H. Hoffmann

25/5 Hd.

GEM Calorimeter

Hadron/Jet Performance

PAC Review

SSCL, May 25, 1993

Yu. Kamyshkov ORNL/ITEP

GEM LoI '91

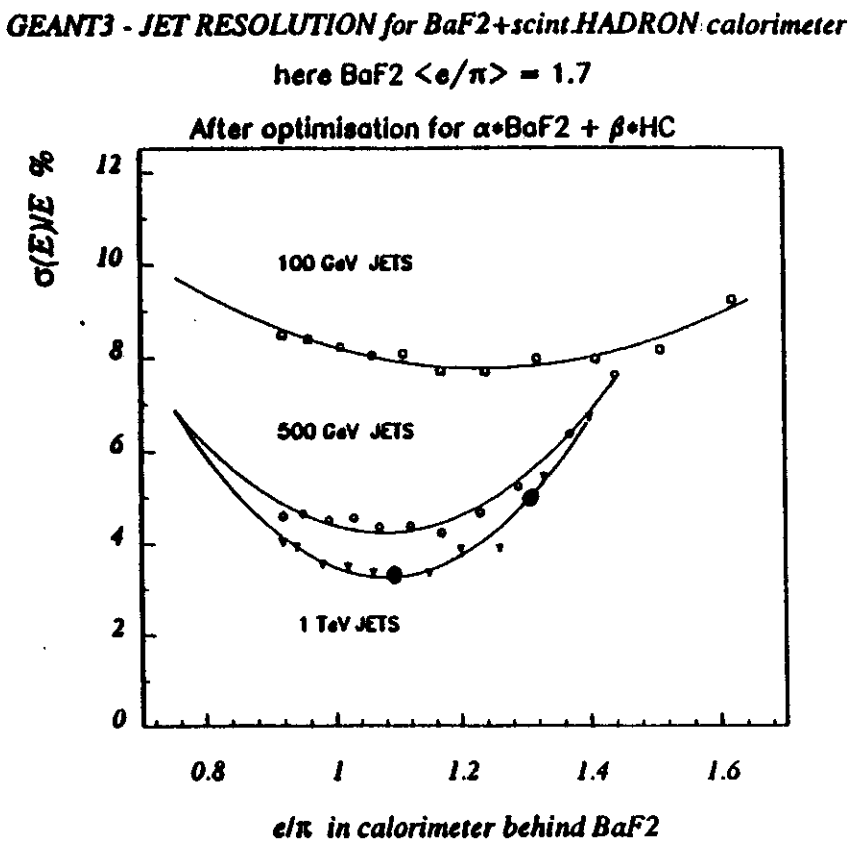


Figure 2.4-6 Dependence of the Energy Resolution on the <e/π> Ratio in the Scintillator Hadron Calorimeter Behind the BaF_2 EM Section

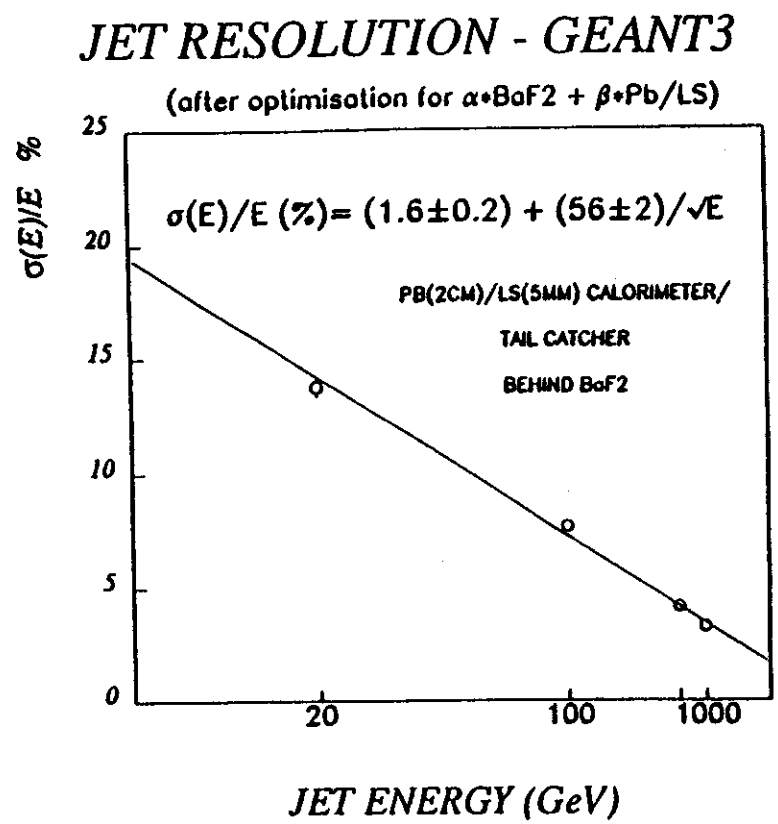


Figure 2.4-5 Jet Energy Resolution for the GEM BaF_2 and Scintillating Fiber Hadron Calorimeter System (20-1000 GeV)

SDC Performance

CALORIMETRY

Barrel ($|\eta| < 1.4$)

EM (γ/e)	$\sigma(Et)/Et = 0.15/\sqrt{Et} \oplus 0.01$
HAD (jets)	$\sigma(Et)/Et = 0.56/\sqrt{Et} \oplus 0.02$

Endcap ($1.4 < |\eta| < 3$)

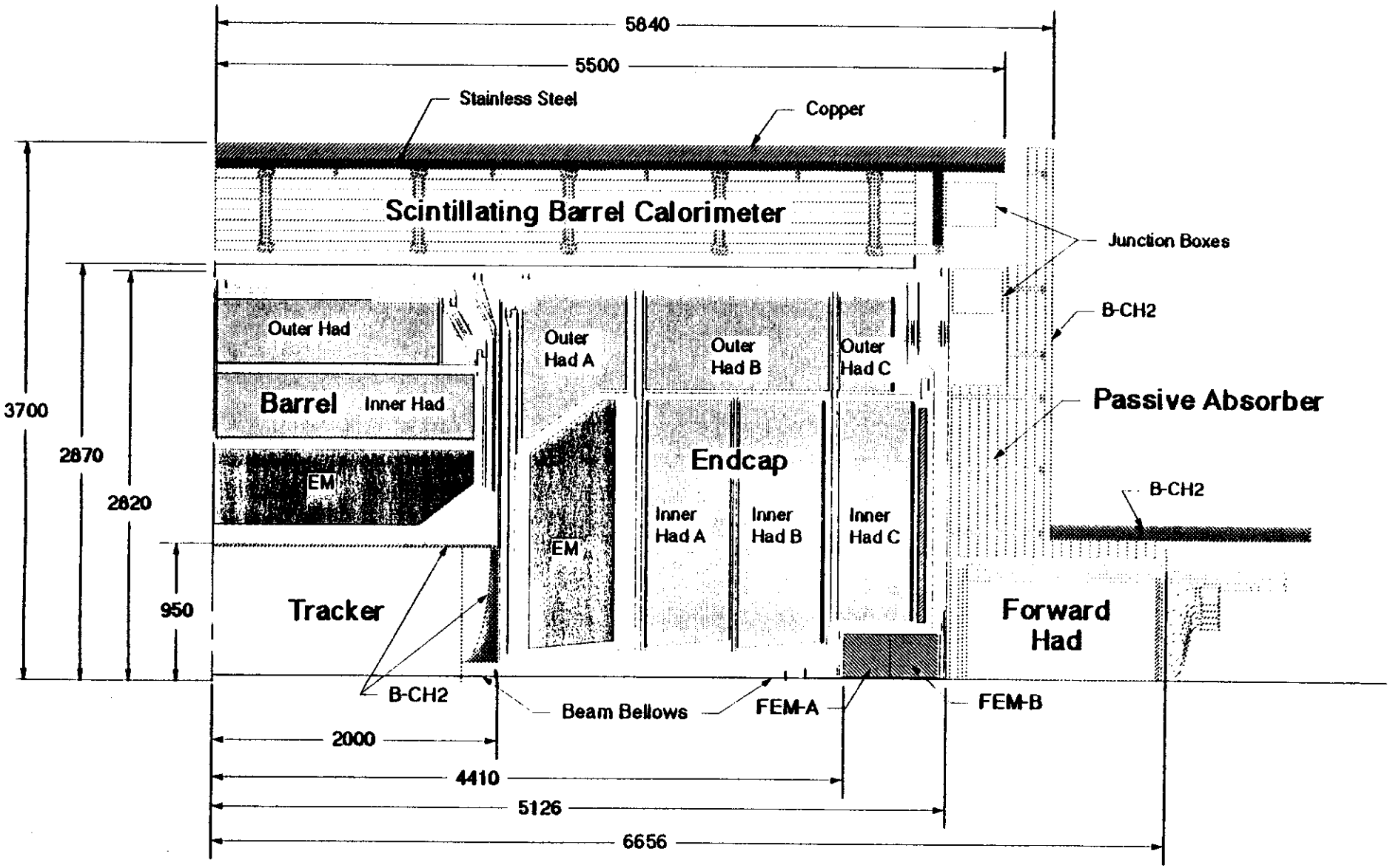
EM (γ/e)	$\sigma(E)/E = 0.18/\sqrt{E} \oplus 0.01$
HAD (jets)	$\sigma(E)/E = 0.74/\sqrt{E} \oplus 0.02$

Forward ($3 < |\eta| < 5$)

HAD (jets)	$\sigma(E)/E = \sim 1/\sqrt{E} \oplus 0.08$

Noble Liquid Calorimeter Overview

All dimensions are in mm.



Barnstable: Overview:930426
3/16/93BarStl. Cold Cu/Warm.Cu
3/16/93NdcpStl. Cold

$e/\pi \neq 1$

but

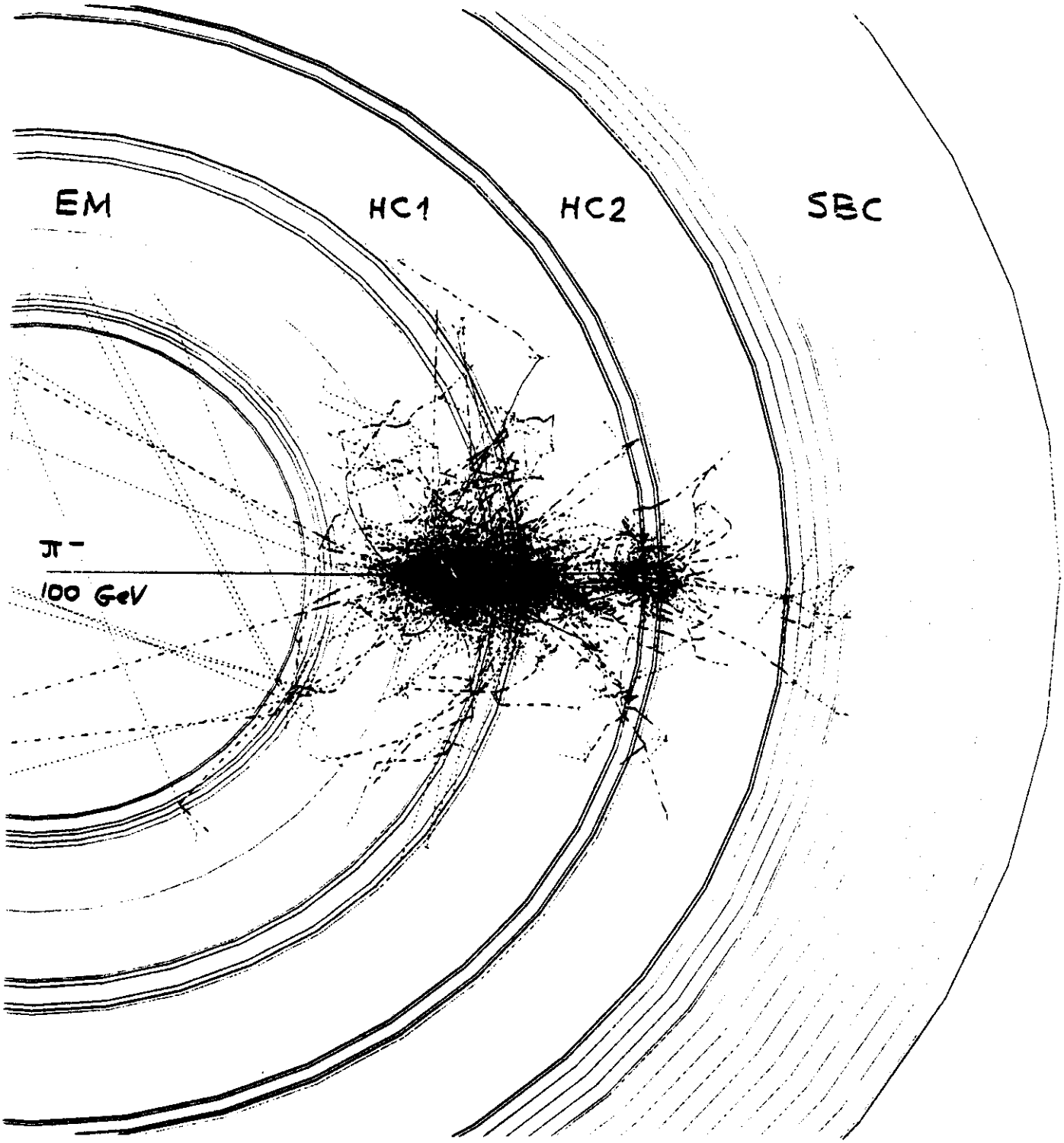
1) Longitudinal segmentation improves resolution;

