STT Status

Peter Wintz (IKP, FZJ) for the STT Group

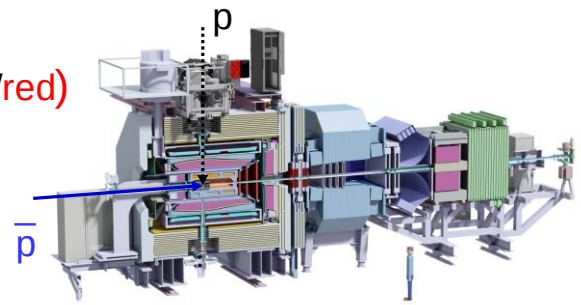
TRK Session @ PANDA CM 17/3, Novosibirsk, Sep 2017

Overview

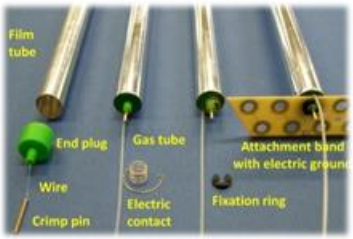
- PANDA-STT Detector
- Electronic Readout System(s)
- Project Status
- Testbeam Results
  - Spatial resolution
  - T0-Determination
- Phase-0 Experiment

PANDA – Central Straw Tube Tracker

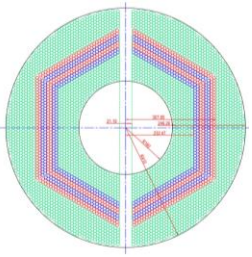
- 4224 straws in 19 axial (green) and 8 stereo (±3°) layers (blue/red)
  - 27µm Al-Mylar film, 1400 mm length, 10 mm diameter
  - Ar/CO_2 gas mixture at 2 bar pressure
- X/X_0 = 1.25% by self-supporting quad-layers
- Drift time readout & spatial resolution (σ = 150µm)
- Charge readout for PID by dE/dx
- Momentum resolution $\sigma(p)/p$ ~ 1-2% (@ 2T, STT+MVD)
- Continuous data stream readout (~ 15GB/s)



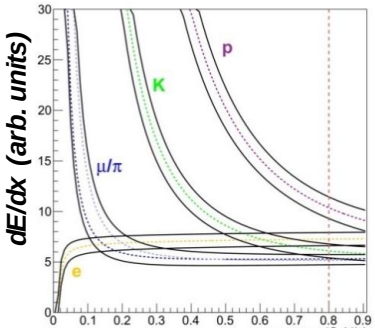
PANDA spectrometer

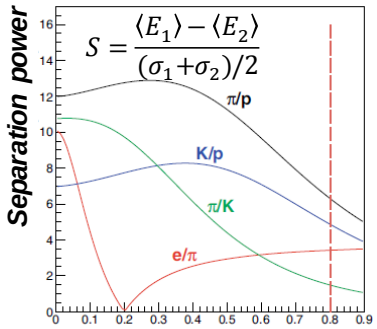


Straw materials

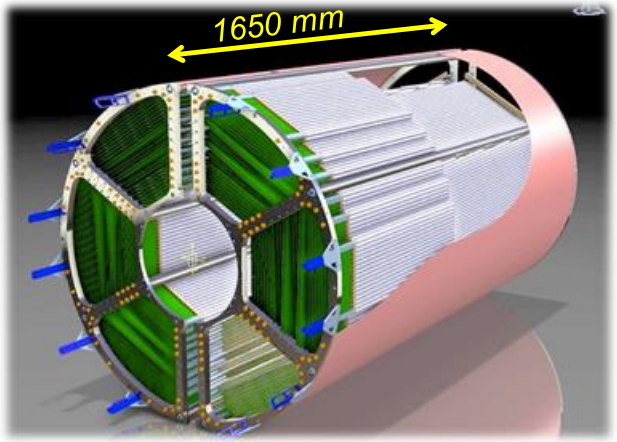


Straw layout





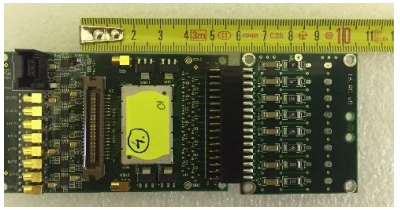
PID by dE/dx simulation for STT (from TDR)



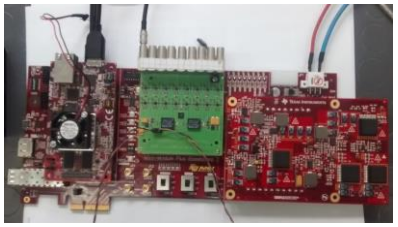
STT 3D – view

Electronic Readout System(s)

