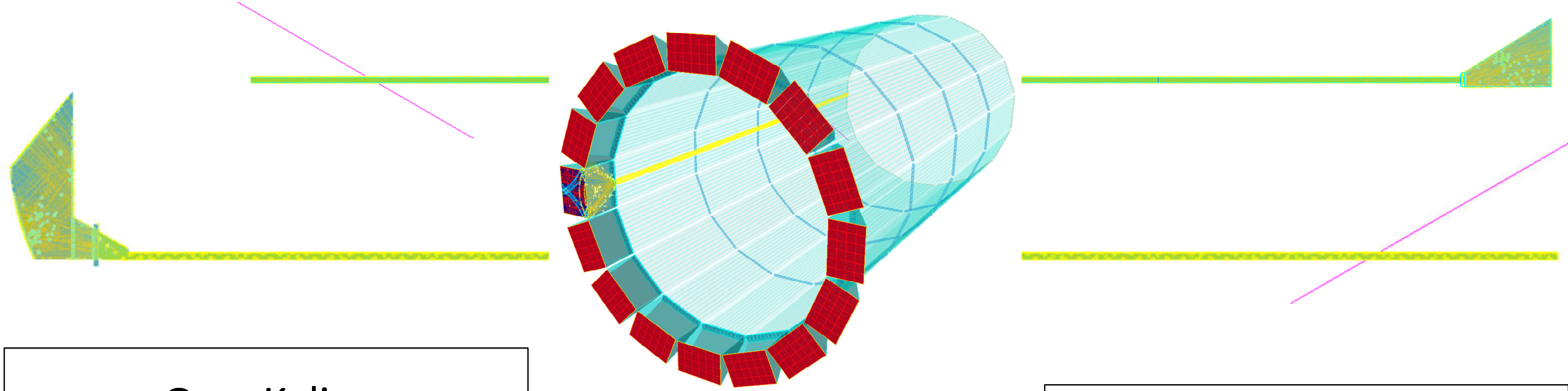
Barrel DIRC Detectors for the EIC

Comments and Questions from Pavia Meeting



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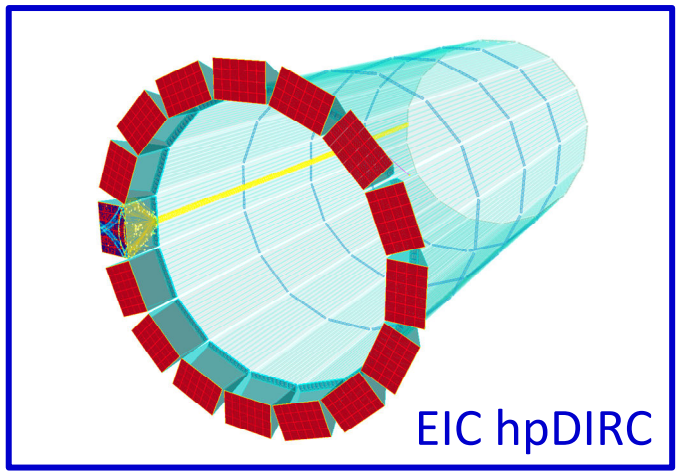
for the eRD14 DIRC group

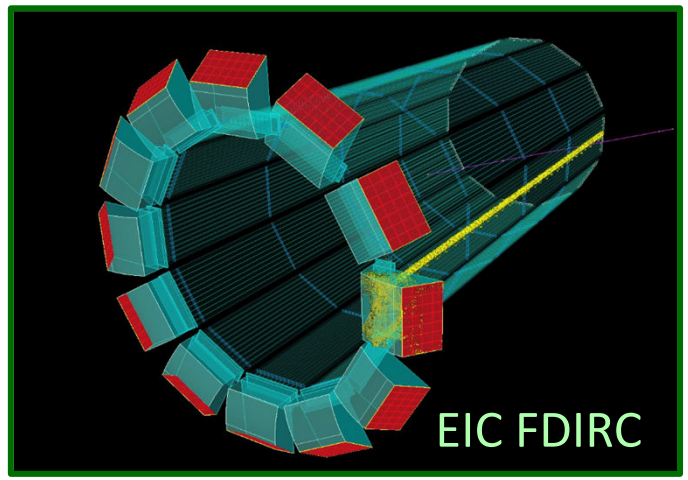
- hpDIRC and FDIRC options
- Flexibility of Integration

EIC DIRC Topic Overview

Today: discuss some of the comments and questions we received during the Pavia meeting

