FCAL interaction length

200 GeV/c pions
Glauber calculation

See Brabson et al., NIM A332 (1993) 419

Lead Glass F8-00: 45% PbO, 42.8% SiO2, 10.4% K_2O, 1.8% Na_2O
Nuclear collision length = 22.5 cm, Radiation length = 3.1 cm
Density = 3.6 g/cm^3
http://pdg.lbl.gov/2012/AtomicNuclearProperties/index.html

Element	Pion λ_I (g/cm2) PDG	Fraction
Pb	226.2	0.176
O	121.9	0.559
Si	137.7	0.168
K	148.1	0.082
Na	132.2	0.016

$$\frac{1}{\lambda_{LGD}} = \sum \frac{m_i}{\lambda_i}$$

$$\lambda_{LGD} = 138 g/cm^3 = 38 cm$$

As a check, one may scale the nuclear collision length
To Pb glass PDG: λ_C = 95.9 g/cm^3, λ_I=158 g/cm^3

$$\lambda_{LGD} = 22.5 cm(158/95.9) = 37 cm$$

Mass fractions ?

FCAL interaction length

See Brabson et al., NIM A332 (1993) 419

Lead Glass F8-00: 45% PbO, 42.8% SiO2, 10.4% K_2O, 1.8% Na_2O
Nuclear collision length = 22.5 cm, Radiation length = 3.1 cm
Density = 3.6 g/cm^3
http://pdg.lbl.gov/2012/AtomicNuclearProperties/index.html

Element	Pion λ_I (g/cm2) PDG	Fraction
Pb	226.2	0.42
O	121.9	0.28
Si	137.7	0.20
K	148.1	0.086
Na	132.2	0.013

$$\frac{1}{\lambda_{ABS}} = \sum_{i=1} \frac{f_i \rho_{PbG}}{\lambda_i}$$

$$\lambda_{ABS} = 44cm$$

$$L_{FCAL} = 45cm$$

Are the pion absorption lengths reasonable?

