GEM-based TPC system with a self-calibrated drift velocity

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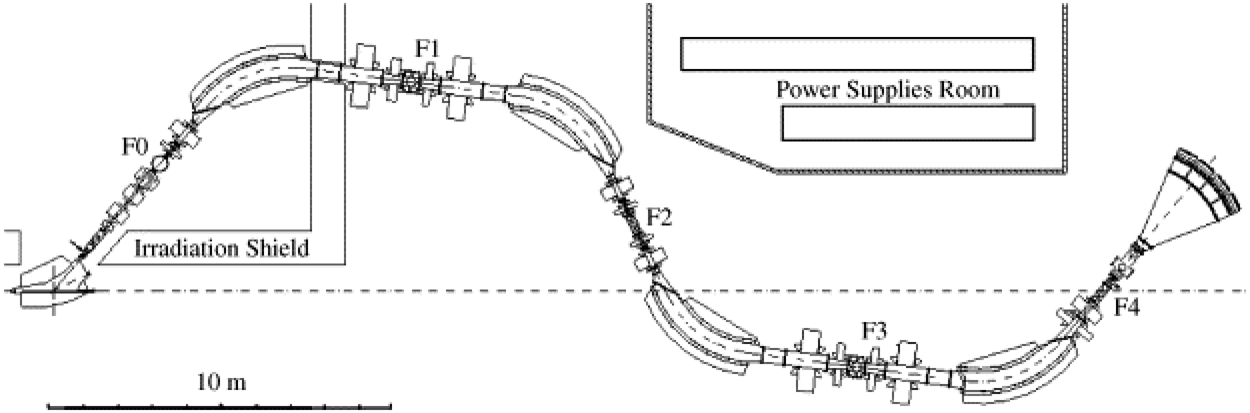
All colors of Physics

Overview

- Small “classical” TPC using double GEM readout
- Laboratory and beam tests confirming expected behaviour
- High ionization (Q= +26) beam test results
- “Twin” or tandem operation: off-time background reduction
- Perpendicular setting: drift velocity online calibration

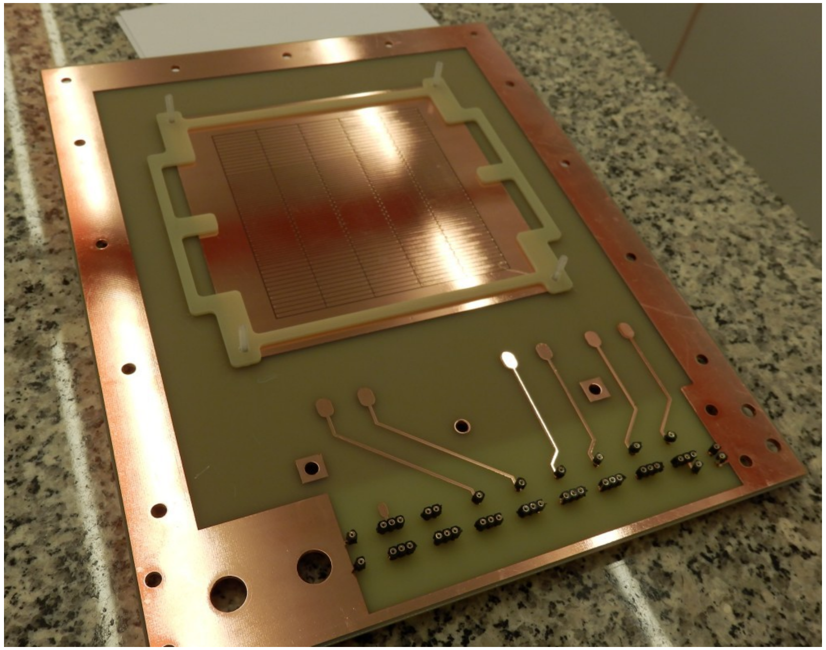
Motivation

- Cooperative activity with Institute of Modern Physics (Lanzhou, China), **Z-identified radioactive beam tagging**, improvement of dE/dx measurement
- **Low material budget, good track position resolution** (0.1mm, angle res. 1mrad), aperture 100mm x 100mm
- **TPC option is attractive**, but high intensity is a challenge (as always were)



