Spring 2017 Modern Physics Project – Radiation Shielding Test 3/14/2017

1) Why is low Z (low numbers of protons) material preferable in high energy radiation environments?

2) What materials would you use to shield against neutron radiation? Explain your answers.

3) Iron and concrete are often used at particle accelerators as shielding, why?

4) What thickness of iron is needed to block 99.999% of high energy gamma rays? (see attached data table for iron)

5) For a 10 GeV muon in air $-\frac{dE}{dx} = 2.6\ \frac{MeV\ cm^2}{g}$ and the density of air is 1.22 kg/m^3. How much energy will 10 GeV cosmic ray muons lose by going through 15000 m of air?

6) Using the attached plot, calculate how far a 1.0 GeV/c pion will travel through carbon until it stops. The pion mass is 0.139 GeV/c^2 and the density of carbon is 2.25 g/cm^3.

7) How do protons with 1 MeV of kinetic energy interact with shielding material differently than protons with 100 MeV of kinetic energy?

8) Explain why high energy muons go the farthest through shielding of any charged particle.

Atomic and nuclear properties of iron (Fe)

Quantity	Value	Units	Value	Units
Atomic number	26			
Atomic mass	55.845(2)	g $mole^{-1}$		
Specific gravity	7.874	g cm^{-3}		
Mean excitation energy	286.0	eV		
Minimum ionization	1.451	MeV $g^{-1}cm^2$	11.43	MeV cm^{-1}
Nuclear collision length	81.7	g cm^{-2}	10.37	cm
Nuclear interaction length	132.1	g cm^{-2}	16.77	cm
Pion collision length	107.0	g cm^{-2}	13.59	cm
Pion interaction length	160.8	g cm^{-2}	20.42	cm
Radiation length	13.84	g cm^{-2}	1.757	cm
Critical energy	21.68	MeV (for e^-)	21.00	MeV (for e^+)
Molière radius	13.53	g cm^{-2}	1.719	cm
Plasma energy $\hbar\omega_p$	55.17	eV		
Muon critical energy	347.	GeV		
Melting point	1811.	K	1538.	C
Boiling point @ 1 atm	3134.	K	2861.	C

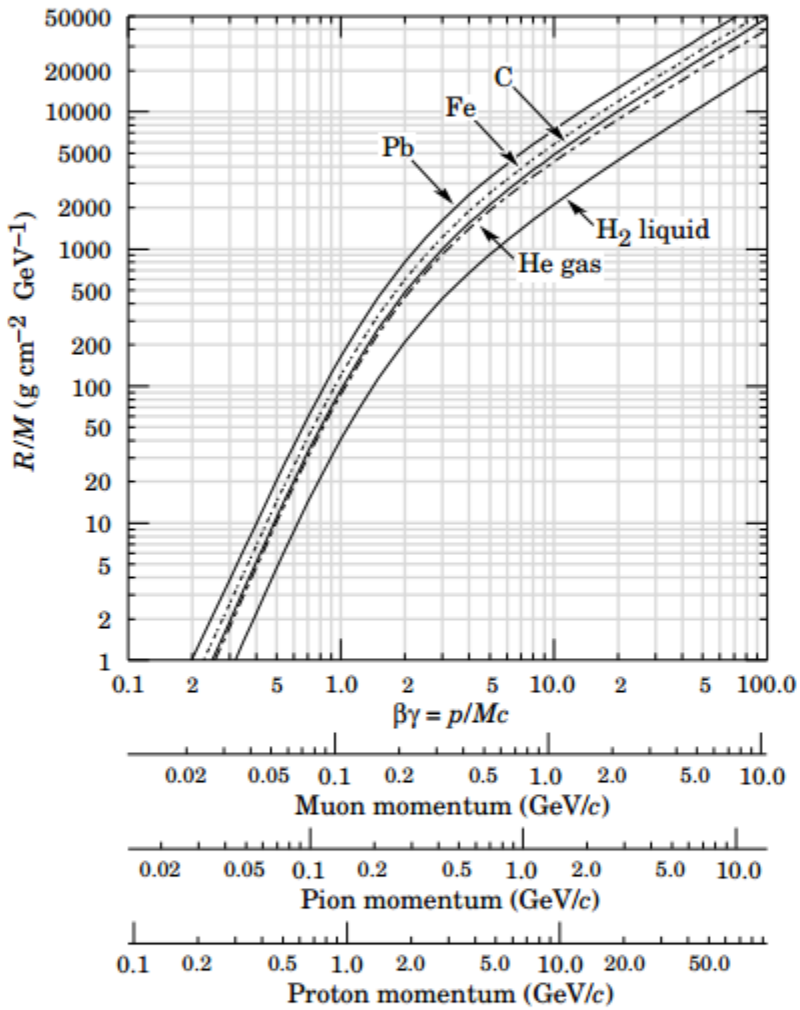

Figure 33.4: Range of heavy charged particles in liquid (bubble chamber) hydrogen, helium gas, carbon, iron, and lead. For example: For a K^+ whose momentum is 700 MeV/c, $\beta\gamma = 1.42$. For lead we read $R/M \approx 396$, and so the range is 195 g cm^{-2} (17 cm).