DE LA RECHERCHE À L'INDUSTRIE

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Micromegas technology for ATHENA

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EIC YR – Tracking WG

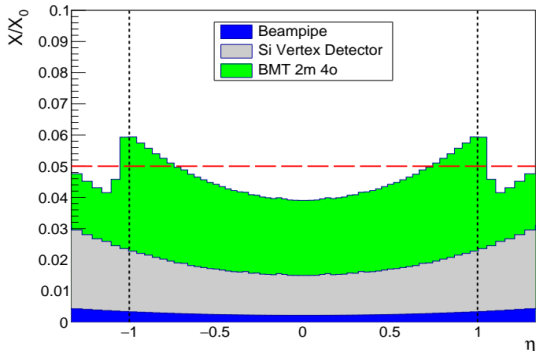
15 June 2021

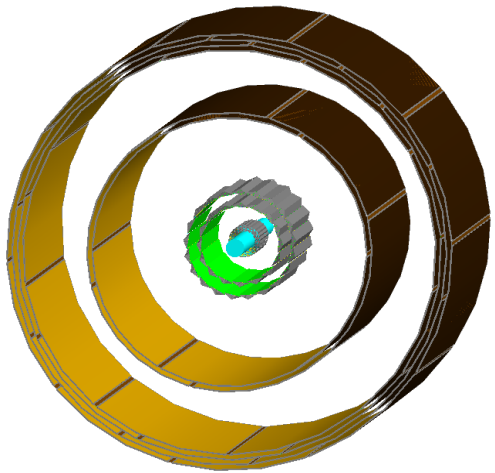
Yellor Report – Hybrid detector

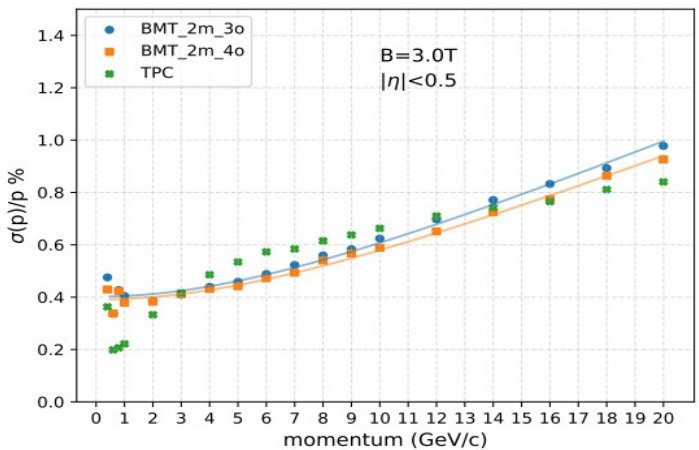
Requirements:
- Maximum total material budget: 5% of X0
- Compatible with physics performances

Simulations:
- Beam pipe
- Si 3 vertex + 2 tracking layers
- MPGD layers: 6 (max)

MPGD layers implementation:
- Detailed implementation based on CLAS12 Micromegas
- 2D readout, assuming 150µm resolutions
- Tiles ~50cm wide
- ~2cm gaps filled with PCB and Cu 25µm
- **Material budget: ~0.4% of X0**



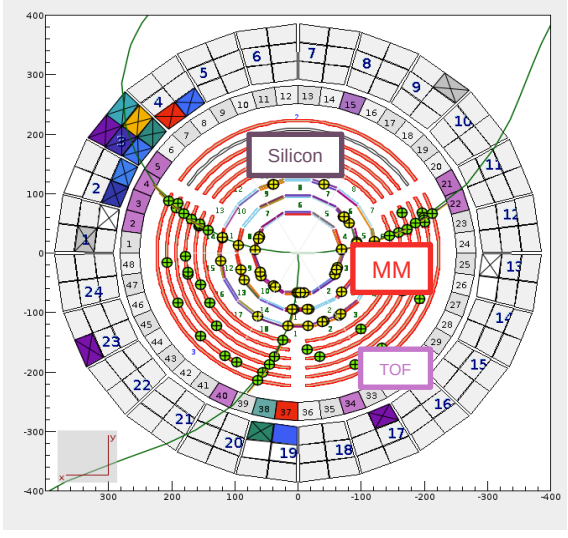


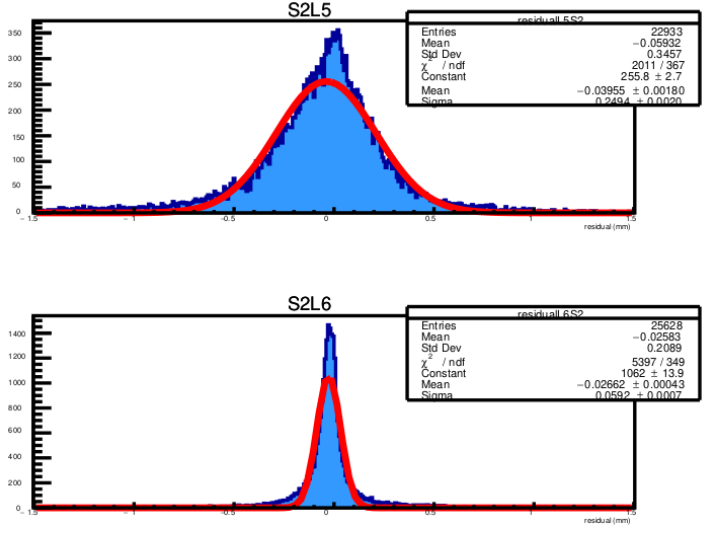


Results:
- **At 3T, tracking performances within specs**
- **Material budget within limits**

