Motivation	Disc DIRC 00000000	Further Investigations	Summary	Appendix

The Disc DIRC Čerenkov Detektor at PANDA

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Outline				



- FAIR
- PANDA

2 Disc DIRC

- Particle Identification
- Focussing Light Guides Design
- Time of Propagation Design (ToP)

3 Further Investigations

- Photon sensors
- Dispersion

Motivation ●○○	Disc DIRC	Further Investigations	Summary	Appendix
FAIR				

Facility for antiproton and ion research



New accelerator facility

- Gesellschaft f
 ür Schwerionenforschung (GSI)
- Darmstadt, Germany

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PANDA					

Antiproton **an**ihilation at **Da**rmstadt



Research

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

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

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PANDA				
Target spect	rometer			
Solenoid Supply Box Upstream Door Solenoid Sub-Colls Solenoid Sub-Colls Solenoid Cryostat Beam Pipe Micro-Vertex Detector Central Tracker Barrel DIRC Barrel DIRC	Torget Produc	tion Instrumented Flux Return Yoke Barrel Downstream Do Muon Filte Disc DIRC Drift Detect GEMs ElectroMk Calorime Nuon Rar	or r : tors agnetic ter	► FSpec

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

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PANDA				
Target spectr	ometer			
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- Little space for Čerenkov detector in forward region
- Disc DIRC in magnetic field



- 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 $\left(\cos\theta = \frac{1}{n\beta}\right)$

Focussing Light Guides	s Design					
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						
Time of Propagation Design (ToP)						
Motivation 000	Disc DIRC	Further Investigations	Summary	Appendix		



Setup

- Octagonal disc
- Dichroic mirrors in alternating order between disc and sensors split wavelength spectrum into two ranges (λ < 500 nm or λ > 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				
Time of Propagation Design (ToP)					
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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)

Disc DIRC ○○○○●○○○	Further Investigations	Summary	Appendix			
Time of Propagation Design (ToP)						
Reconstruction						
	Disc DIRC 000000000 gn (ToP) ON	Disc DIRC Further Investigations	Disc DIRC Further Investigations Summary 000000000000000000000000000000000000			



- 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.

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Time of Propagation Design (ToP)					
Prototype)				



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

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Results from cosmics measurements with prototype



Time of propagation calculated for relativistic particles:





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Time of Propagation	Docian (ToP)			

Results from cosmics measurements with prototype



Time of propagation calculated for relativistic particles:





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Results from cosmics measurements with prototype



Time of propagation calculated for relativistic particles:





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Time of Propagatio	n Dosign (ToP)			

Results from cosmics measurements with protoype





Calculated time differences: • 0.40 ns

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Time of December 1	- Designer (T-D)			

Results from cosmics measurements with protoype



Calculated time differences:







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Results from cosmics measurements with protoype





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Photon sensors				

Requirements

- Very good time resolution ($\sigma \approx$ 40 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?

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Dispersion				

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

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	Dispersion				

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Summary				

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

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Forward s	pectrometer			



I Back

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Secondary	events			



Motivation	Disc DIRC	Further Investigations	Summary	Appendix
Secondary	v events			





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



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Voltage supply							

Problem



Noise from high voltage modules

Solution



Ferrites in feed lines

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Voltage div	ider 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