Slowing down RIBs to coulomb barrier energies

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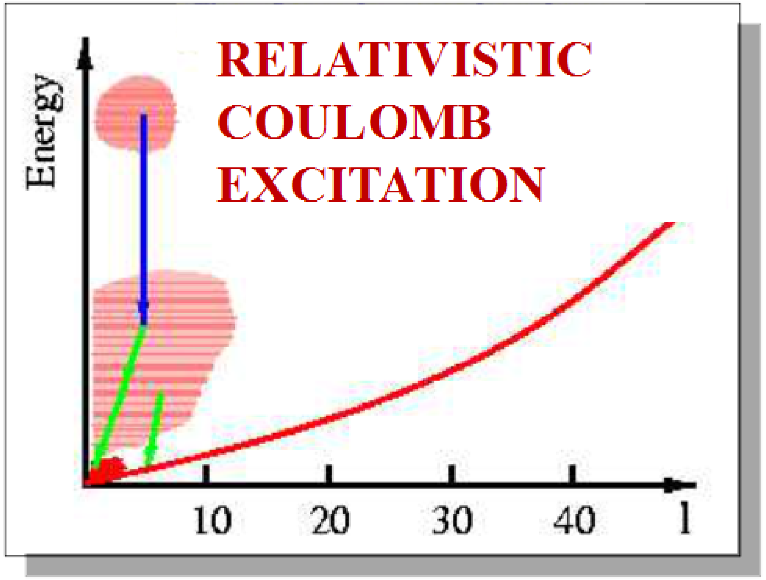
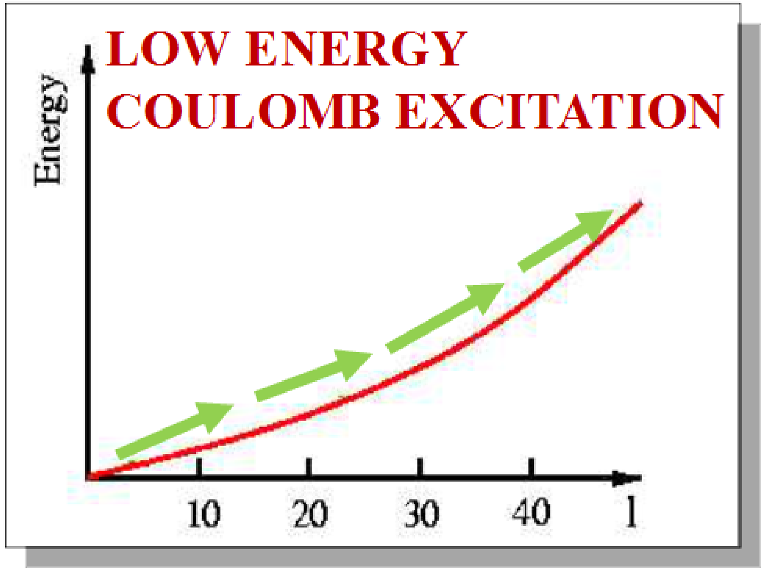
Agenda

- Concept idea
- Feasibility studies
- Ancillary detector developments
- Conclusion

Concept idea

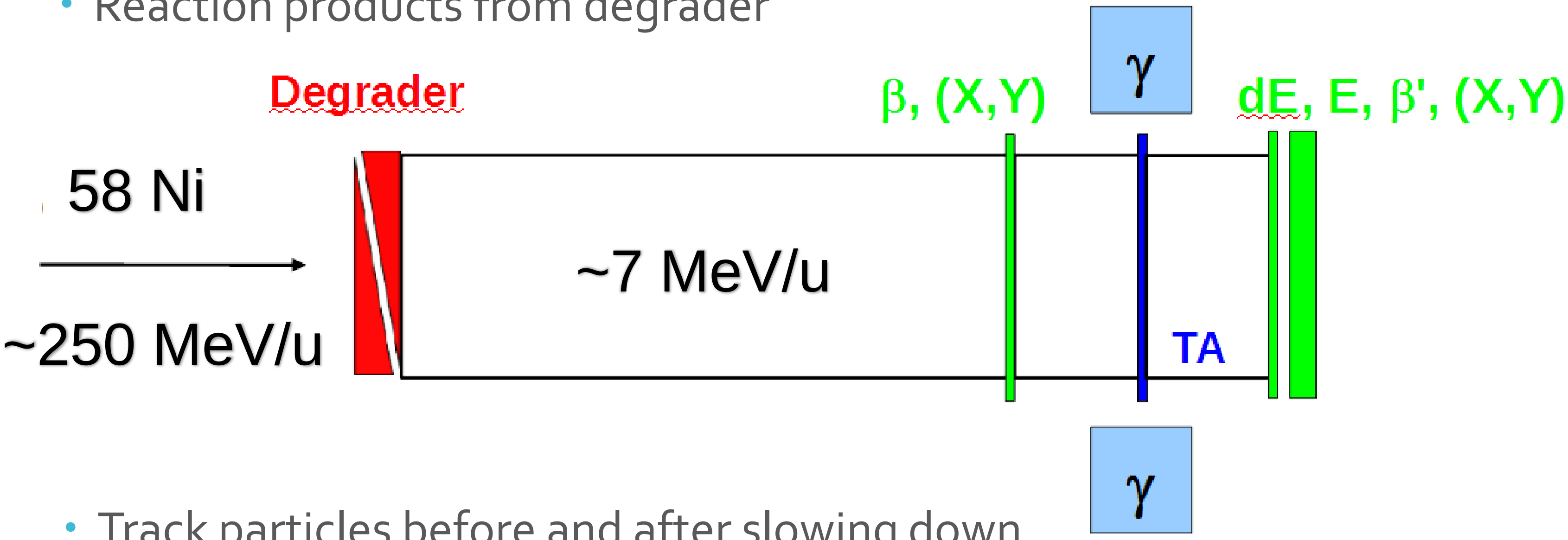
- Exotic –short lived- nuclei produced with in-flight method at FAIR/SFRS have energies far above the Coulomb barrier
- Deceleration of these unique beams in thick degrader to 5-10 MeV/u
- High-spin physics:
  - Multi-step coulomb excitation
  - Transfer, Resonance, Fusion-evaporation
- Compared to other existing experiments with slow down beams, e.g. MSU or RIKEN, or isotope online method we have access to other energies and nuclei ->complementary





