ICHEP 2022 BOLOGNA

ICHEP 2022 XLI International Conference on High Energy Physics Bologna (Italy)

6 13 07 2022

The µ-RWELL technology at the IDEA detector

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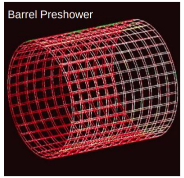
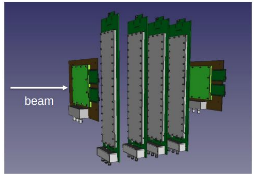
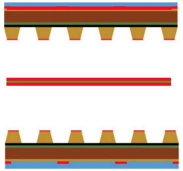
Outline



IDEA, pre-shower and muon chamber



The µ-RWELL technology, measurements and **optimization**



Further activities, simulation and new layouts

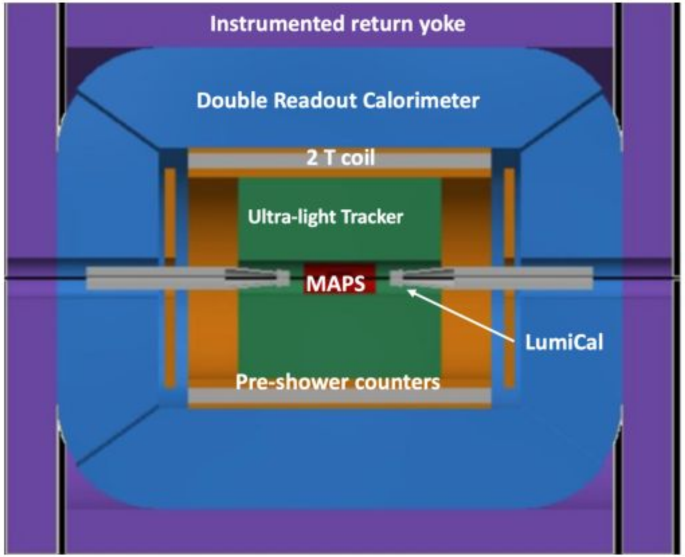
IDEA detector

International **D**etector for **E**lectron-positron **A**ccelerators

Combining novel elements with past and present lepton colliders, the FCC-ee design achieves outstandingly high luminosity.

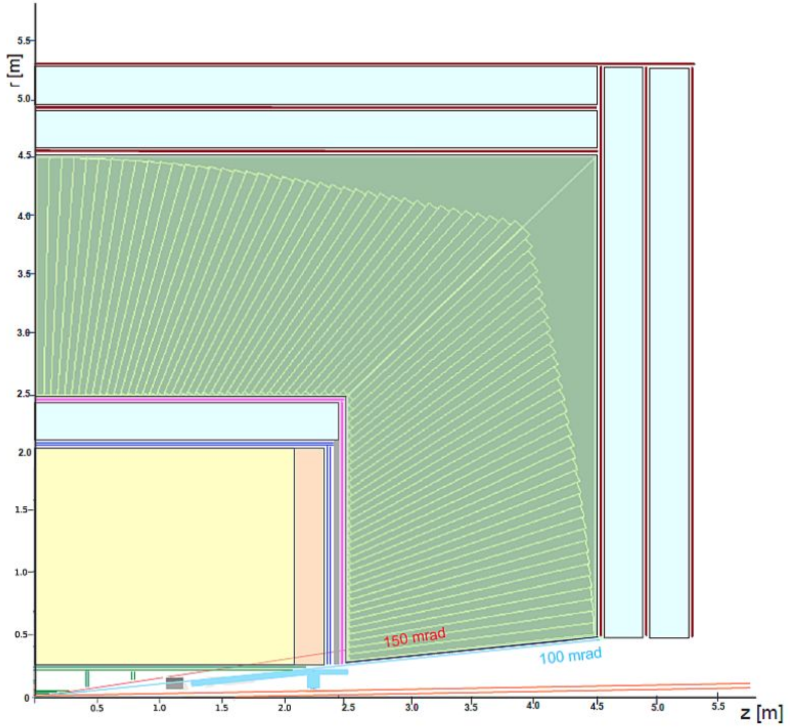
This will make the FCC-ee an instrument to study the heaviest known particles (Z, W and H bosons and the top quark) to improve the precision measurement in literature and the sensitivity to new physics.

