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

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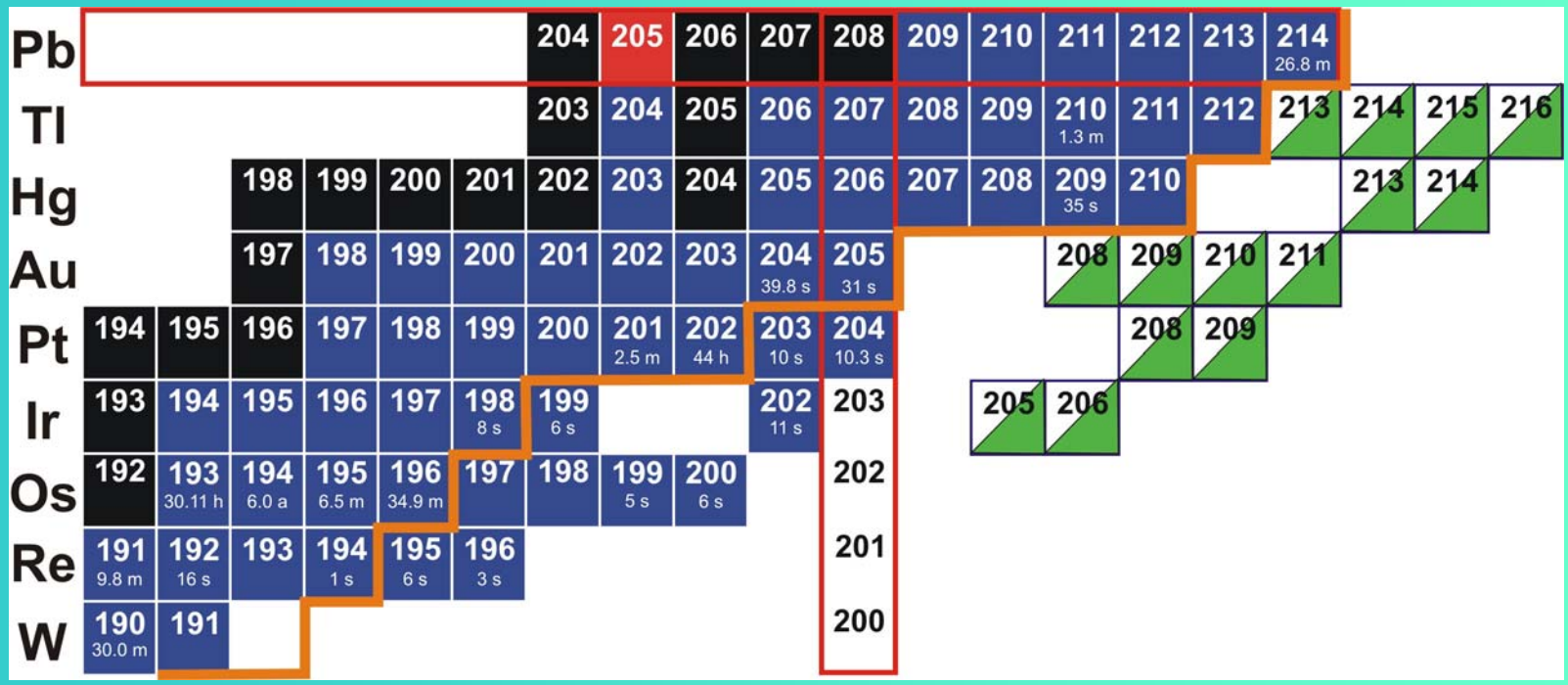
Experiment S410: approved 21 shifts (category A)

