

Straw Tube Trackes readout and FT performance in April beam time

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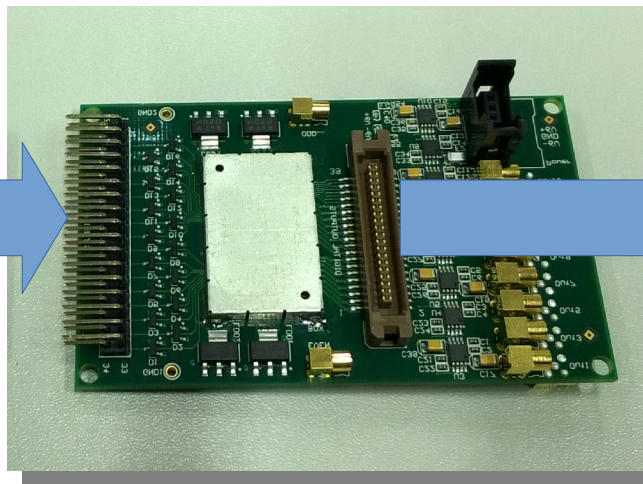
Kraków, 30.01.2017

Plan of presentation

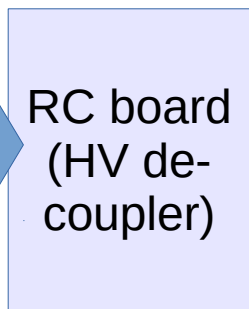
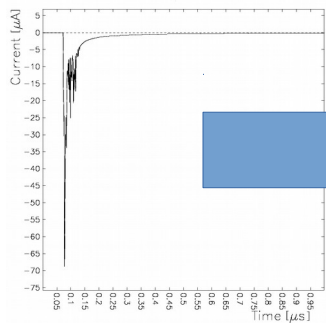
- Readout concept for the Straw Tube Trackers (PASTTREC and TRBv3)
- Results for the FT operation in the proton beam
- Readout architecture based on the TRBv3

