Momentum measurement in emulsion by the MCS (angle method)

Giovanni De Lellis
University of Naples

- Test-beam exposure
- Emulsion analysis
- Momentum measurement (MCS: angle method)
- Results

Test-beam exposure

CERN-PS T9 experimental area (November 2000)

- significant electron contamination
- ~5X^0 absorber applied before the last focusing magnet

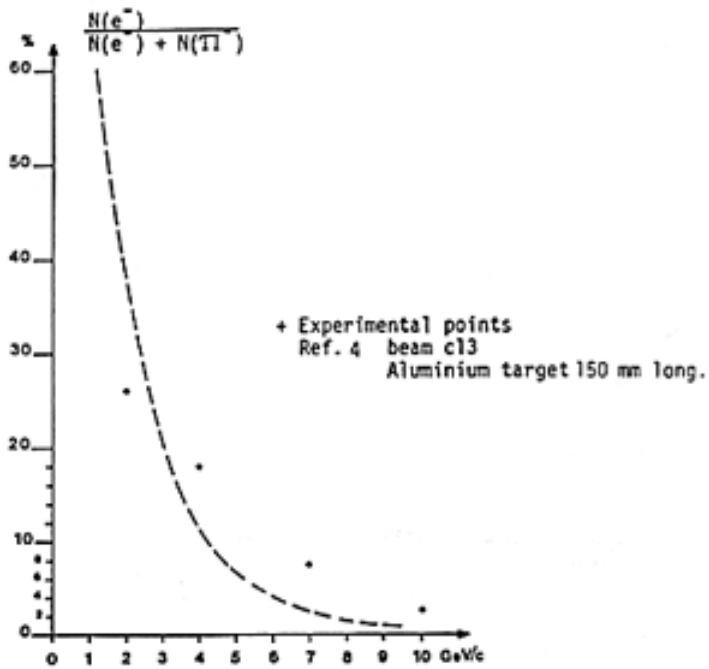


Fig 4.
Percentage of e^- in a negative beam calculated in Ref. 5 (zero degree production angle).

e contamination at the per-mill level

MCS brick exposure

- 40 compact cells with FOMOS emulsions (60/185/60) prepared at T9 PS
- exposed to 2, 3, 4, 5 GeV π^-

Aim

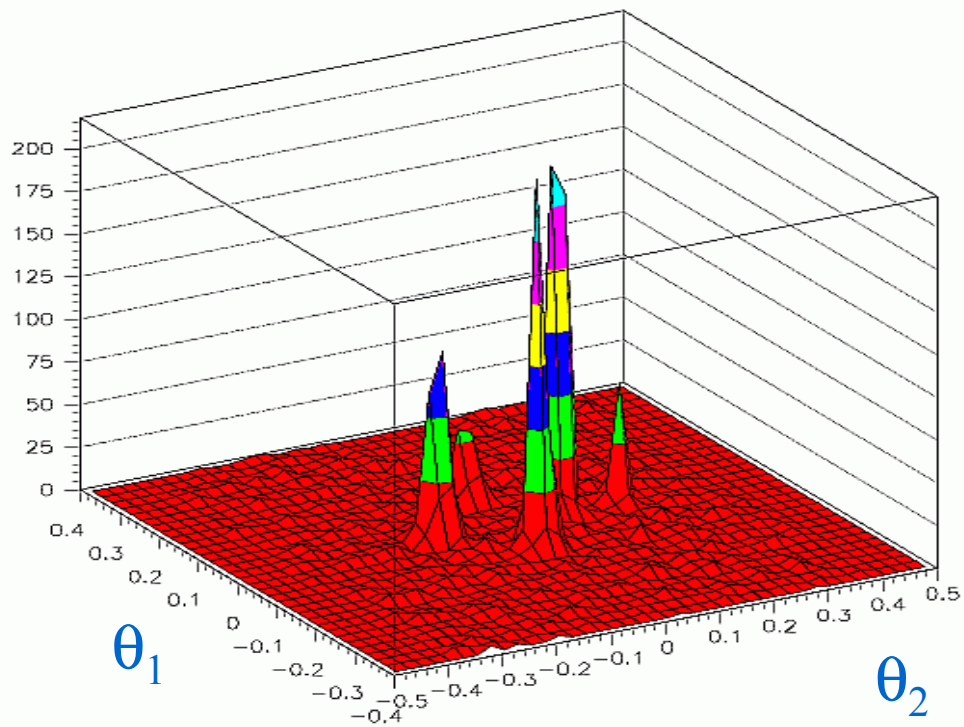
- prove the feasibility of the angular method
- measure $\Delta p/p = f(p)$

