First high rate test of a MRPC detector with novel low resistivity float-glass electrodes

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Introduction

A new low-resistivity float-glass (Picotech S.A.S.) is under consideration for high rate MRPC purposes

- Glass panes with an area of more than 1 m^2 and a thickness of 400 µm are available
- The surface quality of the rough material is excellent and it don't need additional polishing
- The mechanical strength of the pane allows a robust detector assembling procedure
- The long term behavior of the bulk resistivity differs in comparison to other low-resistive RPC electrode materials

Introduction

MRPC prototypes with this low-resistive float-glass are assembled at CERN and a test of a 6-gap RPC at the PS T10 shows an efficiency of 90 % at 90 kHz/cm²

- *To consolidate the results a 10-gap MRPC has been built at CERN and tested at the high-rate electron accelerator ELBE@HZDR for fluxes up to 200 kHz/cm²*
- *A dedicated bulk resistivity measurement system at HZDR has been used to characterize the long term behavior of the new low-resistive float-glass*

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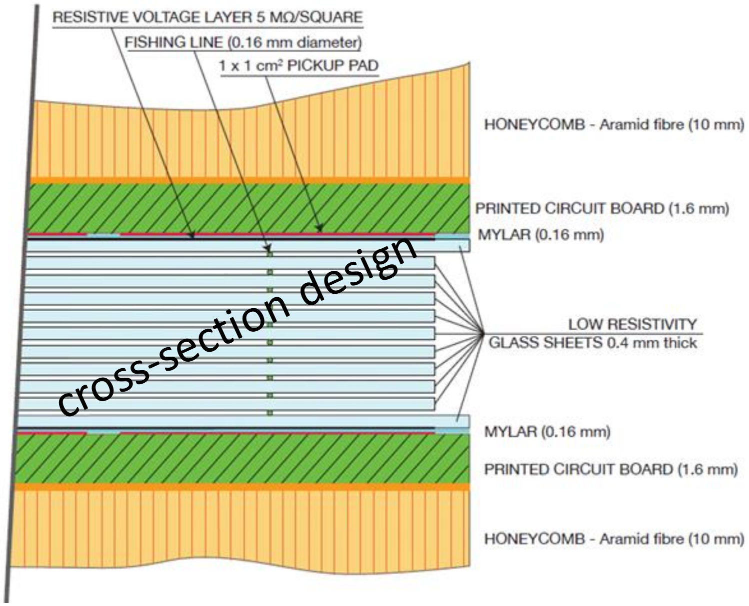
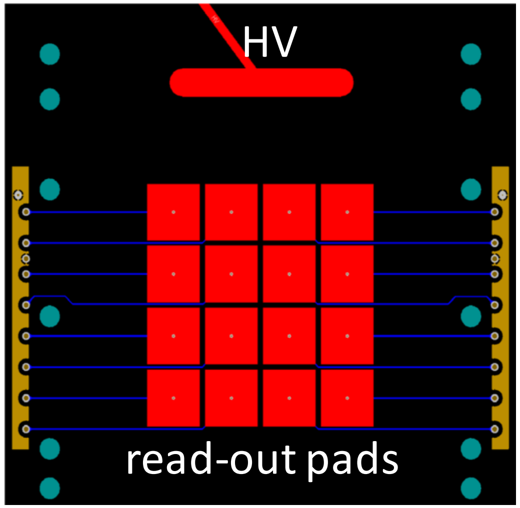
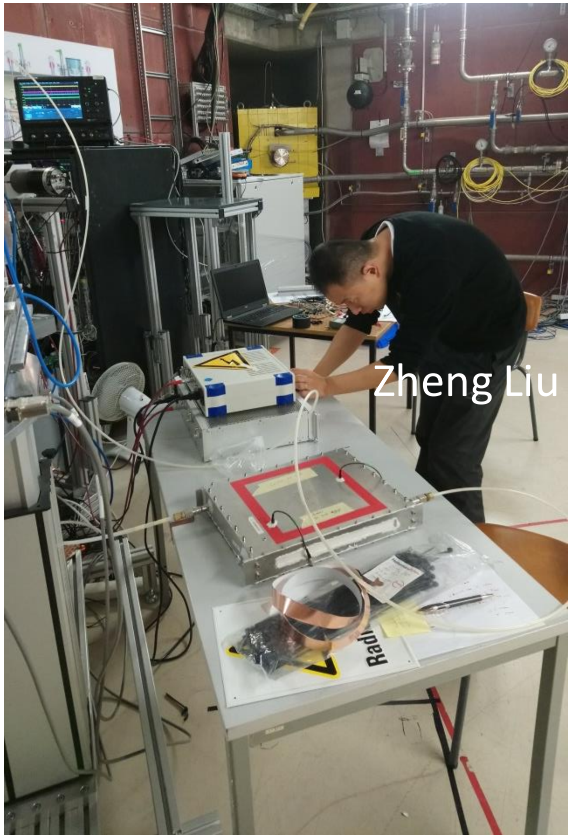
Detector test: MRPC construction



