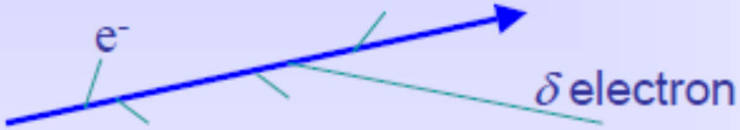
Interaction of charged particles

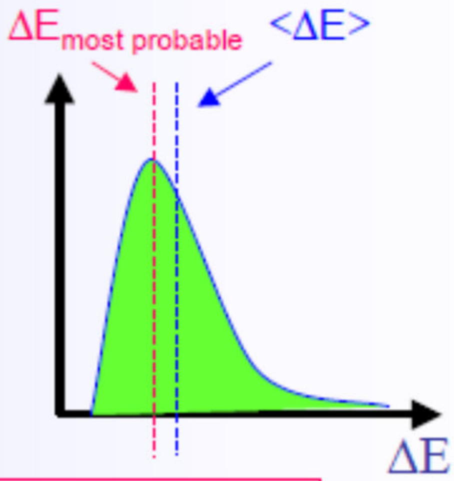
Real detector (limited granularity) can not measure <*dE/dx*> !

It measures the energy ΔE deposited in a layer of finite thickness δx.

For thin layers or low density materials:

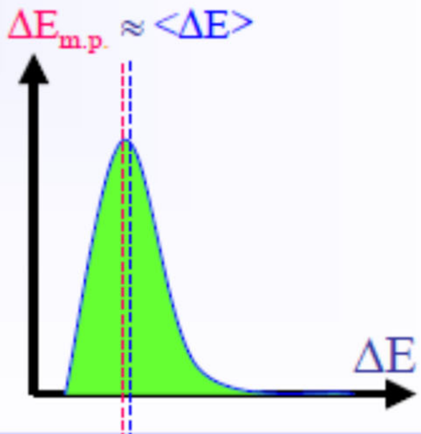
→ Few collisions, some with high energy transfer.





→ Energy loss distributions show large fluctuations towards high losses: "Landau tails"

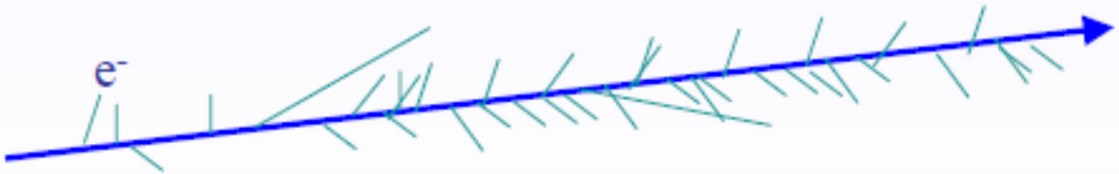
Example: Si sensor: 300 μm thick. $\Delta E_{m.p} \sim 82$ keV $\quad \langle\Delta E\rangle \sim 115$ keV



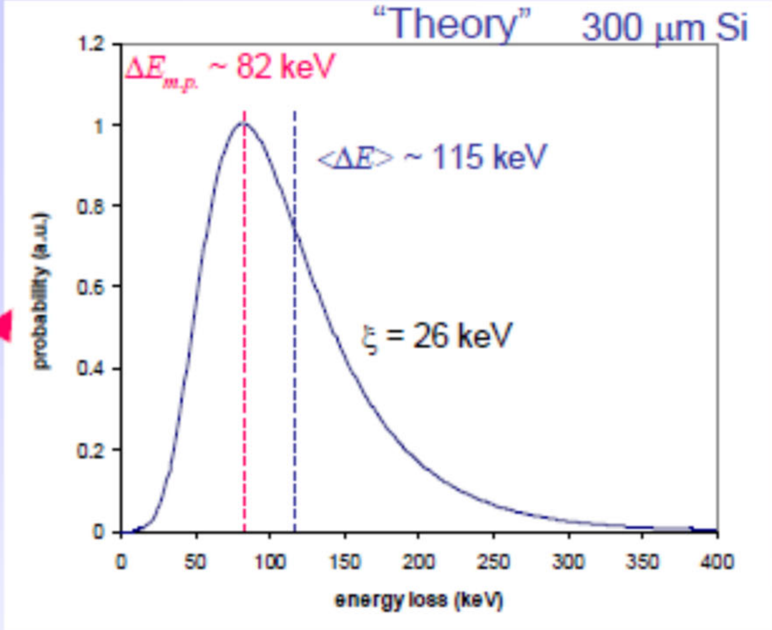
For thick layers and high density materials:

→ Many collisions.

→ Central Limit Theorem → Gaussian shaped distributions.



