Search for Proton Radioactivity in the Trans-lead and Sub-tin Regions

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On behalf of the AIDA Collaboration

(Edinburgh, Liverpool, STFC DL, RAL)

Outline

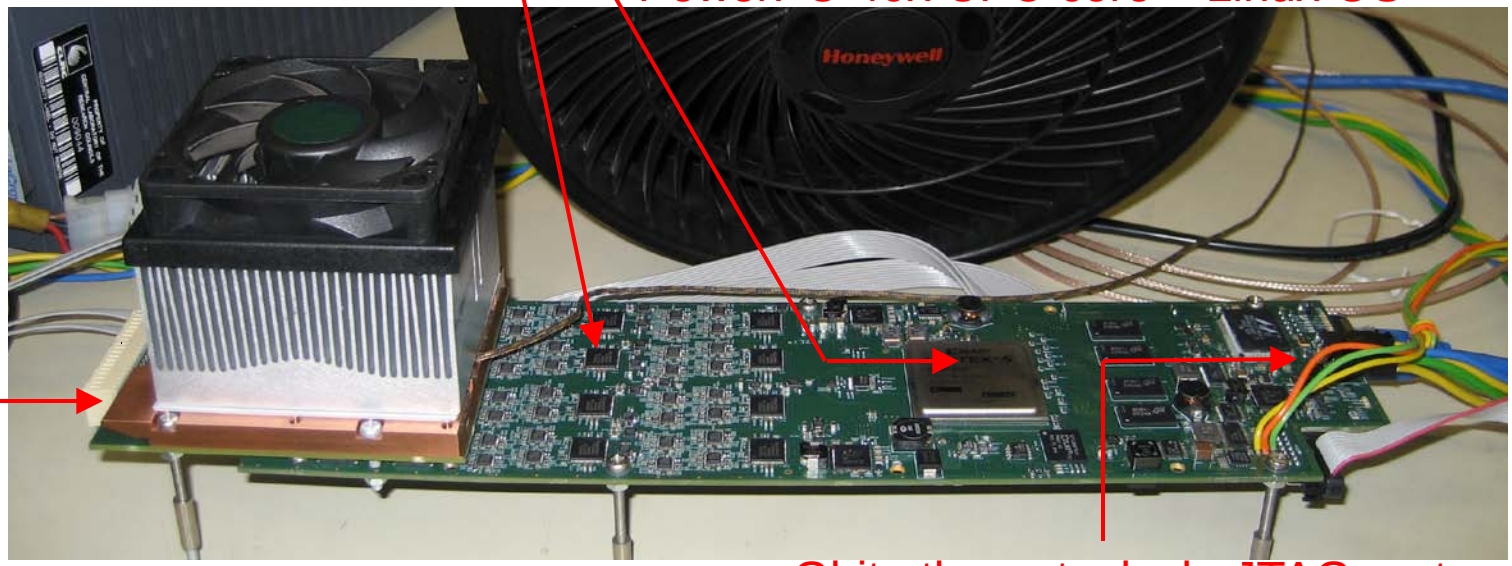
- Status of the AIDA detector
- Overview of the g.s. proton radioactivity
- Search for p-emitters in the trans-lead region (submitted to GPAC)
- Search for p-emitters in the sub-tin region

AIDA: status

- Systems integrated prototypes available
  - prototype tested on the MARS @ Texas A&M,
  - some modifications made
- Production submitted in Q3/2010

Mezzanine:
4x 16 channel ASICs
Cu cover
EMI/RFI/light screen
cooling

FEE:
4x 16-bit ADC MUX readout (*not visible*)
8x octal 50MSPS 14-bit ADCs
Xilinx Virtex 5 FPGA
PowerPC 40x CPU core – Linux OS

