Improved results of the PM Cal Nov 2015 BFT test

Padme Coll. Meeting
1/3/2016

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PM Calo runs : 304 (150 MeV), 305 (297 MeV), 302 (431 MeV)
3*3 cm crystals (same as old BTF test)

Always used positive signal - pedestal subtracted
Normalized at 1 V
9 read detectors + trigger signal

Signal noise vs threshold

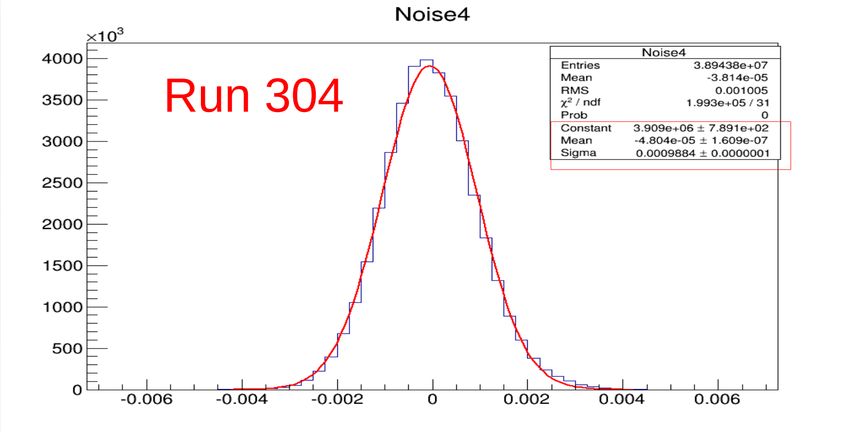
Detector 4 at lower HV – to “unify” multiplication used factor 1.2 on signal

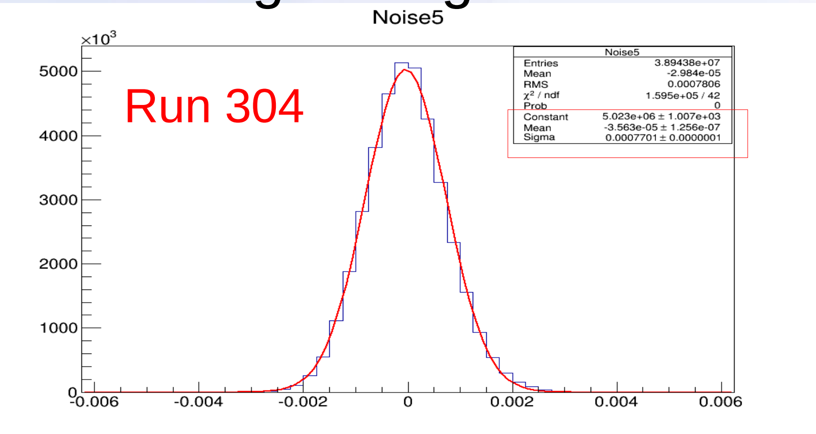
From start of signal (first 120 channels) : pedestal and noise

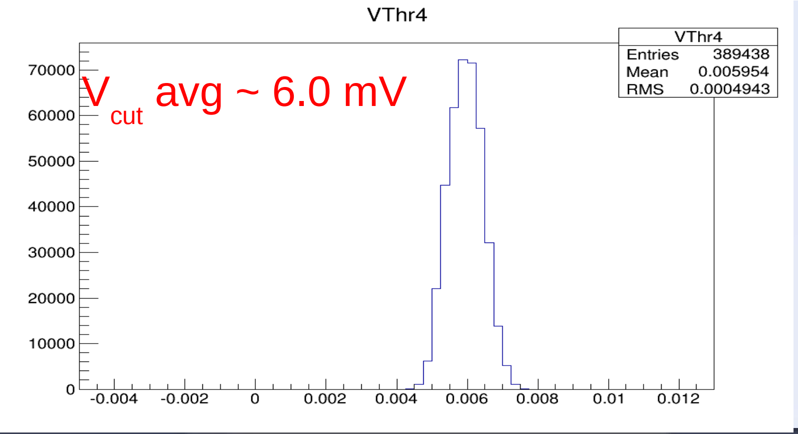
Good centering det 4 : σ_{noise} = 0.99 mV (factor 1.2)

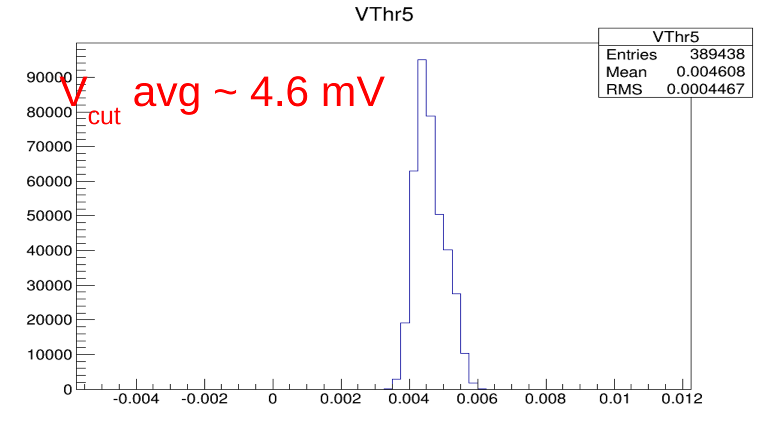
Good centering det 5 and others : σ_{noise} = 0.77 mV (factor 1.0)

In the following used 6 σ cut for all detectors for “good signal” threshold







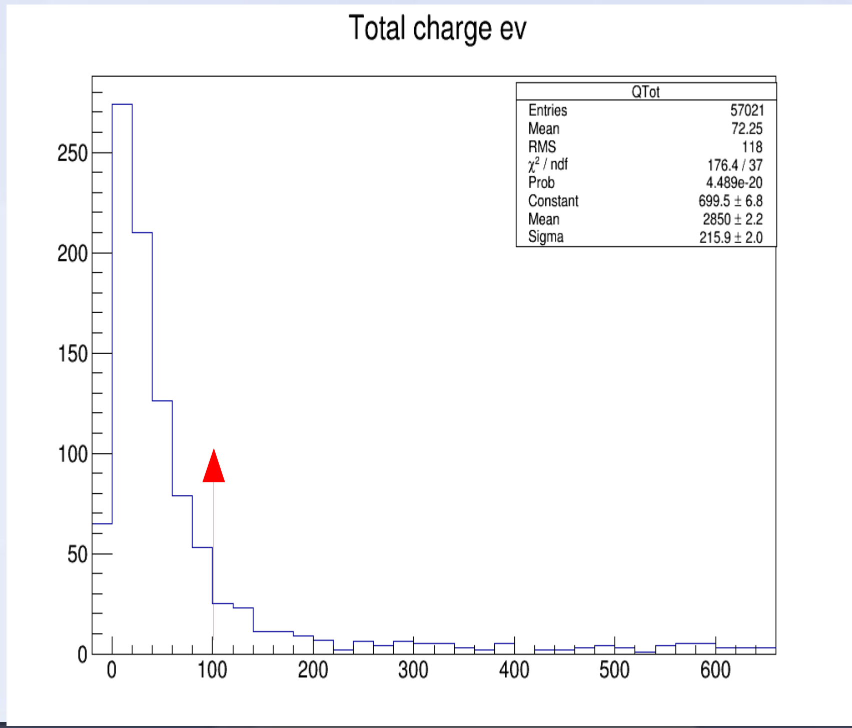


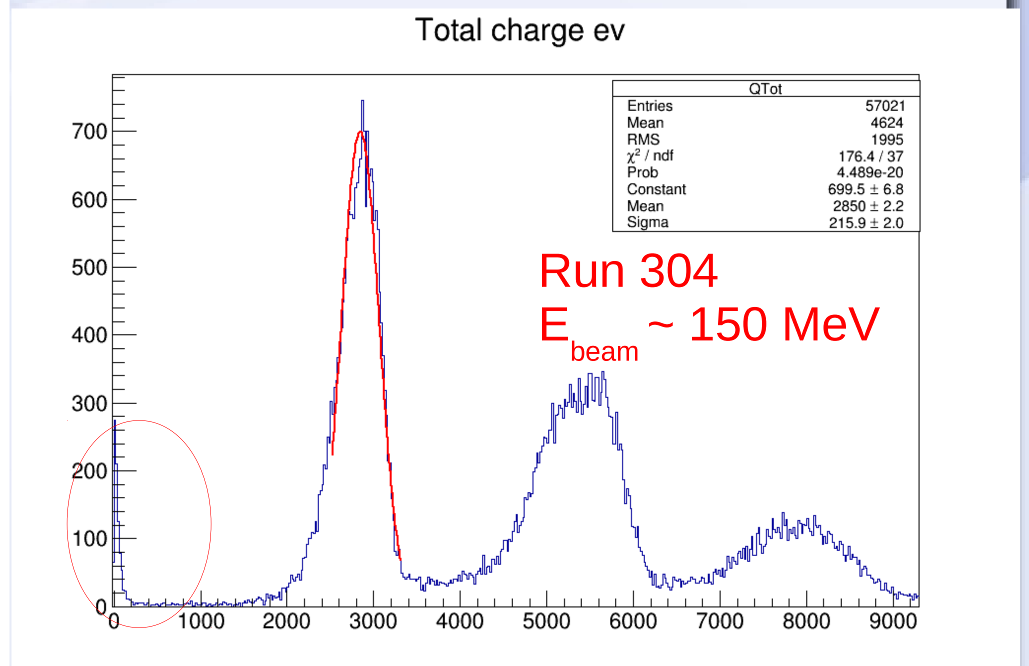
Qtot threshold

In Run 304 (E_{beam} ~ 150 MeV) peak at Q_{tot}~2850 pC for 150 MeV particle (assuming > 1 detector/event with max on det 4)

In exploded figure of left part we see the remaining noise peak with a cut a 6 σ_{noise} per each detector

