

μ RWELL R&D plans for 2021

Marco Poli Lener
On behalf of WP7 group

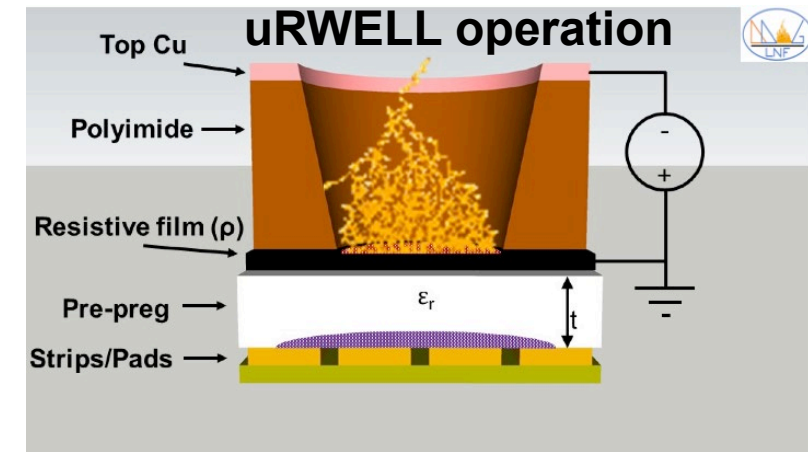
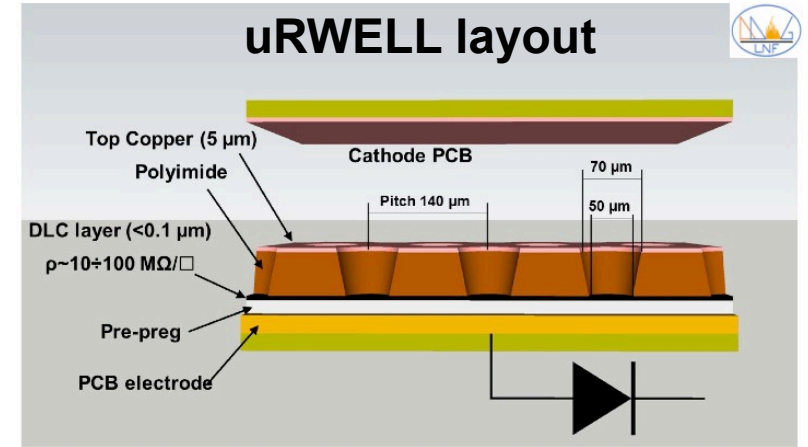
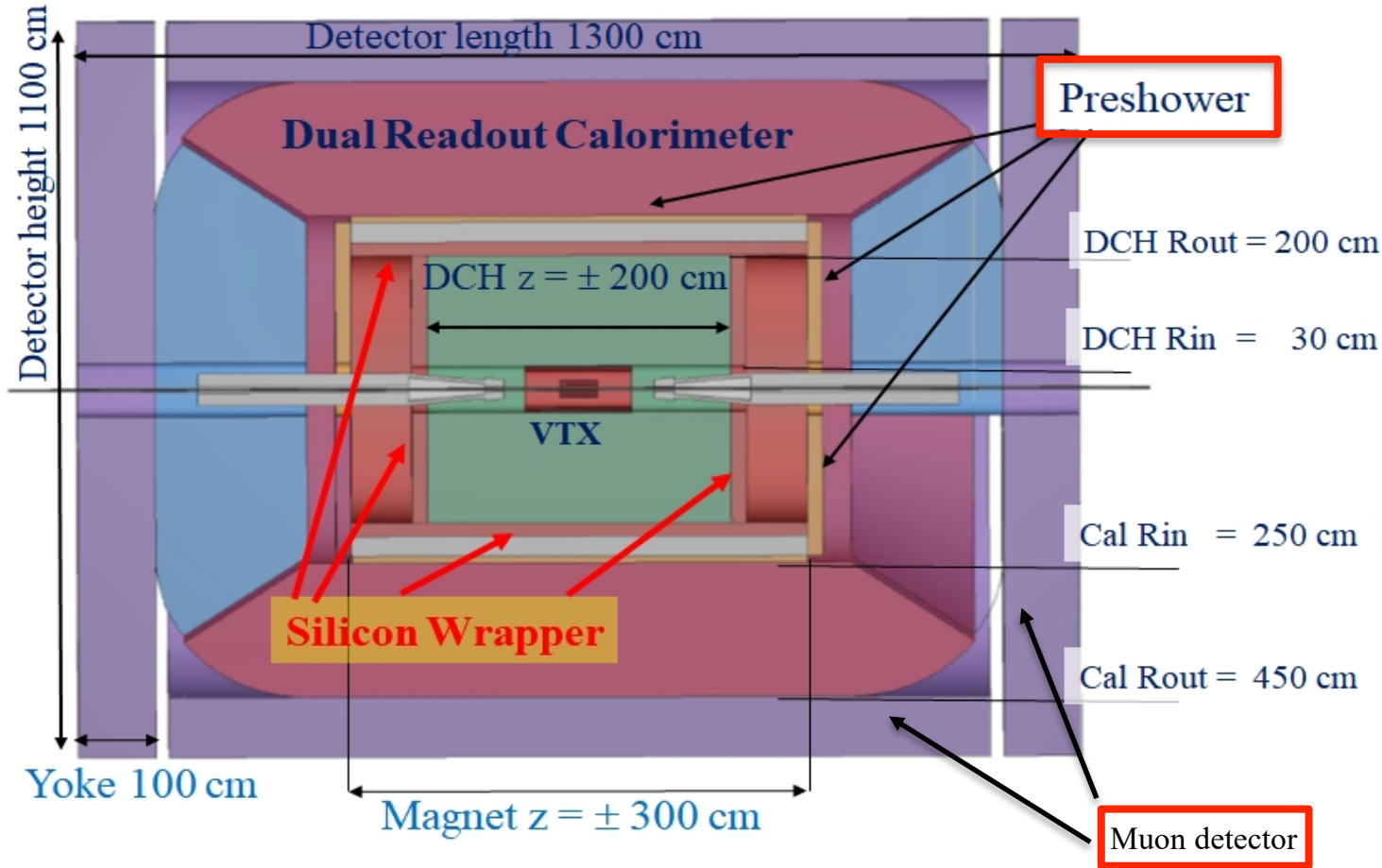
INFN BO, FE, LNF, TO

