Results of STS@HADES Calibration

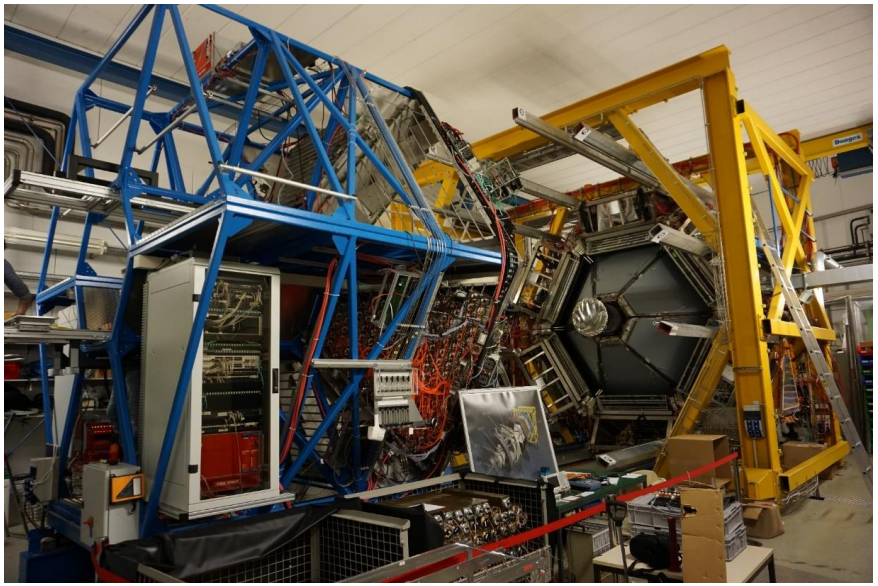
26.10.2021 I GABRIELA PÉREZ ANDRADE

TRACKING SESSION

PANDA COLLABORATION MEETING 2021/3

Outlook

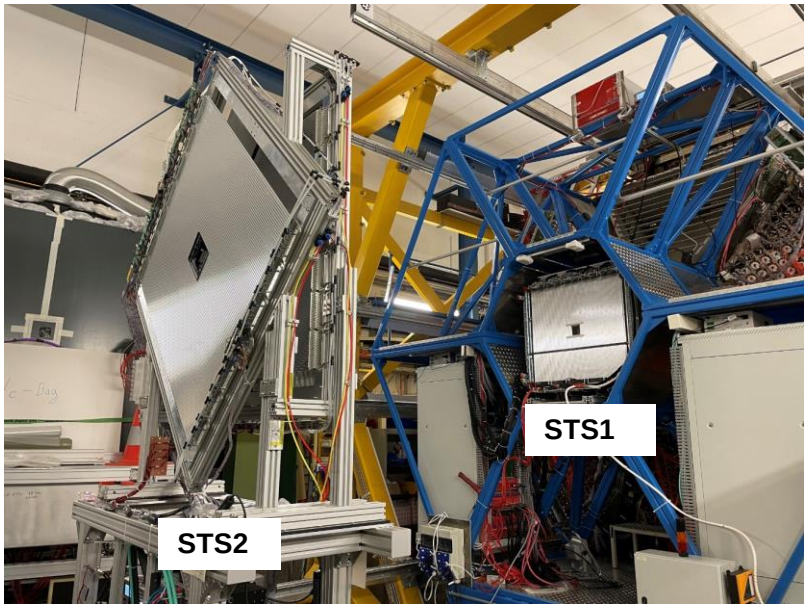
- STS Detector System Overview
- Status of STS calibration
- Summary

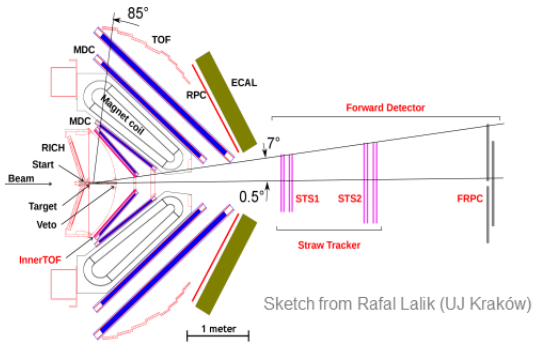


STS detector system

- Two stations (STS1/2) consisting of four double layers of self-supporting gas-filled straws
- Each straw diameter is 10 mm and is made of 27µm thin Al-Mylar walls with 20 µm thin W/Re wire along it axis.
- Gas mixture: Ar/CO_2 (90/10) @ 2 bar
- Front-end electronics(PASTTREC FE-boards), TRB3 readout, common DAQ STS1/2

Station	STS1	STS2
No. Straws	704	1024
Straw length	76 cm	125 cm
Orientation (azimuthal)	0°, 90°, 90°, 0°	0°, 90°, 45°, -45°
Beam opening	8×8 cm^2	16×16 cm^2
Distance to target (commiss. beamtime)	~ 3.50 m	~ 5.50 m



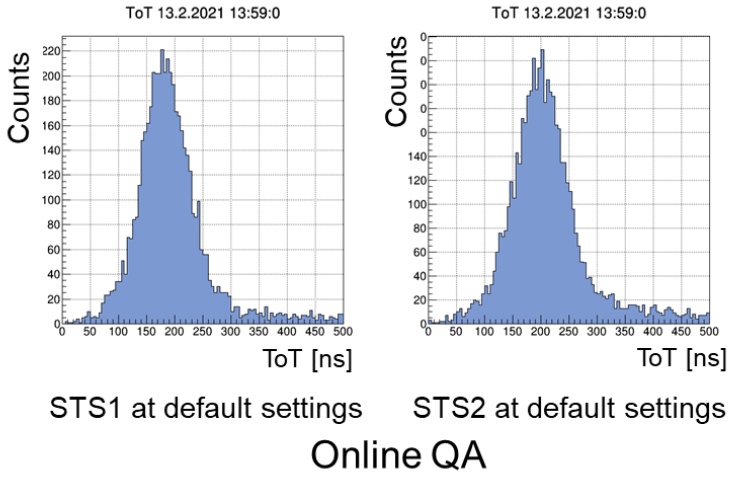


Sketch from Rafal Lalik (UJ Kraków)

HADES Commissioning Beamtime

February 2021

- SIS18 delivered proton beam with 2 GeV and 4.2 GeV kin. Energy
- STS stations and readout performance tested under experiment conditions (*e.g.* high intensities of 10^5 p/s per straw)
- Several data takings for different ASIC settings were completed.
- STS operation was stable and no self-sustaining currents were observed even at the highest beam intensities (10^5 p/s per straw).
- Very low noise was observed.
- Preparation for the four week experiment beamtime scheduled for February 2022 is ongoing:

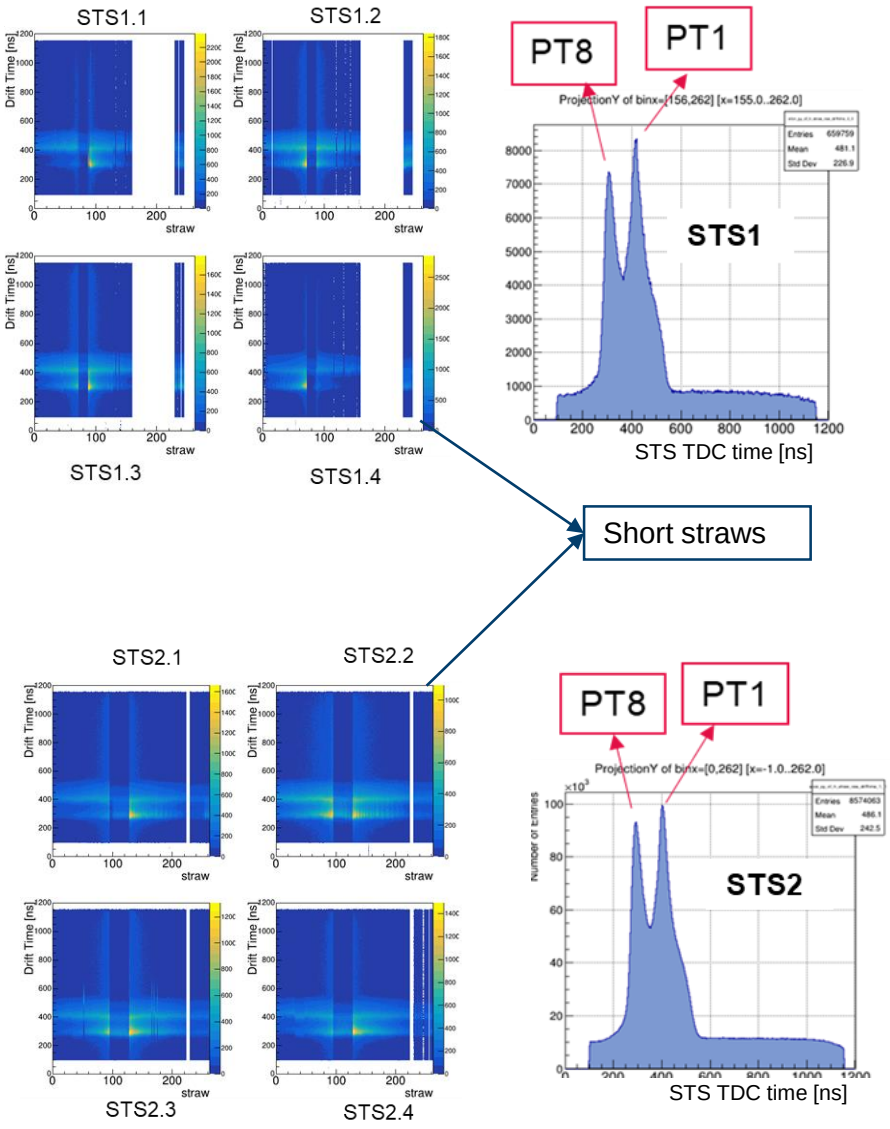


STS1 at default settings STS2 at default settings

Online QA

- **STS calibration method implementation**

Raw time spectra

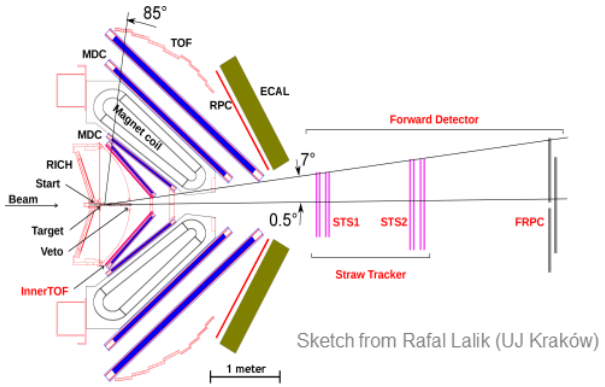


Raw STS TDC time:
hit detection time (*time offset* + *ToF* + *drift time*)

Calibrated time: drift time

Different triggers used:

- PT8 (registered hit in fRPC)
- PT1 (TOFRPC, Mult > =2)



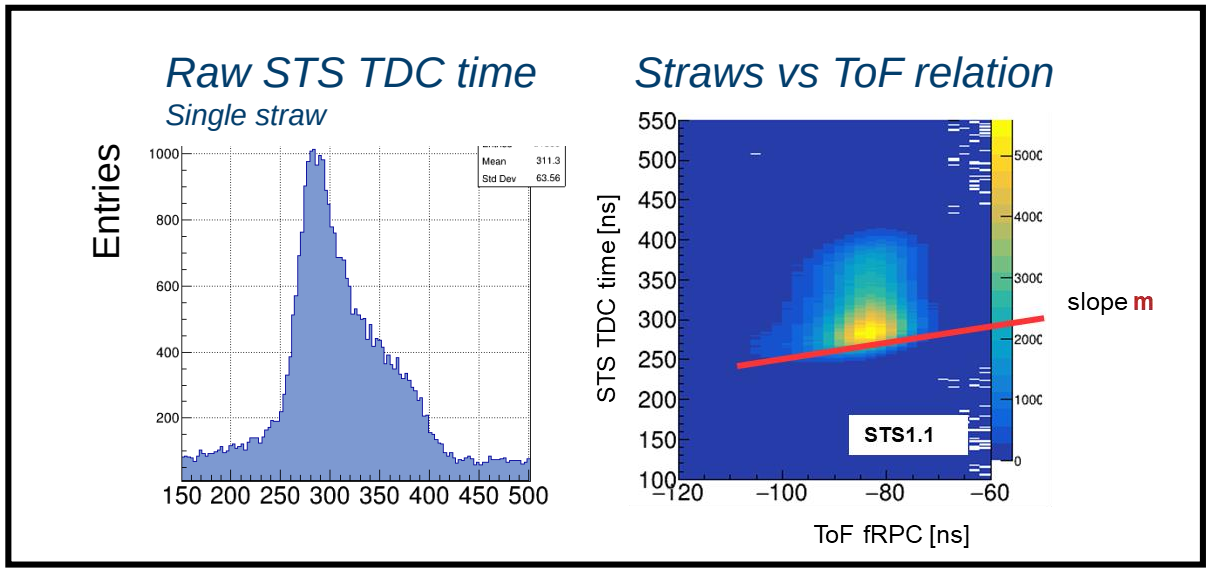
Sketch from Rafal Lalik (UJ Kraków)

STS - Drift time calibration

Raw STS TDC time:
hit detection time (*STS time offset* + *ToF* + *drift time*)

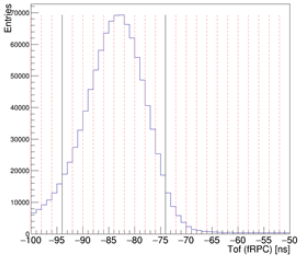
Calibrated time: drift time

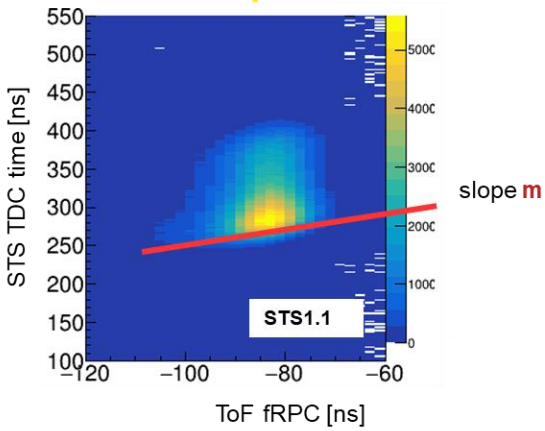
- **Drift time** = *raw STS TDC time* - (***ToF*** **–** ***ToF*** $_{ref}$) * **m** - *STS time offset*
  - ***ToF*** $_{ref}$: Arbitrary selected from *e.g.* scattering or fastest particle (well known ToF)
  - ***ToF*** *: associated fRPC time of flight*
  - **m** : from fRPC/STS linear relation
  - *STS time offset* : shifting *raw STS TDC time* to t = 0 (w.r.t. ***ToF*** $_{ref}$)

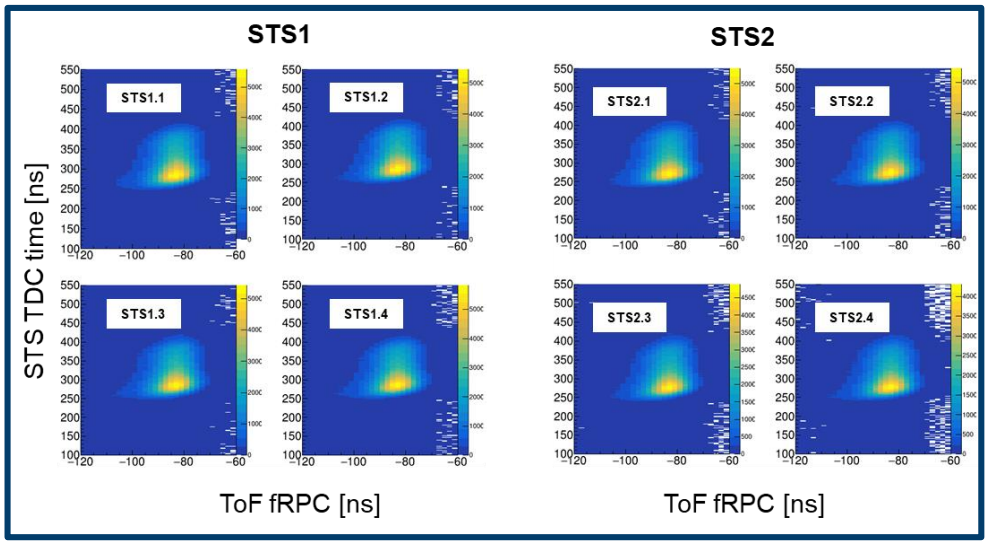


- Negative ToF values due to current calibration

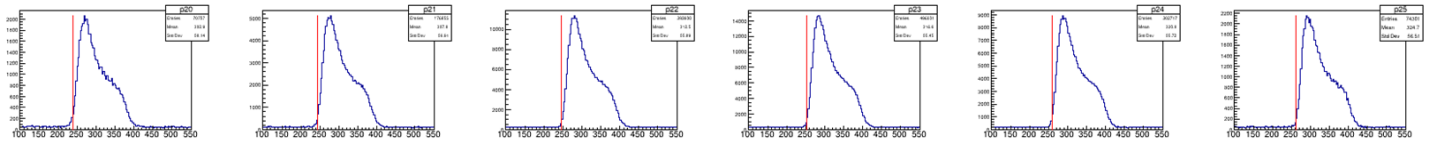
STS vs Time of Flight (fRPC) information







