The Disc DIRC Čerenkov Detektor at PANDA

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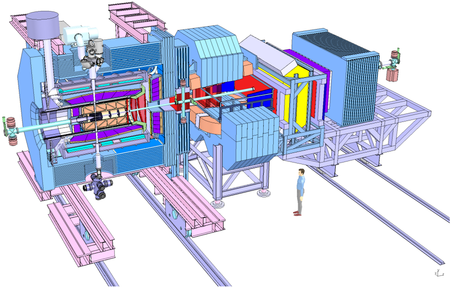
Outline

Facility for antiproton and ion research

New accelerator facility

- Gesellschaft für Schwerionenforschung (GSI)
- Darmstadt, Germany

Antiproton anihilation at Darmstadt

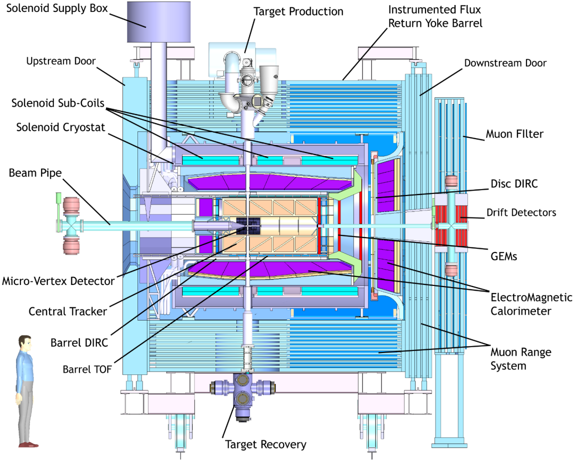


Research

- Strong interaction, confinement
- Structure of hadronic mass
- Search for new hadrons: hybrid/glueball states

- Fixed target
- Antiproton beam of 1.5 . . . 15 GeV

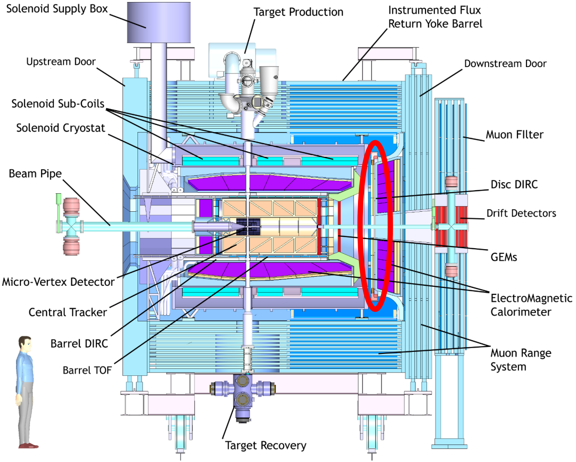
Target spectrometer



FSpec

- Little space for Čerenkov detector in forward region
- Disc DIRC in magnetic field

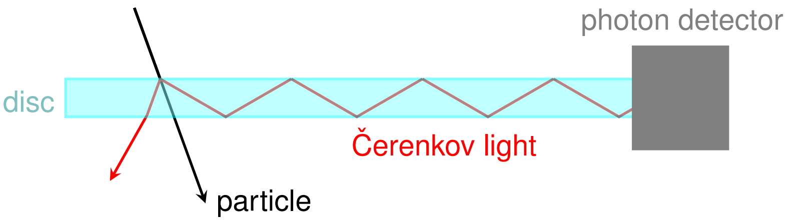
Target spectrometer



FSpec

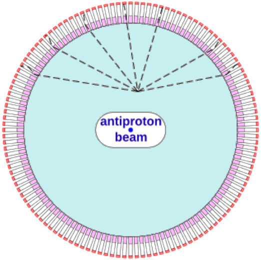
- Little space for Čerenkov detector in forward region
- Disc DIRC in magnetic field

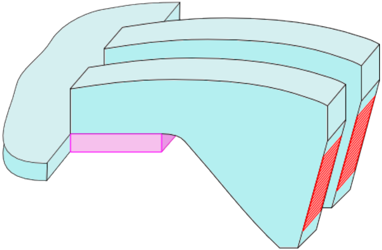
Disc detector of internally reflected Čerenkov light