Detector construction

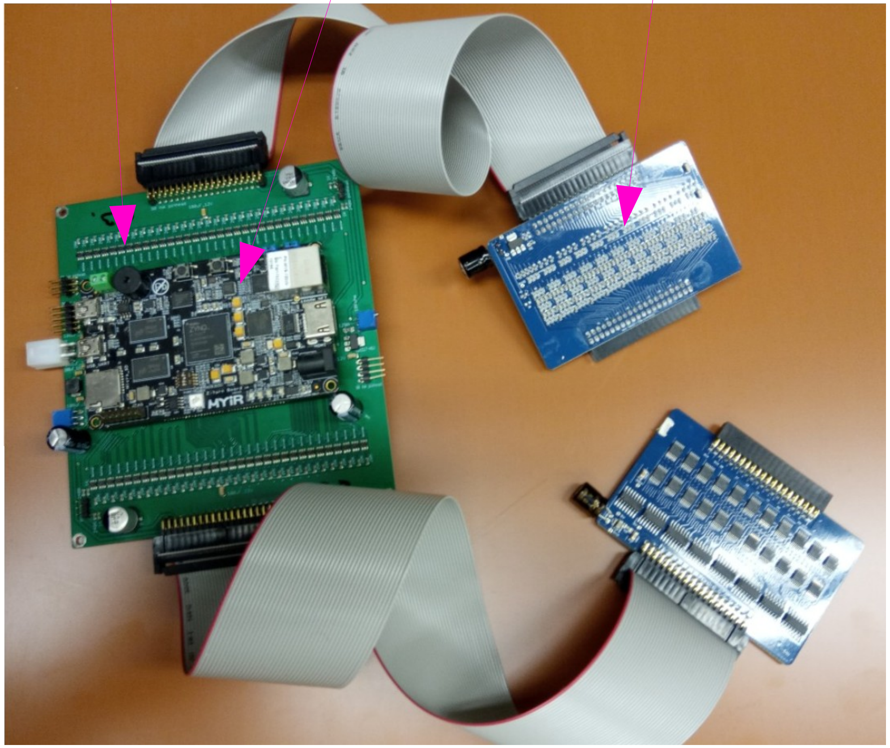
- Standard 10cm GEM-s, double on a resistor chain
- 5 pad rows, 64pads/row (1.2mm x 18mm)
- Field cage: 2mm pitch Cu strips printed on Kapton



G. Galgóczi, JINST Proc. 15 , C08027 (2020)

Readout system

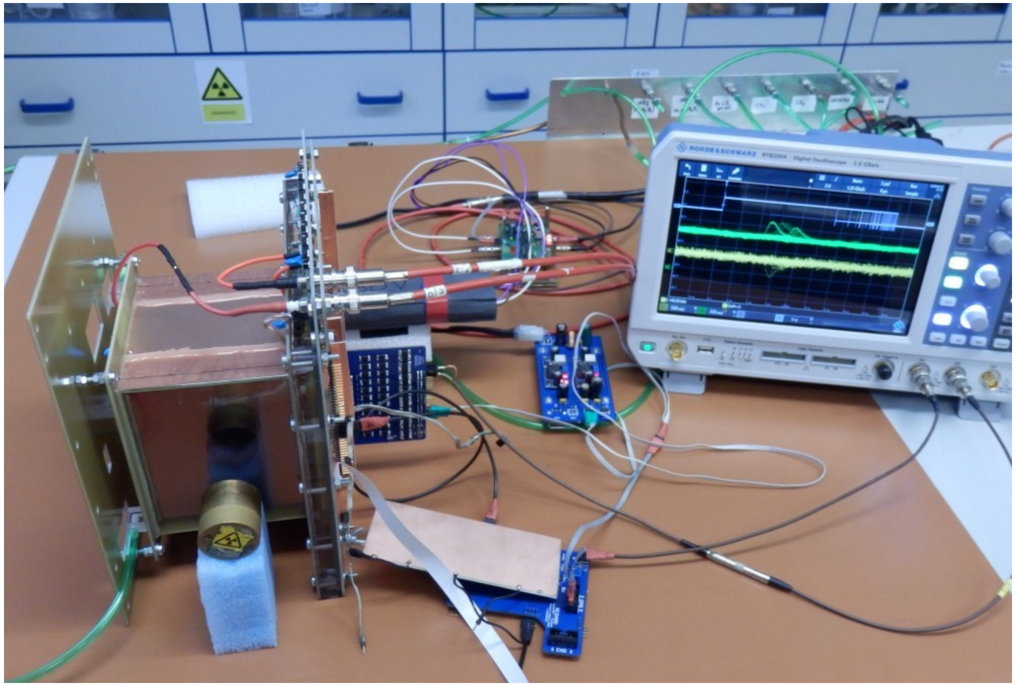
- Custom designed tabletop readout system for the small TPC: FPGA-s directly controlling 3MS/s ADC-s (12 bit, around 10bit effective), will need to improve
- Front-ends custom design standard CMOS, 1 microsec shaping (compatible with ADC-s)
- FPGA-s (Zynq) run the ADC-s continuously, then internal ARM transfers data to PC using Ethernet
- Triggering: external, free-running or threshold



