Evaluation of FEB Configurations

COSY beam 02-2019

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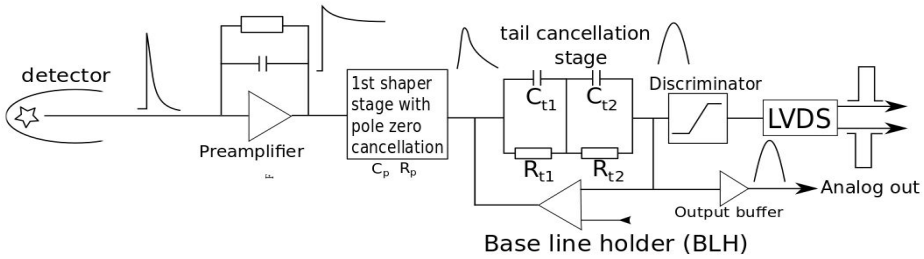
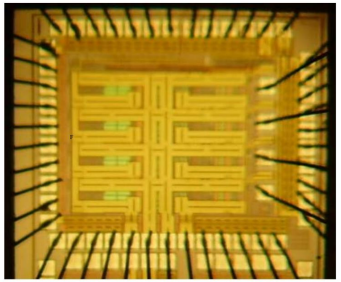
Front-end electronics

- The FEE card contains two 8-channel PASTTREC chips **(D.Przyborowski et al.,JINST_013P_0516. (2016))**

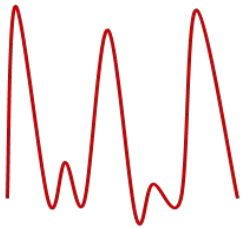




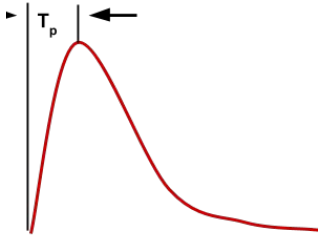
Schematic representation of the front end electronics functions with a concepts of signal shaping with analog circuitry.

- To avoid a large dead time electronics integrate over only a small (20%) of the total charge
- Shapers for signal shaping.
- Tail cancellation using CR-RC , Discriminator for signal separation.

Detector Pulse

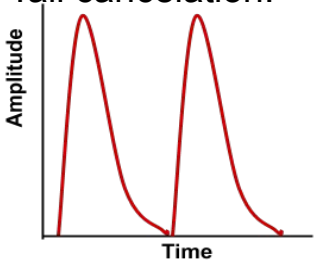


Shaping



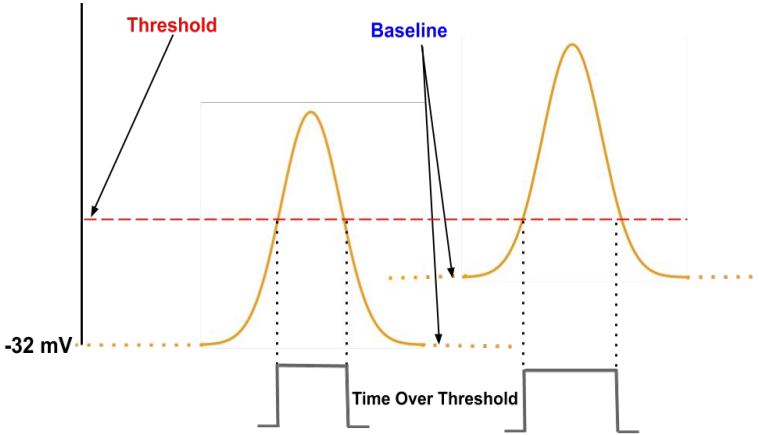
Long ion tail

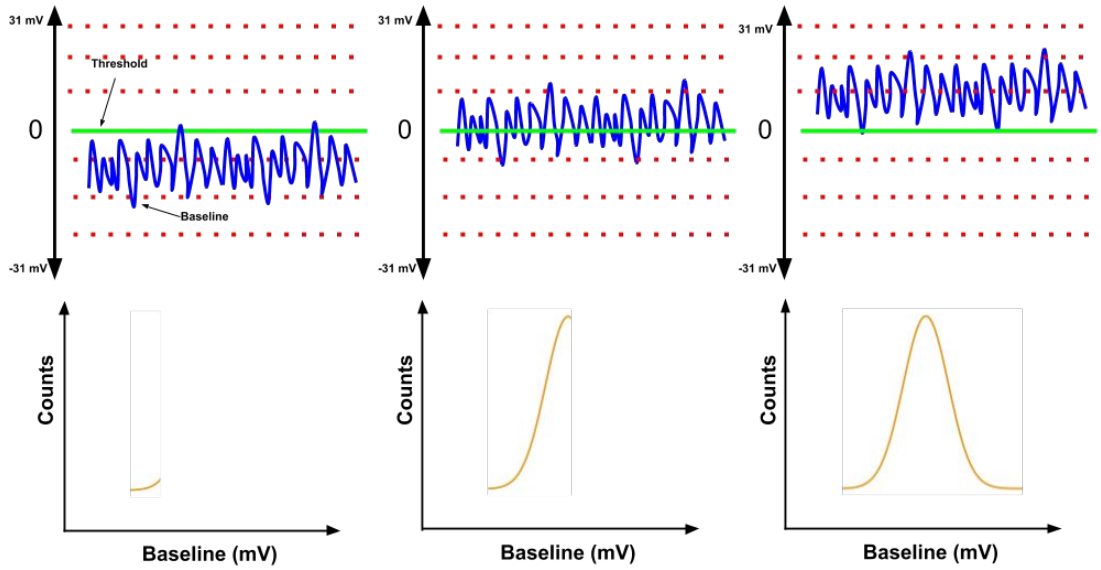
Tail cancelation.



Baseline Alignment

- Baseline adjustment - 31 mV to + 31 mV (1 LSB = 2 mV)
- Automatic baseline alignment technique developed
- One channel at a time



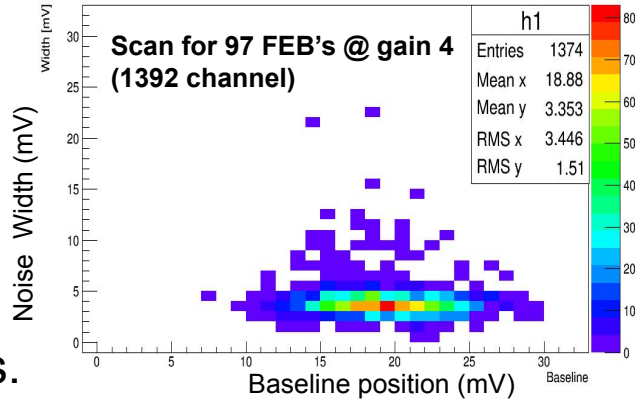


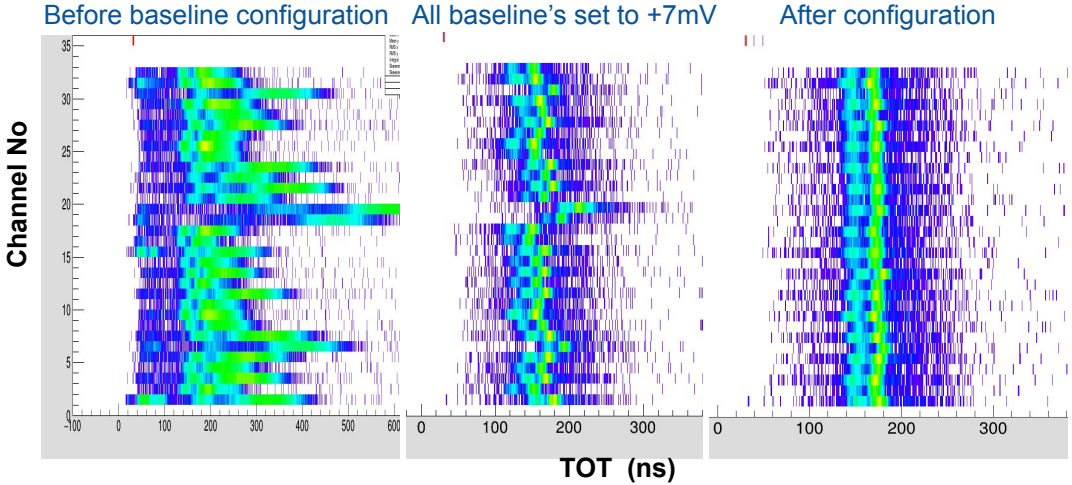
Software:

- Written in Python 3
- Uses TRBnet interface to Communicate with ASICs

Noise scan and base Alignment

- Lower noise = lower operational Dirsc.threshold.
- Accurate recognition of baseline position (LSB).
- Multiple FEE's scanned simultaneously.
- Database to store and manage board settings.
- Tests of the procedure with ^{55}Fe source, cosmic rays.

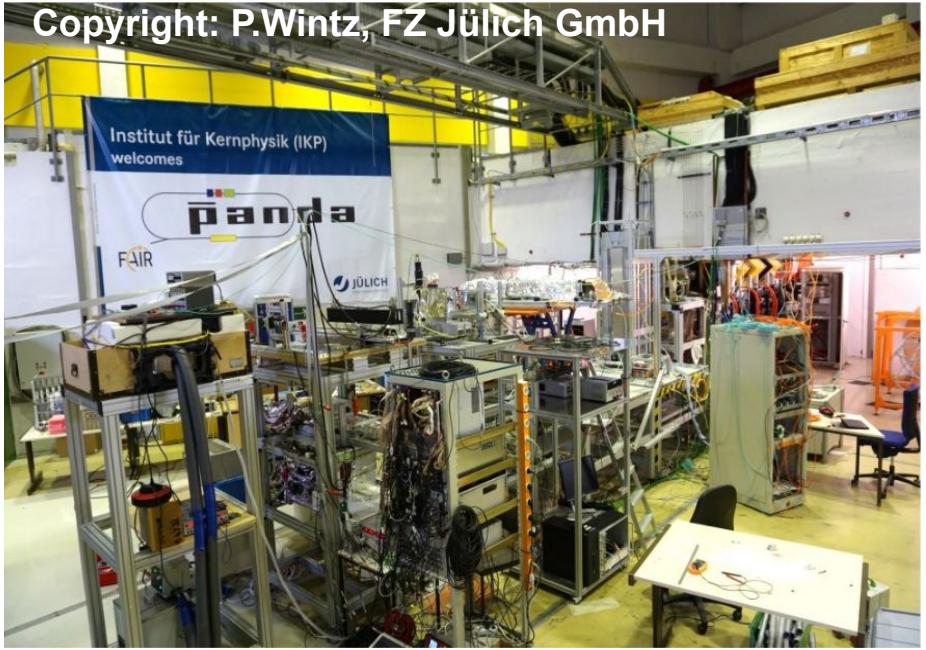




	Board	Setting 1 (mV)	Setting 2 (mV)	Setting 3 (mV)
Gain 4	A	3.87	3.65	4.2
	B	5.26	4.8	5.5
	C	5.62	4.25	5.4

Beam @ COSY

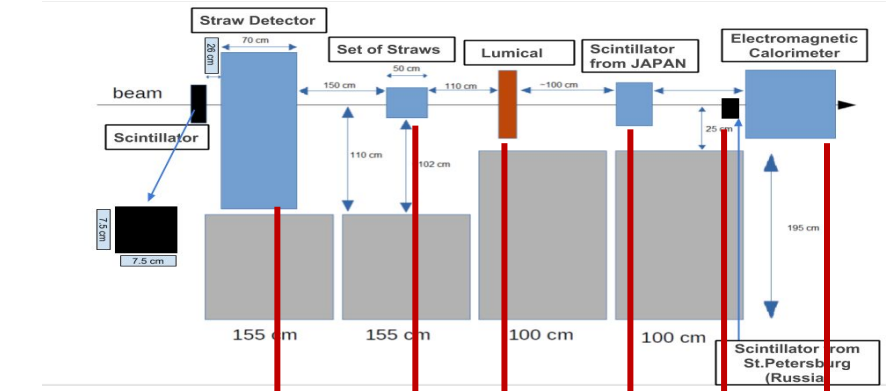
- FEB 2019 - 7 days of beamtime commissioned for Forward Tracker tests.
- COSY beam ideal for HADES/PANDA straw tests.
- External proton beam
  - Momentum : 3 GeV/c
  - Intensity: up to 400 kHz
  - Beam spot : $\Delta x \approx 2$ cm, $\Delta y \approx 2$ cm



- Special Thanks to P.Wintz, P.Kulessa and FZ Jülich.

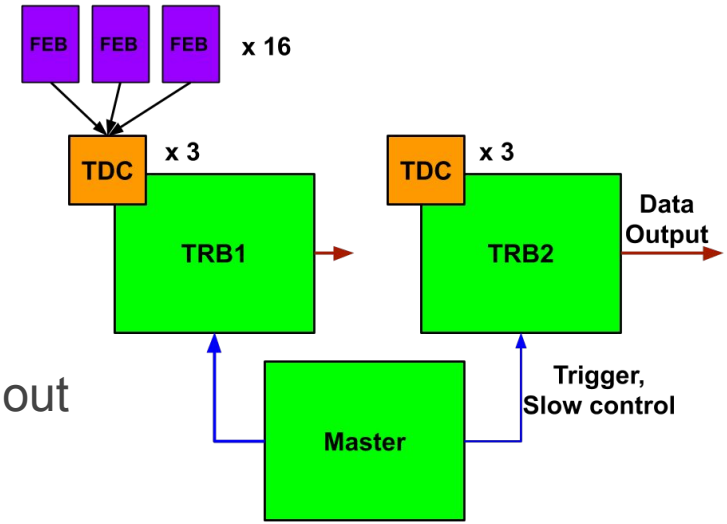
Measurement Goals

- Evaluation of straw modules
- Evaluation of the FEB's
- Operational parameters
  - Operational Voltage
  - Threshold
  - Peaking Time
  - Gain
  - Baseline calibration
- Testing of the readout



