RD_FCC – GR1 @ WP7: LNF

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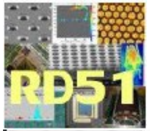

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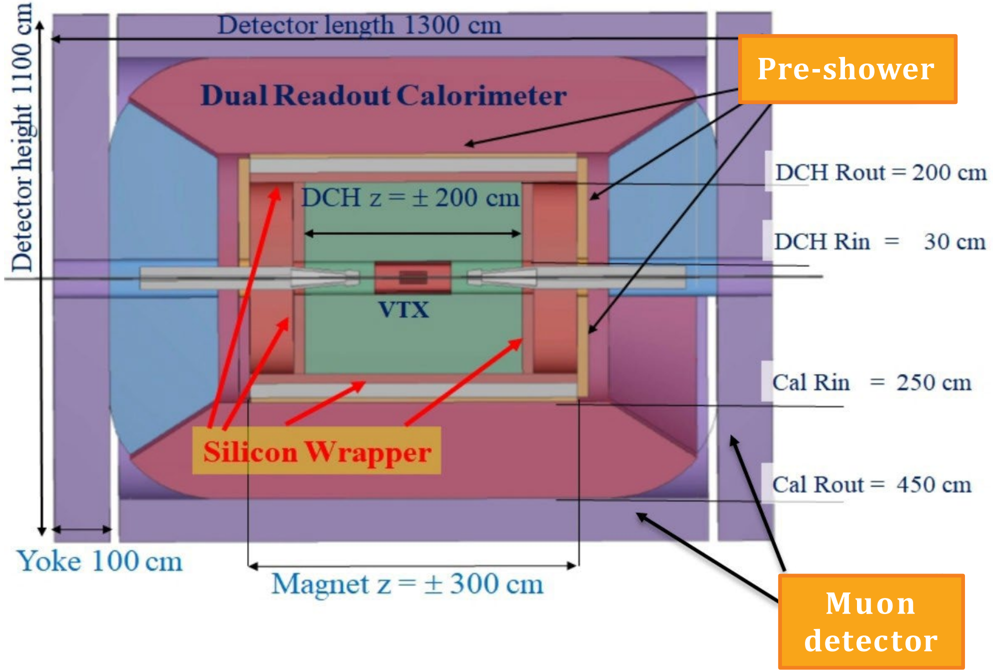
RD-FCC → μ-RWELL for tracking and muon system

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



Pre-shower

Tiles: 50x50 cm^2 with X-Y readout
Strip length: 50cm
TOT: 330 m^2, 1.5×10^6 channels (0.4 mm strip pitch)

Muon detector

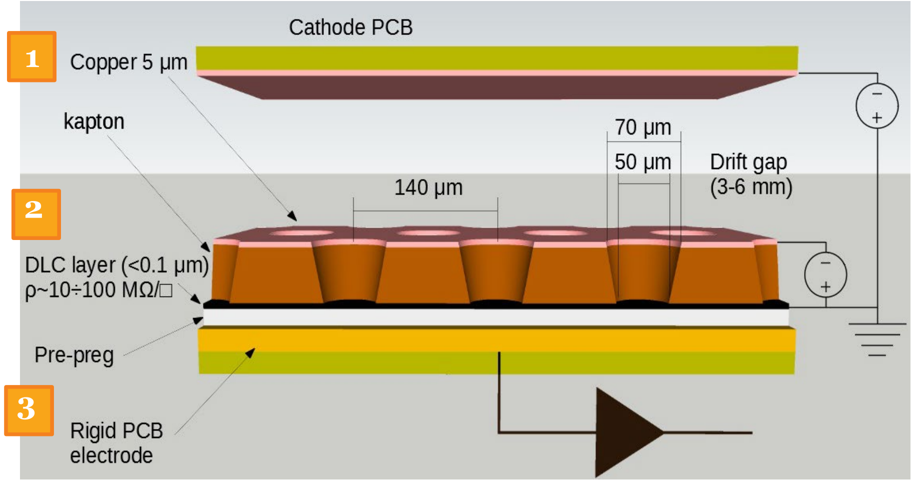
Tiles: 50x50 cm^2 with X-Y readout
Strip length: 50cm
TOT: 4000 m^2, 5×10^6 channels (1.5 mm strip pitch)

