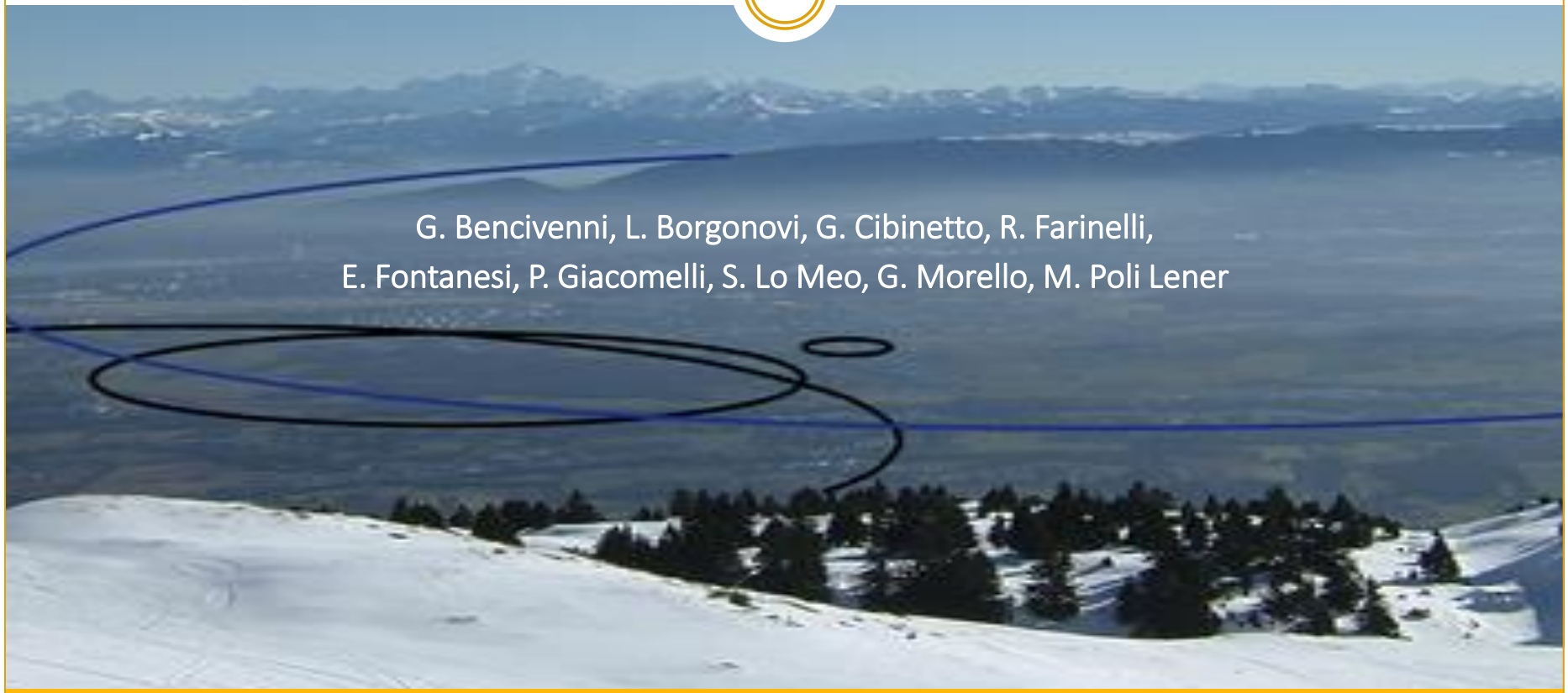
STATUS of the IDEA preshower simulation in Geant4



G. Bencivenni, L. Borgonovi, G. Cibinetto, R. Farinelli,
E. Fontanesi, P. Giacomelli, S. Lo Meo, G. Morello, M. Poli Lener

Current status

2

- Description of a μ-RWELL (HR layout – SG2++) detector implemented in Geant4
- μ-RWELL occupancy studies
- Full barrel geometry implemented
- Preliminary studies to define the endcap geometry: it was suggested to use only square chambers

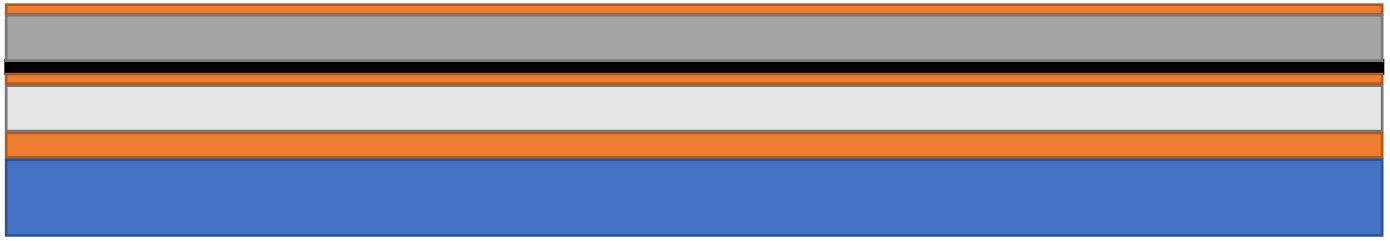
https://agenda.infn.it/event/19360/contributions/95298/attachments/64209/77599/IDEA_preshower_simulation_in_Geant4_EF.pdf

