WP 5.4: Cylindrical μ-RWELL as Inner Tracker for τ-charm factories

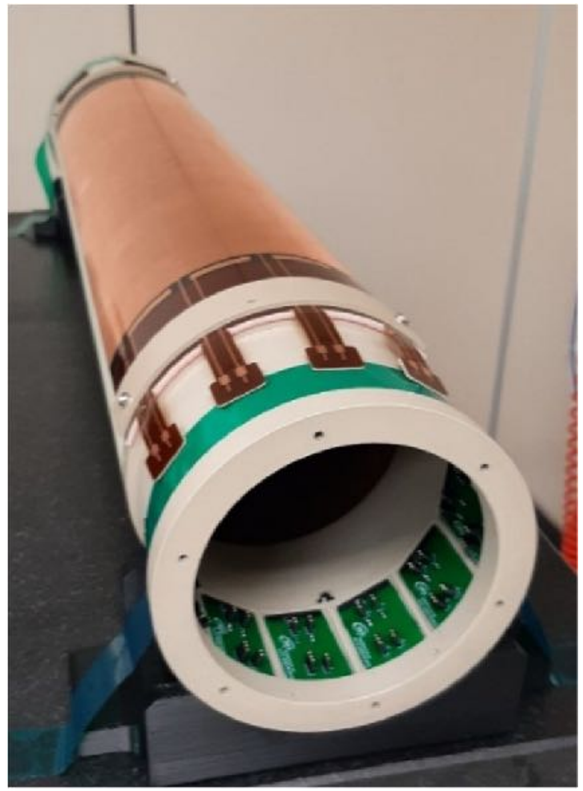
G. Cibinetto on behalf of INFN Ferrara – LNF – Torino groups

Eurizon Annual Meeting - FAIR Darmstadt - Feb. 9-10, 2023

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 871072

Outline

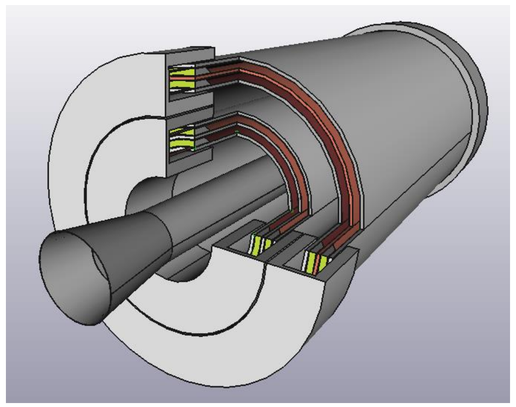
- Goal of the task and introduction
- Detector design
- Prototype construction
- Software developments
- Summary and schedule



Design of a cylindrical modular μ-RWELL as Inner Tracker

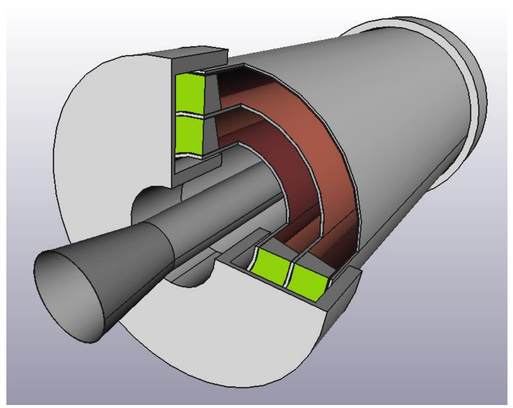
Low X_0 cylindrical μ-RWELL

Two B2B small-drift-gap cylindrical detector



- N.2 small-gap B2B C+layers —> 1.72%X0
- 2x1 cm gas gap/B2B device
- 4 cm global sampling gas

