Task 9.4.1

Resistive Plate Chambers (RPCs) Tests at TREF neutron beam-line in TUM-FRM II

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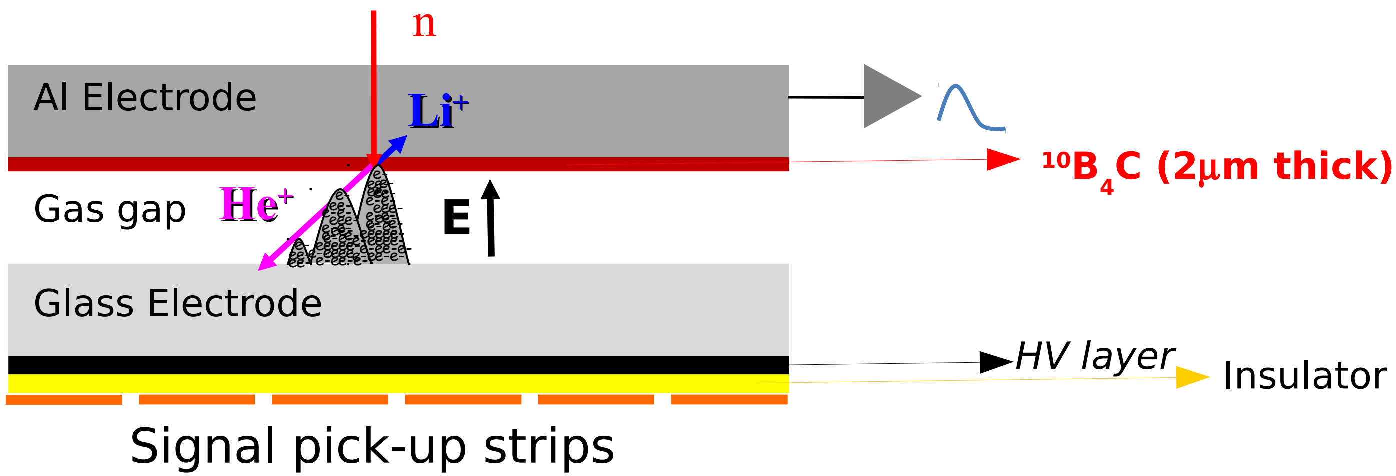
OutLook

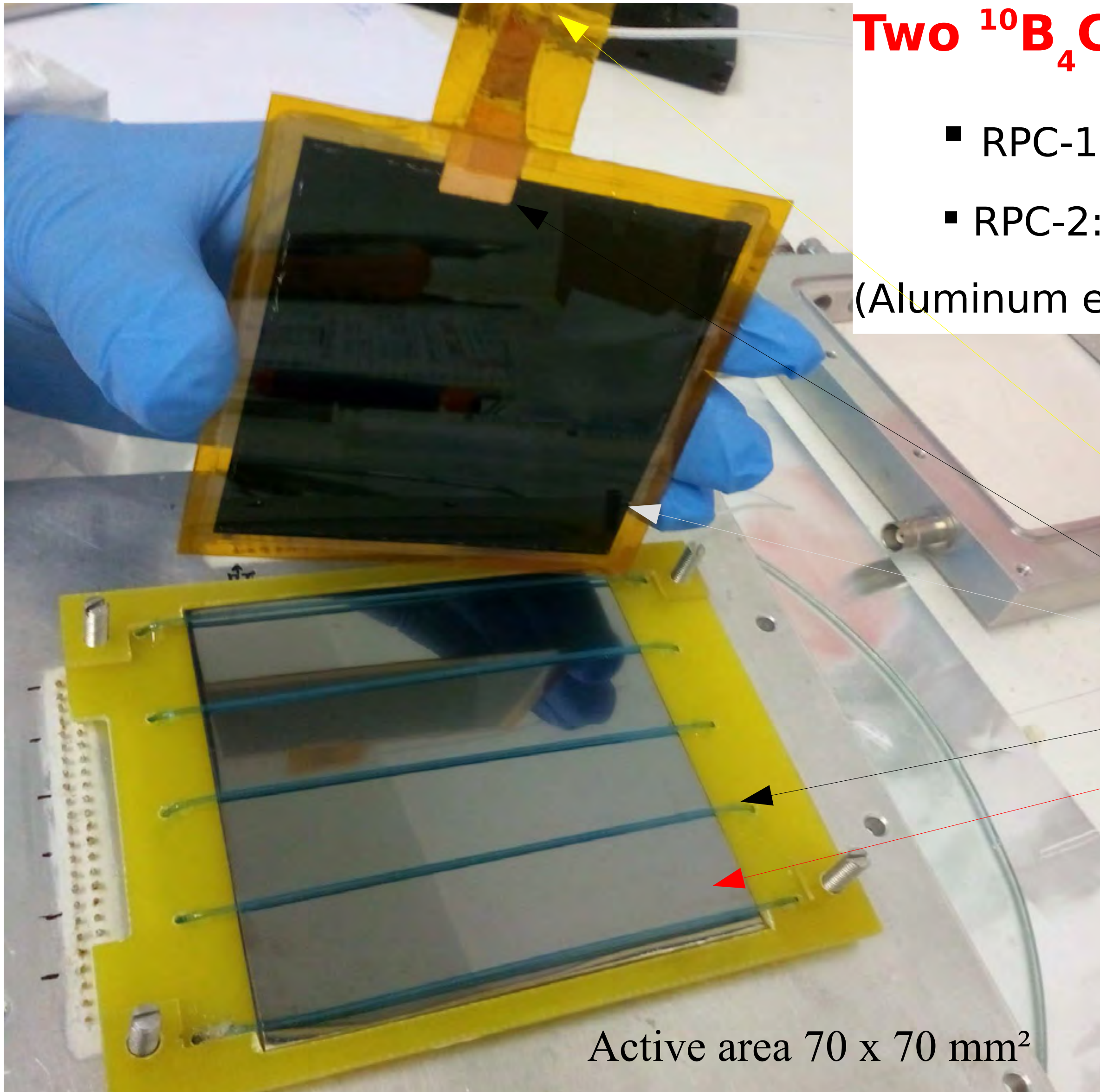
- RPC and setup description
- Plateau
- Efficiency
- Spatial resolution
- Conclusions

WP 9: Testing RPCs at TUM-FRM II
RPC detetector



- Aluminum electrode: 1 mm thick, 80x80 mm².
- $^{10}B_4C$ layer: 2 µm thick.
- Gas-gap: filled with $C_2H_2F_4$ @ atmospheric pressure.
- Glass electrode: 0.35 mm thick, 80x80 mm².
- HV layer: 70x70 mm² (active area).
- HV insulator
- Signal pick-up strips engraved on a PCB

WP 9: Testing RPCs at TUM-FRM II
RPC detetector



Two $^{10}B_4C$ coated RPCs,

- RPC-1: *gas-gap width* = **1 mm**
- RPC-2: *gas-gap width* = **0.35 mm**

(Aluminum electrode coated with $^{10}B_4C$, 2μm thick)

HV insulator

HV layer

Plate of float glass.

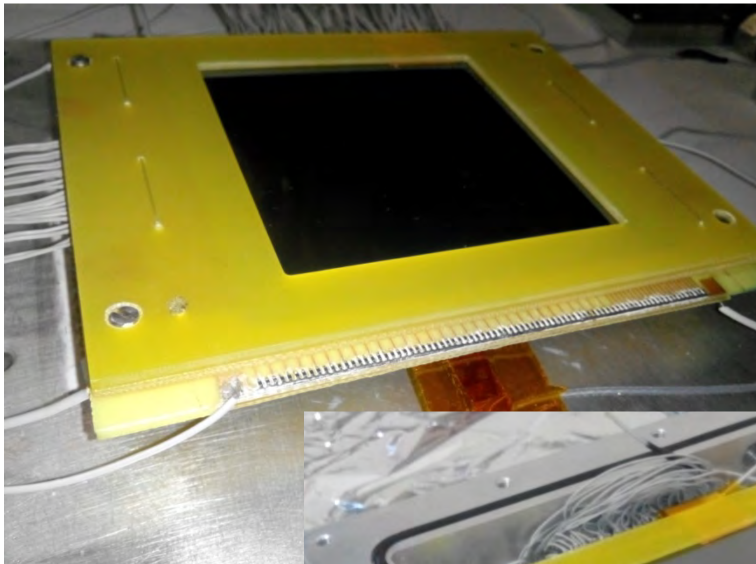
Nylon mono-filaments gas gap spacers

2 μm of $^{10}B_4C$ on Aluminum electrode

ESS Detector Coatings Workshop in Linköping

WP 9: Testing RPCs at TUM-FRM II
RPC detetector

Stack of two RPCs



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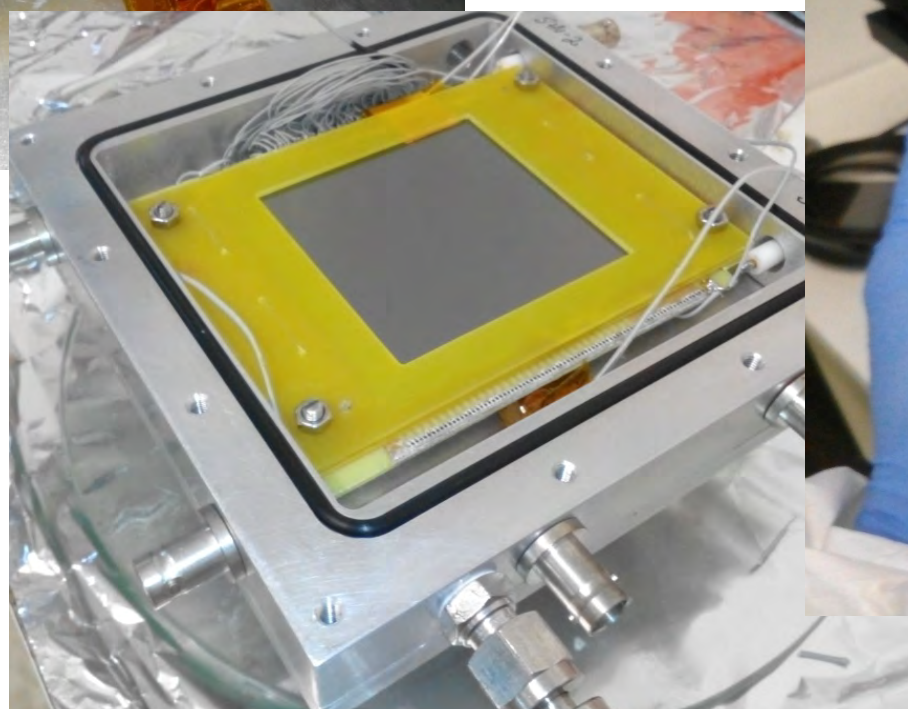
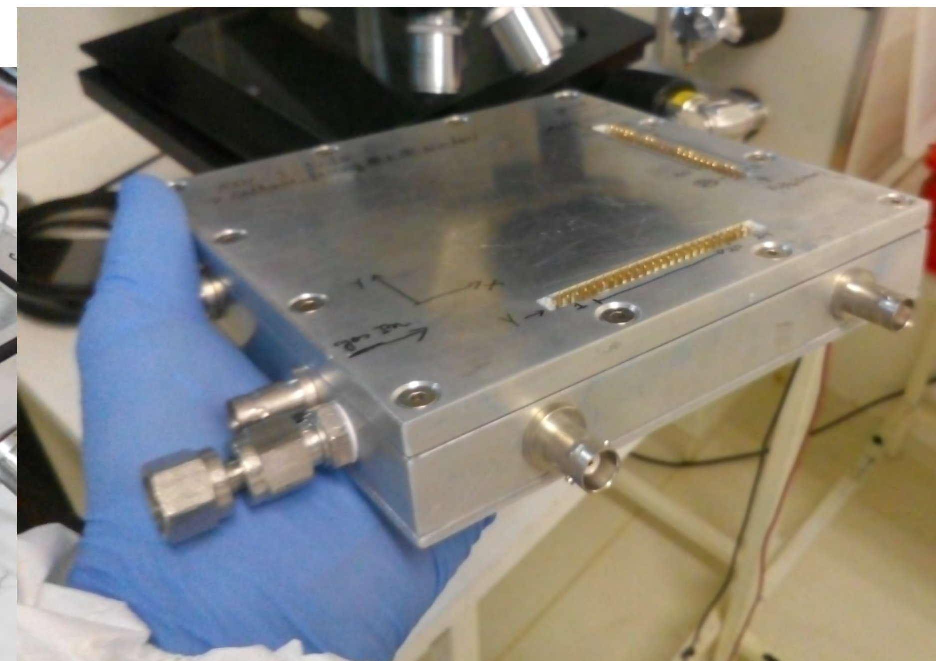
(Aluminum electrode coated with $^{10}B_4C$, 2μm thick)

