GEM TN-93-365

GEM Physics Simulation Meeting - SSCL

March 17, 1993

Abstract:

Agenda, attendees and presentations of the GEM Physics Simulation Meeting held at the SSC Laboratory on March 17, 1993.

GEM PHYSICS GROUP --- TDR MEMORANDUM #13
KENNETH LANE --- MARCH 12, 1993
(internet: lane@buphyc.bu.edu, lane@weyl.bu.edu)

AGENDA FOR GEM PHYSICS MEETING AT SSCL -- MARCH 17 AT 1PM

The meeting on Wednesday will be devoted to intensive discussions of new developments and problem areas. The topics and suggested speakers are listed below. Speakers are requested to keep talks SHORT and INFORMATIVE. Much of the discussion will be informal! The room will be announced on or before Wednesday. Check the user's office.

1) Muon simulation issues: Triggering, pattern recognition, geometrical acceptance, momentum resolution, L = 10**34 problems, etc. Speakers
15 include:

   Torre Wenaus (gemfast code), Peter Dingus (trigger), Vladimir (pattern), Renyuan Zhu (H -> ZZ* -> 4 mu), Bing Zhou (discussion leader).

2) EM calorimeter (and CT) issues: EM resolution, noise terms, gamma/e discrimination, L = 10**34 problems, etc. Speakers include:

:15 Hong Ma (all simulation and detector issues; R(jet/e)), Renyuan Zhu (H -> gamma gamma and H -> ZZ* -> eeee), Shawn McKee (R(gamma/e)), Harvey Newman (discussion leader).

3) Jets and related calorimeter issues: Calorimeter inhomogeneities, transition regions, noncompensation, jet energy correction, jet
00 clustering algorithms in various circumstances. Speakers include:

   Chiaki Yanagisawa (t -> jets), Rob Carey (all issues and discussion leader -- to be confirmed!) others?

4) CT issues: L = 10**34 operations and capabilities, b-tagging; tau-tagging, etc. Speakers include:

00 Chiaki (b-tag for top; tau-tag for H^+); Shawn McKee (all topics and discussion leader), others?

5) Physics justification for and inputs to detector design: Why LKr? Why the chosen segmentation? Why R_CT = 95cm, etc., etc. Speakers
:00 include:

   Barry Barish (who dealt this mess?), Harvey Newman (discussion leader), (these two can switch roles if desired); all others.
   Barry -- if you read this far, please confirm.

6) Figures for Chapter 2 - Physics: Format, tools, etc. -- Frank Paige (physics figure maven)

This is a LOT of material to cover in 5-6 hours. Be concise and be pertinent! Thanks.

Physics Simulation Meeting. 3/17/93

TORRE WENAUS	LLNL	WENAUS @ MSF.SSC.
BING ZHOU	B.U.	Zhou@ BUPHY
Rob Carey	BU	CAREY @ BUPHYC
Harvey Newman	Caltech	newman@cithex
Jim Branson	UCSD	BRANSON@UCSDHEP1 .UCSD.E
Ren-yuan Zhu	CALTECH	ZHU@CITHE
Barry Barish	Caltech	BARISH@CITHE
KENNETH LANG	BU	LANG@BUPHYC.BU.EDU
Frank Paige	SSC	Paige@ SSCVX1
Shawn McKee	U of Mich	MCKEE @ SSCVX1
Mark Clemen	Univ of Pittsburgh	CLEMEN@ VMS.CIS.PITT.ED
Vladimir Gavrilov	ITEP/SSCL	GAVRILOV@ SSCVX1
John Hilgart	SSC	hilgart @ssvx1
Irwin Sheer	SSCL	Irwin_Sheer@SSC.gov
Ken McFarlane	SSCL	mcfarlane@sscvx1
Chiaki Yanagisawa	~~S~~ Stony Brook	CHIAKI@SBHEP
Peter Dingus	SSCL	DINGUS@SSCVX1
JOHN WOMERSLEY	SSCL	womersley@ssc.gov
HENK Uijterwaal	SSCL	HENK@ Pdsf.ssc.gov
A. Vanyashin	SSCL	vanyashin@sscvx1

gem

γeμ

Presentation by:

Irwin Sheer

Tomasz Skwarnicki
3/12/93

GEMFAST STATUS

vII202 released on 3/9

Major changes:

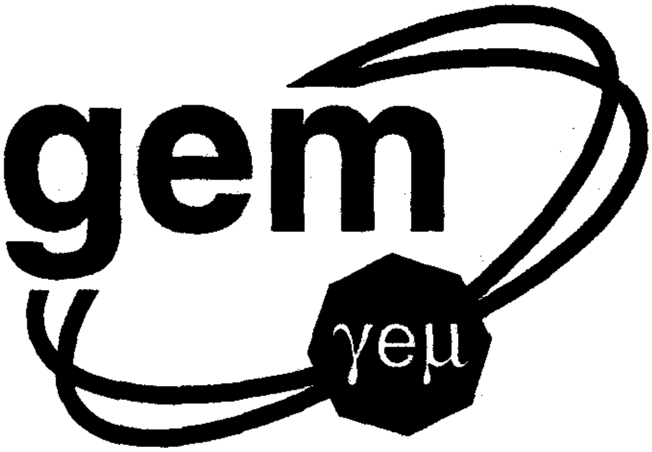
1. Muon code from Torre Wenaus describing recent design.
2. New parametrizations of material in CT used in the gamma conversion code (from Shawn McKee). For high luminosity running (>3 10**33) Silicon tracker is assumed to be removed (less material). Luminosity is selected by setting ALUM33 variable in fsi_fasopt.inc (default=1.0 i.e. 10**33).

   There was also a bug in early vII201 release concerning conversion probability, which was too high by (9/7)**2=1.65.

   Minor change in fsi_ctrecon.f (effecting EFFCT).
3. pile-up energies are now scaled in fsi_addpile by SQRT(ALUM33). If you set ALUM33=10.0 (exactly) then you will use pile-up files generated specially for 10**34. For all other ALUM33 setting you will use 10**33 files scaled by sqrt(ALUM33) (e.g. ALUM33=9.999 is 10**34 pile-up simulated from 10**33 files). Note that the scaling by sqrt(ALUM33) is not an exact procedure.
4. PTRIGMU removed from fsi_fascom.inc (and TRCUTMU from fsi_fasopt.inc). Muon trigger simulation is now a part of Henk's trigger simulation package (gemfast/libtrf).
5. User callable fsi_ctiso has different isolation cuts defaults.

vII203 released on 3/12

1. Improved muon code from Torre Wenaus.
2. All INTEGER*2 variables (pointers IGTOxx and other) in gemfast include files: fsi_fascom.inc, fsi_fascal.inc were changed to a full INTEGER (i.e.*4).
3. Minor change to fsi_cajets.f to allow jet finding with negative cut on cell energies (from Hong Ma).



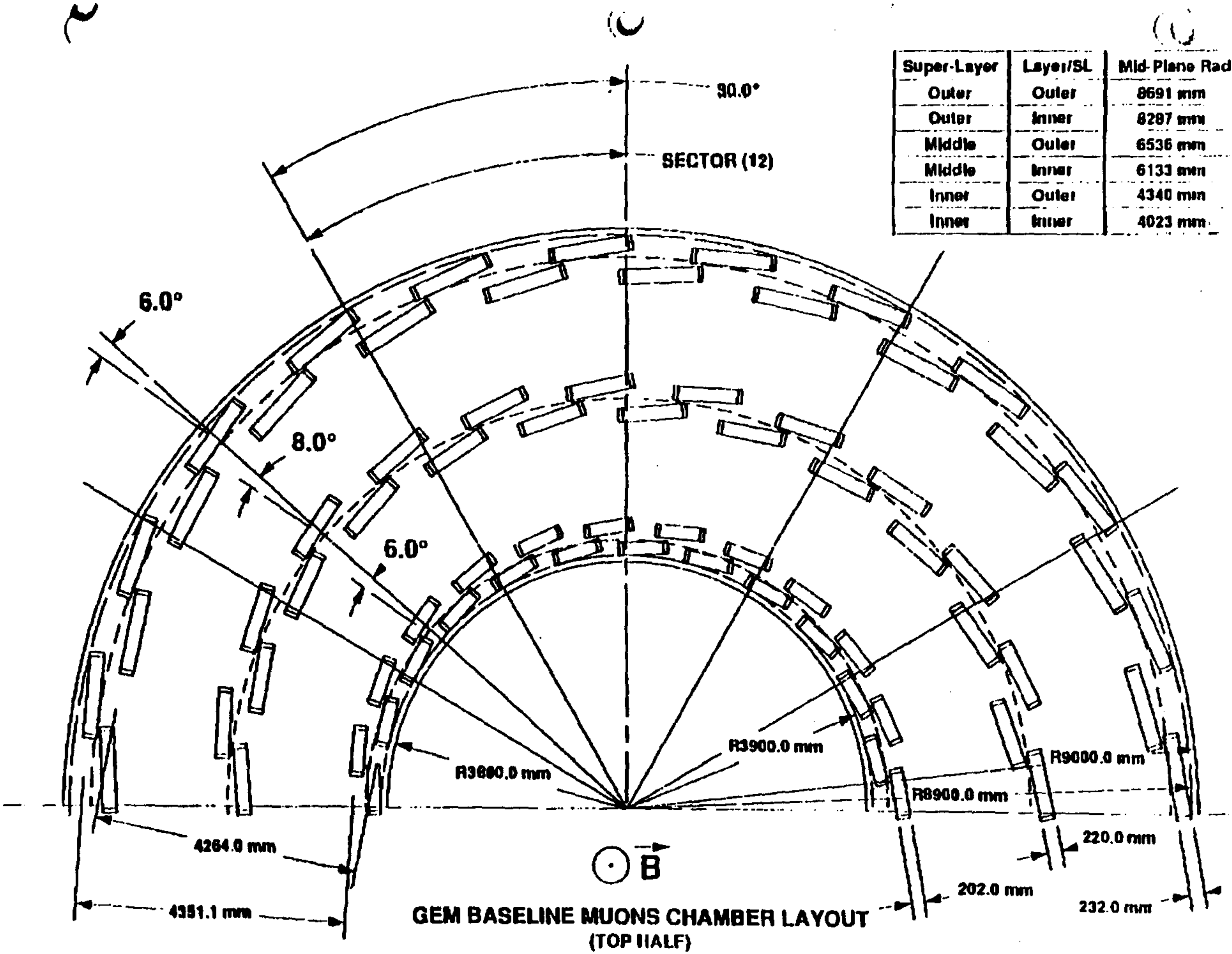
Presentation by:

Torre Wenaus

MU SYSTEM PARAMETRIZATION UPDATE

MAR 17 93

T WENAUS



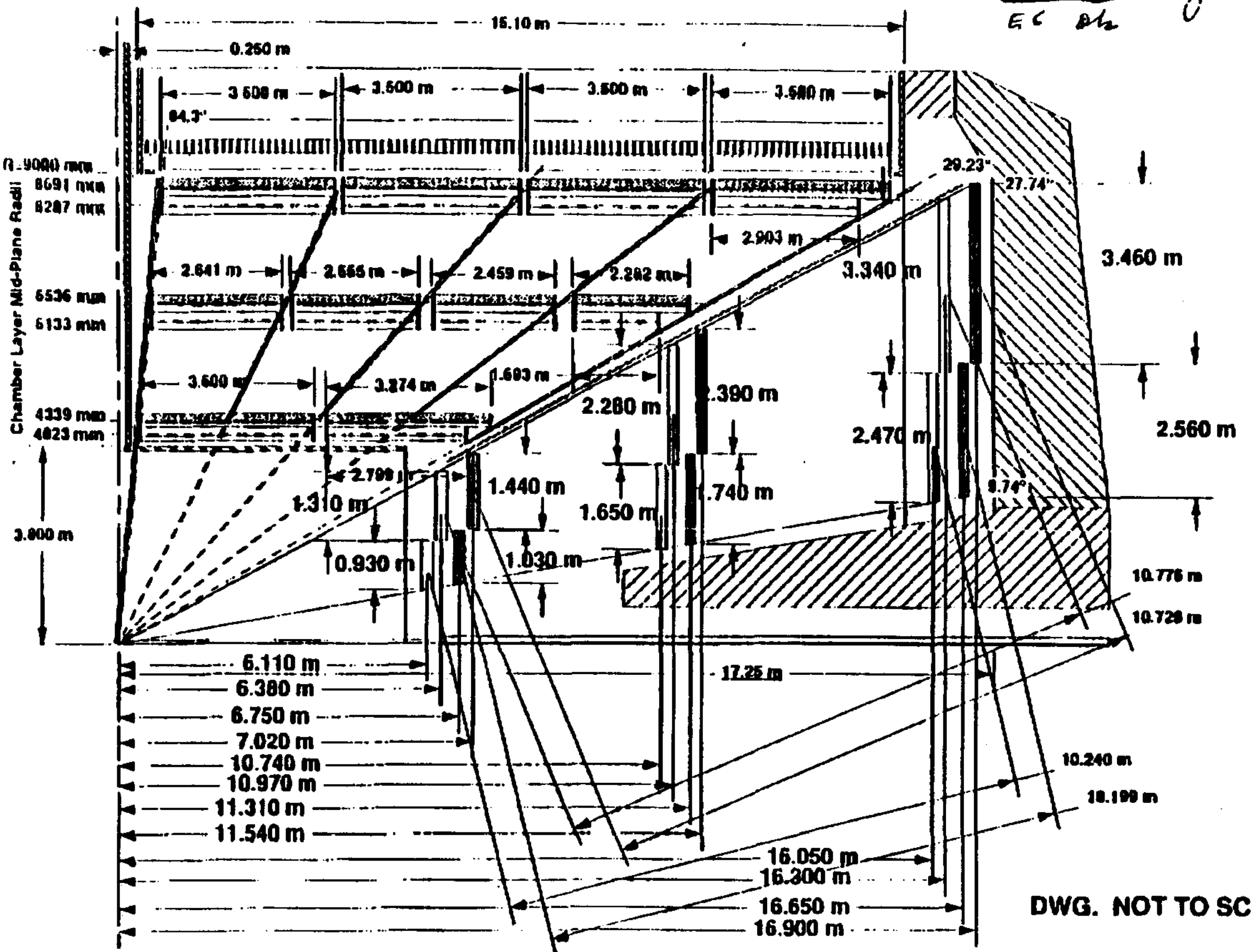
Super-Layer	Layer/SL	Mid-Plane Radii
Outer	Outer	8691 mm
Outer	Inner	8287 mm
Middle	Outer	6536 mm
Middle	Inner	6133 mm
Inner	Outer	4340 mm
Inner	Inner	4023 mm

GEM BASELINE MUONS CHAMBER LAYOUT
(TOP HALF)
(CCW TILTED MAGNET END)

F. Nimble
03 March 1

Out dated layout of barrel

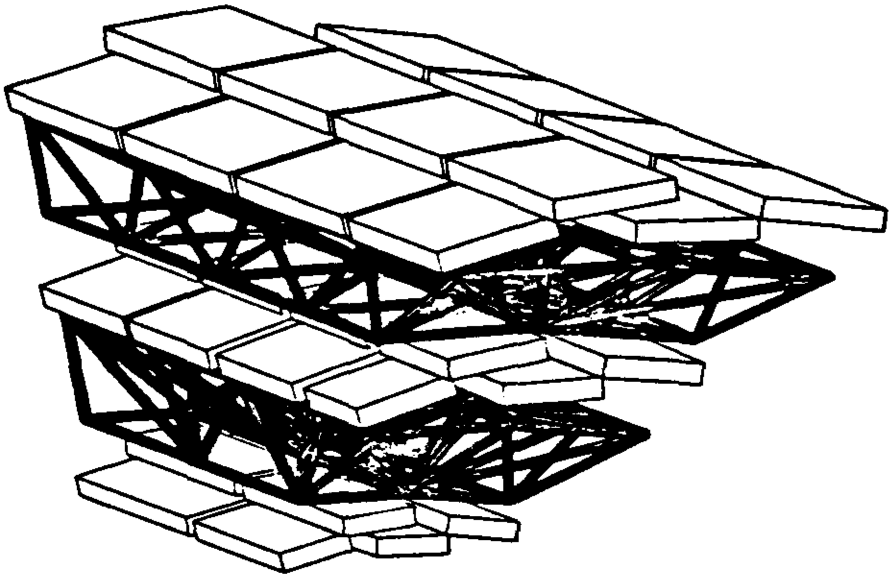
EC [illegible]

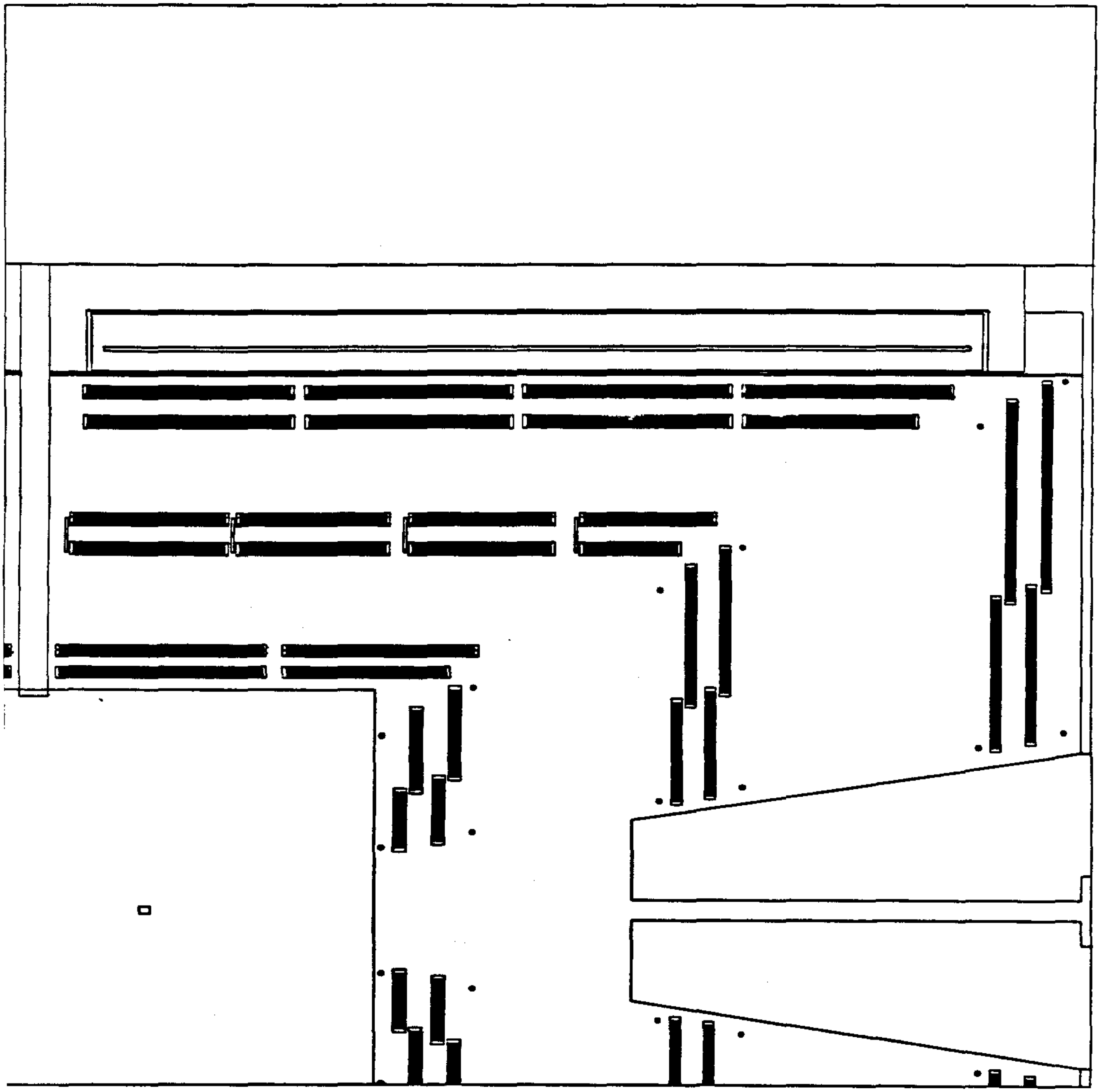


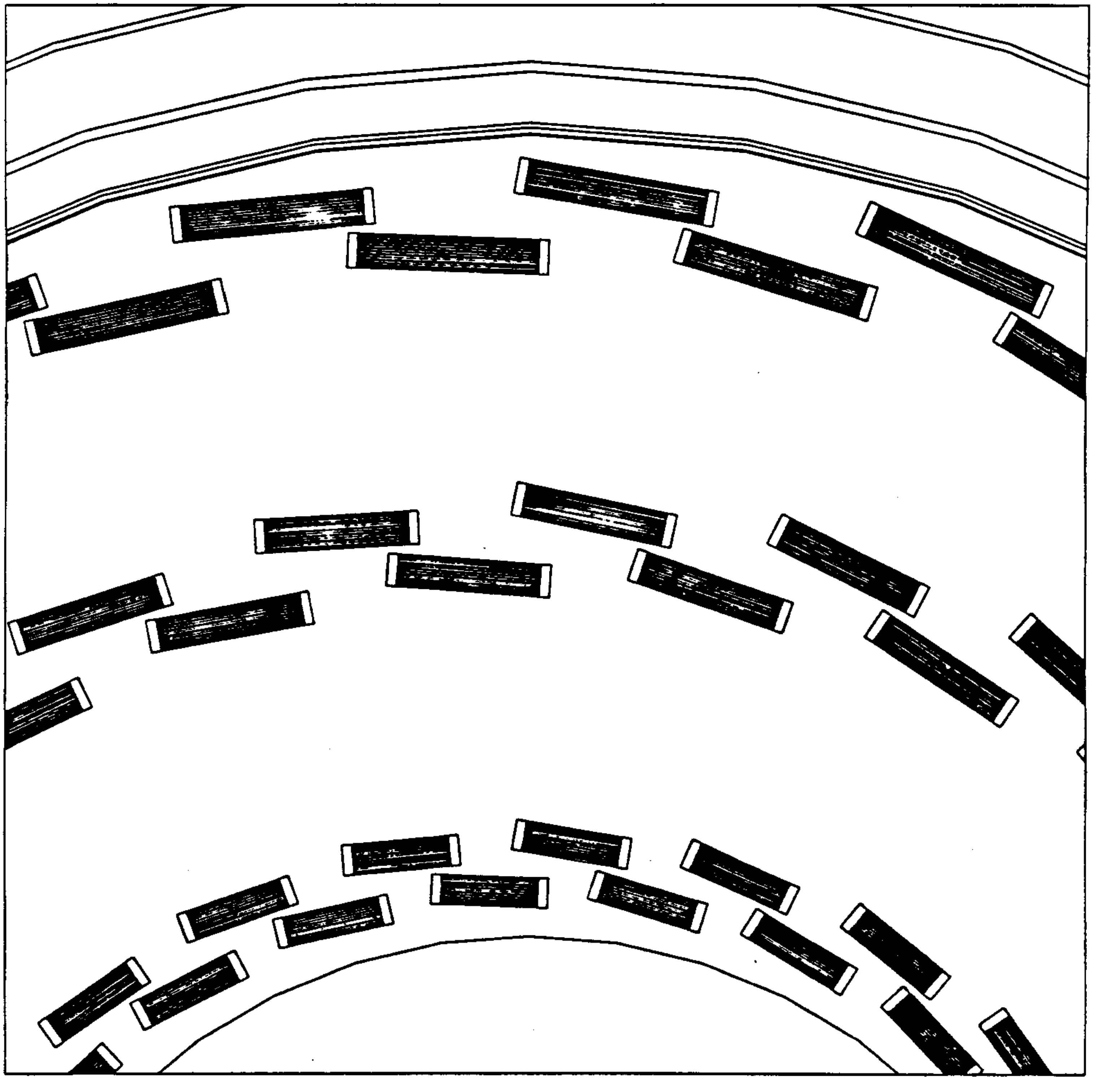
DWG. NOT TO SCALE

PROJECTIVE ALIGNMENT
WITH RADIAL SUPPORT PLATES
IN BARREL
(SYSTEM DIMENSIONS)

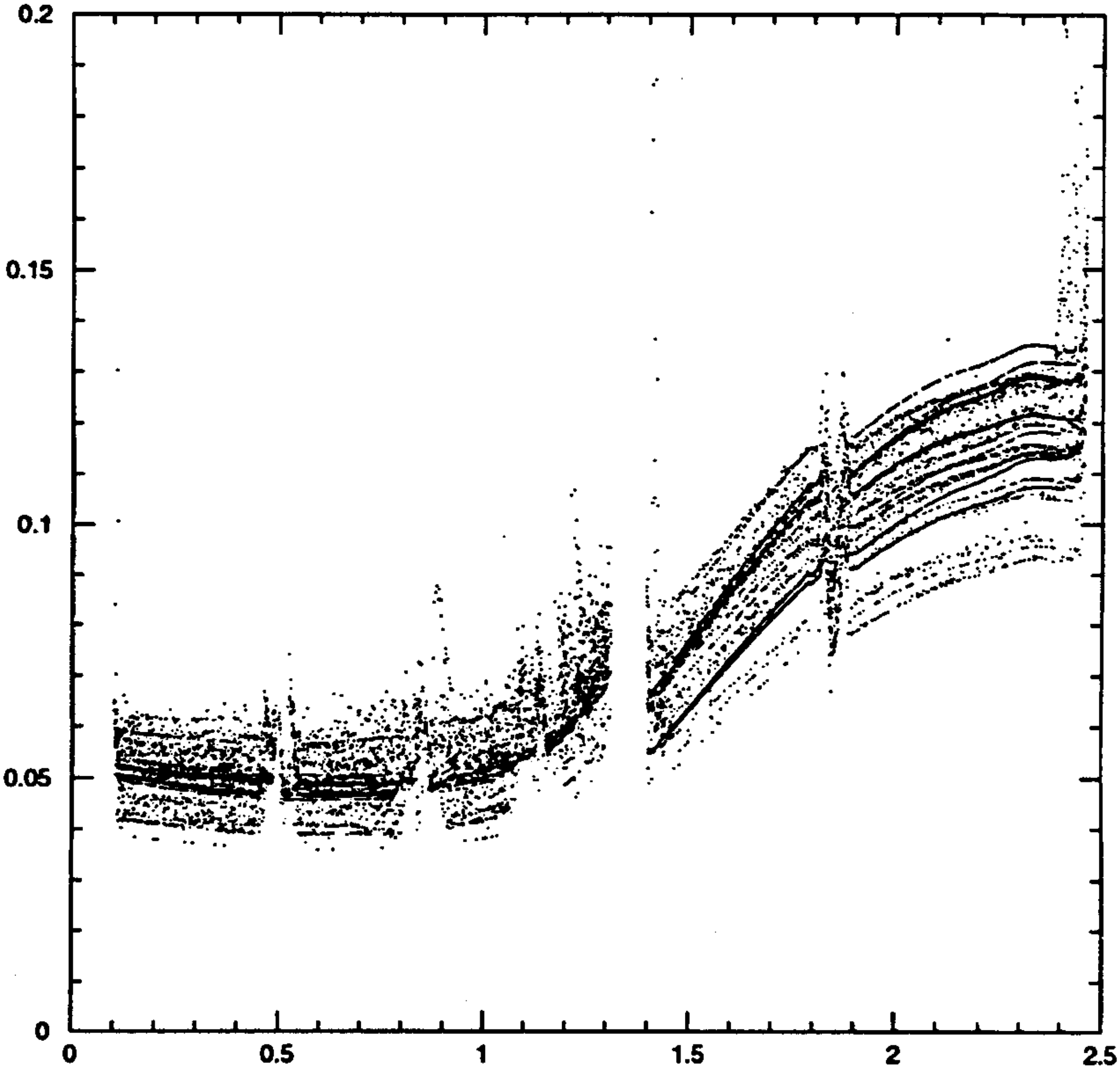
F. NIMBLETT
03 Mar. '93

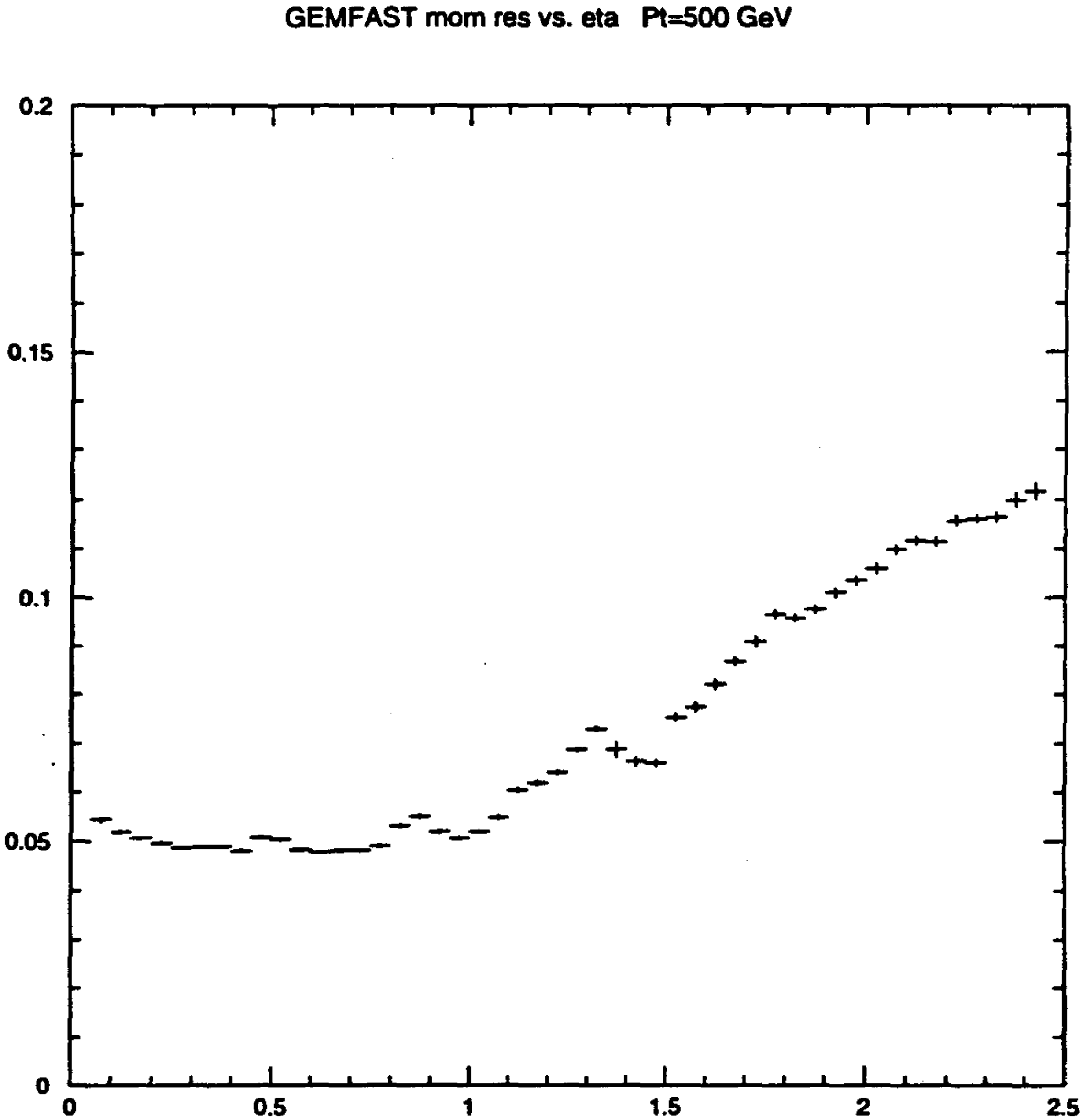




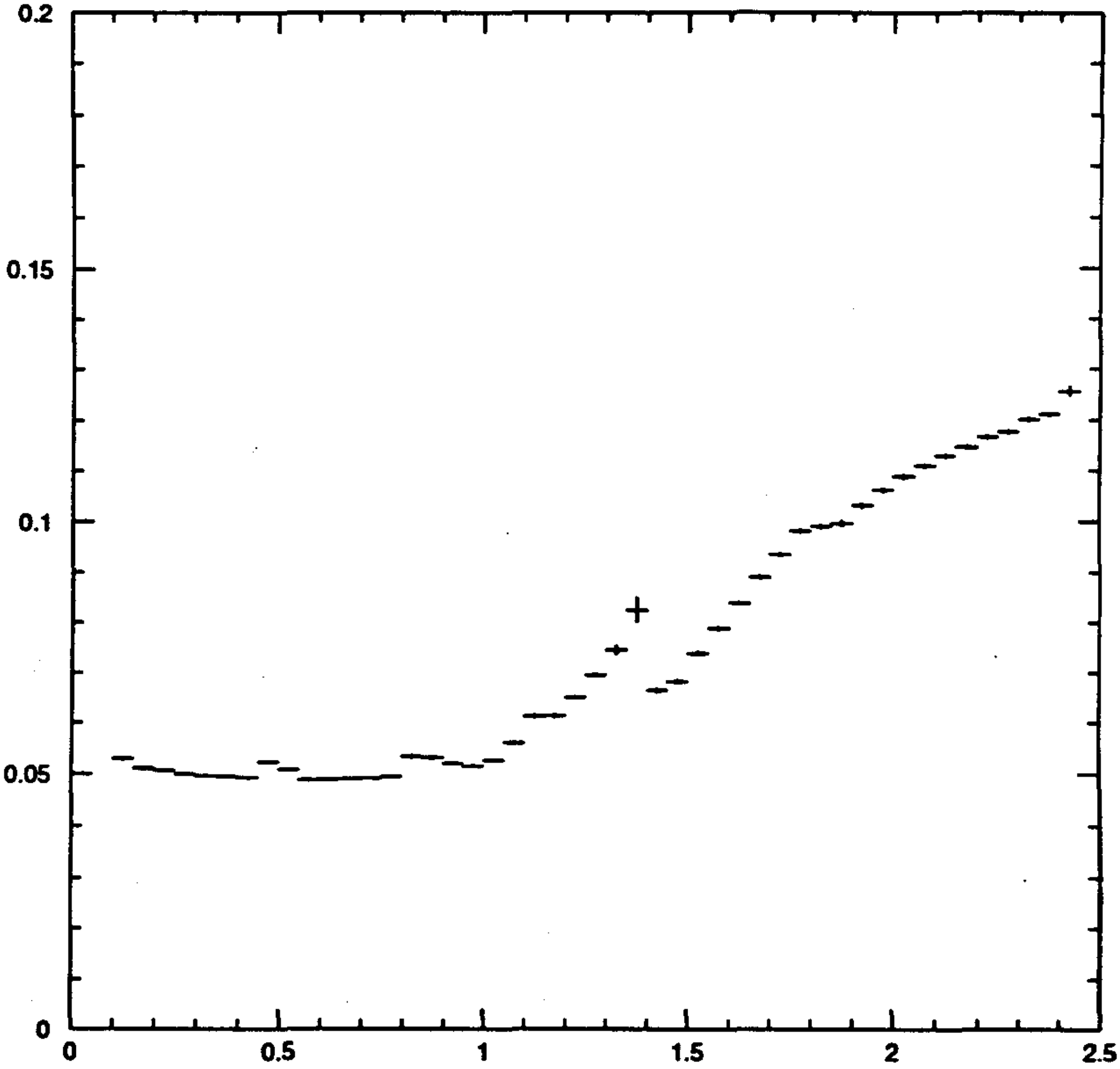


Monte Carlo mom res vs. eta   Pt=500 GeV

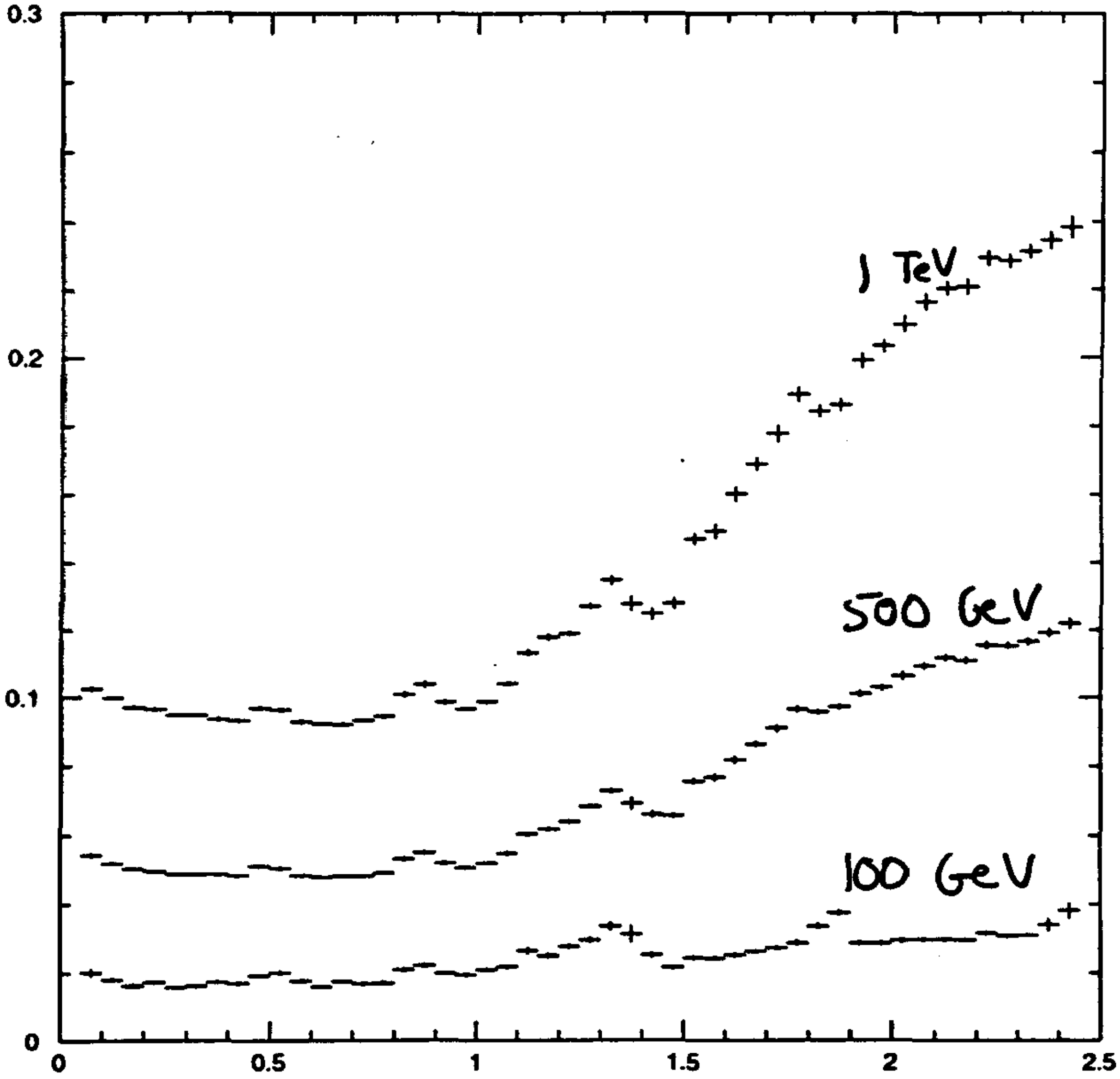



GEMFAST mom res vs. eta   Pt=500 GeV
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5

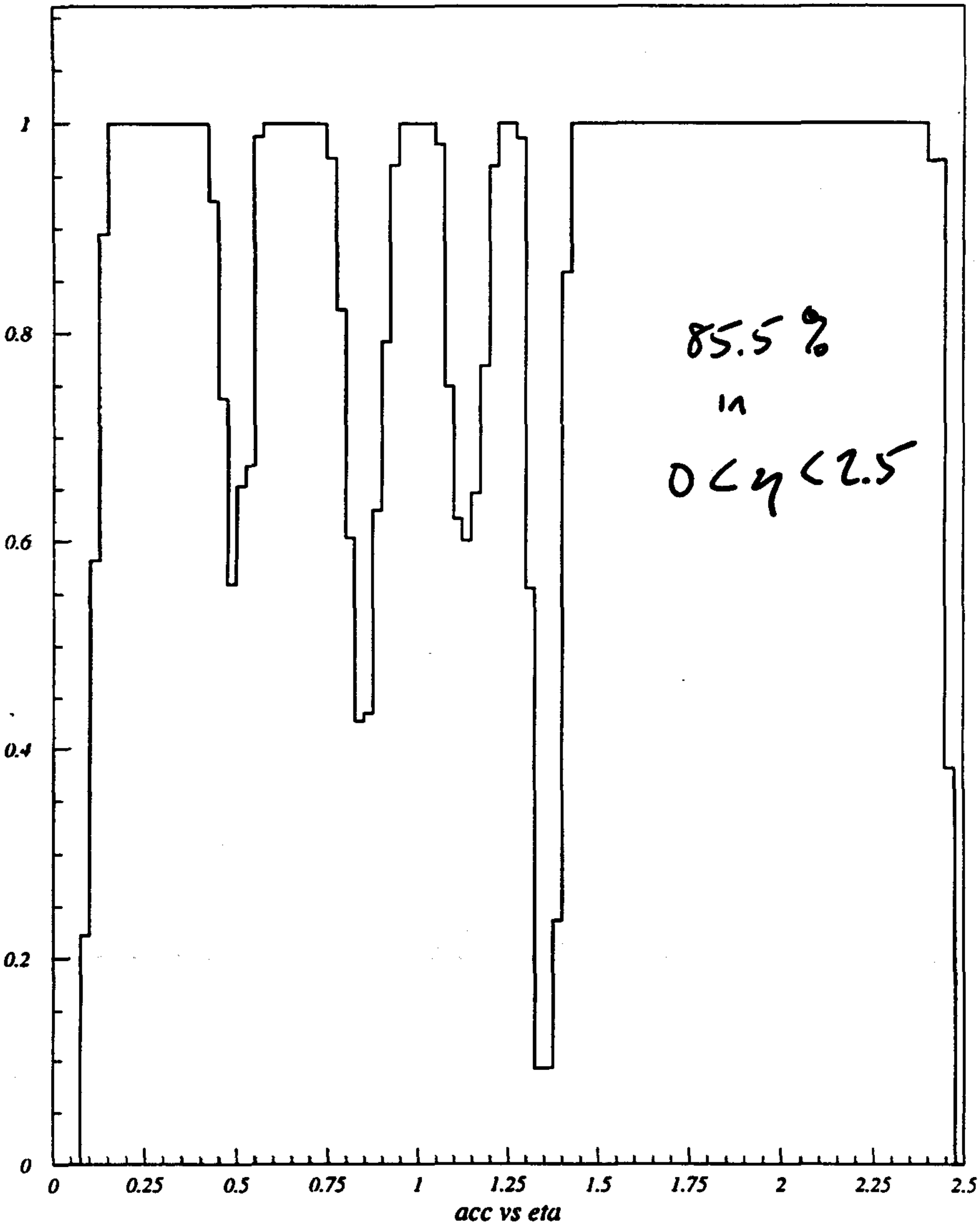
Monte Carlo mom res vs. eta   Pt=500 GeV



