

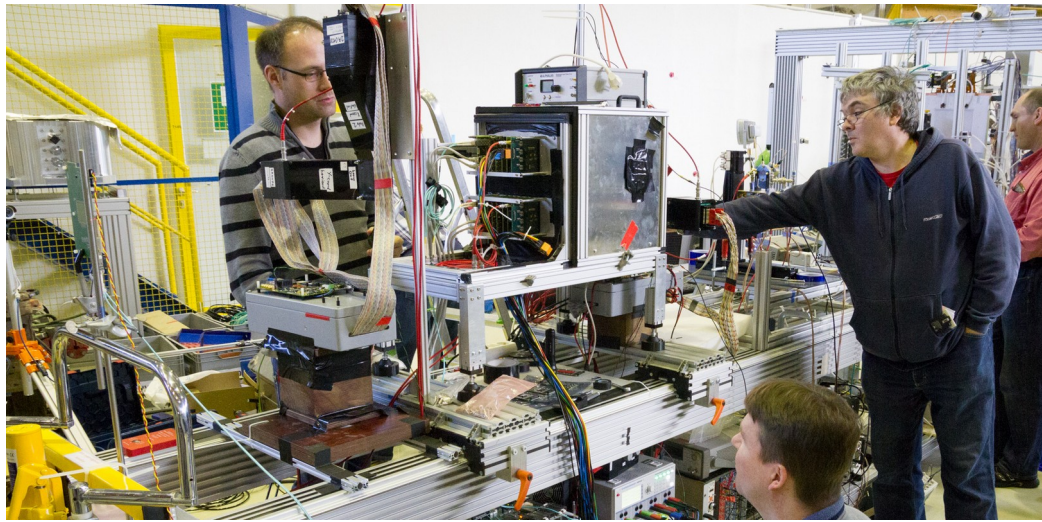
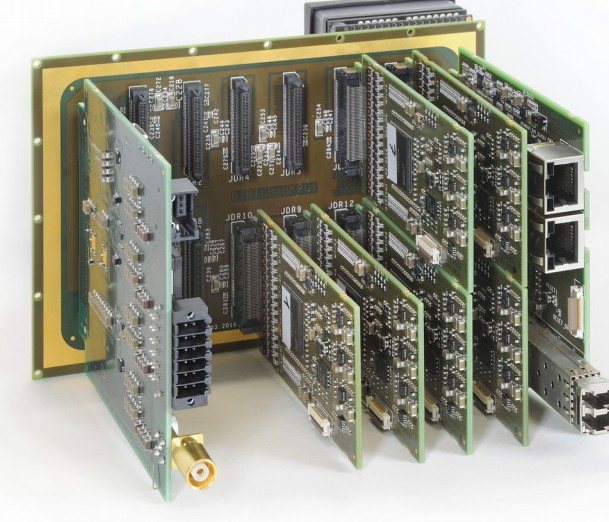
Performance of the new DiRICH based readout chain for MAPMTs in test beam data

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Motivation

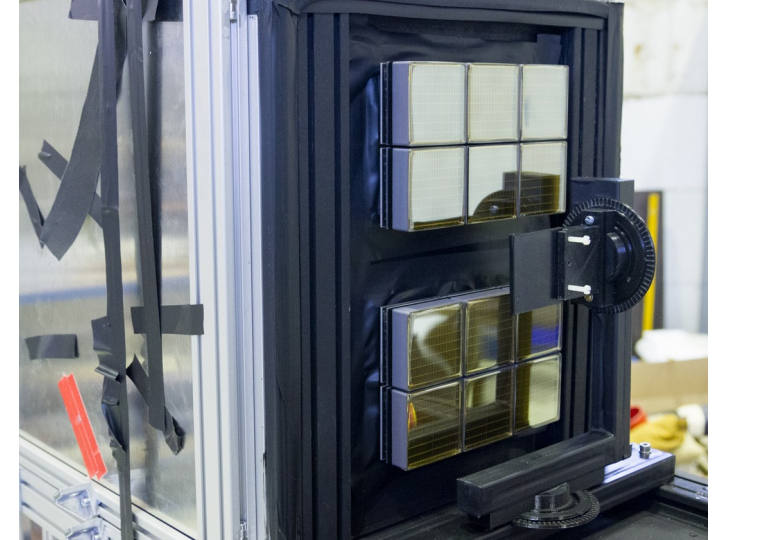
- Test of the CBM and HADES RICH detector readout chain under realistic beam conditions.
- Enhancing the photon detection in the UV region by using wavelength shifter coating (p-terphenyl)
- Signal discrimination, time-over-threshold measurement and data handling in FPGA-TDC based readout electronic.



