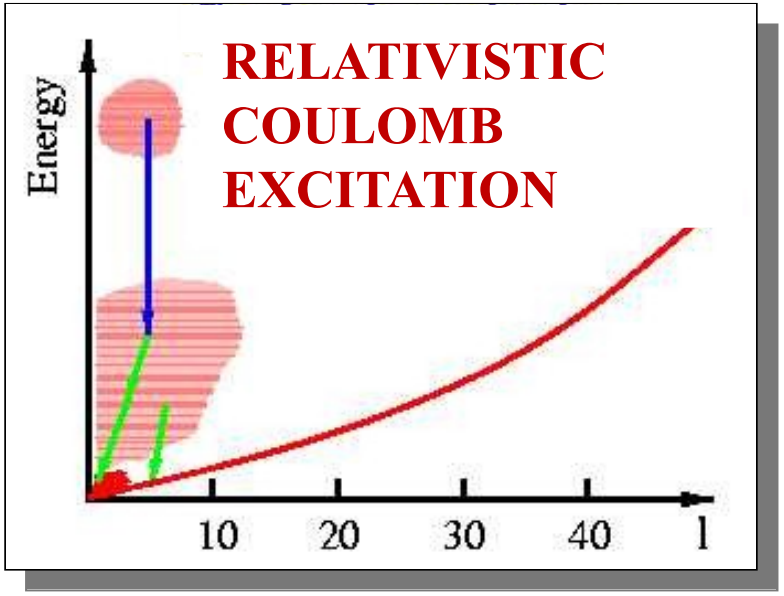
Development of Slowed Down Beams at GSI

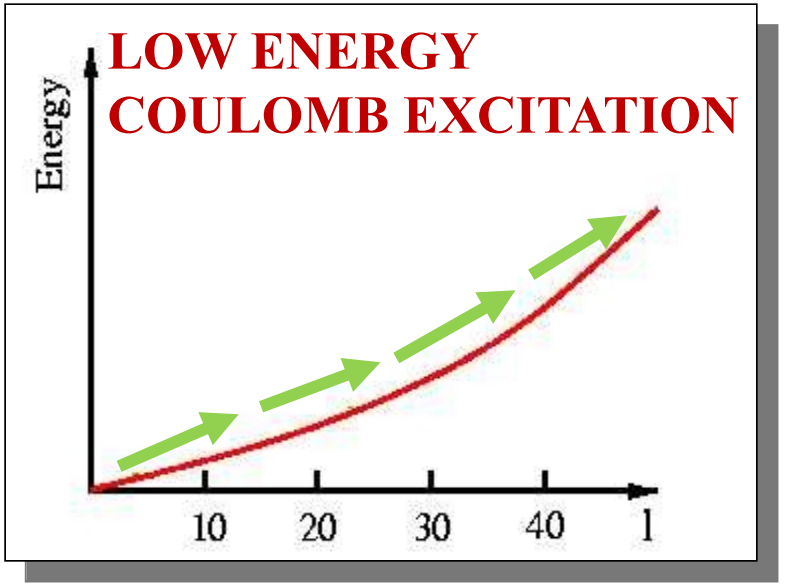
P.Boutachkov

TU Darmstadt, Germany

- Physics objectives
- Test experiments and detector development
- Future experiments and developments

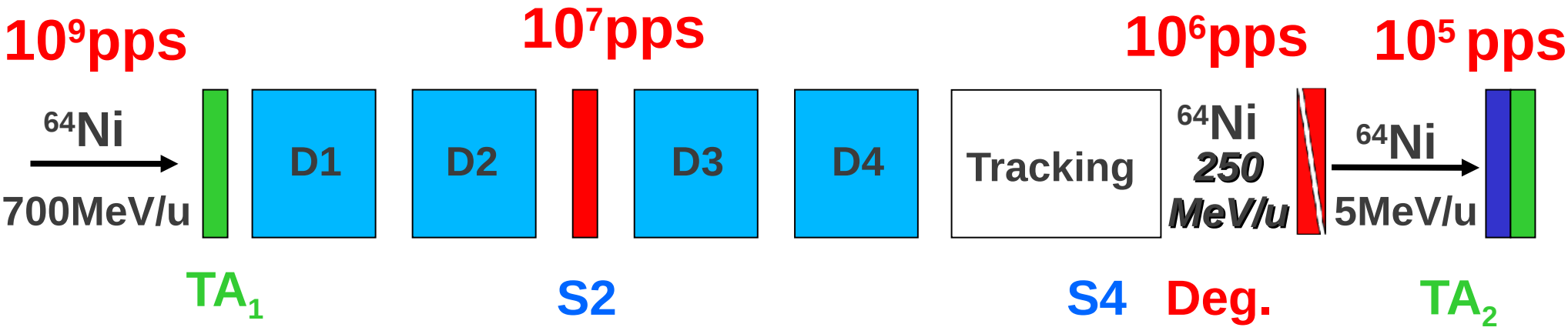
The Idea

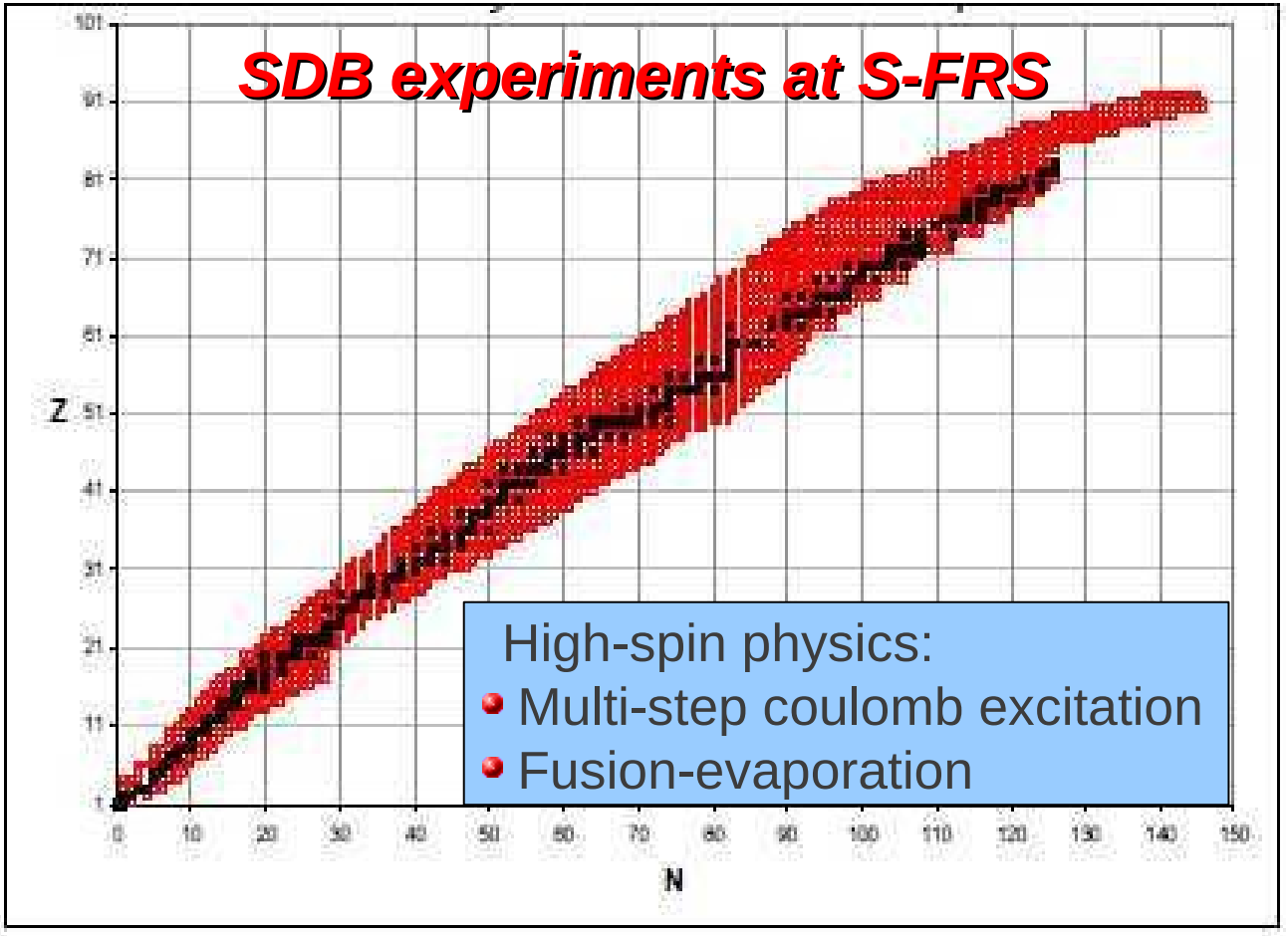




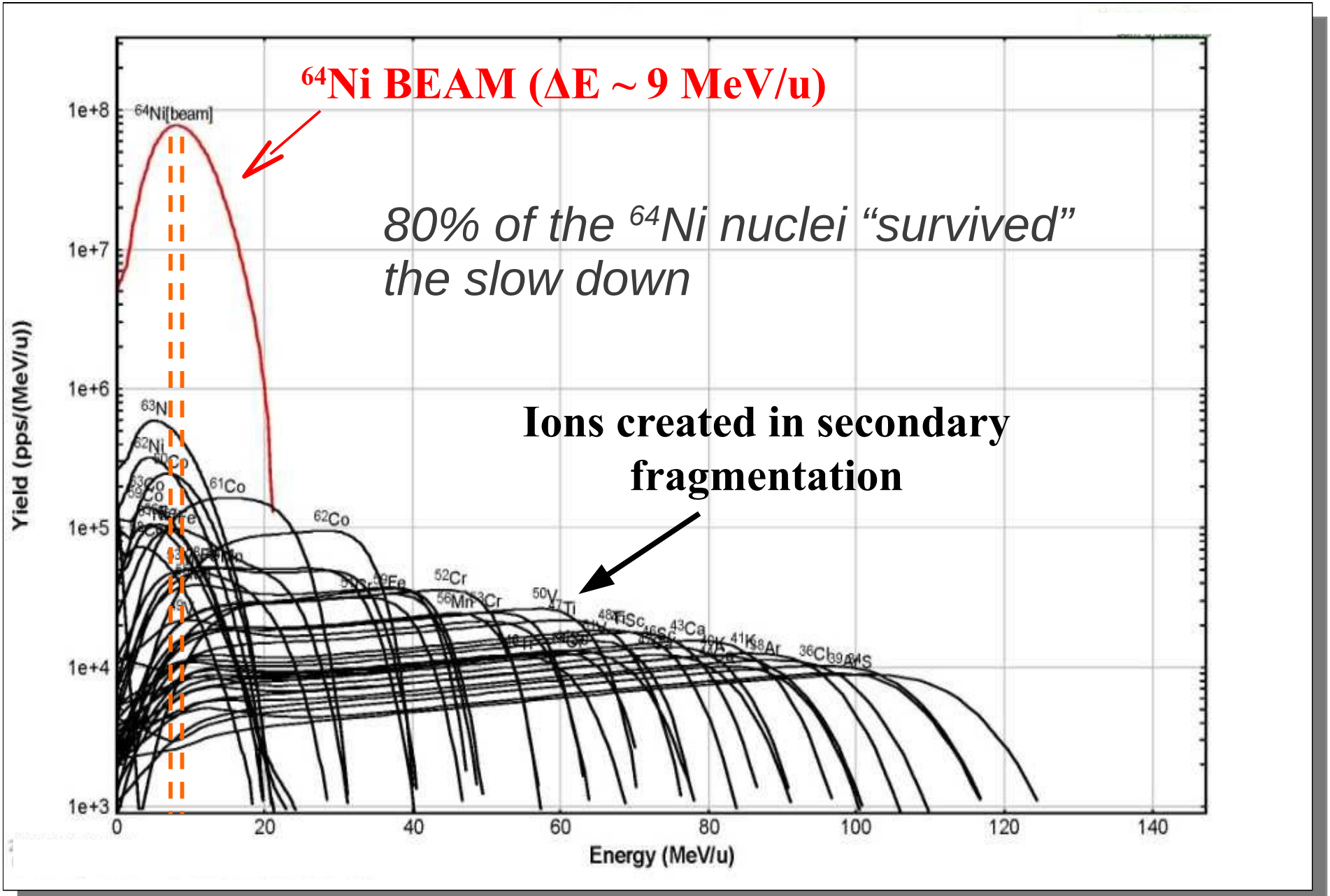
Slow down short lived beams provided by FRS/S-FRS to coulomb barrier energies with a thick degrader

