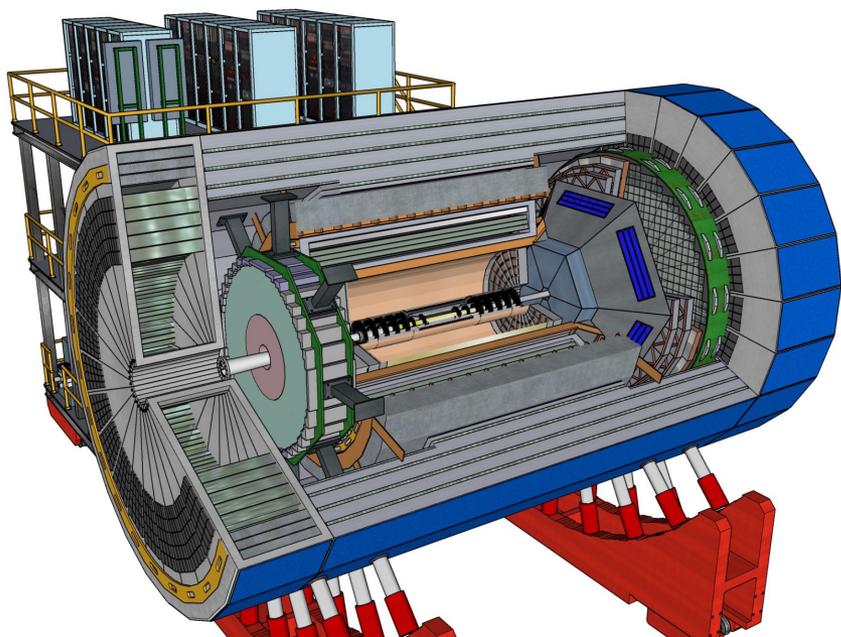


# ECCE 1<sup>st</sup> order integrated tracking detector layout

Xuan Li (LANL), Nilanga Liyanage (UVA)

# ECCE General Detector Technology candidates

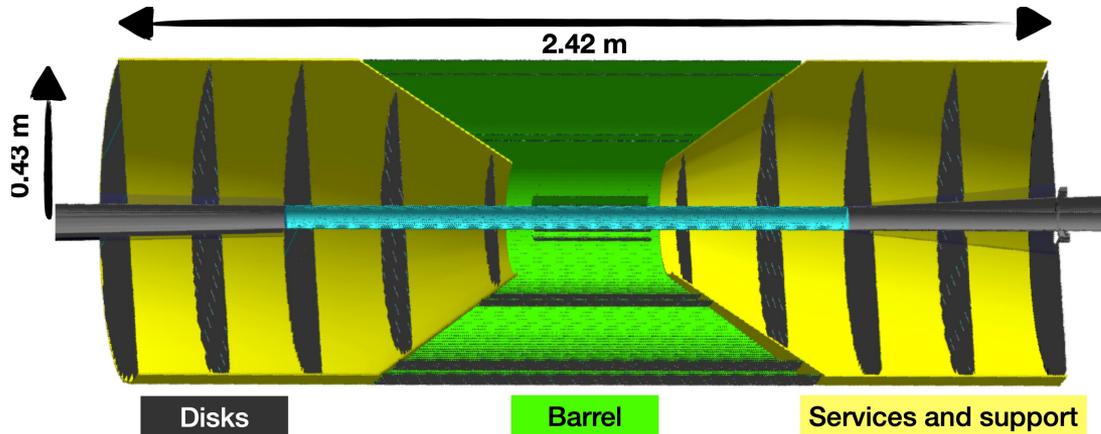
- Initial inputs based on the June 8 ECCE tracking discussions.



