Inner MPGD layer: CyMBaL

Cylindrical Micromegas Barrel Layer

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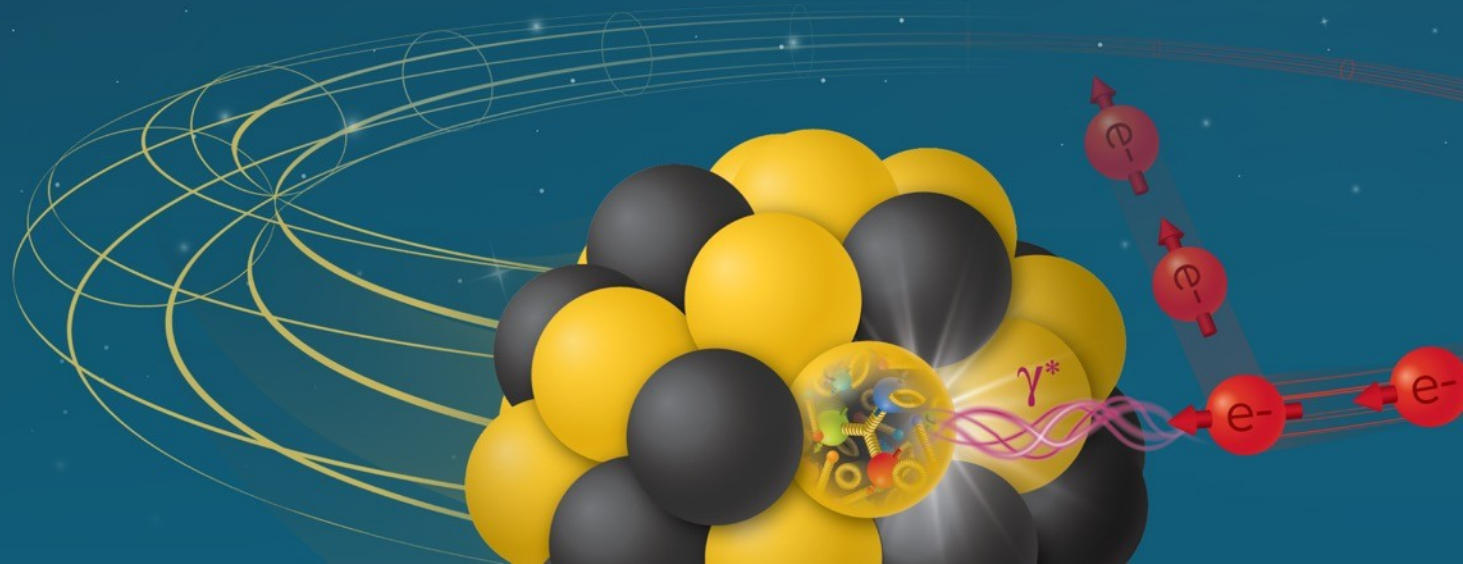
For CEA Saclay team

Incremental Design and Safety Review
of the EIC Tracking Detectors
March 20-21, 2024

Electron-Ion Collider



Charge Questions Addressed

1. Are the technical performance requirements appropriately defined and complete for this stage of the project?
2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?
3. Are the current designs and plans for detector, electronics readout, and services sufficiently developed to achieve the performance requirements?
4. Are plans in place to mitigate risk of cost increases, schedule delays, and technical problems?
5. Are the fabrication and assembly plans for the various tracking detector systems consistent with the overall project and detector schedule?
6. Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?
7. Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?

CyMBaL – Requirements

Charge 1

Requirements:

- Provide redundancy and pattern recognition for tracking
- Spatial resolution: ~150μm
- Timing resolution ~10ns
- Peaking times: ~100ns
- Light detector: ~0.5%X0 in active areas
- Hermetic

External constraints:

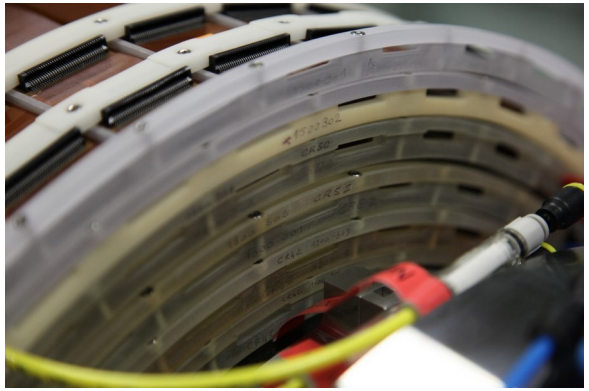
- Tight space: about 5cm radial keeping zone
- Magnetic field ~2T
- Wrap around the SVT in the entire length

Solutions:

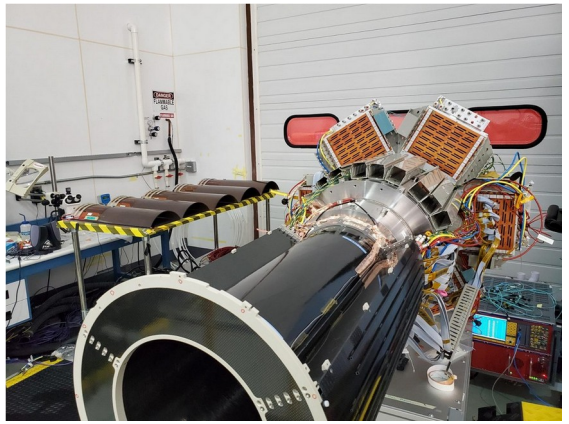
- Cylindrical resistive Micromegas technology developed for CLAS12 BMT:
  - Material budget ~0.4%
  - Working in high radiation environment and in B=5T
- Modular design
  - Possibly, just a single module design to pave the whole surface

Ongoing R&D:

