

Tracking detectors

Plamen Boutachkov

TU, Darmstadt, Germany

- Tracking for the Super-FRS, Haik Simon (GSI Darmstadt)
- Si tracking detectors, Oleg Kiselev (GSI Darmstadt)
- Beam tracking with LYCCA, Pavel Golubev (LUND University)
- HYDE detector: status and perspectives. Ismael Martel (Universidad de Huelva)
- GEM-TPC development for the S-FRS Francisco Garcia (University of Helsinki)
- MCP progress Michael Pfeiffer (University of Cologne)

Delta E Measurements:

TEGIC

- **Fast ΔE counter**
100 kHz – 10MHz, res. 1-2%,
large dynamic range
 - TEGIC (RIKEN, ca. 1MHz)

Beam

Problem(s)

- Drift times ~ few μs
- Pile up !

□ no analog shaping,
sample signal directly

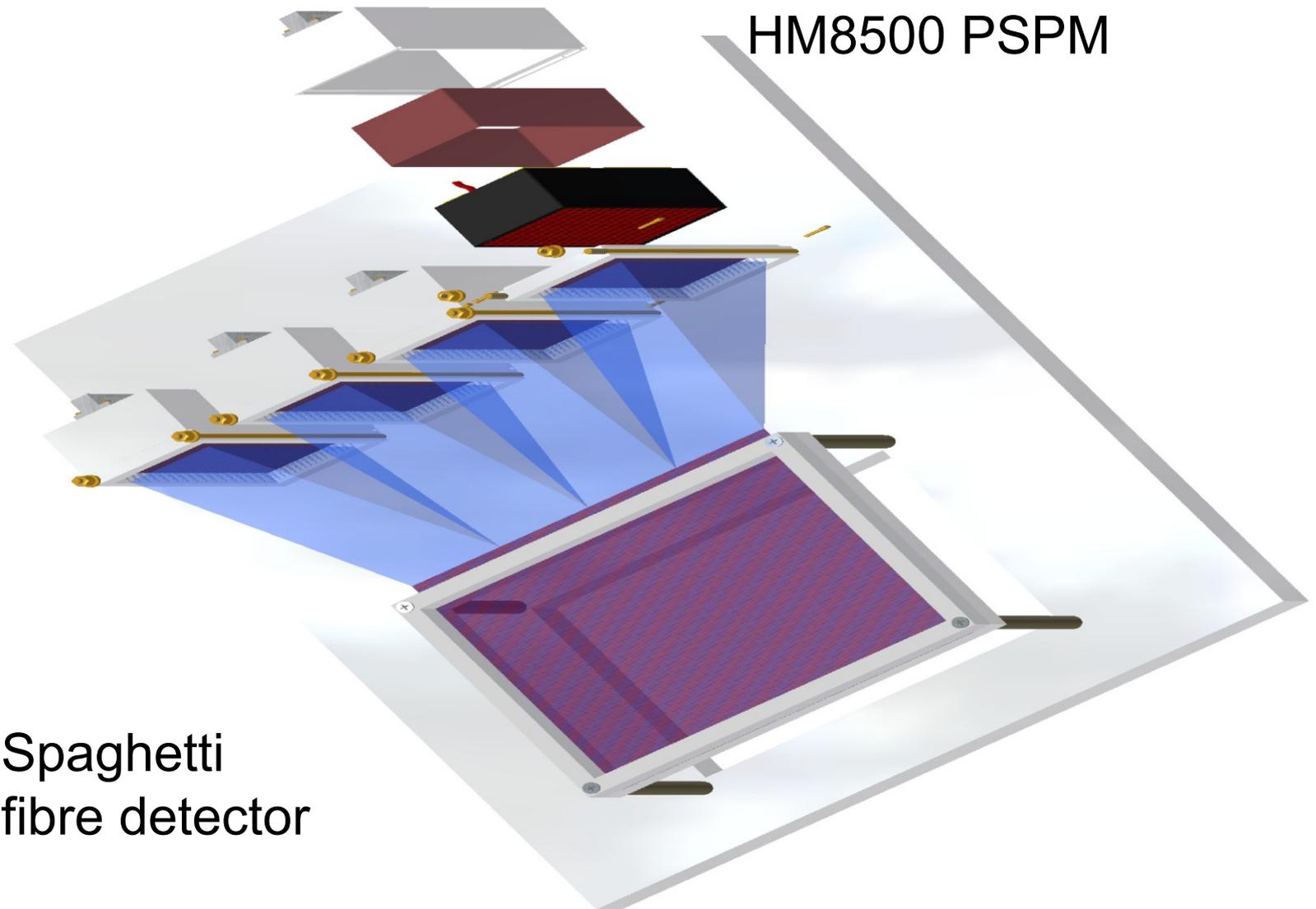


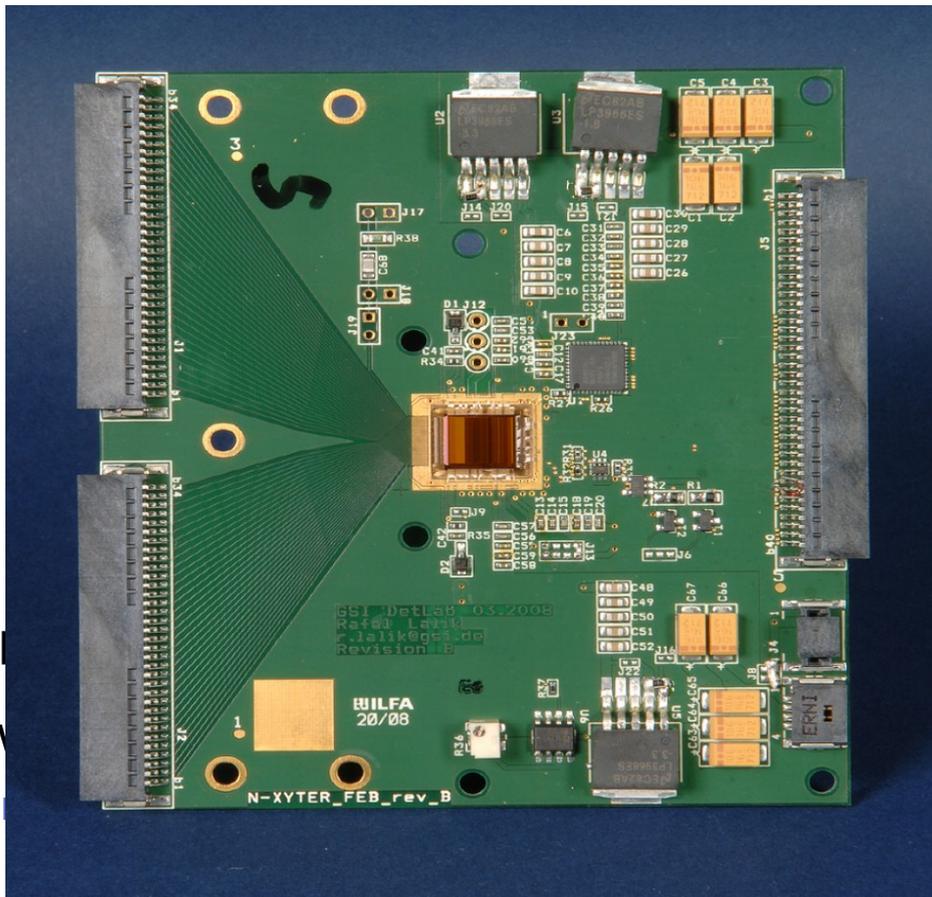
K. Kimura et al.,
Nucl. Instr. and Meth. A538(2005)608

P10 425mm normal pressure
Electrodes(anode/cathode) $4\mu\text{m} \times 25$ Mylar
14 mg/cm^2

Distance(anode-cathode) 2cm
Detector Window 150 μm Kapton

Other tracking ideas





Simple hybrid PCB with signal fan-in

ADC

interconnect to DAQ chain (SysCore, Exploder)

CBM beam time September 2008: whole signal chain operative

arbeiten
'Chip-In-Board'

avoids space eating vias

allows pitch adaptation:

50,7 μm on chip

101,4 μm on PCB (two levels)

10 Rev. C boards, fully functional



Si tracking detectors

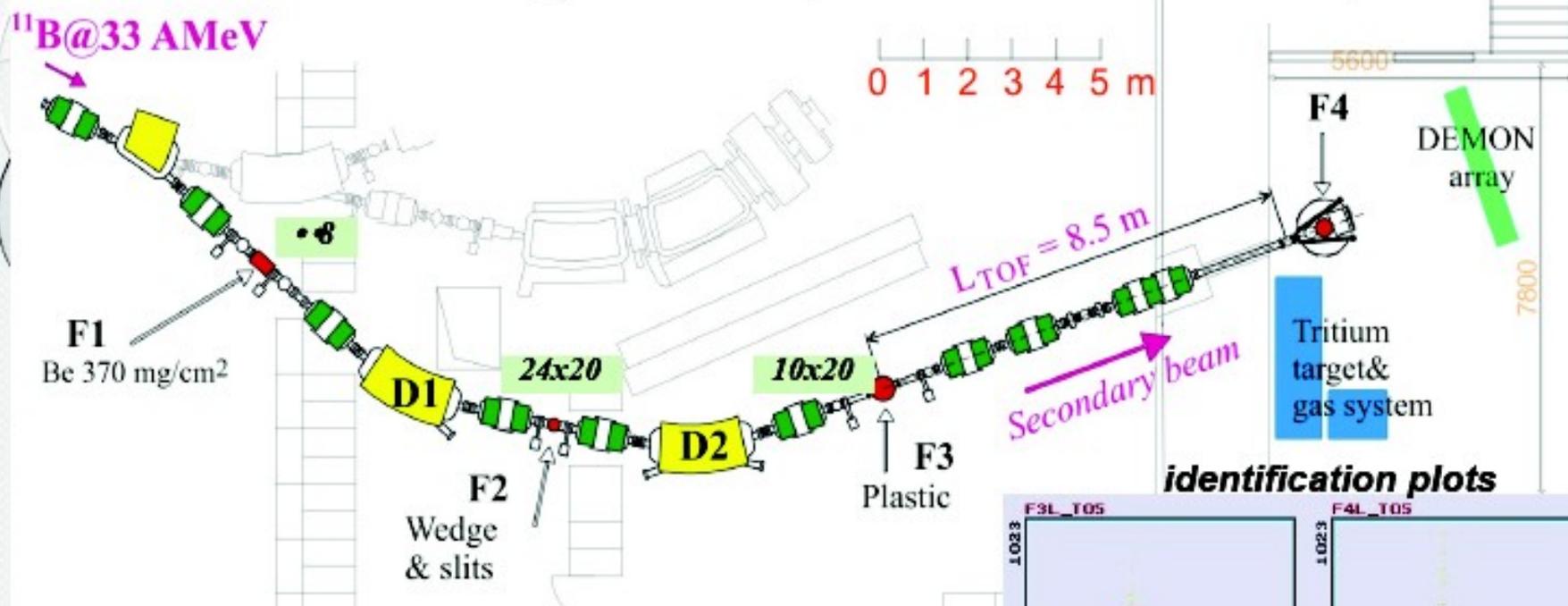
Vladimir Eremin

Ioffe Physical-Technical Institute, St Petersburg

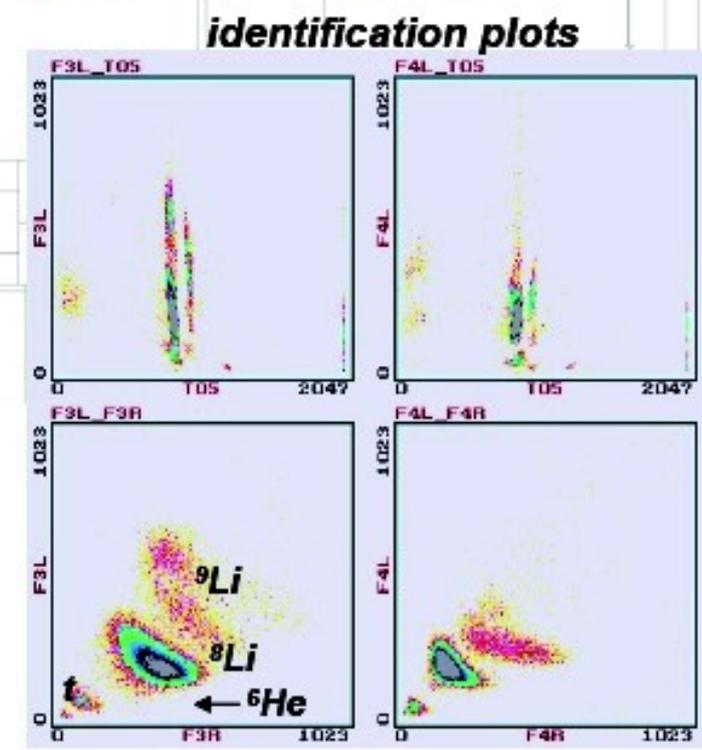
Oleg Kiselev

TU Darmstadt & GSI Darmstadt

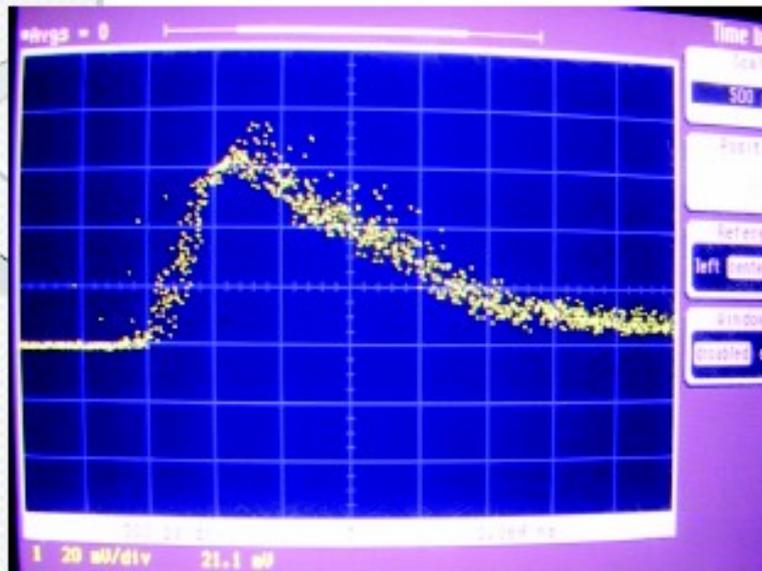
ACCULINNA fragment separator at U-400 cyclotron



