CALORIMETER REPORT

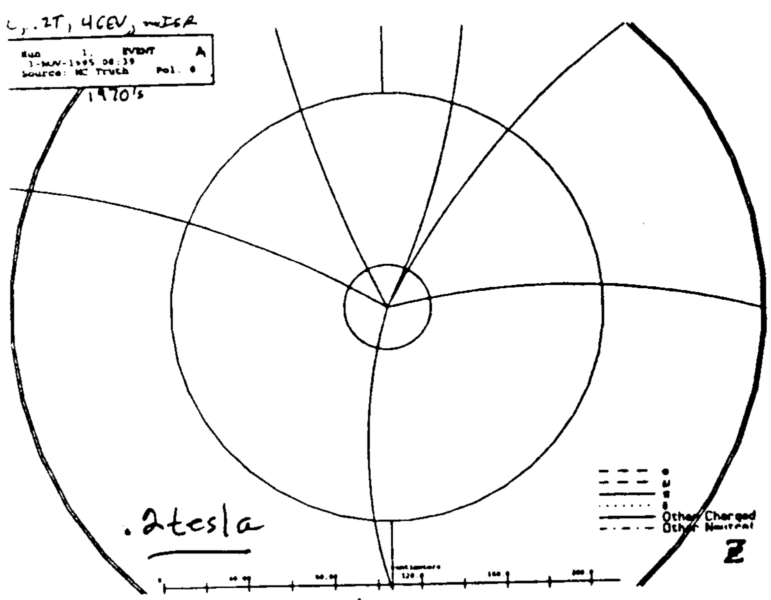
TALKS

ANDY WHITE	CALORIMETRY (PLENARY)
RAY FREY	SUBGROUP PLANS AND GOALS
RICHARD DUBOIS	CALORIMETER SIMULATION, GISMO VALIDATION, RESULTS
YOSHIAKI FUJII	STUDY OF A TILE-FIBER CALORIMETER OPTION AT LCs
VOLKER KORBEL	CALORIMETER OPTIONS FOR TESLA
REN-YUAN ZHU	CRYSTAL TECHNOLOGIES FOR LCs
DAVE WINN	HADRON CALORIMETRY USING CERENKOV AND IONIZATION
DAVID WAGNER	SUSY REQUIREMENTS FOR CALORIMETR
TAKASHI MARUYAMA	IR MASKING REQUIREMENTS AND IMPACT ON CALORIMETRY
GARY BOWER	EVENT/JET CHARACTERISTICS @ 500 G
JOANNE BOGART	CLUSTERING FOR AN LC DETECTOR
STEVE BERRIDGE	A SILICON-TUNGSTEN PROTOTYPE

