Status Report of the Prototype Development of a GEM-TPC for the SuperFRS

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OUTLINE

- Introduction and Motivation
- GEM Technology and Characterization
- First GEM-TPC Prototype HB1 – Tests
- Status of the Prototype HB2 – AFTER and Prototype HB3 – Xyter Readout electronics
- Tasks Schedule for 2011
- Todo

INTRODUCTION

FAIR is 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

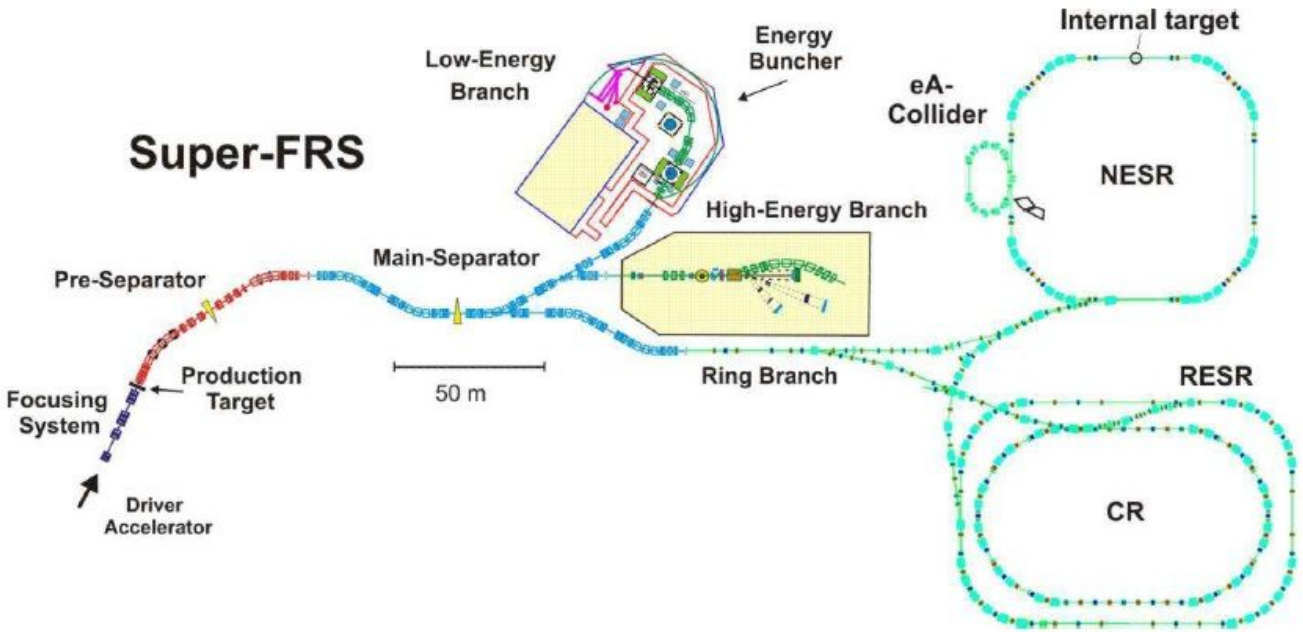
Time Table spans till end 2018

MOTIVATION

NUSTAR collaboration (Nuclear Structure, Astrophysics, and Reactions) has more than 700 members in total.

Part of the Finnish Contribution will be in the superconducting in-flight separator (Super-FRS) Diagnostic systems, which is a work package dedicated to provide 36 GEM-TPC detectors

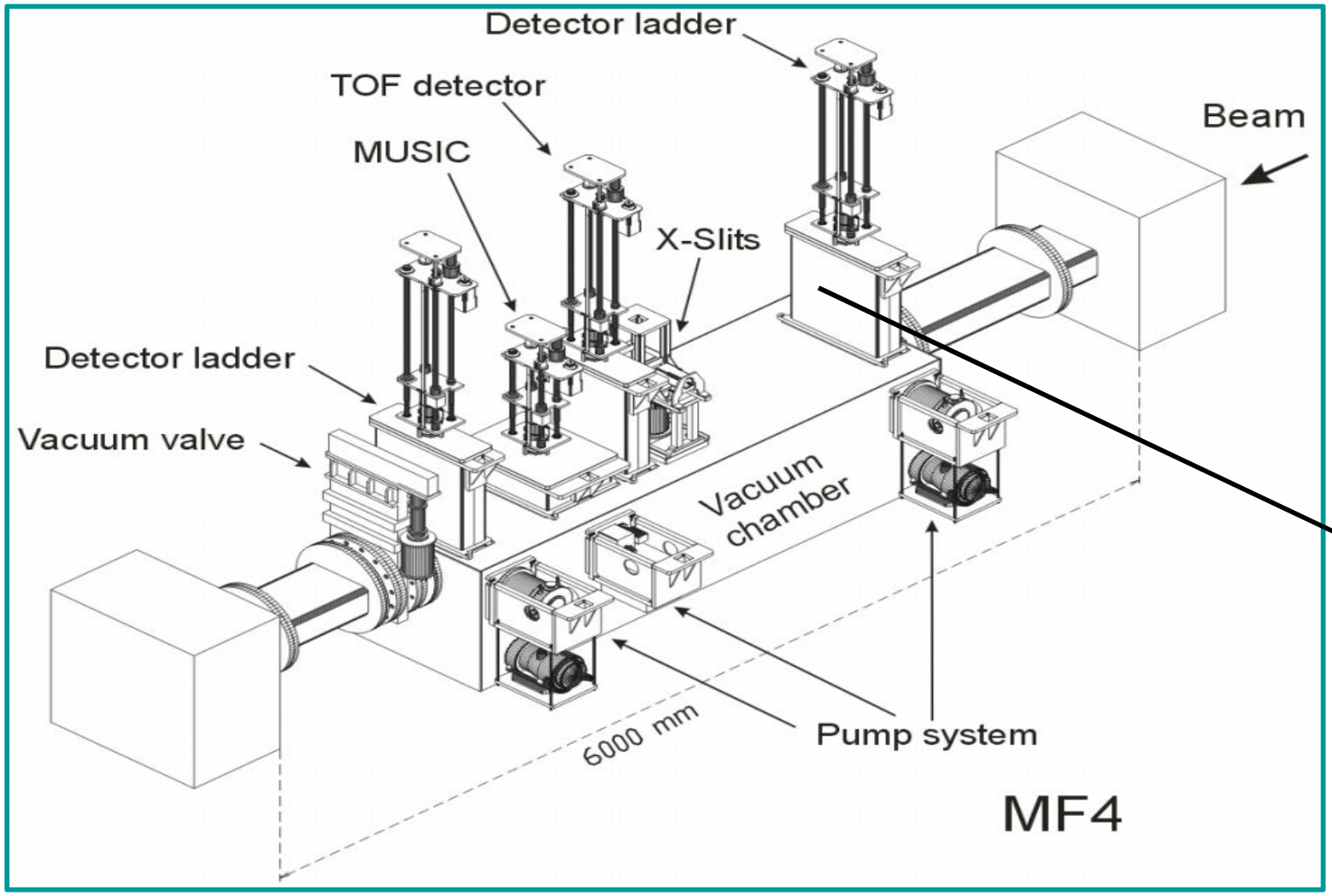
The NUSTAR Facility at FAIR
(The 3 Branches of the Super-FRS)

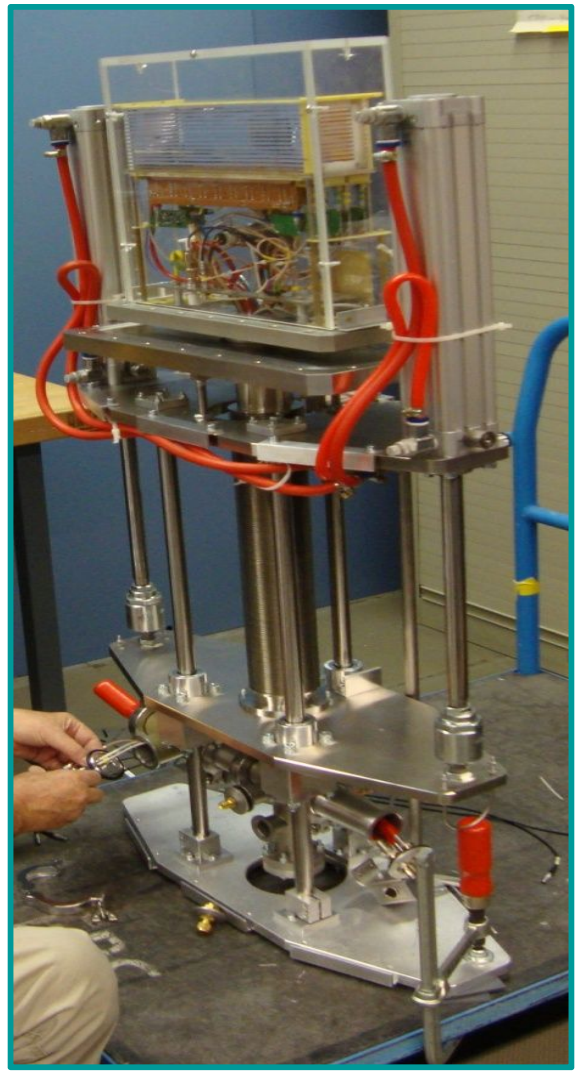


NUSTAR = **Nu**clear **S**tructure, **A**strophysics and **R**eactions

MOTIVATION (cont.)

