Radiation hard ceramic based Resistive Plate Chambers (RPC) for forward TOF and T_0 systems

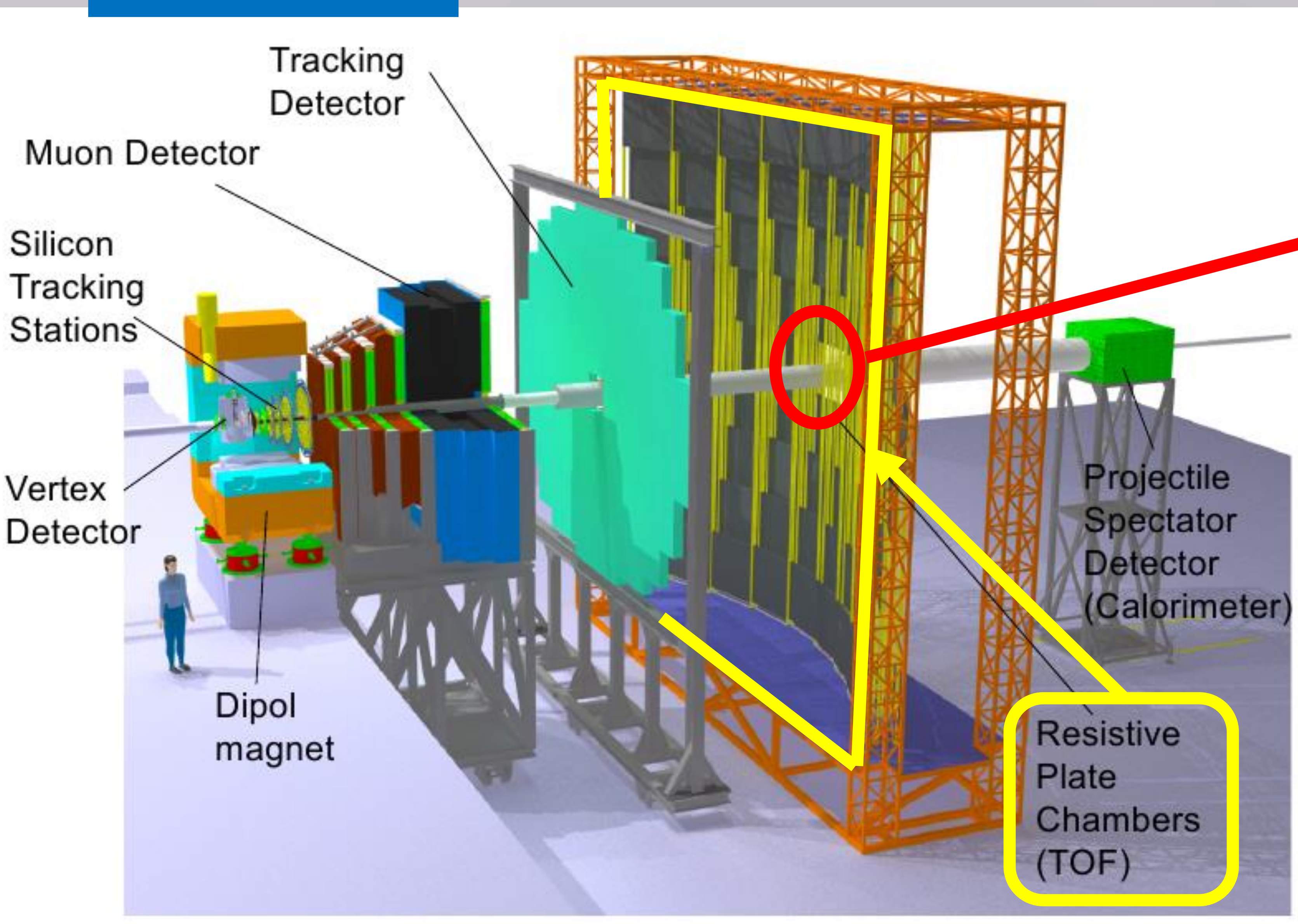
A. Akindinov[1], L. Naumann[2], J. Dreyer[2], X. Fan[2], B. Kämpfer[2], R. Kotte[2], A. Laso Garcia[2], D. Mal'kevich[1], A. Nedosekin[1], V. Plotnikov[1], D. Stach[2], R. Sultanov[1] and K. Voloshin[1]
[1]ITEP, Moscow, Russia, [2]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

