Study of heavy neutron-rich nuclei important for the stellar nucleosynthesis r-process around N=126

Teresa Kurtukian-Nieto
CEN Bordeaux-Gradignan

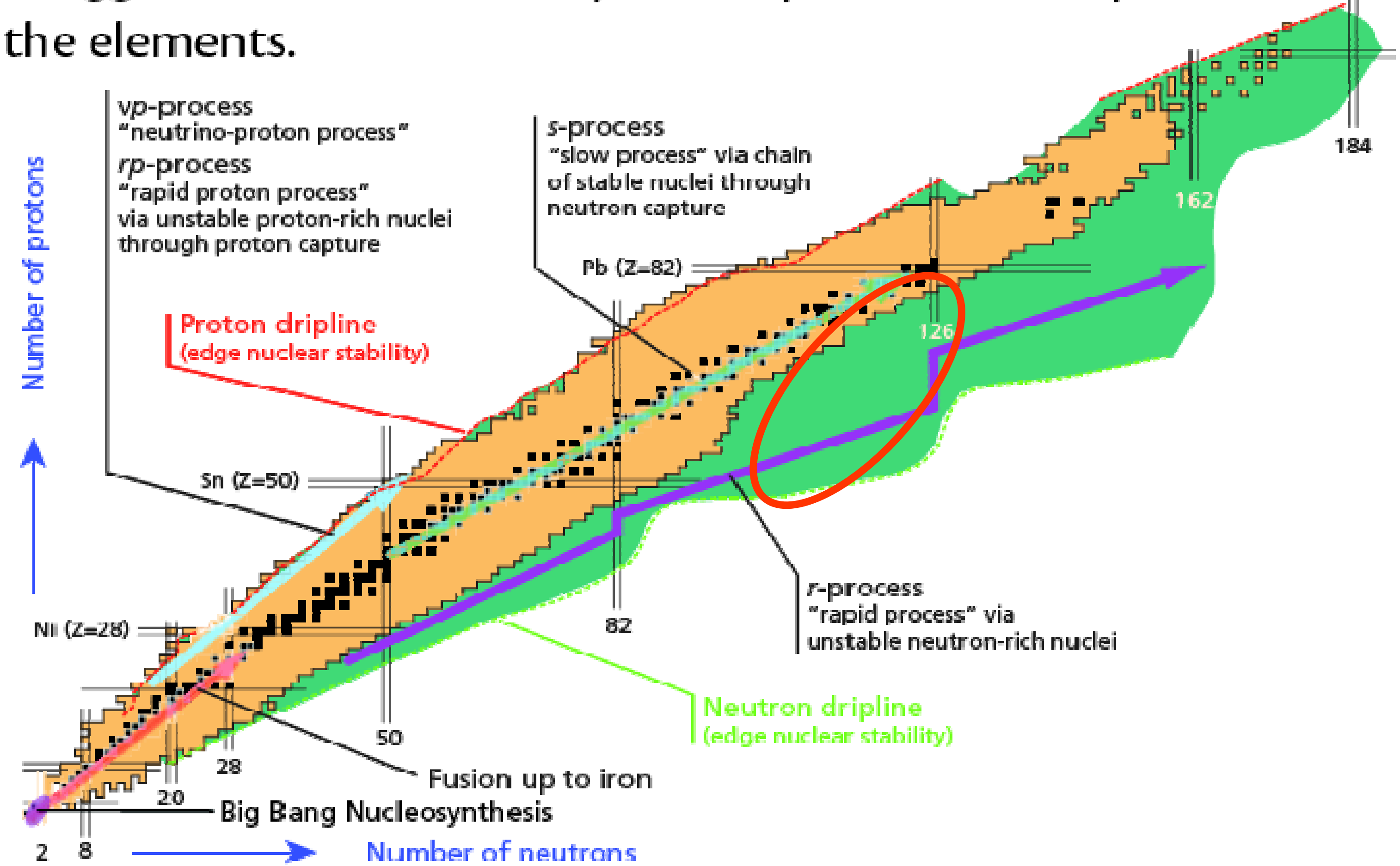
DESIR WORKSHOP 2010 Leuven, Belgium
May 27th 2010