The Idea

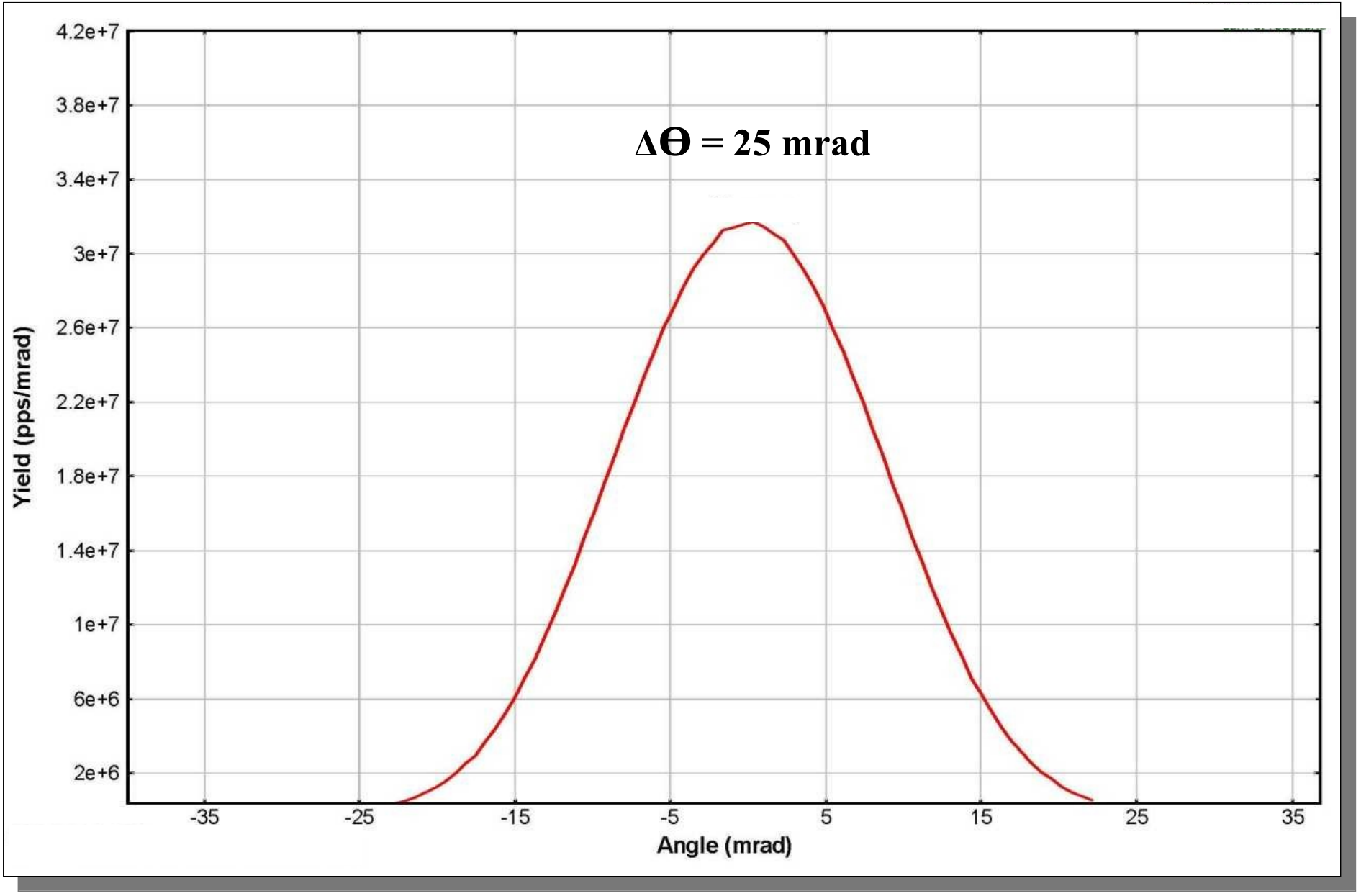

10⁹pps
10⁷pps
10⁶pps
10⁵ pps
⁶⁴Ni
700MeV/u
D1
D2
D3
D4
Tracking
⁶⁴Ni
250 MeV/u
⁶⁴Ni
5MeV/u
TA1
S2
S4
Deg.
TA2


SDB experiments at S-FRS
Z
N
High-spin physics:
Multi-step coulomb excitation
Fusion-evaporation

