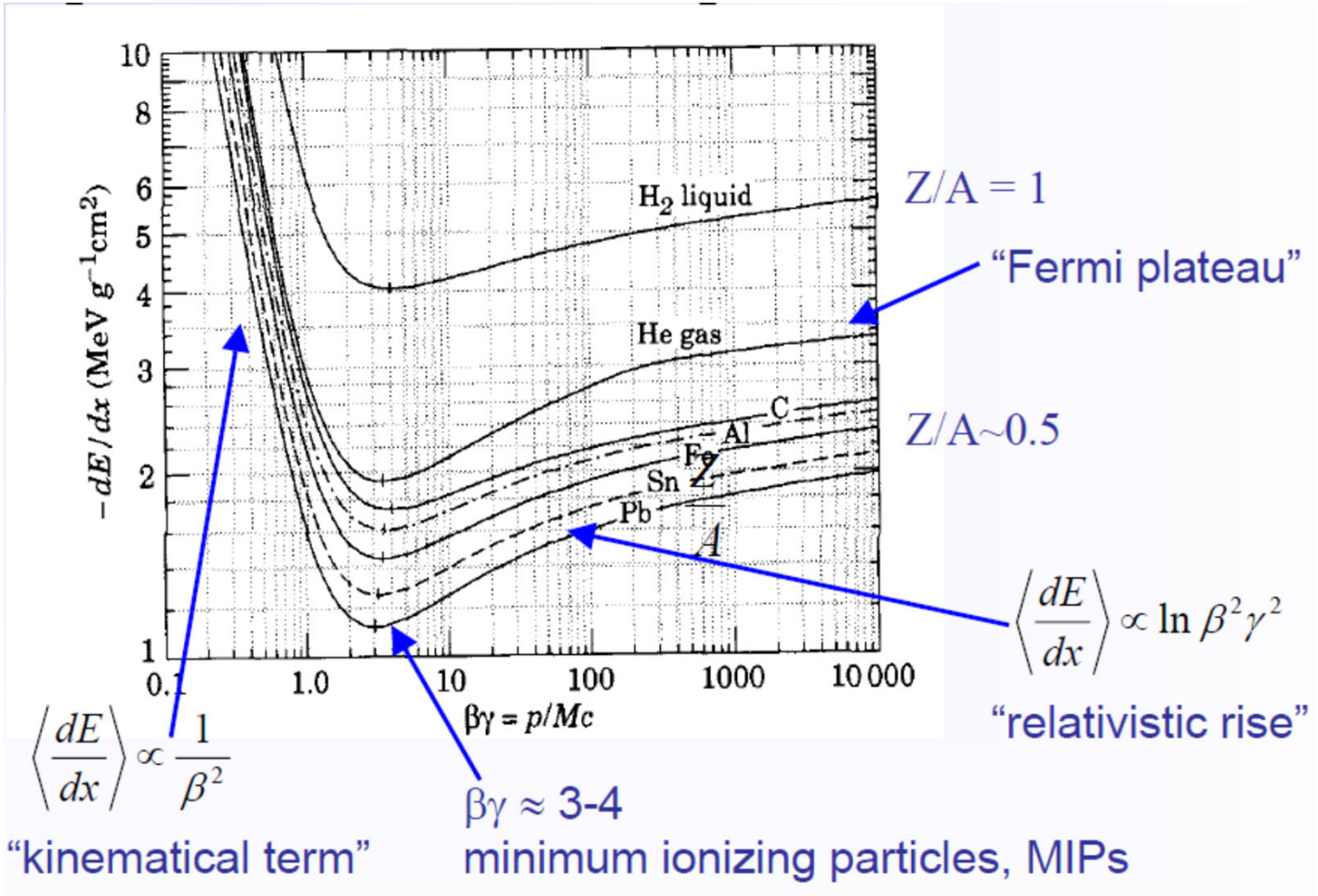
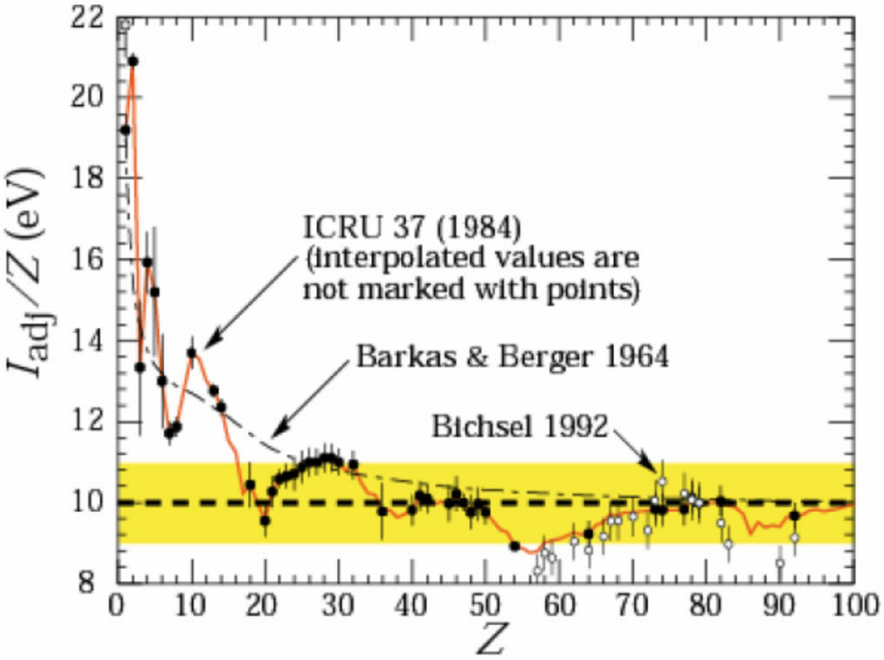
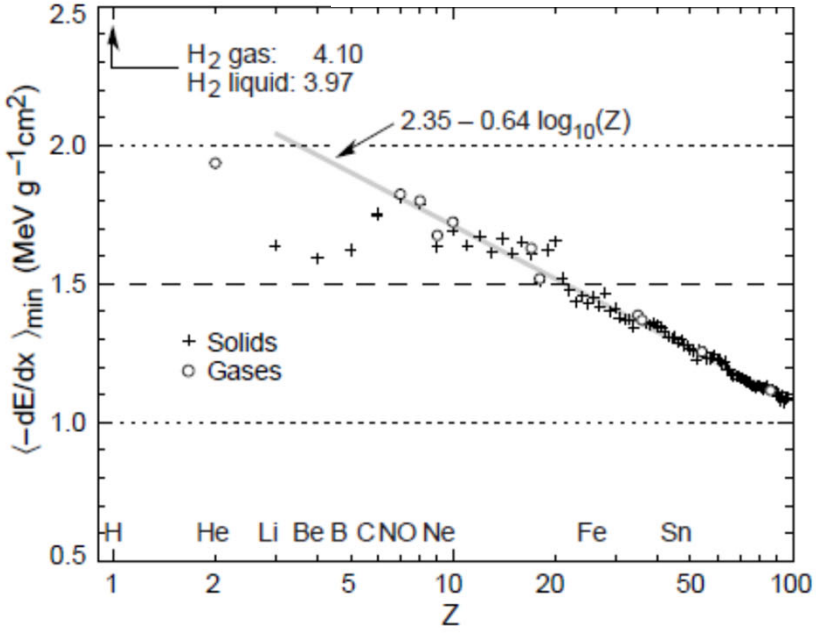