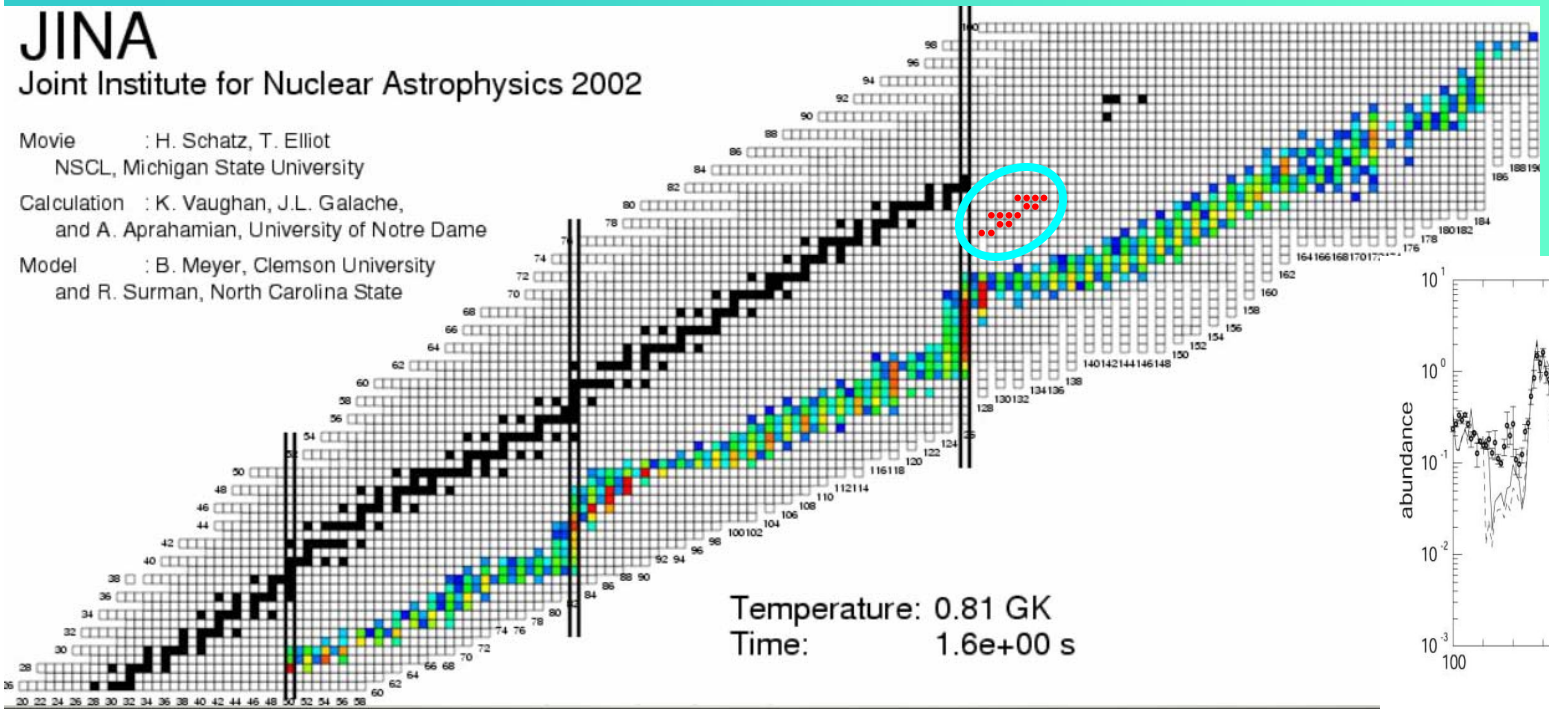
WHAT

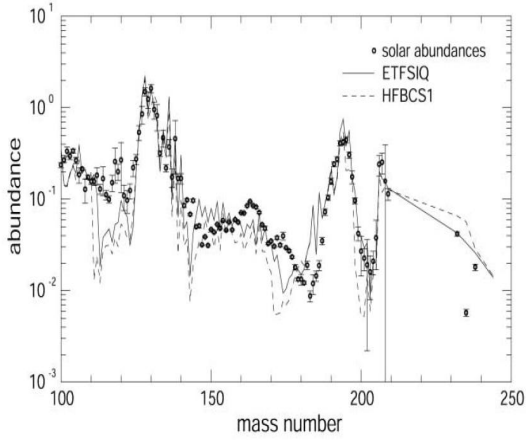
- We want to measure for the first time half-lives ($T_{1/2}$) and neutron emission probabilities (P_n) for very neutron-rich Ir, Pt, Au, Hg and Tl isotopes



WHY

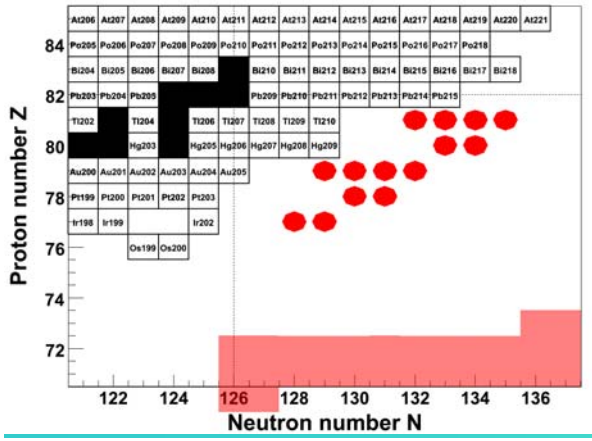
- They will have an impact on r-process calculations beyond the 3rd peak
- They will help to disentangle the r-process contribution to the nucleo-synthesis of nuclei (Pb/Bi) at the termination of the s-process path
- They will help to improve the calculation of actinide production and U/Th cosmo-chronometers

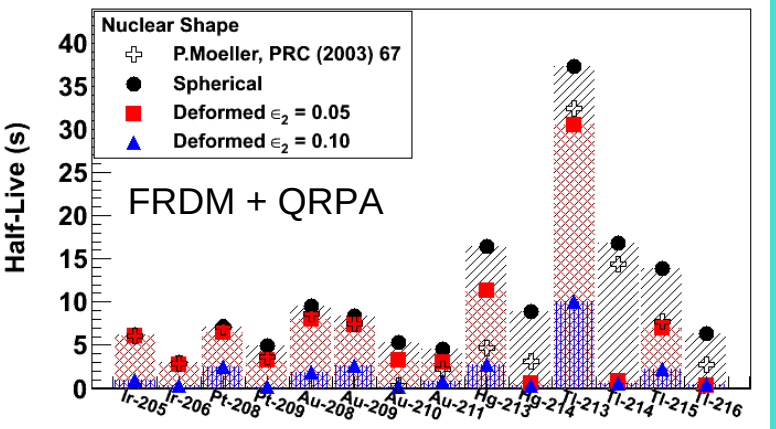


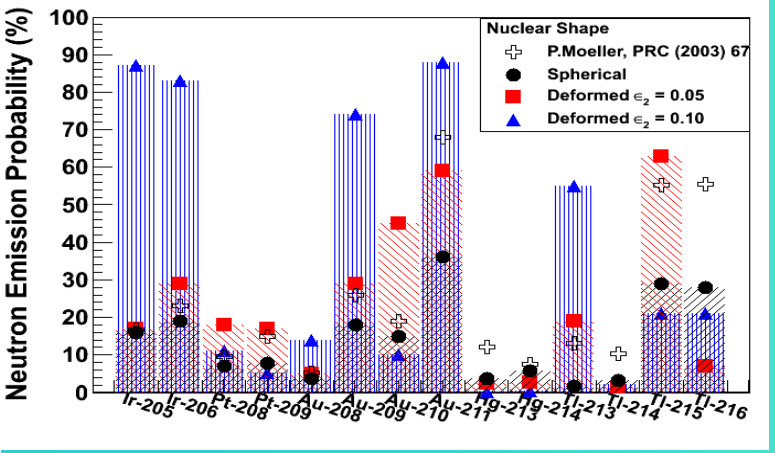


WHY

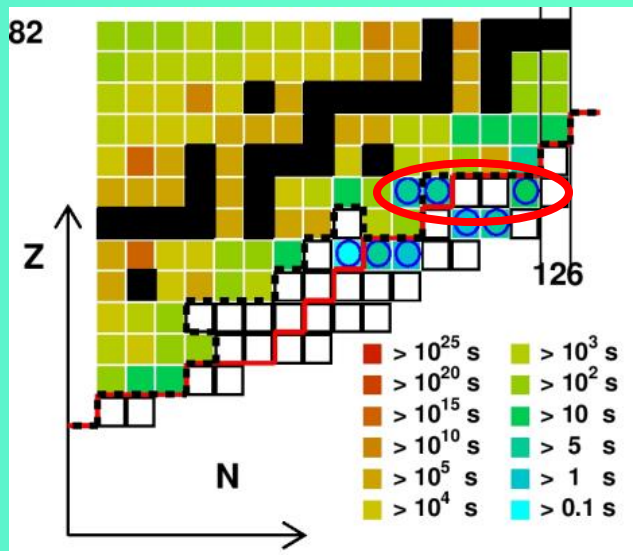
- Large uncertainty in the calculation of $T_{1/2}$ and P_n in this region:



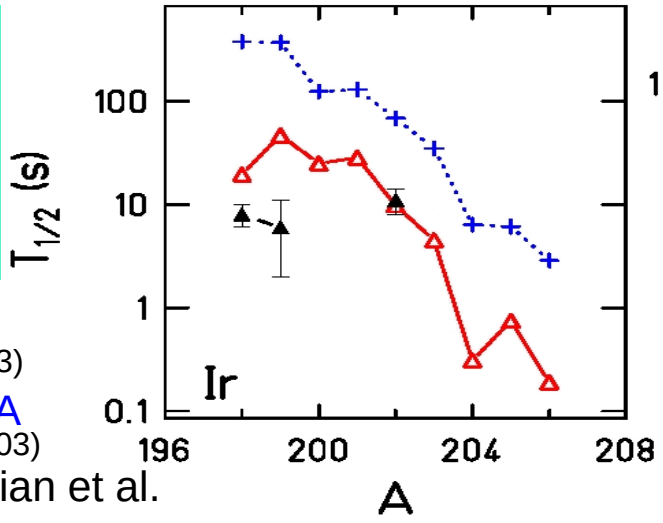




Kratz & Pfeiffer (priv. comm.)



T. Kurtukian et al. (subm. Phys. Lett B)



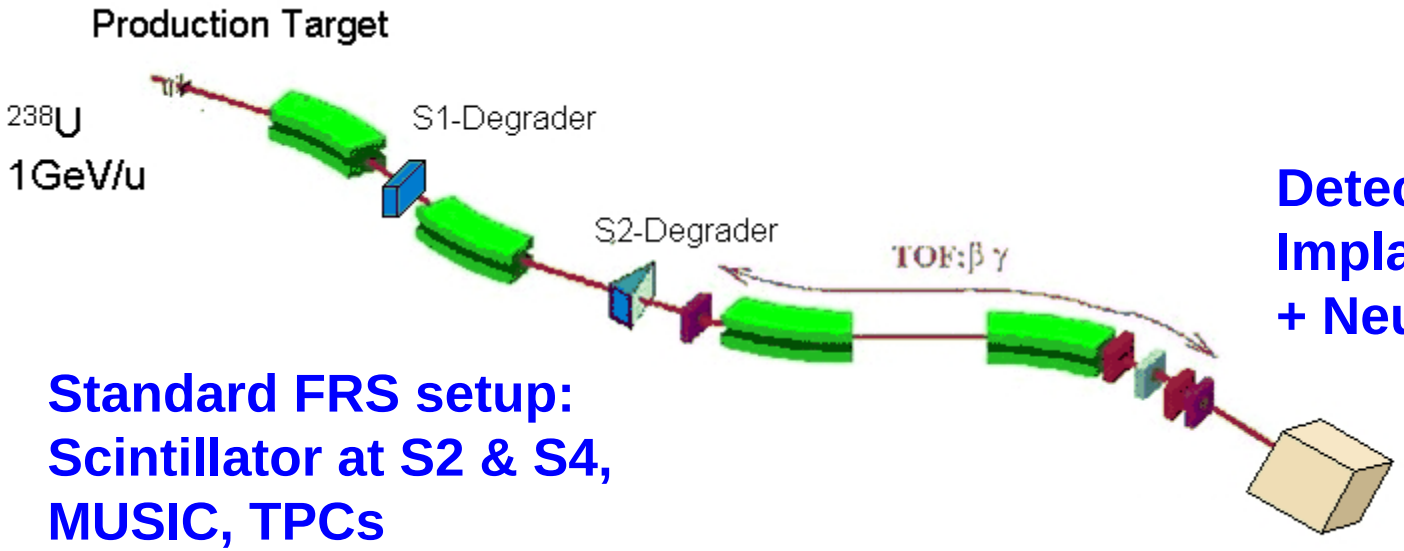
△ DF3 + QRPA
(I.Borzov, et al. 2003)

\+ FRDM + QRPA
(P.Moeller, et al. 2003)

▲ Exp. T. Kurtukian et al.

WHERE

- GSI offers a unique opportunity to access this region
- SIS: high energy (1GeV/u) intense (2×10^9 pps) ^{238}U beam to produce the very neutron rich isotopes and reduce contaminant charge states
- FRS: to provide high transmission and selectivity



Standard FRS setup:
Scintillator at S2 & S4,
MUSIC, TPCs

Detection setup:
Implantation detector
+ Neutron counter

Be target: 1.6 g/cm^2 ; Nb stripper: 223 mg/cm^2 ;
S1 degrader: 2 g/cm^2 ; S2 degrader: 2-4 g/cm^2

