Neutron-rich nuclei along the Z=82 and N=126 closed shells

S347: N=126 (Zsolt Podolyák, University of Surrey)

24 shifts; accepted

S350: Z=82 (Giovanna Benzoni, INFN Milano;

Jose Javier Valeinte Dobón, INFN Legnaro)

18 (+6) shifts; accepted

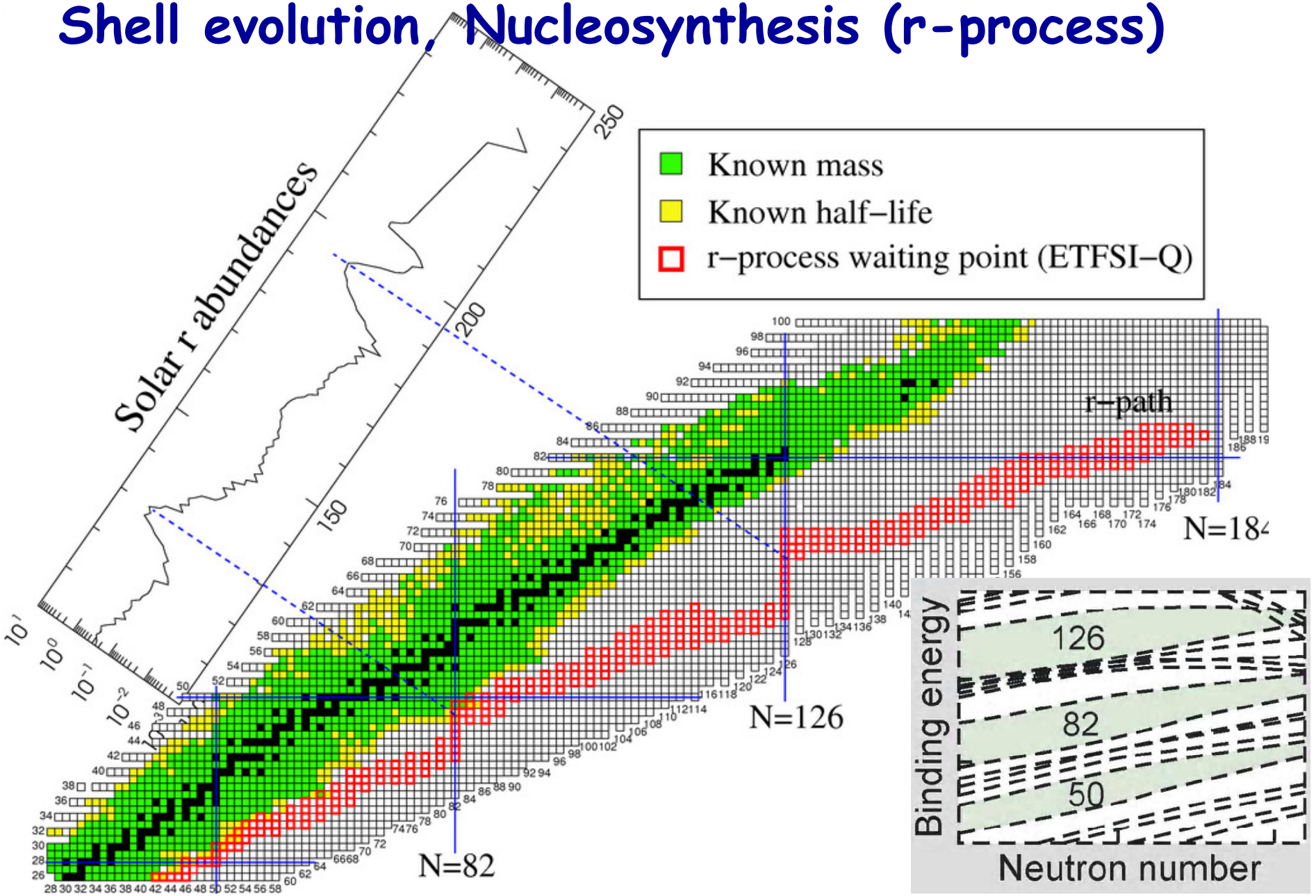
RISING

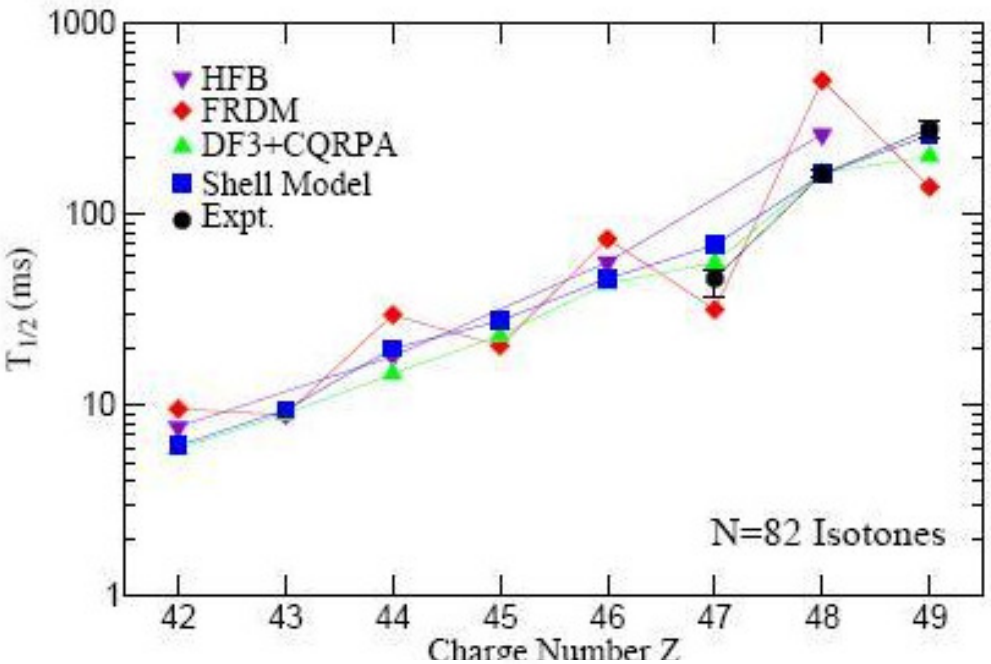
University of Surrey, UK
GSI, Darmstadt, Germany
University of Köln, Germany
University of Warsaw, Poland
Santiago de Compostella, Spain
ATOMKI, Debrecen, Hungary

INFN Legnaro, Italy
INFN Milano, Italy
GSI, Germany
Compostella, Spain
...