Emulsion quality monitoring

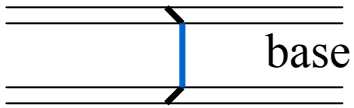
Sensitivity: ~ 30 grains/100μm

Fog density: ~ 8 grains/$(10\mu m)^3$

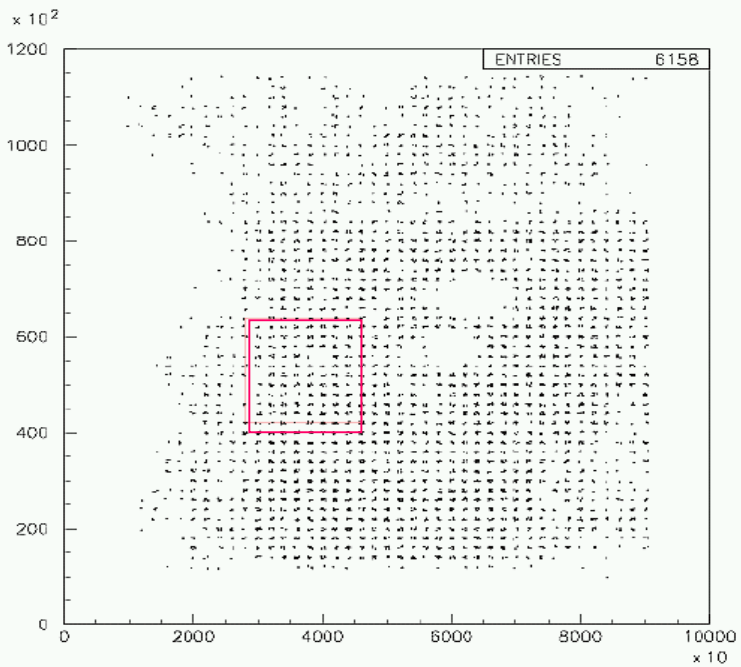
$P(GeV)$	$\delta(tr/mm^2)$ nominal	θ_1 (mrad)	θ_2 (mrad)	$\delta(tr/mm^2)$ measured
2	5	+100	0	2.5
3	10	-100	0	6.2
4	20	0	-100	13.8
5	25	0	+100	13.0
5	4	0	+200	5.0



