Status of GEM-TPC Developments – A tracking Detector for SuperFRS

COLLABORATORS

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EE - GSI – Darmstadt - Germany

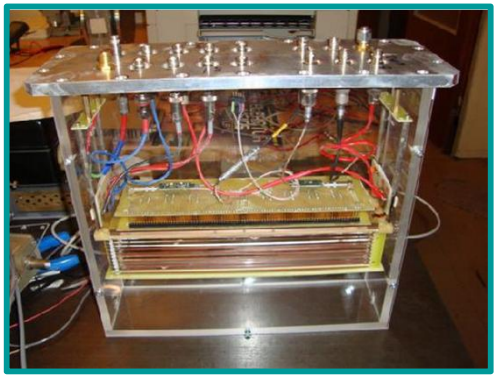
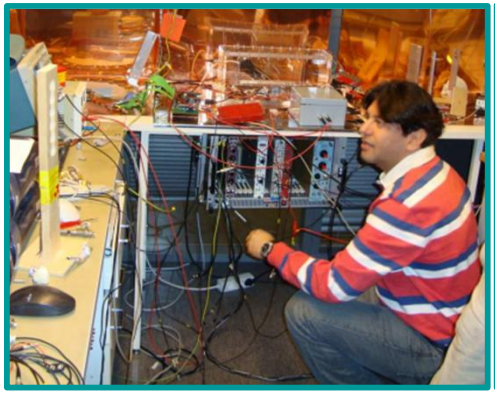
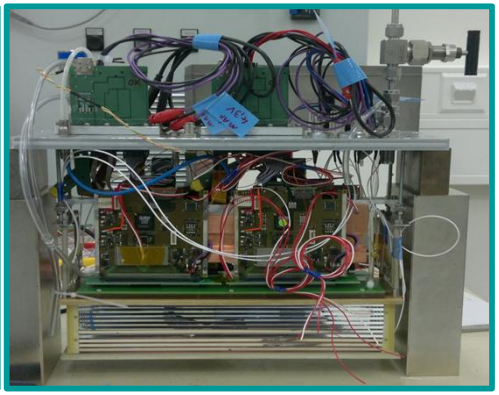
OUTLINE

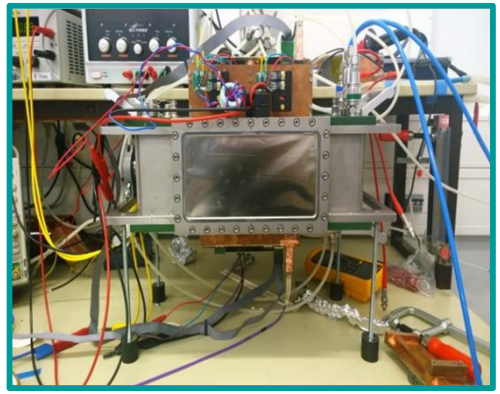
- INTRODUCTION & MOTIVATION
- CHARACTERIZATION OF COMPONENTS
- GEM OPTICAL CHRACTERIZATION
- POOF of CONCEPT for a GEM-TPC – PROTOTYPE HB1
- LAB. COMISSIONING of HB1
- BEAM TEST of HB1 at GSI
- BEAM TEST of HB3 at GSI
- Twin GEM-TPC SIMULATIONS and DESIGN
- Twin GEM-TPC - HGB4 ASSEMBLING
- Twin GEM-TPC - HGB4 COMMISSIONING
- Twin GEM-TPC - HGB4 BEAM TEST
- HGB4 CONTROL SUM
- SUMMARY

INTRODUCTION

IT HAS BEEN A LONG JOURNEY:

- First meeting at Eurorib'08 with H. Simon
- Meeting at HIP and GSI in Oct. 08 and Feb. 09
- Creation of Consortium: Comenius Univ. and Univ. of Helsinki Feb 09
- First visit to Bratislava, March. 09
- Design of GEM stack at HIP, April 09
- Production of GEM foils at CERN by R. Oliveira, Nov. 09
- Successful Tests of the First GEM stack, Dec. 09
- Integration of the HB1, GEM-TPC, Feb. 10
- First Test Beam at GSI with HB1, GEM-TPC, Aug. 10
- Meeting at HIP and NUSTAR meeting at GSI in Jan. 11 and Feb. 11
- Concept of GEM-TPC for SuperFRS presented to RD51, Apr, 11
- First discussions about twin TPC by B. Sitar, June 11
- NUSTAR meeting in Bucharest, Oct. 11
- The twin GEM-TPC design starts by R. Janik, Jan. 12
- NUSTAR meeting at GSI, Feb. 12
- Integration of GEMEX into HB2 and HB3, GEM-TPC, Apr. 12
- Beam Test at GSI with HB2 and HB3, May. 12
- Redesign and production of HGB4 by B. Voss, Jan 13
- Beam test at GSI with HGB4, June 14



MOTIVATION

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

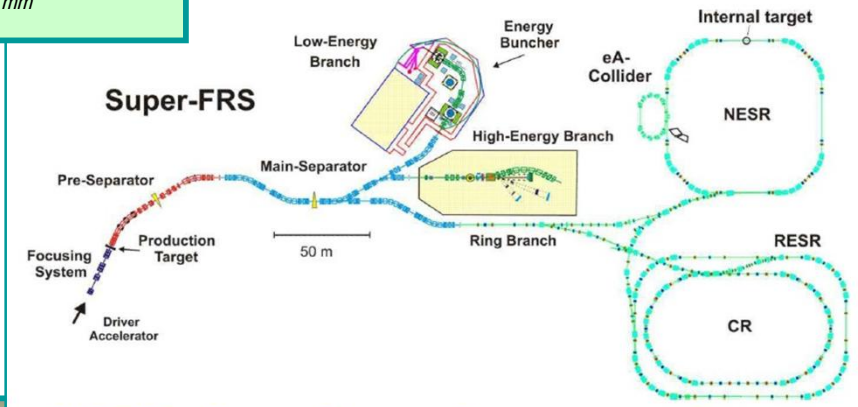
Time line:
R&D finish and Design frozen: Q4/2015

Mass production: Q2/2016 – Q3/2018

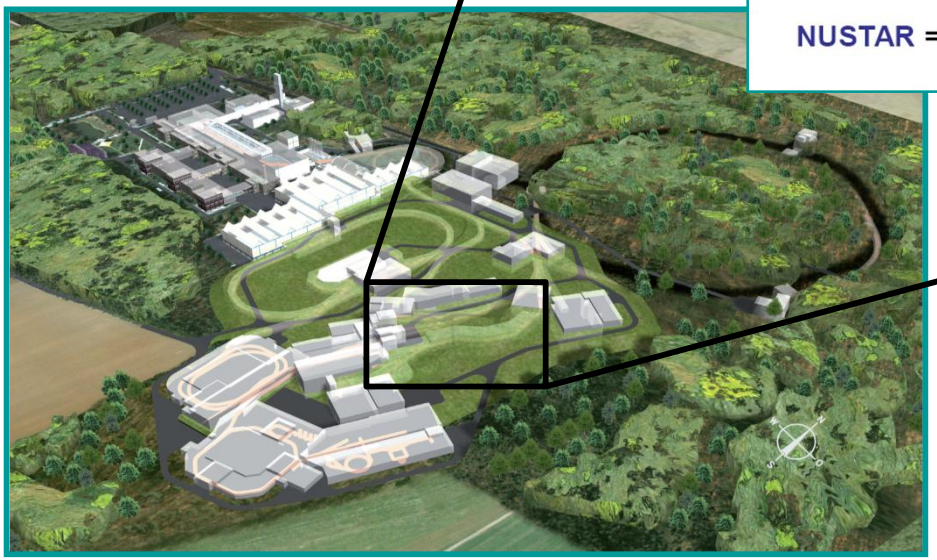
Projectile:
Elements p – U
Energy up to 1.5 GeV/u
Intensity up to 10^{12} /spill

Spot size on target:
σ_x= 1.0 mm
σ_y = 2.0 mm

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



NUSTAR = Nuclear Structure, Astrophysics and Reactions



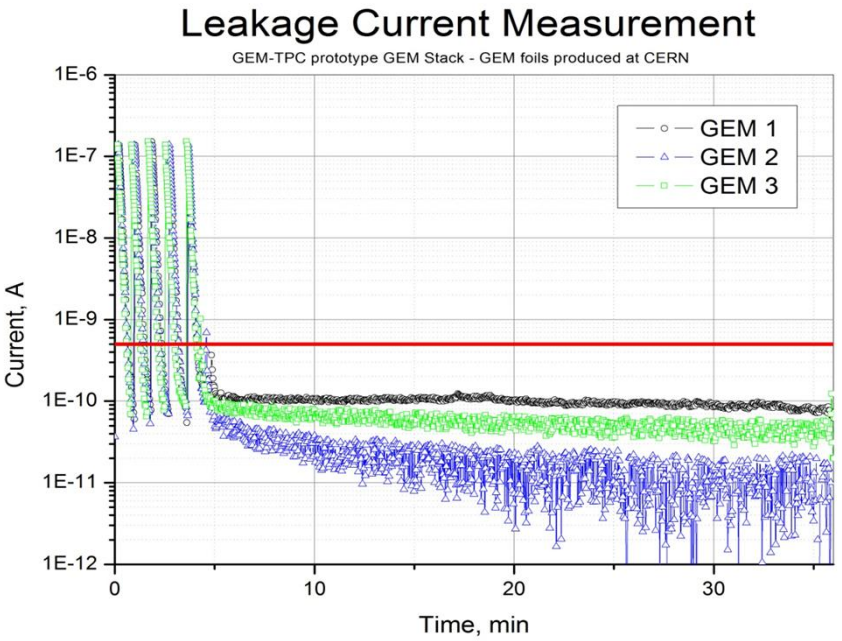
Time Table spans till end 2019

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

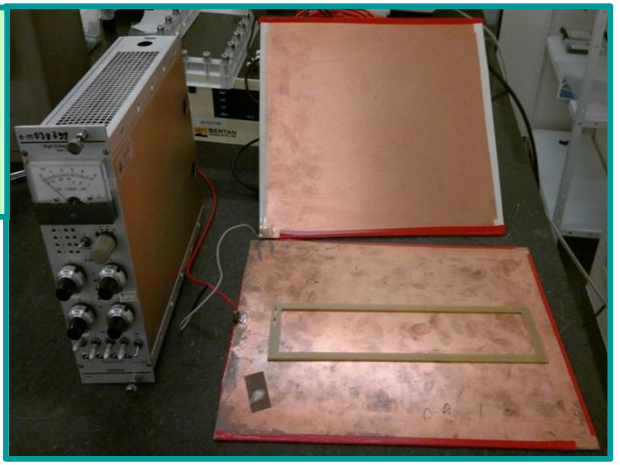
Part of the Finnish Contribution will be in Diagnostic systems, which is a work package dedicated to provide 36 GEM-TPC detectors.

