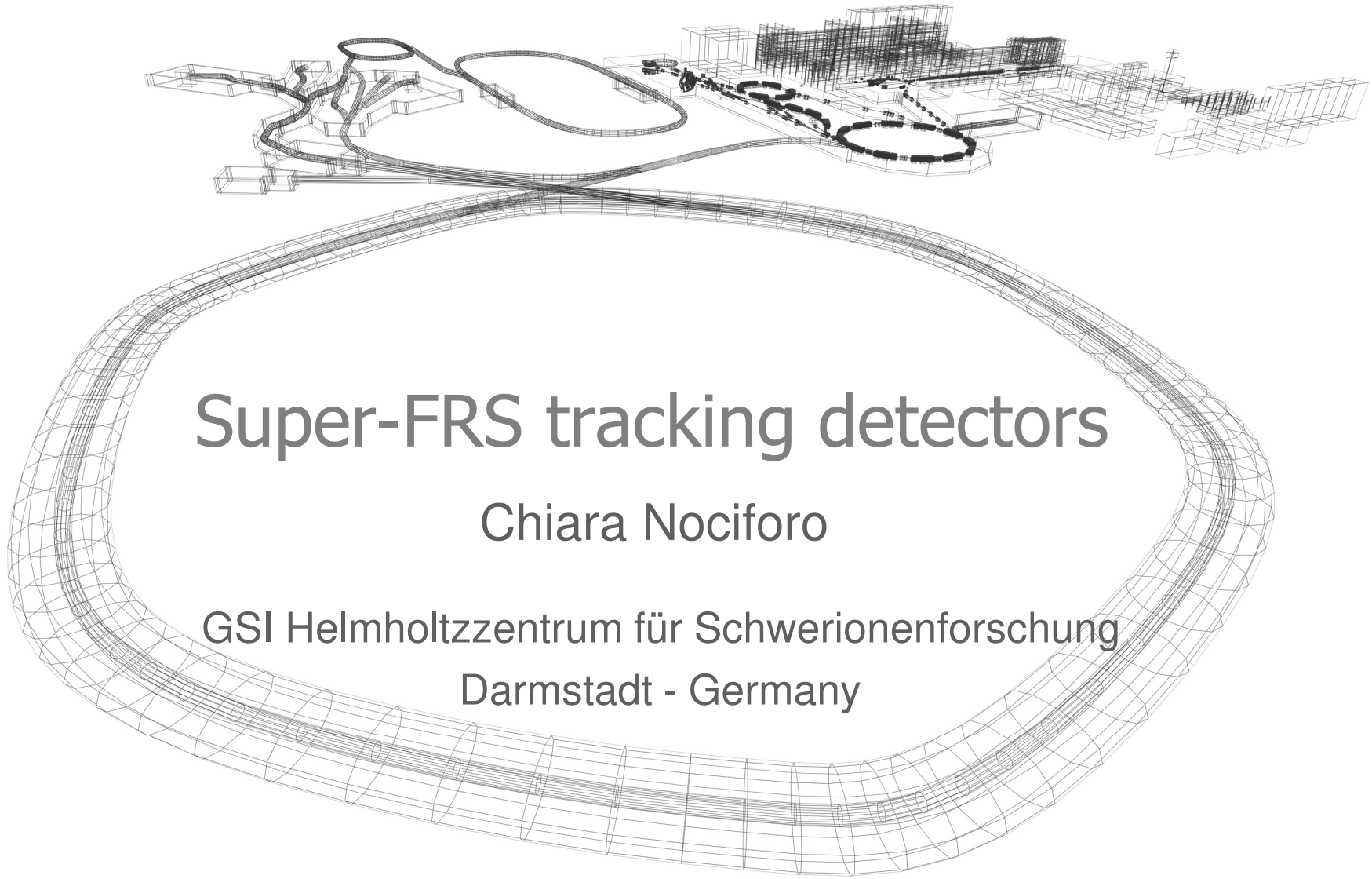


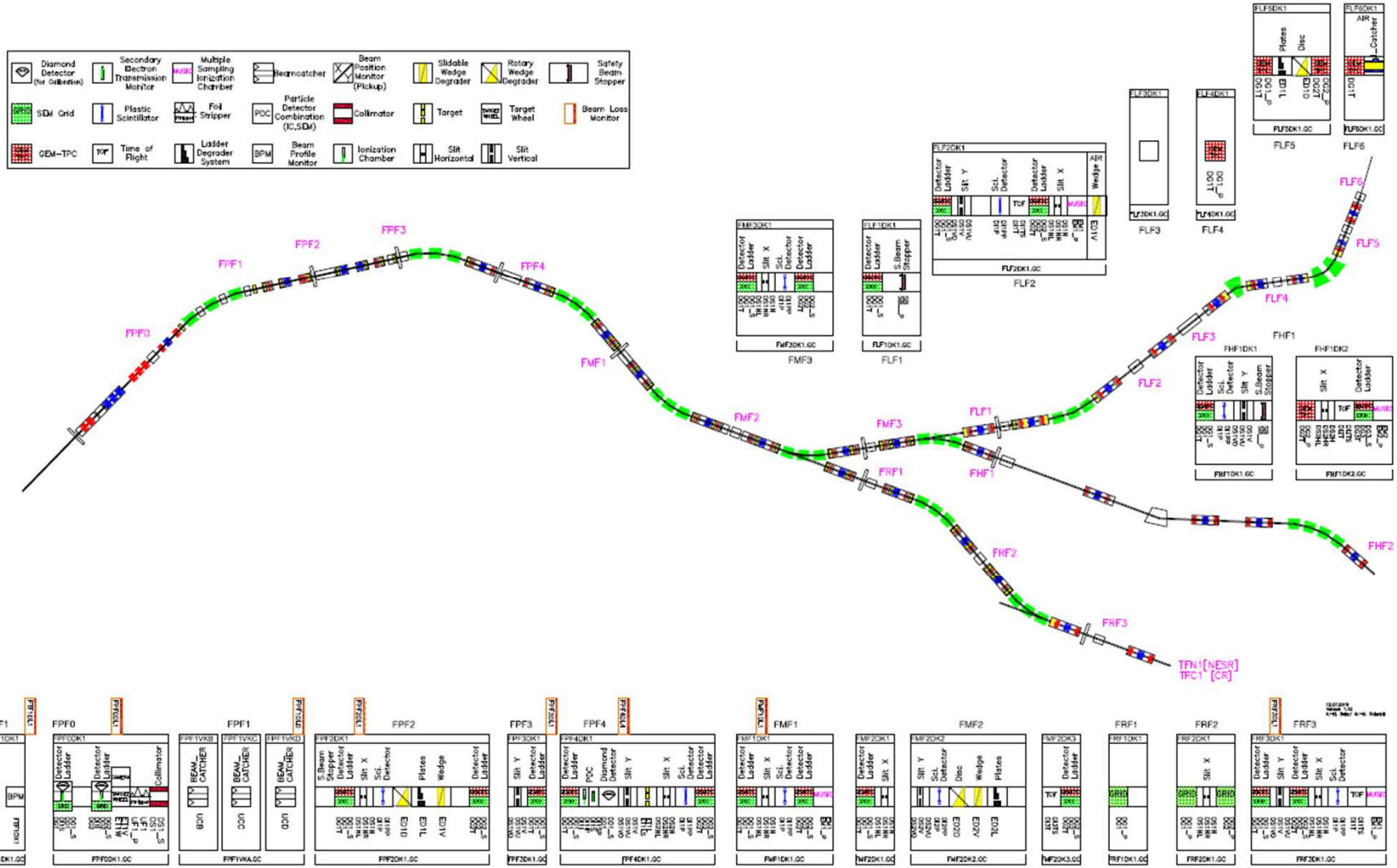
Super-FRS tracking detectors

Chiara Nociforo

GSI Helmholtzzentrum für Schwerionenforschung

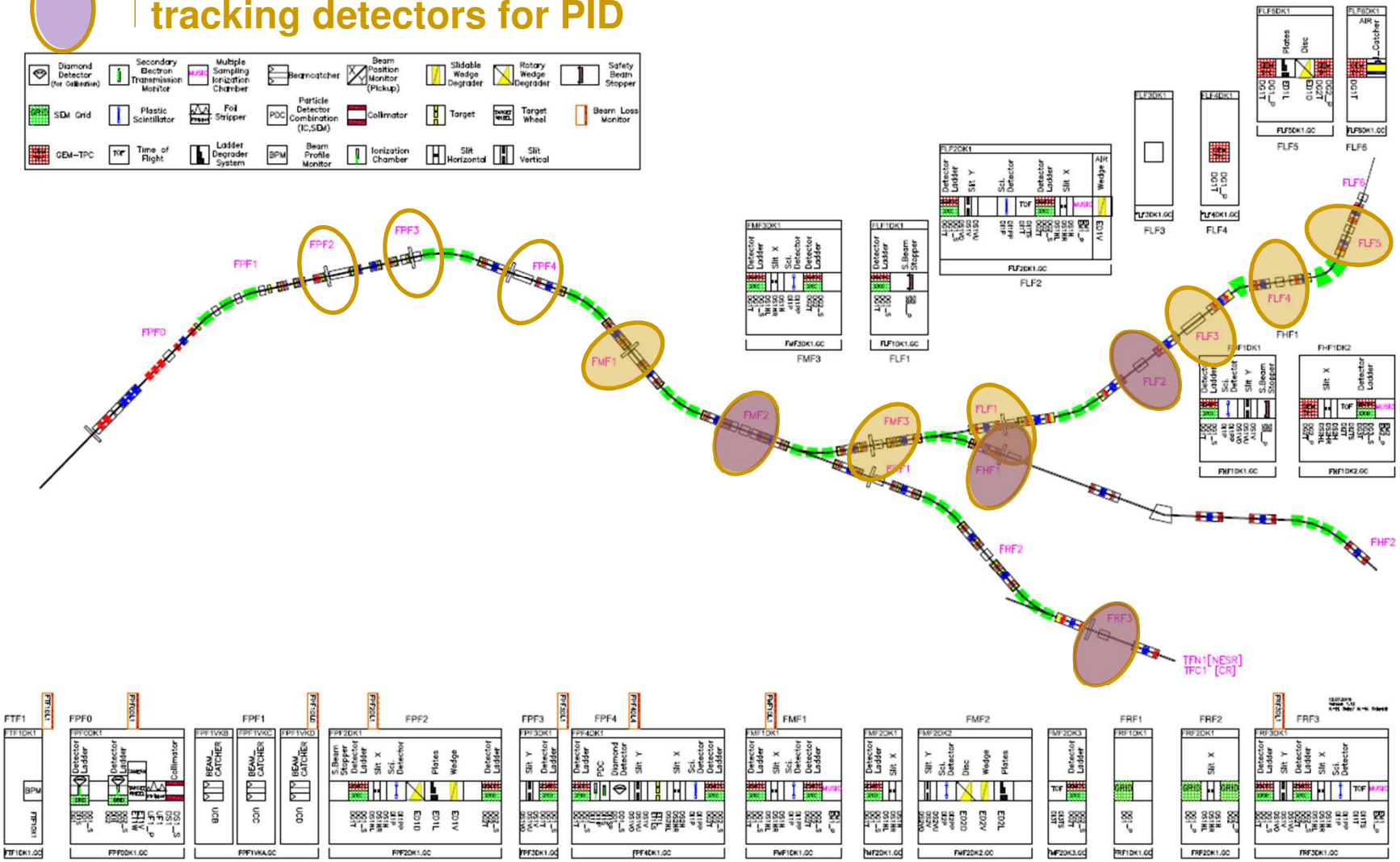
Darmstadt - Germany

Super-FRS layout



Super-FRS layout

tracking detectors for PID



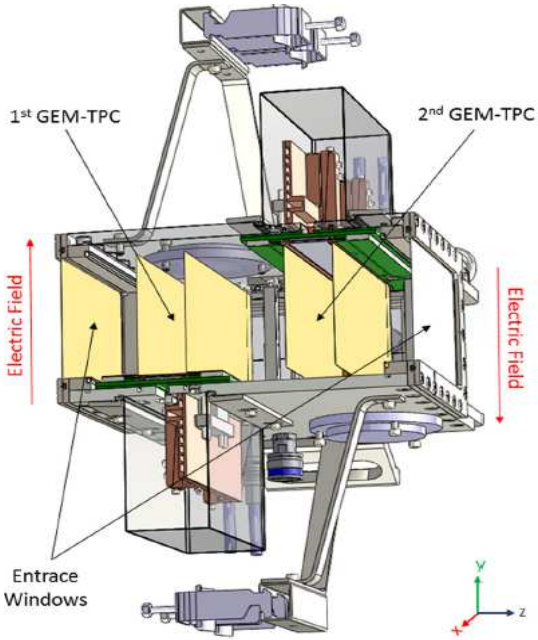
Tracking requirements
(Bρ reconstruction)