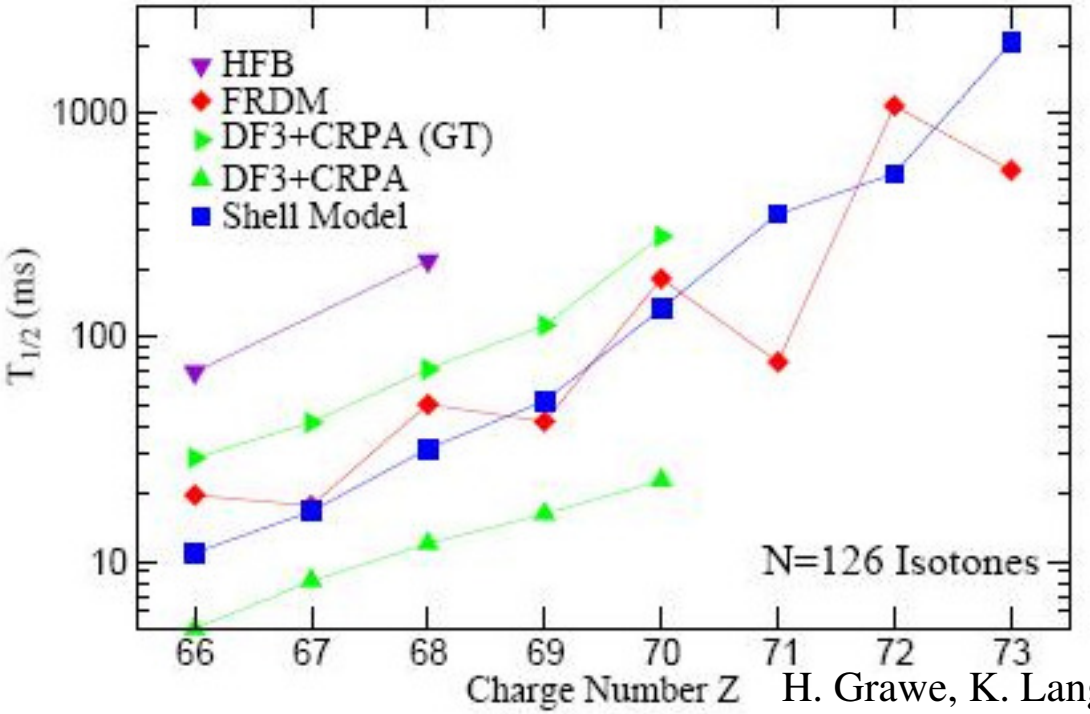
Fundamental questions in nuclear physics:

Shell evolution, Nucleosynthesis (r-process)





N=82

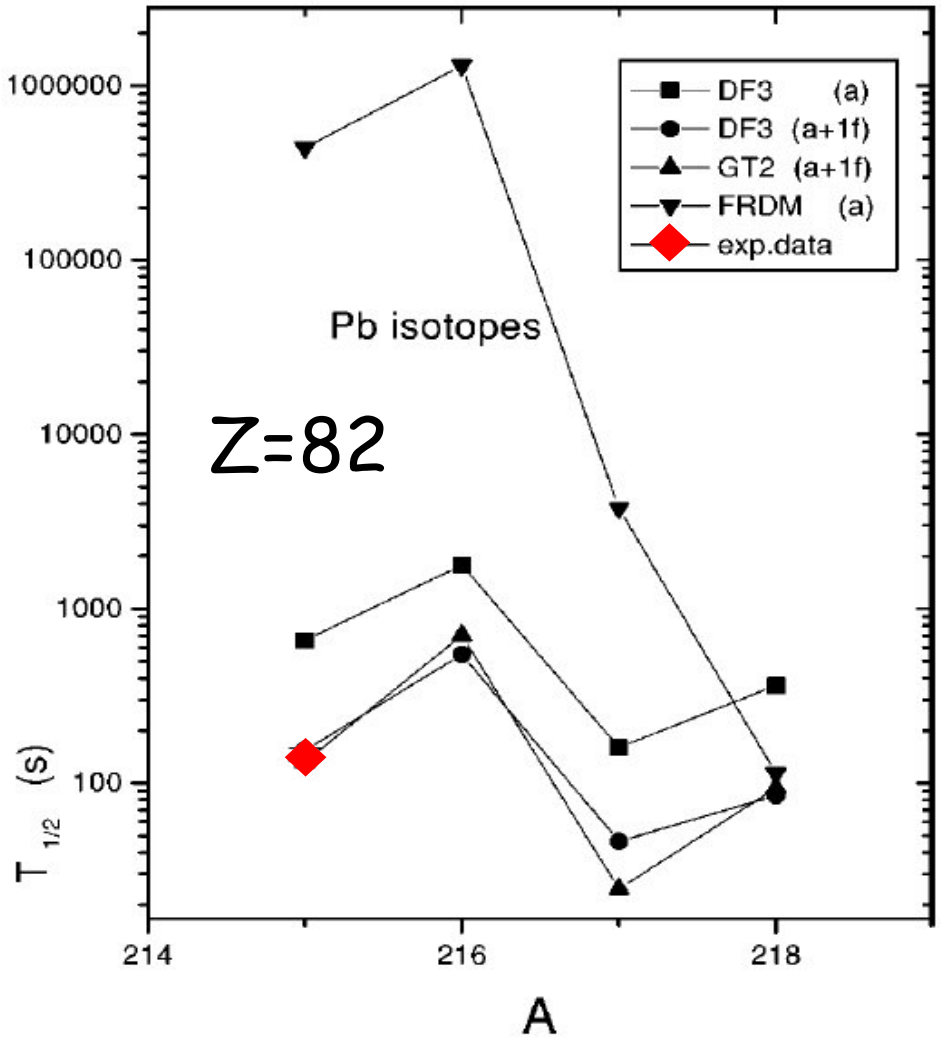


N=126

Larger differences
(lack of experimental data)

