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CEPC Physics&Detector meeting

μRWELL R&D plans for IDEA

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Program of 2020

The 2020 program is centered mainly on the following activities:

1. construction at **ELTOS/CERN/TECHTRA** (**Technology Transfer**) of medium/large size **high-rate μRWELLs (300x250 ÷ 600x250 mm^2)**
2. *design, construction and characterisation of a* ***cilindrica μRWELL*** *(CREMLIN-plus - started on 01/02/2020)*
3. *design, construction and characterisation of μRWELL to detect thermal neutrons (**ATTRACT – uRANIA**)*

Results obtained

1.1 - The **production of medium/large size high-rate μRWELL** based on the SG2 layout, because of COVID-19**, has had some delay.** The new production of DLC+Cu (e DLC) will be completed in July. The orders of the new detectors large size will be done within September 2020. The μ**RWELL production should therefore be completed by the end of 2020. TEST foreseen** in **2021.**

1.2 - TEST is ongoing at CERN on a new μRWELL high rate layout further simplified wrt. SG2 that could be very **interesting for future developments for CepC and FCC-ee (IDEA).**

2 – The design of the cylindrical μRWELL is ongoing.

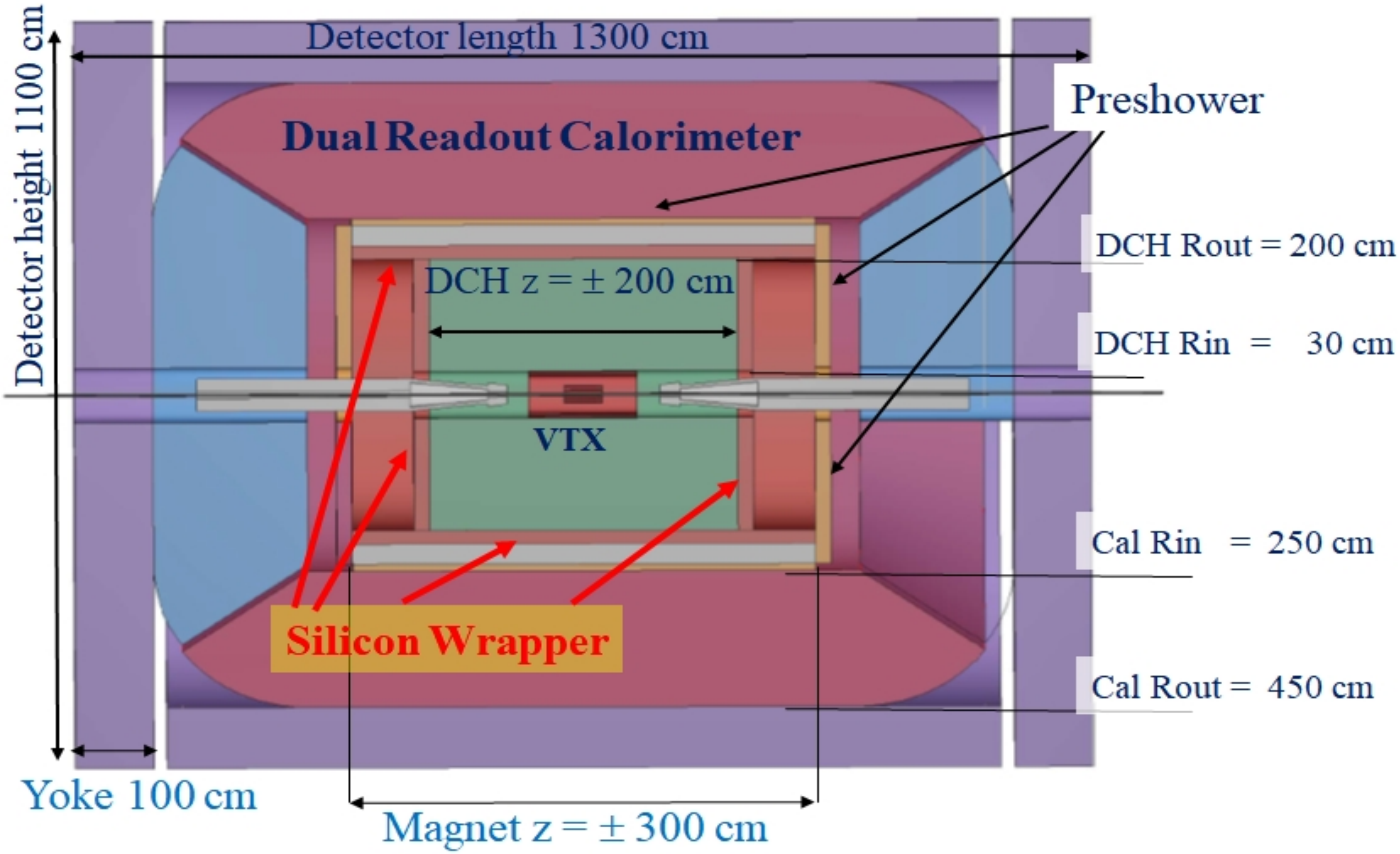
By September a real-size mock-up of the mechanics should be completed on the basis of which the detector design will be finalised.