One B2B large-drift-gap cylindrical detector

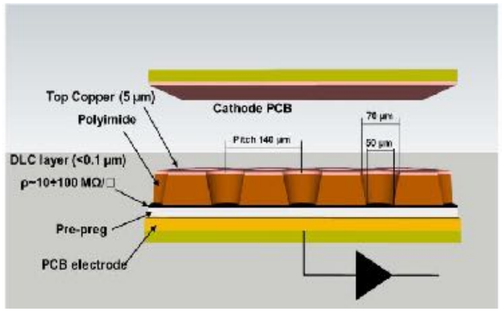


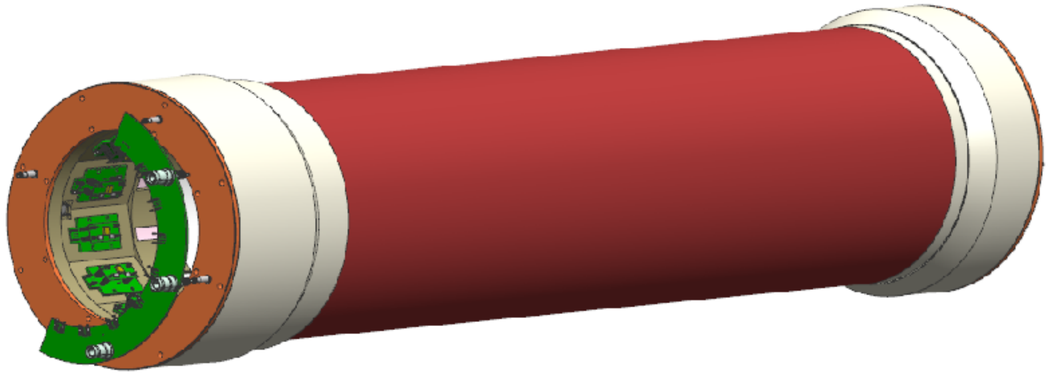
- N.1 large-gap B2B C+layers —> 0.86%X0
- 2x1 cm gas gap/B2B device
- 10 cm global sampling gas

- Additional 10-15% reduction in the material budget achievable with
  - high module FR4
  - low resistivity DLC cathode
  - aluminum Faraday-Cage/shielding
- micro-TPC readout mode allowing space resolution of O(100 μm) for inclined tracks (on the radial view)
- time resolution 5-10 ns

Design of a cylindrical modular μ-RWELL as Inner Tracker

Single-layer, small-drift-gap C+RWELL prototype

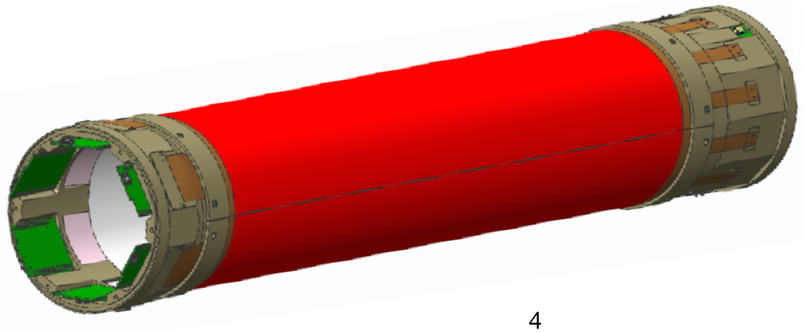


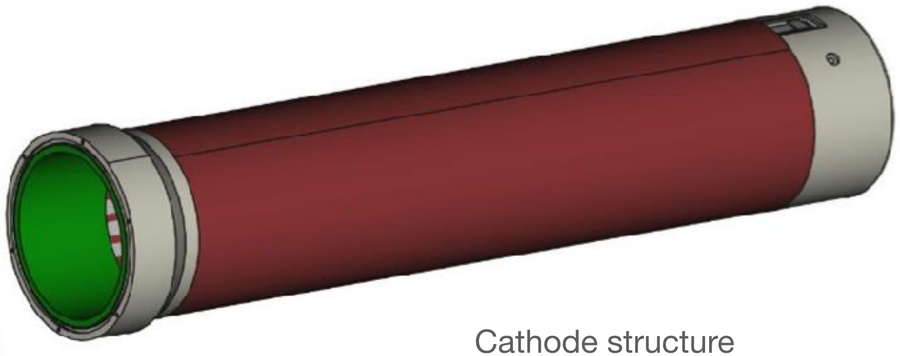


Prototype dimensions

- Drift gap = 10 mm
- Anode diameter = 168.5 mm
- Cathode diameter = 188.5 mm
- Active length = 600 mm
- Length = 1011 mm