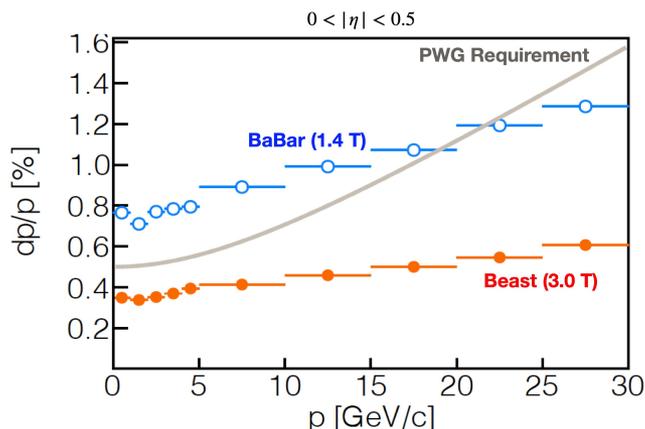
- Preferred technologies:
  - **Electron endcap:**  $\mu$ Rwell/MPGD, MAPS based silicon, LGAD based ToF (1 or 2 planes).
  - **Central Barrel:**
    - MAPS based silicon,
    - LGAD based ToF (1 or 2 layers) or **LYSO based ToF (5X5mm<sup>2</sup>, 5cm long bars)?**
    - DIRC
    - **$\mu$ Rwell/MPGD?**
  - **Hadron endcap:** MAPS based silicon,  $\mu$ Rwell/MPGD, LGAD based ToF (1 or 2 planes).
- Any further inputs?

# Central Barrel vertex/tracking - I

- LBNL All-Silicon Tracker design based on  $10\ \mu\text{m}$  pixel pitch MAPS (ITS-3 65 nm) technology.



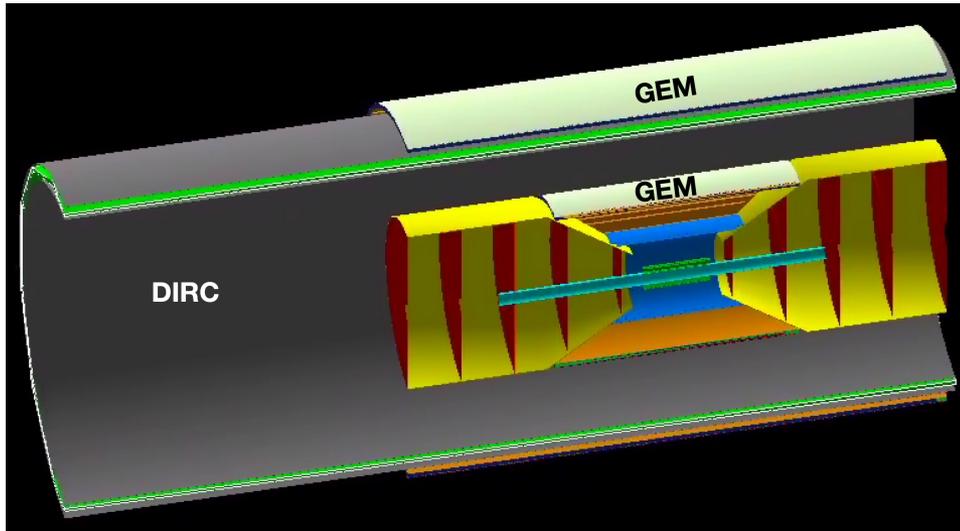
- Detector geometry implemented in Fun4All.
- Tracking performance evaluated. arXiv: 2102.08337



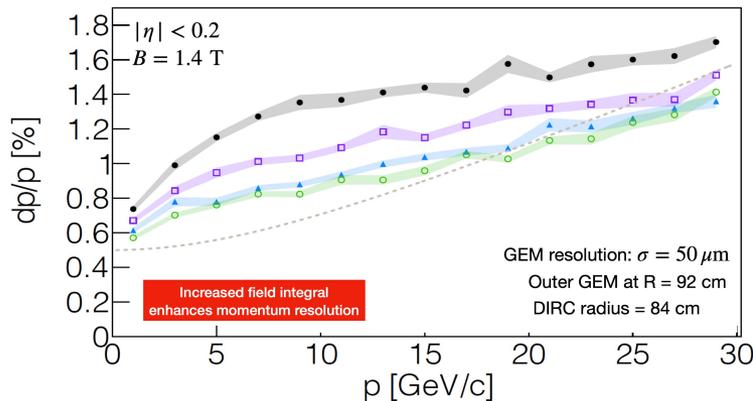
- Detector R&D status? TBD
- Prototype sensors availability? TBD
- Readout options? TBD
- Costs and Risks? TBD.

