8.Mar.2002
EW2002@Nagoya

Electron identification and shower analysis in ECC

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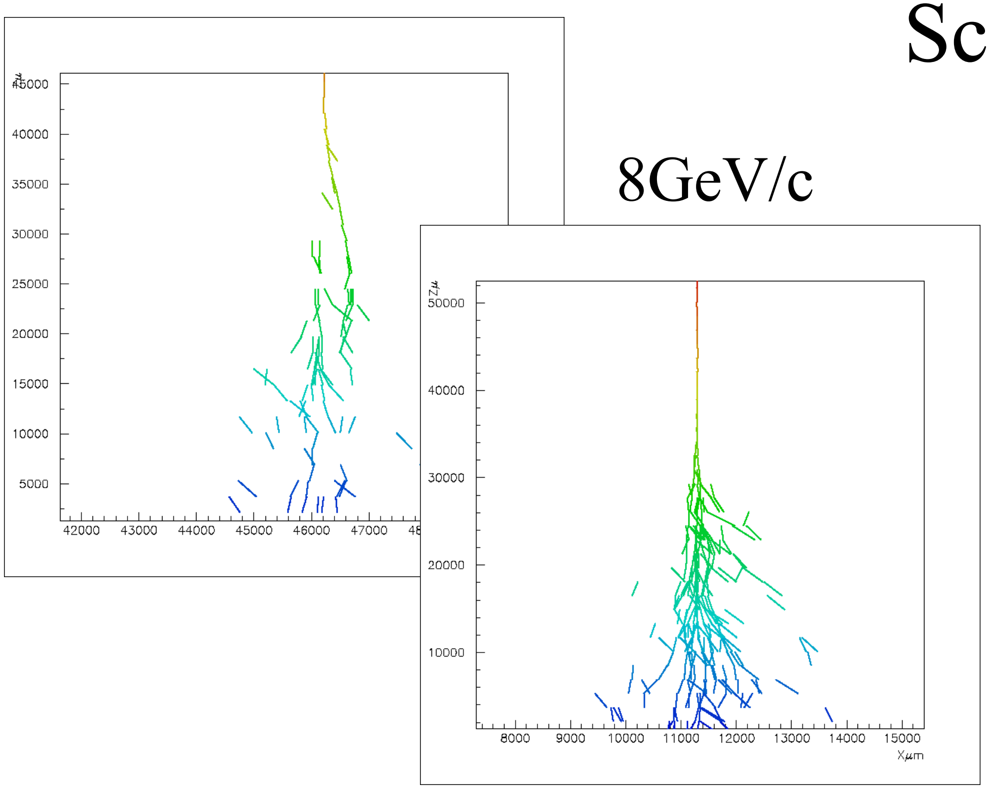
Test experiment at CERN PS in May 1999

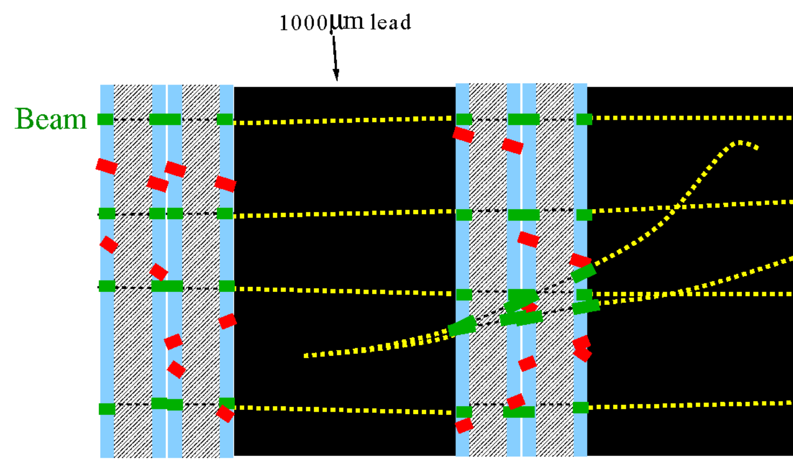
2GeV/c

8GeV/c



Scanned at Nagoya

To achieve low background emulsion plates are used as doublet.



2GeV/c 2events

8GeV/c 4events

More statistics are required!