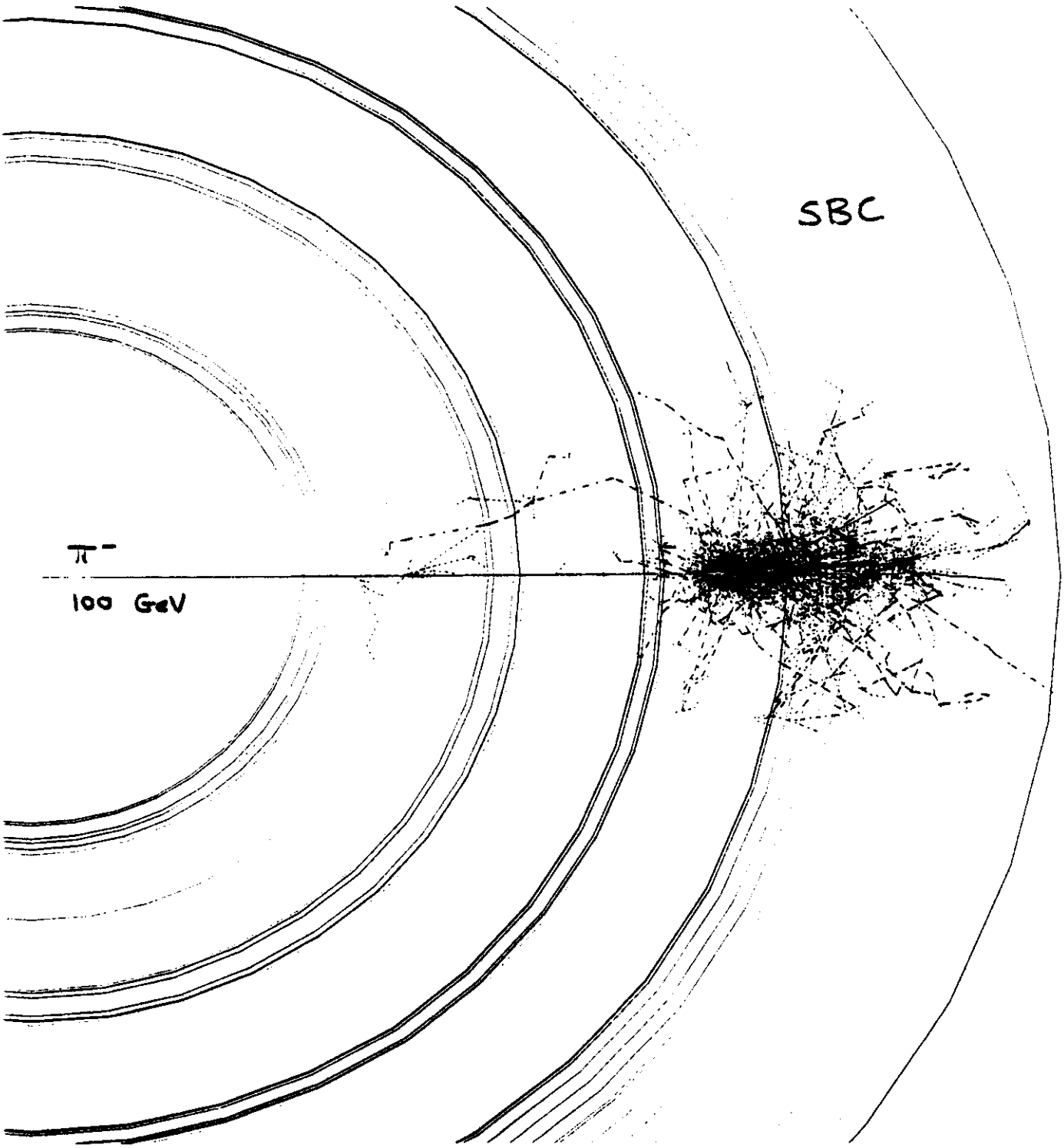
2) Jet resolution is better than hadron resolution

Other decision issues :

1. Separation Liquid/Scintillator
2. Longitudinal segmentation
3. SRC instrumentation level
4. Resolution vs. (?)
5. [illegible]
6. [illegible]
   [illegible] segmentation [illegible]
7. Total absorbtion thickness

More optimization is due


EM
HC1
HC2
SBC
π −
100 GeV


SBC
π⁻
100 GeV

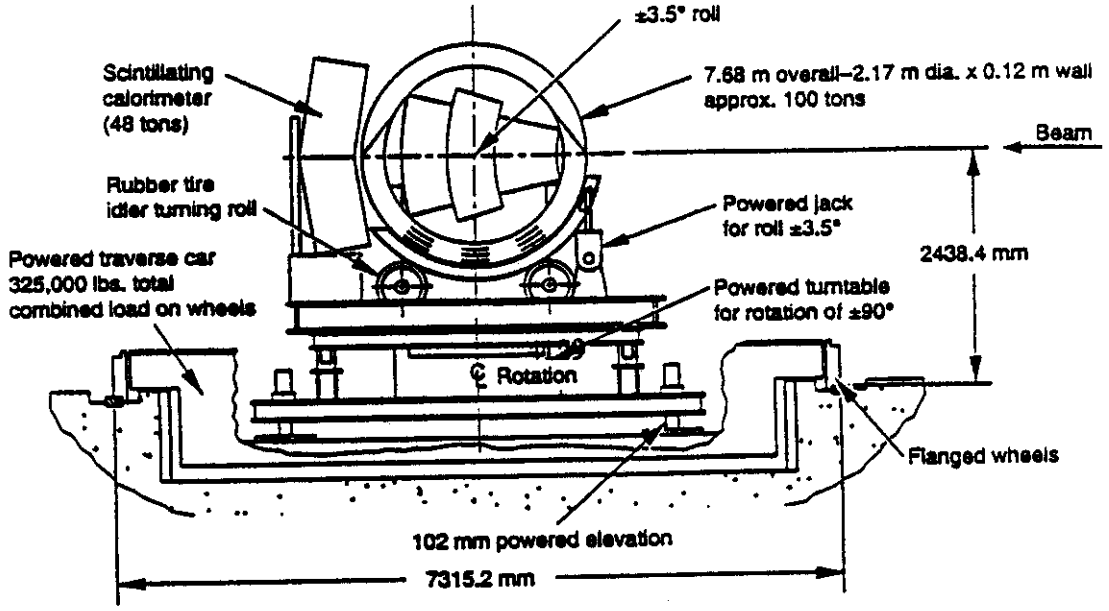


FIG. 5-51. GEM Test Beam Cryostat transporter.

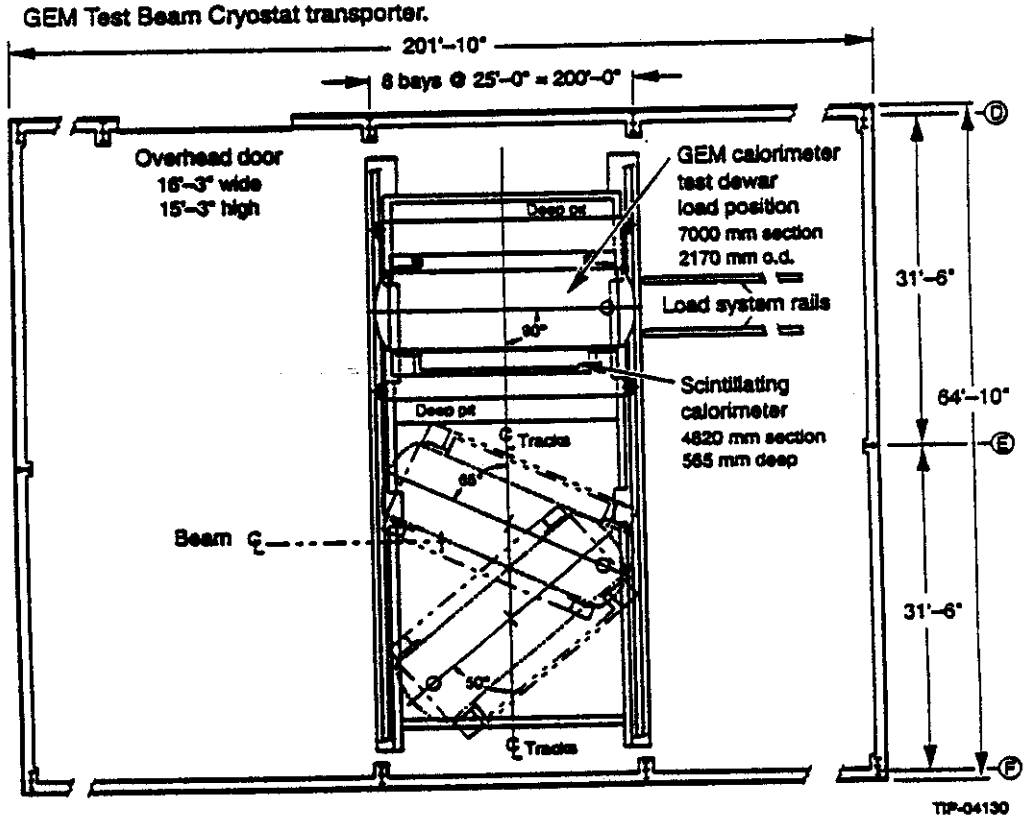
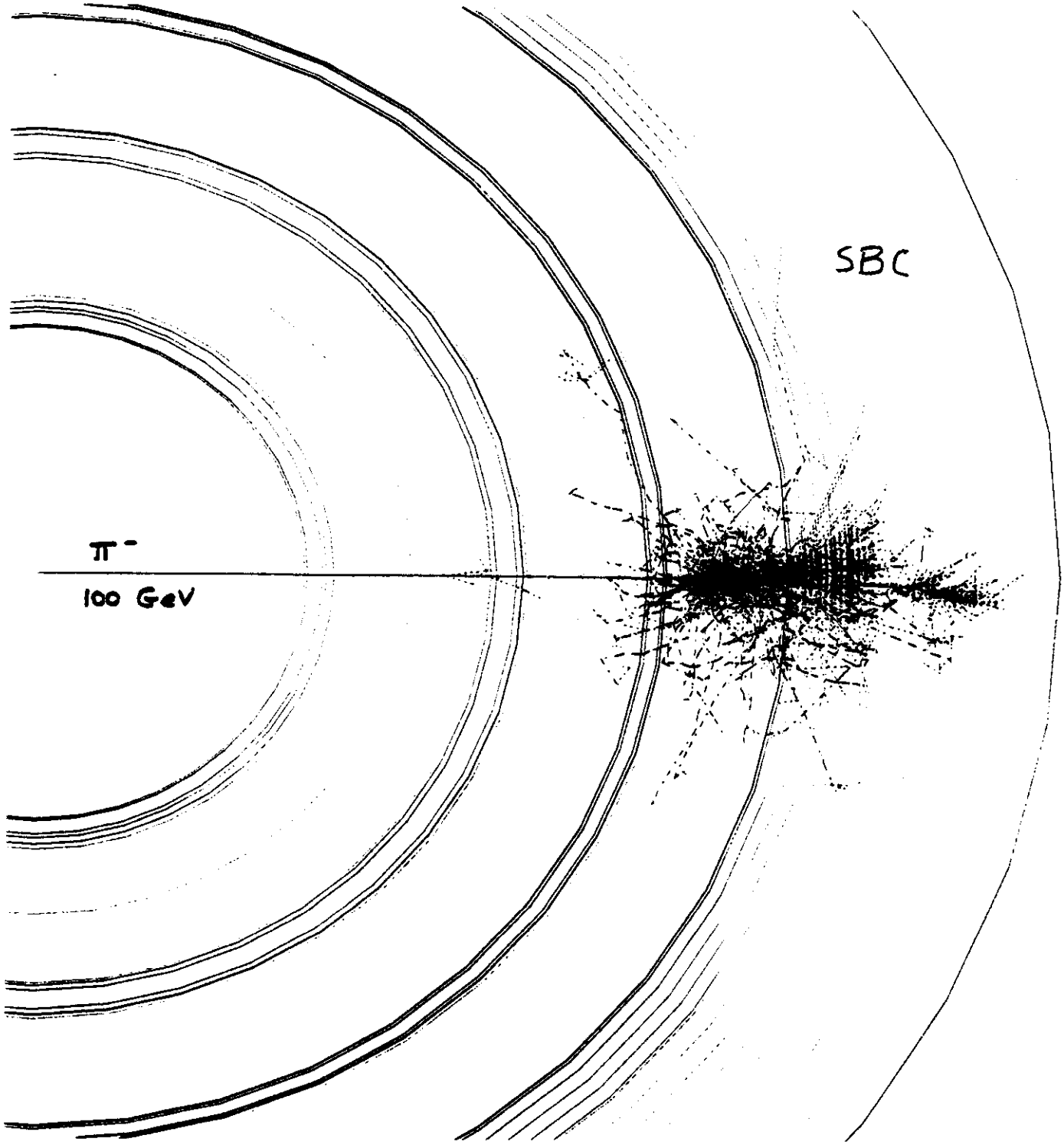
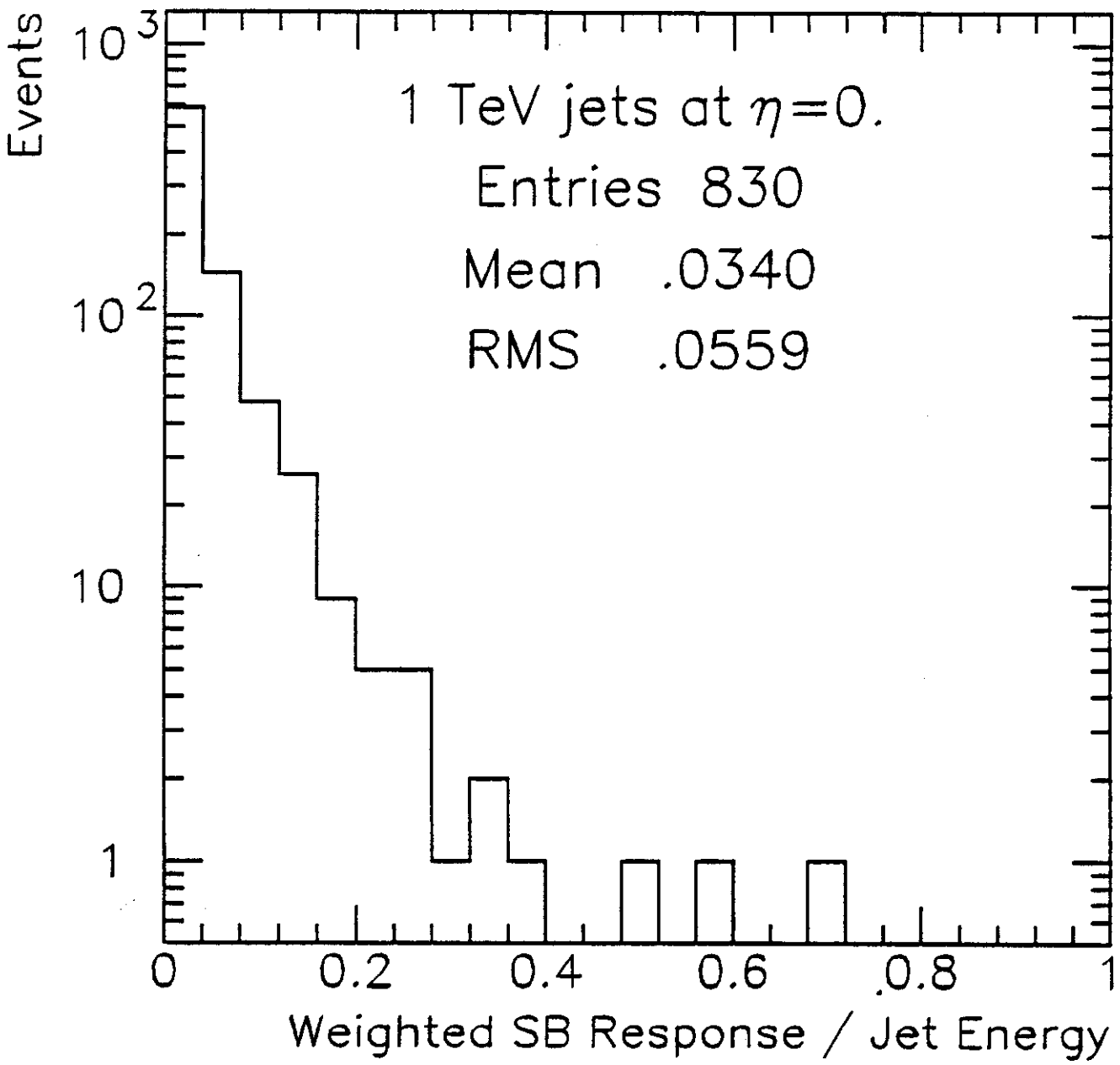


FIG. 5-52. GEM Test Beam Facility in FNAL's MWEST Hall.