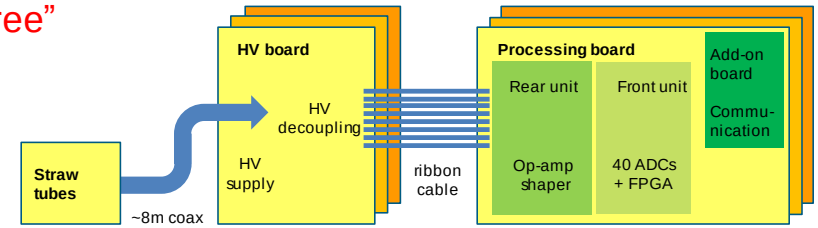
- Two concepts for charge readout: measure signal pulse area or pulse width
- TDC - system (AGH & JU Krk, IKP Jül)
  - Charge information by time-over-threshold measurement (pulse width)
  - Front-end ASIC, LVDS signals to TRB3 readout (TDC in FPGA)
  - PASTTRECv1-ASIC designed, verified in 2016 & no v2 needed
  - dE/dx separation power by time-ovr-thresh demonstrated & competitive
  - TRB3 sufficient for phase-1, not for full lumi (BW limit by GbE)
  - TRB HW upgrade is a general FAIR project (activities ongoing)
  - Mech. detector FE-layout in progress (FEBs, cooling)
- ADC - system (IFJ Krk, IKP & ZEA-2 Jül)
  - Charge information by pulse area (integration)
  - Waveform sampling ADC (160 MSPS, interleaving mode)
  - WF readout & signal processing (in real-time) by central FPGA
  - System scheme finalised: “front-end electronics free”
  - HW designs completed, all HW in production
  - Prototypes tested in-beam 2016



FE-board with ASIC



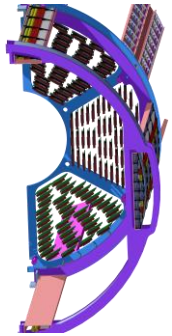
ADC/FPGA testboard



STT Pre-Series Test (M8)

1. Decision on final electronic readout system based on in-beam test results
   - Two concepts for charge readout under study
   - Pre-series systems set up in progress for both ROs (~ 400ch each, = 10% of STT)
   - Straw test systems available for in-beam tests and both ROs
   - Aim for decision on final electronic readout by Q2-2018
   - Decision process started in Jan-´17, review panel set up, regular meetings, criteria next

2. Set up one STT sector in prototype mech. frame
   - Mech. FE-layout (space limitations)
   - Cooling scheme if FE-electronics
   - Straw module alignment scheme
   - Aim for pre-series test by Q3-2018



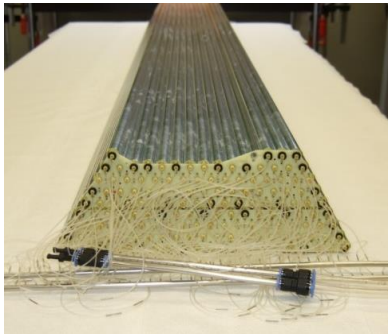
FE layout for TDC readout system

STT prototype mech. frame (LNF)

PANDA – STT Project Status

Important timemarks

- Straw production soon finished (~7000), assembly of quad-layer modules next
- Decision on final electronic readout by Q2-2018
- Pre-series test (FAIR-M8) by Q3-2018
- STT main production period 2018 – 2021, FAIR-M9 in Q2-2021
- Off-site tests in Q3/Q4-2021, ideal option would be at COSY (?!)
- STT ready for installation at FAIR in Q1/2022 (FAIR-M10)



Two inner quad-layer modules (axial).

Phase-0 experiment

- Upgrade HADES with new (PANDA-type) forward straw tracker station (STS)
- Physics program: Dalitz and radiative hyperon decays
- Forward (baryon) tracking ($\theta < 6.5°$) by STS, dileptons and mesons by HADES
- Joint PANDA-STT/FT project, synergies with HADES-DAQ group (TRB system)

	2017				2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Straw-Tube-Tracker							**M8**											**M9**			**M10**			
Phase-0 @ HADES	**STS1+2 Production**						**Install**		**Experiment**															

Beamtests in 2016

- New beam test area, counting rooms and various detector systems set up in 2016
- Two straw test systems installed for both readouts, renewed in 2017
- Proton and deuteron beam time (1+1 week) in 2016, momentum range: 0.5 - 3.0 GeV/c
- Covered dE/dx measurement range: ~ 5 - 50 keV/cm (= 1 - 10× MIP, in Ar/CO_2 at 2 bar)
- Varied beam spot size and intensity (micro-pulsing)
- High rate straw exposure (~ 10-100× PANDA-STT), stable operation, no break-downs

One of the two straw test systems.