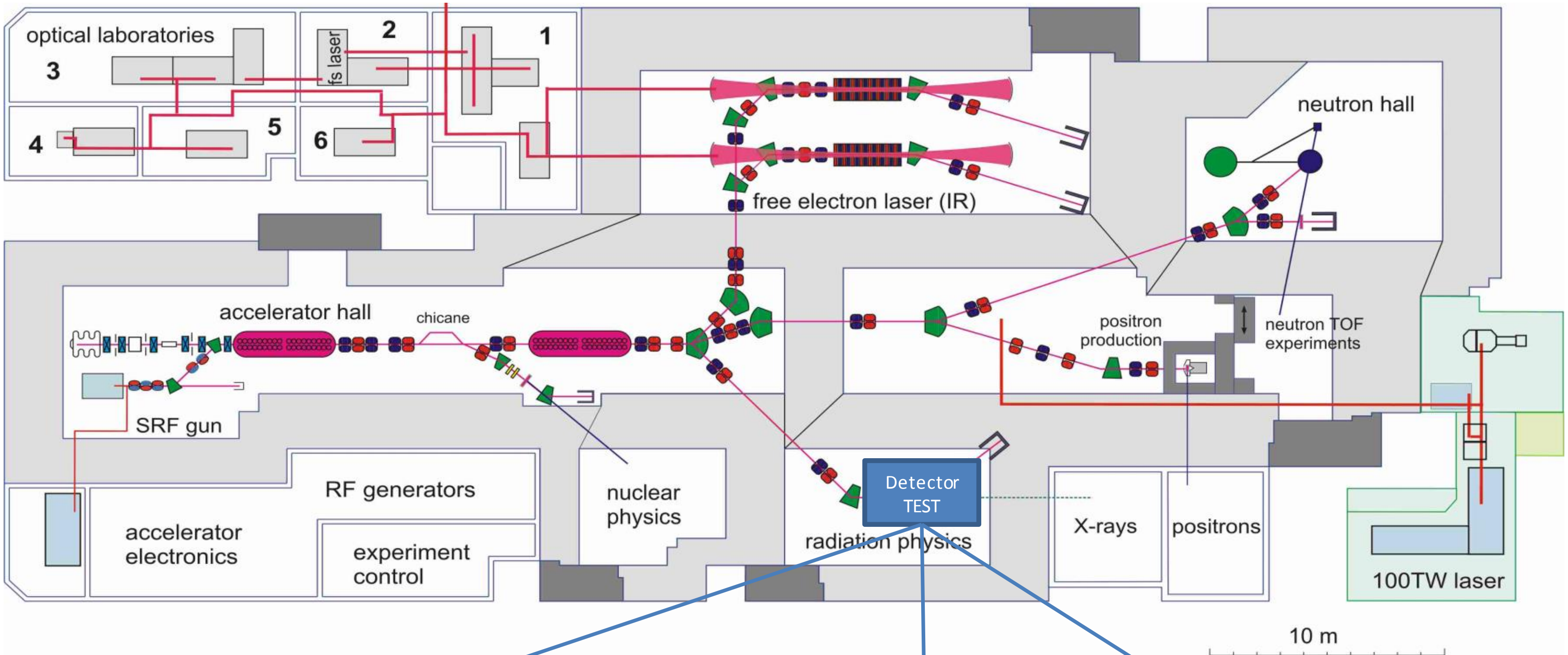




MRPC:	
Gas-gaps:	10 per 160 µm
Floating electrodes:	9 per 400 µm
Read-out pads: 2x (4x4)	per 1x1 cm²
HV-electrode area:	5x6 cm²
Gas-mixture:	C2H2F4(95%), SF6 (5%)
Gas-flow:	30 ml/min

Detector test-facility @ELBE

The radiation source **ELBE** (**E**lectron **L**inac for beams with high **B**rilliance and low **E**mittance) delivers multiple secondary beams, both electromagnetic radiation and particles.



single electrons

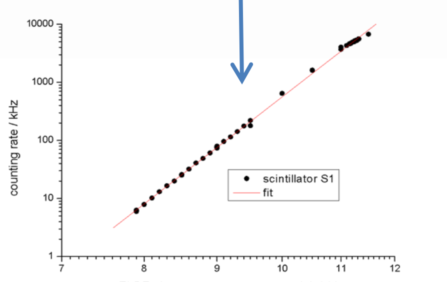
electron energy 12 - **40** MeV

pulse repetition freq. 13.7 MHz/2^n

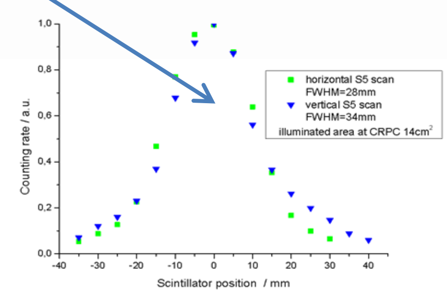
pulse duration **5** ps

aver. beam current **10^{-17}** -10^{-3} A

RF-reference time jitter 35 ps



rep. rate 1Hz - 1MHz



spot size ≥10 cm²

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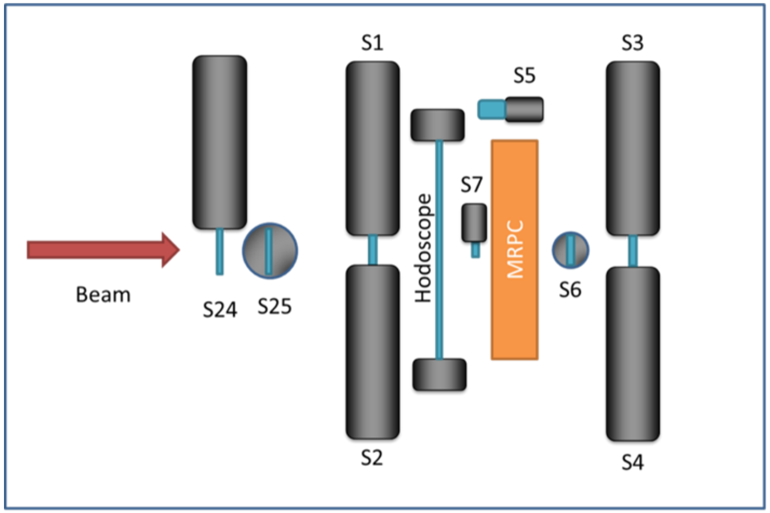
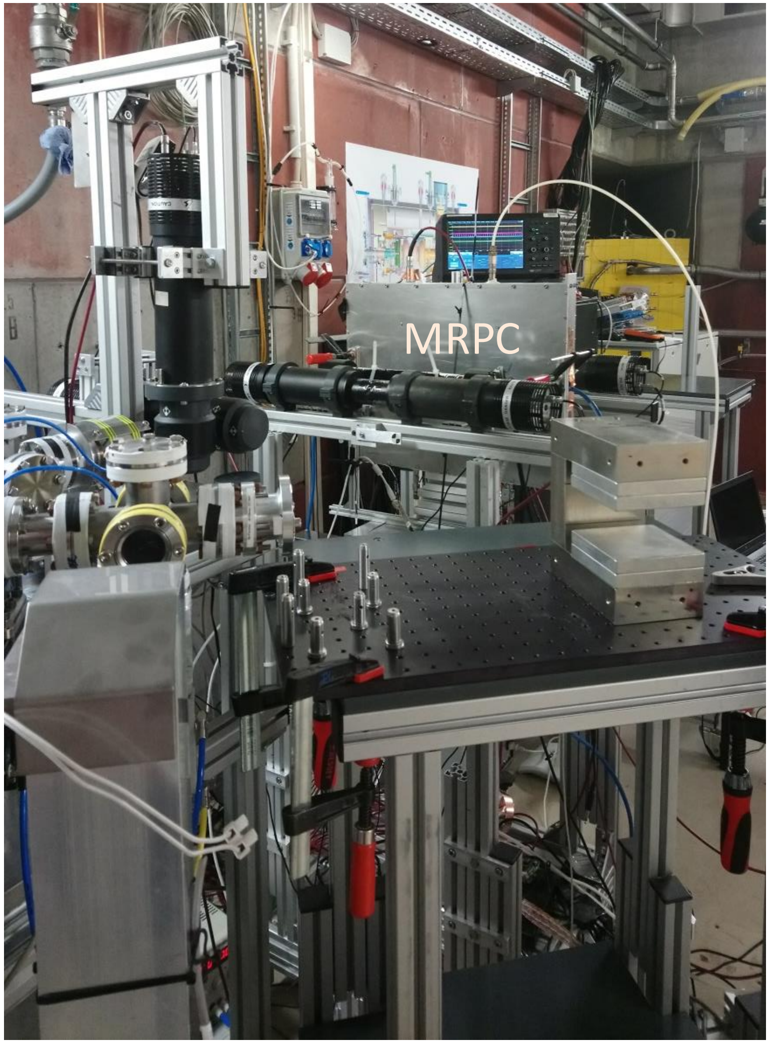
Detector test-facility @ELBE



