CEPC Workshop
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IDEA's Muon detector optimisation ideas

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IDEA detector layout

Beam pipe: R~1.5 cm

Vertex:
- 5 MAPS layers
- R = 1.7-34 cm

Drift Chamber:
- 4 m long, R = 35-200 cm

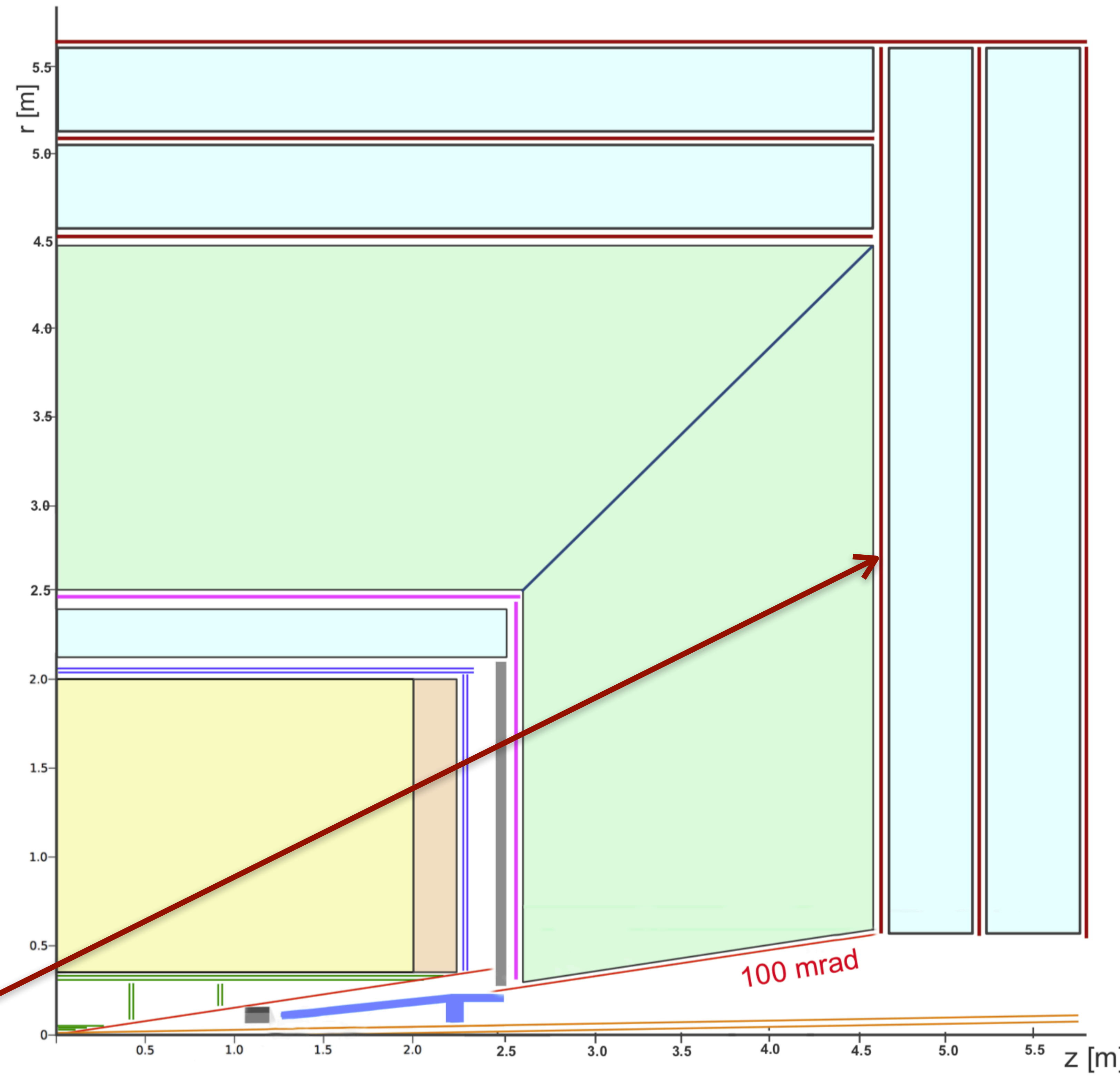
Outer Silicon wrapper:
- Si strips

Superconducting solenoid coil:
- 2 T, R ~ 2.1-2.4 m
- $0.74\ X_0$, $0.16\ \lambda$ @ 90°

