



SuperFRS GEM-TPC Development for the FAIR Facility STATUS REPORT



COLLABORATORS

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OUTLINE

- INTRODUCTION and MOTIVATION
- ORGANIZATION and MILESTONES
- CHARACTERIZATION OF COMPONENTS
- GEM-TPC and POOF of CONCEPT - PROTOTYPE HB1
- LAB. and BEAM TESTS at GSI for HB1
- GEMEX INTEGRATION - PROTOTYPES HB2 and HB3
- LAB. and BEAM TEST at GSI for HB2 and HB3
- SIMULATIONS of the EFFICIENCY (HB1, HB2/HB3 and HGB4)
- Twin GEM-TPC PROTOTYPE - HGB4
- SUMMARY

INTRODUCTION

FAIR is a Facility for Antiproton and Ion Research.

The concept of the FAIR Facility aims for a multifaceted forefront science program, beams of stable and unstable nuclei as well as antiprotons in a wide range of intensities and energies, with optimum beam qualities



Time Table spans till end 2018

MOTIVATION

The superconducting in-flight separator (Super-FRS) has three branches and will run in slow and fast extraction mode.

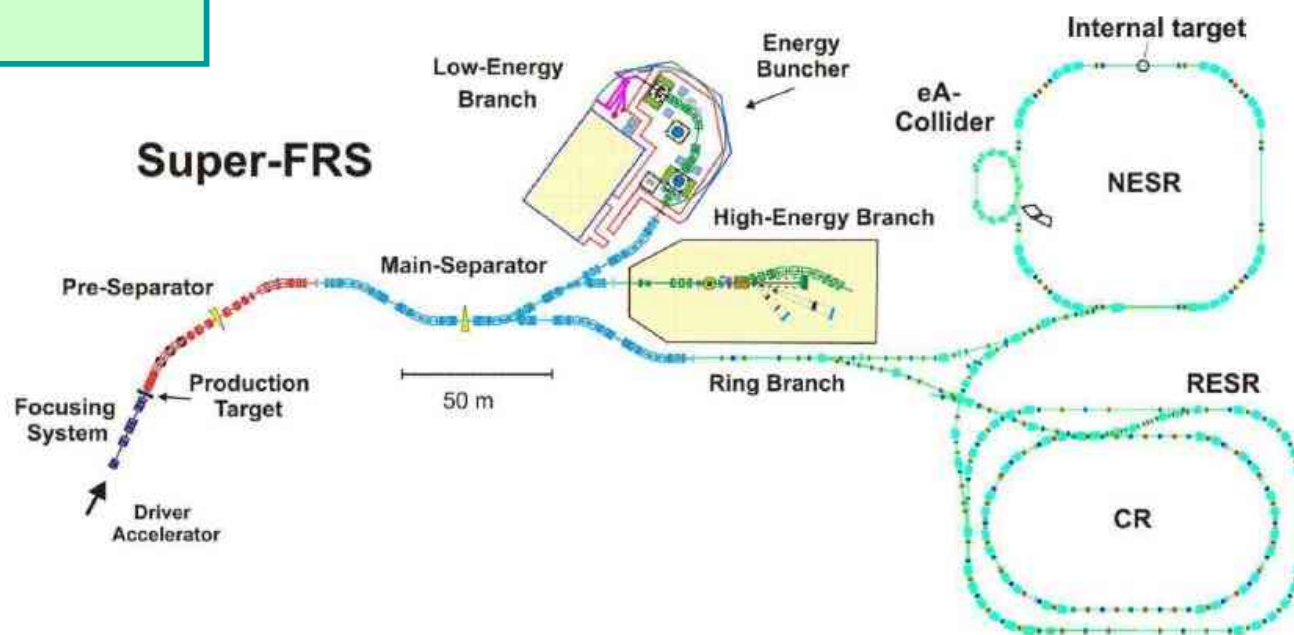
Part of the Finnish Contribution will be in Diagnostic systems, which is a work package dedicated to provide 36 GEM-TPC detectors.

Followed the LOI an EOI has been already submitted to the In-kind review board for this workpackage.

Projectile:
Elements $p - U$
Energy up to 1.5 GeV/u
Intensity up to $10^{12} / \text{spill}$

Spot size on target:
 $\sigma_x = 1.0 \text{ mm}$
 $\sigma_y = 2.0 \text{ mm}$

The NUSTAR Facility at FAIR
(The 3 Branches of the Super-FRS)



NUSTAR = Nuclear Structure, Astrophysics and Reactions

MOTIVATION (cont.)

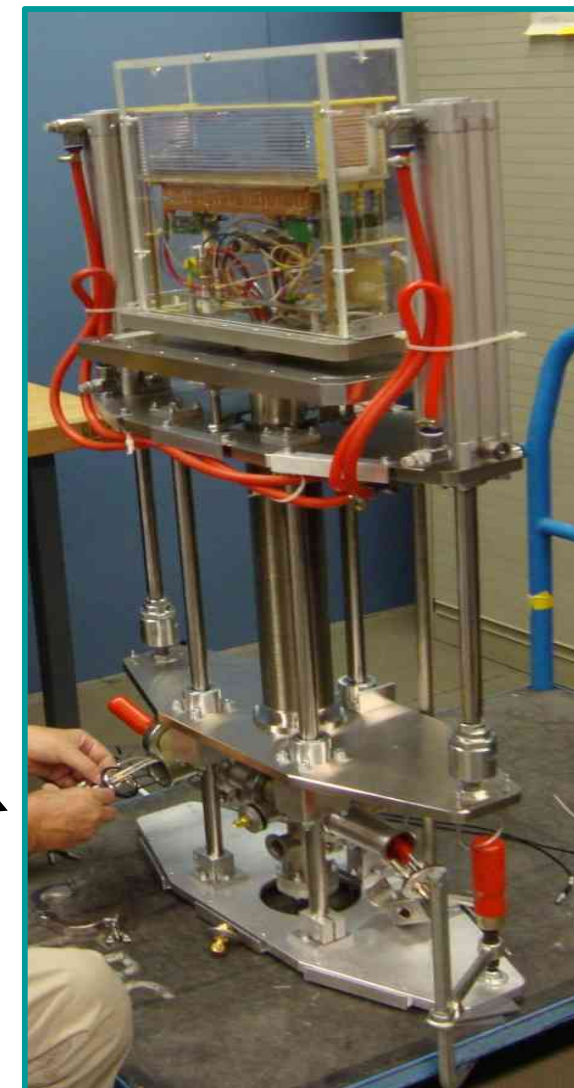
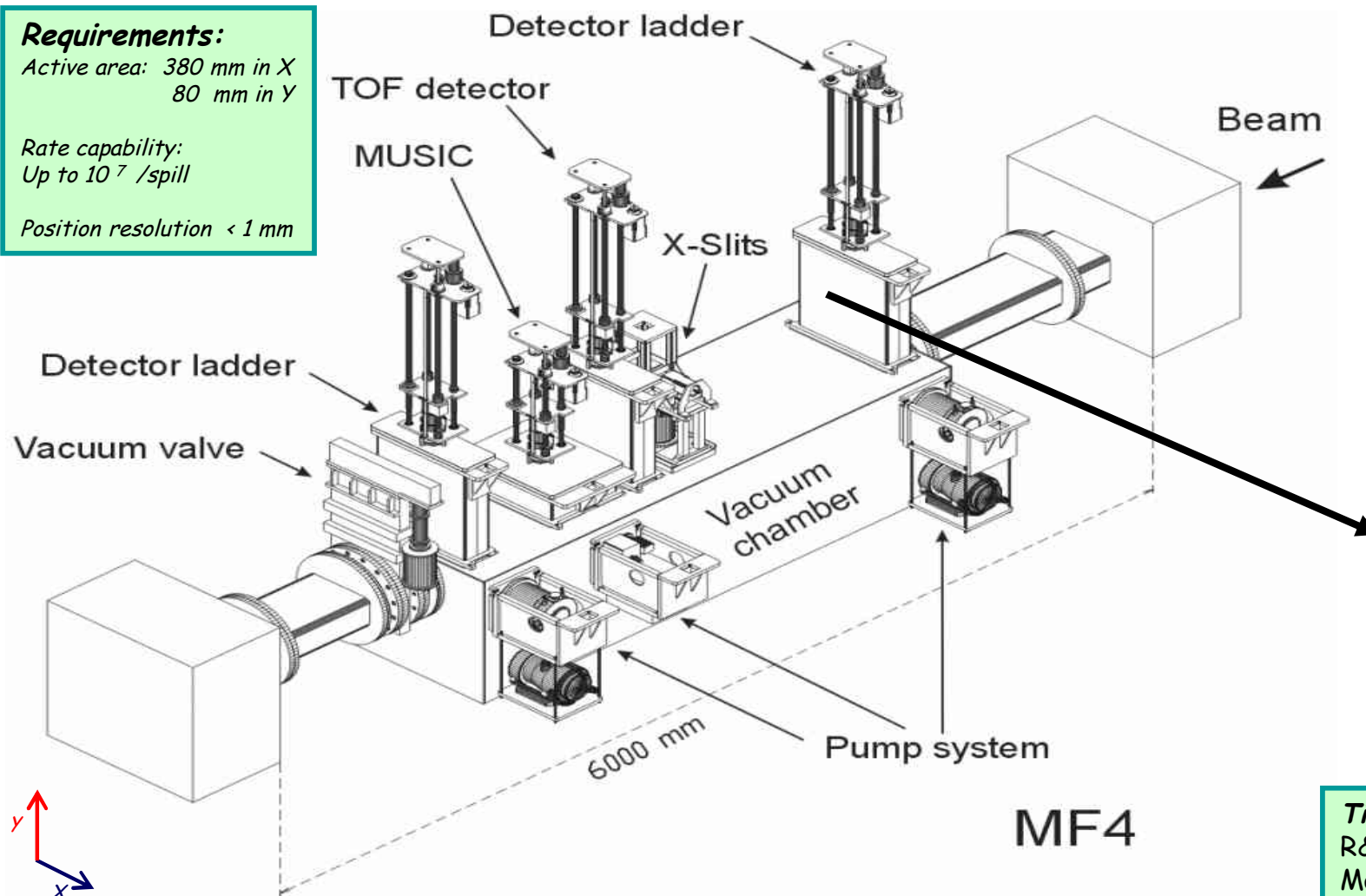
DIAGNOSTIC SYSTEM STATION

Requirements:

Active area: 380 mm in X
80 mm in Y

Rate capability:
Up to 10^7 /spill

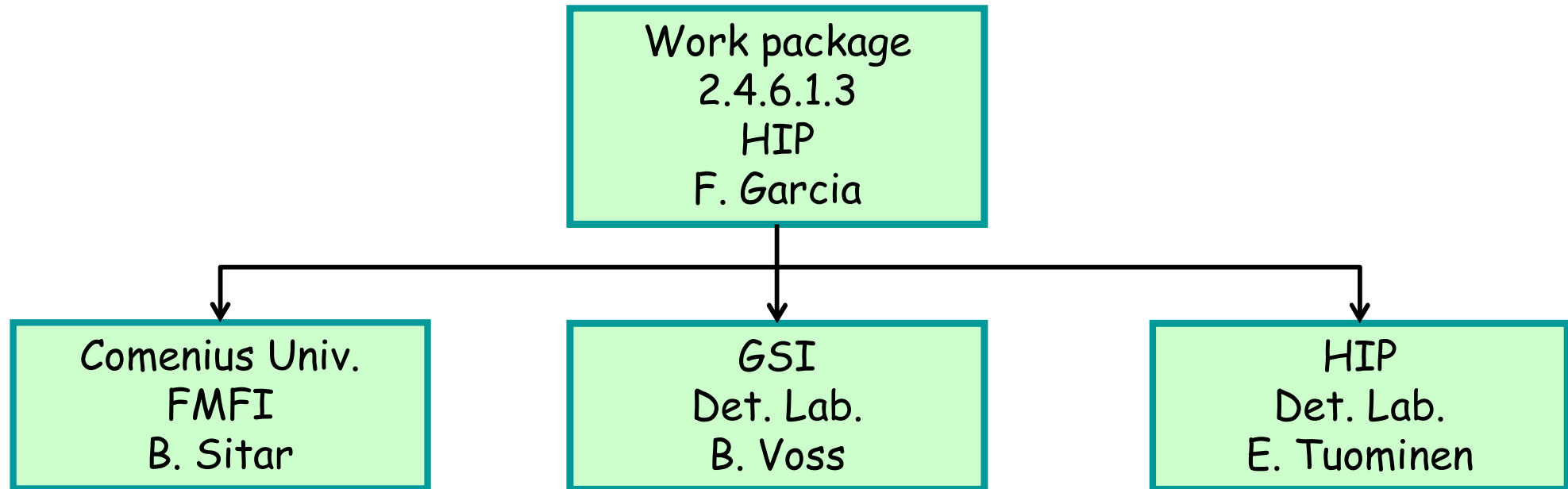
Position resolution < 1 mm



Time line:

R&D finish and Design frozen: Q4/2014
Mass production: Q2/2015 - Q3/2017

ORGANIZATION and MILESTONES



Issues:

- Consolidation of the Consortium
- Proposal to the In-Kind review board has been submitted
- This year is dedicated to produce Final Prototype
- Requirements has been established

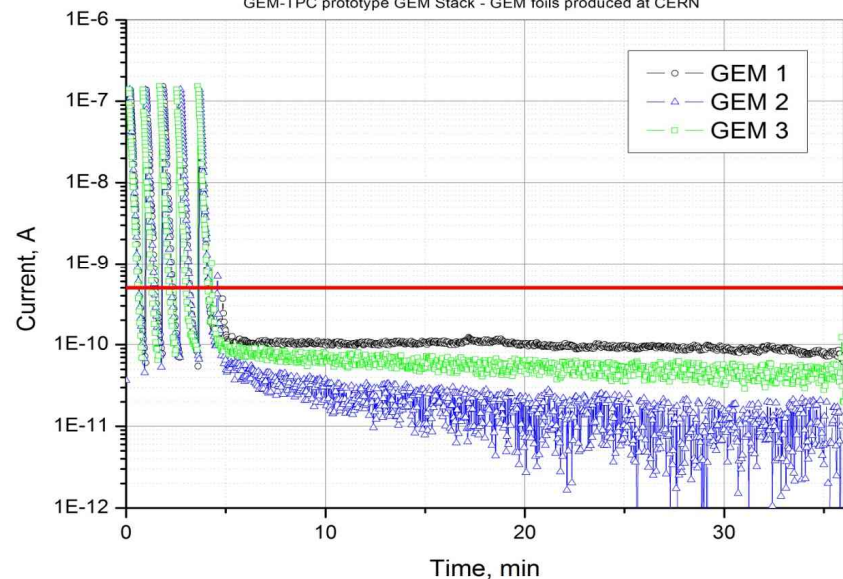
Relevant Milestones:

