JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

panda

Research Teaching Society AG Düren

DIRC Detector Possibilities for SCTF

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SCTF Online Meeting

HIC for FAIR
Helmholtz International Center

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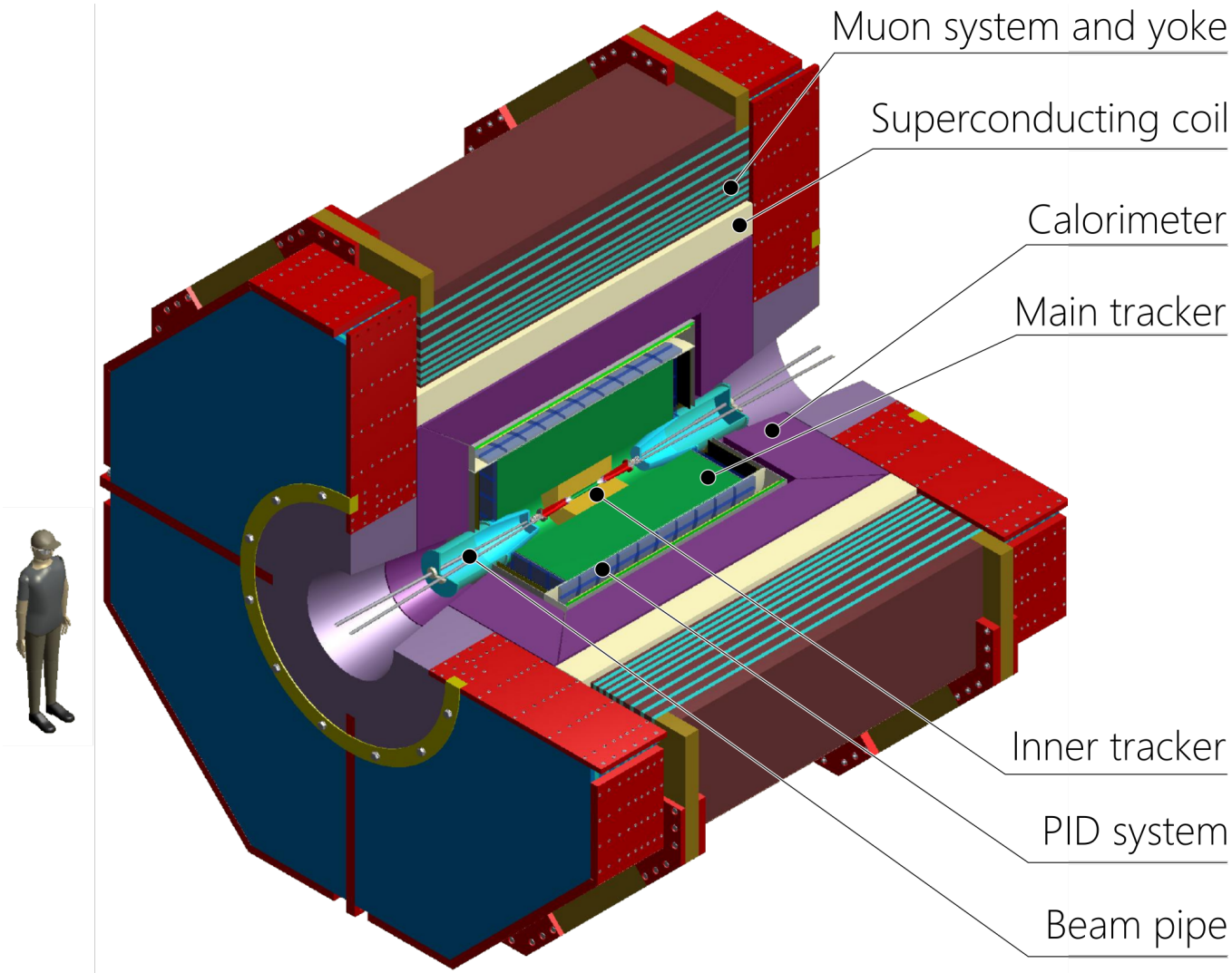
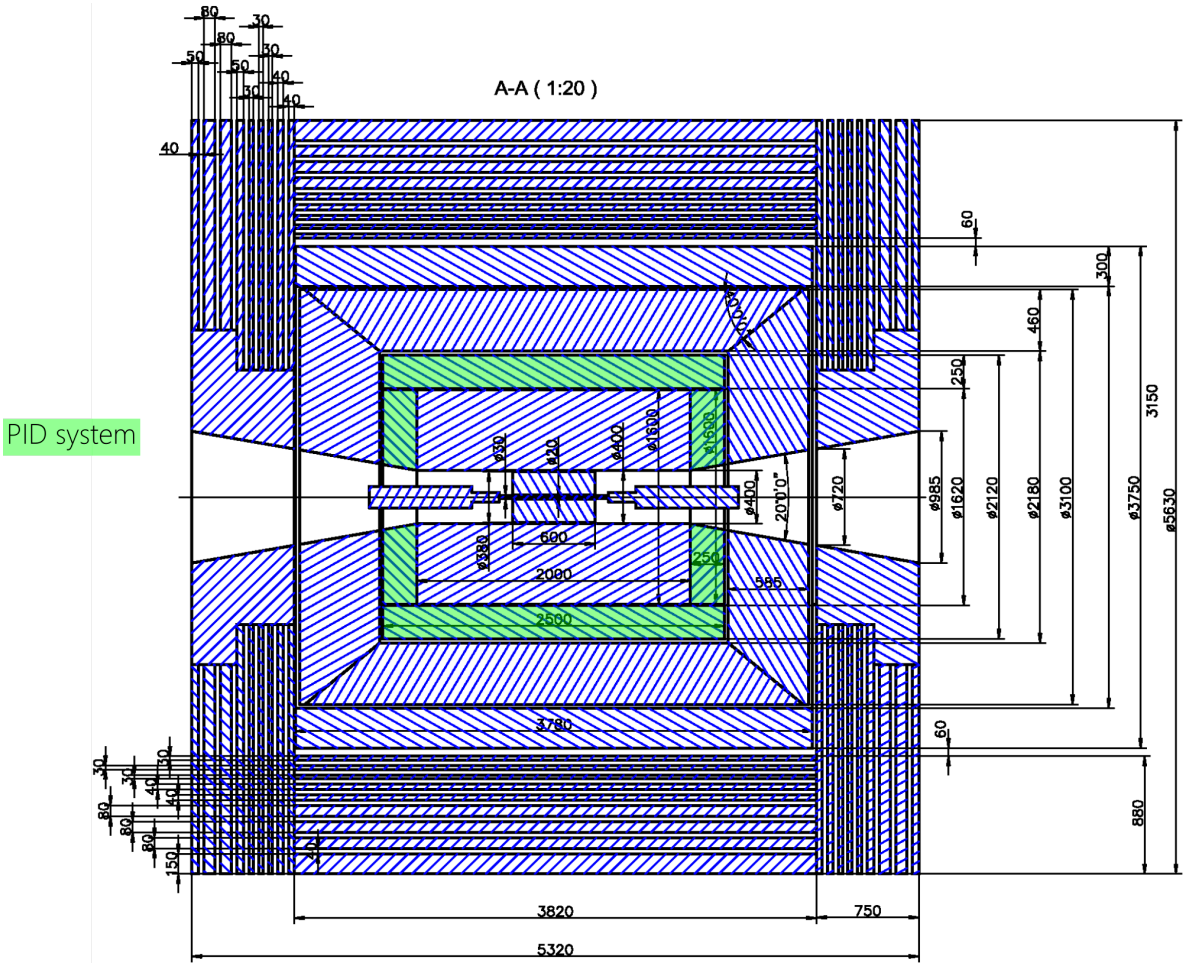
HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

