# Collaboration 22-88

## Production and β decay studies of neutron-rich nuclei around N=126 important for the r-process of nucleosynthesis at FRS/SFRS

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&
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GSI Helmholtzzentrum fur Schwerionenforschung

# Background

**Experiment S468 from GSI-NUSTAR:** Search for new neutron-rich isotopes and exploratory studies in the element range from terbium to rhenium

**Approved, 2017, run in April 2020.**

**→This proposal focuses on isotopes "south west" of $^{208}$Pb**

**Mapping the frontier of heavy neutron rich isotopes:**

- ➔ "How many nuclei do exist?"
- ➔ Benchmark of the NUSTAR-FAIR phase-0 facility
- ➔ Exploratory experiment in the N=126 region

**Nuclear structure far from stability**

- ➔ Region neutron-rich region around N=126 hard to reach and to identify at other facilities

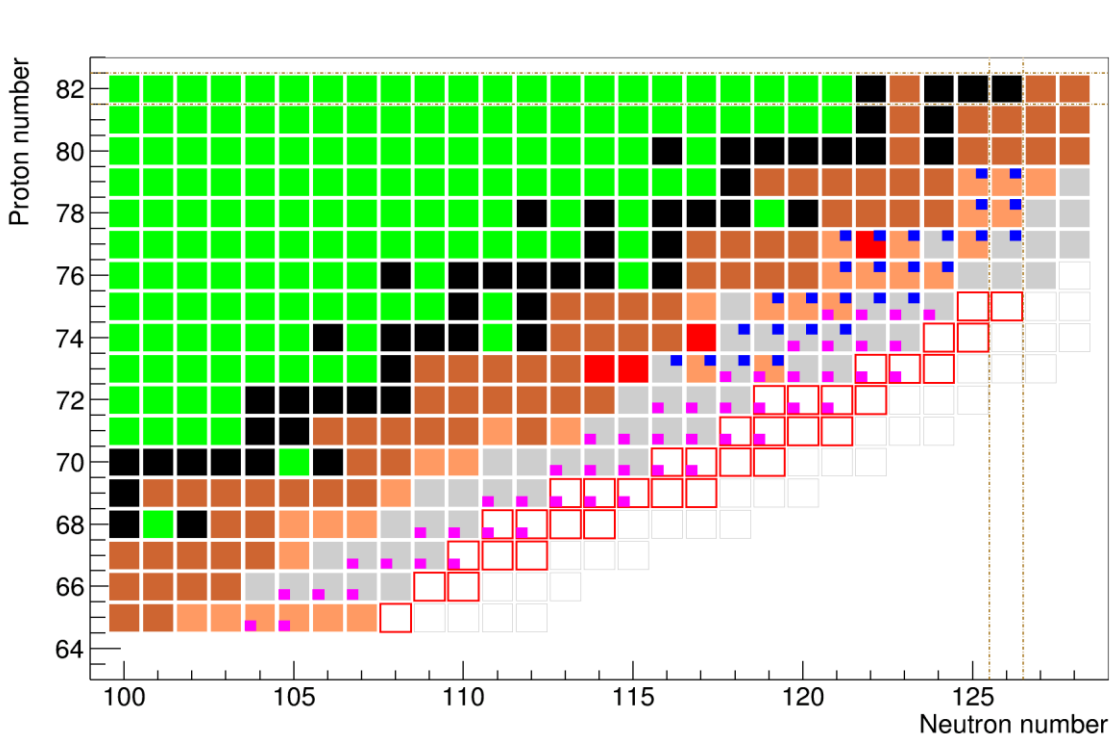
**Nuclear astrophysics: nuclear data around the third r-process abundance peak**