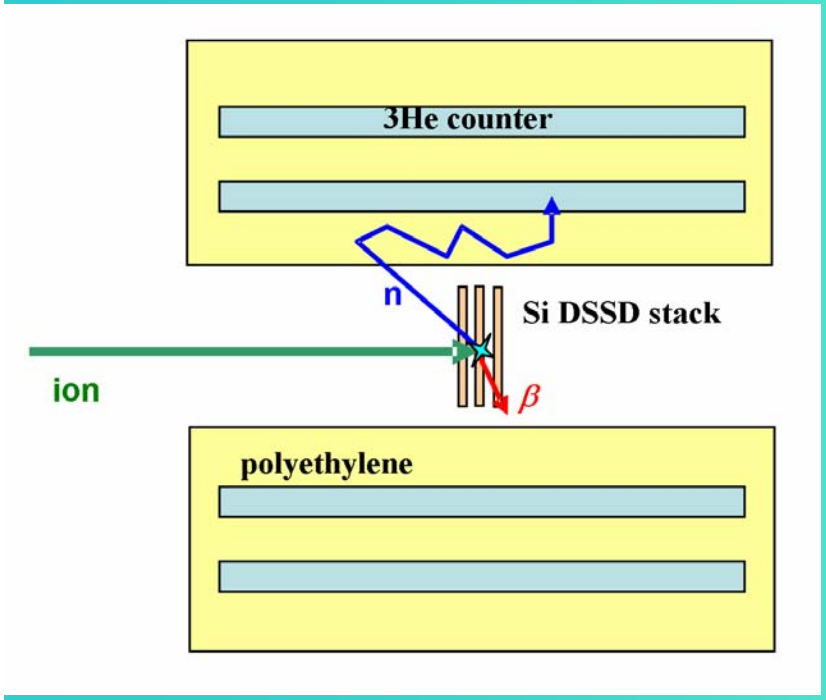
HOW

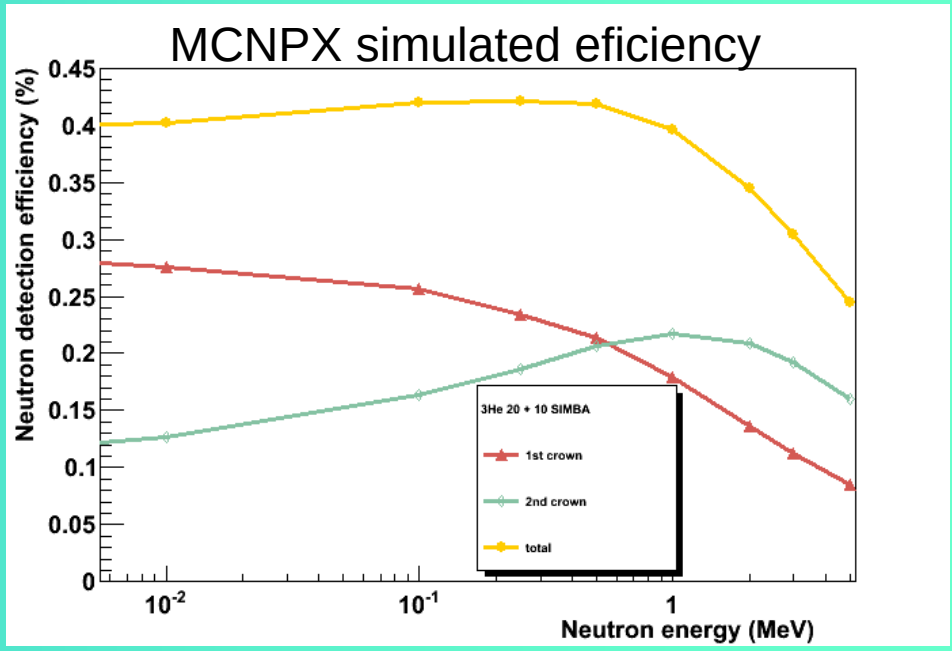
4π Neutron counter

BEta deLayE Neutron detector

(UPC-Barcelona, IFIC-Valencia, CIEMAT-Madrid, U. Giessen)

- 60cm long ∅2.5cm 3He counters
- 20×20atm + 10×10atm
- PE moderator matrix 50cm×50cm×70cm
- PE shielding: additional 20cm