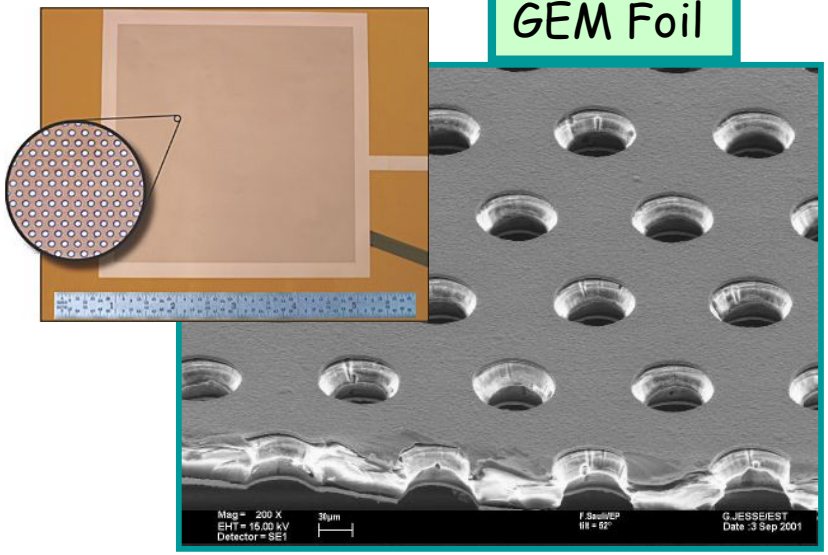
DIAGNOSTIC SYSTEM STATION



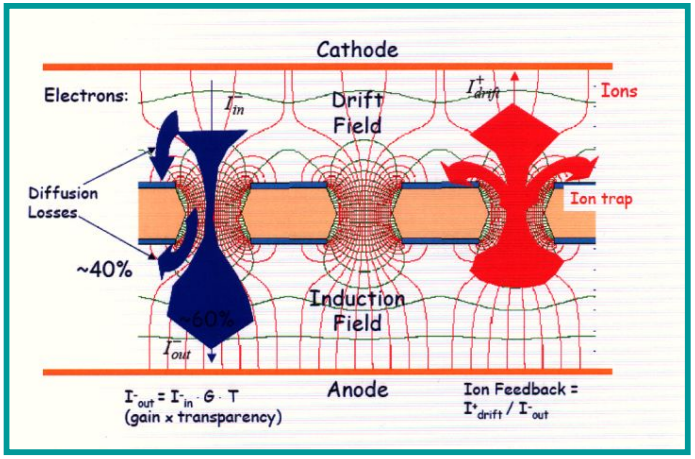


GEM TECNOLOGY and CHARACTERIZATION

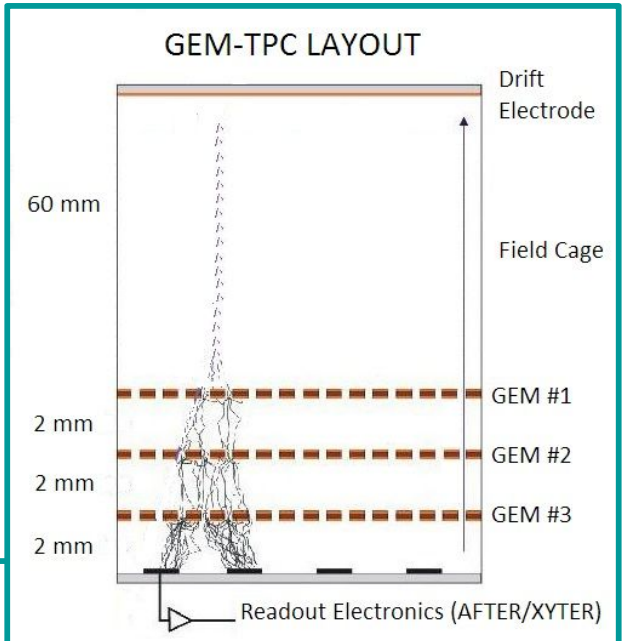
GEM Foil



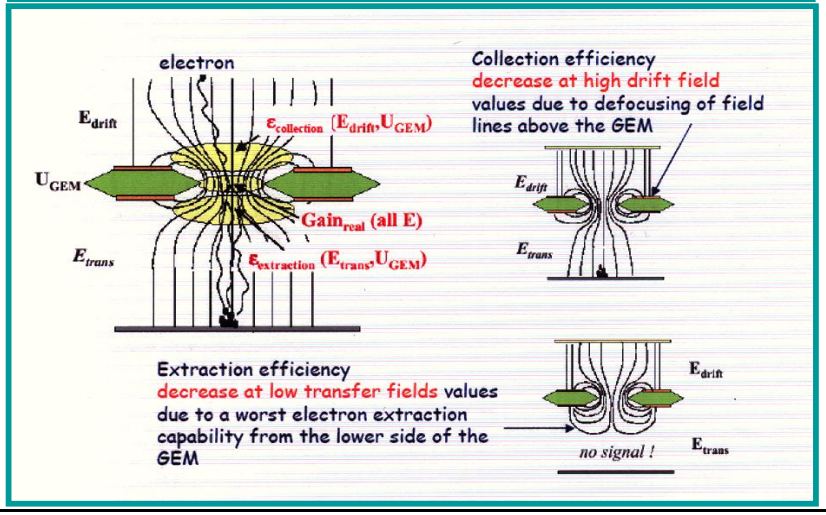
GEM Operation Principle

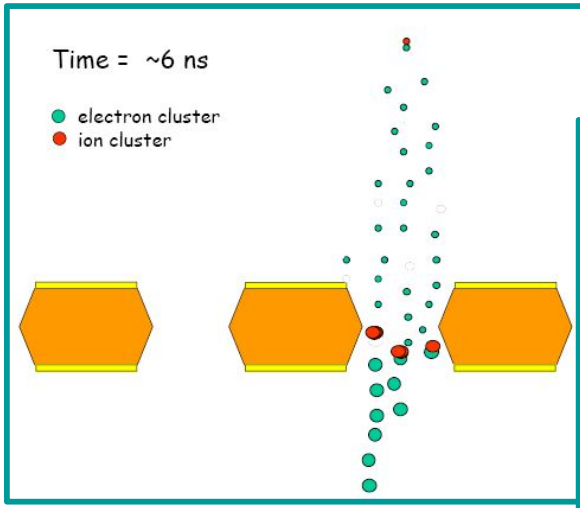


GEM-TPC LAYOUT

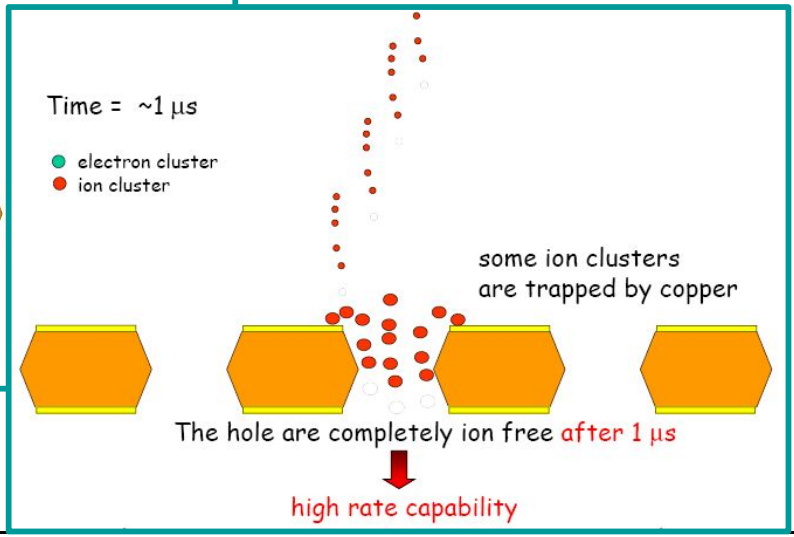


Extraction of the Electron Cloud and Signal Induction



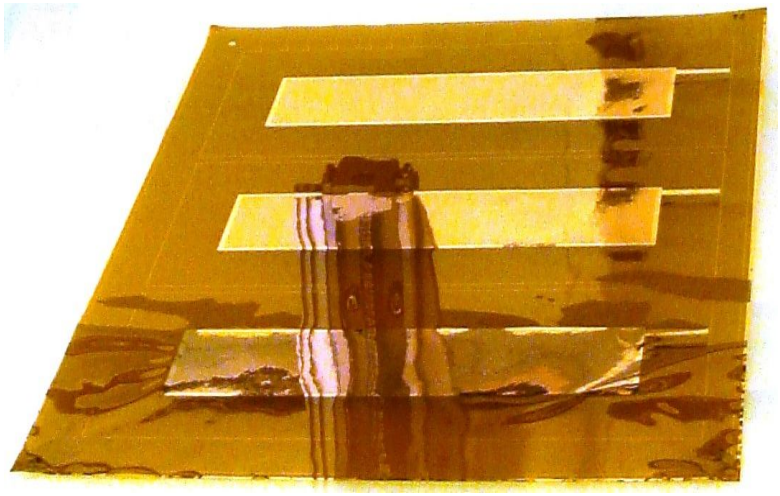


Avalanche development in time domain



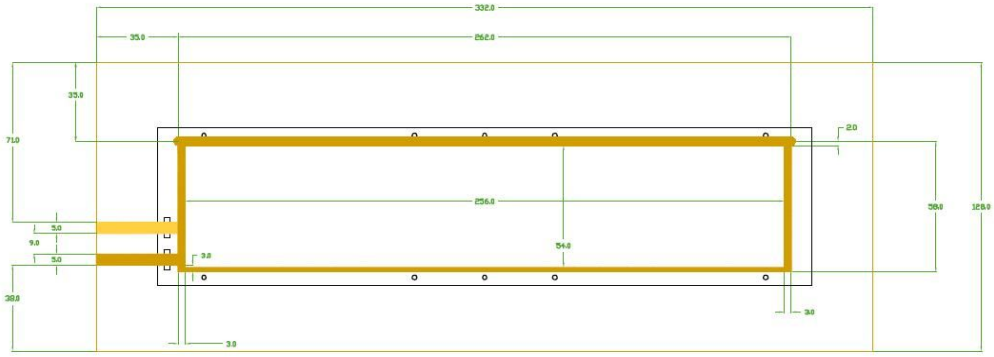
GEM TECNOLOGY and CHARACTERIZATION (cont.)

GEM mask designed at HIP and manufacture at CERN – workshop (Rui de Oliveira)

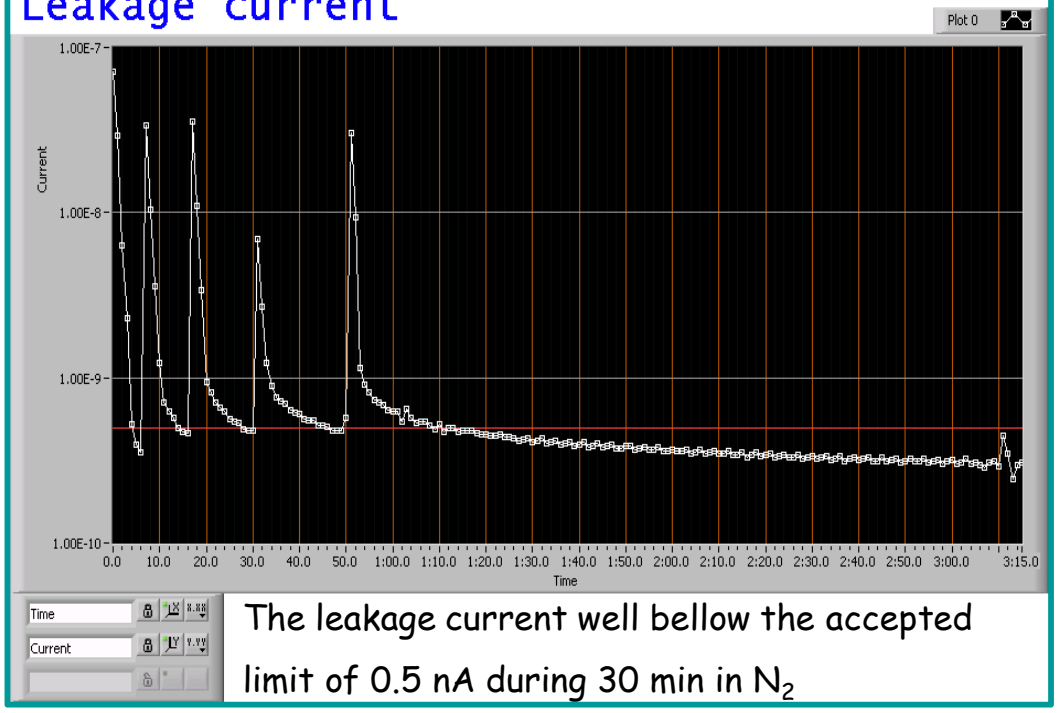


GEM Foil

First GEM mask

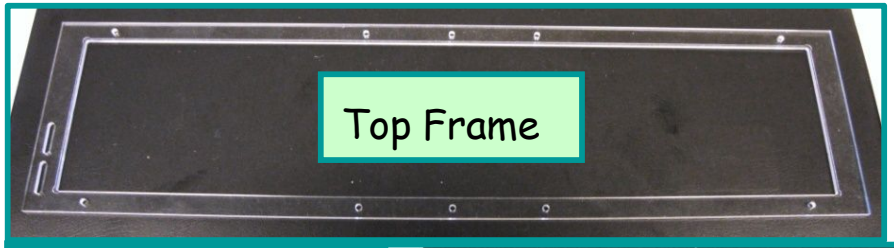


Leakage current

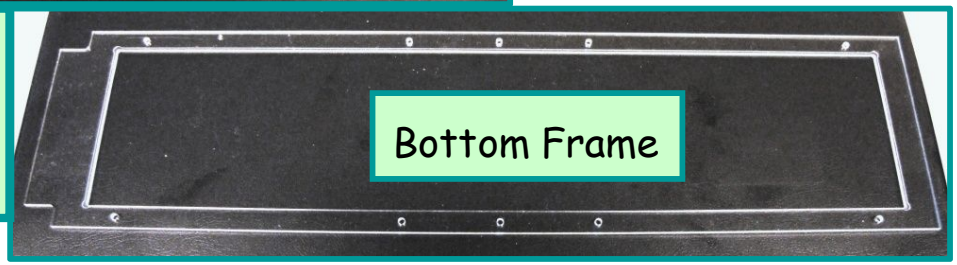


The leakage current well bellow the accepted limit of 0.5 nA during 30 min in N_2

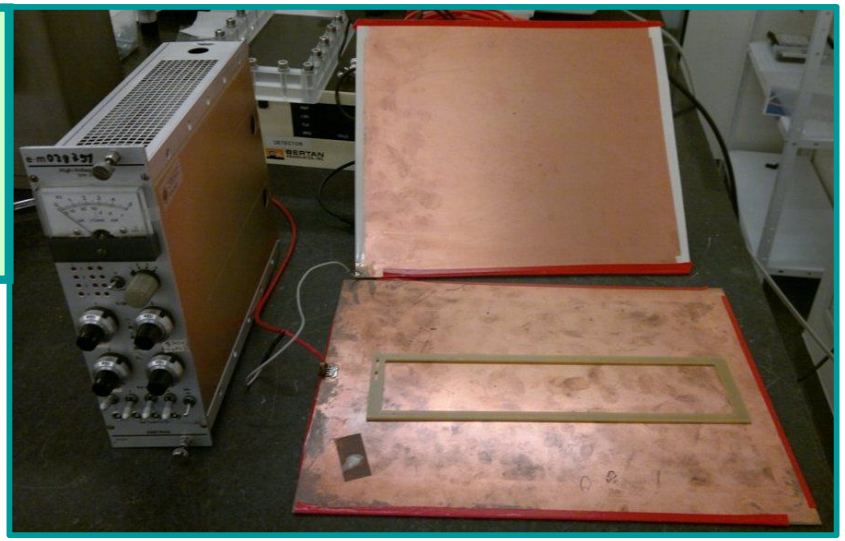
GEM TECNOLOGY and CHARACTERIZATION (cont.)