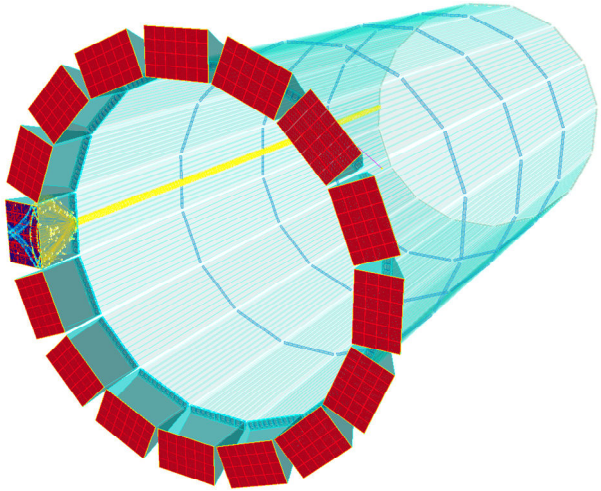
- **Quick reminders**:
  - DIRC PID performance is largely independent of barrel radius
  - DIRC PID performance is largely independent of bar length
- **Considering two possible EIC DIRC scenarios**
  - **hpDIRC** (pushing DIRC performance to highest momentum):
    - Excellent performance over wide angular range
      (≥ 3 s.d. π/K up to 6 GeV/c, contribution to low momentum e/π)
    - Bar length and shape of small expansion volume flexible
      (to help with sensor orientation in B-field and detector integration)
  - **FDIRC** (reusing BaBar bar boxes):
    - More limited PID coverage (≥ 3 s.d. π/K separation up to ~4.5 GeV/c, TBD)
    - Length and radius of bar boxes fixed; larger expansion volume required
      (less flexibility for integration)





EIC DIRC Options

EIC hpDIRC

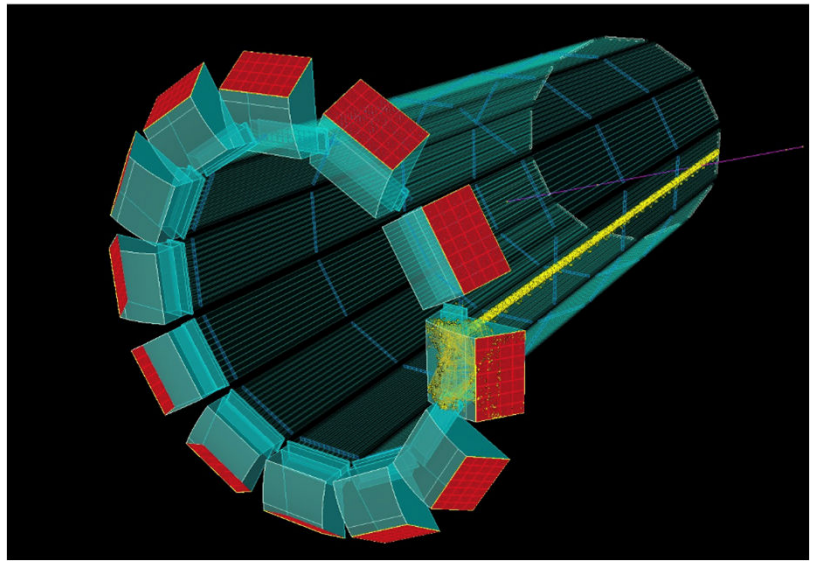


Focusing by spherical lens

Prism as expansion volume

Barrel radius, length of bar box (3-4.8 m, 3 or 4 bars) and size/shape of prism can be optimized for detector integration

EIC FDIRC



Focusing by cylindrical mirror

Focusing block as expansion volume

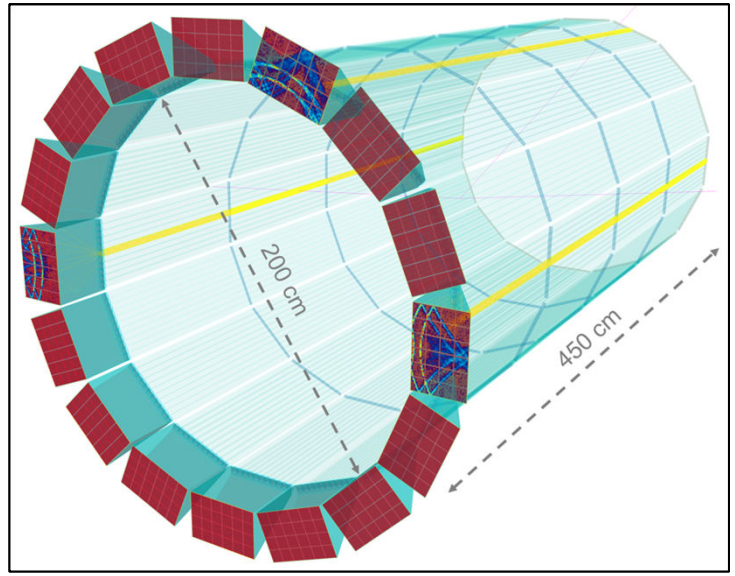
Length of bar box and location of focusing block fixed