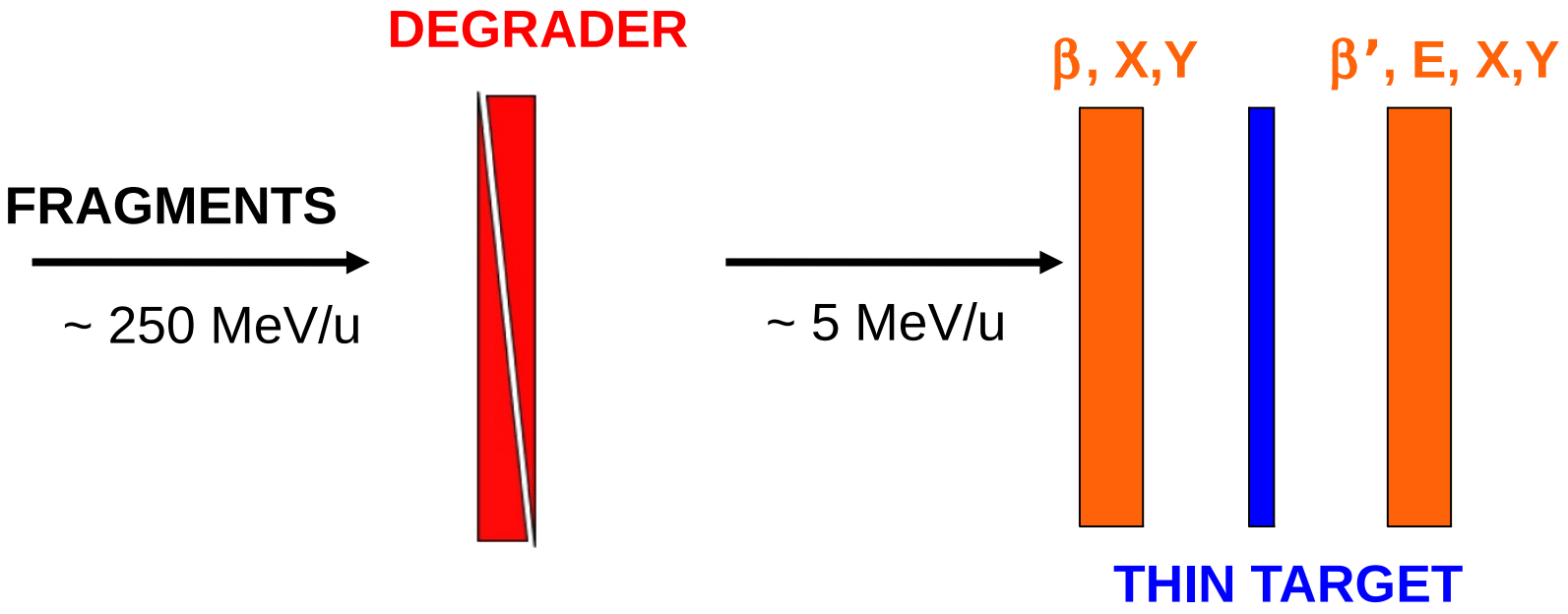
Experimental Problem



Experimental Problem



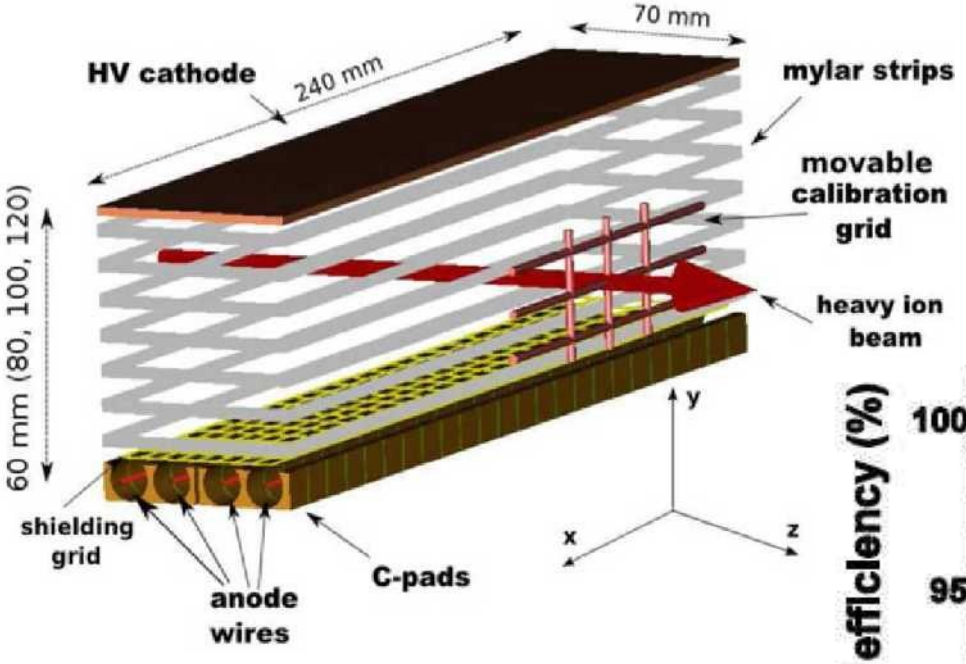
Proposed Solution

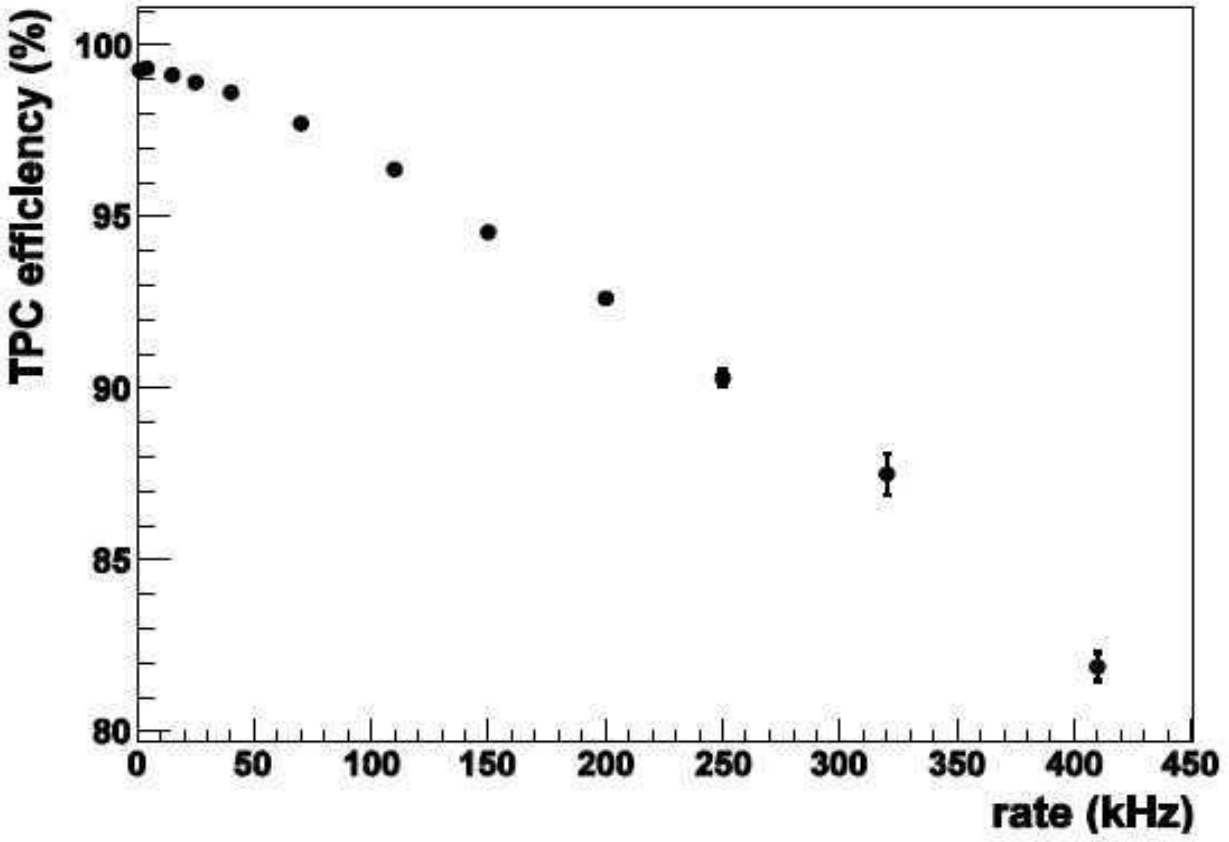


- Beam tracking before and after slowing down.
- Measure the beam velocity after slowing down, *neglecting the contaminations.*

Tracking before slowing down
X,Y: TPC

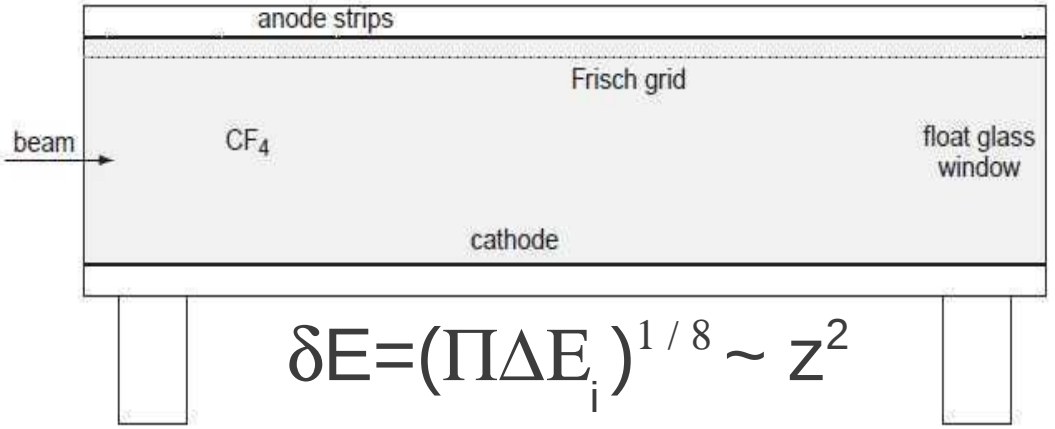
Comenius University Bratislava
GSI Darmstadt
Helsinki Institute of Physics



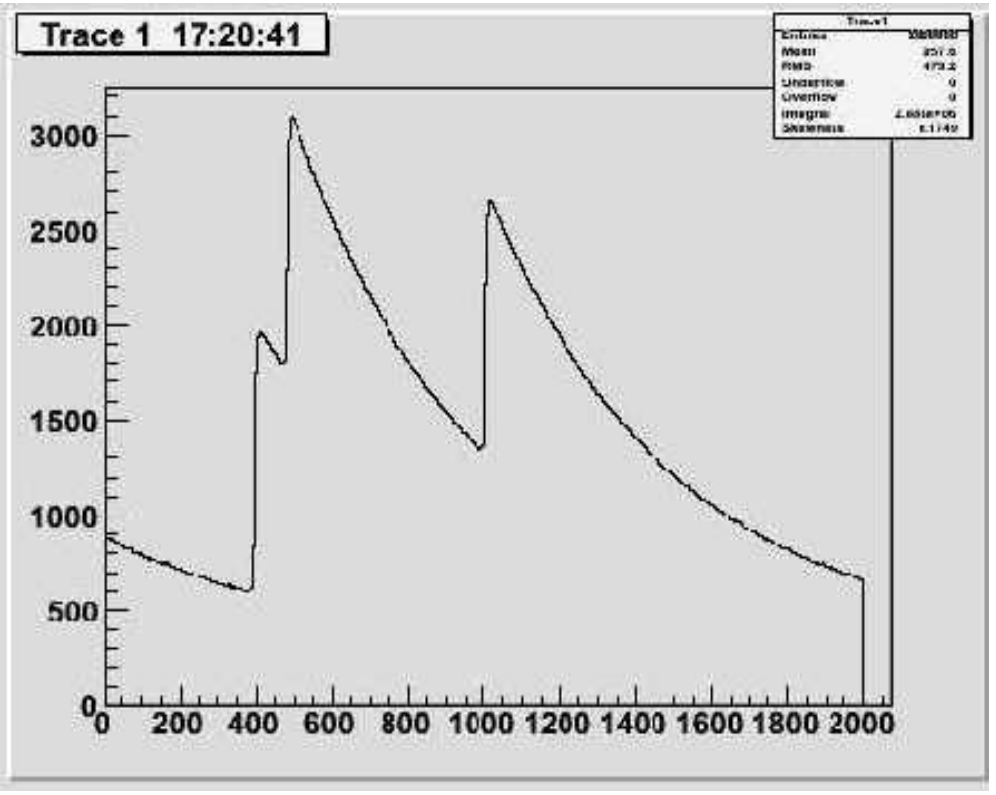


R.Janik *et al*, NIM **A**640 (2011) 54

Tracking before slowing down
Z: MUSIC



$$\delta E=(\Pi \Delta E_i)^{1/8} \sim z^2$$



T [25 ns/ch]

Can operate at ~200 kHz

Future: digital readout(SIS)

Estimated upper limit for the Doppler shift due to energy+angular straggling

E=10 MeV/u L=1.5 m

- Scintillator, 100 micron

$$dE_\gamma / E_\gamma = 0.02$$

- Diamond, 40 micron, no energy loss information

$$dE_\gamma / E_\gamma = 0.05$$

- Si, 40 micron, 100ps time resolution, energy loss added back

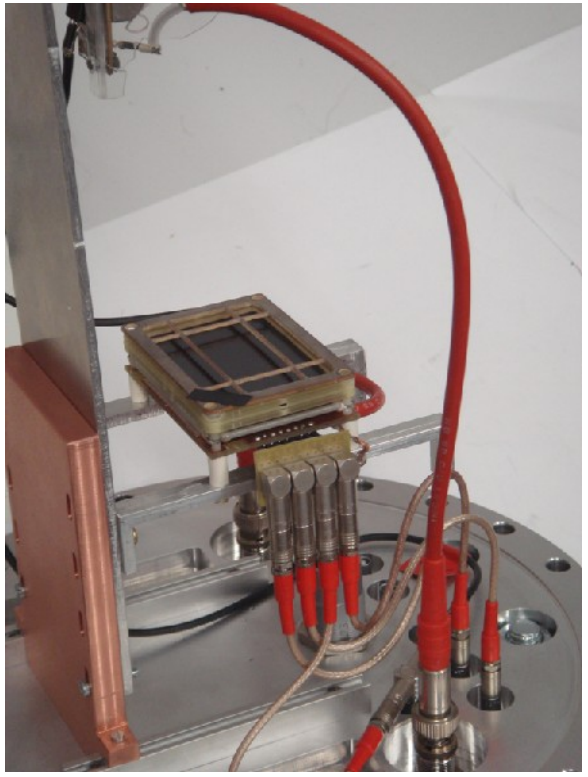
$$dE_\gamma / E_\gamma = 0.017 \text{ (1\% energy resolution)}$$