INTRODUCTION

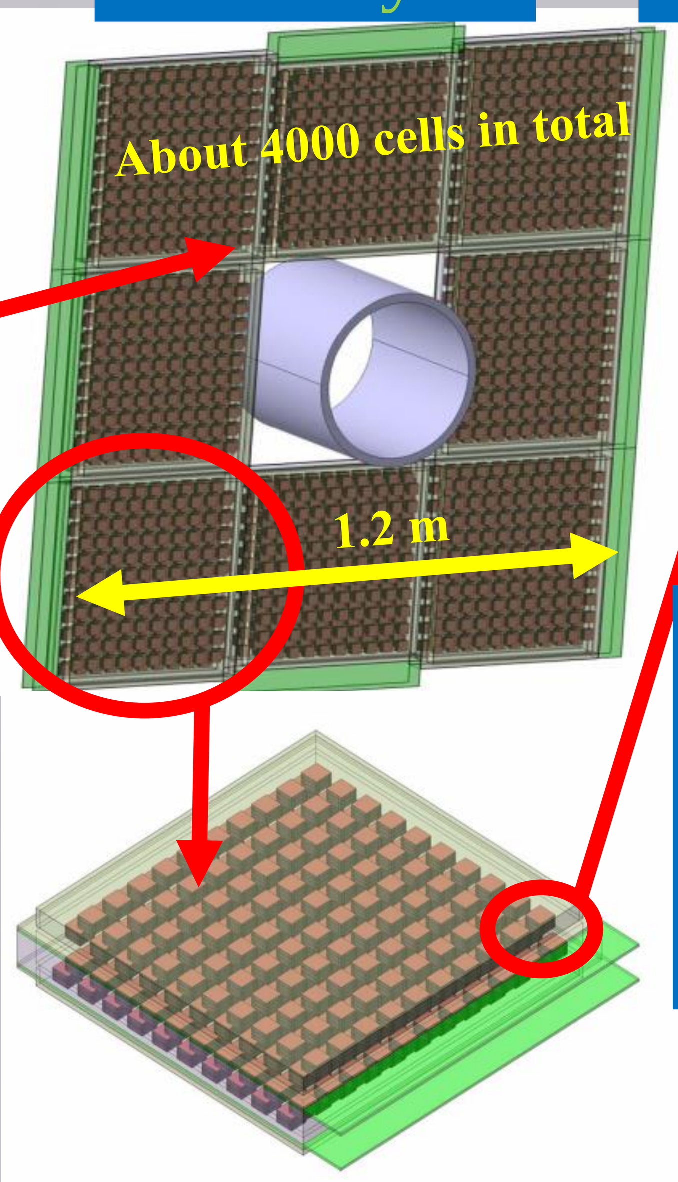
Important scopes of many modern High Energy Physics and Heavy Ion experiments are the start time and reaction plane determination. Despite of progress in timing RPC development during last two decades, mostly within the framework of ALICE R&D, present float glass based time of flight systems with pad readout (like ALICE and STAR) have limited rate of operation and high level of cross-talk. To use RPC systems for start time and reaction plane determination in the forward region, low resistive radiation hard material and chess-board like single cell systems should be used.

