WP 5.4: Cylindrical μ-RWELL for SCTF

G. Bencivenni[1]

I. Balossino[2], M. Bertani[1], S. Cerioni[1], G. Cibinetto[2], E. de Lucia[1], D. Domenici, R. Farinelli[2], G. Felici[1], I. Garcia[2], M. Gatta[1],

M. Giovanetti[1], M. Melchiorri[2] , G. Mezzadri[2], G. Morello[1], E.Paoletti[1], M. Poli Lener[1], M. Scodeggio[2]

1. Laboratori Nazionali di Frascati – INFN, Frascati – Italy
2. Sezione di Ferrara – INFN, Ferrara – Italy

The Manpower

LNF – INFN

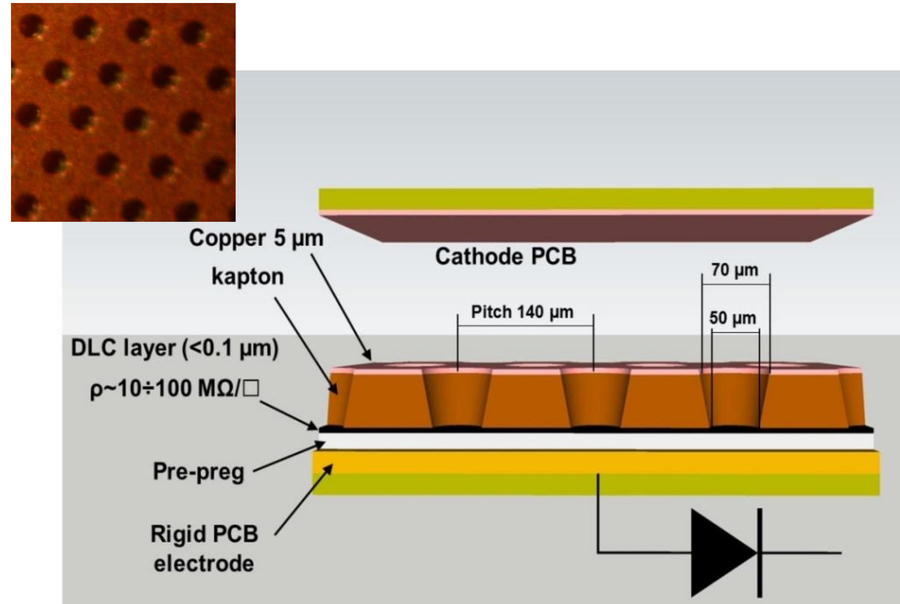
G. Bencivenni (I-Ric*) LNF-group Leader
M. Bertani (Ric)
S. Cerioni (Tech)
E. De Lucia (RIc)
D. Domenici (Ric)
G. Felici (Dir. Tec.)
M. Gatta (Tech.)
M. Giovannetti (PHD student)
G. Morello (Ric. TD)
E. Paoletti (Tech)
M. Poli Lener (Tec.)

Ferrara – INFN

G. Cibinetto (Ric) Ferrara-group Leader
I. Balossino (similfellow INFN-IHEP)
R. Farinelli (PostDoc)
I. Garzia (Researcher – Ferrara University)
M. Melchiorri (Tech.)
G. Mezzadri (similfellow INFN-IHEP)
M. Scodeggio (PhD student)