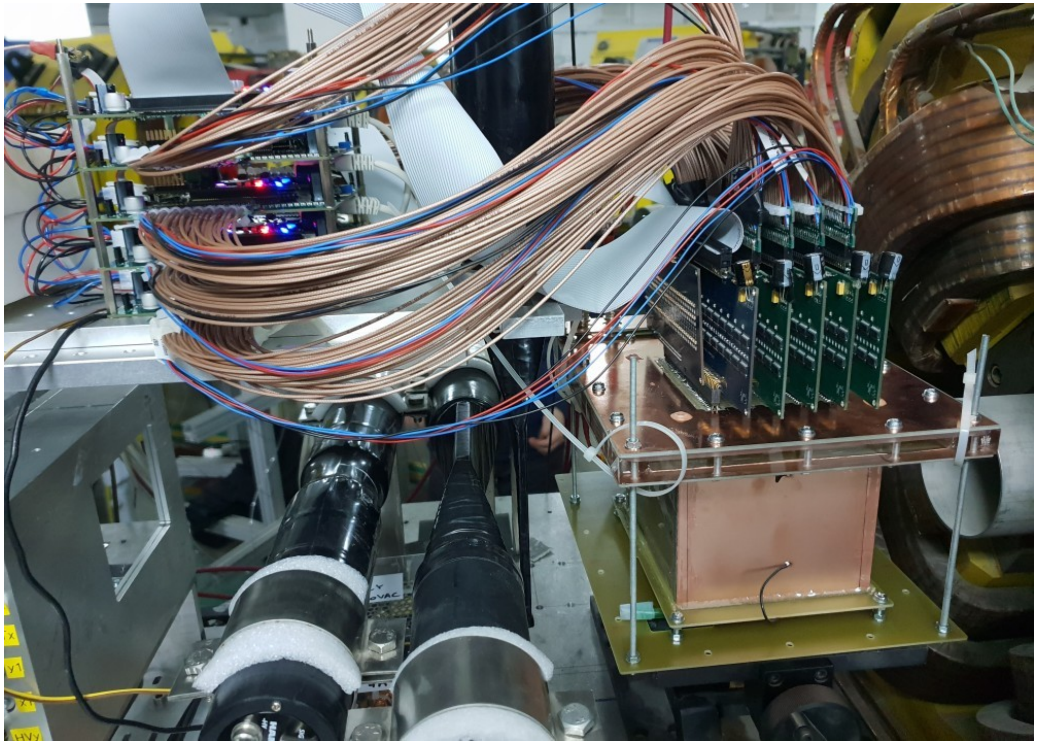
Lab and beam measurements

- Double GEM, safely sensitive to MIP (beta)
- Gain reduced for high ionization beam test

Lab setup with Sr-90



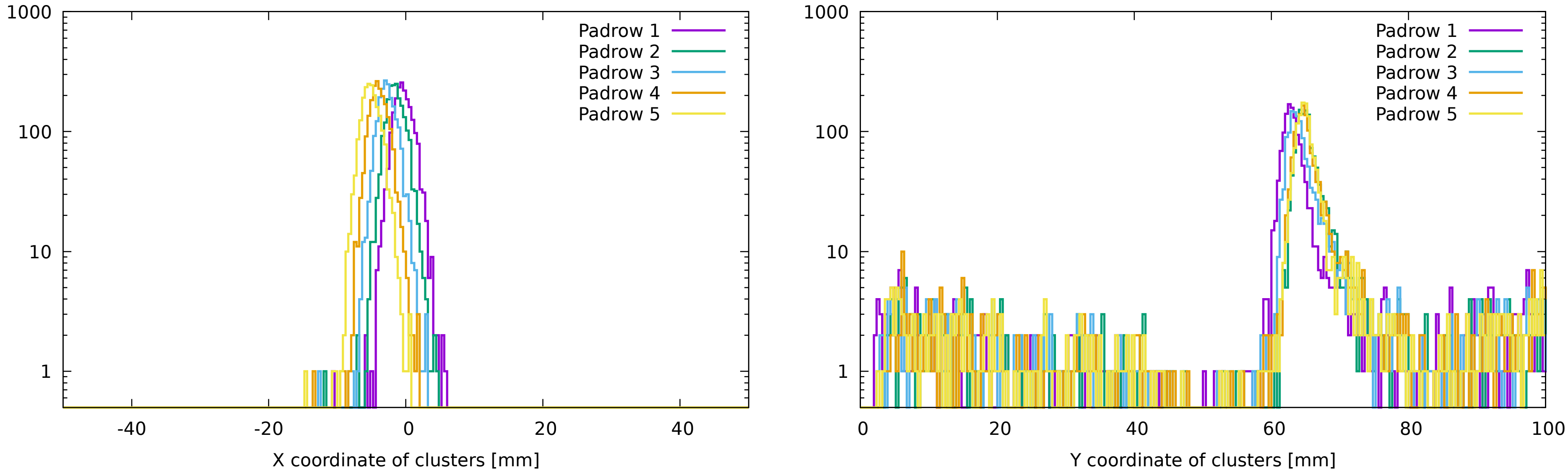
Beam testing at IMP



Tracking performance: confirmed excellent

- Well defined tracks of Kr beam (+26 ionization)

(Low intensity case, high intensity inconclusive)