Interaction of charged particles



Landau's theory J. Phys (USSR) 8, 201 (1944)

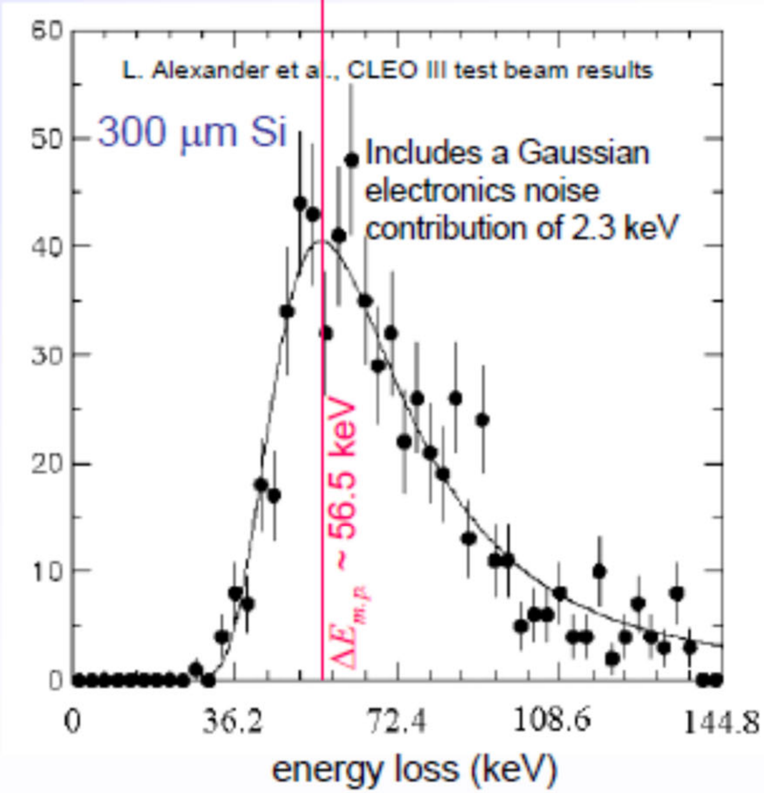
$$f(x,\Delta E) = \frac{1}{\xi}\Omega(\lambda) \qquad \Omega(\lambda) \approx \frac{1}{\sqrt{2\pi}}\exp\left\{-\tfrac{1}{2}(\lambda + e^{-\lambda})\right\}$$