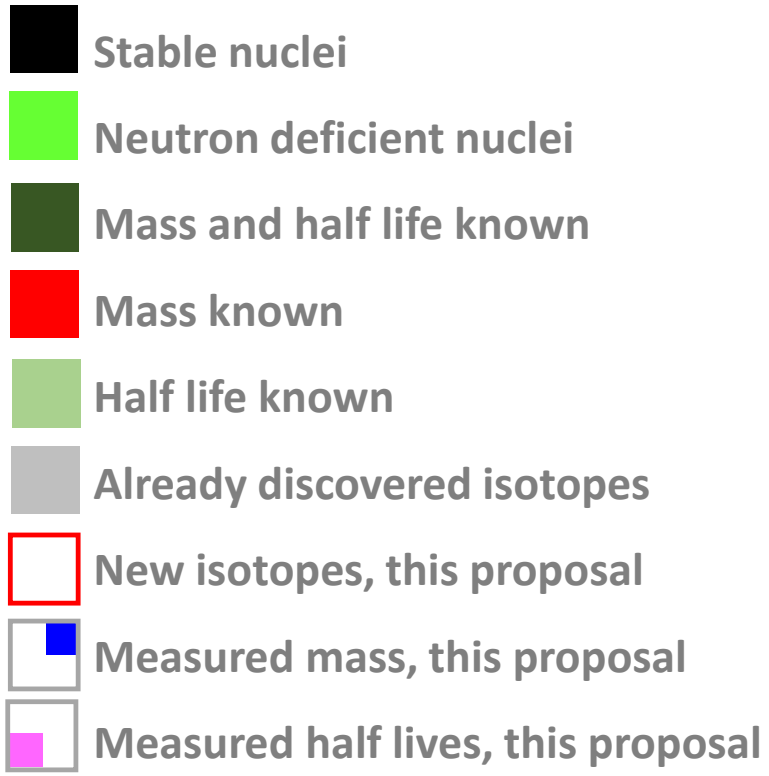
- ➔ Mass and lifetime measurements constrain the astrophysical scenarios
- ➔ Nuclear structure information helps to improve theory and its predictive power

# S468

## Use 208Pb fragmentation to produce neutron-rich isotopes of elements 65Re to 75Tb

- Identification of new neutron rich isotopes
- Measurement of production cross sections and longitudinal momentum distributions
- Mass and half-life measurements after implantation




Spokespersons: Stéphane Pietri (GSI), Alison Bruce (Univ. of Brighton), Tuomas Grahn (Univ. of Jyväskylä), Wolfgang Plass (JLU Giessen)

# Experimental campaigns at N~126 @ FRS $^{208}$Pb beams

**Pre- RISING S277 (2003): FRS + active stopper**

- production of heavy neutron-rich nuclei in fragmentation reactions induced by $^{208}$Pb projectiles
- first half-lives measurements using ion-β position-time correlations with an active stopper
- cross section measurement