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

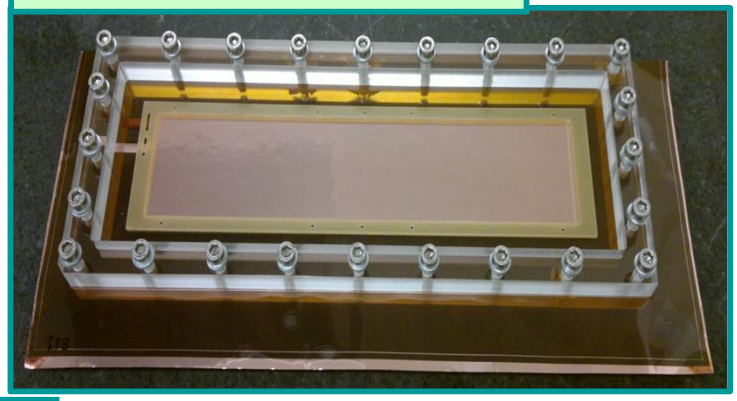
CHARACTERIZATION OF COMPONENTS

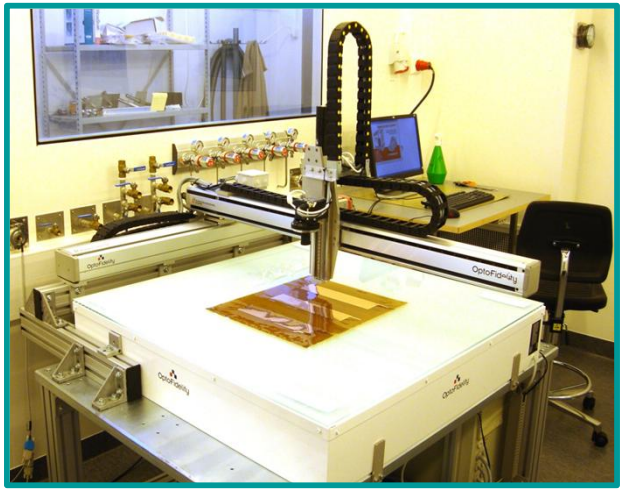


Electrostatic Test for all the frames @ 5 kV Possible breakdowns corrected with Nuvovern

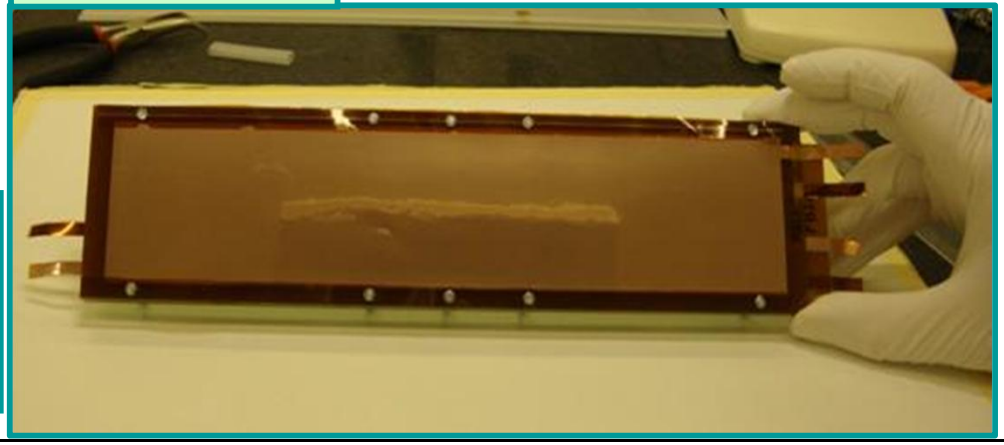


Top frame glued to the GEM foil



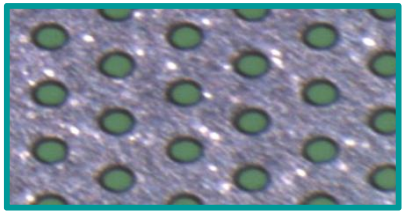


Triple GEM stack



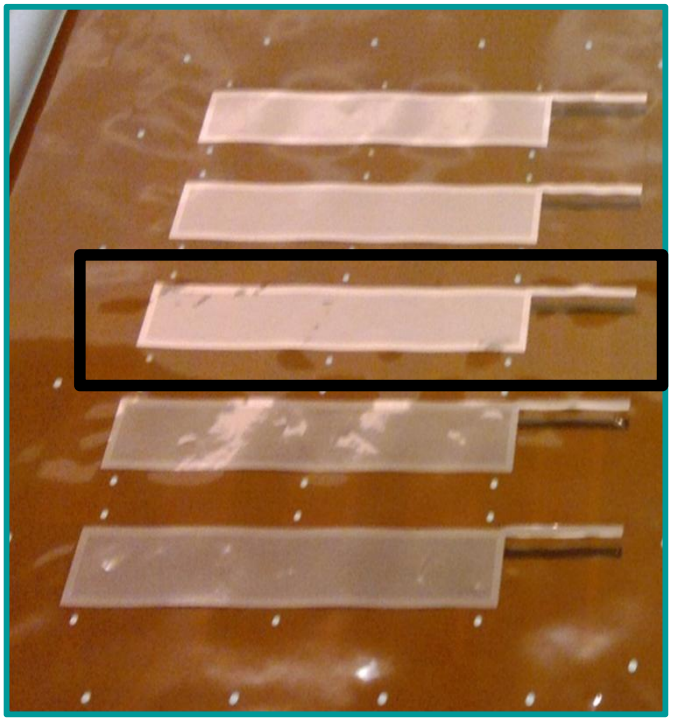
R. de Oliveira et al.