Front end electronics - PASTTREC

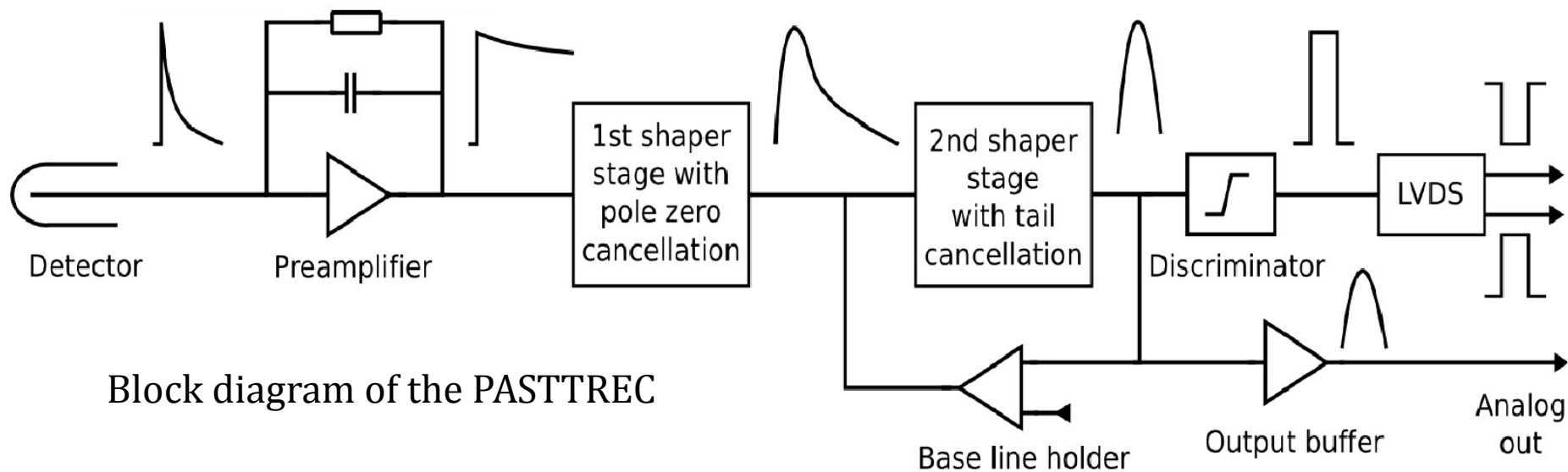
Front end electronics PCB



Straw tube signal



Digital signal

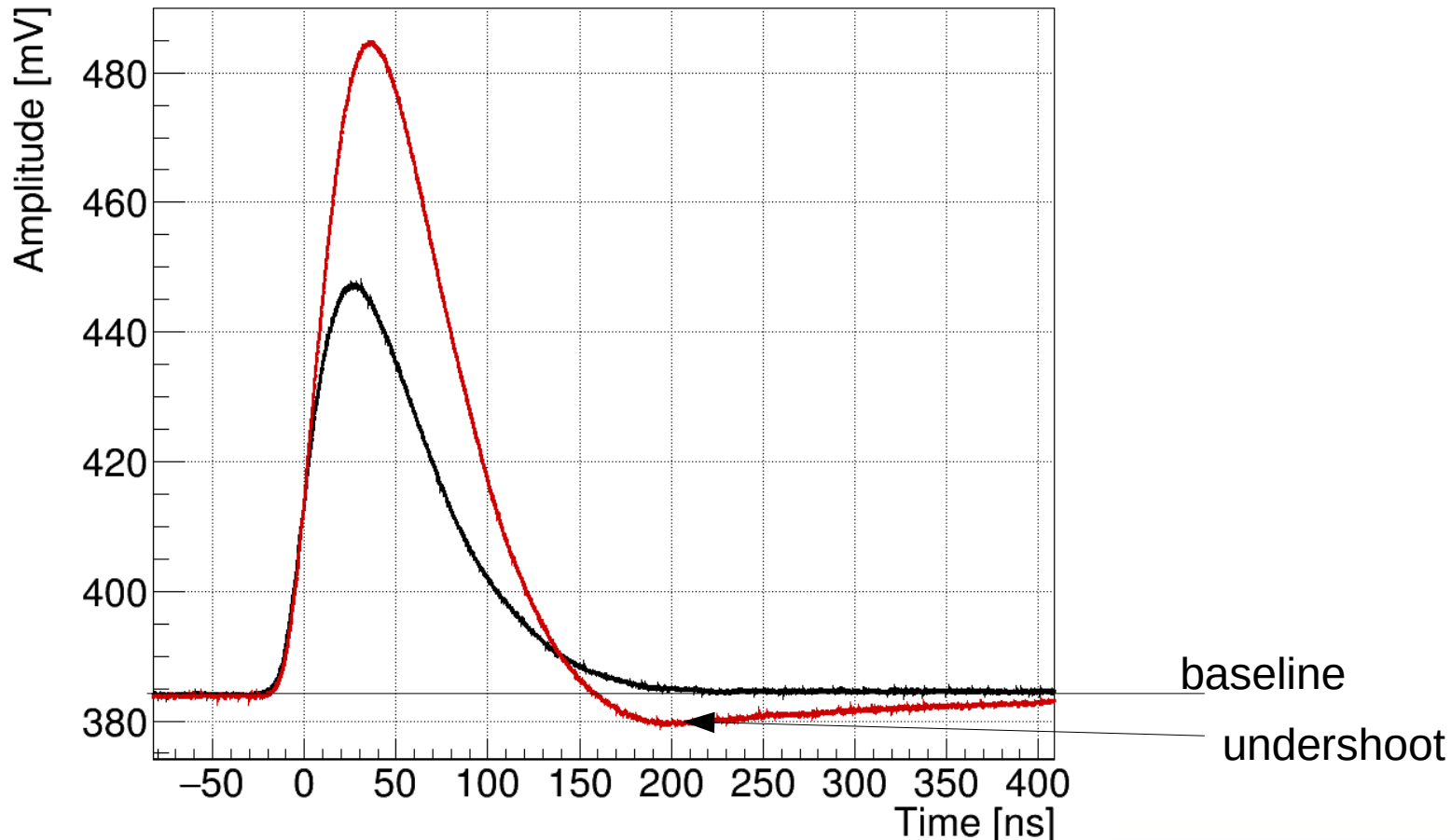


Block diagram of the PASTTREC

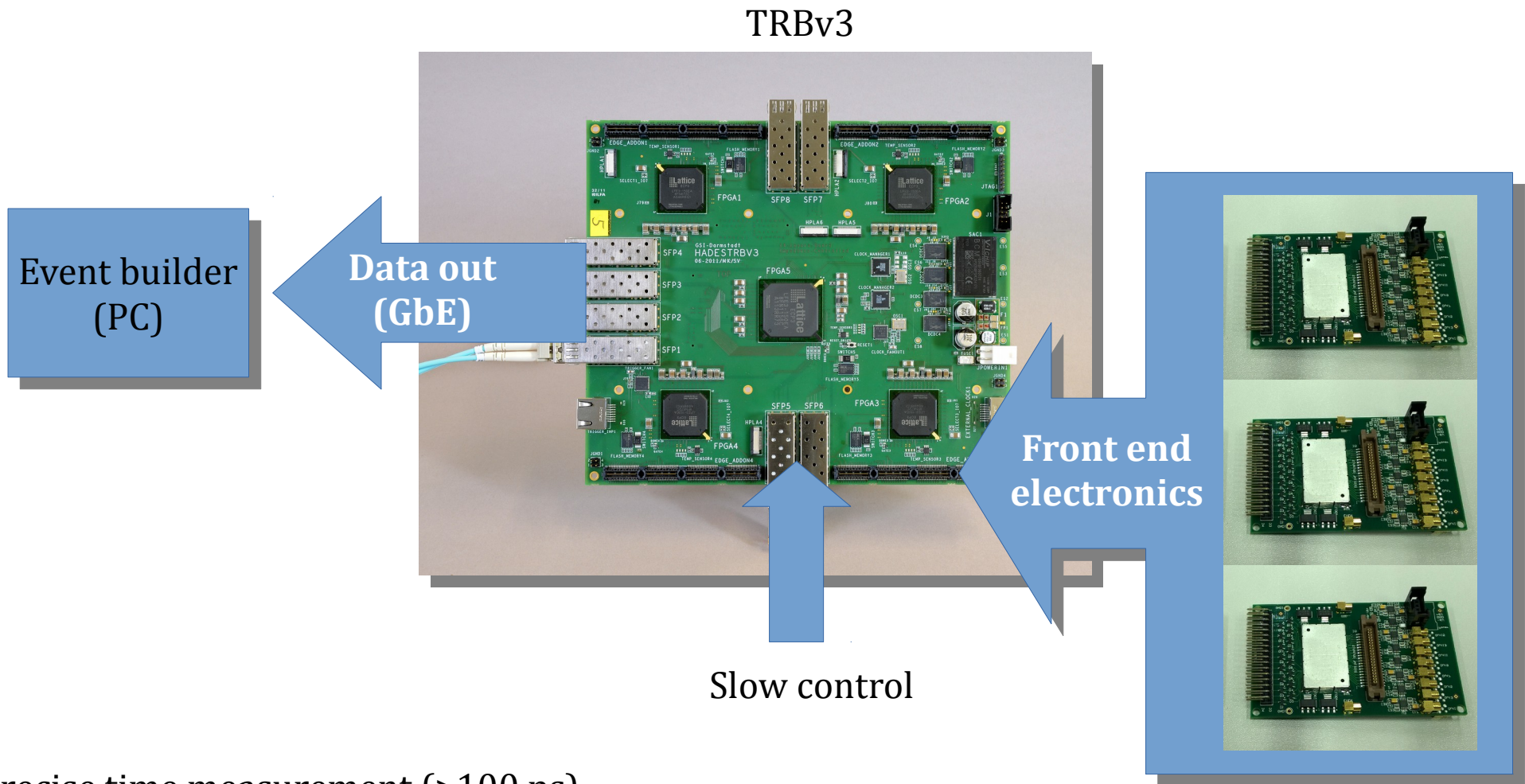
PASTTREC = amplification, shaping and discrimination.

PASSTREC configuration

- The total amount of all settings for the PASTTREC is 65536 (gain, peaking time and tail cancellation).
- For the gain = 1 and 2 mV/fC and peaking time 15, 20 and 35 the optimal tail cancellation settings found.



TRBv3 – readout platform



- Precise time measurement (>100 ps).
- 192 TDC channels.
- Time of arrival and TOT measurement.

TRBv3 – readout platform

Slow control of the PASTTREC integrated with the TRBv3 system.

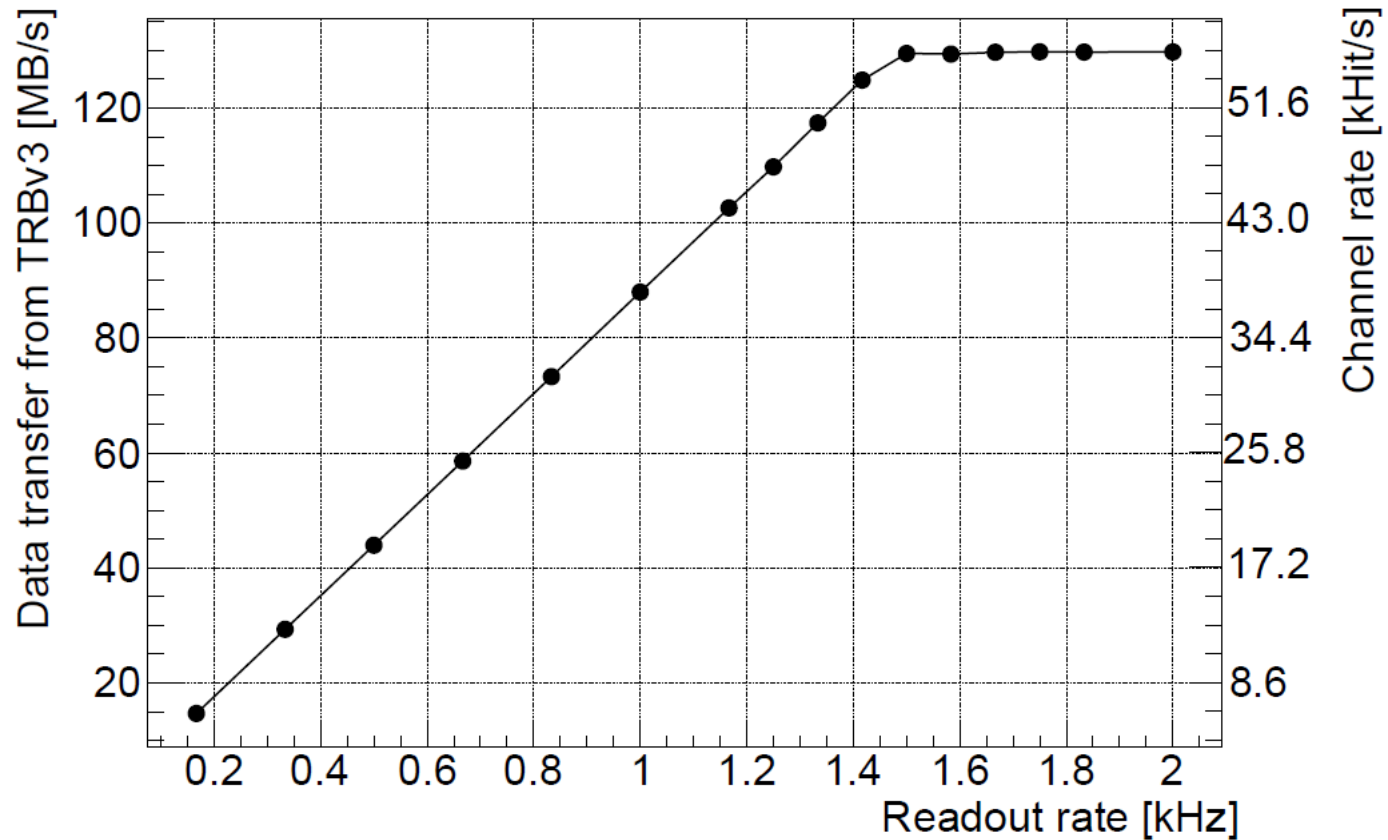
The screenshot displays the TRBv3 software interface, which is used for the slow control of the PASTTREC system. The interface is divided into several sections:

