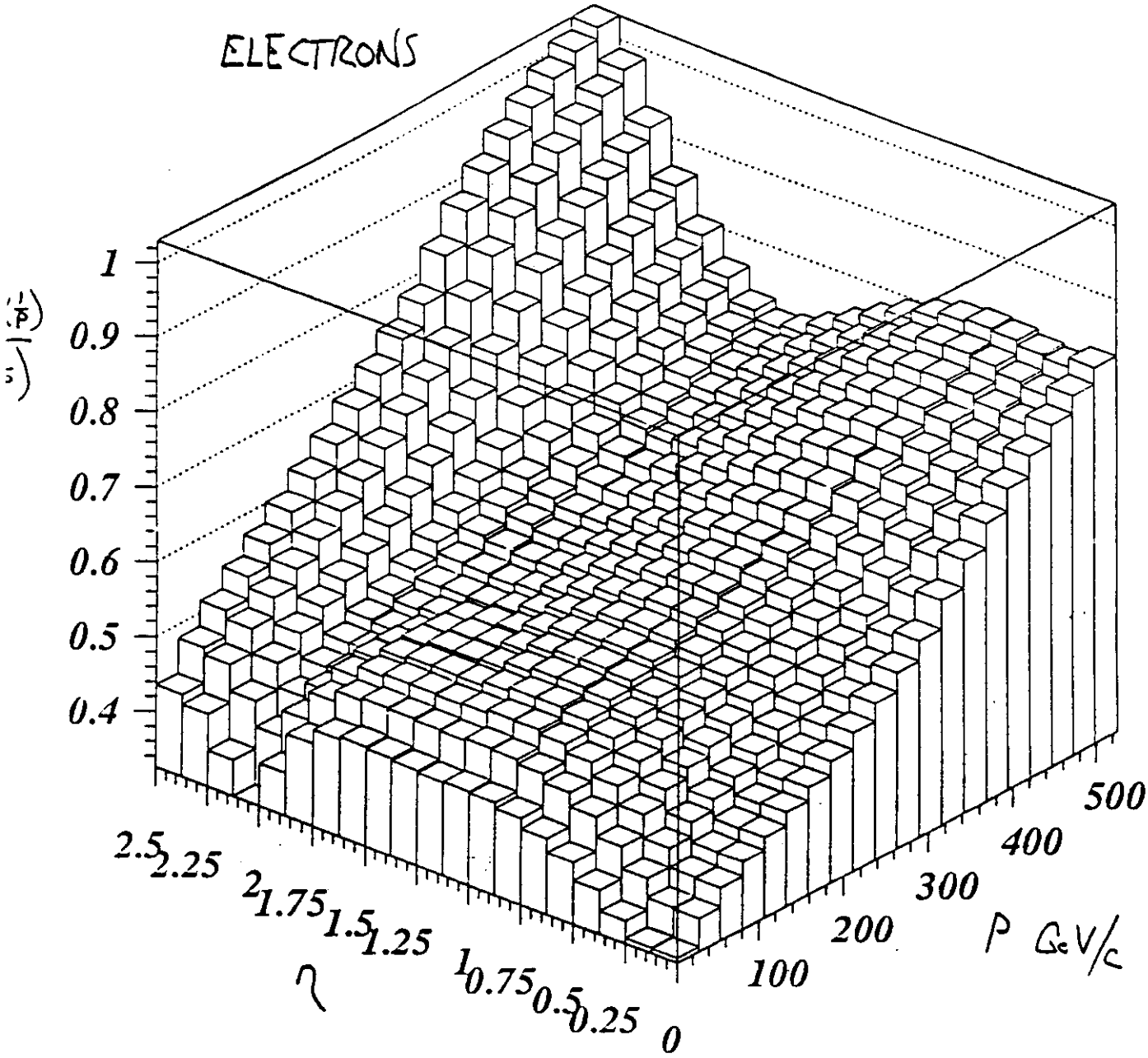
FSI-CTRECON Shawn, Melynda

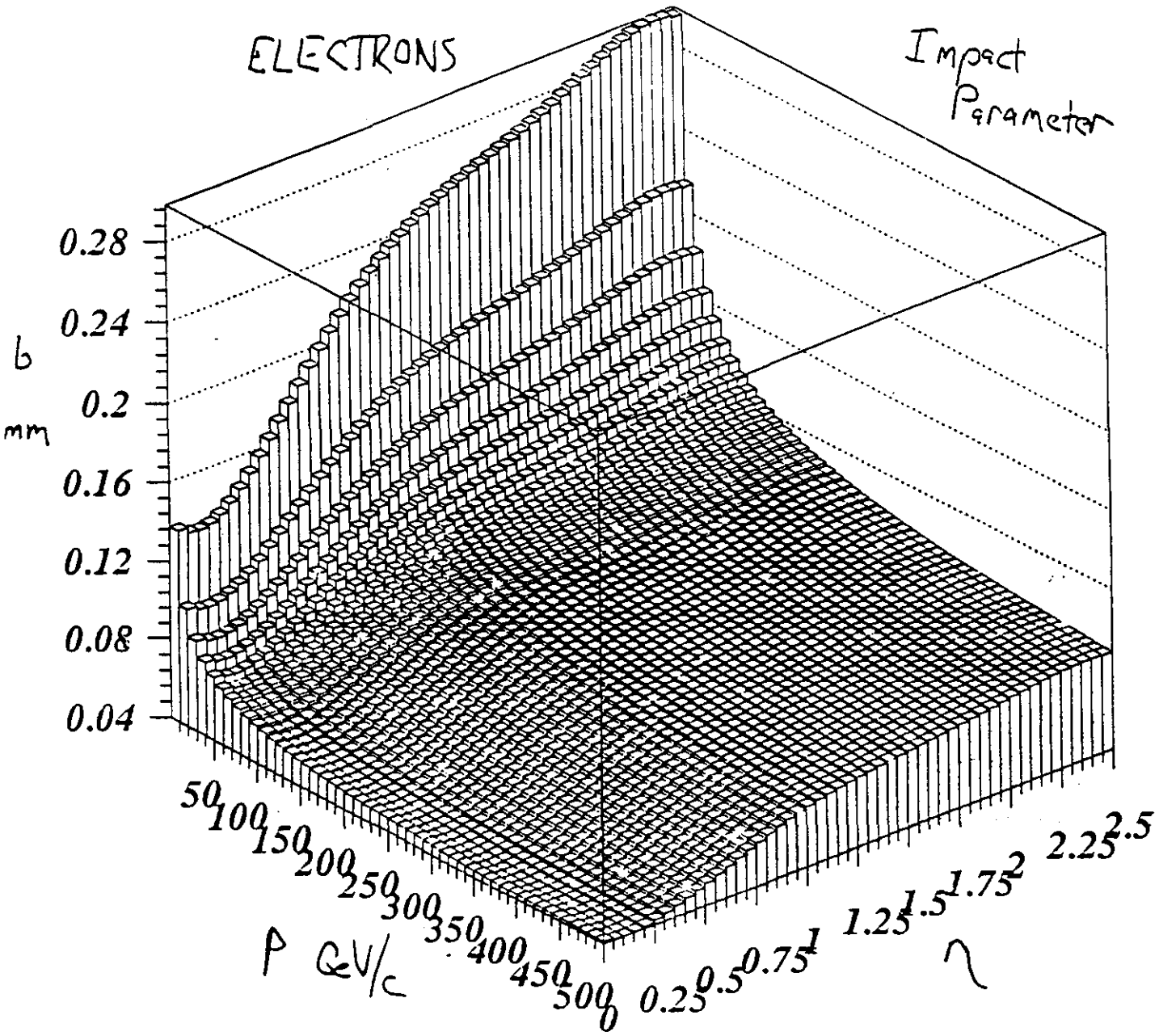
PICTURE

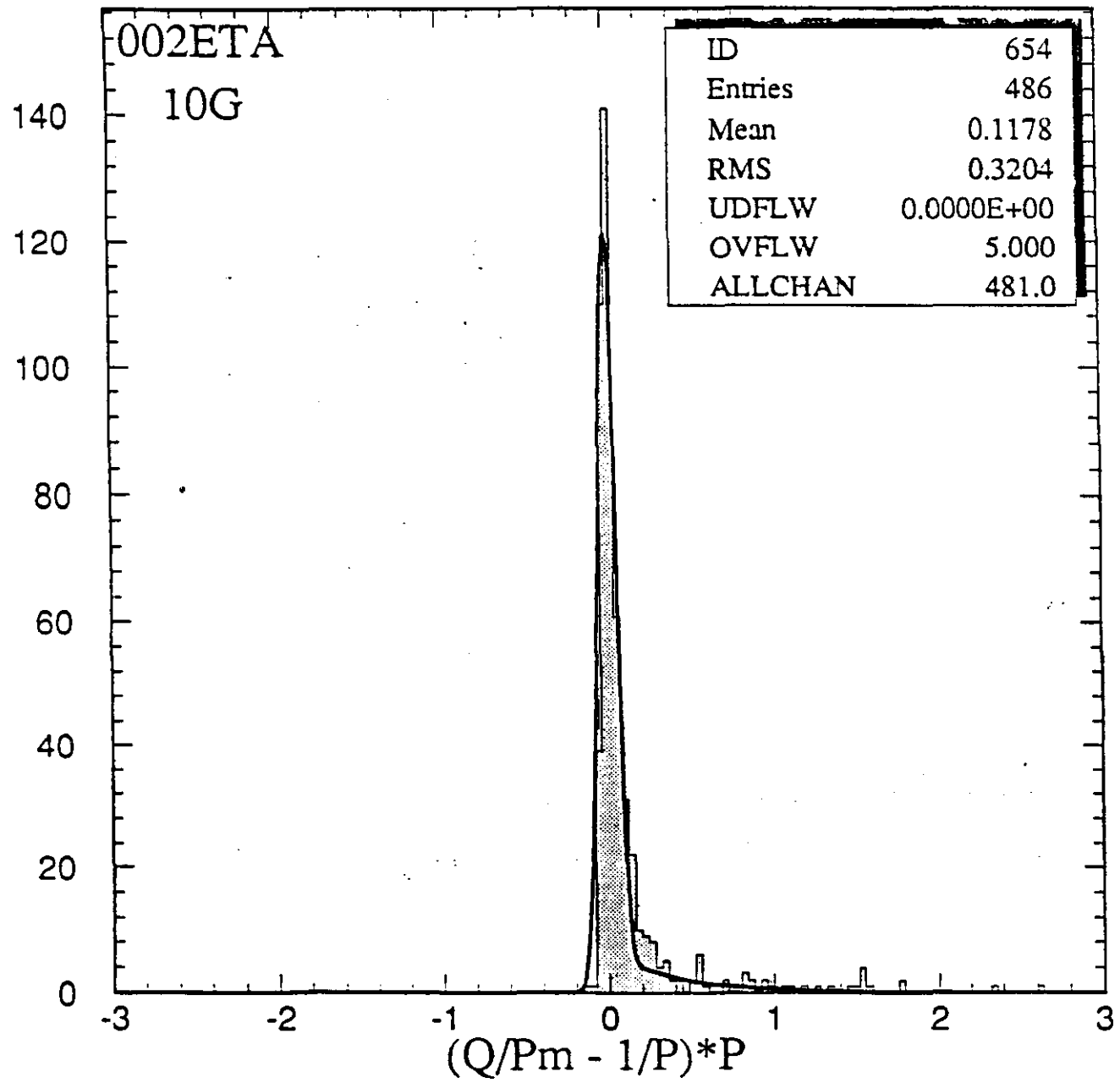
(at the moment EFFCT is redundent with ICLCT and does not know about actual particle vertex

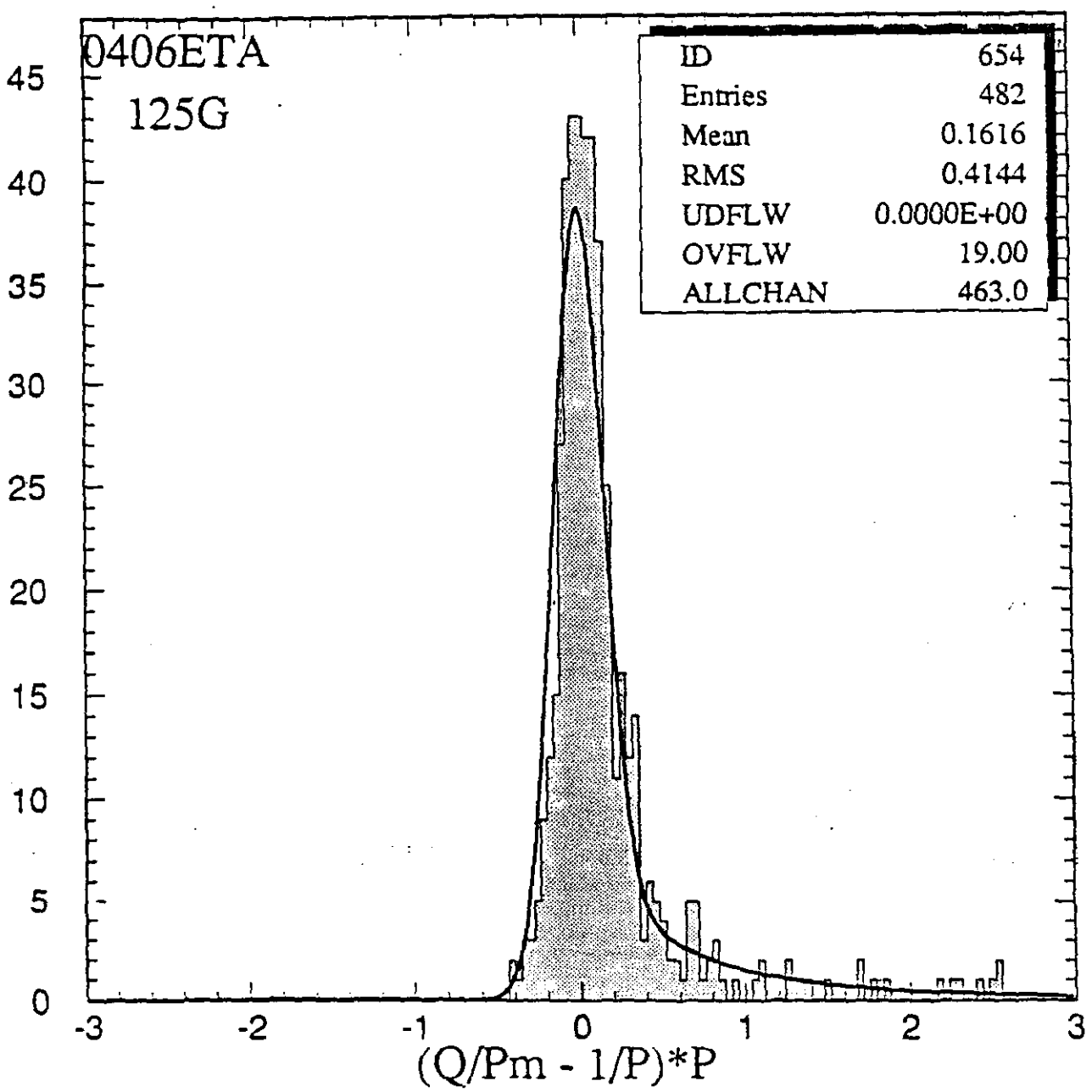

MUONS
0.5
0.4
0.3
0.2
0.1
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
η
50
100
150
200
250
300
350
400
450
500
P GeV/c

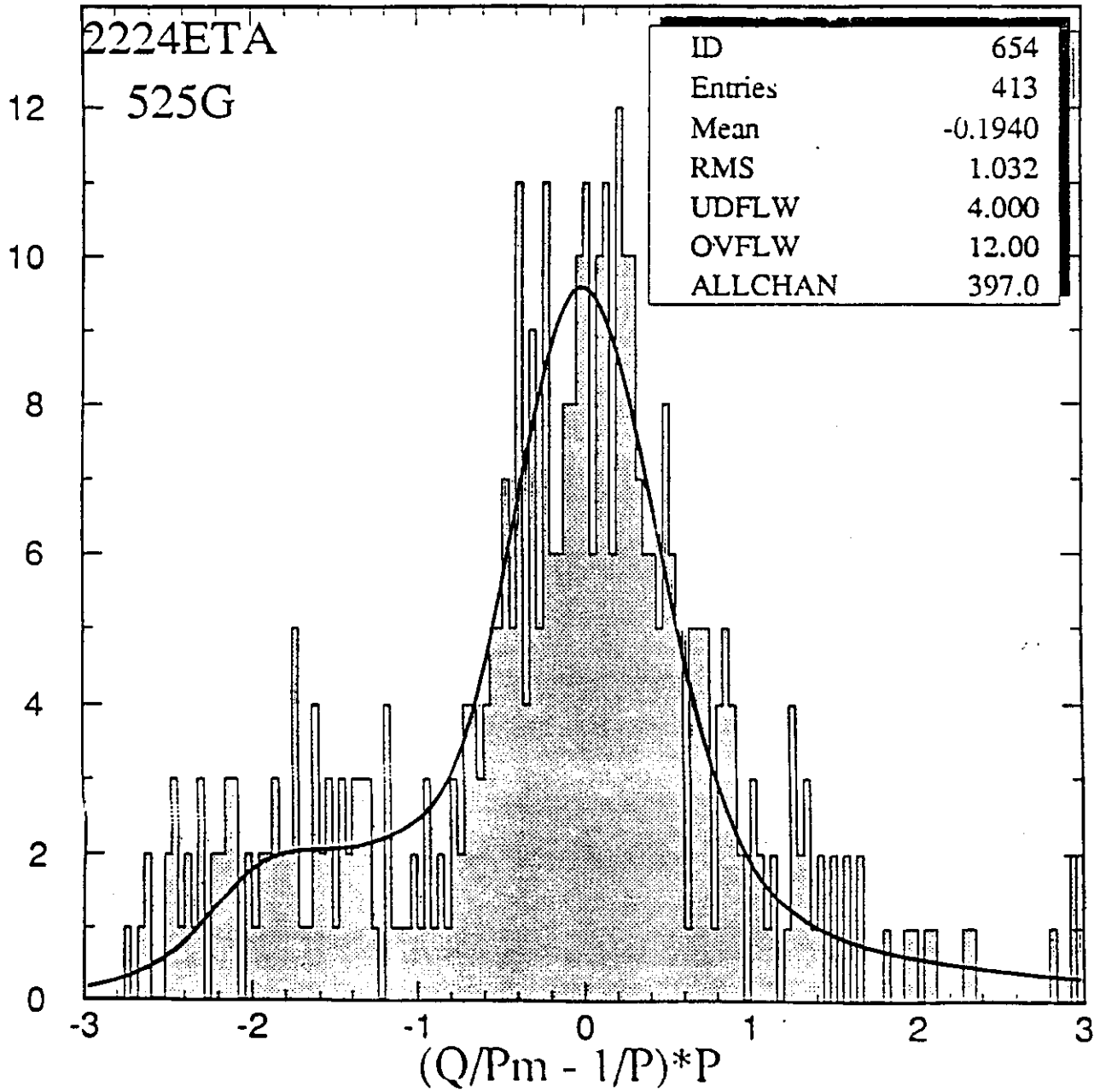

MUONS
Impact Parameter
0.28
0.24
0.2
0.16
0.12
0.08
0.04
50
100
150
200
250
300
350
400
450
500
P GeV/c
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
R


ELECTRONS
1
0.9
0.8
0.7
0.6
0.5
0.4
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
η
100
200
300
400
500
P GeV/c


ELECTRONS
Impact Parameter
b
mm
0.28
0.24
0.2
0.16
0.12
0.08
0.04
50
100
150
200
250
300
350
400
450
500
P GeV/c
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
η


002ETA
10G
ID 654
Entries 486
Mean 0.1178
RMS 0.3204
UDFLW 0.0000E+00
OVFLW 5.000
ALLCHAN 481.0
140
120
100
80
60
40
20
0
-3
-2
-1
0
1
2
3
(Q/Pm - 1/P)*P


0406ETA
125G
ID 654
Entries 482
Mean 0.1616
RMS 0.4144
UDFLW 0.0000E+00
OVFLW 19.00
ALLCHAN 463.0
45
40
35
30
25
20
15
10
5
0
-3
-2
-1
0
1
2
3
(Q/Pm - 1/P)*P


2224ETA
525G
ID 654
Entries 413
Mean -0.1940
RMS 1.032
UDFLW 4.000
OVFLW 12.00
ALLCHAN 397.0
0
2
4
6
8
10
12
-3
-2
-1
0
1
2
3
(Q/Pm - 1/P)*P

fsi-ctslay.f

written by Tomose S.
geometry coded by
Shawn McKee

ICLCT = # of Si layers hit + 100 × # of IPC layers hit
negative if not from IP region

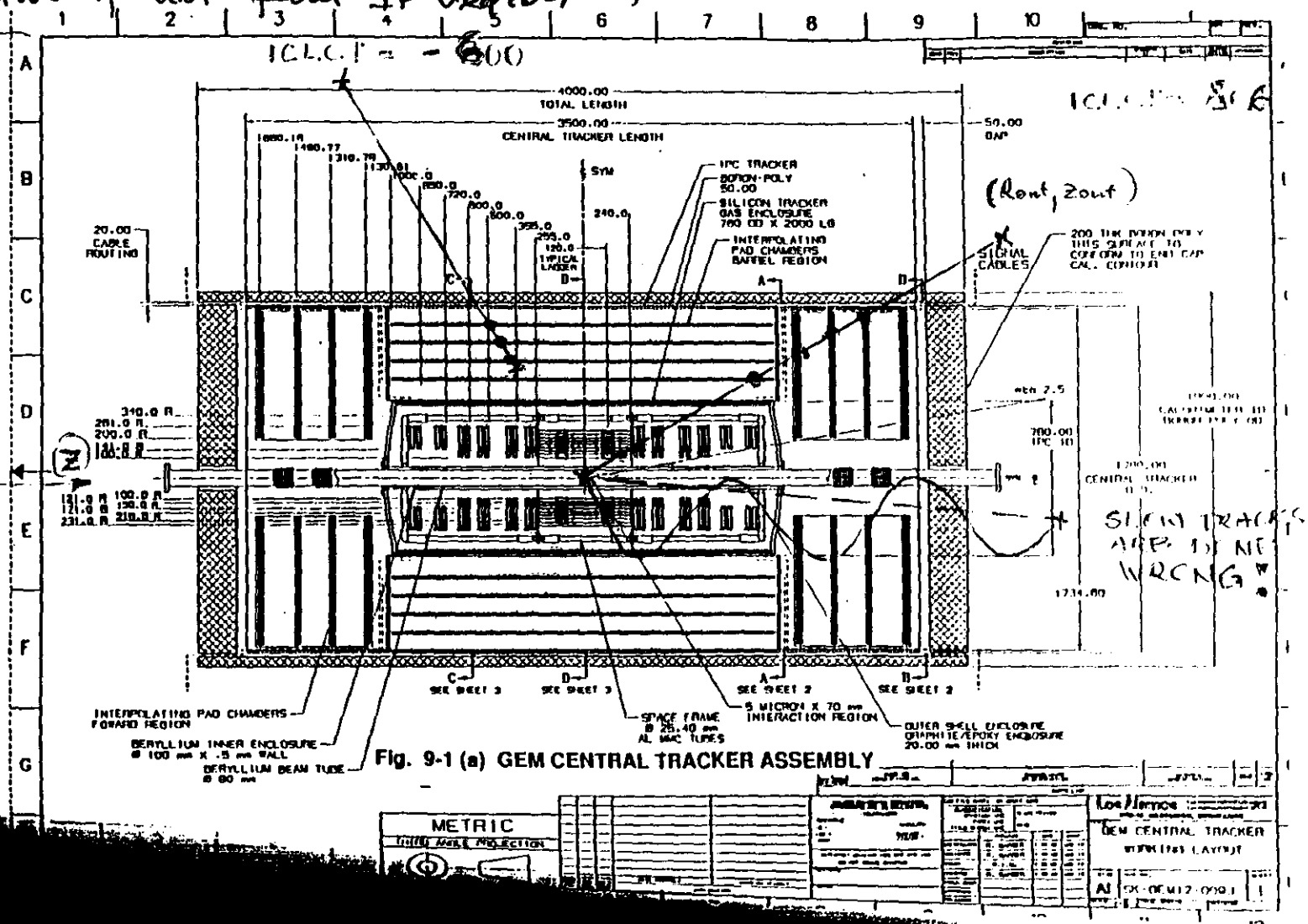
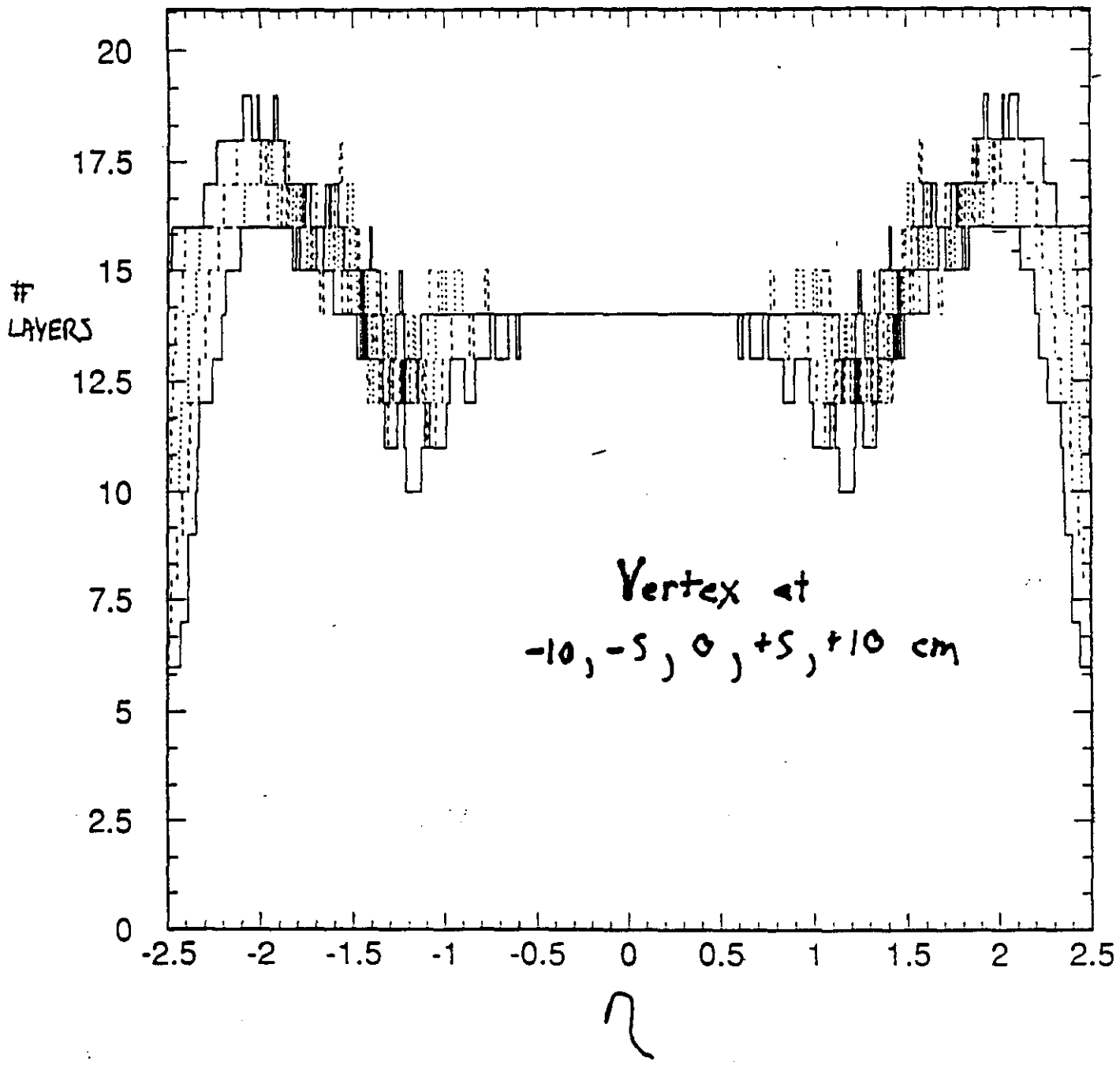
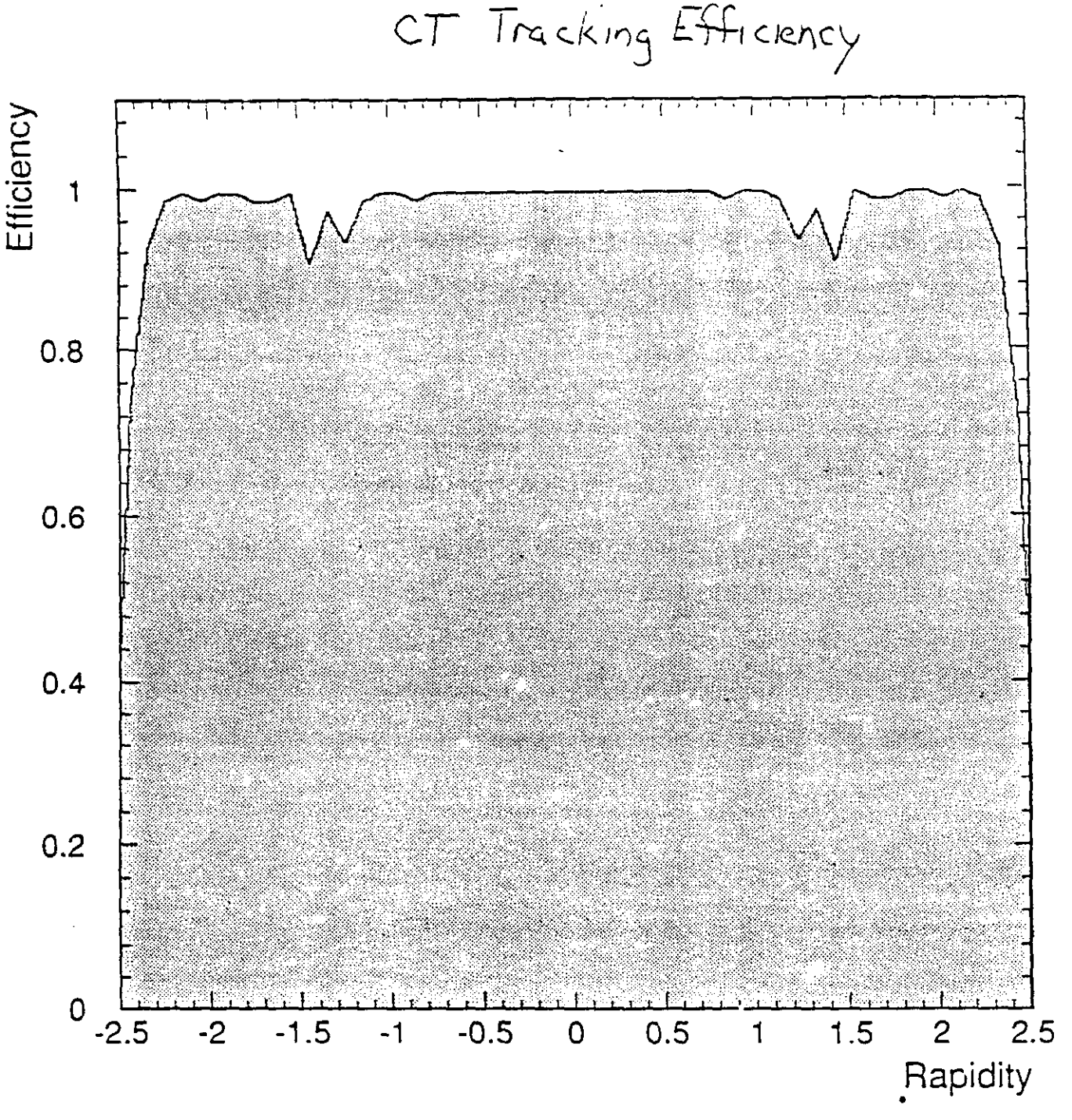


Fig. 9-1 (a) GEM CENTRAL TRACKER ASSEMBLY

FSI_CTSLAY

Tracking Layers




CT Tracking Efficiency
Efficiency
1
0.8
0.6
0.4
0.2
0
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
Rapidity

Shawn is working on FSI_CTRECON based on FSI_CTSLAY result
expected soon

when ready do:

IF(2NDM() . GT . EFFCT(ICT)) "skip ICT tra

- Impact of event environment on reconstruction efficiency
  tough problem for gemfast

  - isolation check on <u>generated</u> particle directions (no curvatures, no secondaries

    IF (FSI_CTISO (ICT, $\Delta\eta$, $\Delta\varphi$)) "ICT track is isolated

    0. 0. ← pesymistic defaults

    by Irwin Sheer

  - full simulations on reconstruction of specific final states (e.g. H→eell) is in progress
    results will serve evaluation of FSI_CTISO

  - **late Feb (if at all)**
    gemfast simulation of 3D-hits in CT
    isolation criteria based on # of hits surviving track overlapps
    will be low (will not be run by default
    physics analyzeres can add this code after all other selection/analysis to check the effects of track overlapps

- High luminosity parametrizations

  Shawn & Melynda will provide impact parameter resolutions from IPC alone (used for vertex calculations)

  soon ?

- photon conversions

  we will add explicit $\gamma \to ee$ conversions in CT

  Shawn is working on material thicknesses

  Tomasz will help coding $\gamma \to ee$

  very soon

EC, HC, SC Status

- gflash V1.3 modified from GEANT environment to gemfast

H1 package developed on LAr/Pb + LAr/Fe
EM HAD
tested on beam data up to 170 GeV
(previously used parametrizations were developed on <40 GeV data)
and used by H1 up to 500 GeV

PICTURES

provides:

- correlated fluctuations of shower profile parameters
  previously no fluctuations
- hadronic shower fluctuates into early π^0s + late π^0s + charged πs parts
  previously fixed EM component
- transverse profile changes with shower depth
  previously transverse profile same at all depths
- shower develops along true incident particle direction
  previously only radially.

gflash must be evaluated / tunned

Hong Ma is working on it!

(Sasha Savin and Kostya Shmakov will perhaps also contribute)

PICTURES

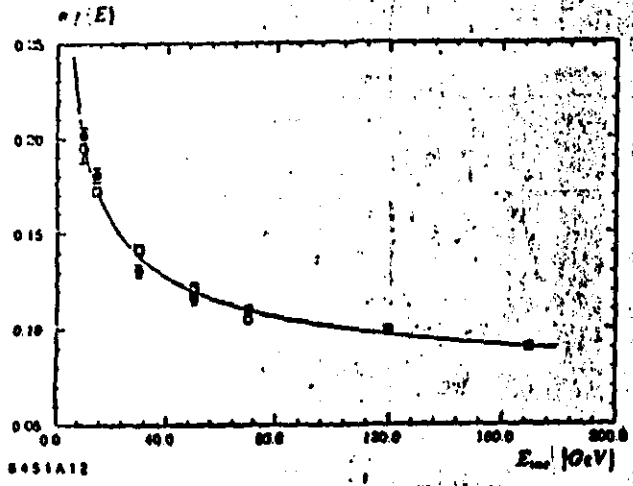


Figure 13: Energy resolution of the calorimeter (EC + HC + TC) for π^- showers: experiment (τ) and GFLASH (•).

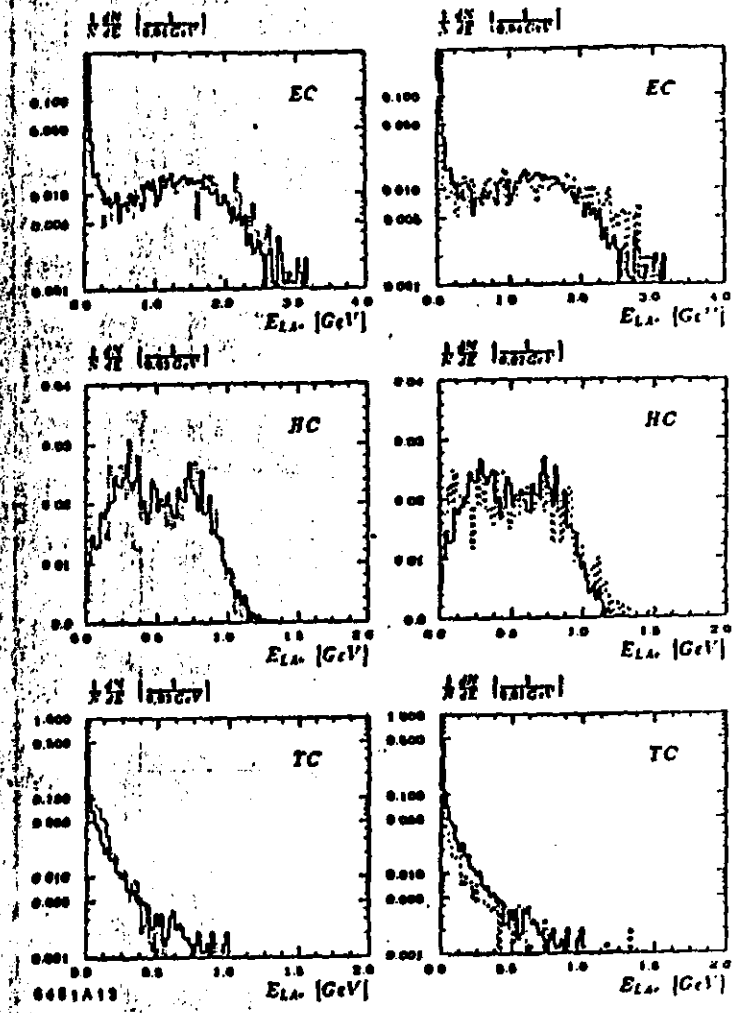
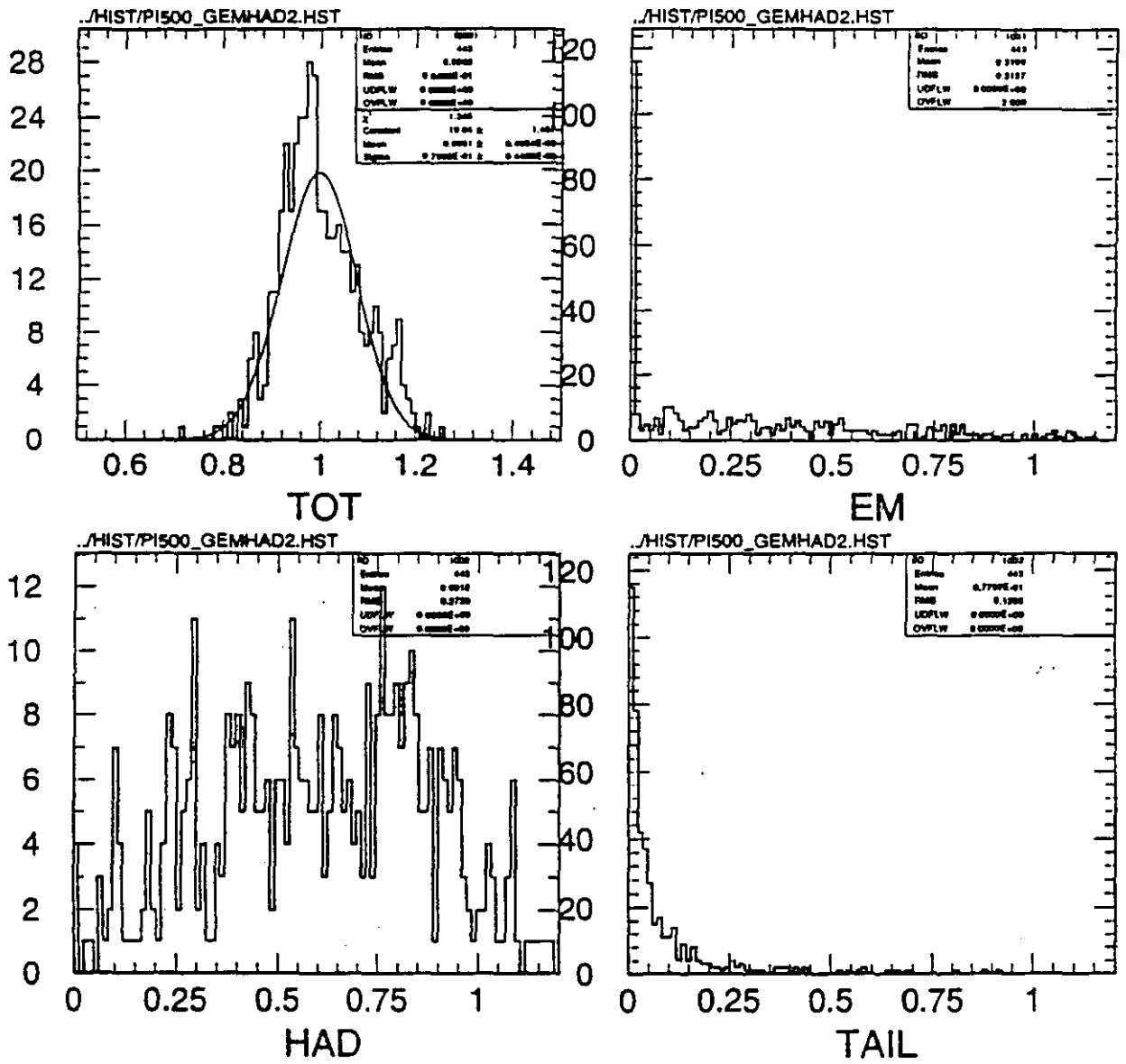


Figure 14: Energy distributions in the modules EC, HC, and TC for 30 GeV π^- showers: experiment (—), GFLASH (···), and GEANT (– – –).

