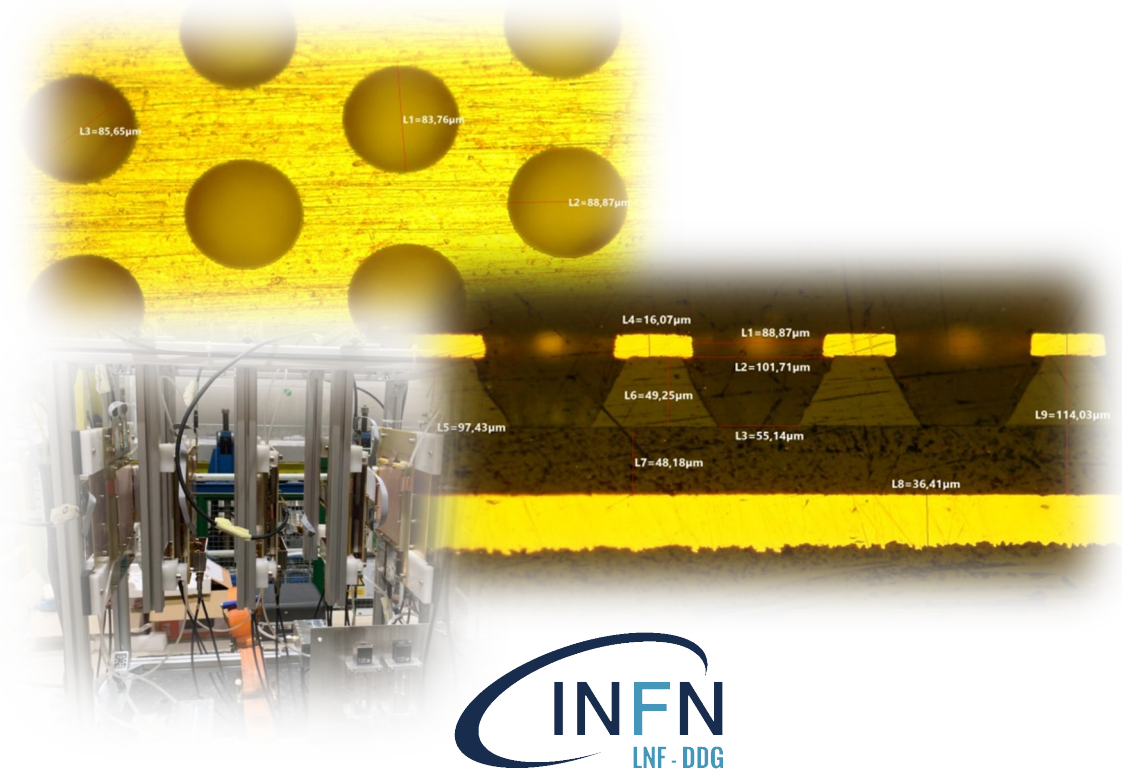
Status of μ-RWELL for FCC_ee: Pre-shower & Muon system



Marco Poli Lener
on behalf of Bo, Fe, LNF, To

INFN
LNF - DDG

IDEA⟶ µ-RWELL for pre-shower and muon apparatus

The **IDEA detector** is a general purpose detector designed for experiments at future e^+e^- colliders.
Pre-shower detector and the Muon system are designed to be instrumented with µ-RWELL technology.

Pre-shower & Muon requirements:

Tiles: 50x50 cm^2 with X-Y readout

Efficiency ≥ 98%

Space resolution ≤ 100 µm (Pre-shower)

≤ 400 µm (Muon)

Particle Flux < Hz/cm^2 (Pre-shower)

< 1kHZ/cm^2 (Muon)

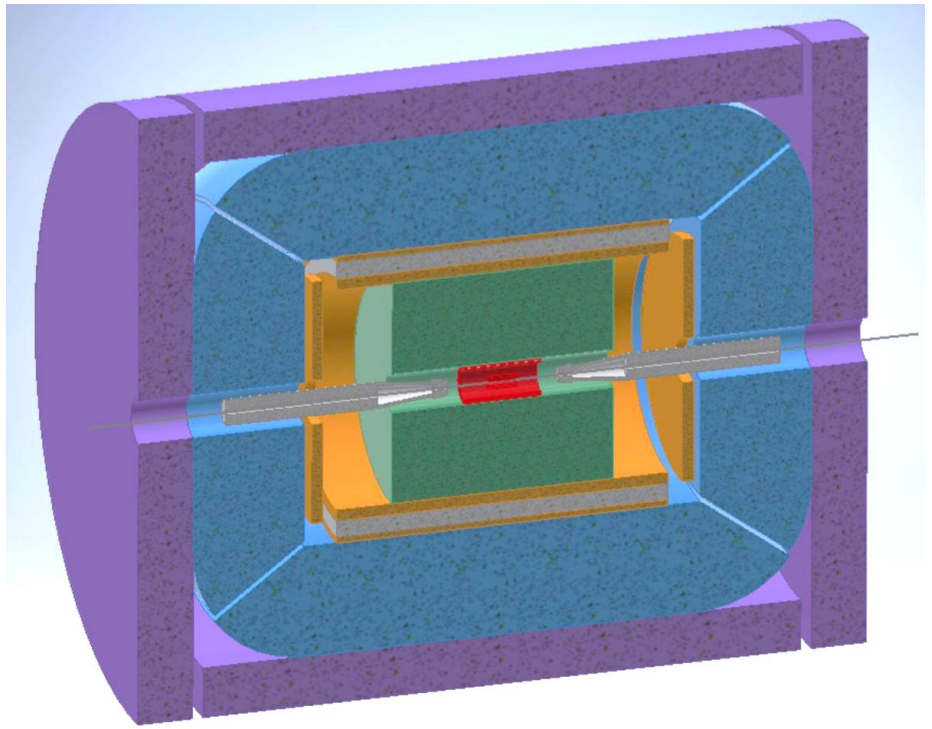
Instrumented Surface/FEE:

130 m^2, 520 det., 3×10^5 ch. (0.4 mm strip pitch)

1500 m^2, 6000 det., 5×10^6 ch. (1.2 mm strip pitch)

Mass production → Technology Transfer to Industry

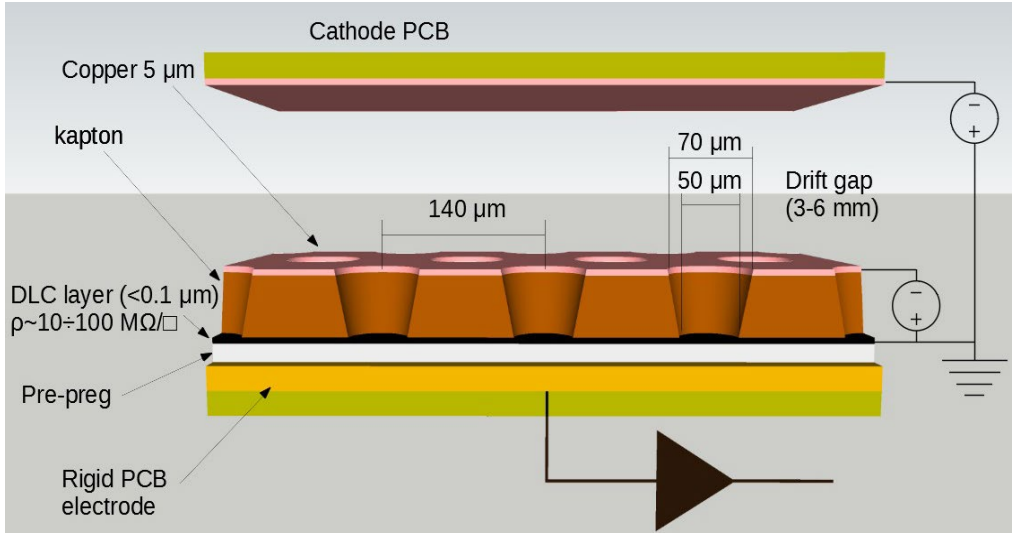
FEE Cost reduction → custom made ASIC (TIGER, …..)



Italian Institute involved: Laboratori Nazionali di Frascati, Bologna, Ferrara, Torino

The μ-RWELL

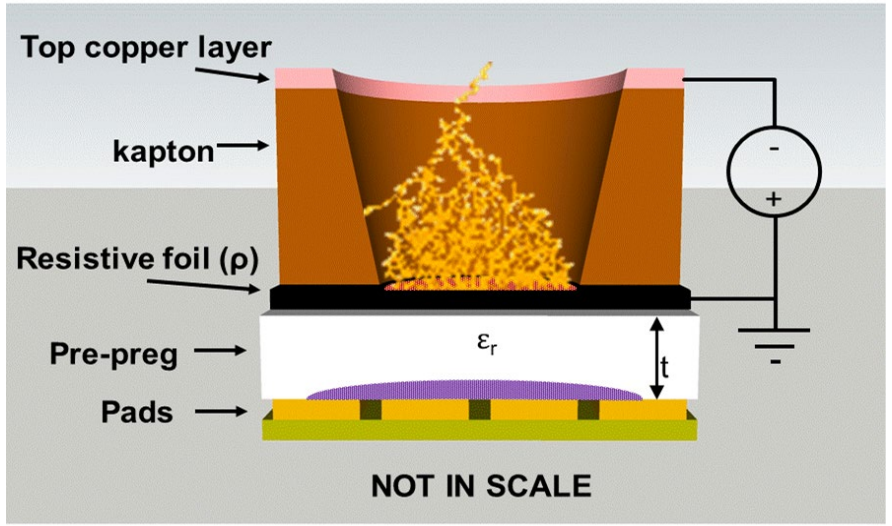
G. Bencivenni et al., The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD, 2015 JINST 10 P02008