- Momentum resolution (1st order)

D ~ 6 cm/% , Δx < 1mm → Δp/p ~ 10^{-4}

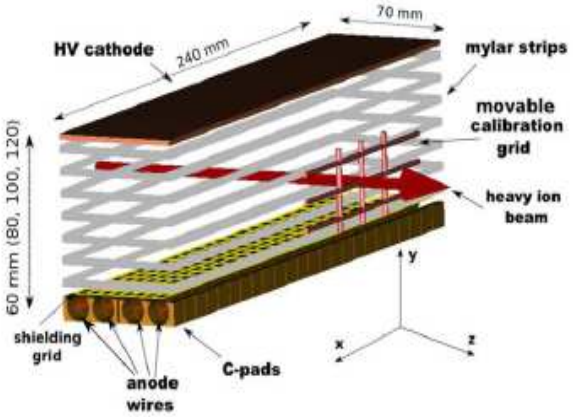
$$B\rho = B\rho_0 \left(1 - \frac{x_{FHF1} - M\, x_{FMF2}}{D}\right) + \Delta(B\rho)$$

(Bρ) includes corrections for additional momentum spread
dditional matter and reaction



Time Projection Chamber (TPC)

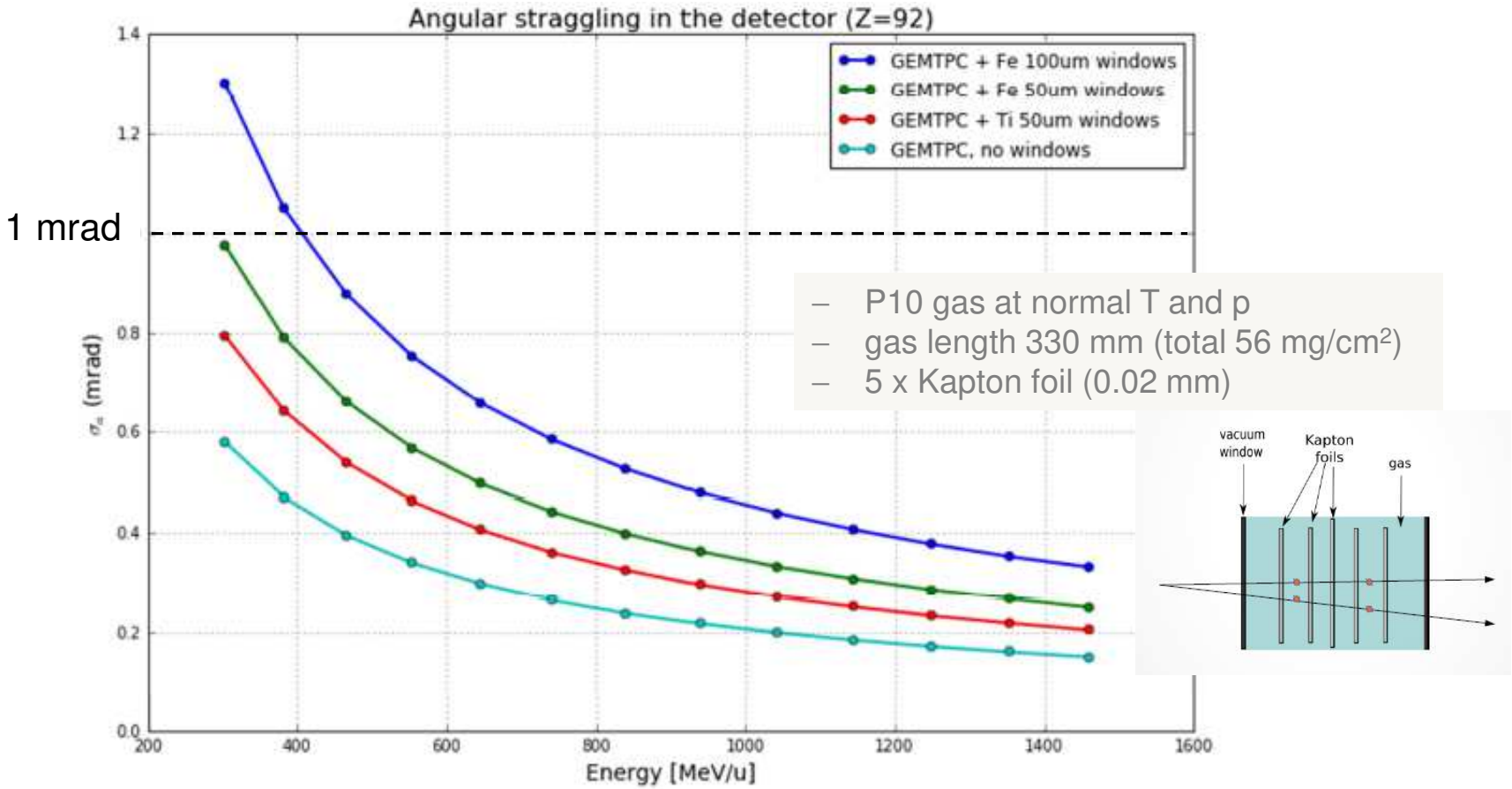
FRS TPC: R. Janik et al., *NIM A* 640 (2011) 54