Anode structure

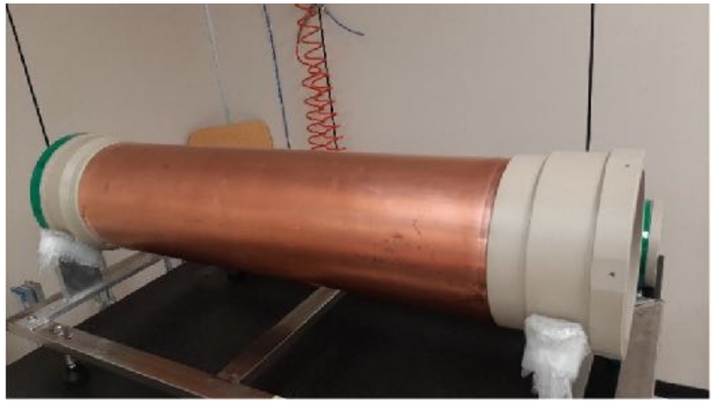


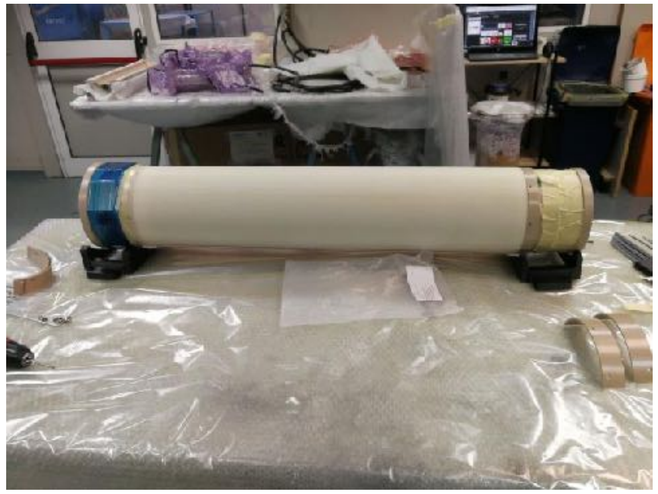


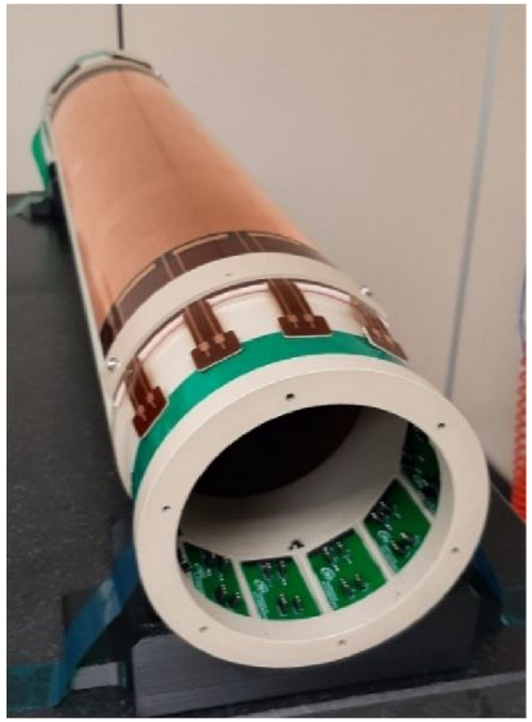
Cathode structure

Prototype assembly

Work performed at Loson company

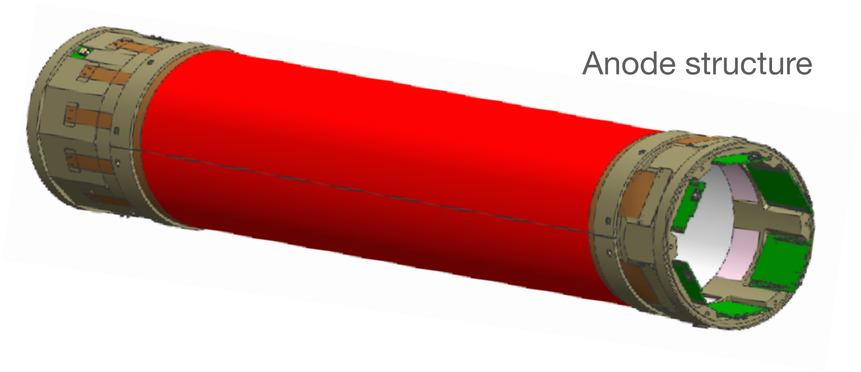




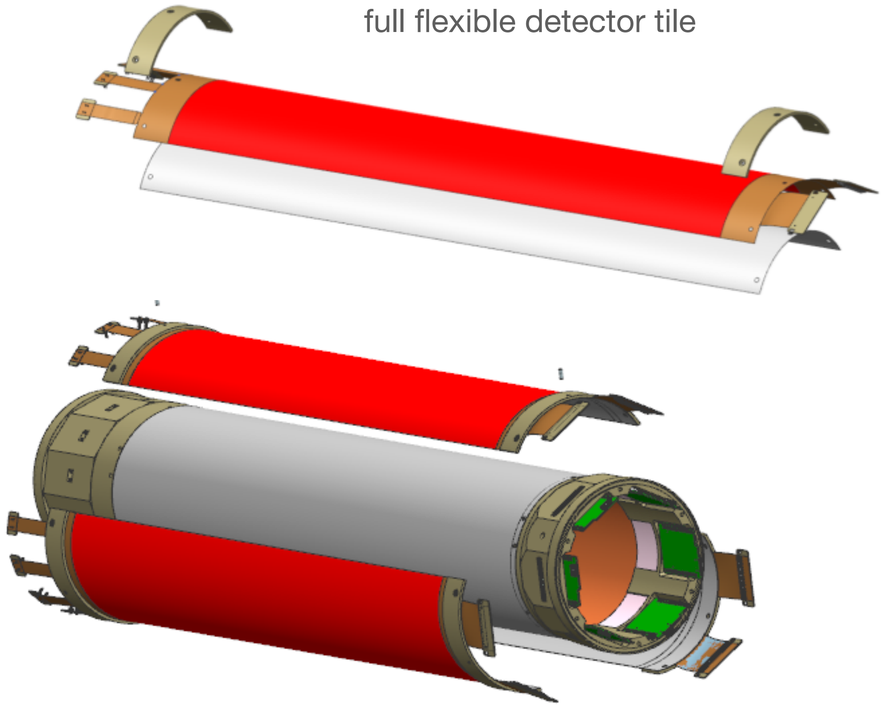


