S410 EXPERIMENT GSI – SEPTEMBER 2011

Measurement of β⁻delayed neutrons around the third r-process peak

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FRS User meeting 2011 - GSI, 28th November 2011

Contents

- Introduction and astrophysics motivation
- Setup: FRS – SIMBA – BELEN
- Current analysis status and its outlook
- Summary and future goals

Experiment

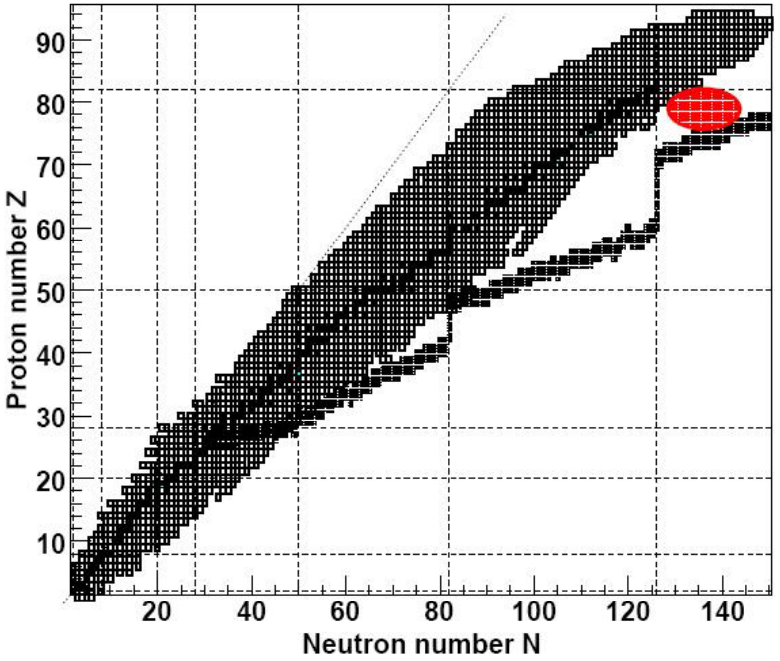
S410: **Beta-decay measurements of new isotopes near the third r-process peak (N~126)**

- Performed at GSI in September 2011 with a week of beam time
- Shared setup with S323 experiment

The measurements settings were centered on two isotopes: ^{215}Tl, ^{211}Hg.
We have preliminarily identified the following nuclei:

$^{211\text{-}217}$Tl $^{207\text{-}214}$Hg $^{205\text{-}210}$Au

^{203,206}Pt ^{199,202}Ir



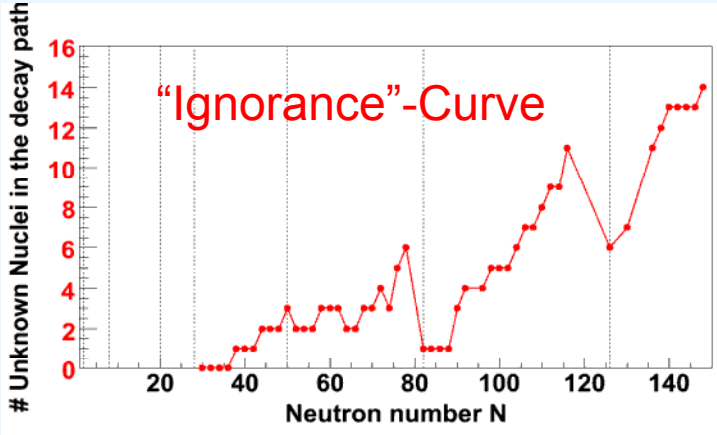
Motivation

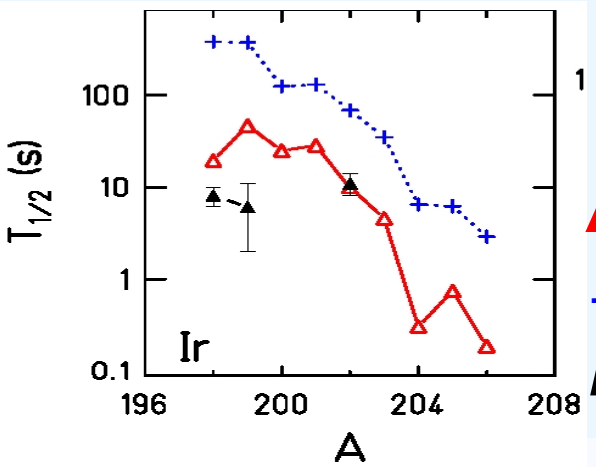
Nuclear structure knowledge: → beta decay studies of these nuclei

Half lives ($T_{1/2}$)
Beta delayed neutron emission probabilities (P_n)

