GLAST Cigale Note Nov.2000

Investigation of decay time constants in CsI(Tl)

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November 2000

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Abstract :

Signals produced by GeV muons in CsI(Tl) are investigated for ballistic deficit modeling purpose. The signals are found very well reproduced by a two component decay with time constants of 0.70 and 3.5 microseconds and intensities of 53 and 47% respectively.

1− Experimental considerations

A Crismatec crystal log 23 x 30 x 370 mm^3 is used together with the Hammamatsu custom photodetector developed for the Naval Research Lab. An Ortec Preamplifier 142B is connected to the large diode after the feedback capacitor has been modified for increasing the signal decay constant to the base line. The response of the Ortec preamplifier is as fast as 30 ns (0 to peak risetime for gammas or muons in silicon). The signal decay (for both muons in silicon and CsI(Tl)light) is much better approximated by a strait line that intercepts the base line after 100 microseconds than by an exponential function with time constant of 100 microseconds.

Four signals were recorded using a HP oscilloscope with 500 Msample/s sampling rate.

2− Data analysis

The PAW package were used for data analysis.

Fits were performed using exponential decay with 100 microseconds time constant and strait line crossing the base line 100 microseconds after the signal rise which better corresponds to the true signal shape.

In the data analysis it has been checked that the 25 ns time constant decay of CsI(Tl) may be neglected.

In case of strait decay, the following FORTRAN function is fitted to the 1000 data points recorded per signal:

```
function sig(x)
common/pawpar/par(4)
 if(x.gt.par(2))then
  signal=par(4)*par(1)*(1−exp(−(x−par(2))/0.700)) + (1.−par(4))*par(1)*(1−exp(−(x−par(2))/3.5))
  signal= signal /100.*(100.−x+ par(2)) +par(3)
 else
  signal= par(3)
 endif
```

```
sig=signal
end
```

with

par(1) = normalization factor (mV)
par(2)= Time zero for signal rise (musec).
par(3) = offset (mV)
par(4)= ratio of intensity for the T1=0.7 microseconds light emission to the total emission.

The following parameters are fixed in the calculations:
T1 = 0.7 microseconds
T2 = 3.5 microseconds
Decay intercept with the base line = 100 microseconds.
All fits are performed with errors equal to .0005 mV for all data points.

3− Results :

Excellent fits are obtained for the following values for the ratio of intensities T1/(T1+T2).

Results of fit using strait decay to the base line :

	ratio	Red. Chi2 for 10000 pts
scan0	53.%	0.35
scan1	53.%	0.30
scan2	52.%	0.32
scan3	53.%	0.20

The fits to the 4 data sets using strait decay give a mean ratio of 53 % with very good looking adjustments (see Figure 1).
Very similar results are obtained for fits using exponential decay because of the restricted time period which is used for the fit (< 20 microseconds).

Results of fit using exponential decay to the base line :

	ratio	Red. Chi2 for 10000 pts
scan0	55.%	0.36
scan1	54.%	0.32
scan2	53.%	0.33
scan3	54.%	0.54

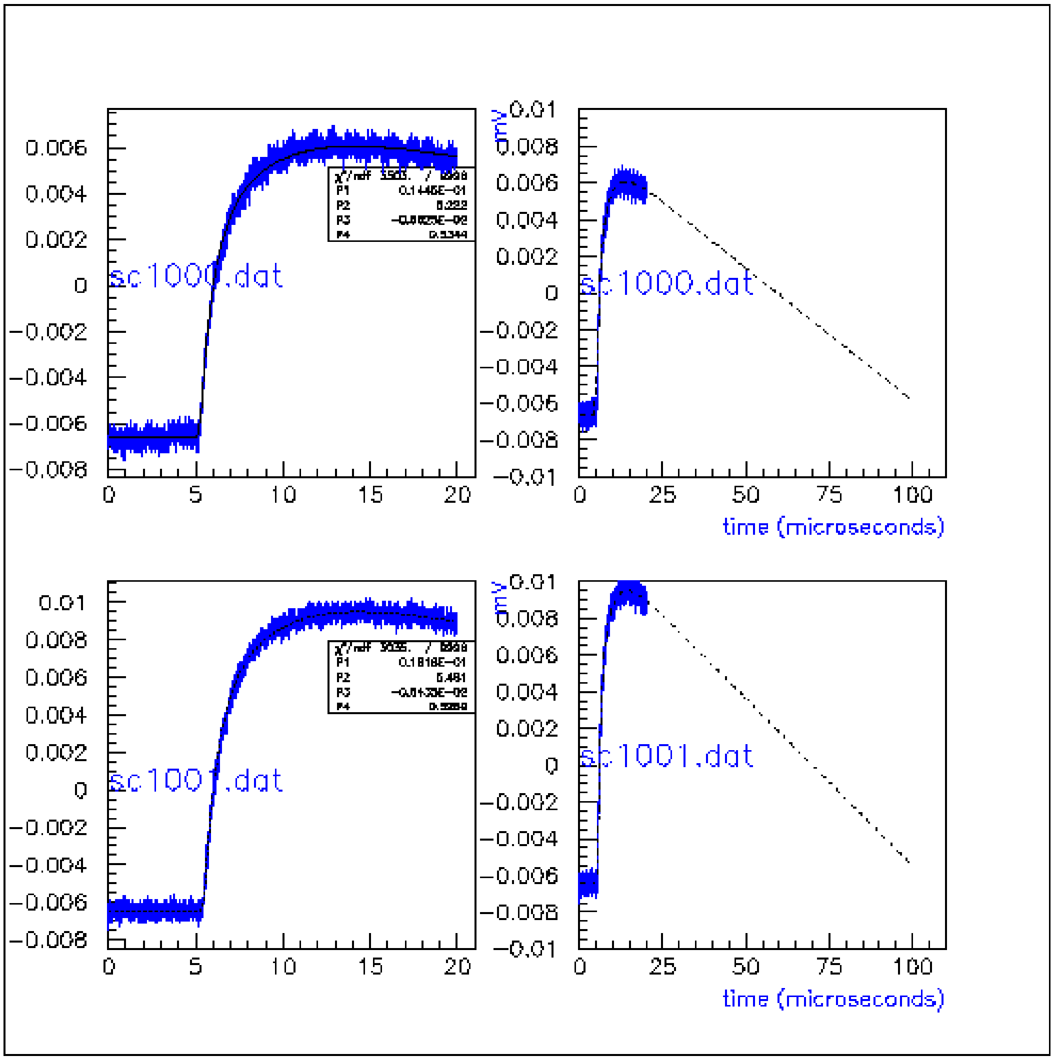
All these results are found insensitive to reasonable changes in the fixed parameter values.
Finally, figure 2 shows the signal rise that would be obtained for a infinite decay constant.

