VMM3a-based Readout Solution for SPD-NICA Straw Tracker



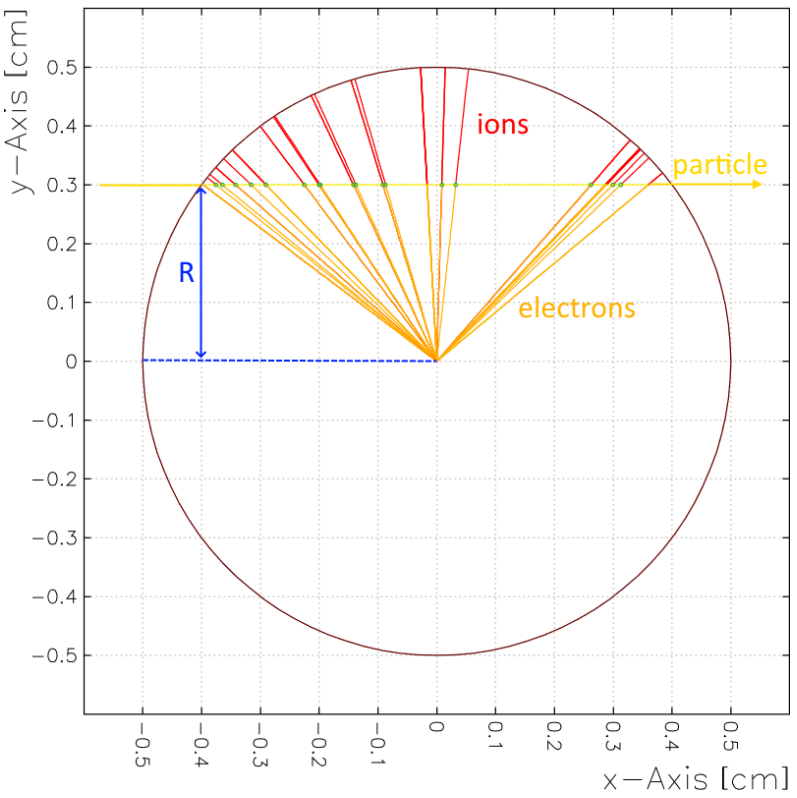


Speaker: Vitaly Bautin
on behalf of Straw Tracker Team

AYSS-2026, Tashkent

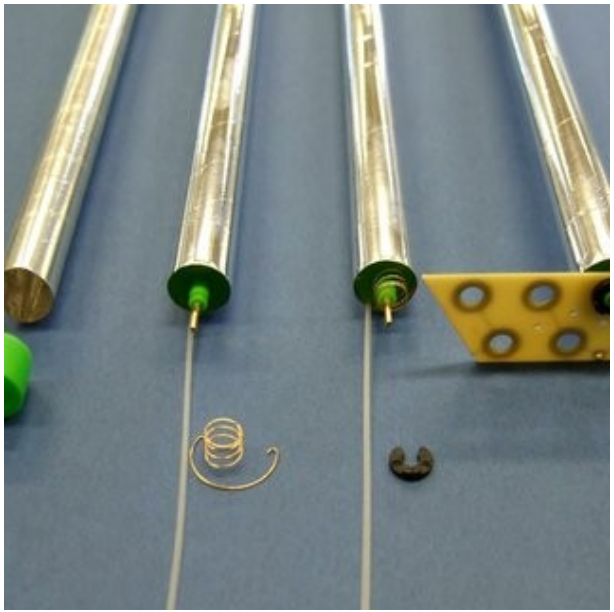
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What is the Straw Tracker?



Track coordinates are reconstructed on the measured signal arrival time defined by the drift time of primary electrons from the track to the anode wire.

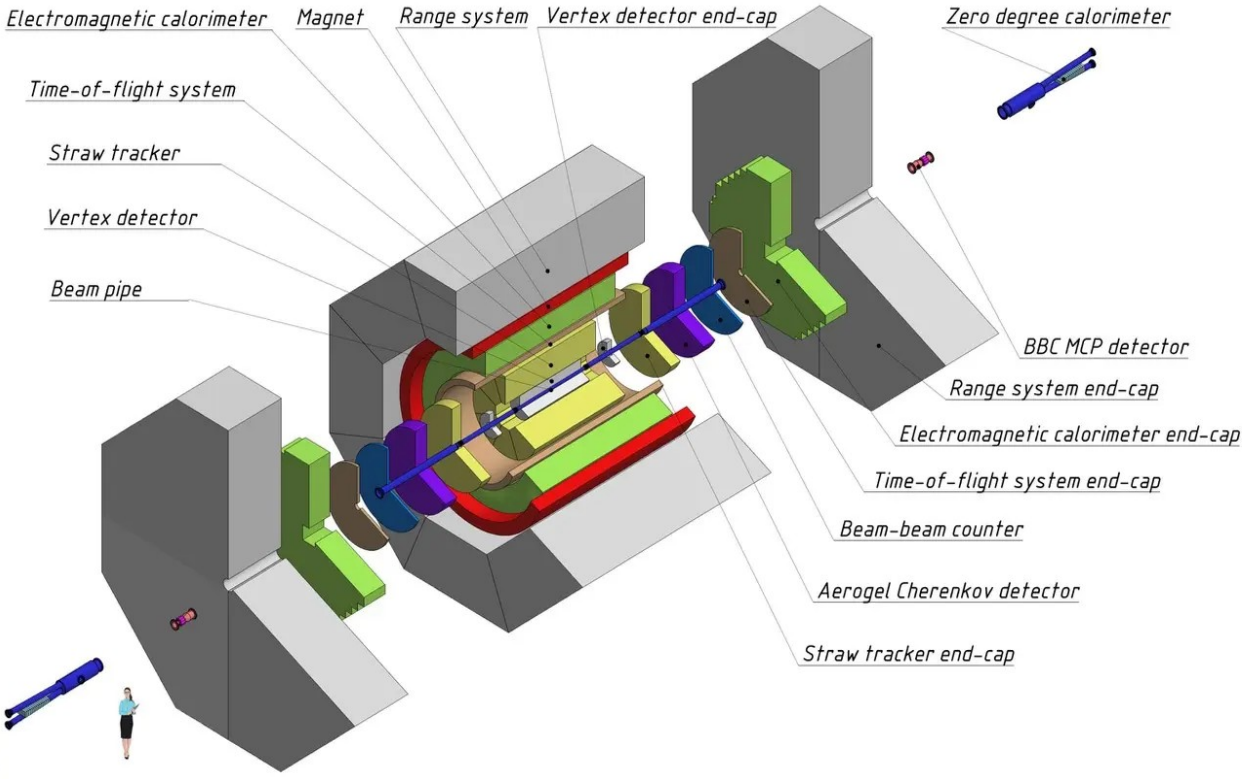
The drift time $\boldsymbol{time_{drift}}$ is measured as a difference between the time when a particle crossed the straw and the time of straw signal crossing a low threshold.



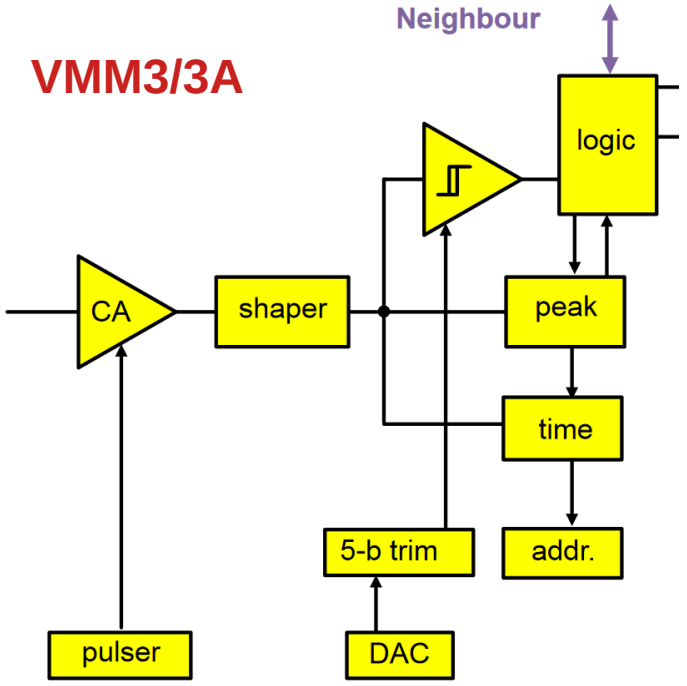
Motivation:

- 30k+ channels
- 150um spatial resolution
- dE/dX charge resolution
- Simultanious Charge & Time measurements

A dedicated R&D is ongoing to study the possibilities for STT Front-End Electronics (FEB).



