Fragmentation Physics

The input required for reliable galactic cosmic ray (GCR) simulations is a set of double differential cross sections for the scattering and fragmentation processes

$A_{Beam}\ A_{Target} \longrightarrow A_{Frag1},\ A_{Frag2},\ \ldots$

In order to make reliable measurements of the fragmentation cross section, the incident beam must be well described. This means the beam must be an isotopically pure narrow, pencil beam. The NSRL measurements begin with a round beam spot at the target of diameter ~1 cm. We make use of a thin trigger scintillator upstream of the target and demand that the energy deposited in that scintillator be consistent with the heavy ion species of the beam.

Fragmentation scintillators are located downstream of the target. We typically make use of 4 scintillators, F1 - F4. The first three are of dimension 14mm x 15mm perpendicular to the beam, with thickness of 5, 2, and 6mm respectively. The fourth is 10mm x 10mm and 2mm thick, and is used to select particles that are centered in the previous three detectors; I.e. at zero degrees. Additional fragmentation scintillators in different sizes and shapes are available, or can be produced in a short time.

Most data taking involves recording the pulse height and timing information for hits in all scintillators whenever there is a hit above threshold in the trigger scintillator. Under special conditions we took data using F4 as the trigger, with the threshold set low enough so that we were efficient for triggering on Z=1 tracks.

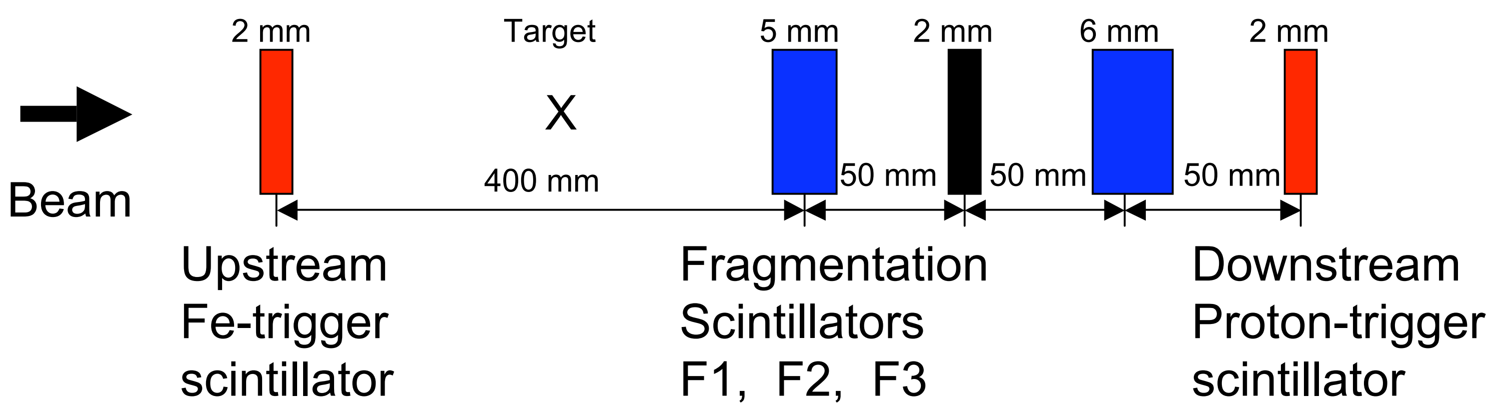
A spectrum taken with silicon detectors is compared to a similar spectrum taken with scintillators.

Beam Composition Study

NSRL Beam: 1000 MeV/n Fe-56

Small Pencil Beam (1cm diameter)

Scintillator Configuration:



Beam Composition Study

Triggering conditions:

1) Fe trigger: Thin scintillator (2mm thick) 40 cm upstream of fragmentation detector set to a high threshold selecting only Fe in software

2) Proton trigger: Thin scintillator 19 cm downstream of detector set to a low threshold, efficient for Z=1 tracks.