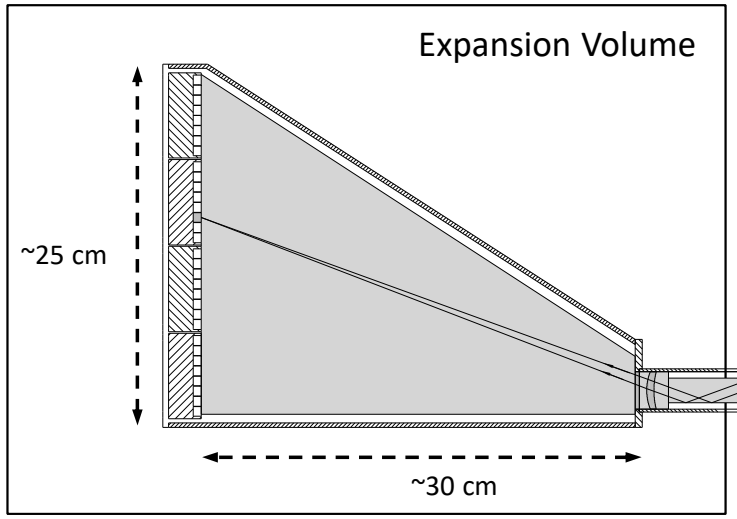
Size of focusing block can be somewhat optimized for detector integration, less flexibility than hpDIRC

EIC High-Performance DIRC (hpDIRC)

Expected performance: ≥ 3 s.d. π/K separation up to 6 GeV/c

- Generic reference design:
  16 sectors, one bar box and one expansion volume per sector
- Focusing optics:
  Radiation-hard 3-layer spherical lens
- Expansion volume:
  Solid fused silica prism: 24 x 36 x 30 cm^3 (H x W x L)
  Additional longitudinal space for MCP-PMTs, readout cards, cables: ~20cm
- Number of sectors, barrel radius and bar length can be optimized for integration, PID performance largely independent of barrel radius and bar length
- Expansion volume shape can be optimized for MCP-PMT magnetic field performance (tilted backplane) but length is directly related to performance



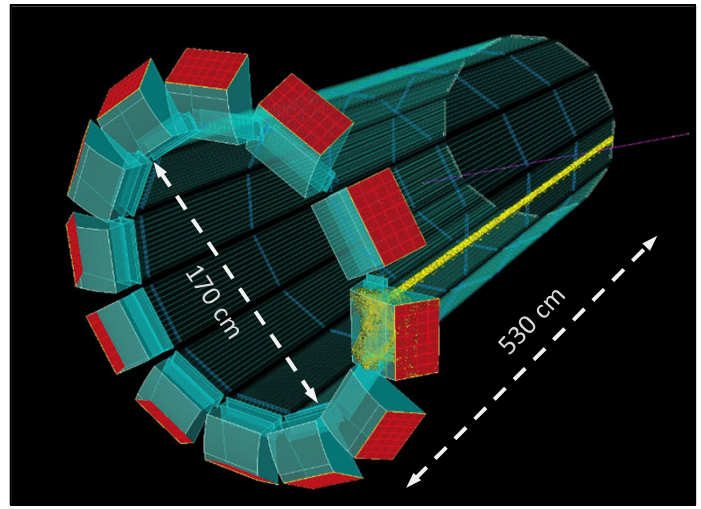


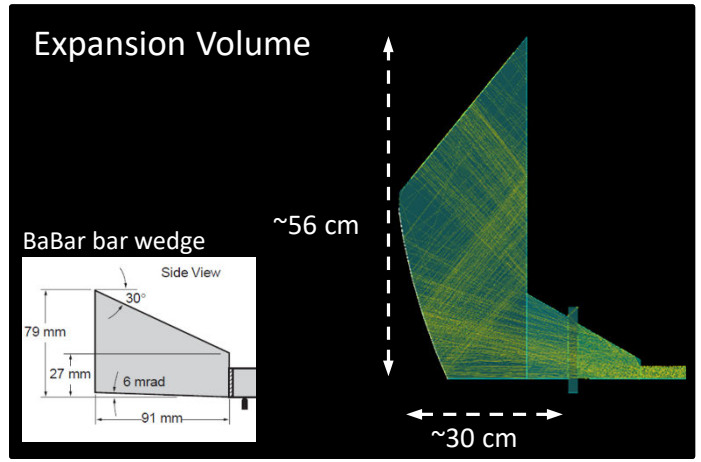
EIC fDIRC Design Facts

EIC Focusing DIRC (fDIRC): reuse legacy BaBar DIRC bar boxes, update optics and readout

Expected performance: TBD (SuperB fDIRC: ≥ 3 s.d. π/K separation up to 4.5 GeV/c – *NIMA 775 (2015) 112*)

- Existing bar box defines geometry:
  - 12 sectors, one bar box and one expansion volume per sector
- Focusing optics:
  - Cylindrical mirror (coating on back side of focusing block)
- Expansion volume:
  - Solid fused silica block: 56 x 42 x 22 cm^3 (H x W x L) (SuperB fDIRC)
  - Additional longitudinal space for coupling wedge, readout cards, cables (~20cm), some additional transverse space for dark box and mechanics (<10cm).
- Assume that bar boxes cannot be modified due to high risk of damage and bar surface contamination, barrel radius and bar length are essentially fixed
- Expansion volume can likely be made ~5cm smaller in depth and height
- Performance worse than hpDIRC due to 1D focusing and 6mrad angle of bar wedge