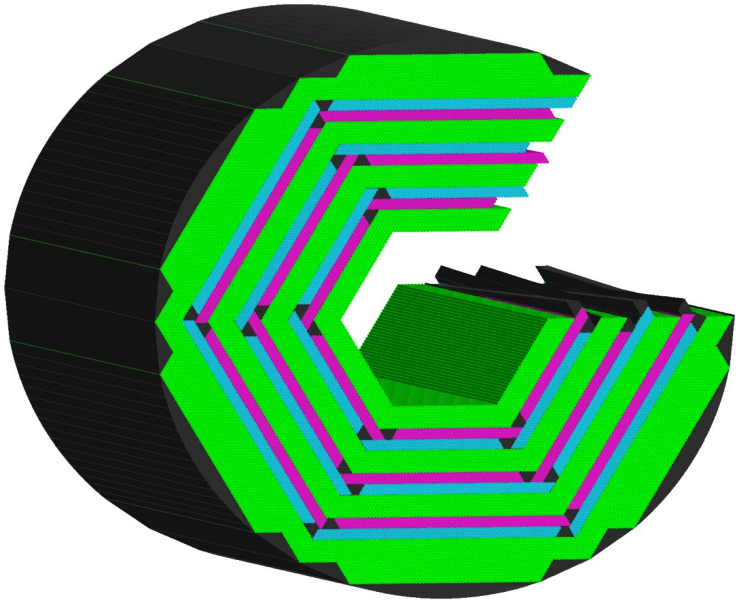
Investigating existing readout solutions

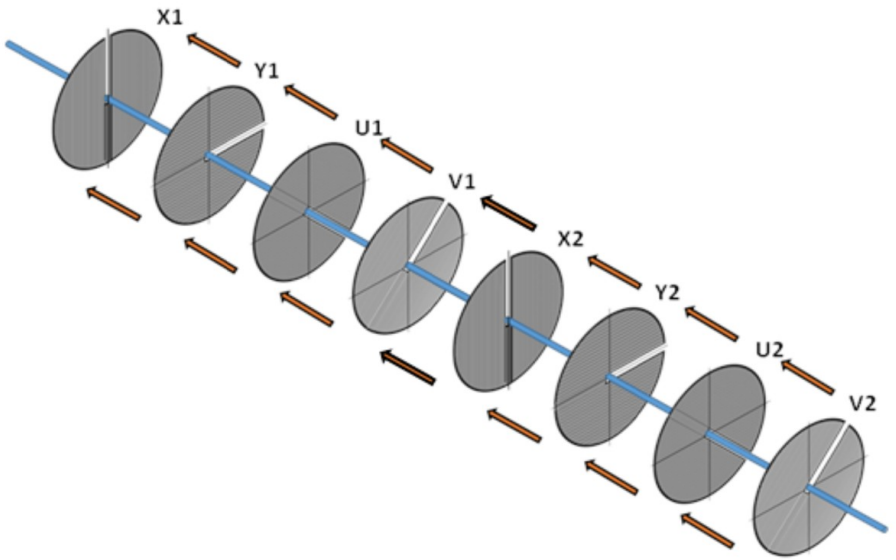


Number of channels	64
Clock frequency	10...80 MHz
Input capacitance	<300 pF
Dynamic range	up to 2 pC
Gain	0.5, 1, 3, 4.5, 6, 9, 12, 16 mV/fC
Peaking time	25 / 50 / 100 / 200 ns
ENC (energy branch)	<3000 e^-
TDC binning	~1 ns
Maximum event rate	140 kHz/ch
Consumption	15 mW/ch

VMM3/3A ASIC is well known chip for gaseous detectors. It has amplifier and shaper adjustable in a wide range. But it was not really done for the precise timing measurements so its fastest shaping is 25ns and ToA mode has some issues.

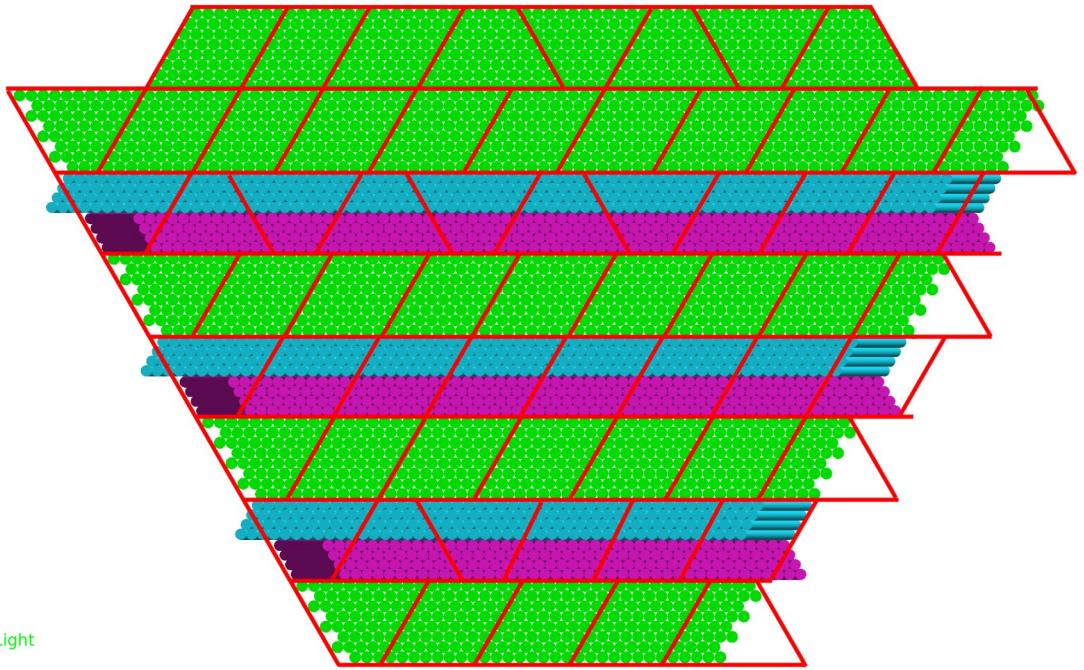
SPD FEE Prototype

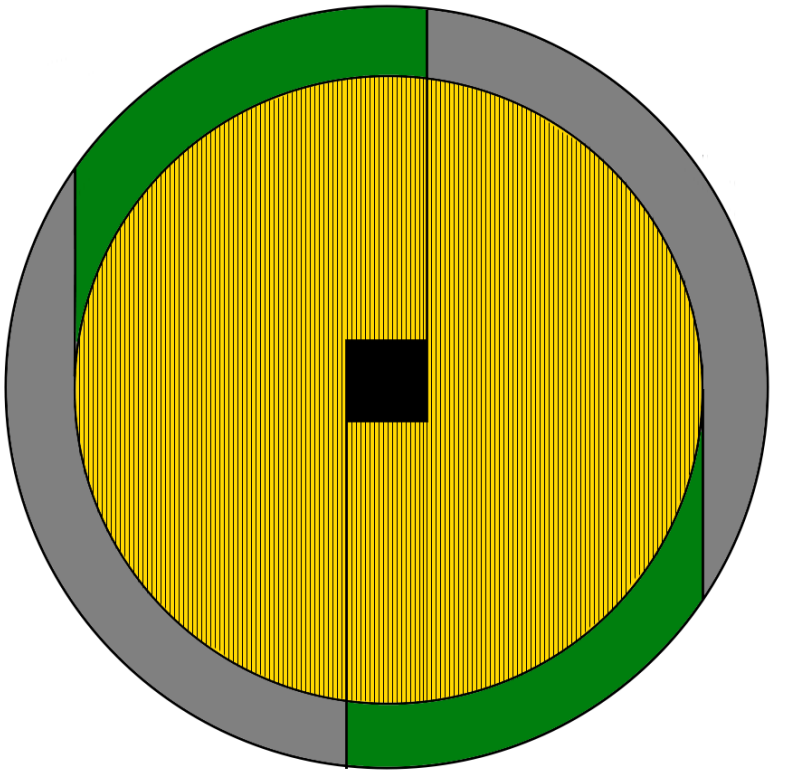




	Straws	FEBs
Secstant	4096	64
Barrel (x6 secstant)	**24576**	**384**
Endcap Disk (1 side)	160	4
Endcap Disk	320	8
Endcap (8 Disks)	2560	64
Both Endcaps	**5120**	**128**
Straw Tracker	**29696**	**512**