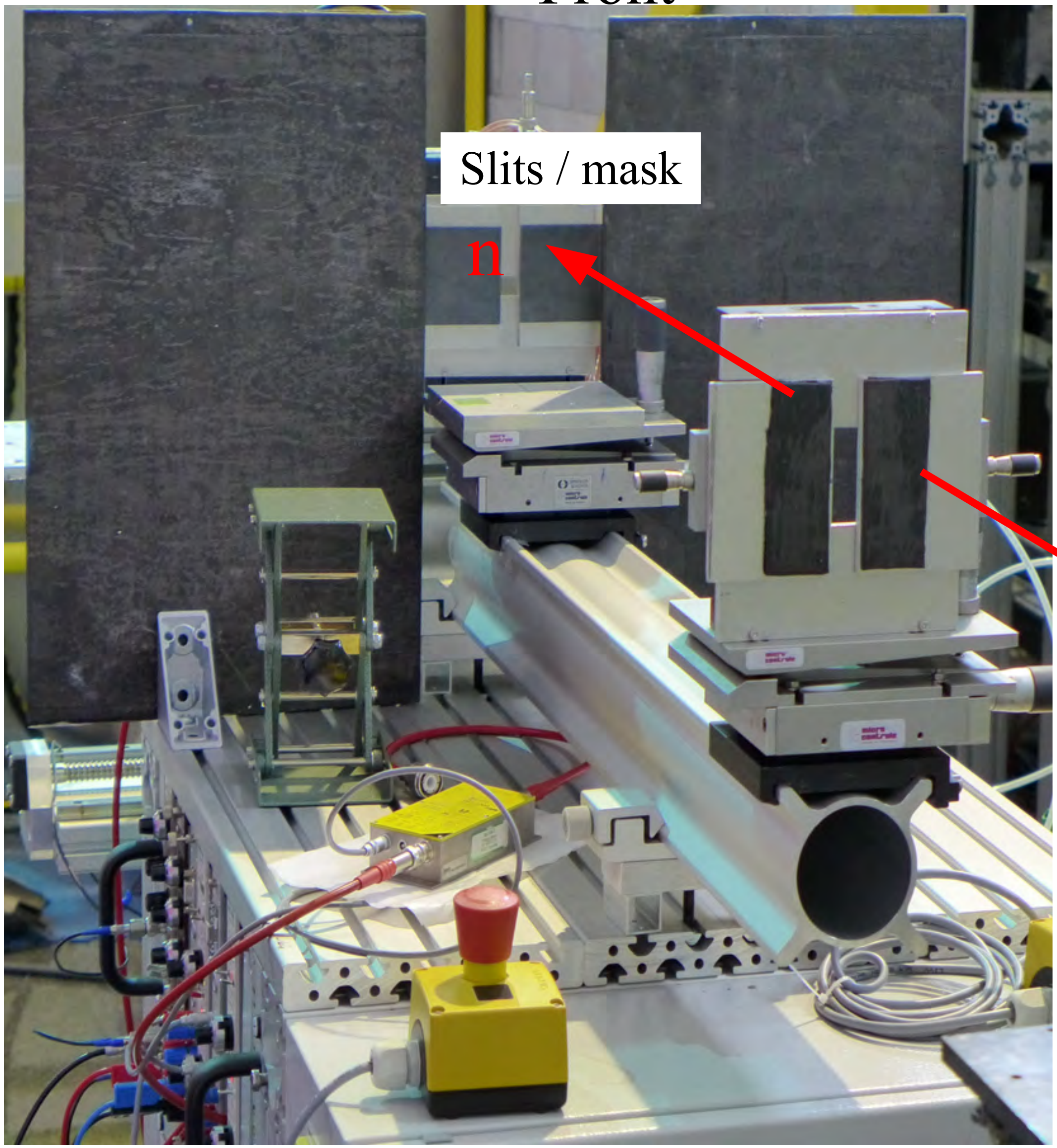




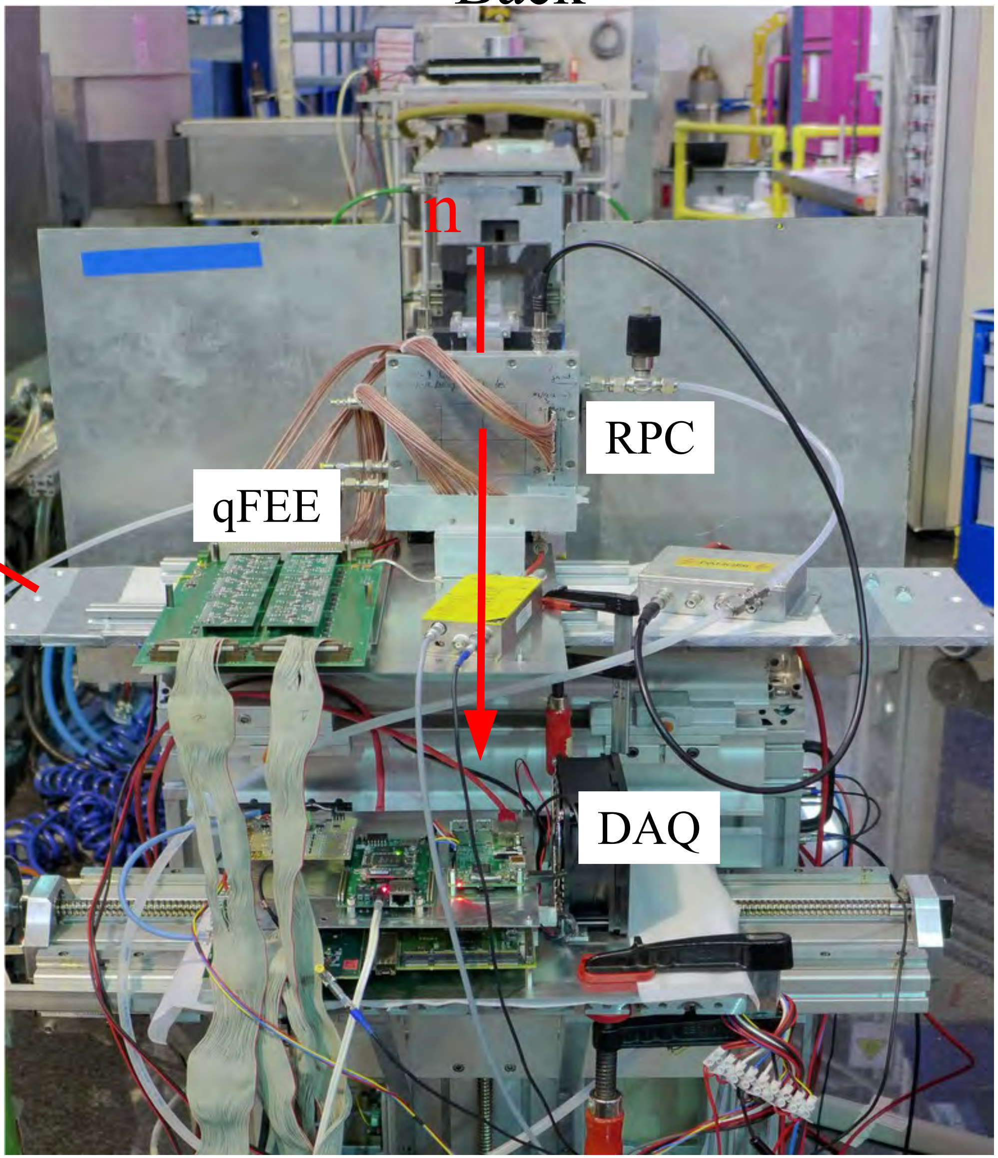
Gas tight box

WP 9: Testing RPCs at TUM-FRM II
Setup

Front



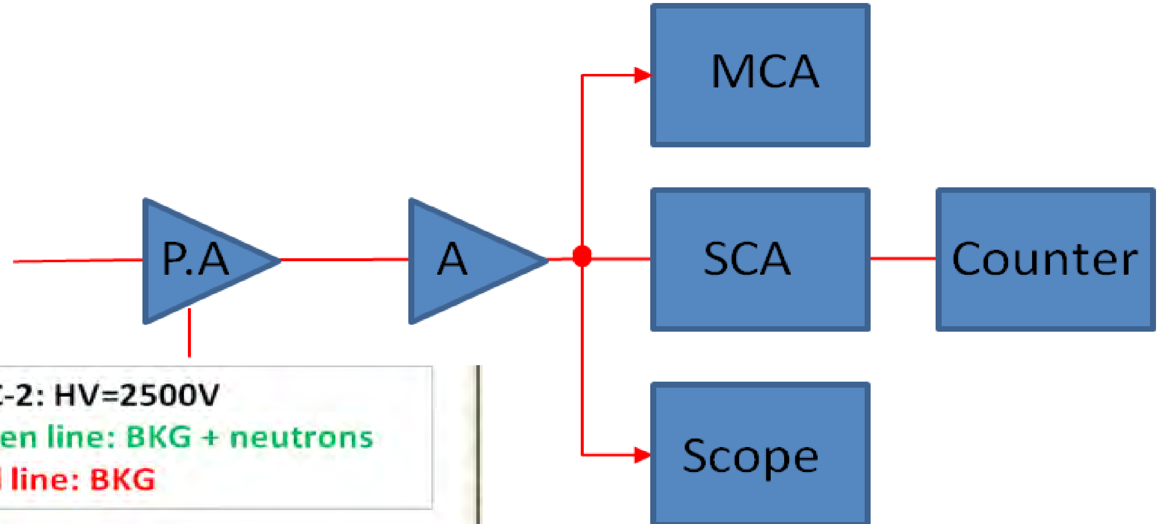
Back

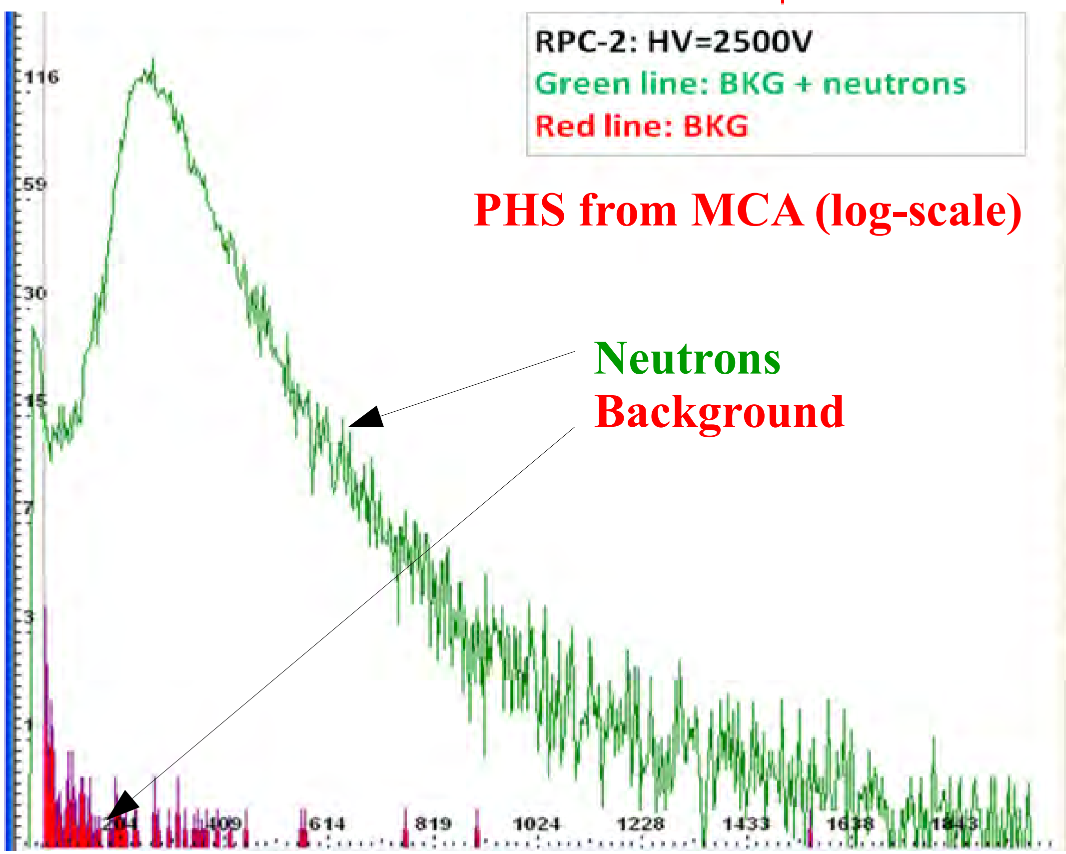


TREF/FRMII neutron beam line λ 4.7 Å

WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements

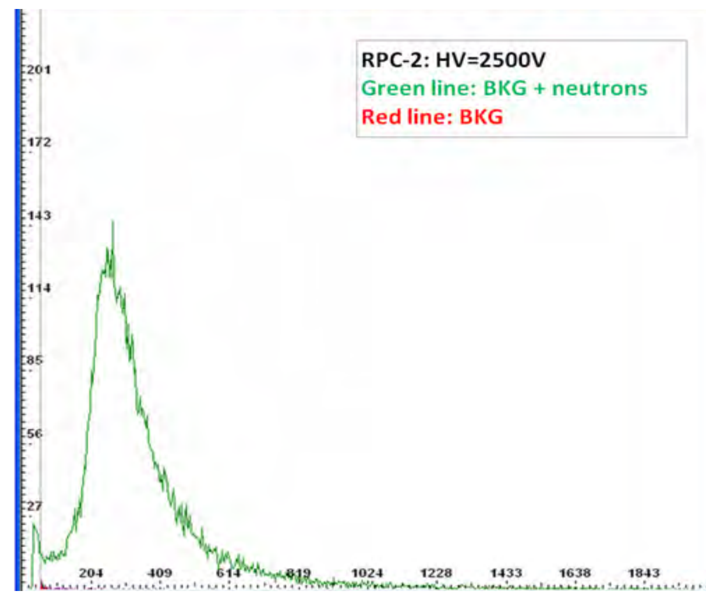
RPC
Aluminum plate





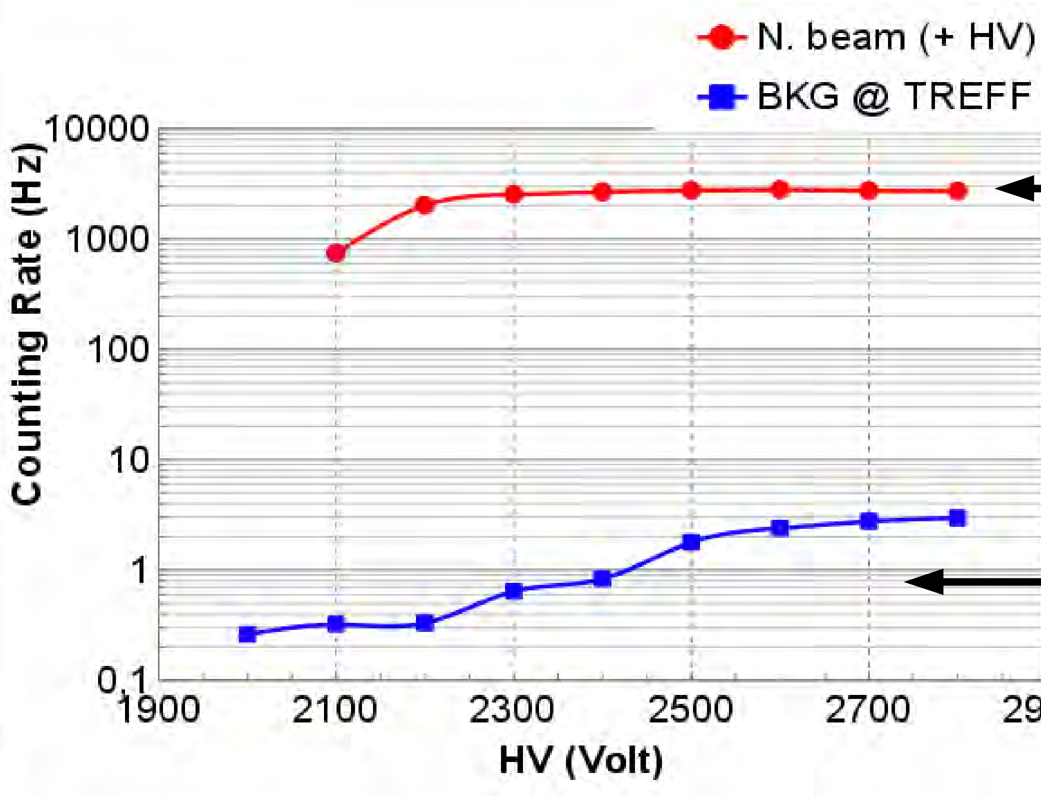
PHS from MCA (log-scale)

PHS from MCA (linear-scale)

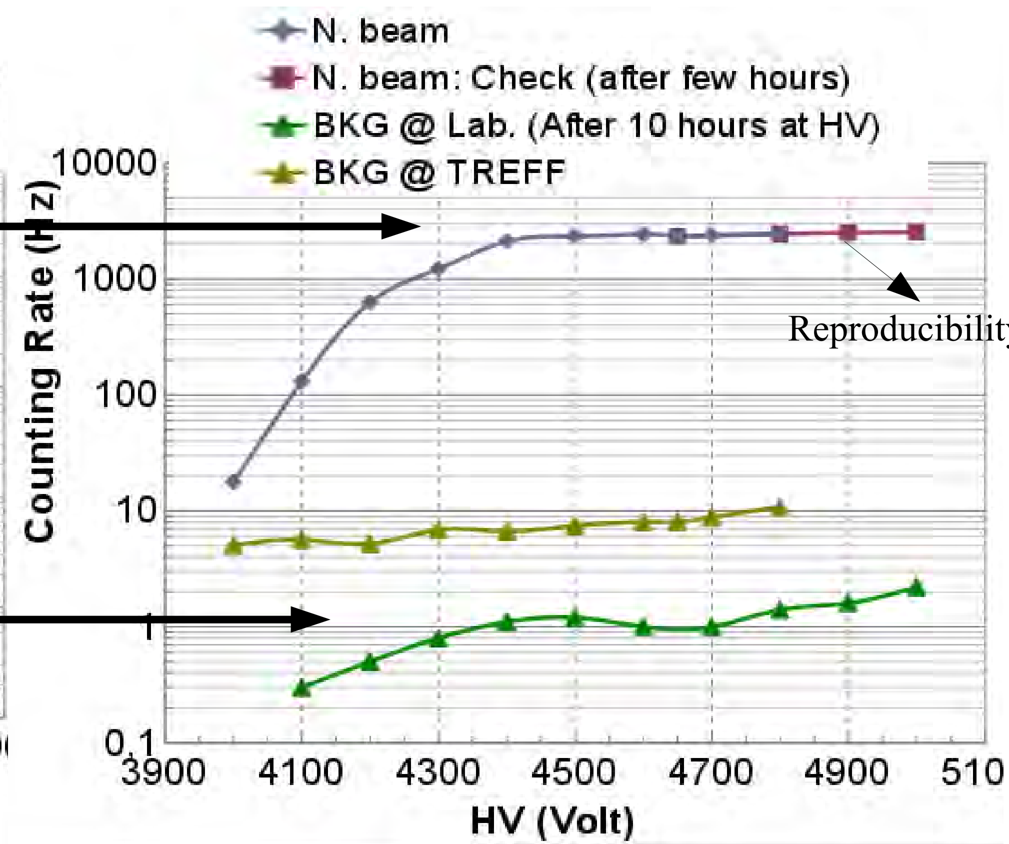


Neutron signal clearly visible

RPC 0.35 mm gap



RPC 1 mm gap



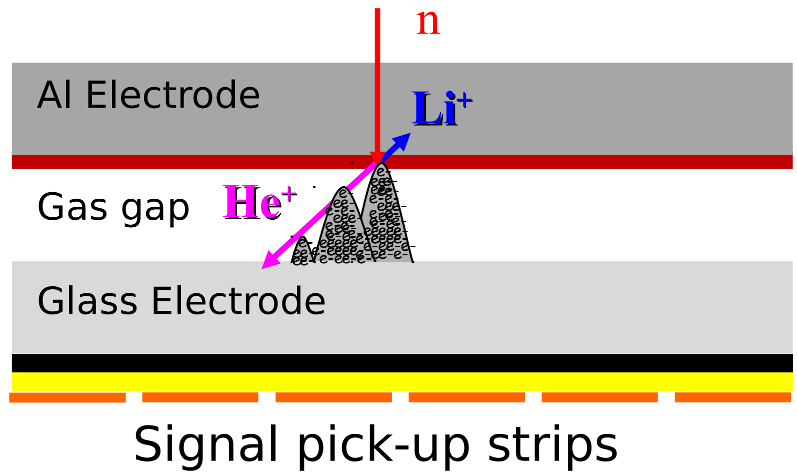
Similar behaviour of RPCs with 1 mm and 0.35 mm gap width
Wide HV plateau > 500 V

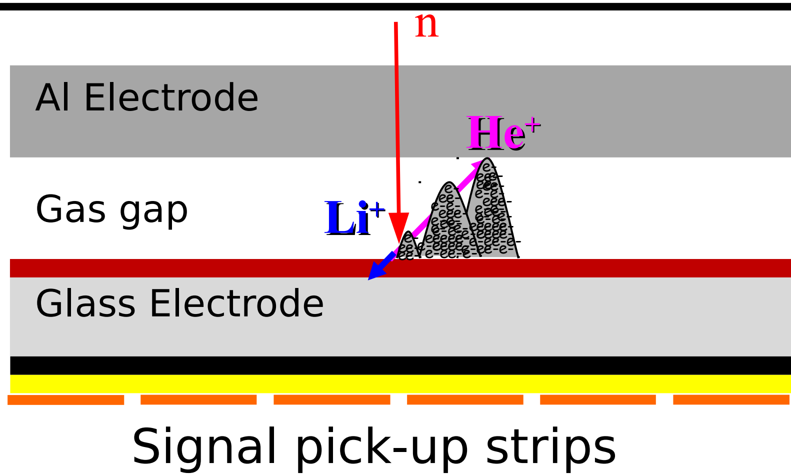
WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements. Inverted polarity

Mimic the behavior of having the $^{10}B_4C$ layer in the second electrode.

