The µ-RWELL Technology for IDEA apparatus

Emma Di Fiore for *µ-RWELL Muon System group for IDEA*

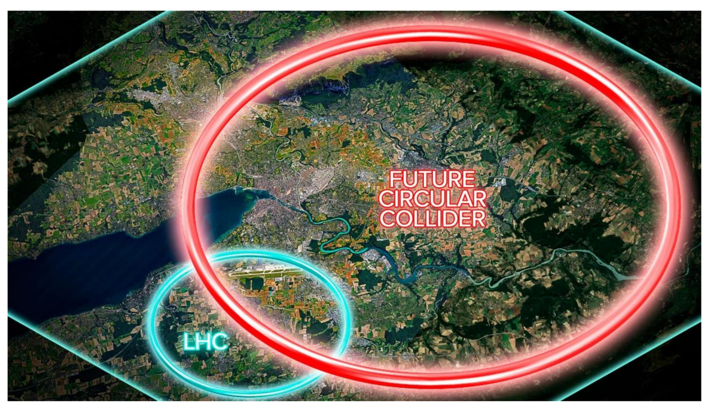
Università degli Studi di Ferrara, Italy
Istituto di Fisica Nucleare, Sezione di Ferrara, Italy

FUTURE CIRCULAR COLLIDER

INFN Istituto Nazionale di Fisica Nucleare

EXPERIMENT

The Future Circular Collider



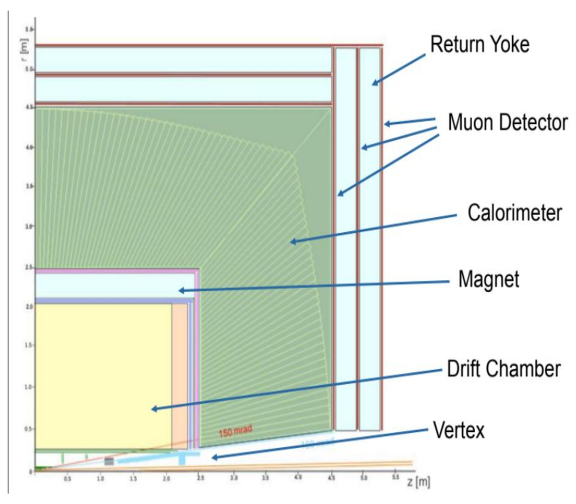
TWO STAGES:

- **FCC-ee:** about 15 years from the mid-2040s
- **FCC-hh:** about 25 years from the 2070s

PHYSICS AT FCC-ee:

FCC-ee will study with the highest possible statistics the **Z**, **W**, **HIGGS** and **TOP QUARK**

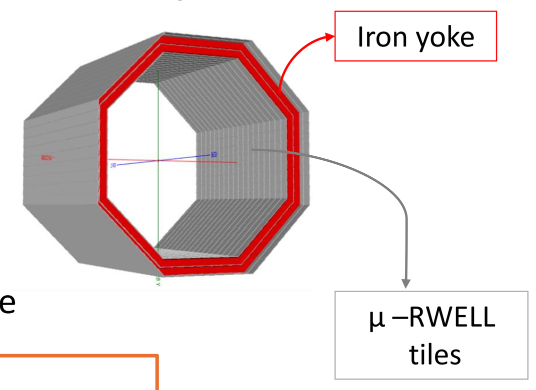
It would also provide precision measurement on the **LONG LIVED PARTICLES**, such as ALPs [1]



The IDEA Muon detector at FCC:

The muon detector is composed of **three layers** in between the **iron return yoke** to:

- Reconstruct and tag **MUONS**
- Reconstruct **LONG LIVED PARTICLES**



DETECTOR TECHNOLOGY:

- 50x50 cm^2 **µ -RWELL tiles** with **X-Y readout**
- **1525 m^2** area
- **5 milion channels** with **1.5 mm strip pitch** segmented anode

REQUIREMENTS:

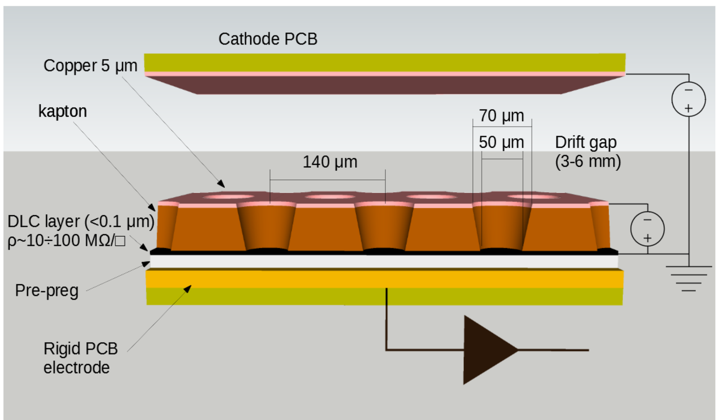
- **Efficiency > 98%**
- **Spatial Resolution < 400 µm**
- **Mass Production**
- **Optimization of FEE channels/cost**

TECHNOLOGY

The µ-RWELL Technology

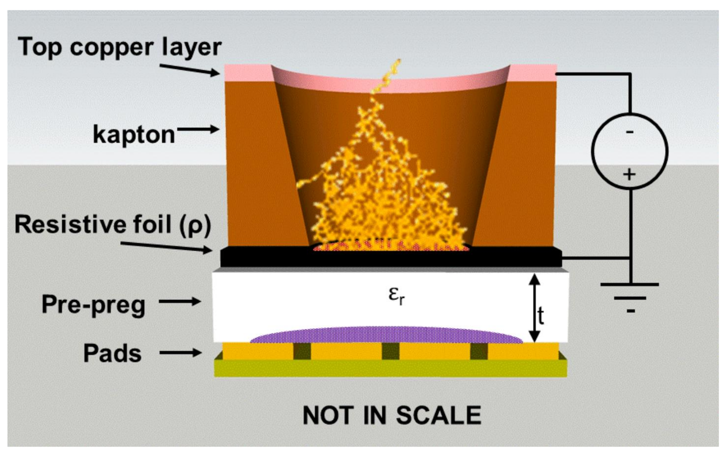
The micro-Resistive WELL is a **single-amplification stage** Micro-Pattern Gaseous Detector, composed of two main components:

1) **Cathode**
2) **Micro-RWELL Printed Circuit Board (PCB):**
   - Kapton foil with the **WELL structure**
   - **Resistive** Diamond Like Carbon (**DLC**)
   - Strip or pad **readout**



OPERATION:

- Charged particle **ionizes** the gas
- **Drift field** guides electron towards the WELL
- **One amplification stage** inside the WELL ~ 10^4 V/cm [2]
- **Signal induced capacitively** (through the DLC) to the readout PCB
- The presence of the DLC influences the charge distribution on the readout

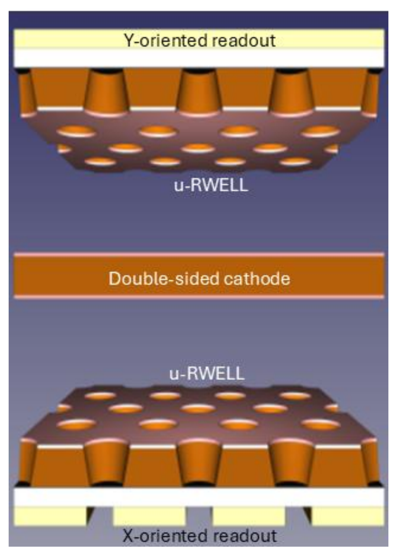


MEASURED PERFORMANCE:

- **Efficiency > 98%**
- **Spatial Resolution < 100 µm** over [0-45°] [3]
- **Rate capability > 1MHz/cm^2** [4]

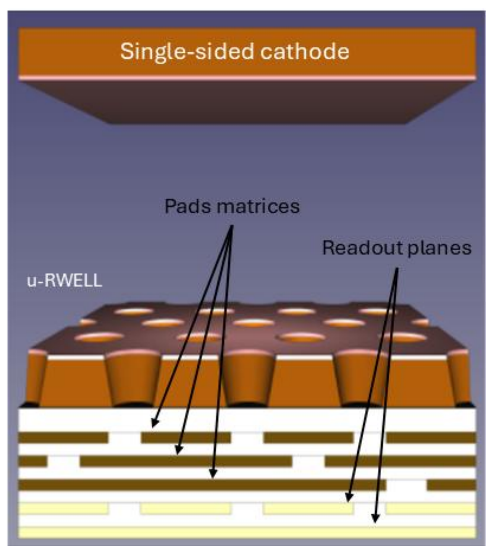
For a 1D prototype with DLC resistivity of 100 MΩ/□