- Čerenkov light is emitted in disc (fused silica, 2 cm thick).
- Photons are propagated to detector by total internal reflexion.
- Particle identification possible, if momentum and velocity are known
  - Momentum from PANDA tracking detector
  - Velocity from Čerenkov angle $\left(\cos\theta = \frac{1}{n\beta}\right)$

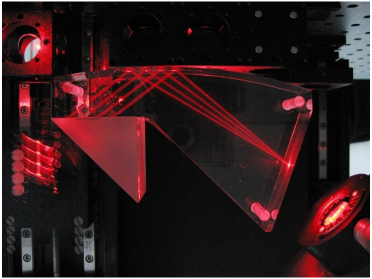
Principle — focussing light guides



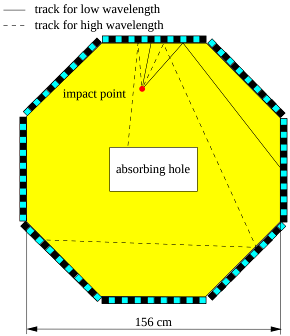


Determination of Čerenkov angle

- First space coordinate from light guide position
- Second space coordinate from multi pixel photon detector



Principle — time of propagation



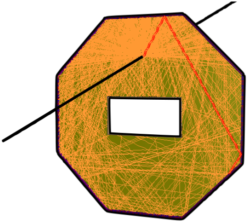
Setup

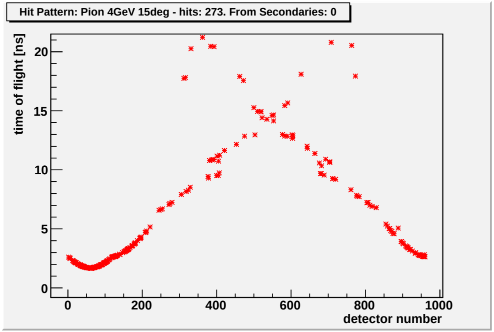
- Octagonal disc
- Dichroic mirrors in alternating order between disc and sensors split wavelength spectrum into two ranges ($\lambda < 500$ nm or $\lambda > 500$ nm)
  - Reduction of dispersion effects
  - Increase of path lengths

Determination of Čerenkov angle

- One space coordinate from position of photon detector
- Time of propagation

Monte Carlo simulation

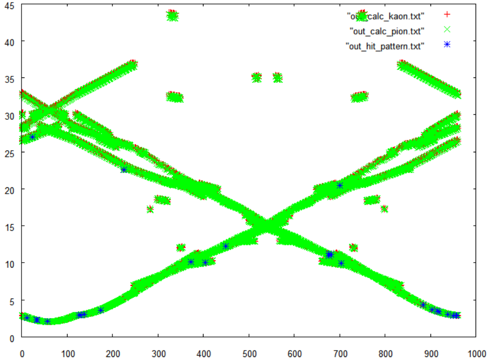




4 GeV pion

- $\approx$ 420 Čerenkov photons emitted
- 273 photons propagated by total internal reflexion
- $\approx$ 70 photons detected in reality (depending on photon detection efficiency)

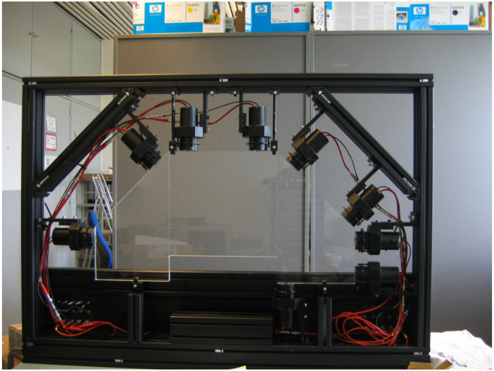
Reconstruction



- No start signal
- Short and long paths are needed

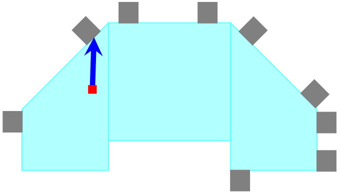
- Calculation of time of propagation:
  - Kaon (red)
  - Pion (green)
- Comparison with simulation (blue) or finally measurement identifies particle.