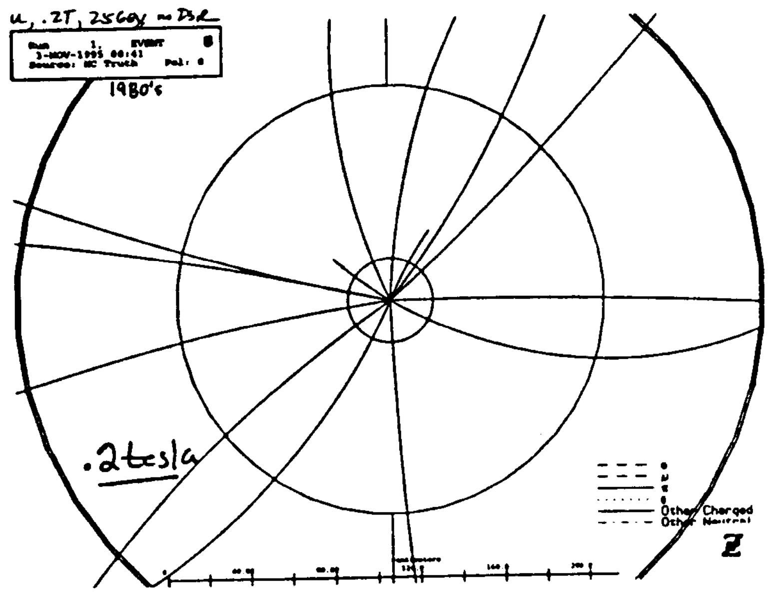
DISCUSSION

MEETINGS / SCHEDULE

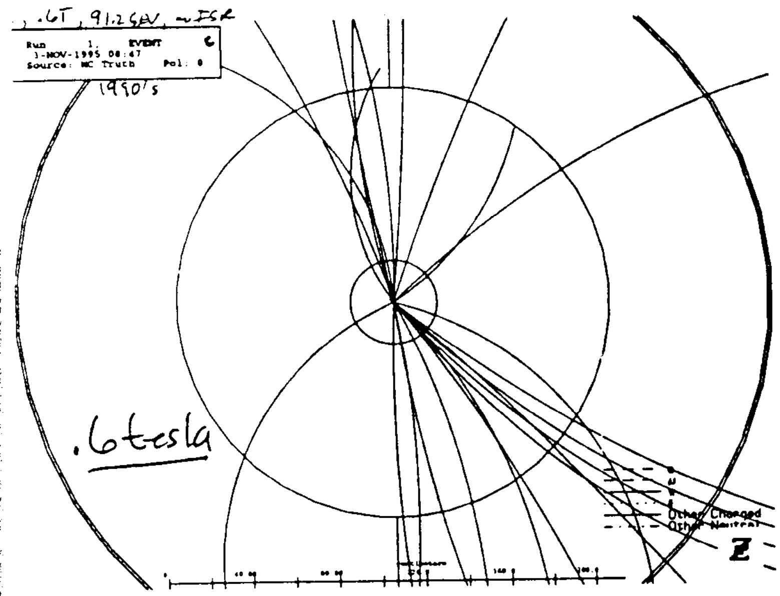
RRD, HOMEWORK



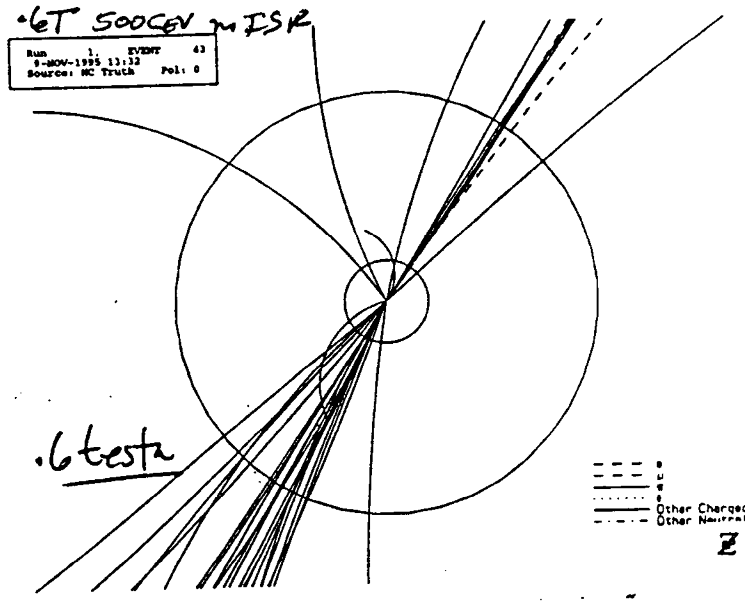
4 GeV



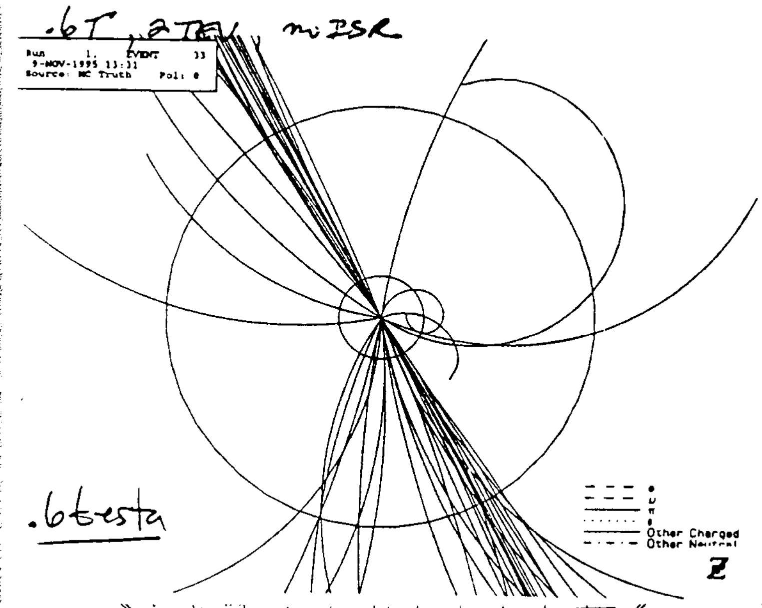
25 GeV



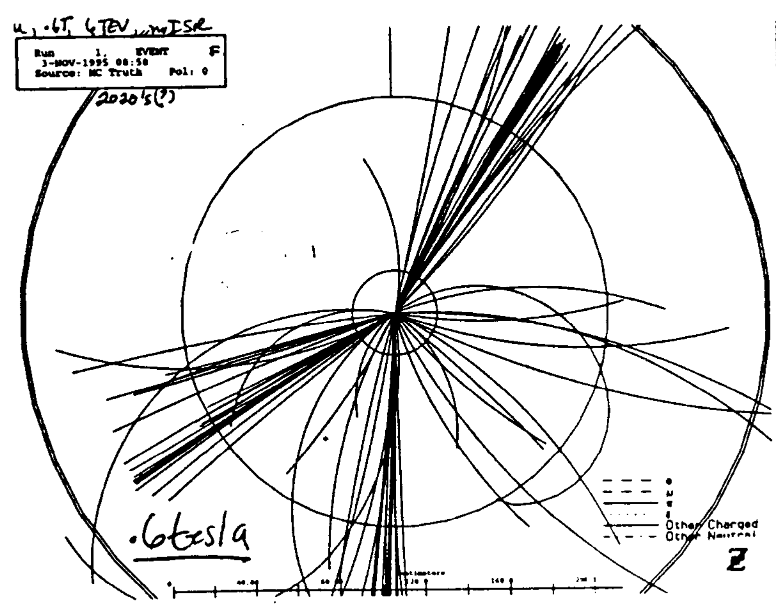
91 GeV



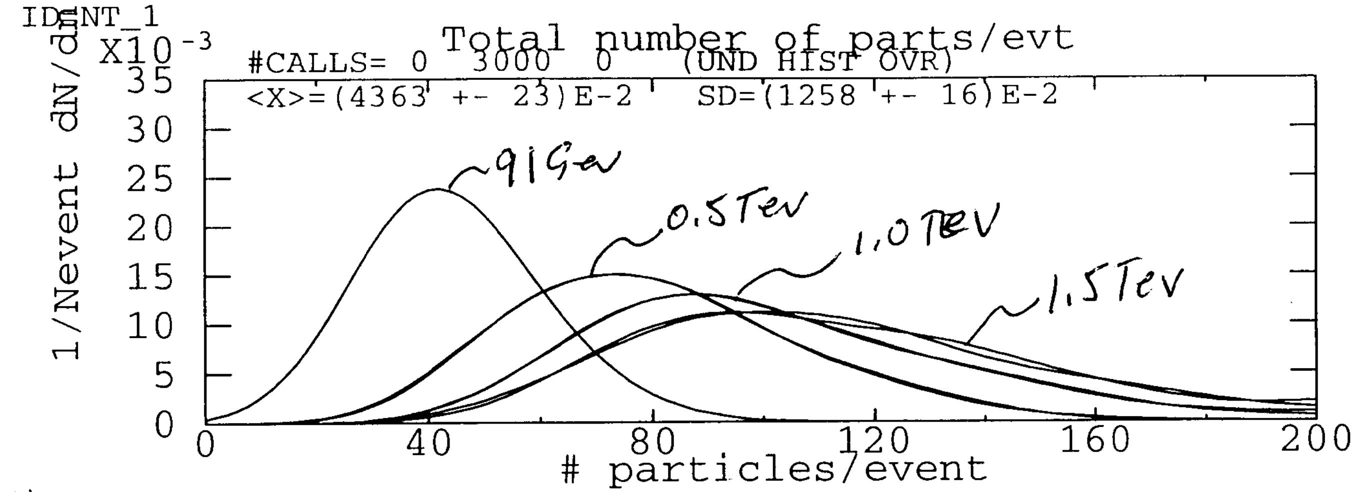
500 GeV

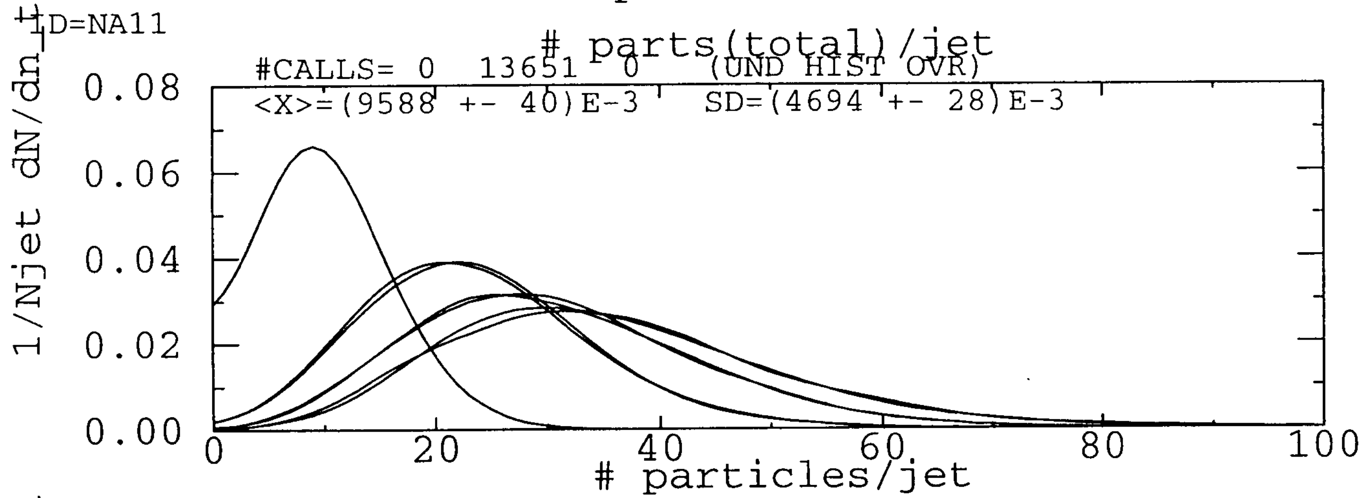


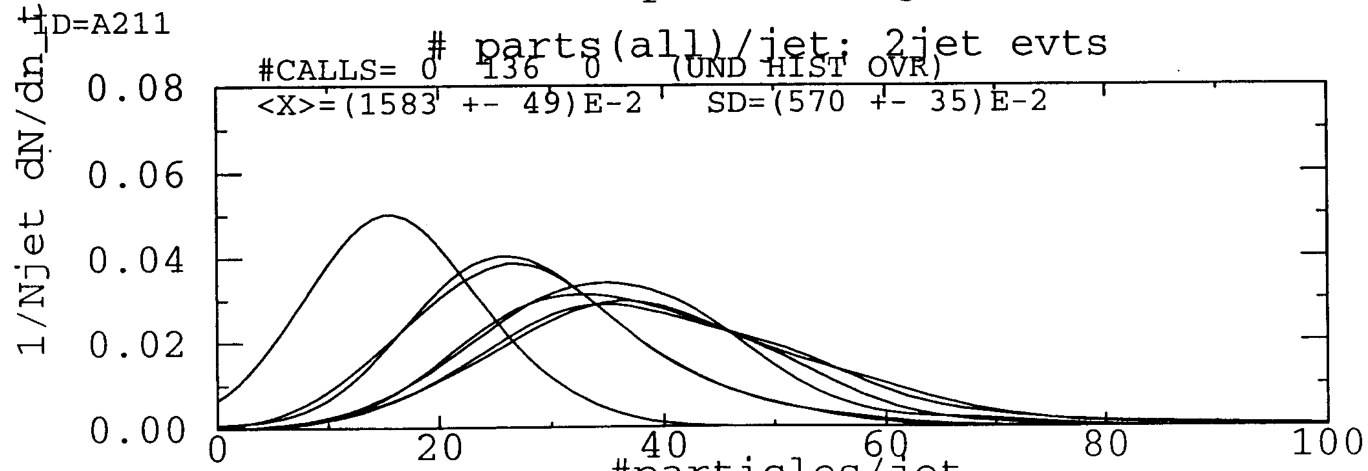
2 TeV



6 TeV



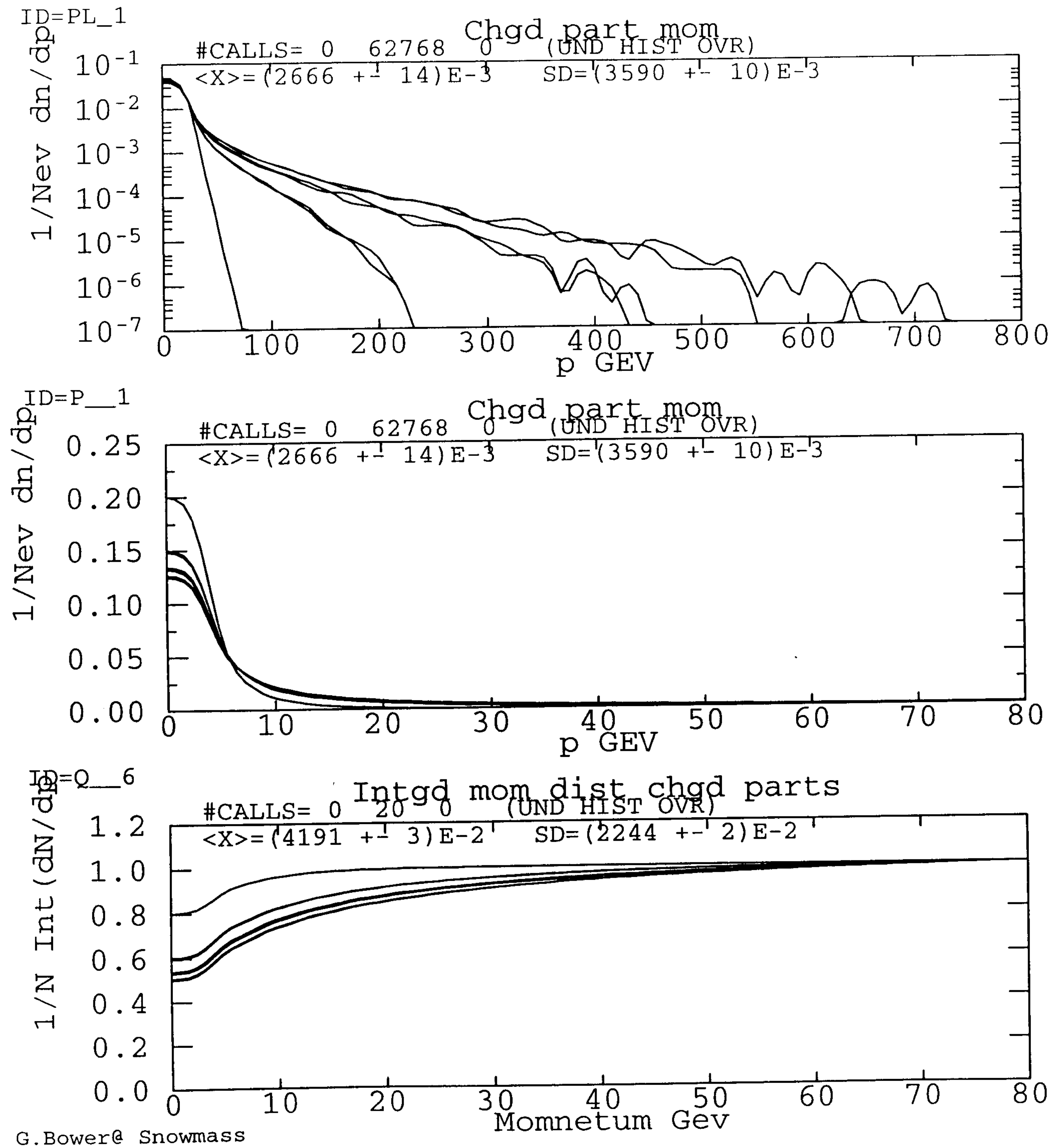




G.Bower@ Snowmass

Note x-scale

Ycut = 0.002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Chgd part mom
#CALLS= 0 62768 0 (UND HIST OVR)
<X>=(2666 +- 14)E-3 SD=(3590 +- 10)E-3
1/Nev dn/dp
p GEV
ID=P__1
Chgd part mom
#CALLS= 0 62768 0 (UND HIST OVR)
<X>=(2666 +- 14)E-3 SD=(3590 +- 10)E-3
1/Nev dn/dp
p GEV
ID=Q__6
Intgd mom dist chgd parts
#CALLS= 0 20 0 (UND HIST OVR)
<X>=(4191 +- 3)E-2 SD=(2244 +- 2)E-2
1/N Int(dN/dp
Momnetum Gev
G.Bower@ Snowmass

note x-scale

TECHNOLOGIES & CHOICES

[PROBABLY >1 "ACCEPTABLE" DESIGN]

[PARAMETER OPTIMIZATION ↔ TECHNOLOGY CHOICE INTERDEPENDENCE]

I. COMPACT ECAL ? e.g., W/Si vs CRYSTALS ← SNOWMASS (W/Si)

e.g. $PbWO_4$ vs PbF_2 (?)