By the end of 2020 we should have all the components for the assembly that will occur in the first months of 2021.

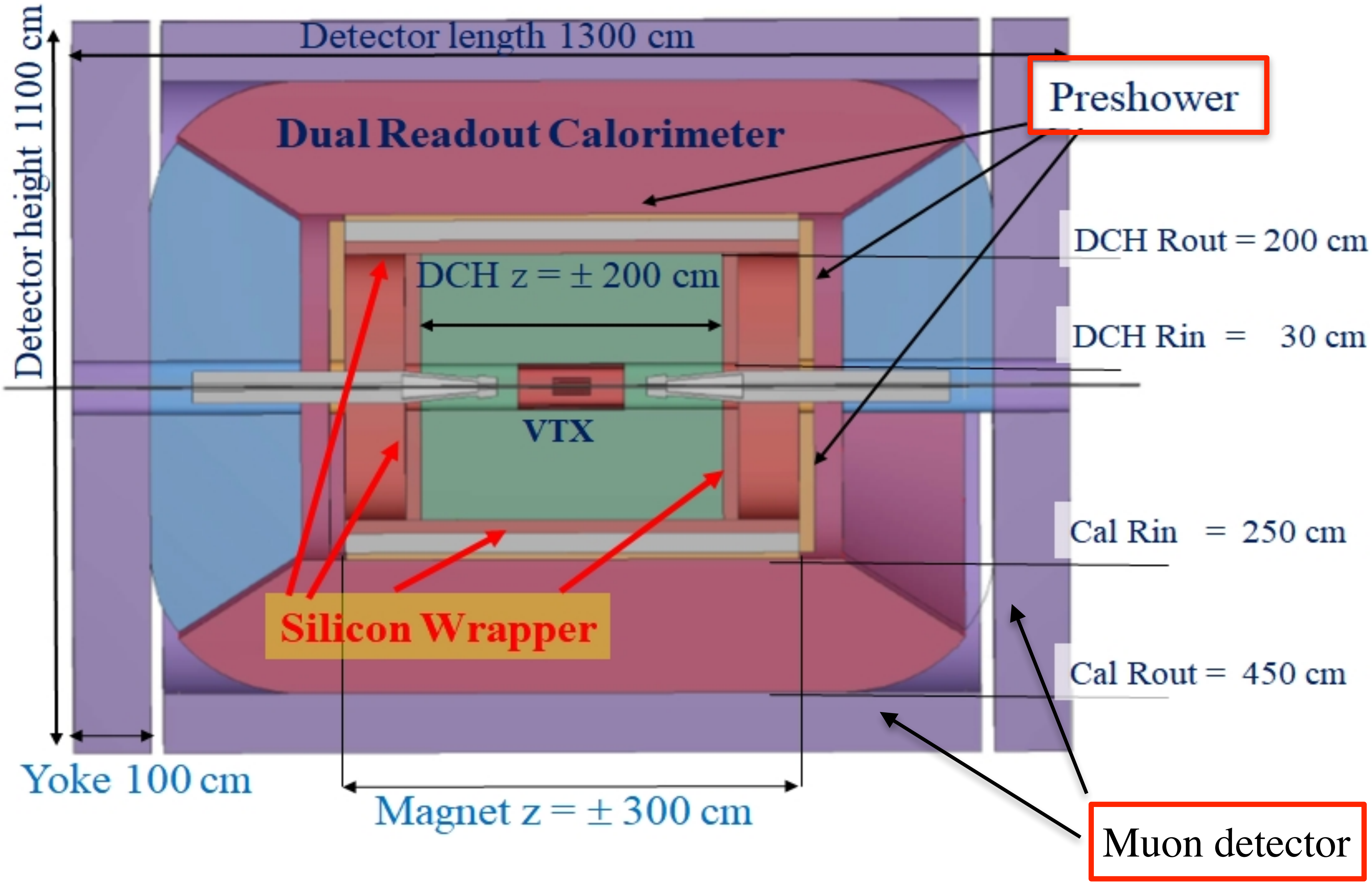
3 - ATTRACT – uRANIA: the first test at ENEA-HOTNES was performed on December 2019, obtaining a an efficiency for thermal neutrons of 3.5%.

The work of ATTRACT – uRANIA continues with the implementation of converters with more elaborate geometries with the aim of reaching an efficiency of 7-8% per single layer of detector. End of July we will have the second test at ENEA-HOTNES.