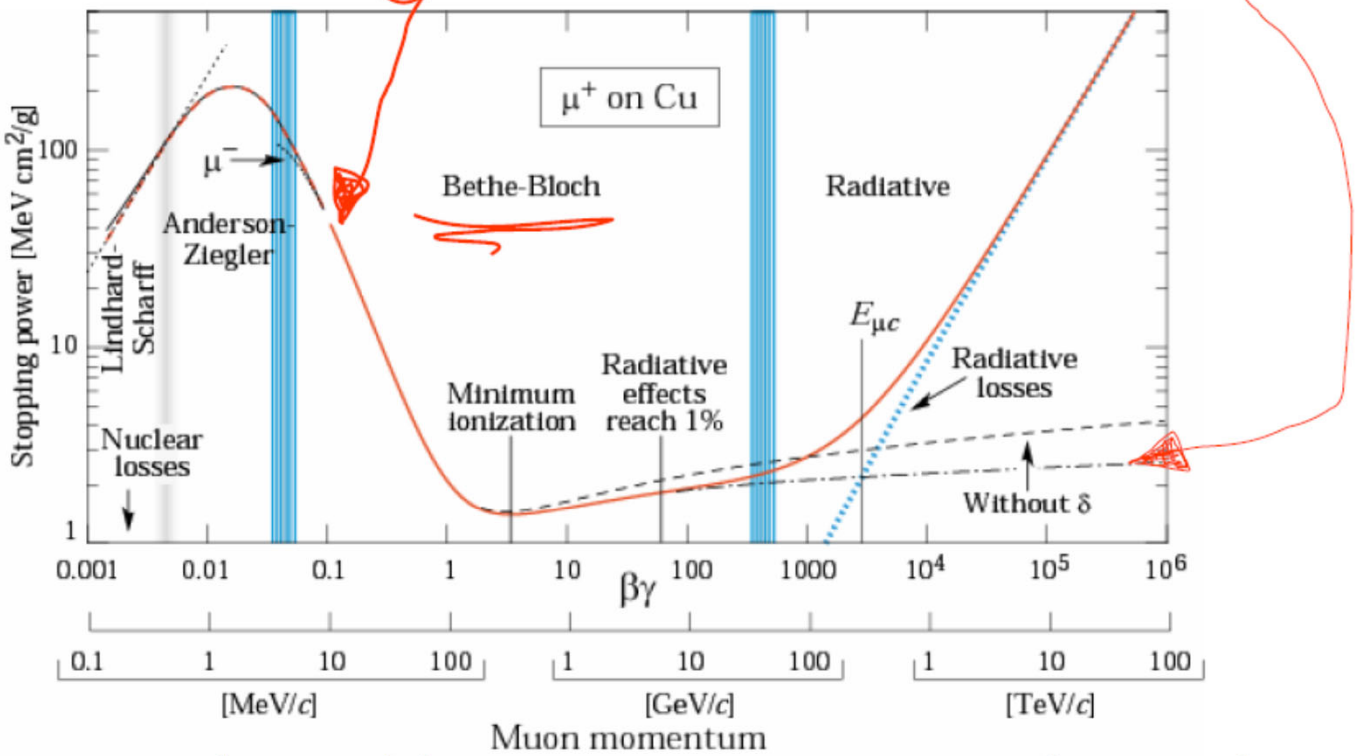
$$-\frac{dE}{dx} = \rho K z^2 \frac{Z}{A}\frac{1}{\beta^2}\left[\ln\frac{2mc^2\beta^2\gamma^2}{I} - \beta^2 - \frac{\delta(\gamma)}{2}\right]$$


I_{adj}/Z (eV)
Z
ICRU 37 (1984)
(interpolated values are
not marked with points)
Barkas & Berger 1964
Bichsel 1992
10 ± 1 eV