Test experiment at CERN PS in May 2001

P = 2 and 4GeV/c   e enriched π^- beam

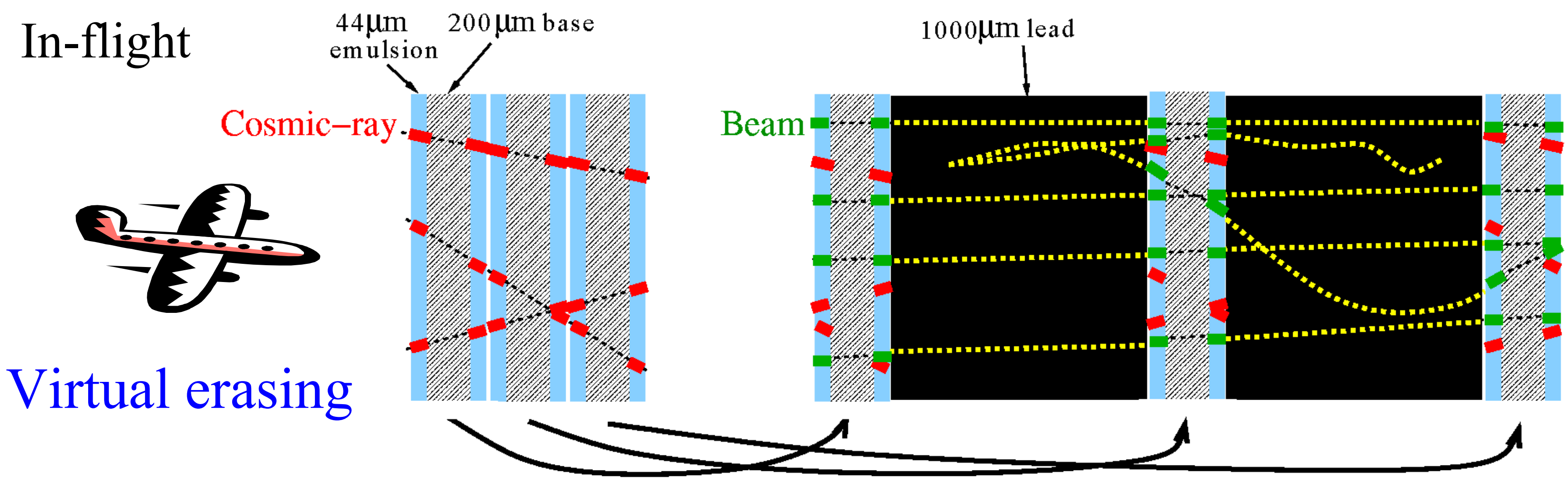
Interesting energy region for OPERA

- electron identification
- Analysis of cascade shower

To achieve low background

~ 1 tracks/mm^2

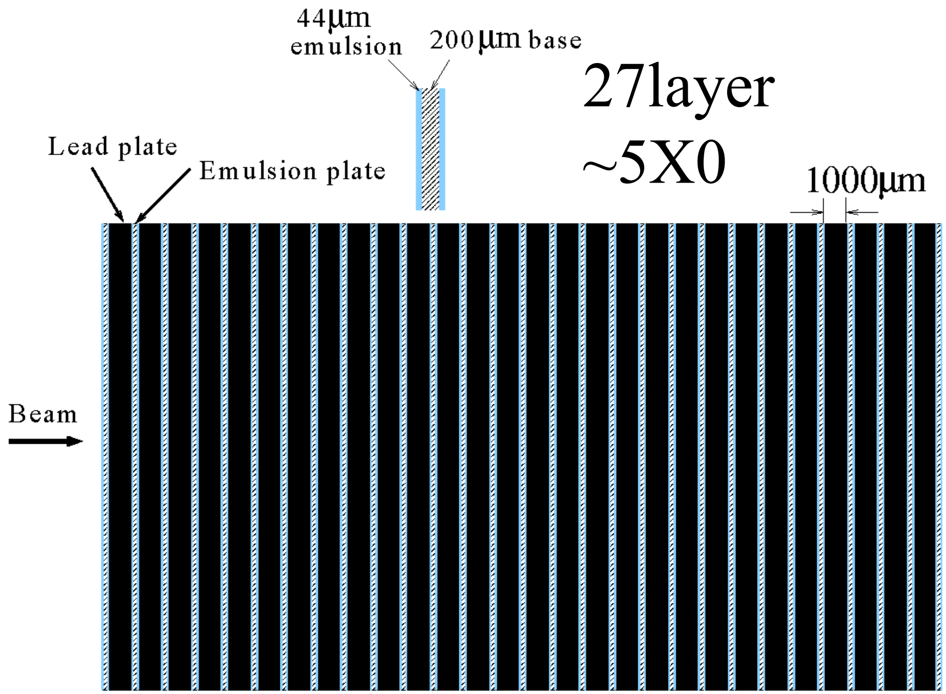
- Fuji-emulsions stored for about 2 month are refreshed at Nagoya   Real erasing
- Packed in transportation from Nagoya to CERN

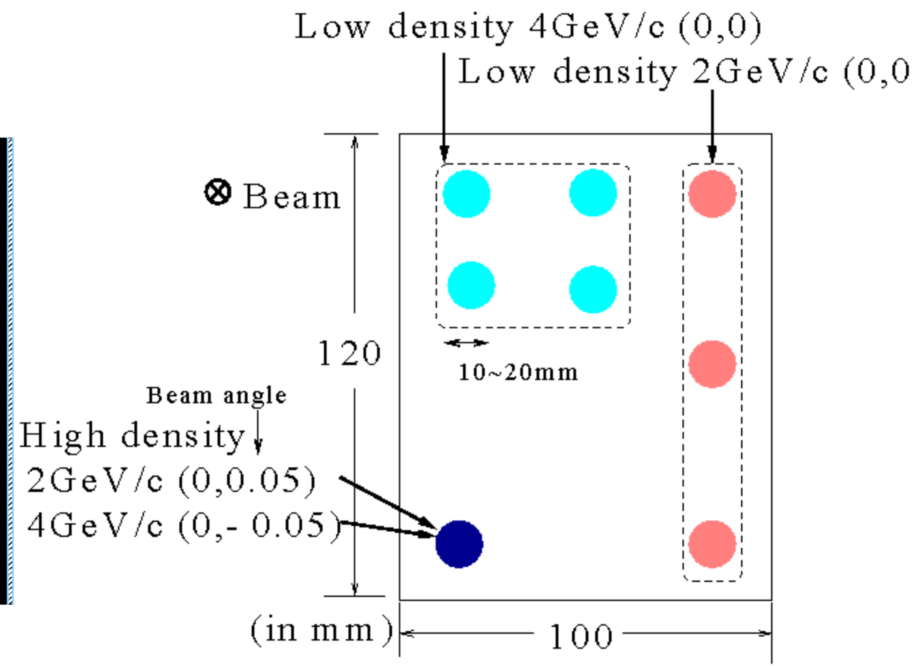


- Developed soon after the beam exposure

Emulsion plates are used as singlet.

Beam exposure (May 17th 2000)





- High density (~10^3/cm^2) run
  to study e/π identification
  with high statistics

r(e)~60%(2GeV/c),~30%(4GeV/c)

100~300electron

- Low density (~ a few 10^2/cm^2) run
  to study cascade shower
  in low background condition

r(e)~10%(2GeV/c),~2%(4GeV/c)

~10electron

Net Scan by UTS at Nagoya

- High density Oct. 2000 (one week)

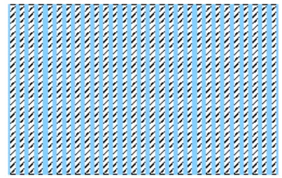
(1cm × 1cm) × 1 beam spot × 27 plates

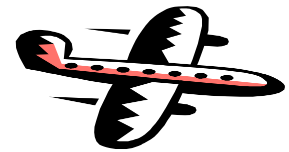
- Low density Dec. 2000 (one month)

