Geant Simulation in Target Region

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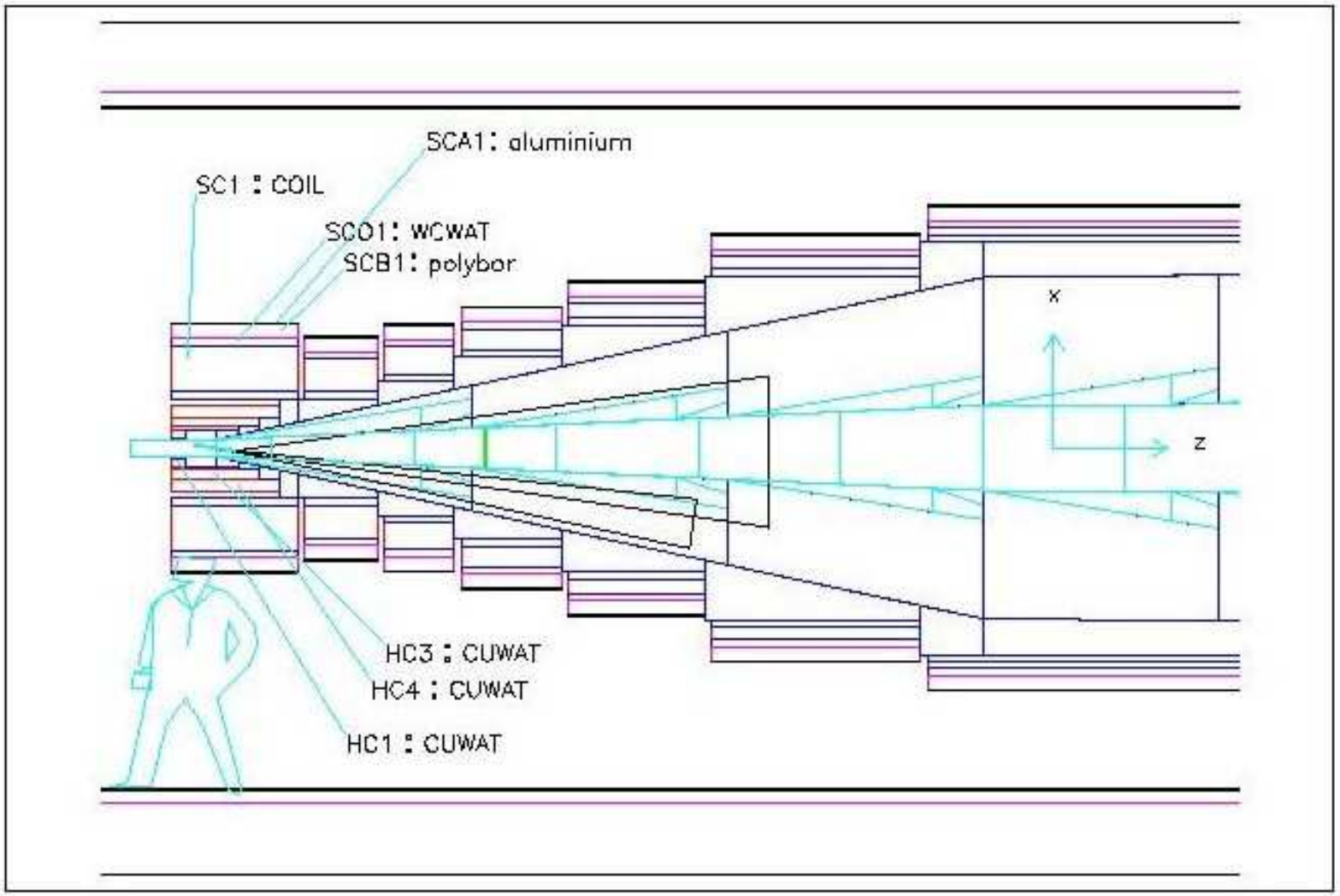
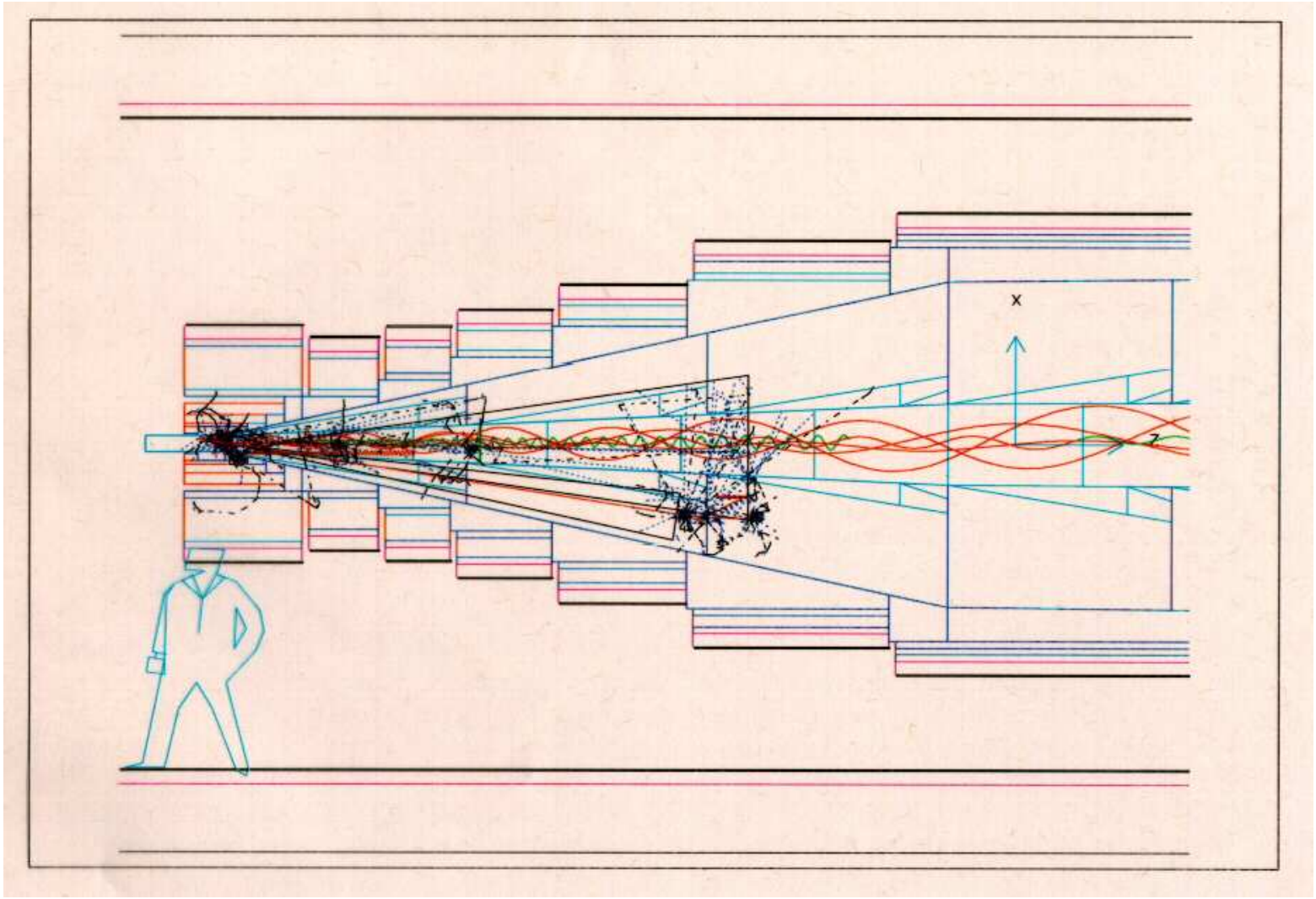
* Did the work