SCTF Design


Muon system and yoke
Superconducting coil
Calorimeter
Main tracker
Inner tracker
PID system
Beam pipe

SCTF Detector

DIRC detectors in the green area (Barrel and Disc DIRC)



Goal: Covering full solid angle and phase space

$\bar{\text{P}}$ANDA Spectrometer

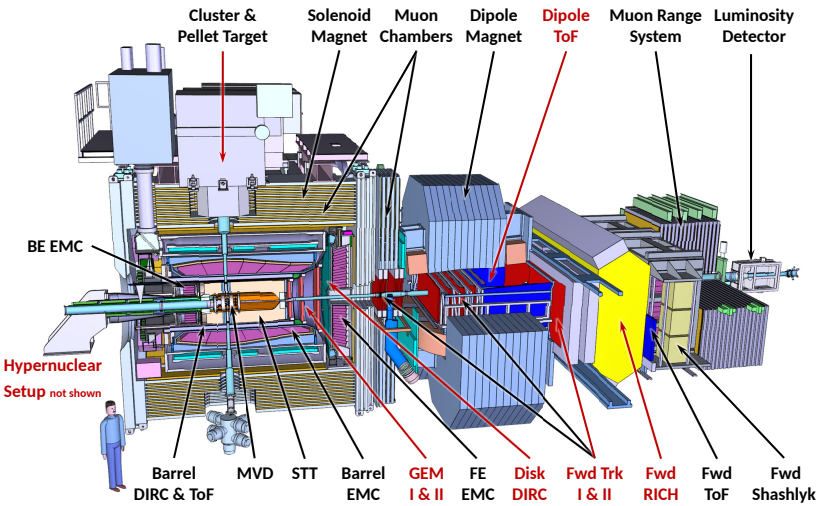
FAIR

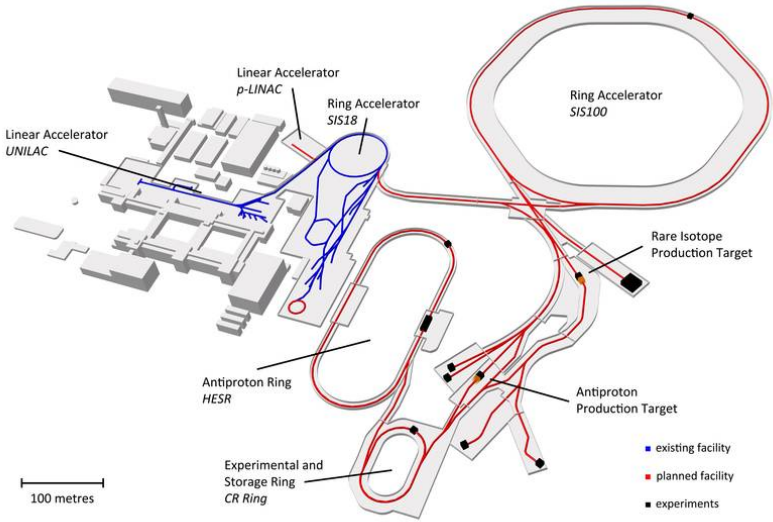
- Antiprotons $\bar{p}$ from HESR
- High luminosity mode:

$$\mathcal{L} = 2 \cdot 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$$

- Average interaction rate:

$$\dot{N} = 2 \cdot 10^{7}\,\mathrm{s}^{-1}$$





PANDA

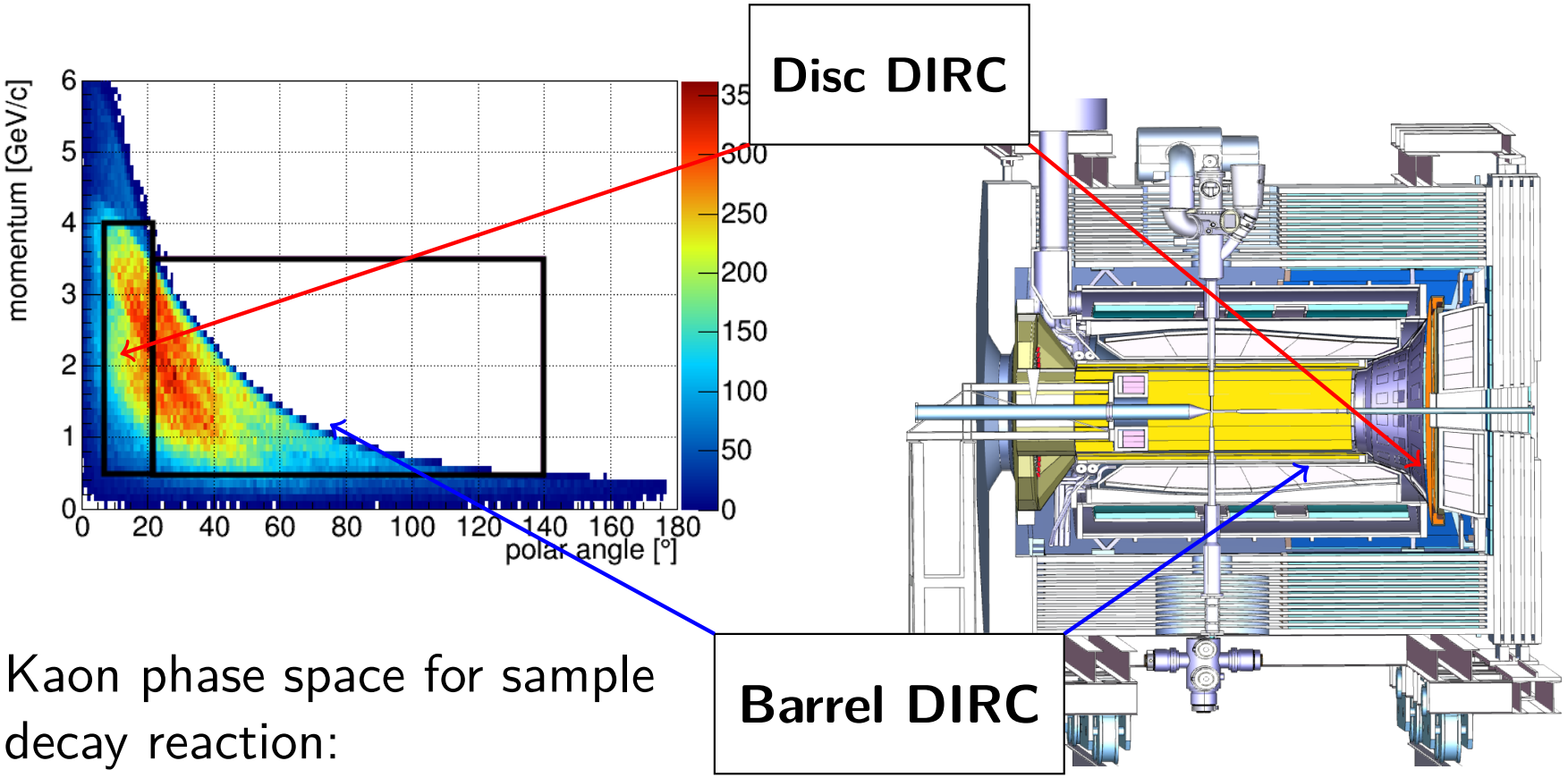
- $\bar{p}p$ collisions with hydrogen target
- Created particles with forward boost in z-direction
- Excellent PID necessary to fulfill physics program goals