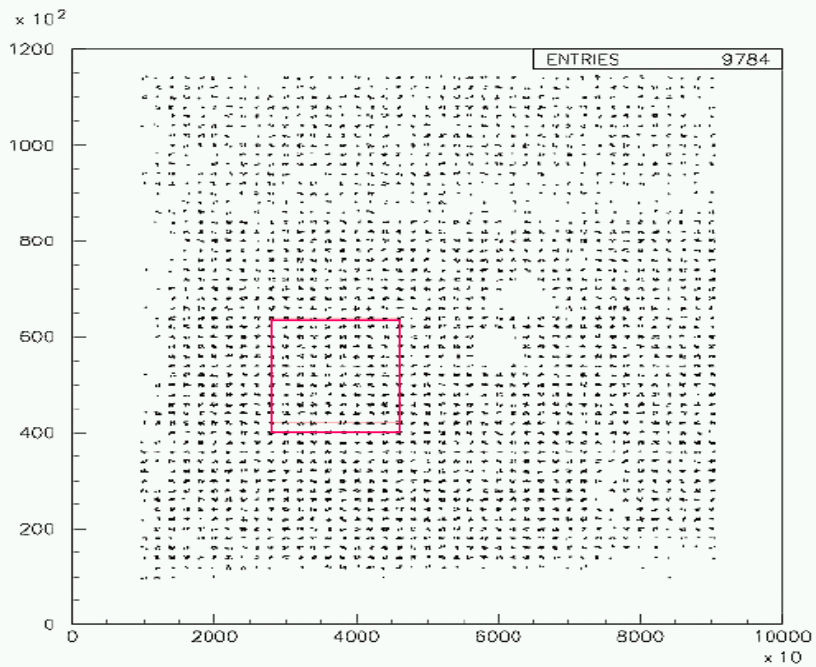
Distortion effect



full plate scanning



25 *mrad* allowance



50 *mrad* allowance

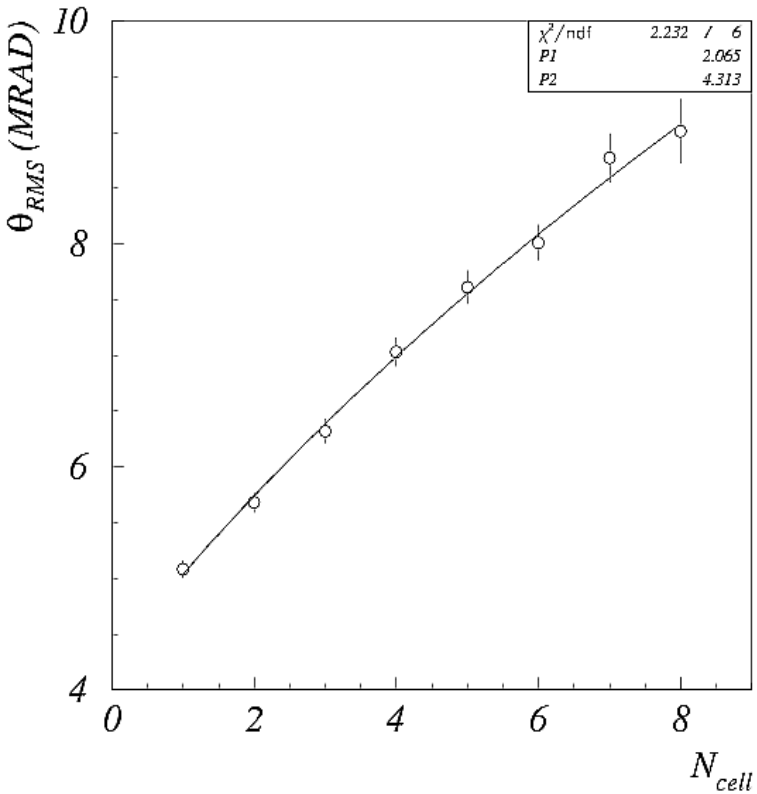
Emulsion analysis

- Half brick used (19 ES)
- Plate by plate quality monitoring
- Define a common "good quality region" (red box in the previous plots ~ 3cm^2)
- Make a general angle scanning on the first plate (~ 17000 tracks)
- Use measured angles as predictions for next plate scanning
- We end up with track (i.e.19 aligned segments)

		P (GeV)
2438 tracks	1296	5
	201	2
	422	3
	519	4

Getting the resolution

RMS values for each Δcell = k



$$\Delta\theta_{ik} = \theta_{i+k} - \theta_i$$

$$\langle\theta^2_{obs}\rangle_k = \sum_i (\Delta\theta_{ik})^2/N$$

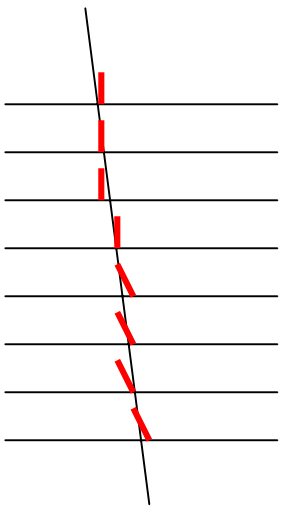
$$\square(x) = \sqrt{P_2^2 + (13.6)^2(x/5.6)/P_1^2}$$