The **μ-RWELL** is a **resistive MPGD** composed of two elements:

- **Cathode**
- **μ-RWELL_PCB:**
  - a **WELL** patterned **kapton foil** (w/**Cu-layer on top**) acting as **amplification stage**
  - a **resisitive DLC** layer(*) w/ **ρ~10÷100 MΩ/□**
  - a standard **readout PCB** with **pad/strip** segmentation

(*) DLC foils are currently provided by the Japan Company – BeSputter



The **"WELL"** acts as a **multiplication channel** for the ionization produced in the drift gas gap.

The **resistive stage** ensures the **spark amplitude quenching.**

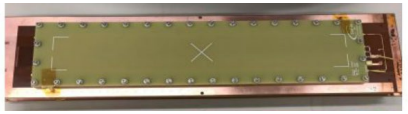
Drawback: capability to stand high particle fluxes reduced, but **largely recovered** with appropriate **grounding schemes** of the **resistive layer**

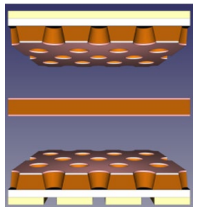
u-RWELL R&D History

New u-RWELL ideas (in collaboration with RD51)

1D Layout optimization

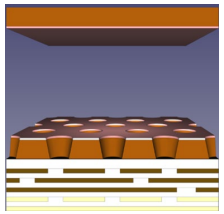
2D layouts optimization

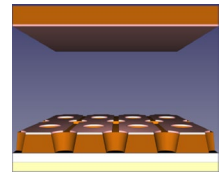




2x1D layout

Capacitive Sharing layout

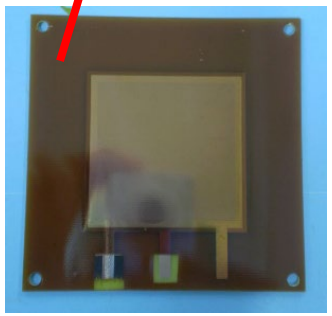




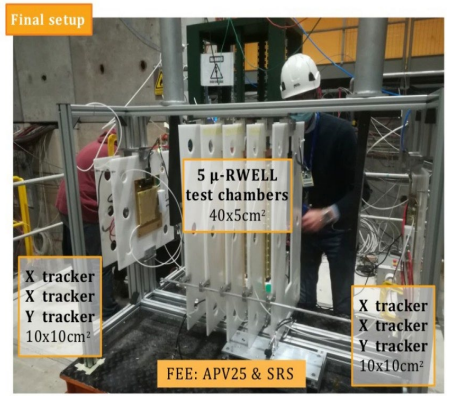
TOP layout

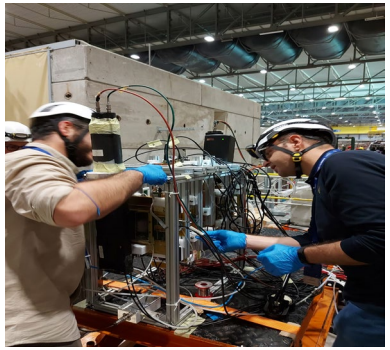
R&D for FCC start

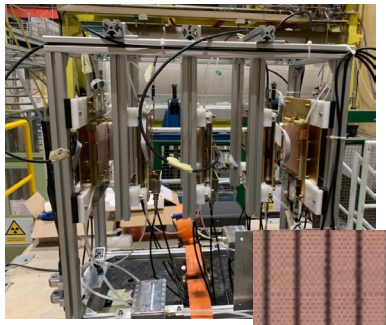
2009 2020 2021 2022 2023 2024

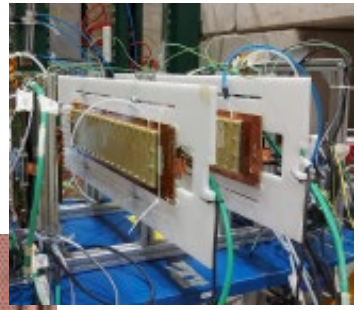


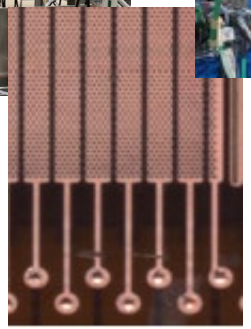
IDEA slice test:
DC + pre-shower +
dual_calo + muon