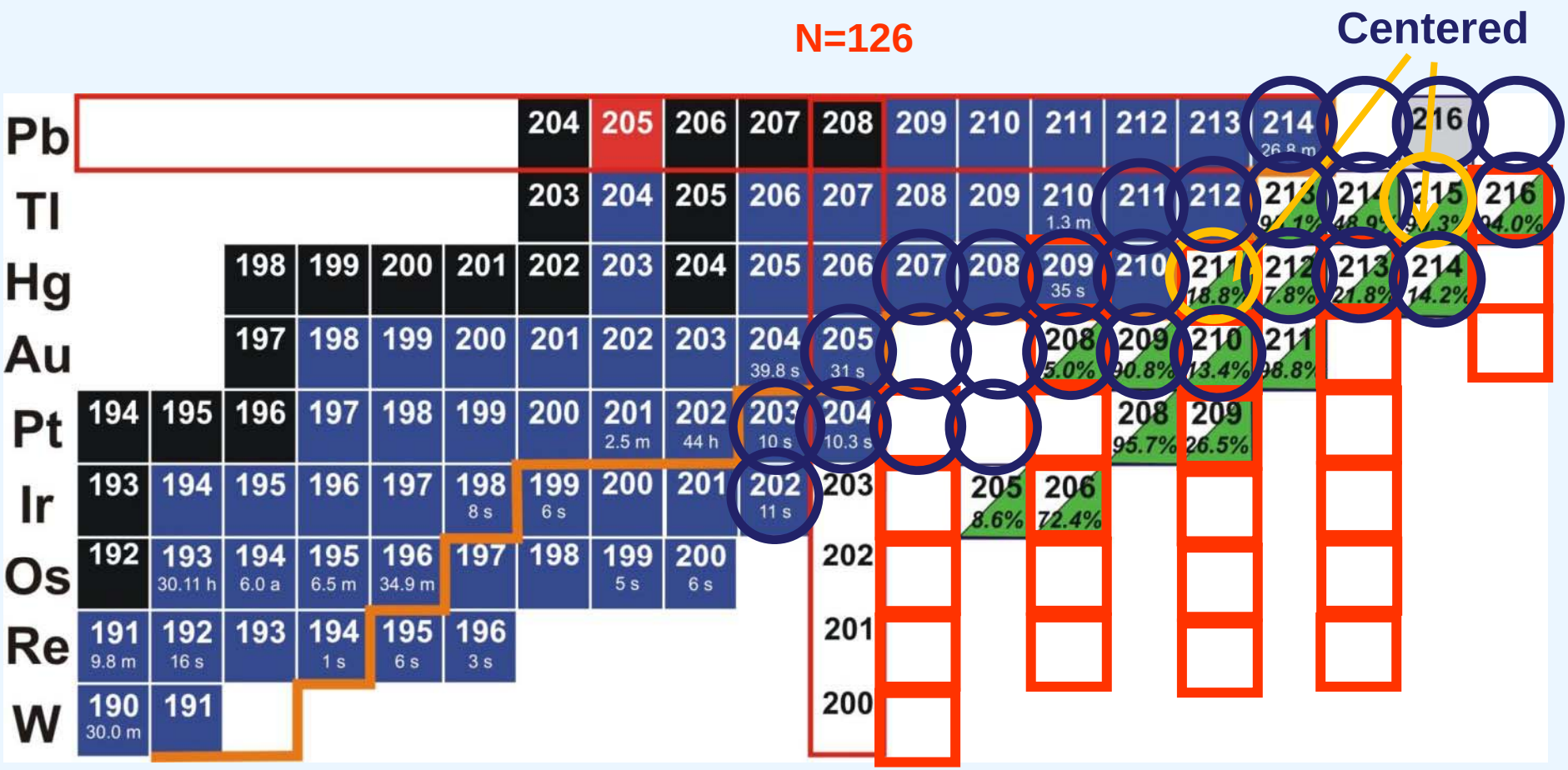
provide information about their decay mechanism and nuclear structure in this mass region

Astrophysics (r-process): nucleosynthesis aspects of the heavy mass elements. The new values for $T_{1/2}$ and Pn, will provide valuable information for the test of theoretical models.