Preshower: ~1 X_0

Dual-Readout Calorimeter:
- 2m / 7 λ_{int}

Yoke + Muon chamber



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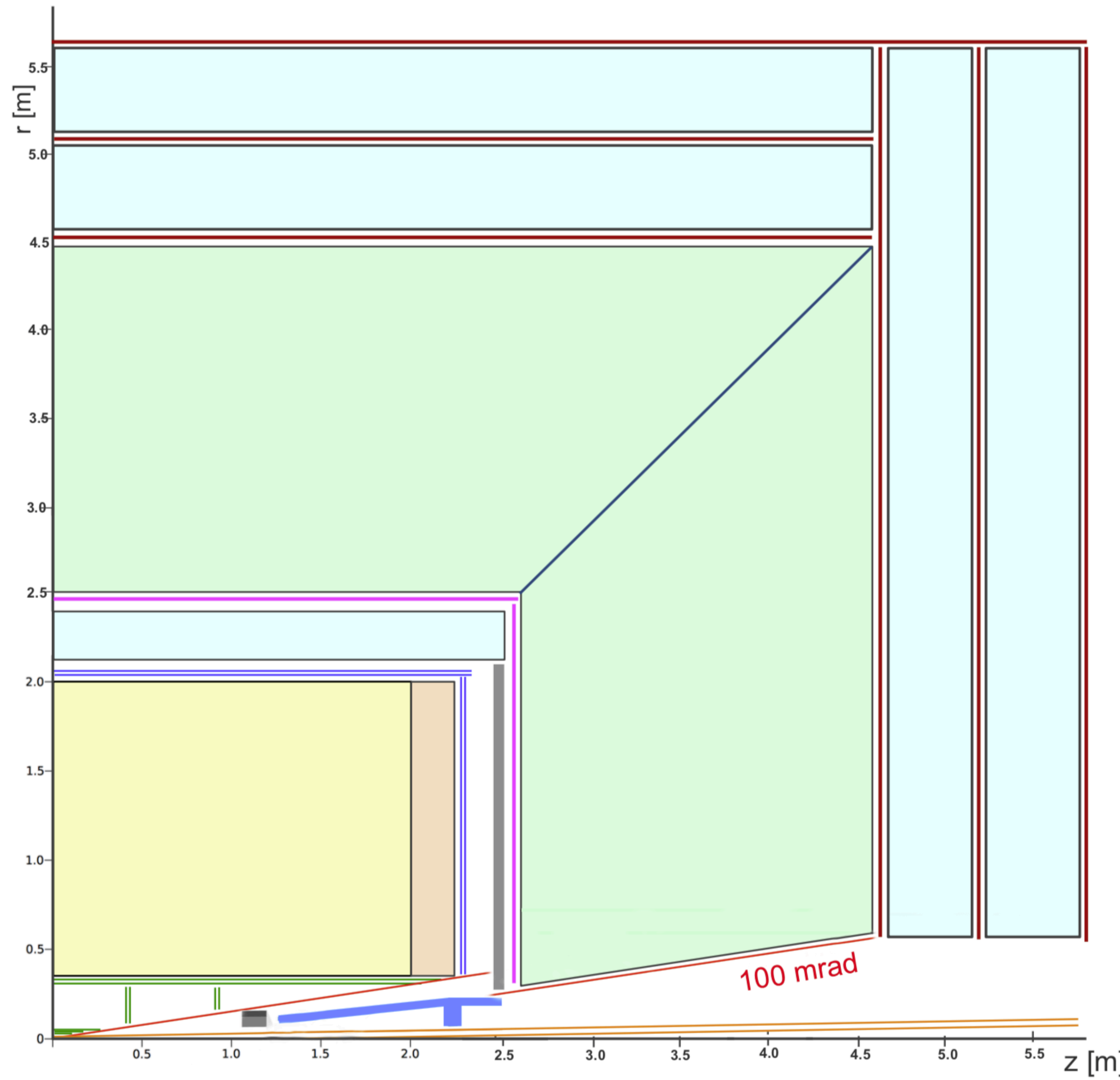


