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Two real-size high-rate MRPC modules for CBM-TOF

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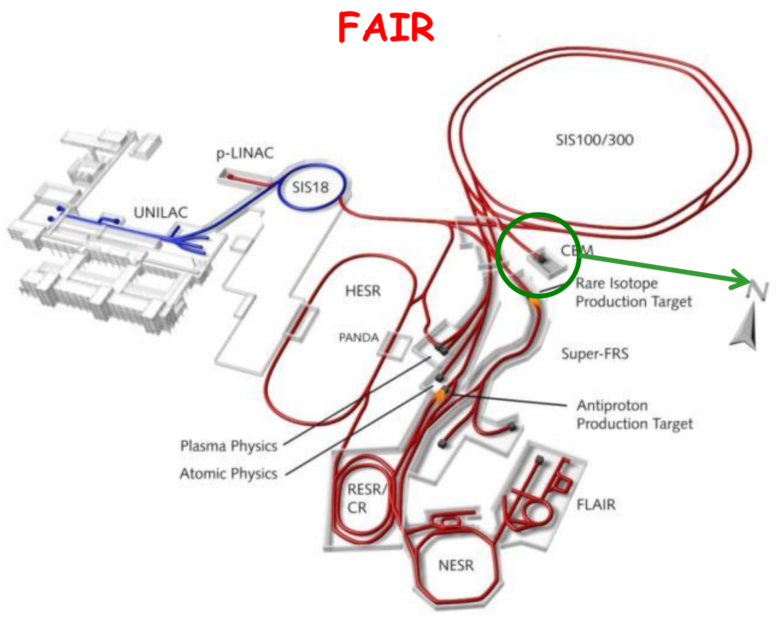
Abstract: The Compressed Baryonic Matter experiment at the future Facility for Antiproton and Ion Research will use a time-of-flight (TOF) wall for hadron identification, which is at the moment planned to be based on the MRPC technology. We propose a realistic design for building the TOF wall by resorting to a single technology based on low-resistivity doped glass and relying on small structural modifications of the modules developed and tested during the last two years. Following the encouraging results previously obtained with small counters, two types of modules have been built at Tsinghua University with the new material. The beam tests prove their suitability as the building blocks of the present hadron-identification concept of the CBM experiment.

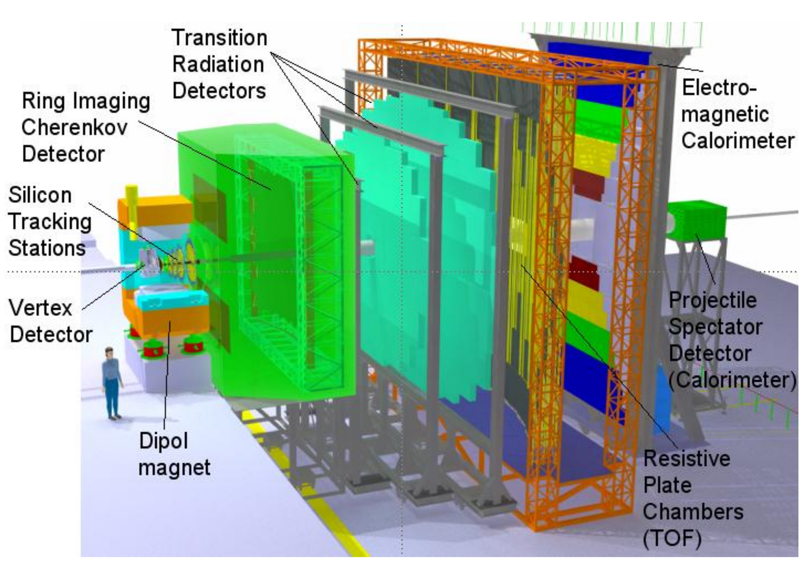
CBM experiment:

The CBM experiment at the future FAIR in Darmstadt, Germany, aims at exploring the QCD phase diagram under extremely high net baryon densities and moderate temperatures. For hadron identification, a Time-of-Flight (TOF) wall placed at 10m distance from the target. The wall features a TOF resolution better than 80ps and an occupancy per cell below 5% over an area of 150m². The challenge is to keep high efficiency (above 90%) and good time resolution (less than 80ps) at a particle flux up to 20kHz/cm².