1 b

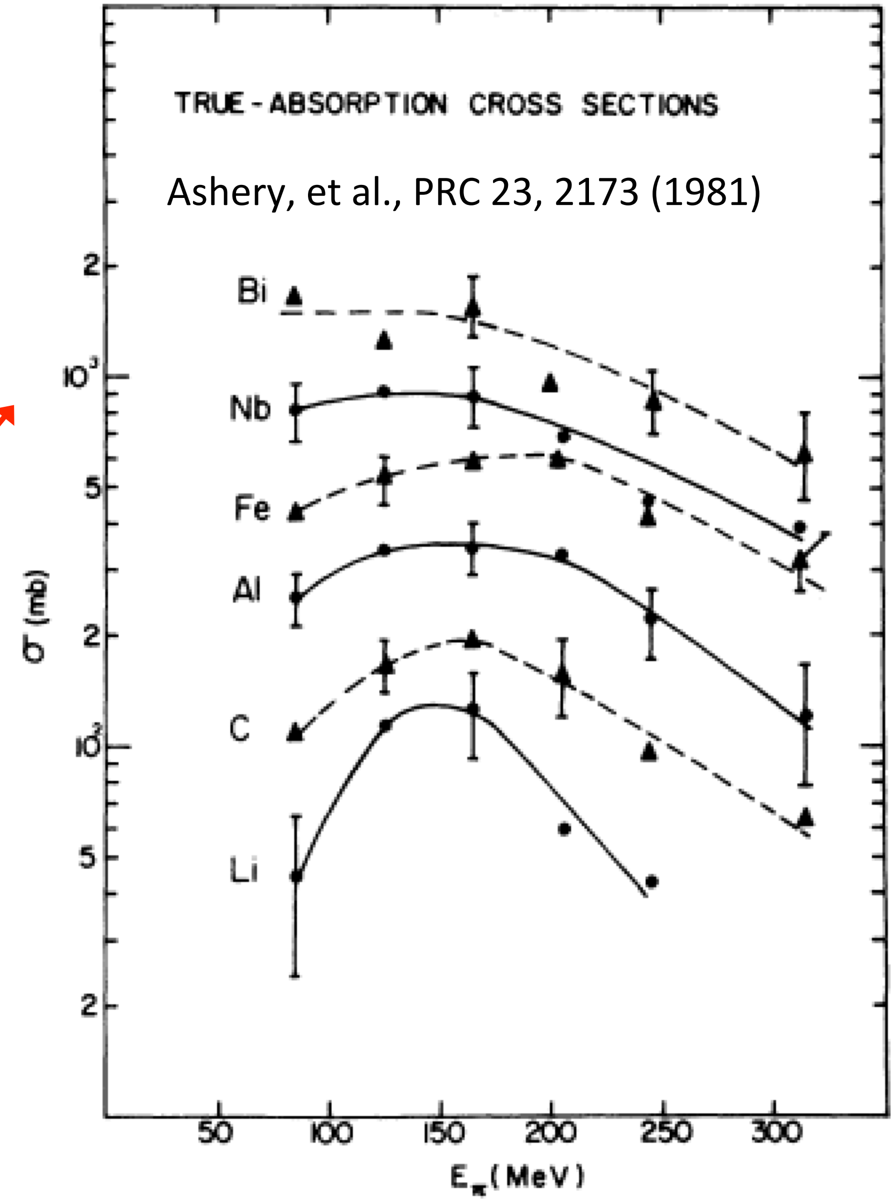

FIG. 7. The true absorption cross sections of π^+ for all the studied target nuclei, as a function of bombarding energy. The lines are drawn to guide the eye and typical error bars are shown.

TABLE IV. Total nonelastic cross sections for incident π^- mesons.

Target	π^- Energy (MeV)	Nonelastic cross section (mb) Theory	Exp.[a]
Be	485	165 ± 7	184 ± 6 [b]
	598	182 ± 7	179 ± 6 [b]
	894	217 ± 7	189 ± 5 [b]
	1256	218 ± 7	200 ± 6 [b]
C	216	414 ± 9	350 ± 24
	256	360 ± 7	326 ± 31
	350	239 ± 5	166 ± 21
	485	217 ± 8	231 ± 7 [b]
	598		226 ± 7 [b]
	600	233 ± 5	216 ± 10
	894		233 ± 6 [b]
	970	271 ± 5	252 ± 13
	1200	262 ± 5	246 ± 14
	1256		239 ± 5 [b]
	1510	258 ± 5	240 ± 14
Al	970	477 ± 13	442 ± 20
Cu	970	819 ± 12	806 ± 35
Sn	970	1194 ± 17	1199 ± 52
Pb	216	2022 ± 21	2356 ± 152
	256	1906 ± 20	2430 ± 183
	970	1712 ± 18	1690 ± 100
	1510	1700 ± 18	1600 ± 95