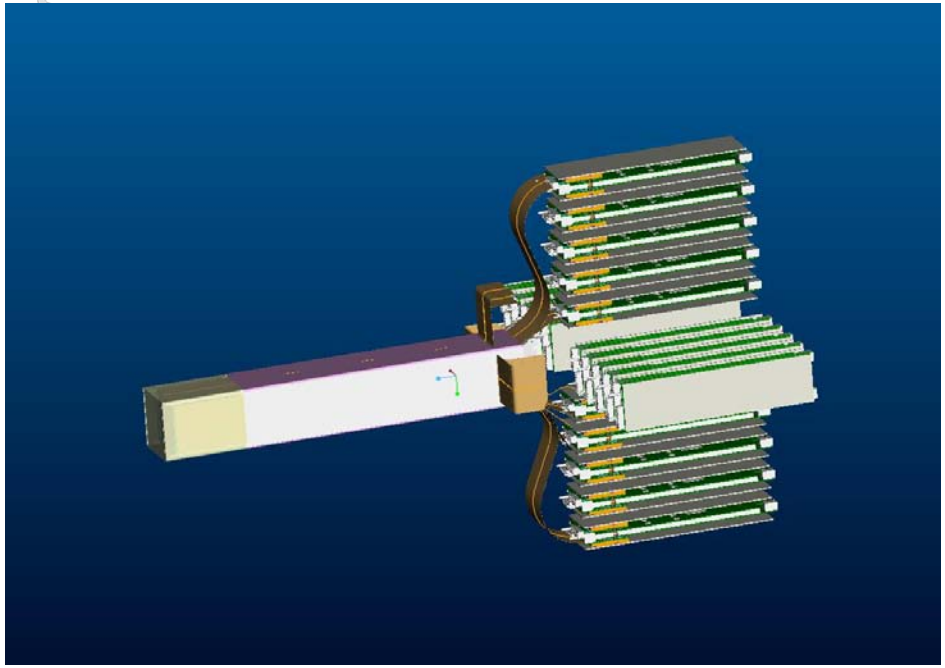


FEE width: 8cm
Prototype – air cooling
Production – recirculating coolant

Gbit ethernet, clock, JTAG ports
Power

Prototype AIDA Enclosure

- Prototype mechanical design
- Based on 8cm x 8cm DSSSD
  evaluate prior to design for 24cm x 8cm DSSSD
- Compatible with RISING, TAS, 4π neutron detector



- 12x 8cm x 8cm DSSSDs
  24x AIDA FEE cards
- 3072 channels
- Design complete
- Mechanical assembly in progress

In –beam test on the FRS approved (S390)
Hope to be scheduled in the 2nd half of 2011

Overview of the proton radioactivity

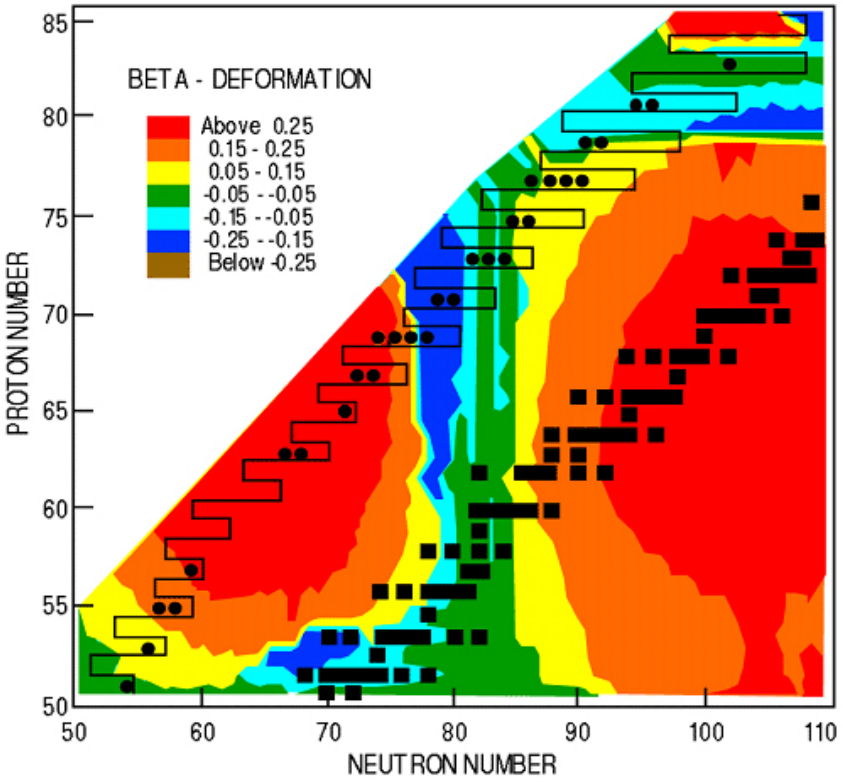
Proton radioactivity provides information on