- 2D readout with small number of channels



Close up of the BMT: fits in a tight space

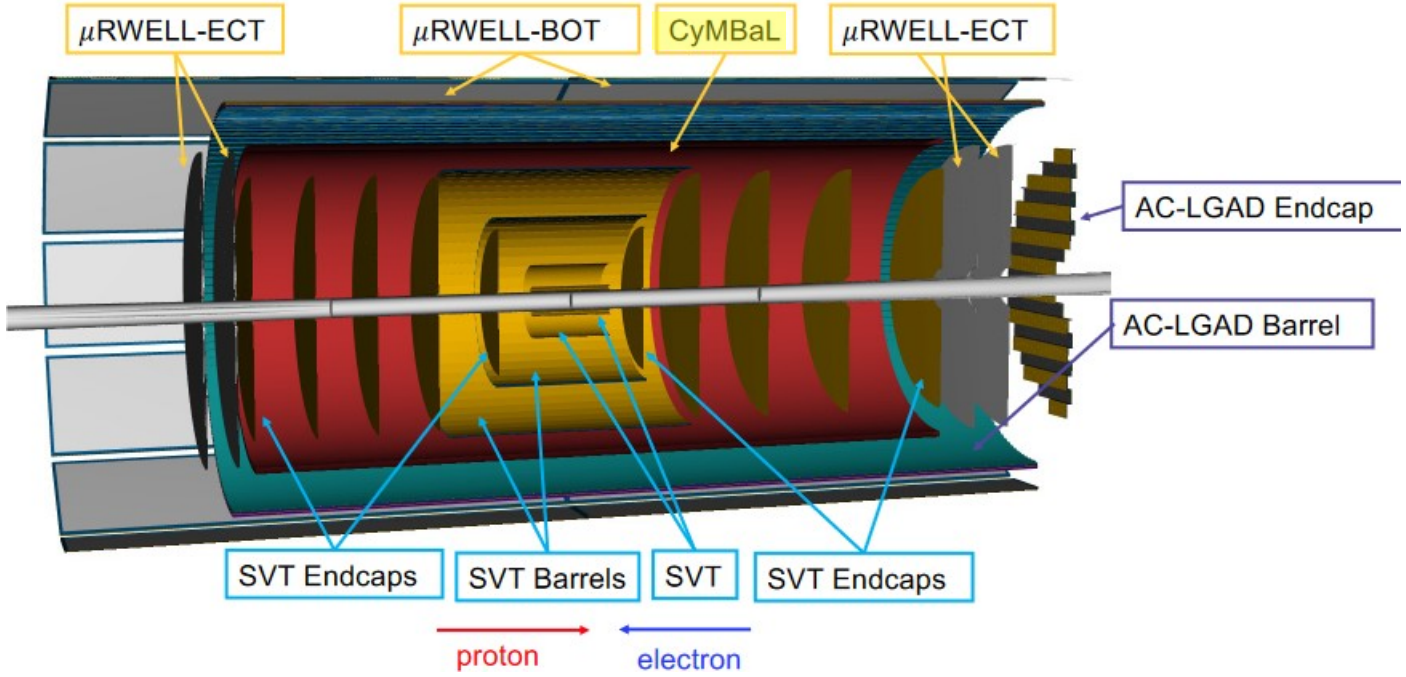


BMT open for maintenance

CyMBaL – In the tracking system

Charge 1

- The inner MPGD layer wraps around the SVT
- Provides additional hit points for pattern recognition
- Keeping zones:
  - Z = [-105, 135.5] cm
  - R = [50, 55]cm