Requirements:

- **Tiles 50x 50 cm^2**
- **Efficiency ≥ 98%**
- **Space resolution ≤ 100 µm (pre-shower)**
  ≤ 400 µm (muon)
- **Mass production → Technology Trasfer to Industry**
- **FEE Cost reduction →custom made ASIC (TIGER)**

The μ-RWELL: detector scheme

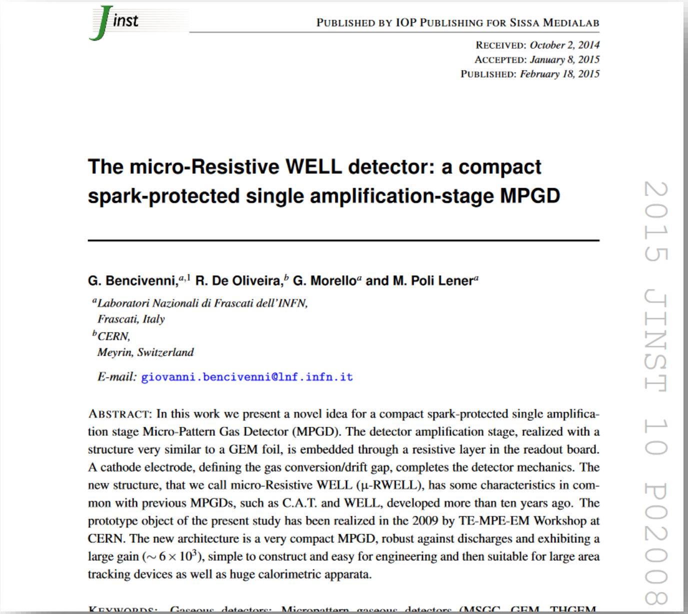
The μ-RWELL is a Micro Pattern Gaseous Detector (MPGD) composed of only two elements: the μ-RWELL_PCB and the cathode.
The core is the μRWELL_PCB realized by coupling three different elements:



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

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

3 a standard readout PCB



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The micro-Resistive WELL detector: a compact spark-protected single amplification-stage MPGD

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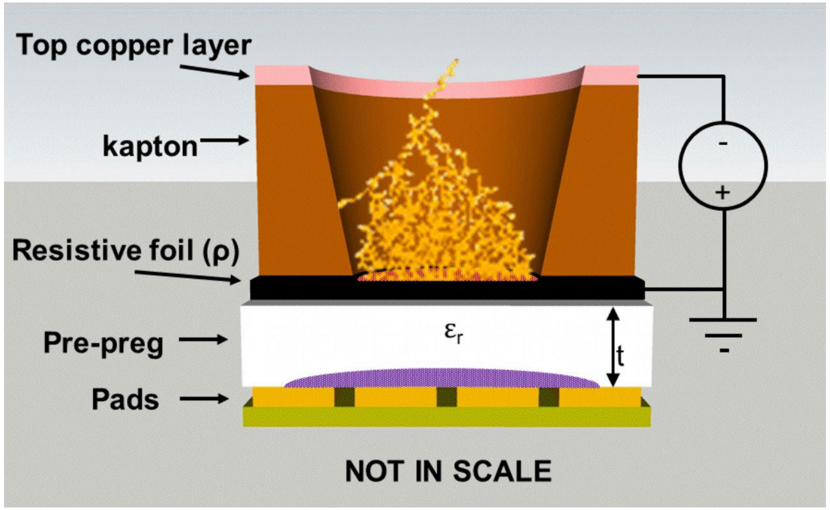
ABSTRACT: In this work we present a novel idea for a compact spark-protected single amplification stage Micro-Pattern Gas Detector (MPGD). The detector amplification stage, realized with a structure very similar to a GEM foil, is embedded through a resistive layer in the readout board. A cathode electrode, defining the gas conversion/drift gap, completes the detector mechanics. The new structure, that we call micro-Resistive WELL (μ-RWELL), has some characteristics in common with previous MPGDs, such as C.A.T. and WELL, developed more than ten years ago. The prototype object of the present study has been realized in the 2009 by TE-MPE-EM Workshop at CERN. The new architecture is a very compact MPGD, robust against discharges and exhibiting a large gain ($\sim 6 \times 10^3$), simple to construct and easy for engineering and then suitable for large area tracking devices as well as huge calorimetric apparata.

