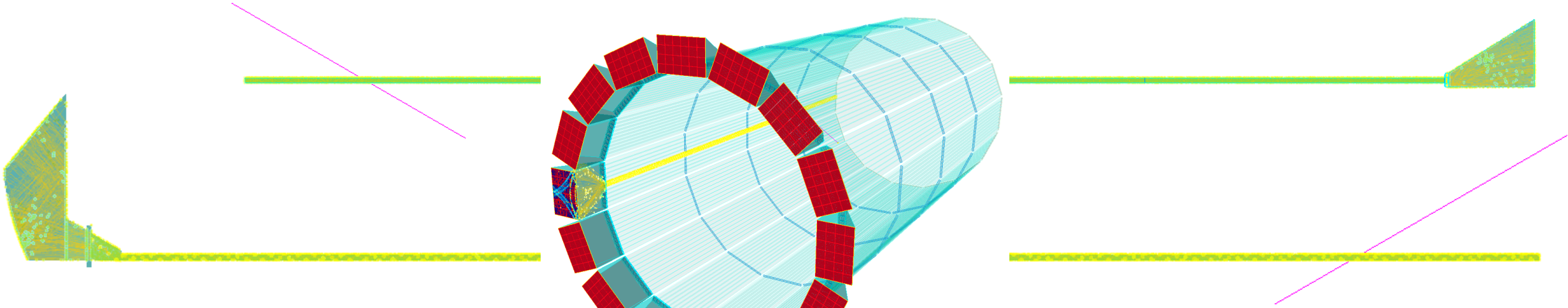
Barrel DIRC Detectors for the EIC



Greg Kalicy

Jochen Schwiening

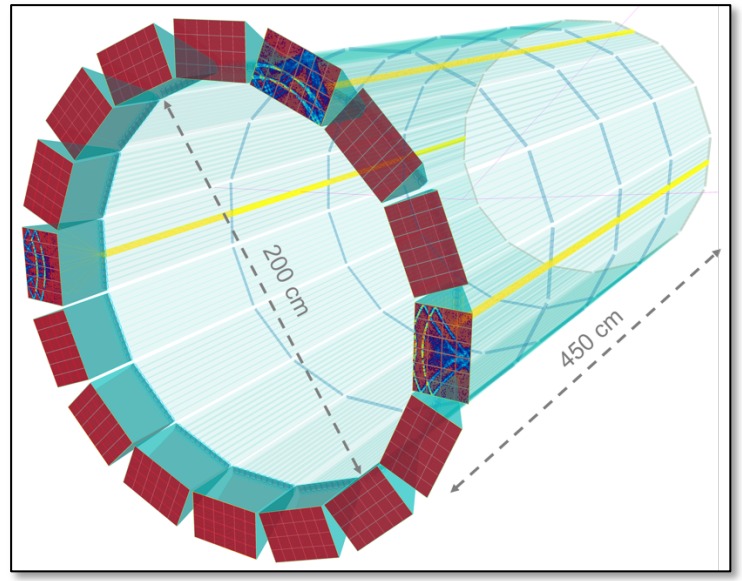
for the eRD14 DIRC group

- External requirements
- Detector integration concepts
- Simulation assumptions
- More detail to follow on May 15th

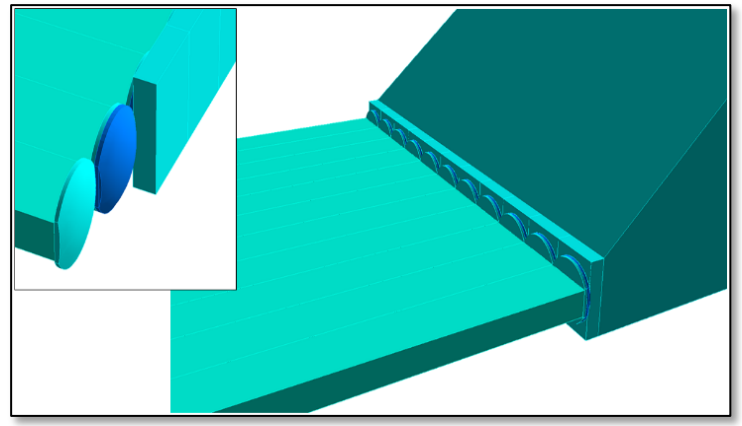
HPDIRC DESIGN REMINDER

Concept: fast focusing DIRC

Inspired by design elements from BaBar, SuperB, Belle II, and PANDA



- Generic reference design: 1m barrel radius, 16 sectors
- 176 radiator bars (11 per sector), synthetic fused silica,
  17mm (T) × 32mm (W) × 4200mm (L)
- Focusing optics: innovative radiation-hard 3-layer spherical lens
- Compact photon camera:
  30cm-deep solid fused silica prisms as expansion volumes
  Lifetime-enhanced MCP-PMTs with 3x3mm^2 pixels
  Fast readout electronics (~100,000 channels , <100ps single photon timing)
- Expected performance (Geant4 simulation):
  30-100 detected photons per particle,
  ≥ 3 s.d. π/K separation at 6 GeV/c