- Threshold Settings ver 3.1:** This section contains configuration options for the TDC (Time-to-Digital Converter) and cable connections. It includes a 'Configuration' section with a 'TDC addr' field (set to 'e000,e001') and a 'Configuration file' field (set to 'Choose File'). Below this are buttons for 'create', 'save settings as', 'Reset', and 'send settings to ASICs'. There are also 'Select all' and 'Apply to all' buttons.
- TDC-e000:** This section shows checkboxes for 'Cable conn-1' through 'Cable conn-4' and 'Asic-1' through 'Asic-2'. Below this are checkboxes for 'Cable conn-1' through 'Cable conn-4' for each ASIC.
- Parameter Tables:** Two tables show parameters for 'TDC-e000 Cable-1 Asic-1' and 'TDC-e000 Cable-1 Asic-2'. Both tables have the same values: Amplification [mv/fC] = 0.67, Peaking time [ns] = 35, TC1C2.0 [pF] = 16.5, and TC1R2.0 [kΩ] = 31.
- File Browser:** A file browser window shows the directory structure of the analysis. The 'Pavel' directory is selected, showing sub-directories for 'Pavel_Ref1D', 'Pavel_Ref2D', and 'Pavel_Tot2D'.
- Analysis Terminal:** A terminal window shows the command 'Pavel Time over threshold 11:43:25 2016-05-17 Analysis/Histogram'.
- Histogram Plot:** A 2D histogram plot shows the distribution of 'tot.ns' (total time) on the y-axis (ranging from 0 to 1000) versus an x-axis (ranging from 0 to 140). The plot shows three distinct peaks at approximately x=20, x=50, and x=80, indicating the time over threshold for different channels.
- Log Window:** A log window at the bottom shows the system's activity, including the initialization of the analysis and the start of the client function.

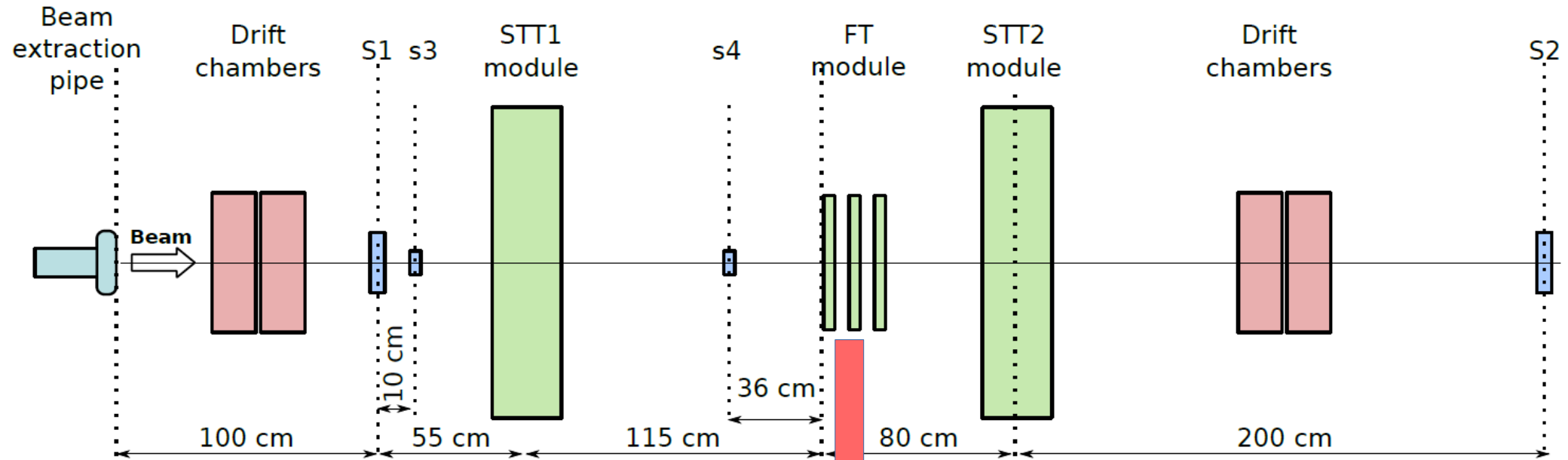
TRBv3 is delivered with the software for data unpacking and online QA – go4.

TRBv3 – performance

- 35 hits between consecutive triggers (read requests)
- 55 kHits/s/channel with all channels equally loaded.



In beam measurement



FEE

TRBv3

PC

In beam measurement

Collected data sets:

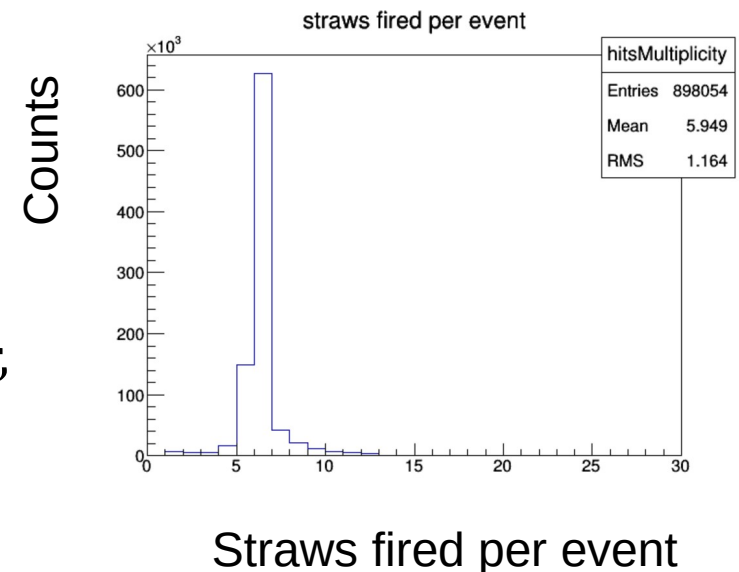
- 3 different PASTTREC settings (1 gain and 3 different peaking times)
- 2 different high voltages (1700 and 1800 V)
- 4 different thresholds (10, 20, 30, 40 mV)

Measurement conditions:

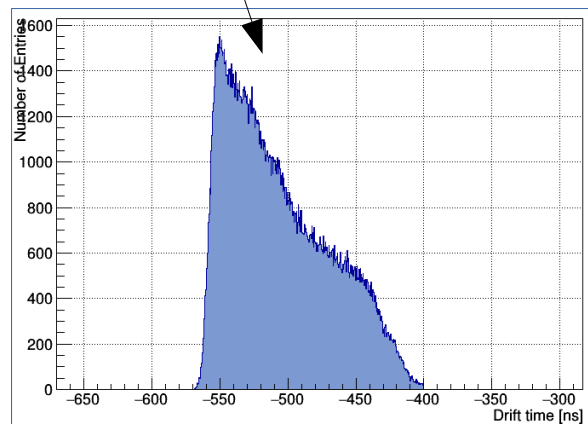
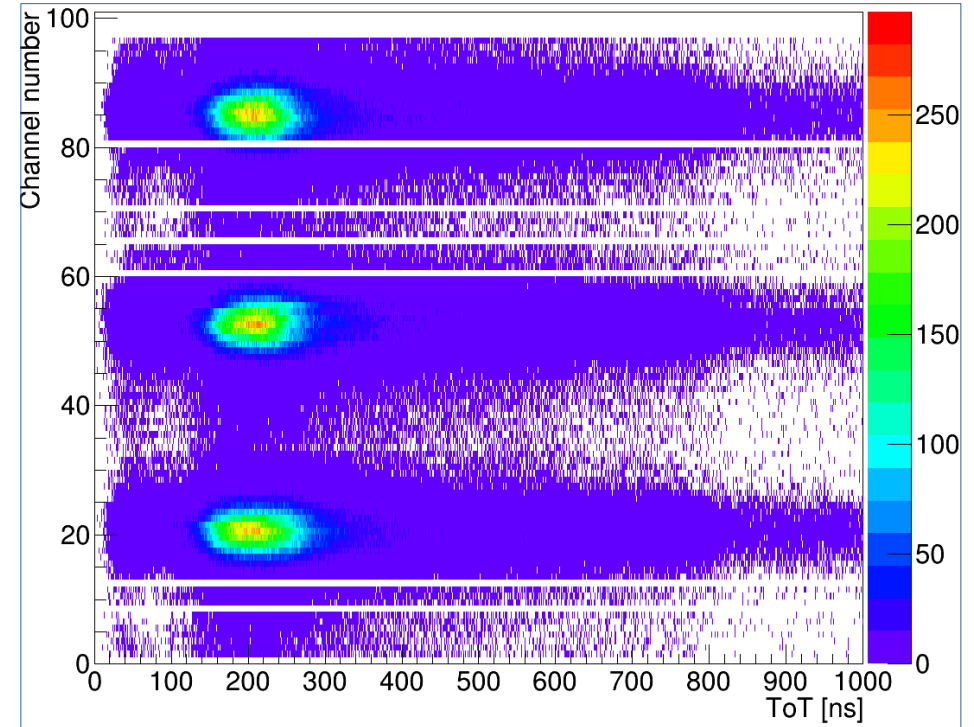
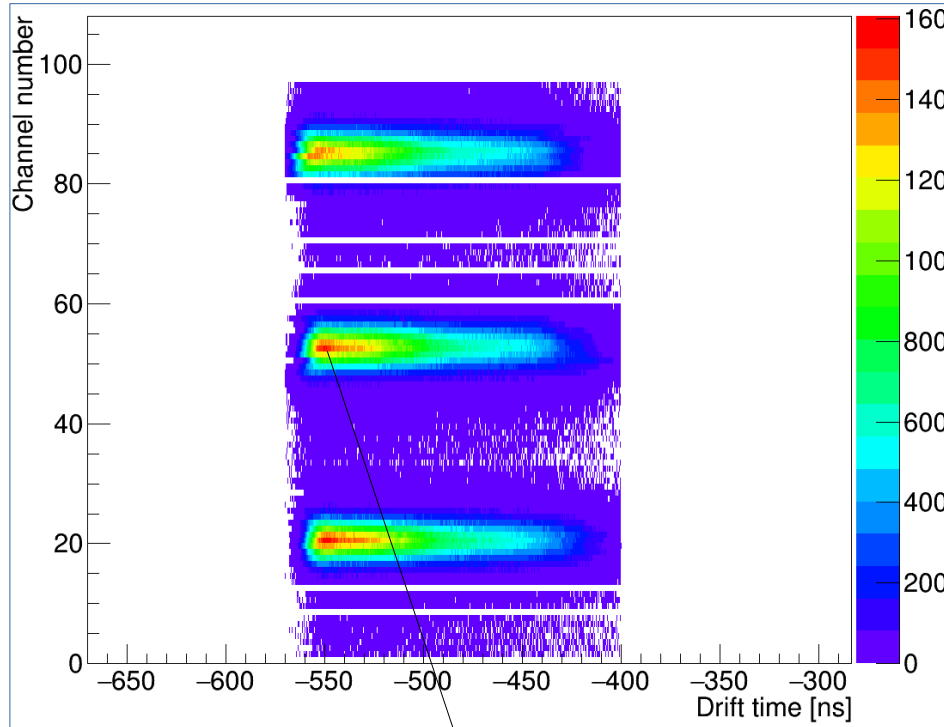
- 6 FEBs and one single TRBv3,
- Baseline tuning of the PASTTRECs done with the beam,
- Standard gas mixture was used (Ar/CO₂ 90:10)
- Trigger with S1

Data analysis conditions

- Gain = 1 mV/fC, peaking time = 15, 20 and 35 ns, HV 1800V and threshold 10 mV were taken.
- Time window on the hits was applied.
- Drift time to radius calibration with uniform illumination method was performed.
- Drift time offsets elimination (different cable length compensation) was done.
- Data filtration (events with exactly one hit per layer selected – 6 hits per events) was performed.
- Track finding:
 - Prefit to the center of straws using TlinearFitter,
 - Fit to the drift radius using TMinuit,
 - Criteria for successful track finding : $\text{Chi}2/(\text{degree of freedom}) < 10$.



Drift time and TOT spectra (750 MeV)



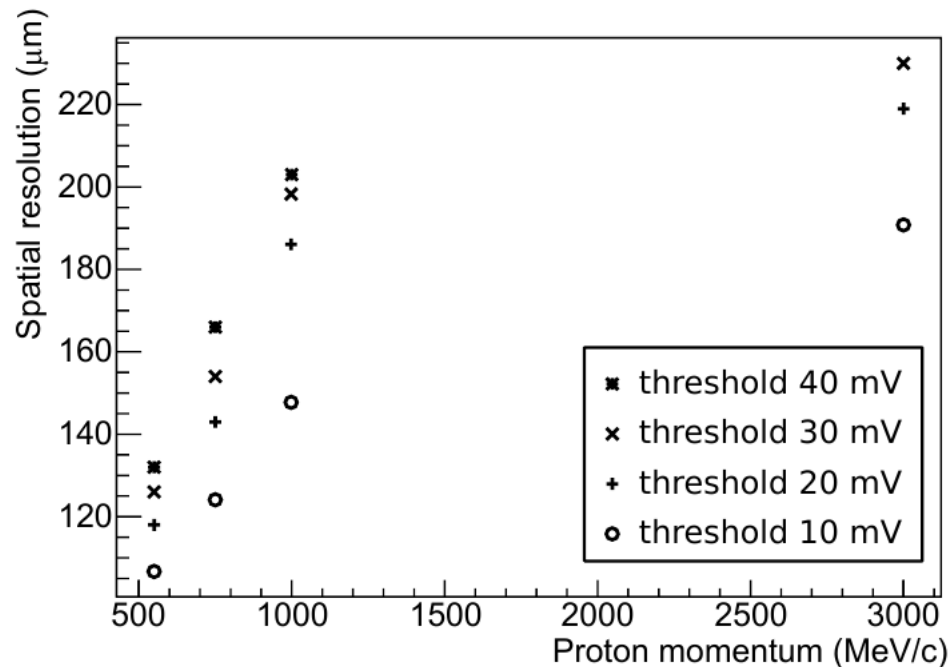
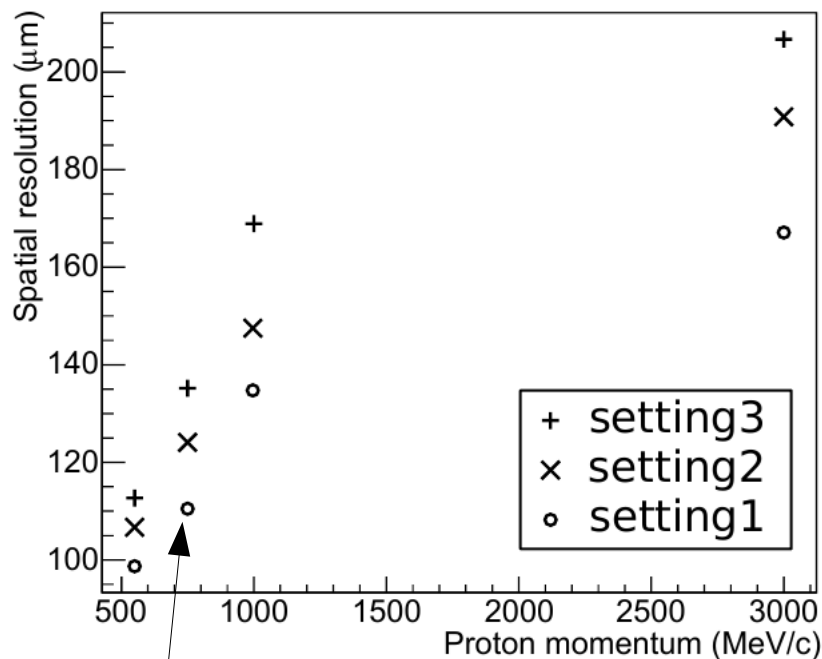
On the drift time spectrum one can see the hits correlated with the trigger signal. The TOT spectra have similar distribution over channels (uniform baseline).

Very low threshold (10mV!).