- Preparation work → ending Feb. 2014
- M4 Contract sign → ending Dec. 2014

CHARACTERIZATION OF COMPONENTS

Leakage Current Measurement

GEM-TPC prototype GEM Stack - GEM foils produced at CERN

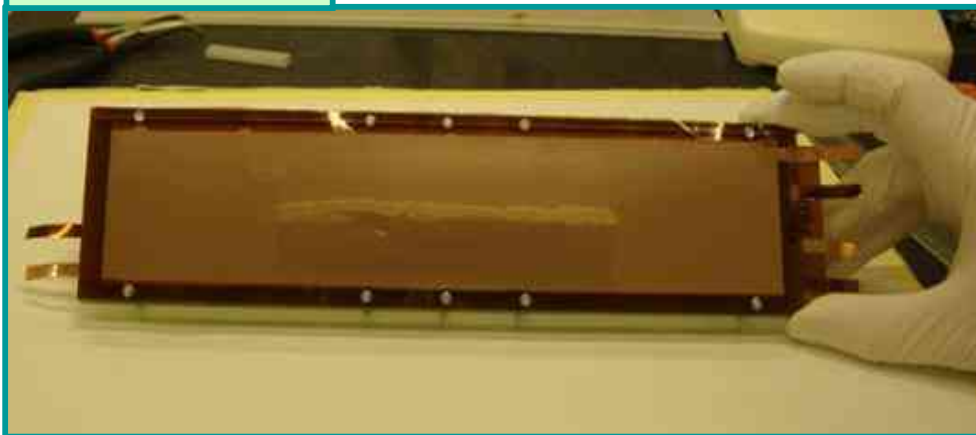


Electrostatic Test for all the frames @ 5 kV Possible breakdowns corrected with Nuvovern

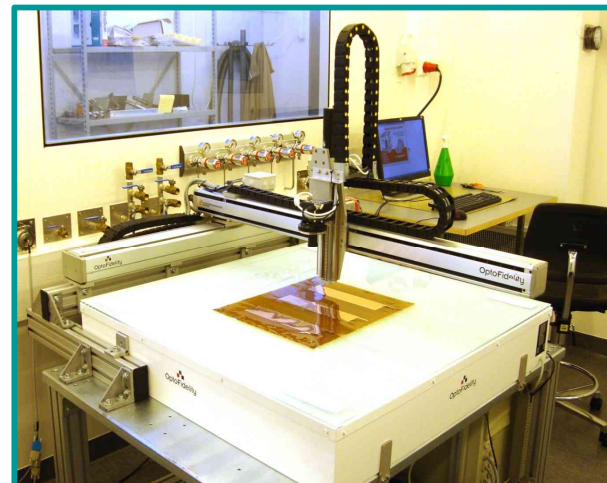
Top frame glued to the GEM foil



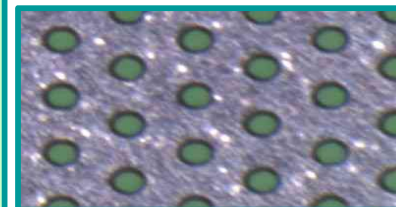
Triple GEM stack



R. de Oliveira et al.



Based on 9 Mpix camera with integrated telecentric optics for this setup one pixel corresponds to 1.7 x 1.7 microns



GEM-TPC and PROOF of CONCEPT - PROTOTYPE HB1

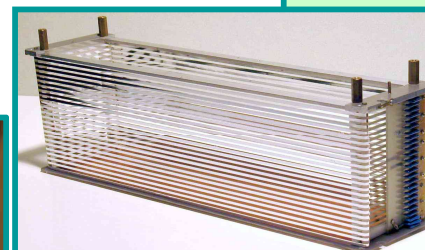
Capacitance measurement setup



Flange of the GEM-TPC HB1, read out by delayed lines



Comenius University - Bratislava

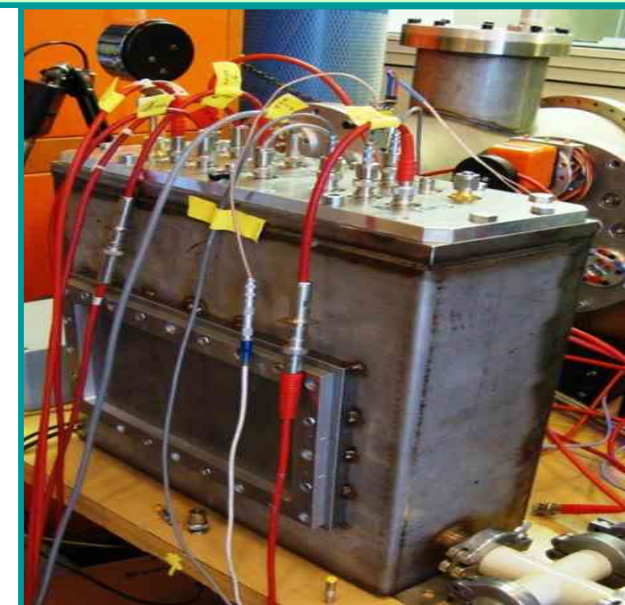


Field cage of 60 mm drift

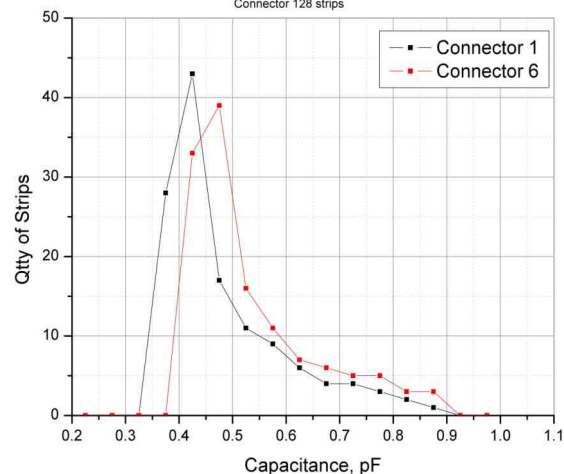
Triple GEM stack



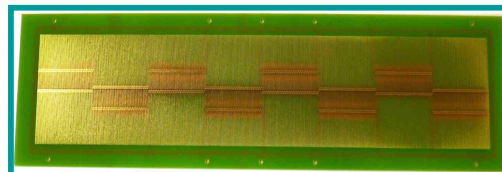
First GEM-TPC called HB1 detector (Helsinki Bratislava prototype 1)



Readout Board Capacitance Distribution
Connector 128 strips



Right: The electrodes of the board with strips of 200 μm width and 500 μm pitch

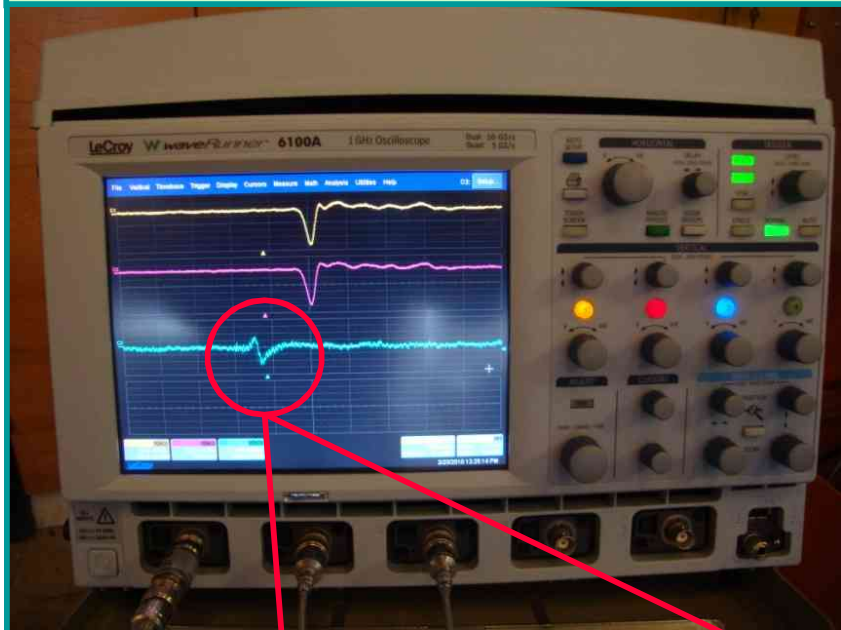


And 8 Header Panasonic connectors with 130 Pin each



LAB. TEST for HB1

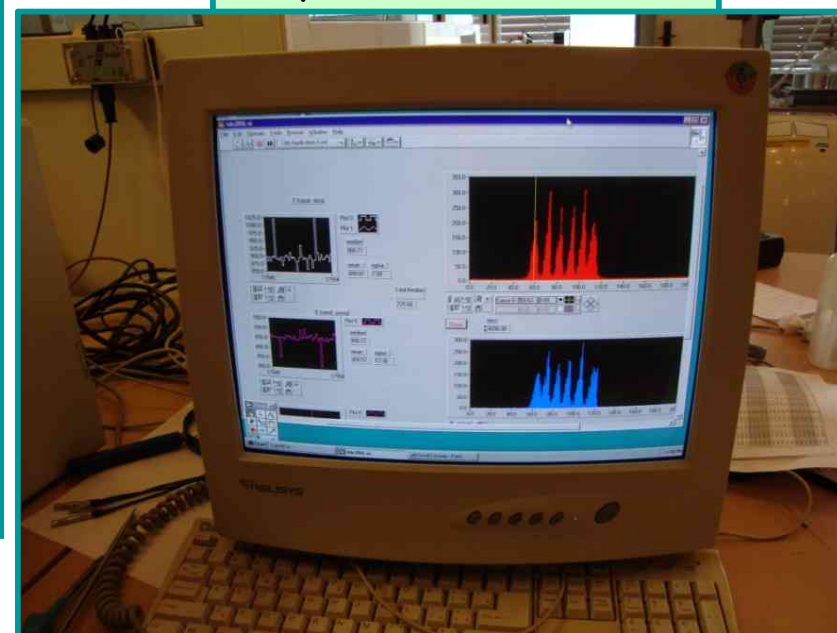
GEM-TPC test in lab at Comenius University



It can be observed:

- Signals from the delayed lines are very clean
- Same relative time between them
- Trigger signal bipolar, it can be that the 40% negative overshoot is due to e-transparency losses in the GEM 3

GEM-TPC tracking capabilities for ^{55}Fe



In the picture above there are multiple picks from the different source positions. The source was not very well collimated therefore a mm scale resolution on X was achieved and the trigger was taken from the bottom of the GEM3



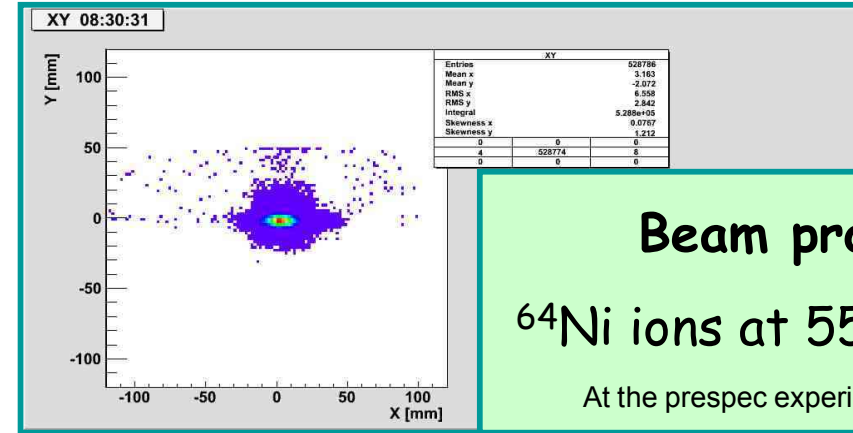
Trigger Signal before reshaping



Trigger Signal with rise and decay time reshaped

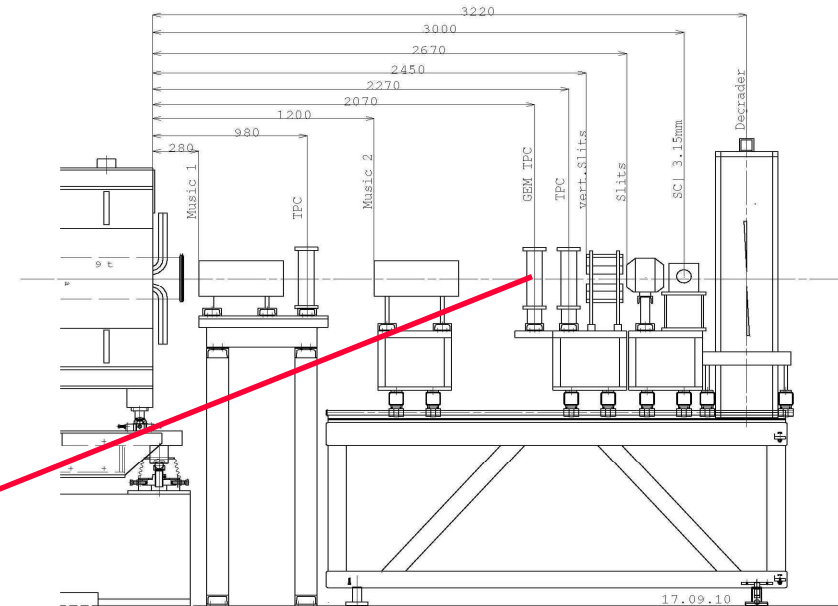
BEAM TEST for HB1 at GSI

GEM-TPC Beam test at GSI - Darmstadt



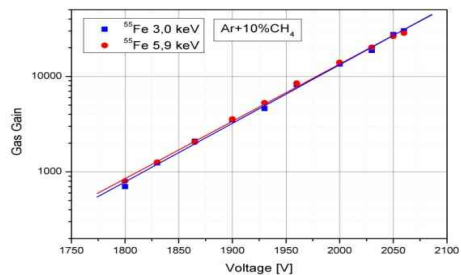
Beam profile
 ^{64}Ni ions at 550 MeV/u
 At the prespec experiment - S363