- Secondary Electron Detectors, 150 ps time resolution

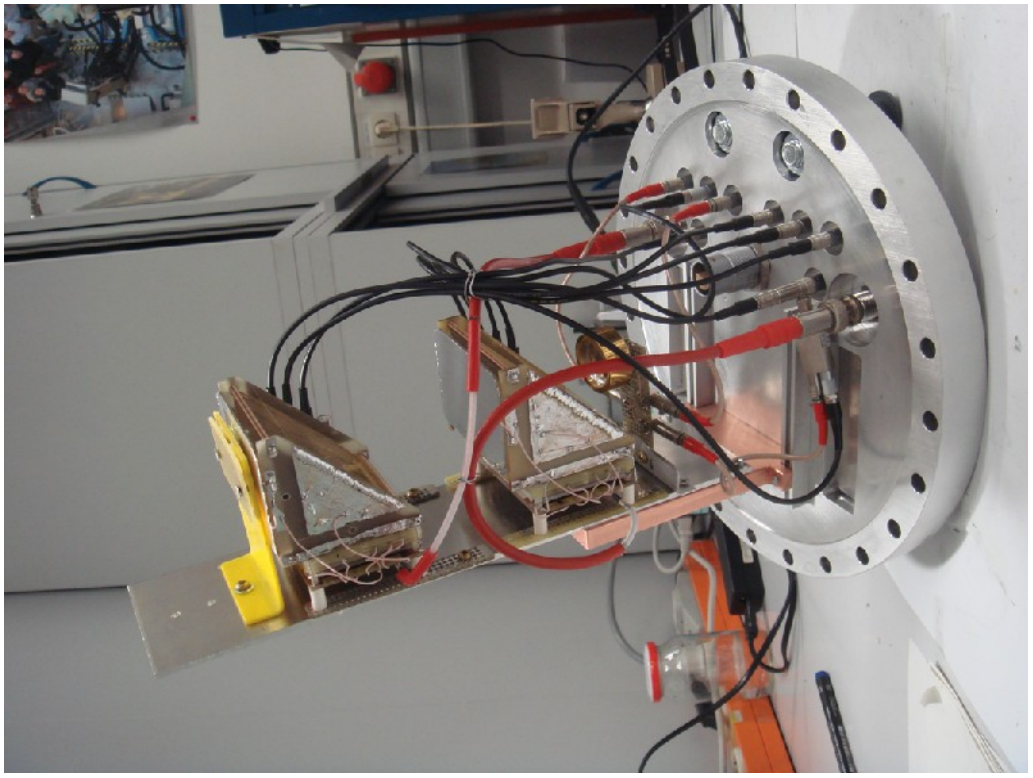
$$dE_\gamma / E_\gamma = 0.0075$$

Tracking after slowing down X,Y, TOF: MCP

Electronics:
Phillips 715 CFD:
walk +/- 75 ps
CAEN V1290A TDC,
Resolution 25 ps



ΔX(FWHM) ~ 1 mm

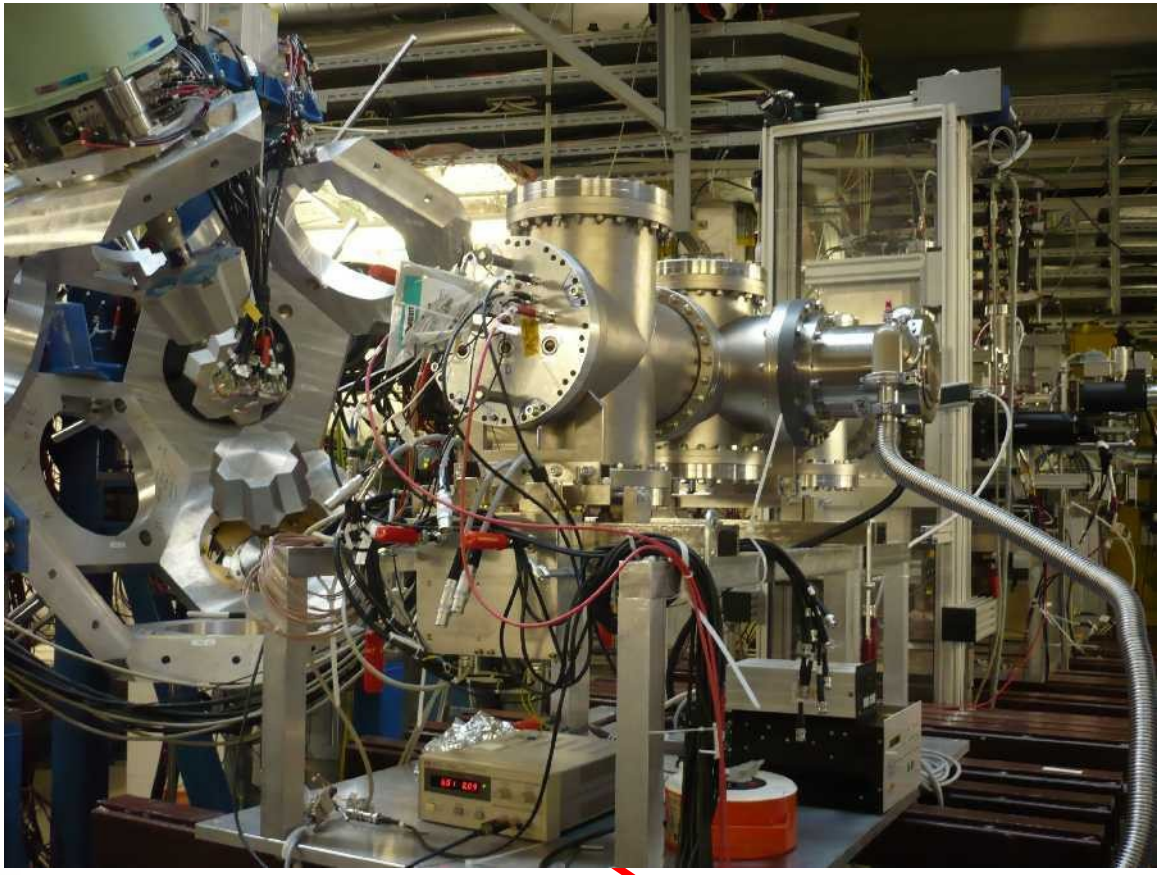


4 x 6 cm, 1.5 μm Mylar foil
ΔT(FWHM) ~ **140 ps**
ΔX_{α}(FWHM) ~ 3 mm
ΔX_{fr}(FWHM) ~ 1.5 mm
ε_{α}~ 85 %
ε_{fr}~ 100%