In Beam @ COSY test setup

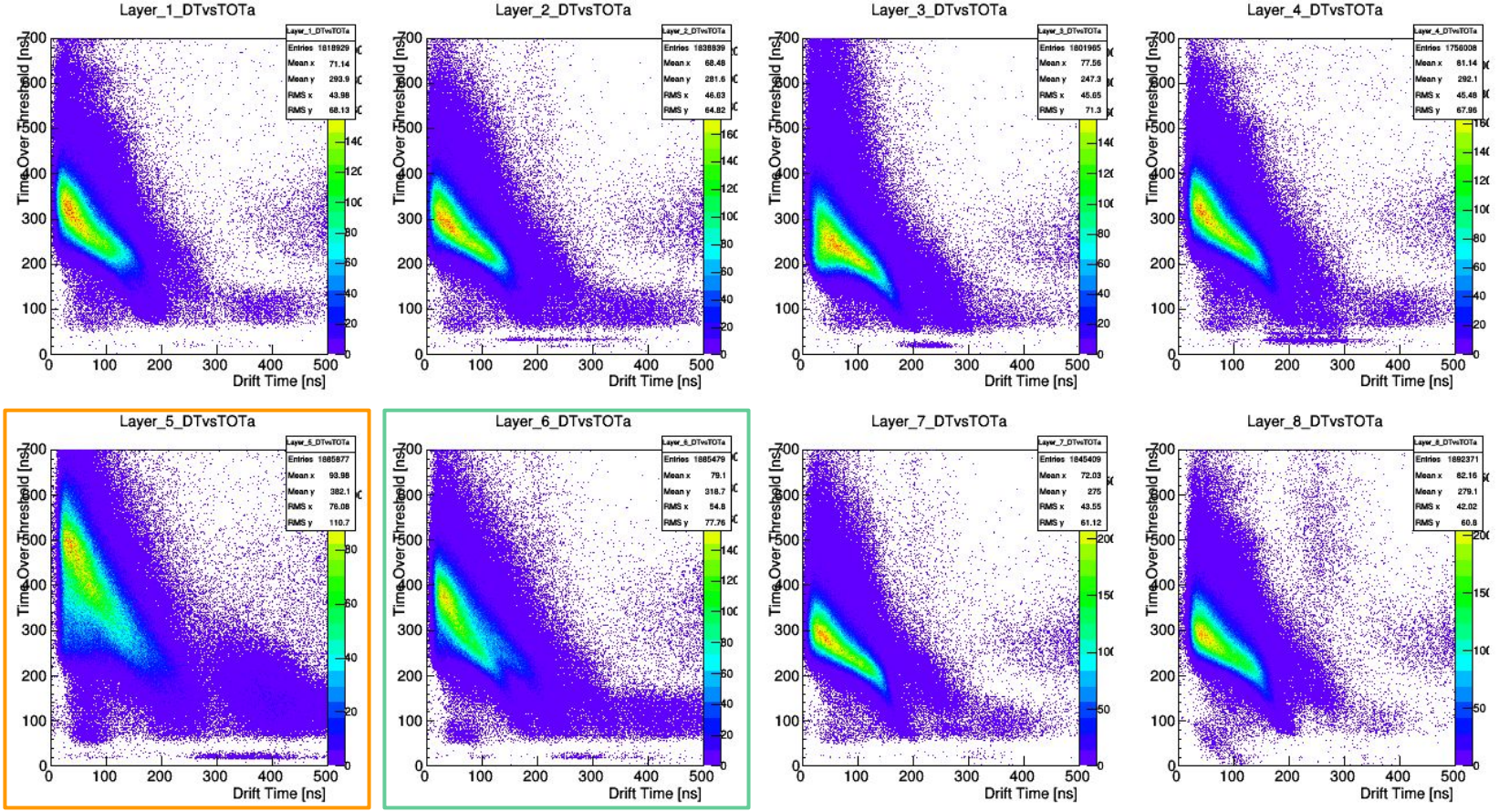
- 8x Double layers, 32 straws each
  - 4x straight modules
  - 2x skewed +5°
  - 2x skewed -5°
- Plastic scintillator for Reference time
- 16x PASTTREC FEE's, 2x Readout TRB's
- Continuous trigger readout



Test setup

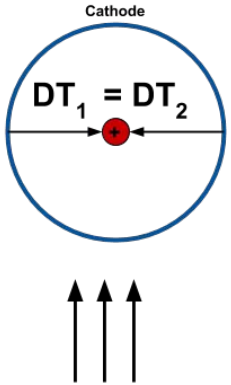
Time Over Threshold Vs Drift Time

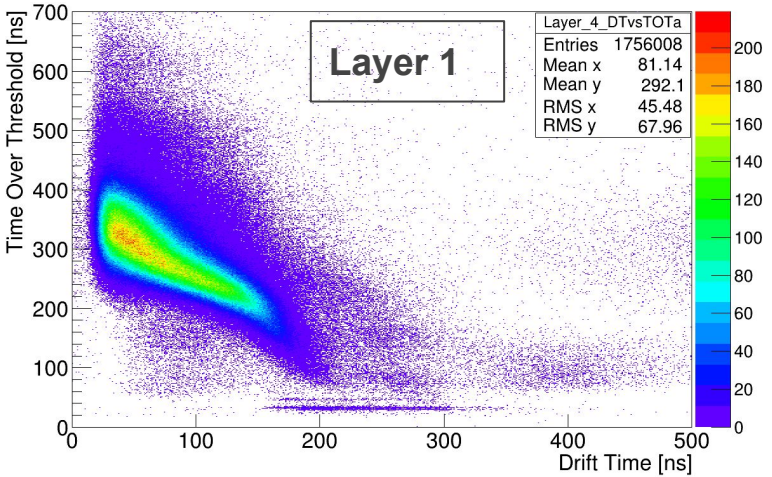
- DT vs TOT for 8 layers in 500 ns time coincidence with the scintillator.

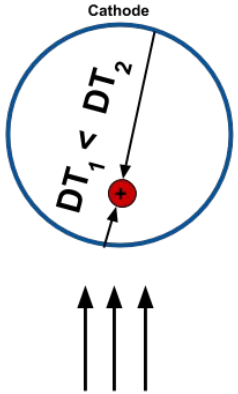


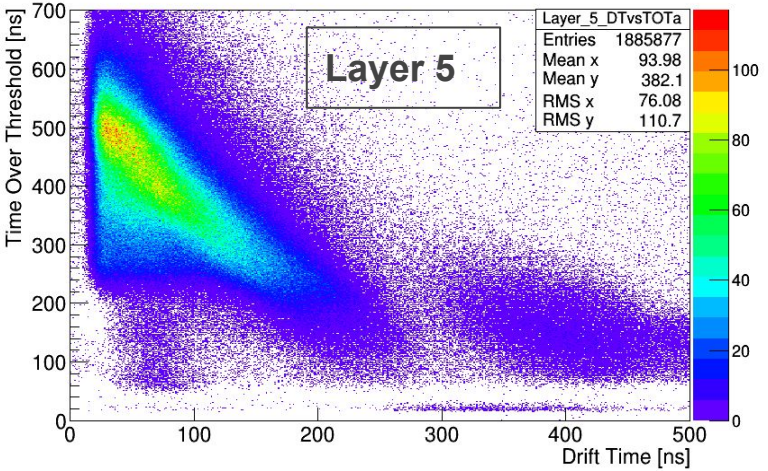
Anode position displacement

- Displaced anode gives rise to longer drift time's.
- Anode displacement can be of two kinds.
  - Perpendicular
  - Along
- Caused due to the bending or backling of straws
- Data can be cleaned by rejecting the second signal