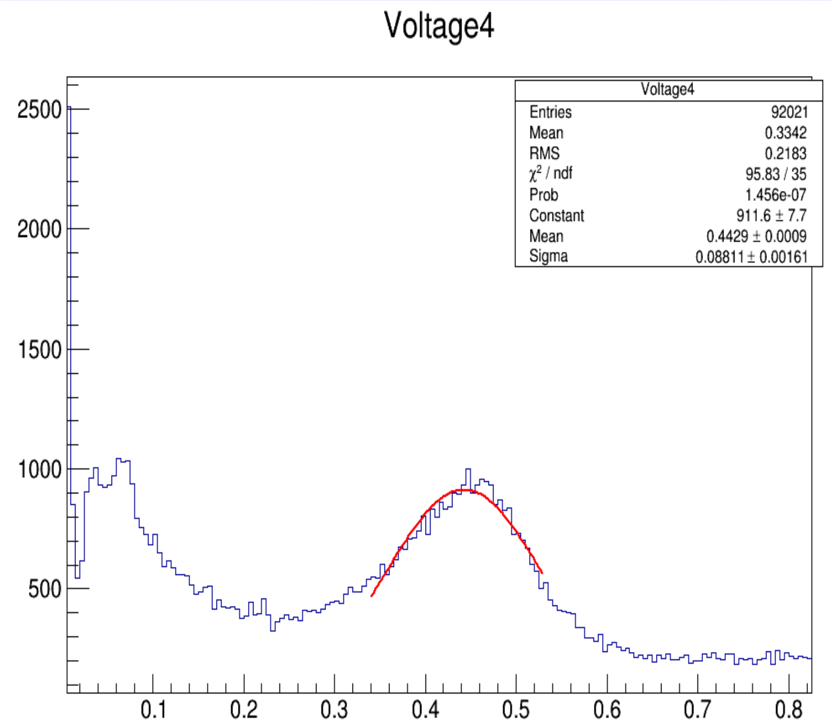
We can appreciate a peak on the background for $Q_{tot} \geq$ 100 pC ≅ a minimal energy ~ 5.3 MeV

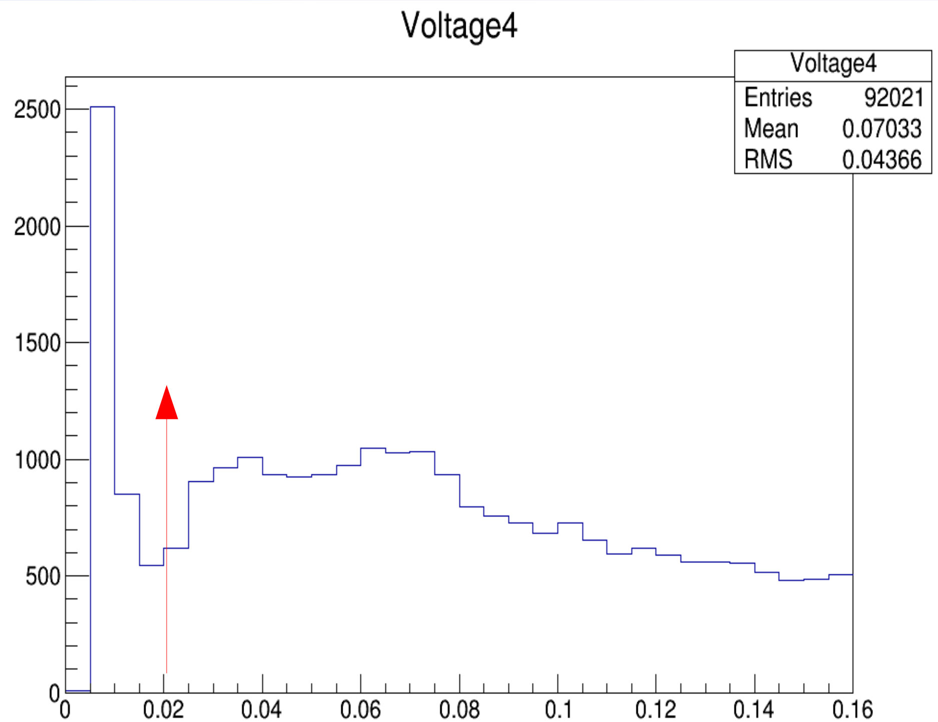




Single det threshold- Vmax

For very low signals most probably we'll have signal on only 1 detector
We examine then what happens on the “central” detector as single det
Only detector 4 : peak for 150 MeV particles at ~ 442 mV
With cut at 6 σ_{noise} we can appreciate a signal over ~ 20 mV ≡ 6.5 MeV

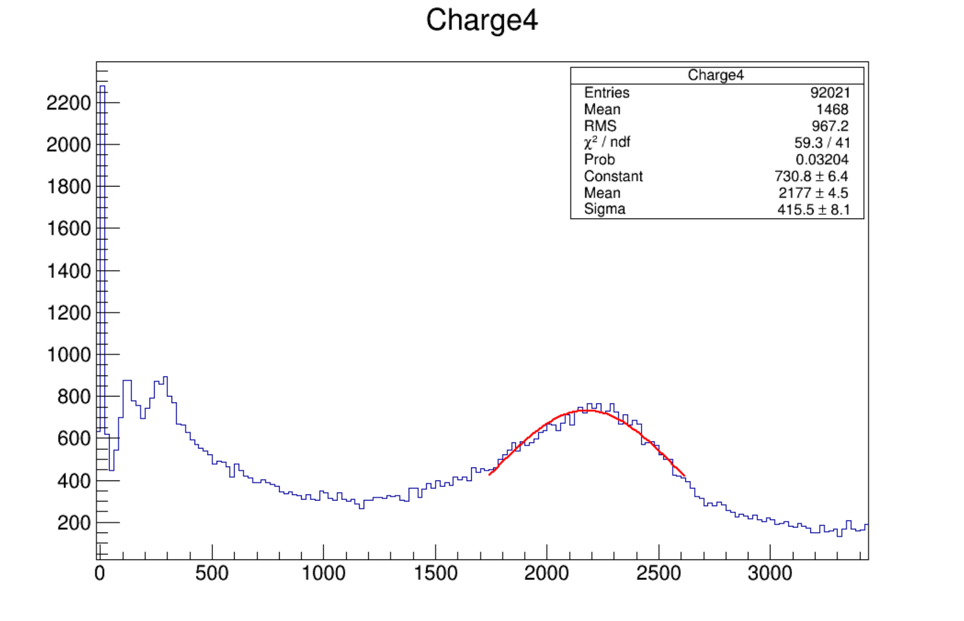


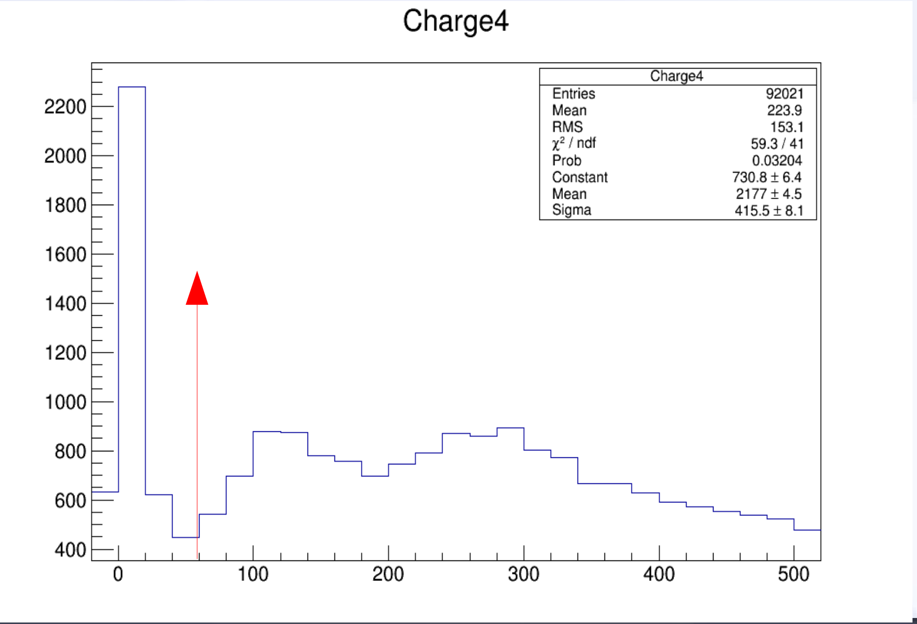


Single det threshold- Qtot

For very low signals most probably we'll have signal on only 1 detector
We examine then what happens on the “central” detector as single det
Only detector 4 : peak for 150 MeV particles at ~ 2170 pC
With cut at 6 σ_{noise} we can appreciate a signal ≥ 60 pC ≡ 4.2 MeV

We can see in charge a signal at a minimum of ~ 4 MeV





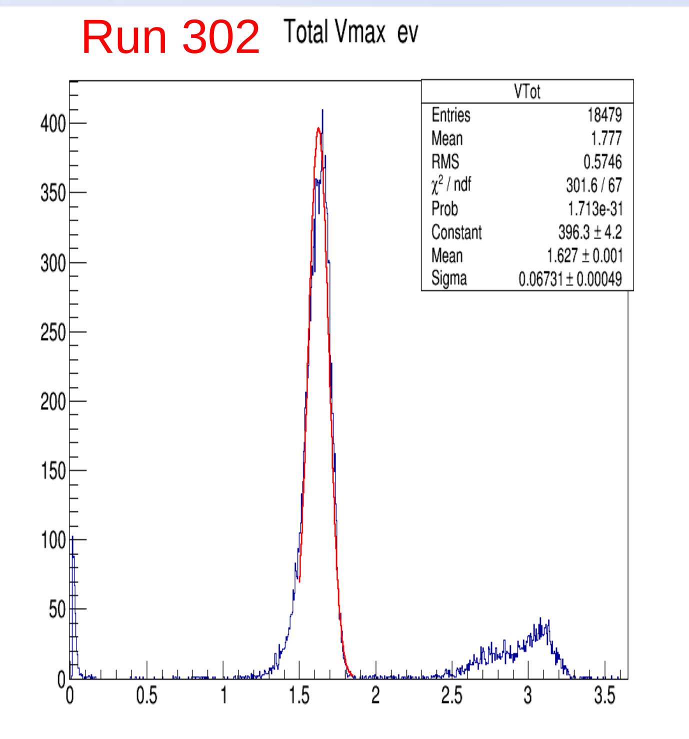
Vmax fit

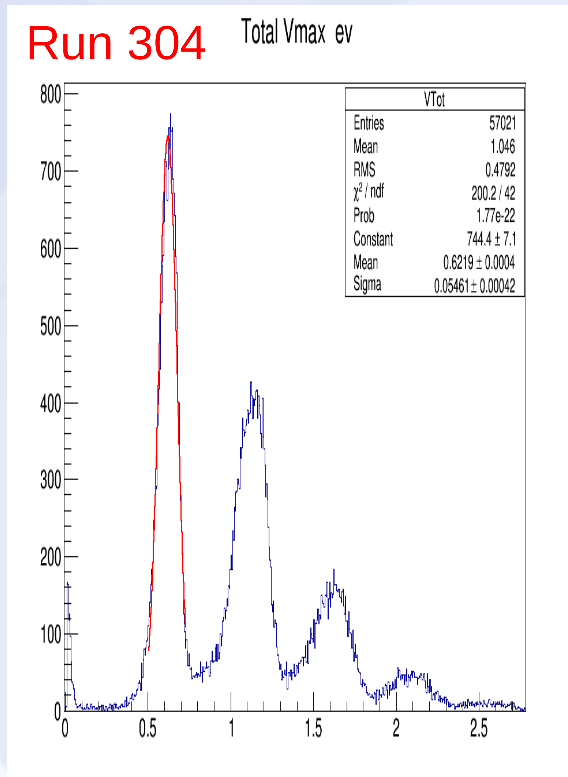
Sum of Vmax for all det with Vmax > 6 σ_{noise}