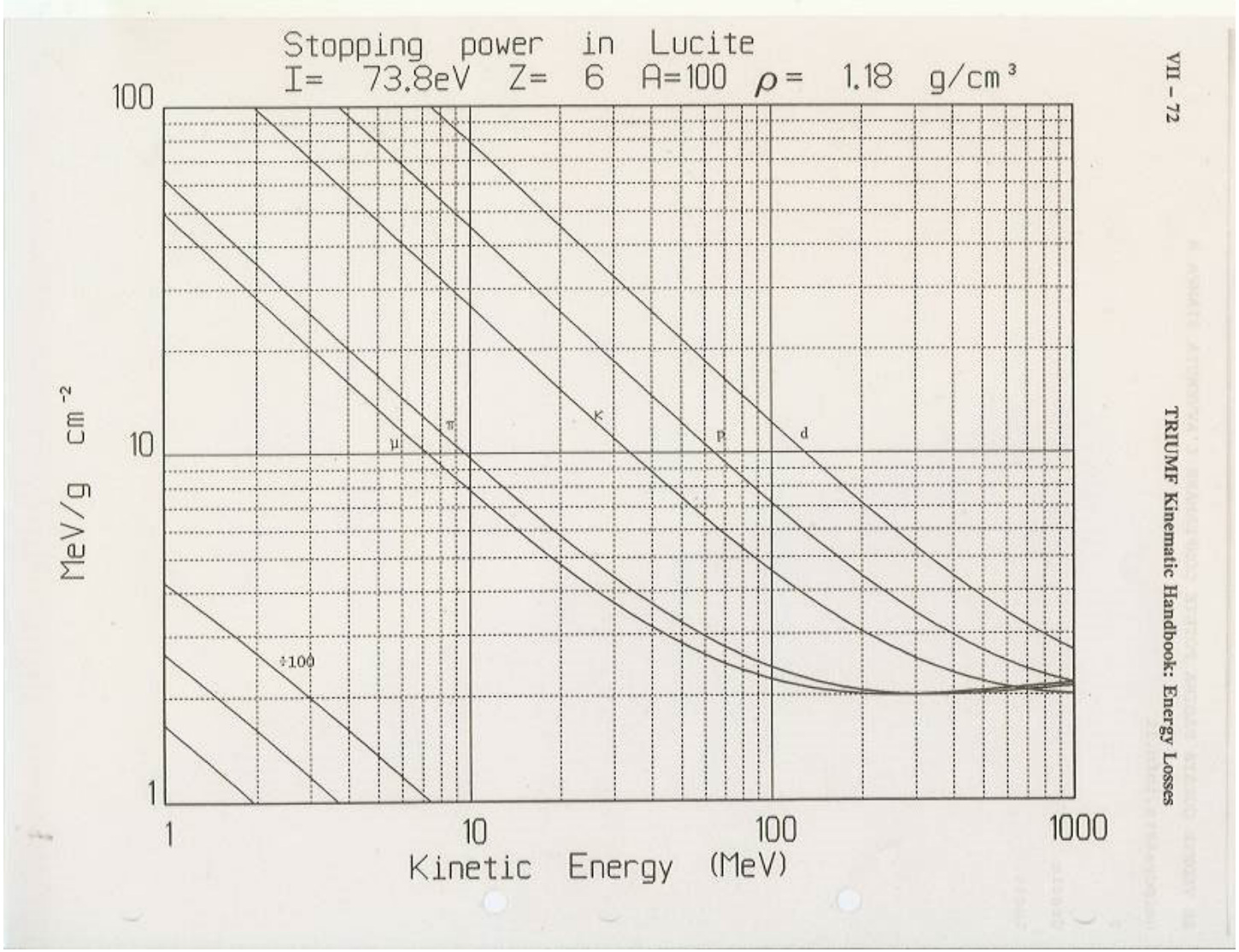

$\langle -dE/dx \rangle_{min}$ (MeV g^{-1}cm^2)
Z
H_2 gas: 4.10
H_2 liquid: 3.97
2.35 – 0.64 log$_{10}$(Z)
Solids
Gases
H He Li Be B C N O Ne Fe Sn

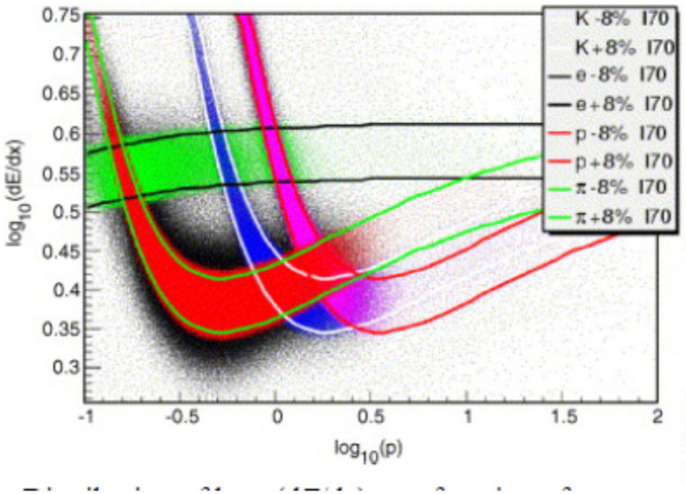
Material	Z	A	Z/A	dE/dx min ($MeVcm^2/g$)	Density (g/cm^3)
H_2 (liquid)	1	1.008	0.992	4.034	0.0708
He	2	4.002	0.500	1.937	0.125
C	6	12.01	0.500	1.745	2.27
Al	13	26.98	0.482	1.615	2.70
Cu	29	63.55	0.456	1.403	8.96
Pb	82	207.2	0.396	1.123	11.4
W	74	183.8	0.403	1.145	19.3
U	92	238.0	0.387	1.082	19.0
Scint.			0.538	1.936	1.03
BGO			0.421	1.251	7.10
CsI			0.416	1.243	4.53
NaI			0.427	1.305	3.67

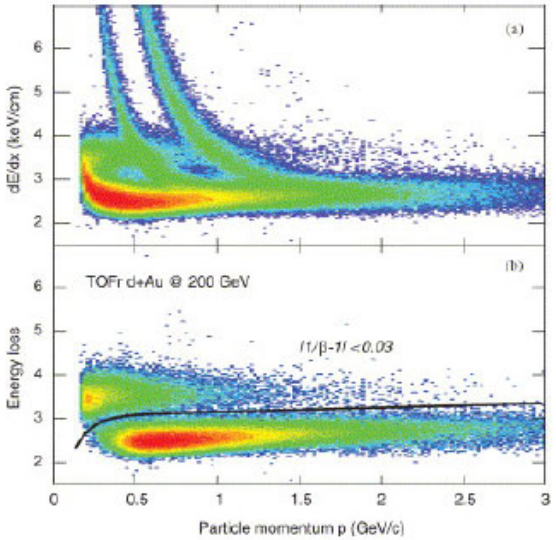
$$\frac{dE}{dx} = Kz^2 \frac{Z}{A}\frac{1}{\beta^2}\left[\frac{1}{2}\ln\frac{2m_e c^2\beta^2\gamma^2 T_{\max}}{I^2} - \beta^2 - \frac{\delta}{2}\right]$$



Stopping power (≡⟨dE/dx⟩) for positive muons in copper as a function of βγ =p/Mc over nine orders of magnitude in momentum (12 orders of magnitude in kinetic energy). Solid curves indicate the total stopping power.