bruenle FRAME 1 SEPTEMBER 17, 2010 12.27.34



GEM-TPC Gain

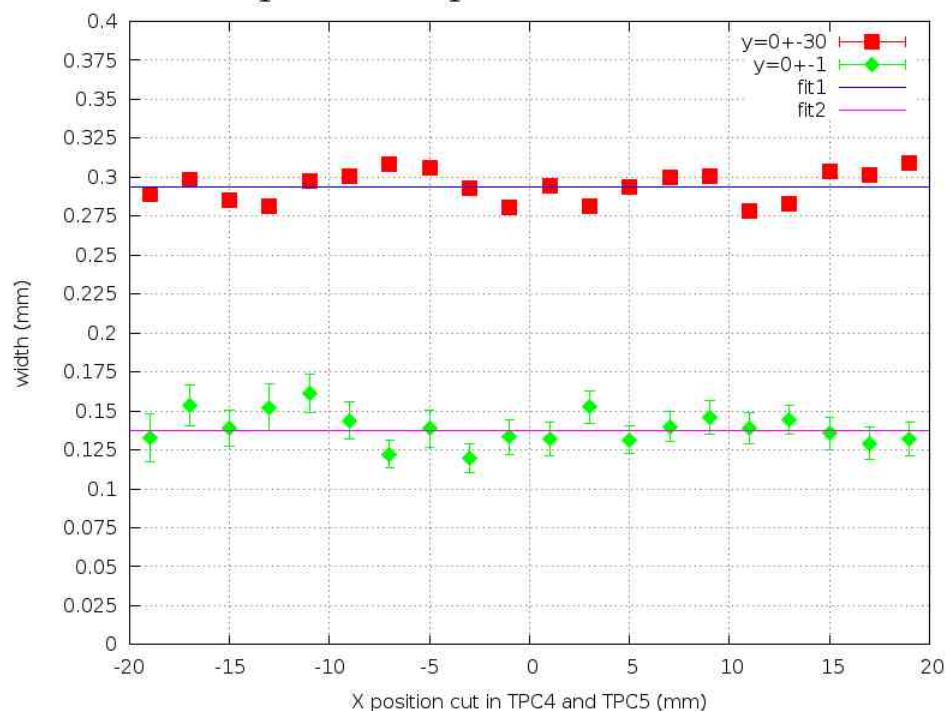
GEM-TPC at S4



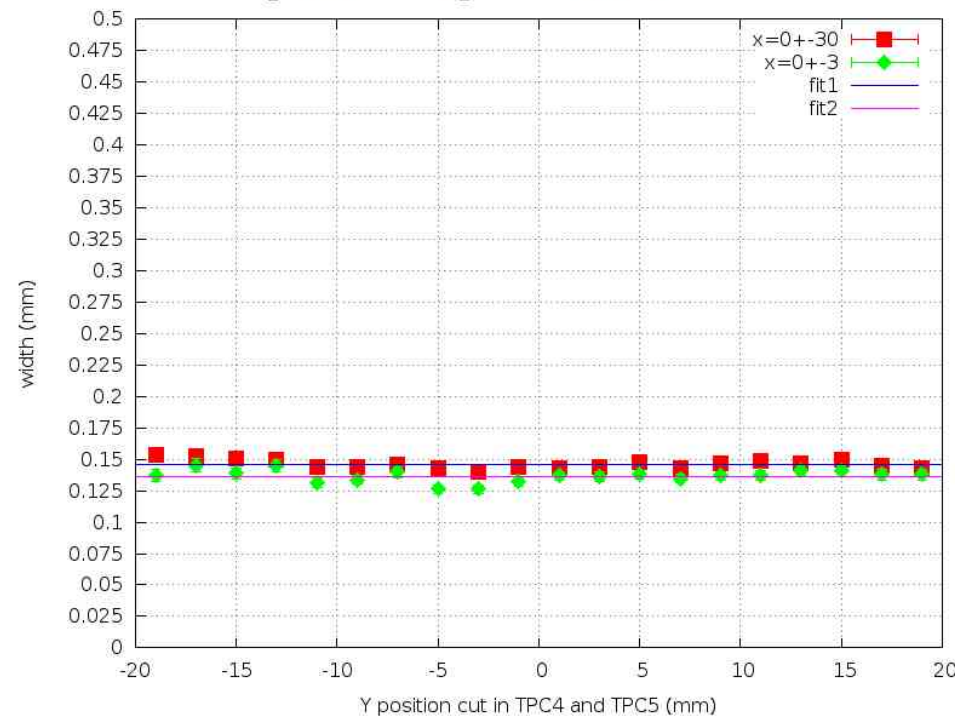
GEM-TPC BEAM TEST - HB1 (Cont.)

GEM-TPC Results for the Beam test @GSI

GEM-TPC POSITION RESOLUTION
parallel strips + beam focused



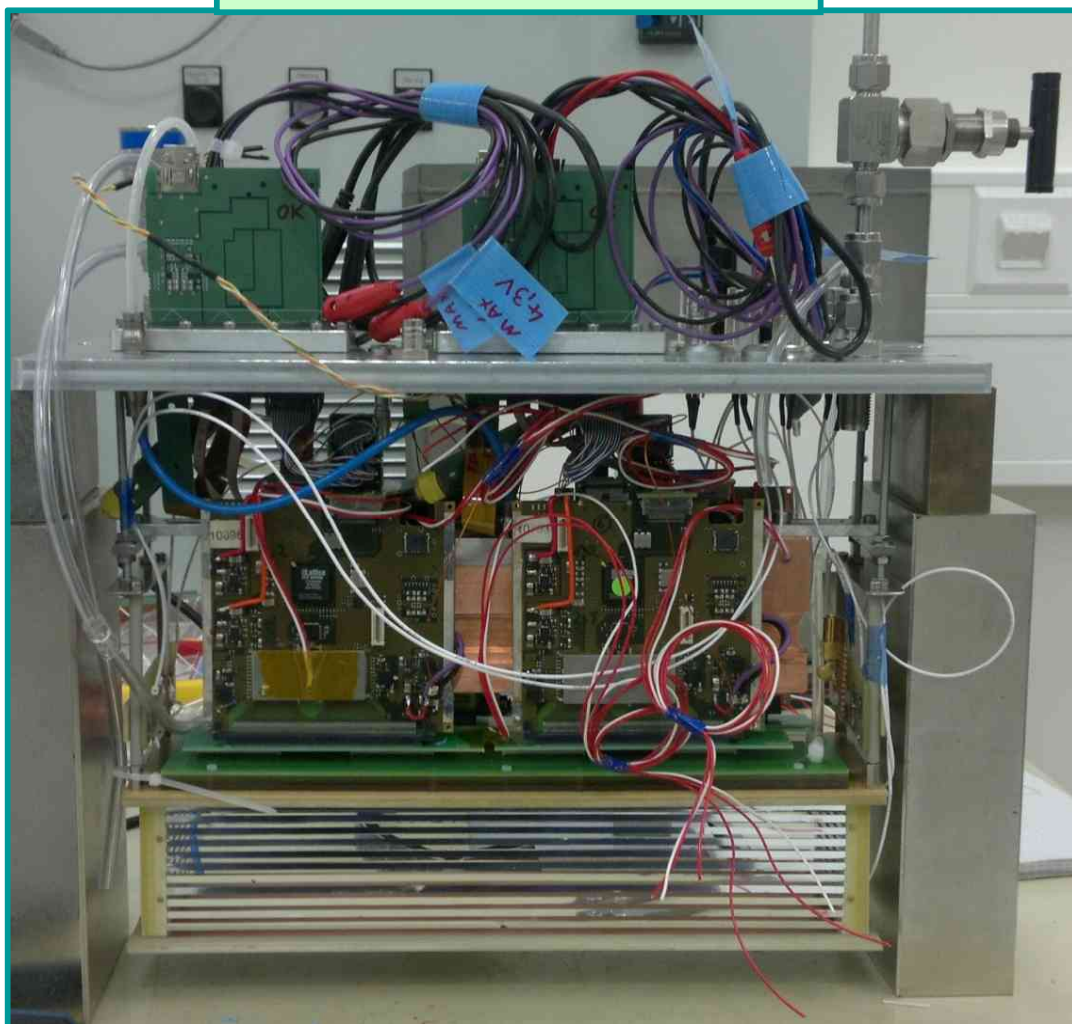
GEM-TPC POSITION RESOLUTION
parallel strips + beam focused



The GEM-TPC shows that the resolution in Y (Drift) reaches value around 130 μm and on X between 130 to 300 μm

GEMEX INTEGRATION - PROTOTYPES HB2/HB3

HB3 with four GEMEX cards



J. Hoffmann et al.



Gas tightness test

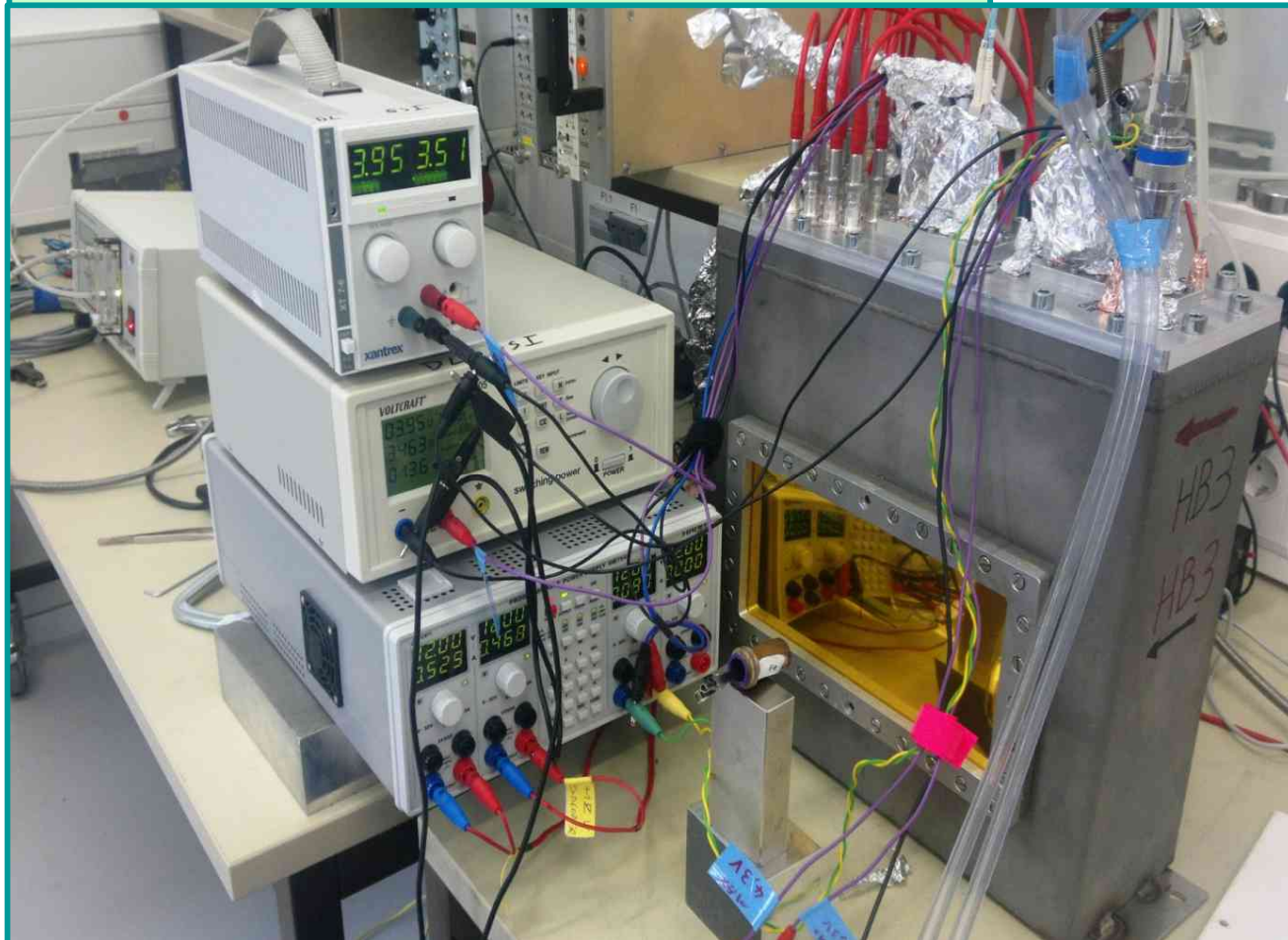


GEMEX card with two n-xyters.

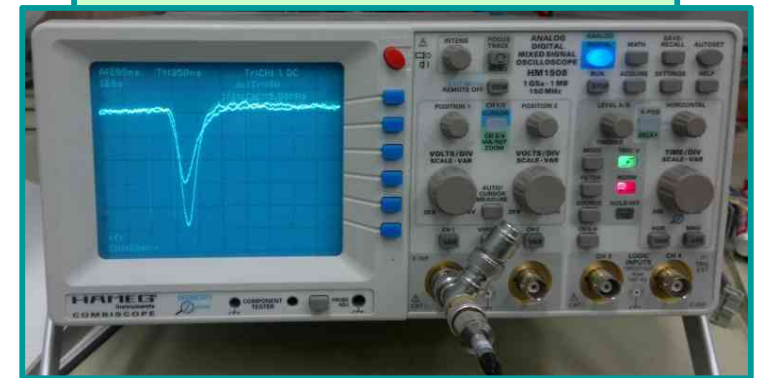
One n-Xyter ASIC has 128 channels.
The data output contains the signal amplitude and a time stamp.
Run in self trigger mode, by storing hit over the threshold

LAB. TEST for HB3

HB3 under test in the Lab.



