Gamma filter efficiency.

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The analysis of the LAT data runs collected with gamma filter selection shows that there is a strange peak in the time from previous event distribution (see Fig.1). This effect was first noticed by Eric Grove.

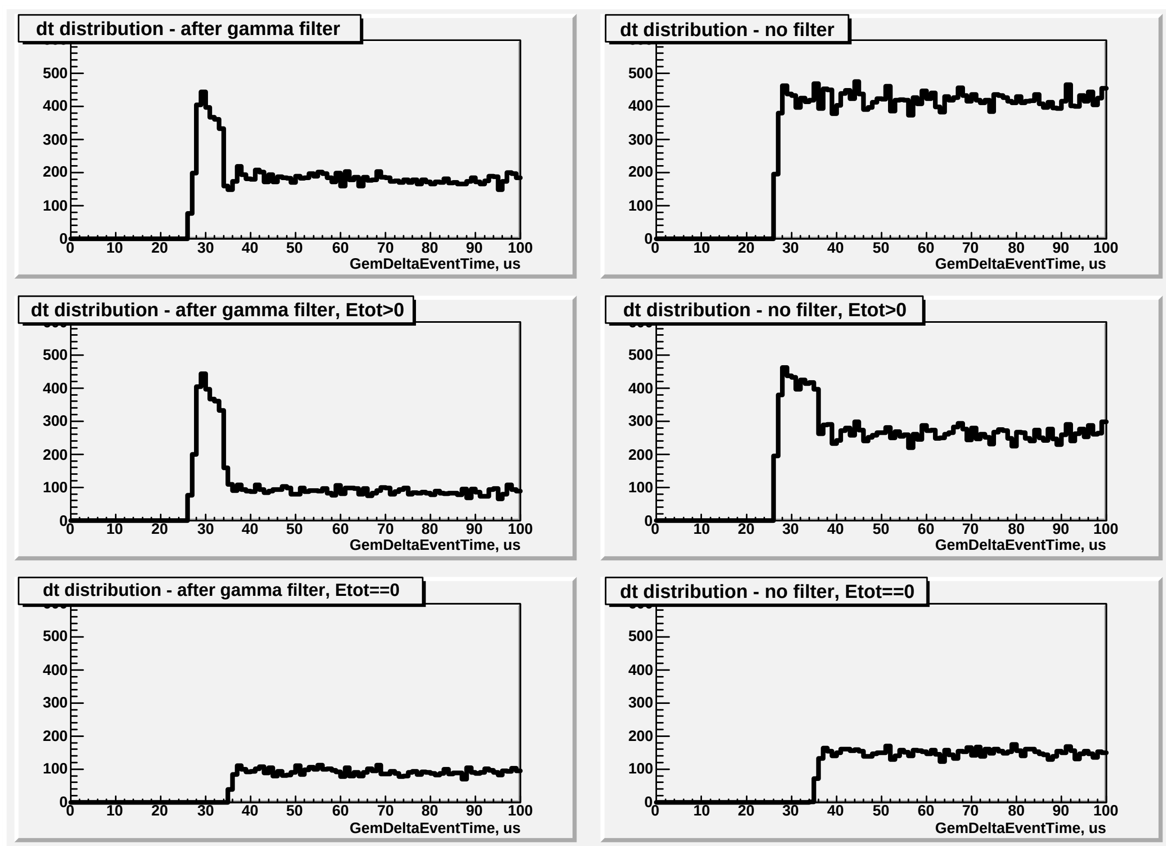

Fig. 1 The distributions of the time from previous event (GemDeltaEventTime) for the events selected by gamma filter (left) and without selection (right).

The top right plot of Fig. 1 showing the GemDeltaEventTime distribution for standard LAT muon data collection (LAT-22x run configuration) doesn't have any anomaly right above the dead time (26.5 μs), while the top left plot with the same histogram for the events selected by gamma filter (LAT-22xGammafilterNoPer run configuration) shows the increased number of events in the region 26.5 μs < GemDeltaEventTime < 35 μs .

If one plots the same histograms for the events with (middle plots) and without (bottom plots) energy deposition E_{tot} in the calorimeter, it becomes clear, that the peak for small GemDeltaEventTime appears even without gamma filter selection for the events with nonzero CAL energy (right moddle plot). But for the run without gamma filter this enhancement is fully compensated by the absense of events in this region (26.5 μs < GemDeltaEventTime < 35 μs) with E_{tot} =0 (see bottom right plot), so that at the histogram for events with any CAL energy (top right plot) this peak disappears.

At the same time the corresponding histograms with E_{tot} =0 (left bottom plot) and E_{tot} >0 (left middle plot) for gamma filter selected runs do not provide such a compensation when being summed on left top plot – this could be explained by the different efficiency of gamma filter selection for these two event classes (with E_{tot} =0 and E_{tot} >0).

The existence of the peak on GemDeltaEventTime histogram is explained by the shaped readout noise in the CAL (see Fig. 2).