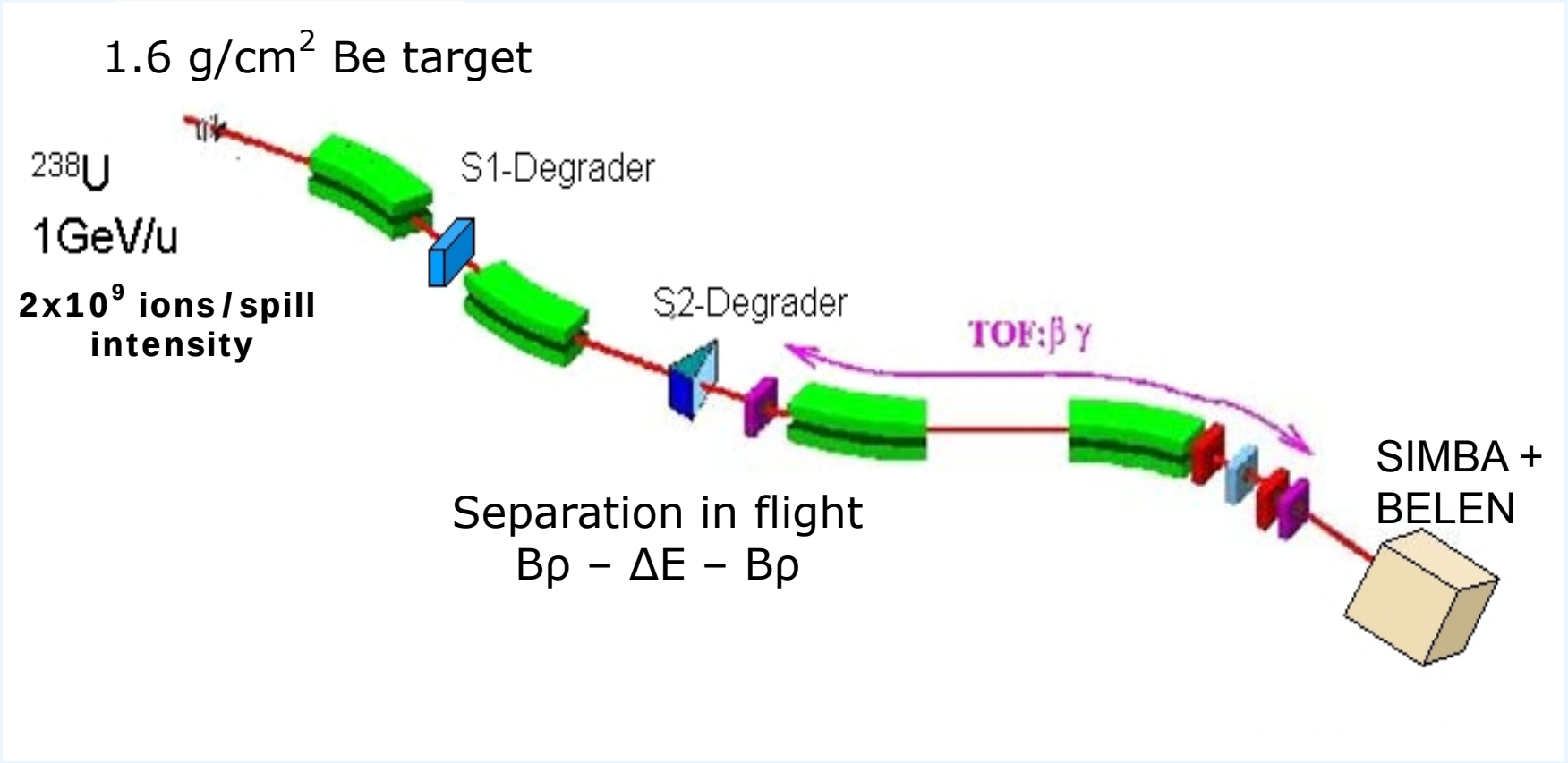




State of the art



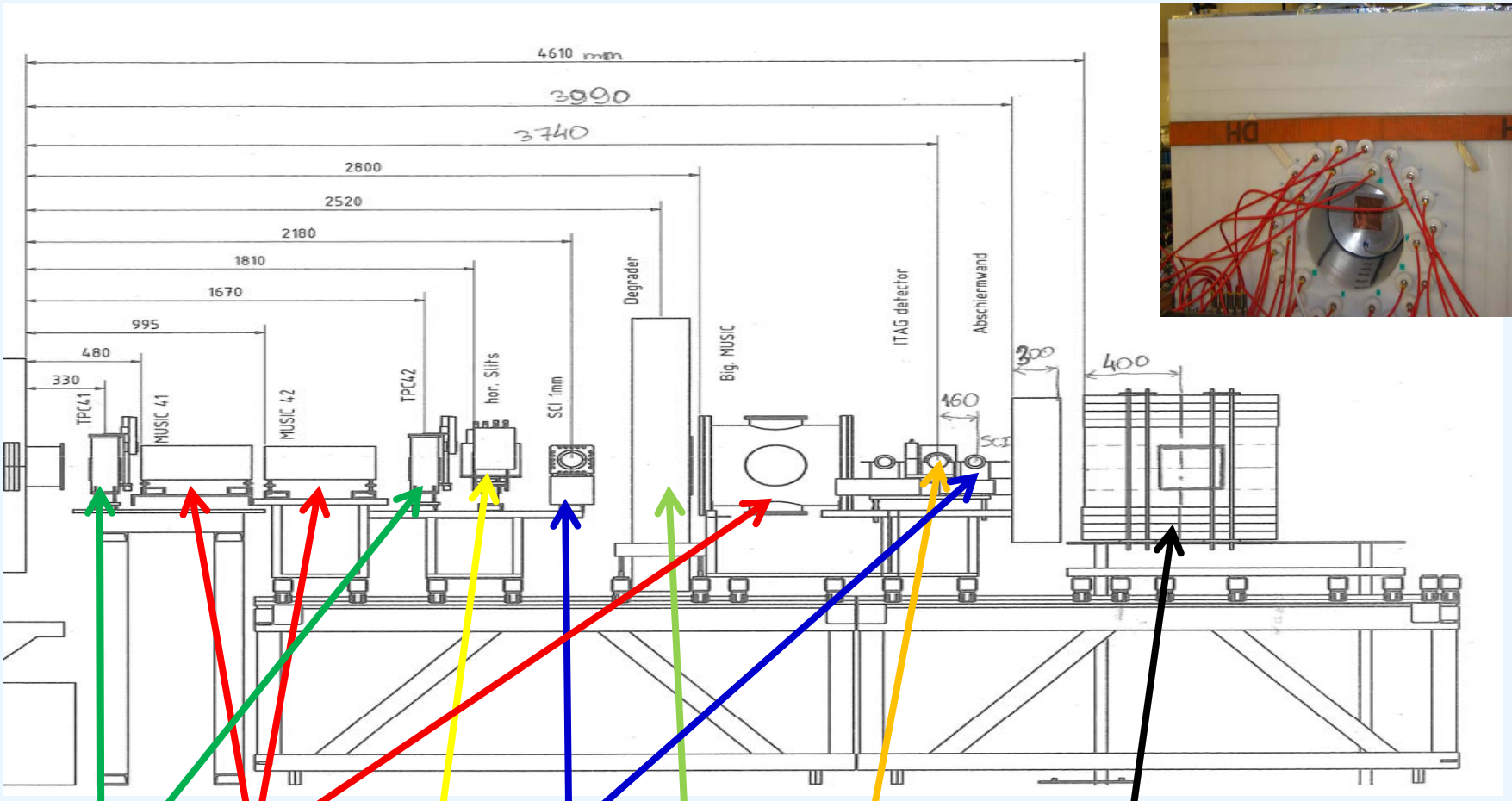
Fragment separator spectrometer (FRS). Beam characteristics.



Bρ settings for: ^{215}Tl, ^{211}Hg and as references ^{216}Po, ^{205}Bi, ^{135}Sb

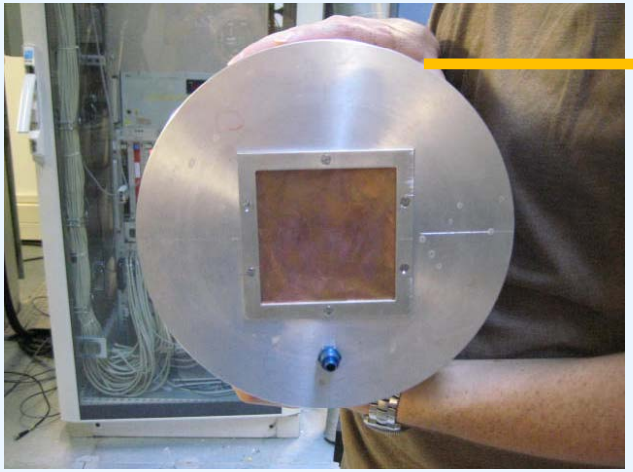
Spill length ~1s with a period around 4s

Experimental hall (S4) configuration and settings



Implantation detector: SIMBA (Silicon Implantation Detector and Beta Absorber)