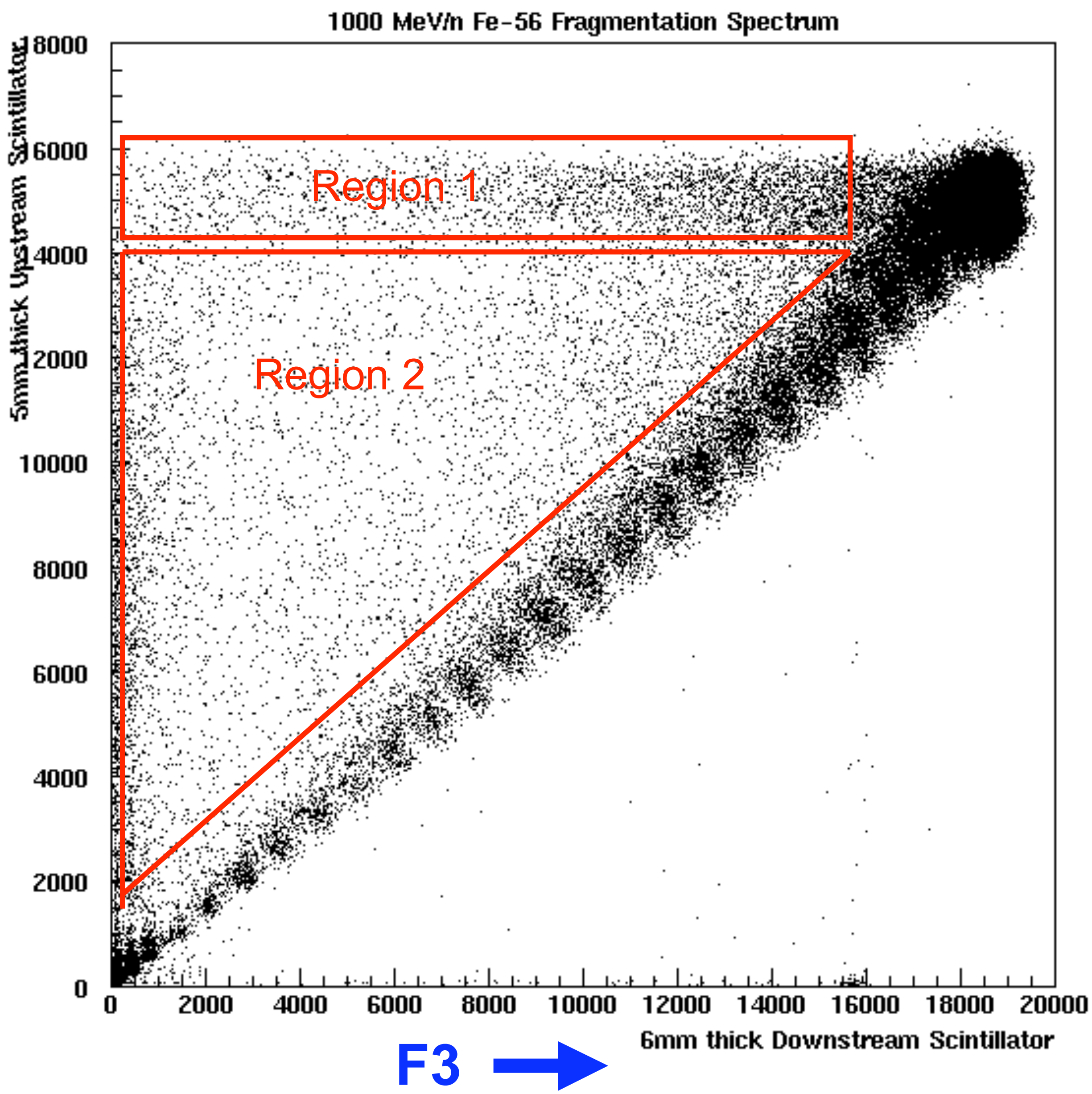
Deposited energy spectrum taken with scintillator detectors

2-D plot showing energy deposited in Fragmentation counter F1 versus the energy in Fragmentation counter F3

No Target (air) was used for this data.