(*) task 5.4 Responsible

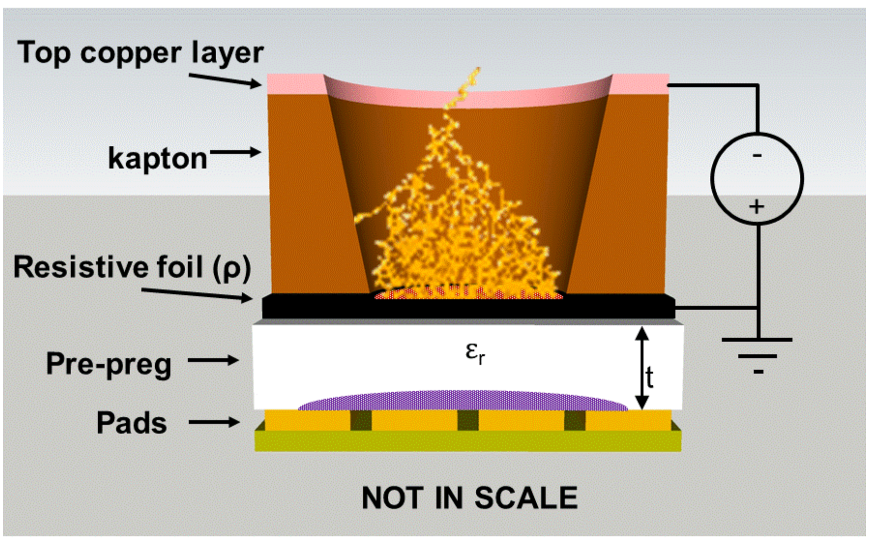
The µ-RWELL architecture



The µ-RWELL is composed of only two elements:

- µ-RWELL_PCB
- drift/cathode PCB defining the gas gap

µ-RWELL_PCB = amplification-stage ⊕ resistive stage ⊕ readout PCB

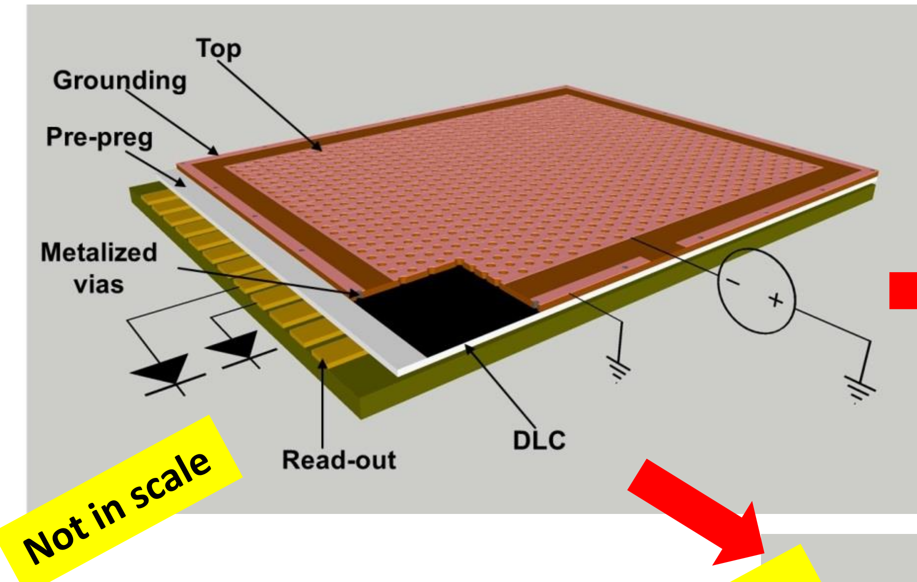


- The “WELL” acts as a multiplication channel for the ionization produced in the gas of the drift gap
- The charge induced on the resistive layer is spread with a time constant, τ ~ ρ×C

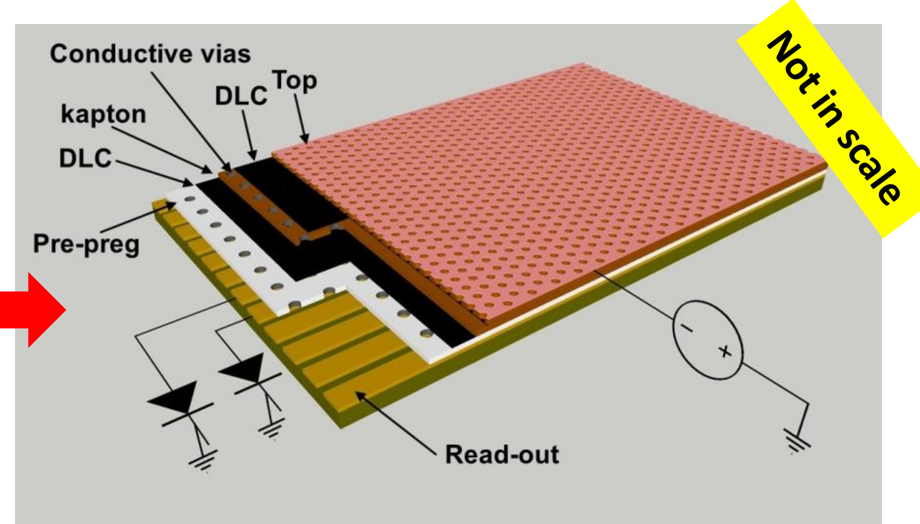
$C = \varepsilon_0 \times \varepsilon_r \times \frac{S}{t} \cong 50\, pF/m$ (pitch-width 0,4 mm)

