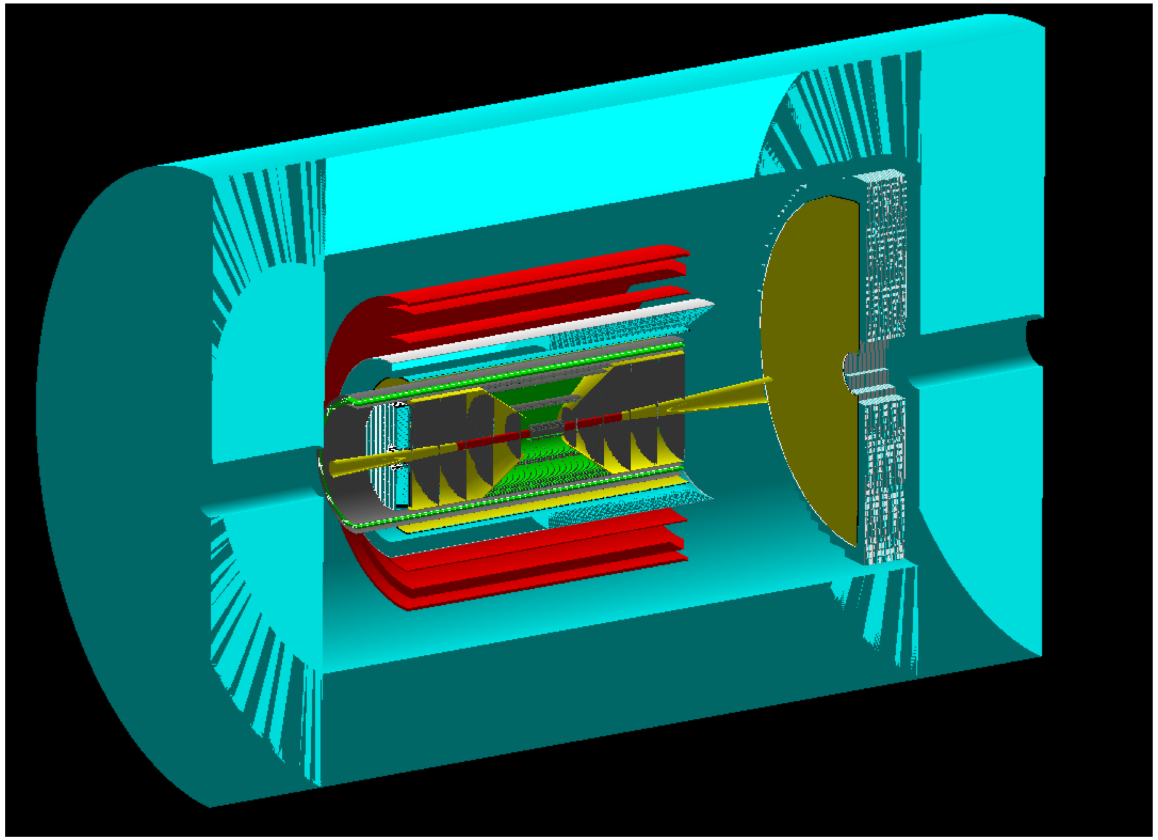
CORE: a COmpact detectoR for the EIC
- May update