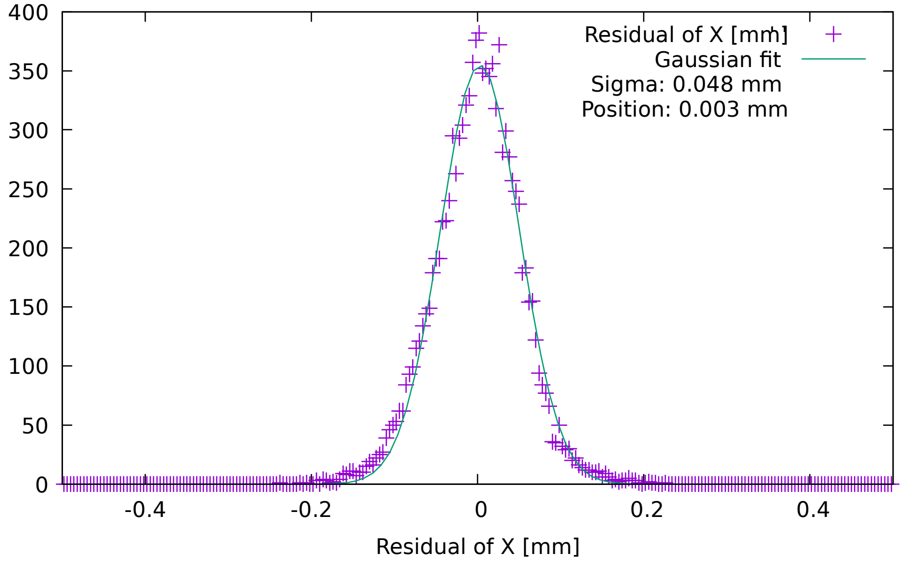
Work done by G. Galgóczi, see ”A GEM based TPC for beam monitoring”. JINST Proc. 15 , C08027 (2020)

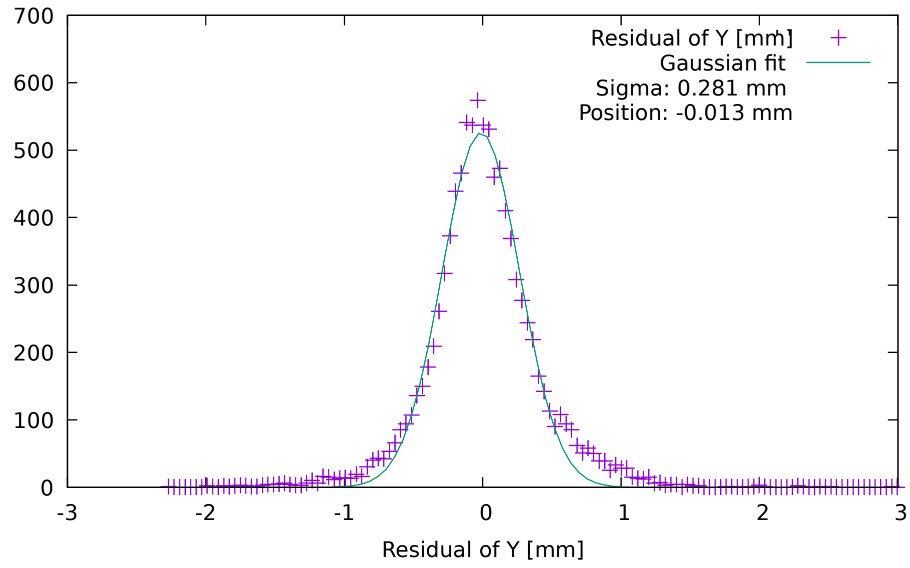
Position resolution
(from track residual)

- With the present readout, position resolution:

Pad direction 48 micron

Drift direction 280 micron



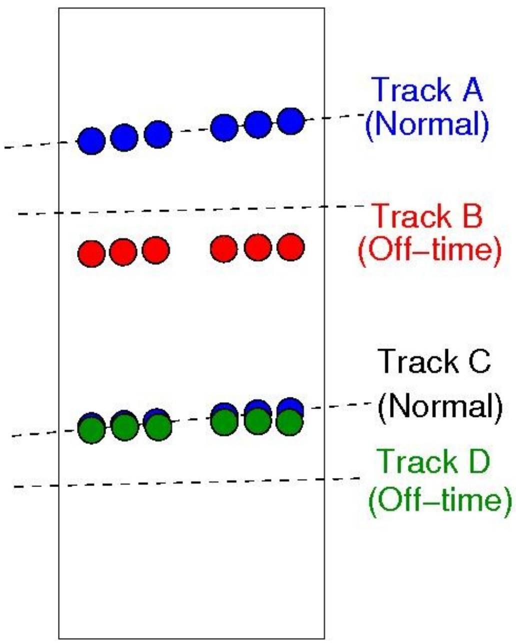


G. Galgóczi, JINST Proc. 15 , C08027 (2020)

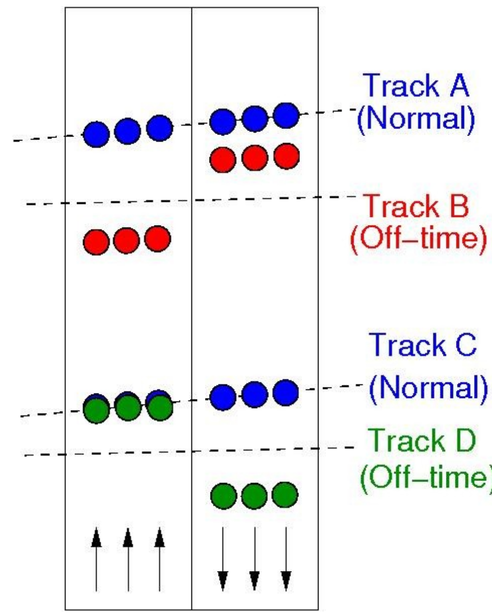
Improvement possibility: “Twin configuration”