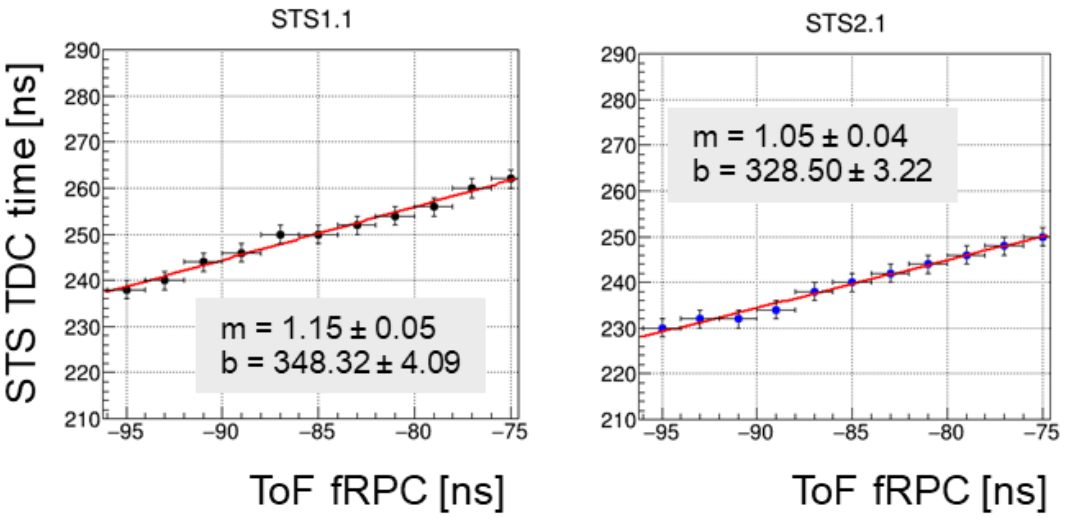
STS1.1, TDC time [ns]



STS TDC time [ns]

Ref points:
STS : defined by 70% & 15 % of max entry (5 bins mean, **2 ns bin size**)
fRPC: middle point of 2 ns slice, range from -95 to -75 ns, full region under ToF peak

STS vs Time of Flight (fRPC) information



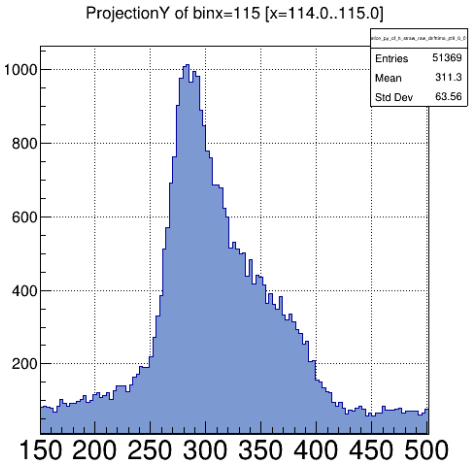
- STS1 times start after STS2 times: different LVDS cable lengths.
- Maybe it is not possible to resolve a TOF difference for STS1(2).1 and STS1(2).4 (half meter distance)

STS - Drift time calibration

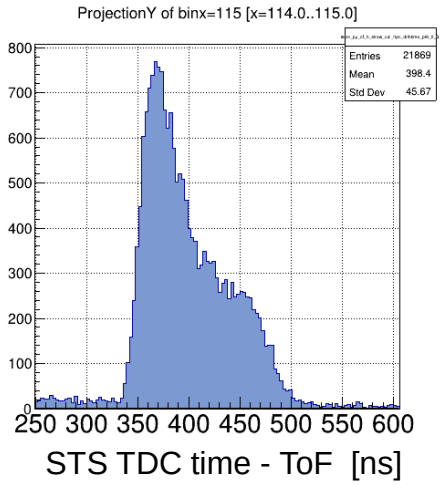
Offset calculation

- **Vector candidates**: events with hits at STS which can be correlated with a hit at fRPC (ToF)