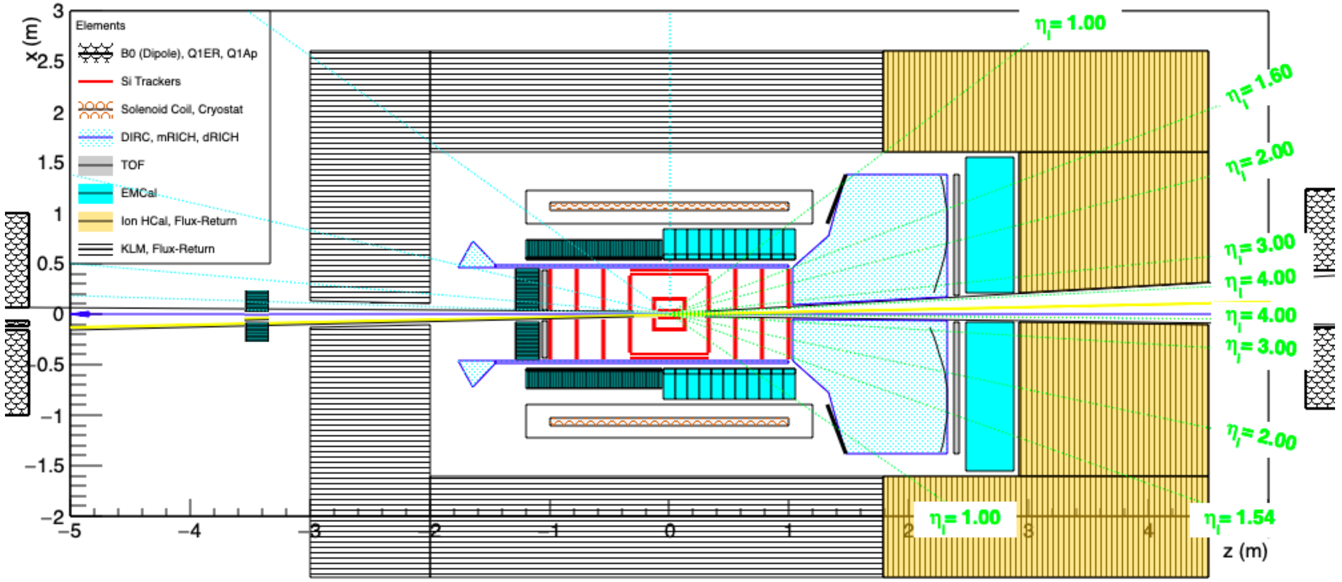


Pawel Nadel-Turonski

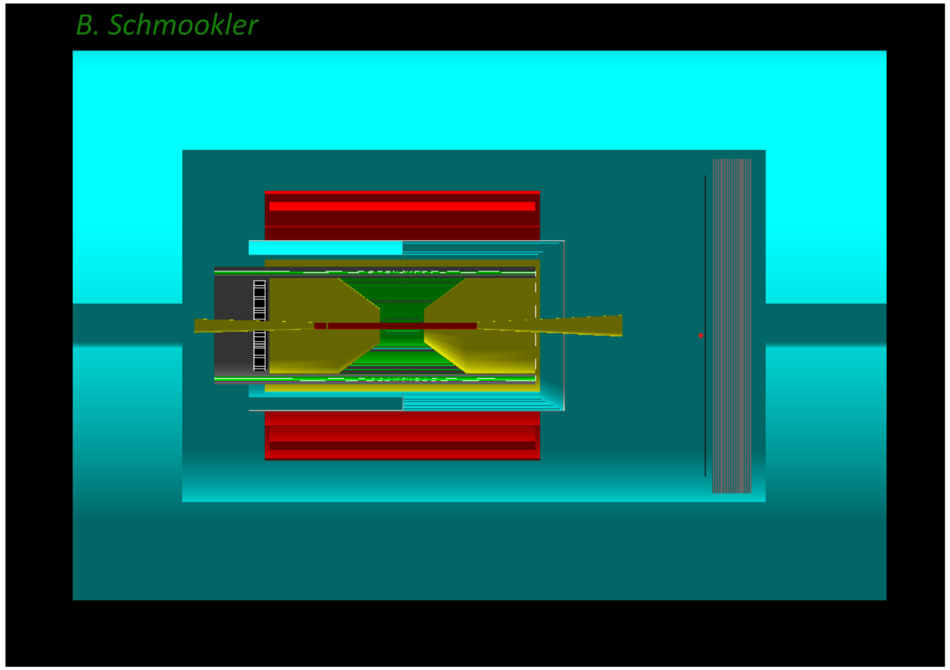
Stony Brook University

CORE meeting, May 3, 2021

CORE update

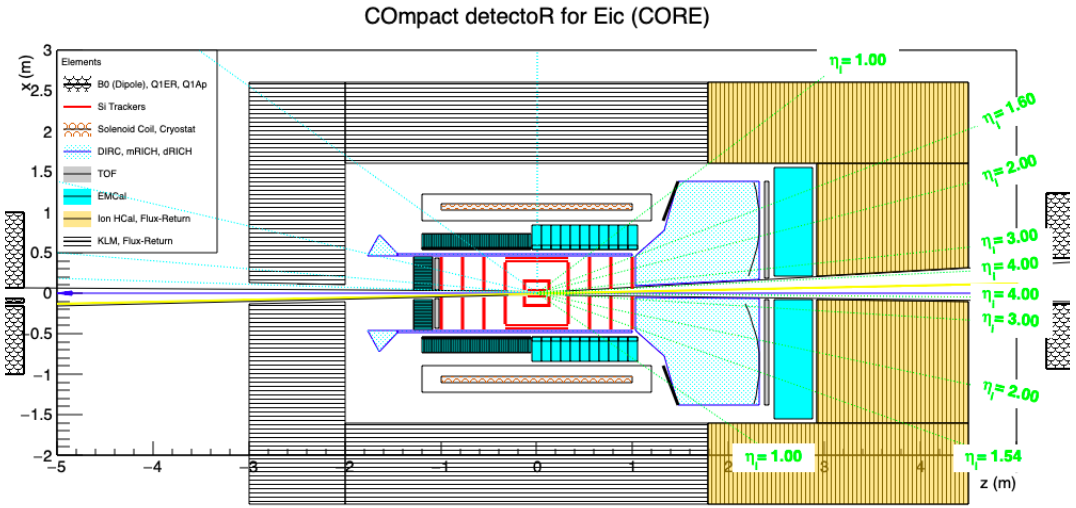


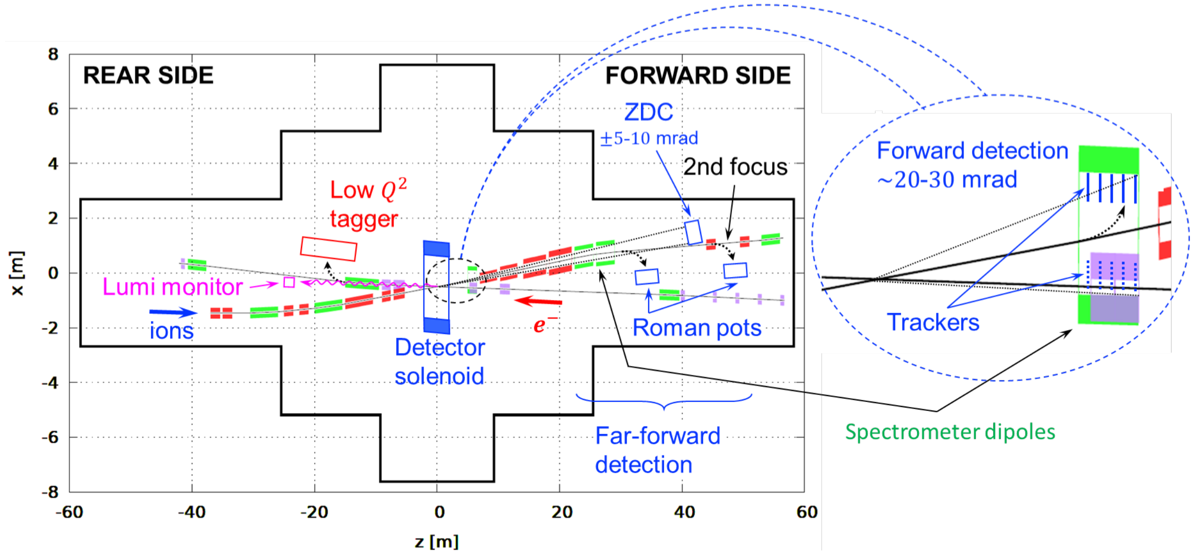
CORE in Geant (fun4all)



- The CORE design is stable
- As a Detector 2 proposal, CORE will pursue integration with IP8
  - Several physics studies underway
- Some technology options are now baseline choices: W-Shashlyk EMcal for $\eta > 0$, KLM for for $\eta < 1$, LGADs for e-side TOF, GEMs and scintillator TOF behind dRICH

Integration of CORE with IP8 (Detector 2)





- Despite its compact size, CORE has a lot of room available for supports and services
- In its nominal configuration, CORE fits into a -3 m to +4.5 m IR space.
  - The maximum luminosity depends on detector length
- The interplay between the forward detection and CORE will be an important part of the detector proposal.