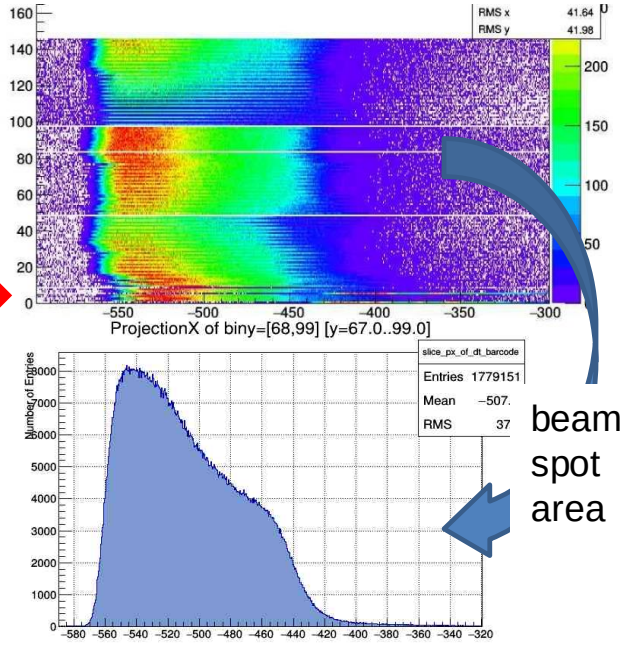
Test setups in new beam area. Beam from the back with ~2m beam line height.

ASIC/TRB – Readout Status

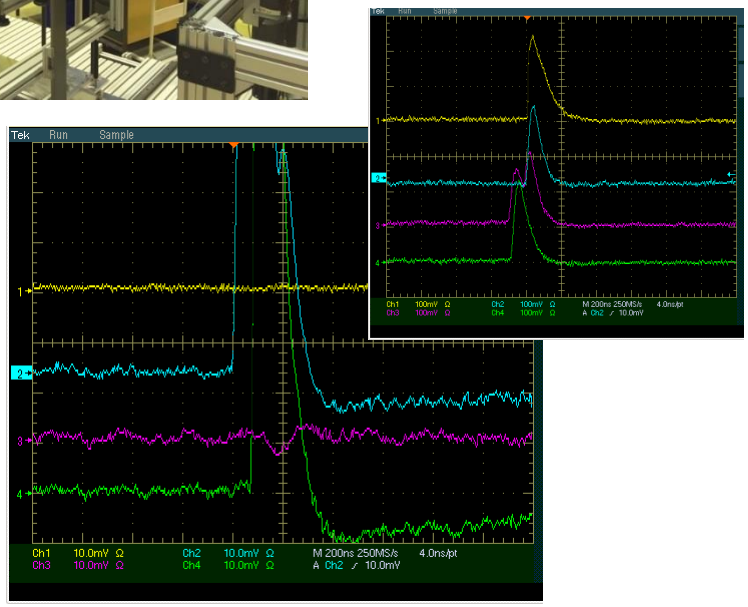
(Raw Spectra from April 2016 Beam Time)

In-beam position of straw setup (beam from the right)

FEB replaced later (ch1-16)

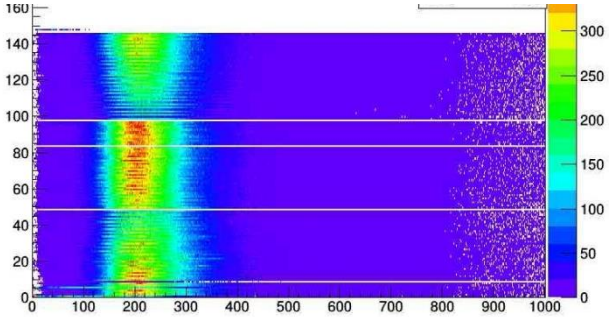


beam spot area



ASIC analog output signals (in-beam), NL <5mV (stable), thresh. at 10mV

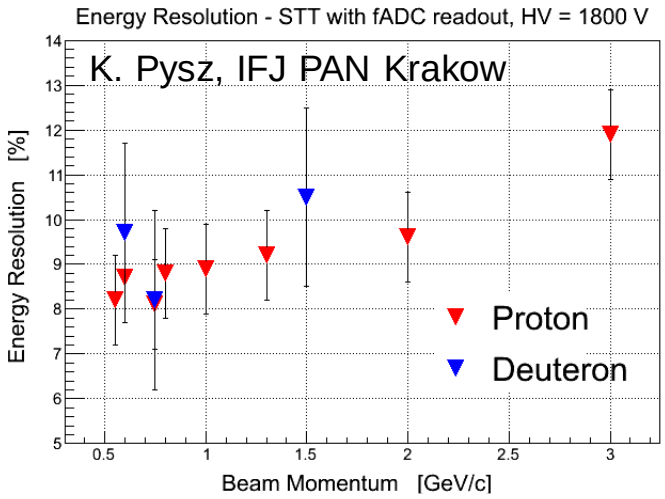
TDC time (top) and time-over-threshold (below) vs channel