** Scientific Reporter who may incorrectly report it.

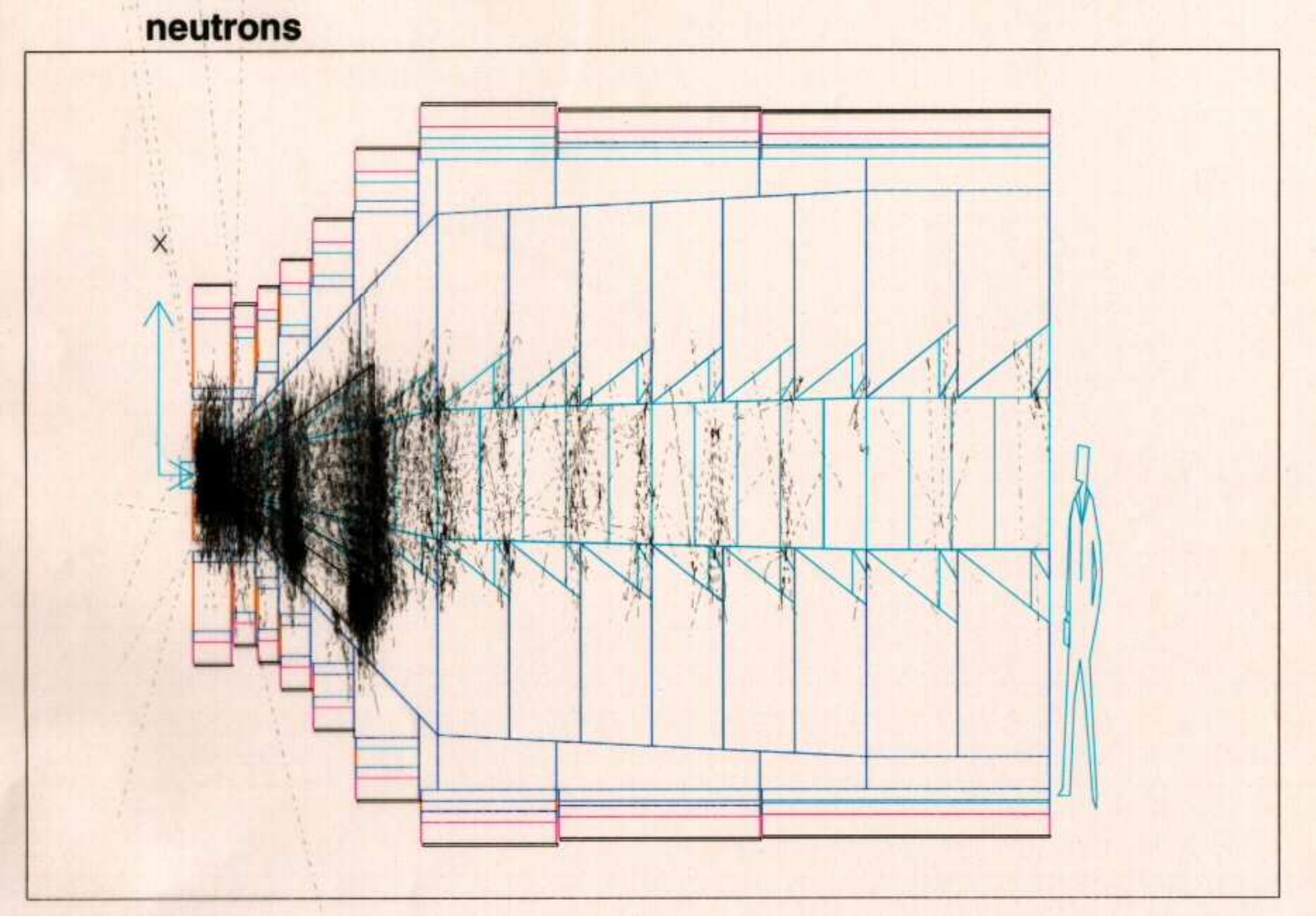
Target Region Geometry



Typical Proton On Target



Neutrons from Typical Proton on Target



Radiation Limits of Magnet Materials

- These radiation properties are provided my mostly by Al Zeller.
- There are big uncertainties on these numbers.
- Insulation: (Typically only dielectric properties required)
  - **Epoxy**
    - For dielectric properties only: Max lifetime dose = 5×10^{8} Gy.
    - For structural properties: Max dose < 10^{8} Gy.
  - **Kapton**
    - Dielectric Properties: Max dose < ~5×10^{9} Gy.
  - **Ceramic**
    - Dielectric Properties: Max dose < 10^{11} Gy.

Radiation Limits (cont.)