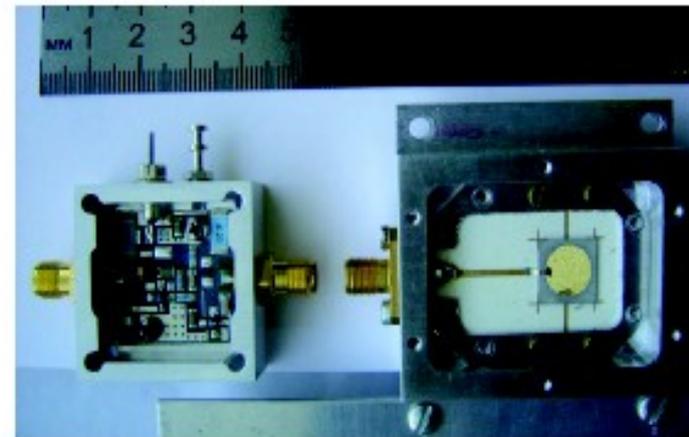
**F4: SC (4x4 mm²) & CVD (5x5 mm²) diamonds
300 μm thick, no backing • E-ToF ?**



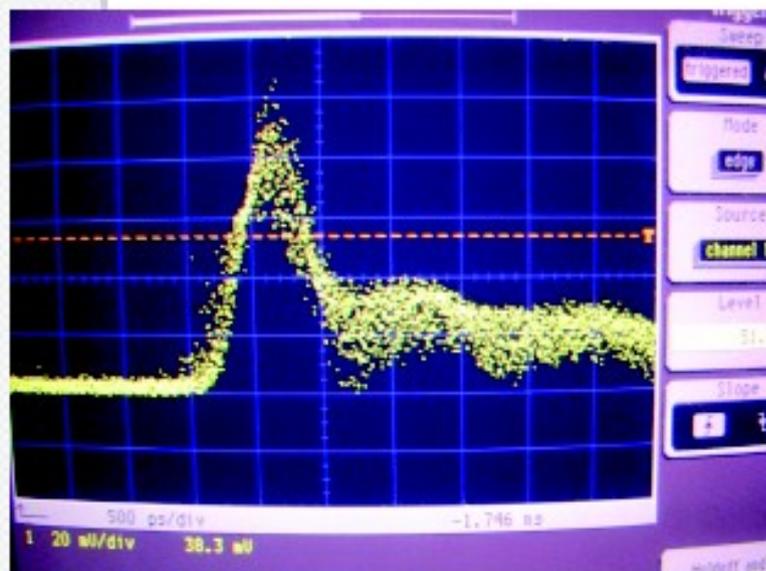
First results for CVDD & Si μ -strip detector



The typical pulses from CVDD in the case of ${}^6\text{Li}$ ions (59 MeV) at the intensities of $\sim 5 \times 10^7$ pps.

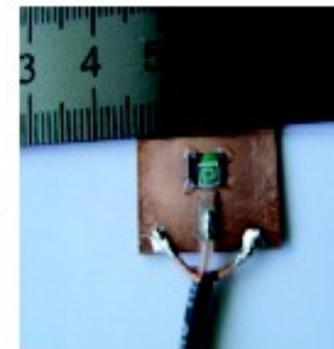


GSI



The typical pulses from Si micro-strip detector irradiated by alpha source ${}^{238}\text{Pu}$ (5.5 MeV).

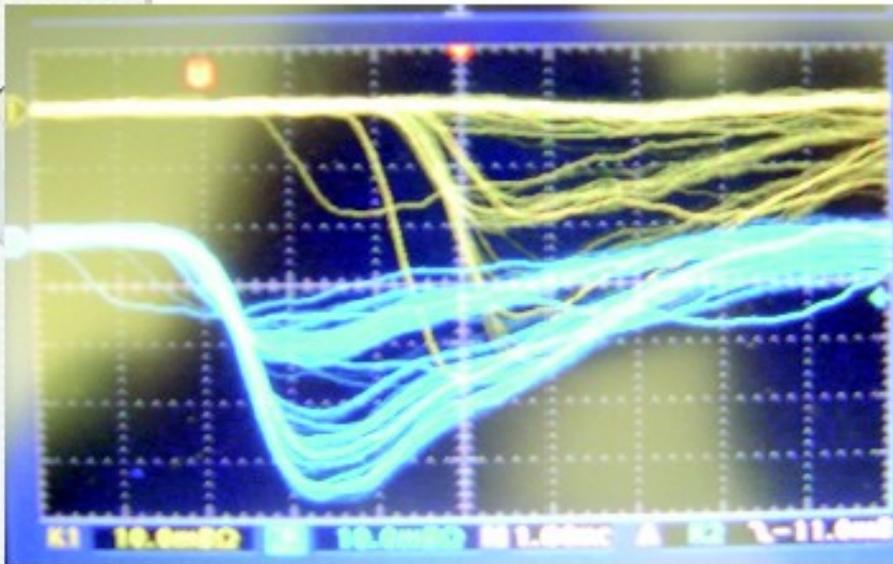
*PTI,
St.Petersburg*



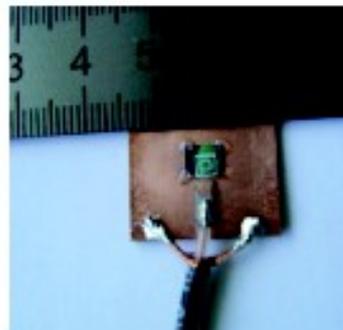
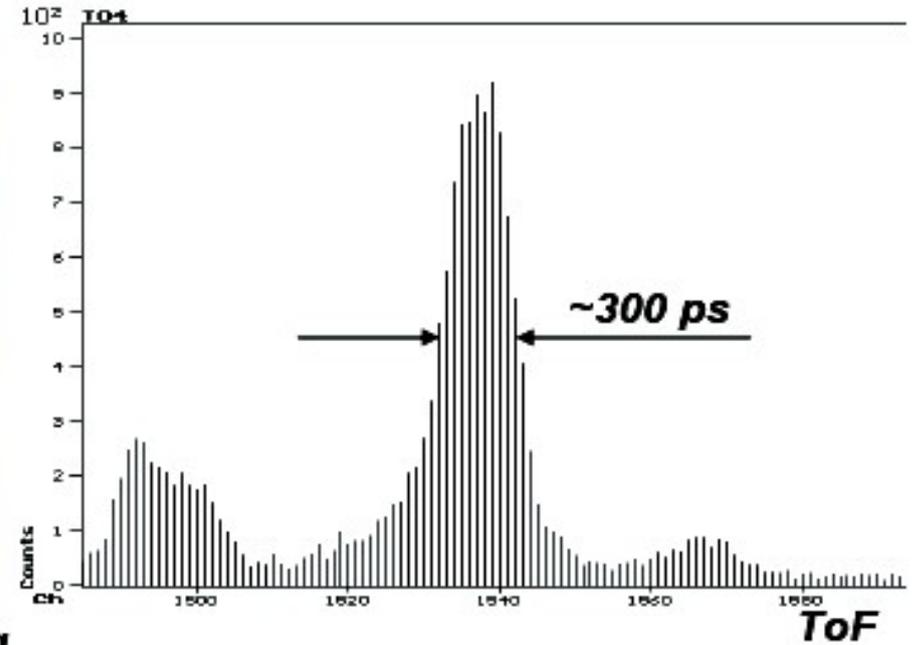
December 2007 – January 2008

A. Fomichev, JINR Dubna

Si microstrip detector



1.5x1.5 mm², 300 μm thick, backing

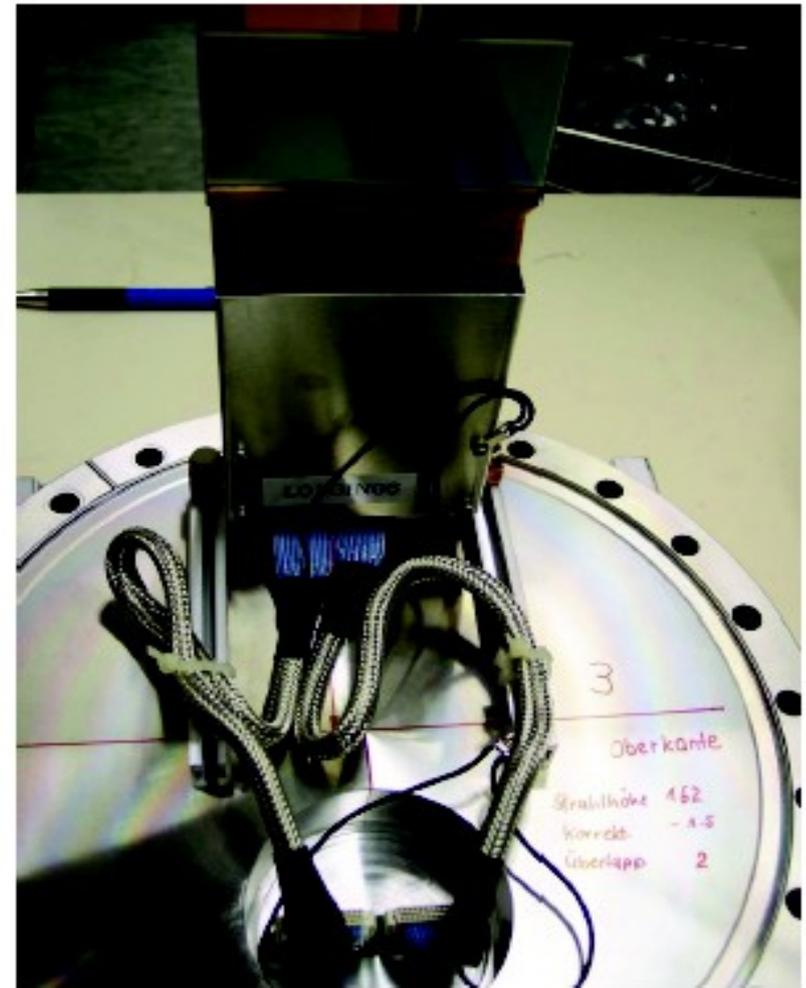


Si vs. diamond:

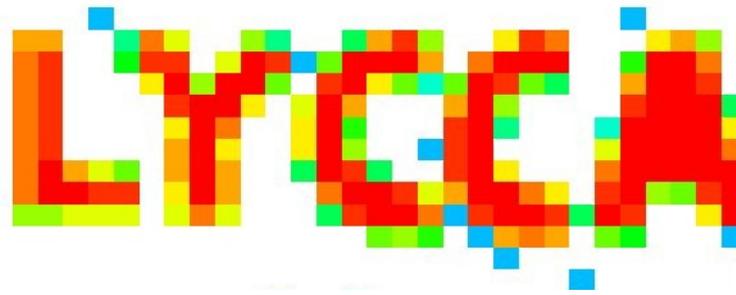
- * the same time resolution
- ** good amplitude resolution
- *** simplicity in operation
- **** not expensive
- radiation hardness ??