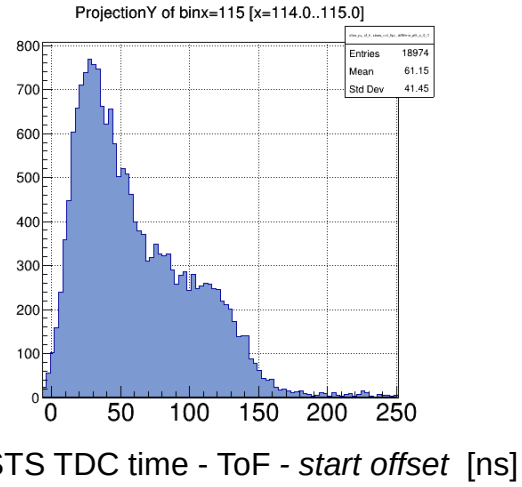
Raw data



Forward vector candidates



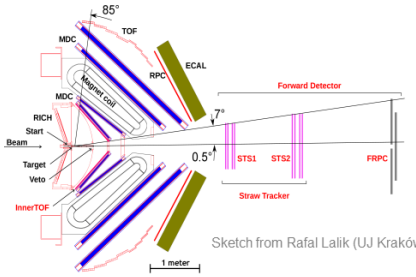
Forward vector candidates

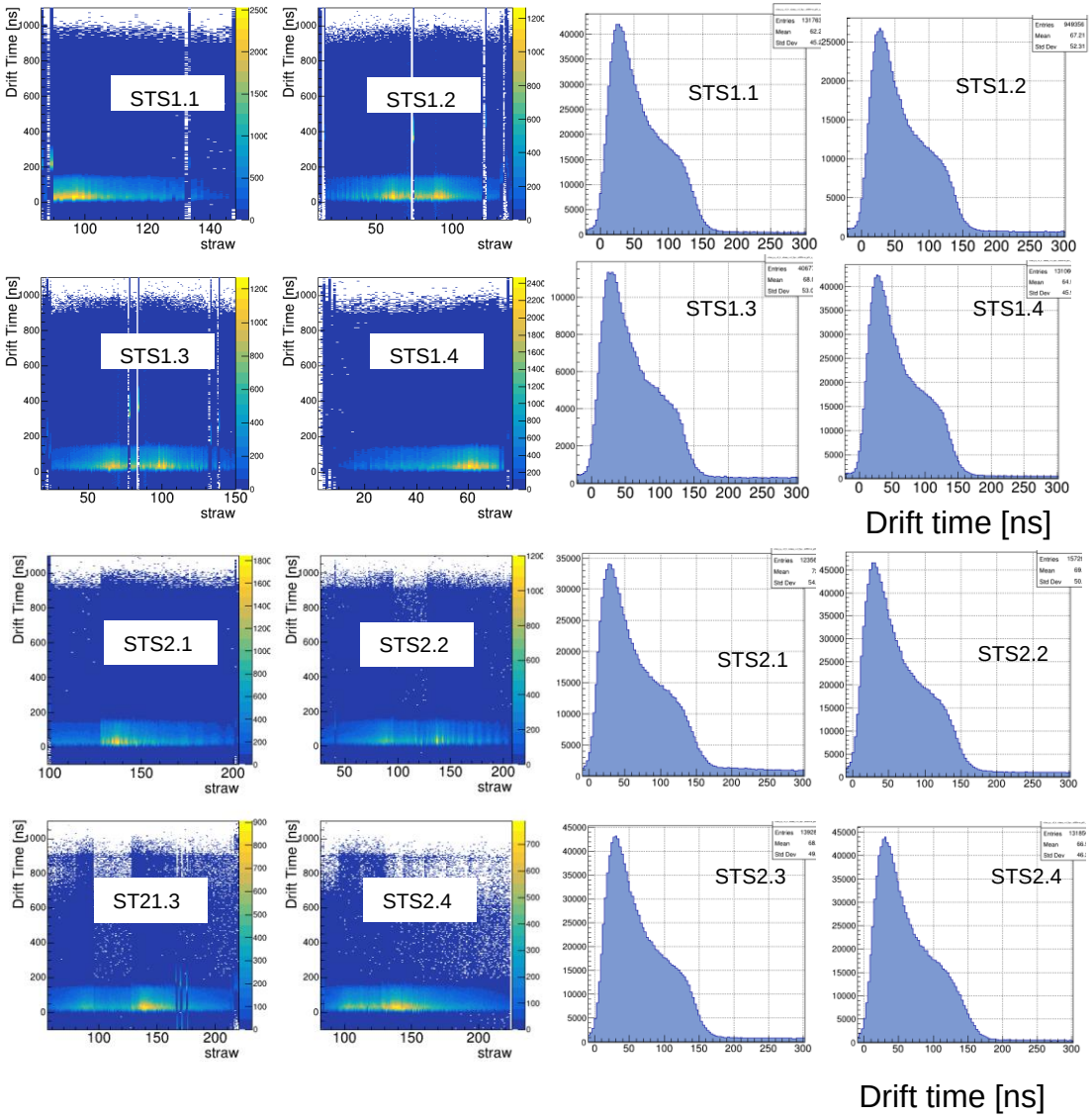


STS TDC time – associated *ToF:*
Reduced statistics by selecting tracks with recorded and calibrated TOF

STS - Drift time calibration

Offset correction

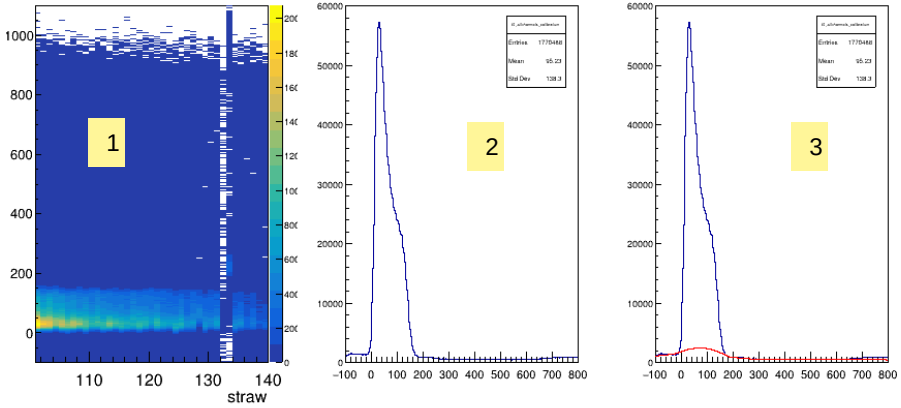


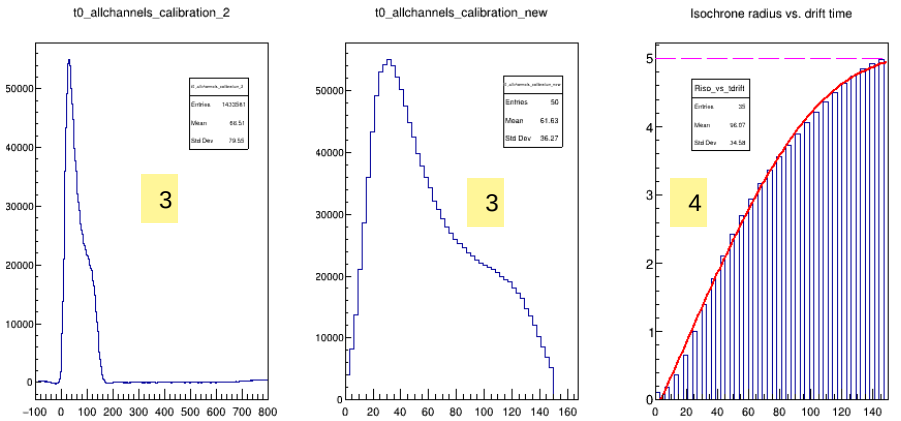


- *hit detection time - start offset – fRPC ToF*
- Events with vector candidates -> **less statistics** but also **less background**
- Drift time range looks ok: sharp leading edge, range of ~ 150 ns
- To determine: offset correction is channel specific or same for a channel group

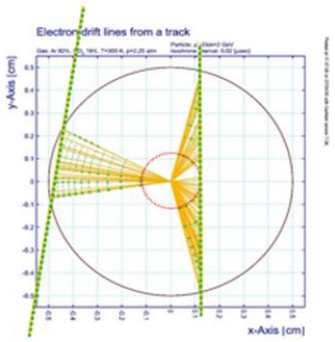
Isochrone parametrization

1. Offset correction calculated and applied
2. Sum of all channels dt spectra
3. Find and remove background
4. Calculate time-distance equivalence :
   - $R(t) = \left(\frac{\sum_{i=0}^{i_t} N_i}{N}\right) \times (\mathrm{R}_{straw} - \mathrm{R}_{\min}) + \mathrm{R}_{min}$
   - $\mathrm{R}_{\mathrm{straw}} = 0.00505\ \mathrm{m}$
   - $\mathrm{R}_{\min} = 0.0001\ \mathrm{m}$
   - Pol4 fit: describes the r(t) relation with sufficient accuracy.

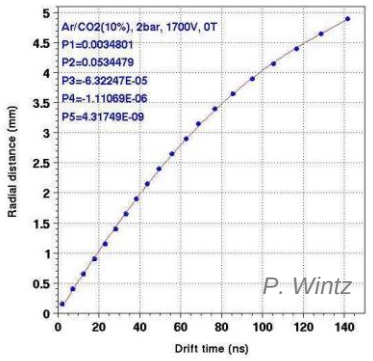




- Parametrization limits are important:
  - Smearing effects close to the wire and close to the straw walls.



Drift path of electrons from the particle's path to the anode wire



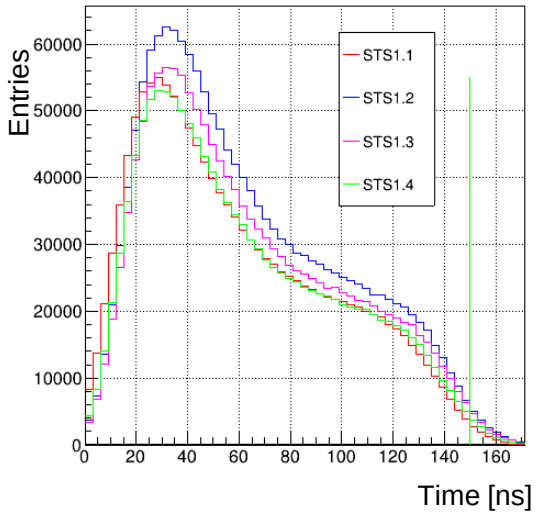
Isochrone parametrization currently used for tracking (from simulation)

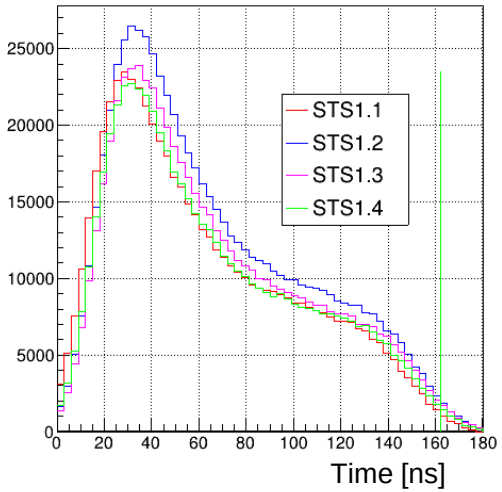
STS1, Gain 1
HV = 1800 V

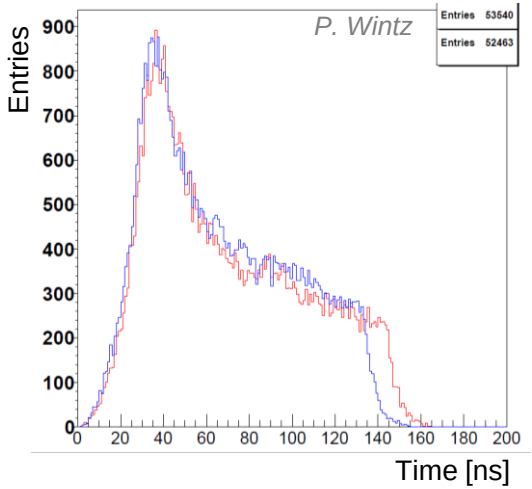
Station.Doublelayer	Tmax [ns]
STS1.1	150
STS1.2	150
STS1.3	150
STS1.4	150