IDEA detector layout

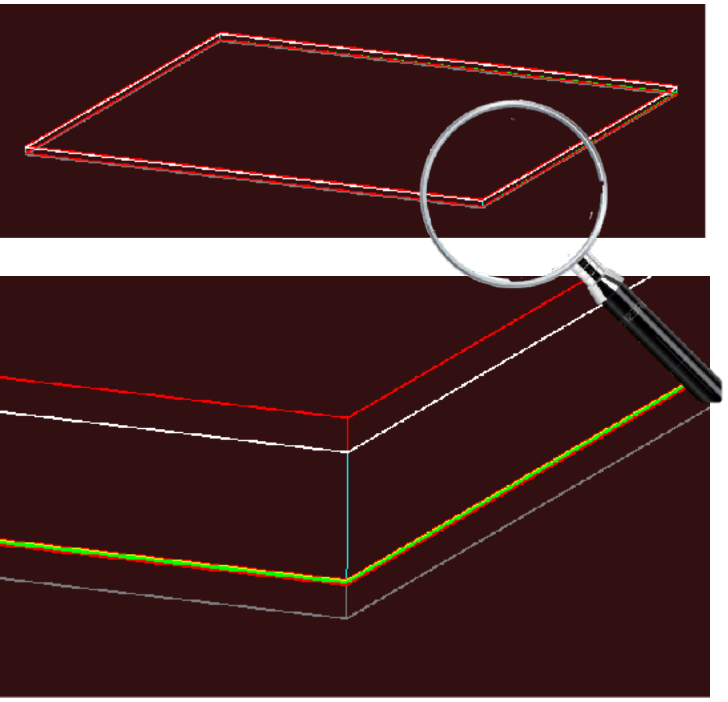


IDEA detector layout



Preshower and the muon detection system are designed with the µRWELL technology

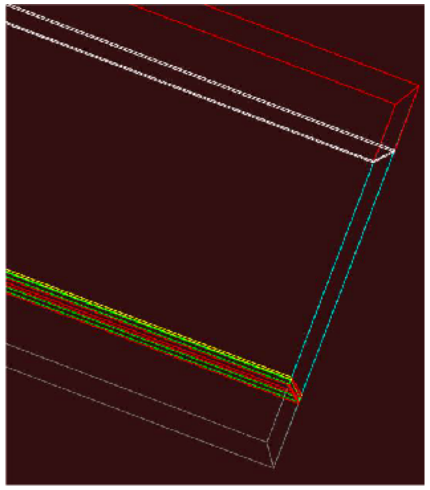
IDEA full simulation of preshower



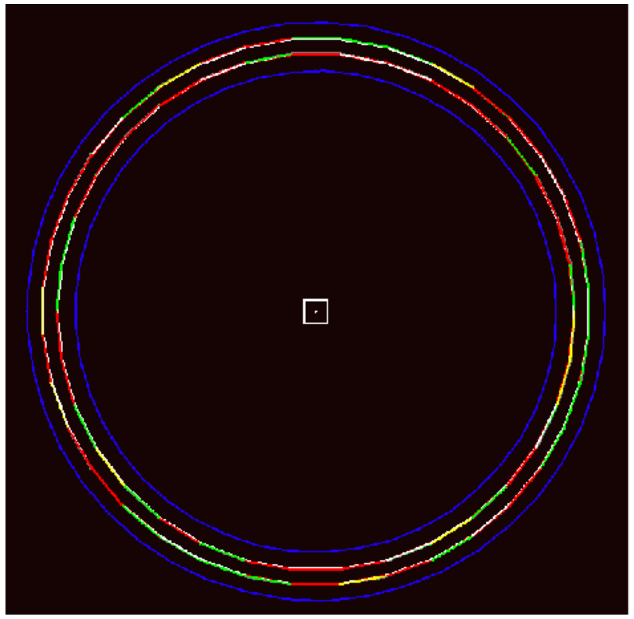
All the materials and dimensions of a HR µRWELL HR-SG2++ have been considered

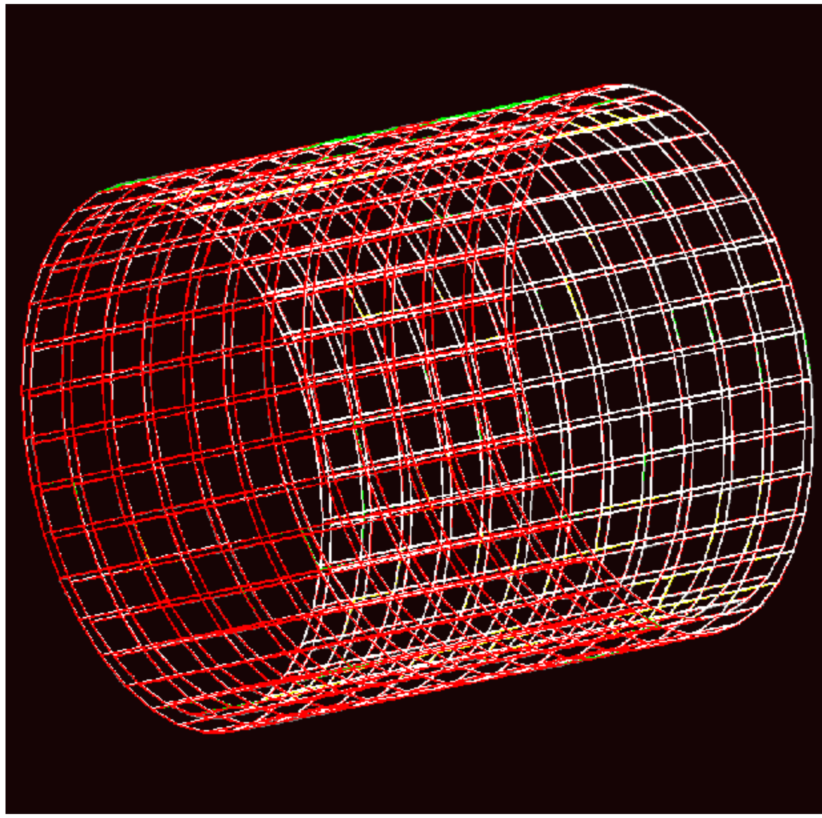
Chamber thickness: 9.4601mm

- **Cathode thickness: 1.635mm**
- **Driftgap: 6mm**
- **µRWELL+readout thickness: 1.8251mm**