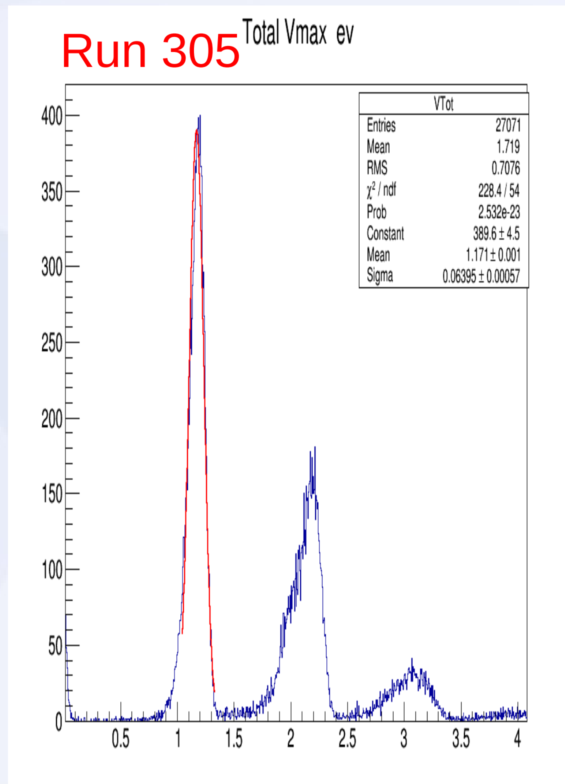
Corrected Vmax by – 6% when signal saturated

Good gaussian fit on 1 particle signal

Signal for multiple particles ~ proportionals

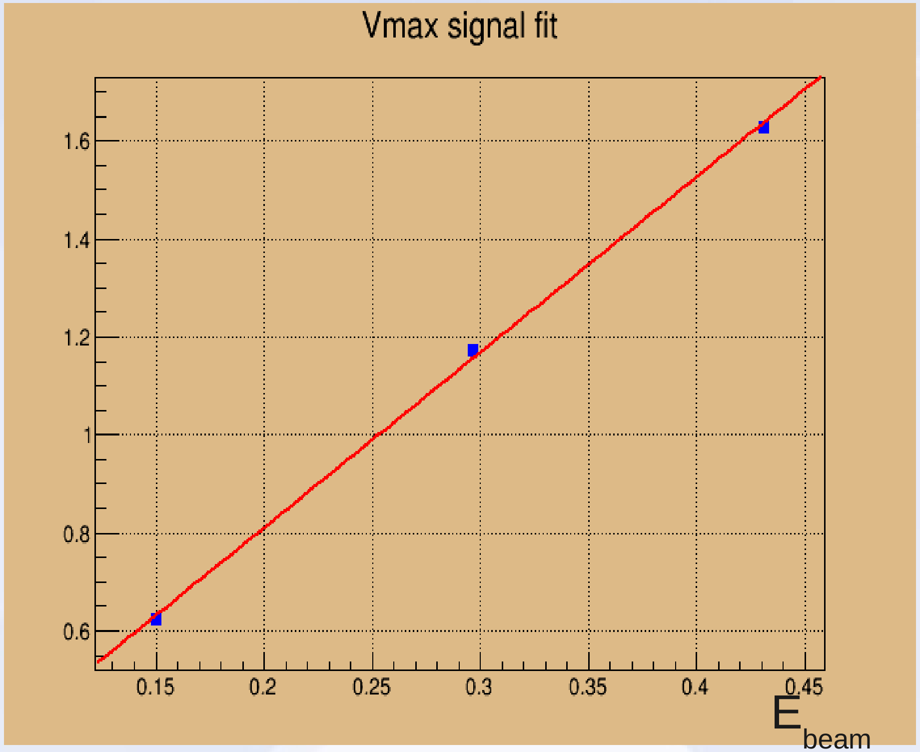


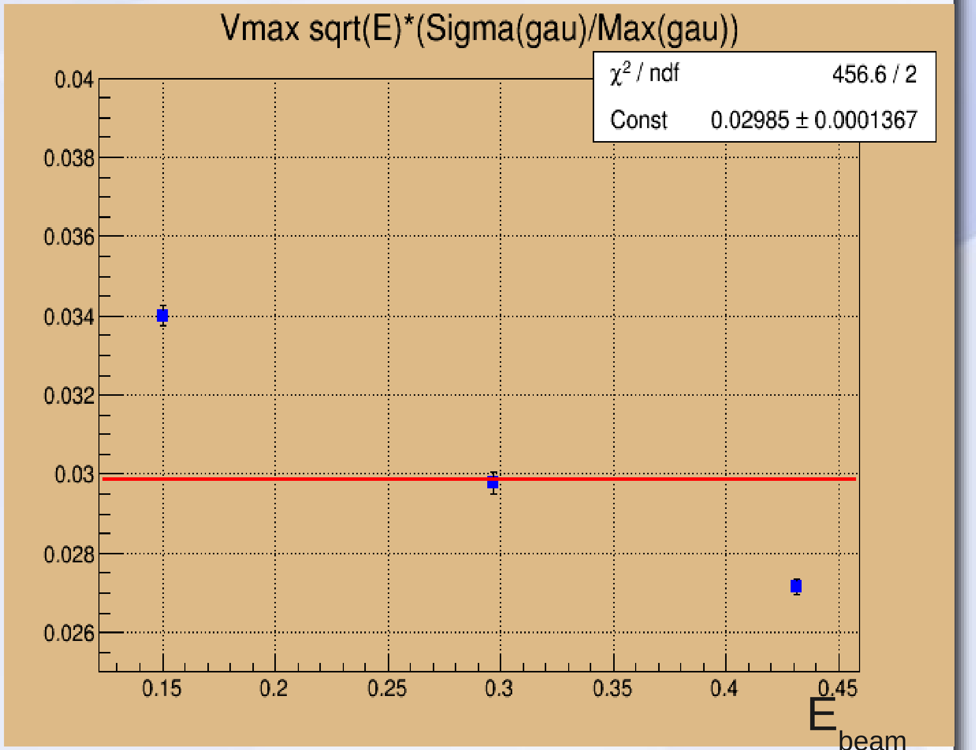




Vmax linearity - resolution

Excellent signal linearity
Resolution at 1 GeV NOT constant : from 3.4% to 2.7% . avg ~ 3.0%





Qtot fit

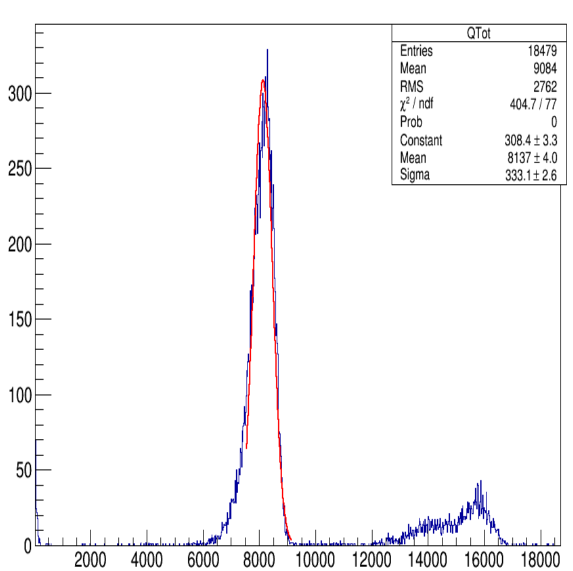
Sum of Qtot(Tstart-900) in T_{sig}-T_{trig} for all det with Vmax > 6 σ_{noise}