HPDIRC GEOMETRY

Pavia comment: concern about radius/length of hpDIRC barrel clashing with barrel EMcal geometry

- Current hpDIRC barrel radius (100cm) and length (420cm) in our generic design and simulation were picked a long time ago, hold no special meaning
- Barrel radius and length have almost no impact on hpDIRC PID performance
- Minor impact of radius on hpDIRC:
  - larger radius → smaller sagitta, reduction in radial thickness; slightly better azimuthal coverage
  - smaller radius → fewer bars and lenses required, lower cost
- Minor impact of barrel length on hpDIRC[§]:
  - shorter barrel → may require fewer bars, lower cost
  - longer barrel → longer photon paths, more chromatic dispersion of the photon time
- hpDIRC derives PID power from imaging in both time and pixel space (it's not a time-of-propagation detector)

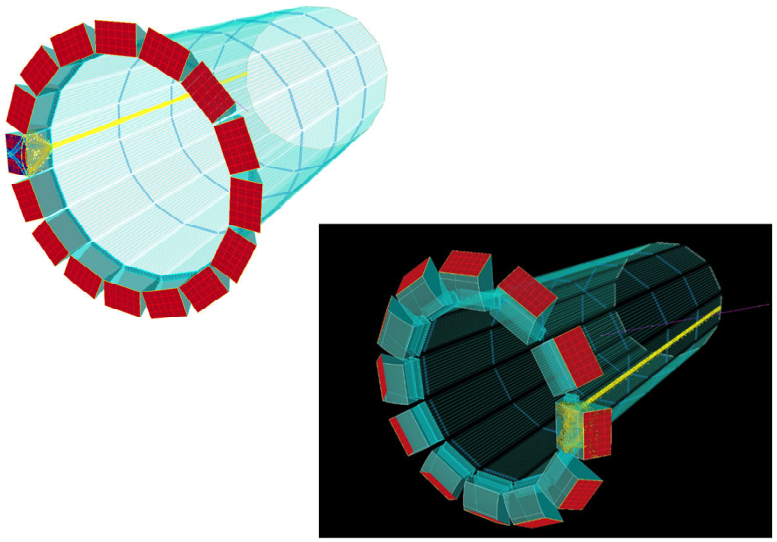
→ The radius and length of the hpDIRC barrel will be optimized for overall detector integration and cost without significant impact on the expected hpDIRC PID performance

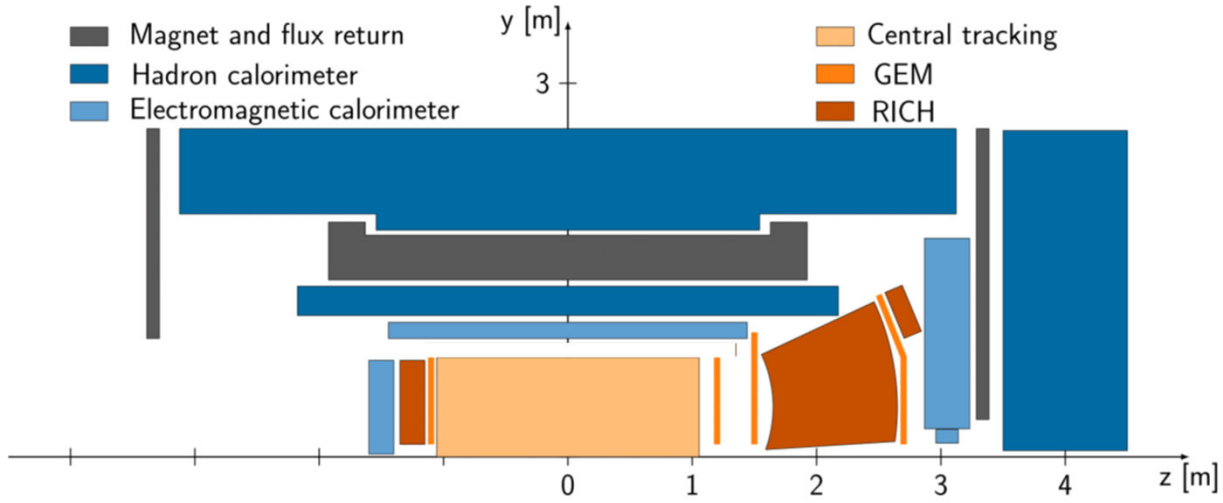
[§] *A potential "ultimate DIRC" design option may require 50-100cm additional barrel length compared to other hpDIRC designs.*

DIRC Integration Issues

Pavia comment: concern about integration of DIRC into EIC central detector, placement of expansion volume