BFTC (Beam Fragmentation T_0 Counter) as part of the CBM TOF detector

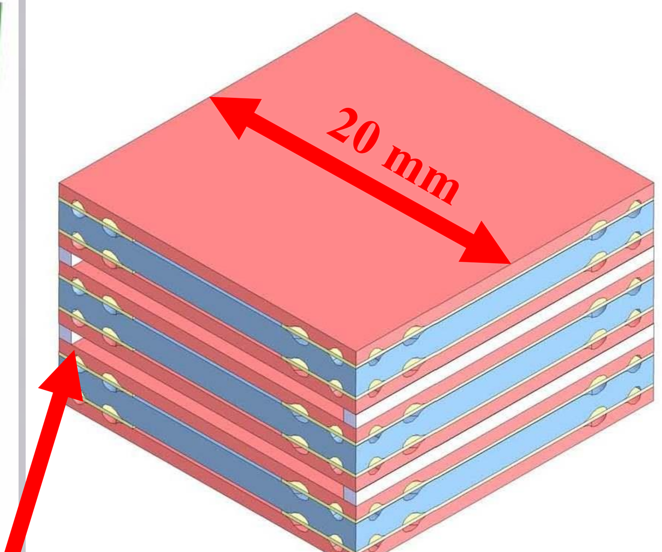
CBM detector



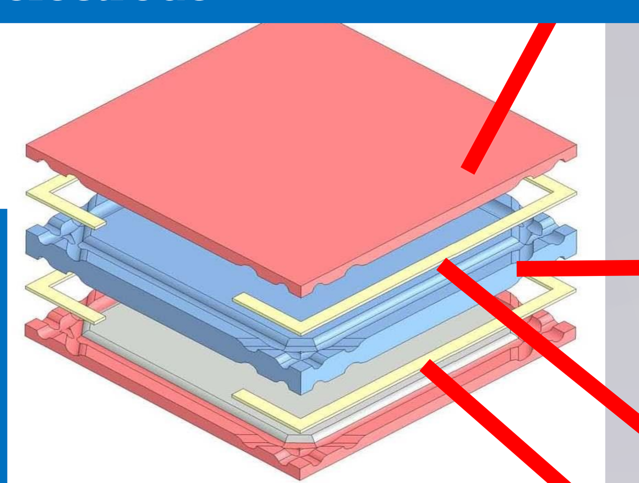
BFTC layout

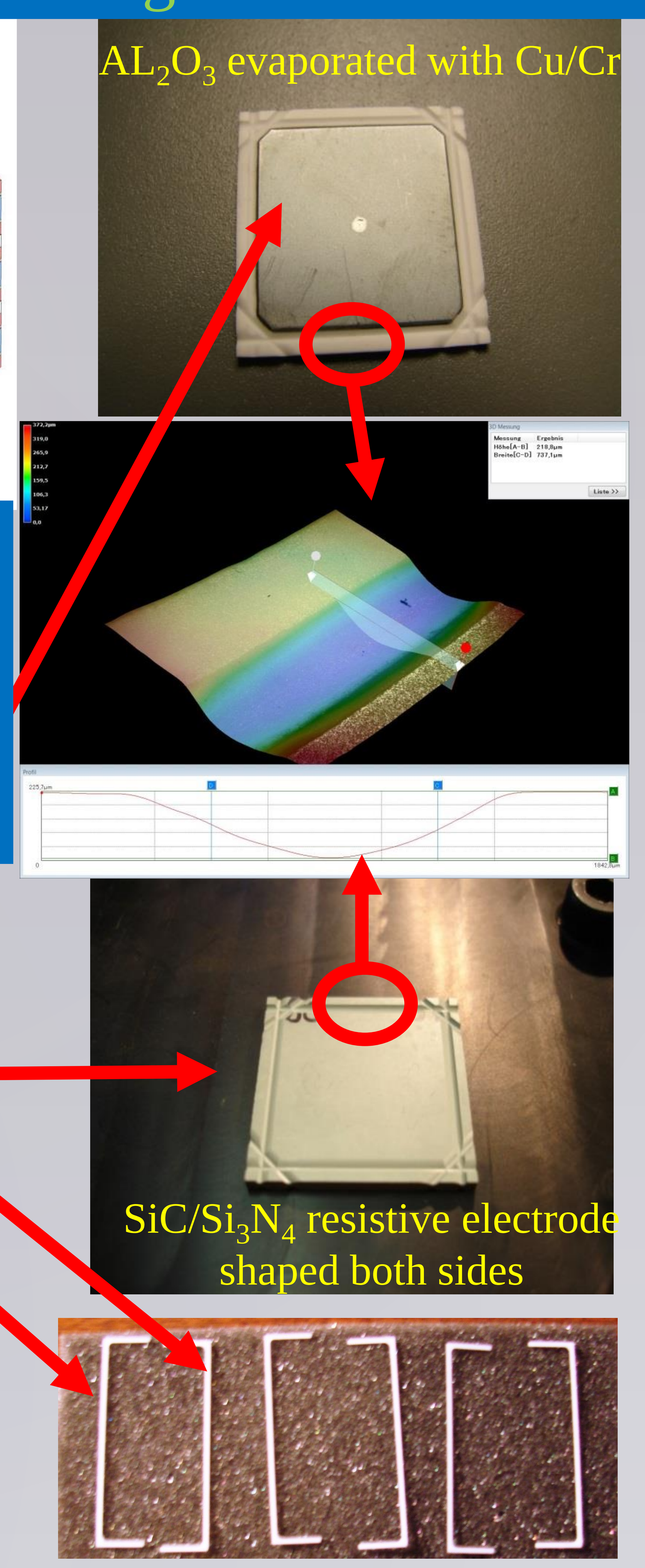


Single cell design with Rogowski electrodes



Six 250 µm gaps chamber composed of 3 double gap "sandwich" chambers of each two Al_2O_3 electrodes and one SiC/Si_3N_4 resistive electrode