Stopping power in Lucite
I= 73.8eV Z= 6 A=100 ρ = 1.18 g/cm³
100
10
1
MeV/g cm⁻²
μ
π
K
p
d
÷100
1
10
100
1000
Kinetic Energy (MeV)

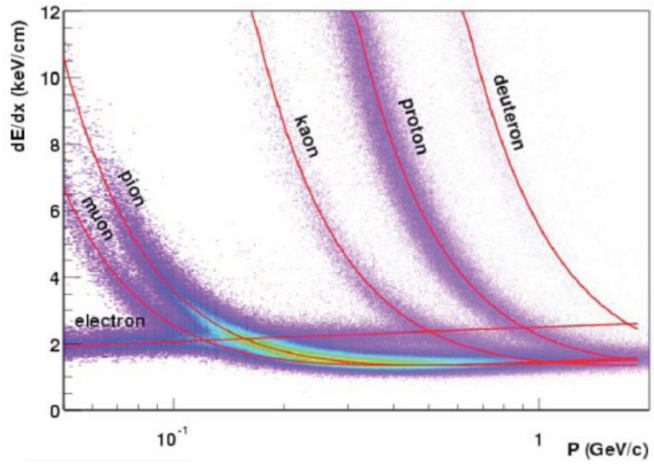




dE/dx in the TPC vs. particle momentum (p) without (upper panel) and with (lower panel) TOFr velocity cut of $|1/\beta-1|<0.03$.

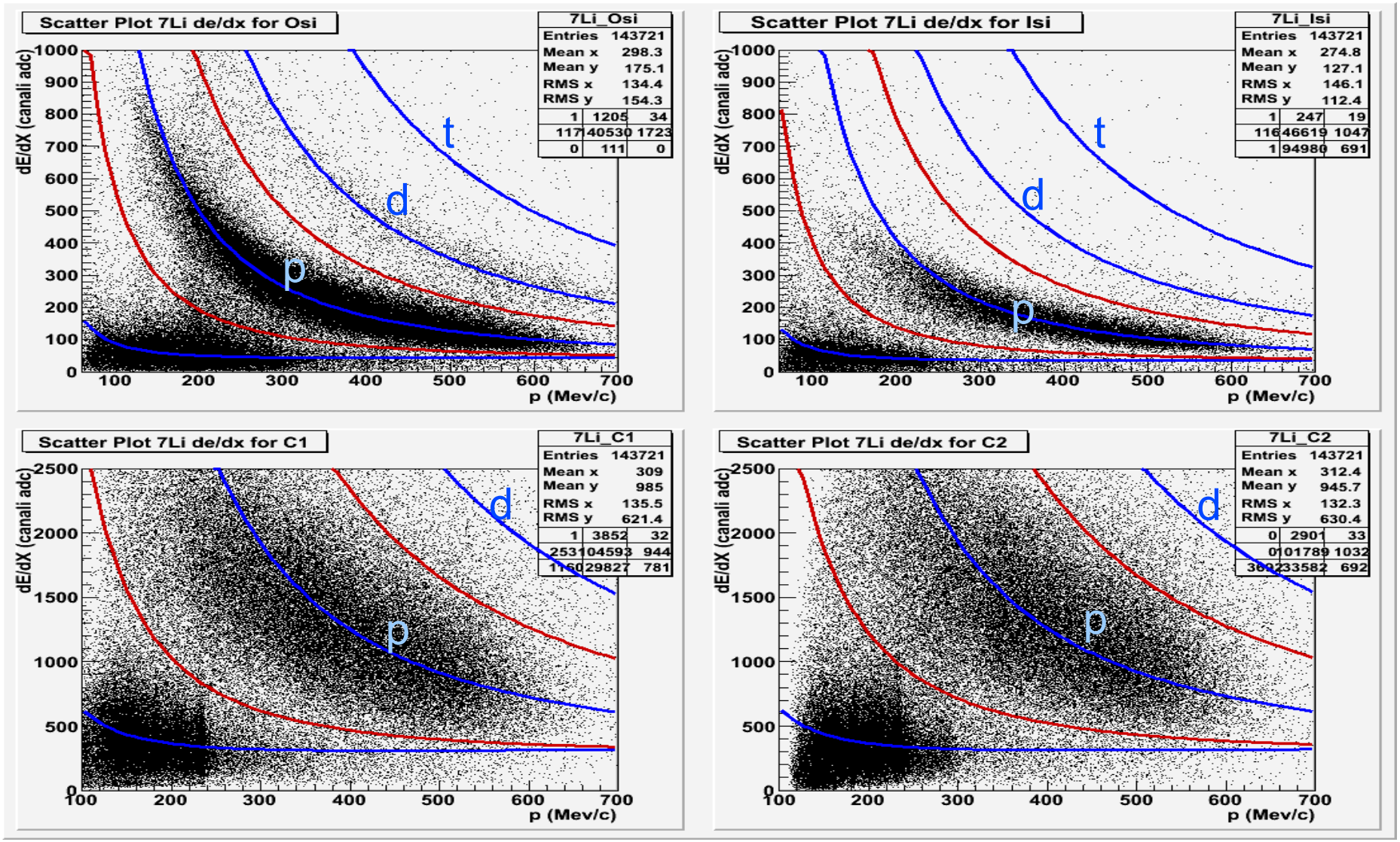
- STAR Time-Projection Chamber (TPC):