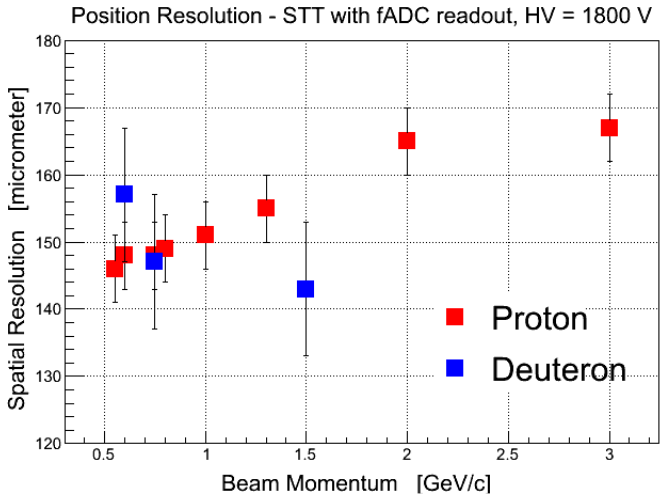


Results for (F)ADC Readout System

Reminder:

- PID by dE/dx separation for STT early demonstrated by FADC system (TDR)
- FADC (240 MHz) prototype system, 128 channels, (WASA-type FADC)
- System used for (direct) cabling tests & design of FE-electronics-free scheme
- First 16-ch prototype of new ADC readout (160 MSPS) tested in-beam in 2016
- Next step: set up pre-series system



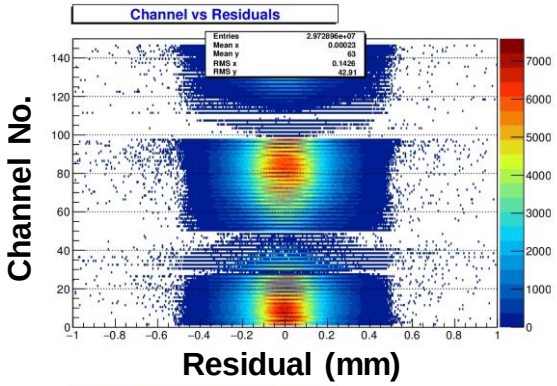


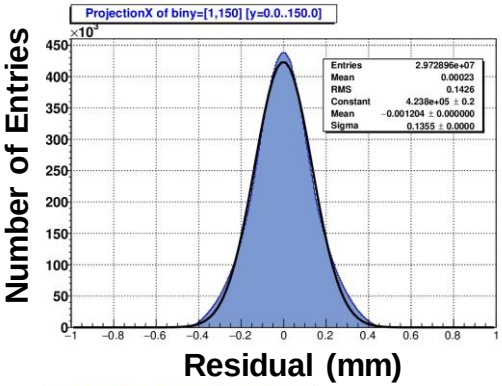
Collection of measured dE/dx resolution (left) and spatial resolution (right) with the FADC system.

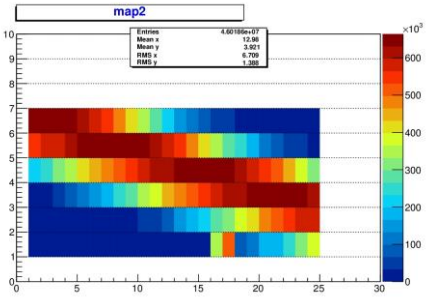
STT Spatial Resolution

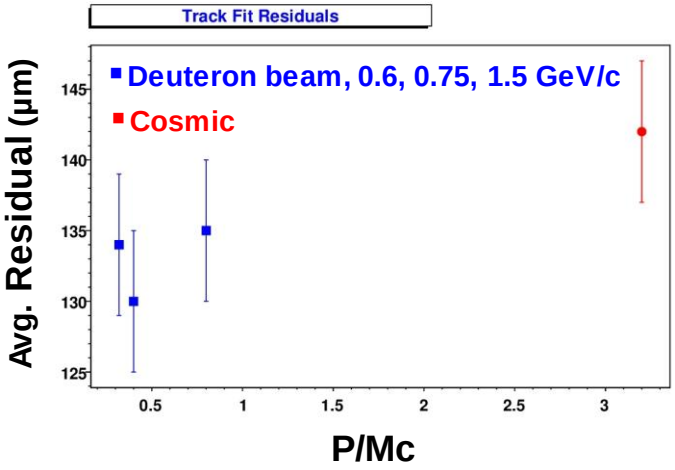
- Results here for ASIC/TRB readout (analysis by Peter)
- Similar results expected for ADC-based readout
- Full dE/dx range covered: ~ 5-50 keV/cm
- Results for deuteron testbeams & cosmic data-taking