ACKING ↕

VS

LARGE ECAL, HCAL e.g., SCINT. TILE ← JLC, ECFA

VS

SCINT FIBER — SAMPLING

VS

LIQUID Ar

e.g., Fe vs. Cu vs Pb ABSORBER

Fe ← SNOWMASS HCAL

Cu ← ECFA HCAL

Pb ← JLC ECAL, ECFA ECAL, JLC HCAL

II. COIL LOCATION:

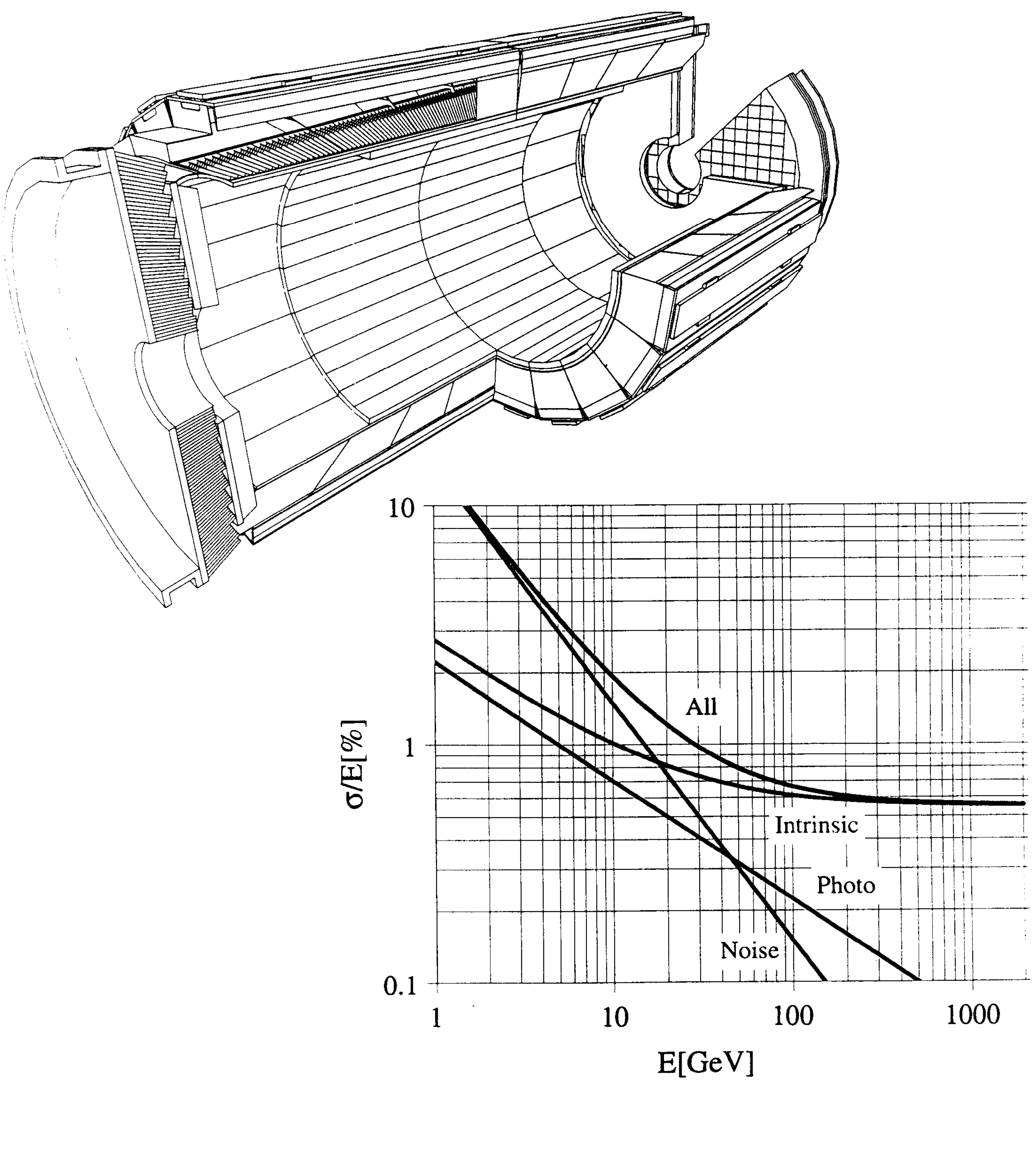
INSIDE HCAL ← SNOWMASS

VS

OUTSIDE HCAL : TAILCATCHER ?

OUTSIDE HCAL ← JLC, ECFA

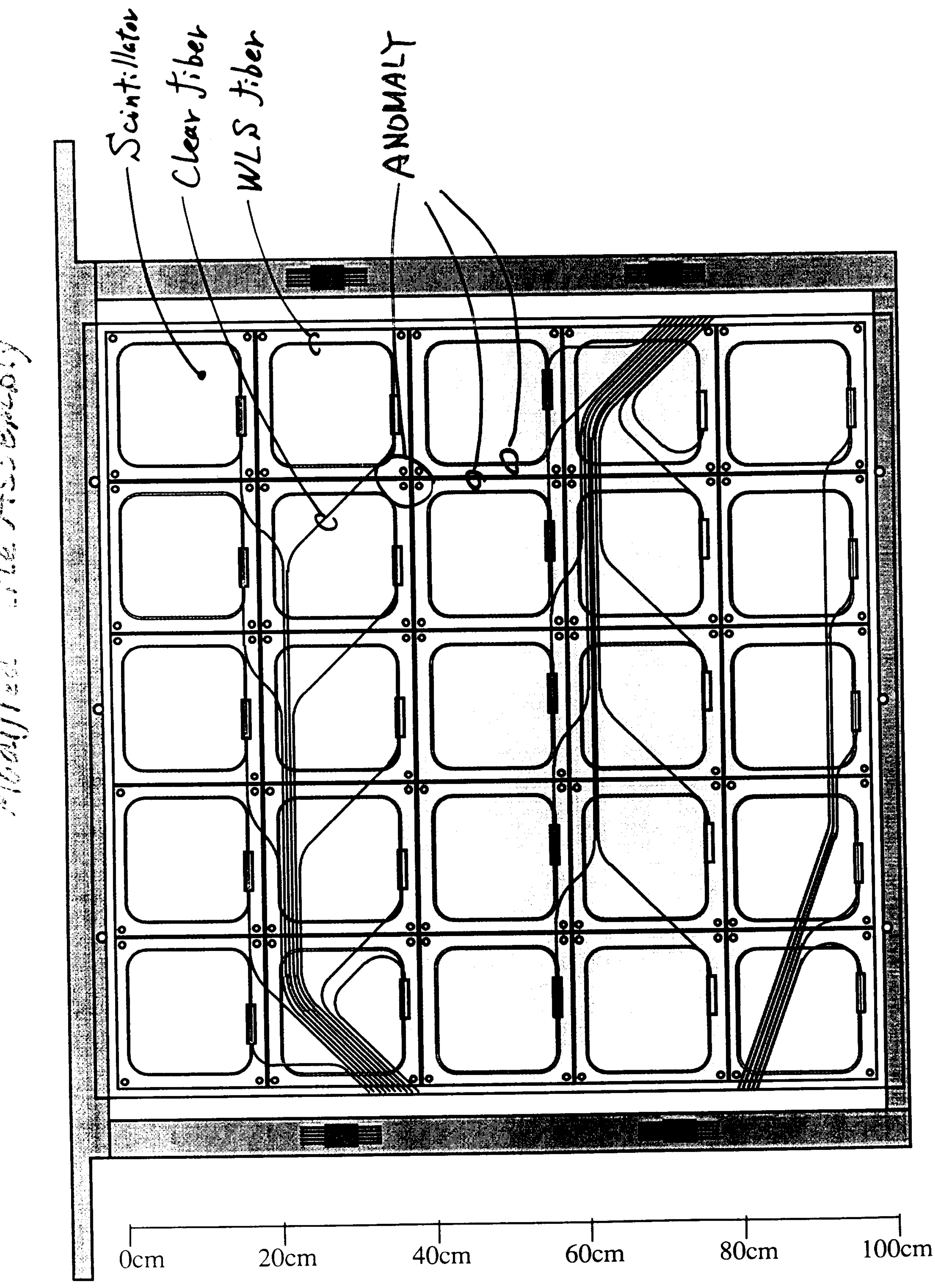
CMS $PbWO_4$ ECAL and Resolution



Possible Choices of Crystal Technology

- Oxides:
  - BGO is a mature and dense crystal ($\rho = 7.13$ g/cc, X_0 = 1.12 cm, $R_{Molière}$ = 2.3 cm), but has a slow scintillation (300 ns) and not cost effective ($7/cc) due to expensive raw material (GeO_2).
  - $PbWO_4$ is a mature and dense crystal (ρ = 8.28 g/cc, X_0 = 0.89 cm, $R_{Molière}$ = 2.0 cm). It is a fast and cost effective crystal ($2.5/cc). Its low light yield is overcome by using Si avalanche photodiode. $\sigma = 4.1\%/\sqrt{E} \oplus 0.37\% \oplus 0.15/E$ has been achieved with 25 mm^2 APD readout in beam test. It is possible to develop a brighter $PbWO_4$ crystal.

- Halides:
  - CsI is a mature and cost effective crystal ($2/cc), but has low density (ρ = 4.5 g/cc, X_0 = 1.85 cm, $R_{Molière}$ = 3.5 cm). In addition, CsI(Tl or Na) is too slow ($\sim$1 μs) and CsI is less bright.
  - PbF_2 is a mature and dense crystal (ρ = 7.77 g/cc, X_0 = 0.93 cm, $R_{Molière}$ = 2.1 cm). It is also cost effective (less than $PbWO_4$). However, it is not yet a scintillator, but being used as a Čerenkov radiator. A scintillating PbF_2 crystal may be developed by selected doping.