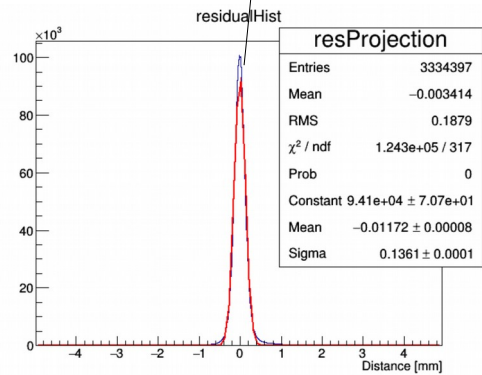
Spatial resolution

Setting1 = Gain 1mV/fC, 15 ns peaking time
 Setting2 = Gain 1mV/fC, 20 ns peaking time
 Setting3 = Gain 1mV/fC, 35 ns peaking time
 Threshold = 10 mV

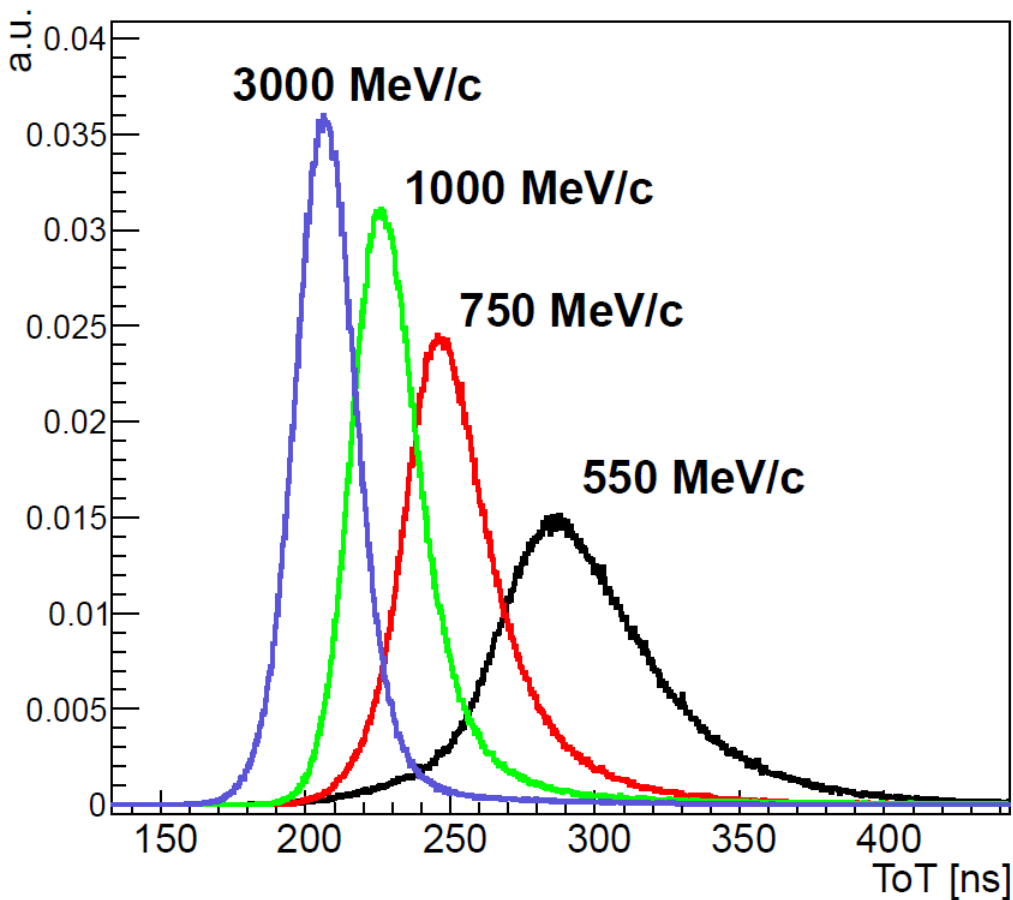
Threshold = 10 mV, 20 mV, 30 mV and 40 mV
 Setting2 = Gain 1mV/fC, 20 ns peaking time



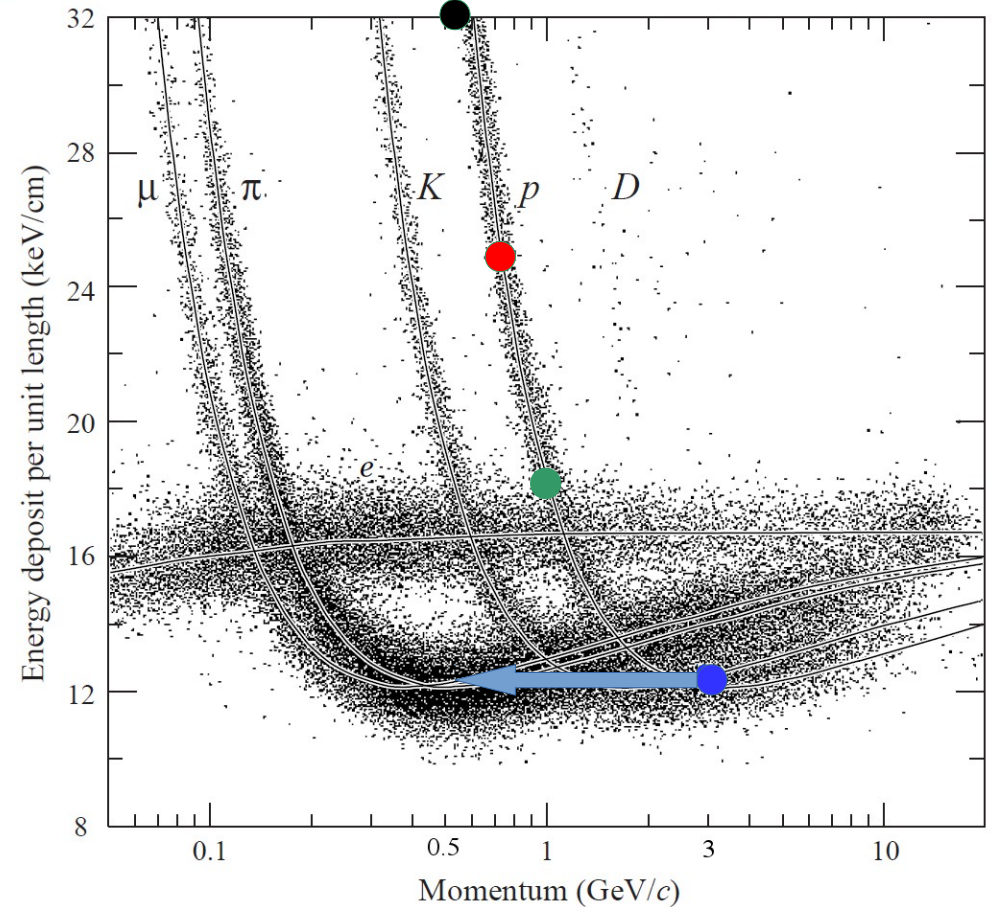
Sigma of residual distribution



Energy loss measurement



TOT truncated mean 20 %.



Energy loss for different particles.

Source: K. Olive and P. D. Group, "Review of particle physics", Chinese Physics C, vol. 38, no. 9,

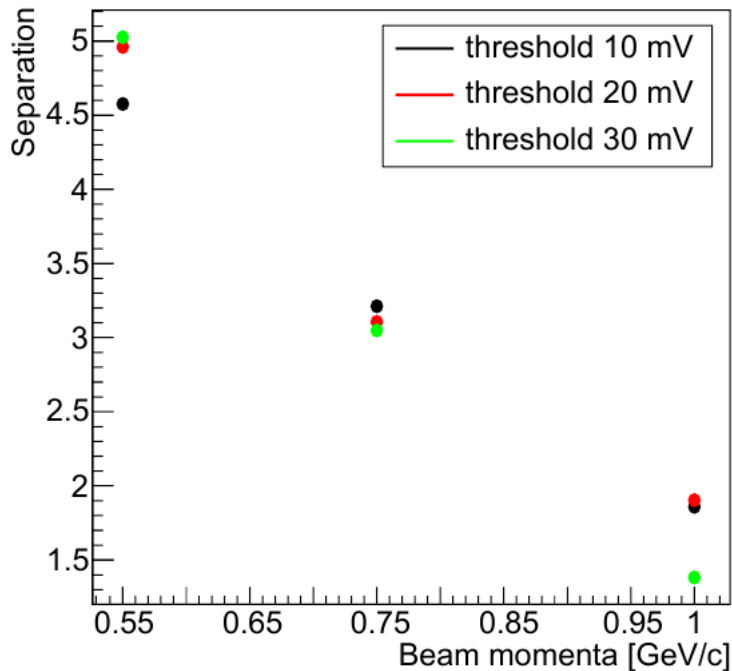
Correction of the TOT values for dependence on r and then calculation of the truncated mean.

