Measurement of β-delayed neutron emission probabilities relevant to the A = 130 r-process abundance peak

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for the BRIKEN collaboration

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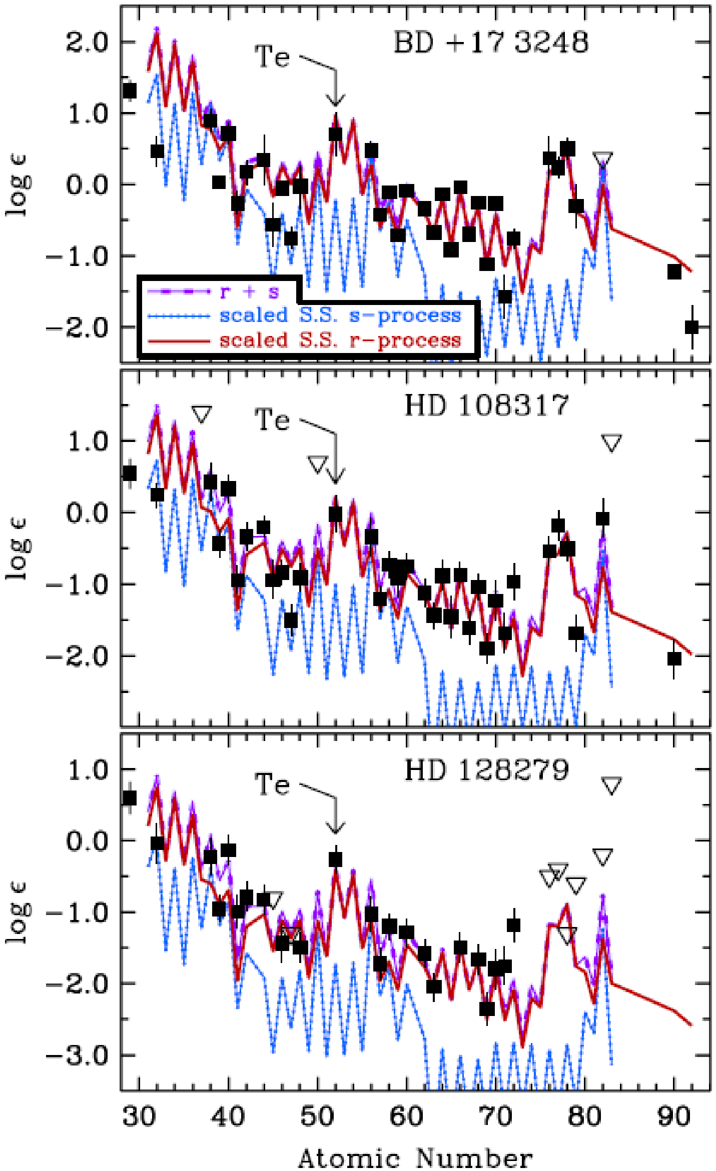
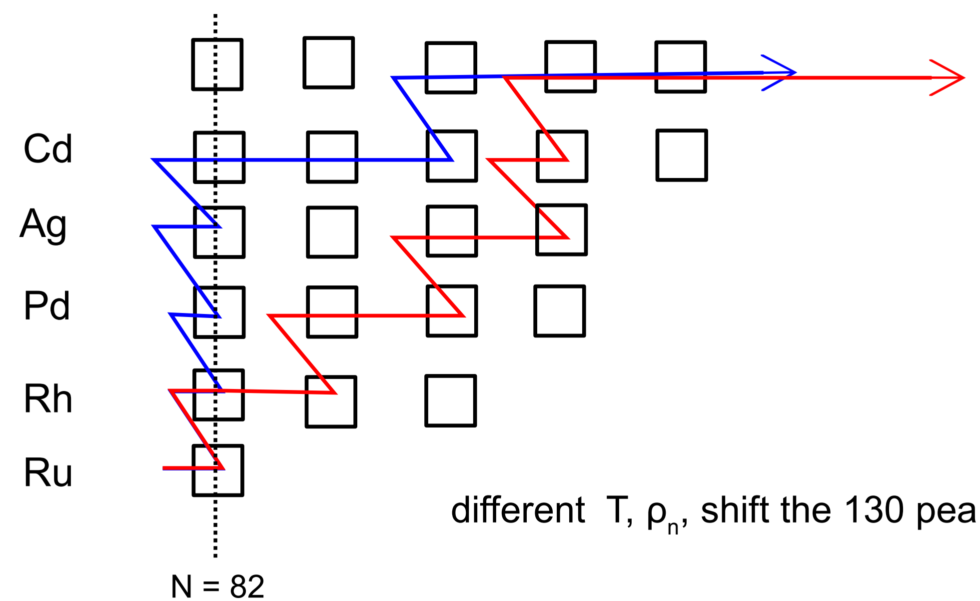
The A = 130 peak and metal poor stars