SBC
π⁻
100 GeV


1 TeV jets at η=0.
Entries 830
Mean .0340
RMS .0559
Events
10^3
10^2
10
1
0
0.2
0.4
0.6
0.8
1
Weighted SB Response / Jet Energy

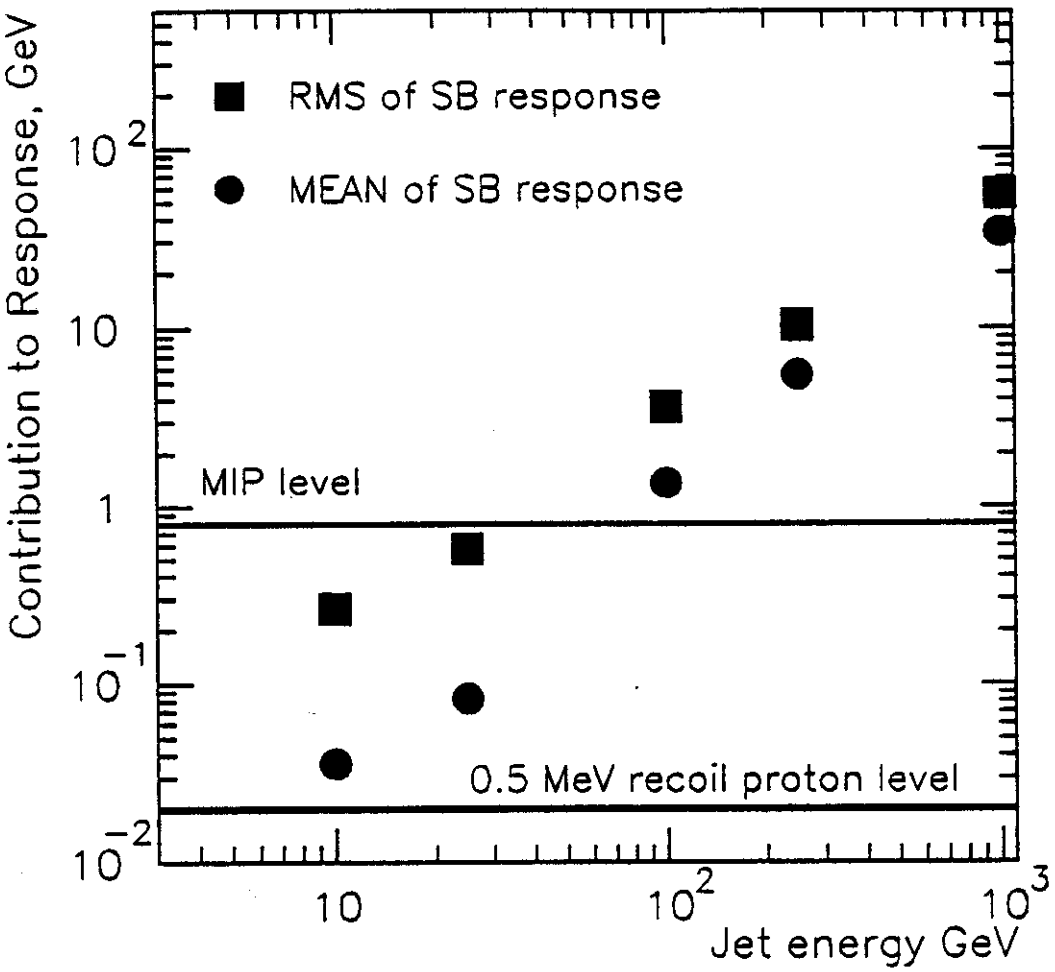
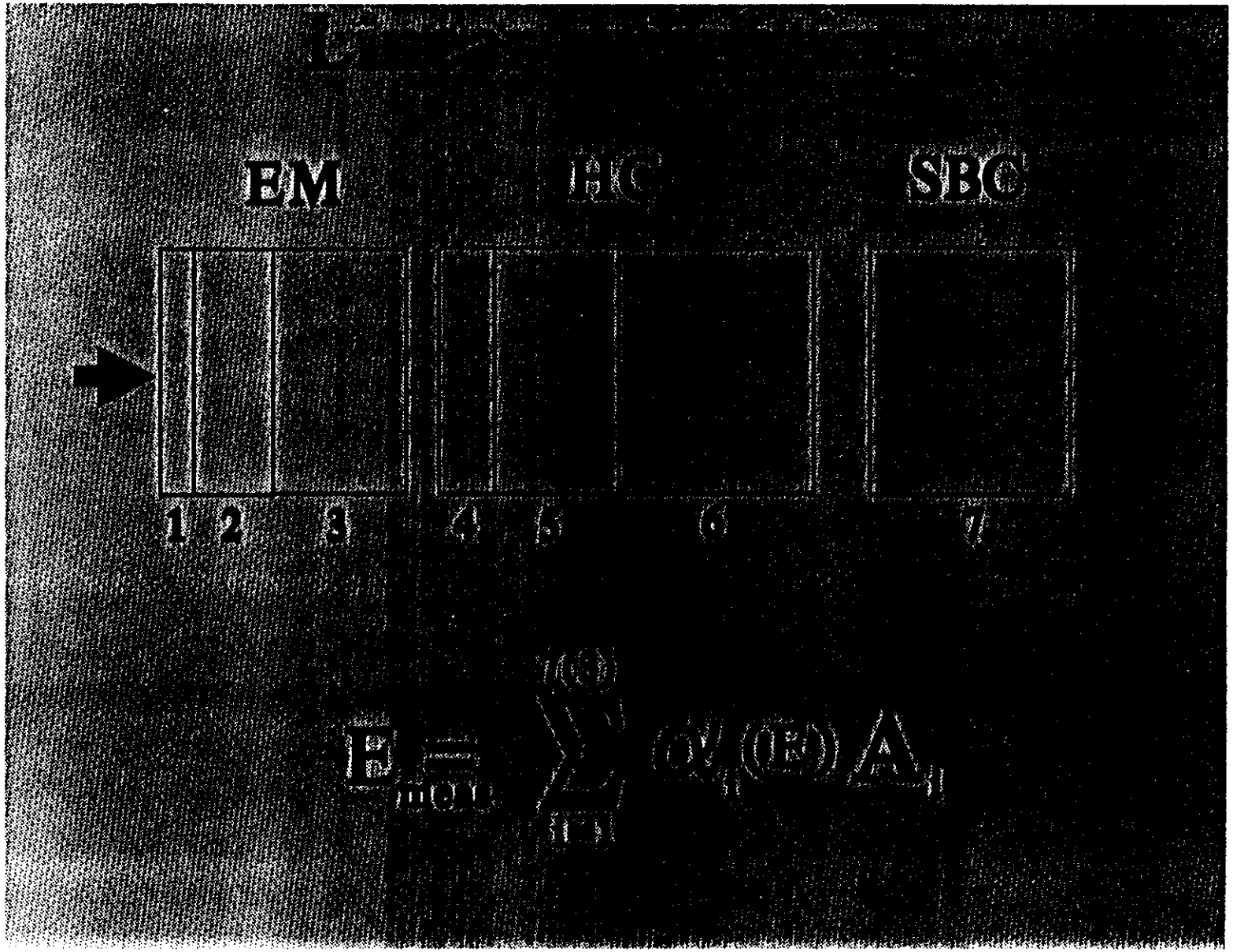


Figure 10: ***SBC response (MEAN and RMS) vs Jet energy. MIP and 'neutron' levels are shown.***