Concept idea
-challenges & solutions

- Angular broadening
- Energy straggling
- Reaction products from degrader



- Track particles before and after slowing down
- Measure X;Y;β (ToF) and ΔE;E
- reducing background by tracking

Concept idea
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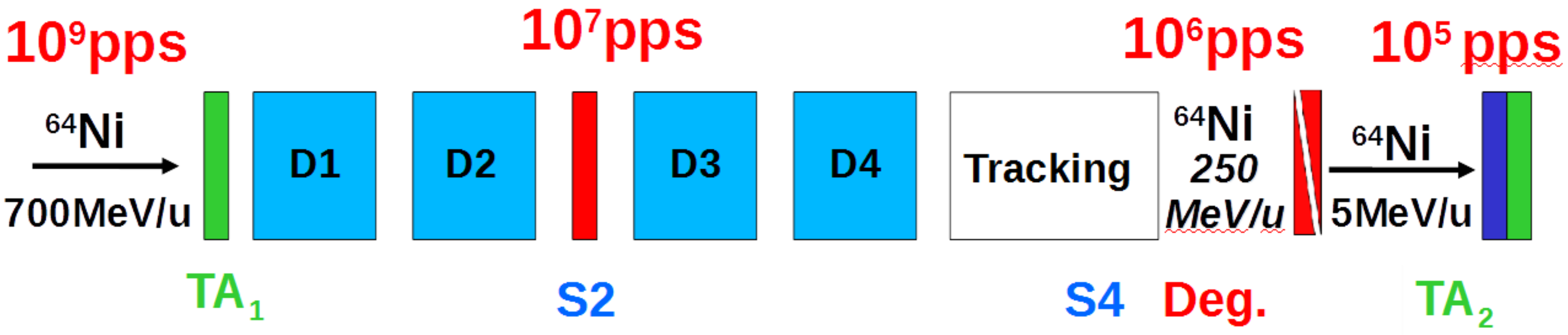

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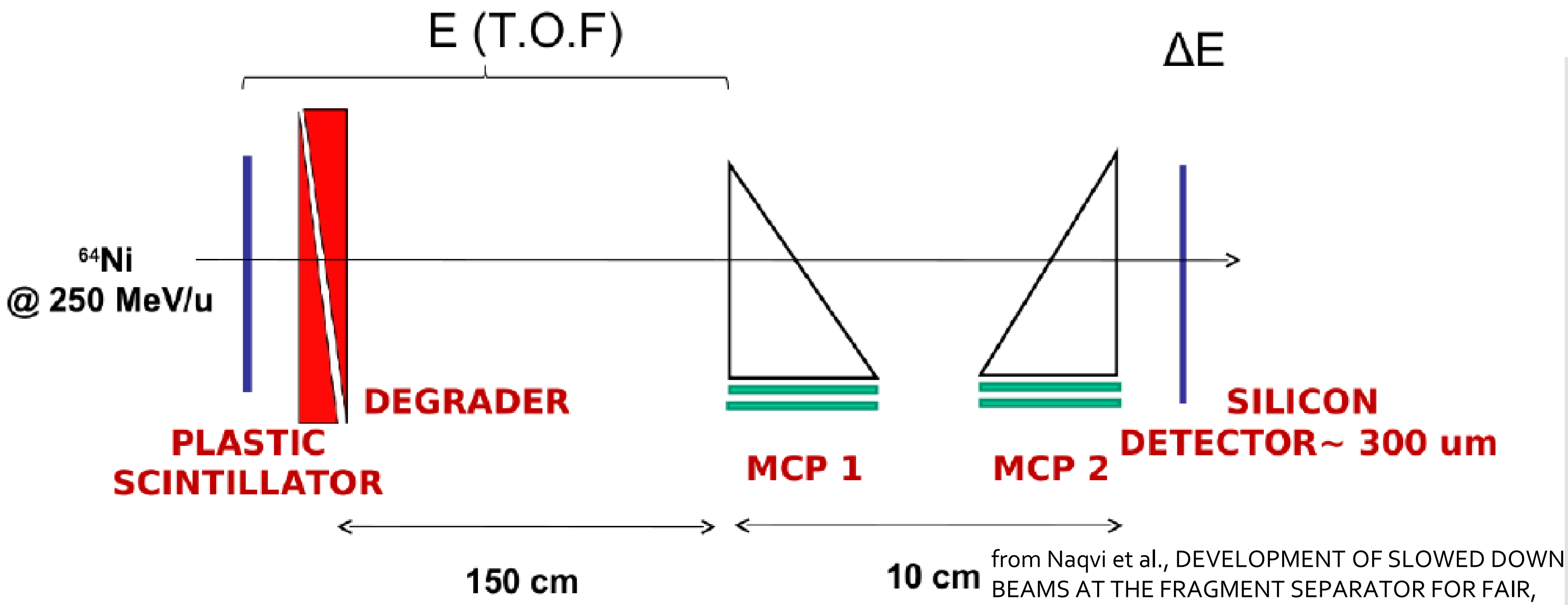
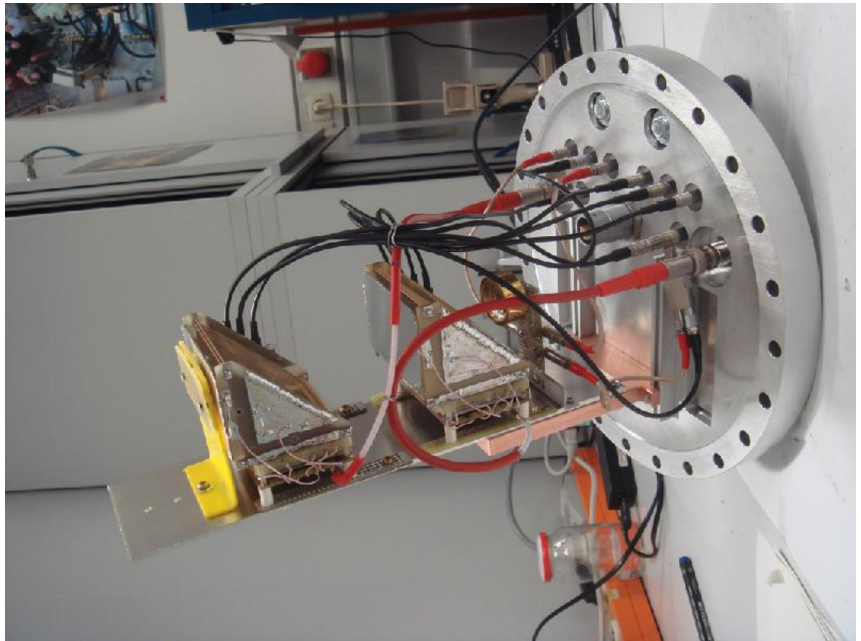
Feasibility studies