´Twin´ Gas Electron Multiplication (GEM)-TPC

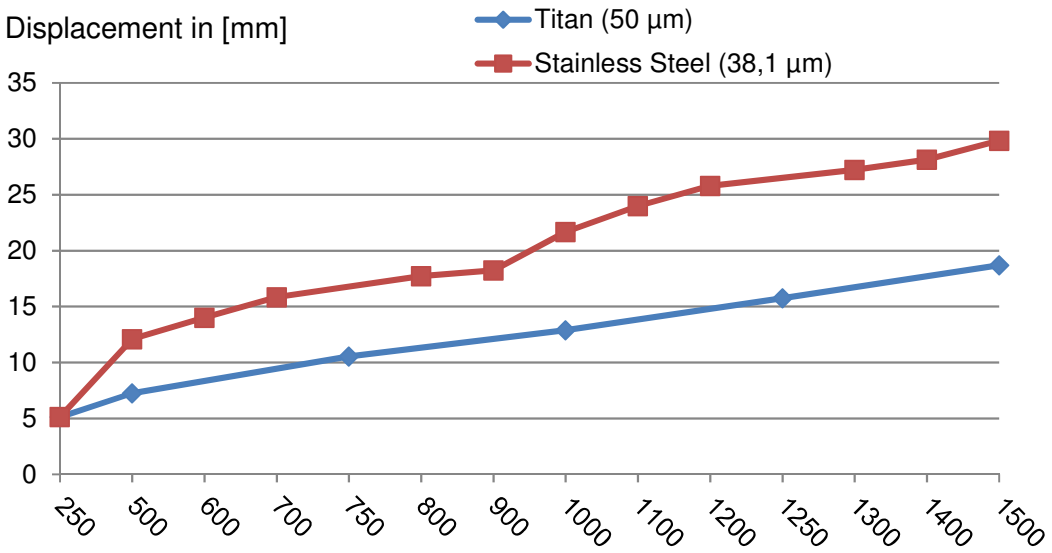
Super-FRS GEM-TPC: F. García et al., *NIM A* 884 (2018) 18

Angular straggling for U ions



- The use of thin & low Z windows to minimize angular spread

Pressure test

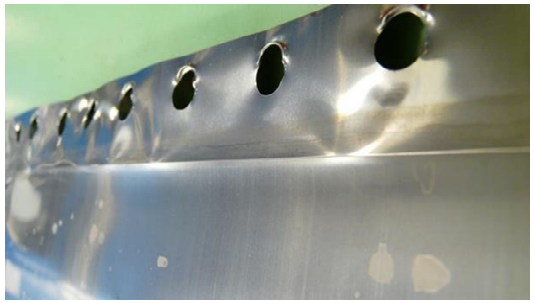


courtesy of M.-M. Schmidt

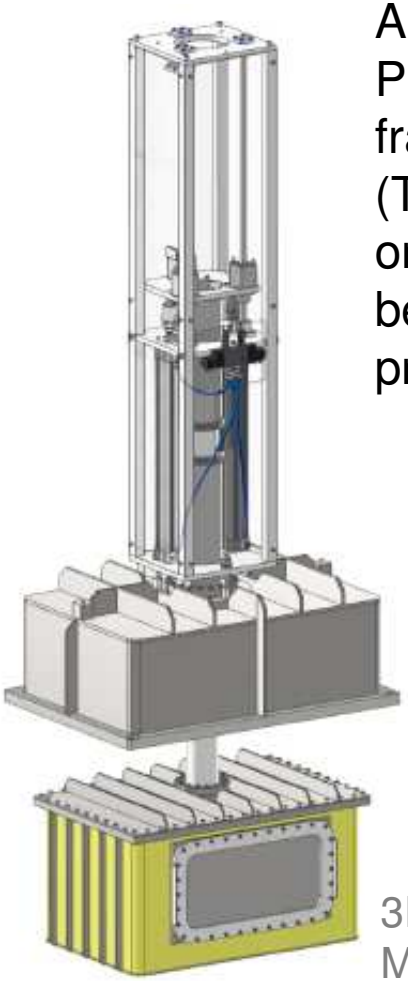
Ti foil after test at 1.5 bar

Δp [bar]	Δl [mm]		
	Ti (50 µm)	SS 316L (38 µm)	Ti* (50 µm)
0.5	7.25	12.09	
1	12.9	21.67	13.4
1.5	18.7	29.84	15.6

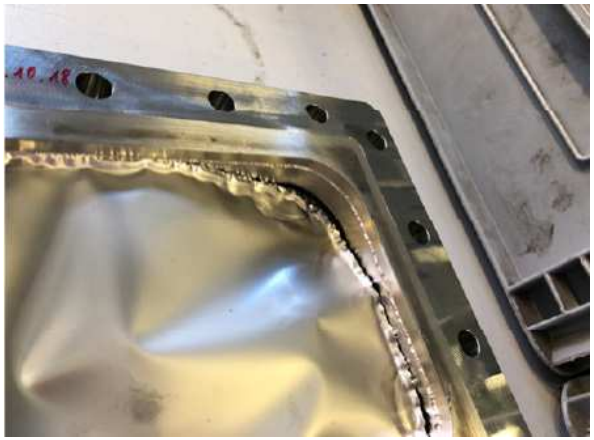
*simulated elliptical shape



Vacuum window



A different test commissioned to the PINK GmbH Vakuumtechnik for frame (Ti), support frame (Ti) and foil (Ti, about 200x100 mm^2) made of one material failed because the foil became fragile during the heating process.

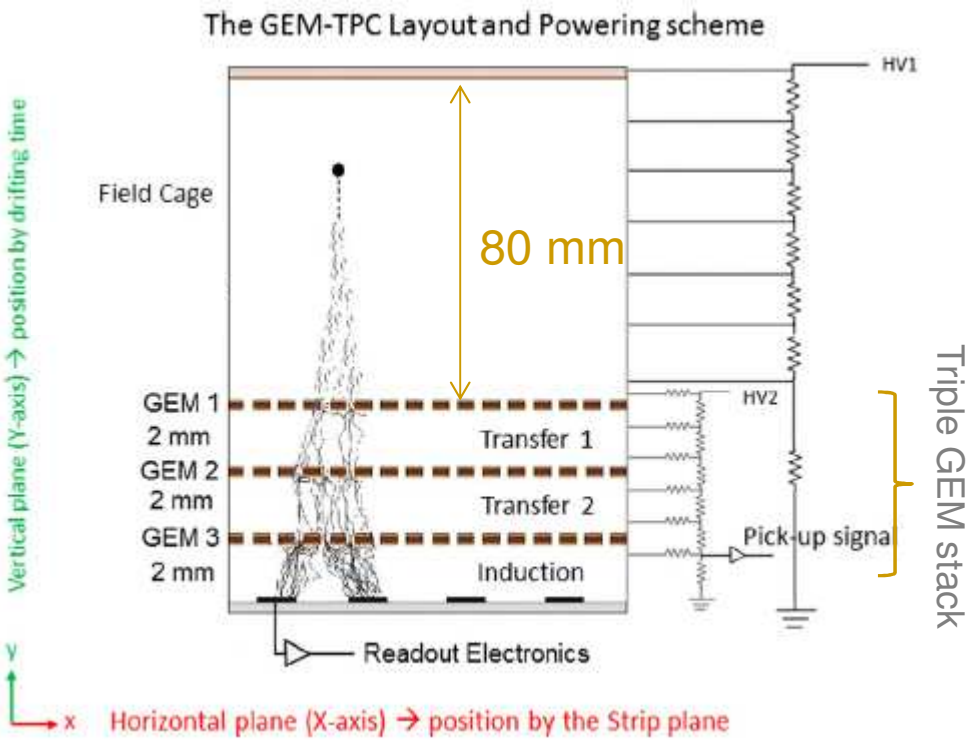


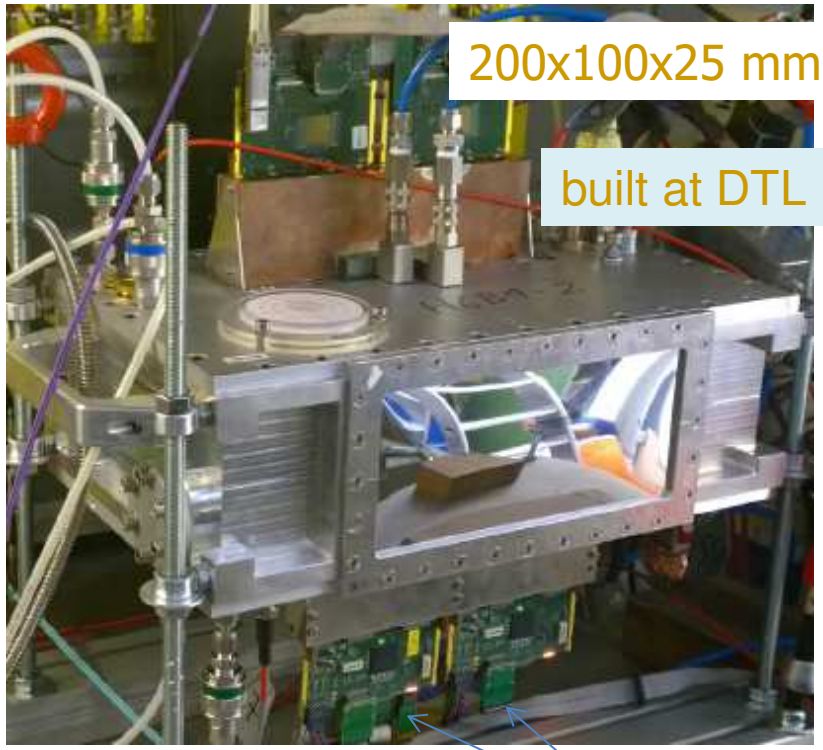
- According to in-house experts the right procedure to weld a Ti foil on a Ti frame, is the e-beam technique. A rounded or elliptical shape of the foil should be preferred.