Gruppi coinvolti nei progetti Eu:

- CREMLIN+ \rightarrow R&D for a full cylindrical μ RWELL – Inner tracker for the Super c-tauFactory – Novosibirsk
- AIDAInnova \rightarrow TT of the μ RWELL technology to ELTOS, development of new tracking algorithms

IDEA detector layout

IDEA detector is a general purpose detector designed for experiments at future e^+e^- colliders (FCCee and CepC).



Preshower detector and the Muon system are designed with the μ RWELL technology

IDEA Muon detector dimensions

Barrel

R [mm]	Length [mm]	Thickness [mm]	pixel size [mm]	area [cm ²]	# of channels
2460	±2480	20	0.4×500	768K	384K

Endcap

R _{in} [mm]	R _{out} [mm]	z [mm]	Thickness [mm]	pixel size [mm]	area [cm ²]	# of channels
248	2440	±2460	20	0.4×500	370K	185K

Tiles: 50x50 cm² with X-Y readout
Strip Length: 50 cm
Strip pitch: 0.4 mm
Input FEE capacity (Cap_{inp}) ~ 70 pF

$$C = \epsilon_0 \times \epsilon_r \times \frac{S_{strip}}{t} \approx 36 \text{ pF} \times S(\text{cm}^2)$$

IDEA's Pre-Shower detector would have in total:

- ~ 330 m² total
- ~ 1.5 M channel in total

GOAL:

- Riduzione del n° canali di elettronica senza aumentare la Cap_{inp} → ottimizzando la resistività del piano resistivo delle μRWELL
- Riduzione del costo di singolo canale FEE → custom-made ASIC (TIGER)

Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm ²]	# of channels
μRwell	4520	±4500	20		1.5×500	2.6M	341K
iron	4560	±4500	300	1.5			
μRwell	4880	±4500	20		1.5×500	2.8M	368K
iron	4920	±4500	300	1.5			
μRwell	5240	±5260	20		1.5×500	3.5M	462K

Disk	R _{in} [mm]	R _{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm ²]	# of channels
μRwell	454	5220	±4520	20		1.5×500	1.7M	227K
iron	454	5220	±4560	300	1.5			
μRwell	454	5220	±4880	20		1.5×500	1.7M	227K
iron	454	5220	±4920	300	1.5			
μRwell	454	5220	±5240	20		1.5×500	1.7M	227K