Observation of Te in metal poor stars



I. Roederer et al., 2012

- New Te observation (A ≤ 130) and Ba (A ≥ 140) highlight r-process conditions in single r-process events
- Te/Ba ratio is sensitive to
  - \+ r-process conditions
  - \+ contribution of the weak r-process
- Pn is one of the important unknown affecting the ratio Te/Ba

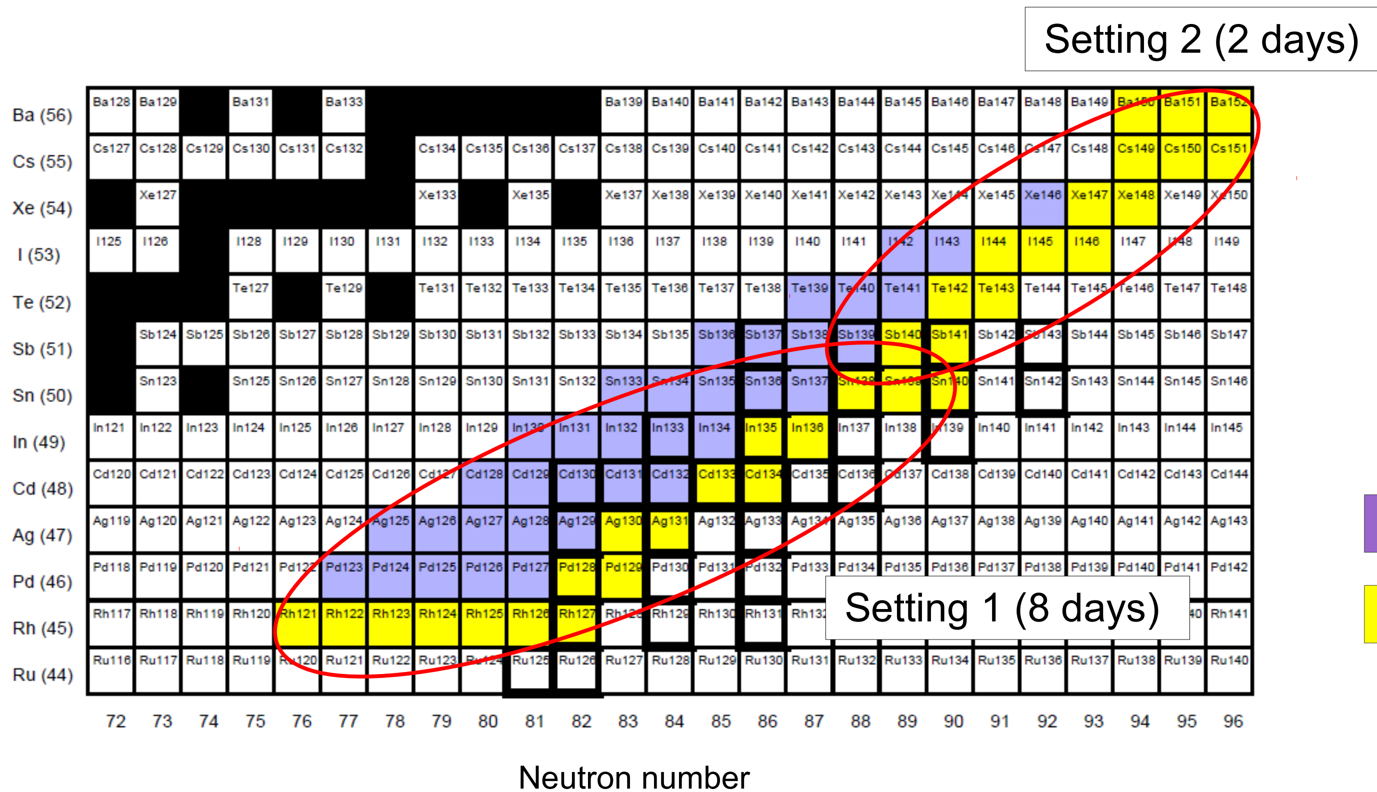


Pn vs. (n, γ) competition during freezout?