Detector Layouts

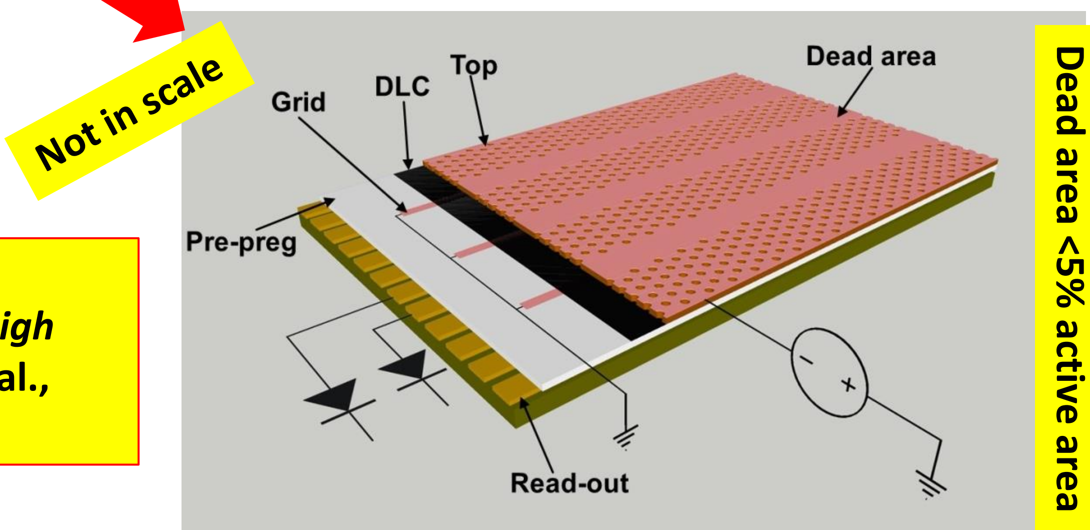
Single resistive layer – LOW RATE



Double resistive layer – HIGH RATE



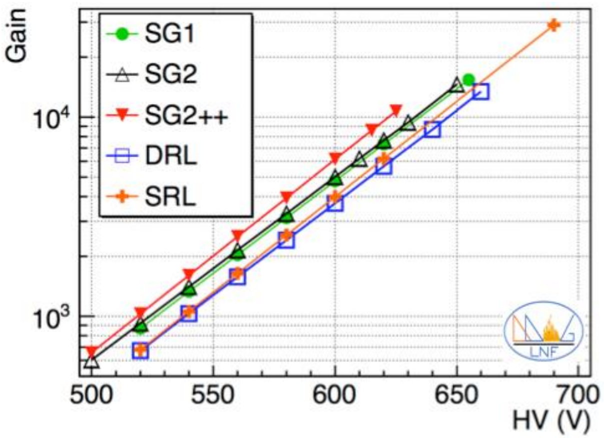
Detailed description in:
***The micro-RWELL layouts for high particle rate*, G. Bencivenni et al., 2019_JINST_14_P05014.**