Detector Setup Top View

Scintillation-counters:

Beam-spot: S5 (Ø 9 mm)
Beam-rate: S25 and S24 (4x4 cm²)
Trigger: S1S2 and S3S4 (2x2 cm²)
Trigger: S6 (4x4 cm²)
Pad definition: S7 (1x1 cm²)
Hodoscope: 16 fibers (2x2 mm²)



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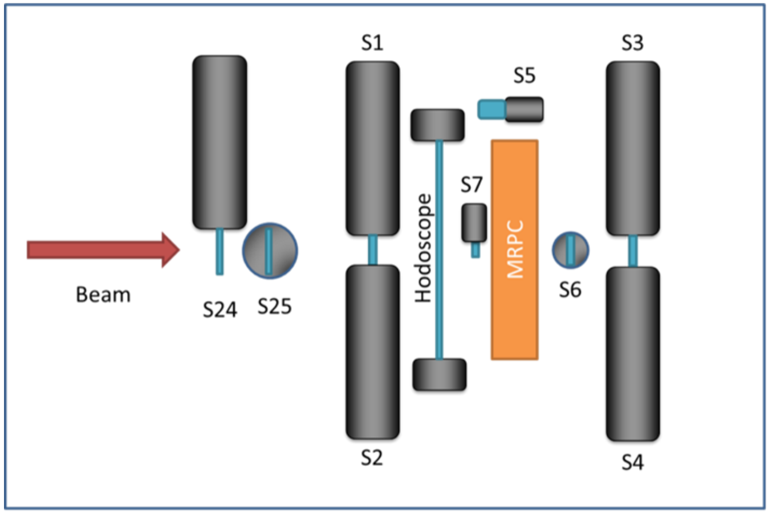
Detector test-facility @ELBE



Detector Setup Top View

MRPC *differential signals* →
→ NINO ASIC *discriminator* →
→ LVDS-to-NIM *converter* →