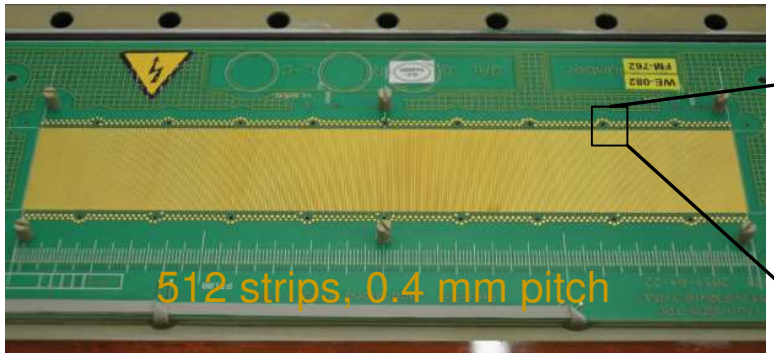
3D model (CDR)
MUSIC drive and pocket at FMF1
by J. Tuunanen (JYFL Jyväskylä)

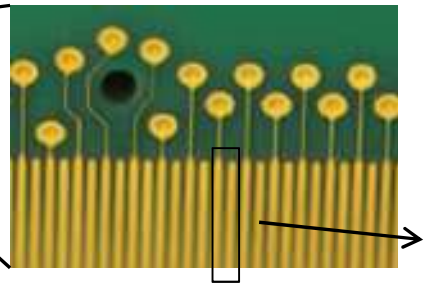
UNIVERSITY OF JYVÄSKYLÄ
JYVÄSKYLÄN YLIOPISTO

(Twin) GEM-TPC design







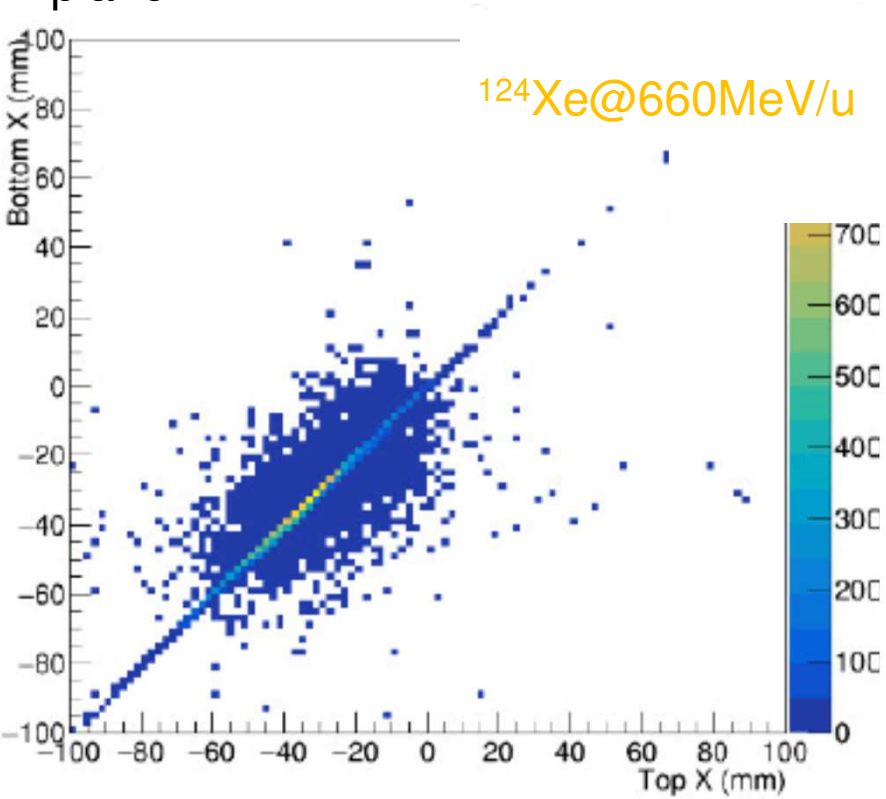


GMX-NYXOR cards
designed by GSI-EEL

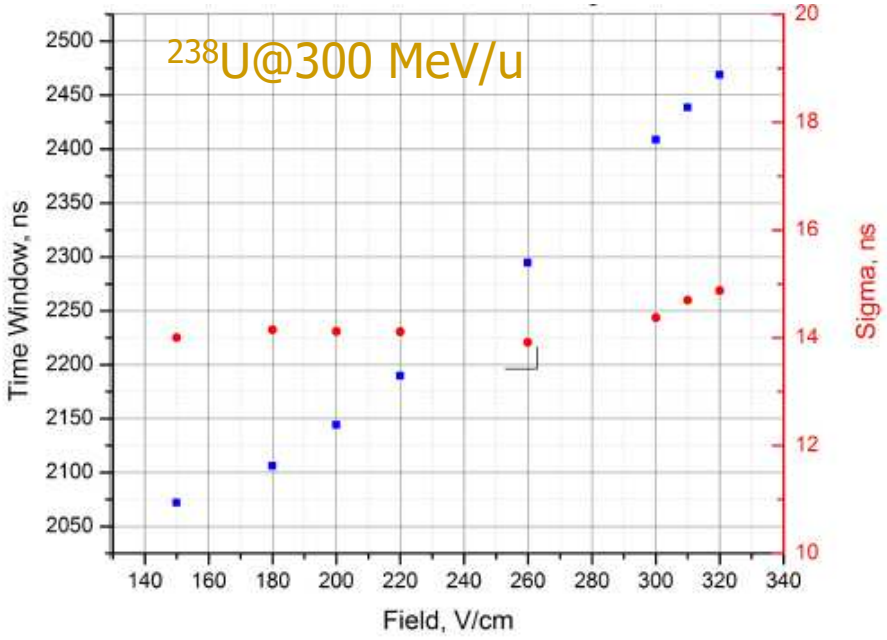
strip area: 30x0.25 mm²

Test results

- correlation between top and bottom anode signals
- clusters size: 15-20 strips (= 6-8 mm), too small pitch → redesign of the strip plane



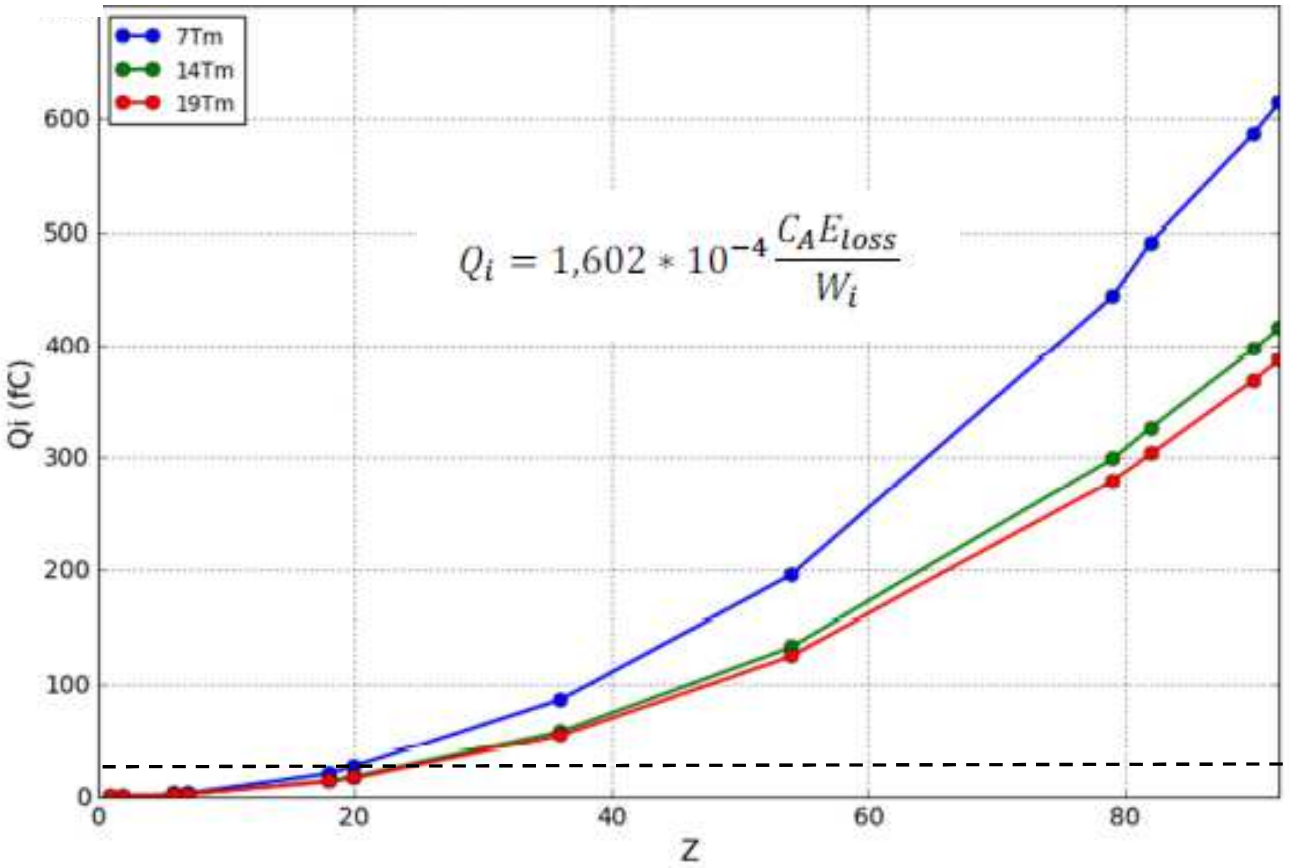
C. S. = $Tdrift_{up}$ + $Tdrift_{down}$ – 2 T_{ref}



- $\sigma_{C.S.}$ ≈15 ns (at low rate) → value not fully in agreement with simulations, <3 ns measured for Twin TPC
- GEM operated at gain ≈ 1 for Z>50.

