JÜLICH
FORSCHUNGSZENTRUM

Status of STT Developments in Jülich

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and

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December 3, 2010 **PANDA STT Group Meeting**

Overview

PANDA STT

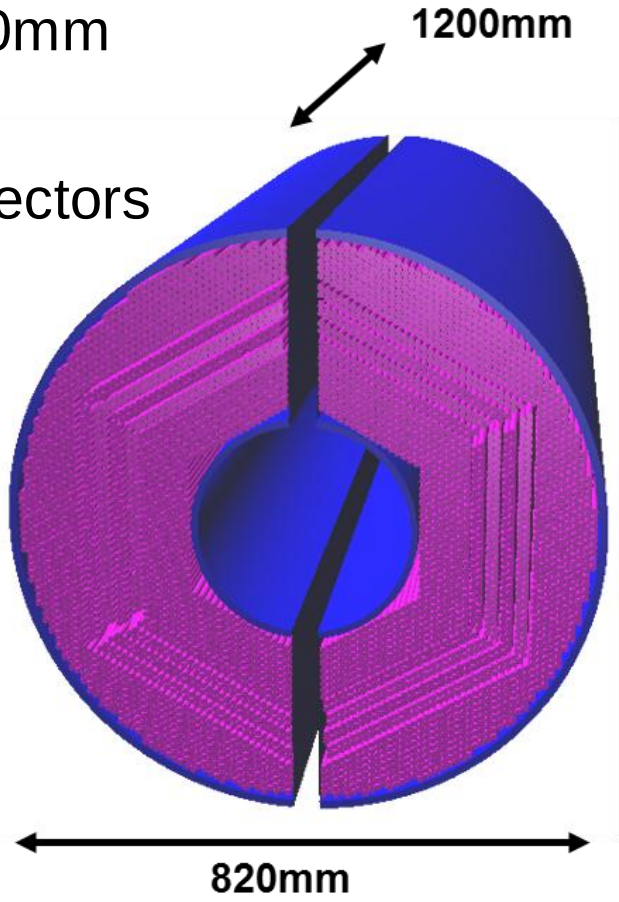
- Design update
- Prototype construction
- Readout options ($\rightarrow$ Krzystof)

Installed STT system at COSY-TOF

- Operation status
- Calibration and resolution results

STT Concept

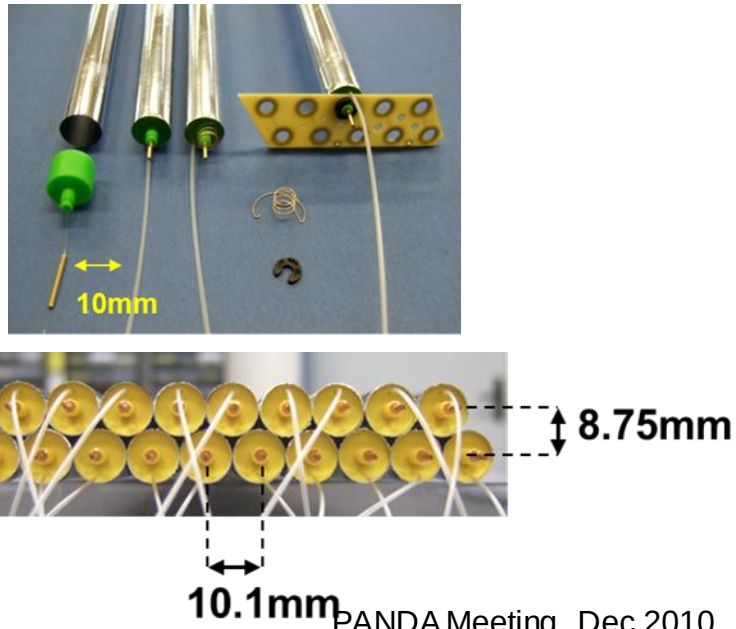
- 4580 Straw tubes
- Al-mylar: d=27µm, ∅=10mm, L=1200mm
- Close-packed with <20µm gaps
- 21-27 planar layers in 6 hexagonal sectors
- 8 layers skewed (3D reconstruction)
- Time readout (isochrones)
- Amplitude readout optional (dE/dx)
- $\sigma_{r\phi} \sim 150\ \mu m$, $\sigma_z \sim 2.9$ mm
- $\sigma_p \sim 1\%$ at B=2Tesla