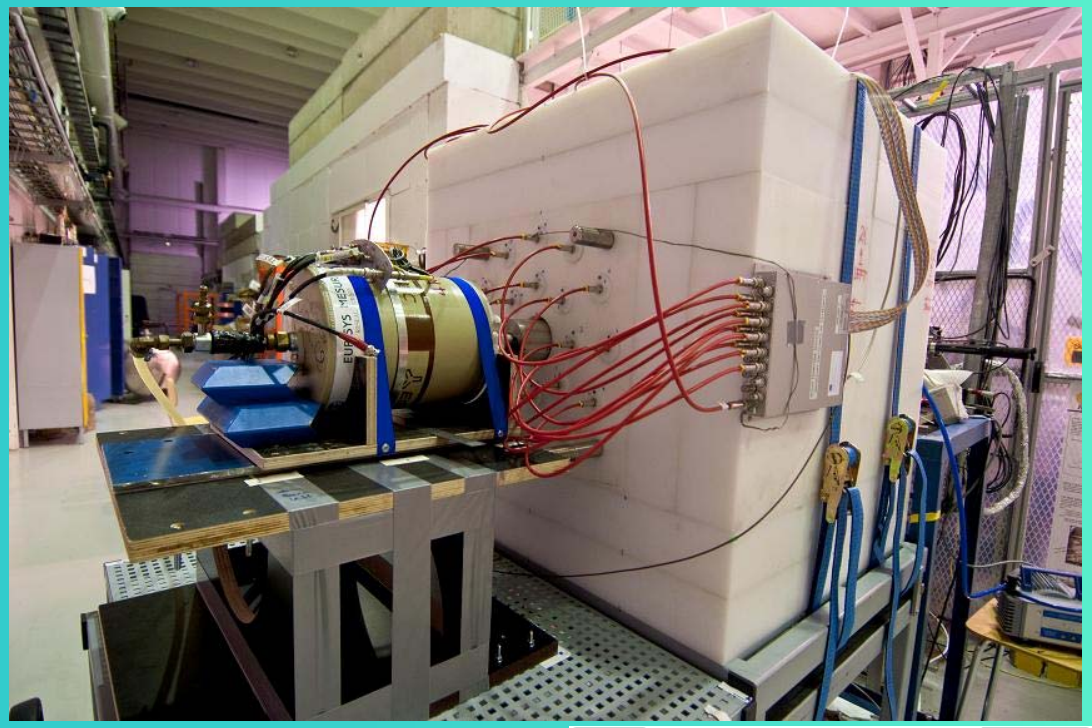


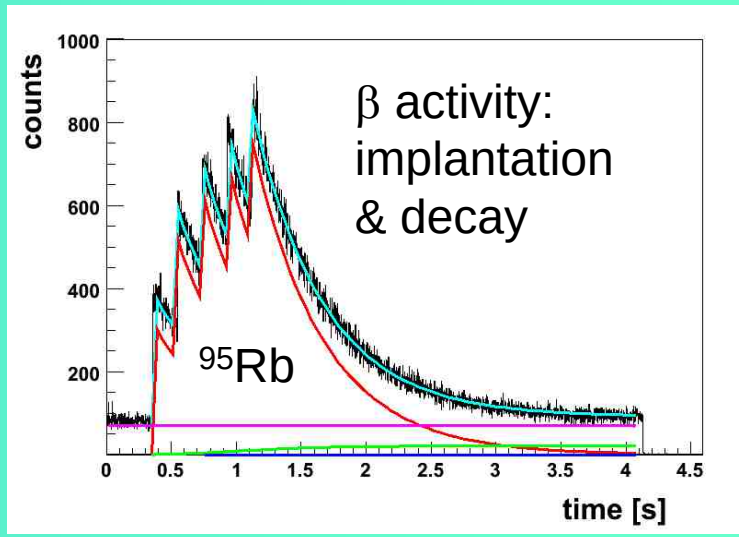


B. Gomez-Hornillos et al., INPC2010

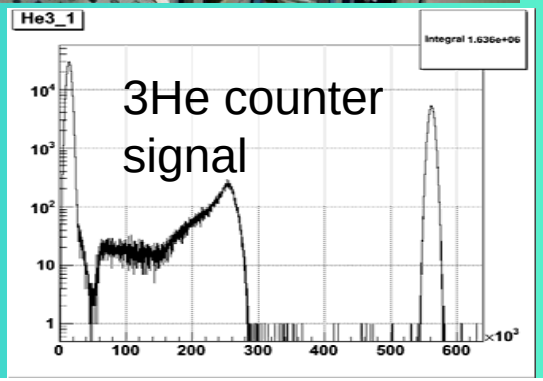
HOW

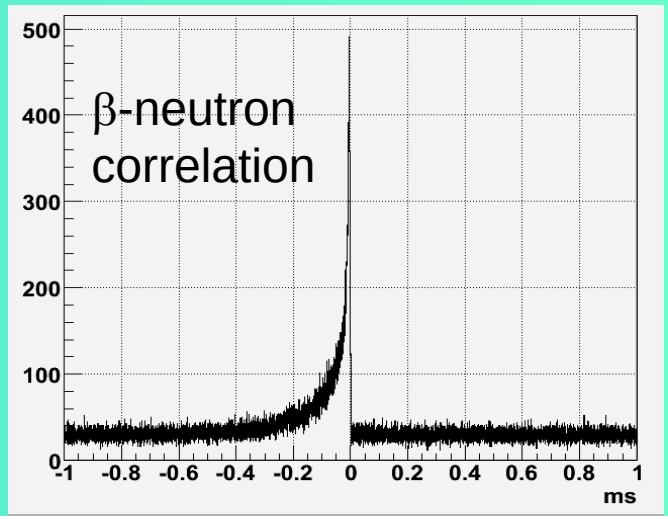
- Version with 20 counters used at JYFL (IGISOL+JYFLTRAP)
- Experiments in November 2009 and June 2010
- Self-triggered DACQ (time stamped energy for every counter)





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





HOW

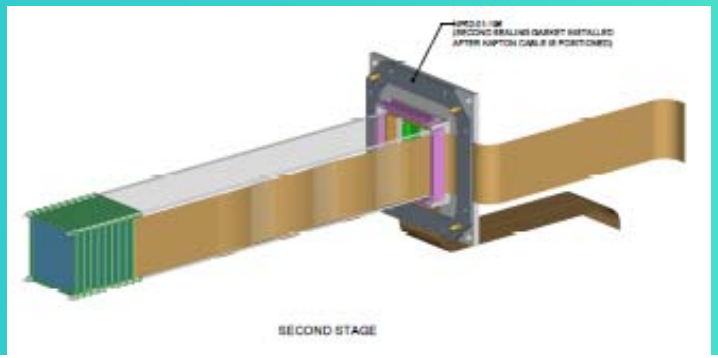
Implantation detector

OPTION 1 (stand-alone):

- 5 x DSSSDs (5cm×5cm×1mm)
- 16×16 strips, pitch 3mm
- 160 channels

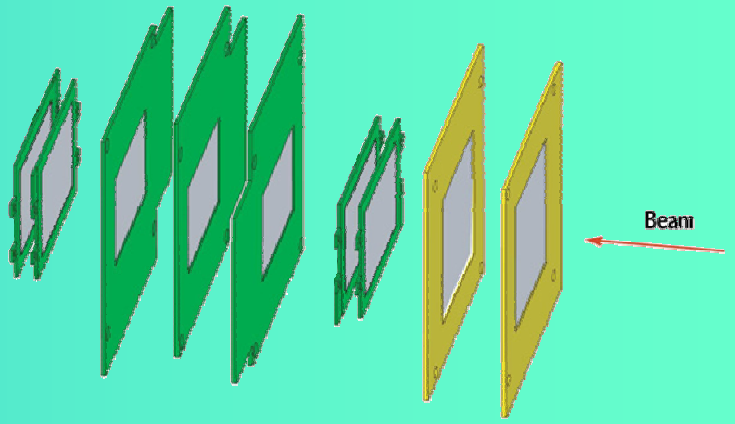
OPTION 2 (AIDA):

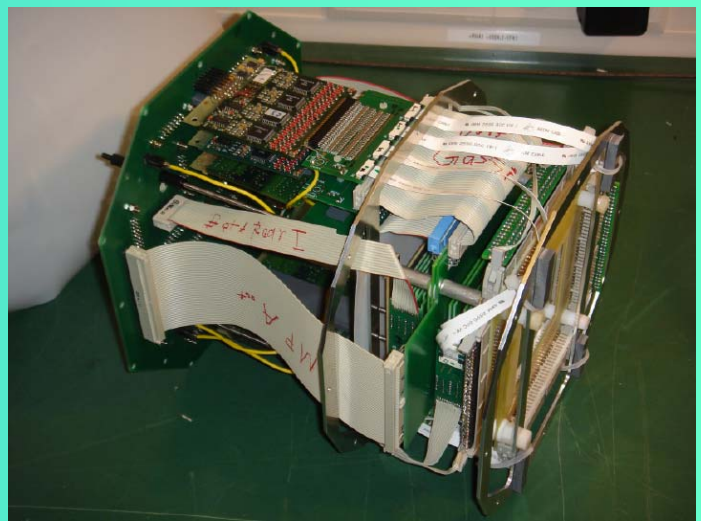
- 5 x DSSSDs (8cm×8cm×1mm)
- 128×128 strips, pitch 0.625mm
- 12800 channels



OPTION NOW: SIMBA (TUM)

- **2×SSSSD (6cm×6cm×0.3mm) +**
2×SSSSD (6cm×4cm×1mm) +
3×DSSSD (6cm×4cm×0.7mm) +
2×SSSSD (6cm×6cm×1mm)