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



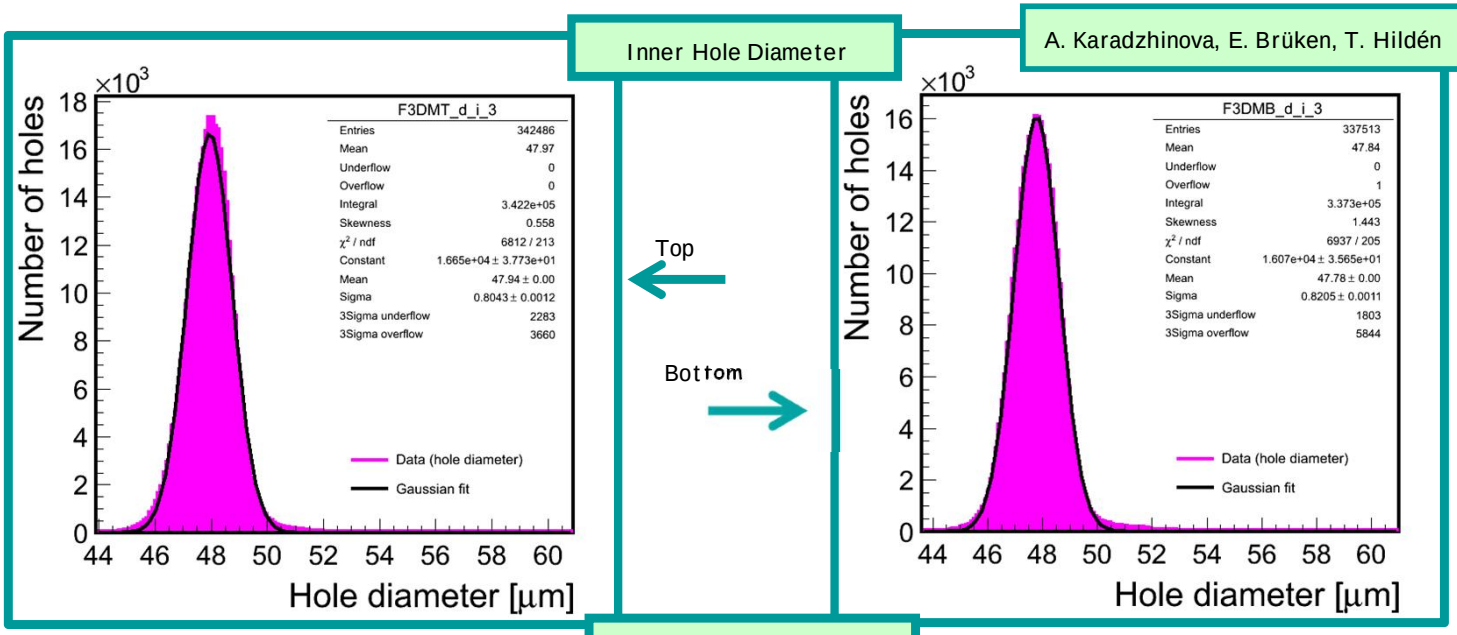
GEM OPTICAL CHARACTERIZATION

Optical Characterization for the SuperFRS GEM foils

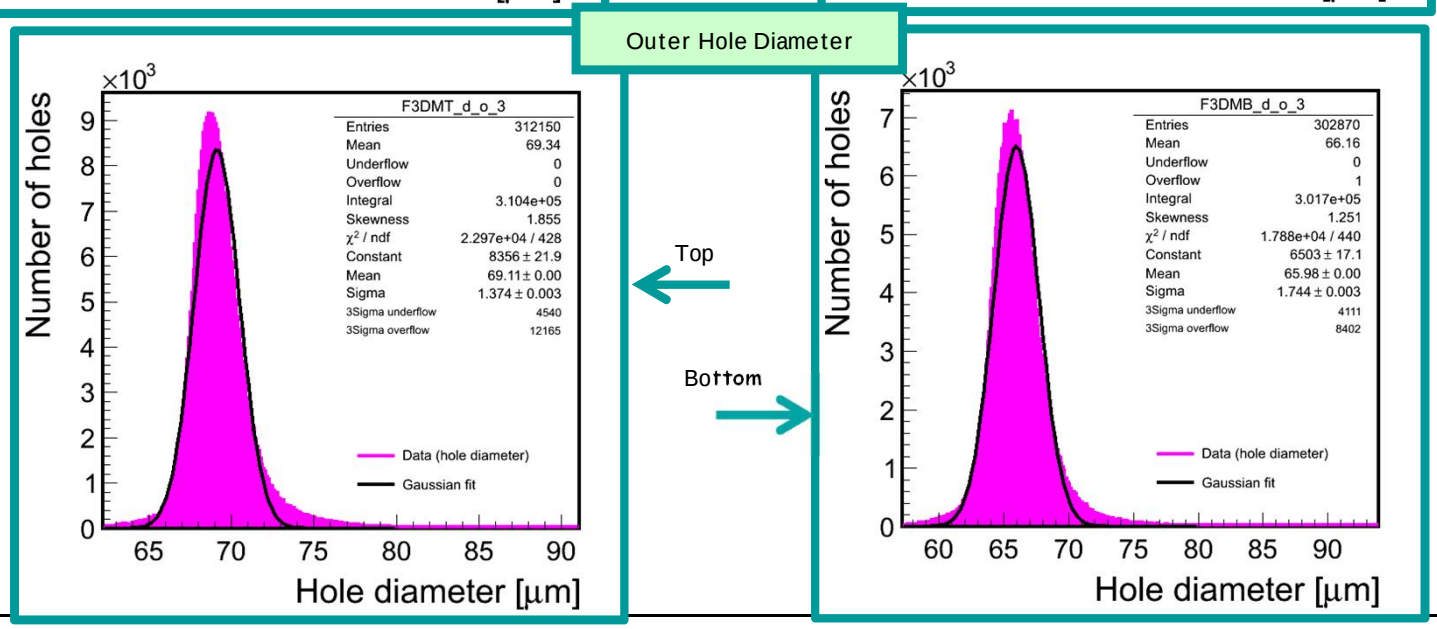


A. Karadzhinova, E. Brüken, T. Hildén

Inner Hole Diameter



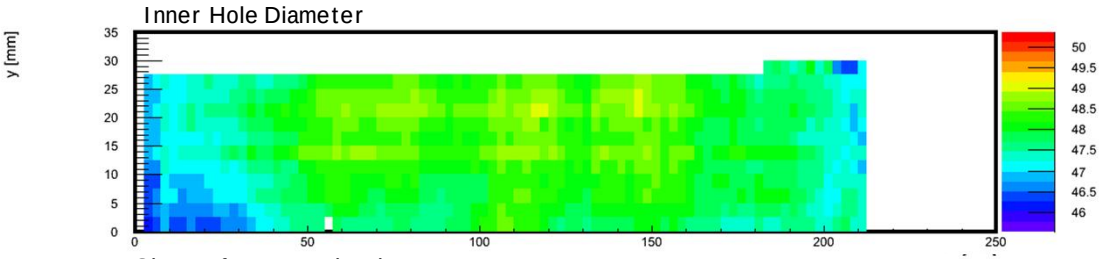
Outer Hole Diameter



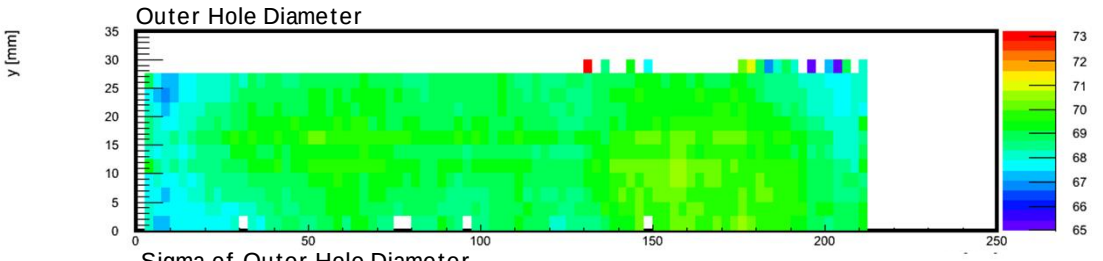
GEM OPTICAL CHARACTERIZATION (cont.)

Mapping for all the parameters per GEM foil and per side

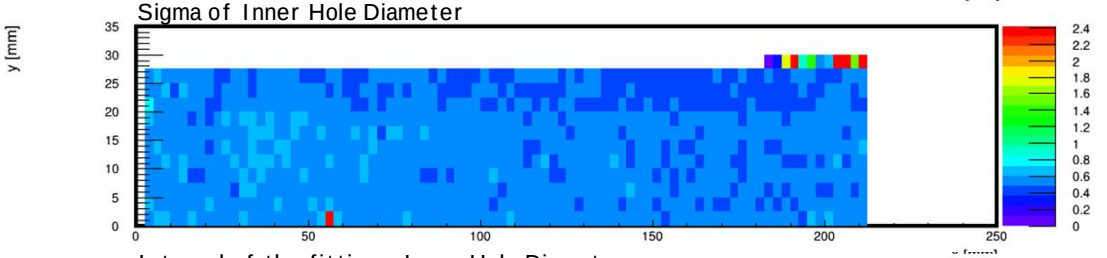
Inner Hole Diameter



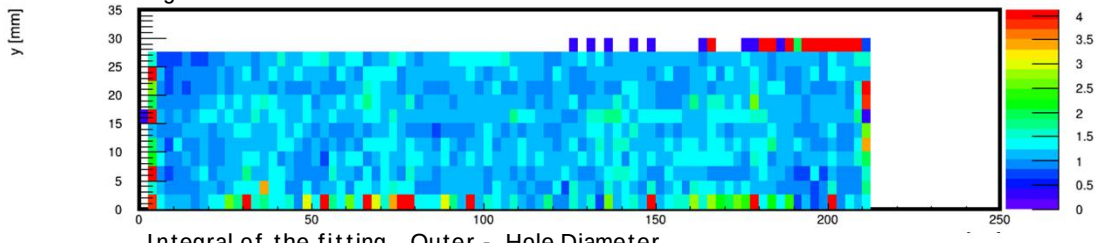
Outer Hole Diameter



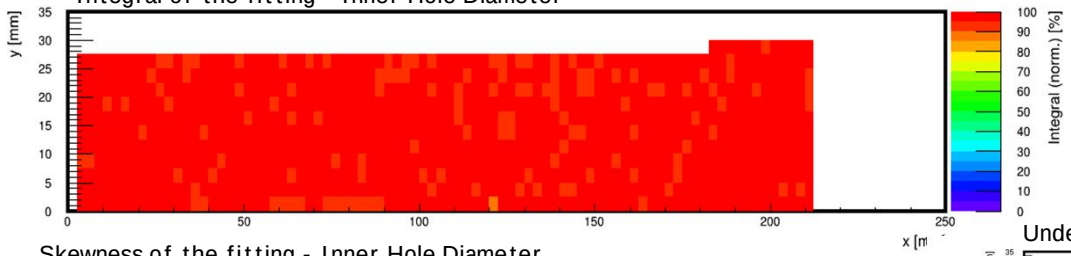
Sigma of Inner Hole Diameter



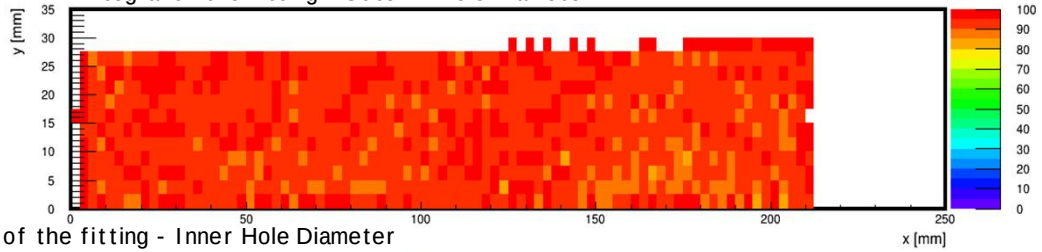
Sigma of Outer Hole Diameter



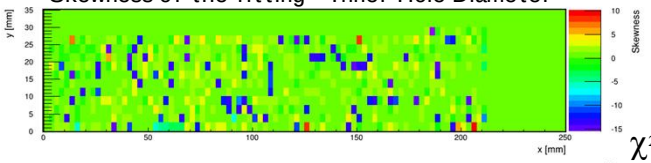
Integral of the fitting - Inner Hole Diameter



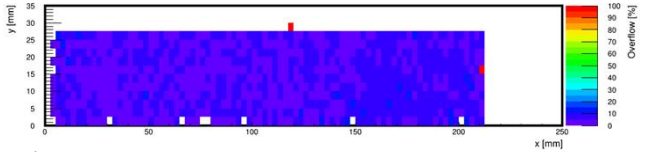
Integral of the fitting – Outer - Hole Diameter



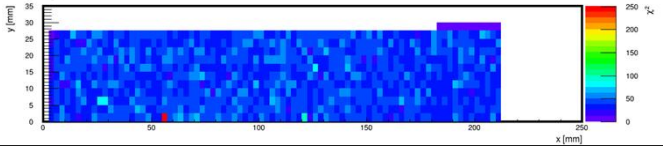
Skewness of the fitting - Inner Hole Diameter