DIRC External Requirements

Tracking	
Angular resolution (at DIRC radius)	σ = 0.5 mrad at high momentum (see next slide for momentum-dependence)
Position resolution (at DIRC radius)	Few mm
Momentum resolution (at DIRC radius)	Not very sensitive, post-DIRC track point(s) beneficial (non-Gaussian tails)
Magnetic Field	No specific B-field value assumed in simulation/reconstruction Favor 1.5 T solenoid field to match currently available MCP-PMTs
Space Requirement	*(Note: generic simulation, not matched to any particular detector yet)*
Radius	100 cm (hpDIRC, standalone Geant4 simulation) 83.65 cm (BaBar DIRC bar box reuse)
Radial thickness (in active region)	7-8 cm including mechanical support
Total length (bars plus expansion volume)	330-450 cm (hpDIRC, depending on detector framework) 530 cm (BaBar DIRC bar box reuse)
Material budget (in active region)	~16-18% of a radiation length at normal incidence
Expansion volume size	24 x 36 x 30 cm^3 (H x W x L) fused silica prism (hpDIRC) 56 x 42 x 22 cm^3 (H x W x L) fused silica block (FDIRC, to be optimized)

HPDIRC RESOLUTION – EXTERNAL REQUIREMENTS

$$\sigma^2_{\theta_c}(particle) = \sigma^2_{\theta_c}(photon) / N_\gamma + \sigma^2_{correlated}$$

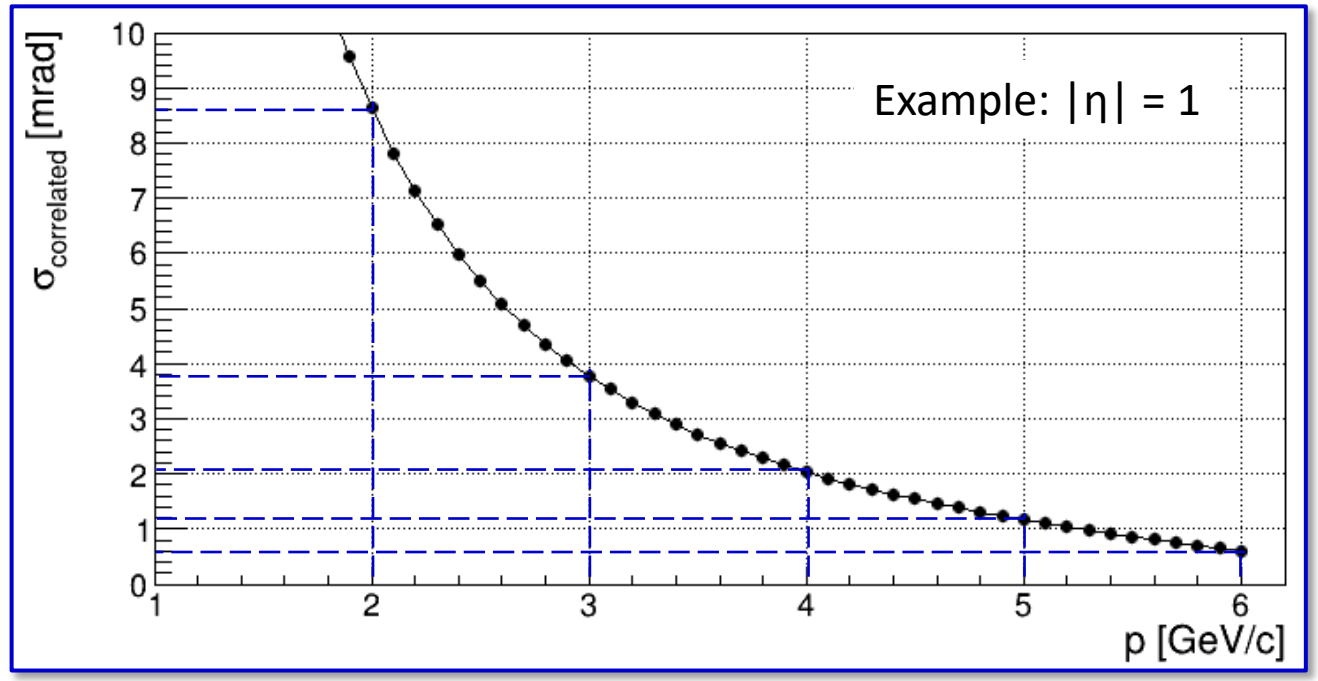
$\sigma_{\theta_c}(particle)$ Cherenkov angle resolution per particle

