GEM TN-92-229

Physics Simulation Group Meeting - SSCL

October 7, 1992

Abstract:

Agenda, attendees, and presentations of the GEM Physics Simulation Group Meeting held at the SSC Laboratory on October 7, 1992.

Agenda for Physics/Simulation Meeting, Wednesday Oct. 7th

The meeting starts at 1pm and runs to about 6 pm (there is a GEM dinner in the evening). It will be in the Project Management Conf. room, no. 322 in Bldg. 4.

1) Physics Considerations for Hybrid vs Integrated Calorimeter
   - Yamamoto/Mrenna --
   - A. Vanyashin -- Jet rejection in hybrid
   - ORNL? --
   - A. Golutvin -- comparison of integrated and ideal calorimeter
   - N. Mokhov -- Neutron fluxes

2) Physics topics and responsibilities for TDR
   Lane

3) Development of Tools
   - Full Simulation (Yu Fisyak)
   - Improvements to FAST (Skwarnicki)
   - GEM software structure description -- Sheer

4) Other topics
   - Forward Calorimeter

Physics Simulation 10/7/92

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Presentation by:

H. Yamamoto

Effect of the dead space at $\eta = 0$ to missing E_T Physics

1. Use a simple detector simulation

2. Generate $d\sigma / d\eta\, dp_t$ (gluon, d,u,s,c,b)

   η distribution is almost flat
   => fraction jet ($\eta < 0.25$) ~ 10%

3. shoot gluon and u quark jets gun at $\eta = 0 - 0.3$

   Fixed jet energy
   => fraction jet (miss $E_t > 100$ GeV) ~ 5%

   Using spectrum from 2.
   => $d\sigma / dE_t$ (miss Et) =
   $10^{-3} \times d\sigma / dP_t$ (QCD 2 jet)
   $10^{-3} = 0.1 \times 0.05 \times \underline{1/5}$
   missing Et < jet energy

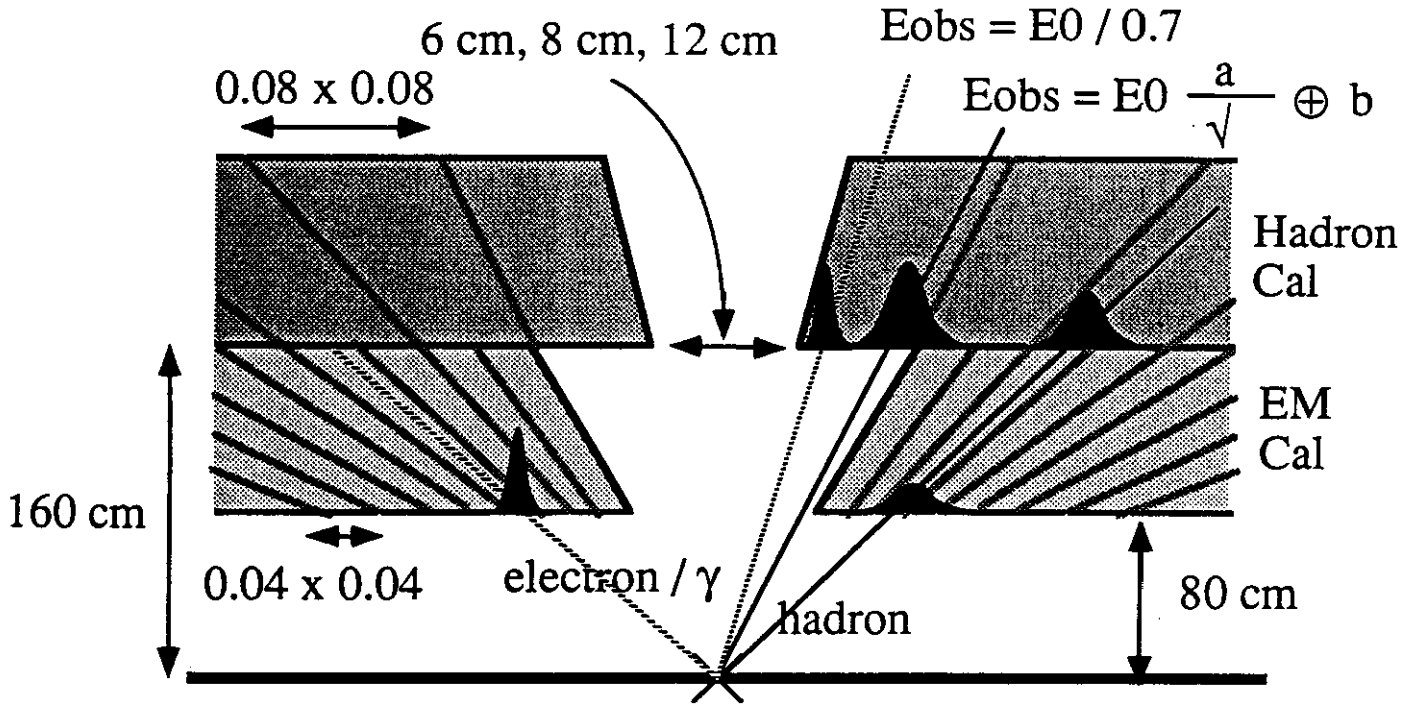
4. Summary

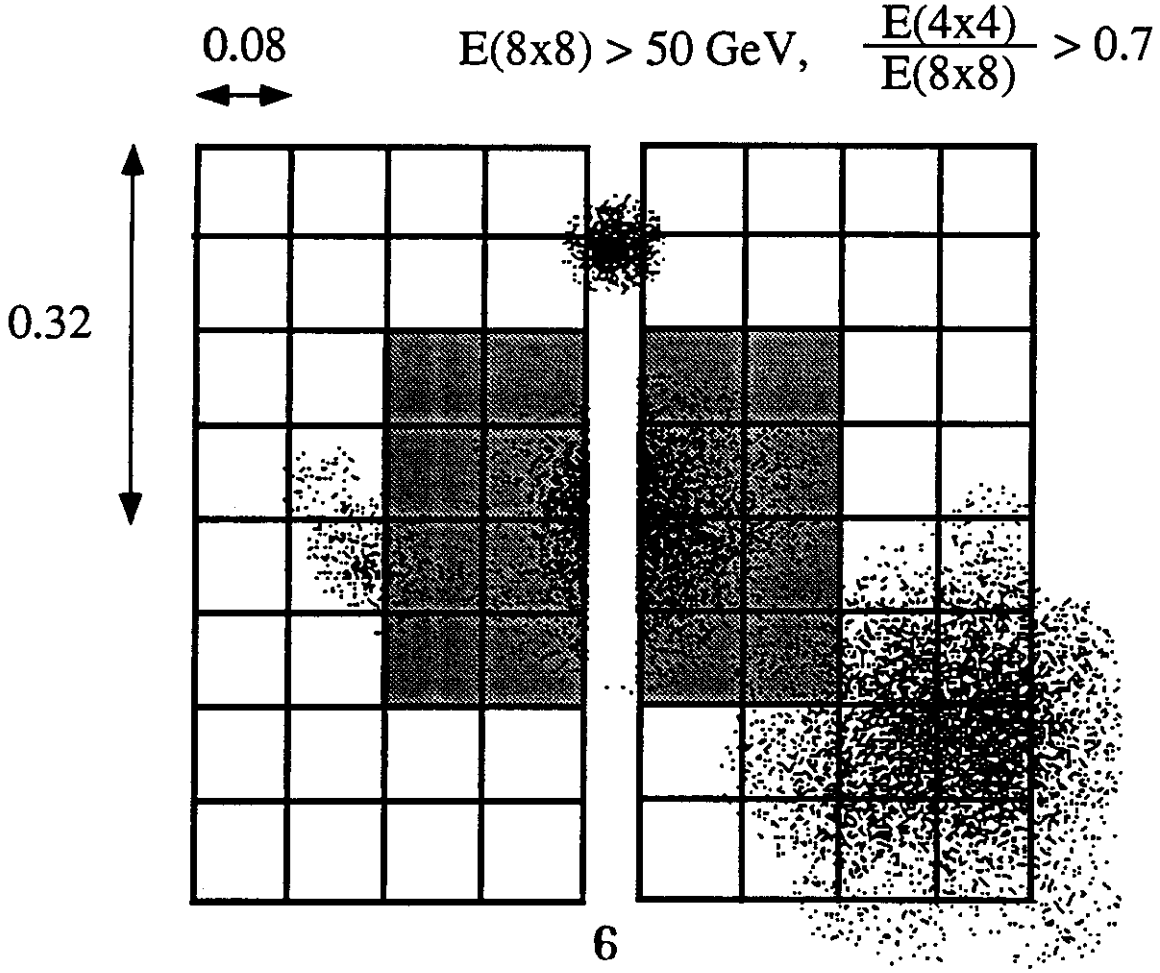
   σ (dead space at $\eta = 0$) ~ σ ($\eta < 5$)

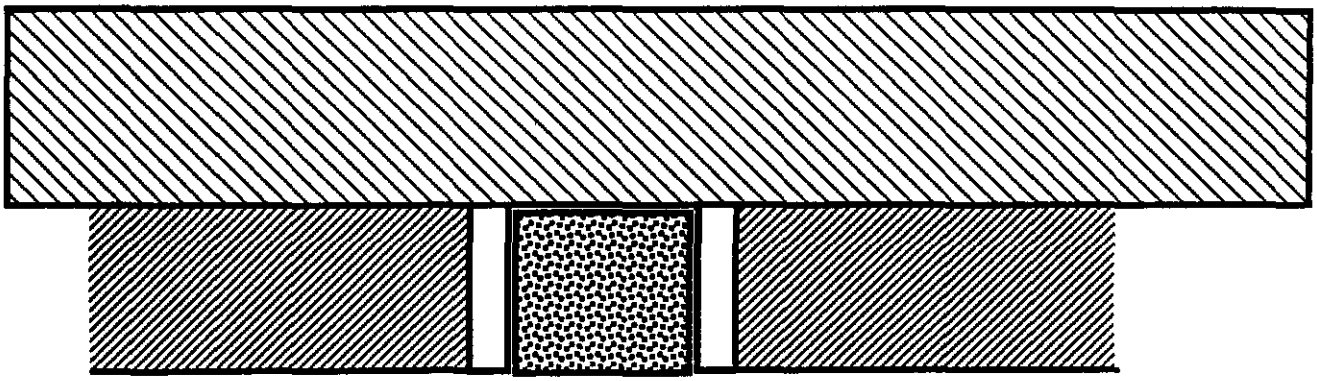
   can use different cut (no E44/E88 cut etc) to estimate

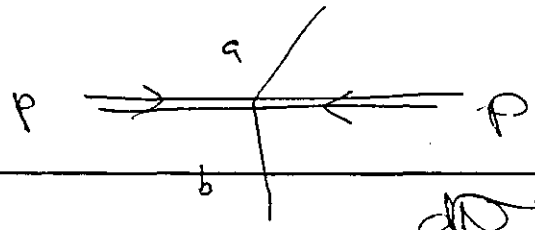
   jets rejected by the cut (gluon jet / u jet)

	0.0-0.1	0.1-0.2	0.2-0.3
100 - 200 GeV	0.35 / 0.56	0.21 / 0.41	0.046 / 0.036
200 - 400 GeV	0.46 / 0.64	0.30 / 0.47	0.052 / 0.044
400 - 800 GeV	0.51 / 0.68	0.34 / 0.54	0.051 / 0.044

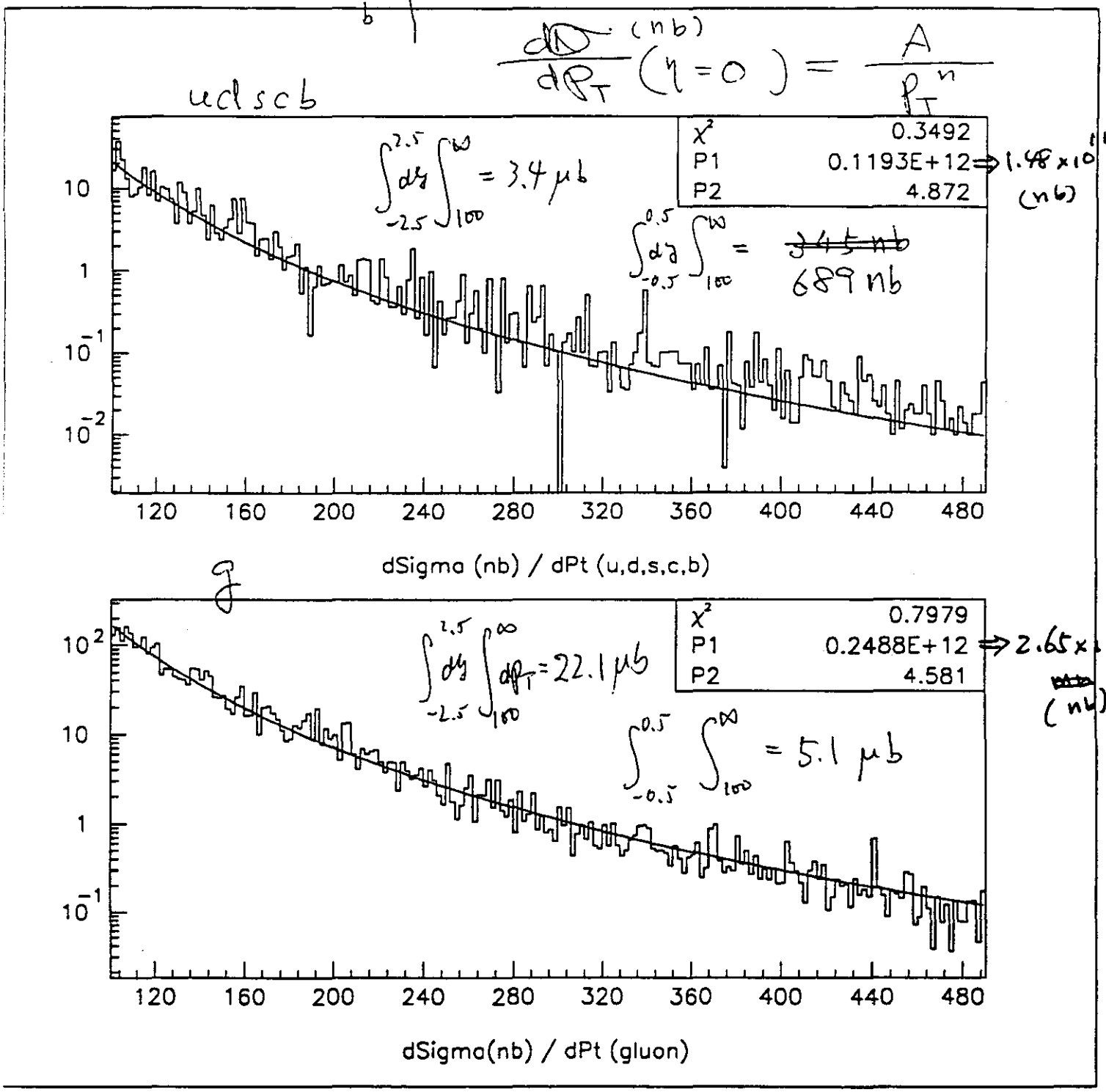

6 cm, 8 cm, 12 cm
Eobs = E0 / 0.7
0.08 x 0.08
Eobs = E0 $\frac{a}{\sqrt{}}$ ⊕ b
Hadron Cal
EM Cal
160 cm
0.04 x 0.04
electron / γ
hadron
80 cm