GEMFAST mom res vs. eta

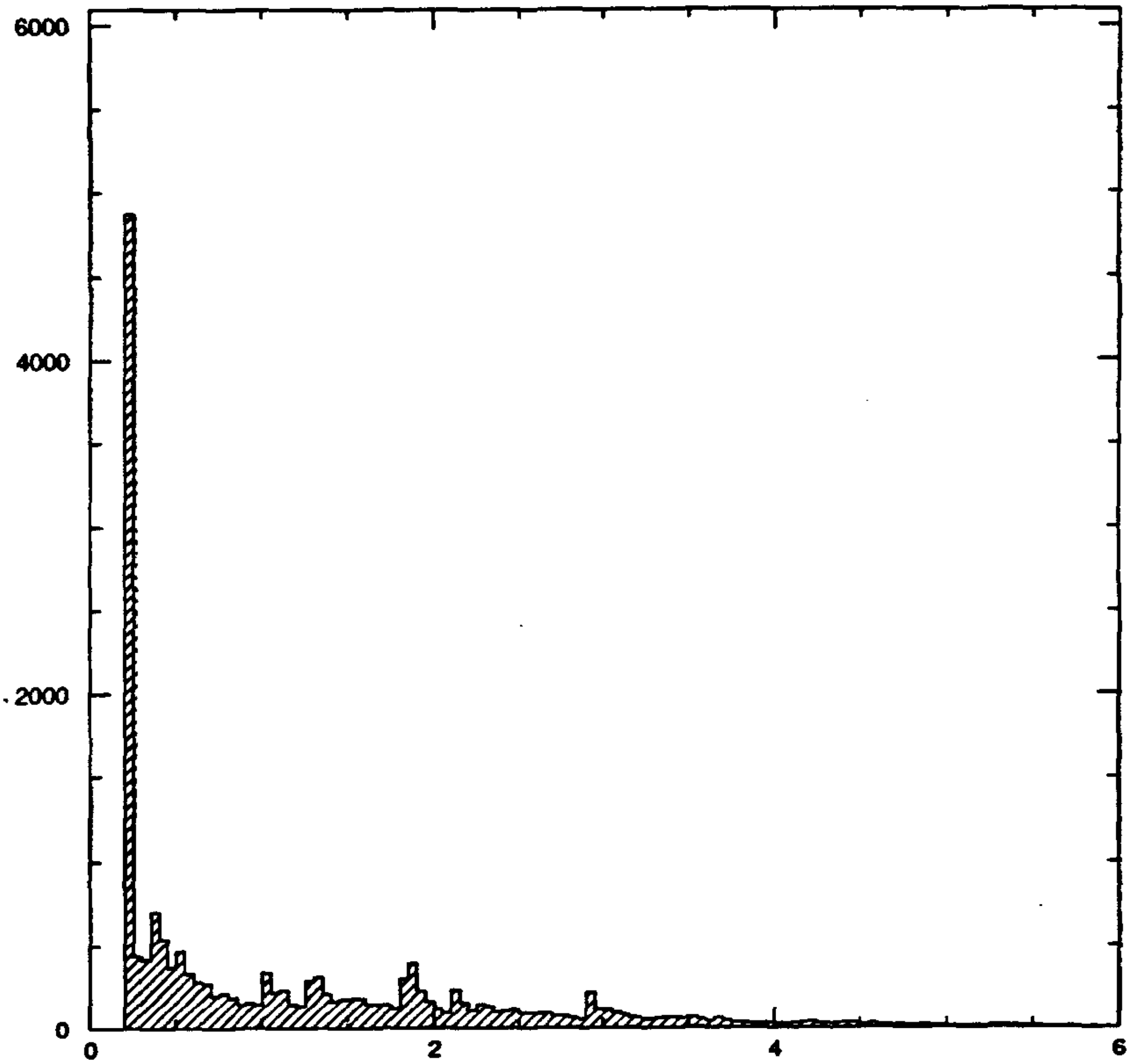


ACCEPTANCE

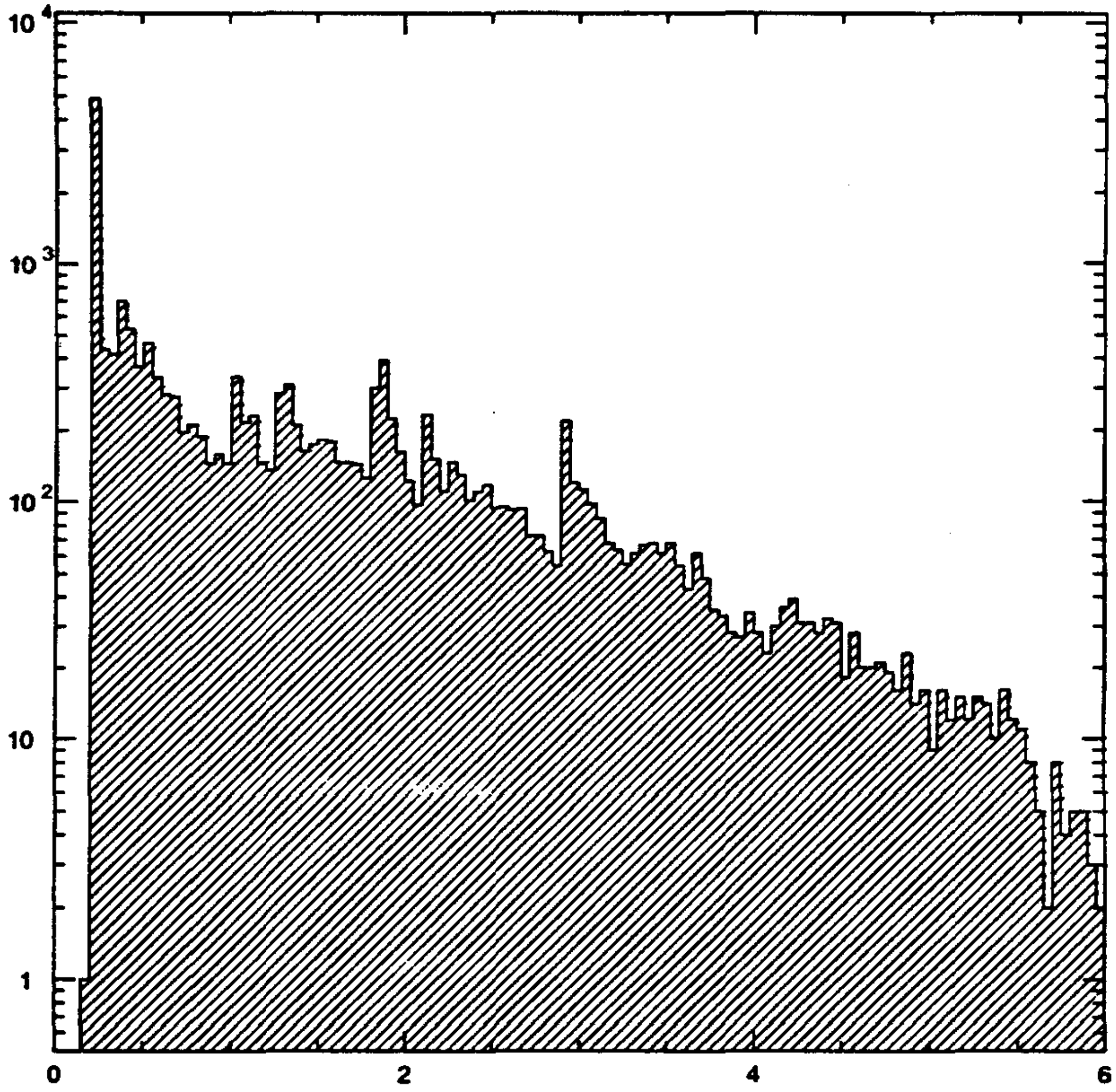


85.5 %
in
$0 < \eta < 2.5$

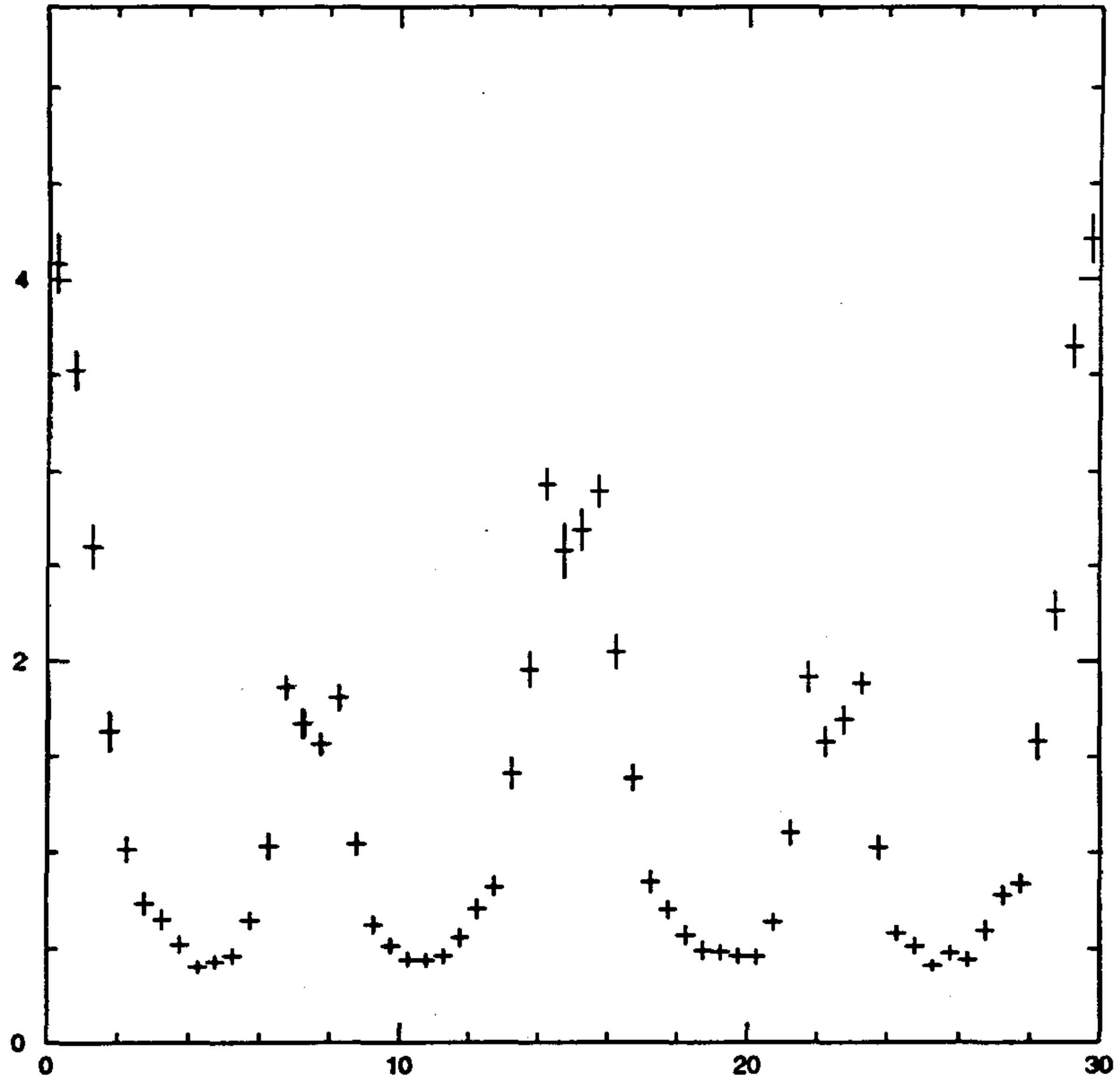
Radiation lengths, measured muons



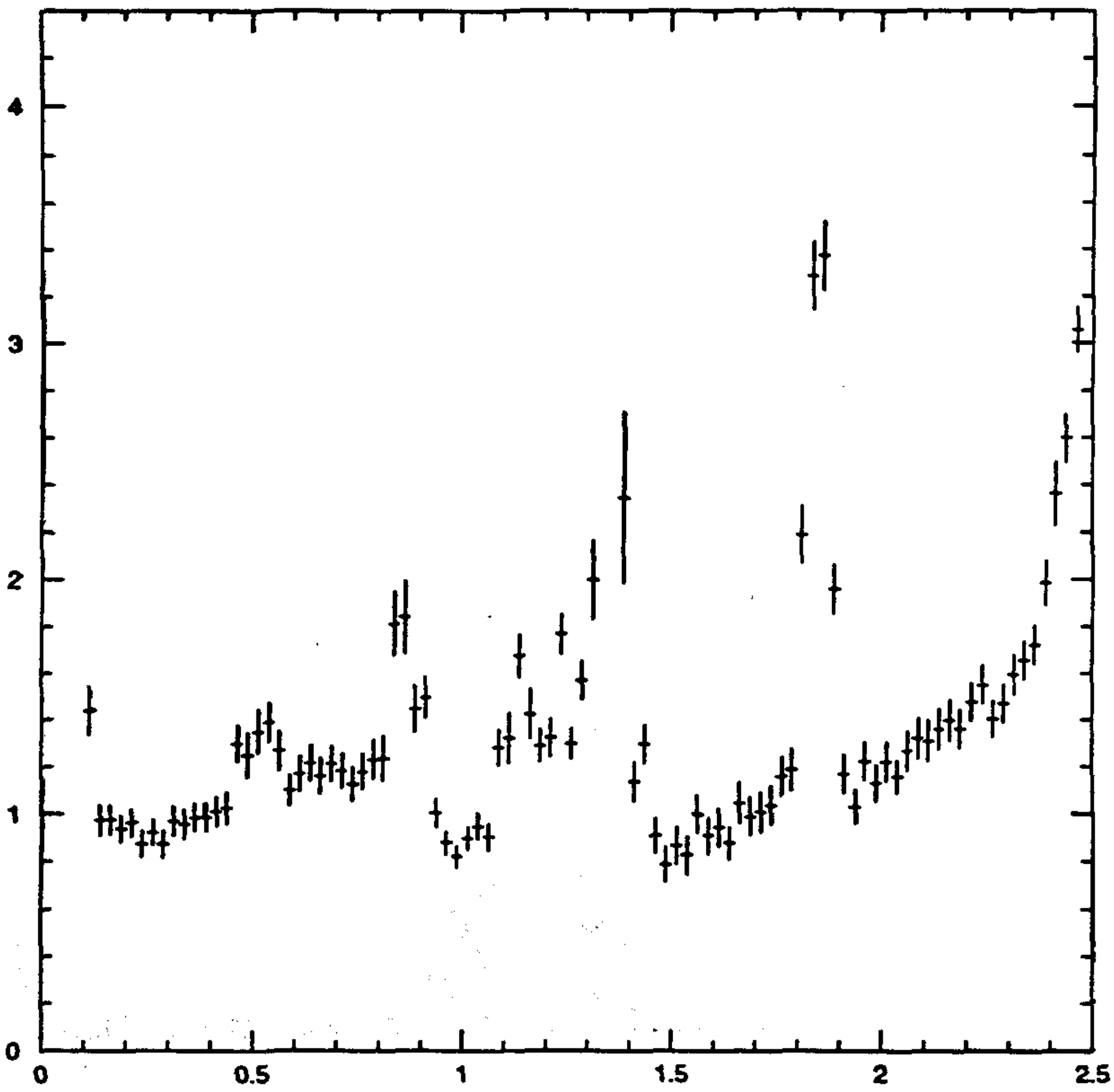
Radiation lengths, measured muons



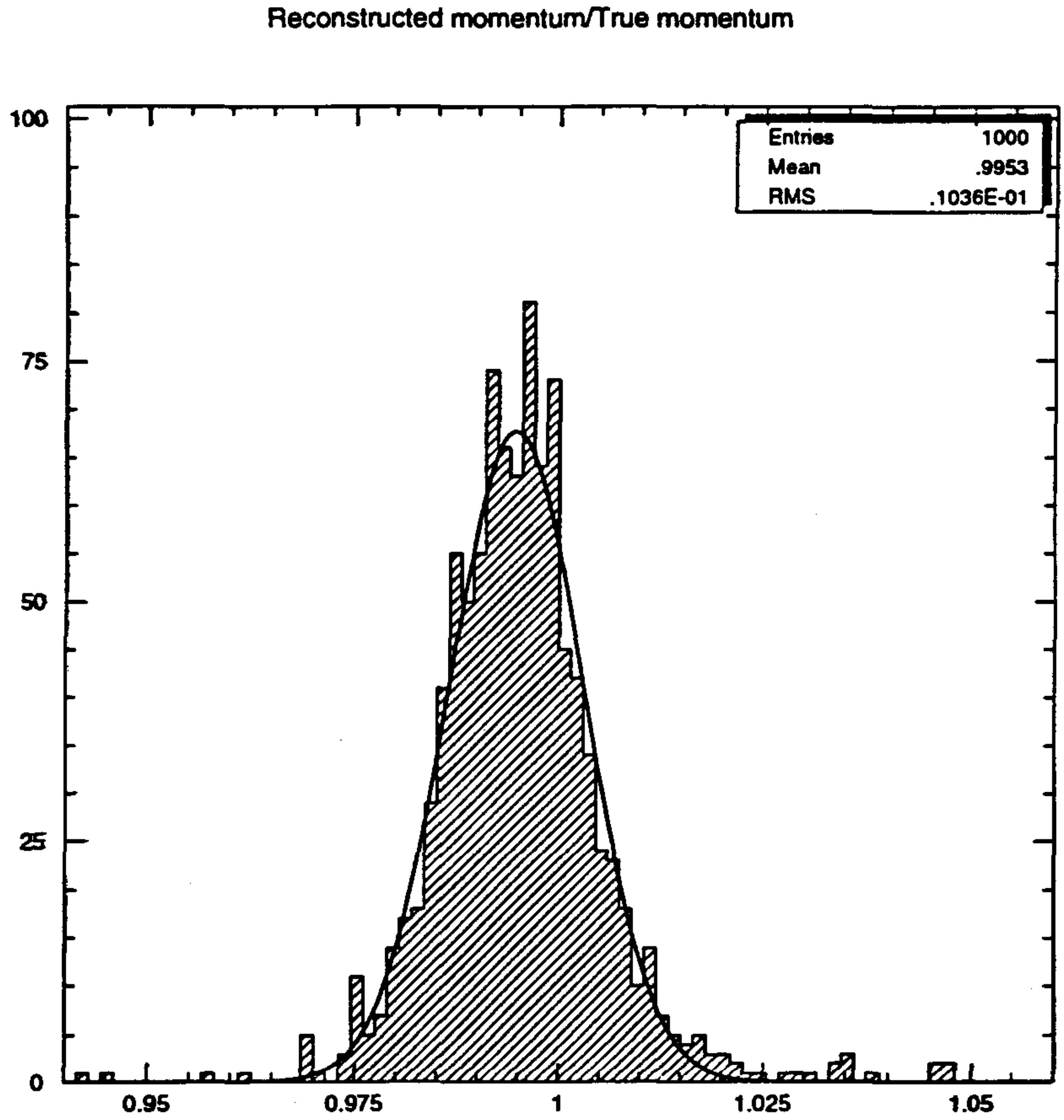
Average X0 vs. phi, endcap, measured muons



Average X0 vs. eta, measured muons

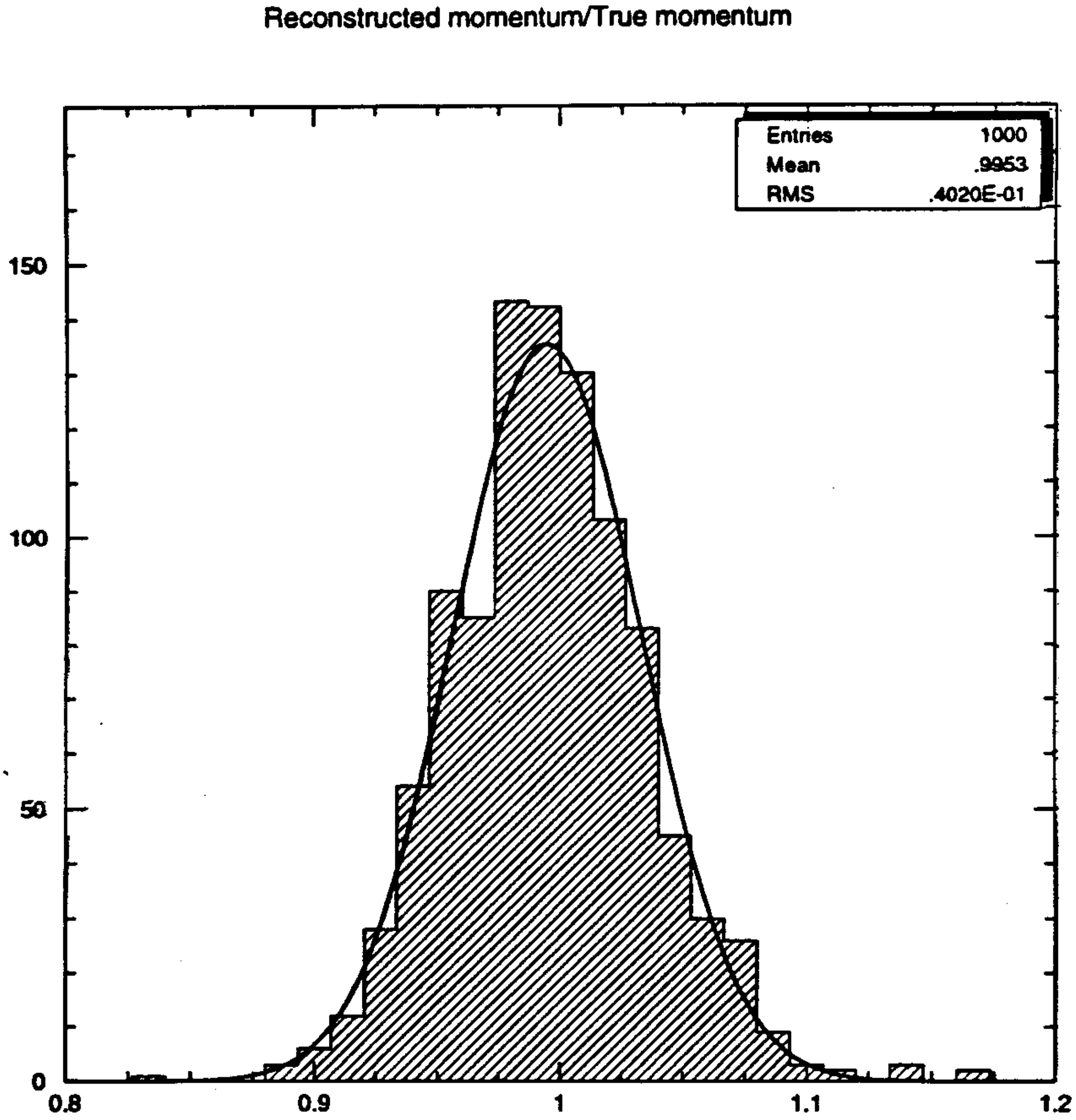


FULL RECONSTRUCTION WORKING:



500 GeV

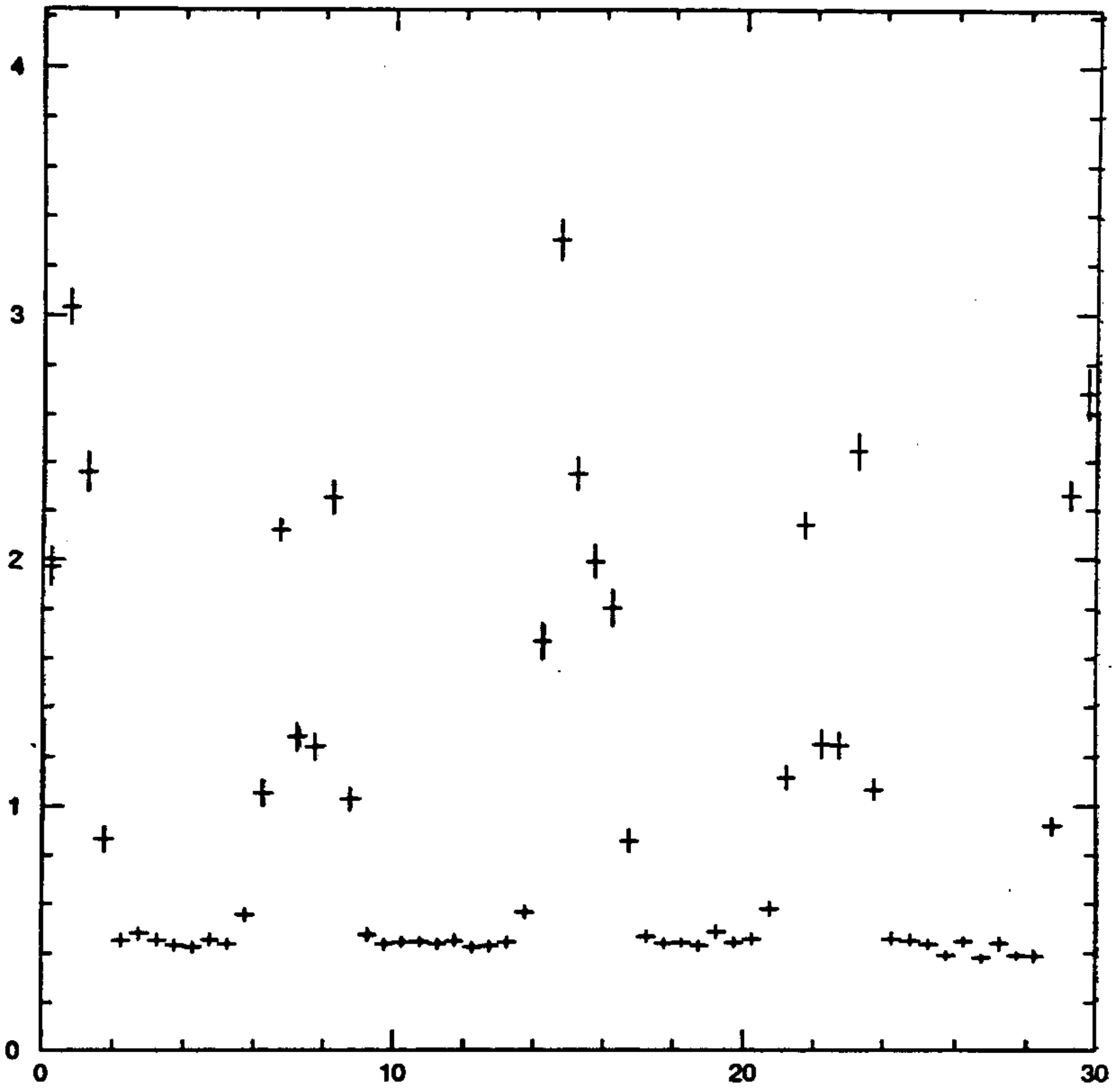
RES SMEARING OFF



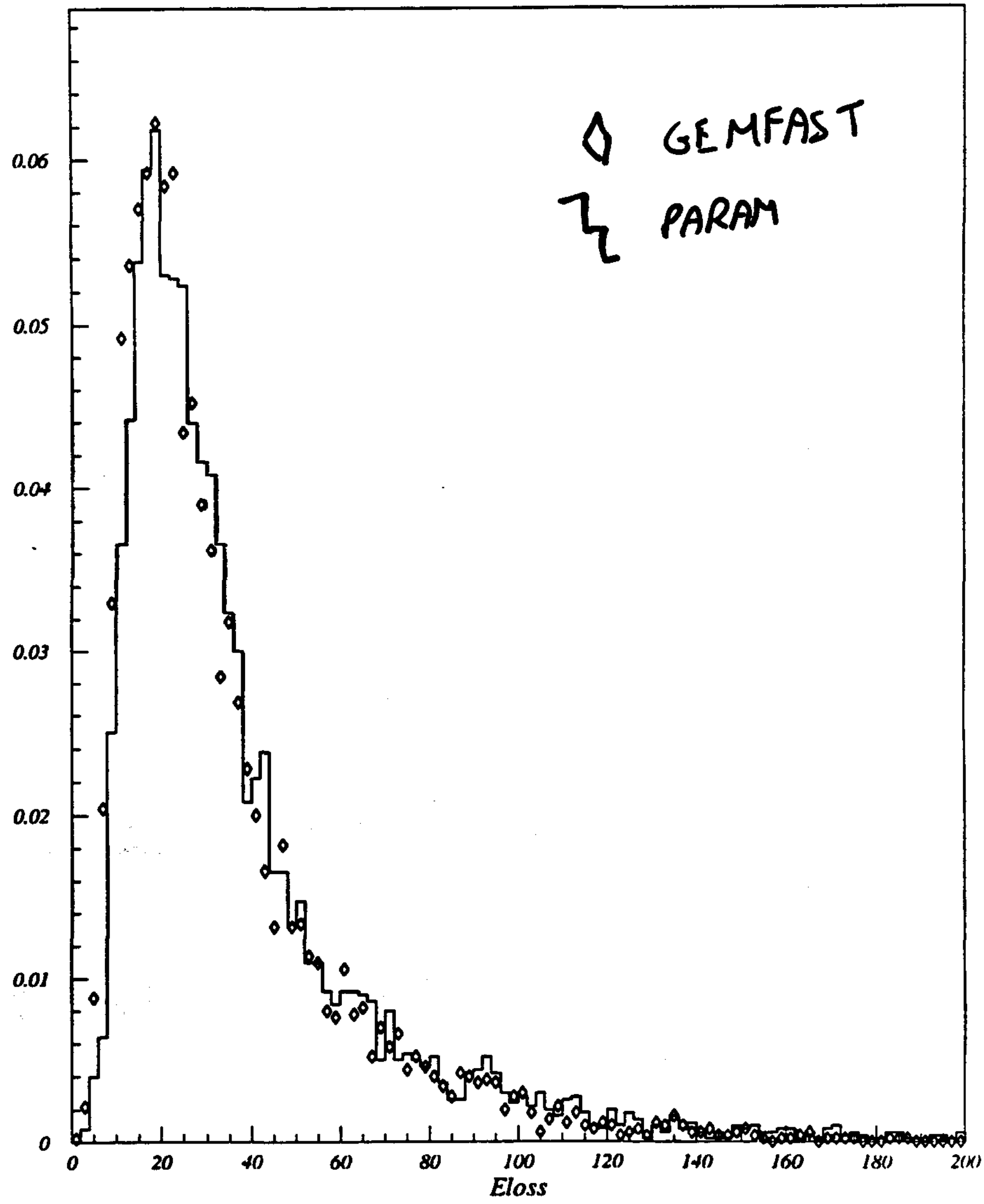
500 GeV

RES SMEARING ON

Average X0 vs. phi, barrel, measured muons



4 TeV


◊ GEMFAST
PARAM
0.06
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60
80
100
120
140
160
180
200
Eloss

SUMMARY:

- MON RES, ACCEPT. PARAMS BASED ON MAR 3 TDR BASELINE
- MAR 3 BARREL CONFIG IN Z OBSOLETE; η COVERAGE OF 85.5% FALLS A FEW %.
- $\Delta p/p$ 5% BARREL / ~12% ENCAP AT 500 GeV MAINTAINED
- $\Delta p/p$ AT LOWER p HAS SLIPPED DUE TO INCREASED X_0: $\Delta p/p \simeq 2\%$ $p_T \lesssim 100$ GeV
- FULL MUON RECO WORKING; SHOULD SOON HAVE $\Delta p/p$ AND RECO EFF. FROM FULL RECO IN PRESENCE OF BACKGROUND.
- PETER'S E LOSS PARAM IN GEMFAST WORKING OK.

gem

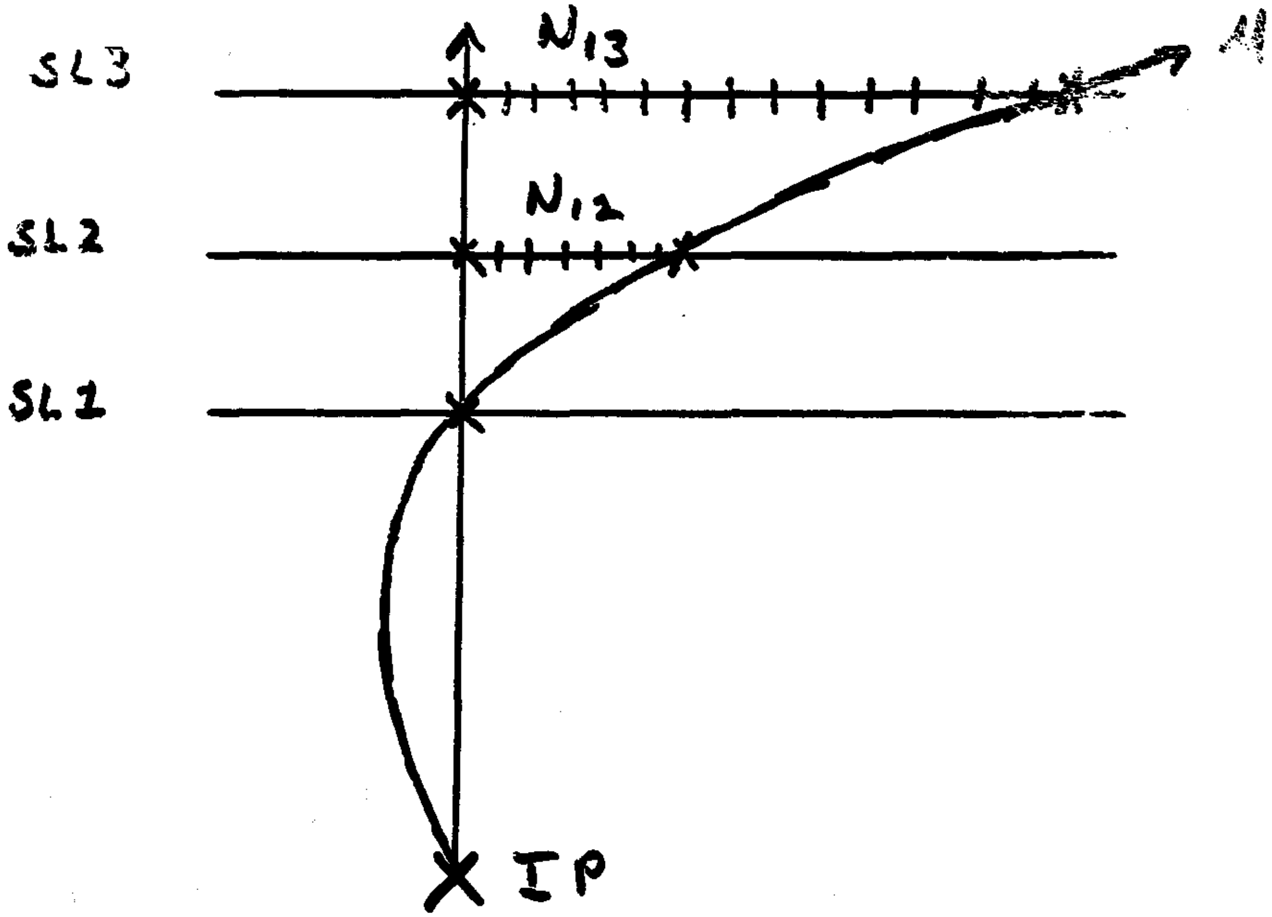
γeμ

Presentation by:

Peter Dingus

P. Dingus 3/16/93

WE BASED A MUON TRIGGER ALGORITHM ON A SAGITTA-LIKE VARIABLE;



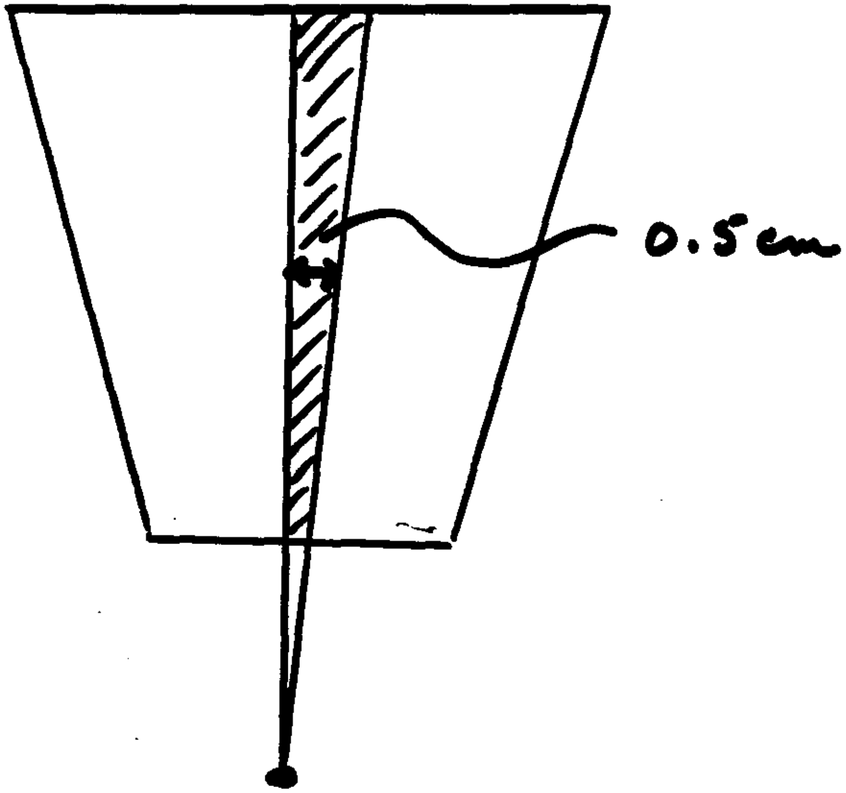
$$S\phi \equiv |N_{13} - N_{12}|$$

A Baseline II hit-level Monte Carlo was used, with the magnetic field map '600' supplied by J. S.

The plane configuration 6-6-6 was used in the barrel with pad sizes;

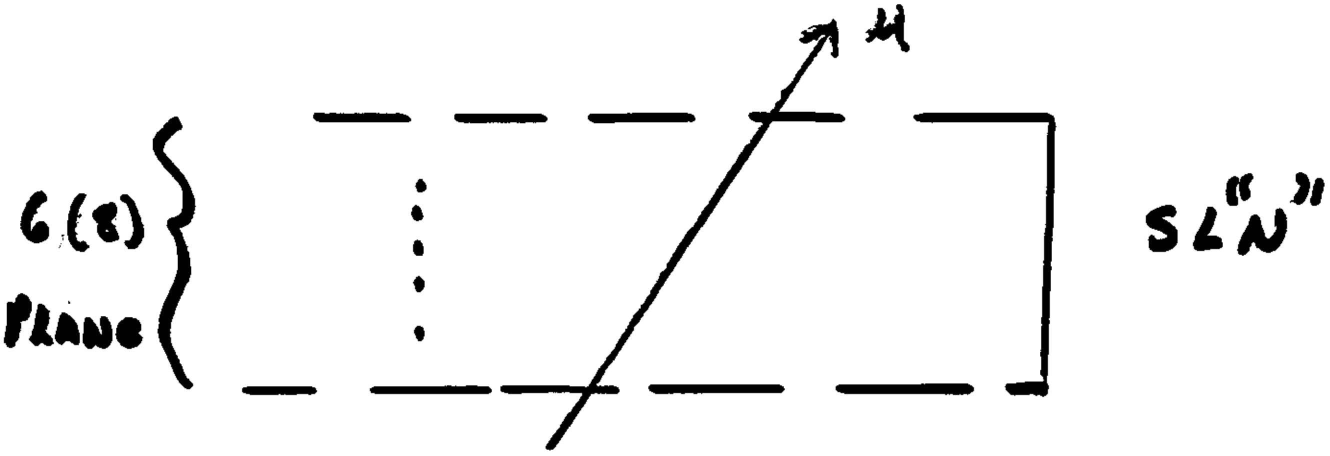
SL1 → 0.5 cm
SL2 → 0.8 cm
SL3 → 1.0 cm

The end-cap had 8-6-6 configuration with pie-shaped radial pads such that at the radial center



OF A STRIP. THE PAD SIZE WAS 0.5 cm.

THE HITS SEEN ON EACH OF THE superLAyers (THE "Average" PAD NumBer) were DeTermineD By ONLy THE 1ST AND LAST PLANE OF THAT SuperLayer.

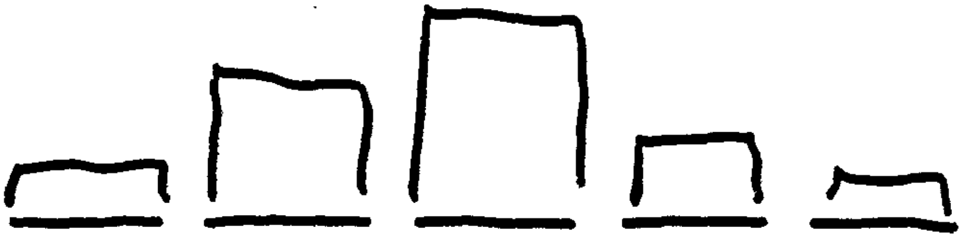


THIS HAD THE EFFECT OF MAKING Sϕ A "MORE" GAUSSIAN VARIABLE EVEN AFTER AVERAGING. TO INHANCE THIS THE PADS IN SUBSEQUENT PLANES WERE OFFSET BY 1/2 A PAD.

IN ORDER TO BE AS CONSERVATIVE AS POSSIBLE A LARGE UNCERTAINTY WAS ASSUMED IN THE DIGITIZATION.