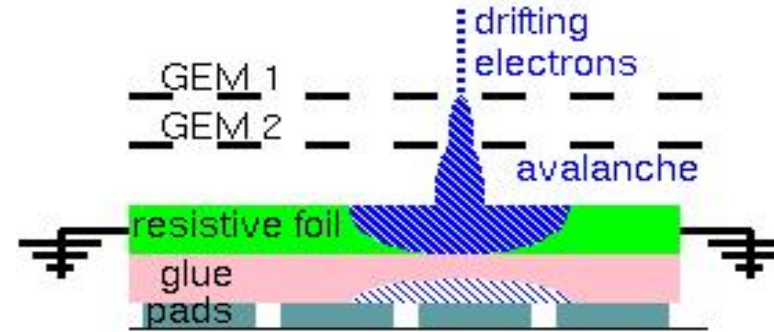
Tiles: 50x50 cm² with X-Y readout
Strip Length: 50 cm
Strip pitch: 1.5 mm
Input FEE capacity (Cap_{inp}) ~ 270 pF

IDEA's Muon detector would have in total:

- ~ 4000 m² total
- ~ 5 M channel in total

Example: Charge dispersion in a GEM- TPC with a resistive anode

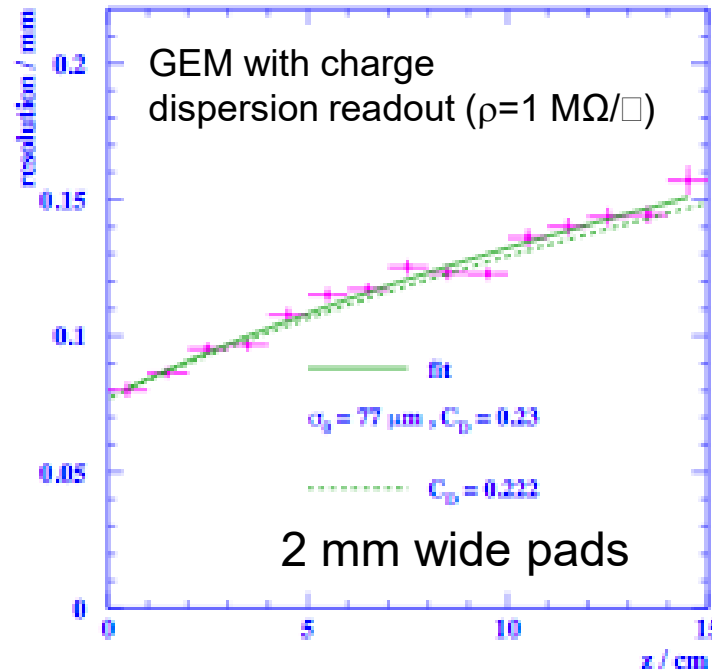
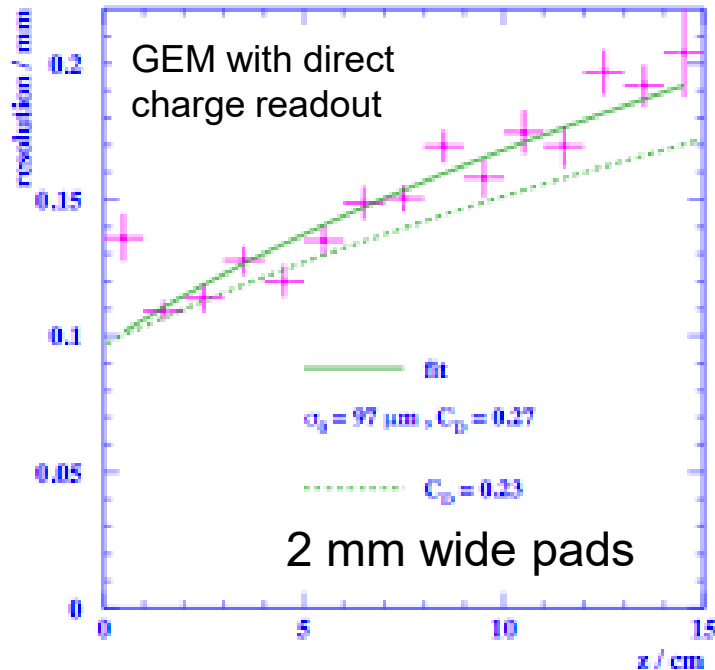
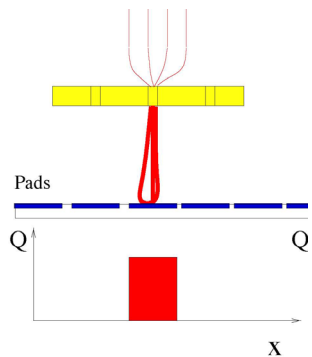
Modified GEM anode with a high resistivity film bonded to a readout plane with an insulating spacer