Dynamic range

- Deposited charge in P10 gas volume 400x80x30 mm^3



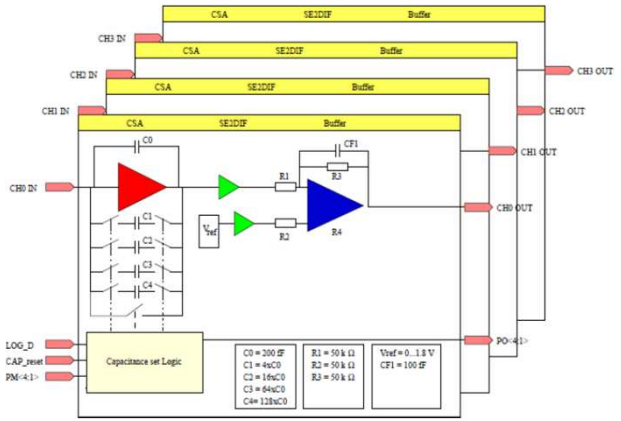
up to pC (VMM3a,CSA)

20 fC (nXYTER)

F-DS-BD-71e_SFRS_Tracking Detector_v2.0

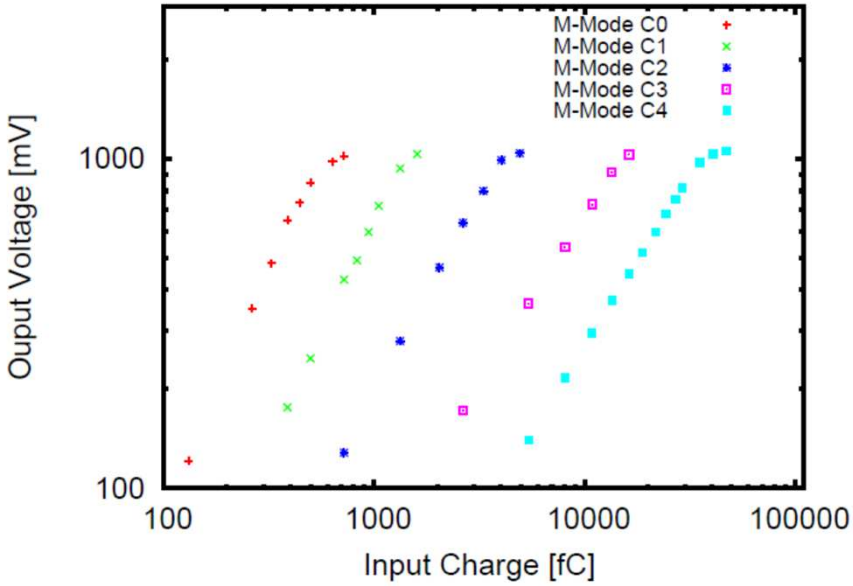
CSA characterisation

Noise :	0.3 fC
Max. input range:	22 pC
Rise time (10-90):	18 ns
Dynamic range:	$> 5 \times 10^4$
Gain for C_0	3 mV/fC
Supply voltage:	1.8 V
Current per ASIC:	16 mA
Output voltage swing:	0.8 V
CSA with active reset	without shaping



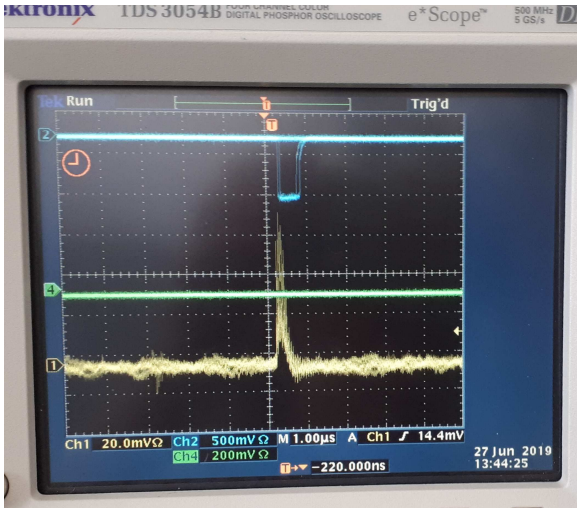
- 4chs /chip designed by *P. Wieczorek* (EEL ASIC group)
- pre-amplification stage of the beam profile readout (POLAND)
- planned to be extended to 32 chs for HIT detection

Gain linearity

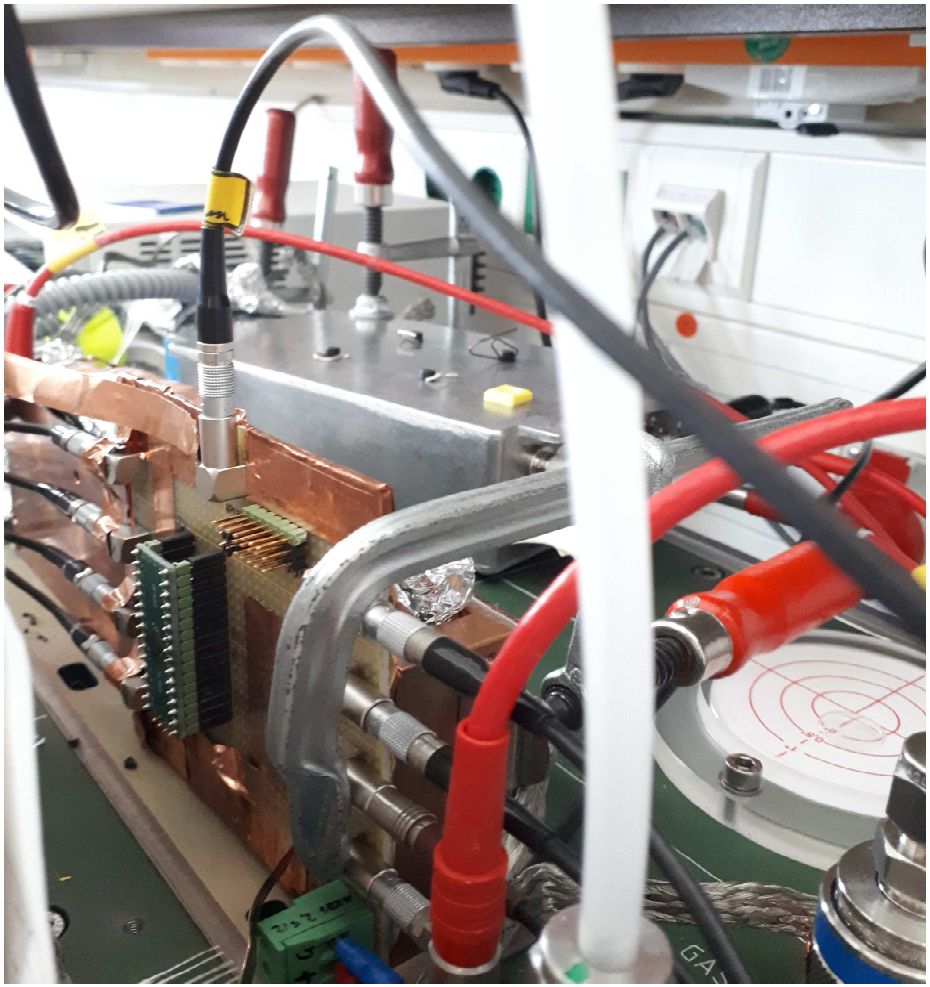


Test with source (July 2019)

- coupled to GEM-TPC pad plane,
  8 strips readout by FEBEX,
  measured 60 keV gamma (^{241}Am),
  output voltage ~ 20mV