- Measurement of cherenkov rings with low noise due to application of time-over-threshold cut.

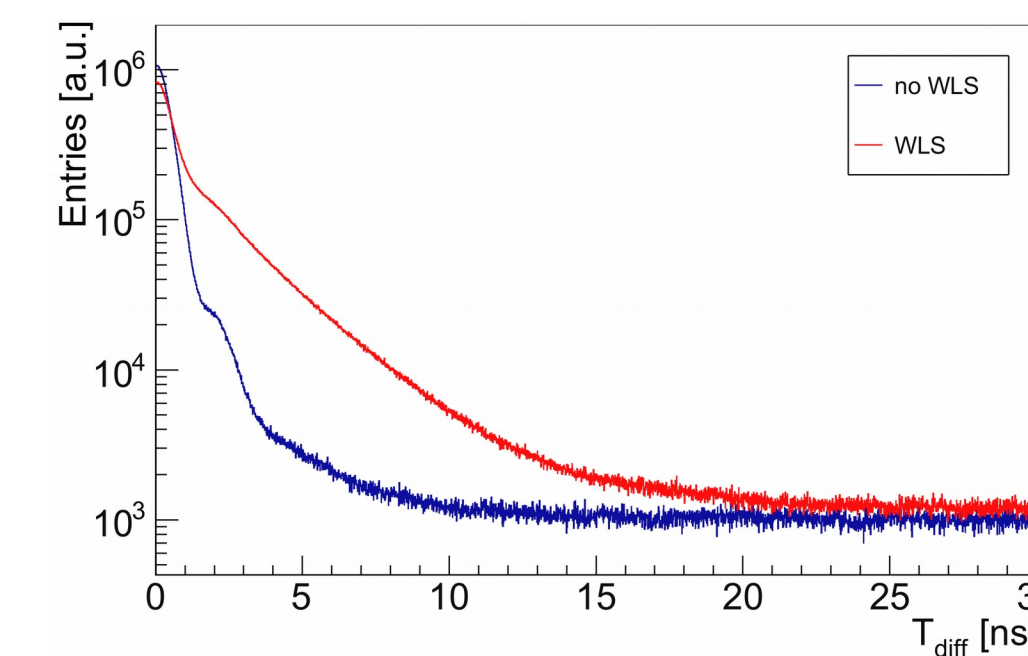
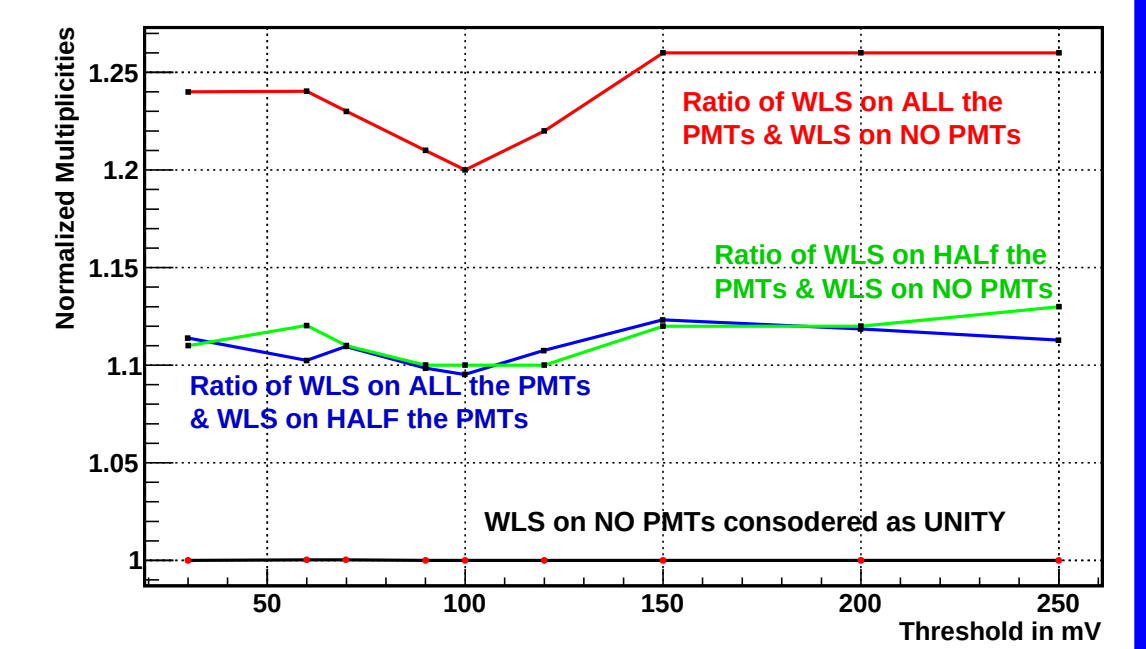
Prototype