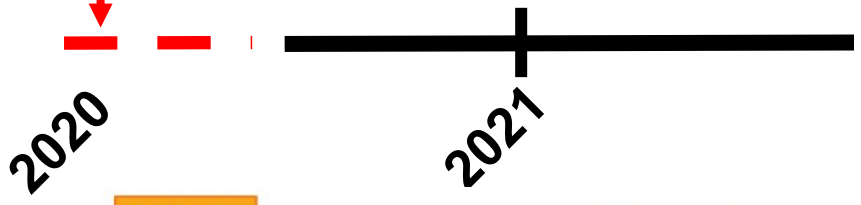


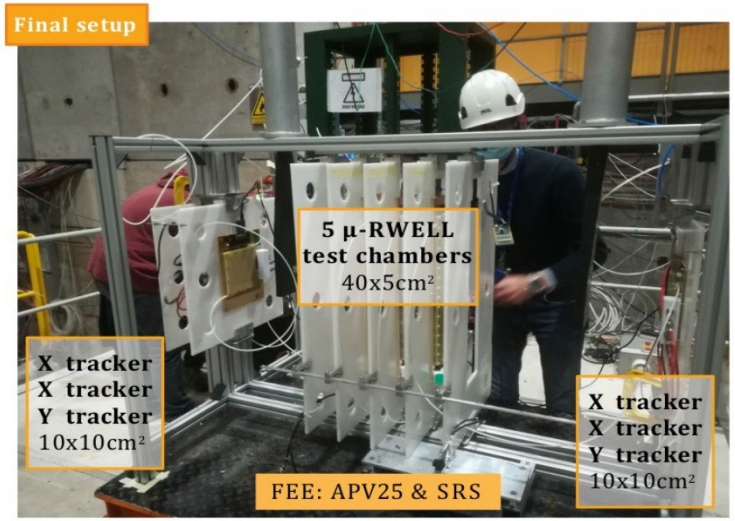


Layout 1D optimization

R&D for FCC: 1D R/out

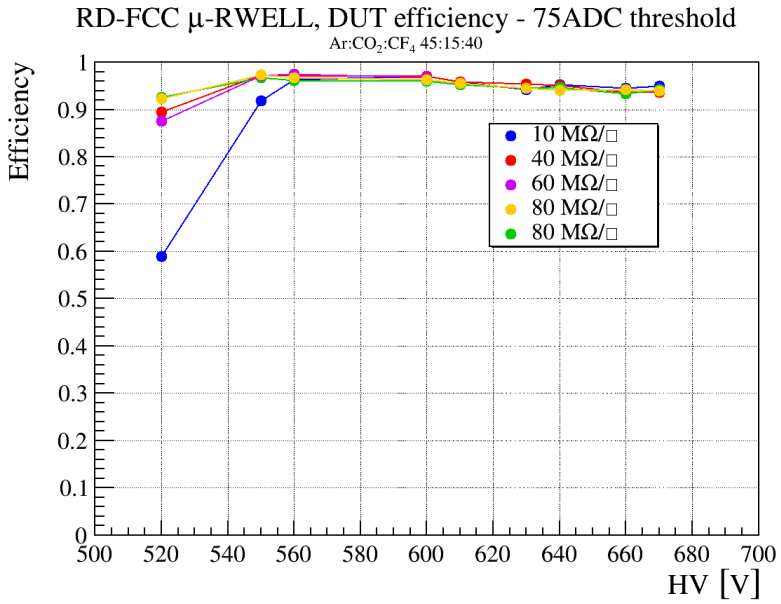
TB with DC + pre-shower + CALO+ Muon

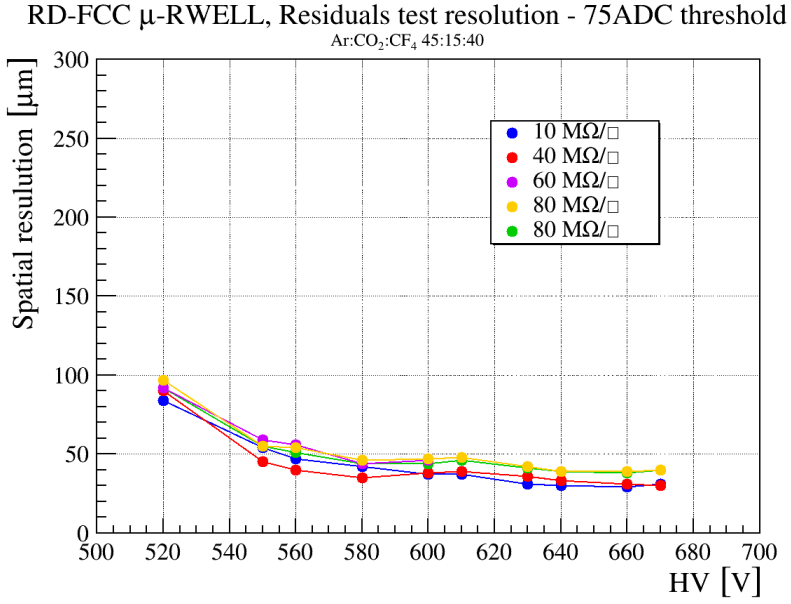




Active area= 400x50 mm2
Pre-preg thickness= 50 um
Resistivity= 10 ÷80 MΩ/□
Strip pitch= 0.4 mm
Strip width = 0.150 mm
Ratio p/w= 2.66

