TIC - Tracking

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Questions posed by Klaus:

- What is the status of the design and layout for the Si and Gaseous Trackers and what will be the advancements between now and August?

- Does the present technical design and implementation fulfill the YR requirements, i.e., will it stand a technical design review, and if not what is the strategy to mitigate?

The short response: “It depends.”

A reminder of Yellow Report Table 11.2

Table 11.2: Requirements for the tracking system from the physics groups.

Tracking requirements from PWGs						
			Momentum res.	Material budget	Minimum pT	Transverse pointing res.
η						
-3.5 to -3.0	Central Detector	Backward Detector	σp/p ~ 0.1%×p ⊕ 0.5%	~5% X0 or less	100-150 MeV/c	
-3.0 to -2.5					100-150 MeV/c	dca(xy) ~ 30/pT μm ⊕ 40 μm
-2.5 to -2.0			σp/p ~ 0.05%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 30/pT μm ⊕ 20 μm
-2.0 to -1.5					100-150 MeV/c	
-1.5 to -1.0					100-150 MeV/c	
-1.0 to -0.5		Barrel	σp/p ~ 0.05%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 20/pT μm ⊕ 5 μm
-0.5 to 0						
0 to 0.5						
0.5 to 1.0						
1.0 to 1.5		Forward Detector	σp/p ~ 0.05%×p ⊕ 1%		100-150 MeV/c	dca(xy) ~ 30/pT μm ⊕ 20 μm
1.5 to 2.0					100-150 MeV/c	
2.0 to 2.5					100-150 MeV/c	
2.5 to 3.0			σp/p ~ 0.1%×p ⊕ 2%		100-150 MeV/c	dca(xy) ~ 30/pT μm ⊕ 40 μm
3.0 to 3.5					100-150 MeV/c	dca(xy) ~ 30/pT μm ⊕ 60 μm

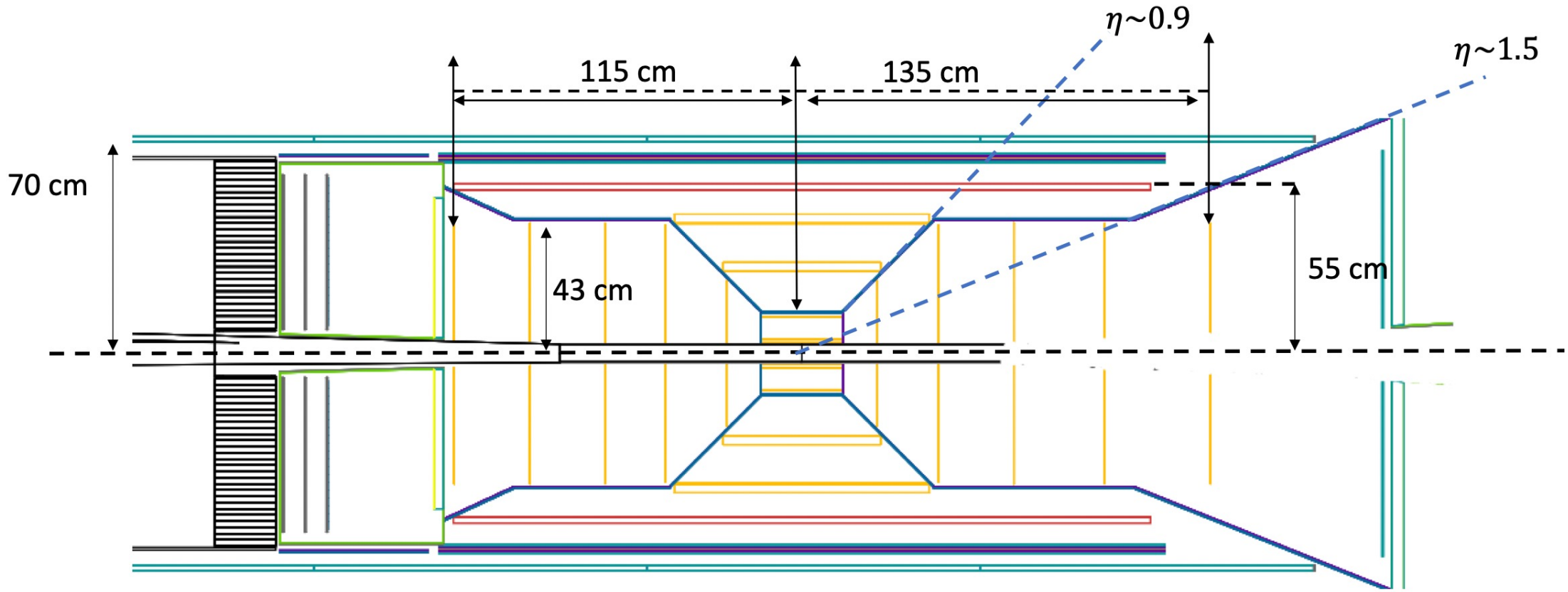
The requirements for the tracking in an EIC detector are derived from the physics simulations and are represented by the detector requirements table shown in Table 11.2. The ranges in pseudorapidity are accompanied with requirements for relative momentum resolution, allowed material budget in terms of radiation length, minimum p_T cutoff, transverse and longitudinal pointing resolutions. These requirements form the basis of the designs and concepts that are presented.