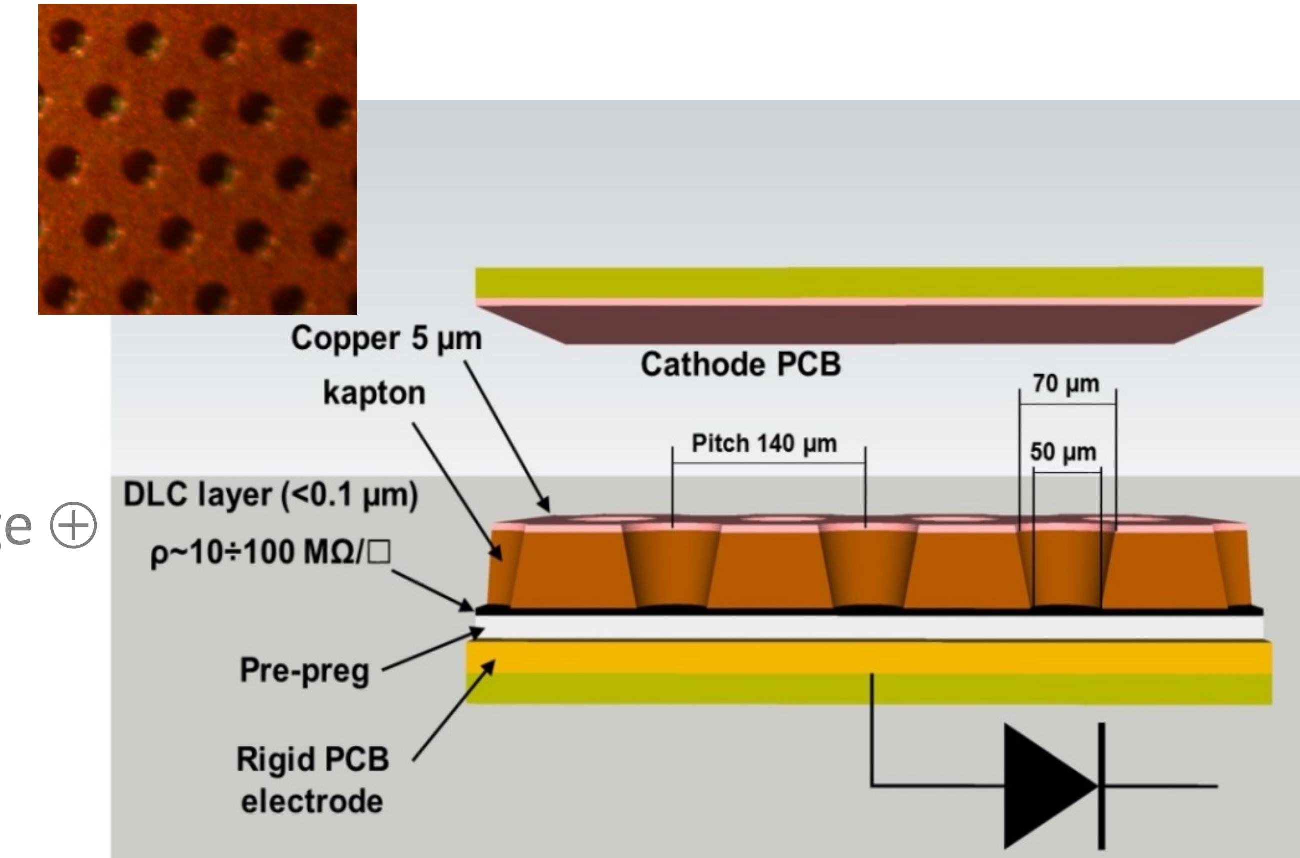
IDEA preshower and muon detector

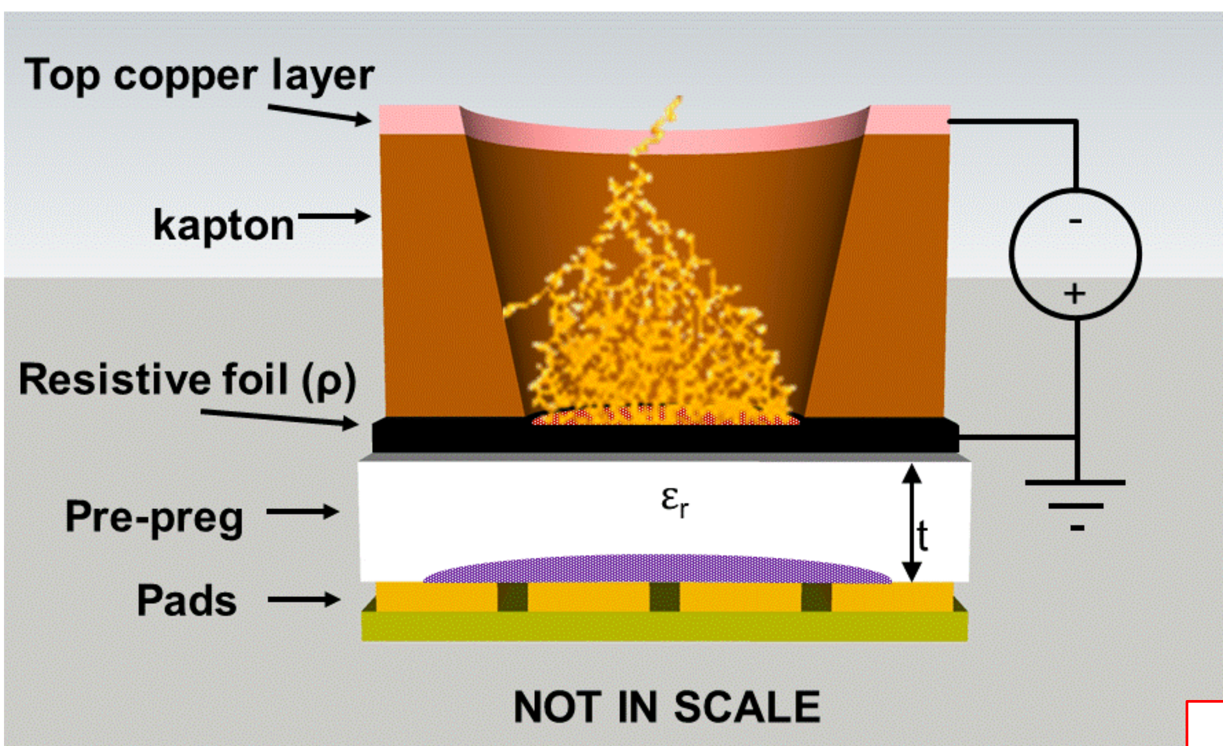
Detector technology: μ-RWELL

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