^{55}Fe Signals in the Lab

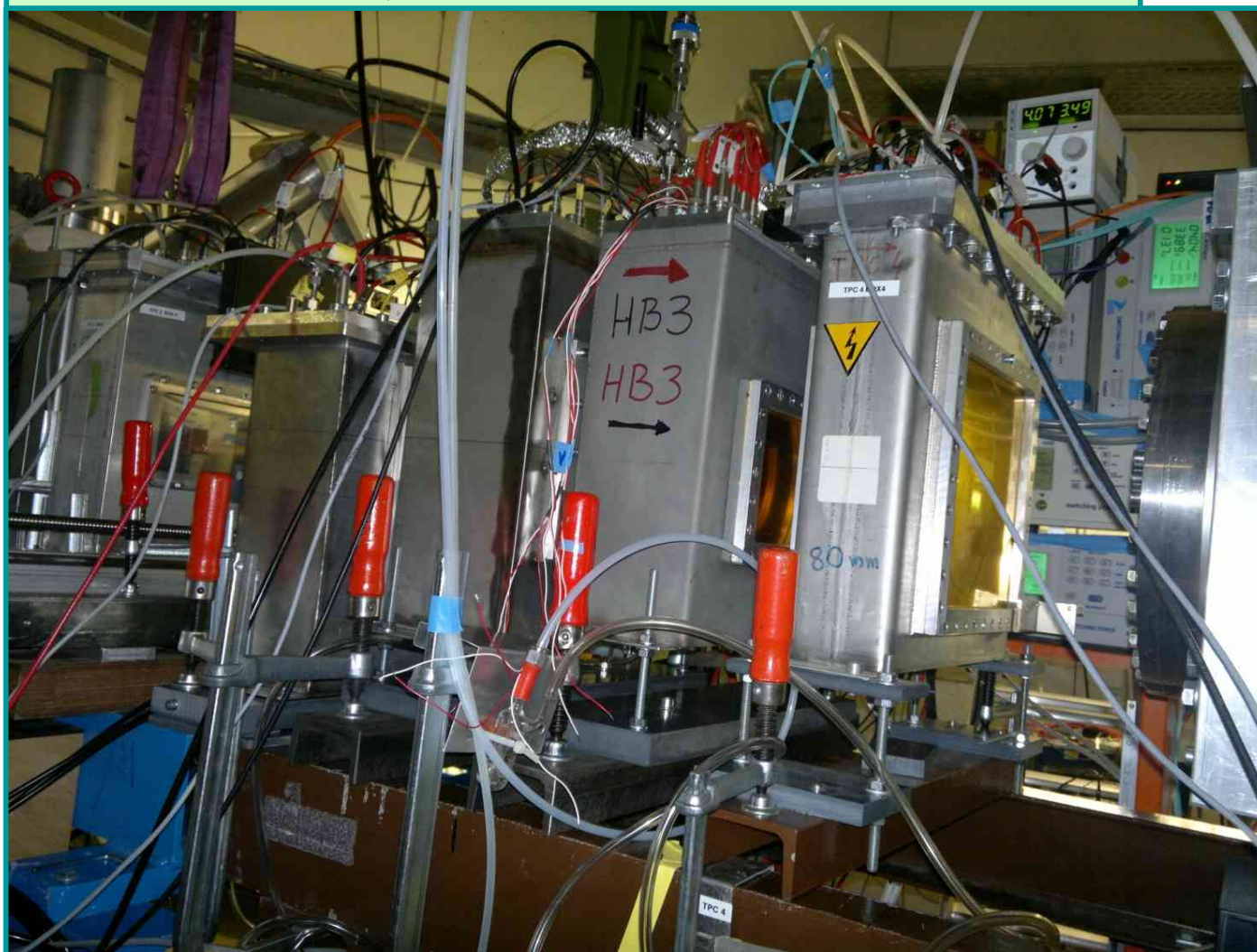


Noise of 32 MHz from
Explode clock in the
trigger lines

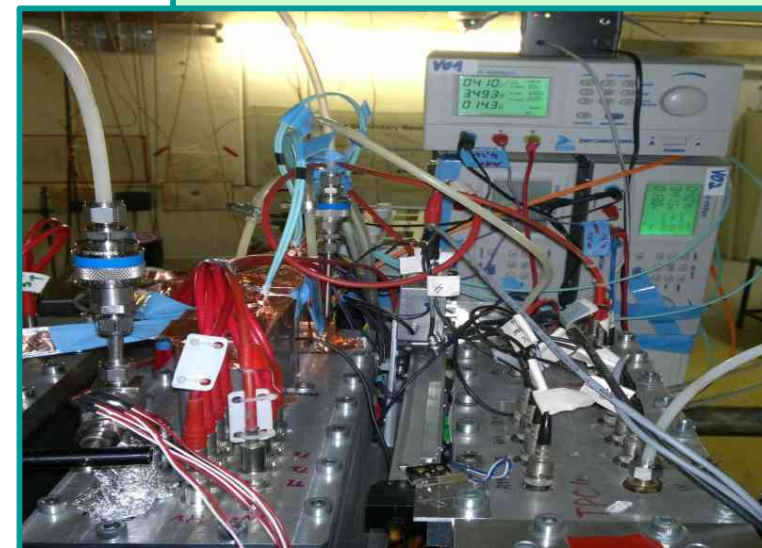


BEAM TEST at GSI for HB2 and HB3

HB3 @ S2 and ready to take the Beam of ^{197}Au at 770 MeV/u



Slow Control and Power - ok

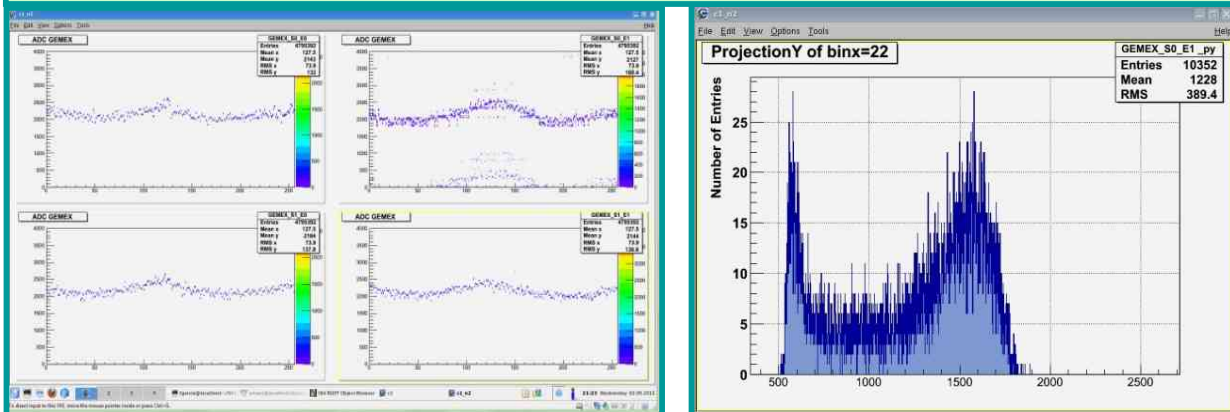


Noise at S2



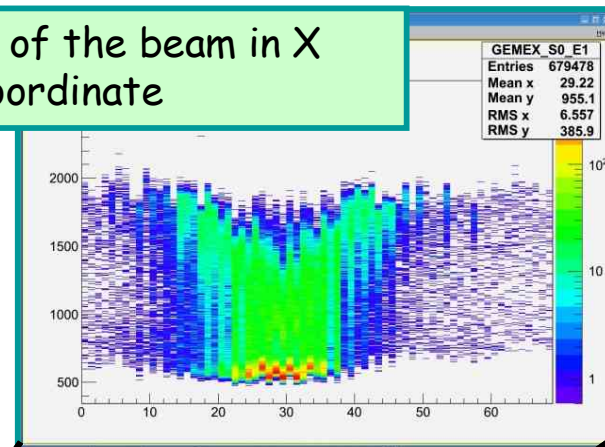
BEAM TEST at GSI for HB2 and HB3 (cont.)

Pedestals of 4 GEMEX cards and Pulse Height distribution of one channel



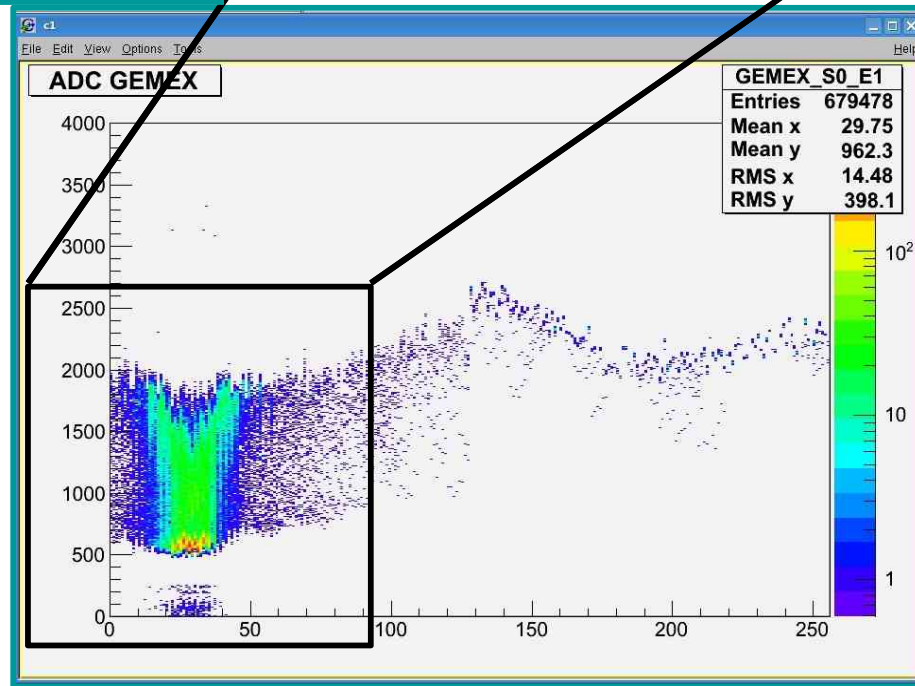
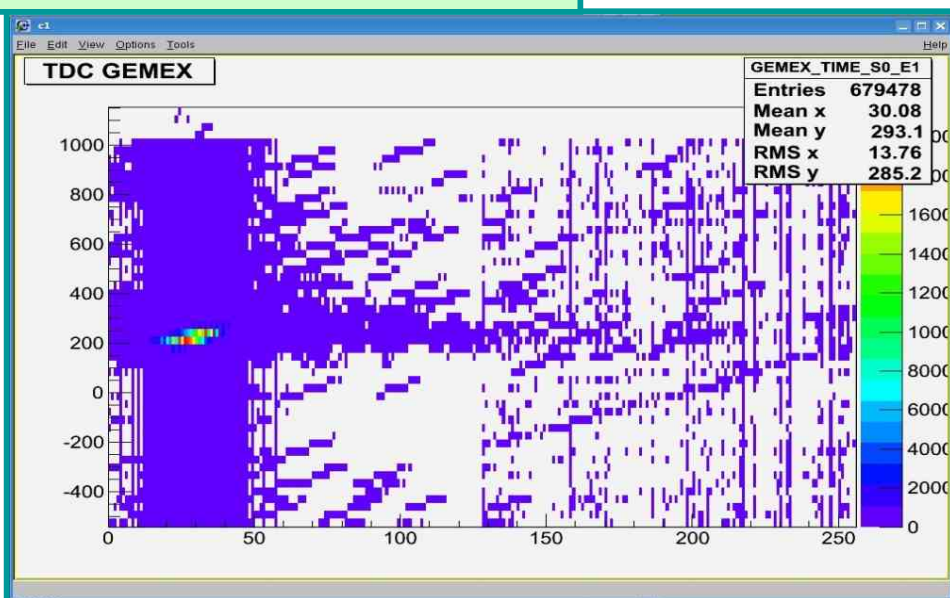
Projection of the beam in X coordinate

In X direction the beam size was of 7 mm. HB3 shows 15 channels at 0.5 mm per channel



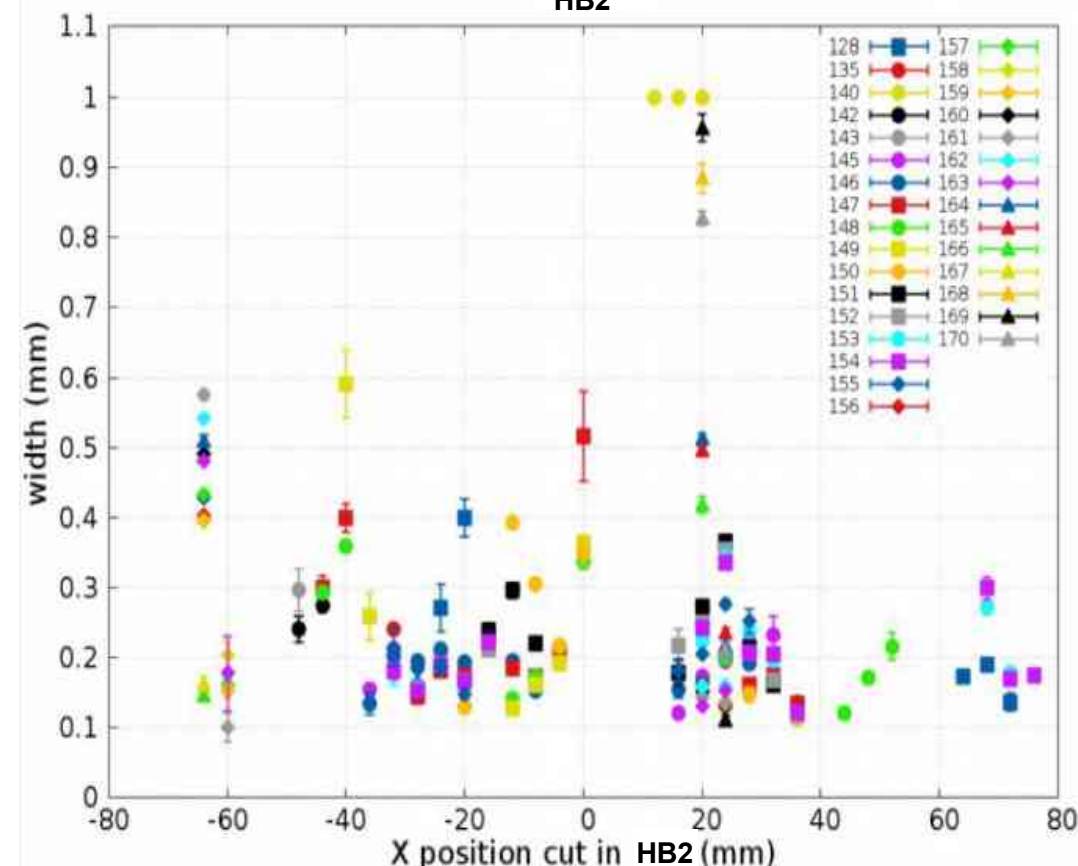
Projection of the beam in Y coordinate

In Y direction the beam was at the center. HB3 shows 200 counts which is a systemic error to be corrected during data analysis

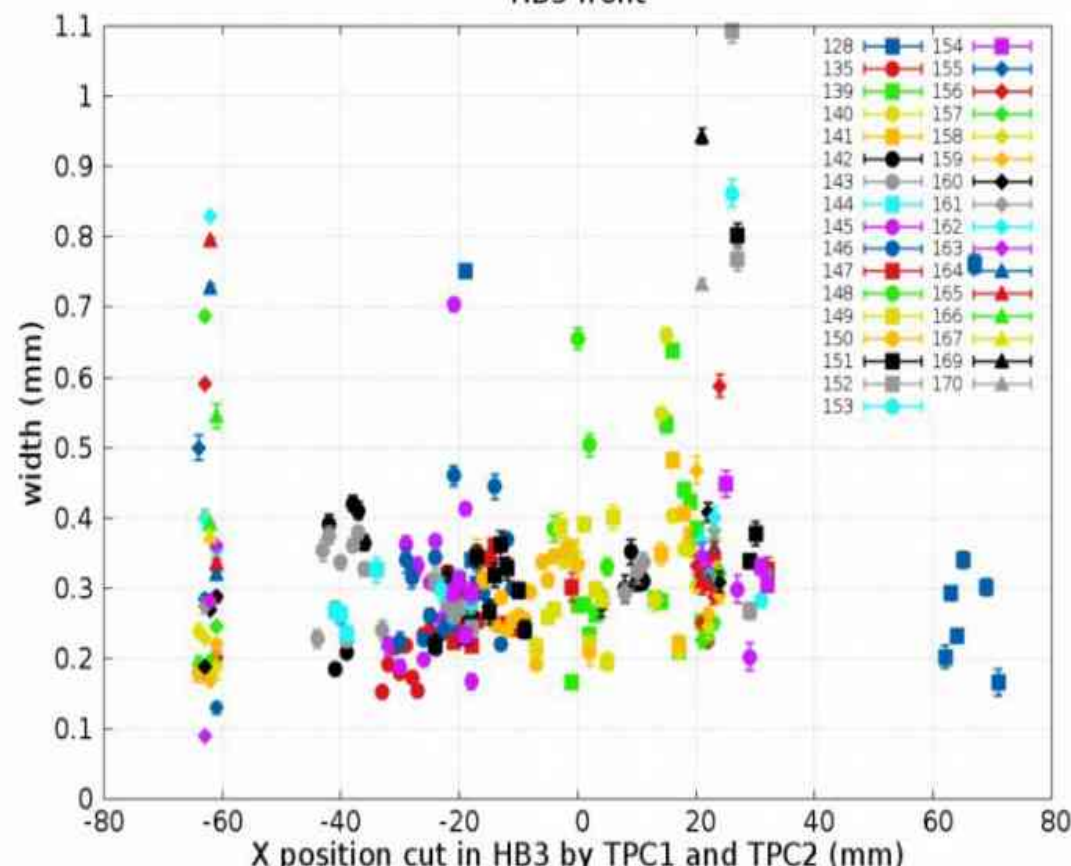


BEAM TEST at GSI for HB2 and HB3 (cont.)