GEANT

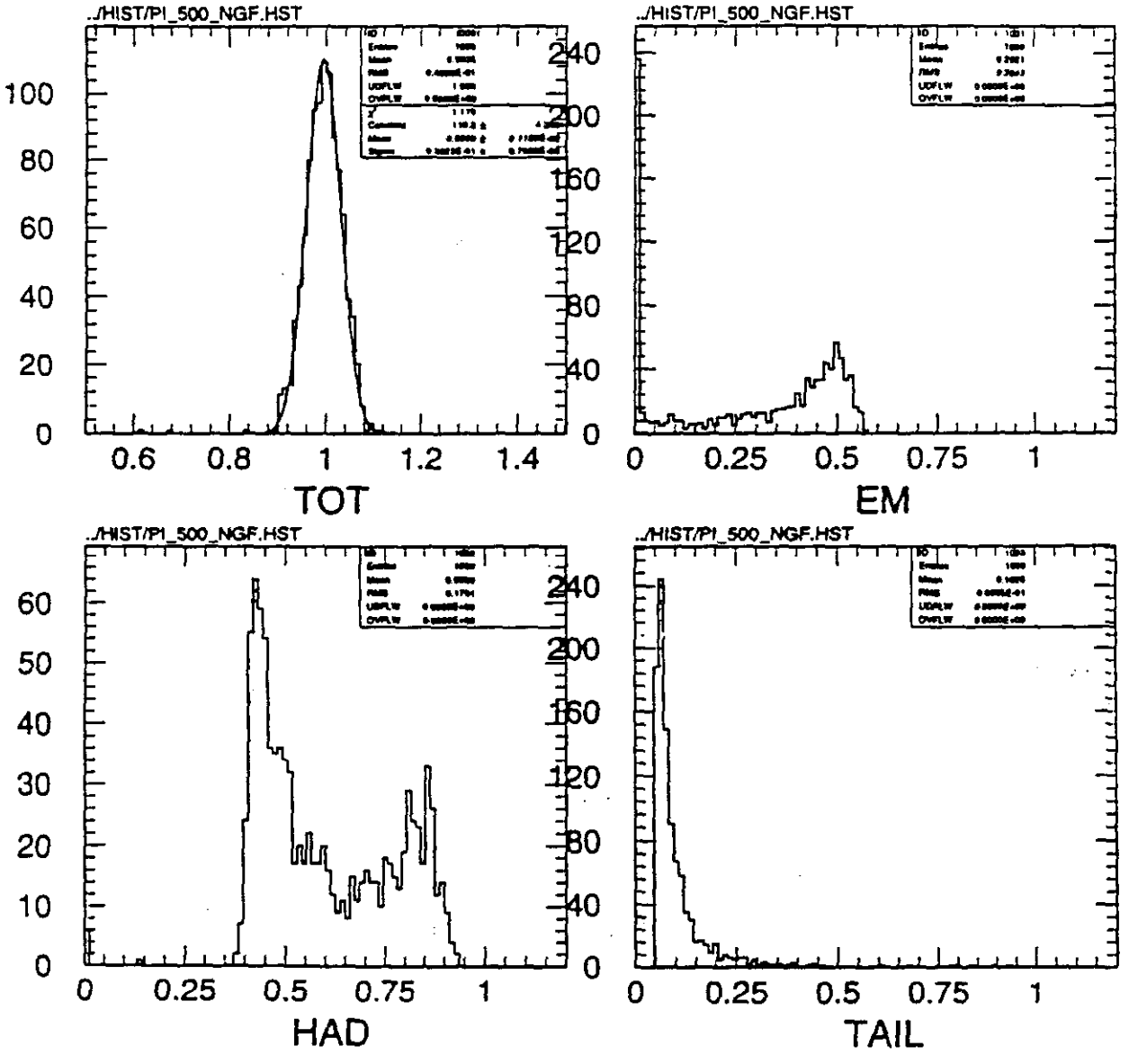
93/01/05 11.02



0.062

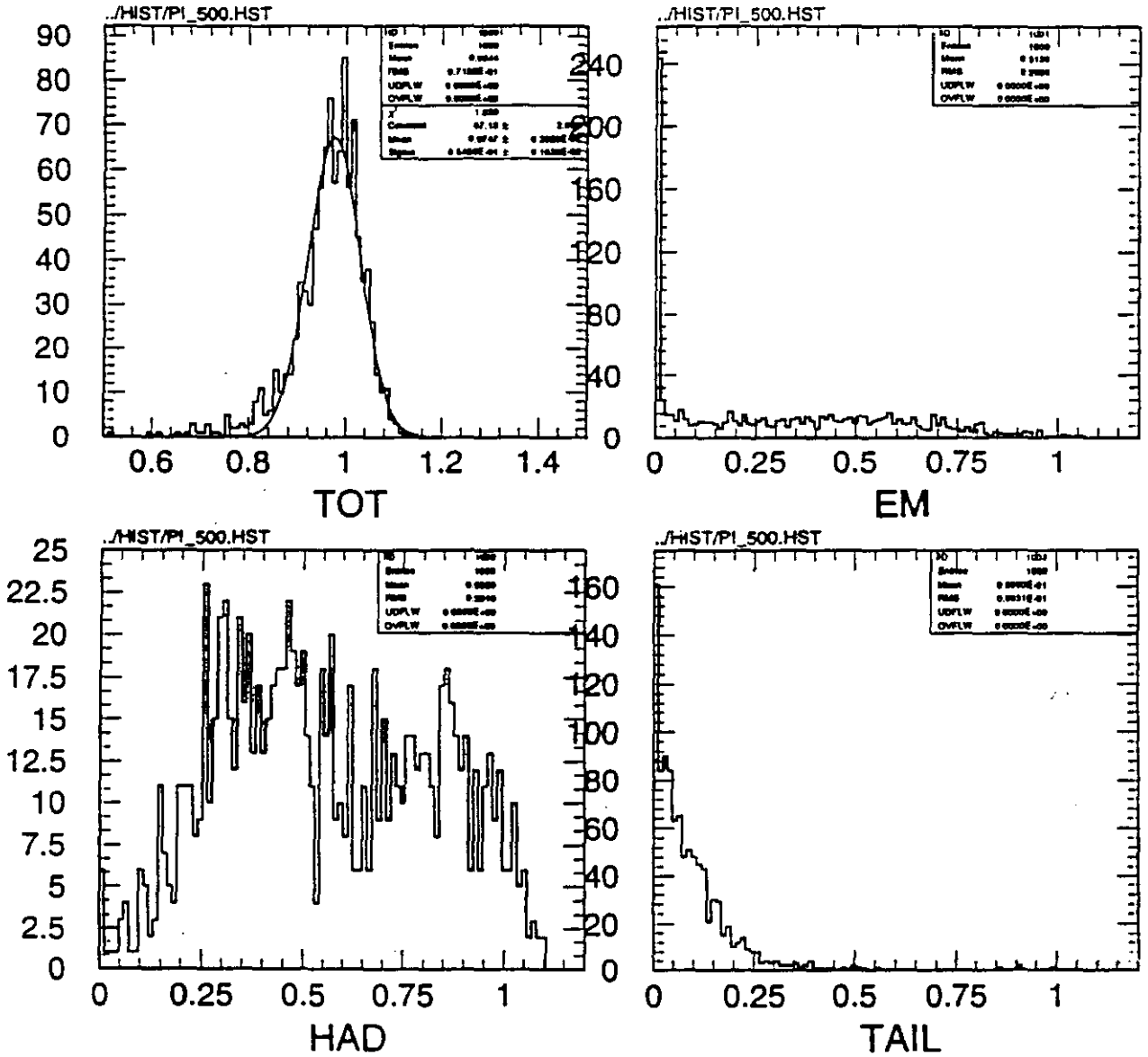
old gemfast
Bock's parametrization

93/01/05 13.23



new gemfast
gflash

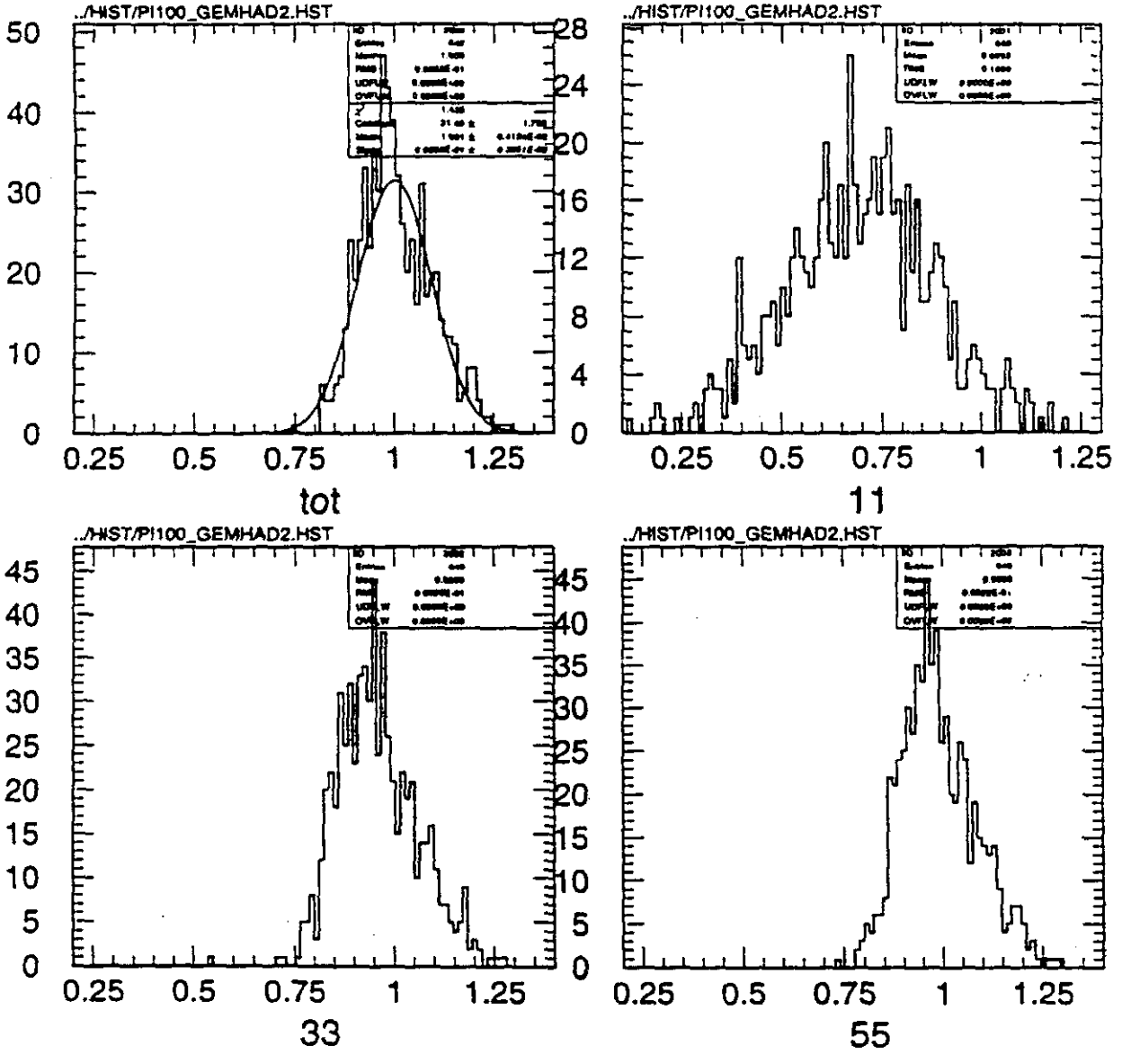
93/01/05 13.59



0.085

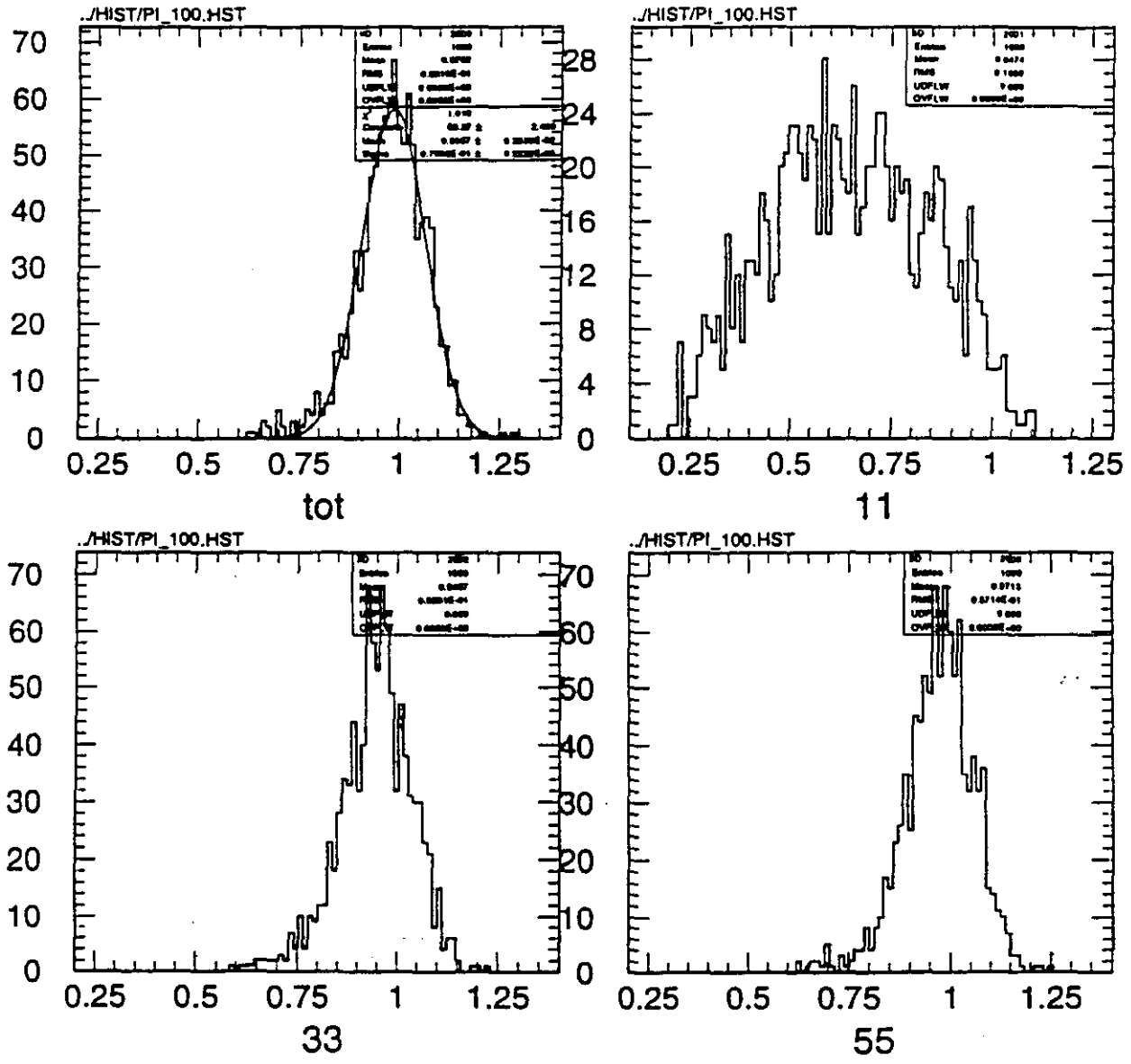
GEANT

93/01/05 10.50



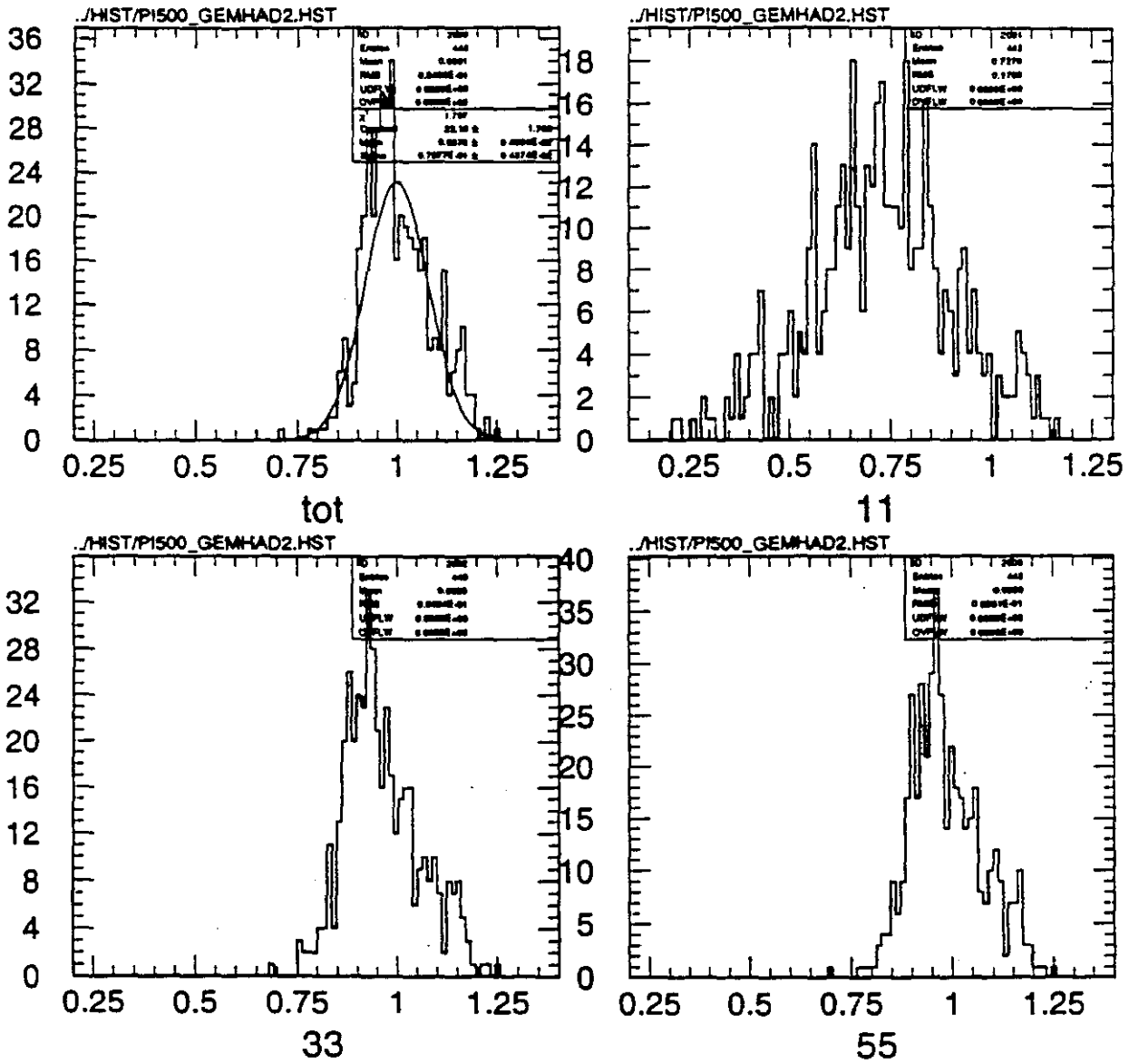
zemfast/qflash

93/01/05 14.00



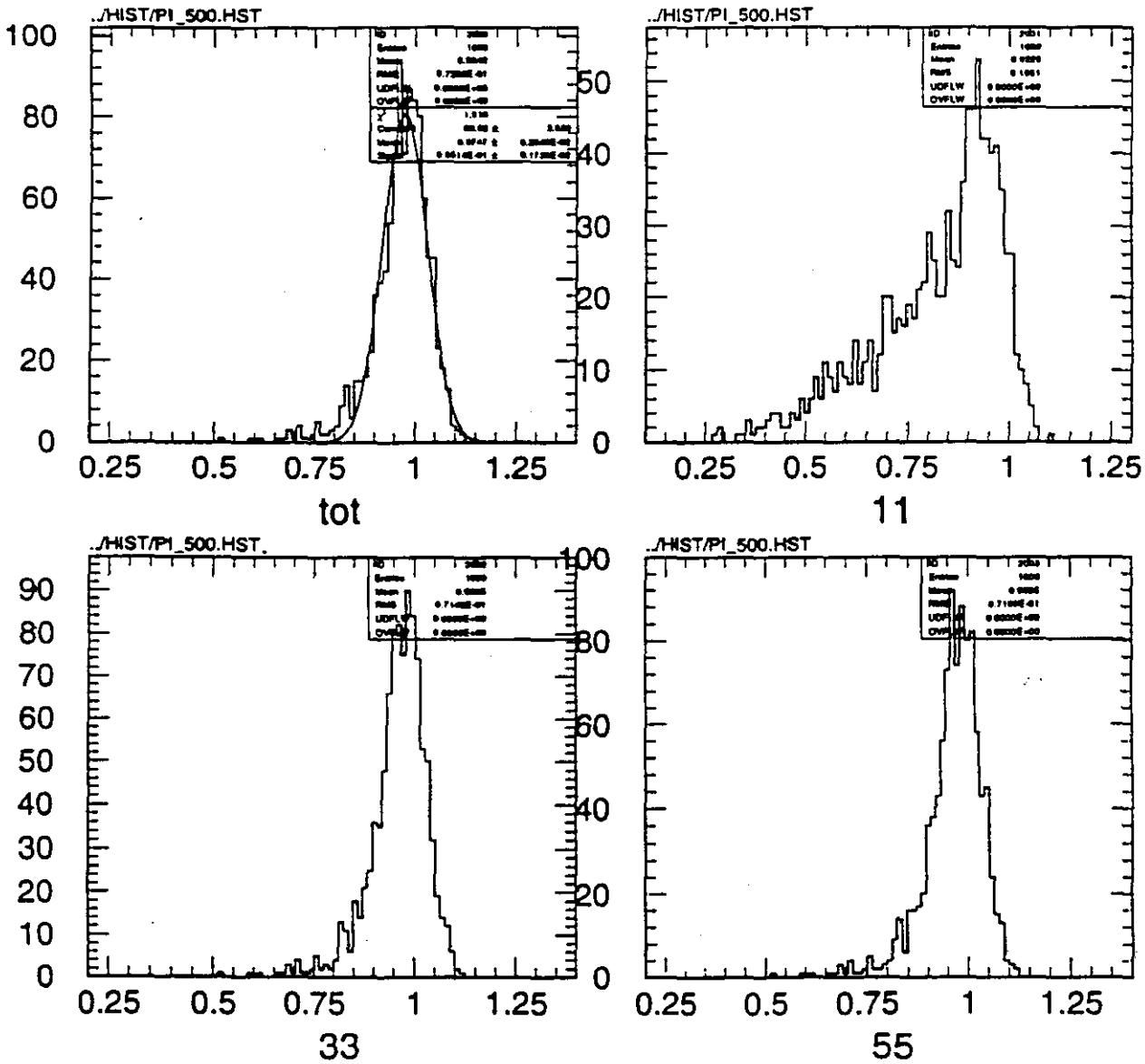
GEANT

93/01/05 11.03



qemfast / qflash

93/01/05 13.59



energy resolution are specified by user (external parameters to gflash)

Hong is tunning EM resolutions to get right 5x5 resolution
very soon

Sasha Savin is tunning HAD resolutions to get right jet resolutions

we decided not to simulate e/h ≠ 1 effects in gemfast (possible with gflash) to avoid complicated weighting corrections in gemfast (which cannot be done right in gemfast since not all longitudinal segmentation is simulated)

we will use fake single π resolution to get expected jet resolution

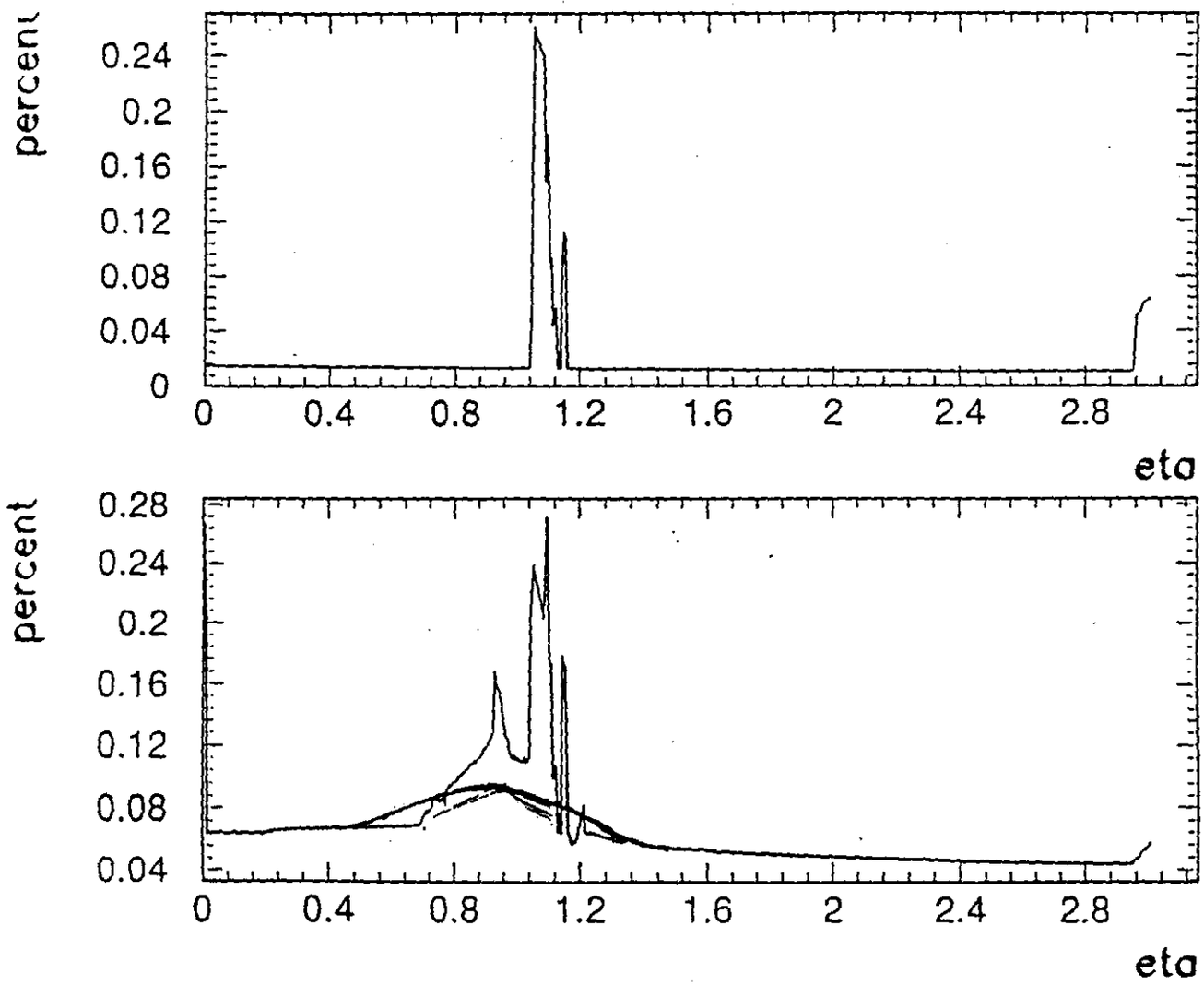
Savin already has full simulation results (with weighting), though only at η=0
very soon

What is HAD resolution in barrel-endcap crack region?

Discrepancy between Martin Marietta calculations and Mike Shupe's simulations

Mike is working to understand this!
soon

EM and HAD resolution at 200 GeV Et



SC – scintillating tail catcher

present geanfast has active barrel part and dead endcap absorber

simulation results by S. Savin and Y. Yefremenko show no big advantage for jet resolution and no effect on muon resolution (by measurement of energy loss in SC)

K. Shmakov is working to see if SC matters for $\not{E}_T$

Will we instrument it at all

NEED DECISION NOW

until decided keep SC active in geanfast (may need some tunning!)

- accurate off-time pile-up simulation is still missing for Baseline-11

We should get started on it now
(Sasha Vaniashin)

STATUS OF FC

Mike Shupe is running UA2MIX MC and updates FSI_FCSMEAR routine.

BASELINE - II DESIGN IS NOT FIXED

Fortunately Mike says the biggest effect comes from η - acceptance (now $\eta < 5.7$)

Technology and design details are 2nd order effects!

Mike's lowest simulation point is 10 GeV. Should be go lower?

must figure out a way to do pile-up simulation in FC

off-time

Status of MU

energy loss

Peter Dinus wrote new energy loss code

PICTURES

we also still have old Roger McNeil parametrization

which one is better ?

NEED SOMEBODY TO COMPARE THEM AND SELECT DEFAULT

momentum resolution

Tomasz S. updated old Sullivan's parametrization algorithm to new semi-analytical calculations (v11101)

Torre Wenaus submitted new code yesterday (will appear in v11102) based on more complete simulations

also includes reconstruction efficiency which will replace present Baseline parametrization

SEE TORRE'S TALK AT THIS MEETING

WARNING !

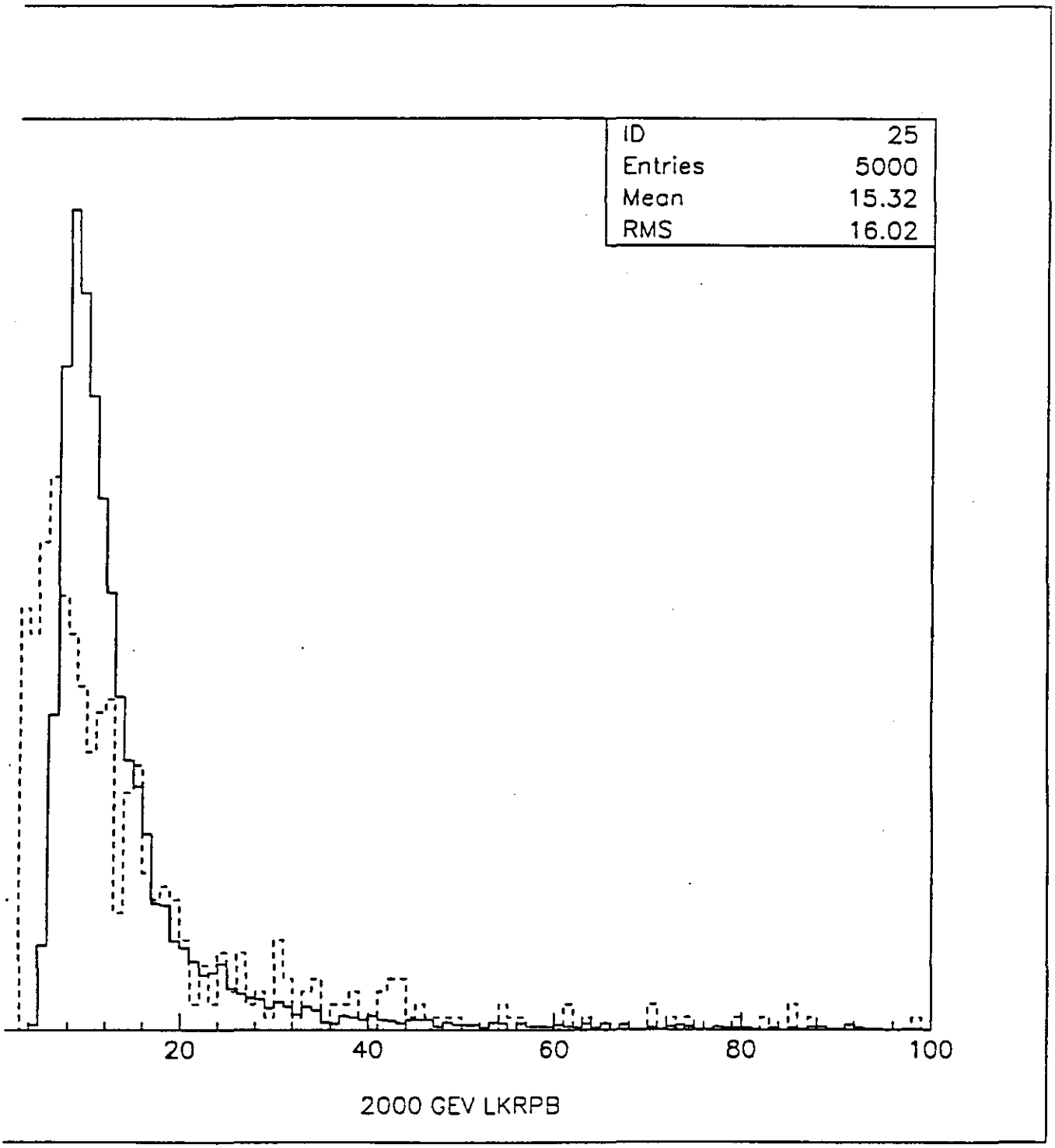
there were two bad bugs introduced by Tomasz rearranging old MU code (thanks to Jaroslav, Shi and Peter)