-2008: 64Ni



from Naqvi et al., DEVELOPMENT OF SLOWED DOWN BEAMS AT THE FRAGMENT SEPARATOR FOR FAIR, ACTA PHYSICA POLONICA B; Vol.42 (2011), p.725-728

- FRS detectors used for particle identification before degrader
- Beam Profile Monitors (Thin Foil Detectors) were used for X;Y;ToF measurement
- Active Target was used for Δ E measurement

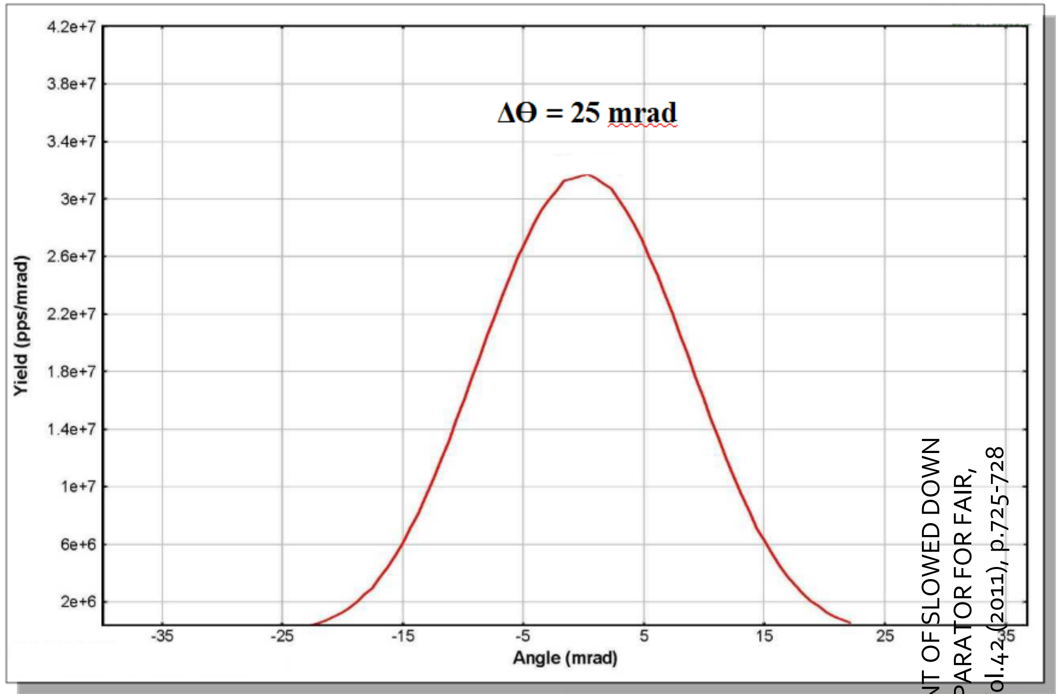


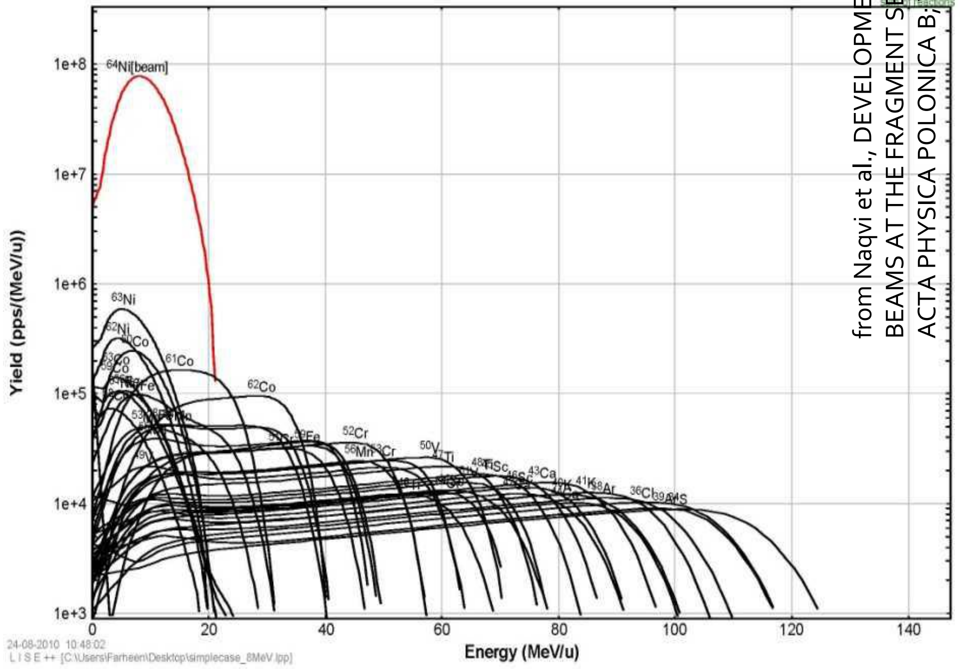
Feasibility studies
-2008: 64Ni

- Angular spread becomes not neglible
- Distance between degrader and target relevant

SIMULATIONS

- Energy spread 9 Mev/u
- Creation of secondary fragments in the degrader
- Integrated background contribution in relevant energy gate is <1%