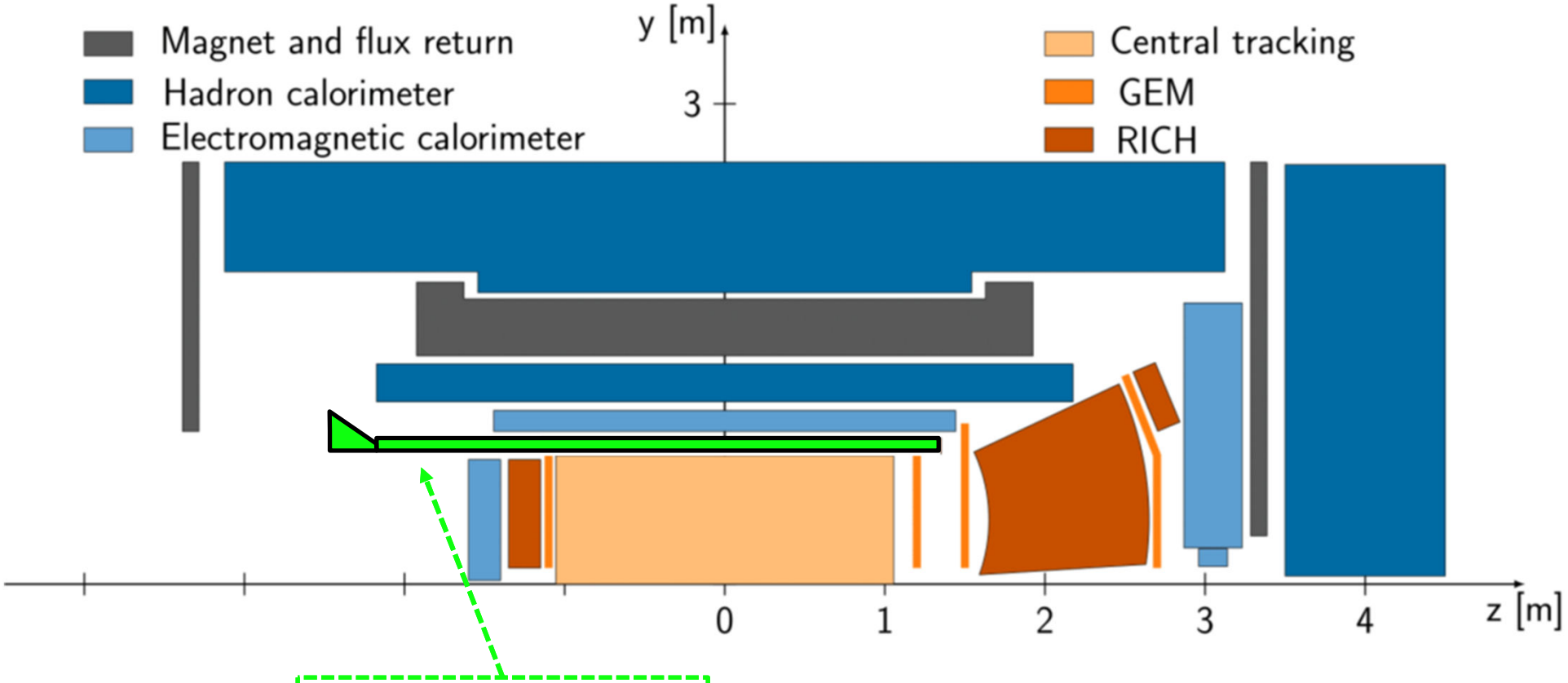
- Since then started discussion with Elke and Alexander about ways to integrate hpDIRC and/or FDIRC options into the most recent detector concept based on the interactive detector matrix – stay tuned
- Continuing the effort to implement full hpDIRC simulation into ePHENIX framework, to be completed this FY
- Meanwhile we are investigating simplified possible integration scenarios based on ePHENIX drawings





