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Performance of the large-area micro-RWELL detectors

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VEPP-2000

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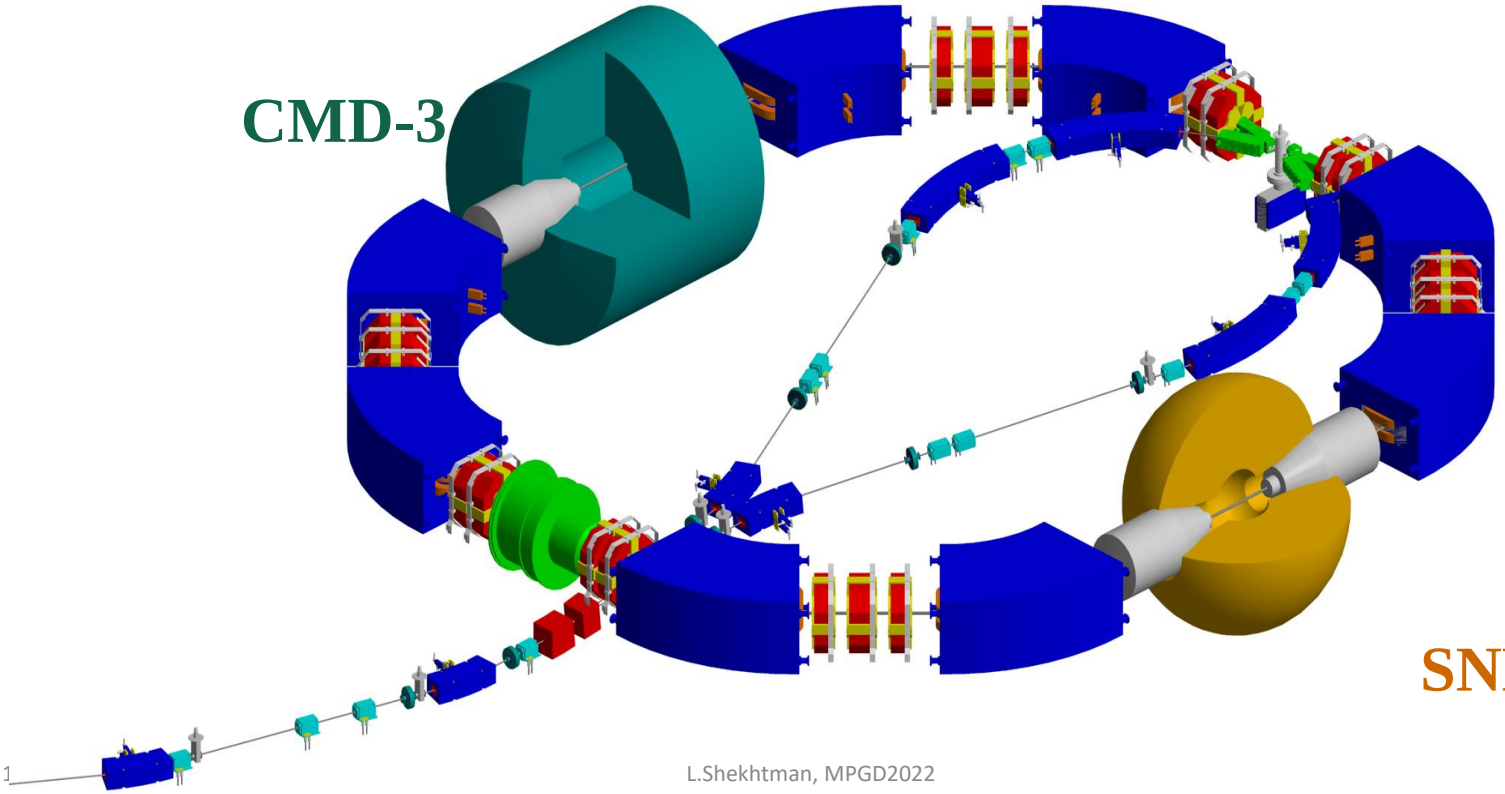
- beam length – 3.3 cm
- revolution time – 82 ns
- circumference – 24.4 m
- $L = 10^{32}$ cm^{-2}s^{-1} at 2.0 GeV,

energy spread – 0.7 MeV
beam current – 200 mA
beta function in IP $\beta_x = \beta_z = 4.3$cm
$L = 10^{31}$ cm^{-2}s^{-1} at 1 GeV