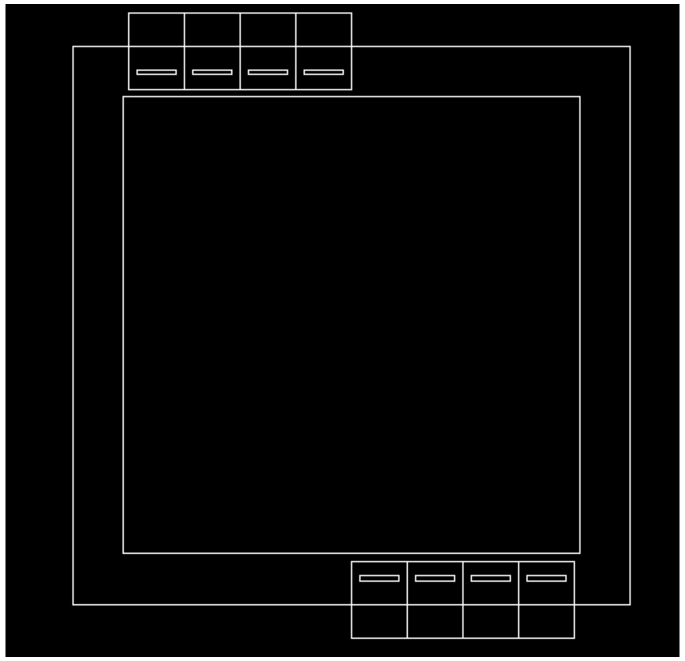


Barrel preshower





First considered chamber size:
500 mm x 500 mm



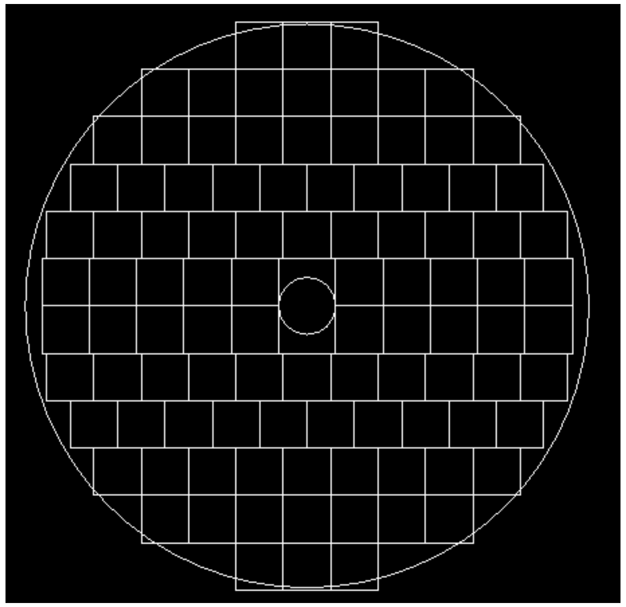
Need to evaluate the realistic ACTIVE AREA of the detector:

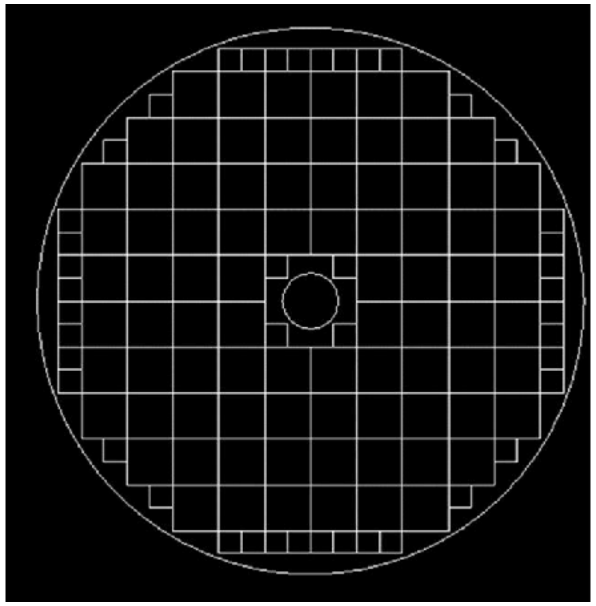
- HV cables
- 8 APV25 (128 channels):
  50 mm x 68 mm x 1.6 mm
- Panasonic connectors (perpendicular to strips):
  35 mm x 4.2 mm x 7mm

ACTIVE AREA = 410 mm x 410 mm

Pitch: 400 µm=> 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





Description of a µRWELL (**HR layout–SG2++**) detector implemented

IDEA Muon detector dimensions

Barrel

Layer	R [mm]	Length [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# 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