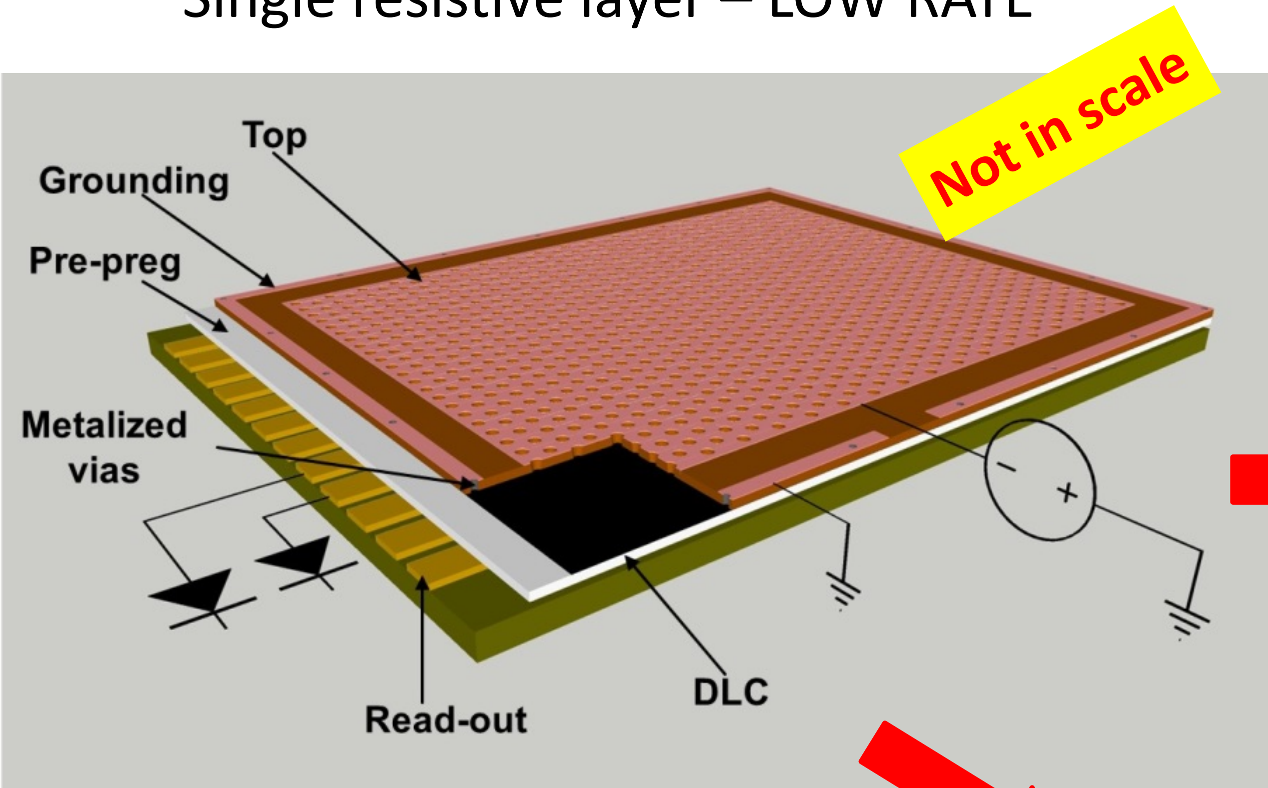


- The "WELL" acts as a multiplication channel for the ionization produced in the gas of the drift gap
- The charge induced on the resistive