ECAL Electronics Radiation Damage Studies:

Comparing Two Accelerators PSI and FSU

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Radiation Studies – ECAL Electronics

- Want to test radiation damage effects on ECAL electronics boards
- Use low energy (15-25 MeV) proton beam
- Desired exposure >500 Gy (see backup slides for calculations)
- This equals >6.4x10^{11} protons delivered
- Two sites under consideration
  - Paul Scherrer Institute (PSI)
    - Large user facility
  - Florida State University (FSU)
    - Smaller, nuclear (light ion) accelerator

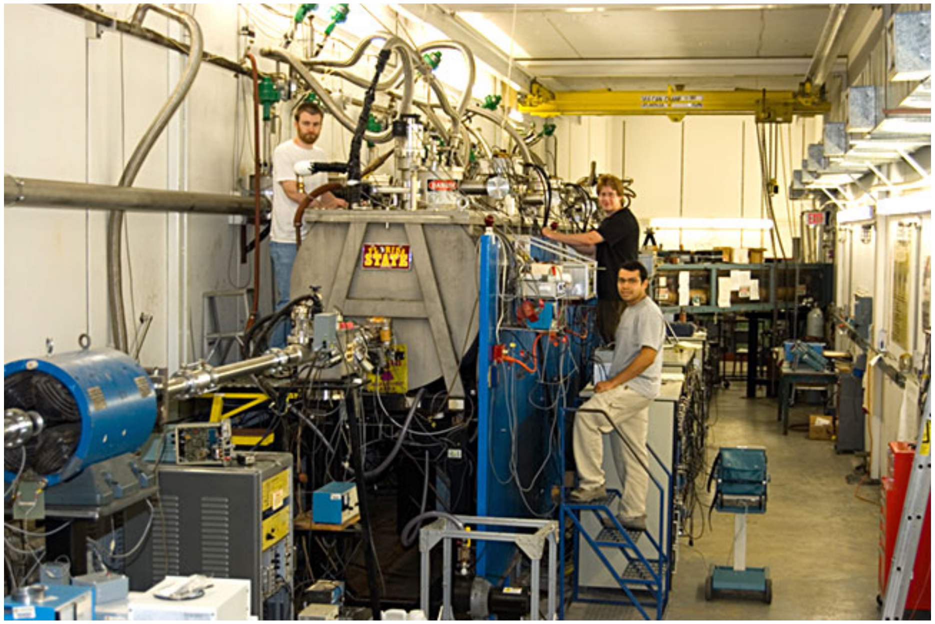
Comparison of PSI versus FSU

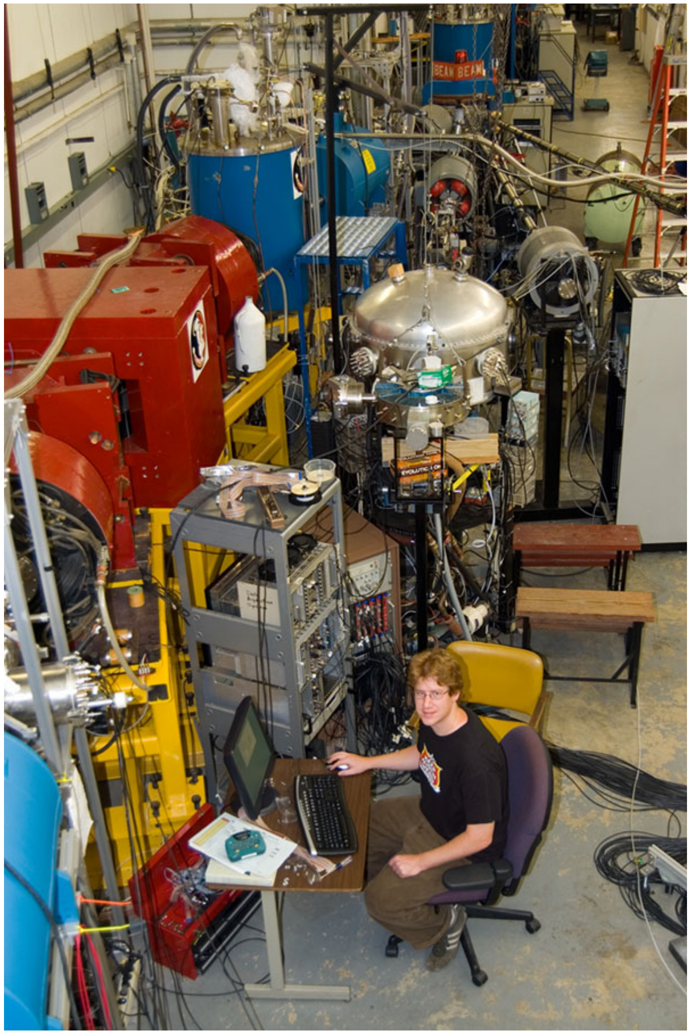
	PSI	FSU
Beam Energy	25 MeV	18 MeV
Beam Intensity	$5 \times 10^8/cm^2/s$ 3.4×10^{15} protons/day	$1.5 \times 10^{12}/cm^2/s$ 10^{17} protons/day
Beam size	5 cm diameter	5 mm diameter
Running time	Beam size >> chip size 6.4×10^{11} protons/(5×10^8 protons/ cm^2/s * 0.194 cm^2) = 6600 s	Beam size ~ chip size 6.4×10^{11} protons/1×10^{17} protons/ day = 6.4×10^{-7} days = 0.56 s