Corrected Qtot by – 2% when signal saturated

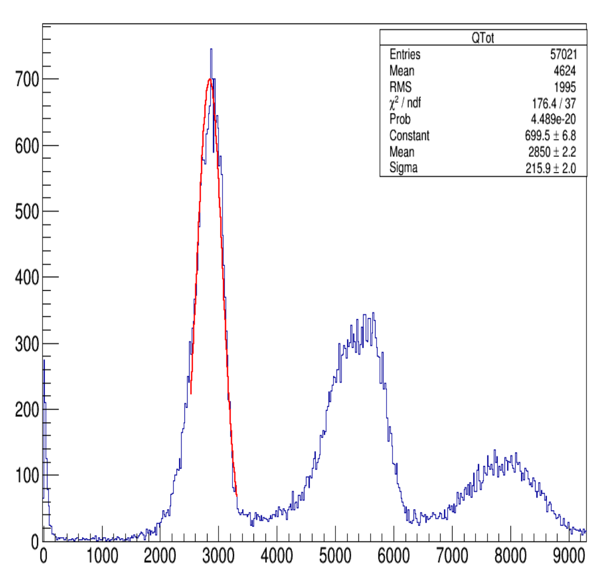
Good gaussian fit on 1 particle signal

Signal for multiple particles ~ proportionals

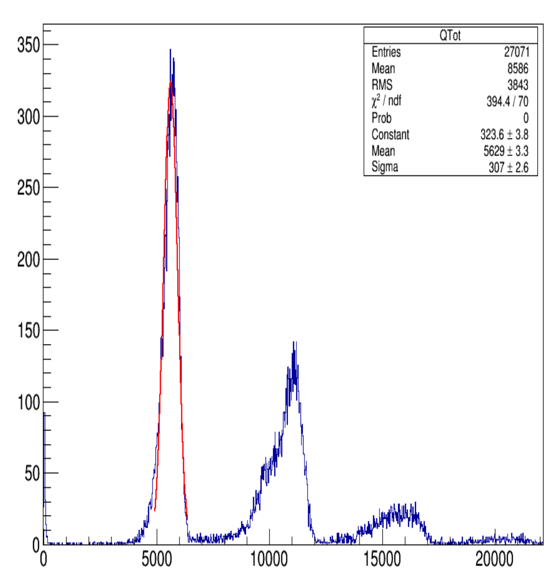
Run 302 Total charge ev



Run 304 Total charge ev

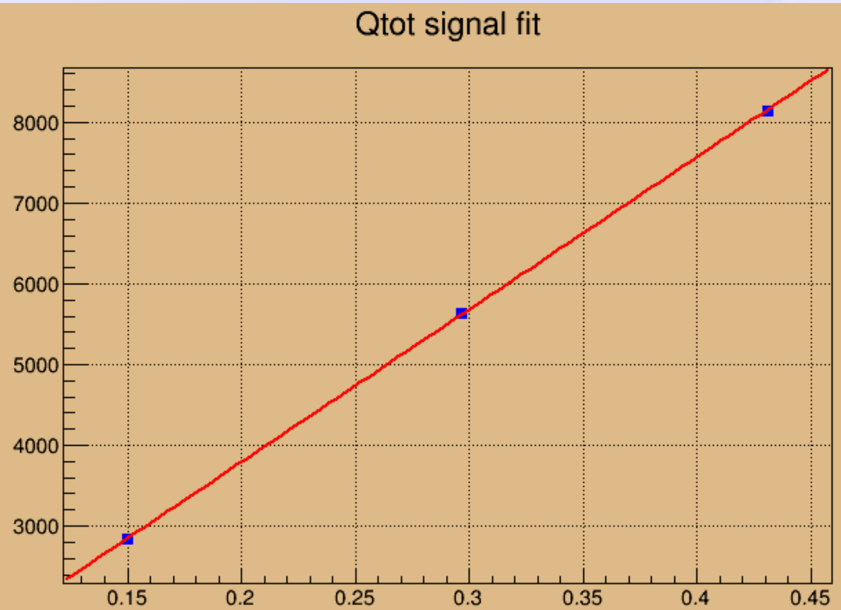


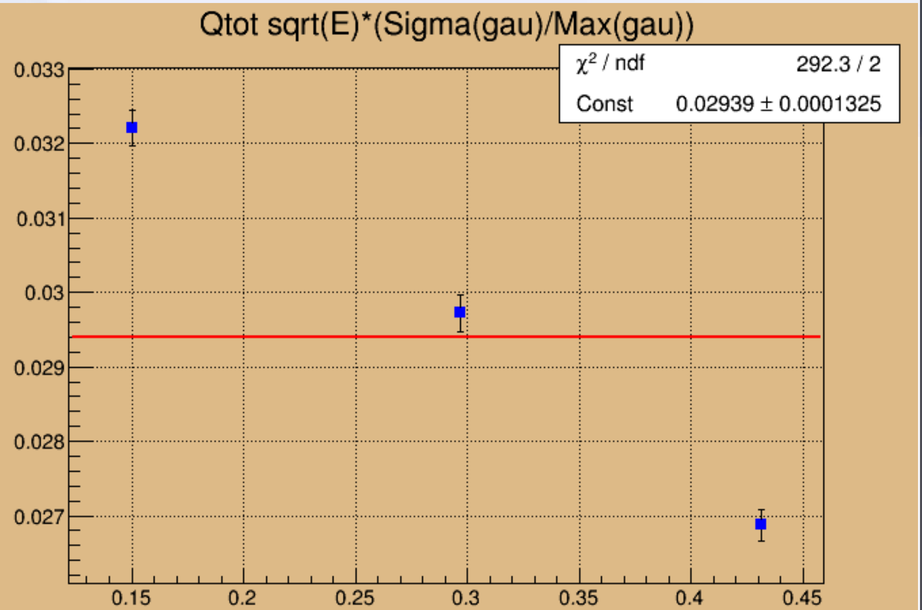
Run 305 Total charge ev



Qtot linearity - resolution

Excellent signal linearity
Resolution at 1 GeV NOT constant : from 3.24% to 2.7% . avg ~ 2.9%





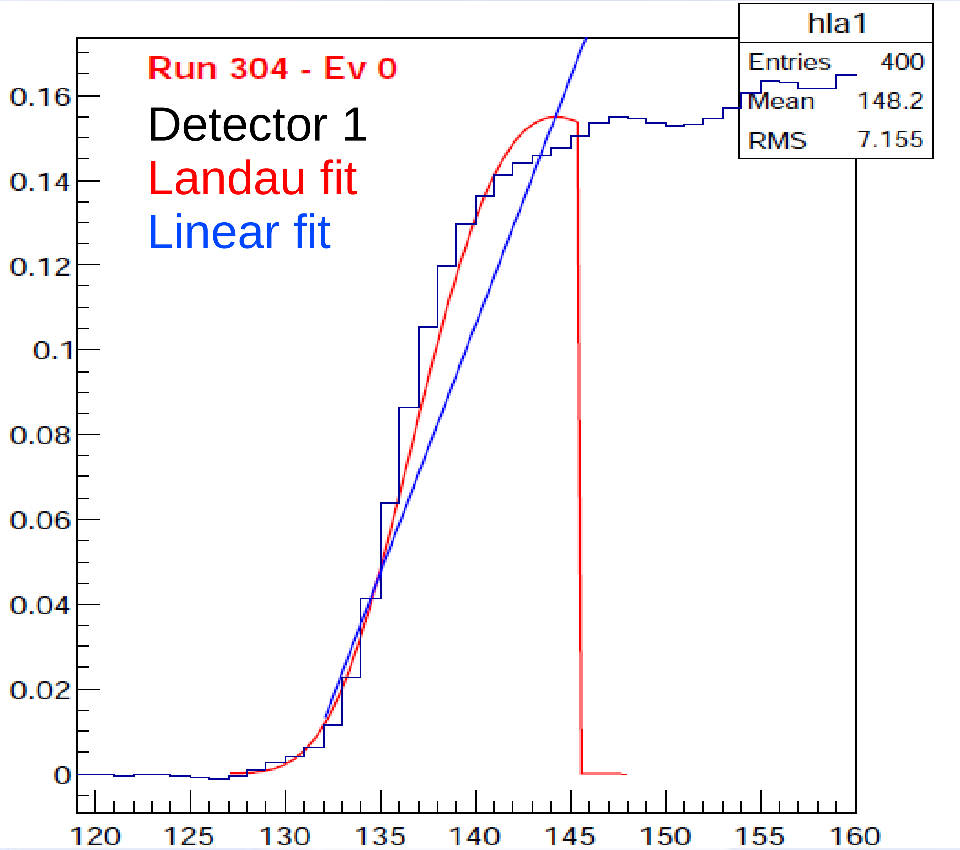
Time resolution - Landau

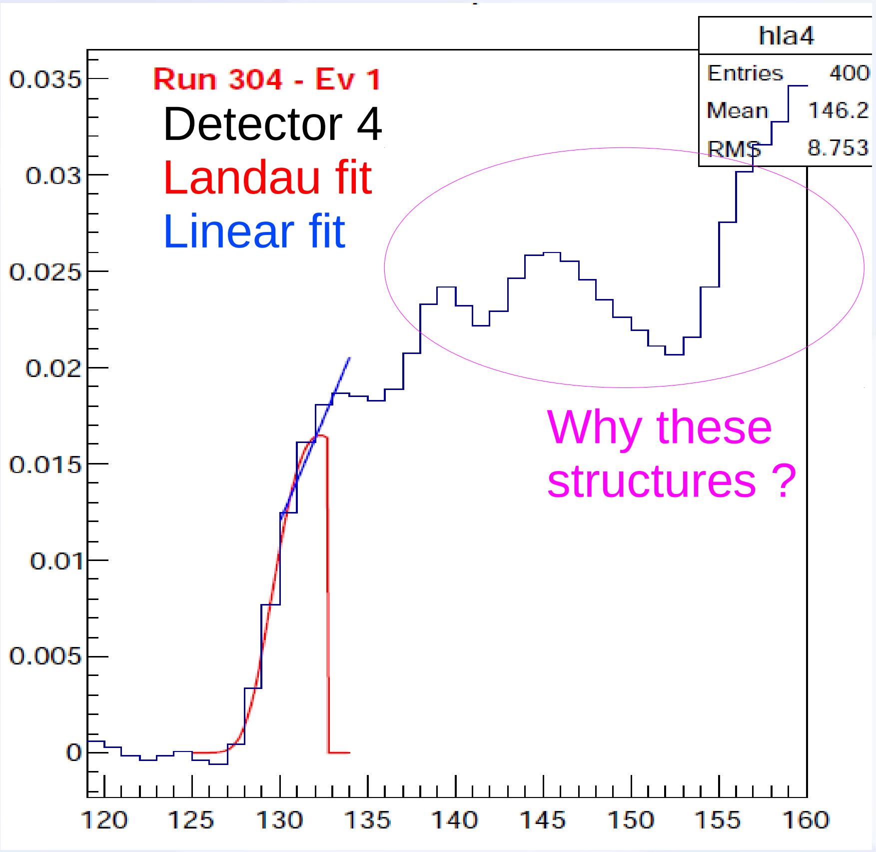
Idea : fitting the signal start_time-Ttrig from threshold (> 4 mV) to the first maximum (<150 nsec) with a Landau and take mpv -3σ as starting point of signal.

Signal smoothed with Smooth(6) to avoid noise fluctuations.

Seems to do the jobs quite well also for smaller signals.