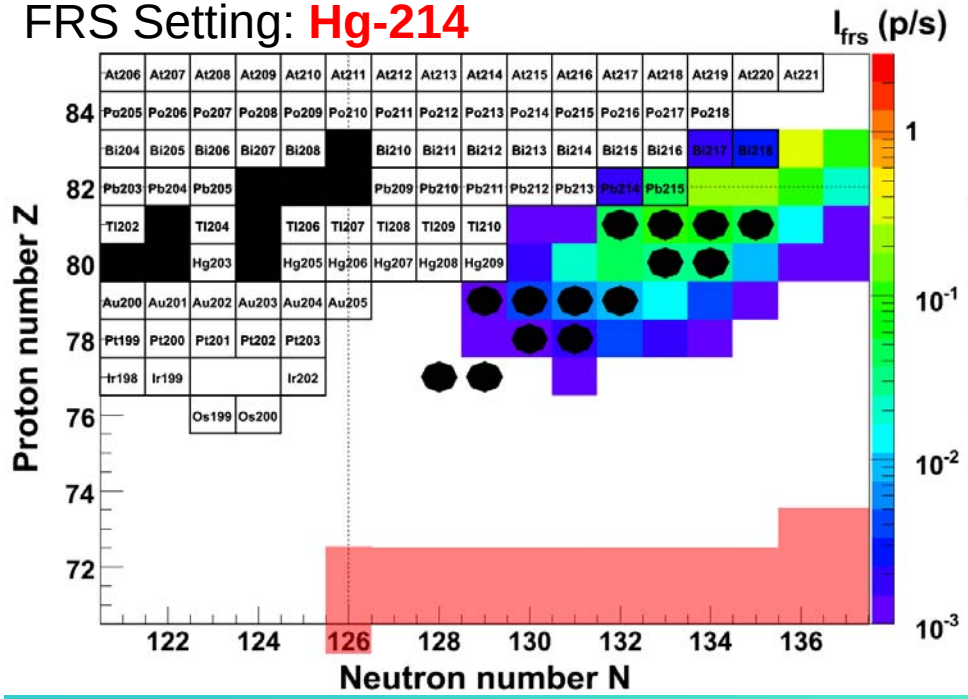




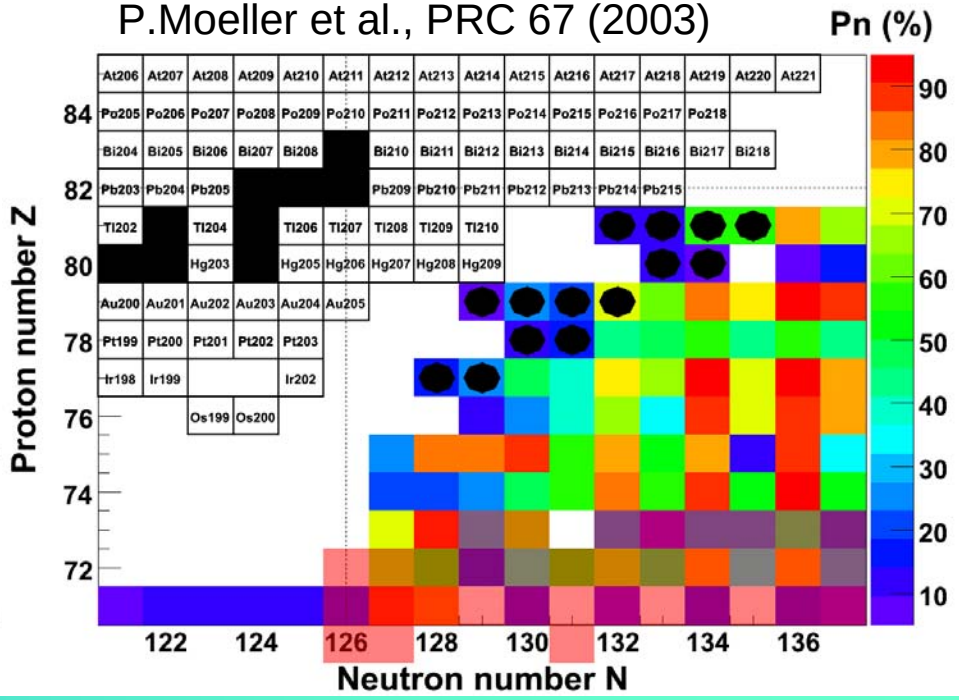
LISE++ & MOCADI calculations

2×10^9 pps ^{238}U @ 1Gev/u on 1.6 g/cm^2 ^{9}Be target
(ABRABLA-2001 by K.H.Schmidt, COFRA and interpolation by H. Weick and J. Kurcewicz)

FRS Setting: **Hg-214**



P.Moeller et al., PRC 67 (2003)



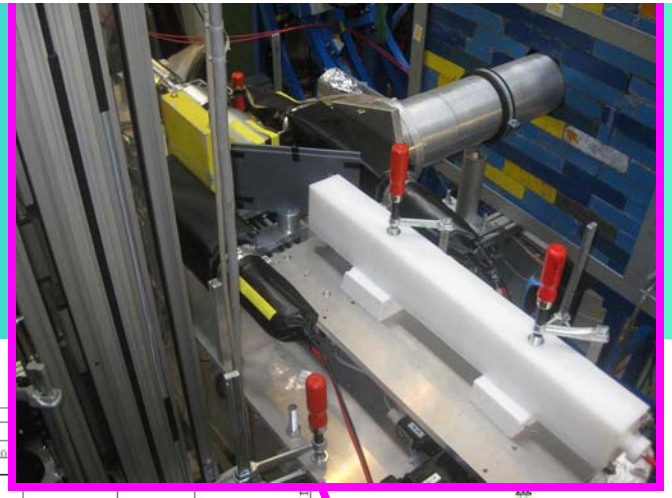
(OPTION B) 2 days x 206Ir + 2days x 211Au + 2 days x 214Hg