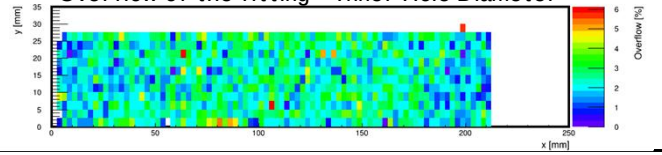
Underflow of the fitting - Inner Hole Diameter



χ^2 of the fitting - Inner Hole Diameter

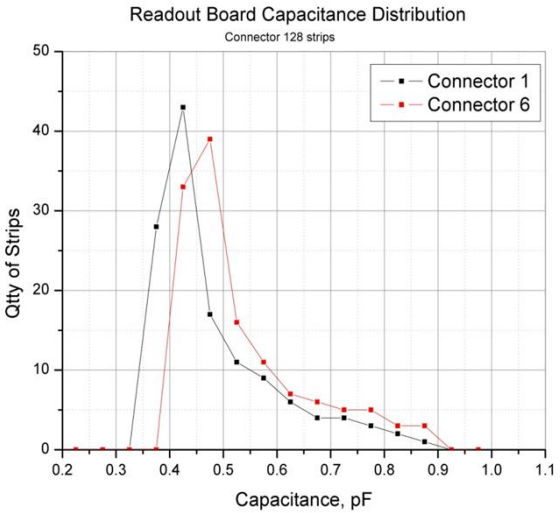


Overflow of the fitting - Inner Hole Diameter

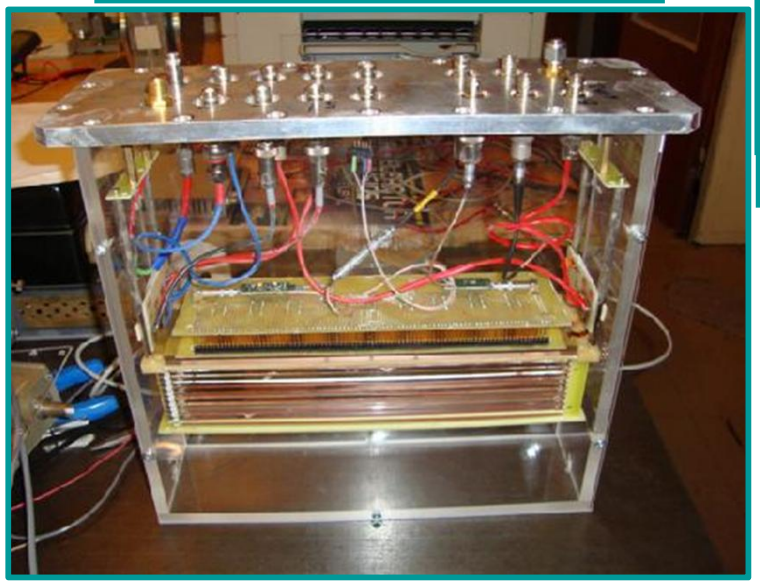


PROOF of CONCEPT for GEM-TPC, PROTOTYPE HB1

Capacitance measurement setup

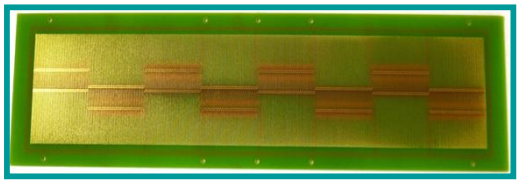


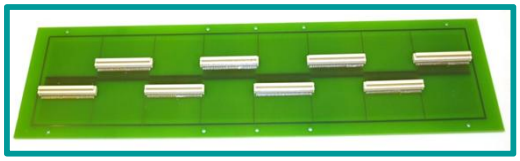
Flange of the GEM-TPC HB1, read out by delayed lines



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





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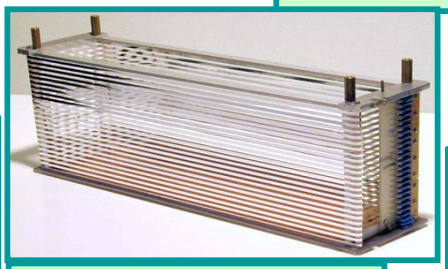
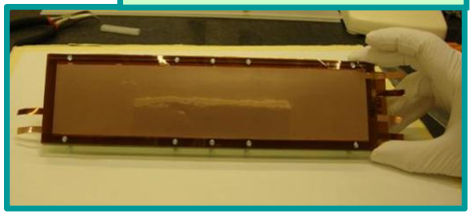
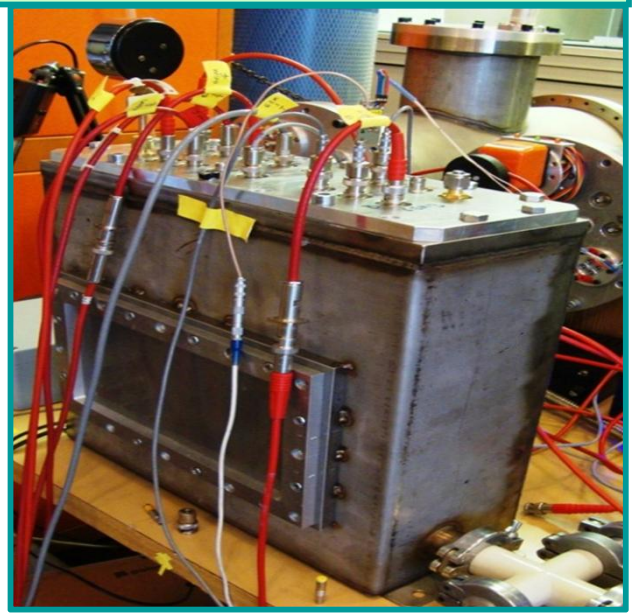


Field cage of 60 mm drift

Triple GEM stack

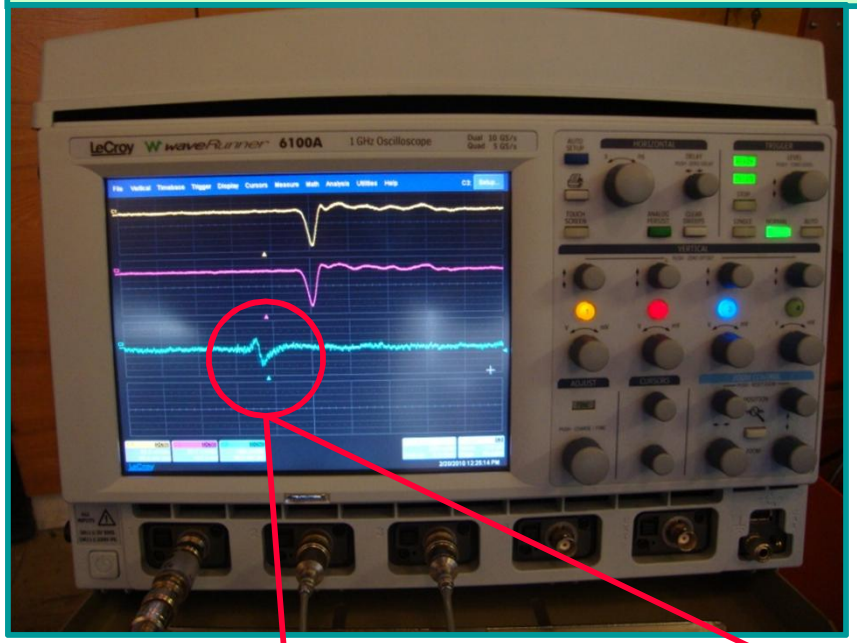


First GEM-TPC called HB1 detector (Helsinki Bratislava prototype 1)



LAB. COMMISSIONING of HB1

GEM-TPC test in lab at Comenius University



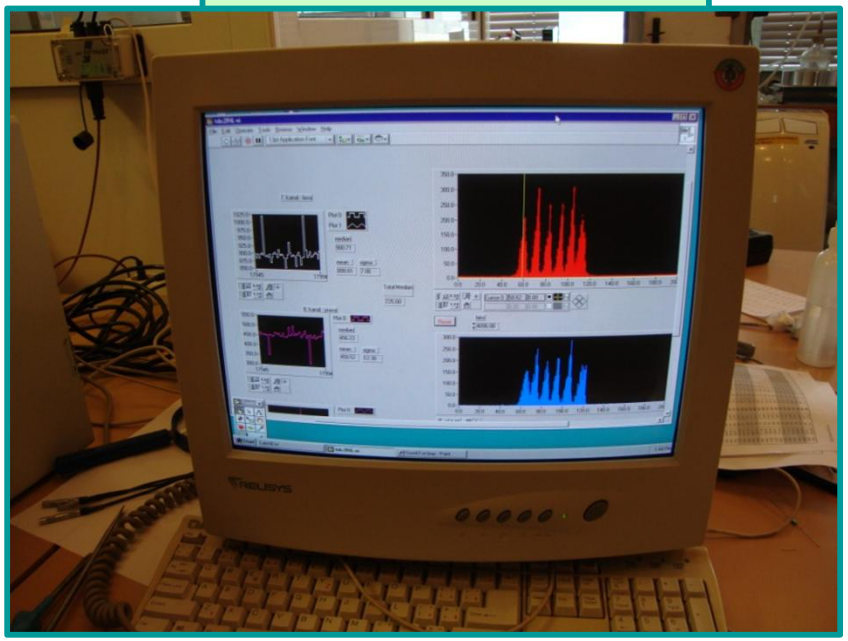
It can be observed:

- 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 loses in the GEM 3

Trigger Signal before reshaping

Trigger Signal with rise and decay time reshaped

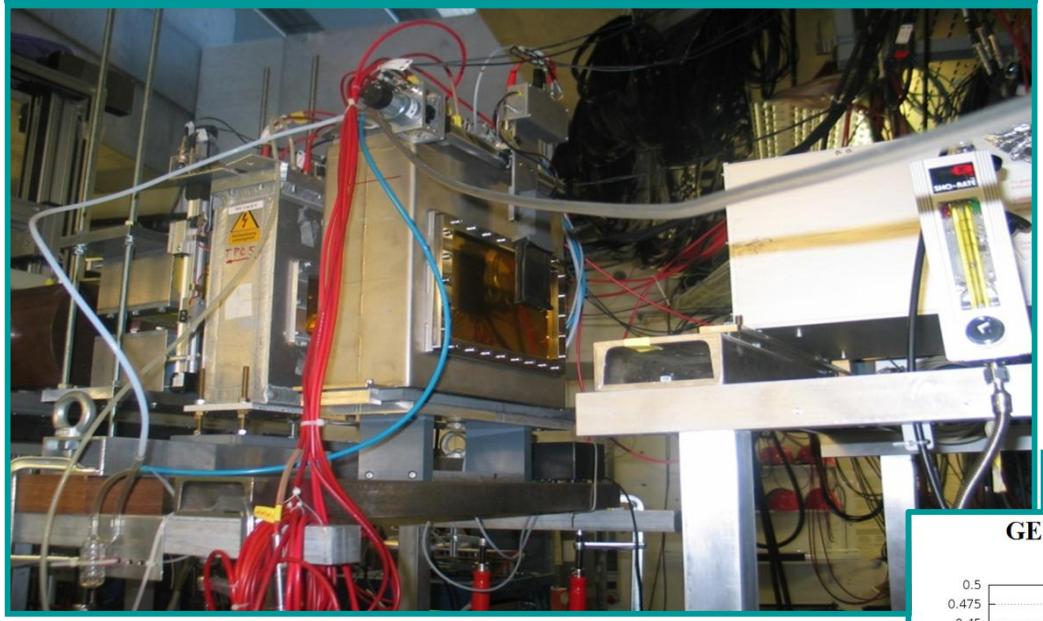
GEM-TPC tracking capabilities for ^{55}Fe

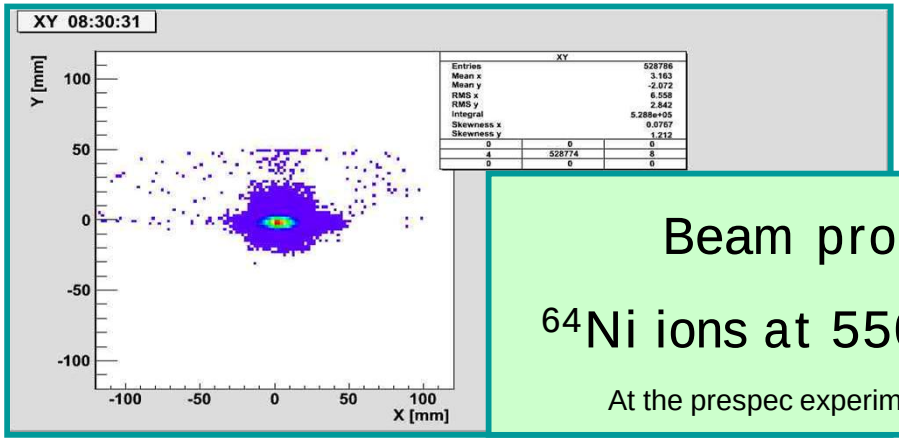


In the picture above there are multiple picks from the different source positions.
The source was not very well collimated therefore a mm scale resolution on X was achieved and the trigger was taken from the bottom of the GEM3

BEAM TEST of HB1 at GSI

GEM-TPC Beam test at GSI - Darmstadt

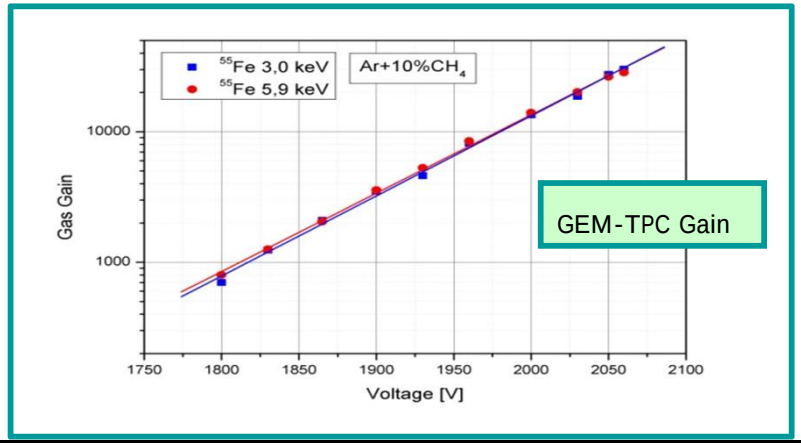




Beam profile

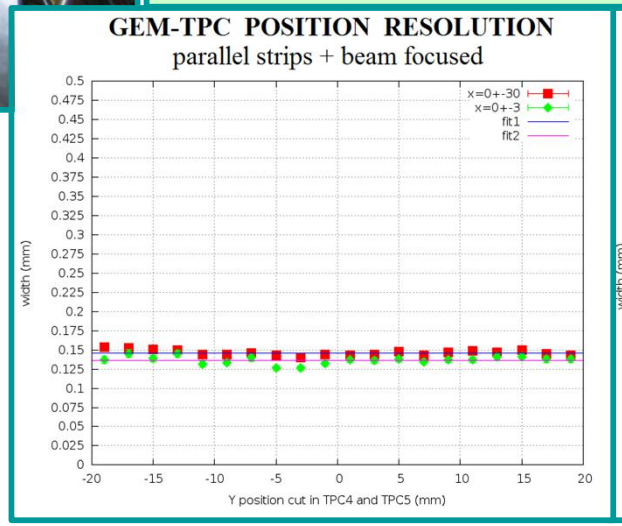
^{64}Ni ions at 550 MeV/u

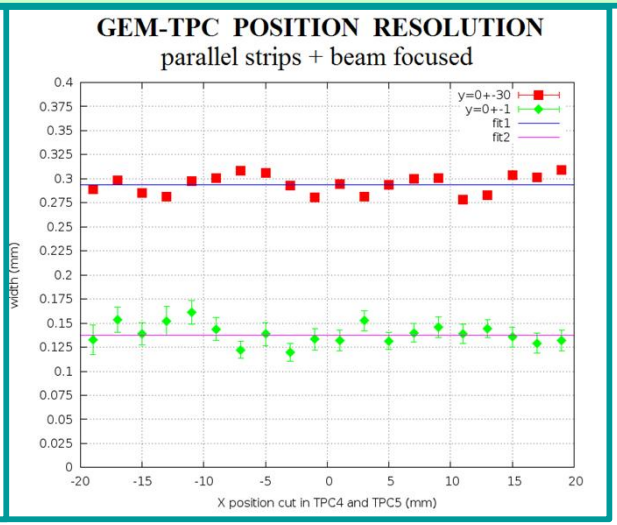
At the prespec experiment - S363



GEM-TPC Gain

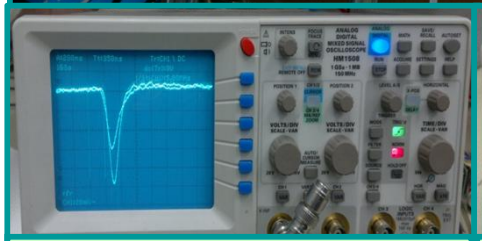
The GEM-TPC shows that the resolution in Y (Drift) reaches value around 130 μm and on X between 130 to 300μm





BEAM TEST of HB2/HB3 at GSI

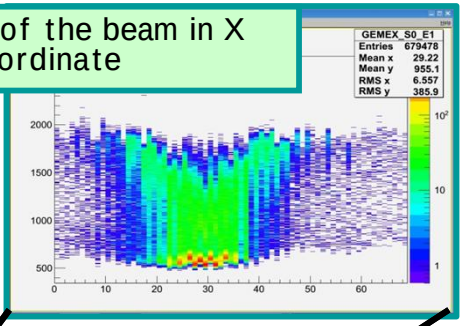
HB3 @ S2 and ready to take the Beam of ^{197}Au at 770 MeV/u



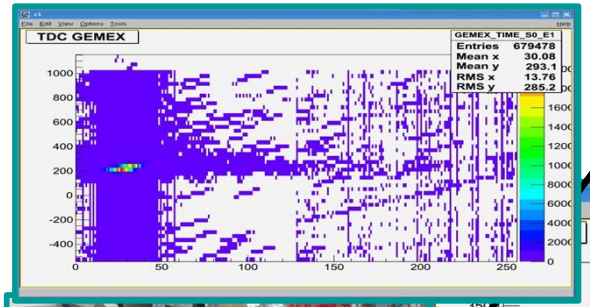
^{55}Fe Signals in the Lab

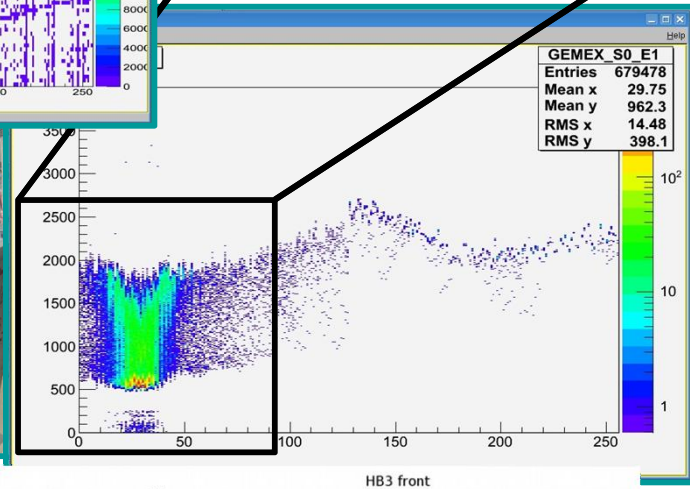
Noise of 32 MHz from Explode clock in the trigger lines