P_1 = momentum = 2.0 GeV

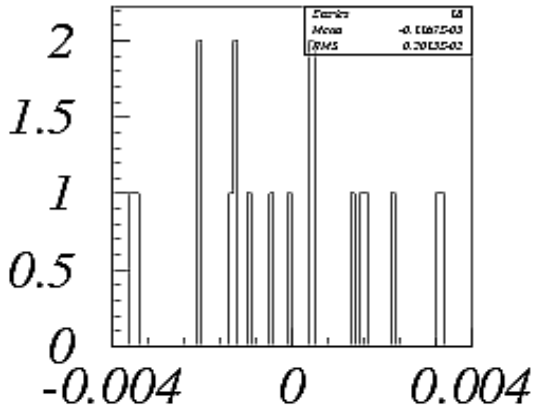
$P_2/\sqrt{2}$ = resolution = 3.0 mrad

Planarity check

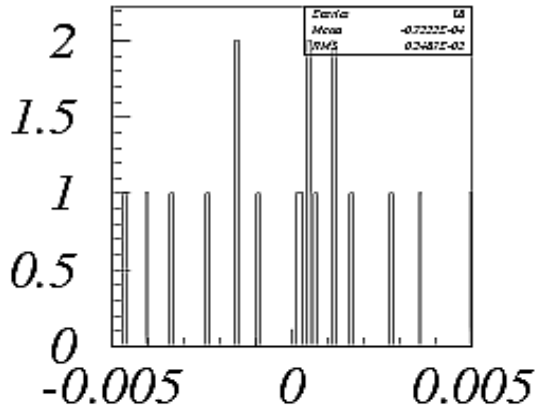
Average trajectory of several hundred tracks