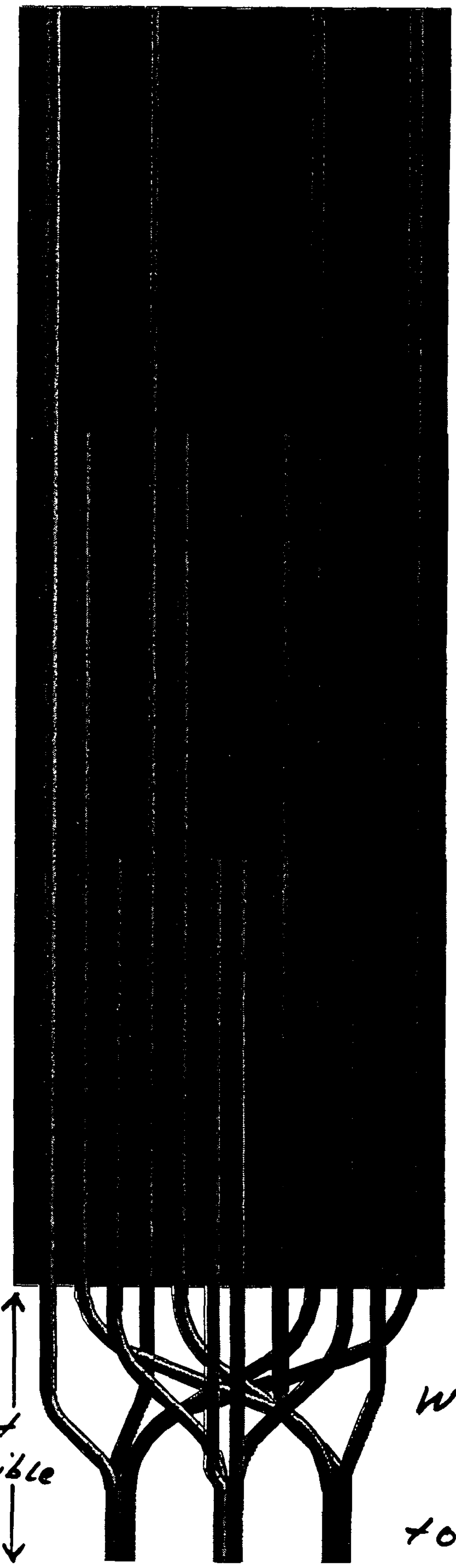
Modified tile assembly
Scintillator
Clear fiber
WLS fiber
ANOMALY
0cm
20cm
40cm
60cm
80cm
100cm

ECFA-DESY CDR Calo proposal

Principle

elm or had.

3 segment tower (shashlik)



to readout:

APD's, phototriodes

Fig 8a, b

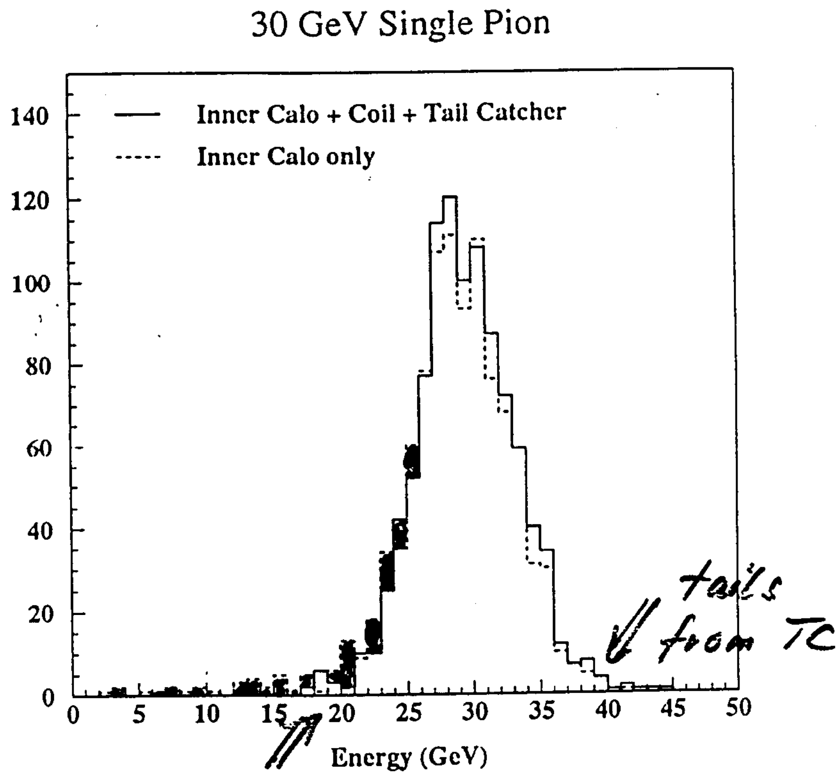
22.9.98

Containment studies, W^+W^- events, 800 GeV:

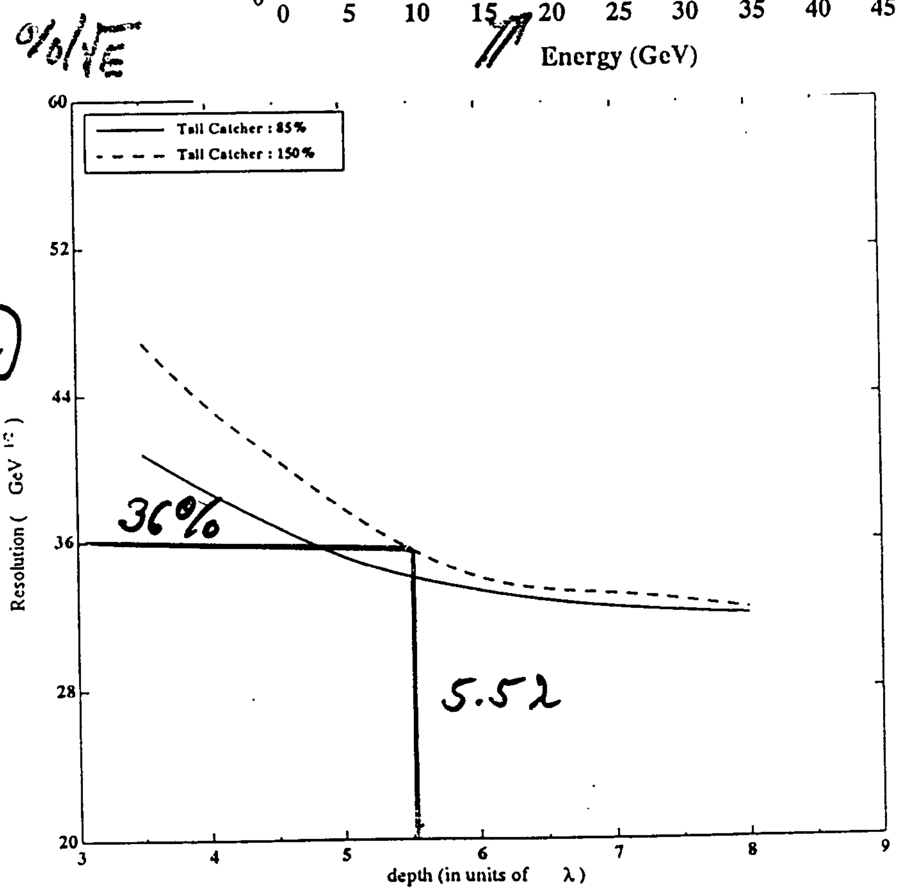
$e^+e^- \to W^+W^-$

$(\approx 90^\circ)$

b)



a)



a) intrinsic resolution vs inner calorimeter depth in λ,
b) containment of 30 GeV single pion shower

III. Measuring jets, energy

COMPENSATION: HADRONIC SHOWERS BEST MEASURED IF RESPONSE TO EM AND HADRONIC COMPONENTS EQUALIZED.

"INTRINSICALLY" COMPENSATED CALORIMETER

e.g., JLC STUDY FINDS $e/\pi = 1$ FOR
2 mm SCINTILLATOR / 10 mm Pb
BUT, NON-OPTIMAL σ_E/E

VS

"ENERGY WEIGHTING": IF HAVE FINE GRANULARITY, CAN USE INFORMATION TO DAMPEN CONCENTRATED EM DEPOSITS TO EQUALIZE RESPONSE.
e.g., H1

VS

SEPARATED FUNCTION ("ENERGY FLOW")

- MEASURE CHARGED ENERGY IN TRACKER
- REMOVE CHARGED CLUSTERS IN CALORIMETER
- MEASURE γ ENERGY IN ECAL
- MEASURE NEUTRAL HADRONS IN HCAL