(1cm × 1cm) × 7 beam spots × 27 plates

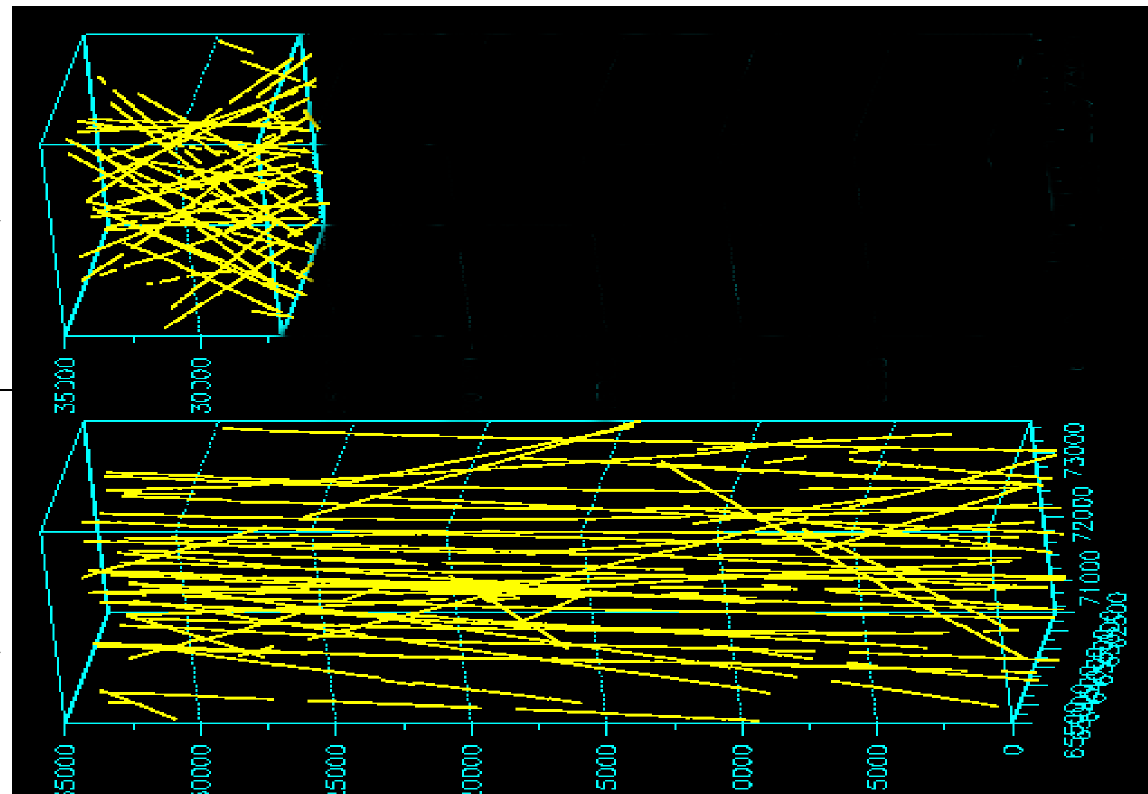
Tracking in ECC by two kind of configuration

Only Em



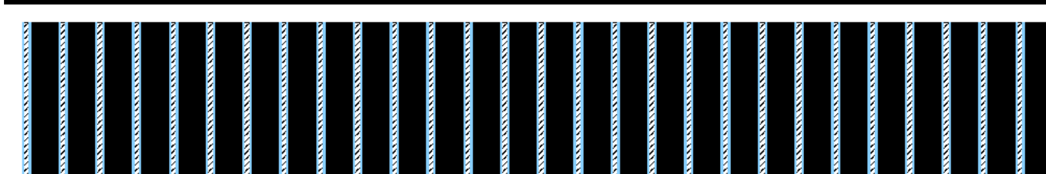


Cosmic-ray
In-flight
~300tracks/cm^2
Isotropic



Beam
at CERN
~300tracks/cm^2
Parallel

Em+Pb…



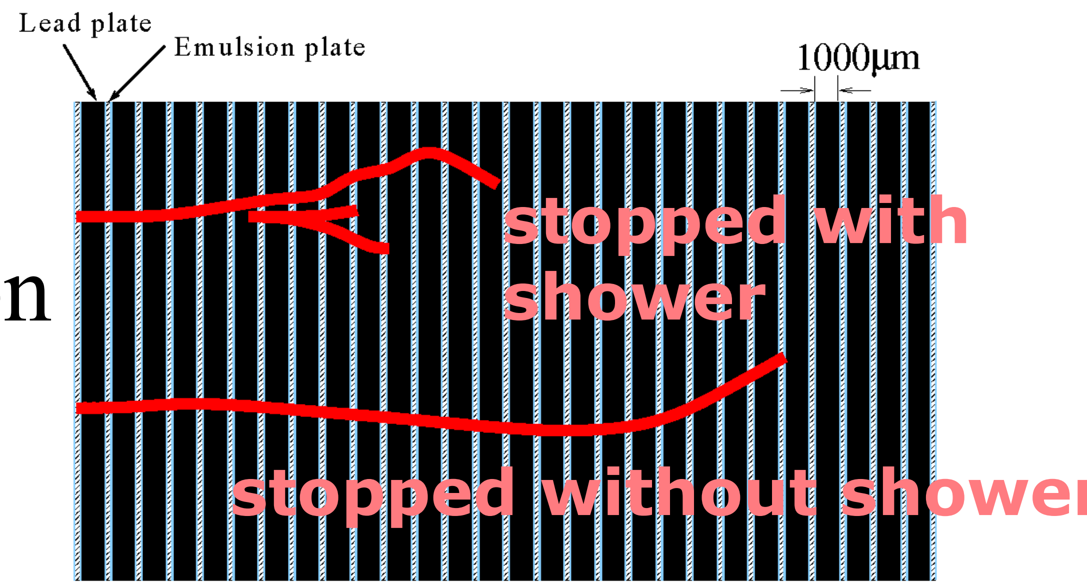
e/π identification (High density)