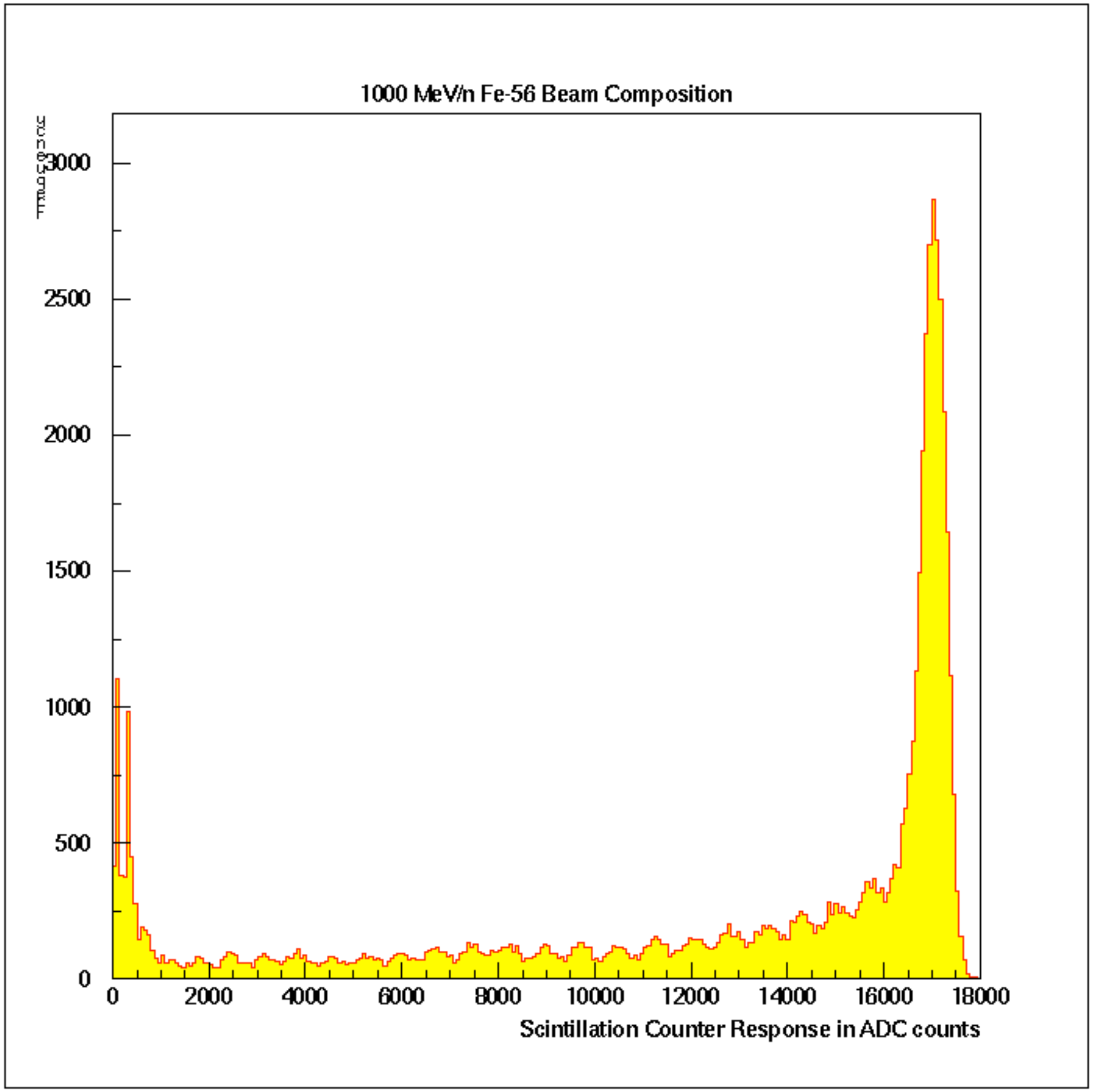
Events in region 1 are from Fe ions that fragment in F1 or F2.

Region 2 events come from Fe ions that fragment in the trigger scintillator.