Si microstrip detectors for tracking of the fast ions

- AMS – like design
- 4 x 7 cm², 300 μm thick, 100 μm strip pitch (X & Y)
- Energy resolution • 50 keV
- Dynamic range – from p to Fe
- Work in vacuum without active cooling
- No timing information



Used in several experiments at FRS and LAND/Cave C



Lund



York

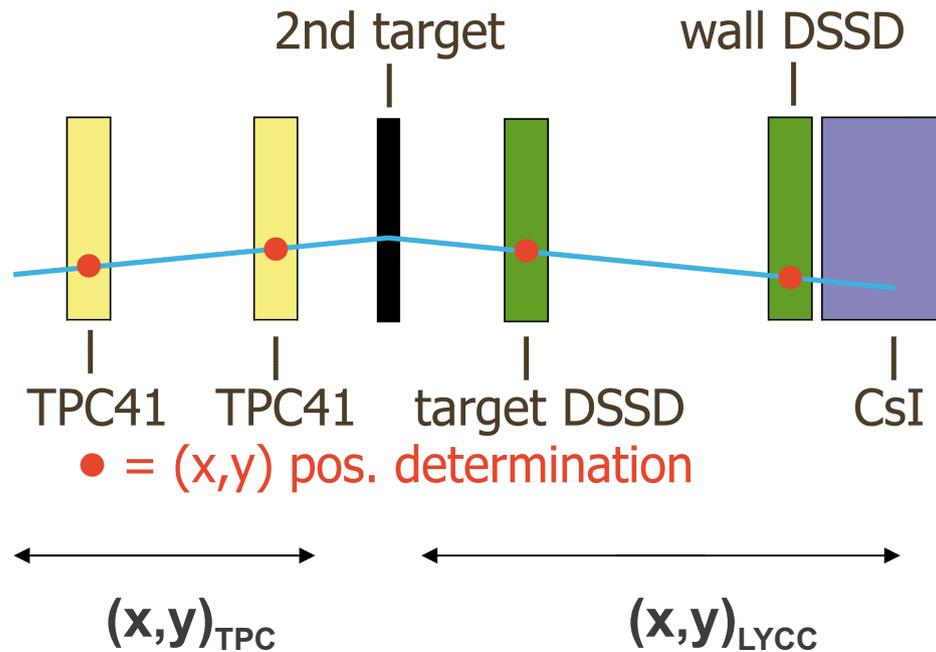


Cologne



Calorimeter

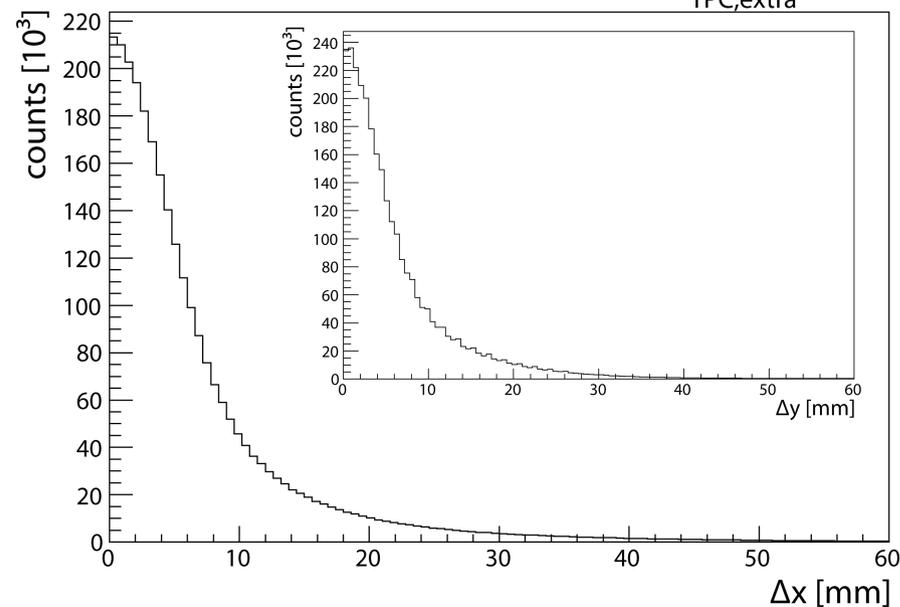
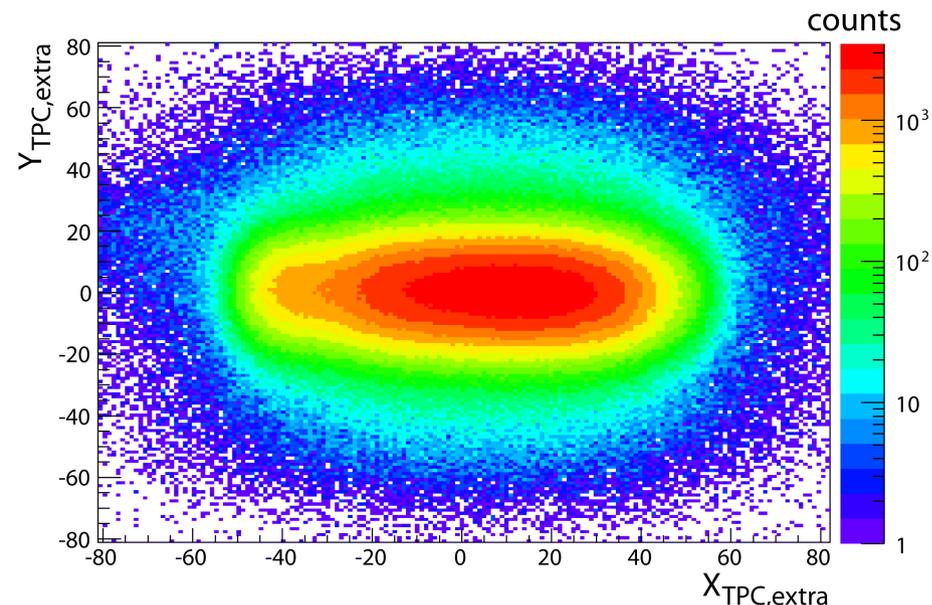
LYCCA: Tracking accuracy



A

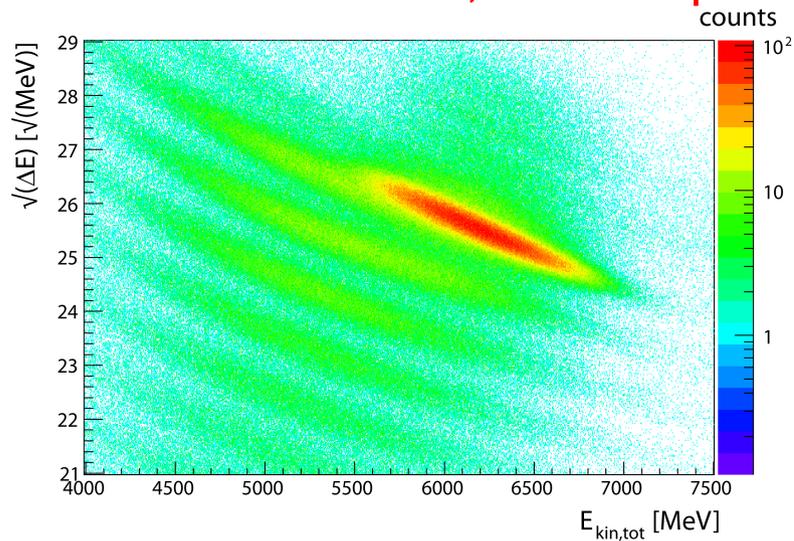
Tracking for in-beam γ -spectroscopy experiments:

- Scattering angle (corr. for ToF, reaction channel)
- Doppler correction (pos. sensitive Ge + particle tracking)

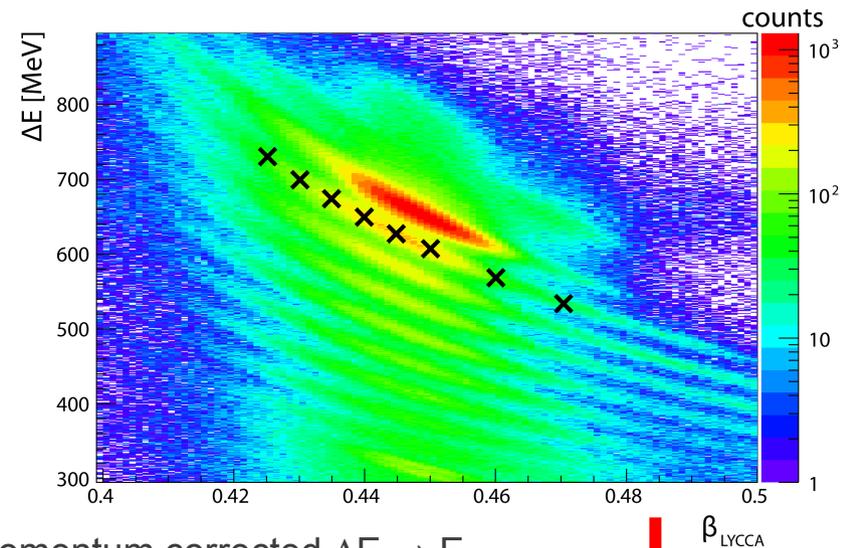


LYCCA: Z Identification

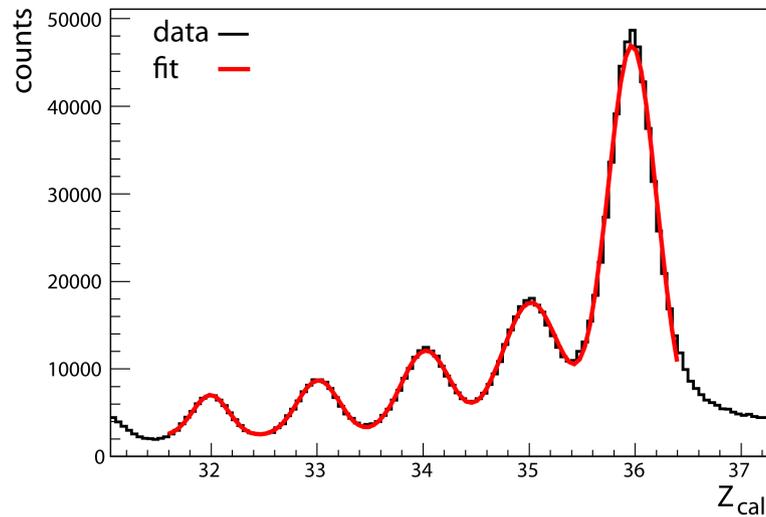
84Kr fission beam, S369 exp. data



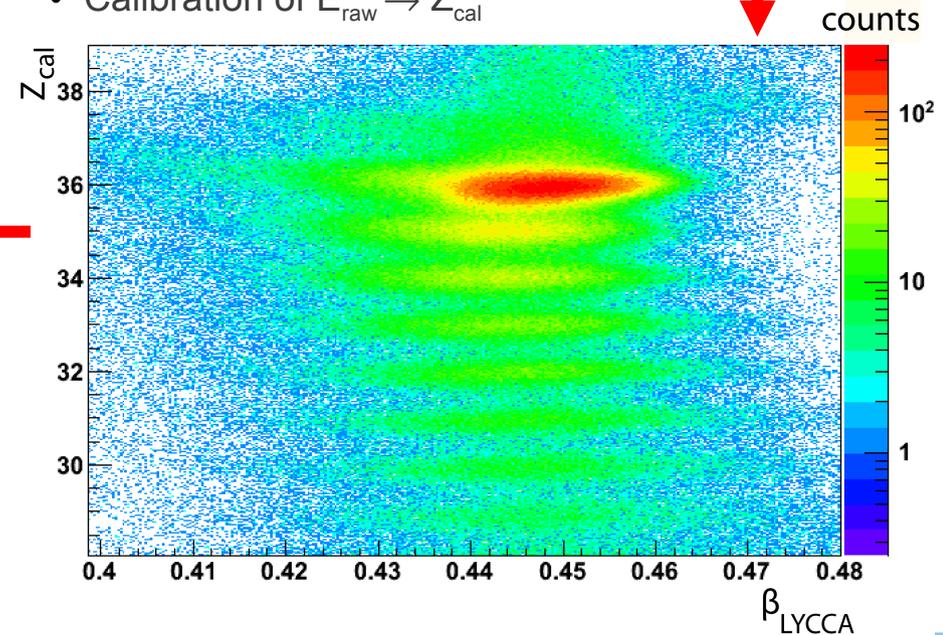
• ΔE vs $\Delta\beta_{LYCCA}$



- momentum corrected $\Delta E \rightarrow E_{raw}$
- Calibration of $E_{raw} \rightarrow Z_{cal}$