2015 JINST 10 P02008

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

The μ-RWELL: principle of operation

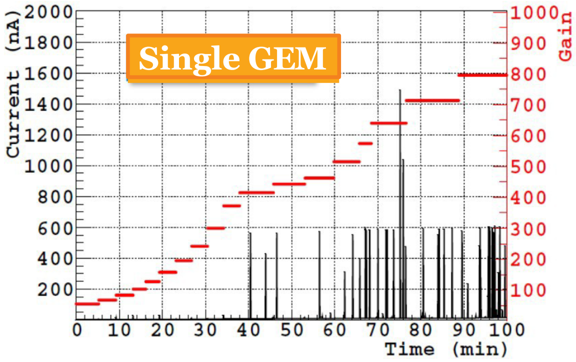
Applying a suitable voltage between the **top Cu-layer and the DLC** the WELL acts as a **multiplication channell for the ionization** produced in the conversion/drift gas gap.

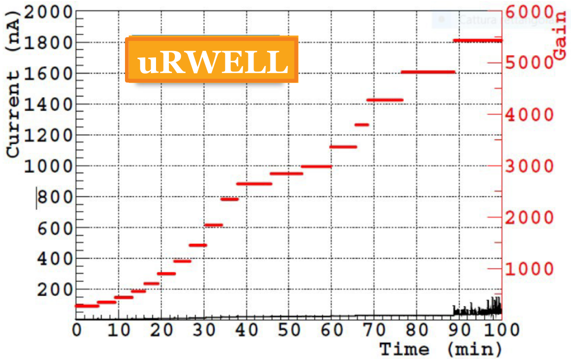


Introduction of the **resistive stage:**

Pros: suppression of the transition from streamer to spark
→Spark amplitude reduction

Cons: reduction of the capability to stand high particle fluxes.
But an **appropriate grounding schemes** of the resistive layer solves this problem (see next slide)



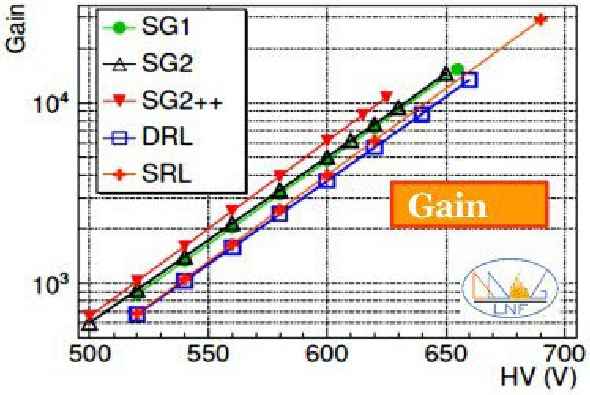


Comparison between the **current** drawn by a single GEM and a μ-RWELL at various **gas gain**.

