TRIUMF Experiment E614
Addendum to Technical Note 33

Cosmic Rays: calibration uses

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Abstract

This addendum deals with some of the points raised in connection with TN-33: Use of cosmic rays for calibration of drift planes. The yoke was incorporated into GEANT, the positions where the useful cosmics crossed the yoke were histogrammed, and the statistics were calculated without the contribution from the dense stacks. Matters useful to the simulation of high energy particles with E614 GEANT are also listed here.

Notes on simulating cosmics

The cosmic ray particles we are dealing with are a fair bit more energetic than particles of the type previously simulated with E614 GEANT, and we need to consider if we need to change settings within GEANT to properly simulate them. In particular, the ERAN card in the `e614.ffcards` file needs to be changed to deal with the higher energies. Unfortunately GEANT is picky over what values it allows (segmentation errors result) so it seems safest to stick to the default values given in the GEANT manual:

```
ERAN 0.00001 1000. 90
```

The first two entries give the minimum and maximum energies the process cross-sections are calculated for, in GeV. The third is the number of logarithmic energy bins used in this range.

Note that we also want the maximum track length (MAXS) to be fairly long, say 10m, as it is the high angle cosmics with long tracks in EVOL that we are interested in. With the field off, we can extend EVOL and WORL in the `ugeom.F` file to look at cosmics at even higher angles; I have done this in my simulation.

A problem was encountered while simulating high-energy muons. At the boundary between two materials, just before the muon crossed into the new material, the step size went down to the minimum displayable value (which was actually less than the minimum value set in the STPL card) and the simulation continued with the particle on the boundary, until the simulation was finally terminated after 30000 steps. In this time the particle remained in the material just before the boundary and very slowly drifted along the boundary in some direction (I expect this drift is a result of some errors or approximations made in the tracking routine). This hanging of the program occurred not every time such a muon crossed a boundary, but every 50 events or so. Favorite places to hang were the air-iron interfaces and in the G10 lamels in the detector, although it was by no means limited to just these materials or locations. Changing the minimum step size in STPL had absolutely no effect on the simulation.

The only ways found to alleviate these problems was to turn down the energy of cosmic rays to below about 100MeV (this is not really acceptable for simulations of cosmic rays), and to change the epsil parameter in the STPL card, the precision to which the volume boundaries and the tracks are calculated. In the absence of any real understanding of the problem, which seems to be part of the CERN muon tracking routine, I took the second approach. In the `material.F` file I changed epsil to 0.002 for the non-sensitive materials, while keeping it at 0.00002, the E614 default, for the sensitive materials, which need to have a good accuracy to calculate for example the position of wires in the chambers. This seemed to provide a fix to the problem. If we are interested in having a high accuracy and understanding of GEANT in this energy regime this problem will need to be looked into.

Addition of yoke to E614 GEANT

The current design of yoke was added to the `ugeom.F` file, and will probably be incorporated into the next version of GEANT. At the moment the modeling of the yoke is fairly rough, with the only holes in the yoke being along the beamline. The dimensions used will be obvious from the `ugeom.F` file. It was found to be necessary to use a 'MANY' volume where the beam enters the yoke.

Refinements of simulation

The dense stacks were excluded from the current simulation. The only detectors used to get cosmic ray information were the drift chamber pairs. This obviously will lengthen the length of time needed to collect the required data.

Furthermore, the position that the useful cosmic rays crossed the yoke was histogrammed, this will help position the scintillator or triggering detector.

Results of simulation

2100000 particles were sent through a window having measuring 2070cm by 290cm in z and x respectively; the extra length in z was to simulate the passage of near-horizontal cosmic rays through the detector, from the direction in which these will be of greatest use to us. To do this I had to lengthen WORL and EVOL as described above.

This corresponds to 269 seconds of cosmics (four and a half minutes).

The resulting graphs are Figures 1 to 5.