→ **WaveCatcher** T_{MRPC}, ToT, N_{MRPC}

→ **RF&S1S2&S3S4** $N_{Trigger}$, T_{Ref}

Efficiency

$$\varepsilon = N_{MRPC}/N_{Trigger}$$

Time resolution

$$\sigma(t) = FWHM\,(T_{MRPC} - T_{Ref}) / 2.3548$$

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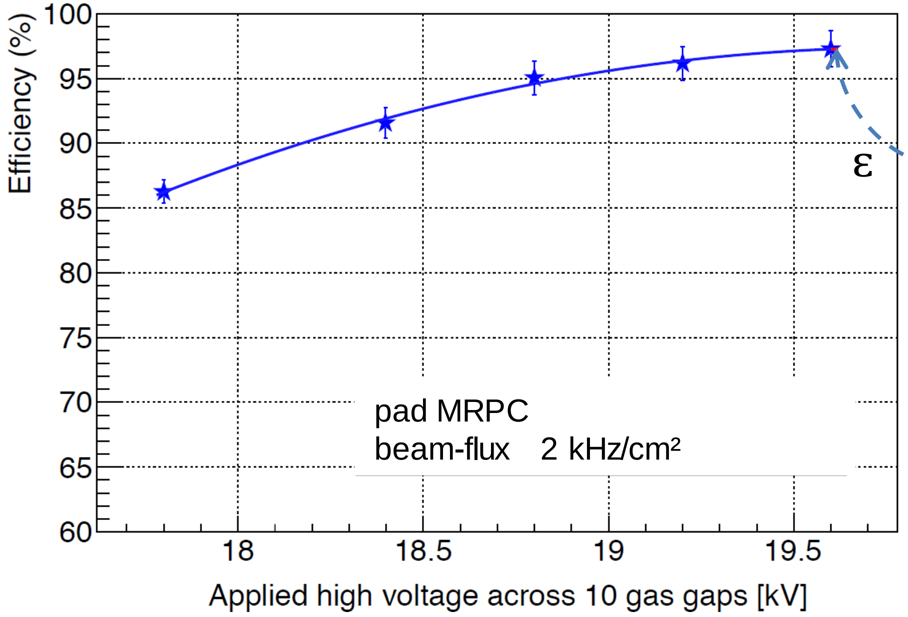
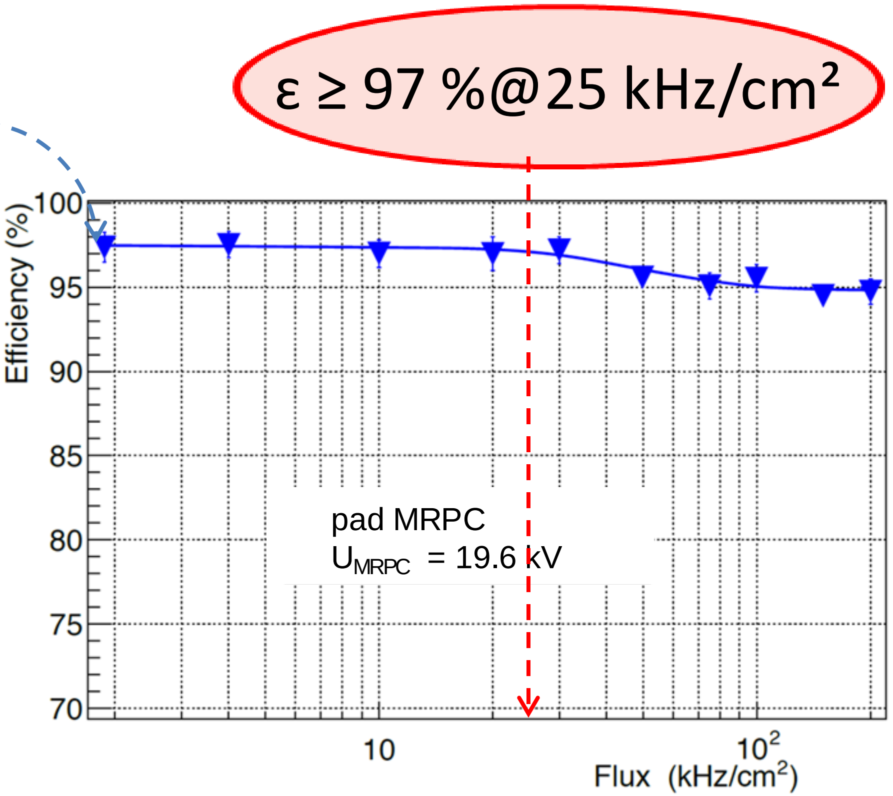
Detector test: MRPC working characteristc and rate capability