• Hi $\vec{B}$ GOOD (?)
• NEED GOOD GRANULARITY IN CALORIMETER
• NEED SMALL R_M / R_{inner}

VS CORRECTION FROM DIFFERING CERENKOV, IONIZATION RESPONSES

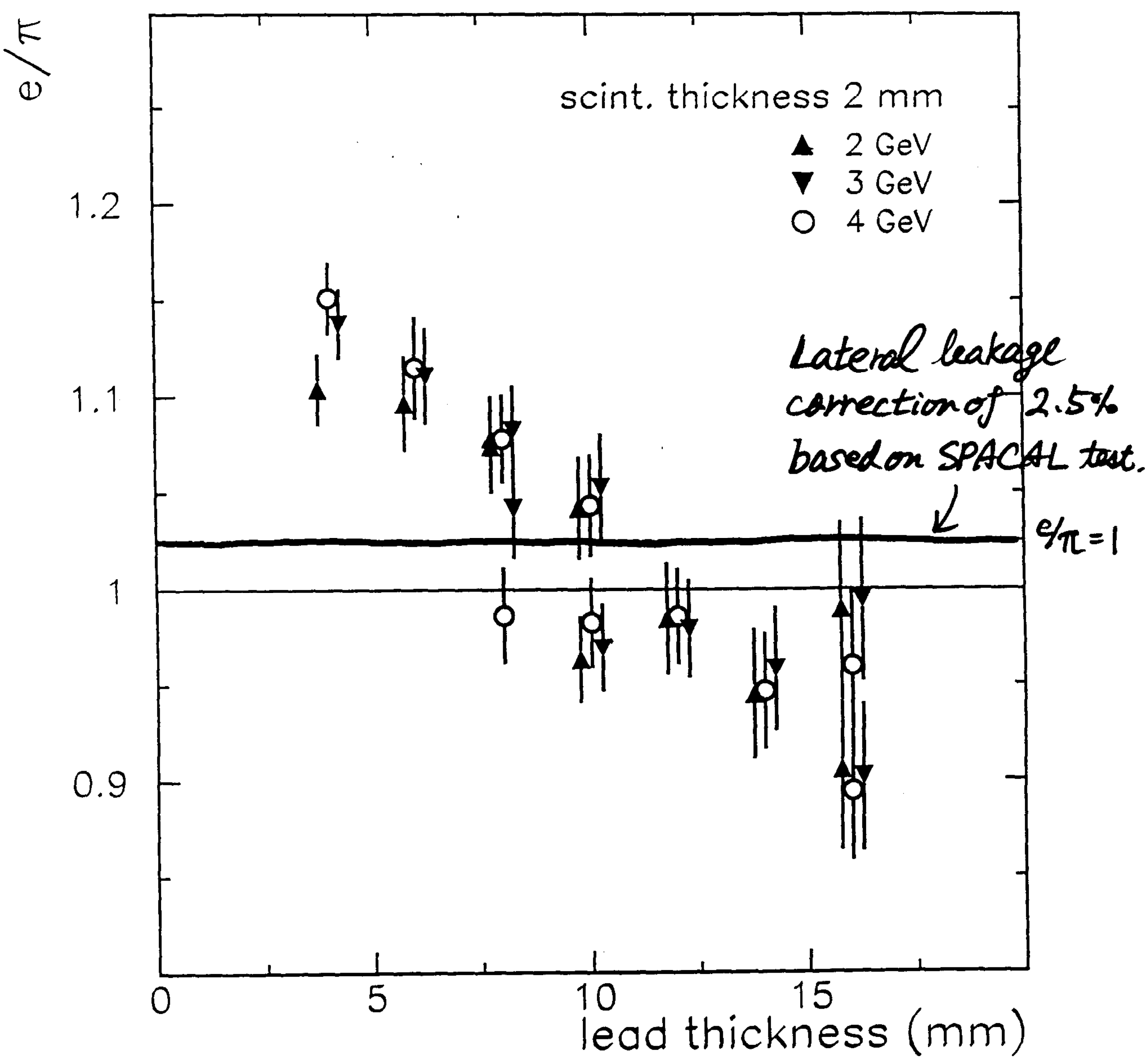


Figure 20: The e/π ratio vs. Pb thickness. The dashed line indicates e/π = 1 after a shower leakage correction.

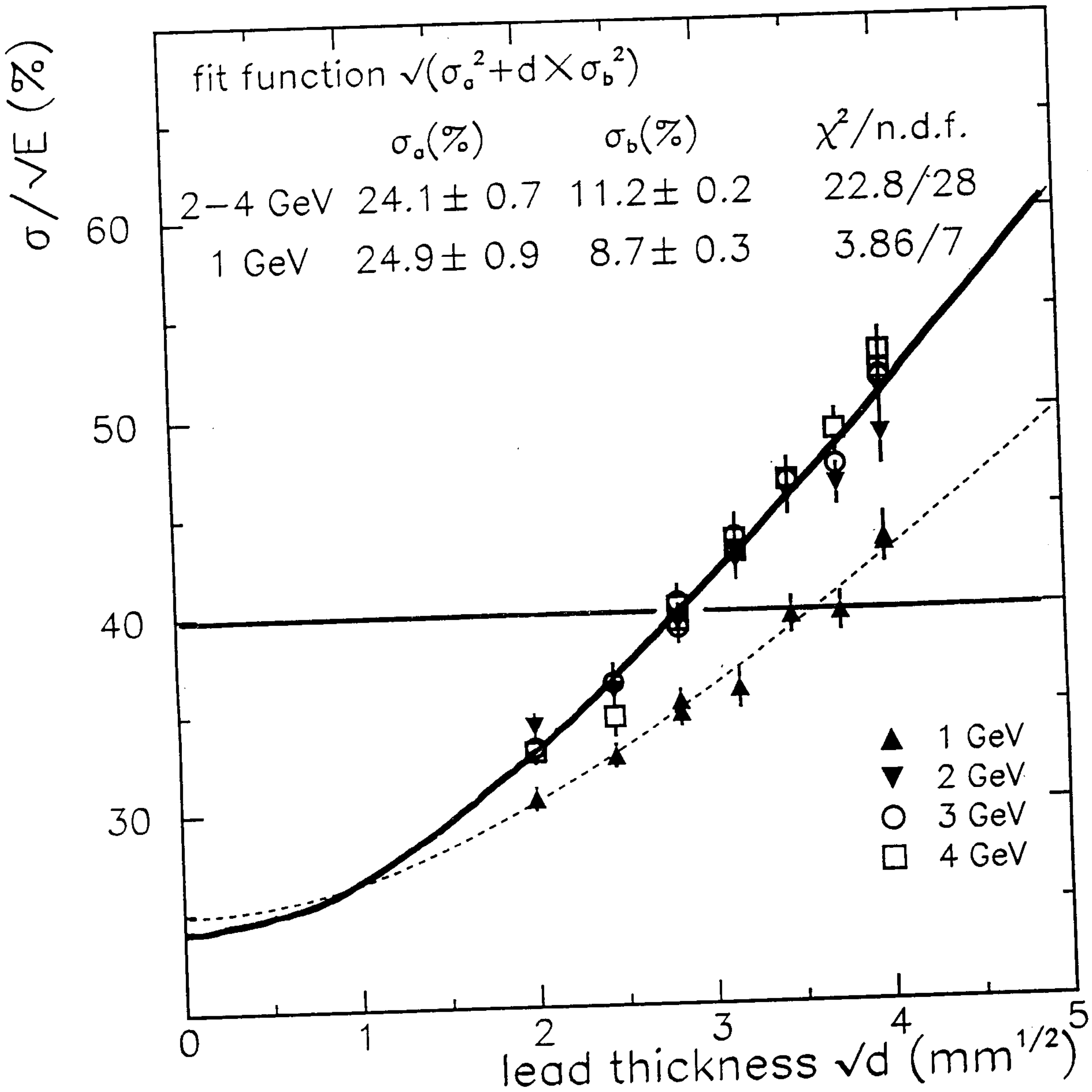


Figure 16: Energy resolution $\sigma/\sqrt{\mathrm{E}}$ vs. Pb thickness for π's Solid and dashed curves shown in the figure are fitting results to Eq. (4) except for 1 GeV and 1 GeV.

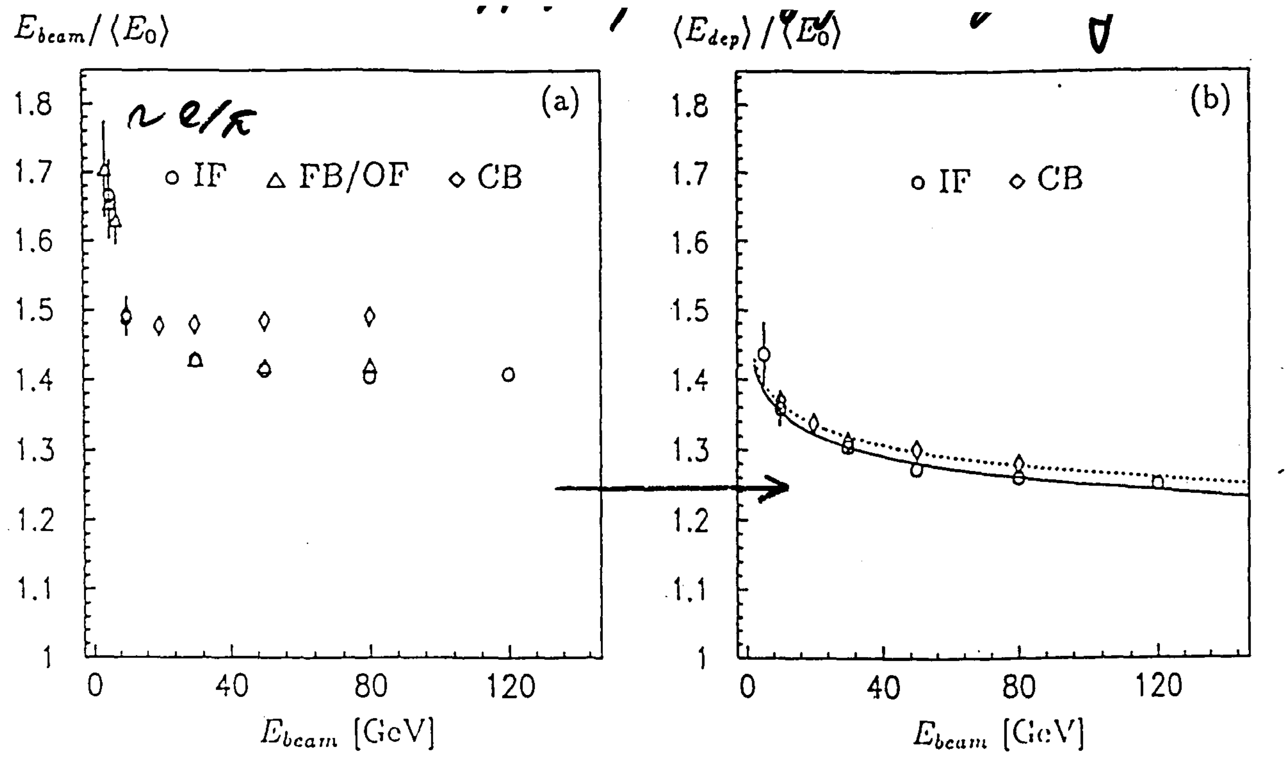
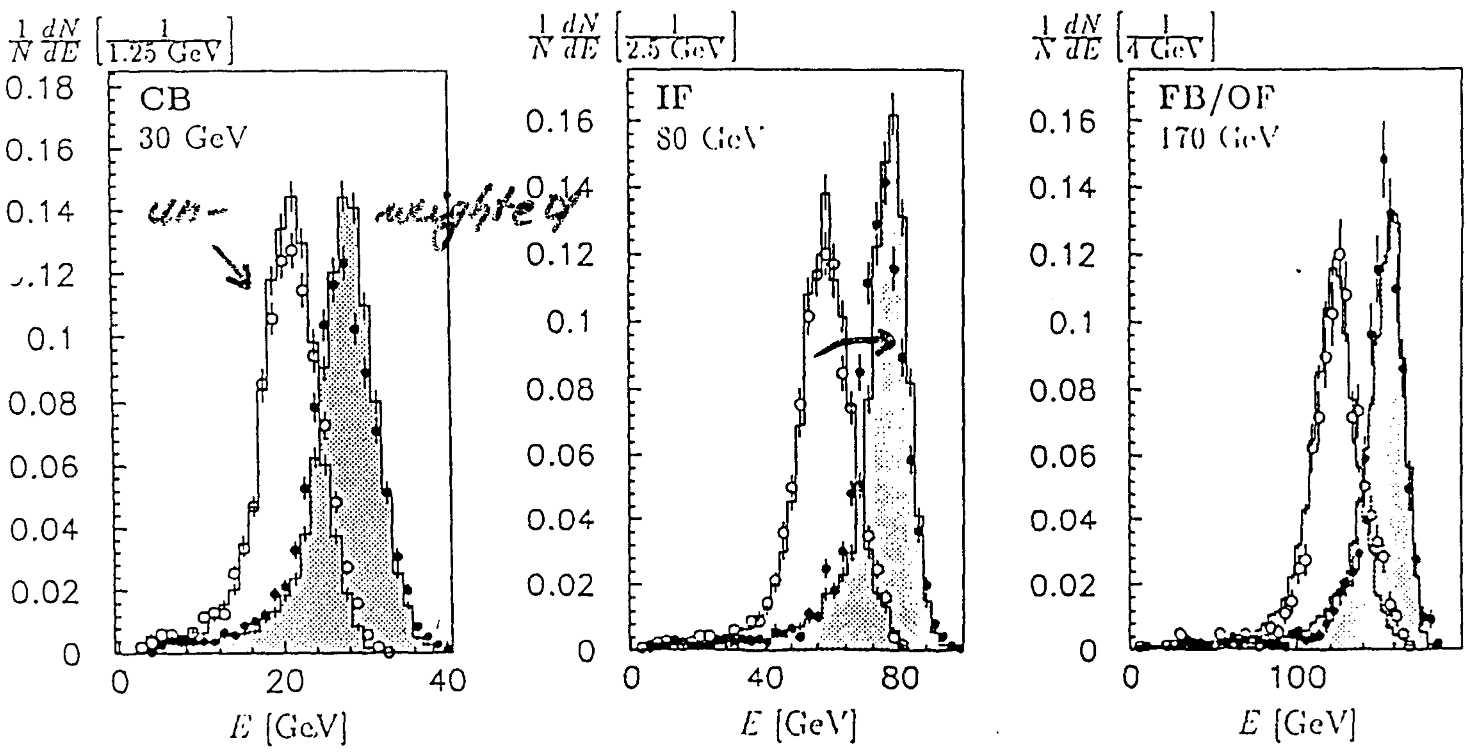