HPDIRC INTEGRATION EXAMPLE

Day-one detector based on sPHENIX, 2018 LoI layout

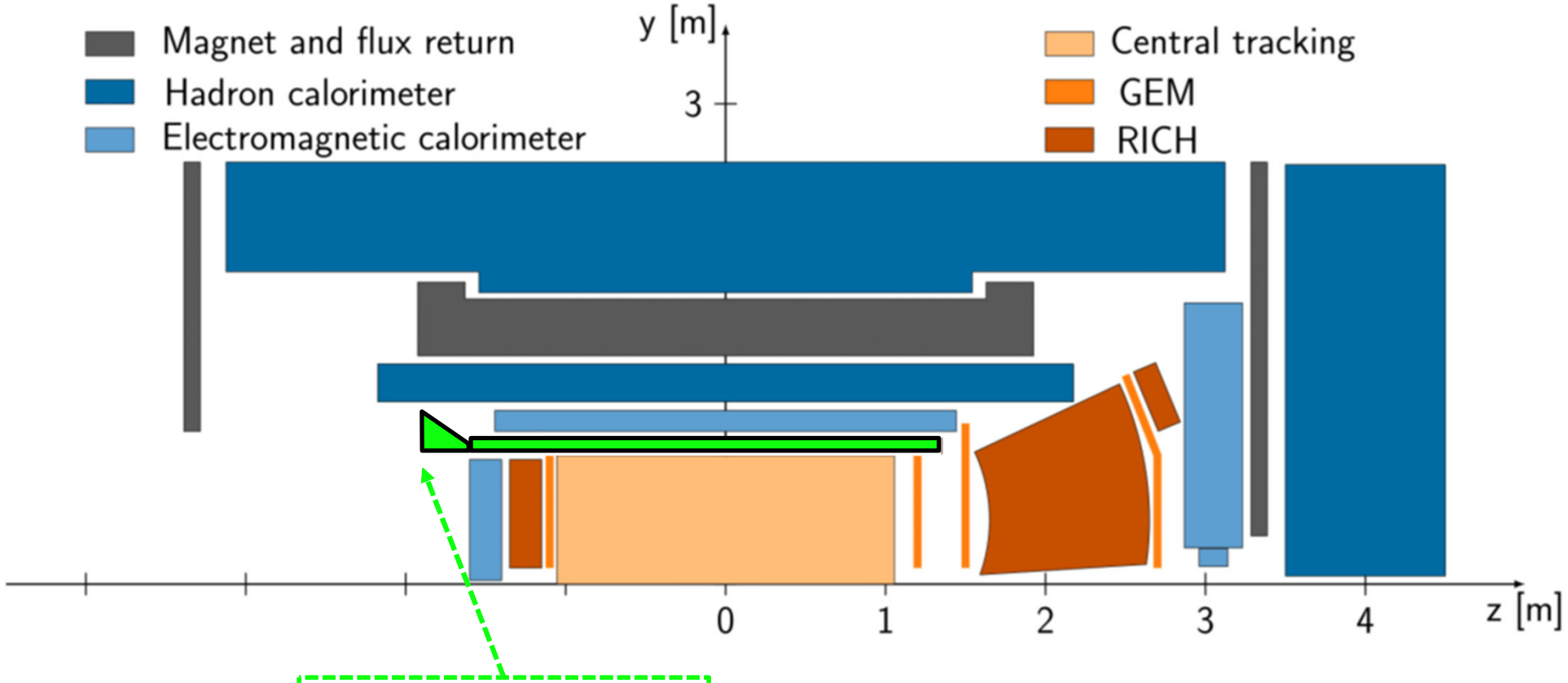


Cartoon of possible hpDIRC integration: example 1

- Total bar length 3.6m at 0.85cm radius (3 short bars glued end-to-end)
- Prism expansion volume located outside Barrel EM calorimeter acceptance