**RISING S312 (2007): FRS + active stopper + RISING gama detectors (105 Euroball clusters)**

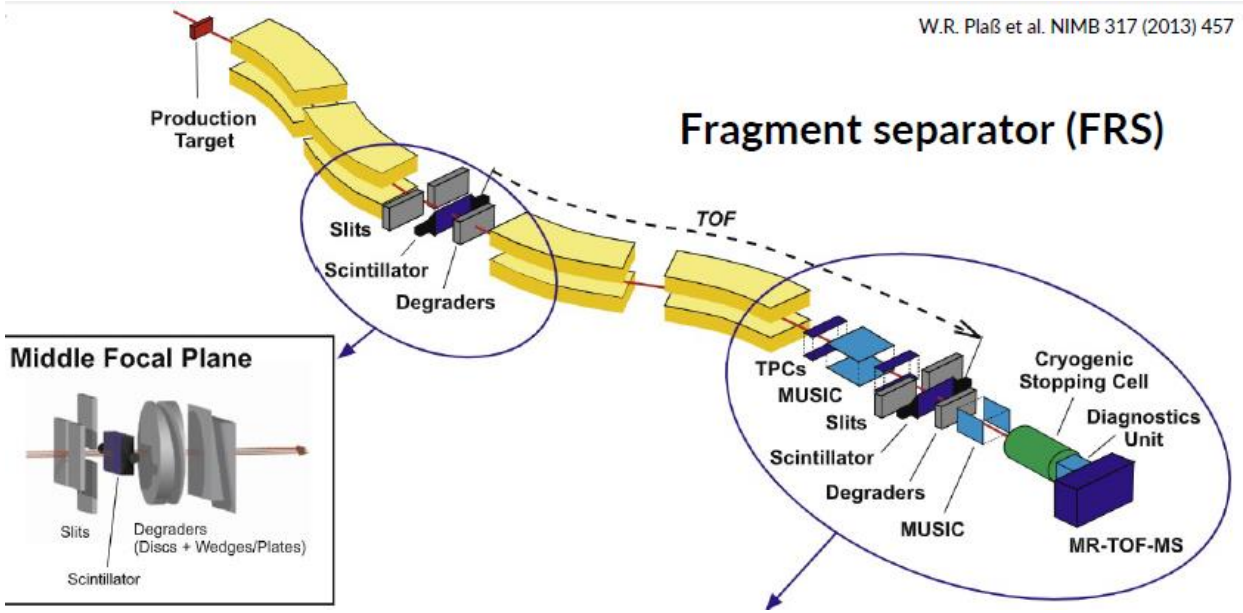
- half-lives measurements using ion-β-g position-time correlations with an active stopper+RISING
- low lying excited states

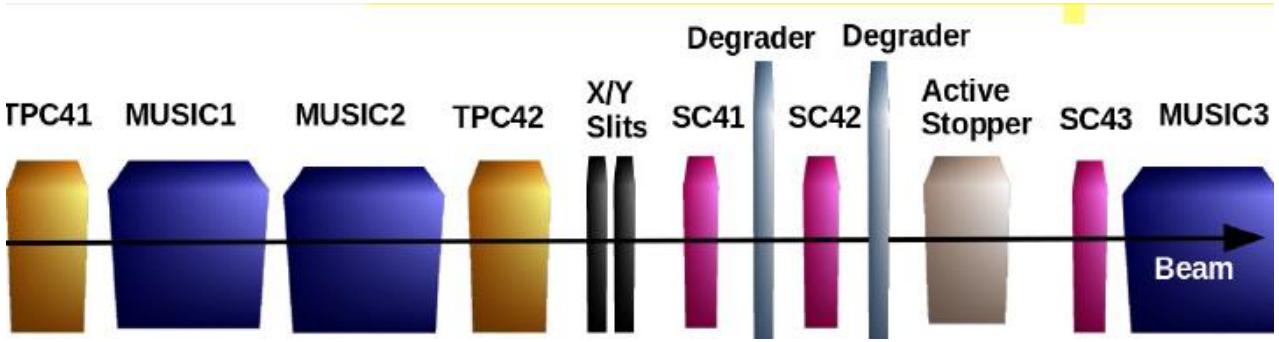
**Super-FRS Exp. S468 (2020) : FRS + active stopper or Cryogenic stopping cell**

- use maximum duty cycle for new isotope production
- active stopper for beta decay life time measurement
- cryogenic stopping cell for mass measurement

# Experimental setup – S468

**$^{208}$Pb+$^{9}$Be@ 1 A GeV at the entrance of the FRS (2.5 g/cm$^2$ target with Nb backing)**



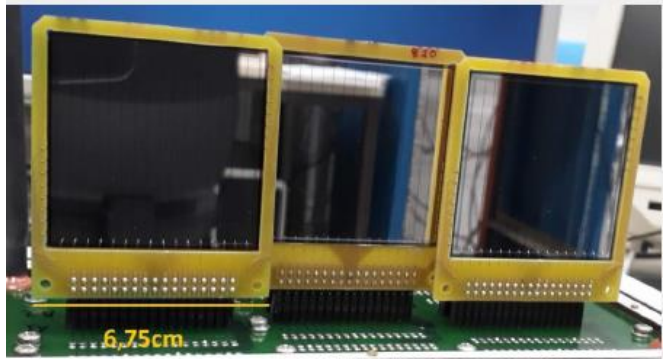




Standard FRS for Br-DE-Br separation

Upgraded FRS identification detectors to use Br-DE-ToF method (MUSIC with drift stabilization, segmented plastic at middle focal plane, TPC)