- A proton beam with 1.6 GeV/c momentum crossing a 3mm quartz plate produces cherenkov radiation.
- Proximity focusing gives ring on multi anode photomultiplier (MAPMT) plane.
- 12 Hamamatsu H12700 MAPMTs are used.
- 24 DiRICH modules with 768 channels in total.
- Data acquisition is done with TrbNet.
- DABC is used as eventbuilder.



Wavelength Shifter Coating

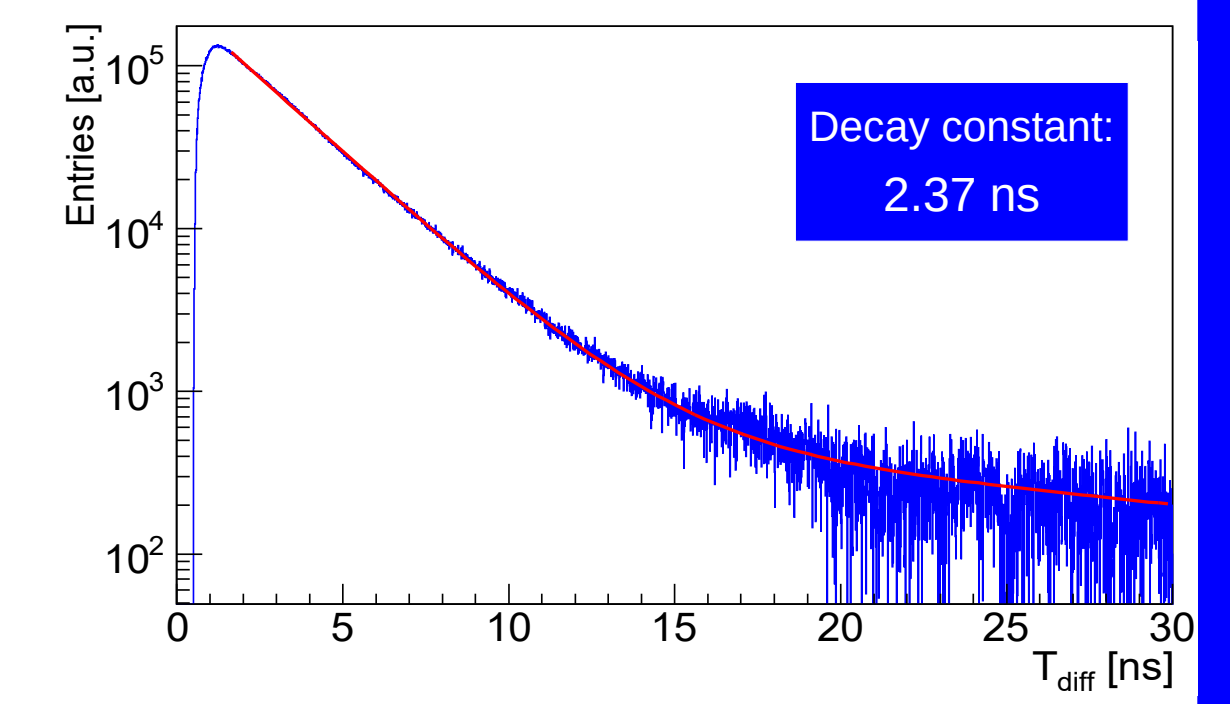
- MAPMT plane measured with full, half and without WLS coating (p-terphenyl).
- WLS increases the number of cherenkov photons by approx. 20% over whole threshold range (without cuts). (See details in: NIM A 783 (2015) p.43)



- Decay constant is extracted by subtracting the T_{diff} distribution with WLS from without WLS and fitting the distribution with a decay function.
- The measured decay constant is 2.37 ns, comparing well to results from fluorescence measurements (2.3 ns).