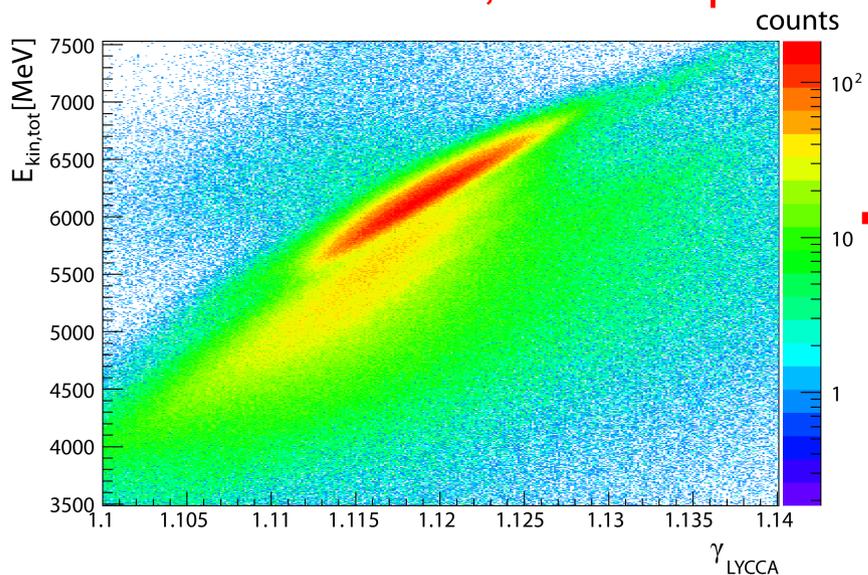


$\Delta Z = 0.55 \pm 0.07$ for $33 \leq Z \leq 36$

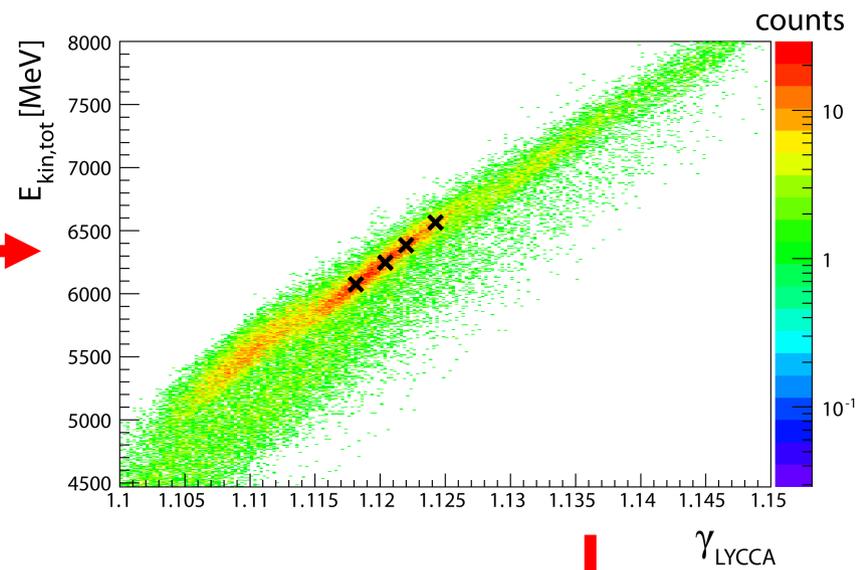


LYCCA: A Identification

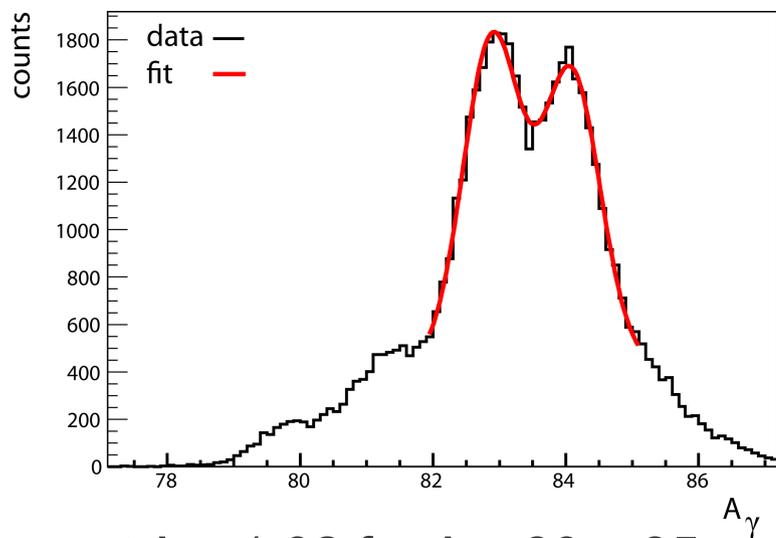
84Kr fission beam, S369 exp. data



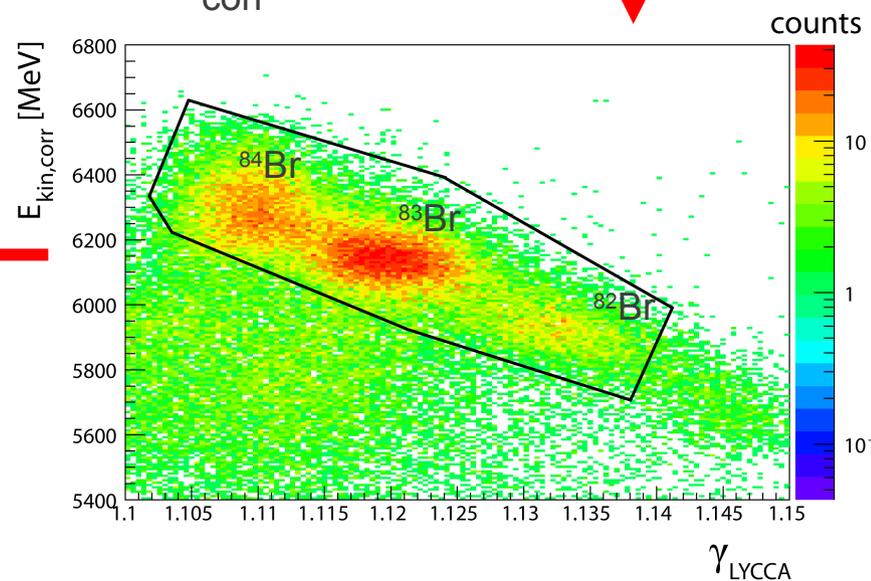
FRS gate:
Z=35



$E_{kin,tot}$ moment
corr



$\Delta A = 1.02$ for $A \sim 80 \div 85$



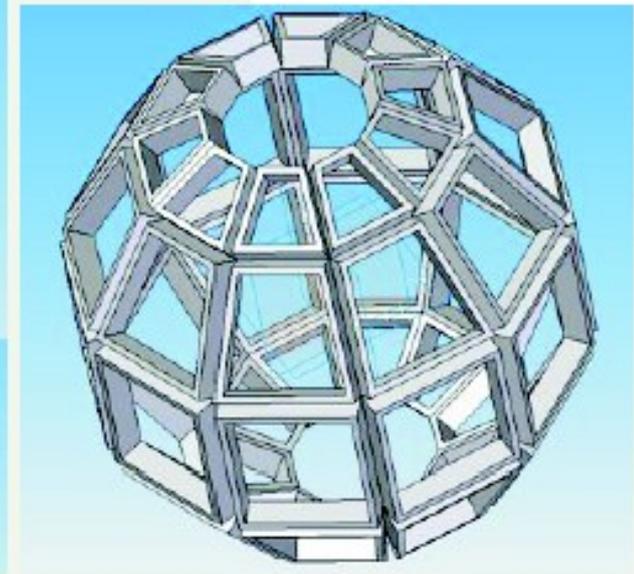
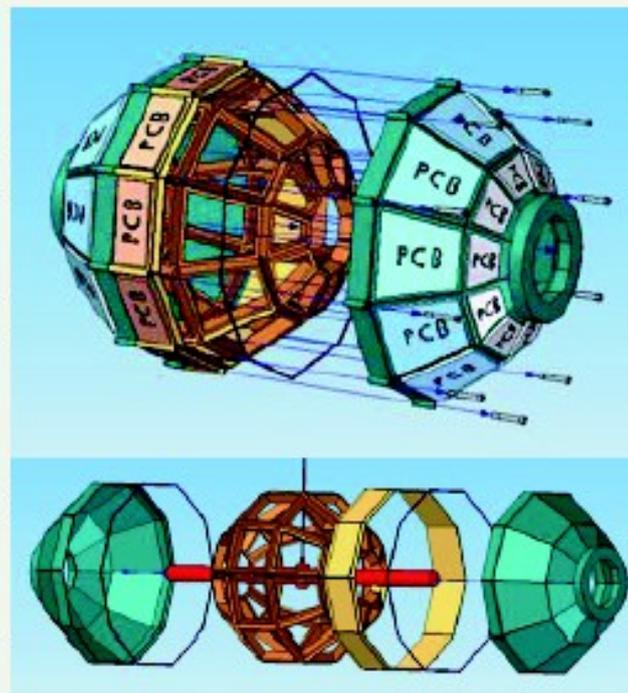
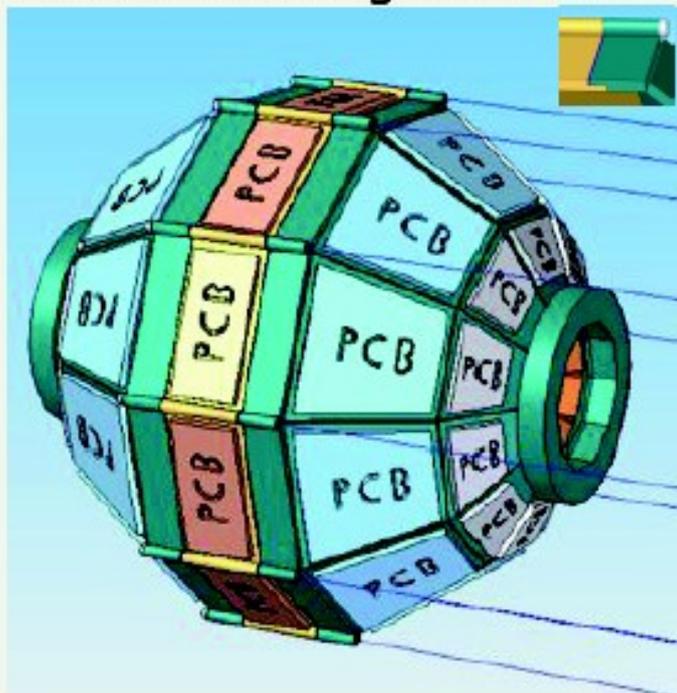
Status and perspectives of HYDE detector

I. Martel, M. Lozano, A. Czermak, J.A. Sánchez-Galán, R. Jiménez-Naharro,
R. Berjillos, A. Bergillos, J. Dueñas, J.L. Flores, M. Sánchez-Raya, A.
Sánchez-Benítez

For the HYDE collaboration.



Mechanical design of HYDE



Characteristics:

- ~ 4 PI ARRAY
- Detection of charged particles.
- Particle ID using PSA, DE/E and TOF.
- Energy & angular resolution (< 150 keV, $1^\circ/0.1^\circ$).
- Large multiplicity (> 3)

Design constraints:

- Subsystem of AGATA array
- Use at other RIB facilities (SPIRAL2, HIE-LEGNARO-SPEs)
- Modularity and portability

Construction:

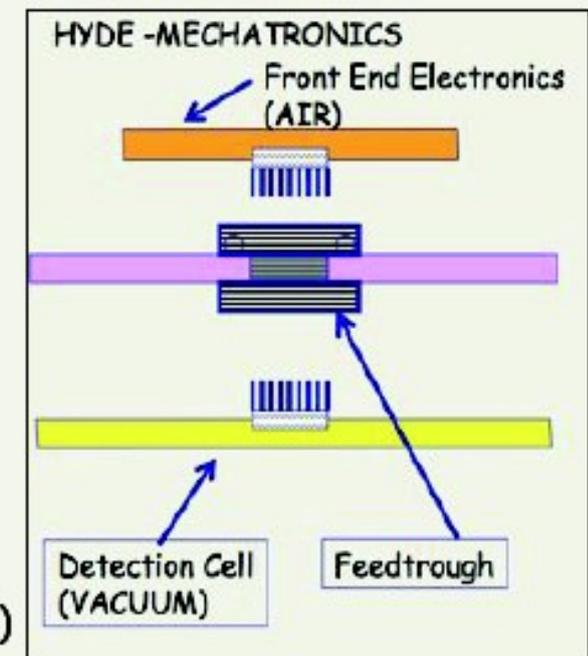
- Chamber < 380 mm diameter
- 49 DETECTOR CELLS
- 3 different shapes: square + 2 trapezoids fitting 4" wafer.
- Cylindrical symmetry/10 sides

Mechatronics

- FFE on air
- 31.360 channels
- High density feedthroughs
- Multiplexing.

Detector cell (Silicon)

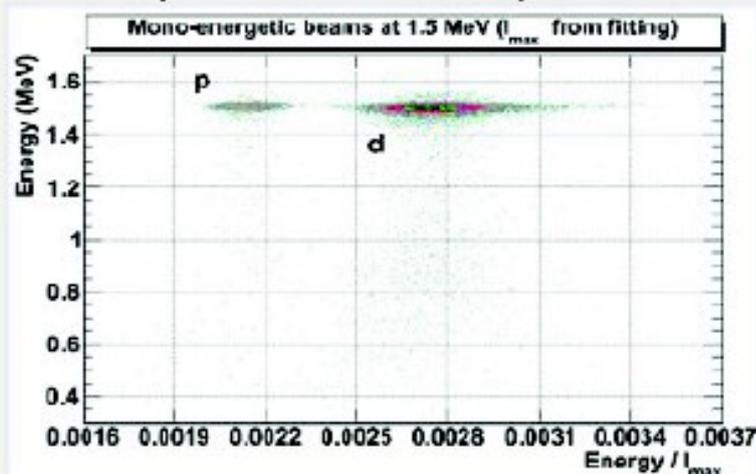
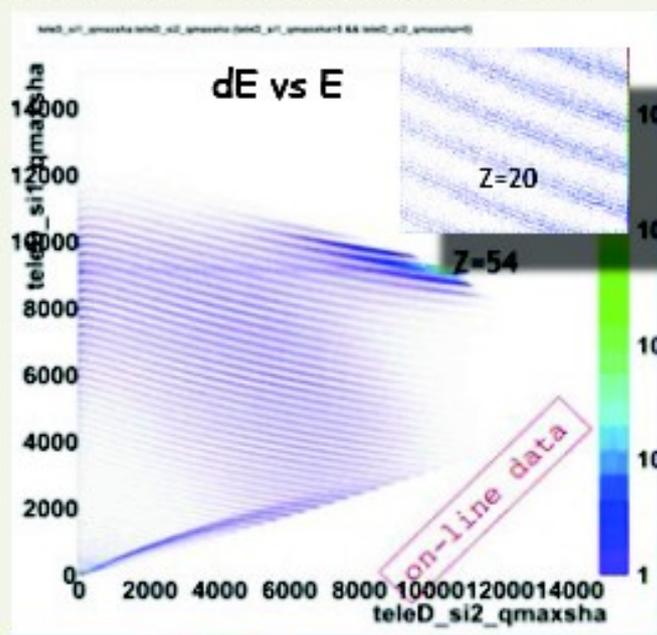
- 4 inches, NTD silicon wafers
- Strip size 0,4 mm, Multilayer (5 layer)



HYDE - PARTICLE IDENTIFICATION

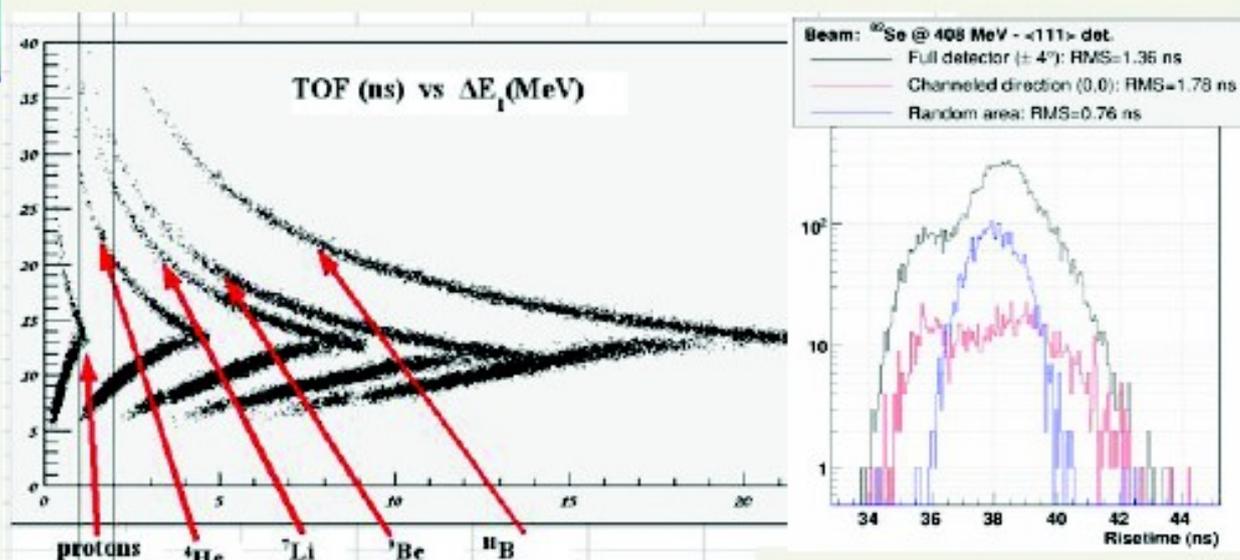


Results from FAZIA collaboration (G. POGGI, Spiral2 Week January 2010)/LNS-Catania experiments.