now fixed in v11101 RELINK your code

NEED SOMEBODY TO DEBUG perfect MU CODE

trigger efficiency

Peter promised update.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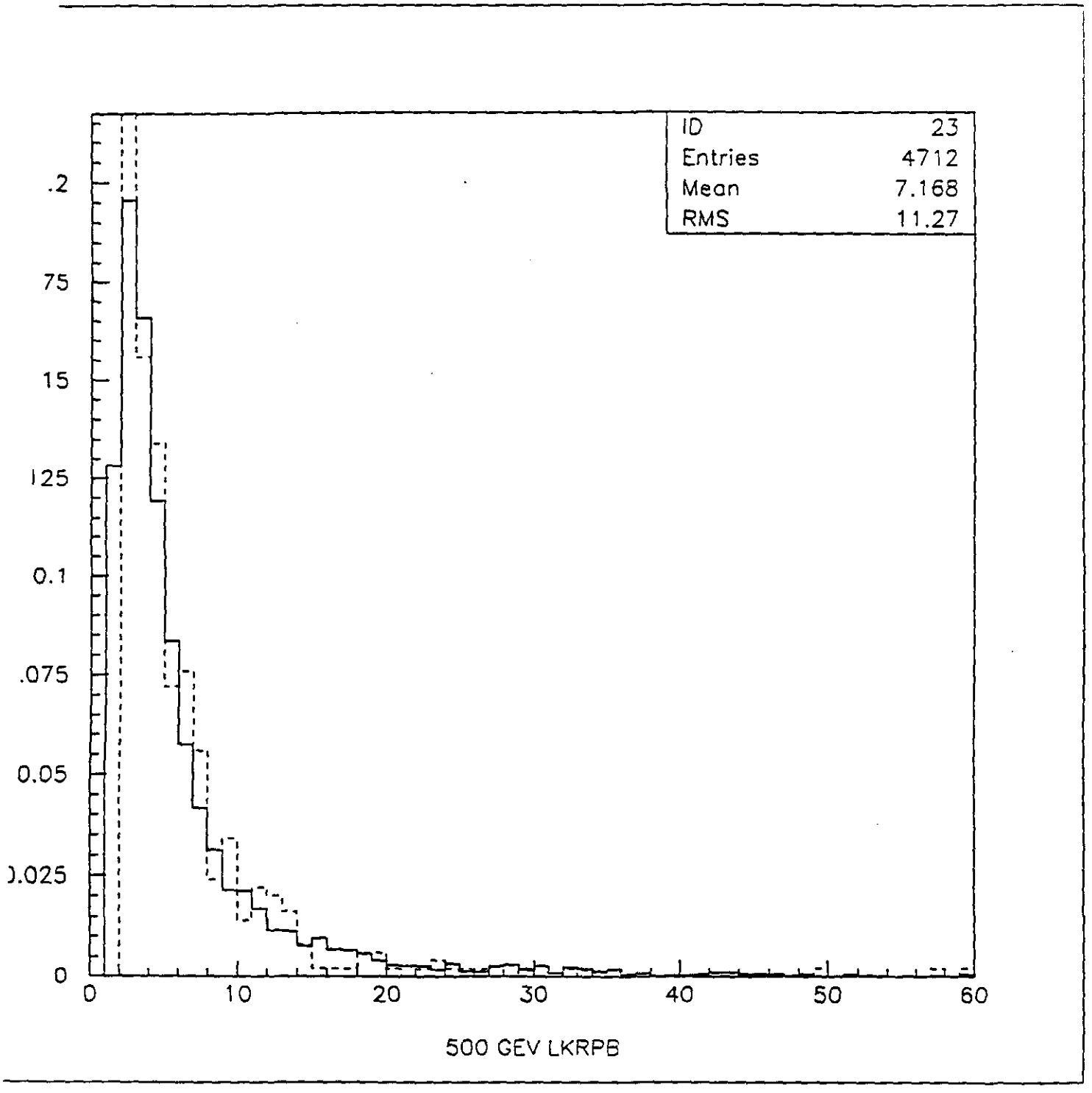
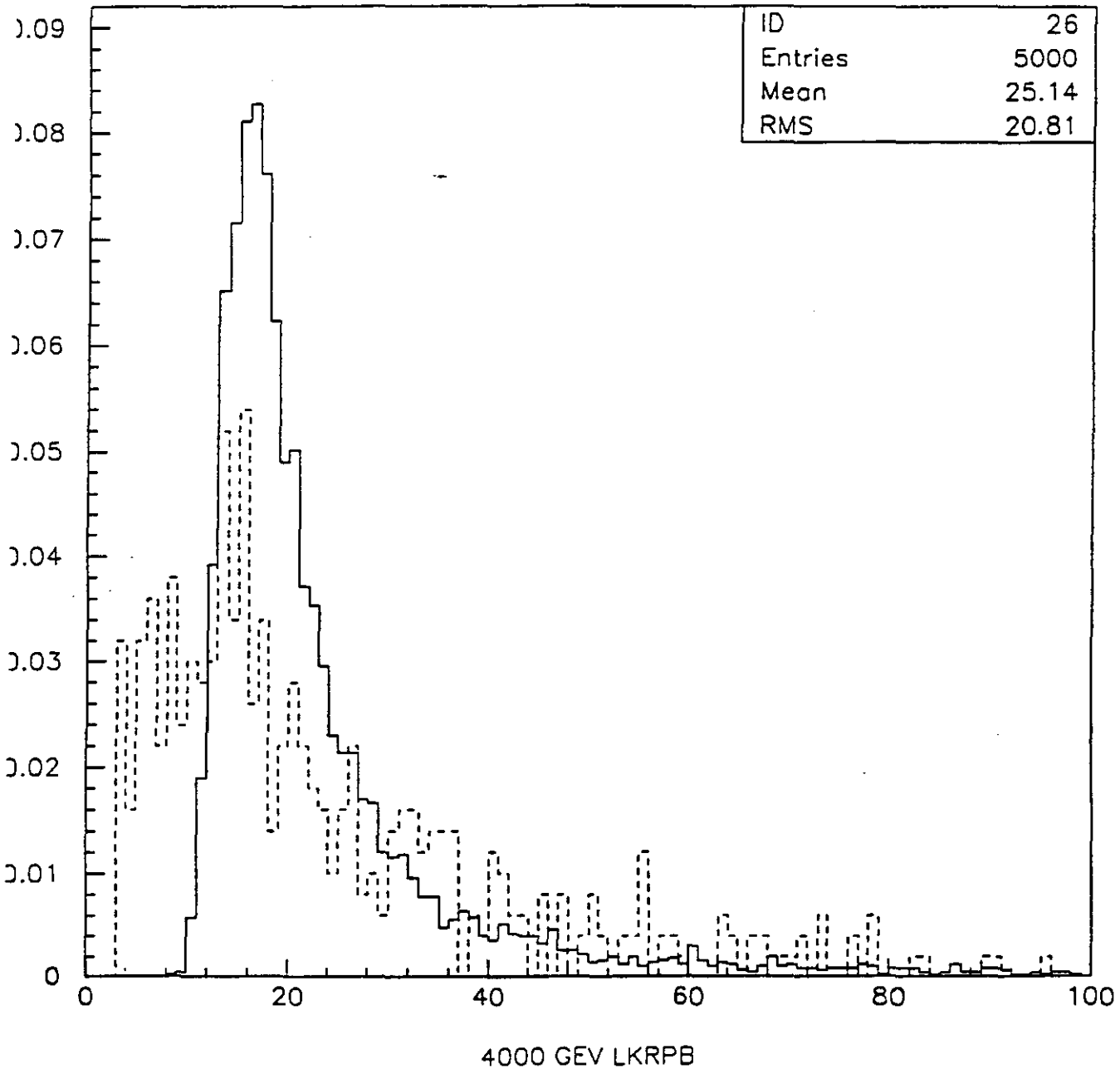
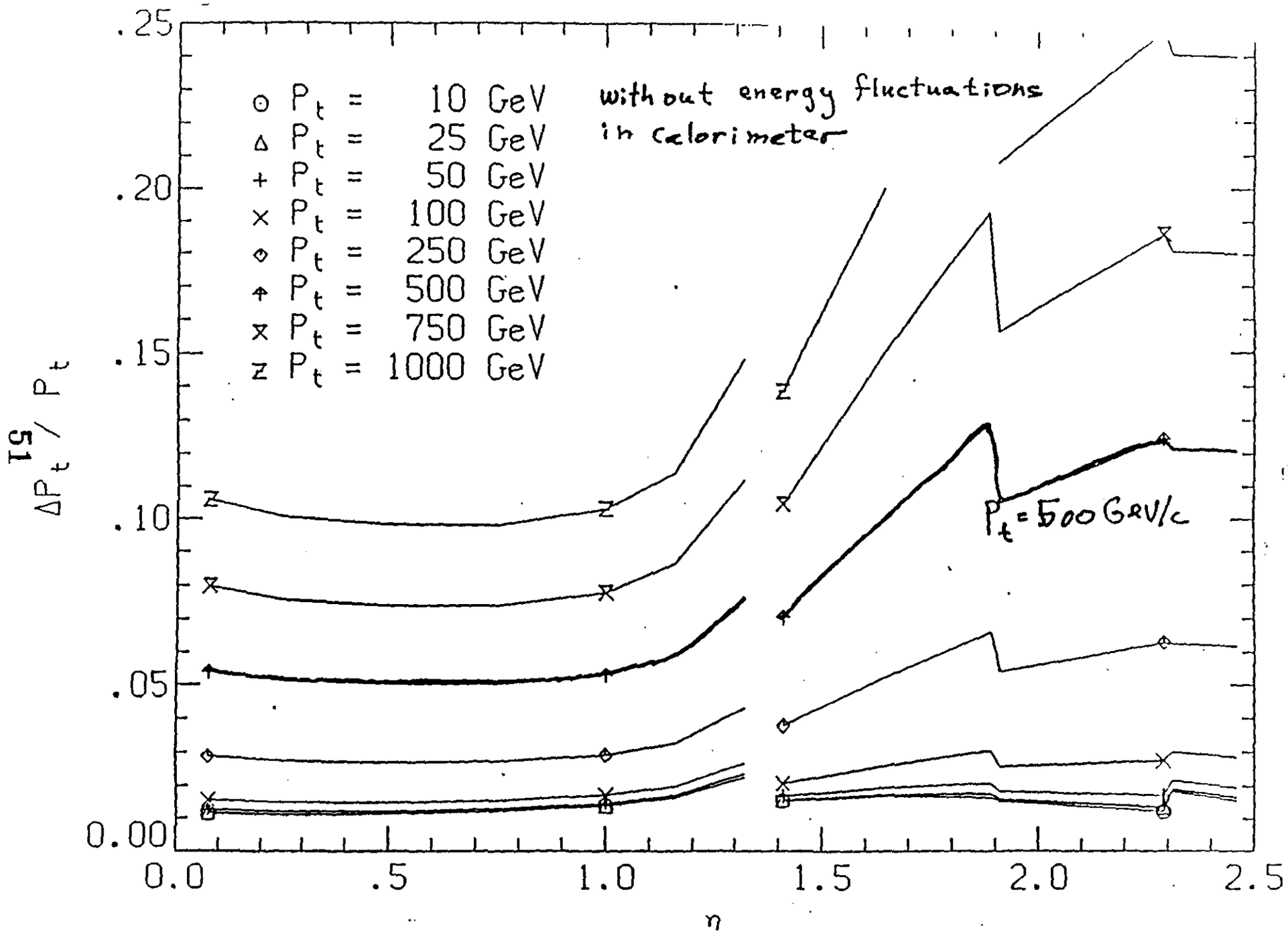
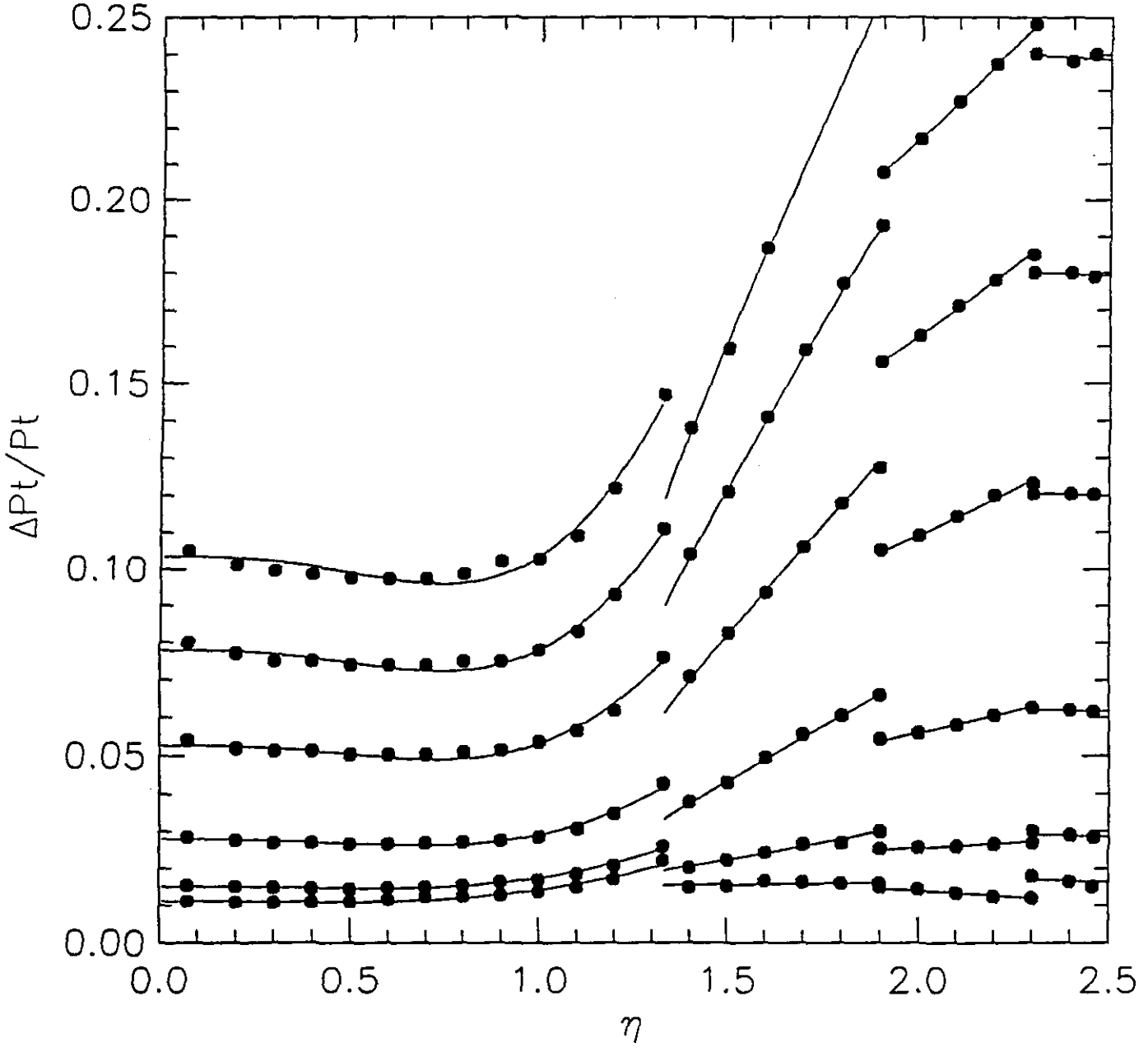
Entries 5000
Mean 15.32
RMS 16.02
20
40
60
80
100
2000 GEV LKRPB


ID 23
Entries 4712
Mean 7.168
RMS 11.27
.2
75
15
125
0.1
.075
0.05
).025
0
0
10
20
30
40
50
60
500 GEV LKRPB


ID 26
Entries 5000
Mean 25.14
RMS 20.81
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60
80
100
4000 GEV LKRPB



Muon CSC option but modified locations: 11/25/92


0.25
0.20
0.15
0.10
0.05
0.00
ΔPt/Pt
0.0
0.5
1.0
1.5
2.0
2.5
η

STATUS of TRIGGER CODE

Henk V. upgraded Charles Allen's calo. code to Baseline-11 gemfast

Henk and Ken McFarlan work on trigger criteria for various processes

Henk will implement his code under /gem as separate project
His code can be called after the call to gemfast

PLANS

next week release v11102 which will include Torre's MU code (also release it on all platforms)

much improved demonstration of user code:

- will include selection of γ, e, μ, jet
- pointing the user to all gemfast information and utility subroutines

user will need to tune particular cut values to his analysis

will include example of $H \to \gamma\gamma$, $H \to ee\mu\mu$, $H \to ee jj$ (no cut optimization)

will ask subdetector experts to improve

will also expect people who provided parametrizations to make single particle studies with gemfast

e.g. CT, MU $\frac{\delta P_t}{P_t}$ vs η for e, μ

EC, CA $\frac{\delta E}{E}$ vs η for γ, e, π, j

even though gemfast has been much improved it is still not complete and moved out

please help gemfast now!

gem

γeμ

Presentation by:

Torre Wenaus

GEM CSC MUON SYSTEM

SIMULATION + PARAMETRIZATION FOR MOMENTUM RESOLUTION + ACCEPTANCE

T. WENAUS

JAN 13 '93.

OUTLINE

- DETECTOR SPEC
- SIMULATION
- PARAMETRIZATION
- COMPARISON WITH SULLIVAN
- STATUS, IMPROVEMENTS

MUON SYSTEM SPEC

BASED ON DEC VERSION OF BASELINE II AND INFO FROM FRANK TAYLOR

CSC INTRINSIC RES 75 μ
INTERNAL ALIGNMENT 50 μ
CHAM-CHAM ALIGNMENT 25 μ
FIELDMAP VERSION 600
BARREL CHAMBER CONFIG 8:4:4

ENDCAP:

FORWARD	$2.30 < \eta < 2.46$	8:8:4
INTERMED	$1.90 < \eta < 2.30$	8:4:4
OUTER	$1.40 < \eta < 1.90$	8:4:4

CHAM THICKNESS

.078 X_0 THROUGH CHAM CENTER
.514 X_0 THROUGH CENTER + FRAME
(5 cm FRAME OF DEAD MATERIAL AROUND CHAMBER FIDUCIAL)

SUPPORT STRUCTURES

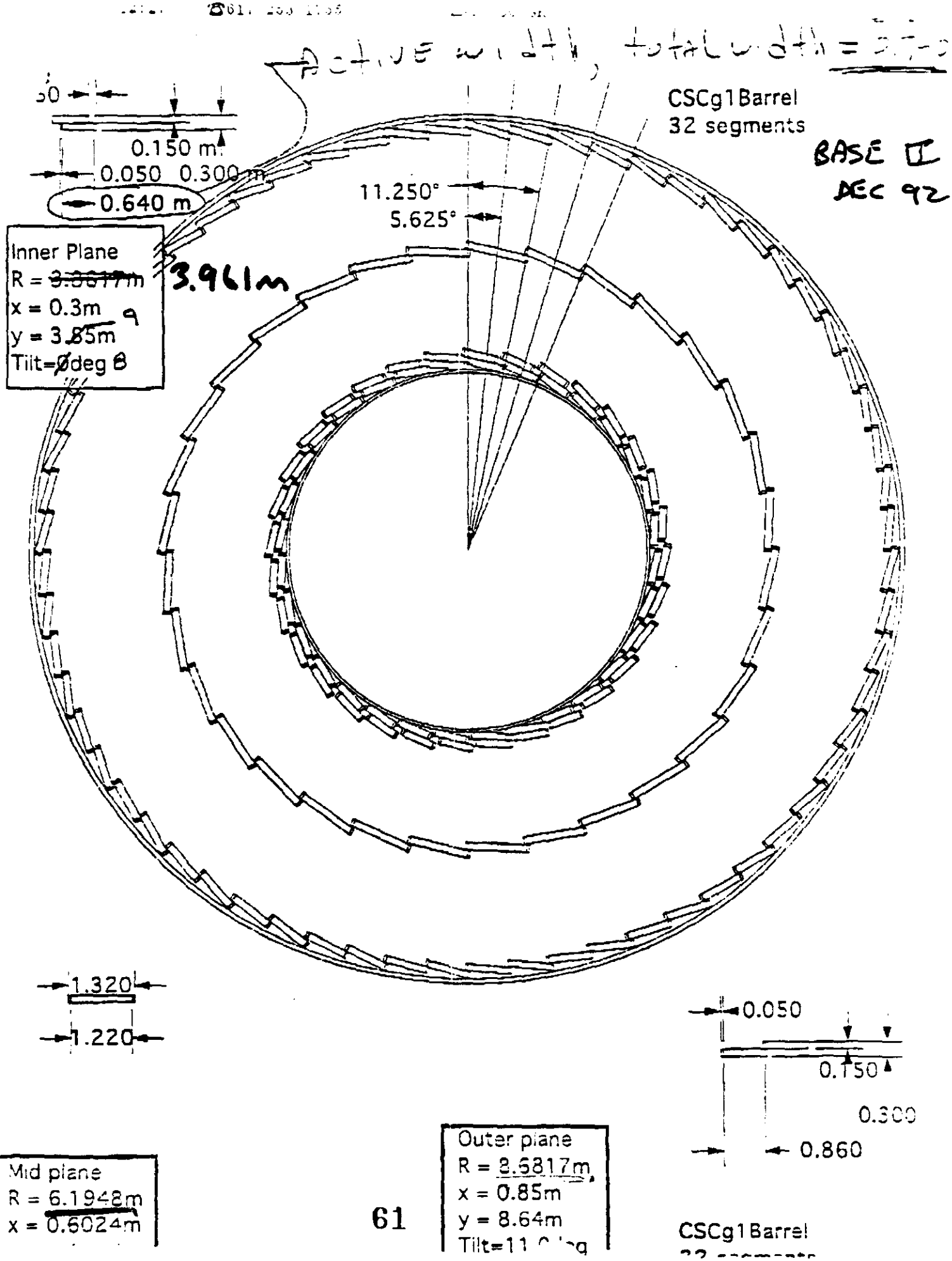
3" Al TUBES, 1/4" WALL

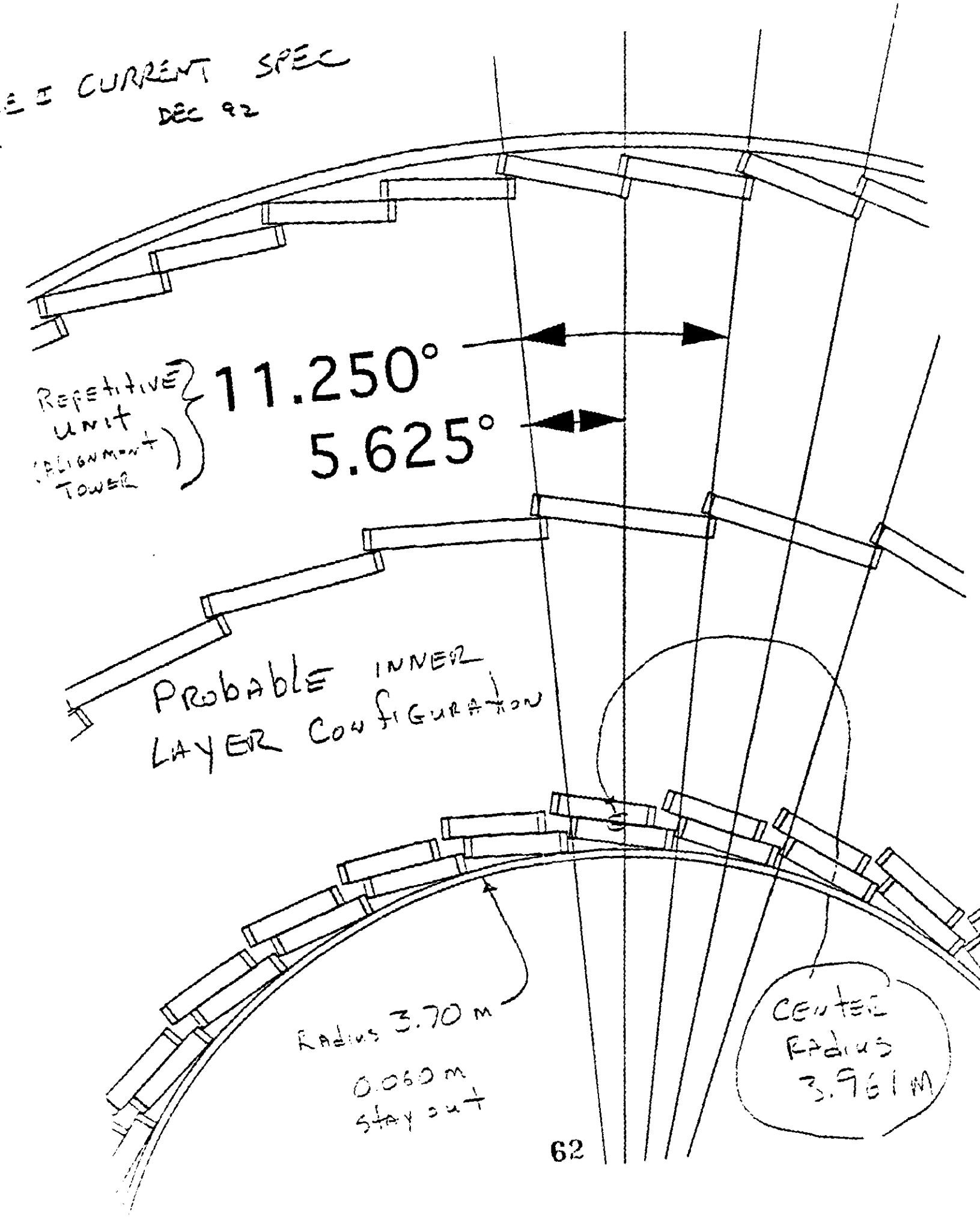
1 1/2" Al SUPPORT PLATES AT SL2

N.B. COMPLETE, CONSISTENT DETAILS OF THIS DET CONFIGURATION WERE NOT AVAILABLE

- DIFFERENT CHAM THICKNESS NUMBERS IN SAME DOCUMENT (CHAM DESIGN NOT WELL ENOUGH DEFINED FOR NUMBERS TO BE RELIABLE)
- NO SPACE IN CHAM CONFIGURATION FOR SUPPORT STRUCTURES
- SUPPORTS NOT WELL DEFINED; APPROXIMATION USED.
- FROM SEPT → DEC, CAP SL1 CHAM COUNT WENT FROM 4 TO 8, BUT NO NEW CHAMBER LAYOUT WAS AVAILABLE

  ⇒ LEVER ARM OVERESTIMATED?

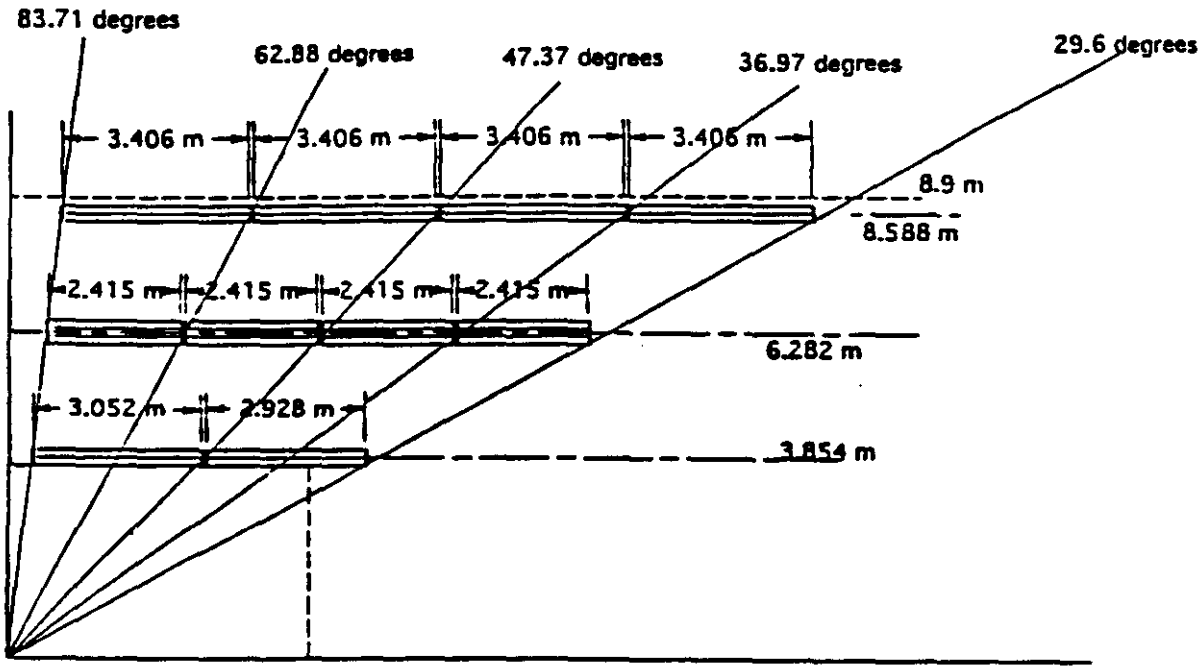

Active width, total width = 3.720
CSCg1Barrel
32 segments
BASE II
DEC 92
0.150 m
0.050 0.300 m
0.640 m
11.250°
5.625°
Inner Plane
R = ~~3.8617m~~
x = 0.3m
y = 3.85m
Tilt=0deg
3.961m
1.320
1.220
0.050
0.150
0.300
0.860
Mid plane
R = 6.1948m
x = 0.6024m
Outer plane
R = 8.6817m
x = 0.85m
y = 8.64m
CSCg1Barrel


E I CURRENT SPEC
DEC 92
Repetitive unit (Alignment Tower)
11.250°
5.625°
Probable INNER LAYER Configuration
Radius 3.70 m
0.060 m stay out
Center Radius 3.961 m

BASE I DEC 92

CSCf2crzBarrellayout

Lengths of active areas

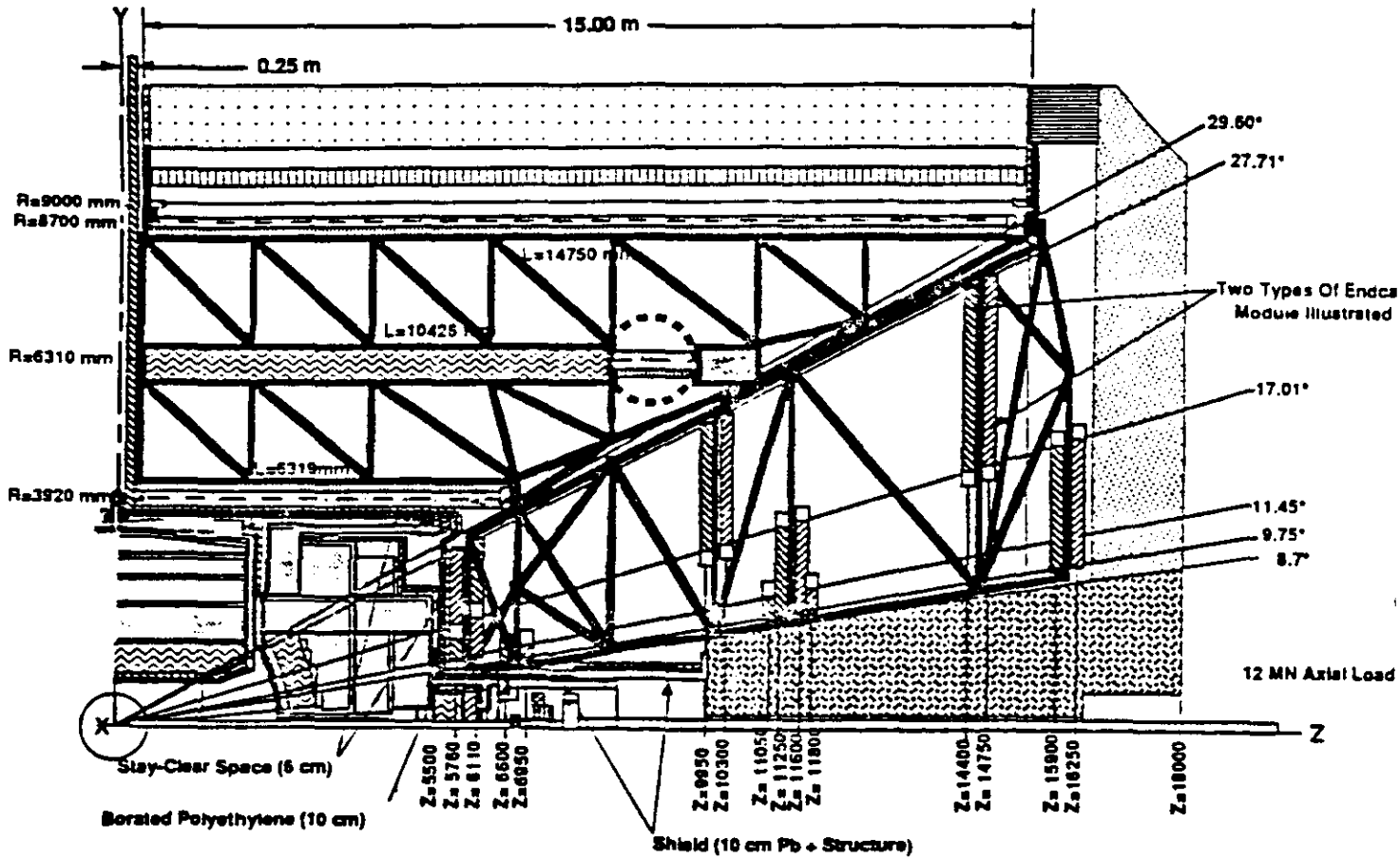


N.B. NO SPACE WHATSOEVER BETWEEN CHAMS

I ADDED SPACE IN SL2 FOR Al SUPPORT PLATES SPECCED BY LUNL ENGINEERS.

Figure 1.2 Side (r-z) view of the barrel CSC system.

BASE II DEC 92



GEM MUON SYSTEM (BASELINE)

With Baseline LAr Calorimeter Illustrated

Figure 1.3 Side (r-z) view of the endcap CSC system.

BASE I DÉC 92

An accounting of the mass and radiation lengths in the principal components is given in Table 2.1 for a typical CSC module. Each chamber in the module has an active area surrounded by frames that are taken to be inactive for detecting muons. When the modules are overlapped to avoid acceptance losses, muons will sometimes traverse the frames of one chamber as well as the active area of another. For this (rough) design, muons traversing the active area only will pass through 8% of a radiation length. Approximately 10% of the time a muon would also pass through the frame of an overlapping module, for a total of 51% of a radiation length. The average thickness in radiation lengths, including the overlap, is about 12%.

Table 2.1 Material in a typical CSC

Material Audit for Cathode Strip Chamber Module

Calculation of mass and radiation lengths for a four chamber module

Active area of chamber:
length (m) = 3.0
width (m) = 1.5
total area (m^2) = 5.0

frame material (and dead area):
width (m) = 0.050

(including inactive frames)
fraction of active area overlapped by frames = 0.098

component	material	density	cm/X0	thickness (cm)	mass (Kg)	normal X0
Hexcel core	Nomex	0.14	485.7	2.5	86.80	0.0257
circuit boards	.031" G10	1.7	19.4	0.079	66.39	0.0406
copper	1/2 oz.ft^2	8.96	1.43	0.0017	7.56	0.0119
frames	~ lucite	1.2	34.4	3.0	82.80	0.4360

total mass (Kg) =	243.5	
mass/area (Kg/m^2) =	49.1	
average X0's =	0.119	
X0's through center =	0.078	
X0's, center + frames =	0.514	<- includes material of overlapping chamber
area-weighted ave X0's =	0.121	

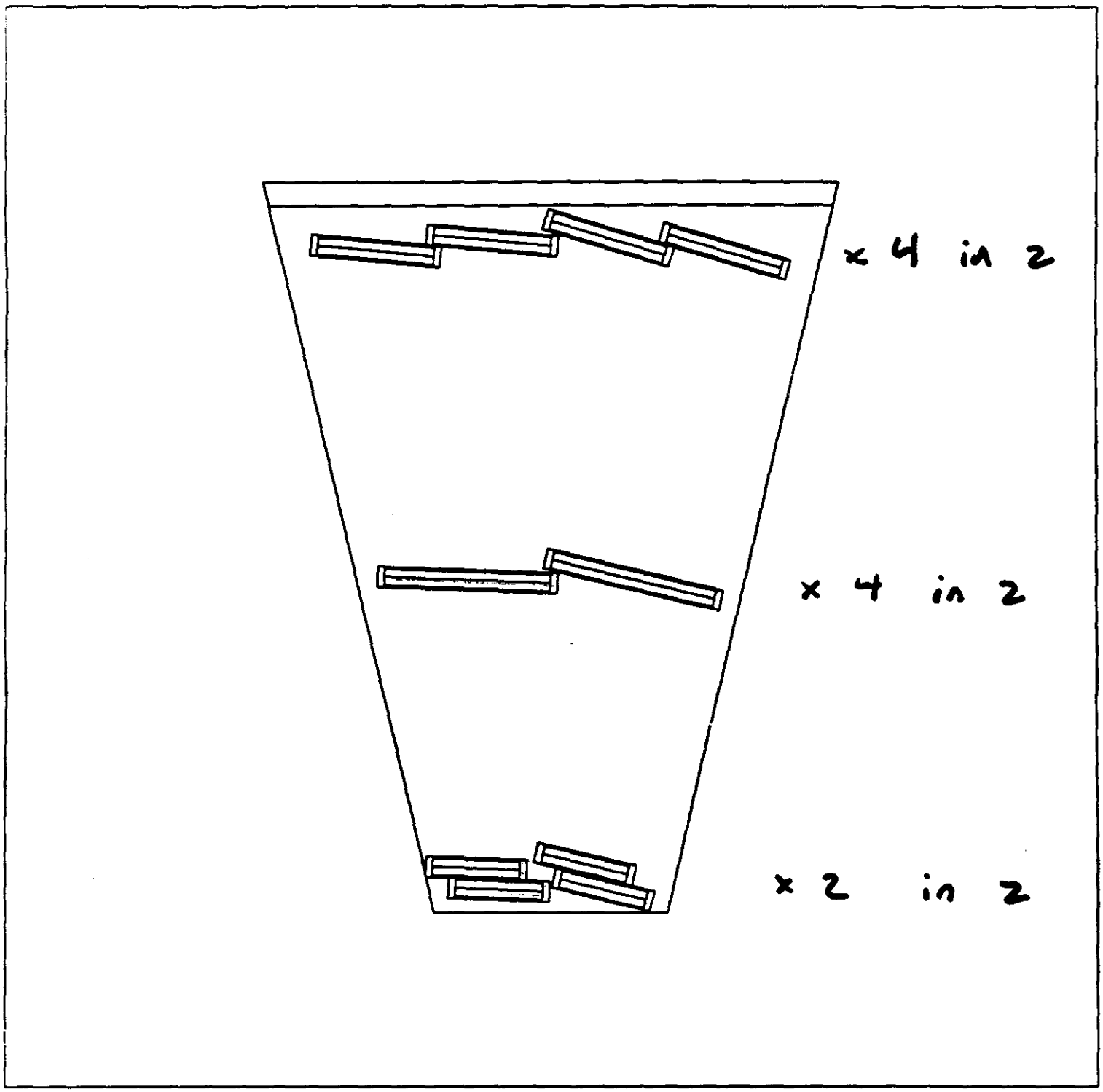
Wires are strung on printed circuit frames of precision thickness that are glued to the precision cathode. Wires are tensioned to ~170 grams, ~ 2/3 of the elastic limit; they are held by glue and solder and the wire pitch is set by the fixturing during construction. The panel takes the load of the anode wires; the symmetric loading offsets any tendency to distort the panel. The frames are circuit board material of precision thickness. They bus HV and route anode signals to an edge connector. On the non-precision cathode lamination is a frame fabricated with precise moldings produced with pultrusion technology; this frame controls the gas gap and provides access for electrical contact to the non-precision cathode. Gas distribution is achieved through a manifold built into this frame. This approach provides a precise, low-weight, low-cost structure that avoids extensive machining. It allows accurate control of the important parameters and provides access to the precision cathode all around the perimeter for alignment.

One alternative under study is to use Iarocci-type "profile" chambers where the wires are strung in individual channels in a conductive plastic extrusion. This approach has potential advantages in robustness of the chamber and disadvantages in efficiency and attainable wire pitch.