0.08
E(8x8) > 50 GeV, $\frac{E(4x4)}{E(8x8)} > 0.7$
0.32

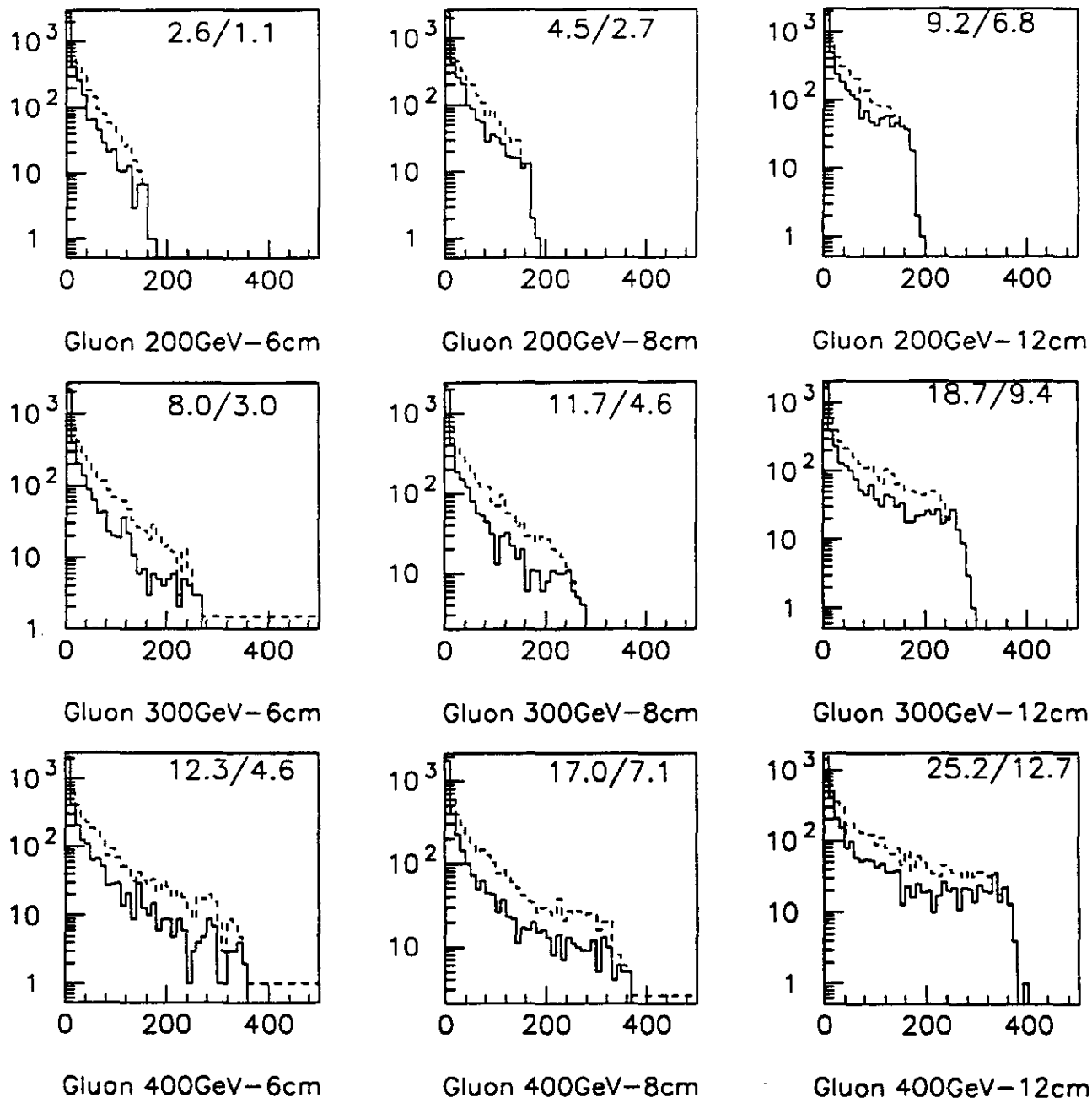




$$\frac{d\sigma}{dp_T}(\eta = 0) = \frac{A}{p_T^{\,n}} \quad (nb)$$



$\not{E}_T$ by Gluon Jet in $\eta < 0.25$



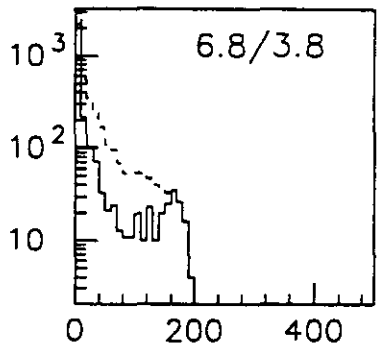
A/B (in %) — — — — w/o cut

↑ w/ cut

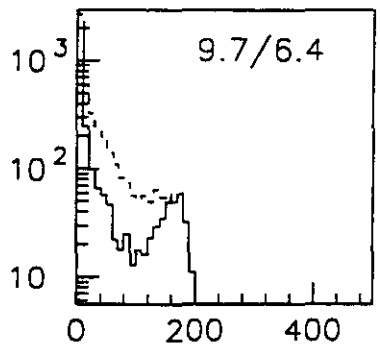
frac of jet with $\not{E}_T > 100$ GeV w/o cut

——— $\left\{ \begin{array}{l} \sum_{8\times8} E_T > 50 \text{ GeV} \\ \sum_{4\times4} / \sum_{8\times8} > 0.7 \end{array} \right\}$ cut

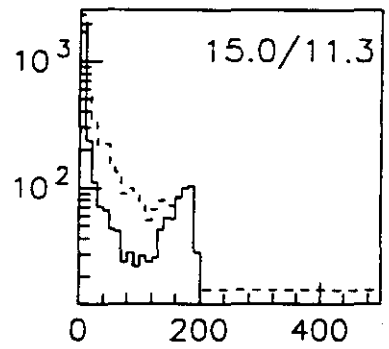
$\not{E}_T$ by U Quark Jet in $\eta < 0.25$