50x50 cm²
strips 50 cm
pitch 1.5 mm

Endcap

Disk	R_{in} [mm]	R_{out} [mm]	z [mm]	Thickness [mm]	int. length	pixel size [mm]	area [cm²]	# 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

IDEA's Muon detector would have in total:

Barrel **900x2** m² (1800 m² total)

Barrel **1200000x2** channels

Endcaps **500x2x2** m² (2000 m² total)

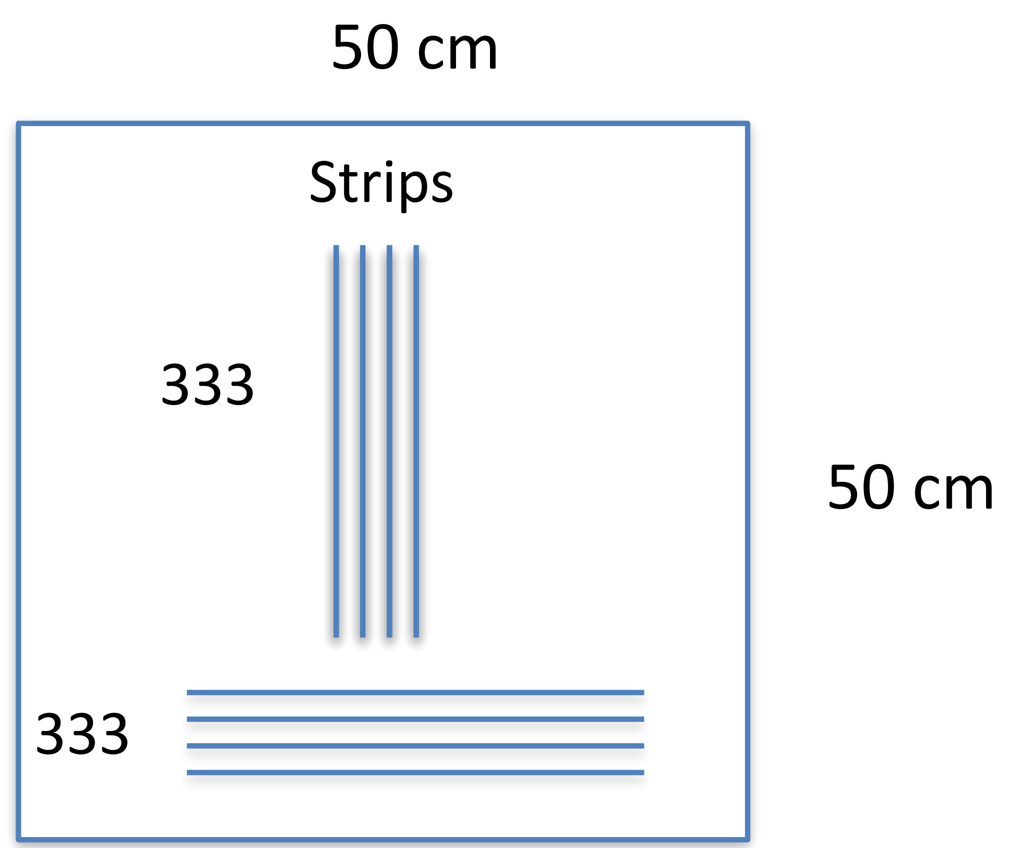
Endcaps **1350000x2** channels

~5M channels in total

μRWELL module for IDEA muon det.

Assume a **modular** construction with μRWELL detectors with an active area **50x50** cm^2

Each detector has x and y readout with 50 cm long strips and a strip pitch of 1.5 mm