- See the work from Francisco Garcia for Super-FRS, earlier in the “Sextant” detector (Legou et al 2007)

Standard



Twin



F. Garcia et al:

GEM-TPC Prototype for Beam Diagnostics of Super-FRS in NUSTAR Experiment – FAIR (2009)

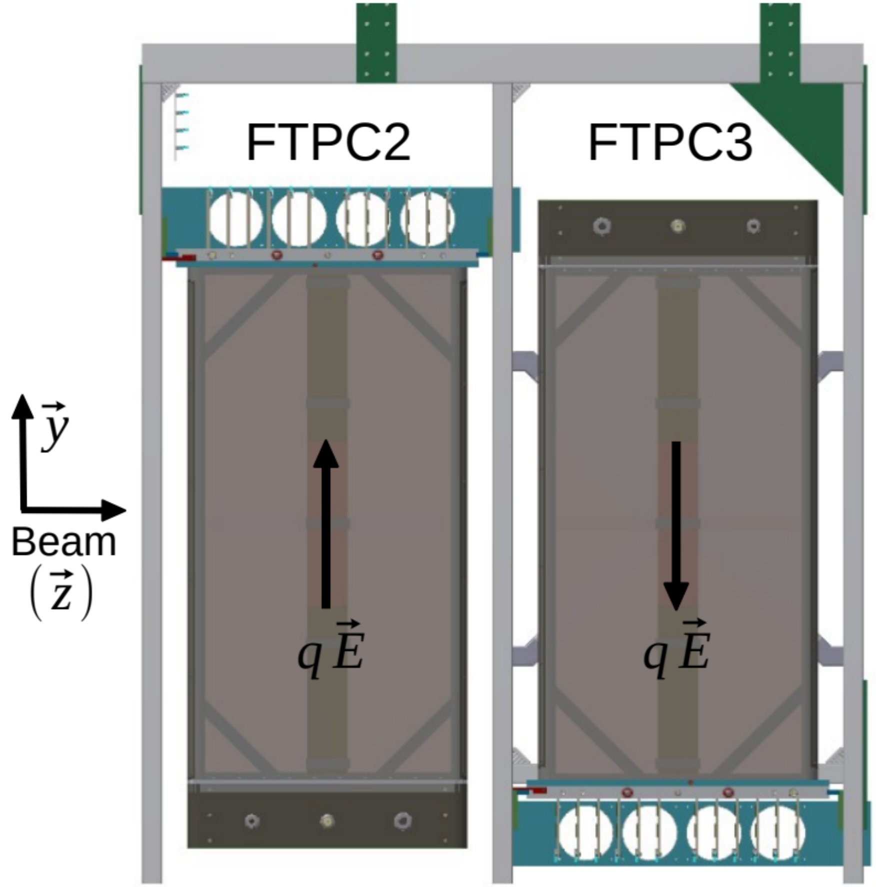
Super-FRS GEM-TPC Prototype Development Based on n-Xyter Asic for the FAIR Facility (2012)

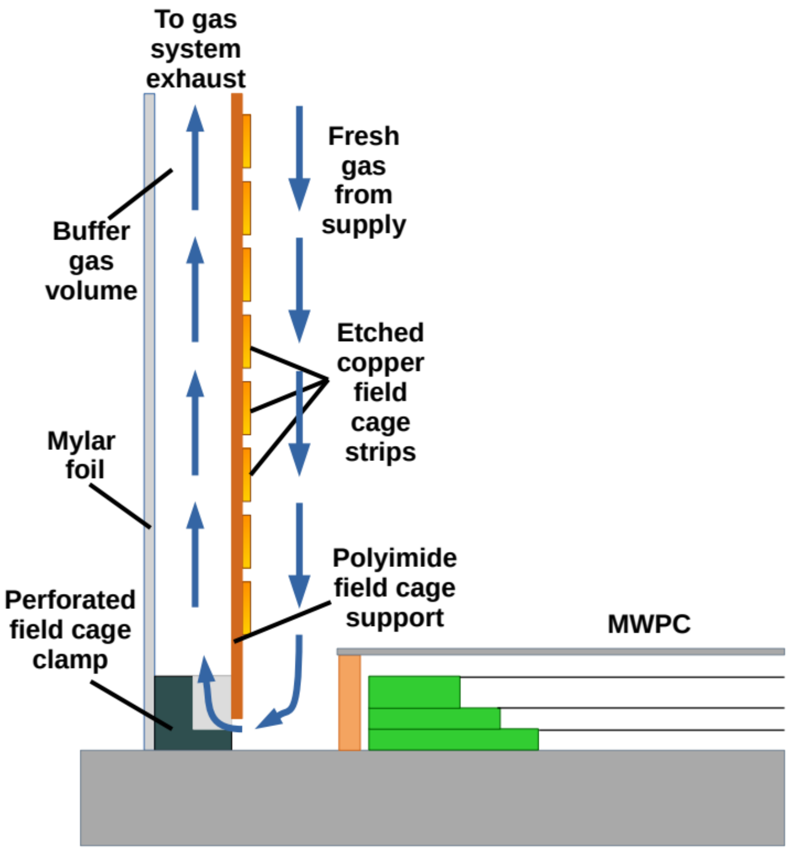
Twin GEM-TPC prototype (HGB4) beam test at GSI and Jyväskylä

