NSRL Fault Study #3 (*C-A fault study 218*) Results
May 19th 2006
A. Rusek, I. Chiang, P. Pile

This is a summary of the fault study conducted on the evening of May 16th 2006, from about 16:00 to 21:00. The purpose of the study was to obtain data from a fault on the RD1/RD2 magnet, to form the basis on which a decision can be made on the conditions under which that magnet can serve as the critical device for NSRL target room access.

1- Beam Conditions

protons, extracted at 1000 MeV (1700 MeV/c momentum) and 1.5×10^{11} /spill, 16 spills/min. Beam intensity was very stable throughout the study.

2- Optimizing the source

With the RD1/RD2 magnet field set to zero, after establishing a small beam centered on the 93 SWIC (and, presumable the RD1/RD2 magnet), the response of the scintillator, placed at the center of the beam in the target area, was recorded. The beam was then steered left and right and the scintllator response recorded. The maximum response was found at and near the center, as can be gathered from the data summarized in table 1 and plotted in figure 1 below.

Position on 93 SWIC (mm)	Scintillator Response (counts/spill)
-20	25
-10	80
0	80
10	25

Table 1

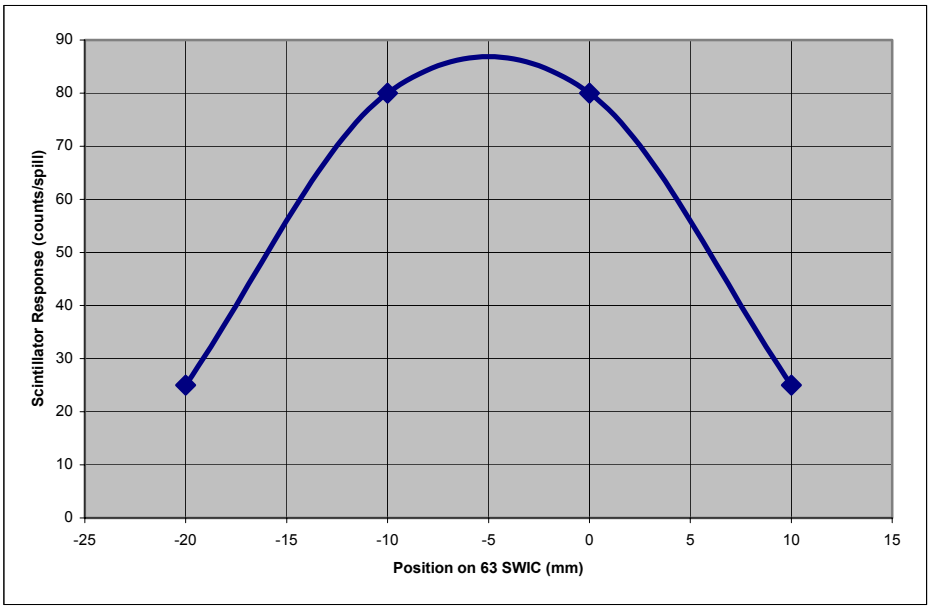


Figure 1: Scintillator response vs. beam position on the 63 SWIC at the entrance to the RD1/RD2 magnet.

3-Optimizing the Acceptance

Using the pixel-ion-chamber-with-gain (PICWG) a small, well-centered beam was established in the target area. Figure 2 is a beam intensity distribution plot as presented by the PICWG display software.

The downstream portion of the beam line was scaled to various energies. At each setting, the beam was again centered and shaped, until it looked like the one in figure 2, and the scintillator output was maximized. The beam line settings along with the scintillator and chipmunk responses are shown below.