Minimal Shapes Layout

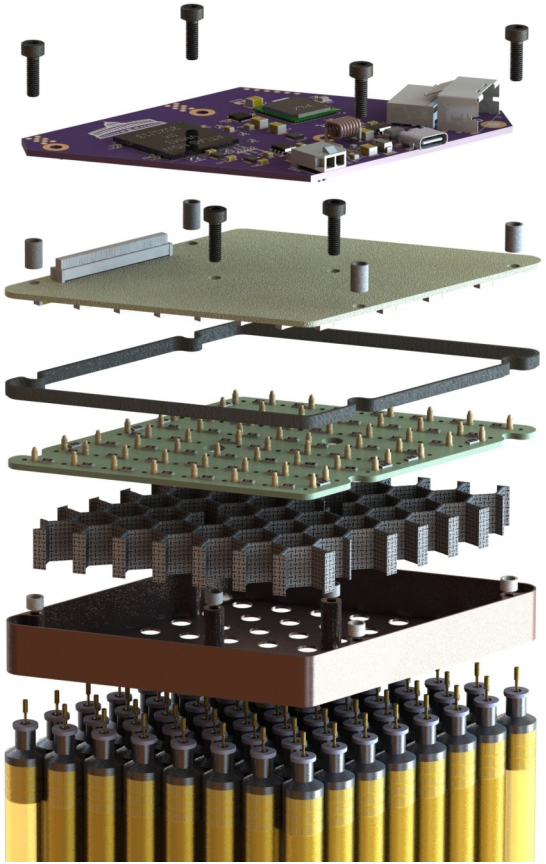


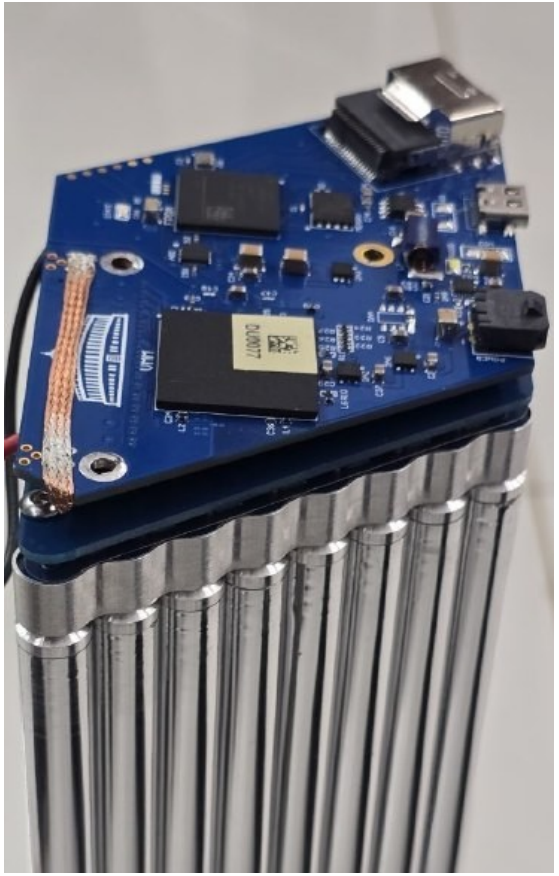


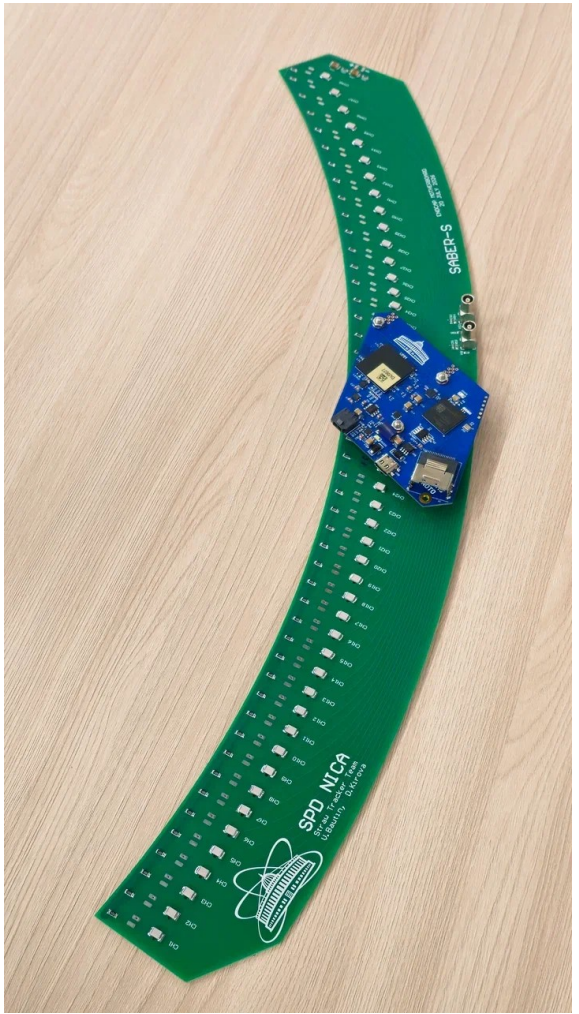
In order to make production easier, we had to find minimal board shapes quantity