Design: N.A. Kondratjev

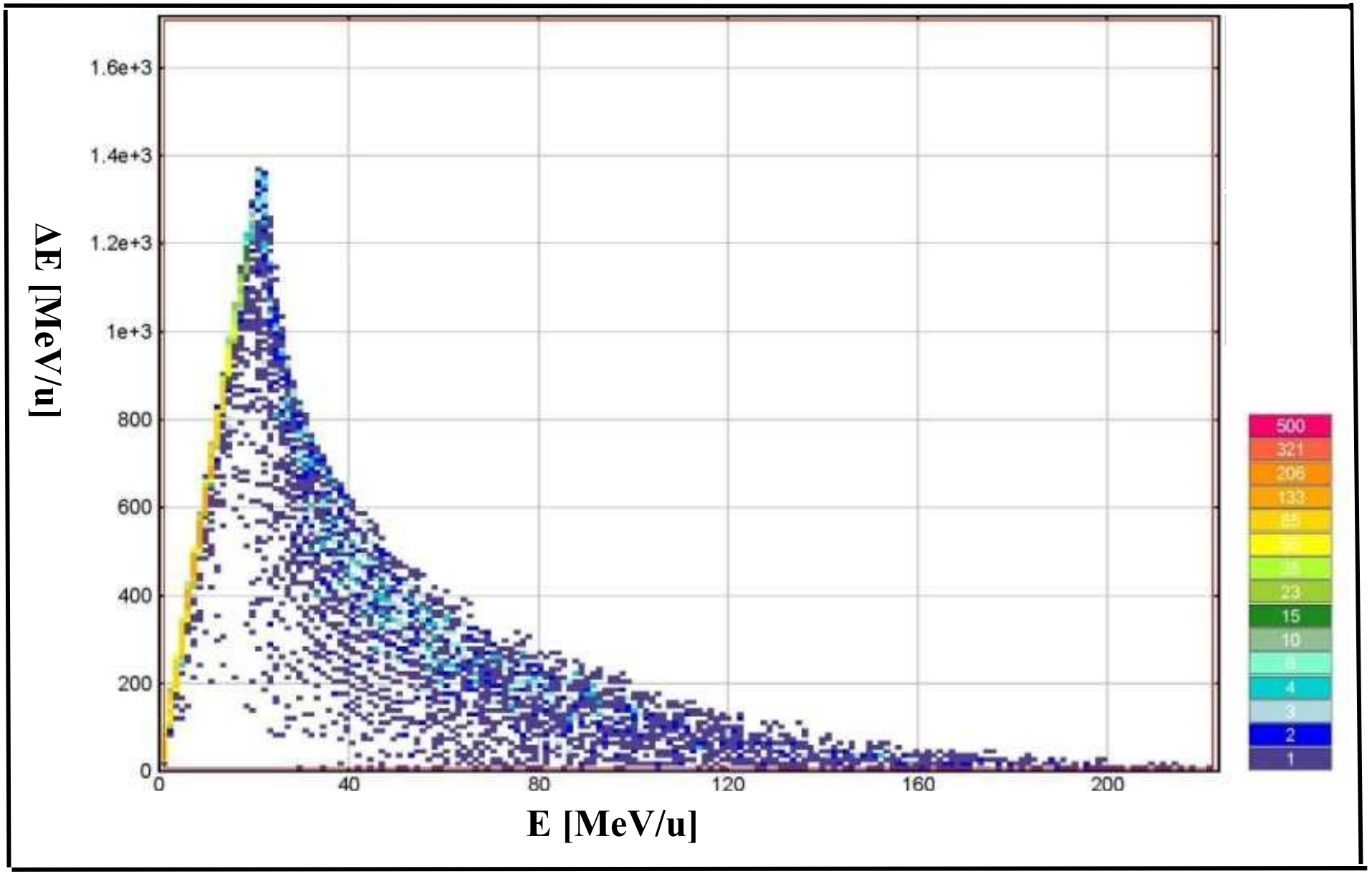
Slowed Down Beams (SDB) test at FRS

^{64}Ni

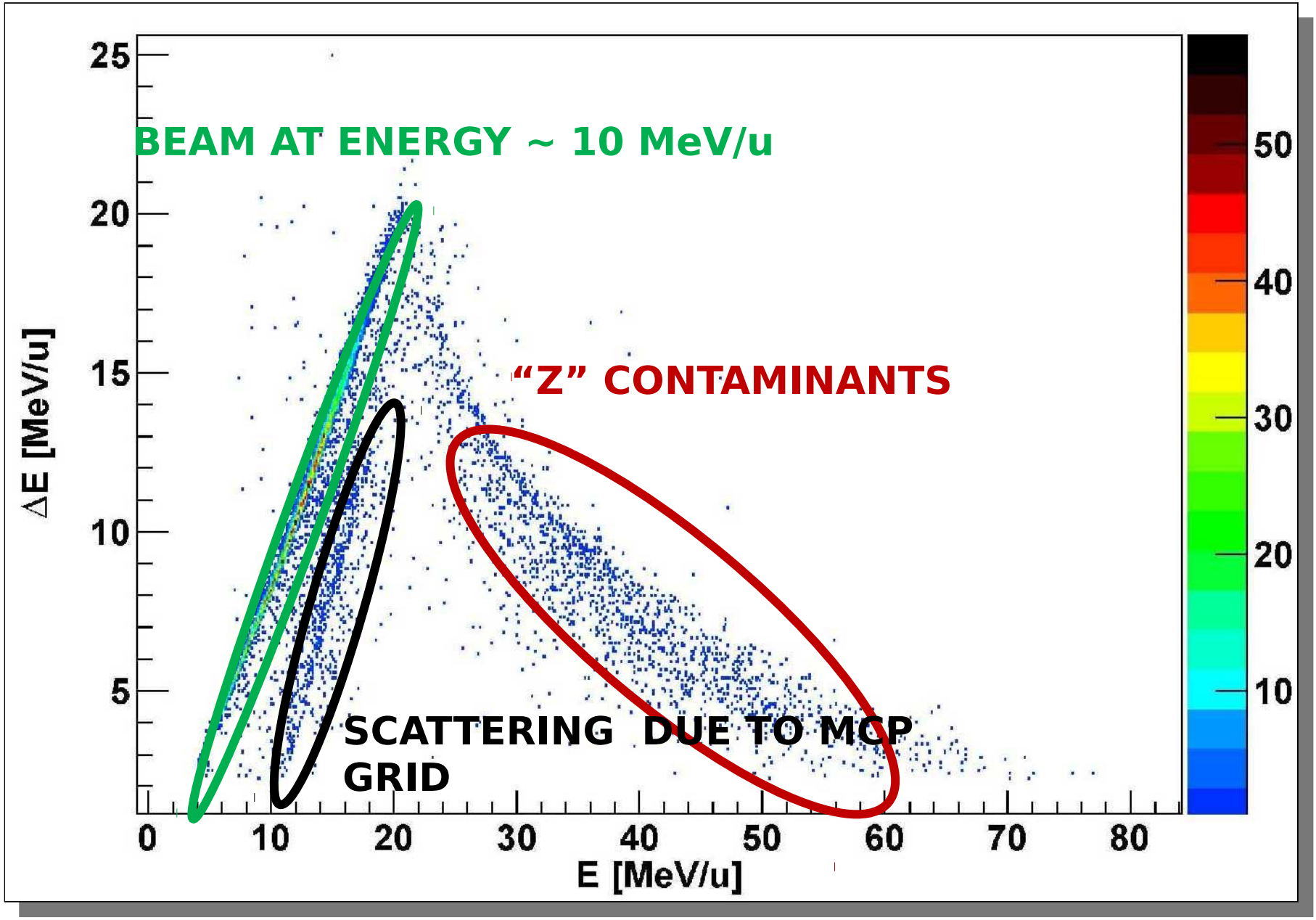


S4: TPC, MUSIC,
two SC41: 5mm(BC410),10mm(BC422)
2xMCP, 2xDSSD

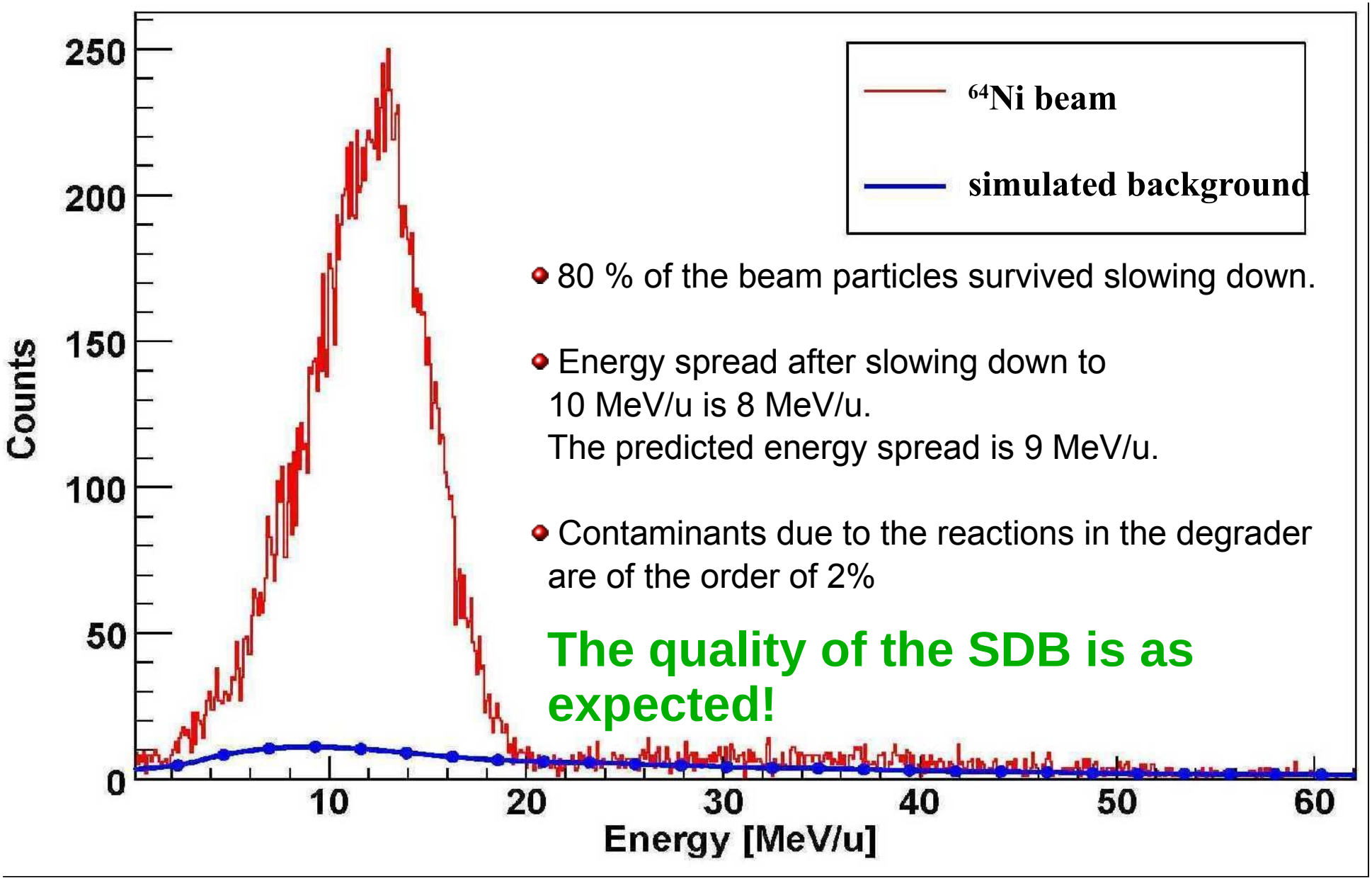
Simulation


ΔE [MeV/u]
1.6e+3
1.4e+3
1.2e+3
1e+3
800
600
400
200
0
0
40
80
120
160
200
E [MeV/u]
500
321
206
133
85
55
35
23
15
10
6
4
3
2
1

Results from the test performed in 2008



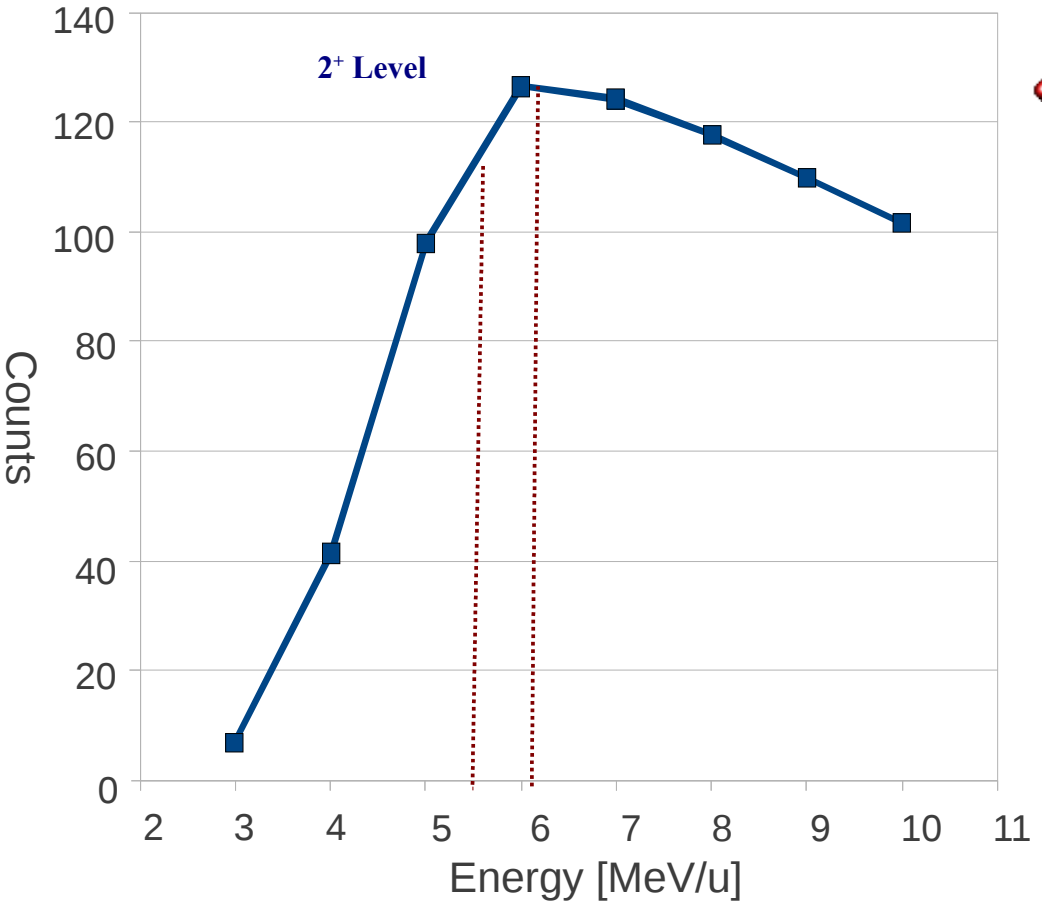
Results from the test performed in 2008



- 80 % of the beam particles survived slowing down.
- Energy spread after slowing down to 10 MeV/u is 8 MeV/u.
  The predicted energy spread is 9 MeV/u.
- Contaminants due to the reactions in the degrader are of the order of 2%

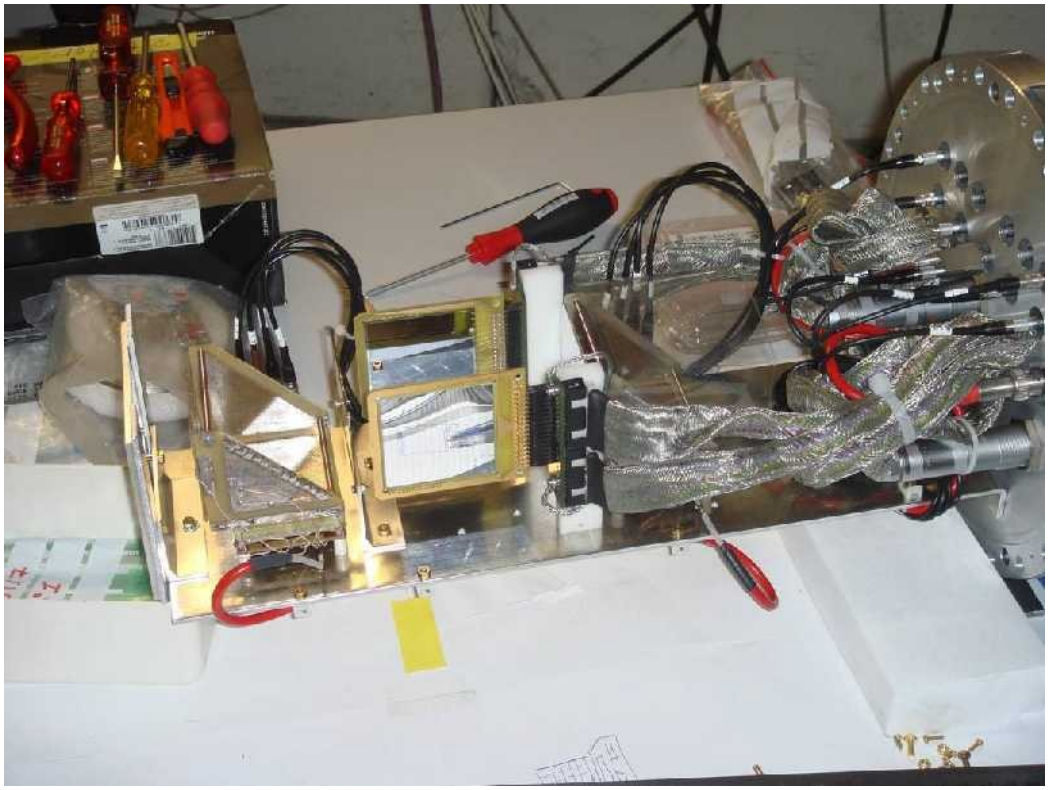
The quality of the SDB is as expected!