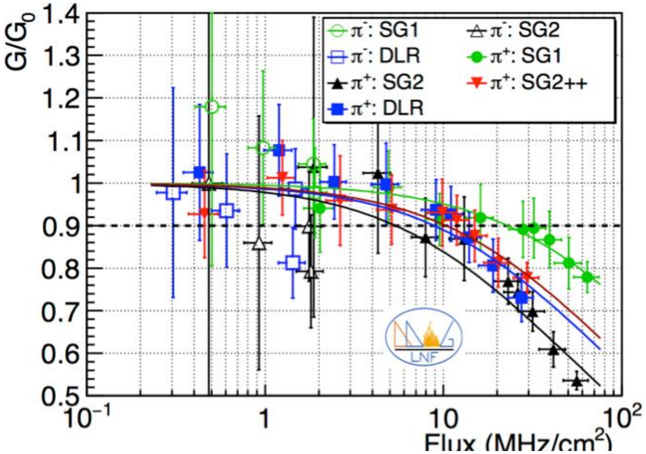
Single resistive layer w/dense grid grounding (SG++) – SIMPLIFIED HIGH RATE LAYOUT

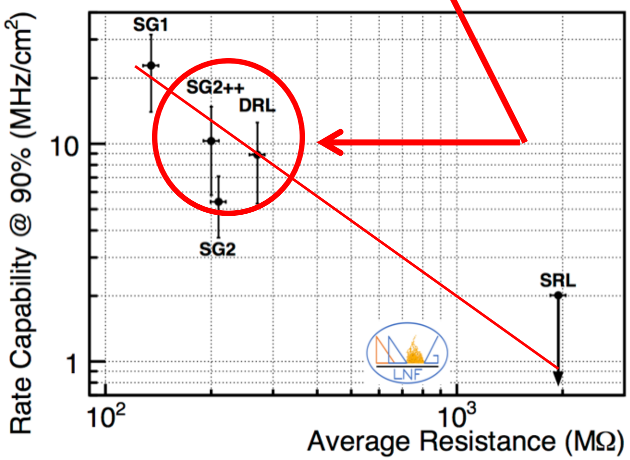
Detector performance

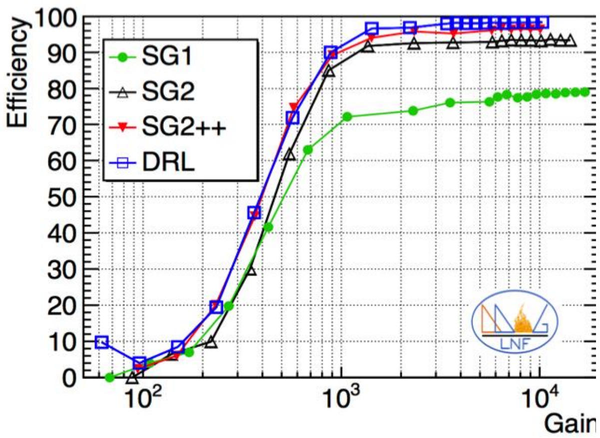
G ~ 10^4

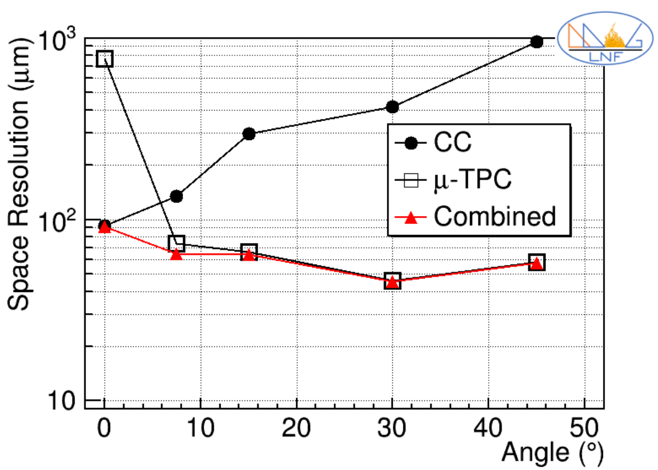


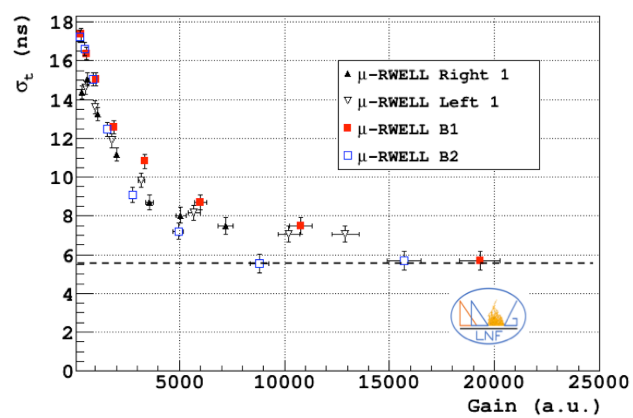
Rate capability ~ 10 MHz/cm^2











Efficiency ~ 98%

σ_x ~ 60 μm

σ_t ~ 5- 6 ns

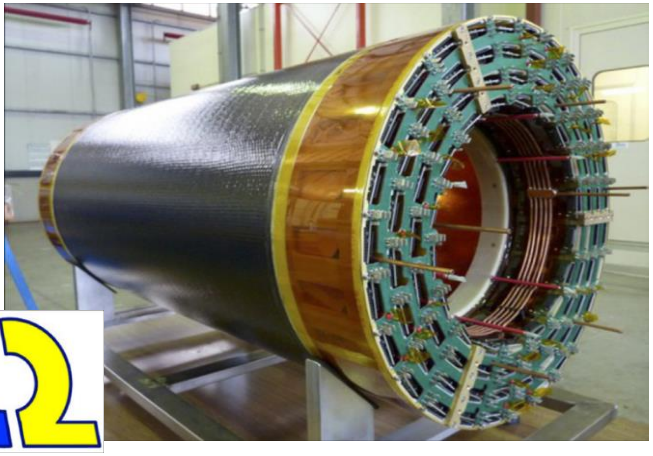
Inner tracker based on C-RWELL

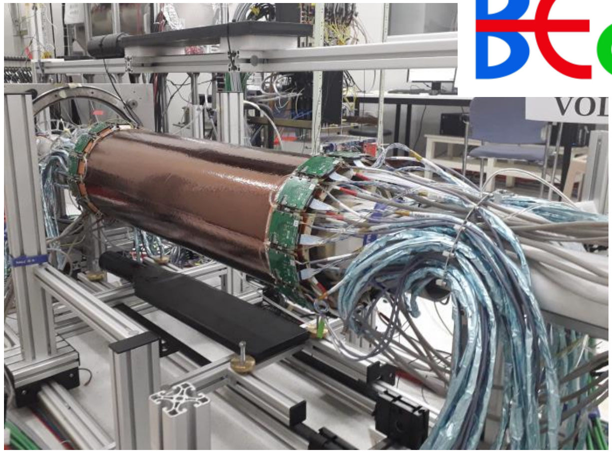
The aim of **WP5.4 of the CREMLIN-plus** is the R&D on the inner tracker of the SCT detector based on the **Cylindrical μ-RWELL (C-RWELL) technology.**

The **C-RWELL** will be a very **low material budget (1% X_0)** full cylindrical IT, proposed by the **LNF-INFN and Ferrara-INFN groups.**

Both teams have long been **involved** in the **R&D, design and manufacture of MPGDs for high energy physics experiments.**

In particular they have been involved in the development of both **planar GEM (LHCb**) as well as **Cylindrical-GEM detectors** for the Inner Tracker of the **KLOE-2 experiment (LNF),** and **BESIII (Ferrara - LNF).**





The C-RWELL for SCT

The C-RWELL , based on the micro-RWELL concept, wrt the CGEM experience, will exploit **several innovative concepts:**

- **openable detector**
- **floating-amplification** → ***easy repairing***
- **reversed conical hole-shape** → ***Gain × 2***

that will make the **C-RWELL a highly reliable and performing IT,** while the spark suppression mechanism, intrinsic to the μ-RWELL technology, make the operation of this detector in harsh environment safer with respect to other MPGD based devices.