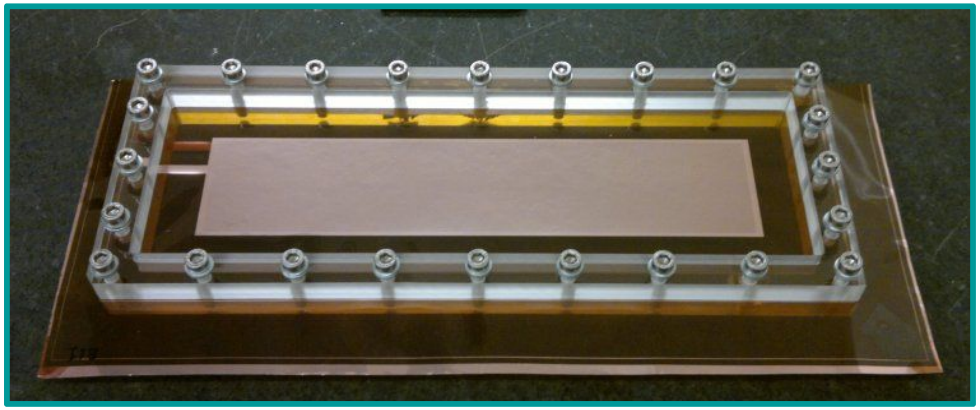
First mechanical models for the top and Bottom frames



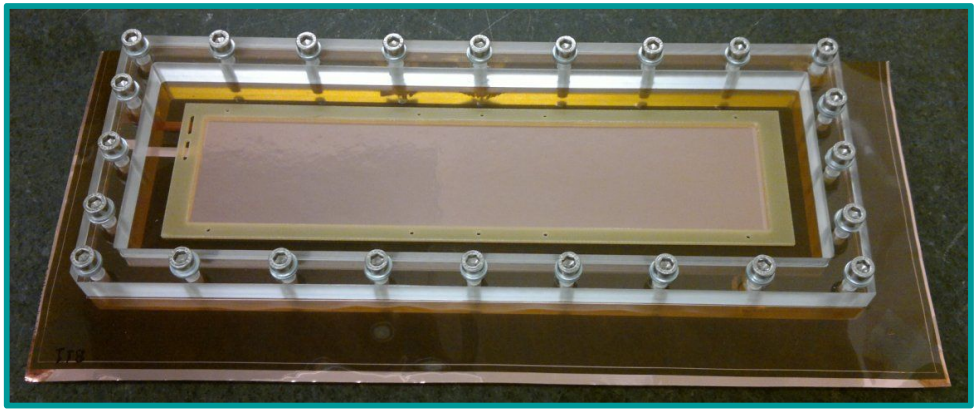
Electrostatic Test for all the frames @ 3 kV
Possible breakdowns corrected with Nuvovern



GEM Foils stretcher – No repels or undulation visible

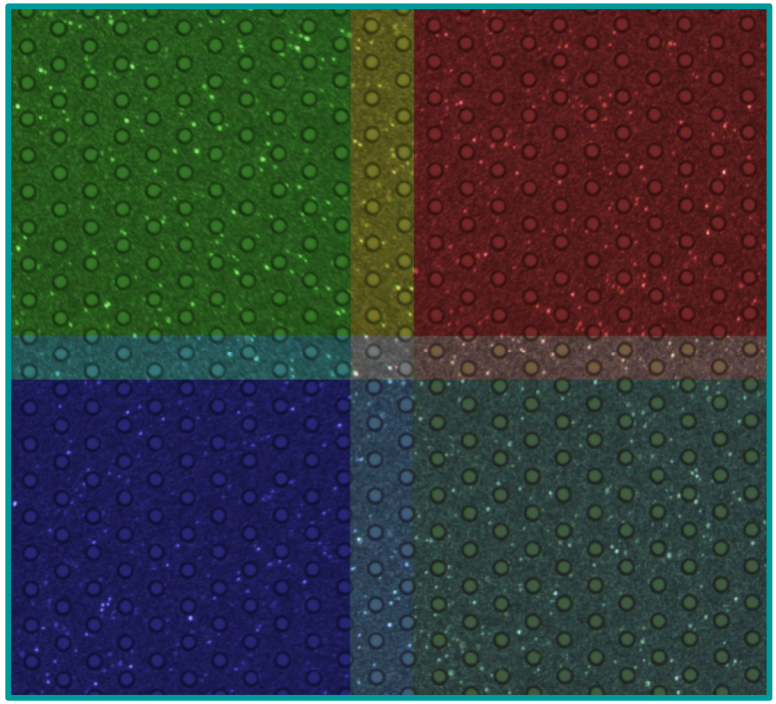


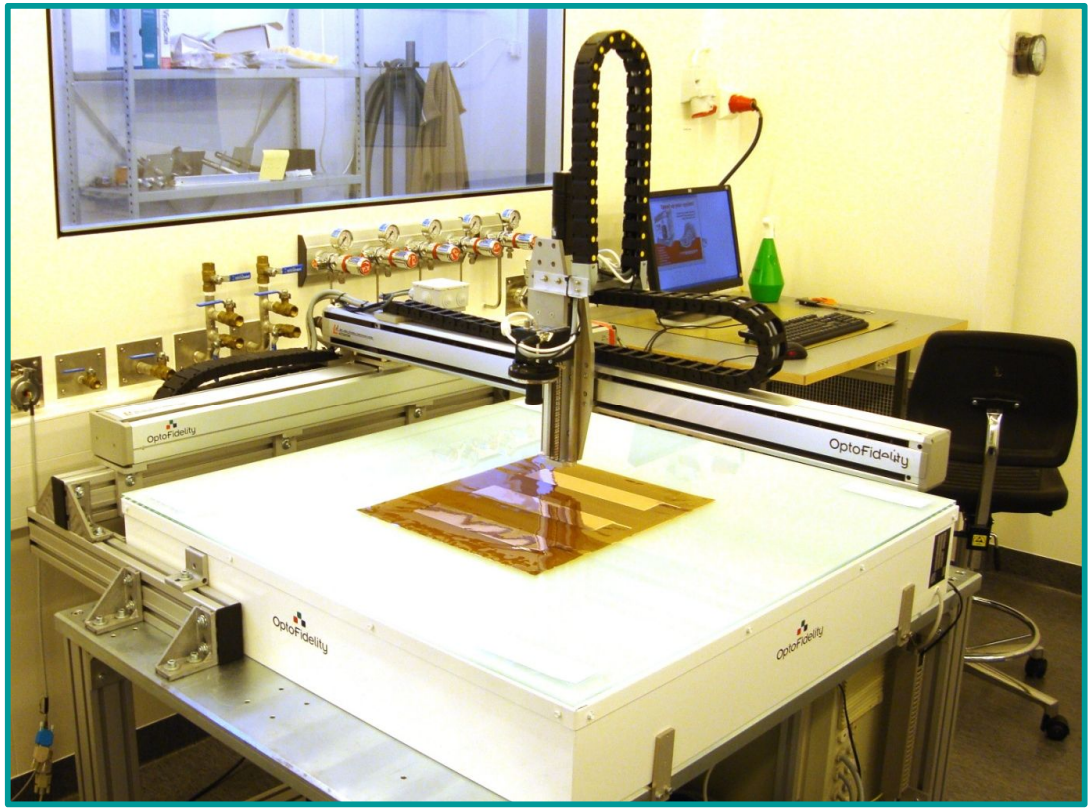
Top frame glued to the GEM foil, after cured in owen



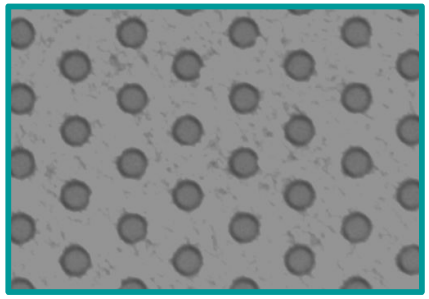
GEM TECNOLOGY and CHARACTERIZATION (cont.)

FOUR images Stitched
The overlapping on these images is of 245 μm and 140 μm

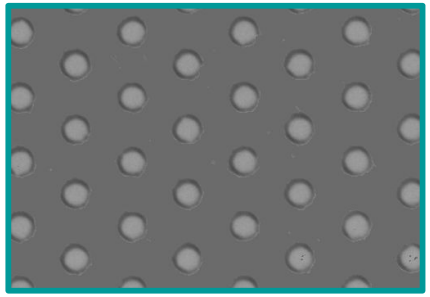




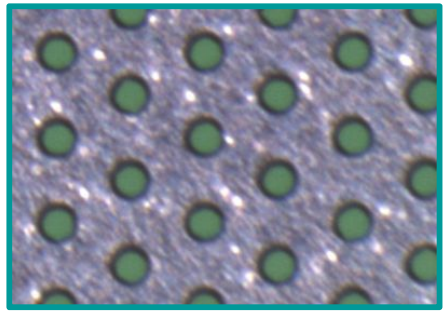
After Apply Red Filter
This procedure is used to find defects and to find the outer diameter of the holes



After Apply Green Filter
This procedure is used to find blind holes and to measure the inner diameter of the holes

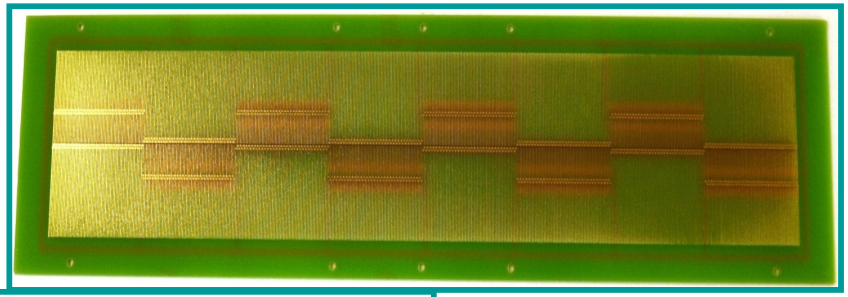


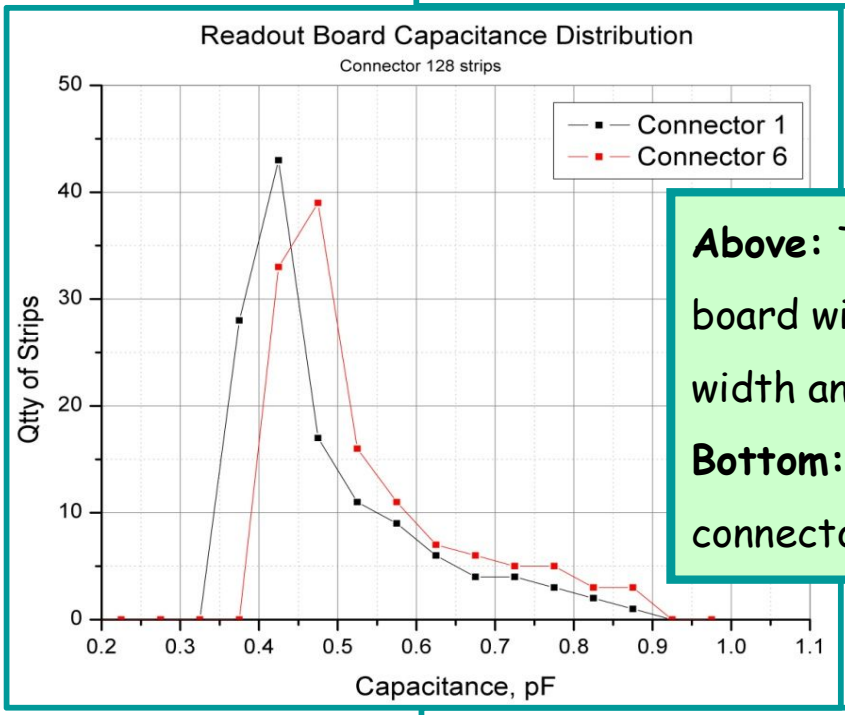
New System
Based on 9 Mpix camera with integrated telecentric optics for this setup one pixel corresponds to 1.7 x 1.7 microns



GEM TECNOLOGY and CHARACTERIZATION (cont.)