Efficiency vs. HV



Efficiency vs. flux

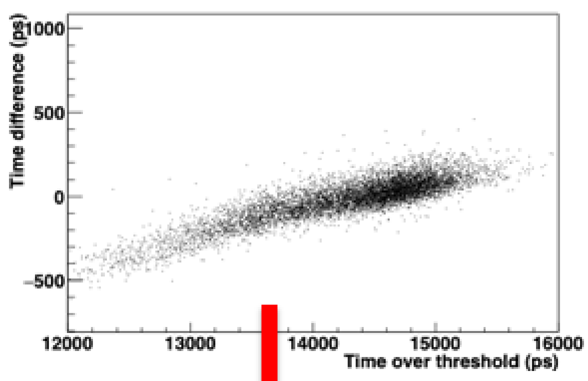


Detector test: MRPC time resolution

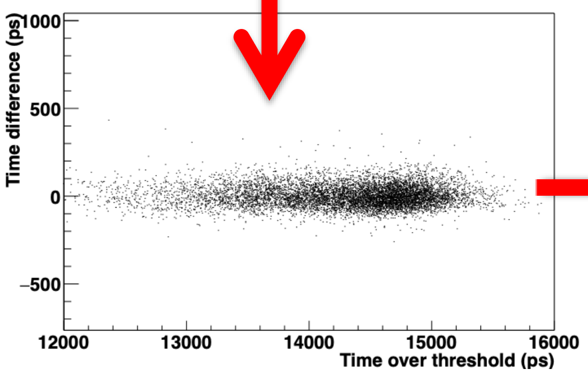
U_{MRPC}=19.2 kV; beam-flux 2 kHz/cm²

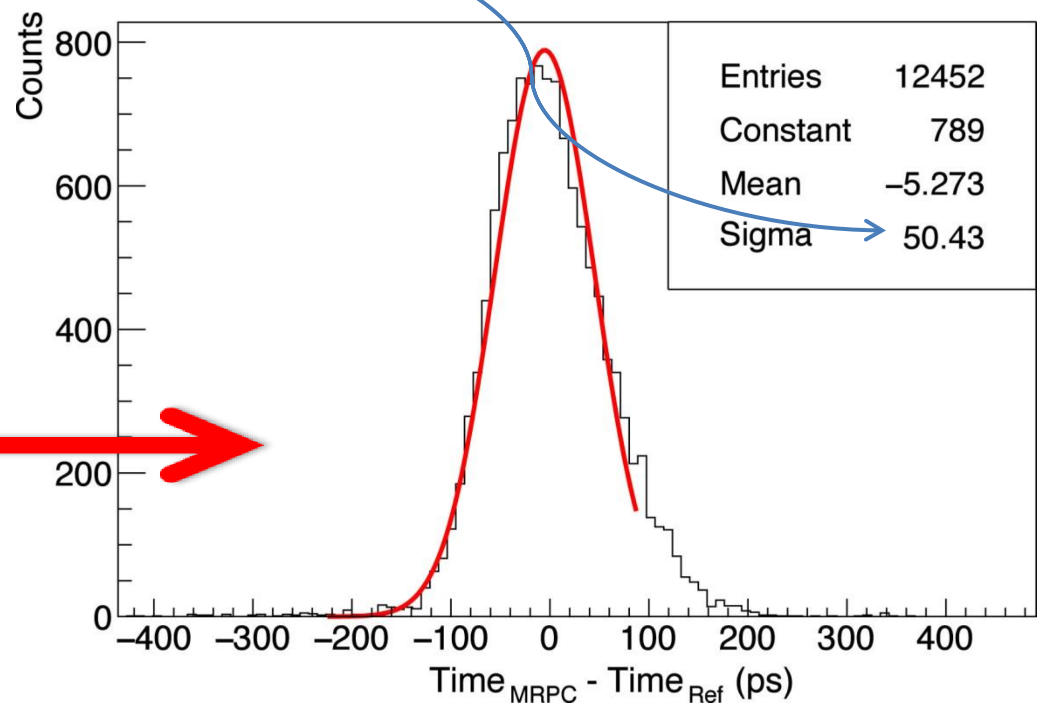
RF-reference time jitter

$$\sqrt{50.4ps^2 - 35ps^2} = \mathbf{(36.0 \pm 0.8)\ ps}$$



slewing correction





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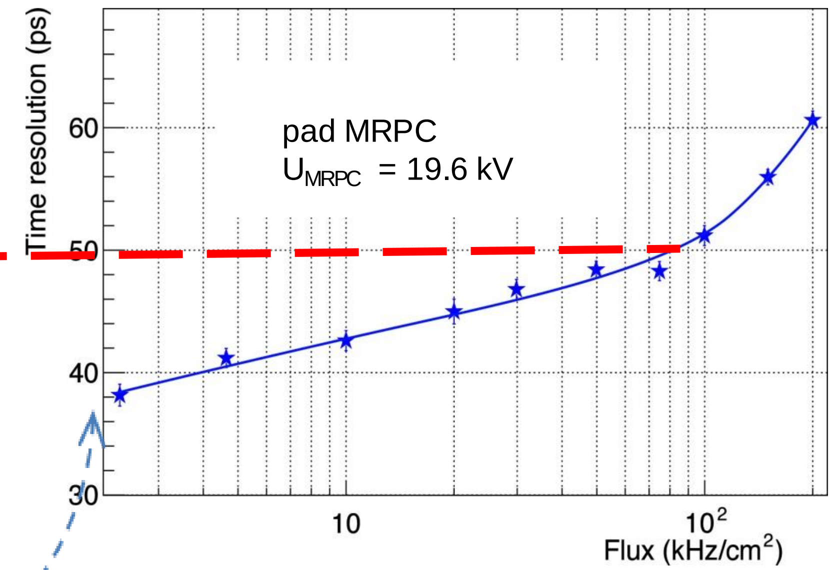
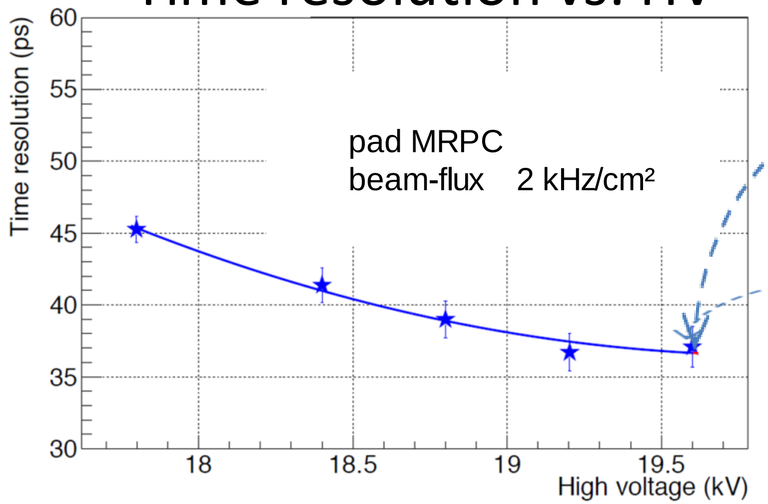
Detector test: MRPC time resolution

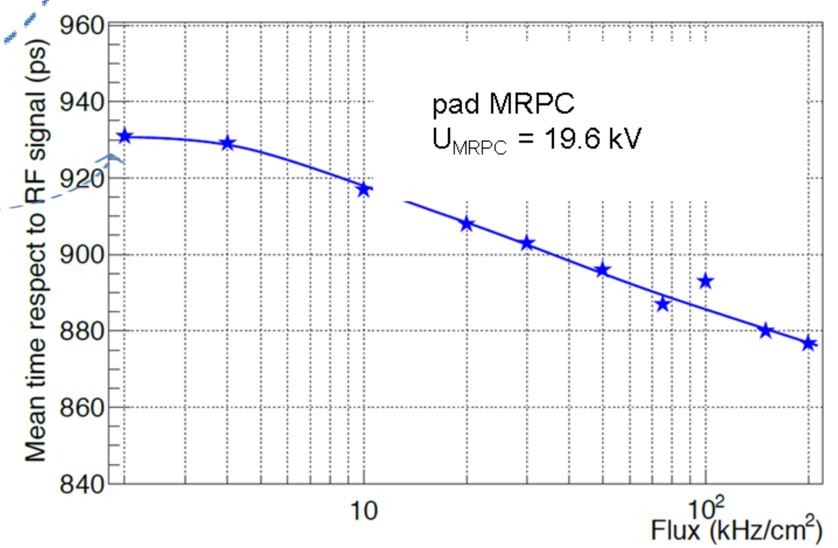
50 ps @ ≤ 100 kHz/cm²

Time resolution vs. Flux



Time resolution vs. HV





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Summary (I) - Detector test @ ELBE

- Single electron cw beam 34 MeV
- RF time-jitter 35 ps
- Beam-spot size ≥ 10 cm^2 → Read-out pad size ≈ 16 cm^2