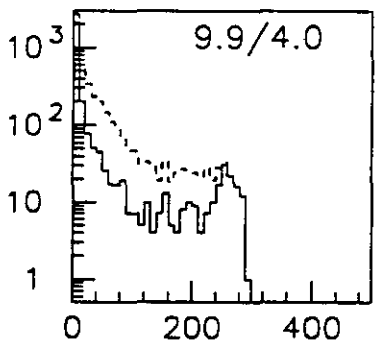
Quark 200GeV−6cm



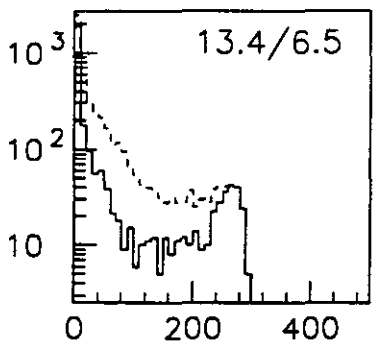
Quark 200GeV−8cm



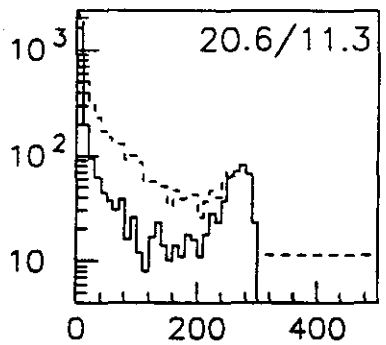
Quark 200GeV−12cm



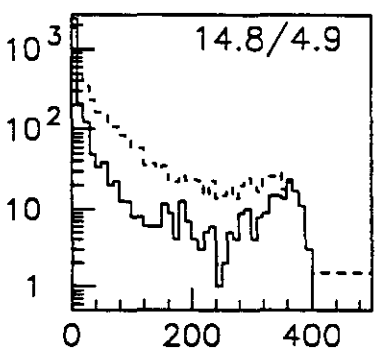
Quark 300GeV−6cm



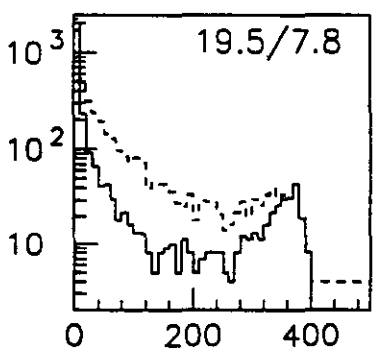
Quark 300GeV−8cm



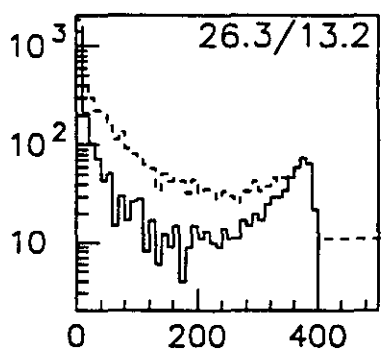
Quark 300GeV−12cm



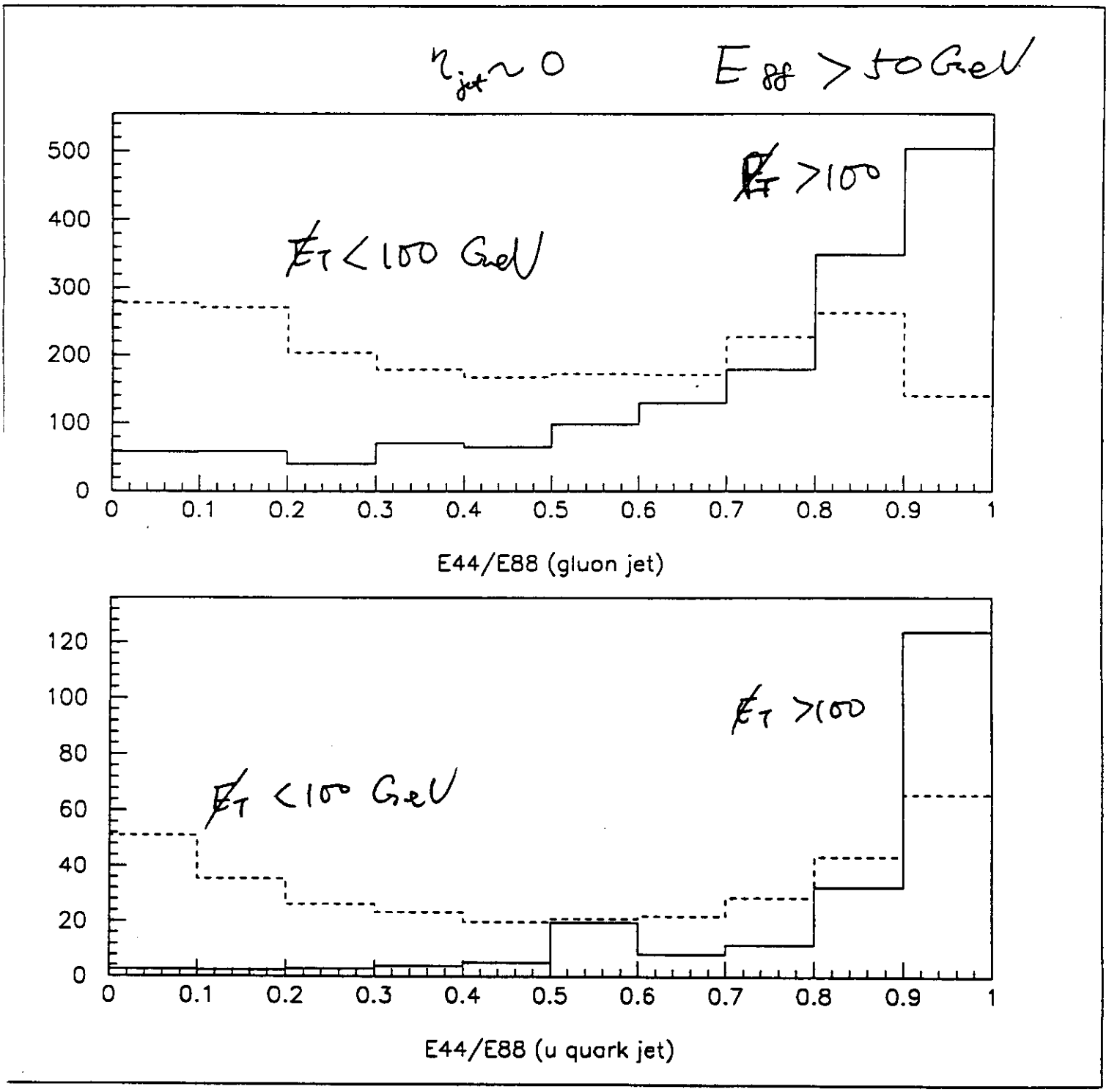
Quark 400GeV−6cm

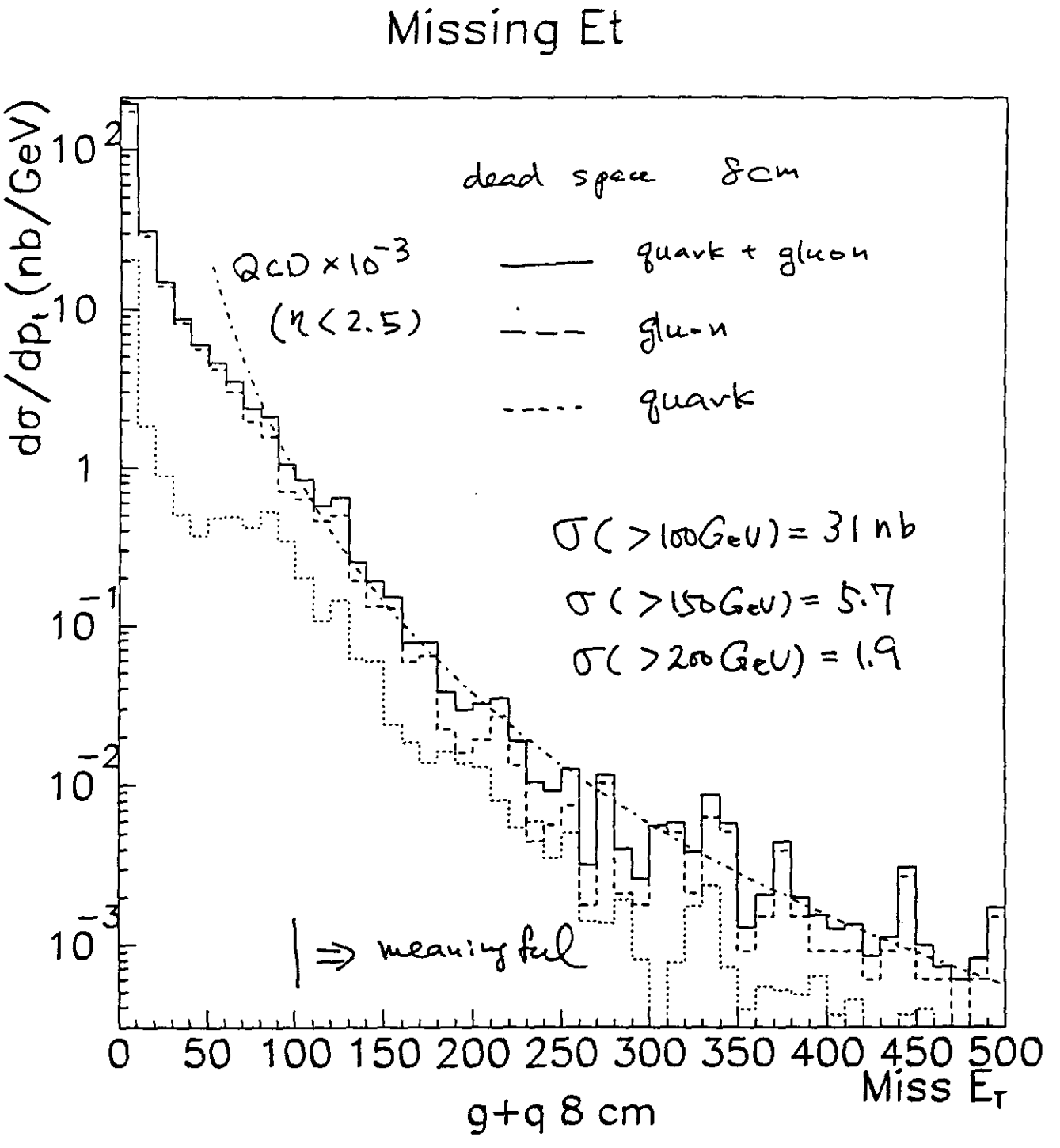


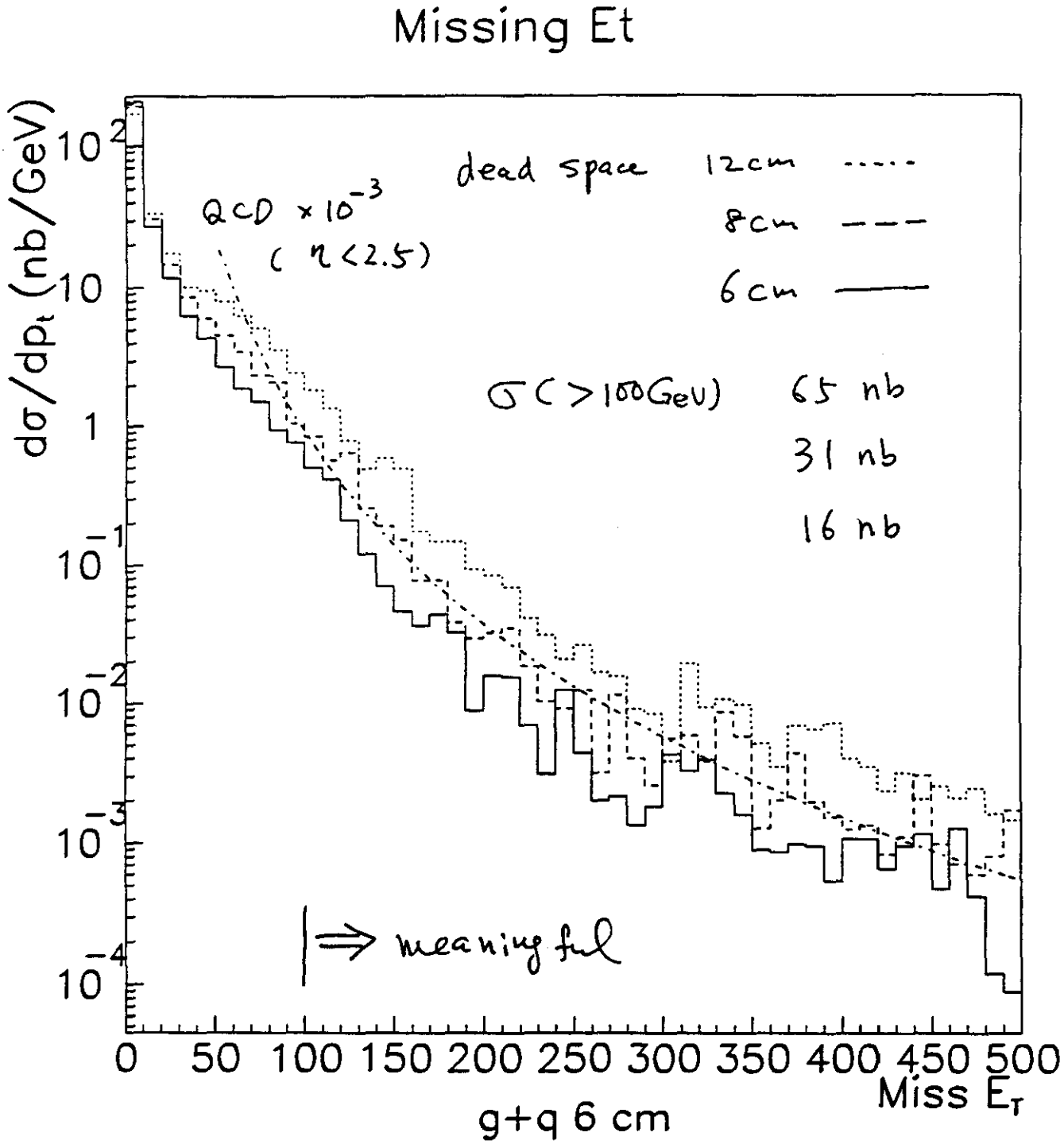
Quark 400GeV−8cm



Quark 400GeV−12cm


$\eta_{jet} \sim 0$
$E_{88} > 50$ GeV
$\not{E}_T > 100$
$\not{E}_T < 100$ GeV
500
400
300
200
100
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
E44/E88 (gluon jet)
120
100
80
60
40
20
0
$\not{E}_T > 100$
$\not{E}_T < 100$ GeV
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
E44/E88 (u quark jet)


Missing Et
dσ/dp_t (nb/GeV)
dead space 8cm
QCD × 10^-3
(η < 2.5)
quark + gluon
gluon
quark
σ(> 100GeV) = 31 nb
σ(> 150GeV) = 5.7
σ(> 200GeV) = 1.9
⇒ meaningful
Miss E_T
g+q 8 cm


Missing Et
dσ/dp_t (nb/GeV)
dead space 12cm
8cm
6cm
QCD ×10^-3
(η<2.5)
σ(>100GeV) 65 nb
31 nb
16 nb
⇒ meaningful
0 50 100 150 200 250 300 350 400 450 500
Miss E_T
g+q 6 cm

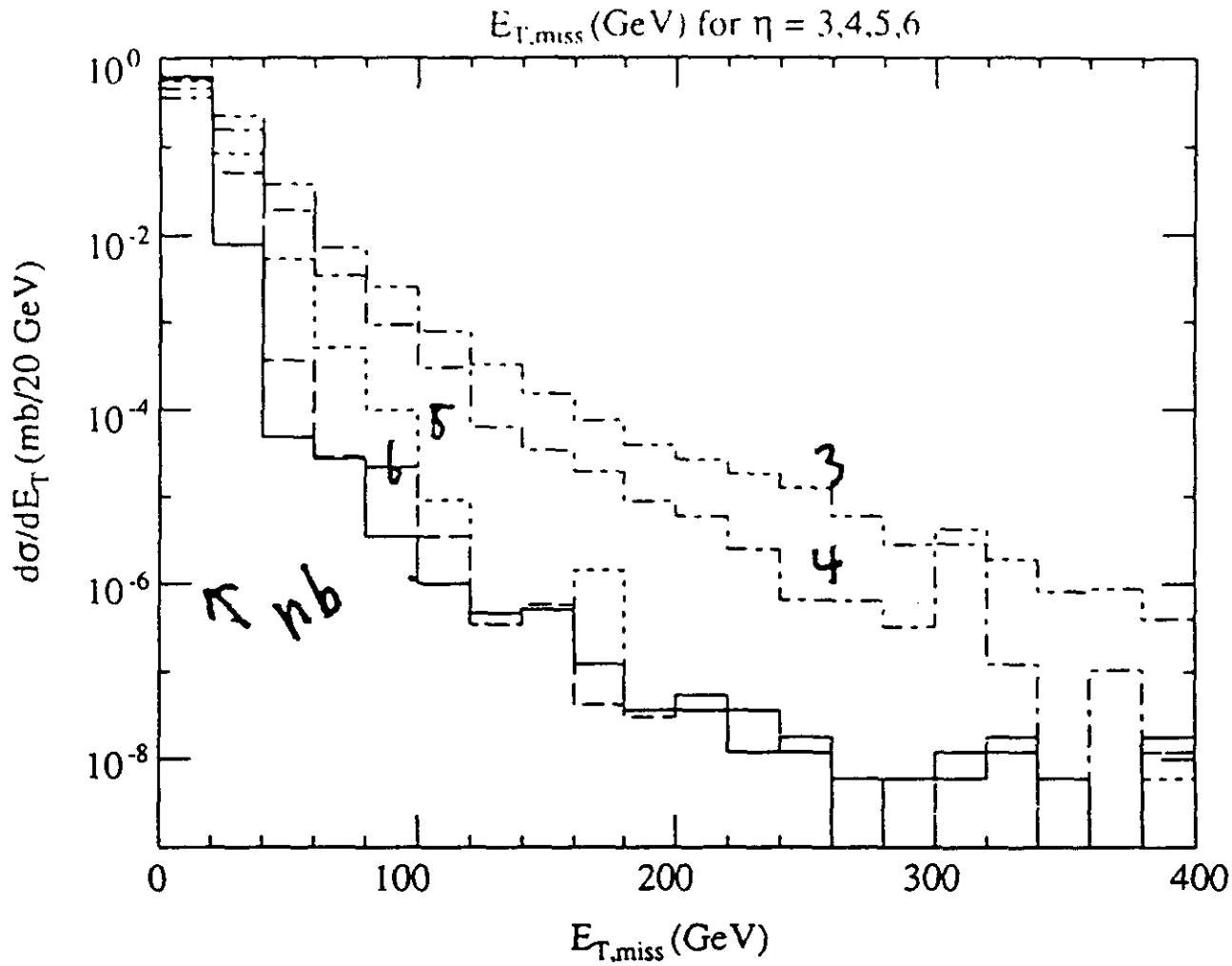


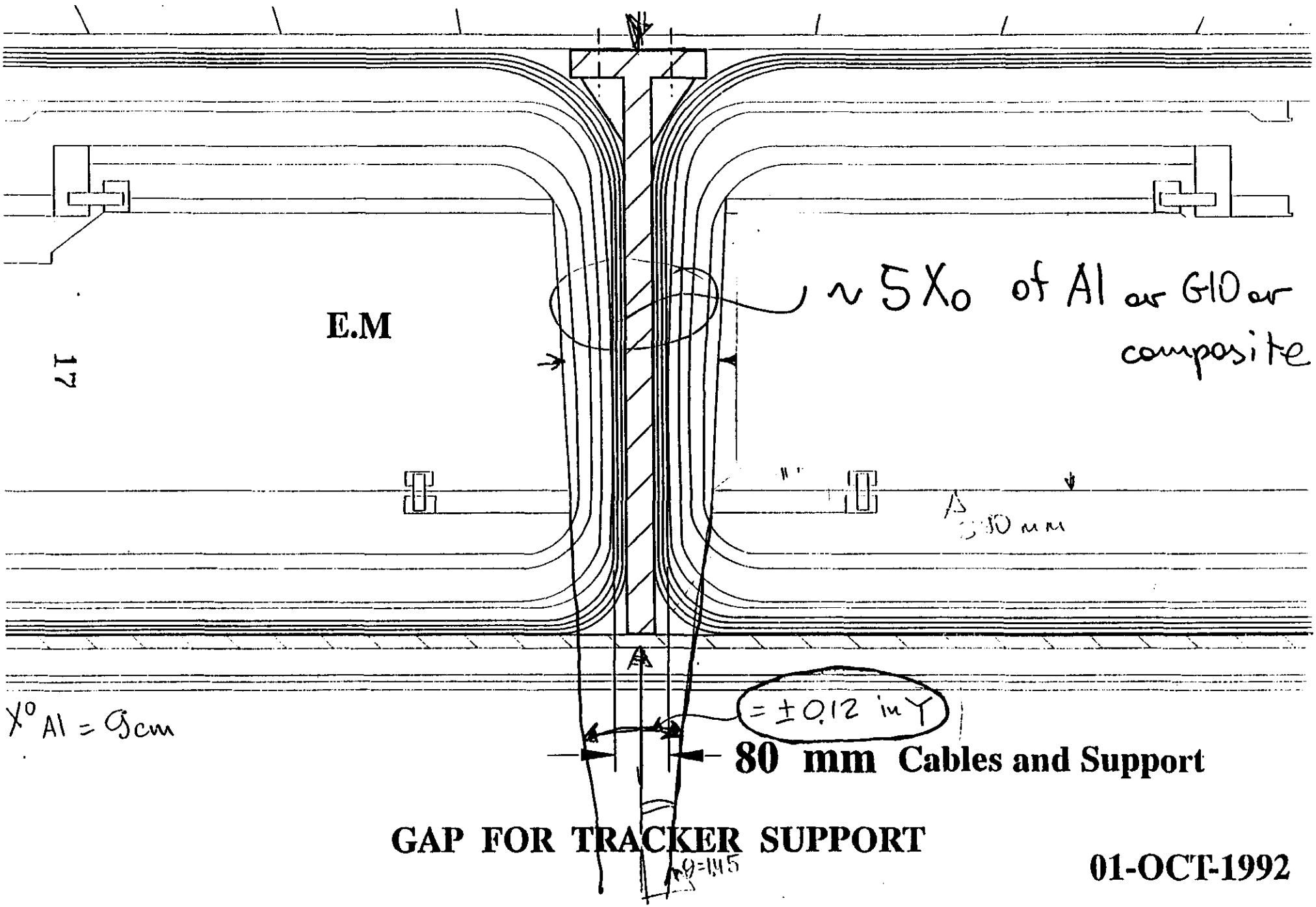
Figure 3.4-1 $\not{E}_T$ **distributions for an idealized calorimeter. Solid curve: sum of calorimeter, essentially the sum of the neutrinos. Broken curves: sums of clusters with E_T > 10GeV and η < 6, 5, 4, and 3 in order as curves are higher**

gem

γeμ

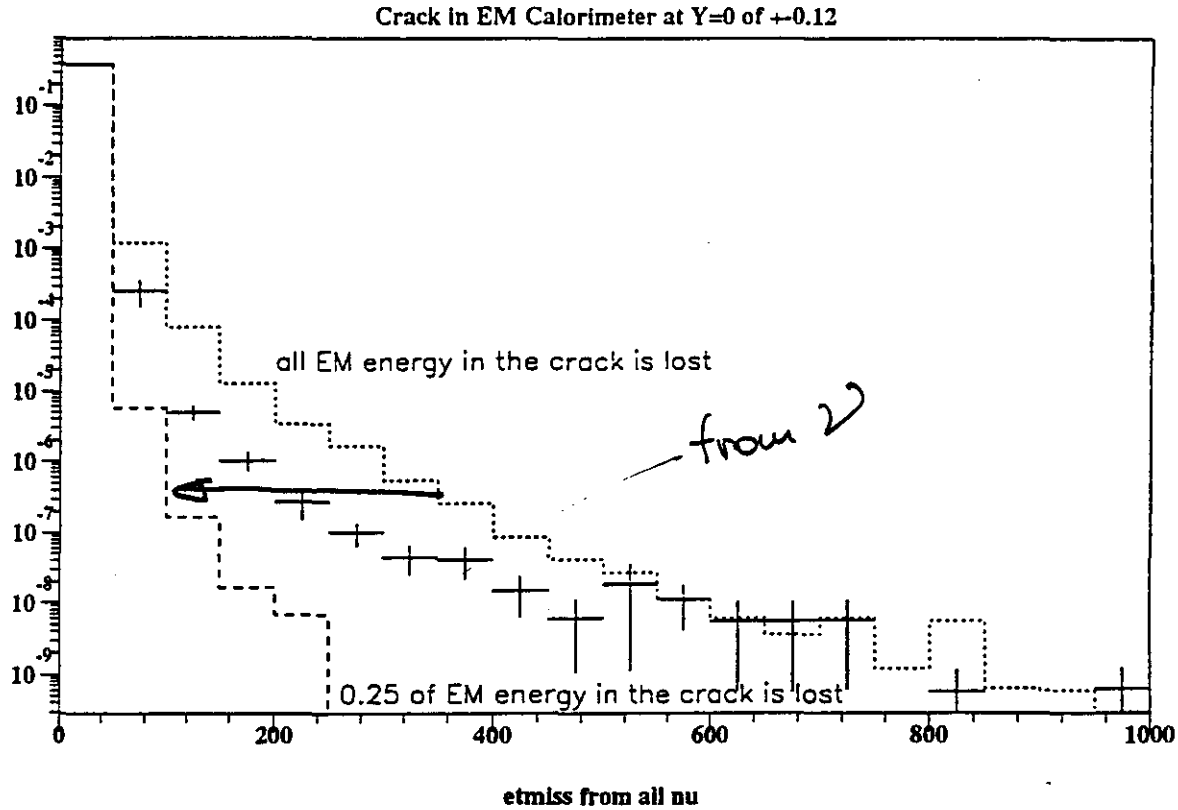
Presentation by:

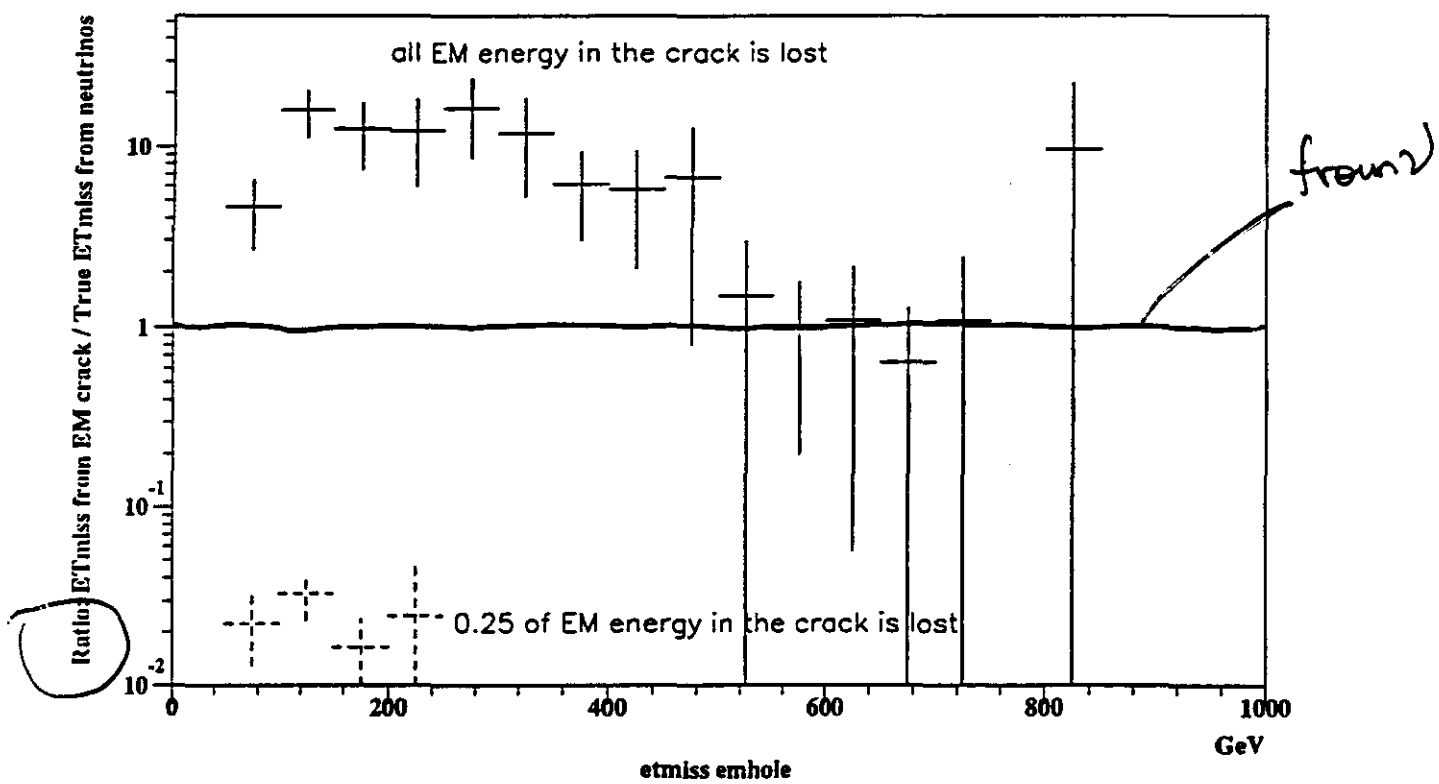
A. Vanyashin


E.M
~ 5 X0 of Al or G10 or composite
= ± 0.12 in Y
80 mm Cables and Support
X0 Al = 9cm
GAP FOR TRACKER SUPPORT
01-OCT-1992

EM resolution within crack : $\frac{100\%}{\sqrt{E}} \oplus 0.4\%$

92/10/07 11.5





EM+ HAD

92/10/04 20.02

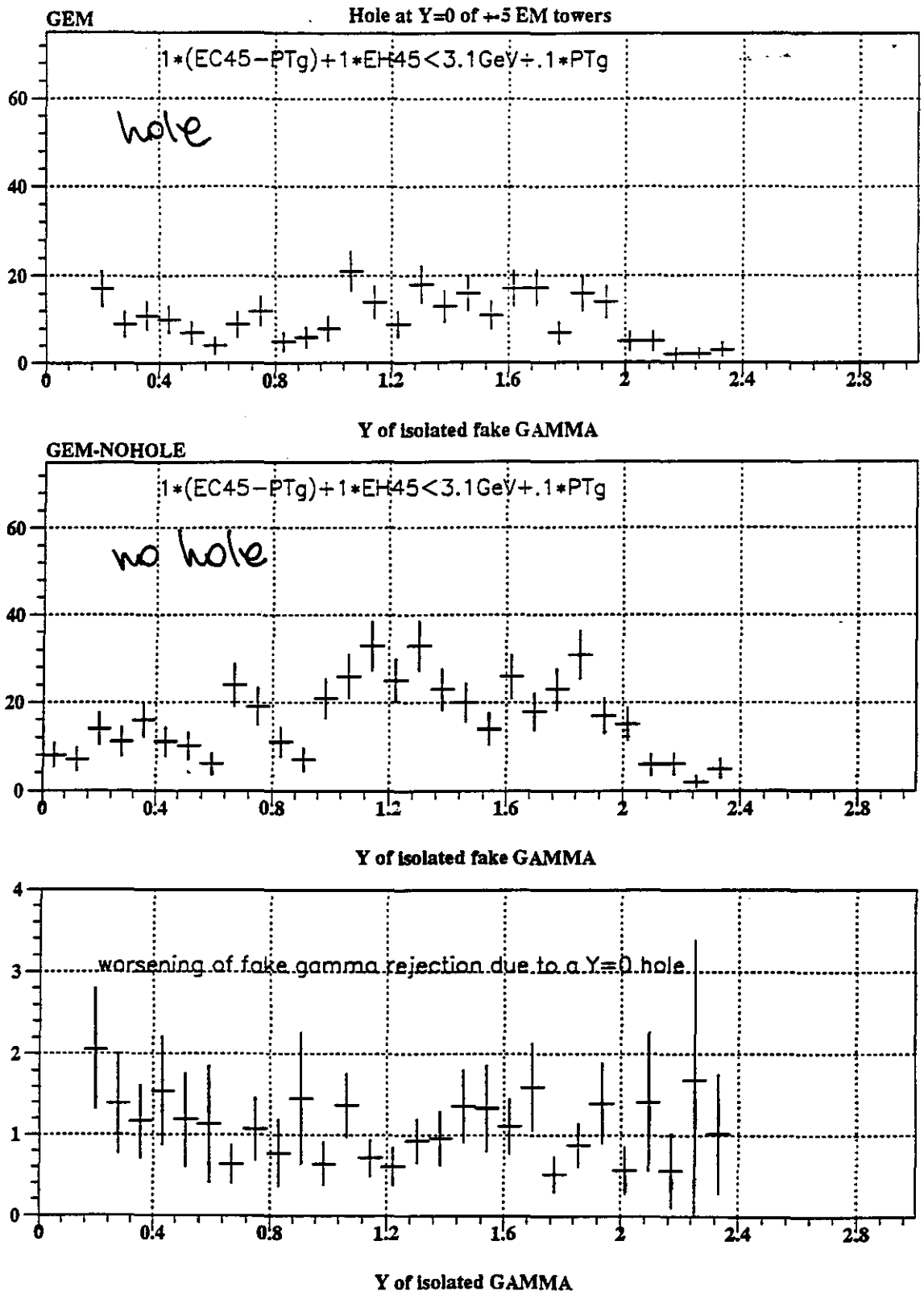


Figure 4: Worsening of isolated gamma rejection for the case when both EM and HAD calorimeters used in isolation cut of 3.1 GeV in 0.45 cone.

EM only

92/10/04 19.56

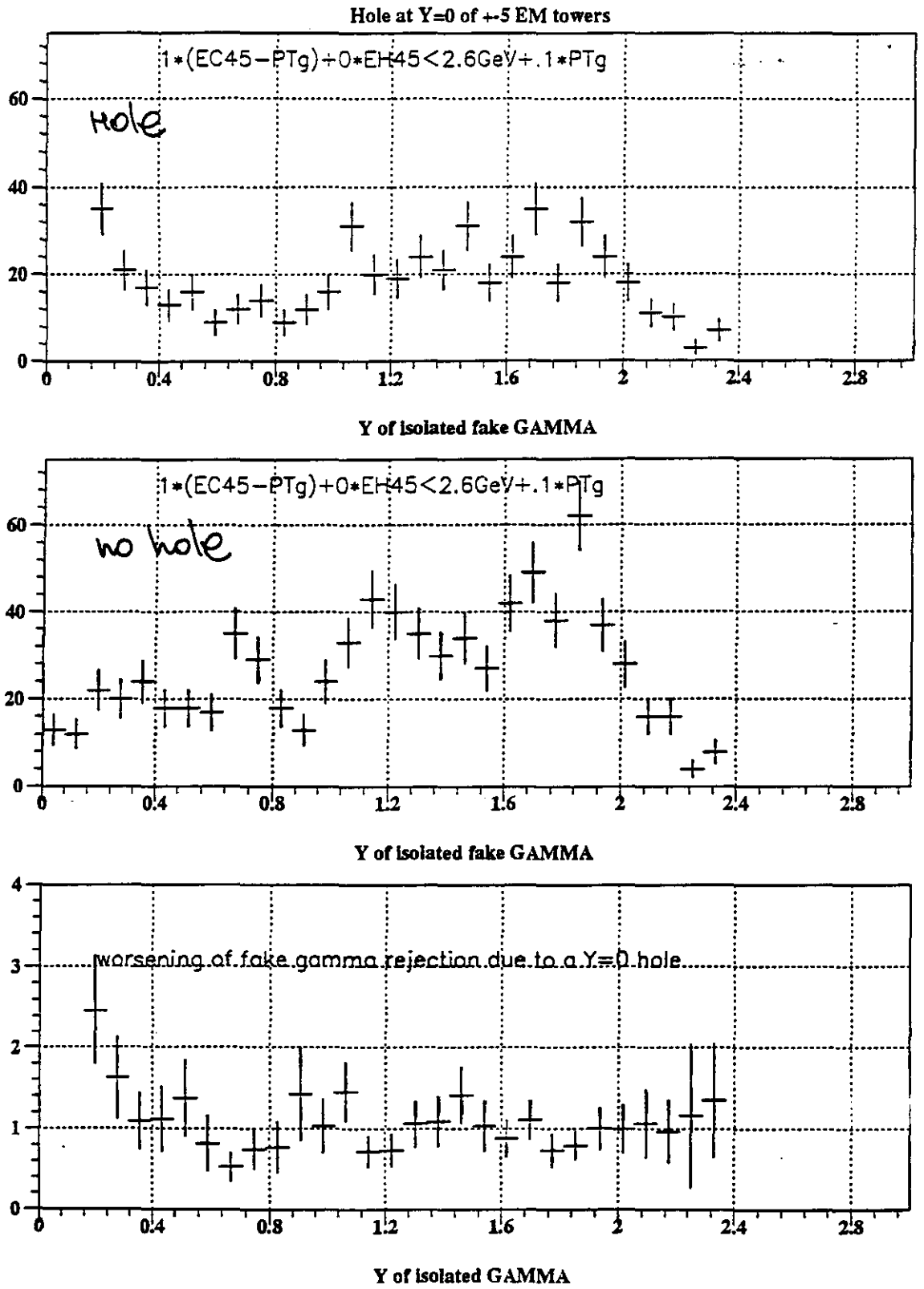


Figure 3: Worsening of isolated gamma rejection for the case when just EM calorimeter used in isolation cut of 2.6 GeV in 0.45 cone.

Y=0 crack effect:

zero EM energy in ±5 tower rows around Y=0

Isolation Cut

- Generate 2jets ~~per event~~ with PYTHIA5.6, deposit all EM energy and part of hadron energy (from GEANT) in calorimeter cells with ~~parametrized shower spread~~. Record cell numbers hitted by charged track with 8 kG field.

FAST!

- Search through all cells ($\Delta\eta \times \Delta\phi$=~~0.04 × 0.04~~ 0.033 × 0.033) to identify all cells hit by photons only, find E_T^{cell}.

- Charge Veto: if there is a charged track hitting neighboring 8 cells ⇒ **Reject**;

- Define the sum of E_T^{cell}'s of these 9 cells ($\sum_{9cells} E_T^{cell}$) as the E_T^{photon};

- Isolation Veto: if the sum of the transverse energies in a cone of radius R ($R=\sqrt{\Delta\eta^2+\Delta\phi^2}$), excluding the E_T^{photon}, is larger than 10% of the E_T^{photon} plus an isolation energy cut (E_T^{cut}).

$$\sum_{r<R} E_T - E_T^{photon} \geq (E_T^{cut} + 0.1 E_T^{photon}) \Rightarrow \textbf{Reject};$$

Figure 2: Isolation algorithm (GEM TN-92-126).