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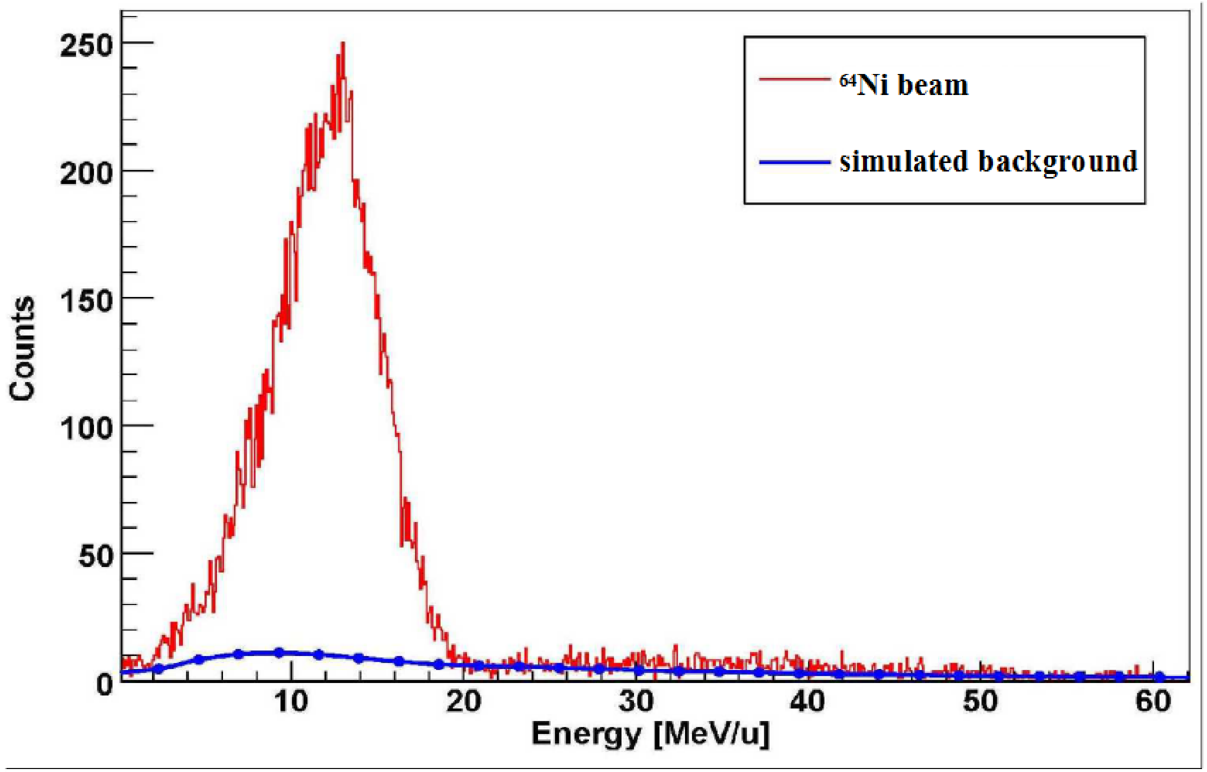
Feasibility studies
-2008: 64Ni

- 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%

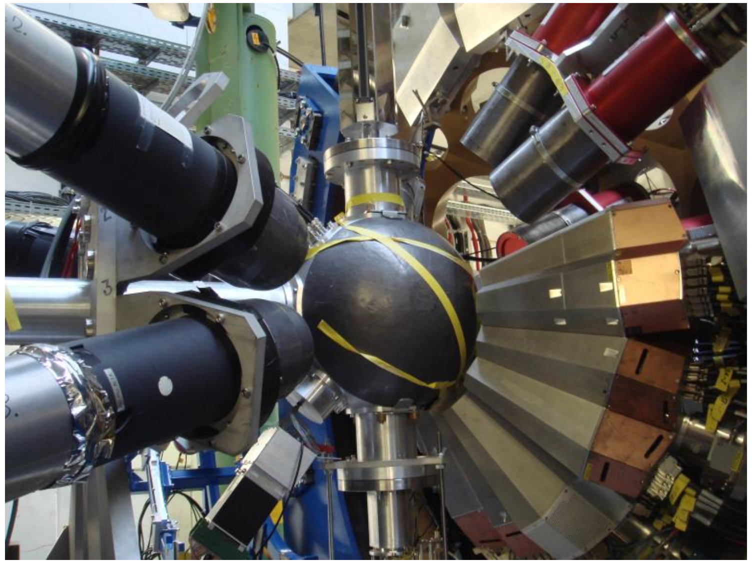


from Naqvi et al., DEVELOPMENT OF SLOWED DOWN BEAMS AT THE FRAGMENT SEPARATOR FOR FAIR, ACTA PHYSICA POLONICA B; Vol.42 (2011), p.725-728

