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β delayed Neutron emission measurements around the third *r-process* peak

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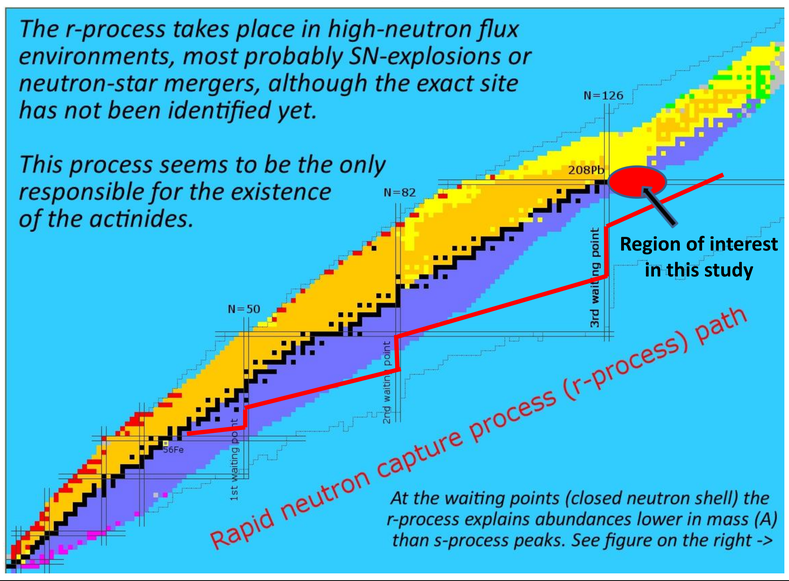
INTRODUCTION: About half of the elements heavier than iron are produced in the Universe by means of *s-process* (slow) and *r-process* (rapid) neutron capture reactions and subsequent β-decays



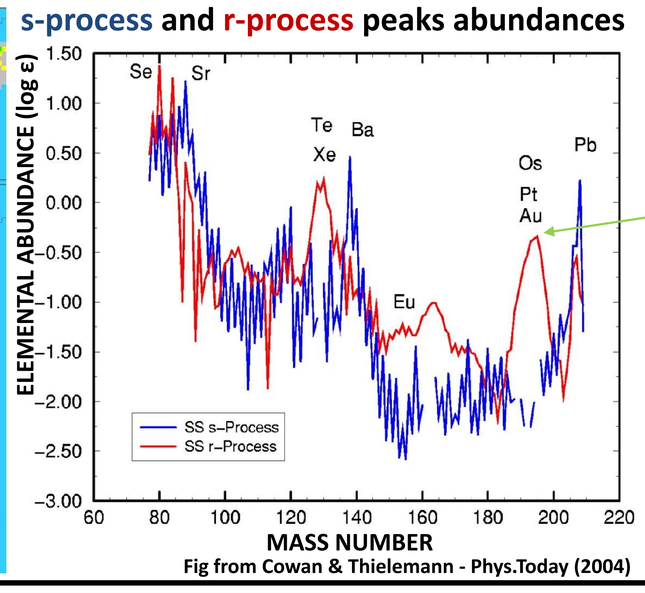


Fig from Cowan & Thielemann - Phys.Today (2004)

Exotic nuclei along the neutron-shell closure N=126 act as a bottleneck, thus originating **the third *r-process* abundance peak**. At present, this is one of the regions most difficult to reproduce with *r-process* model calculations. To a large extent, this can be attributed to scarce experimental information available for β-decay half-lives, masses and β-delayed neutrons, and the uncertain performance of nuclear models far-off stability.