See **G. Gaudio**'s talk for more information.



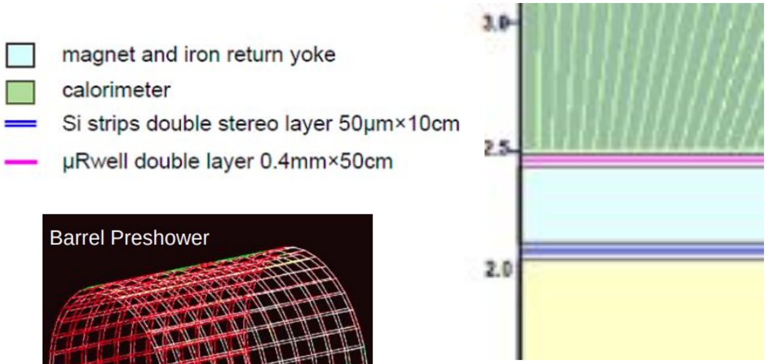
IDEA detector concept

- drift chamber
- drift chamber service area
- magnet and iron return yoke
- calorimeter
- Si pixels
  - 20µm×20µm (inner barrel layers)
  - 50µm×1mm (outer barrel layers)
  - 50µm×50µm (forward disks)
- Si strips double stereo layer 50µm×10cm
- µRwell double layer 0.4mm×50cm
- µRwell double layer 1.5mm×50cm
- absorber (lead)
- luminometer
- steel simulating compensating and shielding solenoids
- vacuum tube



The IDEA pre-shower

High resolution before the magnet to improve cluster reconstruction



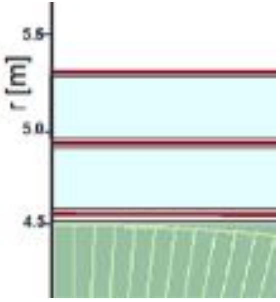
Efficiency > 98%
Space Resolution < 100 μm
Mass production
Optimization of FEE channels/cost

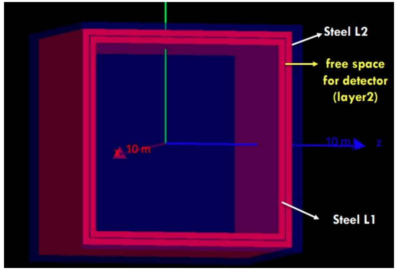
50x50 cm^2 2D tiles

pitch = 0.4 mm
FEE capacitance = 70 pF
1.5 million channels

A first testbeam to explore the interplay between preshower and calorimeter

The IDEA muon detector





Reconstruct and tag the muon

Efficiency > 98%
Space Resolution < **400 μm**
Mass production
Optimization of FEE channels/cost

50x50 cm^2 2D tiles
to cover more than **4330 m^2**

pitch = 1.5 mm
FEE capacitance = 270 pF
5 million channels

µ-RWELL
technology and optimization

μ-RWELL technology

The μ-RWELL is composed of only **two elements**:

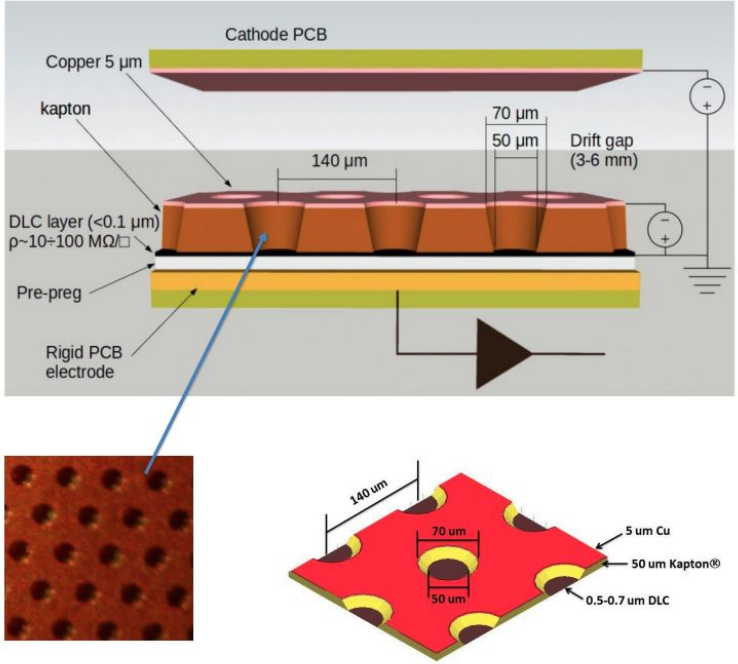
- μ**-RWELL_PCB** = amplification-stage ⊕
  resistive stage ⊕
  readout PCB
- **cathode** defining the gas gap

μ-RWELL **operation**:

1. A charged particle **ionises** the gas between the two detector elements
2. Primary electrons **drift** towards the μ -RWELL_PCB (anode) where they are **multiplied**, while ions drift to the cathode or to the anode
3. The signal is **induced** capacitively, through the DLC layer, to the readout PCB
4. HV is applied between the resistive stage and the cathode to collect the primary electrons
5. HV is also applied between the resistive stage and the copper layer on the top of the kapton foil (anode), providing the amplification field

See **G. Morello**'s talk for more details on performance and characterization

G. Bencivenni et al., 2015 JINST 10 P02008



μ-RWELL technology

Well **known performance** on prototypes 10x10 cm^2 active area:

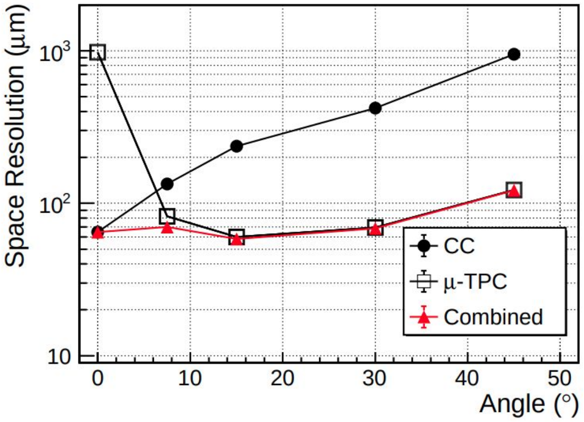
efficiency > 98%
spatial resolution < 100μm
rate capability >> 1 MHz/cm^2

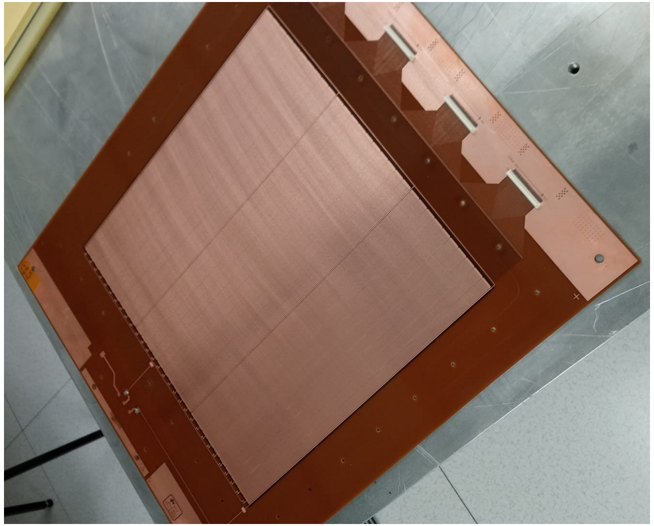
The detector is build up by two “pieces” only.
This simplifies the construction and assembly.