- WLS decay constant was measured by calculating the time differences of all hits in a ring to the earliest hit.

$$T_{diff} = T_{ref} - T_{hit}$$



Timing Precision

- Temperature dependence of FPGA-TDCs is corrected by a linear calibration in software.
- Inner channel delay correction is applied.
- Calibrated data is filtered by applying a
 - Time-range cut
 - Time-over-Threshold cut
 - Ringfinder
 - Ring-Center cut
- Leading edge time of Channel N and N-1 in the same DiRICH are compared.
- Mean of all sigma values is $\sigma = 361,7$ ps (see Fig. (I)).
- The time precision after unfolding the two channels is 255.76 ps (threshold: 80mV).
- Precision is dominated by MAPMTs, not by the DiRICH electronics (~ 30 ps).

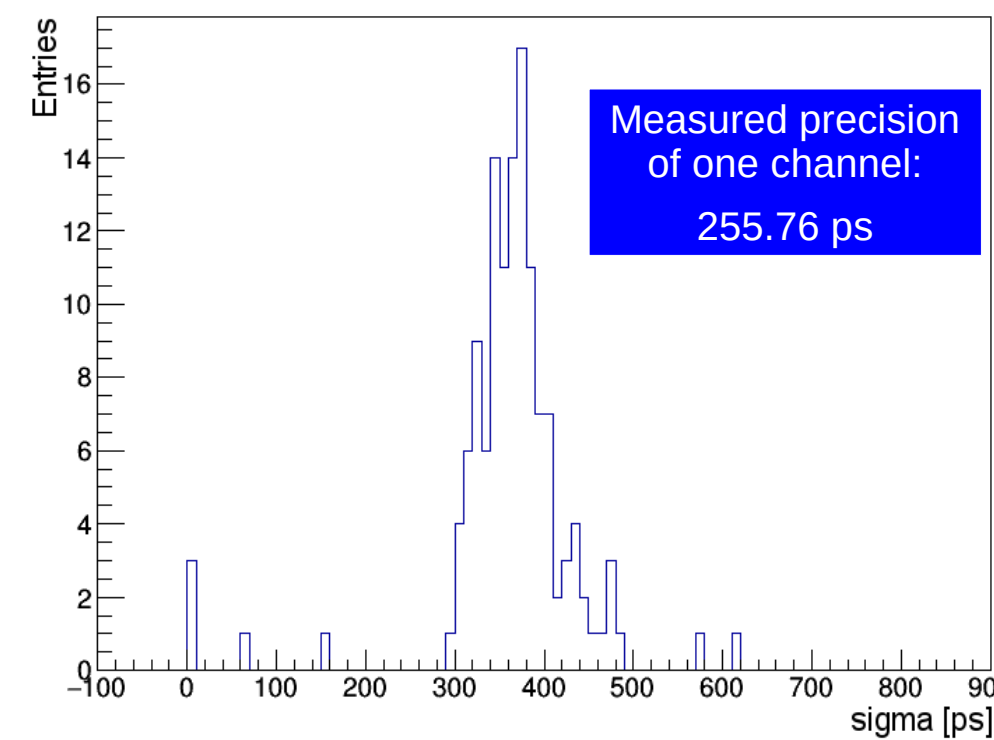


Figure (I): Distribution of folded precision between two channels in the same DiRICH.

