ECCE Gaseous Tracking Design

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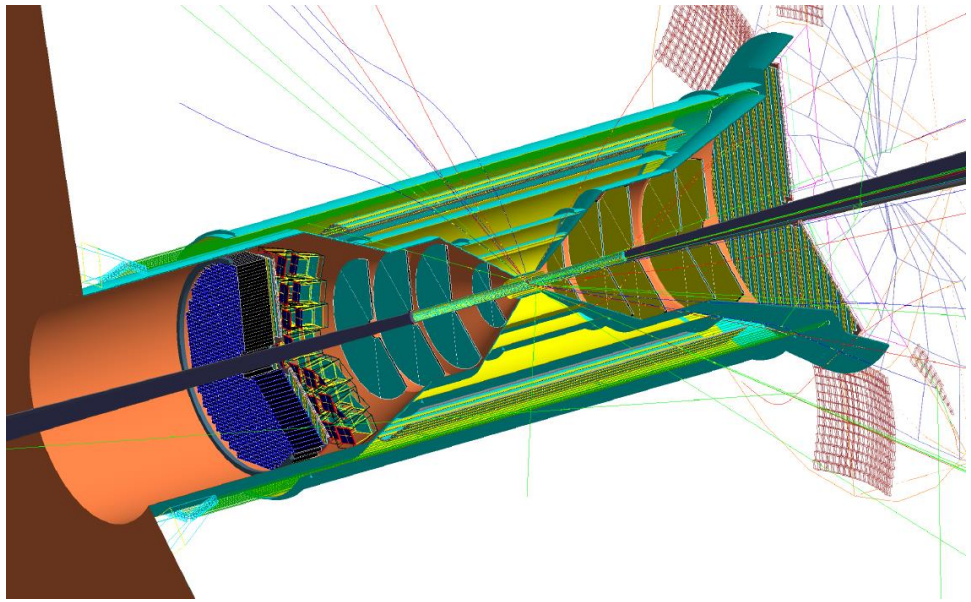
EIC-Project Joint Tracking WG – Kick-off Meeting, 04/27/2022

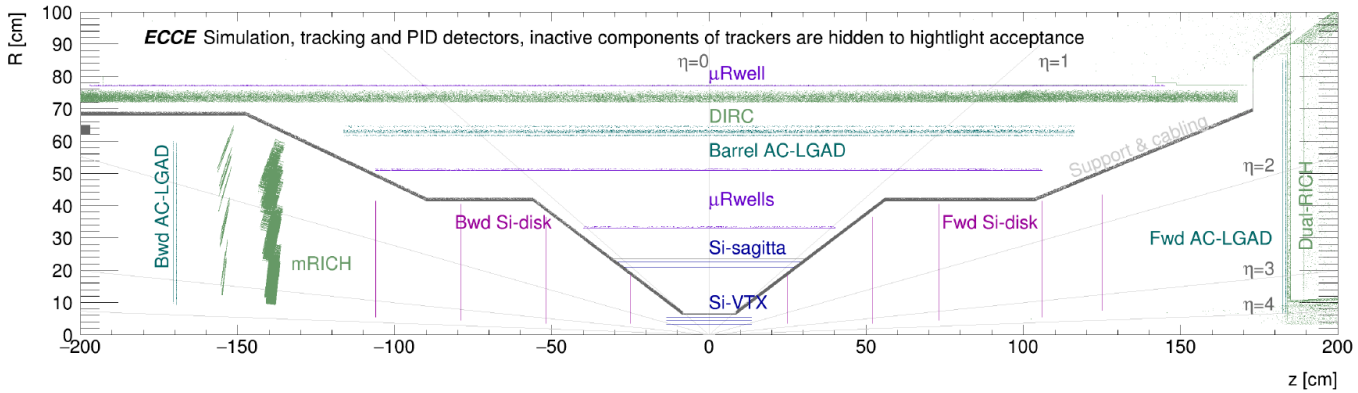
Overview of ECCE Tracking Detector

Current design:

- MPGD cylindrical layers only in the barrel region of ECCE tracking detector
- 2 inner layers #1 & #2 between the Si sagitta layers and hpDIRC:
  - Provide cost effective solution to complement the Si layers at larger radius ➔ optimize tracking performance
- 3rd outer layer between the DIRC and EMCAL
  - Help with impact point and direction of the charged particles producing Cherenkov ring in the DIRC ➔ Tracking / PID DIRC integration

Region	Layer index	technology	radius	minimum z	maximum z	pixel pitch
barrel	1	MAPS	3.3 cm	-13.5 cm	13.5 cm	10 μm
⋮	2	⋮	4.35 cm	-13.5 cm	13.5 cm	10 μm
⋮	3	⋮	5.4 cm	-13.5 cm	13.5 cm	10 μm
⋮	4	⋮	21.0 cm	-27 cm	27 cm	10 μm
⋮	5	⋮	22.68 cm	-30 cm	30 cm	10 μm
Region	Layer index	technology	radius	minimum z	maximum z	strip pitch
barrel	1	μRWELL	33.14 cm	-40 cm	40 cm	400 μm
⋮	2	⋮	51 cm	-106 cm	106 cm	400 μm
⋮	3	⋮	77.0 cm	-197 cm	145 cm	400 μm
Region	Disk index	technology	z location	inner radius	outer radius	pixel pitch
e-endcap	1	MAPS	-25 cm	3.5 cm	18.5 cm	10 μm
⋮	2	⋮	-52 cm	3.5 cm	36.5 cm	10 μm
⋮	3	⋮	-79 cm	4.5 cm	40.5 cm	10 μm
⋮	4	⋮	-106 cm	5.5 cm	41.5 cm	10 μm
Region	Disk index	technology	z location	inner radius	outer radius	pixel pitch
h-endcap	1	MAPS	25 cm	3.5 cm	18.5 cm	10 μm
⋮	2	⋮	49 cm	3.5 cm	36.5 cm	10 μm
⋮	3	⋮	73 cm	4.5 cm	40.5 cm	10 μm
⋮	4	⋮	106 cm	5.5 cm	41.5 cm	10 μm
⋮	5	⋮	125 cm	7.5 cm	43.5 cm	10 μm





ECCE tracker layout including support structure in simulation

ECCE Cylindrical µRWELL Trackers

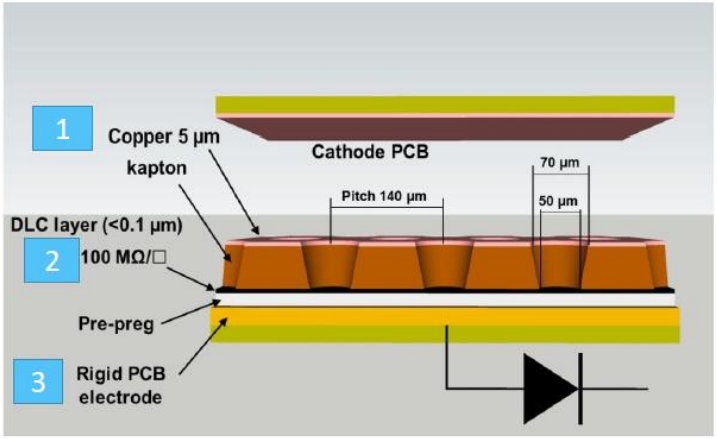
Basics requirement for ECCE cylindrical MPGD trackers:

- µRWELL is the MPGD technology of choice
  - Micromegas: alternative option to be considered
- Large area detectors:
  - Larger layer: Length = 342 cm, radius = 77 cm
- Low mass ➔ 0.04% to 1% r.l.
  - What is the actual requirement?
- Space point resolution ➔ ~50 µm to 100 µm
- Front end electronic candidates are SALSA chip
  - SAMPA or VMM3 as fallback options

Taken separately, these requirements are easily within reach, combined into a same detector ➔ Lot of challenges MPGD community have to overcome

MPGD community:

- US: Large MPGD community in NP field.
  - eRD6 ➔ eRD108, MPGD development at BNL & JLab
- Europe: CEA Saclay, RD51 @ CERN, INFN institutions
- Korean & Chinese in ECCE collaboration
  - Important in-kind collaboration (uRWELL foils, DLC layers…