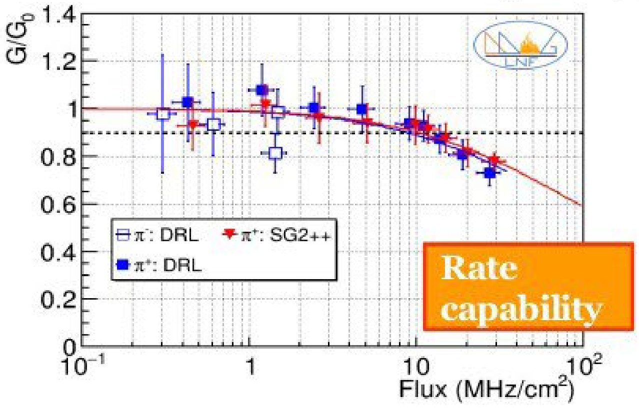
The black spikes are the sparks in the detectors, clearly dumped in the μ-RWELL for higher gains

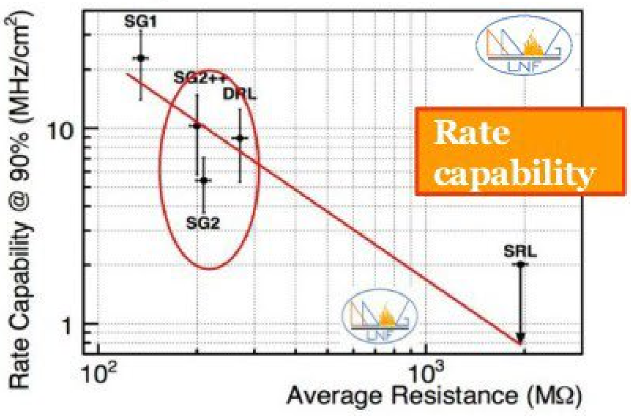
µ-RWELL performance overview

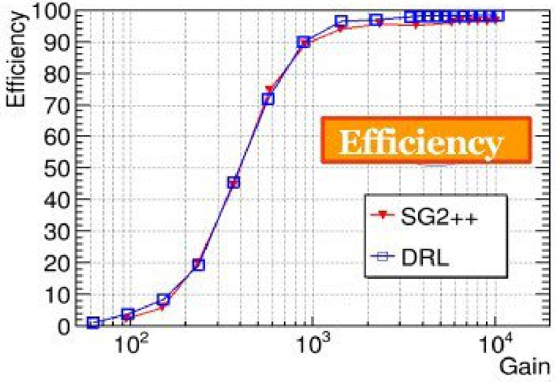
Gain up to 10^4



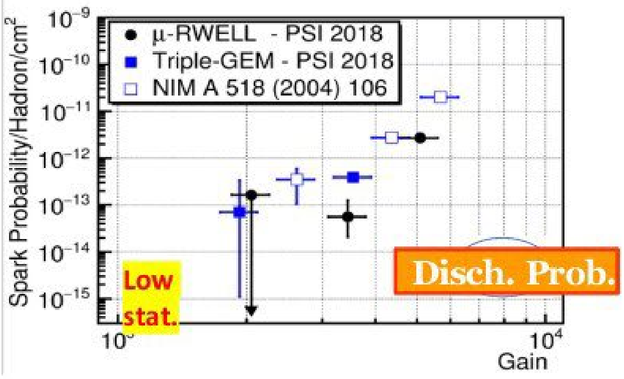
Rate Capability (@ G= 5000) ~ 5-10 MHz/cm^2