μ-RWELL scheme

3

Cathode:
FR4 +
copper

Drift gap



μ-RWELL +
readout PCB
Top copper (w/ hole) +
kapton (w/ hole) +
DLC +
grid (w/ strips) +
pre-preg +
copper (w/ strips) +
FR4

μ-RWELL description

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CATHODE	
1.6 mm	FR4
35 μm	Copper
GAS GAP	
6mm	$ArCO_2CF_4$ (45/15/40) Or $ArCO_2$ (70/30)? => Eco-friendly gas mixture
μ-RWELL + readout PCB • Top copper + kapton + resistive layer + grid + pre-preg + readout	
5 μm	Copper } Taking into account holes and dead zones on the amplification stage [*]
50 μm	Kapton } Taking into account holes and dead zones on the amplification stage [*]
0.1 μm	DLC (Diamond-like-Carbon)
35 μm	Copper - Taking into account strips [*]
100 μm	Same material of DLC layer (same density)
35 μm	Copper - Taking into account strips [*]
1.6 μm	FR4

[*next slide]

μ-RWELL materials

- **Copper** and **Kapton** from G4NistManager

- **DLC**: new material with Carbon density (2.00 g/cm^3); the same density is assumed to describe the **film glue** in the pre-preg

- **FR4**: fiber glass (60%, 1.99 g/cm^3) + epoxy (40%, 1.25 g/cm^3)
  ⇒ Simulated as permaglass with FR4 density (1.85 g/cm^3)
  Implemented previously for GEM description

Fiber glass	
SiO_2	60%
B_2O_3	5%
Al_2O_3	13%
CaO	22%

- **$ArCO_2CF_4$**:
  ⇒ Argon and $C0_2$ from G4NistManager (1.661 kg/m^3 and 1.842 kg/m^3)
  ⇒ CF4 implemented as new material with density: 3.78 kg/m^3
  Density of each component weighted accordingly with their volume percentage (45/15/40)
  ⇒ Defined fraction mass values:
  f_Ar = 0.295
  f_CO_2 = 0.109
  f_CF_4 = 0.596

μ-RWELL materials

- In order to take into account holes and dead zone on the amplification stage, copper and kapton density have been redefined:

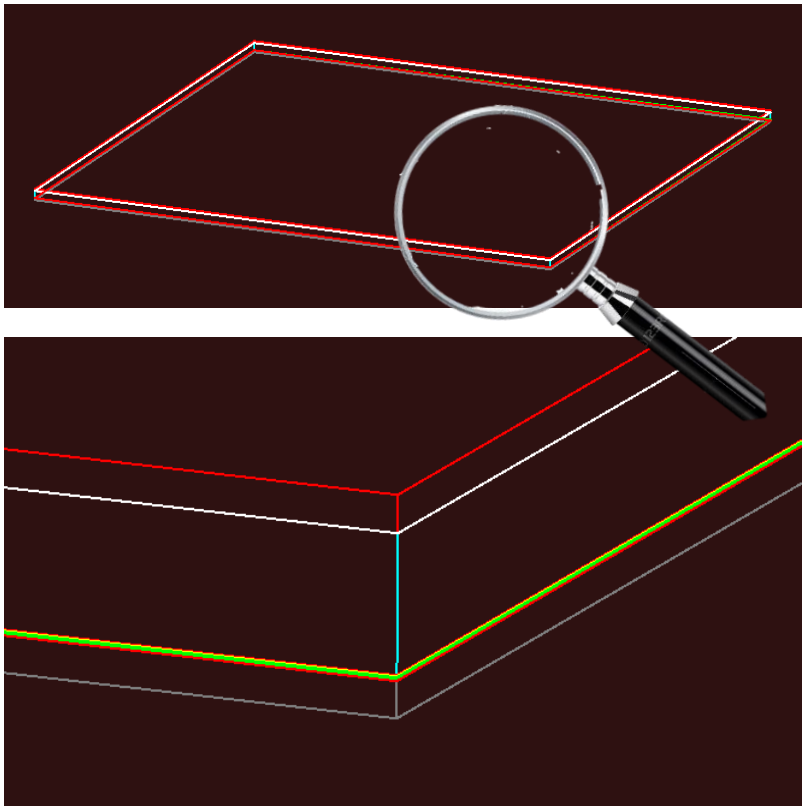
  - Copper: we consider each hole as a cylinder
    - 5 μm thickness
    - 70 μm diameter
    - 140 μm pitch
  - Kapton: we consider each hole as a trunk of cone
    - 50 μm thickness
    - 50-70 μm diameter
    - 25-35 μm r-R
    - 140 μm pitch

  Considering a **pitch** of **12 mm** and a **dead zone** of **0.6 mm**, a weight is introduced to distinguish active (95%) and dead (5%) area on the amplification stage.