STS1, Gain 4
HV = 1650 V

Station.Doublelayer	Tmax [ns]
STS1.1	162
STS1.2	162
STS1.3	162
STS1.4	162



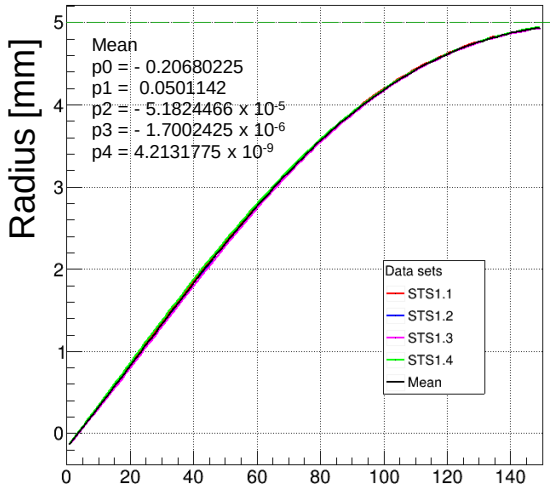




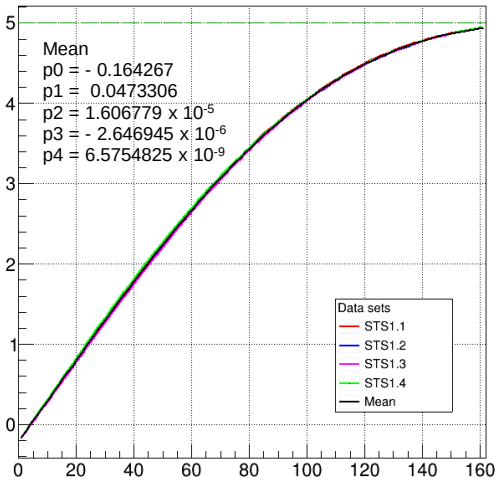
Garfield simulation of the drift spectrum for 1650 V (red) and 1800 V (blue).

- Bin size 3 ns.
- Lower drift electron velocities with lower HV

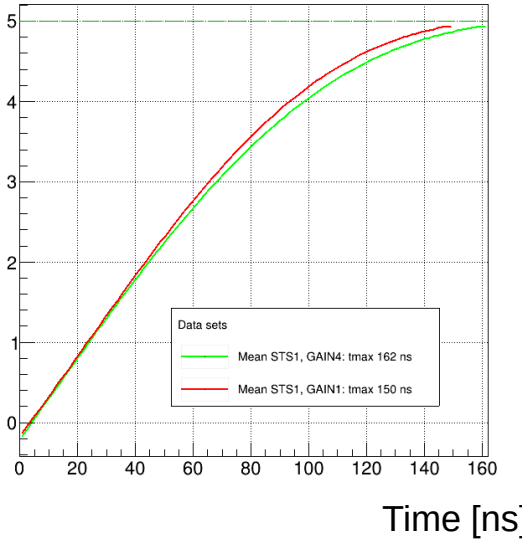
STS1, Gain 1 mV/fC
HV = 1800 V



STS1, Gain 4 mV/fC
HV = 1650 V



STS1, Gain 1 vs Gain 4



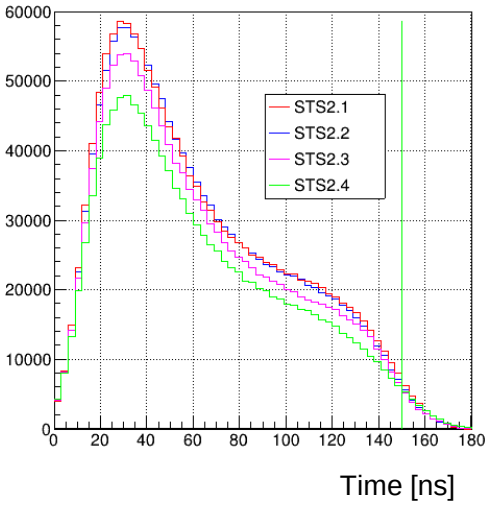
- Isochrone parametrization of four STS1 double layers overlaps:
  - Feasible to use global parametrization (mean?)
- Higher gain (lower voltage):
  - Larger drift time range (~ 10 ns)
  - Lower drift electron velocities

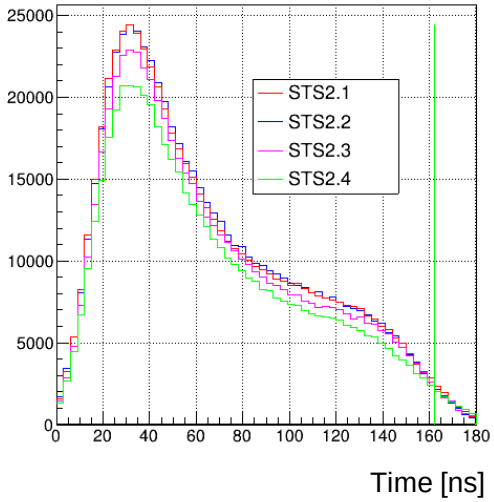
STS2, GAIN 1
HV = 1800 V

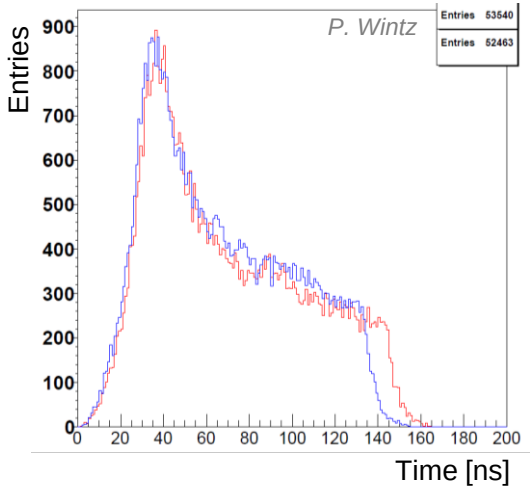
Station.Doublelayer	Tmax [ns]
STS2.1	150
STS2.2	150
STS2.3	150
STS2.4	150

STS2, Gain 4
HV = 1650 V

Station.Doublelayer	Tmax [ns]
STS2.1	162
STS2.2	162
STS2.3	162
STS2.4	162



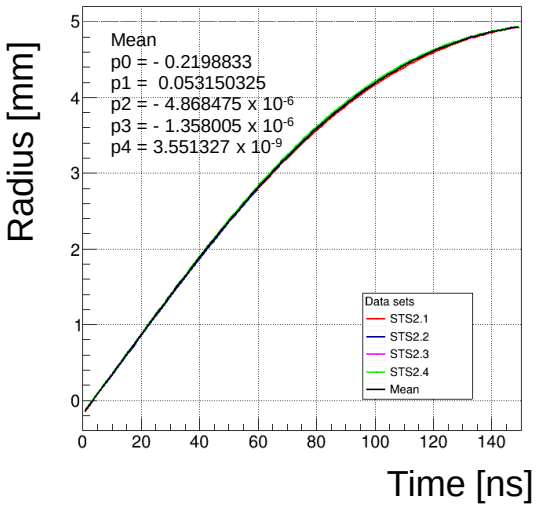




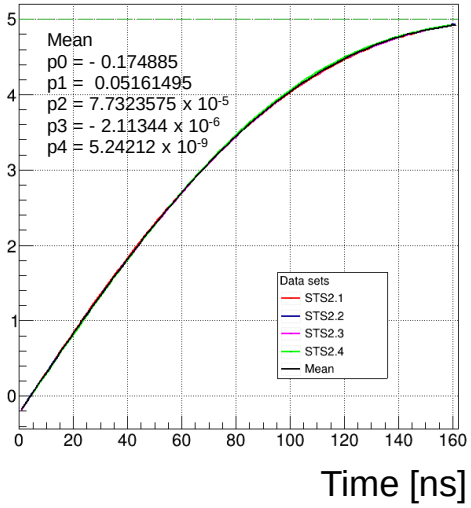
Garfield simulation of the drift spectrum for 1650 V (red) and 1800 V (blue).