Based on current predictions, A = 130 is build up almost entirely during freezout

Farouqi et al., 2010

Goals of the experiment



Measurement of

33 P1n

11 P2n

3 P3n

All relevant to the A=130 peak

Remeasure

First measured

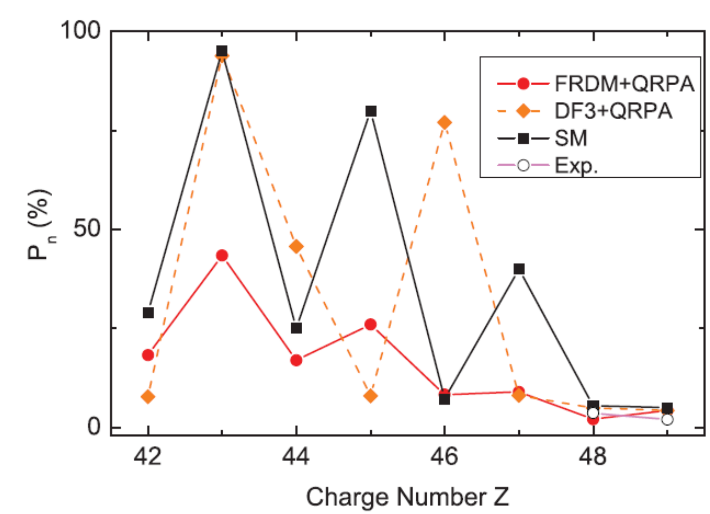
Main Motivations

1) N = 82 nuclei (^{129}Ag, ^{127}Rh)
   – possibly the most exotic probe of shell model
   – possibly the largest source of neutron during freezout