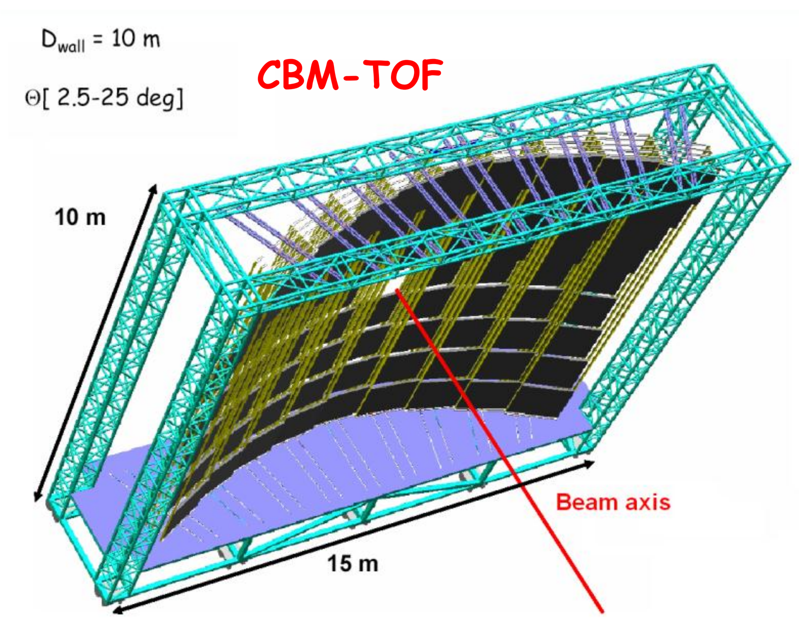
FAIR



CBM detector



CBM-TOF requirements:

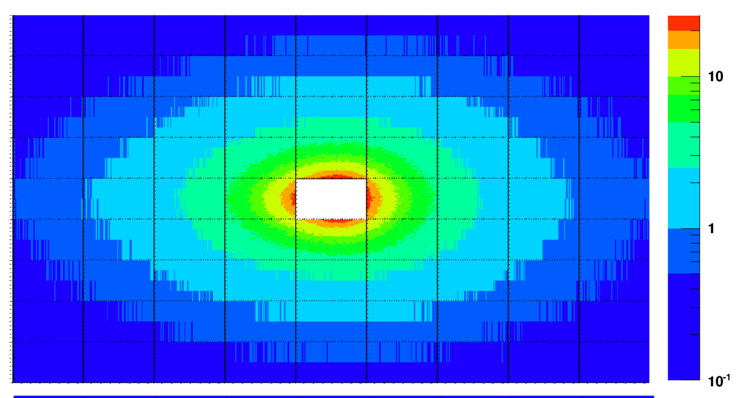


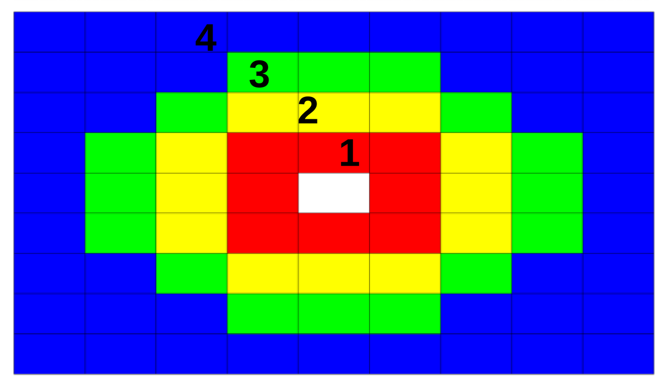
9 columns with 9 supermodules each
$A_{super-module}$ = 1.5 m x 1 m

1	8.0-25 kHz/cm², #SM: 8 (low resistive glass/ceramic)
2	3.8-8.0 kHz/cm², #SM: 12 (low resistive glass)
3	1.5-3.5 kHz/cm², #SM: 16 (low resistive glass)
4	0.5-1.5 kHz/cm², #SM: 44 (float glass, warming up / backup: low resistive glass)

full system time resolution sT ~ 80 ps

- Efficiency > 90 %
- Rate capability ≤ 25 kHz/cm2
- Polar angular range 2.5° – 25°
- Occupancy < 5 %
  (for Au-Au(central) at E=25 GeV/A)
- Low power electronics (~75.000 channels)
- Pile-up < 5%