SIMULATION

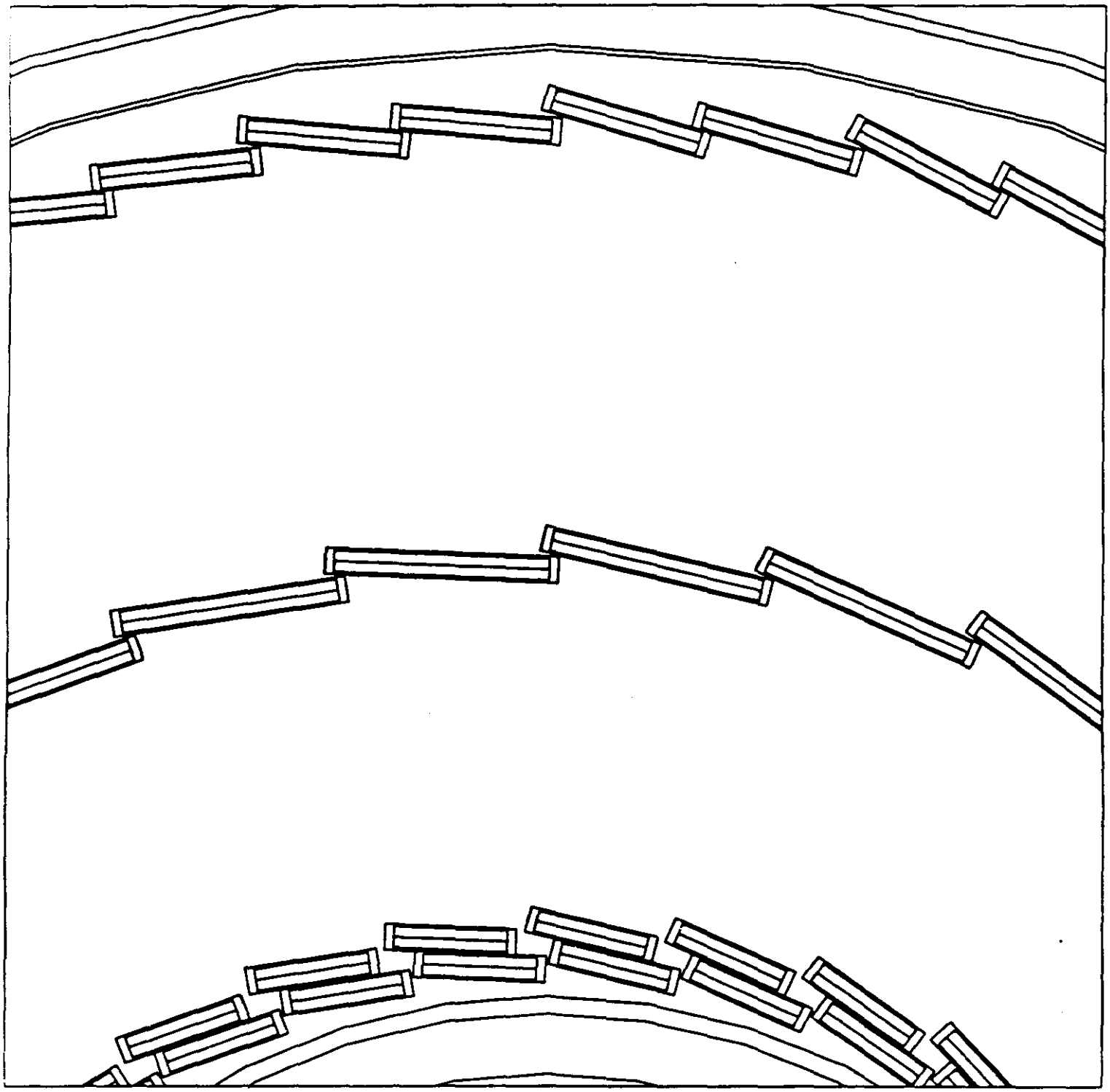
- GEANT SIMU DERIVED FROM YURI's SIGEM
- DETAILED TO LEVEL OF INDIVIDUAL CHAMBERS WITH PROPER FIDUCIAL SIZE, & FRAME, WALL X_0 THICKNESS
- SUPPORT SPACE FRAMES AND SL2 SUPPORT PLATES INCLUDED

MU BARREL SECTOR

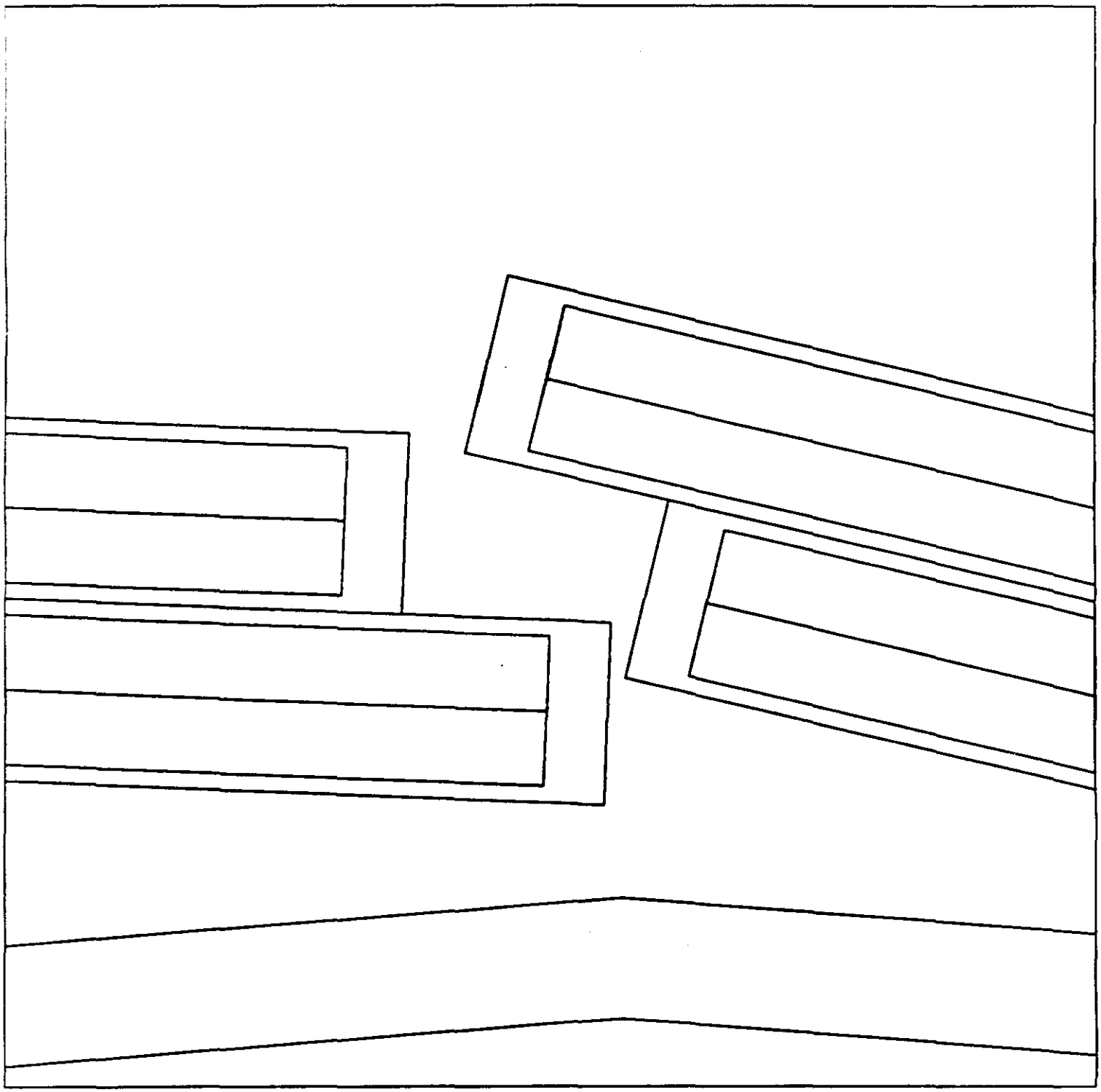


CHAMBERS: 510 WALLS + FRAMES
WITH AIR FIDUCIAL

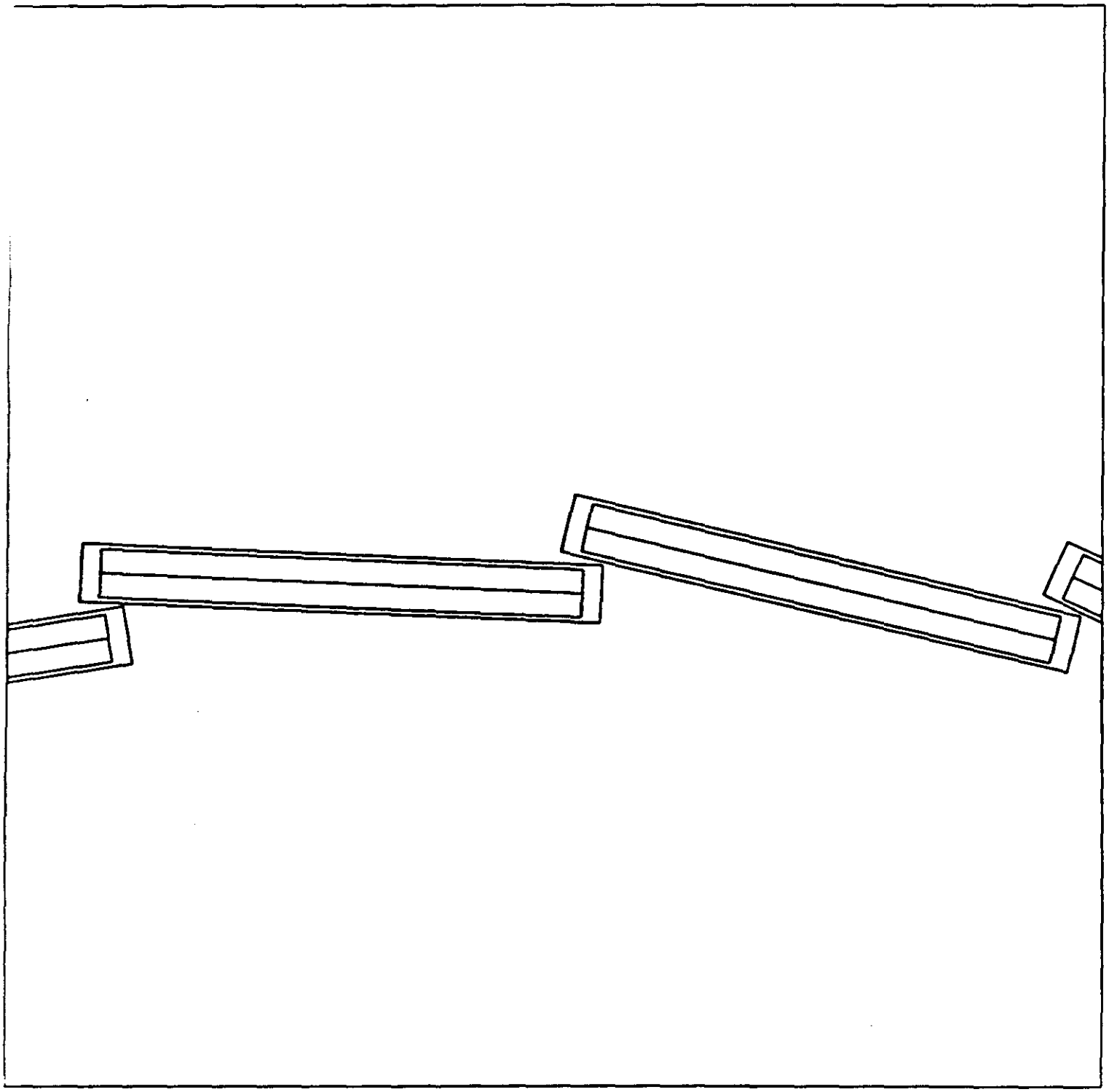
MU BARREL



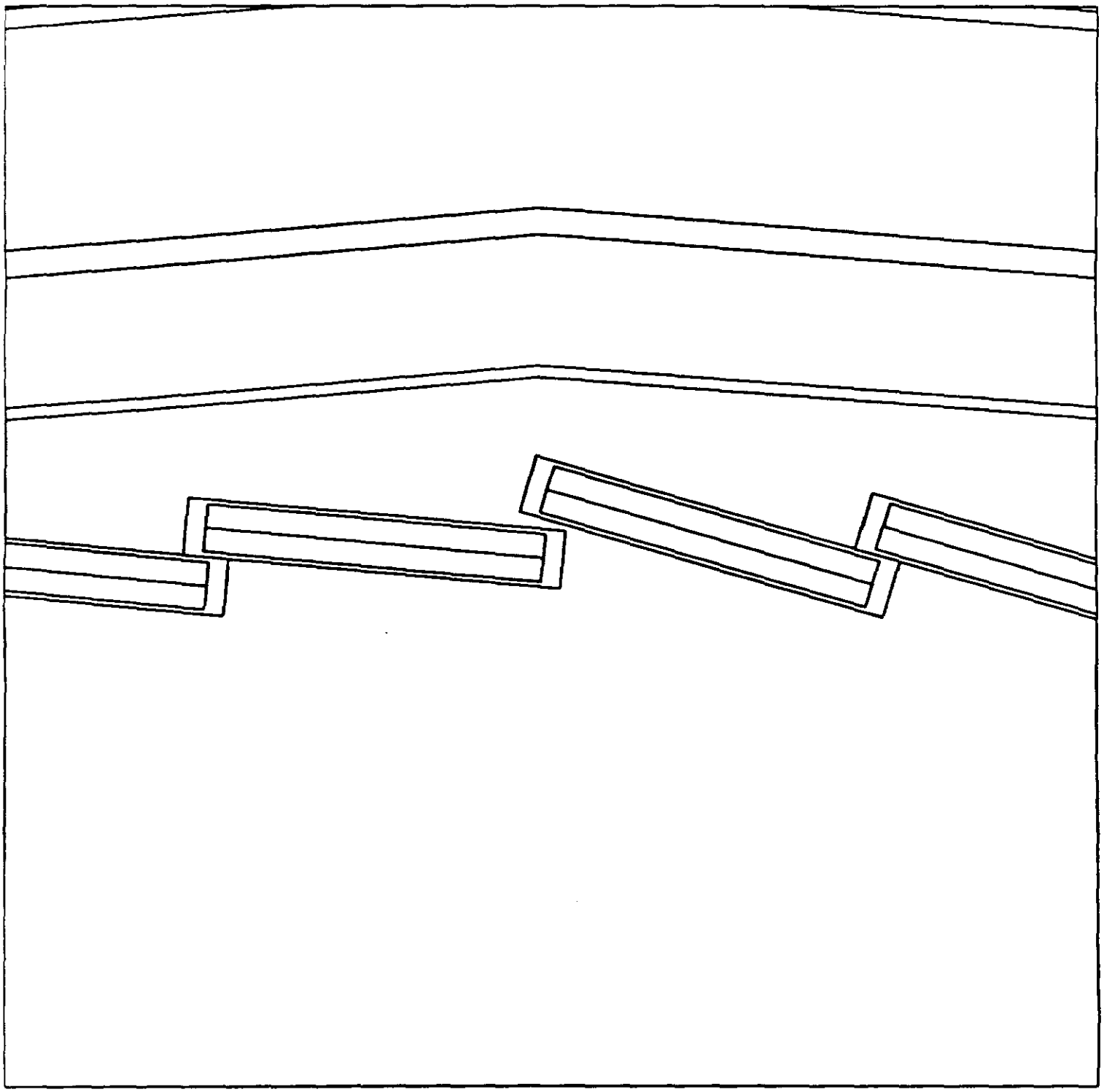
SL!



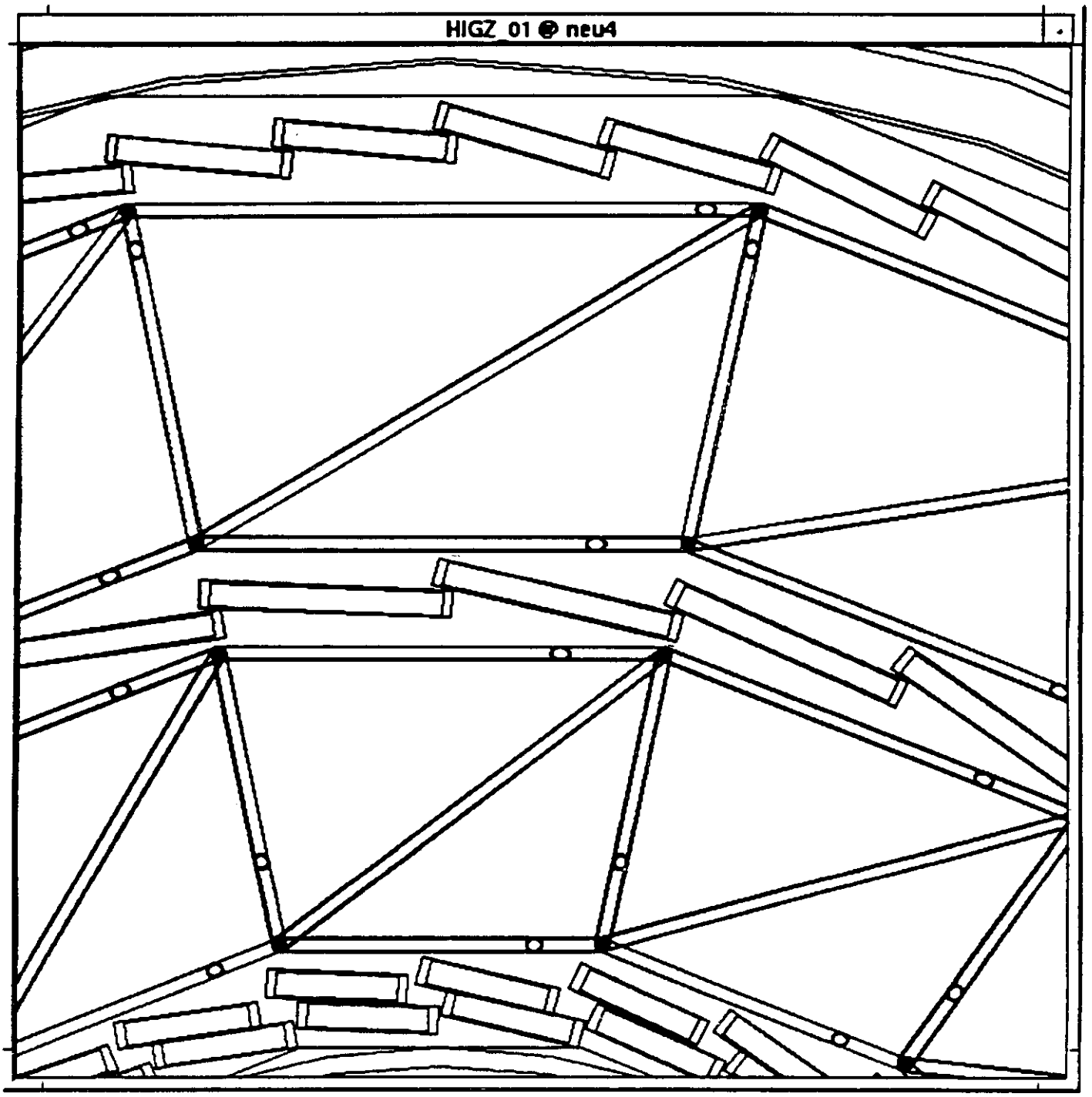
SL2



SL3

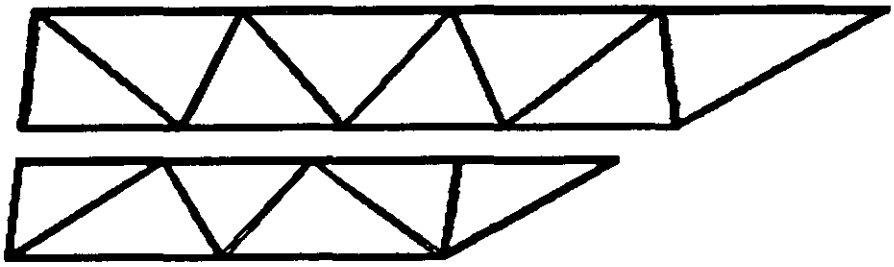


BARREL WITH SUPPORT STRUCTURES

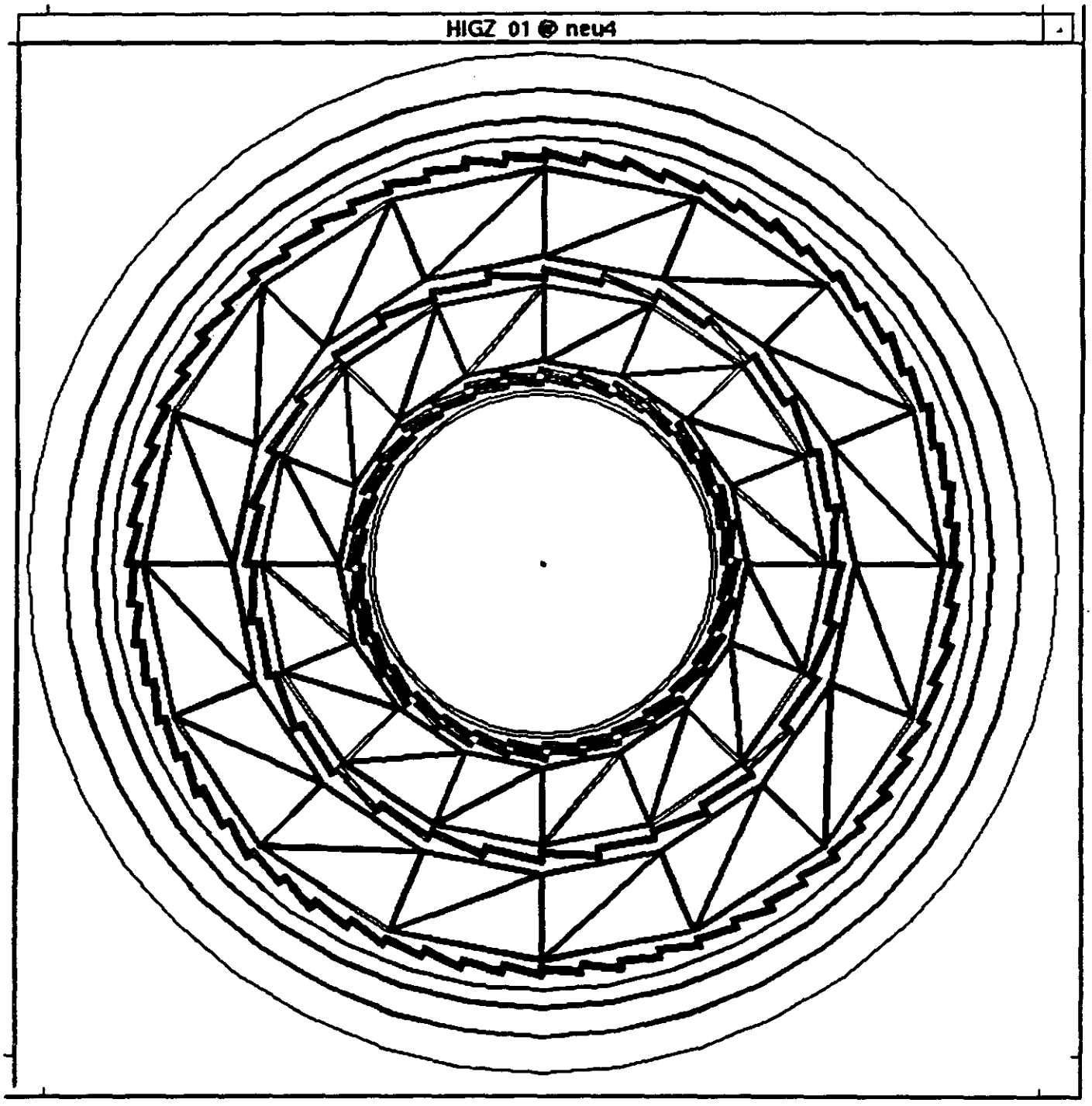


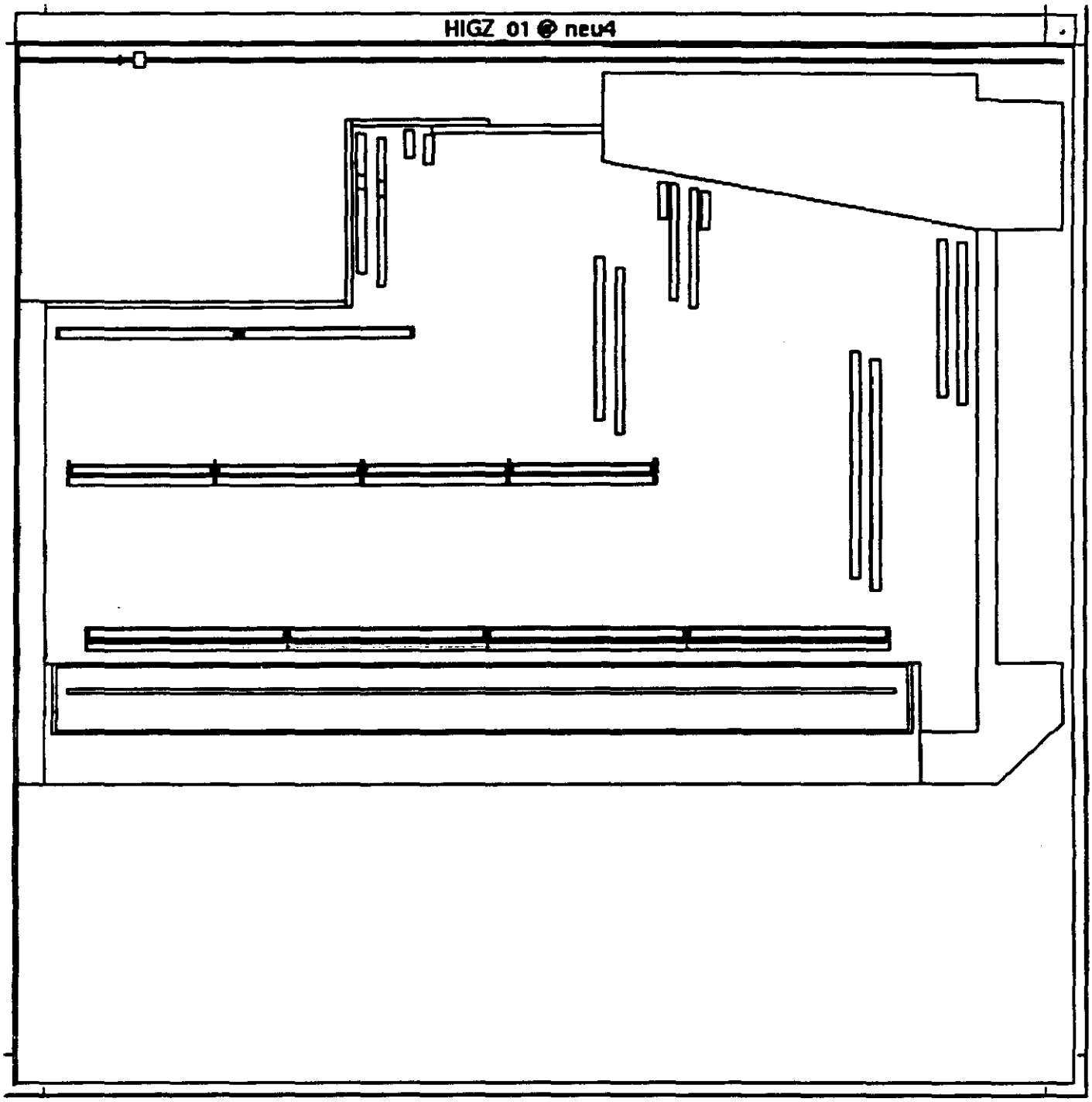
BARREL SUPPORT, SIDE

HIGZ 01 @ neu4

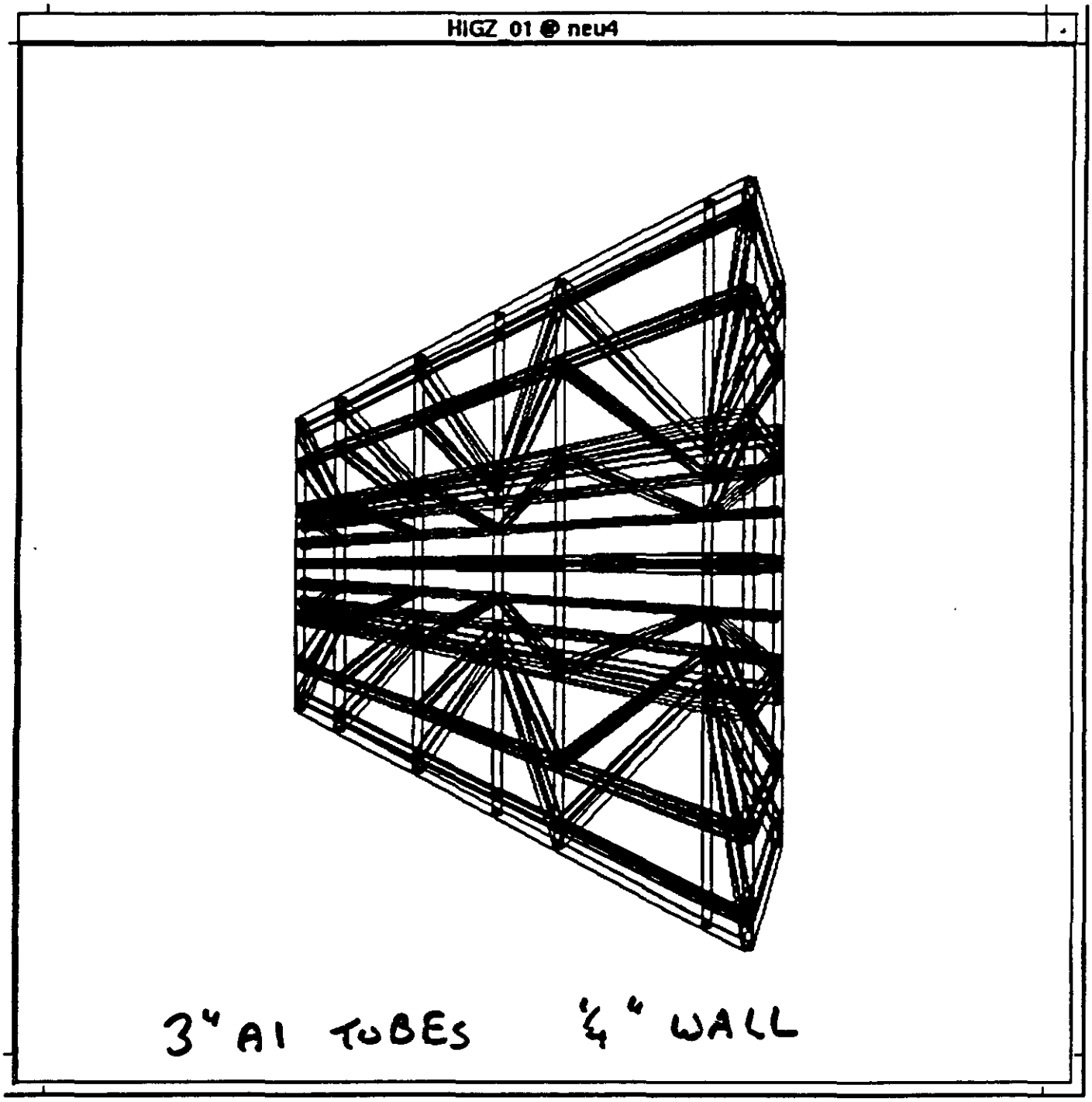


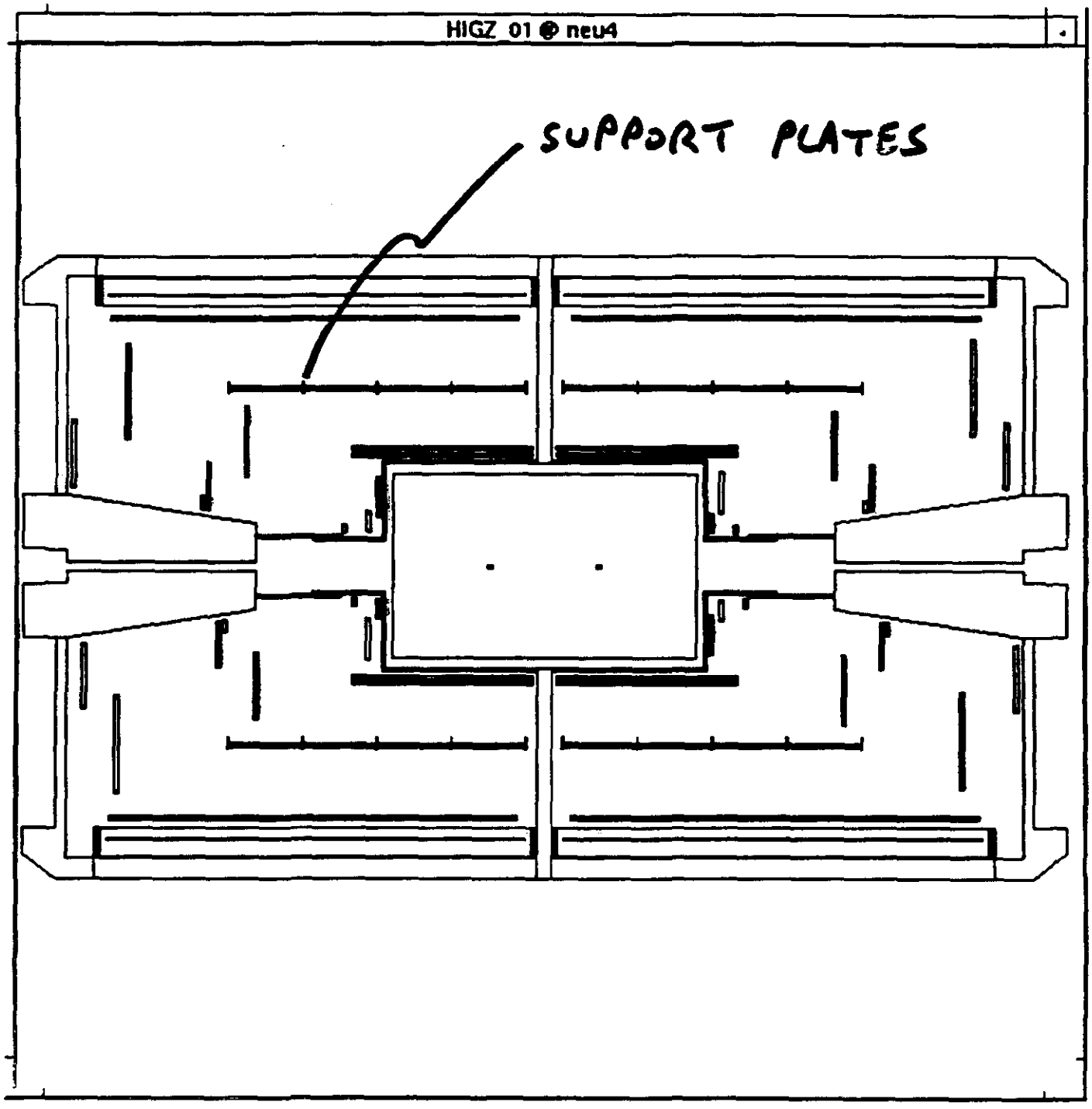
3" Al TUBES
¼" WALL


HIGZ 01 @ neu4


HIGZ 01 @ neu4

ENDCAP SUPPORT STRUCTURE



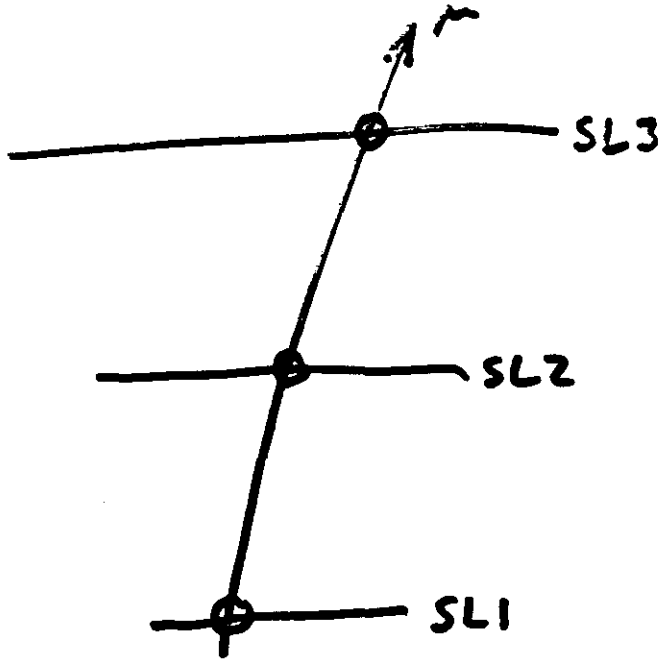

HIGZ 01 @ neu4
SUPPORT PLATES

MUON TRACKING

MUONS TRACKED THROUGH MUON SYSTEM USING GEANE, NOT GEANT TRACKING

GEANE CALCULATES THE AVERAGE PARTICLE TRAJECTORY AND A PROPAGATED ERROR MATRIX INCLUDING MULT SCATT

⇒ PRECISE MULT SCATT ERROR INCLUDING ALL MATERIAL ALONG PATH IN ONE SHOT, INSTEAD OF ACCUMULATING STATISTICS

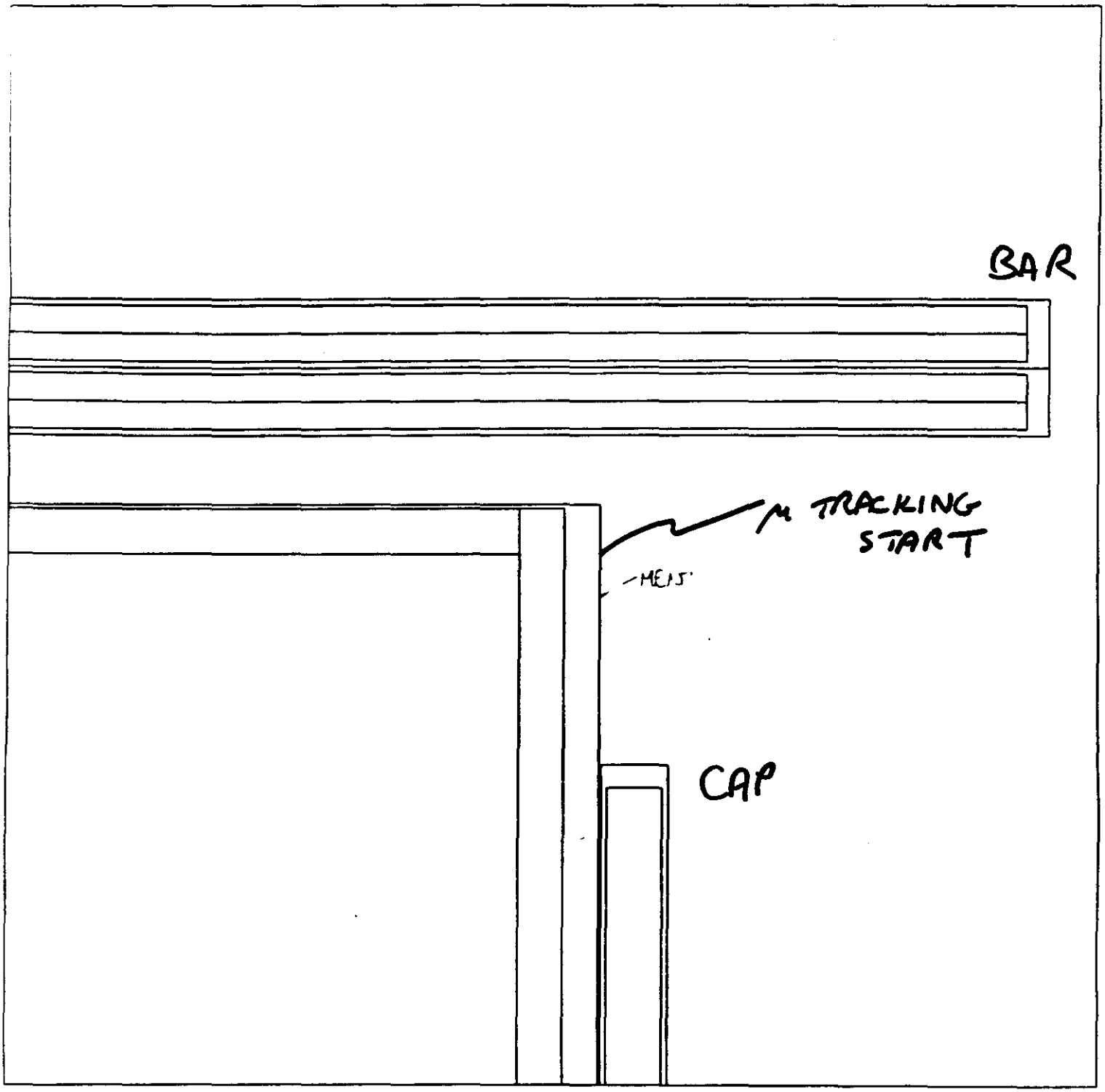


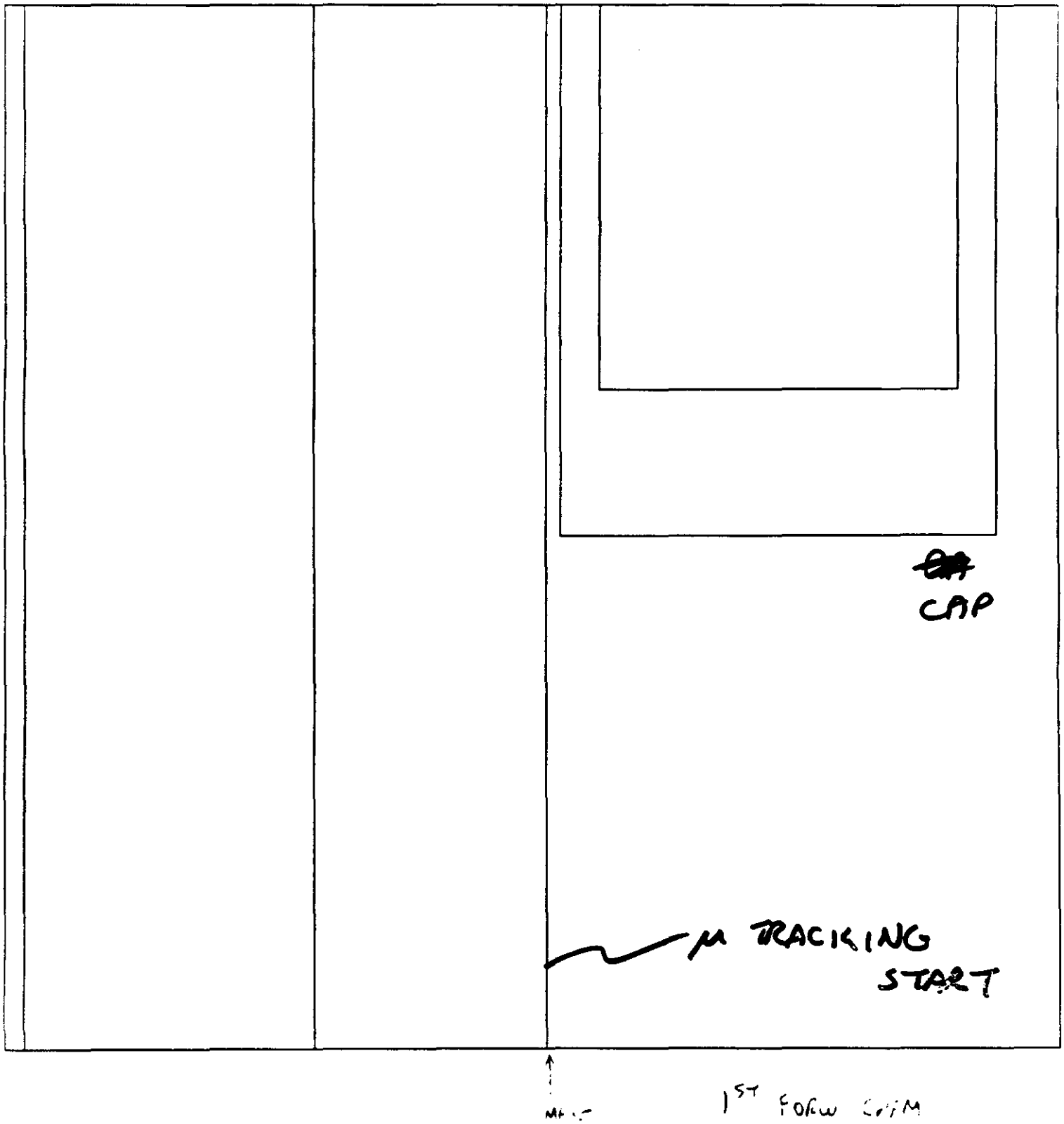
- POSITION, ERROR PREDICTIONS ARE EXTRACTED FROM GEANE AT EACH CHAMBER
- SAGITTA OBTAINED FROM POSITIONS (GEANE SWIMS PARTICLES THROUGH FIELDMAP)
- GEANE TRACKS TO PRECISE CHAMBER FIDUCIAL VOLUMES