H. Grawe, K. Langanke, G. Martinez-Pinedo, to be published.

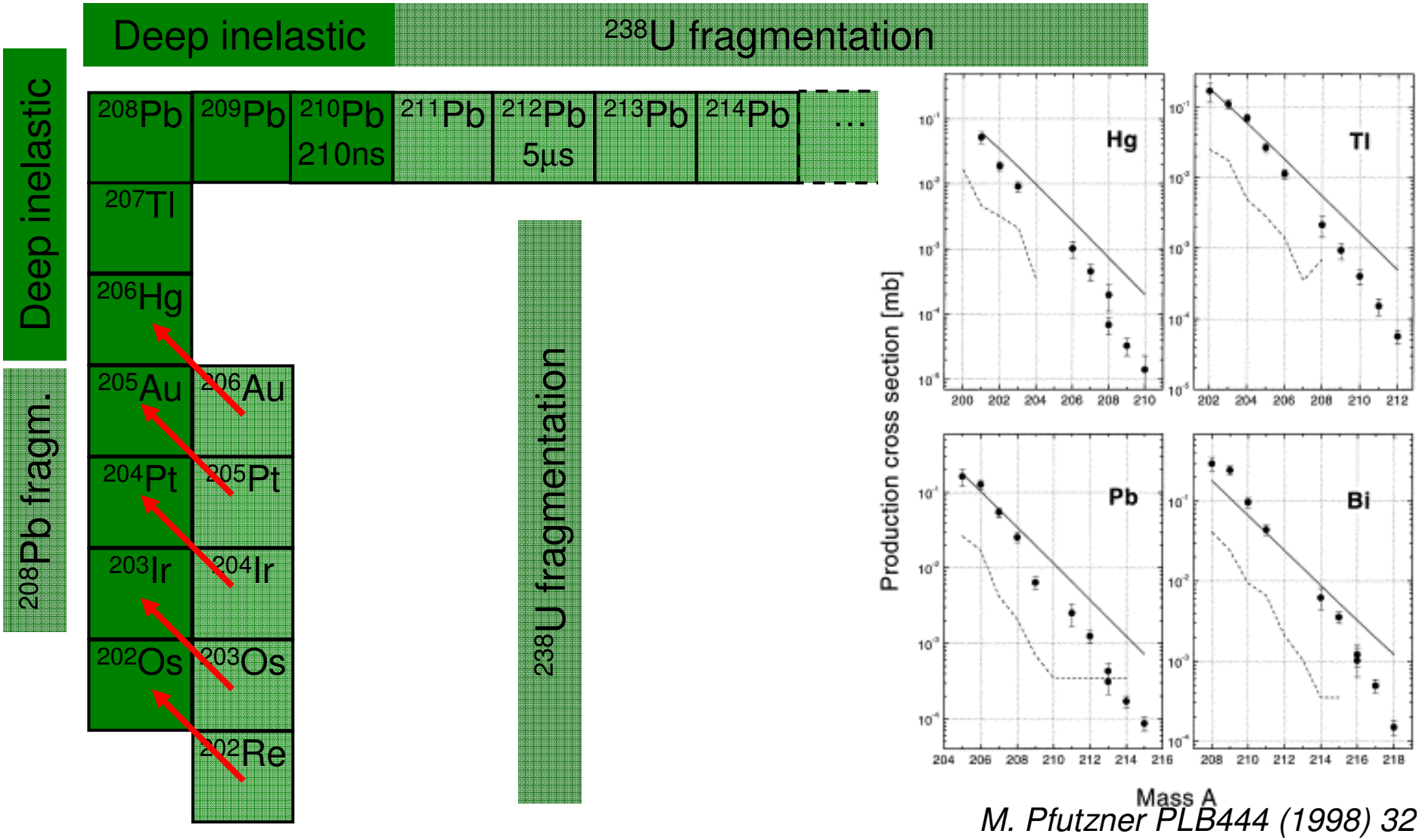
Beta-decay lifetimes



- Experimental β-decay data needed around ^{208}Pb to validate theoretical models.
- Models might differ by orders of magnitude to reproduce the lifetimes.
- β-lifetimes needed for r-process calculations.
- Last lifetime measured for ^{215}Pb

I.N. Borzov PRC67, 025802 (2003)

Experimental approach



M. Pfutzner PLB444 (1998) 32

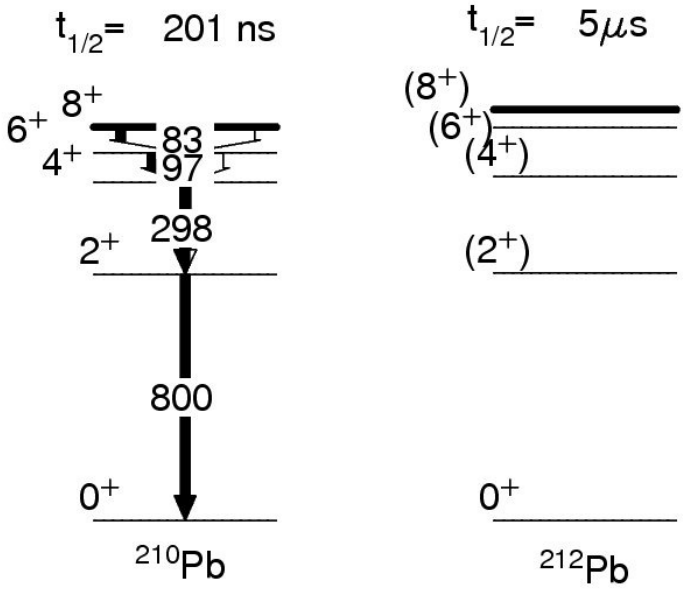
GSI UNILAC-SIS + FRS + RISING is unique
to study heavy neutron-rich nuclei.

What is known along Z=82?

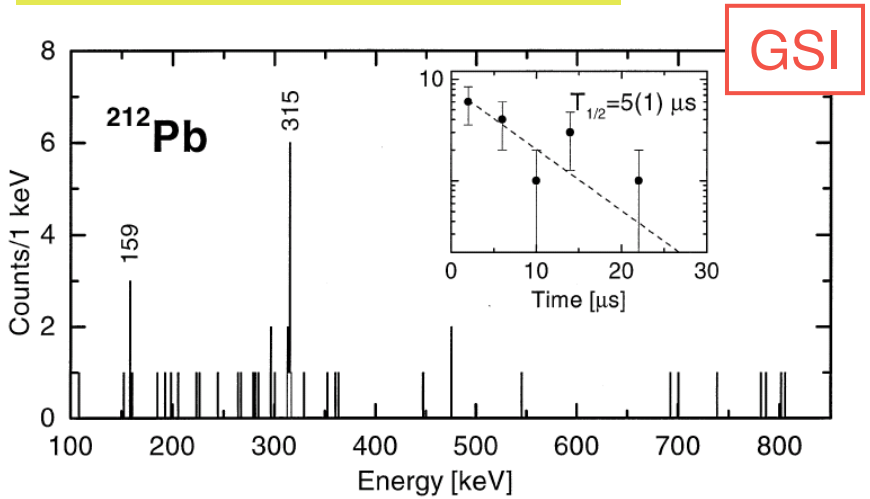
What we know, where we want to go

Presence of isomers involving high-j orbitals $vg_{9/2}$, $vi_{11/2}$, $vj_{15/2}$

Taking advantage of these isomers we want to study the developmet of nuclear structure from ^{212}Pb up to ^{220}Pb



Configuration $(vg_{9/2})^4$



- 5x10^6 pps
- 2 HPGe detectors (Eff$_\gamma$=1%)
- 350 ions implanted

Neutron-rich lead isotopes known up to ^{212}Pb

M. Pfutzner PLB444 (1998) 32.

Beam time request

Ions/s = σ x I_{beam} x N_{target} x *Transmission*

I_{beam} = 3x10^8 pps, N_{target}= 1.6 g/cm^2, *Transmission* = 40%

	$COFRA(mb)$	Ions/hour	Ions/day
^{212}Pb	9.05×10^{-4}	41.60×10^{3}	1.00×10^{6}
^{214}Pb	1.84×10^{-4}	9.30×10^{3}	2.20×10^{5}
^{216}Pb	3.01×10^{-5}	1.30×10^{3}	3.30×10^{4}
^{218}Pb	3.69×10^{-6}	1.80×10^{2}	4.40×10^{3}
^{220}Pb	3.17×10^{-7}	15.0	3.50×10^{2}