The uRWELL technology fully compatible with standard PCB building procedures (SBU) **allows an easy Technological Transfer** to industry, opening the way towards industrial **mass production**.

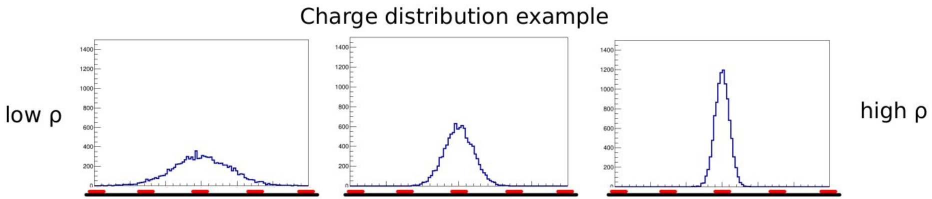
See **G. Morello**’s talk for more details
on high rate R&D and Technological Transfer

G. Bencivenni et al., JINST 16 (2021) 08, P08036





Detector optimization



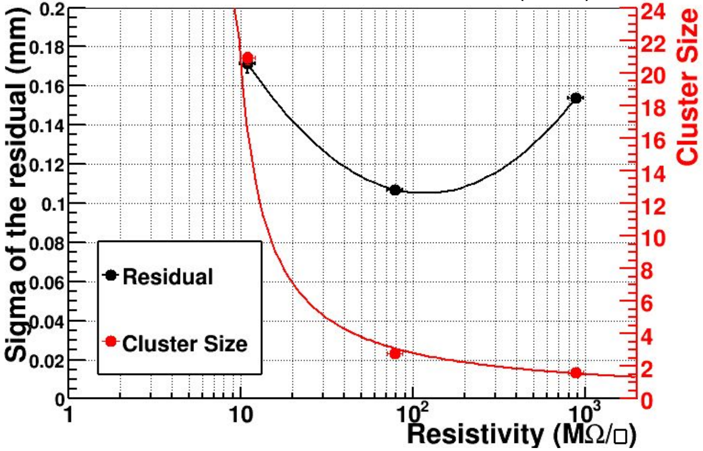
The use of **low resistivity** increases the charge spread (cluster size) on the readout strips and then spatial resolution is worsening.

At **high resistivity** the charge spread is too small (Cl.size ~1) then the Charge Centroid method becomes no more effective (σ~ pitch/12).

Preshower -> reduce the resistivity to reduce the cluster size, keeping the same spatial resolution

Muon chamber -> reduce the number of channel matching the cluster size (resistivity) with a larger pitch (1.5 mm)

G. Bencivenni et al., NIM A 886 (2018) 36



Experimental measurements

Setup:

Active area: 5 x 40 cm2
Strip length: 40 cm (close to 50cm)
FEE capacitance ~ 50 pF
6 detector for tracking, event selection and alignments
DUTs are in the middle

Settings:

Gas mixtures: Ar/CO2/CF4 (45:15:40)
Electronics: APV25 + SRS
Beam: muons w/ 140-180 GeV/c