1 **a WELL** patterned kapton foil acting as **amplification stage** (GEM-like)

2 **a resistive DLC layer (Diamond-Like-Carbon)** for discharge suppression w/ surface resistivity ~ 50÷100 MΩ/□

3 a standard readout PCB

µRWELL concept

- Single stage Micro amplification
- µRWELL is a GEM-like providing the electron amplification
- DLC layer help suppress or minimize discharge rate and adverse effects
- Standard pad or strip readout
- In principle simpler construction than triple-GEM

Category	In-Kind ($M)	On-Project ($M)	Total ($M)
Tracking	**6.7**	**20.2**	**26.8**
Inner Barrel µRWELL	0.5	1.5	2.0
Outer Barrel µRWELL	0.5	2.0	2.4
Si Tracker	5.7	16.7	22.4

Cost estimate for ECCE µRWELL layers

Where MPGDs are not in ECCE detector

Last 3 bullet points of the global charge for the detector working group

- Each joint WG should hold at least one kickoff meeting where the designs of each proposal are presented in detail. It is critically important that WG members understand the scientific and technical reasoning behind different design choices before engaging in optimization discussions.
- The WG conveners will lead a discussion to identify any non-trivial differences and/or aspects in need of further optimization.
- For each non-trivial difference working groups will then work to prepare a pro/con list accounting for technical performance, risk and cost. The resolution of non-trivial differences should be discussed in close consultation with the Global detector/integration WG, physics working groups, the EIC project, relevant detector consortia and R&D efforts.

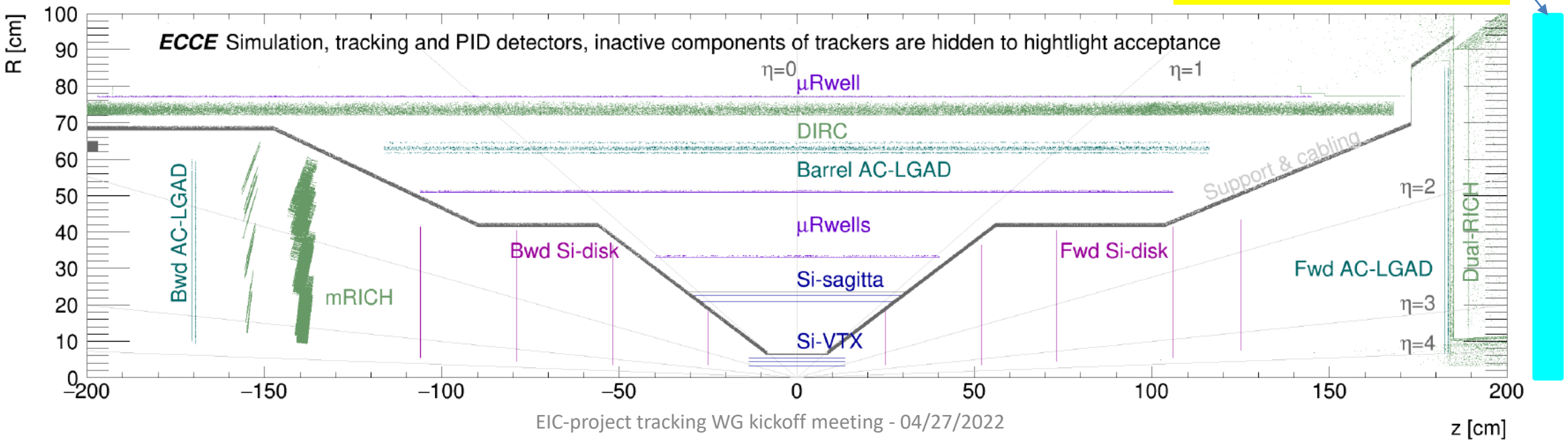
What is not in ECCE Design?