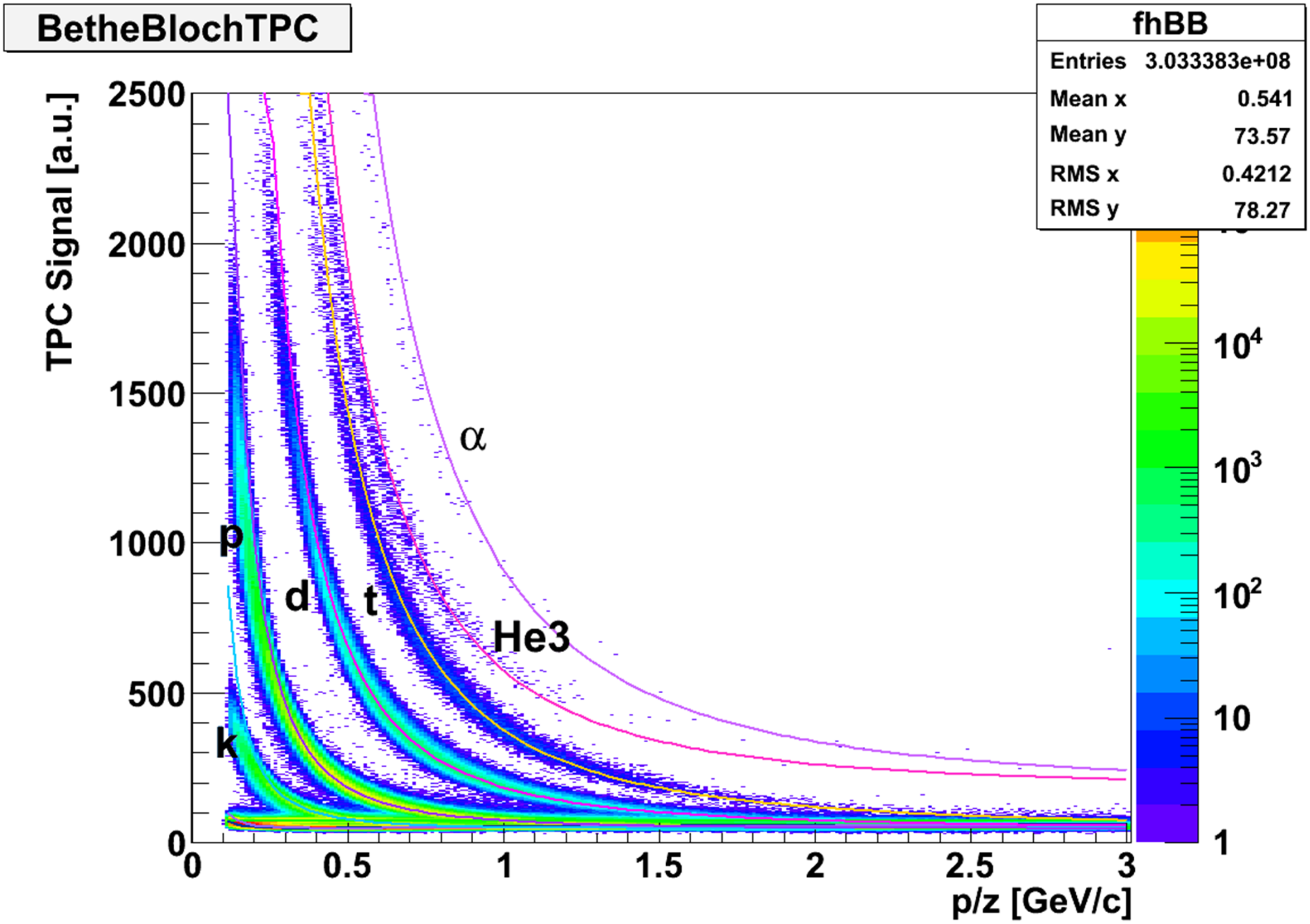
10% Methan / 90% Argon (2mbar above athm. pressure)