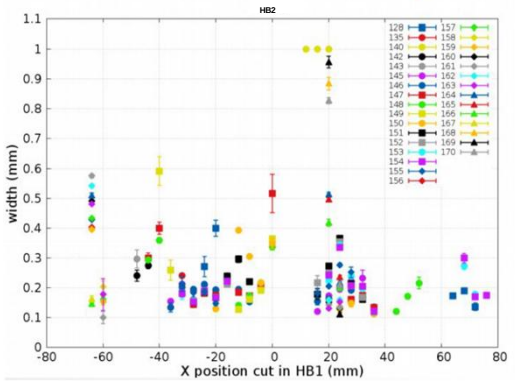
Projection of the beam in X coordinate

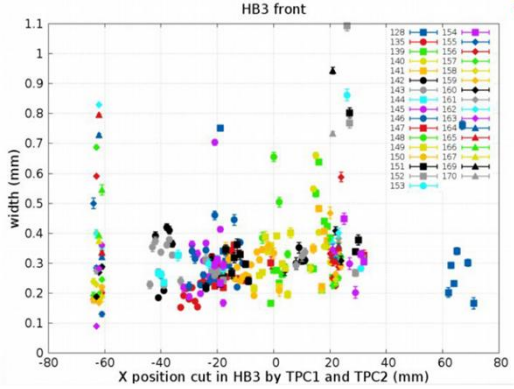


Projection of the beam in Y coordinate

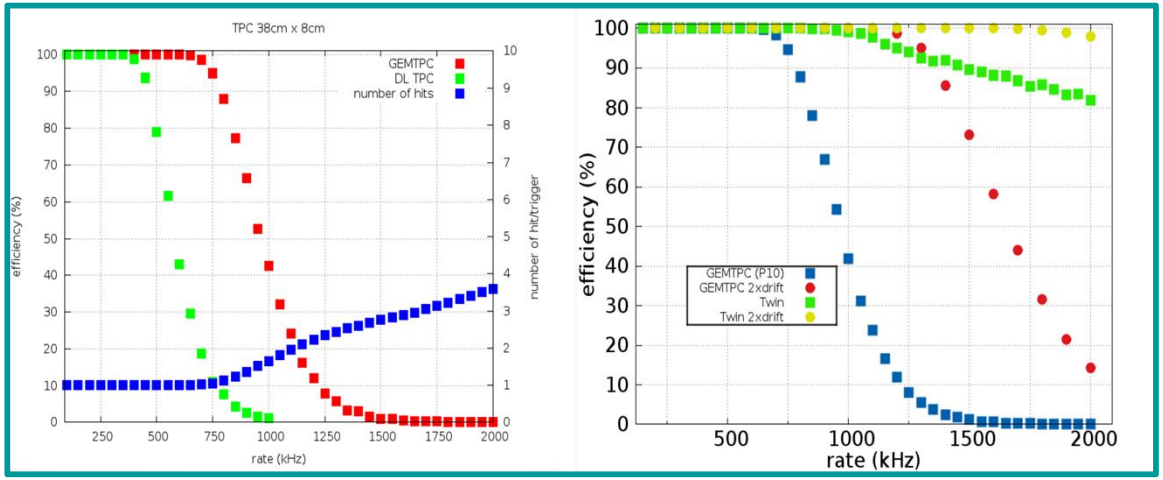


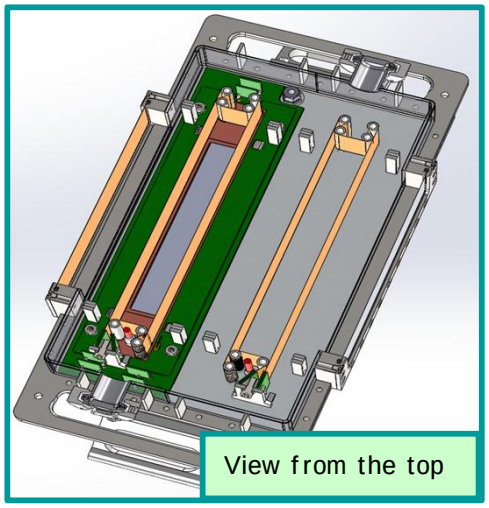


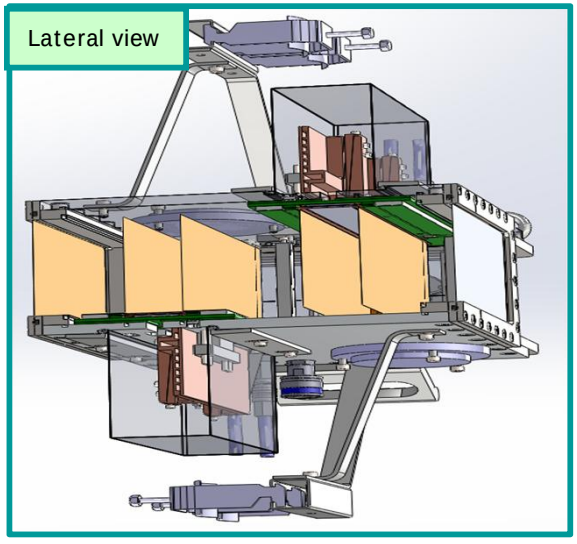


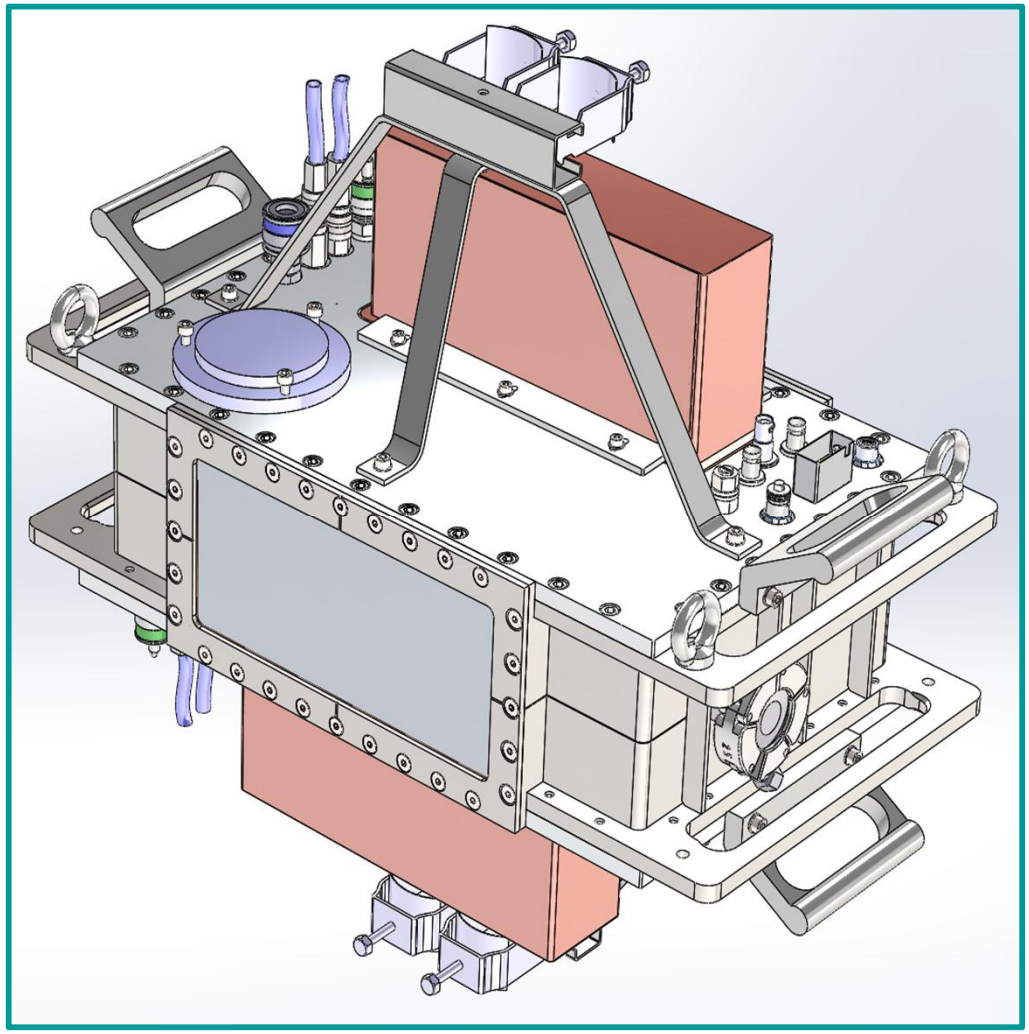


TWIN GEM-TPC SIMULATIONS and DESIGN







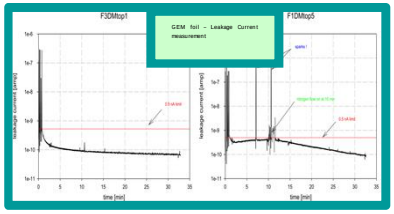


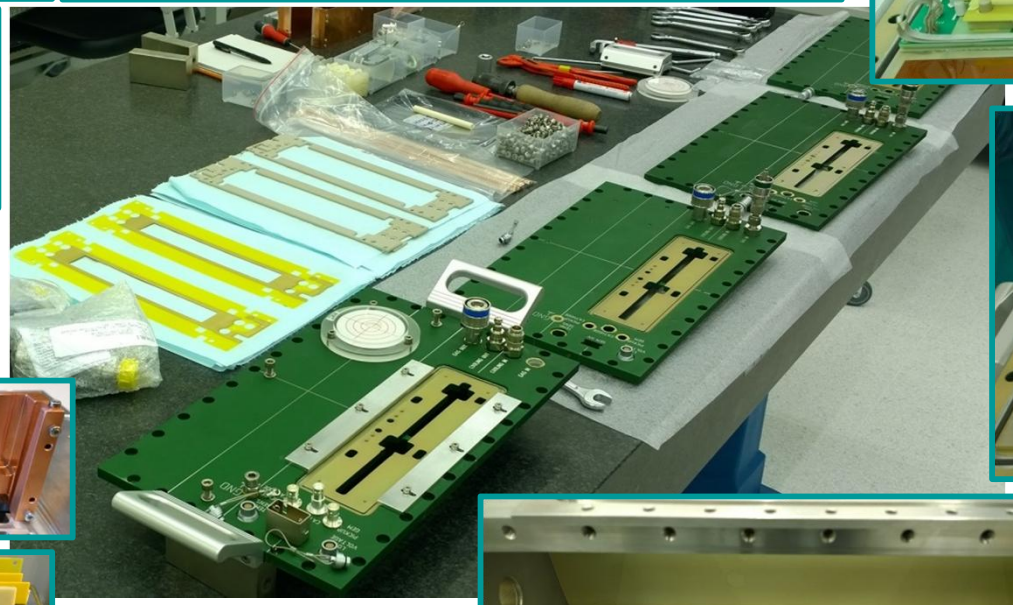
Efficiency Plots simulations for the GEM-TPC equipped with Delayed lines and with GEMEX readout for the case of P10 and a faster gas. The twin GEM-TPC using a 1.6 μs time window and a 21 ns check sum can reach 1.75 MHz