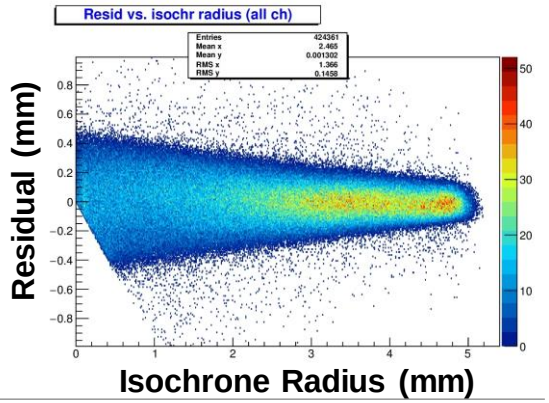
- Correction of r(t) relation according to resid. shifts
- Spat. resolution σ = 130 – 142 µm (avg. residuals)
- Design goal (150µm) reached (inspite mech. distortions)





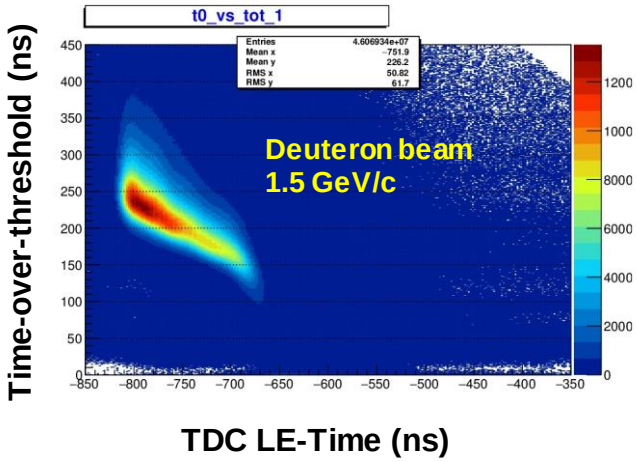


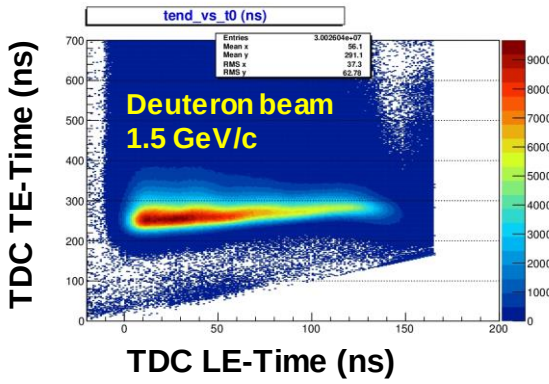


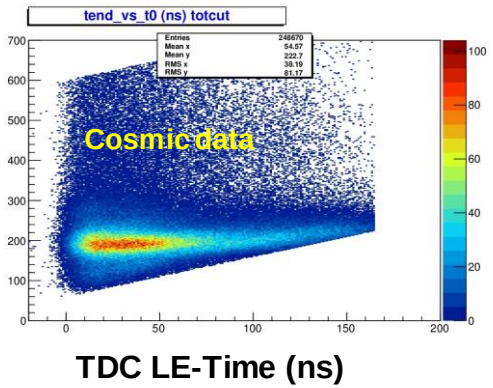


T0 Determination by STT (Step 1)

- Straw TDC-time raw hits, check if absolute time information can be extracted
- Raw hits: TDC LE-time and TE-time, time-over-threshold ToT = TE – LE time
- Drift time (LE-time) range: ~160 ns (~ 200 ns @ B=2T)
- ToT range: several 100 ns (dE/dx Landau-tail)
- TE-time shows smaller variation
- TE-time is single track specific (dE/dx ↔ ToT)