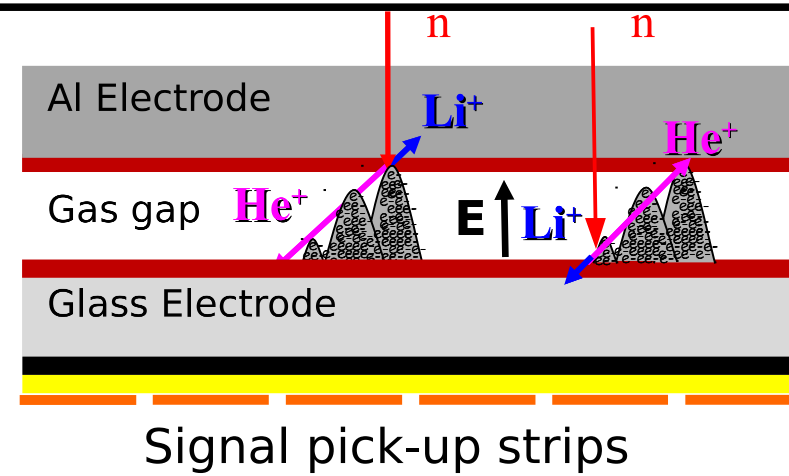
Implications on the RPC efficiency.

Current arrangement
$^{10}B_4C$ in **first electrode**





$^{10}B_4C$ in **second electrode**

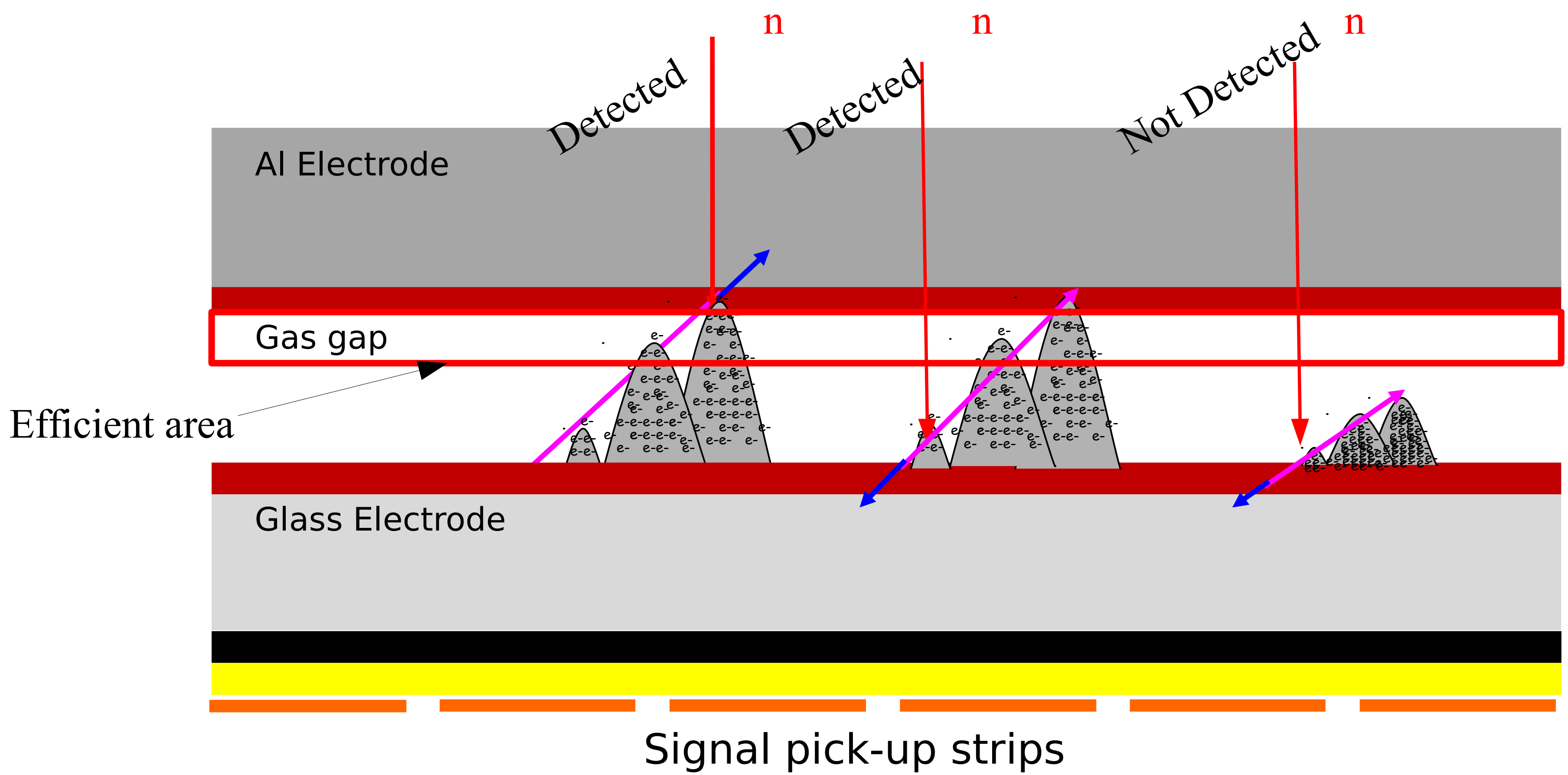


$^{10}B_4C$ in **both electrodes**

WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements. Inverted polarity

Mimic the behavior of having the $^{10}B_4C$ layer in the second electrode.

Implications on the RPC efficiency.

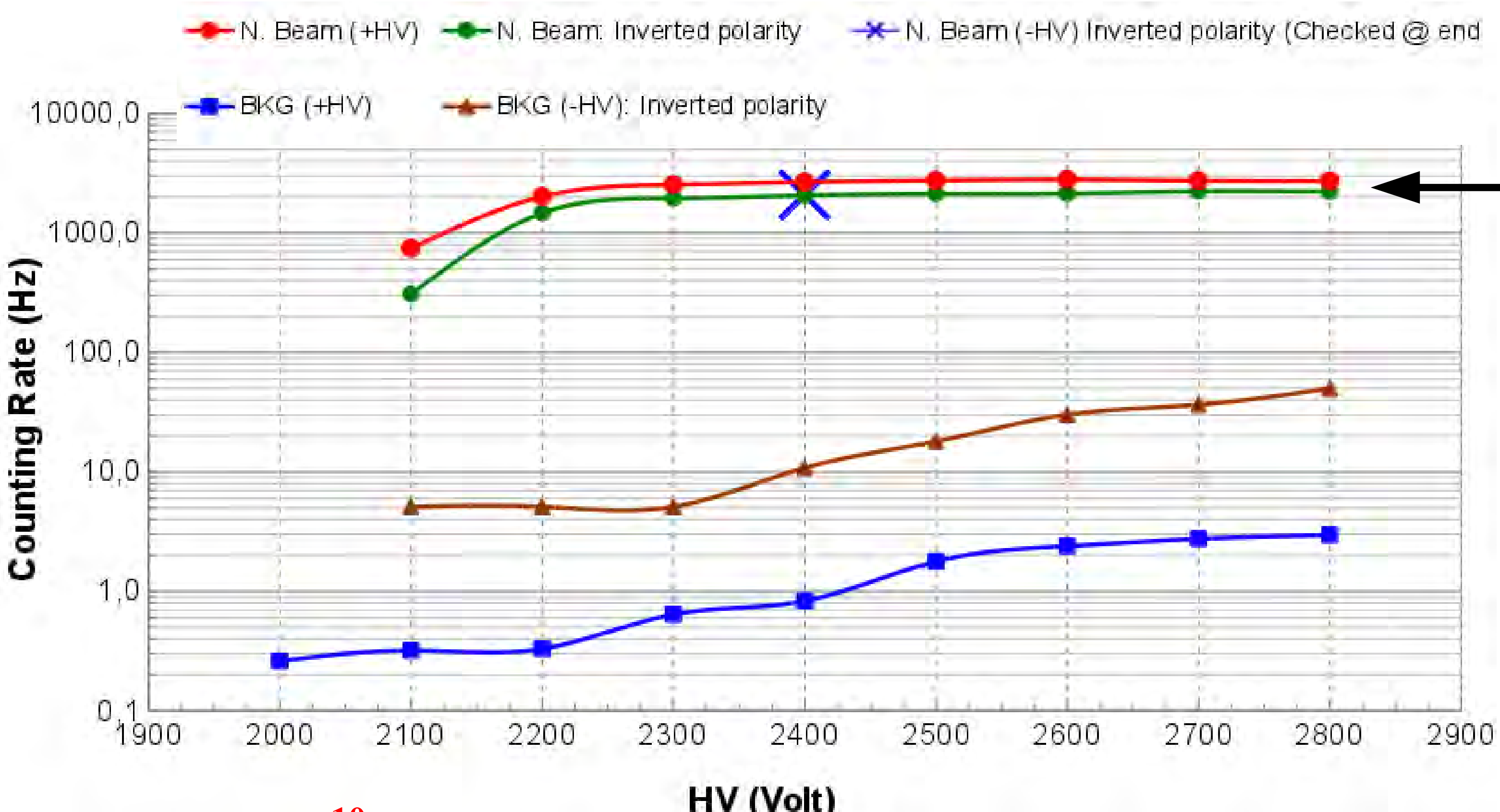


WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements. Inverted polarity

Mimic the behavior of having the $^{10}B_4C$ layer in the second electrode.

Implications on the RPC efficiency.

RPC 0.35 mm gap



Inverted polarity (=> $^{10}B_4C$ on the second layer) shows ~ 22% less counts.

WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements. Inverted polarity

Mimic the behavior of having the $^{10}B_4C$ layer in the second electrode.

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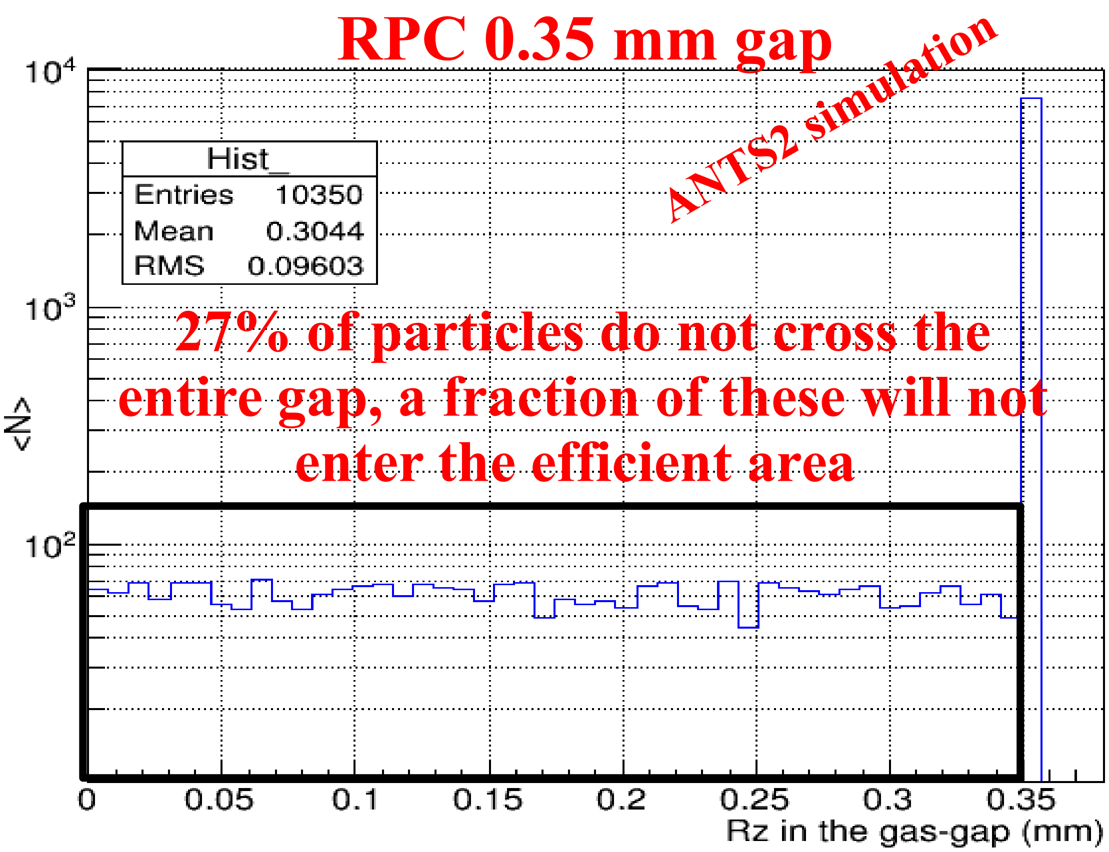