SIMBA detector



Front view

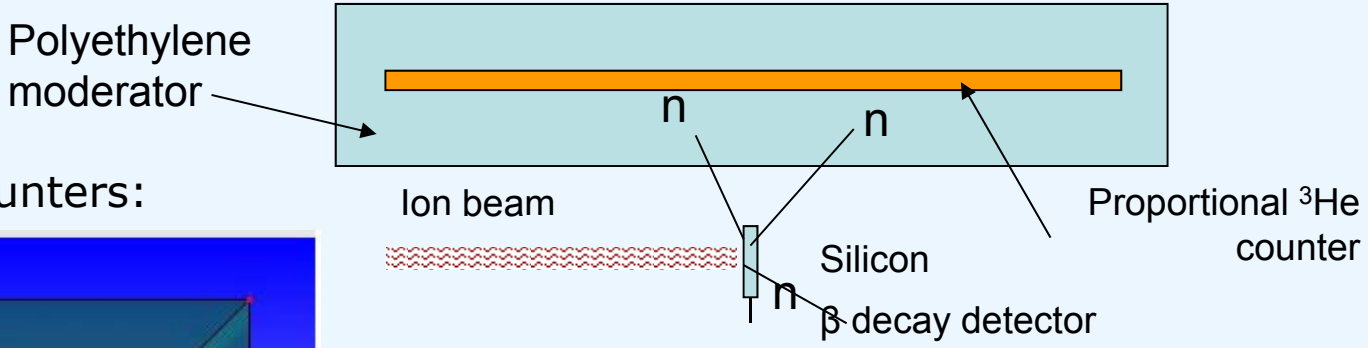
Multilayer silicon detector

Allows to measure both ion implants and β-decays.

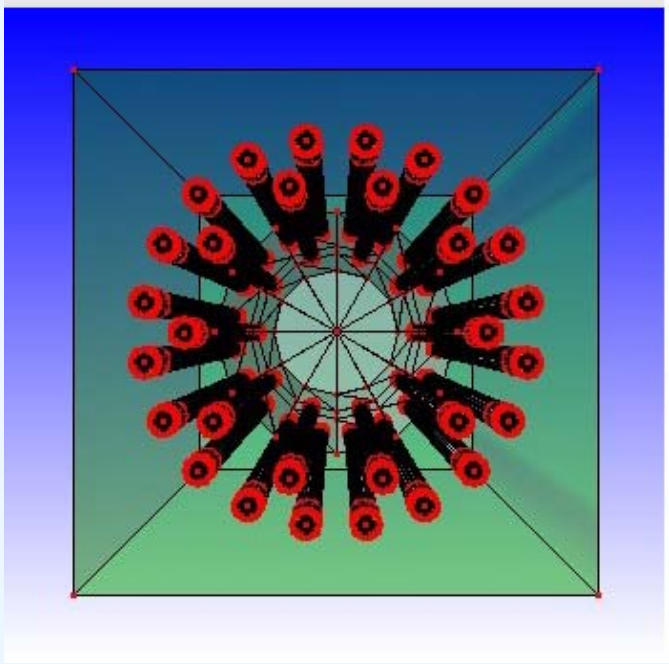
Decay events can be correlated in time with the detection of neutrons.

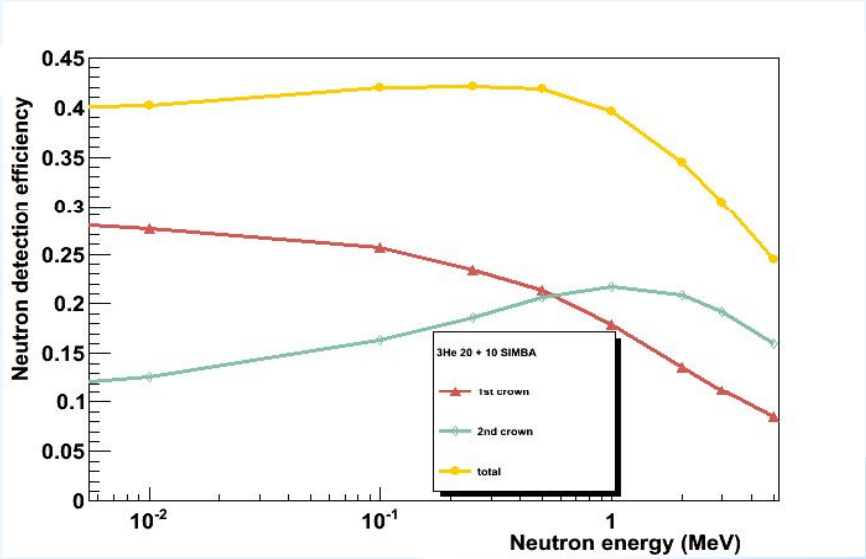
Neutron detector: BELEN (Beta Delayed Neutron Detector)

- Neutron detector designed by UPC GRETER research group (Barcelona)
- The detection of the neutron is based on the detection of products of the reaction of the neutron with 3He counters: **$^{3}He + n \rightarrow {}^{3}H + {}^{1}H + 765$ keV**



- 30 ^{3}He counters:

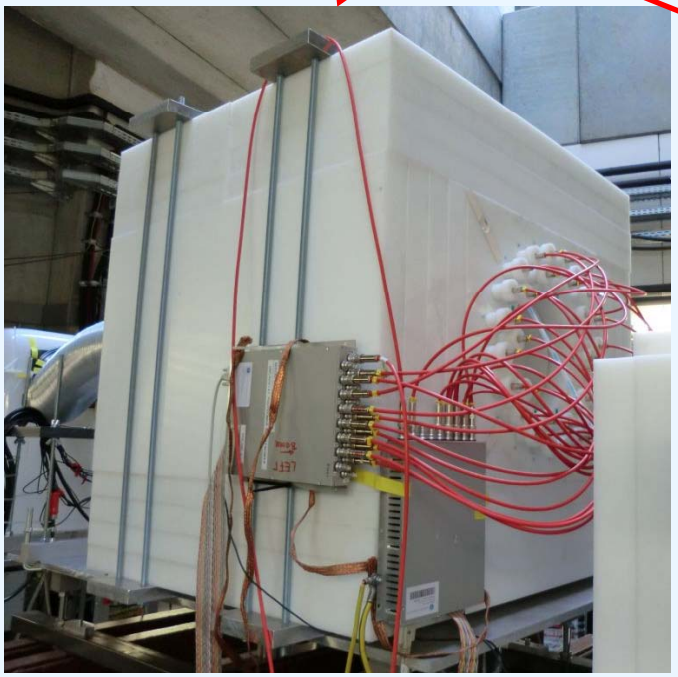




Neutron detector: BELEN (Beta Delayed Neutron Detector)