$$\lambda = \frac{\Delta E - \Delta E_{m.p.}}{\xi}$$

$$\xi = \frac{2\pi N e^4}{m_e v^2}\frac{Z}{A}x$$

x (300 μm Si) = 69 mg/cm²

charge collection is not 100%



CERN Academic Training Programme 2004/2005

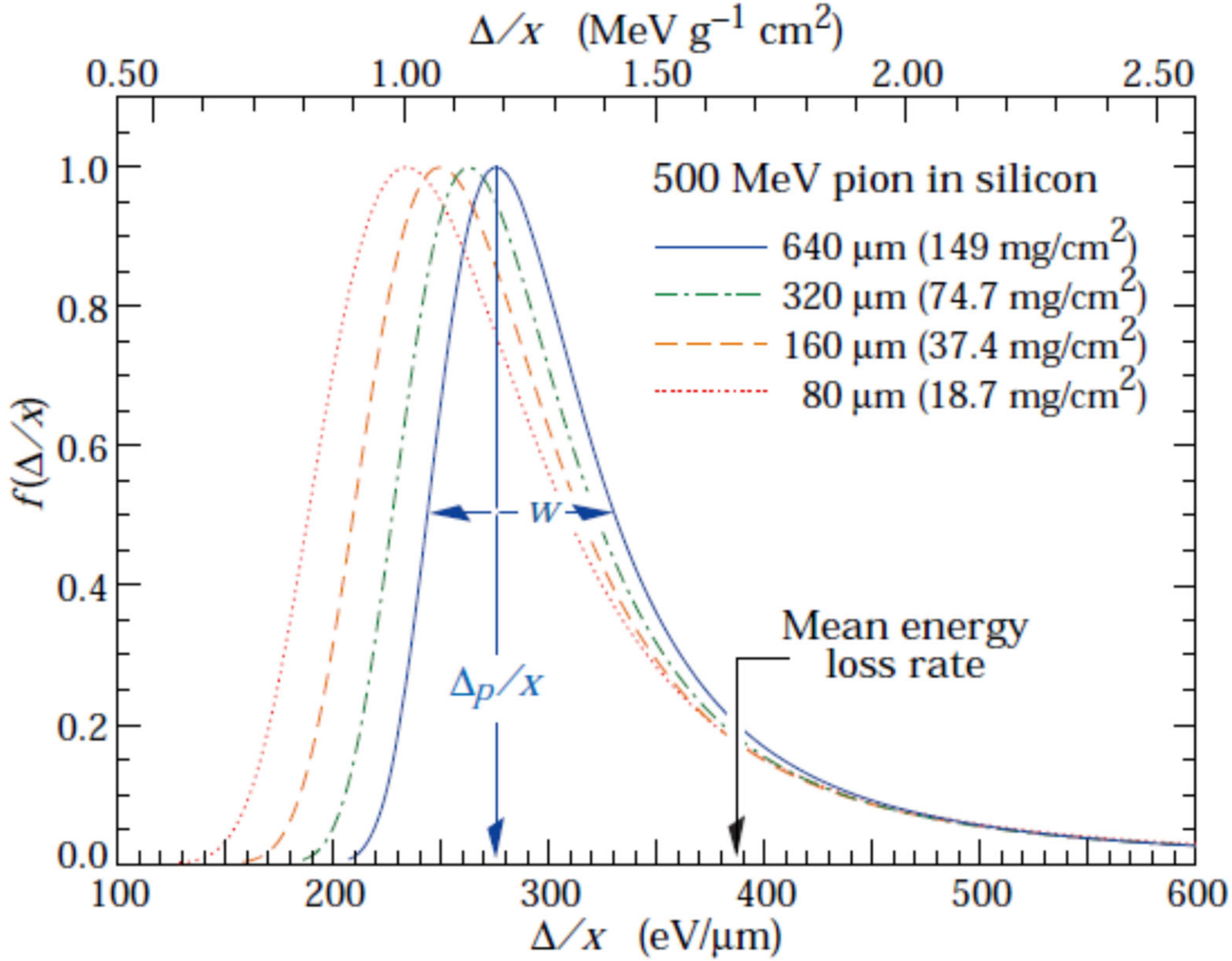


Figure 27.7: Straggling functions in silicon for 500 MeV pions, normalized to unity at the most probable value δ_p/x. The width w is the full width at half maximum.

fluttuazioni che sono descritte dalla distribuzione

Landau :

$$L(\lambda)=\frac{1}{(\sqrt{(2\pi)})}\exp\left(\frac{-1}{2}(\lambda+e^{(-\lambda)})\right)$$

- $$\lambda=\frac{(\Delta E-\Delta E_m)}{(\zeta)}$$

- $$\zeta=2\pi N_0 r_e^2 m_e z^2 c^2 \frac{Z}{A}\frac{1}{(\beta^2)}\rho x$$

La grande fluttuazione nella perdita di energia tra un evento ed un alt

condiziona la risoluzione energetica dei rivelatori sottili .

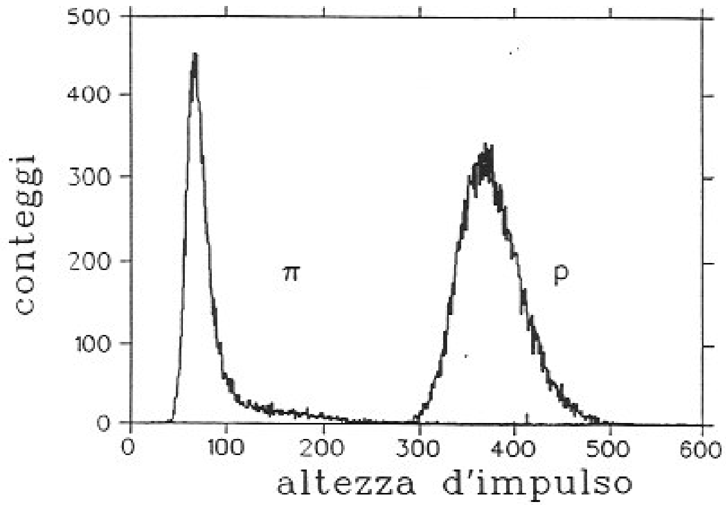


Fig.5.6- Altezza d'impulso di π^+, p in $\Delta E1$ per p=400 MeV/c.

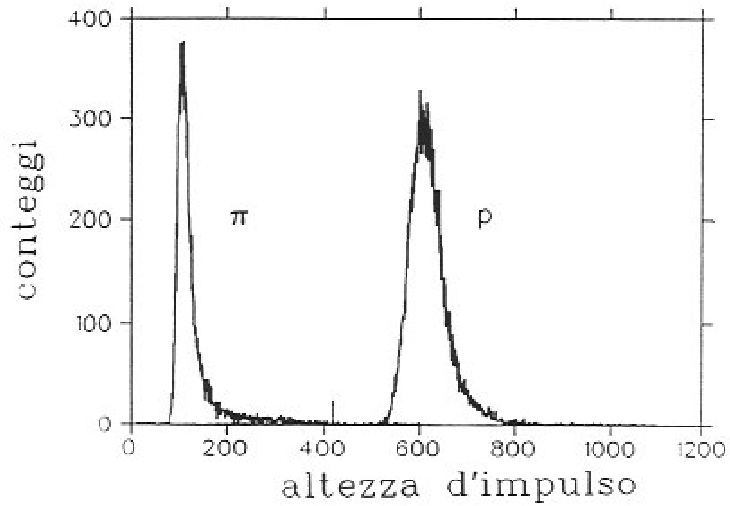


Fig.5.7- Altezza d'impulso di π^+, p in $\Delta E2$ per p=400 MeV/c.