- FRS Ion catcher for masses

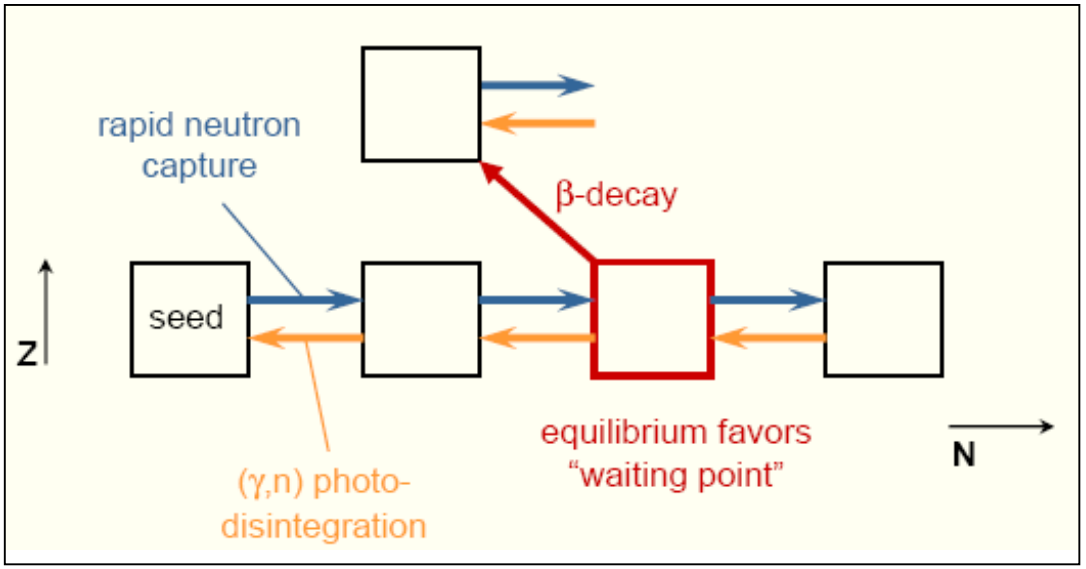
- Active stopper for beta life times

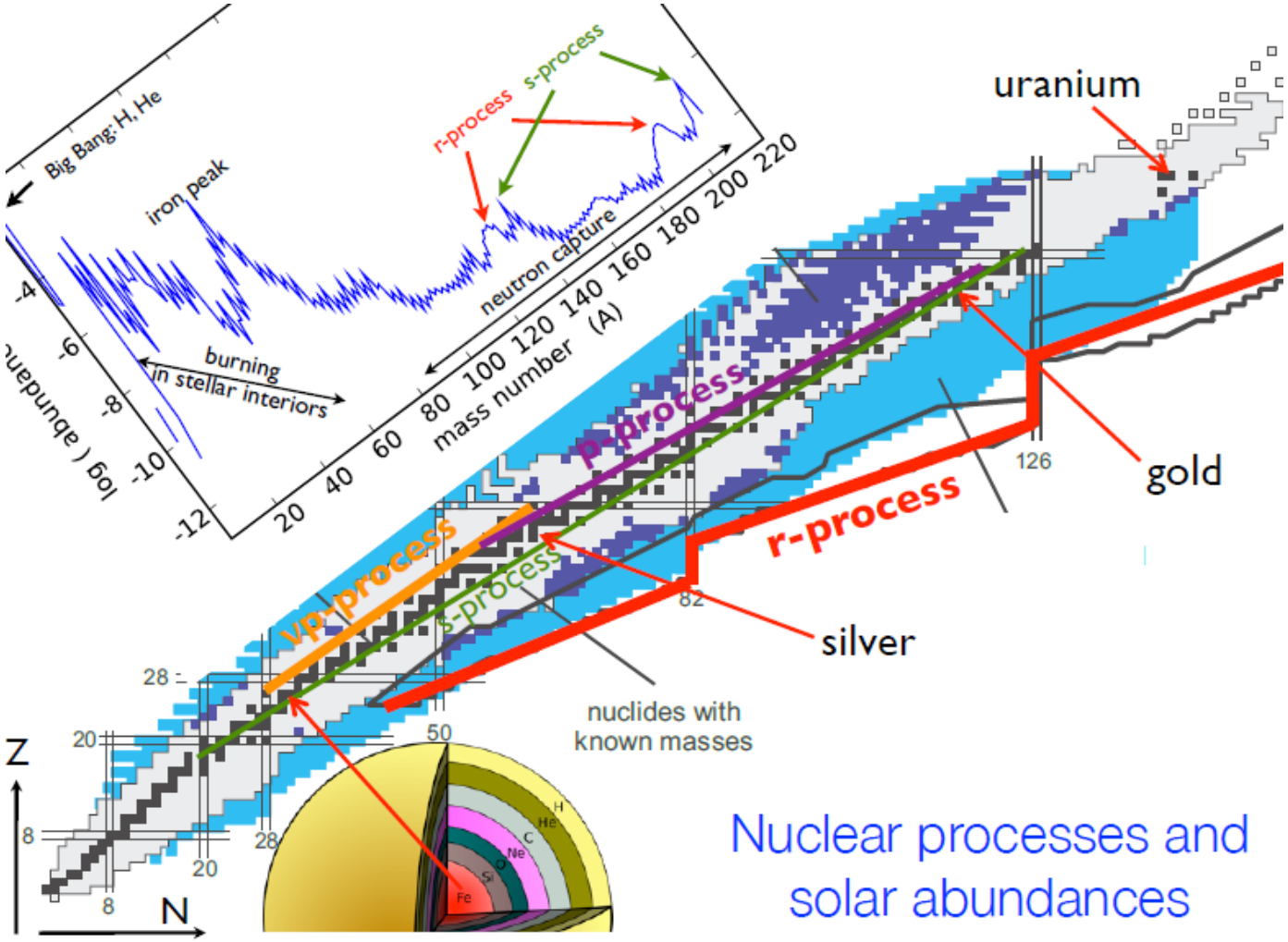


# Interest to combine mass and half lives – r-process

**Masses help determine Qβ, and with T1/2 improve model for not reachable parts of the r-process path**

**Third waiting points (N=126) strongly determine abundance of heavy elements**



# III. Status report for the period January 1st to December 31st, 2022

## III.1 IN2P3 scientists in GSI

| | |
|---|---|
| Total time approved for 2022 | 30 |
| Total time used for 2022 | 10 |
| List of scientists | 1. Teresa Kurtukian Nieto (10 days) |

## III.2 GSI scientists in France

| | |
|---|---|
| Total time approved for 2022 | 20 |
| Total time used for 2022 | 11 |
| List of scientists | 1. Heidi Roesch (11 days) |