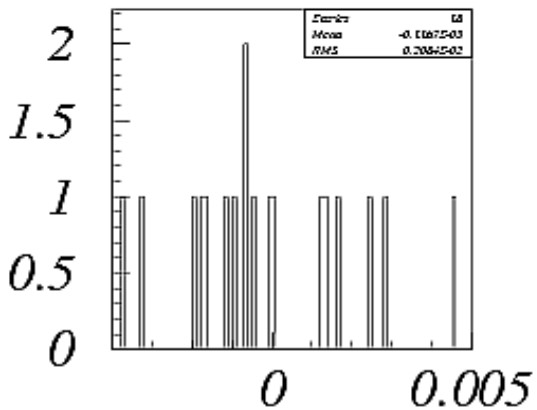
2.0 mrad



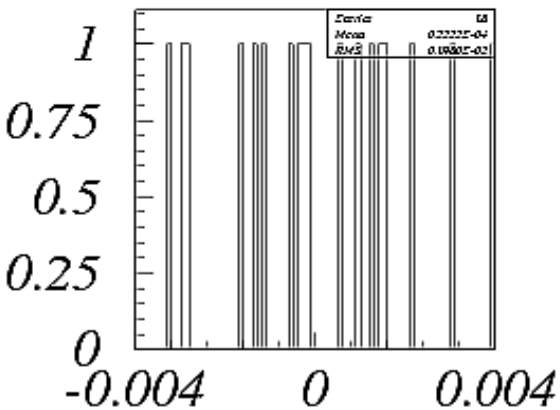
2.5 mrad



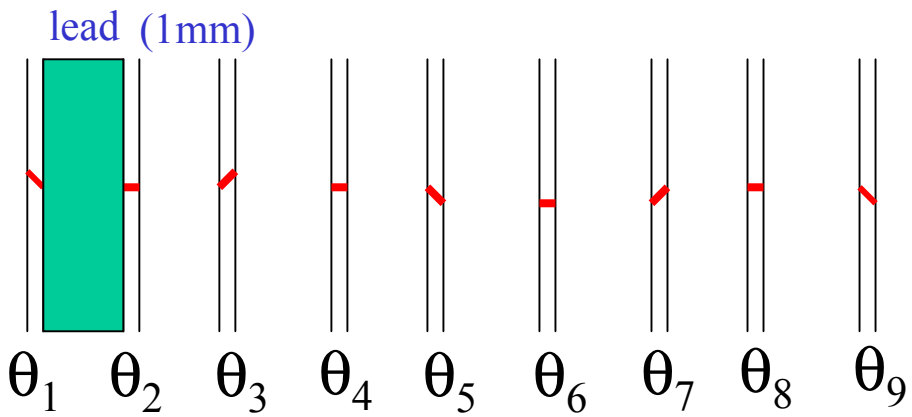
2.1 mrad



2.0 mrad



Angle method



Assume to measure angular offset

ε = measurement error

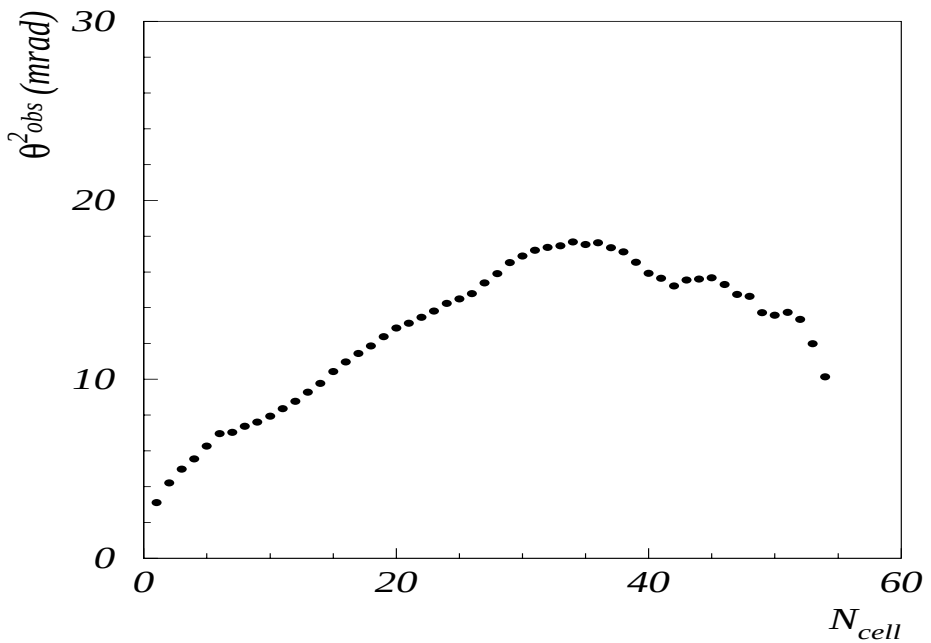
2.5 GeV/c π

θ_i = relative to a reference track

$\Delta\theta_{ik} = \theta_{i+k} - \theta_i$

$\langle\theta^2_{obs}\rangle_k = \sum_i (\Delta\theta_{ik})^2/N$

$\langle\theta^2_{obs}\rangle = \langle\theta^2_{sc}\rangle + \varepsilon^2$



How to get the momentum error from data: an example

