Monte carlo Simulations of Decaying Concentrators SNO-STR-90-43

A simple monte carlo program written by David Sinclair and adapted to include reflectors has been used to study the repercussions of 'black' reflectors. Four hundred electrons (5 MeV) are generated at each 0.5 meter step in radius in the SNO detector. They are each given an initial random direction and tracked till they are below the cerenkov threshold. Their cerenkov radiation is traced out to the PMT sphere and then handed over to the concentrator ray tracing routines. The program includes attenuation by the water and by the acrylic sphere, but does not treat reflections at the acrylic sphere. The PMTs are given an overall efficiency of 15%.

In all of the seven simulations presented here, we use 6663 Burle PMTs which gives us 32% hard coverage. All the concentrators are truncated in length to the criteria of only loosing 3% coverage (the 46 degree cones from 27cm to 20cm, the 56 degree cones from 17cm to 12cm). The results are presented in figures 1 and 2.

46 degree cone, 90% reflectivity \
46 degree cone, 50% reflectivity / figure 1
46 degree cone, 0% reflectivity /

56 degree cone, 90% reflectivity \
56 degree cone, 50% reflectivity / figure 2
56 degree cone, 0% reflectivity /

No reflector (Bare tube) figures 1 and 2.

The 'no reflector' case has a flat response in the D20 as expected. At 6.5 meters the number of hit tubes increases slightly because more than half of the light is no longer attenuated by the acrylic sphere. At 8 metres the response is coming back down because we are very close to the tubes and there is now a significant proportion of double hits (and triples) which are counted just as singles -- the average number of 'hits' was 25, whereas the average number of 'tubes' was 19.

At 90% reflectivity the 46 degree cone increases the coverage by a factor of 2 (37 hit tubes vs. 19 hit tubes), the 56 degree cone gives a factor of 1.5 (29 tubes vs. 19 tubes). However, the 56 degree cone has a flat response out to 7 metres giving us an extra metre of light water.

If the reflectors were to go jet black then the 56 degree cone seems a safer option. At 6 metres the response has fallen to 14 hit tubes for the 56 degree cone and 11 tubes for the 46 degree cone. However, to gain this margin of safety we must compromise considerably on light collection, which will of course be more serious the less hard coverage we can afford. We will be in a better position to decide the appropriate angle after we know the type and the number of PMT's we are going to buy. Furthermore, it seems unlikely that the reflectors will experience substantial loss of reflectivity. Nevertheless if the reflectivity was to degrade slightly then the response of both types of cone would drop proprotionaly whilst remaining flat in the D20. This is demonstrated in the attached plots for the extreme case of a drop to 50% reflectivity.

M.E. Moorhead
Oxford SNO Collaboration
April 6,1990

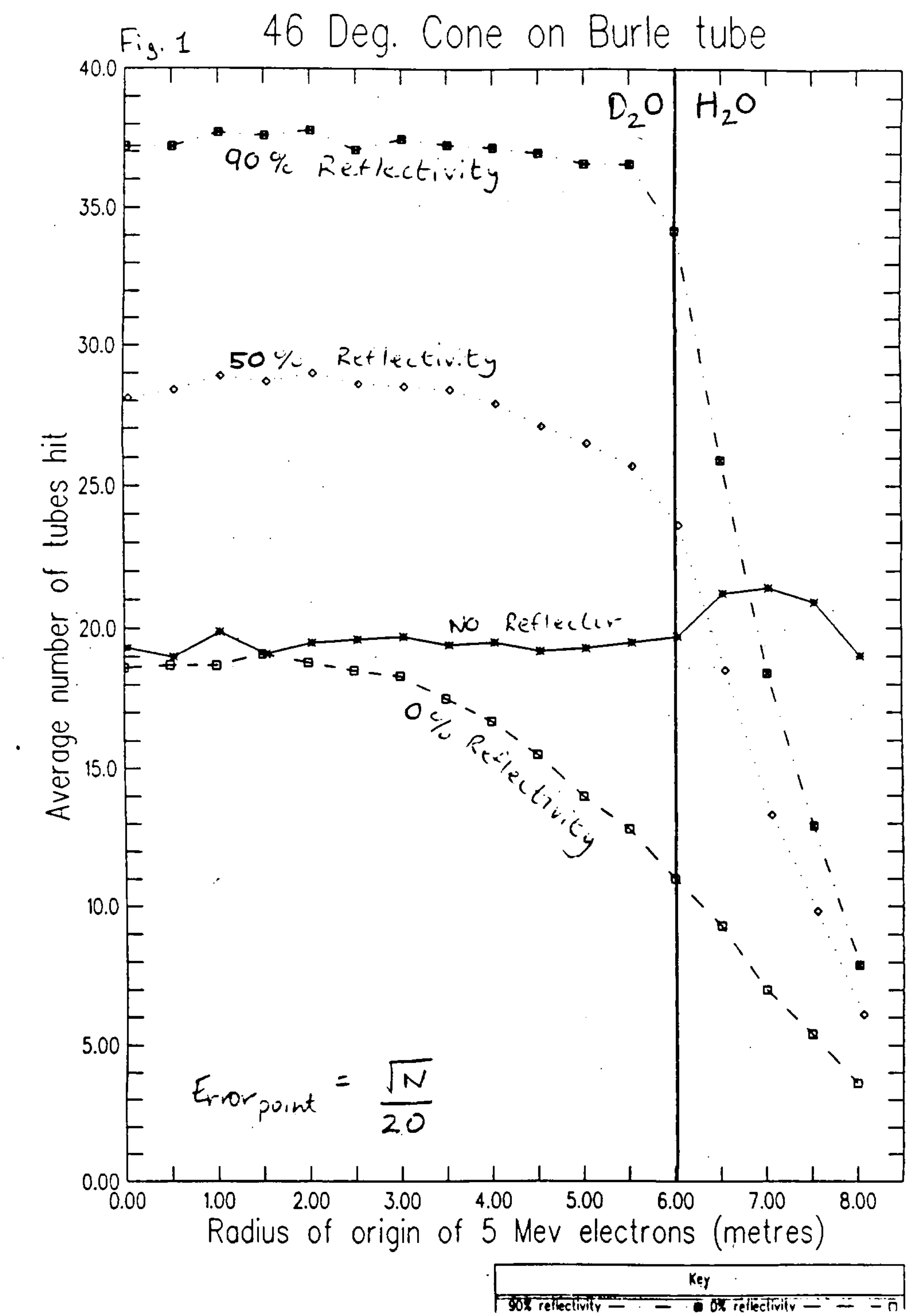

Fig. 1
46 Deg. Cone on Burle tube
D_2O
H_2O
90% Reflectivity
50% Reflectivity
NO Reflector
0% Reflectivity
$Error_{point} = \frac{\sqrt{N}}{20}$
Average number of tubes hit
Radius of origin of 5 Mev electrons (metres)
Key
90% reflectivity
0% reflectivity

Fig. 2

56 deg. Cone on Burle tube