4− Conclusions

In case of atmospheric muons, CsI(Tl) light output is very well reproduced by using 2 time decay constants of 0.7 and 3.5 microseconds with nearly equal intensities of 53% and 47% respectively.

Figures

Figure 1a) and 1b): Four signals (blue line) and fits to the data (black line), using a strait decay to the base line.



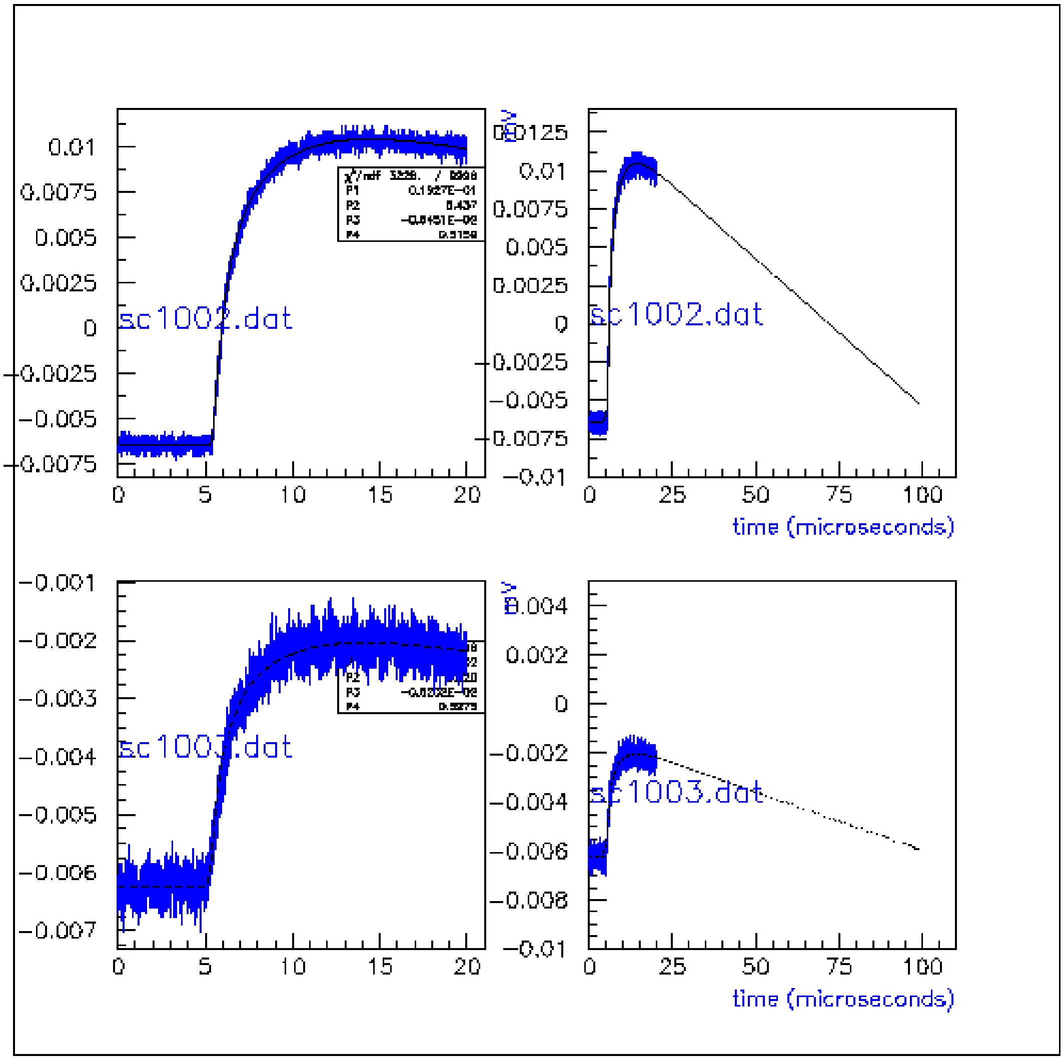

sc1002.dat
sc1002.dat
sc1003.dat
sc1003.dat
mV
mV
time (microseconds)
time (microseconds)
P1
P2
P3
P4
P2
P3
P4
0.01
0.0075
0.005
0.0025
0
-0.0025
-0.005
-0.0075
0.0125
-0.01
-0.001
-0.002
-0.003
-0.004
-0.005
-0.006
-0.007
0.004
0.002
-0.008
0
5
10
15
20
25
50
75
100

Figure 2: Signal rise calculated for an infinite decay (black).