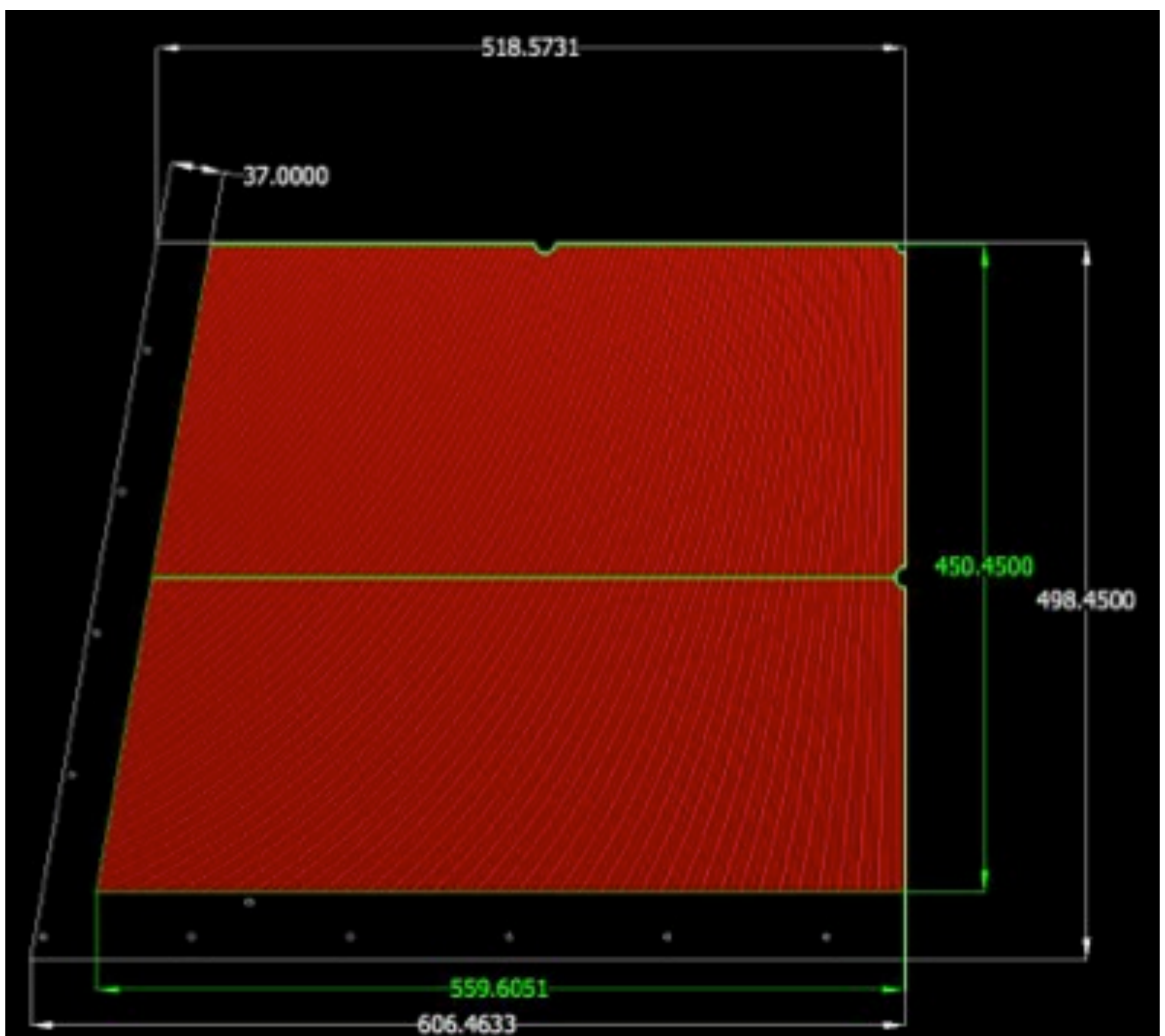
The CMS M4 μRWELL chamber has a similar strip pitch with about half the strip length.

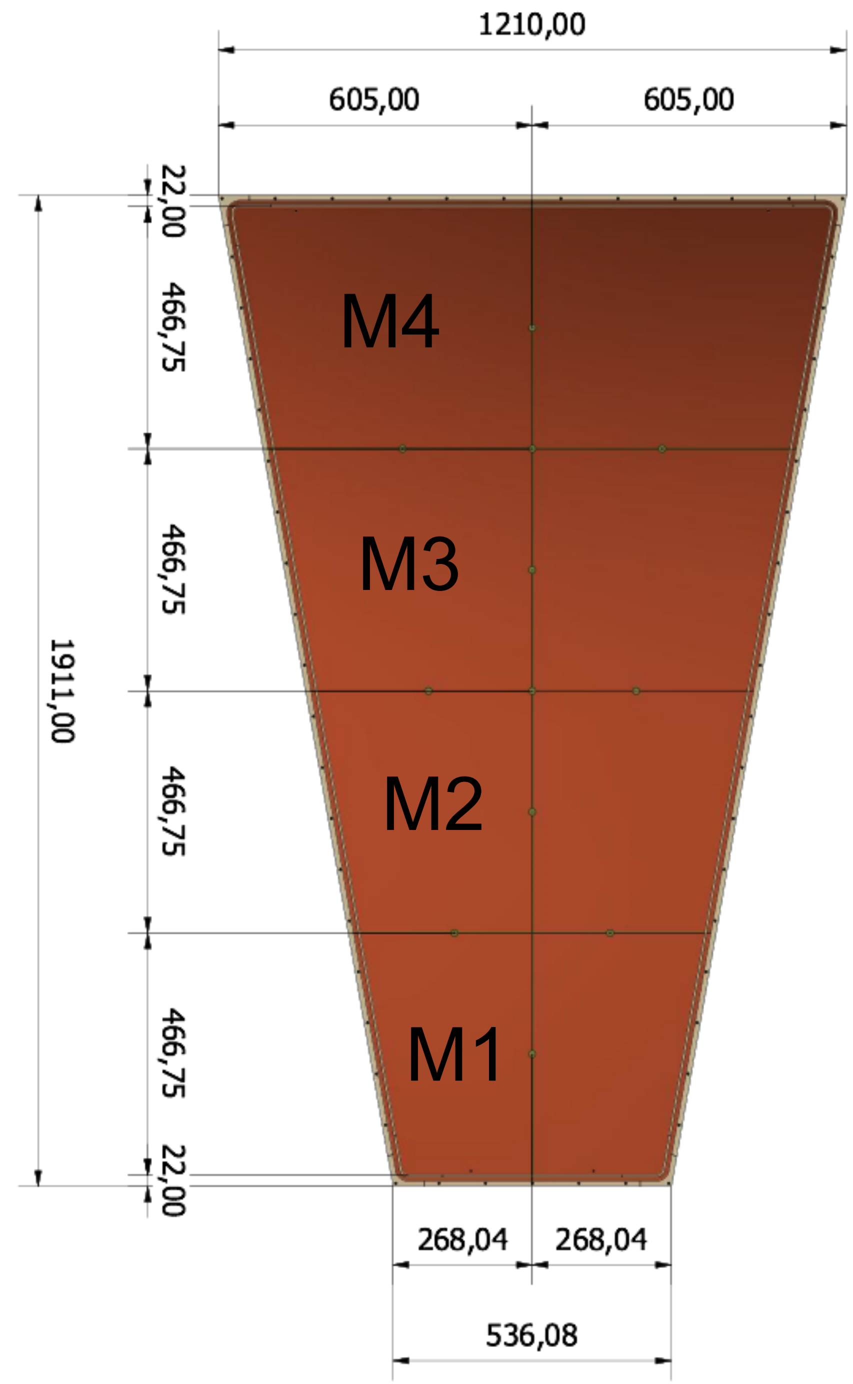
Testing a M4 chamber gives a good idea of how an IDEA μRWELL module could work.