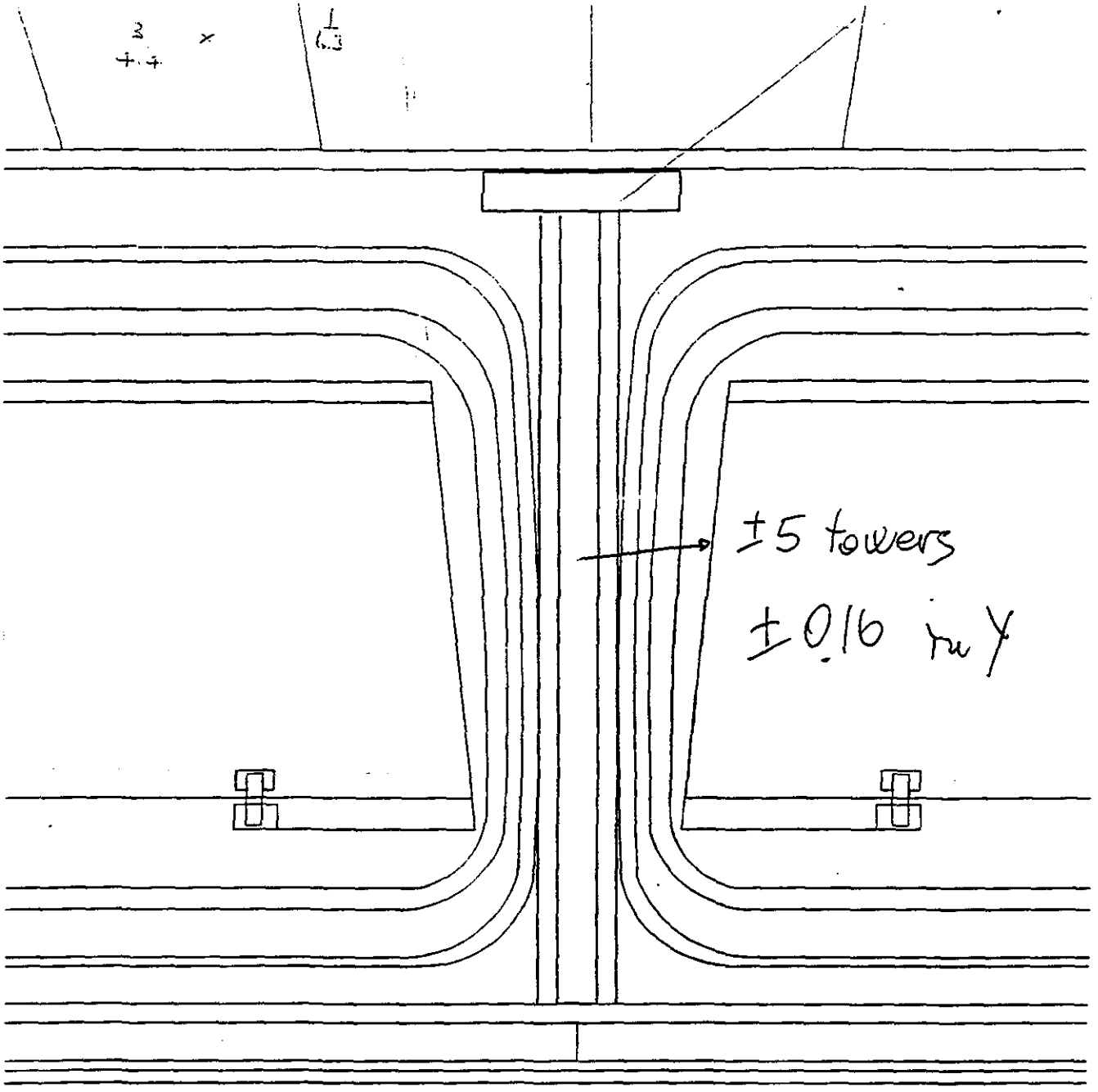
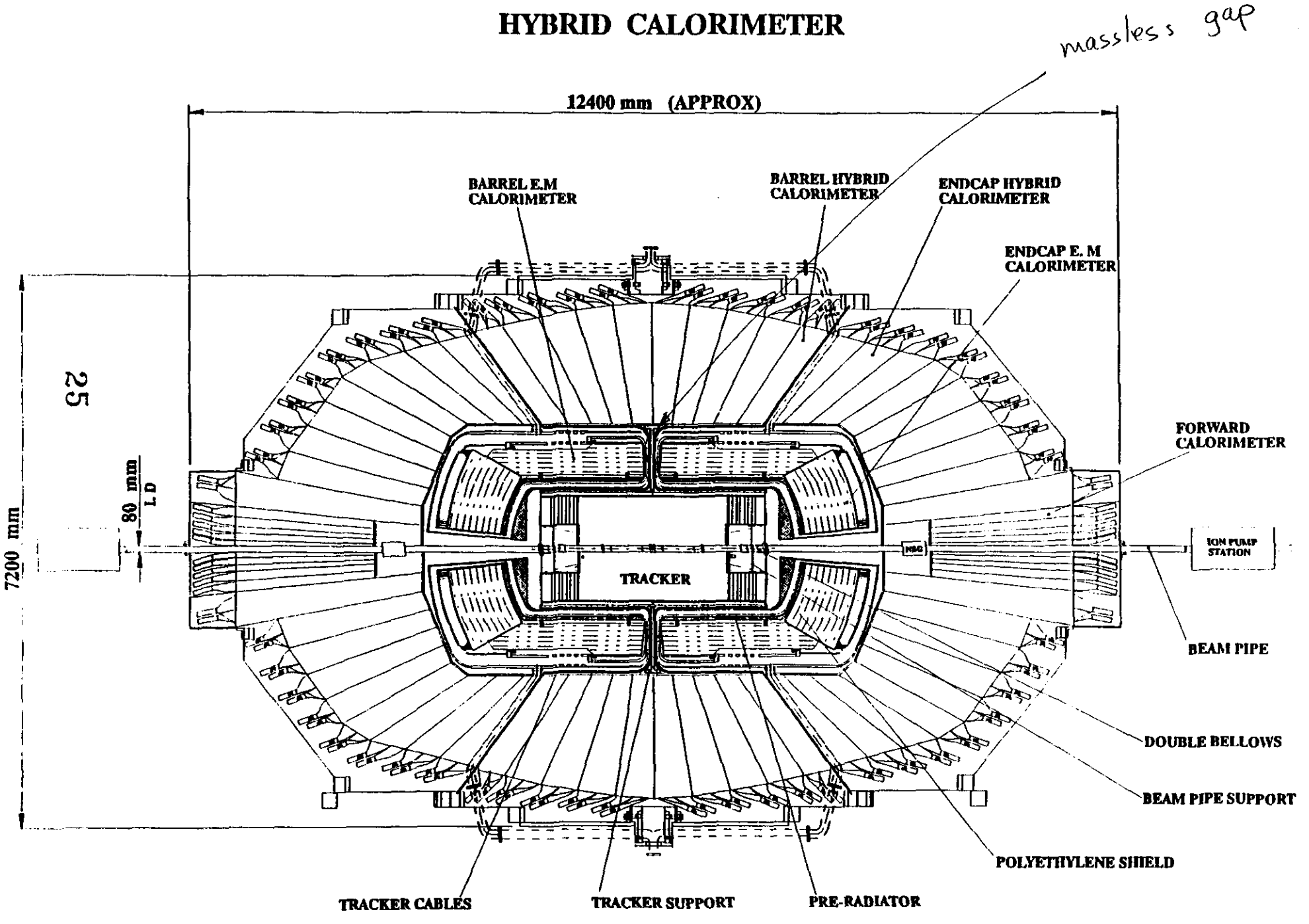


Figure 1: Possible "two cups" design of GEM LKr EM calorimeter for the Hybrid Option.

Presentation by:

Yu. Kamyshkov

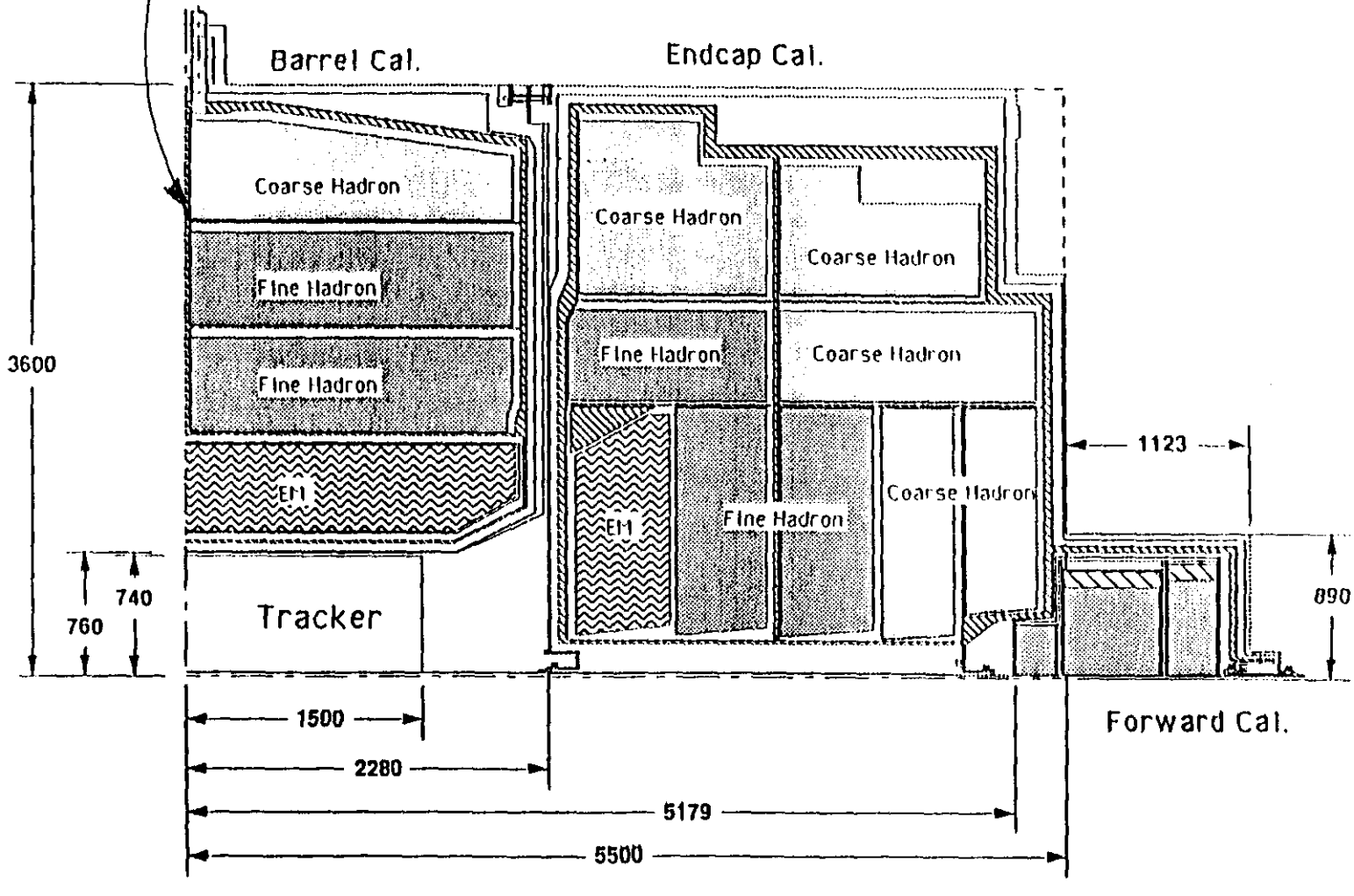
HYBRID CALORIMETER



SCALE: 0.015 GDD-000088 06-OCT-1992

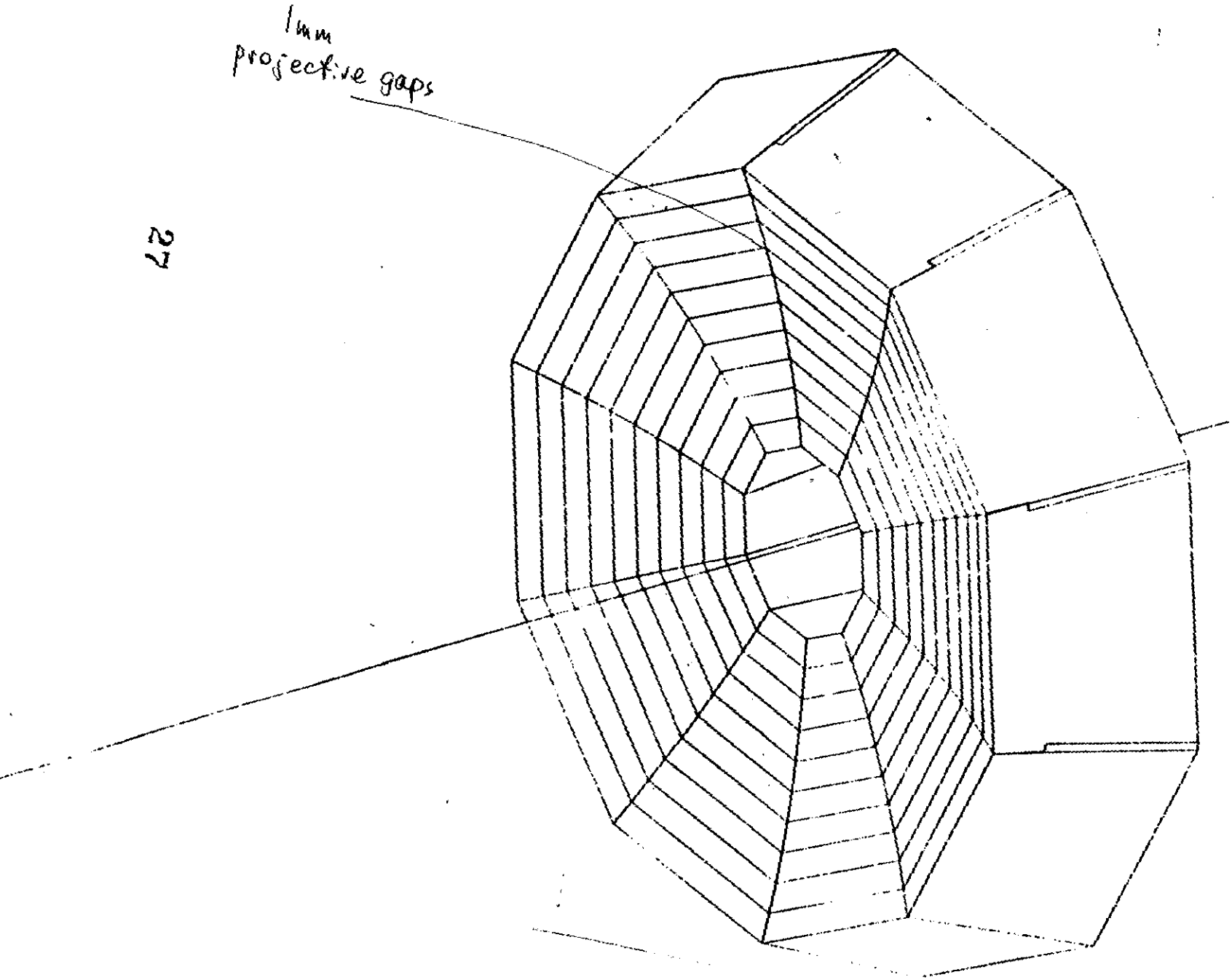
projective crack

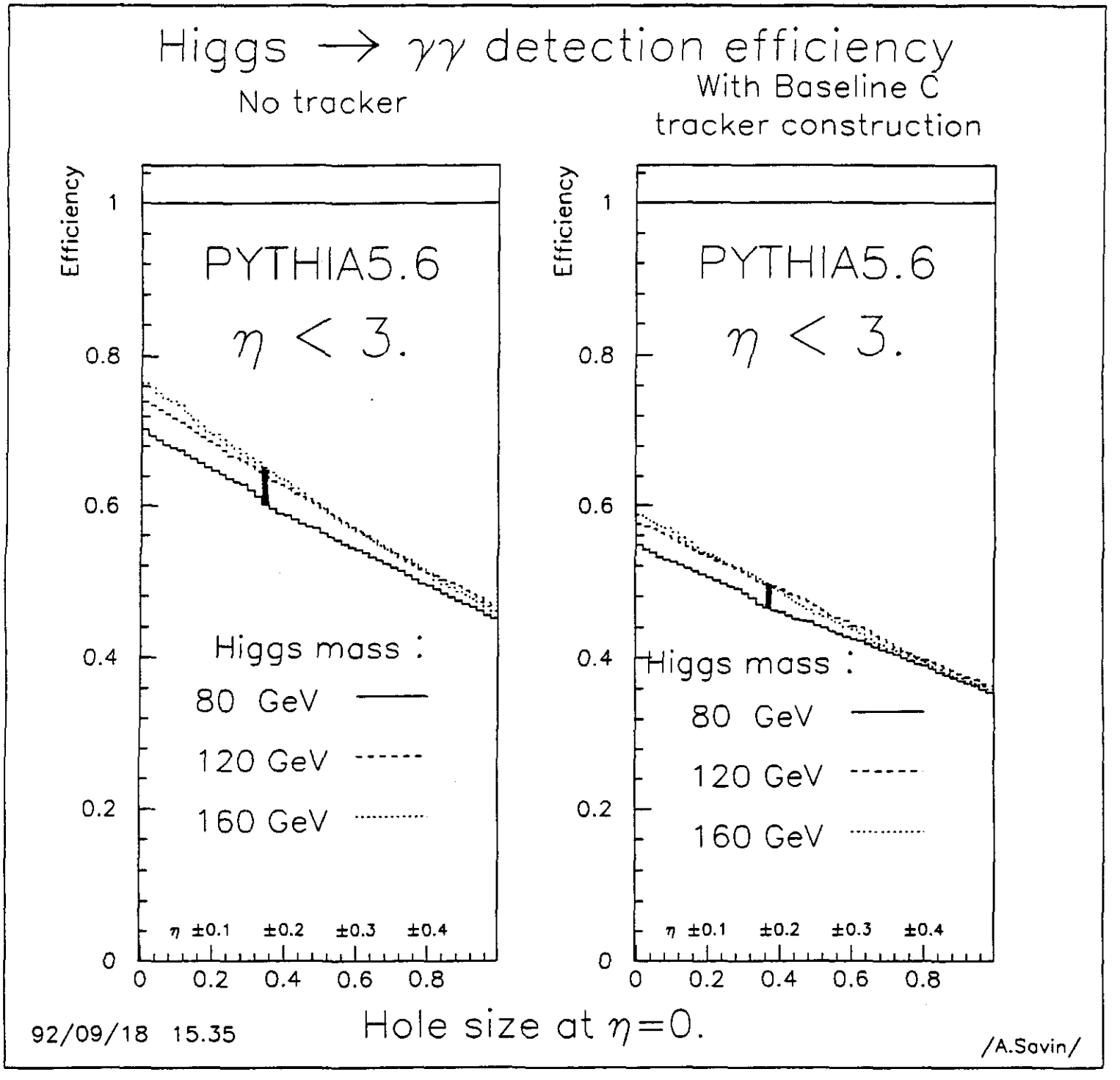
LIQUID ARGON CALORIMETER - 12 X 14 LAMBDA, FLAT ENDCAP HEAD