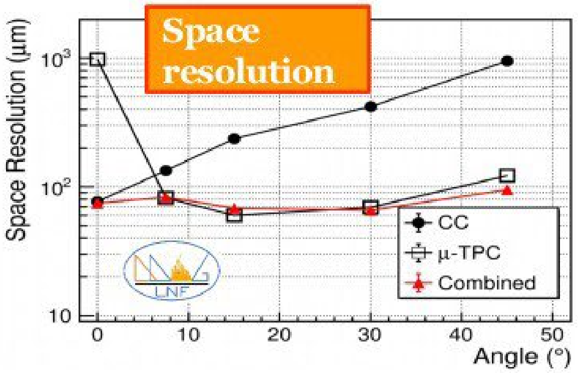




Efficiency ~ 98%



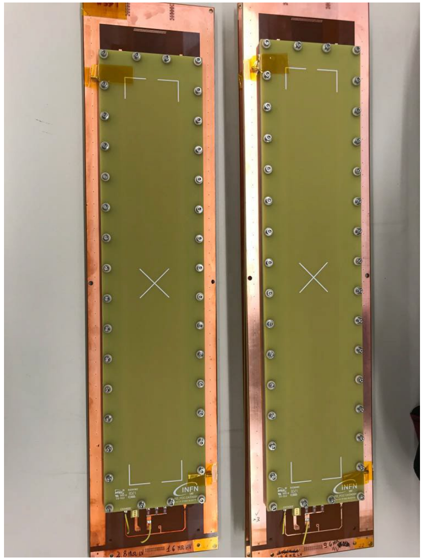
Discharge probability ~ 10^{-13} @ 4000

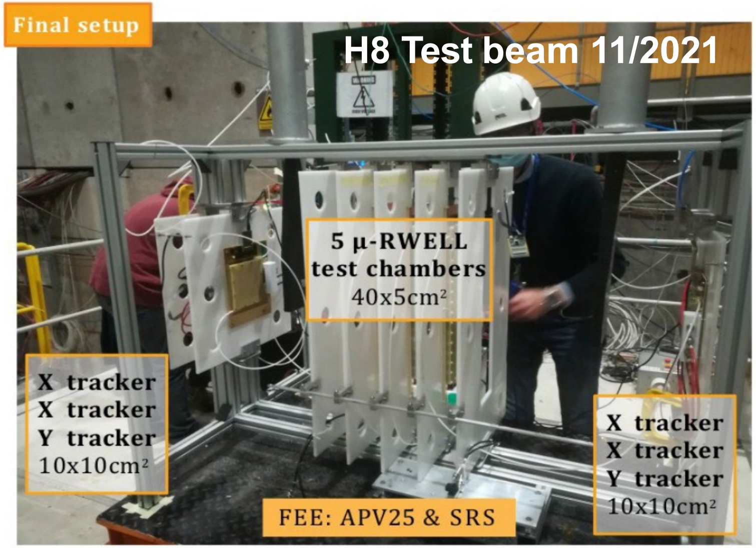


Space resolution ~ 100 µm

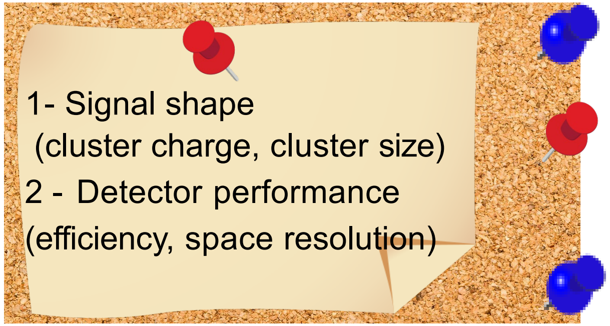
2021 Test Beam: 1D readout u-RWELL

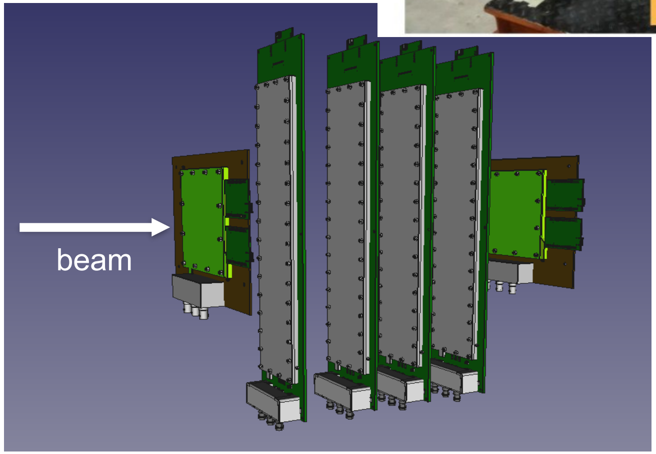
New μ-RWELL prototypes with 40cm long strips (1D readout)