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WP 9: Testing RPCs at TUM-FRM II
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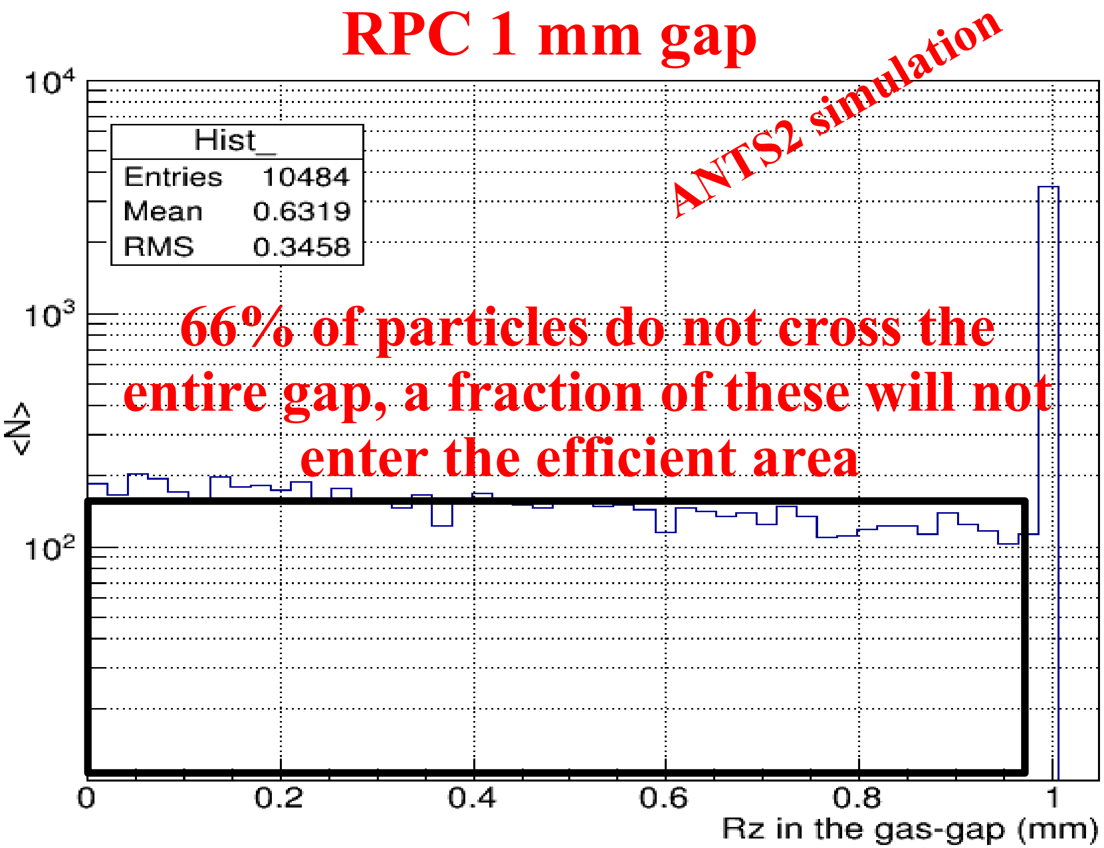
RPC 1 mm gap



Should be worse for the 1 mm gap, not measured

WP 9: Testing RPCs at TUM-FRM II
Plateau meassurements. Inverted polarity

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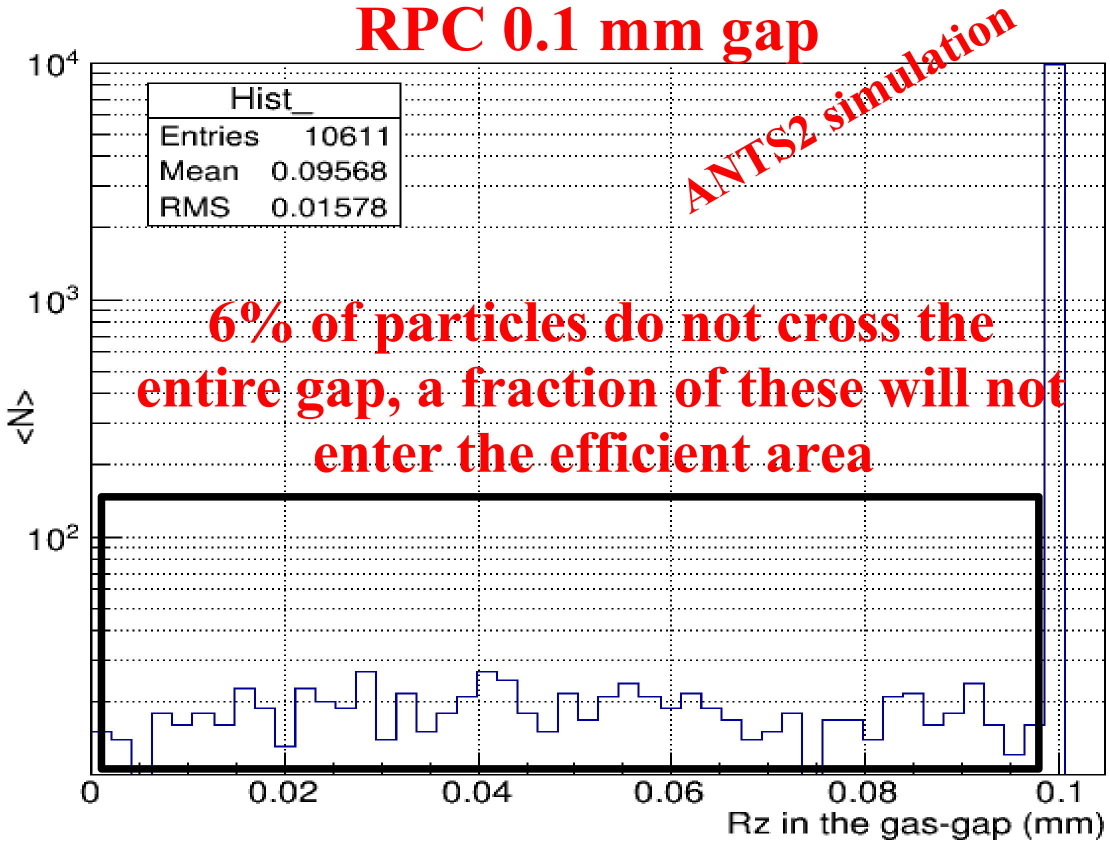
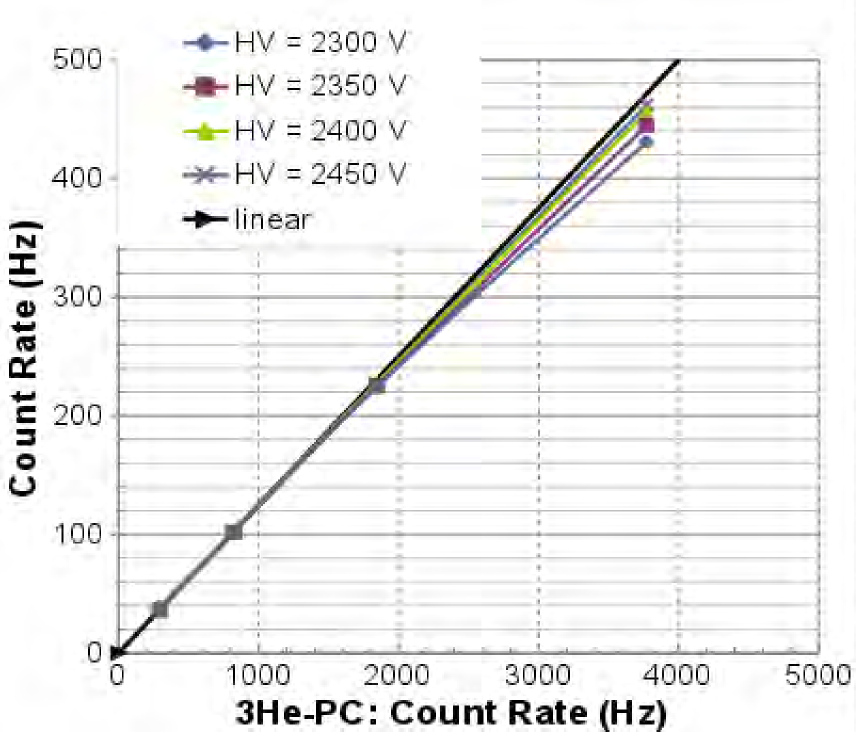


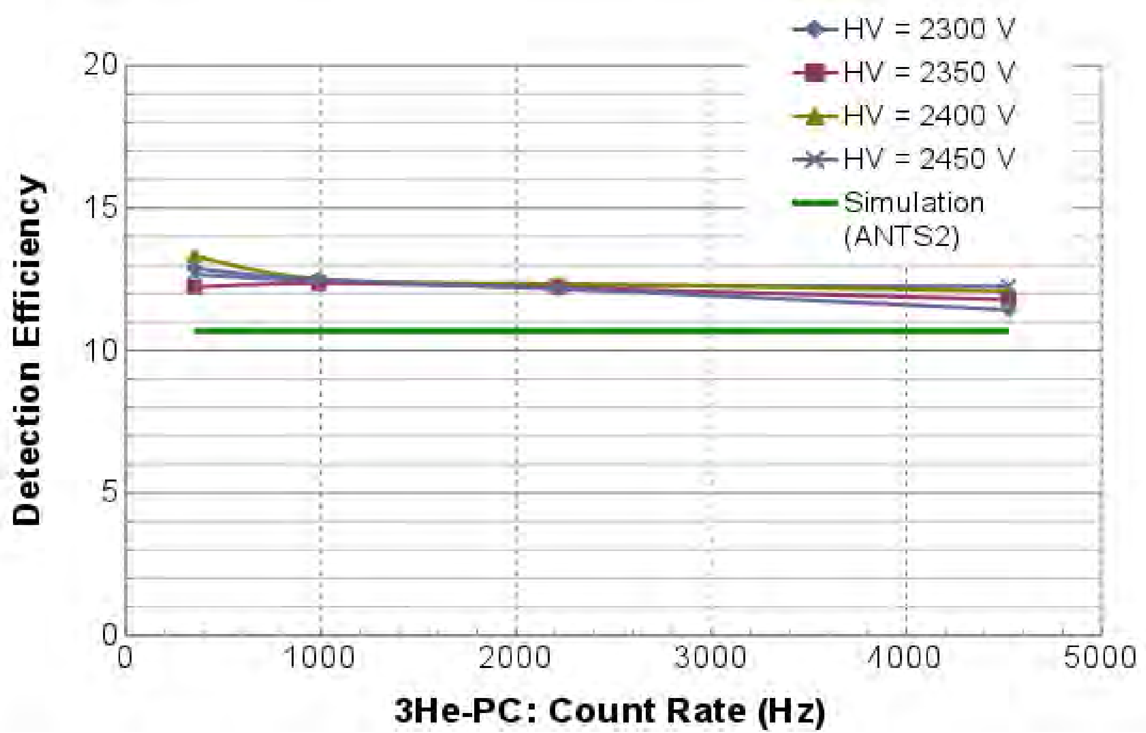
Should be better for the 0.1 mm gap, not measured

WP 9: Testing RPCs at TUM-FRM II
Detection efficiency

Detection efficiency estimated using a ^{3}He –Proportional counter (efficiency ~ 97,3 %) as a reference.

RPC 0.35 mm gap

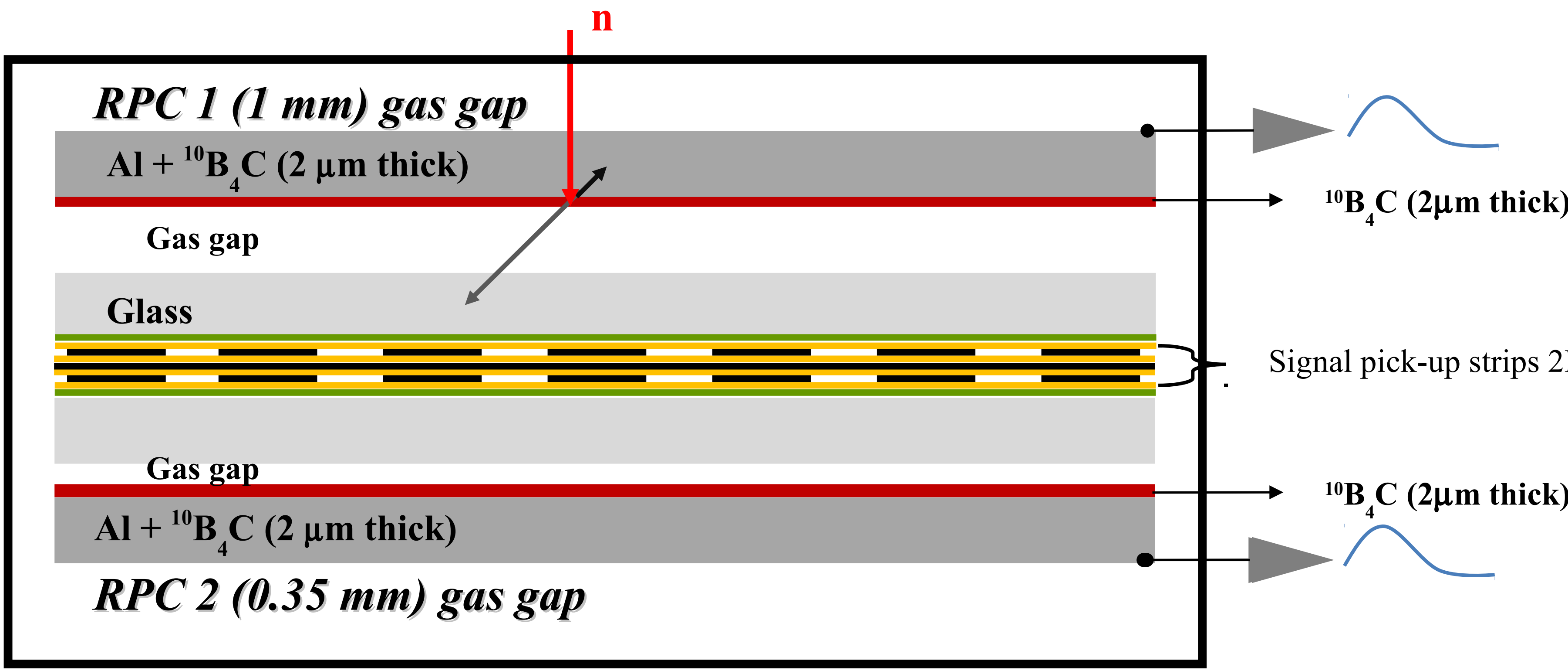




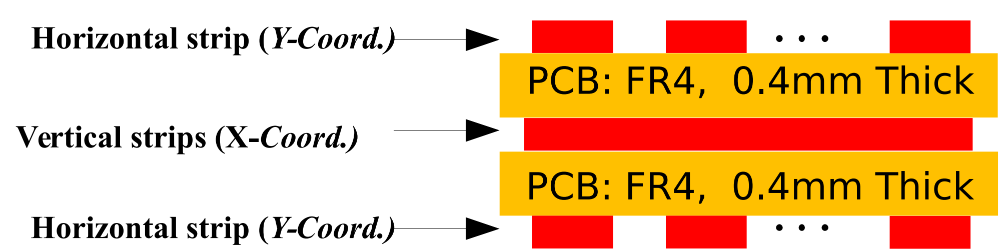
Efficiency around 12.5% in the plateau region of 2300-2450V from 0 to 4 kHz in the ^{3}He-PC
Small disagreement with ANTS2 simulation, to be investigated.

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Setup

Measure 2D spatial resolution (X,Y) and the influence of the different gap widths, 0.35 and 1 mm.