- dp/p is a combination of the constant and proportional term,
- Both matter over most of the EIC range, but the trade-offs can be different,
- E.g. in the central barrel, the terms are balanced for p = 10 GeV/c; in the (very) forward region this is for p = 20 GeV/c, and in the backward region for p = 5 GeV/c.
- Transitions are, of course, not as hard as suggested by the table; little if any EIC physics is about achieving "5σ" (i.e. more about measurement qualities than discovery probabilities),

YR tracking requirements do not strictly specify a range, other than the implied phase-space (kinematic) limits.

That said 1, it would seem ill-advised to do anything other than accept the YR as a snapshot of community best knowledge.
That said 2, most of us know that that there is no known technology that can achieve backward dp/p.

Current Tracking Configuration

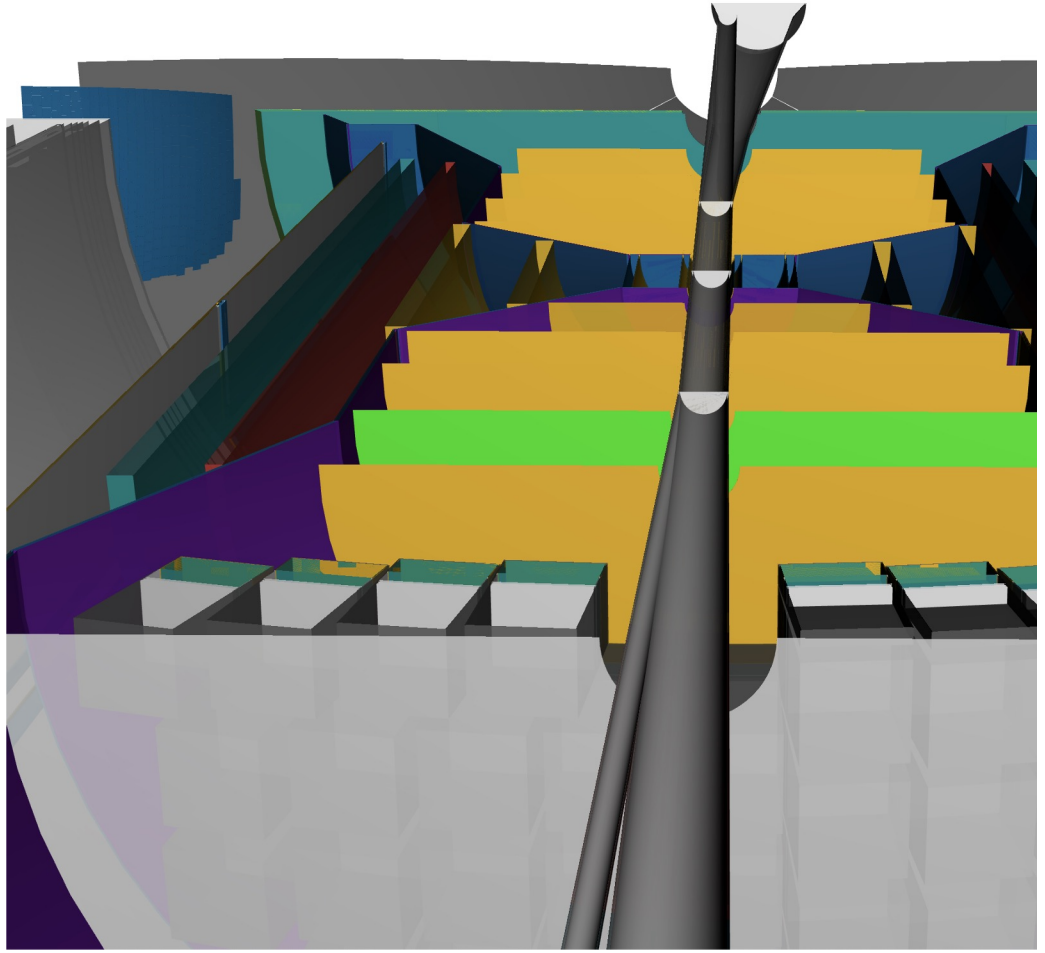


Mid- and forward rapidity silicon configurations can meet vertex and dp/p resolution requirements,
Backward (electron-going) resolutions out of reach – not helped by short(-er) lever-arm,

Outer MPGD layers to aid in pattern recognition and background rejection. Configuration just starting.

