PHYSICS SIMULATION WITH THE LAMBDA DISKS DETECTOR OF THE PANDA EXPERIMENT

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Outline of my talk

- **Introduction**
  - PANDA Experiment

- **Tracking detectors**
  - Micro Vertex Detector (MVD)
  - Lambda Disks Detector

- **Motivation of my work**

- **Analysis**
  - Simulation with $p\bar{p} \rightarrow \Lambda\bar{\Lambda} \rightarrow p\bar{p}\pi^+\pi^-$ channel
    - Decay Length of produced hyperons
    - Event Statistics with two different models
    - Angular Distribution
    - Hit Count Studies
    - Reconstruction Efficiency
    - Invariant Mass

- **Summary and Outlook**
Introduction

PANDA (AntiProton ANnihilation at DArmstadt) Experiment

PANDA Physics Motivation

Quantum Chromodynamics (QCD) in non-perturbative regime

Target Spectrometer

- Tracking detectors (MVD, STT, GEM)
- Particle Identification detectors (DIRC, RICH)
- Electromagnetic Calorimeter (EMC)

Forward Spectrometer

- Straw Tracker Tube (STT)
- Electromagnetic Calorimeter (EMC)
- Muon Detection System (MDT)
Tracking detectors

Micro Vertex Detector (MVD)

- Inner most detector of PANDA
- Tracking detector for charged particles
- High vertex resolution for primary and secondary interaction vertices of short lived particles
- Improvement in momentum resolution

- 2 barrel pixel layers
- 4 pixel disks
- 2 barrel strip layers
- 2 mixed disks
- 2 optional Lambda Disks
Tracking detectors

Lambda Disks Detector

- Additional disks forward to MVD
- Use free region between MVD and GEM
- Downstream to MVD at 40 cm and 60 cm from the interaction point
- Used double sided silicon strip sensors similar to MVD last disks
- Inner ring with radius $r = 5.5$ cm
- Outer radius with radius $r = 13.5$ cm
Motivation of my work

Physics programs of PANDA

- Charmonium spectroscopy
- Search for gluonic excitations
- Hadron in nuclear matter
- Electromagnetic process
- Hyper nuclei physics
- Hyperon physics

Why do we need PANDA Lambda Disks?

- Possibility to determine the spin observables and CP violation in the strangeness sector
- Determination of improvement of Λ hyperon reconstruction with these additional Lambda Disks
Analysis

Simulation of $p\bar{p} \rightarrow \Lambda \bar{\Lambda} \rightarrow p\bar{p}\pi^+\pi^-$ physics channel

Simulation with two different decay models

- Low Energy Model (Beam Momentum- 1.8 GeV/c)- based upon experimental data from LEAR at CERN
- High Energy Model (Beam Momentum- 3 GeV/c)- simulates decay above 2 GeV/c

Life time $\tau(\Lambda) = 2 \times 10^{-10}$ sec, Decay length = 7.89 cm
Analysis

Decay Length of produced hyperons

Monte Carlo simulation of decay length

Beam Momentum = 3 GeV/c

\[(c^*\tau)_\Lambda = 7.905 \pm 0.024 \text{ cm}\]

\[(c^*\tau)_{\bar{\Lambda}} = 7.874 \pm 0.000 \text{ cm}\]

Result is in good agreement with the PDG value within some statistical errors

\[c^*\tau = \frac{M_{\Lambda}}{P_{\Lambda} \text{ slope}} = \frac{1}{\text{slope}}\]

\[M_{\Lambda} = \text{mass of Lambda}\]

\[P_{\Lambda} = \text{momentum of Lambda}\]
Analysis

Decay Length of produced hyperons

Monte Carlo simulation of decay length

Beam Momentum = 1.8 GeV/c

\((c^*\tau)_\Lambda = 7.855 \pm 0.024 \text{ cm}\)
\((c^*\tau)_{\bar{\Lambda}} = 7.836 \pm 0.024 \text{ cm}\)

Result is in good agreement with the PDG value within some statistical errors.
How many events decayed before first Lambda disks?

Beam Momentum = 3 GeV/c

99.97% and 89.08% events of \( \Lambda \) and \( \bar{\Lambda} \) of total events decay before first Lambda disks.

