Time over Threshold Issues for the GLAST Tracker

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INTRODUCTION

The GLAST Silicon Tracker (TKR) front-end outputs a fast Time-over-Threshold (TOT) signal. It is OR'd in a silicon plane and used two ways: as a fast OR in the trigger and after digitization in the controller chip as an estimator of the collected charge. As shown by M. Hirayama [1], the TOT width is nearly linear with input charge up to a total width of 100us, at which the signal saturates. Two questions arise: how much dead time is introduced by the long pulses of the TOT in the trigger and the digitization, and how important the TOT measurement is for GLAST science and operations.

The GLAST dead time is in principle determined by the readout time of the calorimeter, which used to be 20us, but is hoped to end up considerably smaller. This means that a TKR readout time of 20us and above is clearly undesirable, if it happens often. The charge corresponding to TOT = 20us is about 100fC, or 20 minimum ionizing particles (MIP's) at normal incidence. This corresponds to ions beyond B, while a TOT > 100us corresponds to ions beyond Ne.

RATE OF EVENTS WITH LARGE PULSE HEIGHT

The trigger rate of GLAST is determined by the charged Cosmic Ray (C.R.) flux. We will assume here a C.R. trigger rate in GLAST of 5kHz, which with 20us dead-time gives an average dead time of 10%. The C.R. flux is mainly protons and Helium ions, with much smaller admixture of heavier ions. Table 1 shows the relative abundance of ions, with oxygen set to one. All ions beyond He add up to about 3.5/767 = 0.46% of the total C.R. rate.

Table 1 : Relative Abundance of ions in C.R. Radiation (O = 1) from PDG

Z	Element	F	Z	Element	F
1	H	730	13–14	Al-Si	0.19
2	He	34	15–16	P-S	0.03
3–5	Li-B	0.40	17–18	Cl-Ar	0.01
6–8	C-O	2.20	19–20	K-Ca	0.02
9–10	F-Ne	0.30	21–25	Sc-Mn	0.05
11–12	Na-Mg	0.22	26–28	Fe-Ni	0.12

The total dead time from the heavy ions is thus 0.0046*100us*5kHz = 0.23%, or an increase of 2.3% of the instrument dead time of 10%.

SCIENCE VALUE OF TOT MEASUREMENT

One problem in the TOT measurement is that it is OR'd in a plane and thus provides accurate information on the deposited charge for a single track in a tower only, but not for several tracks (noise hits are most likely ok because they tend to be very short). We assume that there is little scientific interest in tagging the heavy ion component below Ne with the GLAST TKR. Given that heavy ions are so rare in C.R., the identification of the heavy ions for background rejection can't be a science driver.

One idea mentioned is the ability to tag hadrons traversing the calorimeter and ranging out in the tracker, with a correspondingly large energy deposit in the silicon. I am not aware of a quantitative study of this effect, and it could well be that most of the energy is deposited in the converter.

A potentially interesting application of the TOT is the photon/electron discrimination. As shown by E. de Couto e Silva with the BTEM data, the silicon layer closest to the conversion point shows a pulse height corresponding to 2 MIP's for photons, when the two lepton tracks coincide in one strip, while an electron shows the usual one MIP TOT. Taking into account tracks with large angle of incidence, a reasonable range for the detected charge is about 10 MIP's, i.e. 50fC, at which the charge should saturate. To allow for further improvement in calorimeter readout speed, the TOT for this charge should be 10us. The resolution needed for the digitization could be modest (~8bits).

CONCLUSIONS

Although the rate of heavy ions is low enough not to impact the dead time too much with the very large TOT pulses, I propose to limit the length of the TOT signal to 10us corresponding to 50fC.

REFERENCE

Masaharu Hirayama: "Electrical Test of HP 0.5-mm Test Chip for Front-end Electronics for GLAST Tracker", SCIPP 00/15, May 2000.