  ⇒ ACCEPTANCE

- MULT SCATT ERROR IN BEND DIRECTION CALCULATED FROM ERROR MATRIX

  ⇒ MS CONTRIBUTION TO SAGITTA UNCERTAINTY


BAR
TRACKING START
CAP


CAP
TRACKING
START
1ST FORW SWIM

SAGITTA ERROR

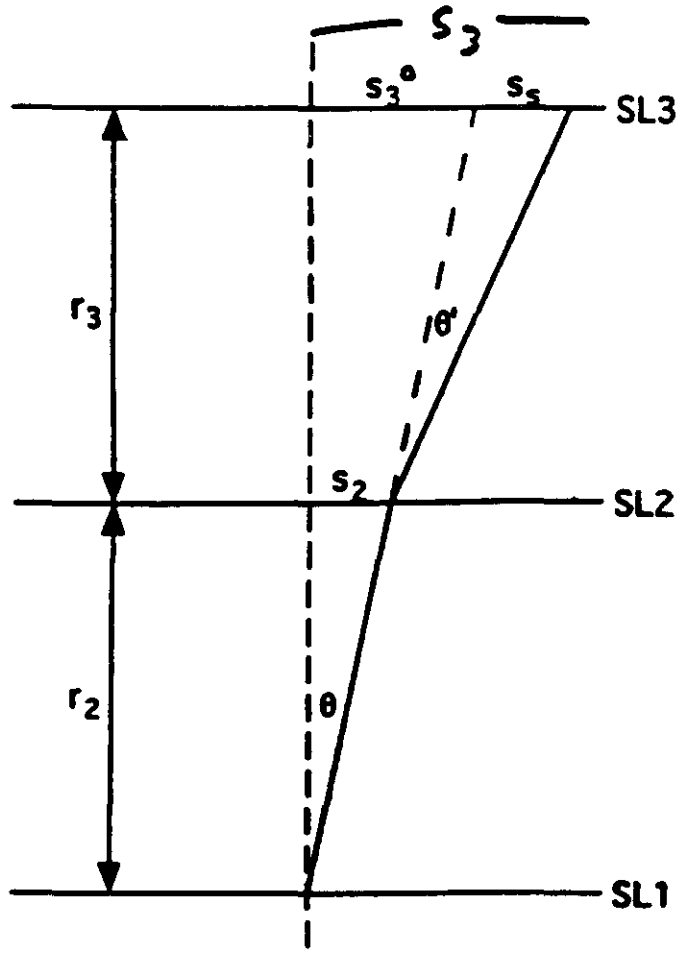
$$\frac{\Delta s}{s} = \frac{d\,1/p}{1/p}$$

$$= \sqrt{(\sigma_1^2 + \sigma_3^2)/4 + \sigma_2^2 + \sigma_{MS}^2}$$

$$\sigma_i^2 = \frac{\text{INTRINSIC}^2 + \text{INT. ALIGN}^2}{\text{NHITS}}$$

$$+ \text{EXT. ALIGN}^2$$

MS SAGITTA CONTRIBUTION



MS CONTRIB TO SAGITTA:

$$ds = \tfrac{1}{2}(s_1 + s_3) - s_2 = \tfrac{1}{2} s_3 - s_2 \qquad (\text{if } r_2 = r_3).$$

$$= \tfrac{1}{2}\left[\theta(r_2 + r_3) + \theta' r_3\right] - \theta r_2 = \underline{\underline{\tfrac{1}{2}\theta' r_3}}$$

NO SL2 SCATT: $s_2/r_2 = \dfrac{s_3^\circ}{r_2 + r_3}$

$$\Rightarrow s_3^\circ = s_2 \frac{r_2 + r_3}{r_2}$$

WITH SL2 SCATT, SL3 MS ERROR

σ_3 IS

$$\sigma_3 = \sigma_3^0 \oplus \sigma_3^s$$

$$\sigma_3^{s\,2} = \sigma_3^2 - \sigma_3^{0\,2}$$

$$= \sigma_3^2 - \left(\frac{r_2 + r_3}{r_2}\sigma_2\right)^2$$

GEANE CHECK:

σ_3^s FROM SL2 → SL3 TRACKING = $\underline{.0019}$

σ_3 FROM SL1 → SL3 " = .00560

σ_2 " " " = .00249

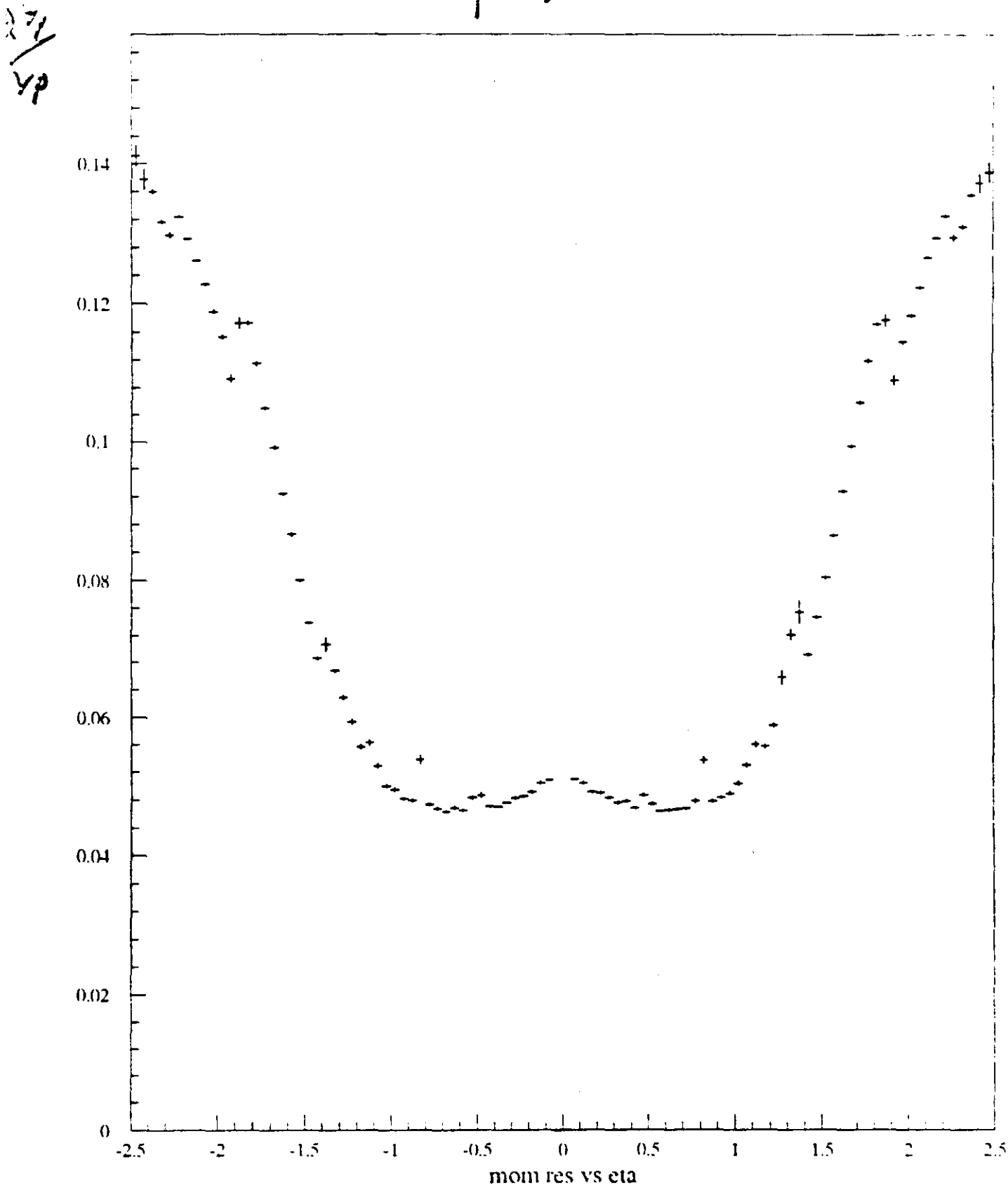
$$\Rightarrow \sigma_3^2 - \left(\frac{r_2 + r_3}{r_2}\sigma_2\right)^2 = \underline{.0019}$$

σ_3^s FROM FORMULA = $\underline{.0019}$

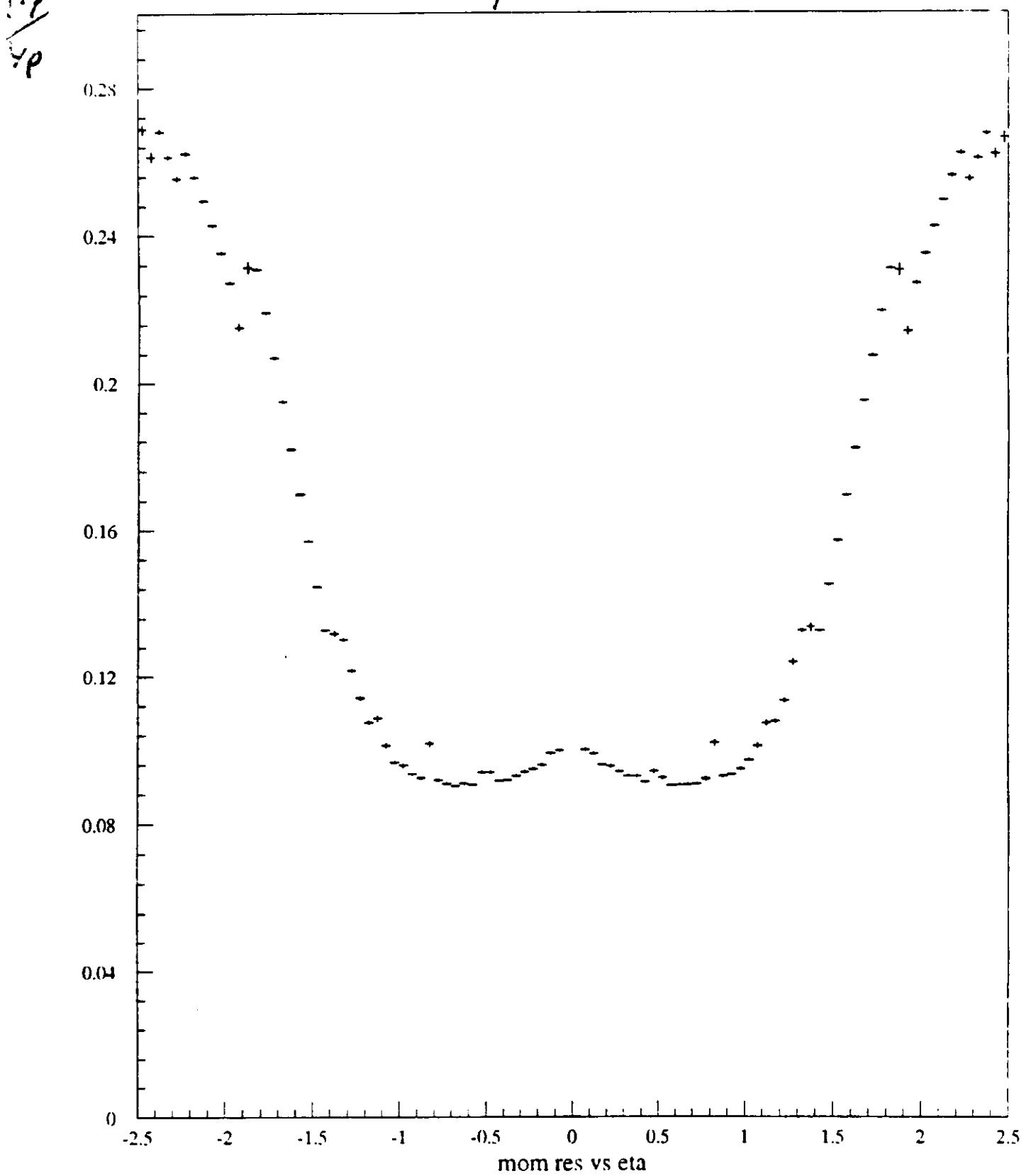
$$\theta_{proj} = \frac{21\ \text{MeV}}{\sqrt{2}} \frac{\sqrt{x/X_0}}{\beta p}\left(1 + \frac{1}{9}\log_{10}\frac{x}{X_0}\right)$$

MS SAGITTA FROM GEANE AGREES WITH FORMULA. $\sigma_{MS} = \sigma_3^s/2$.

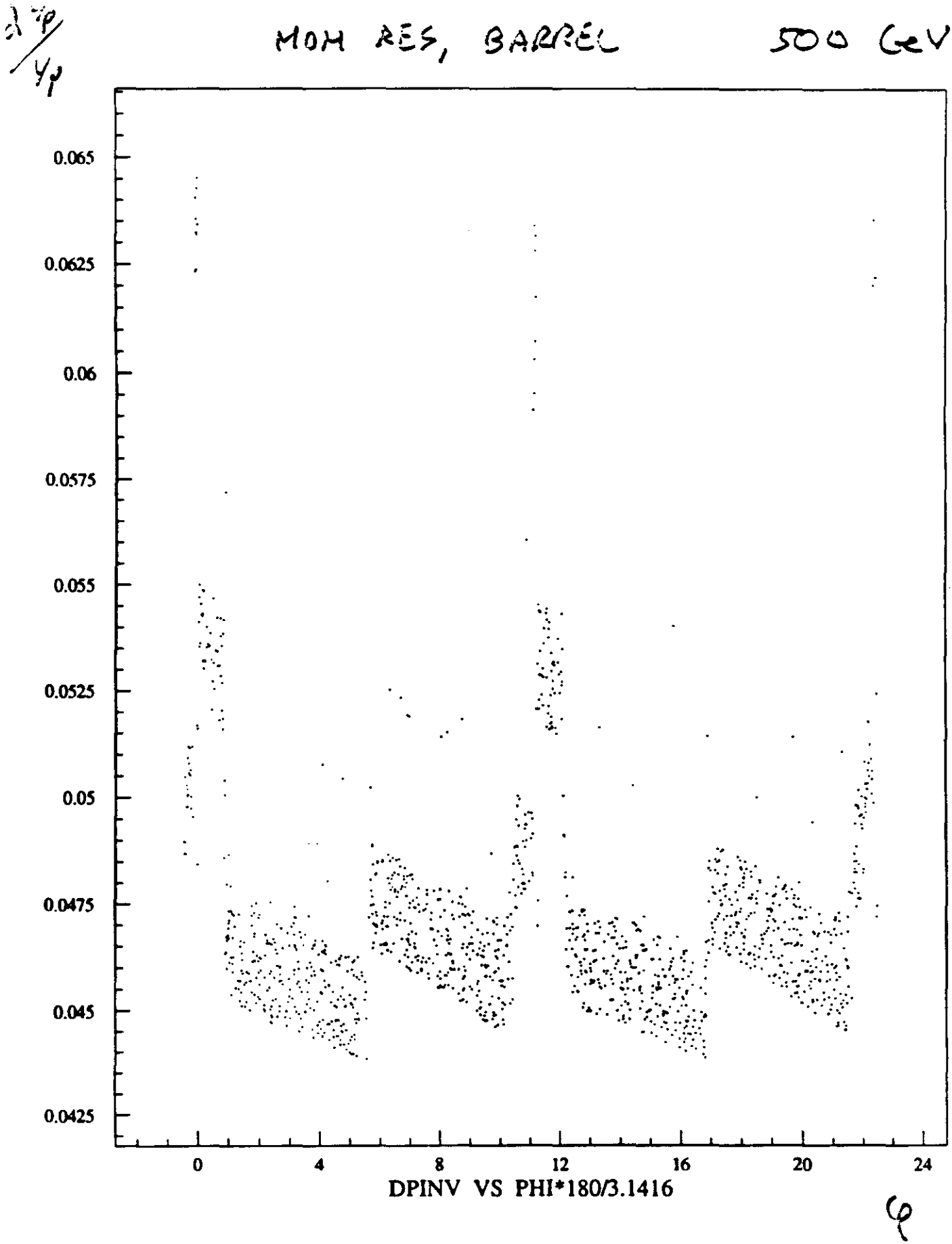
MOM RES vs η , MC 500 GeV

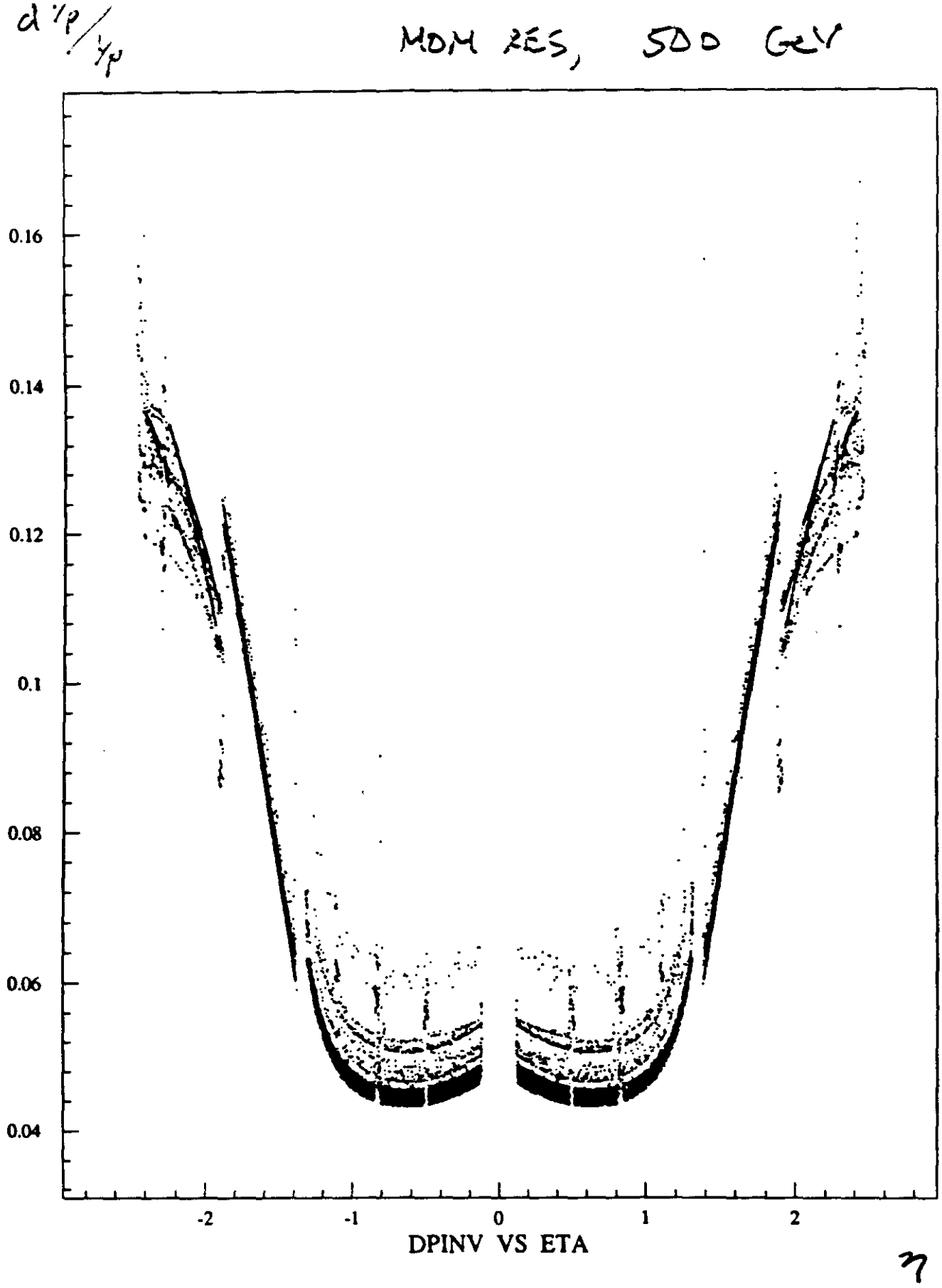


MOM RES vs η , MC 1000 GeV

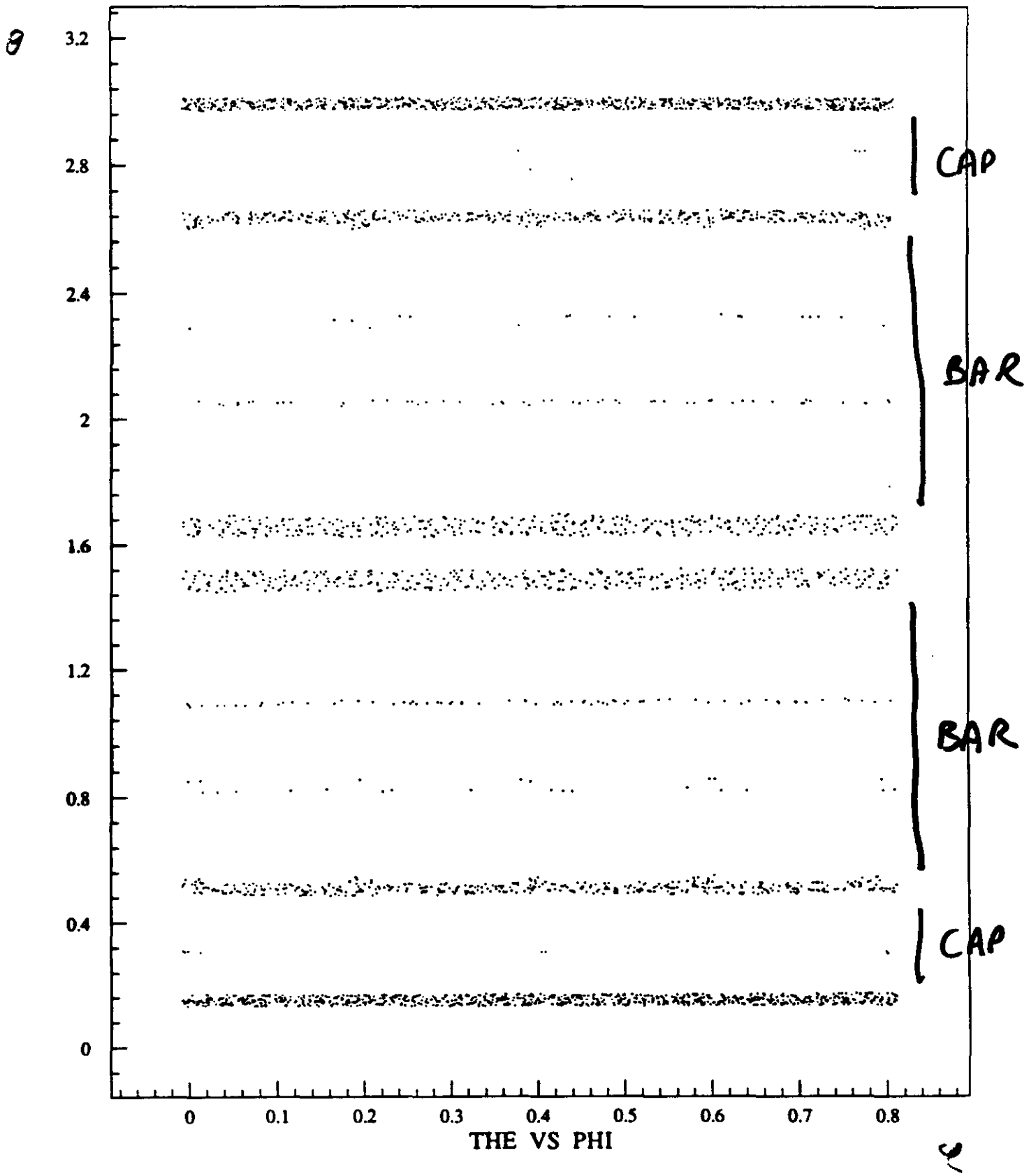


η

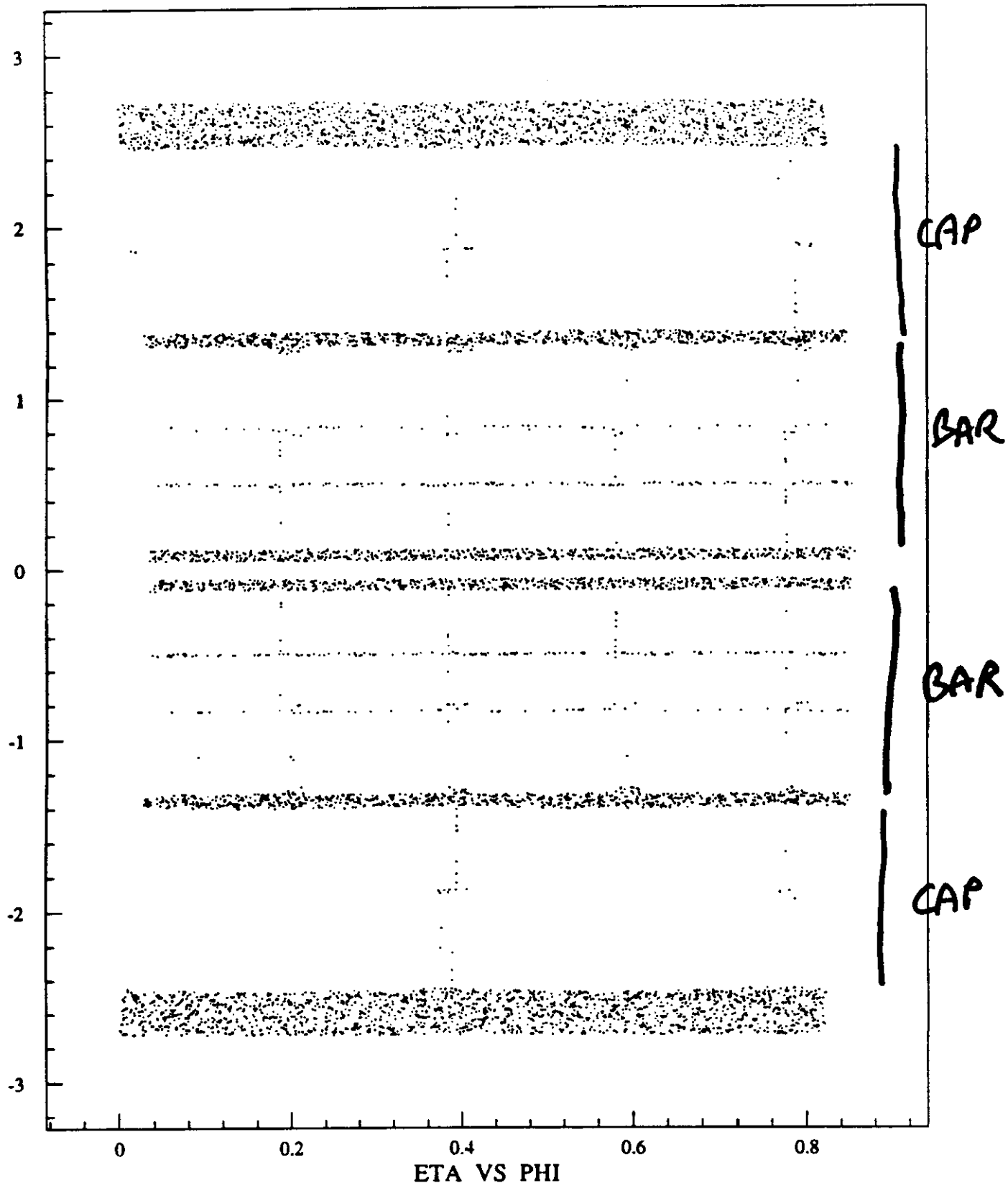

MOM RES, BARREL 500 GeV
$\delta p/p$
0.065
0.0625
0.06
0.0575
0.055
0.0525
0.05
0.0475
0.045
0.0425
0
4
8
12
16
20
24
DPINV VS PHI*180/3.1416
φ


d 1/p / 1/p
MOM RES, 500 GeV
0.16
0.14
0.12
0.1
0.08
0.06
0.04
-2
-1
0
1
2
DPINV VS ETA
η