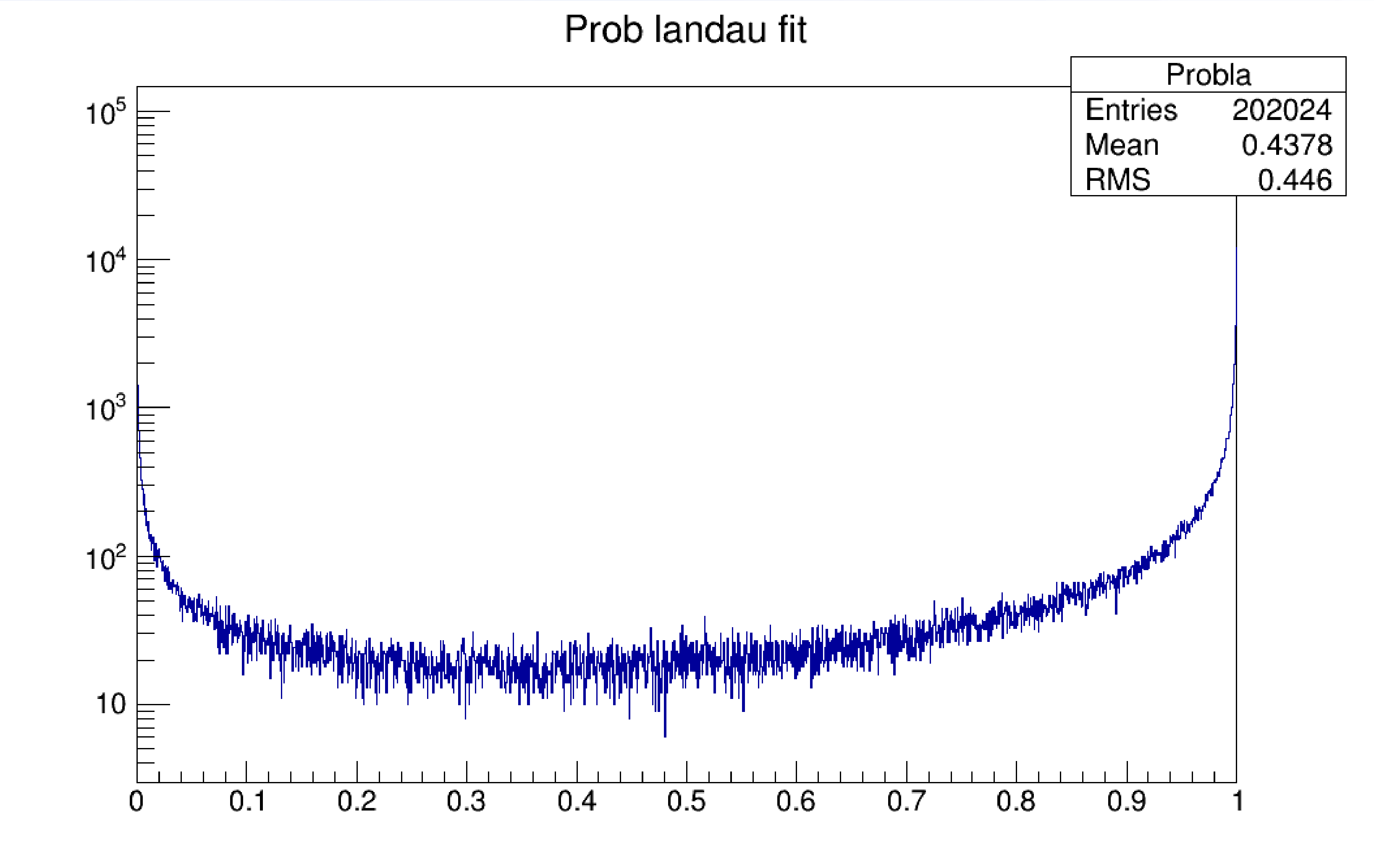
Works in the same way for saturated and unsaturated signals.





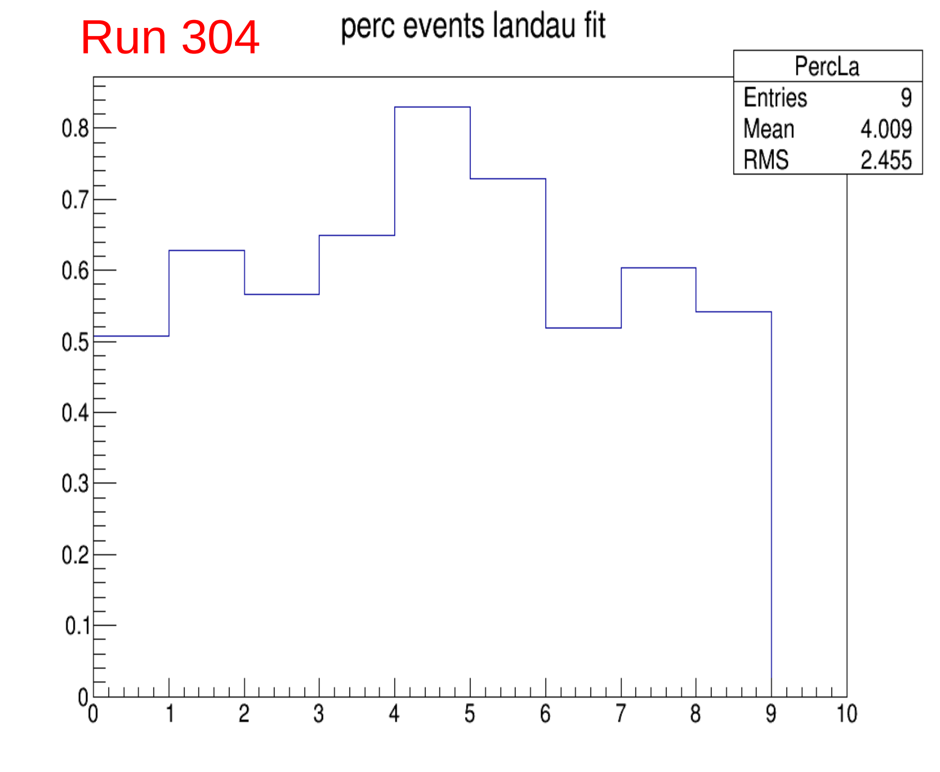
Landau fit probability

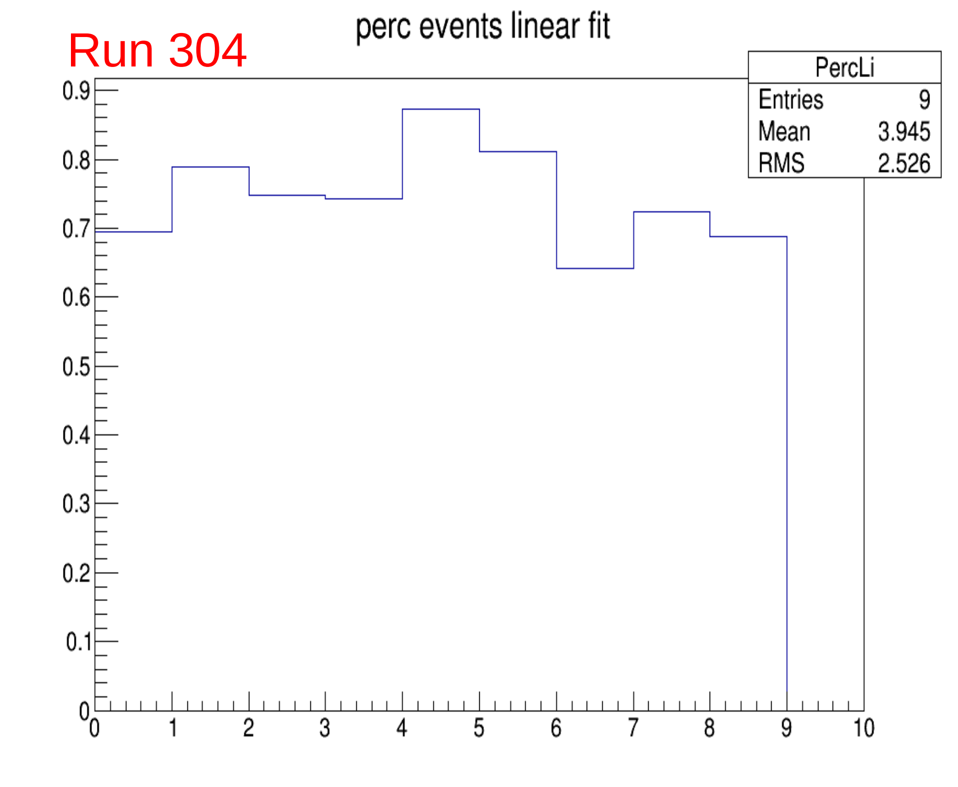
Fit probability distribution seems decent for Landau



Fit efficiency

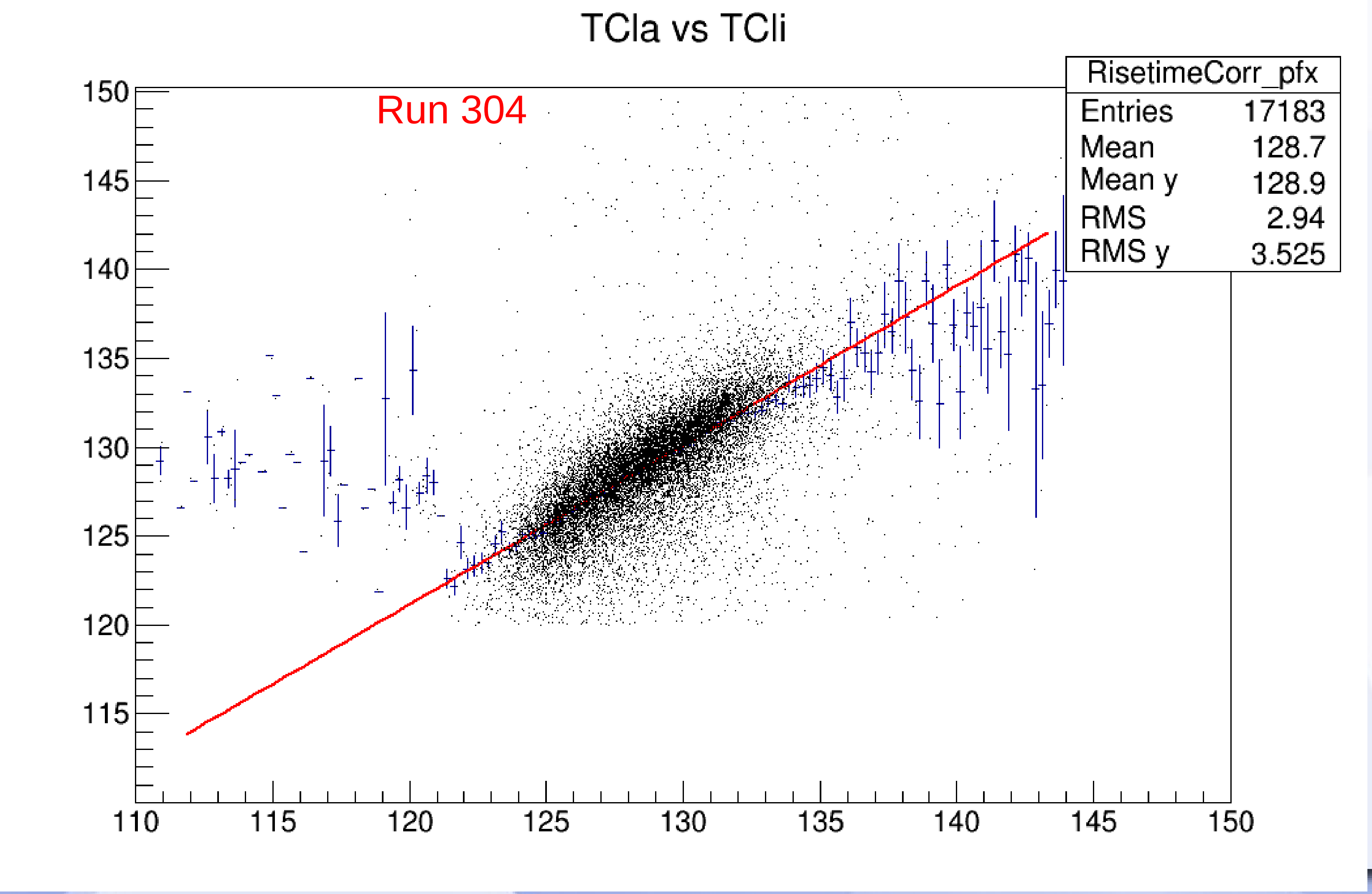
Run 304 – efficiency (events fit OK /total) for Landau and linear fit vs crystal number
Linear fit more "efficient", but less robust and less precise.
Efficiency improves in higher energy runs.