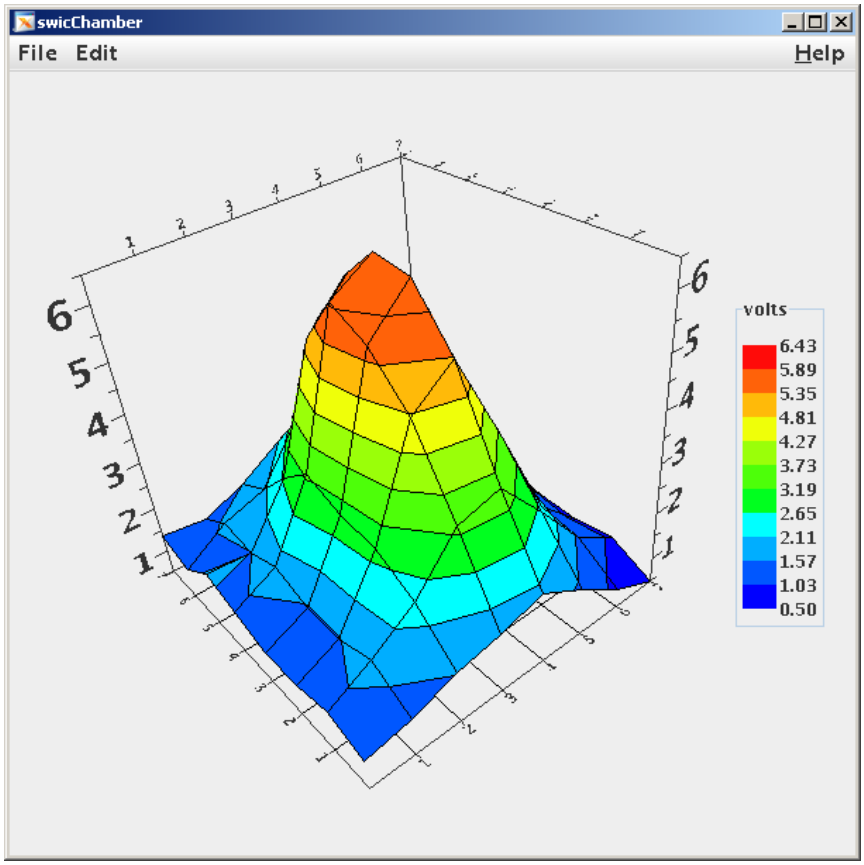


Figure 2: Beam intensity distribution during the fault study. Each pixel is 3 x 3 cm^2.

4-Results

The scintillator and chipmunk readings are given in table 2 and plotted in the following two figures. The beam was tuned to a small spot and centered on the scintillator at every momentum setting.

Momentum (MeV/c)	Energy (MeV)	Scintillator (counts/spill)	Chipmunk (mrem/hour)
200	21	6000	225
300	47	5000	225
400	82	6600	225
500	125	7000	220
600	175	6400	200
800	295	5400	100
1000	433	3300	75
1200	585	1700	60
1320	681	800	40
1700	1004	120	20

Table 2: Data taken during the fault study, with the beam tuned to a small spot on the source (vacuum flange) and a small spot on the target area.

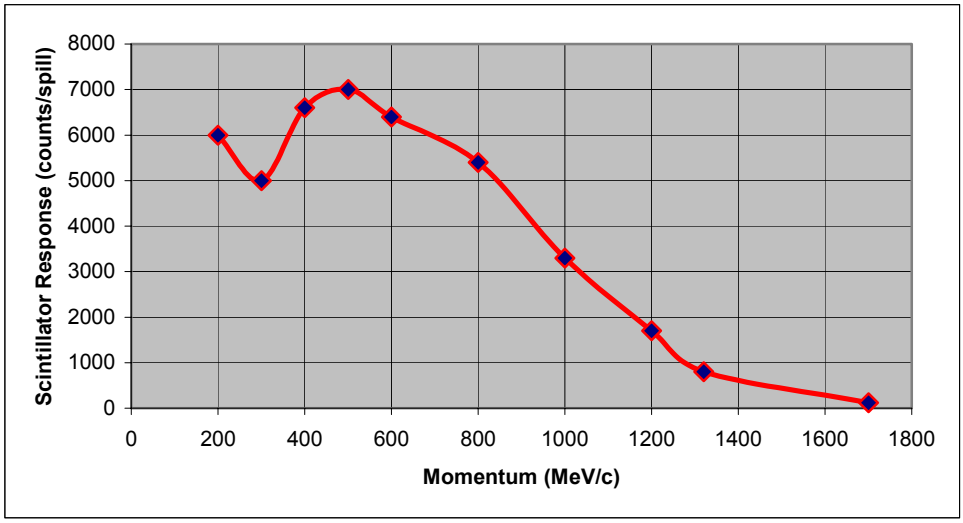


Figure 3: Plot of scintillator response against beam momentum.

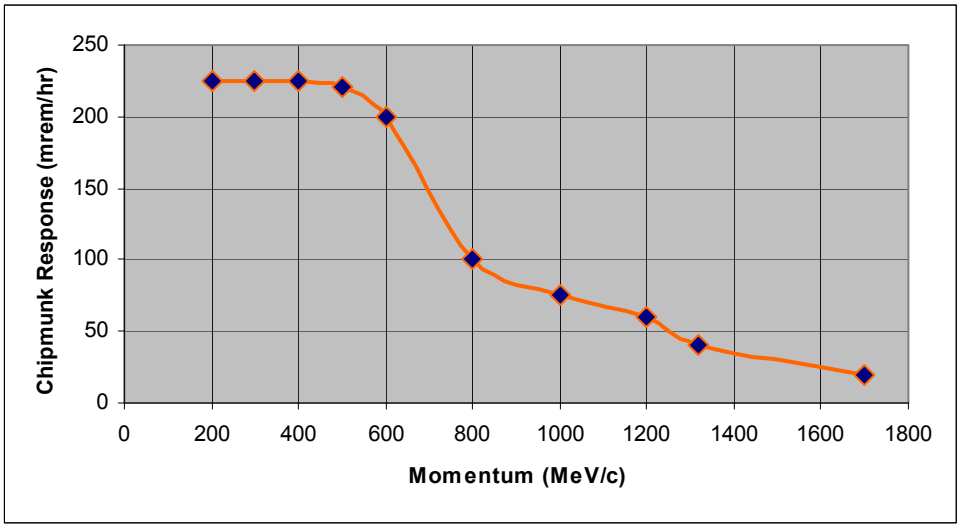


Figure 4: Plot of chipmunk response against beam momentum.