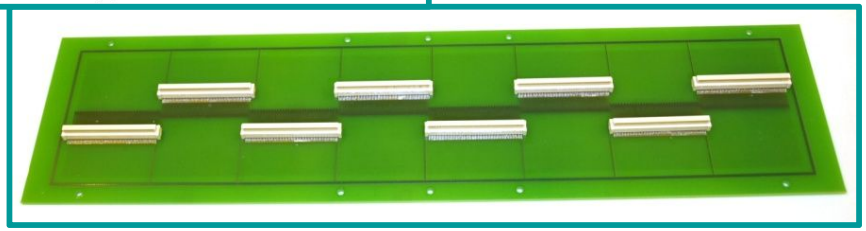
Capacitance measurement setup





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

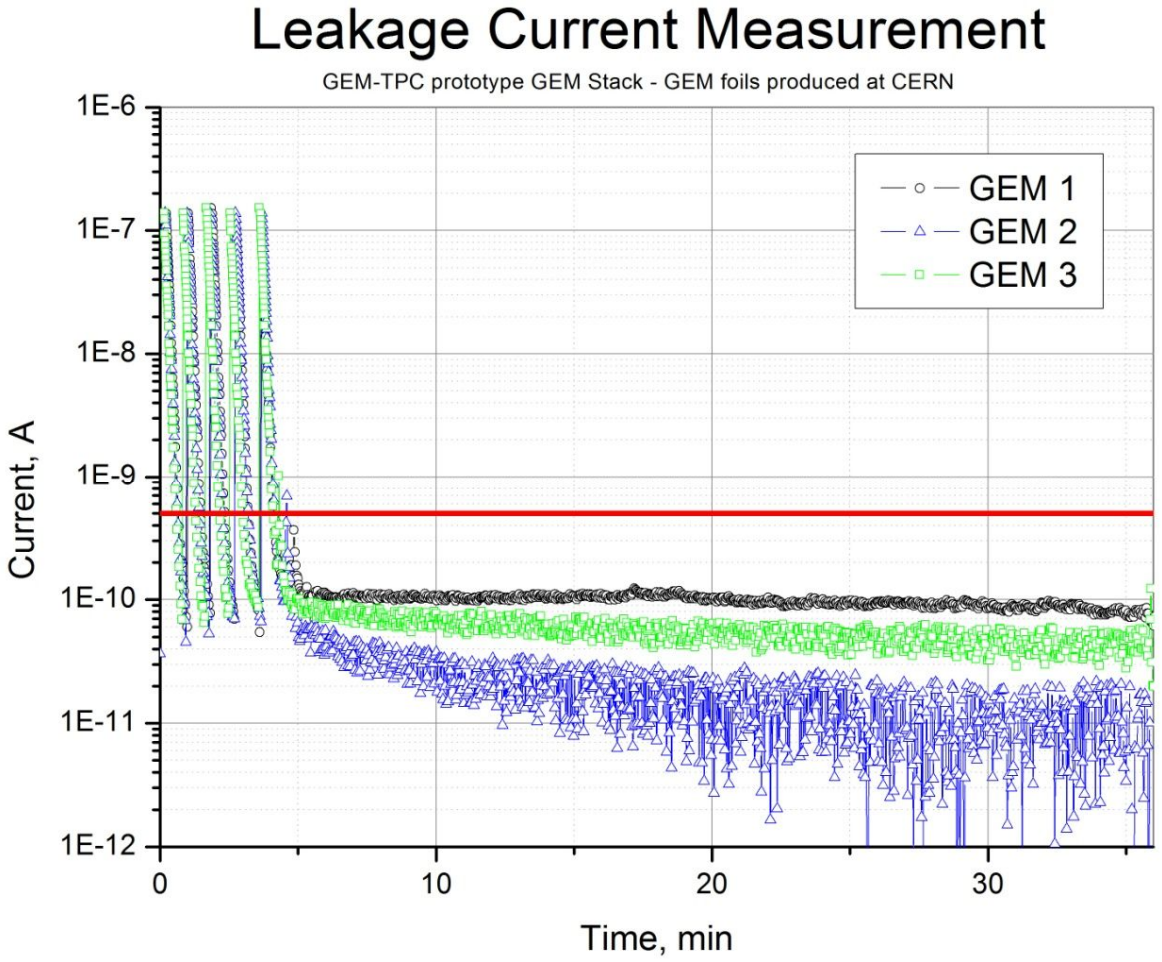
Bottom: 8 Header Panasonic connectors with 130 Pin each

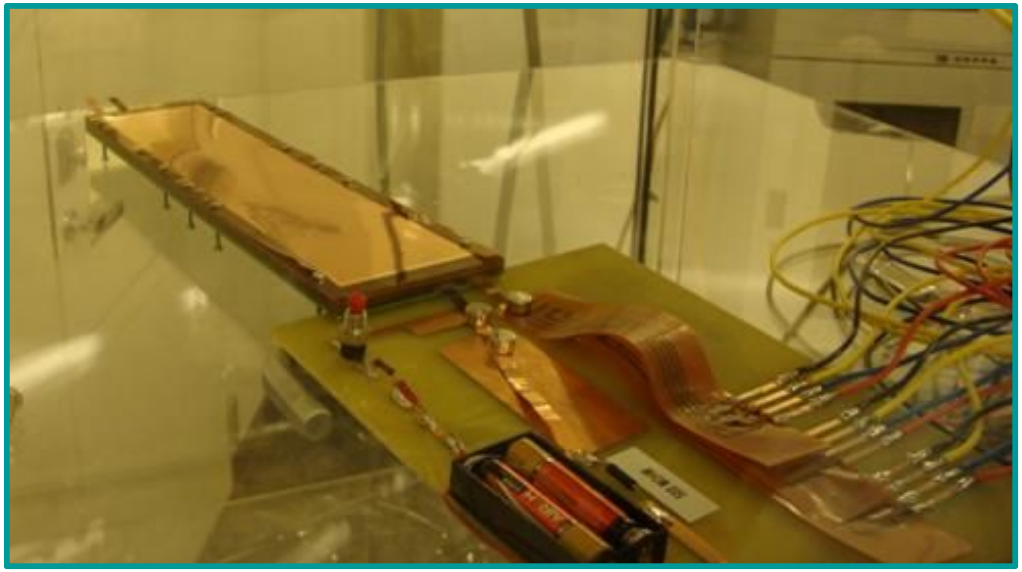


GEM TECNOLOGY and CHARACTERIZATION (cont.)

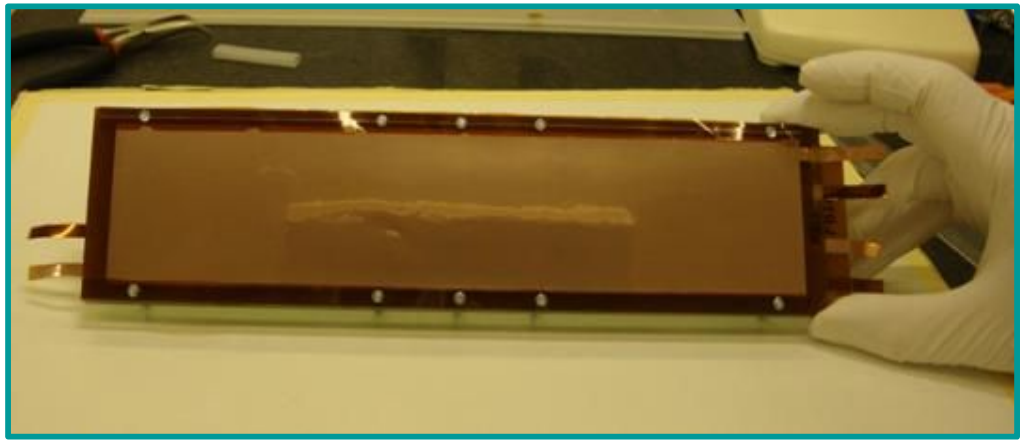
GEM Stack tests:

Triple GEM leakage current measurements





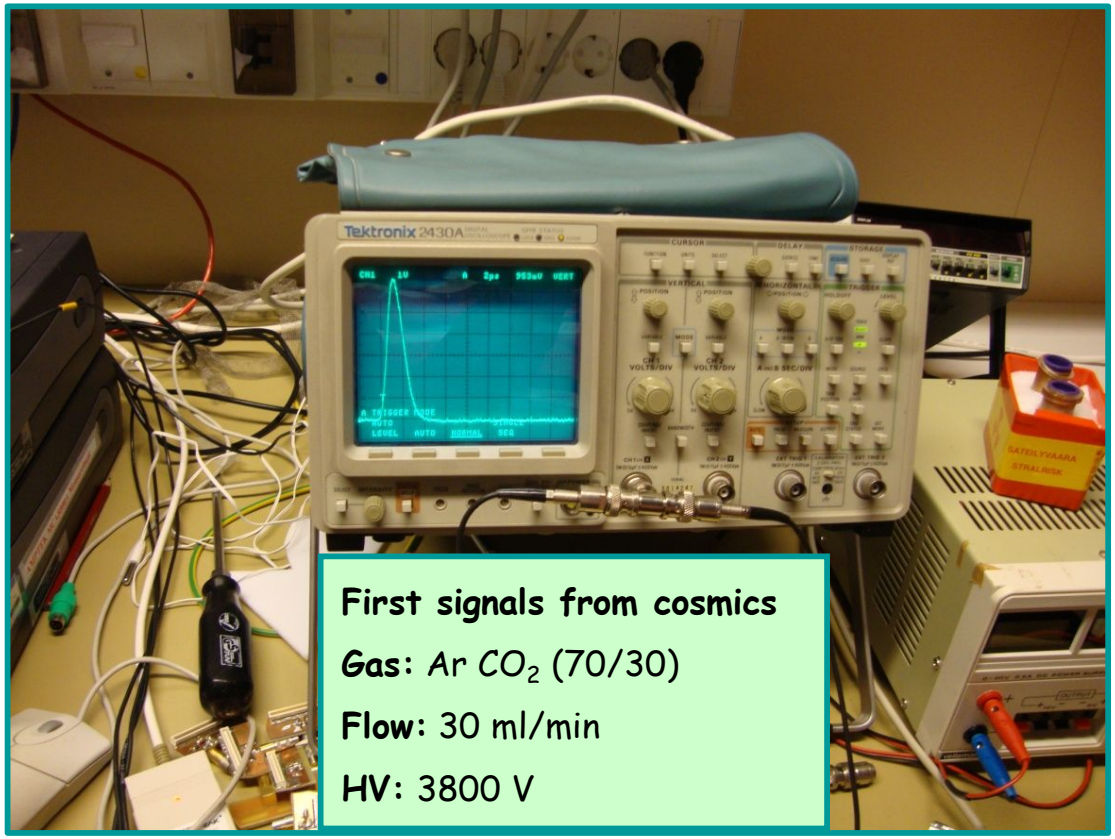
GEM Stack for the GEM-TPC prototype HB2



GEM TECNOLOGY and CHARACTERIZATION (cont.)