The µ-RWELL for IDEA - 2D r/out layouts



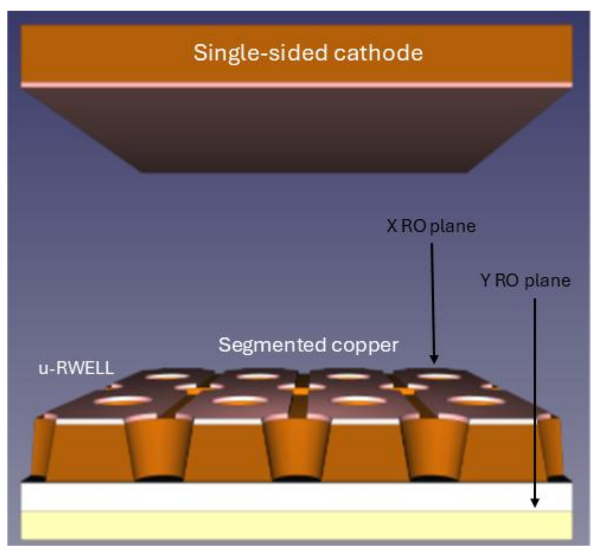
2x1D µ-RWELL

- Shared cathode
- 1 view per µ-RWELL
- **Easy PCB** construction
- Operation at **lower gas gain**



µ-RWELL 2D Capacitive Sharing r/out

- **Charge-Sharing** [5] performed through the **capacitive coupling** between a **stack of layers of pads** and the readout board
- Good performance but need **higher gain**
- **Reduce the FEE channels,** but the total charge is shared between the X and Y readout



µ-RWELL TOP r/out

- X strips patterned on the TOP of the amplification stage introduces **dead zone in the active area**
- Operation at **lower gas gain**

TEST BEAM with APV25

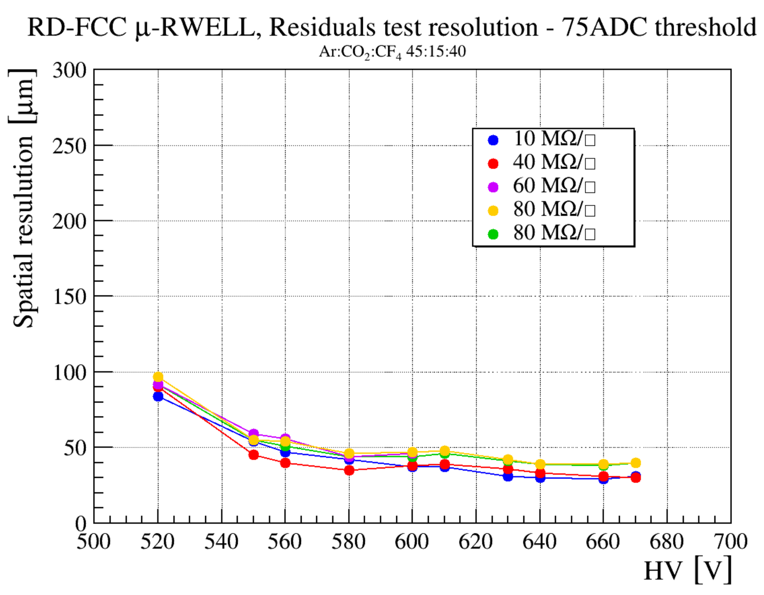
Resistivity Scan: The dependence on the **DLC resistivity** is negligible for the spatial resolution. For resistivities below 40 MΩ/□, the spreading of the signal could introduce **inefficiency** since each of the strip will be below the detection threshold