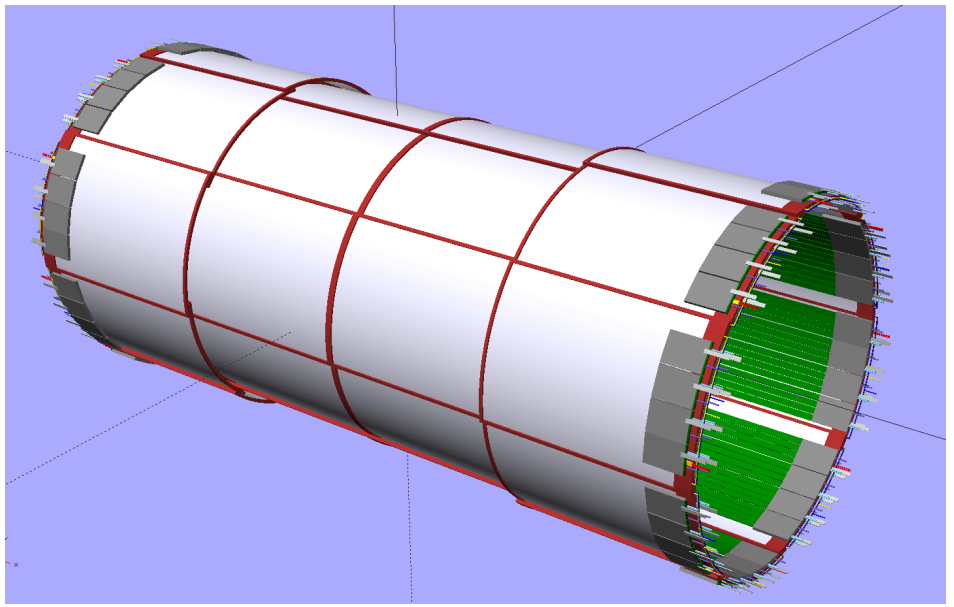


CyMBaL – Layout

Charge 3, 4

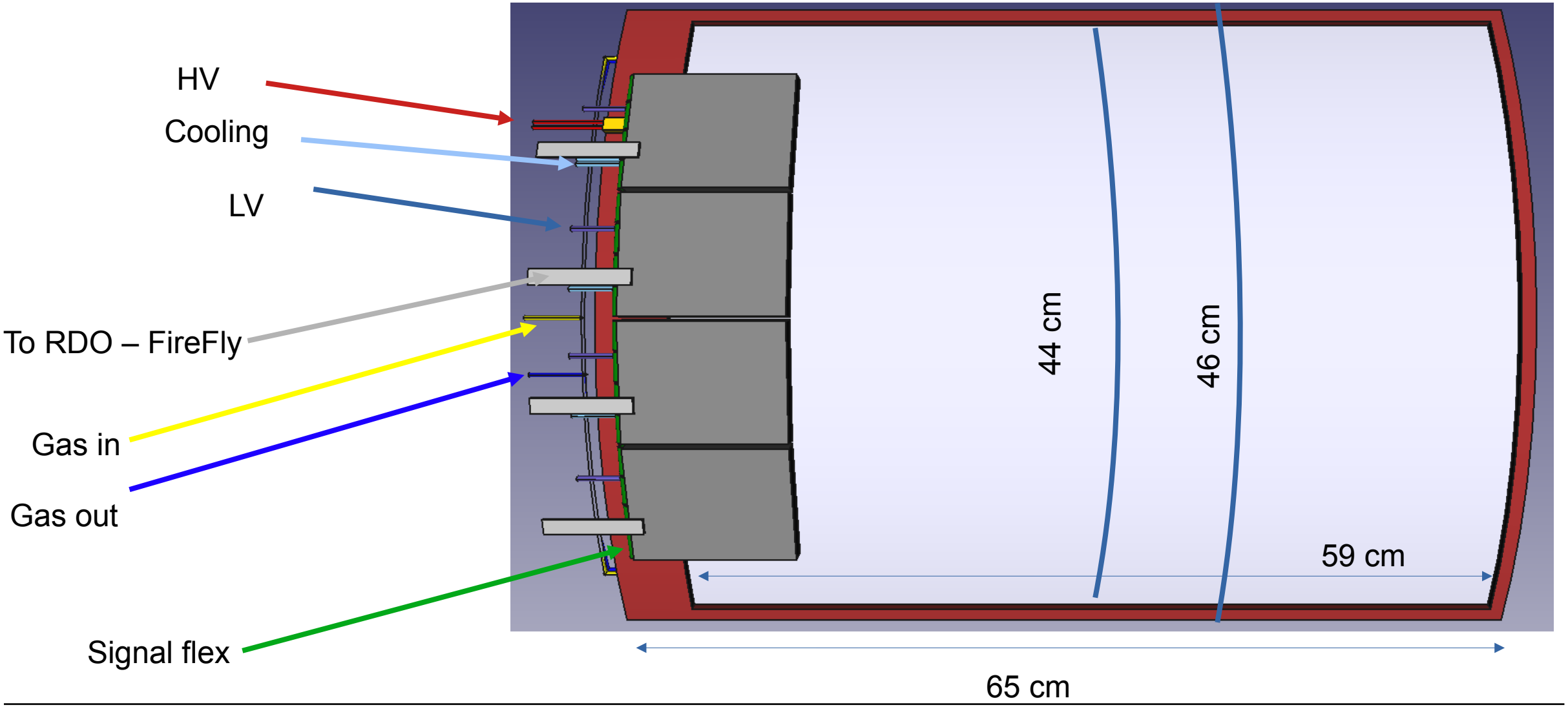
- A **single module PCB readout design**, with two curvature radii (50cm and 52.5cm)
  - **Simplify production, reduce costs**
  - **Industrial PCB production (Elvia, ...)**
  - **Micromegas bulking possible at several sites, example Saclay, Elvia, CERN, ...**
- Overlaps in phi and z allow for hermeticity
- Front end boards (FEBs) on system edges to reduce material budget
- FEB based on SALSA ASIC

Some numbers:
- 32 modules organized like: 8 modules in phi times 4 modules in z
- 1024 readout channels/module
- 32K readout channels