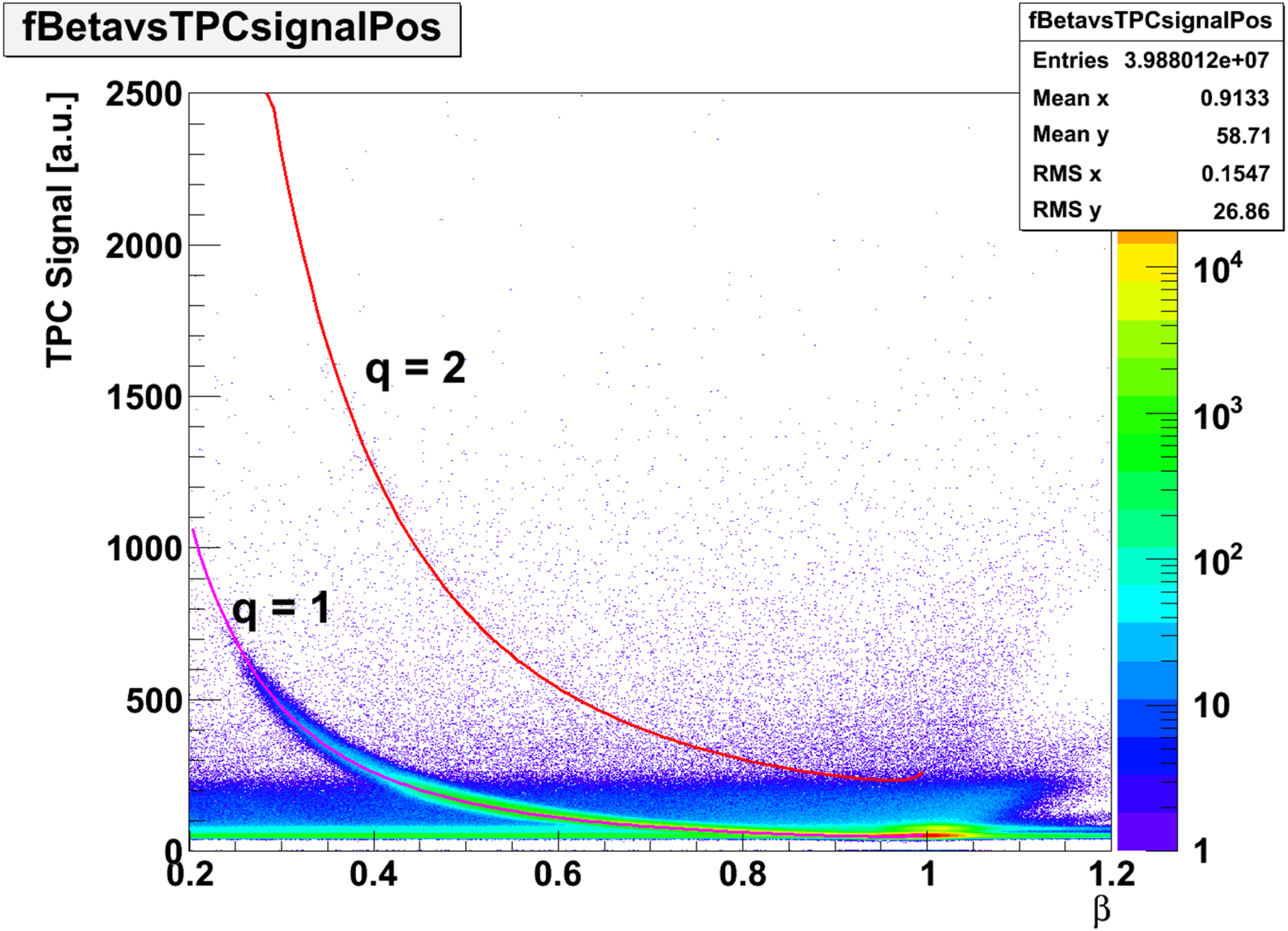


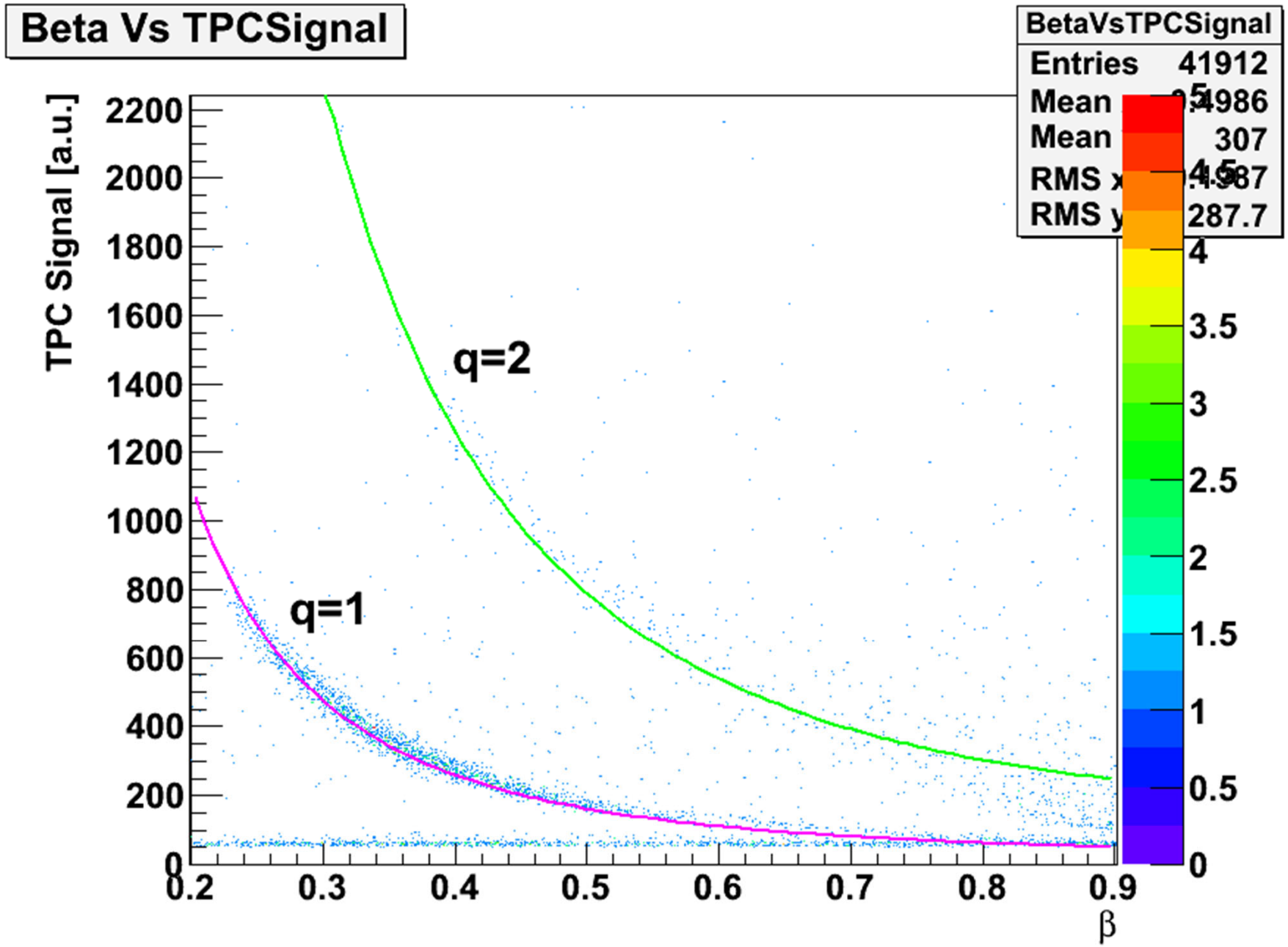
Discriminazione particelle

Selezione per pioni, protoni, deutoni e trizi




BetheBlochTPC
fhBB
Entries 3.033383e+08
Mean x 0.541
Mean y 73.57
RMS x 0.4212
RMS y 78.27
TPC Signal [a.u.]
p/z [GeV/c]
p
d
t
He3
α
k
0
500
1000
1500
2000
2500
0.5
1
1.5
2
2.5
3
1
10
10^2
10^3
10^4