Particle Identification

No hadronic calorimeter in PANDA

Two DIRC detectors for PID in target spectrometer

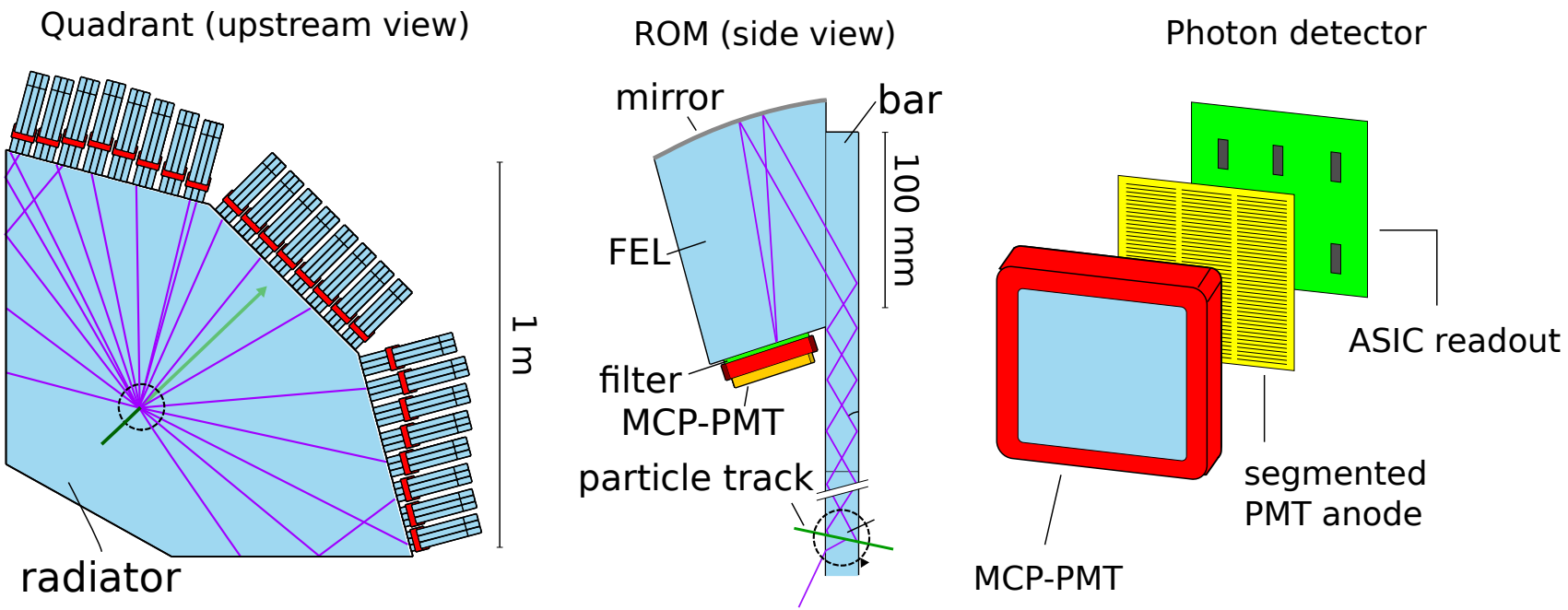
DIRC: Detection of Internally Reflected Cherenkov Light



Kaon phase space for sample decay reaction:
$J/\Psi \rightarrow K^+K^-\gamma$ @ 6.5 GeV/c

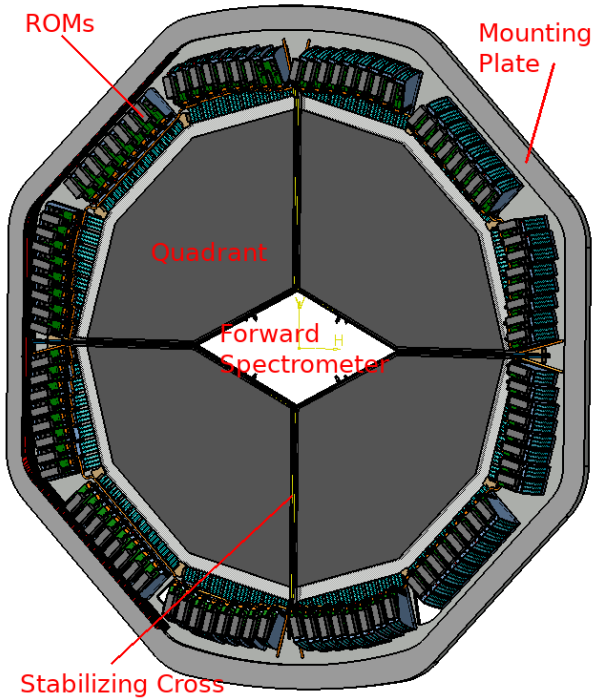
Disc DIRC Design Parameters:

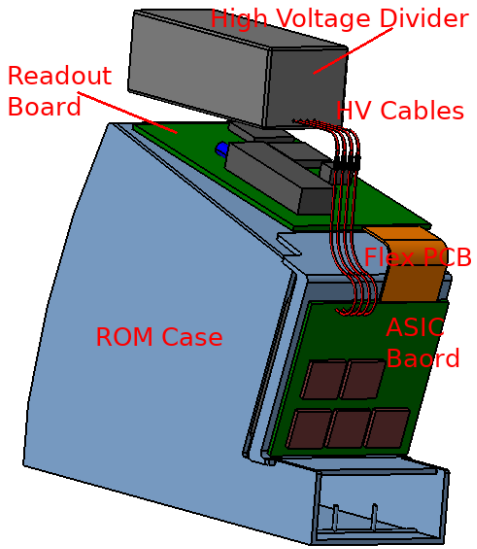
- Separation of π/K
- Momentum range: $0.5\,\mathrm{GeV/c} \leq p < 4\,\mathrm{GeV/c}$
- Polar angle range: $5^\circ \leq \theta \leq 22^\circ$
- Performance goal: $\geq 3\,\mathrm{s.d.}$ separation over full phase space
  $\Rightarrow$ Average detector resolution $\leq 1.7\,\mathrm{mrad}$ required



Technical Specifications

- 8 Readout Modules (ROMs) per side $\Rightarrow$ 96 ROMs in total
- Readout: PETsys TOFPET ASICs with 30 ps LSB
- 5 ASICs with 64 channels per ROM
- 300 pixels per MCP-PMTs $\Rightarrow$ 28,800 readout channels
- Approx. 1 charged track per collision (22 photon hits per track)
- Hit frequency per channel: 60 kHz in high luminosity mode
- Connection to PANDA DAQ system
- Using SODAnet for time synchronisation

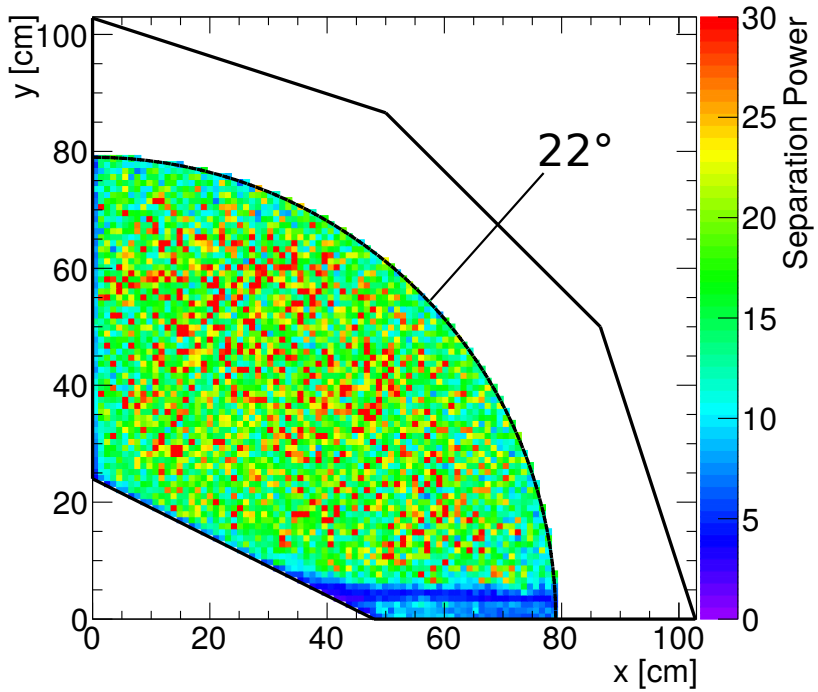




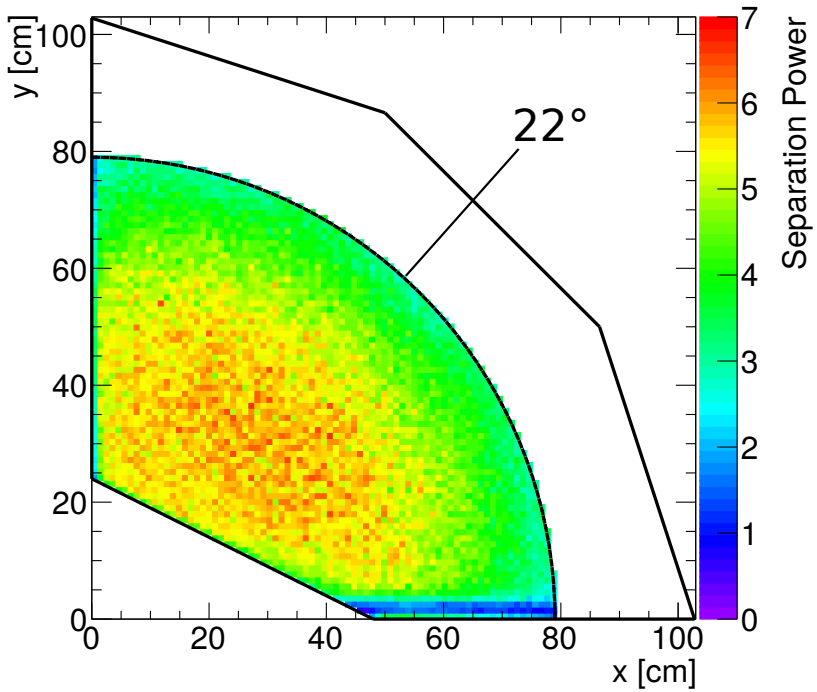
High Resolution Simulations

Simulatiated scan with high resolution for π^+/K^+ for full radiator quadrant including solenoid field of target spectrometer:

Momentum 2 GeV/c



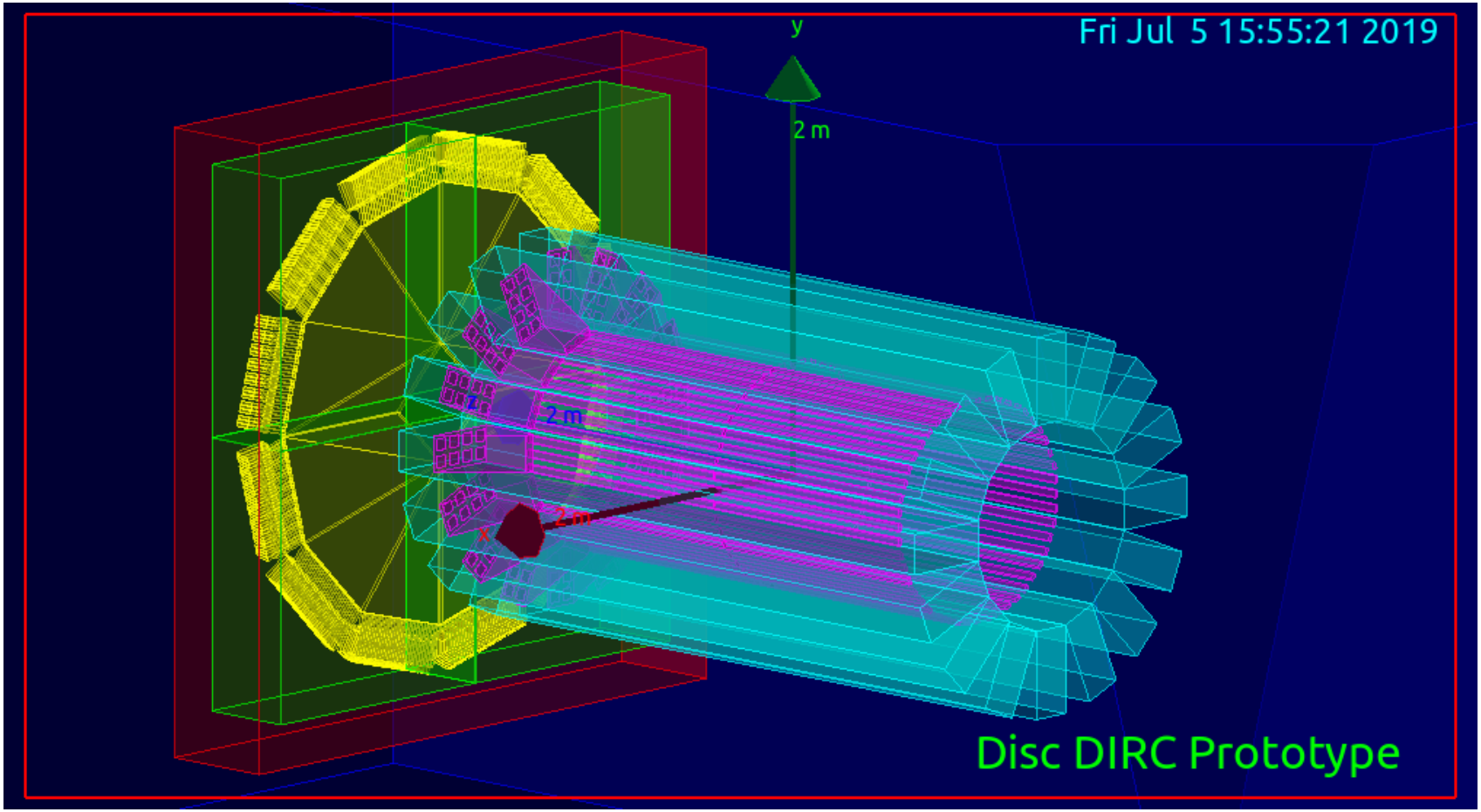
Momentum 4 GeV/c



- Overlapping of hit patterns (drop of separation power)
- *Inefficient area* shifting as function of momentum

Geant4 Simulations

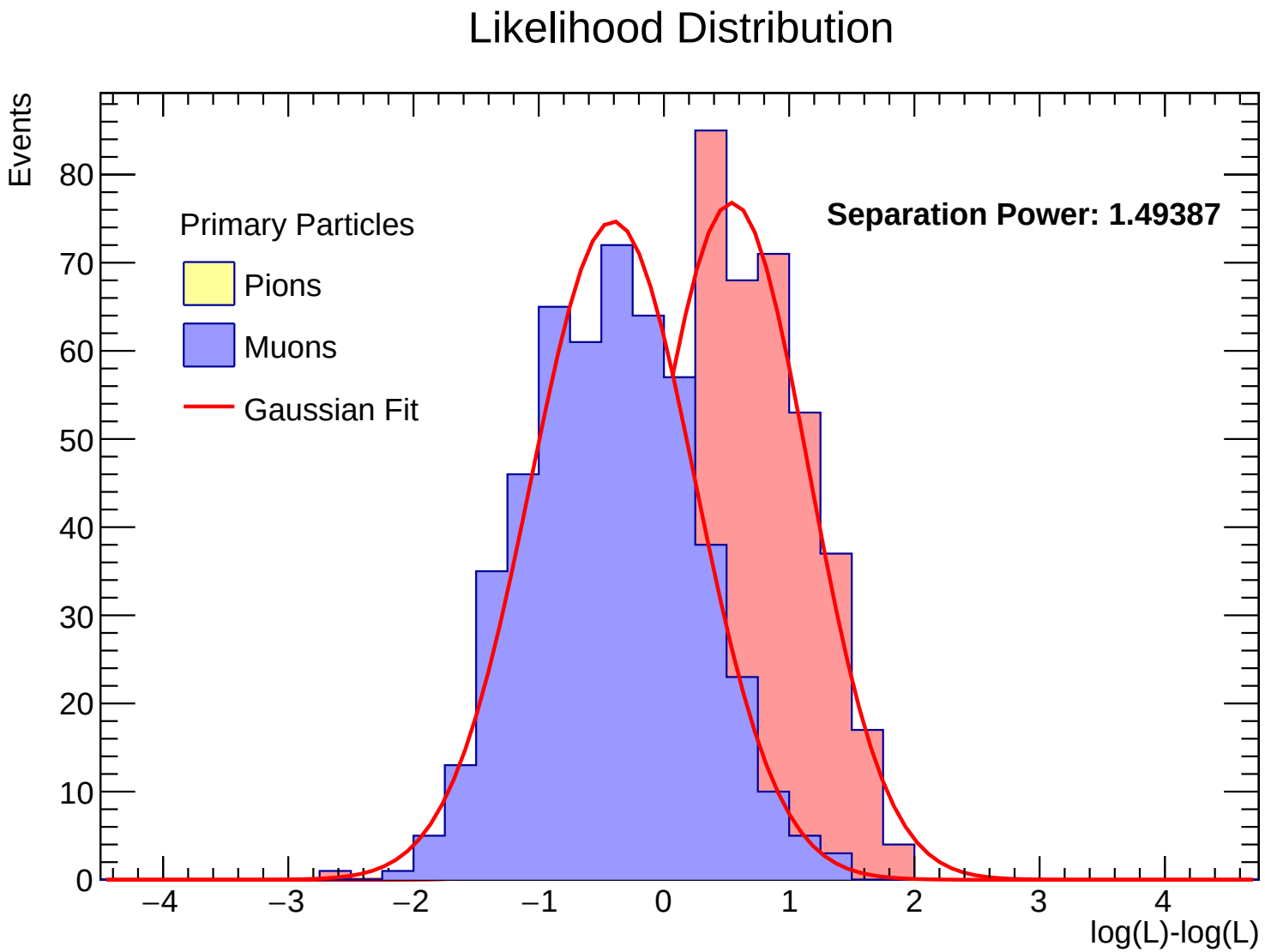
All detector components recently implemented in standalone Geant4 framework