electron

Shower detection

$$E_e(z) = E_0 e^{-\frac{z}{X_0}}$$

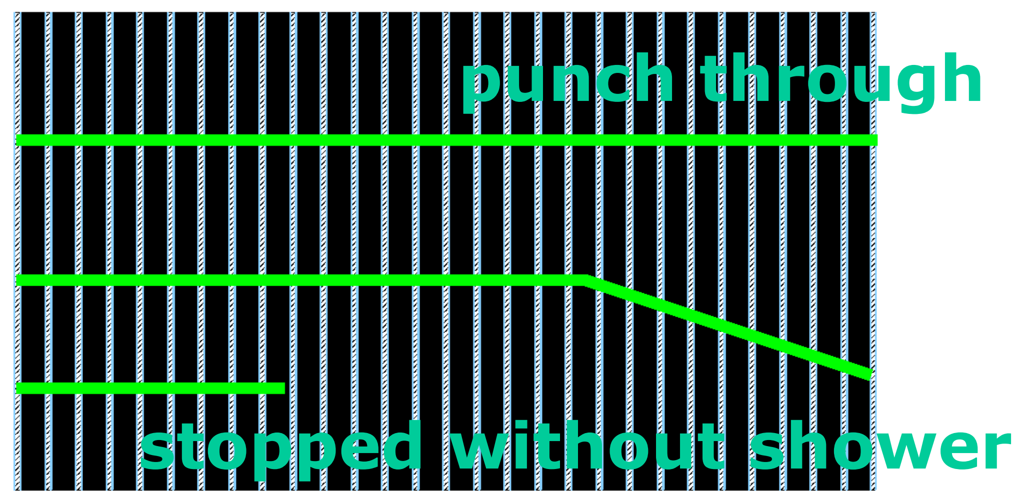
X_0=5.6mm in lead



π

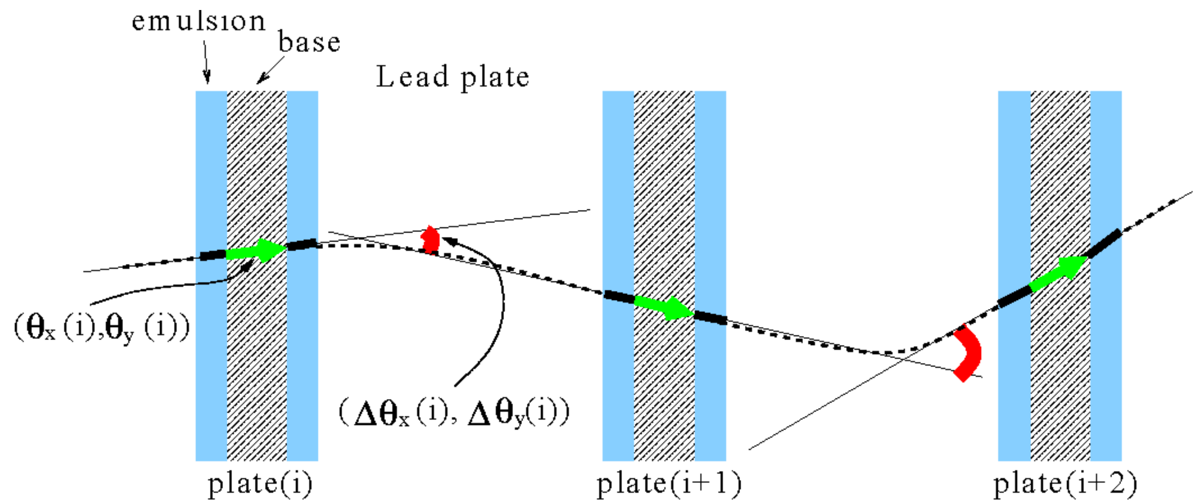
$$E_\pi(z) = E_0$$

λ_{int}=170mm in lead



χ^2 analysis to measure energy variation

$$\Delta\chi^2 \equiv \chi_e^2 - \chi_\pi^2$$: separator



$$\chi^2_{e,\pi} \equiv \sum_{i=1}^{N-1} \frac{\{(\Delta\theta_x(i) - \Delta\Theta_{e,\pi}(i))/\Delta\Theta_{e,\pi}(i)\}^2 + \{(\Delta\theta_y(i) - \Delta\Theta_{e,\pi}(i))/\Delta\Theta_{e,\pi}(i)\}^2}{2(N-1)}$$

$$\Delta\Theta_{e,\pi}(i) \equiv \sqrt{\left(\frac{13.6(MeV/c)}{p_{e,\pi}(z)}\sqrt{d/X_0}\right)^2 + (\sqrt{2}\delta\theta)^2}$$

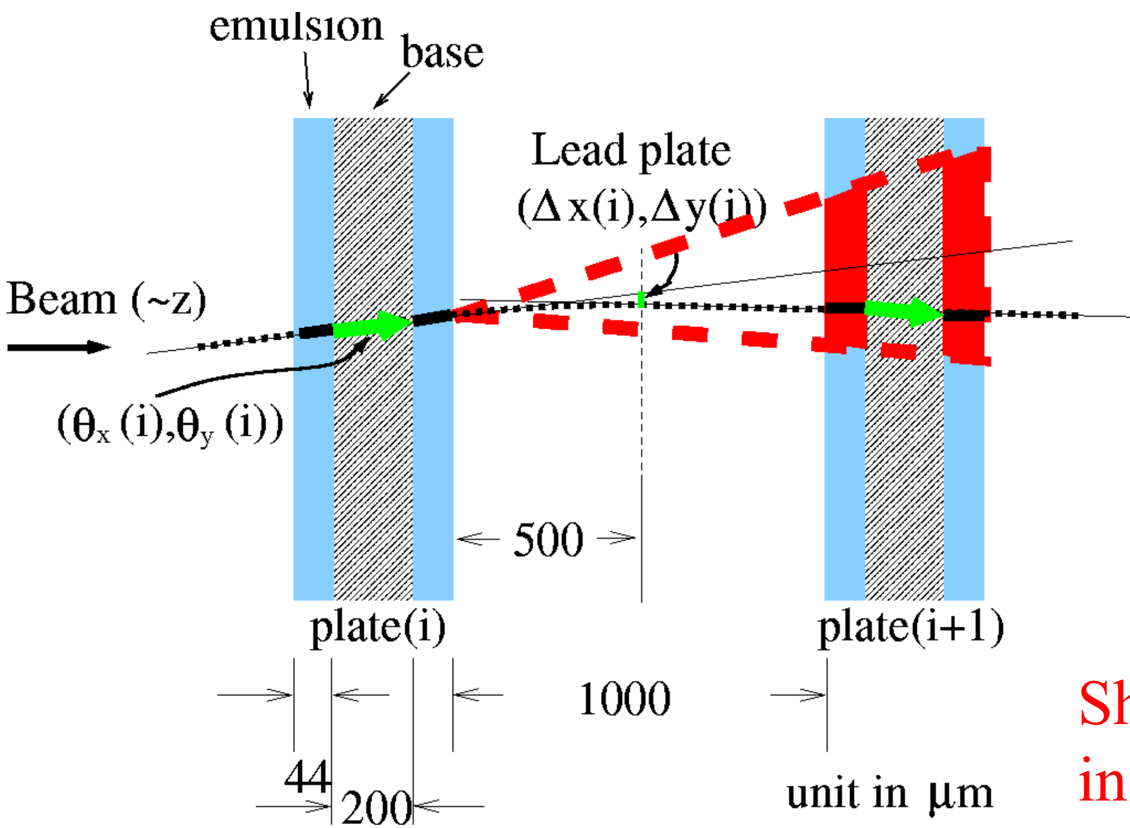
d: 1mm $\quad$ $\delta\theta$: 2.3mrad

$$E_e(z) = E_0 e^{-\frac{z}{X_0}}$$

$$E_\pi(z) = E_0$$

In practical experiments incident momentum are unknown,
so E_0 is treated as a free parameter to minimize chi-square.