## III.3 Scientific results of the above-mentioned collaboration

| | |
|---|---|
| Description | |

# Preliminary results form collaboration

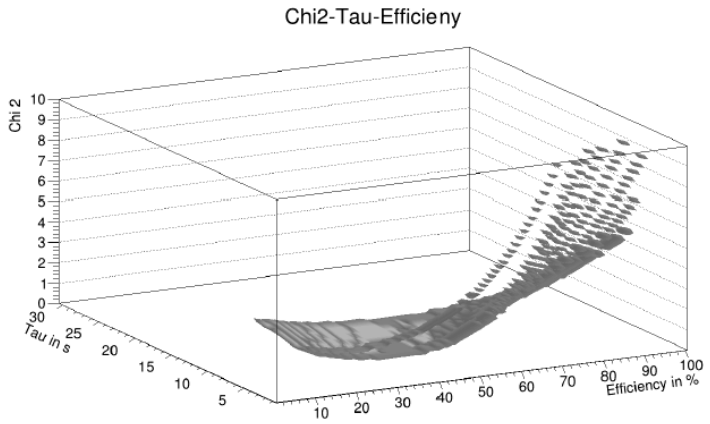
**Goal of collaboration between GSI and LP2I: implement the simulation codes and the backward/forward beta decay analysis**

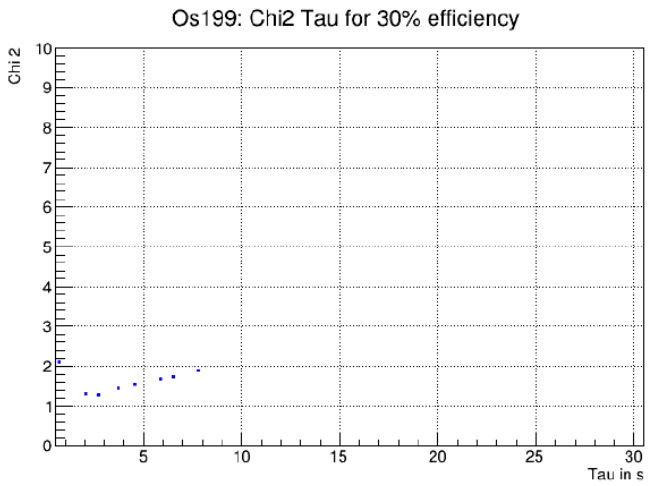
**This was done in 2022, travel of student to LP2I and Teresa travel to GSI**

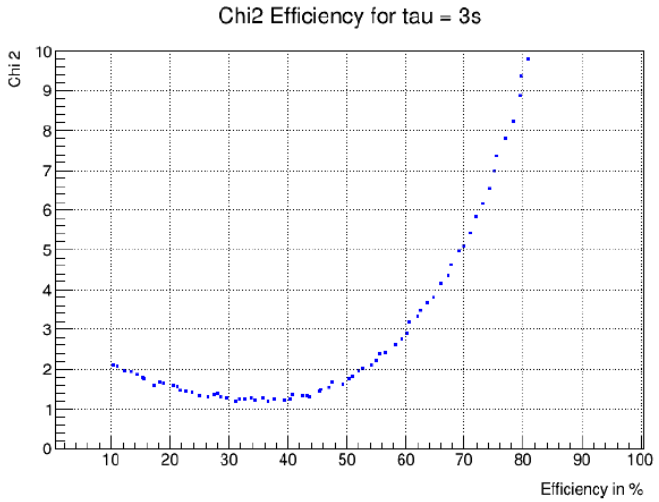
$\chi^2$ vs efficiency and tau for 0s199