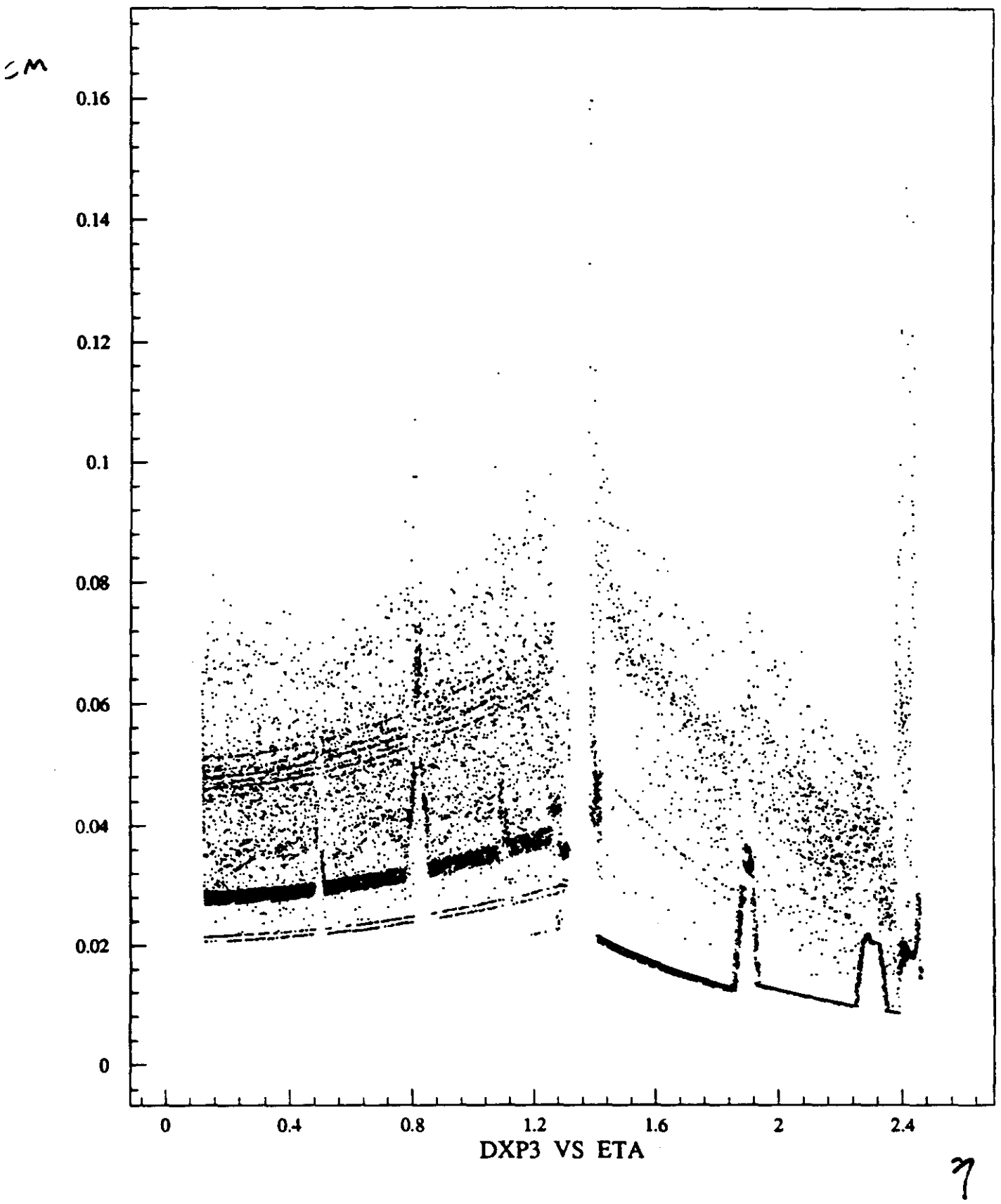
<3 SUPERLAYERS 500 GeV



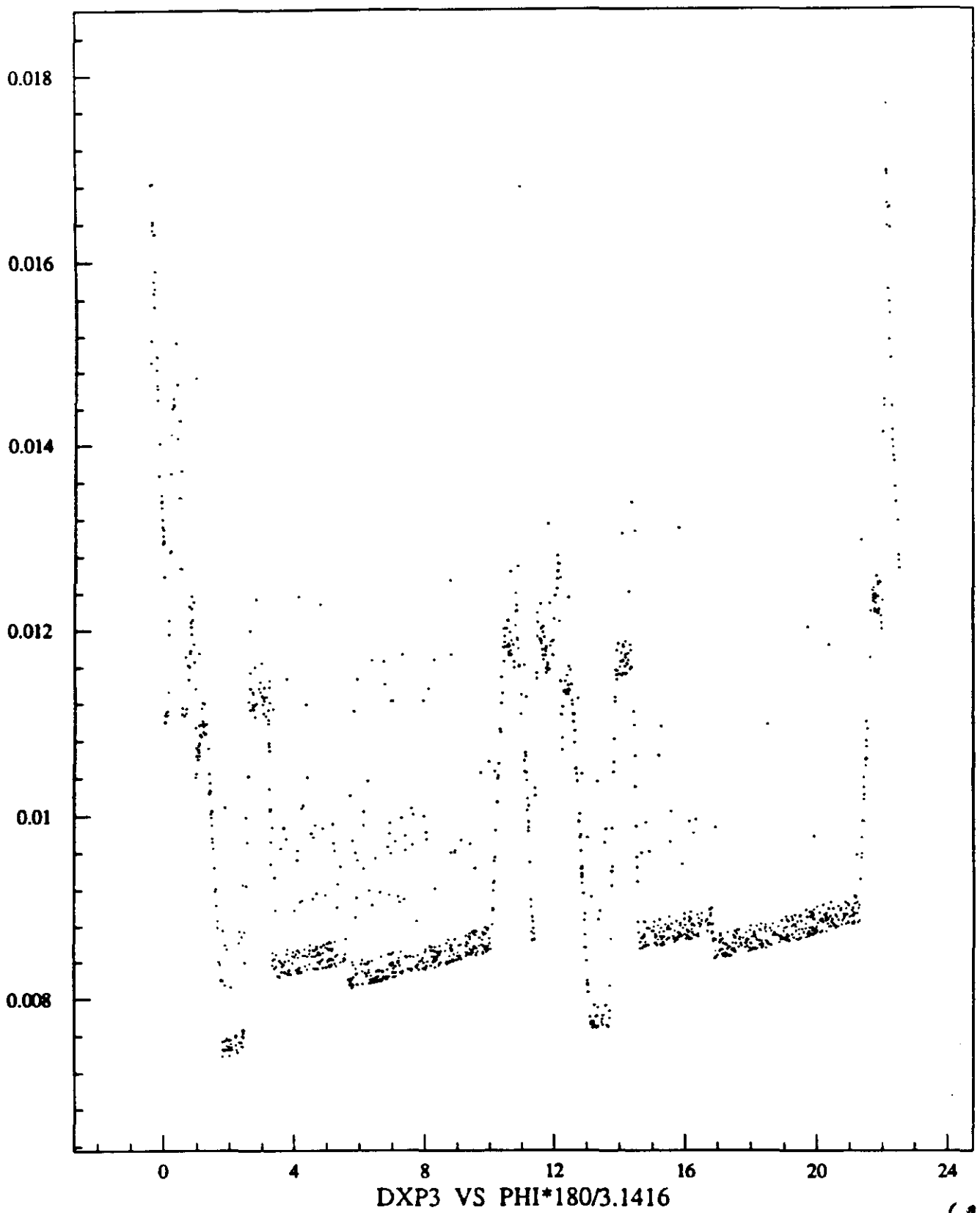
<23 SLs HIT η vs φ 10 GeV



MULT SCATT AT SL3 100 GeV

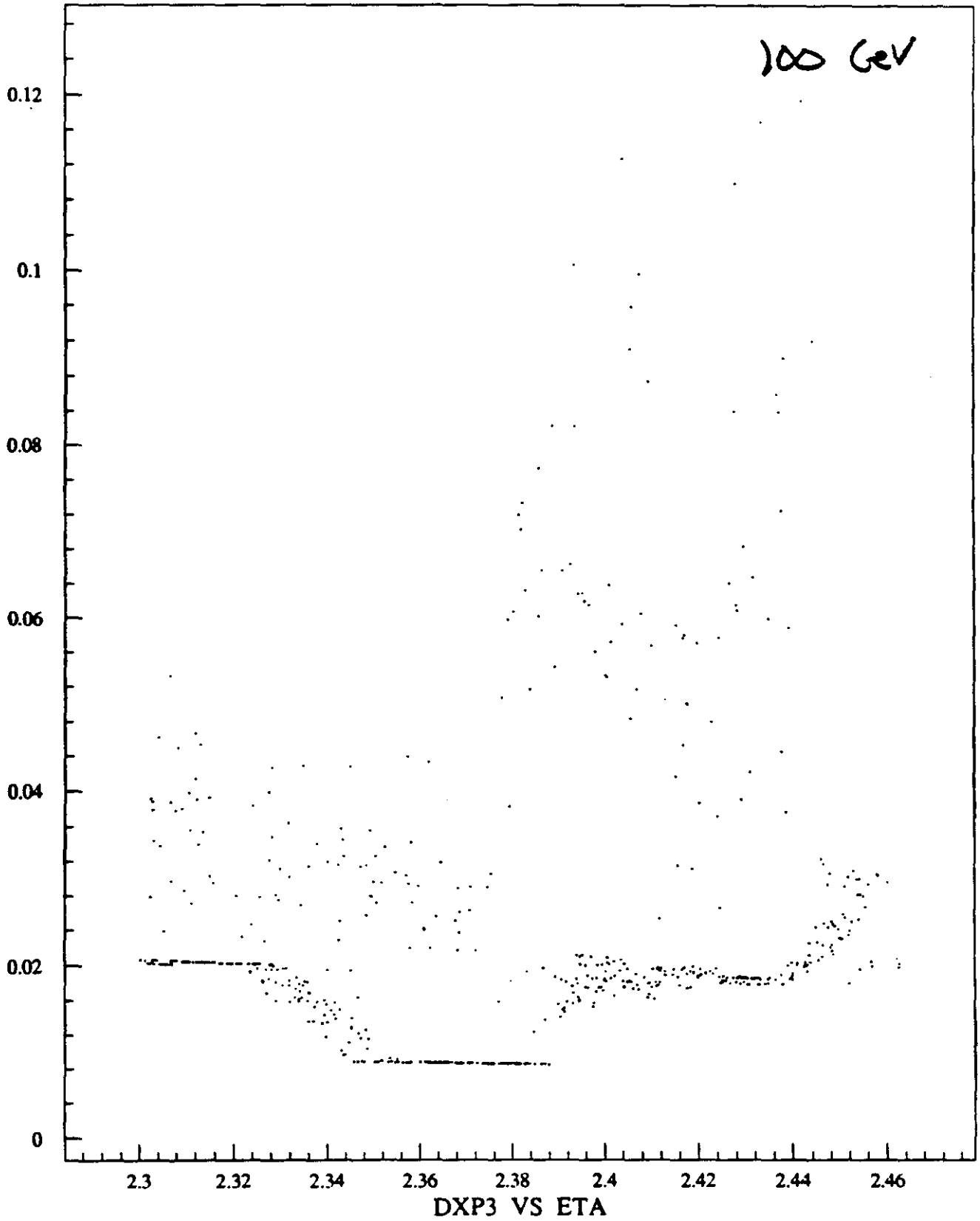


MULT SCATT AT SL3



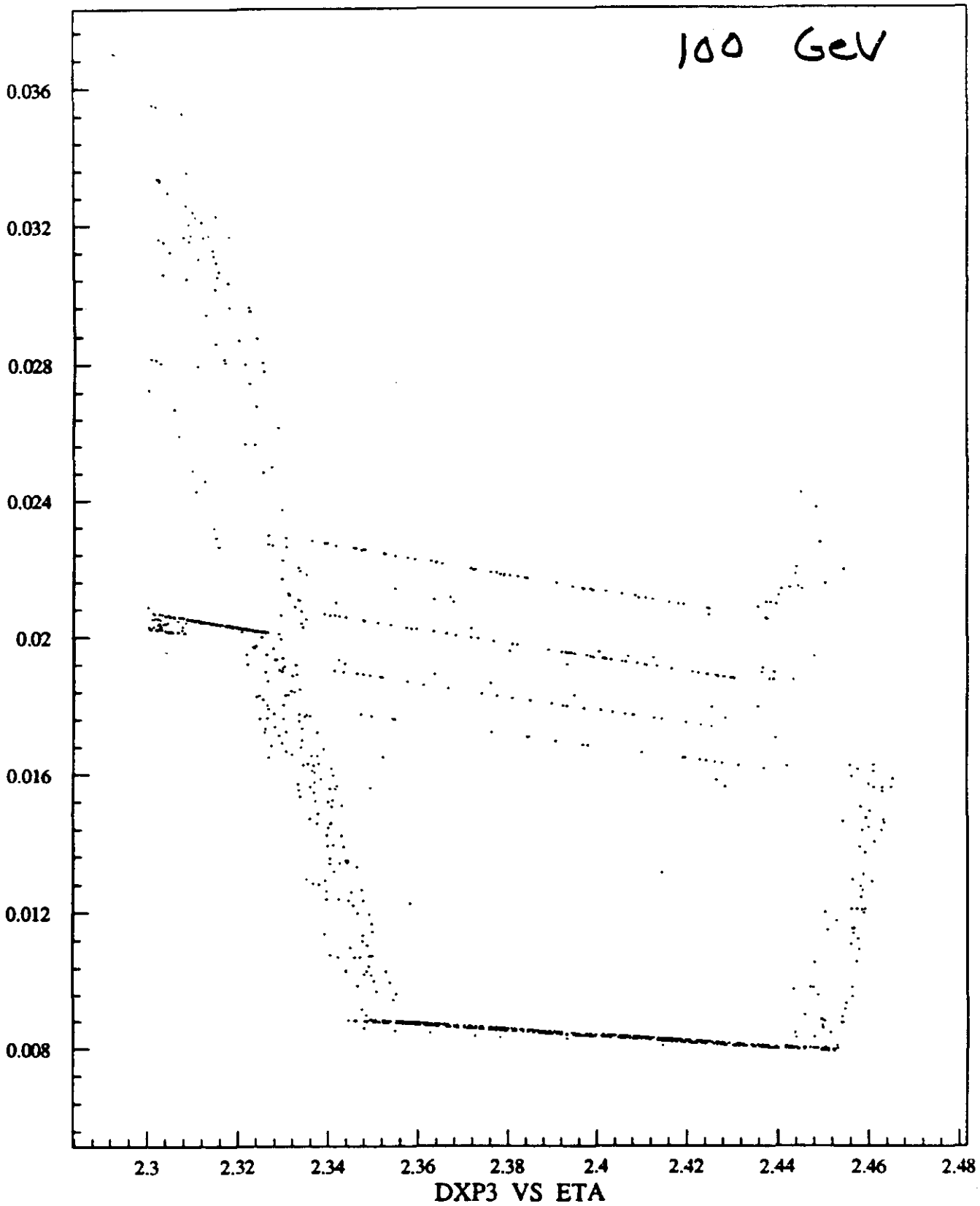
φ

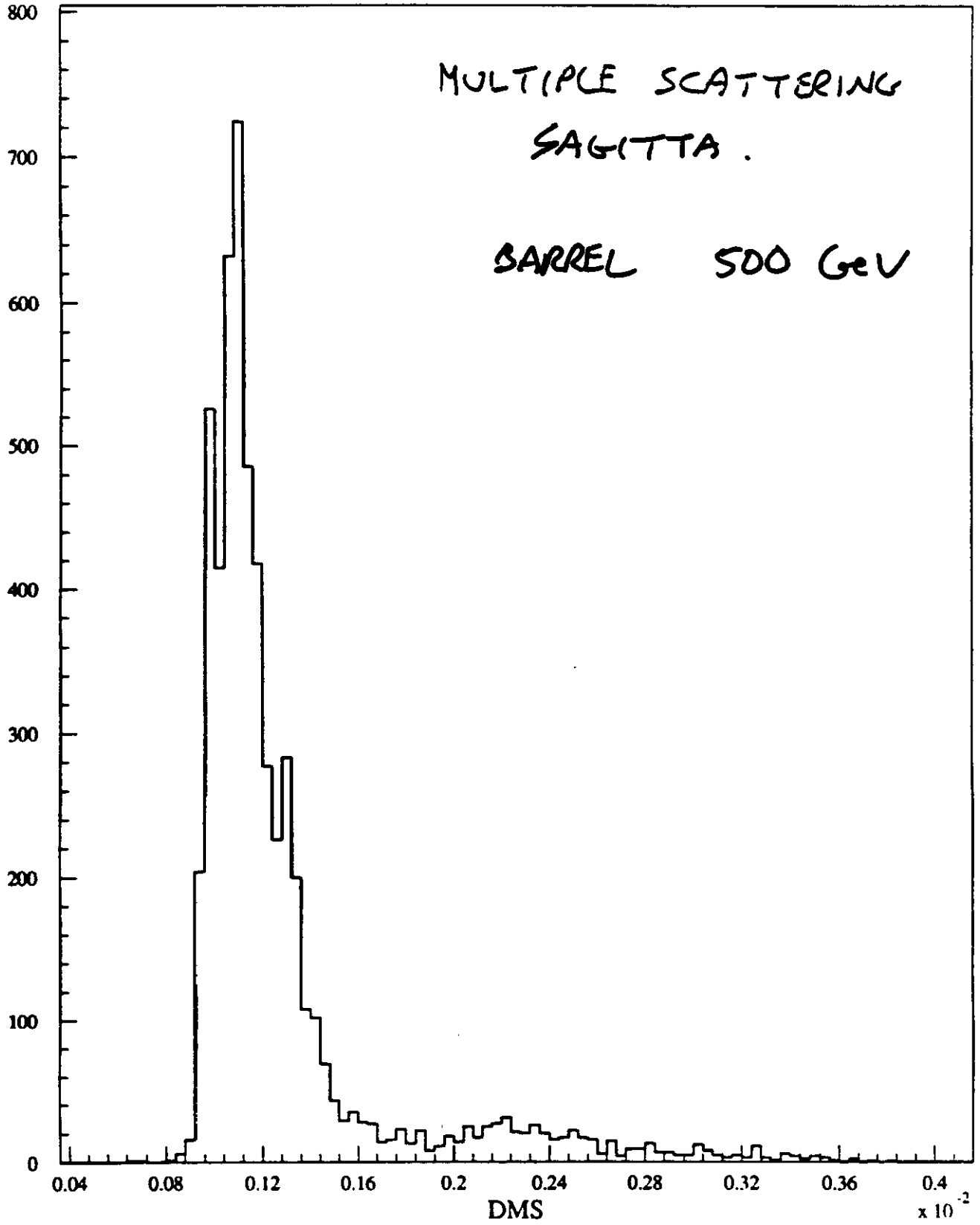
MS AT SL3, FORWARD, W/SUPPORT



η

MS AT SL3, FORWARD, NO SUPPORT




MULTIPLE SCATTERING
SAGITTA.
BARREL 500 GeV
800
700
600
500
400
300
200
100
0
0.04
0.08
0.12
0.16
0.2
0.24
0.28
0.32
0.36
0.4
DMS
x 10^-2

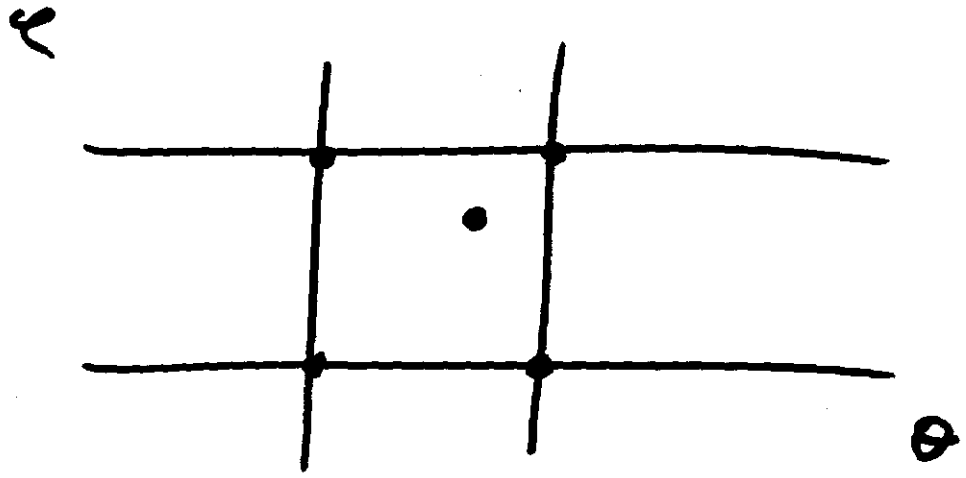
PARAMETRIZATION

- SIMU IS RUN WITH N EVENTS RANDOMLY DISTRIBUTED IN EACH $1^\circ \times 1^\circ$ θ, φ BIN (N=4 AT PRESENT).
- RUNNING TIME ~ 1 hr FOR ~ 40k ev., ONE MOMENTUM POINT
- DATA SETS TAKEN AT 10, 25, 50, 100, 200 500, 1000 GeV.
- TABLES IN θ, φ, p WITH $2^\circ \times 2^\circ$ BINS BUILT FROM DATA:

$$d\,{}^1/_p \,/\, {}^1/_p, \quad \frac{d \cos\theta}{\cos\theta}, \quad \text{ACCEPTANCE}$$

- ACCEPTANCE = PROBABILITY OF MEASURING A MUON IN ALL 3 SUPERLAYERS

- BILINEAR INTERPOLATION BETWEEN BINS IN θ, φ



- LINEAR INTERPOLATION BETWEEN MOMENTUM POINTS
- EXTRAPOLATION OVER 1000 GeV: ACCURATE: ACCEPT, d theta DON'T CHANGE, MOM RES IS LINEAR IN p.
- ON LOW END, TABLES SHOULD GO TO LOWEST MOMENTUM OF INTEREST; EXTRAPOLATION OFF LOW END NOT ACCURATE

TRACKS NOT ORIGINATING FROM VERTEX (OFF-RADIAL):

RESOLUTION DEGRADED TO CROSS-SECTOR RESOLUTION (ASSUMING SECTOR-SECTOR ALIGNMENT OF 1mm) AND ACCEPTANCE CHECKED.

PARAM ACCESSED VIA

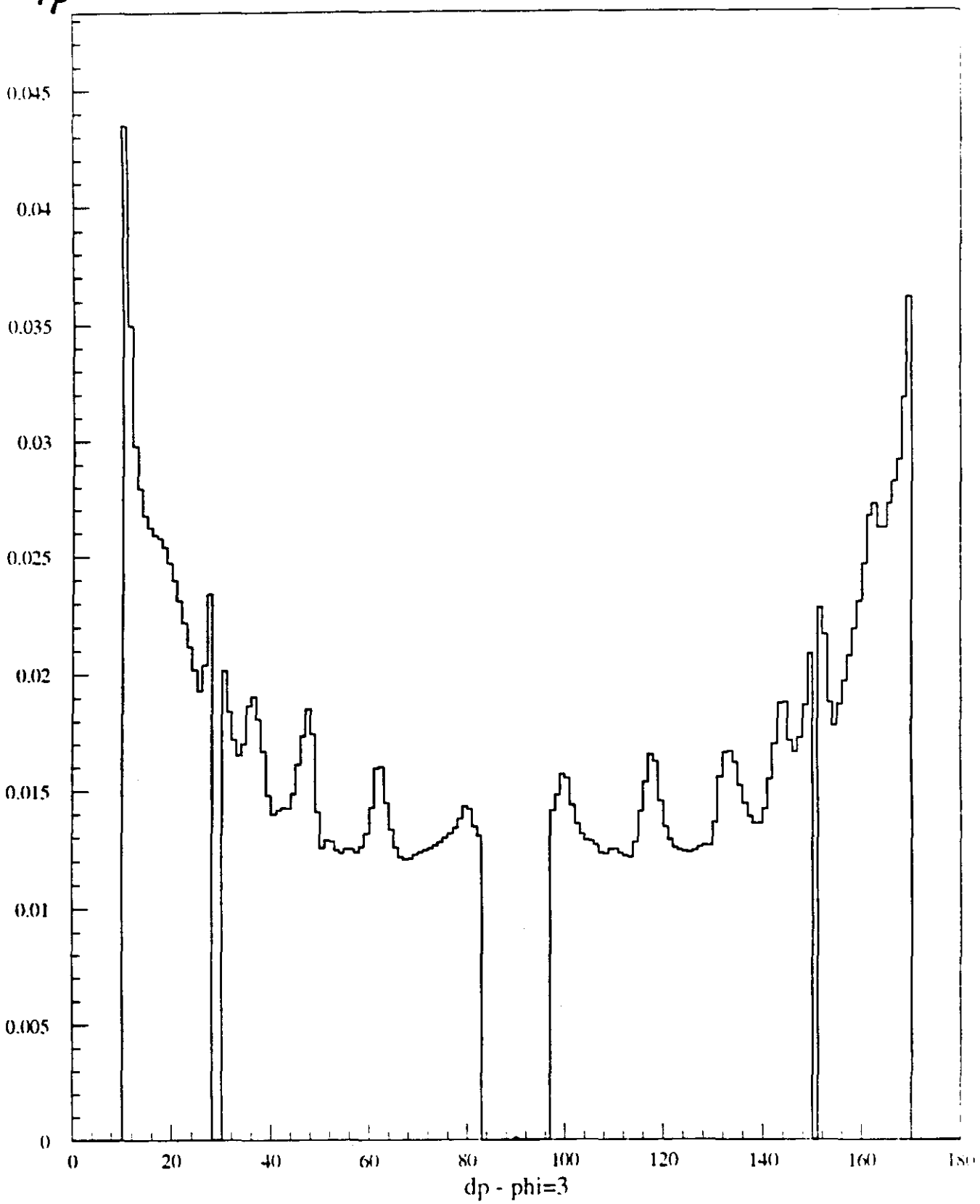
fsi_mudp

ROUTINE ; TABLES IN

fsi_mudp.dat

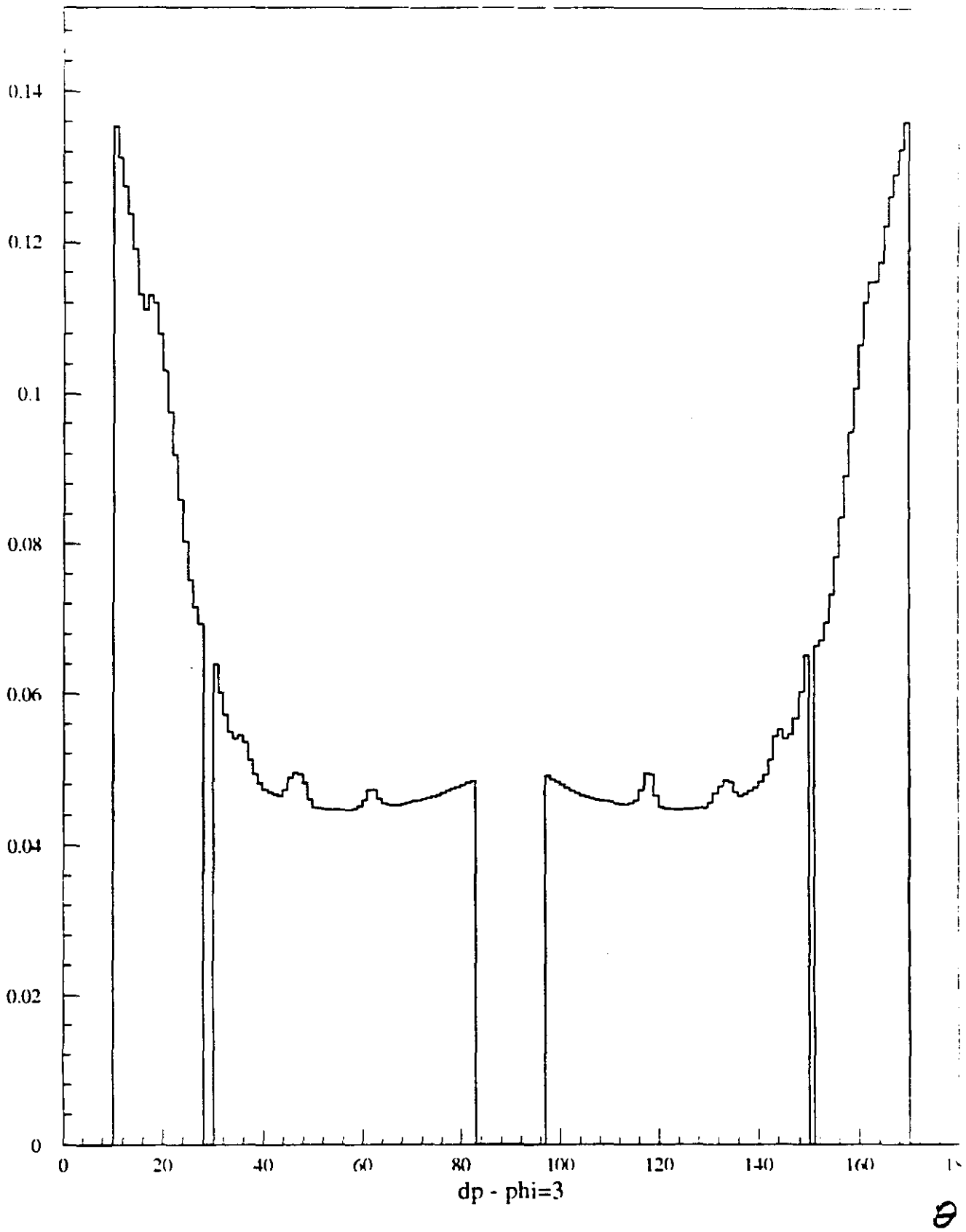
```
call fsi_mudp
     ( xin,   POS'N AT μ SYSTEM ENTR.
       pin,   MOM      "      "      "
       chg,   CHARGE
       dp,    MOM RES
       dth,   d cos(theta)/cos θ
       acc,   ACCEPTANCE
       istat) STATUS      0 = O.K.
```

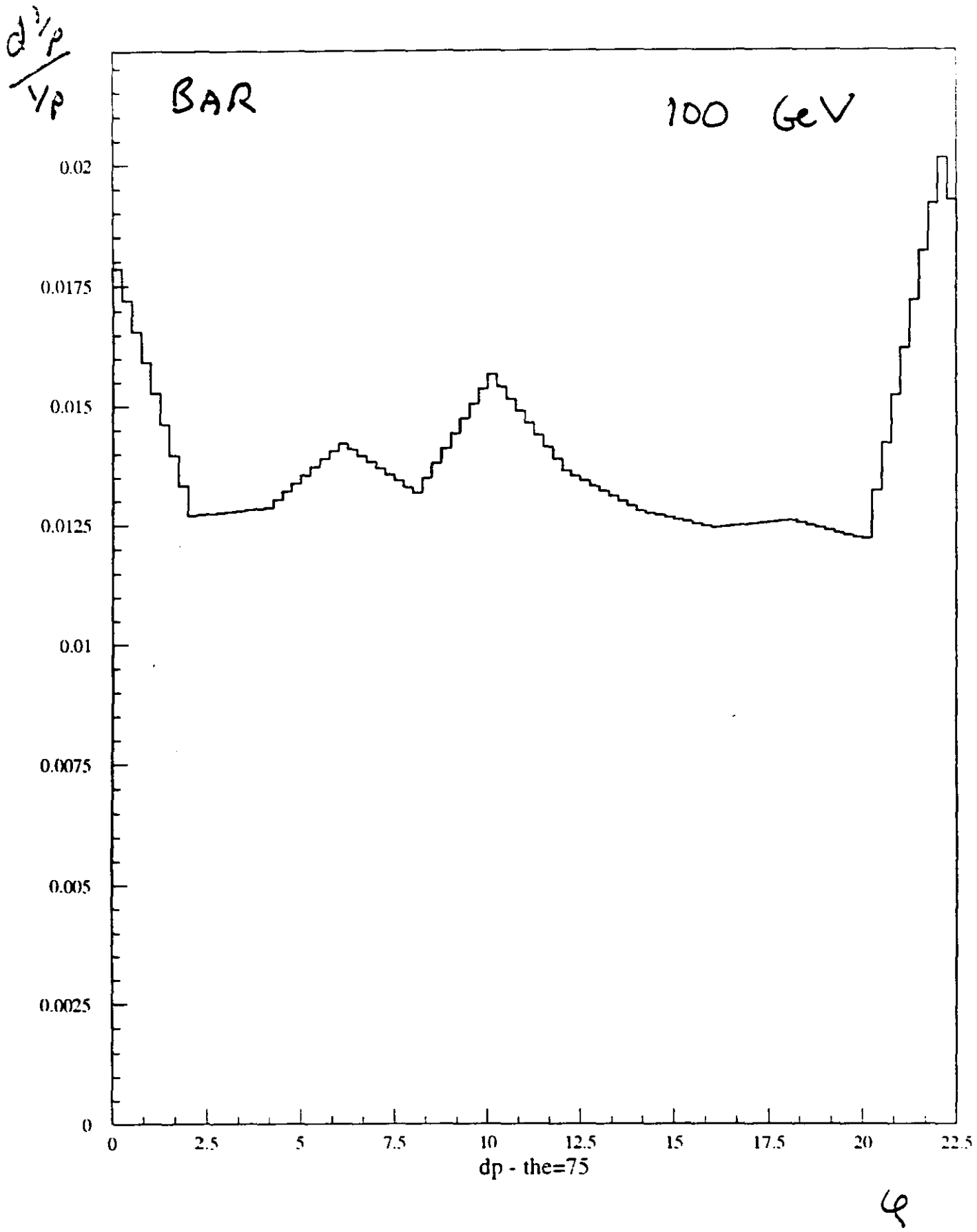
d^2p / dp PARAM $\varphi = 3°$ 100 GeV



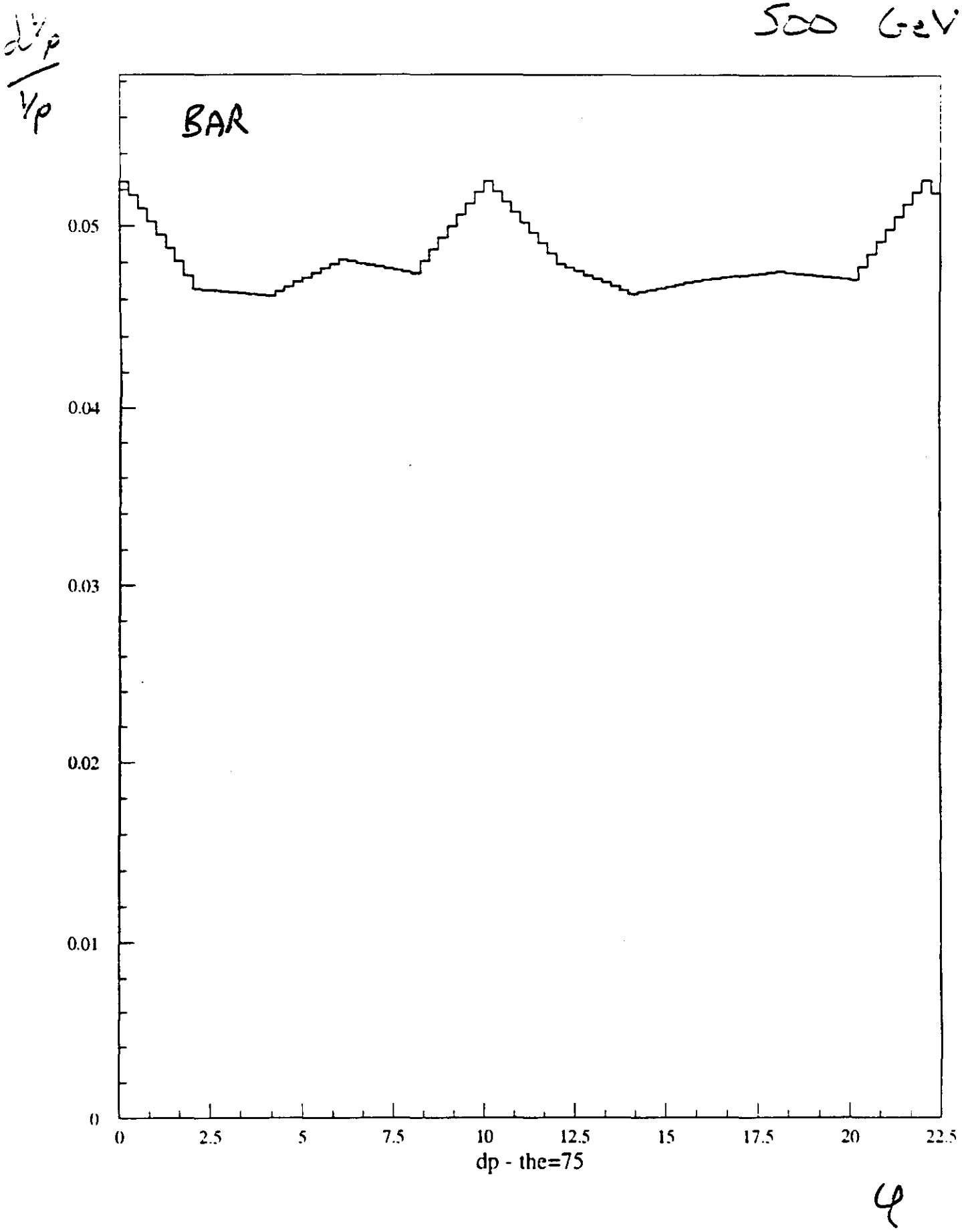
θ

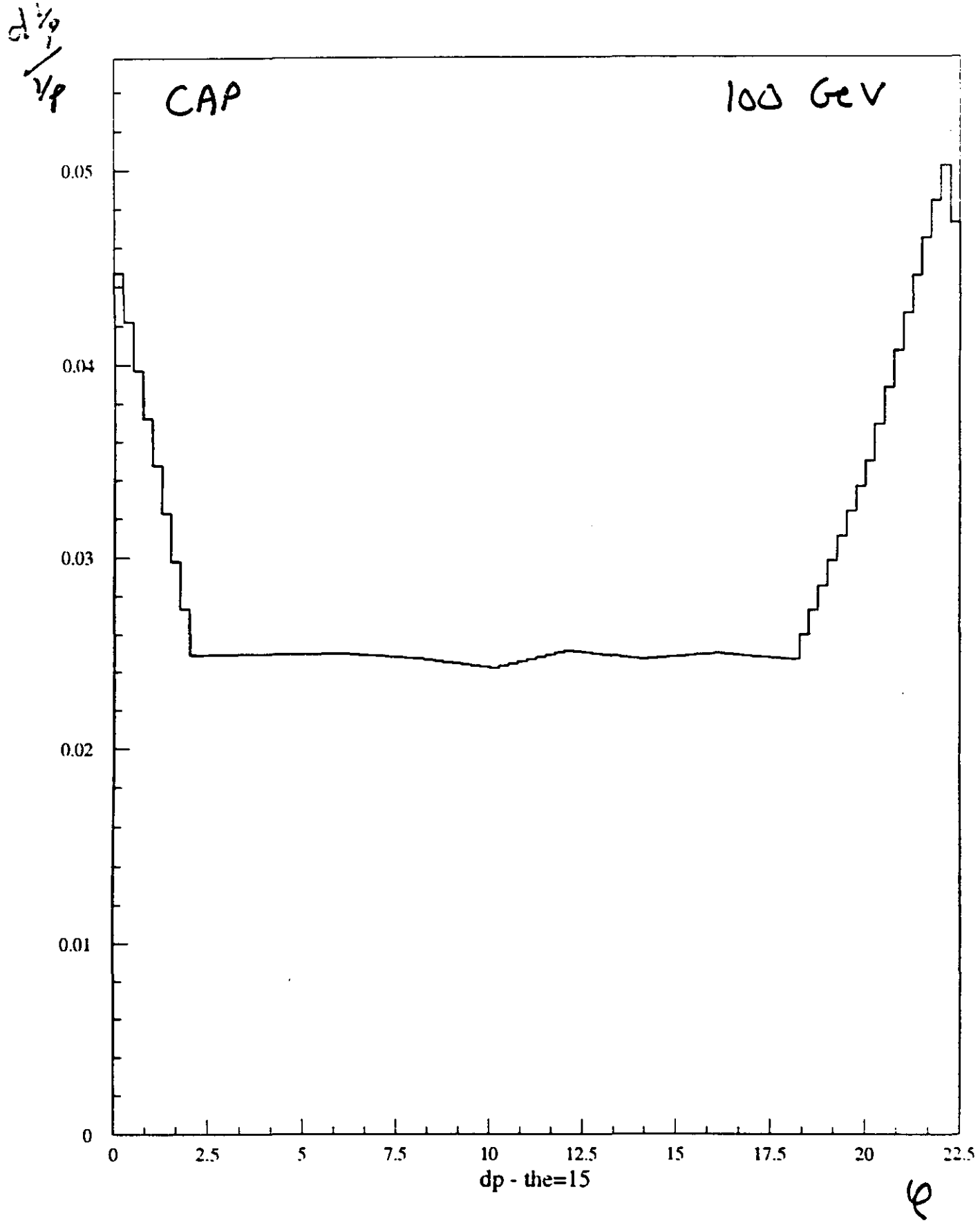
$d^2\sigma/dp$ PARAM $\varphi = 3°$ 500 MeV

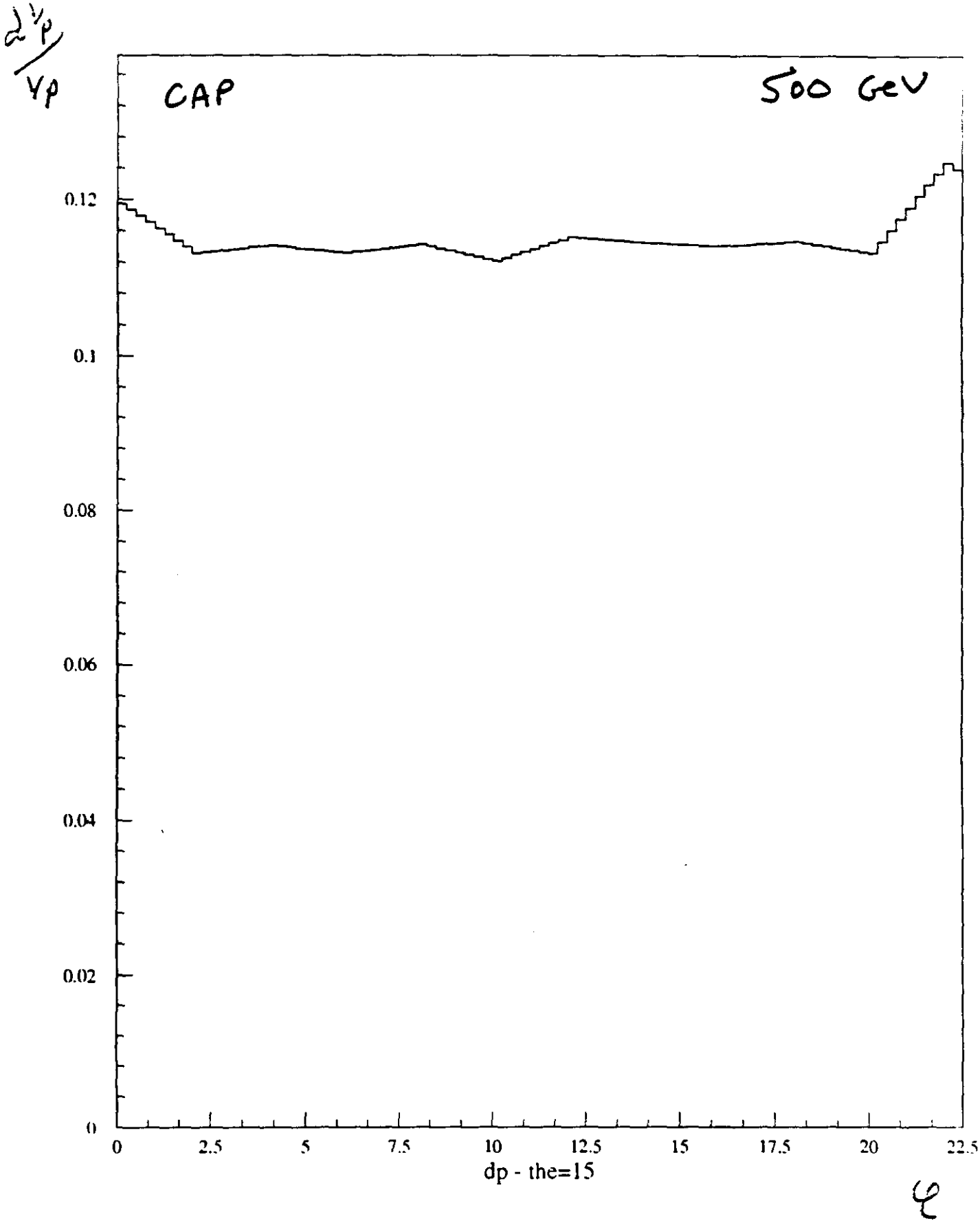



d³p / 1/p
BAR
100 GeV
0.02
0.0175
0.015
0.0125
0.01
0.0075
0.005
0.0025
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
dp - the=75
φ