Track following of low momentum track and detection of shower track



tolerance

Angle

< 75mrad

Position

< 45 μm

P_{min}~100MeV/c

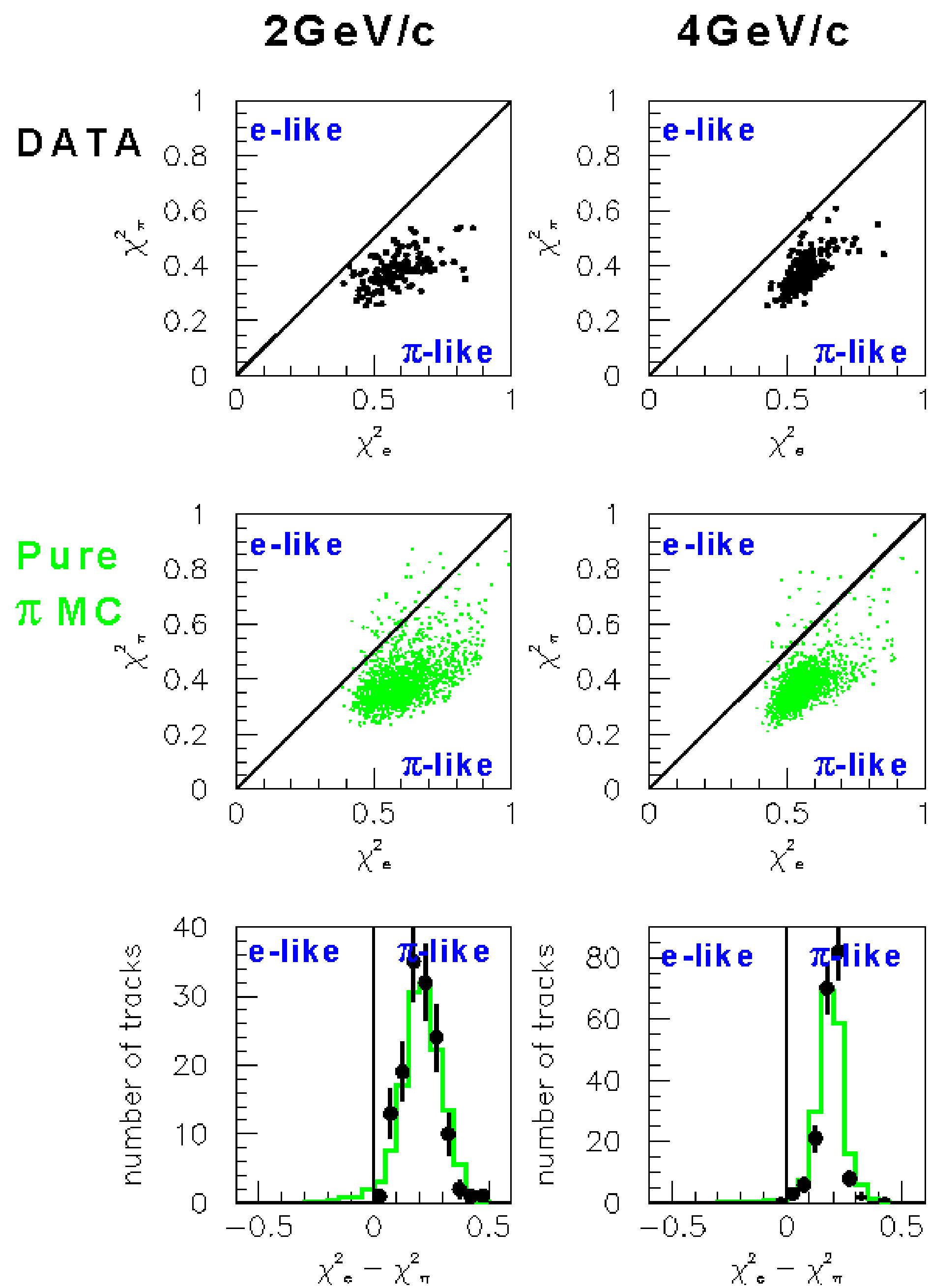
Shower tracks are searched in these tolerances.

Results of track following

beam momentum	2GeV/c	4GeV/c	
too short (2,3 plates)	16	1	
stopped with shower	126	65	→ electron-like
punch through	138	194	→ χ^2analysis
stopped without shower	202	106	→ χ^2analysis
Total incident beam in fiducial area	482	366	