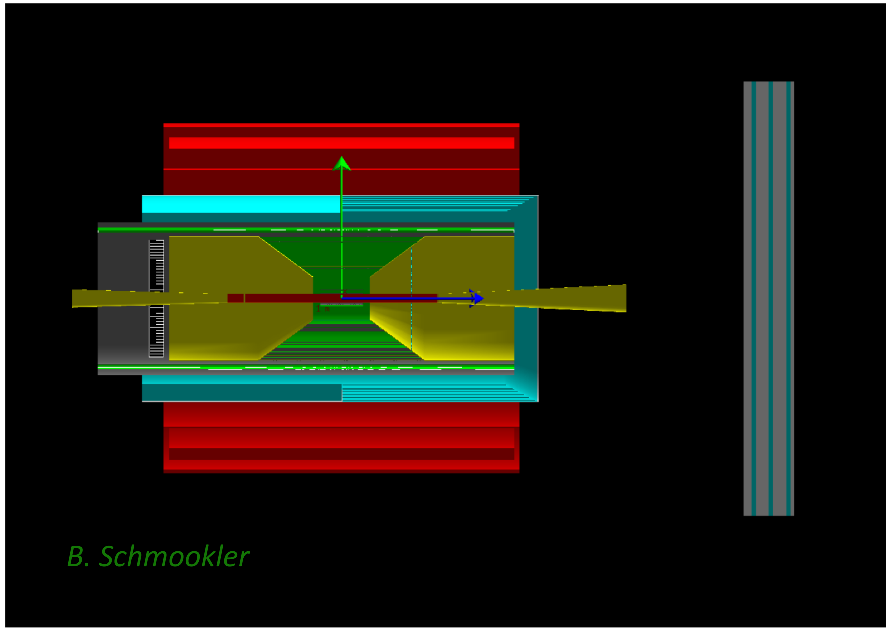
Solenoid options

- The CORE solenoid is 2.5 m long with a 0.9 m inner radius
- CORE is compatible with any field in the 2-4 T range
- 4 T is affordable due to the small volume of CORE
  - Can be operated at 2 T (better acceptance, hID)
- 2 T is the current low-cost, low-risk baseline option

solenoid	field (T)	volume (m^3)	2020 cost (M$)	with 50% contingency
EIC-IP6	3	29	21	32
CORE	4	6.4	11	16
CORE	3	6.4	7	11
CORE	2	6.4	4	6
CORE 1 m	2	7.9	5	7

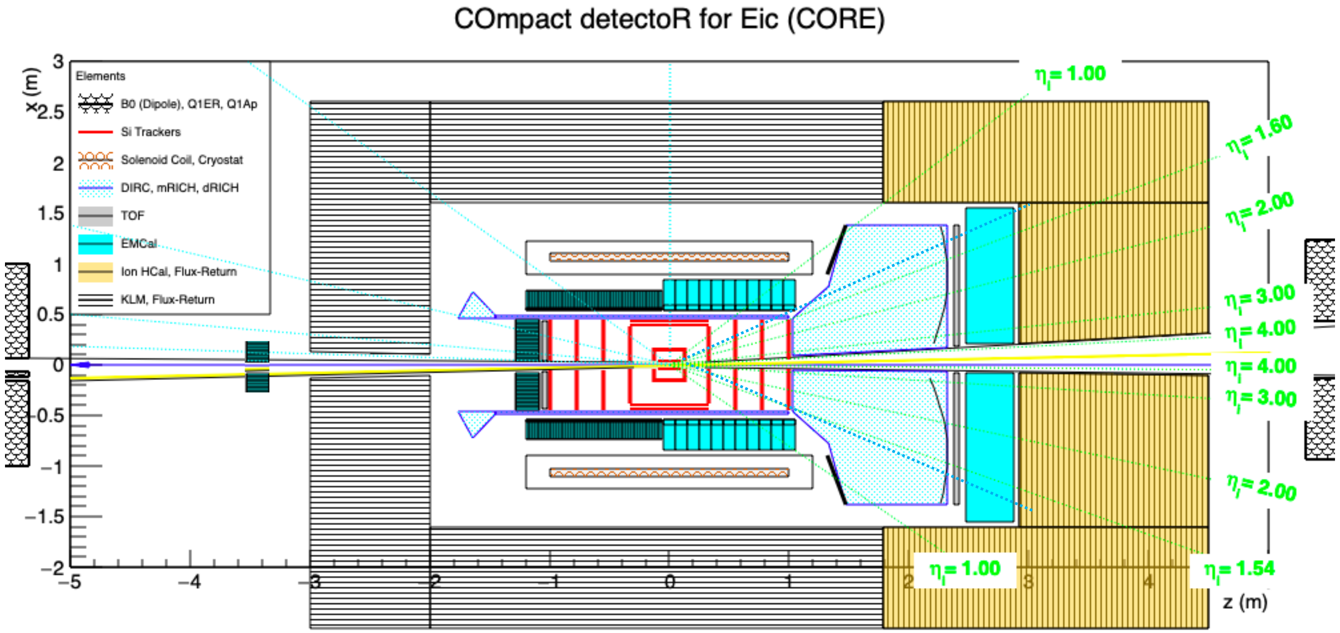
cost (2020 M$) = 1.8 x 0.458 x (stored energy)$^{0.7}$

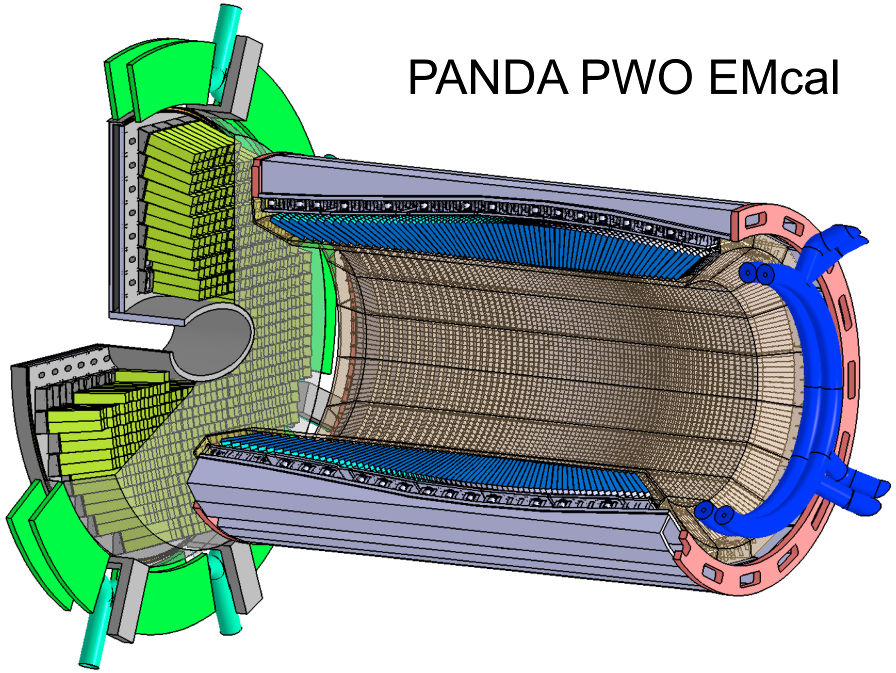
M. A. Green and S. J. St. Lorant, Adv. Cryo. Eng. **39**



- Note that increasing the CORE inner radius from 0.9 m to 1,0 would cost about $1M for the baseline 2 T option.
- A 1 m radius would leave 50 cm between the DIRC and solenoid

4π EMcal





PWO for electron hemisphere: (up to 2π, $\eta < 0$ coverage)

- Both the endcap and barrel would be projective (*cf.* PANDA)
  - Note that in the simulations the PWO is currently not projective
- The small-angle EMcal behind the main detector endcap could also be SciGlass.