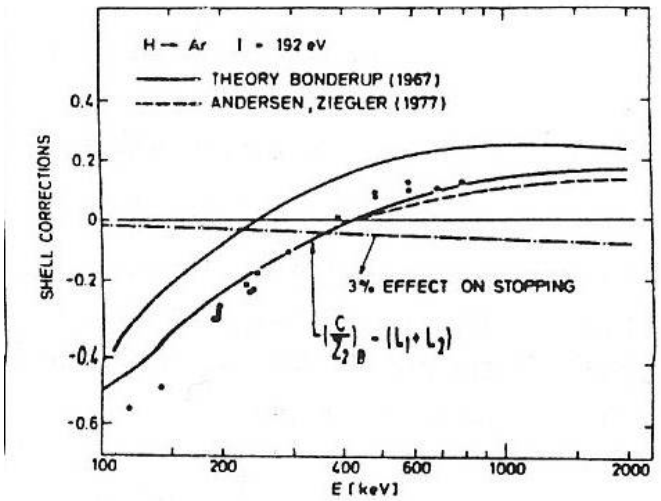

fBetavsTPCsignalPos
fBetavsTPCsignalPos
Entries 3.988012e+07
Mean x 0.9133
Mean y 58.71
RMS x 0.1547
RMS y 26.86
TPC Signal [a.u.]
2500
2000
1500
1000
500
0
q = 2
q = 1
0.2
0.4
0.6
0.8
1
1.2
β
10^4
10^3
10^2
10
1

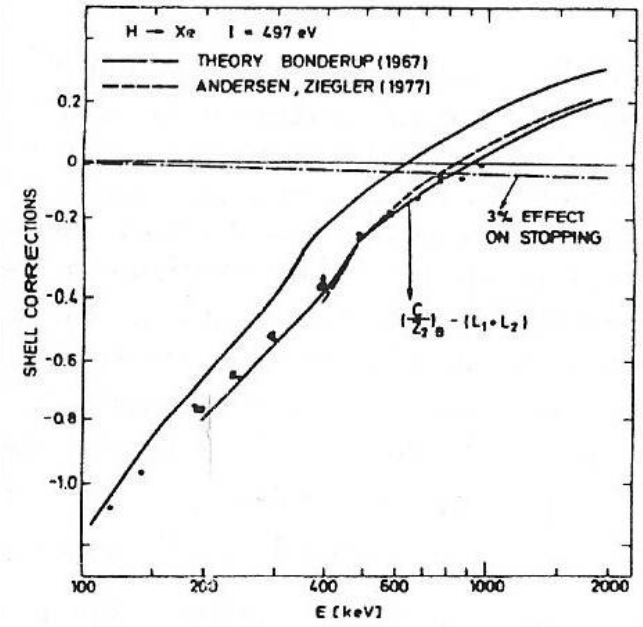

Beta Vs TPCSignal
BetaVsTPCSignal
Entries 41912
Mean
Mean
RMS x
RMS y
287.7
TPC Signal [a.u.]
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
q=2
q=1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
β
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

http://www.nist.gov

Stopping-Power and Range Tables
for Electrons, Protons, and Helium Ions

https://physics.nist.gov/PhysRefData/Star/Text/PSTAR.html
http://physics.nist.gov/PhysRefData/Star/Text/ASTAR.html


H — Ar I = 192 eV
THEORY BONDERUP (1967)
ANDERSEN, ZIEGLER (1977)
SHELL CORRECTIONS
0.4
0.2
0
-0.2
-0.4
-0.6
3% EFFECT ON STOPPING
$(\frac{C}{Z_2})_B - (L_1 + L_2)$
100
200
400
600
1000
2000
E [keV]


H — Xe I = 497 eV
THEORY BONDERUP (1967)
ANDERSEN, ZIEGLER (1977)
SHELL CORRECTIONS
0.2
0
-0.2
-0.4
-0.6
-0.8
-1.0
3% EFFECT ON STOPPING
$(\frac{C}{Z_2})_B - (L_1 + L_2)$
100
200
400
600
1000
2000
E [keV]