- Nb_3Sn conductor:

Kinetic Energy Spectrum	$I_c=0$	$I_c= 0.5\ I_{c0}$
E_n>100 KeV	10^{24} n/cm^2	7×10^{23} n/cm^2
E_n> 1 MeV	8×10^{22} n/cm^2	2×10^{22} n/cm^2

  - **The above limits were obtained for reactor, spallation, and fusion sources. The neutron spectra are different than those expected from an accelerator beam on a target.**
    - The criterion with E_n>1 MeV is chosen in the analysis since that part of the spectrum looks similar.
- NbTi
  - **Cooling considerations may preclude this.**
  - **NbTi would anneal with with warming up.**

Total Energy Deposited in Magnets

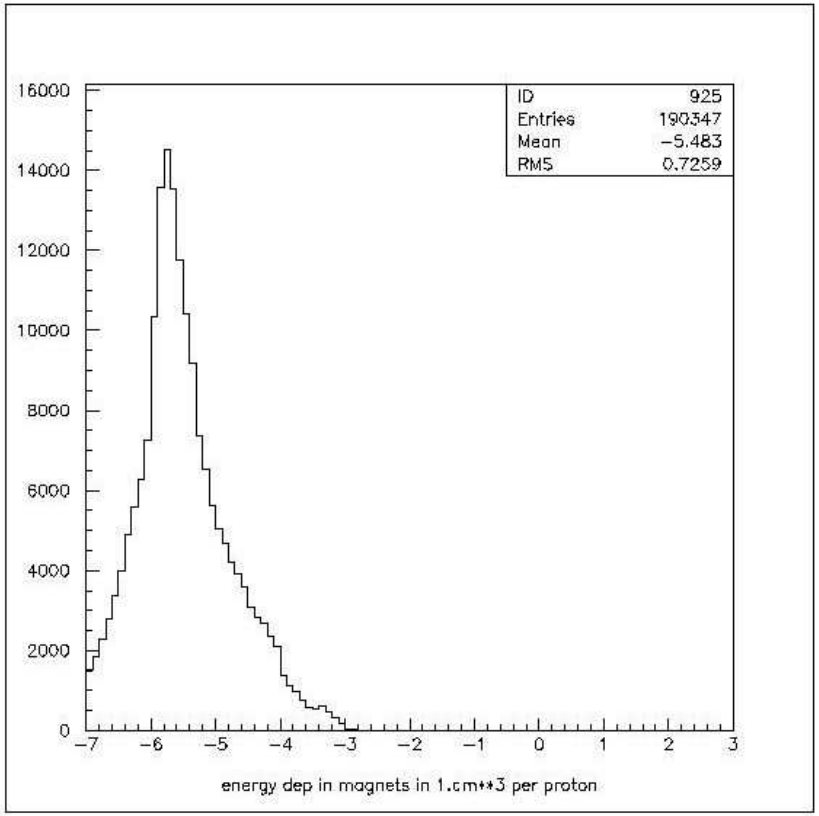
Magnet Coil	Total Energy Deposited per Proton on Target (GeV)	Power Deposited in Magnets (Watts)
HC 1 (inner most warm)	0.025	1000
HC 2	0.149	5900
HC 3	0.302	12000
HC 4	0.213	8400
SC 1 (Surrounding HCs)	0.086	3500
SC 2	0.024	1000
SC 3	0.007	200
SC 4	0.004	100
SC 5	0.002	60

- **Approx. 3% of total proton energy is deposited in magnets.**
- **Also ~3% of energy is in particles that go down beam pipe.**
- **The remainder goes into the shielding.**
- **Power assumes 10^{14} p.o.t. and a frequency of 2.5 Hz.**

Determining Hot Spots of Magnets

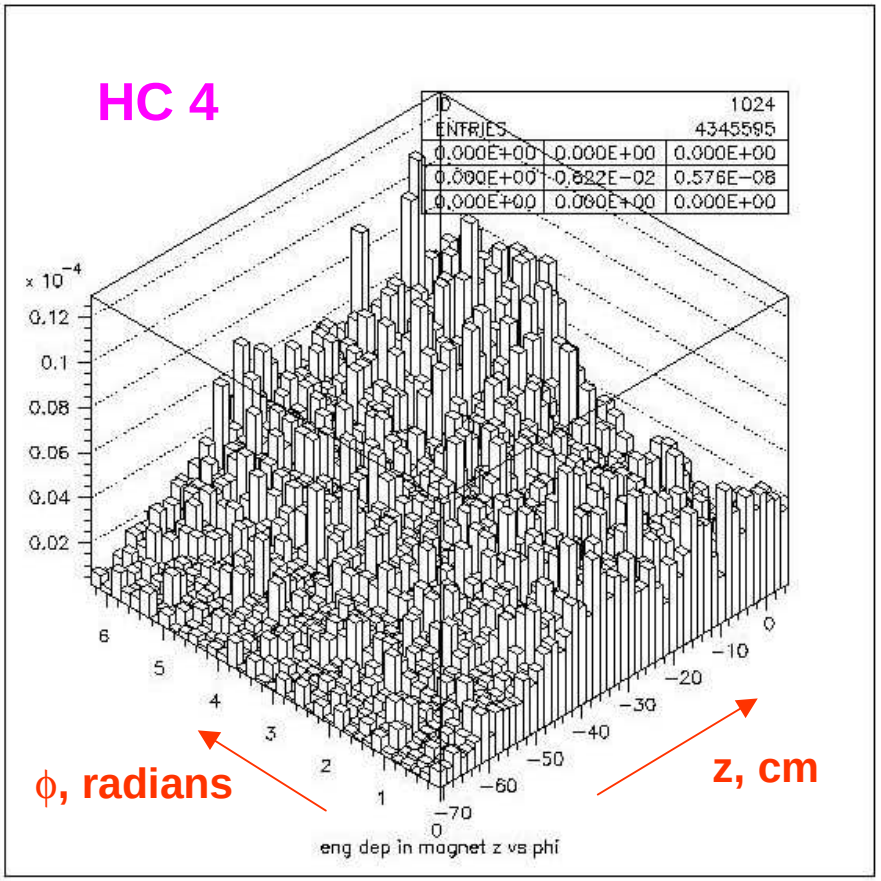
Energy Deposited into cells in magnet SC1