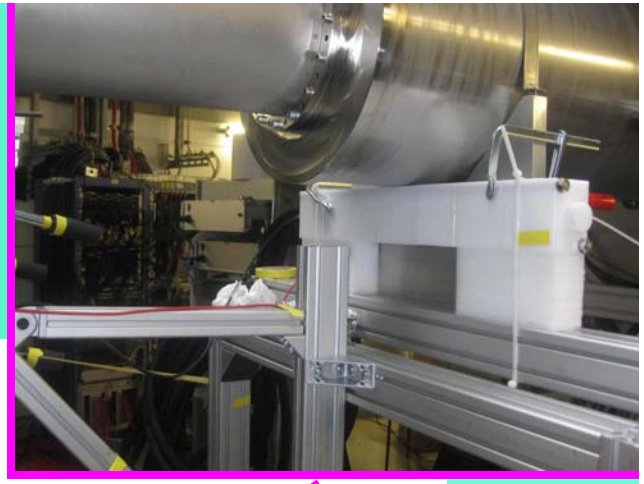
Total # Counts β-n coincidence

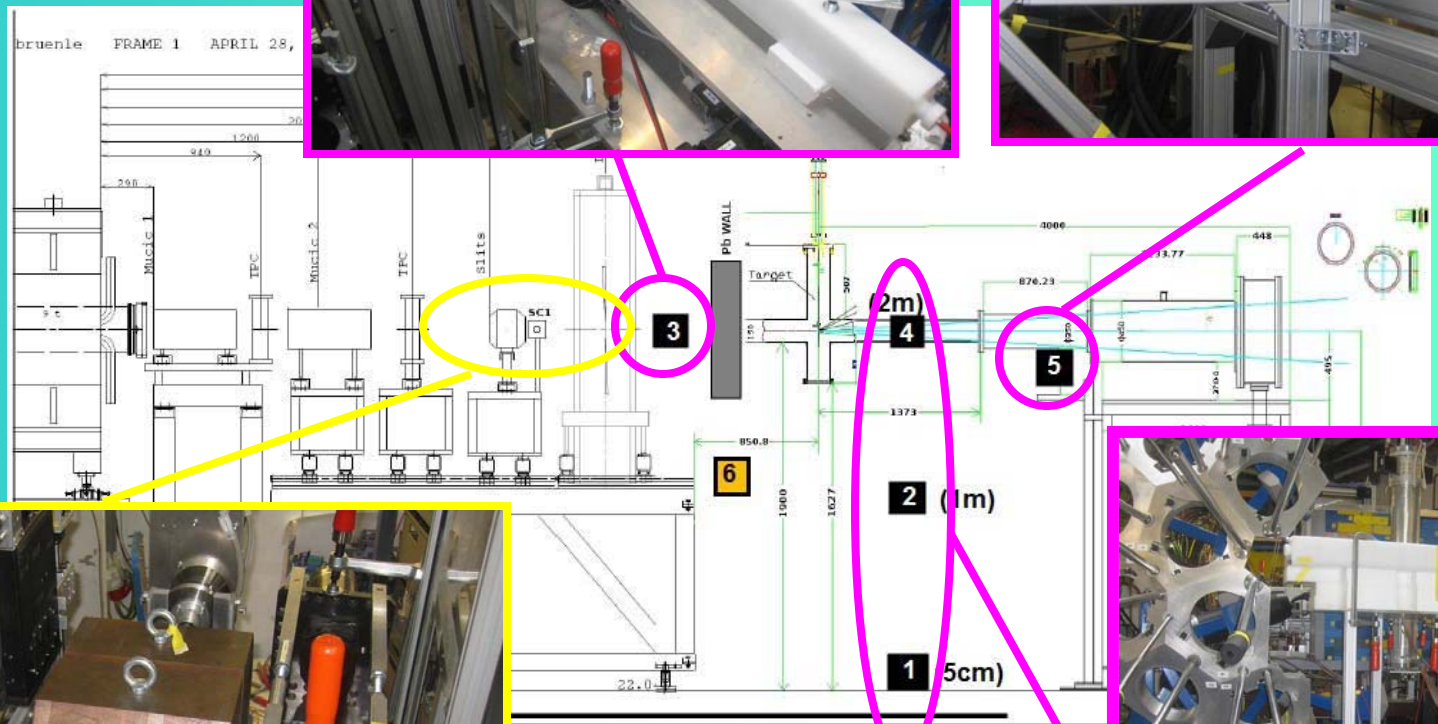
205 Ir	206 Ir	208 Pt	209 Pt	208 Au	209 Au	210 Au	211 Au	213 Hg	214 Hg	213 Tl	214 Tl	215 Tl	216 Tl
41	52	25	66	105	408	355	864	299	82	787	620	2289	1005