Separation power

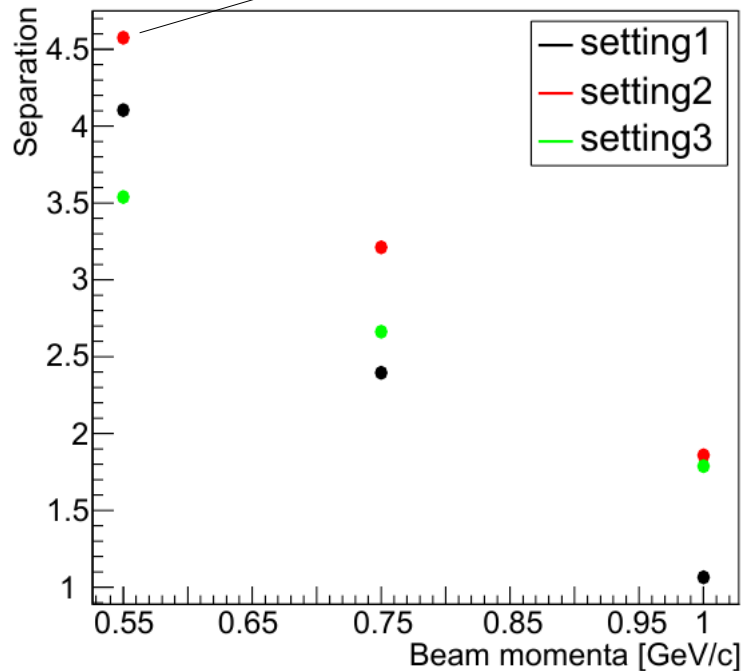
$$sep = \frac{ToT 1 - ToT 2}{(\Delta ToT 1)/2 + (\Delta ToT 2)/2}$$

Separation power calculated with respect to protons $p = 3 \text{ GeV}/c$.

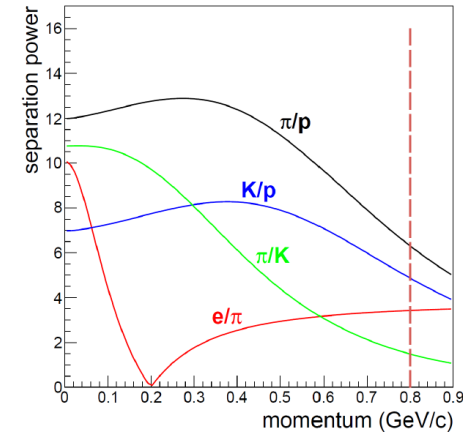
STT TDR simulation for proton ($p = 550 \text{ MeV}/c$)
pion ($p = 550 \text{ MeV}/c$)
returns separation ≈ 10 .