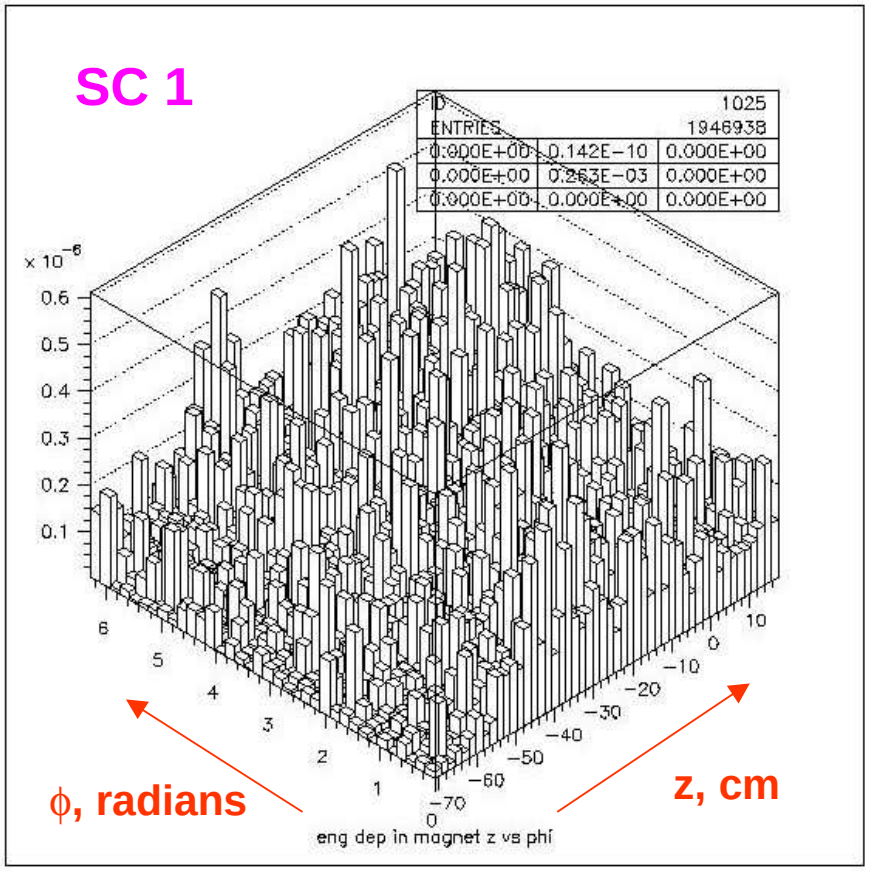
- Each magnet coil is segmented into ~1 cm^3 cells.
- Deposited energy is accumulated in these cells.
- Histogram at left shows distribution of energy deposited in cells for magnet SC1.
- Hottest cell has deposited KE ≈ 1 MeV.



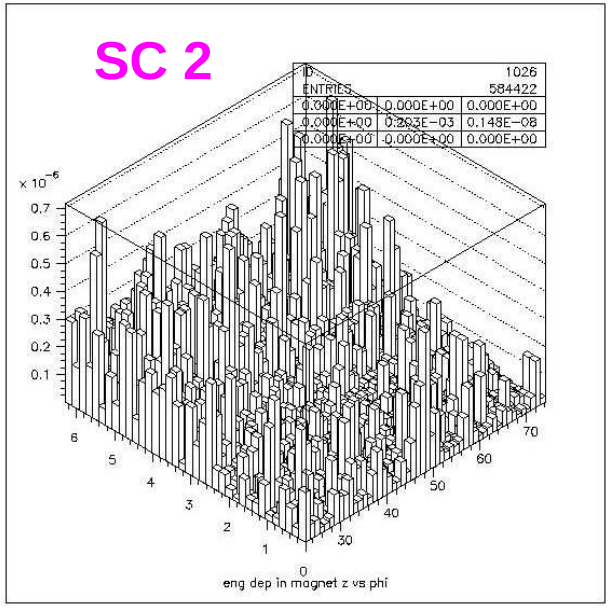
$Log_{10}(E/GeV)$

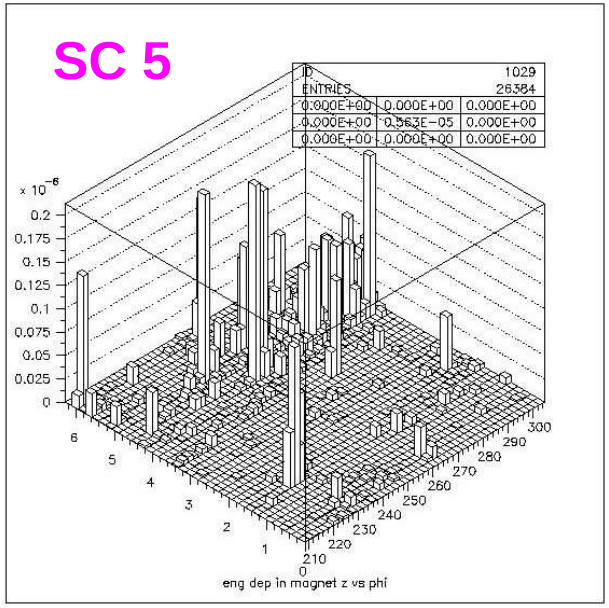
Distribution of Energy Deposited in Cells Near Target