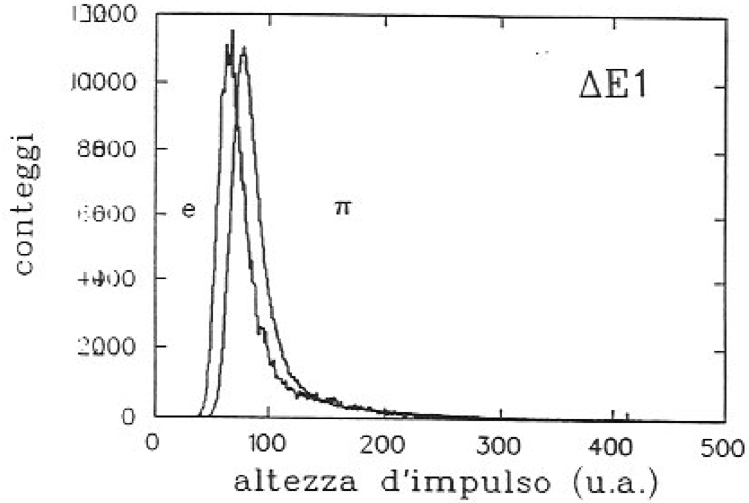


Fig.5.10- Altezza d'impulso di e^+ π^+ in ΔE1 per p=240 MeV/c.