1) THE TRIGGER CAN BE GANGED

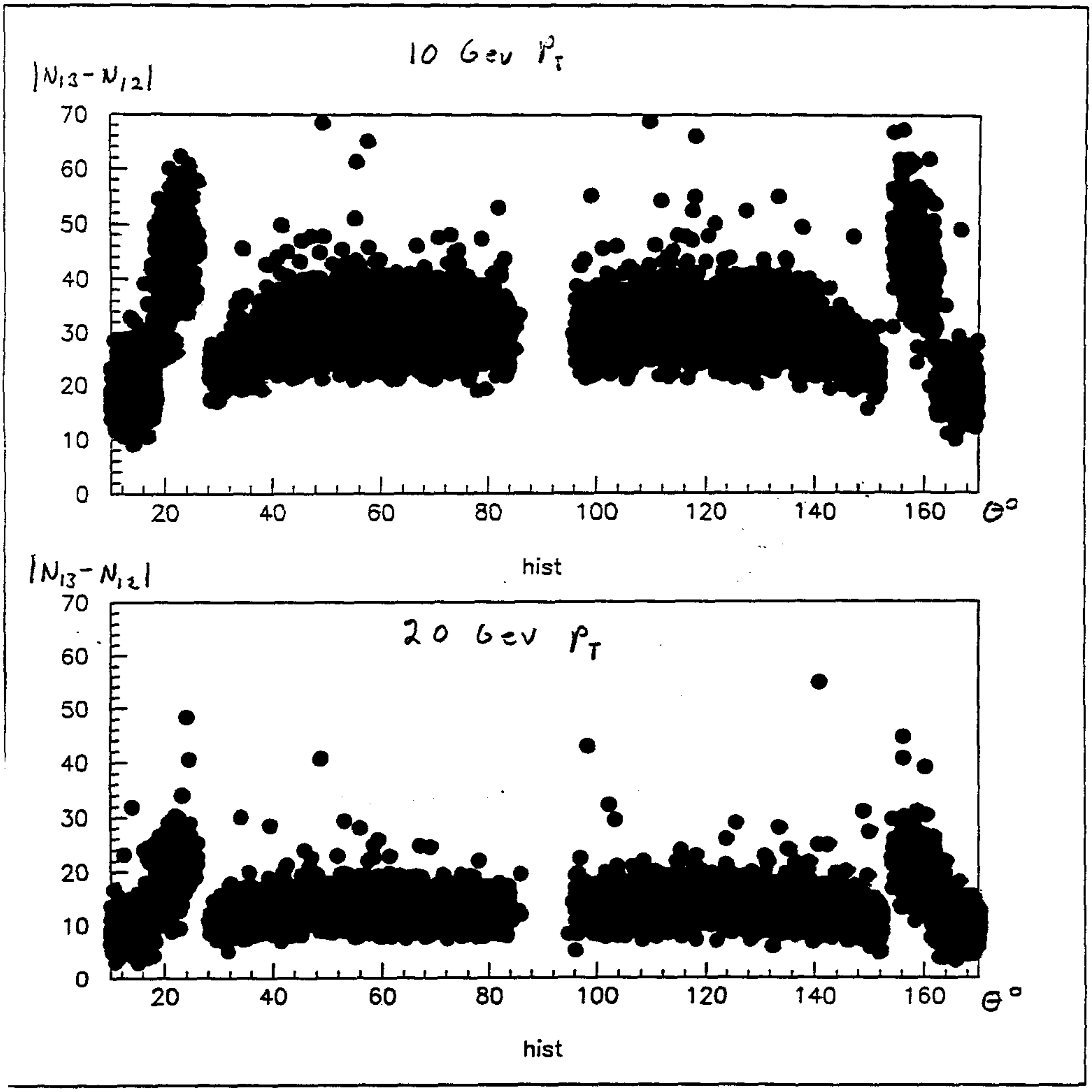
2) THE SIGNAL APPEARING ON DIFFERENT PADS CAN BE DISCRIMINATED :

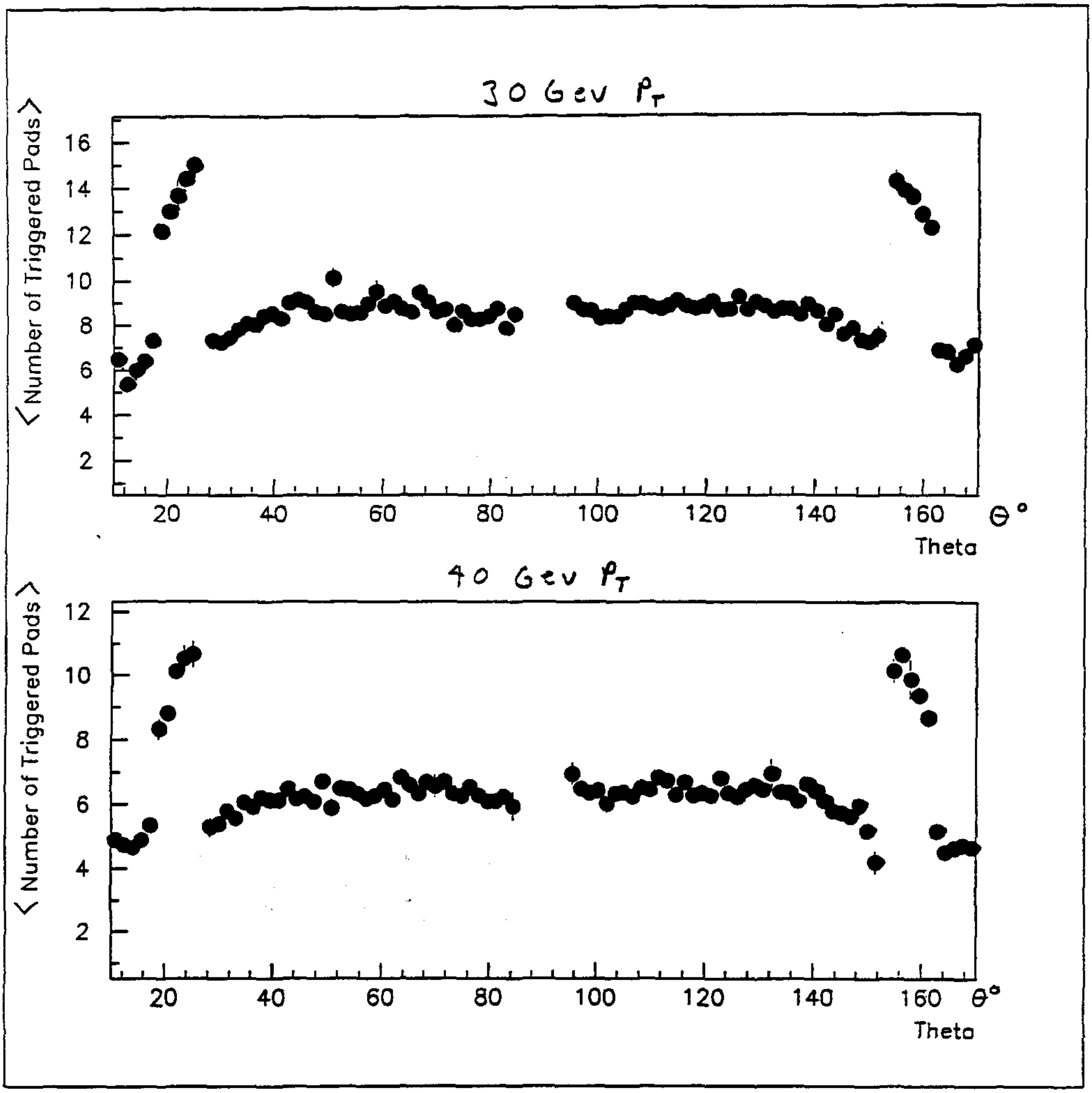


AND ONE OF SEVERAL PADS TAKEN.

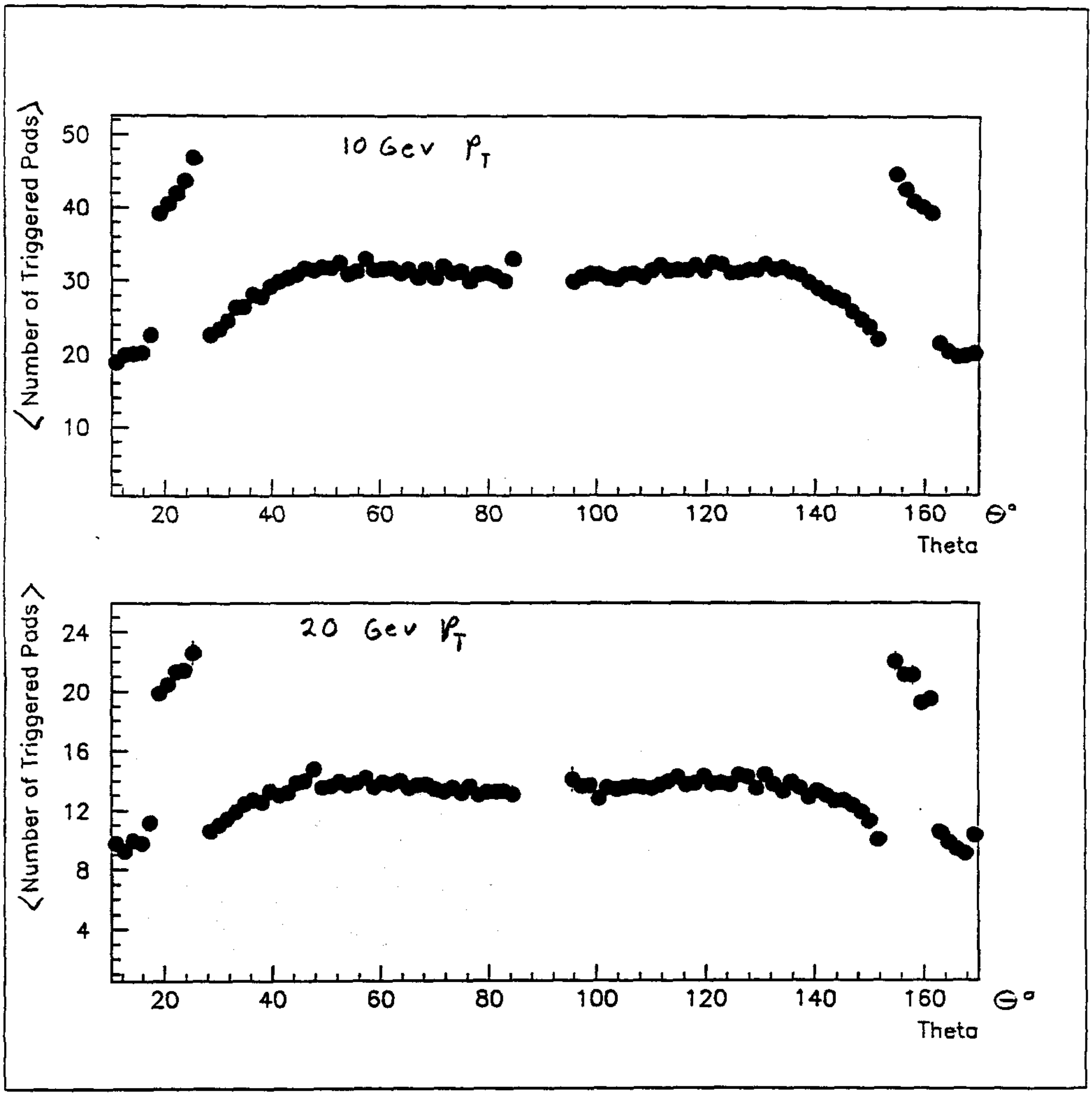
3) SOME % OF THE TIME ~10% THE RESOLUTION OF THE HIT IS SPOILED BY BACKGROUND.

OWING TO THESE EFFECTS THE PLANE SPACE-POINT WAS "UNIFORMLY" RANDOMIZED BY ± 1 pAD.

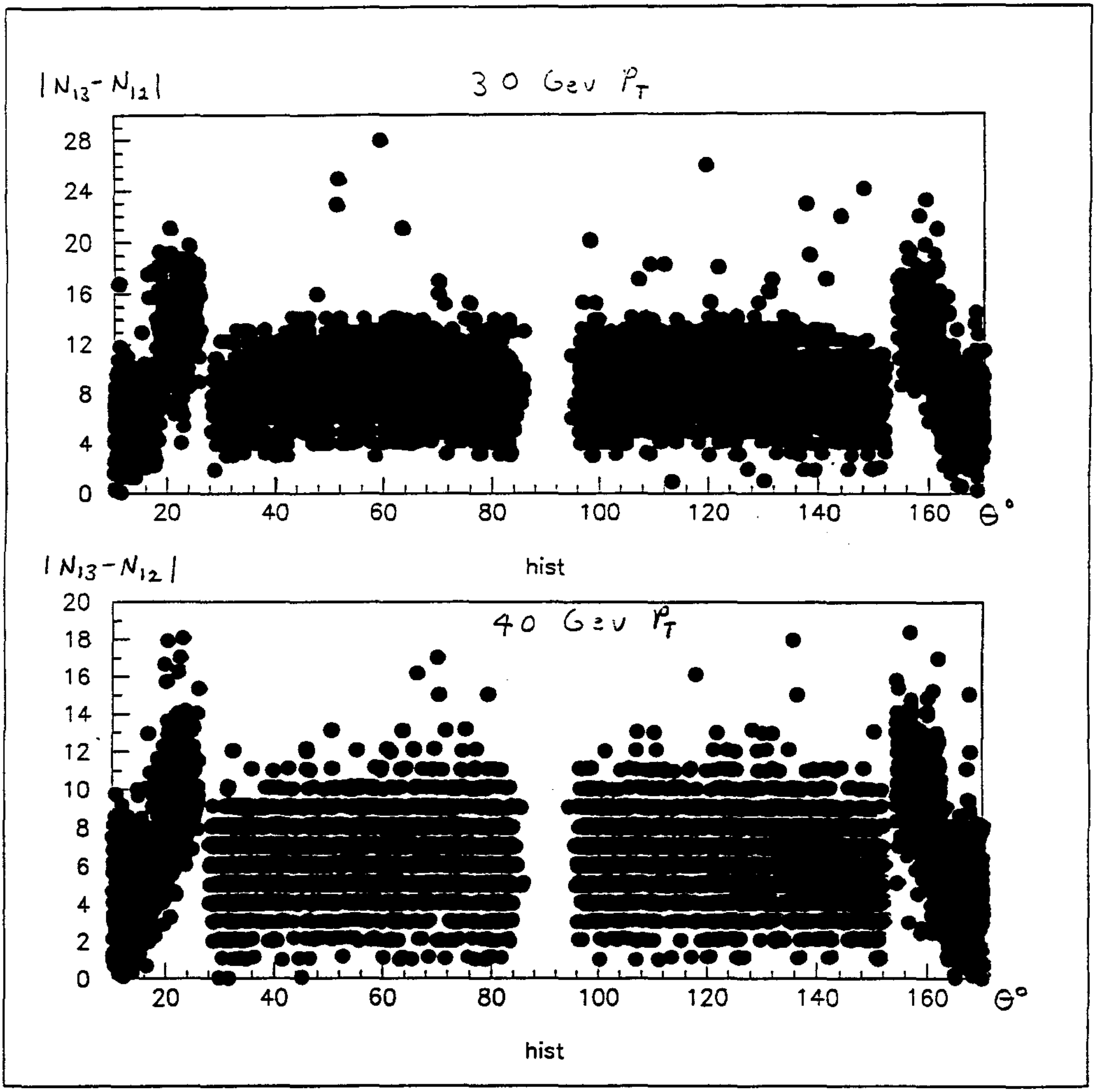

10 Gev P_T
$|N_{13} - N_{12}|$
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
$\theta°$
hist
$|N_{13} - N_{12}|$
20 Gev P_T
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
$\theta°$
hist

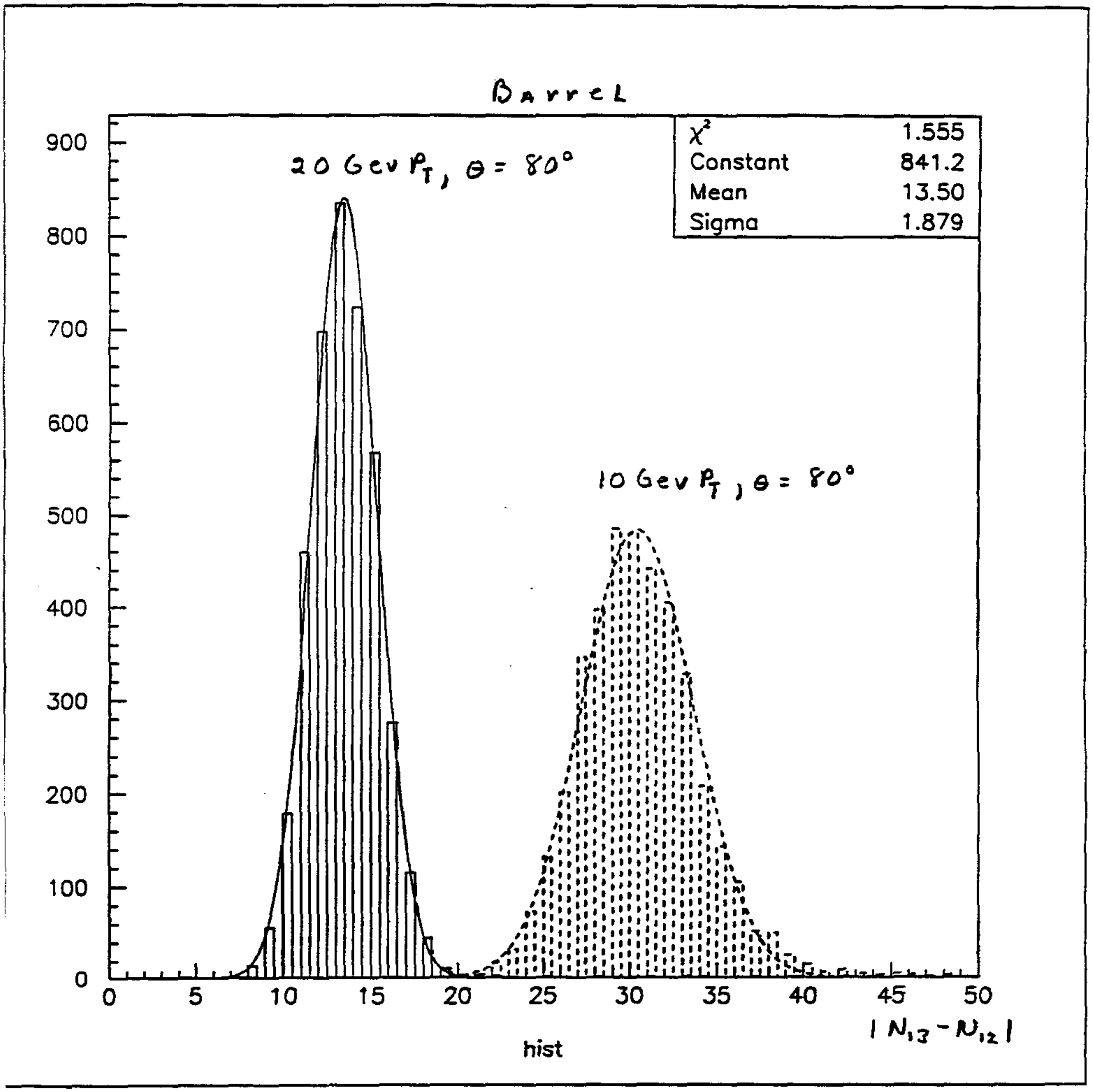


$\langle$ NUMBER TRIGGERED PADS $\rangle = \langle | N_{13} - N_{12} | \rangle$

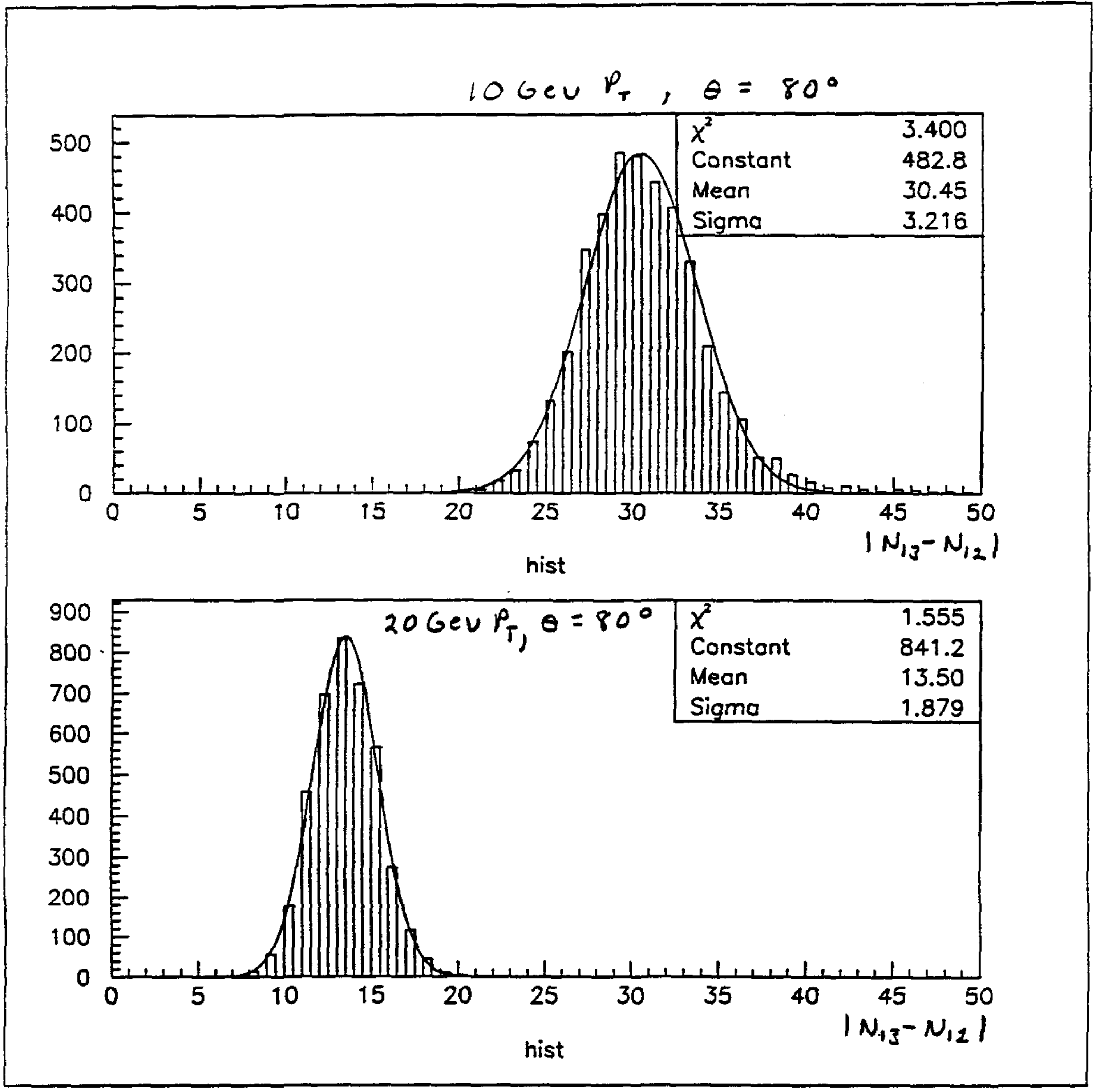


$\langle$ NUMBER OF TRIGGERED PADS $\rangle \equiv \langle |N_{13} - N_{12}| \rangle$

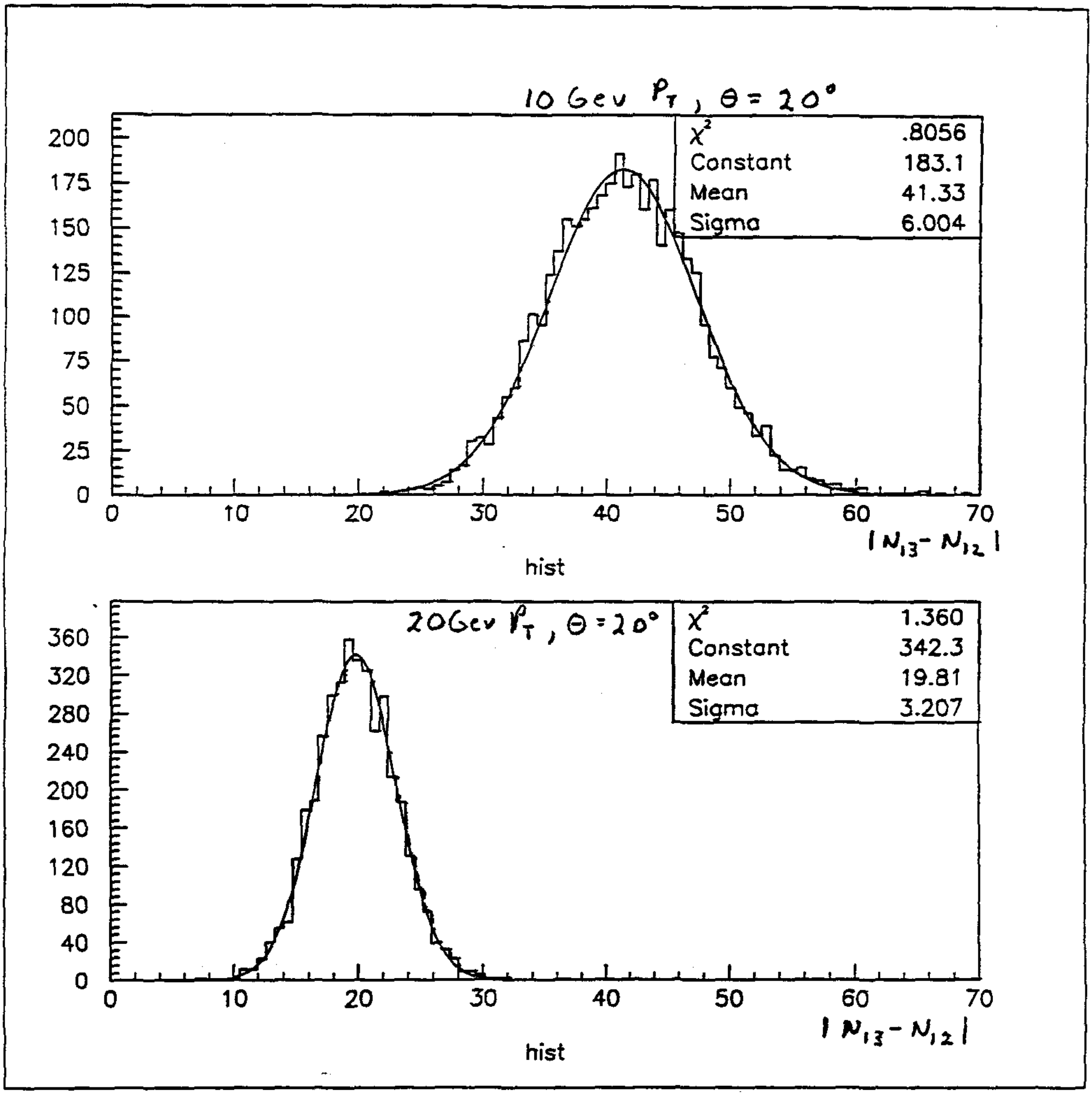

|N₁₃ - N₁₂|
3 0 Gev P_T
0
4
8
12
16
20
24
28
20
40
60
80
100
120
140
160
θ°
hist
|N₁₃ - N₁₂|
40 Gev P_T
0
2
4
6
8
10
12
14
16
18
20
20
40
60
80
100
120
140
160
θ°
hist

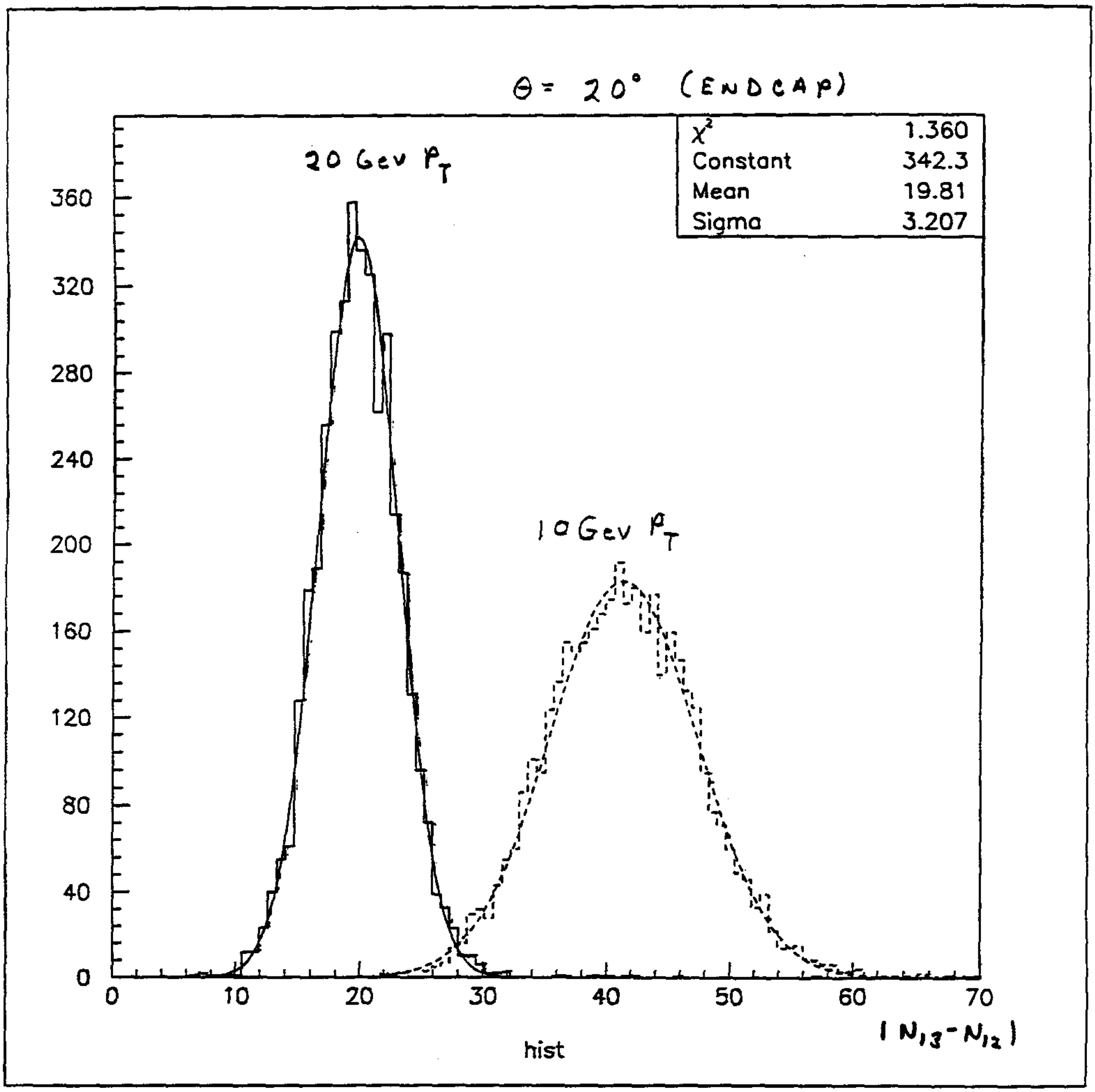

Barrel
20 Gev P_T, θ = 80°
10 Gev P_T, θ = 80°
χ^2 1.555
Constant 841.2
Mean 13.50
Sigma 1.879
0
100
200
300
400
500
600
700
800
900
0
5
10
15
20
25
30
35
40
45
50
$|N_{13} - N_{12}|$
hist

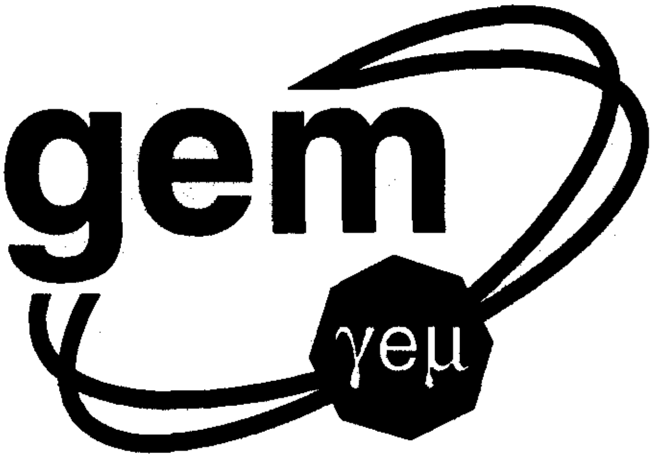
Barrel


10 Gev P_T , $\theta = 80°$
χ^2 3.400
Constant 482.8
Mean 30.45
Sigma 3.216
0
100
200
300
400
500
0 5 10 15 20 25 30 35 40 45 50
$|N_{13} - N_{12}|$
hist
20 Gev P_T, $\theta = 80°$
χ^2 1.555
Constant 841.2
Mean 13.50
Sigma 1.879
0
100
200
300
400
500
600
700
800
900
0 5 10 15 20 25 30 35 40 45 50
$|N_{13} - N_{12}|$
hist

END CAP


10 Gev P_T , $\theta = 20°$
χ^2 .8056
Constant 183.1
Mean 41.33
Sigma 6.004
0
25
50
75
100
125
150
175
200
0
10
20
30
40
50
60
70
$|N_{13} - N_{12}|$
hist
20Gev P_T , $\theta = 20°$
χ^2 1.360
Constant 342.3
Mean 19.81
Sigma 3.207
0
40
80
120
160
200
240
280
320
360
0
10
20
30
40
50
60
70
$|N_{13} - N_{12}|$
hist

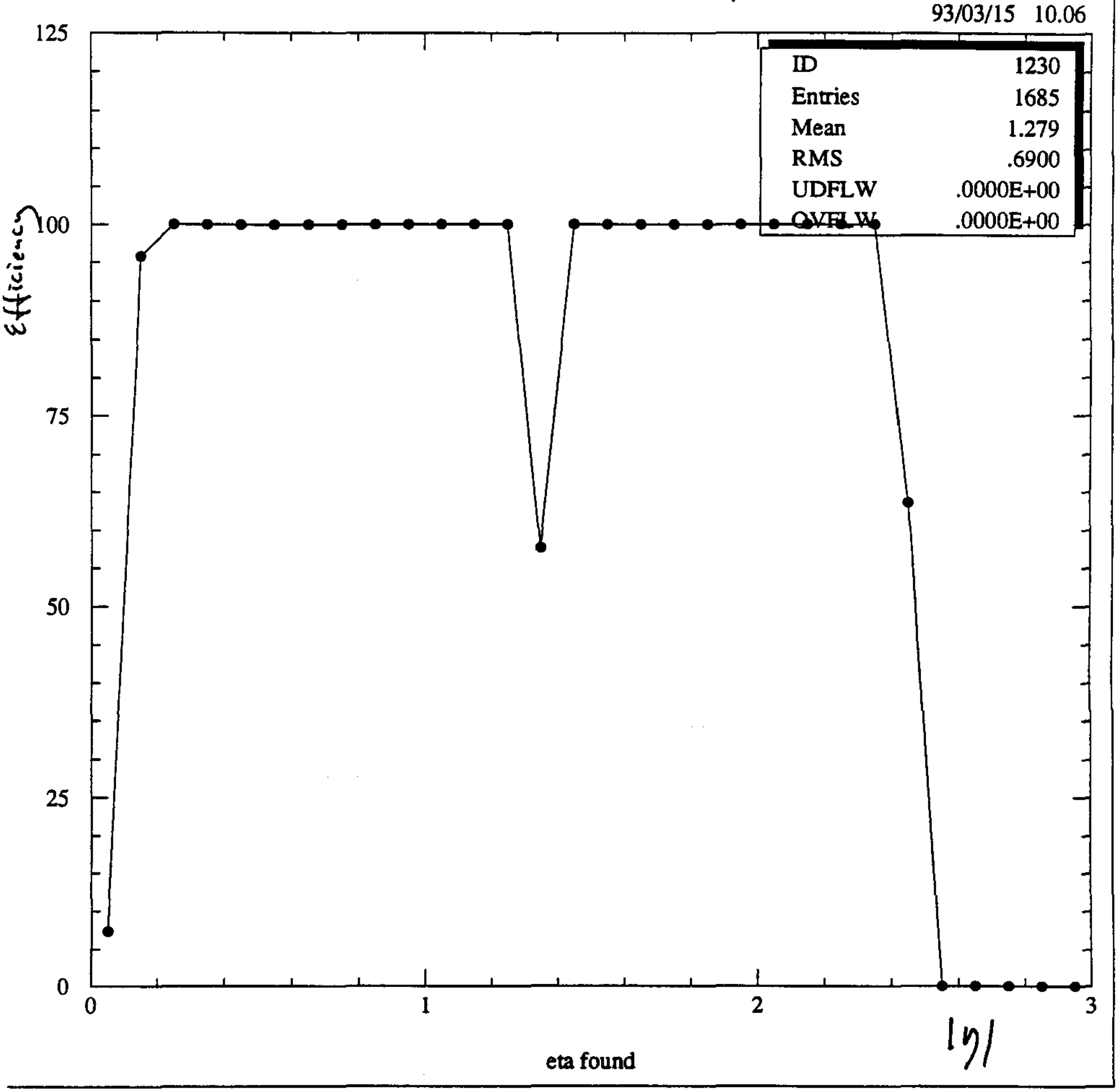

θ= 20° (ENDCAP)
20 Gev P_T
10 Gev P_T
χ² 1.360
Constant 342.3
Mean 19.81
Sigma 3.207
0
40
80
120
160
200
240
280
320
360
0
10
20
30
40
50
60
70
hist
|N13-N12|



Presentation by:

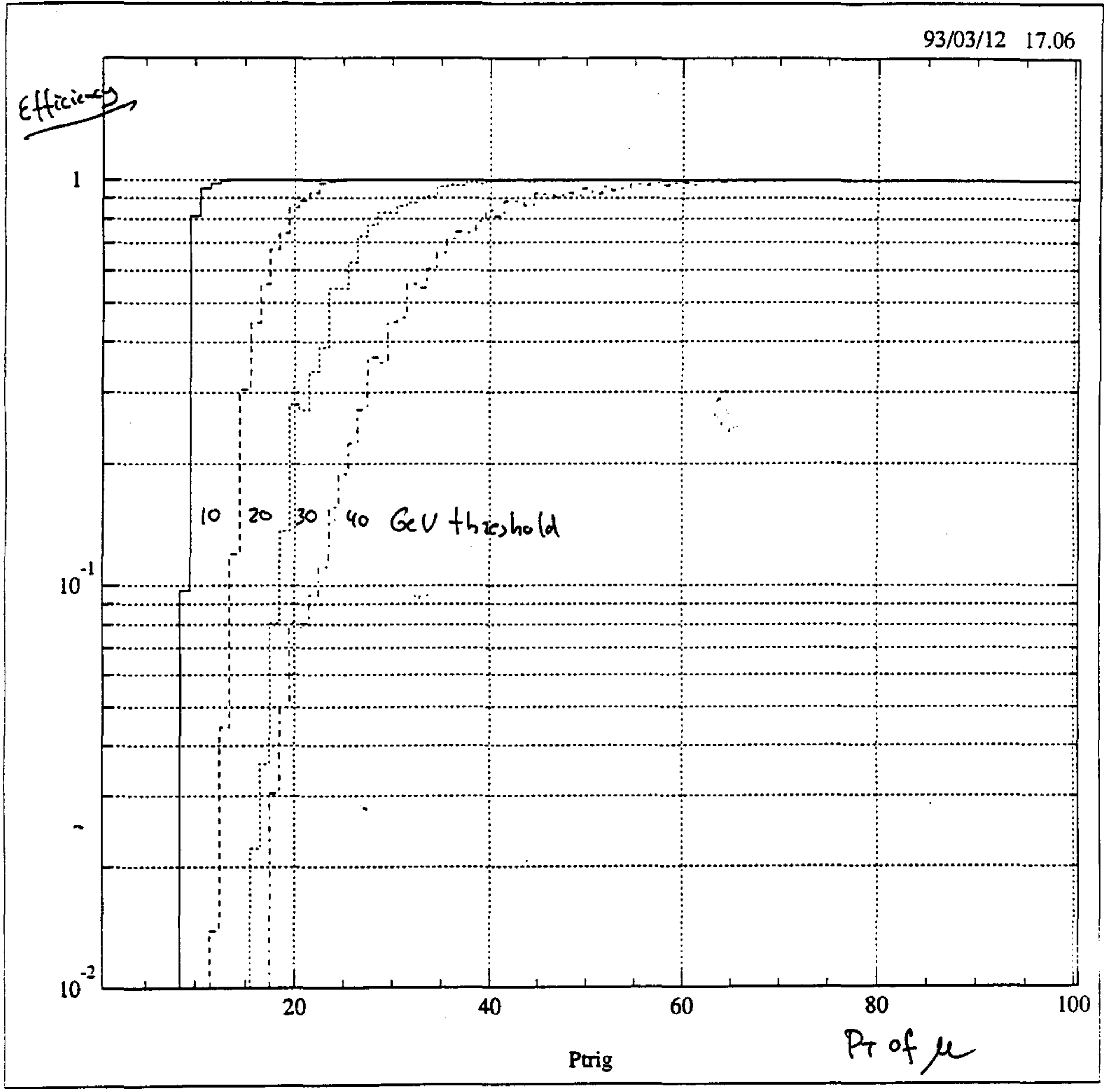
Henk Uijterwaal

Acceptance as a function of η

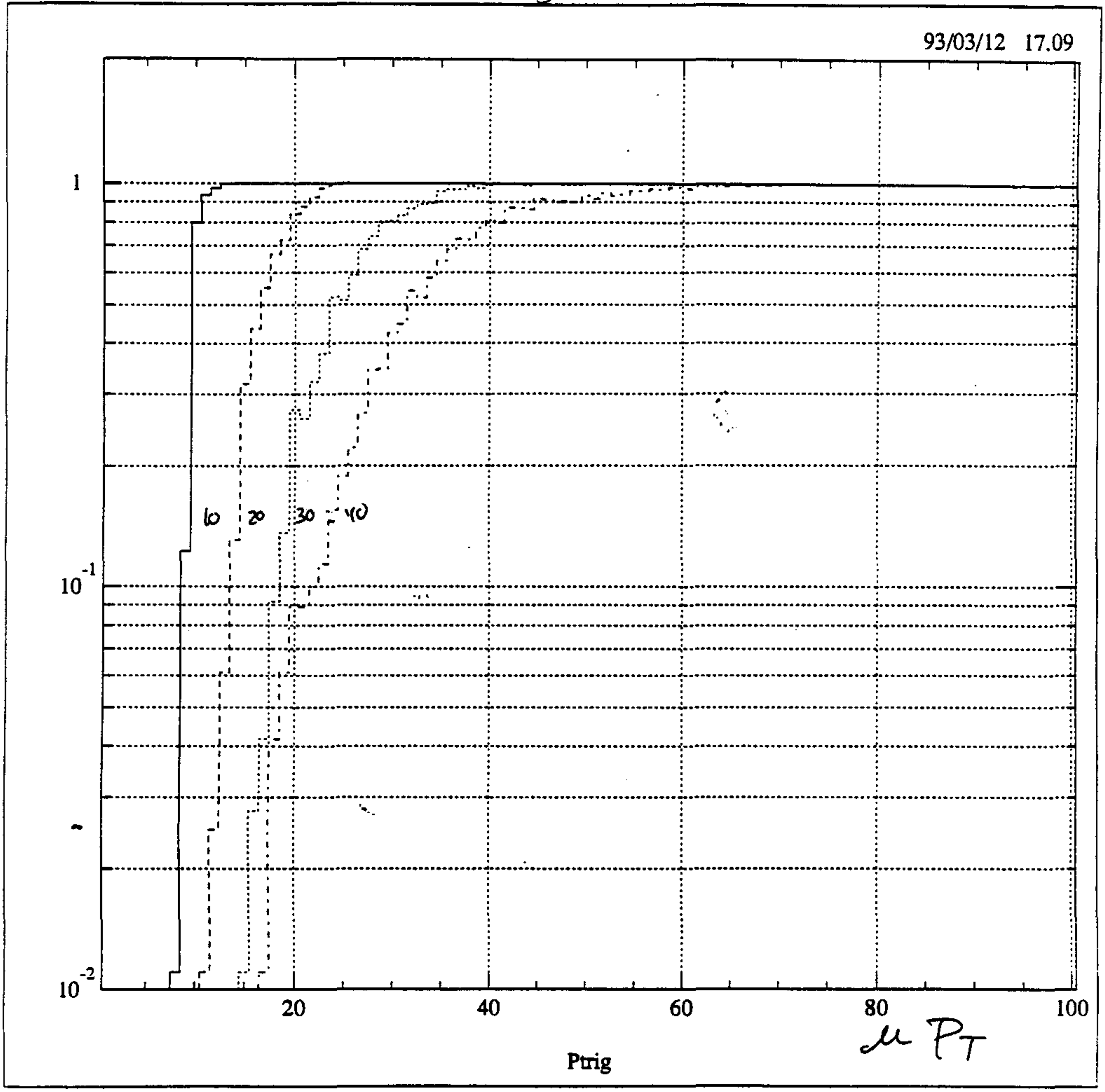


8°

Barrel Θ = 80°

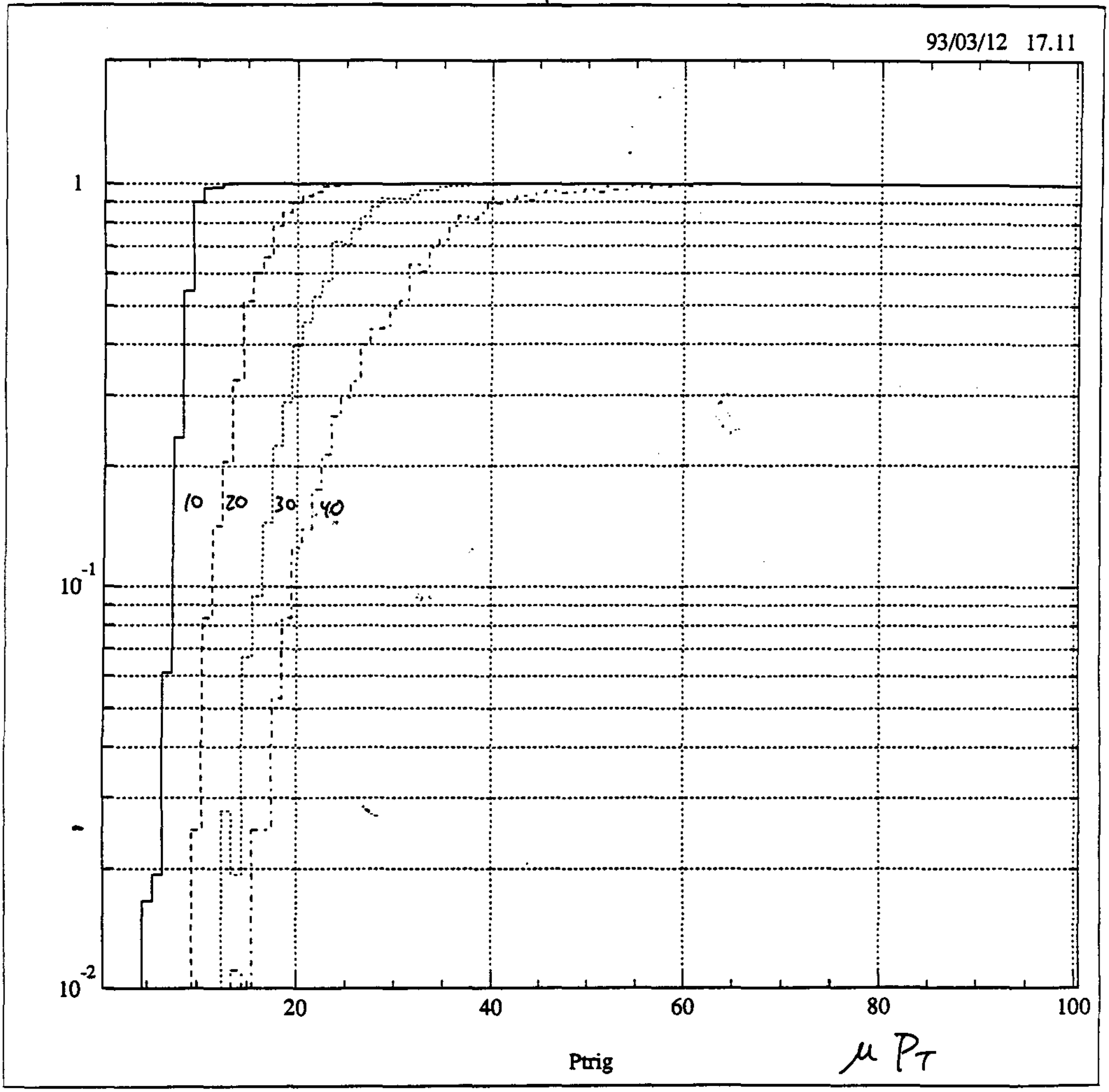

93/03/12 17.06
Efficiency
1
10⁻¹
10⁻²
20
40
60
80
100
10 20 30 40 GeV threshold
Ptrig
PT of μ