EM
EIC
SBC
1
2
3
4
5
6
7

Jets

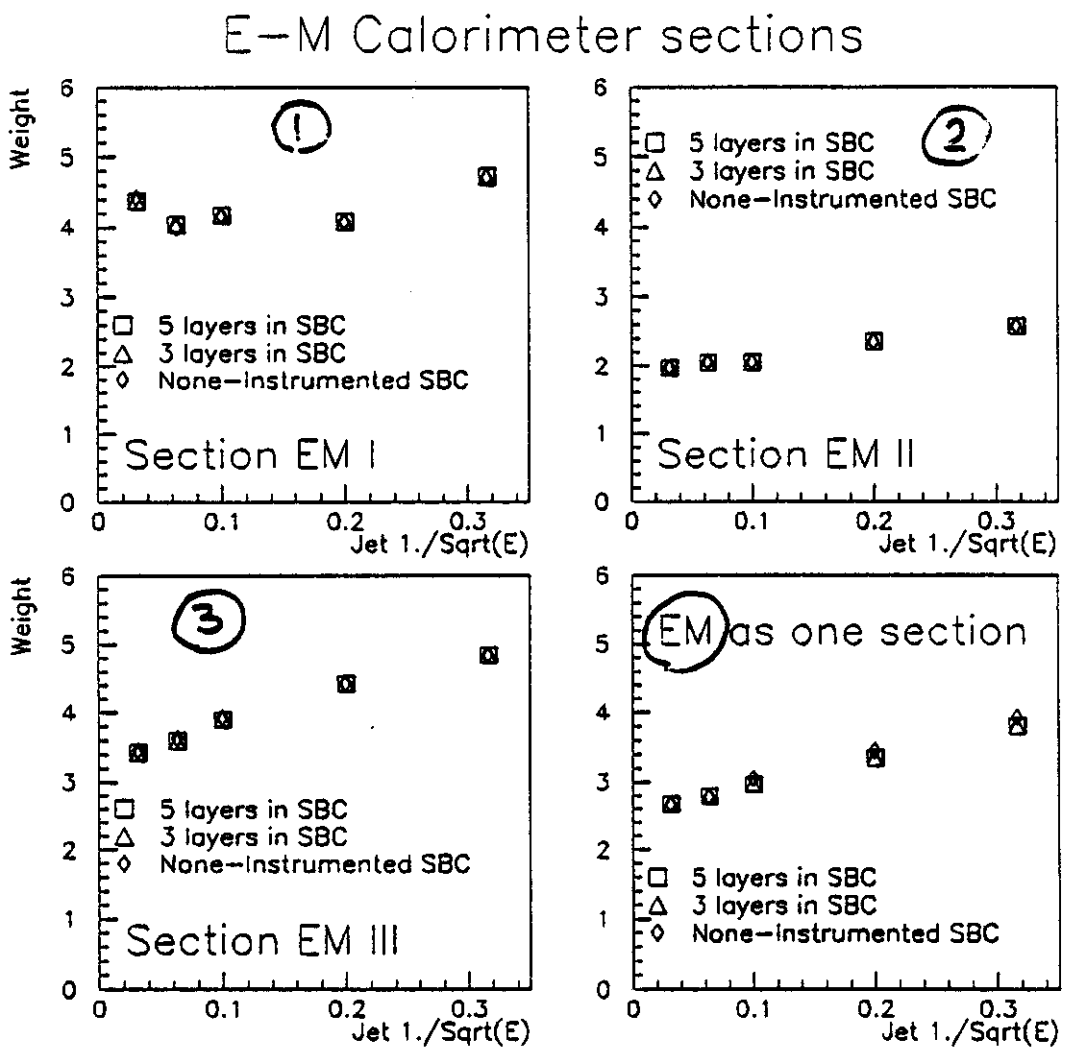


Figure 16: ***Weights for EM sections***

Jet 3

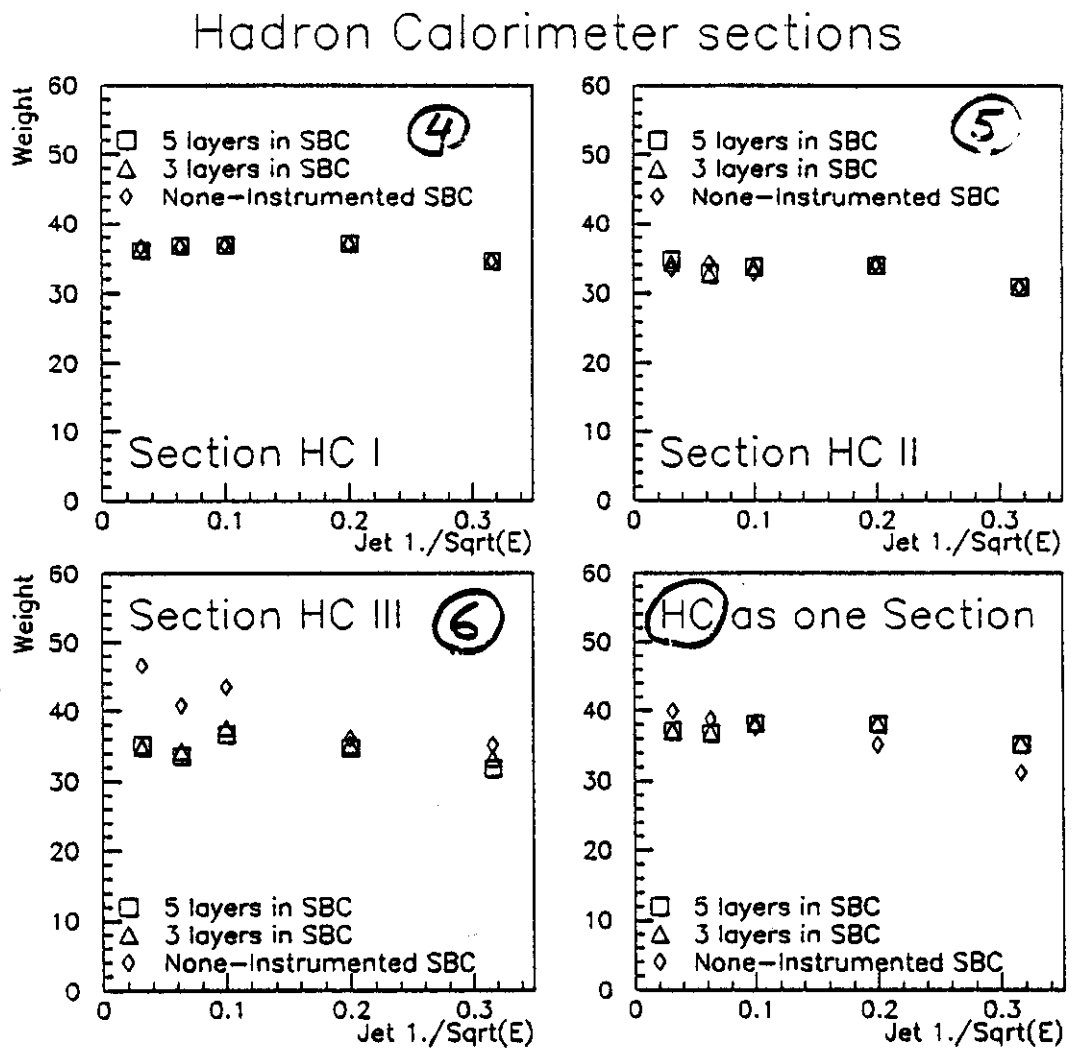


Figure 17: ***Weights for HC sections***

Jets

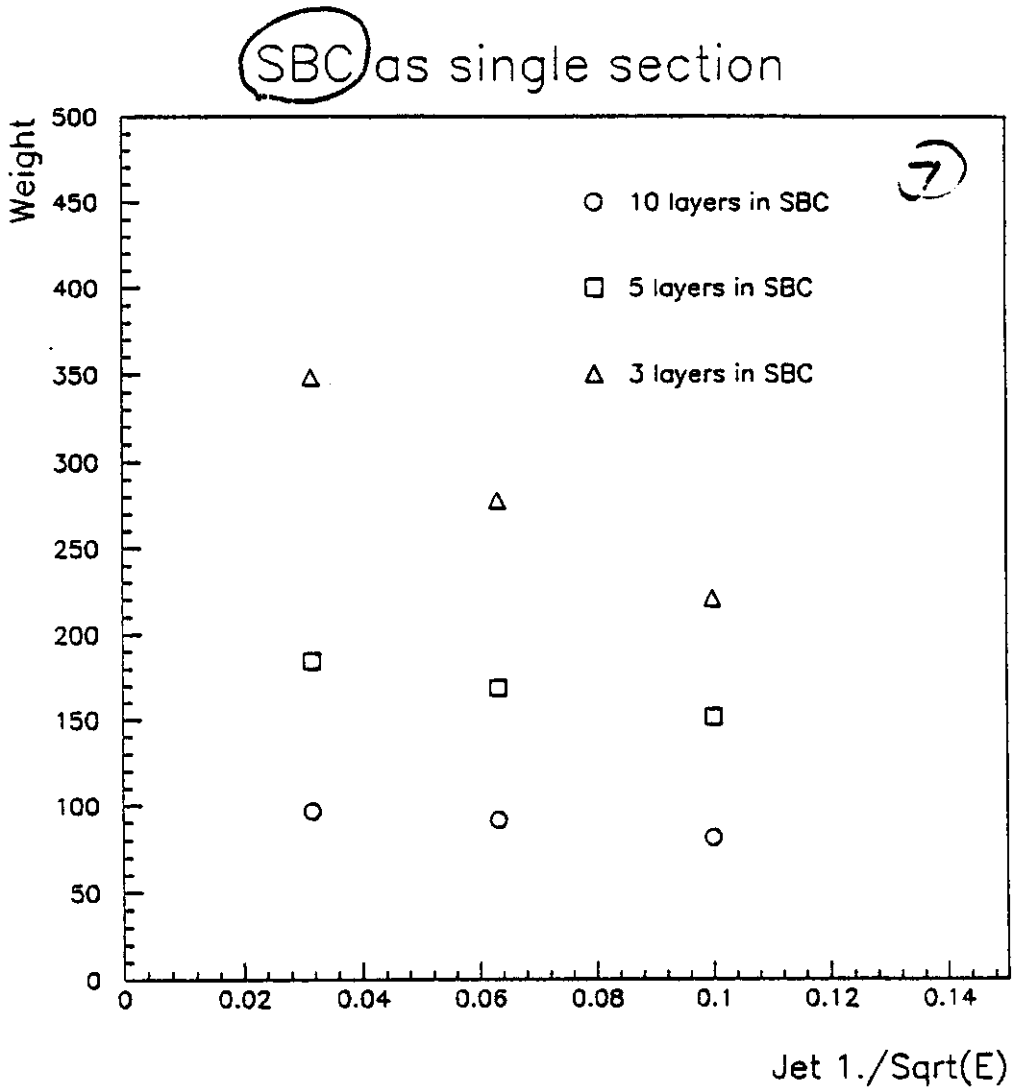


Figure 18: ***Weight for Scintillating Barell Calorimeter***

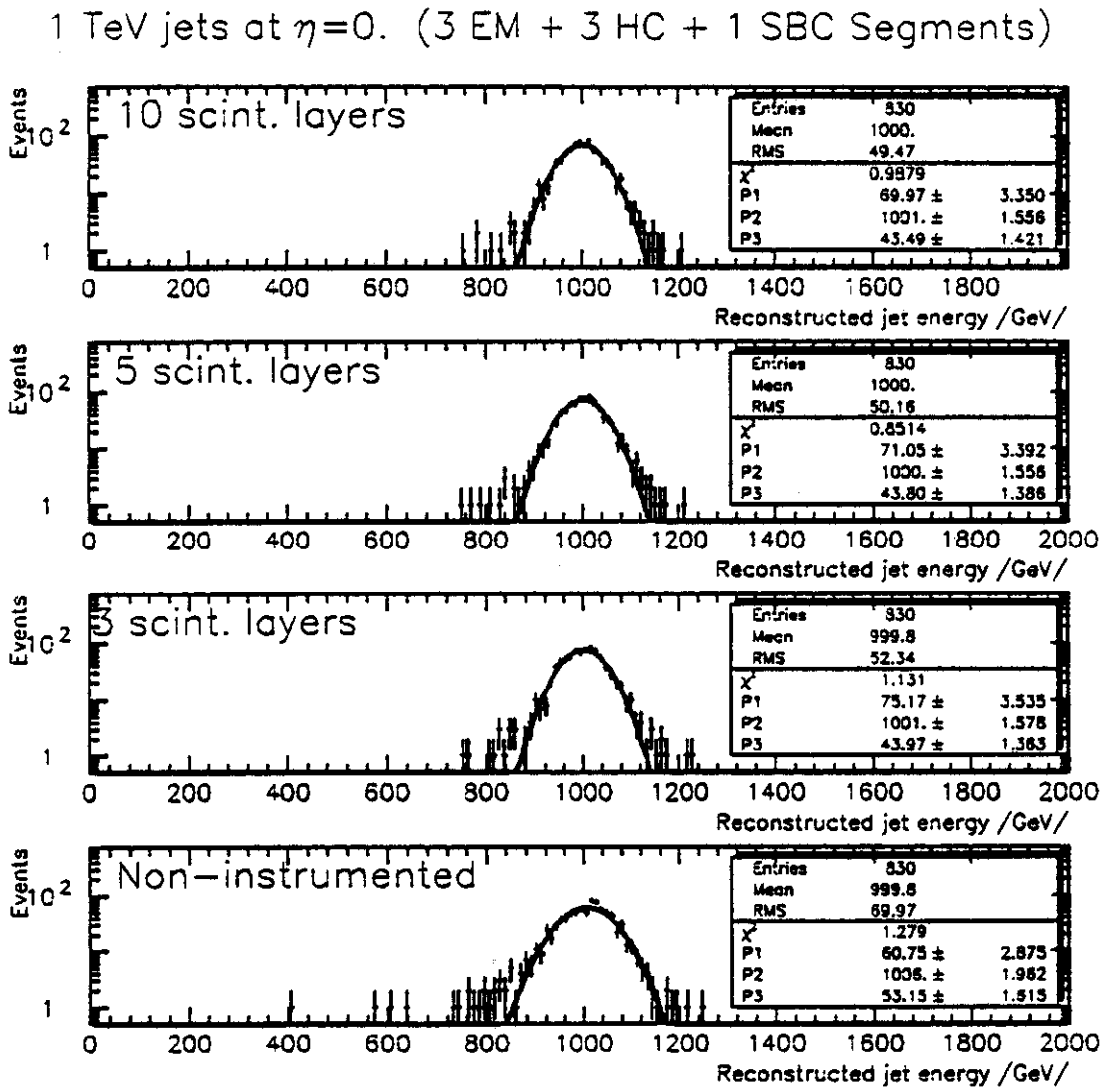


Figure 20: ***Response spectrum for 1 TeV jet (3 segments in EM and 3 in HC)***