- Last PSA test at Orsay Tandem for light particles/500um
NTD looks promising → test thin silicon (20um/100um)

- Good identification up to $Z \sim 25$ with $\sim 5\text{GeV}$
- 100MS/s 14 bit digitizer
- Highly uniform Si: NTD
- Silicon doping uniformity $\sim 1\%$ (TOPSIL)
- Channeling
- Voltage stability



TOF simulation for HYDE/A. Sánchez-Benítez) Limited by Si response $\sim 1\text{ns}$

L.Bardelli et al, NIM A605 (2009) 353

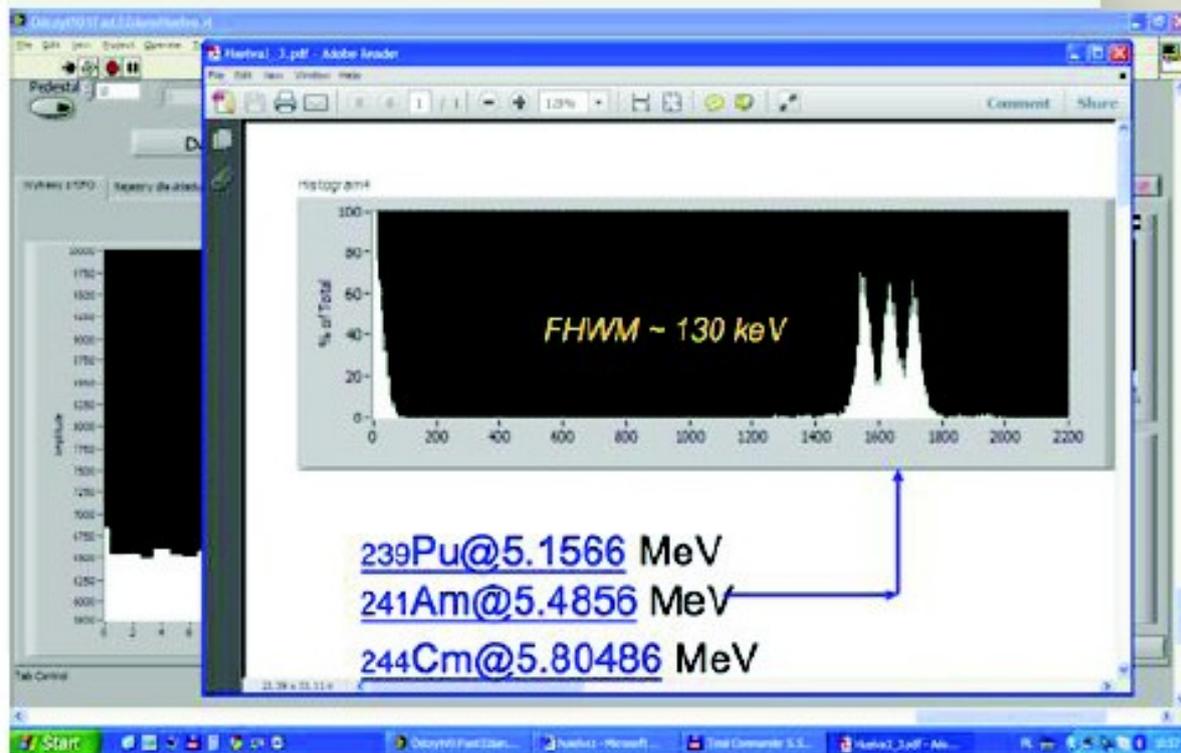
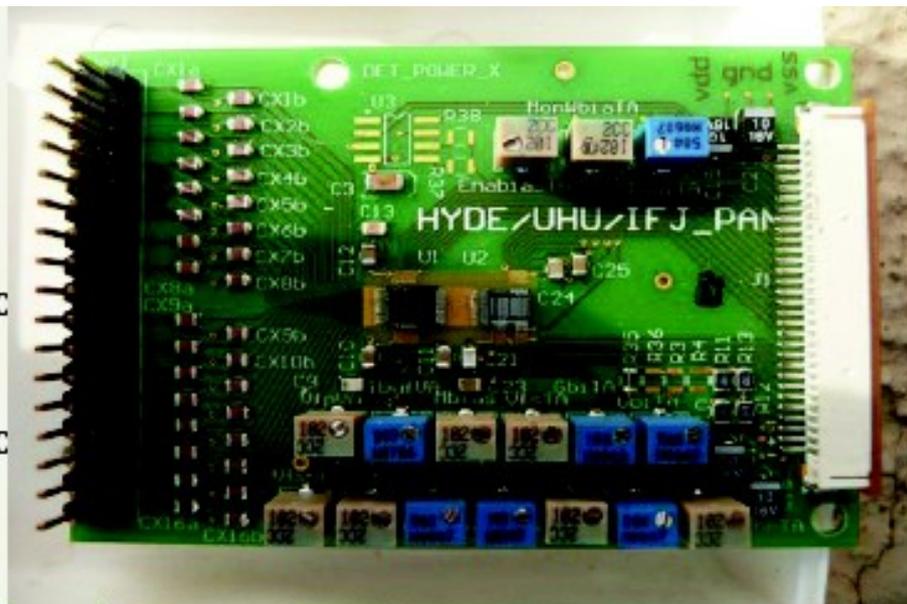


Universidad de Huelva

HIGH DENSITY FEE

First tests May 2011

- First test board with VA-TA chips (IDEAS-Norway)
- Hybrid equipped with Readout board (ADC and dedicated XILINX SPARTAN FPGA).
- Readout frequency, 4 MHz clk. (8 μ s for 32 channels)
- Dead time for 1 KHz event rate per detector is estimated to be around 0.8%.
- Power dissipation is around 100 mW per hybrid.

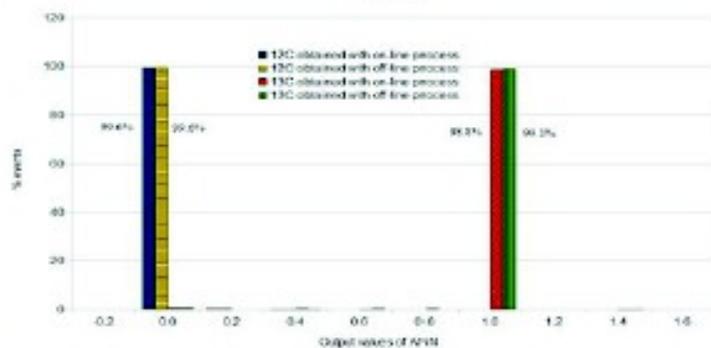
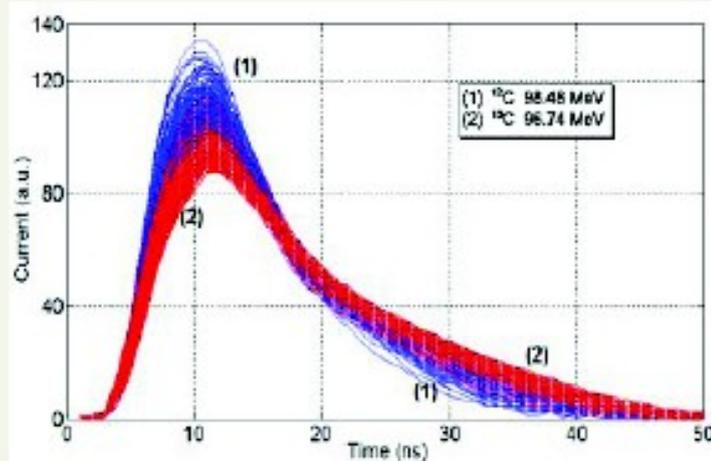


- All tests were done at UHU 18 – 27 May 2011.
- After the tests \rightarrow decisions shall be taken to design dedicated ASICs (multichannel amplifier) and/or Hybrids.



FPGA implementation of neural networks for PSA

Test with $^{12,13}\text{C}$ ions @ 7 MeV/u



Configuration parameters

Neurons per MLP: 2
Architecture: 8x8x2 layers
Data size: 14 bits

No. MLP in FPGA: 8
Device: Spartan3AN-700



Mean deviation between on-line and off-line identification below 1%
Maximum data input frequency: 236 MHz
Maximum operation frequency: 74 MHz
Identification delay about 20 μs to a clock frequency of 50 MHz



Universidad de Huelva

I. MARTEL, Univ. Huelva

The detector

- SC-CVD diamond film 50 μm thickness ($4 \times 4 \text{ mm}^2$).
- Ohmic contacts: DLC (3 nm) / Pt (16 nm) / Au (200 nm).
- Al wire bonding connections.
- Transmission type mounting.
- Final capacitance of the detector 9.5 pF.



Huelva prototype of diamond detector
(already available commercially)

* Collaboration with companies:

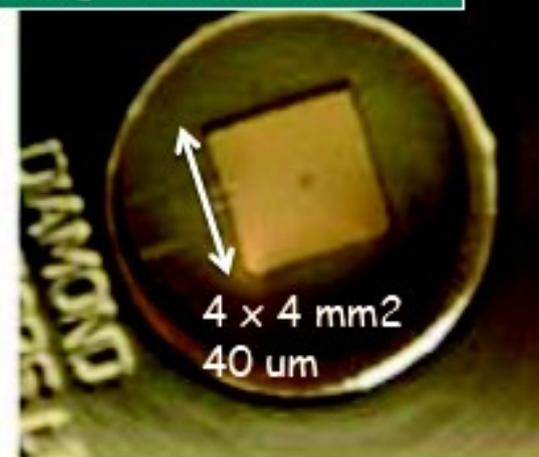
- Element 6
- Diamond Detectors Ltd

* We are working for common interest at different insitutions/applications →

GSI/FAIR → Tracking systems

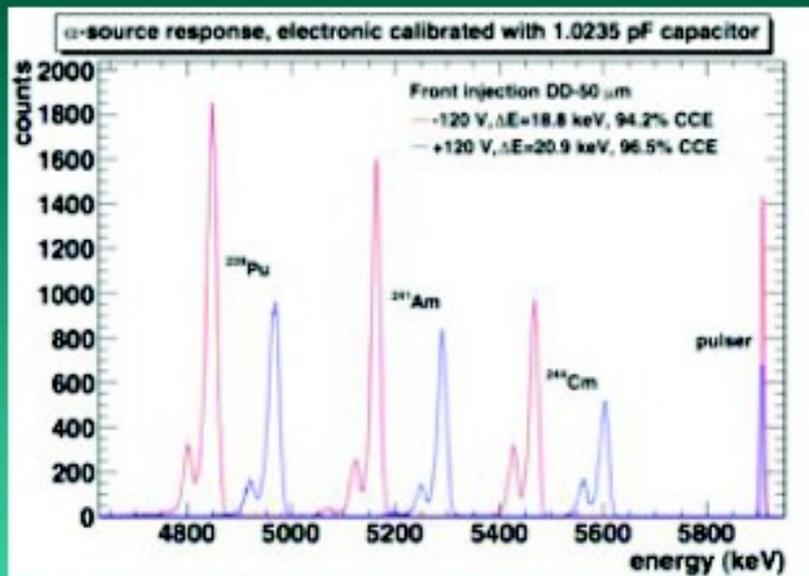
GANIL/SPIRAL2, IPN/ORSAY → Beam diagnostics