l_p wavefunction

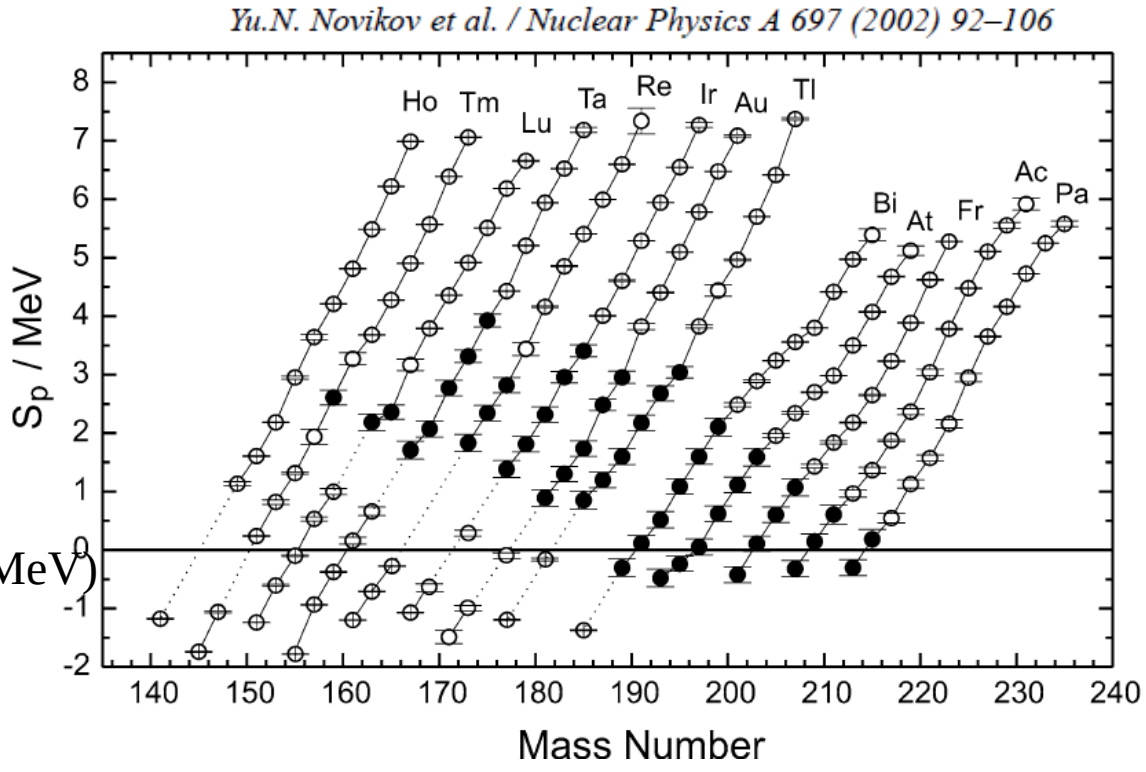
deformation

Z = 53 – 83 (except Z = 61)

to extend these studies to the trans-lead and sub-tin regions



Proton drip-line and candidate p-emitters



p drip-line p-emitters (Q_p~1.5 MeV)

189Bi,	185Bi,
195At,	189,190At
201Fr,	197Fr,
207Ac	203Ac
213Pa.	207Pa

2–5 mass units from the lightest known isotopes.