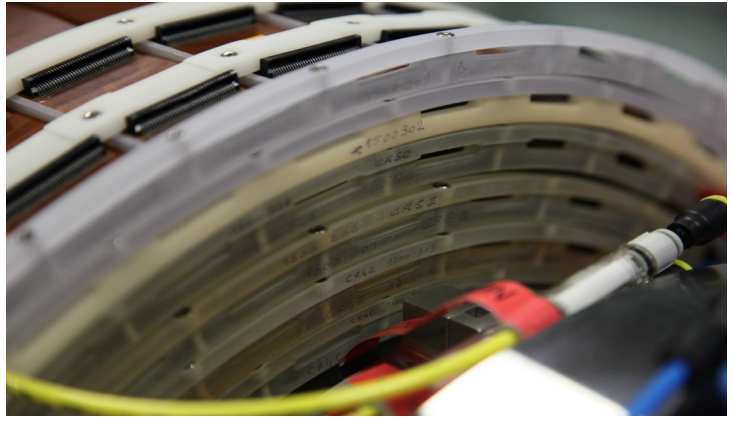
CLAS12 Micromegas Vertex Tracker

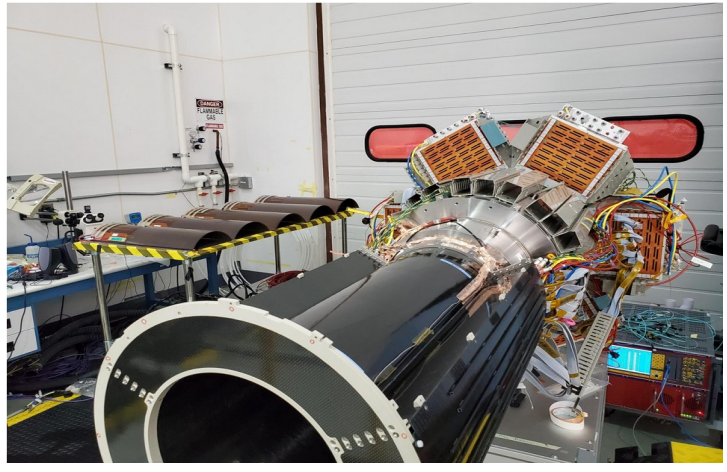
- 4 m² of curved Micromegas detectors
- DREAM based Front-End Electronics ~ 20k ch.
- Low momentum particles => Light Detectors ~0.4% of X0
- Limited space of ~10 cm for 6 layers (small radius ~12 cm)
- High magnetic field (5T)
- 6 Layers with different R (18 detectors total), 1D readout
- Up to 30 MHz of particle rate
- Taking data since 2017





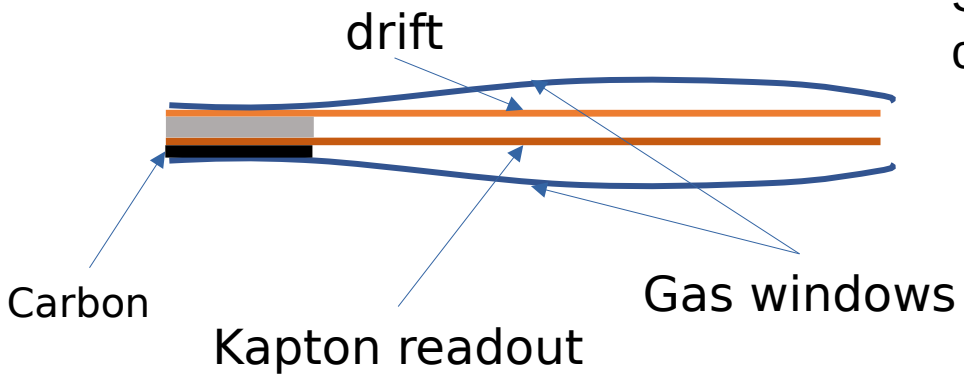
Residuals examples with preliminary alignment





Path(s) to Micromegas in ATHENA

- **Curved Micromegas**
- Consolidated technology
- CLAS12 MM are 1D readout
- ~0.4% of X0 per tile
- 2D readout already used in other experiments
- Ongoing R&Ds to improve resolutions (See next slides)
- A 2D prototype Micromegas tile to be build in 2023