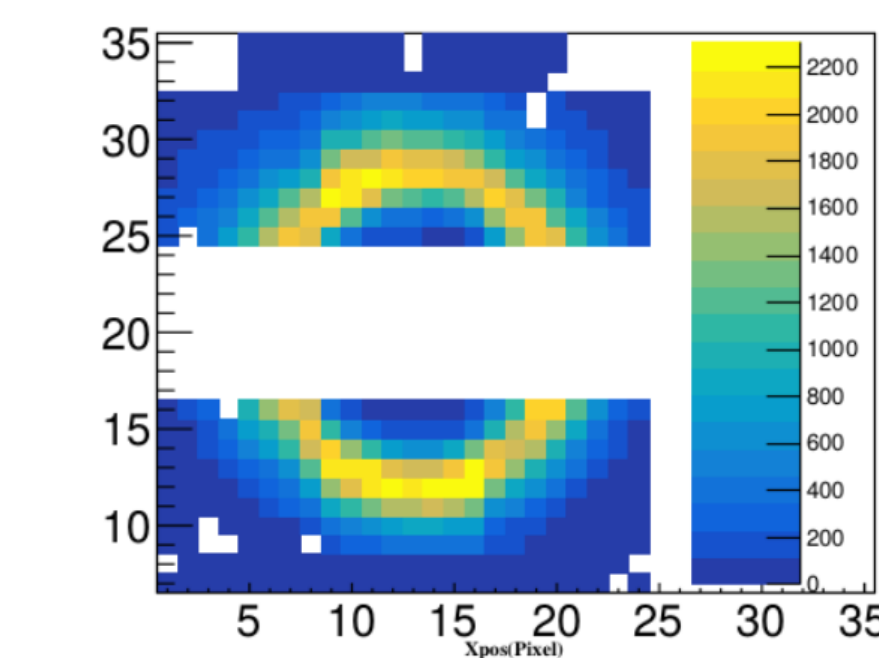


Figure (II): Typical integrated 2d hit map obtained with this setup.

Time-Over-Threshold

- Typical PMT signal traces for single photon illumination (Figure (III)).
 - positive signal after preamplification (red box) for pixels directly hit by photon.
 - negative pulse and wiggle (blue box) in neighbouring pixels due to capacitive crosstalk in PMT.
- Time-over-Threshold (ToT) distribution at low threshold (Figure (IV))
 - the crosstalk signal can cause additional "fake" hits, preferably in the vicinity of the real photon hit.
 - Due to its reversed polarity and different signal shape, this cross talk can be efficiently suppressed using an additional selection criteria on the measured ToT.
- The direct photon hits peak in the region of $ToT=32$ ns (the measured ToT contains an artificial offset), the capacitive crosstalk signals result in a significantly smaller ToT.
- An additional ToT cut allows to minimize the discrimination threshold significantly, resulting in improved detection efficiency and better timing precision.
- Figure (V, left) shows the total number of photons on the whole PMT plane per event (Hit multiplicity) for thresholds of 30 mV and 120 mV.
- Single event plots with and without ToT-cuts for these two thresholds respectively are shown in figure (V, right).
- The measured multiplicity with a threshold of 30 mV was 15. The application of a ToT-cut gives a remaining multiplicity of 12.
- Applying a ToT-cut at 120 mV threshold reduces the multiplicity from 11 to 9.
- The ToT-cut effectively suppresses the crosstalk especially at low threshold without compromising on efficiency.