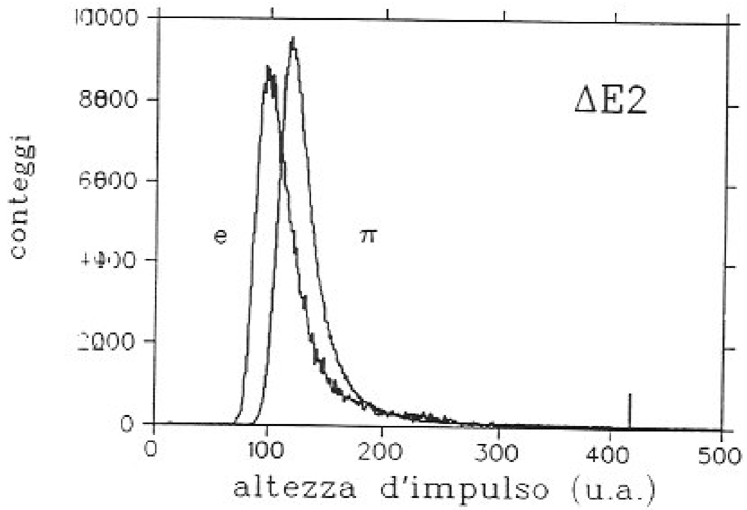
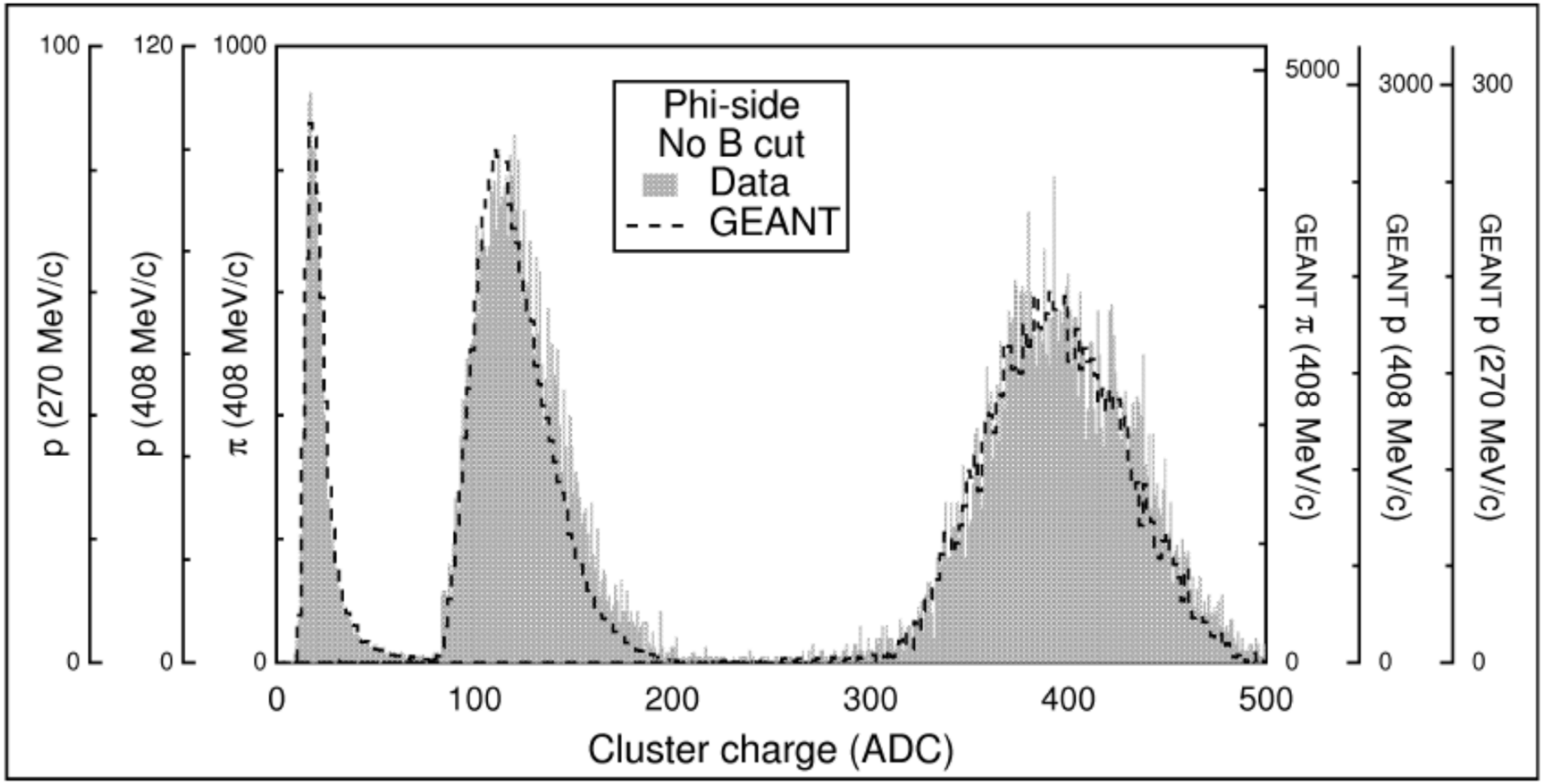