Eff$_\gamma$=9%, Eff$_\beta$~ 100%
Isomeric ratio = 50%

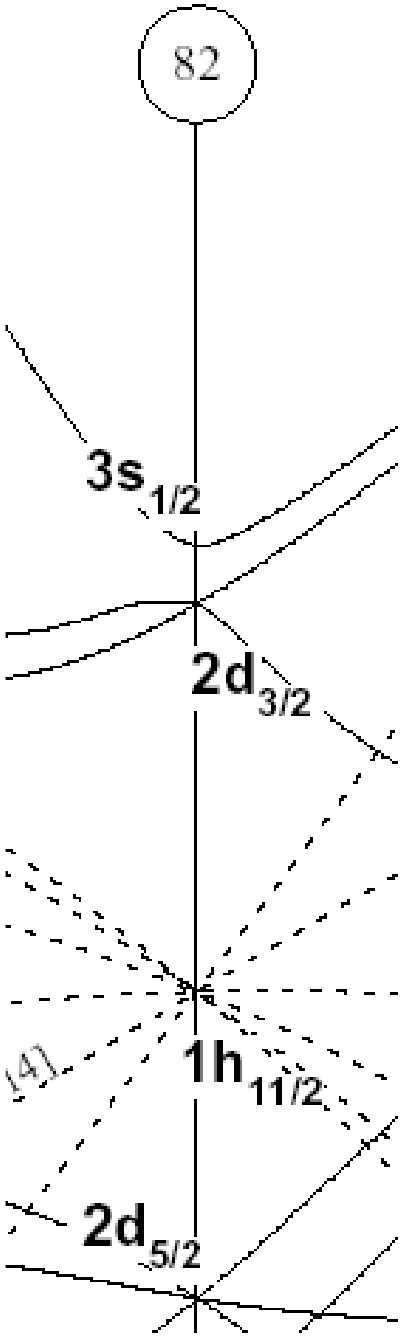
➔~ 1700 isomeric γ decays/day for ^{212}Pb
➔~ 15 isomeric γ decays/day for ^{220}Pb
➔~ 10^4 β decay/day for ^{216}Pb
➔~ 200 β decay/day for ^{220}Pb

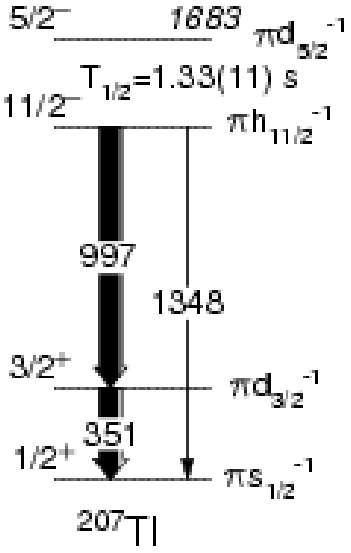
18 shifts (+ 3) accepted

Summary

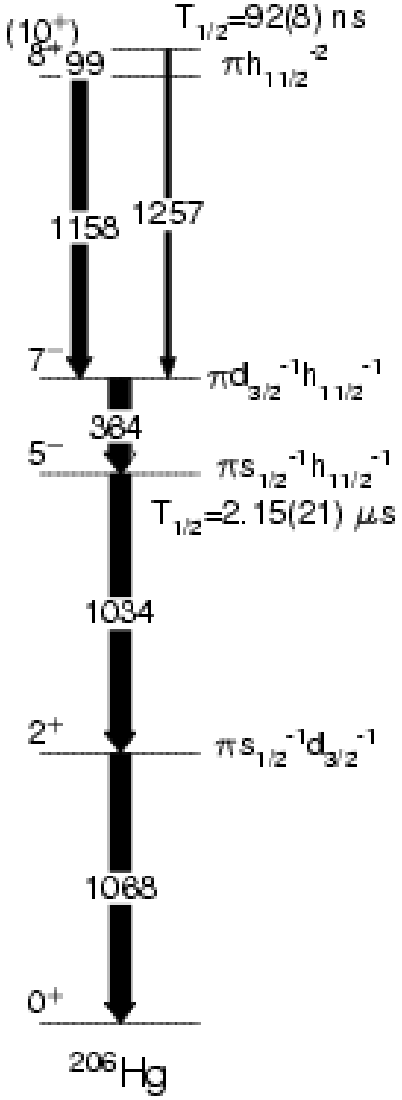
- Shell evolution of lead isotopes from ^{212}Pb up to ^{220}Pb by means of delay-gamma ray spectroscopy
- Beta-decay lifetime measurement of the very neutron-rich nuclei ^{216}Pb, ^{217}Pb, ^{218}Pb, ^{219}Pb, ^{220}Pb
- Use of ^{238}U fragmentation at 1GeV/u + FRS + RISING
  - UNIQUE worldwide facility to populate and study the neutron-rich lead isotopes
  - High beam intensity ➔ 3x10^8 pps
  - γ-ray efficiency 9-14% (1.3-0.6 MeV)
- Clearly reacheable ^{212}Pb and feasible to reach ^{220}Pb
- Request: 21 shifts + 6 parasitic shifts for FRS settings

What is known along N=126 ?



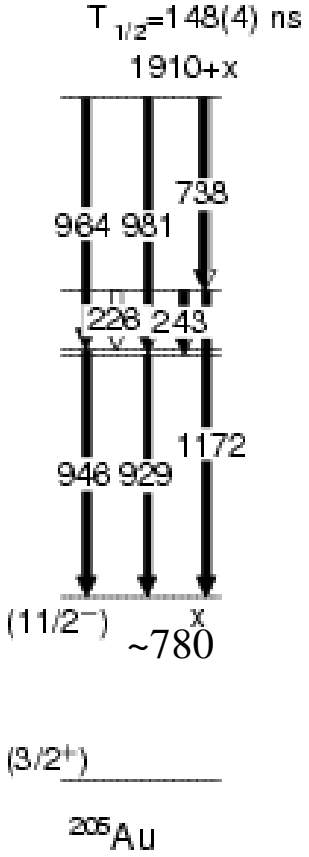


Z=81

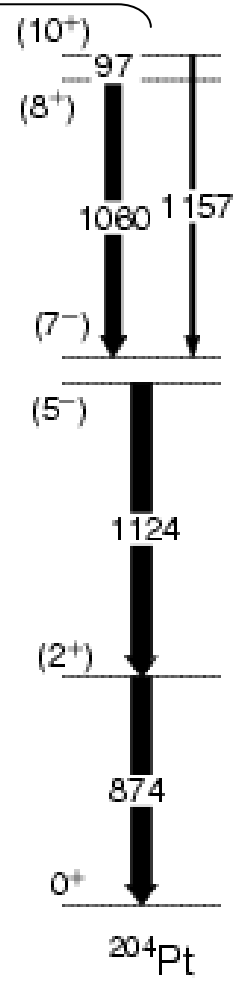


Z=80

RISING exps.