Reminder from TIC May 8, 2023 – SVT

- Geometry is based on simplified shapes with average material; cylinders for the innermost vertexing barrel layers; triangular staves for outer barrel layers; disks constructed from pie-pieces,
- Respects ~evolving envelopes – will need to evolve further,
- Beam opening in the disks are centered and thus affect e.g. small-x acceptance (illustrated on the right),
- Support and services based on average material; known missing outer supports for disks at largest-|z| (probably good to fix ~now),
- Digitization based on 10μm pixel pitch; ok-enough for now,
- Truth-seeded tracks have shown unphysically small uncertainties at small-momenta because of (what I would characterize as) fit-initialization; addressed parameter-by-parameter in a somewhat ad-hoc basis,
- Good progress on ACTS track-finding; initial set of tuning parameters,
- Based on single-track simulations, however (e.g. no two-track simulations),
- Effort/responsibilities: several.



20 μm pitch in June campaign;

(Backward) envelope is better understood with the start of change control towards pfRICH.

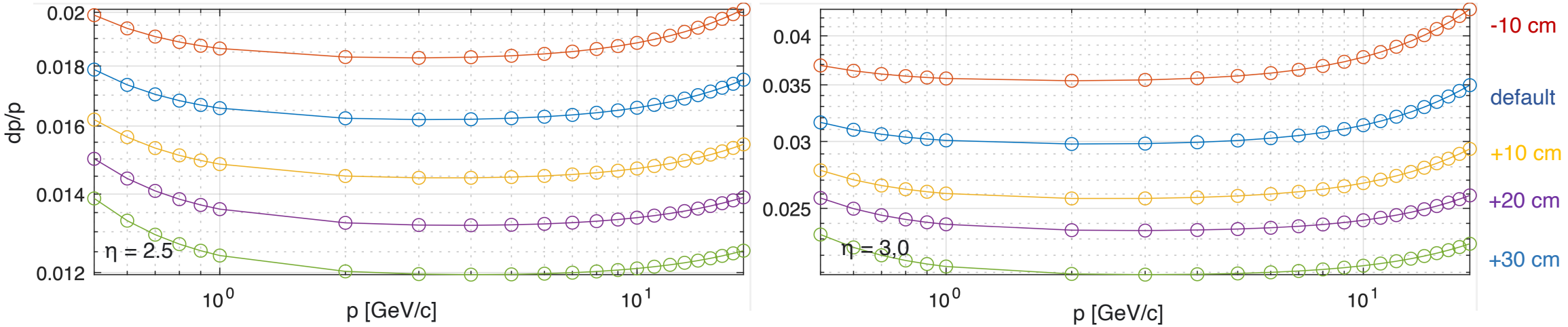
Impact from backward PID envelopes on dp/p from tracking