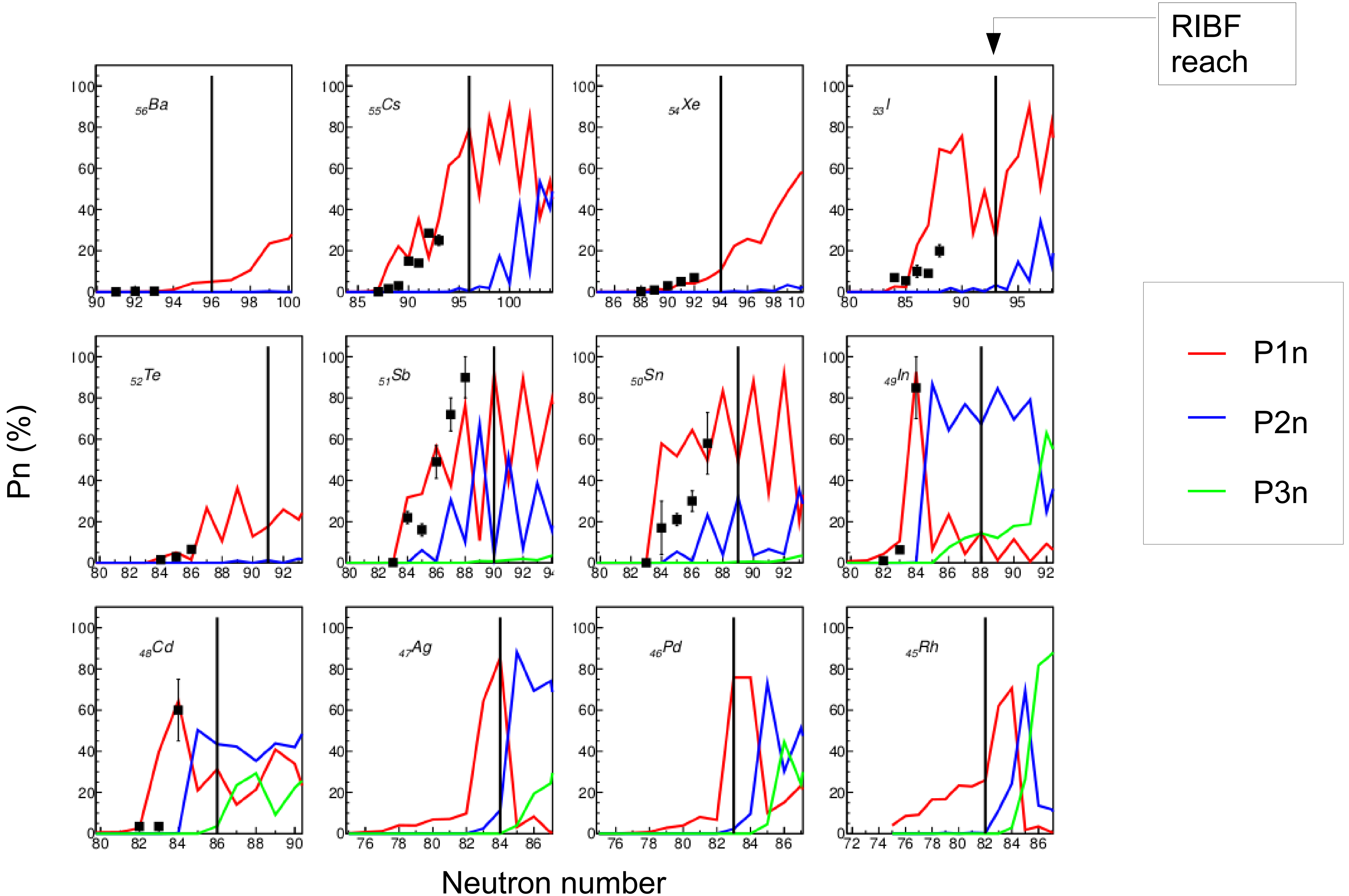
2) Rh, Pd, Ag are progenitors of Te (^{131}Ag, ^{129}Pd)
   Sb, Sn, In are progenitors of Ba

3) Candidate for b-2n, b-3n emission (^{134,135,136}In)