Resistivity Scan @ fixed pitch

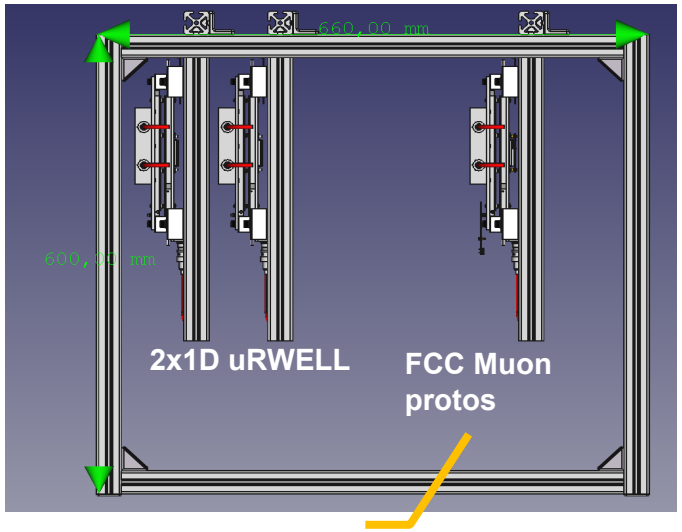




Same performance except the **10 MΩ/□ proto**
Efficiency knee @ 550 V, σ_x < 100 um

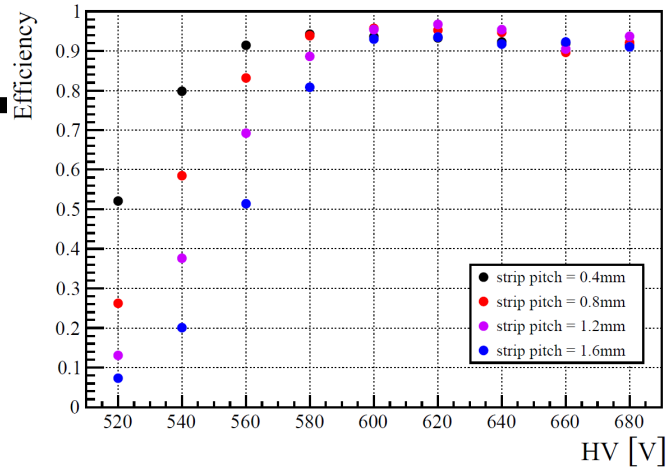
R&D for FCC: 1D R/out

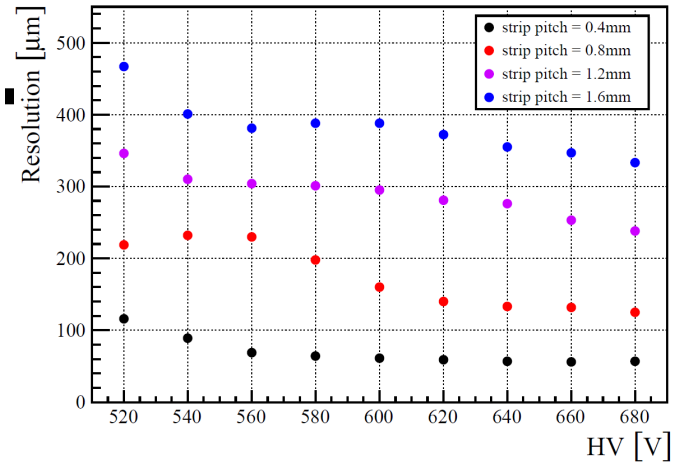
2022



Active area= 400x50 mm2
Pre-preg thickness= 50 um
Resistivity= 30 MΩ/□
Strip pitch= 0.4-1.6 mm
Strip width = 0.15 mm
p/w ratio= 2.66 – 10.66

R/O pitch scan @ fixed resistivity





Larger is the strip pitch, lower is the charge signal requiring a higher gain to reach full efficiency.