Twin GEM-TPC – HGB4 Assembling

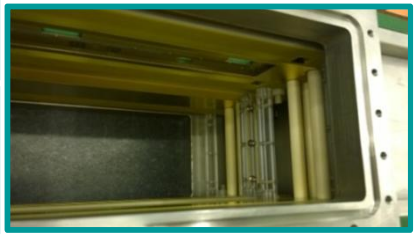
GEM foil Framing –Frascati stretcher

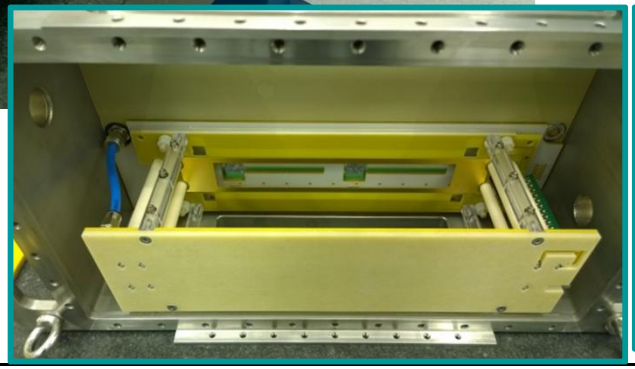
G. Bencivenni

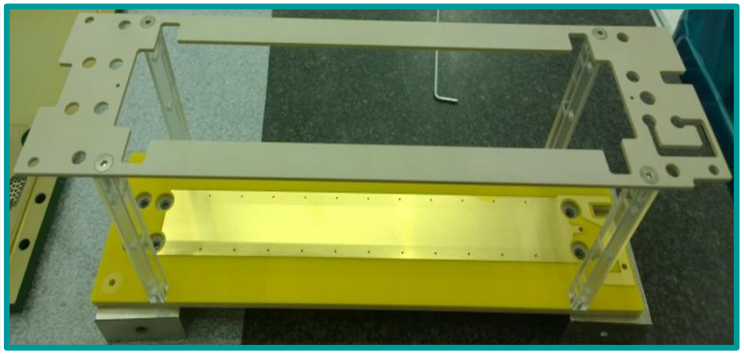




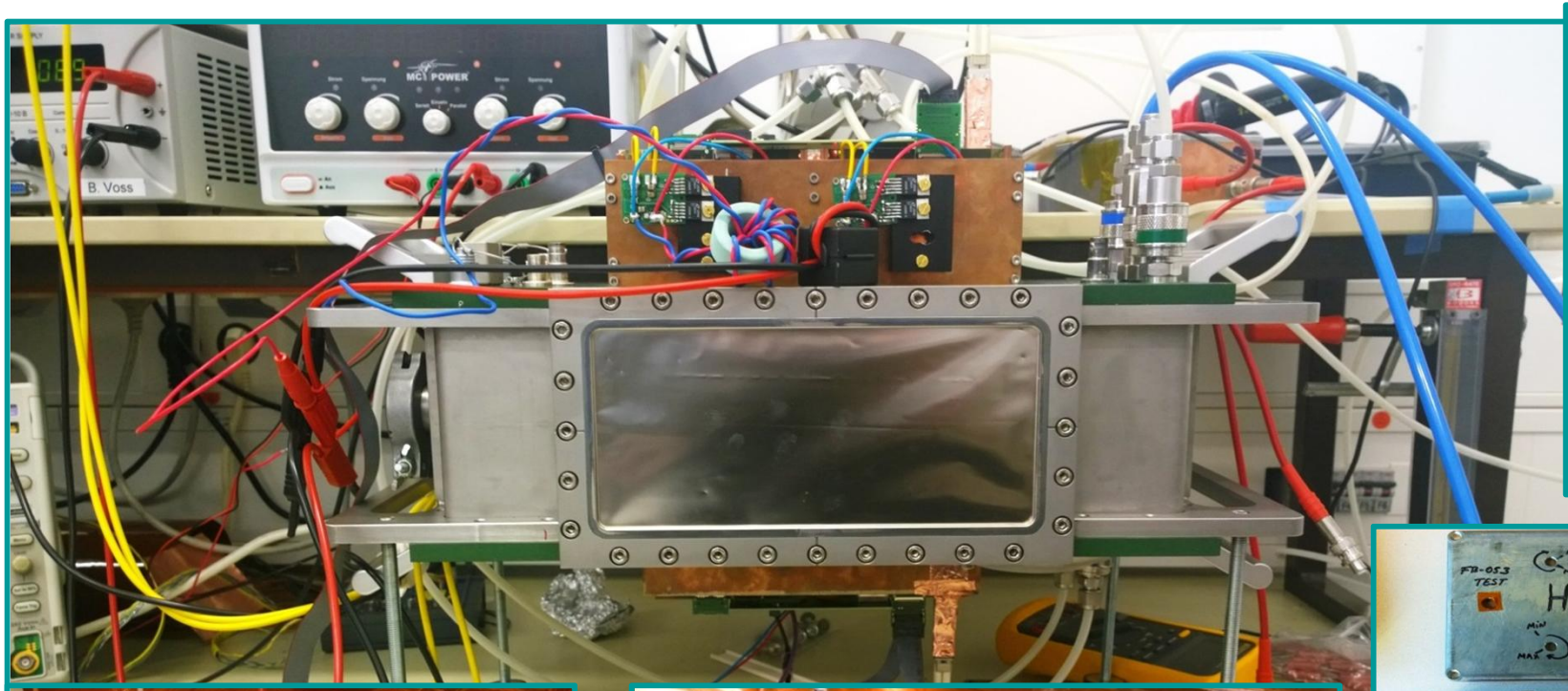
Twin GEM TPC Components

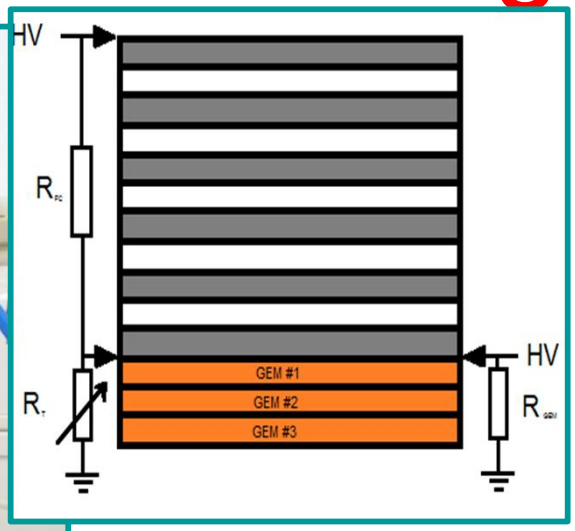


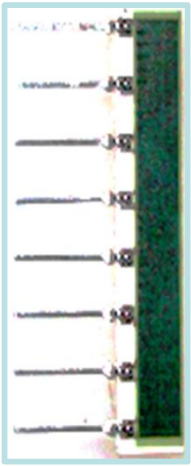


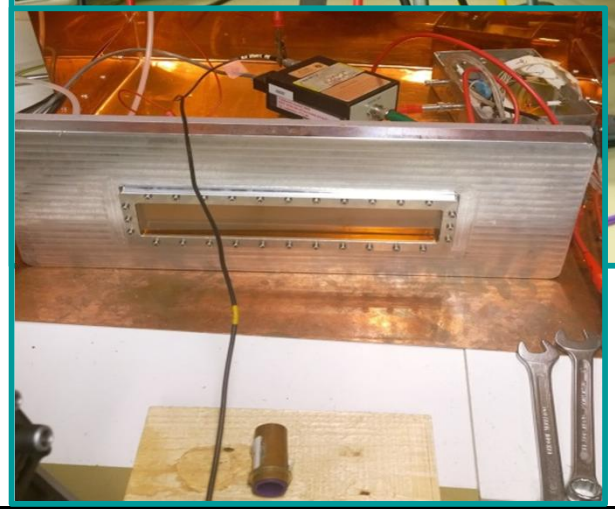


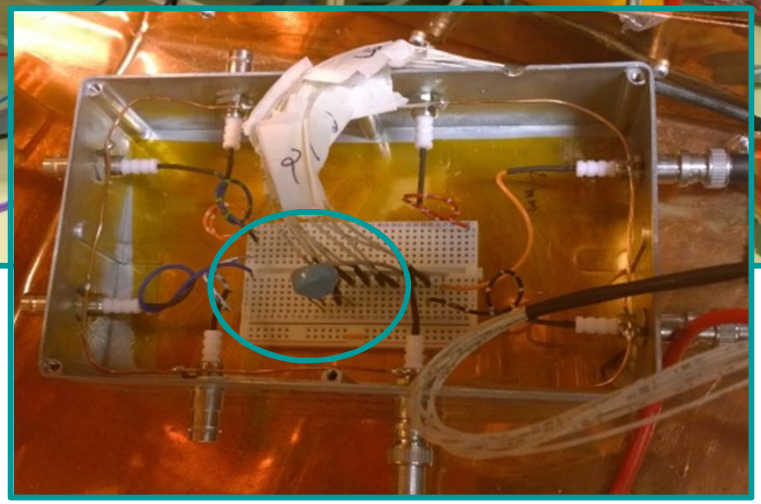
Twin GEM-TPC – HGB4 Commissioning

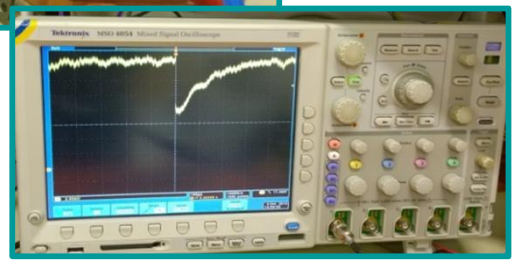






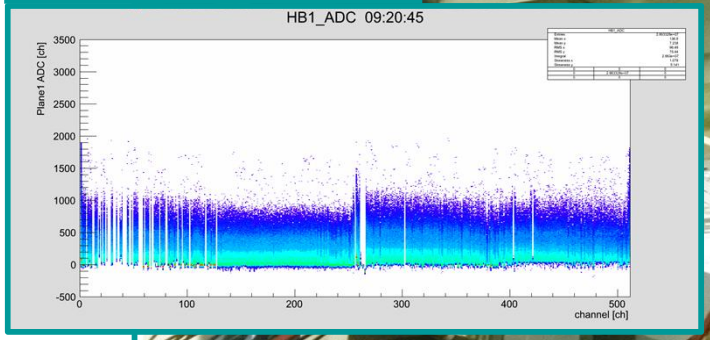






Twin GEM-TPC – HGB4 Beam test

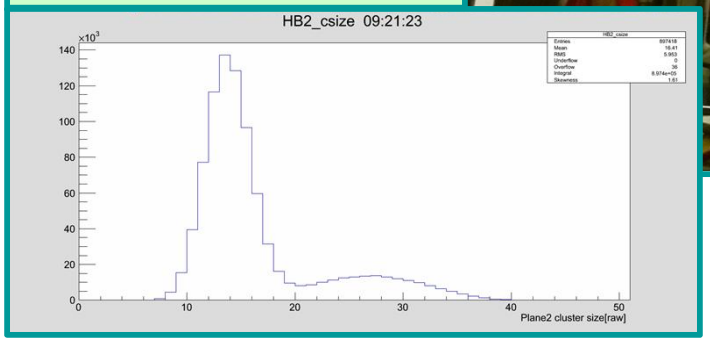
Hits on the X coordinate



Projectiles: ^{238}U @ 330 MeV/u Master Trigger from Sofia experiment was taken

Correlation hits on X of front and back field cages

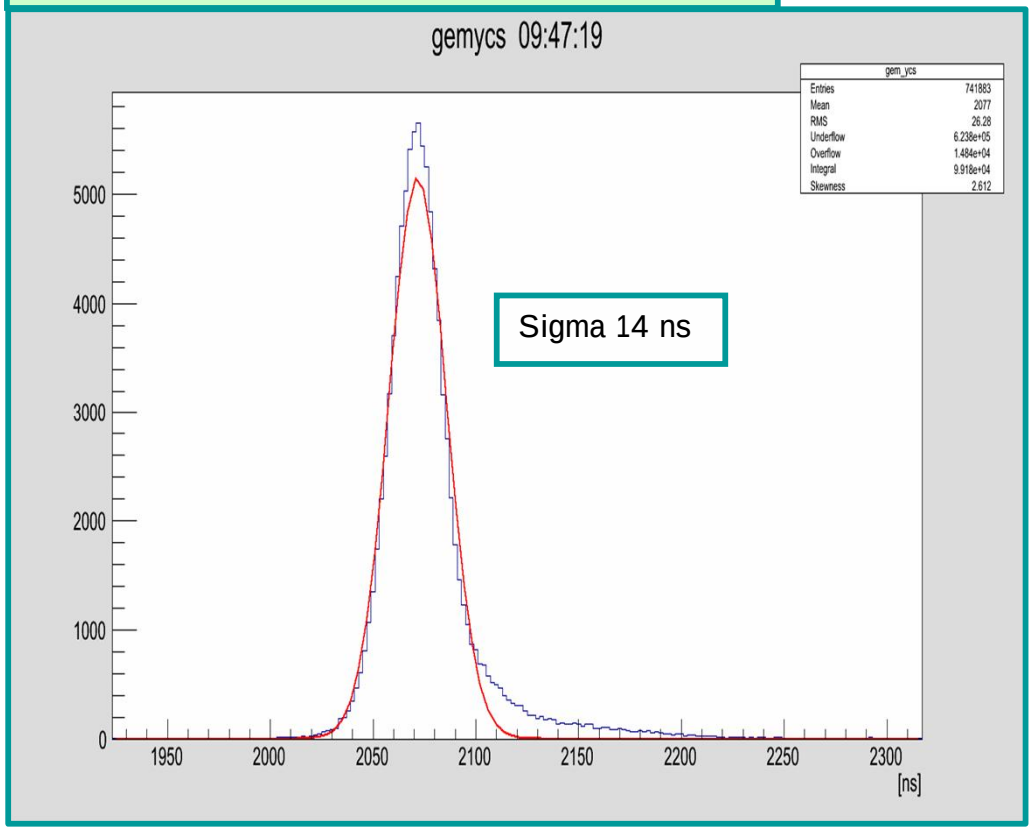