No MPGD layer behind dRICH detector in hadron endcap region

- Unlike in ATHENA tracking design which has a GEM / µRWELL disc behind dRICH in hadron endcap
- ECCE simulation studies ➔ additional tracker behind dRICH **doesn't help** overall tracking that much
  - Impact in negligible for p > 10 Gev
- What about MPGD tracker to provide impact point and direction information for helping Cherenkov ring seed in dRICH?
- What about a single layer of MPGD-TRD layer as alternative option with:
  - Ionization trail of hadrons ➔ provide for impact point and direction information for dRICH
  - TRD photon ➔ additional e/π separation (x10) to complement EMCAL

Bwd AC-LGAD behind EEMCAL in electron endcap already satisfied the need

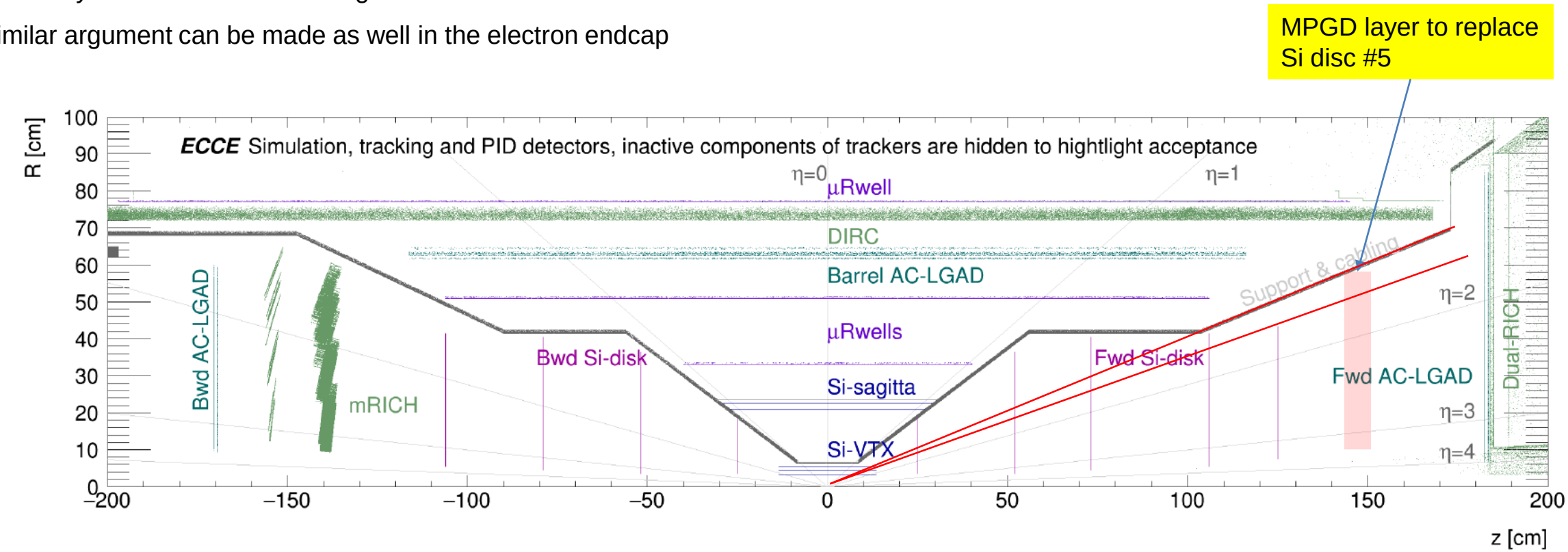
- MPGD layer for dRICH?
- TRD option?



What is not in ECCE Design?

MPGD layers in the endcap tracker:

- ❖ Impact of adding or swapping Si-disc #5 in hadron endcap with MPGD layer ➔ size and z-position to be optimized with simulation
  - Reduce overall tracking detector cost ➔ if swapping shows not significant impacting on the tracking performances
  - Cover larger eta range and longer lever arm (if located at 150 cm instead of 125 cm for example)
  - Any issue with detector integration?
- ❖ Similar argument can be made as well in the electron endcap



WG specific charges for MPGD trackers

Barrel region:

- Specification of cylindrical MPGD trackers ➔ Do we need same specs for all 3 layers
  1. Does the outer layer behind the DIRC need to be low mass? Does it need to below 100 µm spatial resolution
  2. Define the requirement in terms of low mass for the 2 inner layers? ➔ is 0.4% r.l. a must? Will 1% do a descent job? Anything between?
  3. Inclusion of angle dependence of spatial resolution in the performance studies of the detector design
- MPGD technologies complementarity: Micromegas and µRWELL are similar technologies with similar performance
  1. Should we settle for one technology i.e., baseline µRWELL as in ECCE proposal or integrate both in EIC-project detector tracking system?
  2. Should we look at redundancy as well i.e. paired the inner cyl layers (2 + 2) to improve efficiency and compensate for dead area
     1. Each pair can be 1 µRWELL layer + 1 MM layer

End cap region:

- Study adding MPGD layer support for dRICH and additional e/πseparation to EMCAL in hadron region
- Can we optimize the end cap trackers with adding or swapping last Si-disc layer with MPGD layers?

MPGD tracker readout electronics:

- Identify a contact person within tracking WG to interact with DAQ and electronics WG:
  1. Provide relevant inputs to electronics on requirements and specifications needs for MPGD trackers to develop the best ASIC for EIC MPGDs

Broaden EIC MPGD community

- Encourage the inclusion to more international MPGD groups both in tracking WG discussions as well as regarding detector R&D consortium

1. Specifically, we need to approach colleagues from Chinese and Korean institution ➔ Lots of very interesting R&D work on uRWELL / micromegas

eRD108 R&D program: Development of Cylindrical MPGDs

- **Two very distinct motivations for cylindrical MPGD R&D for EIC detector:**
  1. a single cylindrical µRWELL layer directly in front of (and behind) the DIRC subdetector
     - Provide precise directional information to help seed the DIRC Cherenkov ring reconstruction
     - Tracking layer needed in all 3 EIC detector concepts **(ECCE, CORE & ATHENA-all-Si)**
     - Less stringent requirement for low mass detector (thickness > 0.5% r.l. is OK)
  2. several cylindrical Micromegas (MM) detector layers to create a central barrel tracker
     - This is a MPGD of choice for the **ATHENA-Hybrid Tracking** subdetector in the barrel region
     - Development of low mass detector (< 0.5% r.l.) is critical.

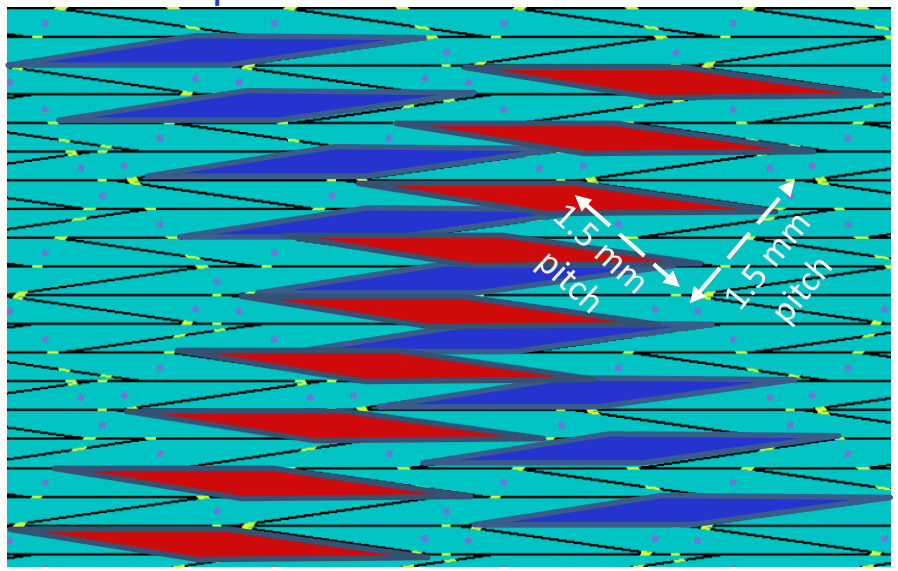
- **Different applications & different R&D focus**
  - We want to emphasize that our R&D program targets two different applications for these two subdetectors
  - The R&D focus mean that the two technologies are not to be considered interchangeable
  - Both R&D projects share common goal for development / optimization of 2D readout patterns for MPGDs.