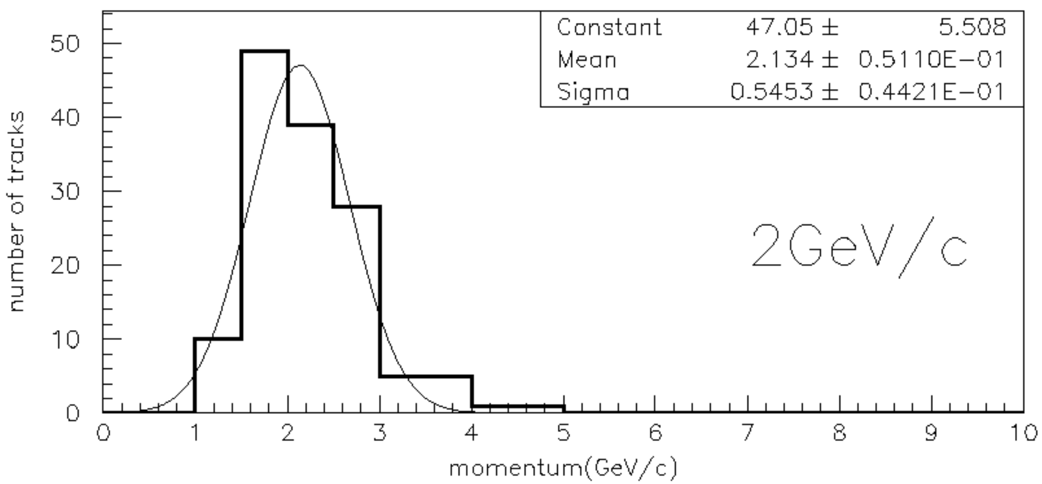
χ^2 for punch through

No interacting π

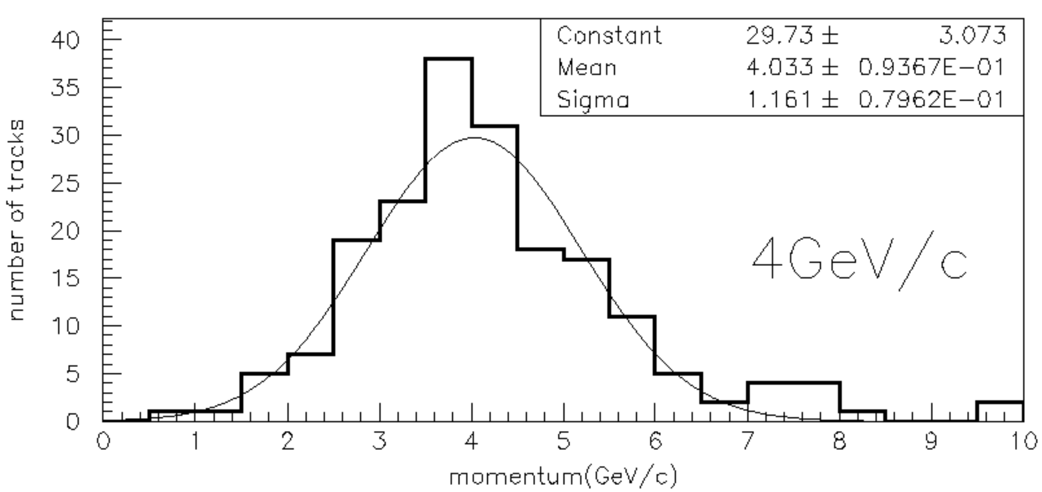


Data and pure π MC agree very well

Momentum measurement by multiple coulomb scattering for punch through tracks



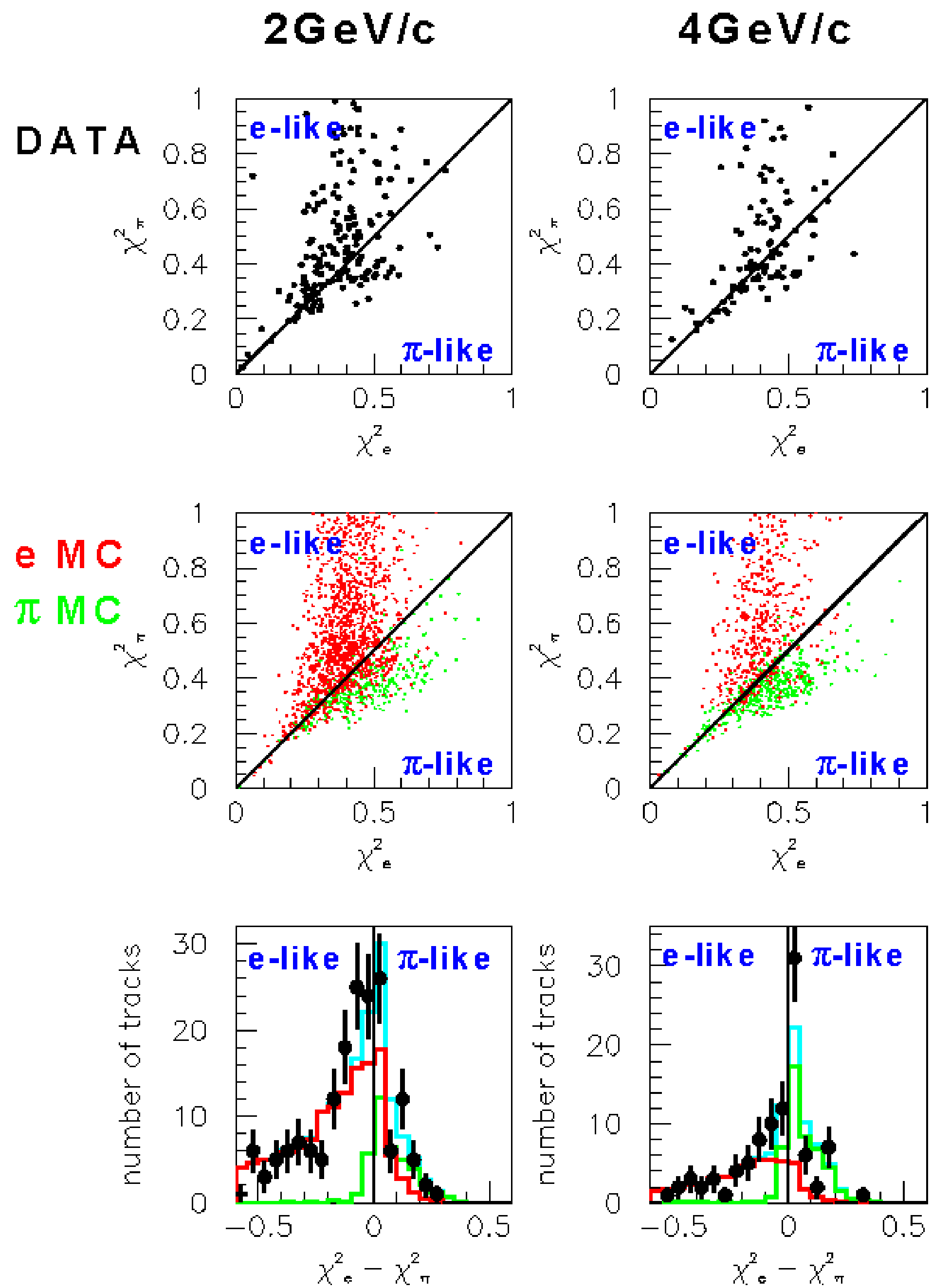
26% error



29% error

χ^2 for stopped tracks

Mixture of
electron
interacted π



Data and MC
agree very well

e-like : shower + negative chi-square

278 events 2GeV/c

126 events 4GeV/c

According to MC

Efficiency 88% mis-id Prob. 6% @2GeV/c

Efficiency 91% mis-id Prob. 4% @4GeV/c

Comparison with cherenkov counter

Installed in the upstream of ECC to monitor e/π ratio.

e/π ratio

	2GeV/c	4GeV/c
ECC	1.42±0.17	0.41±0.05
cherenkov	1.46±0.11	0.32±0.03

Consistent

Data and MC agree very well in $\Delta\chi^2$.

e/π ratio measured by ECC and cherenkov counter agree very much.

Performance of electron identification in ECC is well understood based on high statistics experimental data.

next

Low density run to study cascade shower

Analysis of cascade shower (Low density)

14 electron events @2GeV/c

14 electron events @4GeV/c

detected in low density sample

Detection efficiency is estimated as ~ 95%.