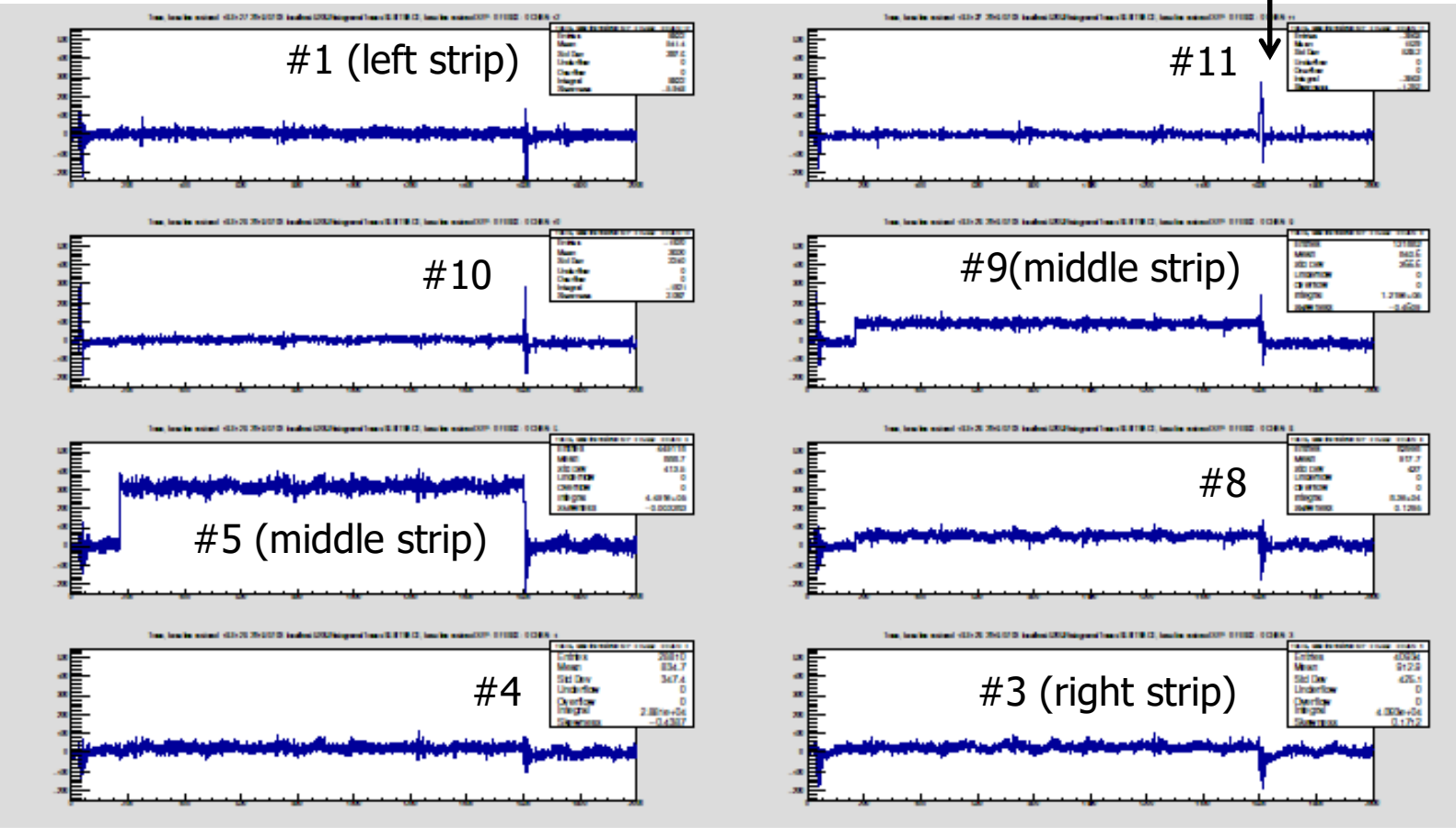


charge collected at the bottom of the 3rd GEM foil and measured in coincidence.



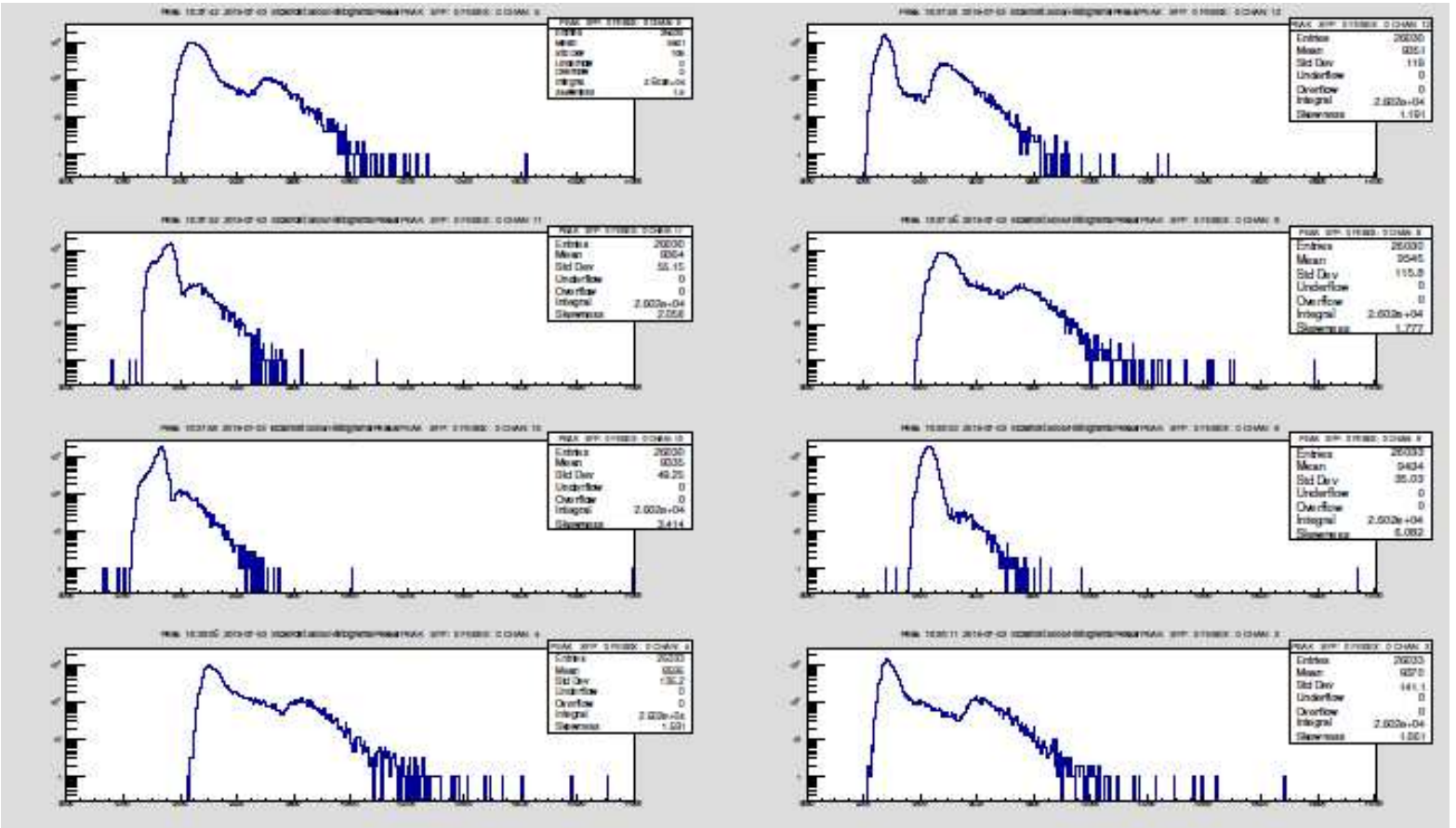
Test with ^{241}Am

- 8 CSA signals (=8 strips equipped), 30 µs integration time (reset signal)
- FEBEX3b: 14 bit, 50 MS/s , timing: 20 ns, input range: ± 1 V