Production and yield

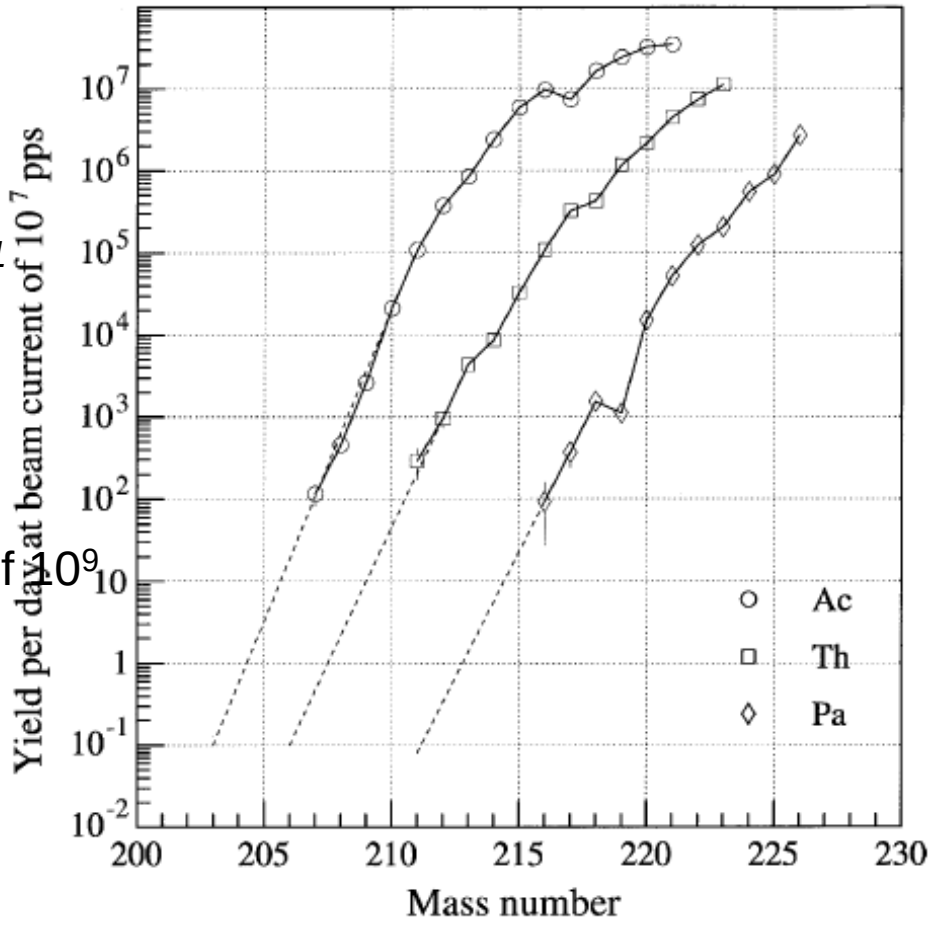
S235:
1*A* GeV 238U + beryllium target (1g/cm^2)

Z.Liu et al.,Nucl.Instrum.Methods Phys.Res. A543, 591 (2005)

secondary beam 930MeV/u.