W-Shashlyk (6%) for hadron hemisphere: ($\eta > 0$ coverage)

- Projective modules in the barrel (more expensive to manufacture)
- Non-projective modules in the endcap.

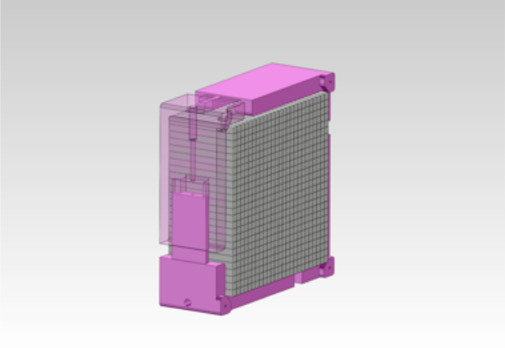
Pre-showers for γ/π^0 separation

- W-Shashlyk may be have sufficient intrinsic position sensitivity not to require a separate pre-shower
  - R&D will determine optimal configuration.
  - No separate pre-shower needs to be implemented in simulation at this point

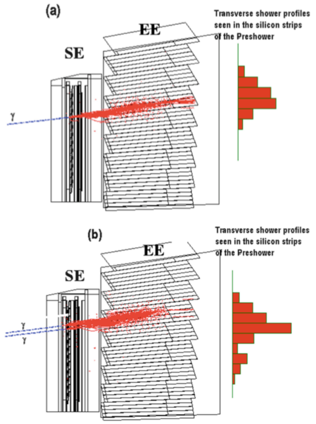
C. Woody

- PWO crystals can provide γ/π^0 separation at lower energies, but a pre-shower will improve separation and increase the energy range
  - Would PWO alone be sufficient for the EIC?
- Several PWO pre-shower options exist.
  - Simplified configuration in simulation?

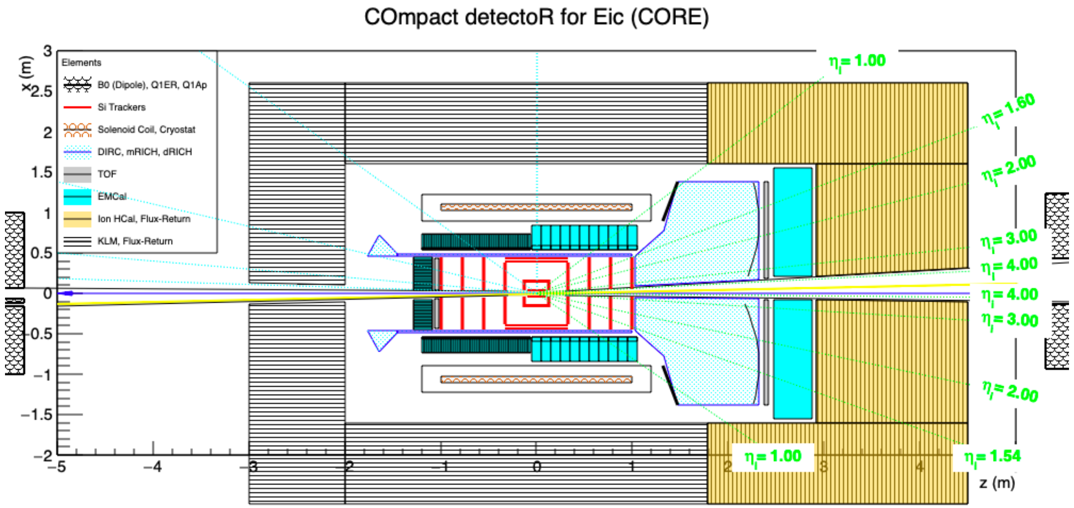
A LYSO pre-shower from the RD2012-13 proposal with fiber readout could be an interesting option.



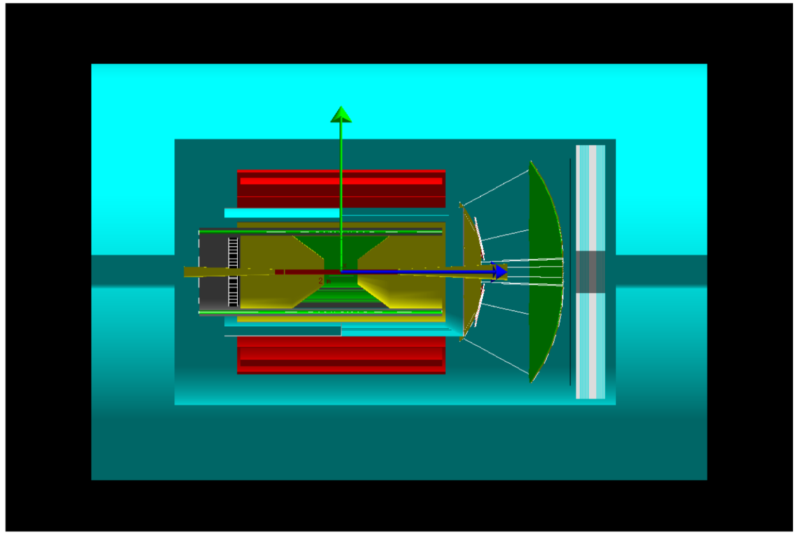
The CMS PWO pre-shower uses cooled 6 mm Si-strip detectors in-between an initial layer and the main PWO blocks



Hadron-side RICH



CORE with a dual-radiator RICH (eRD14)