The envelope of the backward PID system affects the space available for tracking,

The reference MAPS implementation respects the pfRICH envelope in its default form; the mRICH envelope is anticipated to be smaller, thus leaving more space for tracking,

It is thus meaningful to ask what effect additional or reduced space has on dp/p resolution,

Shown here are representative results for η = 2.5 and η = 3.0 for different lengths of the disk array; tracks with η = 2.5 traverse all five disks in the array, whereas tracks with η = 3.0 escape through the beam opening of the innermost disk at z = -25 cm.



The default length L of the traversed five (four) disk array is 90 (70) cm,

Results for a change in L by -10, +10, +20, and +30 cm are shown from fast simulations,

An increase in lever arm is clearly beneficial to momentum resolution, but this does not scale as L^2 as would be expected from point resolution alone due to multiple scattering. The physics impact of this loss or gain in dp/p is not assessed here.

Barrel Tracker MPGD layers – Option#1 ➔ Cyl Micromegas

Goal: highlighted in cyan

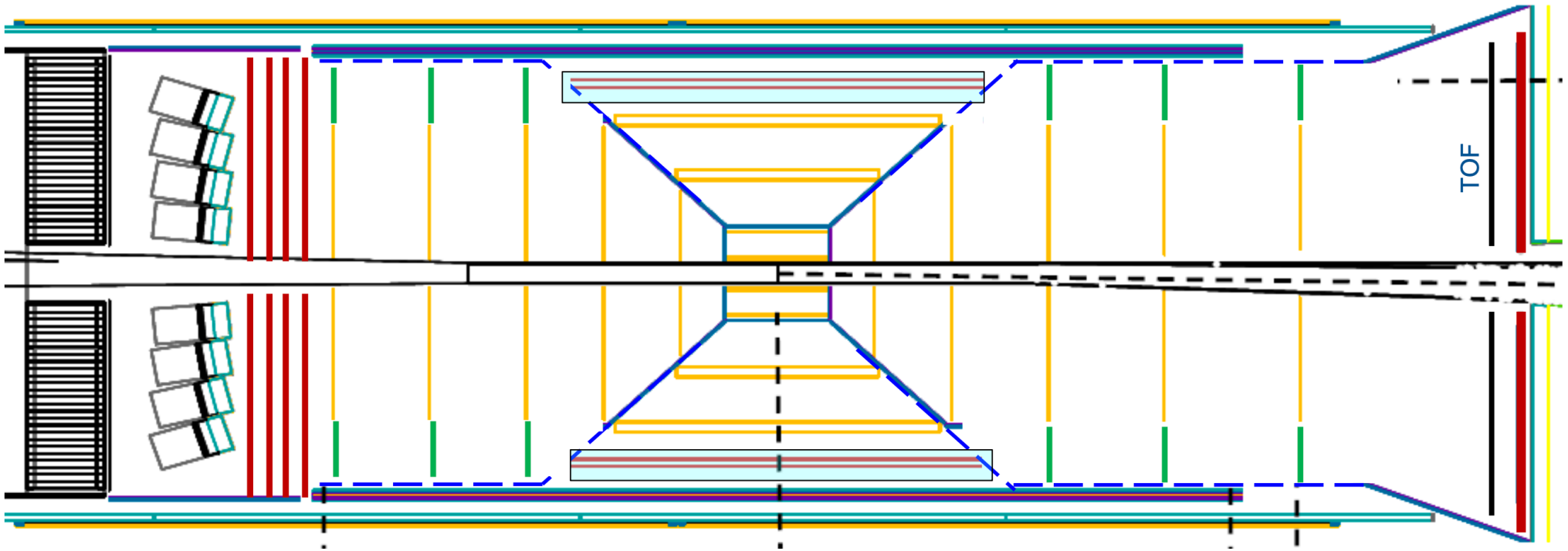
- Two “fast” timing layers in addition to TOF
- Provide additional tracking points for pattern recognition
- **Reduce length in z to match Si layer eta range**