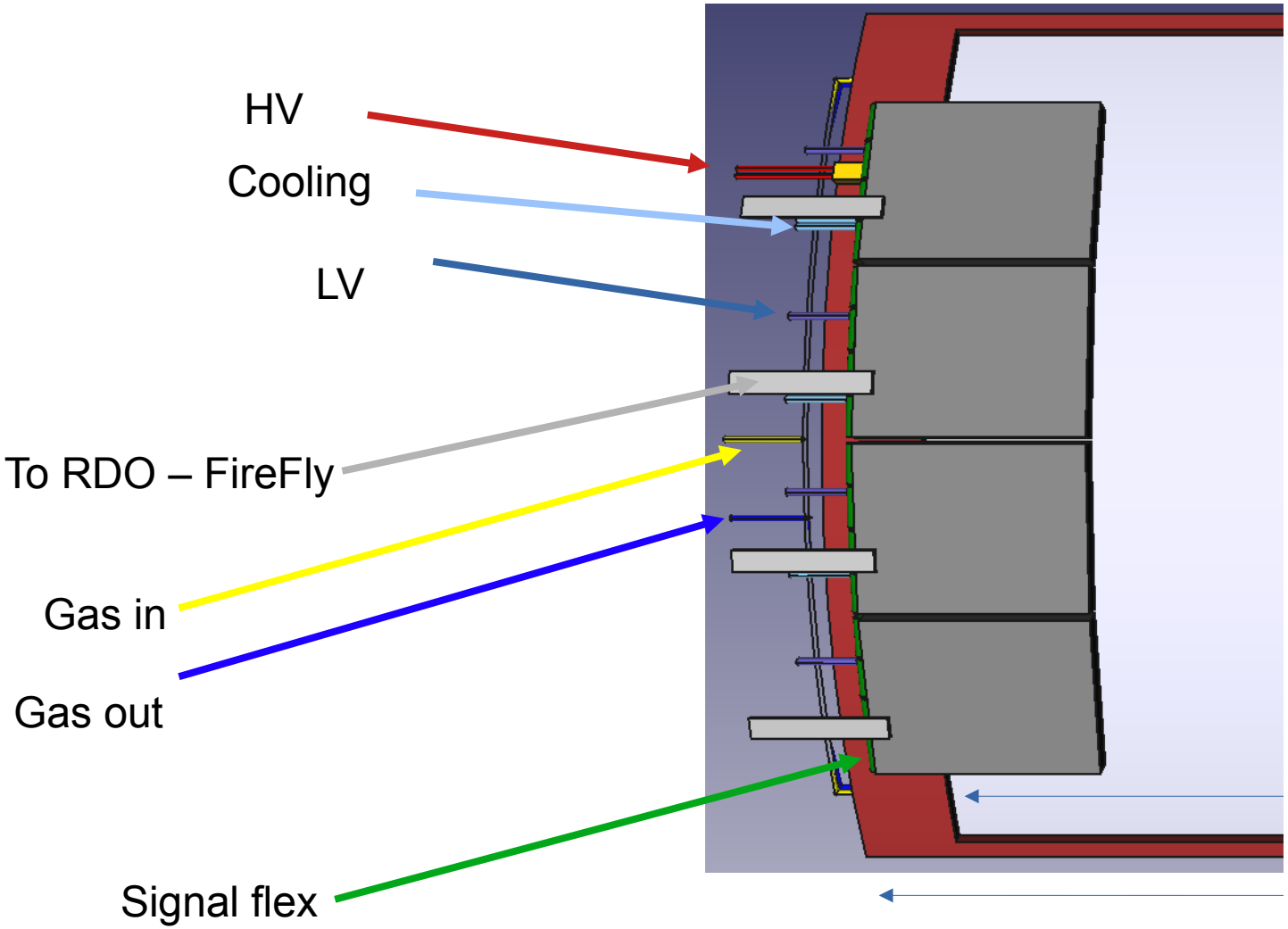
CyMBaL – Module

Charge 3



CyMBaL – Module

Charge 3



Dimensions:

- Size: 65 x 46 cm^2
- Active area: 59x44 cm^2
- r/o strips: ~1 mm pitch in both directions
- Readout strips per module: 1024
- 32 channels per connector → 32 connectors

Services:

- HV: 2 channels (drift and resistive layer)
- Gas: 2 tubes (in and out)
  - Two tiles can be in series
- 4 FEBs per module
- 4 ASICs per FEB:
  - 4-lines bidirectional optical fiber FireFly to RDO
  - 2 short flex cables per ASIC
  - Low voltage
  - Cooling in and out, possibly in series

CyMBaL needs already taken into account in ePIC general service plans

CyMBaL – Module readout scheme

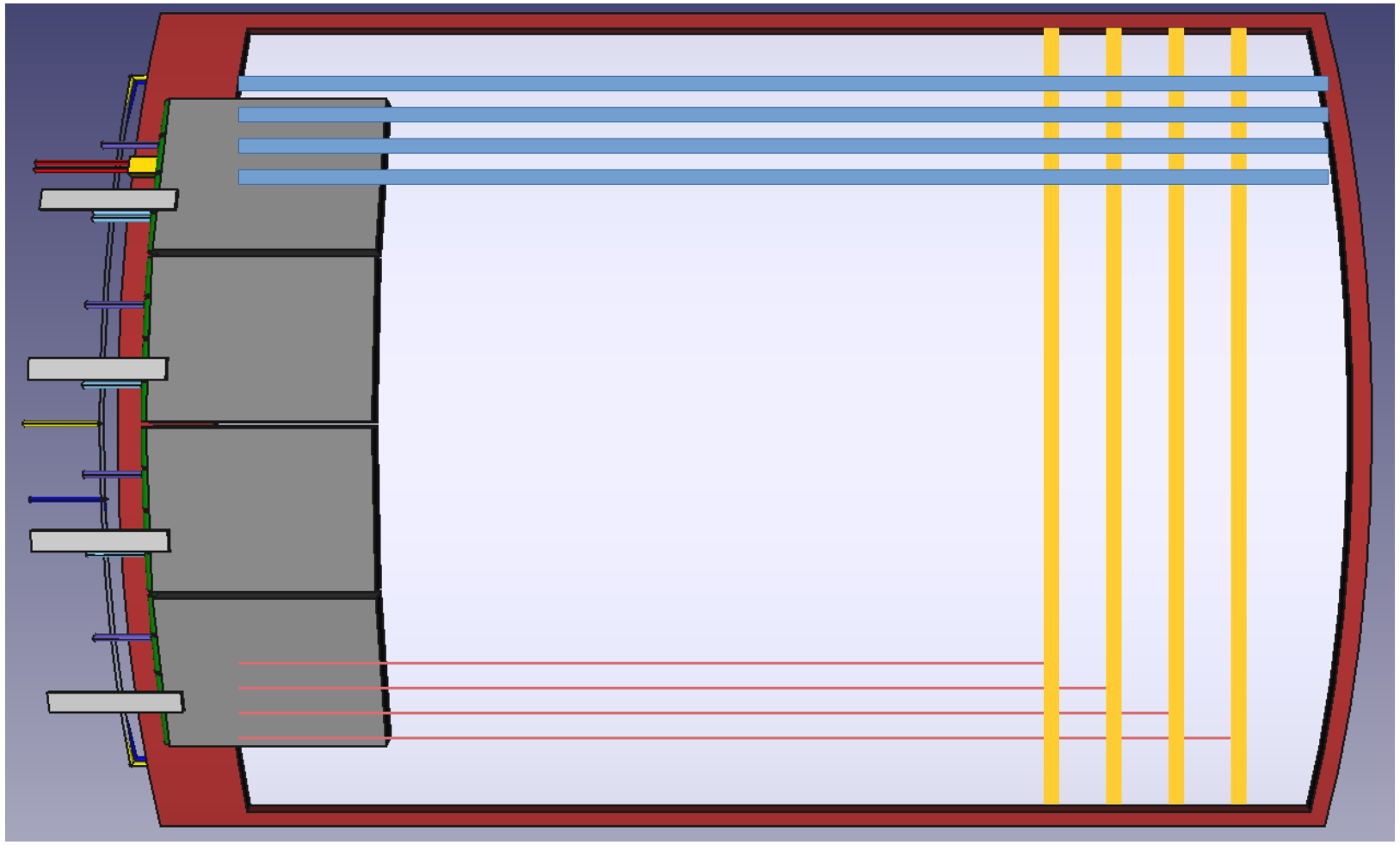
Charge 3

Z; (r phi)