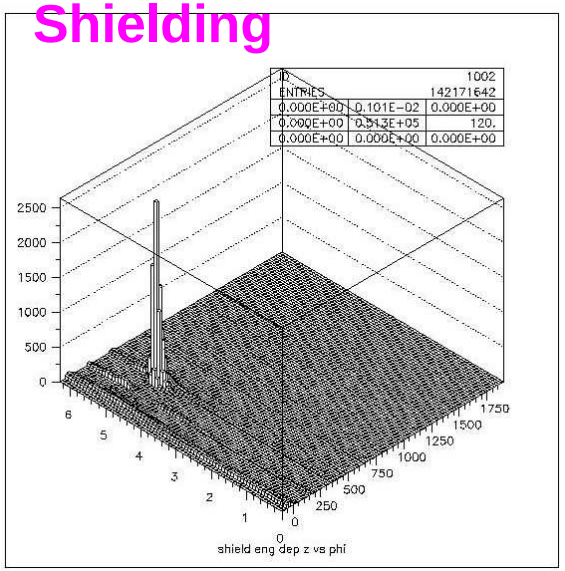




Distribution of Energy Deposited in Cells Away from Target







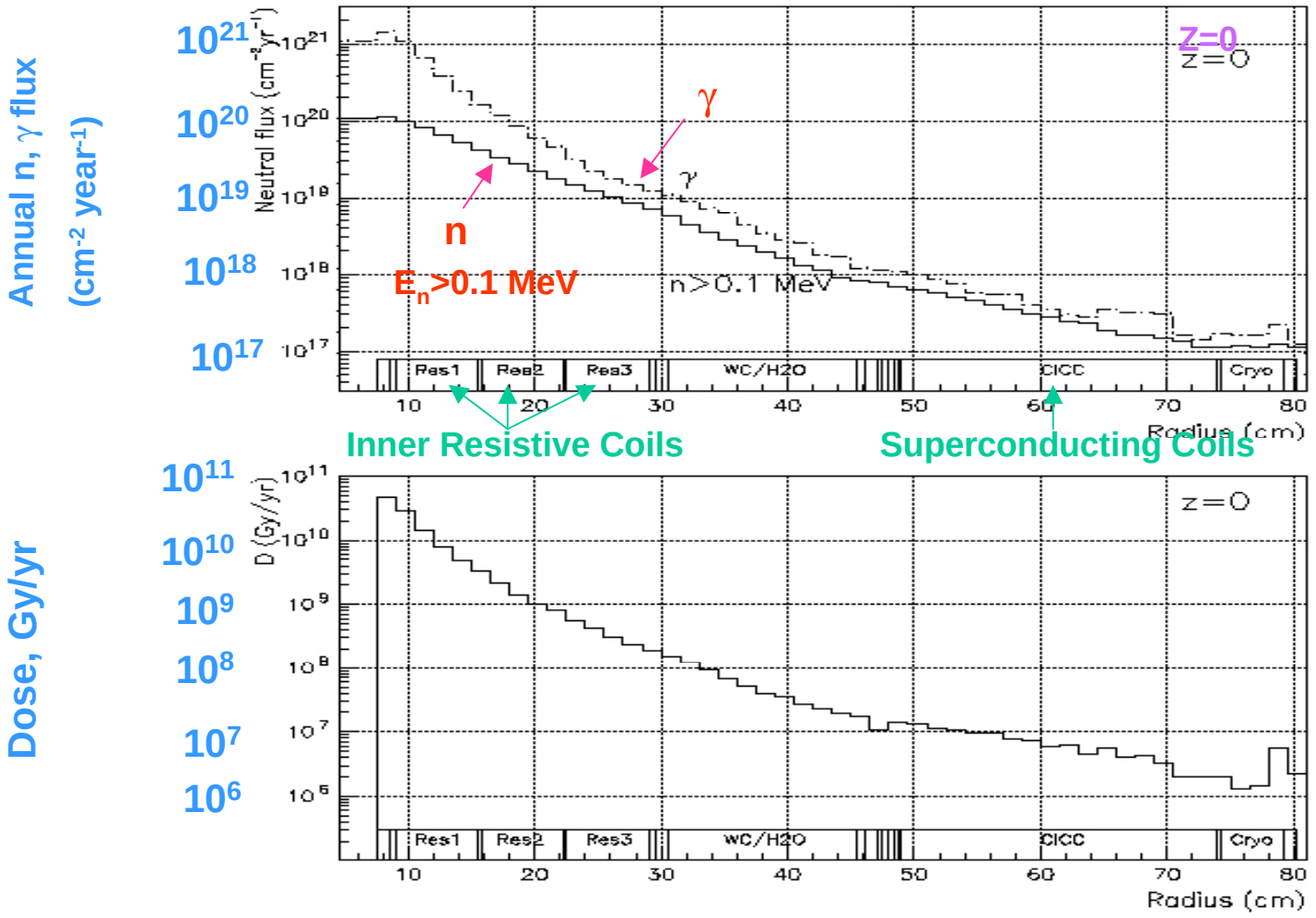
- Large fluctuations appear in magnets away from target.
- These fluctuations appear to be associated with energy deposited downstream of the target.
- Note location is correlation with energy deposited in shielding.

Average Energy Deposited in Superconducting Coils

- Power deposited in SC1:
  - **P_{SC1} = 3.5 Kw = 2.2×10^{22} eV/sec**
- Volume of SC 1:
  - **L=88.2 cm**
  - **R_{in}=40 cm**
  - **R_{out}=72 cm**

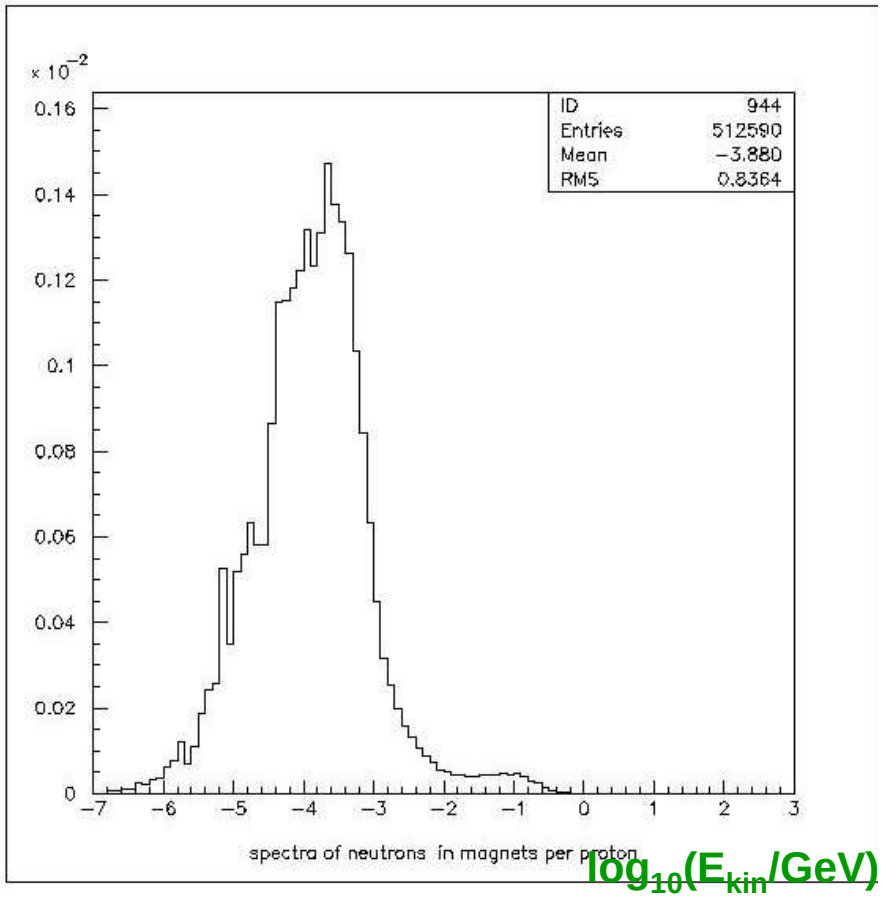
  → **$V=10^6$ cm^3**
- This gives 6.4×10^9 Gy/year as average dose seen in SC 1.
  - **This is consistent with numbers quoted in Feasibility Study 1.**
- We are hesitant about quoting peak dose in the superconducting coils at this time.
  - **We are still working on it.**