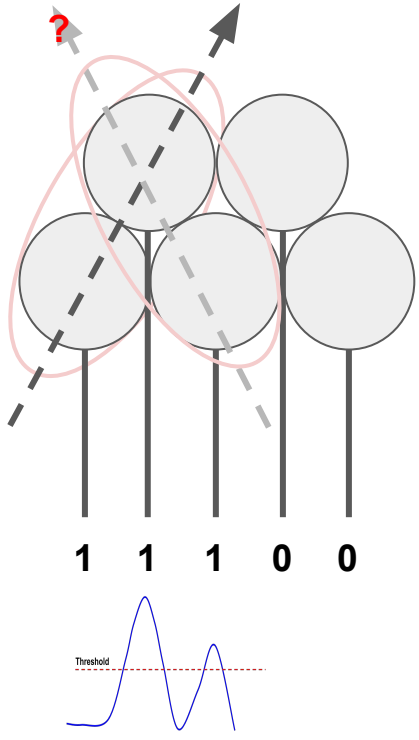


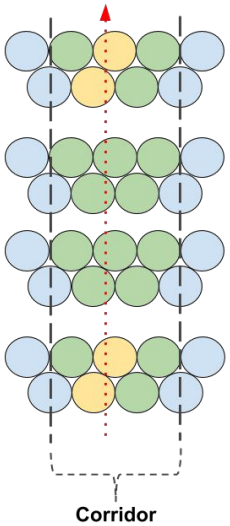


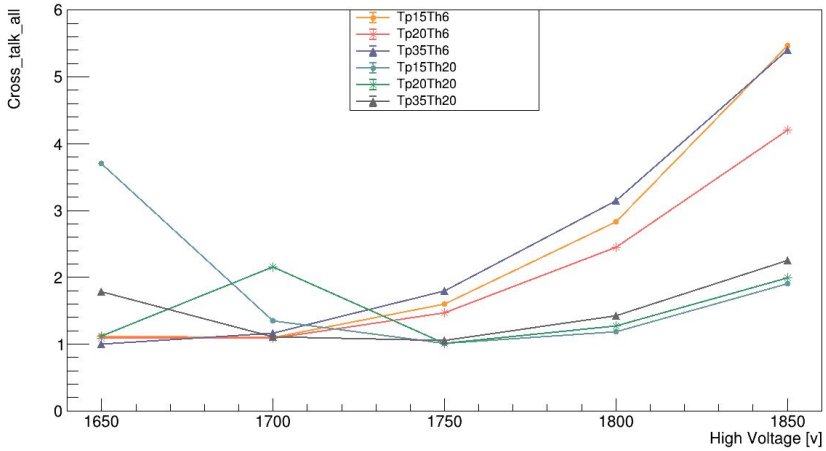


Cross Talk

- Cross talk b/w straws is not observed
- Cross talk b/w electronic channels causes fake hits
- ~1% of tracks in case of FT @ threshold 20 mV
- Corridor width of 5 straws





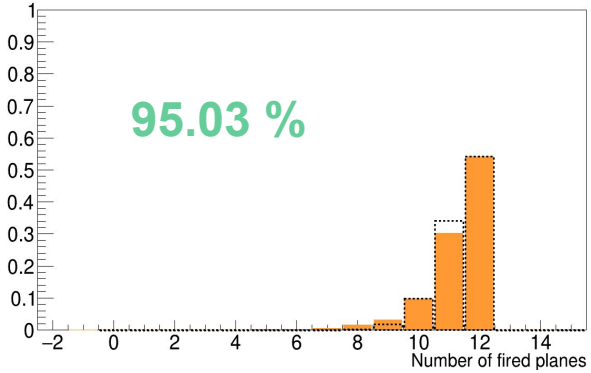


Detection Efficiency

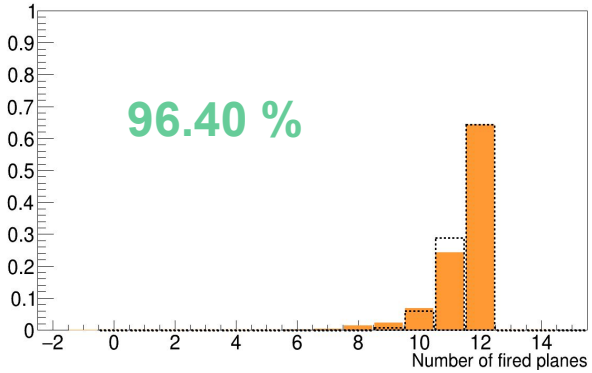
@ Tp 20 ns & Th 6 mV

Data -------- Binomial distribution

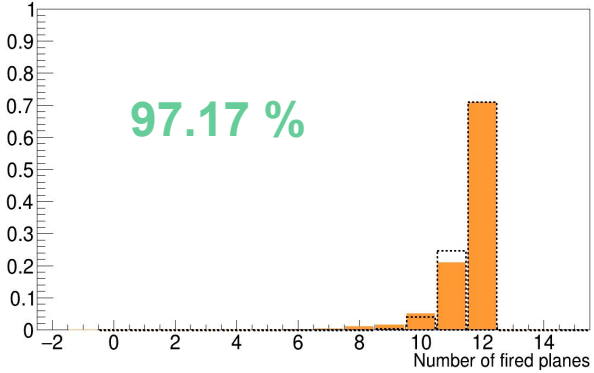
$$P(X) = \frac{n!}{(n-X)!\,X!} \cdot (p)^X \cdot (q)^{n-X}$$