Design of a cylindrical modular μ-RWELL as Inner Tracker

Modular design



Anode structure



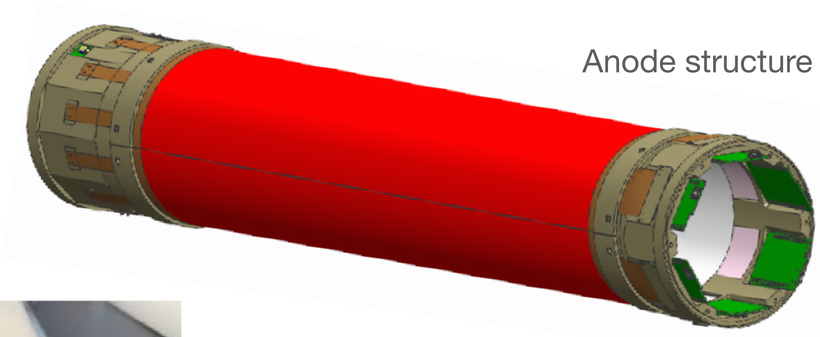
full flexible detector tile

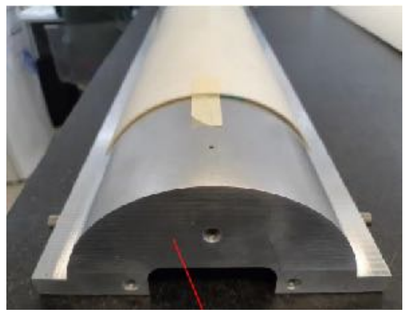
Three of such flexible detector tiles are glued on composite/foam roof-tiles, then mounted on the anode cylindrical support