Pn of N = 82 nuclei

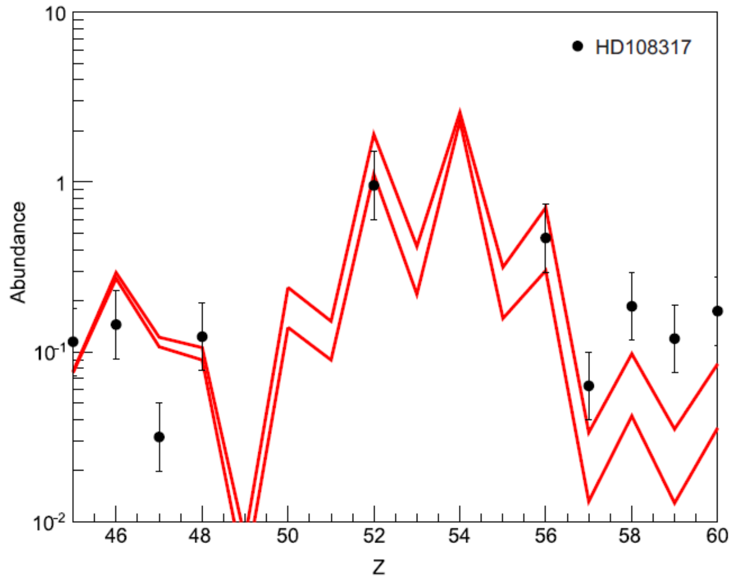


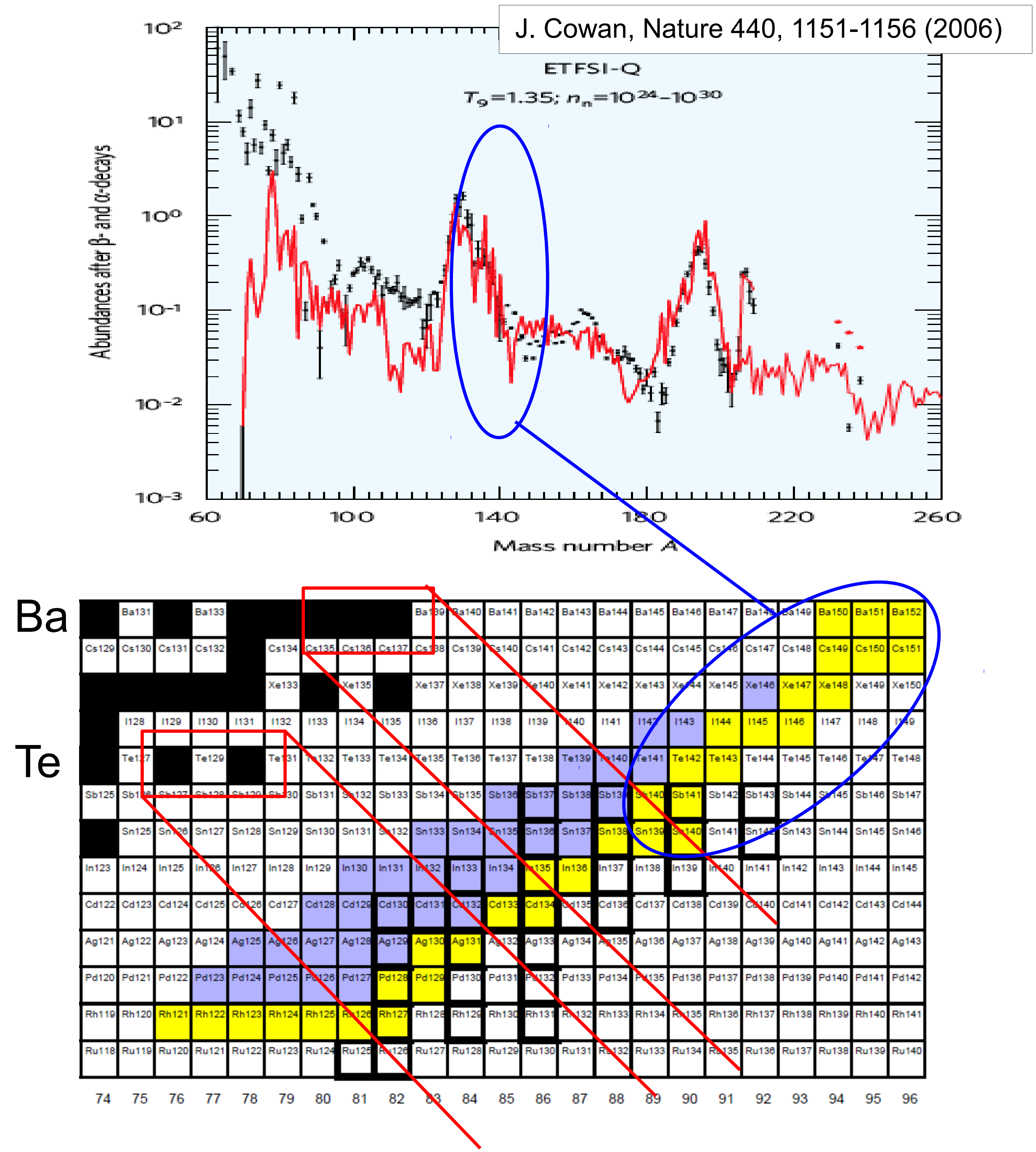
P1n, P2n, P3n predictions (FRDM) and previous measurements