Refining still ongoing

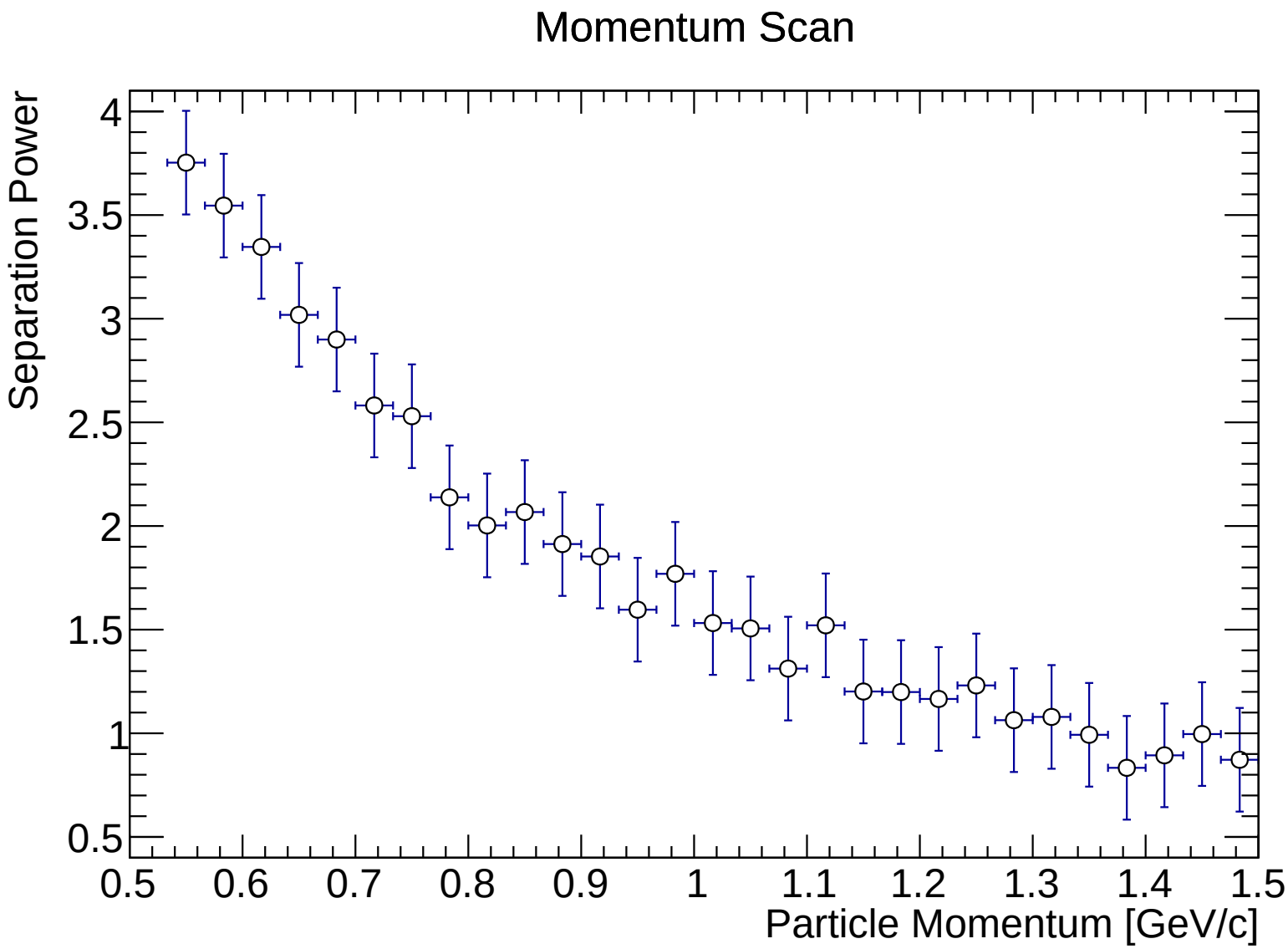
Muon/Pion Separation

Muon/Pion separation for 1 GeV/c momentum:



Momentum scan

Scan for μ^+/π^+ separation in SCTF:



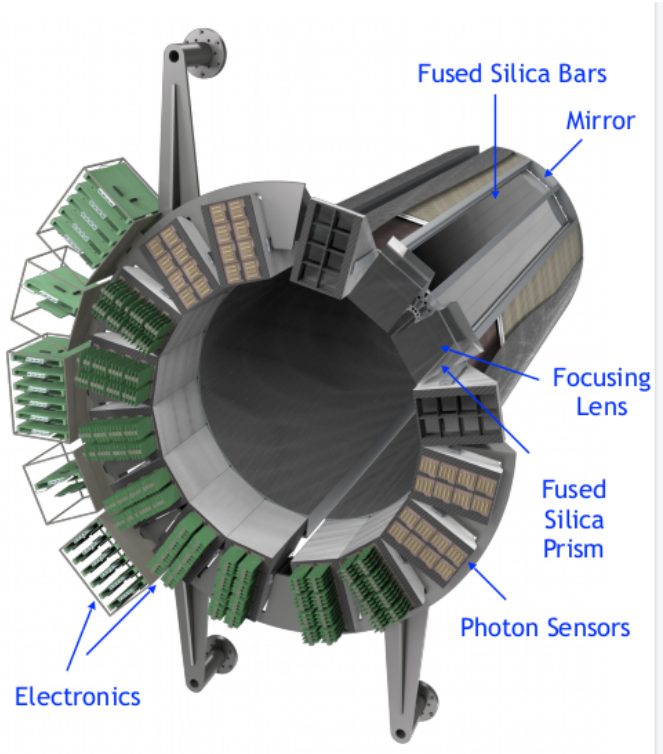
Optimization Possibilities

Many possibilities for optimizations:

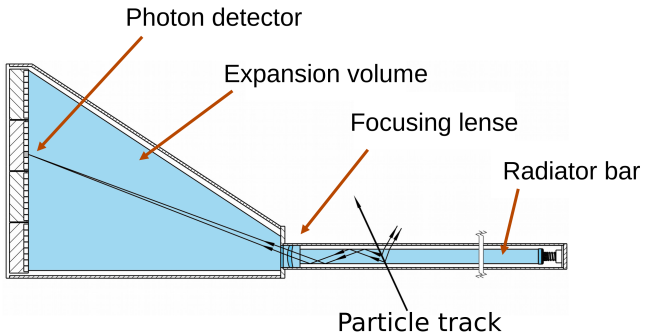
- Increasing radiator thickness for larger photon yield
- Sensor Optimization
  - Specifications of photo cathode
  - Different filter options
  - Increased collection efficiency
- Switching from MCP-PMTs to SiPMs
- Choosing a suitable readout system

Barrel DIRC

- 48 radiator bars (16 sectors), synthetic fused silica 17mm (T) x 53mm (W) x 2400mm (L)
- Mirror attached to one bar end to reflect photon back through to readout end.
- 3-layer spherical lens
- 30 cm deep solid fused silica prisms, 8200 channels of lifetime-enhanced MCP-PMTs
- Fast FPGA-based readout electronics 100ps per photon timing resolution
- Simulations: ≥ 3 s.d. π/K separation for entire acceptance