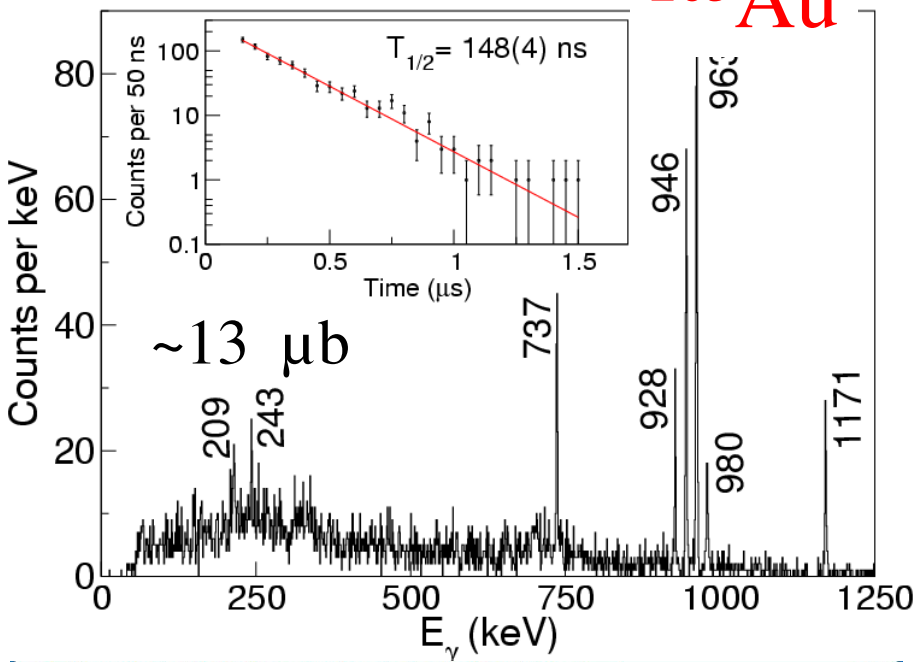


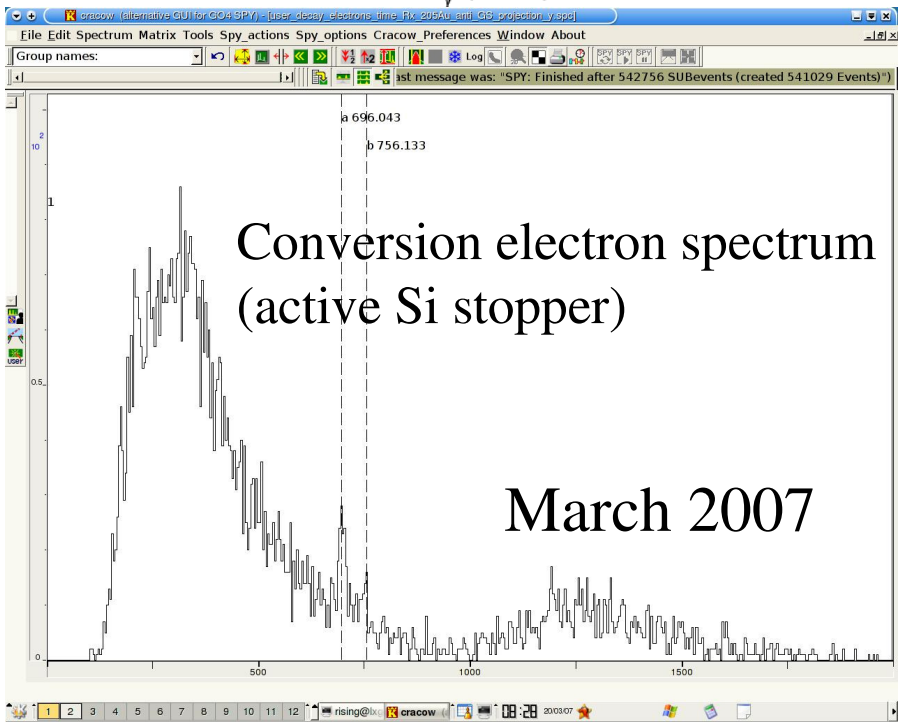
Z=79



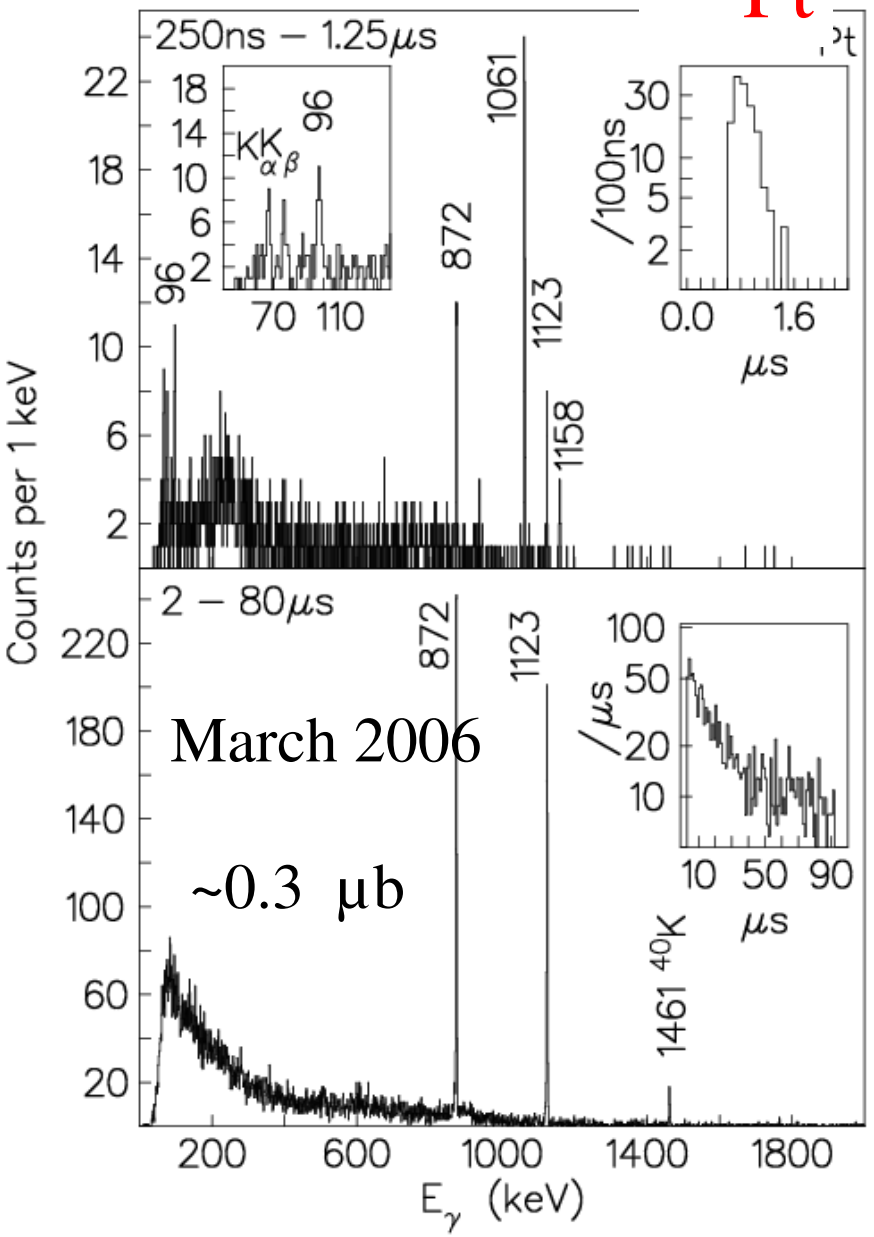
Z=78

^{205}Au



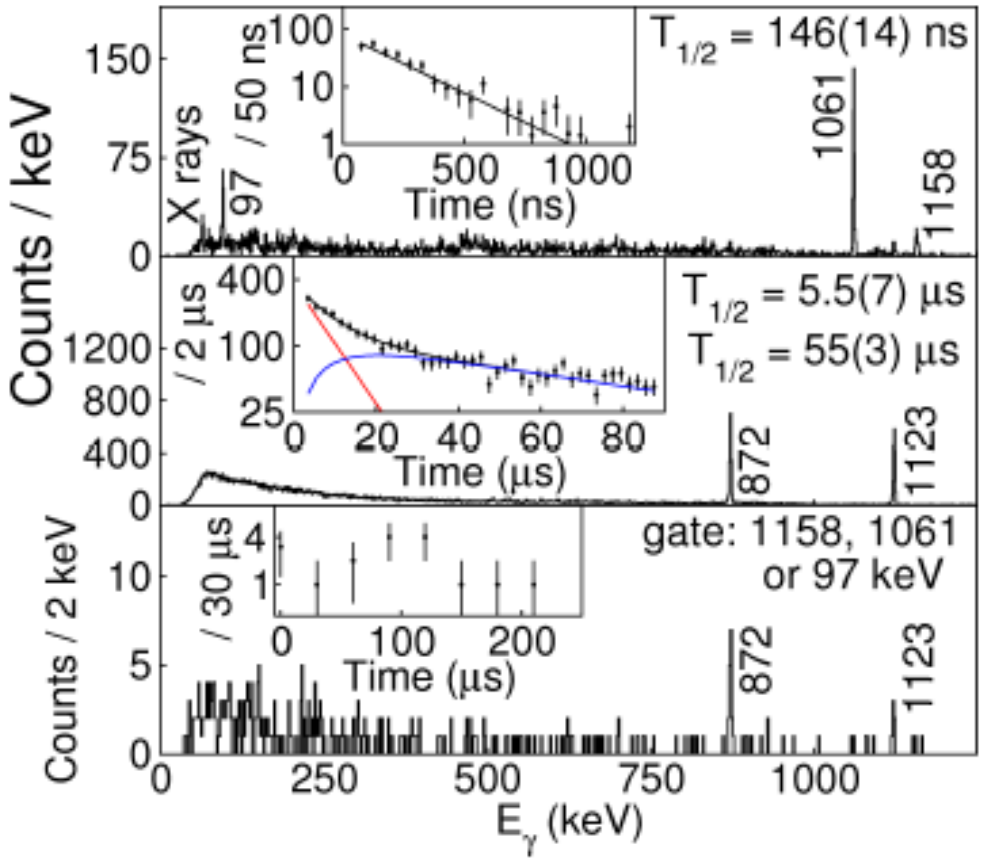


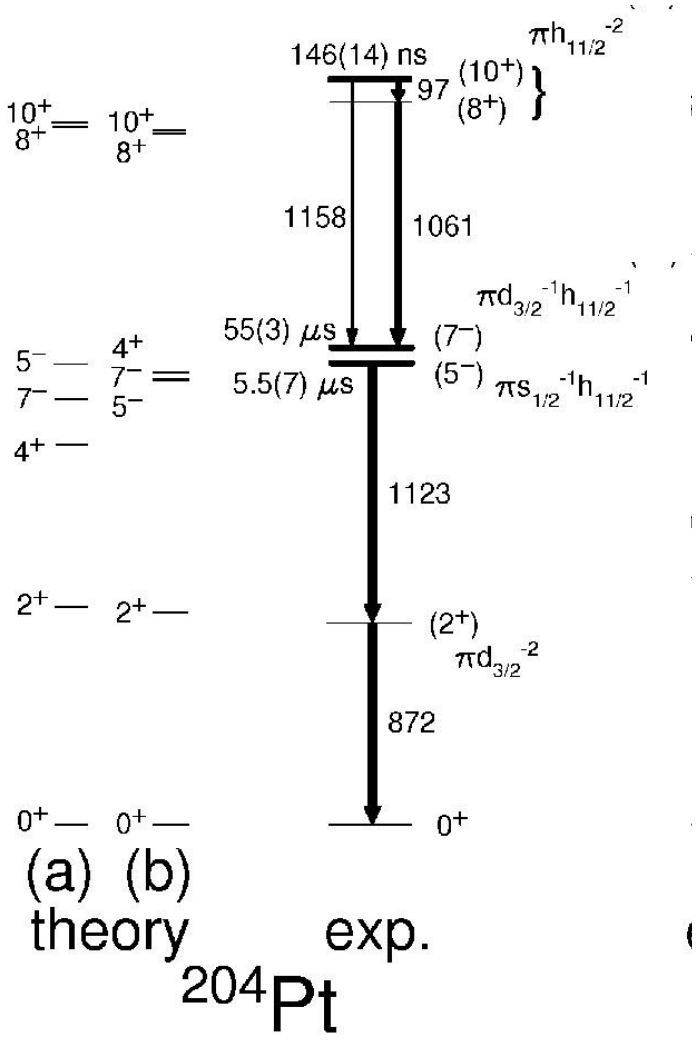
^{204}Pt



^{208}Pb beam was used

What is known along N=126?





^{204}Pt: four proton-hole in double magic ^{208}Pb

S.Steer et al, submitted to Phys. Rev. C (R)

To understand the structure of 204Pt changes in the standard set of TBME needed.