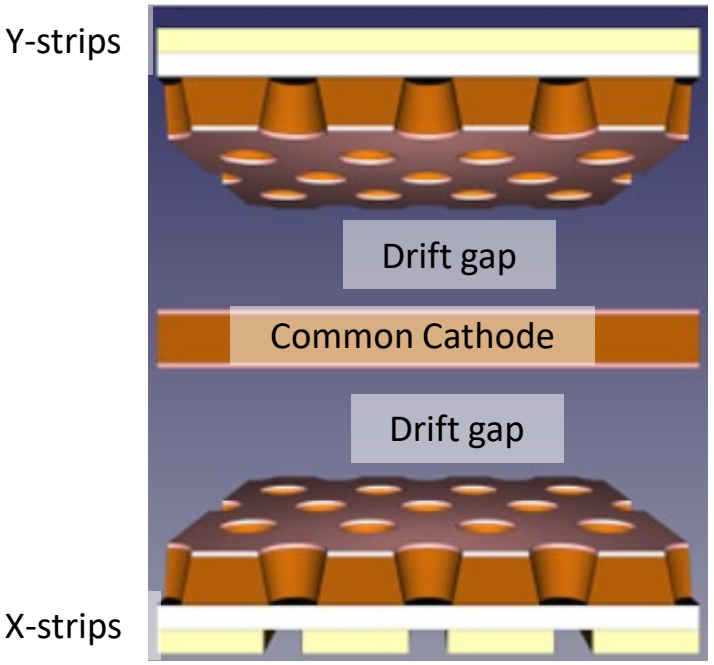
Efficiency knee @ 600 V & σ_x < 400 um for a strip pitch = 1.6 mm

A high p/w ratio implies a worsening of the detector performance

Layout 2D optimization

TB Analysis finalization -2D layouts – 10x10 cm²

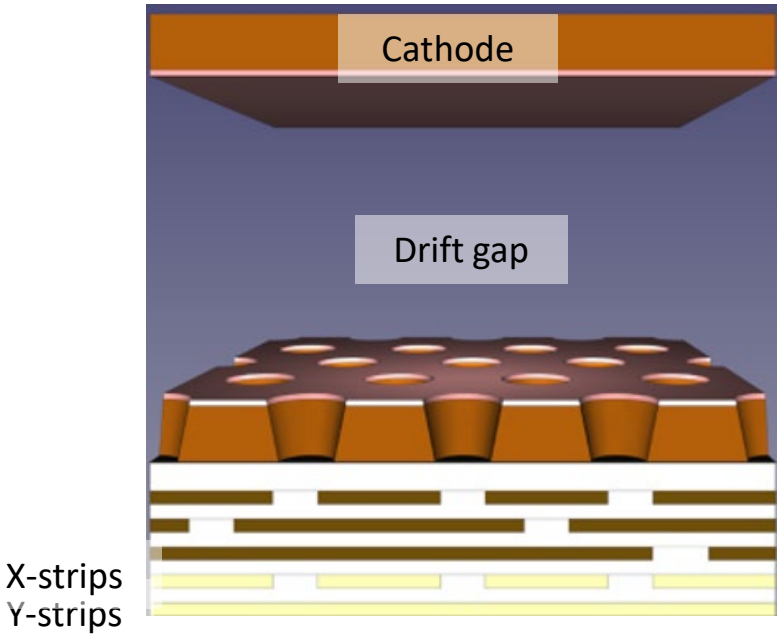
n.2 µ-RWELL 1D [2×1D]



- Lower gas gain w.r.t. the "COMPASS R/O" (X / Y are not sharing any charge)
- Tested @ TB2022

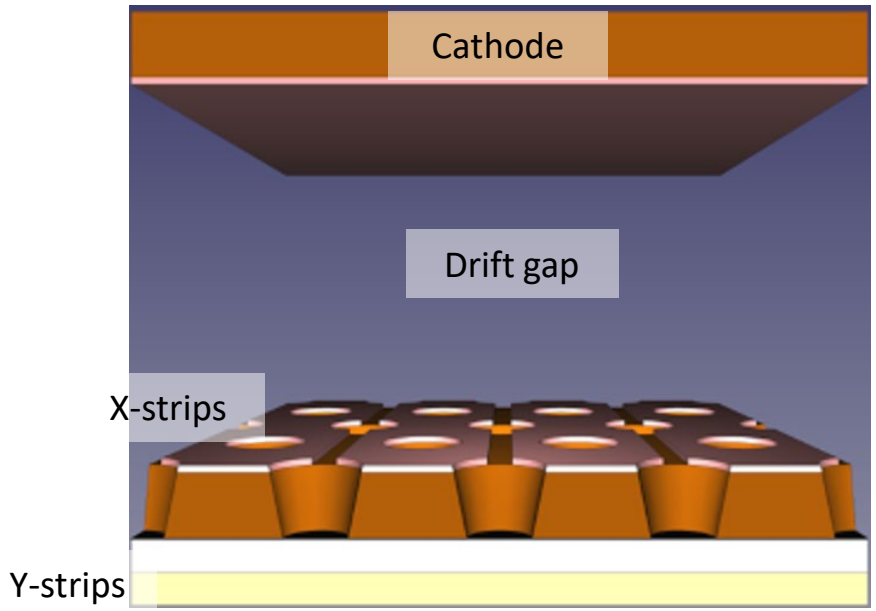
Capacitive Sharing [*]