In addition, the C-RWELL, able to stand particle fluxes well above 1 MHz/cm^2 (*in case of High Rate layout implementation*) **operated in micro-TPC mode, exhibits an excellent spatial resolution, down to 50-60 μm over a wide track incidence angular range, 0-45°.**

WP 5.4 Deliverables & Milestones

D5.2 - m24: Status report on R&D work on Inner Tracker for the SCT detector. This report is supposed to describe joint EU – Russia activities around inner tracker of the SCT detector

D5.7 - m44: Final report on R&D work on Inner Tracker for the SCT detector. This report is supposed to describe the advanced stage of activities of SCT collaboration related to inner tracker of the SCT detector, including the construction and test of prototype.

MIL4 – m42: Construction and test of the Inner Tracker (C-RWELL) prototype for SCT detector

Tentative program

The resistive amplification stage and the readout plane of the C-RWELL , will be performed in collaboration with CERN PCB-Workshop, several Companies specialized in the photolithography of flexible (polyimide) and rigid Printed Circuit Board technology as well as the magnetron sputtering of Diamond Like Carbon (DLC).

The project foresees the following main steps (short term Timetable – M1-M24):

- Design of the mechanics, readout electrodes, amplifications stage: **M4-M6**
- Pre-test of floating concept, choice material for Cyl - supports etc … : **M1-M3**
- Preparation of construction/assembly tools: **M6-M7**
- Ordering/procurement of the detector components **M7-M9**
- Construction of the 1st prototype : **M10- M13**
- Integration with front-end electronics: **M14-M16**
- Test of 1st prototype w/cosmic rays & beam tests: **M17- M21**

The INFN infrastructures

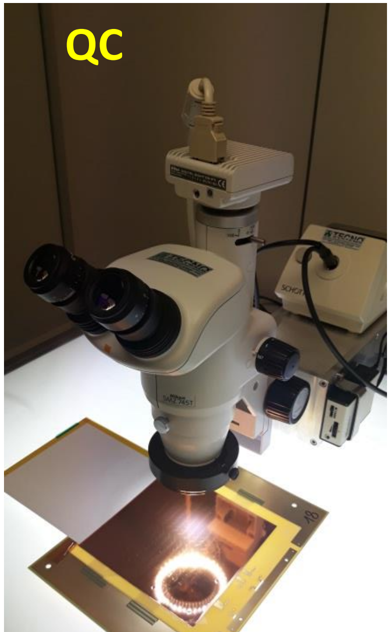
The infrastructures available at the INFN laboratories for the R&D activity on MPGDs and related electronics for HEP experiments are manifold: Mechanical Design Service, Mechanical Workshop, Automation and Electronics Workshop, Large Clean Rooms, X-ray tube facilities.

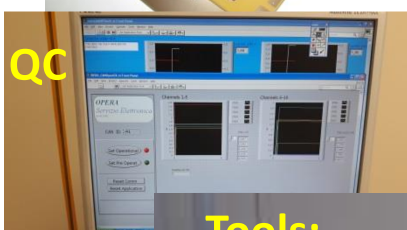
An electron/positron Beam Test Facility (BTF) – E = 25÷500 MeV – is also available for detector characterization.

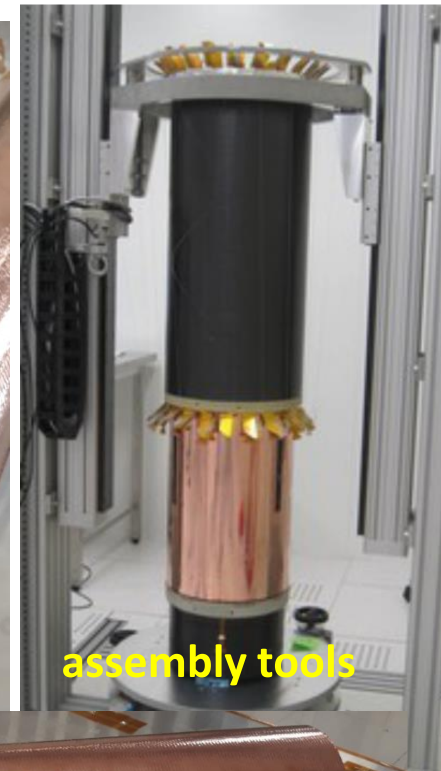
For the construction and assembly of Cylindrical-MPGD a 120 m^2 class 1000 clean room fully equipped with dedicated tools is available.