  - Grid strip:
    - 100 μm size
    - 12 mm pitch
  - Copper readout:
    - 250 μm size
    - 400 μm pitch

μ-RWELL implementation in Geant4

Description of a μ-RWELL
(HR layout [*] - SG2++)
detector implemented in Geant4



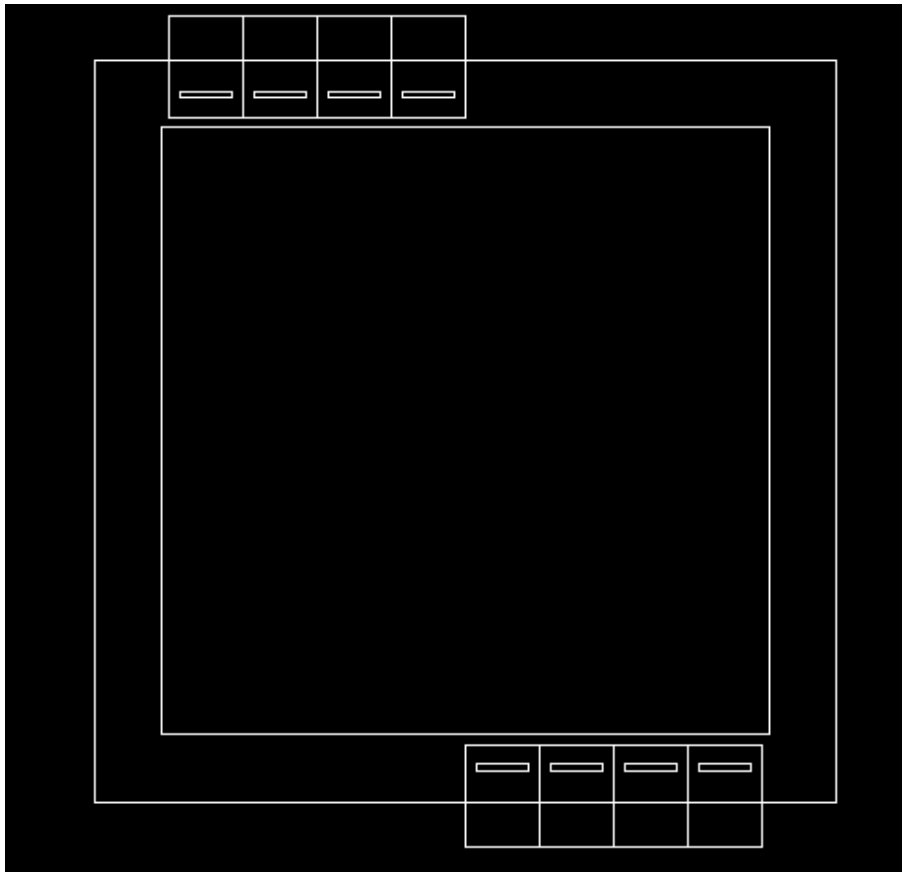
Chamber thickness: 9.4601 mm

- Cathode thickness: 1.635 mm
- Drift gap: 6 mm
- μ-RWELL + readout thickness: 1.8251 mm

CATHODE 1.6 mm 35 μm	 FR4 Copper
GAS GAP 6mm	$ArCO_2CF_4$ (45/15/40)
μ-RWELL + readout PCB Top copper - 5 μm Kapton - 50 μm DLC resistive layer - 0.1 μm Grid - 35 μm Pre-preg - 100 μm Readout - 35 μm 1.6 μm	In Copper and Kapton holes and dead zones on the amplification stage or strips are taken into account