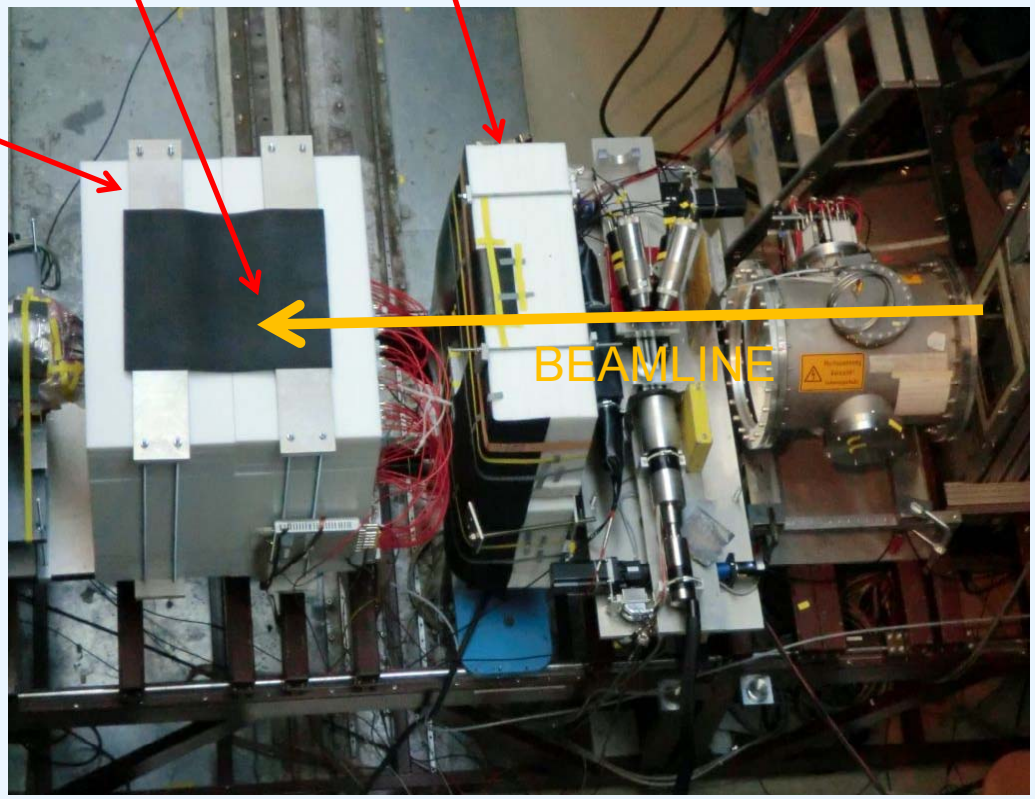
BELEN-30 neutron detector

- 10 with 10 atm pressure
- 20 with 20 atm pressure



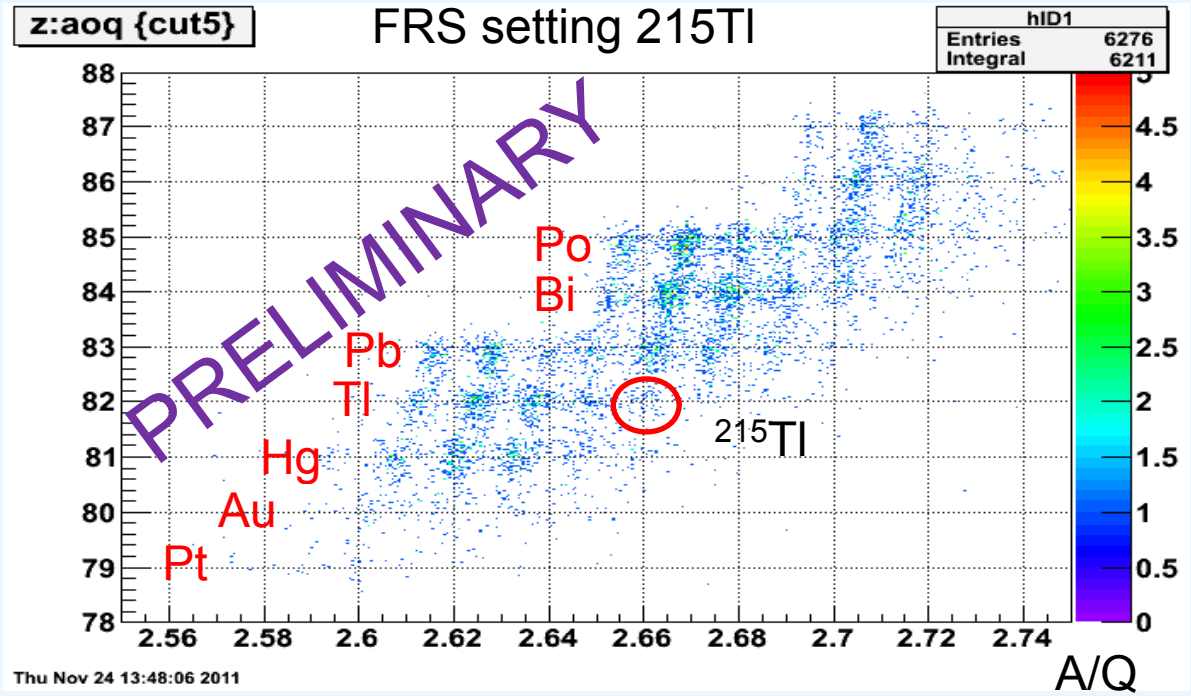
Neutron shielding

SIMBA inside the matrix



Analysis procedure (Preliminary plots / ongoing)