HB2

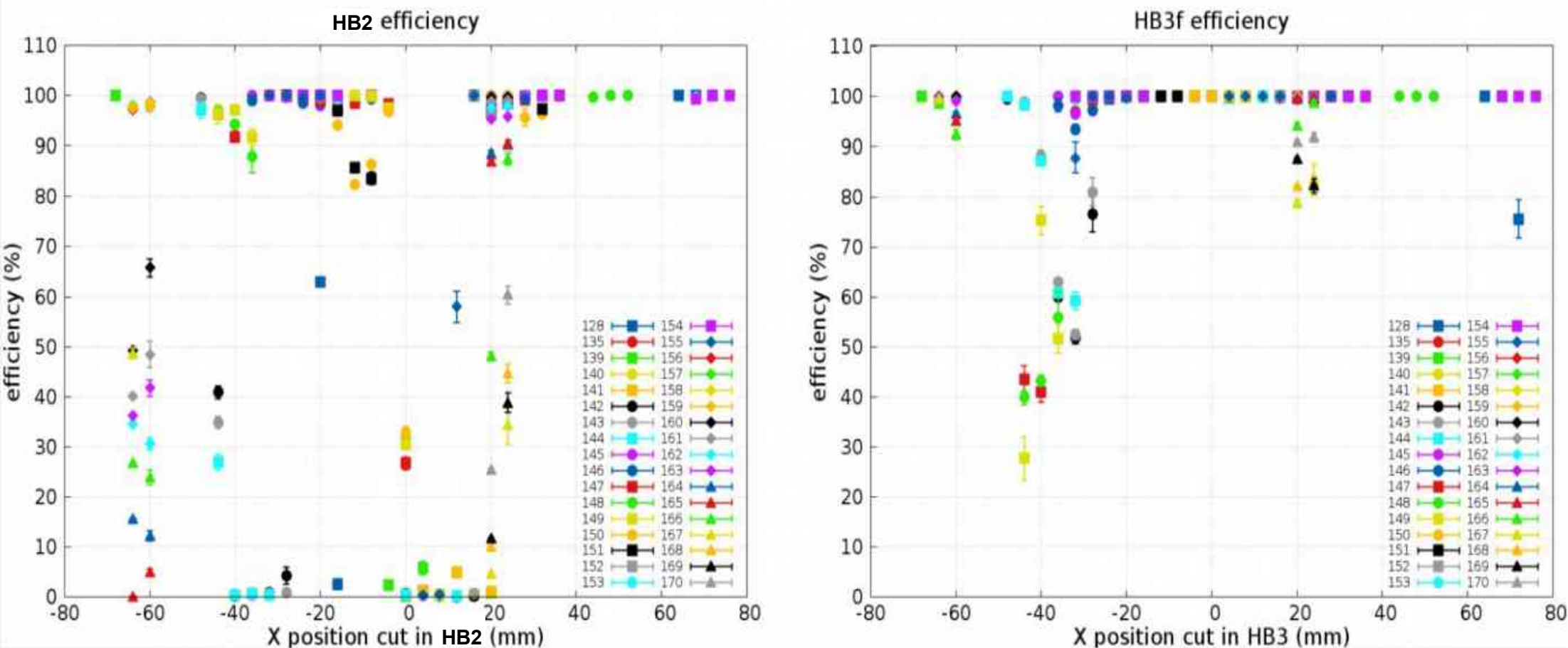


HB3 front



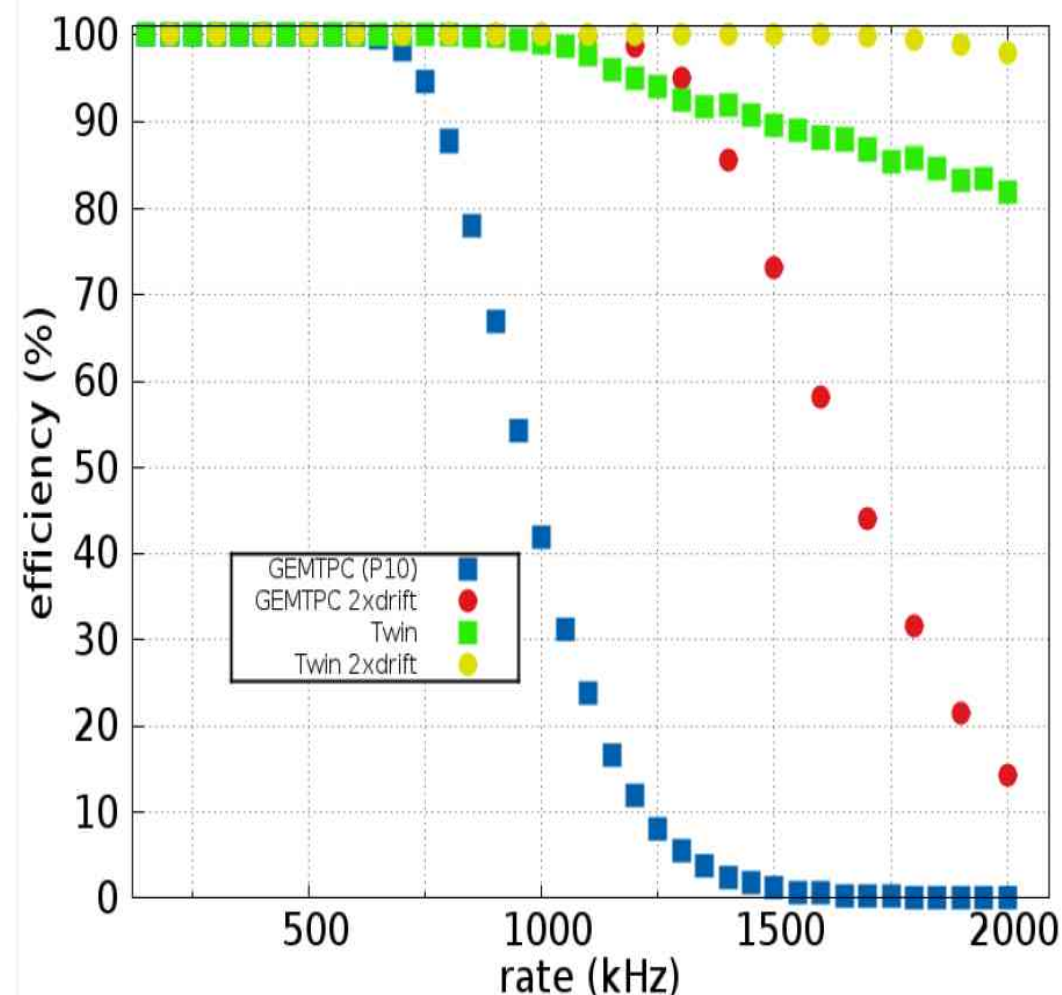
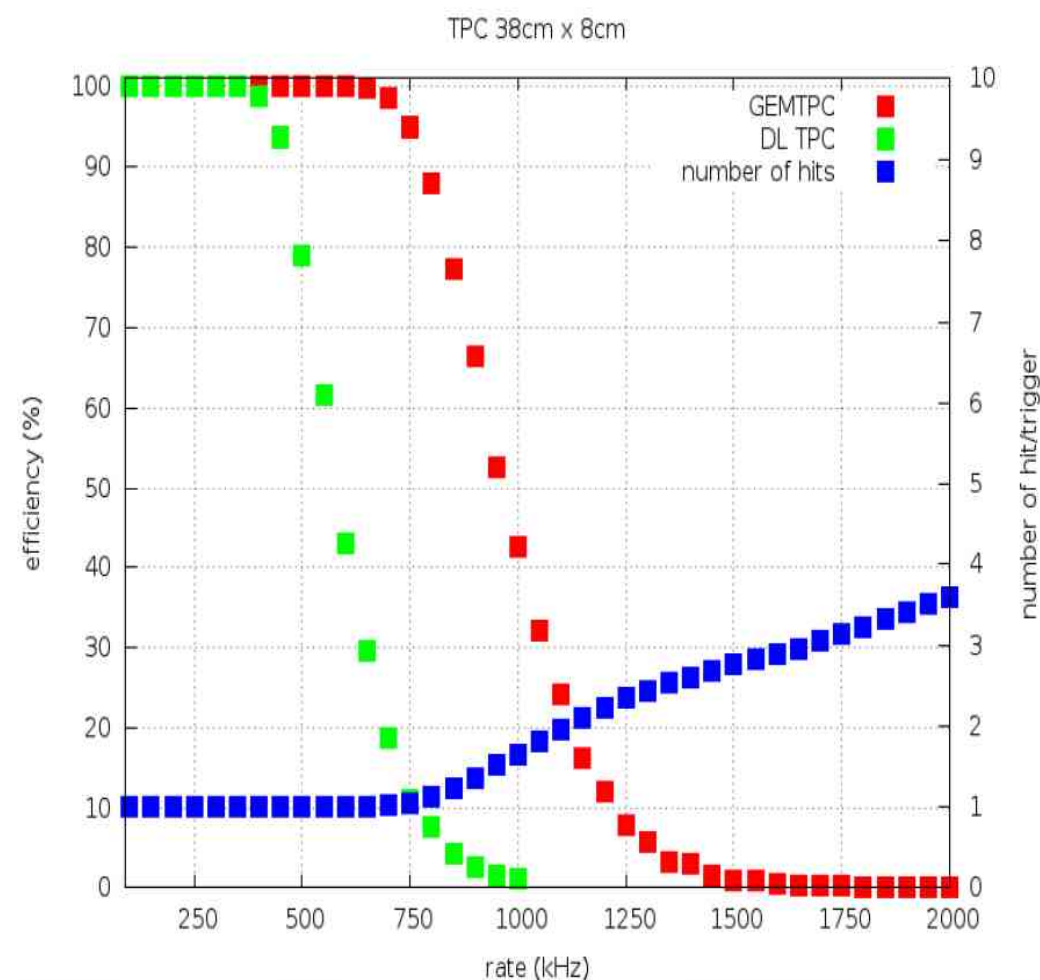
The position resolution in X coordinate for the HB2 and HB3 for all the runs. Variations are due to beam characteristics

BEAM TEST at GSI for HB2 and HB3 (cont.)



Efficiency plots for the HB2 and HB3 for all the runs. Variations in the efficiency are due to beam configuration and readout electronics settings.

SIMULATIONS of the EFFICIENCY (HB1, HB2/HB3 and HGB4)

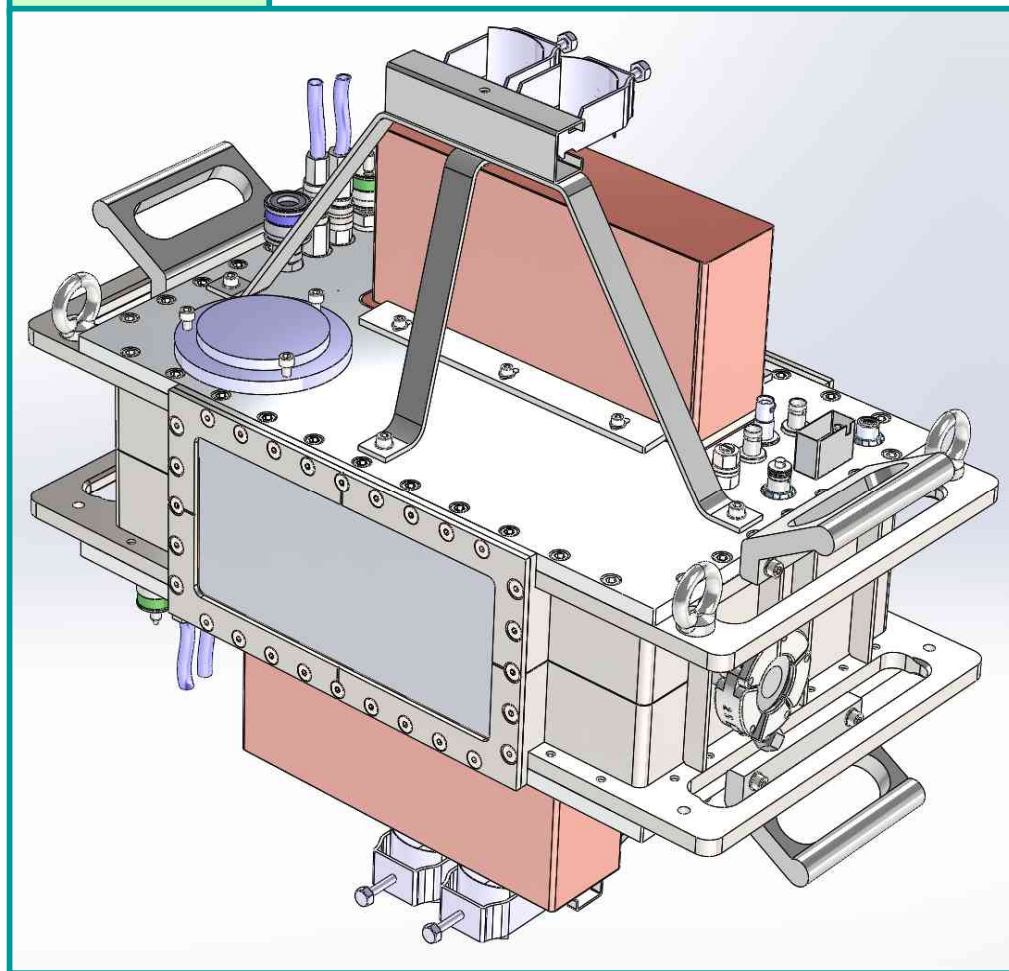
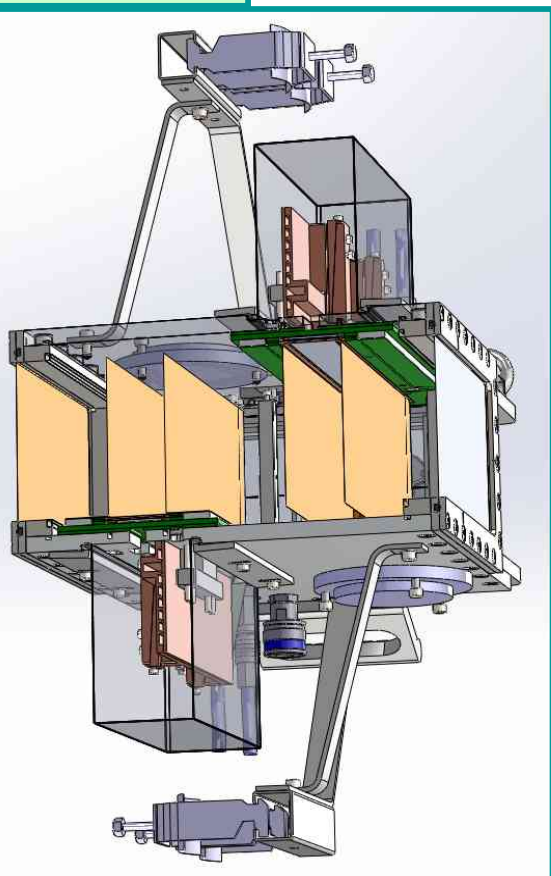


Efficiency Plots simulations for the GEM-TPC equipped with Delayed lines and with GEMEX readout for the case of P10 and a faster gas. The twin GEM-TPC using a 1.6 μ s time window and a 21 ns check sum can reach 1.75 MHz

Twin GEM-TPC PROTOTYPE - HGB4

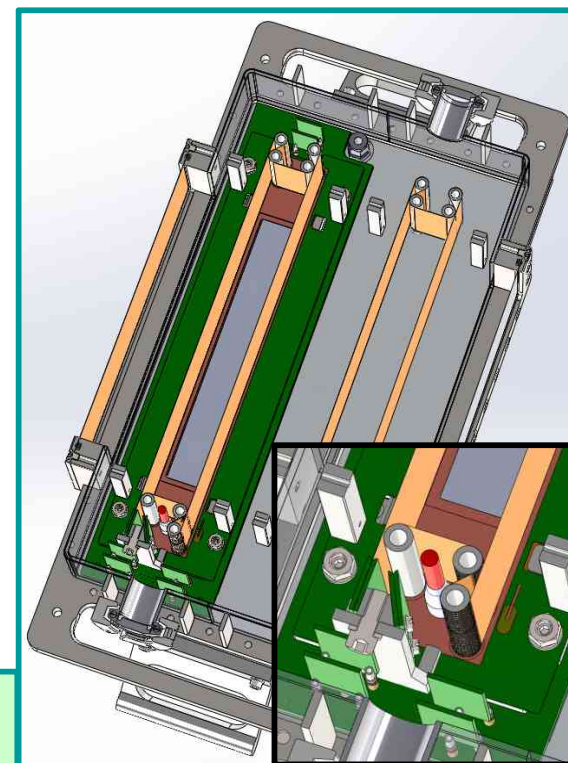
B. Voss et al.