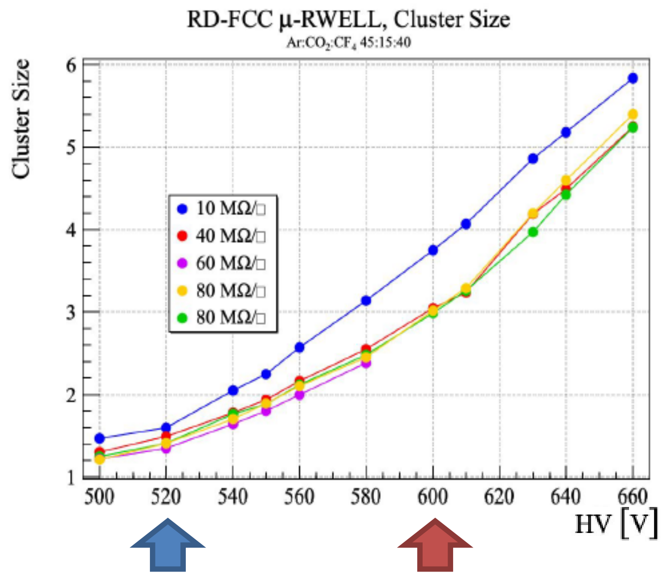
140-180 GeV/c muon and pion beam
Operated in $Ar/CO_2/CF_4$ (45/15/40)

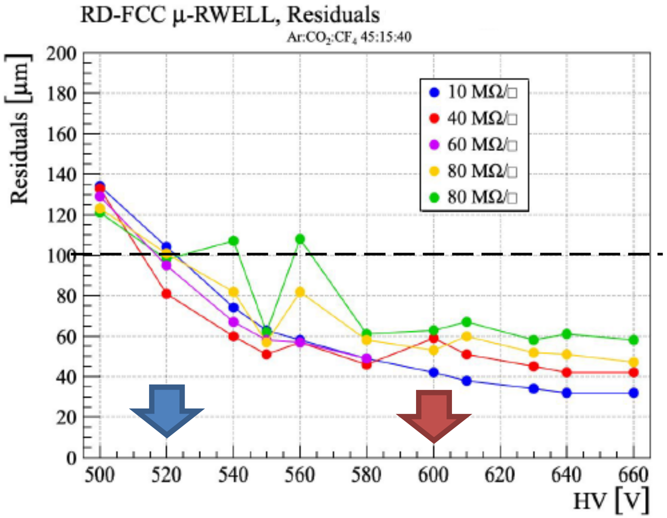




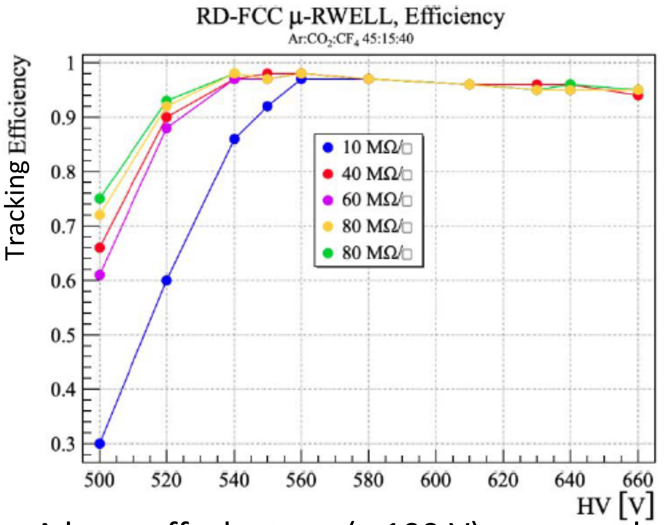
7 μ-RWELL prototypes with resistivity varying between 10 and 80 MOhm/O will allow to define best resistivity for final 50x50 cm^2 detector