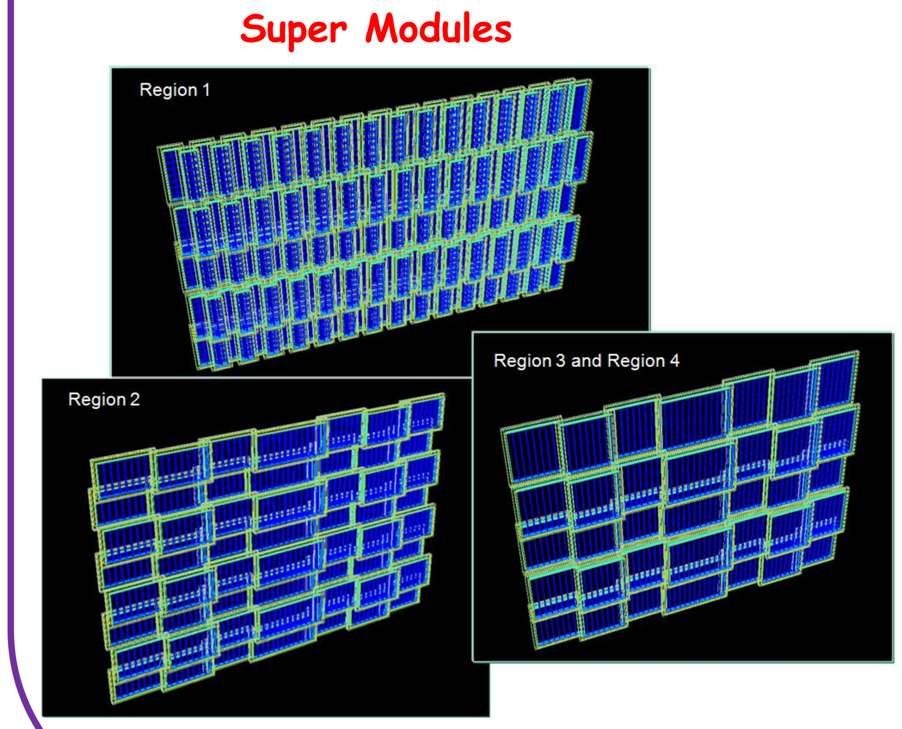




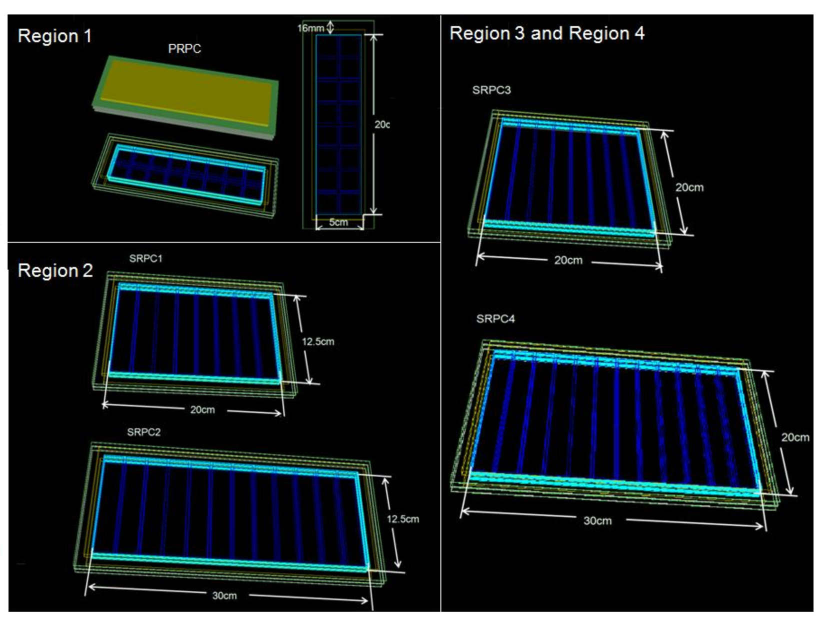
Conceptual design of the Super Modules (SM)

We propose a conceptual design for building the TOF wall by resorting to a single technology based on low-resistivity doped glass and relying on small structural modifications of the two modules developed and tested during the last two years.