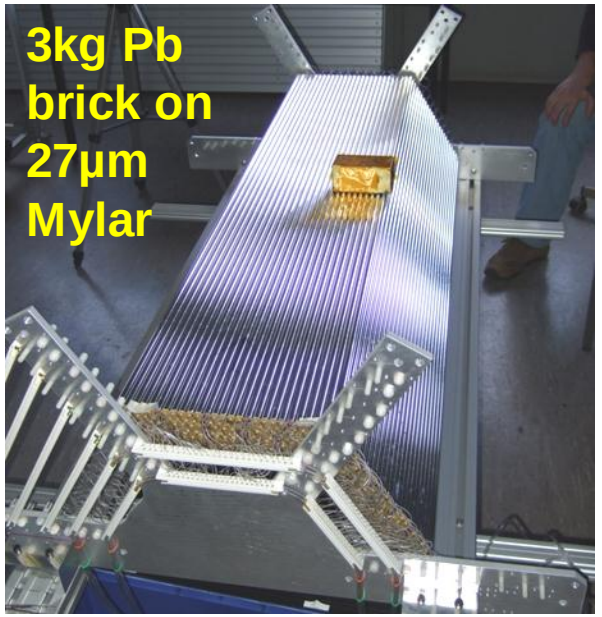


STT Design

Low mass, X/X_0~1%

- 11.5 kg Straw tubes (4580× 2.5g)
  - Close-packed layers, pressurized p=2bar
  - Self-supporting strong wire & tube stretching (220kg/3.5t)
- 9 kg Mechanical frame

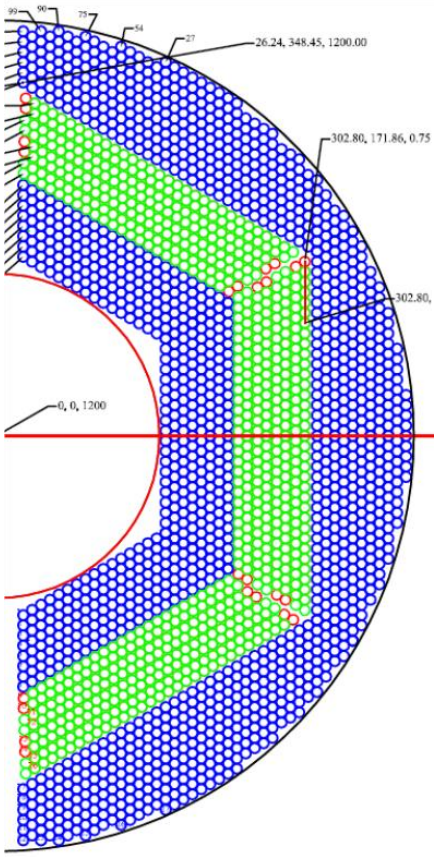




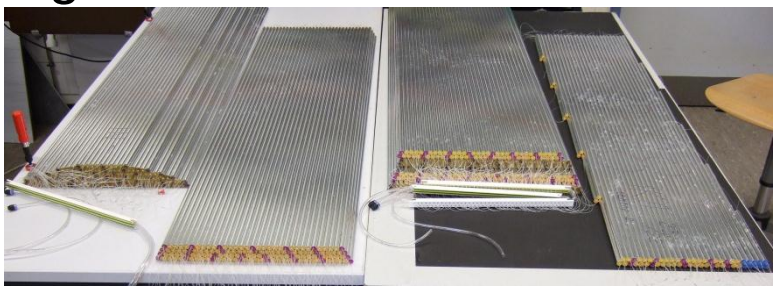
STT Layout

21-27 layers, from inner to outer radius

- 8 Axial layers
- 4 Skewed double-layers (±2.89°)
- 5 Axial layers
- 6 Axial filling layers
- 85% of cylindrical volume filled by straws