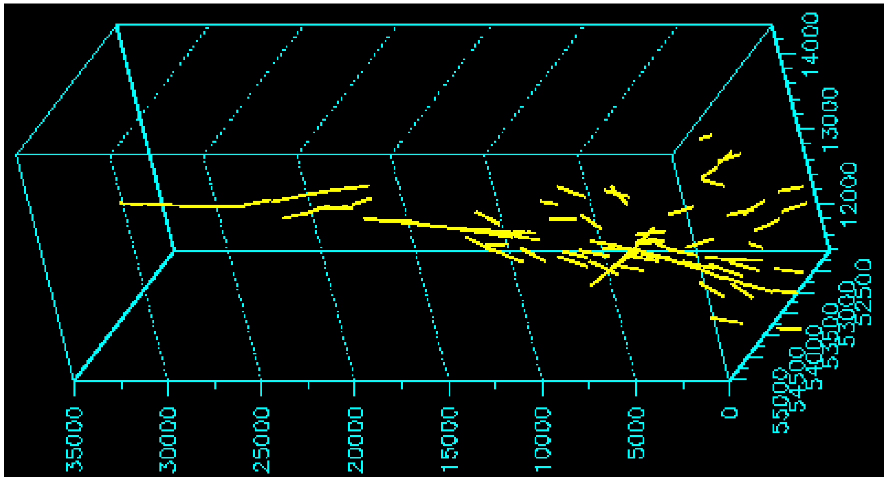
Contamination of π is estimated as ~ 2 events at most.