μ-RWELL: occupancy studies

First considered chamber size:
500 mm x 500 mm



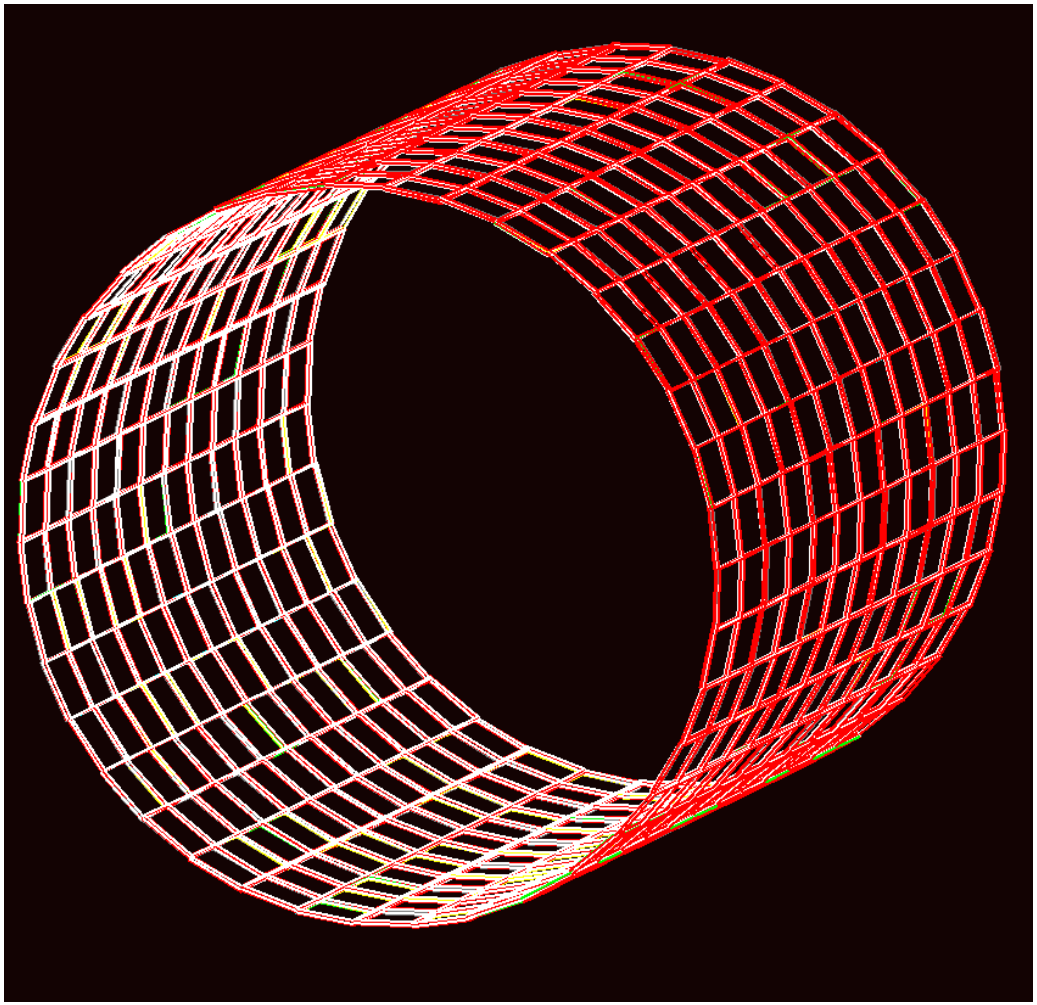
Need to evaluate the realistic ACTIVE AREA of the detector:

- HV cables
- 8 APV25 (128 channels):
  50 mm x 68 mm x 1.6 mm
- Panasonic connectors (perpendicular to strips):
  35 mm x 4.2 mm x 7 mm

ACTIVE AREA = 413 mm x 413 mm

Pitch: 400 μm => 1032 strip
(they will be reduced to 1024, so that they can be read by 8 APV25 (128 channels)