- Tracking detectors calibrations & particle ID
  - SCI21-SCI41 → ToF
  - TPC21-22 – TPC41-42 → Position calibration
  - MUSIC 41-42-43 → Energy Loss calibration
- Particle ID check via ^{205}Bi isomers, ^{216}Po α-decays
- SIMBA calibration implantation patterns
- Analysis of half lives and Pn
- Digital data acquisition system features



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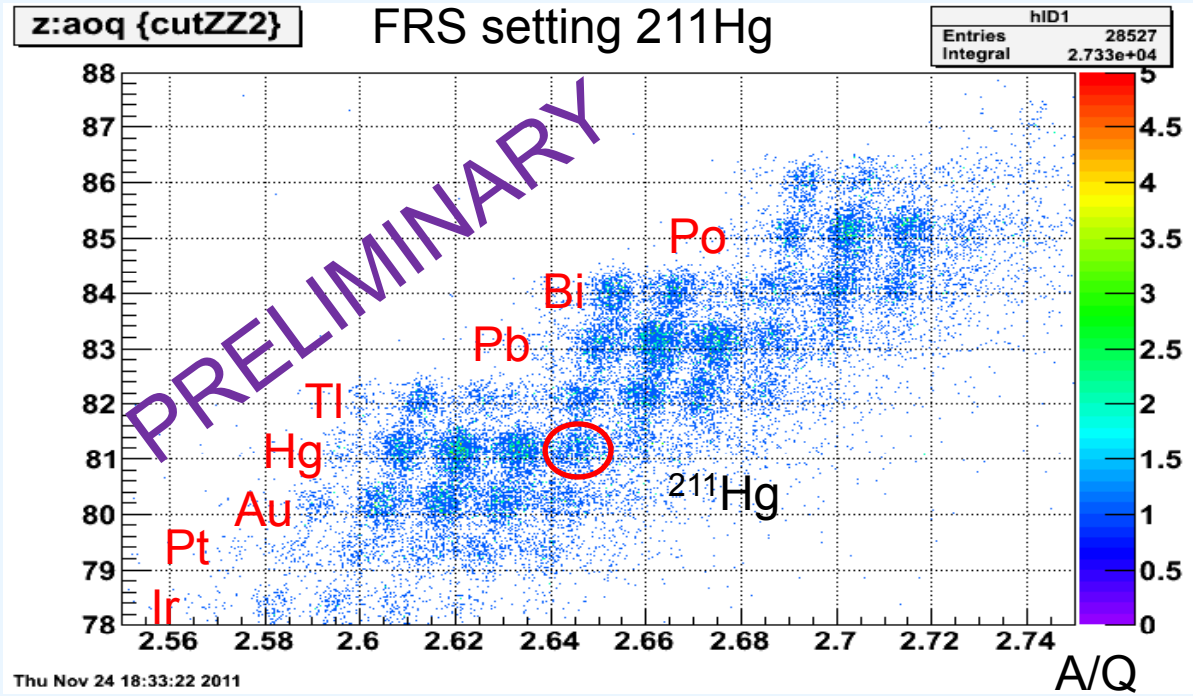

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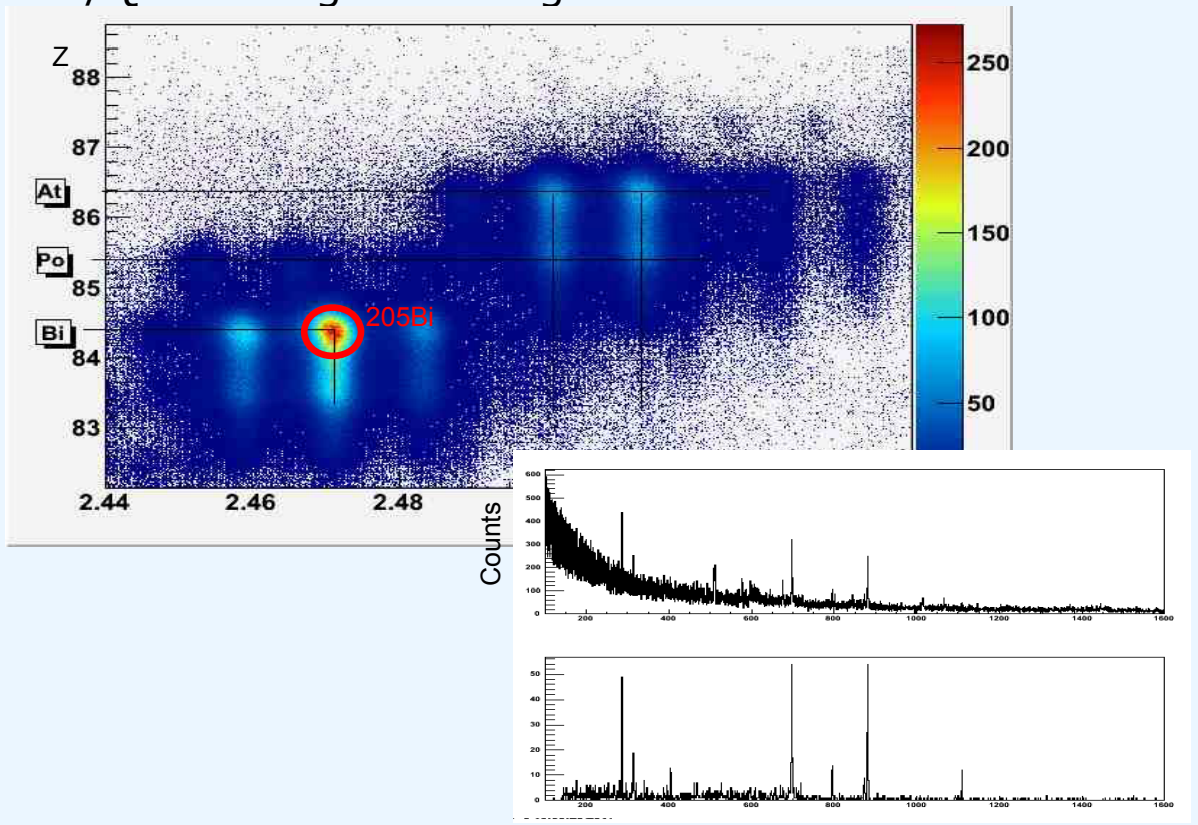
^{205}Bi setting has been used as Z identification reference via isomer gamma rays and ^{216}Po setting as A/Q checking in the region of interest.