Tandem TPC for the NA61 experiment at CERN

A. László et al JINST 15 (2020) p07013

•TPC units and field cage setup (MWPC based integrated to NA61 existing system):



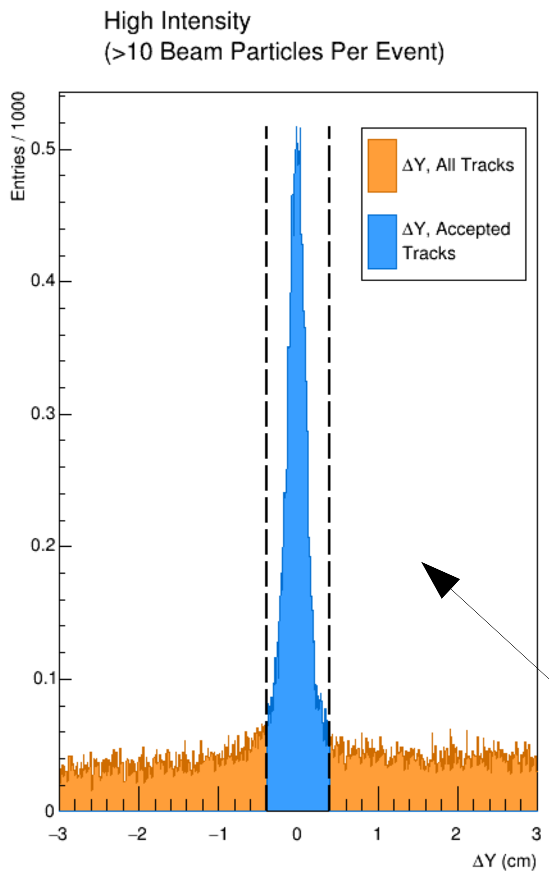


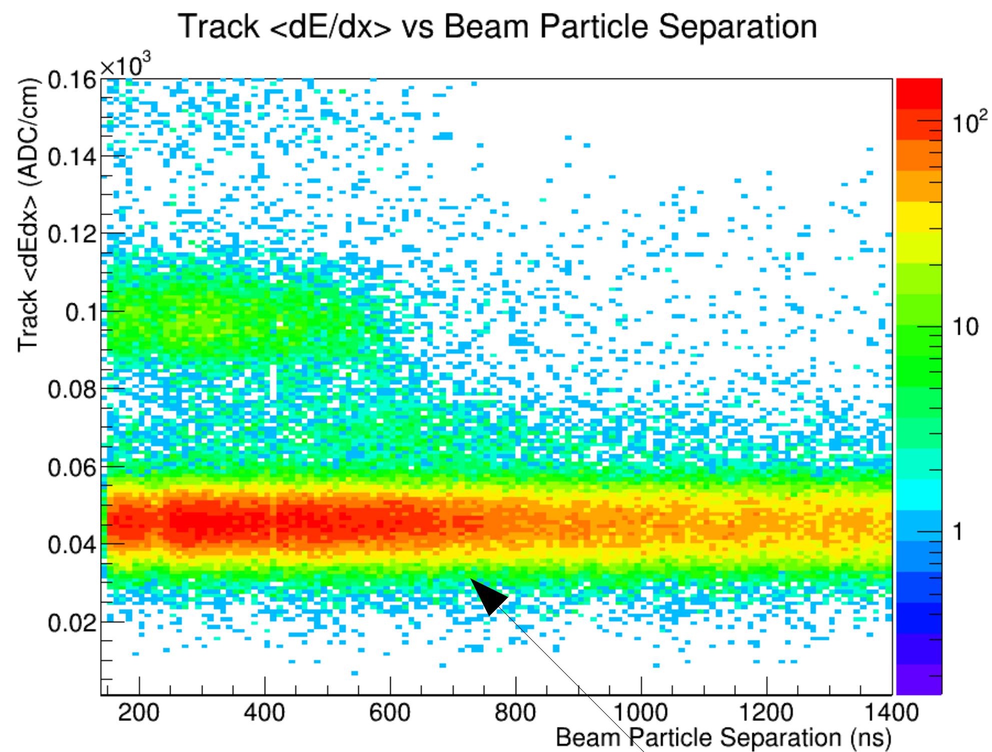
• Integrated field cage + gas vol. (18um thick copper strips etched on 75um thick polyimide foil)

• Exhaust gas washes out a gas buffer volume around chamber (50um thick Mylar foil)

- 43 tracking points (177cm tracking length)
- Tandem cut based out-of-time rejection works down to 600ns particle separation.
- (~ 50usec drift time over ~1 m)