Nuclei identified in this study, some of them for first time:
$^{200\text{-}205}$Pt, $^{203\text{-}209}$Au, $^{206\text{-}214}$Hg, $^{209\text{-}218}$Tl, $^{212\text{-}223}$Pb, $^{218\text{-}227}$Bi, $^{222\text{-}231}$Po, $^{228\text{-}234}$At, $^{231\text{-}237}$Rn

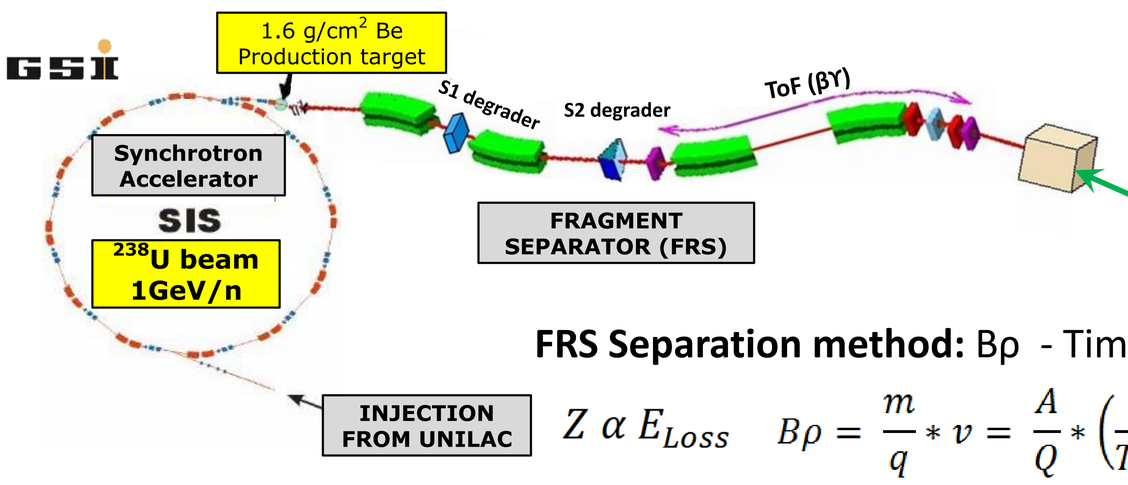
EXPERIMENT: Measurement of β-delayed neutrons around the third r-process peak (GSI-2011)

Goal: to measure for first time **half life** and **β-delayed neutron emission probability (P_n)** for many exotic nuclei around the third *r-process* peak

Delayed neutron emission shifts the abundances towards lower masses and enhances the neutron density in the *r-process* environment. New experimental data will give an important constraint for theoretical models and a valuable input for *r-process* model calculations.

Beam characteristics and separation method

RIB facility of GSI - Darmstadt (Germany)

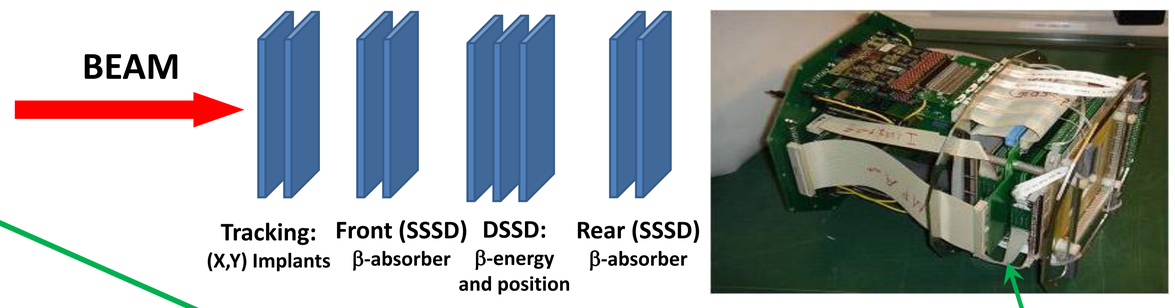


FRS Separation method: Bρ - Time of Flight – Bρ

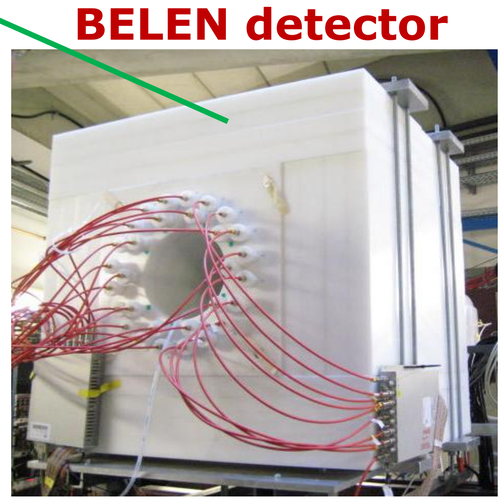
$$Z\ \alpha\ E_{Loss} \qquad B\rho = \frac{m}{q} * v = \frac{A}{Q} * \left(\frac{L}{Tof}\right) \rightarrow \frac{A}{Q} = B\rho * \left(\frac{L}{Tof}\right)$$