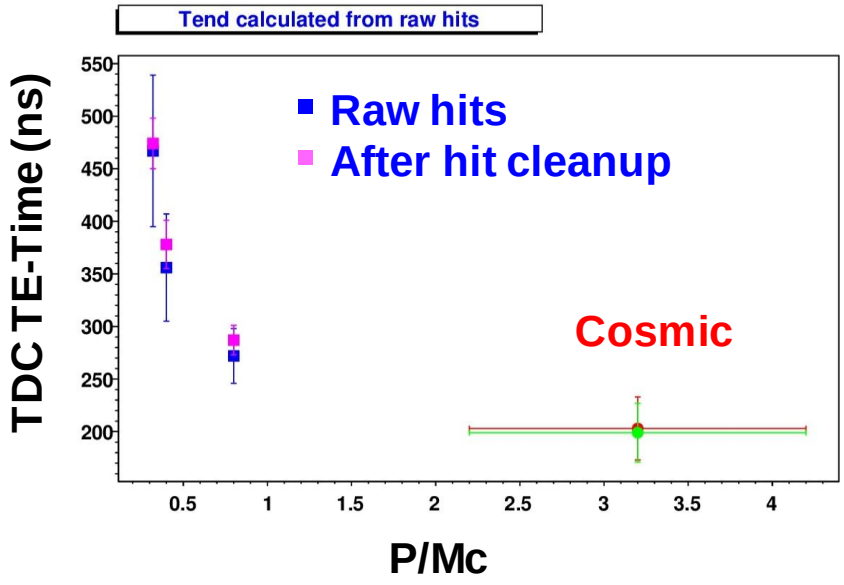


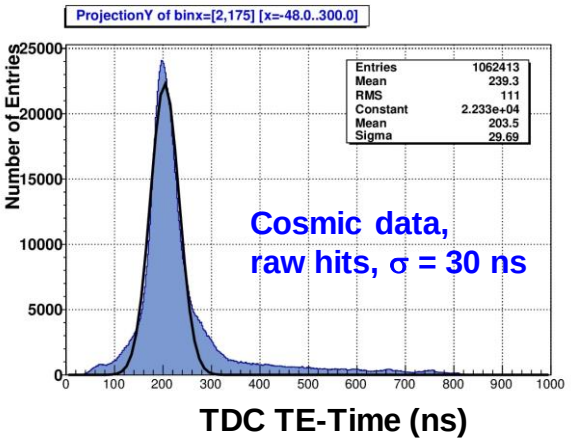


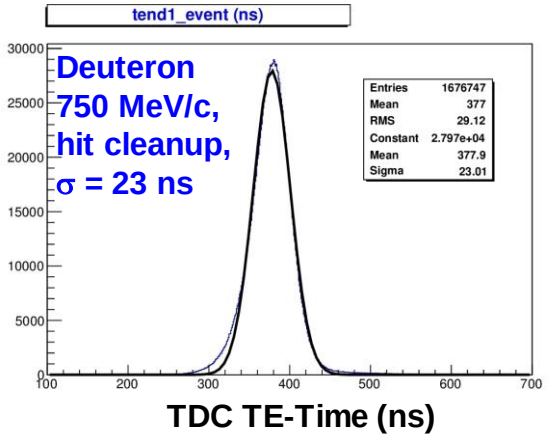


T0 Determination by STT (Step 1)

- Check TE-time resolution, for deuteron testbeam and cosmic data-taking
- Covered dE/dx range ~ 5-50 keV/cm (= full signal dynamical range)
- Cosmic tracks with large θ-angle range, but only 2D-tracking done
- Resolution: σ ~ 25 ns (after cleanup)
- Resolution worse (~30ns) for cosmics as expected
- TE-time valid for single tracks not for all event tracks