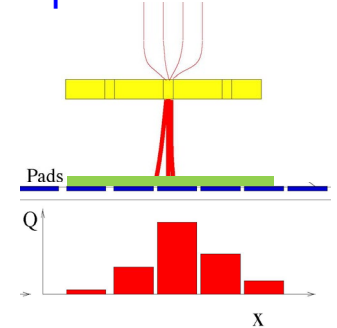
R.K.Carnegie et al.,
NIM A538 (2005) 372

K. Boudjemline et al.,
NIM A574 (2007) 22

Pad width would limit MPGD TPC space resolution

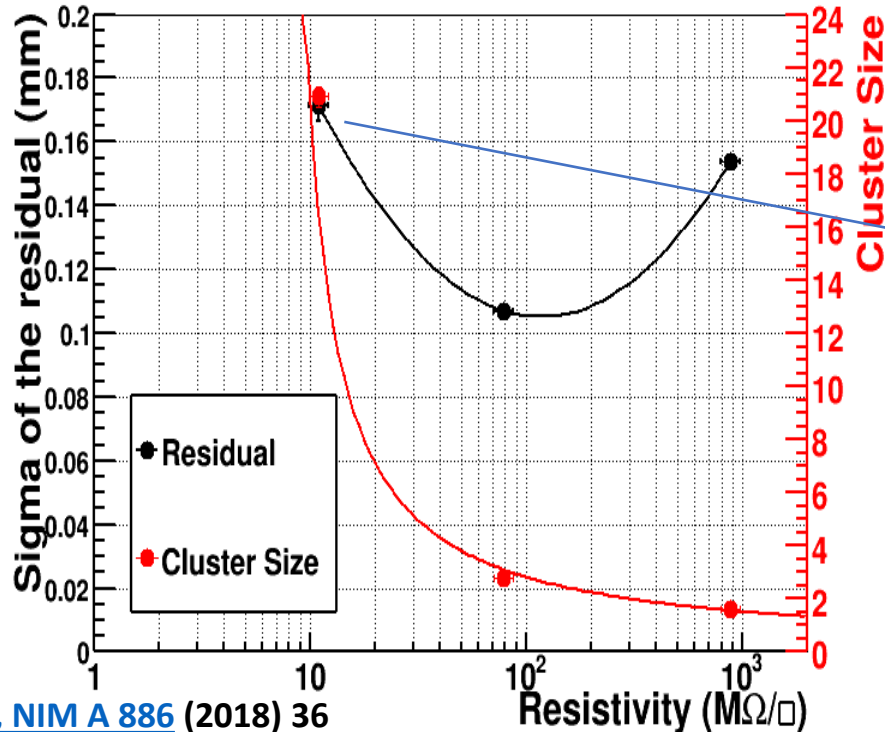


Resistive layer increase charge distribution increasing MPGD TPC space resolution