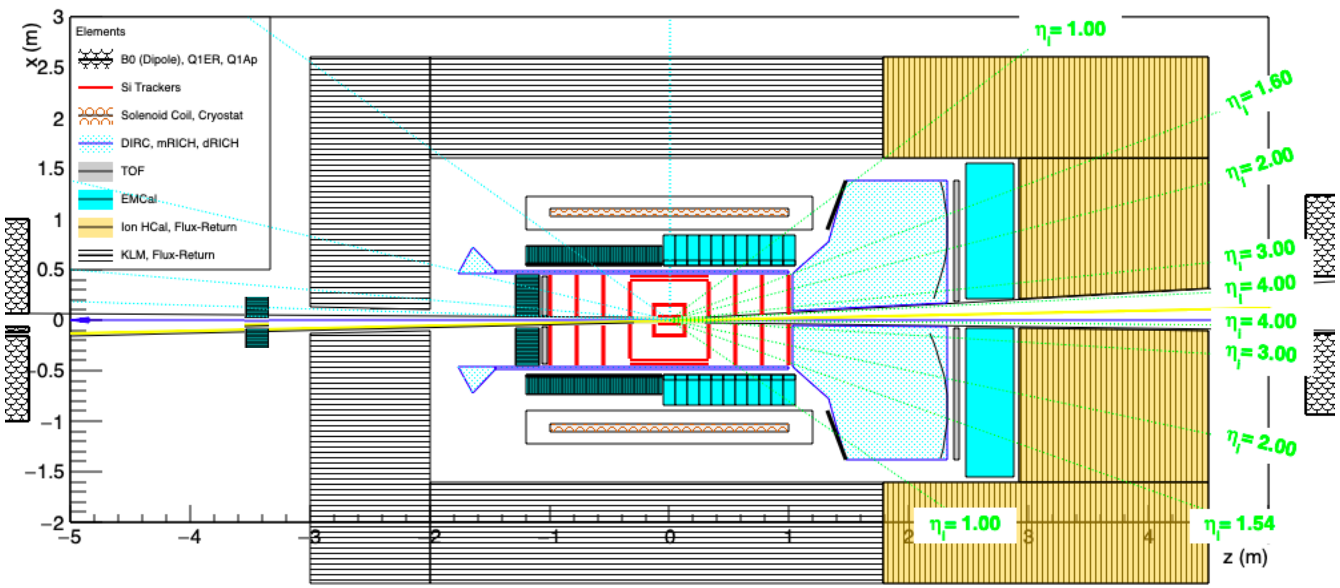
CORE with a gas-only RICH (eRD6)
and LGAD-based TOF behind it

- The dual-radiator RICH (dRICH) is the CORE baseline choice.
- The dRICH, in combination with simple TOF, is a cost-effective solution with continuous coverage over a wide momentum range.
- A dRICH parameterization exists for fast MC

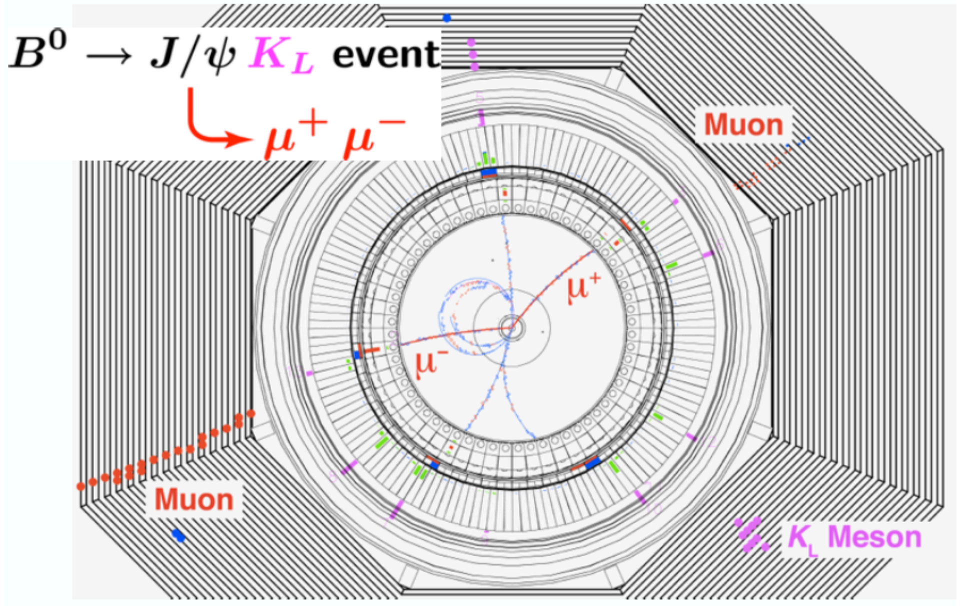
- However, pending the implementation of the dRICH in fun4all, Geant simulations can start using a gas-only RICH in combination with high-resolution LGAD TOF, which is already implemented

Muon ID

COmpact detectoR for Eic (CORE)



The Belle II K_L-μ (KLM) system



- Mid-rapidity muons have relatively low momenta, and it is important to minimize multiple scattering.
- The KLM can provide muon ID in the barrel and e-endcap, and detect neutral hadrons for jets,
  - A discussion has been initiated on jet reconstruction using the neural hadron ID and angle from the KLM, in addition to information from the tracker, Emcal, and PID for other tracks
- In the hadron endcap, both jet and muon energies are large, and a muon tracker like the sTGC (small-strip Thin Gap Chambers) for the “small” wheel of ATLAS can be used (USM, Chile).

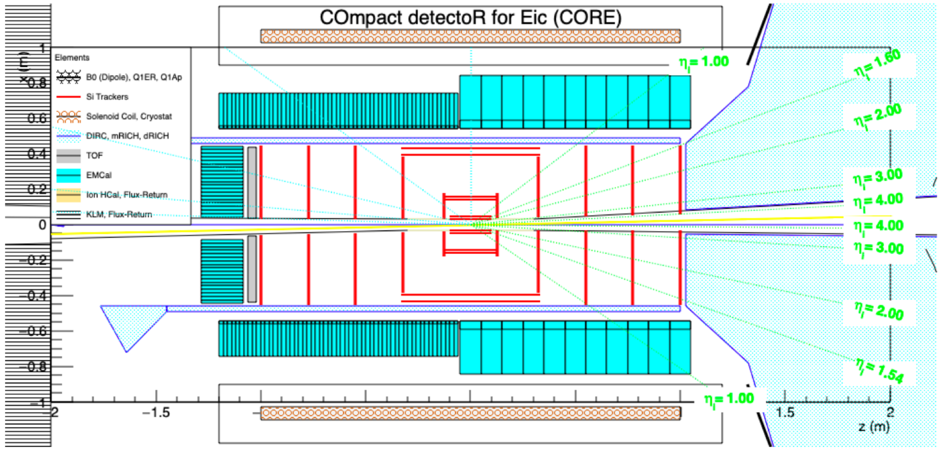
Support from EIC R&D consortia

- eRD1: support for PWO (Carlos)
  - W-Shashlyk and h-side Hcal will benefit from ongoing activities
- eRD5: costing and performance for GEM behind haron endcap RICH (Kondo)
- eRD14: active support for DIRC and dRICH simulations
  - Construction of a second dRICH with eRD14 support is being explored.
- eRD25: support for Si-tracker
- eRD29: costing and performance for e-side LGAD TOF