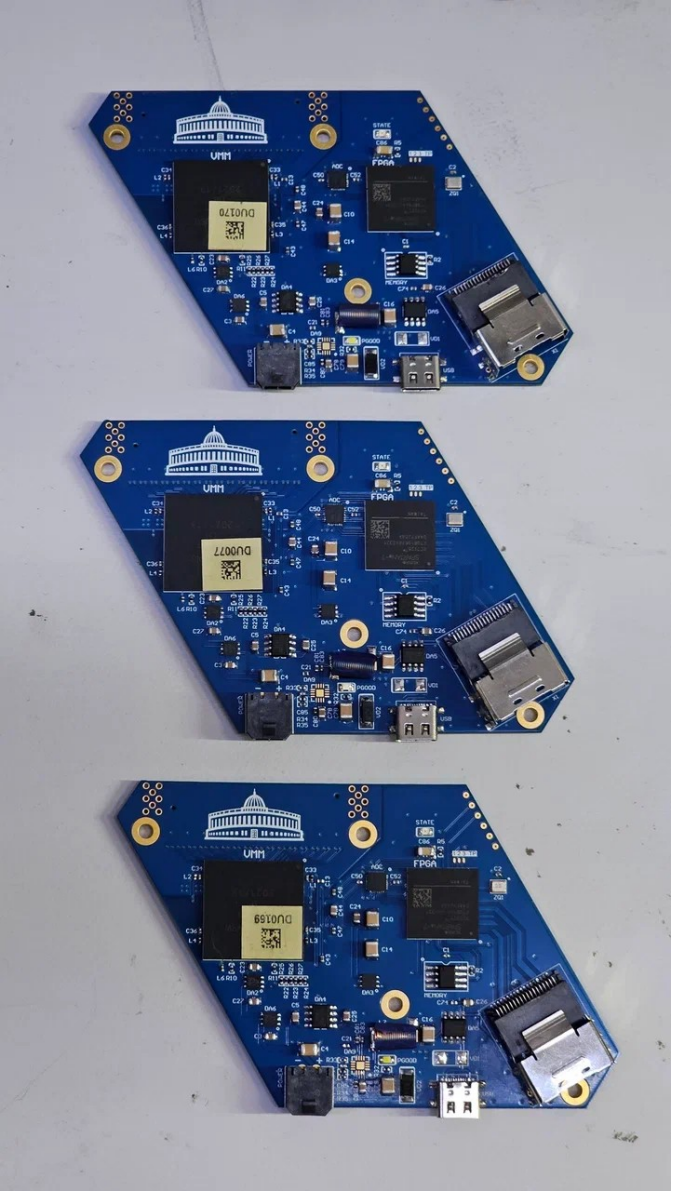
Managed to get compatibility

- Barrel FEE fits Endcap
- Only X-board to be done



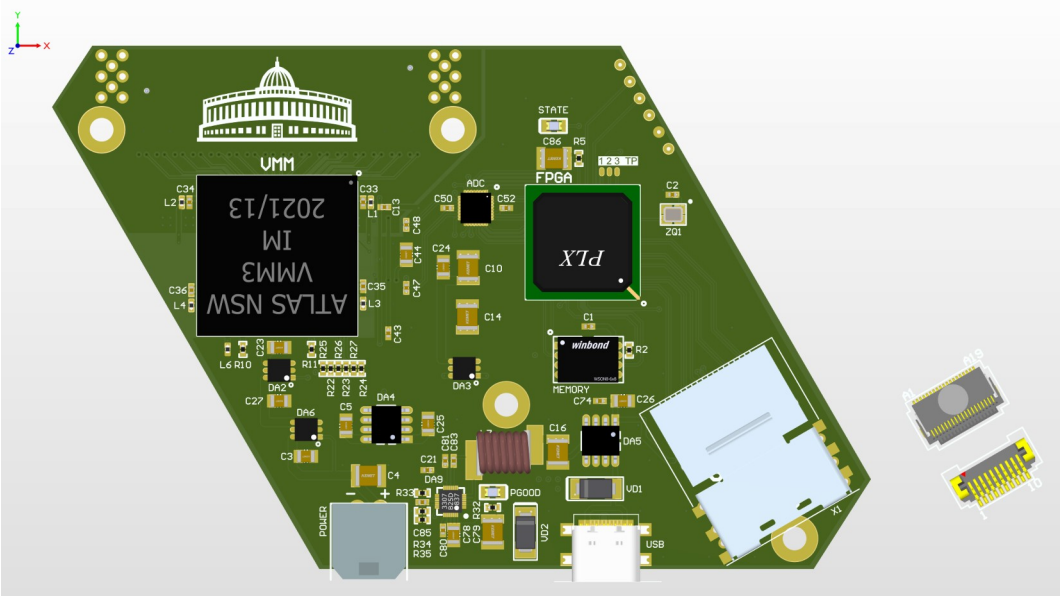






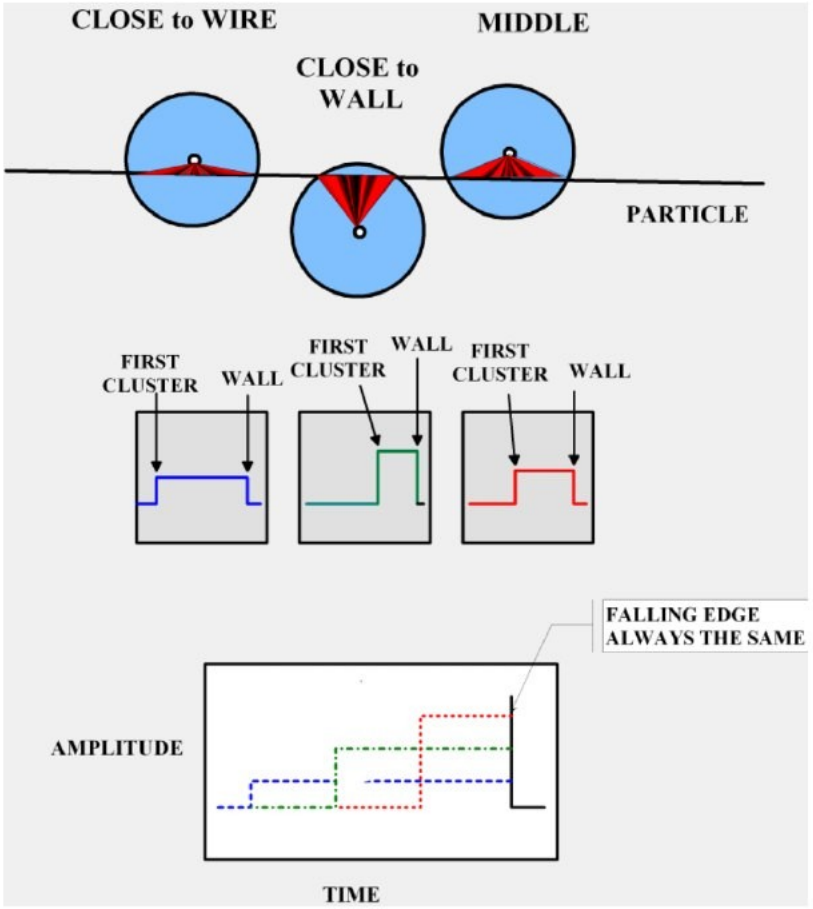
Diamond-shaped FEE Board

- Finally assembled this summer
- First tests work fine (ping, config, test pulses, etc.)
- Stable firmware in process
- DAQ Link connector to be tested
- DAQ integration to be tested



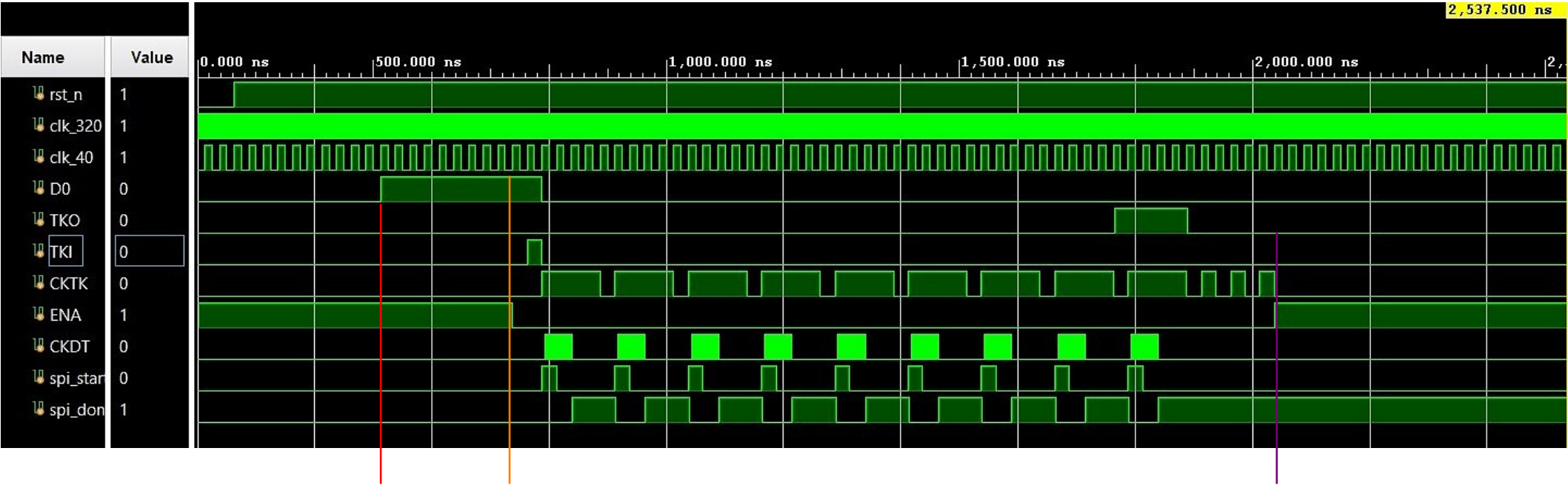
SPD DAQ Sync

How does it work?



- Falling edge has the same time for all straws on track.
- Rising edge gives the arrival time of the first cluster
- The closer is the track to the wall, the bigger is the signal (clusters closer)
- Don’t want to see clusters => shaping must be chosen in relation to gas properties
- Tracks from drift time measurements

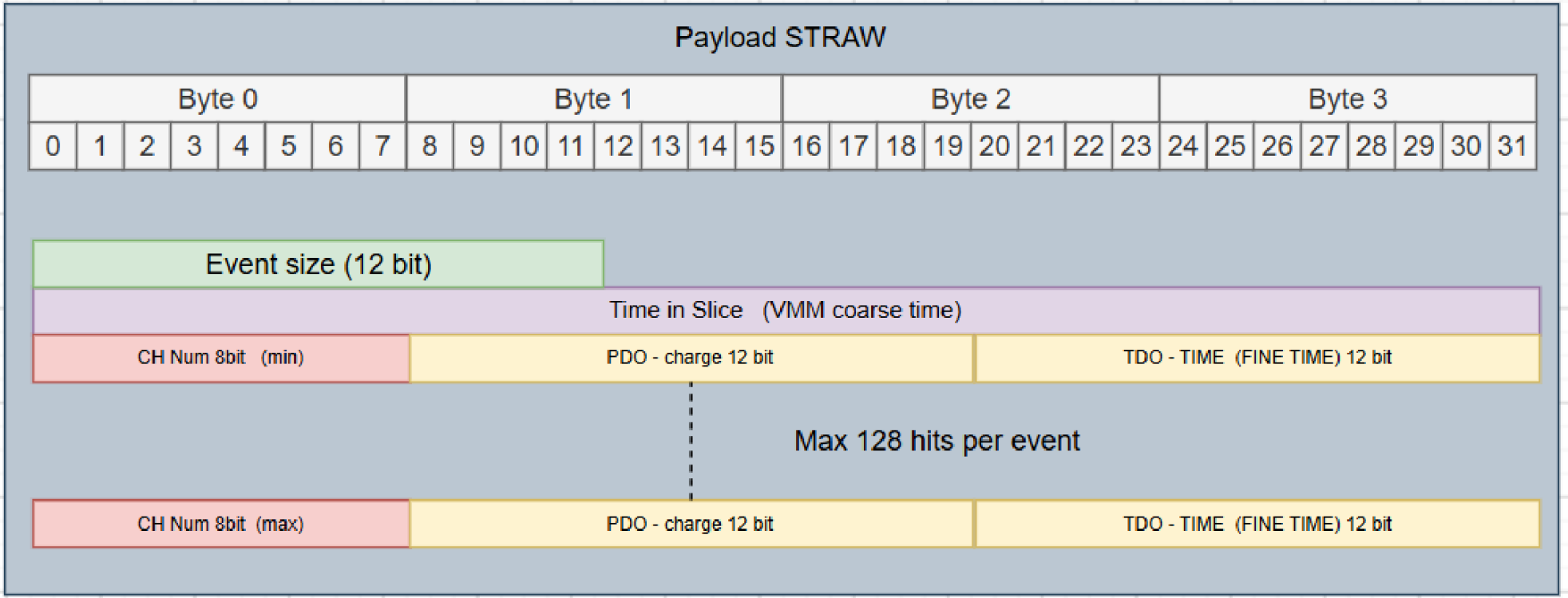
DAQ Sync Discussed Recently



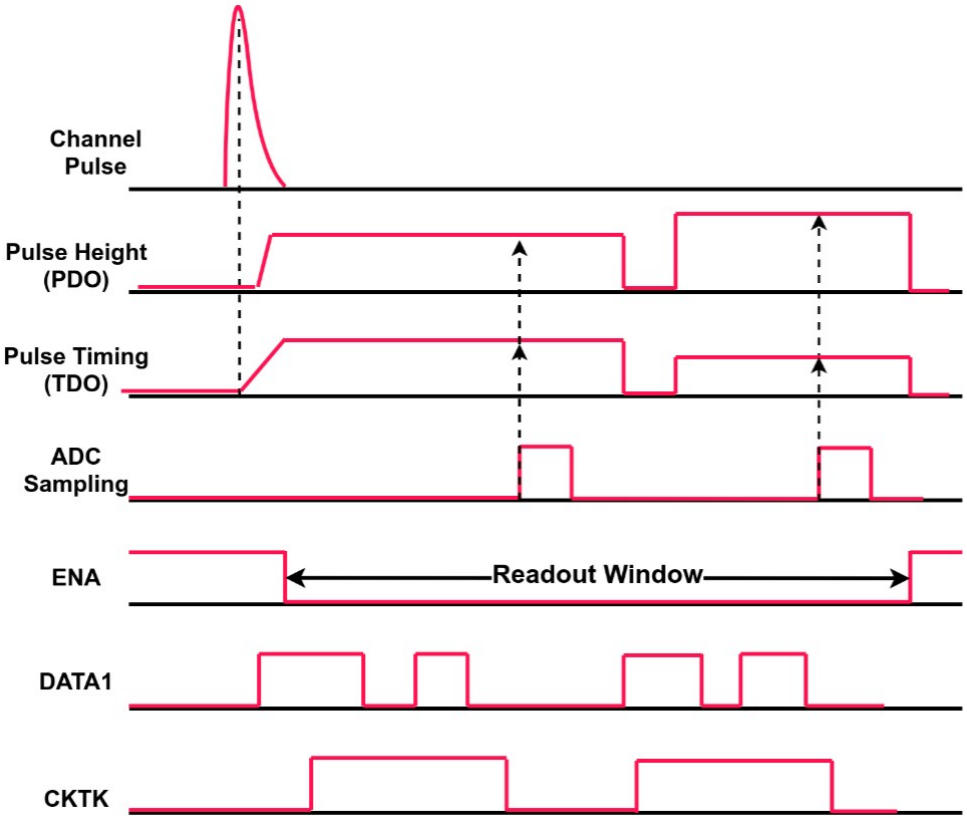
- First hit in one of 64 channels detected
- *Full drift time waiting*
- Common stop for the board issued
- *Hits in one event readout*
- Common stop released
- *Waiting for new events*