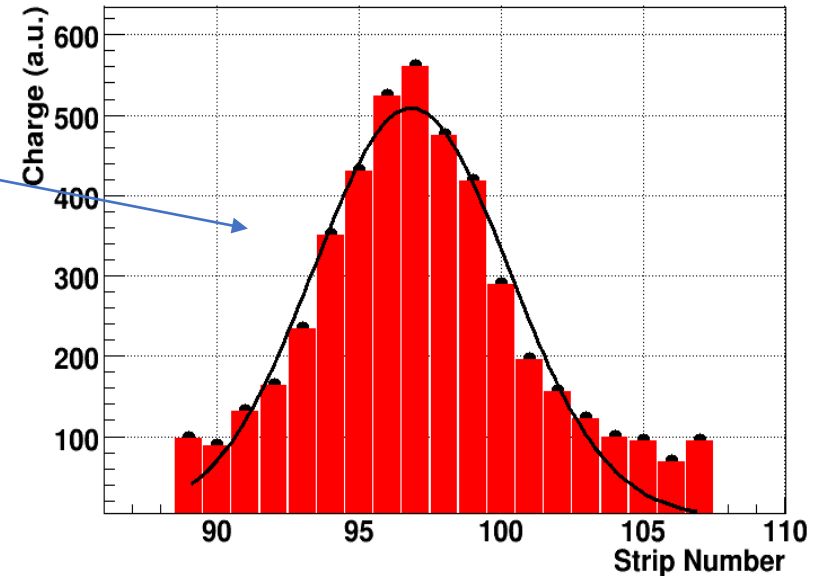


Centroid analysis

APV & 400 μ m strip pitch & $C_{inp}=15$ pF



Charge collected by the APV on the strip readout (resistivity $10 M\Omega/\square$)



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

The use of **low resistivity** increases the charge spread (cluster size) on the readout strips and then σ worsens. At **high resistivity** the charge spread is too small ($Cl_size \rightarrow 1$) then the Charge Centroid method becomes ineffective ($\sigma \rightarrow pitch/\sqrt{12}$).

2021 plans of WP7 (Nuova richiesta)

La richiesta per il 2021 è di realizzare N.10 rivelatori low-rate μ RWELL di area attiva $50 \times 16 \text{ cm}^2$ (con lunghezza strip identica a quella prevista in IDEA) così suddivisi:

- N.5 μ RWELL per Pre-shower
 - **Strip pitch 0.4 mm, strip length 50 cm ($C_{inp} \sim 70 \text{ pF}$)**
- N.5 per Muon detector
 - **Strip pitch 1 mm, strip length 50 cm ($C_{inp} \sim 180 \text{ pF}$)**

La proposta è di misurare l'allargamento della distribuzione di carica per 5 differenti valori di resistività del DLC 10-20-50-100-200 MOhm/square.

Per entrambi i pitch (e diverso valore di resistività) si misurerà la risoluzione spaziale in funzione di:

- **uno strip pitch di 0.4-0.8-1.2-1.6 mm (pre-shower) leggendo tutte le strip, uno sì e una no, ecc;**
- **uno strip pitch di 1-2-3 mm (muon chamber) leggendo tutte le strip, una sì e una no, ecc;**

→ Queste misure forniranno un quadro completo che ci permetterà di scegliere in modo ottimale il valore di resistività e strip pitch in modo da ridurre il numero di canali di elettronica per il preshower e il Muon detector

- **I 5x2 rivelatori saranno prima equipaggiati con APV e testati a TB al CERN-SPS 2021 e successivamente con il TIGER**

2022-2024 plans of WP7

- Define the best resistivity of the DLC for both μ RWELL fundamental tiles
 - Build 50x50 cm² prototypes for preshower and muon system
 - Both prototypes with **bi-dimensional** readout
 - Develop a **custom-made ASIC** for the μ RWELLS, with the experience obtained from the TIGER
 - **Optimise** the **engineering** mass **construction process** together with industry (Eltos)
 - Develop a new reconstruction algorithm, ML-based, to improve the resolution for tracks impinging at an angle far from 90⁰
- Test and validate μ RWELL prototypes in the lab with cosmic rays
- Test and validate μ RWELL prototypes with custom-made electronics in test beams

Several of the points above are already contained in AIDAinnova

- AIDAinnova will mostly provide contracts for young collaborators
- Assume that CSN1 will cover material and equipment costs

Richieste per il 2021 (Categoria 1: Nuova richiesta)

	Capitolo	Descrizione	Richiesta
LNF	Missioni	Test Beam al CERN (2 persone per 2 settimane)	6
		Contatti ditta Workshop CERN/ELTOS per costruzione prototipi	2
	Consumo	Costruzione di: -5 prototipi pre-shower u-RWELL 16x50 cm2 strip pitch 0.4 mm (diverse resistività DLC) -5 prototipi muon u-RWELL 16x50 cm2 strip pitch 1 mm (diverse resistività DLC)	25
		Altri_cons	Bombole gas pre-miscelata Ar/CO2/CF4
		Sub. Tot	35
Bo	Missioni	Test Beam al CERN (2 persone per 2 settimane)	6
		Contatti ditta Workshop CERN/ELTOS per costruzione prototipi	1
	Altri_cons	Tiger readout board	3
		Tiger FEBs Bombole di gas Ar, CO2 e CF4	2
	Sub. Tot	13	
Fe	Missioni	Test Beam al CERN (2 persone per 2 settimane)	5
	Consumo	Transition Board per interfaccia elettronica APV -> TIGER	2
	Altri_cons	gas bombole pre-mix	1
		Sub. Tot	8
To	Missioni	Test Beam al CERN (2 persone per 2 settimane)	5
		Sub. Tot	5
Tot			61
Missioni (indiviso LNF-Bo-Fe-To)			25
Consumo (indiviso LNF-Bo-Fe-To)			27
Altri consumo (indiviso LNF-Bo-Fe-To)			9
Tot			61