~~Endca~~ Barrel $\theta = 45^\circ$



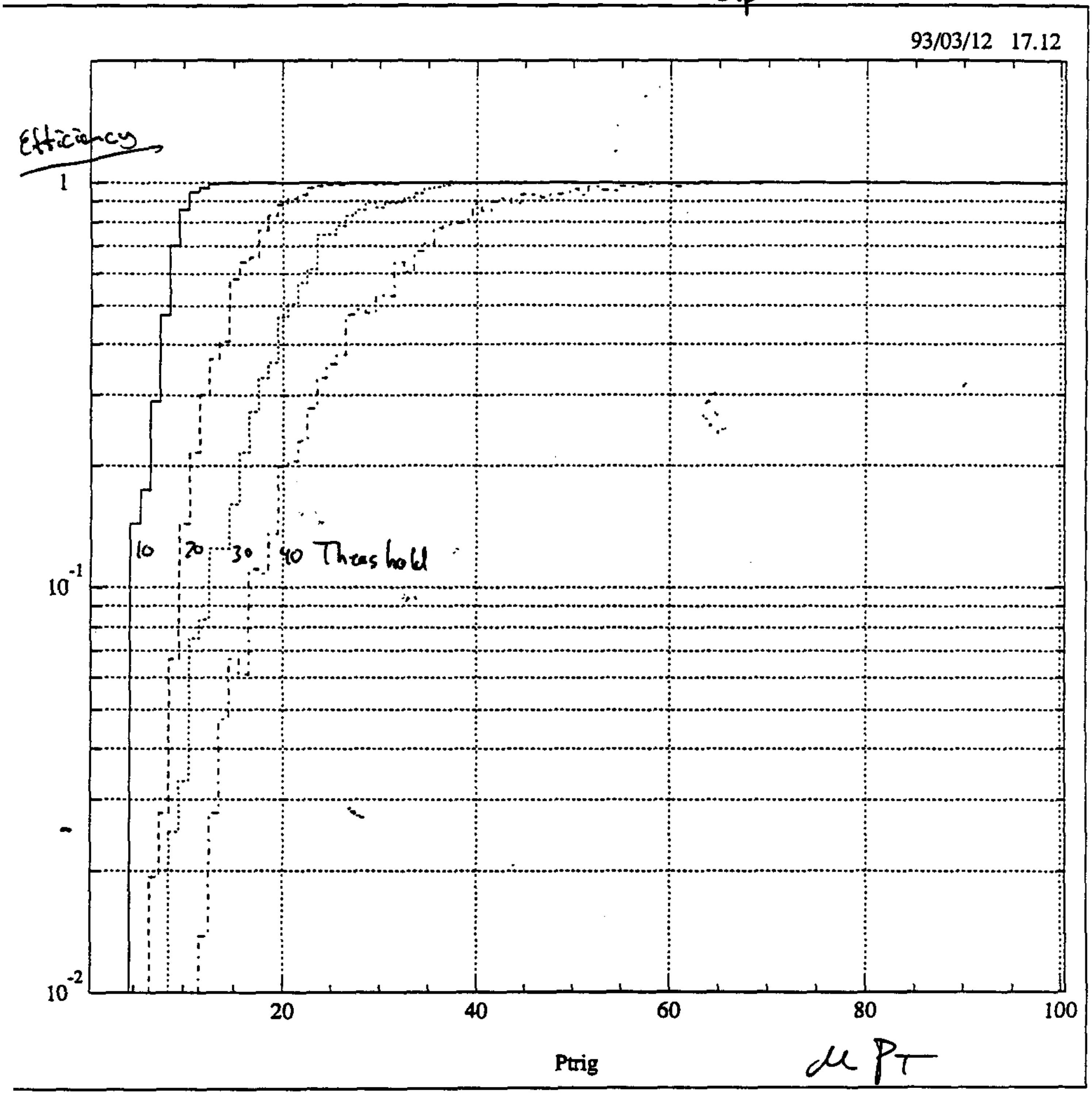
25°

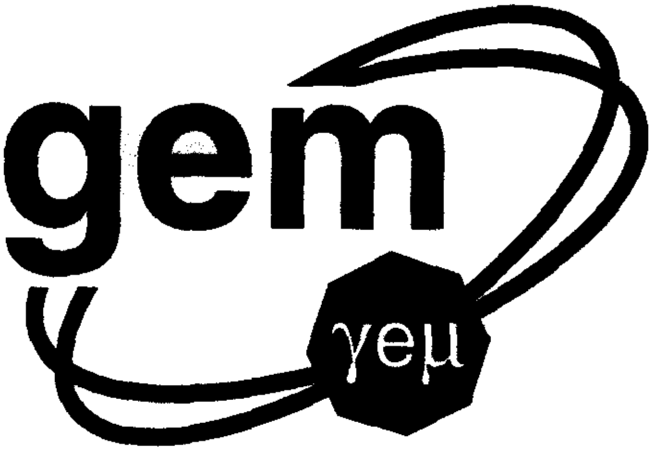
Endcap Θ = 25°



15°

Θ=15° Endcap





Presentation by:

V. Gavrilov

V.Gavrilov ⑤

Muon reconstruction

- φ - projection
  - selection CSC strip clusters
  - fitting track segments (SL)
  - fitting track in muon tower (3SL)
- Z/R projection
  - straight tracks
- Three dimentional analysis
  - event reconstruction
    - vertex
    - PT hadrons, decay μ...
    - pile up....

Muon track reconstruction efficiency

Backgrounds

$\Delta\tau = 0.3\,\mu\text{sec}$

- uncorr. PT

$0.2\text{–}10\,\text{Hz/cm}^2\ (11\text{–}16\lambda)$

occup. $< 0.12\%$ at $\mathcal{L} = 10^{34}$

- cosmic rays

$\sim 0.01\,\text{Hz/cm}$

- neutron /gamma

spec: flux $\leq 10^5\,\text{cm}^{-2}\text{sec}^{-1}$ $(\gamma/n = 0.2)$ $\Rightarrow$ occup. $< 0.35\%$ $\Rightarrow$ losses $\ll 1\%$

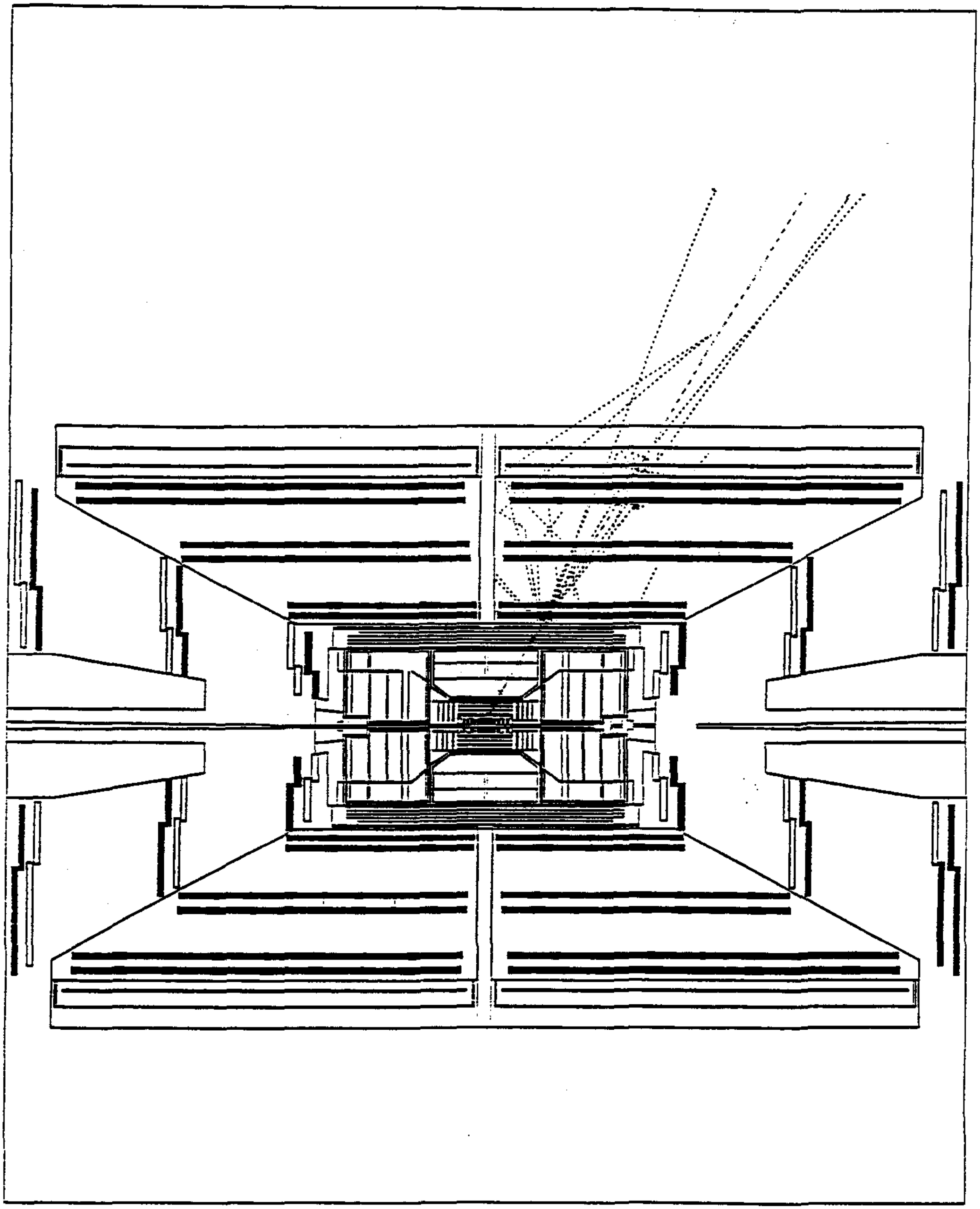
- radioactivation

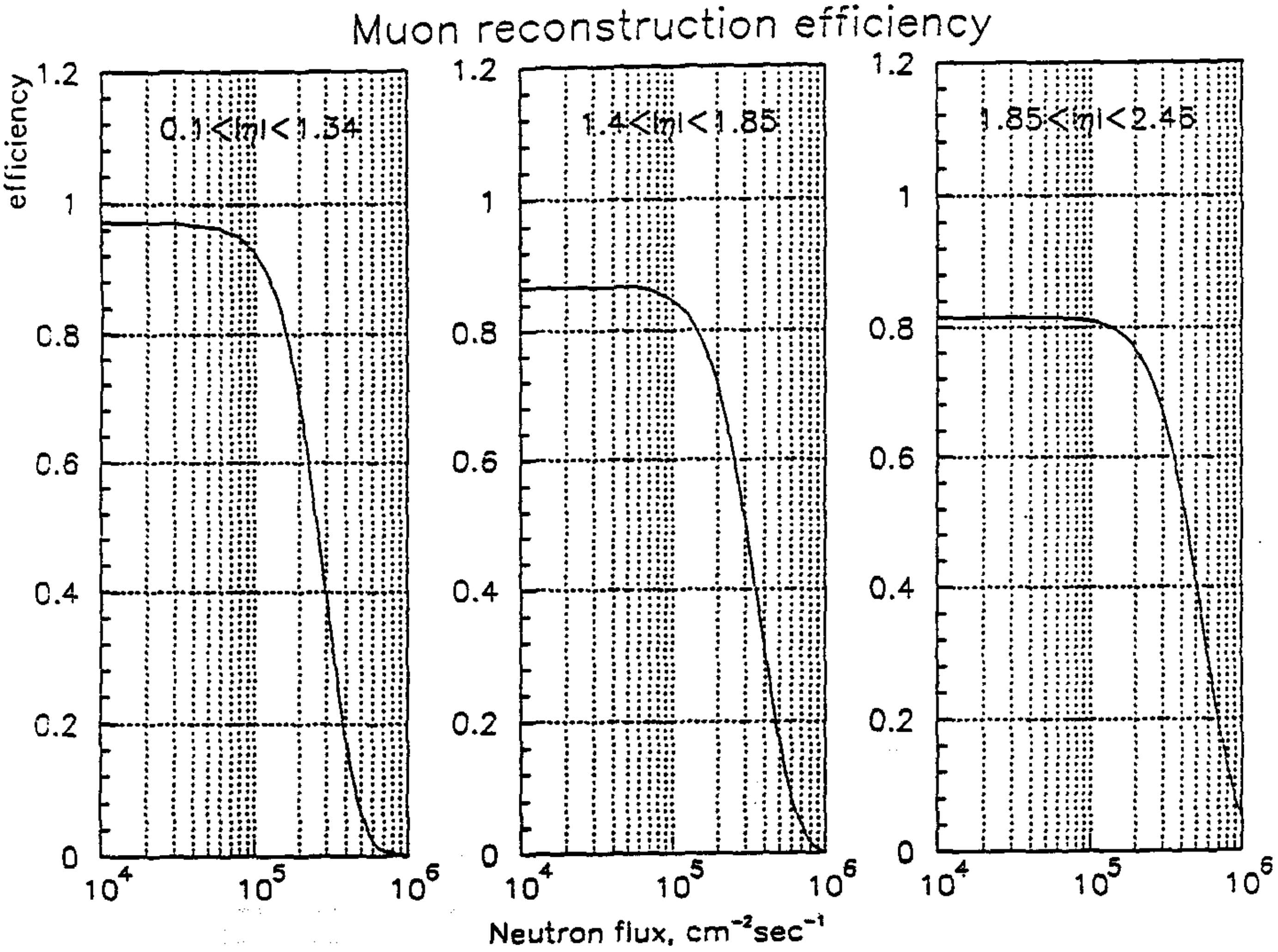
occup. $< 0.15\%$?

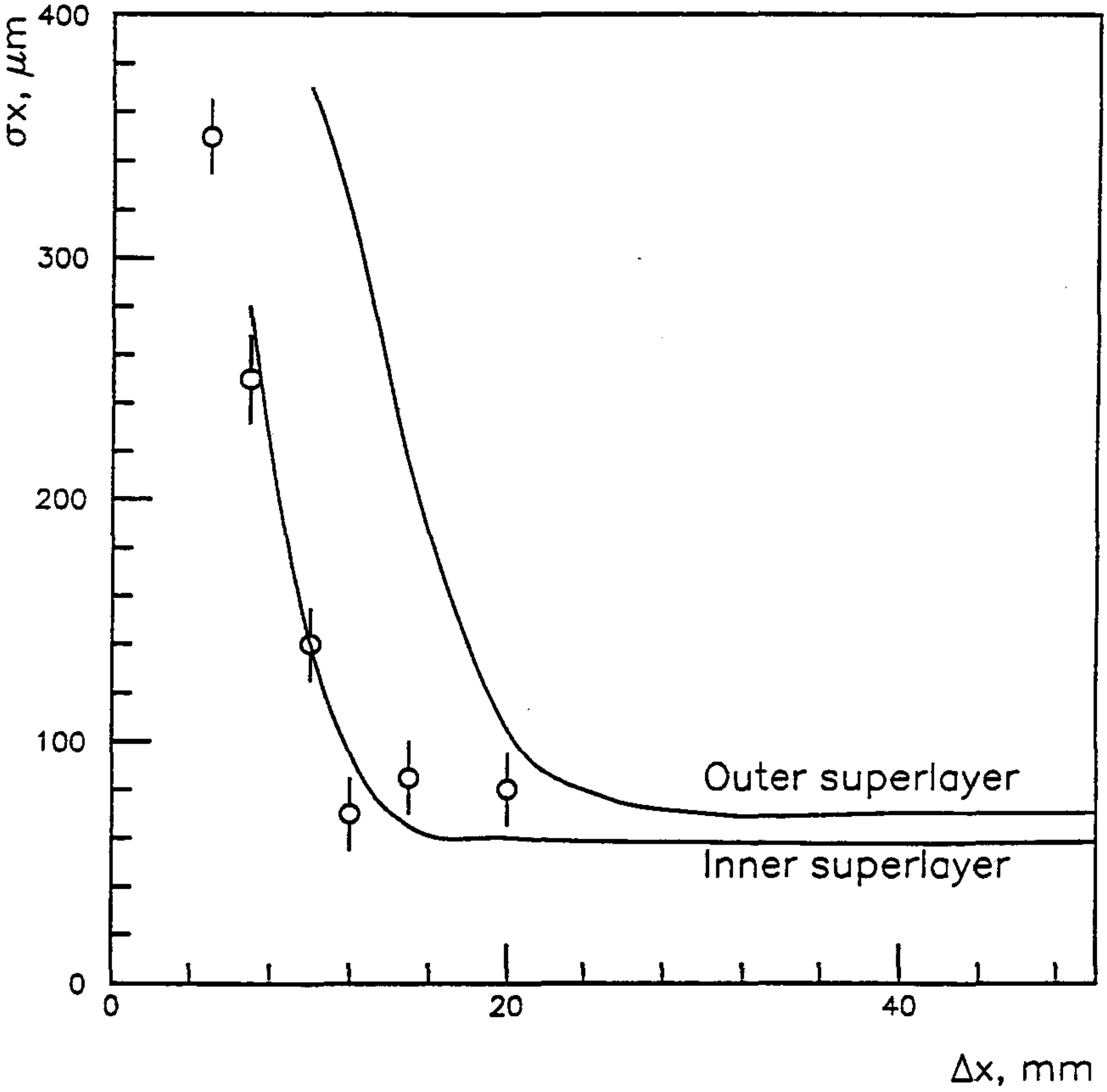
spec: occup. $< 3\%$ $\Rightarrow$ losses $\leq 1\%$

- EM debri

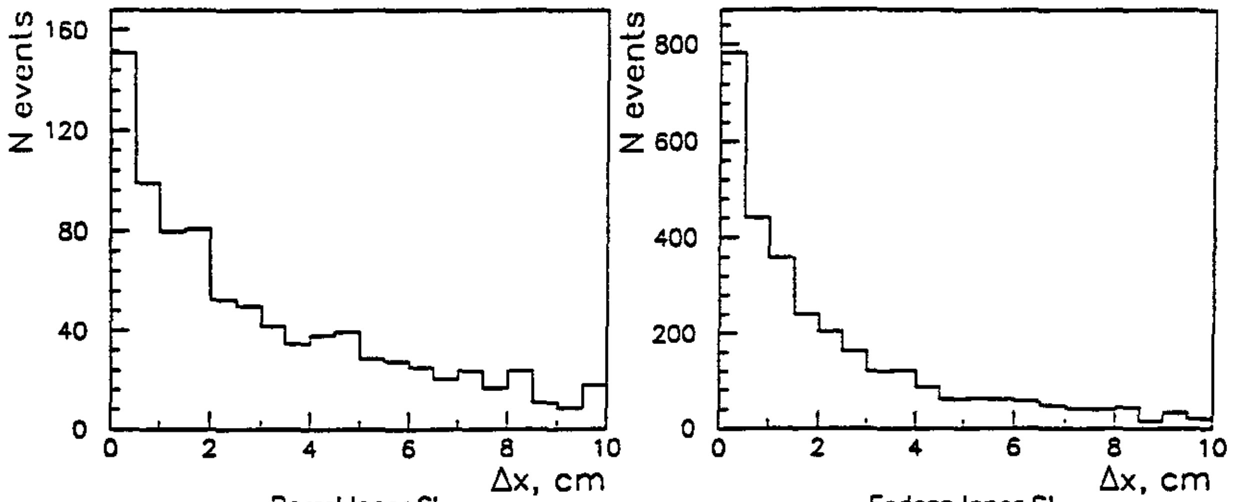
high muon momenta!




Muon reconstruction efficiency
efficiency
1.2
1
0.8
0.6
0.4
0.2
0
10^4
10^5
10^6
$0.1<|\eta|<1.34$
$1.4<|\eta|<1.85$
$1.85<|\eta|<2.45$
Neutron flux, $cm^{-2}sec^{-1}$

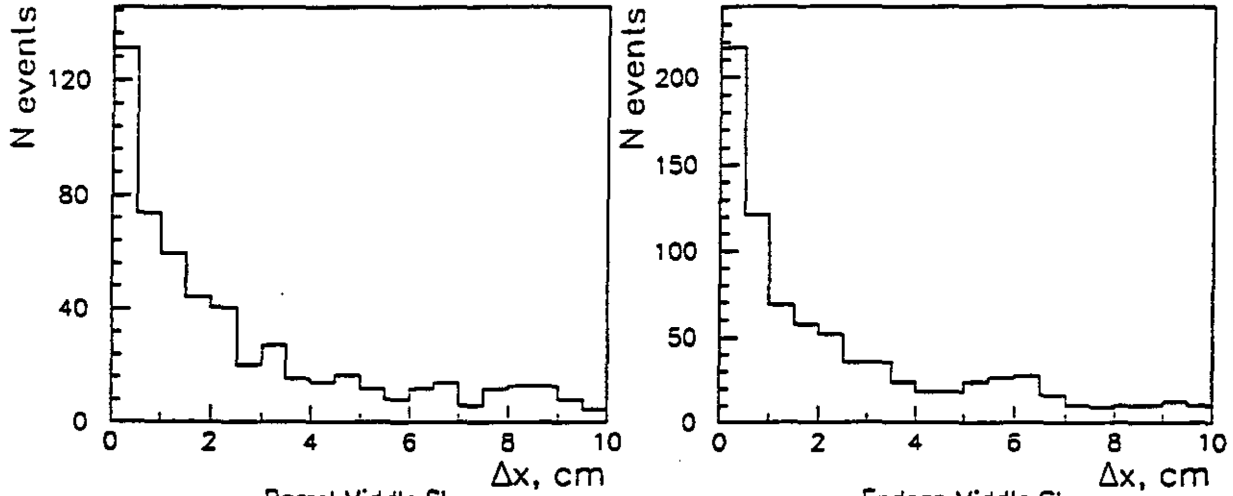

σx, μm
400
300
200
100
0
0
20
40
Δx, mm
Outer superlayer
Inner superlayer

EM debri, P_t=1000GeV



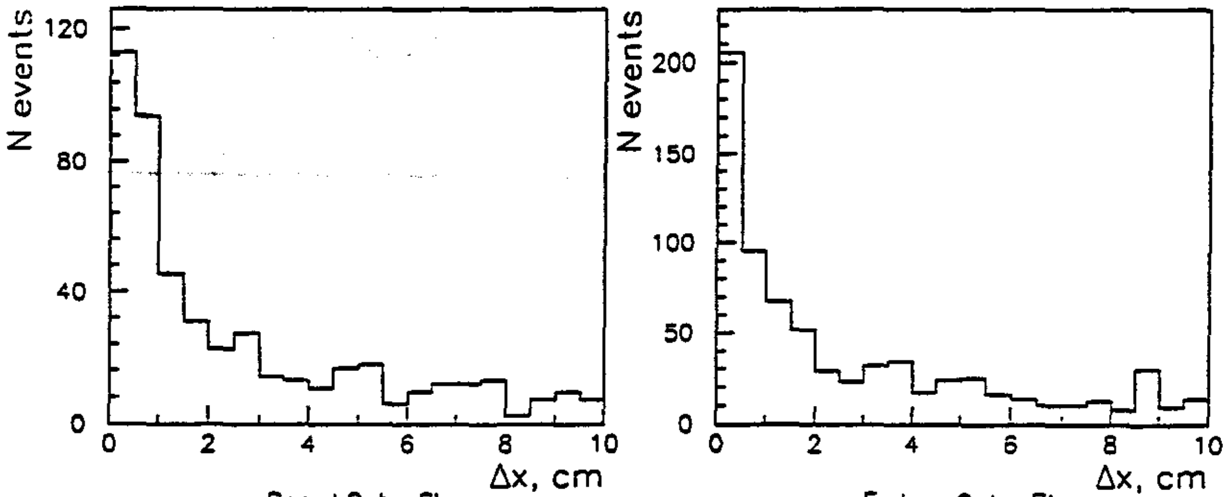
Barrel Inner SL

Endcap Inner SL



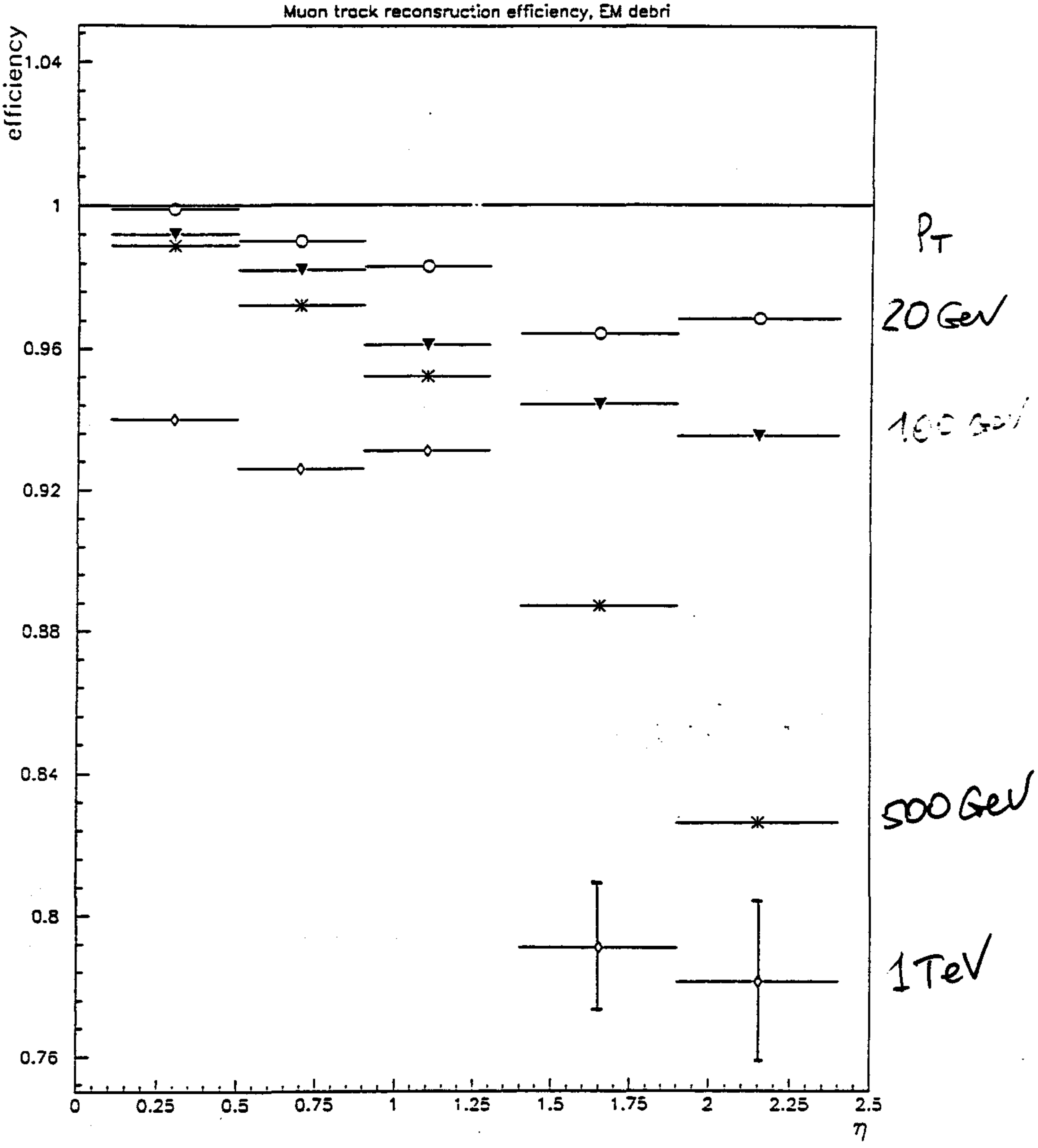
Barrel Middle SL

Endcap Middle SL

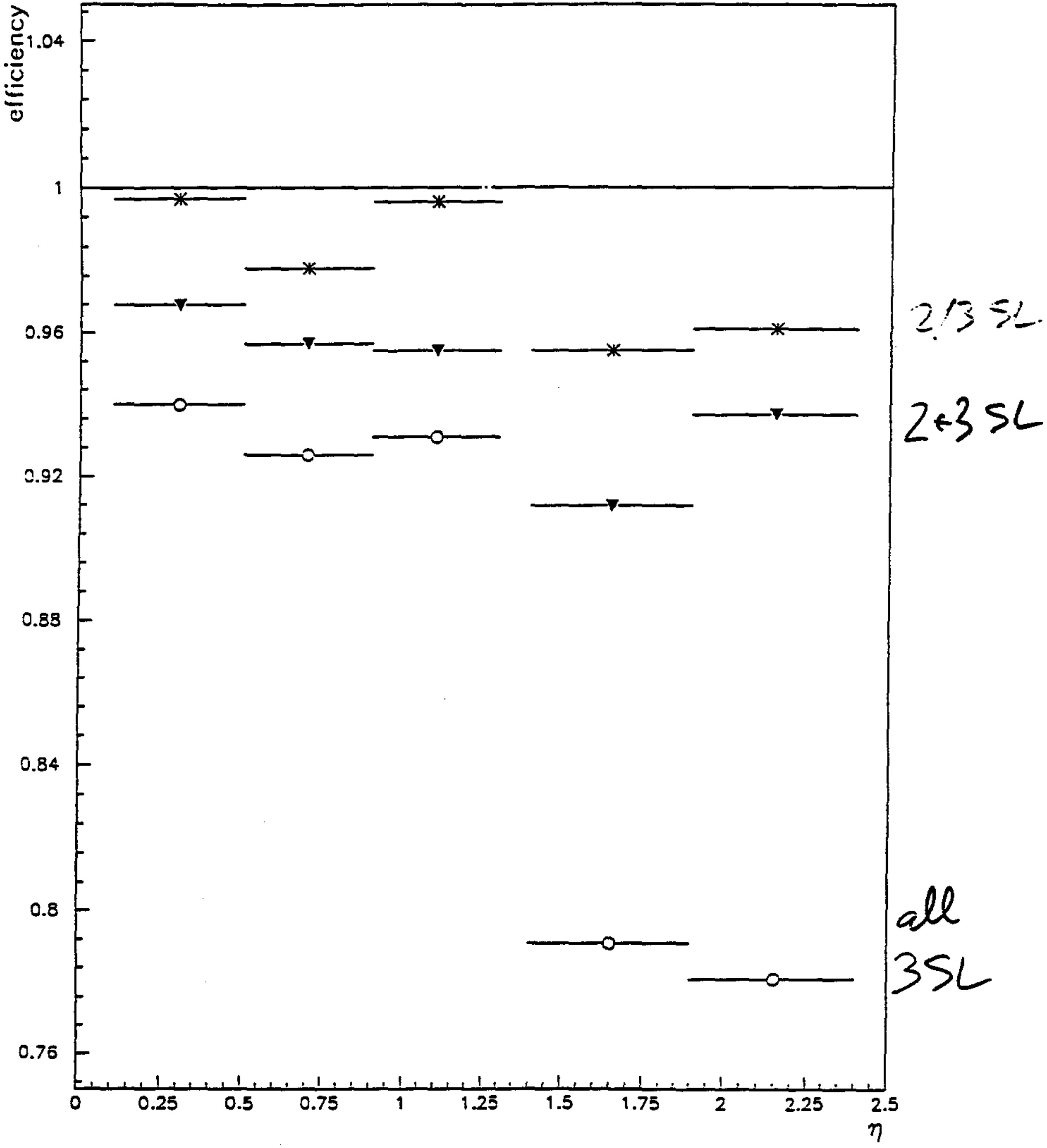


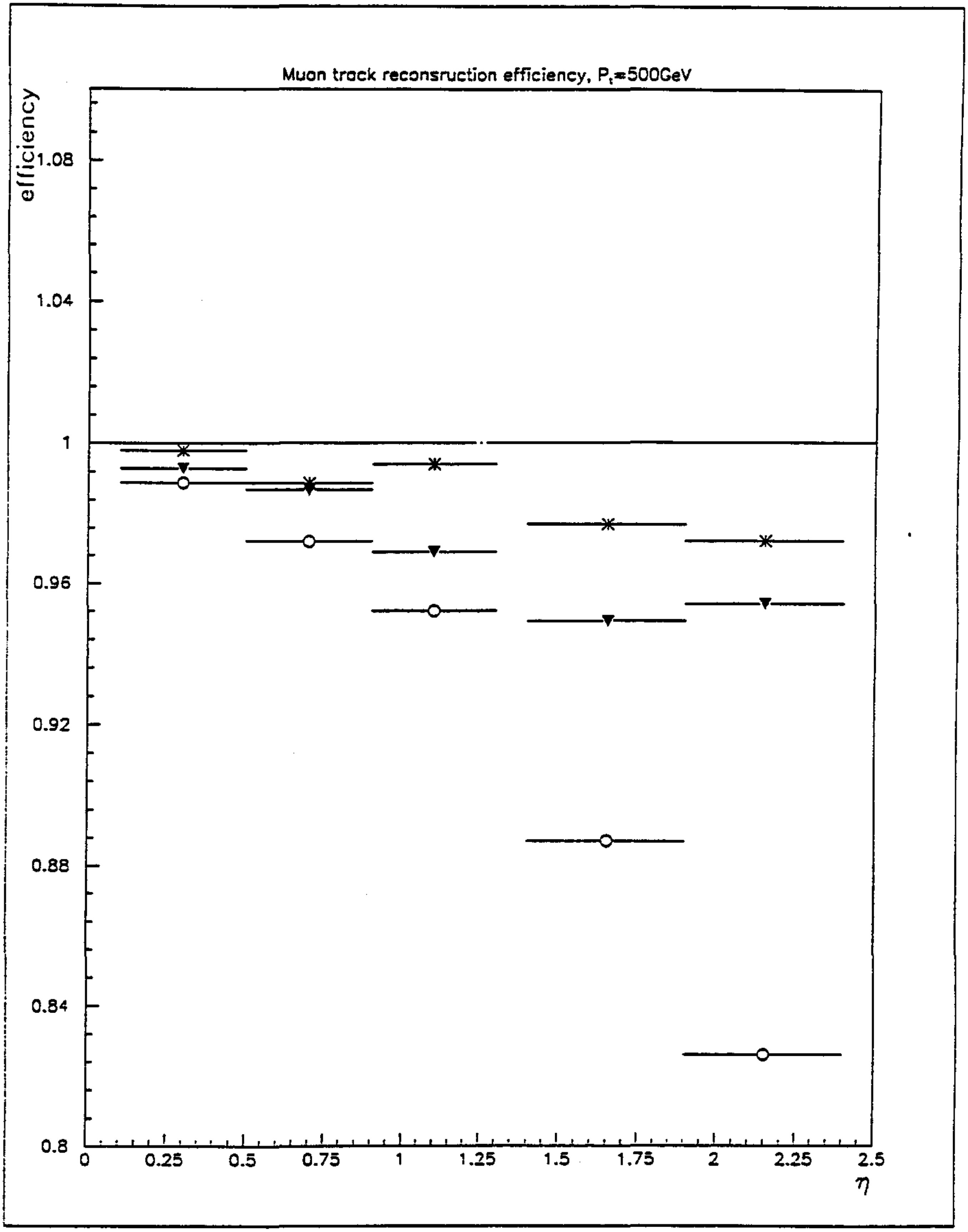
Barrel Outer SL

Endcap Outer SL


Muon track reconsruction efficiency, EM debri
efficiency
1.04
1
0.96
0.92
0.88
0.84
0.8
0.76
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
2.25
2.5
η
p_T
20 GeV
100 GeV
500 GeV
1 TeV