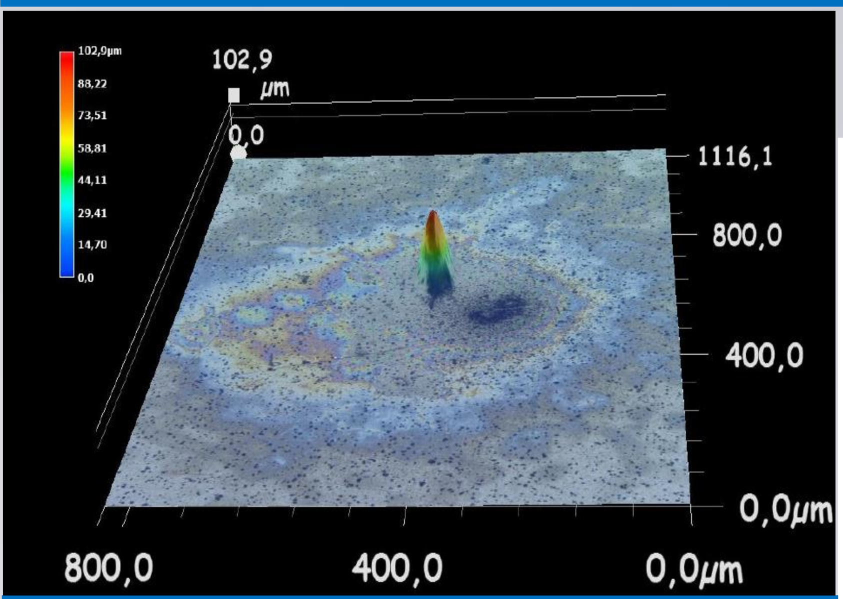


Al_2O_3 250 µm spacers

The present work aims at the development of the Beam Fragmentation T_0 Counter (BFTC) of the CBM experiment . This detector will be located at the forward region around the beam pipe, where the particle flux is expected to be as high as $2x10^5$ cm^{-2} s^{-1}.