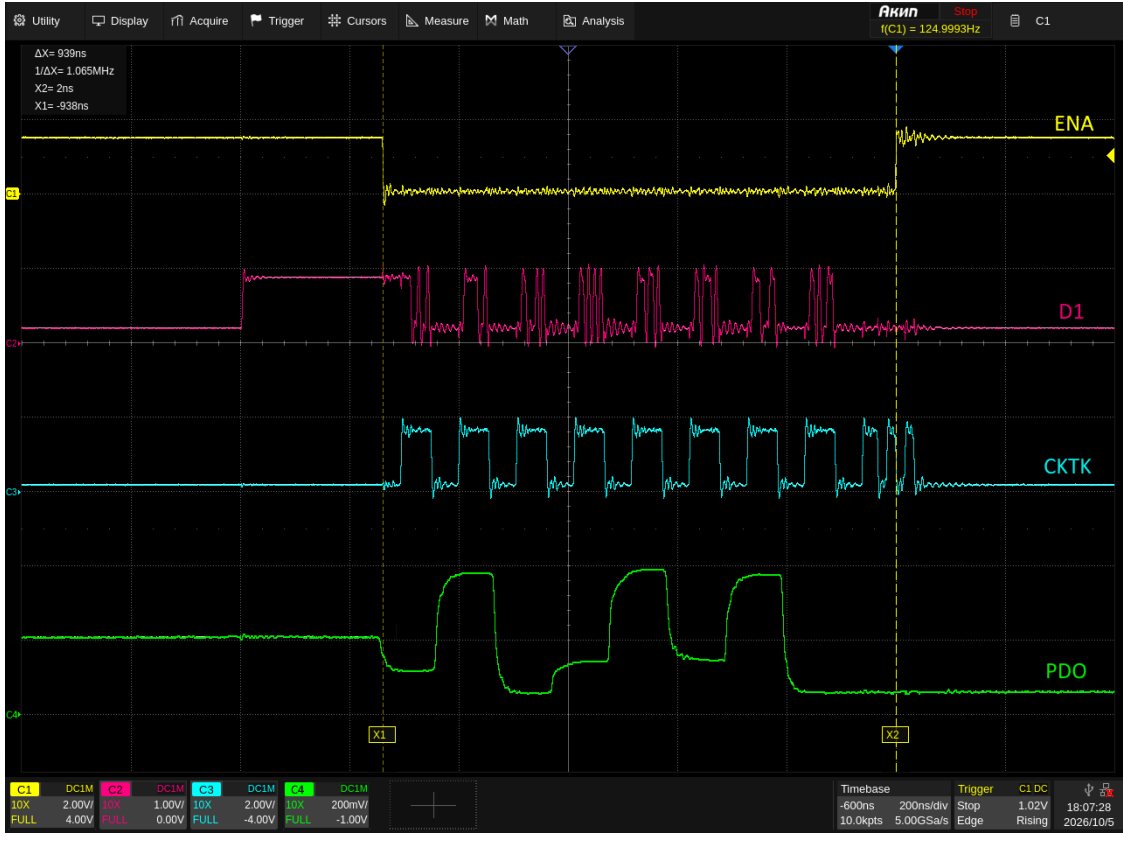
Data Structure has been developed

- Single Coarse Time ID per event for merging
- Fine Times and Charges per each hit in event