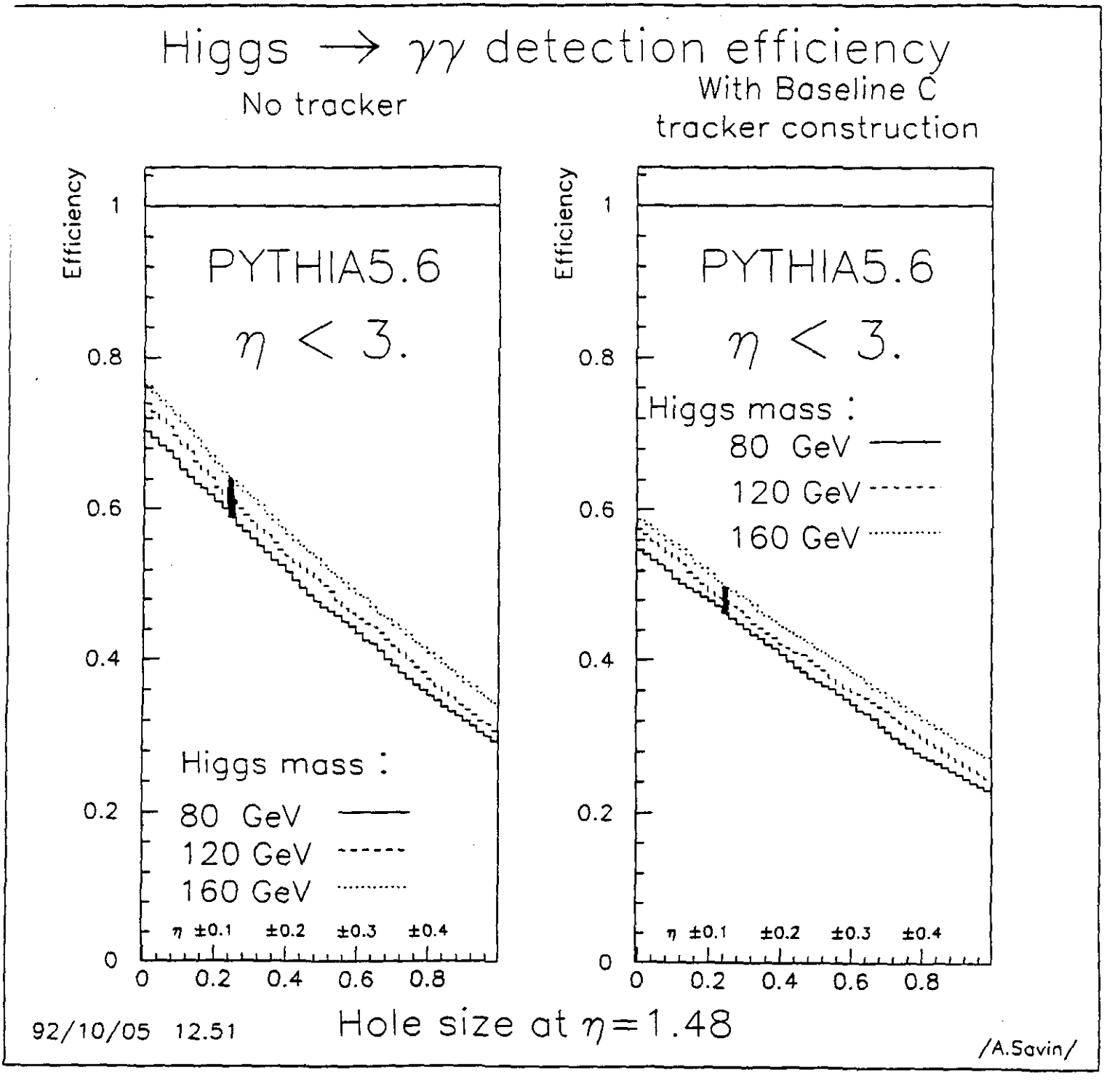


Dimensions in millimeters

LLMASON 920520 BASEL NE


1mm
projective gaps


Higgs → γγ detection efficiency
No tracker
With Baseline C
tracker construction
Efficiency
PYTHIA5.6
η < 3.
Higgs mass :
80 GeV
120 GeV
160 GeV
η ±0.1 ±0.2 ±0.3 ±0.4
0 0.2 0.4 0.6 0.8 1
0 0.2 0.4 0.6 0.8
92/09/18 15.35
Hole size at η=0.
/A.Savin/


Higgs → γγ detection efficiency
No tracker
With Baseline C
tracker construction
Efficiency
PYTHIA5.6
η < 3.
Higgs mass :
80 GeV
120 GeV
160 GeV
η ±0.1 ±0.2 ±0.3 ±0.4
0 0.2 0.4 0.6 0.8 1
0 0.2 0.4 0.6 0.8
92/10/05 12.51
Hole size at η=1.48
/A.Savin/

gem

γeμ

Presentation by:

A. Golutvin

ISOLATION FOR TWO OPTIONS OF HCAL

EC = LKr

1). INTEGRATED OPTION

HC = LAr

$\sigma_{\text{thermal noise}}$ = 130 MeV (per cell)

Integration time = 100 ns

2). „IDEAL" HCAL

Energy resolution = Scint. option

No thermal noise

Integration time = 16 ns

(i.e. pile up from single bunch crossing)

SIMULATION HAS BEEN DONE FOR $L = 10^{33}$

$L = 10^{34}$ — ?

INITIAL CUTS :

1). 2 γ WITH $E_t(5\times5) > 20$ GeV

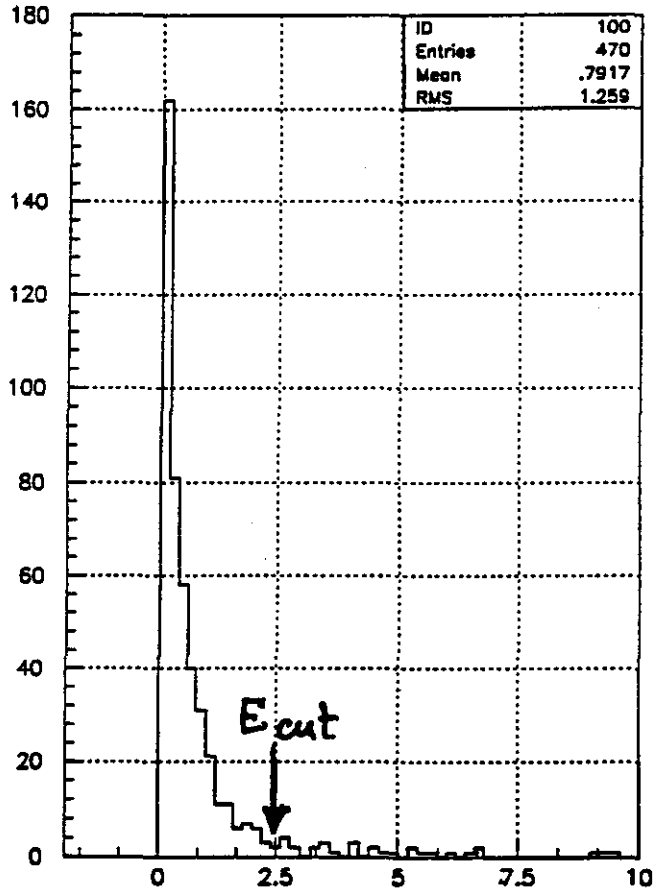
2). $|\eta^\gamma| < 2.5$

3). $E_{HC}(3\times3) / E_{EC}(5\times5) < 0.1$

$E_{HC}(3\times3)$ — 3×3 sum in HCAL just behind EC CLUSTER

HCAL: $H \to \gamma\gamma$

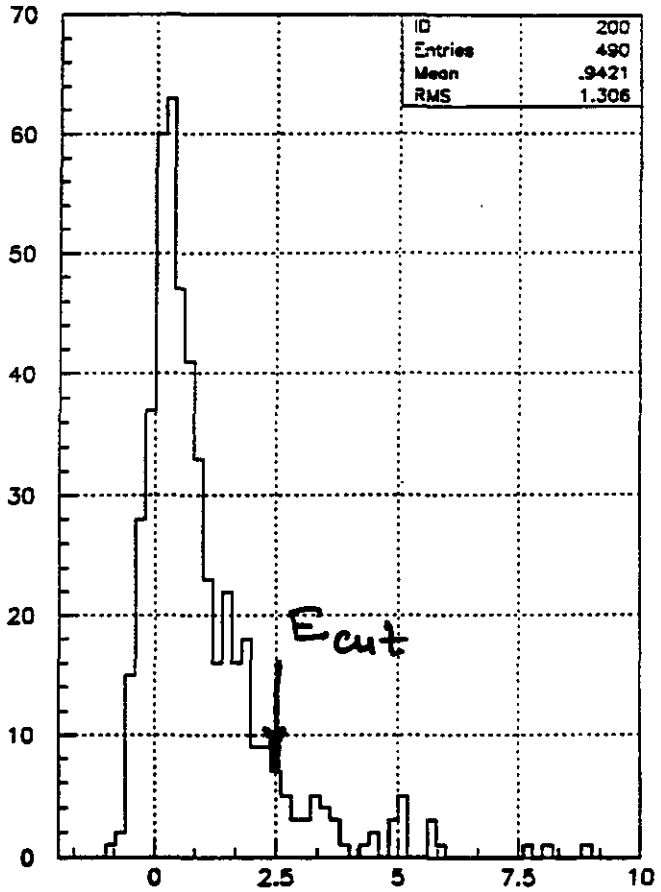
IDEAL HC



E_{cone} [GeV]
R = 0.45

SUM OVER ALL CELLS

LAr

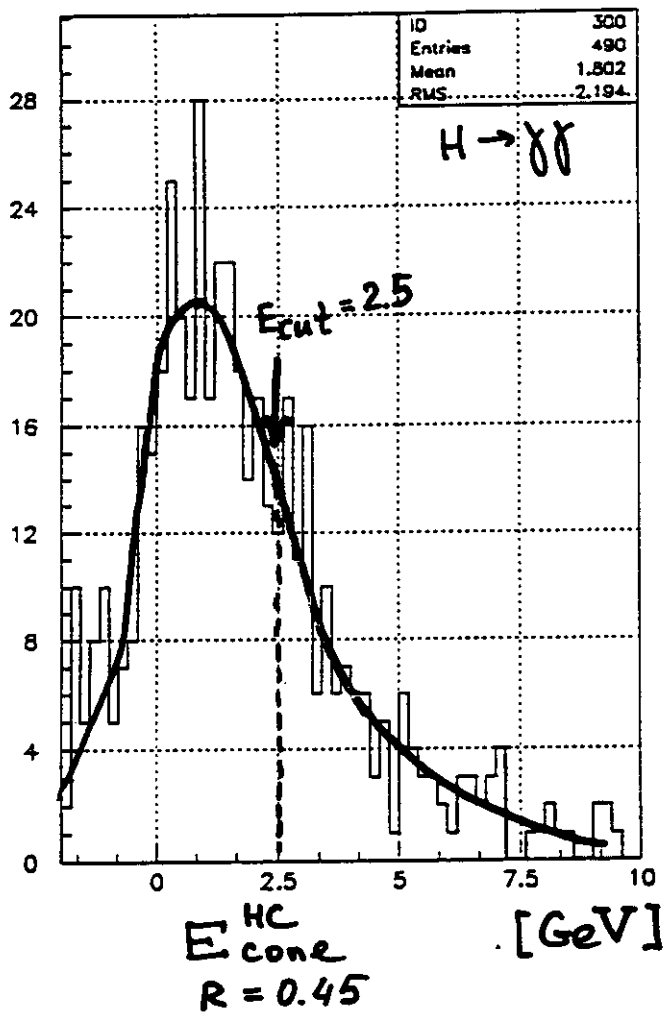


E_{cone} [GeV]
R = 0.45

SUM OVER THE CELLS WITH $E > 3\sigma$ (thermal + pile up)

TO KEEP THE EFFICIENCY FOR $H \to \gamma\gamma$ AT THE LEVEL $> 90\%$ $E^{HC}_{cone} < 2.5$ GeV FOR BOTH OPTIONS