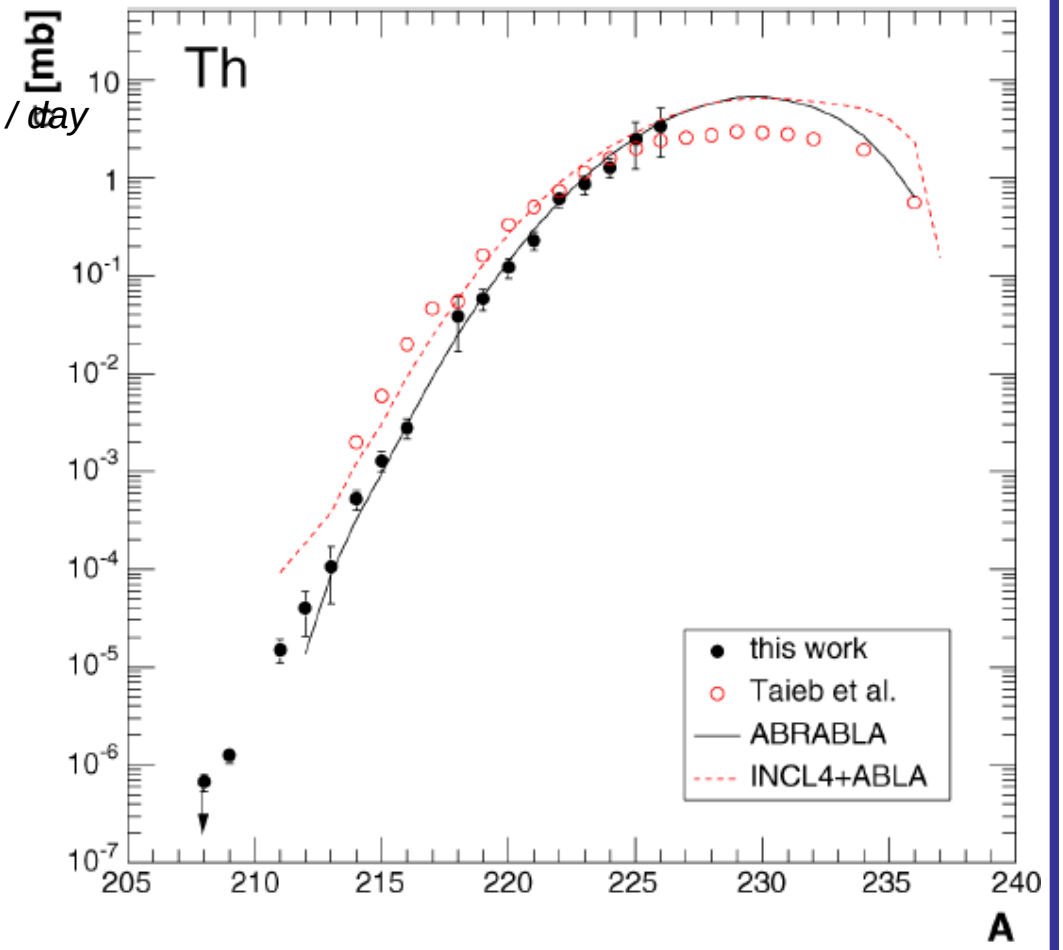
Yeilds extrapolated at the beam intensity of 10^9 pps,

208Th,209Th ~100 per day
and 203Ac:~10 per day



production cross-section from the fragmentation of the 1A GeV 238U

	σ_{th}(*mb*)	σ_{exp} (*mb*)	imp. *yield / day*
209 Th	2.8×10^{-6}	1.3×10^{-6}	100
208 Th	4.5×10^{-7}	$< 6.7\times10^{-7}$	50
203Ac	1.2×10^{-8}		10
204Ac	9.6×10^{-8}		80
205Ac	6.8×10^{-7}		600
199Ra	1.9×10^{-9}		
200Ra	2.0×10^{-8}		20
201Ra	1.7×10^{-7}		150
199Fr	3.4×10^{-6}		3000
198Fr	4.2×10^{-7}		350
197Fr	4.5×10^{-8}		40
196Rn	1.9E-5		15000
195Rn	2.2E –6		2000
194Rn	2.1E –7		200
193Rn	1.7E –8		15
191At	1.8×10^{-7}		150
190At	1.2×10^{-8}		10
189At	6.7×10^{-10}		



J. Kurcewicz et al. / Nuclear Physics A 767 (2006)

Spectroscopy in the p-rich trans-lead and sub-uranium region

proton drip-line -- lightest known isotope -- p-emitter

189Bi,		185Bi
195At,	191At	189At
201Fr,	199Fr	197Fr,
207Ac	206Ac	203Ac
213Pa.	212Pa	207Pa

2–5 mass units from the lightest known isotopes.