HPDIRC INTEGRATION EXAMPLE

Day-one detector based on sPHENIX, 2018 LoI layout

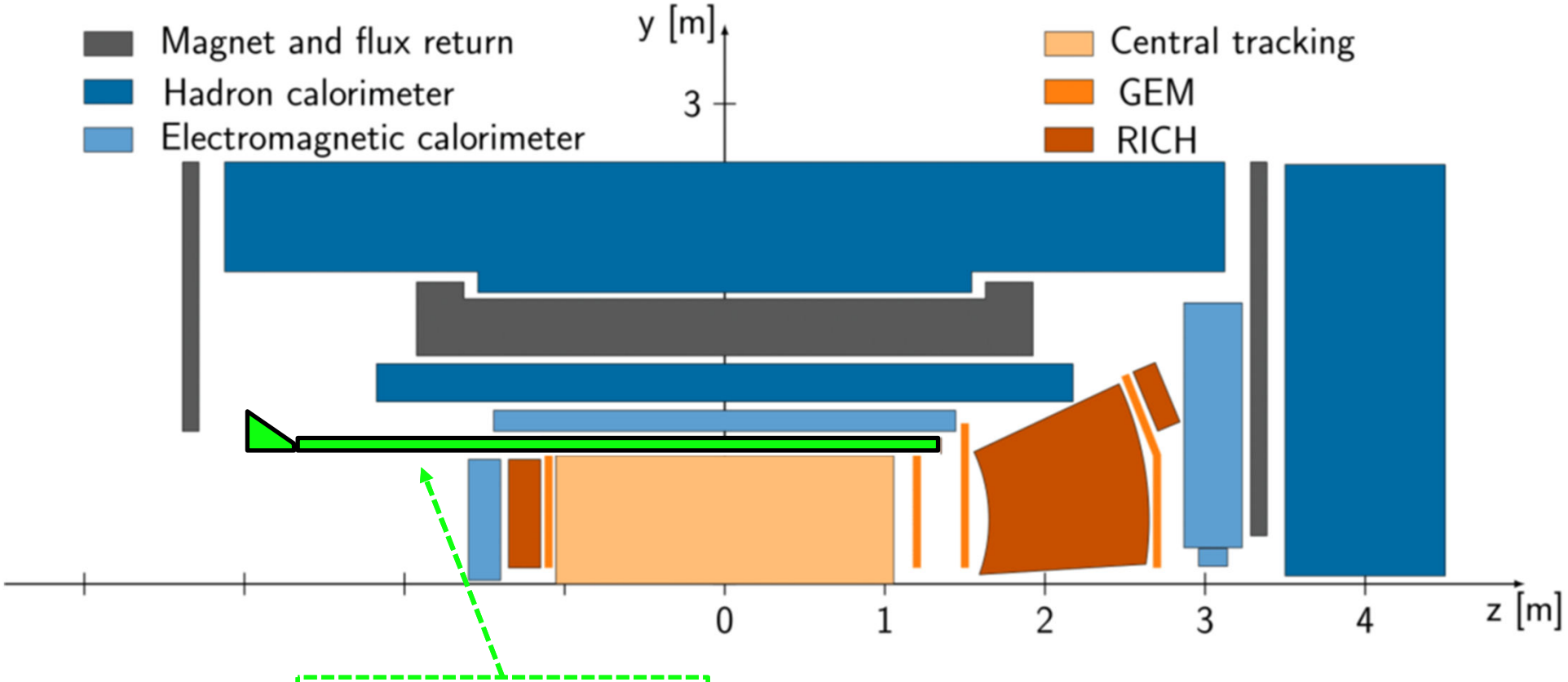


Cartoon of possible hpDIRC integration: example 2

- Total bar length 3.0m at 0.85cm radius (3 short bars (can possibly be reduced to 2 bars) glued end-to-end)
- Prism expansion volume located outside Barrel EM calorimeter acceptance

HPDIRC INTEGRATION EXAMPLE

Day-one detector based on sPHENIX, 2018 LoI layout

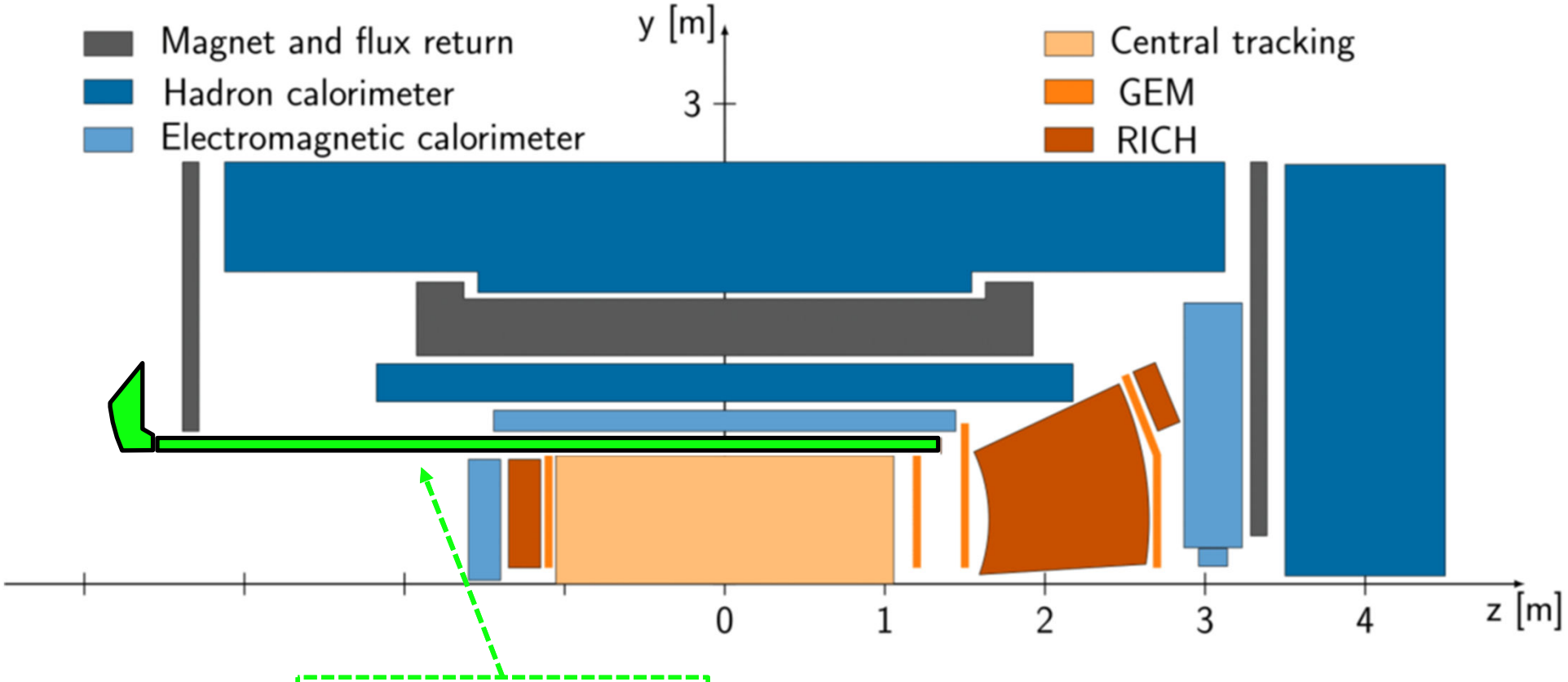


Cartoon of possible hpDIRC integration: example 3

- Total bar length 4.2m at 0.85cm radius (4 short bars glued end-to-end)
- Prism expansion volume located outside Barrel EM calorimeter acceptance