Landau vs Linear fit

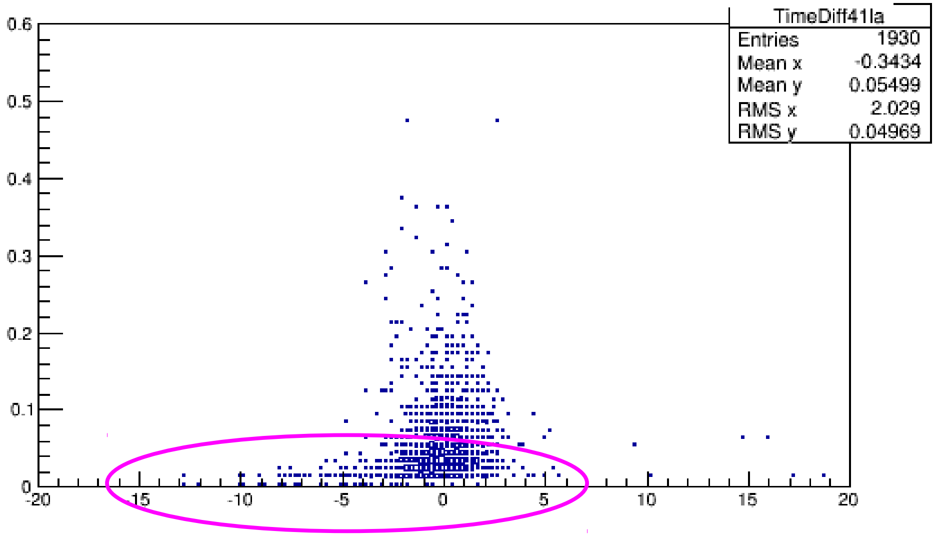
Clear correlation observed – we could use “corrected” linear fit also when Landau fit fails



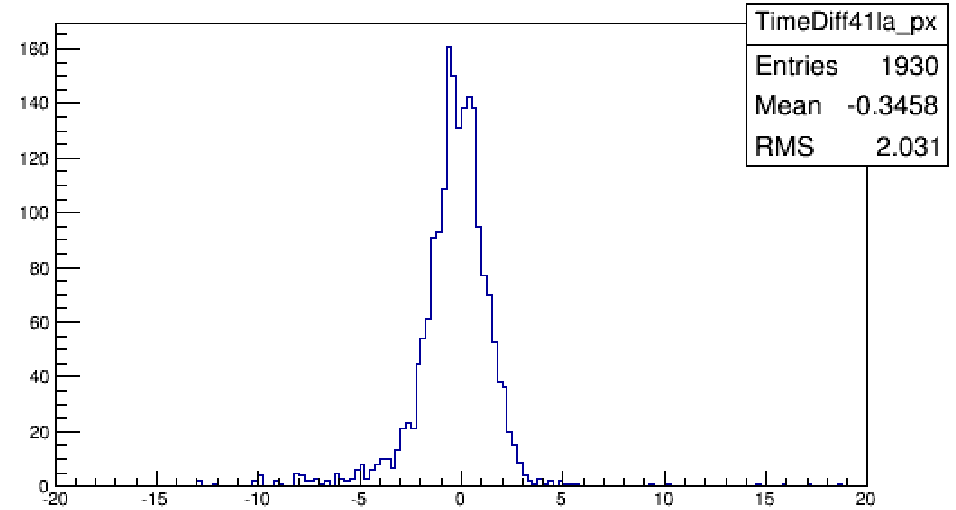
Time resolution 4-1

Run 304 (E~150 Mev) – worst case for time resolution
Difference Tstart_4 –Tstart_1 (Landau fit)

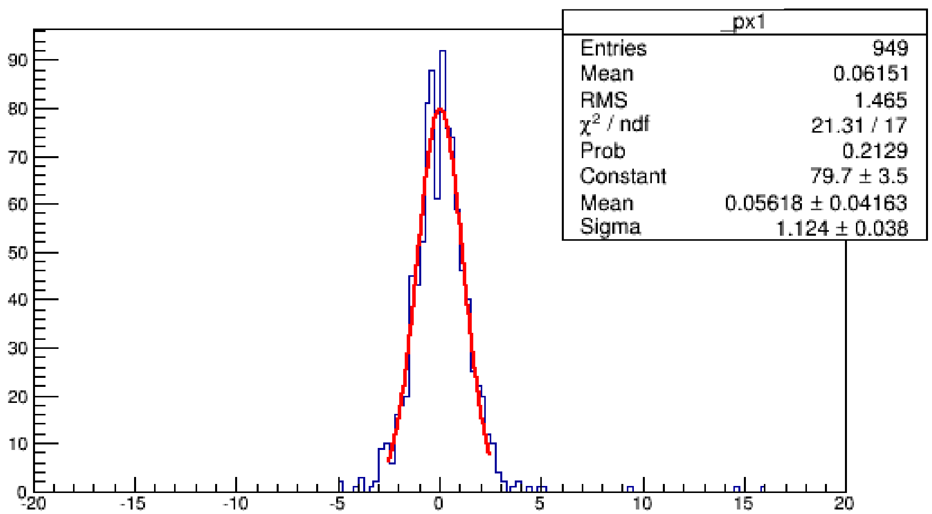
T4-T1 vs min(Vmax4,Vmax1)



Projection all events



Projection only minV>50 mV

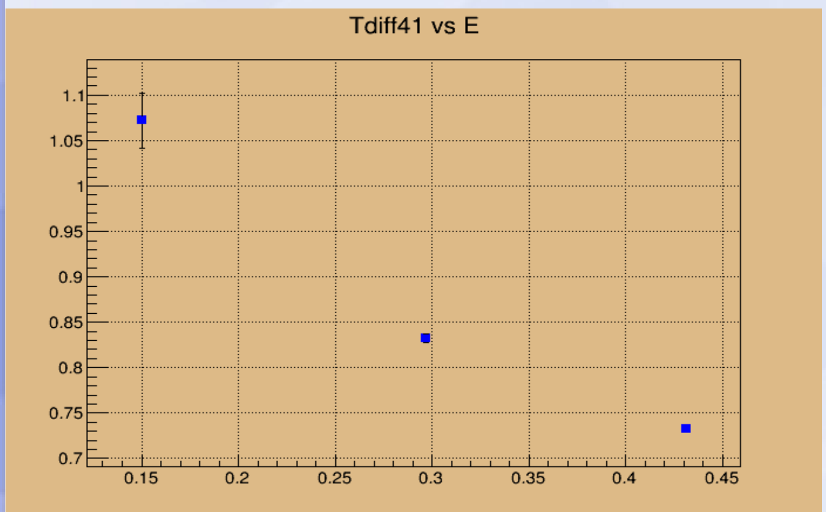


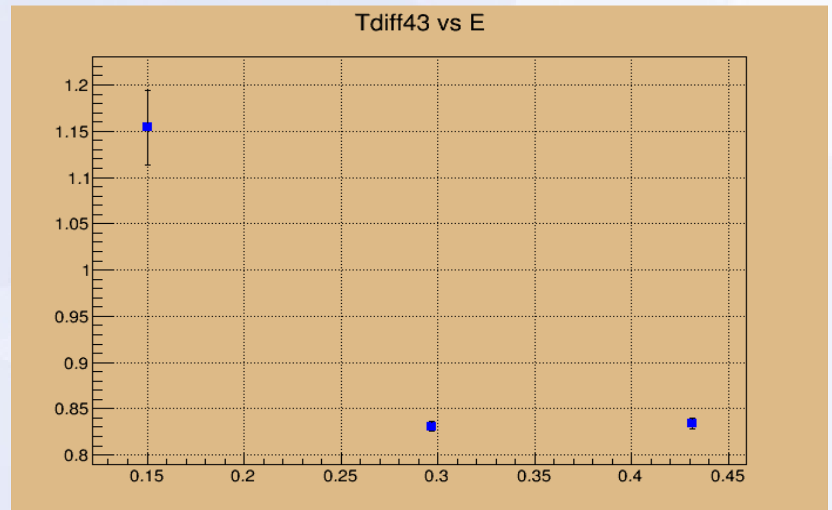
Worst case : resolution at lower minV
Event bulk time resolution improves with a cut minV>50 mV to the level of the nsec