Lateral view

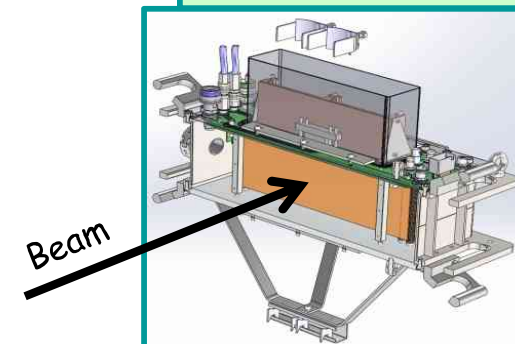


This GEM-TPC has a twin configuration, which means that two GEM-TPC are positioned back to back. This will allow us to increase the tracking efficiency in high rate environment.

View from the top



View beam downstream



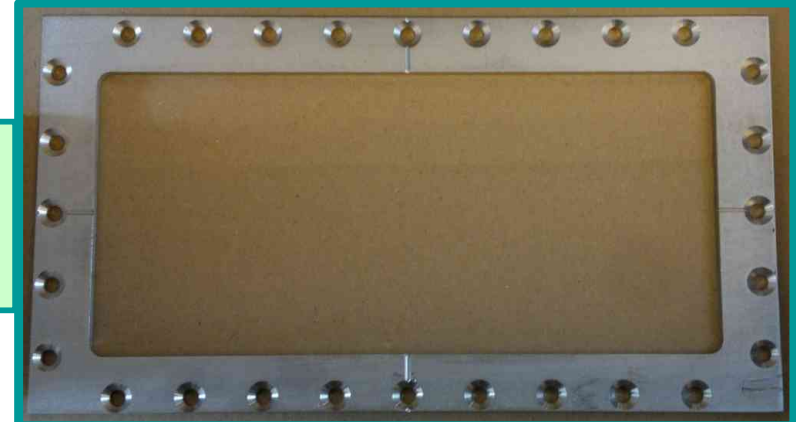
The twin GEM-TPC - HGB4 (Cont.)

Twin GEM TPC box

A total of two has been manufactured



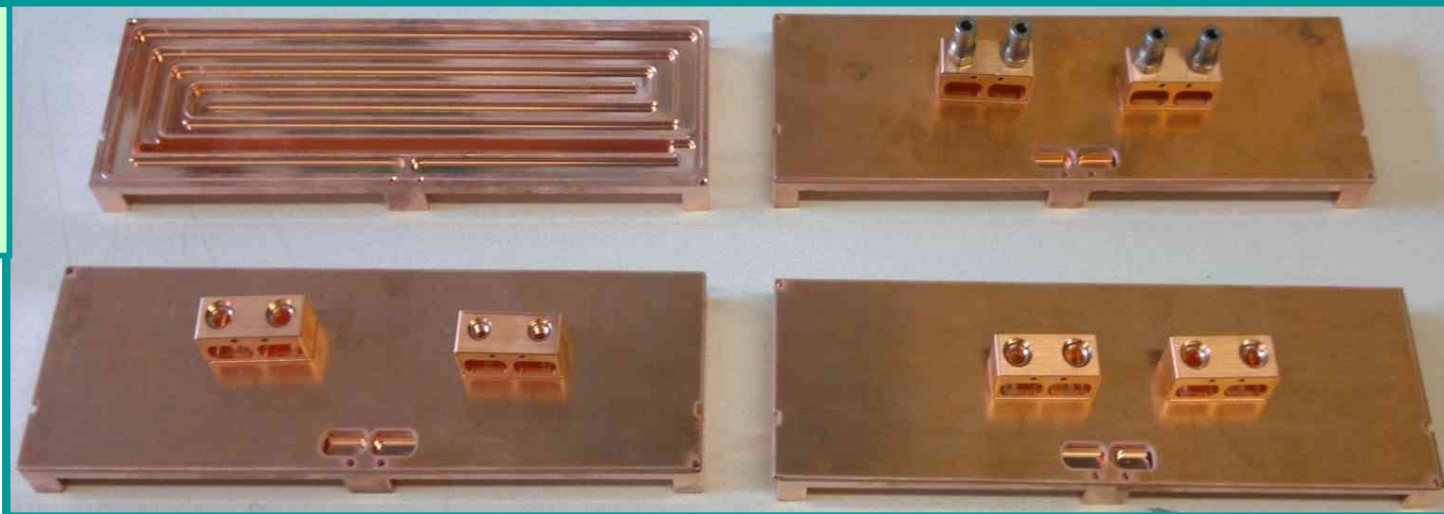
Entrance window Frames.



A total of 4 will be for in Air tests, with a very thin Aluminized Kapton. Two frames will be welded to a thick Stainless steel plates for vacuum and for low pressure operation.

S. Rinta-Antila et al.

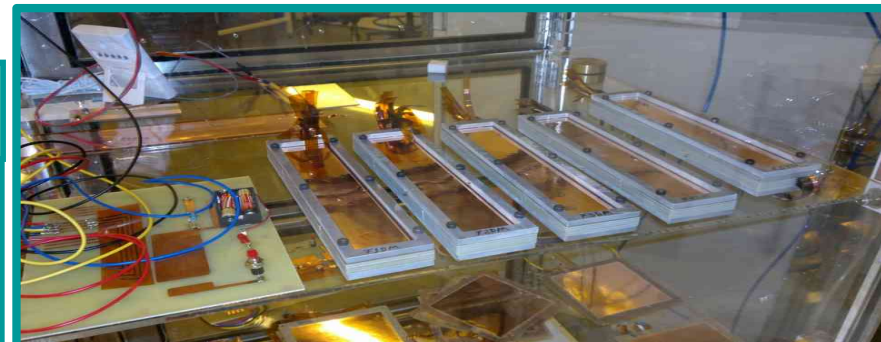
GEMEX readout coolers. A total of 8 pieces has been produced



The twin GEM-TPC - HGB4 (Cont.)

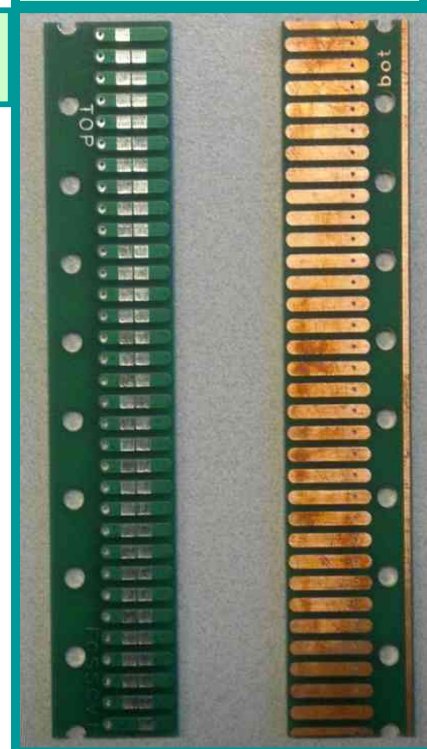
GEM foil Framing -
Frascati stretcher

G. Bencivenni



Field Cage Divider

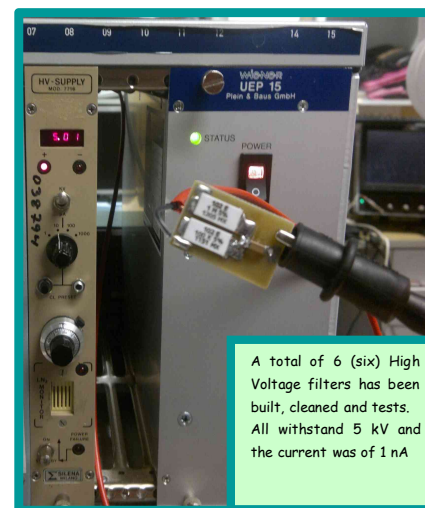
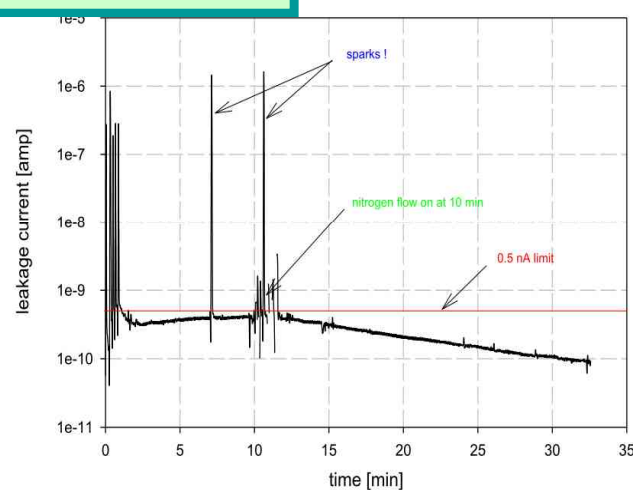
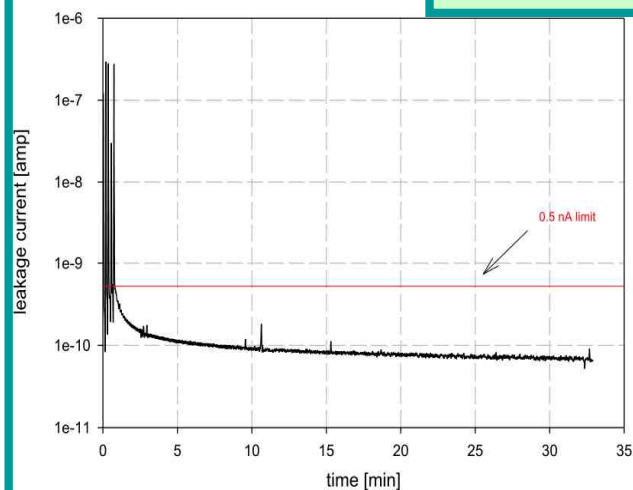
P. Strmen



F3DMtop1

GEM foil - Leakage Current measurement

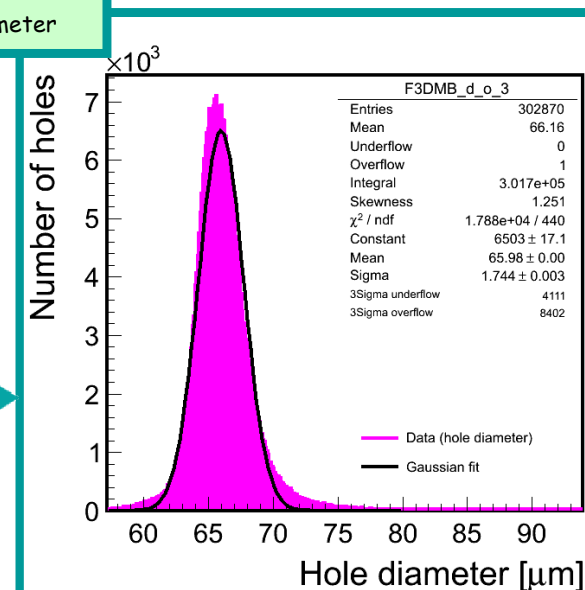
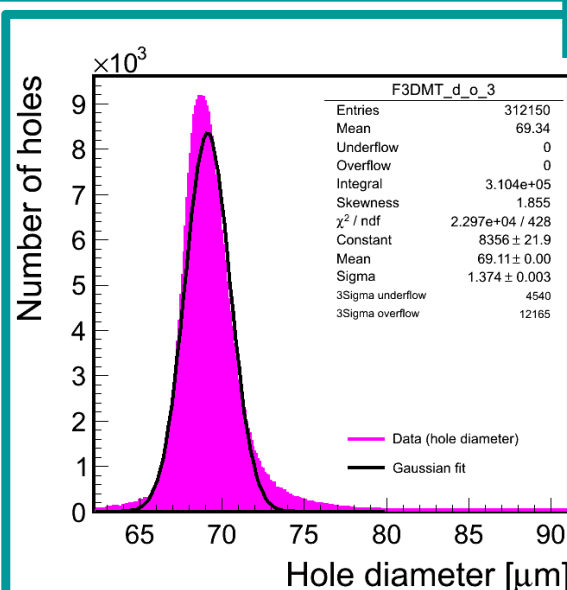
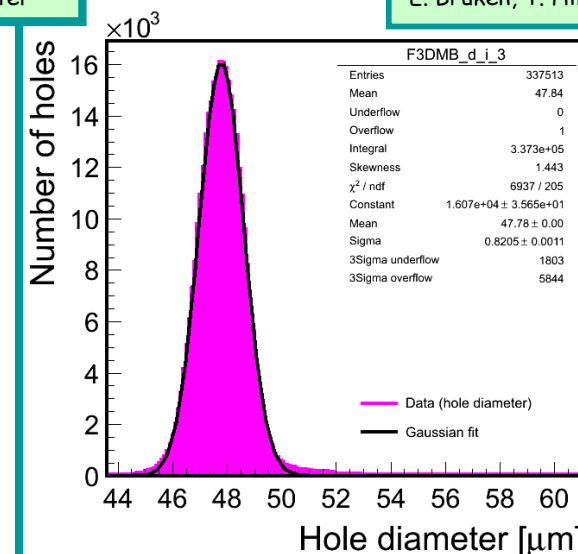
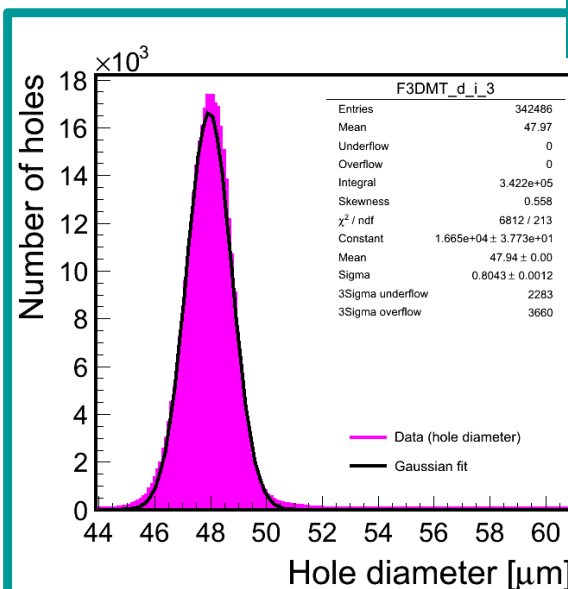
F1DMtop5



The twin GEM-TPC - HGB4 (Cont.)