Design of a cylindrical modular μ-RWELL as Inner Tracker

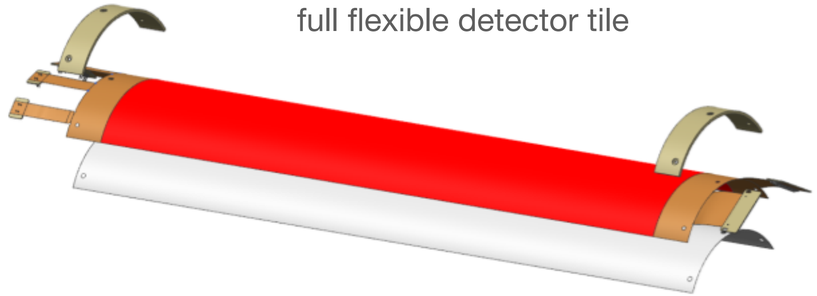
Modular design

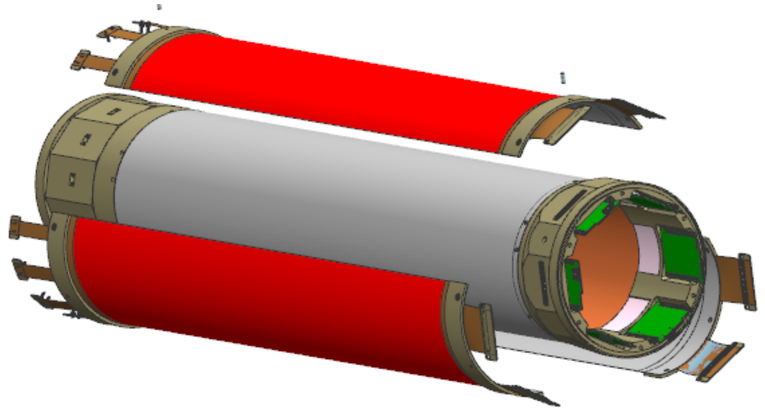
Anode structure





full flexible detector tile

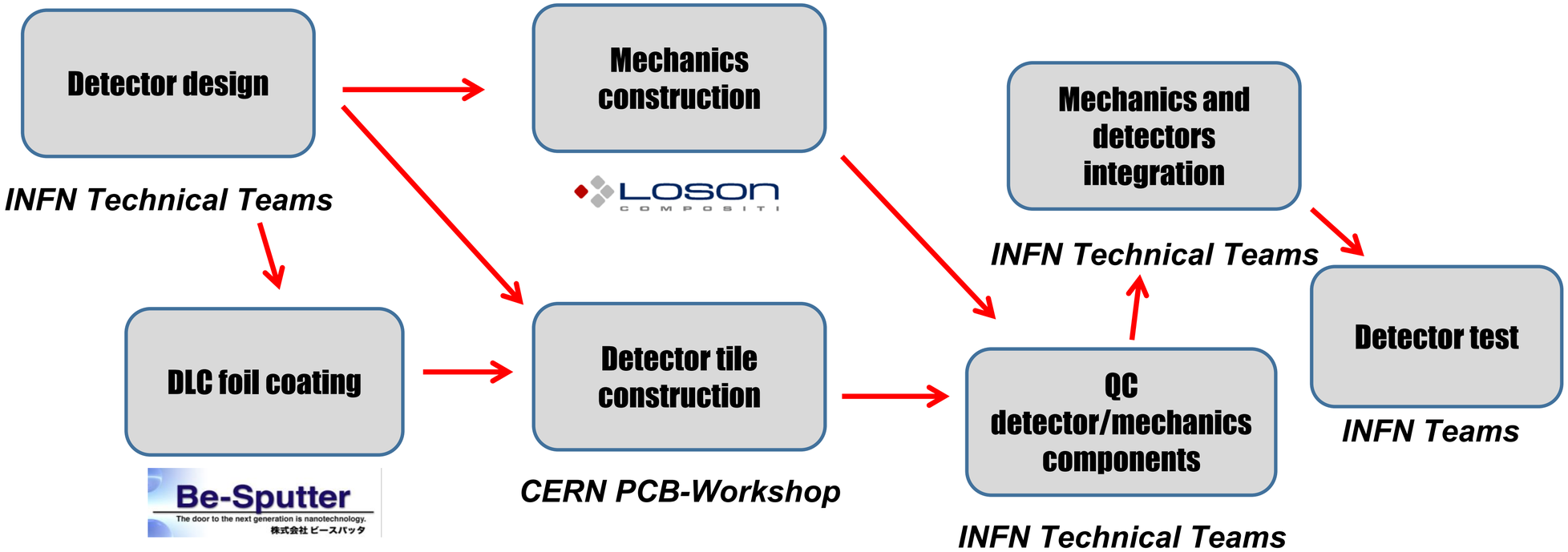




Three of such flexible detector tiles are glued on composite/foam roof-tiles, then mounted on the anode cylindrical support