INFN Istituto Nazionale di Fisica Nucleare

The construction/assembly tools







Summary

- The μ-RWELL technology is proposed for many applications on HEP (LHCb, FCC-ee, CepC) as well as neutron detection (ATTRACT-uRANIA)
- Severe stability studies of DLC & detector ageing test under irradiation are in progress and planned for the near future
- The TT to industry is on-going with the Italian Company ELTOS SpA
- The infrastructures and tools for the construction of Cylindrical MPGDs are available at the INFN
- The INFN Ferrara & LNF teams are leading in the Cylindrical MPGD technology: the design of the new detector is going to be started (regular weekly meetings have been started since January 2020 in order to monitor the on-going activity)

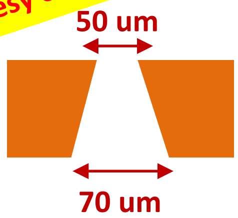
Spares slides

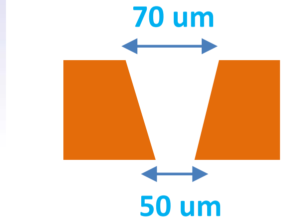
Increasing the Gain of a factor of 2

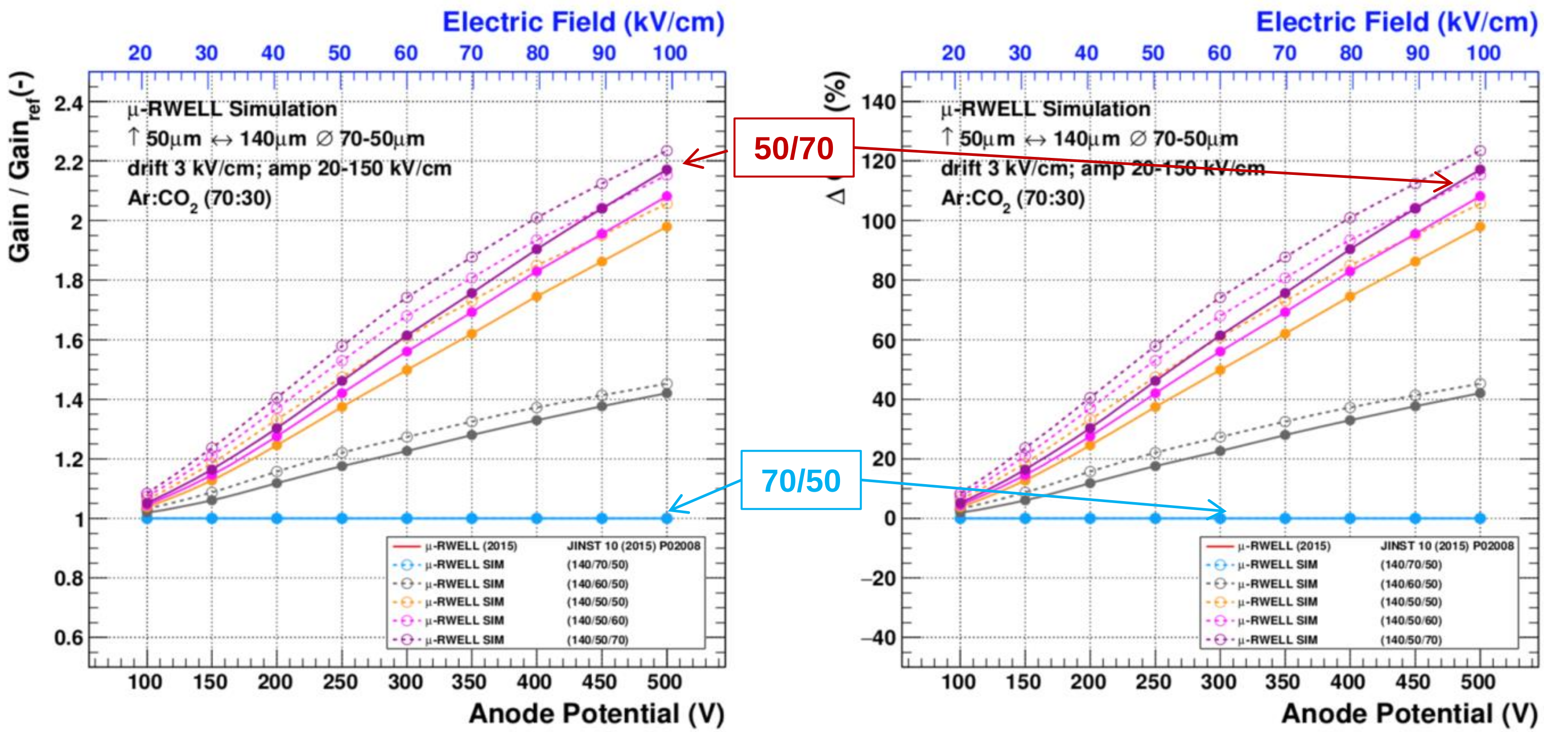
Courtesy of P. Verwilligen

Gain for different hole shapes

FTM (140/50/70) vs μ-RWELL (140/70/50)





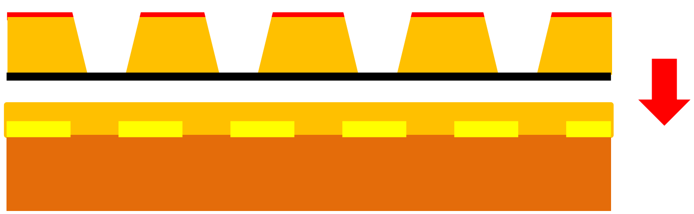