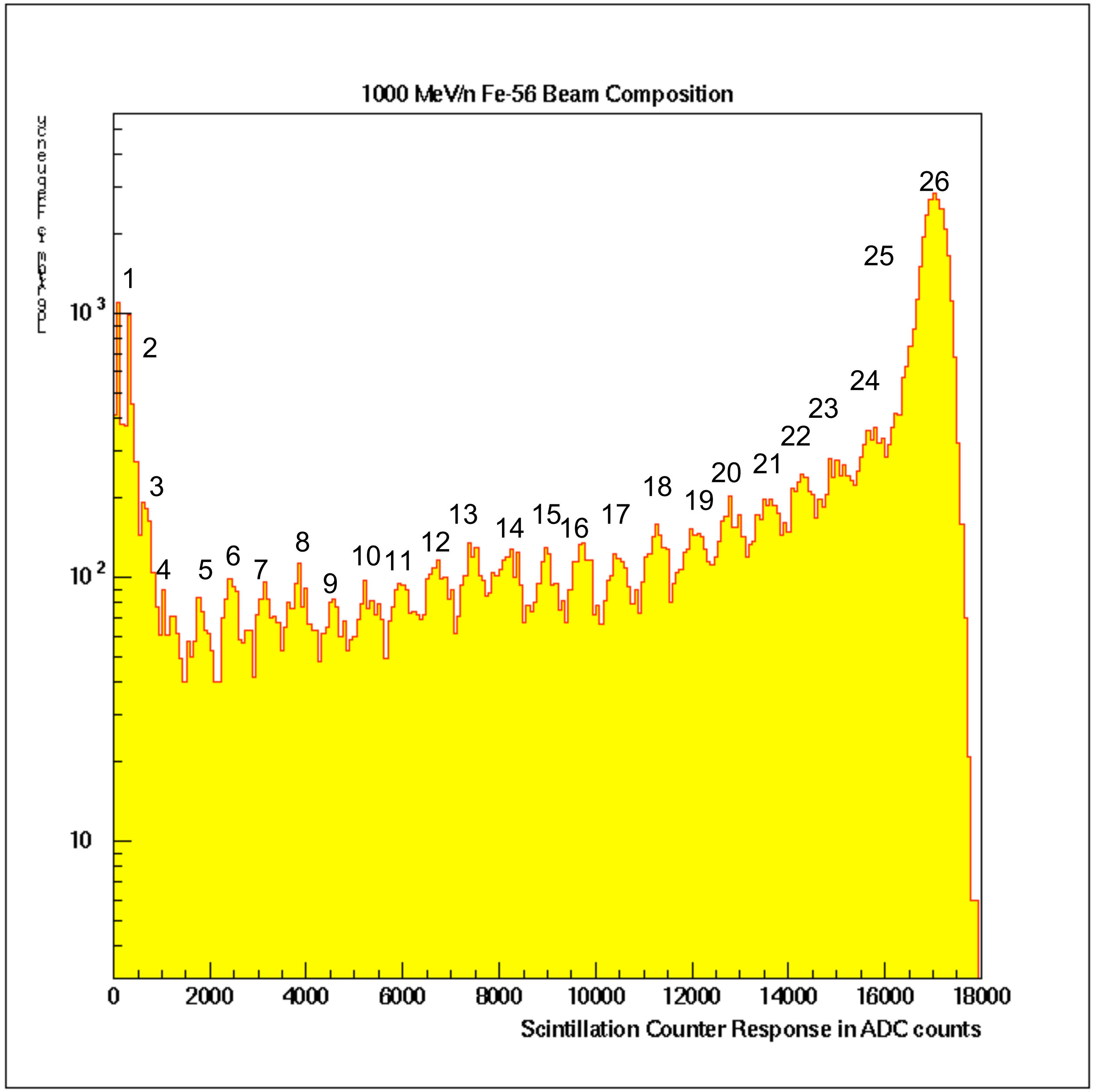


Projection
of the previous
2-D plot.

Target = air.