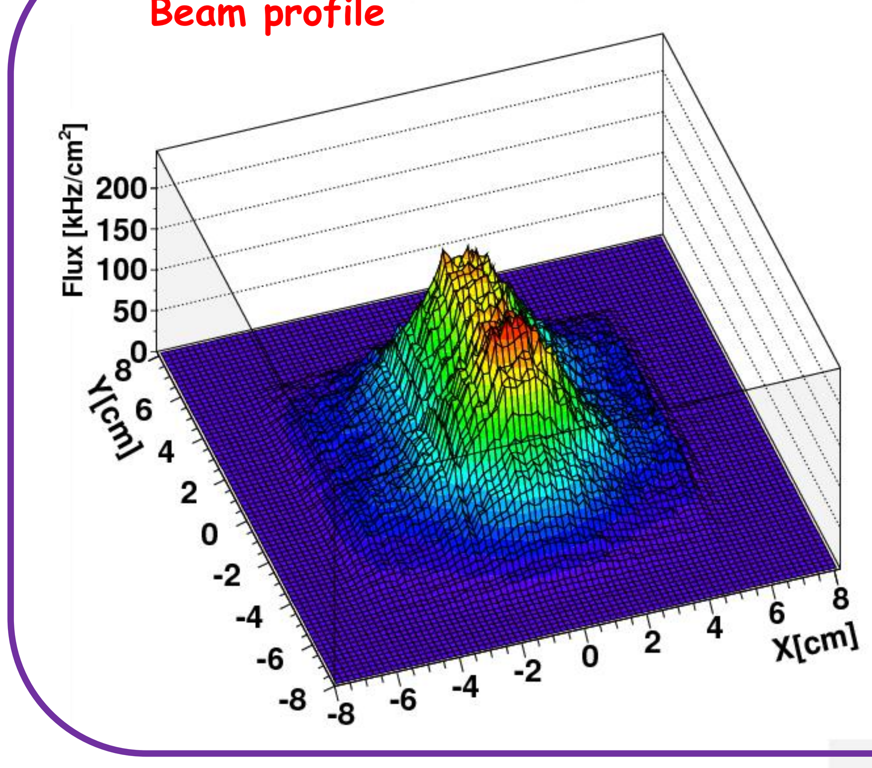
Super Modules



Detector family



Beam profile



Definition of average flux

$$\bar{\phi} = \int_{x_1}^{x_2}\int_{y_1}^{y_2} \phi(x,y)\,p(x,y)\,dxdy$$

$$= \frac{Rate_{S_{24/25}}}{\sum_i\sum_j \phi(i,j)\Delta x\Delta y} \cdot \frac{\sum_i\sum_j \phi(i,j)\phi(i,j)}{\sum_i\sum_j \phi(i,j)}$$

$\phi(x,y)$: local particle flux

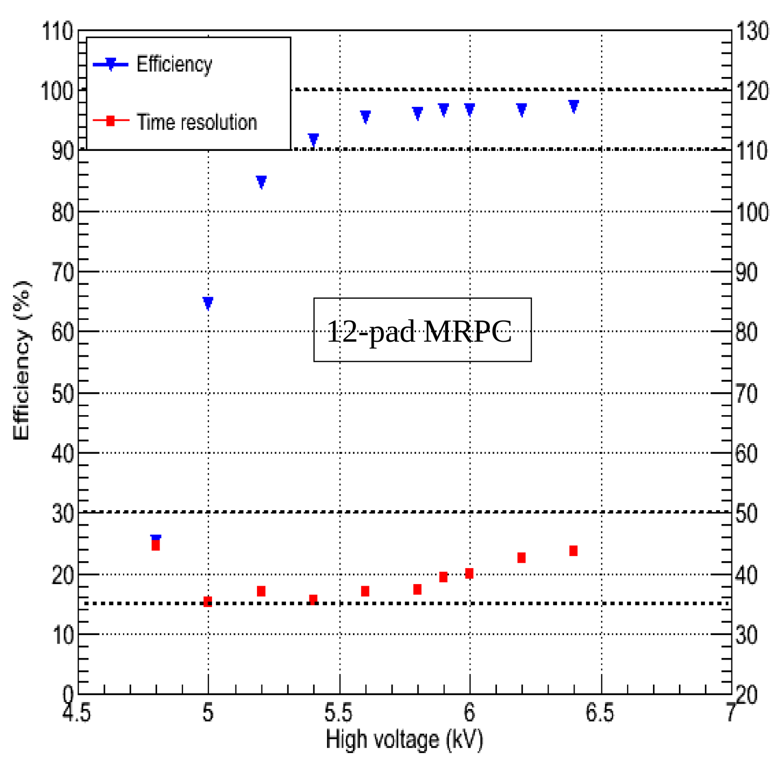
$p(x,y)$: probability distribution $\propto \phi(x,y)$