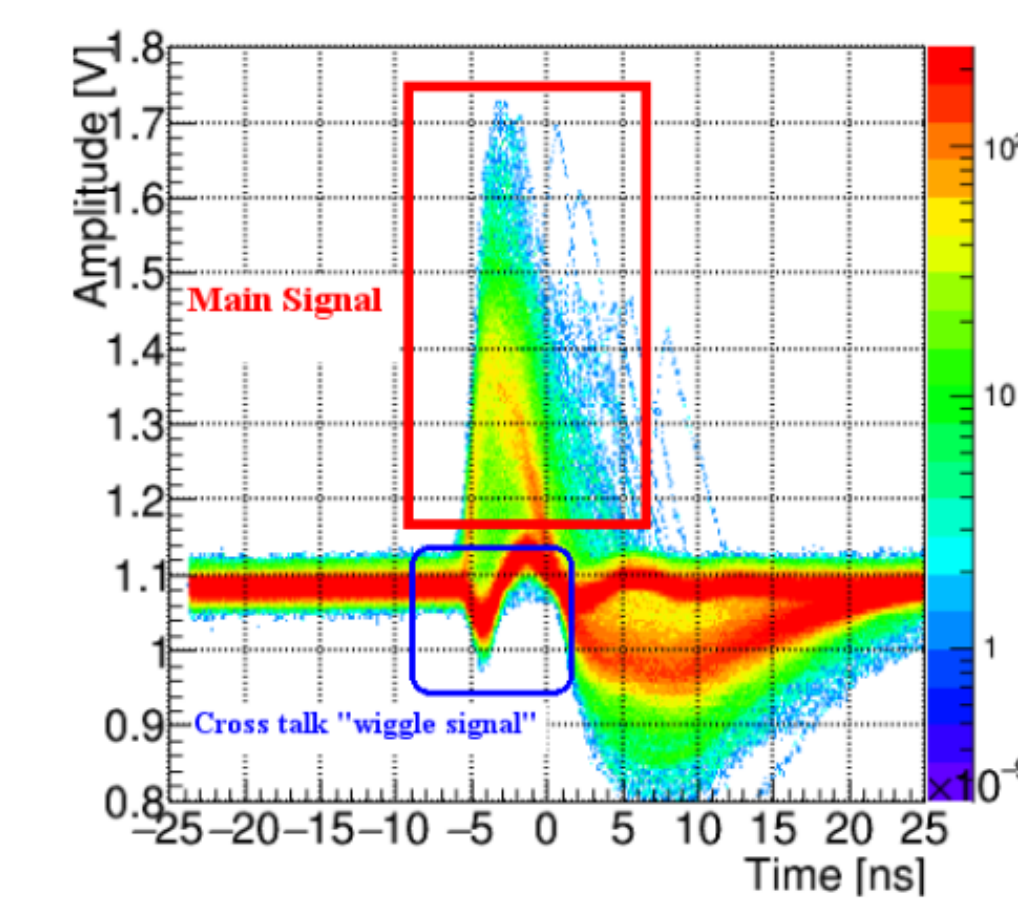


Figure (III) : Signal after preamplification.

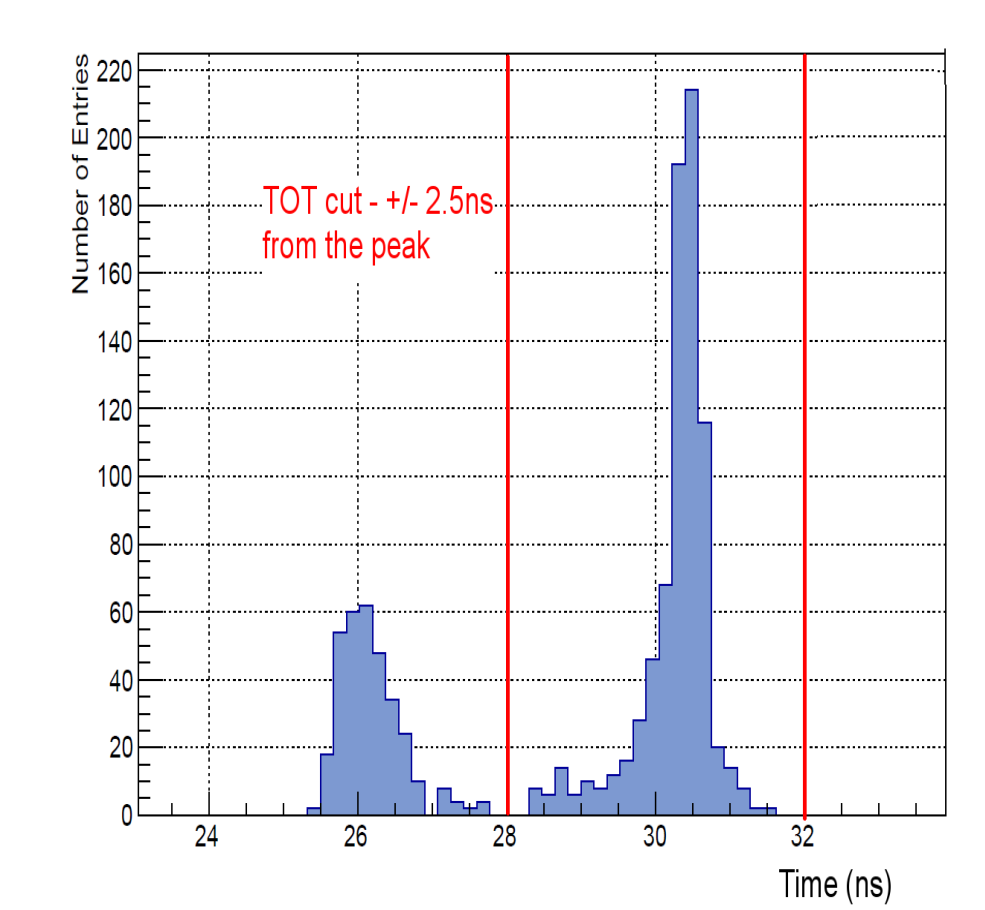


Figure (IV) : ToT distribution with offset from a typical channel @ 30mV threshold.