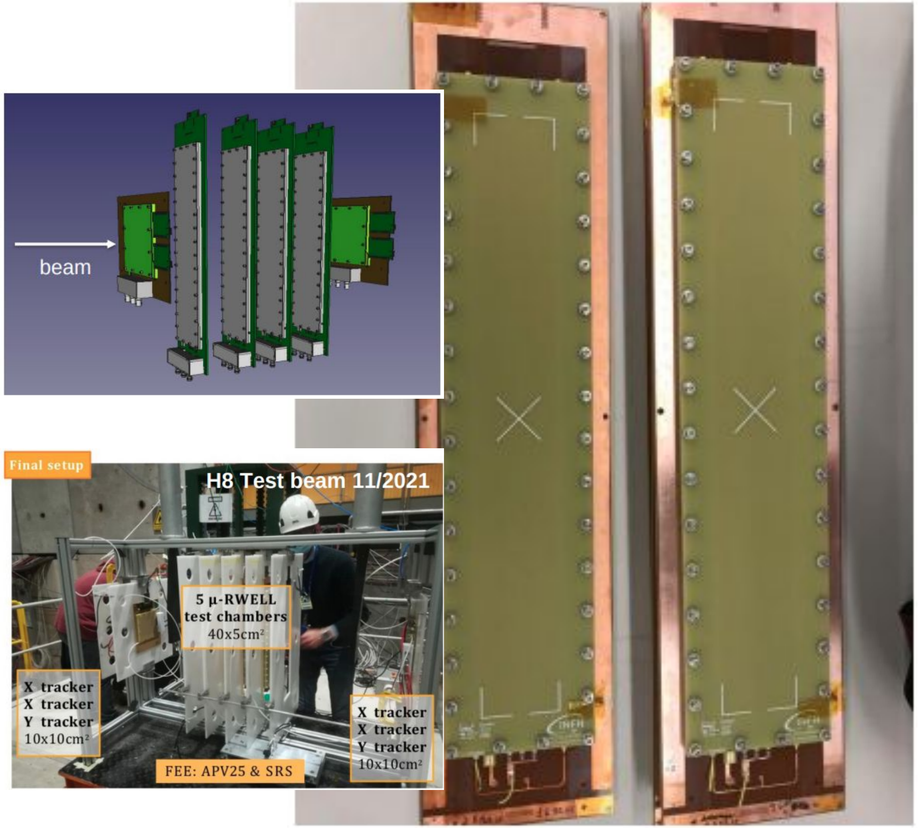
Resistivity range under test: 10-80 MΩ/□

Measurements:

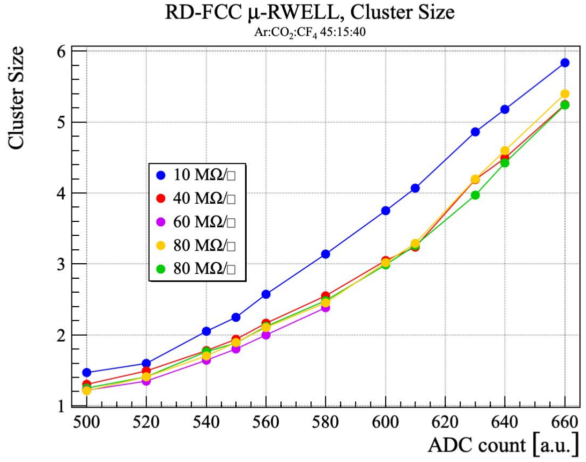
1. HV scan
2. Impinging angle scan
3. Drift field scan

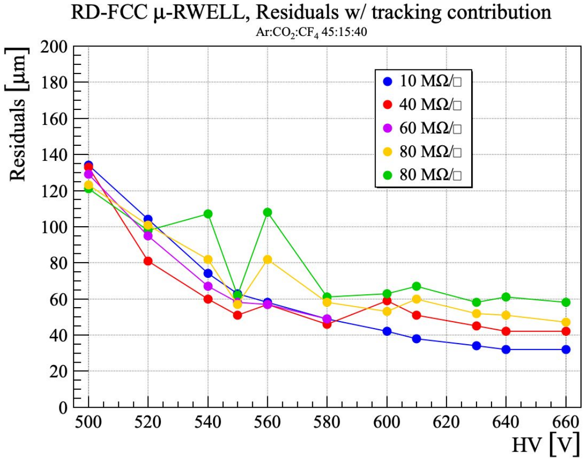
Goals:

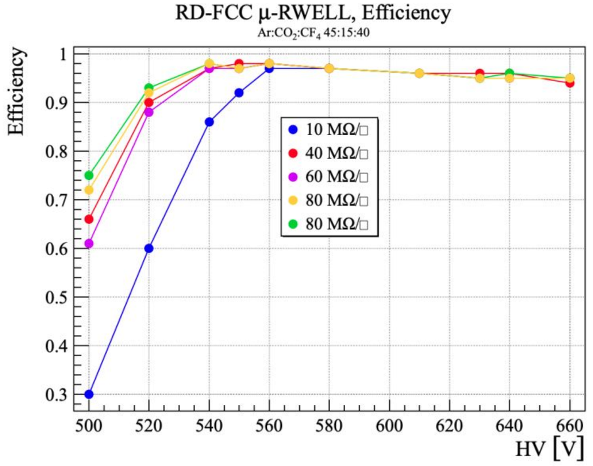
Characterize the μ-RWELL signal shape (charge and multiplicity) as a function of the resistivity



Resistivity scan results







An **HV scan** shows a large range of operability with a cluster size range [1-5]. The core spatial resolution is preliminary but it shows results better than 100 μm with a strip pitch of 400 μm and center of gravity algorithm.

The **dependence** on the DLC **resistivity** is smaller in the range 40-80 MΩ/□ for cluster charge and cluster size, while the major dependency are observed in the spatial resolution behavior.

Further activities

Parametrization of a μ-RWELL

GARFIELD++ capabilities

+

More speed

Parametrization!

- Ionization
- Electron Drift
- Amplification
- Resistive
- Induction
- Readout
- Reconstruction

Available tool: GARFIELD++

STRAIGHTFORWARD CHOICE!

Reading from the webpage https://garfieldpp.web.cern.ch

is a toolkit for the **detailed simulation of detectors which use gases** or semi-conductors as sensitive medium.

the main area of application is currently in **micropattern gaseous detectors.**

Ionisation → Heed generates ionisation patterns of fast charged particles

Electric fields → interfaces with the finite element programs (Ansys, Elmer, Comsol and CST) which can compute approximate fields in nearly arbitrary 3D configurations with dielectrics and conductors

Transport of electrons → Magboltz is used for computing electron transport and avalanches in nearly arbitrary gas mixtures

