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TO: Files

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SUBJECT: M - Remarks on "thin targets"

An important question in M target-area design in view of the increased current design figures (60-μa max) is whether "thin target" experiments are realistic. By "thin target" experiments we mean experiments where the beam passes through a target and is then "buried" in an earth mound. Secondary particles from the target are let through a hole in a shield surrounding the target and are analyzed in an unshielded area.

(a) Liquid hydrogen consumption—If the "thin" target is liquid hydrogen, then at 60 μa the boiling rate is 1.0 liter/hour per cm of beam path in hydrogen. This is substantial but not prohibitive.

(b) Neutron yield—(i) Neutrons from liquid hydrogen. Let us make the conservative assumption that the pion cross section (or rather the cross section to make a single neutron from hydrogen) is 2×10^{-28} cm^2 (equal to the 3/2-3/2 resonance cross section) over all photon energies. At 45 Bev the neutron yield per cm of path is

$$Y = \frac{2}{\pi} \alpha \ln(E_0/\mu)(2 \times 10^{-28}) \ln(E_0/300) \times 0.07 \times 0.6 \times 10^{24}$$

$$= 2.1 \times 10^{-6} \quad \text{neutrons/electron-cm.}$$

For a 20-cm target this is a yield of 4×10^{-5} neutrons/electron.

(ii) Let the target walls be made of stainless steel of ½-mm thickness ($t = 0.4$ g/cm^2). The neutron yield is roughly

$$Y = 0.08(NZ/A^2)(t \times 0.6/E_{res}) \cdot (2/\pi)\alpha \ln(E_0/\mu) = 1.3 \times 10^{-5} \text{ neutrons/electron ,}$$

where $E_{res} \sim 20$ Mev is the energy at the peak of the giant resonance.

(iii) Skyshine. At 60 μa (3.8×10^{14} electrons/sec) a thin target is a neutron source of

$$2 \times 10^{10} \text{ n/sec .}$$

At ~1000 ft the unattenuated flux would be ~2 n/cm^2-sec. At 1000 ft the unattenuated flux and skyshine flux are about equal (and the skyshine falls off as 1/r thereafter), and since the project boundaries are about 1000-ft away at the nearest point, 2 n/cm^2-sec is a reasonable estimate for the skyshine from an open "thin" target.

Since the "outside fence" tolerance is about 1/100 of this amount, we conclude that a shield permitting the target to "see" through 1/100 of a sphere into open space would be safe. This is entirely reasonable since secondary magnetic detectors seeing much in excess of 1/1000 of a sphere become very difficult to design.

(c) Conclusions——We conclude that "thin" liquid hydrogen target experiments are practical at 60 μa. Note that if the target becomes "thick" owing to the beam's striking an obstacle, the neutron yield can become of the order of 10 or 2×10^5 greater than assumed above. Hence radiation interlocking is necessary.

Considering the fact that these calculations do not offer a large margin of safety, we consider more detailed skyshine analysis very necessary.

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WKHP:lb