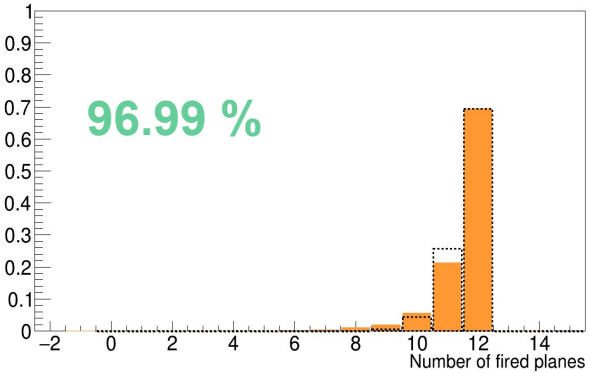
1650 V



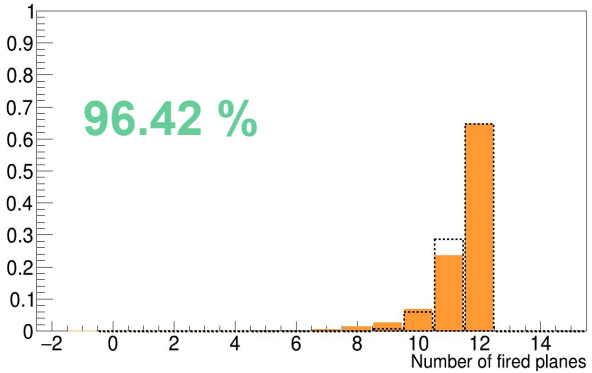
1700 V



1750 V



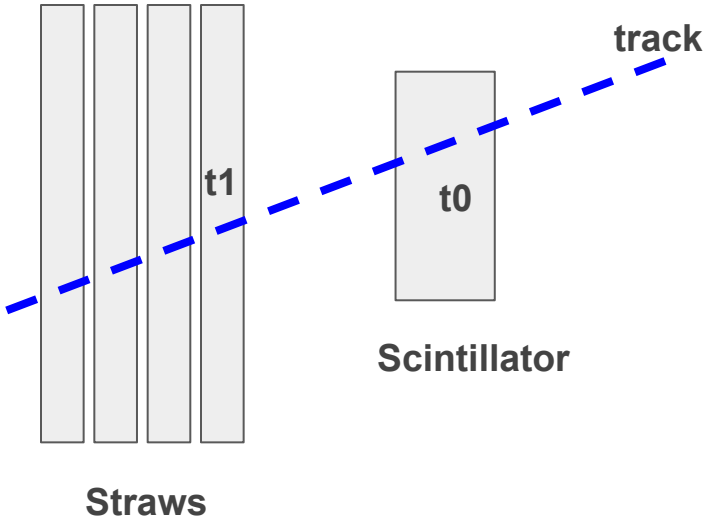
1800 V

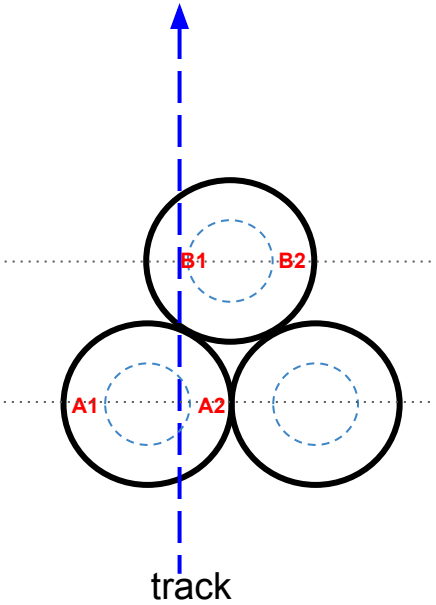


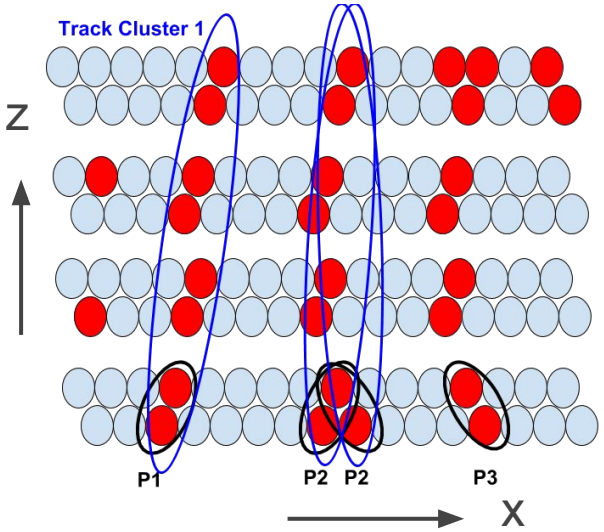
1850 V

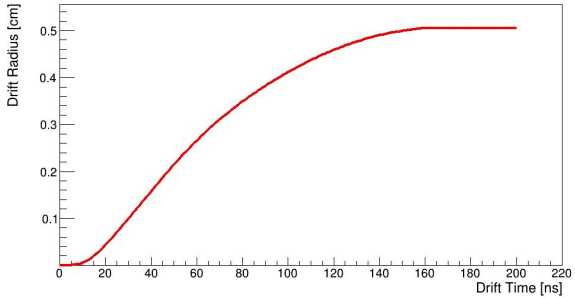
Tracking

- Pair Finding
- Cluster Finding
- Start time from a reference detector
- Left / Right ambiguity



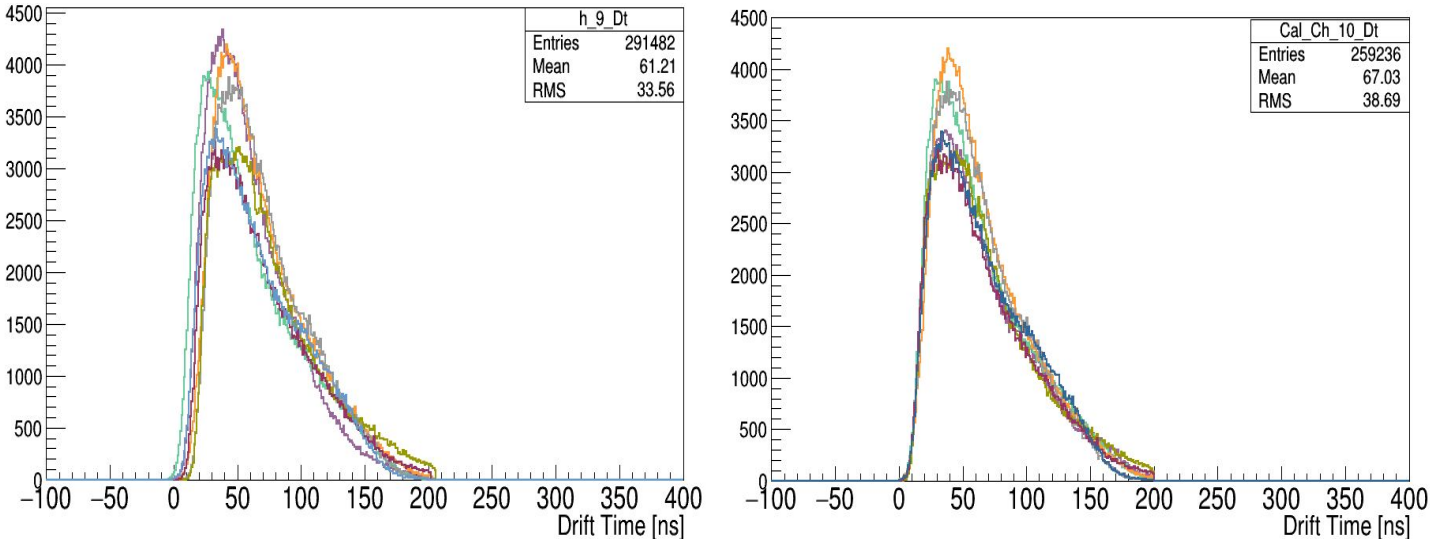






Drift time calibration

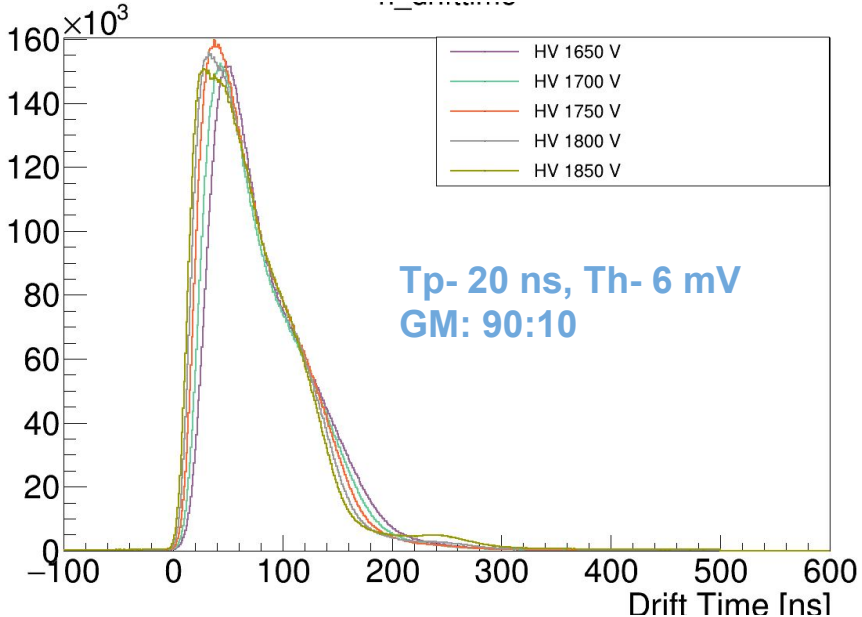
- DT aligned to 1/10 th of max.
- Straw-wise drift time calibration



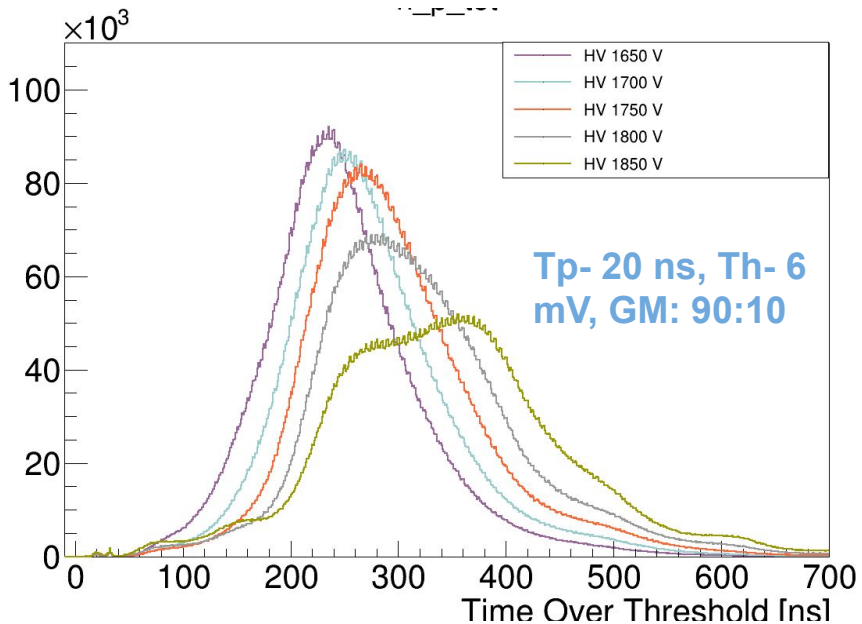
Drift time from 8 channels before calibration (Left) and after calibration (Right).