[*] K. Gnanvo et al., NIM A 1047 (2023) 167782



- Stack of layers of pad
- Reduce the FEE channels
- The charge is divided between X and Y → Higher gas gain required w.r.t. 1D
- Tested @ TB2023

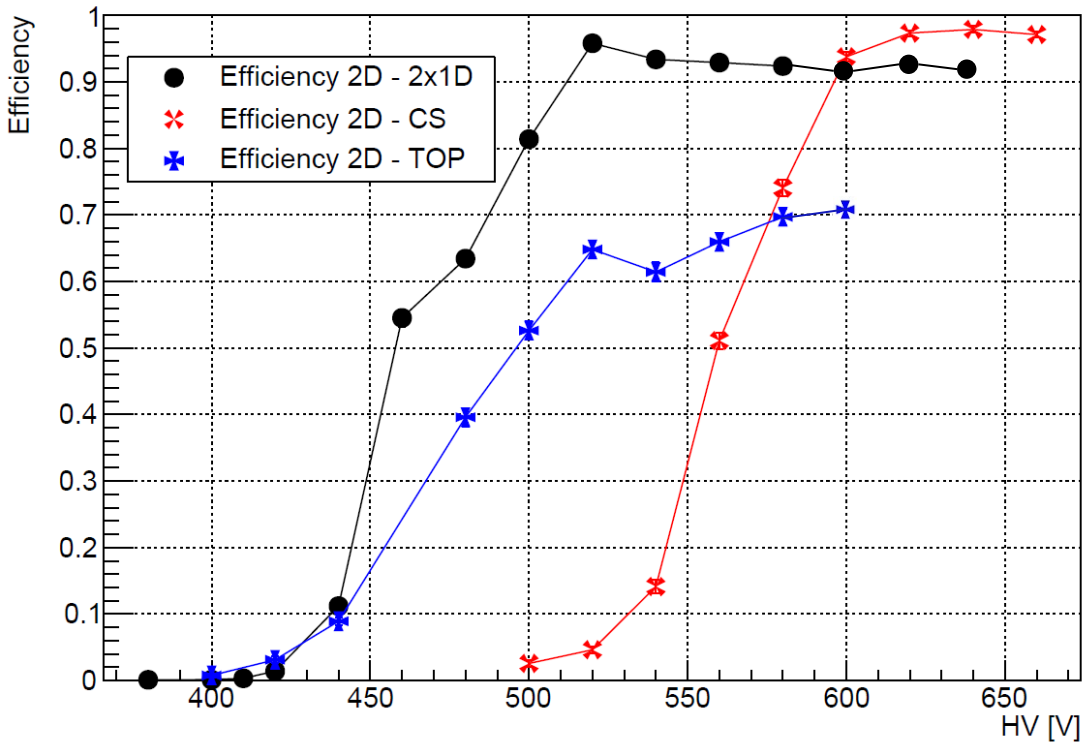
Top R/O



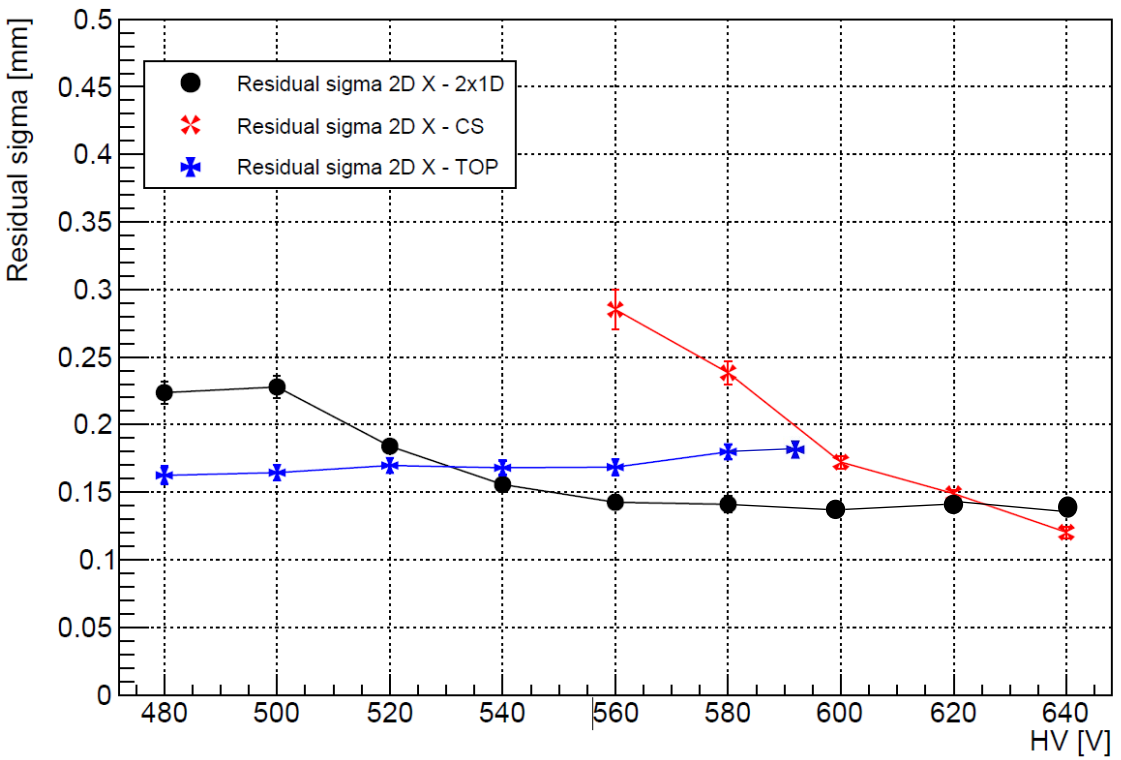
- Lower gas gain w.r.t. the "COMPASS R/O" (X / Y are not sharing any charge)
- The "Top" coordinate introduces dead zone in the active area
- Tested @ TB 2023