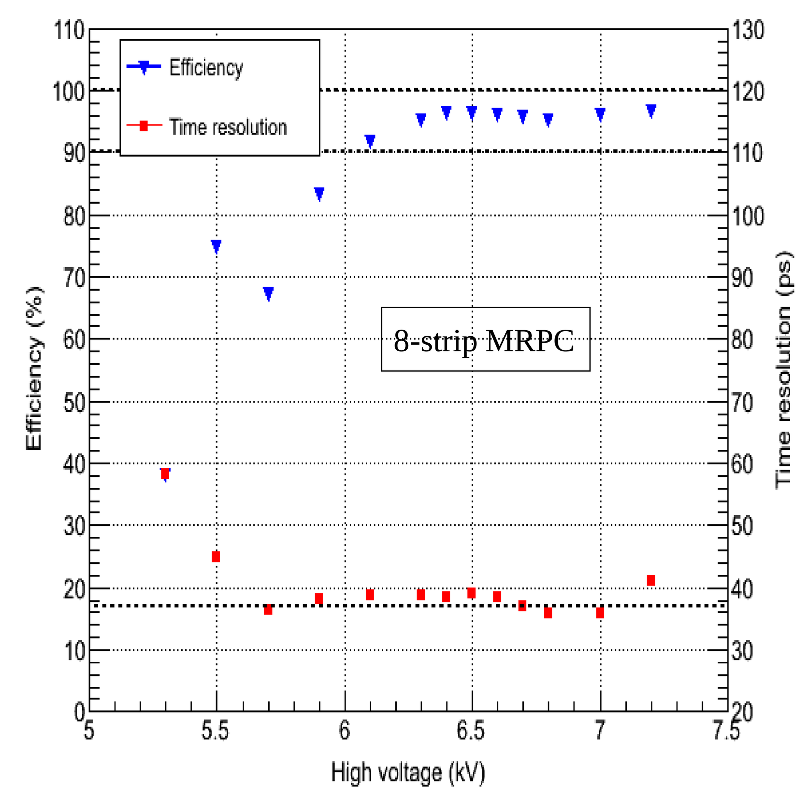
$Rate_{S_{24/25}}$: counting rate from S24/25

Preliminary results:

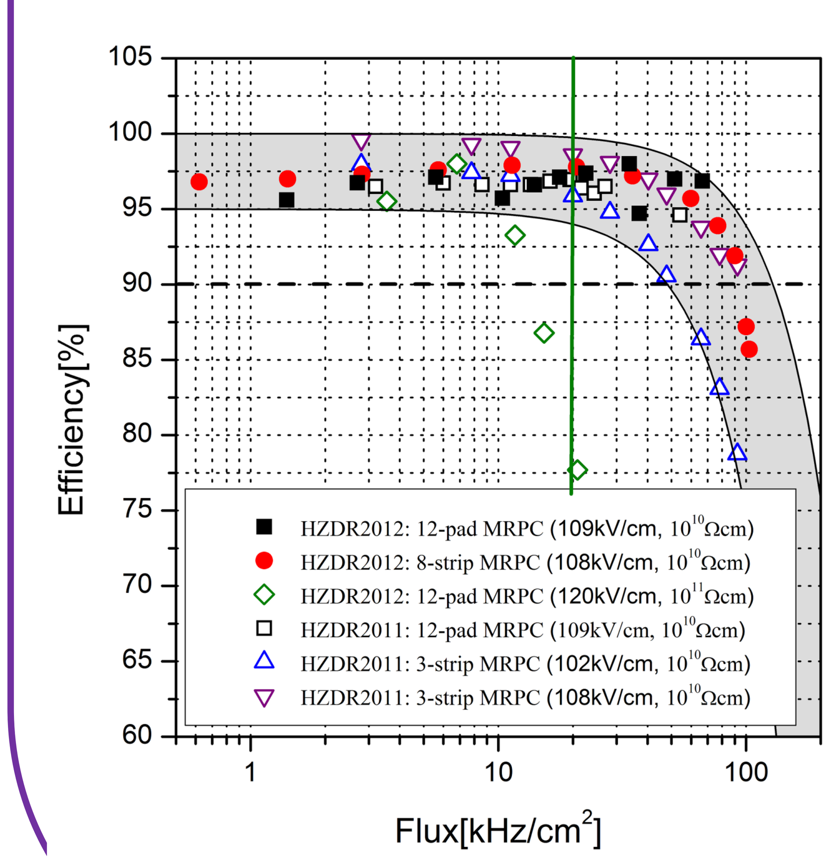
The developed real-size prototypes are able to operate at the required 90% efficiency and 80ps time of flight resolution for fluxes at least twice higher (up to 80kHz/cm²)than the ones expected in the future Time of Flight wall of the Compressed Baryonic Matter experiment at FAIR, thus providing a reasonable safety margin for operation.