$\sigma_{\theta_c}(photon)$ Cherenkov angle resolution per photon

N_γ Number of detected photons per particle

$\sigma_{correlated}$ Contribution from external sources (tracking, multiple scattering, etc.)

Maximum allowed contribution from correlated term while keeping hpDIRC π/K separation power at 3 s.d.



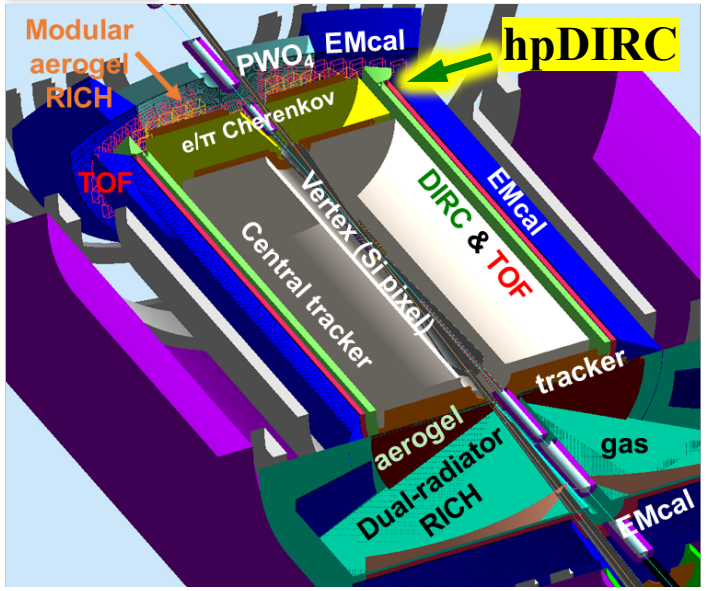
DIRC External Requirements

Tracking	
Angular resolution (at DIRC radius)	σ = 0.5 mrad at high momentum (for hpDIRC)
Position resolution (at DIRC radius)	Few mm
Momentum resolution (at DIRC radius)	Not very sensitive, post-DIRC track point(s) beneficial (non-Gaussian tails)
Magnetic Field	No specific B-field value assumed in simulation/reconstruction Favor 1.5 T solenoid field to match currently available MCP-PMTs
Space Requirement	*(Note: generic simulation, not matched to any particular detector yet)*
Radius	100 cm (hpDIRC, standalone Geant4 simulation) 83.65 cm (BaBar DIRC bar box reuse)
Radial thickness (in active region)	7-8 cm, including mechanical support
Total length (bars plus expansion volume)	330-450 cm (hpDIRC, depending on detector framework) 530 cm (BaBar DIRC bar box reuse)
Material budget (in active region)	~16-18% of a radiation length at normal incidence
Expansion volume size	24 x 36 x 30 cm^3 (H x W x L) fused silica prism (hpDIRC) 56 x 42 x 22 cm^3 (H x W x L) fused silica block (FDIRC, to be optimized)