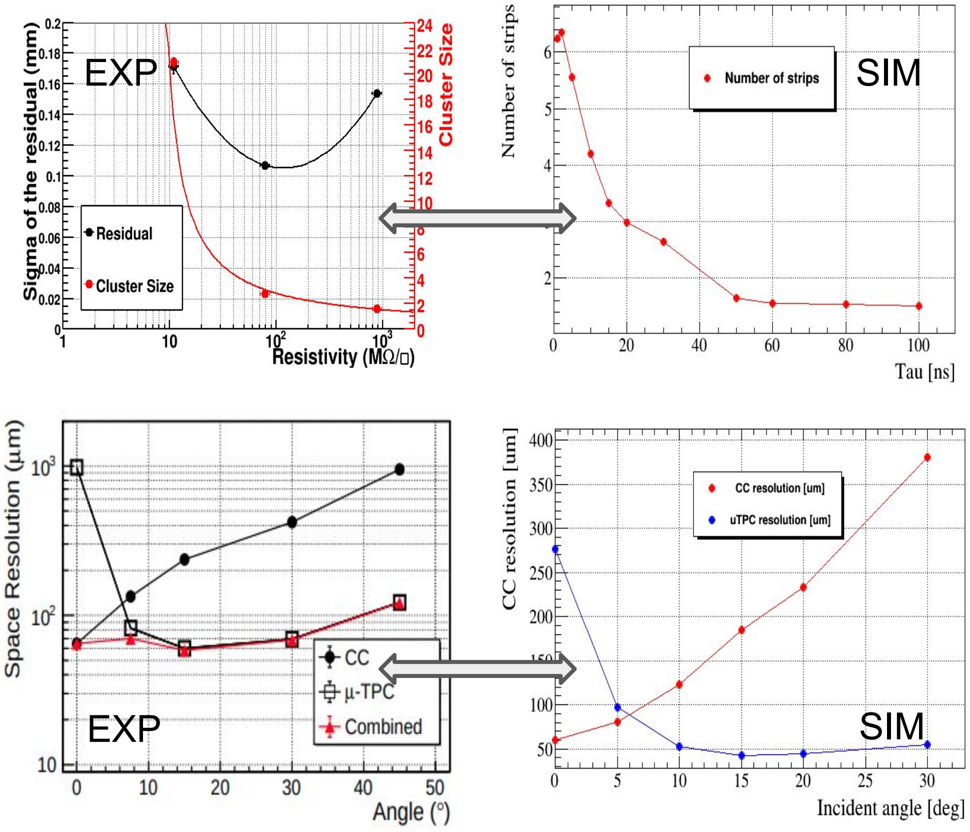
RD51 - GTS 4

Simulation under study

Thanks to a detector parametrization,
it is possible to reproduce the **μ-RWELL signal**.

Different **configuration** (resistivity, angle, etc…) can be tested

First results shows a good agreement with the experimental data but a fine **tuning** of the parameters is needed to exploit the simulation.

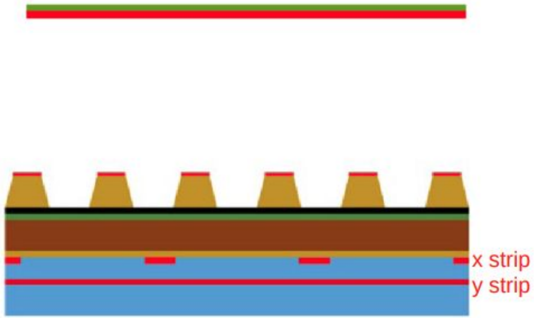


A new TestBeam for 2D readout layouts

μ-RWELL with 2D anode readout

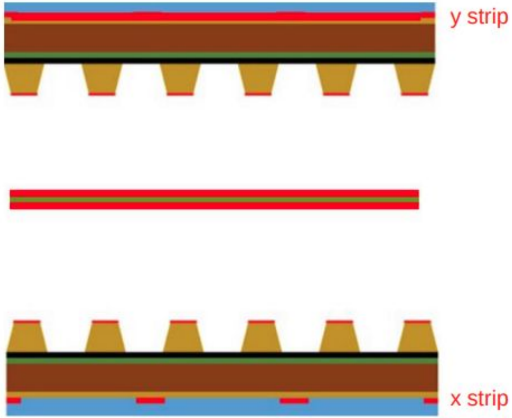
Good performance
but need higher gain wrt. to 1D
μ-RWELL

More complex PCB construction



2 stacked 1D μ-RWELL

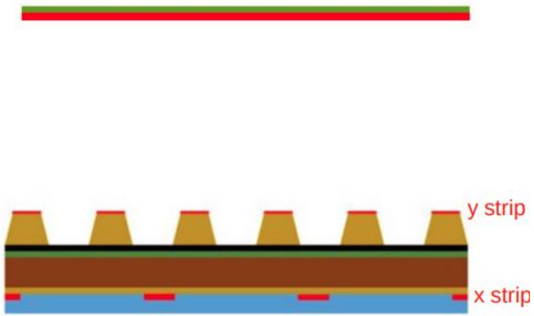
1 view per μ-RWELL
easy PCB construction
2D performance to be
measured



μ-RWELL with strips on top and anode

HV on DLC,
TOP to ground

2D performance to be
measured



Conclusion

The μ-RWELL technology is under **optimization** (resistivity and pitch)
to match the IDEA **requirements** (performance and budget)

A new R&D on the **2D readout** is ongoing
and a testbeam in October 2022 is planned

A preliminary **fast simulation** of the detector have been developed
and after a tuning with the data will provide a tool to extend the investigation

Thank You

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