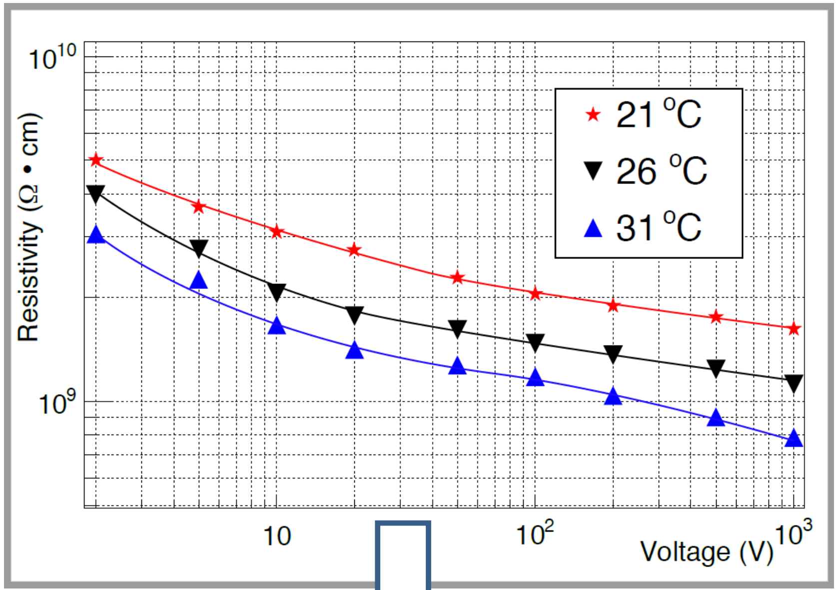
10-gap MRPC

Beam-flux	100 kHz/cm^2	200 kHz/cm^2
Efficiency (ε)	97%	95%
Time resolution (σ)	50ps	60ps

- No long-term MRPC exposure during this beam-time → accumulated charge in the glass electrodes ≤ 10 mC

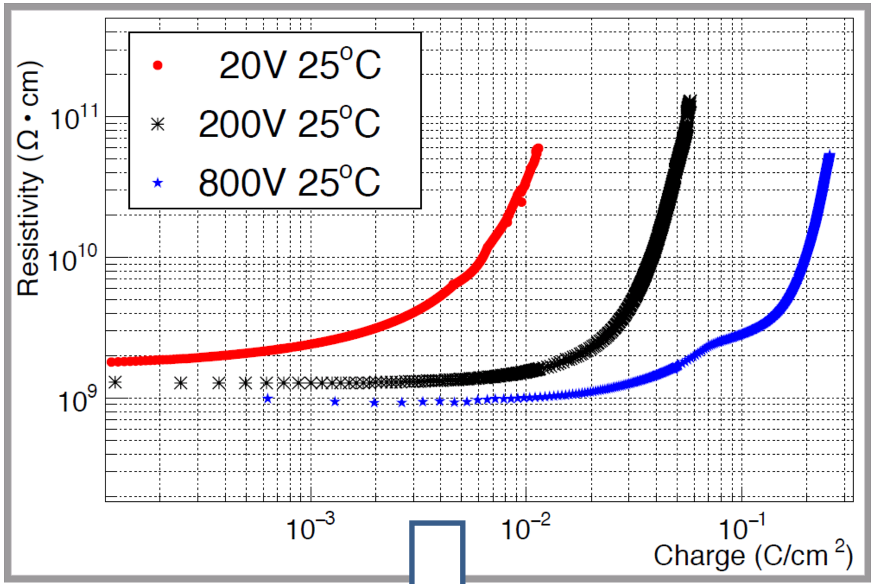
Bulk resistivity test @ CERN

ρ vs. U, T



ρ ~ 1/T
ρ ~ 1/U

ρ vs. Q, U



ρ ~ Q
ρ(Q) - faster increas for lower U

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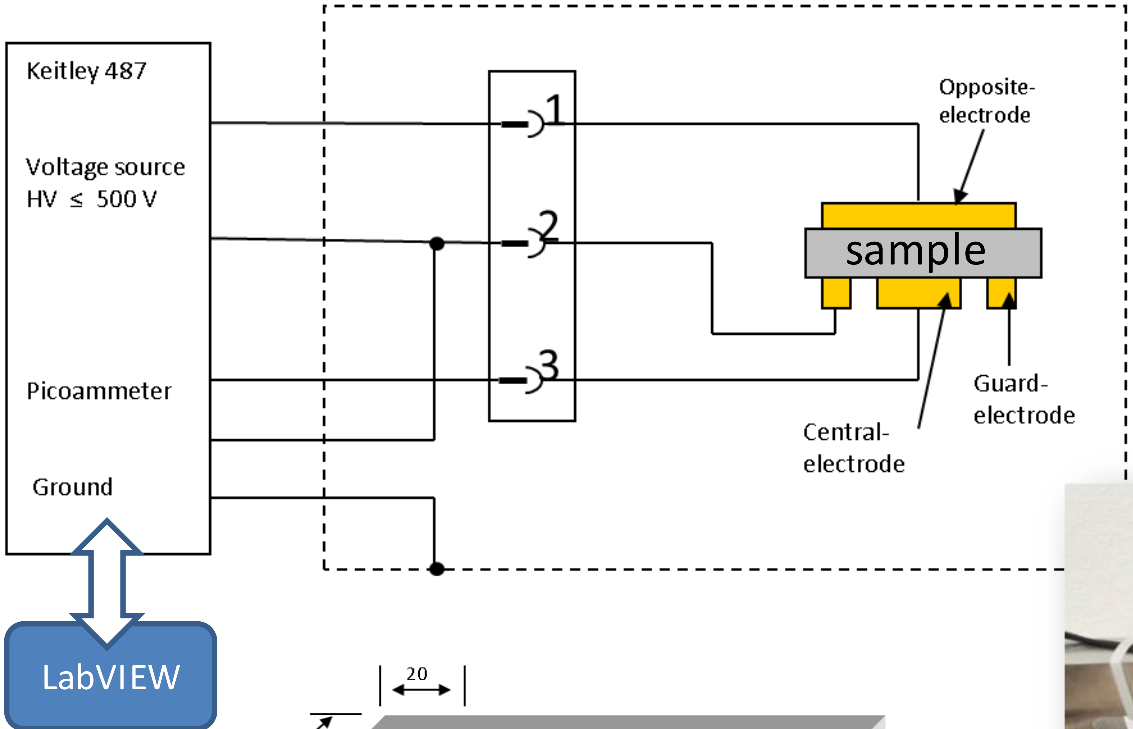
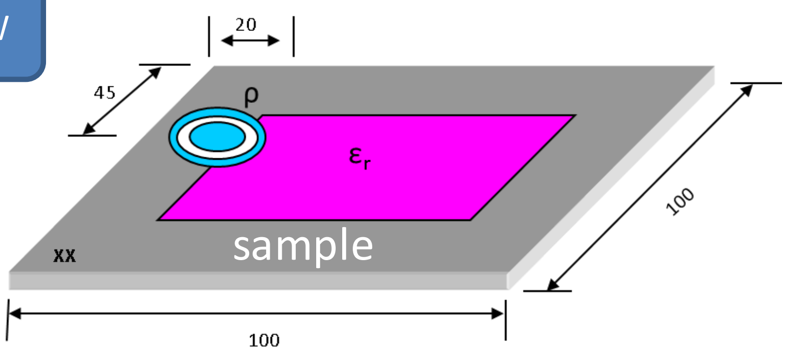
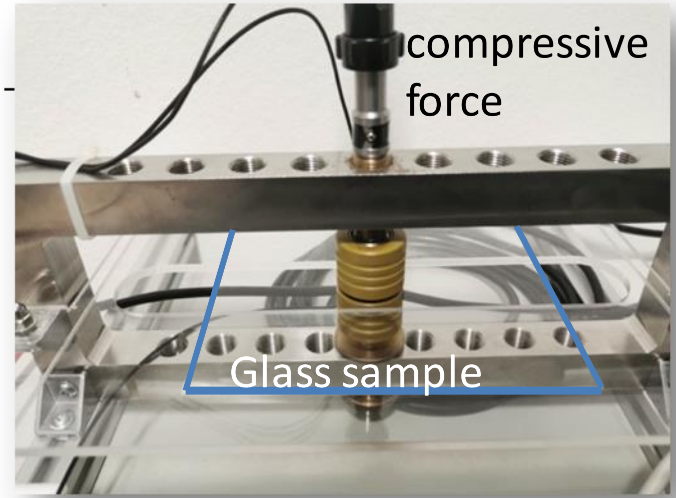
Long-term bulk resistivity test @ HZDR