Pressure (density) dependence of *density correction*

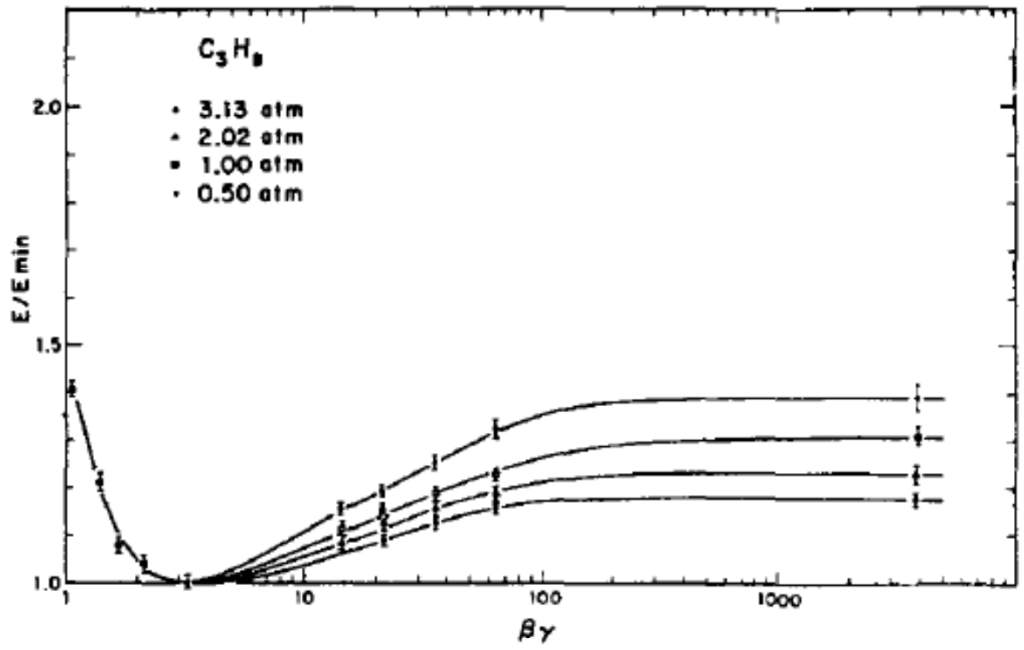


Fig. 2.6 Measured energy loss (reprinted from *Nucl. Instr. and Meth.* **161**, Walenta, A.H., Fisher, J., Okuno, H. and Wang, C.L., Measurement of the Ionization Loss in the Region of Relativistic Rise for Noble and Molecular Gases, 45-58, Copyright (1979), with permission from Elsevier) in propane normalized to the energy loss minimum E_{min} versus $\beta\gamma$. The different slopes of the relativistic rise effect depend on the detecting device pressure.

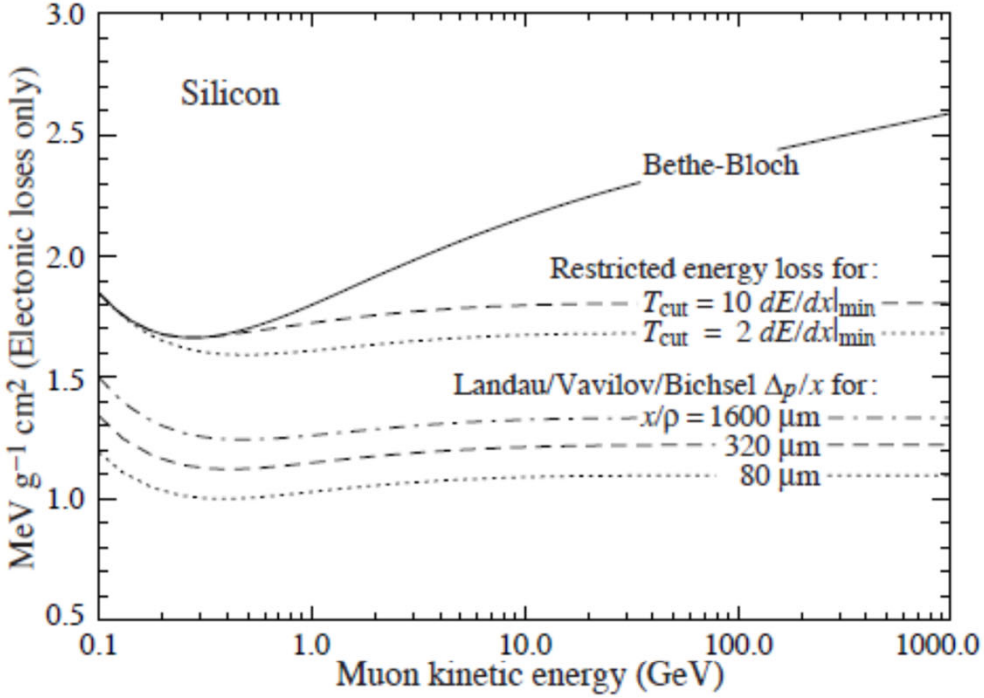
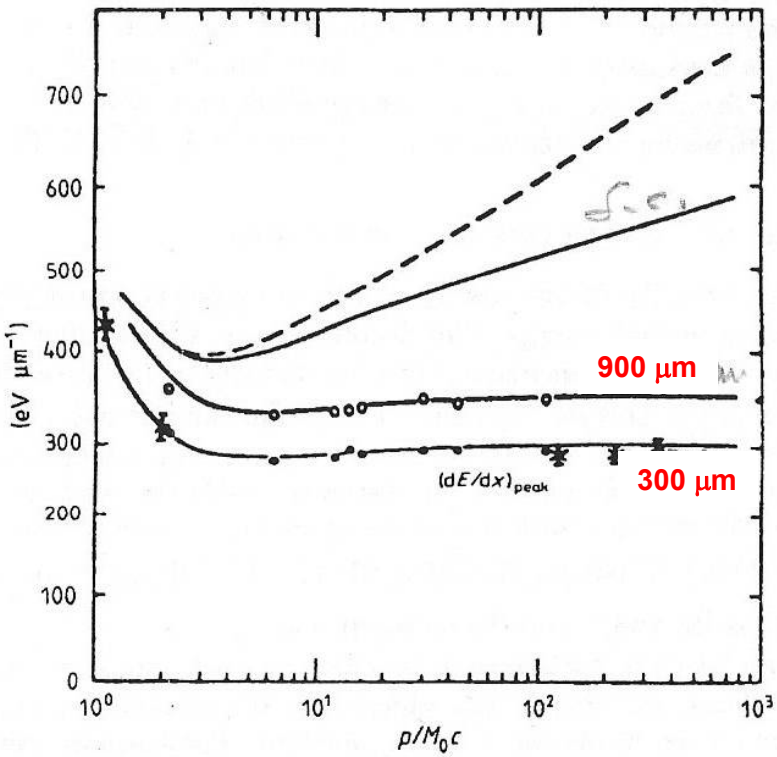


Figure 27.6: Bethe-Bloch dE/dx, two examples of restricted energy loss, and the Landau most probable energy per unit thickness in silicon. The change of Δ_p/x with thickness x illustrates its $a \ln x + b$ dependence. Minimum ionization ($dE/dx|_{\rm min}$) is 1.664 MeV g^{-1} cm^2. Radiative losses are excluded. The incident particles are muons.


700
600
500
400
300
200
100
0
(eV µm⁻¹)
900 µm
(dE/dx)peak
300 µm
10⁰
10¹
10²
10³
p/M₀c