Coulomb excitation of ^{64}Ni and ^{63}Co and test of large tracking detectors

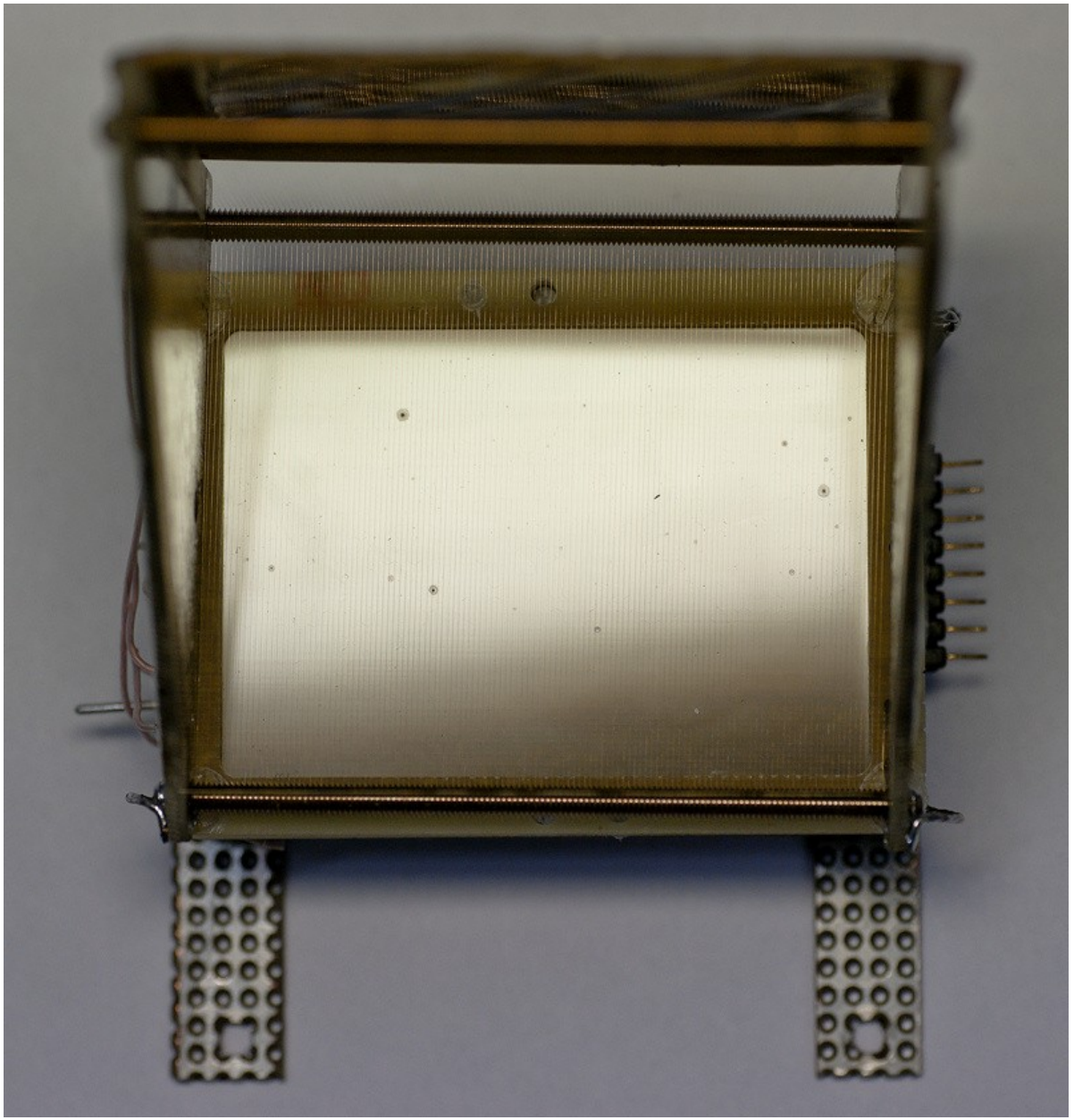


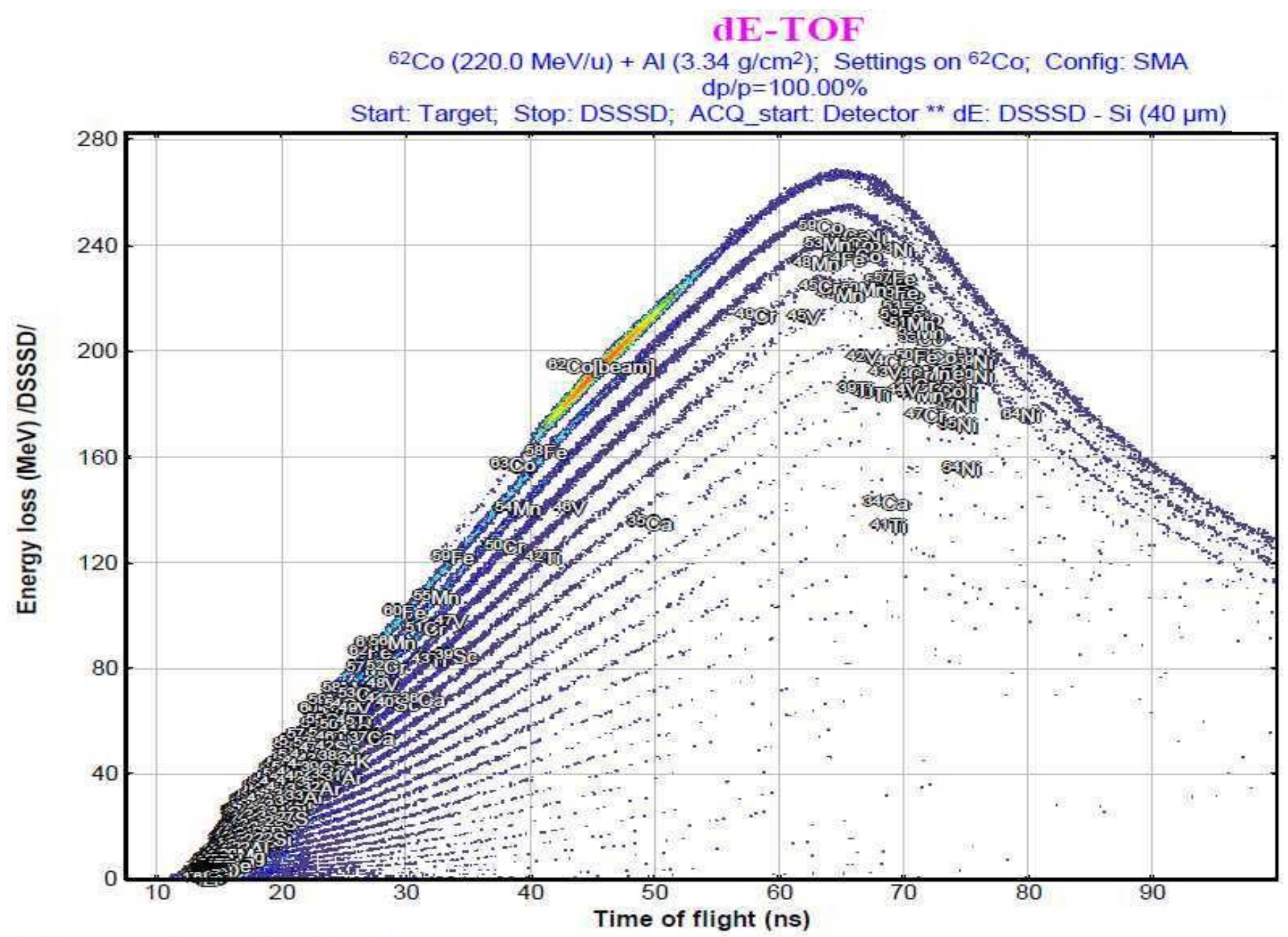
Counts in 10 days of parasitic beam time from the $2^+ \rightarrow 0^+$ transition in ^{64}Ni

- Demonstrate that Coulomb excitation experiments can be performed with SDB at FRS.