# Central Barrel vertex/tracking - II

- Potential hybrid barrel detector between silicon and MPGD/ $\mu$ Rwell tracker.



- Initial detector geometry based on the GEM implemented in Fun4All and corresponding tracking performance evaluated.
- Further updates based on  $\mu$ Rwell technology?

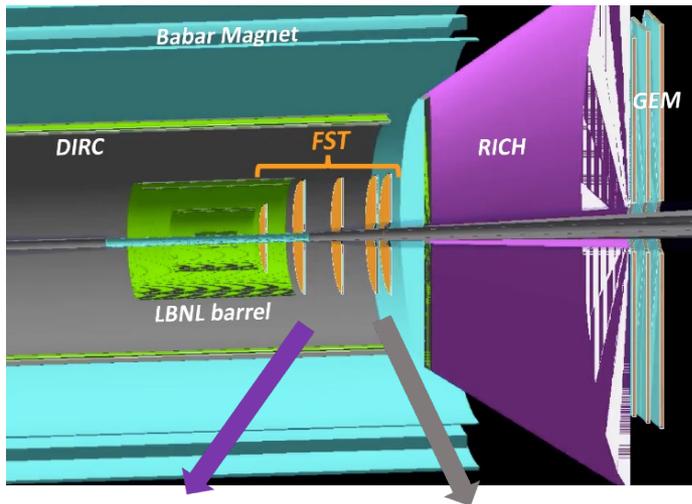


- Detector R&D status? Ongoing by eRD6
- Prototype detector availability? TBD
- Readout options? Could be strip readout modules.
- Costs and Risks? TBD.

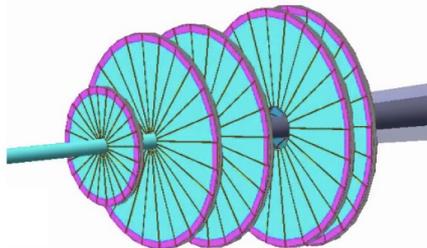
# Hadron endcap vertex/tracking

- LANL Forward Silicon Tracker design based on  $20\ \mu\text{m}$  pixel pitch MAPS (ITS-3 like) technology and  $36.4\ \mu\text{m}$  pixel pitch DMAPS technology.