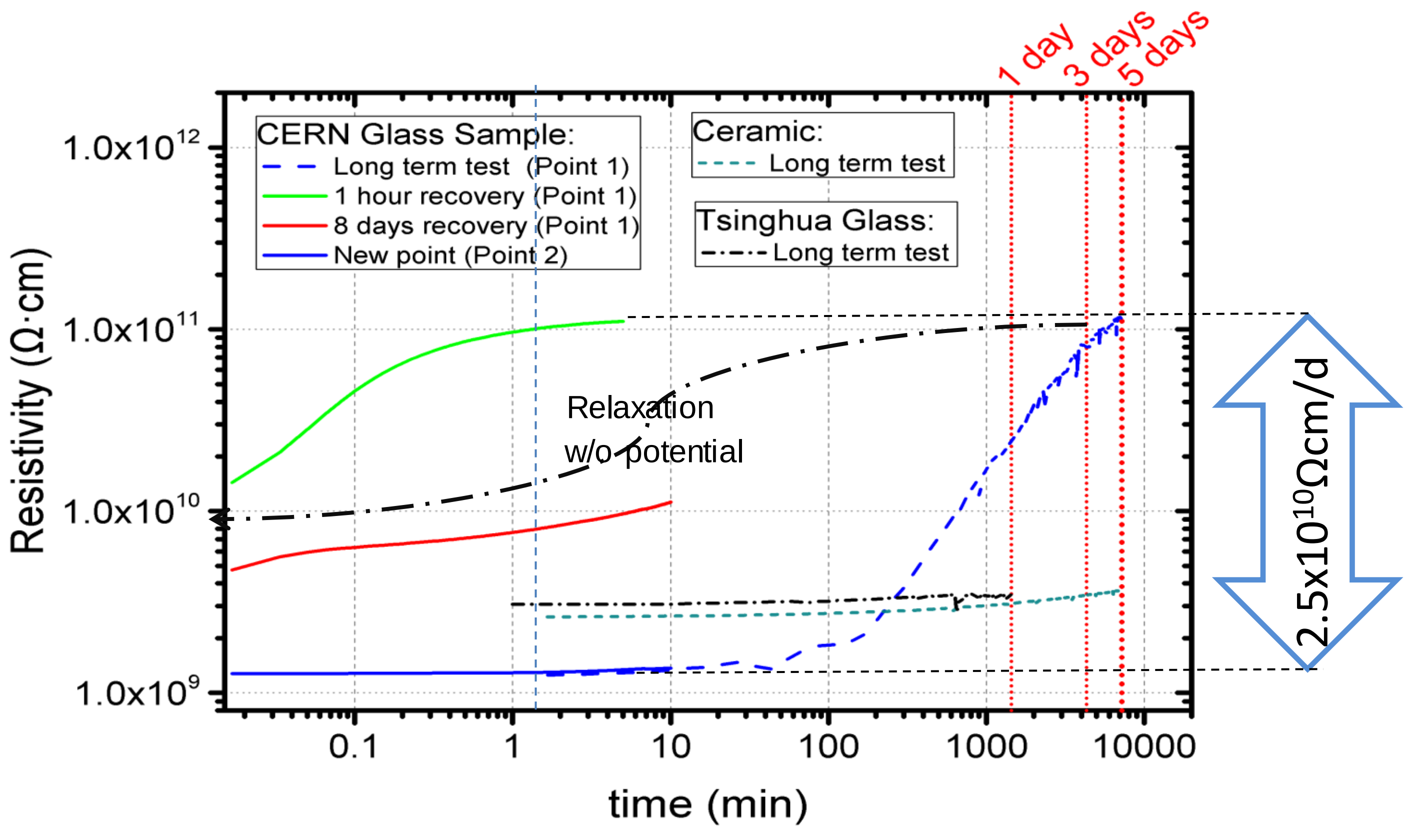
long-term measurement of:
- volume resistivity (ρ)
- surface resistivity
- permittivity