Single cristal diamond



4 x 4 mm²
40 μm

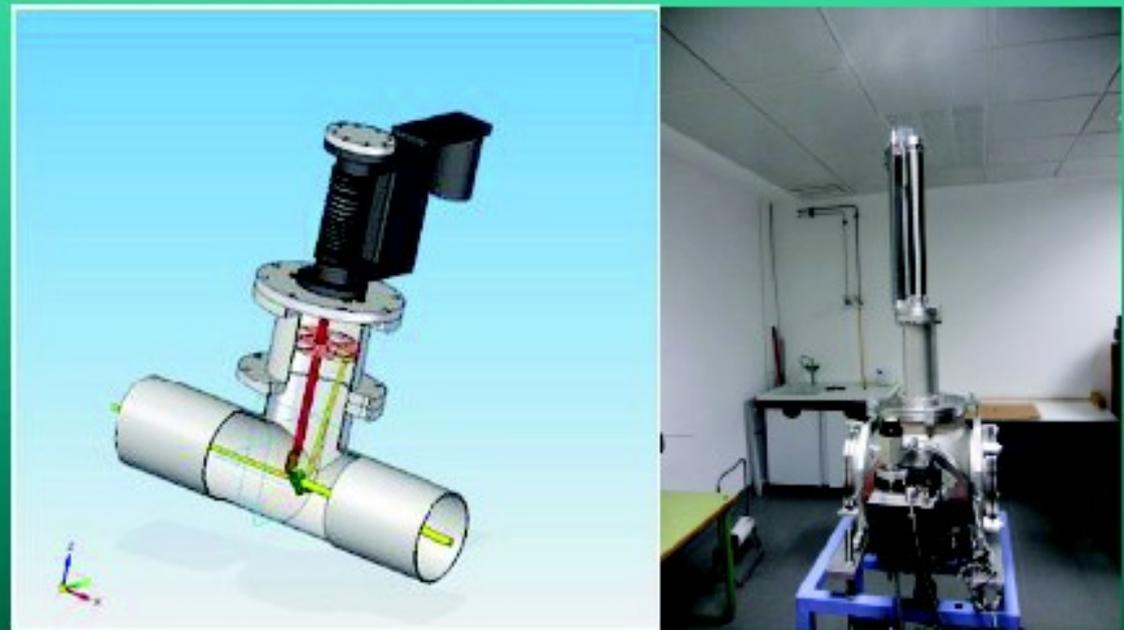
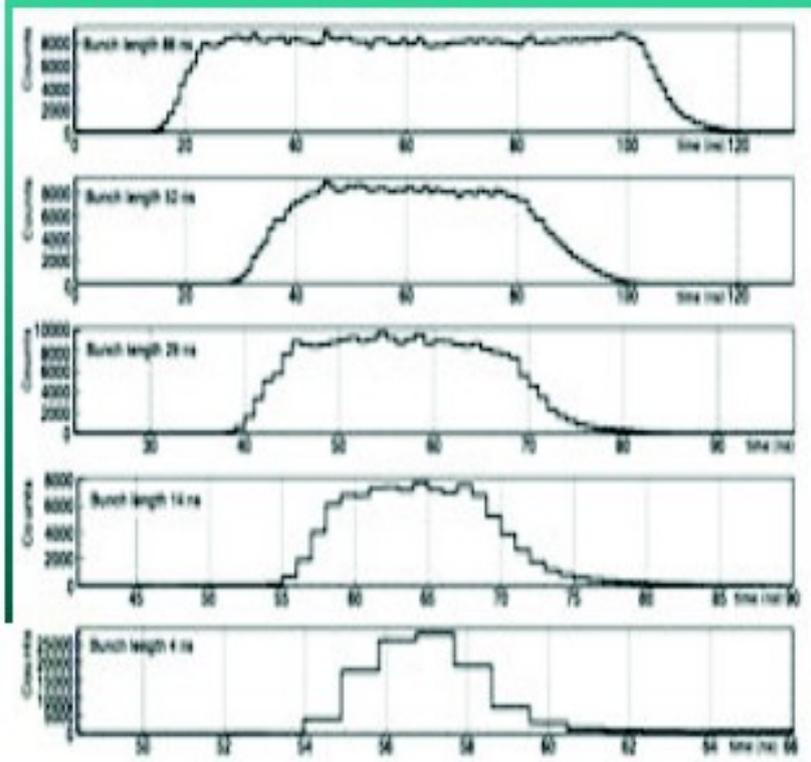
Diamond Detectors for Beam Diagnostic: Test at Orsay Tandem with ^{12}C ions/20 MeV

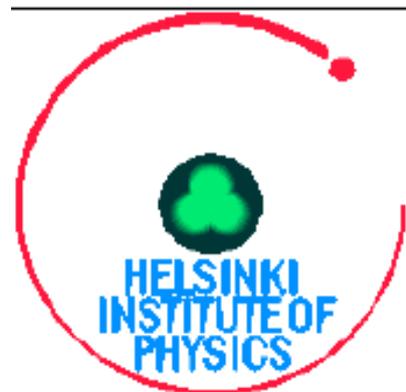


- Single crystal diamond films.
- Thickness 500 μm .
- Good Timing & Energy resolution.
- Studies on different contacts.
- Experiments done for Beam monitoring at Orsay Tandem 2010.

Diagnostic system being built at Univ. Huelva for Spiral2 (preparatory phase UE FP7).

Time structure of bunches





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



COLLABORATORS

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Detector Laboratory - GSI - Darmstadt - Germany

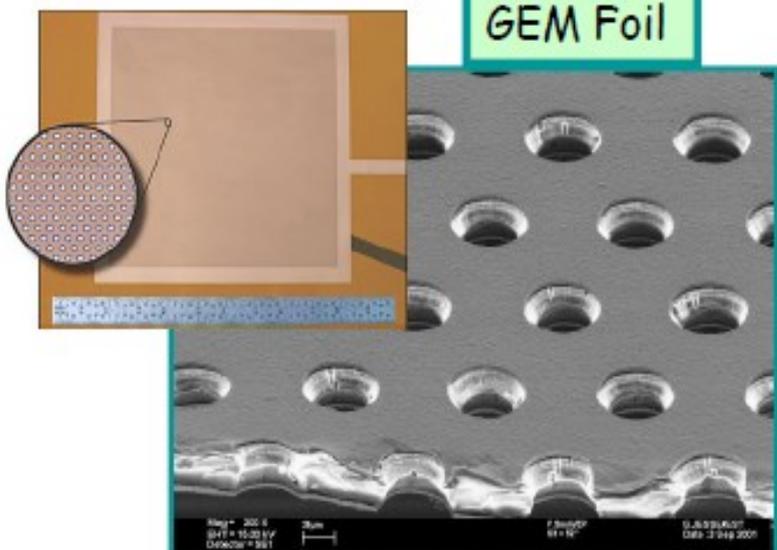
J. Hoffmann, N. Kurz, I. Rusanov, M. Shizu
EE - GSI - Darmstadt - Germany



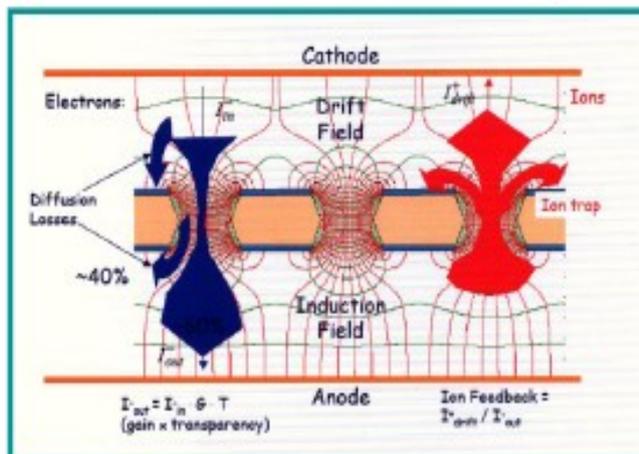


GEM TECHNOLOGY and CHARACTERIZATION

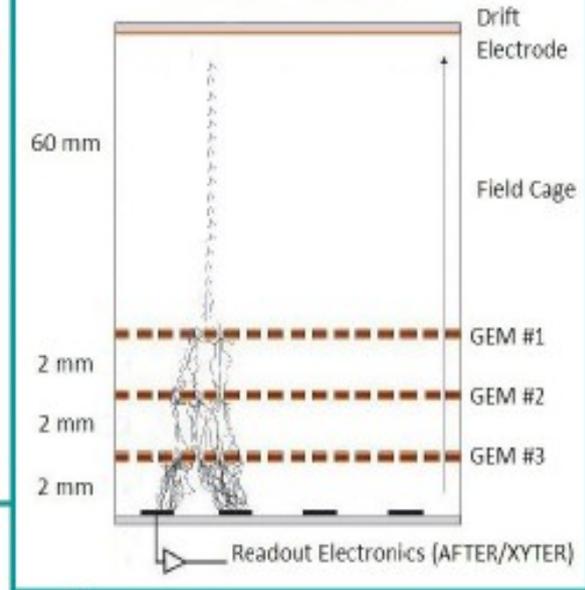
GEM Foil



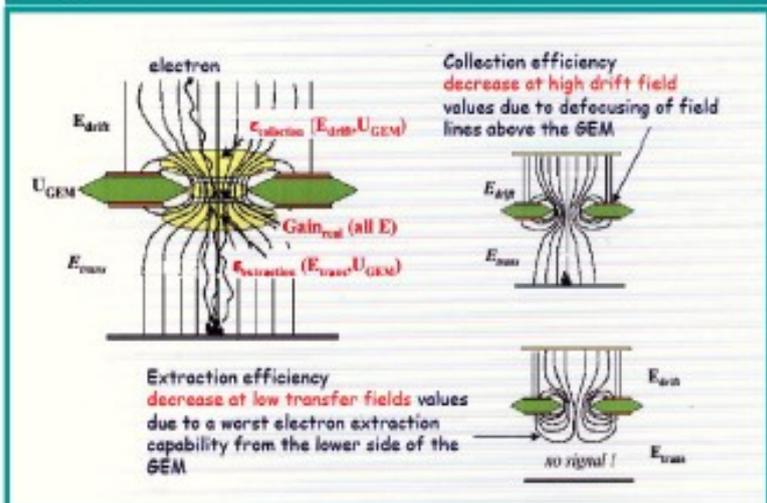
GEM Operation Principle



GEM-TPC LAYOUT

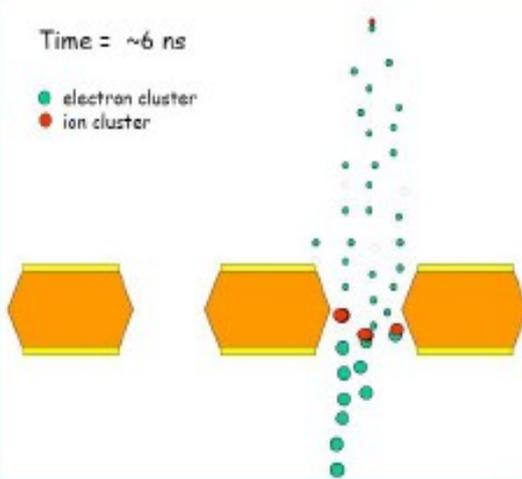


Extraction of the Electron Cloud and Signal Induction



Time = ~6 ns

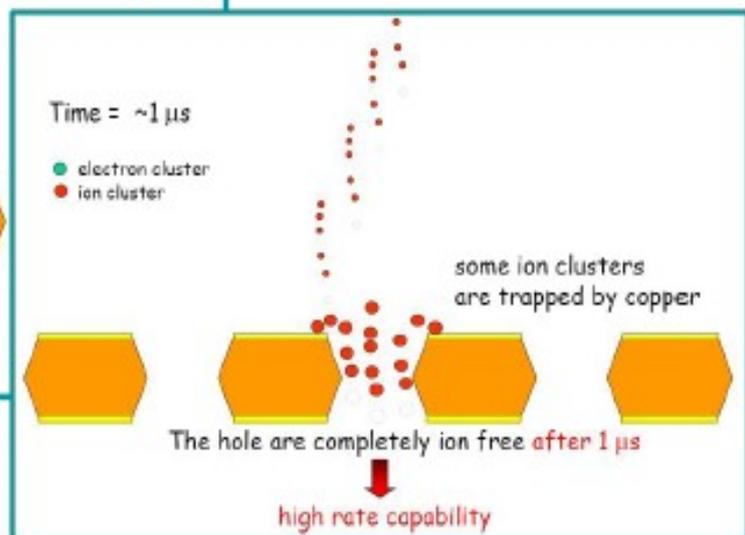
- electron cluster
- ion cluster



Avalanche development in time domain

Time = ~1 μs

- electron cluster
- ion cluster

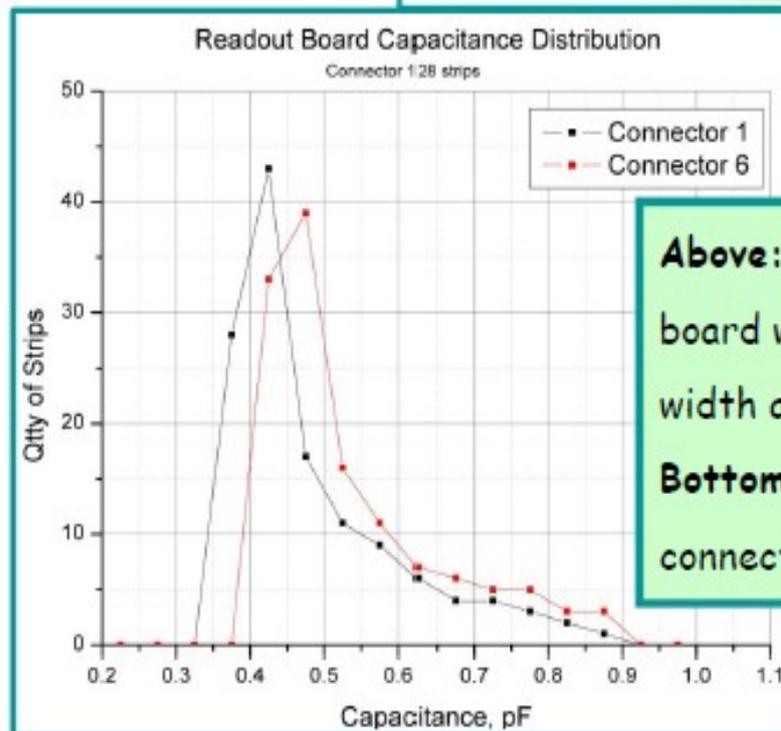
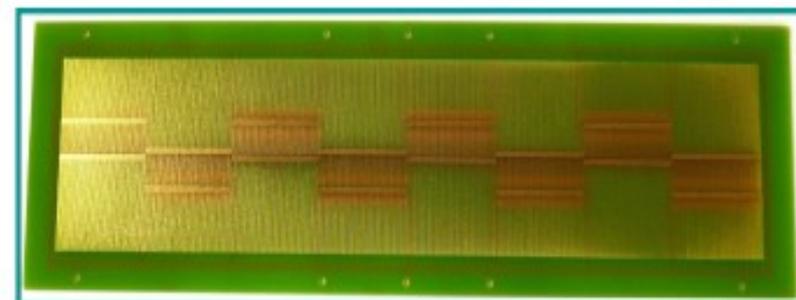




GEM TECHNOLOGY and CHARACTERIZATION (cont.)