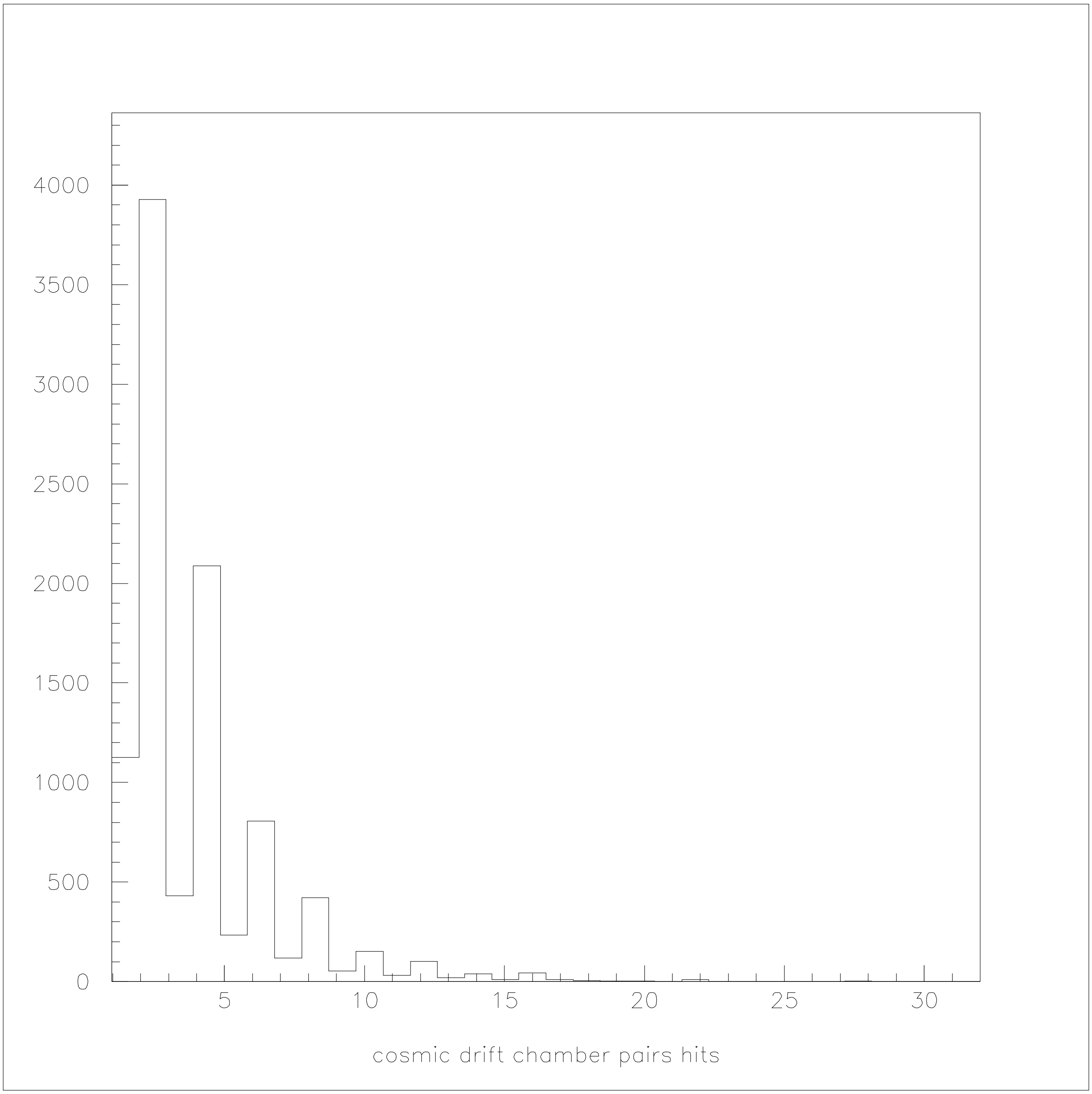

Figure 1: No. of cosmics crossing detector planes

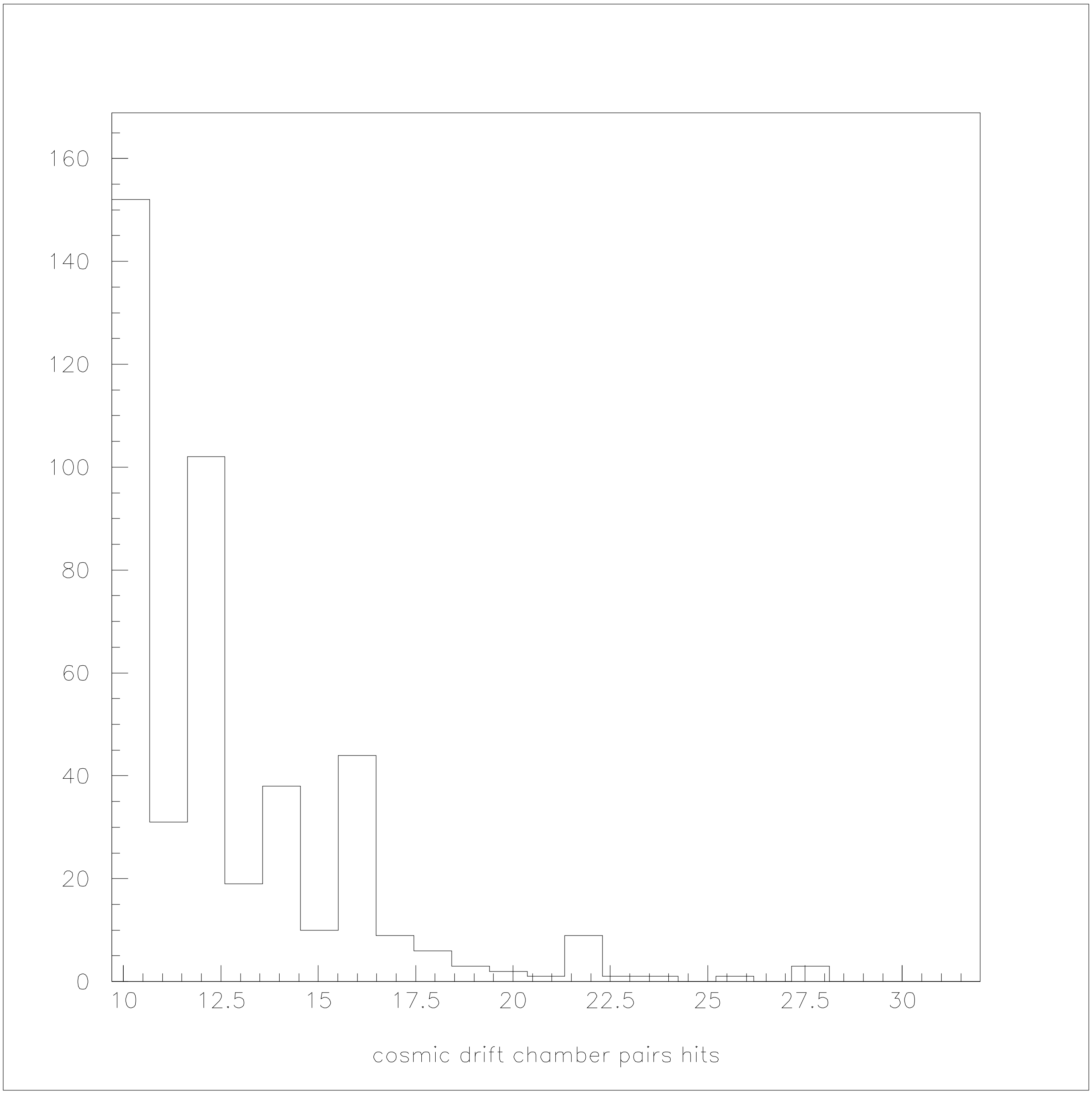

Figure 2: No. of useful cosmics crossing detector planes

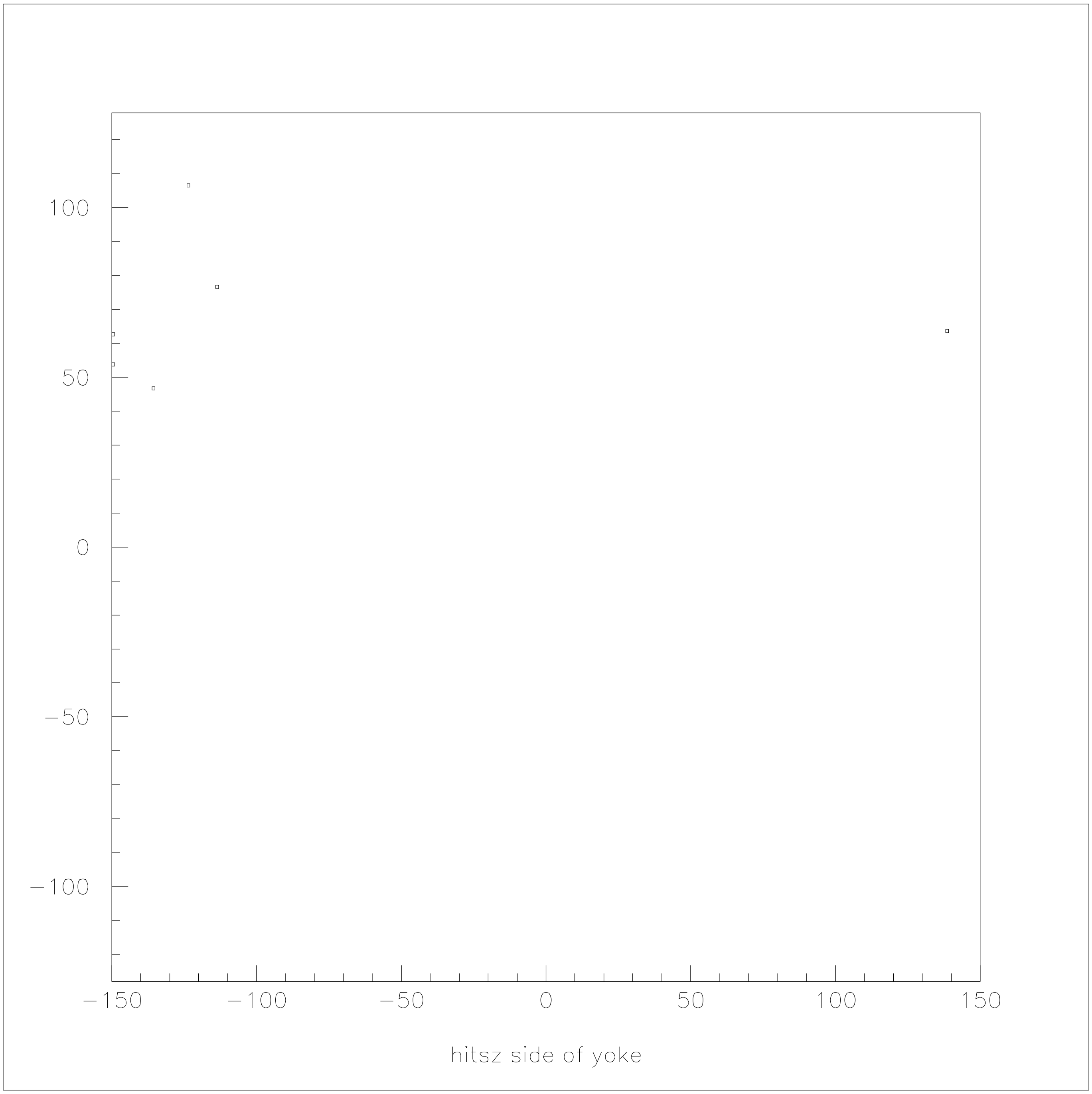

Figure 3: Position of hits to side of yoke