C; (z)

return trail for C strips

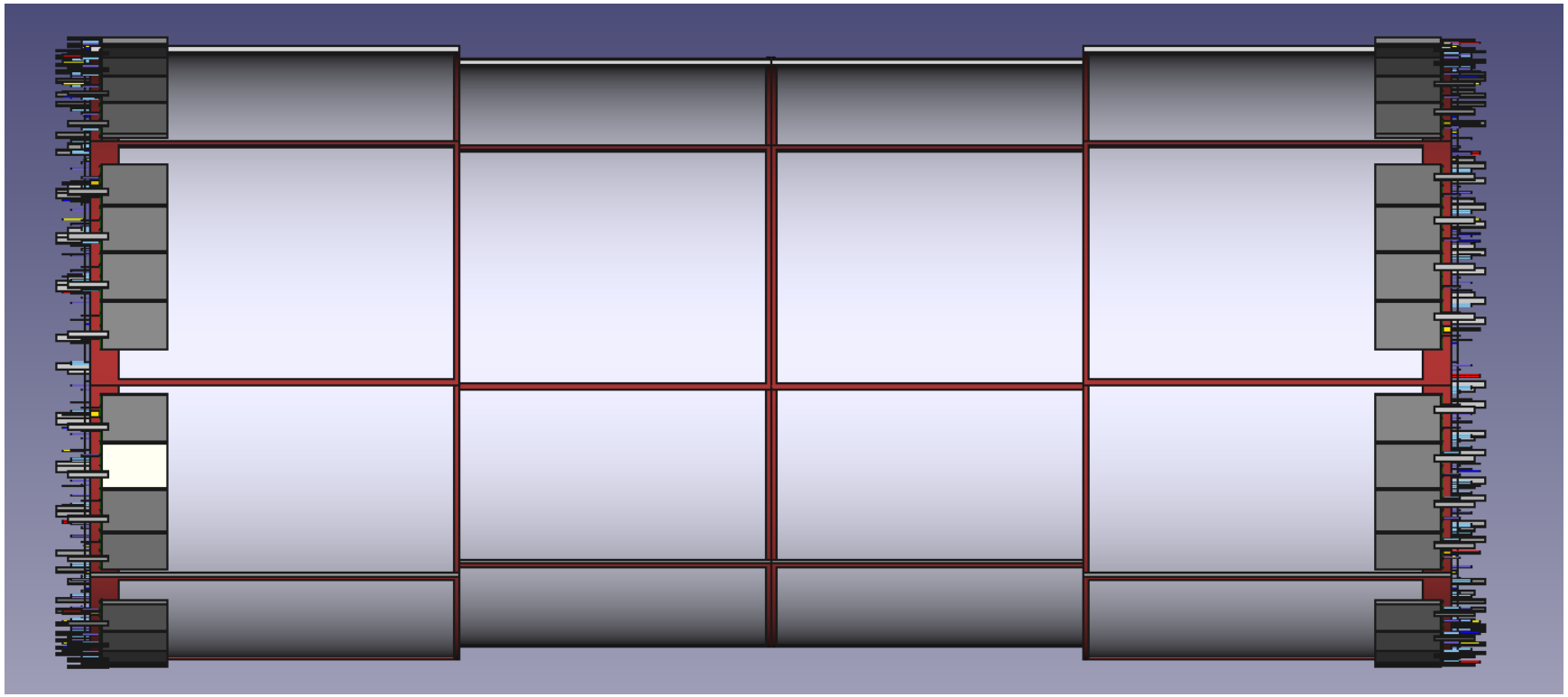
The final readout pattern design will be decided at the completion of the R&D, expected this year.



CyMBaL – Layout

Charge 3

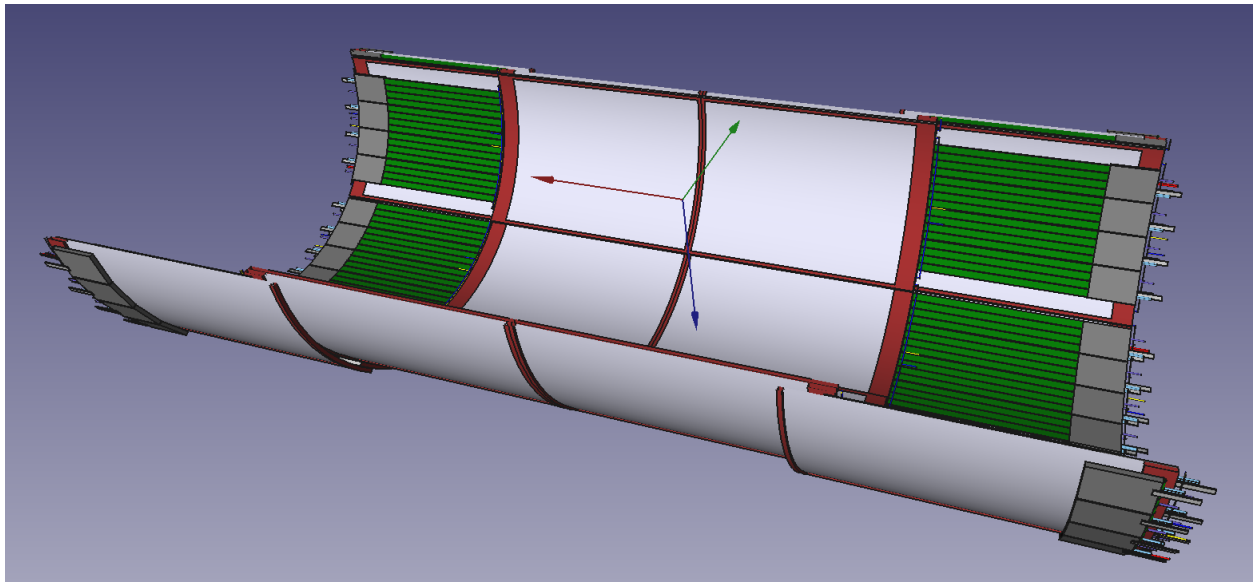
- Length covered by four modules
- Same readout PCB, two different radii
- No overlap in the middle, as there will be already other support structures