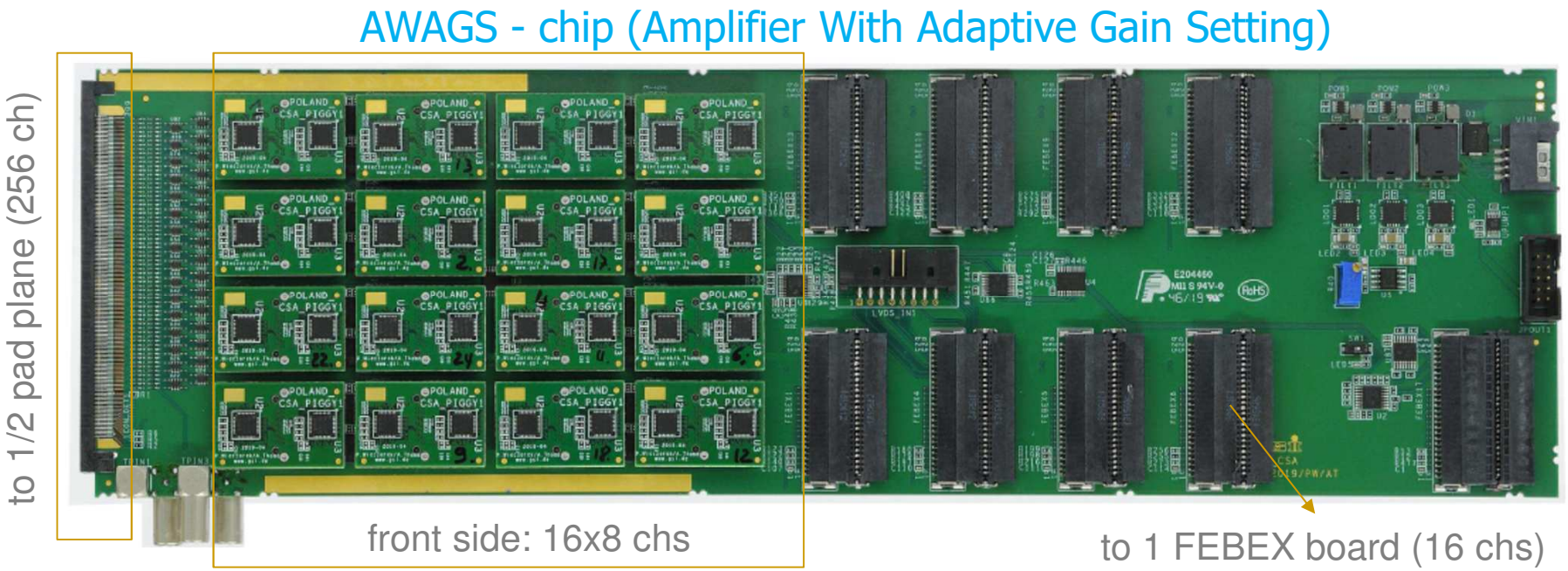
Uncalibrated energy spectra

- 8 CSA signals (=8 strips equipped)
- FEBEX3b: 14 bit, 50 MS/s , timing: 20 ns, input range: ± 1 V



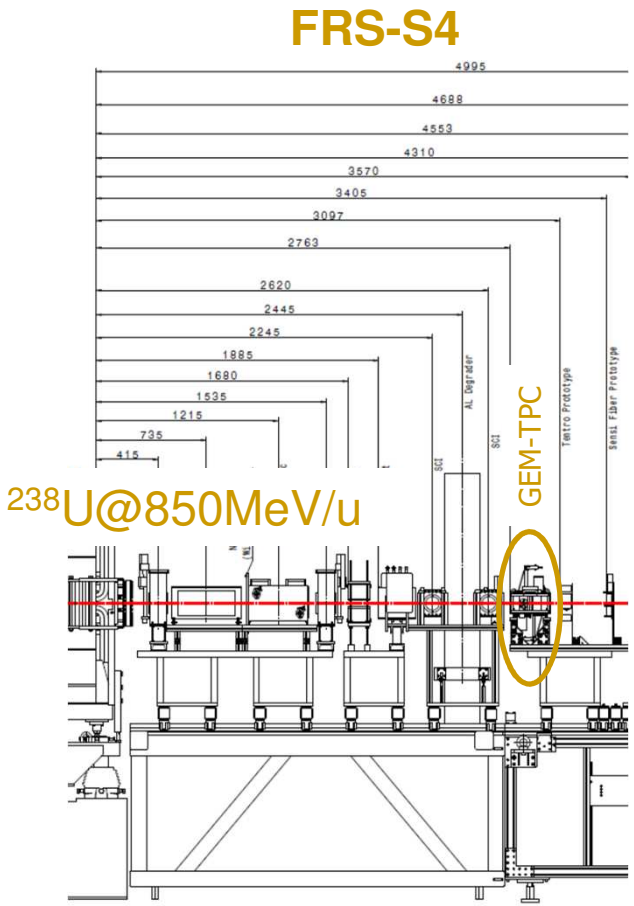
CSA GEM board

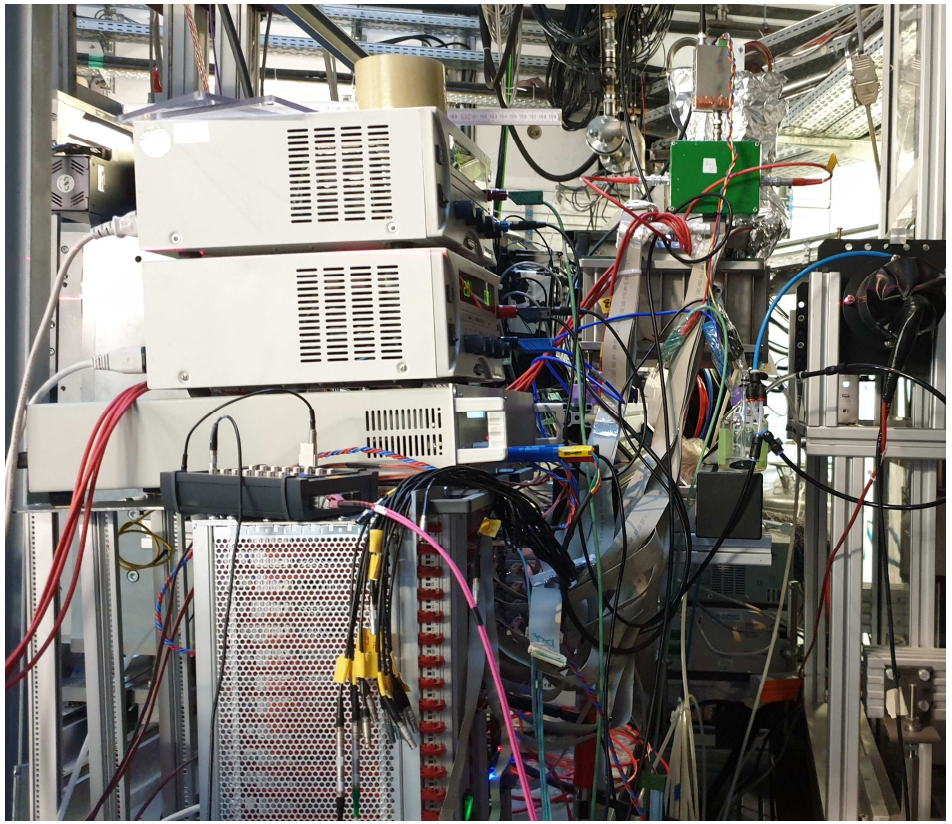
- In Summer 2019 it was agreed with PANDA coll. and EEL to go for production of some boards to be coupled to GEM-TPC pad plane.



- In-beam test with single-, 2- and 4-ch readout was planned during the engineering run FRS-EP-025.01.

Engineering run set up

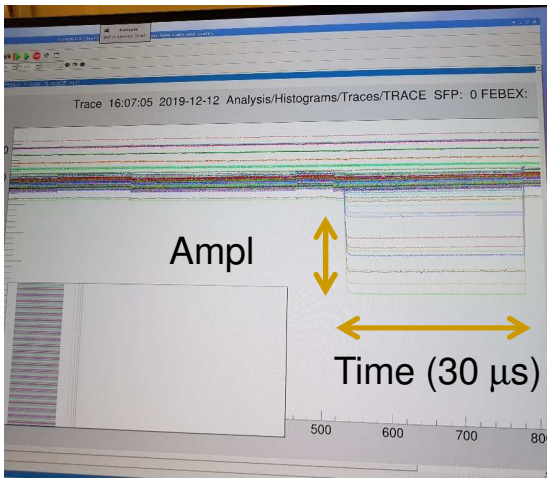


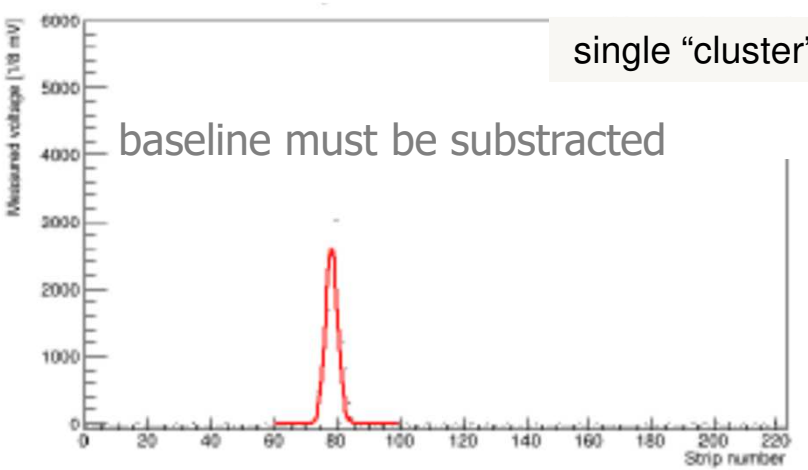


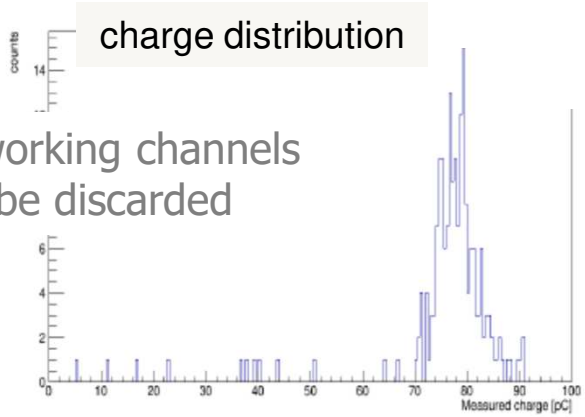
- FRS-S4 TPCs and SCI in front were included into the same MBS DAQ.
- Two scintillating fiber detector prototypes mounted behind and also tested.