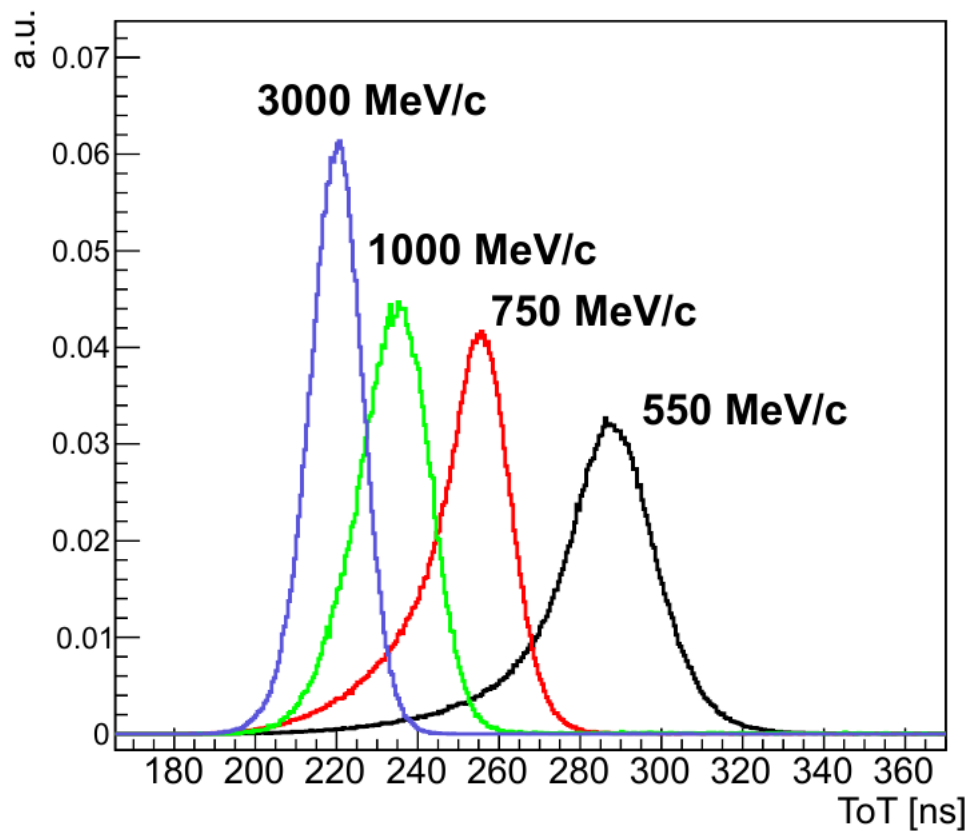
Threshold dependence



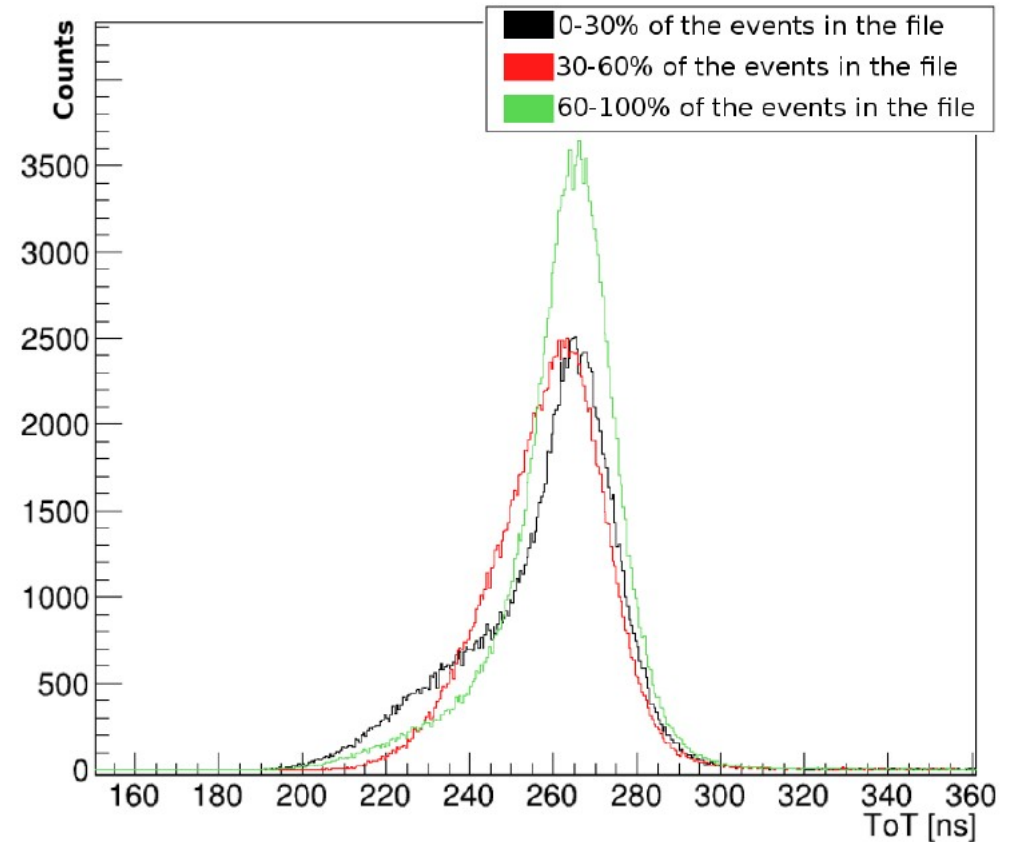
Peaking time dependence



Quick look at the STT

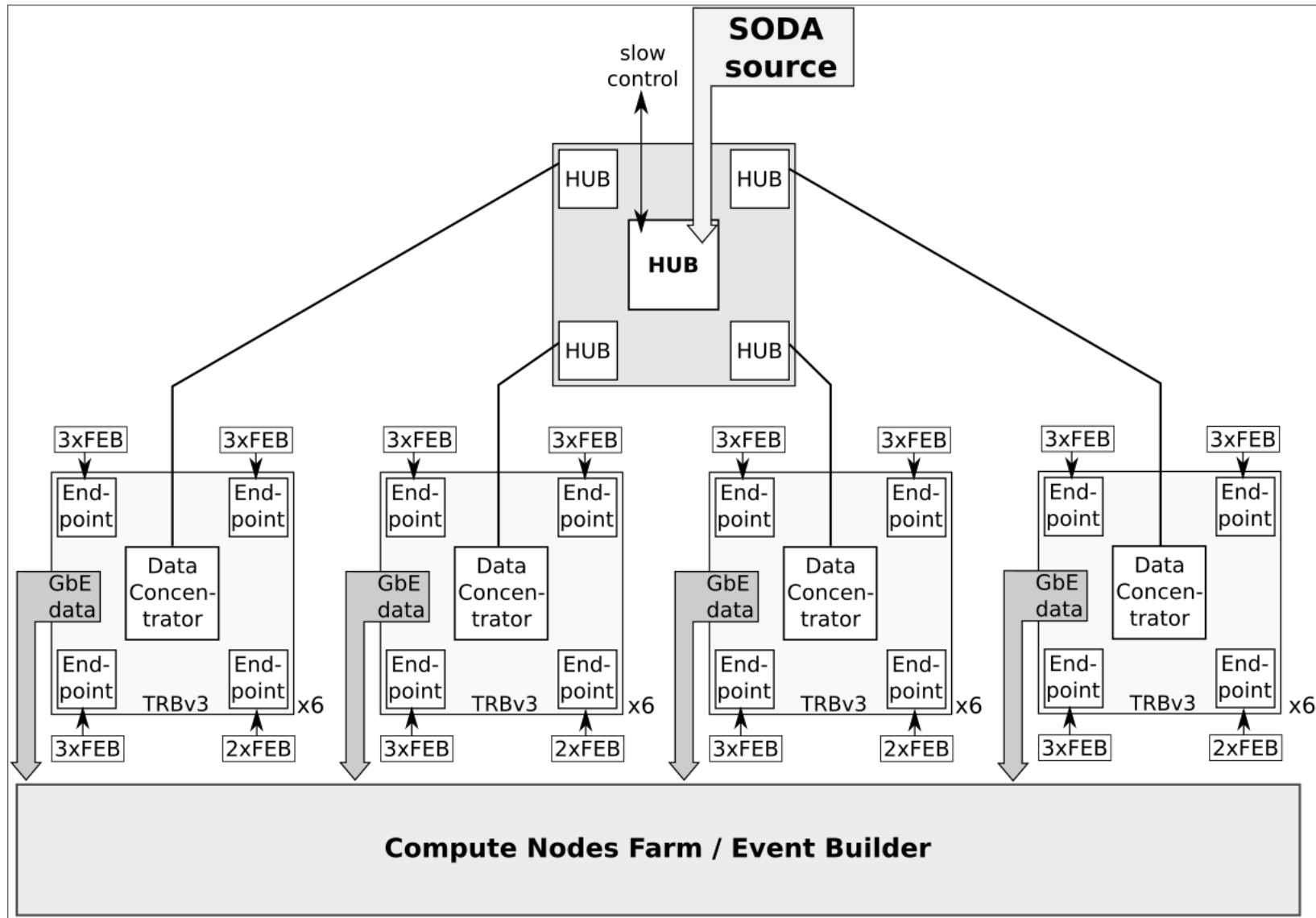


TOT truncated mean 40 %.
Long tails towards short TOTs.



Measuring conditions not stable?

Straw Tube Trackers Readout with TRBv3



System architecture

Limitations and solutions

	STT	FT
Number of channels	4224	12224
Hit rate (High Resolution Mode - HRM)	90 kHz/straw	35 kHz/straw
Hit rate (High Luminosity Mode - HLM)	0.9 MHz/straw	0.35 MHz/straw
Number of TRBs required for HRM	$4224/176 = 24 + 1$ TRBs	$12224/176 = 64 + 4$ TRBs

Solutions:

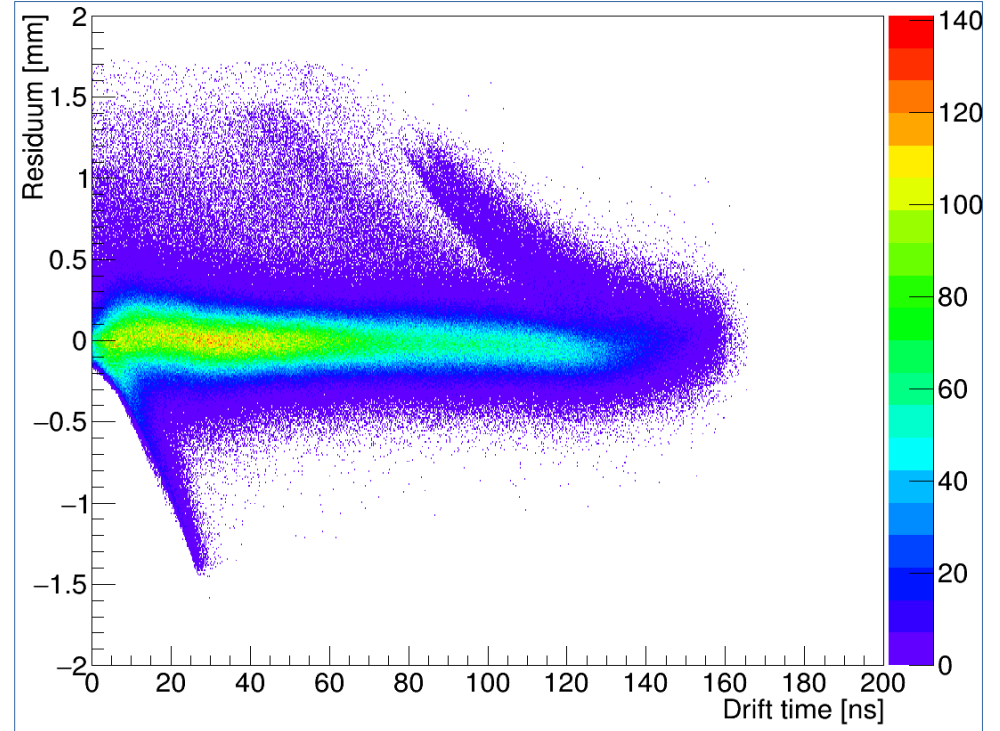
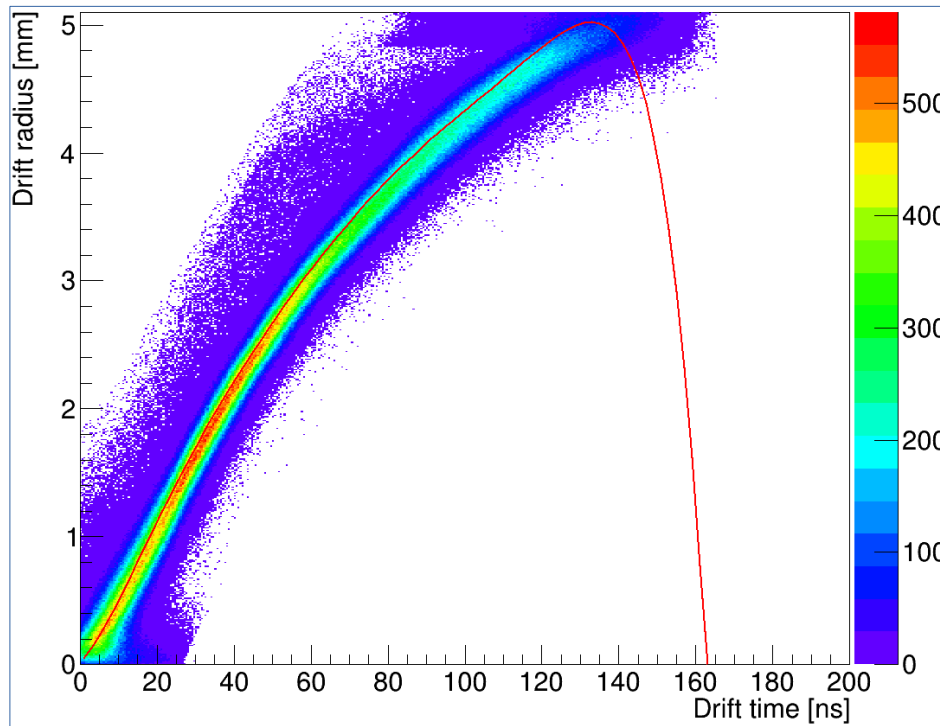
- Implementation of the low resolution TDC (500 ps)
- Changing data format of the TDC word
- Need of new hardware platform

Summary

- Readout of the straw tubes based on PASTTREC and TRBv3 was presented.
- Requirements for spatial resolution achieved. As expected, resolution strongly depends on primary electron detection.
- PID based on TOT is possible, separation power depends on settings. Threshold dependence seems to be weak.
- TRBv3 suitable for the HRM but not good enough for HLM.