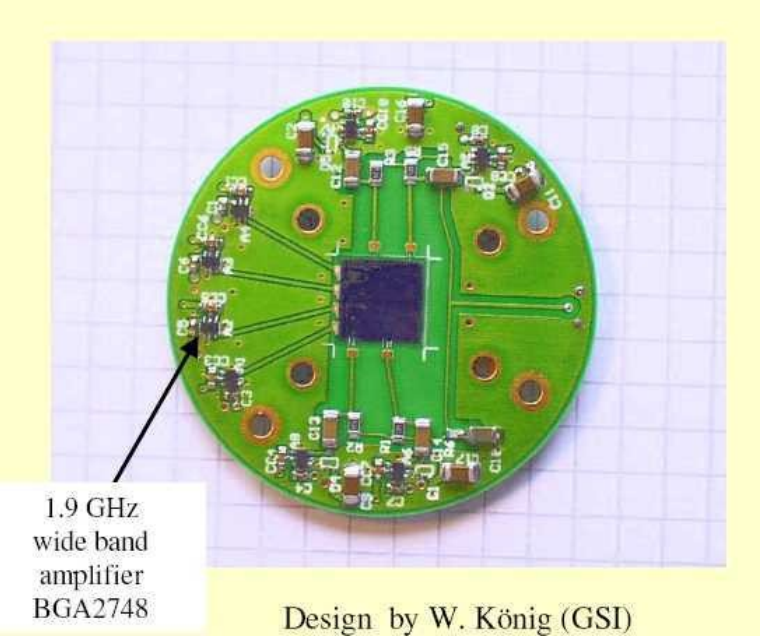
MCP lifetime

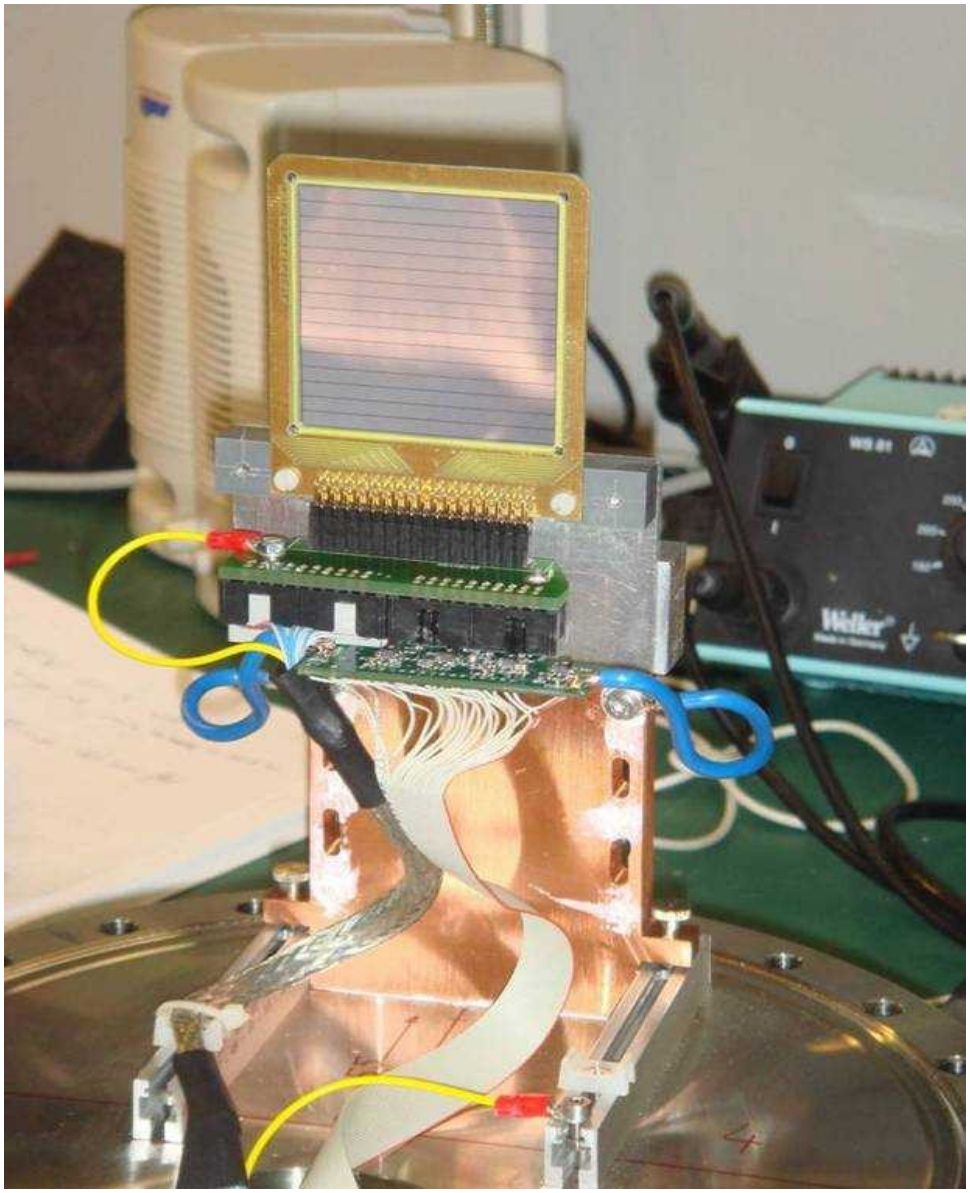




$\triangle E/E \sim 3\% \quad \triangle T \sim 150$ ps

Si fast timing

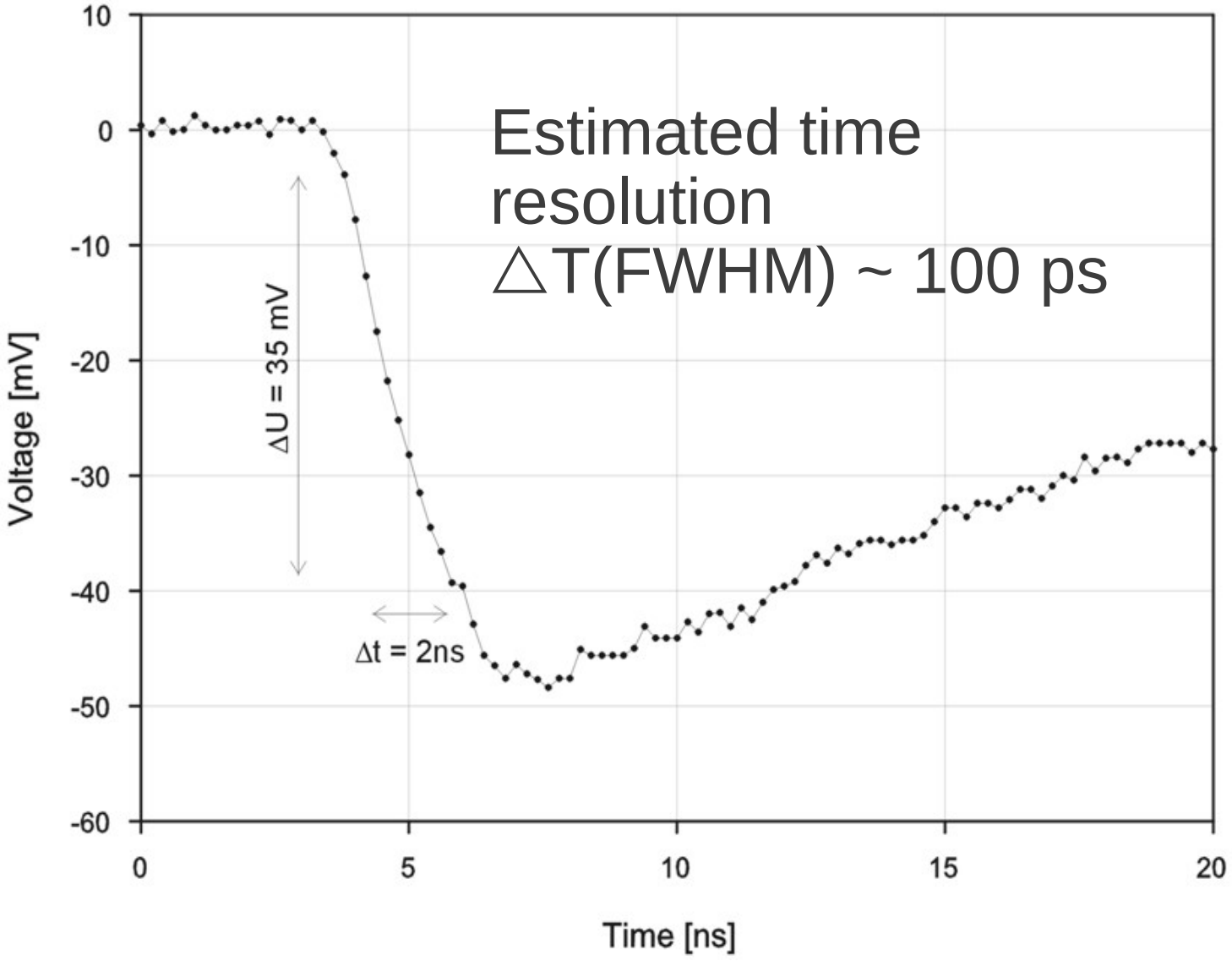




DSSD: 40 μm 5x5 cm²
16x16 strips

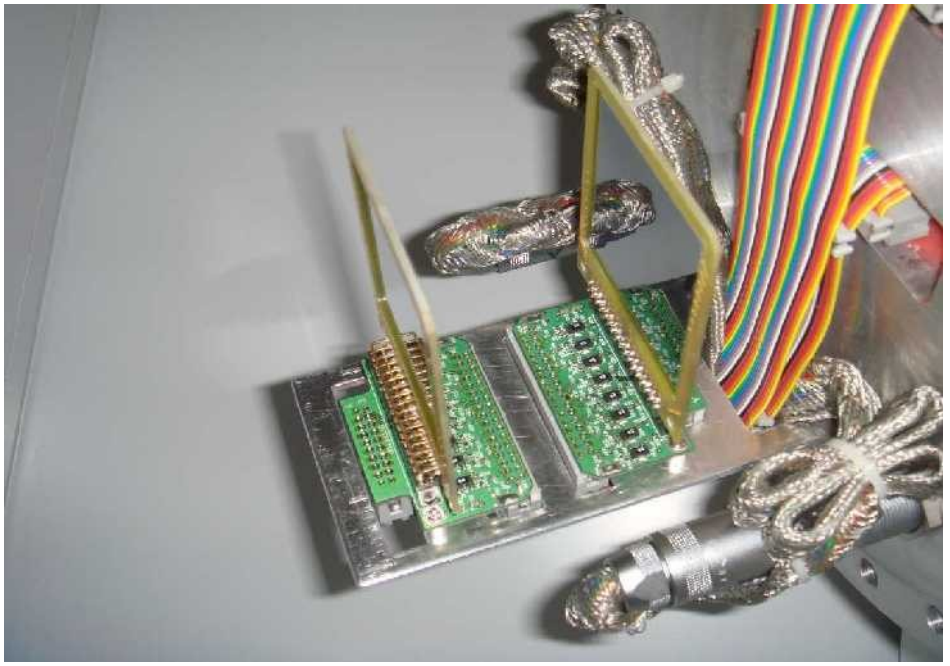
Si fast timing in Aug 2007

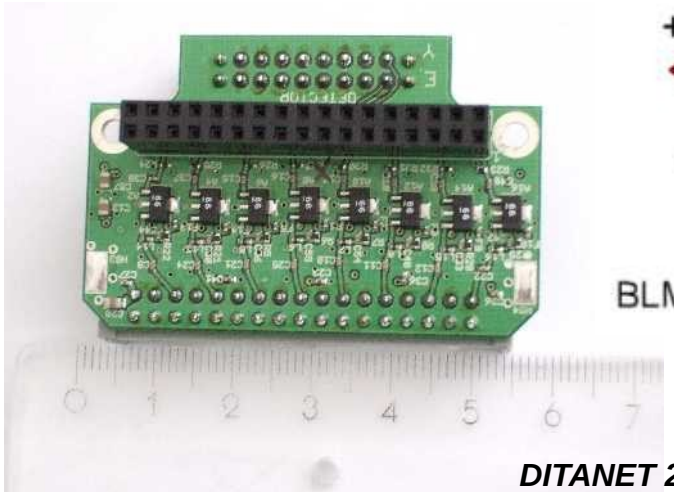
Coulomb scattering of ^{48}Ca beam, 12.6 MeV/u at 20°