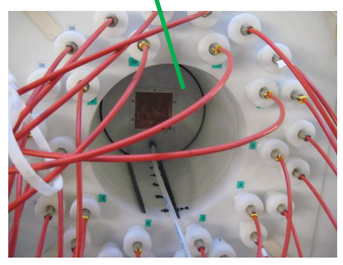
Implantation and β detector (SIMBA)

Based on DSSD silicon layers



BELEN detector





Designed and constructed at UPC (Barcelona-Spain)

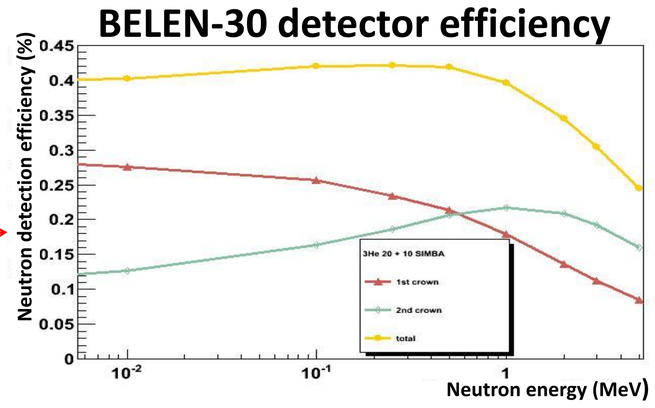
Beta deLayEd Neutron detector (BELEN)

- ✓Based on ^{3}He counters to detect neutrons
  ^{3}He + n → ^{3}H + ^{1}H + 765 keV
- ✓Matrix: Polyethylene as moderator
- ✓Weight: approx 700 kg
- ✓Dimensions: 80cmx80cmx60cm

Challenge: Wide range of neutron energies (**thermal - 5 MeV**):
Approach: detector design providing an efficiency as high and as flat as possible

Name	^{3}He counters	Pressure	Experiment	Average Efficiency
BELEN-20	20	20 atm	JYL-2009	27%
BELEN-20	20	20 atm	JYL-2010	35%
BELEN-30	20+10	20 & 10 atm	GSI-2011	40 %
BELEN-52	42+10	8 & 10 atm	JYL-2013	In progress
BELEN-96	42+10+44	8 & 10 atm	DESPEC	In progress

BELEN-30 detector efficiency



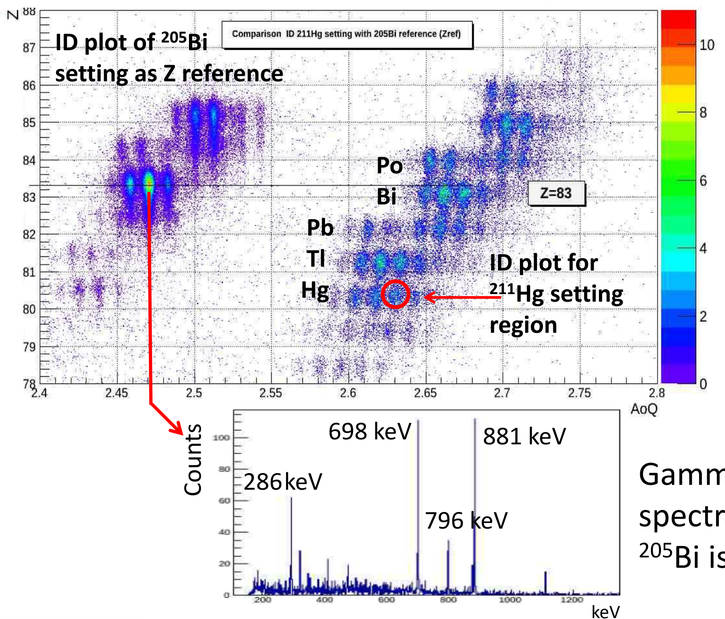
Digital Data Acquisition System (DDAS)

- ✓Negligible dead-time when compared to analog systems.
- ✓Digitizer modules (SIS3302 Struck) provide time-stamps: very versatile for time correlations.