Design and construction flow

Task sharing

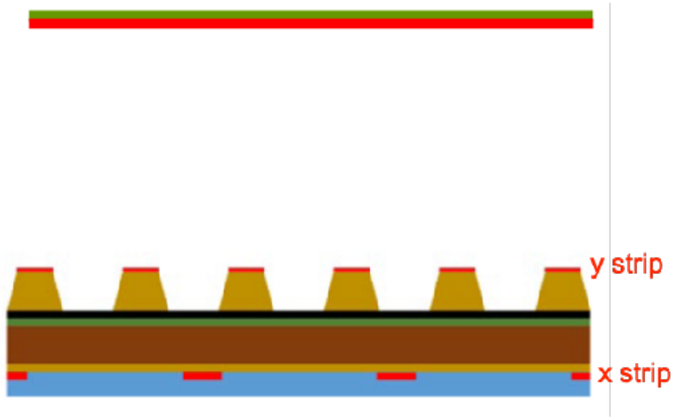


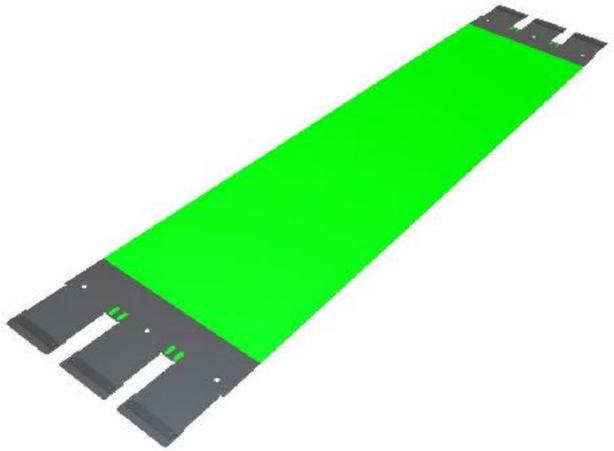
Options for 2D readout

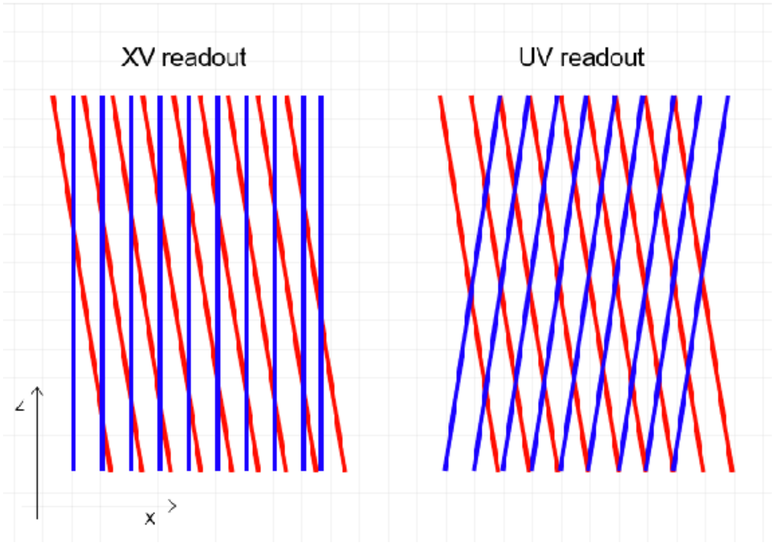
Mechanical constraints

Signal maximum tails/connectors that can be placed on each readout-tile

- n. 6 for signals (3 each side)
- n. 4 for HV (corresponding to n.4 HV sectors)





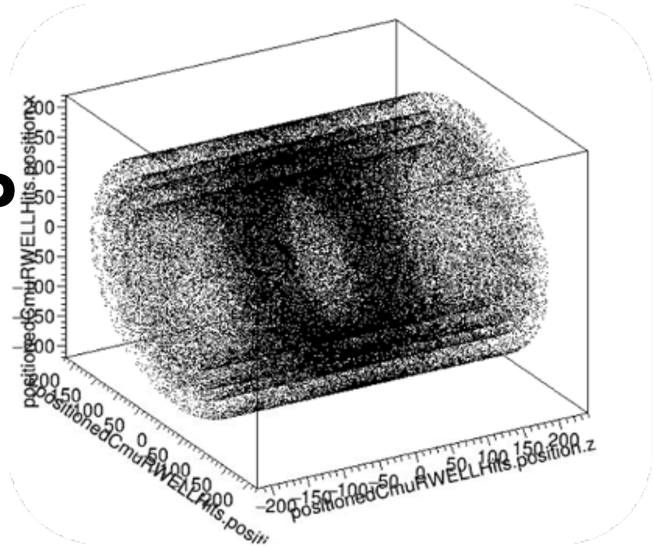


- The Z-spatial resolution depends on the stereo angle
- Assuming a single view spatial resolution ~ 100 μm for X or U/V
- For prototype $\vartheta_{stereo} \sim 13^{\circ}$: for XV $\sigma_Z \sim 600\ \mu m$ while for UV $\sigma_Z \sim 300\ \mu m$