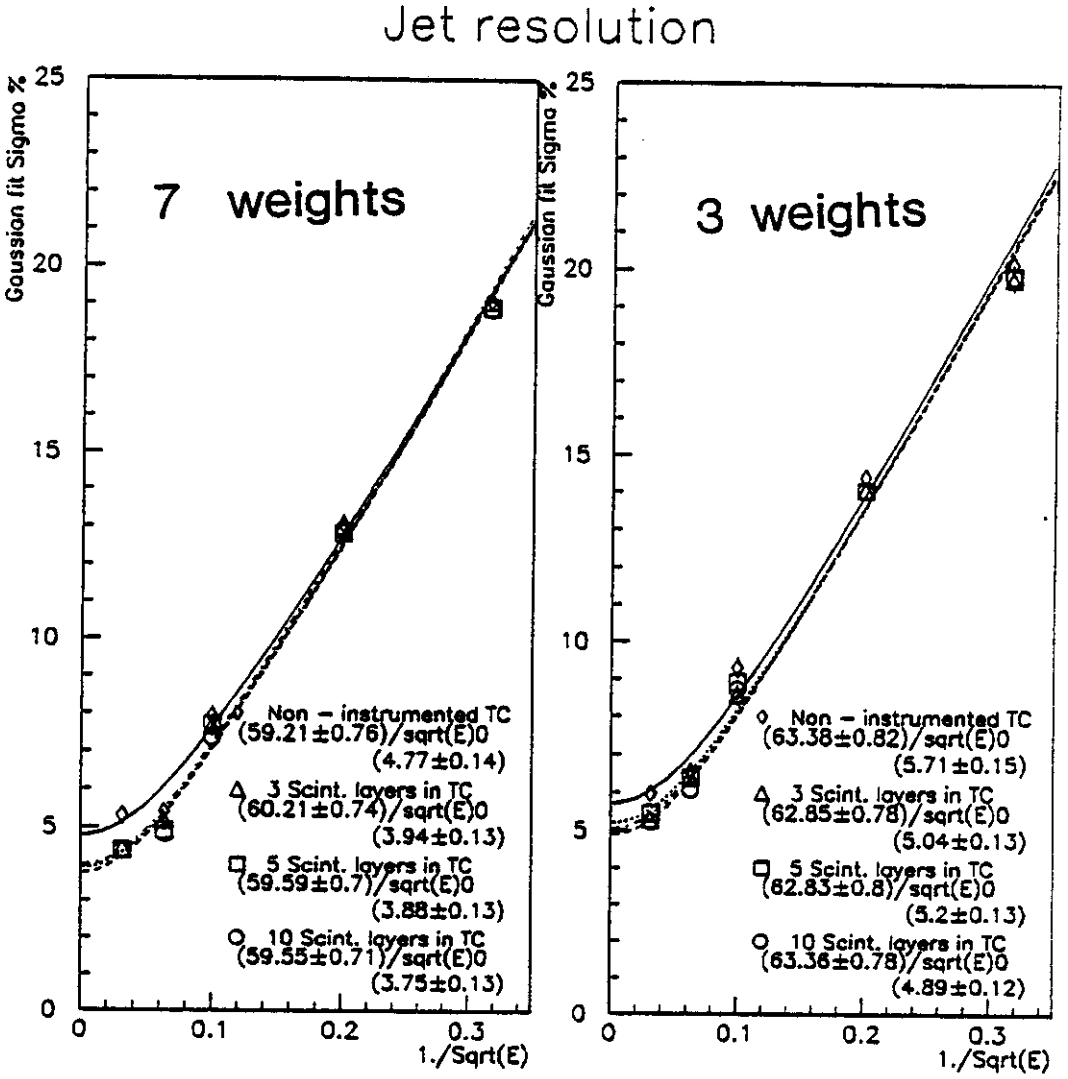


Figure 21: *Parametrization of jet resolution*

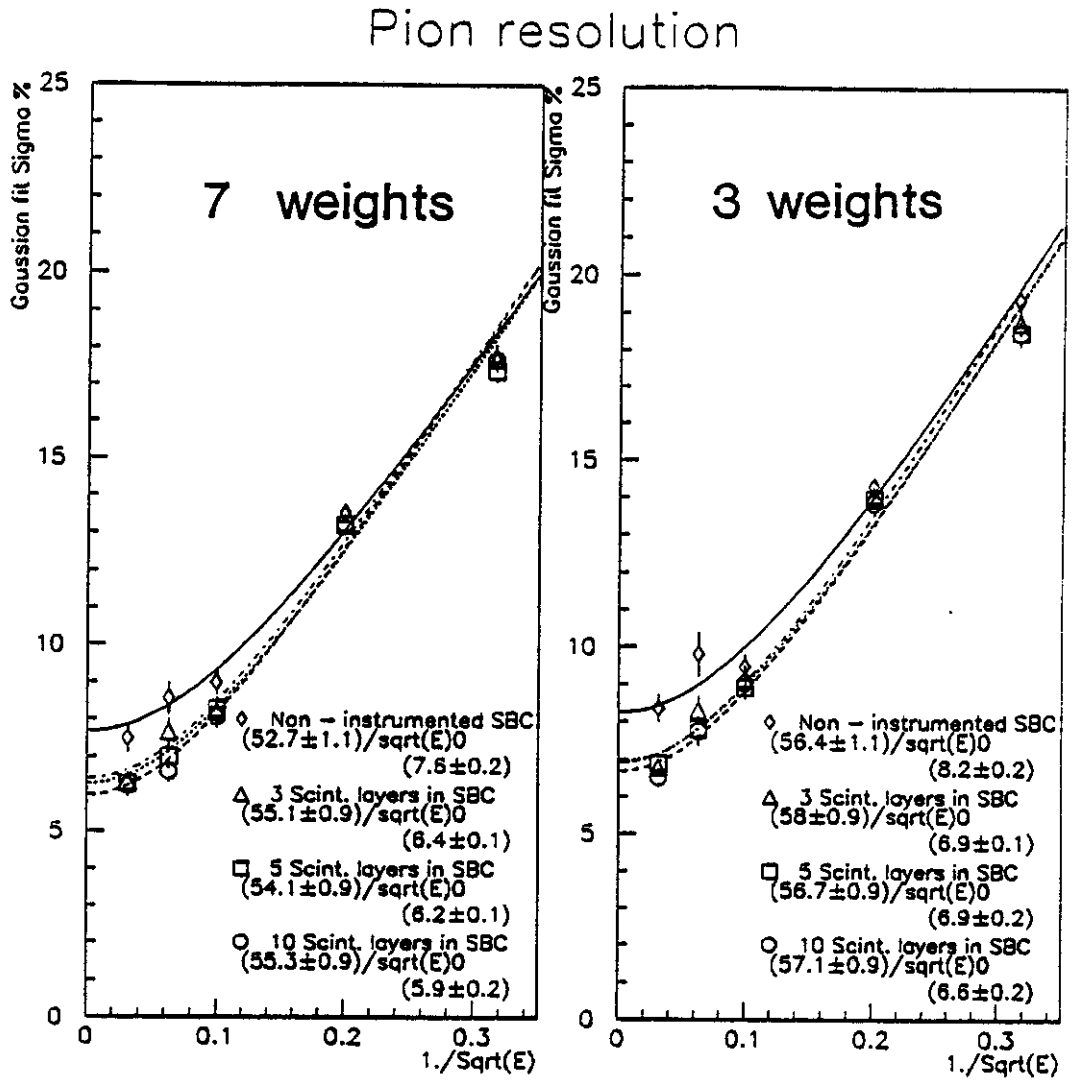
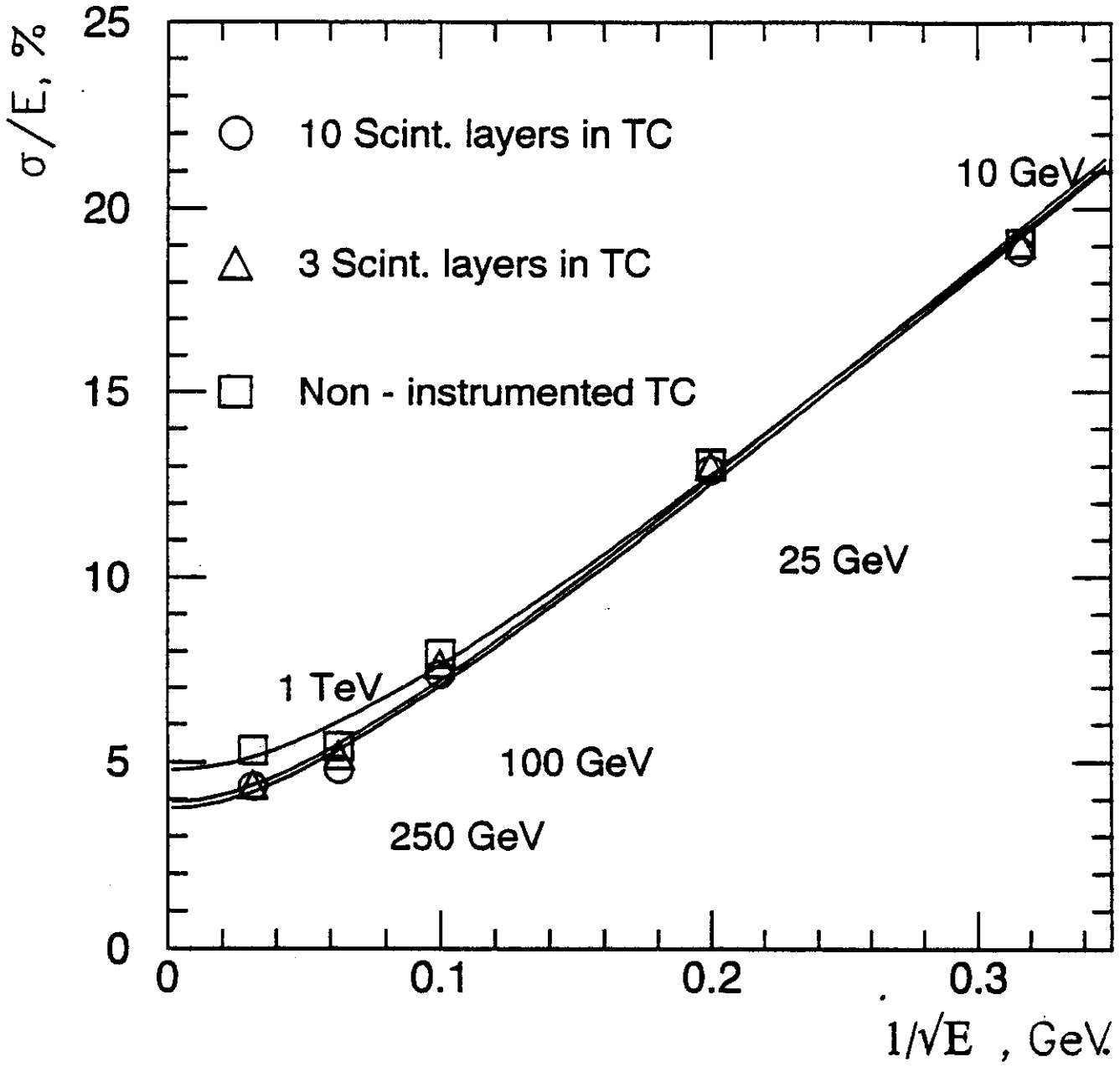


Figure 22: ***Parametrization of pion resolution***


σ/E, %
25
20
15
10
5
0
10 Scint. layers in TC
3 Scint. layers in TC
Non - instrumented TC
10 GeV
25 GeV
1 TeV
100 GeV
250 GeV
0
0.1
0.2
0.3
1/√E , GeV

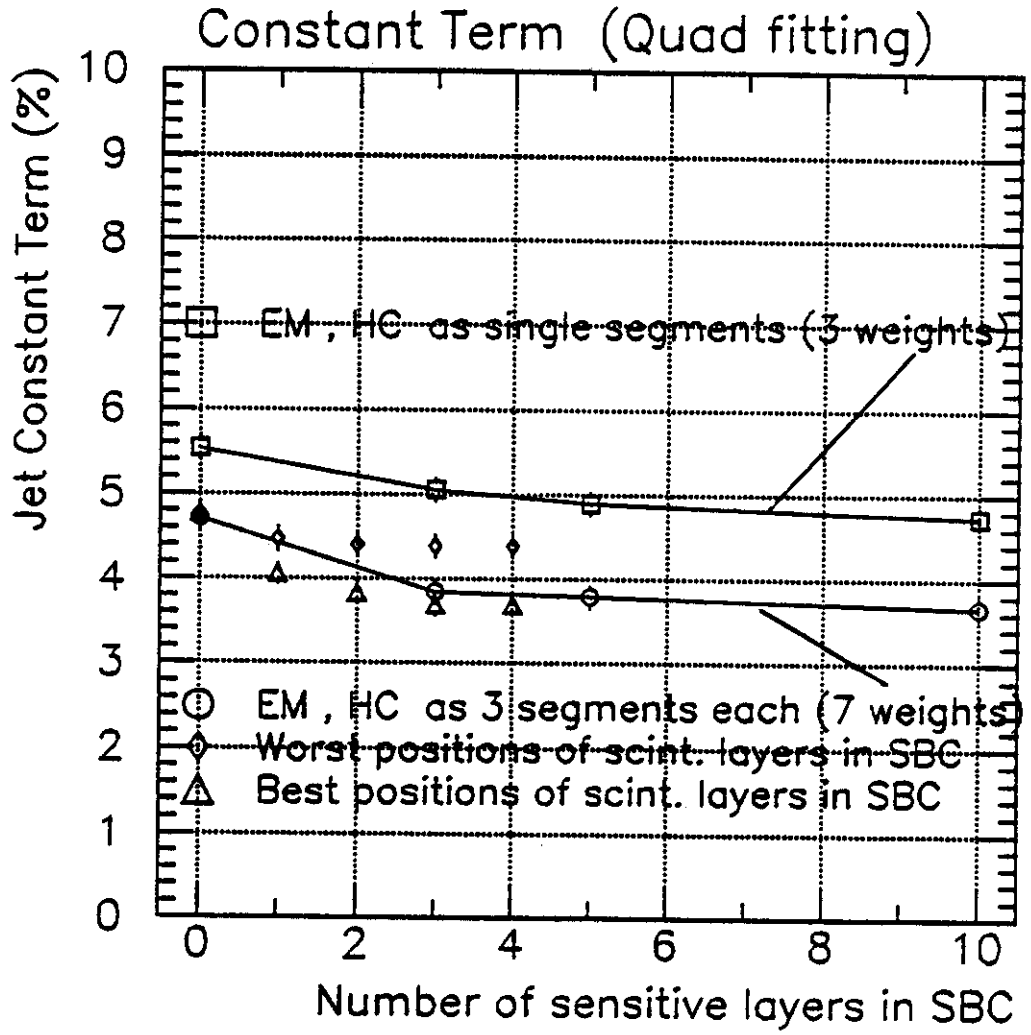
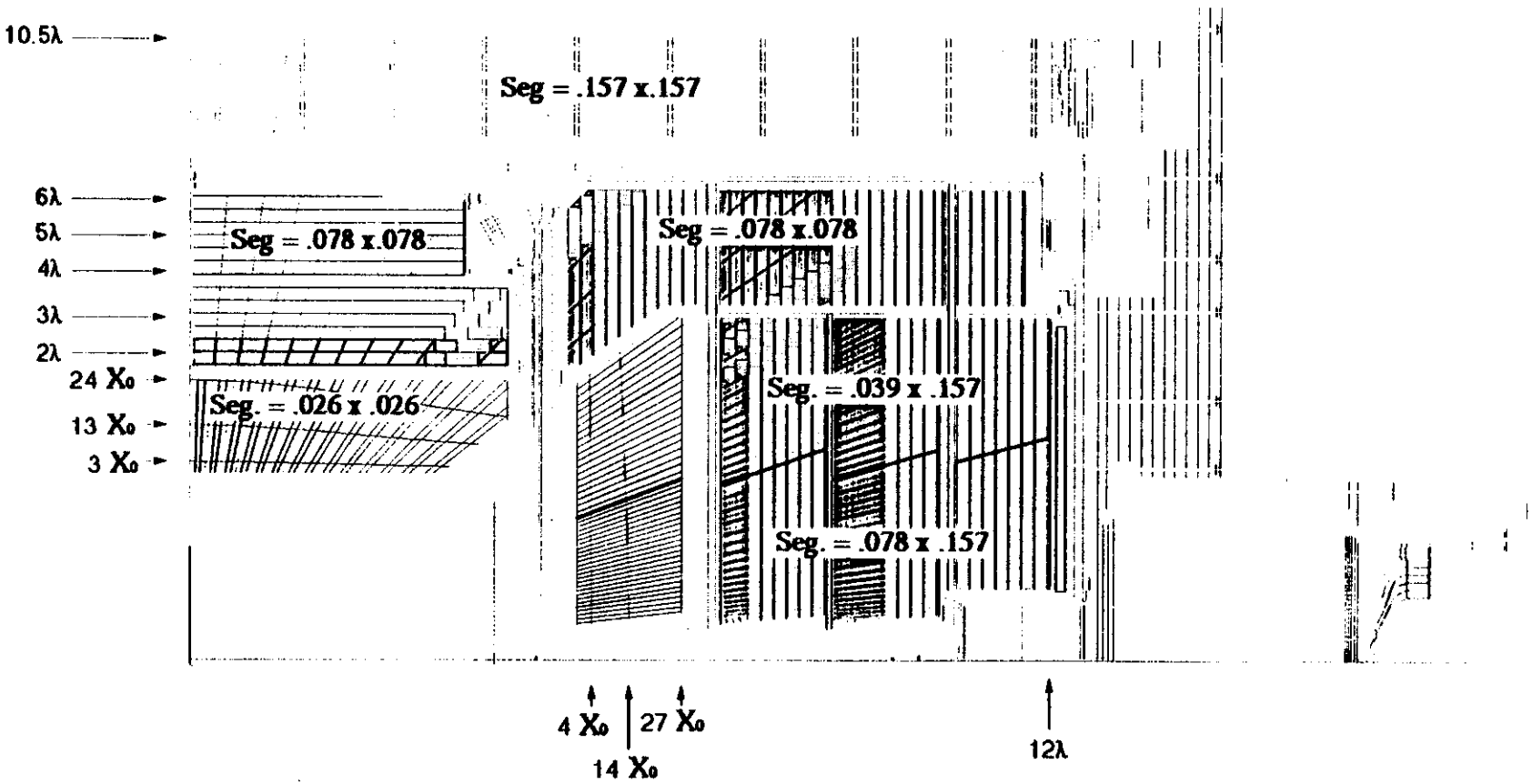