Two Resistive plate chambers 0.35 and 1 mm gap width



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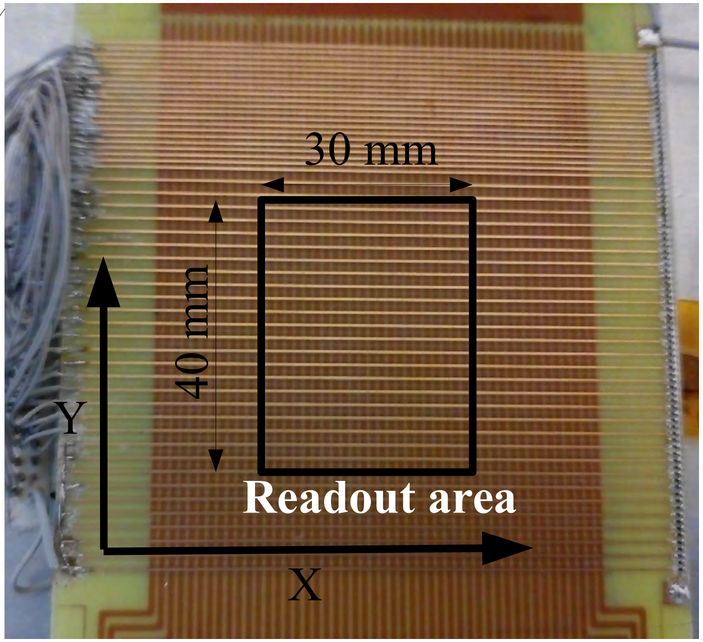
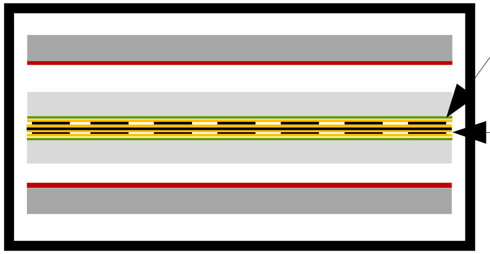


RPC

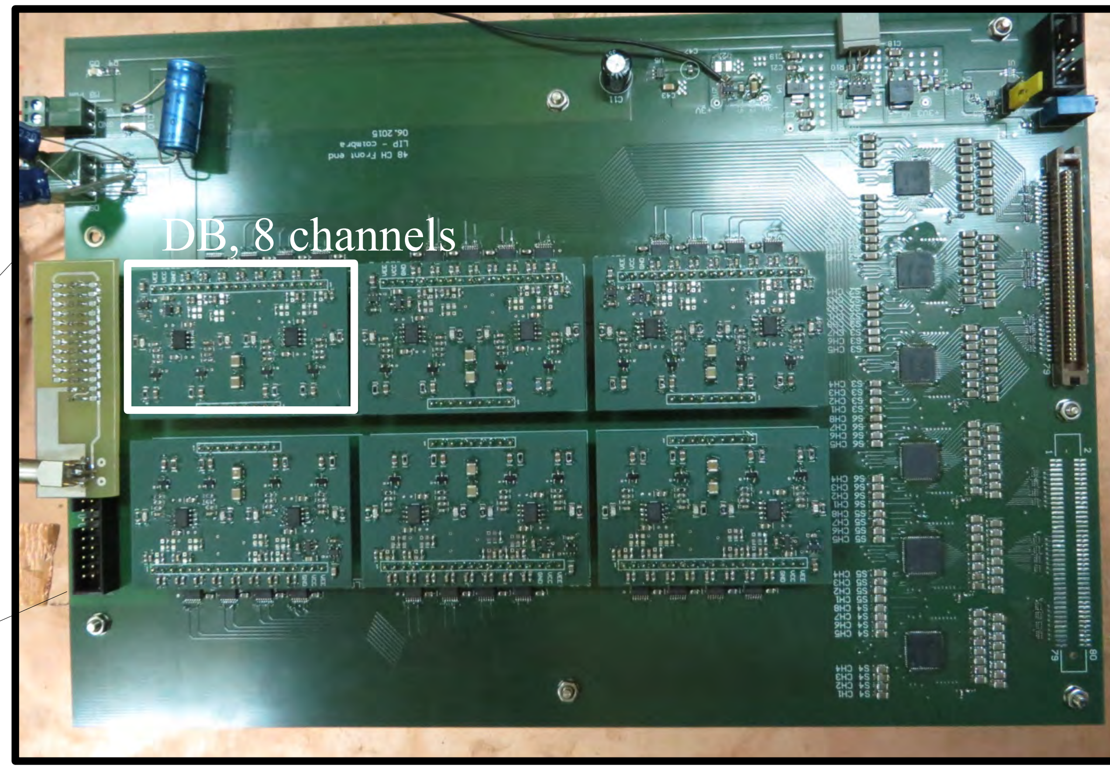


2D strip readout X (1.5 mm pitch), Y (2 mm pitch)
Shared by the two RPCs
Readout area(instrumented) =>
X(30 mm) and Y (40 mm), 20x20 strips

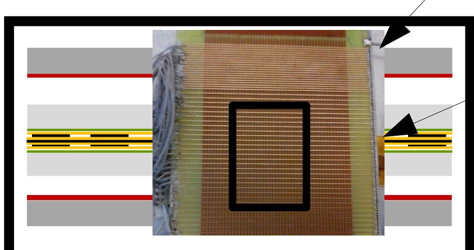
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Setup

Measure 2D spatial resolution (X,Y) and the influence of the different gap widths, 0.53 and 1 mm.

MB



Pick-up strips



Each **individual strip** is **readout** by **charge sensitive amplifiers** (LIP made, P. Fonte), housed into a compact MB equipped with 48 channels.

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Setup

Measure 2D spatial resolution (X,Y) and the influence of the different gap widths, 0.35 and 1 mm.

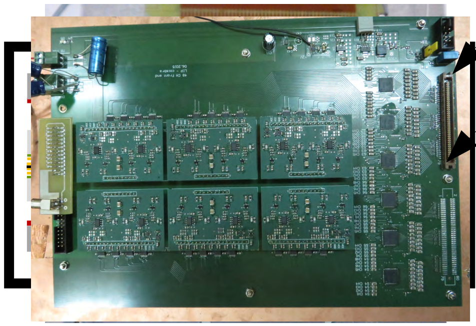
DAQ is based in the new **TRB3 platform** developed at GSI, Germany (http://trb.gsi.de/)

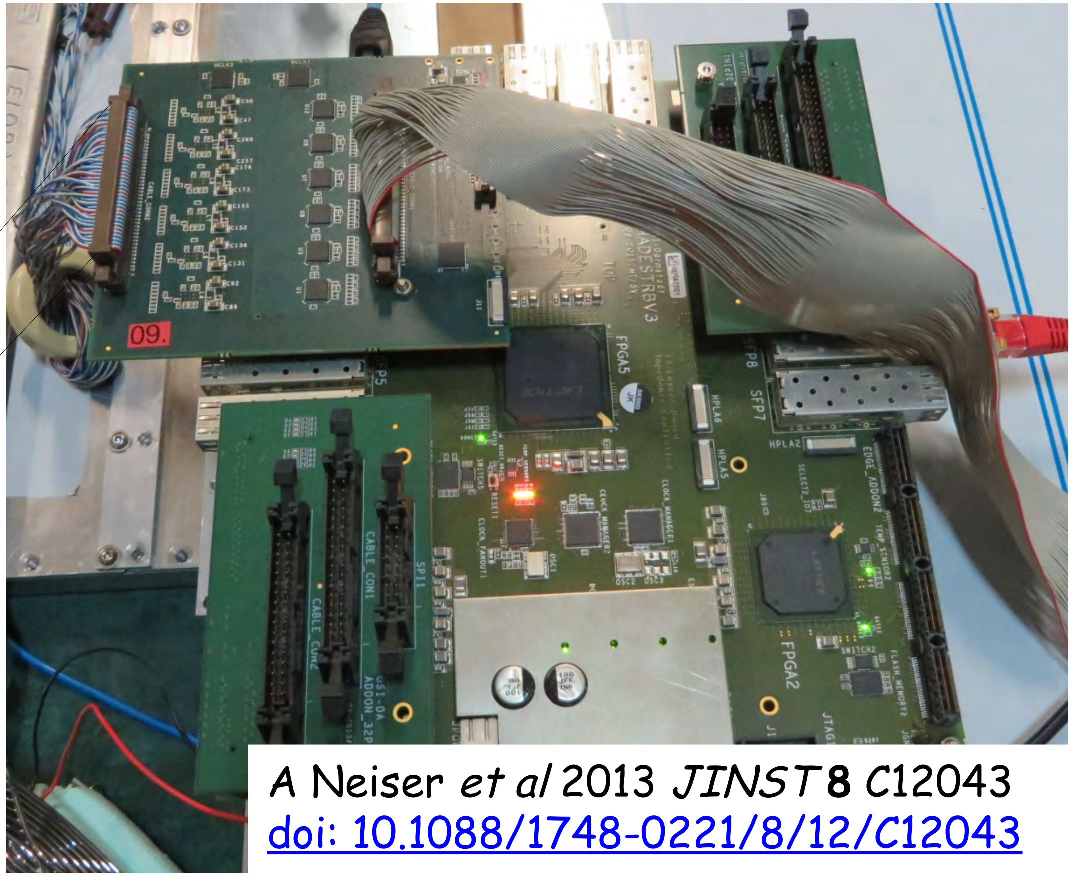
One central FPGA with trigger management capabilities plus 4 sockets with capability to operate.

- 64 Multi-hit TDC
- 48 ADCs channels @ 40 MHz

And much more

qFEE

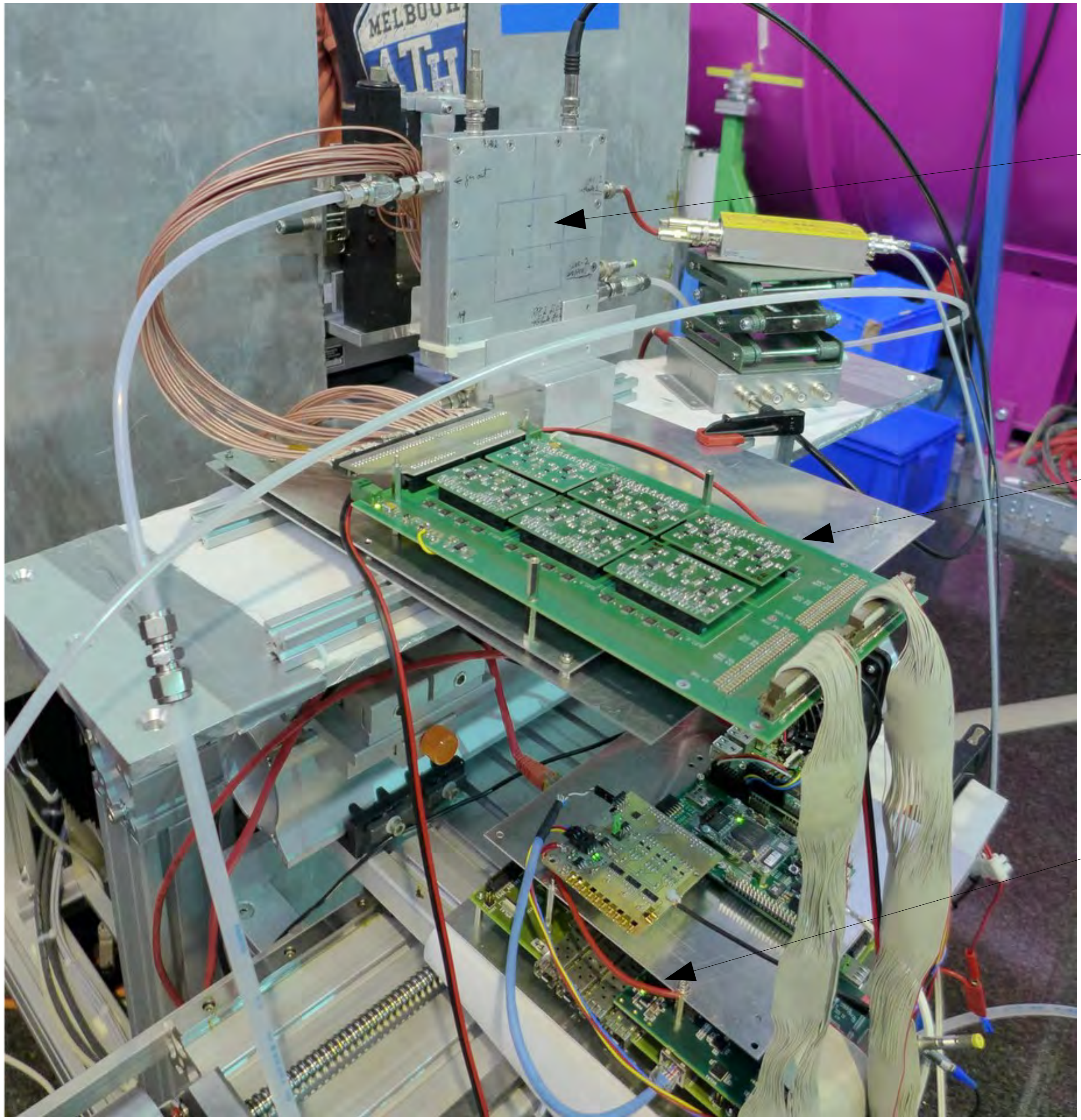




A Neiser *et al* 2013 *JINST* **8** C12043
doi: 10.1088/1748-0221/8/12/C12043

The **output of the charge sensing amplifiers is digitized** by 40 MHz streaming ADCs (AD9219)

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Setup



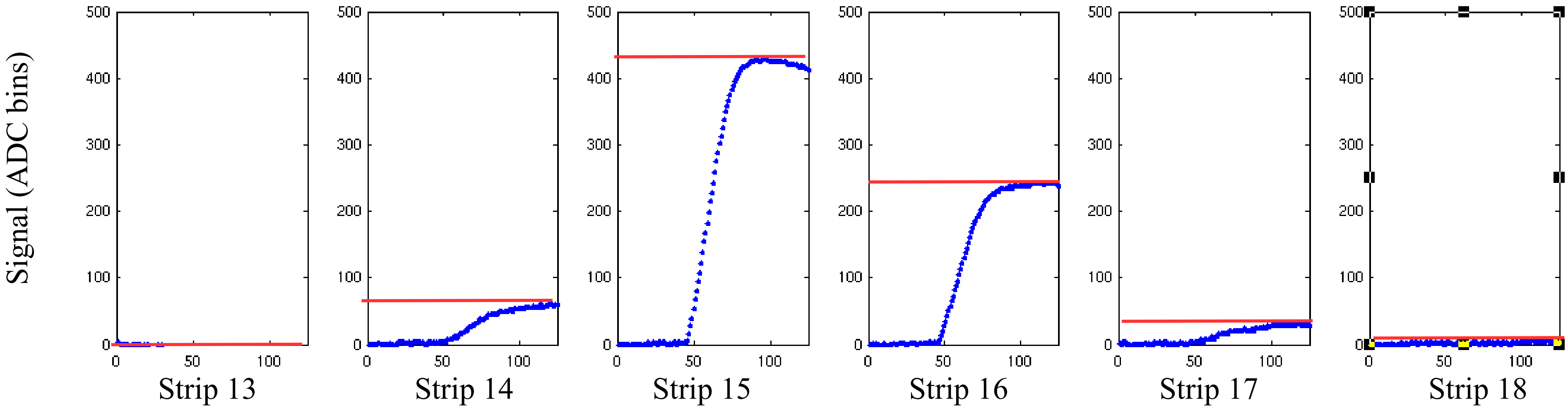
RPC chamber

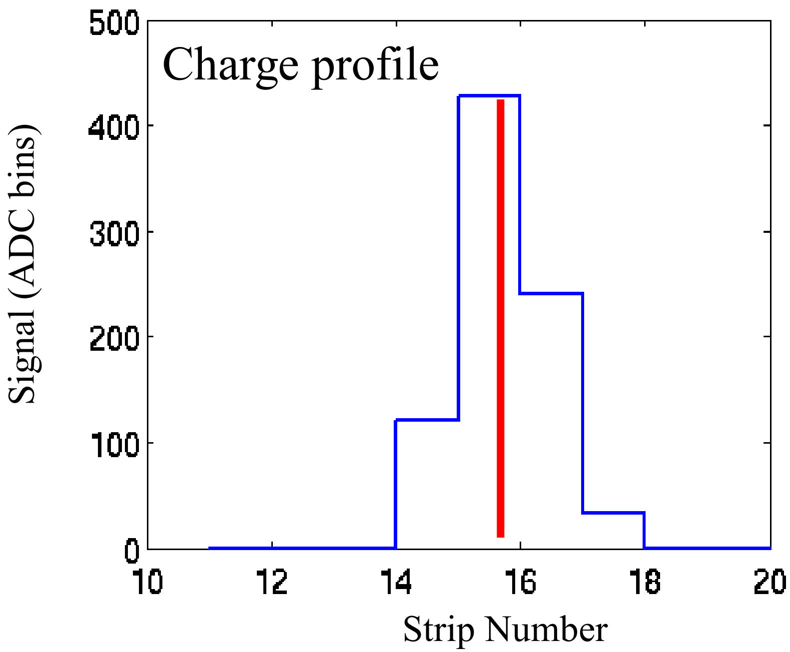
FEE

DAQ

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Position calculation

Charge in each strip is calculated from each waveform as: max(wvf) - min(wvf)