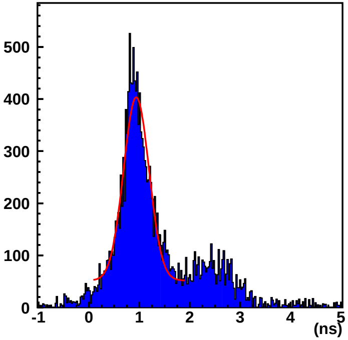
Prototype



- We have a working prototype.
- Test beam experiment was made in October last year.
- Measurements with cosmics are running right now.

Results from cosmics measurements with prototype





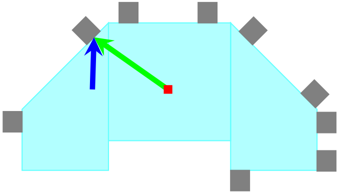
Time of propagation calculated for relativistic particles:

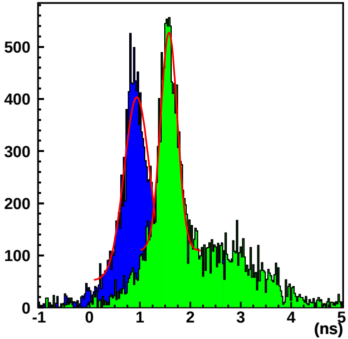
- 0.92 ns

Measured:

- 0.94 ns

Results from cosmics measurements with prototype





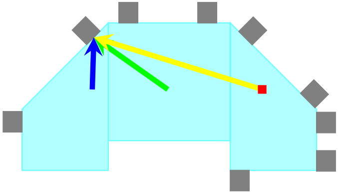
Time of propagation calculated for relativistic particles:

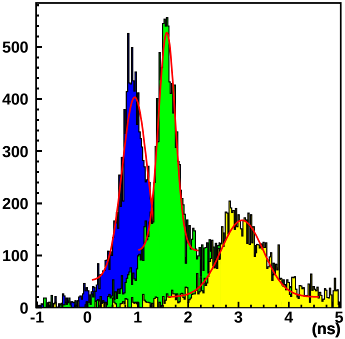
- 0.92 ns
- 1.60 ns

Measured:

- 0.94 ns
- 1.58 ns

Results from cosmics measurements with prototype





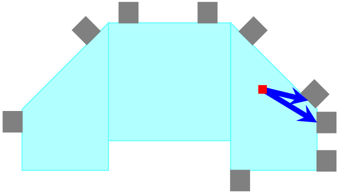
Time of propagation calculated for relativistic particles:

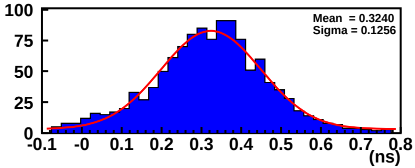
- 0.92 ns
- 1.60 ns
- 3.12 ns

Measured:

- 0.94 ns
- 1.58 ns
- 3.07 ns

Results from cosmics measurements with protoype

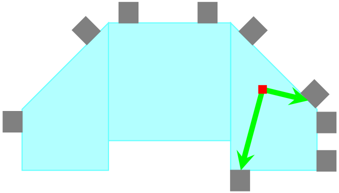


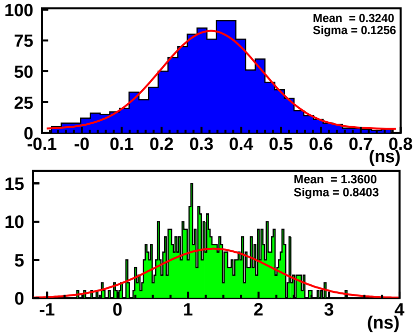


Calculated time differences:

- 0.40 ns

Results from cosmics measurements with protoype



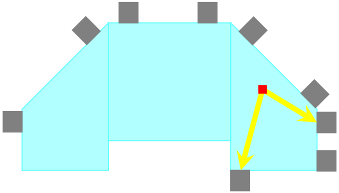


Calculated time differences:

- 0.40 ns
- 1.22 ns

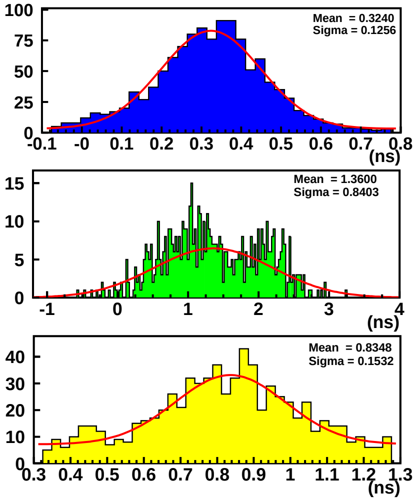
Details

Results from cosmics measurements with protoype



Calculated time differences:

- 0.40 ns
- 1.22 ns
- 0.82 ns



Requirements

- Very good time resolution ($\sigma \approx 40\,\text{ps}$)
- Low dark count rate
- Life time
- Operation in magnetic field ($B \approx 2\,\text{T}$)
- Radiation hardness

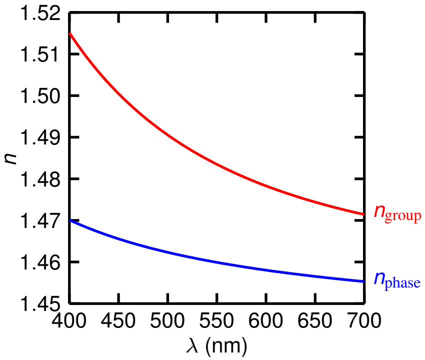
Candidates

- Conventional PMTs: not working in magnetic field
- MCPPMTs: short life time
- G-APDs: high dark count rate, eventually radiation damage

Solutions

- MCPPMTs with protection layer?
- Cooled G-APDs?
- Anything else?

Effects in fused silica



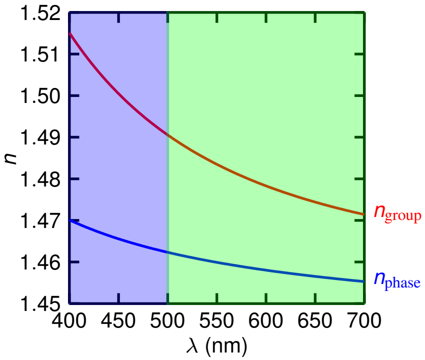
At decreasing wavelength

- n_{phase} increases. Čerenkov angle increases. Time of propagation decreases.
- n_{group} increases. Group velocity decreases. Time of propagation increases.

Further research to reduce dispersion effects

- Cutting out parts of wavelength spectrum
- Chromatic correction by achromatic units or software
- Splitting spectrum with dichroic mirrors as described above

Effects in fused silica



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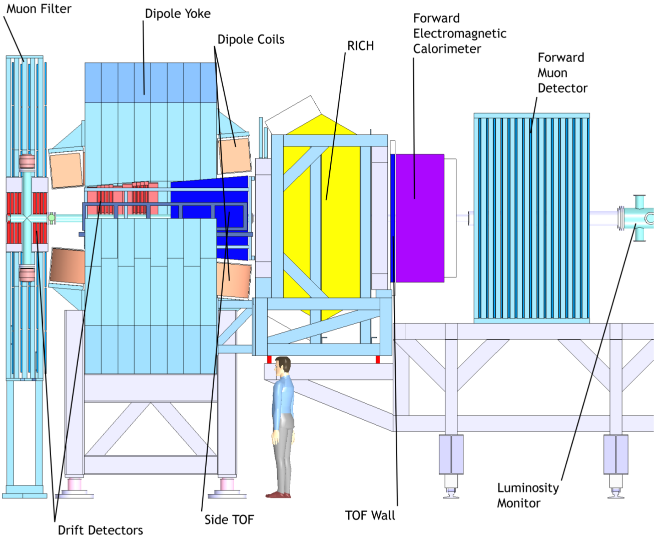
Summary