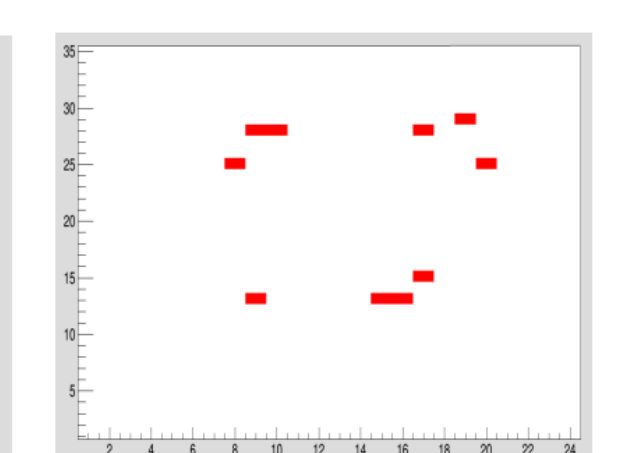
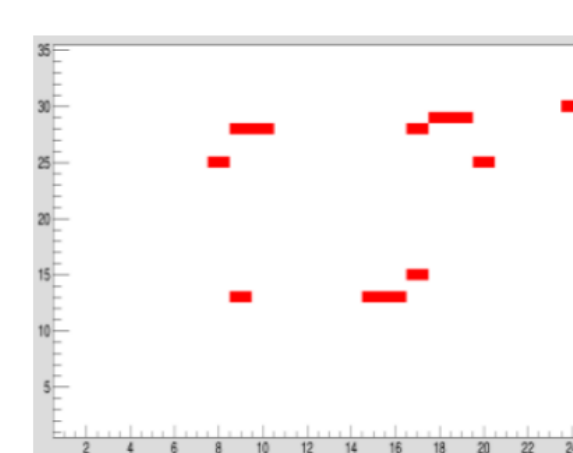
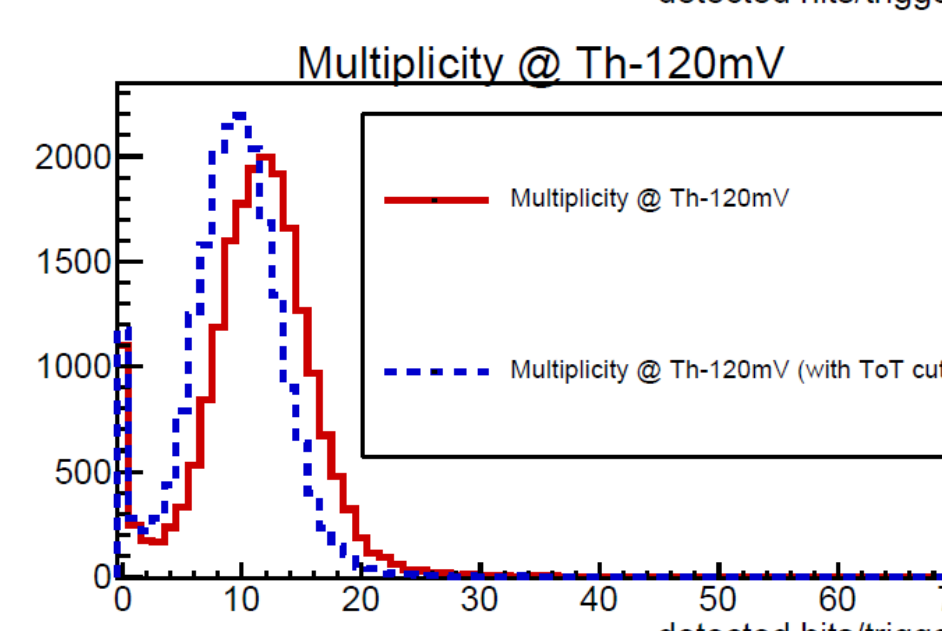
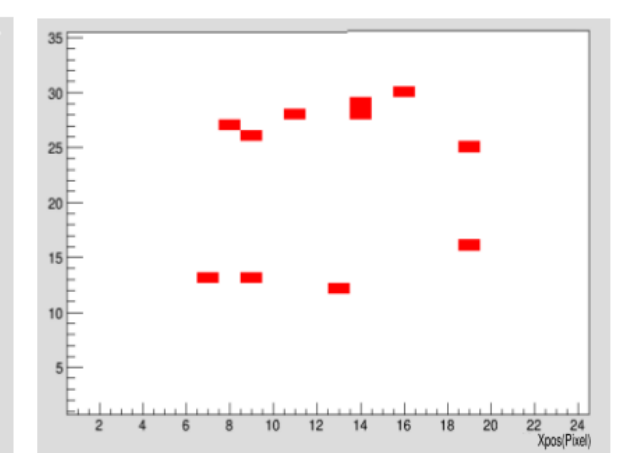
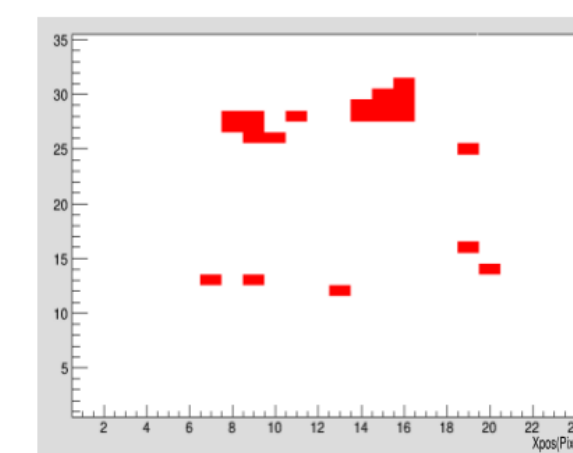