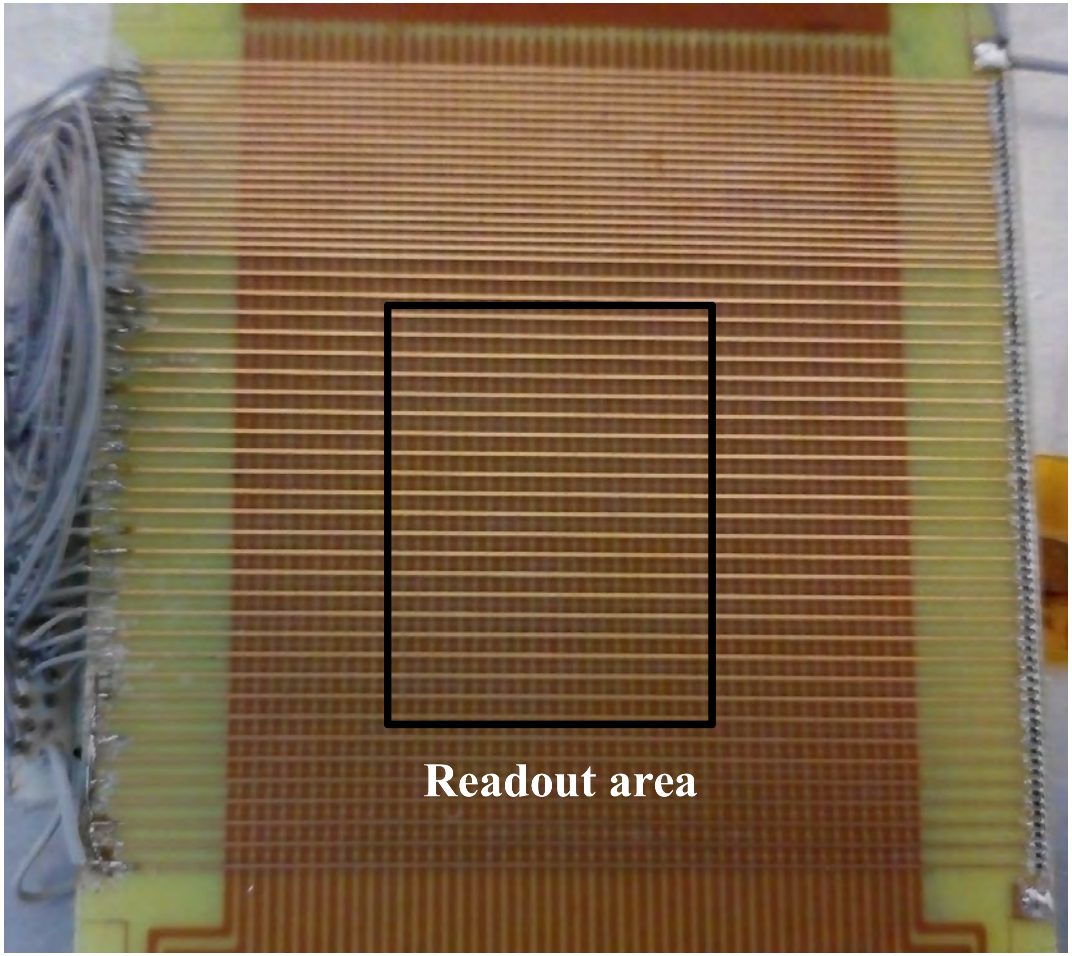


Position is calculated by traditional Centre-of-gravity.

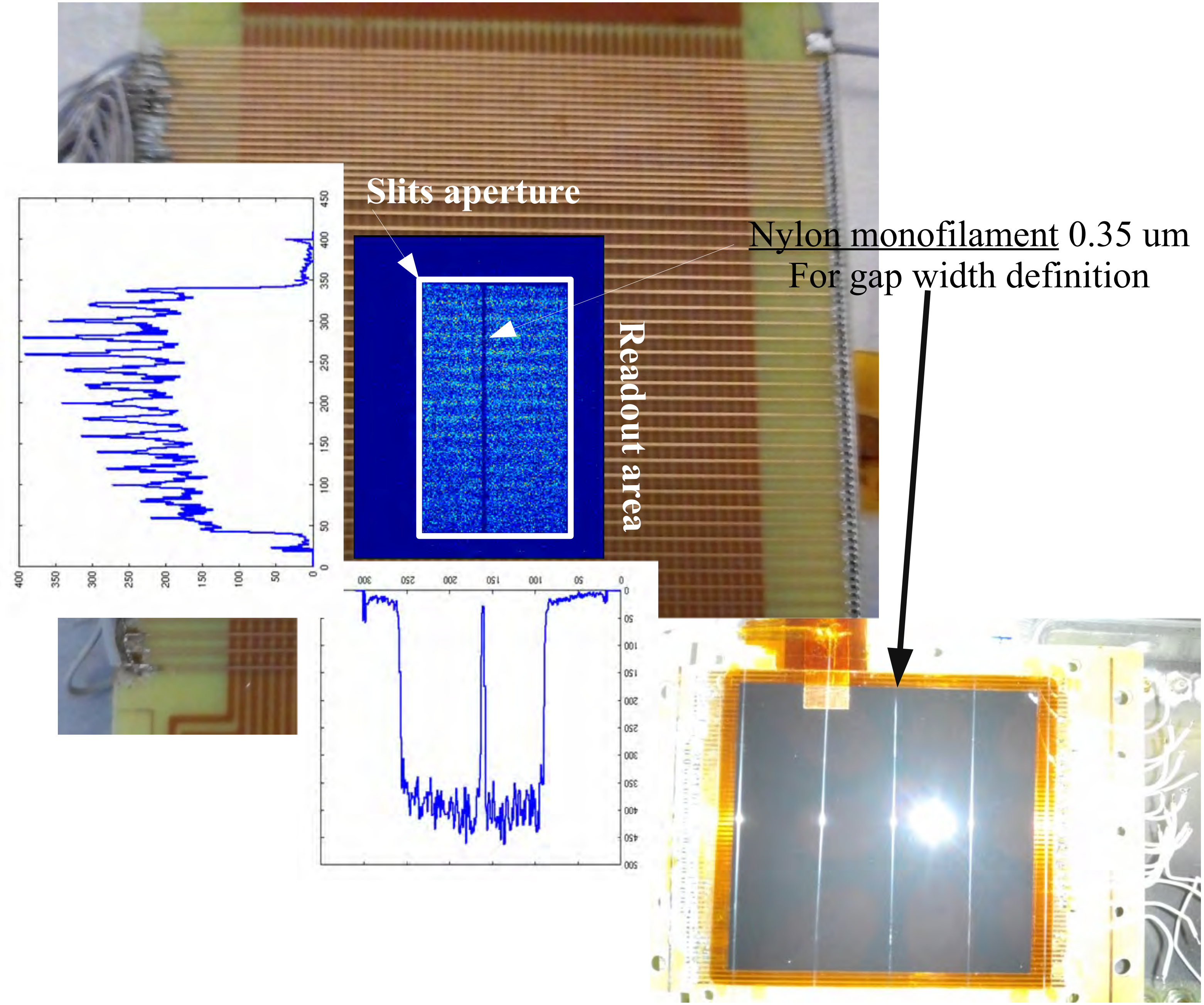
$$X = \frac{\sum Q_i X_i}{\sum Q_i}$$

i = strips with signal above Q_{th}

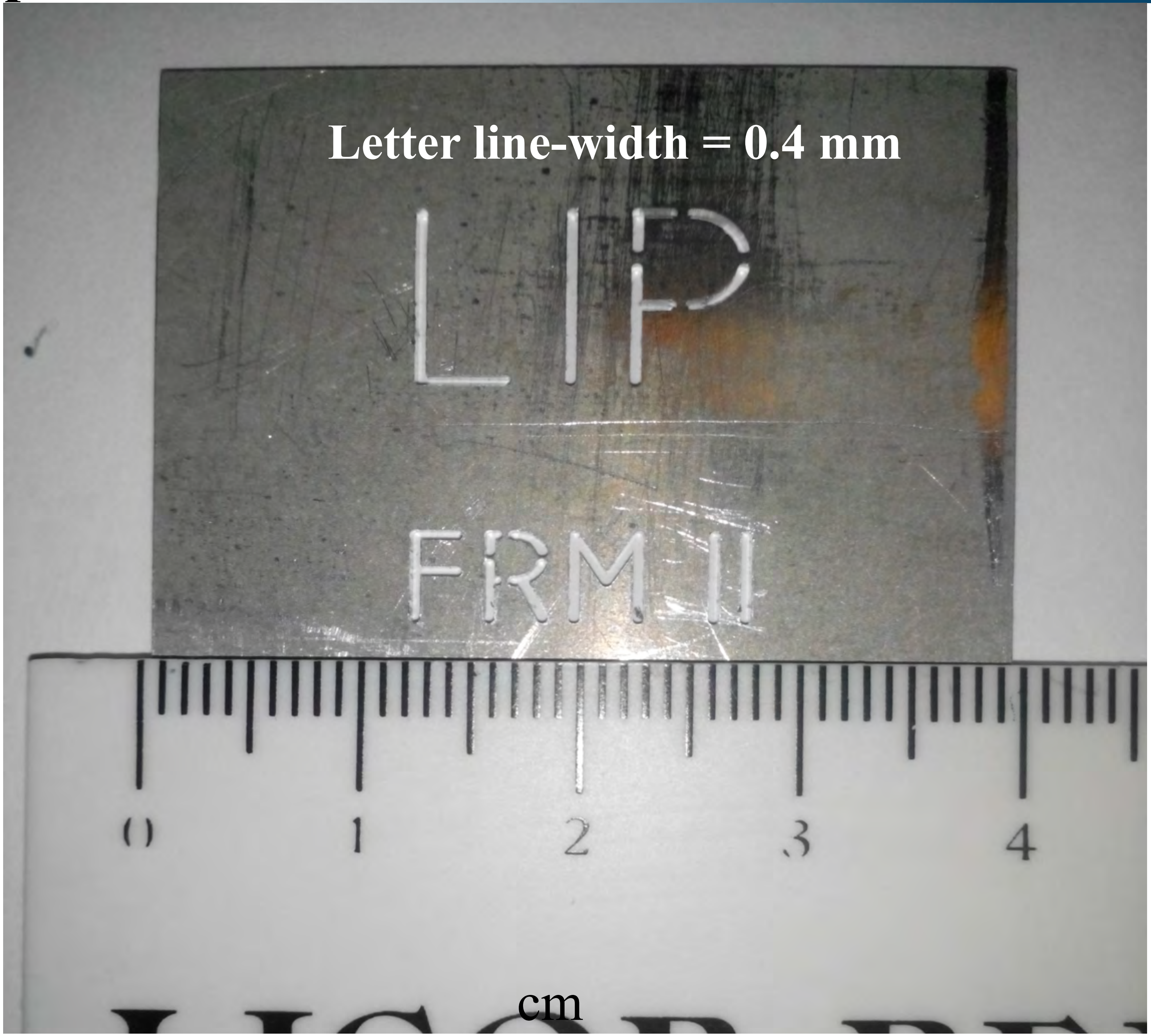
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Position calculation



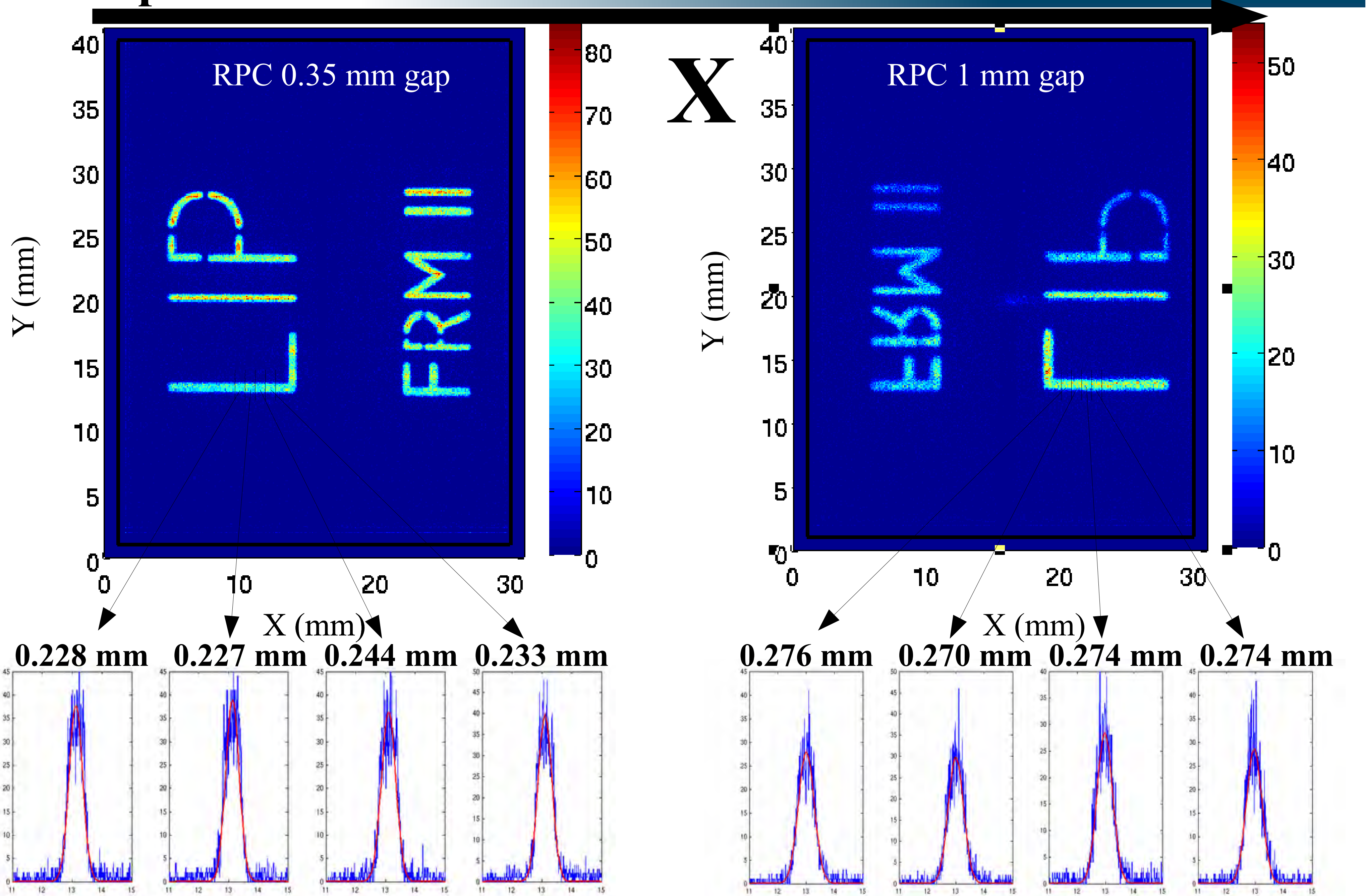
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Position calculation



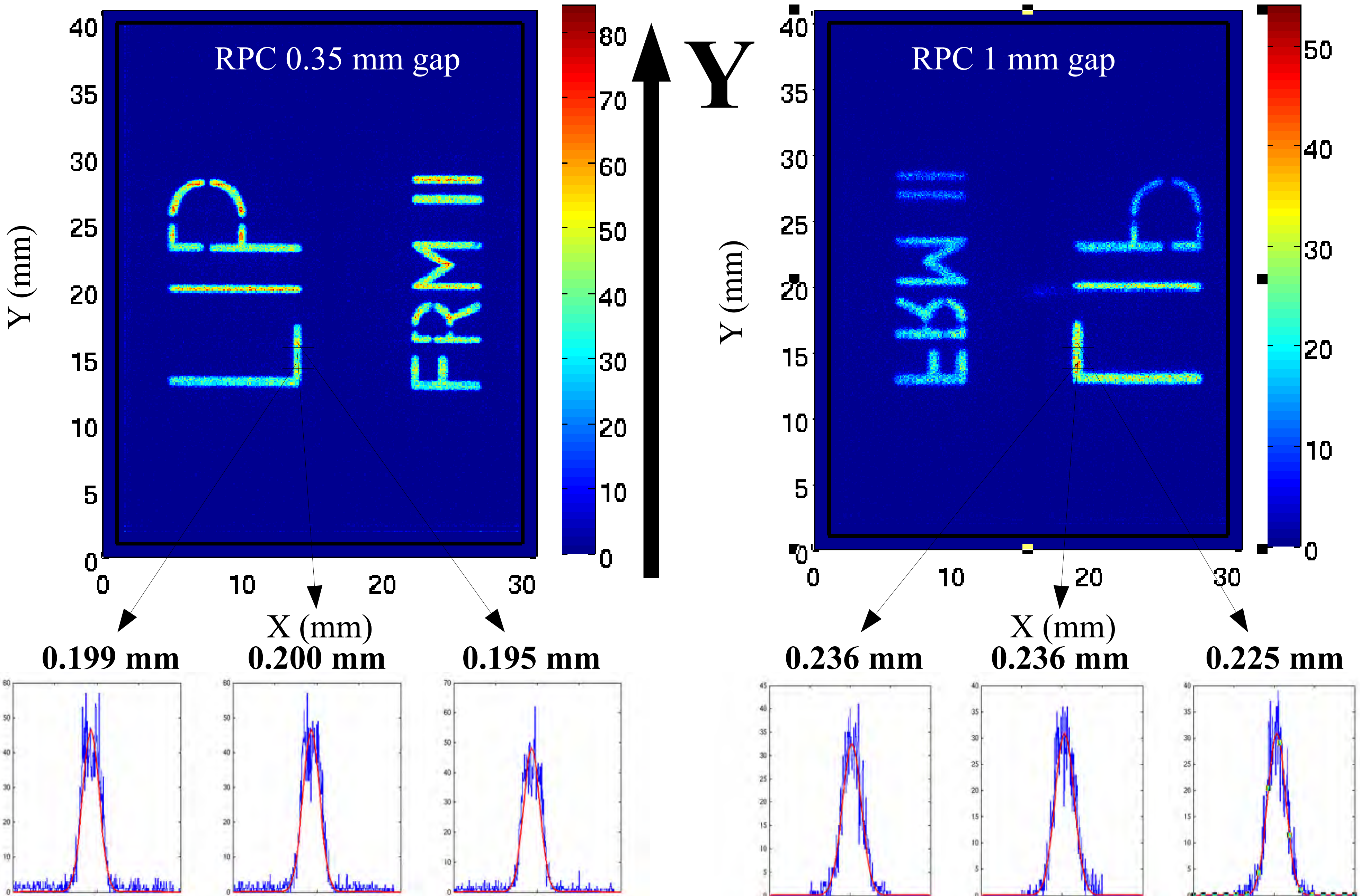
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask.



WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask. X



WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask. Y



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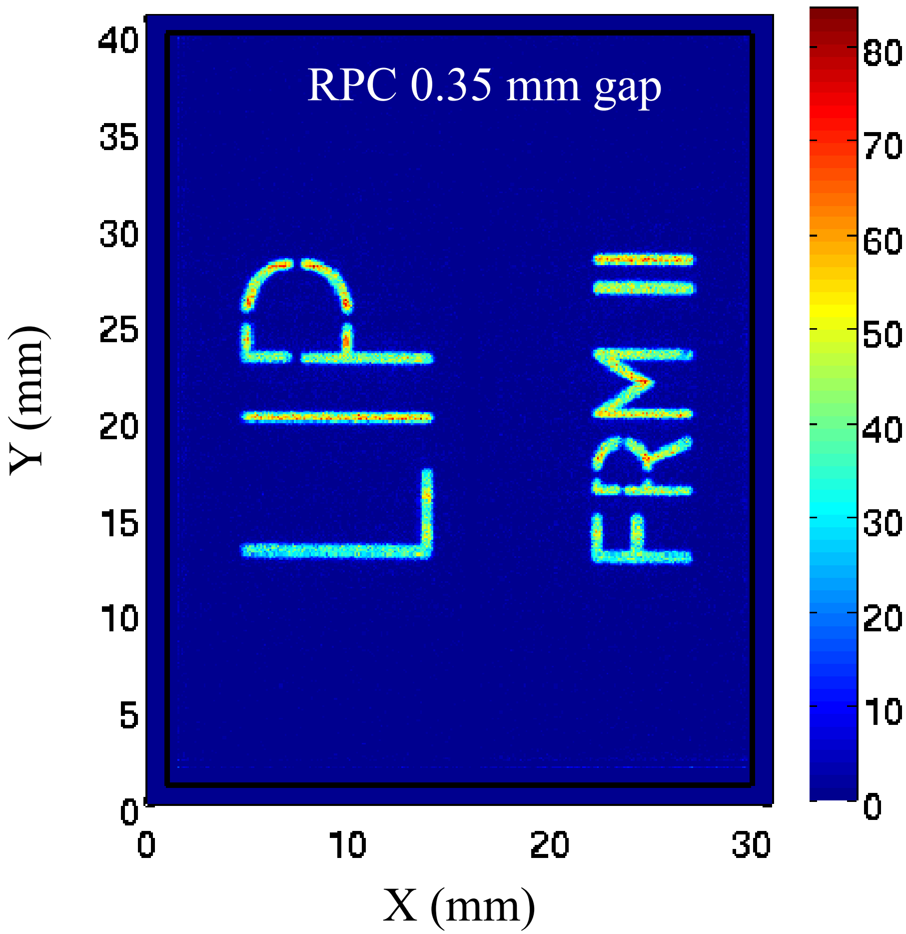
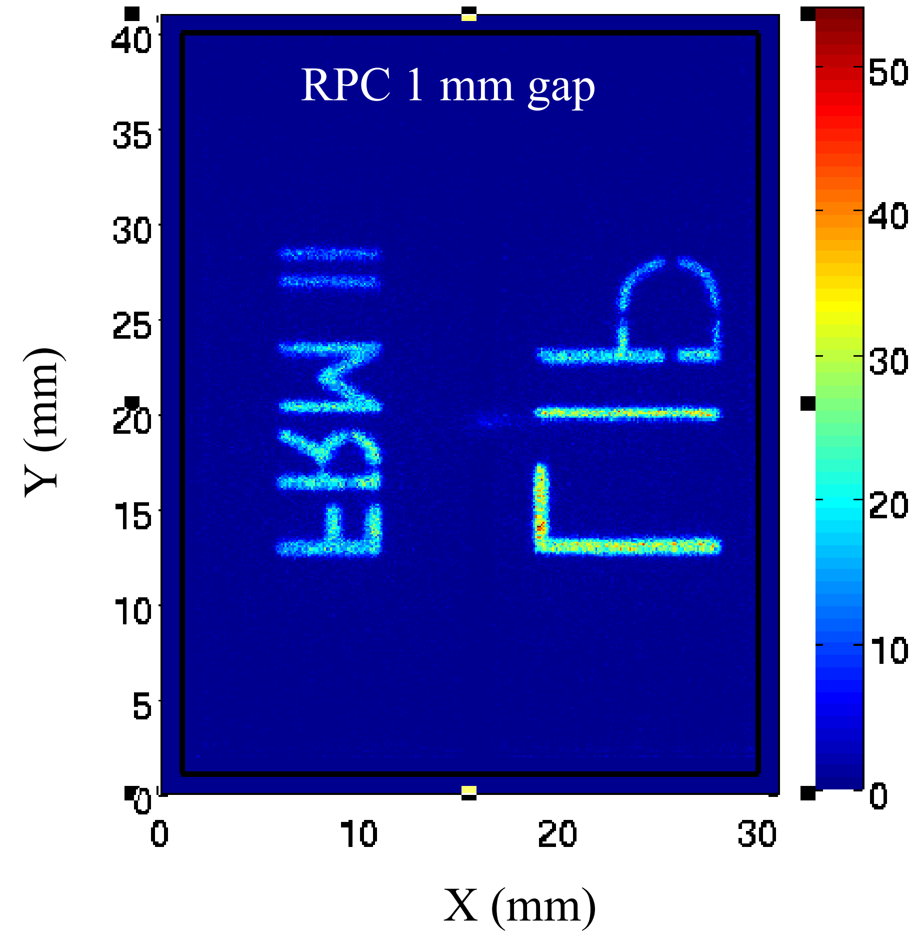


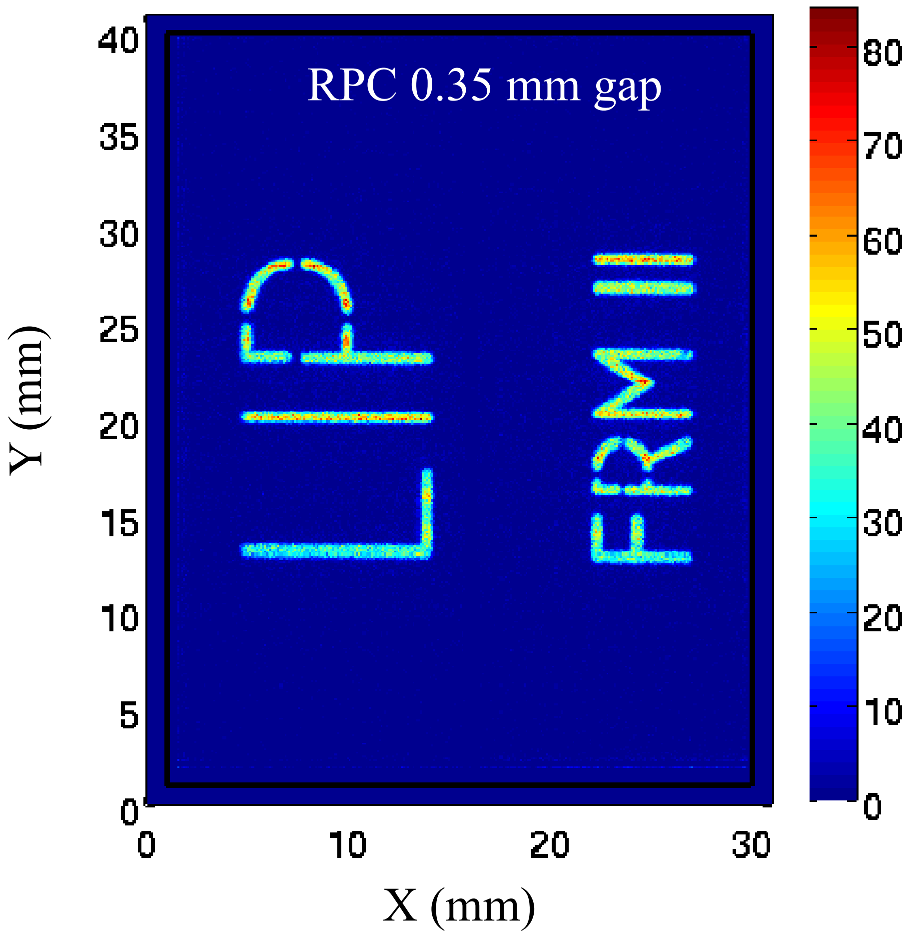


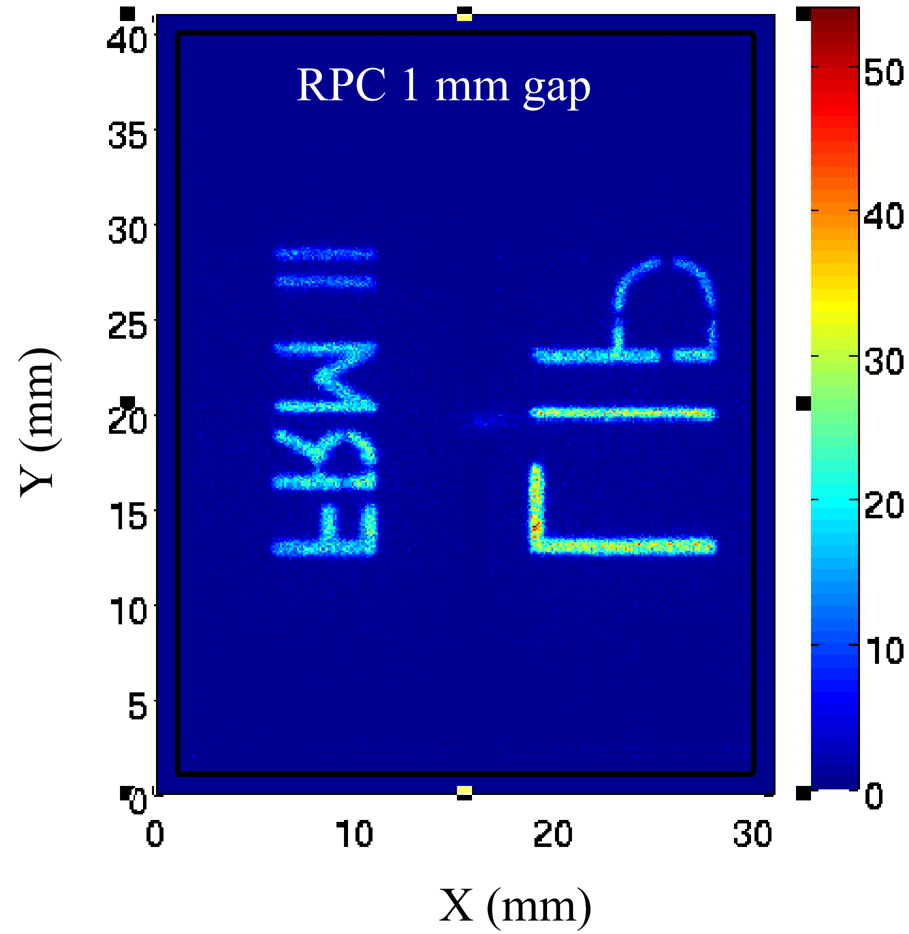
X	**σ_x = 0.233 mm = 0.551 mm FWHM**	**σ_x = 0.273 mm = 0.645 mm FWHM**
Y	**σ_y = 0.198 mm = 0.468 mm FWHM**	**σ_y = 0.232 mm = 0.548 mm FWHM**

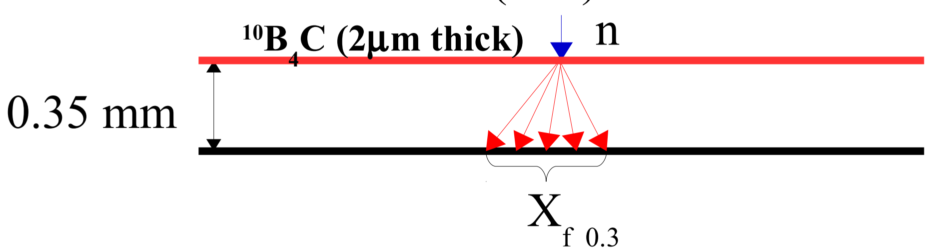
σ_x, σ_y show similar resolutions

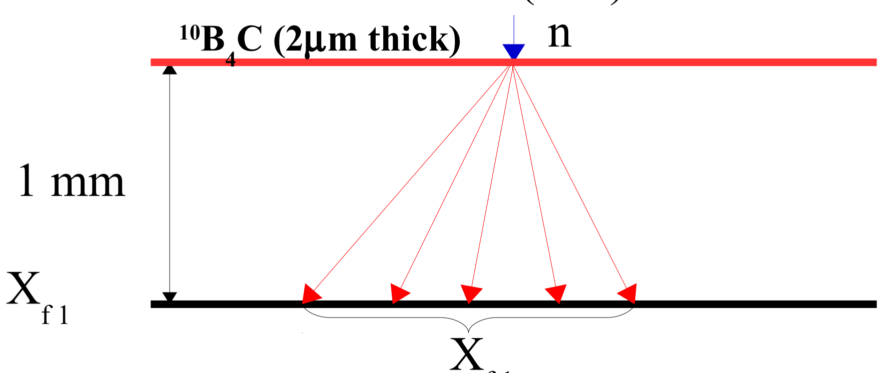
RPC 0.35 mm slightly better than RPC 1 mm <= physics

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask.