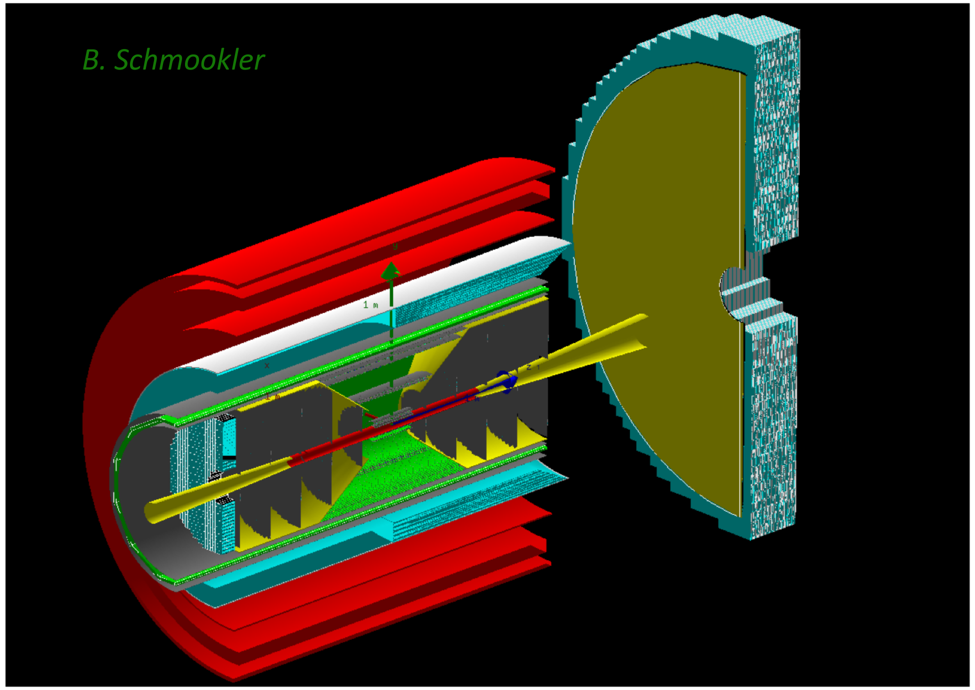
Thank you!

The core of CORE

dRICH photosensors



inner CORE in Geant (fun4all)

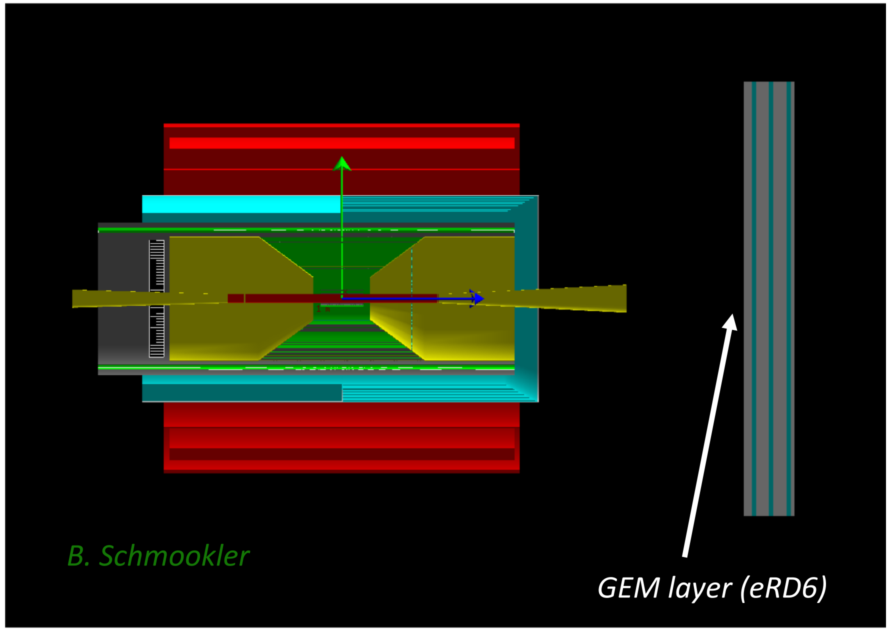


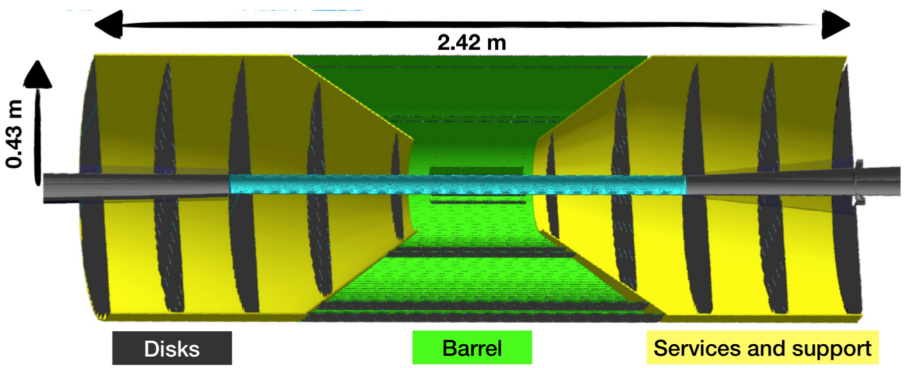
- Small solenoid (2.5 m long, 0.9 m inner radius)
- Small central all-Si tracker (eRD25)
- Radially compact, high-performance barrel DIRC Cherenkov (eRD14)
- Dual-radiator RICH with *outward-reflecting* mirrors in the hadron endcap (eRD14)
- Extended PWO_4 EMcal coverage (up to 2π, η < 0) on the electron side (eRD1)

Central Si-tracker

- A silicon tracker is compact, has a high resolution, and offers opportunities for future upgrades.