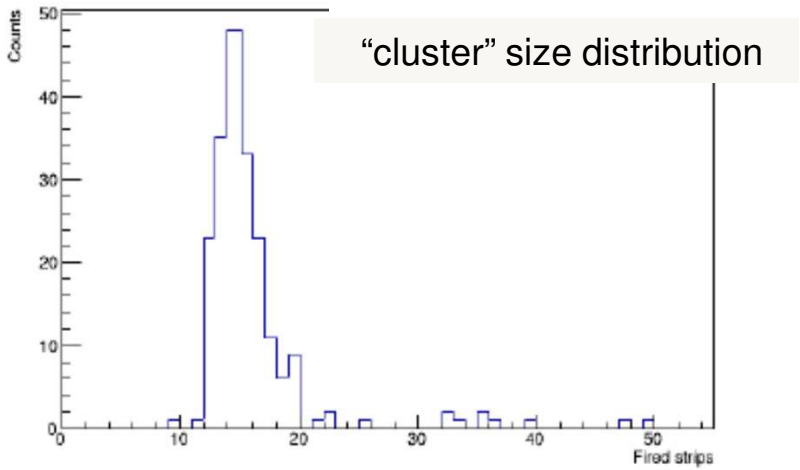
Preliminary results

- Single ion event









- Charge range: 50 – 200 pC (gain 50 -200)

Summary of the measurements

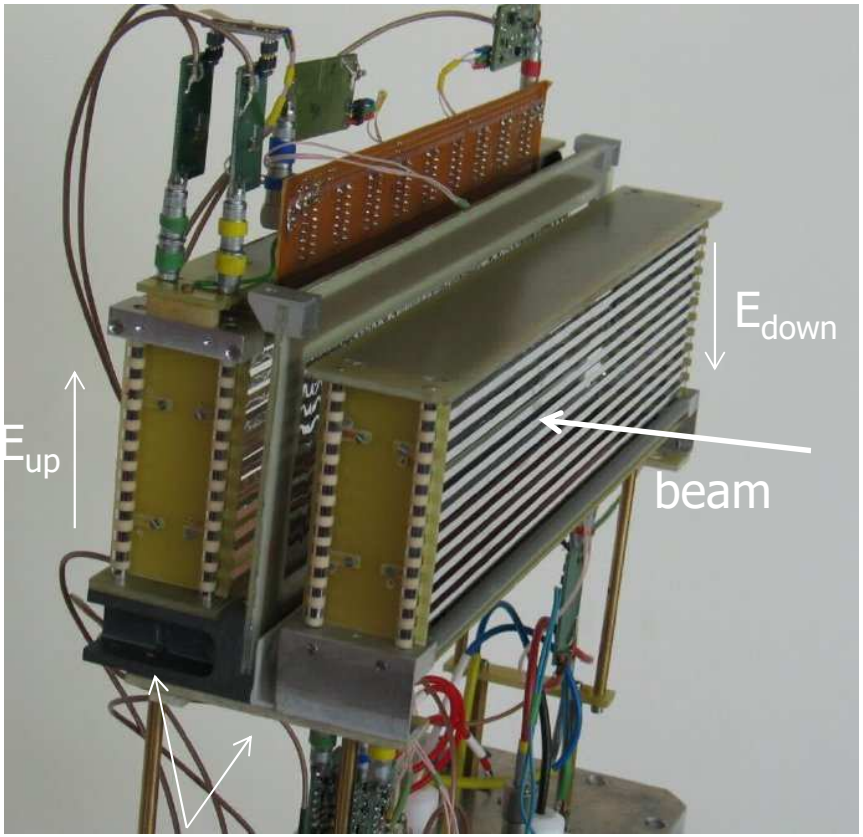
- One board ready two days before the experiment, tested in the lab and mounted on the detector.
- Test with source performed, detector mounted 12 hours before the start of the run.
- In-beam test:
  - change of the electric field value at fixed GEM gain
  - change of GEM gain at fixed electric field
  - change of the CSA gain at fixed GEM gain
  - S4-TPC calibrations and position reconstruction
  - position resolution at different gains
  - horizontal and (small) vertical scan of the chamber.

Acknowledgment

T. Blatz, C. Caesar, D. Chokheli, F. García, T. Grahn, C. Karagiannis, N. Kurz, S. Löchner, M. Luoma, S. Pietri, M.-M. Schmidt, B. Voss, H. Weick, P. Wieczorek and the FRS team

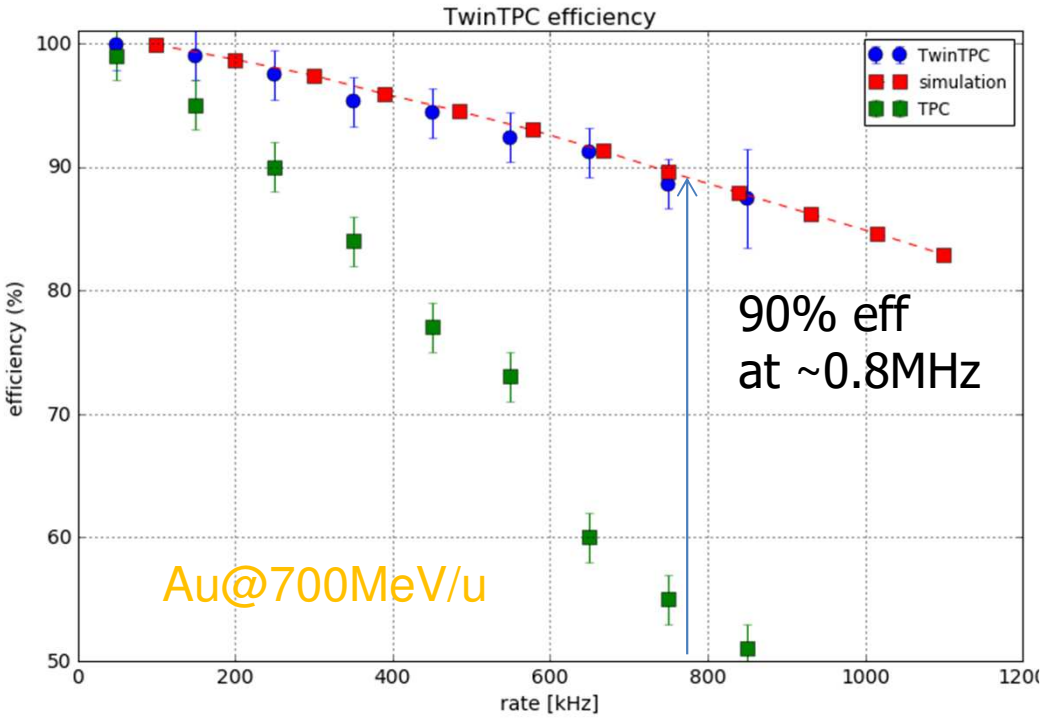
FRS Twin TPC

Built at CUBratislava



200x70x30 mm^3

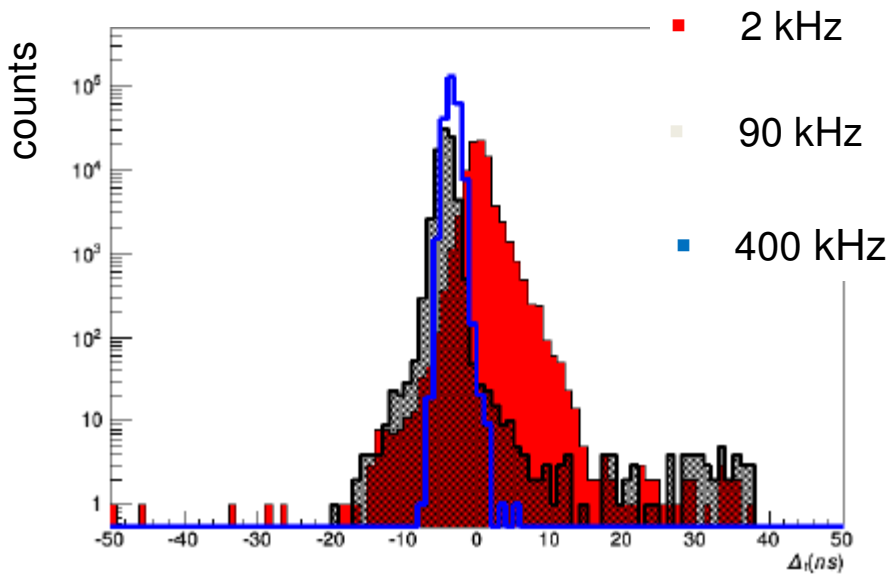
- Delay line, multi-hit TDC (V1290) readout



A. Prochazka et al., GSI Scientific Report (2014)

Time resolution

c. s. = $t_{DL} + t_{DR} - 2t_{an}$ [ns]



$\Delta = t_{an1} - t_{an2}$ [ns]