Beam Momentum = 1.8 GeV/c

99.85% events of \( \Lambda \) and \( \bar{\Lambda} \) of total events decay before first Lambda disks.
Analysis

Angular distribution

Figure: $p$ and $\pi^-$ at $p_{beam} = 3$ GeV/c

Figure: $p$ and $\pi^-$ at $p_{beam} = 1.8$ GeV/c

- Direction of particle inside target spectrometer depends on the beam momentum
- Pion covers the angular range between $0^0$ to $180^0$
Analysis

Hit Count Studies

Without Lambda Disks

- Minimum four hits required for reconstruction of charged particles

With Lambda Disks

Conclusion
-four or more $\bar{p}$ hits with Lambda disks

Analysis - Reconstruction Efficiency

- Detector efficiency as the overall ratio of simulated to reconstructed events
- Efficiency as a function of generated angle
- Lambda Disks positioned at 37 cm and 43 cm
- Work is in progress on secondary track finder algorithm and efficiency would be increase
Analysis - Reconstruction Efficiency

Reconstruction efficiency of $\Lambda$ and $\bar{\Lambda}$ as a function of angle in Center of mass frame

- Reconstruction efficiency suffers due to unavailability of secondary track finder algorithm

Conclusion

- Efficiency of $\Lambda$ and $\bar{\Lambda}$ improves with Lambda Disks
Analysis - Invariant Mass Reconstruction

- Beam Momentum = 1.8 GeV/c
- Invariant mass of $\Lambda = 1.115$ GeV/c$^2$

\[ \sigma \text{ of } \Lambda \text{ without Disks} = 0.0045 \pm 0.0003 \text{ GeV/c}^2 \]

\[ \sigma \text{ of } \Lambda \text{ with Disks} = 0.0056 \pm 0.0005 \text{ GeV/c}^2 \]
Analysis - Invariant Mass Reconstruction

- Beam Momentum = 1.8 GeV/c
- Invariant Mass of $\bar{\Lambda} = 1.115$ GeV/c$^2$

$\sigma$ without Disks = $0.0037 \pm 0.0001$ GeV/c$^2$

$\sigma$ of $\bar{\Lambda}$ with Disks = $0.0039 \pm 0.0001$ GeV/c$^2$
Effect of Lambda Disks on the reconstruction of $p\bar{p}\rightarrow D^{*+}D^{*-}\rightarrow D^0\pi^+\bar{D}^0\pi^-$ channel

Analysis - Invariant Mass Reconstruction

- Beam Momentum = 8.0 GeV/c
- Invariant Mass of $D^{*+} = 1.864$ GeV/c²
- $\sigma$ of $D^{*+}$ without Disks = $0.0330 \pm 0.0004$ GeV/c²
- $\sigma$ of $D^{*+}$ with Disks = $0.0335 \pm 0.0006$ GeV/c²
Effect of Lambda Disks on the reconstruction of $p\bar{p} \rightarrow D^{*+} D^{*-} \rightarrow D^{0}\pi^{+} \bar{D}^{0}\pi^{-}$ channel

Analysis - Invariant Mass Reconstruction

- Beam Momentum = 8.0 GeV/c
- Invariant Mass of $D^{*-} = 1.864$ GeV/c$^2$
- $\sigma$ of $D^{*-}$ without Disks = $0.0299 \pm 0.0003$ GeV/c$^2$
- $\sigma$ of $D^{*-}$ with Disks = $0.0332 \pm 0.0006$ GeV/c$^2$
Summary and Outlook

- The simulation for decay length of Λ and ¯Λ particles have been done and would update from the detector.
- Angular distribution of daughter particles from the channel $p\bar{p} \rightarrow \Lambda \bar{\Lambda}$ have been studied.
- Hit count study with and without Lambda Disks have been done with four different positions of Λ Disks and improvement in acceptance has been observed.
- Reconstruction performance of $p\bar{p} \rightarrow D^{*+}D^{*-} \rightarrow D^0\pi^+\bar{D}^0\pi^-$ and $p\bar{p} \rightarrow J/\psi \pi^+\pi^-$ physics channel with and without Lambda Disks.
- Radiation length and Radiation damage study with the final geometry of Lambda Disks.
- Hardware test for the silicon strip sensor.
- Integration of Lambda Disks into the full PANDA setup.
Thank You