Radial Distribution of n and γ Flux from Feasibility Study 1

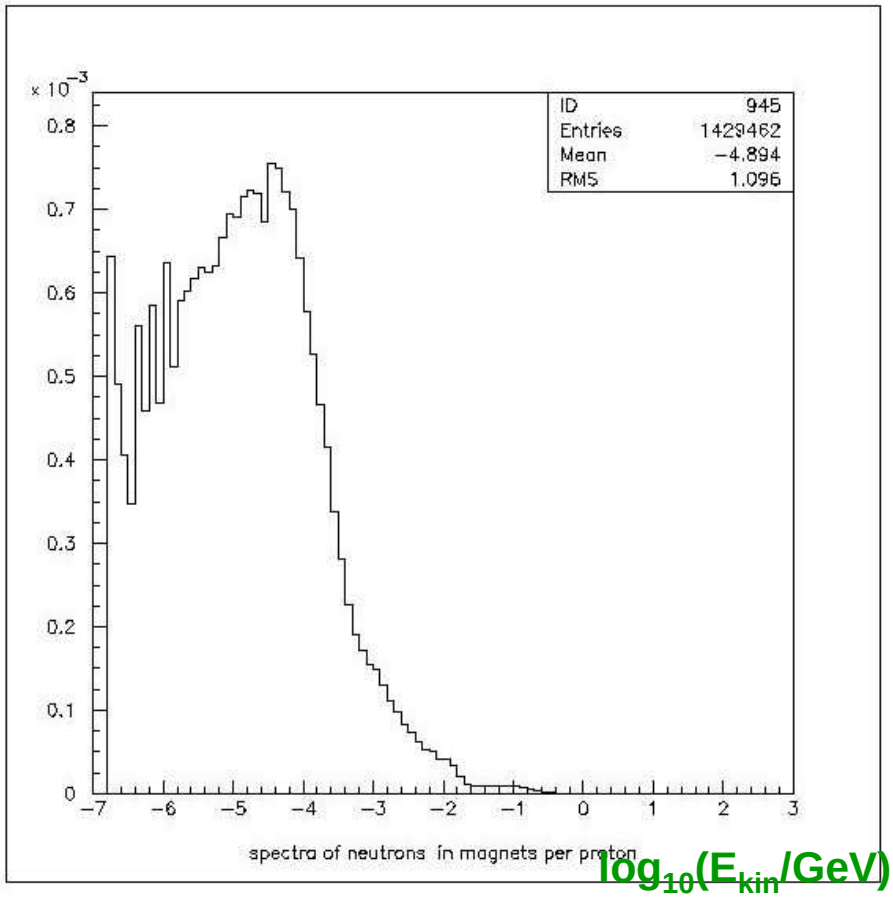


Neutron Spectrum in Magnet Coils

neutron Spectrum in HC 4 (typical of warm coils):



neutron Spectrum in SC 1:

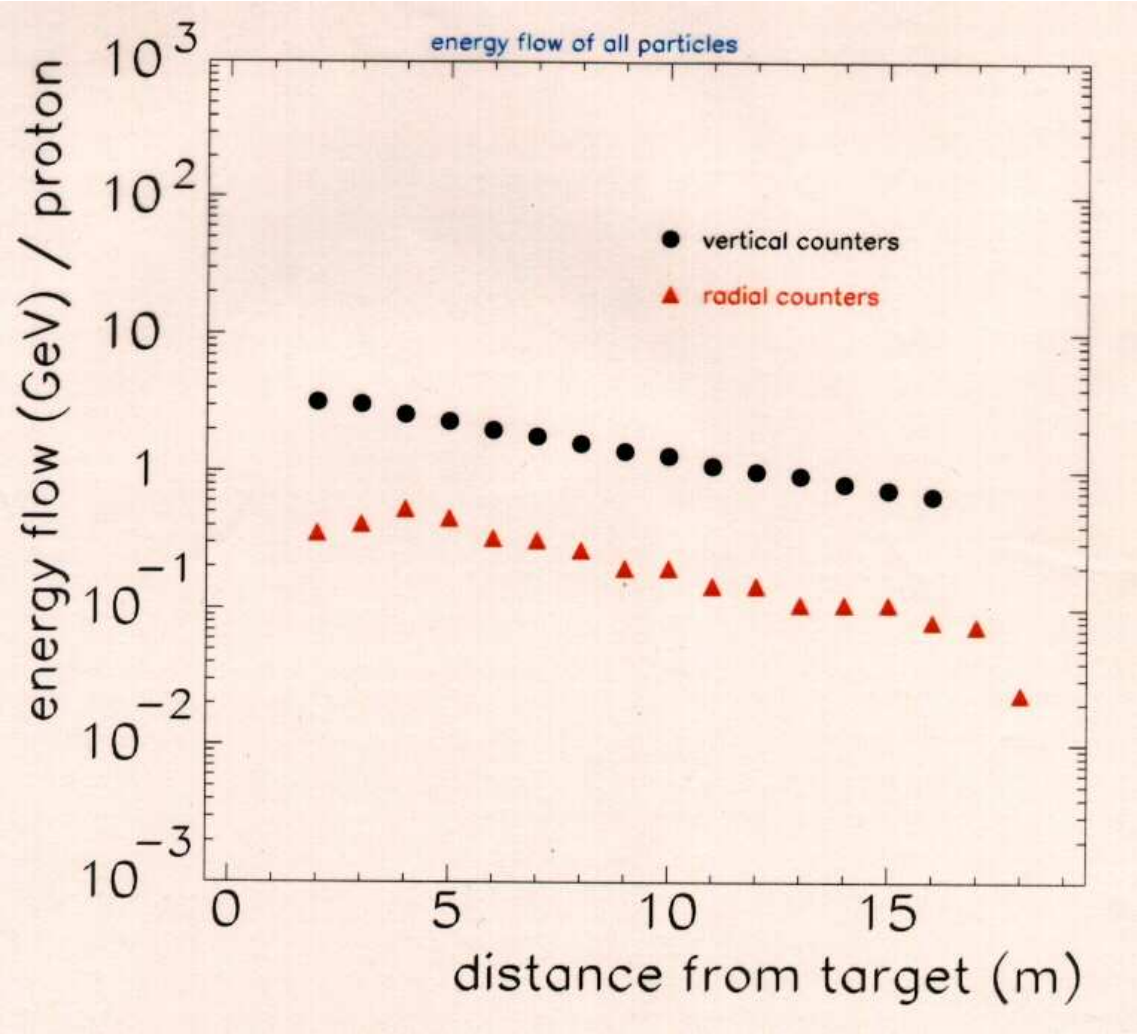


Neutron Flux in Magnet Coils

Magnet Coils	E_{kin}> 100 KeV		E_{kin}> 1 MeV	
	n/cm^2/proton	<Flux>	n/cm^2/proton	<Flux>
HC 1	0.0195	5×10^{19}	0.0069	1.7×10^{19}
HC 2	0.0182	4.5×10^{19}	0.0070	1.8×10^{19}
HC 3	0.0127	3.2×10^{19}	0.0050	1.3×10^{19}
HC 4	0.0462	1.2×10^{19}	0.0193	4.8×10^{18}
SC 1	0.0238	6×10^{18}	0.0120	3.0×10^{18}