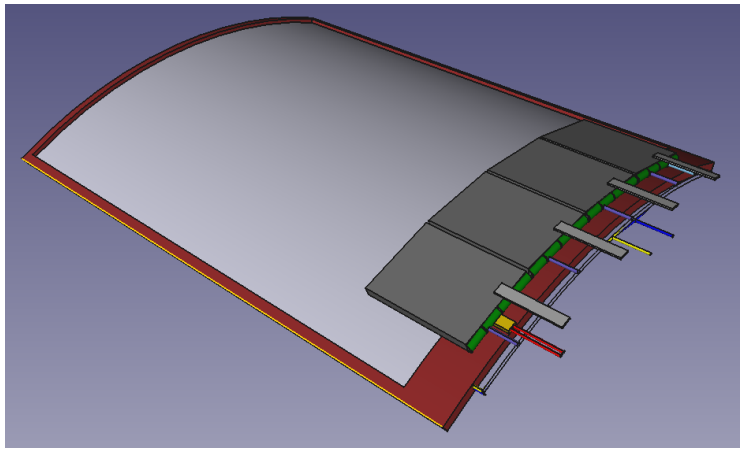


CyMBaL – Layout

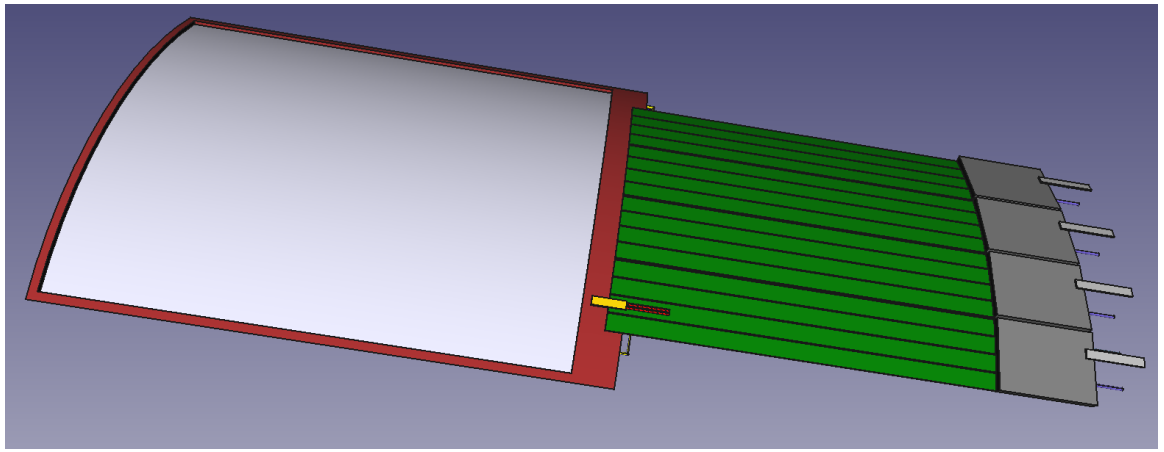
Charge 3

- Front end boards will be placed at the edges of the system
- Inner modules will be connected to the FEBs through ~50 cm of micro-coaxial cables