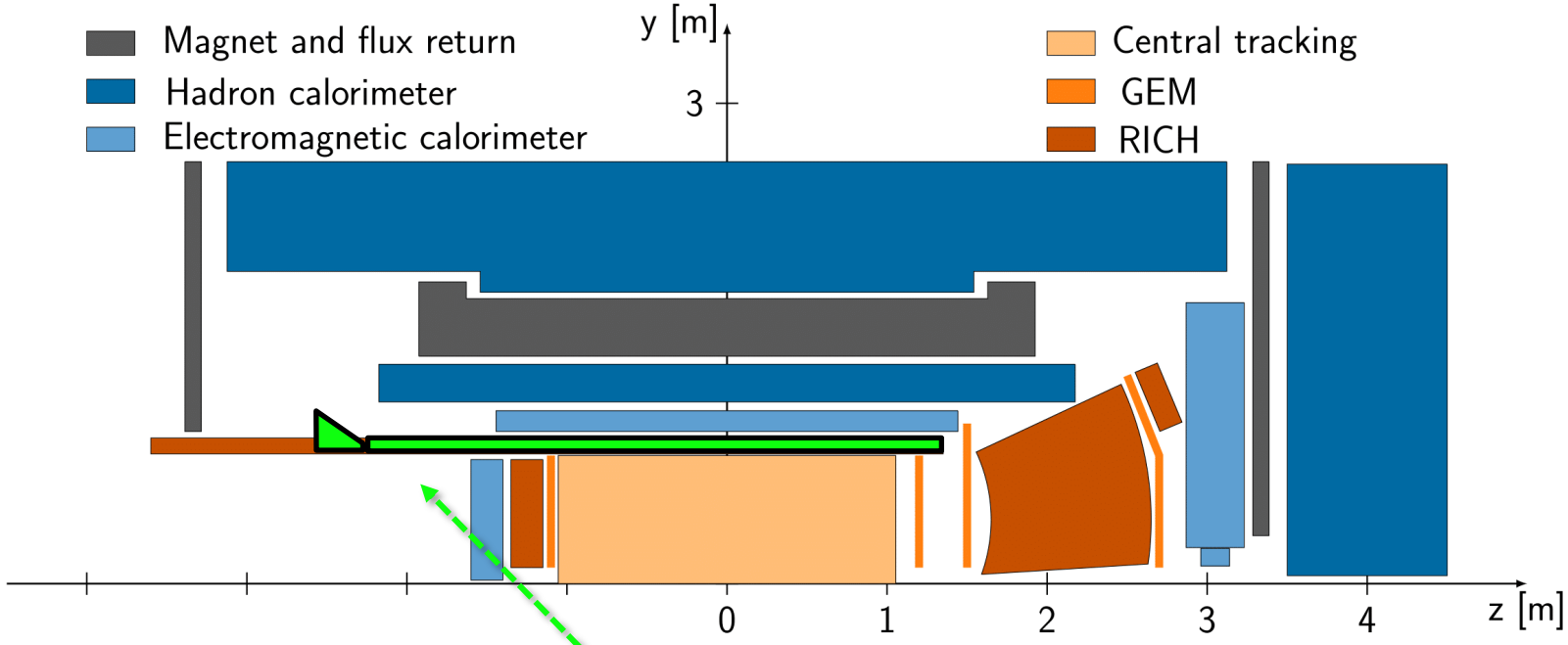
DIRC INTEGRATION

Potential DIRC integration examples

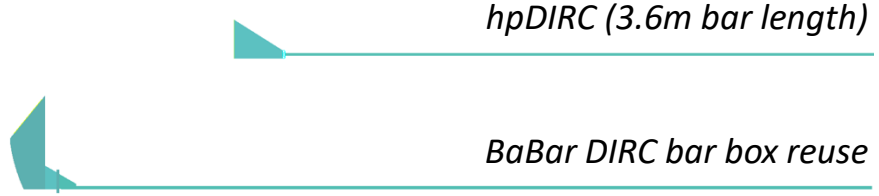
JLEIC



Day-one detector based on sPHENIX, 2018 LoI layout



Geant geometries scaled to EIC-sPHENIX drawing



DIRC expansion volume (prism or focusing block and sensors) can be located outside EM calorimeter barrel acceptance *(depending on bar length)*

DIRC Simulation Assumptions

Bar Material	Synthetic fused silica, polished to 0.5 nm *rms* surface roughness, transmission and reflection coefficient based on PANDA DIRC bar measurements
Bar Dimension	Current simulation uses 1.7 x 3.2 cm^2 bar cross-section (to be optimized) for hpDIRC and 1.7 x 3.5 cm^2 for the BaBar DIRC bar box reuse (Plate and hybrid geometry options to be studied for hpDIRC.)
Focusing System	3-layer spherical lens (hpDIRC), optical properties based on tested prototypes
Mirror	Front-coated mirror, reflectivity based on BaBar DIRC mirror measurement
Glue	Epotek 301-2, transmission based on BaBar DIRC measurements
Optical Cookies	RTV, transmission based on GlueX DIRC measurements
Sensors	MCP-PMTs, 3 x 3 mm^2 pixel size, CE/QE/PDE based on PANDA DIRC measurements
Mechanical System	All DIRC components made from aluminum alloy or CFRP (PANDA DIRC)
Readout Electronics	Assume 100 ps timing precision per photon (sensor, electronics, synchronization) Readout boards and cables not included in Geant simulation
Background	Random dark noise background, based on PANDA DIRC measurements
Tracking	0.5 mrad polar angle resolution, no post-DIRC tracking assumed
Particle Generation	Standalone Geant4, single tracks, no magnetic field