Measurement at beam spot: 300kHz rate over 1 – 2 cm^2 area





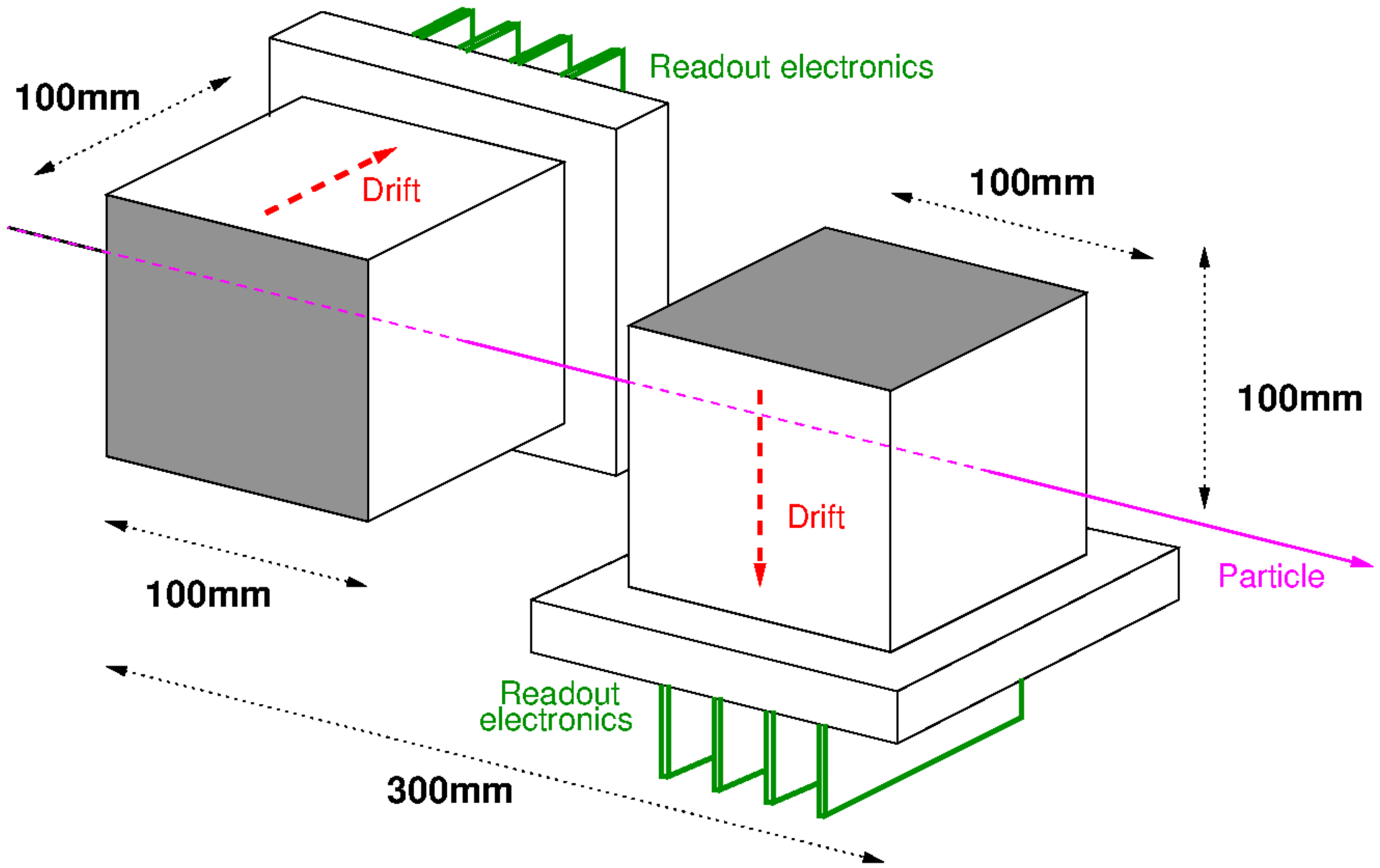
Separation in drift direction

Beam particles!

JINST 15 (2020) p07013.

Perpendicular configuration: self-calibrating drift velocity

- Rotate two TPC-s by 90deg (not 180 as “Twin”)