$\theta^n = \sqrt{<\theta^2_{obs}>} / \theta_{MCS}$

effect of measurement error

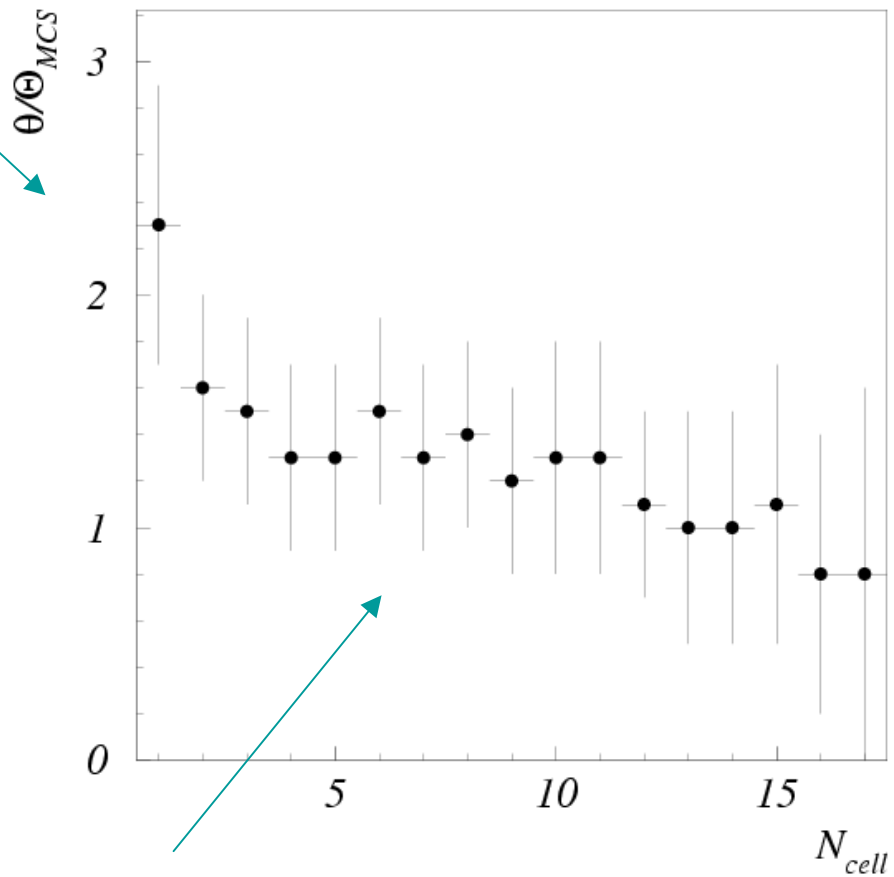
$\sigma(<\theta^2_{obs}>) = 0.8 \times <\theta^2_{sc}> / \sqrt{N_1}$

$N_1 = N_{tot} \times 2 / N_2$

$\sigma = 0.8 / \sqrt{N_1}$

$N_2 = 7$ & $N_{tot} = 17$

$\sigma = 36\%$



N_2

cell number

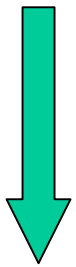
Algorithm

$\theta_{sc} \in [\theta_{min}, \theta_{max}]$

step = 0.05 mrad

Generate 100 sets of MC data

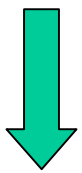
Get the average $<\theta^2_{obs}>$ and its error