Figure 23: *Constant term for different instrumentation of SBC*

Cell Orientation in Modules

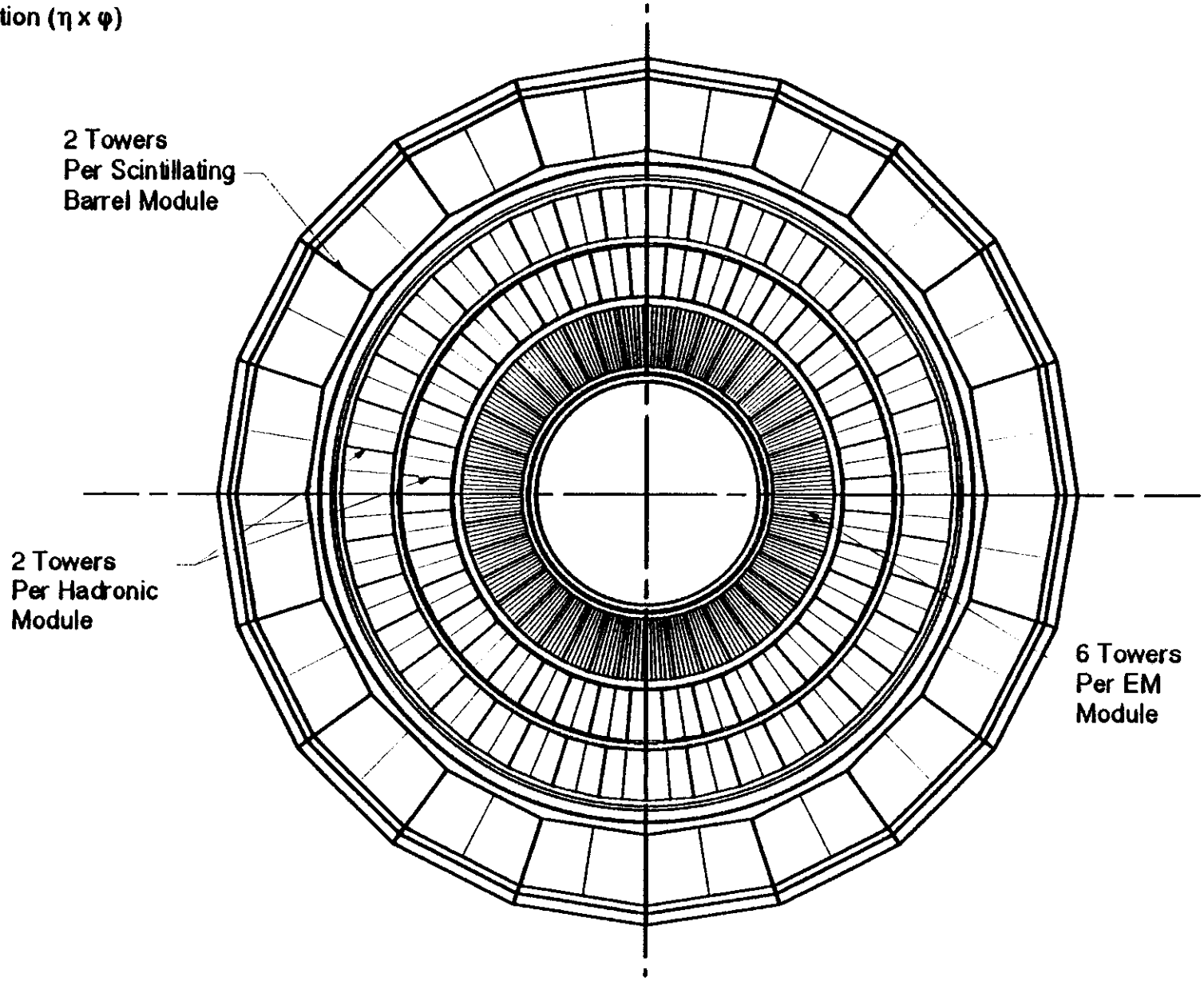
Segmentation ($\eta \times \varphi$)



Barrstable: Segmentation: 930520

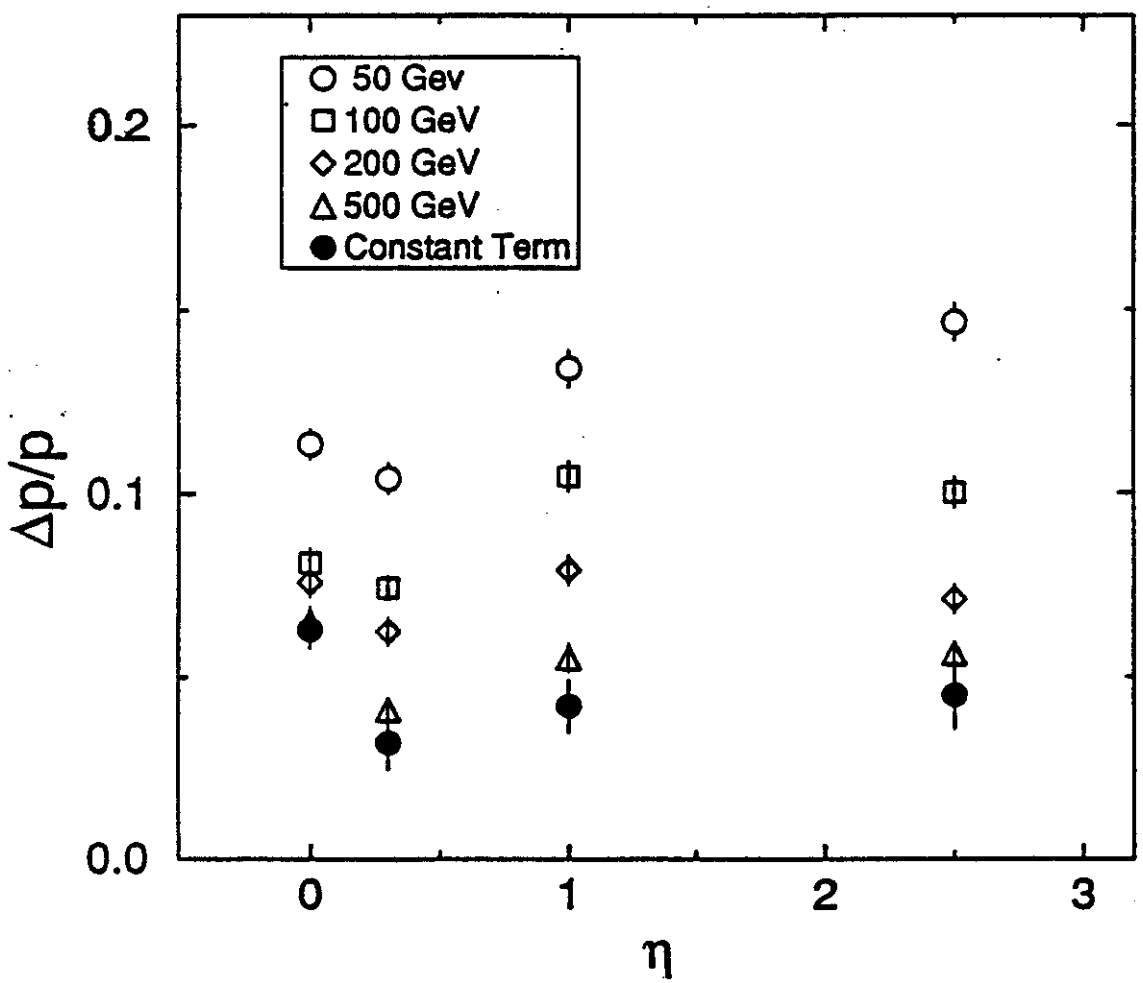
Barrel Calorimeter Segmentation

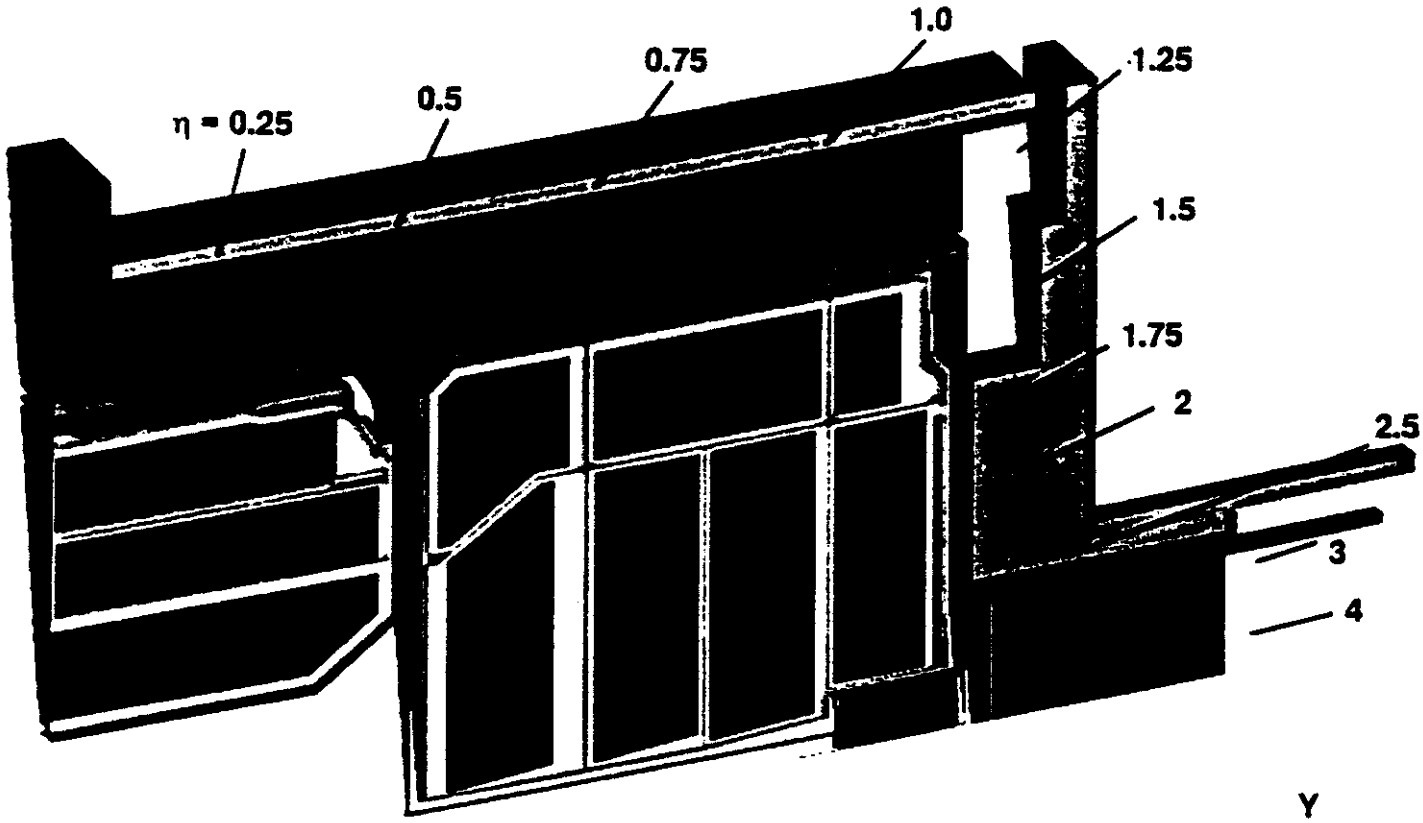
Segmentation ($\eta \times \varphi$)

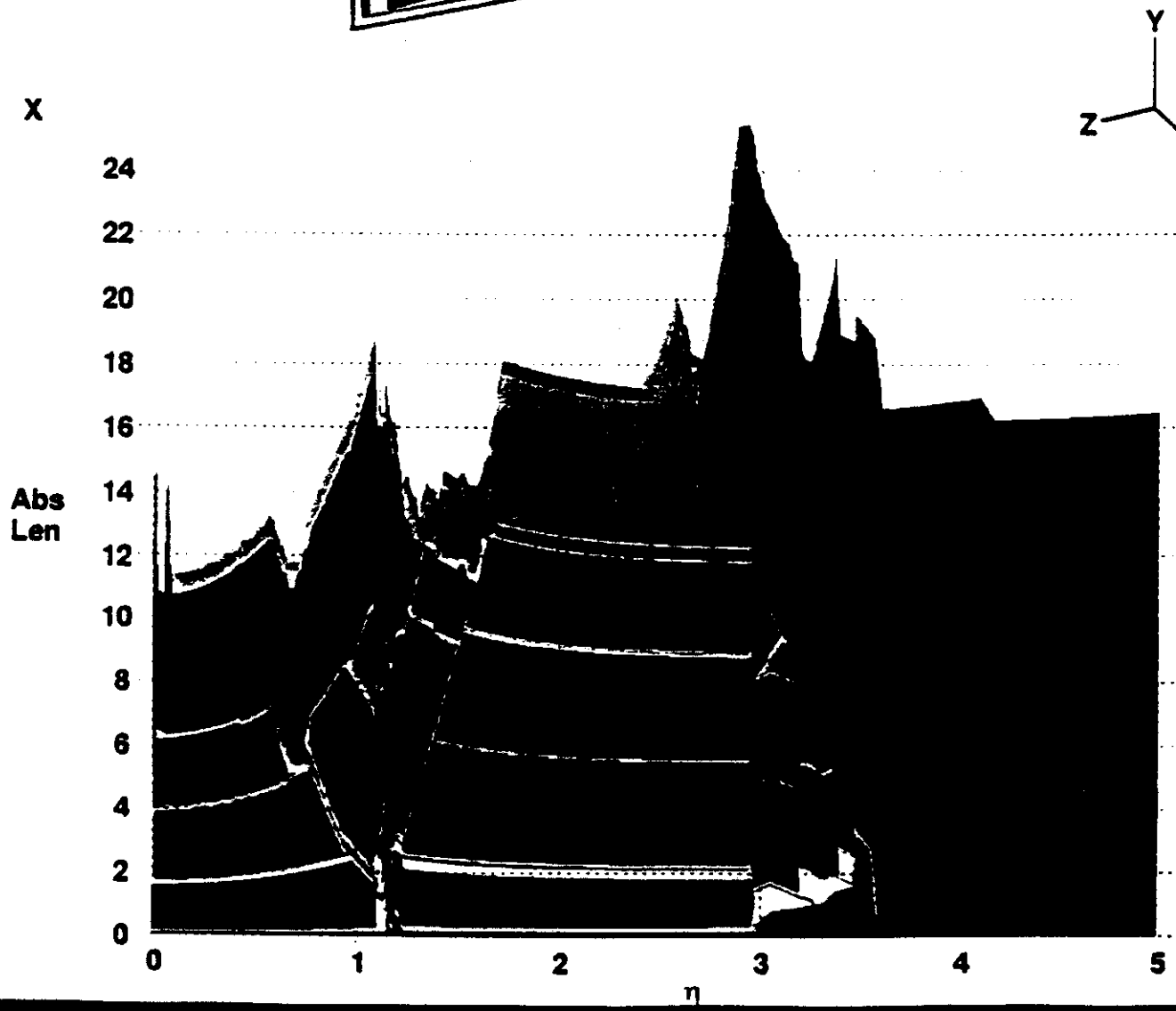


Barnstable: Barrel Phi Seg:930520

Jet Energy Resolution




η = 0.25
0.5
0.75
1.0
1.25
1.5
1.75
2
2.5
3
4


Y
Z
X
X
Abs
Len
24
22
20
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
η

Missing $\not{E}_T$ measurement

- ✓ Forward hole
- ✓ Low (No) instrumented SBC
- Space and Energy resolution
- Nonegaussian tails
- Special regions ($|\eta| = 0.7$)
- Transitions, cracks, dead material
- Noise & pileup