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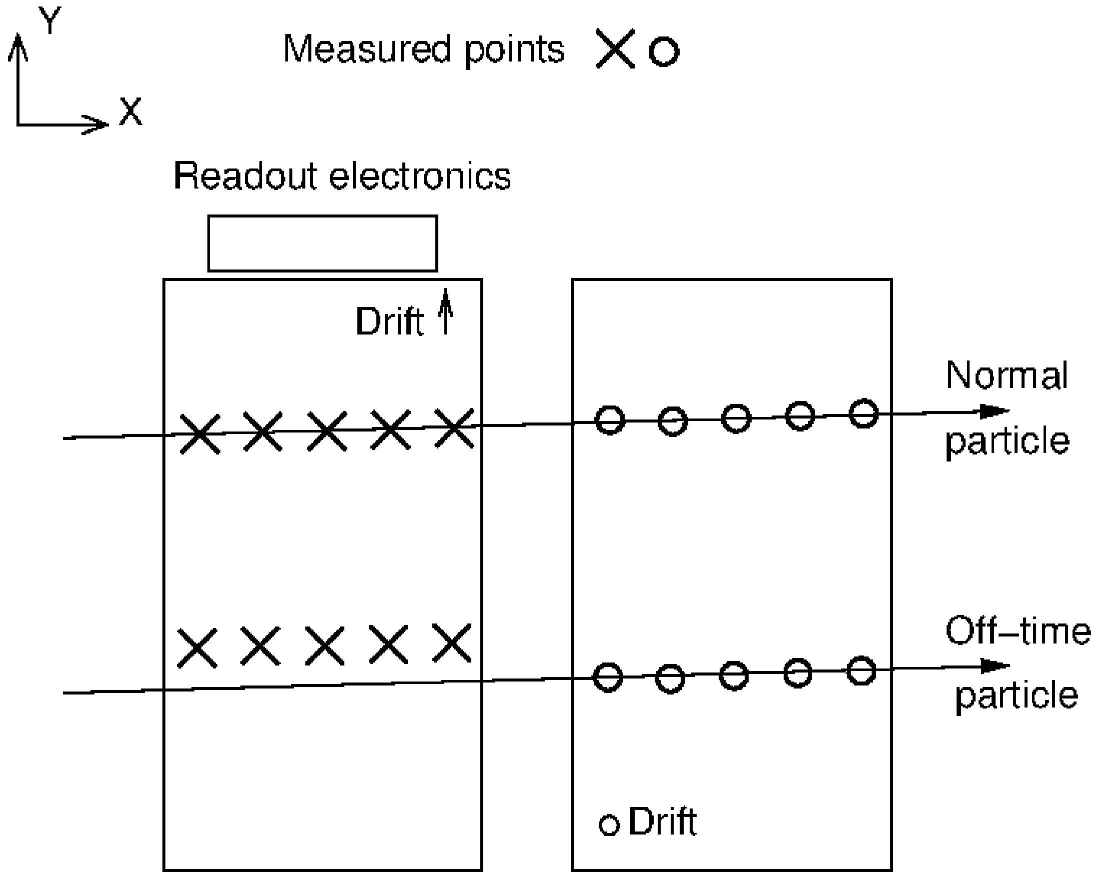

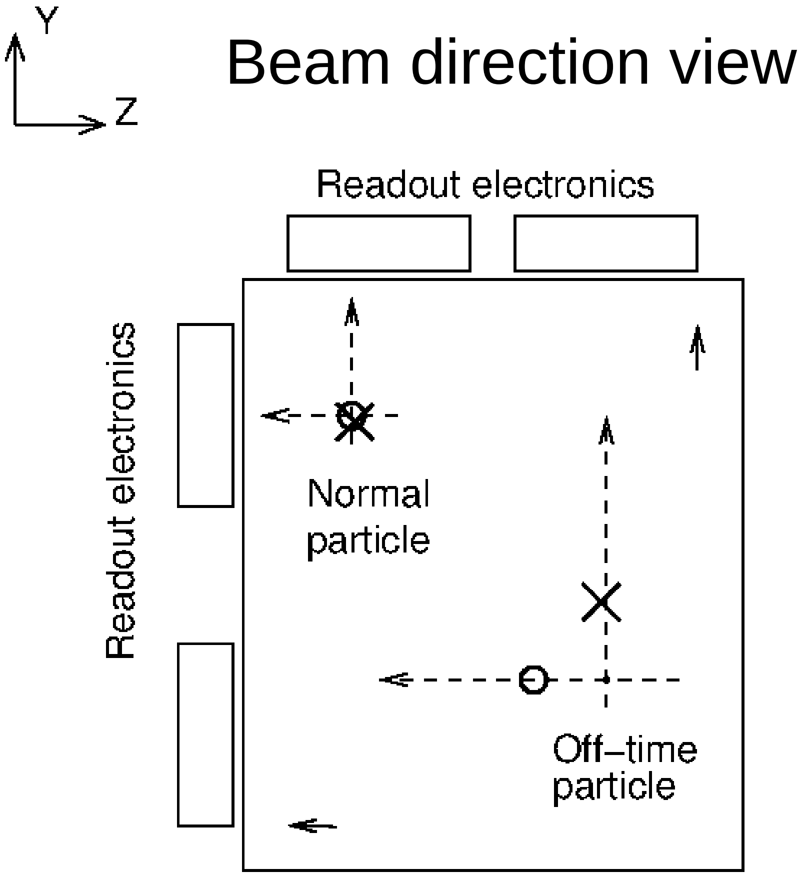

Conclusions

- Double GEM-based TPC works well from MIP to high ionization (limiting is the front end dynamic range)
- “Twin configuration”: nice possibility of background suppression from off-time, developed for Super-FRS (F. Garcia et al), also applied at NA61 (A. Laszlo et al)
- Perpendicular configuration: simplified drift velocity calibration, minimal external information needed
- Plan for an RD51 beam testing (if managable)

Backup: resistor chain

- Resistor chain: designed such that two input voltages used (U_GEM and U_drift)
- Resistor values related to geometry, therefore field matching is automatic (no need for supply on field cage resistor chain bottom)

Backup: field cage and gas envelope

- Low-material-budget direction : beam dir

  perpendicular : solid-wall support

- Double wall : field cage + gas cage

  flow from active vol -> inbetween cages -> exhaust

  low contamination even with sigle gas line and low flow