Outer module

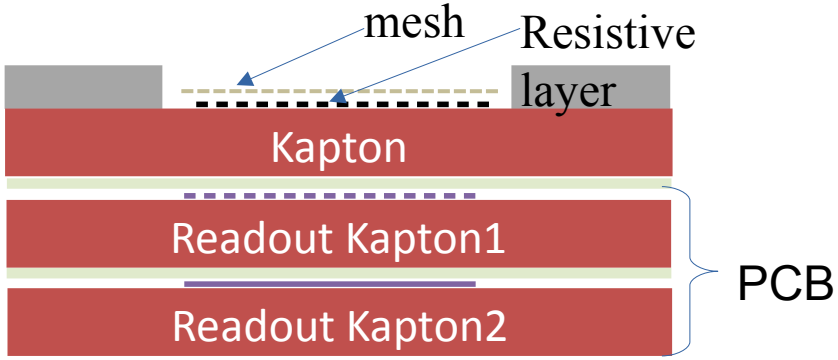


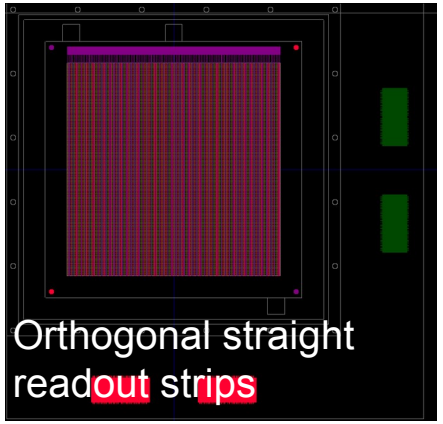
Inner module

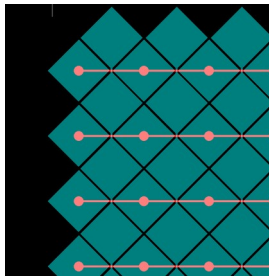
CyMBaL – R&D

Charge 2

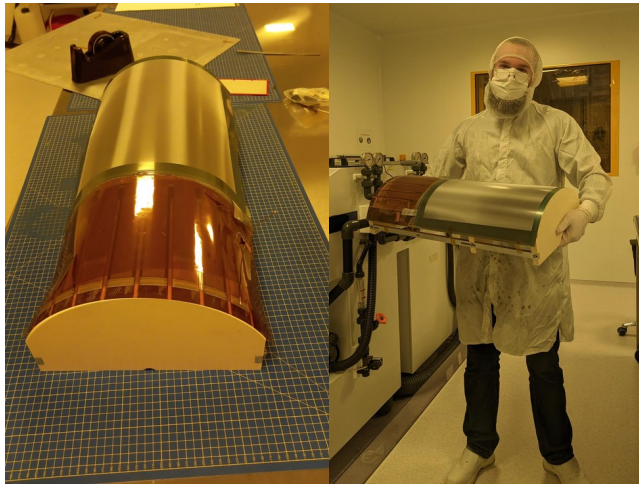
- Upgrade CLAS12 Micromegas technology from 1D → 2D readout
- Goal of the R&D: find the 2D readout pattern that will provide better than 150µm resolution with small number of readout channels
- Developed within Generic EIC R&D programs (eRD6) and EIC Project R&D (eRD108)
- Tests of different patterns with different resistive layers in beam test in 2023
- FY24 goal: build and test a large scale prototype

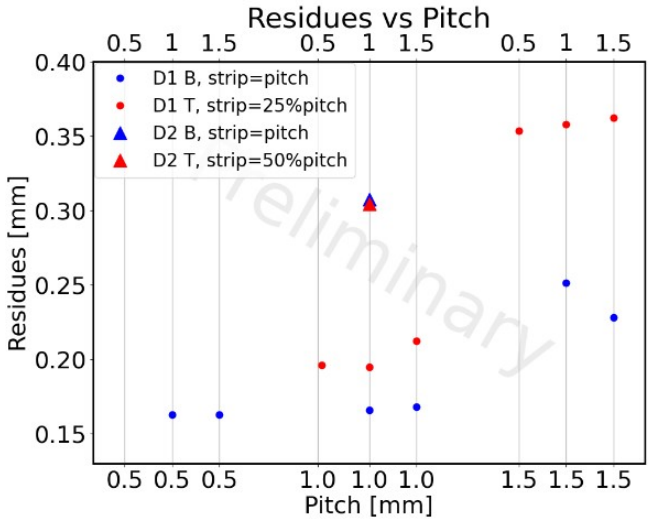






2D orthogonal pad-like





CyMBaL – ES&H and QA

Charge 7

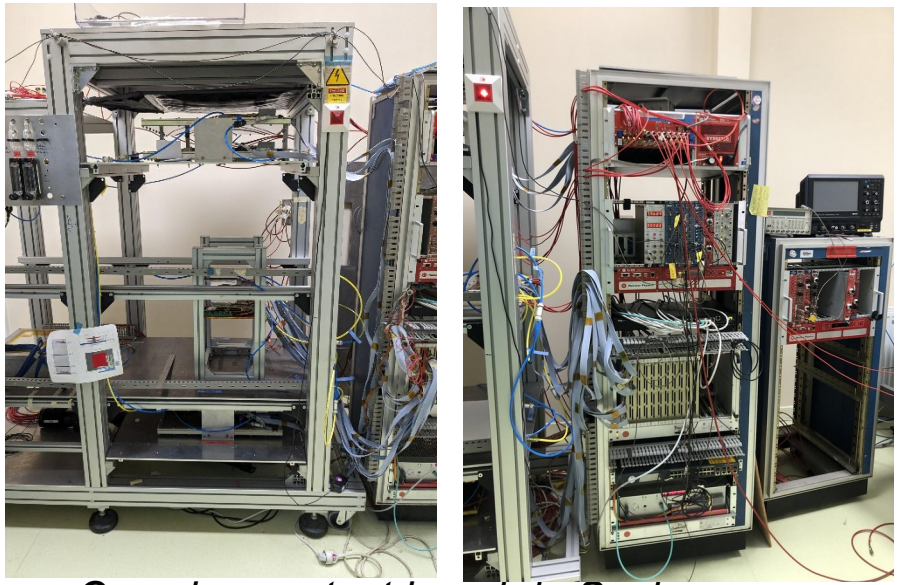
- CEA Saclay MPGD Lab and clean rooms


CEA Saclay MPGD lab

- A list of standard test per module:
  - Validation PCB (metrology and electric tests)
  - Resistive serigraphy metrology and resistivity checks
  - HV tests after Micromegas bulking
  - Gas leakage tests after assembly
  - Electrical and capacitance tests after connector soldering
  - Efficiency measurements with cosmics test bench
  - Gain uniformity with Fe55

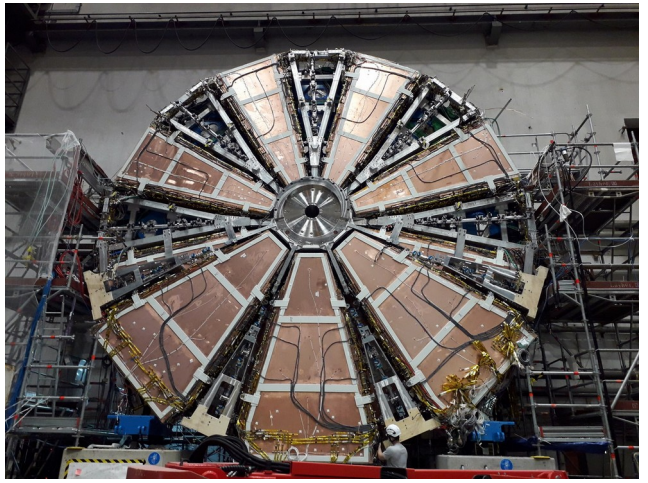
- QA engineer hired end 2023 at MPGD lab

Standard gas mixture (Ar-Isobutane 95:5), potential flammability risks. An non flammable mixture (Ar-CO2-Isobutane 95:2:3), already used for the ATLAS NSW, is being considered.