Muon track reconsruction efficiency, P_t=1000GeV





Muon track reconsruction efficiency, P_t=500GeV

efpt500.ps

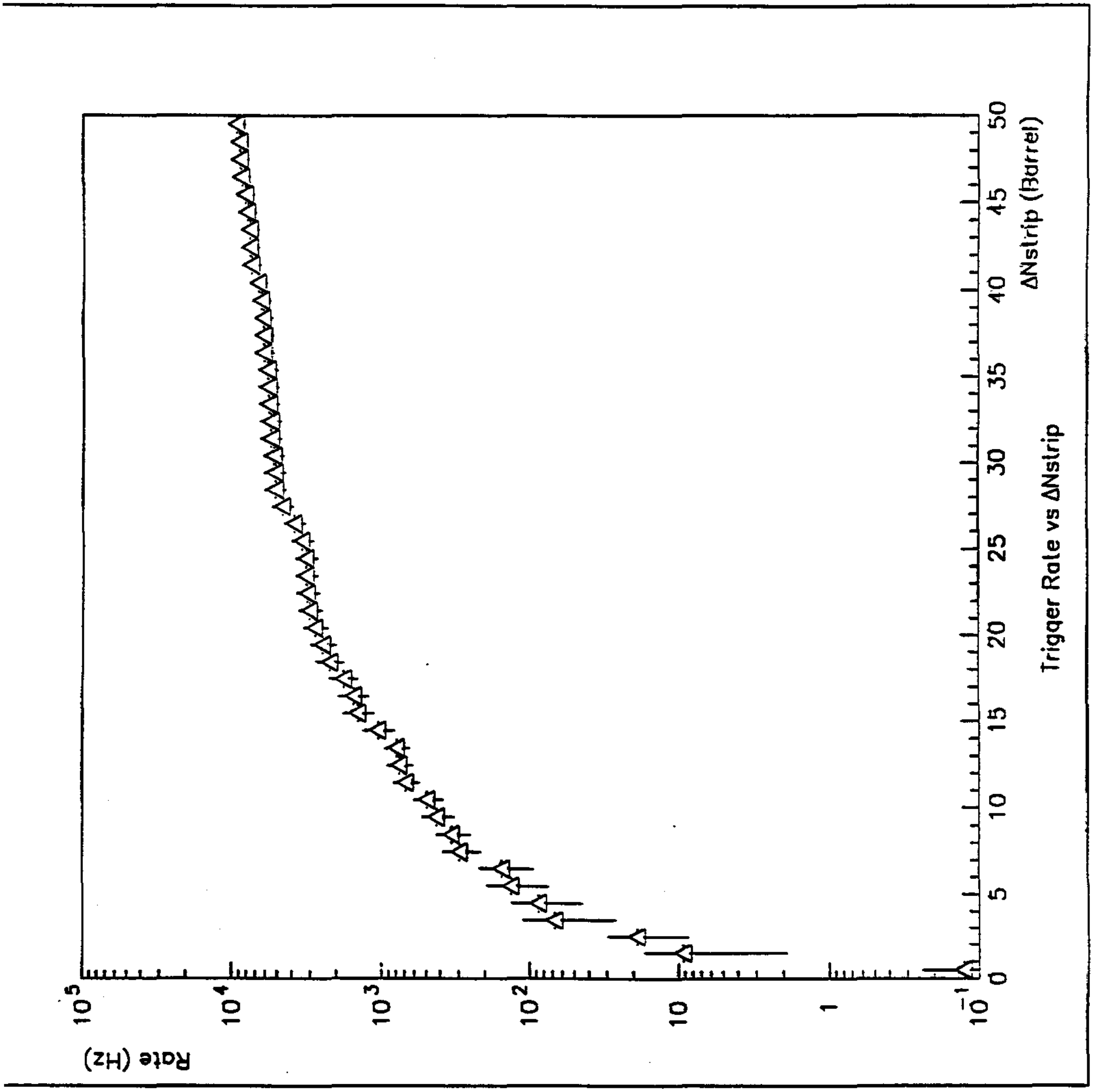
4444

○ - all 3 SL
▽ 2+3SL
* any 2SL of 3

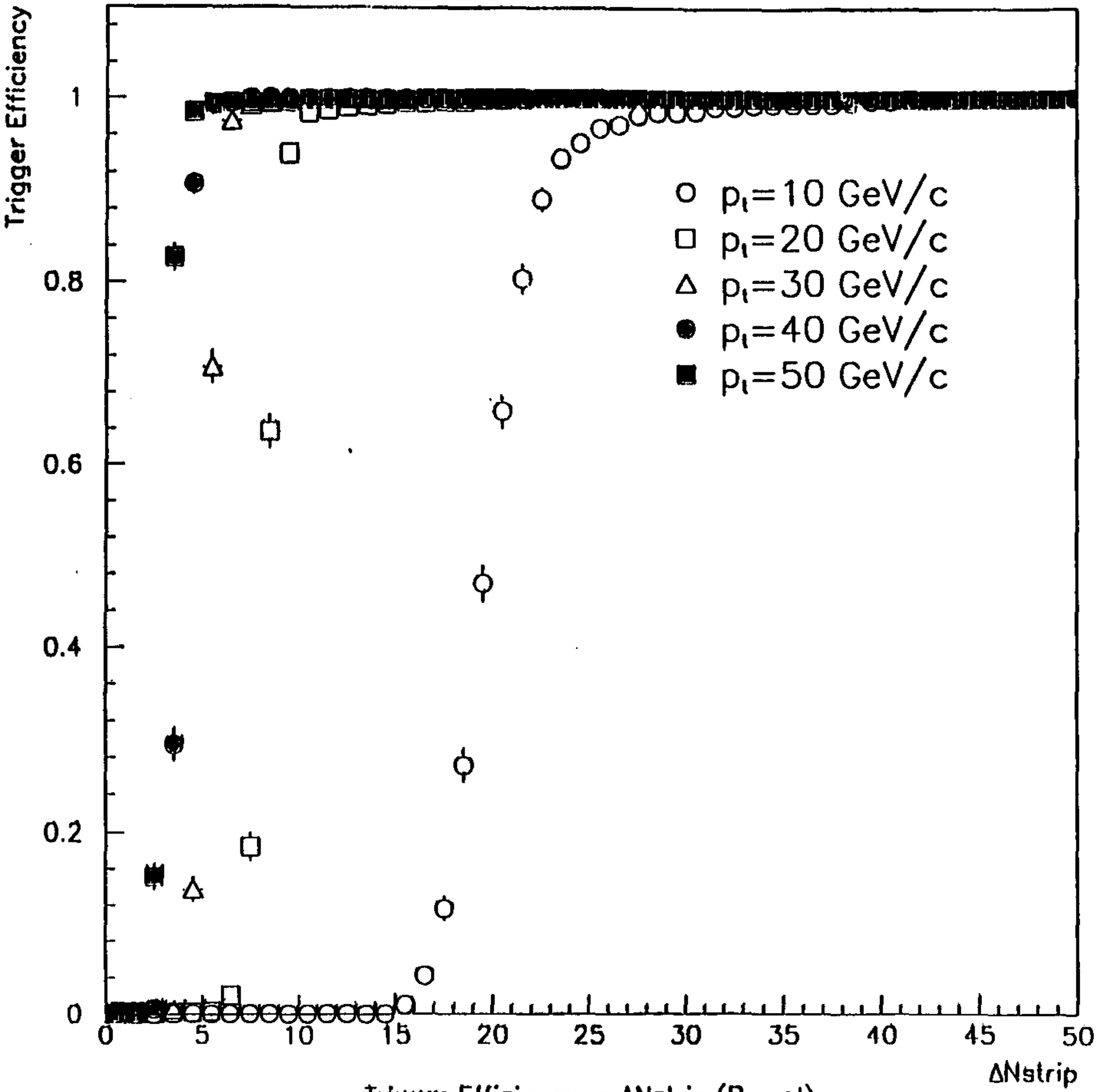
Muon track reconstruction efficiency
e.m. debri (should be multipl. by geometry co

η-range	Muon P_T, GeV					P_T, GeV	
	20	100	500	1000		500	1000
0.1 - 0.5	.995	.99	.99	.94		.99	.97
0.5 - 0.9	.99	.99	.97	.925		.99	.96
0.9 - 1.3	.98	.96	.95	.93		.97	.96
1.4 - 1.9	.965	.945	.89	.79		.95	.91
1.9 - 2.4	.97	.935	.825	.78		.95	.935
	All 3SL					2+3 SL	

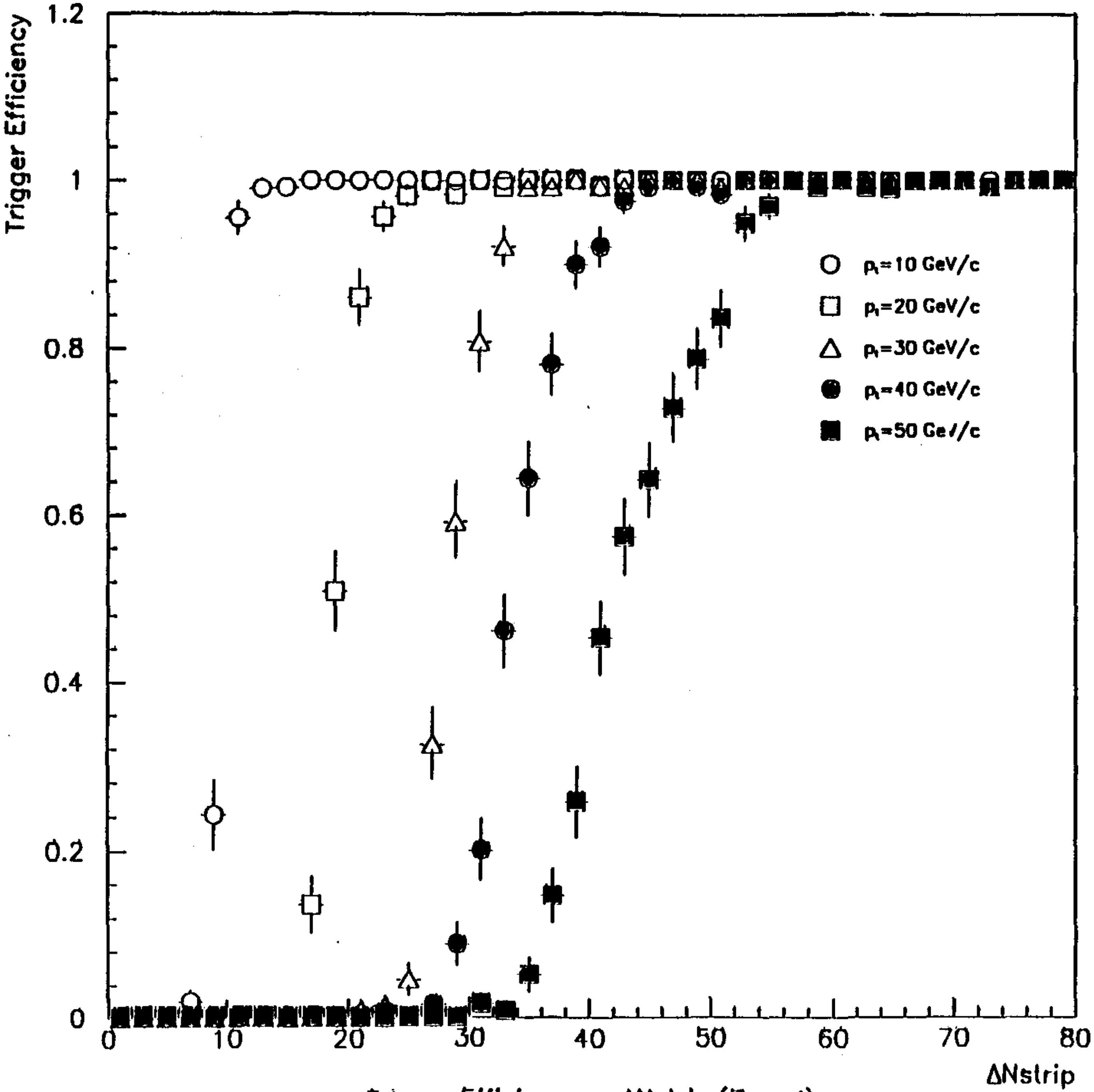
3/17/93
V. Gavrilov



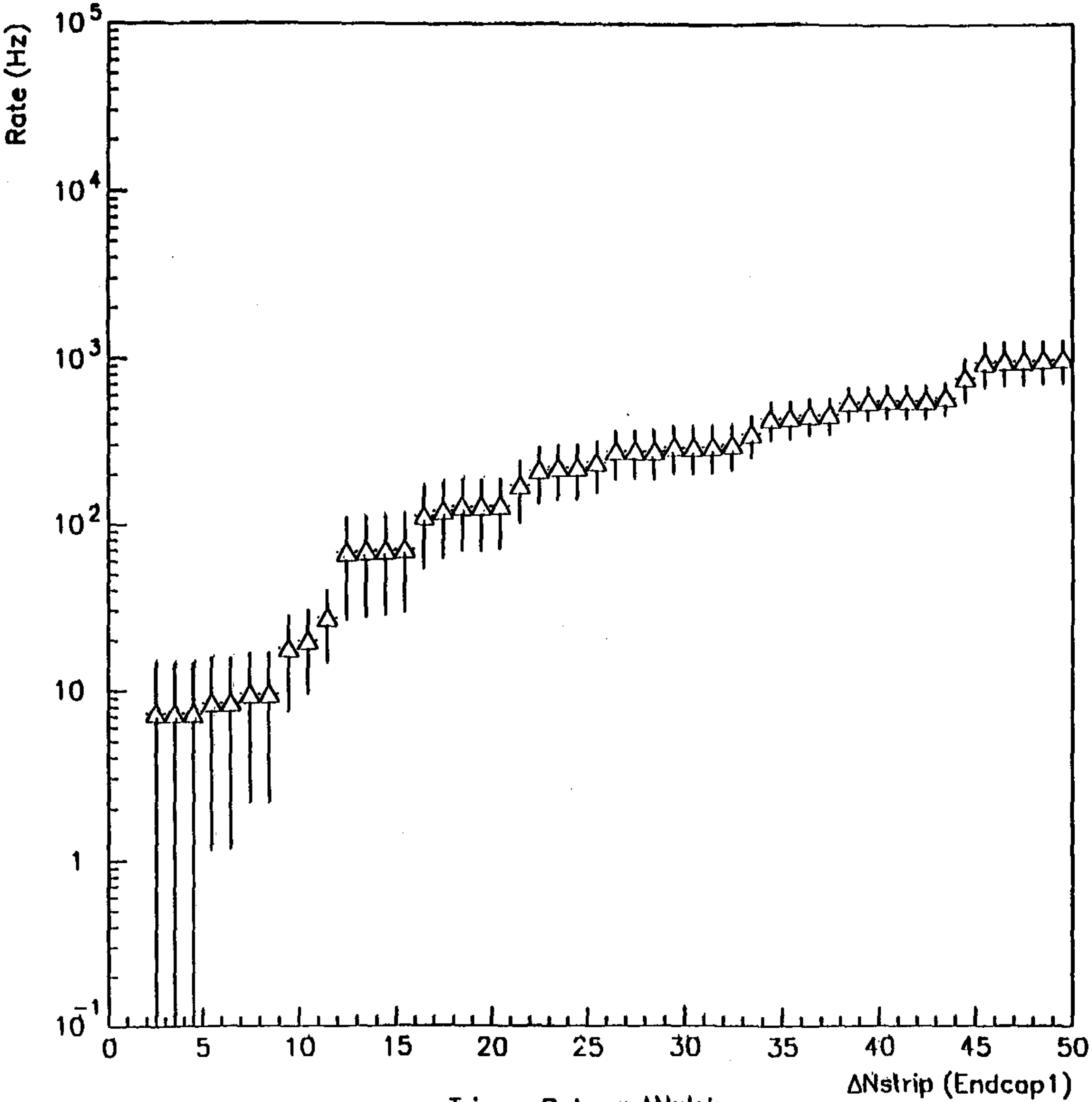
Trigger Rate vs ΔNstrip



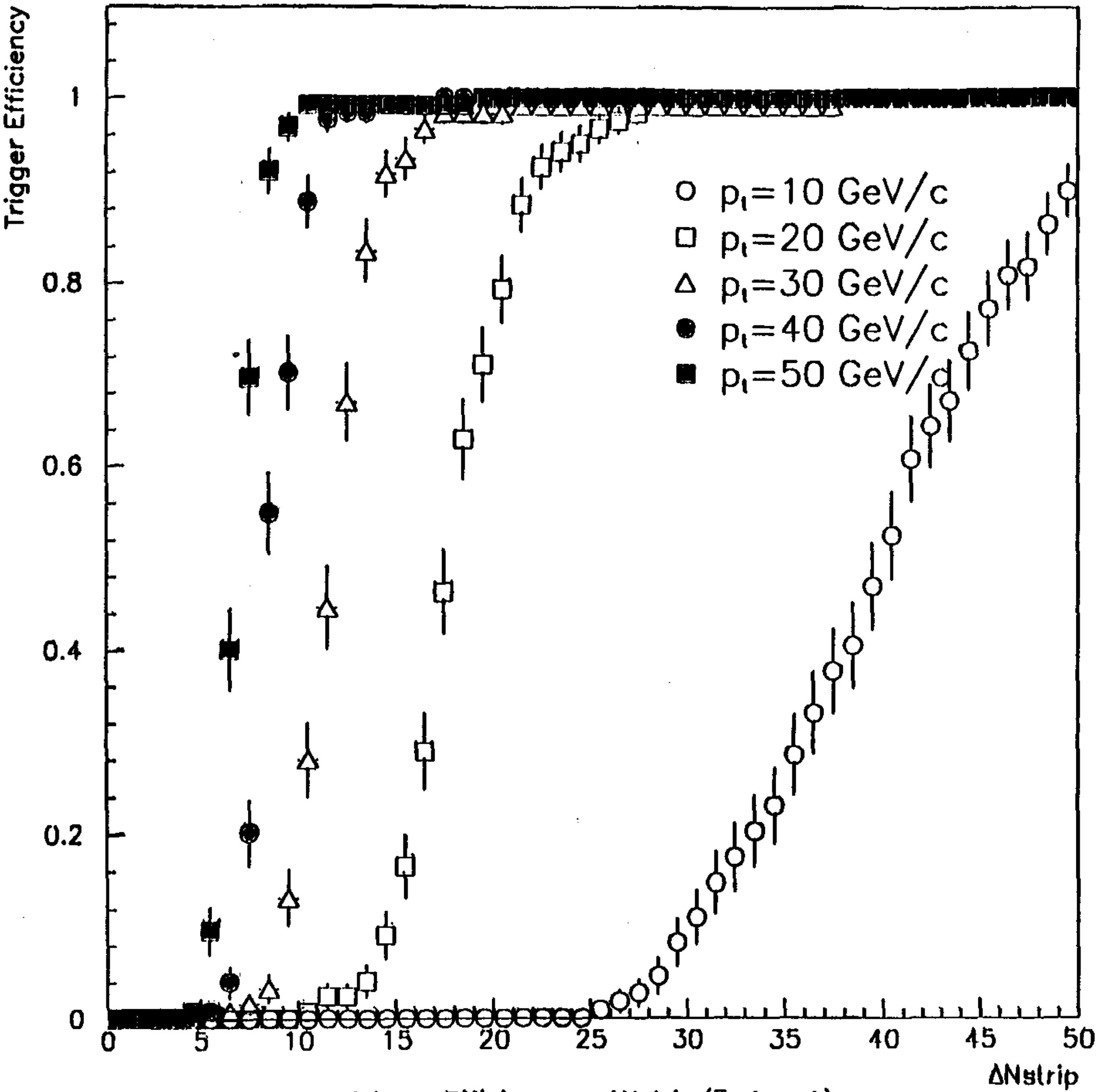
Trigger Efficiency vs ΔNstrip (Barrel)



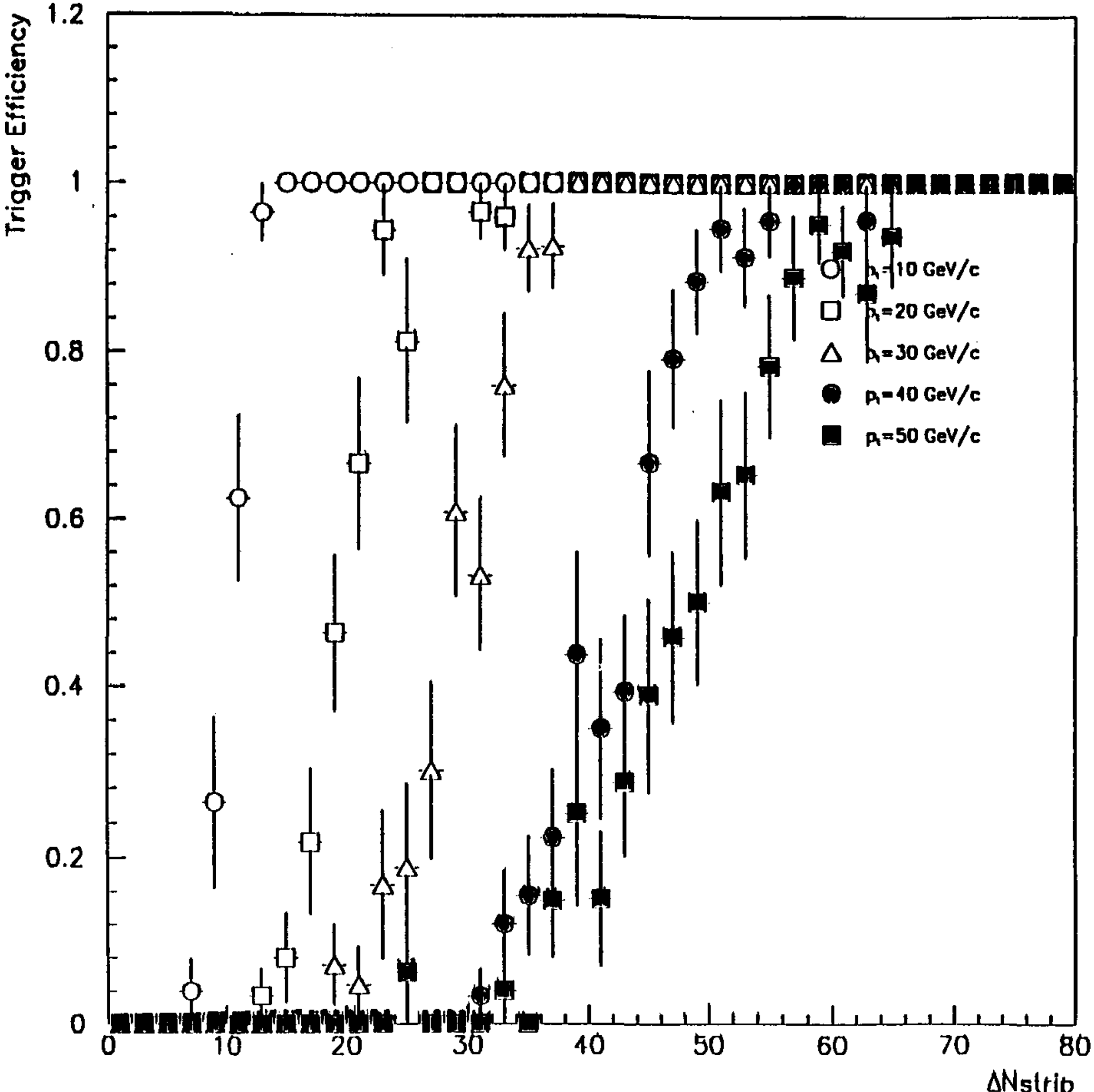
Trigger Efficiency vs ΔNstrip (Barrel)



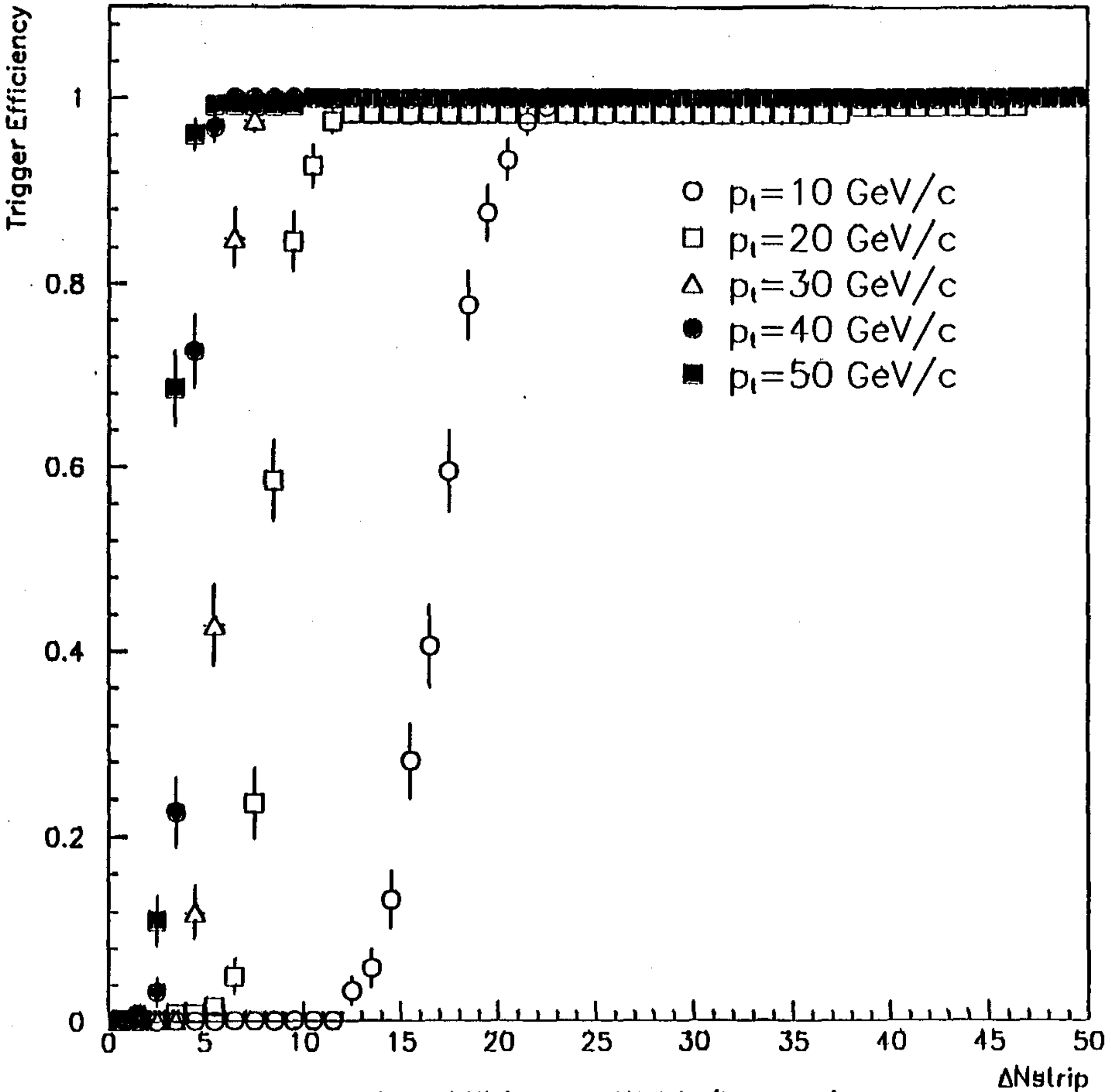
Trigger Rate vs ΔNstrip



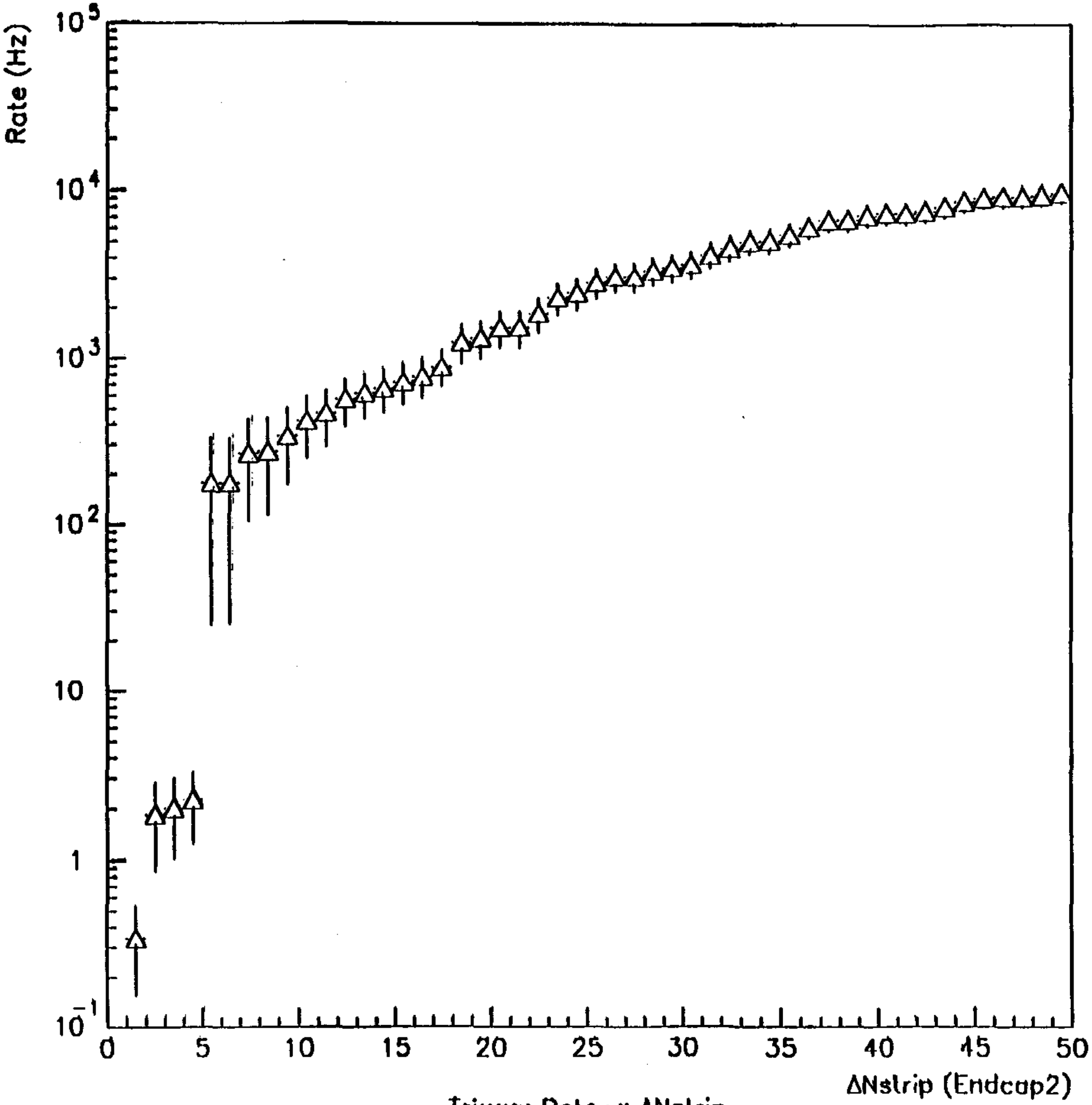
Trigger Efficiency vs ΔNstrip (Endcap1)



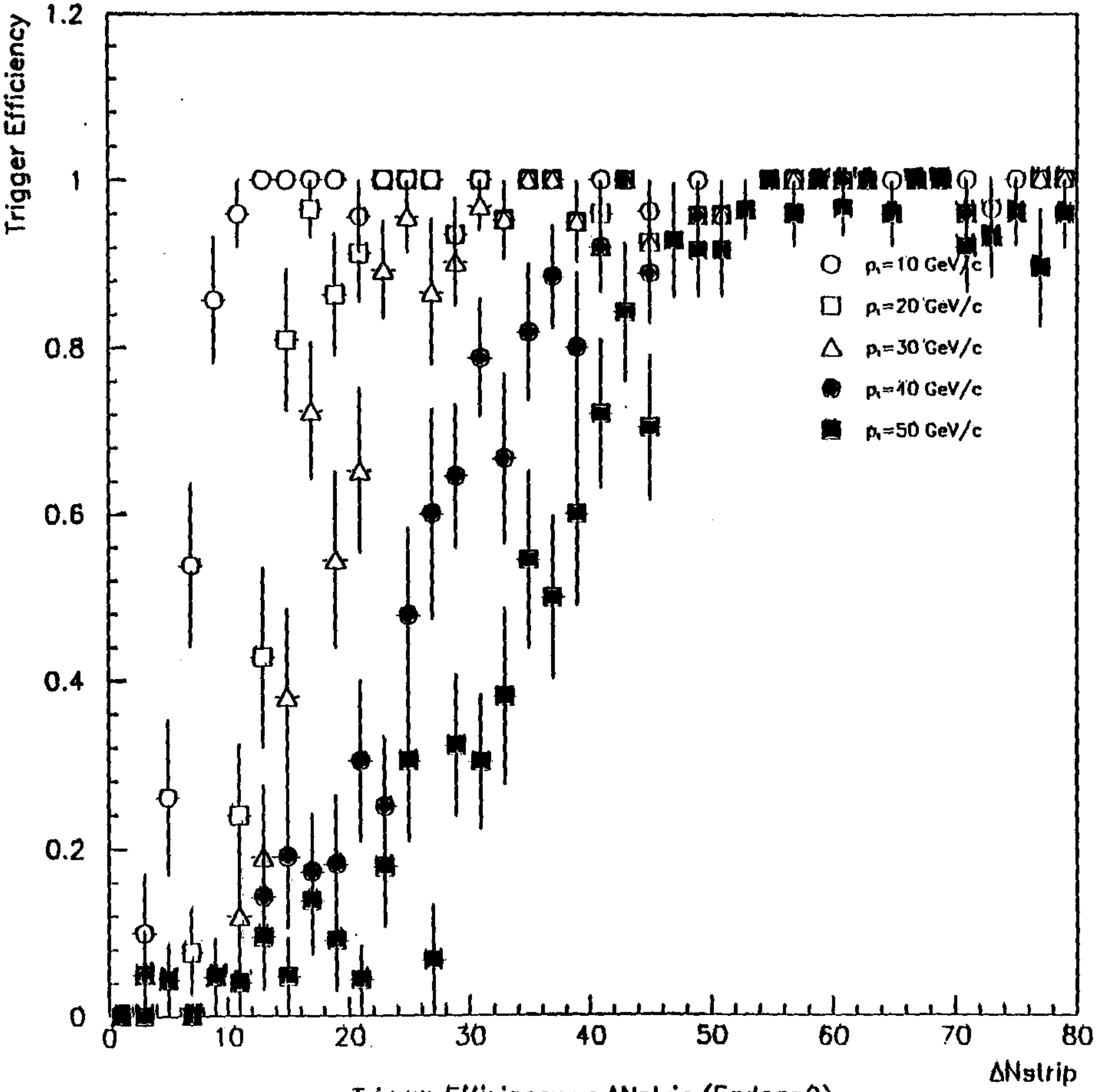
Trigger Efficiency vs ΔNstrip (Endcap1)



Trigger Efficiency vs ΔNstrip (Endcap2)



Trigger Rate vs ΔNstrip



Trigger Efficiency vs ΔNstrip (Endcap2)

gem

γeμ

Presentation by:

Renyuan Zhu

SDC : 0.8 GeV (ΔM_H) R.Zh

GEM Muon (GEMFAST)

- Intrinsic Muon Resolution: 2%

$\Delta M_H = 1.4$ GeV ($H \to 4\mu$ 140 GeV)

- Including ΔE uncertainty:

$\Delta M_H = 1.9$ GeV

$\sigma(\Delta E)$: 2%

- $\sigma(\Delta E)$ should be reduced by choose calculated ΔE

$\Delta E_{\text{measured}} > K\, \Delta E_{\text{calculated}}$: $\Delta E_{\text{meas.}}$

$\Delta E_{\text{measured}} < K\, \Delta E_{\text{calculated}}$: $\Delta E_{\text{calc.}}$

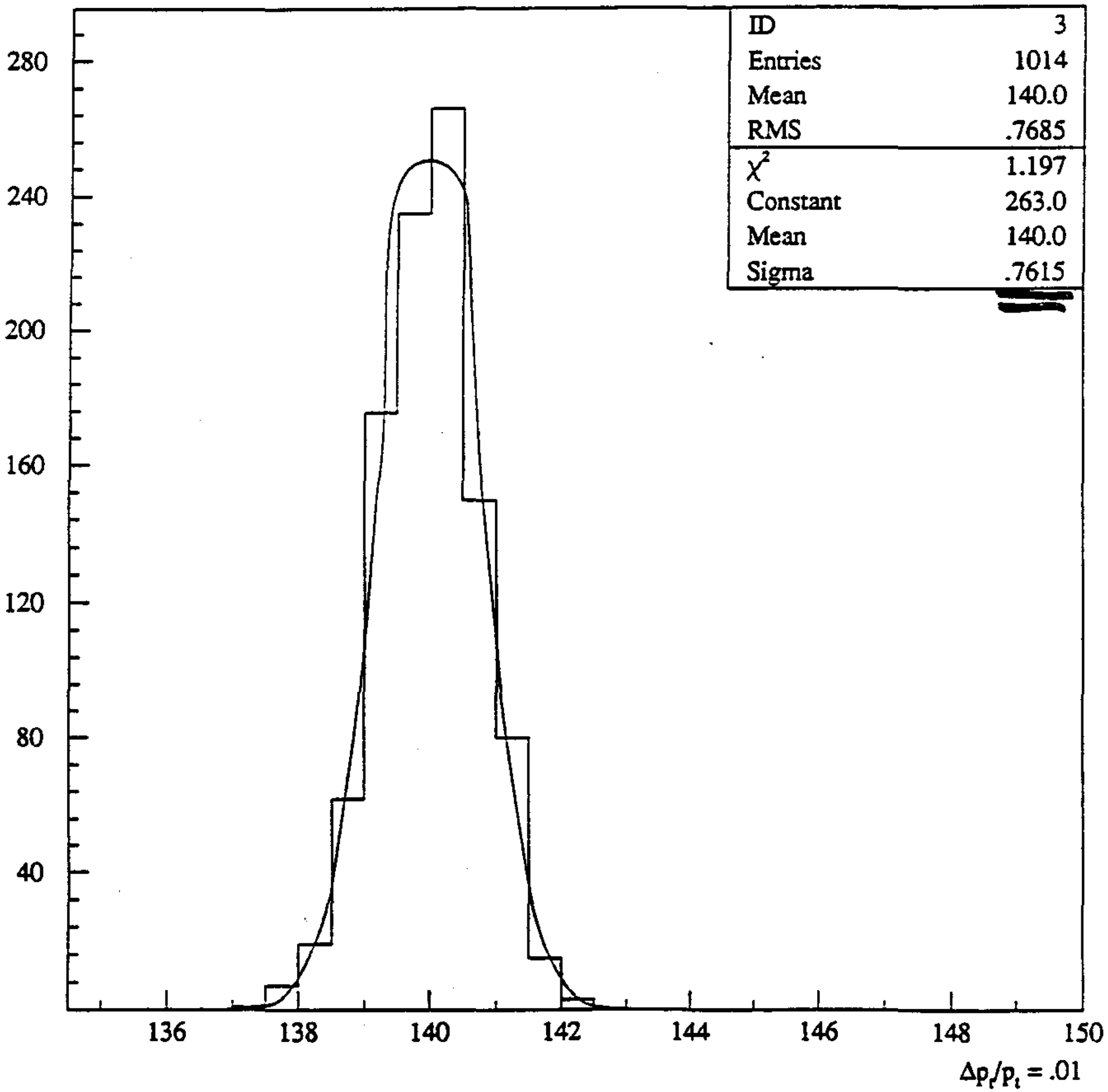
$K = 1.5 \Rightarrow$ did not work

S. Mrenna

$H \to 4\ell$ (140 GeV)

1 % Resolution

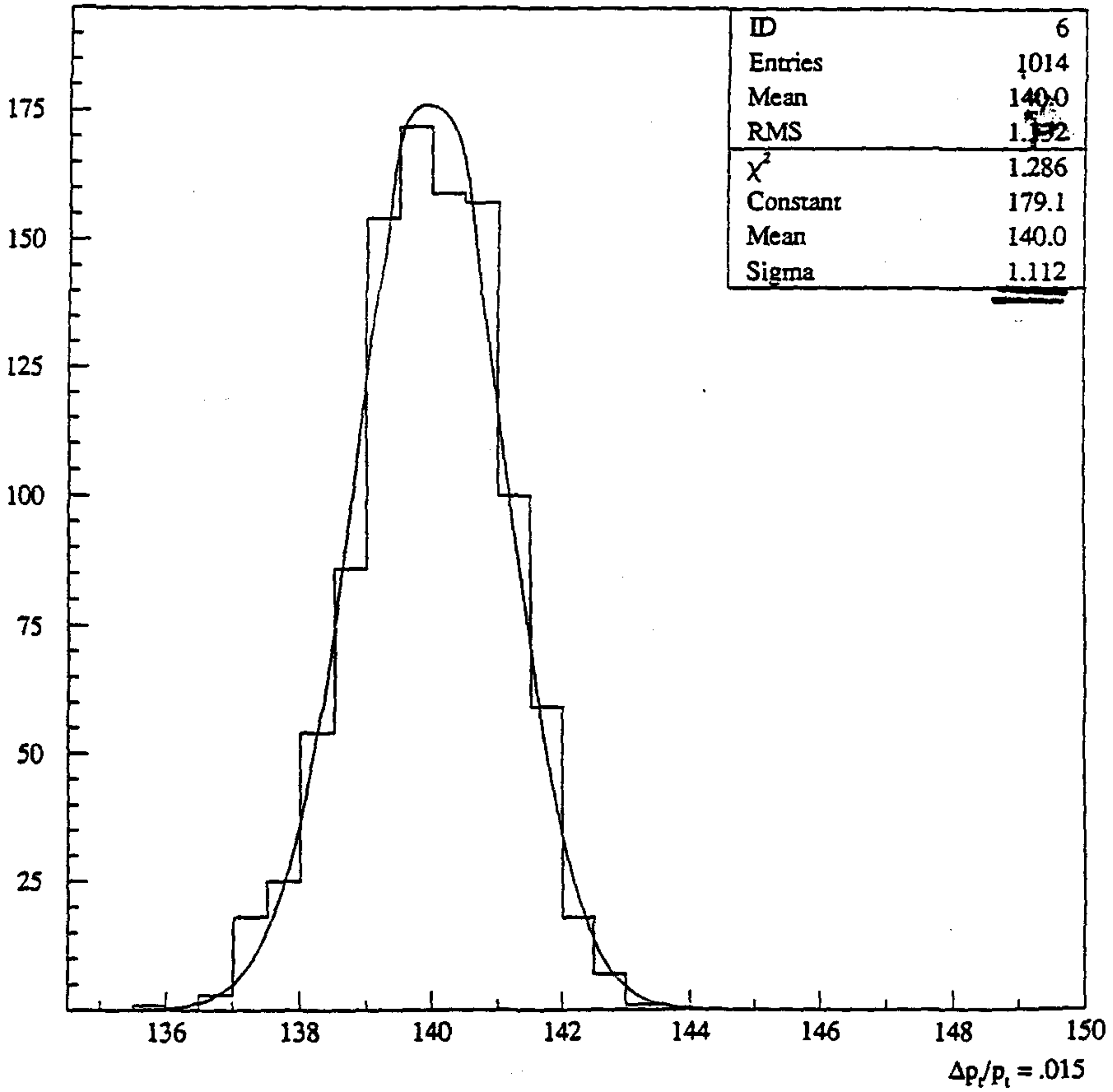
4 Vector Smearing



H → 4μ (130 GeV)

1.3 % Resolution

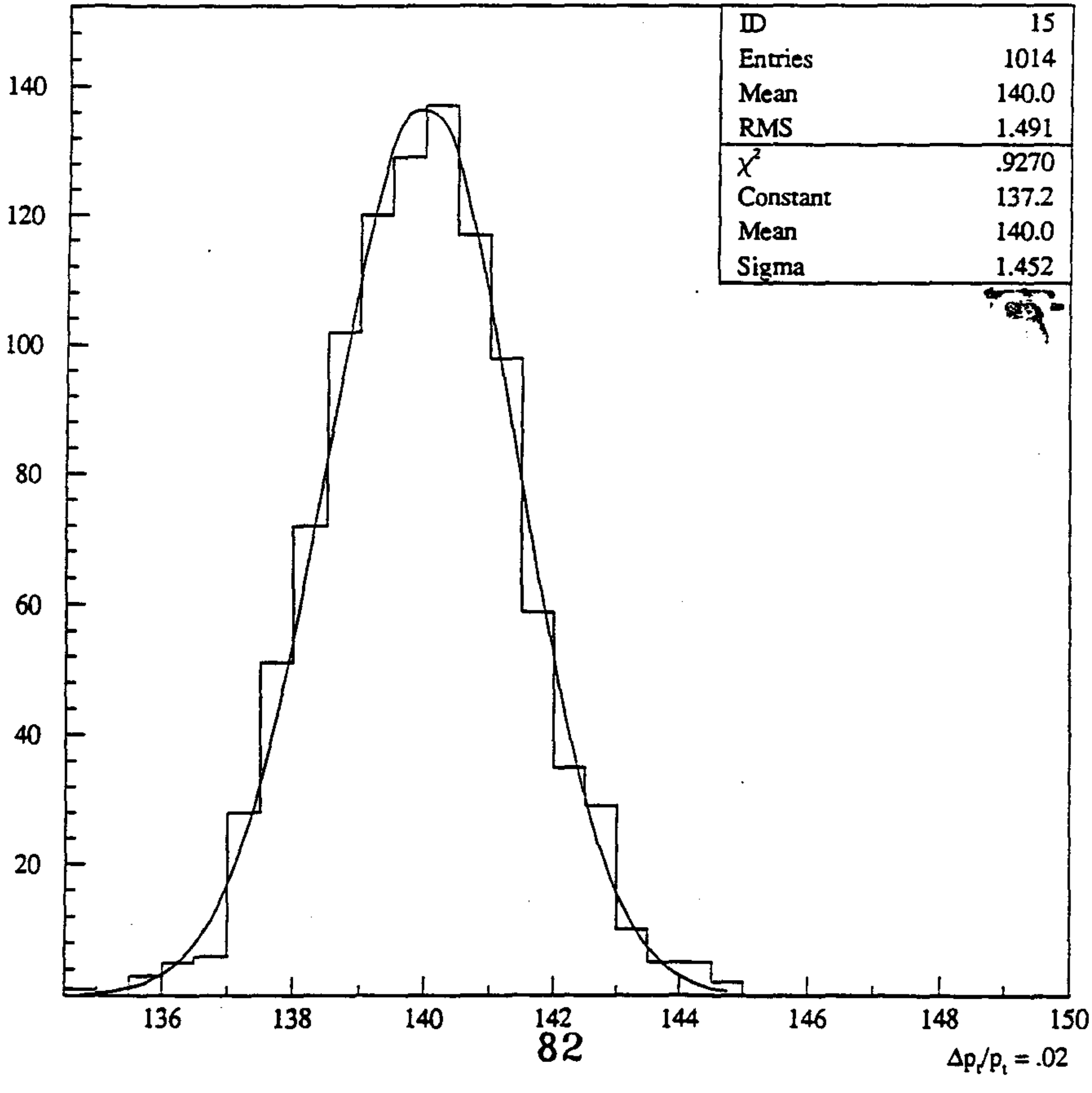
4 Vecta Smearing



$H \rightarrow 4\mu$ (140 GeV)