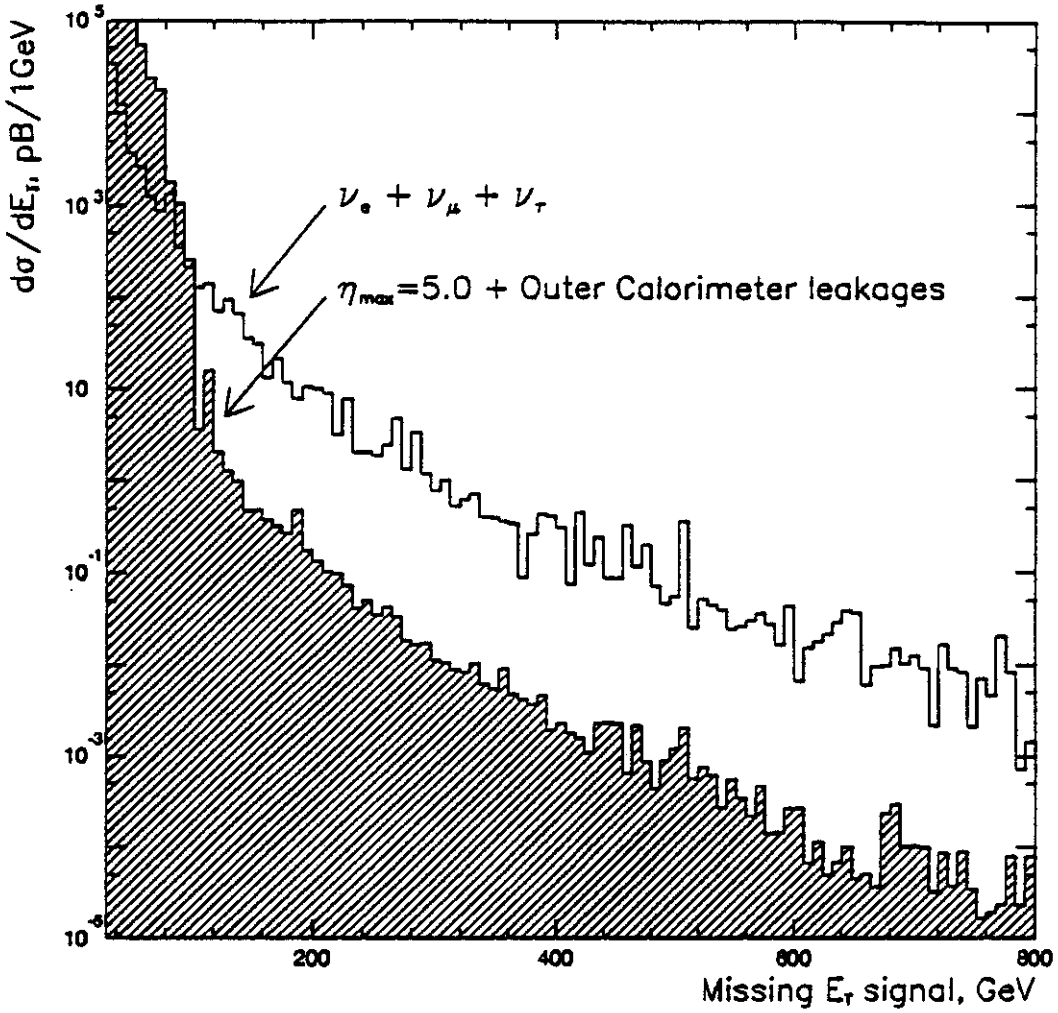
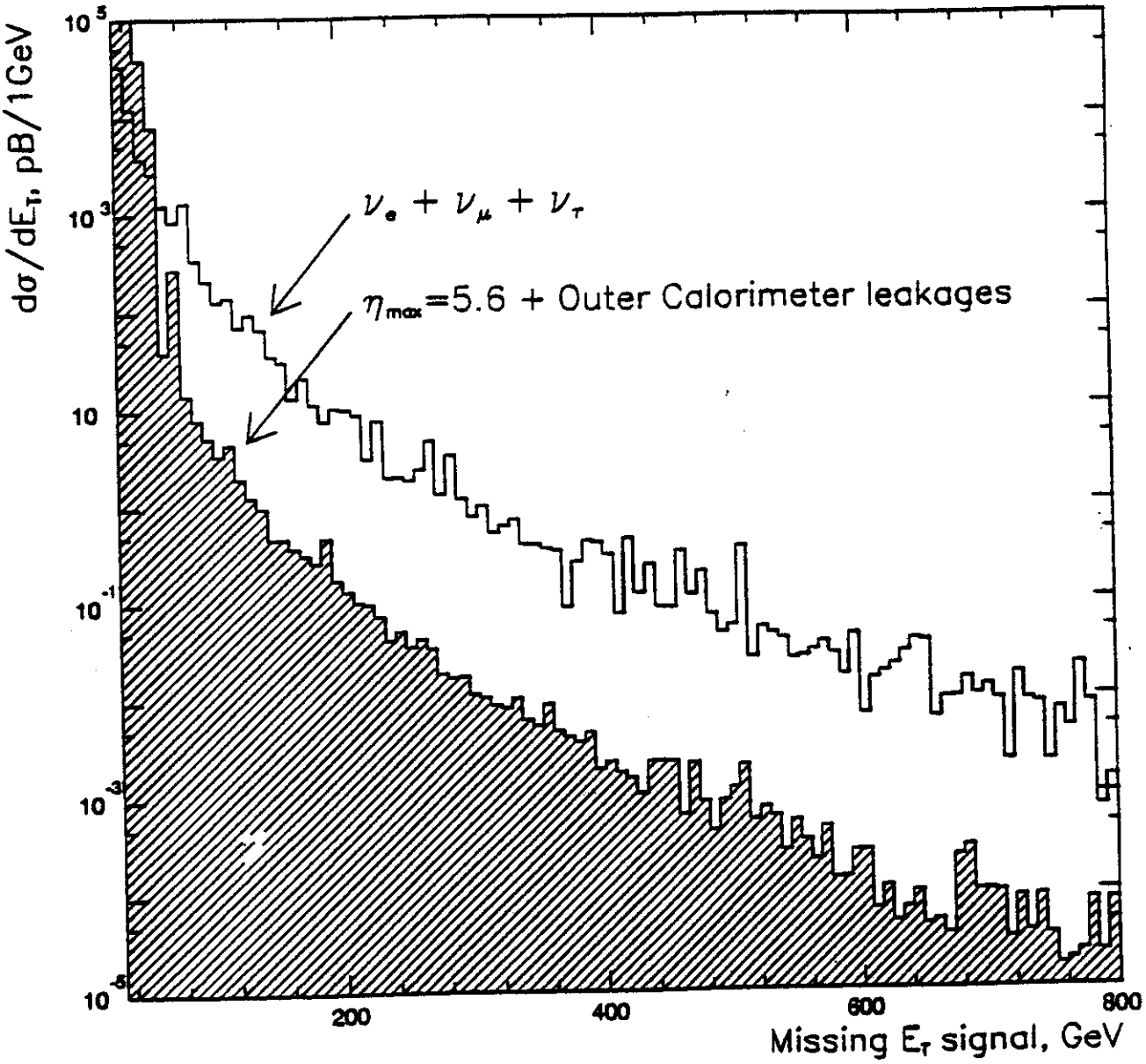
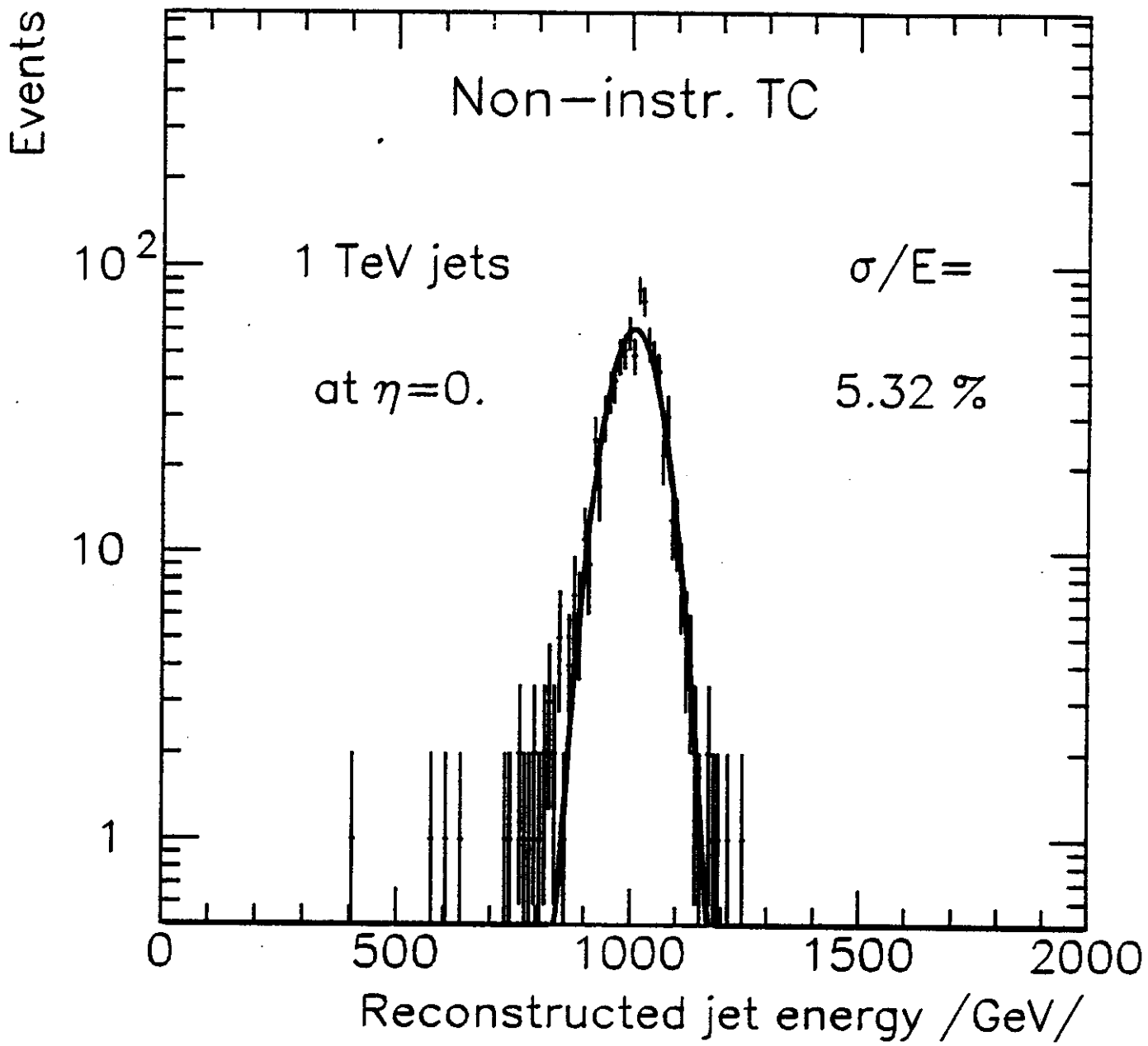
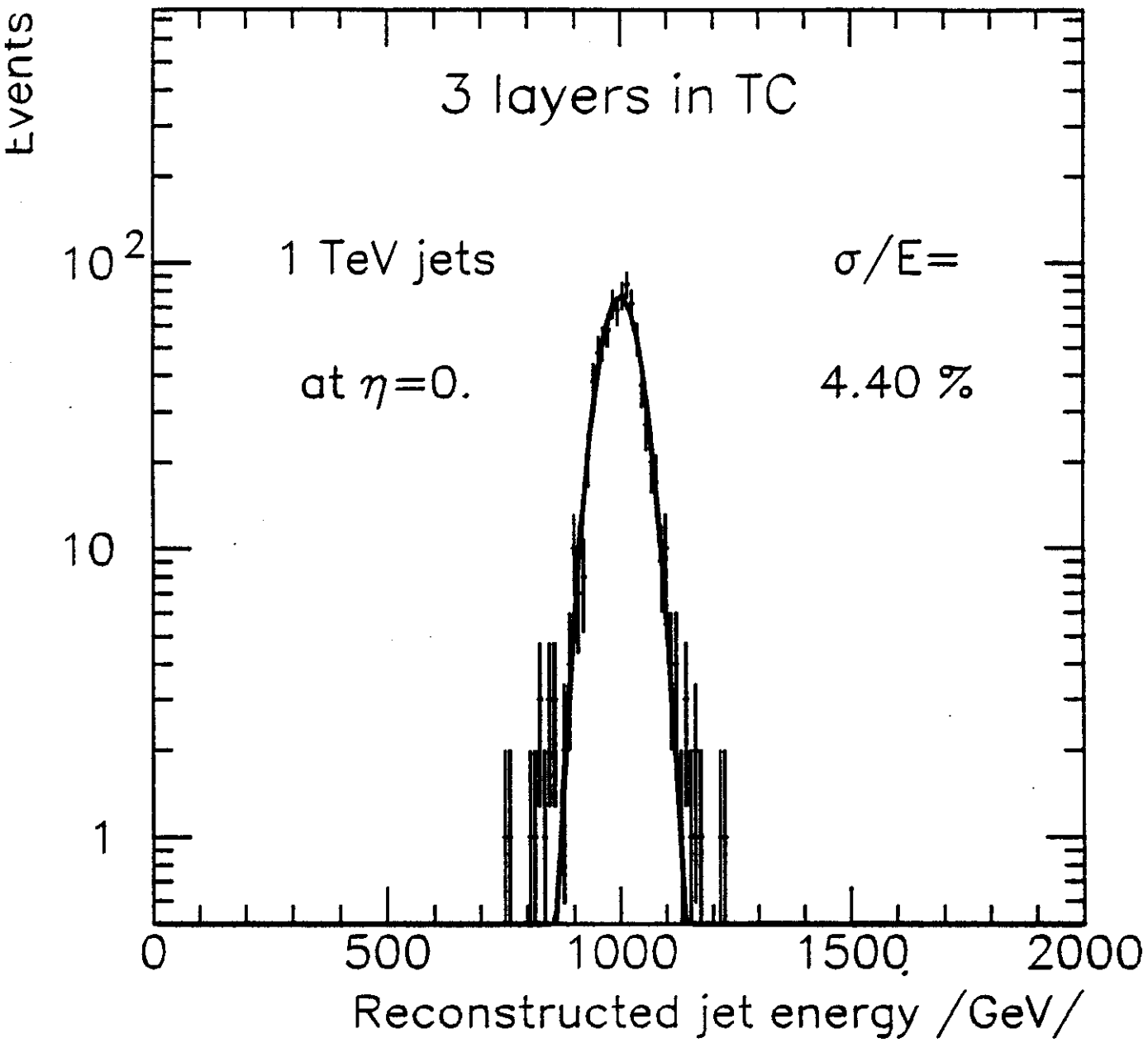


Figure 29: *The effect of limited calorimeter coverage* $|\eta| < 5.2$ *plus* E_T^{miss} *spectrum originated in SBC (in case if it is not instrumented) versus* E_T^{miss} *spectrum from neutrino (Standard Model background)*


dσ/dE_T, pB/1GeV
10^5
10^3
10
10^-1
10^-3
10^-5
200
400
600
800
Missing E_T signal, GeV
ν_e + ν_μ + ν_τ
η_max=5.6 + Outer Calorimeter leakages


Events
Non−instr. TC
1 TeV jets
at η=0.
σ/E=
5.32 %
10 2
10
1
0
500
1000
1500
2000
Reconstructed jet energy /GeV/


3 layers in TC
1 TeV jets
at η=0.
σ/E=
4.40 %
Events
10²
10
1
0
500
1000
1500
2000
Reconstructed jet energy /GeV/

Absorber in Liquid Barrel

Detector	Absorber	e/mip	e/h	h constant term res. Wigmans	h constant term res. Calor '89	h/jet constant term res. GEANT
LAr	Cu	0.91	1.65	9.5%		
	Pb	0.66	1.39	5.8%		
LKr	Cu	1.05	1.90	13.5%	9.0%	
	Pb	0.73	1.53	8.0%	6.5%	6.2/3.9%

NIM A275(1989) 246-257

Perfomance of Pb-Cu Liquid Calorimeter With an Iron Streamer Tube tail Catcher.