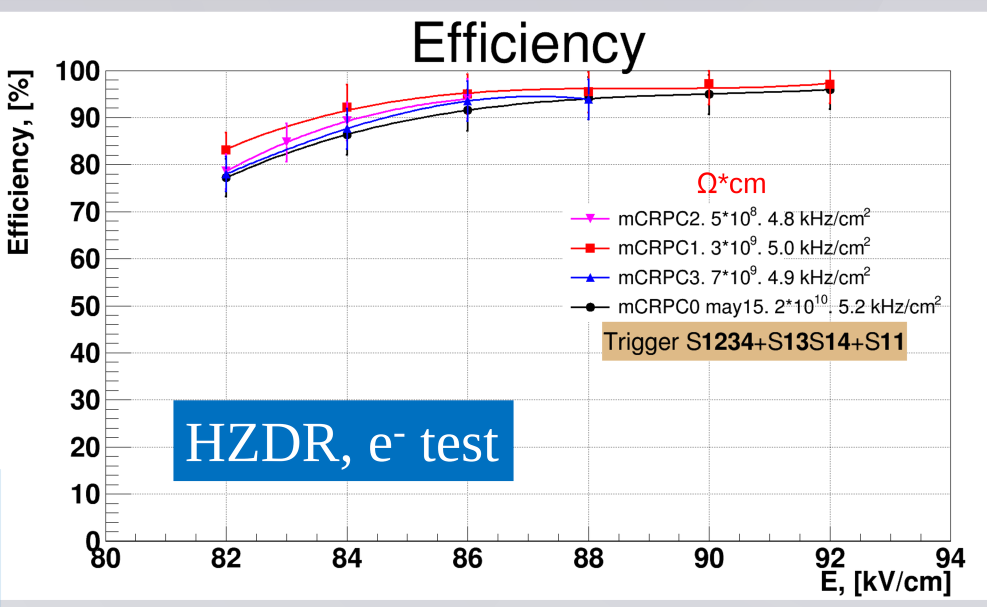
Current R&D status

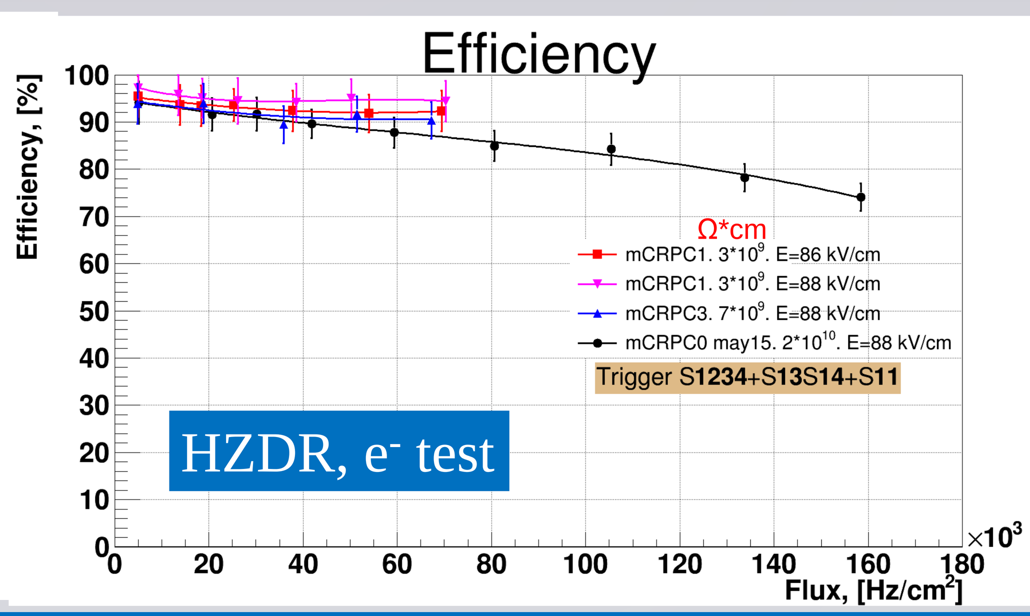
Gas mixture study (aging effects)

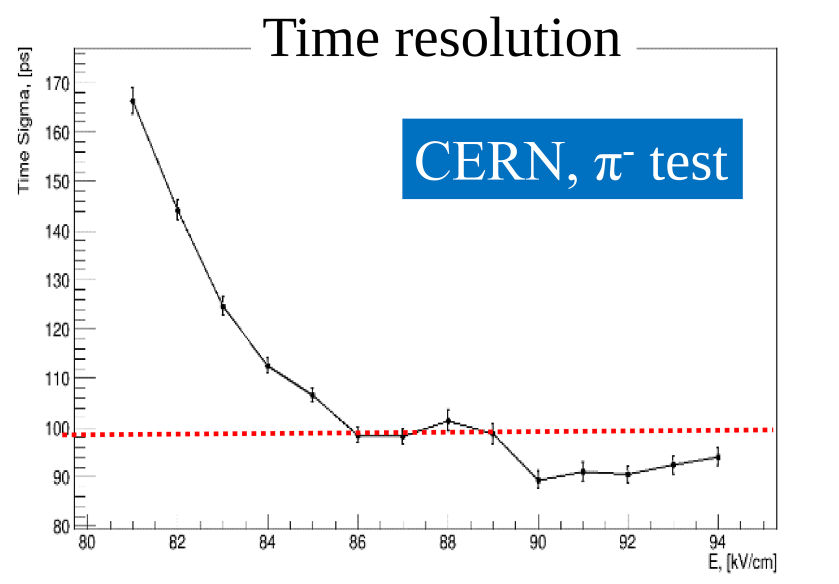


The $90\%C_2H_2F_4/10\%SF_6$ or $95\%C_2H_2F_4/5\%SF_6$ binary gas mixtures were used, since the formerly used iso-butane was found to be responsible for whisker formation (photo).

Beam tests results







Bulk resistivity $5x10^8$ Ohm*cm is too low to operate stably at HV plateau; $2x10^{10}$ Ohm*cm is too high to operate at rates higher than 100 kHz/cm². Efficiency (~96-98%) and time resolution (~80-90 ps) are consistent with expectation. MAXIM 3760 preamplifier was used, for comparison with ALICE R&D data.

Radiation hardness

Two probes of low bulk resistive plates have been exposed to non-ionizing radiation doses in the order of 10^{13} n_{eq}/cm^2 at the neutron beam of MEDAPP at FRM II in Munich. The bulk resistivity of both probes was measured before and after the irradiation. A factor of 2 decrease of the bulk resistivity has been observed. This decrease has no impact on efficiency and time resolution. For the Al_2O_3 electrodes an irradiation with fluxes up to $10^{15}n_{eq}/cm^2$ is possible without any degradation of the detector performance.

Conclusion and future plans

The present R&D results are very promising. The radiation hardness was proved, the mixture 90% $C_2H_2F_4$/ 10% SF_6 after long (a few months) operation showed no aging effects found before for the CBM TOF standard mixture. Rough limits for the resistivity were found. More precise scan for 8 new chambers with electrodes resistivity from $1.5x10^9$ Ohm*cm to $8x10^9$ Ohm*cm will be done soon at HZDR ELBE accelerator to fix the resistivity value for the most stable operation with an efficiency over 95% at rates up to 200 kHz/cm². Also a significant improvement of the time resolution (~60 ps) is expected with advanced CBM PADI FEE.