layer is spread with a time constant, τ ~ ρ×C

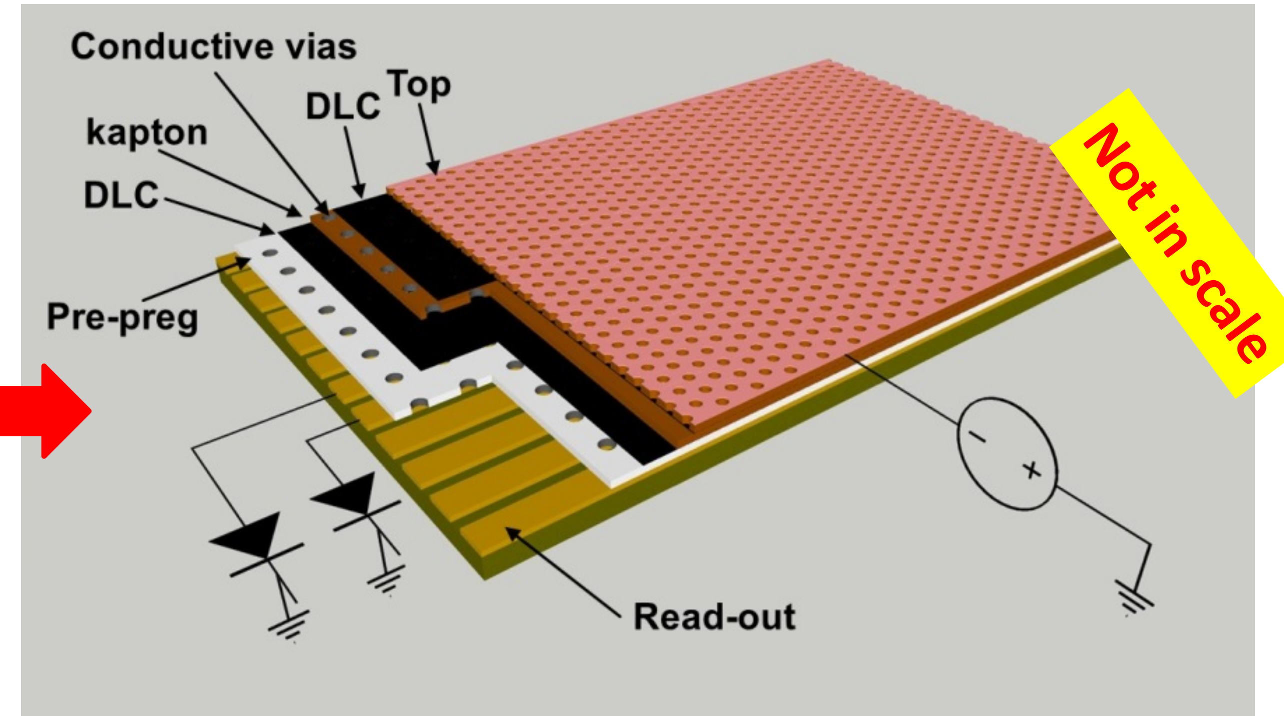
$$C = \varepsilon_0 \times \varepsilon_r \times \frac{S}{t} \cong 50\ pF/m$$ (pitch-width 0,4 mm)