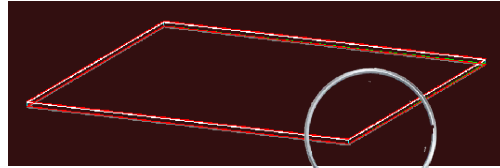
Nei preventivi 2021 Bologna ha messo il metabolismo missioni (3 k€) sulla voce "consumo" e che invece bisognerebbe spostare su missioni

Richieste per il 2021 (Categoria 3: Richiesta già presentata a luglio 2020)

	A	B	C	D	E	F	G	H	I
1									
2	rivelatore	costo unitario	quantita'	totale (kE)	note				
3	<i>camera uRWell</i>	7.5	1	7.5					
4	<i>connettori Hirose</i>	0.006	25	0.15					
5	<i>adattatori Panasonic-Hirose</i>	0.02	25	0.5					
6									
7									
8	HV	costo unitario	quantita'	totale (kE)	note				
9	<i>mainframe</i>	0	0	0	presente nelle varie sezioni - costo 6 kE				
10	<i>modulo caen A1561HD</i>	0	0	0	in house - costo 5.5 kE				
11	<i>PC</i>	0	0	0	in house				
12	<i>cavi</i>	0	0	0	in house				
13									
14									
15	LV, FEE, DAQ	costo unitario	quantita'	totale (kE)	note				
16	<i>mainframe</i>	0	0	0	stesso dell'HV				
17	<i>caen A2519</i>	2.5	1	2.5					
18	<i>TIGER FEB</i>	0.5	6	3	costo per piccole produzioni - 6 FEB per la camera grande				
19	<i>dissipatori cooling</i>	0	6	0	fatti in casa				
20	<i>Readout Cards</i>	3.05	2	6.1	una legge 4 FEB, noi ne dobbiamo leggere 6 per la camera grande				
21	<i>cavi LV e segnale</i>			1					
22	<i>DAQ, trigger e PC</i>	0	0	0	in house				
23									
24									
25	Grand Total			20.75 kE					
26									