- The tracker developed by eRD25 would utilize ALICE ITS3 technology and is designed for the angular resolution requirements of the DIRC, making it a good choice for CORE





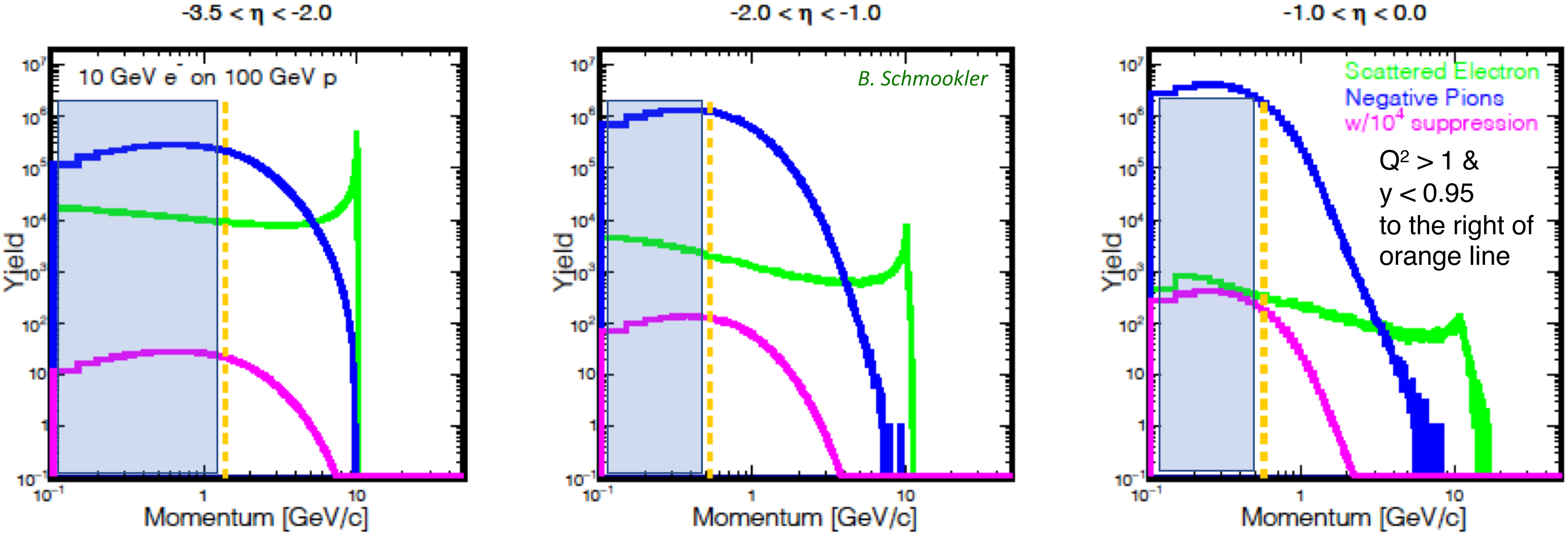
eRD25 tracker

	ITS2/ALPIDE	ITS3
technology	180 nm	65 nm
pixel-size	27 x 29 µm	10 x 10 µm
thickness	50 µm	20-40 µm

Note: modern microprocessors use 7 nm technology. The (unfair) comparison shows an opportunity for future improvements.

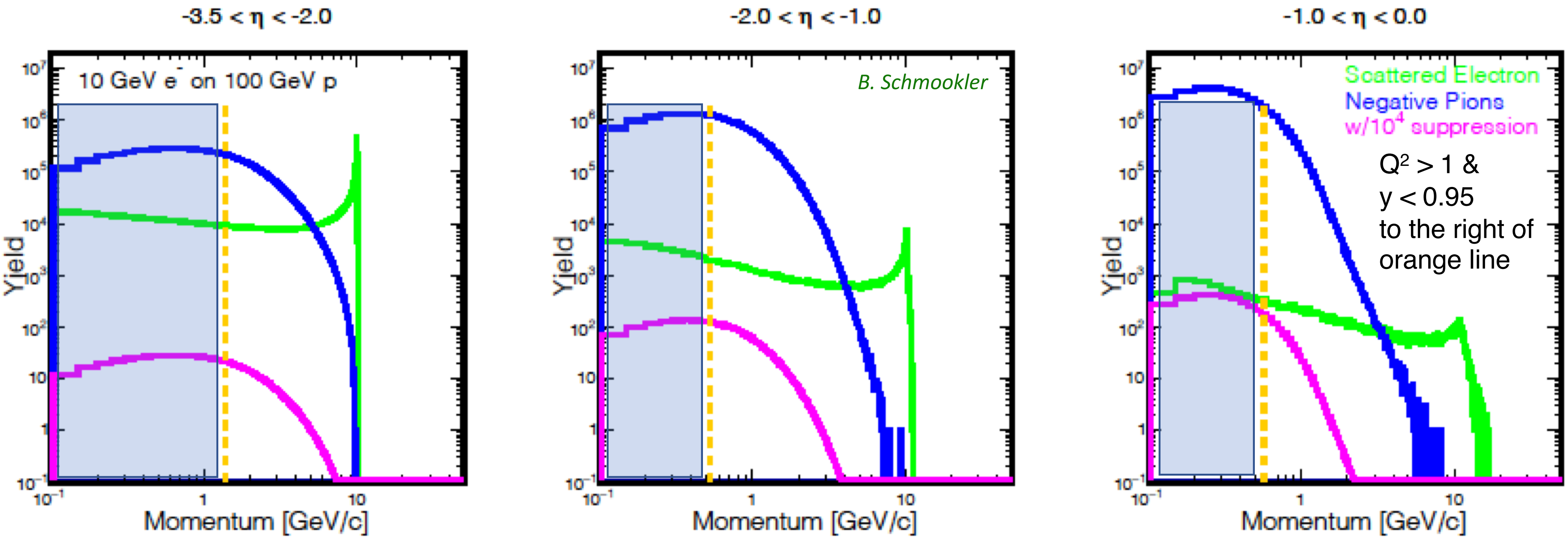
e/π identification in the electron hemisphere

$\eta = -\ln(\tan(\theta/2))$



- For the EIC, a clean identification of the scattered electron is essential.
- The YR requirement matrix lists a pion suppression of up to 1:10^{-4} for the e-endcap and barrel.
- Since the relative pion background rises at larger (less negative) η, the barrel region poses the greatest challenge and requires the best electron ID.
- However, in the reference detector the best EMcal (PWO_4) only covers the inner endcap ($\eta \lesssim -2$).