HV scan : Drift and TOT

- High Voltage : **1650 , 1700 , 1750, 1800, 1850** V
- Peaking Time : 15, **20**, 35 ns
- Threshold : **6** , 20 mV

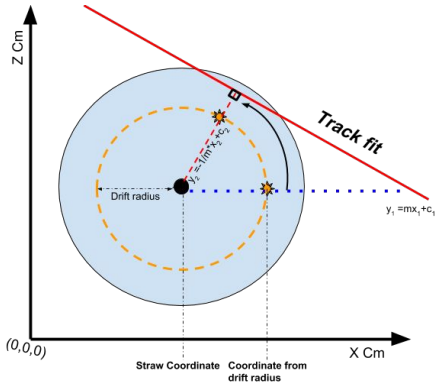


Drift Time @ HV's

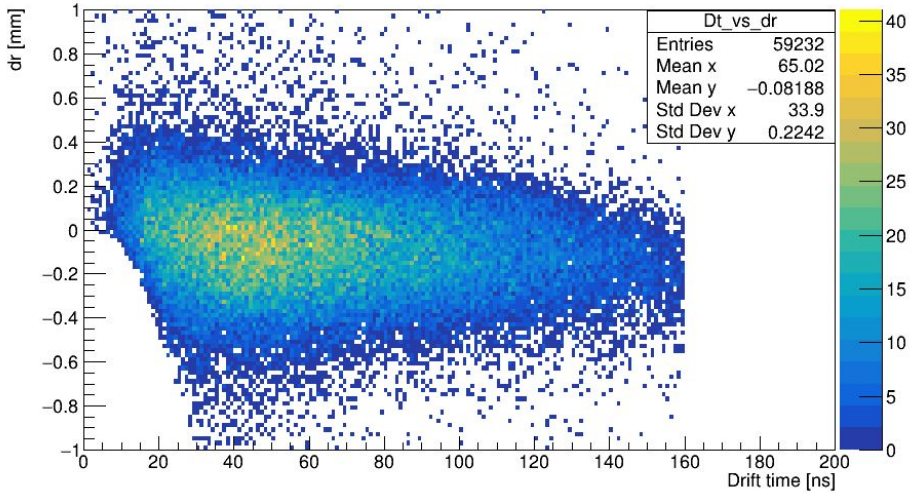


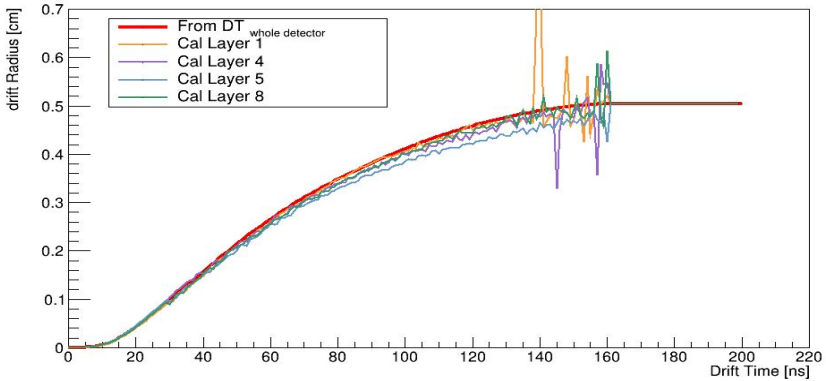
Time Over Threshold @ HV's

Residual vs Drift time



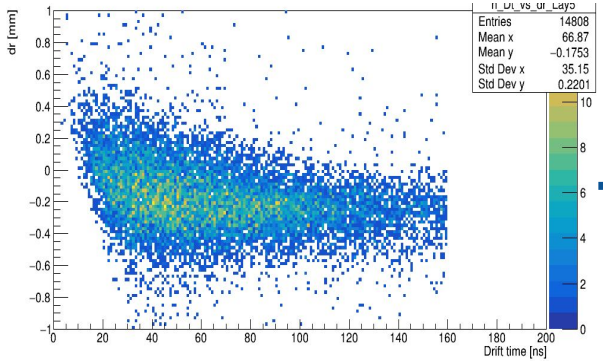
- Position correction for inclined tracks
- Projection from each time bin
- Δx_i - Bin Mean
- Correction Δx_i added to calibration curve
- All of the above done for each layer

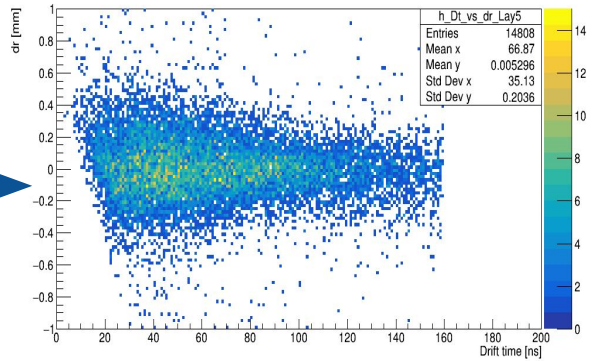


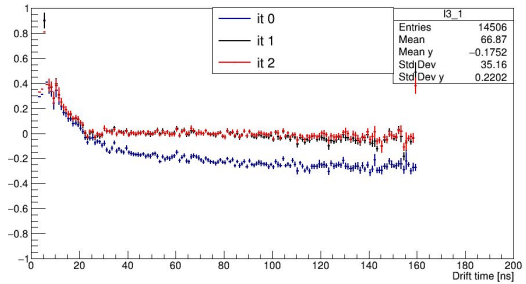


DP Correction

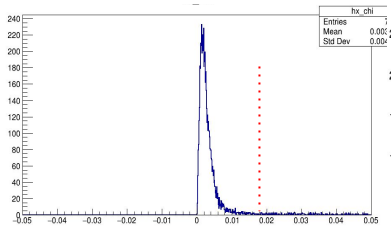
(Ex. Layer 5)

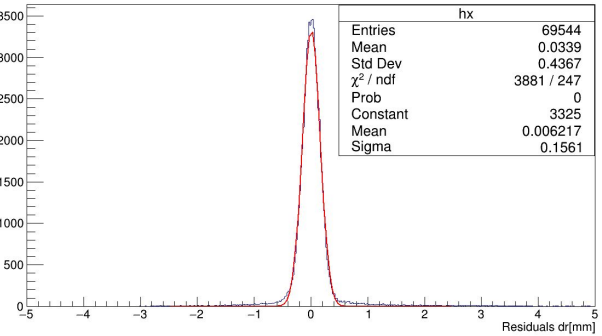






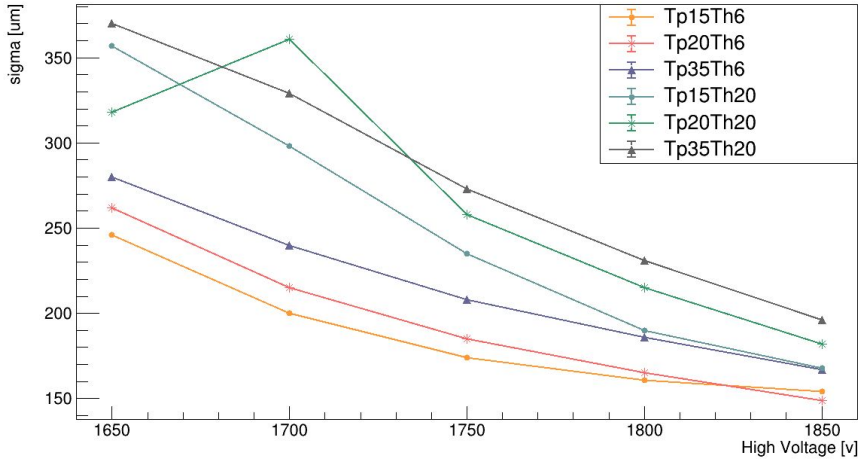
- Corrected over 3 iterations
- Over 35um of gain in resolution
- *Chi*^{2} filter