New M4 large μRWELL chamber

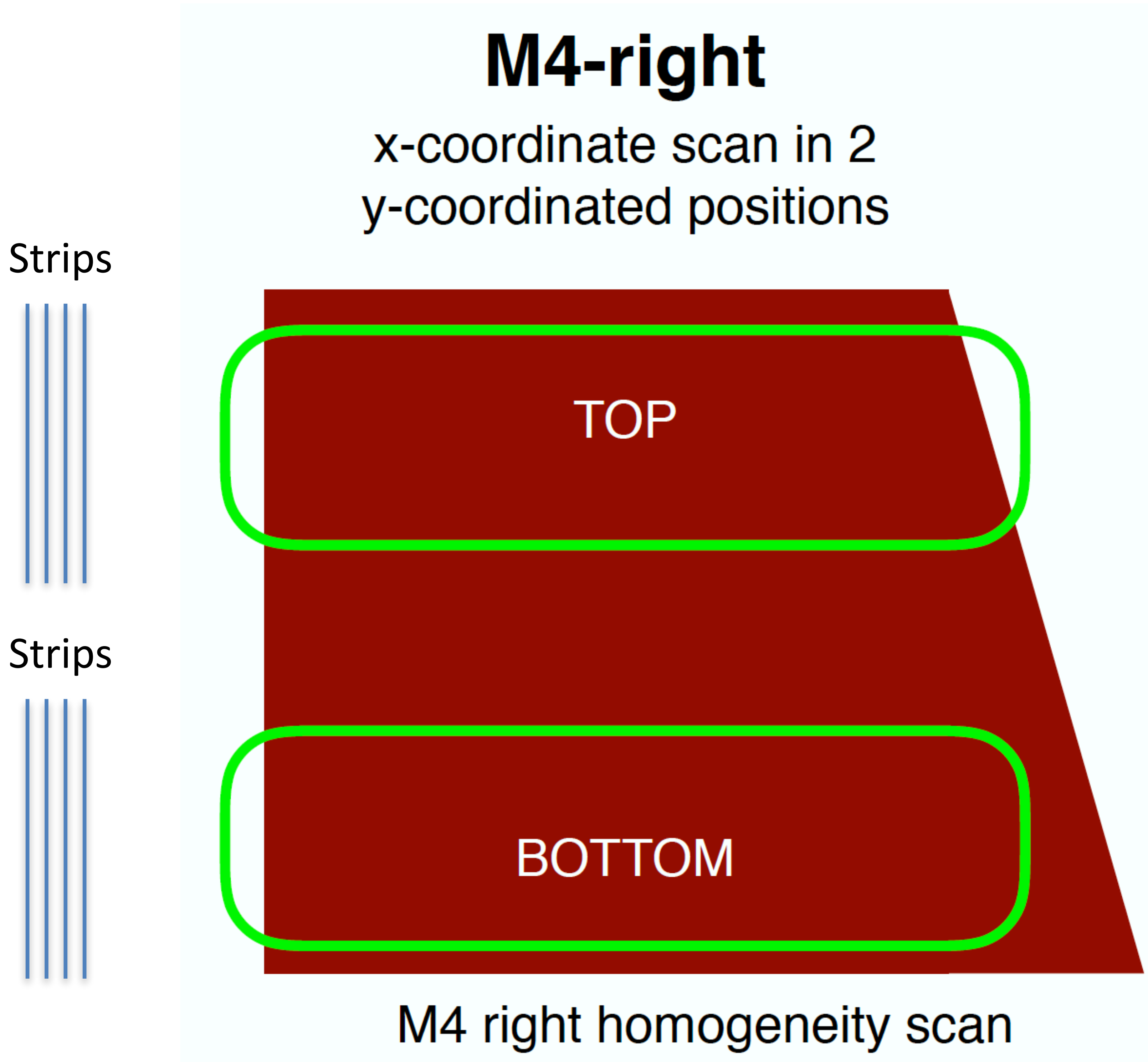
- Rui de Oliveira confirmed me that he can build another large M4 μRWELL chamber in his lab at CERN. He will use the drawings used for the CMS M4.