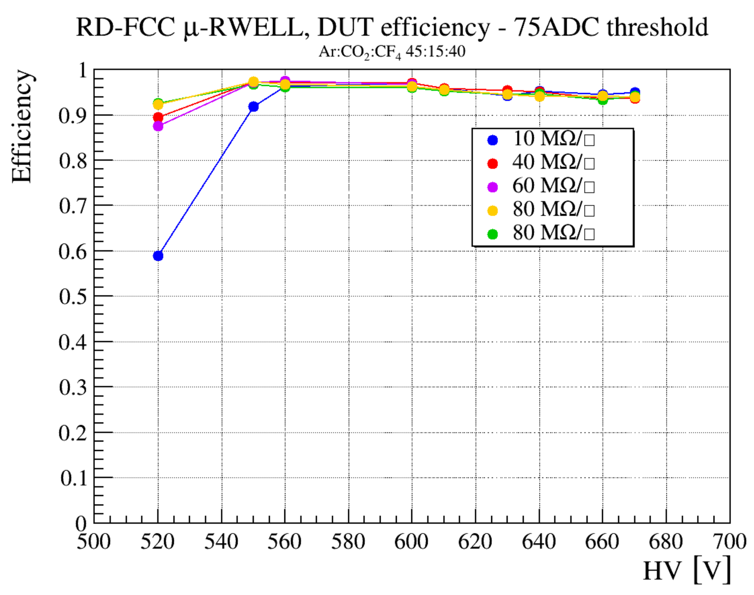
Strip Pitch Scan: For the **largest strip pitch** a **higher** gain is needed to achieve the **efficiency** plateau and the spatial resolution is lower

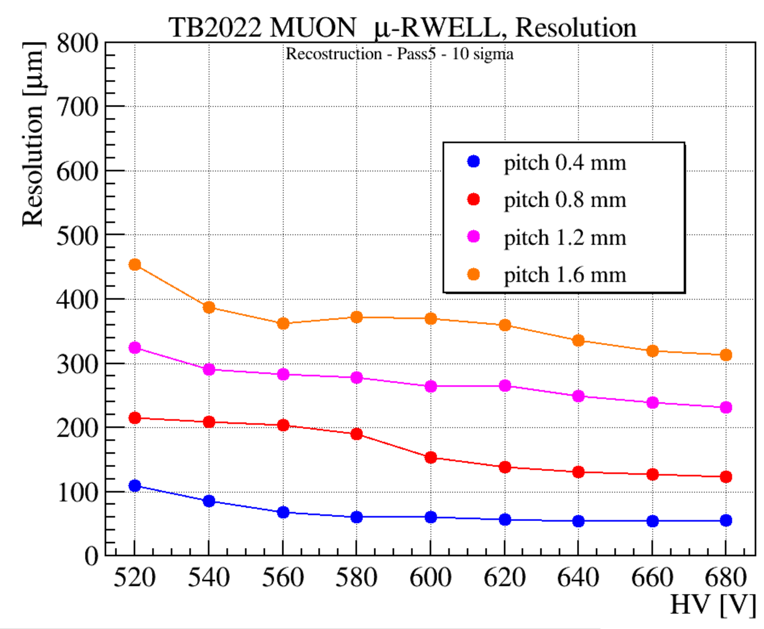
1D µ-RWELLs

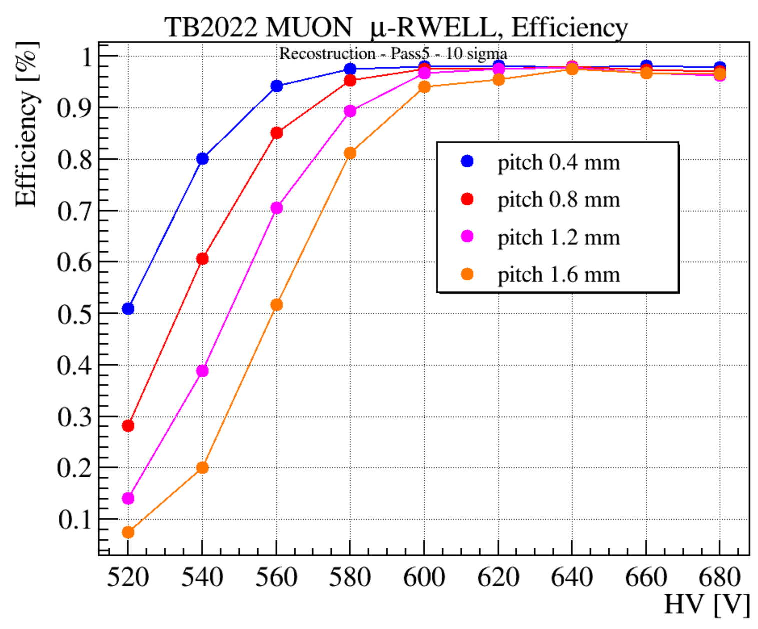
Spatial Resolution and Efficiency:

- **DLC Resistivity**
- **Strip Pitch**





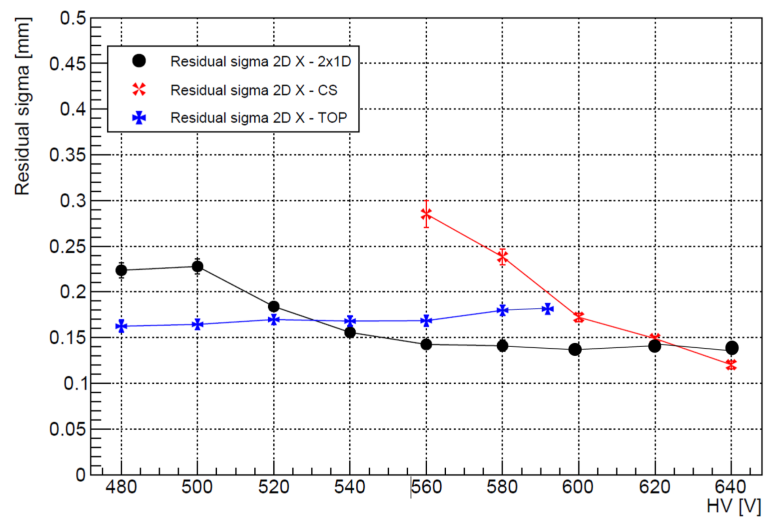


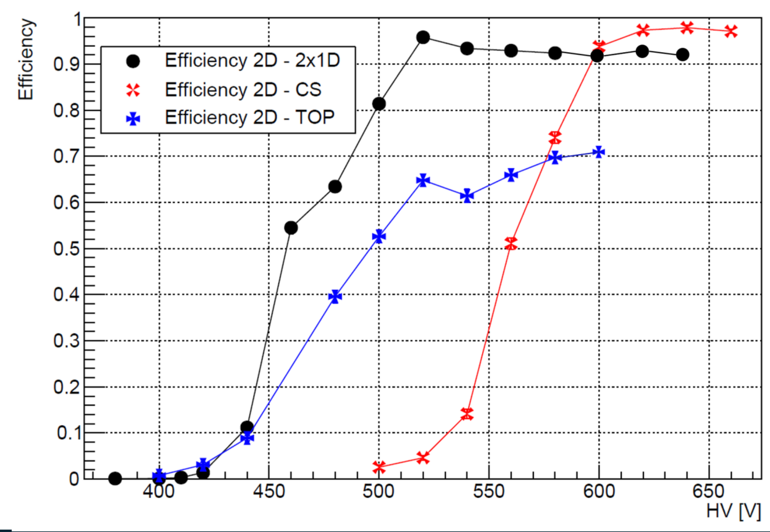


2D µ-RWELLs

Spatial Resolution and Efficiency:

- **3 different 2D readout layouts**





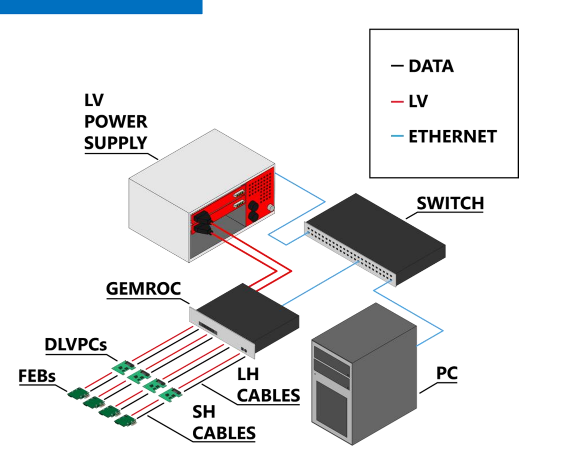
2x1D (pitch 0.8 mm)	Spatial resolution < 200 µm Efficiency ~ 95%
CS (pitch 1.2 mm)	Spatial resolution < 200 µm Efficiency ~ 98%
TOP r/d (pitch 0.8 mm)	Spatial resolution < 200 µm Efficiency ~ 70%