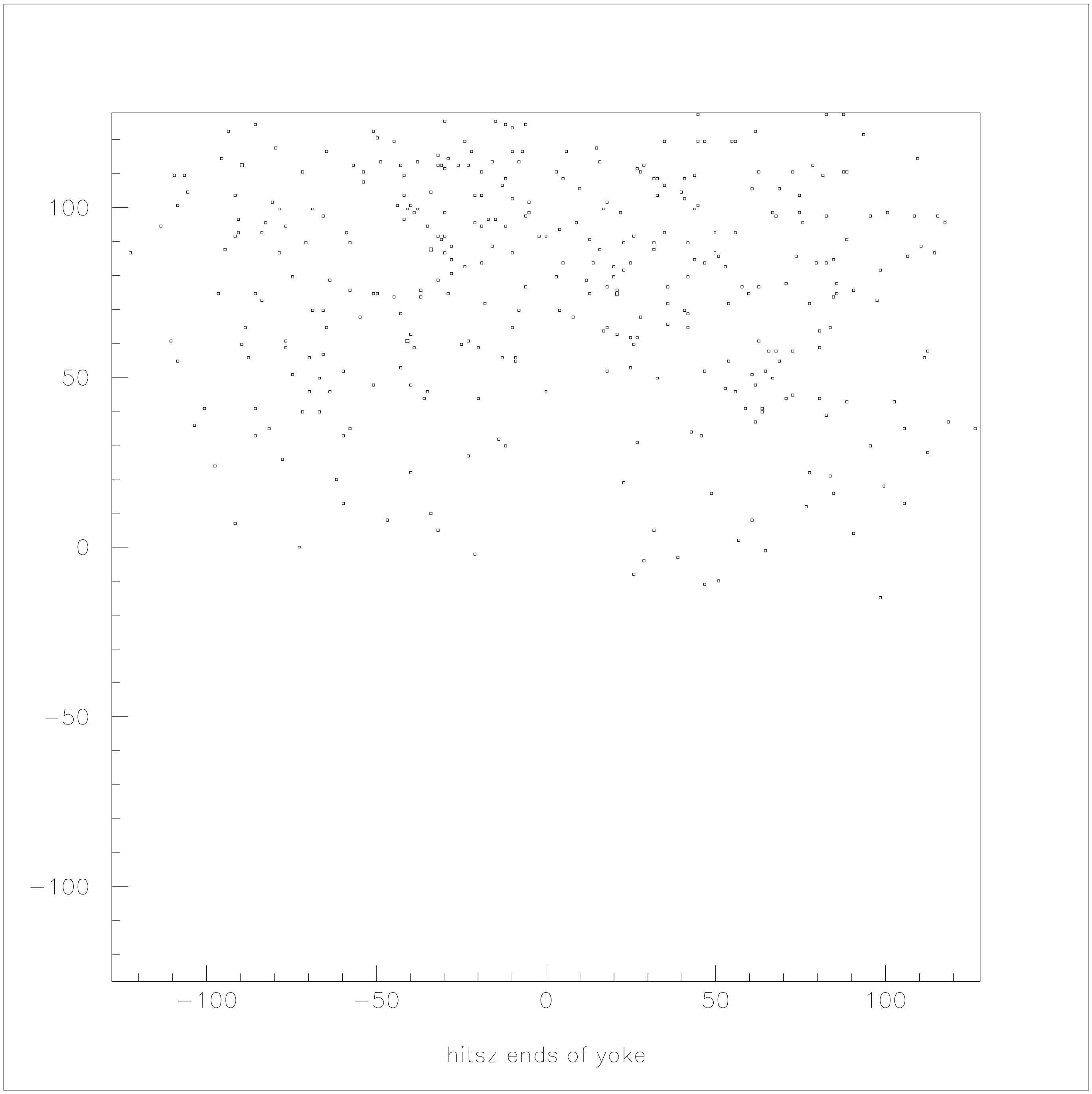

Figure 4: Position of hits to end of yoke

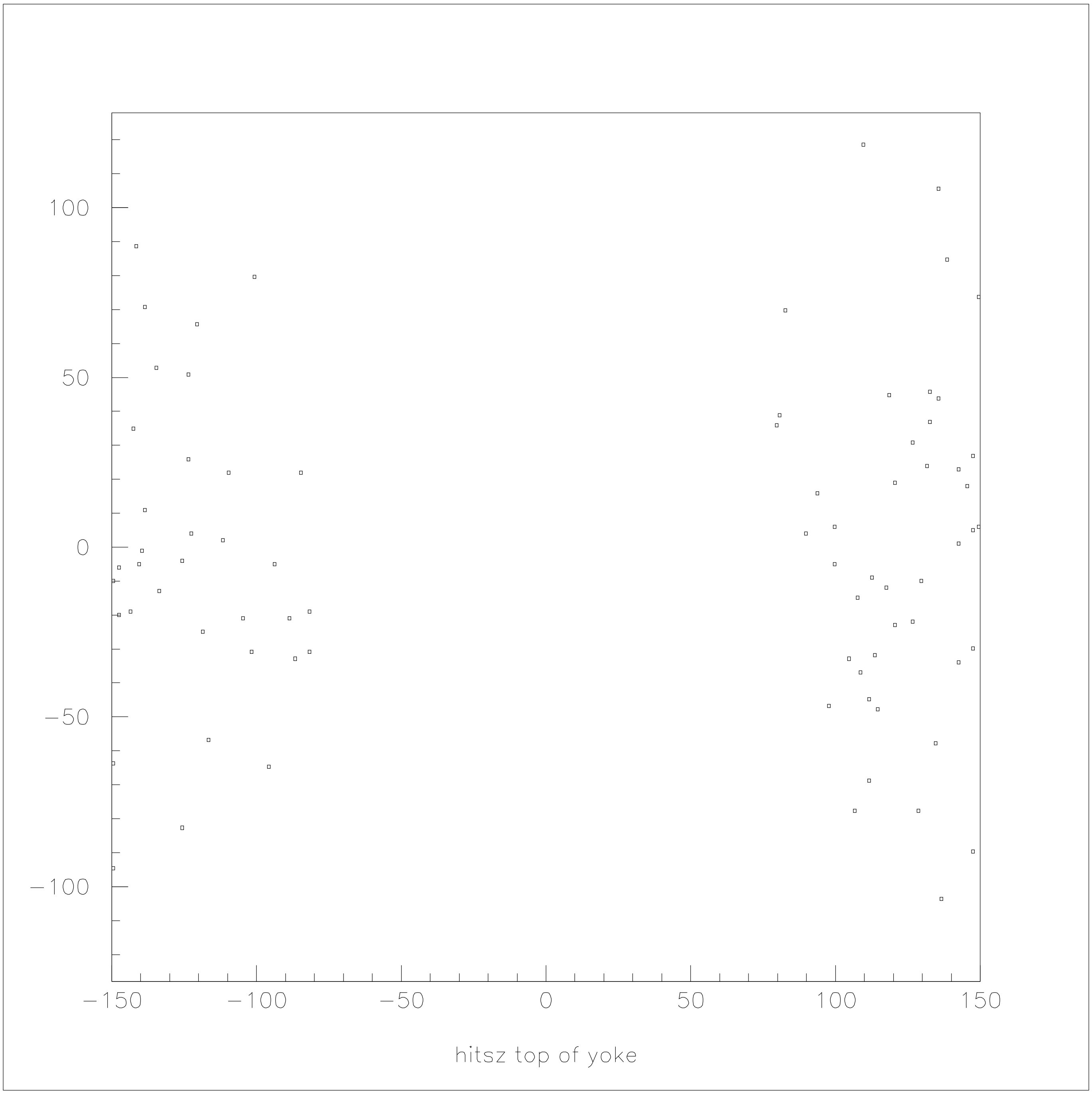

Figure 5: Postion of hits to top of yoke

Figure 2 (No. of useful cosmics) appears to have a slightly odd shape, as it is not a smooth decrease of odd/even planes as you would expect (like Figure 1). This could well be due to the low number of statistics we have in this region. Another possible effect would be the grouping together of pairs in the detector, they are not evenly spaced. This would favour multiples of 4 planes, and could explain the larger peak at 16; however this does not account for the low value of 20.

The integrated flux here is 432, which translates to 8-9 days at 5000 per wire.

The cosmics are entering the detector in roughly the expected regions. The useful places to put the scintillator are on the ends (-128 to 128 in x, -20 to 128 in y), and on the top of the yoke (-100 to 100 in x, -150 to -70 in z, mirrored at opposite end). This is equivalent to 10.8 m^2 of scintillator or equivalent material (to trigger on about 98 percent of the cosmics).