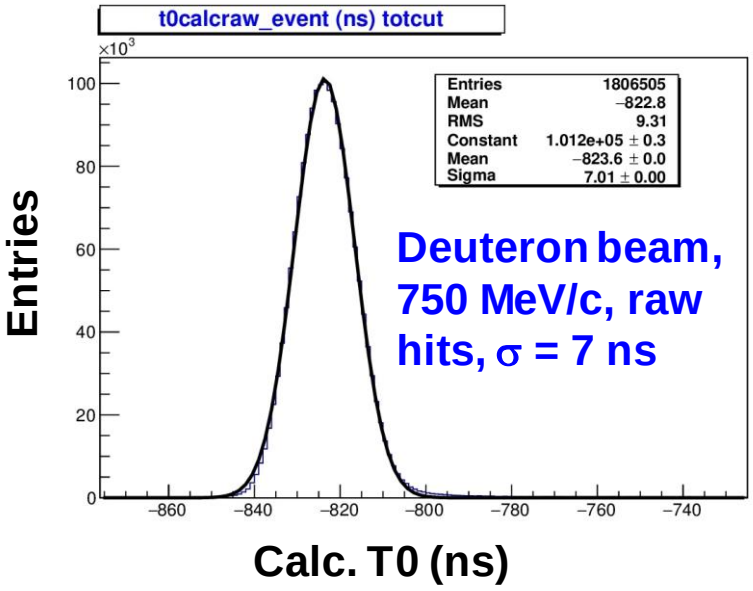


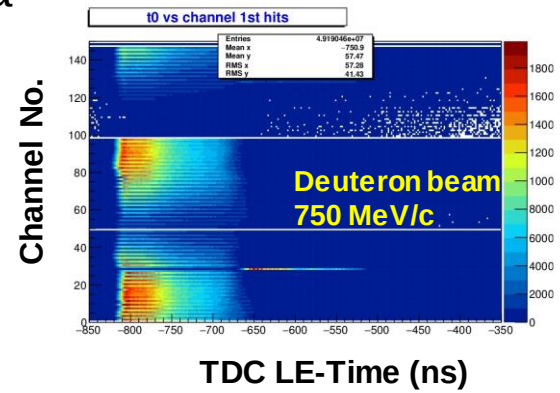


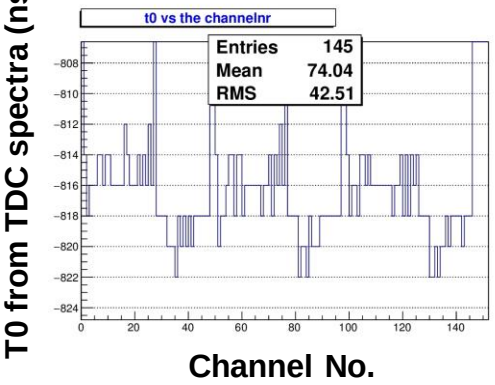


T0 Determination by STT (Step 2)

- TE-time can be used for hit pattern recognition → assoc. track candidate hits
- Better: use multi-dim. space (i_{ch}, TE-time, ..), hits in adjacent straws/layers
- Calculate T0 from raw TDC candidate hits (lin. relation, T0=shift, sum up hits)
- Calc. T0 in good agreement with T0 from TDC spectra
- Note: single channel time offset shifts (TDC)
- T0-resolution: σ = 7 ns (~ 6 ns after cleanup)



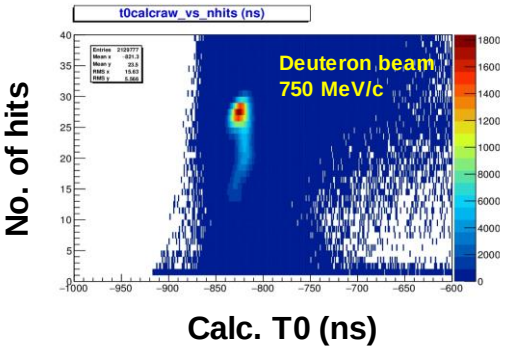


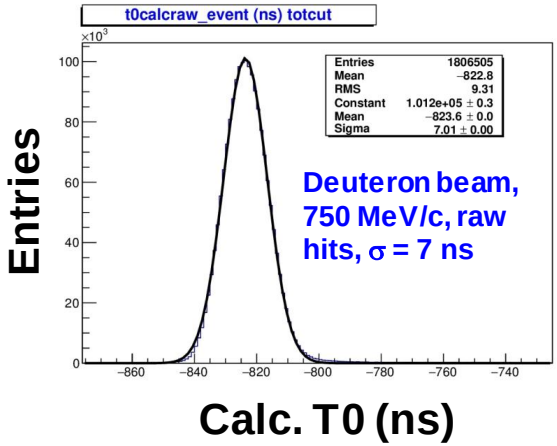


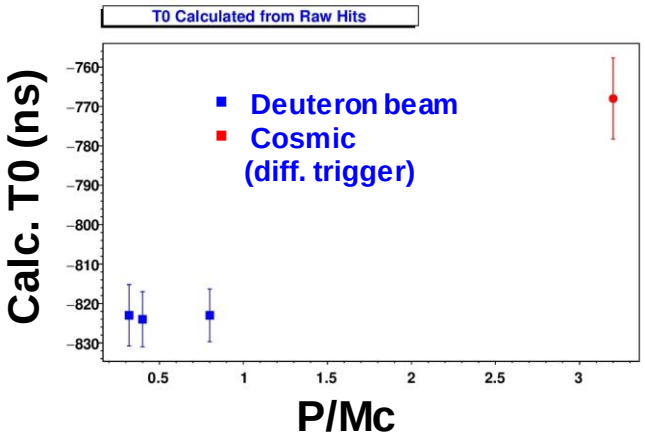
T0 Determination by STT (Step 2)

- Obtained T0 values independent on dE/dx (same for diff. deuteron momenta)
- σ (T0) = 11 ns for cosmics (larger θ-range, but only 2D-tracking!)
- Different cosmic T0 value due to diff. TDC trigger timing
- Minimum number of track hits required for calculation to be studied (see fig.)