CMD-3 detector

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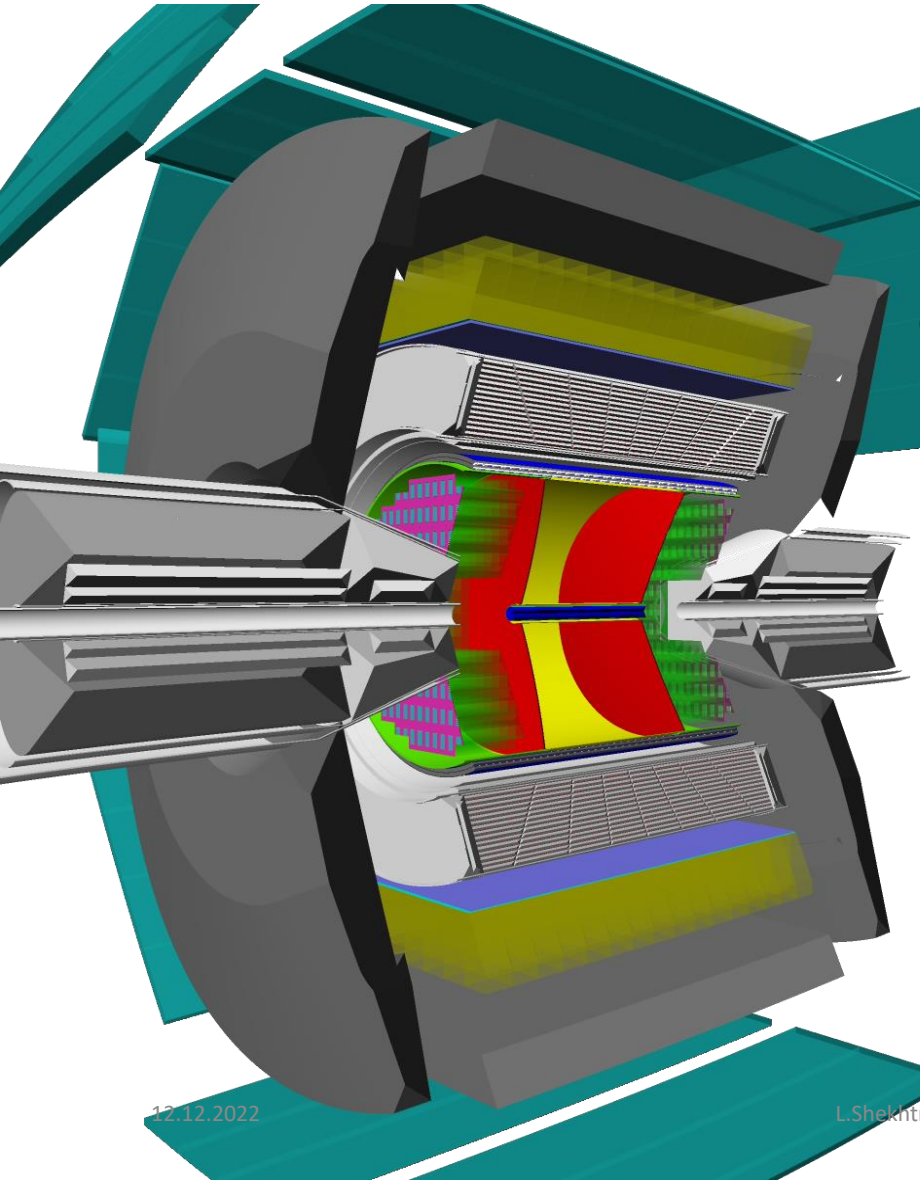

DC – 1218 hexagonal cells with sensitive wires, W-Re alloy, 15 μm in diameter.

Z-chamber – start FLT, precise determine z-coordinate ~ 500 μ (detector acceptance)

LXe calorimeter thickness $7X_0$, 196 towers & 1286 strips. Spatial resol. 1–2 mm.

Calorimeter with CsI crystals (~3,5 t), 8 octants, number of crystals - 1152, 8 X_0.

TOF – 16 counters, time resolution ~ 1ns

MR system – 8 octants (cosmic veto, ~ 1ns)

Project magnetic field - 1,5 T
(current value 1.3 T while)

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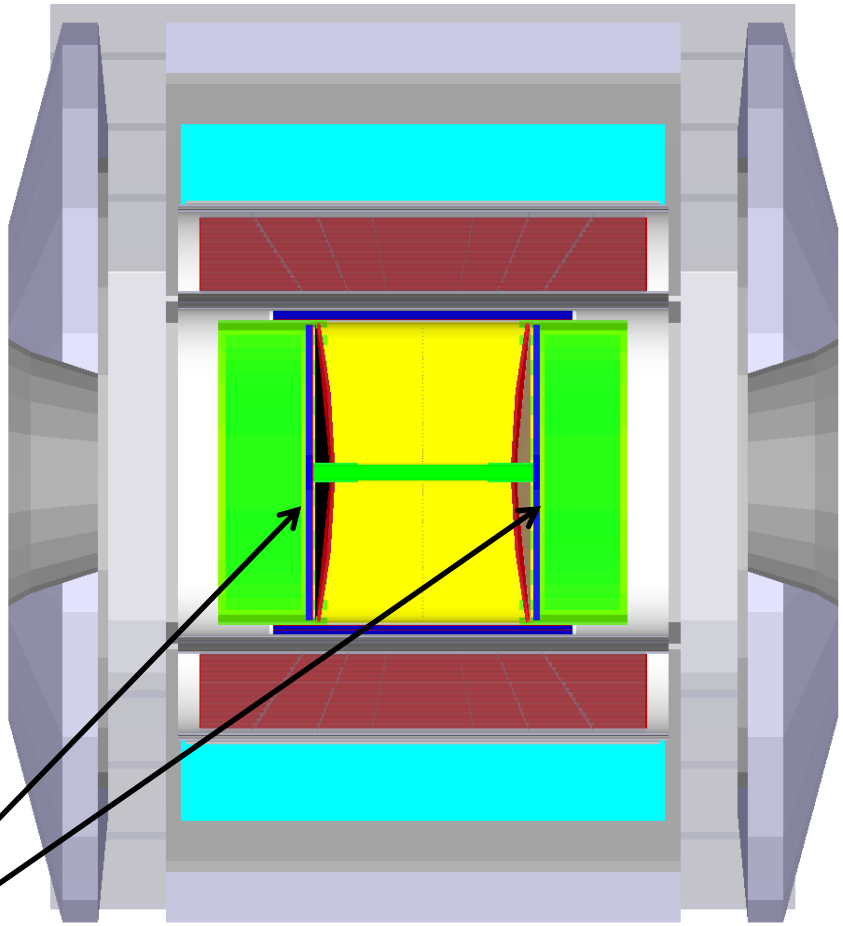
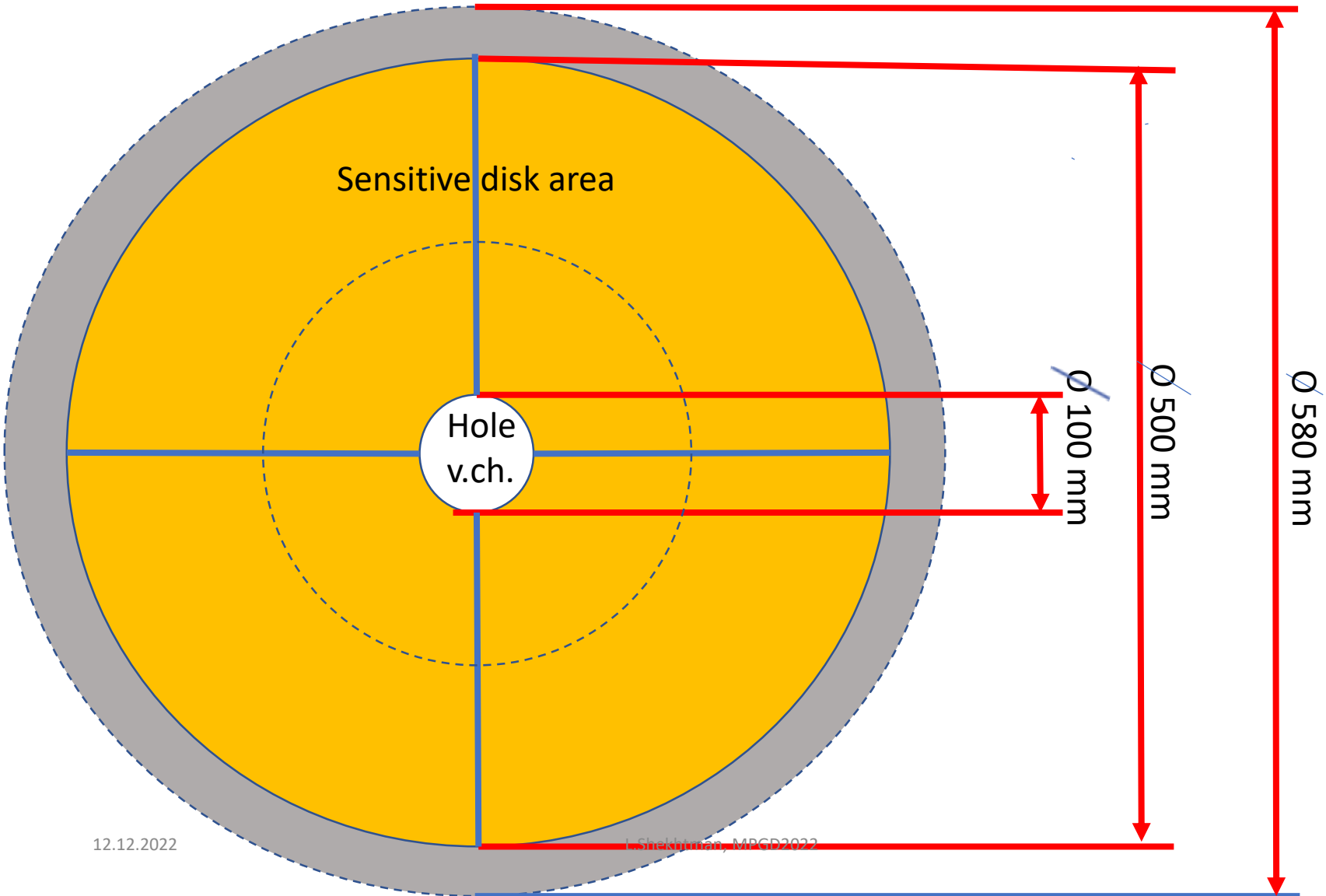
Proposal for the upgrade of the tracking system