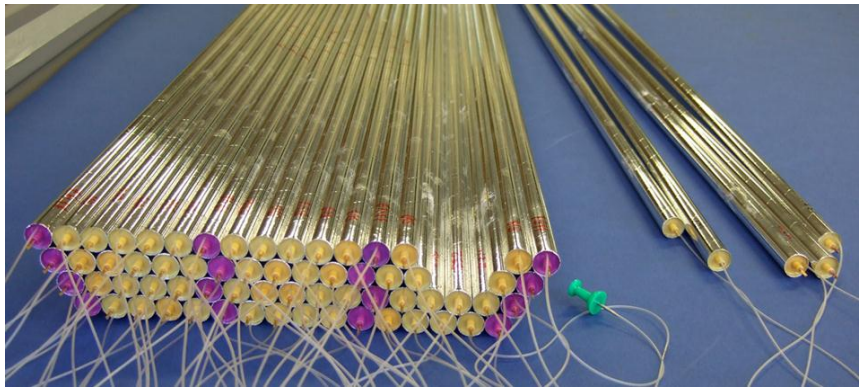
- 2× 2050 straws with 1200mm length
- 2× 240 skewed straws with diff. length
- 4580 straws in total



Straw Modules

Quad-layer module

- 4 close-packed layers, glued together
- Increased rigidity compared to double-layer
- Even number of straws and gas lines per module
- Replacement of single, faulty straws possible
- Module of 2× double-layers (±2.89°) for skewed orientation

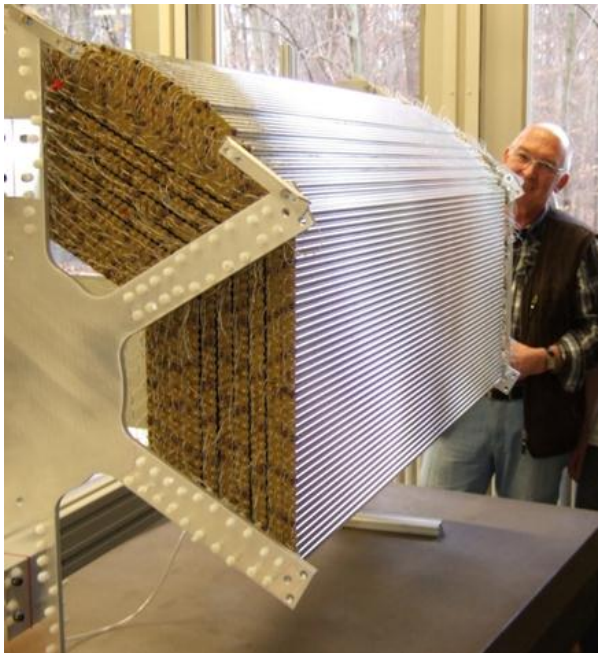


Exchange of single straws in quad-layer module possible

Prototype Construction

Full-scale PANDA-STT prototype:

- Develop assembly technique
- Integrated quad-layer modules with gas manifolds and electric coupling
- Assembly complete hexagon sector on the table
- Insert sector into STT frame structure
- Plug on gas and electric connectors



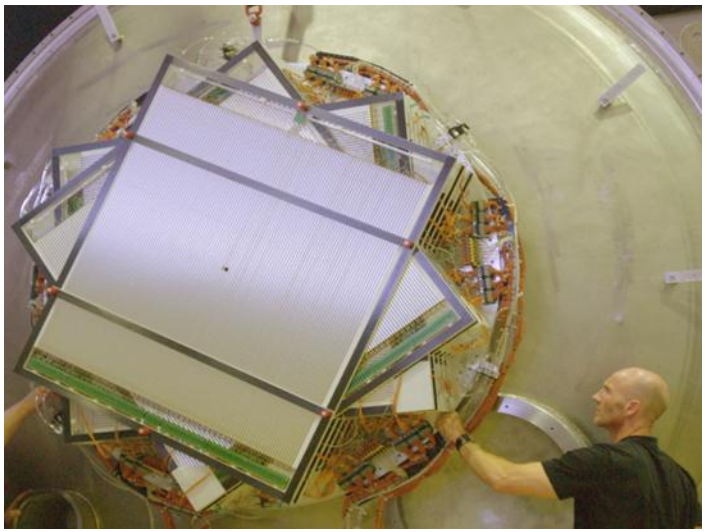
Small-scale prototype:

- 128 tubes with 1500mm length
- Readout development (➔ **Krzystof**)

Testsystem: STT at COSY-TOF

2704 straw tubes

- Al-mylar: d=32µm, ∅=10mm, L=1050mm
- 13 planar double-layers
- Skewed by i×60° for 3D reconstr.
- Ar/CO_2 (20%) at p=1.2bar
- Time readout: discr. + TDC
- Operated in vacuum

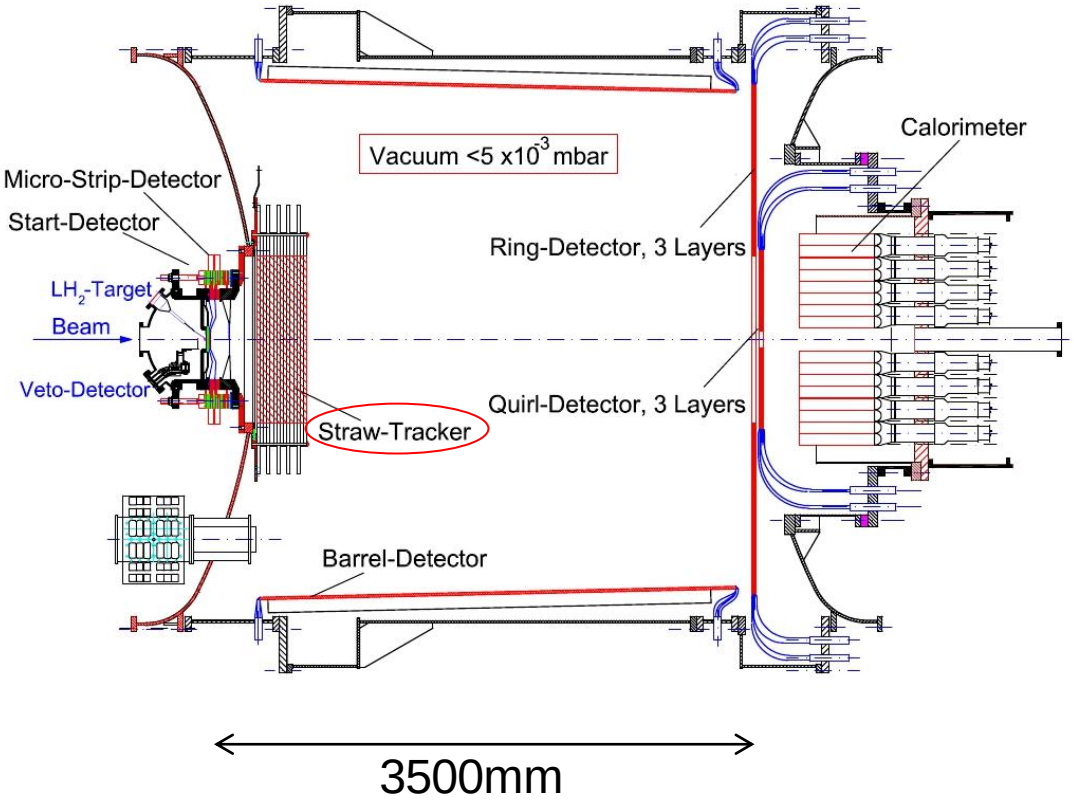


Testsystem for PANDA-STT

- Same straw design, materials, geometry of planar d-layers
- Similar straw calibration method

COSY-TOF Apparatus

p-Beam on target cell inside large Time-of-Flight vacuum vessel, equipped with scintillator hodoscopes and Straw Tube Tracker



Operation Status

- 1st beam time in Aug/Sep 2010: $\vec{p}p \rightarrow pK\Lambda$ at 2.95 GeV/c
- 2 years in surrounding vacuum now
- Gas leakage on permeation level
- No HV problems in vacuum (p_{vac} <10^{-3} mbar)