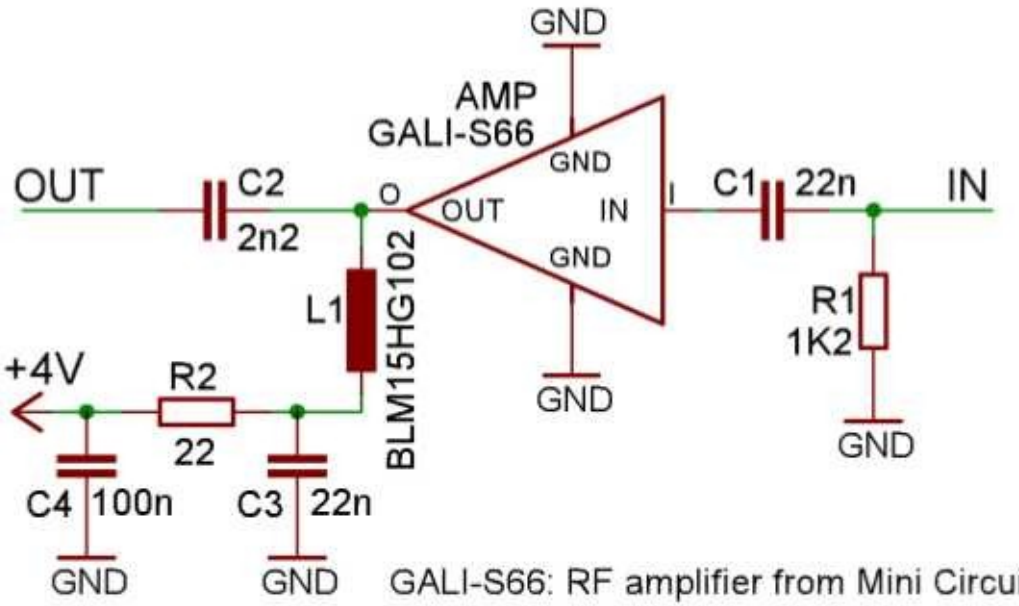


Fast timing with Si-detectors

16 ch Fast pre-amp + 16 ch Level discriminators + 16ch ECL converters



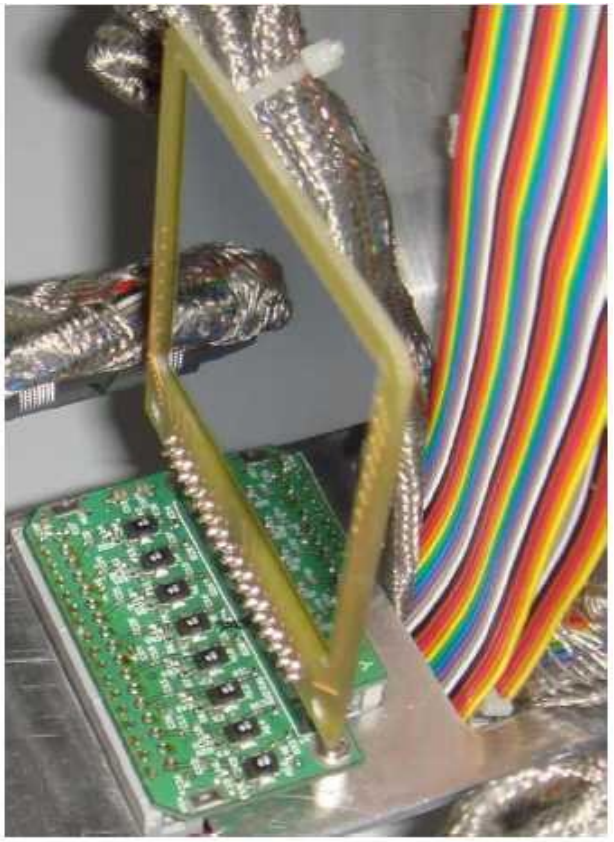


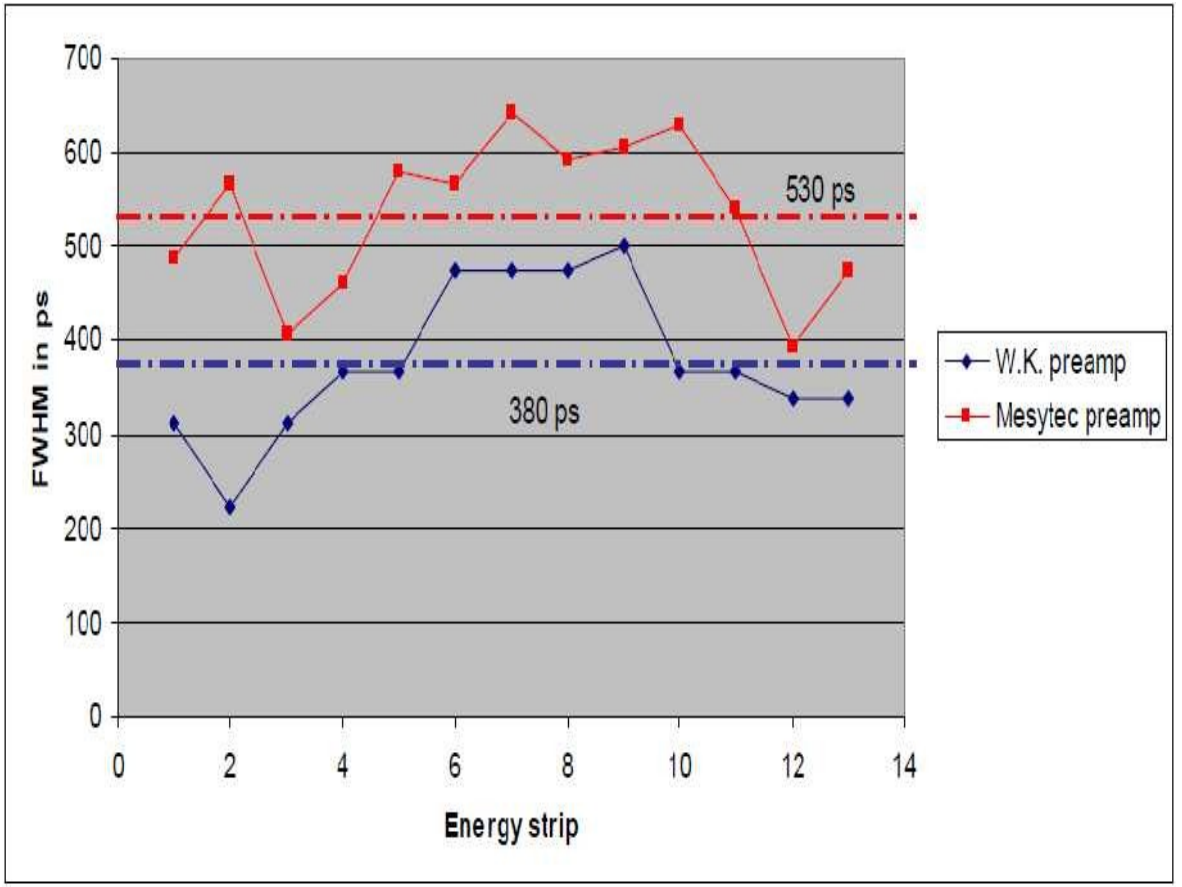


GALI-S66: RF amplifier from Mini Circuits

BLM15HG102: ferrite bead with Z=1KOhm@100 MHz from MURATA

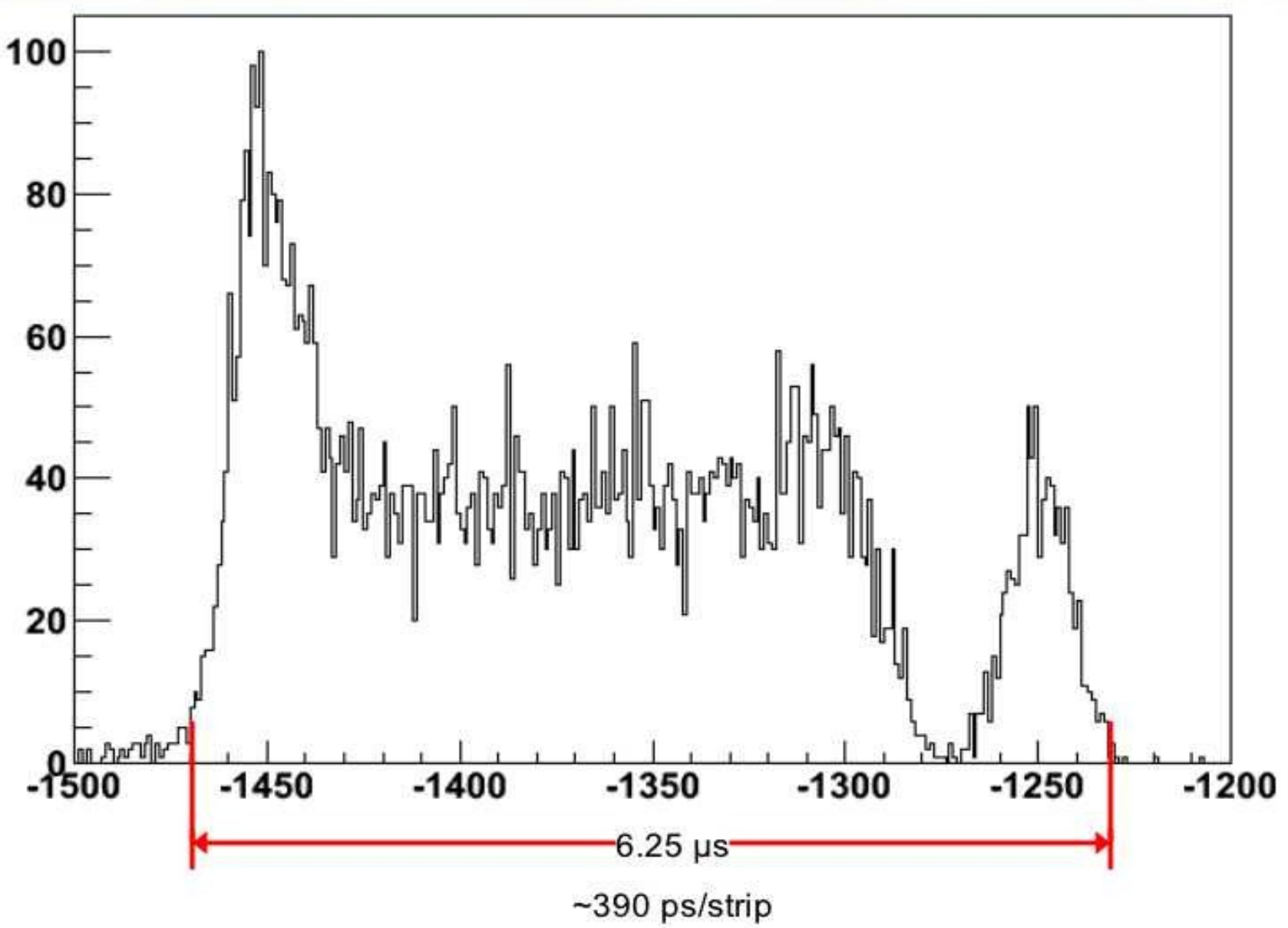
Fast timing with Si-detectors





- MFA-32, Mesytec
- 32ch fast preamplifier
- Eight fast outputs
- Position obtained through readout of a resistive chain

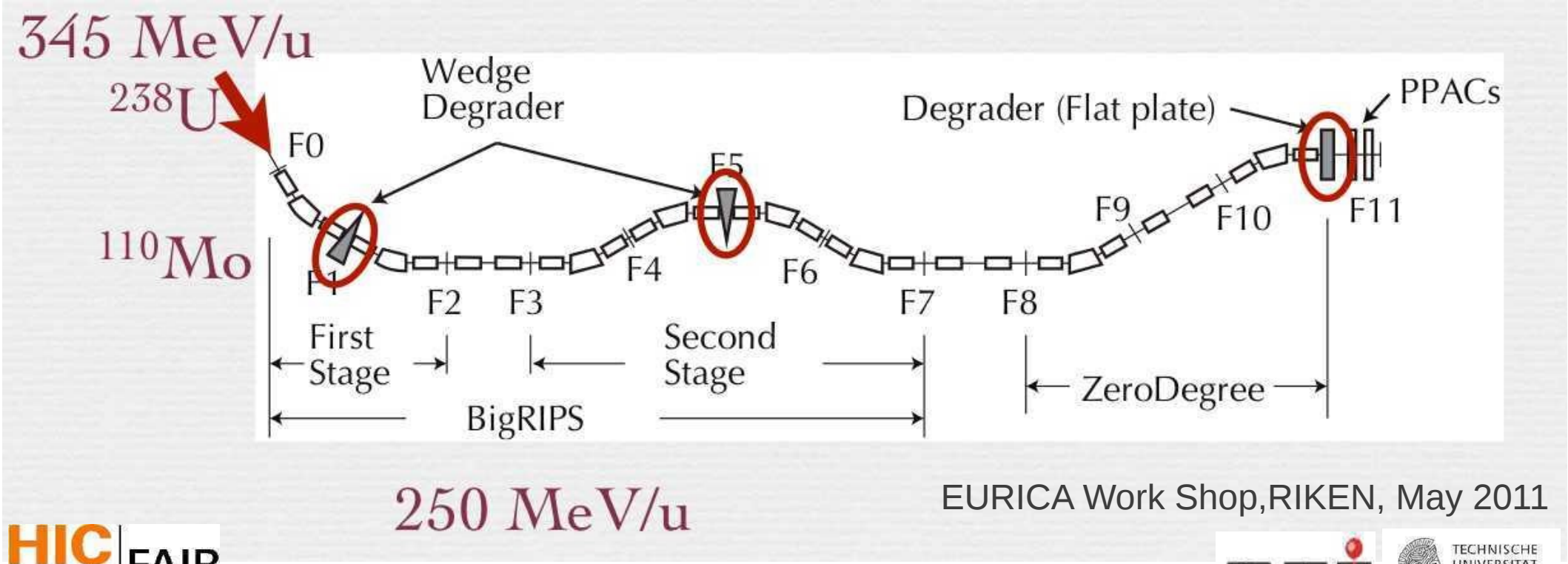
Delay across a strip



Development of slowed down beams around the world

Fusion enhancement with neutron-rich RIB, ^{32,38}S+^{181}Ta,
slowed from 9 MeV/u to ~ 4 MeV/u
K.E. Zyromski, et al. PRC **55**, R562 (1997)

High-spin states in ^{48}Ca, using 5 MeV/u ^{46}Ar beam
slowed from 30 MeV/u to 5 MeV/u
E. Ideguchi, et al. EPJA **25**, 429 (2005)



EURICA Work Shop,RIKEN, May 2011

Conclusions

- MCP detectors needed to perform Coulomb excitation measurement with SDB were build
- The suggested technique to produce SDB for coulomb excitation measurements was successfully demonstrated

Future

- Development of new 16ch pre- amplifier to be used with thin DSSSD
- Coulomb excitation experiment with SDB

SDB Collaboration

GSI group/TU Darmstadt:
P. Boutachkov, M.Górska, J.Gerl, H.Geissel, E. Gregor, I.Kojouharov, W.Koenig, C.Nociforo, W.Prokopowicz, H.Schaffner, H.Weick

Saclay:
A.Drouart, A.Polacco

Köln:
J.Jolie, F.Naqvi, G.Pascovici M.Pfeiffer

Sevilla group:
J.Gomez Camacho, M.Alvarez, J.M.Espino, I.Mukha, J.M.Quesada

LNL group:
J.J.Valiente, A.Gadea

JINR Dubna:
N.Kondratiev

Collaboration

P. Boutachkov[1], F. Naqvi[6], M.Górska[2], J. Gerl[2],
W.Koenig[2], N.A. Kondratjev[3], E.Gregor[1], H.J.Wollersheim[2],
I. Kojouharov[2], H. Schaffner[2], H. Weick[2], M.A.G. Alvarez[4],
I. Mukha[2], Z.Abou-Hoüdar[4] , S. Pietri[2] ,A. Prochazka[2], F. Farinon[2],
C. Nociforo[2], R. Janik[5], P. Strmen[5]

1. TU Darmstadt, Germany
2. GSI Darmstadt, Germany
3.FLNR, JINR, Dubna, Russia
4. Seville University, Seville, Spain
5. Komenskèho University, Bratislava, Slovakia
6. Yale University, USA

Development of the Slowed Down Beam setup for HISPEC

P.Boutachkov, F.Naqvi, M.Górska, J.Gerl, H.J.Wollersheim,
G.Pascovici, M.Pfeiffer
for the PRESPEC collaboration

- Shifts requested: 17 days of parasitic beam time
- Accepted 10 days or **30 parasitic shifts**