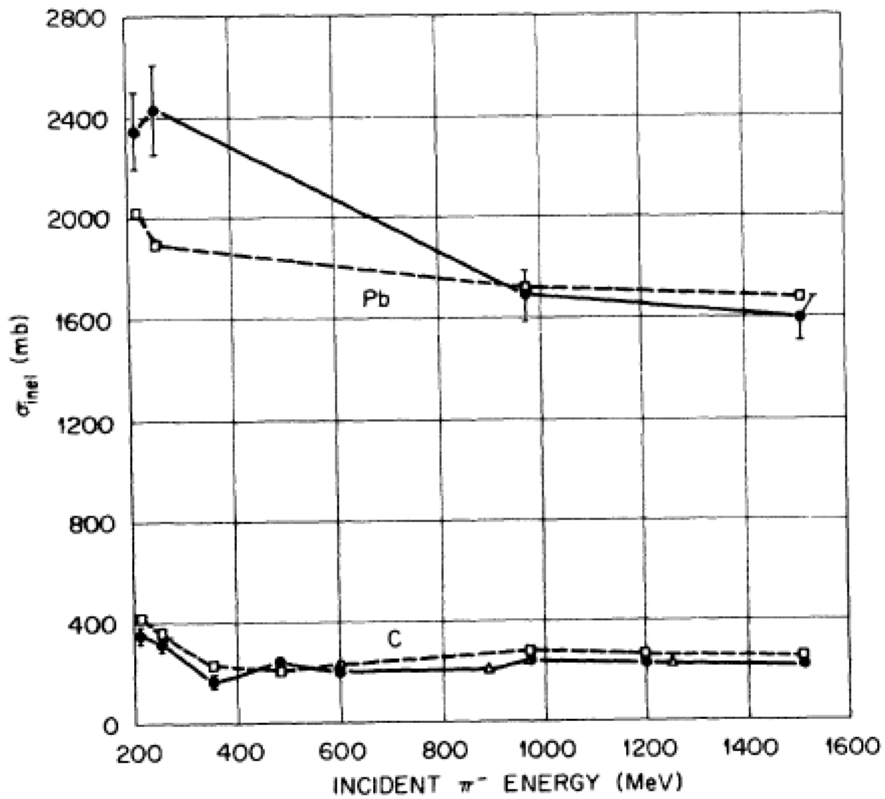

FIG. 13. Nonelastic cross section vs incident π^- energy for C and Pb targets. Solid lines connect the experimental data points. Dashed lines connect the theoretical values. When error bars are not shown, they are smaller than the symbols. The symbols are as follows: □,

H.W. Bertini, Phys. Rev C 6, 631 (1972)

Pion Interaction length in Pb

$$\sigma = 1.6b$$

$$\frac{1}{\lambda_{Pb}} = \sigma \frac{N_0}{208}$$

$$\lambda_{Pb} = 217 \, {}^{g}\!/_{cm^2}$$

and PDG lists 226 g/cm^2

- Bertini nuclear cascade model predicts an average of 20 nucleons and 8 pions emitted from the residual ^{208}Pb nucleus for 10 GeV incident protons.

- Would expect multiplicities to be similar for incident pions.