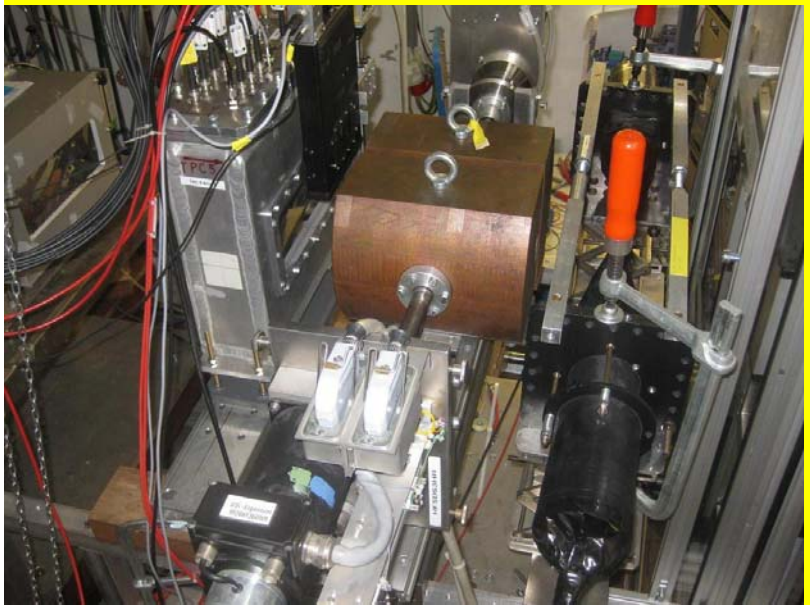
Background test at S4 in June 2010

R. Caballero et al.



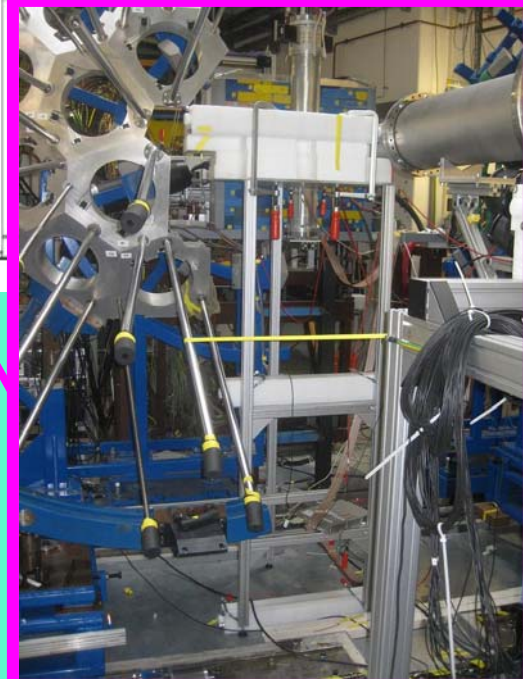




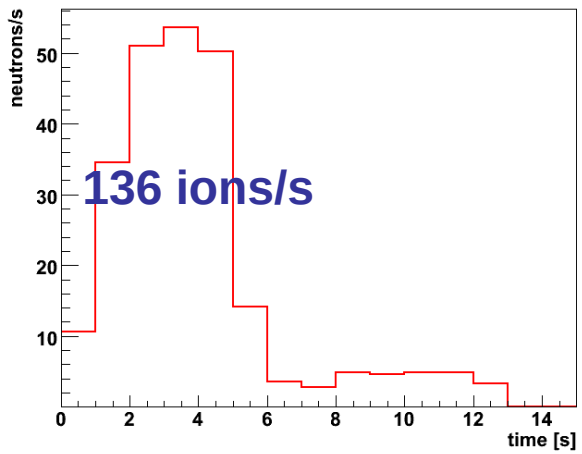


5 BELEN 3He counters embedded in individual PE matrices

7cm×10cm×70cm

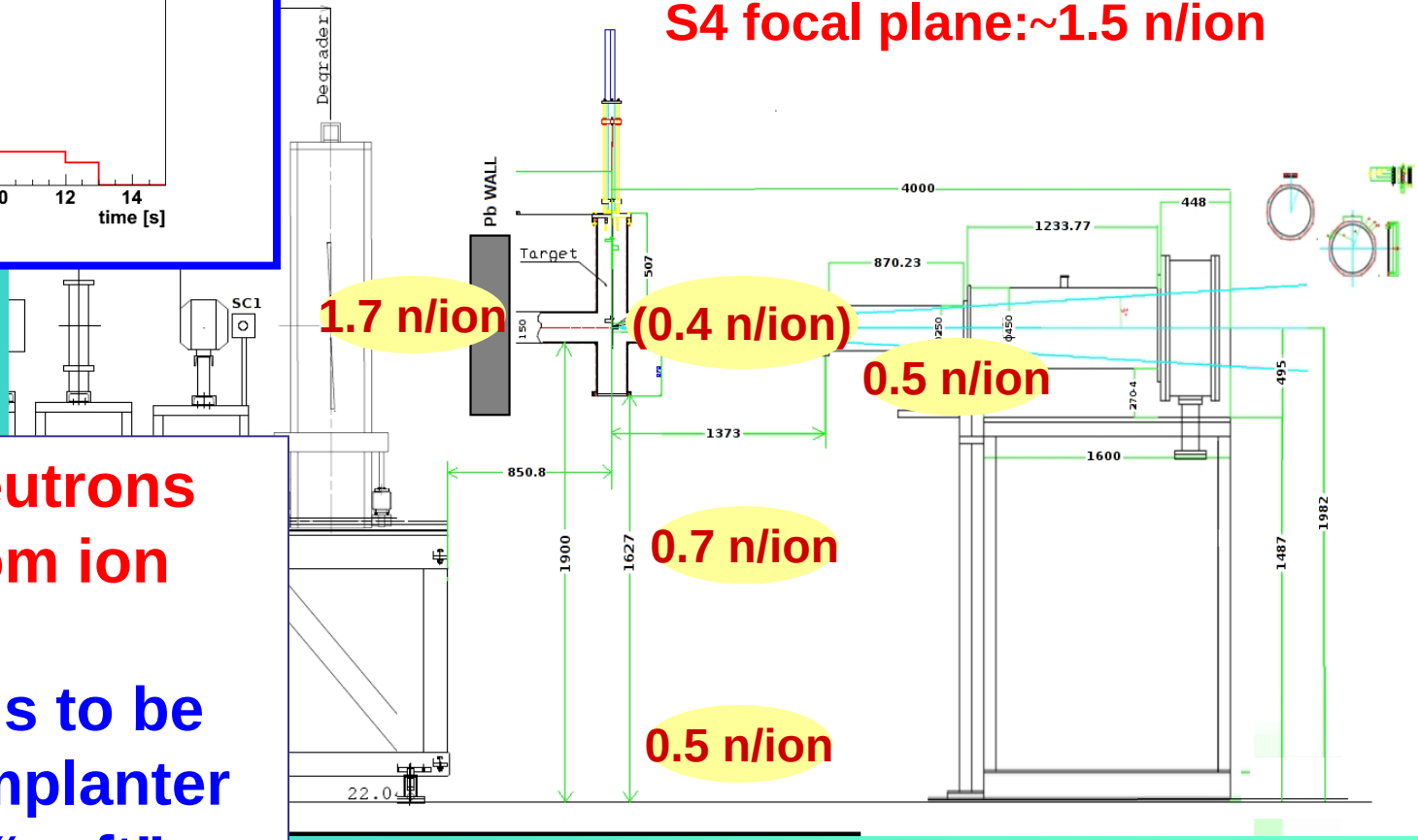


Neutrons during spill



Ambient background: ~5 n/s

Beam induced background at S4 focal plane:~1.5 n/ion



- **Negligible neutrons after 200μs from ion passage**
- **Source seems to be upstream of implanter**
- **Spectrum is “soft”**
- **20cm PE shielding: ~10 reduction**

It is planned to verify the true background rate with the full BELEN setup

WHEN

- Since we are sharing the setup, we propose to combine experiments S323 and S410 in one run
- This will allow an optimal use of the beam time
- Students are waiting for data
- We are ready to take data next year