Sensitivity of the Te/Ba ratio to Pn values

Elemental distribution in HD108317



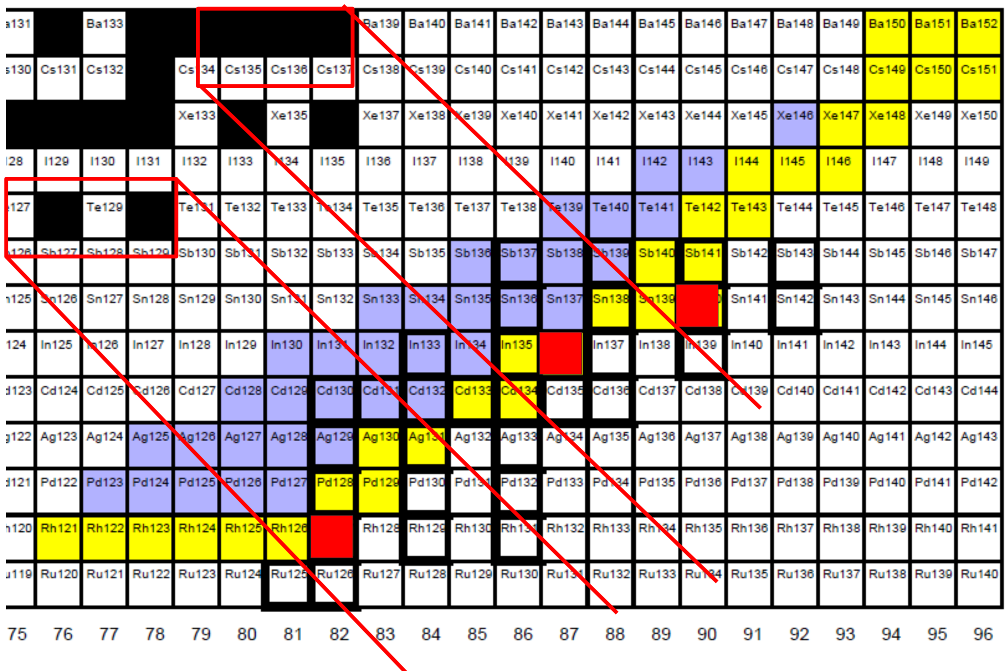


Two r-process calculations changing:

- Only the P-1n values that we will measure
- No P-2n values
- Only shown entropy components for the A=130 peak