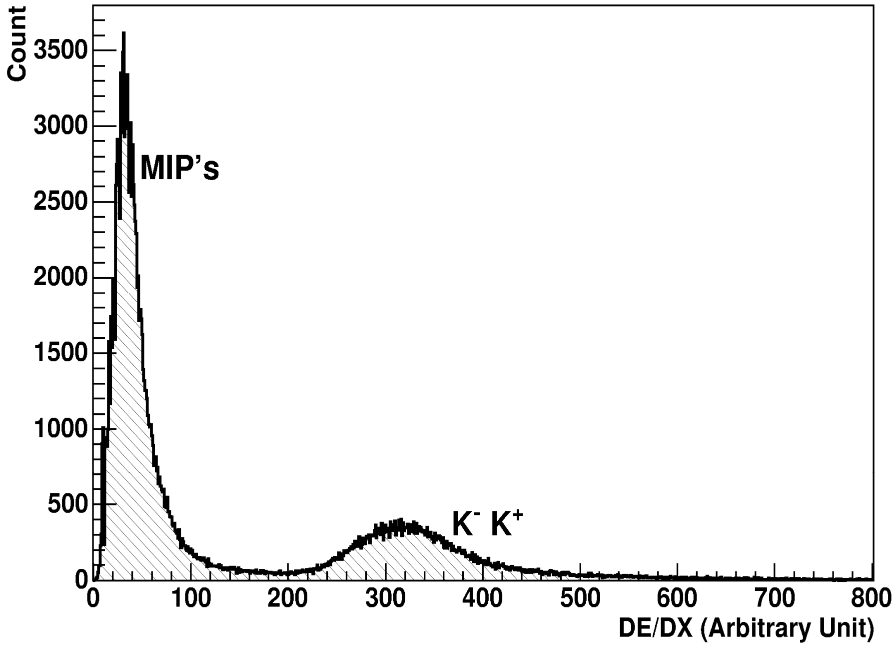
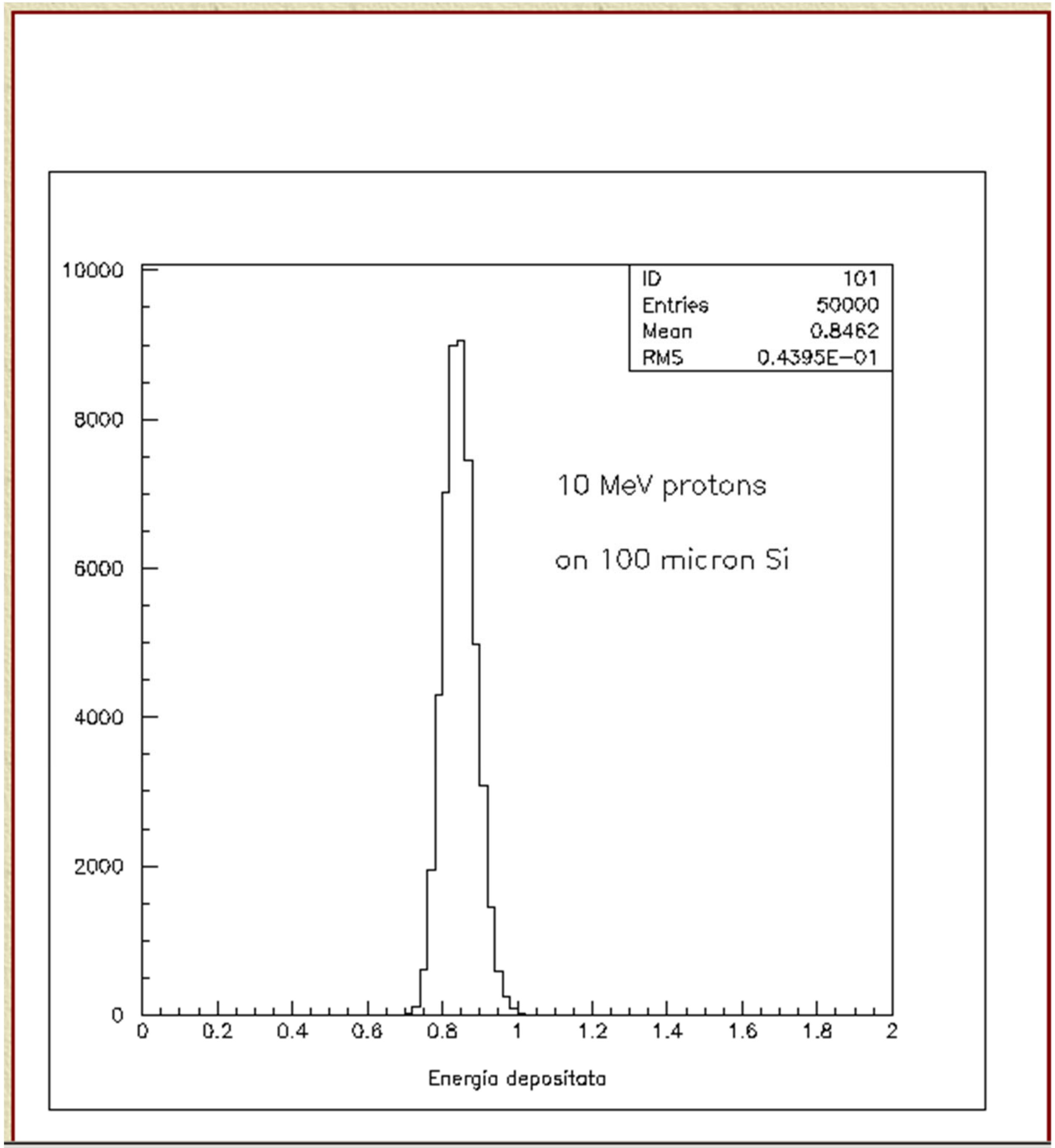