- Bin size 3 ns.
- Lower drift electron velocities with lower HV

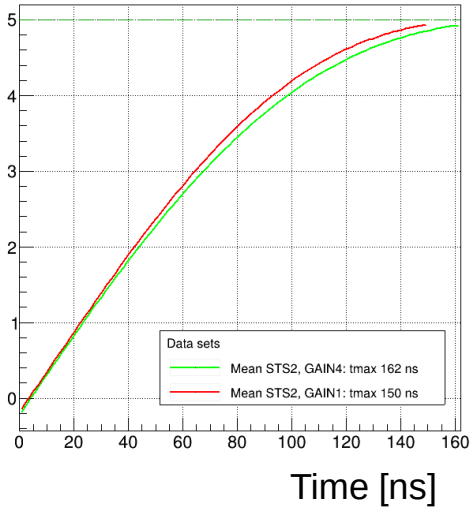
STS2, Gain 1 mV/fC
HV = 1800 V



STS2, Gain 4 mV/fC
HV = 1650 V



STS1, Gain 1 vs GAIN4



- Isochrone parametrization of four STS1 double layers overlaps:
  - Feasible to use global parametrization (mean?)
- Higher gain (lower voltage):
  - Larger drift time range (~ 10 ns)
  - Lower drift electron velocities

Summary/conclusions

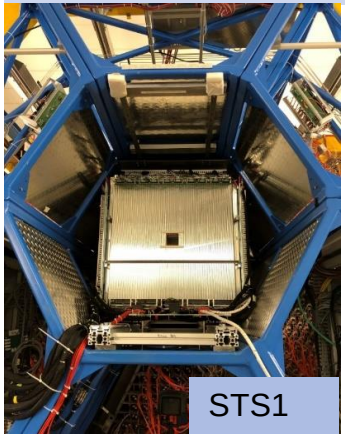
- To define if individual STS time offsets have to be used or possible to use the same for a channel group
- STS calibration needs to include corrections due to time of flight effects
- Linear relation between fRPC ToF and STS times can be used for ToF correction
- Isochrone parametrization is successful for both tested gain factors (1 mV/fC & 4 mV/fC)
- A global isochrone parametrization (STS1, STS2, STS1+STS2) would simplify the calibration

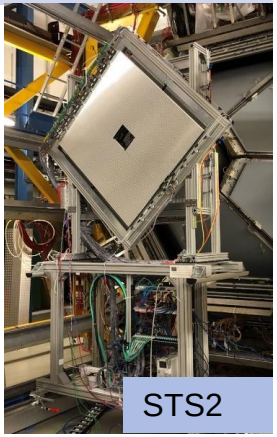
THANK YOU
QUESTIONS?

BACK UP

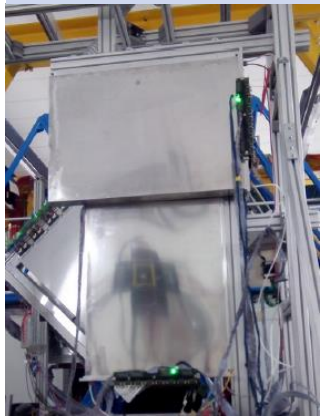
HADES Forward Detector for FAIR Phase-0

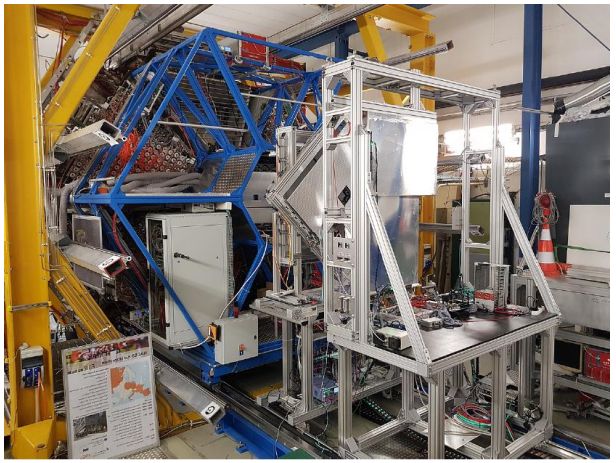
Straw Tracking Stations
(coll. with PANDA@FAIR) σ(x)~150 μm

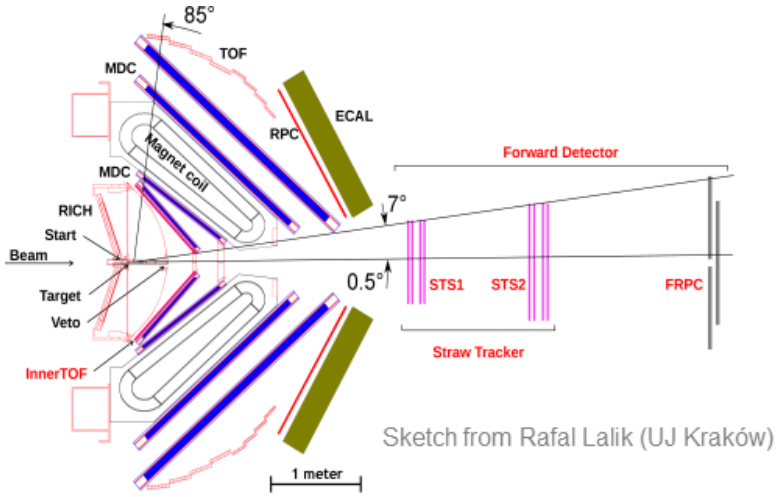




FRPC TOF
σ(TOF) ~ 100 ps

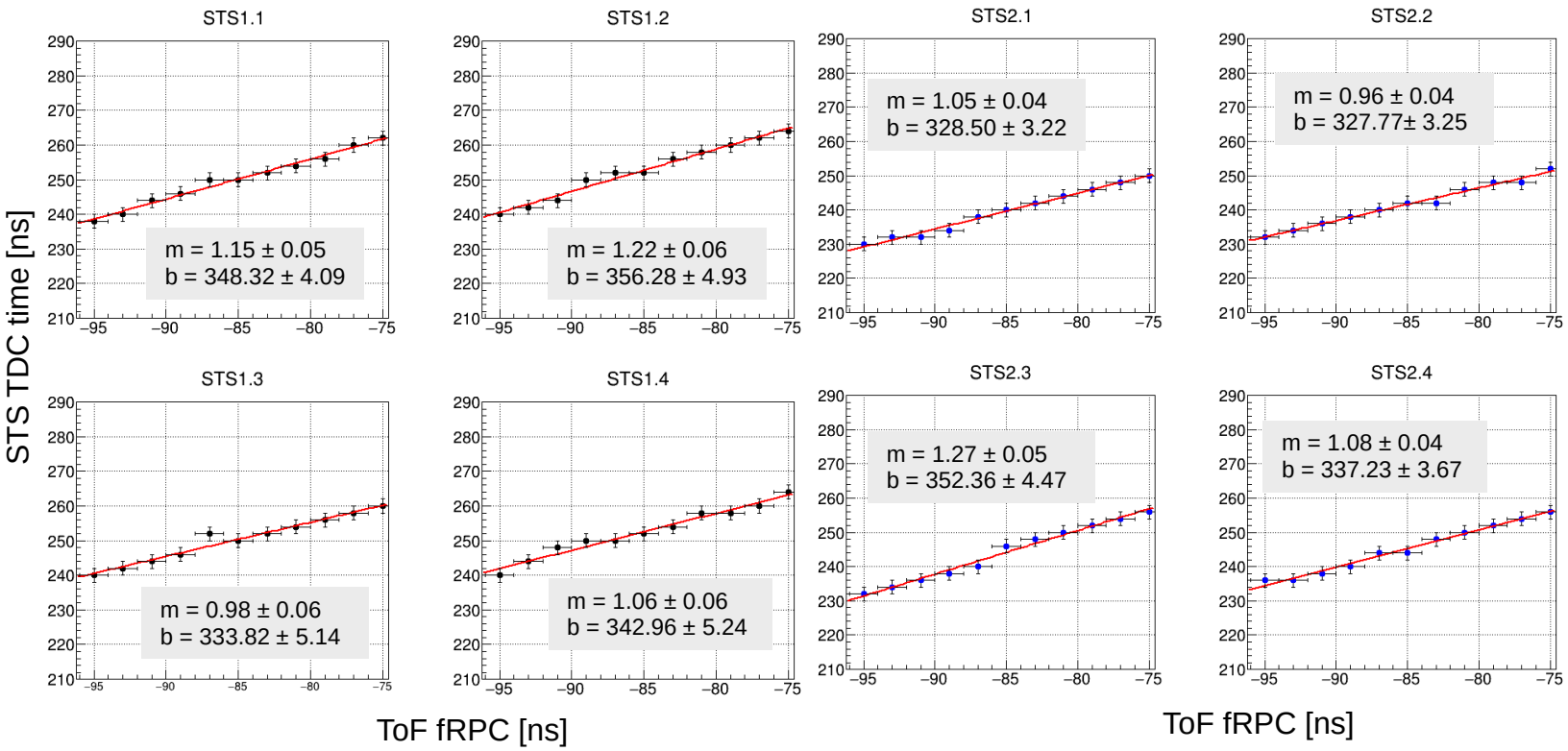






Sketch from Rafal Lalik (UJ Kraków)