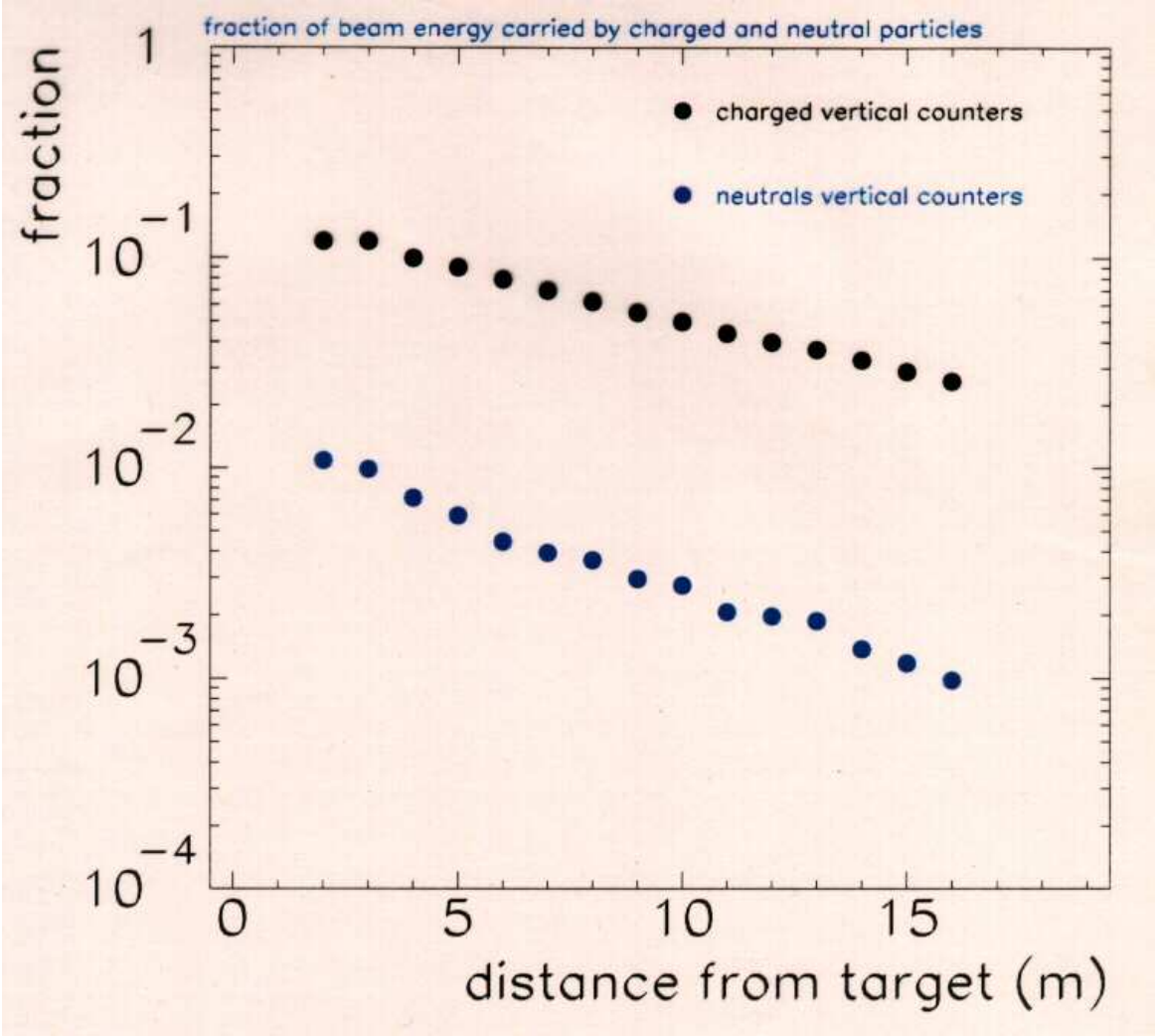
- Neutron fluxes are averages over the magnet coil.
  - **Fluxes for the above listed coils are reasonably uniform over the surface (ie, to a factor of 2).**
  - **Fluxes for coils SC2-SC6 are not uniform over the surface.**
    - These coils have hot spots that are associated to activity downstream of the target.
    - Fluxes in the vicinity of the hot spot are comparable to the flux in SC 1.
- Note that the flux in SC 1 is an order of magnitude larger than that in Feasibility Study 1