WKB half-life estimations for Qp = 1.5 MeV, Z = 89

Configurations

203Ac g.s. 7/2–, l = 3

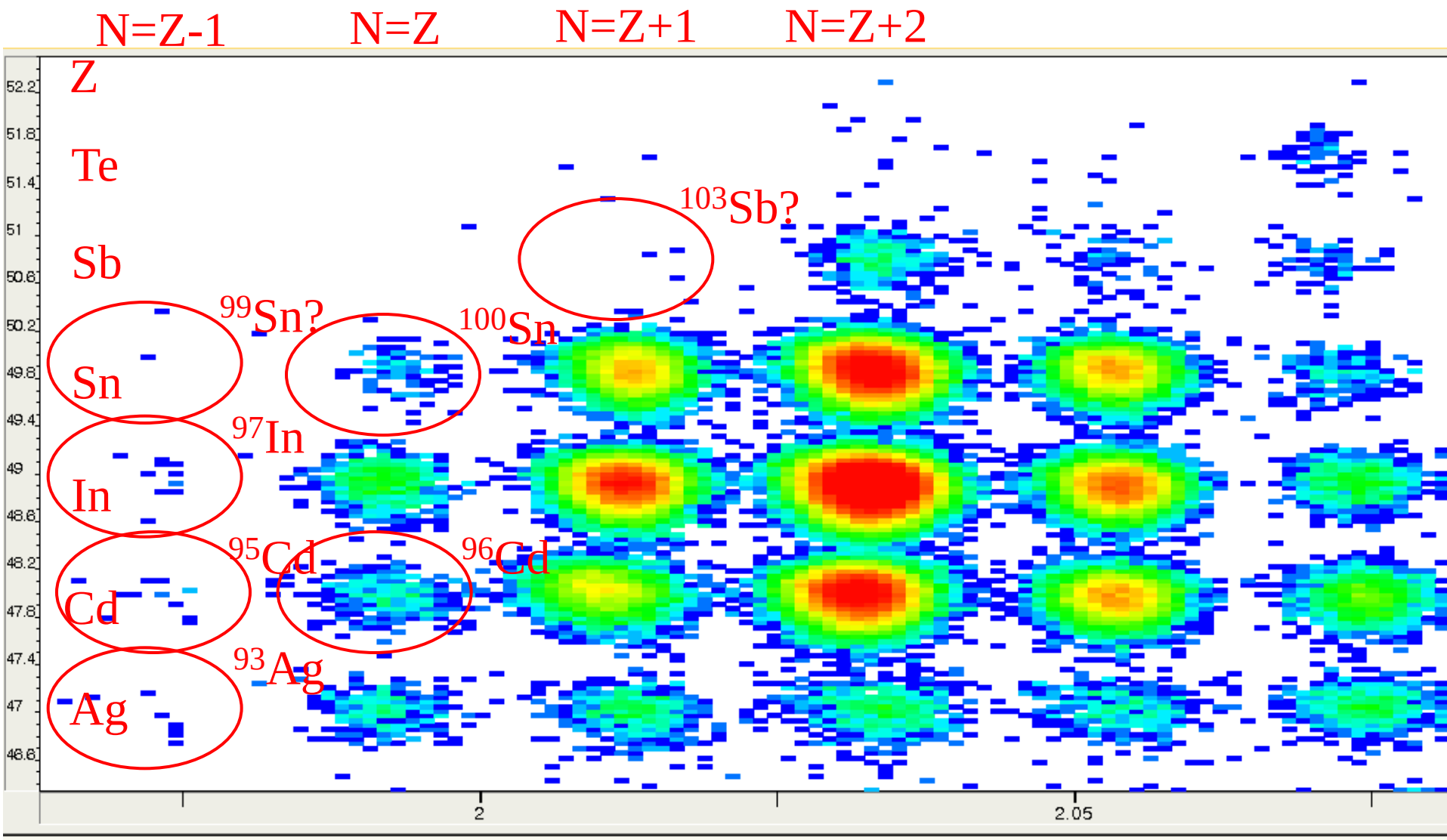
2nd min., 5/2– , l = 3

197Fr g.s. 11/2+, l = 6

2nd min., 5/2+ , l = 2

l	$t_{1/2}$
0	100 μs
1	1.3 ms
2	4 ms
3	30 ms
4	300 ms
5	5 s

Proton Radioactivity Candidates Below ^{100}Sn



Qp and $T_{1/2}$ for ^{97}In, ^{93}Ag and ^{89}Rh

with $T_{1/2}$ > 0.2 μs and L=4 transitions

we get (using Delion et al. PRL96(2006)) the Q_p values:

	our limit	Lalazissis et al.	Herndl, Brown	Audi et al.
		NPA 679 (2001)	NPA 627 (1997)	NPA 729 (2003)
		rel. H B	shell model	extrapolation
^{93}Ag	< 1.1MeV	0.11	0.95	1.43(78)
^{97}In	< 1.2MeV	0.37	1.28	1.81(78)

89Rh : reasonably good candidate

	Audi et al;	Brown et al;	Moller et al;
Qp	700(200) keV	640 Kev	500 keV
T1/2p	300μs	8 ms	5s (bp~2%) : beta dominate

Measurable half-life range

0.5 μs < t/1/2 < 100 ms

93Ag 1.02 MeV > Qp > 0.65 MeV

89Rh 0.94 MeV > Qp > 0.60 MeV

Production and yield

WKB half-life estimations for Qp = 1.5 MeV, Z = 89

l	$t_{1/2}$
0	100 μs
1	1.3 ms
2	4 ms
3	30 ms
4	300 ms
5	5 s

Configurations

^{203}Ac g.s. $7/2^-$, l = 3

2nd min., $5/2^-$, l = 3

^{197}Fr g.s. 11/2+, l = 6

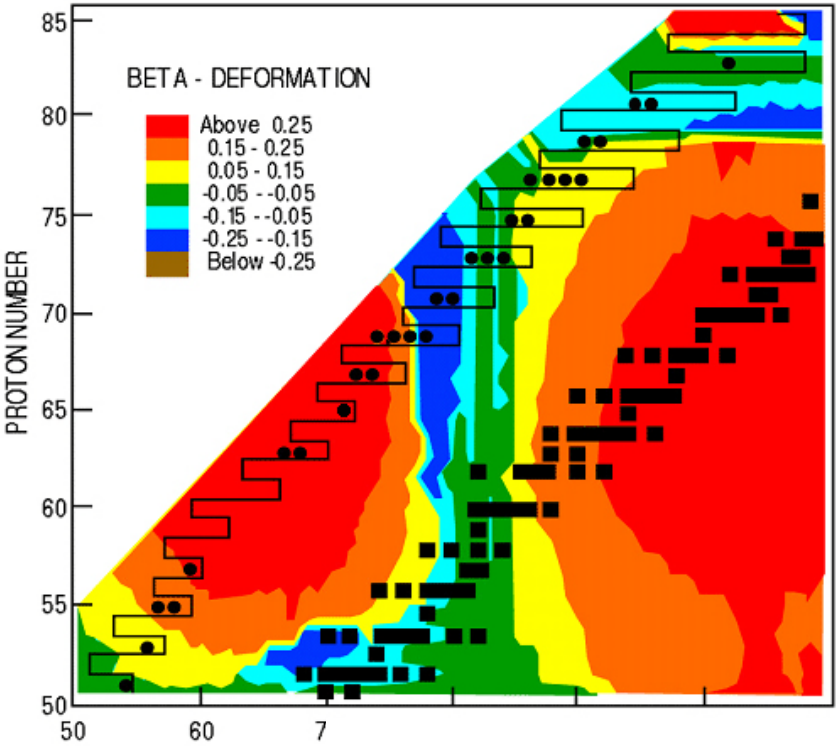
2nd min., 5/2+ , l = 2

Search for p-emitter in the sub-uranium region

p-radioactivity studies have been conducted swathe of the proton dripline,

50<Z<82: g.s. and low-lying isomer

Z<50: high-lying, high-spin isomer
53mCo 19/2-
54mNi: 10+
94mAg (21+)
2p decays
45Fe, 48Ni, 54Zn



the heaviest proton emitter identified so far ^{185}Bi (Z=83)

Our goal is to extend these studies into the sub-uranium region