The IDEA preshower: full barrel geometry



Information provided by preshower detector: particle position

Future μ-RWELL prototypes may provide a bidimensional information per layer

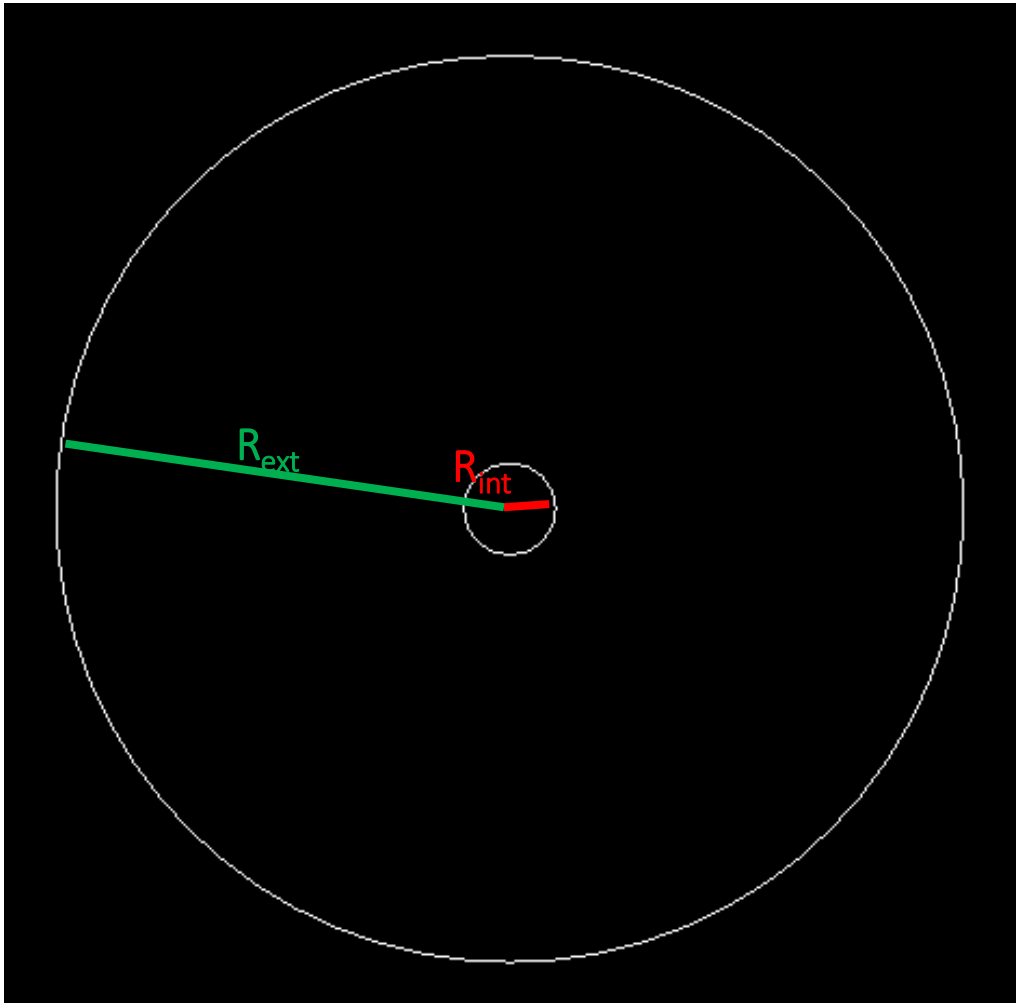
Two μ-RWELL layers

$Z_{preshower}$ = ± 2480 mm = 4960 mm

12 chambers for each sector
38 sectors

BARREL
912 chambers
933888 readout channels

Preshower - Endcap geometry



R_{int} = 248 mm
R_{ext} = 2440 mm

Attempt to identify a possible (optimized) geometry to cover the whole surface using **CAD DraftSight** before implementing it in Geant4

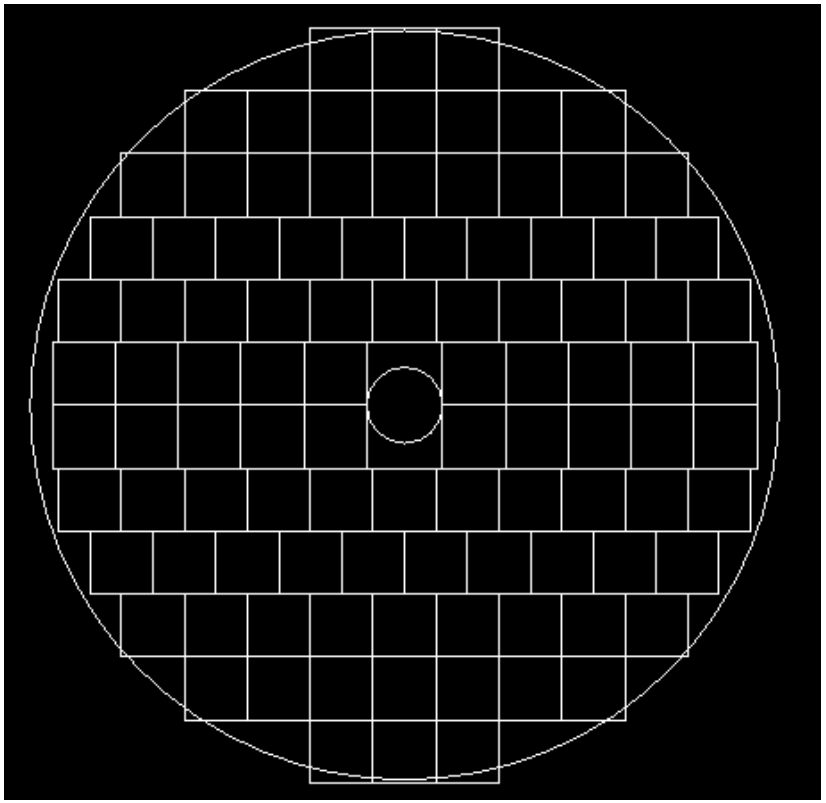
Chambers 410 mm x 410 mm, staggered geometry not considered for the implementation