- T0 resolution is sufficient for 1st tracking iteration
- Preliminary results, further analysis ongoing







Phase-0 Experiment

Forward Straw Tracker Stations (STS) for HADES upgrade at SIS18

- Experiment program of (PANDA) interest: Dalitz and radiative hyperon decays
- STS for (baryon) tracking $\theta < 6.5°$, HADES measures di-leptons and mesons
- Groups: AGH & JU Krakow, Julich, Orsay

HADES experiment proposal for FAIR Phase-0 in progress (news from Piotr)

- Submission to PAC by June-19th, program for 2018/19 and beyond
- Several campaigns: π+p, Ag+Ag, p+p and p+A
- HADES/PANDA program is integral part

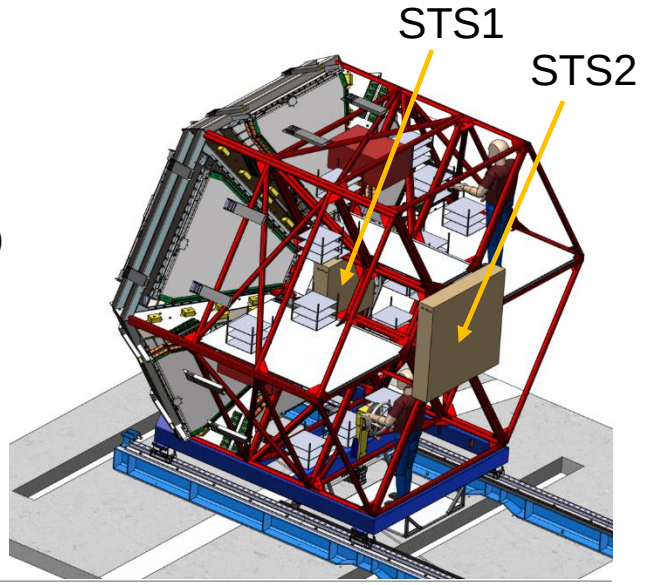
STS1:

- 640+64 straws, 2× 2 double layers (0°, 90°, 0°, 90°)
- 76.6 cm straw length, 2×16 straw modules, same as FT3 (3rd, 4th)
- Active area: 80×74 cm^2, beam hole: 8×8 cm^2

STS2:

- 896+128 straws, 2× 2 double layers (0°, 90°, 45°, -45°)
- 125 cm straw length, 2×16 straw modules, same as FT5
- Active area: 120×112 cm^2, beam hole: 16×16 cm^2

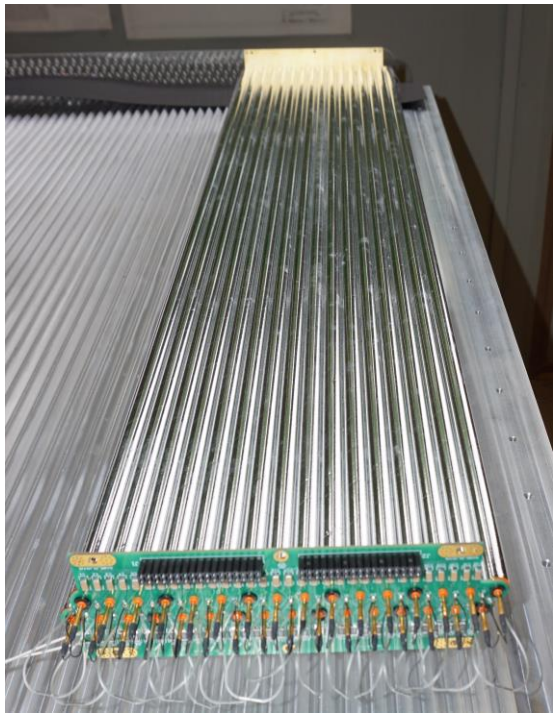
Two tracking stations



Phase-0 Status (Julich)

STS1:

- 270 straws produced, in parallel to STT activities
- 1st full module assembled (2×16 straws)
- Adapter boards (by Krakow) similar to FT design (FEE)
- Mech. frame by Krakow (FT - design)
- Finish straw productions by Q4/17, modules by Q1/18
- STS1 system completion by Q3/2018
- Ready for installation at HADES by Q4/2018



ASIC/TRB3 readout:

- Successfully tested in 2016´ STT in-beam campaign
- Stable running since ~ 1 year, now cosmic runs
- RO compatible to HADES-DAQ
- ASICs and FEBs next order submitted (more spares)

Components for high voltage and gas system

- Gas & HV systems open, reminder: WPs for STT suspended

Phase-0 Status (Krakow)

STS2 (news from Jerzy):

- 12 long straw modules produced (125 cm length)
- Frame with plates for mounting modules finished
- In progress: 4× central shorter modules (50 cm length)
  (HV splitter & cabling, mounting tools & mech. support)
- Test of FEBs ongoing (QA)
- Assembly of 1st half of STS2 and system tests by fall
- Complete 2nd half of STS2 by Q1/2018
- Funding for 2nd half secured by Orsay

Software:

- Forward detectors (STS + TOF-RPC wall) implemented in HYDRA*
- Full simulation of two benchmark channels ongoing
  - $pp \rightarrow p\ \Xi^-(1321)\ K^+\ K^+$
  - $pp \rightarrow p\ \Lambda(1520)\ K^+ \rightarrow p\ \Lambda\ e^+e^-\ K^+$

*HADES analysis framework

Thank you

for

your attention

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