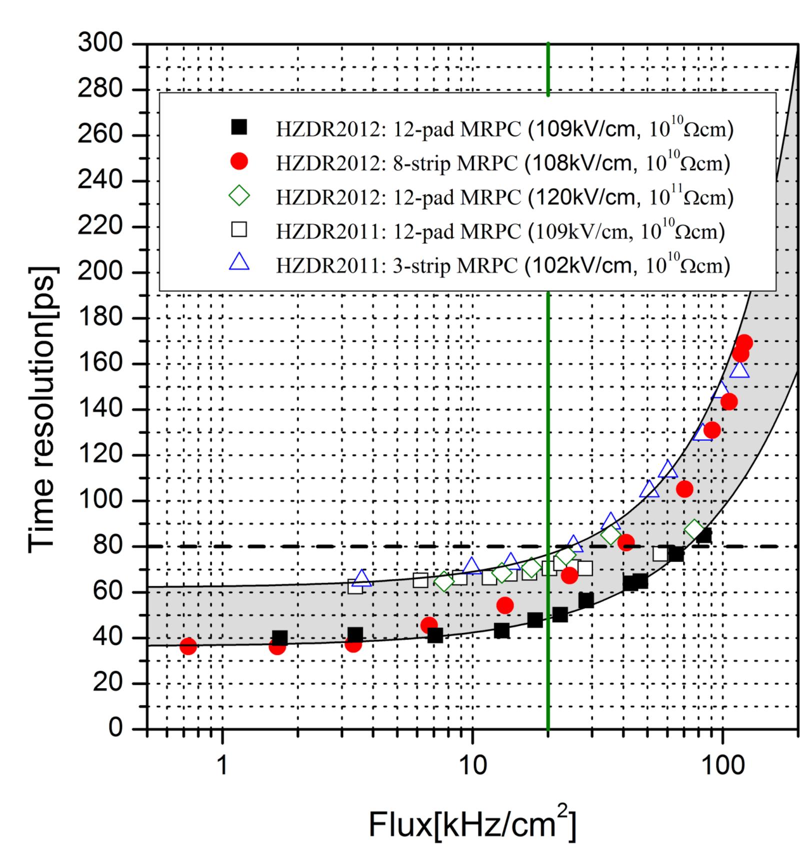
Counter performances as a function of HV





Summary of the counter performances as a function of flux

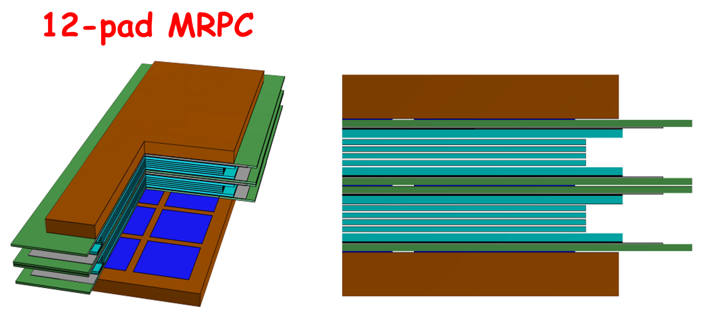




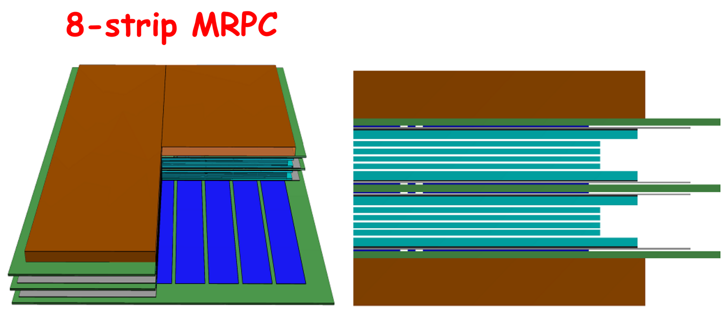
Beam test at ELBE:

Two real-size counters made of low-resistivity doped glass were developed at Tsinghua University and the electron beam of the Electron Linac with high Brilliance and low Emittance (ELBE) facility at Helmholtz-Zentrum Dresden-Rossendorf (HZDR) was used in June 2012 to test the performance.

12-pad MRPC



8-strip MRPC



Test setup (Top view)