Two wheels per part (XY info),
four in total

Preshower - Endcap geometry

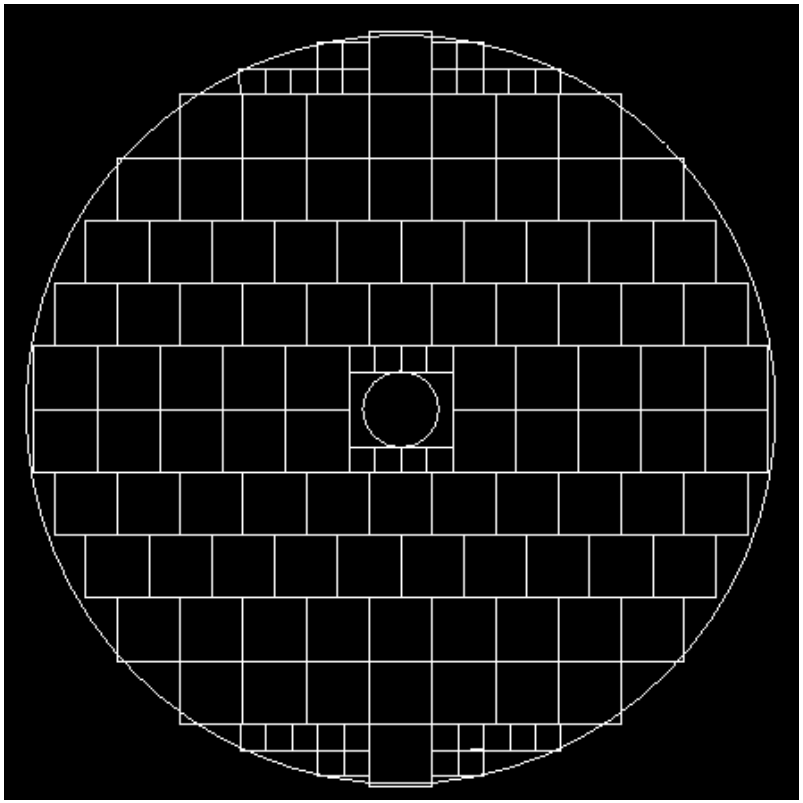
OPTION 1

- Same size: 410 x 410 mm^2
- 100 chambers for X readout => 200 for XY
- 400 chambers in total



OPTION 2

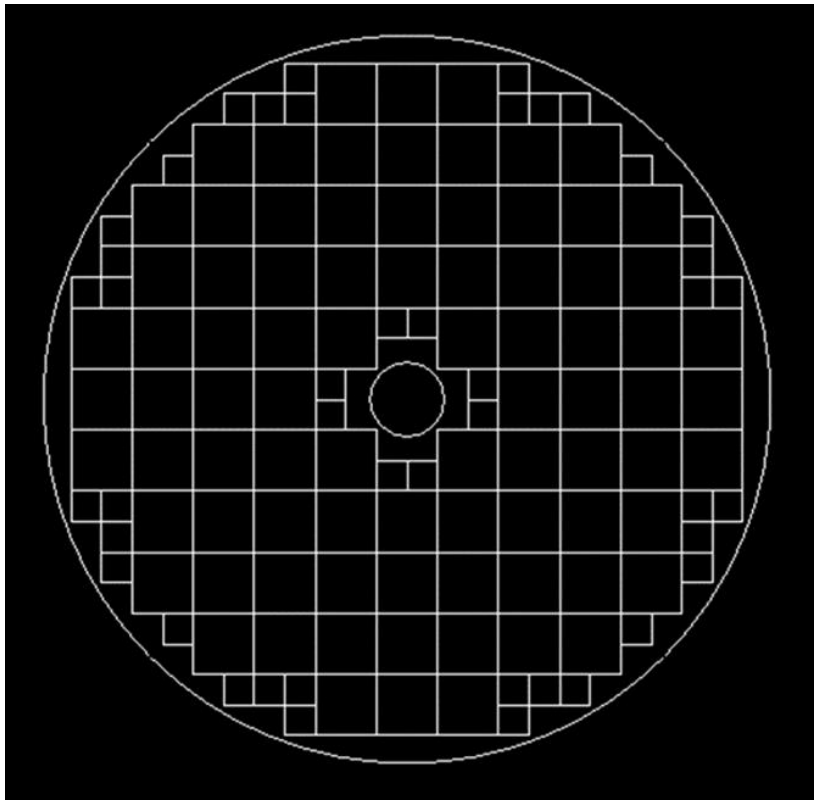
- Two types: 410 x 410 mm^2 / 168 x 168 mm^2
- 96 + 36 chambers for X readout
- 384 large + 144 small chambers