STS vs Time of Flight (fRPC) information

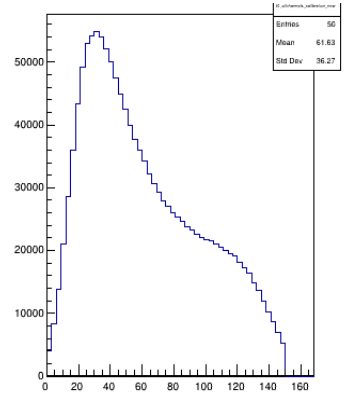


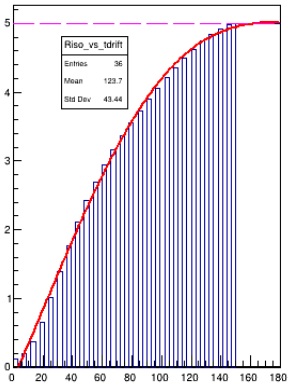
- STS1 times start after STS2 times: maybe due to different LVDS cable lengths.
- Higher statistics are available - > reference points better defined than PT1 events

Open points:

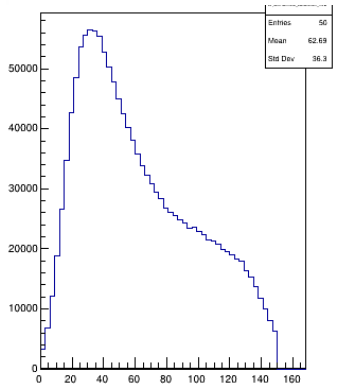
- Improve strategy to calculate reference points
- Maybe it is not possible to resolve a TOF difference for STS1(2).1 and STS1(2).4 (half meter distance)

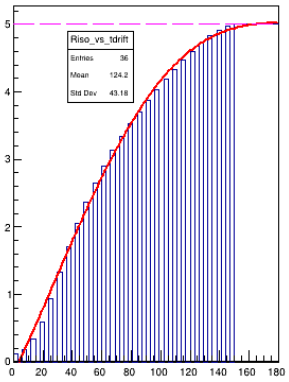
STS1.1, Gain 1



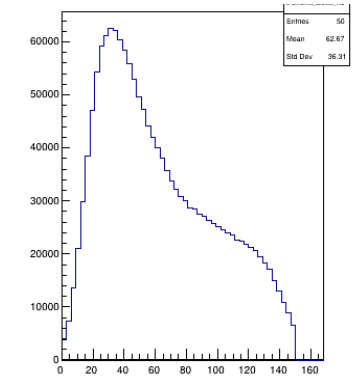


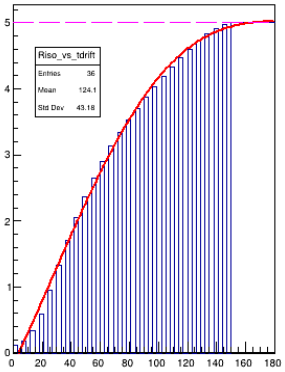
STS1.3, Gain 1



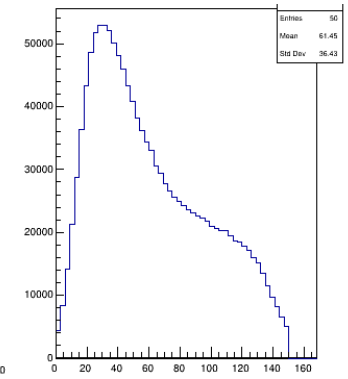


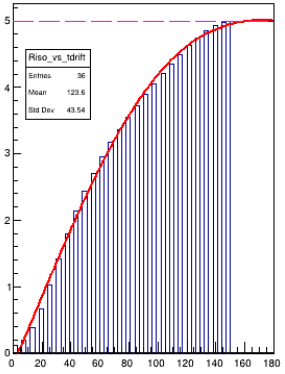
STS1.2, Gain 1

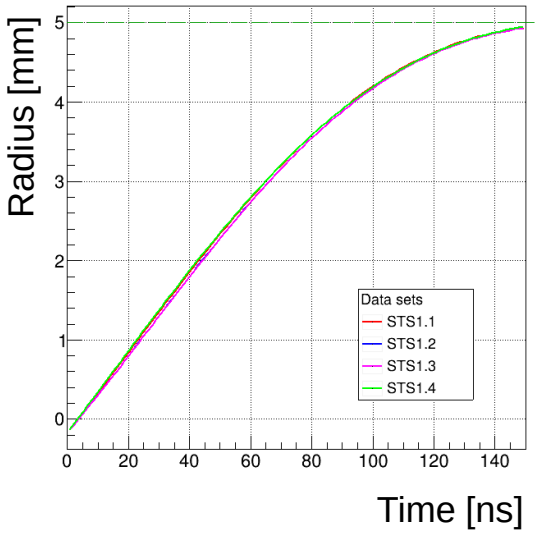




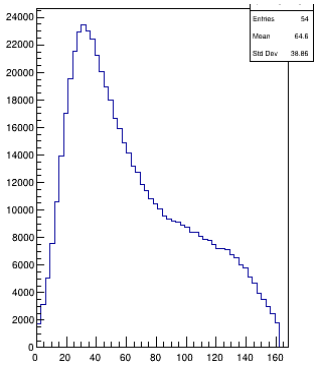
STS1.4, Gain 1

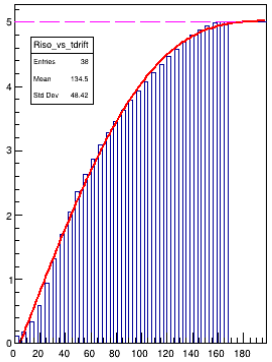






STS1.1, Gain 4





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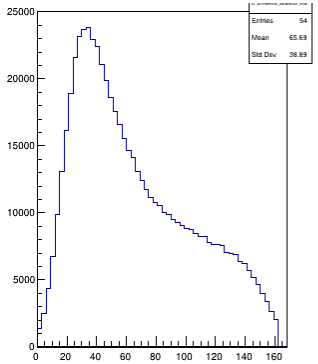

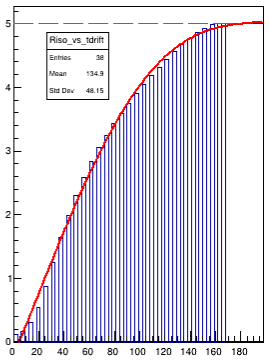

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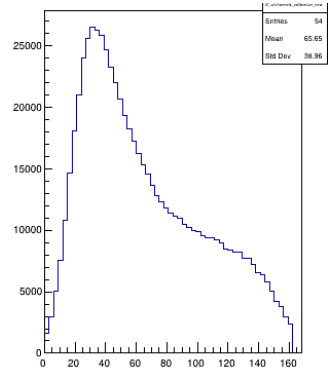
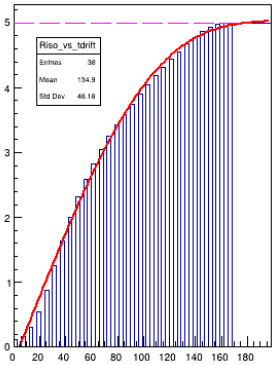
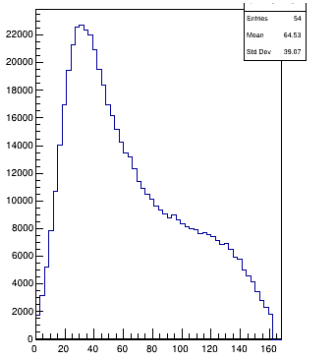
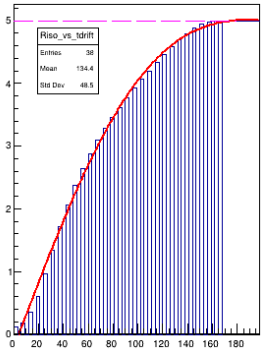
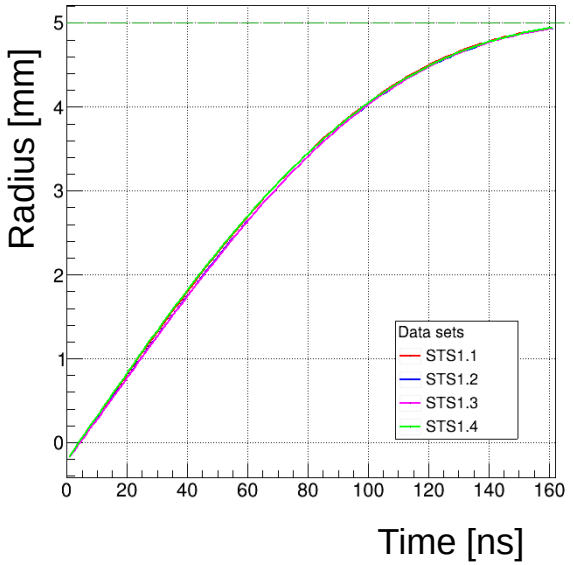