Detector settings

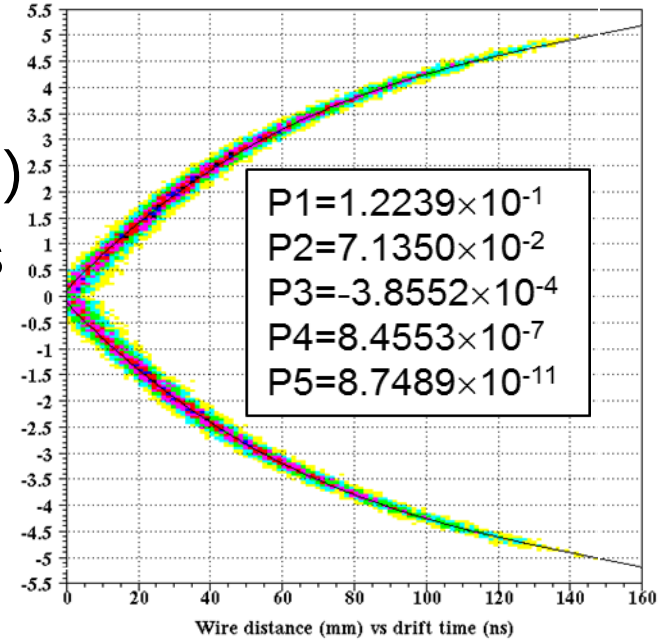
- Ar/CO_2 (20%), p=1.25bar (abs.)
- HV=1840V
- Max drift times ~150ns (PANDA-STT: ~250ns, p=2bar)
- Non-linear isochrone radius – drift time relation

Calibration Method

Method:

- Time offsets adjusted (4 RO crates, synchronised)
- Isochrone calibration by integration of drift time spectrum
  - $\frac{N}{R} = \frac{dN(t)}{dR(t)} \rightarrow R_{iso}(t) = \frac{\sum_{i=0}^{n} N_i}{N} \times (R_a - R_0) + R_0$
  - $R_{iso}(t) = \sum_{i=0}^{4} P_i \times t^i$
- Global parametrisation for all straws
- Track reconstruction (χ^2-fit to isochr.)
- Adjustment of straw (layer) positions
- Iteration of calibration

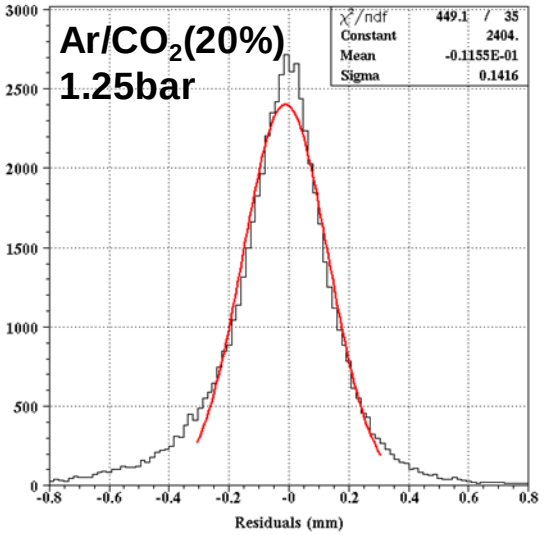
(➔ Ph.D. thesis by S. Costanza)



Spatial Resolution

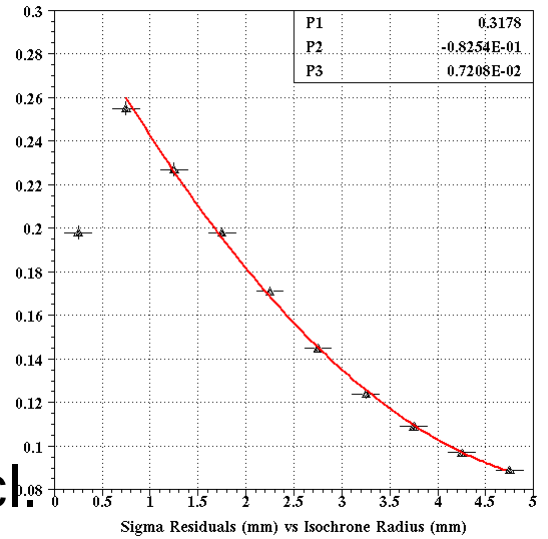
Single (raw) tracks, no event cuts:

- ≥6 hits, (mean 8.3, max 10 hits)
- Residuals < 800µm (~5σ) → refit
- Loose target cut (~10σ)
- ±52° max track angle (σ_θ~21°)



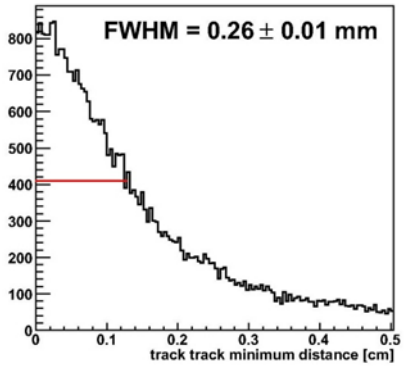
Results (preliminary!):

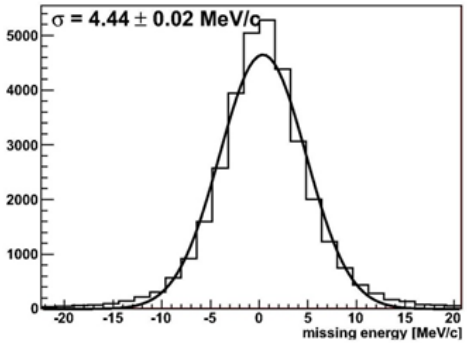
- Residuals: σ_r = 142µm (mean)
- 132-154µm variation for diff straws
- 260-90µm variation over straw radius
- No correction of $\sigma_{\delta e}$, σ_{MS}, $\sigma_{\Delta t/L}$, σ_{tof}, ..
- Still few ×10µm syst. errors in param. incl.

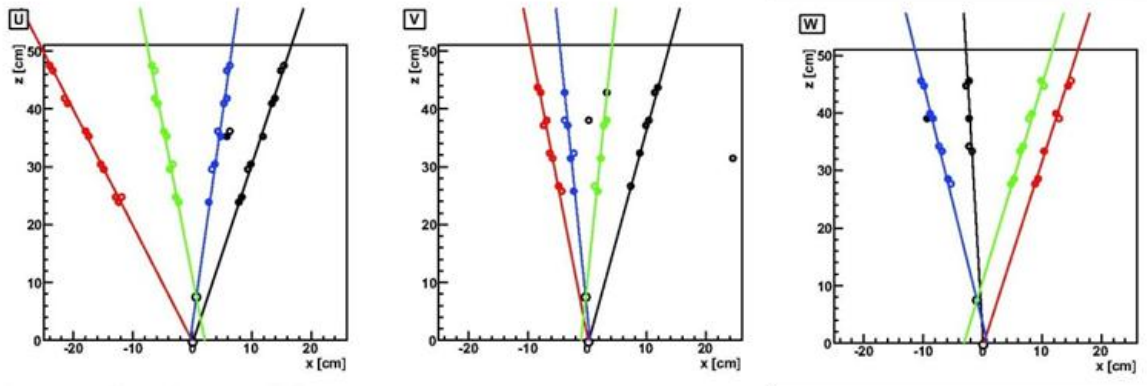


Tracking Results

- STT included in COSY-TOF analysis
- Reconstruction results of pp → pp events
  - σ ~110µm vertex resolution (260µm FWHM)
  - 25 cm distance target - STT
  - 4.5 MeV/c missing energy resolution
- pp → pKΛ event reconstruction with delayed decay Λ → pπ⁻







u/v/w projection planes of STT

Summary

- STT design & prototype construction developing, number of layers increased, 4580 straws in 21-27 layers

- Resolution σ_r<150µm demonstrated with time readout for large STT system (2700 straws, p=1.2bar abs.)
- Global parametrisation of isochrone radius – drift time relation due to precise diameter of pressurized tubes
- Position calibration method benefits from modular design and close-packed layer geometry (<20µm gaps)

- Realistic option: signal amplitude readout for dE/dx, benefits from >20 hits per track