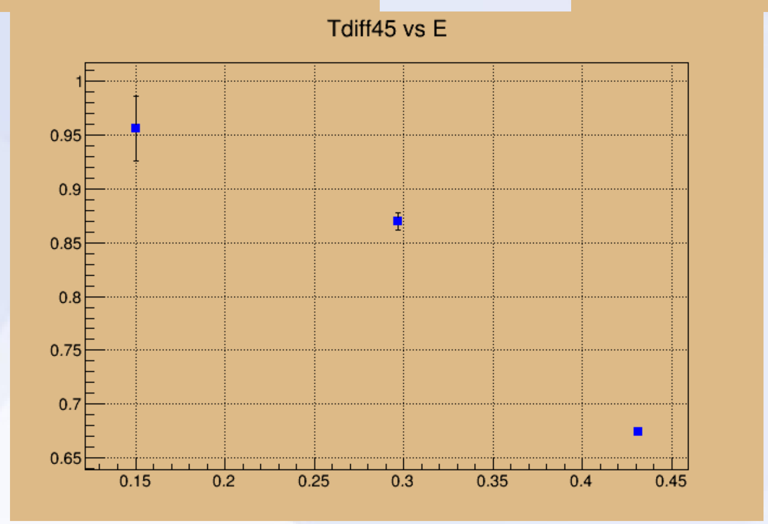
Time resolution vs E

Time resolution (cut at 50 mV minV) improves with energy to levels < O(1 nsec) for higher energies

We may have serious problems with lower energy gammas





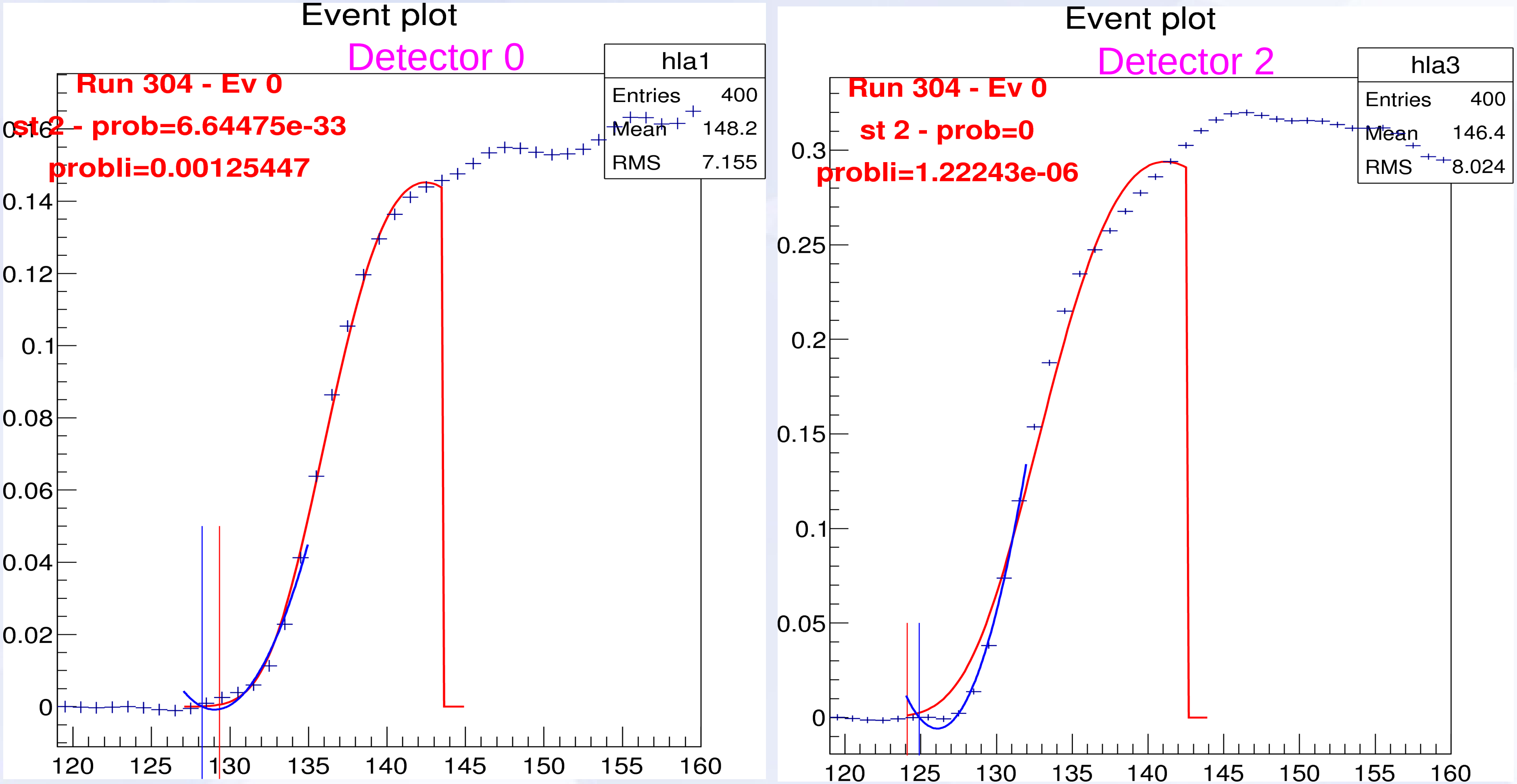


Time resolution - quadratic

Tried also fit with quadratic function $\rightarrow$ better start point : start of signal is NOT linear

Problems : - which of the 2 quadratic solutions to use ?

- same starting point from quadric zero and mpv-3σ landau
- from which prob level accept the fit ?