End-cap discs

End-cap tracker for CMD-3 based on muRWELL technology



End-cap discs

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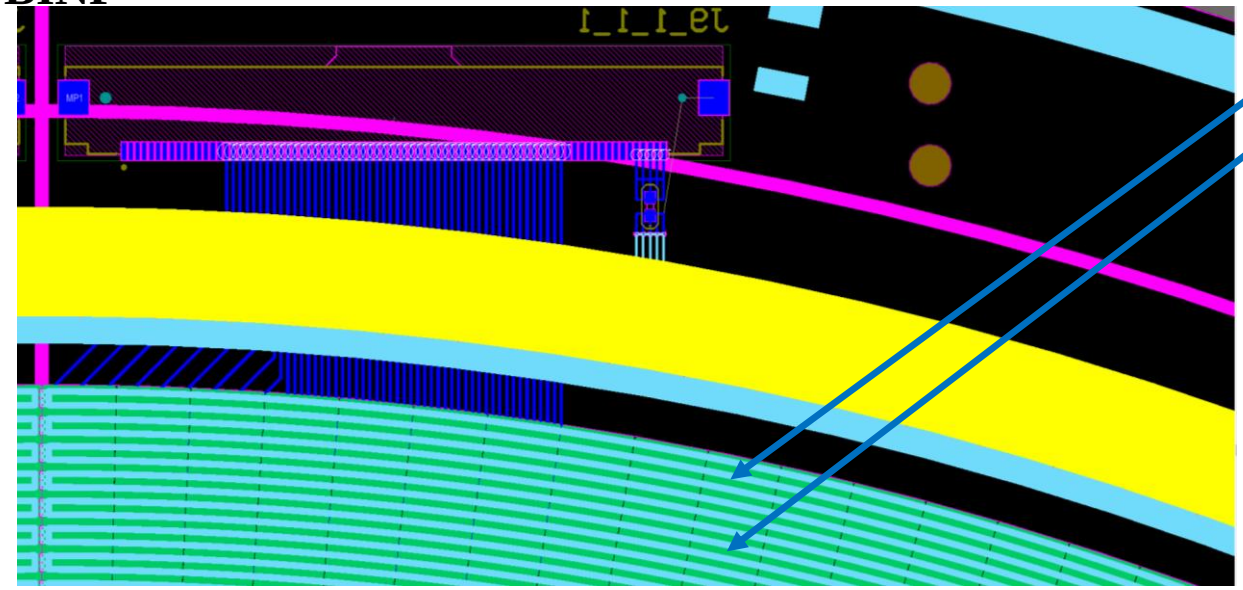
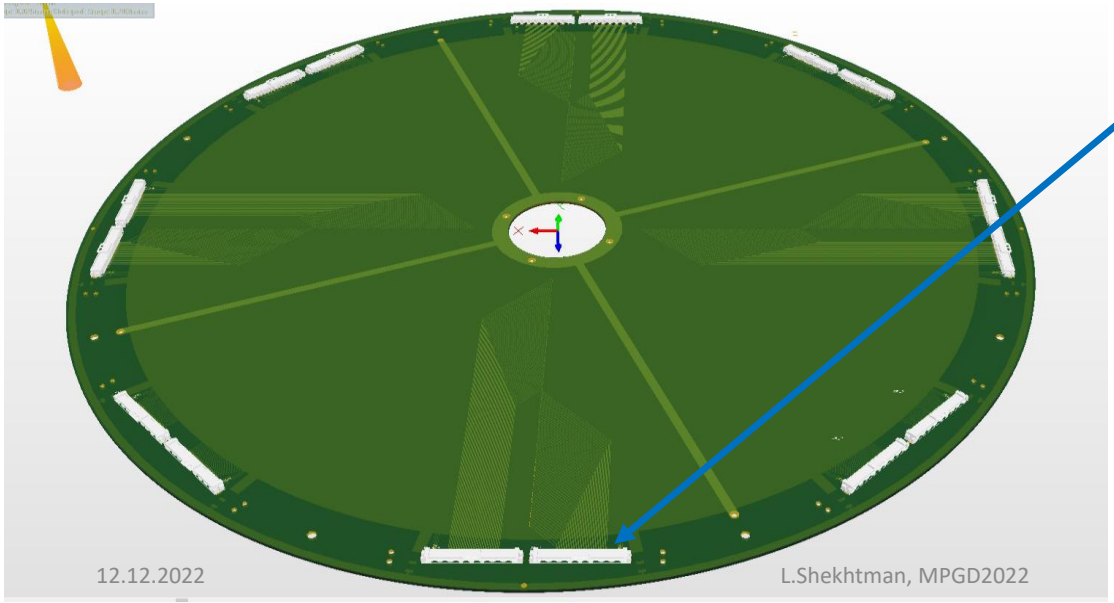