Preliminary Results 2021





With a pitch 0.4 mm at HV=520 V and with CL=1.5 → σ<100 um
With a 0.8 mm pitch, increasing the HV=600V, we estimate a CL=1.5 expecting a σ<100 um
We are extrapolating from 2021 TB runs the performance with 0.8 mm strip pitch



A large eff. pleateau (> 100 V) measured

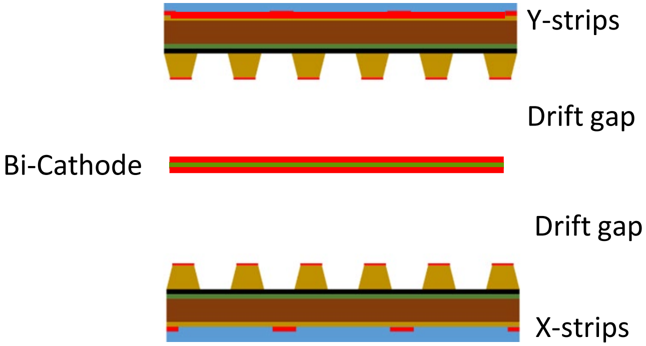
The **increase of the strip pitch** allows to decrease the FEE channels without compromising the spatial resolution

R&D for 2022-23

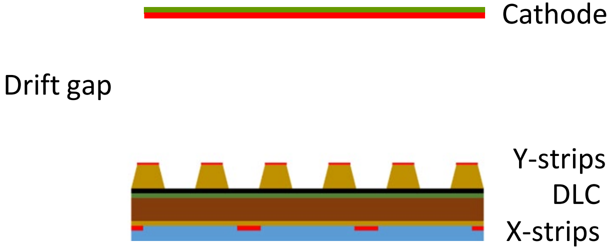
L'R&D for the 2022 foreseen the production of uRWELL with **X-Y readout TB a Ottobre 2022 (SPS-H8-CERN)**

Detector layouts 2D

N.2 u-RWELLs 1D



N.1 u-RWELL 2D



Y coordinate on the TOP of the amplification stage

These layouts allow to operate at lower gain with respect to the GEM detectors in «COMPASS»

Easy production technlogy for both layouts.
Bi-dimensional space resolution to be verified with Beam Test

Technology transfer with ELTOS/CERN

DLC sputtering with new INFN-CERN machine @ CERN

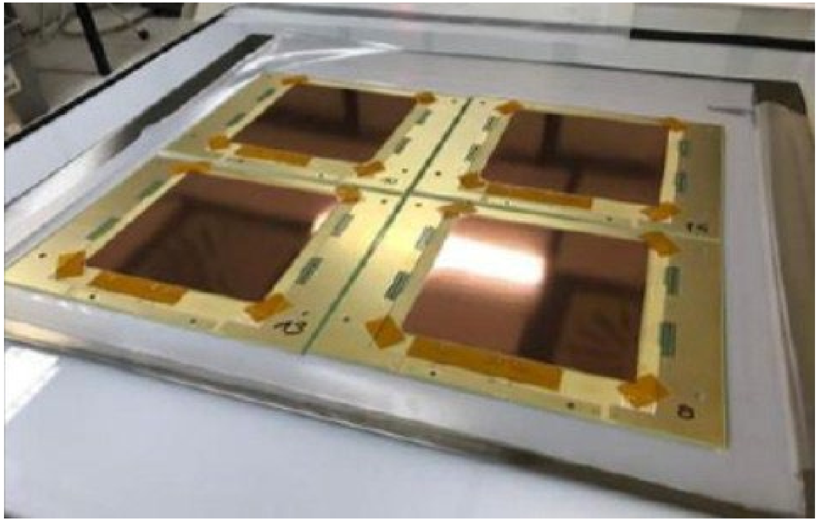
Step 1: producing μ-RWELL_PCB

- with top patterned (pad/strip)
- without bottom patterned

Step 2: DLC patterning

- in ELTOS with BRUSHING-machine

9



Step 3: DLC foil gluing on PCB

-double 106-prepreg (~2x50 μm thick) (already used in ELTOS)