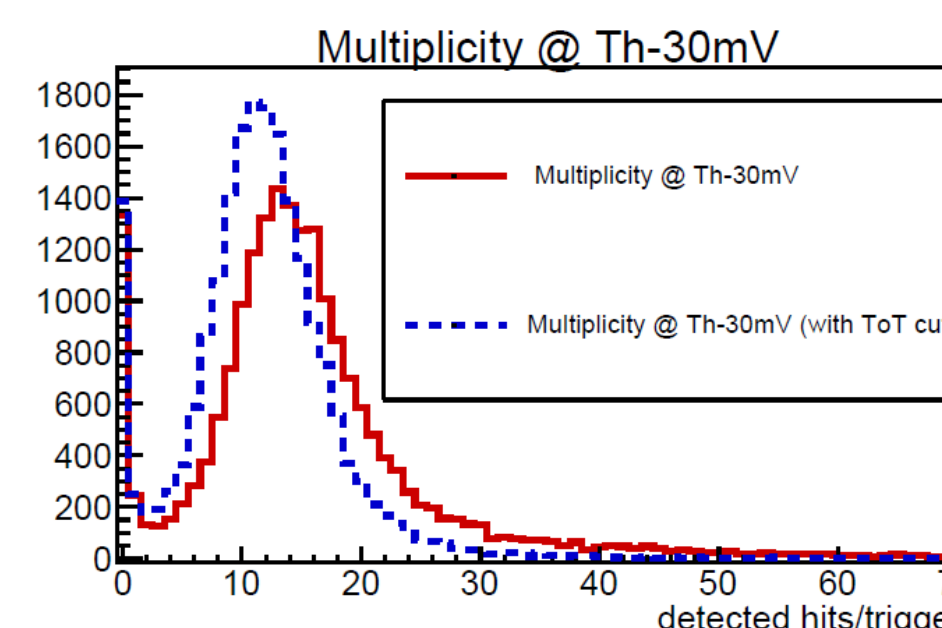


Figure (V) : Hit multiplicity w/ and w/o ToT-cut (left) and single event plots w/ and w/o ToT-cut (right) for two different thresholds.