STS1.4, Gain 4

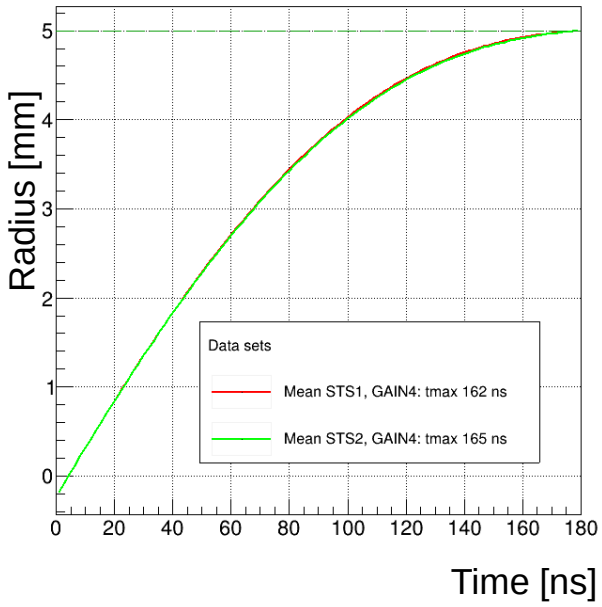




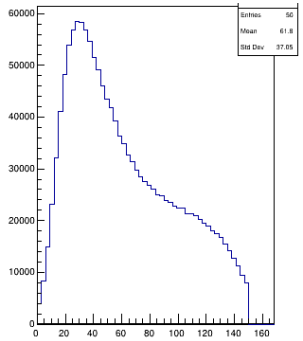


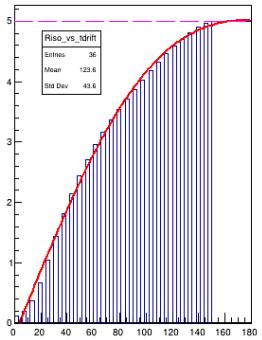
JÜLICH Forschungszentrum

Effect of increasing/decreasing tmax by ~ 3 ns



STS2.1, Gain 1





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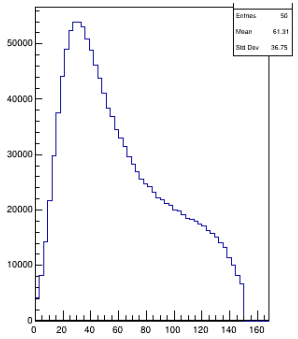

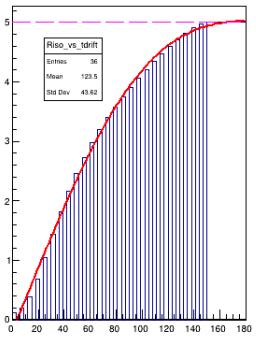

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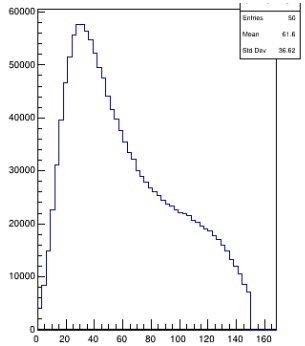

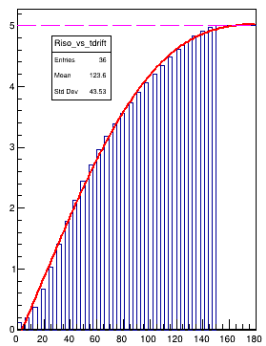

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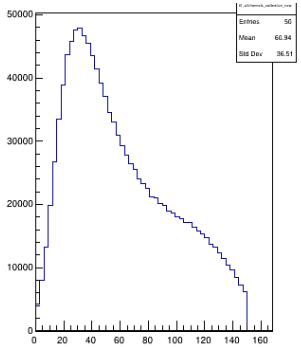
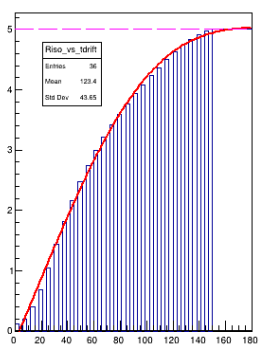
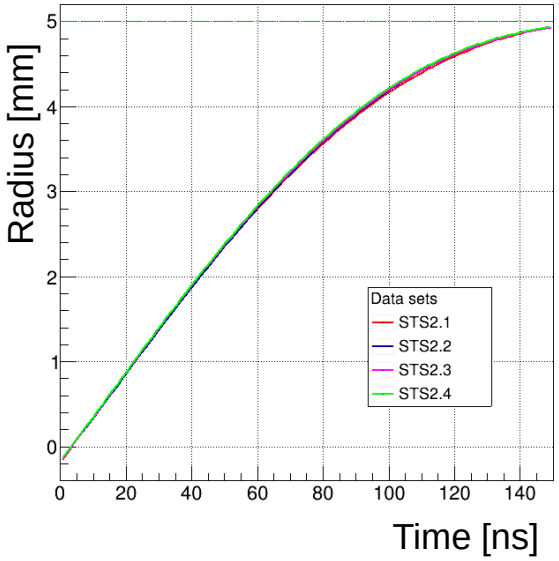
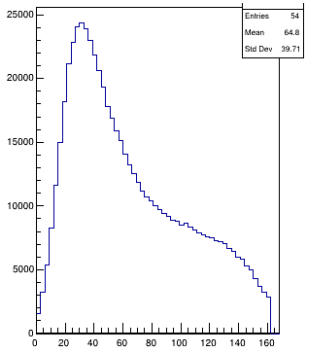
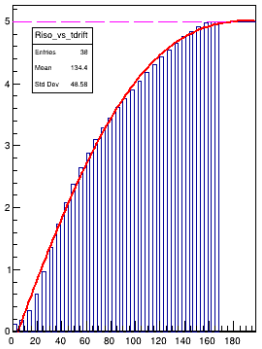




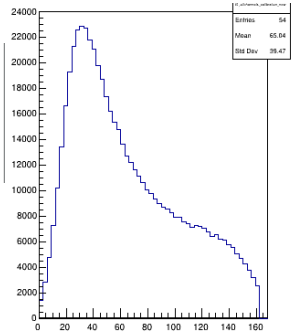


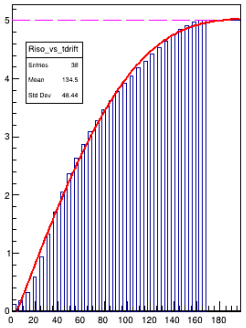
STS2.1, Gain 4



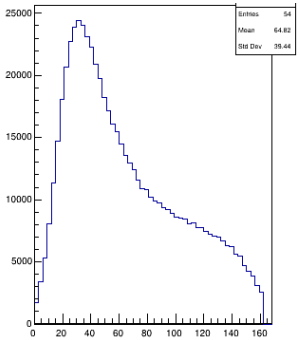


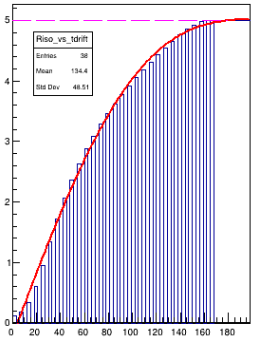
STS2.3, Gain 4





STS2.2, Gain 4





STS2.4, Gain 4