Pros:

- Space between last Si layer and TOF for 2 or 3 MPGD layers
- Low mass active area (~0.4% X0) per layer
- Experience with building CLAS12 Micromegas tracker
- Use standard cheap gas mixture

Cons:

- Worse spatial resolution ➔ ideas to **mitigates** the issue are been explored
- Material thickness (frames, services and support structure)
- Cylindrical make Thin Gap challenging



Barrel Tracker MPGD layers – Option#2 ➔ Planar Thin Gap MPGDs

Goal:

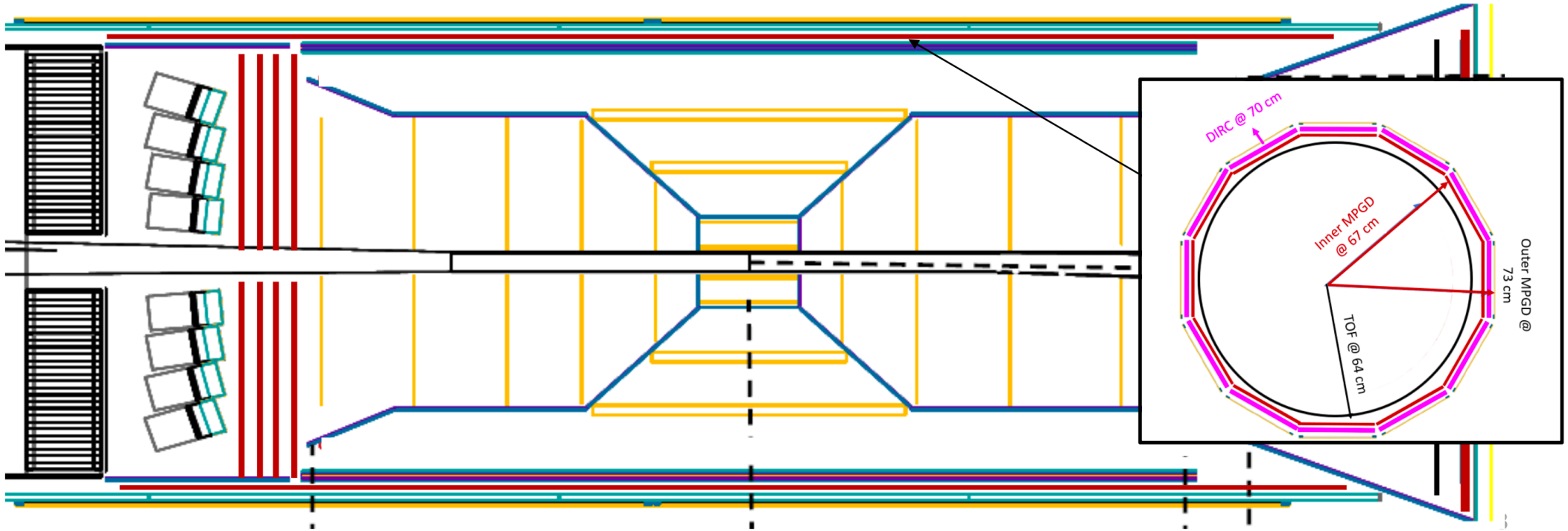
- Two “fast” timing layers in addition to TOF
- Thin Gap MPGDs
- Additional track points for pattern recognition
- angular resolution for DIRC

Pros:

- Thin Gap MPGD address **spatial resolution** issues at large angle and in B-field (E x B)
- Low risk & low cost for large detector
- Thin Gap ➔ better timing performance
- Layers will help with the DIRC ring seeds as
- **No need of MPGD rings in endcap**

Cons:

- Limited space for > 2 layers in current design ➔ More than 2 layers will require smaller radius for the TOF (~5 cm smaller)
- Thin Gap MPGD R&D is new and ongoing
- Cost of heavier gas (Kr or Xe) **might be an issue if needed** ➔ recirculating gas system



- Current focus is on angular resolutions into PID

- Possibly a third hybrid,