- Weak dependence on energy, multiplicities approx. double at 100 GeV

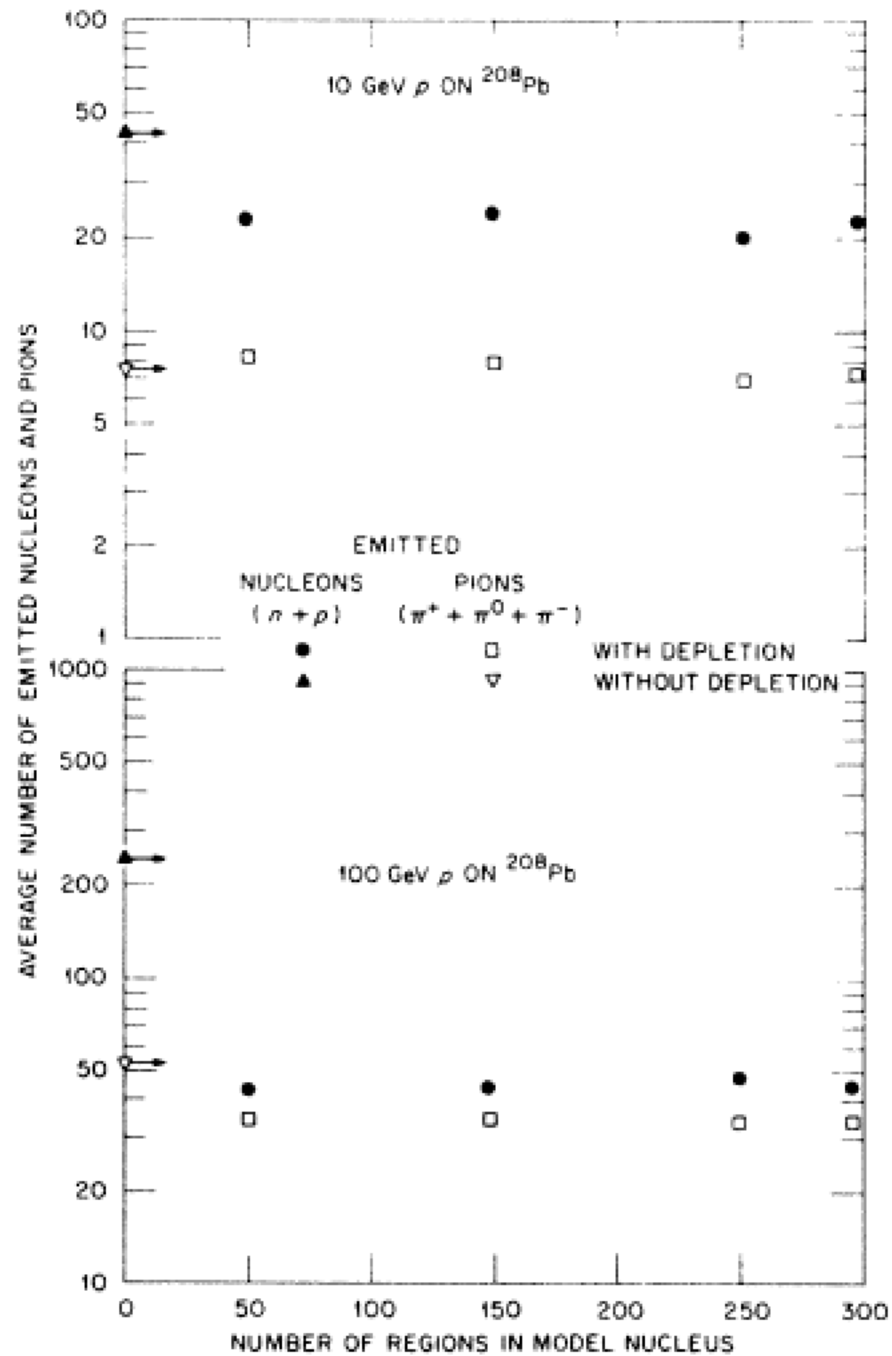

FIG. 6. Average number of emitted nucleons $(n+p)$ and pions $(\pi^+ + \pi^\circ + \pi^-)$ per incident particle collisions vs the number of regions used in the model nucleus. The reactions are 10- and 100-GeV p on ^{27}Al. The results for the cases without the inclusion of nuclear density depletion are independent of the number of regions (indicated by the arrows). The statistical error associated with each data point is about the size of the symbol.

H.W. Bertini, et al., Phys. Rev C 17, 1978382 (1978)

Showers and "black" tracks for pions on emulsions (^{80}Br)