$T_{1/2}$ 5 s +4-2

*https://www.nndc.bnl.gov/nudat3/*



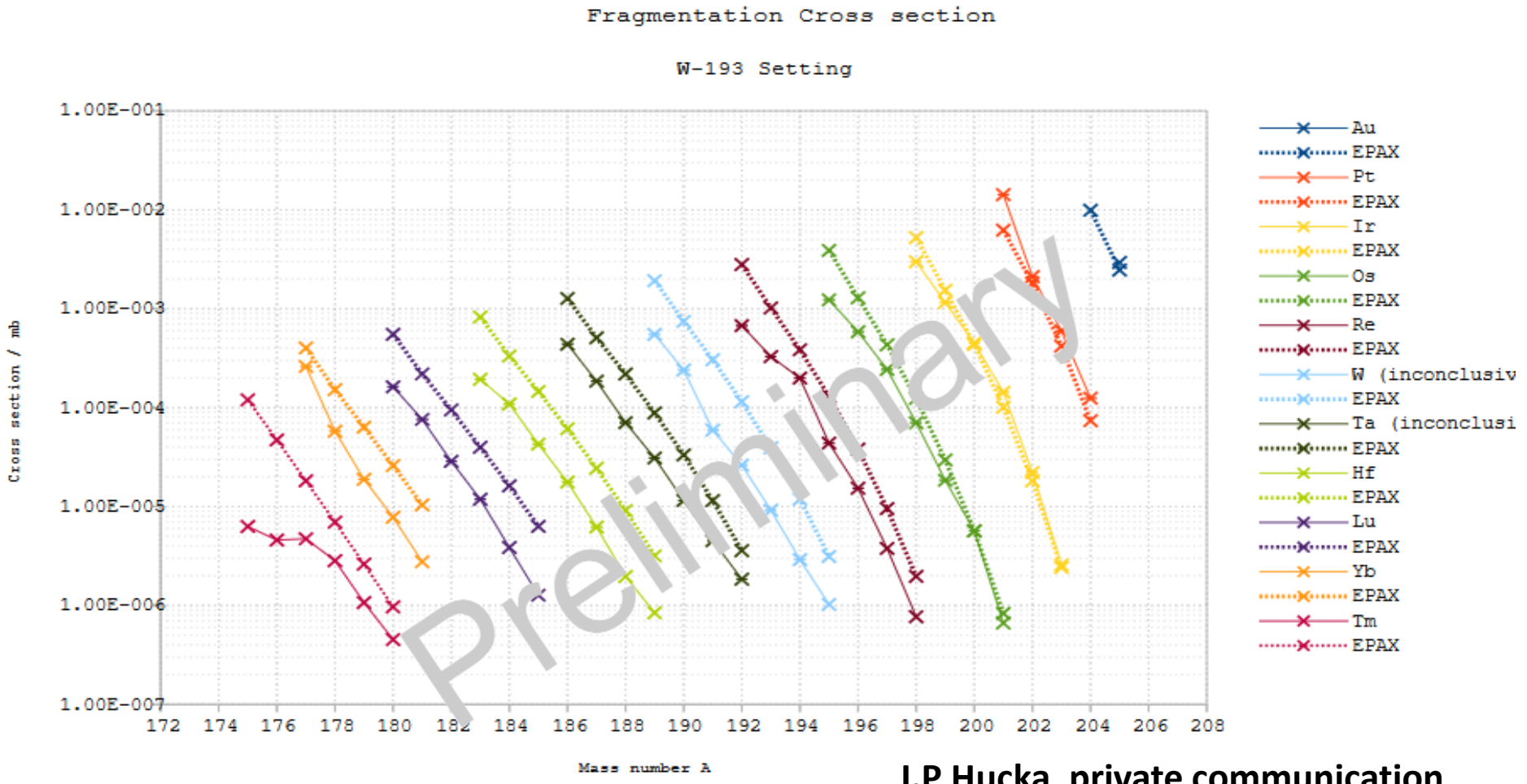

From H. Roesch

**Still some ironing to do, but we are getting there thanks to this collaboration,**

**Goal, publish a paper in 2023 on beta decay..**

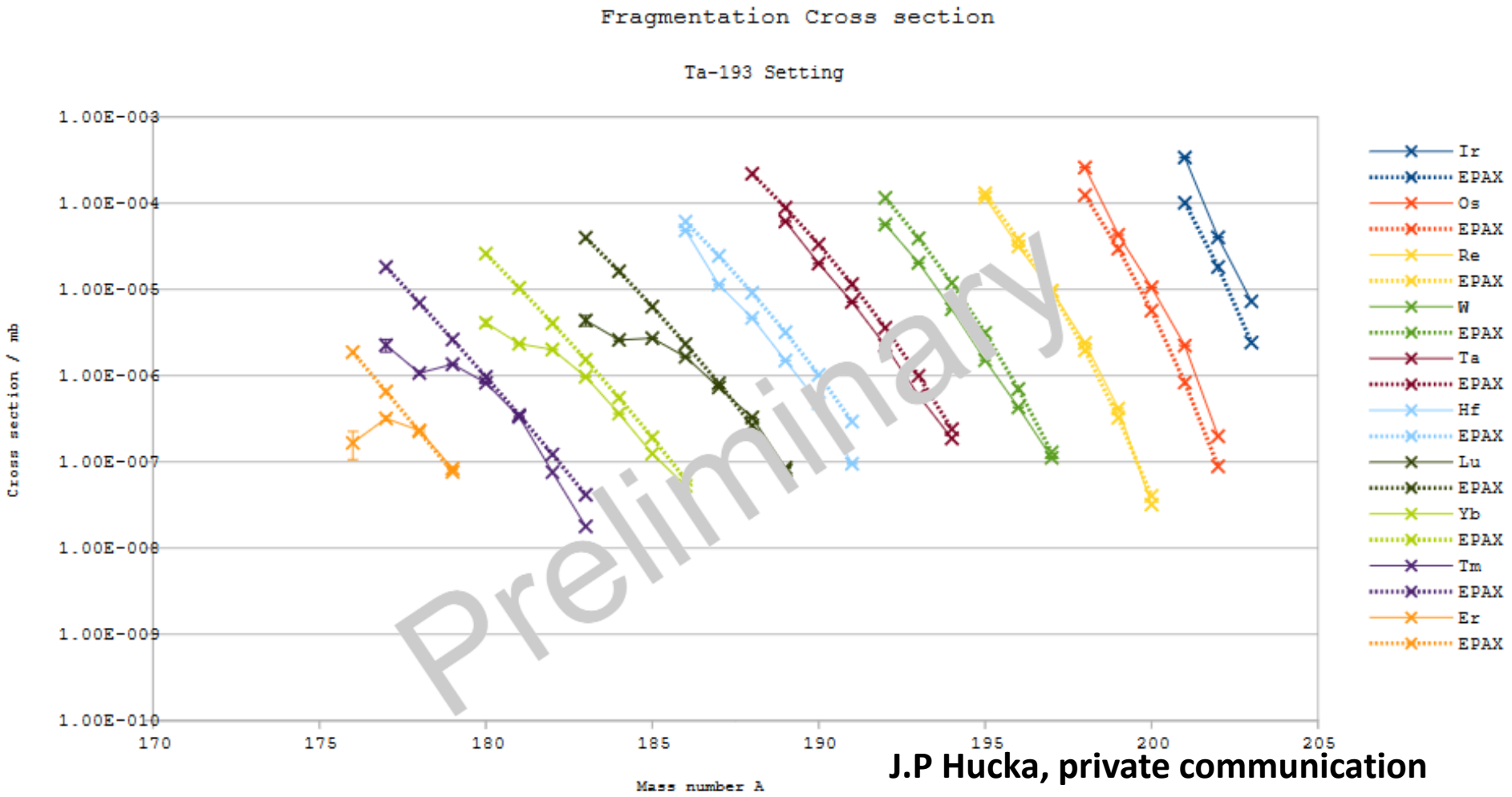
**so we ask for extension**

# Cross sections




**J.P Hucka, private communication**

# Cross sections




**J.P Hucka, private communication**

**Need to work on detector efficiency (seem to change with time/position due to damage) ➔ GSI**

**Need to measure counts based on fit of momentum distribution transmitted ➔ GSI+LP2I (here collaboration requested)**

# Extension request

| IV.2 Estimated duration for IN2P3 scientists in GSI | |
|---|---|
| Total time requested for 2023 | 15 |
| List of scientists | 1. Teresa Kurtukian Nieto (15 days) |
| **IV.3 Estimated duration for GSI scientists in France** | |
| Total time requested for 2023 | 30 |
| List of scientists | 1. Stephane Pietri (15 days)<br>2. Heidi Roesch (15 days) |