GEM Stack tests:

Preliminary measurements in the lab; the radiation used for these tests was the ^{55}Fe and cosmic



First signals from cosmics

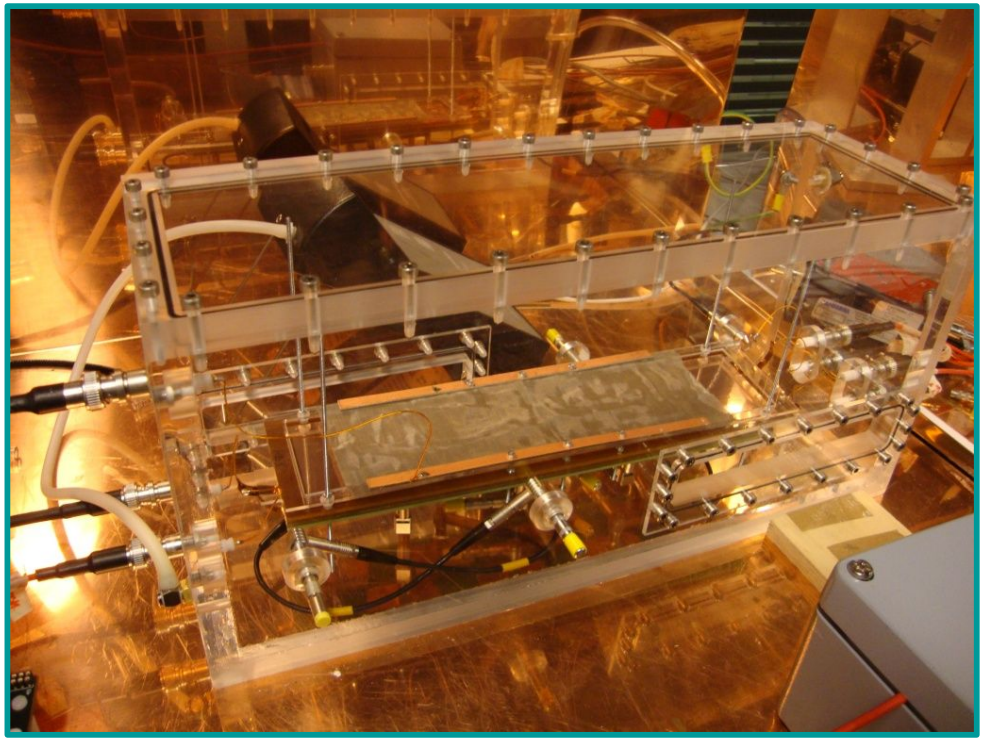
Gas: Ar CO_2 (70/30)

Flow: 30 ml/min

HV: 3800 V

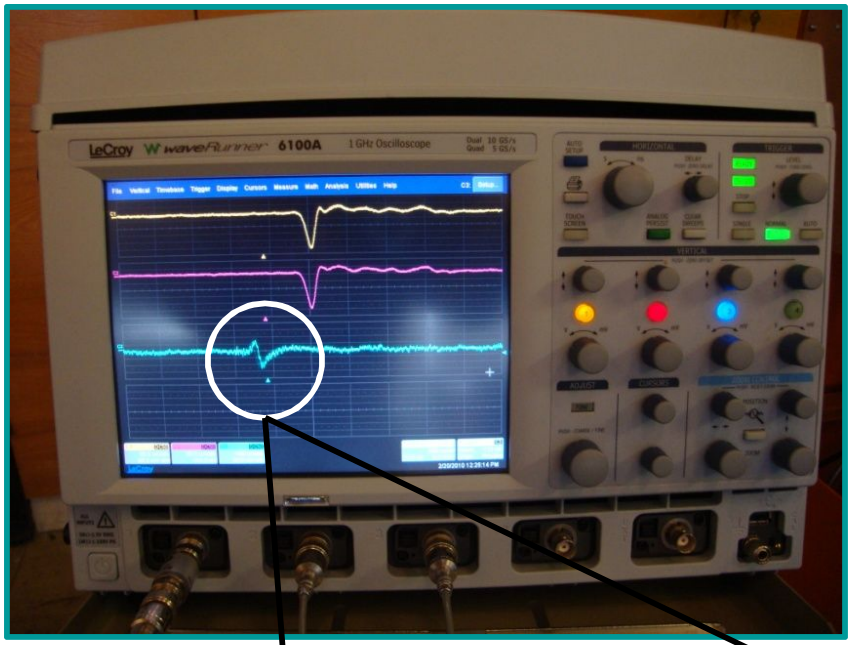
GEM Stack test bench

The GEM stack was assembled as a triple GEM detector with 3 mm of Drift



FIRST GEM-TPC PROTOTYPE HB1 - TEST

GEM-TPC test in lab at Comenius University

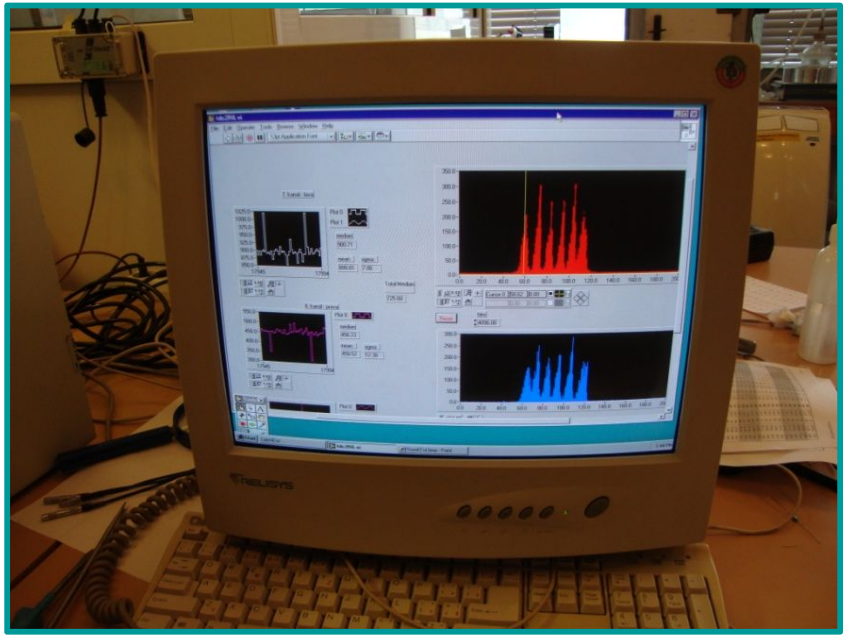


It can be observed:
- Signals from the delayed lines are very clean
- Same relative time between them
- Trigger signal bipolar, it can be that the 40% negative overshoot is due to e- transparency loses in the GEM 3

Trigger Signal before reshaping

Trigger Signal with rise and decay time reshaped

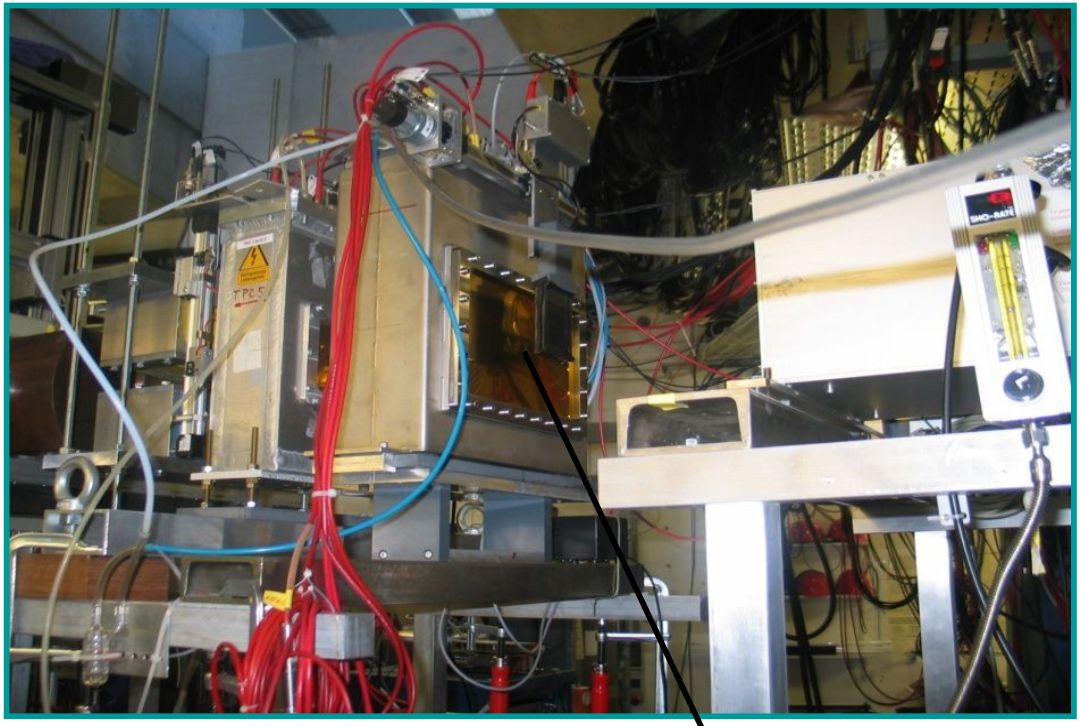
GEM-TPC tracking capabilities for ^{55}Fe

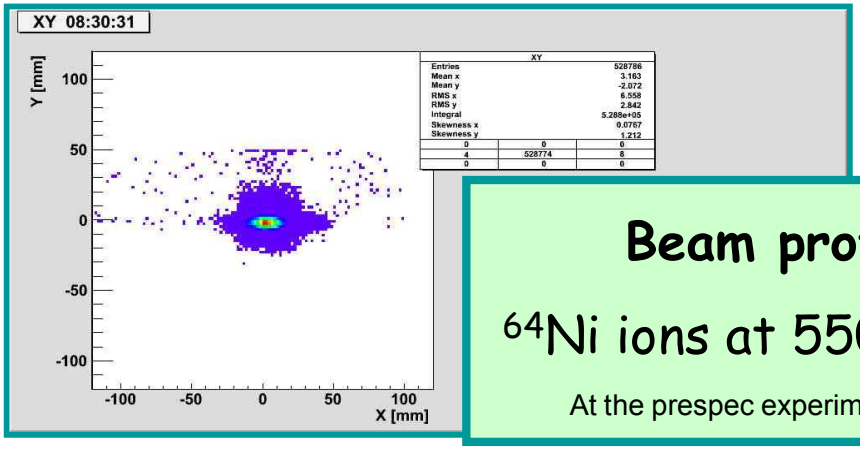


In the picture above there are multiple picks from the different source positions.
The source was not very well collimated therefore a mm scale resolution on X was achieved and the trigger was taken from the bottom of the GEM3

FIRST GEM-TPC PROTOTYPE HB1 - TEST (cont.)