Ratio Te/Ba is affected by a factor > 5

Beam time request



possible

borderline

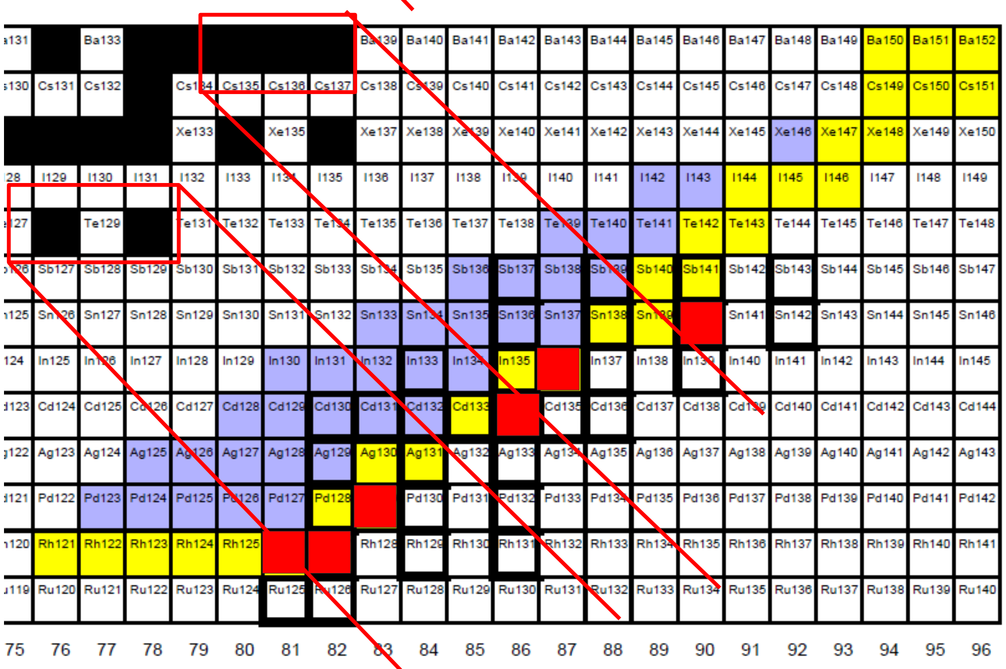
8 days

^{129}Pd 50 ions

Pn = 75 ± 30%

(Neutrons – bg) > 3σ

14 – 0.2 > 11



possible

borderline

4 days

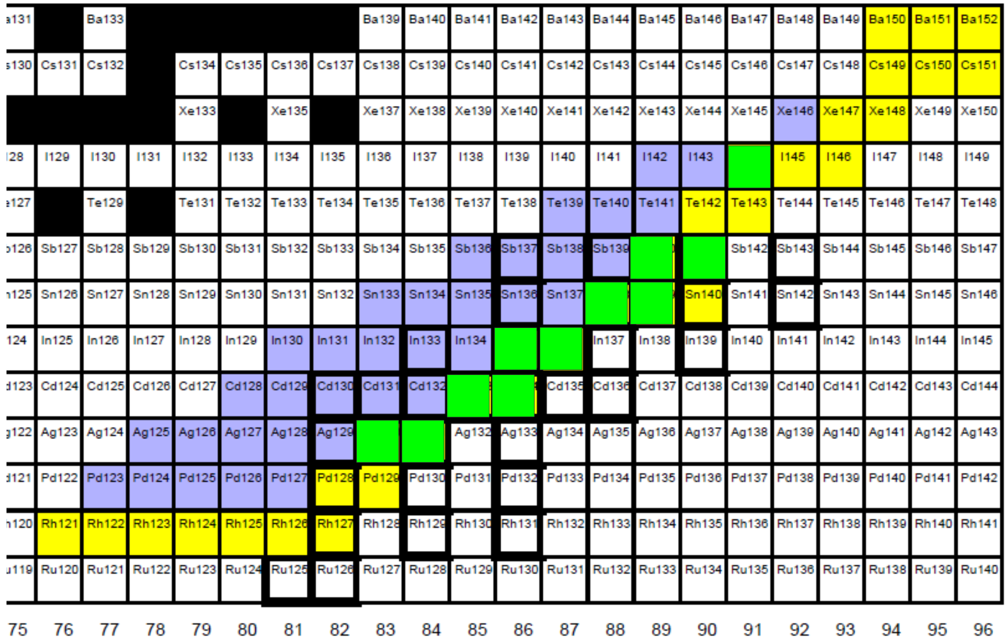
^{129}Pd 25 ions

Pn = 75 ± 40%

(Neutrons – bg) > 3σ

7 – 0.1 < 7.8

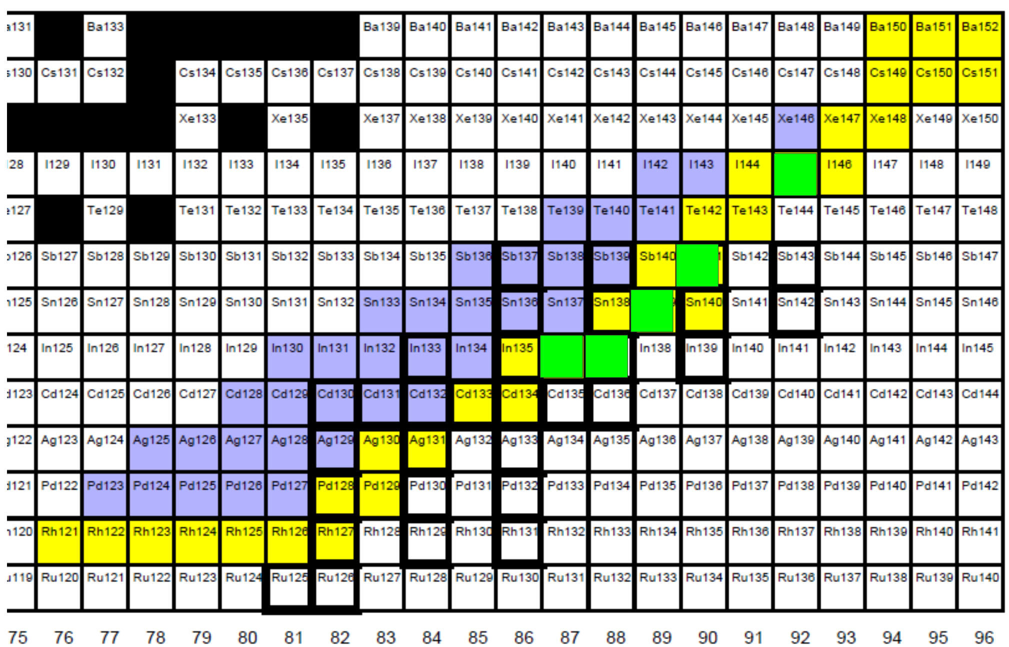
Beam time request (2n emitters)



8 days

11 candidates

possible



4 days

5 candidates

possible

Summary

- Tremendous progress have been made in the astronomical side, and more will come from planned metal poor star survey

- Pn values are among the important nuclear physics input, are highly uncertain, and difficult to predict

- We propose to measure 33 P1n, 11 P2n, 3P3n progenitors of the A = 130 that will:

    1. direct impact in r-process (e.g., reduce the Te/Ba ratio of a factor 5)
    2. provide a volume of data to improve models