0% resolution

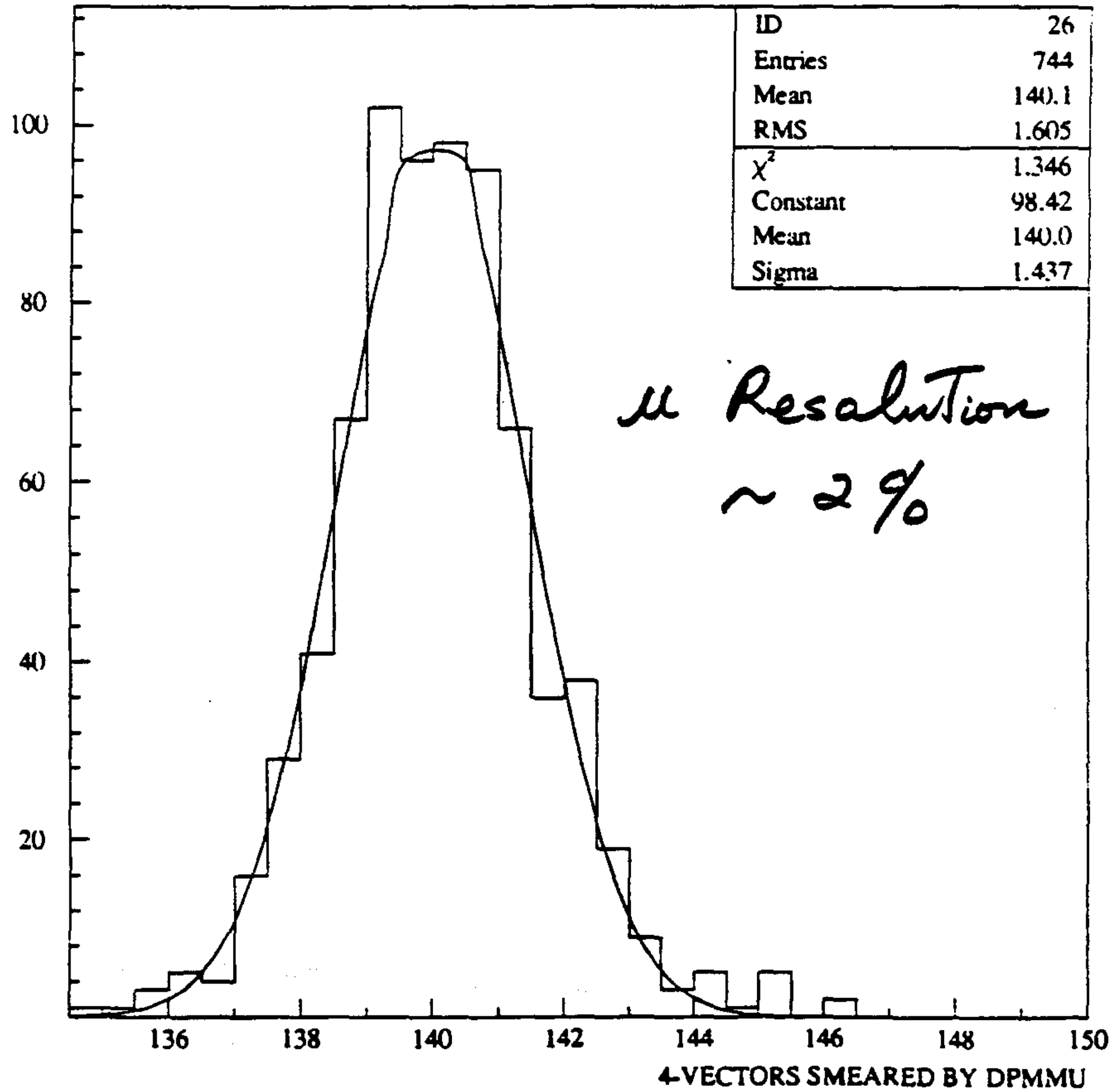
4 Vector Smearing



$H \to 4\mu$ (140 GeV)

4 Vector Smearing with

μ Resolution



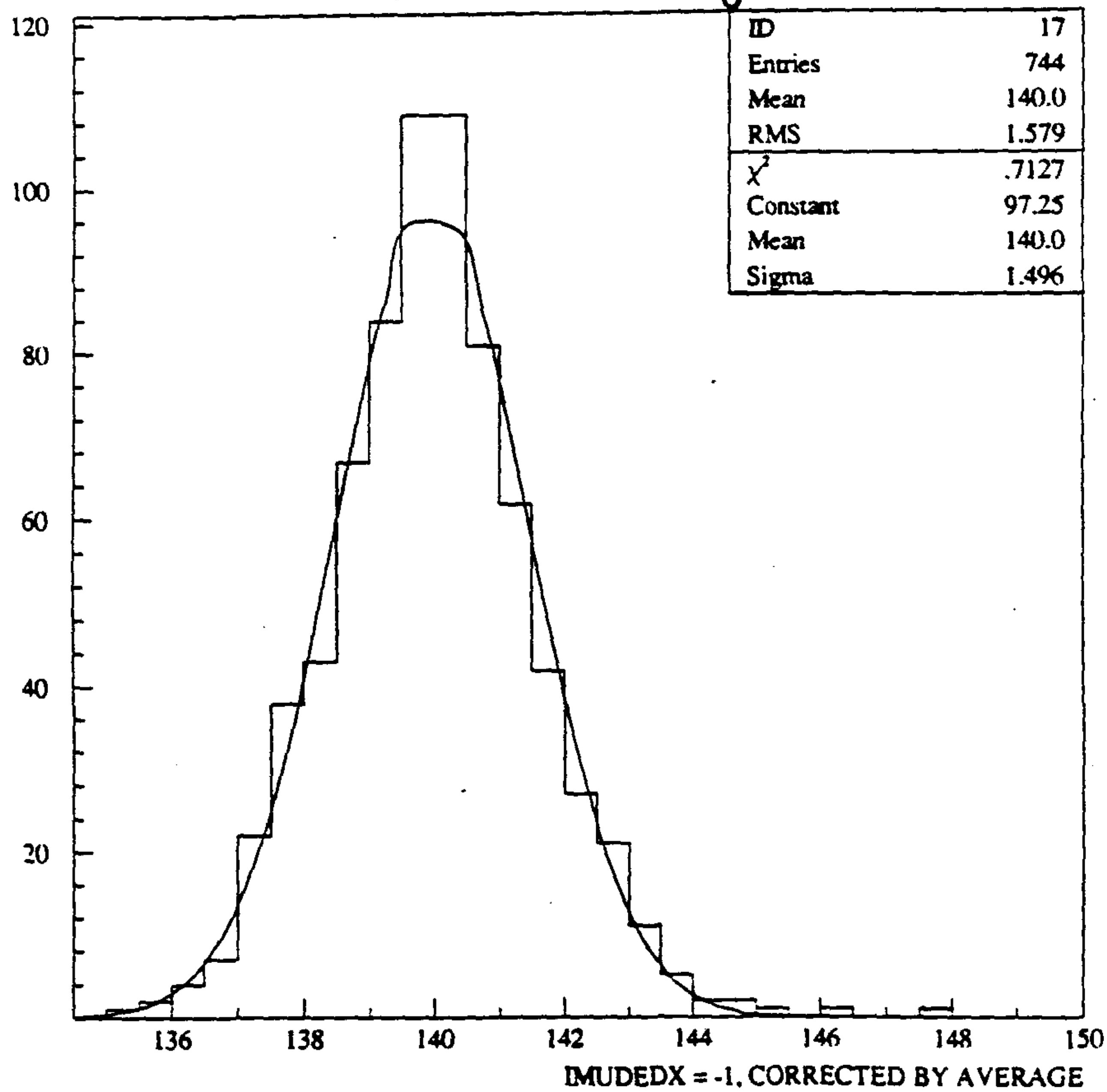
μ Resolution

~ 2%

$H \rightarrow 4\mu$ (140 GeV)

$\frac{dE}{dx}$: Average

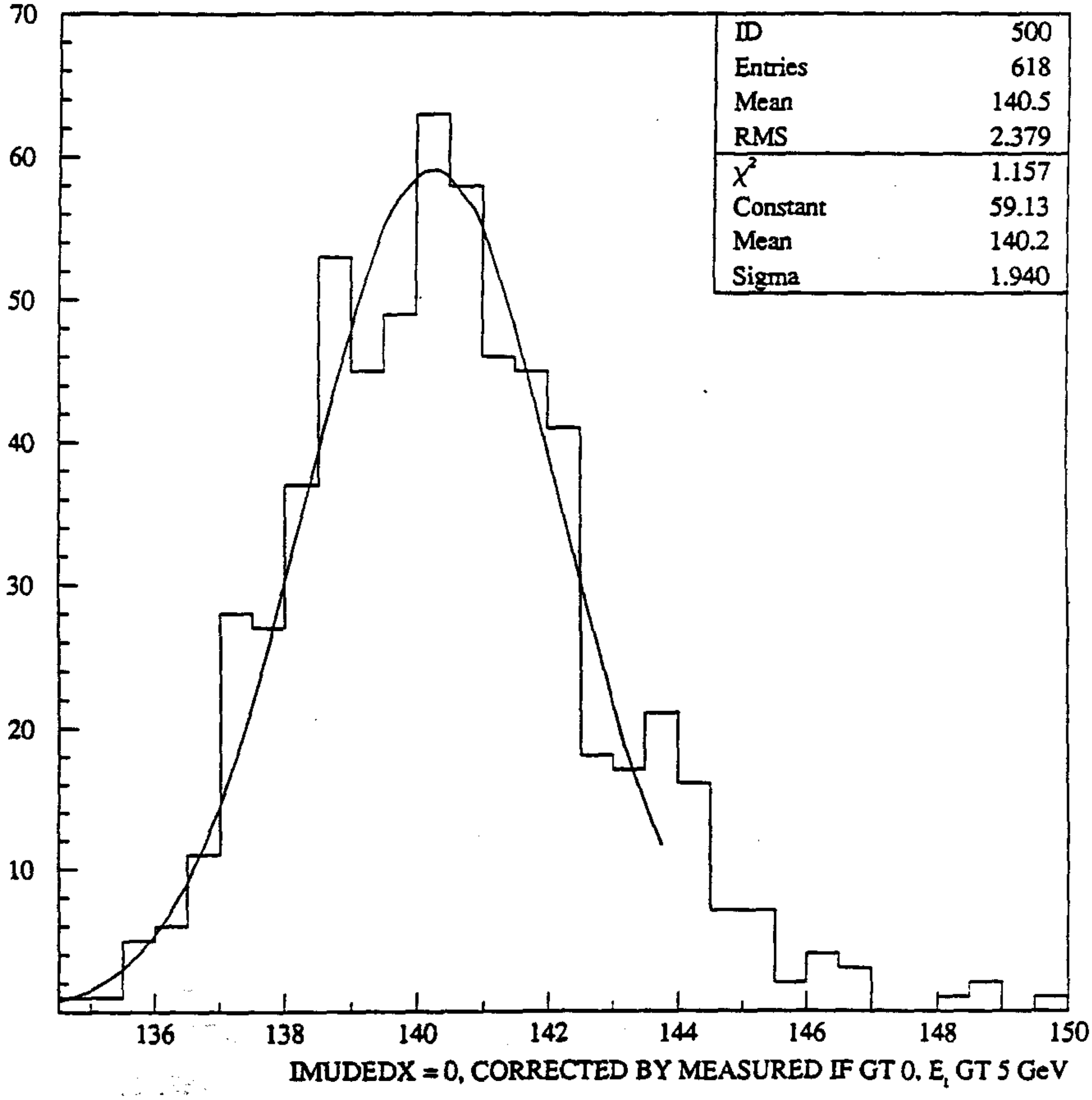
ΔE : Average



$H \to 4\mu$ (140 GeV)

$\frac{dE}{dx}$: McNeil

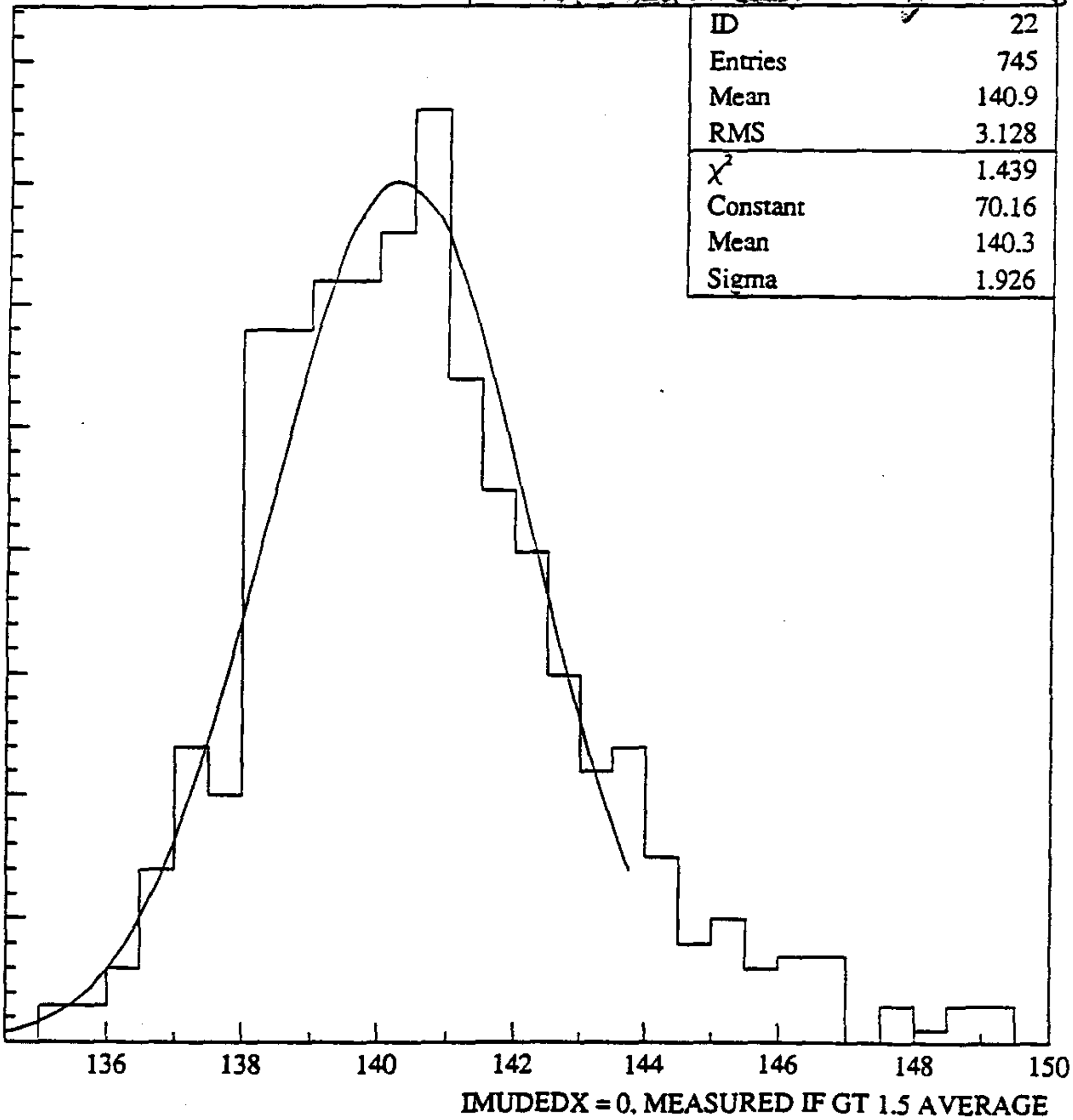
ΔE: measured (all $E_T > 5$ GeV



$H \to 4\mu$ (140 GeV)

$\frac{dE}{dx}$: McNeil

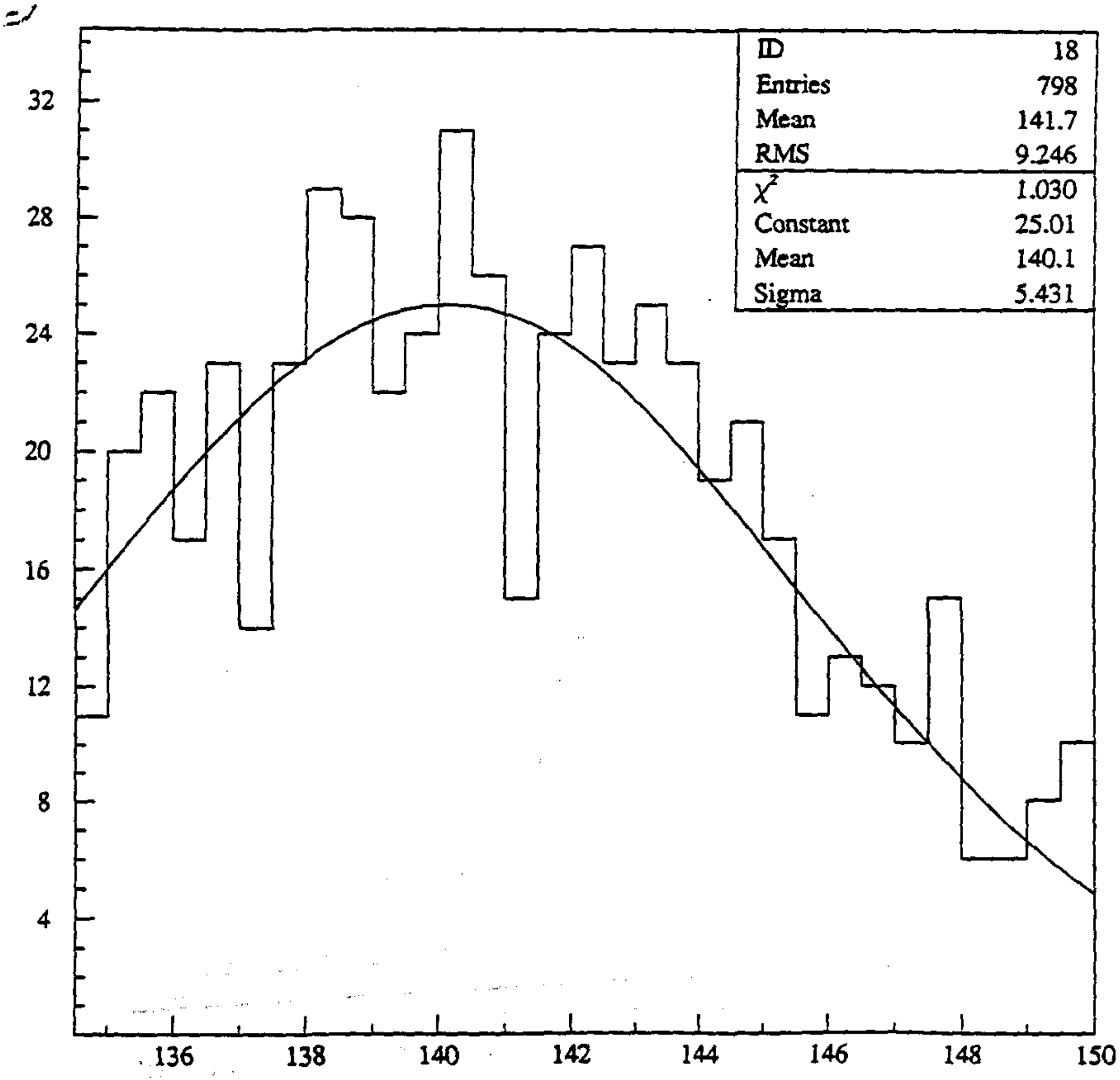
$\Delta E : \begin{cases} \text{Calculated if} < 1.5\,E_c \\ \text{Measured if} > 1.5\,E_c \end{cases}$



$H \rightarrow 4\mu$ (140 GeV)

Central Tracker Resolution

Use CT ?



ID	18
Entries	798
Mean	141.7
RMS	9.246
χ^2	1.030
Constant	25.01
Mean	140.1
Sigma	5.431

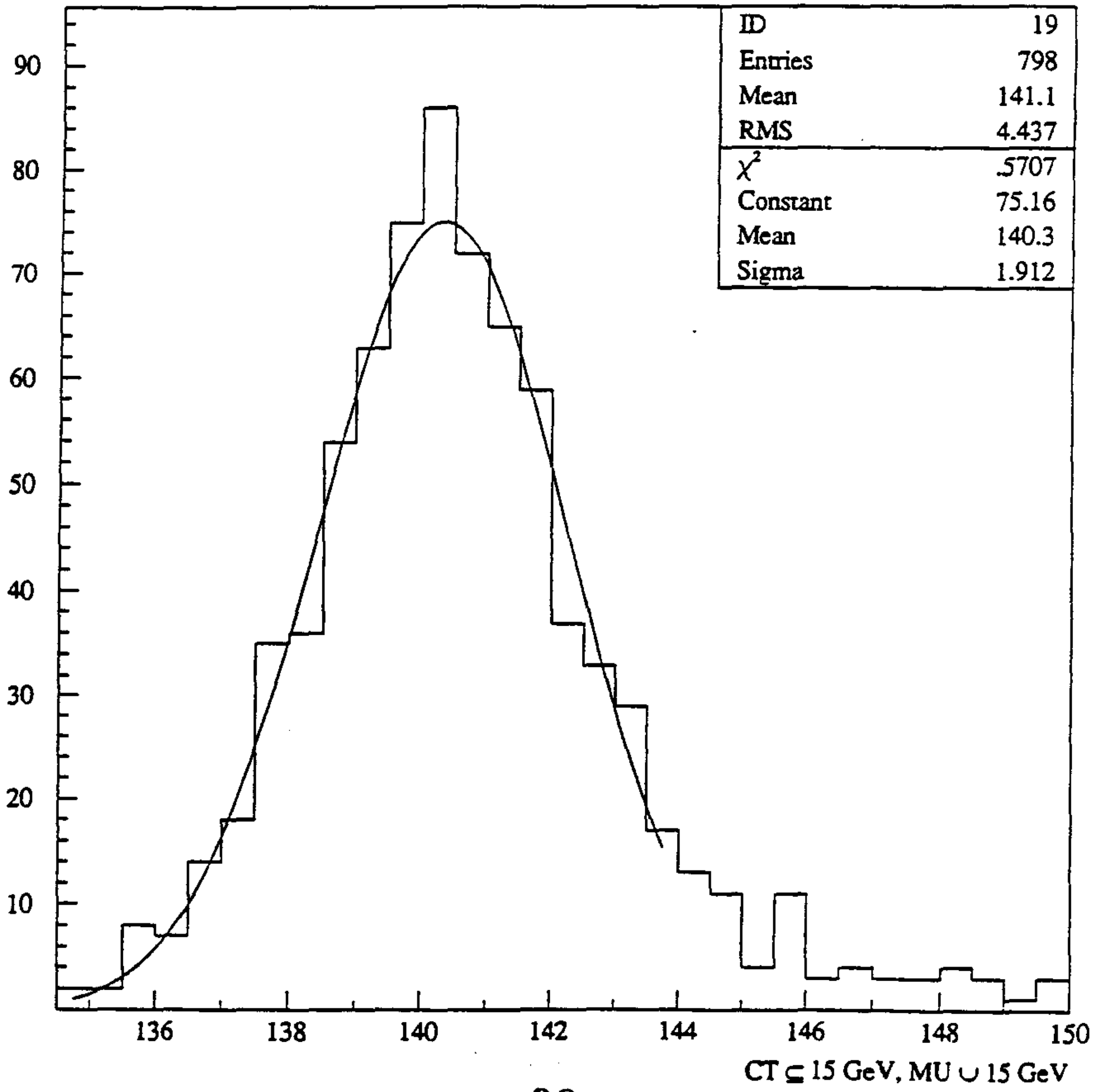
Central Tracker Only

$H \rightarrow 4\mu$ (140 GeV)

$P_T^{\mu} < 15$ GeV : CT

$P_T^{\mu} > 15$ GeV : Muon

USE CT?



Solution

- Reduce material in the middle module of Muon

  2% → 1% ?

  or. Combine CT with $\mu \Rightarrow 1.4\%$?

- Figure out a better ΔE scheme

  Try different K's.

  2% → 1%

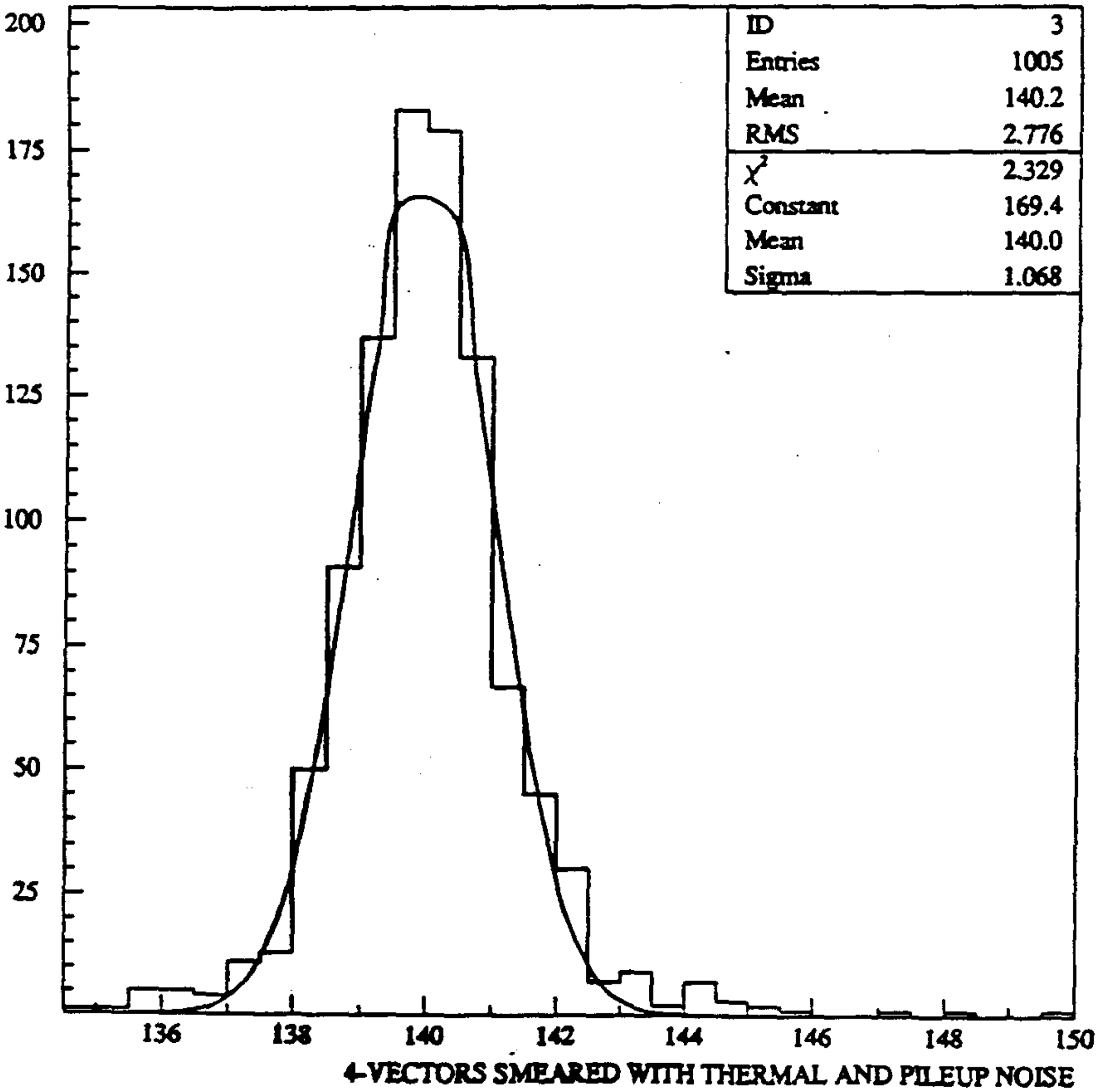
- Goal : $\sigma M_H = 1$ GeV

$H \to 4e$ (140 GeV)

4 Vector Smearing (H. Ma parametr

$\sigma_H = 1.07$ GeV

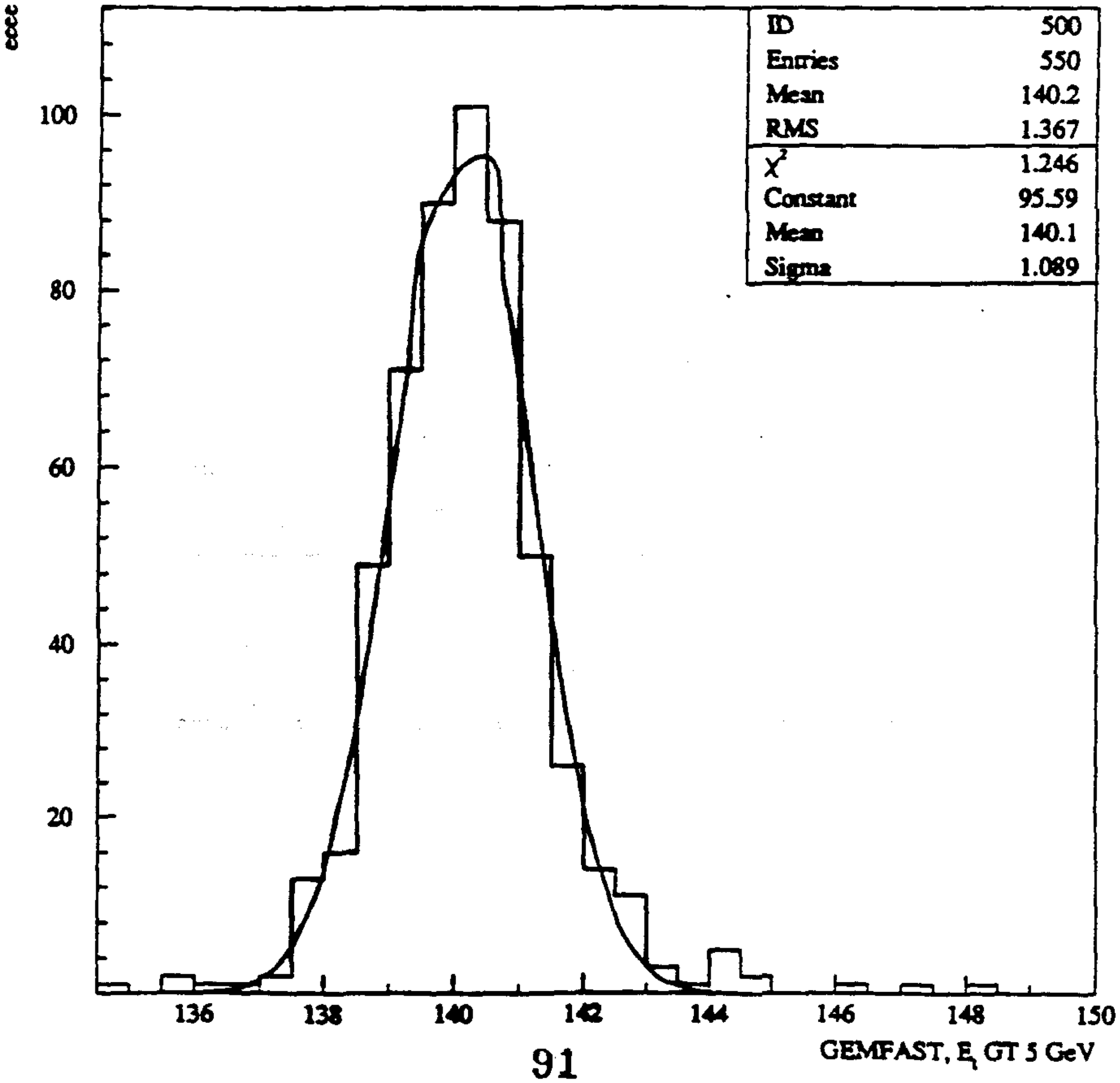
No noise : $\sigma_H = 0.86$ GeV



H → 4e (140 GeV)

GEMFAST

$\sigma_H = 1.09$ GeV



SDC TDR

Table 3-1

A summary of the parameters of the baseline SDC calorimeter which have been assumed in the subsequent analyses. The calorimeter depth is quoted in interaction lengths (λ).

Parameter	Barrel	Endcap	Forward
Coverage	$\lvert\eta\rvert < 1.4$	$1.4 < \lvert\eta\rvert < 3.0$	$3.0 < \lvert\eta\rvert < 6.0$
Radius of front face (m)	2.10		
z position of front face (m)		4.47	12.00
Compartment depth			
EM (+ Coil)	1.1	0.9	
HAD1	4.1	5.1	13.0
HAD2	4.9	6.0	
EM resolution			
a	0.14	0.17	0.50
b	0.01	0.01	0.05
HAD resolution			
a	0.67	0.73	1.00
b	0.06	0.08	0.10
HAD nonlinearity			
α	1.13	1.16	1.16
β	0.31	0.38	0.38

Table 3-3

Two photon invariant mass resolutions in GeV for events from the $t\bar{t} + H$ process. The entries in the table are the sigma of a Gaussian fit to the signal (in GeV). The simulation was done at the particle level using parametrized resolutions, where "Base" refers to the terms given in Table 3-1. The final columns summarize the resolution expected for the high performance option defined in Section 3.1.1.

M_{Higgs}	$a =$ Base $b = 0\%$	$a =$ Base $b =$ Base	$a =$ Base $b = 2\%$	$10\%/\sqrt{E}$	$a = 9\%/14\%$ $b = 0.5\%$	$a = 9\%/14\%$ $b =$ Base
80	1.08	1.23	1.56	0.67	0.80	0.93
100	1.24	1.44	1.89	0.78	0.93	1.11
120	1.39	1.65	2.19	0.87	1.05	1.28
140	1.52	1.81	2.51	0.96	1.16	1.44
160	1.64	2.00	2.81	1.03	1.25	1.61

With High Order Corrections

80 GeV Higgs→ $\gamma\gamma$ Signal (fb)
Irreducible Background (fb/GeV)

Process	σ_{prod}	c1-3/c5(1.5/2/3)	c1-4(50/80/100)	c1-5 (1.5/3
VV→H	17	8.0/4.7/3.7/2.0	5.8/3.8/3.0	1.7/0.43
gg→H	96	44/39/38/35	7.2/0.3/0.1	0.0/0.0
$f\bar{f}$ →H	10	4.8/4.4/4.2/4.0	0.4/.02/0.0	0.0/0.0
Sum	123	57/48/46/41	13/4.1/3.1	1.7/0.43
$q\bar{q} \rightarrow \gamma\gamma$	1350	235/-	4.0/0.1/0.0	
gg→ $\gamma\gamma$	2800	770/-	61/3.4/0.3	
Sum	4150	1000/-	65/3.5/0.3	
NLL	-	1.36/1.0/.98/.95	-/-/16	2.7/0.45
$S/\sqrt{B}$	-	2.6/2.6/2.5/2.3	-/-/1.2	2.1/1.3
"K" factor	-	3.7/3.7/3.5/3.2	-/-/1.2	2.1/1.3

Note, the $S/\sqrt{B}$ includes 6% ($\delta\eta$=0.15) acceptance loss and 90% efficiency of γ identification and 0.6 GeV σ_{M_H}.

Also note NLL x-section using HMRS(B) structure function has 20% lower x-section @80 GeV, comparing ELHQ-1 for signal.

Higgs Mass resolution M_H = 660 MeV,
a la Hong Ma: 3.7 ⇒ 3.3

B. Bailey & J. Owens

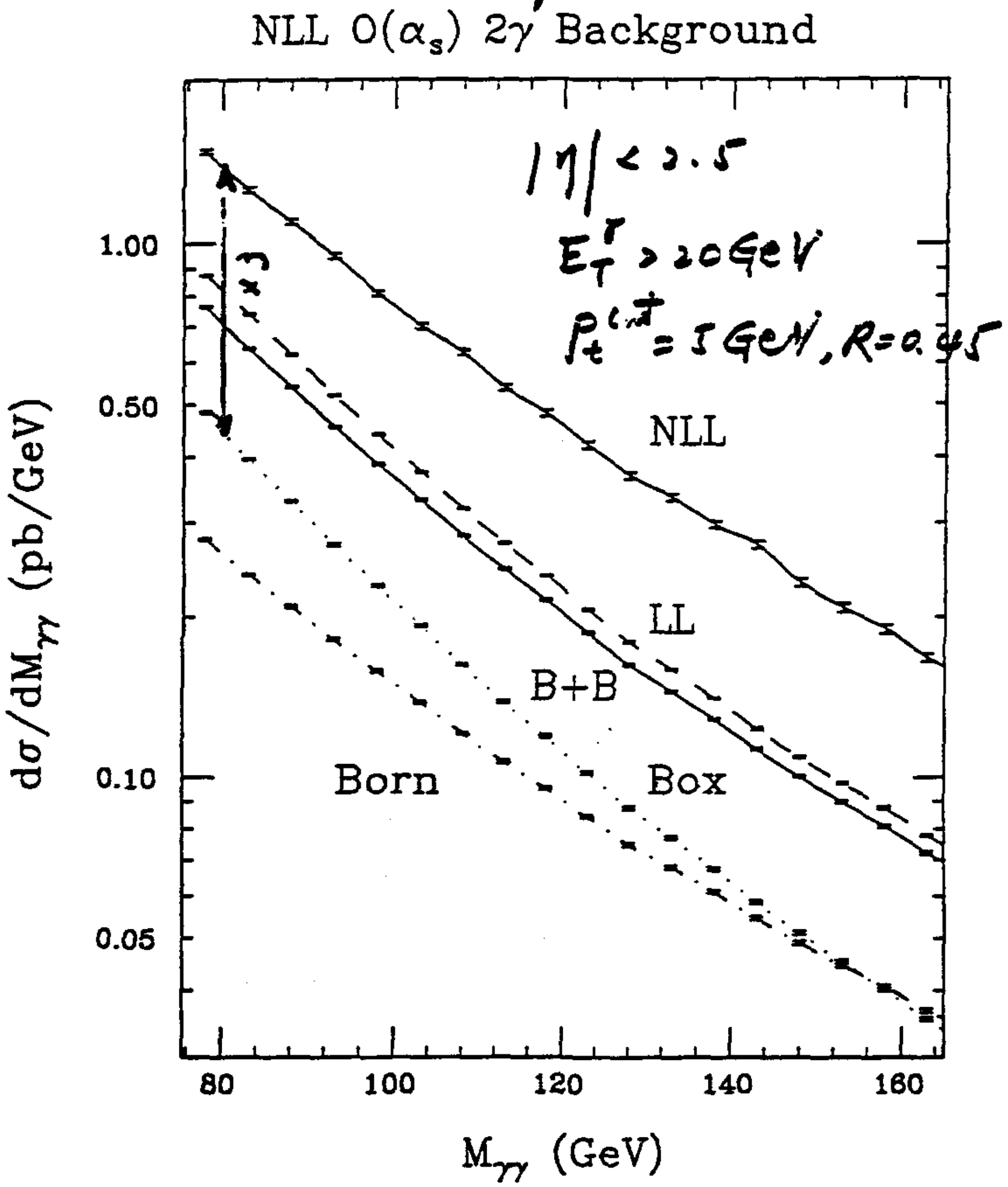


Figure 7: NLL direct photon background cross-section as function of $\gamma\gamma$ invariant mass after the cuts described in the text. Also shown in the figure are cross-sections of Born, box diagram, Born + box (B+B) and LL calculation.

Jet Background (pb/GeV)

Process	σ_{prod}	c1-2	c4 (50/80/100 GeV)
$q\bar{q} \to \gamma g$	235	36	0.6/<0.024/<0.024
$qg \to \gamma q$	3330	800	42/1.0/<0.1
Sum	3600	840	43/1/<0.13
Rejection to NLL	-	620	-/-/8
2jets (nb/GeV)	28,300	6,000	270/9/1.2
Rejection to NLL	-	4.4×10^6	-/-/7.5×10^4

Requested rejection, if jet background is 100%(10%) of NLL/JV:

620 (6200) for quark jet and 2100 (6600) for gluon jet.

GEANT Simulation with 10,000 jets?