GEM-TPC Beam test at GSI - Darmstadt

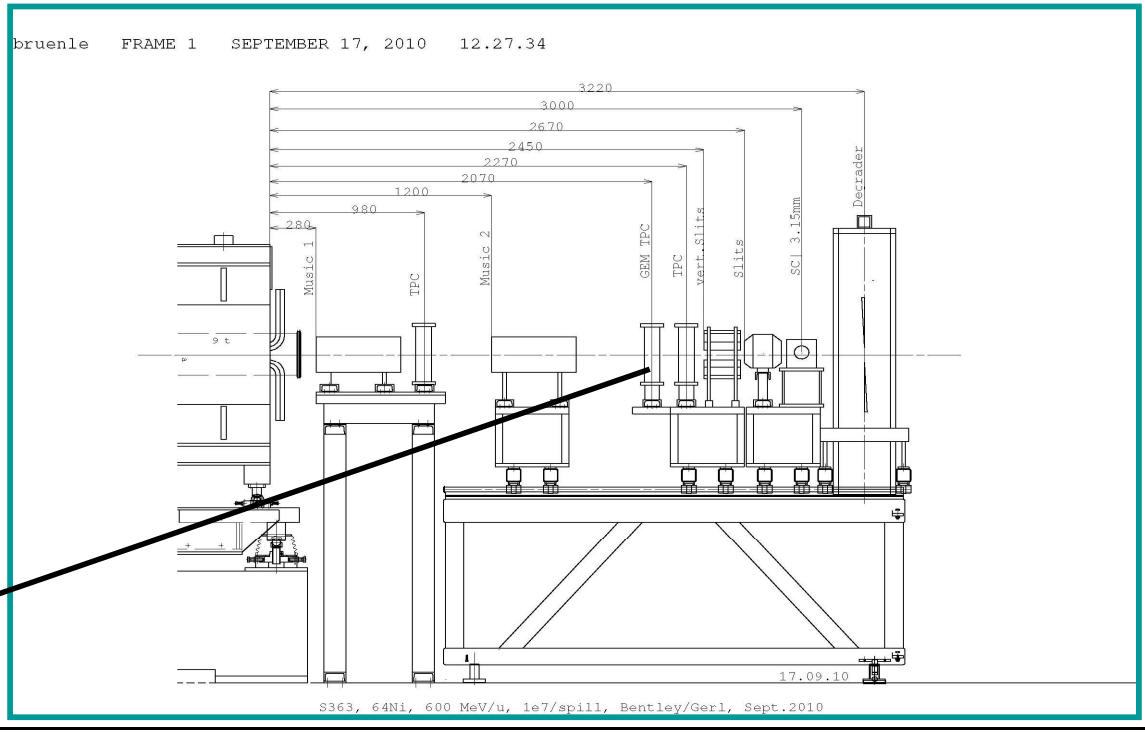


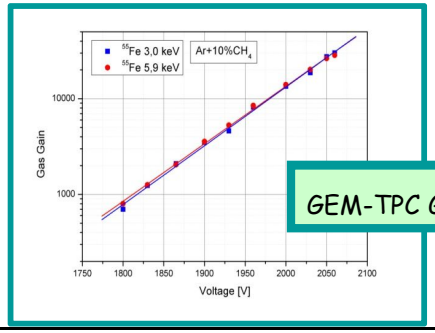


Beam profile

^{64}Ni ions at 550 MeV/u

At the prespec experiment - S363



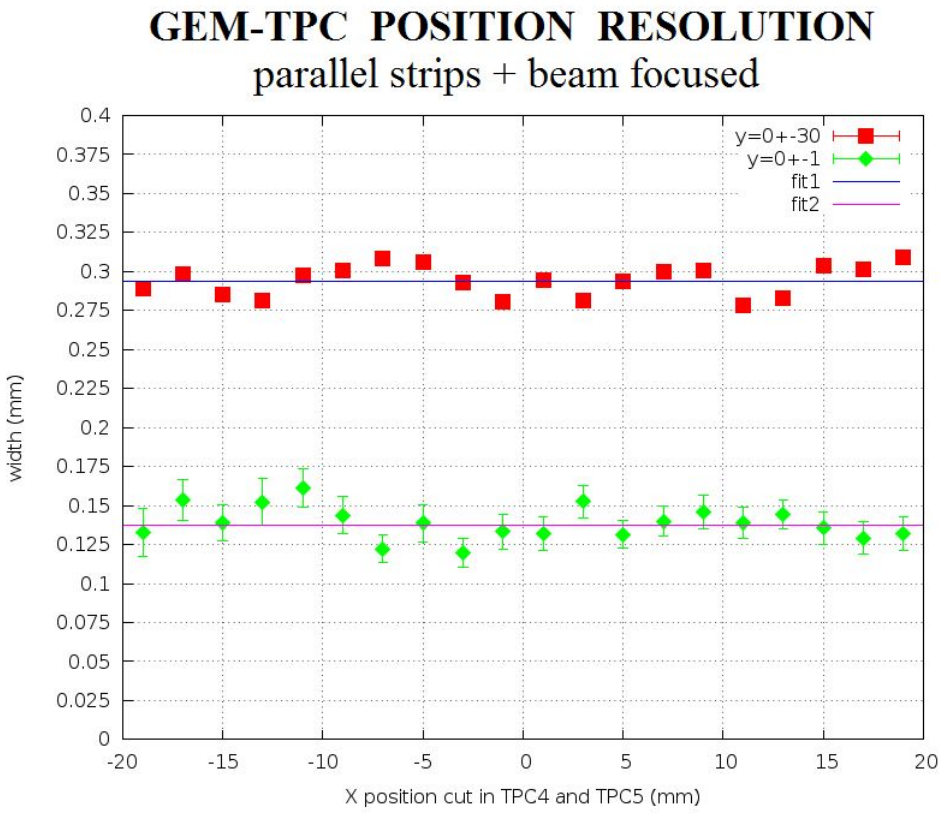


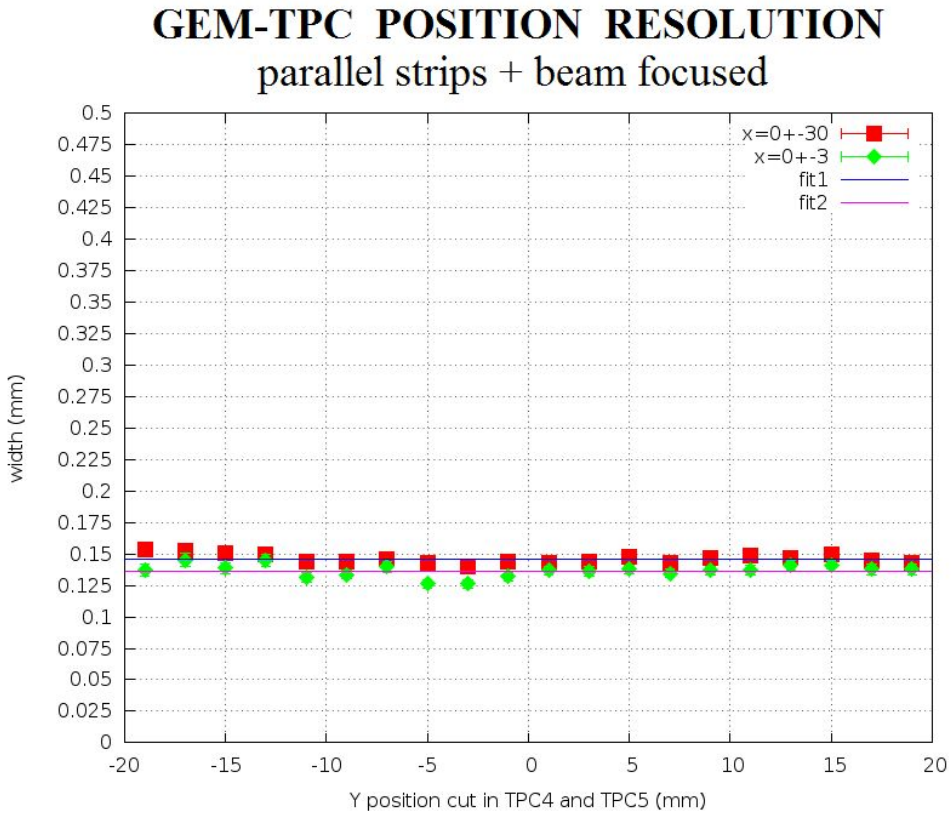
GEM-TPC Gain

GEM-TPC at S4

FIRST GEM-TPC PROTOTYPE HB1- TEST (cont.)

GEM-TPC Results for the Beam test @GSI





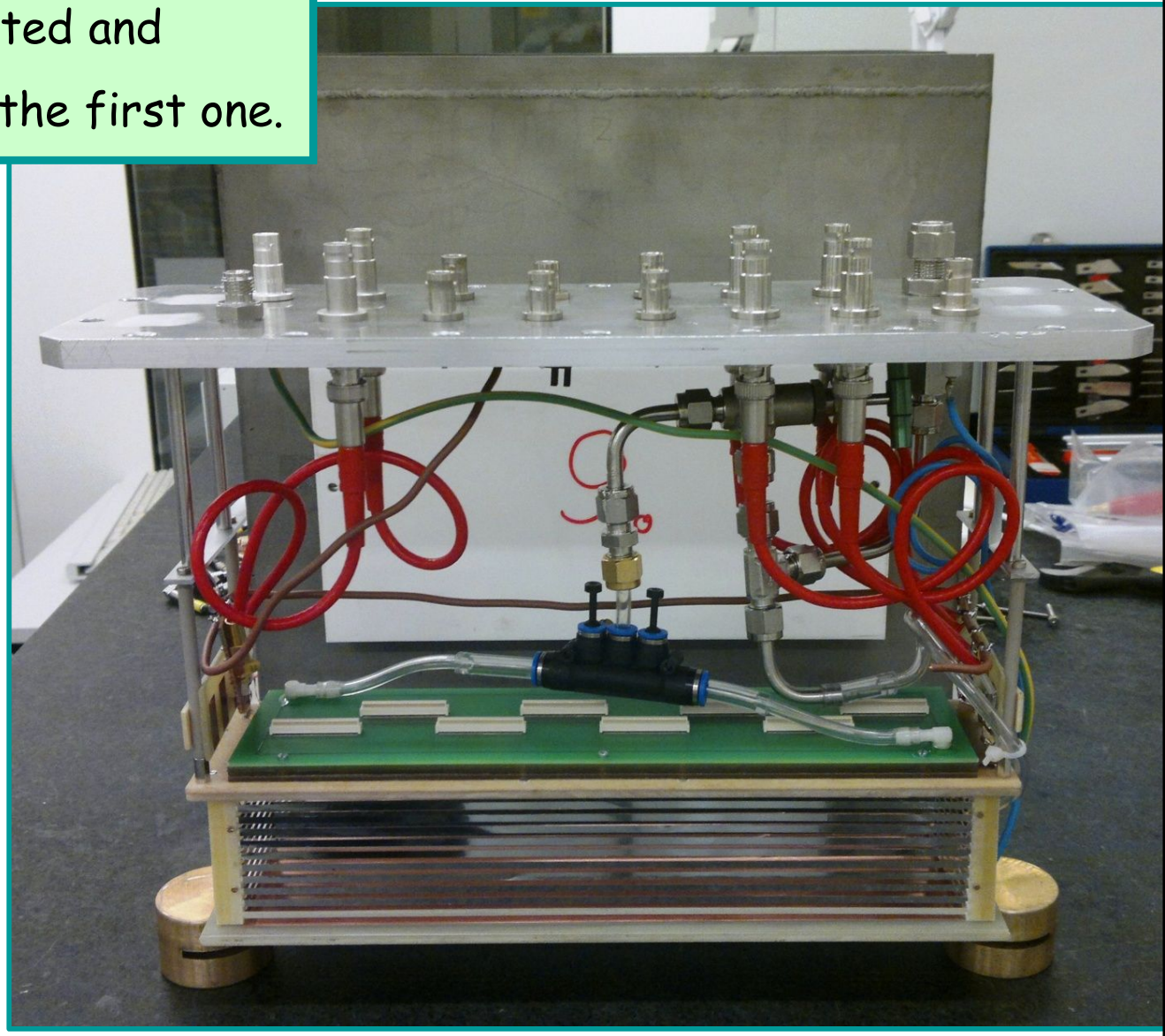
The GEM-TPC shows that the resolution in Y (Drift) reaches value around 130 μm and on X between 130 to 300μm

STATUS OF THE PROTOTYPE HB2

The second GEM-TPC HB2 will be tested and characterized in a similar way as for the first one.

Test in the lab:

- ✓ Foils visual and scanned inspection
- ✓ Foils leakage current measurement
- ✓ Readout board capacitance measurement
- ✓ Energy resolution measurement
- ✓ Gain and its uniformity
- ✓ Oxygen concentration measurement
- ✓ Irradiation with ^{55}Fe

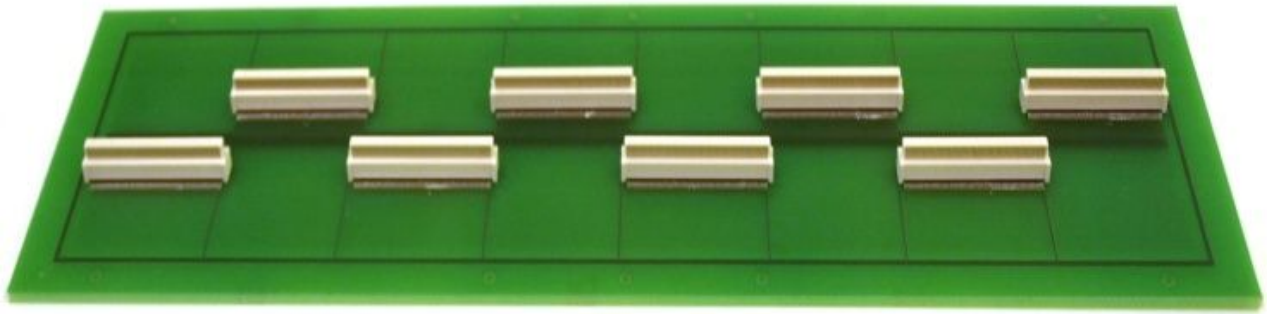


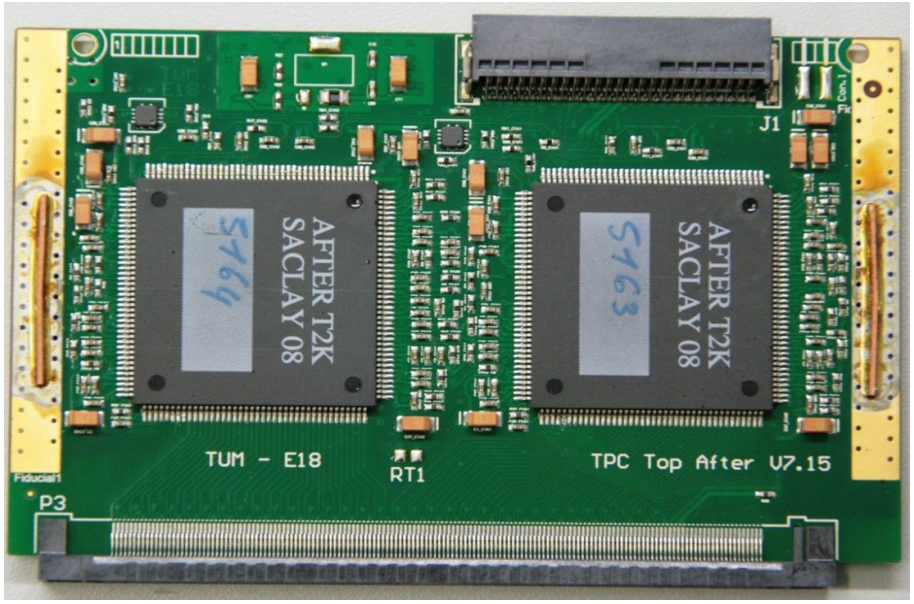
SECOND GEM-TPC PROTOTYPE HB2 (cont.)