Nucleus	N^0 ions Setting 1 (8 days)	N^0 ions Setting 2 (2 days)	P_{1n}(%) FRDM	P_{2n}(%) FRDM	P_{3n}(%) FRDM	# $\beta 1n$ detected	# $\beta 2n$ detected	# $\beta 3n$ detected
^{121}Rh	1300		8			40		
^{122}Rh	3200		9			106		
^{123}Rh	13500		16			807		
^{124}Rh	4000		16			241		
^{125}Rh	1100		23			93		
^{126}Rh	155		23			13		
^{127}Rh	16		25			1		
^{128}Pd	980		6.7			24		
^{129}Pd	53		75	2.4		14		
^{130}Ag	3200		64	2.5		741	18	
^{131}Ag	480		85	11		147	12	
^{133}Cd	2350		21	50		178	255	
^{134}Cd	152		31	43		17	15	
^{135}In	20000		23	64	7.5	1693	2776	192
^{136}In	752		4.3	77	12	12	125	12
^{138}Sn	11000	7950	83	4		5683	161	
^{139}Sn	200	130	44	31		58	23	
^{140}Sn	13	8	88	4		7		
^{140}Sb	10350	13000	11	67	0.9	907	3422	28
^{141}Sb	4769	630	92	3	0.8	1802	38	
^{142}Te		60000	12			2754		
^{143}Te		2200	17	1.2		139		
^{144}I		1.0×10^5	28	1.7		10307	365	
^{145}I		7000	49			1233		
^{146}I		230	26	3		22		
^{147}Xe		10000	6			235		
^{148}Xe		850	10			33		
^{149}Cs		33000	61			7303		
^{150}Cs		2500	65			593		
^{151}Cs		150	78			42		
^{150}Ba		7000	1			25		
^{151}Ba		10000	4			144		
^{152}Ba		5500	5			99		