$qg \to g\gamma$: $3330/1.35 = 2450$

$q\bar{q} \rightarrow g\gamma$ (700K) H. Ma

No Bremsstrahlung

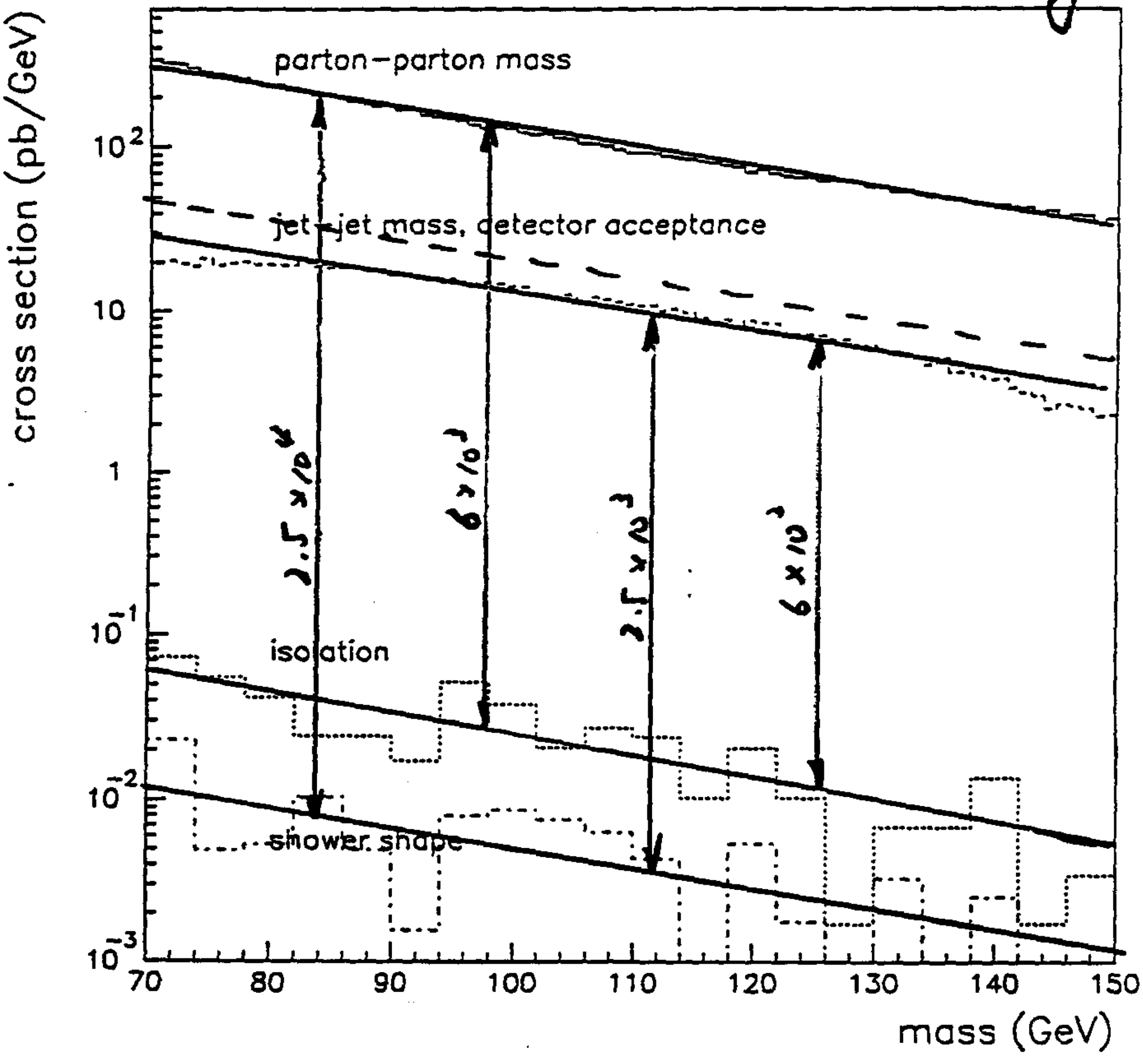


Figure 9: Invariant mass distribution of *gammag* final state before and after isolation cuts and after photon identification

$gg \to g\gamma$ (250K) H. Ma
No Bramsstrahlung

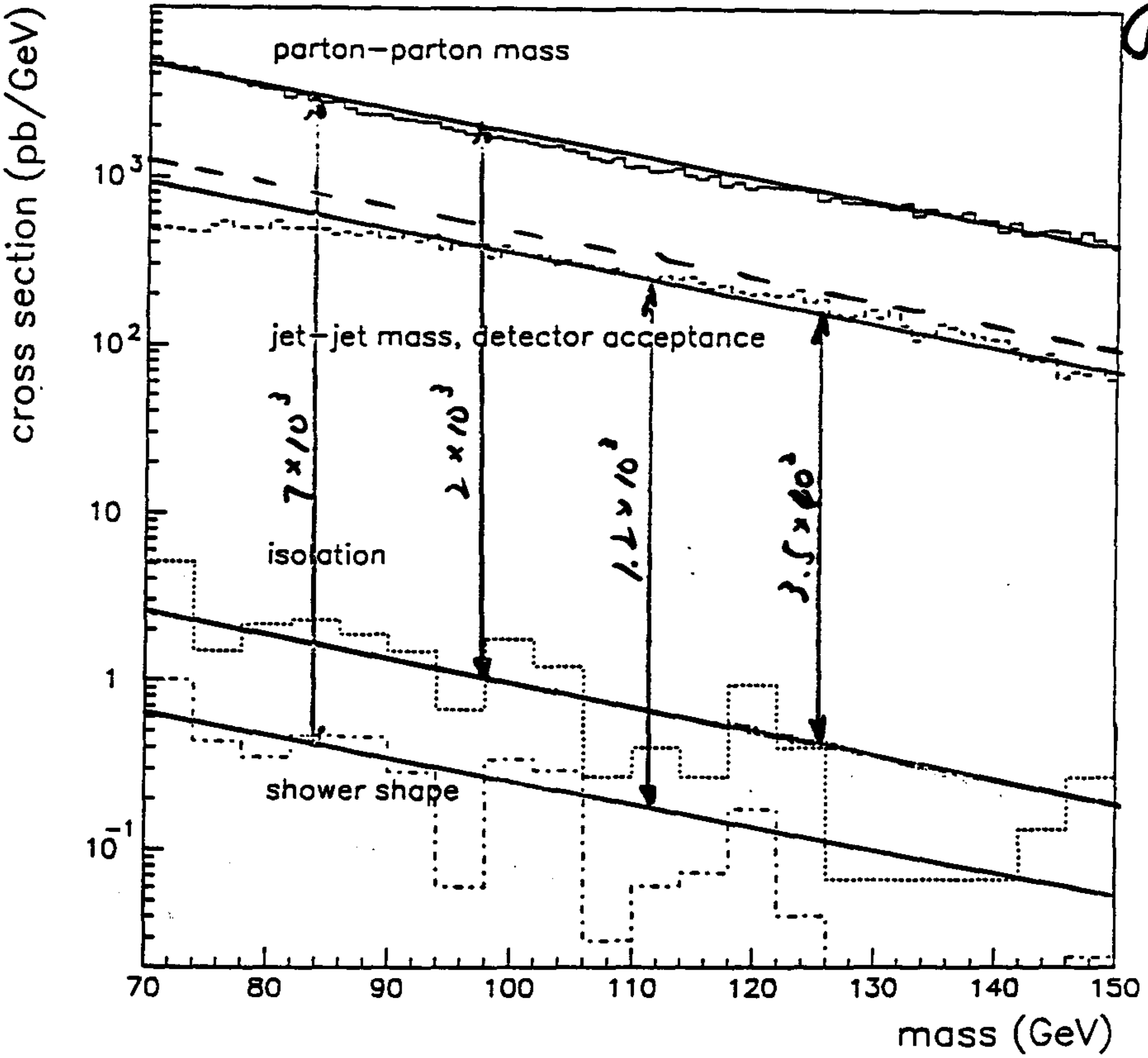
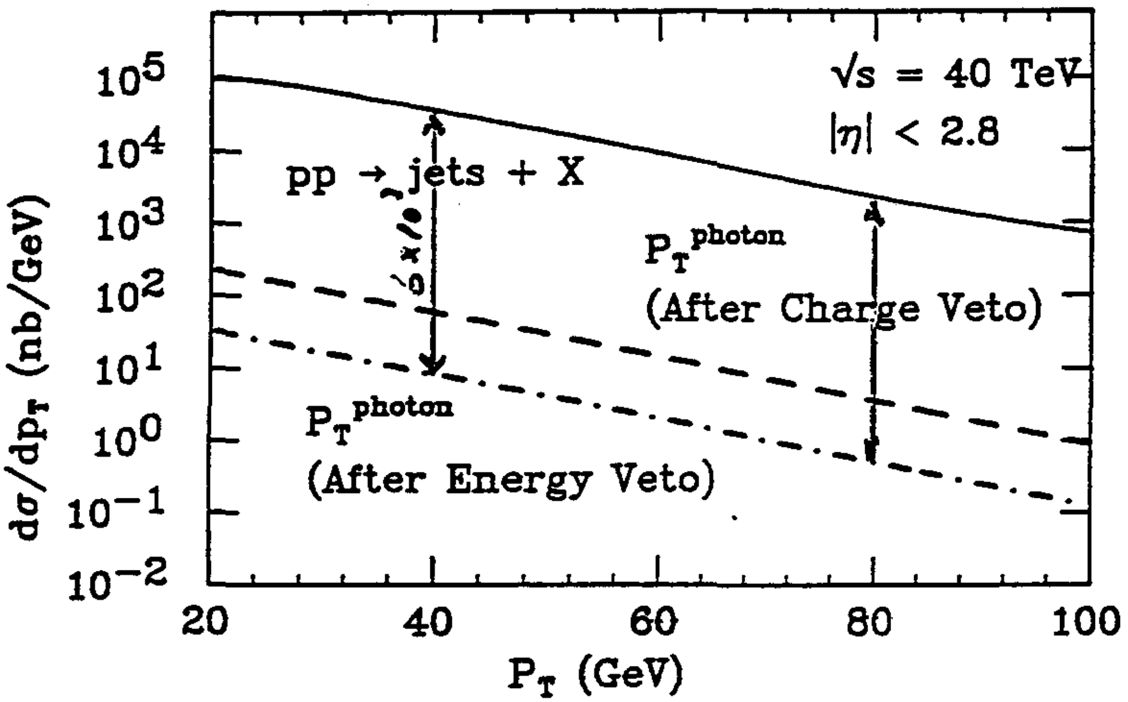


Figure 8: Invariant mass distribution of *gammaq* final state before and after isolation cuts and after photon identification

Isolation Only (1990)

2 jets (SM) BaF₂ (0.6 Cone) $p_t^{cut} = 5$ GeV



No Bremsstrahlung

Drell-Yan Background Rejection

Production X-Section: 2.1 nb for $\hat{p}_T > 20$ GeV.

- Acceptance of event selection cuts: 41%;
- DY Z peak x-section: 160 pb/GeV;
- Irreduciable $\gamma\gamma$ background at Z peak: 0.65 pb/GeV;
- Drell-Yan x-section is 250 times larger at Z peak, the same >250 GeV;
- $R(\gamma/e) = 3 \times 10^{-2} \Rightarrow$ reduce Drell-Yan background to ~0.25 of irreduciable $\gamma\gamma$ background;
- Feasibility: the probability of an electron fails to produce 4 hits out of 8 inner silicon layers of GEM central tracker is less than 10^{-4}, assuming the probability of a single layer being hit is 97%.

GEM Specification:

1×10^{-2} charged track rejection.

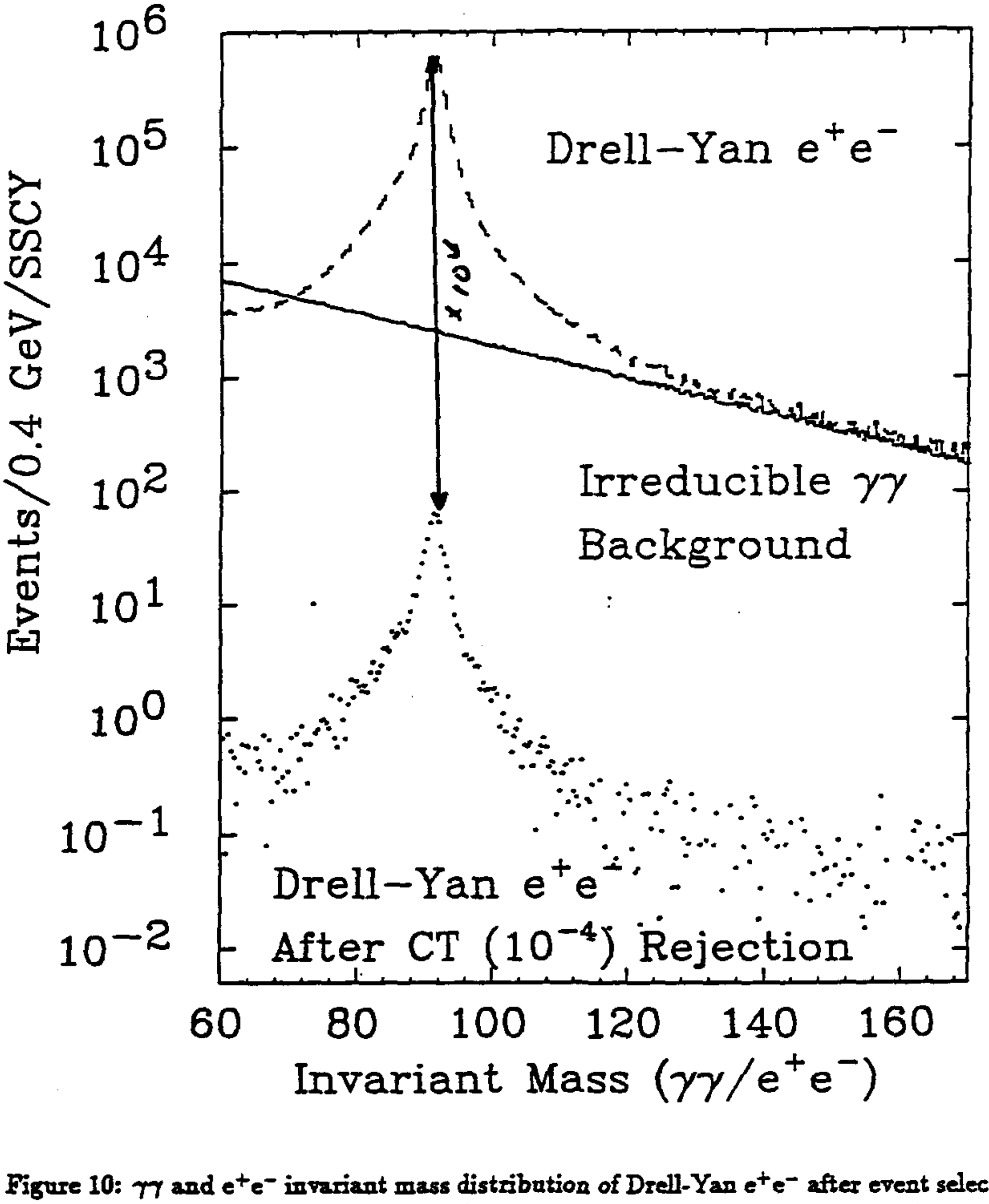
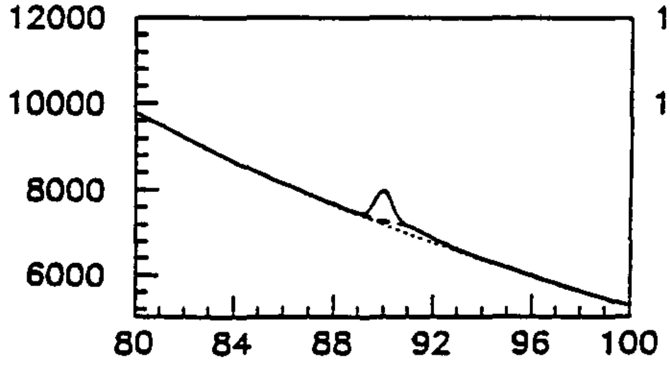
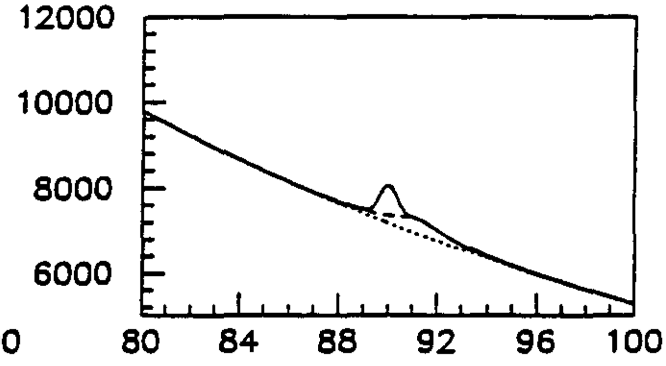


Figure 10: $\gamma\gamma$ and e^+e^- invariant mass distribution of Drell-Yan e^+e^- after event selection cut with no γ/e separation (dashed) is compared with irreducible $\gamma\gamma$ distributions (solid). Also shown in the figure is the Drell-Yan distribution, if 1% of electrons would misidentified as a photon.

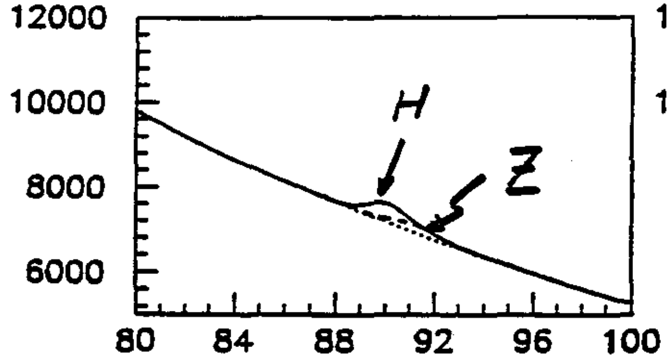
$dN/dM(\gamma\gamma)\ \ R(\gamma/e) = 1\%$



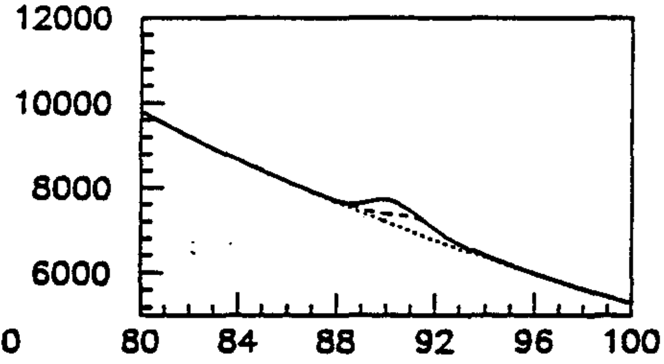
BaF2,K=1



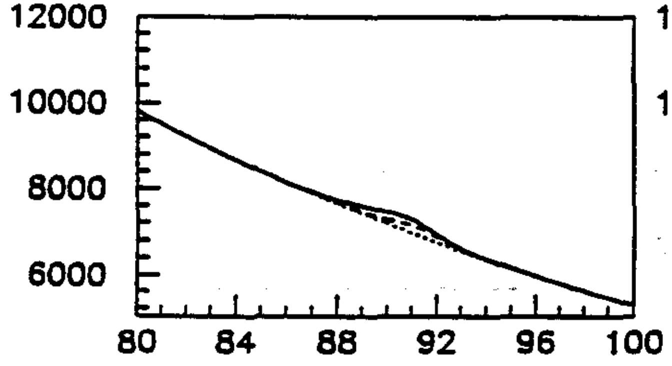
BaF2,K=2



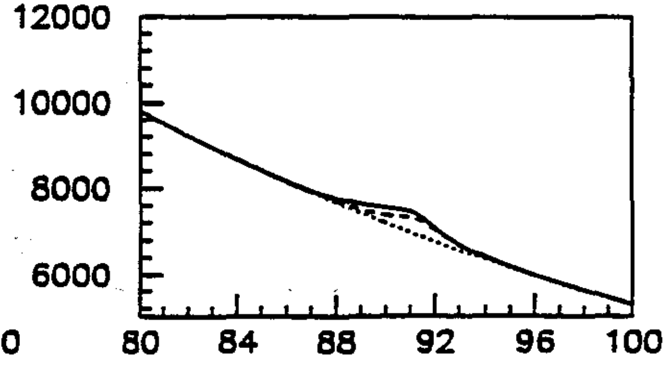
LAr ,K=1



LAr ,K=2

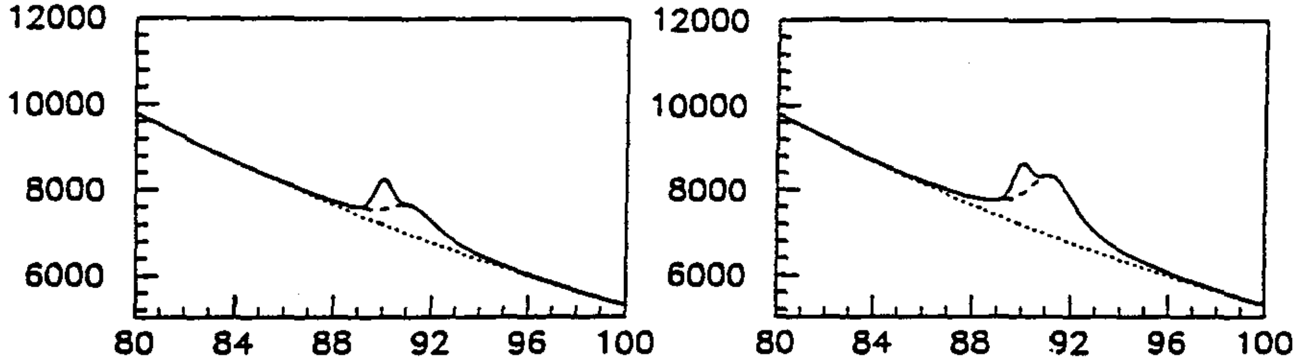


Sampling,K=1

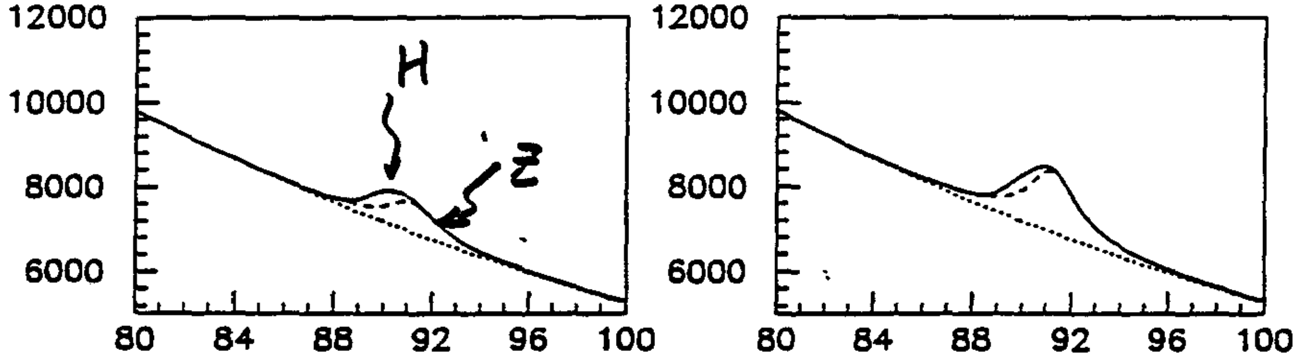


Sampling,K=2

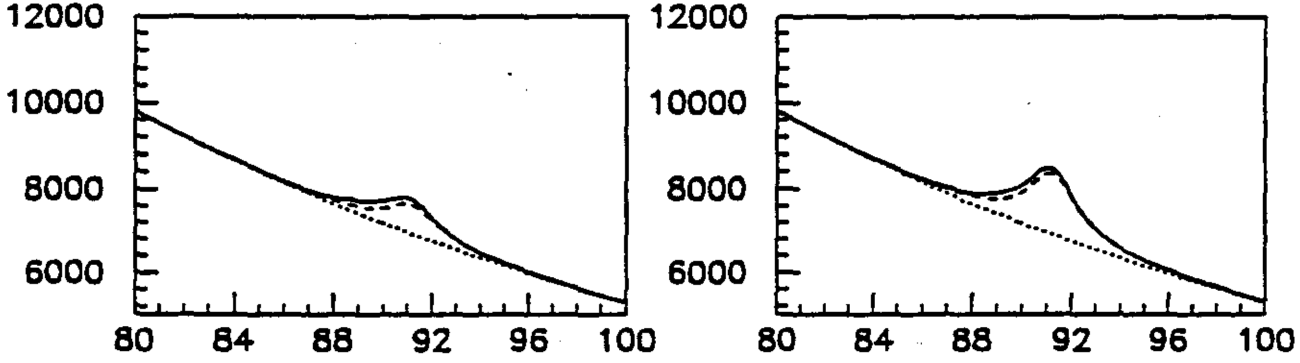
dN/dM($\gamma\gamma$) R(γ/e) = 2%



BaF2,K=1 BaF2,K=2

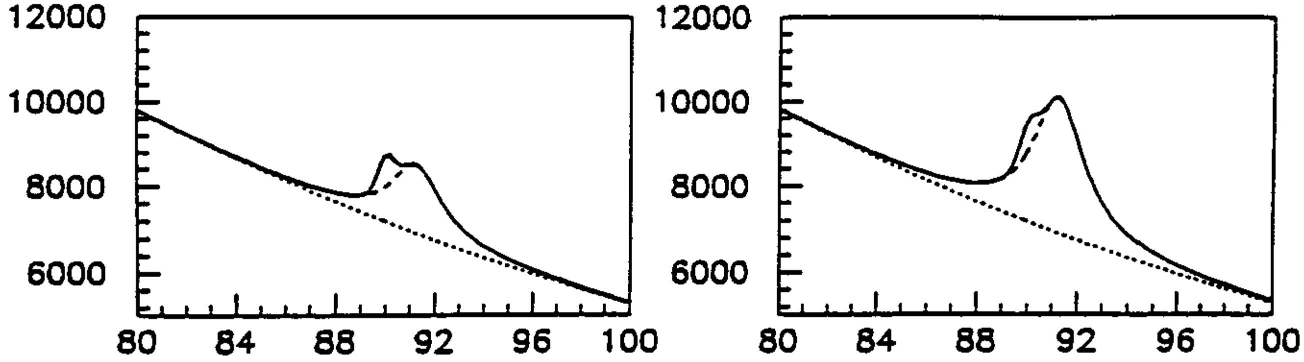


LAr ,K=1 LAr ,K=2

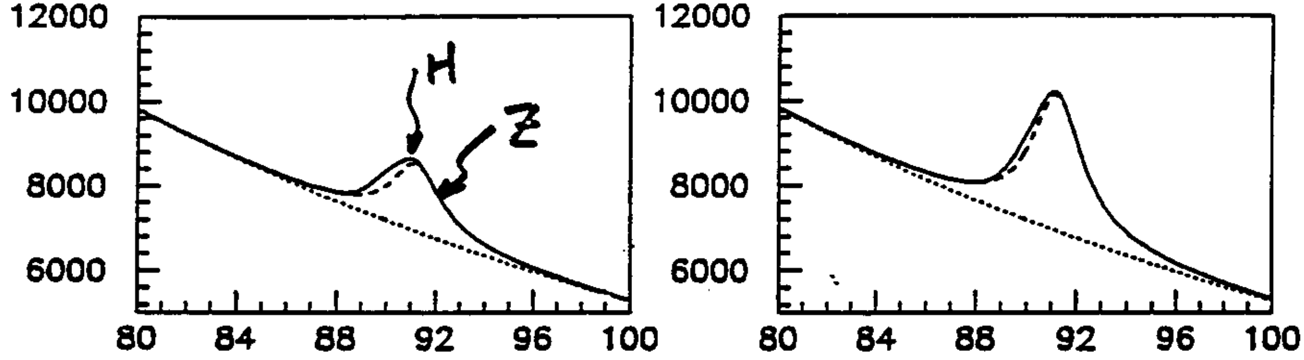


Sampling,K=1 Sampling,K=2

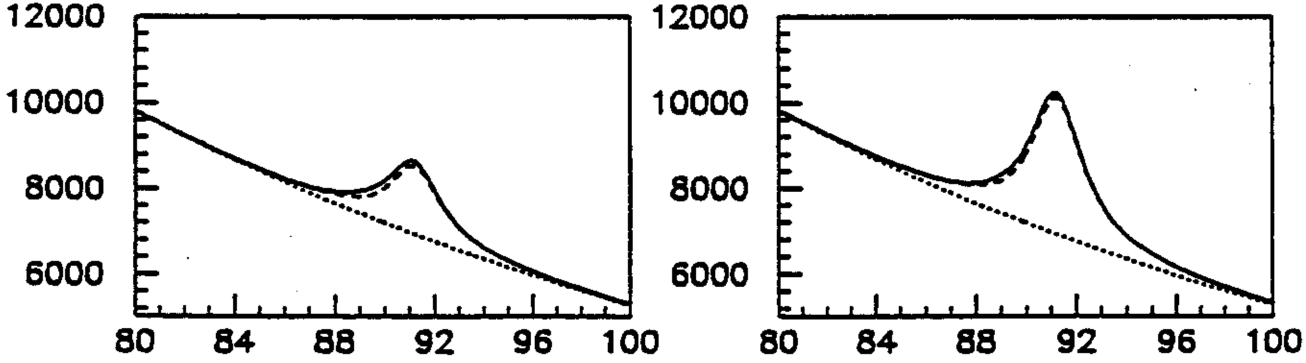
dN/dM($\gamma\gamma$) R(γ/e) = 3%



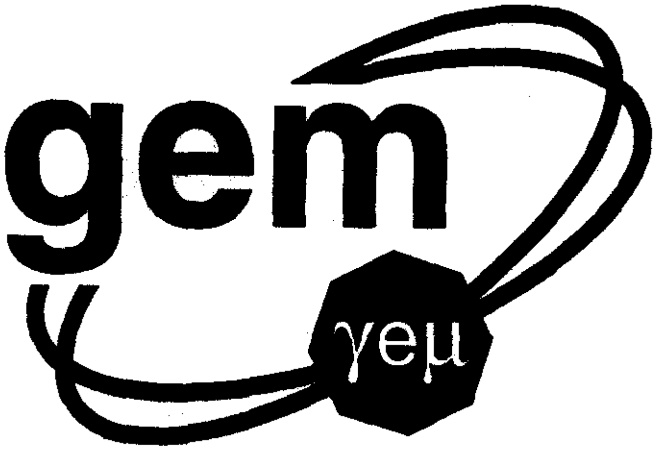
BaF2,K=1 BaF2,K=2



LAr ,K=1 LAr ,K=2



Sampling,K=1 Sampling,K=2



Presentation by:

Hong Ma

pile-up noise

HMa physics Simulation Meeting Mar17,199

1. changing tower size in Endcaps

optimization : 3×3 sum

faster shaping (20 ns)

Example : $H \to \gamma\gamma$ mass resolution :

Constant noise in E_T	600 MeV
GEMFAST 5×5 Sum	710 MeV
optimized (?)	650 MeV

2. Isolation

σ_{tot} = 3.5 GeV in R = 0.45 cone

with threshold on towers = 0.5 GeV

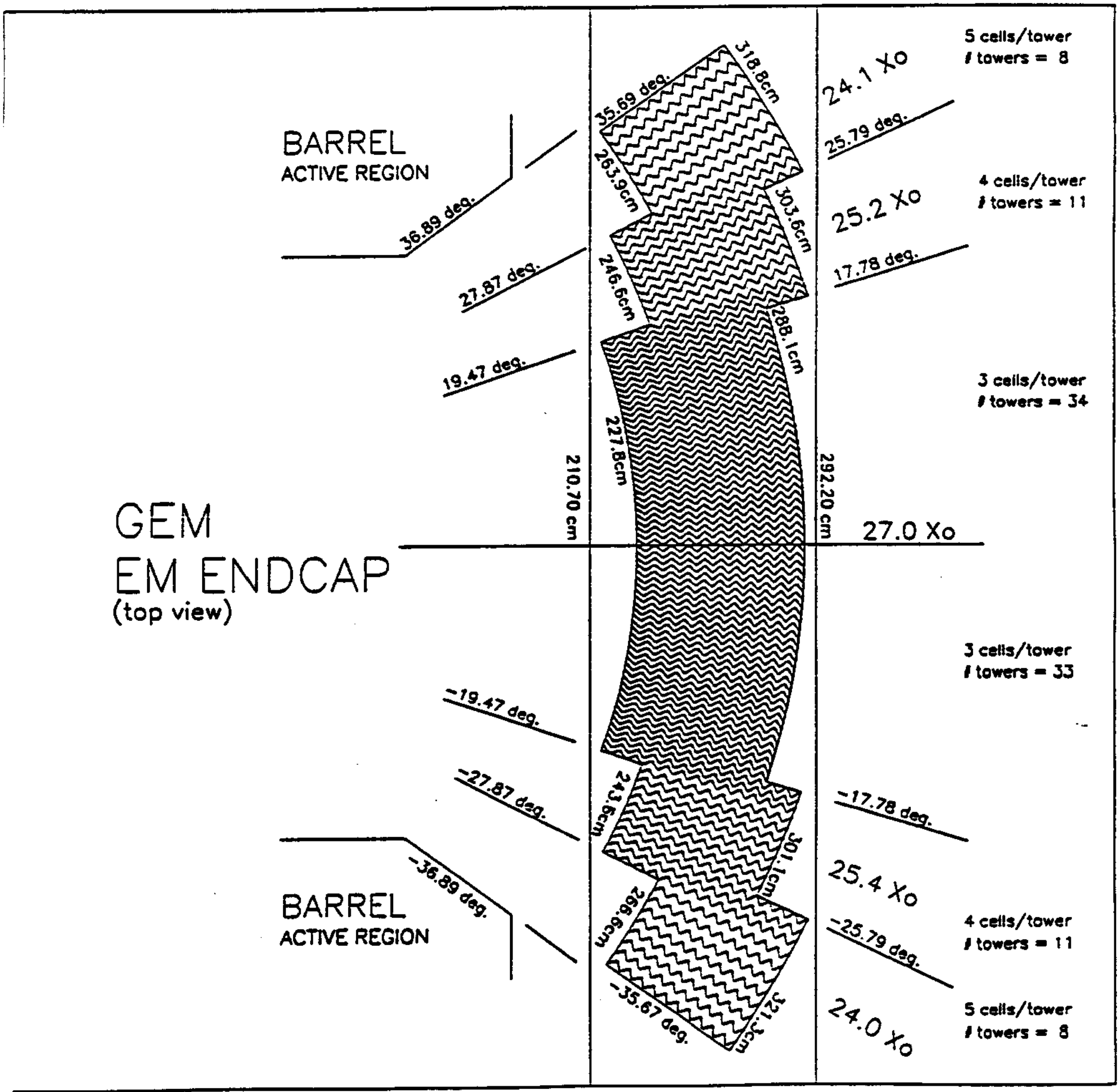
σ_{tot} = 2.2 GeV

isolation cut = 5 GeV

high Photon Efficiency (95%) may rely on

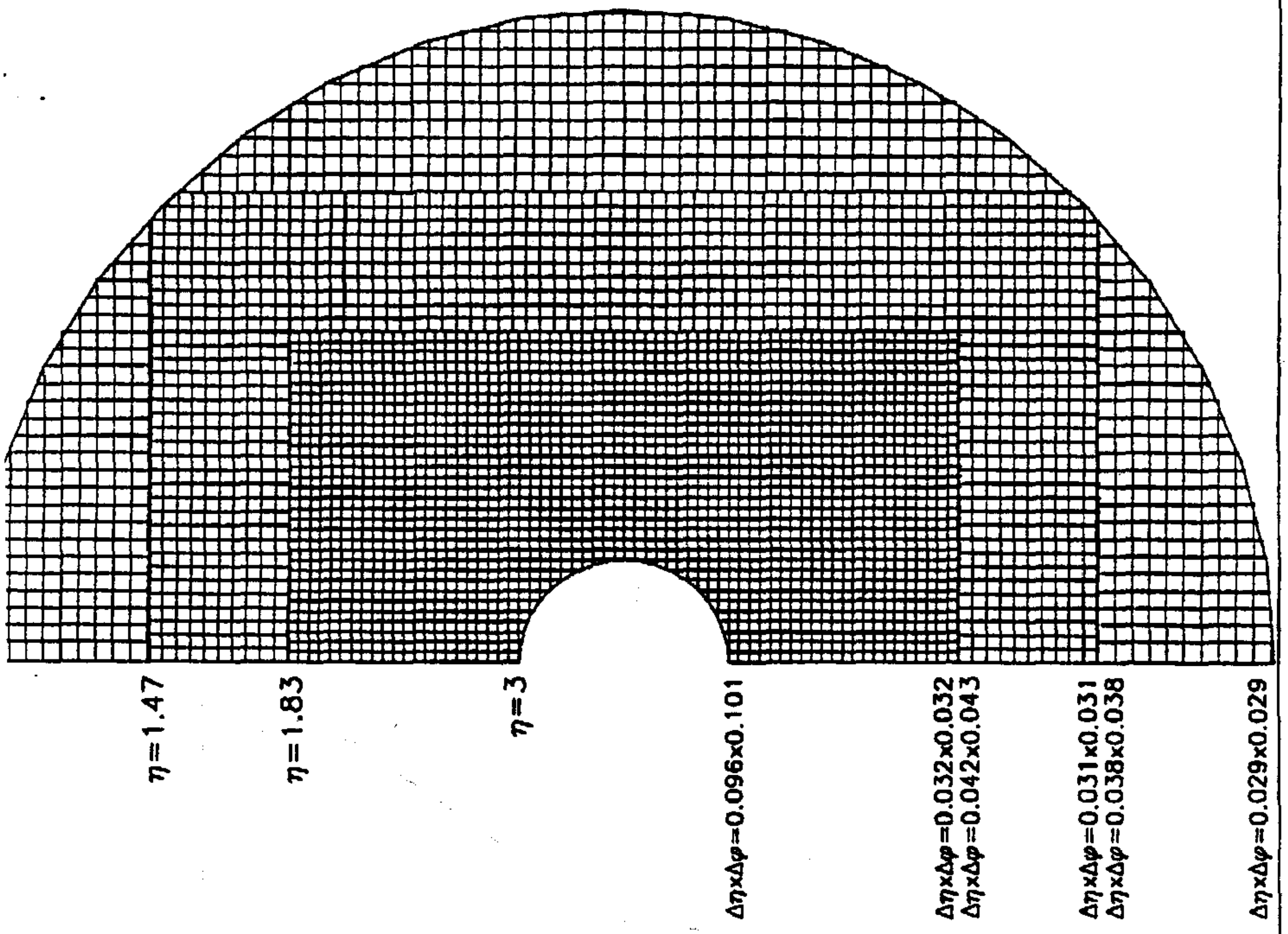
good timing measurement of clusters

(Simulations??)


GEM
EM ENDCAP
(top view)
BARREL
ACTIVE REGION
BARREL
ACTIVE REGION
36.89 deg.
27.87 deg.
19.47 deg.
-19.47 deg.
-27.87 deg.
-36.89 deg.
35.69 deg.
318.8cm
263.9cm
303.6cm
246.6cm
288.1cm
227.8cm
210.70 cm
292.20 cm
243.8cm
301.1cm
266.6cm
321.3cm
-35.67 deg.
24.1 Xo
25.79 deg.
25.2 Xo
17.78 deg.
27.0 Xo
-17.78 deg.
25.4 Xo
-25.79 deg.
24.0 Xo
5 cells/tower
towers = 8
4 cells/tower
towers = 11
3 cells/tower
towers = 34
3 cells/tower
towers = 33
4 cells/tower
towers = 11
5 cells/tower
towers = 8

VER.γ.

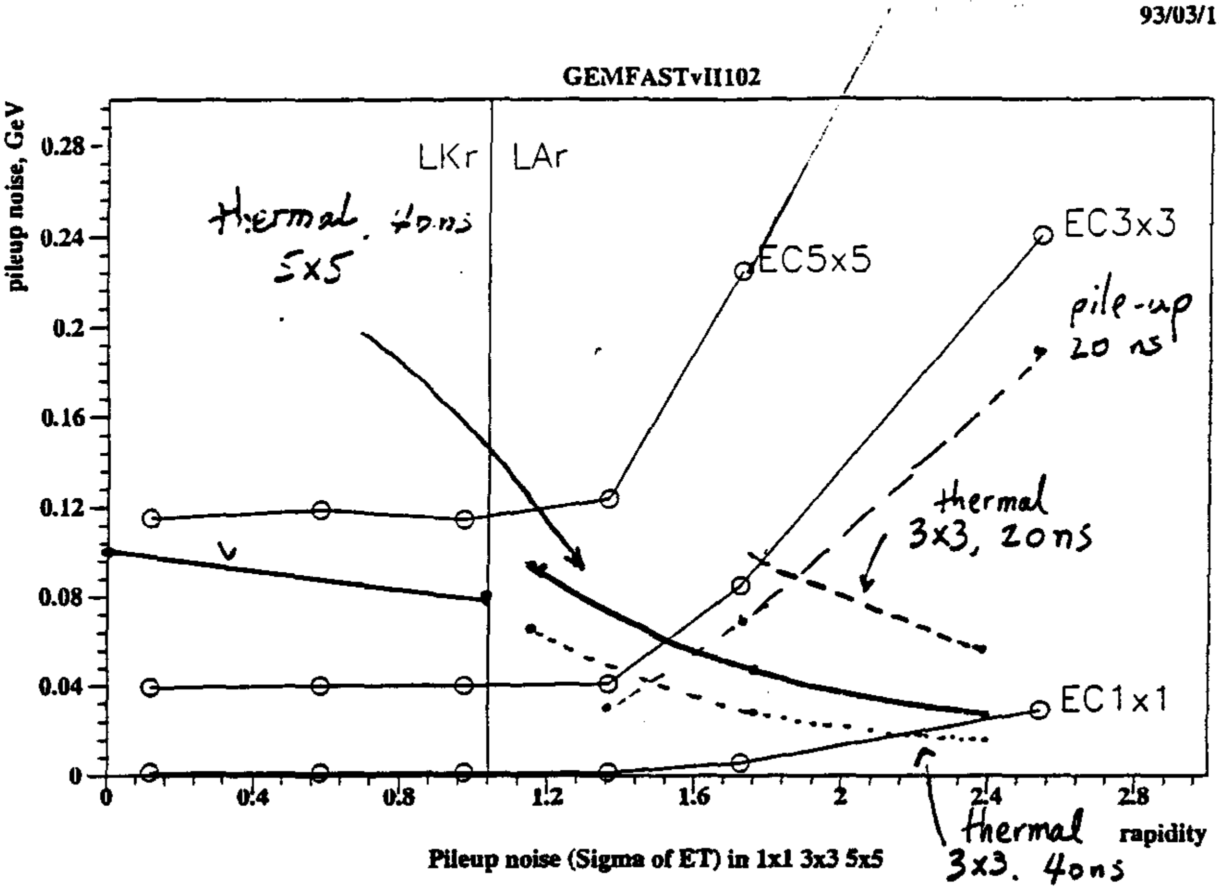
TOWERS IN GEM EM ENDCAP



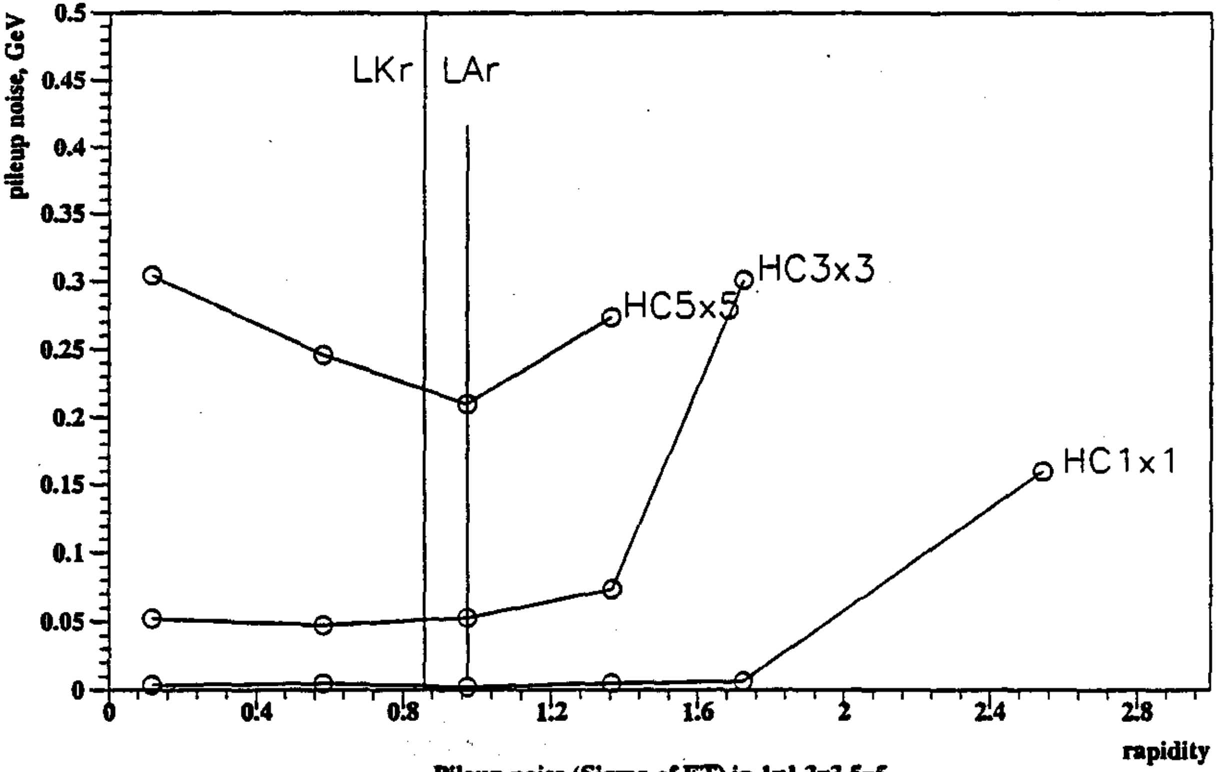
Number complete towers = 44160
Number of incomplete towers = 1128
AXIMAL NUMBER OF CHANNELS = 45288
Both endcaps with 3 long. div.)