IDEA μ-RWELL layout

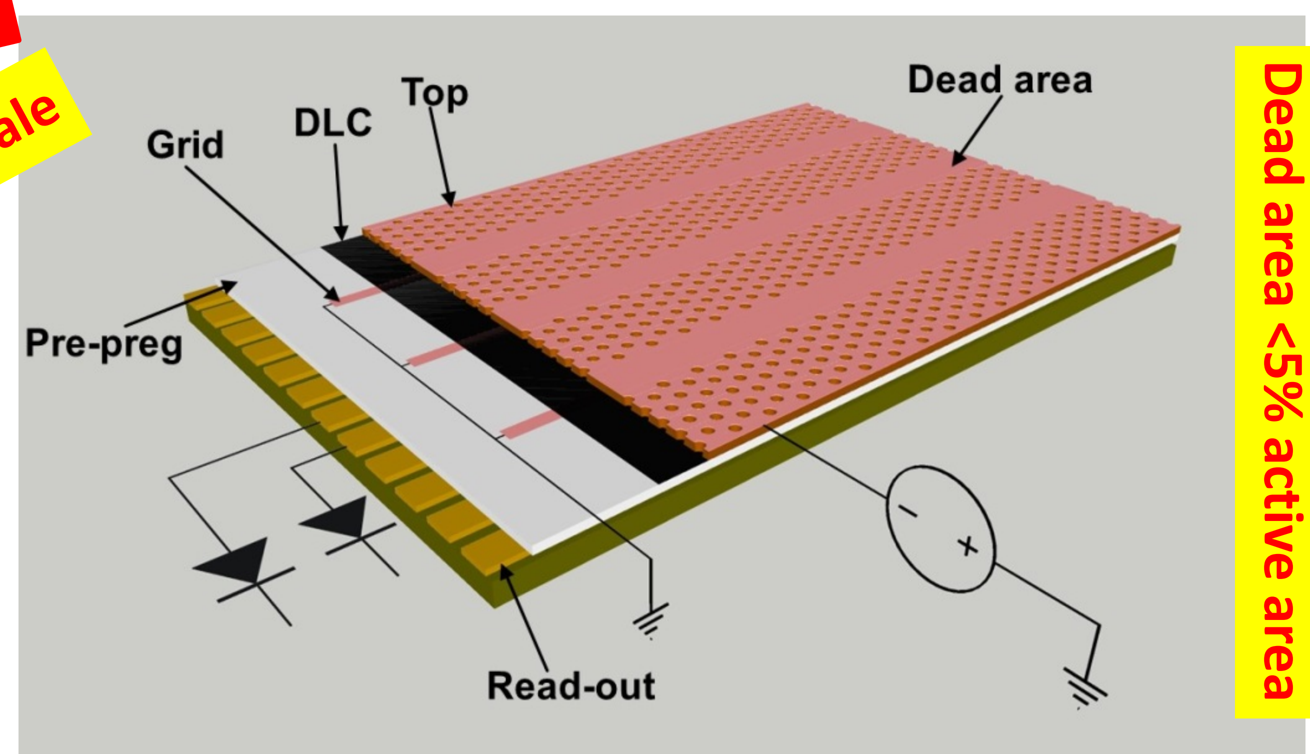
Single resistive layer – LOW RATE



Double resistive layer – HIGH RATE



Not in scale



Dead area <5% active area

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

Single resistive layer with dense grid grounding – SIMPLIFIED HIGH RATE

2

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

Barrel

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

Endcap

IDEA's Muon detector would have in total:

Barrel 900x2 m^2

Barrel 1200000x2 channels

Endcaps 1000x2 m^2

Endcaps 1350000x2 channels

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**

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

Muon detector cost

Some considerations

- Difficult to increase the strip pitch
- Could reduce the number of electronics channels by grouping strips two by two
  - Half the number of channels

	Cost [Meuro]
Detectors	4,9
Installation	0,7
Electronics	7,8
HV/LV Systems	0,7
Gas System	0,3
TOTAL	**14,4**

Assuming 300 MEuro as the cost of a CEPC detector, the Muon detector would be ~4.8% of the total

- Space resolution would still be ~ 600 μm
- Muon detector would measure 3 space (x,y,z) points with high precision
- An efficient muon trigger could be formed

Muon detector cost

More considerations

- Another possibility would be to descope the detector
  - ➡ This should be driven by the CEPC detector requirements
    - Could then become a simple Muon tagger, without the capability of doing standalone track reconstruction
- Move towards a RPC-based muon detector?
  - Would need to investigate the net cost savings
  - We are moving a centimetric space resolution instead of a sub-mm resolution

Backup