12.6 k€ per l'elettronica

IDEA full simulation of preshower

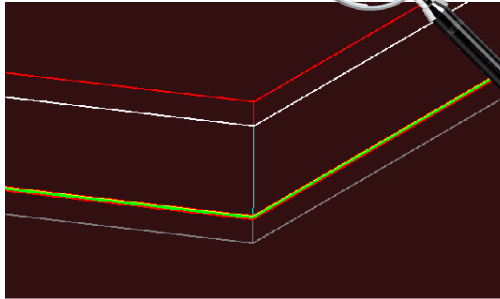


Chamber thickness: 9.4601mm

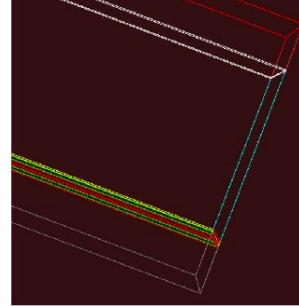
➤ Cathode thickness:
1.635mm

➤ Driftgap: 6mm

➤ μ RWELL+readout
thickness: 1.8251mm

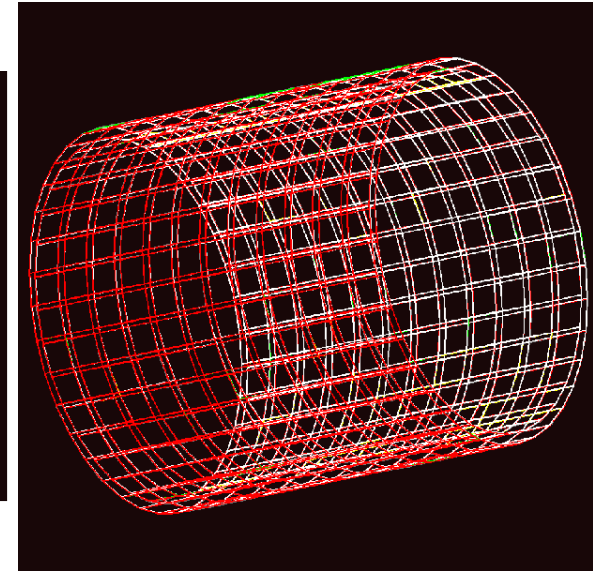
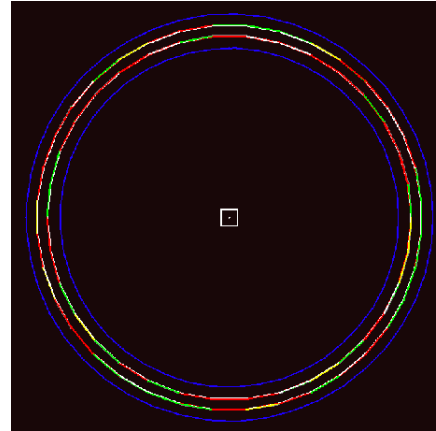


The cathode points to the IP



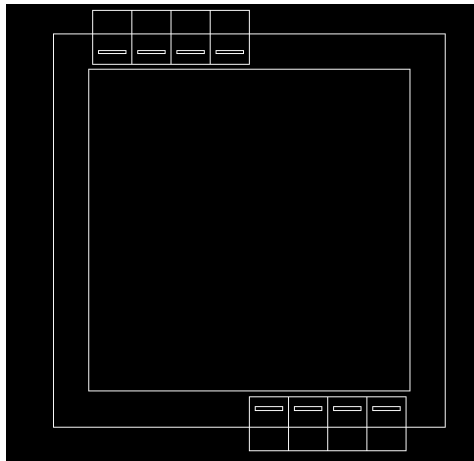
All the materials and dimensions of a HR μ RWELL HR-SG2++ have been considered

Barrel preshower



First considered chamber size:

500 mm x 500 mm



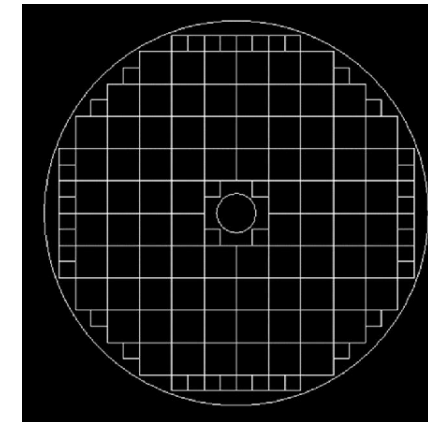
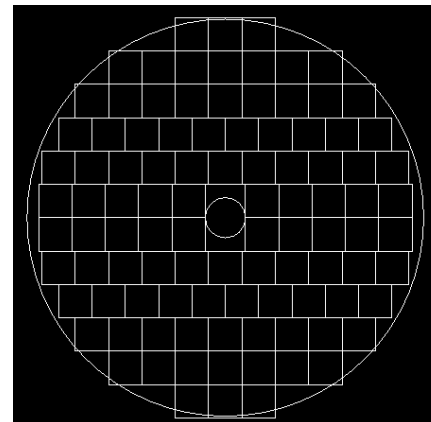
Need to evaluate the realistic ACTIVE AREA of the detector:

- 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 7mm

ACTIVE AREA = 410 mm x 410 mm

Pitch: 400 μ m \Rightarrow 1025 strip
(they will be reduced to 1024, so that they can be read by 8 APV25 (128 channels))

Several options studied for the end-caps



Le seguenti voci verranno impegnate in questo II semestre 2020:

WP7 – LNF Missioni per Contatti ditta Workshop CERN/ELTOS per costruzione prototipi ~ 3 k€
(circa 4.8 k€ disponibili → ~ 1.8 k€ restituiti)

WP7 – LNF Consumo 27k€ per costruzione prototipi medium/large size che stiamo disegnando

Le seguenti voci verranno restituite:

WP7 – LNF Missione TB ~ 5 k€ SJ

WP7 – Fe Missione TB ~ 3 k€