- FSU beam spot is approximately chip size, PSI much bigger
- FSU can be defocused for larger beam spot and intensity turned down for longer running period
  - Slightly higher beam energy may be possible
- FSU beam time is free

FSU Nuclear Accelerator

- On campus nuclear accelerator
  - Tandem + Linac
  - Primarily light ions
- Mostly local users + friends
  - Not a traditional user facility





Back-up Slides

Inputs

- Chip size: 0.2” x 0.15” x 0.025”
- Surface area
  - 0.2” x 0.15” = 0.03 sq in = 0.194 cm^2
- Amount of silicon
  - 0.194 cm^2 x 0.0635 cm x 2.33 g/cm^3 = 0.029 gm
- Position of electronics
  - 1.7 m from beam

Inputs (cont.)

- Assuming dE/dx = 20 MeV cm^2/g for protons in silicon
  - 20 MeV cm^2/g * 2.33 g/cm^3 = 2.2 MeV/cm per proton
- Multiplying by the thickness
  - 2.2 MeV/cm * 0.064 cm = 0.141 MeV per proton

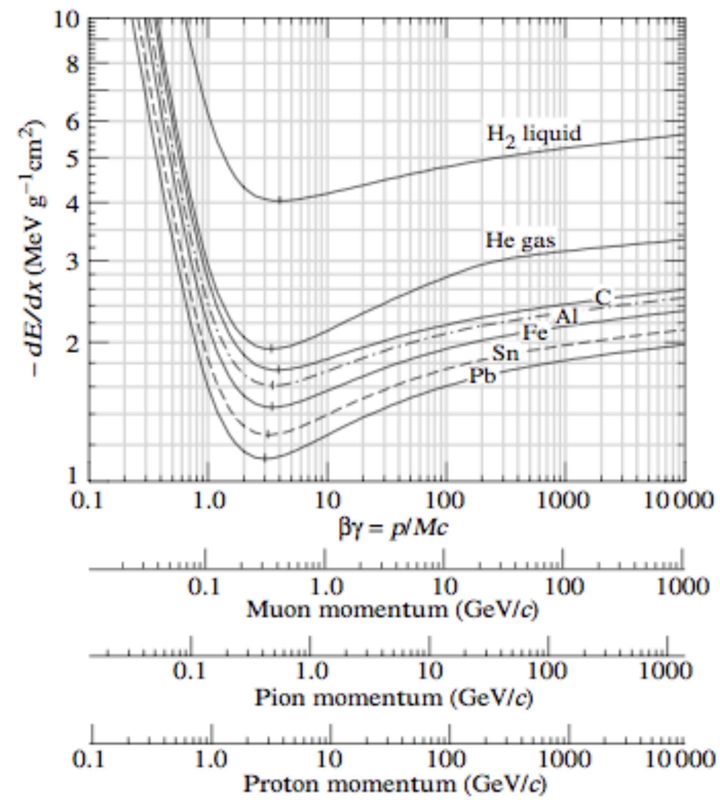


Figure 27.3: Mean energy loss rate in liquid (bubble chamber) hydrogen, gaseous helium, carbon, aluminum, iron, tin, and lead. Radiative effects, relevant for muons and pions, are not included. These become significant for muons in iron for $\beta\gamma \gtrsim 1000$, and at lower momenta for muons in higher-Z absorbers. See Fig. 27.21.

Radiation Requirements

- 1 Gy = 6.24×10^{12} MeV/kg
- 500 Gy * 6.24×10^{12} MeV/kg * 2.9×10^{-5} kg = 9×10^{10} MeV
- 9×10^{10} MeV / 0.141 MeV/proton = 6.4×10^{11} protons
- So we need to deliver 6.4×10^{11} protons to the chip to cause 500 Gy