Energy Flow of Particles

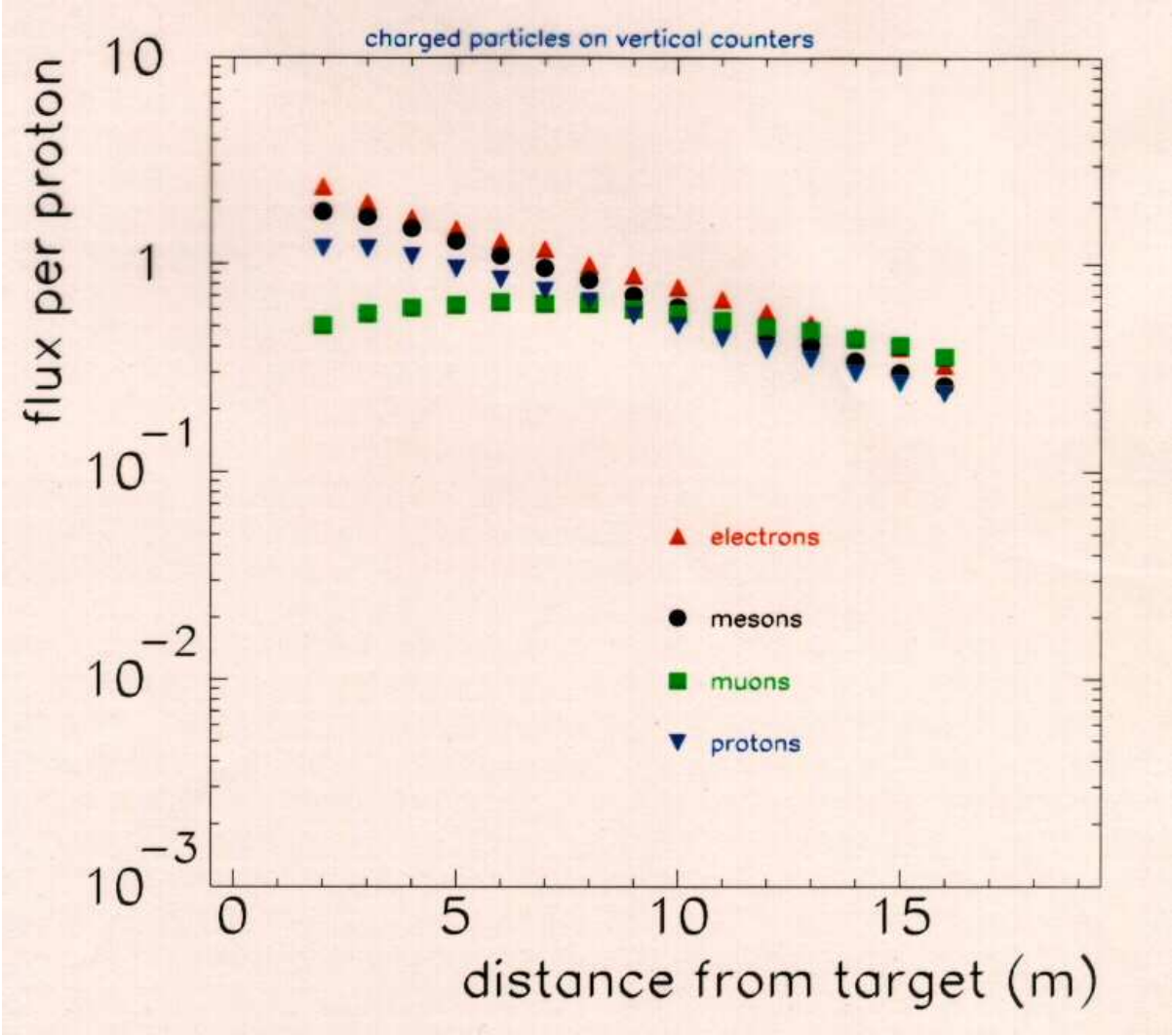
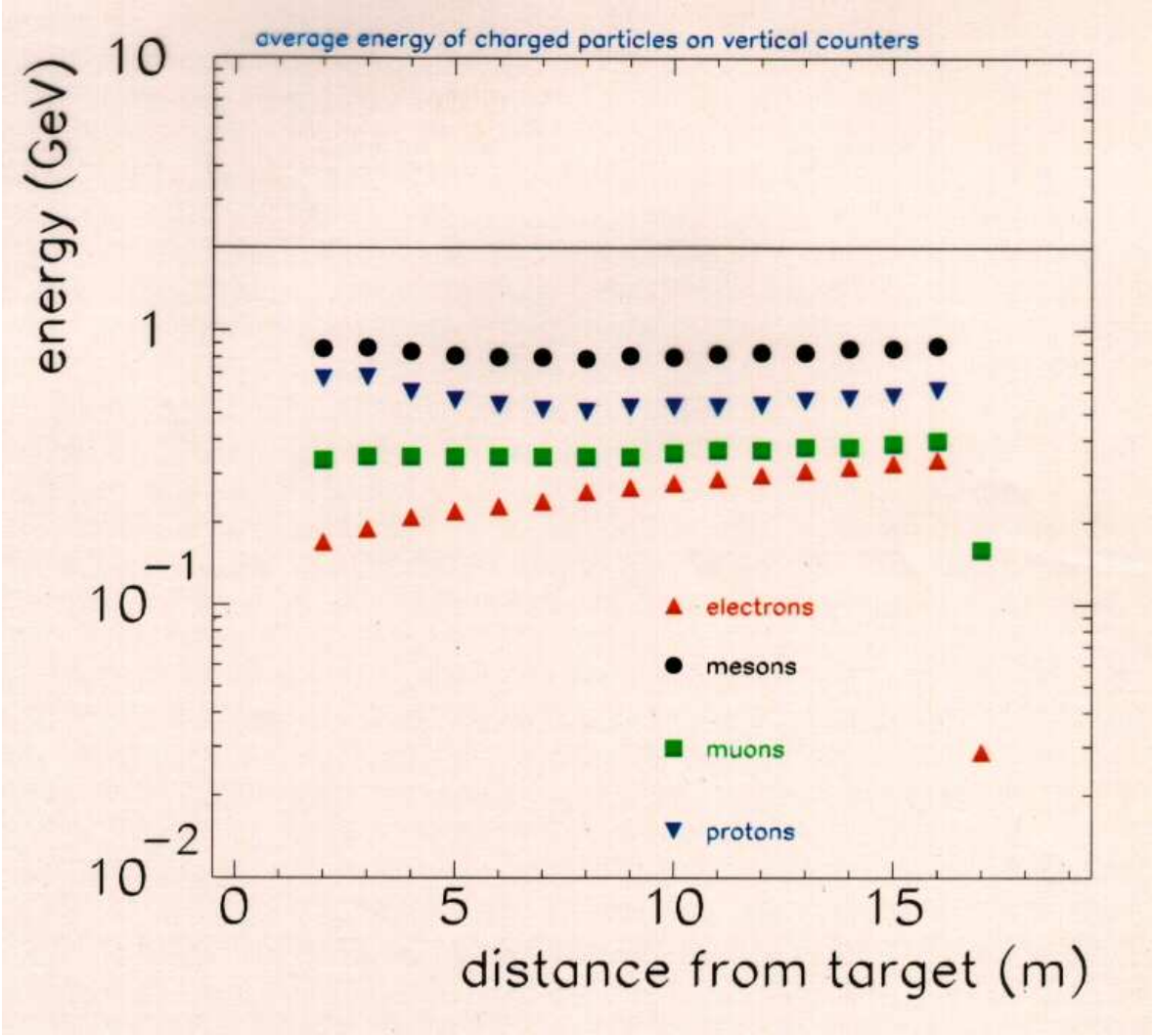


Radial counters indicates energy lost at position.

Fraction of Beam Energy Carried by Charged and Neutral Particles



Fluxes of Charged Particles



Average Energy of Particles