Fig.5.11- Altezza d'impulso di e^+ π^+ in ΔE2 per p=240 MeV/c.

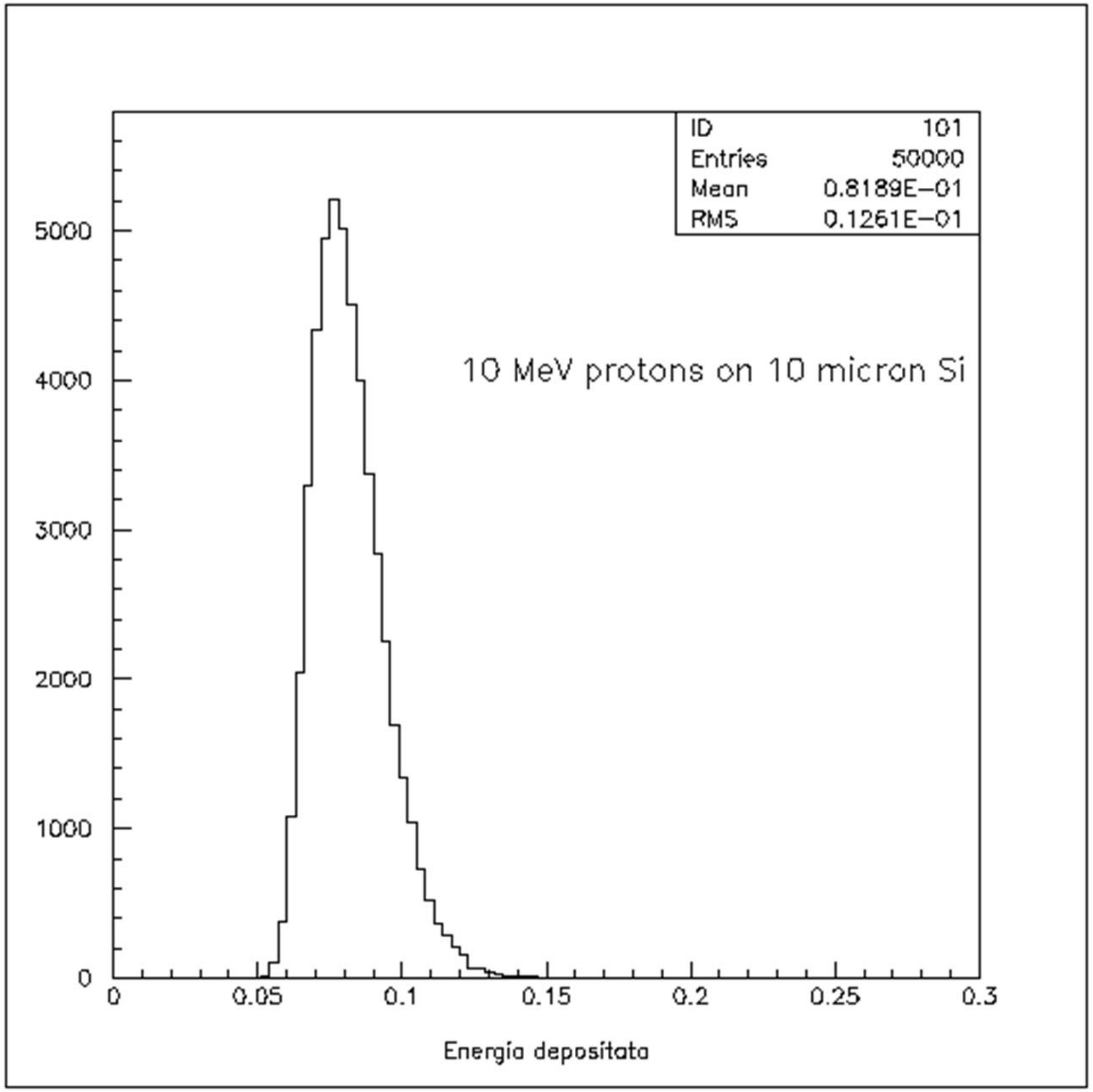

Phi-side
No B cut
Data
GEANT
p (270 MeV/c)
p (408 MeV/c)
π (408 MeV/c)
GEANT π (408 MeV/c)
GEANT p (408 MeV/c)
GEANT p (270 MeV/c)
Cluster charge (ADC)
100
120
1000
5000
3000
300
0
100
200
300
400
500