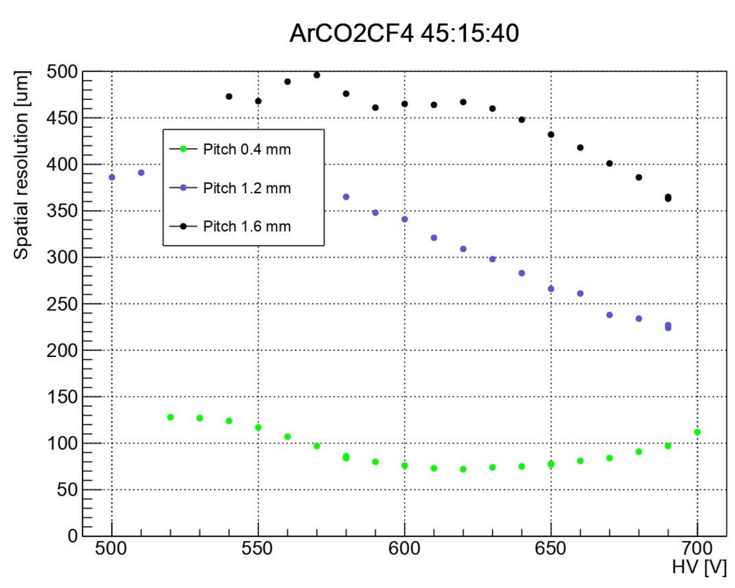
TEST BEAM with TIGER

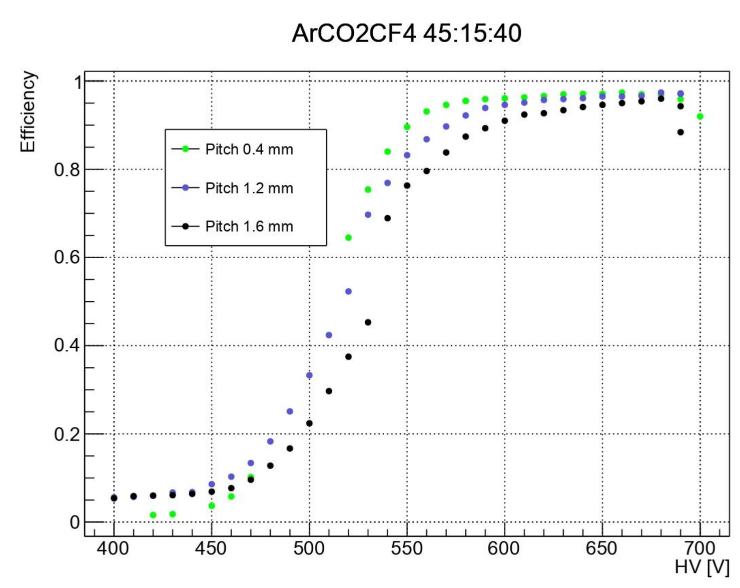
1-D µ-RWELLs

Studies on the Spatial Resolution and Efficiency with TIGER-GEMROC READOUT CHAIN:

- **Strip pitch**





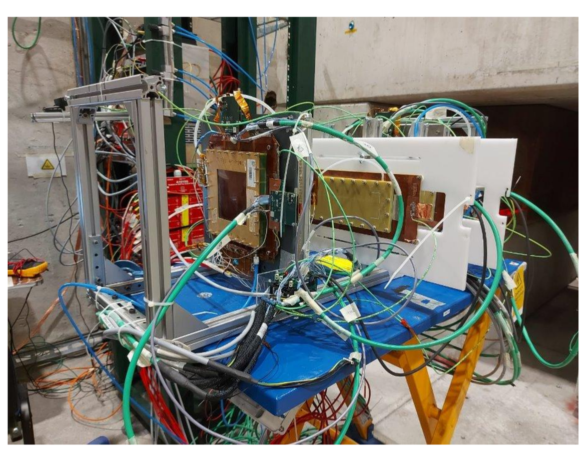


TIGER ASIC

- Developed for BESIII CGEM-IT
- 64 channels
- Analogic measurements of charge and time
- Rate capability 60kHz [6] per channel
- Input dynamic range from 2 to 50 fC
- Low noise level (~ 1fC)

TB results:

- **Spatial resolution** required for muon system achieved with **1.6 mm** strip pitch
- TB noise level 4 fC → **TO BE OPTIMIZED**



References

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2. G. Bencivenni, et al., *The micro-resistive WELL detector: A compact sparkprotected single amplification-stage* MPGD, 2015, JINST 10 P02008
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6. A. Amoroso et al., *The CGEM-IT readout chain,* 2021 JINST 16 P08065