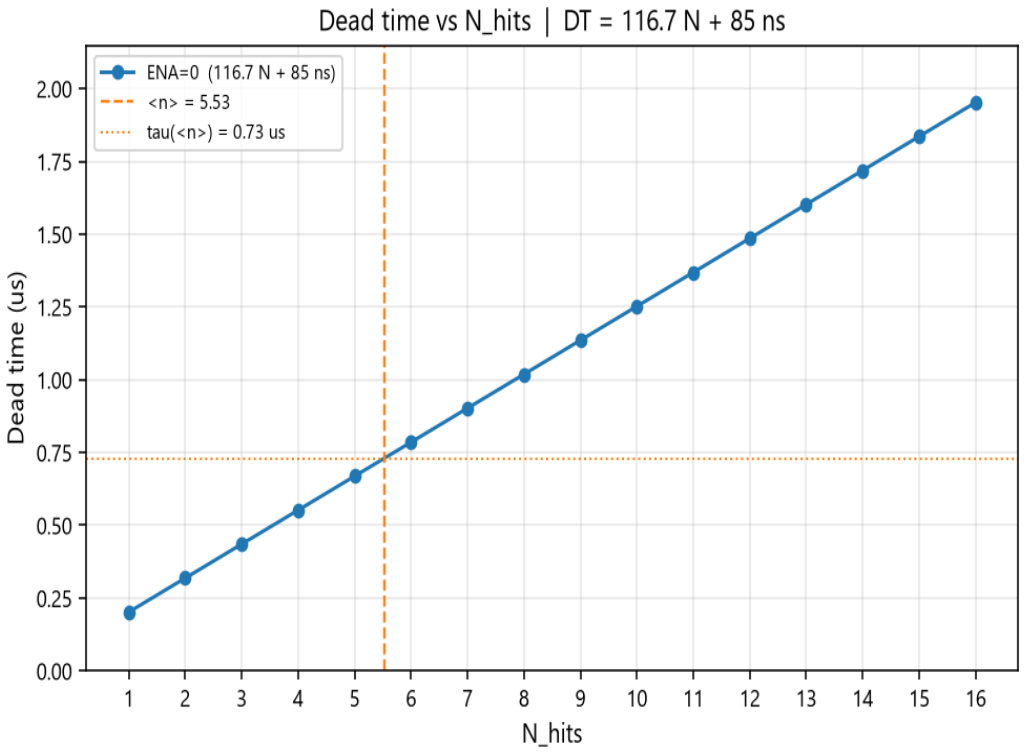


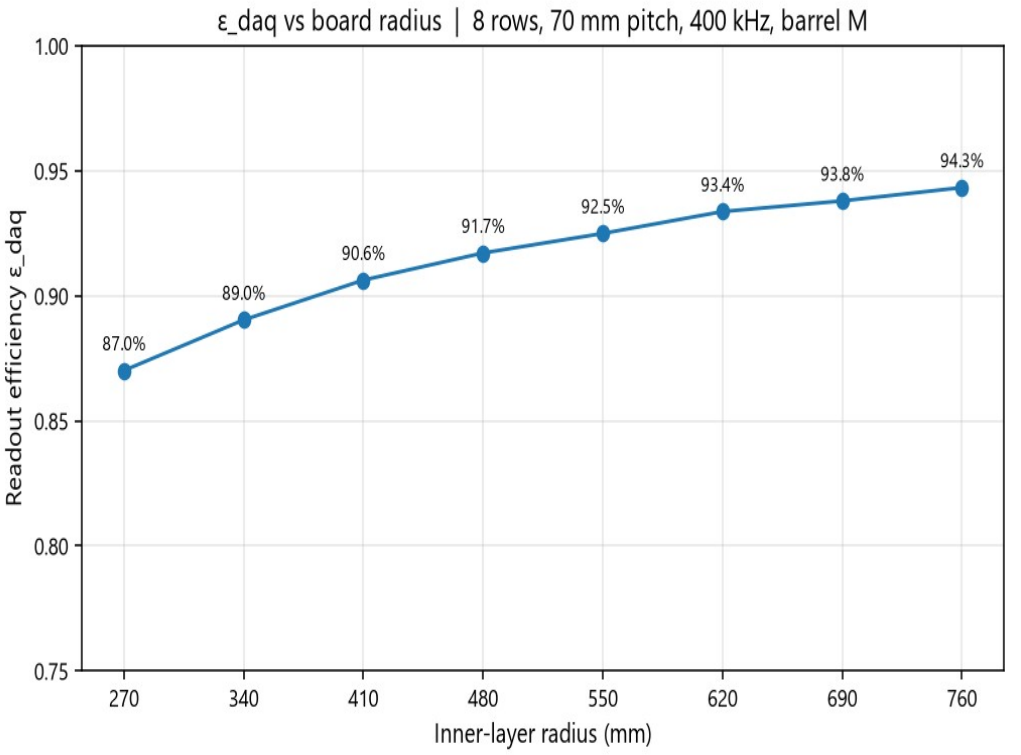
Dead Time Estimation





Efficiency Estimation

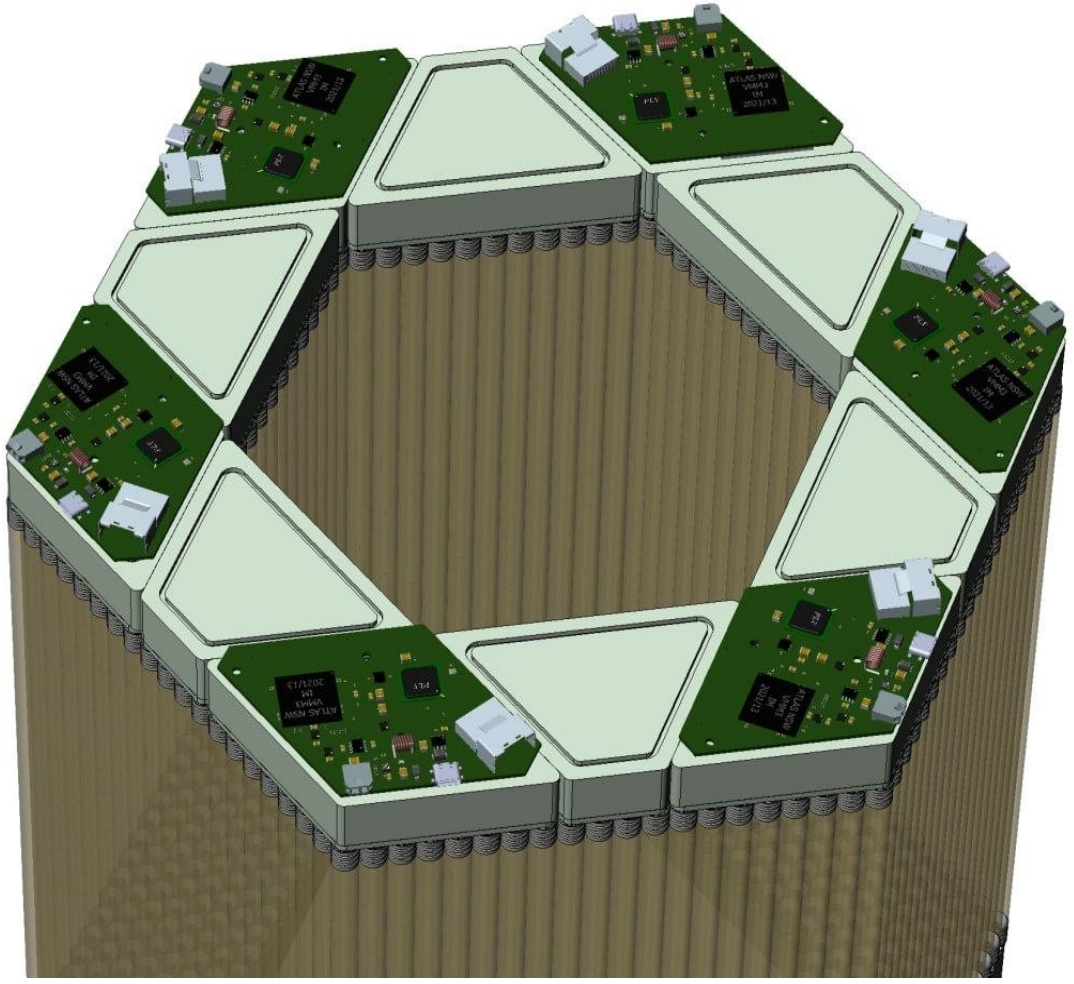




Conclusions

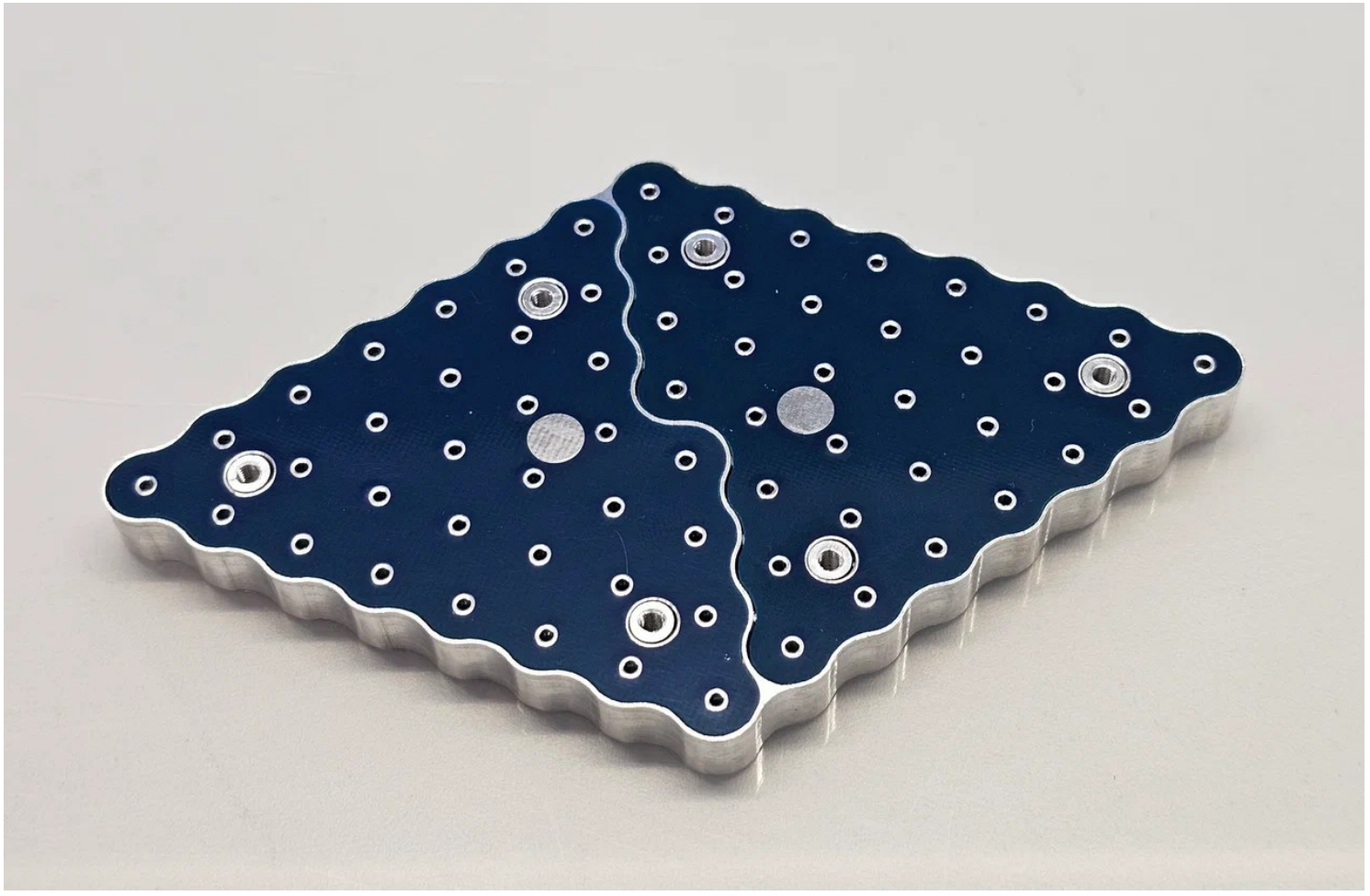
- Backup Readout solution is being developed
- Optimal detector layout has been found
- Test batch of FEBs has been done
- Firmware for readout and sync in development
- Good (~90%) efficieny could be reached