Two-layer readout structure:
Top layer – quarter-arcs(light blue)
Bottom layer – sectors; 144 sectors at 5<R<15cm, 288 sectors at 15<R<25 cm

400 quarter-rings
144+288 sectors

832 channels per disc



Each pad of the readout structure is connected to SMD connectors at the disc perimeter

Two discs were manufactured at CERN workshop during 2019

Design of disc mechanics and final layout in the CMD3

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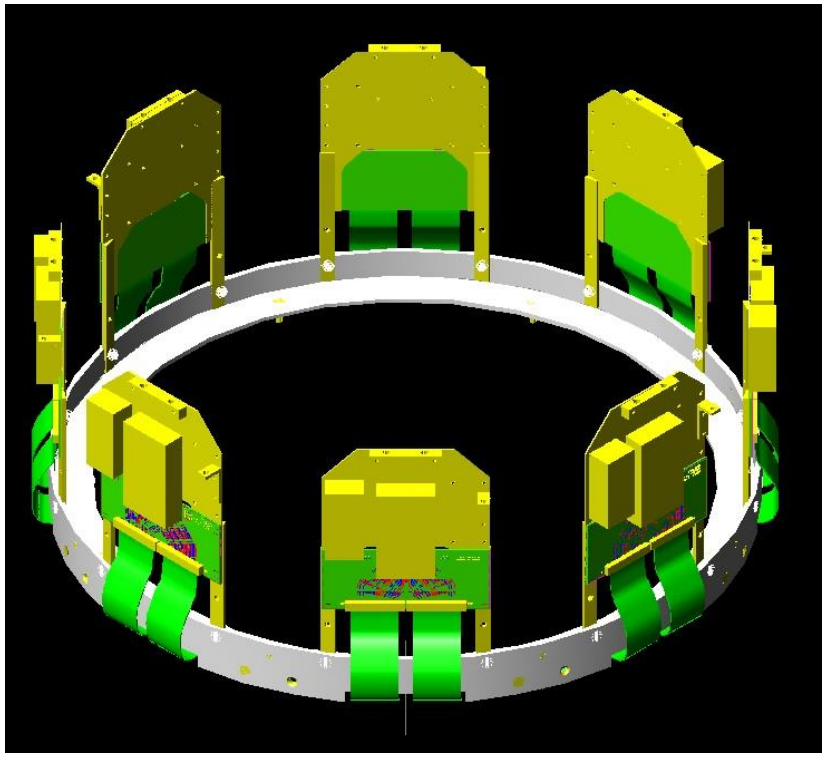
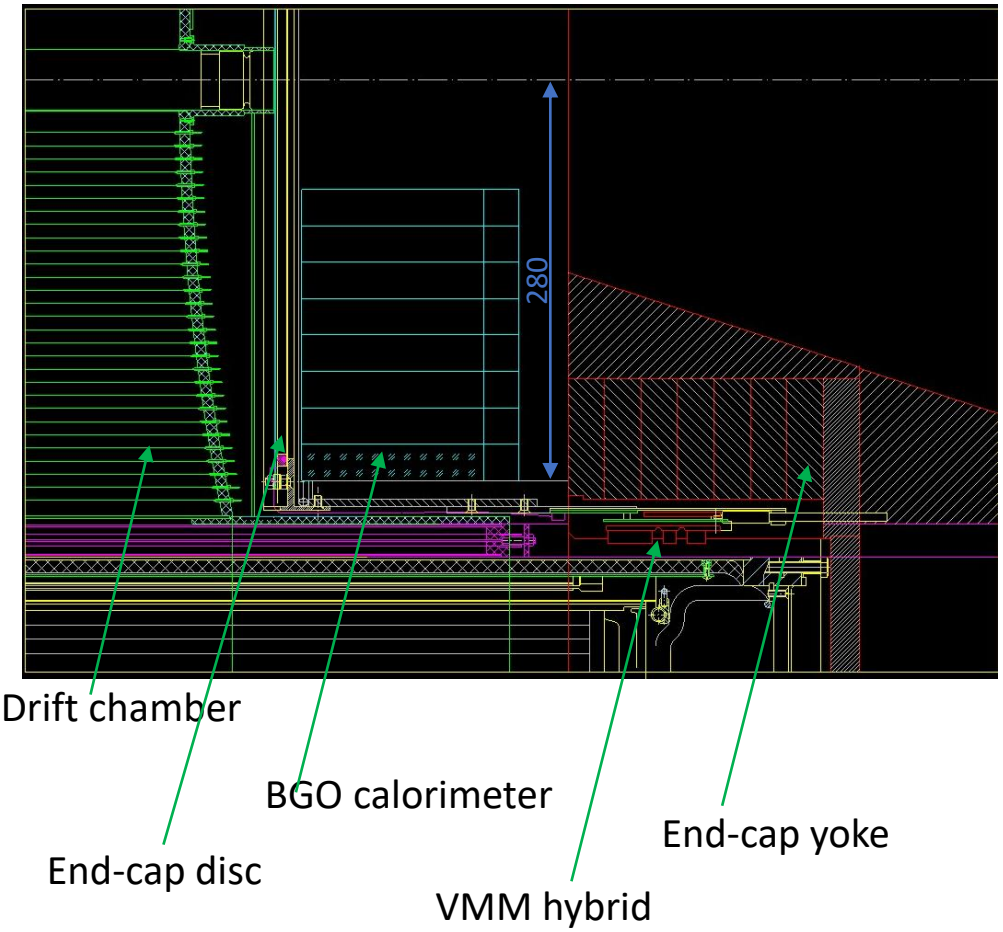