Analysis procedure (Preliminary plots / ongoing)

Tracking detectors calibrations & particle ID

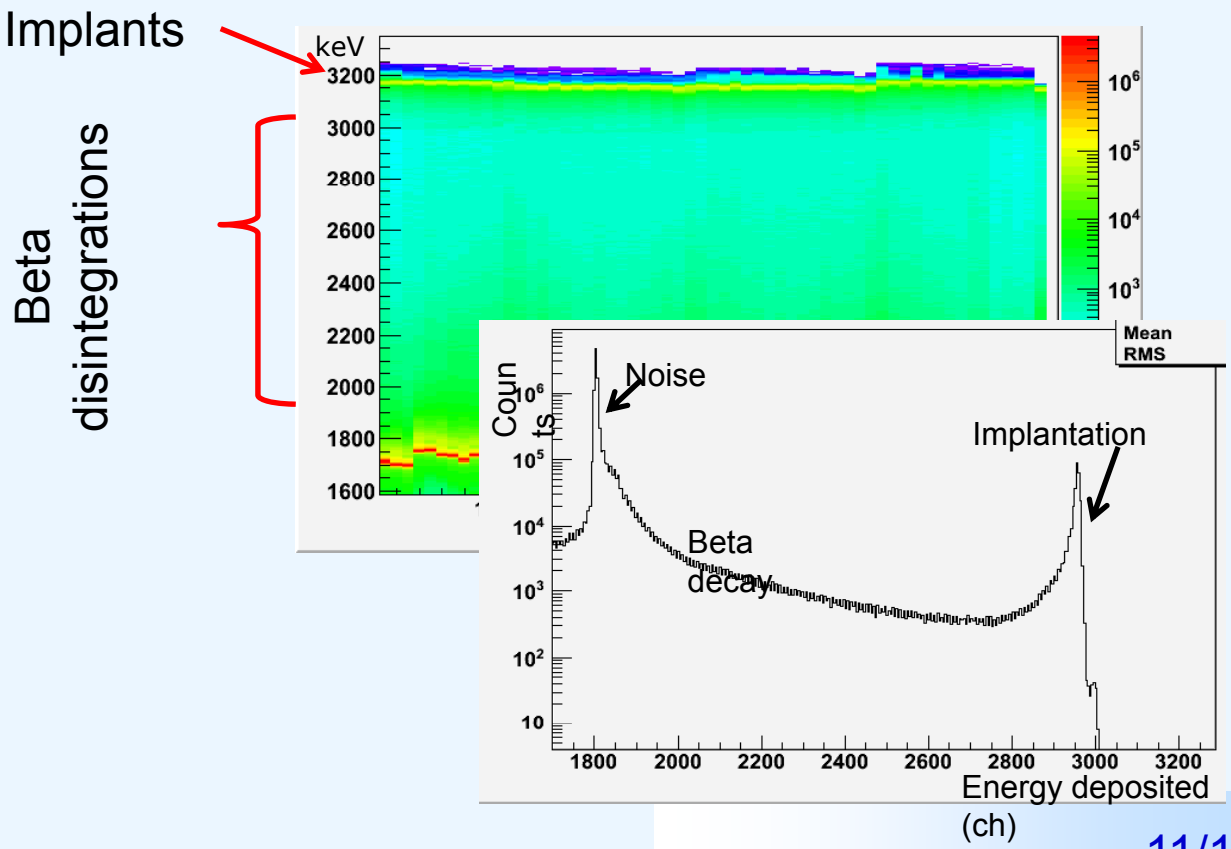
Particle ID check via ^{205}Bi isomers, ^{216}Po α-decays

SIMBA calibration implantation patterns

Analysis of half lives and Pn

Digital data acquisition system features

- SIMBA calibrations are being performed with a ^{137}Cs source
- β^- decay curves will provide half lives values



Analysis procedure (Preliminary plots / ongoing)

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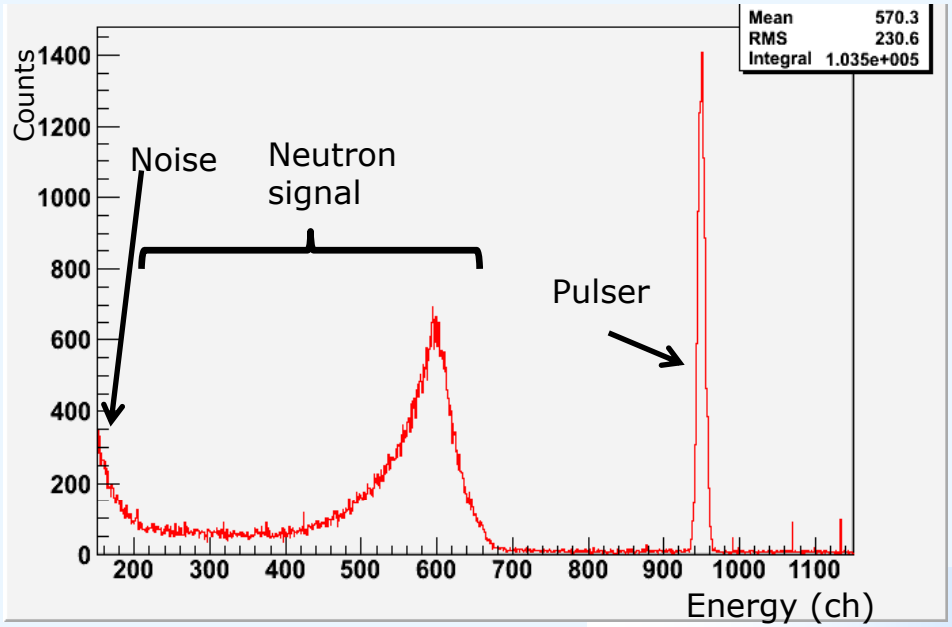
-Time correlation between neutron and beta decay

$$P_n = \frac{1}{\varepsilon_n} \frac{N_{n\beta}}{N_\beta}$$

-^{252}Cf for BELEN efficiency and can be checked with ^{135}Sb



Analysis procedure (Preliminary plots / ongoing)