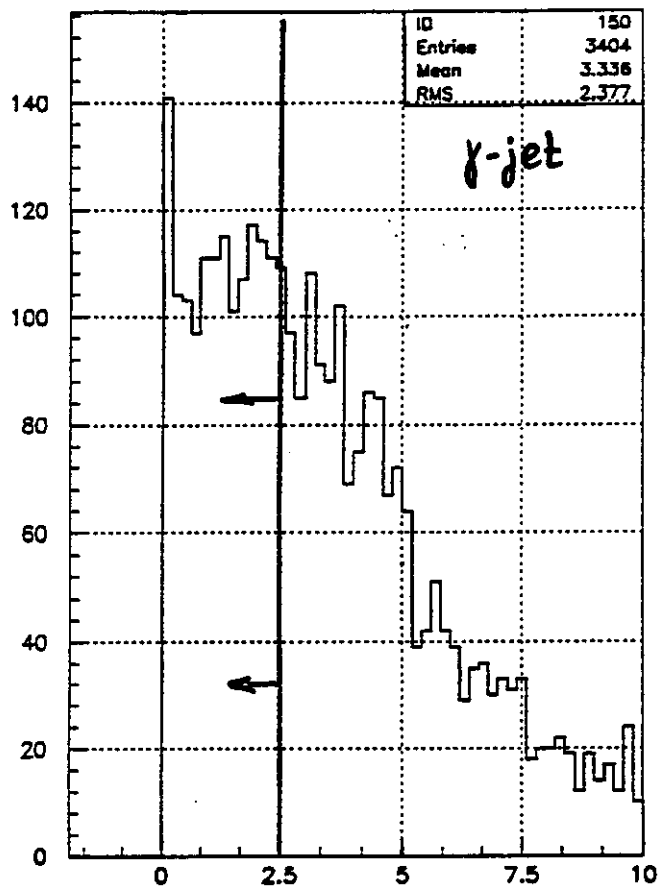
HC = LAr



Sum over all cells

BACKGROUND FROM γ-jet EVENTS

IDEAL HC

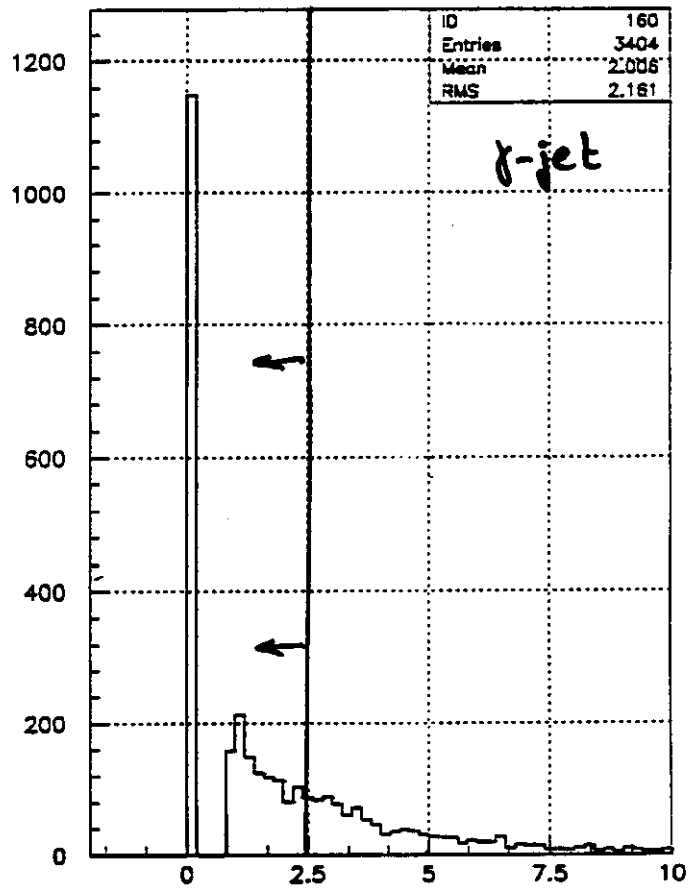


E^{HC}_{cone} [GeV]

R = 0.45

Σ OVER ALL CELLS

LAr



E^{HC}_{cone} [GeV]

R = 0.45

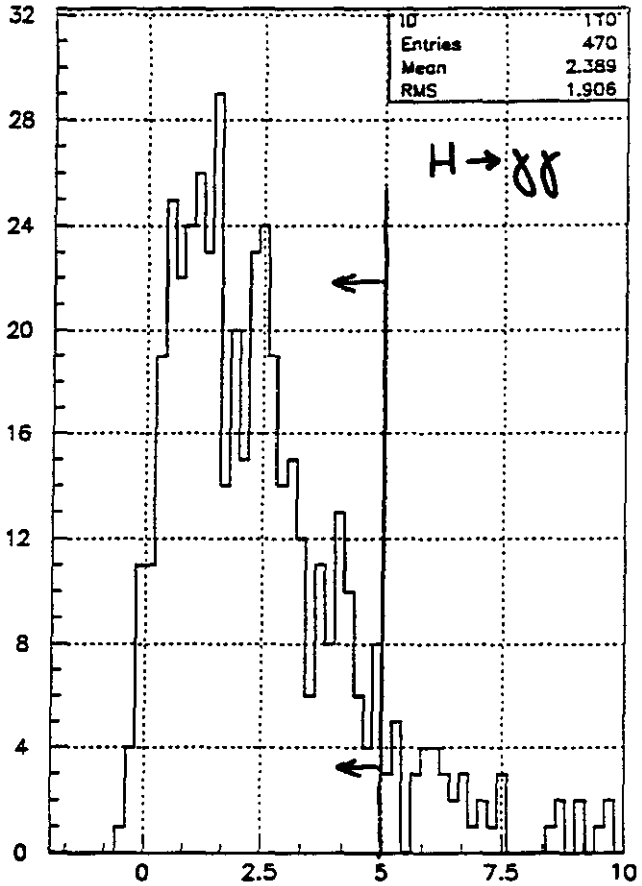
Σ OVER CELLS WITH E > 3i

BACKGROUND SUPPRESSION WITH E^{HC}_{cone} < 2.5 GeV

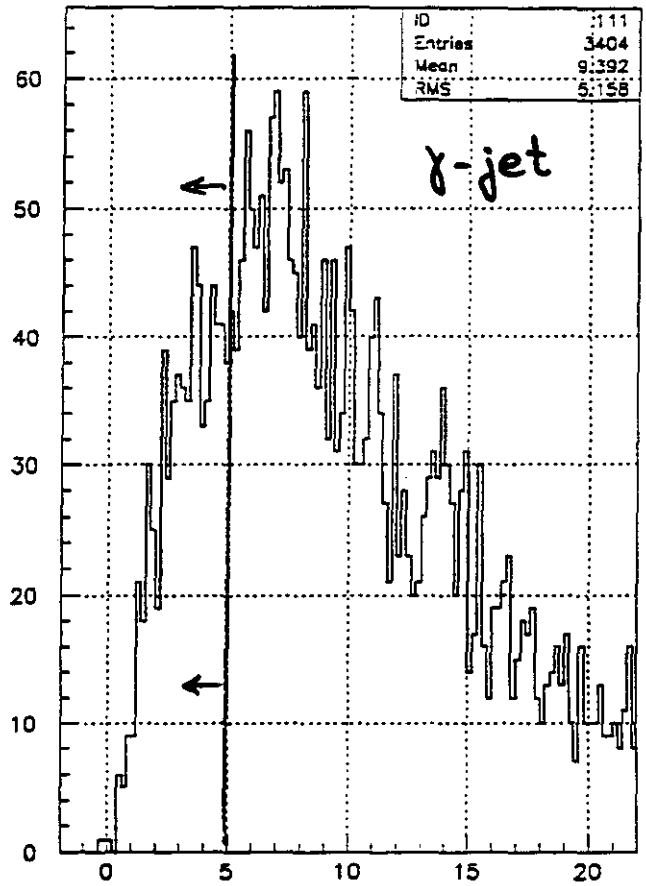
IDEAL HC — 2.2

LAr — 1.6

ISOLATION CUT IN ECAL (LKr)



$E_{cone} - E_{t\gamma}$ [GeV]
R = 0.45



$E_{cone} - E_{t\gamma}$ [GeV]
R = 0.45

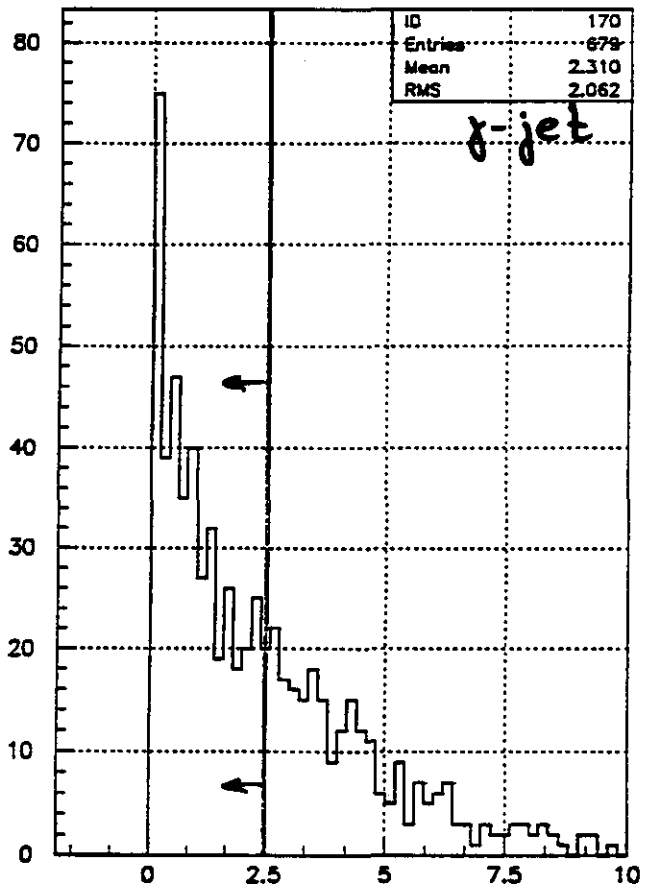
($\sum_R$ OVER THE CELLS WITH $E > 2\sigma_{thermal + pileup}$)

$$E^{EC}_{cone} < 5 \text{ GeV}$$

ISOLATION IN HC AFTER ISOLATION IN EC

$(E_{cone}^{EC} < 5\,GeV)$

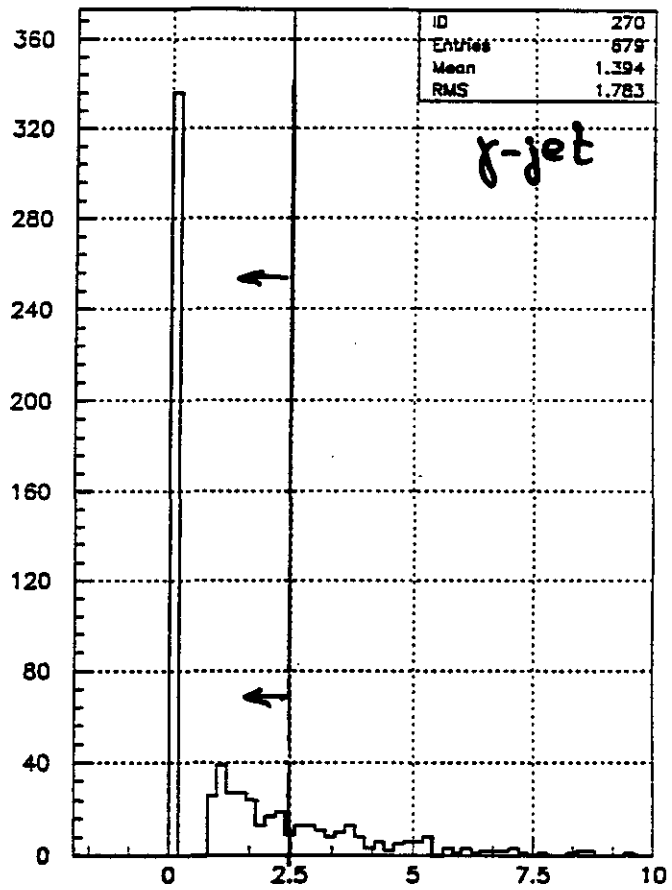
IDEAL HC



E_{cone}^{HC} [GeV]
R=0.45

Σ OVER ALL CELLS

LAr



E_{cone}^{HC} [GeV]
R=0.45

Σ OVER CELLS WITH E>3.

BACKGROUND SUPPRESSION : $(E_{cone}^{HC} < 2.5\,GeV)$

IDEAL HC — 1.6

LAr — 1.3

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Presentation by:

K. Lane

3.4 FAST Physics Simulations for the Technical Design Report

The principal design goals of the GEM detector remain precise measurements of electromagnetic energy and muon momenta with systems robust enough to operate well above the nominal SSC design luminosity. Hadronic energy will be well-measured over the central region, $|\eta| \lesssim 3.0$. Central tracking coverage to $|\eta| = 2.5$ will be an important adjunct to the calorimeter, helping to realize its potential for electromagnetic energy measurement over the entire range of energies, from 25 GeV to several TeV, and up to ultrahigh luminosity. Forward calorimeter coverage to $|\eta| \simeq 5.5$ will determine $\not{E}_T > 100\,\mathrm{GeV}$ with adequate accuracy.

In preparation for the Technical Design Report, technology choices for the GEM calorimeter, muon, and tracking systems will be made by September. With the major elements of the GEM design essentially frozen until the TDR, a FAST parameterization of this "final" version will be executed. The GEM Physics Group then will study an extensive set of processes chosen both for their usefulness in testing the broadest possible range of GEM capabilities and for their physics interest. This effort has two goals: (1) To provide feedback on detector performance to the designers in a timely enough fashion to influence the design and enhance the physics performance of the detector. (2) To provide as accurate as possible a picture of the expected performance capabilities of all of GEM's major subsystems. The processes we plan to study are listed below. Many of them are familiar from recent submissions (including this report) by GEM and other collaborations. Other processes have not received detailed scrutiny before and will require encoding in the event generators.

3.4.1 Standard Model Higgs Physics

1. $H^0 \to \gamma\gamma$ ($M_H \cong 80 - 150\,\mathrm{GeV}$)
2. $t\bar{t} + H^0 \to \ell\gamma\gamma + X$ ($M_H \cong 80 - 150\,\mathrm{GeV}$).
3. $H^0 \to Z^0 Z^0 \to \ell^+\ell^-\ell^+\ell^-$ for $\ell = e, \mu$ ($M_H \cong 140 - 800\,\mathrm{GeV}$).
4. $H^0 \to Z^0 Z^0 \to \ell^+\ell^-$ jet jet ($M_H \simeq 800\,\mathrm{GeV}$).
5. $H^0 \to Z^0 Z^0 \to \ell^+\ell^-\nu\bar{\nu}$ ($M_H \simeq 800\,\mathrm{GeV}$).

3.4.2 Heavy Flavor Physics

+ $m_t = 140$ GeV

1. $t\bar{t}$ production for $m_t \simeq 250\,\mathrm{GeV}$ in standard ($t \to W^+ b$) and non-standard ($t \to H^+ b$) decay modes and mass measurement via the $M_{\ell\mu}$ and multijet distributions.

→ Polarization of W_{70} in $t \to Wb$?

2. Leptoquark pair-production gg, $\bar{q}q \to \pi_{\overline{L}Q}\pi_{\overline{Q}L}$, with decays to heavy flavors such as $\pi_{\overline{L}Q} \to \tau^+ b$ and $\mu^+ b$.
3. Single technieta production, $gg \to \eta_T \to t\bar{t}$.
4. Color-octet technihadron production, gg, $\bar{q}q \to \rho_T^8 \to \pi_{\overline{Q}Q}\pi_{\overline{Q}Q}$ with technipion decays to heavy quark pairs, e.g., $\pi_{\overline{Q}Q} \to b\bar{b}$, $t\bar{b}$, $t\bar{t}$.

3.4.3 Jet Physics

1. Quark substructure in high-p_T and invariant mass jet production (deviation from QCD cross sections at $p_T \gtrsim 4$ TeV). — Effect on Structure Fns.
2. Color-octet technirho or axigluon resonances in dijet production, gg, $\bar{q}q \to \rho_T^8 \to$ jet jet.
3. Color-octet technihadron production, gg, $\bar{q}q \to \rho_T^8 \to \pi_{\overline{Q}Q}\pi_{\overline{Q}Q}$ with technipion decays to light quark pairs.
4. $\widetilde{gg}$ detection via a complicated multijet signature.

3.4.4 Physics at Ultrahigh Luminosity

1. Signal and backgrounds for quark – lepton substructure at the scales $\Lambda \gtrsim 25$ TeV in the Drell-Yan process $\bar{q}q \to \mu^+\mu^-$.
2. Signal and backgrounds for quark – lepton substructure at the scales $\Lambda \gtrsim 25$ TeV in the Drell-Yan process $\bar{q}q' \to \mu^\pm\nu$. Chiral structure of the contact interaction will be probed via the η_μ distribution.
3. Signal and backgrounds for $Z'^0 \to \ell^+\ell^-$, with $\ell^\pm = e^\pm, \mu^\pm$. Precision measurements of the mass and width (via e^+e^-) and asymmetries (via $\mu^+\mu^-$); determination of the reach in $M_{Z'}$.
4. Signal and backgrounds for $W'^\pm \to \ell^\pm\nu_\ell$. Precision measurements of the mass, width and asymmetry; determination of the reach in $M_{W'}$.
5. Signal and backgrounds for color-singlet $\rho_T^\pm \to Z^0W^\pm \to \ell^+\ell^-\ell^\pm + \not{E}_T$ and $\ell^+\ell^-$ jet jet.