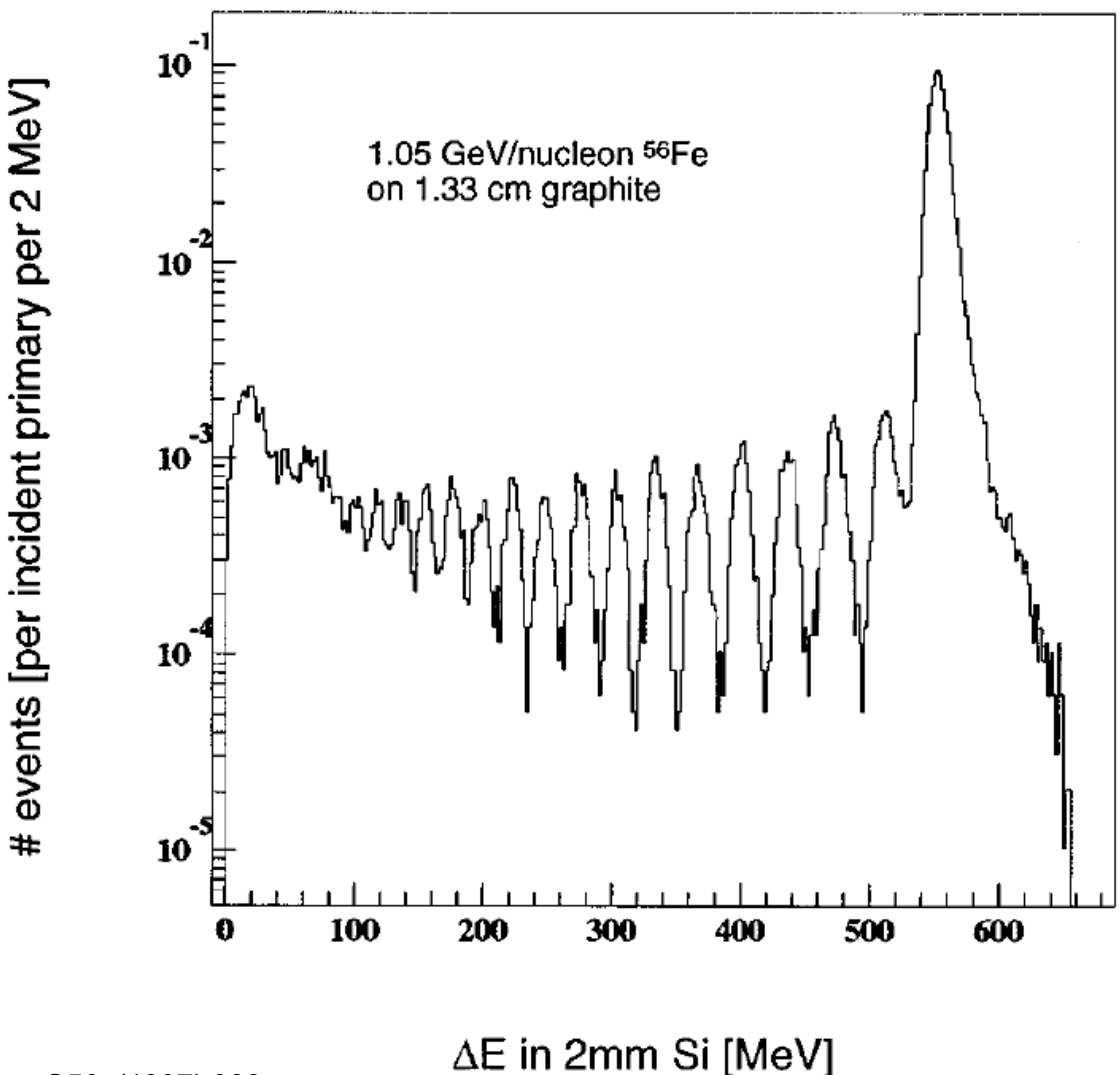


Same data,
with logarithmic
vertical scale



The LBL Silicon detectors have better energy resolution than scintillator, giving good separation between peaks of different Z.