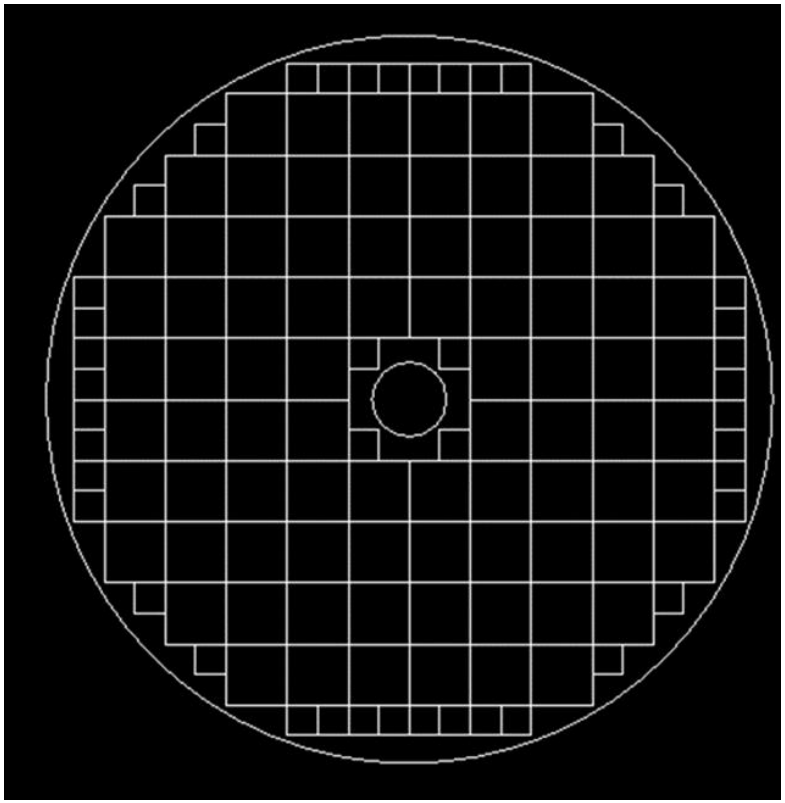


Preshower - Endcap geometry

OPTION 3 and OPTION 4 (by G. Morello)

- Two types: 410 x 410 mm^2 / 205 x 205 mm^2
- 84 + 44 chambers for X readout
- 336 large + 176 small chambers



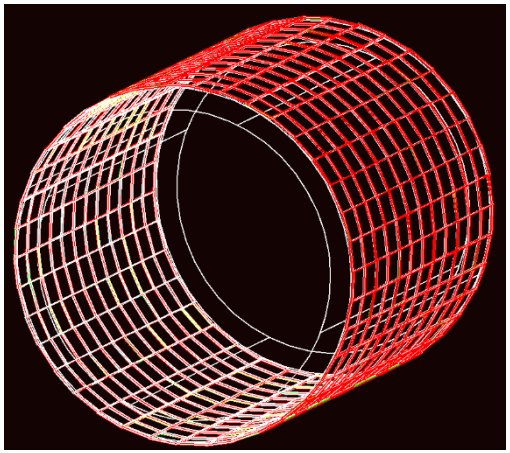


The IDEA full simulation

https://github.com/elfontan/IDEA-Preshower
https://github.com/elfontan/IDEA

Plan to provide a standalone Geant4 simulation of the IDEA detector

+



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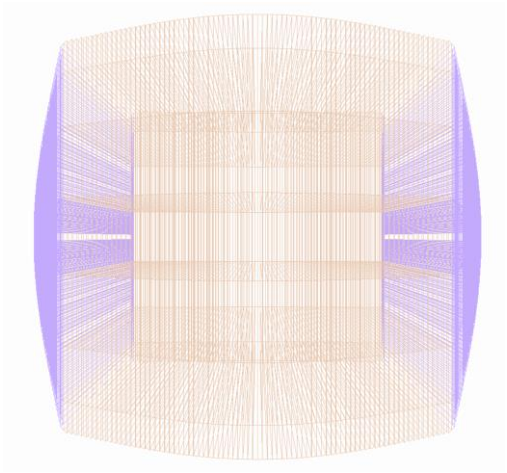