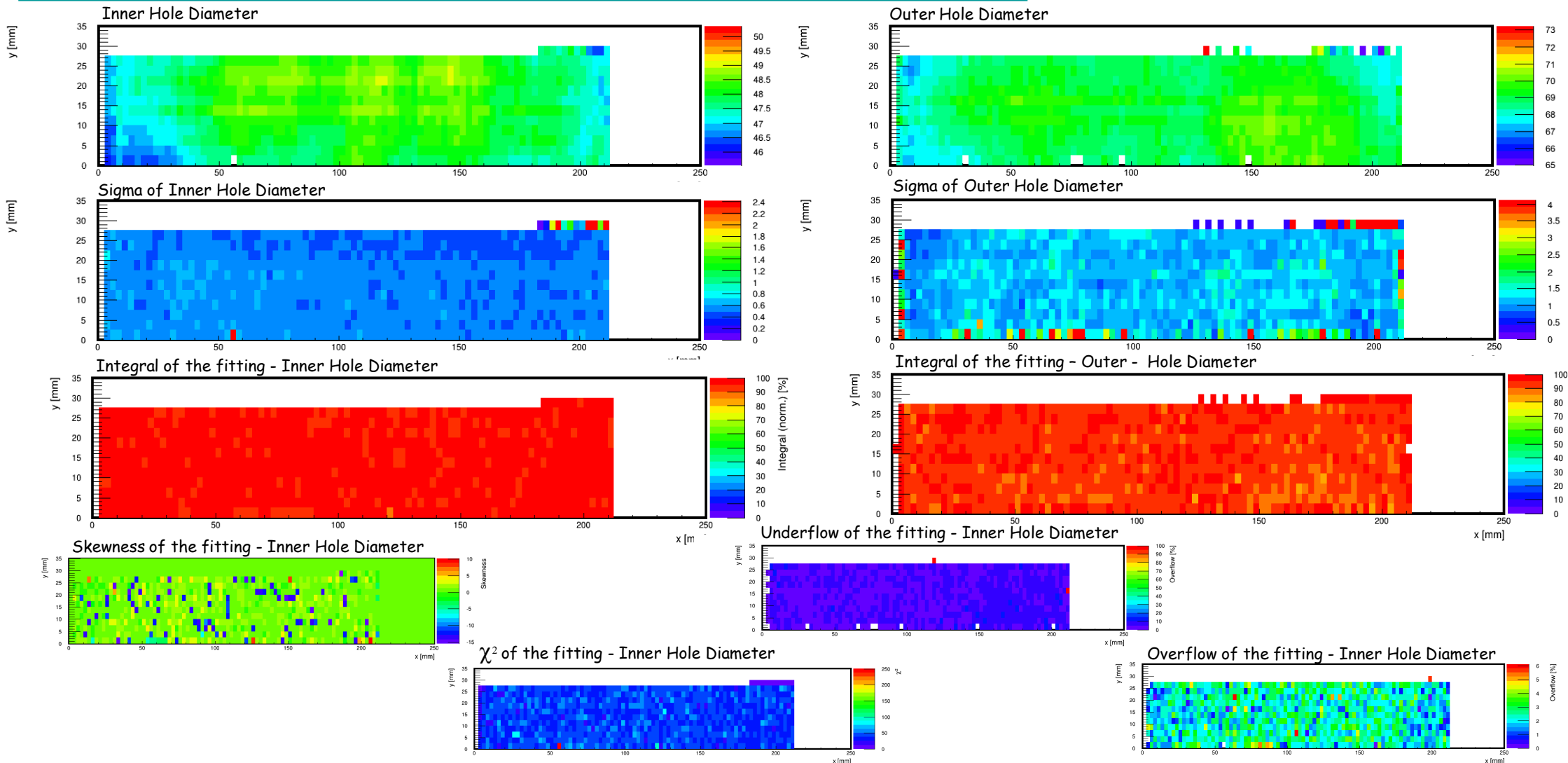
Optical
Characterization
for the SuperFRS
GEM foils

E. Brücken, T. Hildén



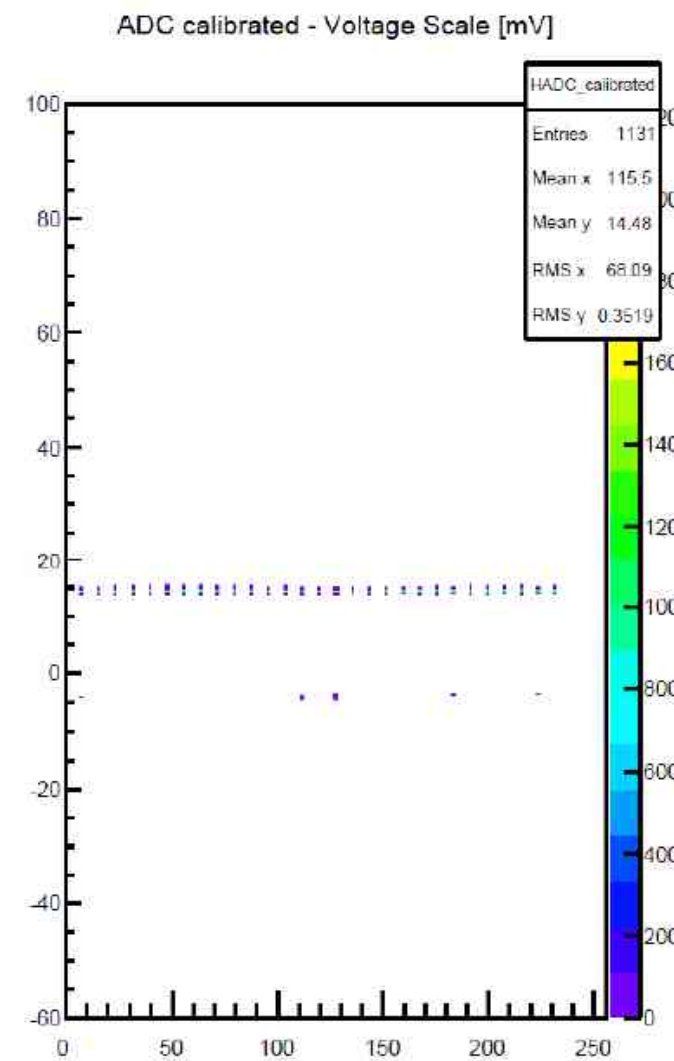
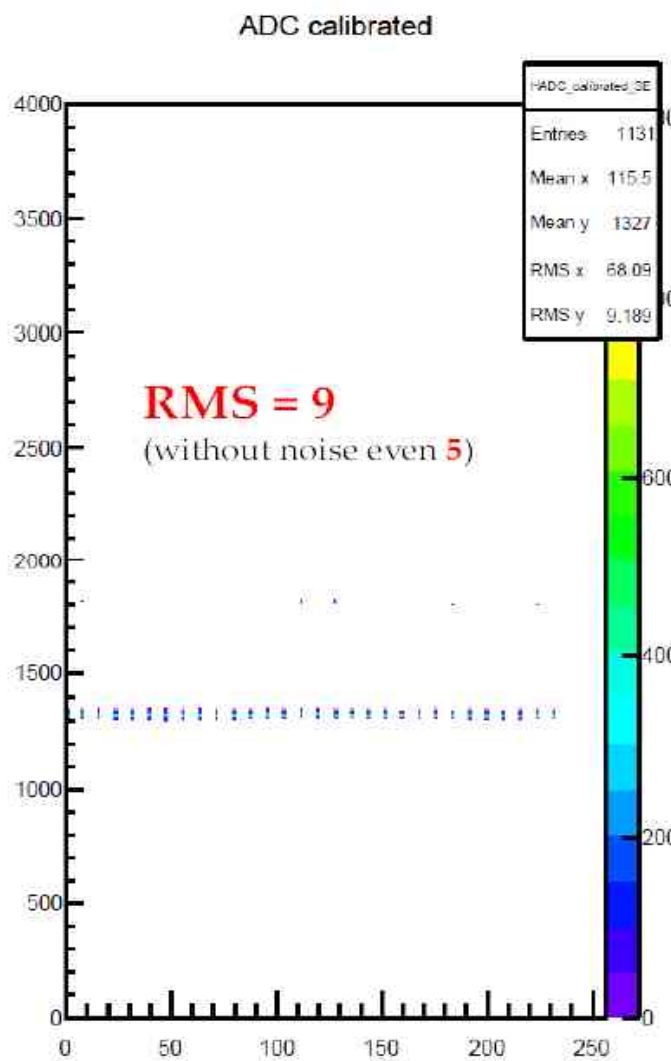
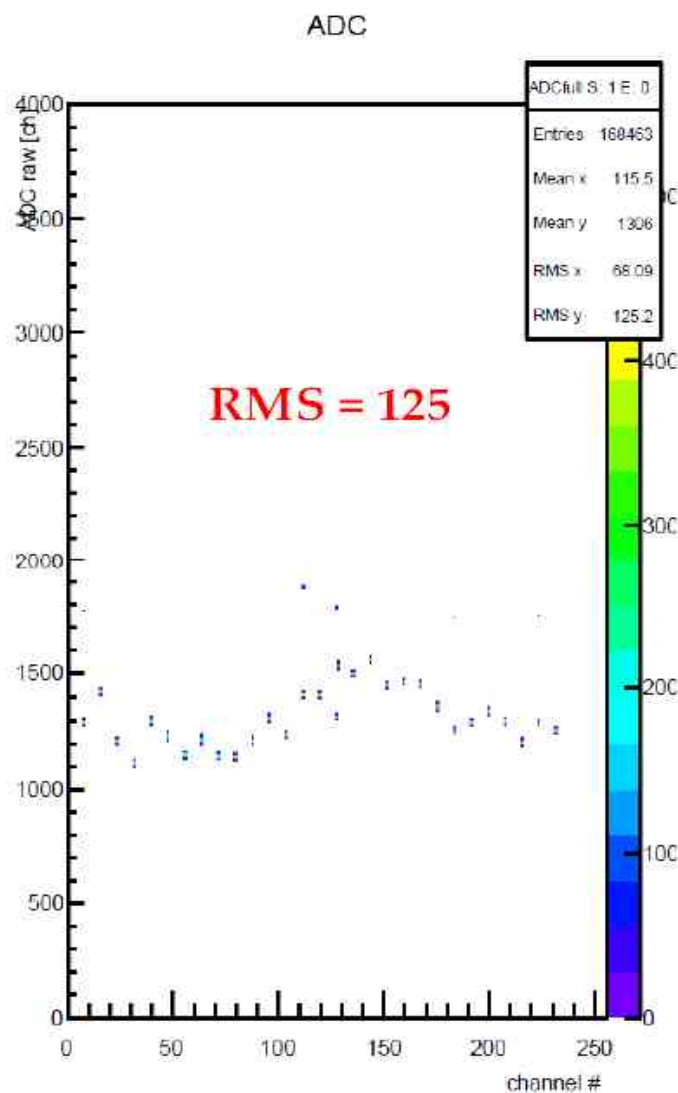
The twin GEM-TPC - HGB4 (Cont.)

Mapping for all the parameters per GEM foil and per side



The twin GEM-TPC - HGB4 (Cont.)

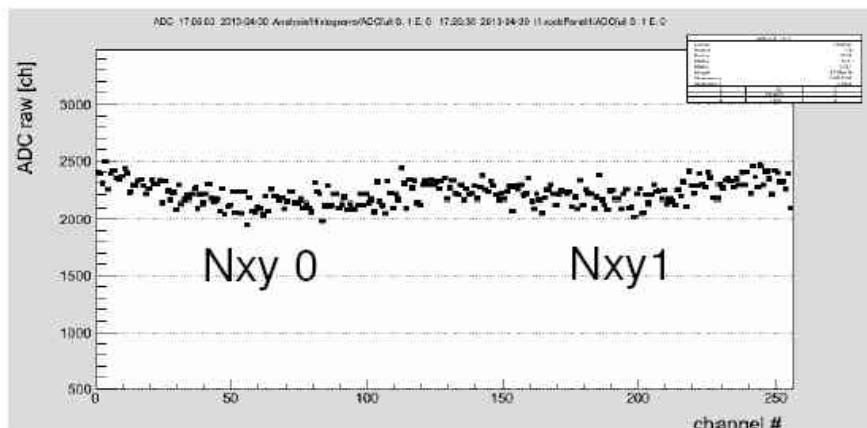
15mV input signal



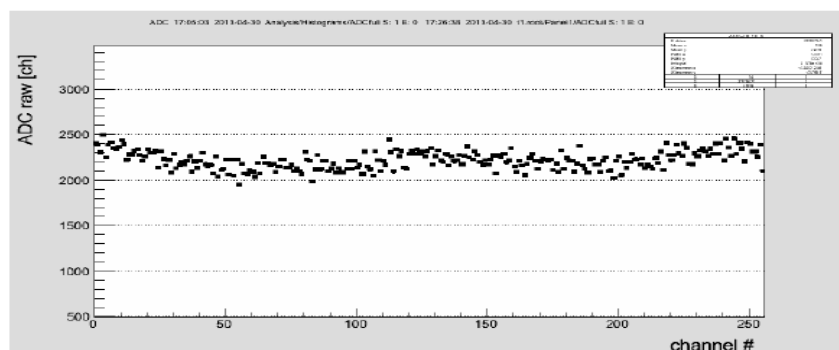
A. Gromliuk

The twin GEM-TPC - HGB4 (Cont.)

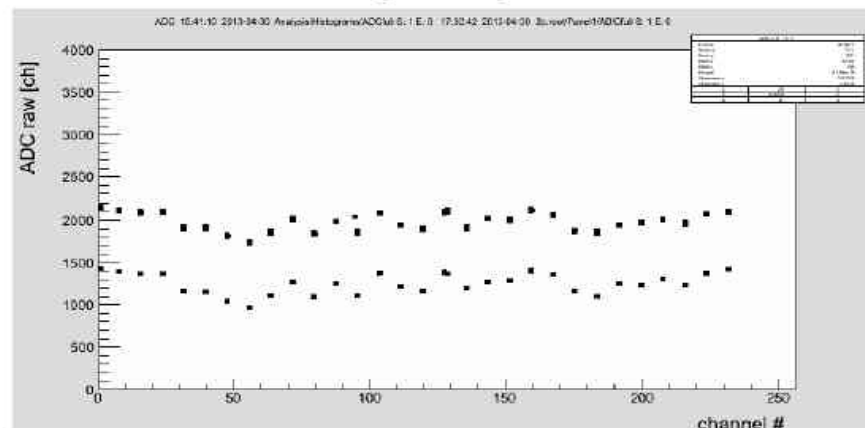
Baselines for all 256 GEMEX ch.