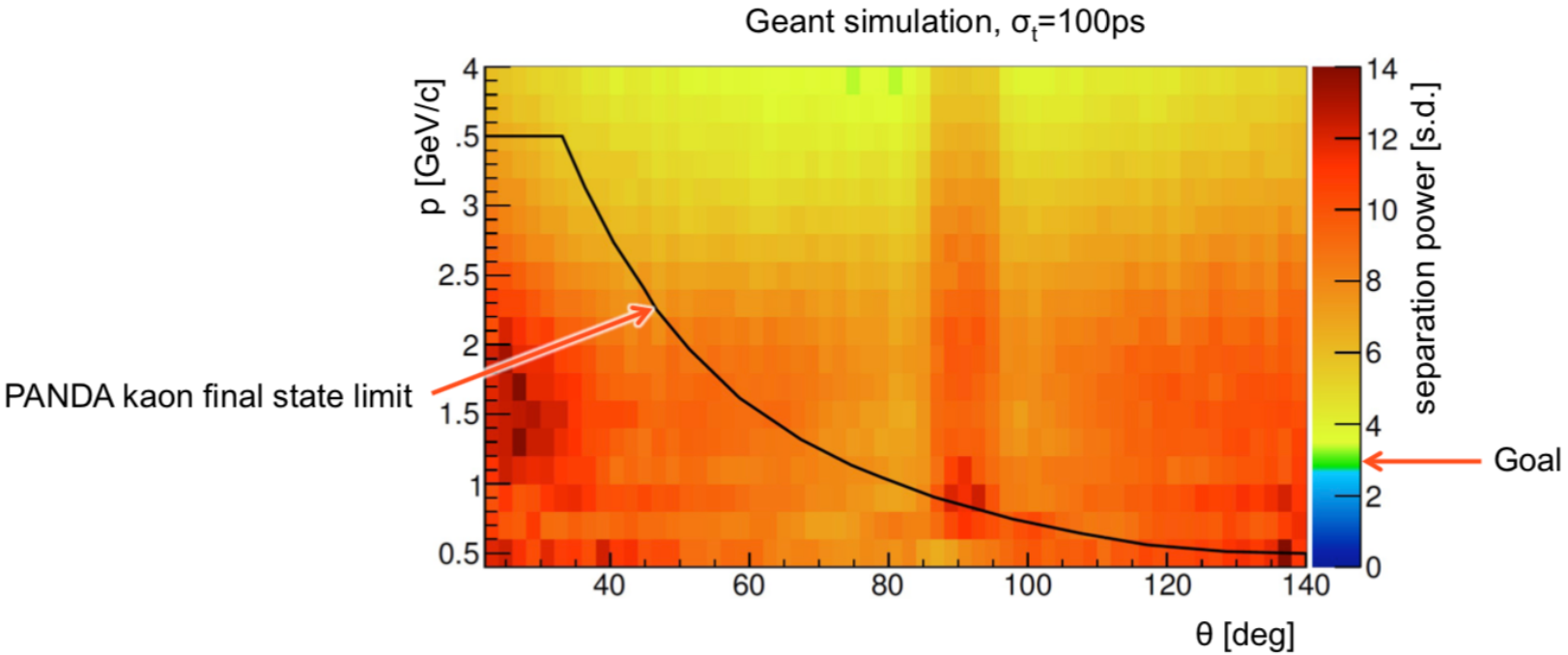


Barrel DIRC



Performance Studies

Performance goal for π/K separation achievable for all required polar angles and momenta



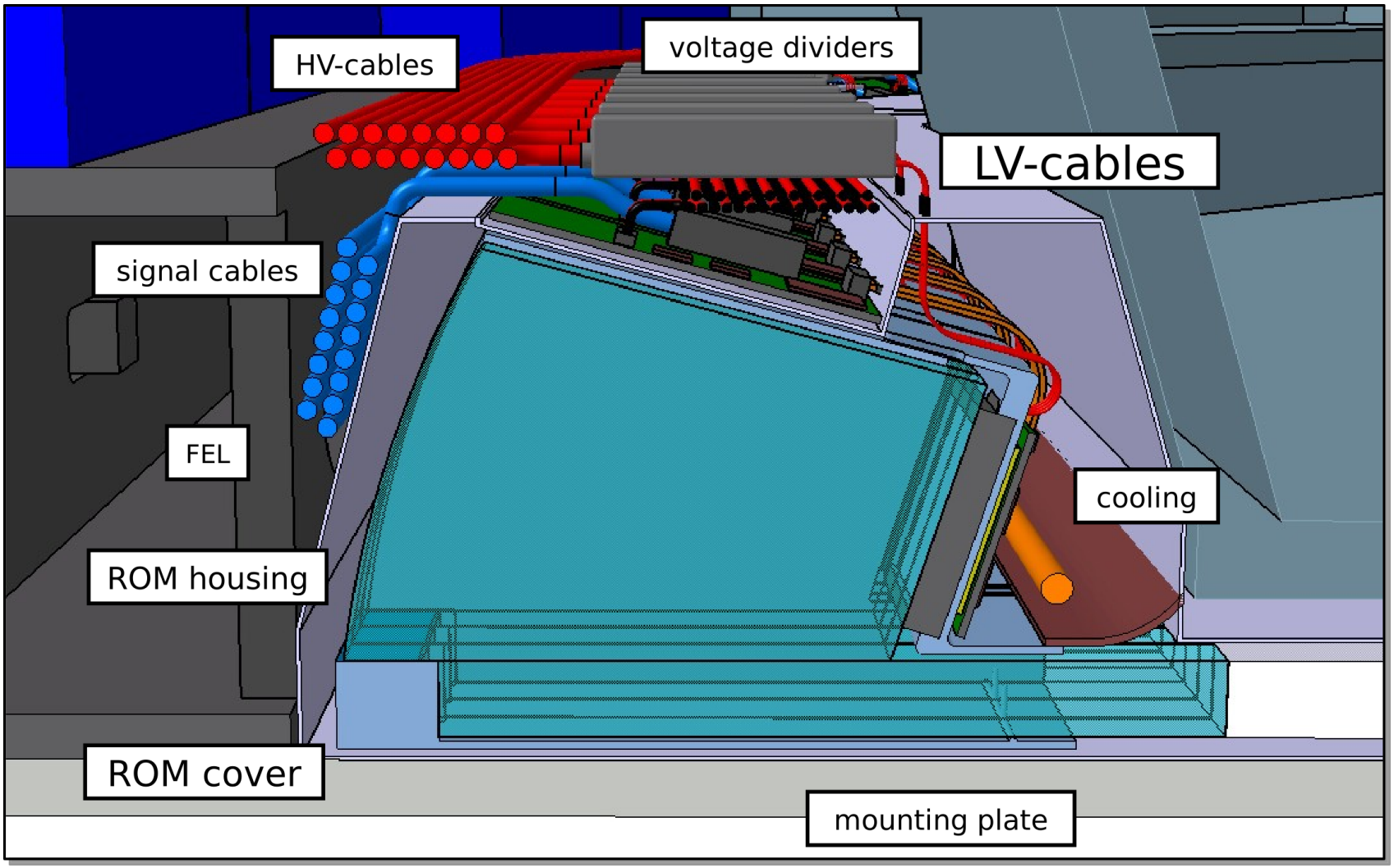
Simulation studies for μ/π separation recently started

Thank you very much for your attention!