fDIRC Integration Example

Day-one detector based on sPHENIX, 2018 LoI layout

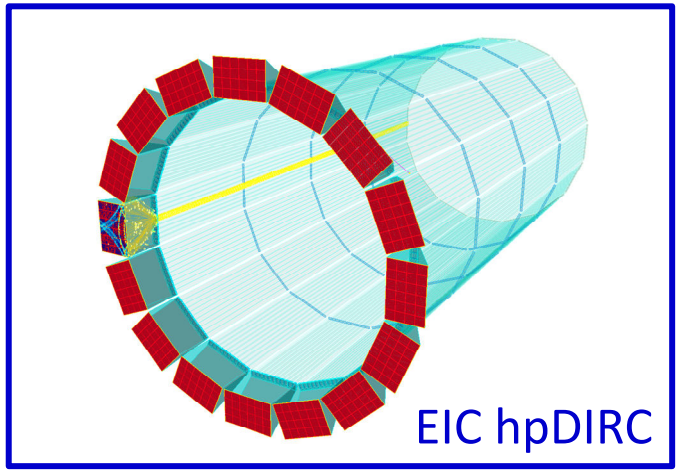


Cartoon of possible fDIRC integration:

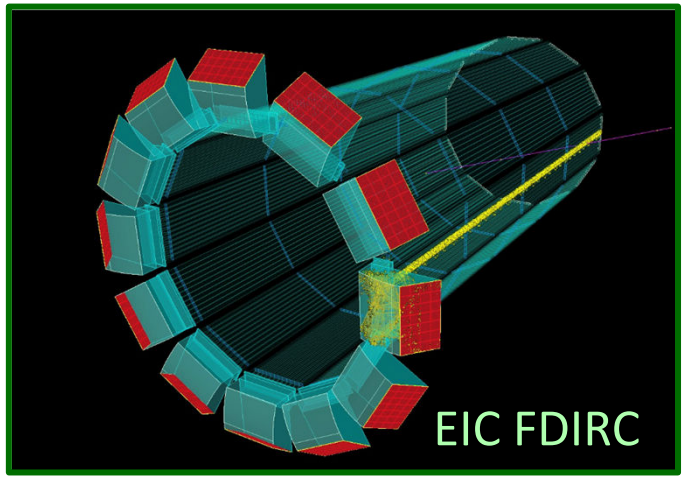
- Total bar length 4.9m at 0.85cm radius (given by BaBar DIRC bar box)
- Focusing block expansion volume located outside flux return

EIC DIRC Summary

- Flexibility of DIRC radius and bar length:
  - PID performance largely independent of either
  - Adjustable for hpDIRC option
  - Fixed for FDIRC option
  - Several possible locations for expansion volume based on ePHENIX drawing



- Flexibility of the Expansion Volume shape:
  - Dimensions adjustable within reasonable limits to keep PID performance stable
  - Detector plane can be tilted to mitigate impact of magnetic field

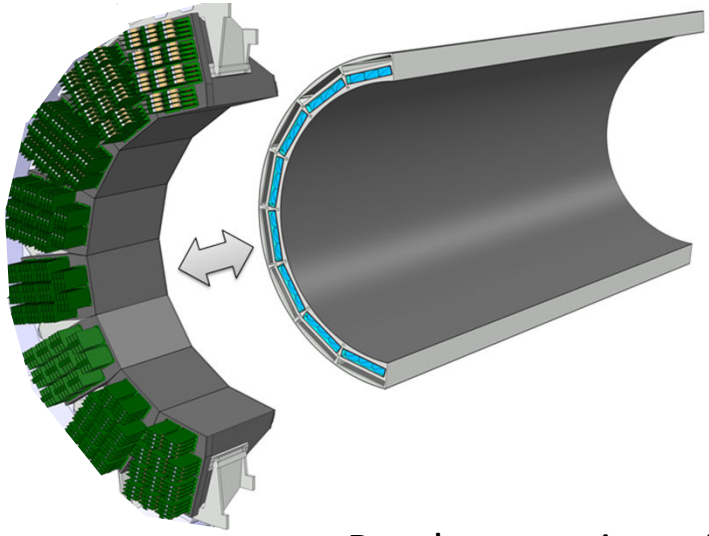


EXTRA SLIDES

DIRC Integration Example

Readout section

Bars section



Example: Barrel DIRC in PANDA (smaller radius, shorter bars than hpDIRC)

- bars long enough to guide light to prism located outside crowded central region
- prism (30cm) inside B field, all mech. components aluminum alloy or CFRP
- modular design, bar boxes/prism boxes can be installed later or removed
- readout cards mounted directly on MCP-PMTs, few cables

Readout section: single unit