TRACKER PRESHOWER DR CALO

↓

μ-RWELL chambers

The minimal unit implemented in Geant4 can be used to develop also the

MUON SYSTEM

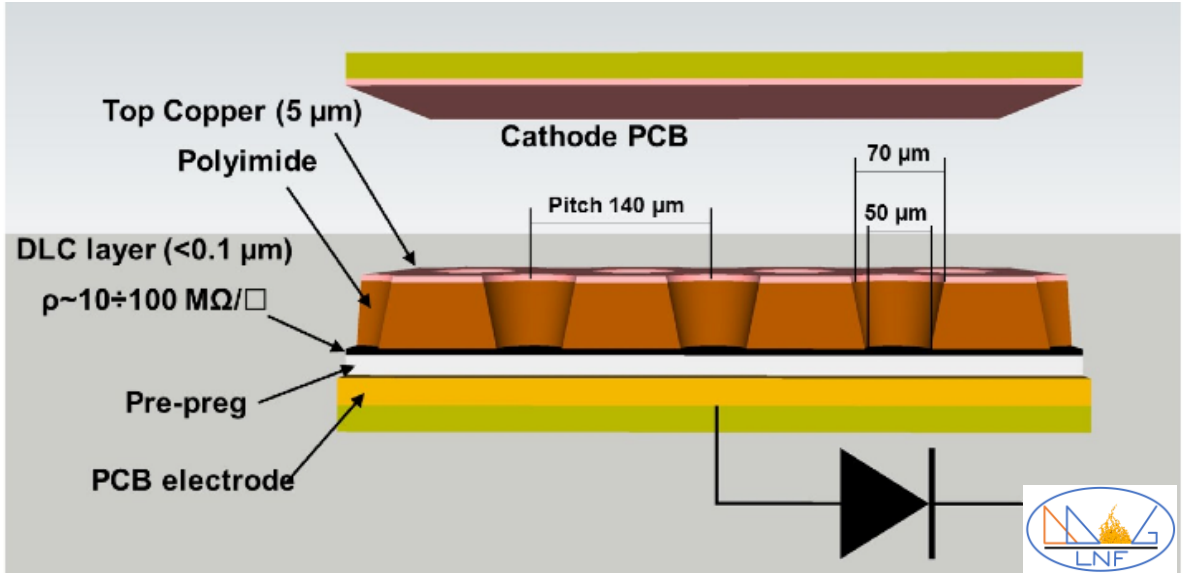
BACKUP

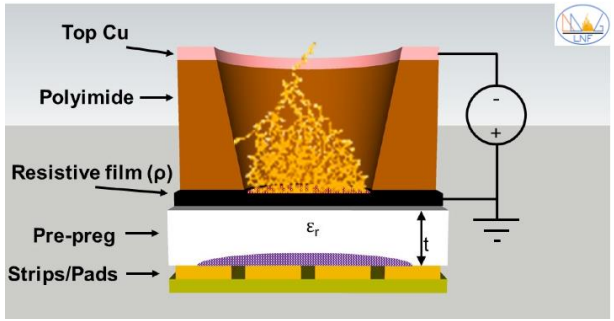
μ-RWELL detector

The μ-RWELL is composed of only two elements: the cathode and the μ-RWELL_PCB

The μ-RWELL_PCB, the core of the detector, is realized by coupling:

1. a **WELL patterned Apical® foil** acting as amplification stage;
2. a **resistive layer** for discharge suppression with surface resistivity ~10÷100 MΩ/□ (various current evacuation schemes [*next slide]);
3. a standard readout **PCB.**





G. Morello @ Oxford: https://indico.cern.ch/event/783429/contributions/3383656/attachments/1830373/2997438/CepC_2019_morello.pdf

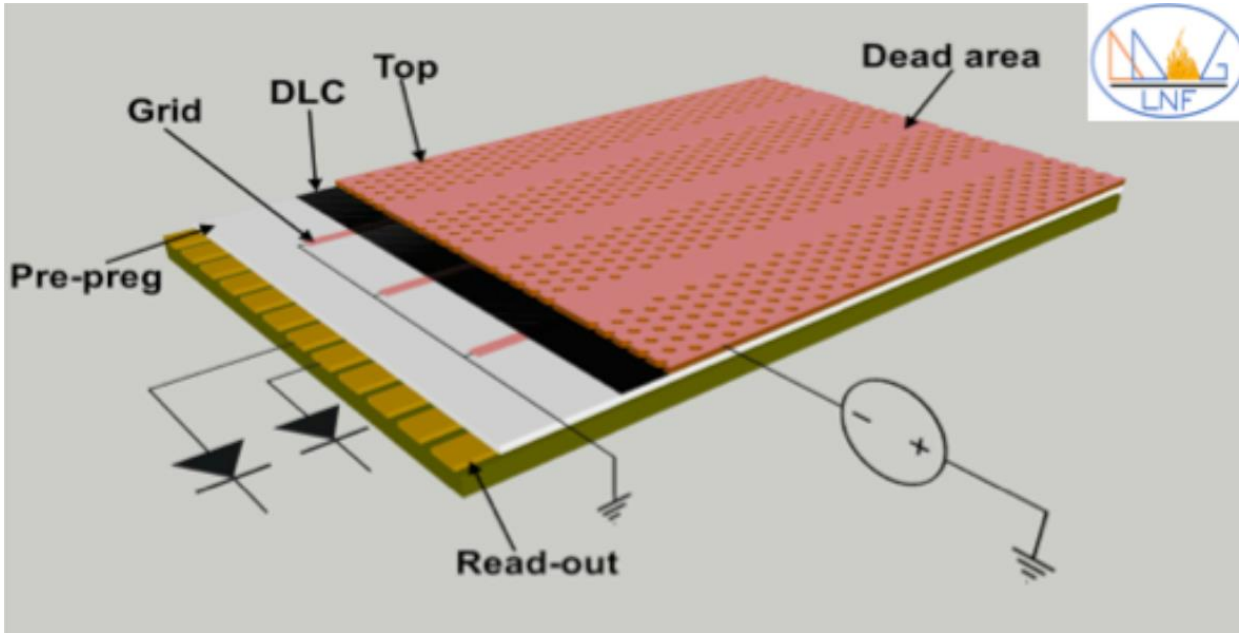
μ-RWELL detector

Two different current evacuation schemes have been studied:

- Low rate layout => LR << 1 MHz/cm^2 - SHiP, CepC, STCF, EIC, HIEPA, FCC-ee
- High rate layout => HR >> 1 MHz/cm^2 - LHCb-Muon upgrade & future colliders (CepC, FCC)
  => Two configurations: the double-resistive layer (DRL) and the silver grid (SG)

IDEA

HR layout => SG2++ (pitch = 12 mm; dead area = 0.6 mm)



G. Morello @ Oxford: https://indico.cern.ch/event/783429/contributions/3383656/attachments/1830373/2997438/CepC_2019_morello.pdf