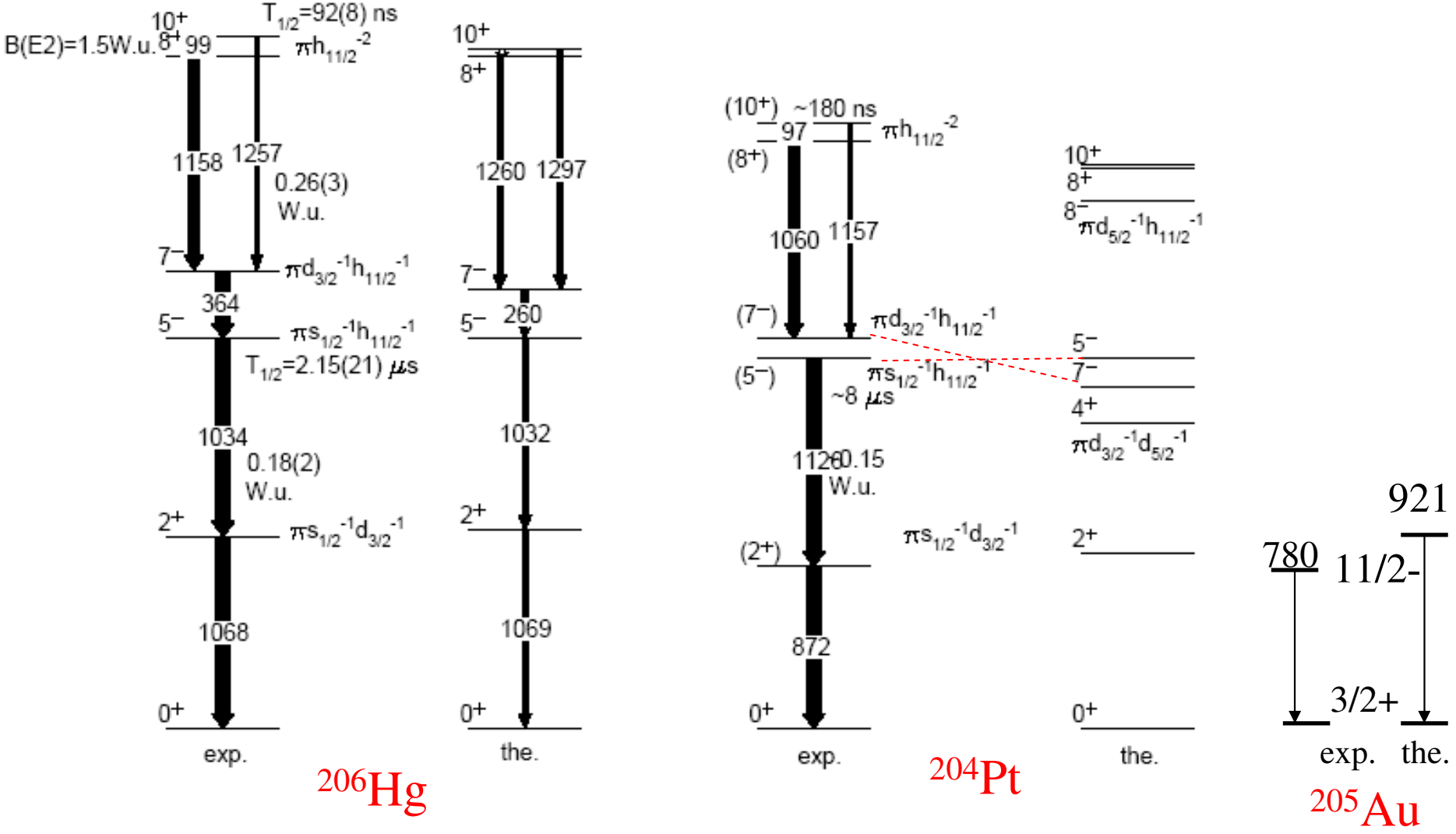
(see also half-lives in this mass region, J.Benlliure et al.

⇒Consistent with shortening the half-lives of the N=126 nuclei with the effect of shifting up the point where the r-process path leaves the N=126 isotones

Shell-model calculations (A.Brown, M.Górska)

Single-hole energies, int. matrix elements fitted on the region

L.Rydstrom et al, NPA512(1990)217 (based on Kuo-Brown interaction)



Problems: states with $\pi d_{5/2}^{-1}$; order of $\pi d_{3/2}^{-1} h_{11/2}^{-1}$ and $\pi s_{1/2}^{-1} h_{11/2}^{-1}$; $h_{11/2}^{-1}$ in 205Au

→ description of the observed states requires SPE or INT modification

Further ‘down’ along the N=126 line

^{205}Au: beta decay from ^{205}Pt

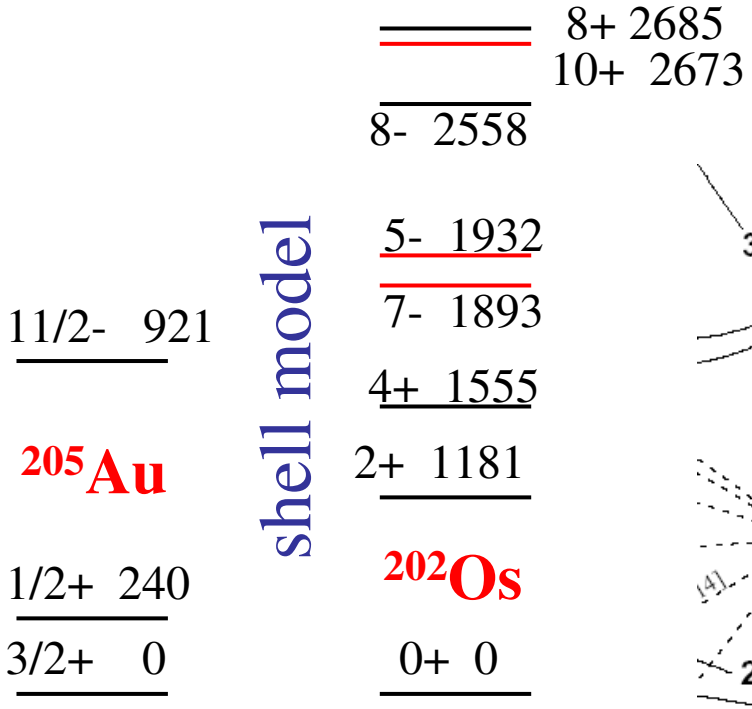
=> will fix the $\pi s_{1/2}$ orbital

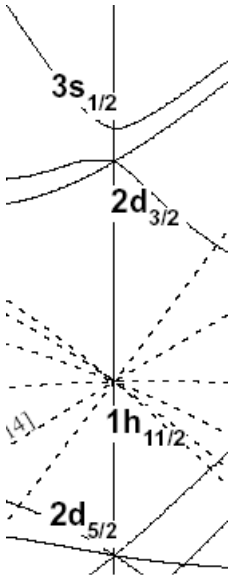
^{203}Ir: beta decay from ^{203}Os ($\nu g_{9/2}$)

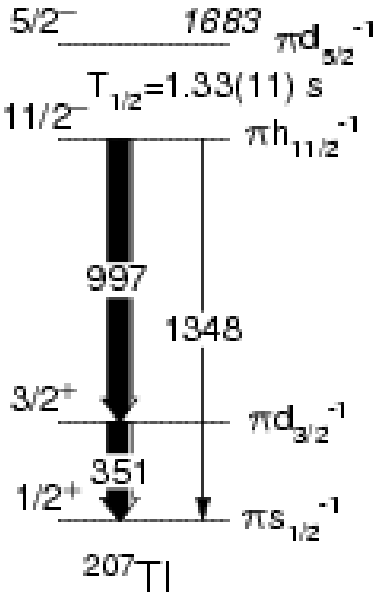
=> will fix the $\pi d_{3/2}$,$\pi s_{1/2}$,$\pi h_{11/2}$