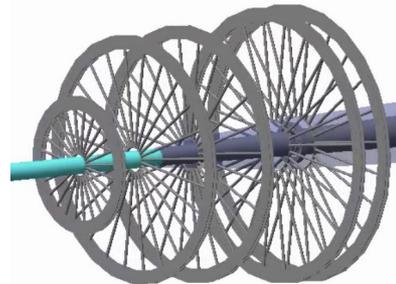
## LANL FST implemented in Fun4All



### Silicon wedge and readout



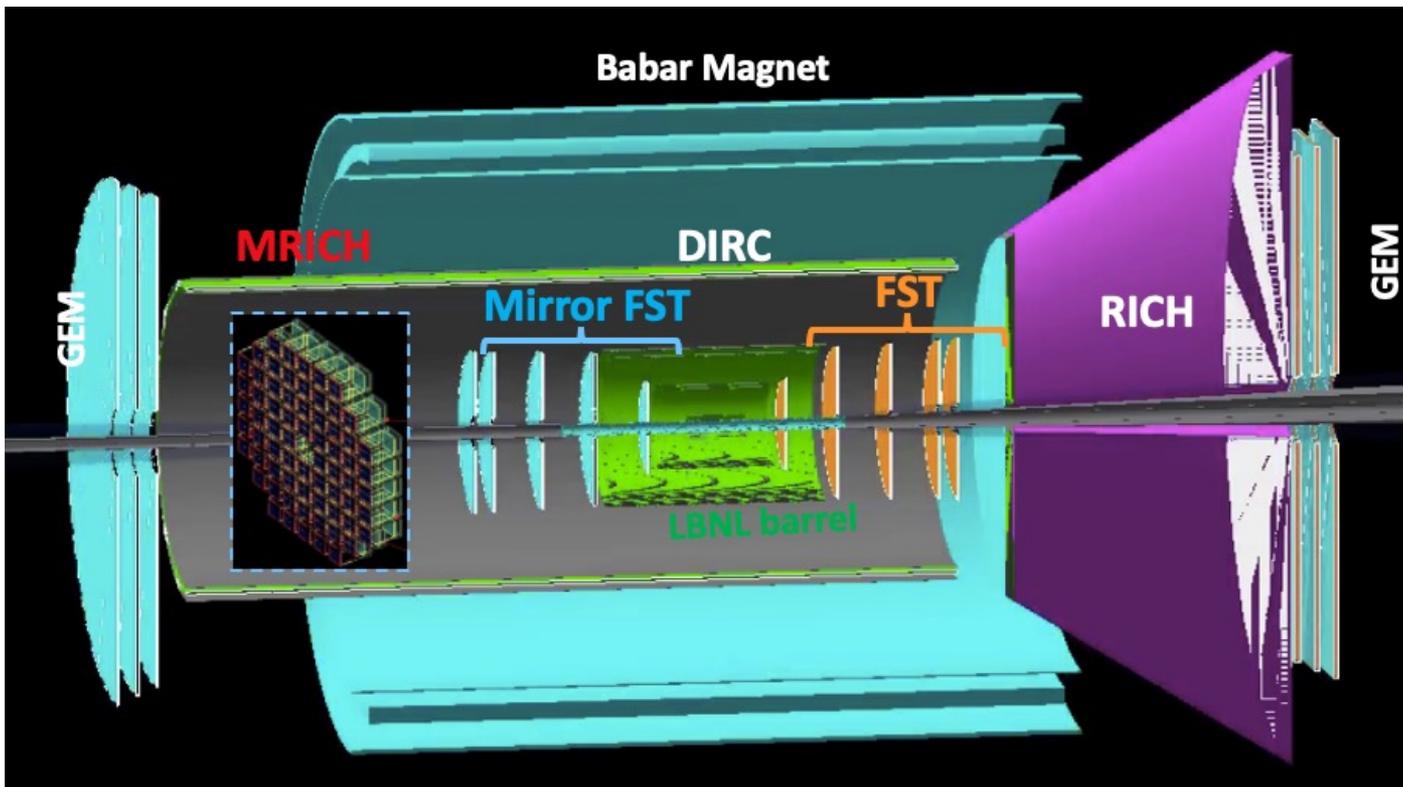
### Support and cooling



- Detector geometry implemented in Fun4All (G4\_EIC\_FST.C).
- Tracking performance evaluated. arXiv: 2009.02888
- Detector R&D status? DMAPS R&D is ongoing.
- Prototype sensors availability? Yes
- Readout options? Under R&D, has initial front-end readout options.
- Costs and Risks? O(\$10-15M). Can be mitigated with the supported the general CERN R&D and has global interests from LHC, Belle and EIC.

# Electron endcap vertex/tracking

- Candidates:
  - LBNL All-silicon Tracker.
  - Mirror of the LANL Forward Silicon Tracker design.
  - Hybrid design between silicon and MPGD/ $\mu$ Rwell tracker.



Strawmen  
reference

# Outer Tracker options - I

- AC-LGAD based ToF, which can be treated as outer tracker design based on 500  $\mu\text{m}$  pixel pitch AC-LGAD technology.