5-Using Normal NSRL Beam

The beam was also tuned to a normal biology-type, that is, a 20×20 cm^2 beam. After beam was established, the RD1/RD2 magnet field was set to zero, and the scintilltor and chipmunk readings recorded. The chipmunk was moved in and out of the beam to get a background reading (it was slightly activated from the time it spent in the beam). The in-beam reading was 10 mrem/hour. Scintillator reading was 80 counts/spill.
The scintillator counts can be converted into dose:

(80 counts/spill)*(16 spills/min)*(60 min/hr)/(3.2×10^4 protons/mrad) = 2.4 mrad/hr

Proton quality factor is 2.0.

2.4*2.0 = **4.8 mrem/hr** (scintillator)

The chipmunk quality factor is 2.5. 2.5/2.0 = 1.25

(10 mrem/hr)/(1.25 rem/rad) = **8 mrem/hr** (chipmunk)

6-Analysis

In the worst case we measure 225 mrem/hr in the chipmunk, with a small beam centered on it, and presumably contained within its cross section. For the purpose of this analysis, we can consider such a beam to be uniform over the area of the chipmunk with a local dose rate of 225 mrem/hr.
The Chipmunk quality factor is set to 2.5, and since the beam is assumed to consist of charged particles only, mostly protons, for which the quality factor is 2.0 we convert to proton-mrem, dividing by 1.25.

225/1.25 = 180 mrem/hr

There were 16 spills per minute during the fault study, each delivering about 1.5×10^{11} protons.

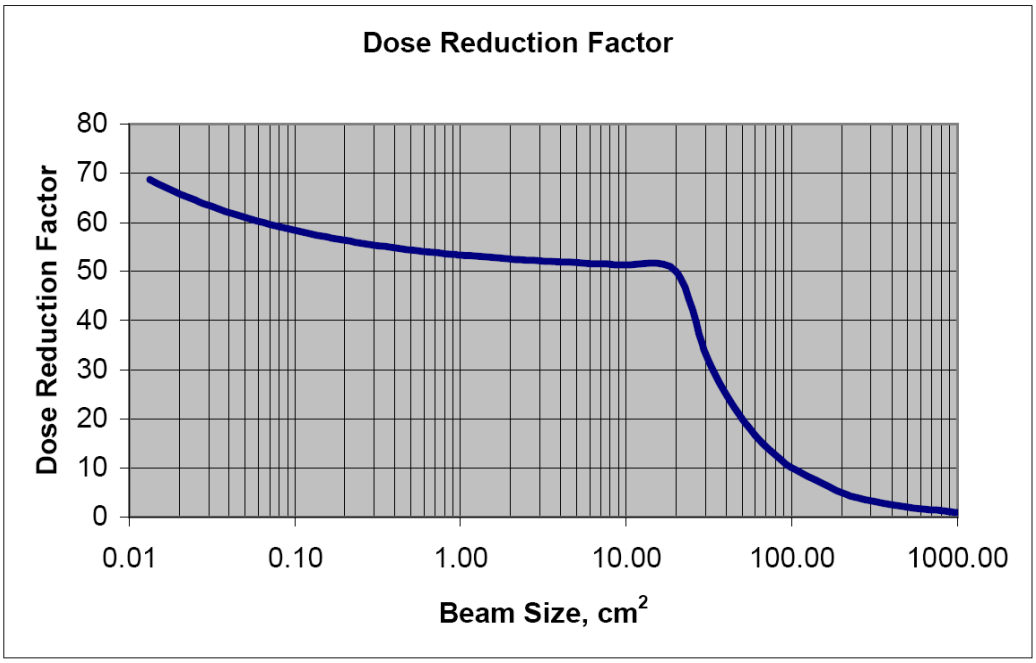
180/60/16/(1.5)*1000 = 125.0 mrem/(10^{14} protons)

If we now use the chipmunk cross sectional area for the beam size, we can use the chart from C-A OPM 9.1.11, shown below, for dose reduction for small beam. The chipmunk diameter is 6" (area 182 cm^2)

125.0/6 = 20.8 mrem/(10^{14} protons). {small beam}

As for the biology beam, we cannot make use of the dose reduction factor, and the expected dose is given as:

8/60/16/(1.5)*1000 = 5.6 mrem/(10^{14} protons). {biology beam}



Dose reduction factor, C-A OPM 9.1.11, page 12.