Back-up

Ongoing R&D on low channel counts readout

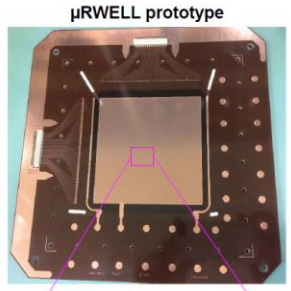
Concept of 2D U/V "zigzag" R/O

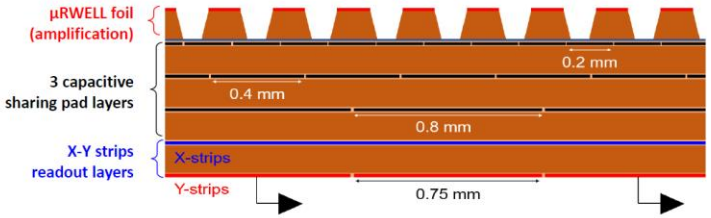
U-strip

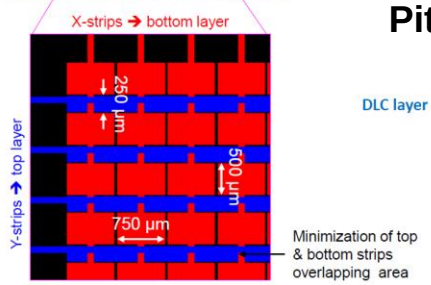


V-strip

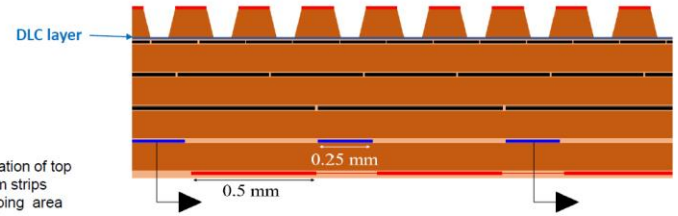
uRWELL with X-Y strip capacitive-sharing R/O

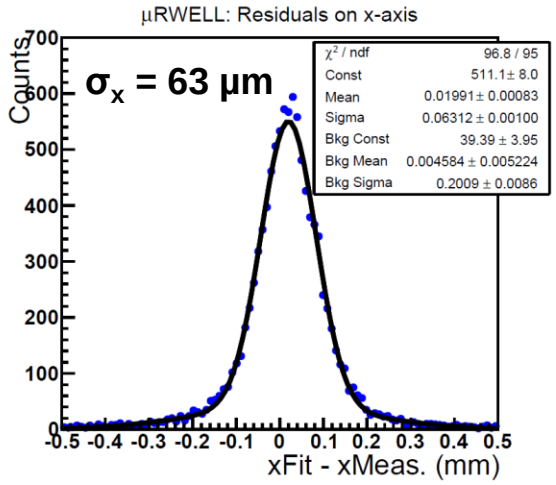


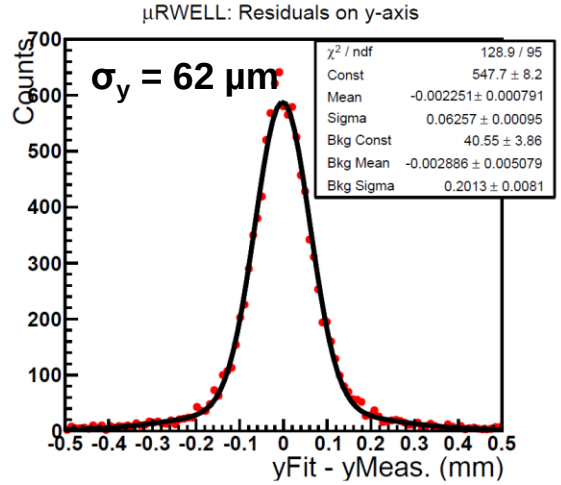




Pitch: 800 µm







Ongoing R&D on low mass detector