Disc mechanics for operation in the laboratory

Final layout in the CMD3



Assembling of the first disc

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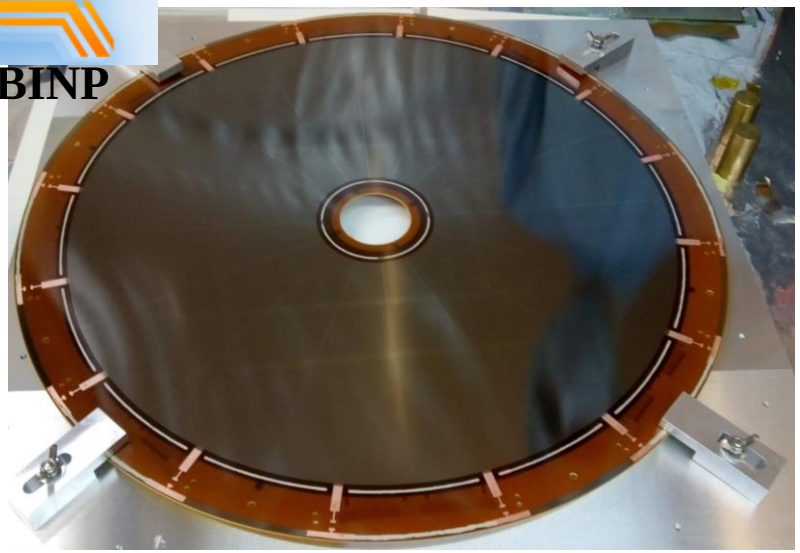
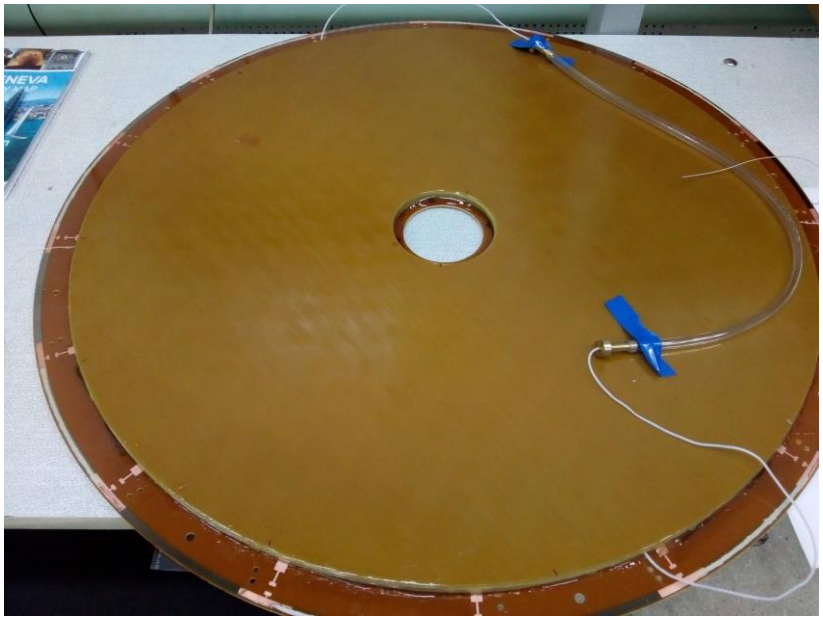
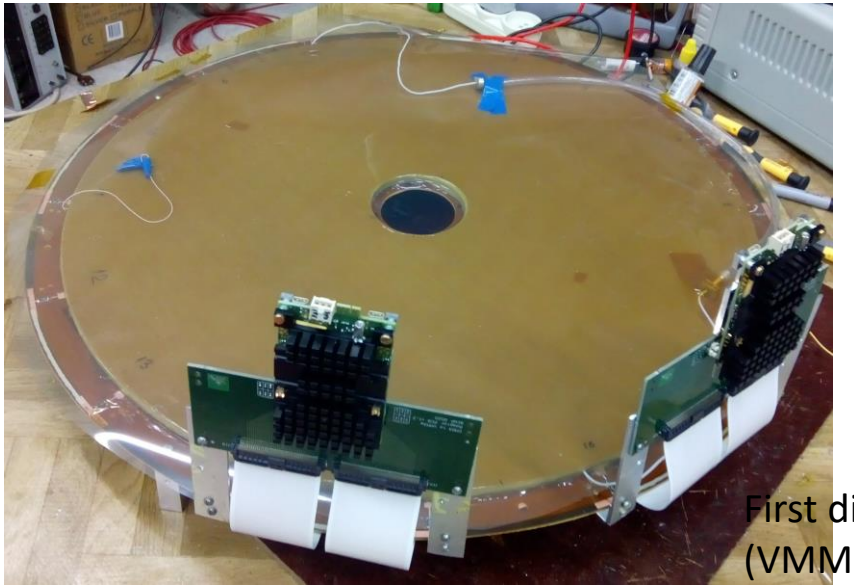