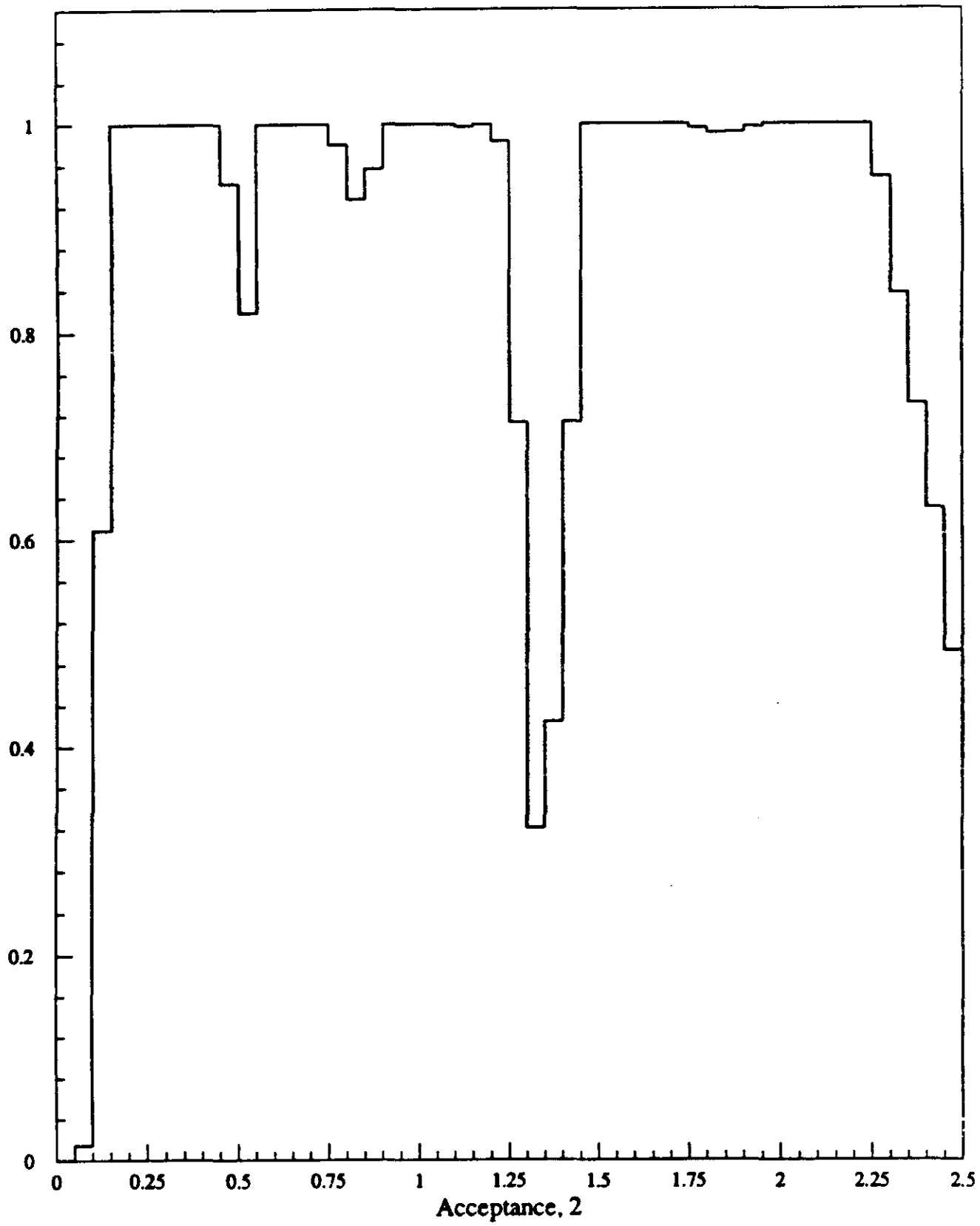
500 GeV


dN/p / 1/p
BAR
0.05
0.04
0.03
0.02
0.01
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
dp - the=75
φ


CAP
100 GeV
0.05
0.04
0.03
0.02
0.01
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
dp - the=15

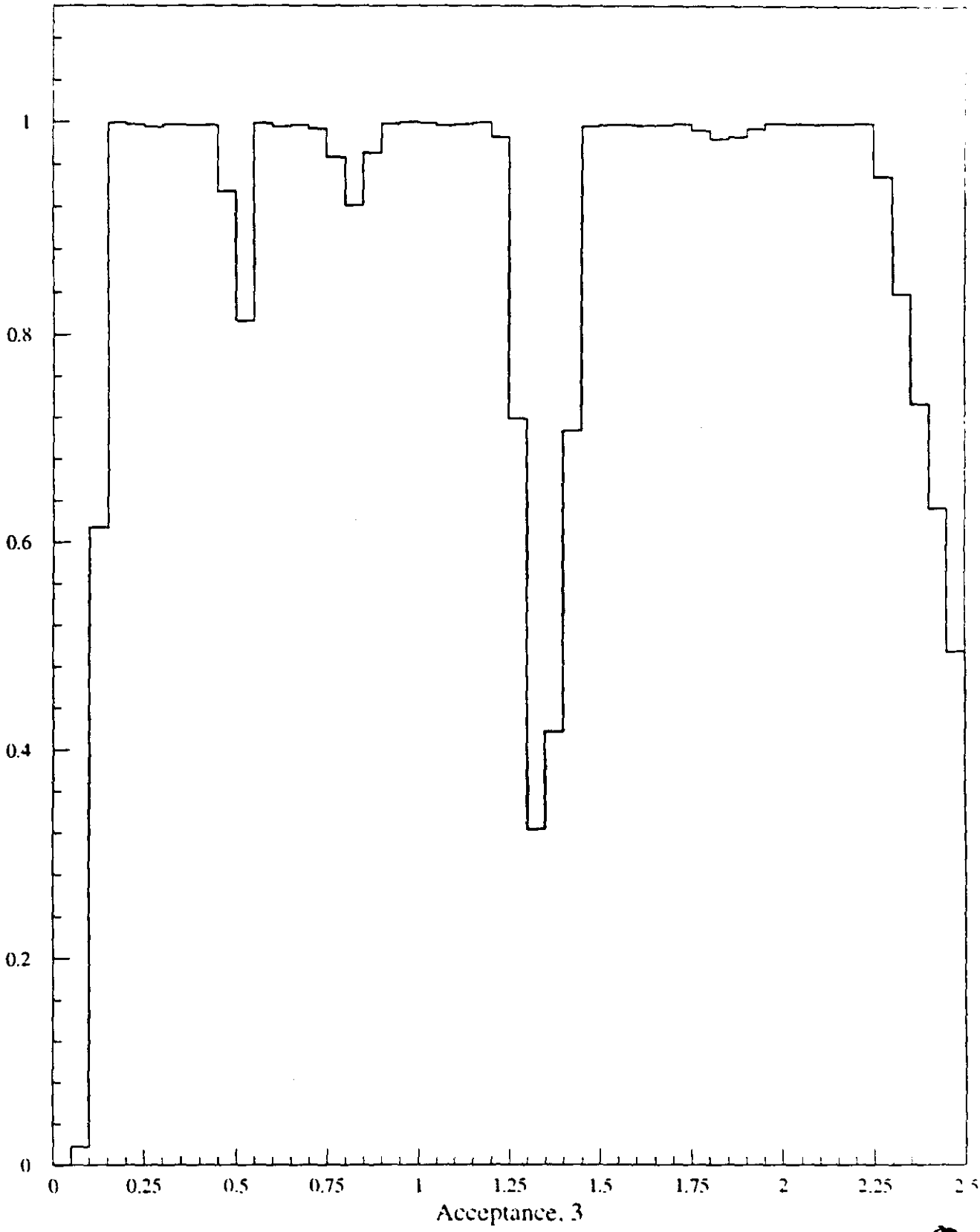

CAP
500 GeV
0.12
0.1
0.08
0.06
0.04
0.02
0
0
2.5
5
7.5
10
12.5
15
17.5
20
22.5
dp - the=15

ACCEPTANCE 500 GeV



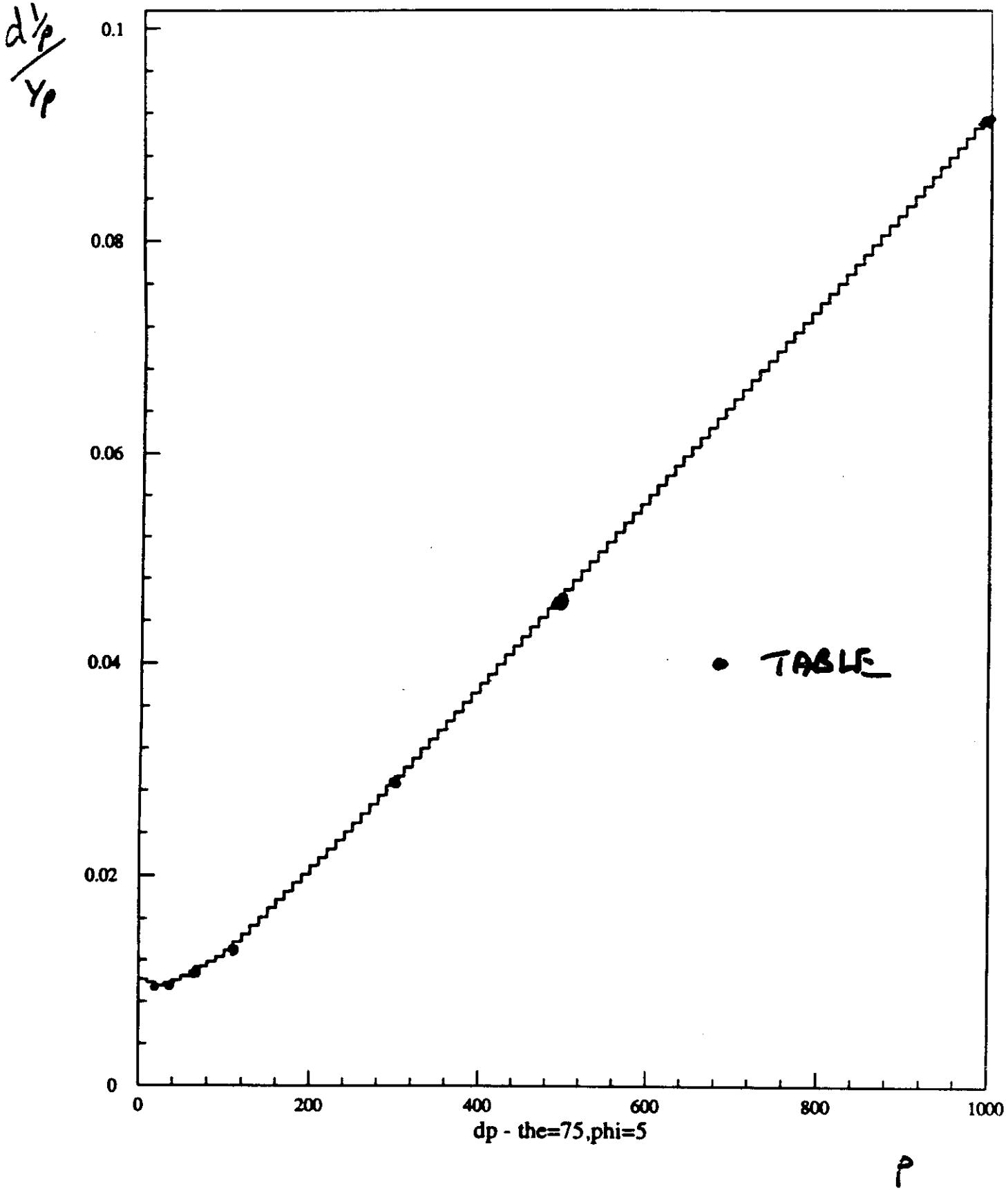
7

ACCEPTANCE 10 GeV

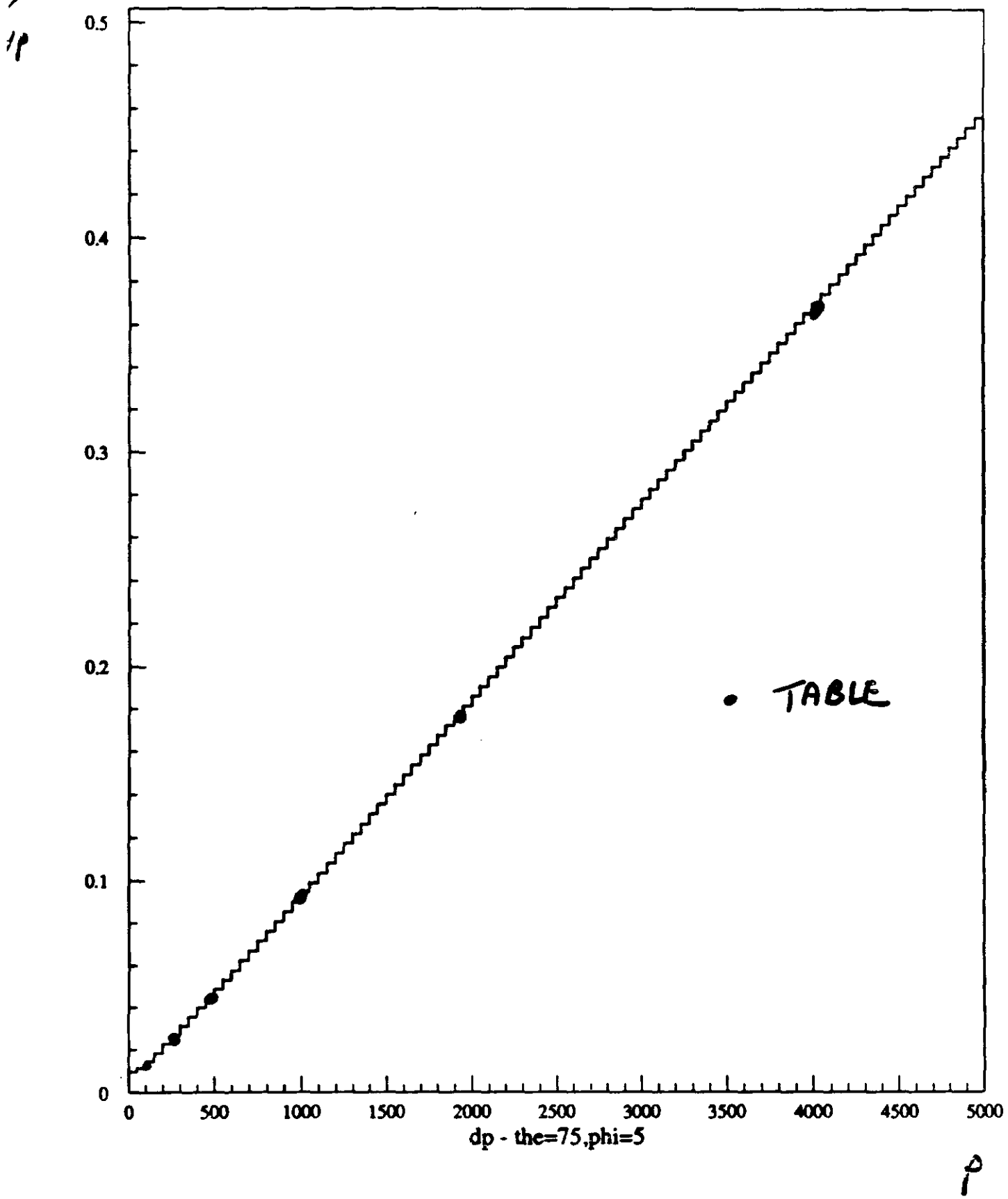


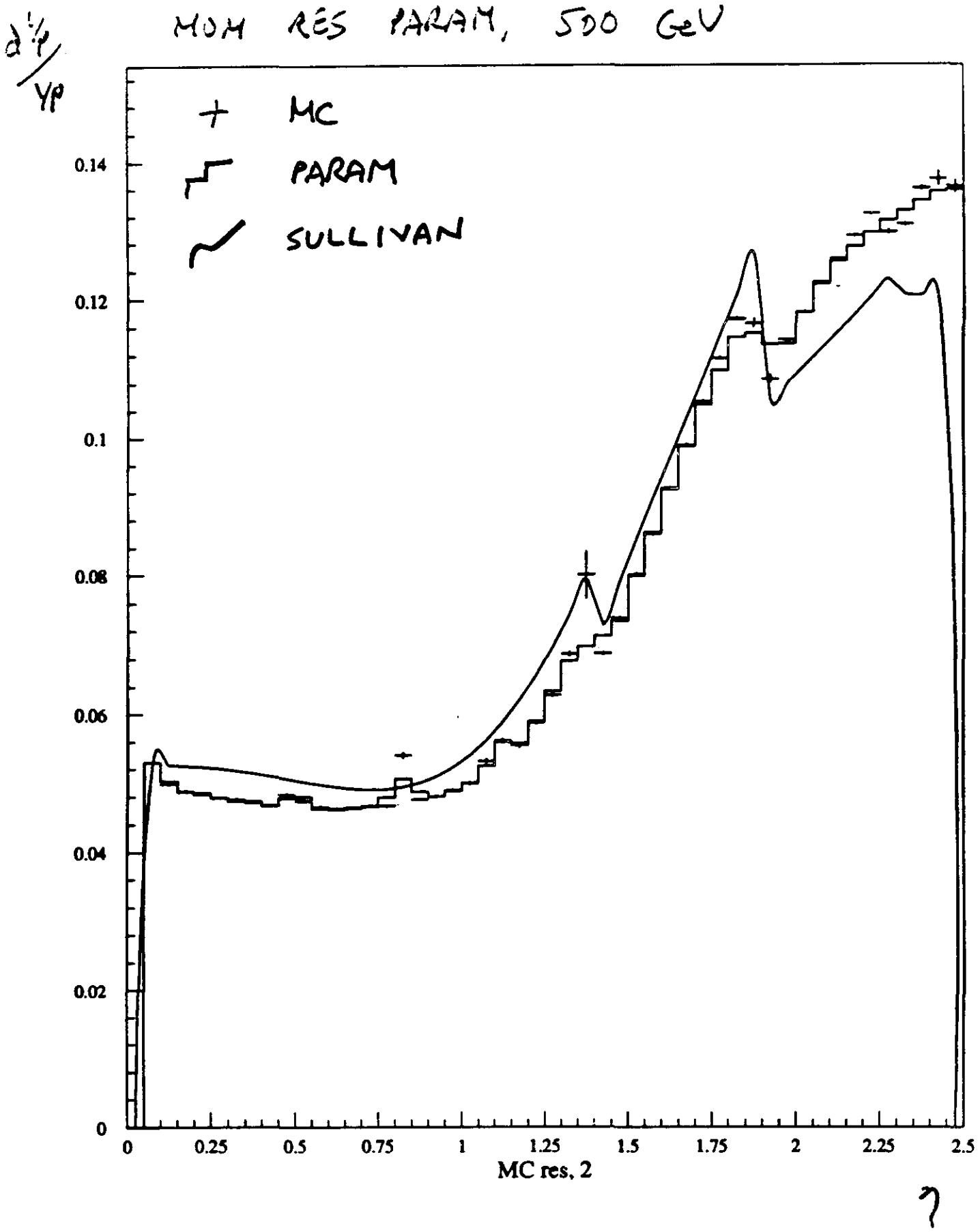
7

MOM RES , PARAM

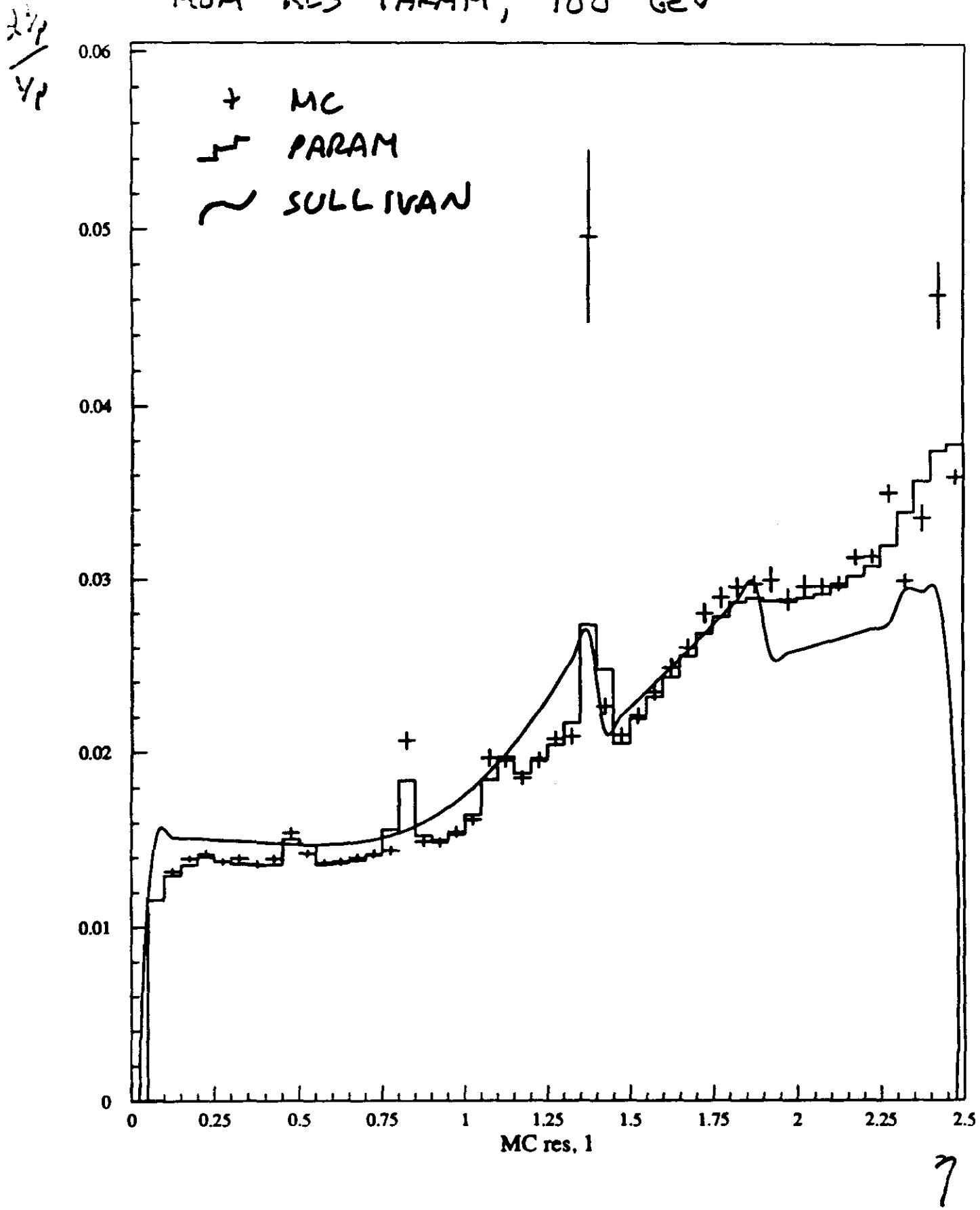


MOM RES, PARAM

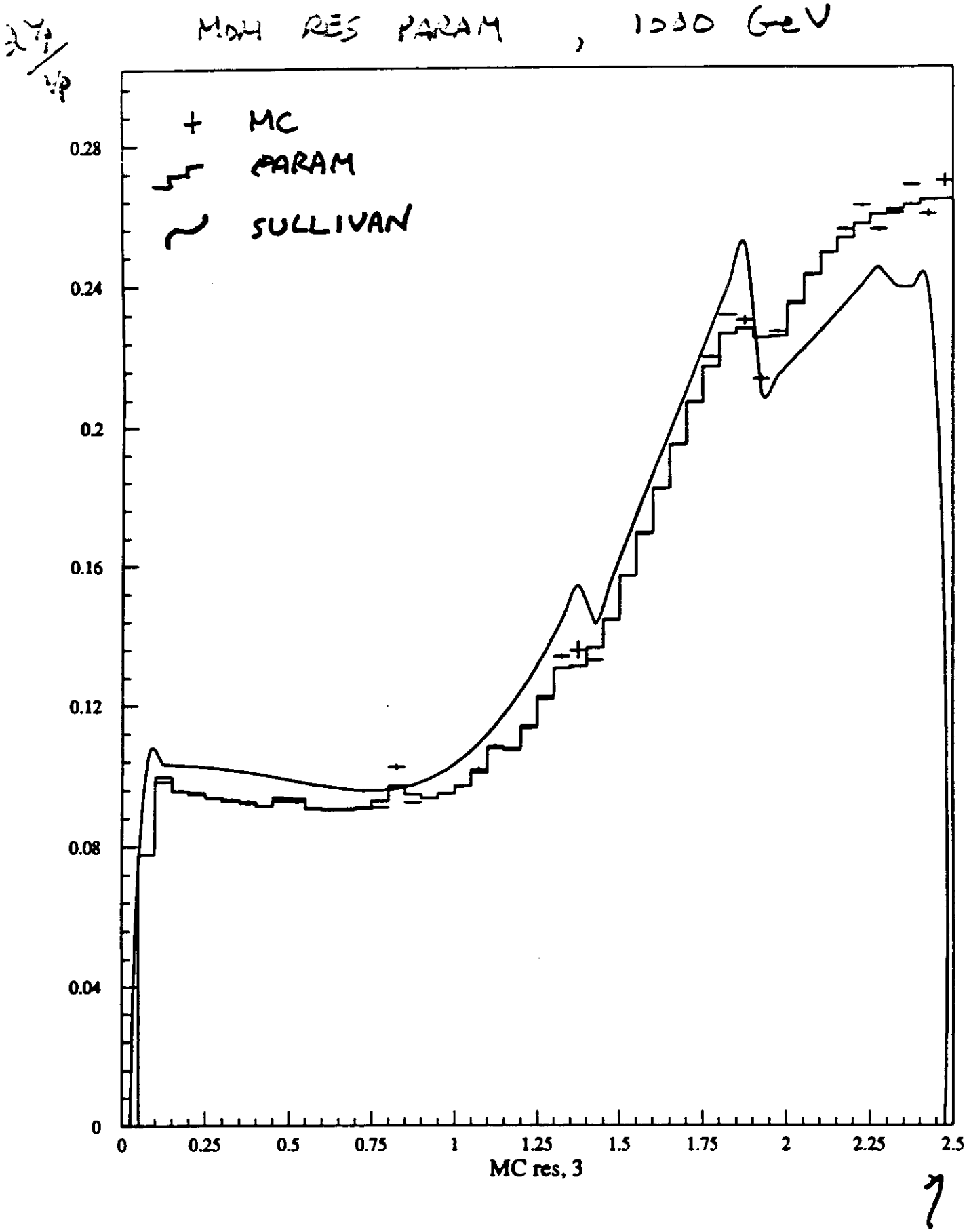


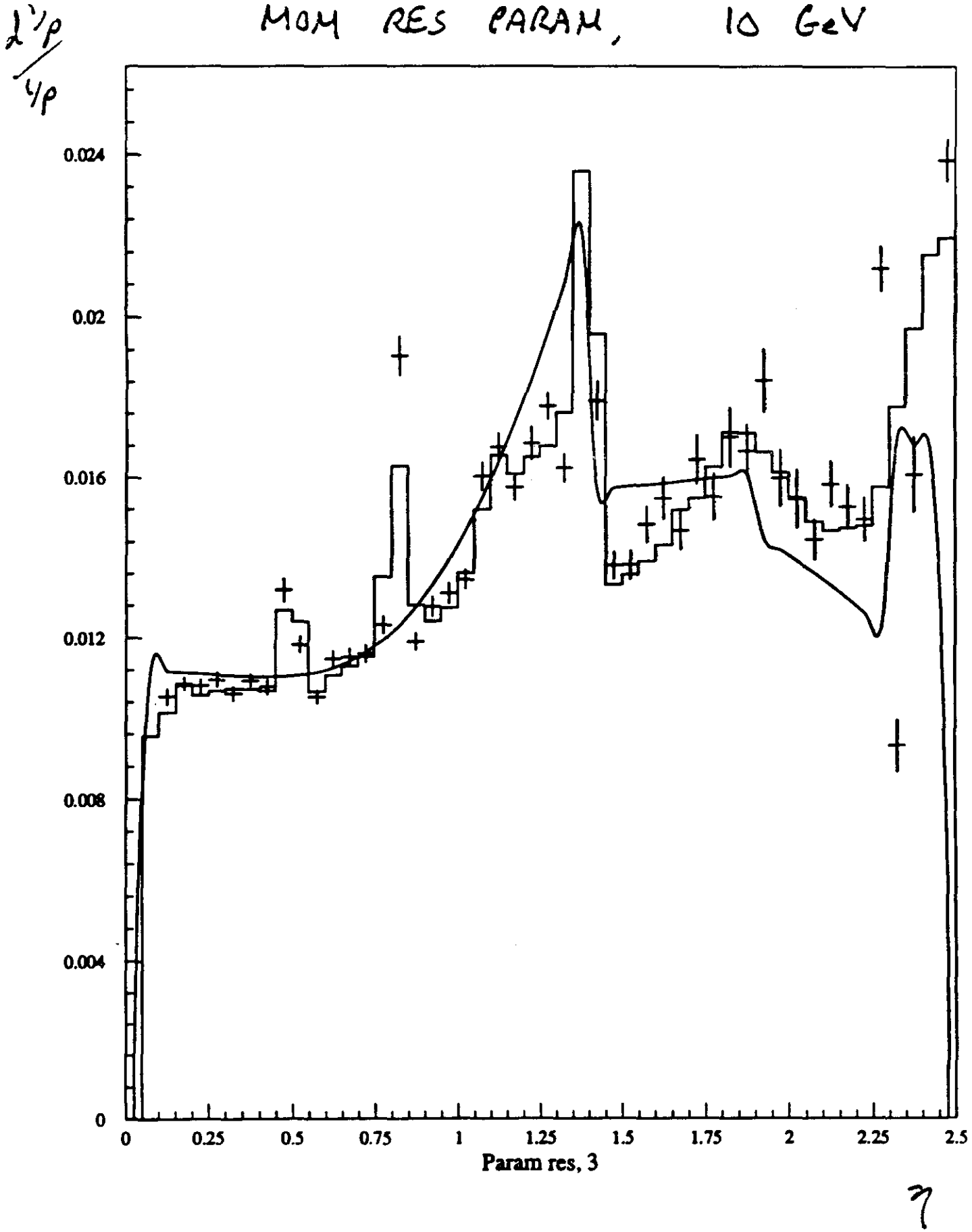

MOM RES PARAM, 500 GeV
d½/Yp
MC
PARAM
SULLIVAN
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
MC res, 2

MOM RES PARAM, 100 GeV



7


MOM RES PARAM , 1000 GeV
MC
PARAM
SULLIVAN
0.28
0.24
0.2
0.16
0.12
0.08
0.04
0
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
MC res, 3


MOM RES PARAM, 10 GeV
0.024
0.02
0.016
0.012
0.008
0.004
0
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
Param res, 3

STATUS + IMPROVEMENTS

- GIVES GOOD, CONSISTENT RESULTS WITH PRESENT GEOMETRY, BUT A COMPLETELY DIFFERENT GEOMETRY WILL BE RELEASED SOON.
  ⇒ GEOMETRY REWRITE
- MU DIRECTION AT MU SYSTEM ENTRY (NOT RADIAL)
- EXPLICIT ANGLE, LORENTZ DEPENDENCIES IN INTRINSIC RESOLUTION

DETECTOR SPEC USED IN THIS WORK OUTDATED —

CSC CHAMBER CONFIGURATION COMPLETELY CHANGED. NEW SPECS NOT YET AVAILABLE (ACCORDING TO FRANK NIMBLETT 1/12).
MAYBE IN A FEW DAYS. HE'LL SEND ME SPECS & I'LL UPDATE SIMU/PARAM.

CHANGES:

- 12 MODULES IN φ, NOT 16.
- 3 CHAM LAYOUT OPTIONS UNDER CONSIDER'N.

	6	6	4
	6	6	6
	8	6	4
SL	1	2	3

6 = 2 chan × 3 gap
4 = 1 " × 4 "
8 = 2 " × 4 "

SL1 : 2 LAYERS, 24 × 2 chan in z
SL2 : 2 " 48 × 4 chan in z
SL3 : 1 or 2 48 × 4 chan in z

... ALSO RDT/RPC STILL IN CONTENTION.

gem

γeμ

Presentation by:

Hiro Yamamoto

30±√N

Ch.	Title	Higgs Mass	Author(s)	Pages	Status
2.3	Standard Model Higgs Physics			30	
2.3.1	Introduction		R-Y. Zhu	2	1.5
2.3.2	Higgs → γγ	80 - 160	H. Yamamoto, R-Y. Zhu	10	2.0
2.3.3	(tt/W) + Higgs → γγ + isolated lepton	80 - 140	H. Yamamoto	4	2.0
2.3.4	Higgs → ZZ*/ZZ → 4 leptons	140 - 800	S. Mrenna	5	2.5
2.3.5	Higgs → ll + jet jet	800	S. Shevchenko	3	2.5
2.3.6	Higgs → ll + νν	800	X. Shi	3	3.0
2.3.7	WW scattering	> 800	S. Mrenna	1	2.0
2.3.8	Properties of Higgs				
2.3.8.1	Spins of Higgs with 4 lepton final state		H. Yamamoto	1	1.5
2.3.8.2	Detailed BR information to confirm SM Higgs		S. Mrenna	1	1.0

Status : 1 : Plan
2 : Analysis
3 : Finalize
4 : Writing

MC : GEMFAST
PYTHIA 5.6
PAPAGENO
PDFLIB

Luminosity : 10^{33} (standard)
10^{34} (when needed)

FIRST, as a physics proposal, that demonstrates the experiment's discovery potential, complementary to SDC.
SDC is giving up intermediate mass Higgs discovery at 10^{33}.

****

Jan. 13, 1993

Caltech TDR progress summary

Hiro Yamamoto
Caltech

****

2.3 Standard Model Higgs Physics

Author : S. Mrenna, S. Shevchenko, X. Shi, H. Yamamoto, R-Y. Zhu
Page : 30
Status : 1: Plan
2: Analysis
3: Finalize
4: Writing

****

2.3.1 Introduction

Author : R-Y. Zhu
Page : 2
Software : PYTHIA 5.6, PDFLIB, GEMFAST
Reference : ****
Status : 1.5

Note, there are few points to be determined (TBD), which means we will do according to recommendations of Frank and Ken.

A. Higgs Production x-section and structure function dependence

a. Fix one set of structure function, e.g. HMRSB or EHLQ1
Discuss Distribution function dependence of Signal, Background, S/N vs PDFLIB sets. (TBD)

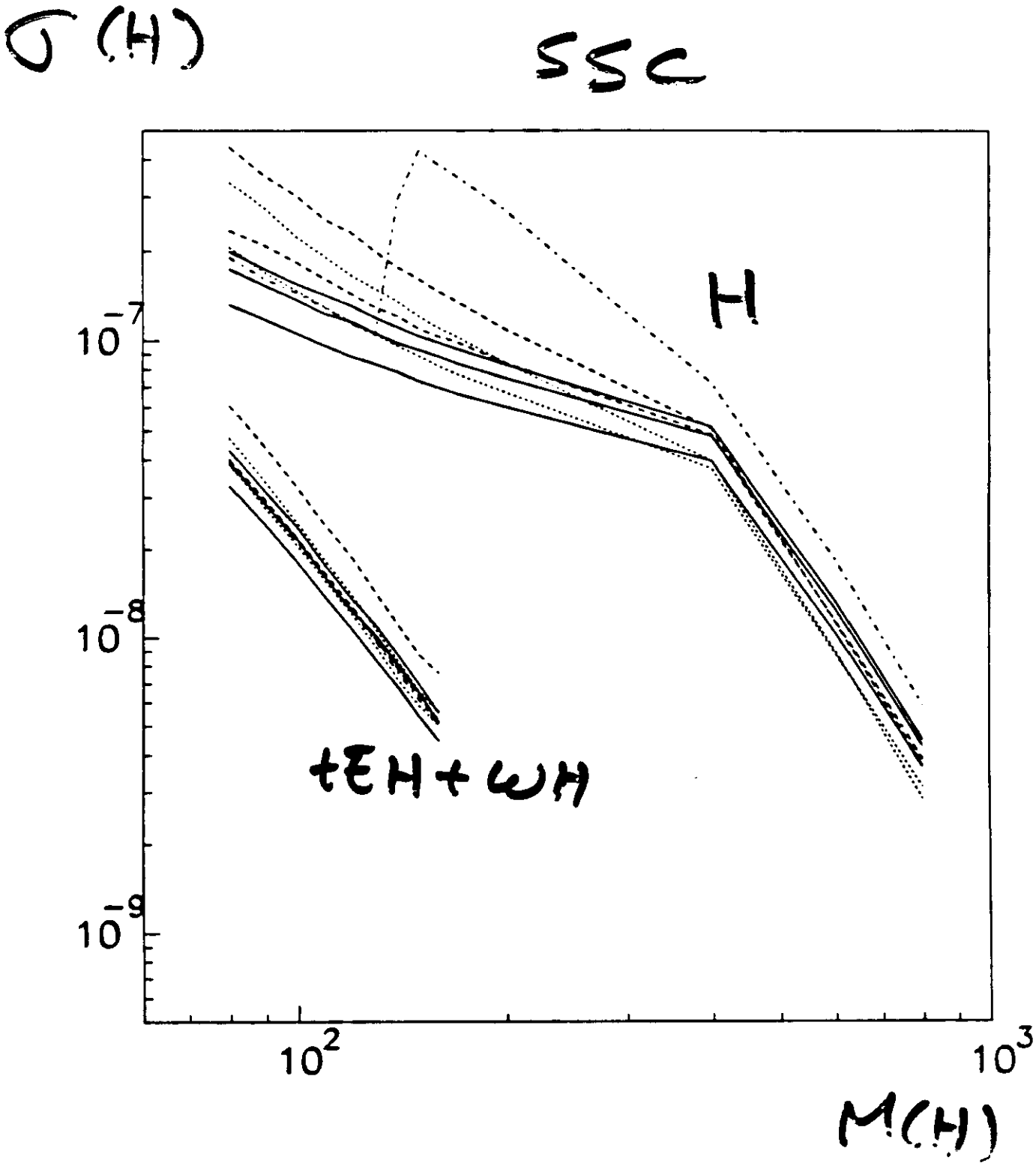
b. Fix K factor for M_H < 2M_t: two approaches: (TBD)

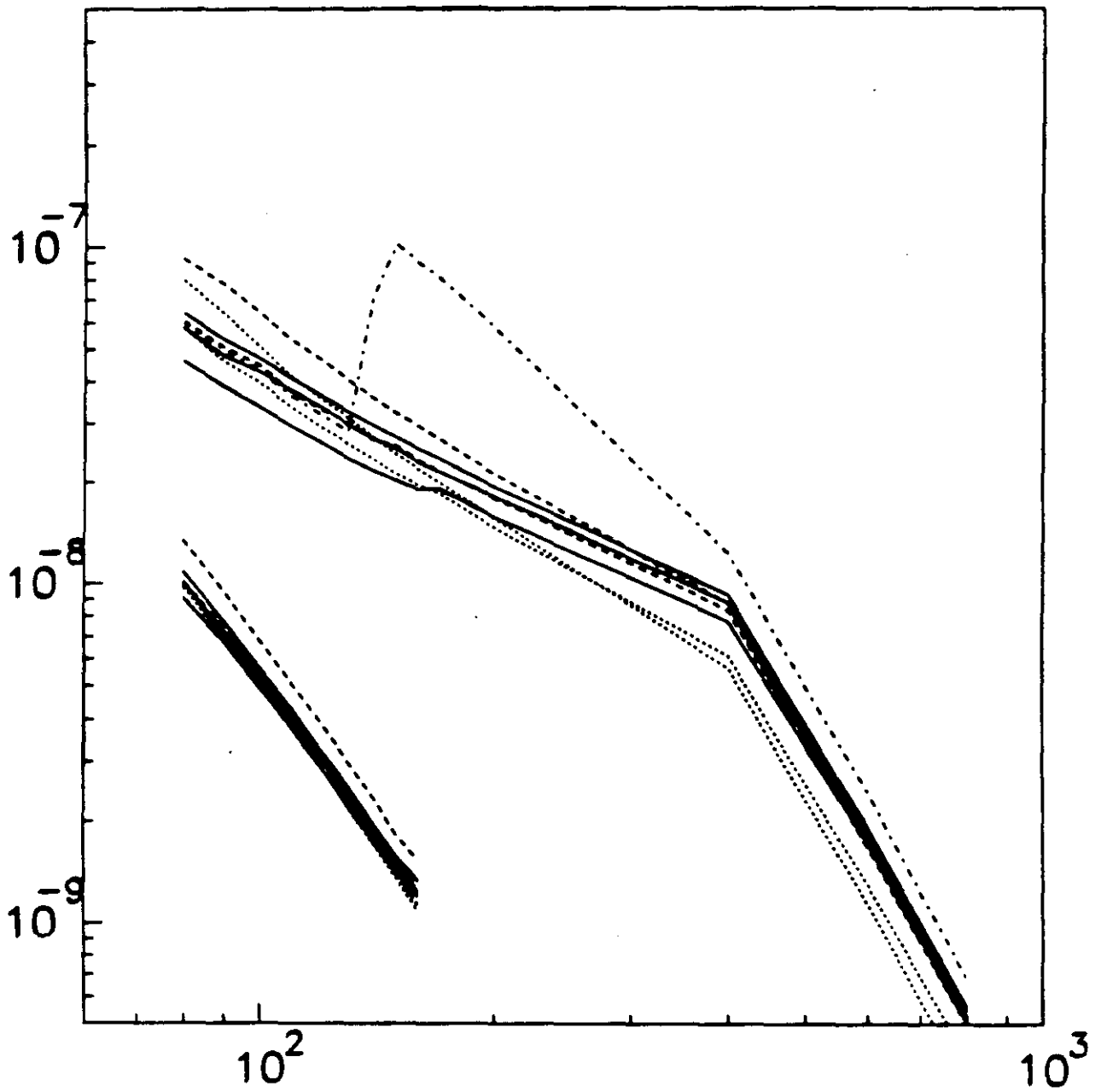
	1.0	2
signal	1.5	1
qq/gg->gam+gam	1.5	1
jet+gam/jet+jet	1.5 or 1.0	1

Note, for M_H > 2 M_t there is no K factor calculated for gg fussion.