Figure 8: *The effective electron-to-pion signal ratio calculated as given in equation (5) for experimental pions, as function of the beam energy E_{beam} in different calorimeter regions (a). Picture (b) shows e/π corrected by Monte Carlo for the effect of limited acceptance and longitudinal energy leakage. The curves show results from fits, as discussed in the text.*

pions:



$$E^i_{\pi c} = \{a_0 + a_1 \cdot \exp(-\kappa E^i_0 / V)\} \cdot E^i_0$$

improved resolution

100 π @ each of 20, 50, 100, 200 GeV

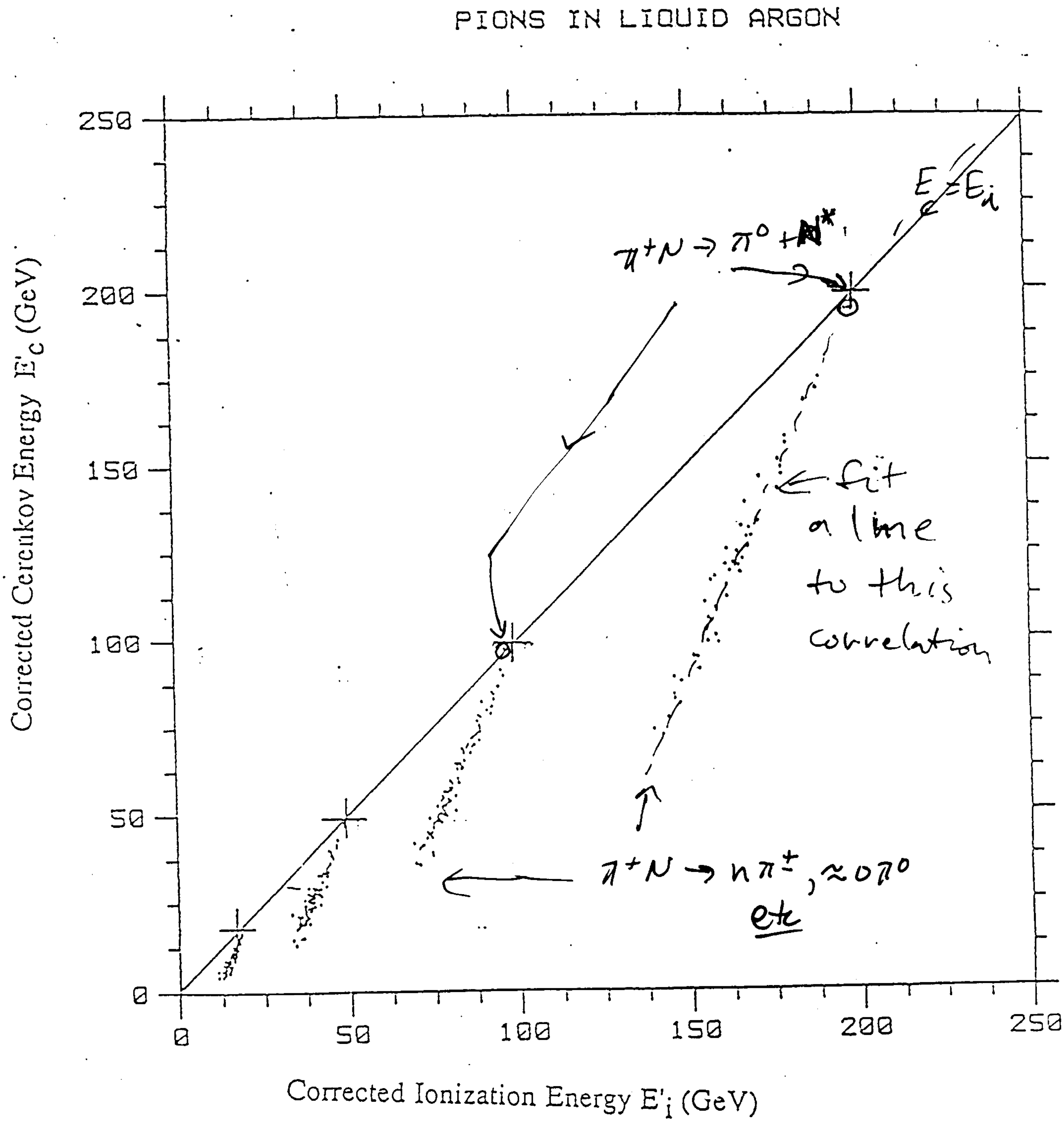


Figure 1: Monte Carlo data of the corrected Cerenkov Energy E'c vs the corrected Ionization Energy E'i for a homogeneous liquid Argon calorimeter (liquid scintillator similar) taken from Fig. 4 of Appendix I. The line E'c=E'i is the response that electrons would deposit. The scatter of the electron points at each energy would be about the thickness of the line on this energy scale. For 100 incident pions in each of 4 different energies 20,50,100, and 200 GeV the respose of each pion shower in E'c-E'i space is shown; the crosses mark the point on the electron line where electrons of those energies would respond. The bands created by the pions are fit by a line as shown schematically in Figure 2 to create a first order compensation.

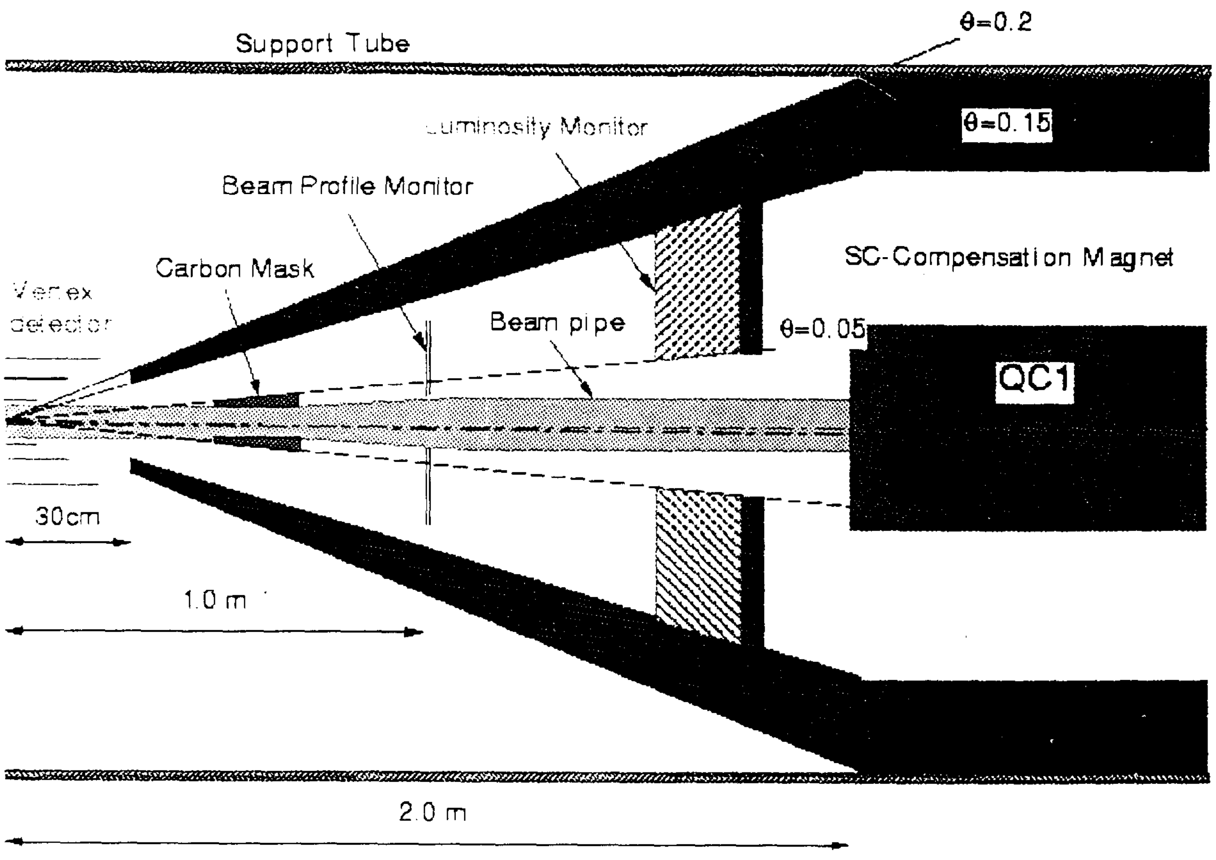
SOME ISSUES RAISED

- CRACKS
- "NON-GAUSSIAN TAILS"
- TIMING REQUIREMENT
- SMALL ∡ COVERAGE
  - REQUIREMENT
  - FEASIBILITY

SUSY $\tilde{e}$ BG FROM $e^+e^- \to e^+e^-e^+e^-$

- OPTIMIZATION AND COMPARATIVE STUDIES WILL SOMETIMES NEED GOOD RECONSTRUCTION TOOLS, WHICH MAY THEMSELVES HAVE DIFFERING OPTIMIZATIONS.