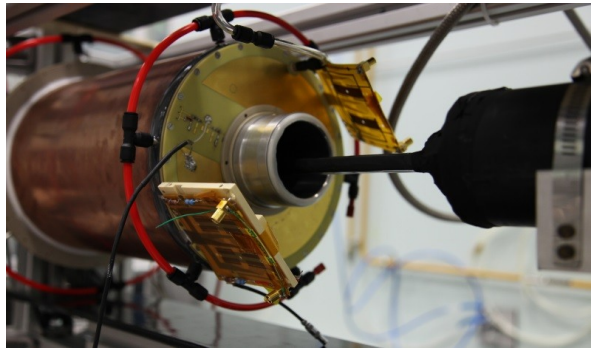

Cosmic rays test bench in Saclay

CyMBaL – Experience

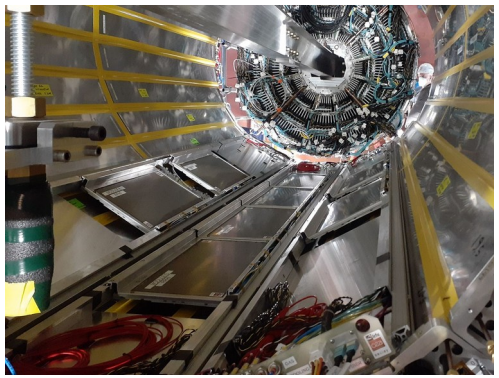
- CEA Saclay among leading experts of Micromegas production
- Experience in design and production of large projects. Examples:
  - **ATLAS NSW**:
    - 392m2 out of 1200m2 of resistive Micromegas produced at Saclay
    - mechanical precision of 100µm
  - **CLAS12 BMT**:
    - ~4m2 of resistive curved Micromegas
    - Taking data since 2017
  - **sPHENIX TPOT**:
    - Ten double sided Micromegas modules for the TPC calibration
    - Delivered to BNL in about 9 months, from conception to shipment
  - **Micromegas for TPC readout**: (Minos, T2K, ILC) and **muon-tomography**
- Synergy with the electronics department for development and testing



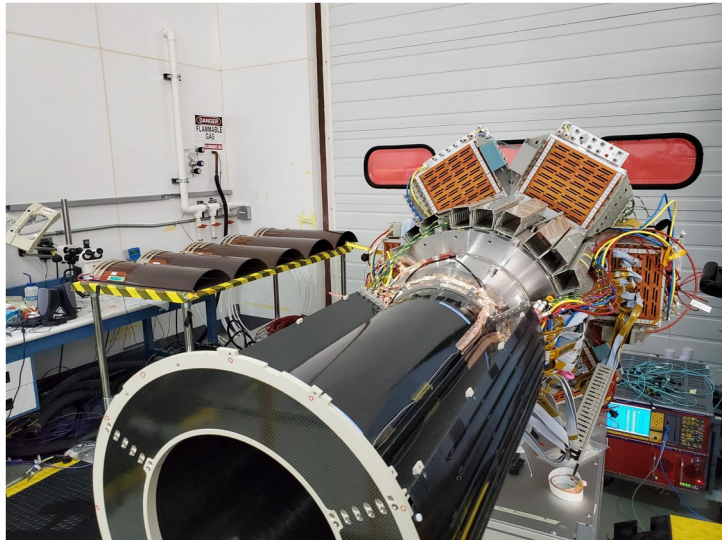
ATLAS NSW



Minos TPC



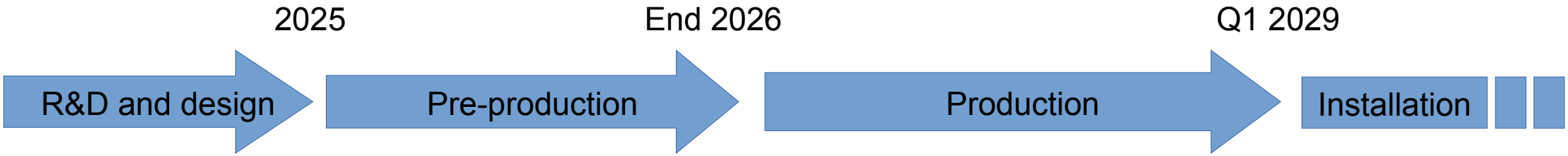
TPOT modules in sPhenix



CLAS12 BMT

CyMBaL – Schedule

Charge 5



- Choice of the 2D readout pattern
- Large scale prototype
- Design of the final module

- First production of few modules
- Adjustment of the design
- Test of components from vendors
- Test of assembly line
- Start procurement for prod
- Validation of detector mechanics with ePIC support structure

- Production of 32 modules
- Validation of modules with cosmics and with Fe55
- Shipments to BNL

CyMBaL – Summary

- The design of the inner MPGD layer, i.e. CyMBaL, is advanced.
  - A modular design to reduce design and costs.
- The technology choice is an upgrade of the current technology used for the CLAS12 BMT
  - Curved, to fit in a narrow space
  - Light, to limit the impact of the material budget on particle reconstruction
- Finalization of the R&D for the final choice of the readout pattern in FY24
- The CyMBaL module design (mechanics plus PCB) will take about six months
- The system design needs interactions with the integration team to define interfaces and supports. Work already started.
- CEA Saclay has consolidated experience in Micromegas production
- The overall schedule is compatible with the Project requirements