Backup

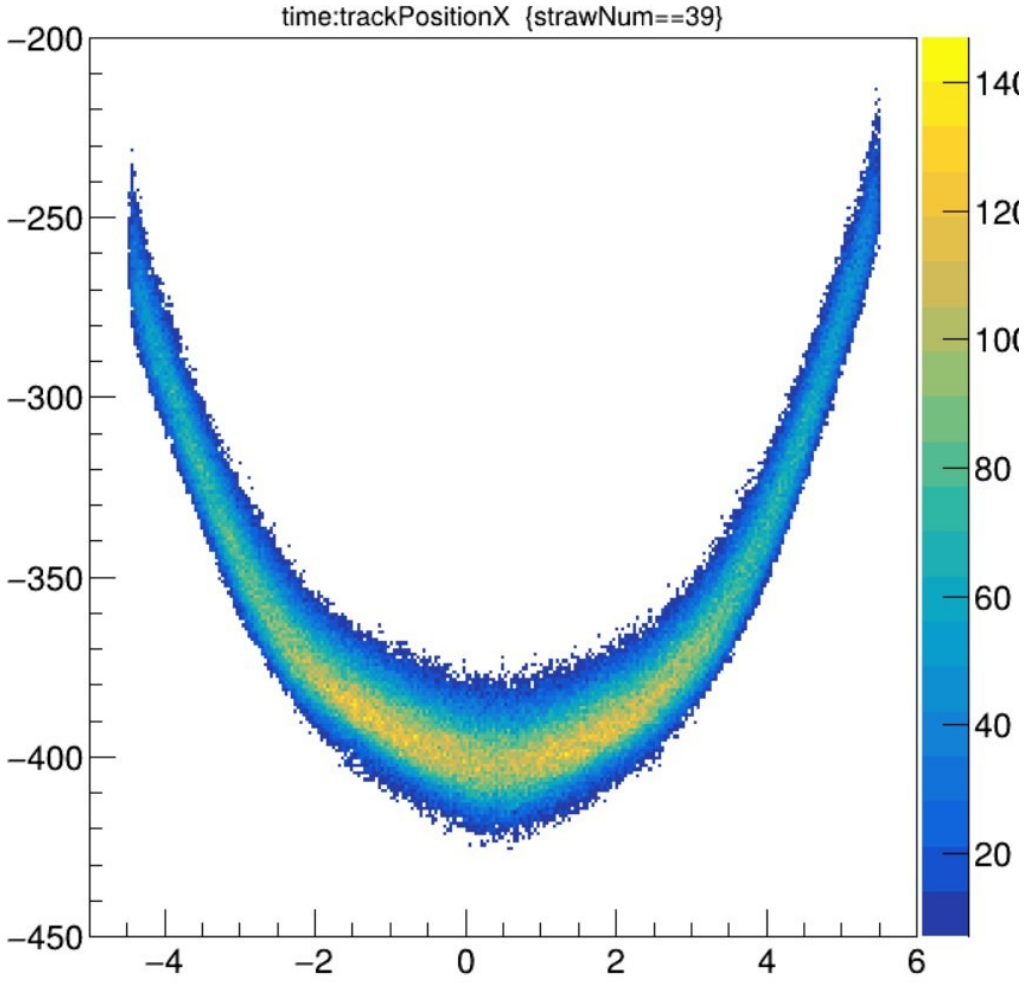


First small 12-tiles prototype will
be assembled in Dubna soon

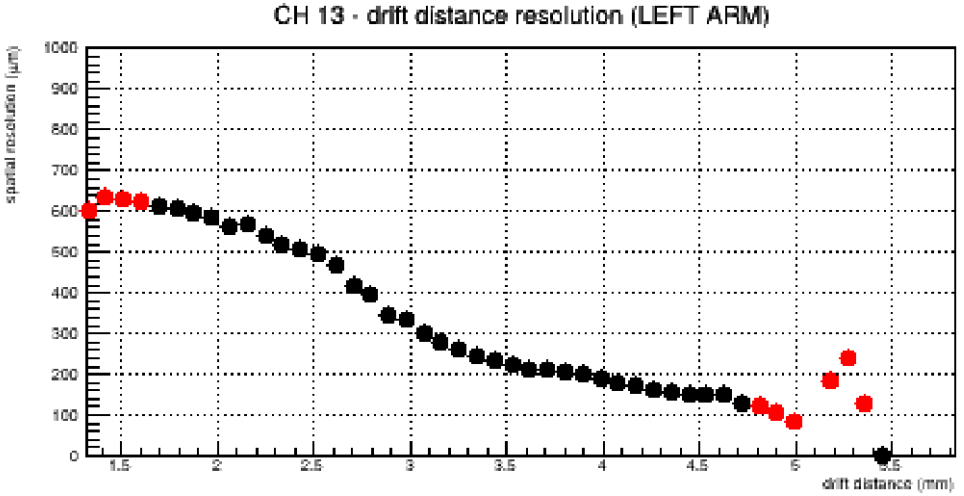
Manifold (Back Part)

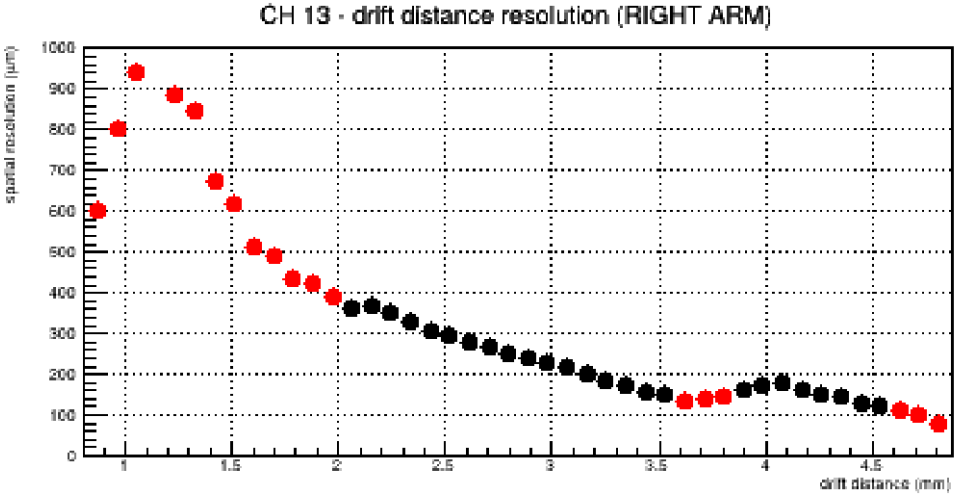


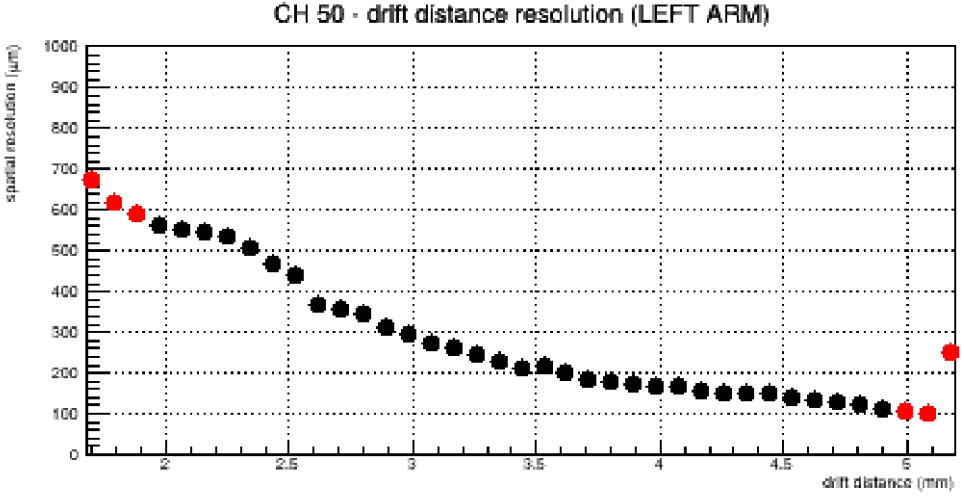
Typical V-shape obtained at the Testbeam