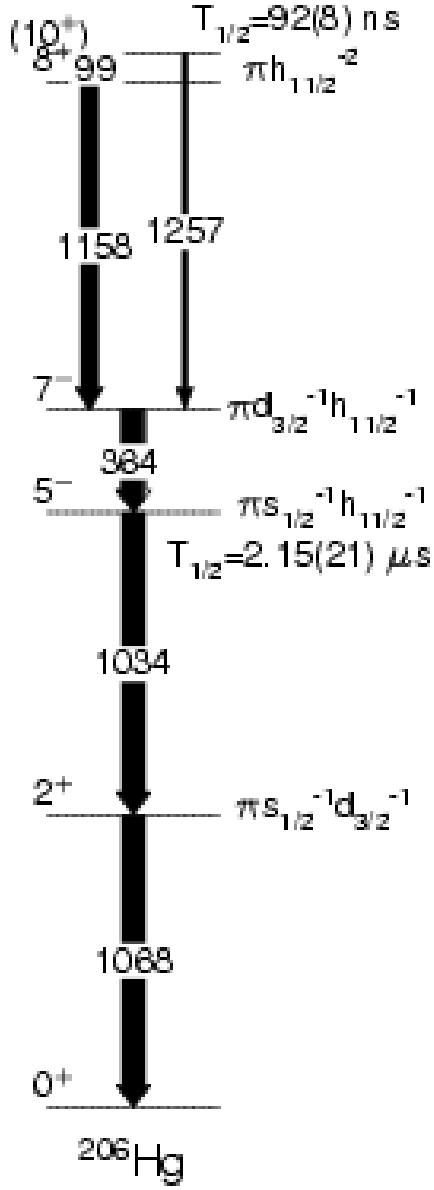
^{202}Os: isomeric decay I=(5),(7),(10)

^{202}Os: beta decay of ^{203}Ir ($\nu g_{9/2}$)









Ion	σ (mb)	*I*(hbar)	Rates(gamma)	Stopper
202Os	1.16×10^{-5} (EPAX)	(10), (7), (5)	150/h	passive
203Os->203Ir	6.32×10^{-6} (EPAX)		80/h	Si
202Re->202Os	1.11×10^{-6} (EPAX)		15/h	Si
205Pt->205Au	1.5×10^{-4} (EPAX)		2000/h	Si

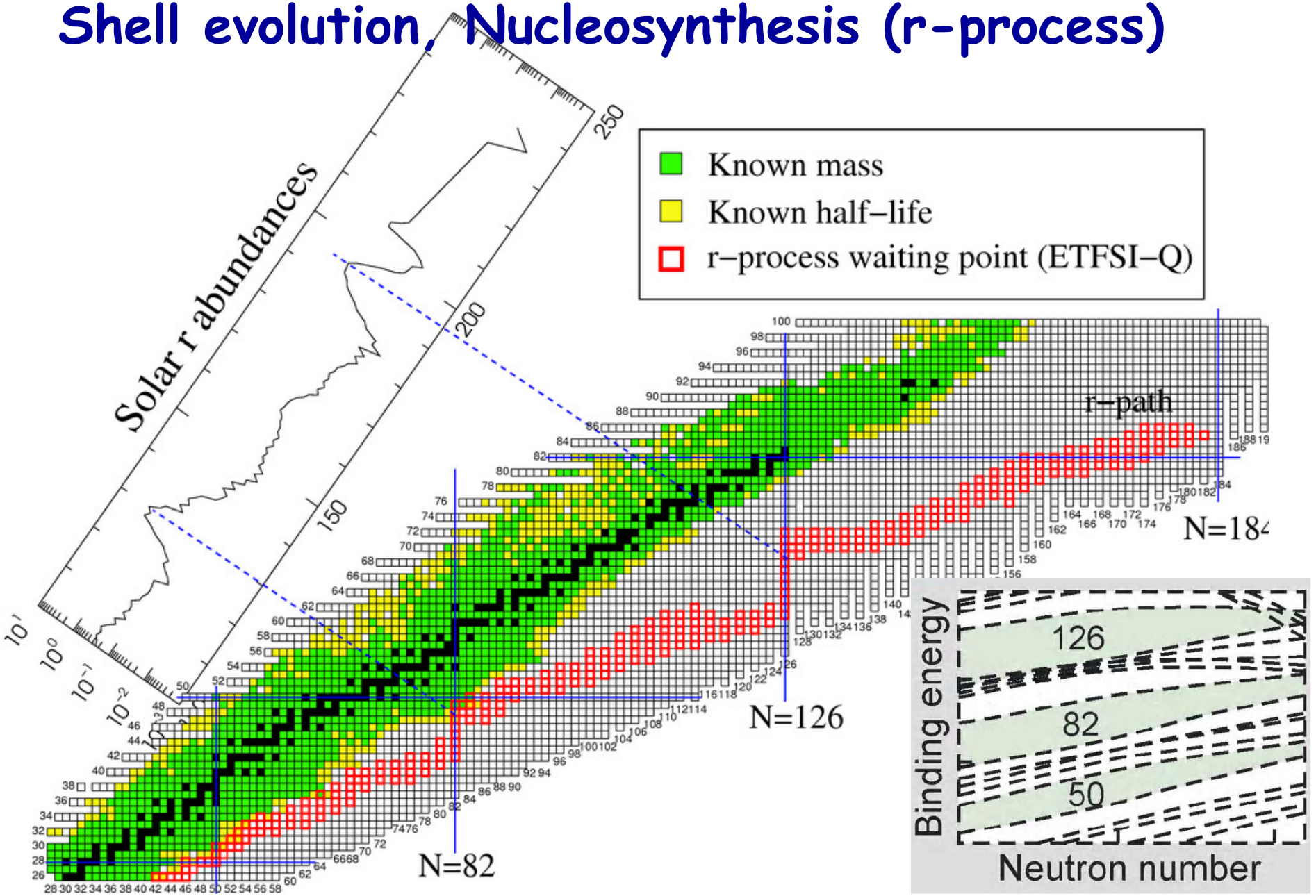
EPAX predictions might be too high COFRA lower

=> 22.6 days of beamtime left;
1.4 (+6) shifts used in 2008

Assumed: 3×10^9 ion/spill (1s ext.) 1 GeV/u ^{238}U; 2.5 g/cm^2 Be target
Transmission, survival=30%.
ε_γ =15%, ε_β=50%; IR=50% (202Os), IR=0.01% (high-spin)

Fundamental questions in nuclear physics:

Shell evolution, Nucleosynthesis (r-process)



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