Capacitance measurement setup



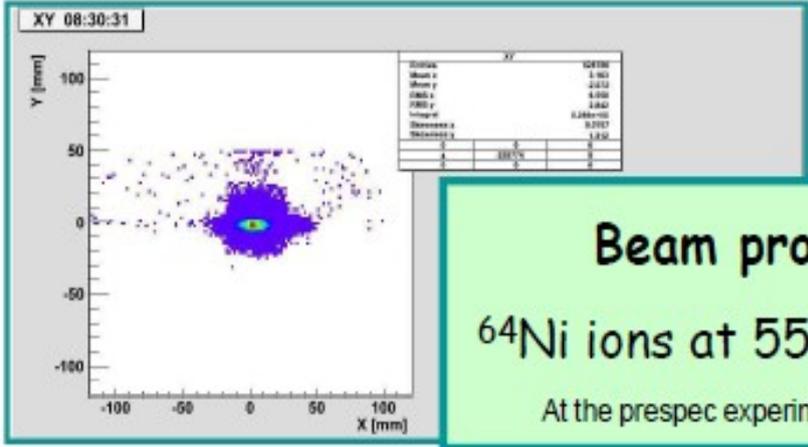
Above: The electrodes of the board with strips of 200 μm width and 500 μm pitch
Bottom: 8 Header Panasonic connectors with 130 Pin each



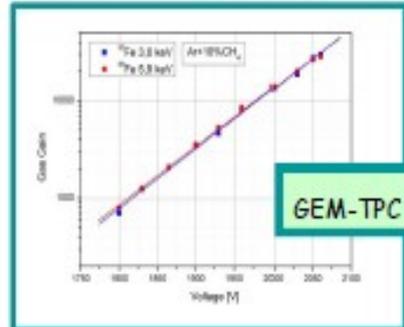


FIRST GEM-TPC PROTOTYPE HB1 - TEST (cont.)

GEM-TPC Beam test at GSI - Darmstadt

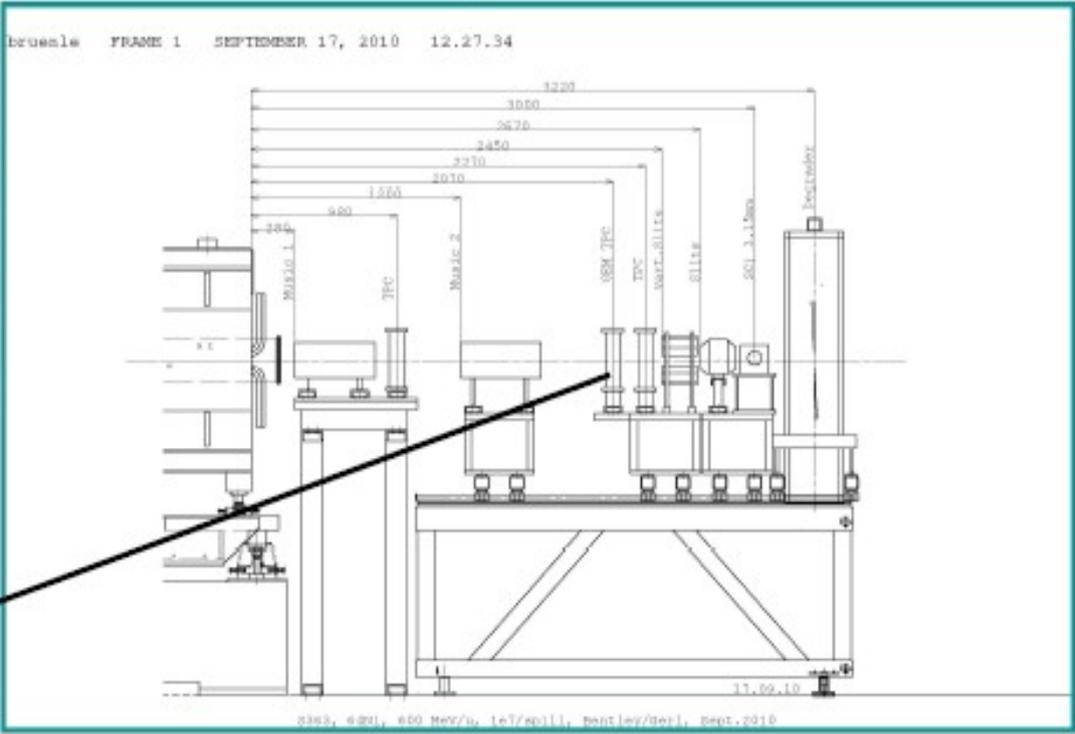


Beam profile
 ^{64}Ni ions at 550 MeV/u
At the prespec experiment - S363



GEM-TPC Gain

GEM-TPC at S4

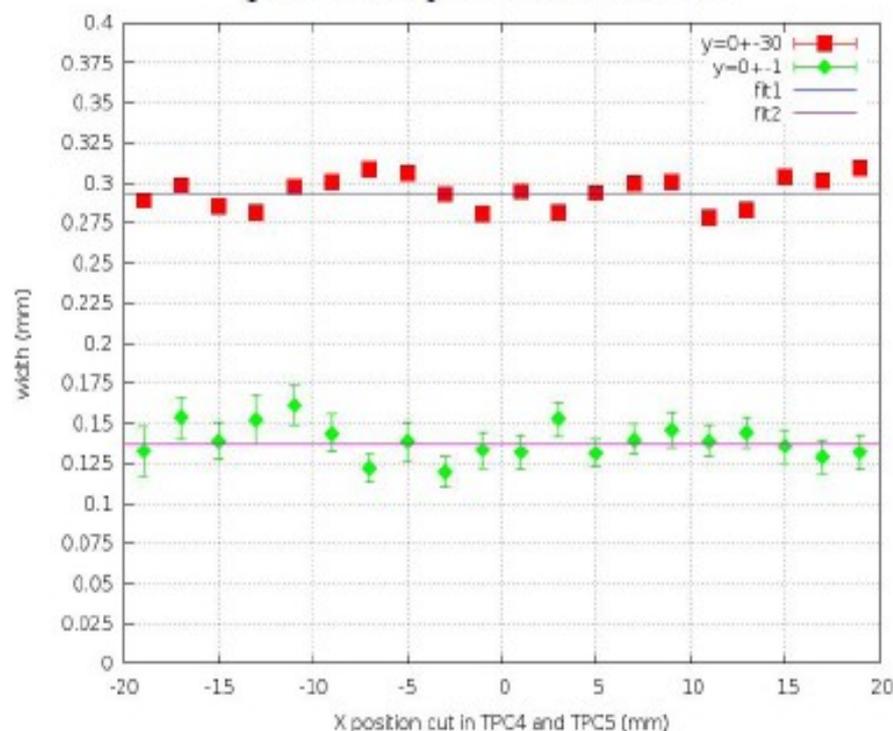




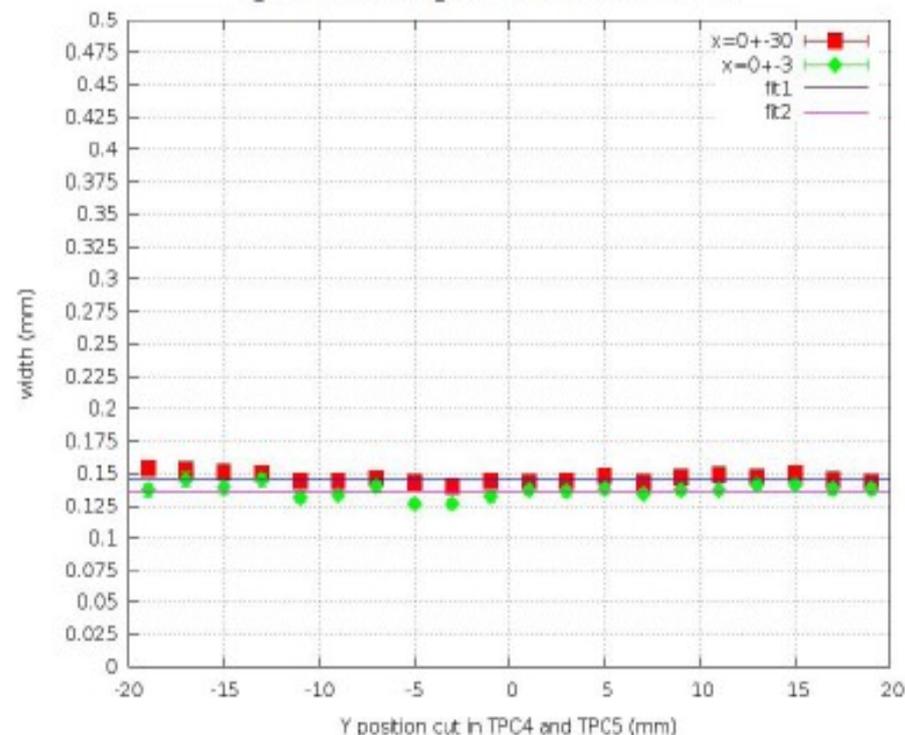
FIRST GEM-TPC PROTOTYPE HB1- TEST (cont.)

GEM-TPC Results for the Beam test @GSI

GEM-TPC POSITION RESOLUTION
parallel strips + beam focused



GEM-TPC POSITION RESOLUTION
parallel strips + beam focused



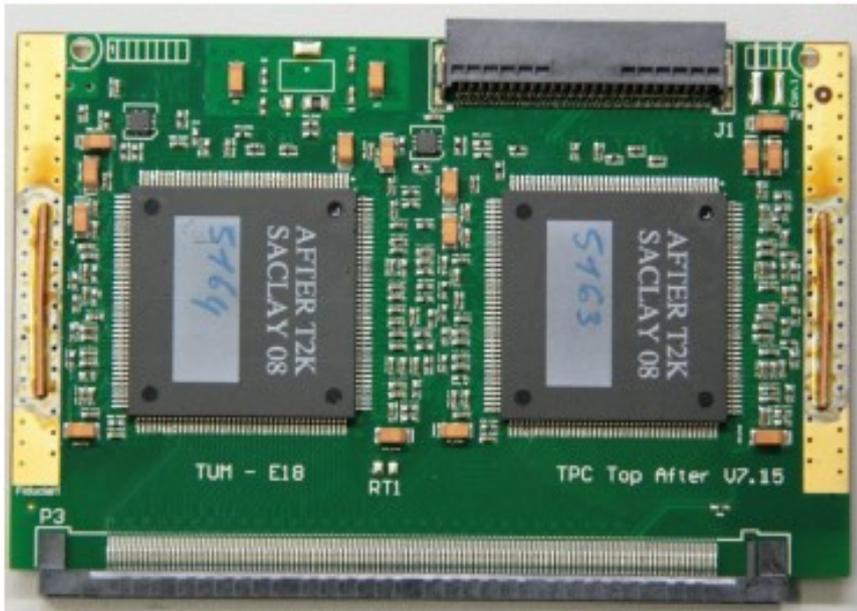
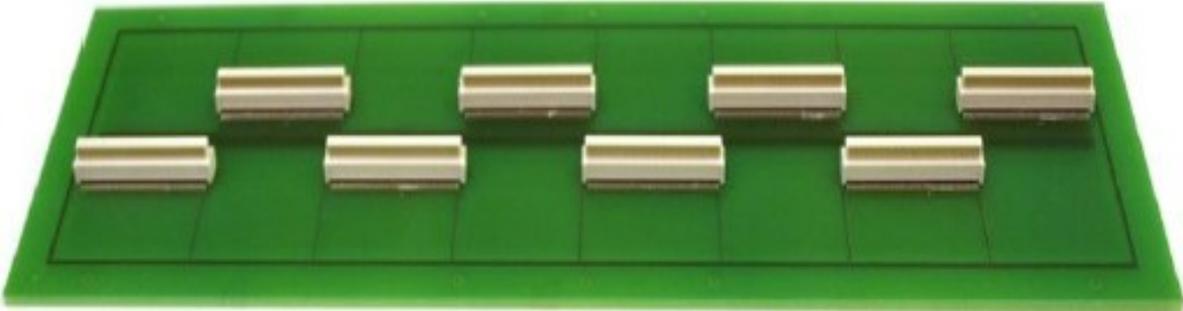
The GEM-TPC shows that the resolution in Y (Drift) reaches value around 130 μm and on X between 130 to 300 μm



SECOND GEM-TPC PROTOTYPE HB2 (cont.)