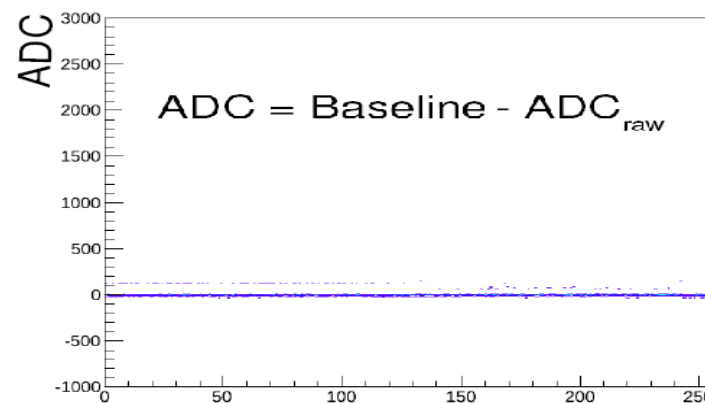
Test trigger mode baselines



2 different charges injected to GEMEX.



External charges

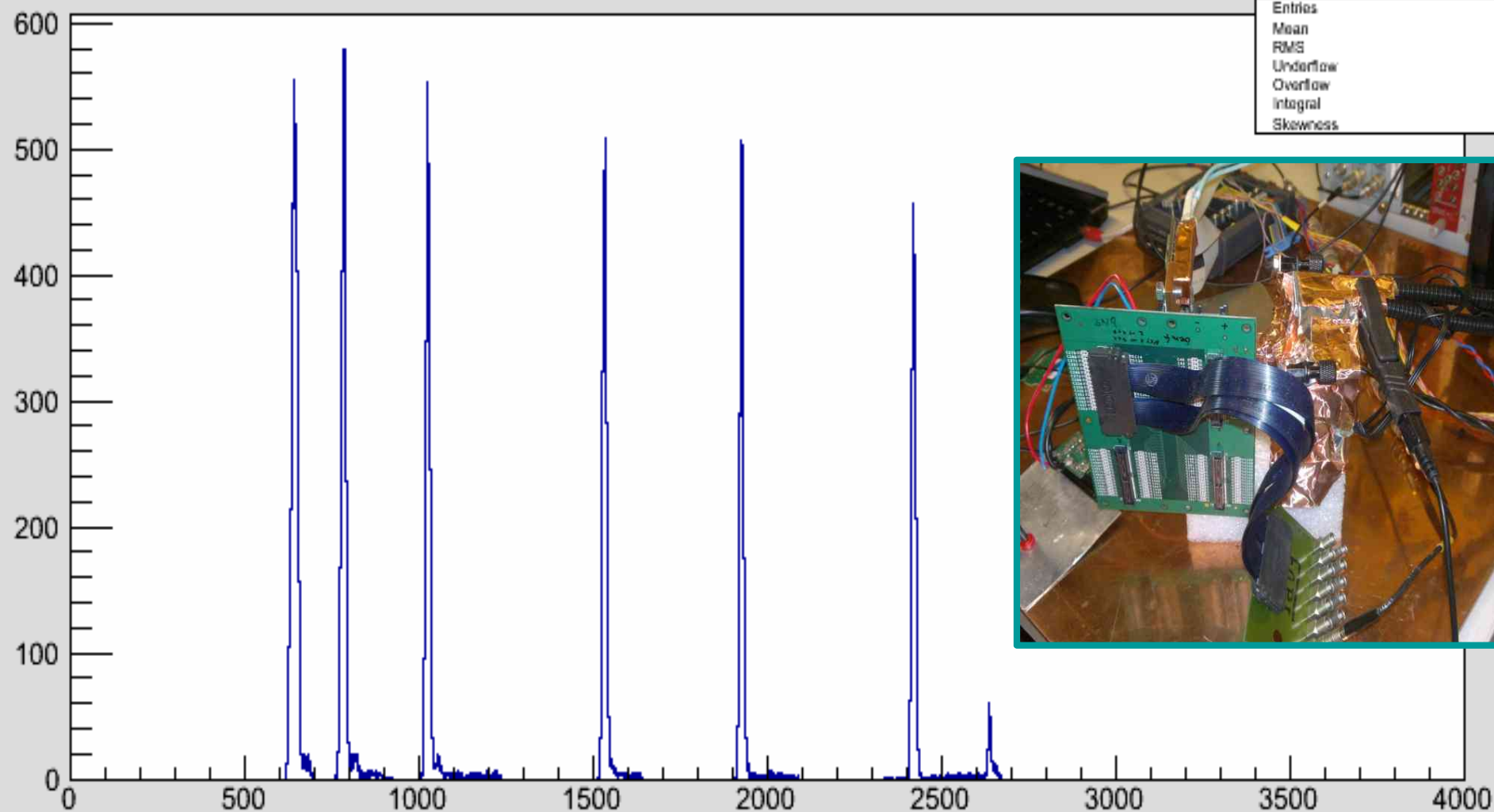


Channel #

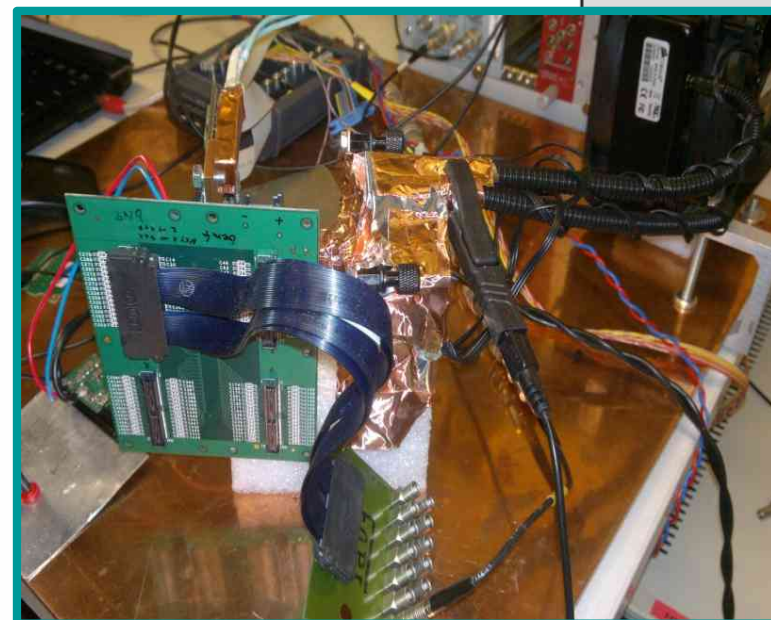
A. Prochazka

The twin GEM-TPC - HGB4 (Cont.)

Charge 09:25:21 2013-09-27 Analysis/Histograms/ADCs/Charge S: 1 E: 0 N: 1 C: 109

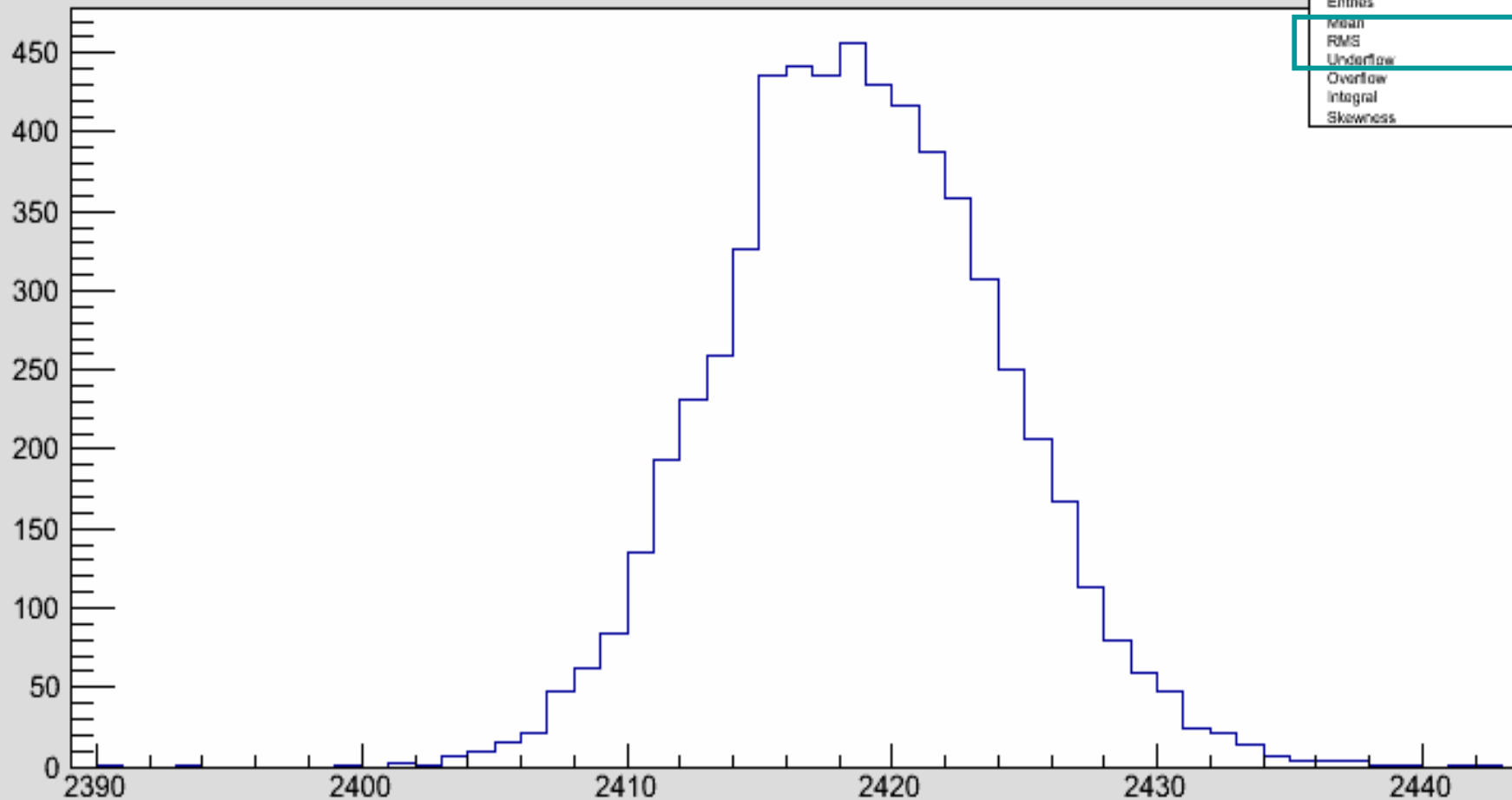


Charge S: 1 E: 0 N: 1 C: 109	
Entries	49318
Mean	1285
RMS	636.4
Underflow	0
Overflow	0
Integral	4.932e+04
Skewness	0.6609



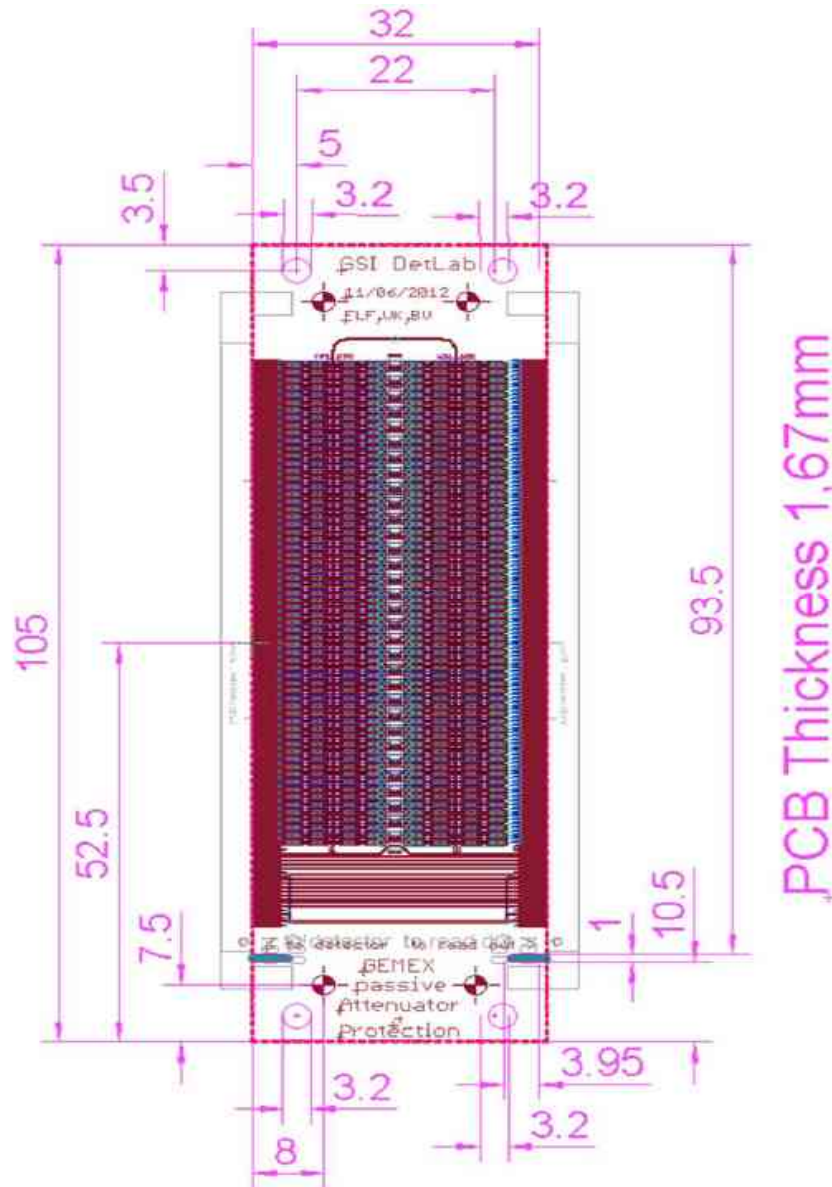
The twin GEM-TPC - HGB4 (Cont.)

Charge 09:25:21 2013-09-27 Analysis/Histograms/ADCs/Charge S: 1 E: 0 N: 1 C: 109



Charge S: 1 E: 0 N: 1 C: 109	
Entries	49318
Mean	2419
RMS	5.334
Underflow	0
Overflow	0
Integral	6073
Skewness	0.1054

The twin GEM-TPC - HGB4 (Cont.)



- Input protection by NUP 4114
- Passive attenuation by a (R-C-C-R) network for all 256 channels
- Reasonably small form factor to serve as an add-on to the GEMEX

A 100 pF separator capacitor and 1 MOhm resistor will be added per channel

SUMMARY

- The concept of a GEM-TPC for the SuperFRS has been tested on the HB1, HB2 and HB3 prototypes
- The results in terms of Position resolution and Tracking Efficiency for low and moderate rates are satisfactory
- The Production of the HGB4 prototype is on going, which is a GEM-TPC in twin configuration and the plans are to participate in beam test during next year at GSI and Jyväskylä
- A lot of effort has been put to secure resources to some of the outsourced components
- The Calibration process for the GEMEX card is well understood and its implementation is in progress on the new Linux based MBS

Thank you for your Attention