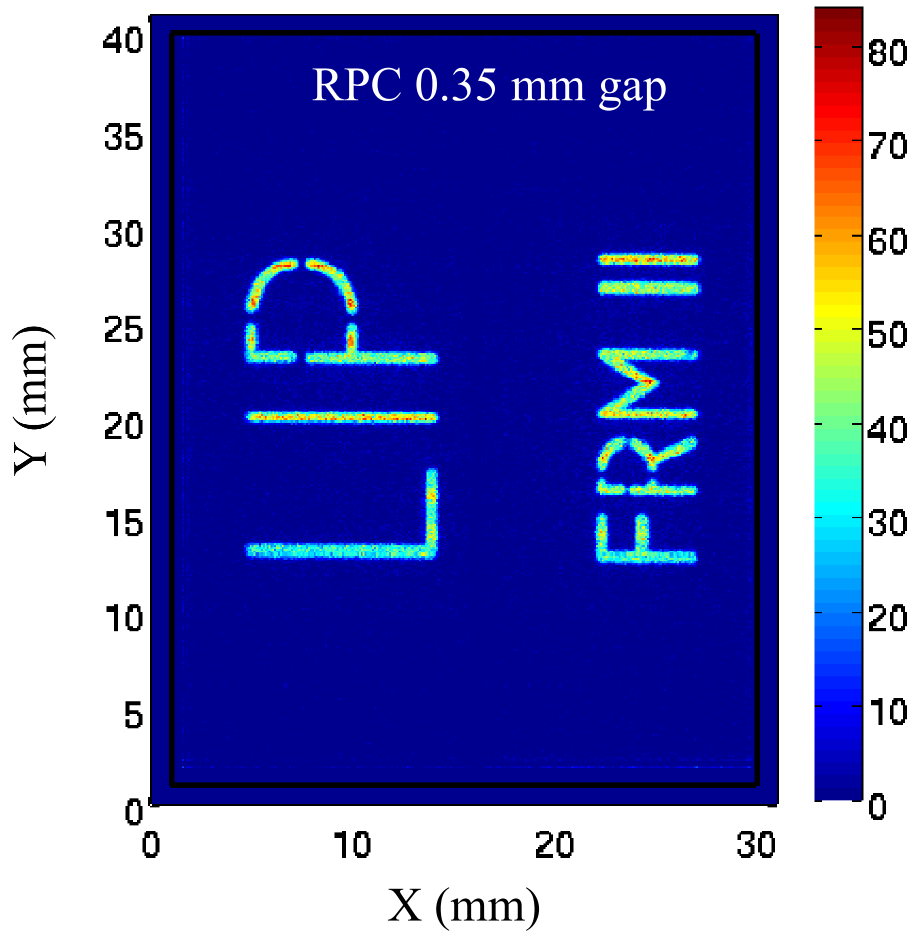


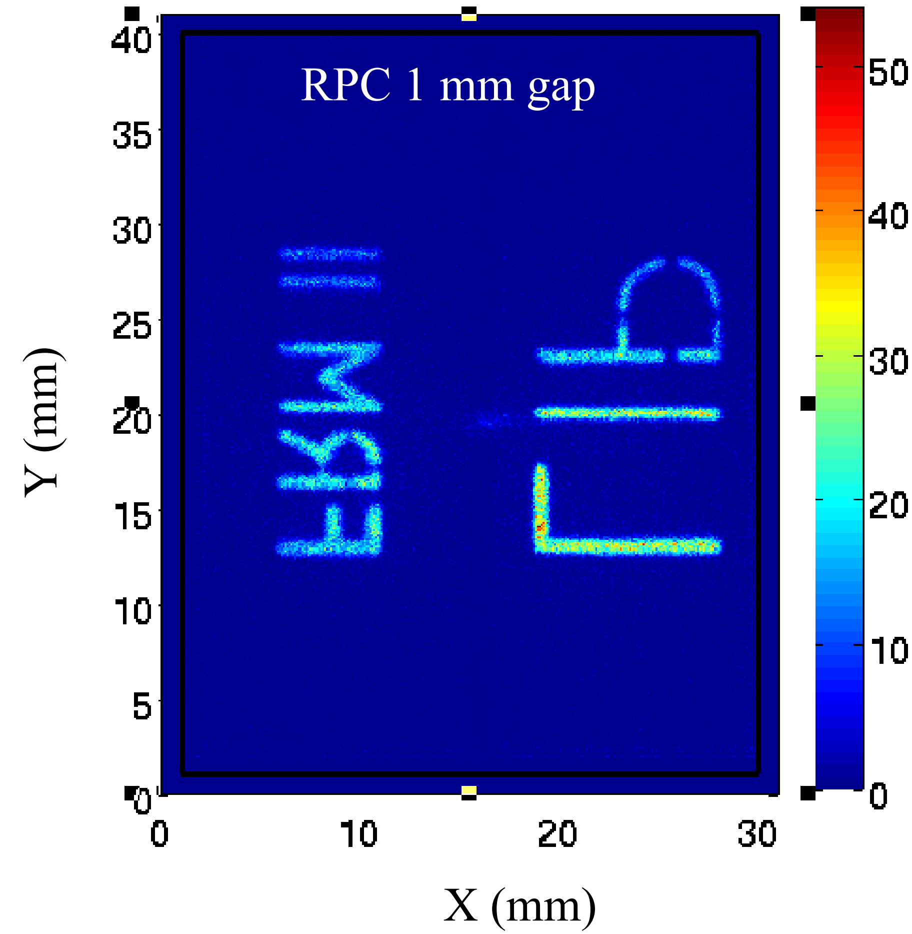


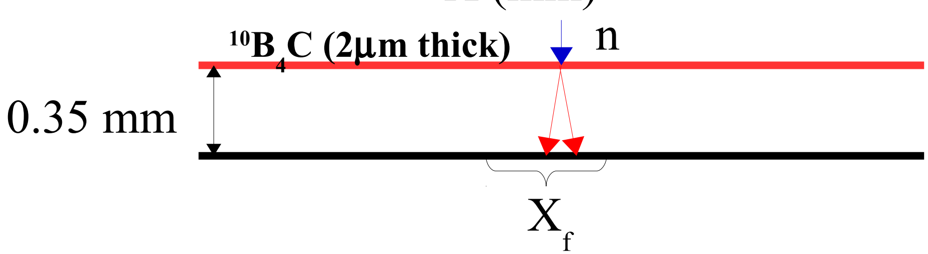


$X_{f\,0.3} < X_{f\,1}$

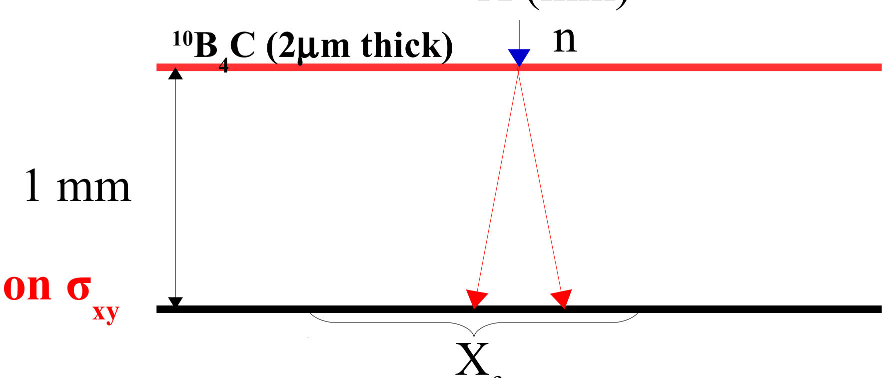
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask.



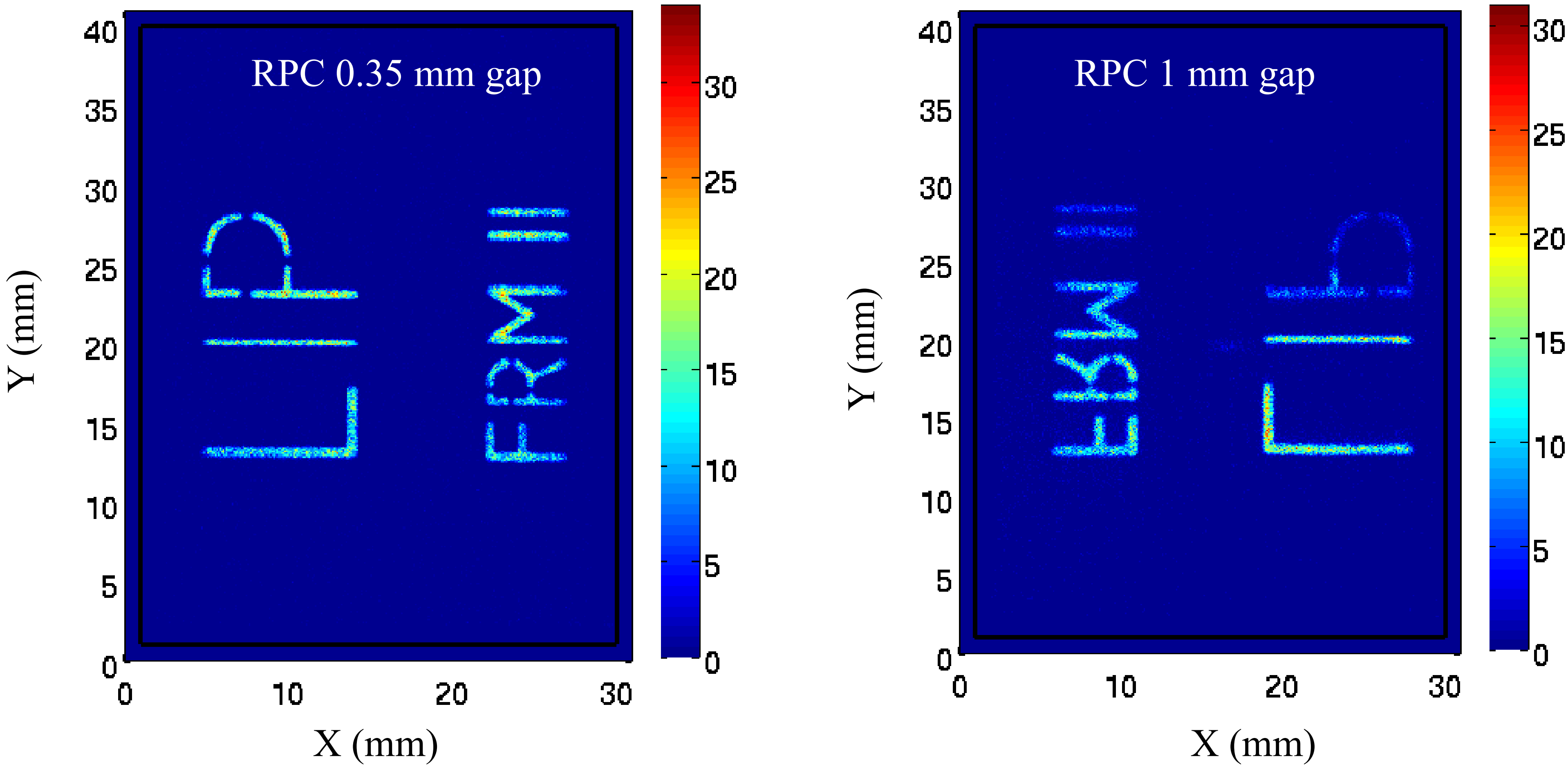




RPC large charge cut => Improvement of 30 % on σ_{xy}



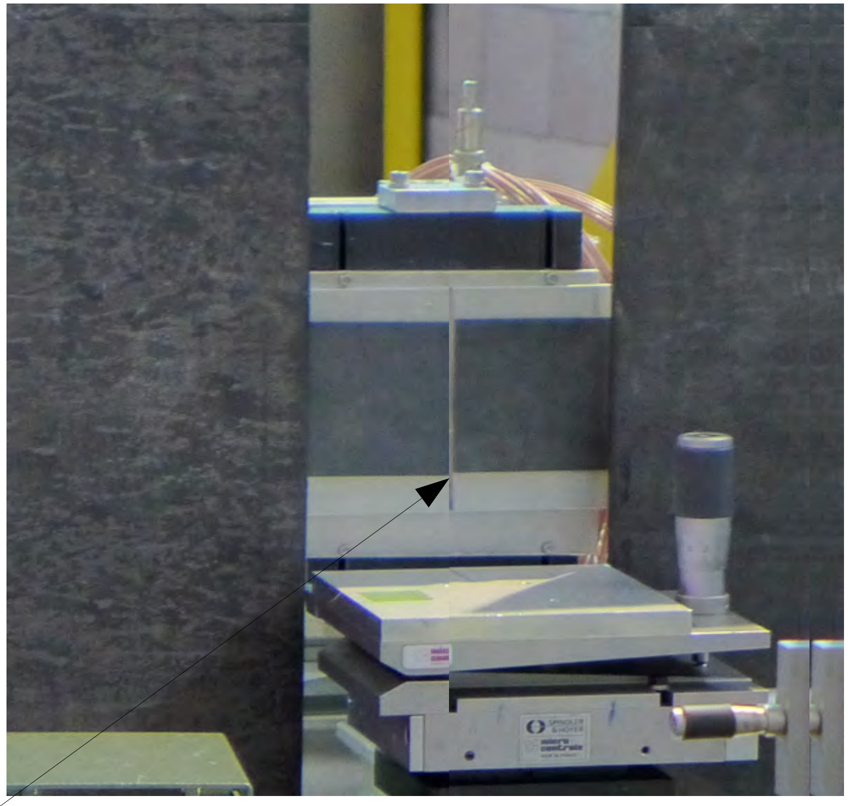
WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium mask.

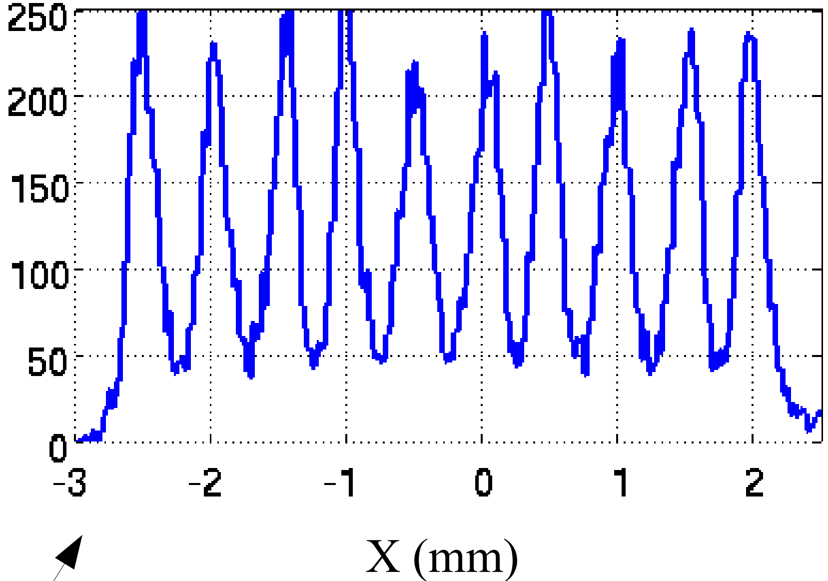


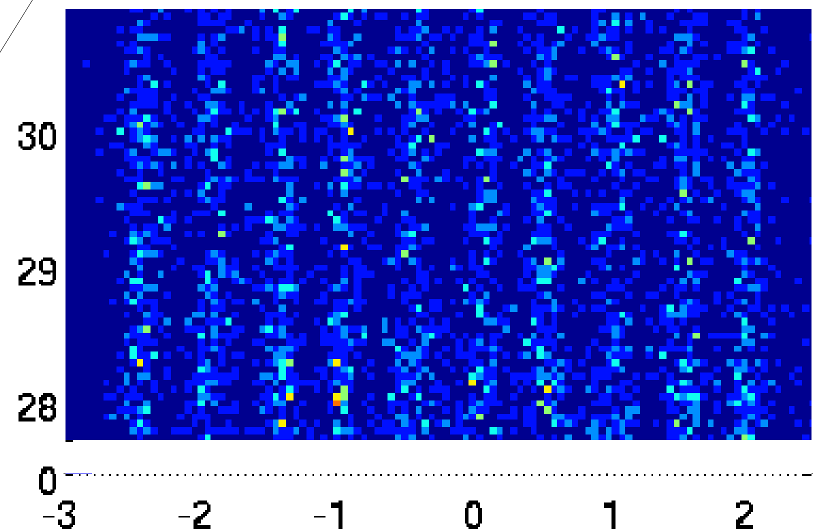
RPC large charge cut => Improvement of 30 % on σ_{xy}

WP 9: Testing RPCs at TUM-FRM II
Spatial resolution. Cadmium slits.

Cadmium mask do not deliver the ultimate **spatial resolution limited due to letter line-width =>**
Spatial resolution measurements with **cadmium slits ~ 0.2 mm width.**







Slit **~0.2 mm width** displaced in **steps of 0.5 mm**
Uniform spatial resolution
σ_x=100 μm = 236 μm FWHM

WP 9: Testing RPCs at TUM-FRM II
Conclusions

- **Wide HV plateau > 500 V, with an efficiency of ~ 12.5 % for λ 4.7 Å and 2 µm $^{10}B_4C$** with similar behaviour for 0.35 and 1 mm gap width.

- **Sub-millimetre 2D spatial resolution** better than **100 µm σ = 236 µm FWHM** with similar behaviour for 0.35 and 1 mm gap width.

Narrow gaps seem to be the more suitable compared with wide gaps.

- **Similar efficiency with $^{10}B_4C$ in first electrode, and better with $^{10}B_4C$ in both electrode.**
- **Slightly better spatial resolution**
- **Lower charge deposition => High counting rate**
- **Lower HV (technical issue but important one)**
- **Compact design, less material.**