Time resolution

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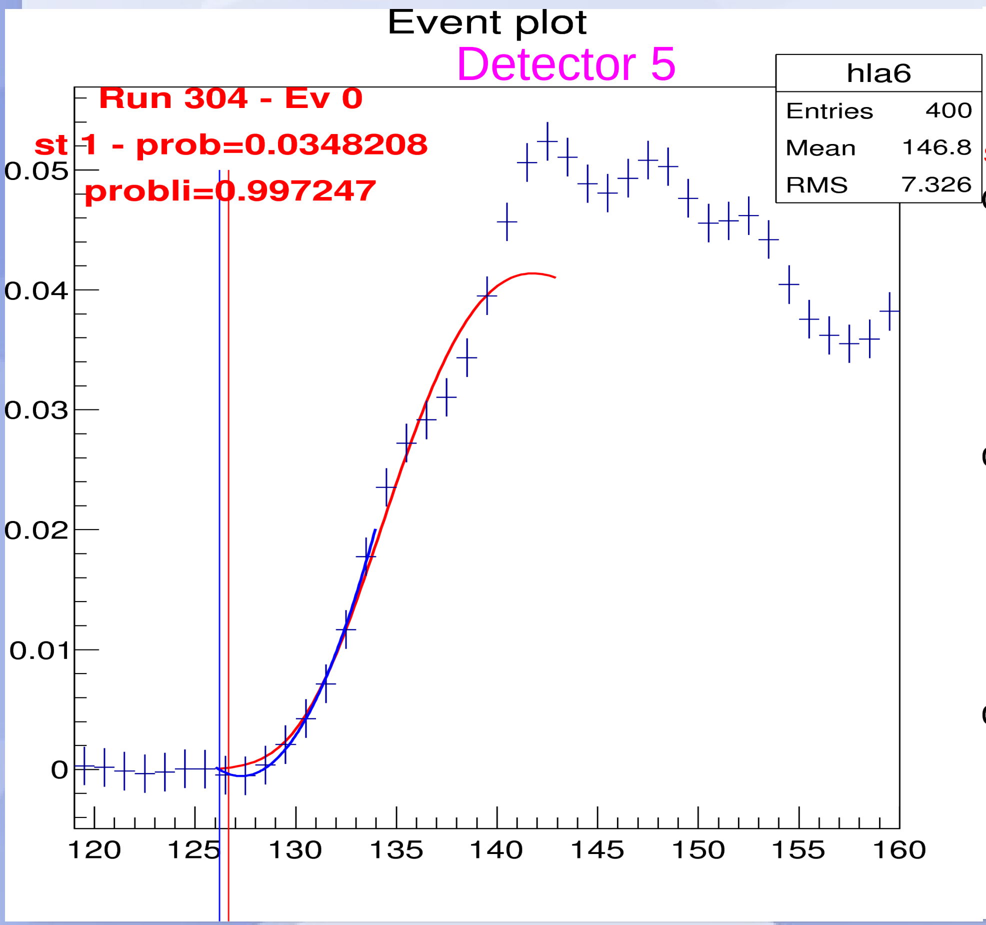
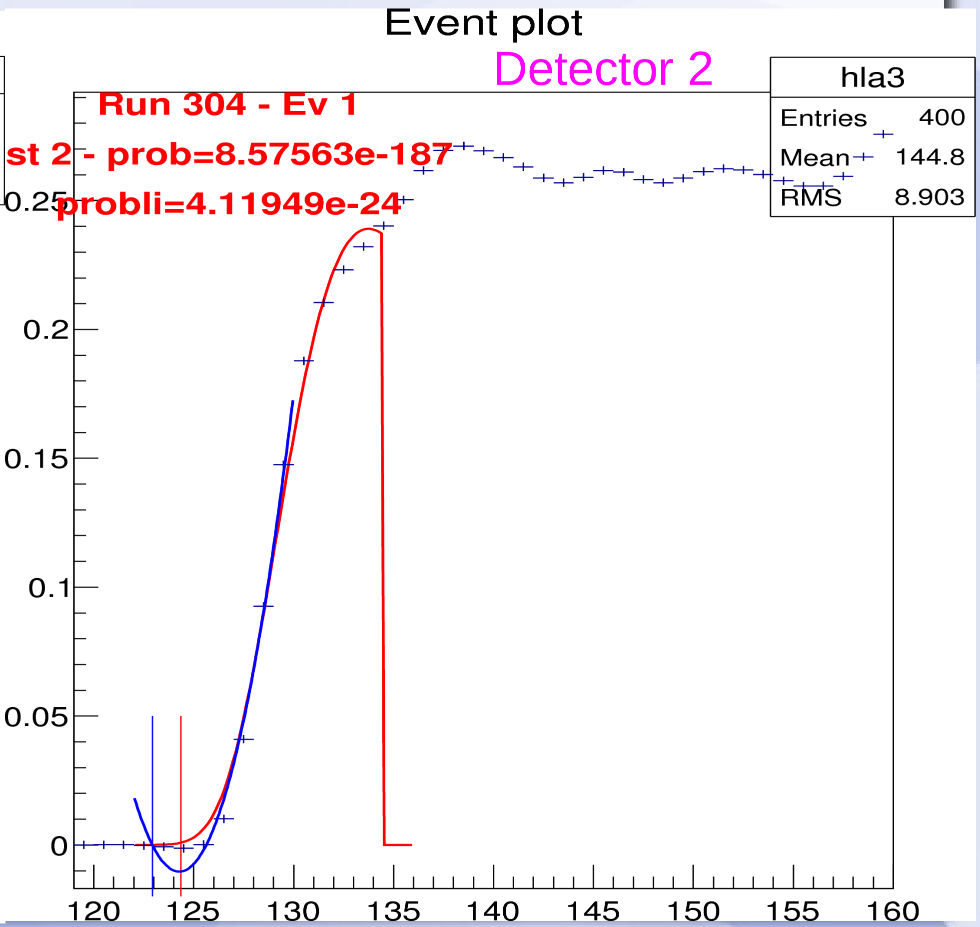
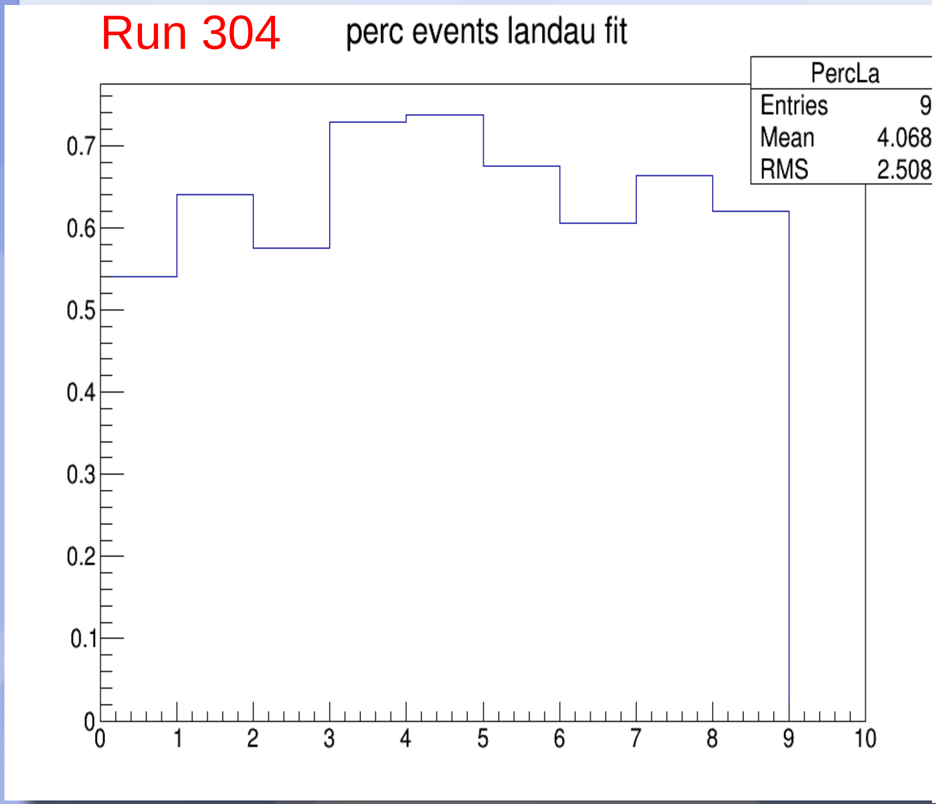
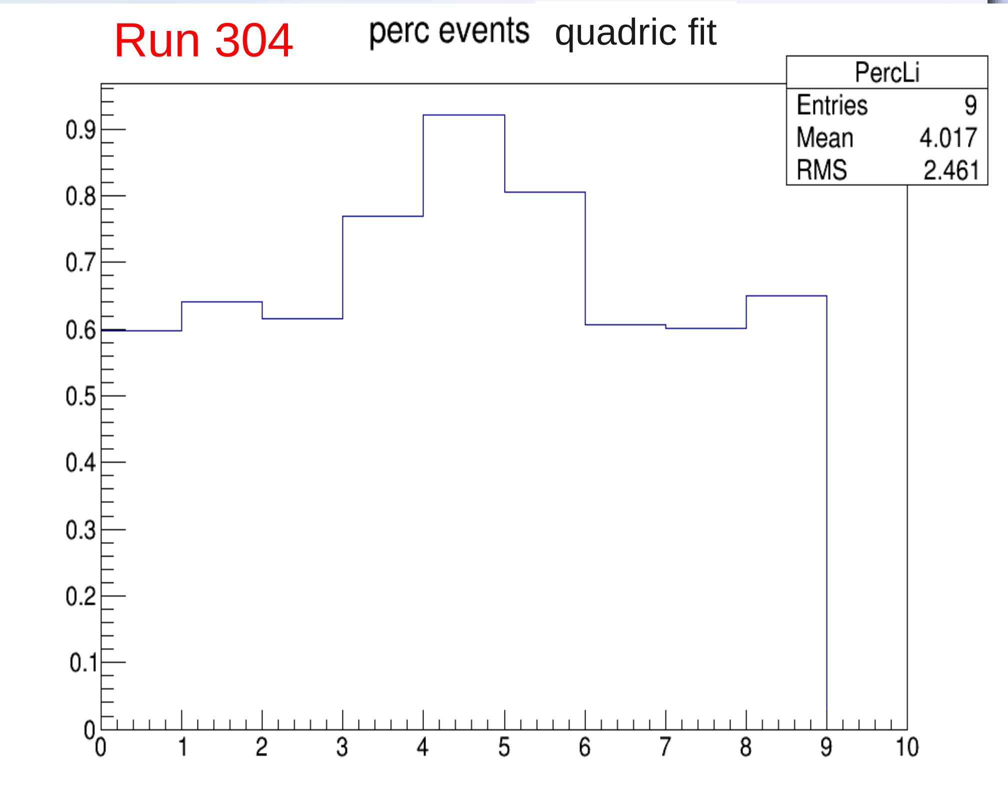




Fit efficiency

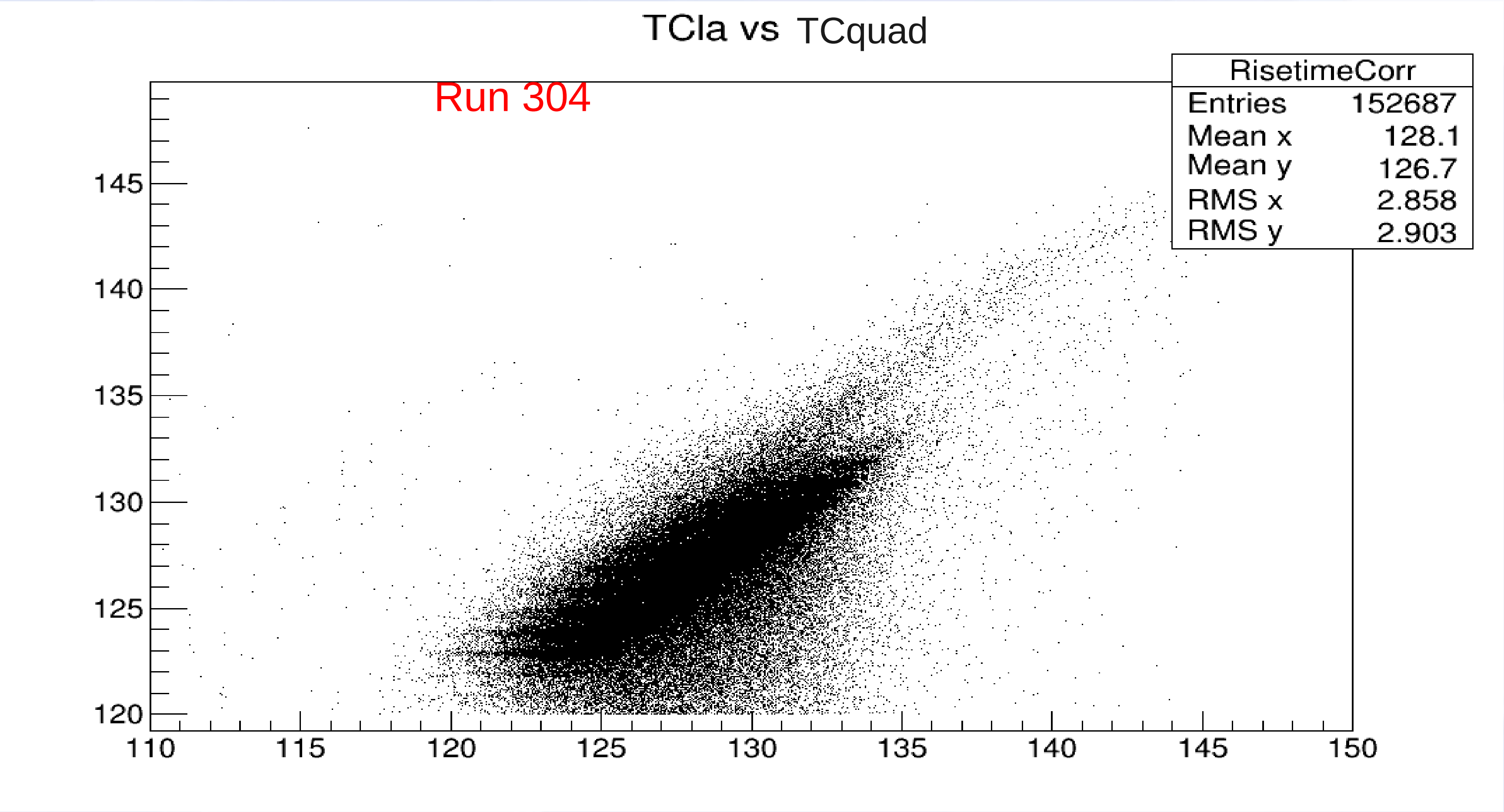
Run 304 – efficiency (events fit OK /total) for Landau and quadric fit vs crystal number
Quadric fit slightly more “efficient” than landau fit.
Efficiency improves in higher energy runs.





Landau vs Quadric fit

Not so clear correlation observed - how to correct ?



Conclusions

Still studying how to finalize Landau fit to improve resolution and efficiency issues.

In case Landau fit does NOT succeed :
- we may use quadratic fit
- in case of failure of both use linear fit
- studying cuts to accept fits
- studying how to “match” fitted signal time starts in all cases

Studies seem promising, but we're not yet OK with foreseen goal.

Also waiting to check results from time resolution studies from runs with diamond detector and scintillator