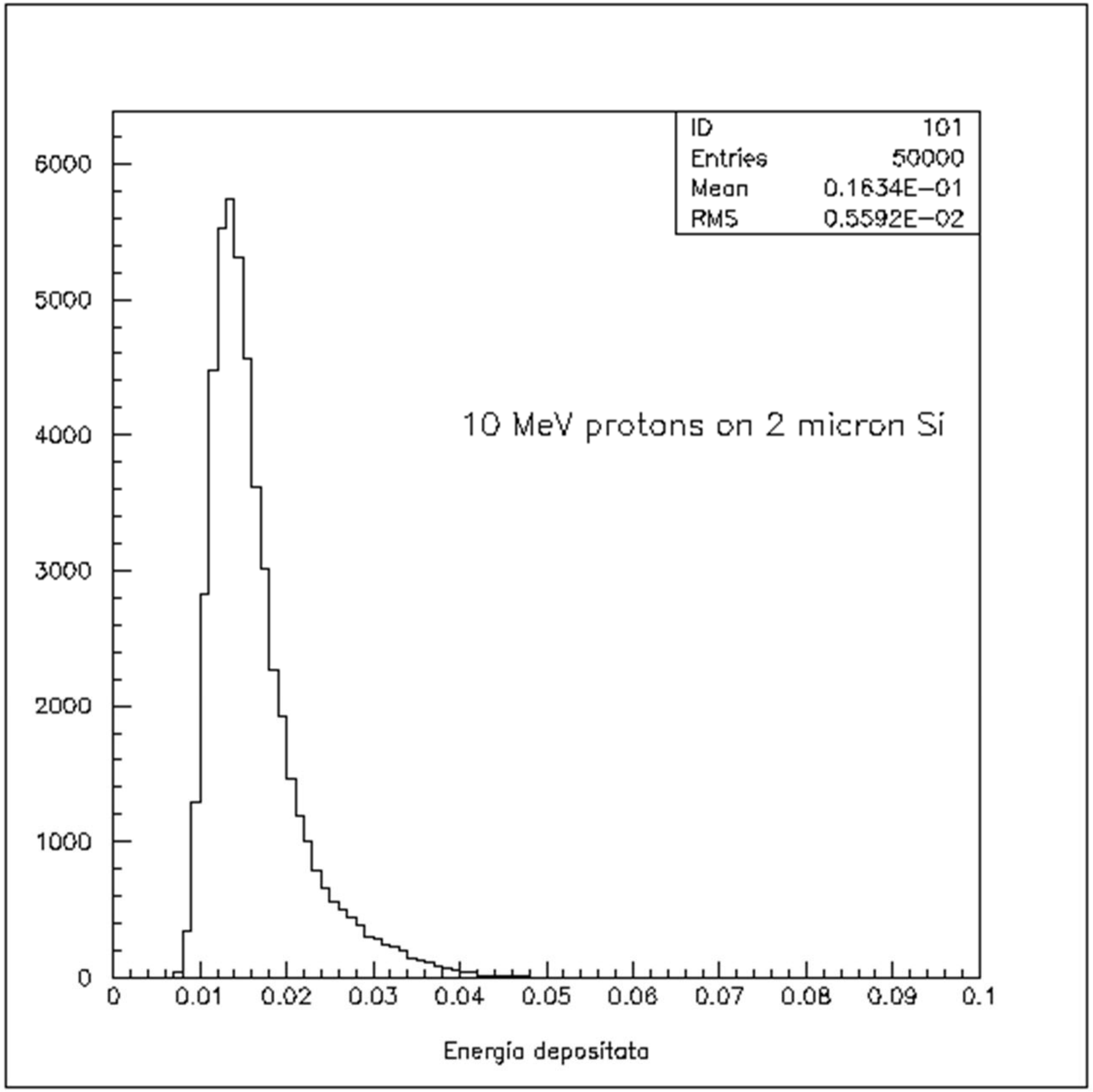


Count
3500
3000
2500
2000
1500
1000
500
0
MIP's
K- K+
0
100
200
300
400
500
600
700
800
DE/DX (Arbitrary Unit)



ID 101
Entries 50000
Mean 0.8462
RMS 0.4395E-01
10 MeV protons
on 100 micron Si
10000
8000
6000
4000
2000
0
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
Energia depositata


ID 101
Entries 50000
Mean 0.8189E-01
RMS 0.1261E-01
10 MeV protons on 10 micron Si
0
1000
2000
3000
4000
5000
0
0.05
0.1
0.15
0.2
0.25
0.3
Energia depositata


ID 101
Entries 50000
Mean 0.1634E−01
RMS 0.5592E−02
10 MeV protons on 2 micron Si
6000
5000
4000
3000
2000
1000
0
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Energia depositata

tions

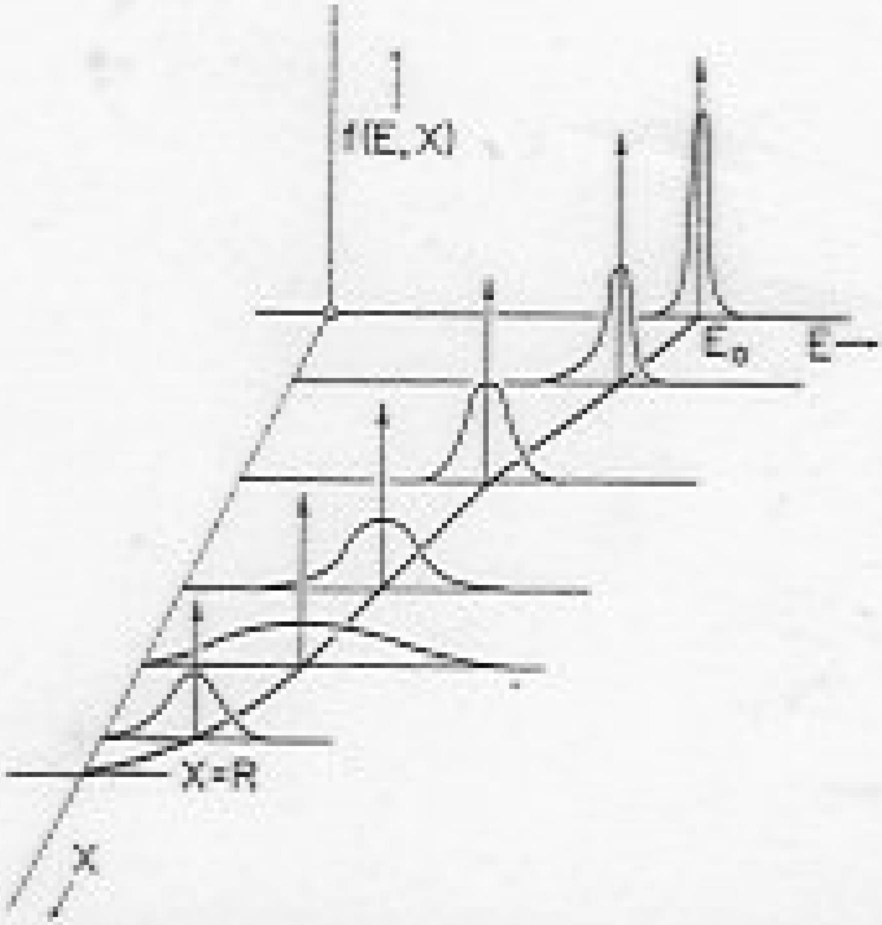


Figure 2.4 Plots of energy distribution of a beam of initially monoenergetic charged particles at various penetration distances. E is the particle energy and X is the distance along the track. (From Wilken and Fritz.[3])