- Energy reconstruction

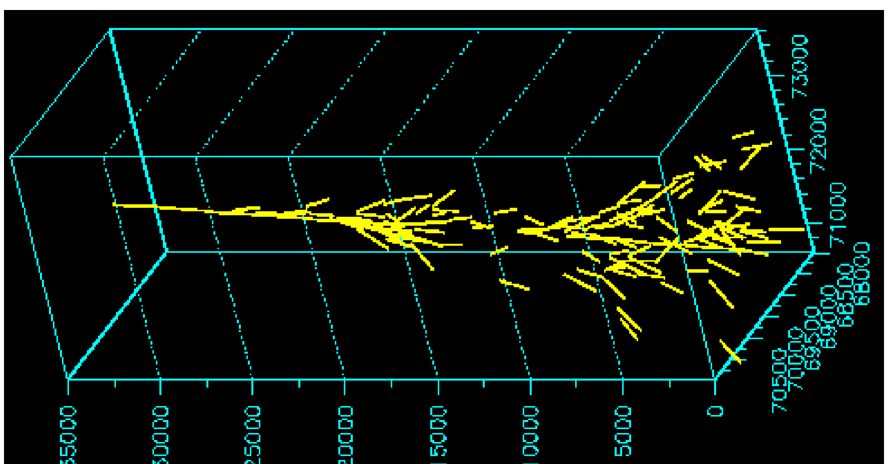
  by counting track segments

Counting track segments in horn

2GeV/c

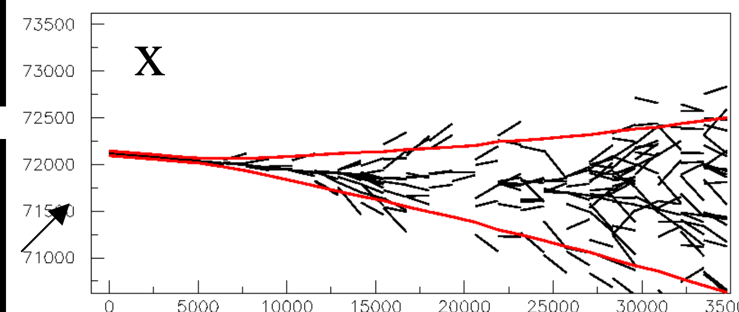


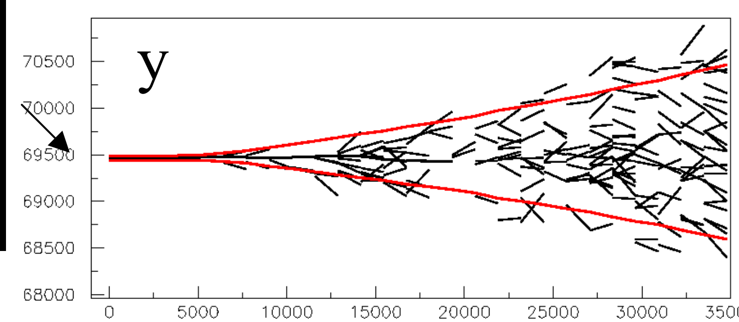
4GeV/c



Δ θ beam<250mrad

Determined as containing 68% @ 4GeV



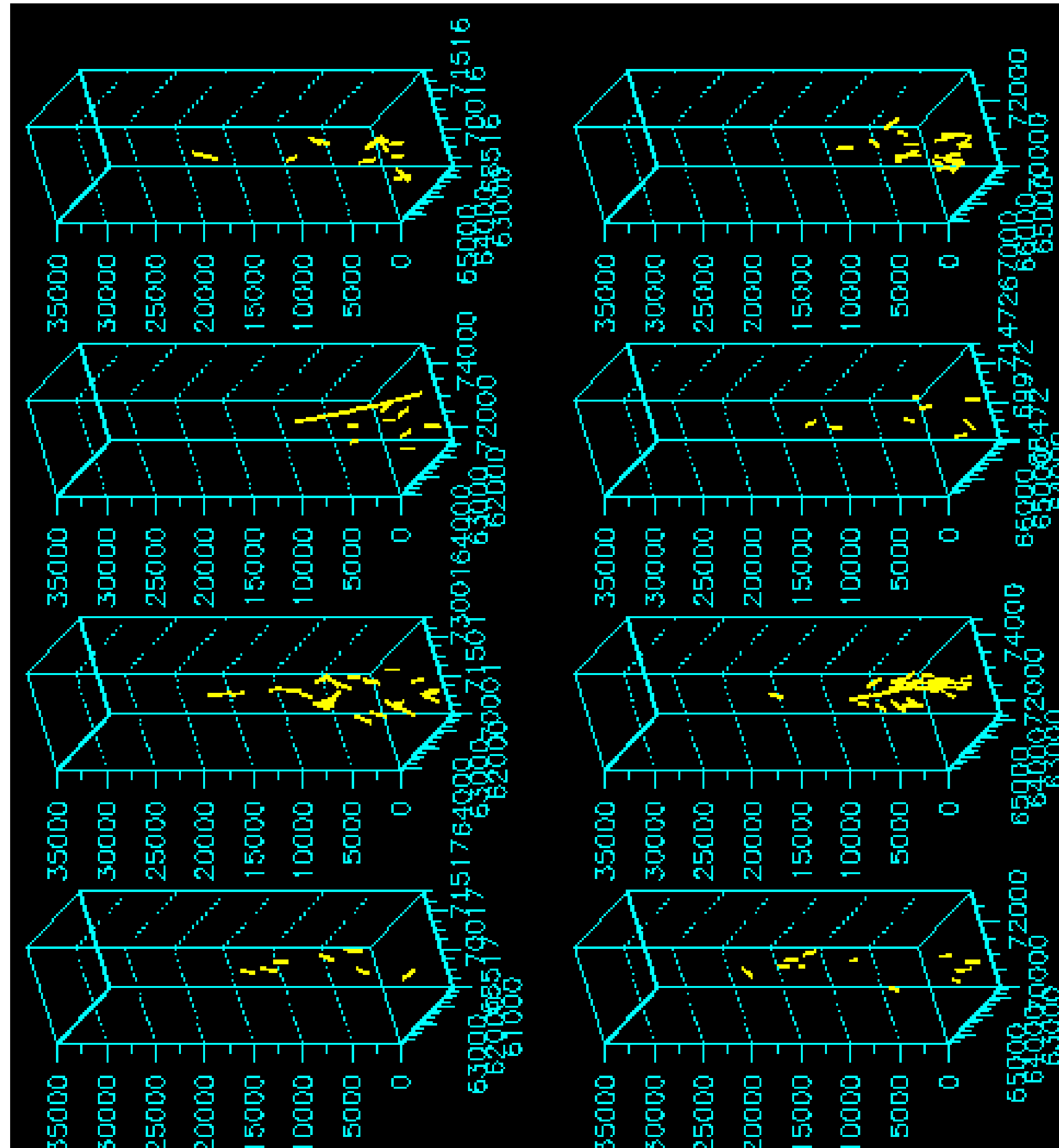


Estimation of background

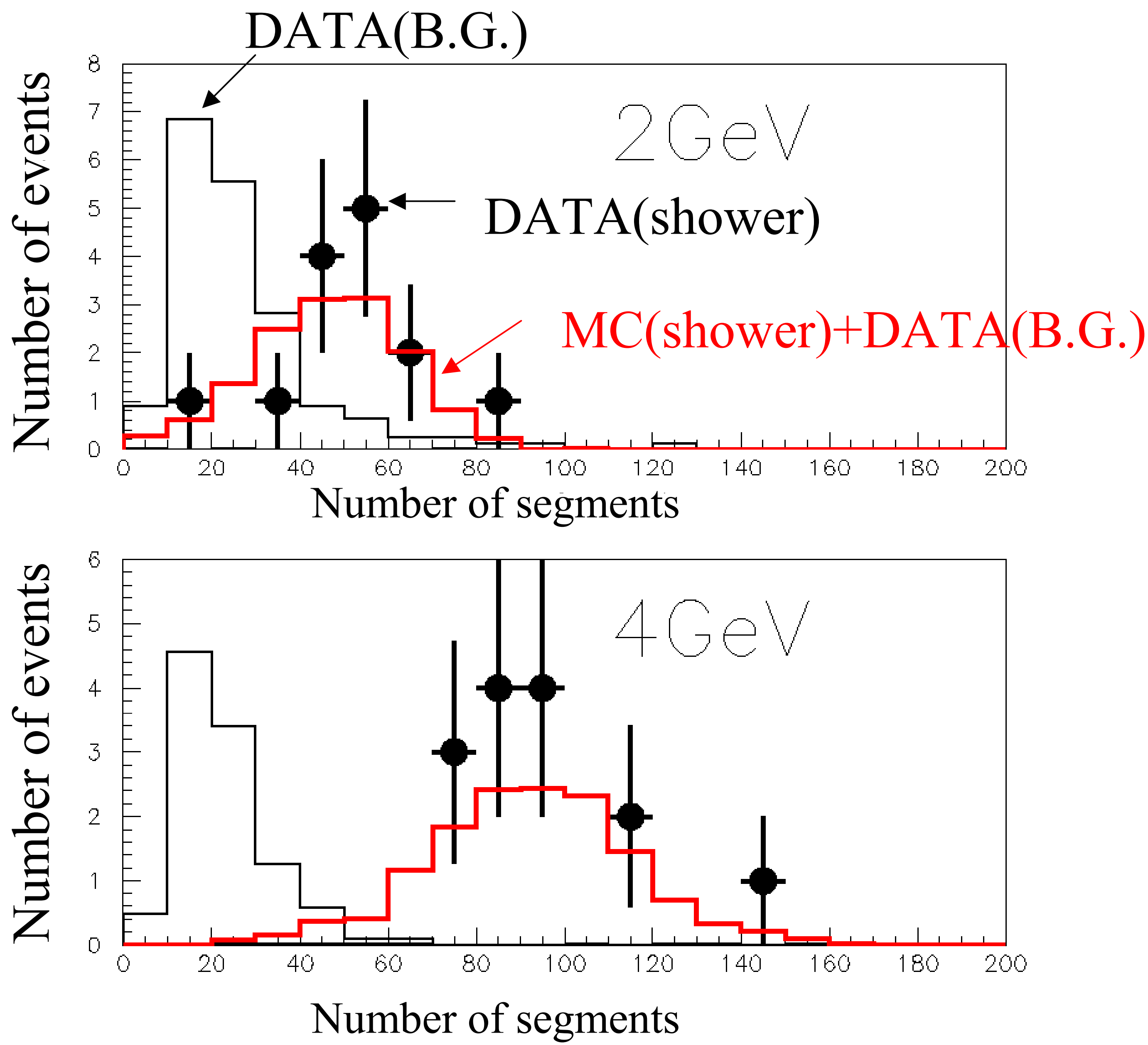
At random volume

Track segments from another electron and interaction are seen.

Random background ~1track/mm^2



Results



average 51

r.m.s. 14

average 94

r.m.s. 18

Summary

- electron identification

278 e-like events @ 2GeV

126 e-like events @ 4GeV

Efficiency ~90%   mis-id Prob. ~5%

- Analysis of cascade shower

14 electrons @ 2GeV

14 electrons @ 4GeV

$E \propto$ (number of segments)

$$\frac{\Delta E}{E} \sim \frac{0.4}{\sqrt{E(\mathrm{GeV})}}$$

@ a few GeV

These performances can be improved in lower background condition.

Refresh in the underground

Lower track density