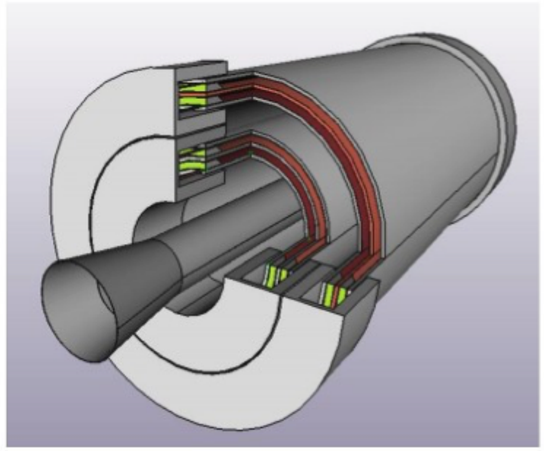
2D readout type	# APV/side	#chs/side	#strips/side	Strip/pitch
XV	3	384	128X, 256V	660um
UV	3	384	192U, 192V	857um

Detector Simulation

Two sets of B2B chambers described in DD4HEP

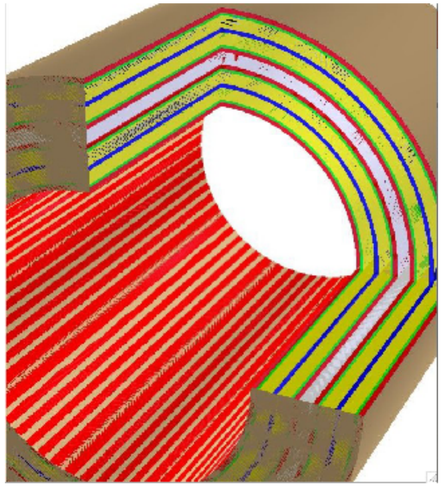


2 SETS OF 2 CHAMBERS BACKTOBACK



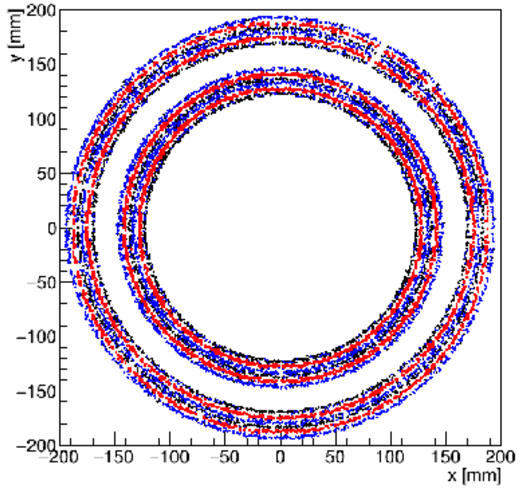
Sensitive material

- Ar - CO2 - CF4 (45% - 15% - 40%)
- Passive materials
- Copper
- Kapton
- Glue
- FR4
- MILLIFOAM
- Diamond Like Carbon
- Pre-preg (106)
  → 70% glue + 30% fiberglass



GEANT4 MC points registered in

each gas gap = 1 cm
→ 4 cm global sampling gas
→ readout with μTPC reconstruction