H1 collaboration.

EM 26.0 X_0 (5 seg.) 2.4 mm Pb, 2.8 mm LAr

HC 6.12 λ (6 seg.) 5. mm Cu, 3. mm LAr

Dead material 1.4 λ

TC 4.5 λ Iron With Streamer Tubes.

Non linear weighting.

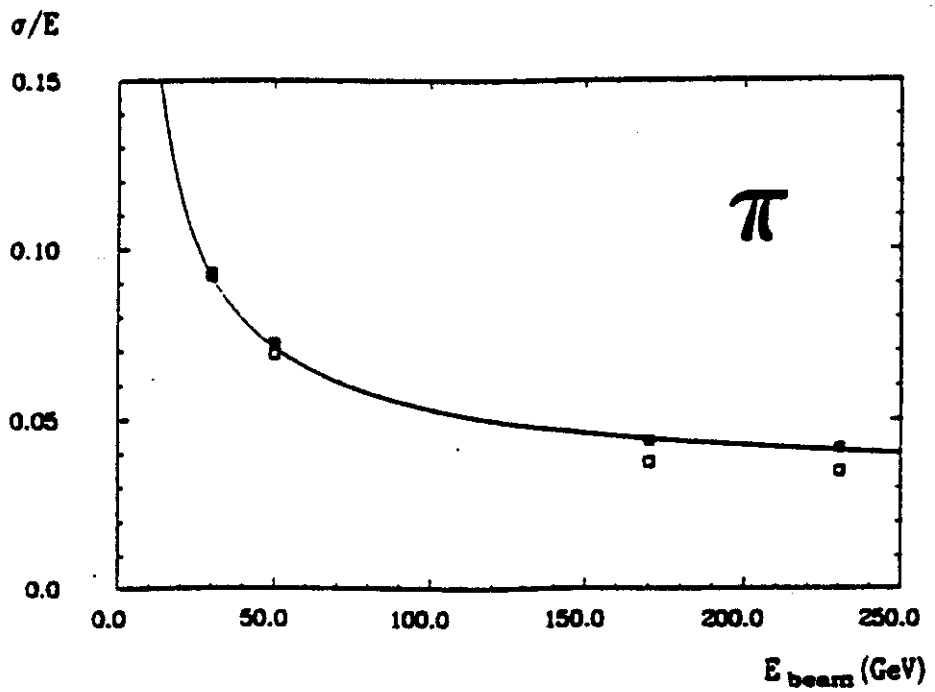


Fig. 14. Energy resolution of the combined system of LAr calorimeter and TC (full symbols) versus beam energy. The curve corresponds to the parametrization given by eq. (4) with $A = 0.424\sqrt{\text{GeV}}$, $B = 1.2$ GeV and $C = 0.029$. The open circles represent the events fully contained in the LAr calorimeter.

$\gamma e \mu$™

Jet resolution is slightly sacrified

But NOT Physics!

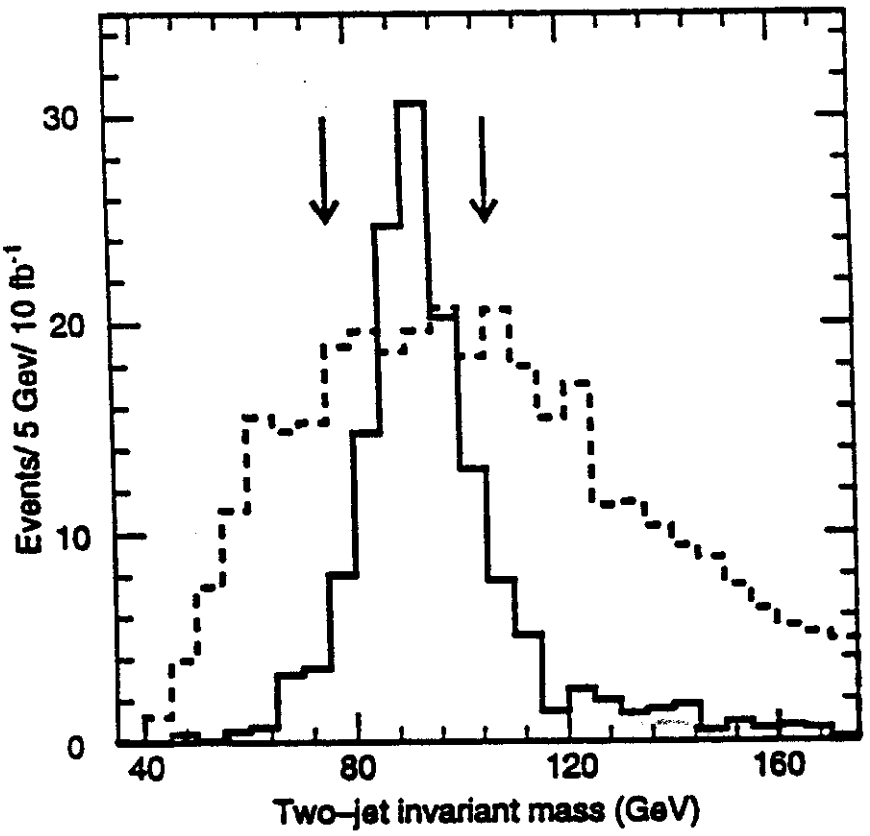


FIG. 2–29. Dijet invariant mass distribution for $H \to ZZ \to \ell^+\ell^- jj$ for $M_H = 800\,\mathrm{GeV}$ (solid) and sum of all backgrounds (dashed), obtained for an integrated luminosity of $10\,\mathrm{fb}^{-1}$. The background is multiplied by a factor of 0.2. to facilitate comparison of the shapes.

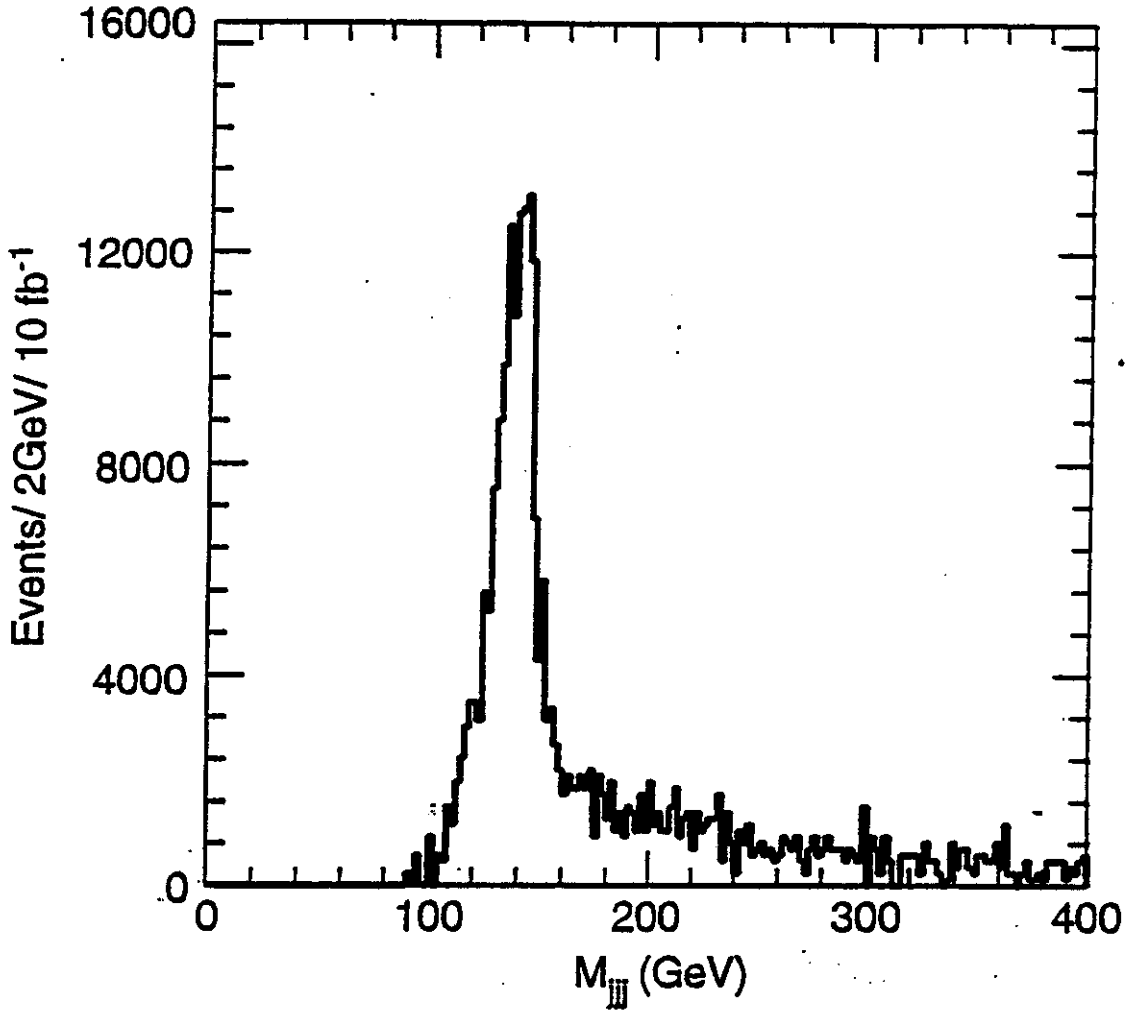


FIG. 2–36: Trijet mass distribution in $t\bar{t}$ events with $m_t = 140\,\mathrm{GeV}$, without b-tagging.

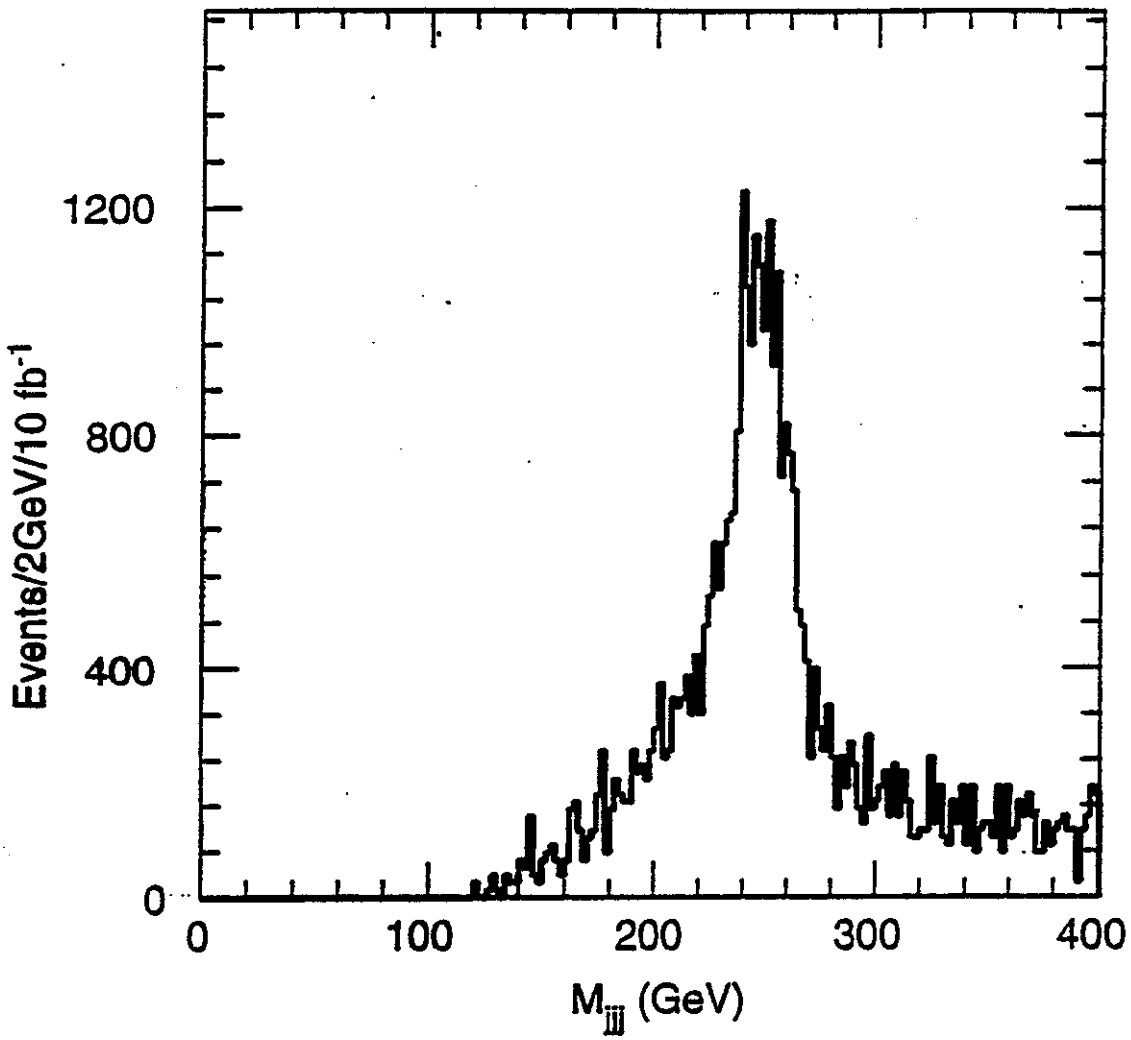


FIG. 2–38: Trijet mass distribution in $t\bar{t}$ events with $m_t = 250\,\mathrm{GeV}$.