- **Flat ultra light Micromegas: “sail tracker”**
- Goals: optimization of overall material budget, simplification of production line
- Modular design
- Very low X/X0: aiming at 0.07%X0 in the active area

Step by step R&D:

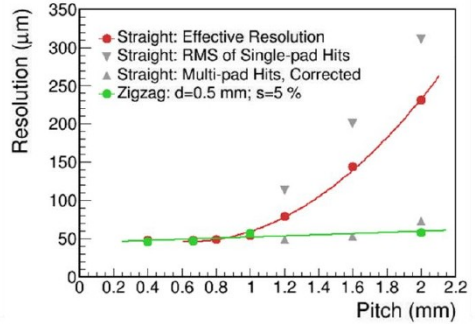
- PCB → Just a Kapton layer (2021)
- Inox mesh → LASER etched Al or Cu (2022)
- Cu strips → deposited Al (2023)

- Some of these R&Ds can be ported to the curved technology too

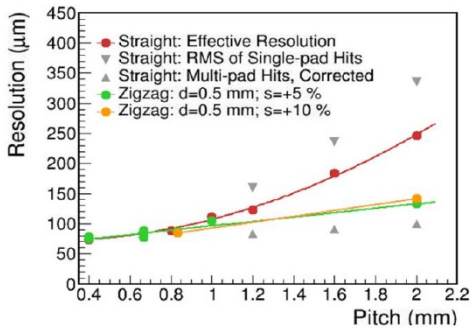
2D diamond status
Most recent results

Maxence Revolle

Zigzag 1D residual
Pitch 2mm

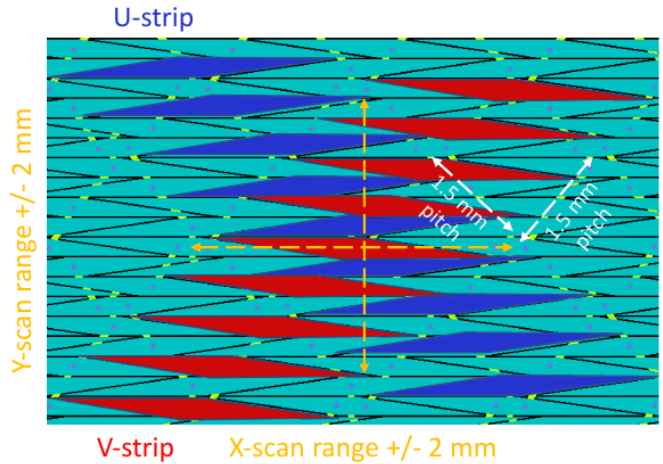


4-GEM : <70µm



Micromegas: <150µm

A Comparative Study of Straight-Strip and Zigzag-Interleaved Anode Patterns for MPGD Readouts
C.Perez-Lara & all, https://arxiv.org/abs/2101.12134



4-GEM

- Measure U- and V-coordinates at once
- Residuals from σ ~ 55 µm to σ ~ 85 µm
- Remaining DNL below ~ 50 µm

Presented at TIPP 2021 by Alexander Kiselev

Resolution of the order of 150um is expected for 2D with Micromegas with 2mm pitch

MPGD WORKSHOP AT SACLAY

120 m² of clean room for Micromegas bulk and resistive layer manufacturing.

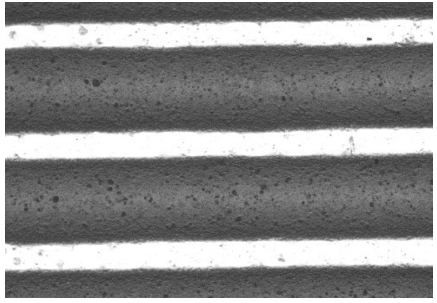
Bulk process: addition of a mesh on PCB by photolithography

- Maximum detector size: 600 x 700 mm².
- Amplification gap from 50 to 292 µm
- Mesh woven (18 µm wires) or thin mesh (down to 5 µm)
- PCB with strip, XY strip, pixel,…
- Production : ~ 150 bulk in 2019
- R&D : thins mesh, curved bulk, segmented mesh, double mesh….

Resistive screen printing on various surface

- Maximum size: 600 x 600 mm²
- Resistive value: from 10 KOhm/sq, to 10 Gohm/sq
- Possibility of neutral on conductive paste
- Substrate: Kapton, glass, FR4
- Production: ~ 100 resistive substrate in 2019
- R&D : mixture for ad hoc resistive value, segmented resistive,…

Double face micromegas



Resist strip of 500 µm

Bulk lab

Resist lab

Summary

- An hybrid EIC detector with a Micromegas barrel tracker fulfills the Yellow Report requirements
- Ongoing R&Ds are aiming at 2D readout with about 150µm resolutions on both directions
- A parallel R&D effort aims at lowering the material budget even further
- Low material budget Micromegas not just for the barrel region
- CEA Saclay can provide engineers for design and production
- Ongoing discussions with the electronics department to develop a ASIC for MPGD readout