GEM-TPC Readout Electronics and DAQ.

T2K FEC developed at **TUM**

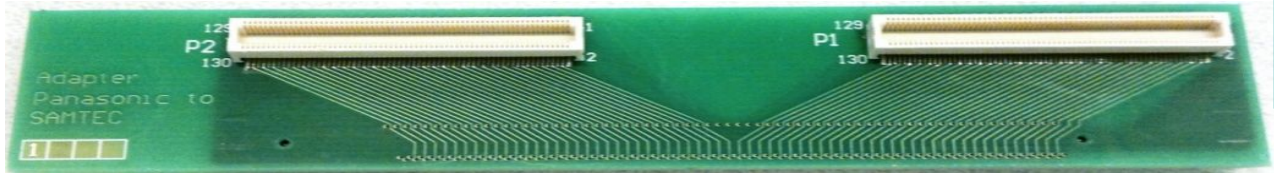
4 AFTER chips for a total of 256 channels





GEM-TPC Readout board with 1024 strips cut in the middle

PAN to SAMTEC Adapter

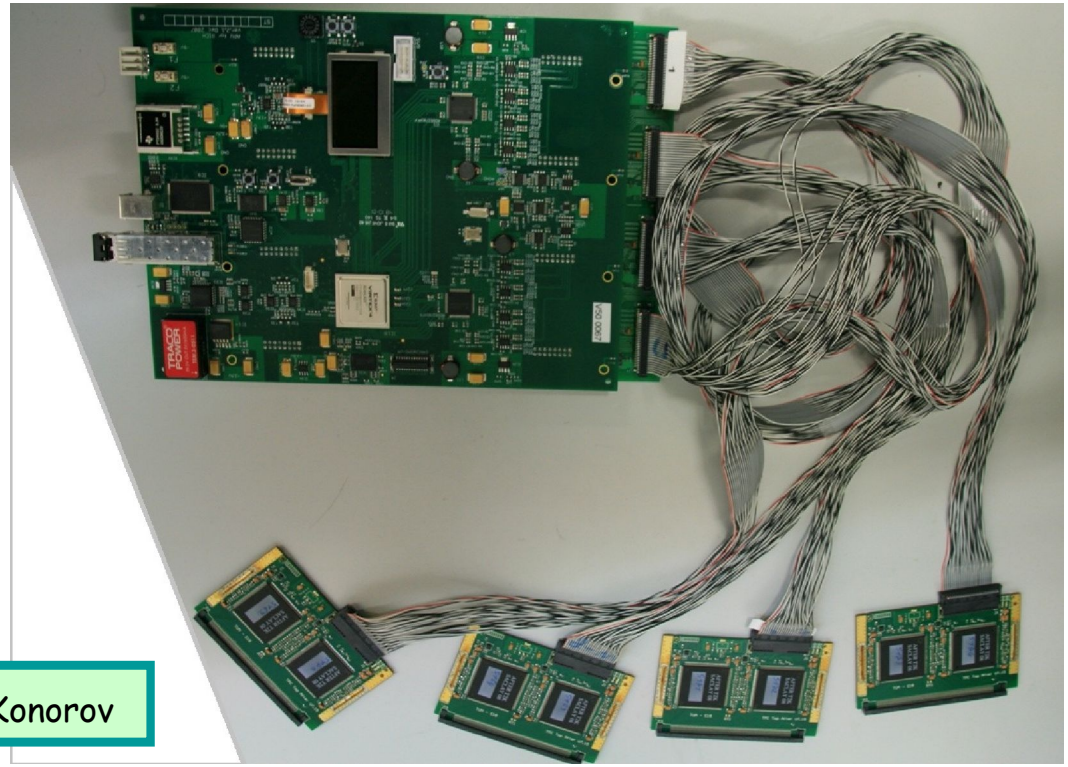


At the top a Samptec connector 300 pins and in the left side two Panasonic connectors of 130 pins each

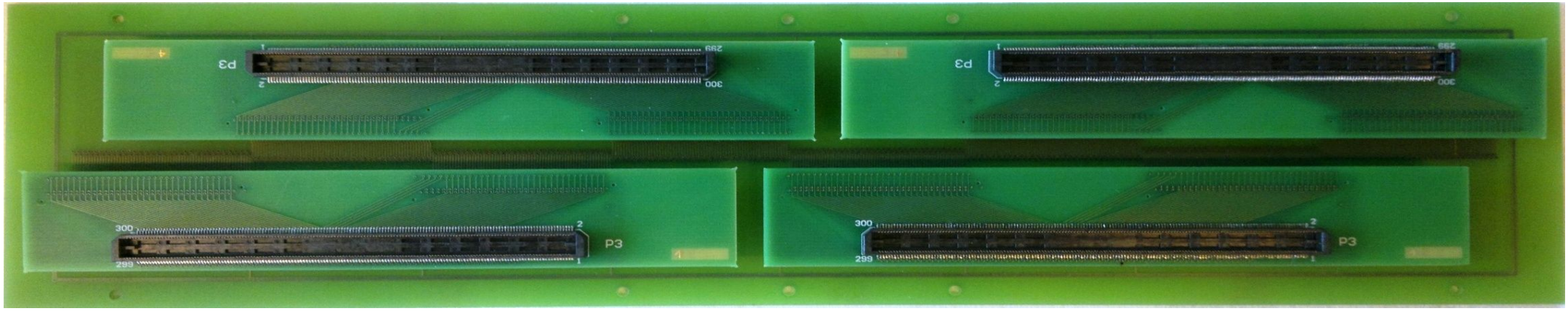
SECOND GEM-TPC PROTOTYPE HB2 (cont.)

GEM-TPC Readout Electronics and DAQ.

The trigger rate expected for the AFTER chip with $ArCO_2$ and 60 mm drift is of about 6.4 kHz. Taken into account that a total of 60 cells are needed and the clock is at 45 MHz

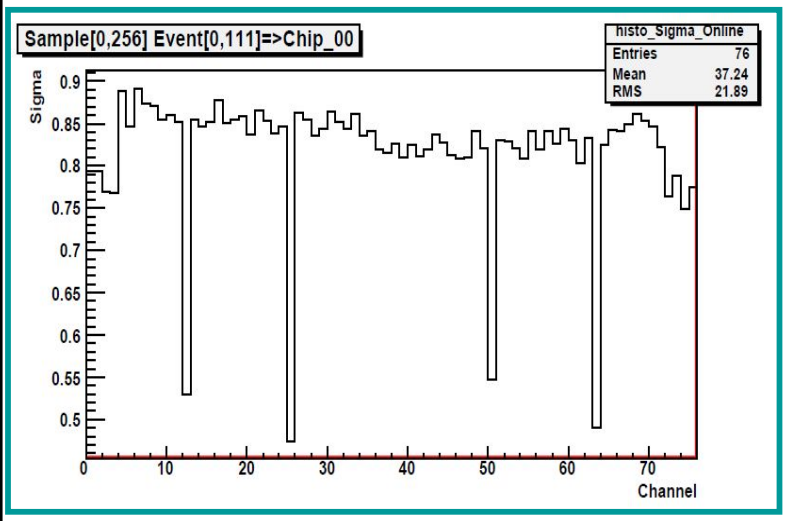


Provide by Igor Konorov



SECOND GEM-TPC PROTOTYPE HB2 (cont.)

GEM-TPC readout electronics performance

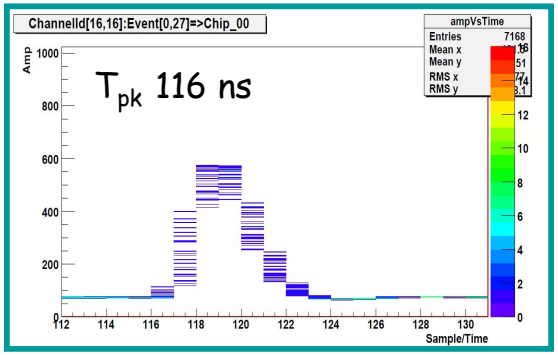


Test of One AFTER Chip which is wasn't connected to the detector and has 8 channels disconnected (the first and the last 4).

There is a fixed pattern with 4 noisy channels.

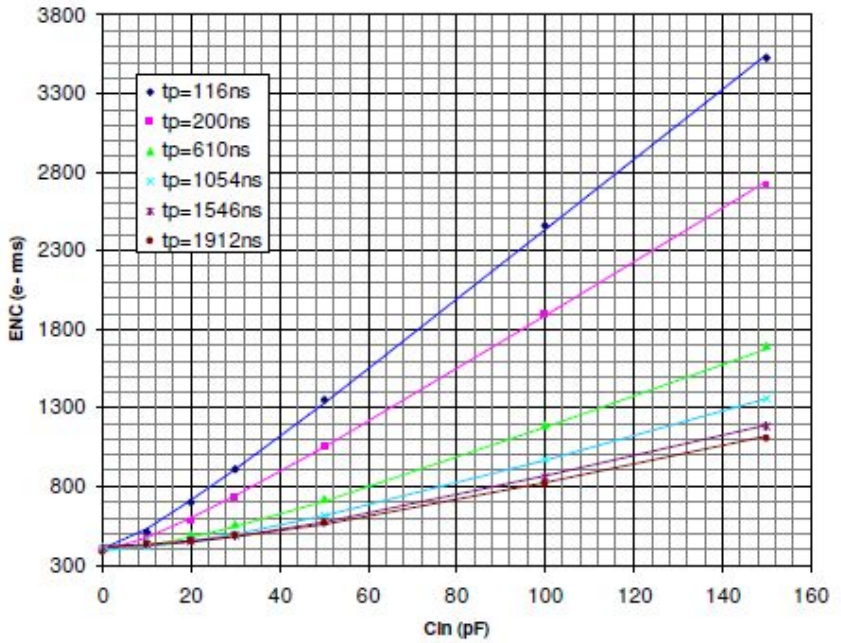
Related to the signal amplitude 1 ADC count correspond to 0.12 fC or 700 e-