B. Define PYTHIA settings in the calculation

QED bremsstrahlung on
Peterson fragmentation function for heavy quraks
****


σ(H)
SSC
H
tEH+ωH
10^{-7}
10^{-8}
10^{-9}
10^{2}
10^{3}
M(H)


10^{-7}
10^{-8}
10^{-9}
10^{2}
10^{3}

$gg \to H \to \gamma\gamma$ $K = 1.5$

$WW \to H$ Compare Pythia to exact!
Renormalize to exact.

$QCD \to \gamma\gamma$

Compare LO + Pythia γ rad
to K factor. Agree?
$\Rightarrow$ rad includes K factor

F. P B. Bevis!

C. Define common cuts. The detailed parameters, Physics cuts and efficiencies are discussed in each section.

isolation cut and the treatment of pileup and thermal noise in isolation cone

Discuss various uncertainties: (TBD)
Fragmentation function uncertainty
QCD calculation umbiguity

D. Define signal significance for high and low statistics.

As discussed in GEM TN-92-126 (TBD)

E. The discovery potential of each channel will be presented as a plot of (Higgs x-section * branching ratio) versus Higgs mass, to reduce the structure function dependence.

NOTE: the detector acceptance and performance and efficiencies are supposed to be covered in GEMFAST program.

F. Define SSCY as intergrated luminosity

Note: Most analysis will for 10^40 as standard, some will be 10^41

****

2.3.2 Higgs -> 2 gammas (Higgs mass : 80 - 160 GeV)

Author : H. Yamamoto and R-Y. Zhu
Page : 10
Software: : PYTHIA 5.6, PDFLIB, GEMFAST
Reference : GEM-TN-92-126
Status : 2

Comparing with the reference, we will add
1) Effect of mass peak from thermal and pileup noise;
2) Higgs vertex with pointing and jet rejection with strip;
3) Higher statistics background and estimation of gamma-gamma background from two jets calculated with scaled alpha etc.
4) Detector simulation with Baseline II design, i.e., GEMFAST

A. Signal and Irreducible Background:

Background x-sections with defined structure function with K factor, as discussed in 2.3.1

Describe kinematic cuts

B. Effect on Higgs mass resolution from energy, position resolutions and noise

Assume (5.6-6.6)%/sqrt(E)+0.4% for Barrel, and 8.5%/sqrt(E)+0.4% for Endcap, as GEMGEM.

C. Higgs vertex determination

Effect of Photon angular resolution and vertex z reslution
Assume 40mr/sqrt(E) in barrel, 50mr/sqrt(E) in endcap.

D. Electron background

NOTE : We need R(gamma/e) justification from CT simulation

E. Jet backgrounds

Desctribe jet rejection with detailed electron/photon ID (lateral/longitudinal shower shape, HCAL veto, E-p matching for electrons and strips for pi_0 rejection)

Use pi0 rejection result of Ma-Leltchoulk paper for both barrel and endcaps, demonstrate high luminosity capability

Estimation of gamma-gamma in jet-jet events

F. Summary plots/tables

Signal over background plots
Significance number table
Discovery potential as integrated luminosity and Higgs mass.

NOTE : We need to know if the trigger is OK at 10^34 from trigger group.

G. Discussion about the light SUSY Higgs search

****

2.3.3 (tt/W) H -> 2 gammas + isolated lepton (Higgs mass : 80 - 140)

Author : H. Yamamoto
Page : 4
Software: : PYTHIA 5.6, PAPAGENO, GEMFAST
Reference : GEM TN-92-126
Status : 2

The structure of this section is as reference, we will do
1) Effect of mass peak from thermal and pileup noise;
2) Looking for additional background;
3) Higher statistics background plots;
4) Detector simulation with Baseline II design, i.e. GEMFAST

A. Signal and background

Background desciption and umbiguity
Kinematics cut

B. Summary plots/tables

Signal over background plots
Significance number table
Discovery potential plot for 10^40 and 10^41

```
*****************************************************************************

2.3.4  H -> ZZ/ZZ* -> 4 leptons ( Higgs mass : 140 - 800 )
        Pages  : 5 pages
        Author : S. Mrenna
        Software : PYTHIA 5.6, PAPAGENO, GEMFAST
        Status : 2.5 for ZZ* and 2.0 for ZZ
        Reference : Talk at Caltech, 12 Jan 1993

  A.  Signal

      A1.  140 GeV < M_H < 2 M_Z

      A2.    2 M_Z < M_H < 400 GeV

      A3.  400 Gev < M_H < 800 GeV

  B.  Background

      B1.  qq~ -> ZZ*, gg -> ZZ*
           i. M_ZZ* > 130 GeV

      B2.  pp~ -> tt~ -> bb~WW~
           i. (semi-leptonic decay of B-meson)

      B3.  pp~ -> Zbb~
           i. (semi-leptonic decay of B-meson)
          ii. M_Zbb* > 130 GeV

      B4.  pp~ -> Ztt~ -> Zbb~WW~

*
* In the following, a '?' denotes a preliminary number (it may change
*    by a factor of 1/2 - 2) or a preliminary thought or idea (it may
*    go away entirely)
*

  C.  Kinematic Cuts

      C1.  Process A1

       0)  >= 4 Bumps in EC
  ?    1)  Et > 5 GeV
       2)  Et of 2 Bumps > 20 GeV
       3)  Sum Et < 5 GeV + .1*Et for R < .3
  ?    4)  Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
       5)  Energy in EC 3x3/5x5 > .90
       6)  HC 3x3 < 0.15 * EC 5x5
       7)  Reconstruct M_Z:  60 GeV < M_Z < 96 GeV
       8)  Reconstruct M_Z*: 10 GeV < M_Z* < 96 GeV

      C2. Process A2

       0)  >= 4 Bumps in EC
       1)  Et > 10 GeV
       2)  Et of 2 Bumps > 20 GeV
       3)  Sum Et < 5 GeV + .1*Et for R < .3
  ?    4)  Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
       5)  Energy in EC 3x3/5x5 > .90
       6)  HC 3x3 < 0.15 * EC 5x5
       7)  Reconstruct M_Z1:  80 GeV < M_Z1 < 96 GeV
       8)  Reconstruct M_Z2:  80 GeV < M_Z2 < 96 GeV
```

C3. Process A3

```
     0)  >= 4 Bumps in EC
?    1)  Et > 10 GeV
     2)  Et of 2 Bumps > 20 GeV
     3)  Sum Et < 5 GeV + .1*Et for R < .3
?    4)  Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
     5)  Energy in EC 3x3/5x5 > .90
     6)  HC 3x3 < 0.15 * EC 5x5
     7)  Reconstruct M_Z1:  80 GeV < M_Z1 < 96 GeV
     8)  Reconstruct M_Z2:  80 GeV < M_Z2 < 96 GeV
?    9)  Pt Z > 0 GeV
```

D. Summary plots/tables

D1. M_H = 165 GeV (Normal Luminosity) 156 GeV < M_H(recon) < 168 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	1.96 fb	none	.411	8
Zbb~	128.4 pb	M(Zbb~)>130 Gev	1.10^-4	<128
Ztt~	460.8 fb	none	.0124	<57
tt~	16 nb	none	<1.10^-3	>0
qq~->ZZ	2 fb	145<M(ZZ)<175 GeV	.096	2
gg->ZZ	Assume .65x qq~->ZZ			1

Note: Et_min = 5 GeV appears to be too low

D2. M_H = 200 GeV (Normal Luminosity) 182 GeV < M_H(recon) < 200 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	21.35 fb	none	.380	81
Zbb~	128.4 pb	M(Zbb~)>130 Gev	>0.	>0
Ztt~	460.8 fb	none	.0111	51
tt~	16 nb	none	<1.10^-3	>0
qq~->ZZ	8.64 fb	180<M(ZZ)<220 GeV	.108	9
gg->ZZ	Assume .65x qq~->ZZ			6

D3. M_H = 600 GeV (Normal Luminosity) 400 GeV < M_H(recon) < 800 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	4.0 fb	none	.420	17
Zbb~	128.4 pb	M(Zbb~)>130 Gev	>0.	>0.
Ztt~	460.8 fb	none	>0.	>0.
tt~	16 nb	none	<3.10^-3	>0.
qq~->ZZ	10.1 fb	300<M(ZZ)<900 GeV	.07	7
gg->ZZ	Assume .65x qq~->ZZ			5

4) Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
5) Energy in EC 3x3/5x5 > .90
6) HC 3x3 < 0.1 * EC 5x5
7) Reconstruct M_Z1: 80 GeV < M_Z1 < 96 GeV
8) Reconstruct M_Z2: 80 GeV < M_Z2 < 96 GeV

D. Summary plots/tables

D1. M_H = 165 GeV (Normal Luminosity) 156 GeV < M_H(recon) < 168 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	1.96 fb	none	.411	8
Zbb~	128.4 pb	M(Zbb~)>130 Gev	2.10^-4	<257
Ztt~	460.8 fb	none	.0142	<65
tt~	16 nb	none	?	?
qq~->ZZ	2 fb	145<M(ZZ)<175 GeV	.096	2
gg->ZZ	Assume .65x qq~->ZZ			1

Note: Et_min = 5 GeV appears to be too low

D2. M_H = 200 GeV (Normal Luminosity) 182 GeV < M_H(recon) < 200 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	21.35 fb	none	.380	81
Zbb~	128.4 pb	M(Zbb~)>130 Gev	>0.	0
Ztt~	460.8 fb	none	.0126	58
tt~	16 nb	none	?	?
qq~->ZZ	8.64 fb	180<M(ZZ)<220 GeV	.108	9
gg->ZZ	Assume .65x qq~->ZZ			6

D3. M_H = 600 GeV (Normal Luminosity) 400 GeV < M_H(recon) < 800 GeV

Process	Cross Section	Restrictions	Efficiency	Events
H->ZZ	4.0 fb	none	.420	17
Zbb~	128.4 pb	M(Zbb~)>130 Gev	>0.	>0.
Ztt~	460.8 fb	none	?	?
tt~	16 nb	none	?	?
qq~->ZZ	10.1 fb	300<M(ZZ)<900 GeV	.07	7
gg->ZZ	Assume .65x qq~->ZZ			5

****

2.3.5 H -> ll + jetjet (Higgs mass = 800 GeV)

Page : 3
Author : S. Shevchenko
Software: : PYTHIA 5.6, GEMFAST
Reference : Talk at CIT on Dec 21
Status : 2.5

A. Signal and background, and kinematic cuts

Important variables to reject backgrounds

1) Transverse energies of leptons and jets
2) Invariane mass reconstructed properly from pairs of ll and jj
3) Transverse energy of reconstructed Z0 bosons from ll and jj

Generator level numbers to get the idea of the background

0) angle between jet and lepton > 20 degree
1) |eta(l,j)| < 2.5
2) pt(l,j) > 20 GeV
3) M(ll) : Mz +- 10 GeV
4) M(jj) : Mz +- 20 GeV
5) Et(ll,jj) > 250 GeV

	# events/year	efficiency
Higgs	110	0.1
Z + jets	800	10^{-4}
tt	< 600	< 10^{-5}

NOTE : Need to generate enough background events

B. Summary plots/tables

Signal over background plots
Significance number table
Discovery potential plot for 10^40 and 10^41

****

2.3.6 H -> ll + nu nu (Higgs mass = 800 GeV)
H -> ee + nu nu
Page : 3 page
Author : X. Shi
Status : 3 (as of Jan 18)
Reference : Presentation at CALTECH on Jan. 18, 1993

A. Signal and background, and kinematic cuts

Important variables to reject backgrounds

[a few plots of interest from X.S presentation]

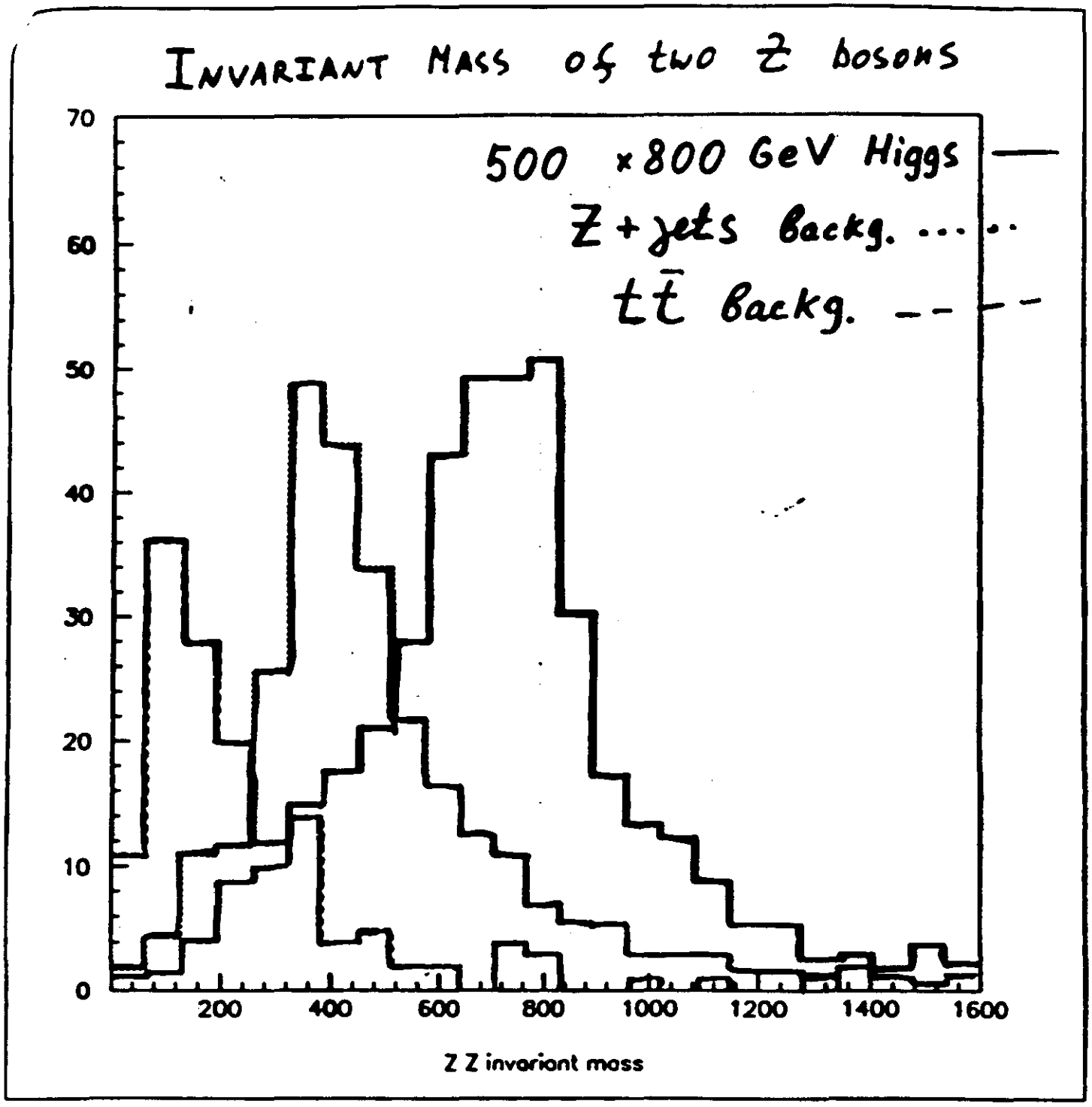
Some numbers to get the idea of the background

[cuts]

Only Et of e > 20 GeV. to be improved

	Xsection(fb)	# events/year	efficiency
Higgs->ZZ->eenn	17.5	175	0.8
Z + jets	3.278E04	3.3 E05	
Z0Z0 continuum	11.7	117	0.6
tt	?	?	? (small)

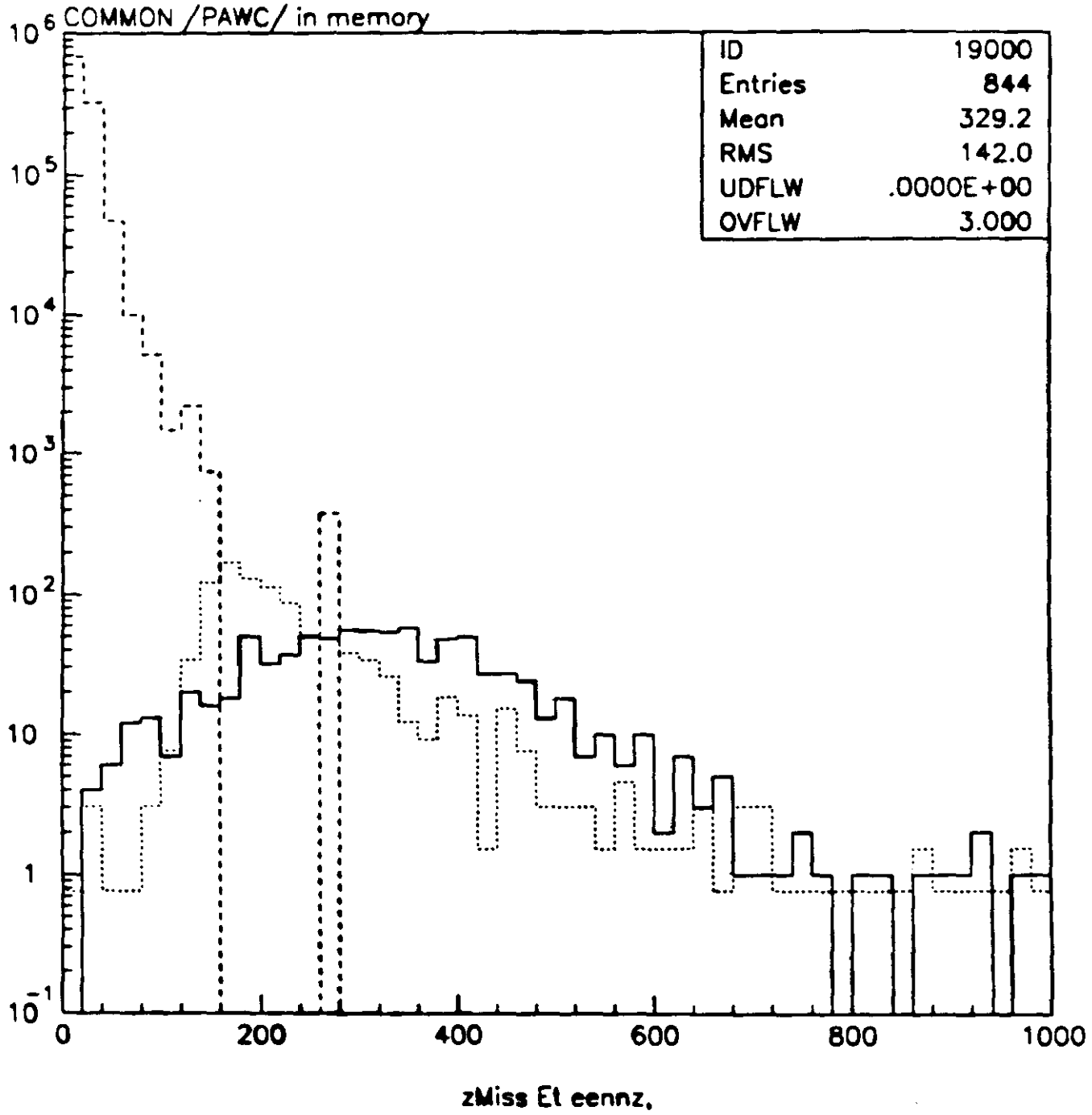
NOTE : Need to generate enough background events



$|\eta_{jet_1, jet_2}| < 2.5$; $|\eta_{e_1, e_2}| < 2.5$; $P_\perp > 20$ GeV

$M_Z - 10\,\text{GeV} < M_{ee} < M_Z + 10\,\text{GeV}$

93/01/11 22.08


COMMON /PAWC/ in memory
ID 19000
Entries 844
Mean 329.2
RMS 142.0
UDFLW .0000E+00
OVFLW 3.000
10^6
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
200
400
600
800
1000
zMiss Et eennz,

H→ZZ→ℓℓνν τ_{max} > 4.5

B. Effect of dead channels and dependence of FC coverage

C. Summary plots/tables

Signal over background plots
[transvrse mass plots of signal and background]
Significance number table
Discovery potential plot for 10^40 and 10^41

****

2.3.7 WW scattering (Higgs mass > 800 GeV)

Author : S. Mrenna
Page : 1 page
Software : PYTHIA 5.6, GEMFAST
Status : 2
Reference : Talk at Caltech, 12 Jan 1993

A. Signal

A1. Z0_L Z0_L Final State
A2. Z0_L W-_L Final State
A3. W+_L W-_L Final State

B. Background

B1. tt~
B2. qq~ -> WW~, gg -> WW~

C. Kinematic Cuts

C1. Process A1

0) >= 4 Bumps in EC
1) Et > 10 GeV
2) Et of 2 Bumps > 20 GeV
3) Sum Et < 5 GeV + .1*Et for R < .3
4) Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
5) Energy in EC 3x3/5x5 > .90
6) HC 3x3 < 0.1 * EC 5x5
7) Reconstruct M_Z1: 80 GeV < M_Z1 < 96 GeV
8) Reconstruct M_Z2: 80 GeV < M_Z2 < 96 GeV
9) To Implement:

Central jet veto ****
Forward jet tagging **
Rapidity gap *
Delta R(l,l) ****
L = 10^34 ? ****

Stars on the scale of 1-4 based on importance (my opinion)

Consider decay mode e e~ nu nu~
Consider decay mode e e~ jet jet

****

2.3.7 WW scattering (Higgs mass > 800 GeV)

Page : 1 page
Author : S. Mrenna
Software : PYTHIA 5.6, GEMFAST
Status : 2
Reference : Talk at Caltech, 12 Jan 1993

A. Signal

A1. Z0_L Z0_L Final State

a. eeee

b. eenn

A2. Z0_L W-_L Final State

a. eeen

A3. W+_L W-_L Final State

a. enen

B. Background

B1. tt~

B2. qq~ -> WW~, gg -> WW~

C. Kinematic Cuts

C1a. Process A1a

0) >= 4 Bumps in EC
? 1) Et > 10 GeV
2) Et of 2 Bumps > 20 GeV
3) Sum Et < 5 GeV + .1*Et for R < .3
? 4) Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
5) Energy in EC 3x3/5x5 > .90
6) HC 3x3 < 0.15 * EC 5x5
7) Reconstruct M_Z1: 80 GeV < M_Z1 < 96 GeV
8) Reconstruct M_Z2: 80 GeV < M_Z2 < 96 GeV
? 9) Pt Z > 0 GeV
? 10) No jet tagging, central jet veto, etc.
? 11) No cut on polarization of Zs (R(1,1) cut)

C1b. Process A1b

0) >= 2 Bumps in EC
? 1) Et > 20 GeV
2) Sum Et < 5 GeV + .1*Et for R < .3
? 3) Only 1 charged track in 5x5 cluster (Pt > .5 GeV ?)
4) Energy in EC 3x3/5x5 > .90
5) HC 3x3 < 0.15 * EC 5x5
6) Reconstruct M_Z: 80 GeV < M_Z1 < 96 GeV
? 7) Pt Z > 50 GeV
? 8) Missing Et > 0 GeV
? 9) No Jet Tagging, central jet veto, etc.
? 10) No R(1,1) cut

Consider decay mode e e~ jet jet
Consider High and Normal Luminosity

D. Summary plots/tables

D1. M_H = 1000 GeV (Normal Luminosity) 400 GeV < M_H(recon) < 1500 Ge

Process	Cross Section	Restrictions	Efficiency	Events
WW/ZZ->ZZ	.495 fb	400<M_H<1500 GeV	.466 (eeee)	2
	6 fb	same	.624 (eenn)	36

****

2.3.8 Properties of Higgs

B. Detailed branching ratio information to confirm SM Higgs
Page : 1 page (???)
Author : S. Mrenna
Software : PYTHIA 5.6, GEMFAST
Status : 0.5
Reference : Talk at Caltech, 12 Jan 1993

When a resonance which looks like Higgs is found, how well can we determine other decay modes ?

D. Summary plots/tables

D1. M_H = 1000 GeV (Normal Luminosity) 400 GeV < M_H(recon) < 1500 GeV

Process	Cross Section	Restrictions	Efficiency	Events
WW/ZZ->ZZ	.495 fb	400<M_H<1500 GeV	.466 (eeee)	2

****

2.3.8 Properties of Higgs

A. Spins of Higgs with 4 lepton final state

Author : H. Yamamoto
Page : 1
Software: : PYTHIA 5.6, GEMFAST
Reference : Presentation at SSCL on Oct, 1992
Status : 1.5

Determine the C,P of X -> ZZ -> llll using the angular distributions of Z, l and two ll planes.
How many events do we need ?
Only electrons -> 10^4I
electrons + muons -> ???

B. Detailed branching ratio information to confirm SM HIggs

Author : S. Mrenna
Page : 1
Software: : PYTHIA 5.6, GEMFAST
Reference : None
Status : 1

When a resonace which looks like Higgs is found, how well can we determine other decay modes ?

gem

γeμ

Presentation by:

Frank Paige

2.7. SUPERSYMMETRY AND $\not{E}_T$ SIGNATURES

Supersymmetry (SUSY) automatically cancels the quadratic divergences in the Higgs sector and so solves the naturalness problem of the standard model provided that the superpartners have masses $\lesssim 1$ TeV. Specific models[1] can be constructed which are consistent with the precision electroweak data and with grand unification, although this of course does not prove the existance of SUSY. The minimal supersymmetric extension of the standard model[2] or MSSM has two Higgs doubles and superpartners for all of the normal particles. In particular there are four neutralinos $\tilde{\chi}_i^0$ which are linear combinations of the partners of the photon, Z, and Higgs bosons and two pairs of charginos $\tilde{\chi}_i^{\pm}$. There is an exactly conserved R parity carried by all superparticles, so they must always be produced in pairs and decay to the lightest supersymmetric particle (LSP), which is absolutely stable. We shall limit ourselves here to the MSSM with the LSP being a neutralino $\tilde{\chi}_1^0$ but not necessarily to the simplest version of grand unification.

2.7.1. $\not{E}_T$ Signature for Light Gluino

Since the LSP is neutral and interacts weakly with matter, it escapes from any collider detector. Thus the basic signature for SUSY is missing transverse energy $\not{E}_T$ plus multiple jets. A stringent test for an SSC detector is to be able to detect a light gluino, one with a mass near the limit expected from the Tevatron. This is also the mass range expected in some models1. If the gluino is lighter than the squarks, then it will decay into $q\bar{q}'\tilde{\chi}_i$, where $\tilde{\chi}_i$ is any of the neutralinos or charginos. This in turn decays into lighter $\tilde{\chi}_i$ plus other particles, eventually reaching the LSP $\tilde{\chi}_1^0$. Because of this cascade, the events are quite complex and the $\not{E}_T$ can be quite small.

A necessary first step in the gluino analysis is to understand the inclusive $\not{E}_T$ performance of the detector. To do this a (so far small) sample of QCD jets has been generated and run through `gemfast`. The sample includes heavy quarks and hence real missing neutrinos. The observed $\not{E}_T$ was calculated using the `gemfast` routine `fci_smear`, which parameterizes the observed p_T for a single particle in terms of its generated p_T. Since this parameterization is based on full GEANT simulations, it includes the Baseline II geometry, energy resolution, transverse and longitudinal shower shapes and their fluctuations, and the various transitions between the calorimeters. It does not, however, produce energy in cells, so it cannot be used to study jets or other properties of the event. The result, shown in fig. 1, is that the observed $\not{E}_T$ cross section is about one order of magnitude above the true one in the 100 GeV range and approaches it for higher values. This is quite similar to what was found for Baseline I.

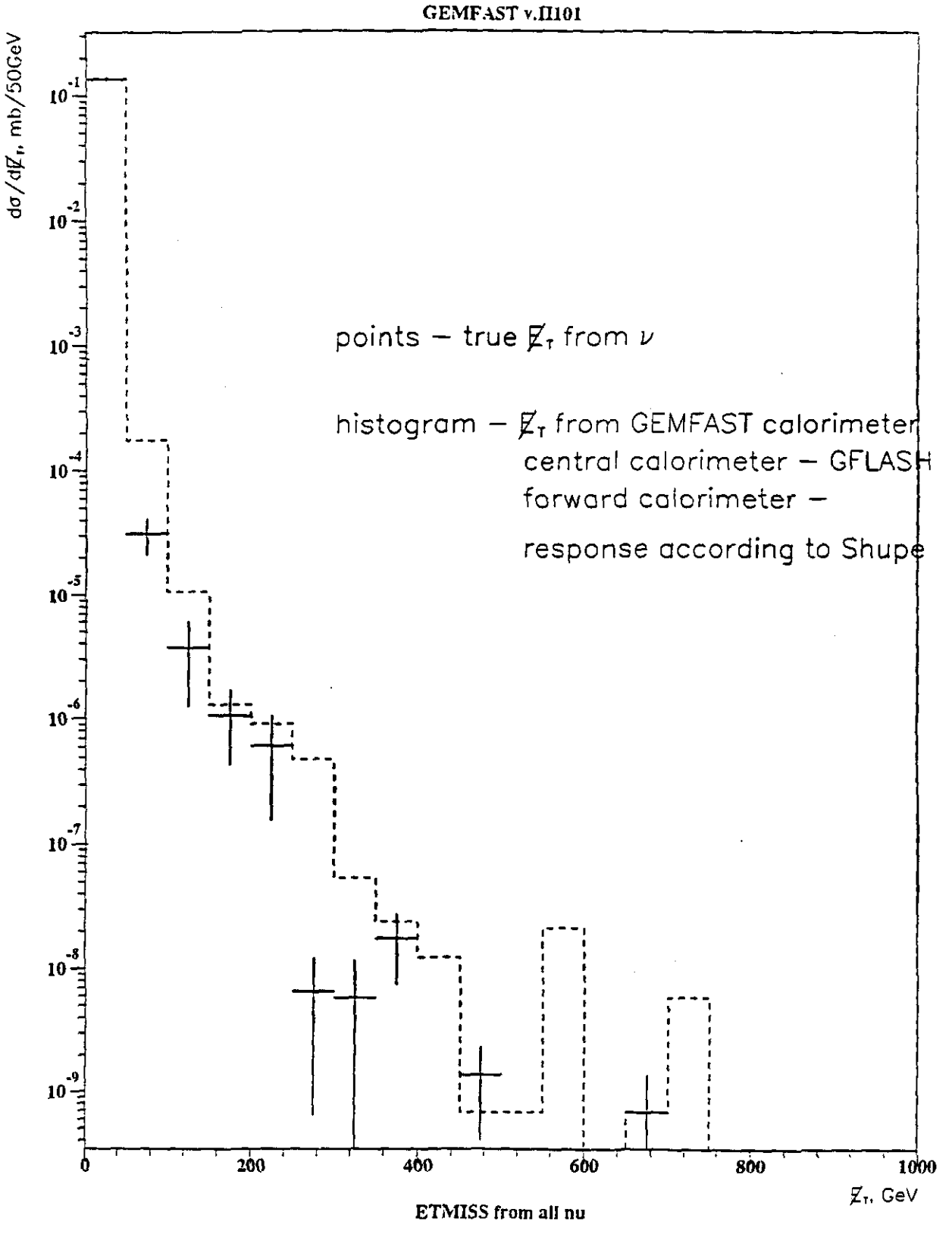
The GFLASH simulation of the central and endcap calorimeters in `gemfast` can also be used to calculate the $\not{E}_T$. Although it does not handle correctly, e.g., the $\eta = 3$ edge, it does contain the basic fluctuations in energy and shower shape. The result, shown in fig. 2.

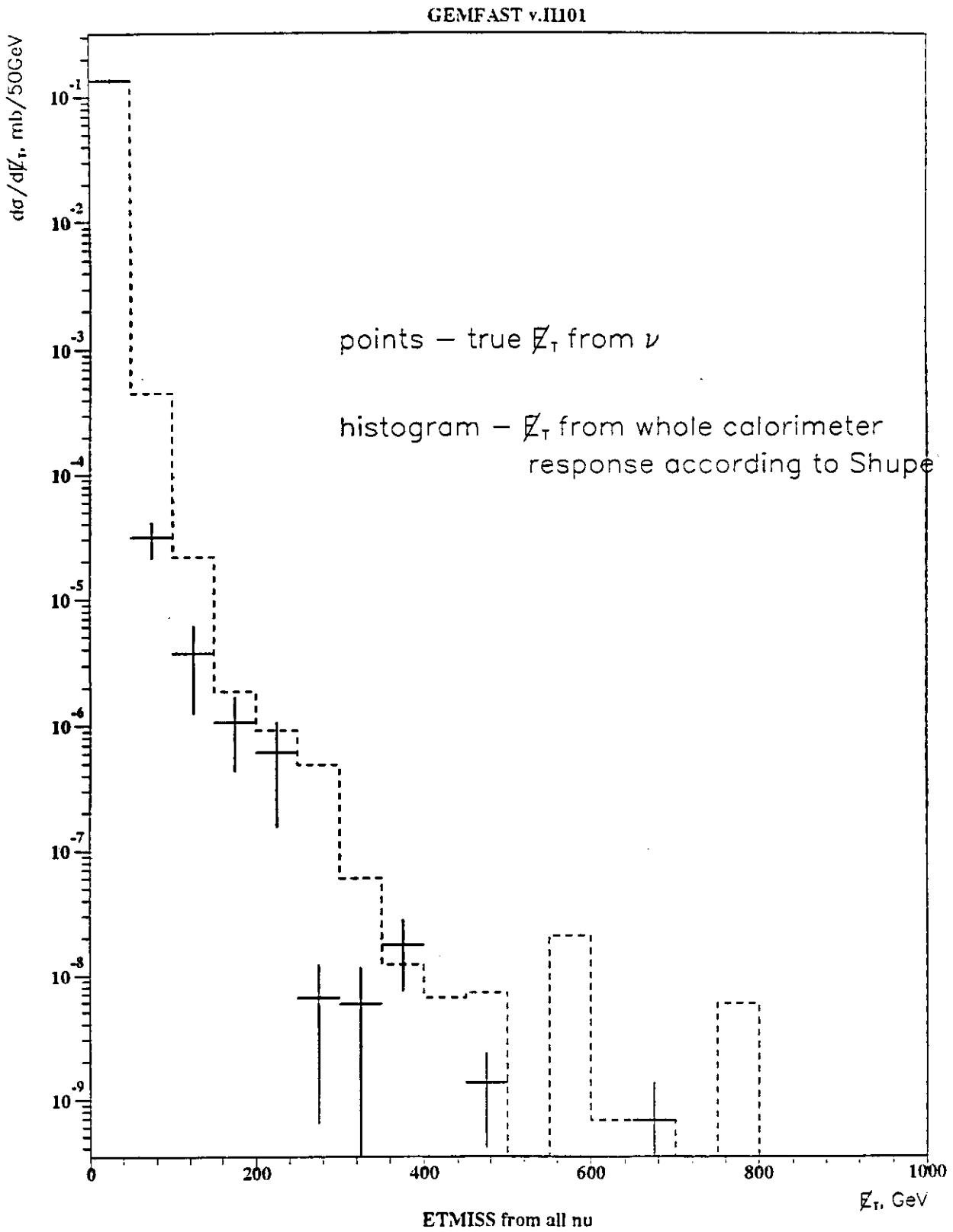
is slightly more optimistic but consistent within the limited statistics. The `fci_smear` simulation should be more reliable for $\not{E}_T$, but the GFLASH simulation is essential to analyze jets and other properties of the events.

From past experience it is expected that further cuts, such as selection of multiple jets in the central region, will make the observed and true $\not{E}_T$ cross sections much closer. Thus we may hope to be able to see a 300 GeV gluino, although this is not yet clear.

References

1. R. Ross and R. Roberts, Nucl. Phys. **B377**, 571, 1992.
2. For a review see H. Haber and G. Kane, Phys. Rept. **117**, 75 (1985).


GEMFAST v.II101
dσ/d∅T, mb/50GeV
points – true ∅T from ν
histogram – ∅T from GEMFAST calorimeter
central calorimeter – GFLASH
forward calorimeter –
response according to Shupe
∅T, GeV
ETMISS from all nu


GEMFAST v.II101
dσ/d∅T, mb/50GeV
points – true ∅T from ν
histogram – ∅T from whole calorimeter response according to Shupe
∅T, GeV
ETMISS from all nu