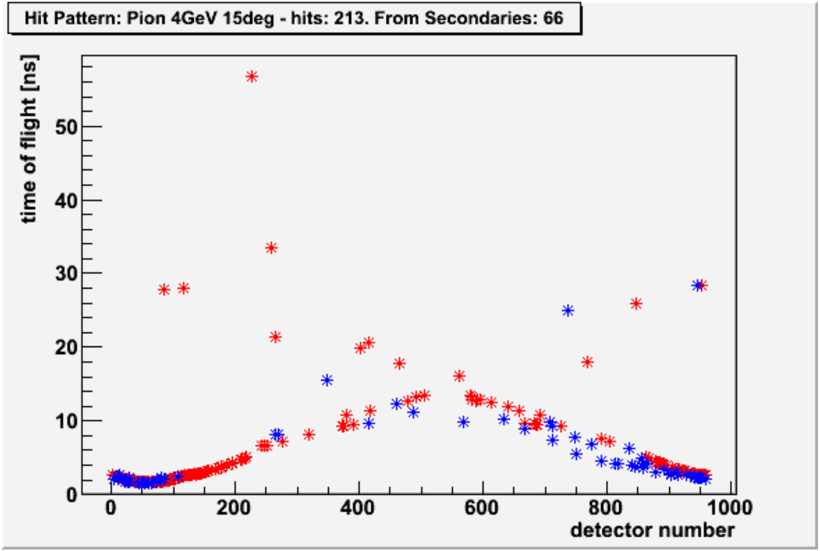
- Disc DIRC will provide particle identification at PANDA.
- Compact detector
- Two designs:
  - Focussing light guides
  - Time of Propagation

Forward spectrometer

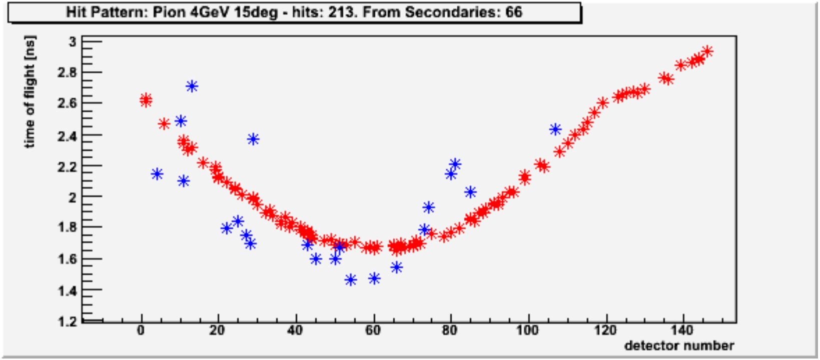


Back

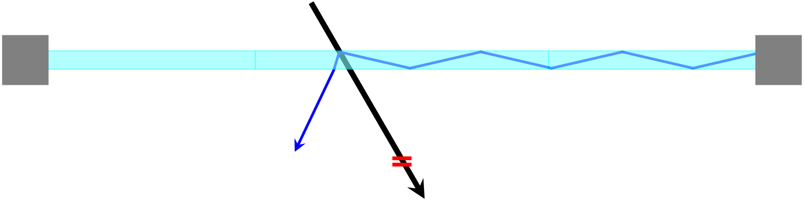
Secondary events



Secondary events



Angle dependence

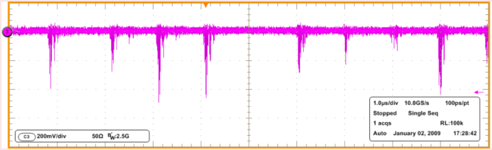


- Right sensor can see emitted cherenkov light.
- Left sensor does not see anything.

Back

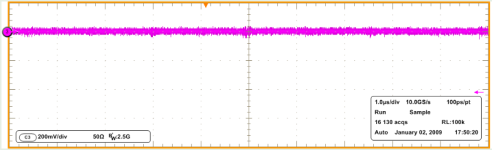
Voltage supply

Problem



Noise from high voltage modules

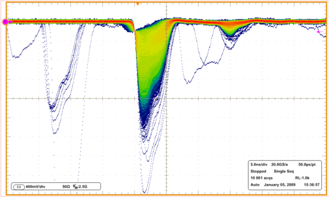
Solution



Ferrites in feed lines

Voltage divider boards

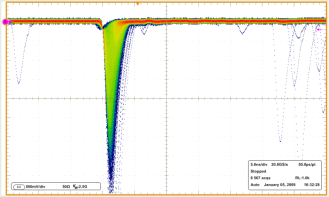
Problem



Our boards were evil:

- Capacitances
- Long unshielded parts in signal cables

Solution



- Voltage divider resistors directly mounted on the MCPs
- Signal cables directly connected to the MCPs