minimum χ^2 analysis

ϑ_y & ϑ_z

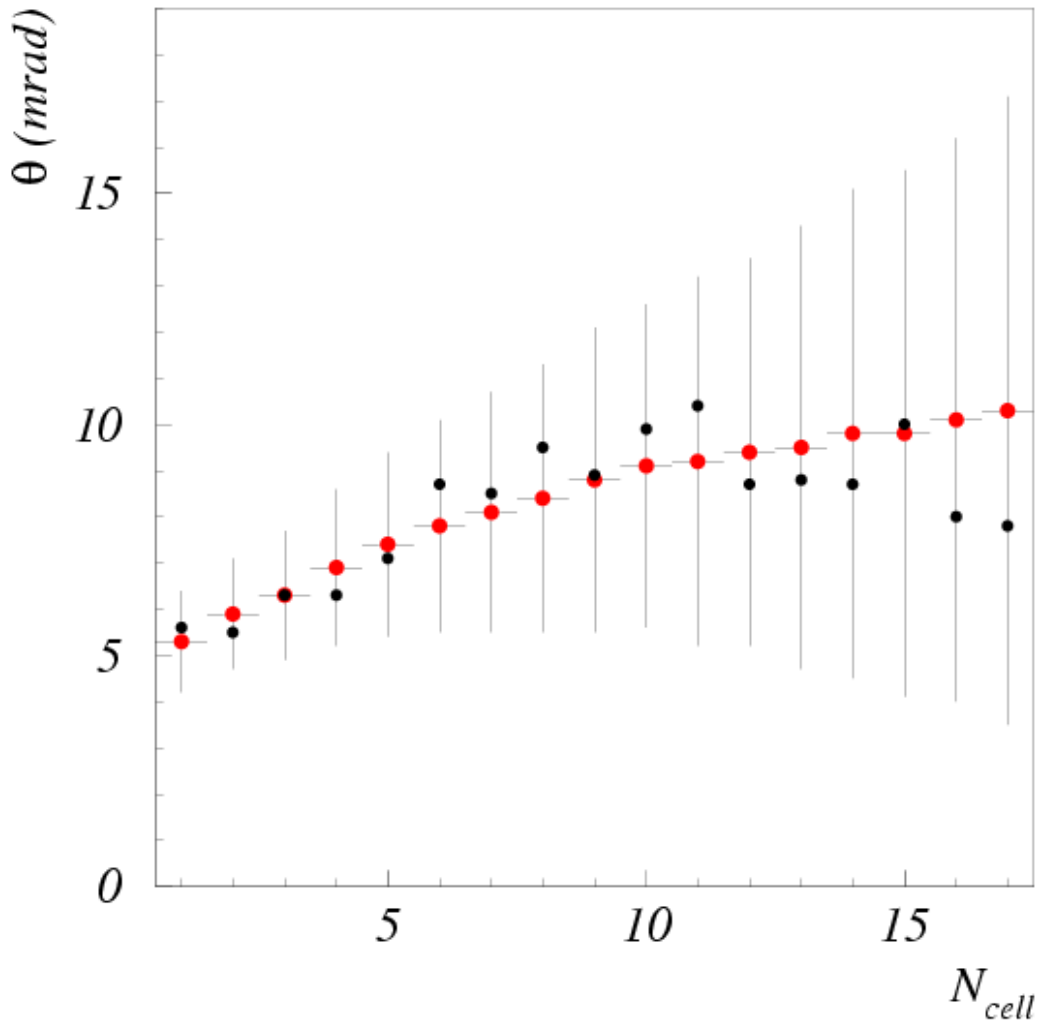
Use P_Y & P_Z to generate 100 simulated data and apply the above procedure to estimate P_Y and P_Z fluctuations



