Particle Identification Algorithms for the PANDA Barrel DIRC

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Motivation:
- Excellent particle identification is required to achieve the PANDA physics goals
- Hadronic PID in the PANDA target spectrometer will be delivered by two DIRC counters
- Developed reconstruction methods for PANDA Barrel DIRC, applied to simulation and CERN test beam data

The PANDA Experiment

The PANDA Barrel DIRC

Key Components
- Radiators: 48 synthetic fused silica bars
- Focusing optics: Spherical lens system
- Expansion volume: Quartz prism, 30 cm depth
- Sensors: Microchannel Plate Photomultiplier Tubes (MCP-PMTs)

DIRC Principle
- DIRC is intrinsically a 3-D device, measuring: x, y, and time of Cherenkov photons, defining: φ, θ, and τ_{propagation}
- Ultimate deliverable for DIRC: PID likelihoods

Time-based Imaging
- Based on Belle II time-of-propagation (TOP) counter
- Create PDFs (Probability Density Function) for the expected photon time for every pixel and for every particle hypothesis
- Measure Cherenkov photons arrival time in each event
- Compare photon arrival time to the corresponding PDFs
- PDFs can be generated using real data, simulations or analytically

Simplified Time-based Imaging
- Generate a large number of photons from a point-like source inside the bar along the charged particle track.
- Database contains: photon generation vectors, photon hit position on the photodetectors, photon propagation time.
- PDFs created for every pixel and for every particle hypothesis by applying cut on the expected Cherenkov angle based on particle momentum and direction
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- PID performed by likelihood fit using different mass hypotheses

Geometrical Reconstruction
- Adapted from BaBar DIRC reconstruction
- Look-Up Table (LUT) creation: Photon gun in Geant4 simulation, store direction vectors from the end of the bar to each pixel
- Reconstruction: direction from LUT for hit pixels are combined with charged track direction
- Provides (ambiguous) Cherenkov angle for each detected photon, timing and angular resolution, Cherenkov angle per particle, photon yield
- PID performed by likelihood fit using different mass hypotheses

Test Beam at CERN PS
- PANDA barrel DIRC prototype setup 2018 at CERN PS
- Mixed hadron beam with momenta up to 10 GeV/c
- πK@ 3.5 GeV/c approximately πp@ 7 GeV/c
- Radiator: Fused silica bar
- Expansion volume: Fused silica prism
- Focusing optics: 3-layer spherical lens
- Array of MCP-PMTs for photon detection
- Readout with timing 150 - 300 ps

Conclusions
- Geometrical reconstruction
  - Performance superior to geometrical reconstruction results
  - Large storage capacities
  - Significant reduction of memory requirements can be achieved by using analytical PDFs
- Simplified Time-based Imaging
  - Faster creation of PDFs
  - Performance close to time-based imaging

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