(a) Ratio of $G_{\text{FTM}}/G_{\mu\text{-RWELL}}$ (b) $\Delta G = (G_{\text{FTM}} - G_{\mu\text{-RWELL}})/G_{\mu\text{-RWELL}}$

Figure: Gain ratio for different hole shapes (70/50 = μ-RWELL; 60/50; 50/50; 50/60; 50/70 = FTM) in Ar:CO_2 70:30 (left) and the percentual difference of the gain ΔG (%) (right).

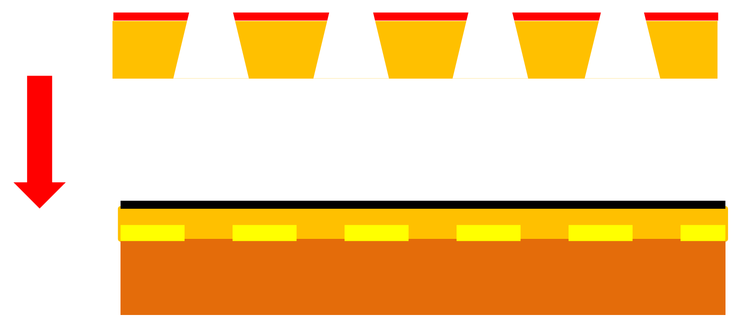
Standard vs floating RWELL

“standard- GEM foil”: standard RWELL layout.
The GEM foil is directly embedded/glued with r/out PCB before the kapton etching.
The DLC is preliminarily sputtered on the back side of the GEM foil before the hole etching



readout PCB is directly coupled with the amplification stage before the kapton etching

“reversed- GEM foil”: floating amplification RWELL layout.
The GEM foil is not glued onto the r/out PCB but left floating, and can be replaced in case of failure. The contact between the amp-stage and the DLC is guaranteed by the electrostatic but also the mechanics (mounted on the readout PCB by vacuum)



readout PCB with DLC-ed kapton foil embedded on top