Feasibility studies

-2014: 58Ni

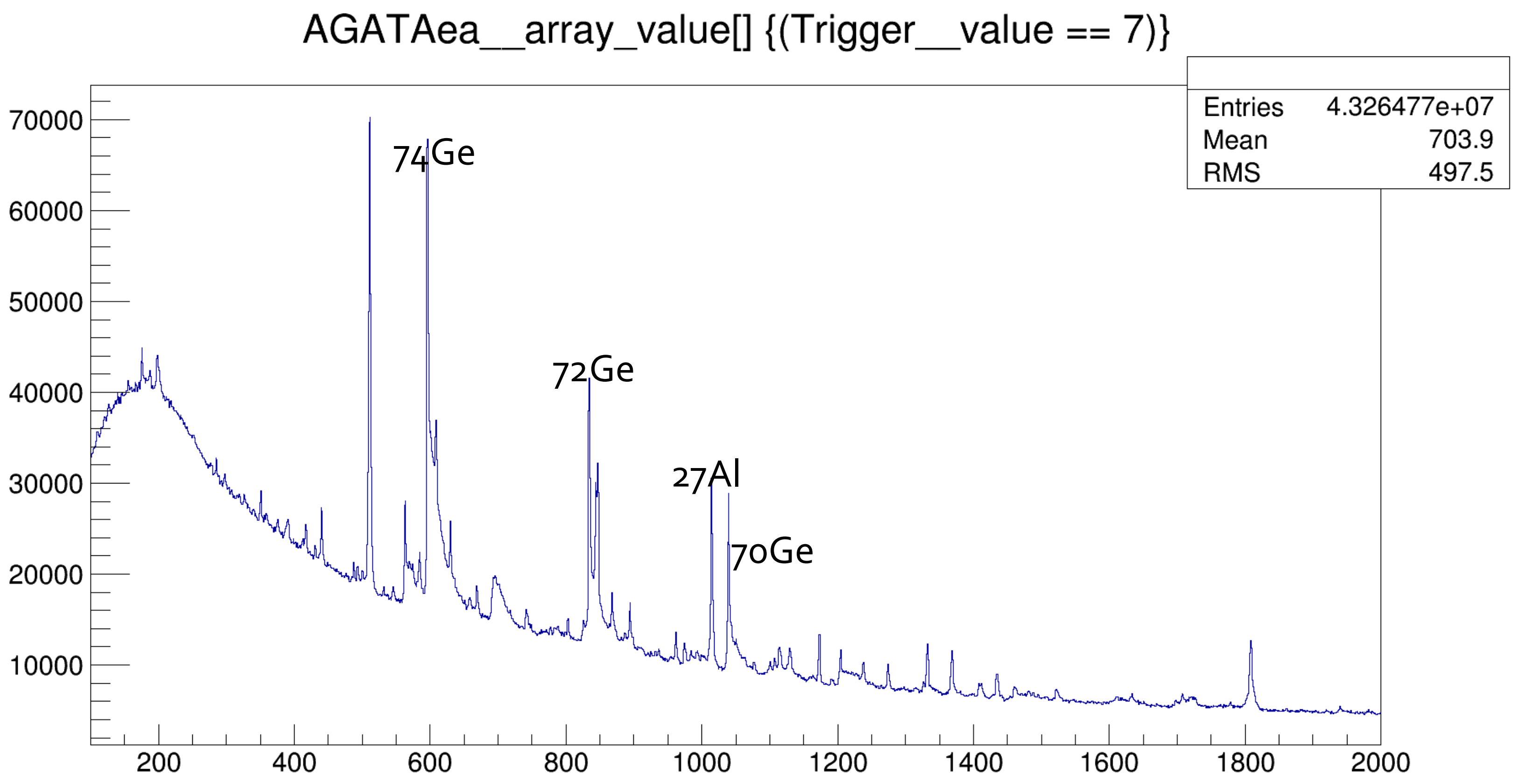
- April 2014: 2 shifts of 58 Ni @ 250 MeV/u
- Slowed down to 7 MeV/u in Al degrader
- Important detectors:
  - FRS scintillator 41
  - BPMs
  - Active silicon target (for energy calibration of the target)
  - AGATA
- Thick Au target



Feasibility studies

-2014: 58Ni

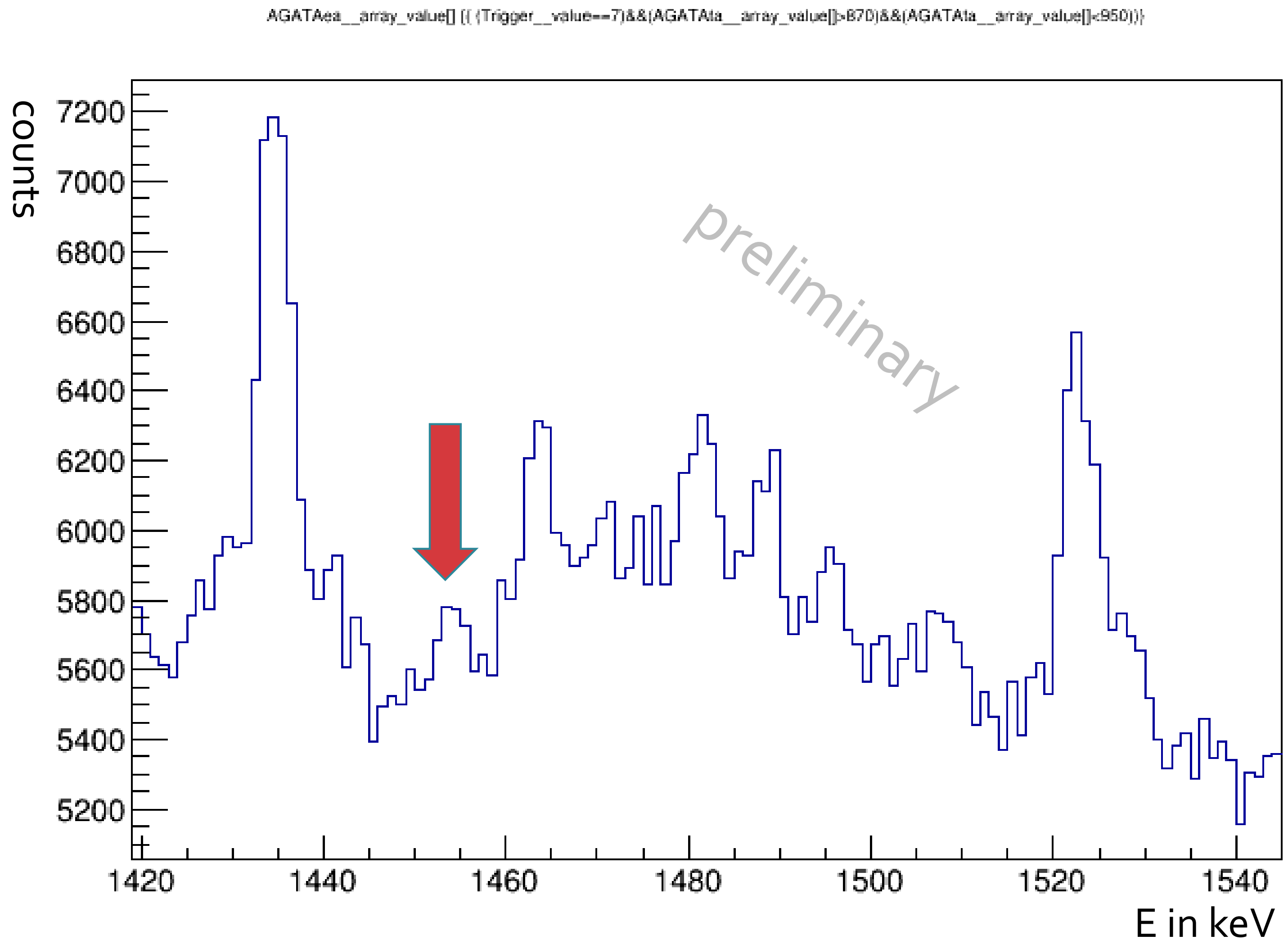
- High background counts and unwanted lines from (fast) neutrons (n,n'γ)
- Lines from elements of the setup can easily be seen: Al,Ge,Pb,Cu,Fe,...
- Lines from Au Target are not easily found because of a large Compton background (only Au X-rays)
- 58 Ni Lines are also not easily found (maybe due to Doppler broadening)