Top copper layer was etched away because of shorts



muRWELL at the jig for gluing



First disc mounted with gas pipes and HV connections to the drift cathode and muRWELL

First disc with two modules of FE electronics mounted (VMM3a)

Assembling of the 2nd disc

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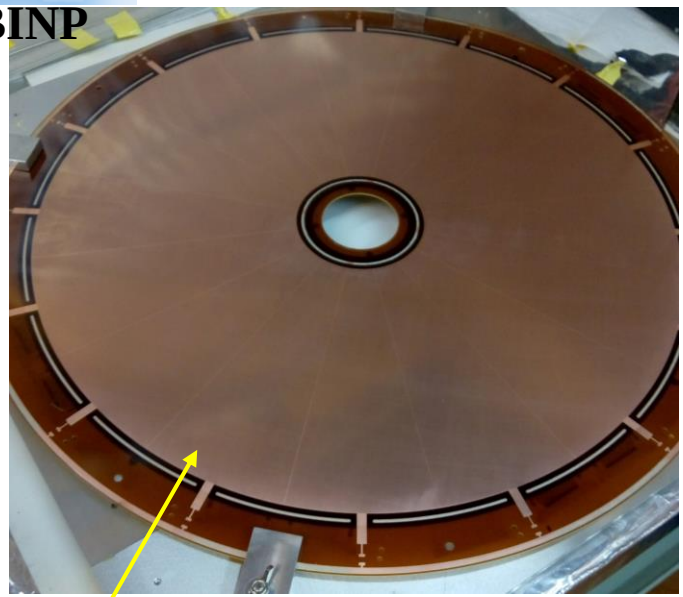
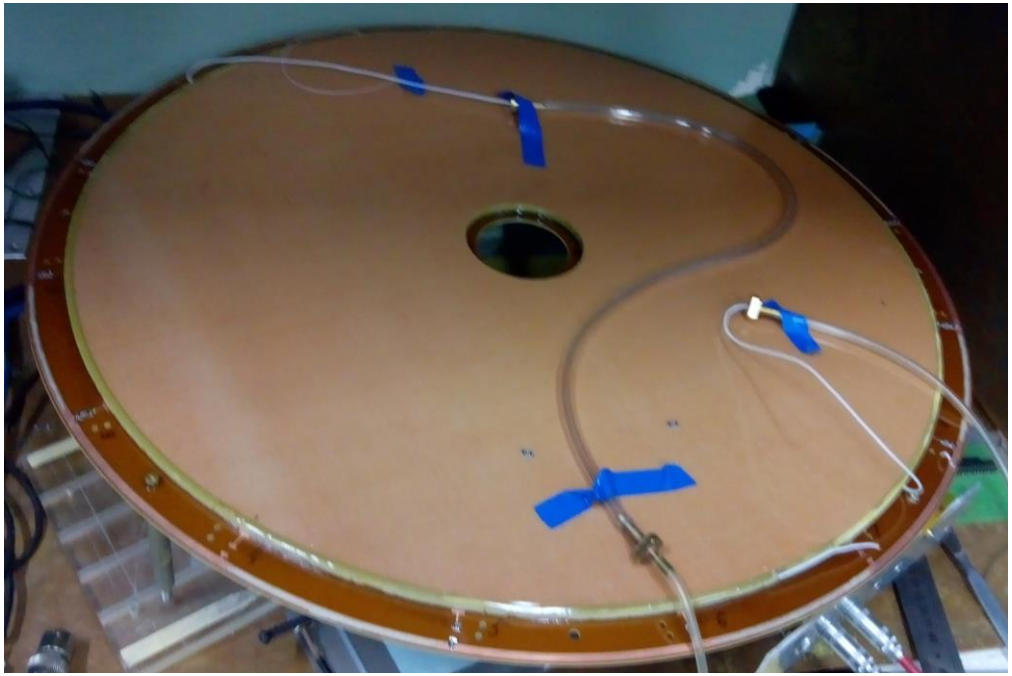


muRWELL at the jig for gluing

High voltage electrode is divided into 16 sectors that are powered independently



Second disc mounted with gas pipes and HV connections to the drift cathode and muRWELL

Tests of the discs in current mode.

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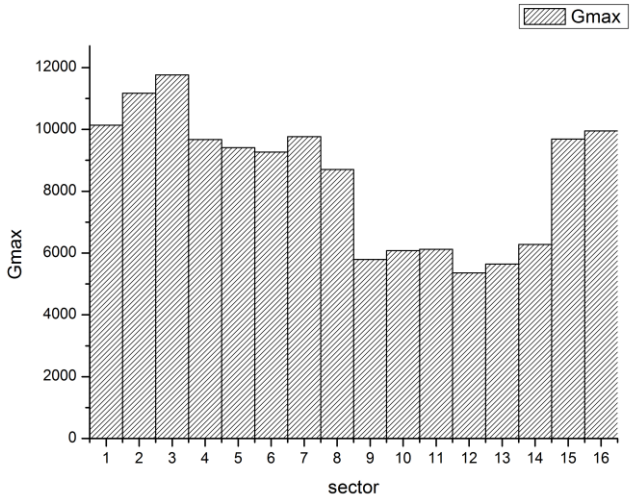
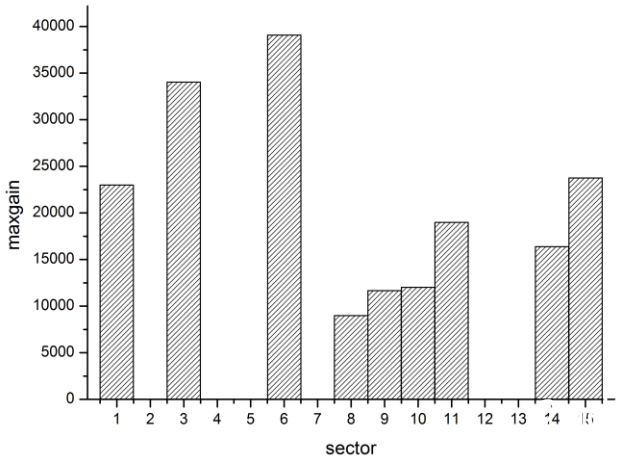
Ar+10%iC_4H_{10}

Comparison of maximum gain per sector in two discs



Disc 1



Disc 2

In the second disc gain reaches much higher value in some sectors, however in many sectors gain before discharge is too small.