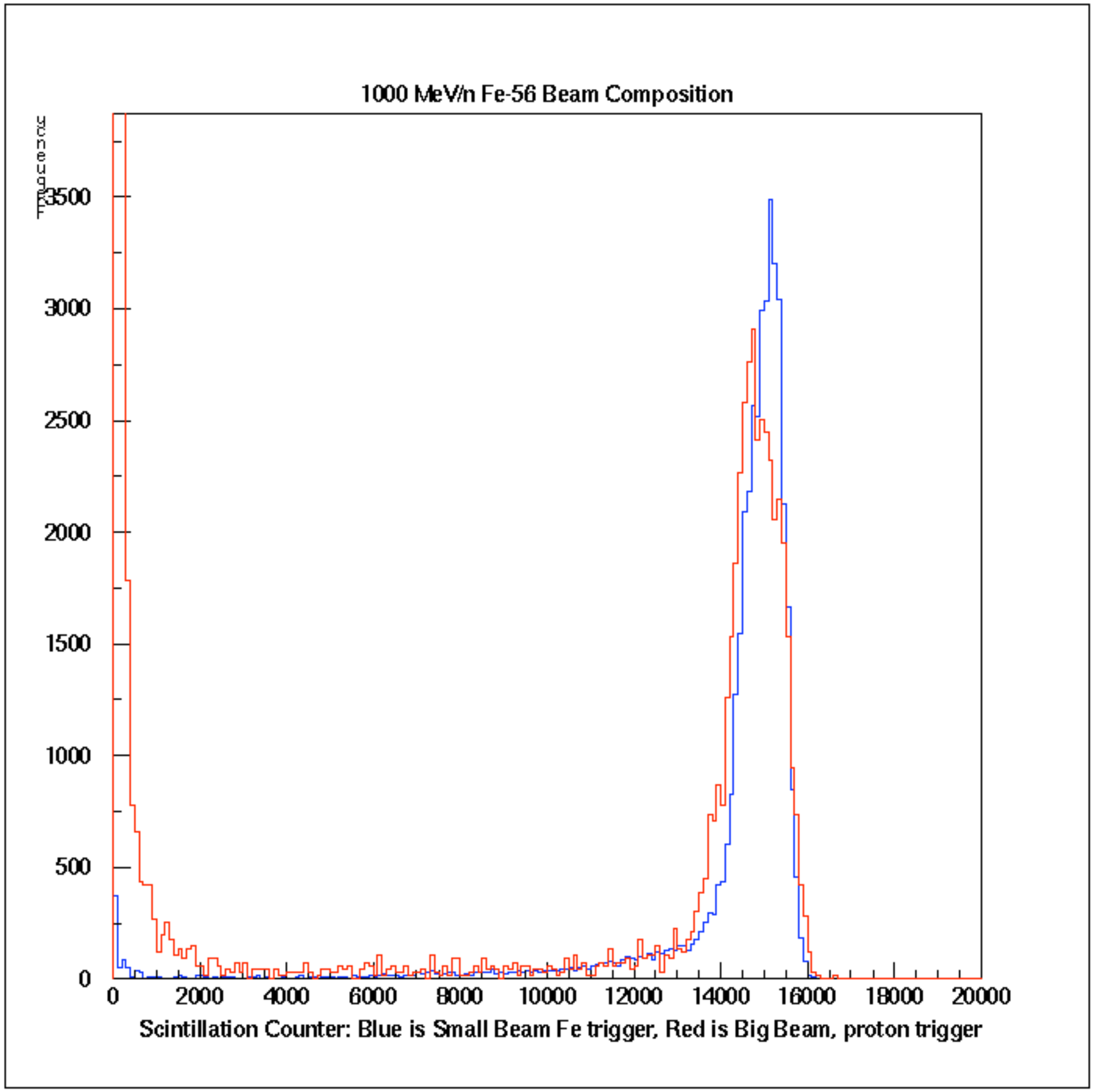
Low-Z peaks are not well defined and efficiency for Z=1 tracks is not good.



From C. Zeitlin *et al*, Phys. Rev. **C56**, (1997) 388.

Comparison of the detector response to small beam triggering on Fe and large beam triggering on all tracks.
Blue shows the Fe-triggers.
Red shows the low-threshold triggers.

(NB: the low-LET peak goes far off the top of the plot. See next.)



Same data with log scale showing the height of the low-LET peak (i.e. low-Z) that is almost completely absent if triggering on incoming Fe tracks using a small sized beam spot as in measurement of fragmentation cross sections.