$\sigma\vartheta_Y$ & $\sigma\vartheta_Z$

$P \pm \sigma P$ = weighted average and error

Scattering as a function of depth



a 2 GeV π^-

$P_z = 2.2$ GeV

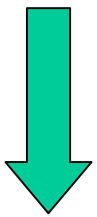
$3X^0$

Momentum distribution

$P(\theta)$ gaussian

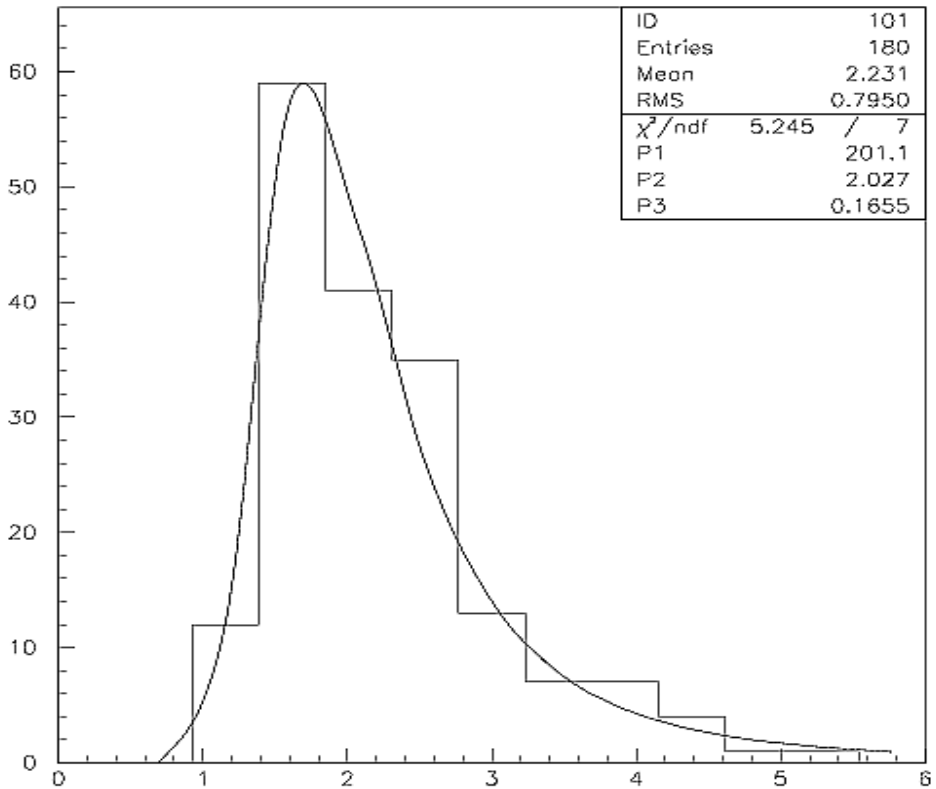
$\Delta p/p = \Delta\theta/\theta$

$P \propto 1/\theta \rightarrow dP \propto d\theta/\theta^2$



$$P(x) = \frac{a_0 \exp(-(1/x - 1/a_1)^2/a_2^2)}{x^2}$$

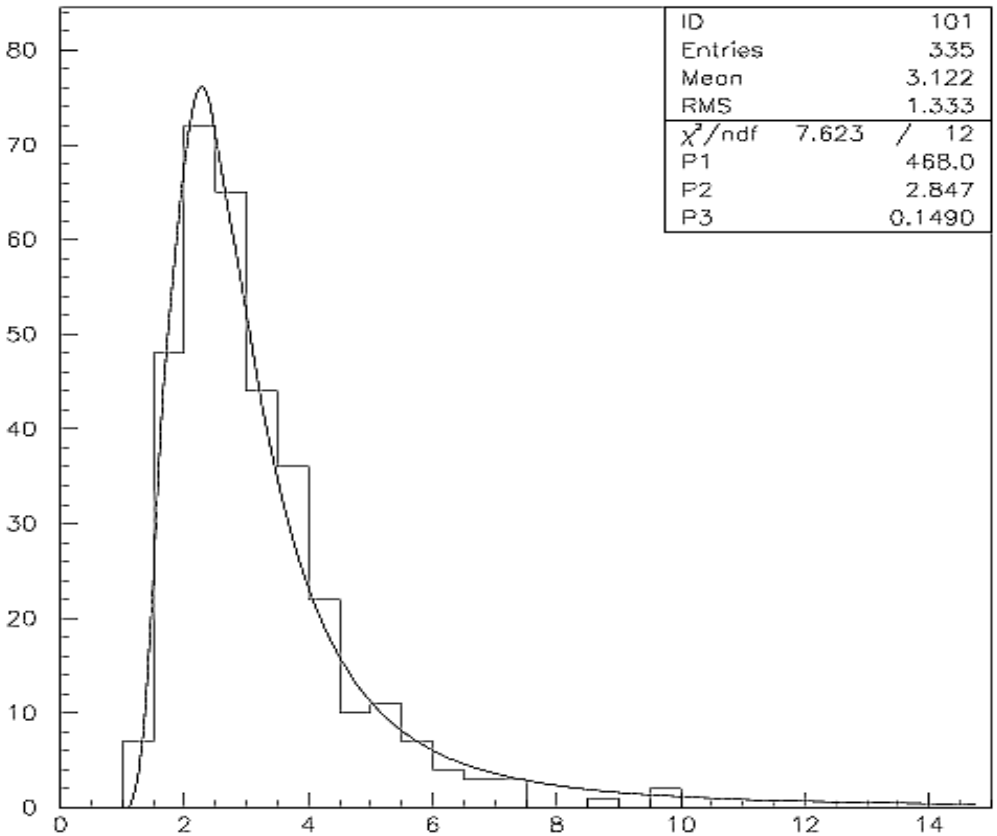
Momentum resolution @ 2 GeV



$P = 2.1^{+0.9}_{-0.5}$

$\Delta p/p = 25\%$

Momentum resolution @ 3 GeV



P (GeV)

$P = 3.0^{+1.9}_{-1.0}$

$\Delta p/p = 33\%$