Tests with SRS-VMM3a electronics.

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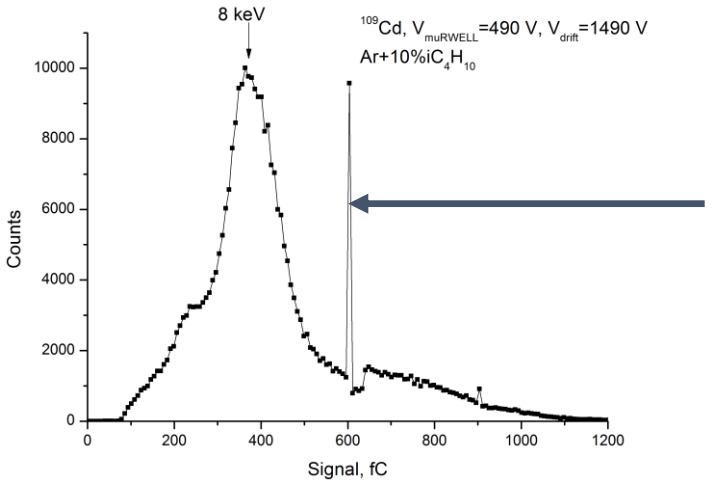
One quarter of the 1st disc is equipped with SRS-VMM3a electronics, 2 hybrids with 2 ASICs each, 256 channels total. VMM ASICs work in self-triggering mode. When signal cross the threshold ADC and TDC are activated and in 200 ns the ASIC sends out a data packet with time stamp, address, amplitude and time-to-peak.

In the current measurements the ASICs operated with the following parameters:

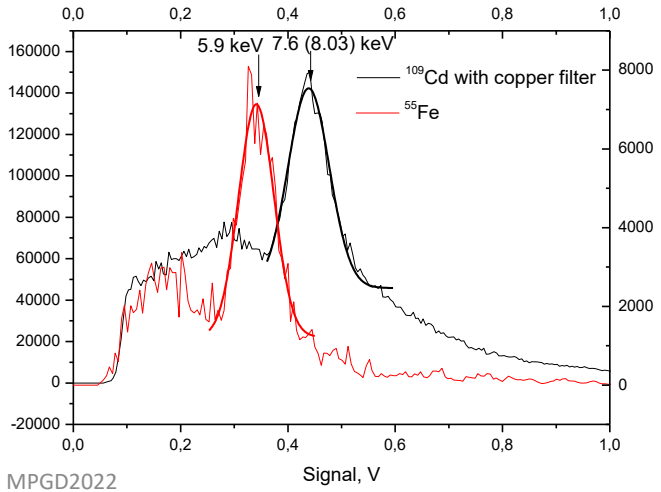
- Amplification 3 mV/fC
- Peaking time 200 ns
- Global threshold ~70-90 fC
- 10-bit ADC mode

Pulse-height spectrum of signals from ^{109}Cd source



ADC overflow

Comparison of Ph-spectra from ^{55}Fe and ^{109}Cd made with small muRWELL prototype. This measurement demonstrate that 21-25 keV and 88 keV photons from ^{109}Cd interact with copper of the drift electrode and produce copper fluorescence



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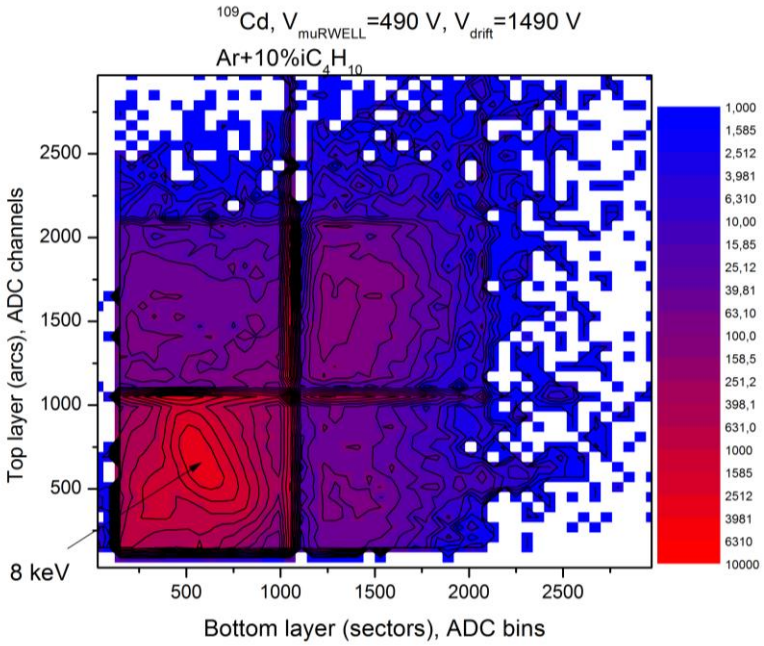
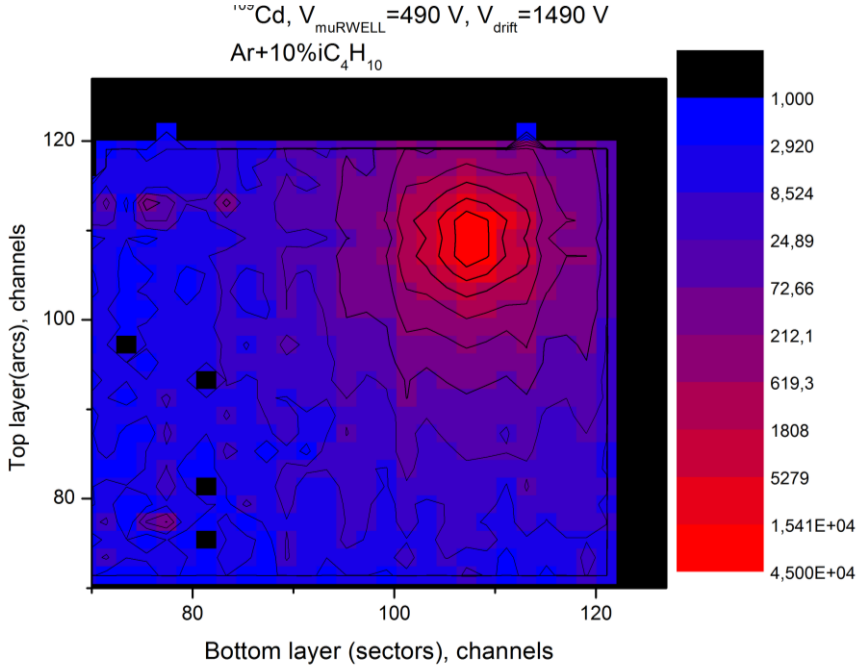
Tests with SRS-VMM3a electronics.