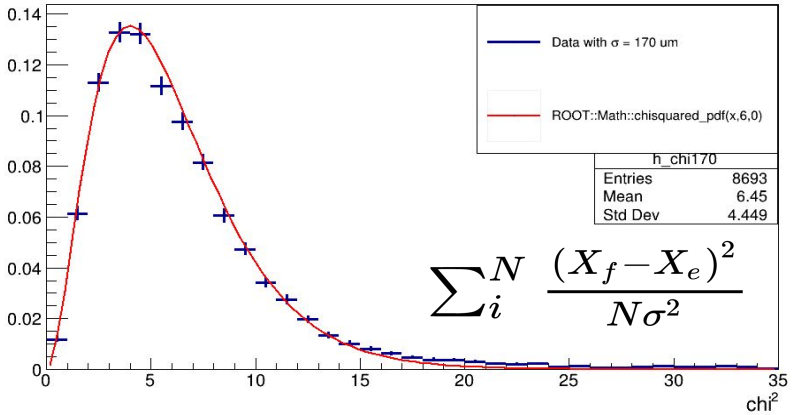


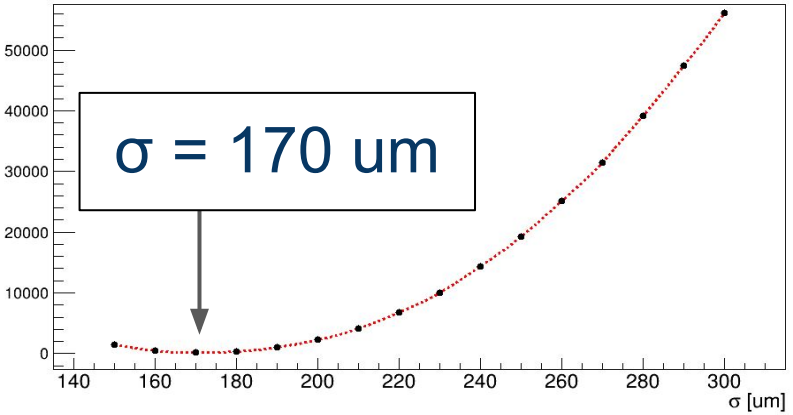


Spatial Resolution

- Resolution in the range of 150 - 370 μm
- σ could be biased by the detector geom.
- σ calculation using *Chi*^{2} test



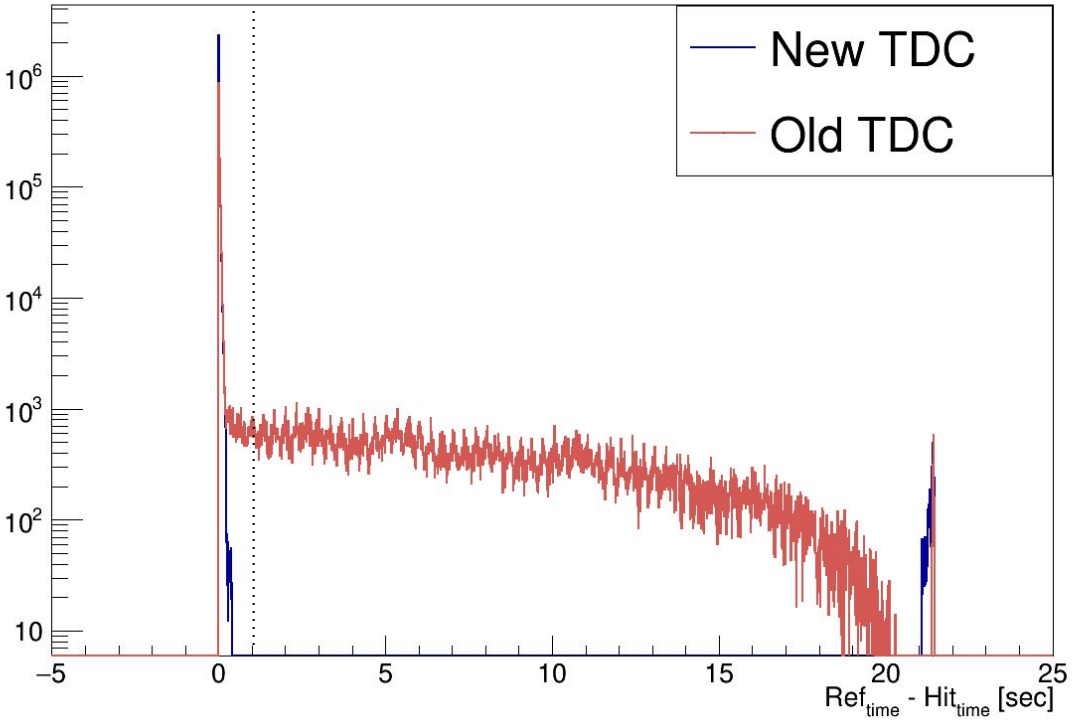




TDC upgrade

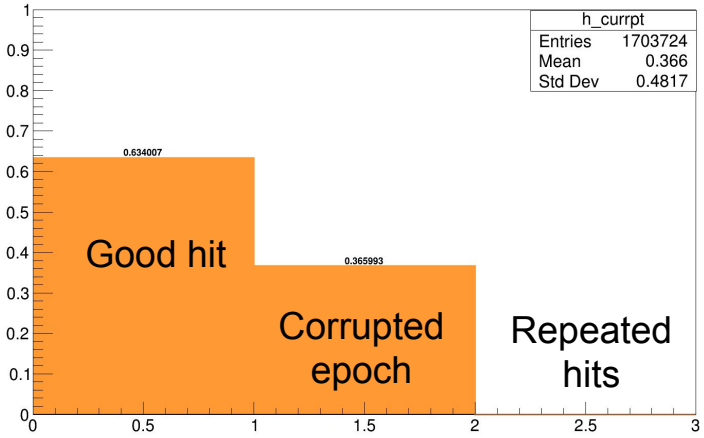
(STS2 full system)

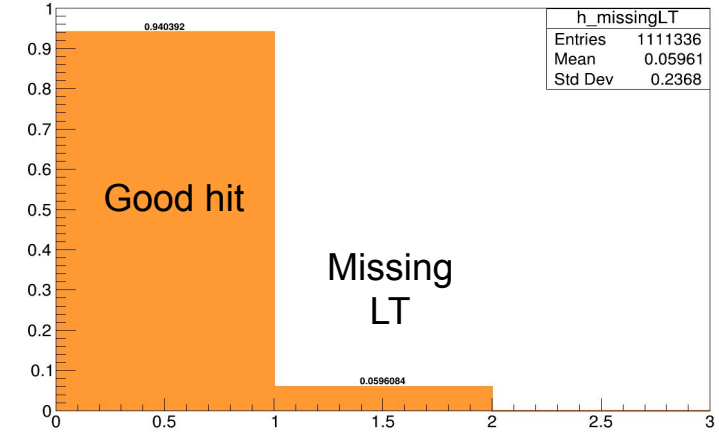
- Cosmics data
- Triggered by scintillator @ 20 - 40 Hz