Backup Slides

Electronics in Final Detector

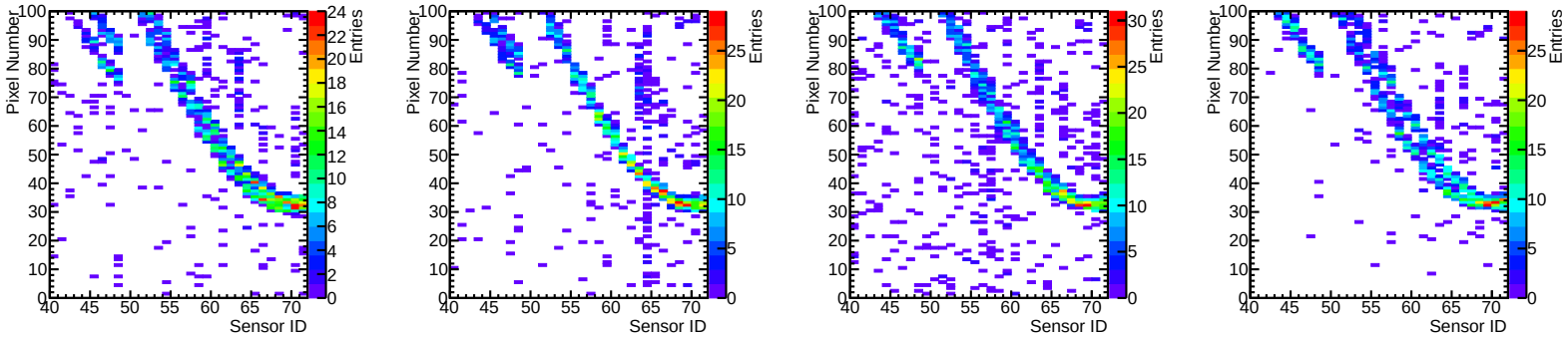
TOFPET ASICS attached to MCP-PMTs



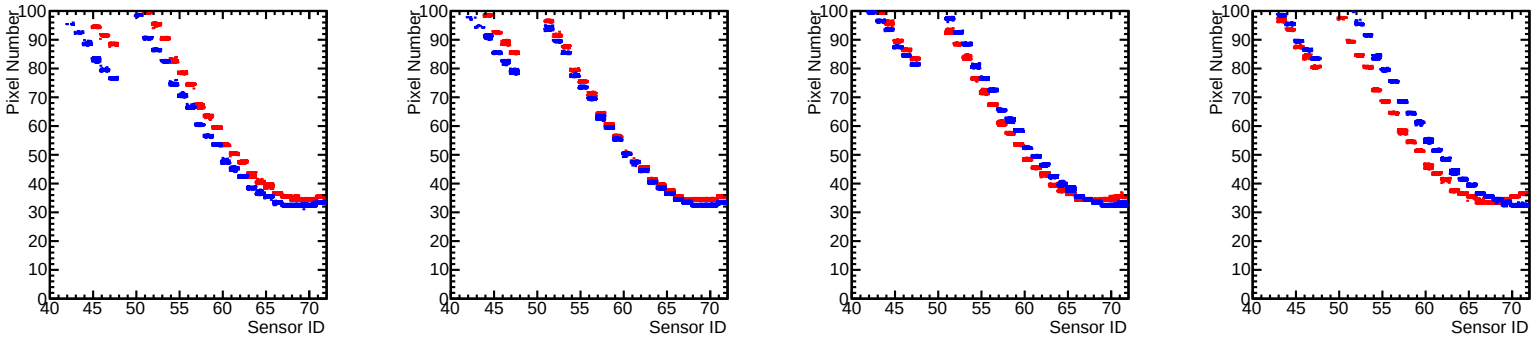
Overlapping Hitpattern

Hitpattern overlap due to reflections at outer rim

Simulated hitpattern



Calculated hitpattern



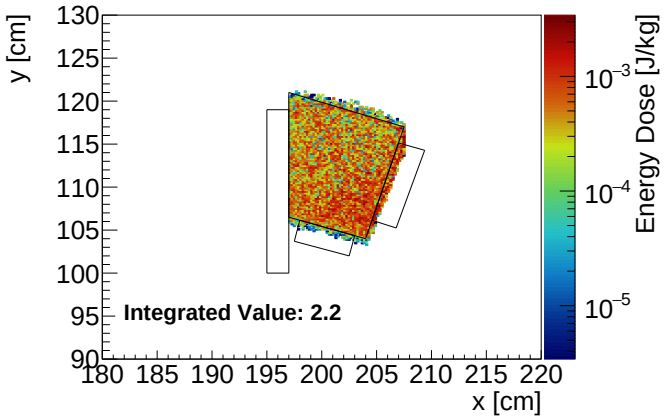
- Simulated hitpatterns are shifting as function of azimuth angle
- Full overlap cannot be observed due to bending inside magnetic field

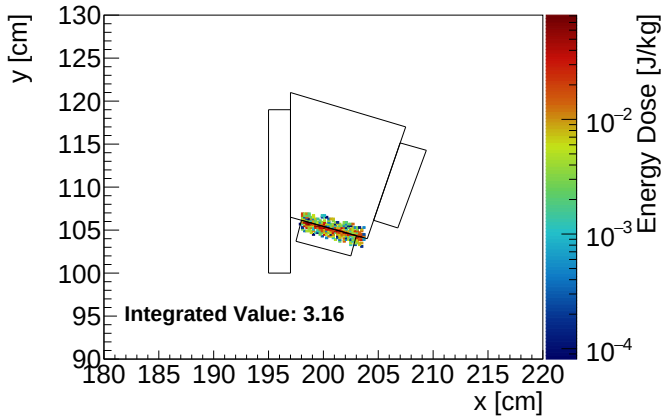
Online Reconstruction

- Requirement: Usable with 20 MHz interaction frequency
- SiTCP package developed at KEK for gigabit ethernet communication
- Prototype working with ML403 board and Xilinx Virtex 4 chip
- Available block RAM: 648 kB
- Clock frequency: 130 MHz
- Sending data in 8 bit blocks per clock cycle into FIFO buffer
- Small self-written C++ client sending simulation data to FPGA card

Radiation Hardness

Simulated Radiation Dose for MCP-PMTs and Filter





0% – 3.5% @ 3 Gy and 0.5% – 4.5% @ 30 Gy depending on filter

Simulated Charged Hadron Rate for MCP-PMTs and PCBs