Developed at IFIC (València-Spain)

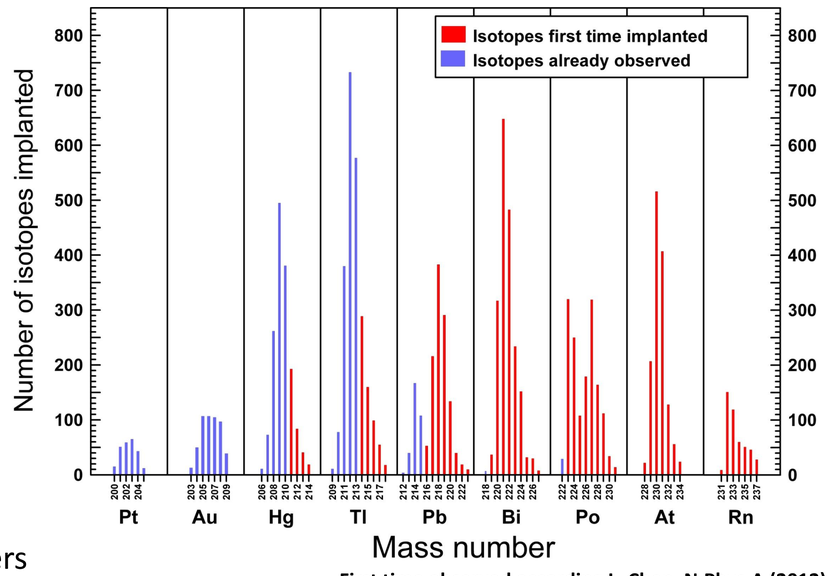
PRELIMINARY RESULTS

IDENTIFICATION: Z and A/Z



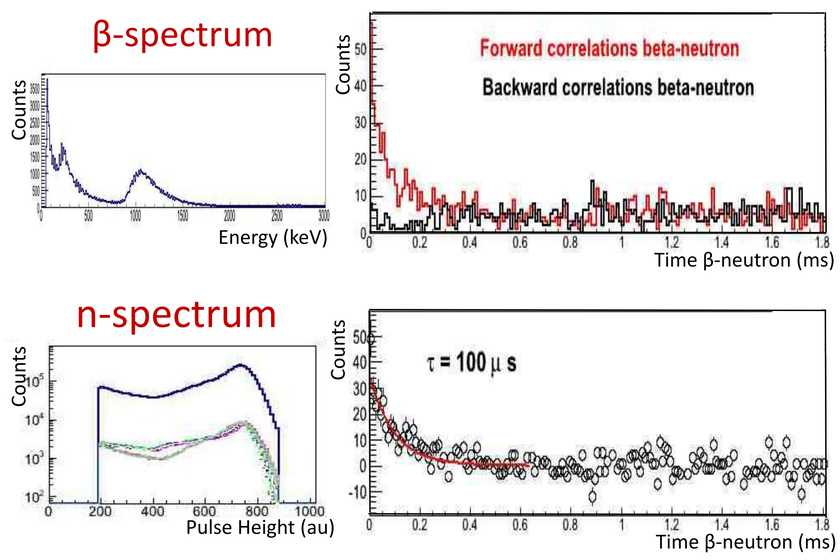
Gamma spectra of ^{205}Bi isomers

Number of implants observed for ^{211}Hg setting and rates Implants/Identifications for each isotope



First time observed according L. Chen, N.Phys.A (2012)

Performance test via decay-neutron time correlations for ^{213}Tl



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