TB Analysis finalization -2D layouts

2D layouts – 10x10 cm^2



2D layouts – 10x10 cm^2



The results of TB-22-23, where the 2D layouts have been compared, gaving the following results:

2x1D layout: spatial resolution < 200um (pitch 0.8 mm), low voltage operating point ~520V, efficiency ≥98% (large eff. plateau)

CS layout: spatial resolution <200um (with pitch 1.2 mm), very high voltage operating point, ≥ 600V, efficiency ≥98%

Top layout: spatial resolution < 200um (pitch 0.8 mm), low voltage operating point ~520V, efficiency ~ 70% (dead-zone)

R&D program 2024

The production of the 2023 & 2024 layouts has been delayed due to the increased workload at the Rui's workshop

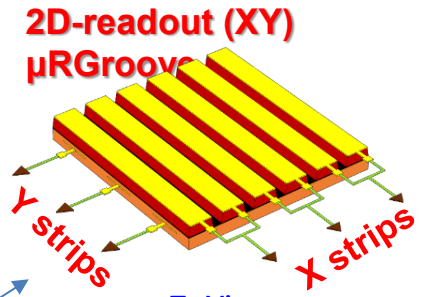
Solutions under study:

1. **µ-RWELL pitch optimization** → This study was done with GEM detectors but never with uRWELL → well pitch from 140 µm to 90 µm with an increase in gain of about a factor of 2. **Designed at the beginning of 2024 & detector delivery in Sept. 2024.**

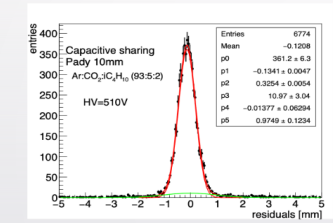
2. **Micro-RGroove layout**→ new layout, where the amplification stage is not based on the **«wells» but on the «grooves».** This facilitates the realization of the strip readout on the top, without introducing dead-zones (introduced by Z. Yi in RD51). **Designed at the end of 2023 & detector delivery in Sept. 2024.**

3. **CS layout with pad**→ new layout, where the readout PCB is not segmented in **strips but with pad.** This choice allows to collect all the charge on a single readout electrode with a small increase of FFE channels (30%). With pad of few cm2 a spatial resolution of ~300 um has been achieved (introduced by M. Iodice in RD51). **Designed in Sept. 2024.**

4. **Hybrid CS** → CS + GEM pre-amplification stage, to lower the operating point, greatly improving the RWELL stability and maintaining high spatial performance with millimetric pitches.

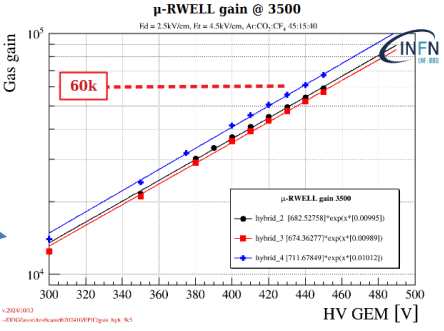


Z. Yi



large pad resolution ~320 µm
→ factor 1/30 of the pad size

M. Iodice



Call for interest

µ-RWELL

- R&D is on going to optmize the detector layout for FCC_ee. LNF responsible for R&D.
- Considering the huge costruction effort, the detector production will be shared among several institute. Collabation is welcome.

Front-end Electronics & Off-detector

- New chip is needed for this technology. Bo/To responsible for the R&D. Collaboration is welcome.

Software

- Simulation, recostruction and software is needed. Bo/Fe responsible for the simulation. Collaboration is welcome.

There are multiple options to contribute, with the possibility of leading contributions in many areas.

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Thanks for your attention