Cluster size from triggers

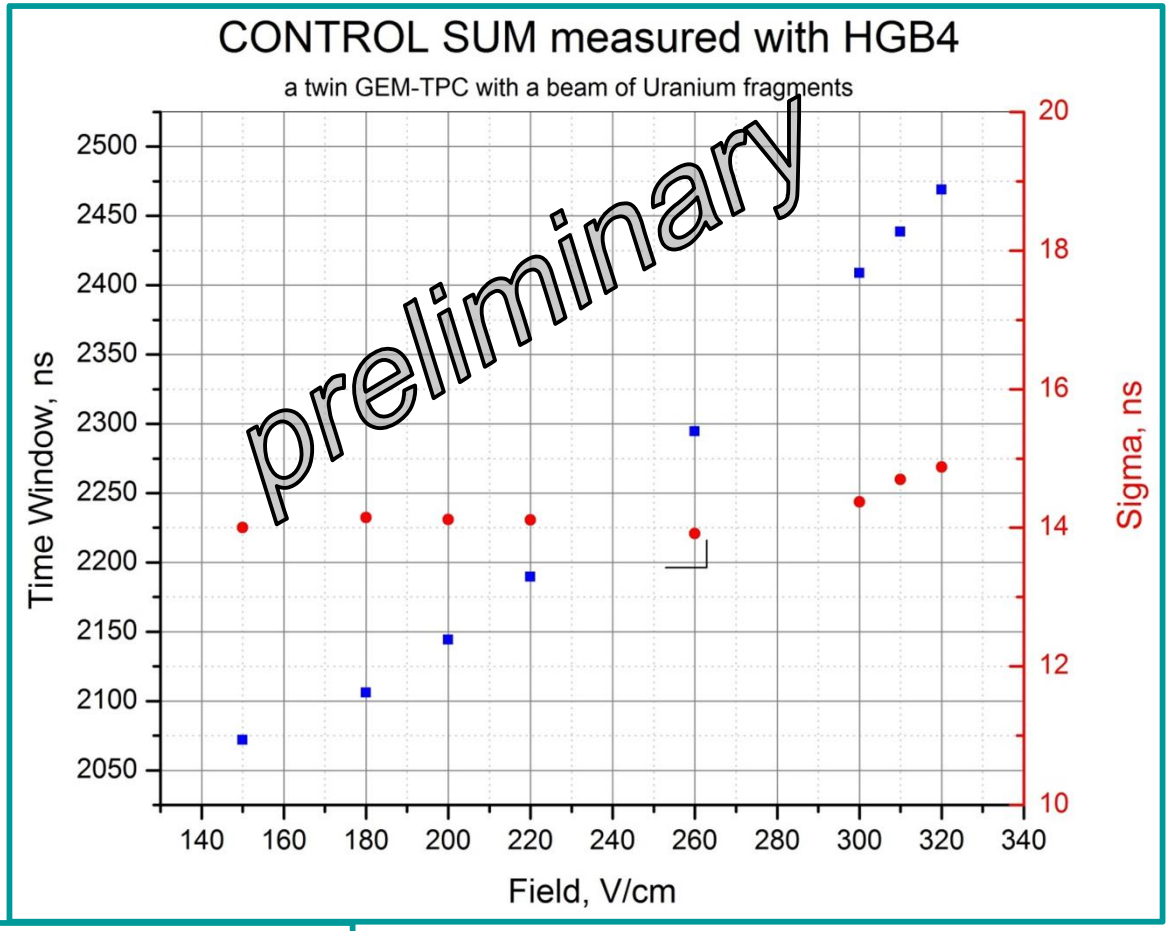


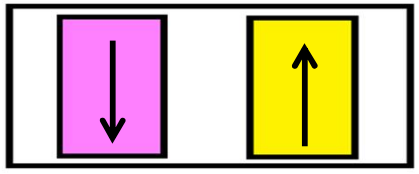
Hits on Time Y coordinate

HGB4 CONTROL SUM

Hits distribution for a field of 150 V/cm







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 HGB4 prototype was tested at GSI and shows that the twin concept combined with GEM-TPC has a lot of potential to cope with tracking at high rate
- The readout electronics GEMEX card need to be refurnished in order to be able to operation it
- Optimization of the Pick up signal from the Bottom of Third GEM is needed

- Many thanks to the FRS people and special thanks to C. Nociforo, P. Stephane, K. Heinz and H. Simon
- Many thanks to the shifters of Cave C at GSI
- Special thanks to the Sofia experiment guys and in particular to J. Taieb

Thank you for your Attention