JLC



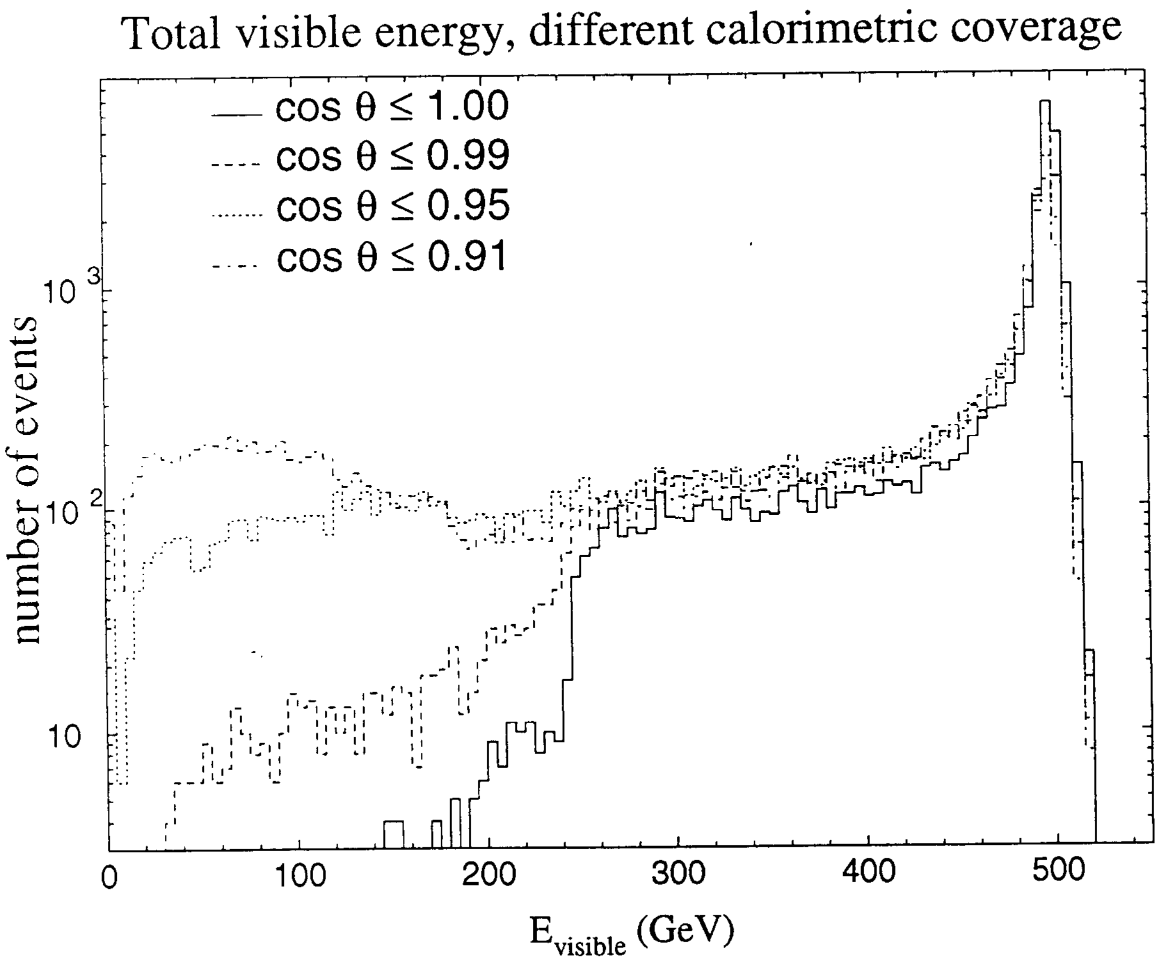
Typical IR masking configuration. (Maruyama talk)

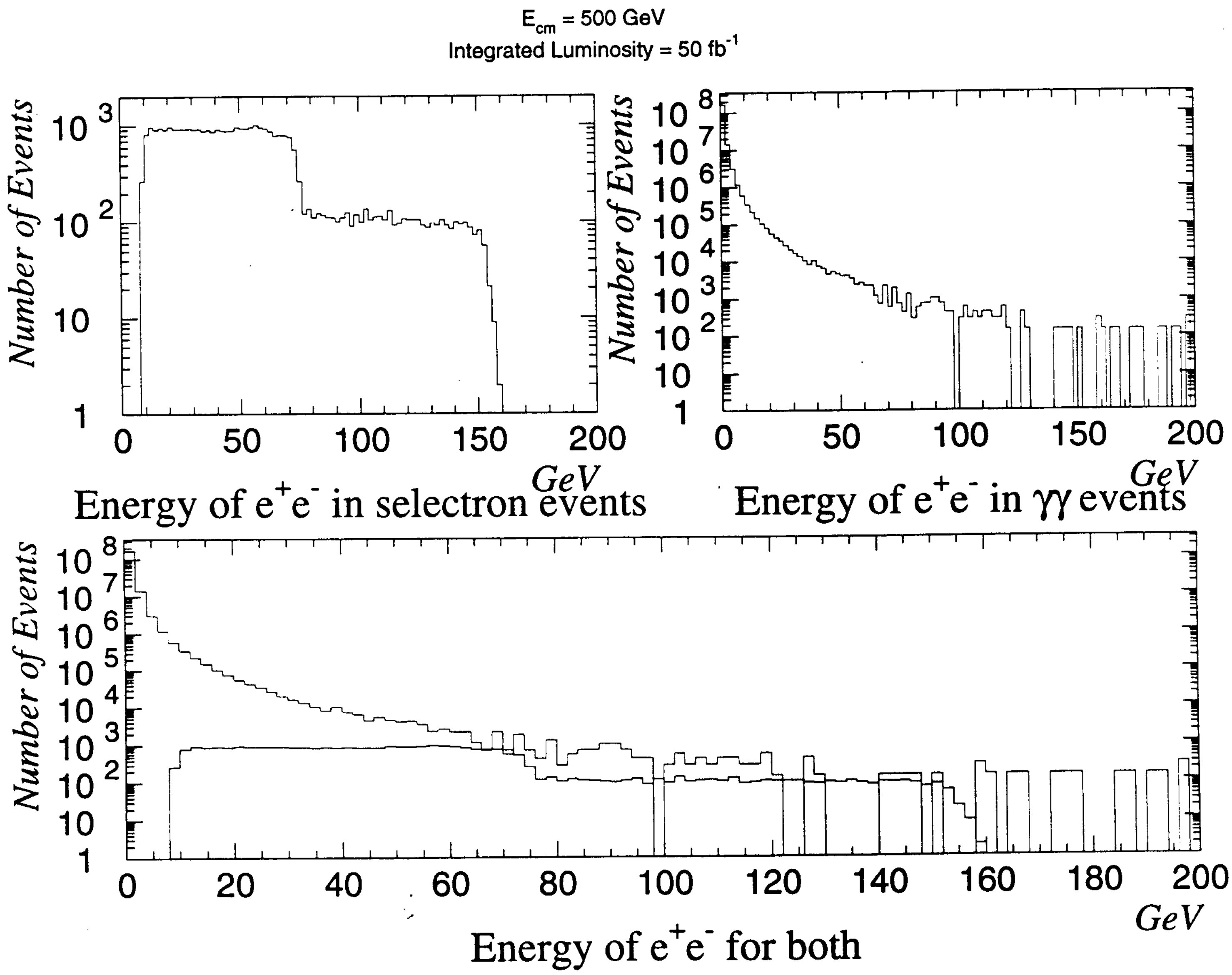
Effect on hermiticity ? (SUSY)

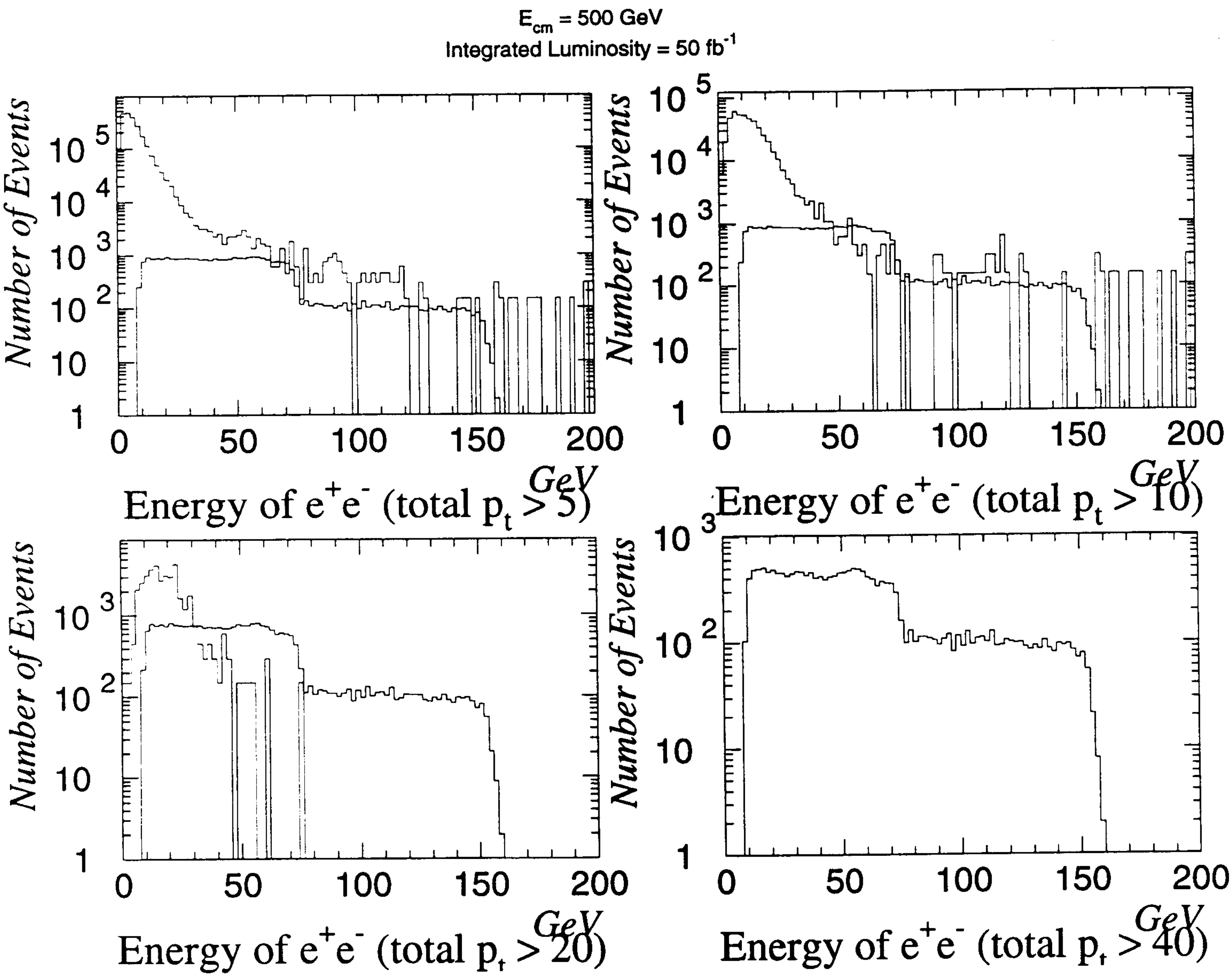
Viable Lum. monitor ?

