Measurement of the spatial and energy-loss resolution with a prototype Straw Tube Tracker (STT) for the ČPANDA experiment

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for the ČPANDA collaboration
**PANDA experiment**

**PANDA (antiProton ANnihilation at DArmstadt)**

Study of the non-pertubative regime and understanding of the QCD spectrum and hadron structure

- One of the key projects at the future Facility for Antiproton and Ion Research (FAIR)
- State-of-the-art general purpose detector
- Precise studies of antiproton-proton annihilations and reactions of antiprotons with heavy nuclear targets
- Centre-of-mass energy between 2.3 GeV and 5.5 GeV

**HESR (High Energy Storage Ring)**

- Luminosity: $10^{31} - 10^{32}$ cm$^{-2}$ s$^{-1}$
- $\Delta p/p$: $4 \times 10^{-5} - 10^{-4}$
The PANDA detector:

- 4π acceptance
- High resolution for tracking and particle identification
- High event rate capabilities
- Flexible readout and event selection

**Several sub-systems**

- Tracking detectors (STT, MVD, GEM)
- Electromagnetic calorimeters (EMC)
- Muon detectors
- Cherenkov detectors (DIRC and RICH)
- Time-of-flight (TOF) detectors
STT specifications

4636 aluminised Mylar tubes
≥ 27 layers of which the 8 central ones are skewed
Single anode wire in the centre made of 20 µm thick gold plated tungsten
90% Ar and 10% CO₂ as quencher

Tasks of STT:

Precise spatial reconstruction of helical trajectories of particles with few 100 MeV/c up to 8 GeV/c
Measurement of the specific energy-loss (dE/dx) for particle identification (separation of protons, kaons and pions in the momentum region below 1 GeV/c)
An Application Specific Integrated Circuit (ASIC) is being developed to read out the straw tube pulses.

Two concepts to measure drift time + signal amplitude (for $dE/dx$):

- **Sampling:** Leading Edge Time, $Q$ (for PID)
  - Amplifier-shaper boards front-end at detector
  - Pulse analysis and readout by FPGA

- **Time Over Threshold (TOT):** Leading Edge Time + Trailing Edge Time, TOT (for PID)
  - Amplifier-Shaper-Discriminator front-end at detector
  - Time Readout Boards (TRB), Time to Digital Converter in FPGA
Test beam measurements

Proton beam with 0.8, 1.0, 1.3, 2.0 GeV/c momenta
Beam intensity ranging from 80 kHz to 200kHz
96 channels readout
Voltages: 1700, 1750, 1800, 1850, 1900 V
2 GeV/c data

Hit map

Typically 12 hits per event

Drift time spectrum

Drift times: ~160 nsec
Mitglied der Helmholtz-Gemeinschaft

Spatial resolution: \(~ 155 \mu m\)

Clean TOT and drift time spectra
Few background hits

Residual spectrum

TOT vs drift time spectrum
Energy-loss resolution

- 10% truncated mean: \( \sigma/\mu = 7.1\% \)
- 20% truncated mean: \( \sigma/\mu = 7\% \)
- 30% truncated mean: \( \sigma/\mu = 7\% \)
Separation power

- Difference between 0.8 and 2 GeV/c at the order of 15%
- Minor changes for the different truncated mean cuts
Conclusions

• Spatial resolution (155 μm) achieves specifications
• TOT/dx resolution is better than expected: ~ 7 %
• Correlation of <TOT/dx> versus momentum measured
• Results based on about half of the number of channels per track that expected for the final STT

Future plans

Tests are planned with a larger prototype
New ASIC and TRB electronics will be used
Thank you
Back up slides
Study of the non-pertubative regime and understanding of the QCD spectrum and hadron structure

**Charmonium Spectroscopy**
- Precise measurement of all states below and above the open charm threshold with mass and widths resolutions better than 100 keV for narrow states

**Gluonic Excitations**
- Two main categories: glueballs (states of pure glue), hybrids (q̅q pair and excited glue)

**Open Charm Spectroscopy**
- Production of a large number of D meson pairs in combination with the well defined production kinematics → significant charmed meson spectroscopy program

**Hyperon Physics**
- Spectroscopy of double and triple states, as well as charm hyperons
- Nuclei in which neutrons or protons are replaced by one or two hyperons

**Electromagnetic processes**
- Investigation of the structure of the nucleon using electromagnetic processes
- Determination of the electromagnetic form factors of the proton
800 MeV/c

tot/dx

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tot/dx_10

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Alexandros Apostolou 31/08/2015
STT data beam time December ‘14

<Q/dx> vs momentum

w/o truncation

truncation 10%

truncation 20%

truncation 30%
MIPs: ~200 electrons/cm for Ar+CO2 @ 2 bar

Charge/distance: \((200\text{e/cm}) \times (5 \times 10^4) \times (1.6 \times 10^{-19}\text{C/e})\) —> 1.6pC/cm

1.6pC/cm corresponds to 5KeV/cm for the MIPs
<Q/dx> vs momentum

- w/o truncation
- truncation 10%
- truncation 20%
- truncation 30%

- 1.7 pC/cm = 5.3 KeV/cm
- 1.4 pC/cm = 4.4 KeV/cm
- 1.1 pC/cm = 3.4 KeV/cm
- 1.0 pC/cm = 3.1 KeV/cm

STT data beam time December ‘14

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3-4 KeV/cm