Average of 10 tracks at 4 GeV

Number of tracks saturates above 4 GeV

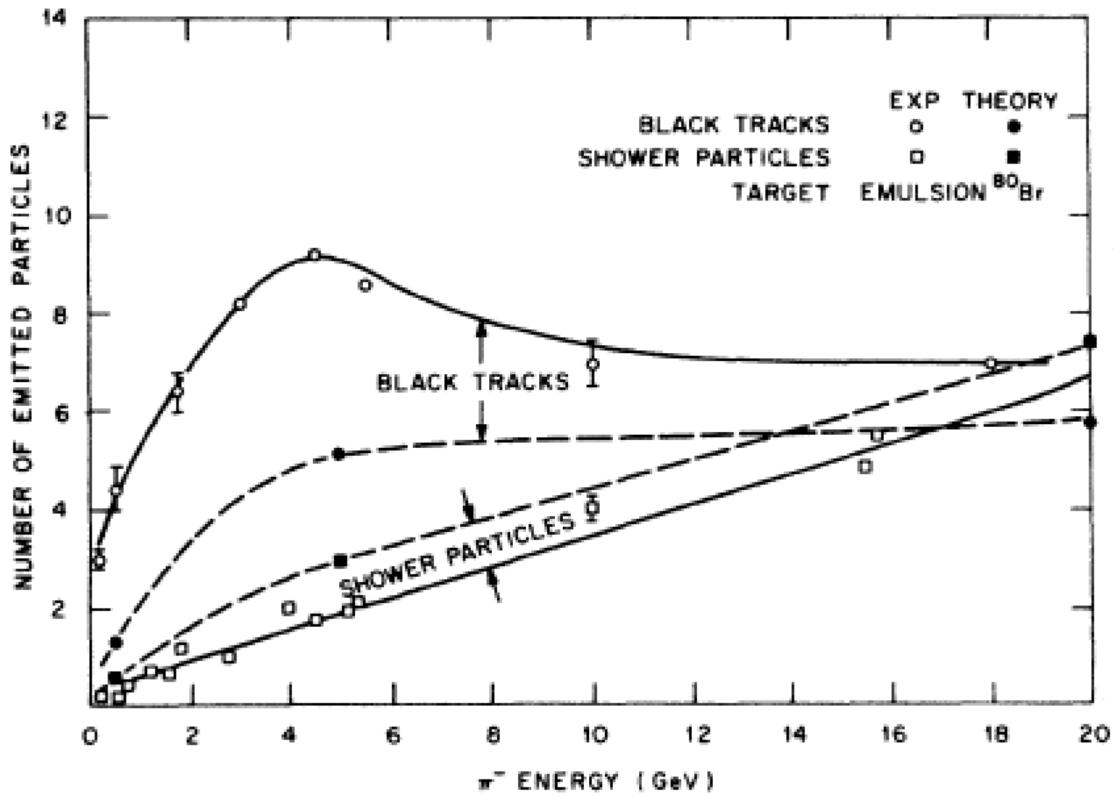

FIG. 9. Average number of shower particles and black tracks vs incident pion energy for π^- on emulsions. Experimental data quoted by V. S. Barshenkov, K. K. Gudima, and V. D. Toneev (Ref. 20). Theoretical results are from π^- on bromine-80. Solid and dashed lines are drawn through the experimental and theoretical data, respectively, merely to guide the eye. See text for details.

H.W. Bertini, et al., Phys. Rev C 17, 1978382 (1978)

FCAL will not see many of the protons, and none of the neutrons emitted

- $n = 1.62$
- T_{min} for protons to produce cherenkov light in PbG is 254 MeV
- $\langle T_{nucleon} \rangle \approx 4$ GeV/20 = 200 MeV

Brabson et al.

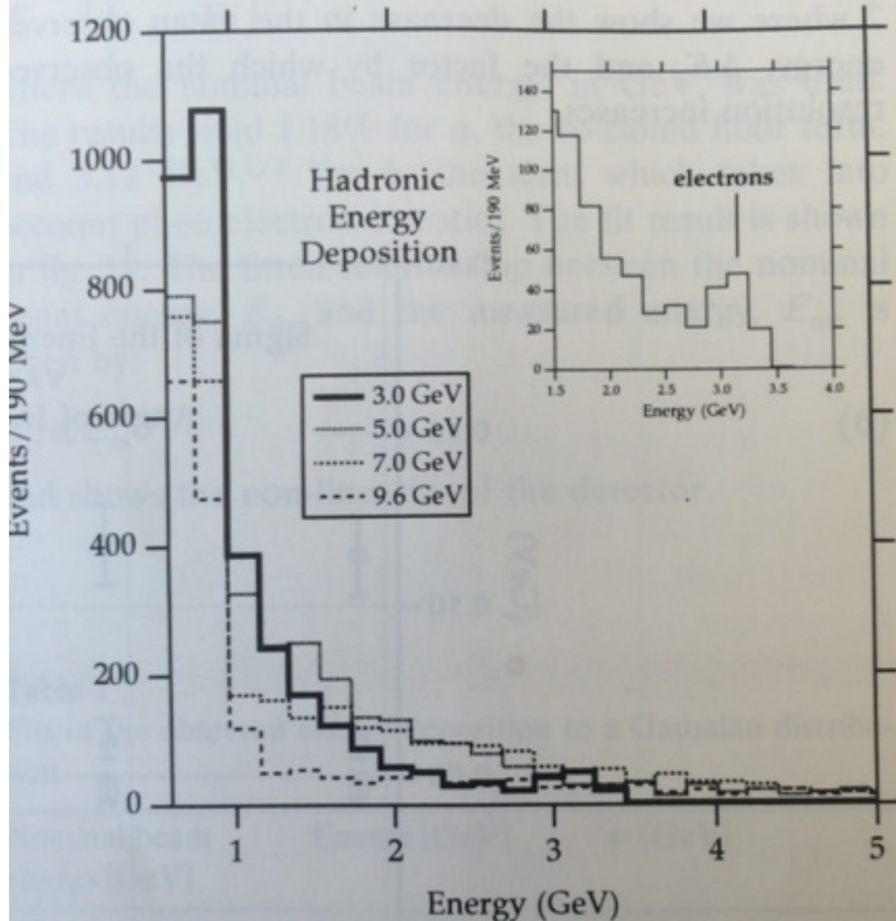

Fig. 17. The energy deposition observed for untagged 3.0, 5.0, 7.0 and 9.6 GeV beam particles, assumed to be primarily hadrons. The insert shows the portion of the 3.0 GeV spectrum showing an electron peak.