Feasibility studies

-2014: 58Ni

- A nickel 2+ 1454 keV peak becomes visible after setting a time gate and subtraction of two background time cuts

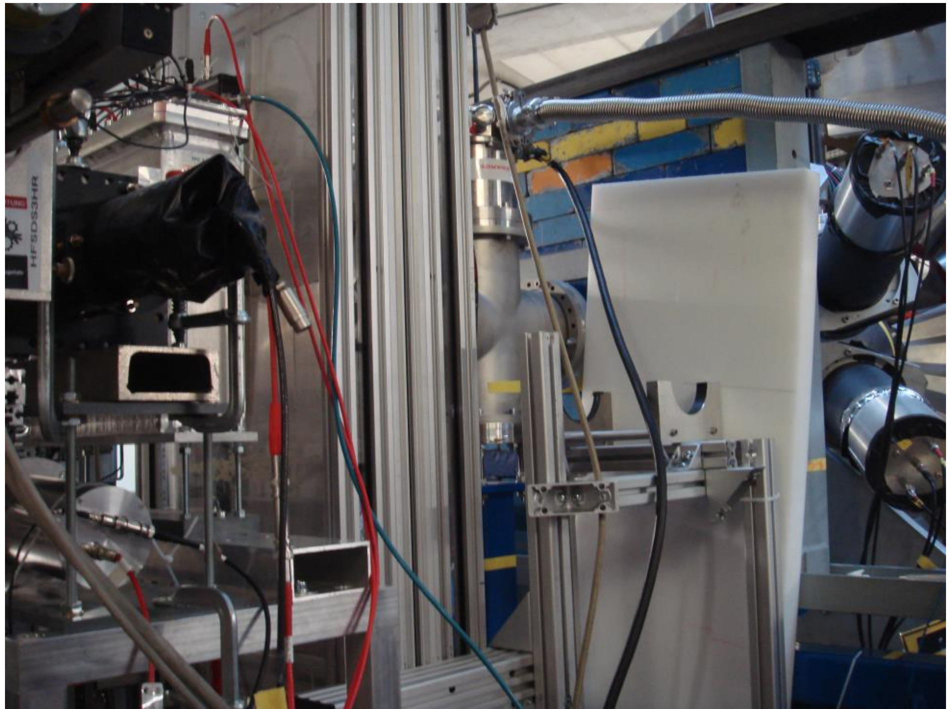


Feasibility studies

-2014: 58Ni

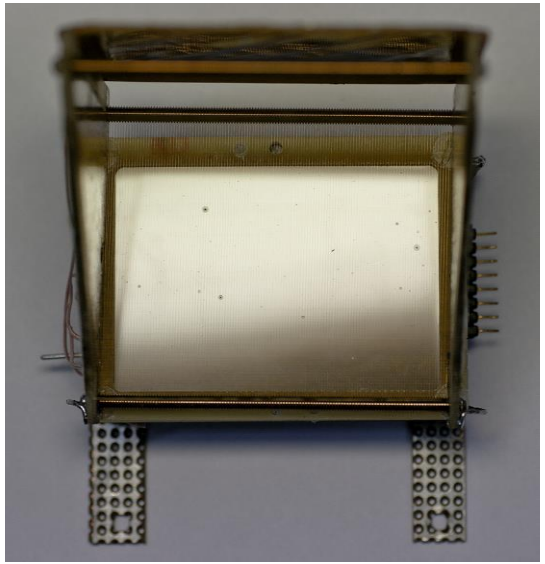
Changes after first test shift:

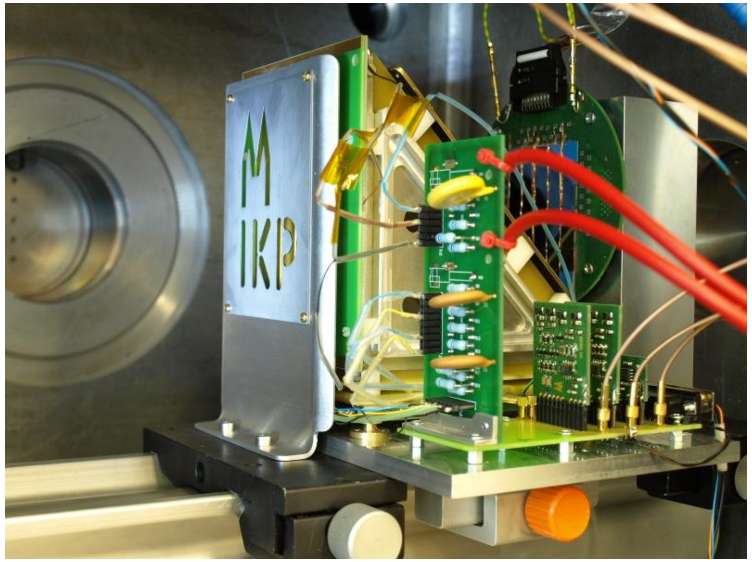
- Earlier degradation for background reduction
  - S4 + Al stack after MUSIC1
- Enhanced shielding
  - Plastic wall

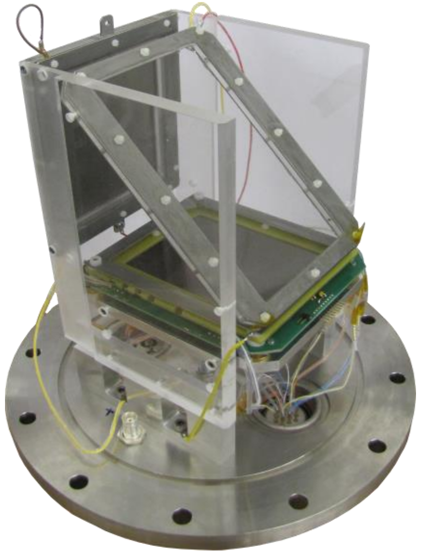


Ancillary detector developments

- Beam Profile Monitors , e.g.thin foil detectors play for this type of experiment an important role
  - Providing good ToF resolution (down to 150 ps) and position information ->Doppler correction
  - Particle tracking and identification
- Ongoing development to bigger active area and better resolutions
  - 2008: 40x50mm^2
  - 2010& 2012: 100x80mm^2
  - 2014: 150mm diameter (in construction)