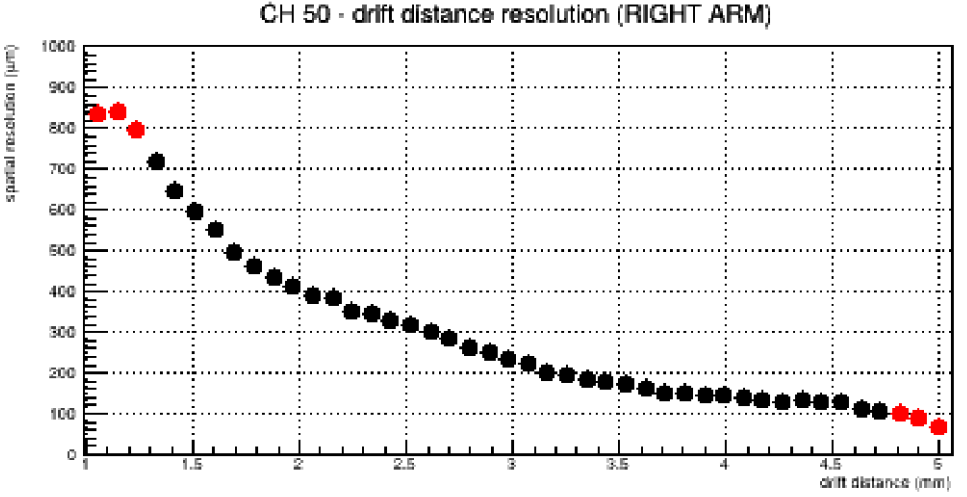


Resolution examples for different straws

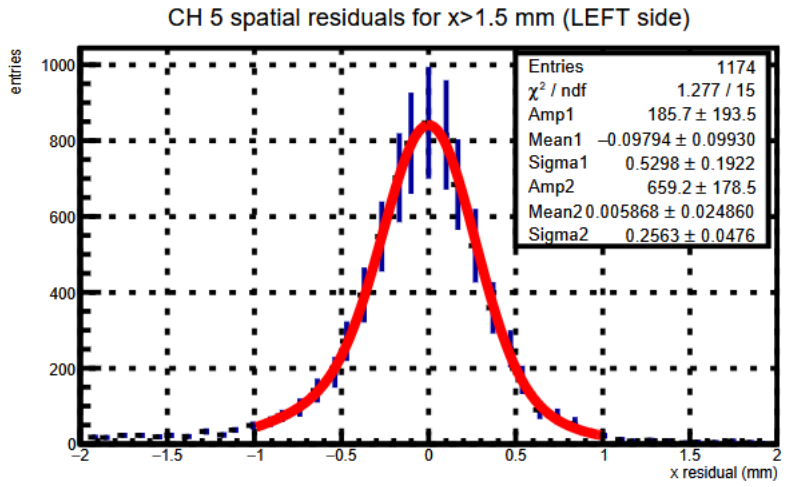


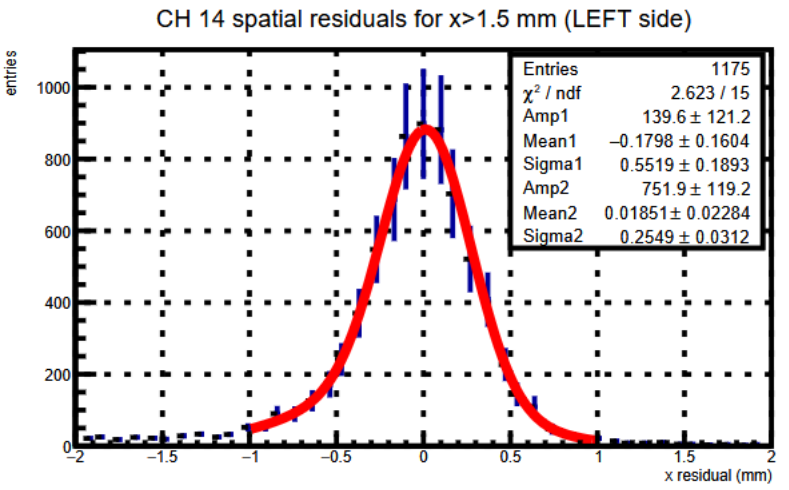


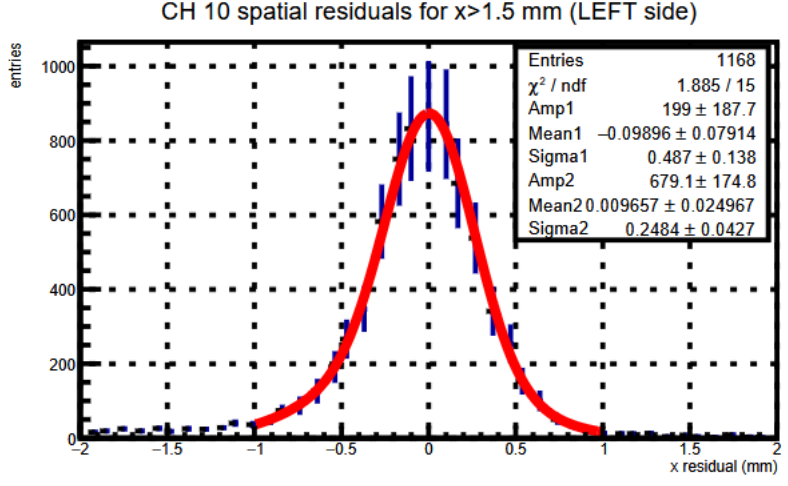


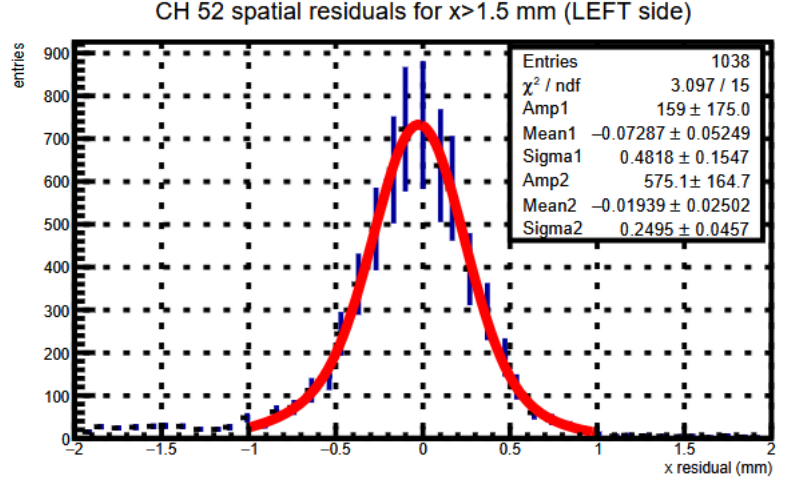


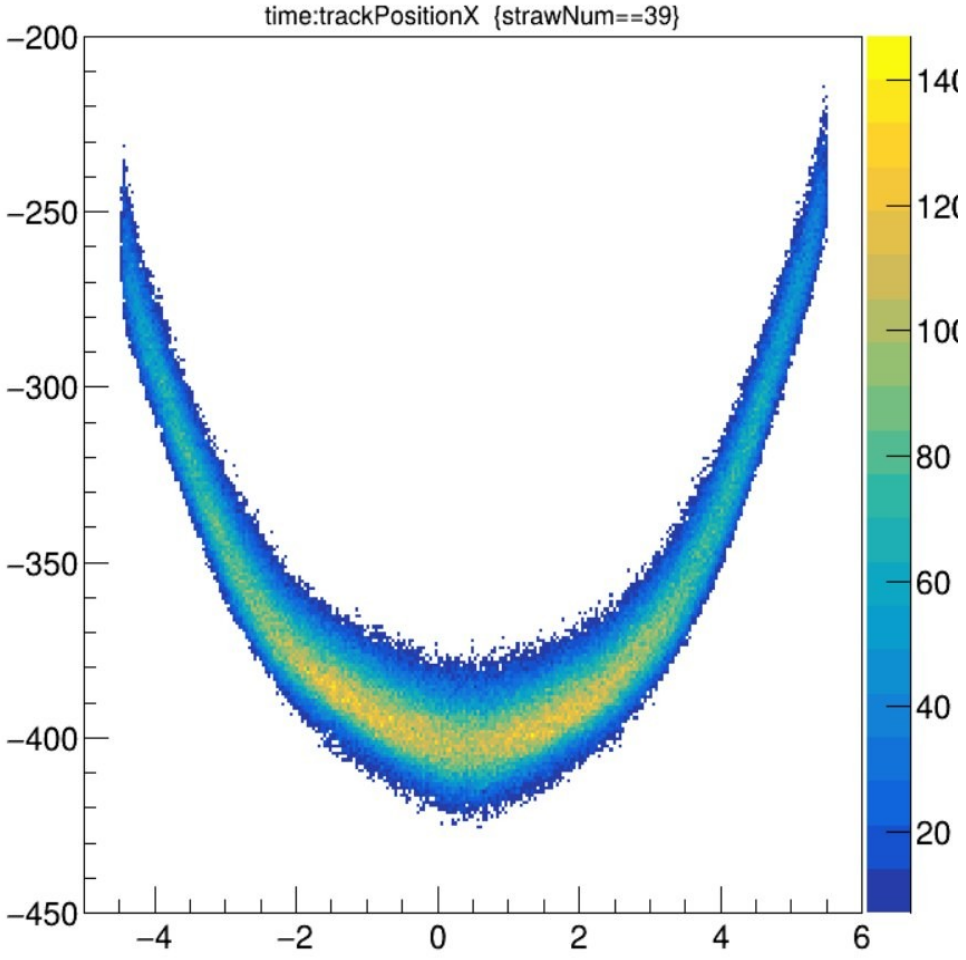
Mean resolutions of the straws











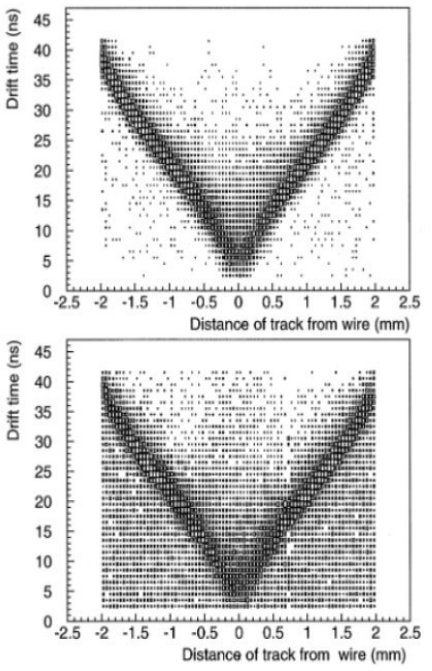


Fig. 1. Measured relationship between drift time (vertical axis) and distance to wire obtained from extrapolation of beam track reconstructed in a Si-microstrip telescope (horizontal axis), for a non-irradiated straw (top) and a at a counting rate of 18 MHz (bottom).

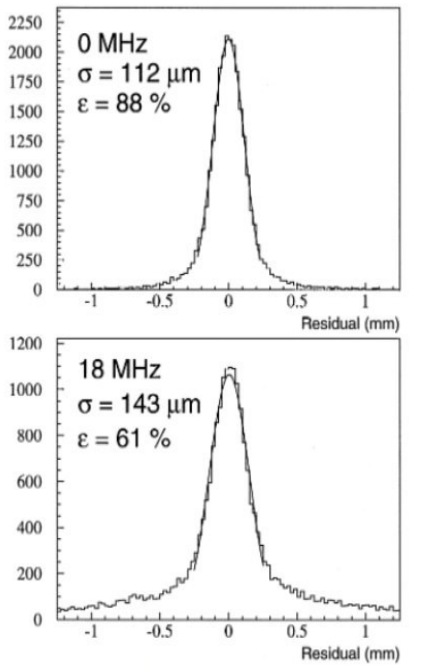


Fig. 2. Distribution of the resulting residual with respect to the beam track, for a non-irradiated straw (top) and at a counting rate of 18 MHz (bottom).