Back up

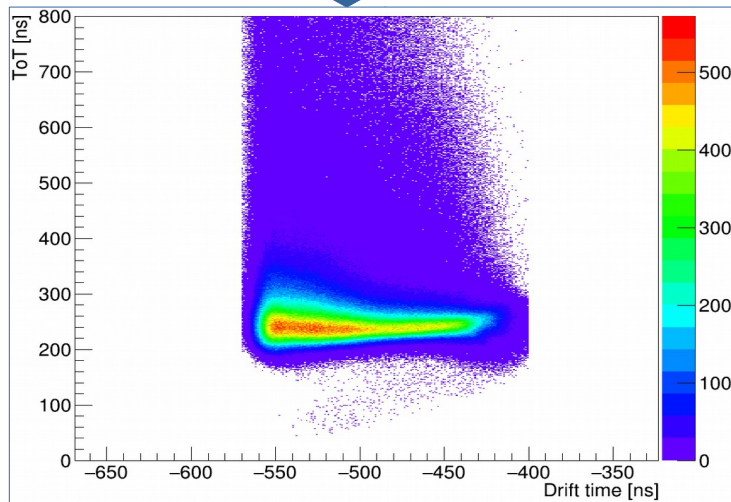
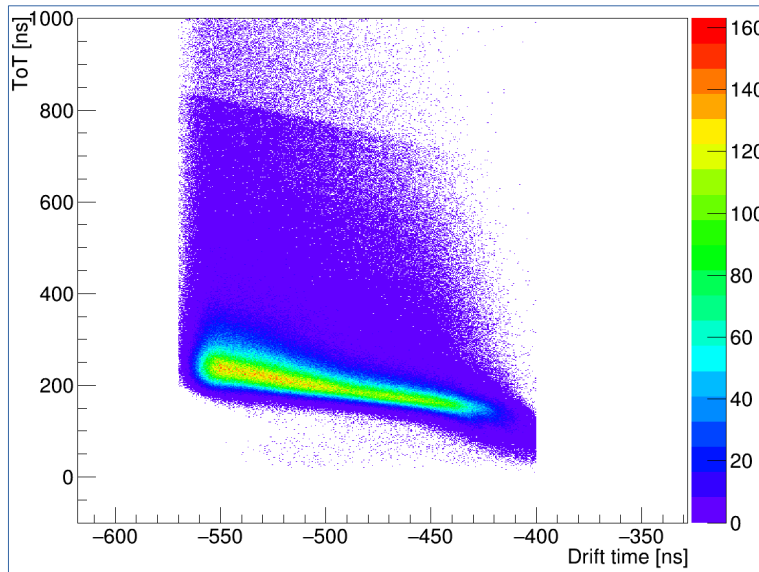
The drift time to radius calibration was done with the uniform illumination method.



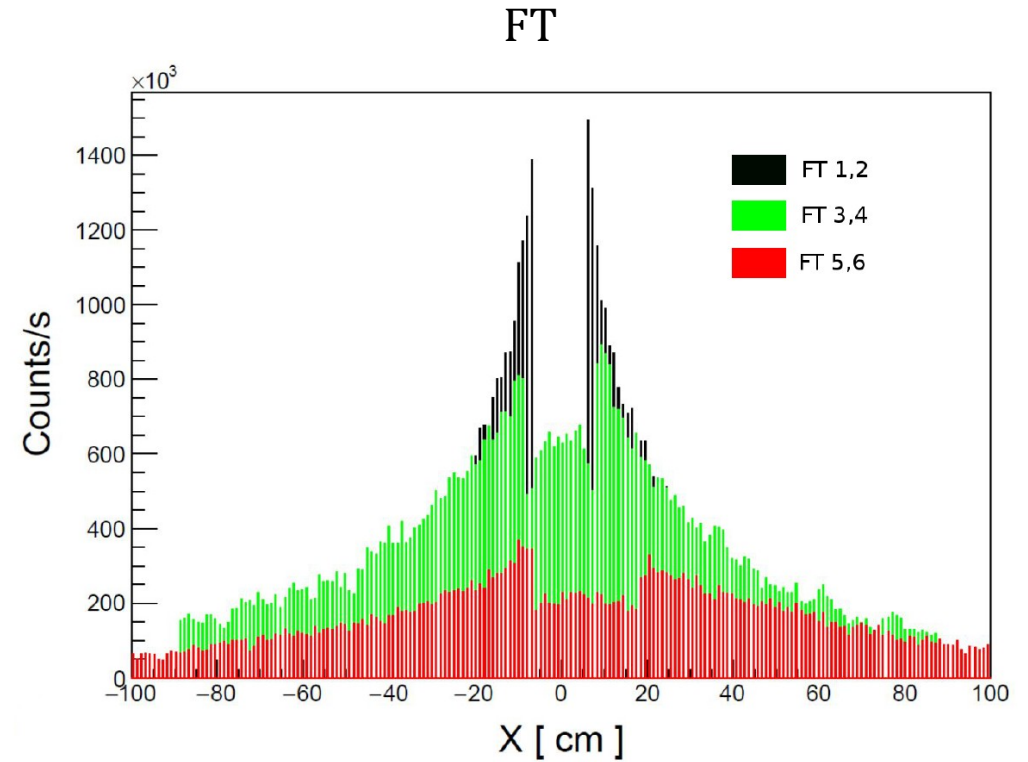
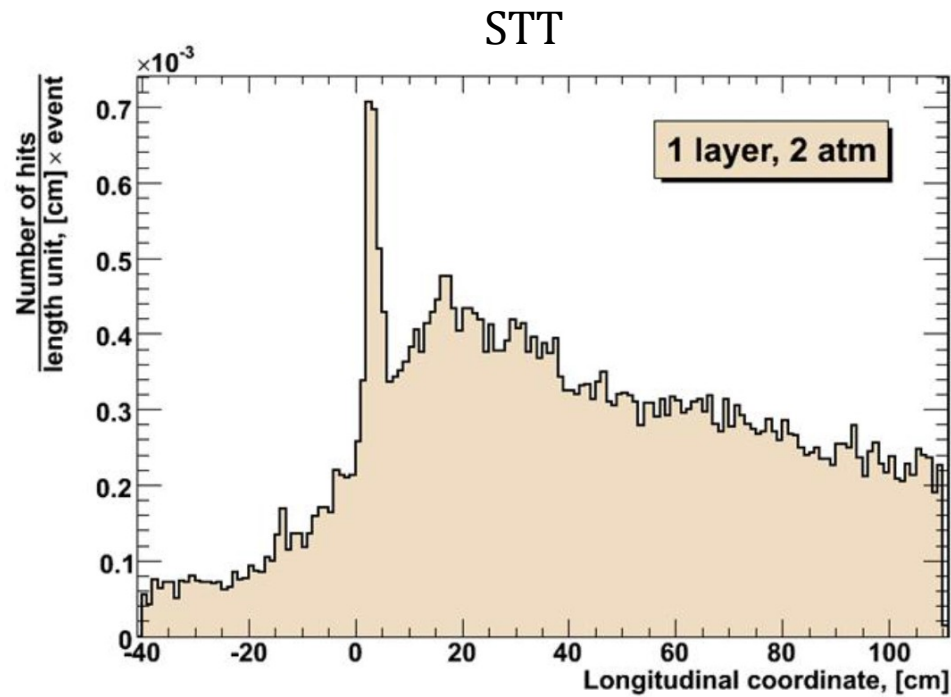
Back up

Correction of TOT for r dependence

FT 750 MeV



Back up



Average hit rates:

STT = 0.9 Mhz/straw in high luminosity mode

FT = 0.35 Mhz/straw in high luminosity mode