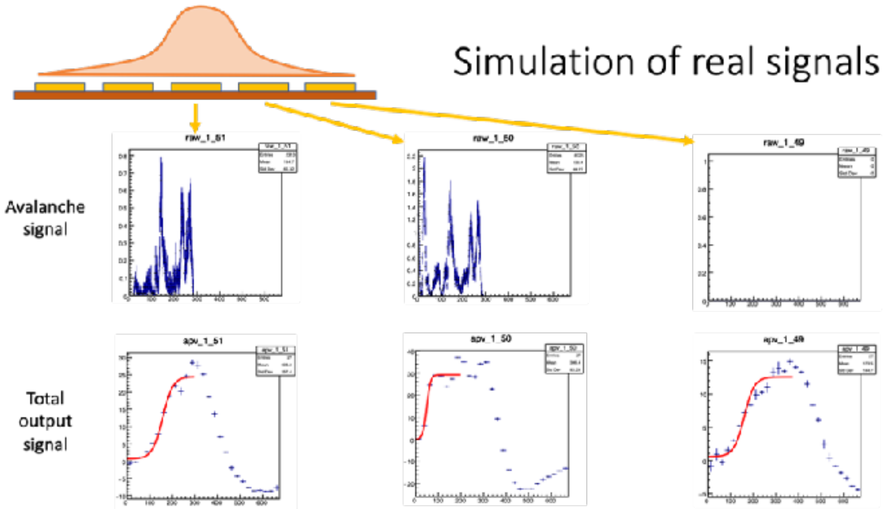


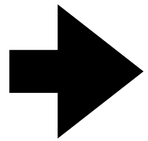
Hits reconstructed in the **middle** of the gas gap using **entry** and **exit** position of the tracks

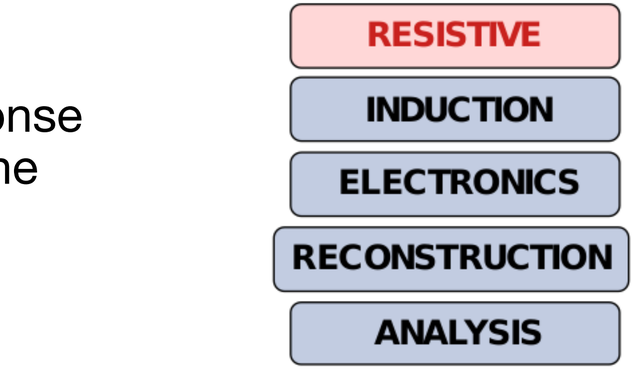
Detector Simulation

Parametrization of the detector response

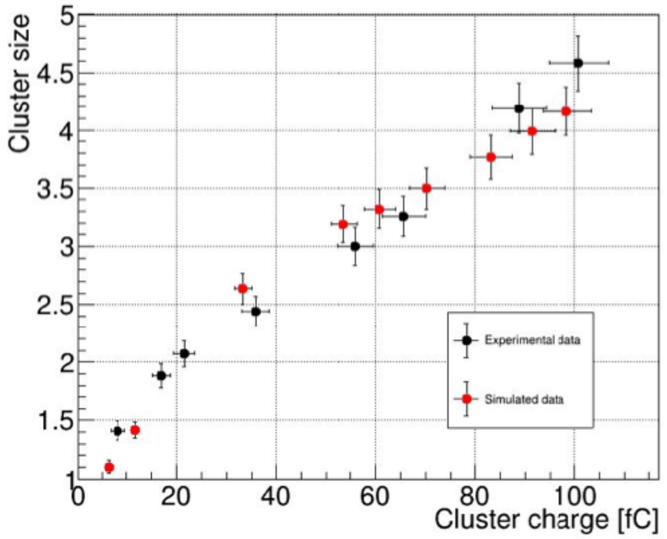
- The complete simulation of the C_RWELL includes also the response of the detector to the energy deposition, with the description of the formation of the electronic signal inside the detector
  - Simulation software developed for BESIII triple-GEM detectors → Adapted to μ-RWELL detector (Parsifal tool-kit)
  - Simulated resistive configuration







Tuning to test beam data



Deliverables & Milestones

- **D5.2 - m24:** Status report on R&D work on Inner Tracker for a SCT detector
- **D5.7 - m44:** Final report on R&D work on Inner Tracker for a SCT detector
- **M4 – m42:** Construction and test of the Inner Tracker (C-RWELL) prototype for a SCT detector

Summary and outlook

- Task 5.4 aims to study the design of a **cylindrical μ-RWELL** Inner Tracker for e^+e^- colliders working in the τ-charm energy region
- Two possible layouts have been proposed —> **small** and **large** drift gaps
- A single-detection-layer prototype of the small drift gap has been engineered to validate the construction technique
- The prototype is almost complete and will be validated with cosmic this year
- In addition a complete **GEANT4 description** and a full **digitization** of the detector response have been developed

Thanks for your attention