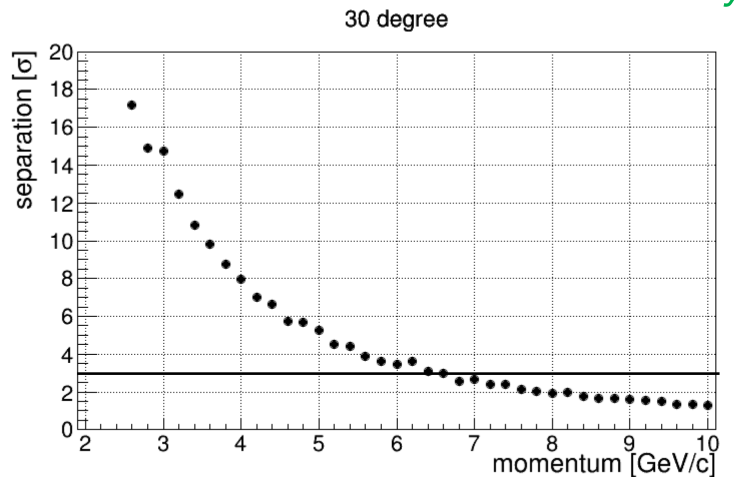
CORE solution for e/π identification in the electron hemisphere

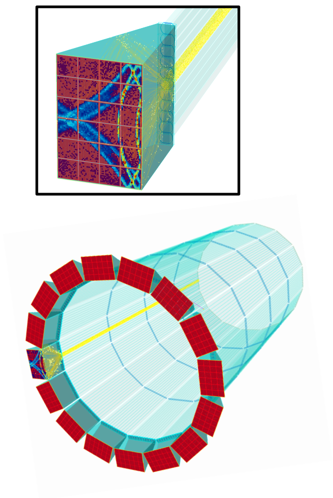


- CORE addresses the eID issue by extending the PWO_4 EMcal coverage up to $\eta < 0$.
- Additional e/π suppression (at least 1:10 up to 1.2 GeV) is also provided by the DIRC
- The result is a barrel eID configuration that can provide good pion suppression with a high electron efficiency (potentially enabling measurement of A_{PV}).
- A better energy resolution also improves photon detection in the electron hemisphere.

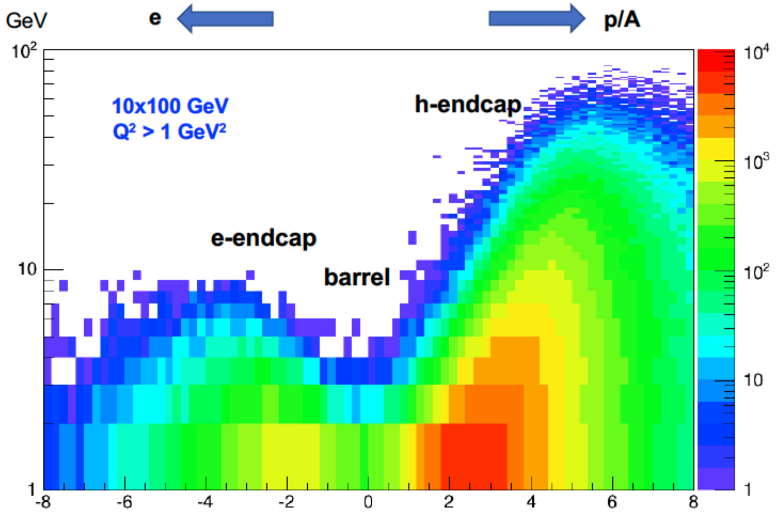
Hadron Identification in the barrel (hpDIRC) and hadron endcap (dRICH)

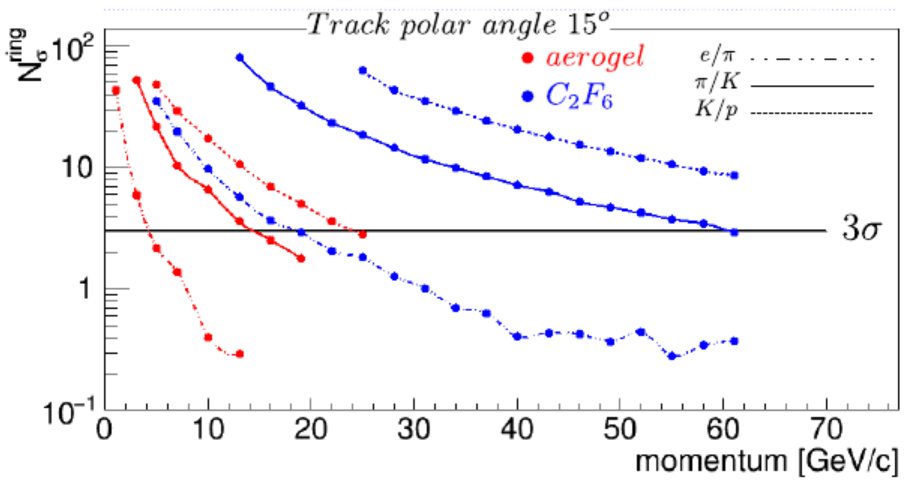
--> *talk by G. Kalicy*

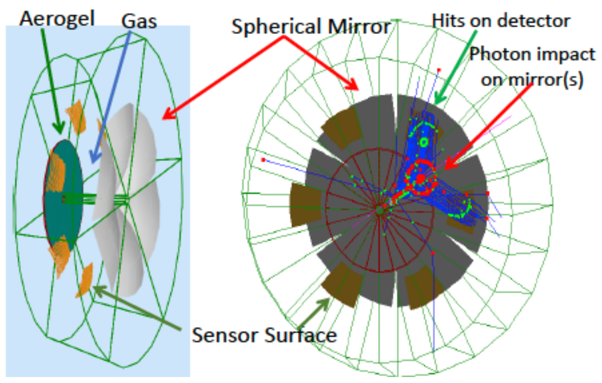




- The hpDIRC has a π/K separation of >4σ up to 6 GeV (and 2σ at 8 GeV).
- The minimum momentum for π/K ID in threshold mode is 0.2 GeV







- Using aerogel and gas radiators with a single set of photosensors the dRICH provides *continuous* π/K separation of >3σ up to 60 GeV and an excellent e/π separation (no TRD needed).
  - e/π: 10σ at 10 GeV

--> *talk by E. Cisbani, M. Contalbrigo*