control of:
- T
- humidity





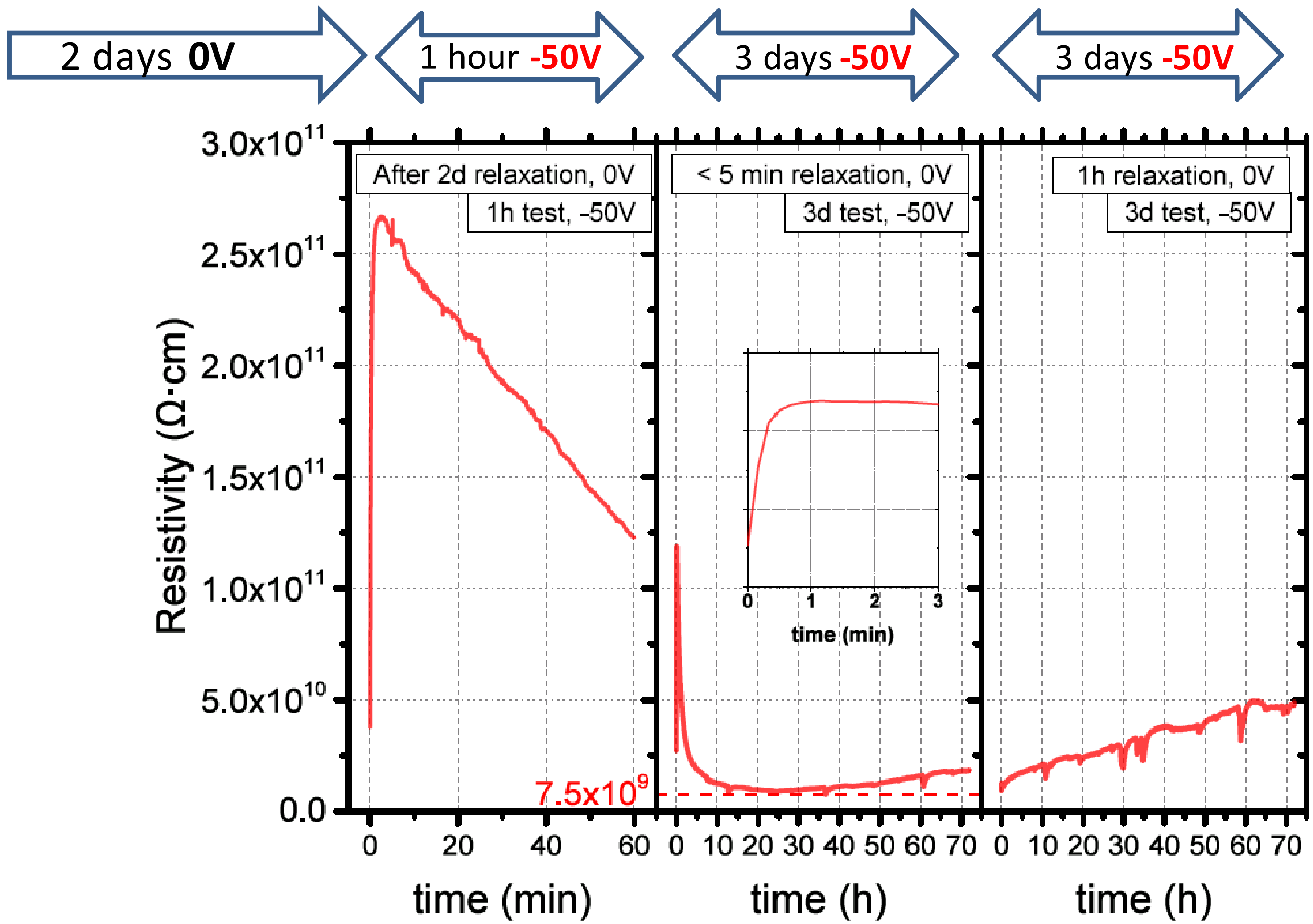
Comparision of ρ(t) for CERN-Glass, Ceramics and Tsinghua-Glass



$\rho(t) = \rho(0) + 2.5\text{x}10^{10}\ \Omega\text{cm/day}$

d = 400 µm, U = 100 V, T = 24 °C

Long-term ρ(t) recovery of CERN-Glass with opposite polarization



gain ≤ 10

Summary (II) – Low-resistive glass

- A new low-resistivity float-glass from CERN exhibits a pronounced charge dependence of the bulk resistivity

- The recovery process of the bulk resistivity has been studied for opposite polarization
  → $\rho(t)$ = const. seems possible

- The permittivity of the 400 µm samples amounts to
  $\varepsilon_r = 6.9$ for fresh samples

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Outlook

- Long-term MRPC test at ELBE in April/May → accumulated charge at highest beam-flux to find the limit for degradations of the efficiency and the time resolution
- Study of the material properties after neutron irradiation of the low-resistive glass sample up to 10^{14} n_{eq}/cm^2
- Study of the permittivity in dependence on the charge

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Novel low resistivity glass: MRPC detectors for ultra high rate applications

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Abstract

Multigap Resistive Plate Chambers (MRPCs) are often used as time of flight (TOF) detectors for high energy physics and nuclear experiments thanks to their excellent time accuracy. For the Compressed Baryonic Matter (CBM) TOF system, MRPCs are required to work at particle fluxes on the order of 1 10 kHz/cm^2 for the outer region and 10 25 kHz/cm^2 for the central region. Better time resolution will allow particle identification with TOF techniques to be performed at higher momenta. From our previous studies, a time resolution of 25 ps has been obtained with a 20 gap MRPC of 140 μm gap size with en hanced rate capbability. By using a new type of commercially available thin low resistivity glass, further improvement MRPC rate capability is possible. In order to study the rate capability of the 10 gap MRPC built with this new low resistivity glass, we have performed tests using the continuous electron beam at ELBE. This 10 gap MRPC, with 160 μm gaps, reaches 97% efficiency at 19.2 kV and a time resolution of 36 ps at particle fluxes near 2 kHz/cm^2. At a flux of 100 kHz/cm^2, the efficiency is still above 95% and a time resolution of 50 ps is

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Preprint submitted to Nuclear Instruments and Methods in Physics Research A January 18, 2020

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