Size: 606.5 x 498.5 x 1 mm
Active area: 559.6 - 480 (w) x 450 (h) mm
373 radial strips
strip pitch 1.29 - 1.5 mm
strip length ~ 22 cm





M4 μRWell prototype



Muon detector cost

	Cost [Meuro]	Engineers [years]	Technicians [years]	Operators [years]
Detectors	4,9	0,4	1,0	0,0
Installation	0,7	0,6	2,8	2,9
Electronics	15,4	0,3	1,5	0,0
HV/LV Systems	0,7	0,2	1,4	0,0
Gas System	0,3	0,2	1,3	0,0
TOTAL	**22,0**	**1,7**	**7,9**	**2,9**

Assumed 3 euro/channel

Assuming the following manpower costs:

Engineer	80 euro/hour
Technician	40 euro/hour
Operator	30 euro/hour

36 hours/week * 48 week/year = 1728 hours/year

	Cost [Meuro]
Detectors	4,9
Installation	0,7
Electronics	15,4
HV/LV Systems	0,7
Gas System	0,3
TOTAL	**22,0**

Electronics is by far the dominant cost

Assuming 300 MEuro as the cost of a FCC-ee or CEPC detector, the Muon detector would be ~7.3% of the total

Proposal presented to RD-FA referees

- Build a large M4 μRWELL detector and equip it with a Tiger-based readout
  - Would be a very valid test of an IDEA-dimension μRWELL detector equipped with a custom-made ASIC
  - The TIGER chip was developed by TO and FE for GEM detectors in the frame of BESIII
  - Manuel is convinced that with a custom-made ASIC, the cost of the complete front-end electronics to readout a μRWELL would not exceed 1 euro/channel
    - This solution would be extremely appealing to reduce the total cost of the IDEA muon detector.
- We could then test the M4 with the Tiger with the large cosmic rays telescope (Bologna), with sources (Ferrara) and with a X-ray gun (LNF) before bringing the whole setup onto a test beam sometime in 2021
- In parallel perform simulation studies, with special emphasis on golden channels, Long Lived Particles, etc. to justify the interest of having a performing tracker in the muon detection system rather than a simple tagger and optimise the detector consequently.
  - This task is foreseen by the IDEA group and will receive special consideration.

2021 plans of WP7

R&D finalised to the realisation of μRWELL for IDEA that foresees

μRWELL "tiles" of 50x50 cm^2 with low-rate layout and these characteristics:

- Pre-shower
  - **Strip pitch 0.4 mm**, strip length 50 cm
- Muon detector
  - **Strip pitch 1 mm**, strip length 50 cm
  - pitch reduced to 1.5 mm from what originally proposed, this is possible only with a sensible reductions of the electronics cost

The proposal is to study several DLC resistivities for both detectors in order to optimise the performances minimising the number of channels:

- **5 detectors of 16x50 cm^2** for each of the **2 strip pitches** with different DLC resistivities: **10 – 20 – 50 – 100 – 200 MOhm/square**
- The 5x2 detectors will be first equipped with APV electronics and tested with beam at the CERN-SPS in 2021 and afterwards equipped with the TIGER

2022-2024 plans of WP7

- Define the best resistivity of the DLC for both μRWELL fundamental tiles
  - Build 50x50 cm^2 high-rate prototypes for preshower and muon system
    - Both prototypes with bi-dimensional readout
  - Develop a custom-made ASIC for the μRWELLs, 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 90^0
- Test and validate μRWELL prototypes in the lab with cosmic rays
- Test and validate μRWELL 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

Backup

Proposal presented to RD-FA referees

rivelatore	**costo unitario**	**quantita'**	**totale (kE)**	**note**
camera uRWell	7.5	1	7.5	
connettori hirose	0.006	25	0.15	
adattatori Panasonic-hirose	0.02	25	0.5	
HV	**costo unitario**	**quantita'**	**totale (kE)**	**note**
mainframe	0	0	0	presente nelle varie sezioni - costo 6 kE
modulo caen A1561HD	0	0	0	in house - costo 5.5 kE
PC	0	0	0	in house
cavi	0	0	0	in house
LV, FEE, DAQ	**costo unitario**	**quantita'**	**totale (kE)**	**note**
mainframe	0	0	0	stesso dell'HV
caen A2519	2.5	1	2.5	
TIGER FEB	0.5	6	3	costo per piccole produzioni - 6 FEB per la camera grande
dissipatori cooling	0	6	0	fatti in casa
Readout Cards	3.05	2	6.1	una legge 4 FEB, noi ne dobbiamo leggere 6 per la camera grande
cavi LV e segnale			1	
DAQ, trigger e PC	0	0	0	in house
Grand Total			**20.75**	**kE**

Richieste 2021 di WP7

Strip pitch (mm)	Costo unitario rivelatore	n. Rivelatori	Totale
1	2500	5	12500
0,4	2500	5	12500
Transition board (APV → TIGER)	2000	1	2000
Test beam CERN H4 (missioni 2 weeks)	12000	1	12000
Totale			**39000**