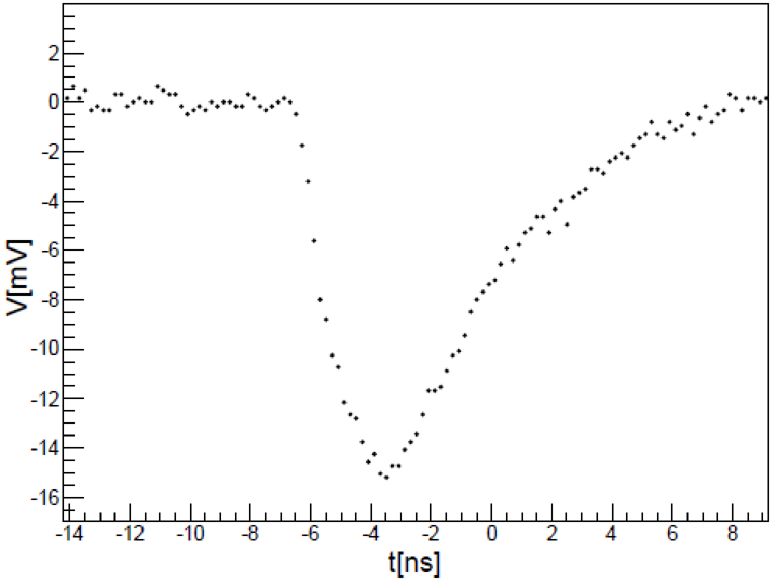


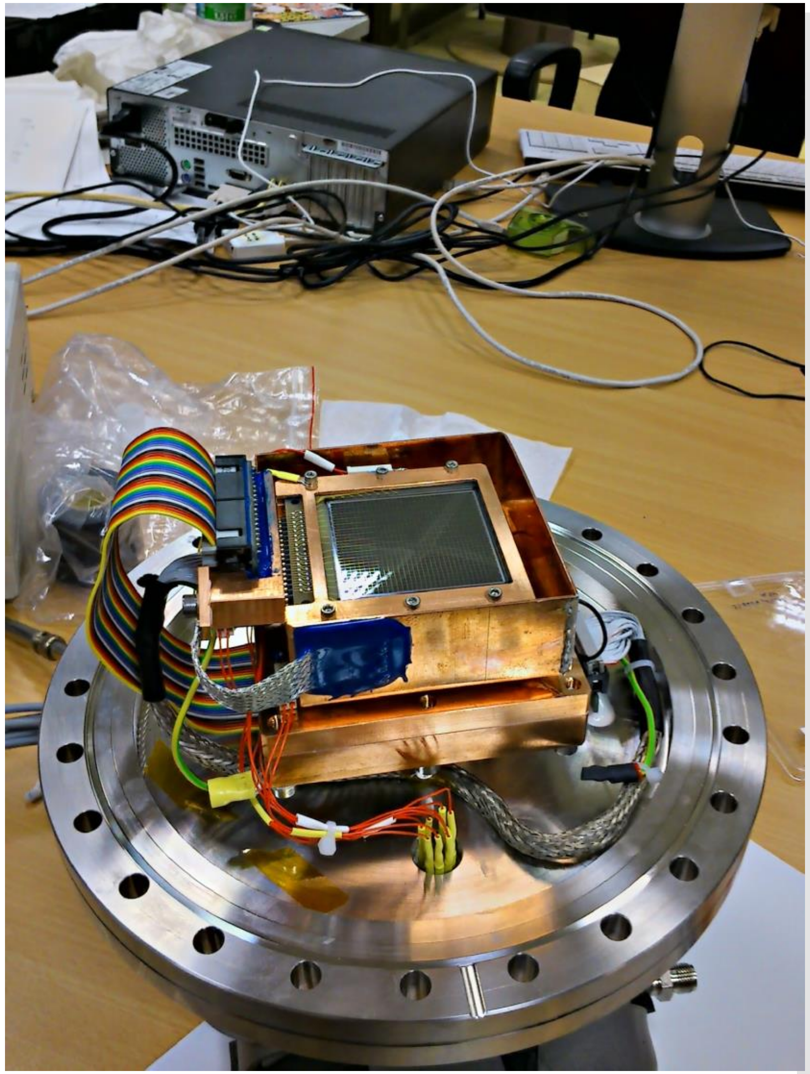




Ancillary detector developments

- Ongoing development in ΔE Detektor: Double Sided Silicon Strip Detectors (DSSSD) for fast timing
- cooled to -17°C
- 50x50 mm²
- 40μm thin
- Timing resolution of ~0.4 ns reached





From *P. Boutachkov, E. Gregor* et al.**Fast Timing with DSSSD Detectors;** GSI SCIENTIFIC REPORT 2012

Conclusion

- The experiment in 2008 showed that:
  - Slowing Down of a fast beam is possible without destroying the beam
  - Beam parameters can be predicted and selected
- Until now we learned from the experiment in 2014:
  - High background component can be reduced by slowing down earlier
  - Additional shielding is necessary because of the fragmentations in the degrader
  - consistency checks for BPMs needed
  - Thin or active target for particle discrimination by E or ΔE essential for studies
  - Gamma detectors can stand the (particle) background from the slowing down

The Collaboration: HISPEC/SDB

GSI group/TU Darmstadt:
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LNL group:
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ikp