□ 3 cells/tower
□ 4 cells/tower
□ 5 cells/tower

GEMFASTvII102



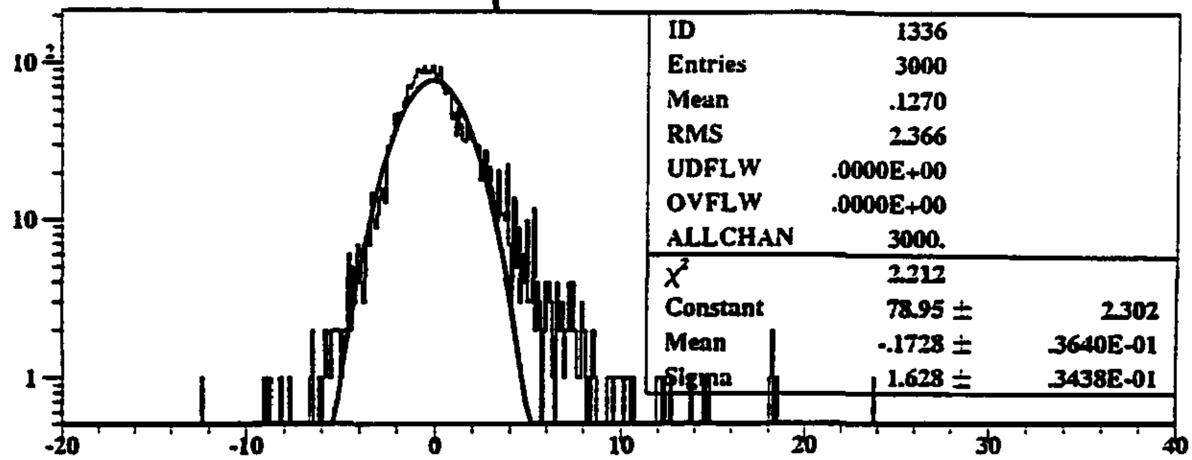
Pileup noise (Sigma of ET) in 1x1 3x3 5x5



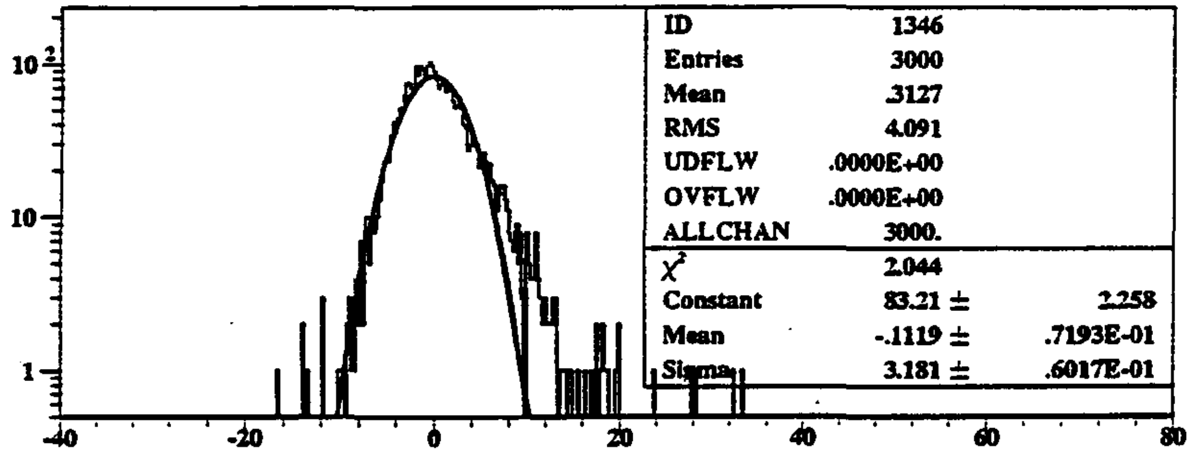
Pileup noise (Sigma of ET) in 1x1 3x3 5x5

93/03/17 14.23

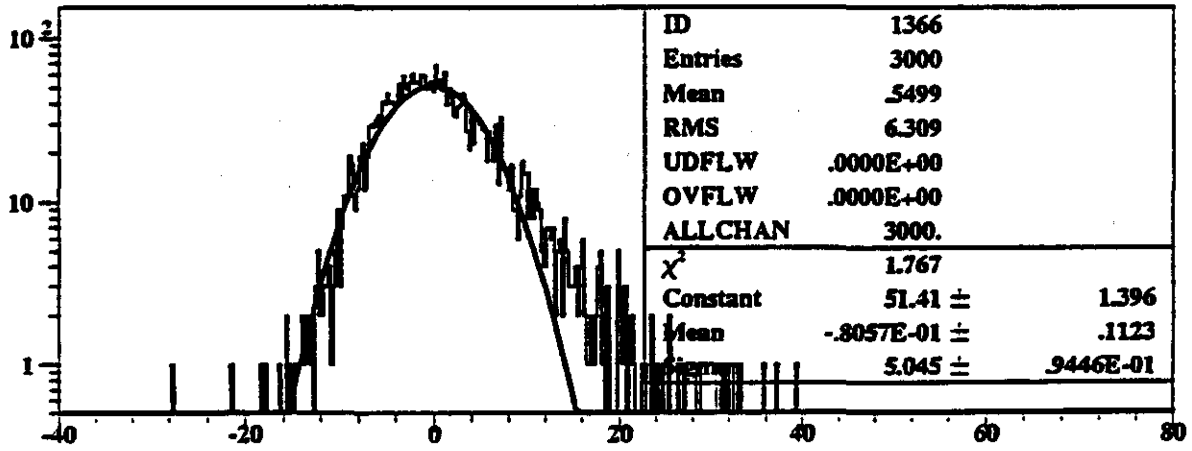
Pile-up noise in a cone



CA 0.3



CA 0.45



CA 0.6

Mar 14, 1990.

The Higgs mass resolution at 80 GeV is re-evaluated, taking into ac the tower size change in the endcap and more realistic pile-up noise. The resolution is calculated using GEMFAST, as well as parametrization of t resolution and noise. The parametrizations, in addition to what are used in GEMFAST, includes the following items:

1) The pile-up noise in 5x5 towers parameterized as
   120+366*(eta-,1.4) MeV   eta > 1.4
   and for 3x3 towers
   40+181.8*(eta-,1.4) MeV   eta > 1.4
   based on Sasha's study.

2) shaping time of 20 ns for towers above eta=1.8 is considered. The ther noise is increased by a factor of 2.83, and the pile-up noise is decreased a factor of 0.8, compared to 40 ns shaping time.

3) Resolution of 3x3 tower is assumed to be 15% worse than that of 5x5 towe

Mass resolution (MeV)	tool	eta cut	other assumptions
550	GEMFAST	2.5	two photon only, no noise
715	GEMFAST	2.5	with all noises, 5x5 towers
615	GEMFAST	1.0	"
654	GEMFAST	1.5	"
674	GEMFAST	2.0	"
540	PARAM	2.5	two photons only, no noise
713	PARAM	2.5	all noises, 5x5 tower
619	PARAM	1.0	"
641	PARAM	1.5	"
669	PARAM	2.0	"

From the above table, it is clear that by taking into account the proper pile-up noise, parameterization gives identically the same resolutio as GEMFAST. The mass resolution given by GEMFAST simulation is fully understood. Since GEMFAST lacks a reliable 3x3 tower resolution, I have to use the parameterization for the further optimization, as shown in following table.

(eta_3x3 is defined as the eta above which 3x3 towers are used,
tp is the shaping time above eta=1.8)

Mass resolution	tool	eta_3x3	tp (ns)	other assumption
713	PARAM	2.5	40	
688	PARAM	1.1	40	
677	PARAM	1.7	40	
666	PARAM	1.7	20	
657	PARAM	1.7	20	E-reso in endcap =8.0%/ and 0.4% const
647	PARAM	1.7	20	E-reso in endcap =7.5%/ and 0.4% const

noise contribution : $\sqrt{666^2-540^2} = 390$ MeV

Table 3-2

A summary of the observed efficiencies of energy isolation cuts for events arising from associated Higgs production versus the size of the isolation cone. These samples used $M_{\rm Higgs} = 80$ GeV, but studies with $M_{\rm Higgs} = 160$ GeV give identical results. An excess transverse energy of less than 10 GeV was required (this cut could be optimized for each cone size). The photons and leptons were required to have $|\eta| < 2.5$ and $p_t > 20$ GeV/c.

Particle	Radius	$W+H$ process	$t\bar{t}+H$ process
Highest p_t ℓ from W	0.2	0.99 ± 0.003	0.94 ± 0.008
	0.3	0.97 ± 0.004	0.87 ± 0.01
	0.4	0.95 ± 0.006	0.80 ± 0.01
Highest p_t ℓ from b	0.2		0.13 ± 0.02
	0.3		0.058 ± 0.013
	0.4		0.035 ± 0.010
Either γ from Higgs	0.2	0.99 ± 0.003	0.95 ± 0.007
	0.3	0.97 ± 0.004	0.90 ± 0.009
	0.4	0.96 ± 0.005	0.82 ± 0.01
Isolation on all lepton/photons	0.2	0.97 ± 0.004	0.86 ± 0.01
	0.3	0.93 ± 0.006	0.73 ± 0.01
	0.4	0.89 ± 0.01	0.58 ± 0.02

Table 3-3

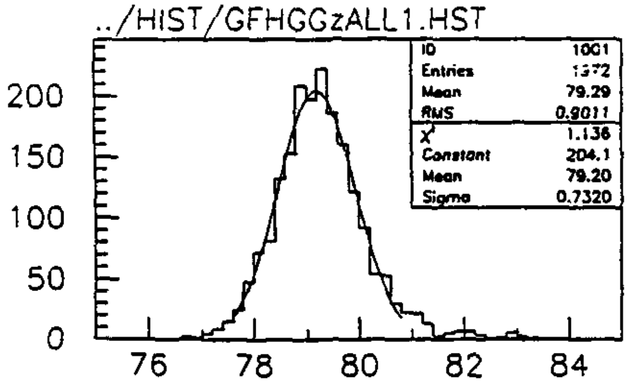
Two photon invariant mass resolutions in GeV for events from the $t\bar{t}+H$ process. The entries in the table are the sigma of a Gaussian fit to the signal (in GeV). The simulation was done at the particle level using parametrized resolutions, where "Base" refers to the terms given in Table 3-1. The final columns summarize the resolution expected for the high performance option defined in Section 3.1.1.

$M_{\rm Higgs}$	a = Base $b = 0\%$	a = Base b = Base	a = Base $b = 2\%$	$10\%/\sqrt{E}$	$a = 9\%/14\%$ $b = 0.5\%$	$a = 9\%/14\%$ b = Base
80	1.08	1.23	1.56	0.67	0.80	0.93
100	1.24	1.44	1.89	0.78	0.93	1.11
120	1.39	1.65	2.19	0.87	1.05	1.28
140	1.52	1.81	2.51	0.96	1.16	1.44
160	1.64	2.00	2.81	1.03	1.25	1.61

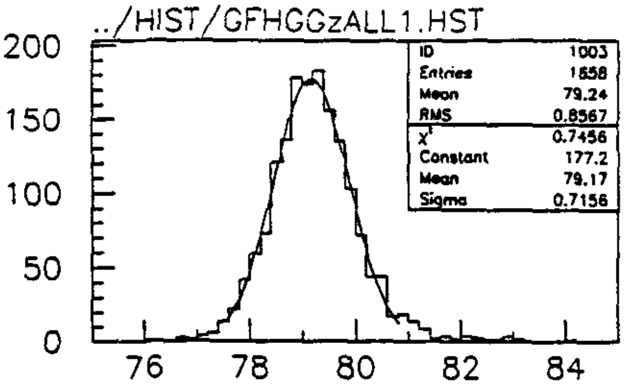
pile-up contribution = 0.4 GeV

of 1.1 GeV for the SDC baseline calorimeter to about 1.2 GeV. Third, the resolution is not a strong function of HAC1 segmentation, even at elevated luminosities of 5×10^{33} cm^{-2}s^{-1} (the mean value of the true minus observed mass changes by less than 250 MeV and the resolution deteriorates by less than 5% for a HAC1 segmentation of 0.2). Finally, the resolution is a strong function of EM segmentation, and $\Delta\eta \times \Delta\phi$ of 0.1 is the coarsest segmentation which gives acceptable performance (the mean value of the true minus observed mass shifts by 800 MeV and resolution deteriorates by 20% at five times de luminosity). Figure 3-10 indicates that even for segmentation, the mass resolution is developi nonGaussian tail at higher luminosity. These stu support the SDC baseline choice of 0.05 EM seg tation, and indicate that the performance of su calorimeter is adequate for precision mass mea ments well beyond the SSC design luminosity.

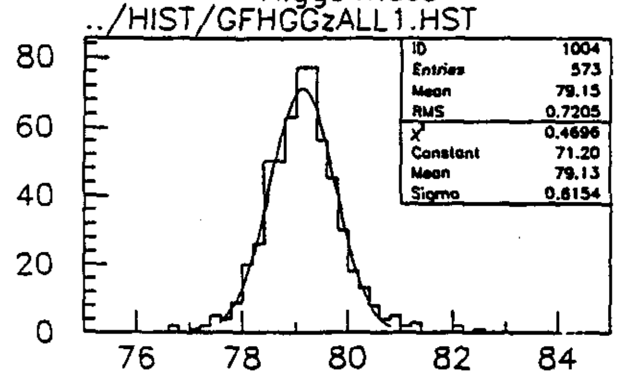
93/03/12 11.09



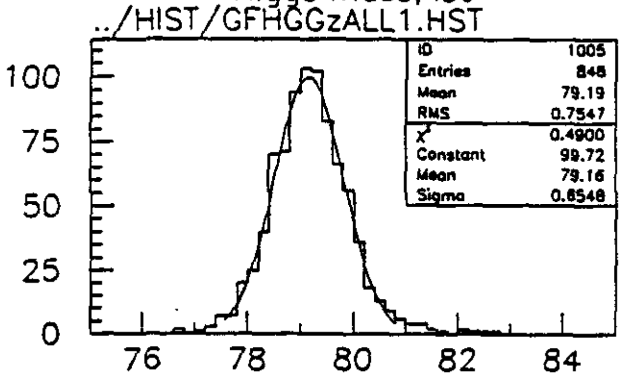
Higgs mass



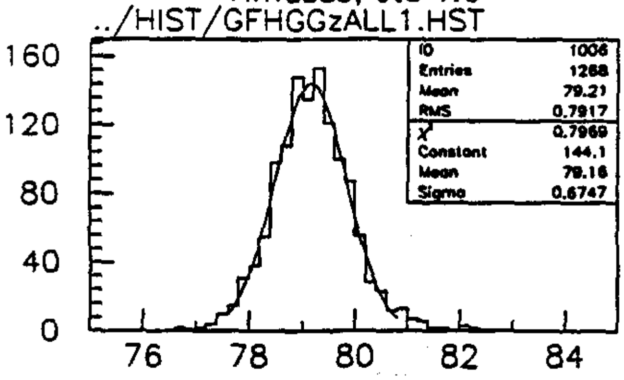
Higgs mass, iso



Hmasss, eta 1.0

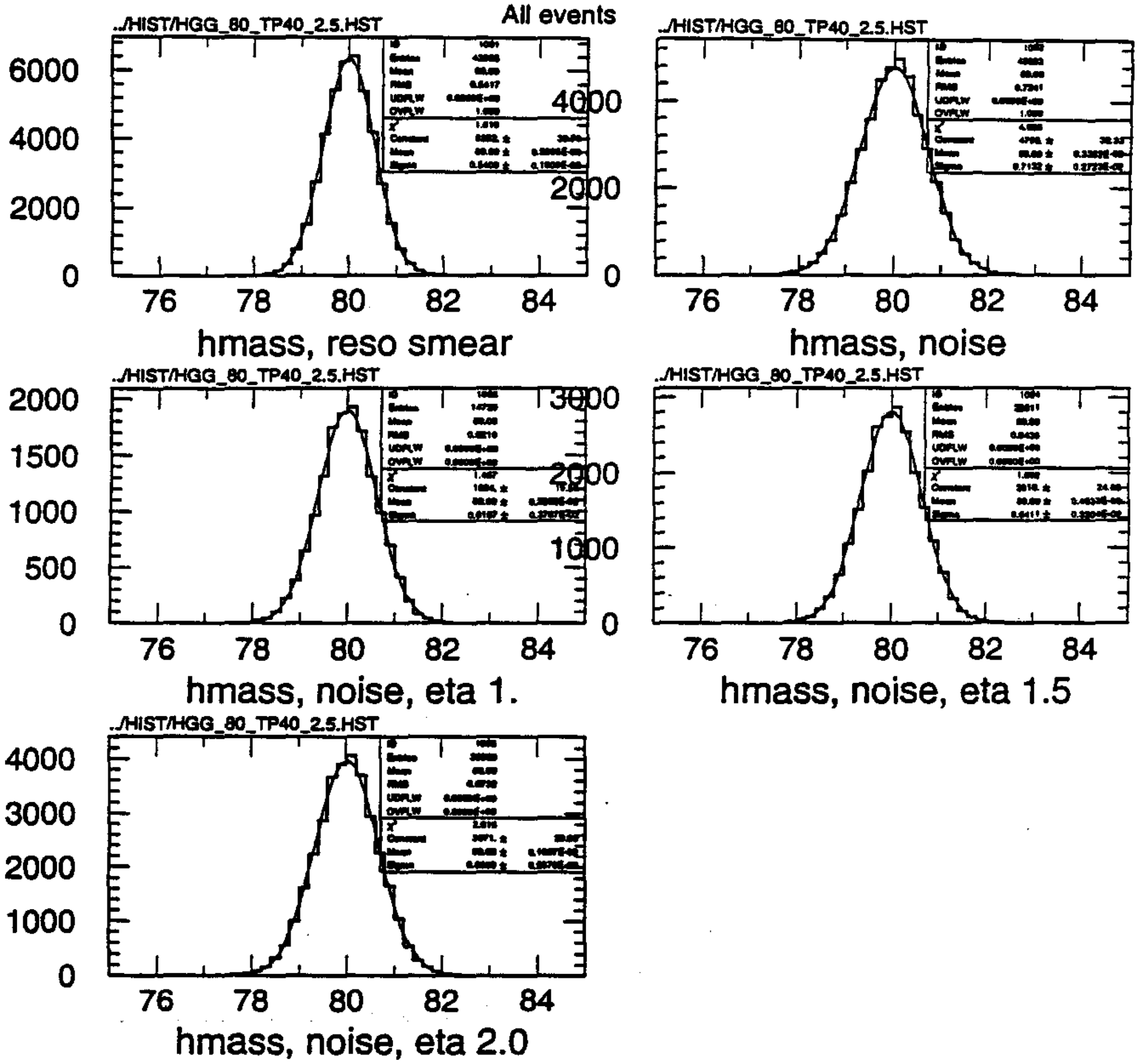


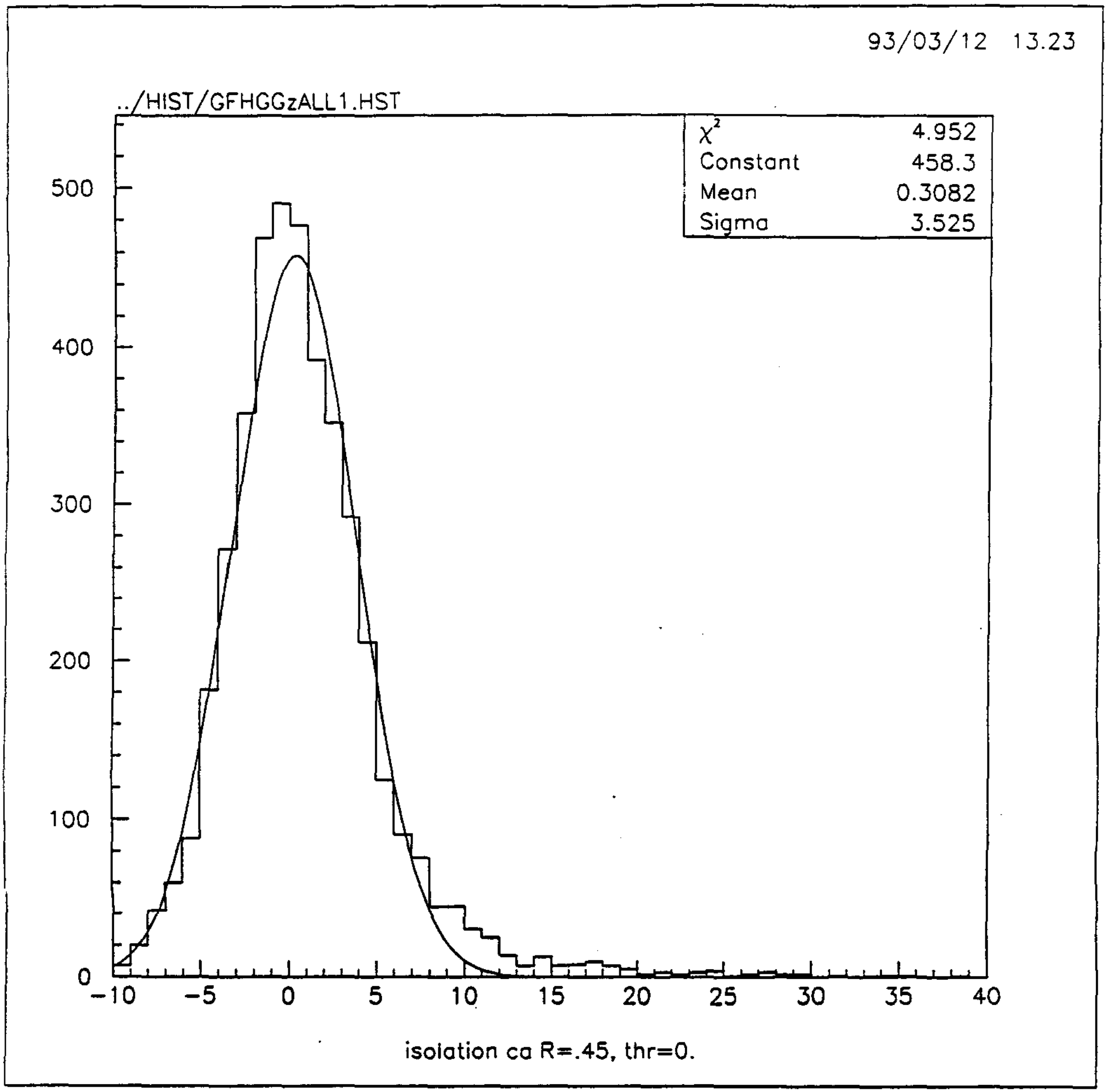
Hmasss, eta 1.5

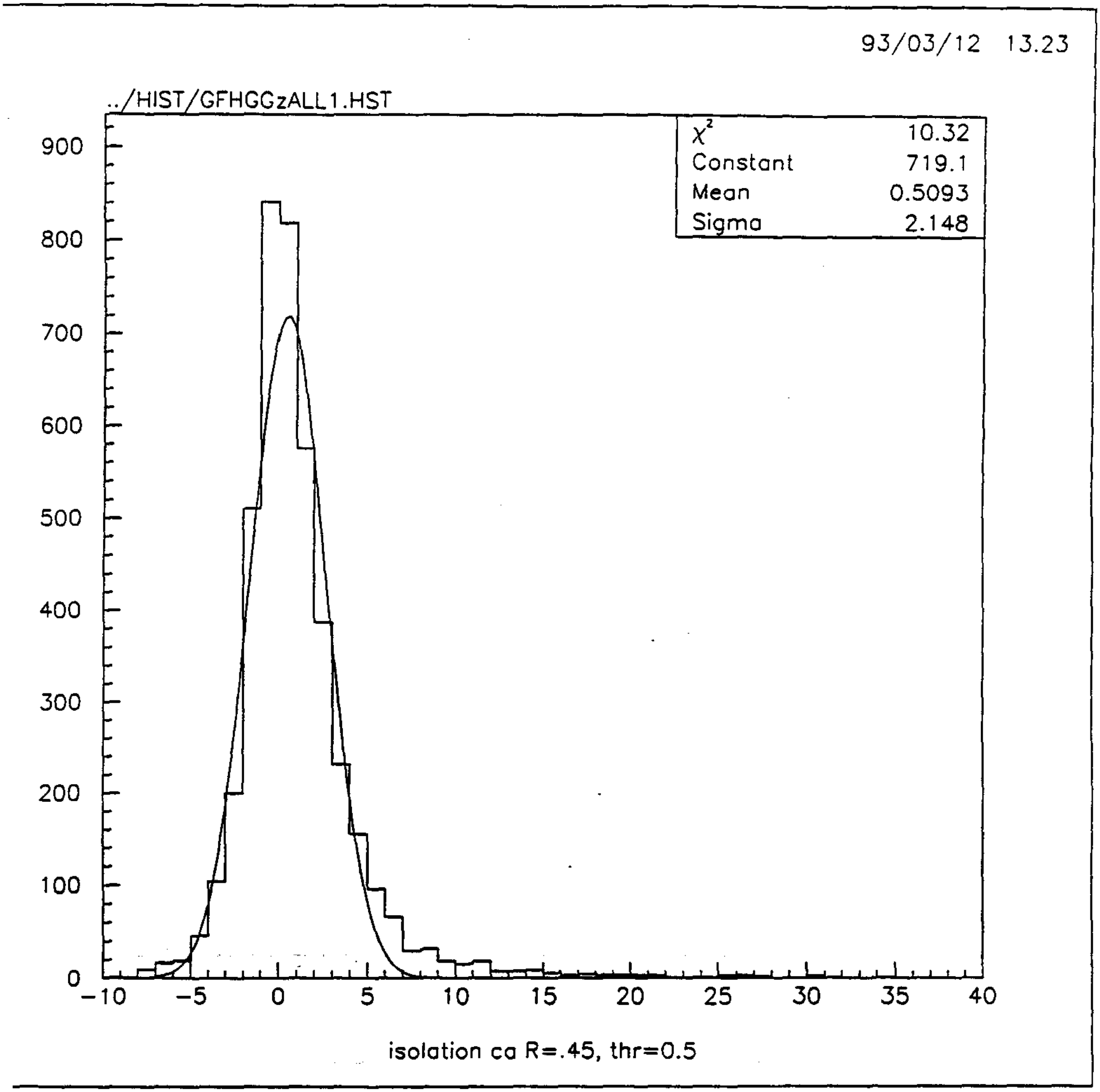


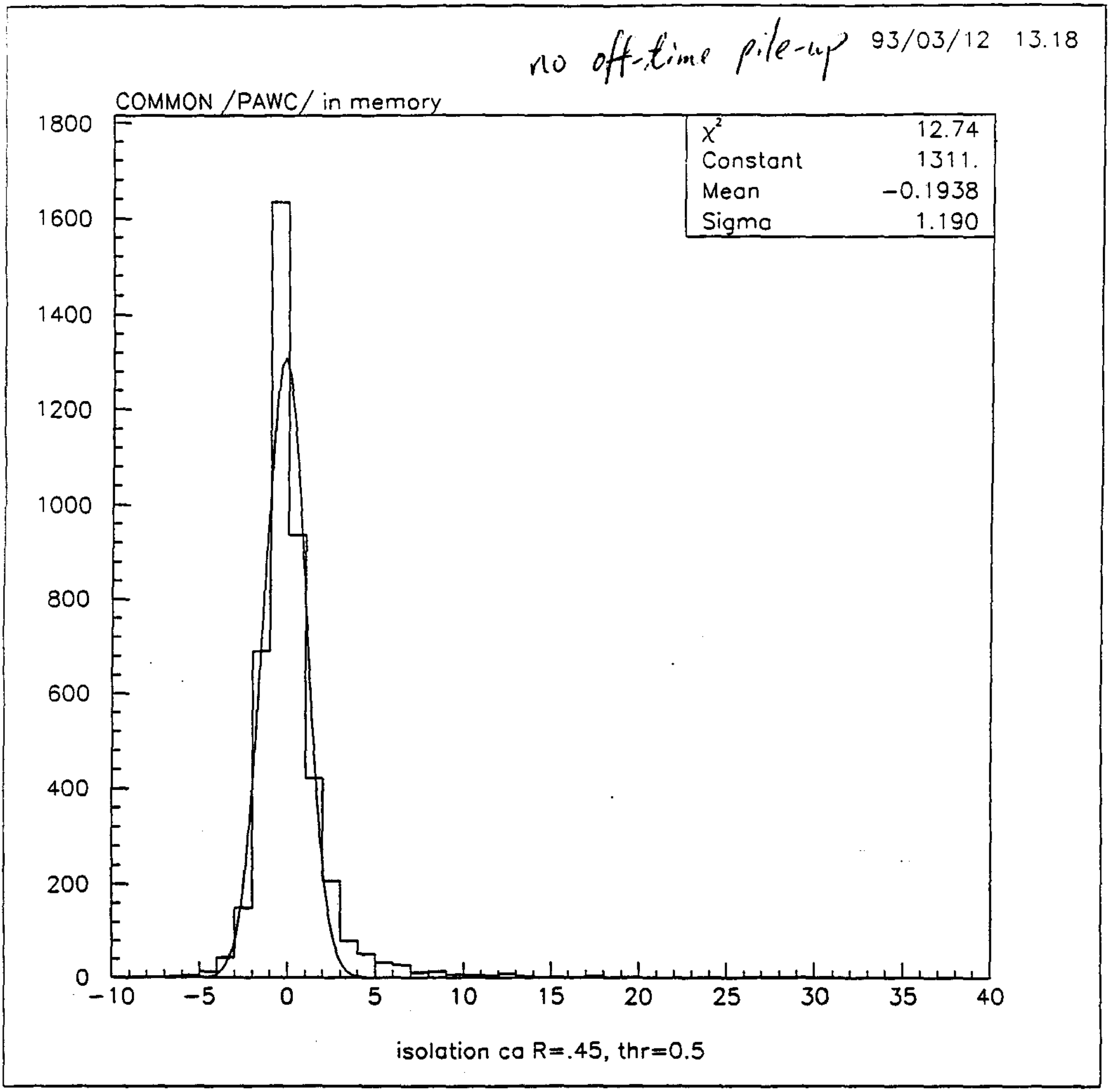
Hmasss, eta 2.0

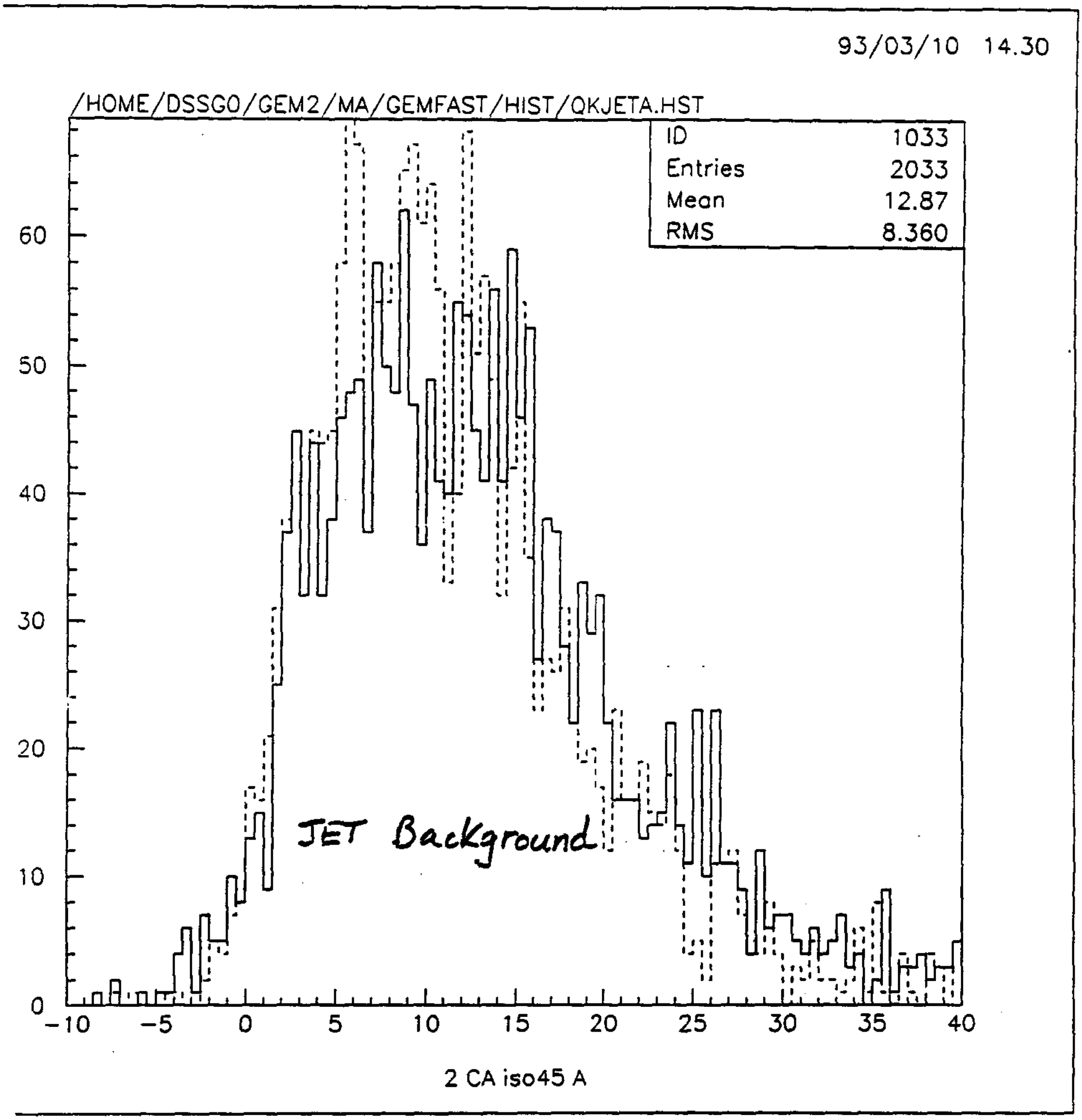
93/03/12 12.51


../HIST/HGG_80_TP40_2.5.HST
All events
../HIST/HGG_80_TP40_2.5.HST
6000
4000
2000
0
4000
2000
0
76
78
80
82
84
76
78
80
82
84
hmass, reso smear
hmass, noise
../HIST/HGG_80_TP40_2.5.HST
../HIST/HGG_80_TP40_2.5.HST
2000
1500
1000
500
0
3000
2000
1000
0
76
78
80
82
84
76
78
80
82
84
hmass, noise, eta 1.
hmass, noise, eta 1.5
../HIST/HGG_80_TP40_2.5.HST
4000
3000
2000
1000
0
76
78
80
82
84
hmass, noise, eta 2.0


93/03/12 13.23
../HIST/GFHGGzALL1.HST
χ^2 4.952
Constant 458.3
Mean 0.3082
Sigma 3.525
0
100
200
300
400
500
−10
−5
0
5
10
15
20
25
30
35
40
isolation ca R=.45, thr=0.


93/03/12 13.23
../HIST/GFHGGzALL1.HST
χ^2 10.32
Constant 719.1
Mean 0.5093
Sigma 2.148
900
800
700
600
500
400
300
200
100
0
−10
−5
0
5
10
15
20
25
30
35
40
isolation ca R=.45, thr=0.5


no off-time pile-up
93/03/12 13.18
COMMON /PAWC/ in memory
χ^2 12.74
Constant 1311.
Mean −0.1938
Sigma 1.190
1800
1600
1400
1200
1000
800
600
400
200
0
−10
−5
0
5
10
15
20
25
30
35
40
isolation ca R=.45, thr=0.5


93/03/10 14.30
/HOME/DSSG0/GEM2/MA/GEMFAST/HIST/QKJETA.HST
ID 1033
Entries 2033
Mean 12.87
RMS 8.360
0
10
20
30
40
50
60
−10
−5
0
5
10
15
20
25
30
35
40
2 CA iso45 A
JET Background

JET Background

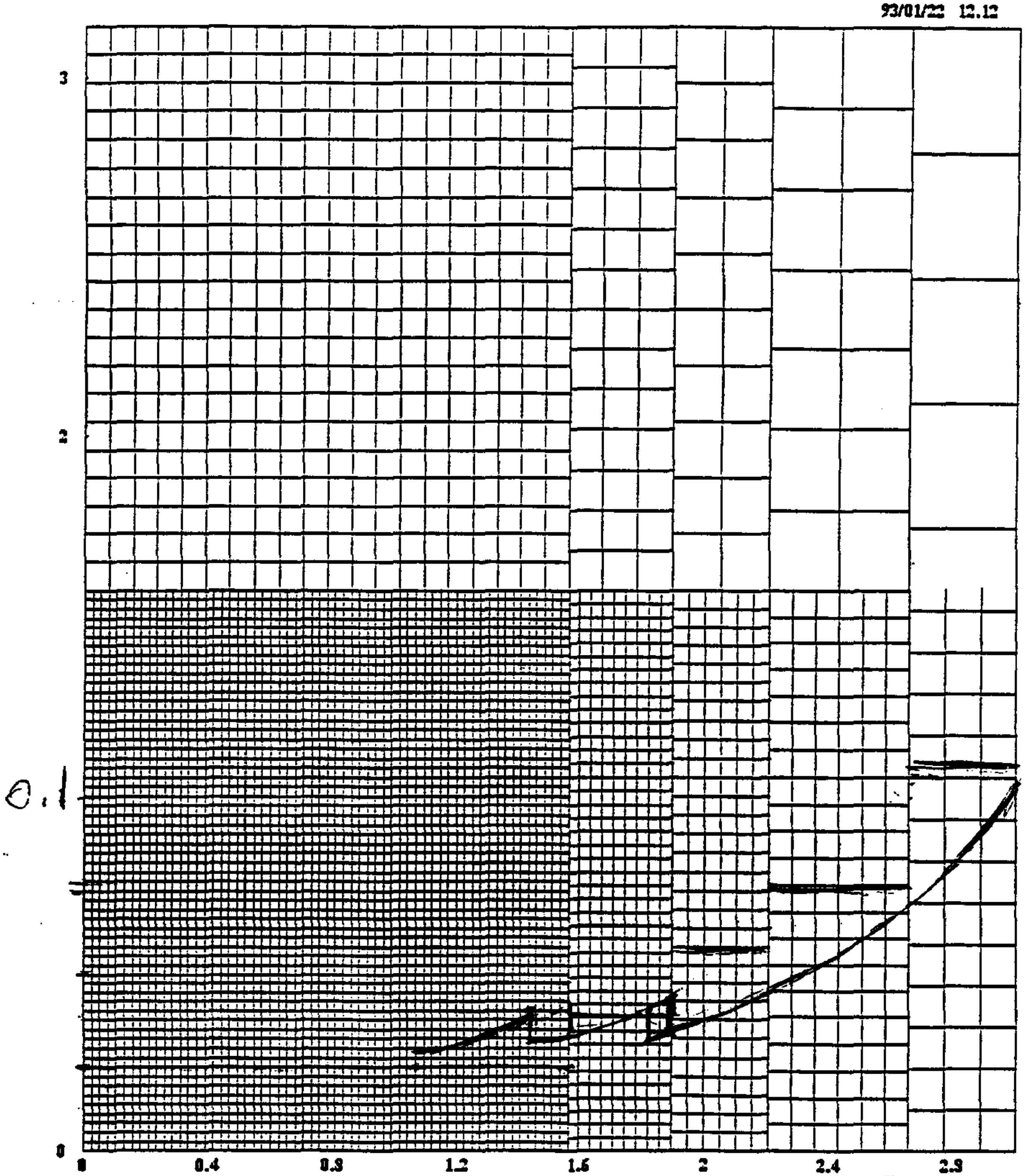
γ-quark final state

		Rejection
total Cross section (70-150 GeV)	1.325×10^{-4} mb	0.24
detector jet acceptance ($20\,\mathrm{GeV}\,E_T$, $\vert\eta\vert < 2.5$)	0.32×10^{-4} mb	
isolation	126.9 pb	
photon ID	17 pb	5×10^{-4}
$\frac{d\sigma}{dE}$ at 80 GeV	0.4 pb/GeV	

γ-gluon final state

		rejection
total cross section	9.7×10^{-6} mb	0.134
detector jet acceptance	1.3×10^{-6} mb	
isolation	2 pb	
photon ID	0.47 pb	3×10^{-4}
$\frac{d\sigma}{dE}$ at 80 GeV	0.007 pb/GeV	

[illegible]



Δη = [illegible] [illegible] [illegible] [illegible] [illegible]

gem

γeμ

Presentation by:

Rob Carey

Rob Carey BU

Compositeness Search

Inclusive Jet P_t spectrum

1) Signal Region

$P_t > 4500$ GeV

$|\eta| < 1$

2) EHLQ - inspired criterion for discovery

An excess of 100 or more jets in a kinematic regime where the expected signal is twice as large as the no compositeness "background"

CTEQ The reigning champion and choice of a new generation

\# jets above a given P_t cut for various λ (TeV)

λ (TeV) \ P_t	4500	5000	5500	6000 GeV
∞	760	347	164	75
30	967	505	290	171 almost
25	1460	790 definitely	432	243

EHLQ1: the Jimmy Connors of the structure Function set (obnoxious sentimental favorite)

λ (TeV) \ P_t	4500	5000	5500	6000 GeV
∞	918	275	113	63
30	1096	549	279	162
25	1492	790	441	259
15				

Morfin Tung II

λ (TeV)	4500	5000	5500	6000 GeV
∞	755	337	160	79
30	978	523	282	162 not quite
25	1393	838	516	315
15				

Remaining Work

1) A few more structure functions, at least the most promising ones

2) Model for residual jet non-linearities

   ⟹ May limit λ reach

   ⟹ Easy to implement

   ⟹ Hard to choose

3) Latest version of GEMFAST

   a) For jet correction
   b) For compositeness

1. Jets in General

A. Jet correction function

fsi_jetcor($\vec{P}^4_{in}$, R_{jet}, Freq of MinBias, $\vec{P}^4_{out}$, ⚑

Inputs: Input raw momentum fourvector

Clustering Cone

Frequency of Min Bias Overlap Events

Flag: 1) Do all corrections

- -1) Do only underlying event correction
- 2) Do only energy rescaling

Output: Corrected Jet 4-vector, pointing in the same direction as raw jet

B. fsi_cluhep (NJET)

⇒ LUCELL on HEPEVT

Jet P_t Response vs η
for various R_{jet} (100 GeV)