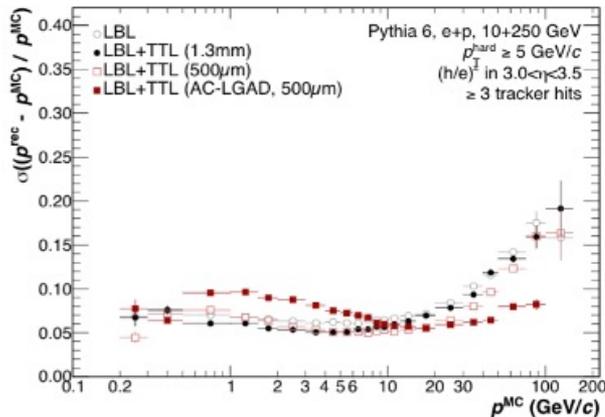
Default:		$R_{\text{barrel}}$	Length	z location	$R_{\text{endcap,in}}$	$R_{\text{endcap,out}}$	$\eta$ coverage	Area (m <sup>2</sup> )
Backward Endcap	ETTL <sub>0</sub>			-1.555	0.077	0.632	[-3.7,-1.6]	1.23
	ETTL <sub>1</sub>			-1.585	0.078	0.62	[-3.7,-1.6]	1.19
Central Barrel	CTTL <sub>0</sub>	0.92	3.6				[-1.34,1.34]	20.8 (6.28)
Forward Endcap	FTTL <sub>0</sub>			2.87	0.116	1.527	[1.3,3.9]	7.28
	FTTL <sub>1</sub>			2.89	0.117	1.538	[1.3,3.9]	7.39
Total area								37.89 (23.37)

- Position resolution:  $\sim 30$  microns (500-micron pitch size). Time resolution:  $\sim 20$  ps.
- An alternative choice of moving central barrel layer closer to  $R=0.5$  m with a total length of 2m right outside the all-silicon tracker.
- Detector geometry implemented in Fun4All**  
[https://github.com/eic/fun4all\\_eicmacros/blob/master/common/G4\\_TTL\\_EIC.C](https://github.com/eic/fun4all_eicmacros/blob/master/common/G4_TTL_EIC.C).

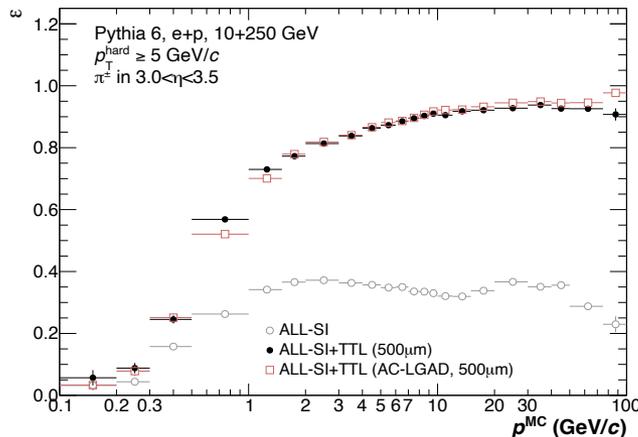
# Outer Tracker options - II

- Tracking performance of the AC-LGAD based ToF.

Momentum resolution:



Efficiency:



- Detector technology? AC-LGADs
- Detector geometry? Any implementation in Fun4All? Yes (see previous slides)
- Tracking performance (momentum/spatial resolutions? Efficiency? ...) Studied (see the left)
- Detector R&D status? Prototype sensors availability? Readout options? General R&D well advanced with worldwide interests. Targeted R&D and prototyping needed to better optimize final specs. Signals will be read out by ASIC chips and CMS/ATLAS designs can be adopted.
- Costs and risks? Synergizing with developments at the LHC, the risk is relatively low. Order of magnitude estimate of cost:  $\sim 0.6 \text{ M}/\text{m}^2$  (based on CMS ETL).