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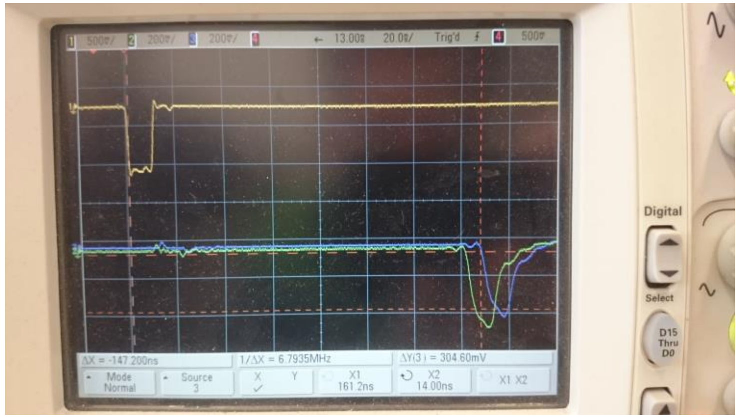
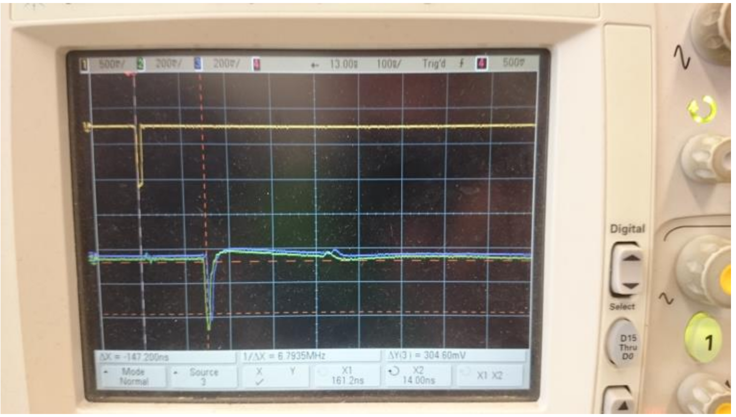
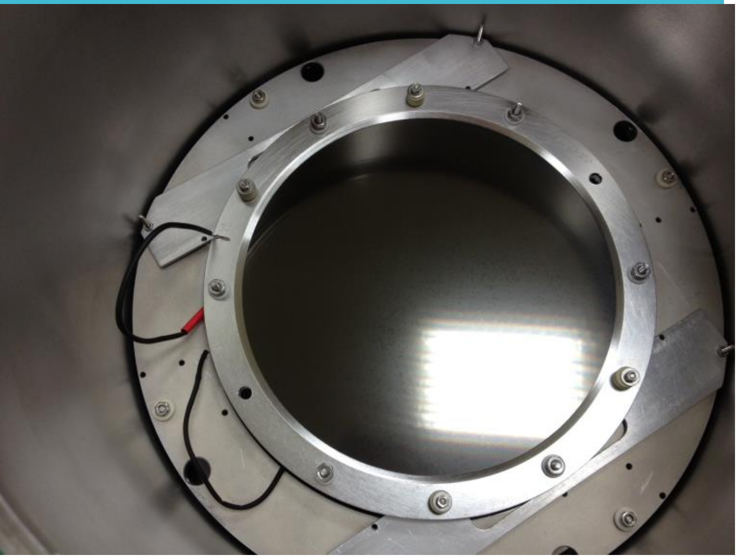
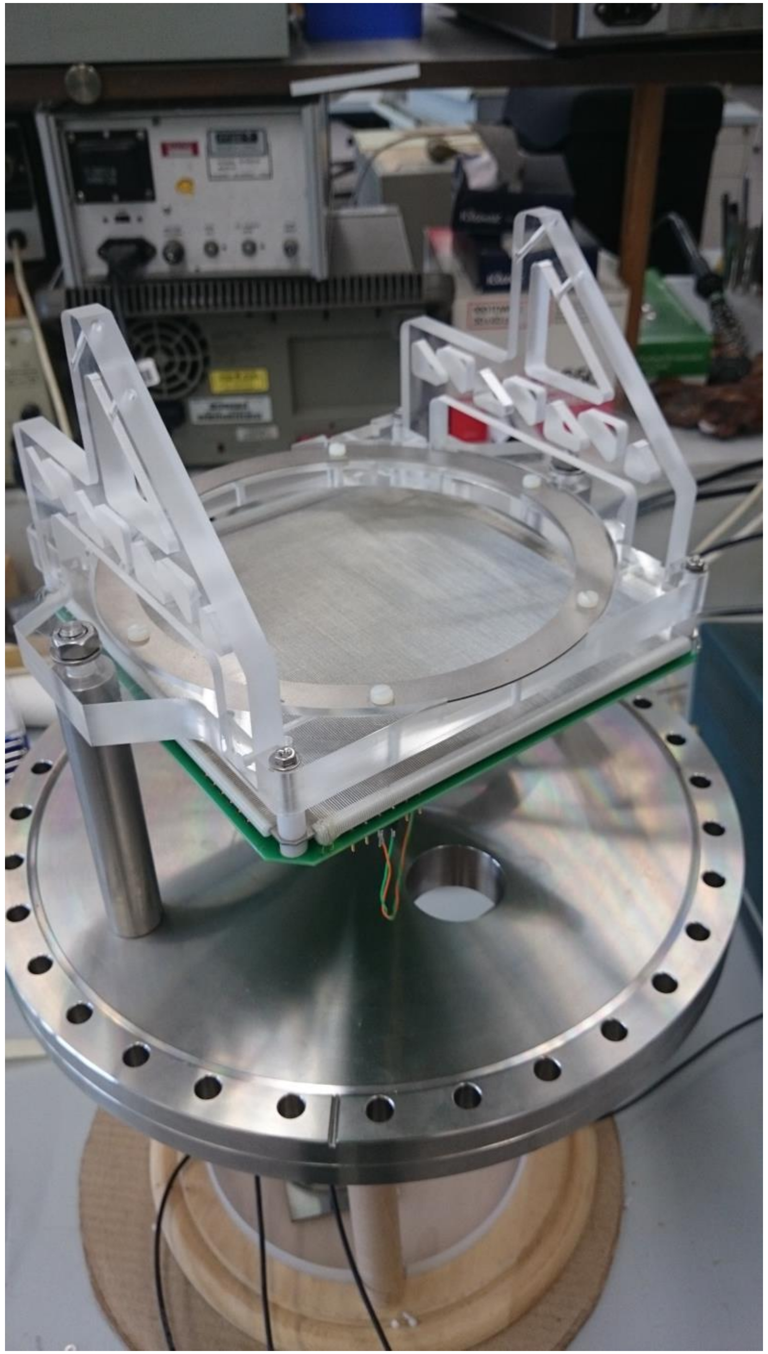
150BPM









Doppler Shift?

- Half life of 1454 state in 58Ni 0.5ps
- Coulomb Barrier at 289.6MeV
- Is a Doppler correction possible? No position on target, no β for particle in target during deceleration