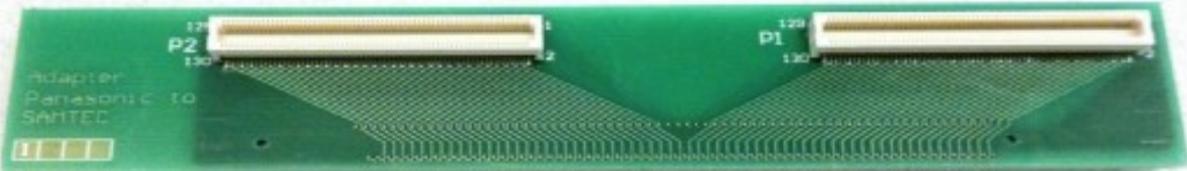
GEM-TPC Readout Electronics and DAQ.

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



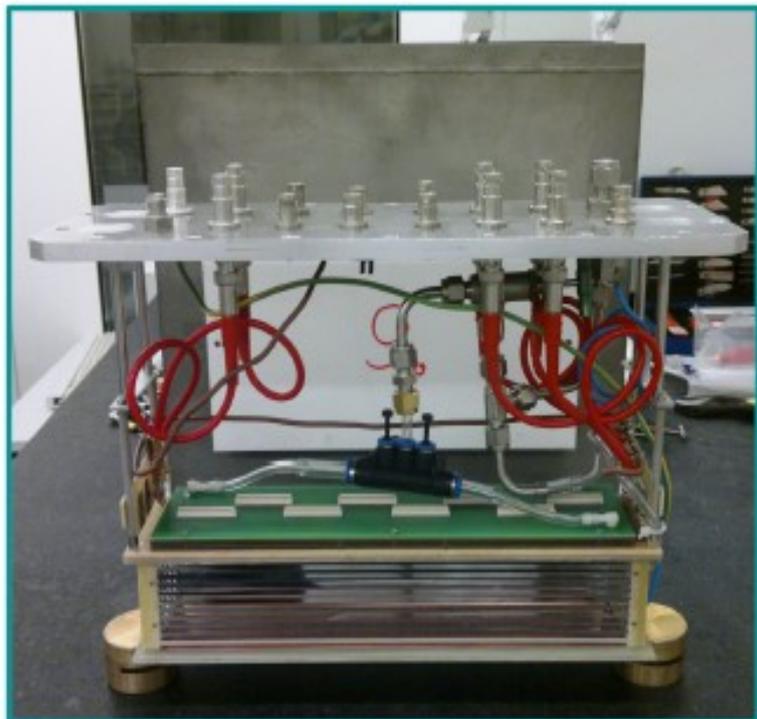
At the top a Samptec connector 300 pins and in the left side two Panasonic connectors of 130 pins each



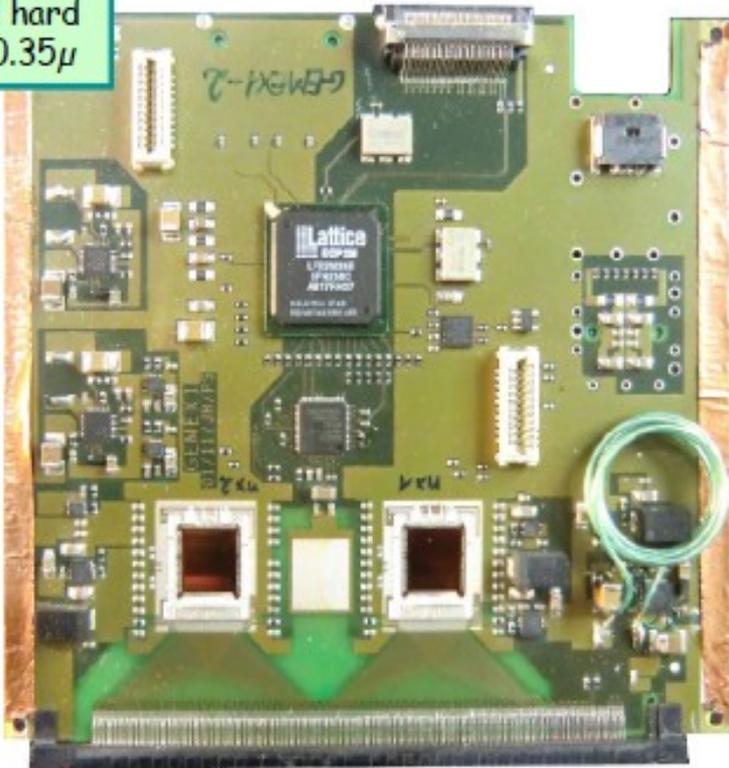
STATUS OF THE PROTOTYPE HB3(cont.)

GEM-TPC Readout Electronics and DAQ.

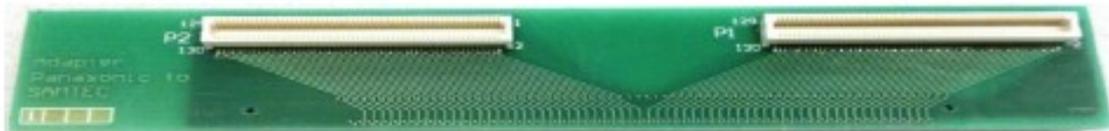
n-XYTER,
non rad hard
AMS 0.35 μ



Provide by the Detector
Laboratory @ GSI
Bern Voss



PAN to SAMTEC Adapter



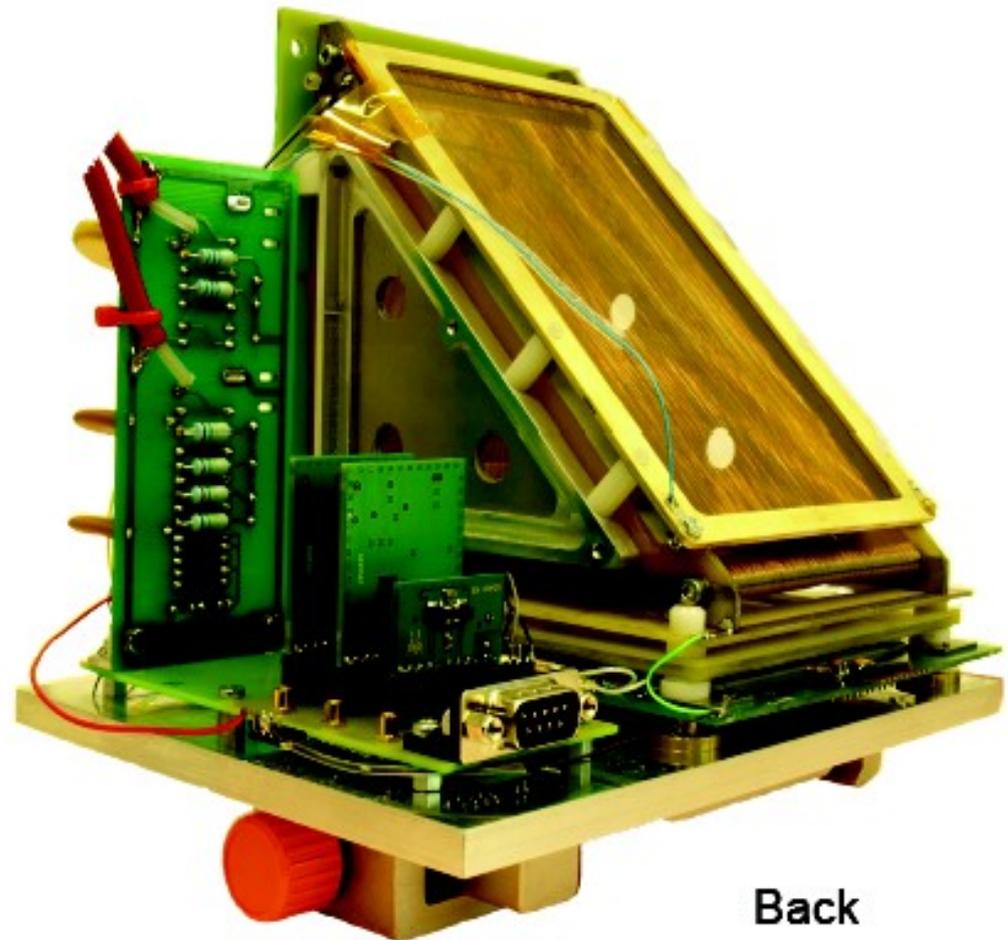
At the top a Samptec connector 300 pins and in the
left side two Panasonic connectors of 130 pins each

Tentative Specifications

- Position and time sensitive beam profile monitor based on secondary electrons
- Timing resolution better than 200ps
- Spatial resolution better than 1mm
- Current active area of 80x100 mm²
- Maximum transparency using most thin and less materials as possible
- Determine each ions track and time of flight using two units on an event by event basis

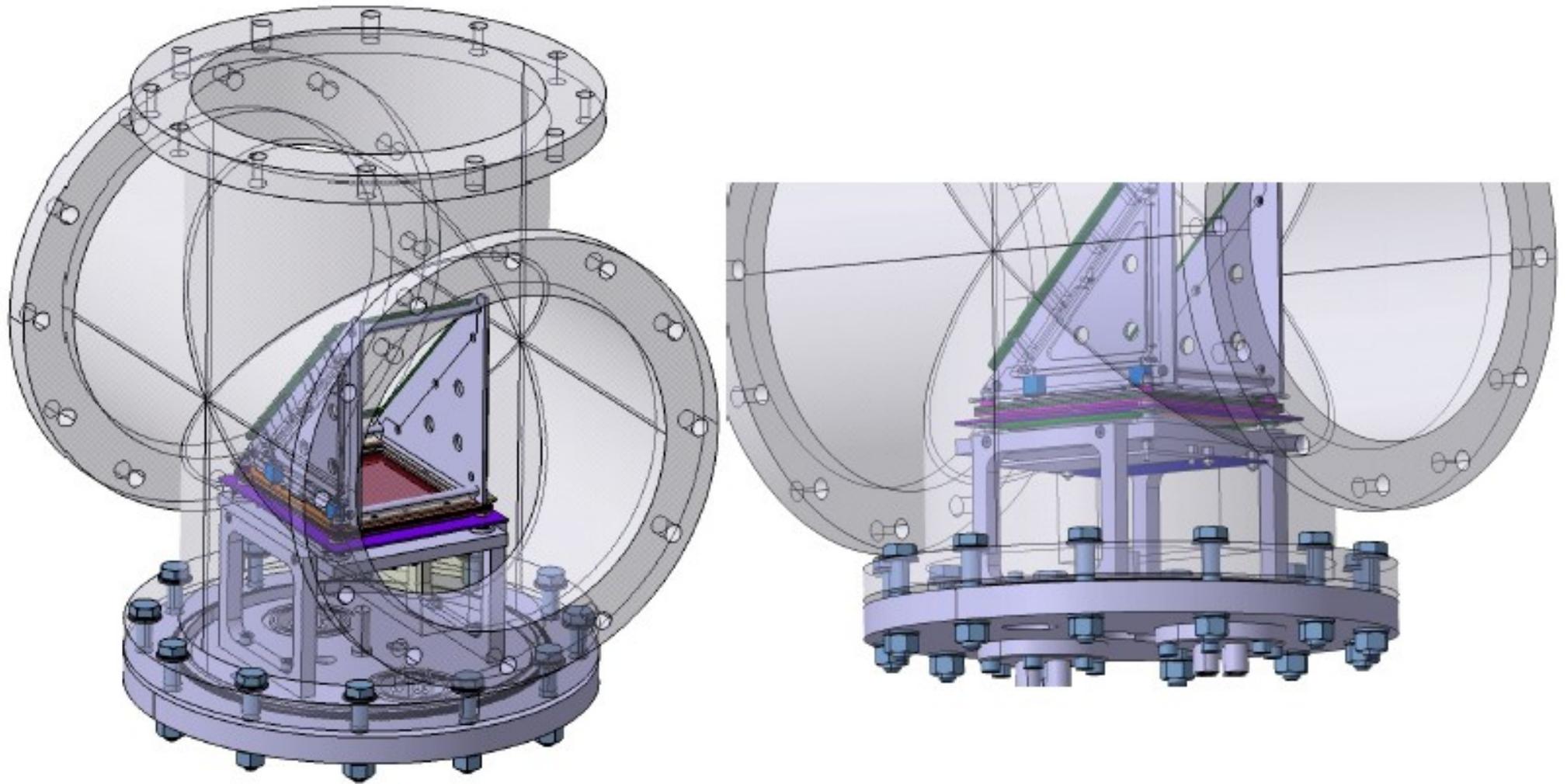


Front



Back

Current Design



Mounted on ISO200 flange:

- electronics close to feedthroughs
- ready for upcoming electronics / design

Future measurements / applications

(p,p' γ)-campaign in Cologne

- ~90% of p' ejected in forward direction
- use of BPM with “center-hole” to decrease counting of primary ions
- distinguish p' by ToF (energy) and trajectory (scattering angle)

Isobaric separation for AMS purposes

- smaller version is built and mounted at Cologne-AMS
- tests are ongoing

Slowed down beam at GSI

- as intentional usage for SED based BPMs
- “Umbrella” proposal is granted

Tracking detectors WG Agenda

- Tracking for the Super-FRS, Haik Simon (GSI Darmstadt)
- Si tracking detectors, Oleg Kiselev (GSI Darmstadt)
- Beam tracking with LYCCA, Pavel Golubev (LUND University)
- HYDE detector: status and perspectives. Ismael Martel (Universidad de Huelva)
- GEM-TPC development for the S-FRS Francisco Garcia (University of Helsinki)
- MCP progress Michael Pfeiffer (University of Cologne)