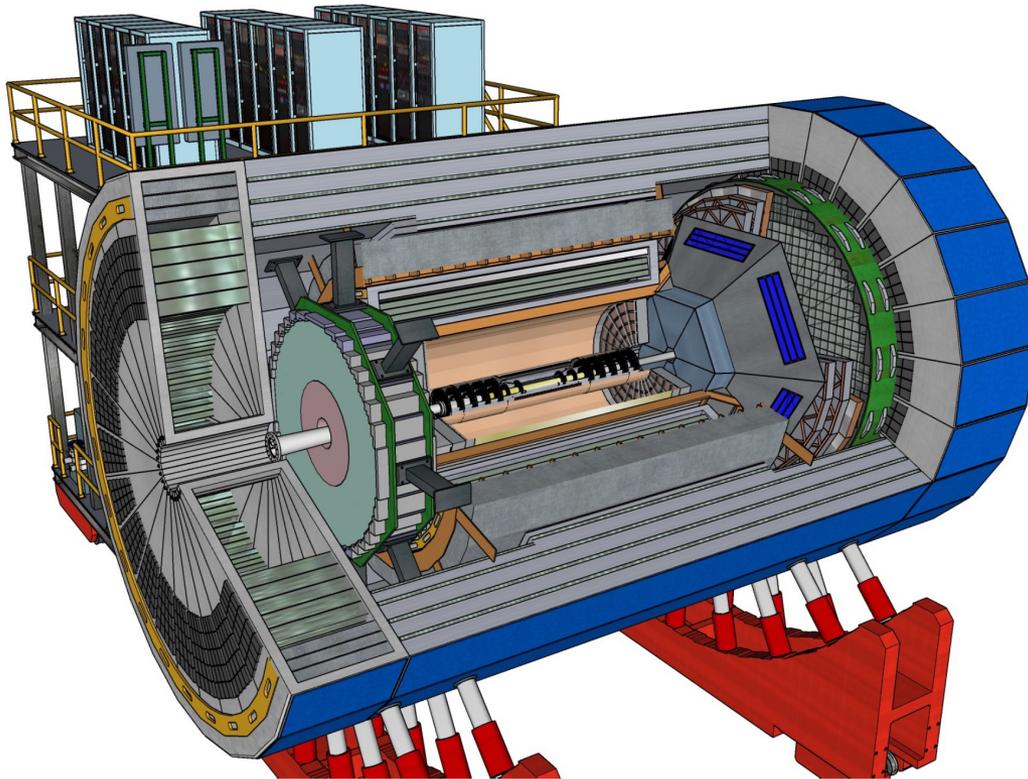
# Conclusions and Outlook

- The first order integrated tracking system is ready for the physics simulation in Fun4All.
- Optimization and tuning is ongoing.
- Further inputs and suggestions are very welcome!

# Backup

# ECCE General Detector Concept

- Presented in the bi-weekly meeting on June 7.



## ECCE ELECTRON ENDCAP STRAWMAN

**Tracking:** MAPS, Micro Pattern Gaseous Detectors (MPGD)

**Electron Detection:** PWO&SciGlass

- Inner part: PWO crystals (reuse some)
- Outer part: SciGlass (backup PbI)

**h-PID:** mRICH

- From yellow report

**HCAL:** Steel from magnet or Pb/Sc or Fe/Sc

- Not instrumented and only serve as flux return?
- Instrumented \w reduced thickness (lower energies)

## ECCE CENTRAL BARREL STRAWMAN

**Tracking:** Silicon barrel tracker (optional Si/GEM hybrid)

**Electron PID:** SciGlass (backup: W/Sc (Pb/Sc) shashlik)

- SciGlass remains to be demonstrated
- Several backup options – lower resolution though

**h-PID:** hpDIRC & AC-LGAD

- Compact
- AC-LGAD never been shown for barrel configuration
- AC-LGAD backup: dE/dx (needs more space)

**HCAL:** magnet steel (reuse) - Fe/Sc

## ECCE HADRON ENDCAP STRAWMAN

**Tracking:** MAPS, Micro Pattern Gaseous Detectors (MPGD)

**h-PID:** dRICH&TOF

**e/h separation:** TOF & aerogel

- TRD to separate electrons from high momentum hadrons?

**Electron PID:** W/ScFi, Pb/Sc or W/Sc shashlik

**HCAL:** Pb/Sc or Fe/Sc

- Alternative for improved resolution: dual readout, high-granularity