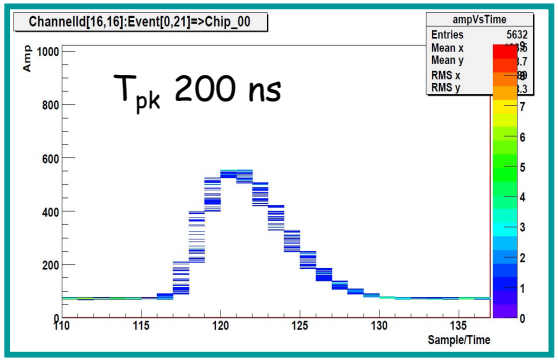
Presented by Igor Konorov at TUM



Calibration Procedure with Test pulses of 50 fC

T2K noise measured @ Saclay

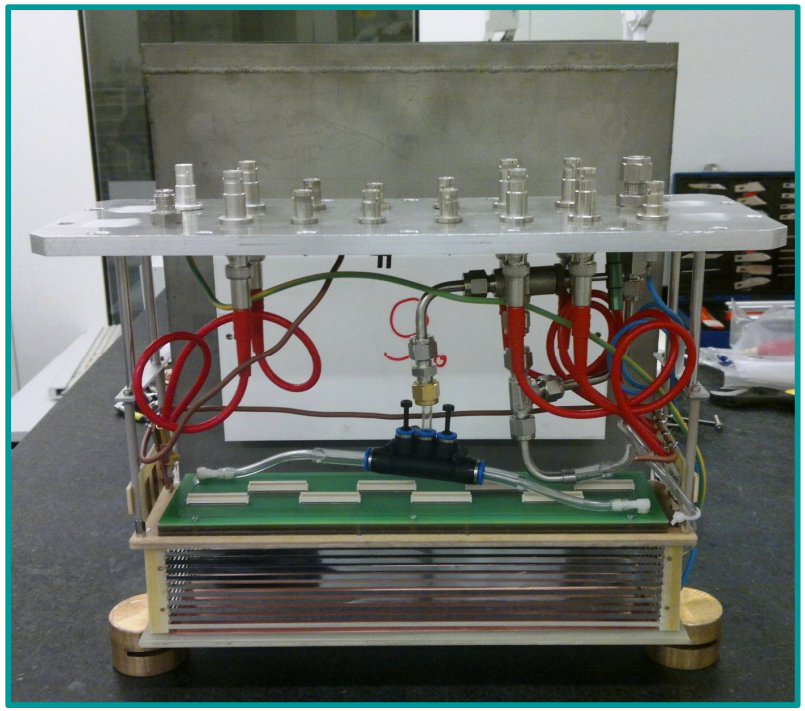




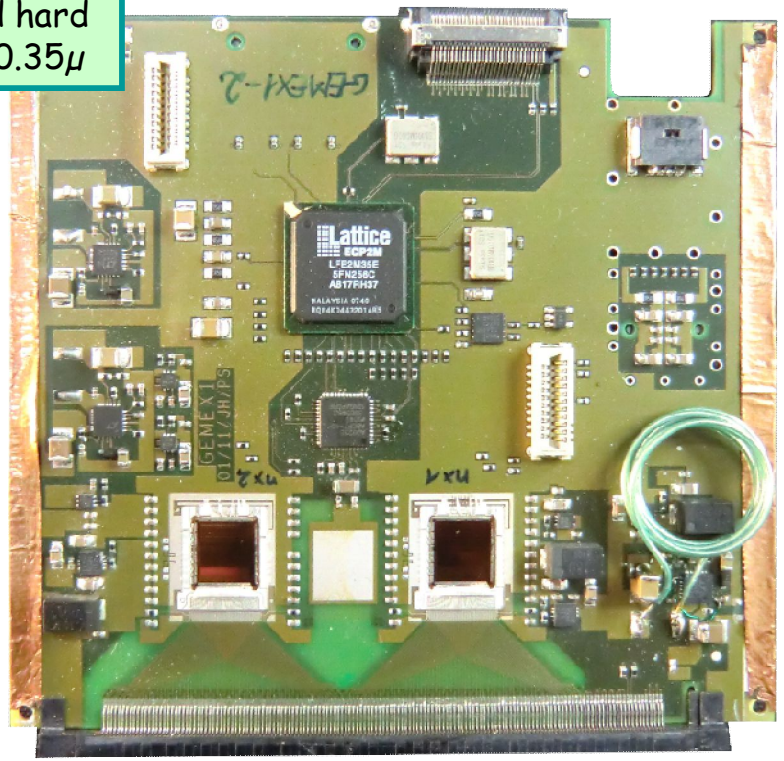
Due to strips and coupled capacitance we can expect a 400 e- noise at all the peaking times

STATUS OF THE PROTOTYPE HB3(cont.)

GEM-TPC Readout Electronics and DAQ.



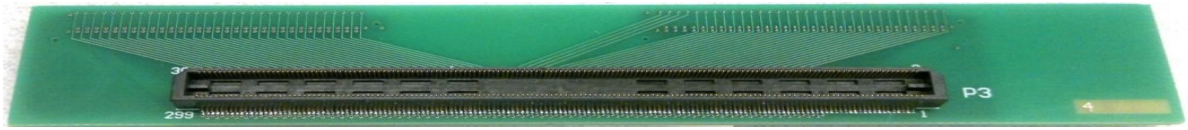
n-XYTER, non rad hard AMS 0.35μ

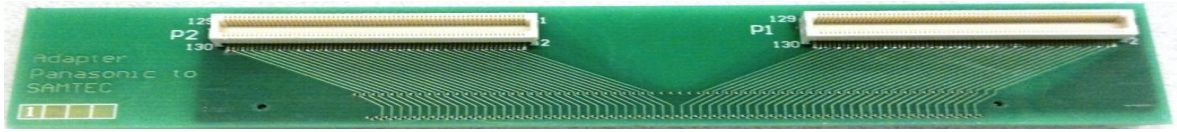


Provide by the Detector Laboratory @ GSI

Bern Voss

PAN to SAMTEC Adapter

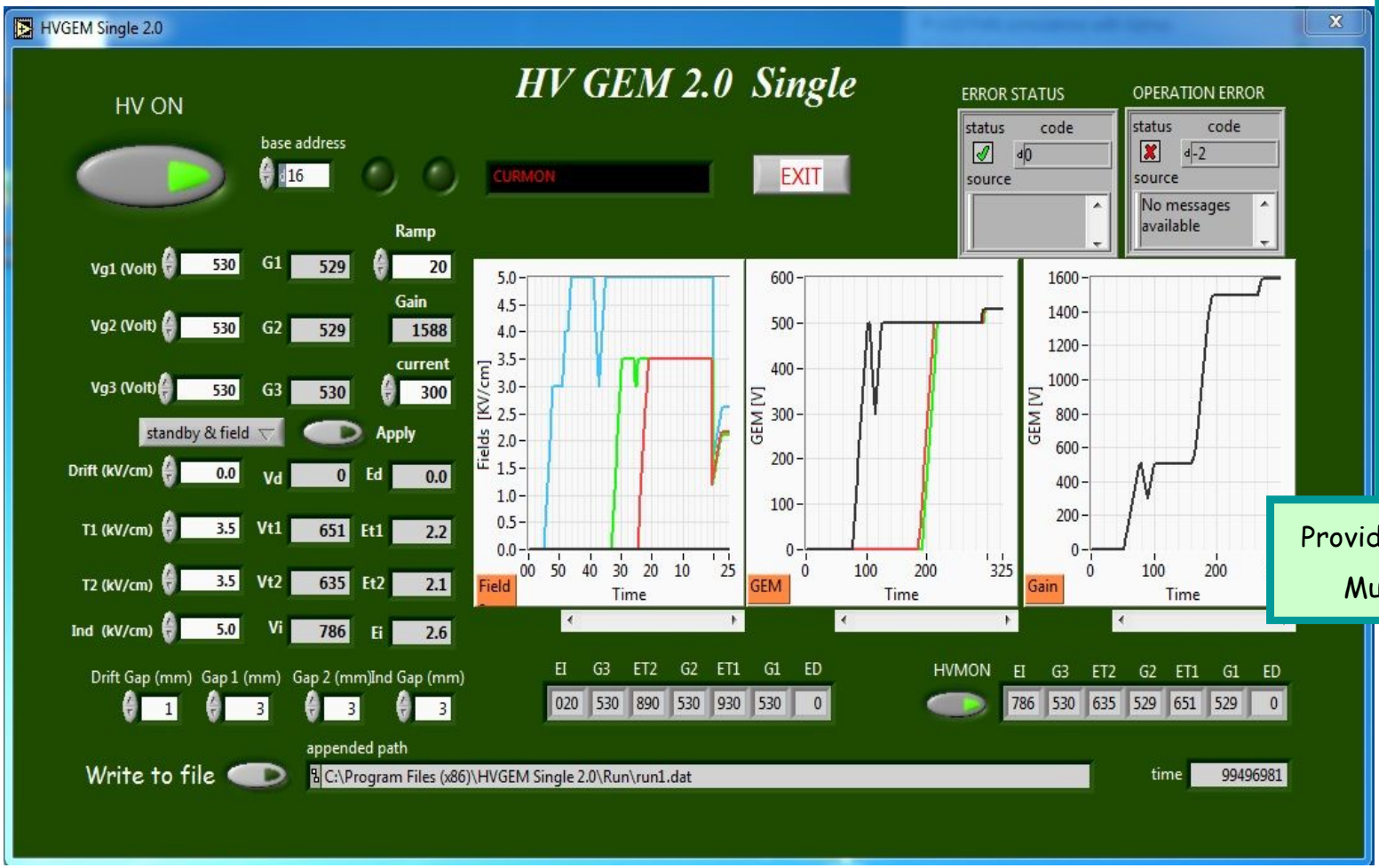




At the top a Samptec connector 300 pins and in the left side two Panasonic connectors of 130 pins each

ACTIVE DIVIDER FOR GEM-TPC

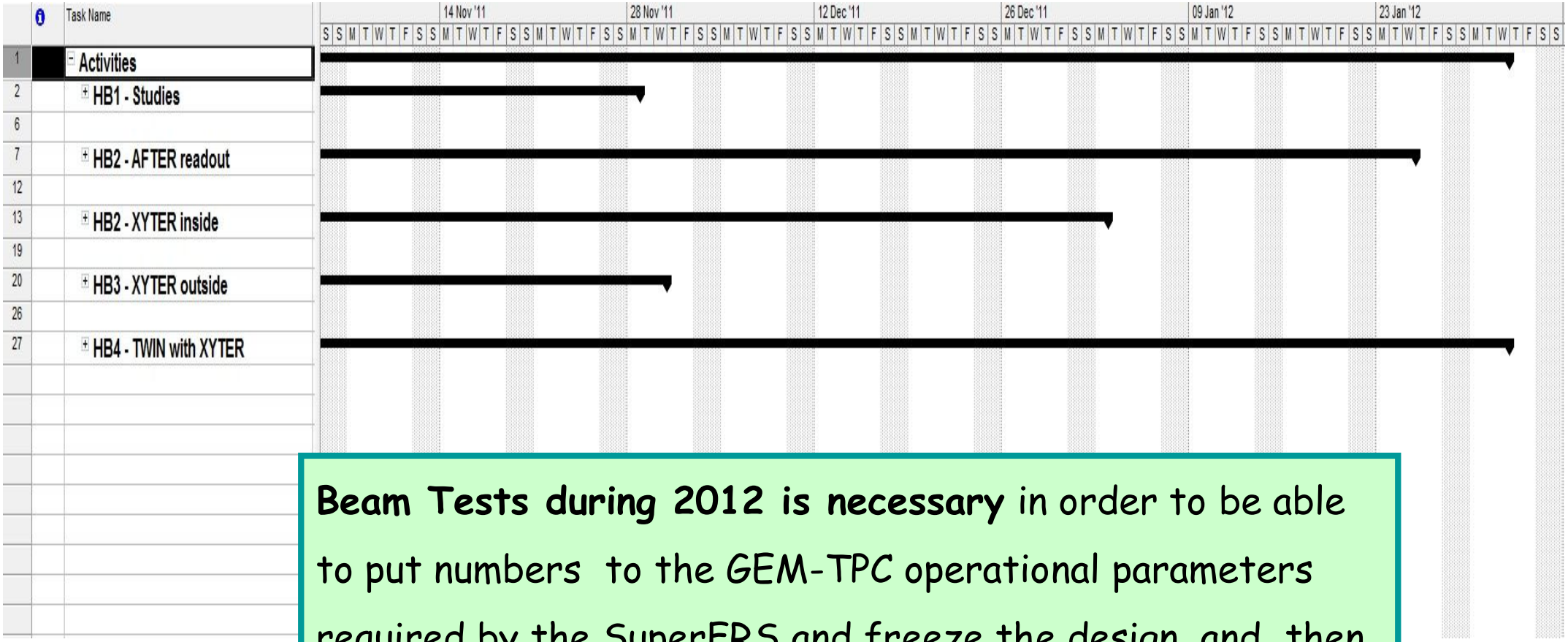
Active Divider for the GEM Stack



Provide by Dr. Fabrizio Murtas at INFN

All Channels with current limit:
In the range from 10nA up to 6μA with a resolution of 40 nA

TASK SCHEADULE for 2012



Beam Tests during 2012 is necessary in order to be able to put numbers to the GEM-TPC operational parameters required by the SuperFRS and freeze the design, and then kick-off mass production

TODO

- Production of a flange for the HB2 with AFTER readout and prepare the DAQ
- Production of a Flange for the nXyter readout of the HB3
- Participate in the Beam campaigns of GPAC at GSI and at Jyväskylä
- Get some simulations results in order to carry out some optimizations
- Design of the components for the Twin GEM-TPC i.e. GEM foils masks, frames, drift foils and flange