Detector Constraints

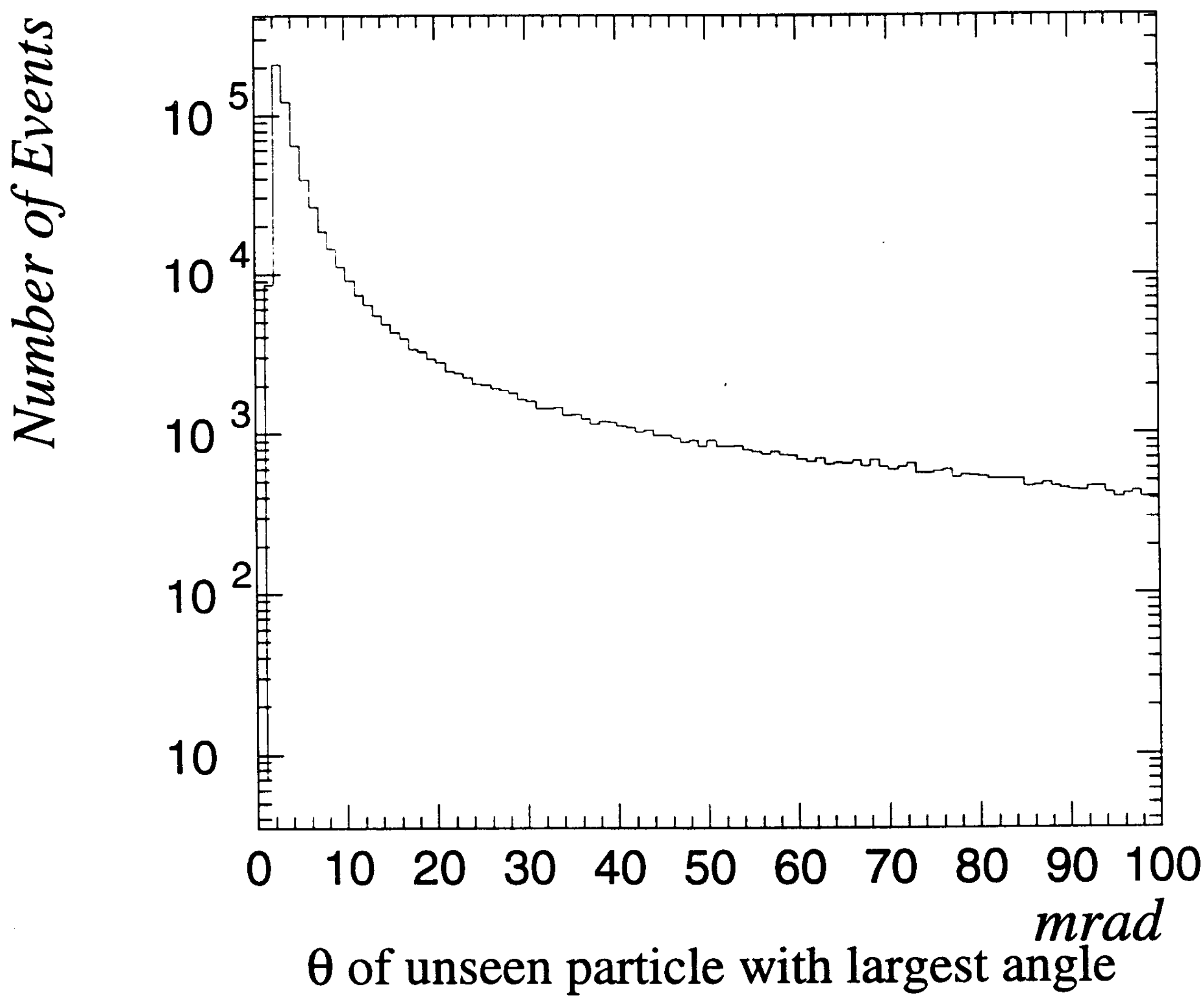
Need good detector coverage:




E_cm = 500 GeV
Integrated Luminosity = 50 fb^-1
Number of Events
GeV
Energy of e+e- in selectron events
Number of Events
GeV
Energy of e+e- in γγ events
Number of Events
GeV
Energy of e+e- for both


E_cm = 500 GeV
Integrated Luminosity = 50 fb^-1
Number of Events
Energy of e+e- (total p_t > 5)
Energy of e+e- (total p_t > 10)
Energy of e+e- (total p_t > 20)
Energy of e+e- (total p_t > 40)
GeV
0
50
100
150
200
1
10
10 2
10 3
10 4
10 5

Electron angle



HOMEWORK, R&D

	INFORMAL VOLUNTEERS
JET RECONSTRUCTION, RESOLUTION - SEPARETED FCU APPROACH - DETECTOR PARAMETERS	U OREGON (FREY) U PENN (HOLLEBEEK) BNL (REHAK) SLAC (BOWER DUBOIS
CALORIMETER CLUSTERING ALGORITHM	→ BOGART)
SUSY $\not{E}$ γ's (S/B)	U COLORADO
FORWARD CAL / LUM	U COLORADO
ELECTRON ID	
CRACKS - HOW TO IMPLEMENT	
DETECTOR PARAMETERIZATIONS	
CRYSTALS	CALTECH (ZHU)
W/Si PROTOTYPE	U TENNESSEE
CHERENKOV + IONIZATION COMPENSATION	FAIRFIELD (WINN) IOWA (ONEL)

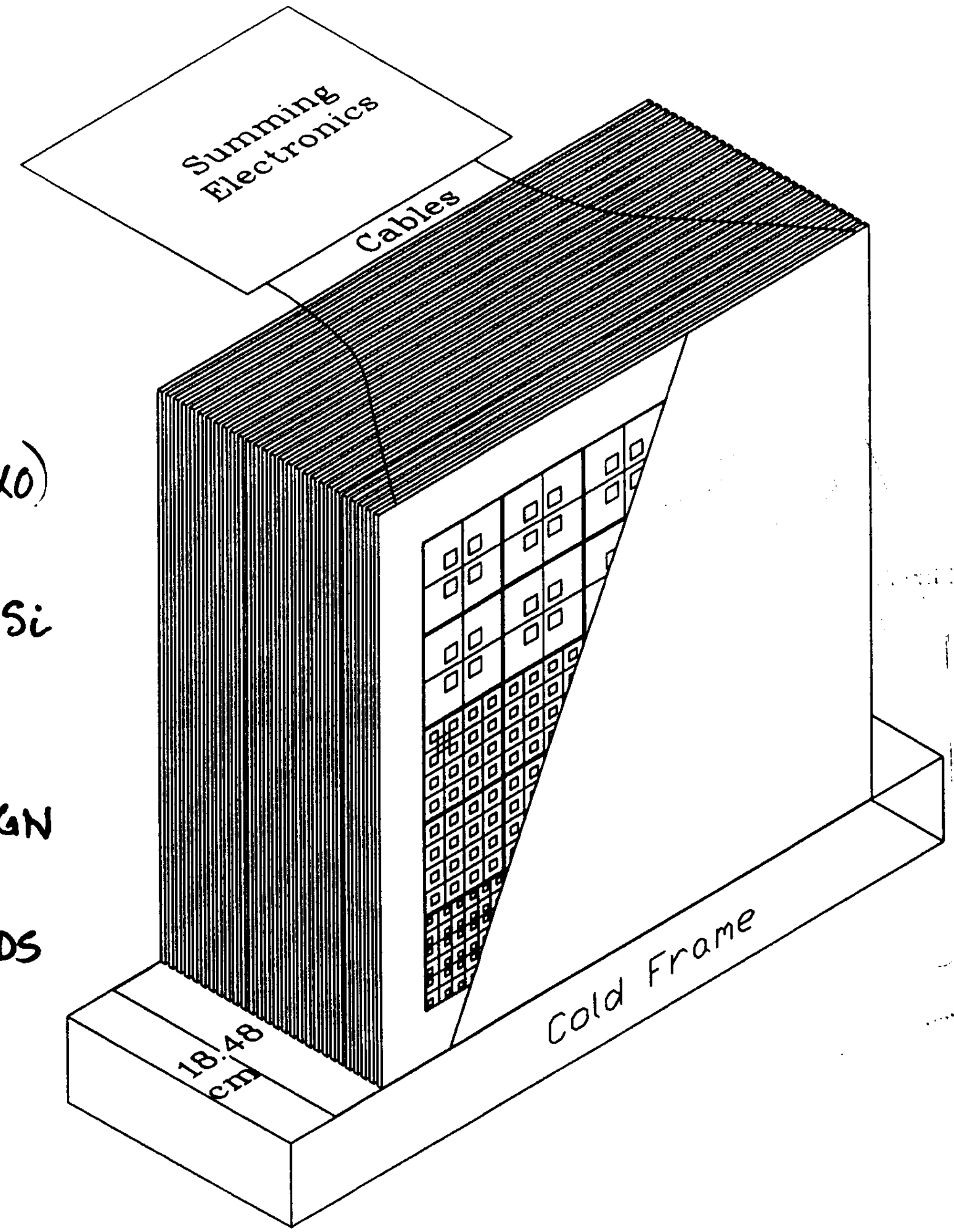
Current Status

A first pass which clusters neighboring hits has been written. So far it has been applied only to EM barrel, but is suitable for Had, endcaps as well.

Sewing together barrel, endcaps is harder, but not horrendous.

Code is written in Java, integrated with Java Analysis Studio (for now a better equipped development environment than C++/Root).

- 28 LAYER
- 3.5 mm W ($\sim 1 X_0$)
- HAMAMATSU 300μ Si
- 3.0 mm SPACING
  FOR COMPACT DESIGN
- PREAMPS NEAR PADS



Oblique Block Cutaway of SECC Calorimeter

SCB 12/9/92
Filename: \acad\brick\brortho

CONCLUSION

THERE IS A HUGE PARAMETER SPACE BEGGING TO BE EXPLORED, SOME QUESTIONS REQUIRING DETAILED SIMULATION AND REASONABLY SOPHISTICATED ALGORITHM DEVELOPMENT.

HELP WANTED !