Correlation between signals in top and bottom layers. Black lines correspond to ADC overflow.



Hit map

Tests with SRS-VMM3a electronics.

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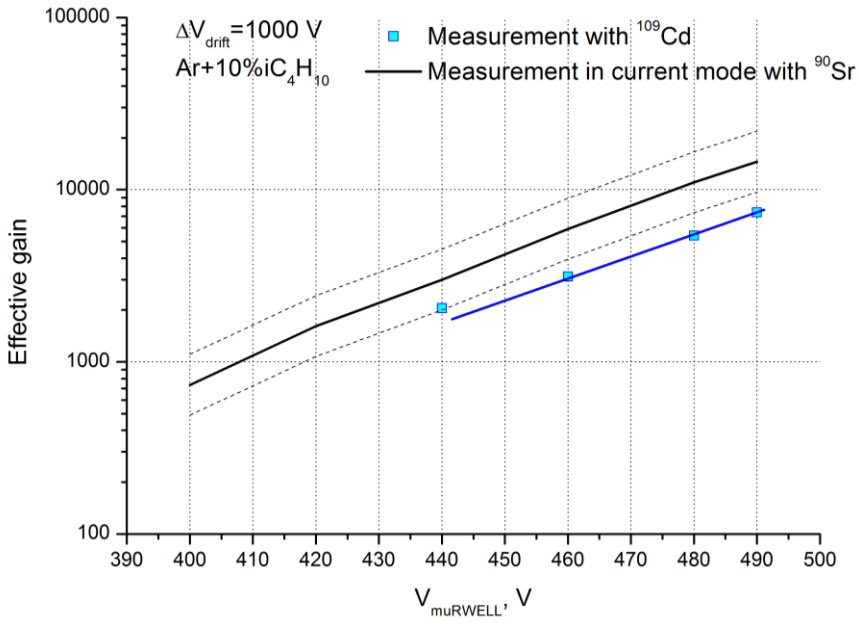
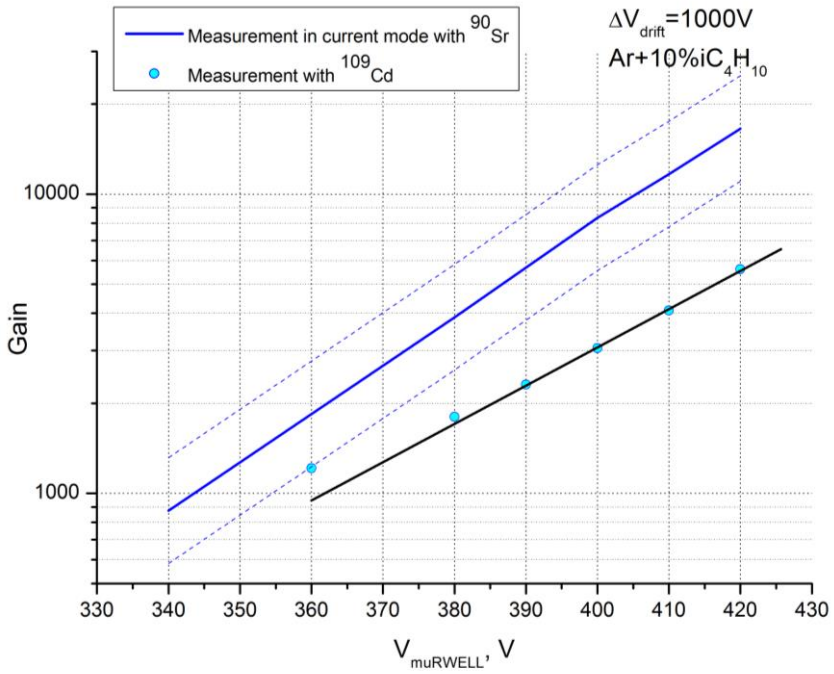
Disc 1 (sectors 2-3)



Disc 2 (sectors 14-15)



Comparison of the effective gain determined from signals, measured from readout electrodes with total gain estimated from current measurements. Dashed lines limit the estimate of systematic uncertainty due to possible error in determination of primary charge

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Summary

- Two discs based on micro-RWELL technology with 6 mm drift gap and two-layer readout structure are mounted and tested. The first disc does not have copper layer on top electrode of muRWELL.

- Both discs show significant non-uniformity of the gain and maximal gain before the discharge. The first disc has all area operational, while the second disc contains some high-voltage sectors that have shorts or discharge at very low gain (below 5000).

- Tests of both discs with multi-channel SRS-VMM3a electronics demonstrated that 30%-50% of total charge is induced at the readout electrodes, the signal is equally shared between the layers of the readout structure and the design of connection of VMM hybrid to the disc through the adapter board works properly.

- Effective gain in the measured sectors reaches 6000-8000 that is not enough to detect signals from minimum ionizing particles with full efficiency. Further increase of gain by a factor 3-5 is needed. We intend to put GEM as additional amplifier on top of muRWELL to reach this goal.