- pre-smoothing + 106-prepreg (~50 μm thick)
- single 1080-prepreg (~75 μm thick)

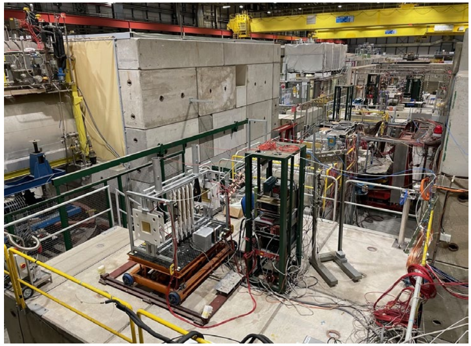
Step 4: top copper patterning

Finalization

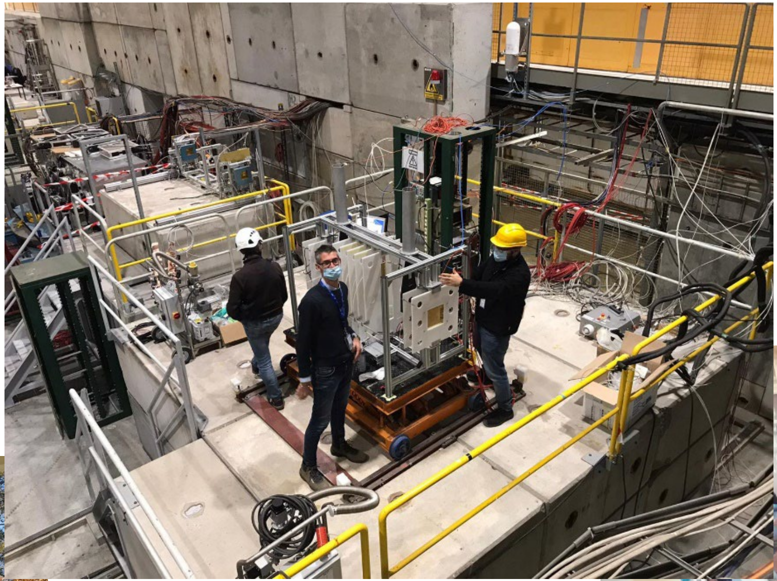
Step 5: Kapton etching on small PCB

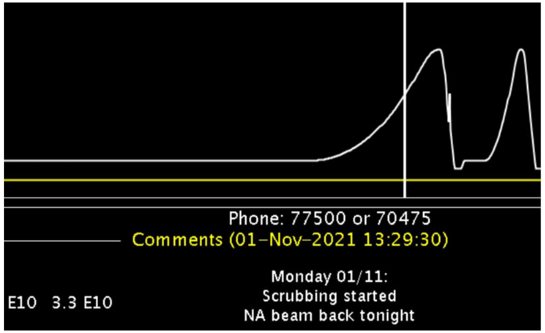
Detector @ CERN for final preparation

Conclusioni



- μ-RWELL now is a mature technology
  - It is also considered for an upgrade of the LHCb Muon apparatus and for the spectrometer of CLAS12 Jlab (White paper for Snowmass)
- IDEA detector concept is considered for both FCC-ee and CEPC future colliders
  - Preshower and muon detectors designed with the μ-RWELL technology
    - Studies aimed at defining the best DLC resistivity and strip pitch for the requested spatial resolution of the preshower and muon detectors
    - 2D μ-RWELL prototype characterization with a new test beam in 2022
    - Continue partnership with ELTOS (preparation) and CERN (finalization) to complete technology transfer
  - Develop a new custom-made ASIC for μ-RWELL readout
  - Final design ready for next FCC-ee and CEPC descriptive document (2025-2027)





Thanks for your attention

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