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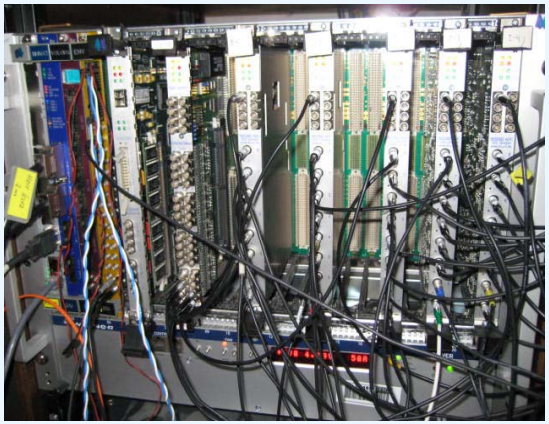
Analysis of half lives and Pn

Digital data acquisition system features

DDAS



-Triggerless digital data acquisition system used for the first time in this type of experiments at GSI.

-It allows to eliminate the dead time of conventional acquisition systems thanks to the double memory digital cards which allow to acquire data and reading of previously taken data at the same time.

-Advantages:

1. Increase the efficiency by about 8% (from 27 to 35%)
2. Flexibility for large time correlation (fundamental to obtain correlations with all neutron and to change the gates offline)
3. Allows to correct some experimental effects, e.g. To reduce neutron background from uncorrelated neutrons.

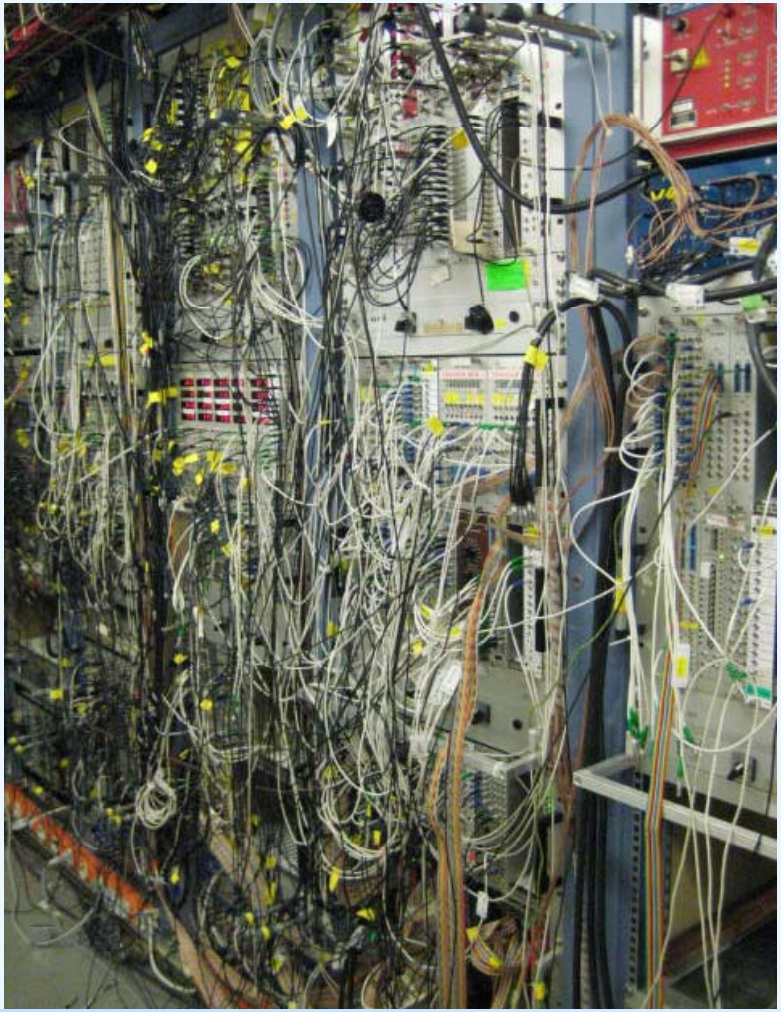
Outlook

- Improved ID-Plot via final calibrations of frs detectors
- Determine implantation rates for each identified isotope
- Determine implant-beta correlations and neutron-beta correlations
- Implement an analysis method for deriving half-lifes and for determining beta-delayed neutron emission probabilities.
- In collaboration with theoreticians, study the impact of these results on nuclear models, as well as on r-process nucleosynthesis calculations.

Future goals

- Upgrade of detector: up to 90 counters (detection efficiency ~70%): collaboration with Dubna
- Combine with AIDA implantation detector (first separate tests in August 2011): talk Robert Page (Tue, 10:10)
- Optimize detection system (BELEN) and its acquisition (DDAS) for future experiments with more exotic beams (FAIR).
- Prepare for first experiments closer to the r-process path @FAIR/DESPEC (>2018)
- Measure P_{xn}

The end!



Thanks to collaborators:

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NSCL, Michigan State University (MSU-USA)

CIEMAT (Madrid)

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CFNUL Universidade de Lisboa (Portugal)

School of Physics & Astronomy, U. Edinburgh (UK)

Department of Physics, University of Liverpool (UK)

STFC, Daresbury Laboratory (UK)

Laboratori Nazionali di Legnaro, INFN (Italy)

Flerov Laboratory, JINR, Dubna (Russia)

CENBG, Université Bordeaux (France)