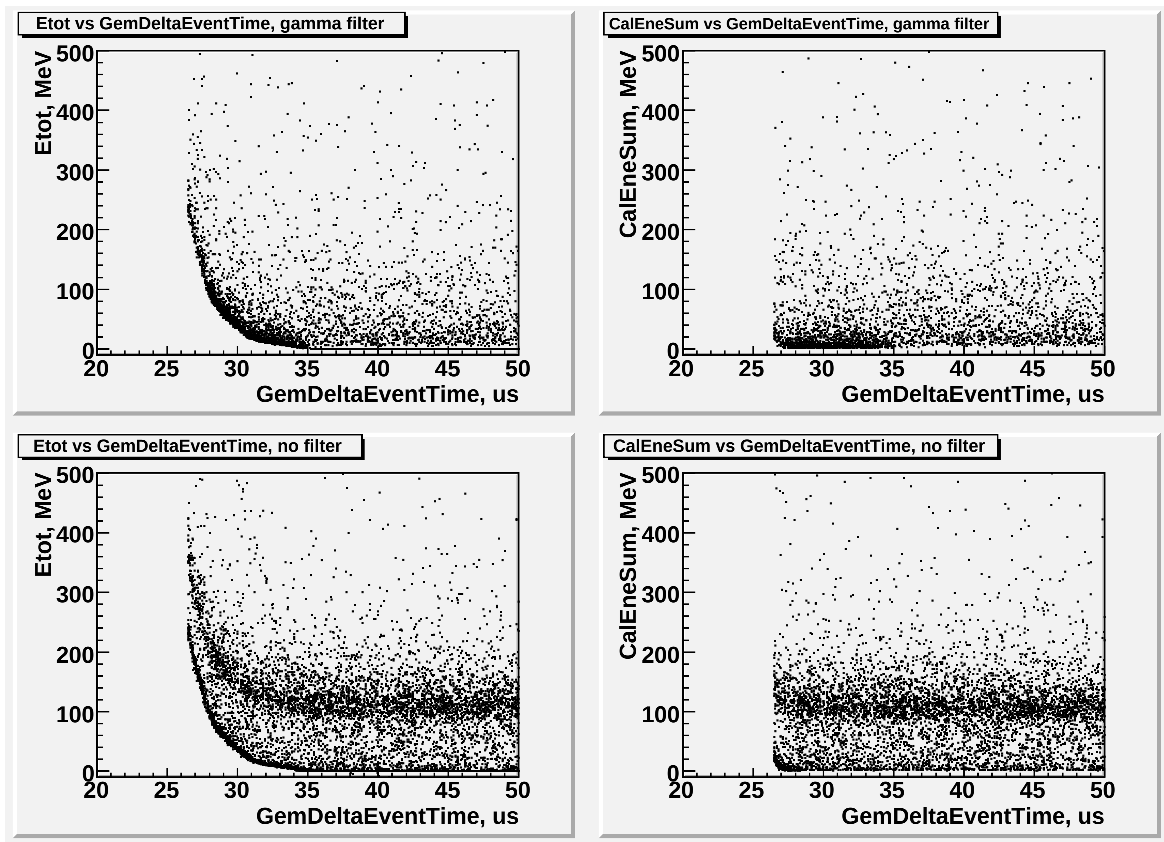

Fig. 2 Energy deposition in the calorimeter as a function of the time from previous event.

The top left and bottom left plots of Fig. 2 show the scatter plots of E_{tot} – the sum of energy depositions in all crystals of the CAL - versus GemDeltaEventTime with and without gamma filter selection. To find E_{tot} the energy in each calorimeter crystal was calculated as an arithmetic mean of the signals measured at two opposite ends of the crystal: $E_{xtal}=(E_{pos}+E_{neg})/2$. This method, used to calculate CAL energy in gamma filter code, is different from the offline reconstruction, where the energy in each crystal is calculated as a geometric mean: $E_{xtal}=\mathrm{sqrt}(E_{pos}\times E_{neg})$. The sum of energies in all CAL crystals calculated with this method (CalEneSum parameter in svacTuple) is shown on right top plot (with gamma filter selection) and right bottom plot (with no selection) as a function of GemDeltaEventTime.

One can see that the parameter E_{tot} is significantly affected by shaped readout noise which has exponential shape and has maximum value ~250 MeV right after the dead time. At the same time, the effect of readout noise on CalEneSum parameter is much smaller, because the readout noise is very channel dependent and big noise at one end of crystal always correspons to small noise at the opposite end, so the geometric mean used to calculate the crystal energy for CalEneSum significantly suppresses the readout noise effect.

Due to the presence of shaped readout noise, the events with GemDeltaEventTime < 35 μs always have non-zero calorimeter energy. So, in the region
26.5 μs < GemDeltaEventTime < 35 μs the events from the class E_{tot} =0 are moved to the class with E_{tot} >0, creating the peak on for the events with non-zero CAL energy. But to understand the presence of this peak on GemDeltaEventTime histogram for all events after gamma filter

selection we need to explain the difference of gamma filter efficiency for these two classes of events.