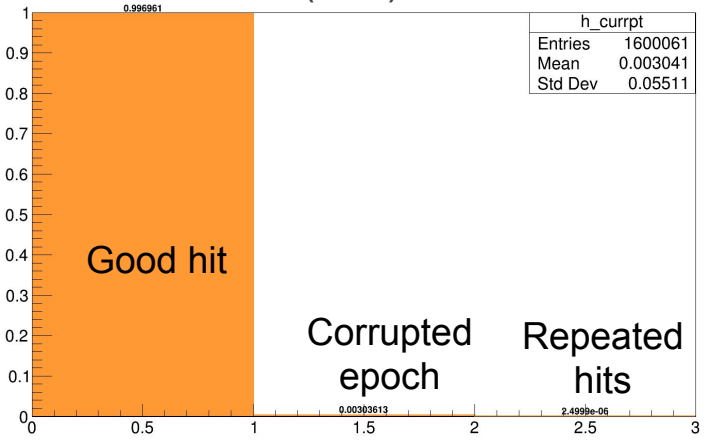
Comparison

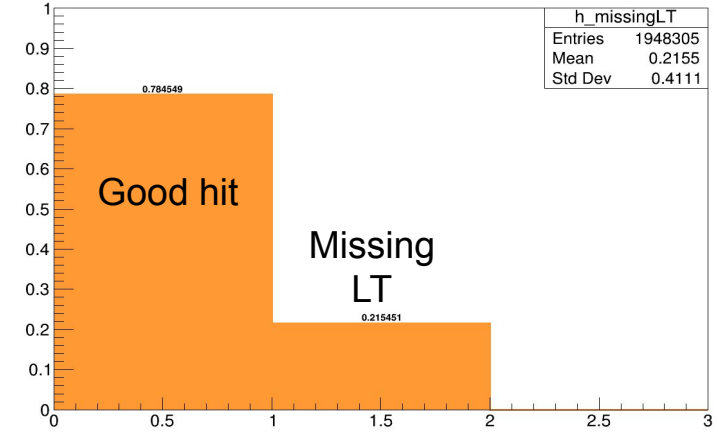
Old TDC
(2015)





New TDC
(2019)





Overview

- Detector has been tested for various electronic configurations
- Preliminary track reconstruction has achieved a track resolution of σ ~170 μm
- Full detector has been tested with the cosmics and ^{55}Fe and ^{90}Sn
- Installation of the detector at HADES in Feb 2020

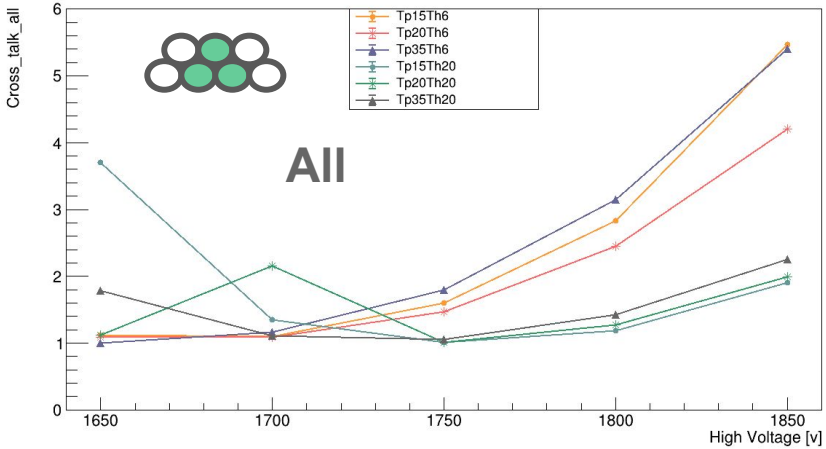
Thank You

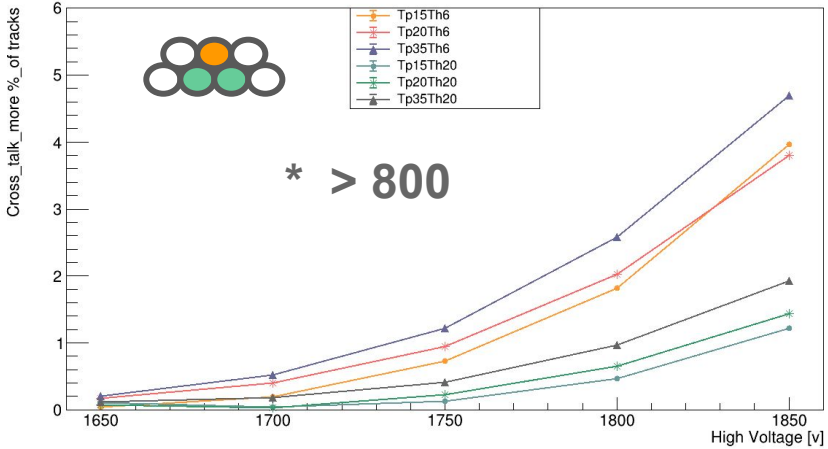
Golden Settings

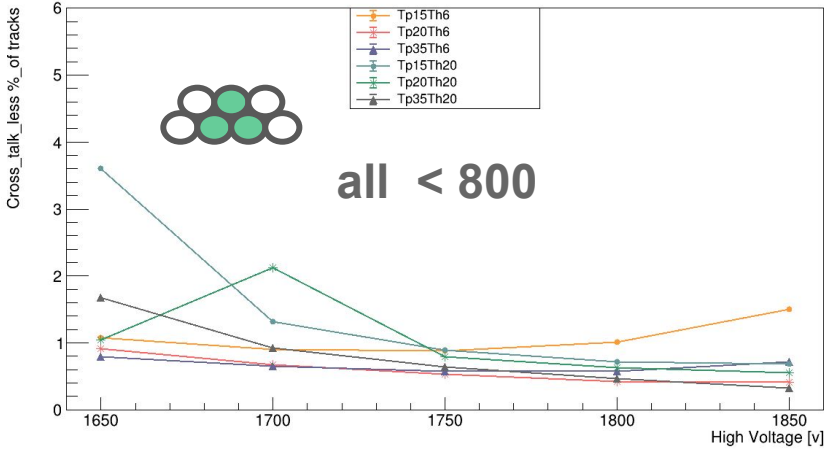
(Dr.Pawel Strzempek)

- **Setting 1 :**
  - Gain 1mV/fC, Peaking time 15ns, TC_{C1} 13.5pF, TC_{R1} 19kΩ, TC_{C2} 1.5pF, TC_{R2} 23kΩ
- **Setting 2 :**
  - Gain 1mV/fC, Peaking time 20ns, TC_{C1} 10.5pF, TC_{R1} 27kΩ, TC_{C2} 0.9pF, TC_{R2} 20kΩ
- **Setting 3 :**
  - Gain 1mV/fC, Peaking time 35ns, TC_{C1} 6pF, TC_{R1} 31kΩ, TC_{C2} 1.65pF, TC_{R2} 23kΩ

Cross Talk


Cross_talk_all
Tp15Th6
Tp20Th6
Tp35Th6
Tp15Th20
Tp20Th20
Tp35Th20
All
High Voltage [v]


Cross_talk_more %_of tracks
Tp15Th6
Tp20Th6
Tp35Th6
Tp15Th20
Tp20Th20
Tp35Th20
* > 800
High Voltage [v]


Cross_talk_less %_of tracks
Tp15Th6
Tp20Th6
Tp35Th6
Tp15Th20
Tp20Th20
Tp35Th20
all < 800
High Voltage [v]

TDC upgrade

- Cosmics data
- Triggered by scintillator @ 20 - 40 Hz