3.4.5 Other Topics

1. Neutral and charged Higgs-like color-singlet scalars (H'^0) and ($H^\pm$) found in extensions of the standard model, supersymmetry and technicolor.

(a) $H'^0 = h^0, \pi_T^0 \to \gamma\gamma$ ($M_{H'^0} < 2M_W$).

(b) $t \to H^+ b$, for $m_t > M_{H^+}$, with $H^+ \to c\bar{s}$ and $\tau^+\nu_\tau$.

(c) Electroweak pair-production of H^+H^-, with $H^+ \to t\bar{b}$ ($M_{H^+} > m_t$).

2. $H^0 \to \ell^+\ell^-\tau^+\tau^-$ at $M_H \simeq 800\,\mathrm{GeV}$.

3. Alternatives to $H^0 \to \gamma\gamma$ will be studied for the intermediate mass Higgs and similar particles (h^0 and π_T^0). Some possibilities are $gg \to H^0 \to \tau^+\tau^-$ and $t\bar{t} \to t\bar{t}H^0$ with $H^0 \to \tau^+\tau^-$ and/or $b\bar{b}$.

4. For either technical or financial reasons, certain subsystems or parts of subsystems may have to be staged. We need to determine alternative search modes and evaluate the backgrounds for new physics processes whose discovery is threatened by staging.

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Presentation by:

N. Mokhov

INTERFERENCE OF COLLIDER AND DETECTORS

Presented

by

Nikolai Mokhov

October 7, 1992

- Beam Loss and Source Term in the IRs
- Detectors and Experimental Halls
- Collimator and Low-beta Quads
- Neutral Beam Dump
- Long Range Beam Loss and Collimators

SOURCE TERM IN INTERACTION REGIONS

- <u>20×20 TeV pp collisions</u> at 10^8 Hz (10^{33} $cm^{-2}s^{-1}$)

  Three components: $x_F < 0.8$ secondaries

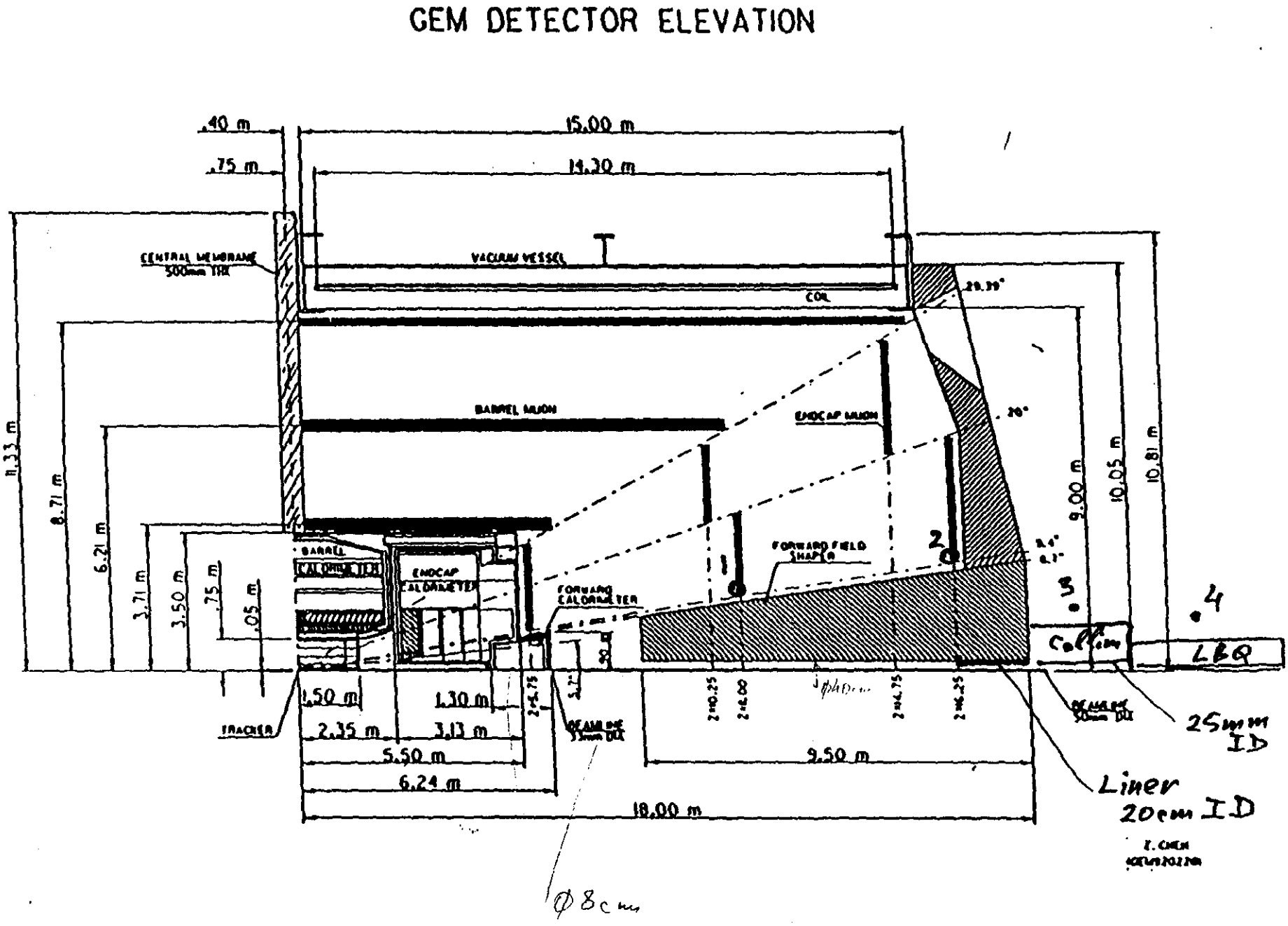
  $x_F > 0.8$ charge particles (protons)

  $x_F > 0.8$ neutrals

- <u>Beam Halo</u> - Low-beta quads are a bottleneck for halo particles, so even with scrapers and collimators in the system on, they will experience increased beam loss, being a source of background to detector

  At $\beta^* = 0.5$ m $\beta_{peak} = 9180$ m. For 50 mm bore quadrupoles with 42mm beam pipe, LBQ aperture is +/- 30 σ. So, at maximum one can expect ~ 10^7 Hz beam loss rate at these locations

- <u>Accidental Beam Loss</u> $(1.3 - 4) \times 10^{14}$ ppp



GEM Detector Layout Showing Top Right Quadrant

PARTICLE BACKGROUND

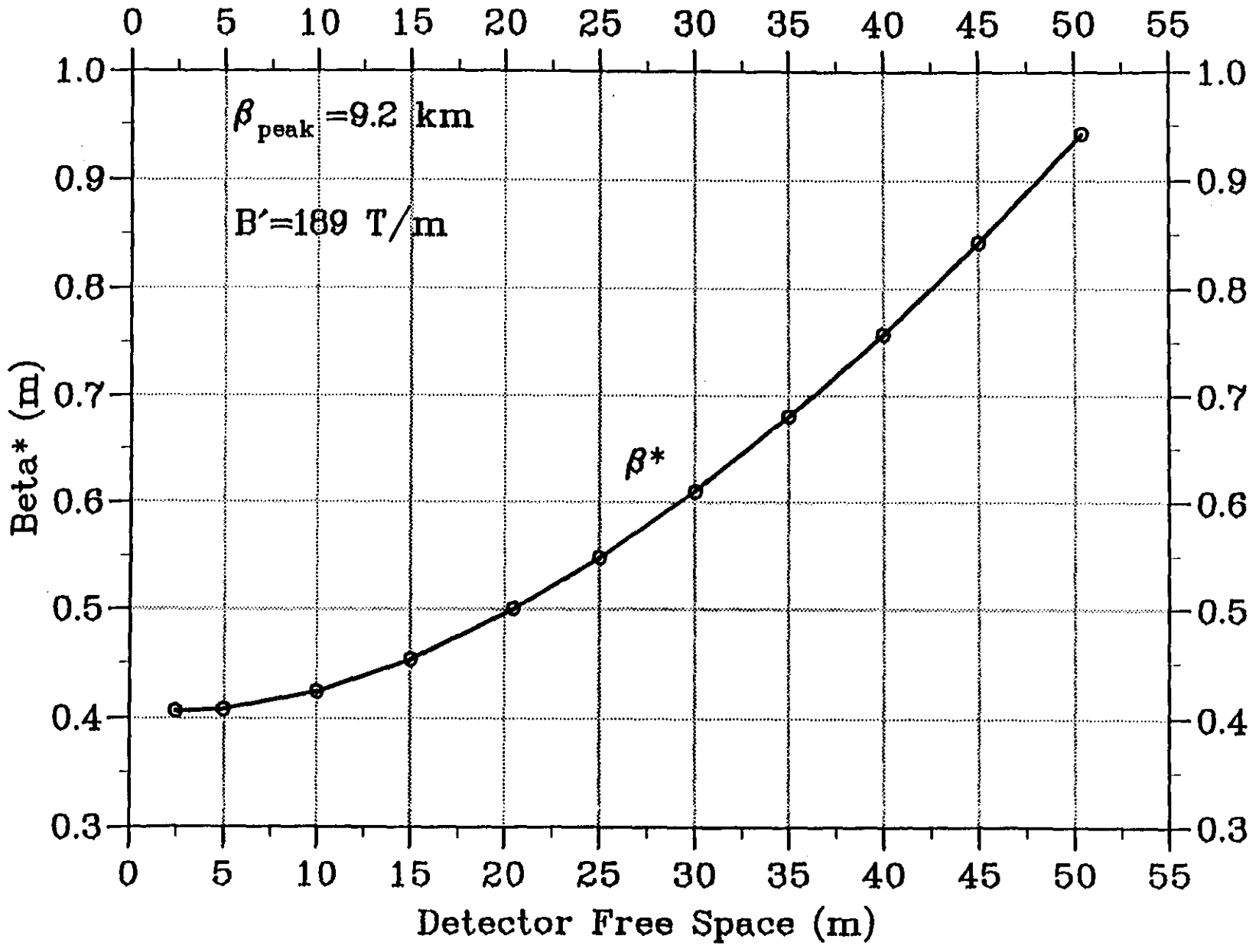
Annual Particle Fluence in GEM Detector (ptcl per cm2)

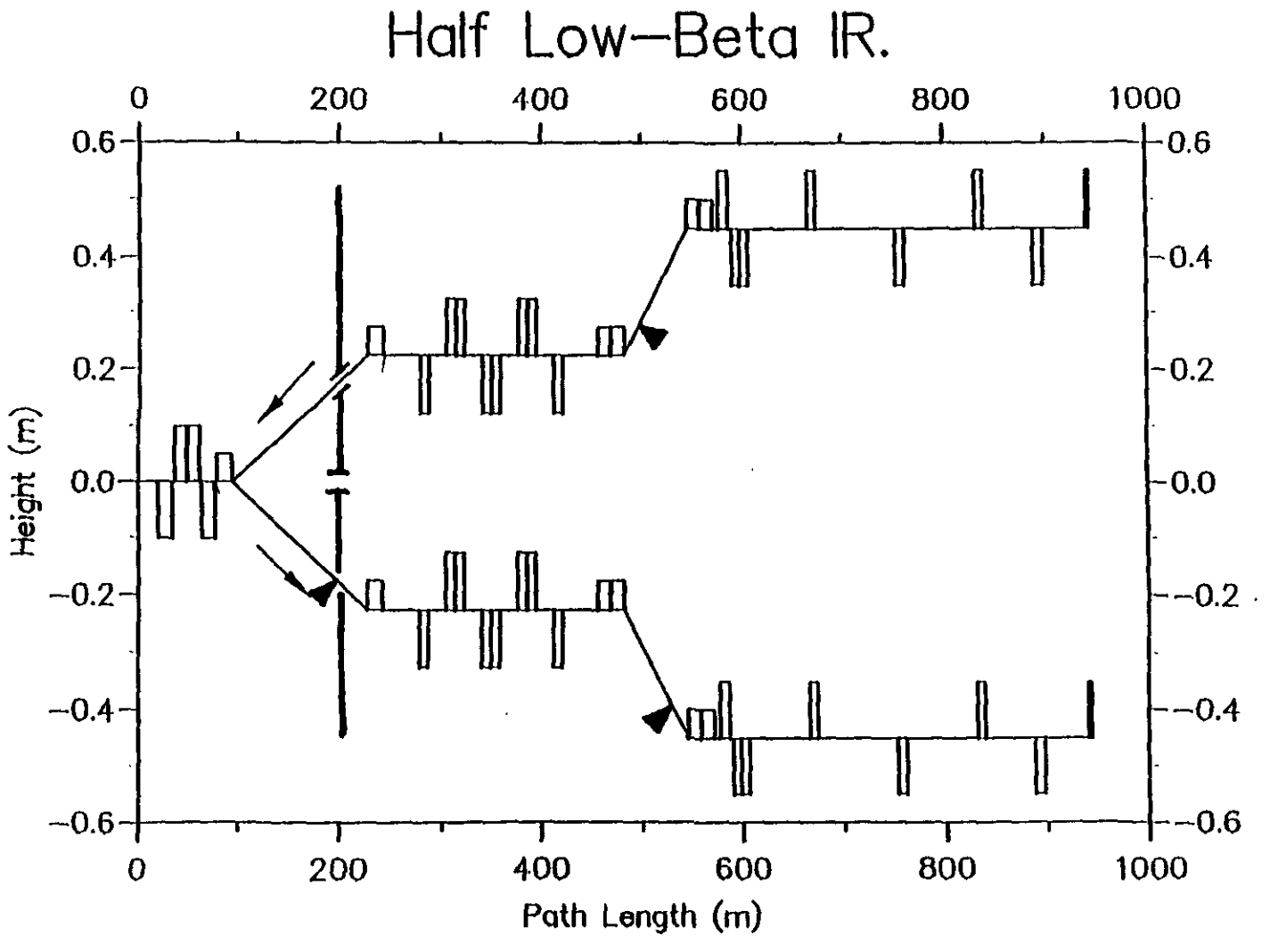
Particle	Point 1	Point 2	Point 3	Point 4
h_{tot}(>14MeV)	7.7×10^{9}	4.4×10^{8}	4.7×10^{10}	2.7×10^{11}
h_{ch} (>14MeV)	3.6×10^{9}	3.9×10^{6}	2.8×10^{7}	3.7×10^{10}
e (>1MeV)	1.9×10^{11}	6.8×10^{5}	5.0×10^{6}	7.9×10^{10}
n (<14MeV)	7.1×10^{10}	6.0×10^{11}	8.6×10^{12}	2.9×10^{12}

20x20 TEV PP-COLLISONS IN LOW-BETA

Component	Length (m)	Energy (%)	γ / tot (E)	γ / tot (No)
Detector	0 - 18	1.6	0.3	0.5
Collimator	18 - 20	4.2		
Q1 - Q2	20 - 45	18.0	0.5	0.4
Q3 - Q4	45 - 81	13.7		
$BV1^-$ - $BV1^+$	81 - 244	15.0		
Leak(Protons)	> 244	24.0		
Leak(Neutral)	> 81	23.5	0.6	0.8

Beta* vs Detector Free Space.




Half Low–Beta IR.
0
200
400
600
800
1000
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
Height (m)
Path Length (m)