Time over Threshold for the GLAST Tracker without fast Recovery

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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], in previous incarnations of the GFEC, the TOT width is nearly linear with input charge up to a total width of 100us, at which the signal saturates. An alternative is to introduce an active current injection circuit, which lead to a fast recovery of the TOT signal. This would limit the TOT to be linear up to 10 MIP's (about 50fC) and saturate at that point at 10us. This situation is described in [2]. If one wants to avoid the complexity of this circuit, one can allow the signal duration of the particle to determine the dead time, but limit the TOT measurement to 25us, after which time the GTRC times out. A MIP would have a TOT of between 1 and 2.5us, with a 1000 MIP signal (> Fe ion) having a dead time of about 1-2.5 msec.

The question arises how much dead time will be introduced by this approach.

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 (for example from the read out of the calorimeter) gives an average dead time of 10%. The C.R. flux consists mainly of 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

DEAD TIME DUE TO C.R. IONS

The signal from an ion with charge z is equal to z^2 MIP's, and it's signal duration equal to z^2 times the signal duration of a MIP. Thus the fractional dead time introduced by the different ions is given by their trigger rate times their pulse duration. This is shown in Table 2, which shows the pulse duration, trigger rate and dead time for the different C.R.

ions. As can be seen, the contributions from heavy ions to the dead time is very small. The total dead time due to the TOT measurement is 0.82%, and this scales with the TOT slope. For example, assuming 2.5 us per MIP increases this number to 2%. The dead time due to ions with signals which time out (i.e. >25us) is 30% of the total, i.e. ~0.2% (0.5% for 2.5us/MIP).
In the scenario where the TOT from a MIP is 1us, the TOT measurement could be limited to 10us, enough to identify the interesting region up to 10MIP. In case of 2.5us/MIP, the TOT has to extend to 25us to include the 10MIP range.
It should be pointed out that while the TOT times out, a large part of the LAT is still active and can receive triggers. Thus the real dead time for the trigger is about a factor 5 down from the numbers in table 2.
The dead time on the single channel is certainly negligible.

Table 2: Dead Time Contribution of different C.R. Heavy Ions

Z	Sinal Strength [# of MIP]	Pulse duration [us]	Partial Trigger Rate for 5kHz Total Trigger [Hz]	Dead Time 1us/MIP [%]	Dead Time 2.5us/MIP [%]
1	1	1	4630	0.5%	1.25%
2	4	4	220	0.09	0.23
3-5	16	16	2.6	0.004	0.01
6-8	49	49	14.3	0.07	0.17
9-10	90	90	2.0	0.02	0.05
11-12	132	132	1.4	0.02	0.05
13-14	182	182	1.2	0.02	0.05
15-16	240	240	0.2	0.005	0.013
17-18	306	306	0.07	0.002	0.005
19-20	380	380	0.13	0.005	0.013
21-25	529	529	0.3	0.02	0.05
26-28	729	729	0.78	0.06	0.15
1-28			5kHz	0.82	2.0

CONCLUSIONS

The rate of heavy ions is low enough not to impact the dead time too much with the very large TOT pulses (<1%). I propose to limit the digitization of the TOT signal to 10MIP, after which time the TOT times out.

REFERENCES

Masaharu Hirayama: "Electrical Test of HP 0.5-mm Test Chip for Front-end Electronics for GLAST Tracker", SCIPP 00/15, May 2000.
Hartmut F.-W. Sadrozinski: "Time over Threshold Issues for the GLAST Tracker", SCIPP 00/xx, July 2000.