To study the gamma filter efficiency let's select the "good" candidates to photon events in two runs of the same duration (0.5 hours): with gamma filter selection and with no filter. The following selection criteria were applied to both runs:

- No signal in ACD: AcdTileCount = 0
- At least one track found by tracker reconstruction: TkrNumTracks>0
- Tracker trigger bit ON: (GemConditionsWord & 2) = 2
- Big time from previous event (to avoid any readout noise problems): GemDeltaEventTime > 500 μs

The Fig. 3 shows the total CAL energy deposition histograms for gamma filter selected run (blue curve) and for the run with no filter (red curve).

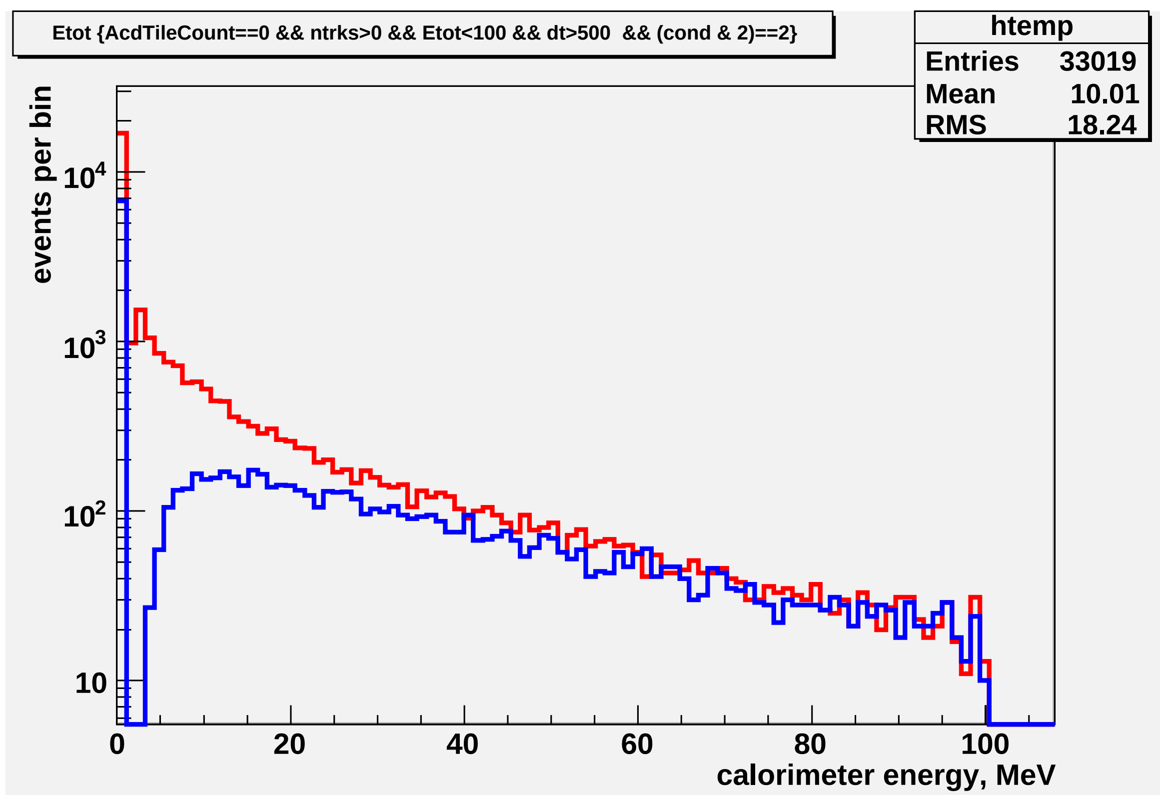

Fig. 3 CAL energy deposition histogram with no filter (red curve) and with gamma filter (blue curve).

The Fig. 3 shows the total CAL energy deposition histograms for gamma filter selected run (blue curve) and for the run with no filter (red curve). One can see that for energies above 80 MeV the blue and the red histograms have approximately the same number of events per bin, meaning that the efficiency of gamma filter for photons is close to 100%. For smaller energies blue curve is always below the red curve and at 15 MeV the discrepancy is of factor of two, meaning that the efficiency of gamma filter drops to 50%. Below 5 MeV efficiency drops dramatically by more than factor of 10, while for the events with zero energy in the CAL the gamma filter efficiency is ~40 %.

The possible explaination of such variations of the gamma filter efficiency could be the efficiency of track finding part of gamma filter code. The search for tracks in gamma filter is based on so called "tolerance" parameter which is constant equal to 32 strip widths (~6 mm) and doesn’t depend on energy. So, for big energies when multiple scattering is relatively small this value of tolerance parameter allows the algorithm to find tracks with good efficiency. When energy decreases, multiple scattering increases and the probability to find a track drops. Additional factor is the requirement of gamma filter to have at least 2 tracks when CAL energy is below 5 MeV. This explains the dramatic drop of efficiency below this energy.

Conclusions from this study:

- CAL shaped readout noise significantly affects the functionning of gamma filter in the region 26.5 μs < GemDeltaEventTime < 35 μs
- The track finding algorithm of gamma filter code could have significant inefficiency for energies below 80 MeV and should be taken into account when calculating the effective area of the instrument in this energy region.