Outline

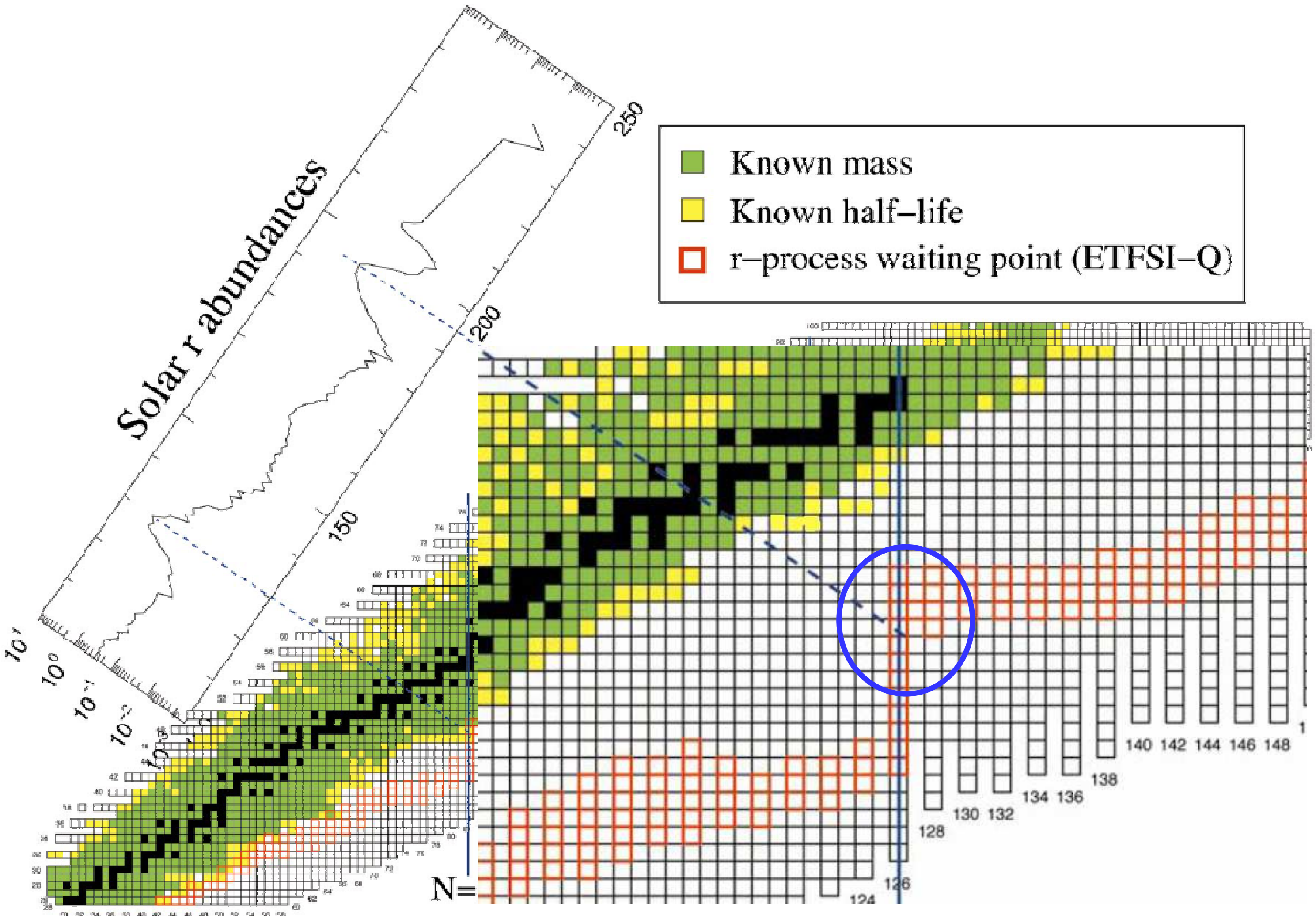
- Physics Motivation
- Production of heavy neutron-rich nuclei:
  - ✓ ISOL or In-flight ?
  - ✓ Reaction mechanism: Multi-nucleon transfer reactions
- Expected yields of N~126 Lu, Hf, Ta, W, Re and Os isotopes
- Experimental Setup @ DESIR-BESTIOL

Stellar nucleosynthesis processes

In 1957 Burbidge, Burbidge, Fowler and Hoyle and independently Cameron, suggested several nucleosynthesis processes to explain the origin of the elements.



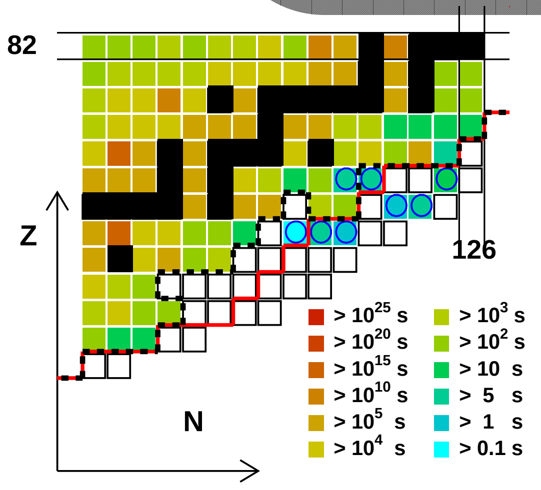
Stellar nucleosynthesis processes



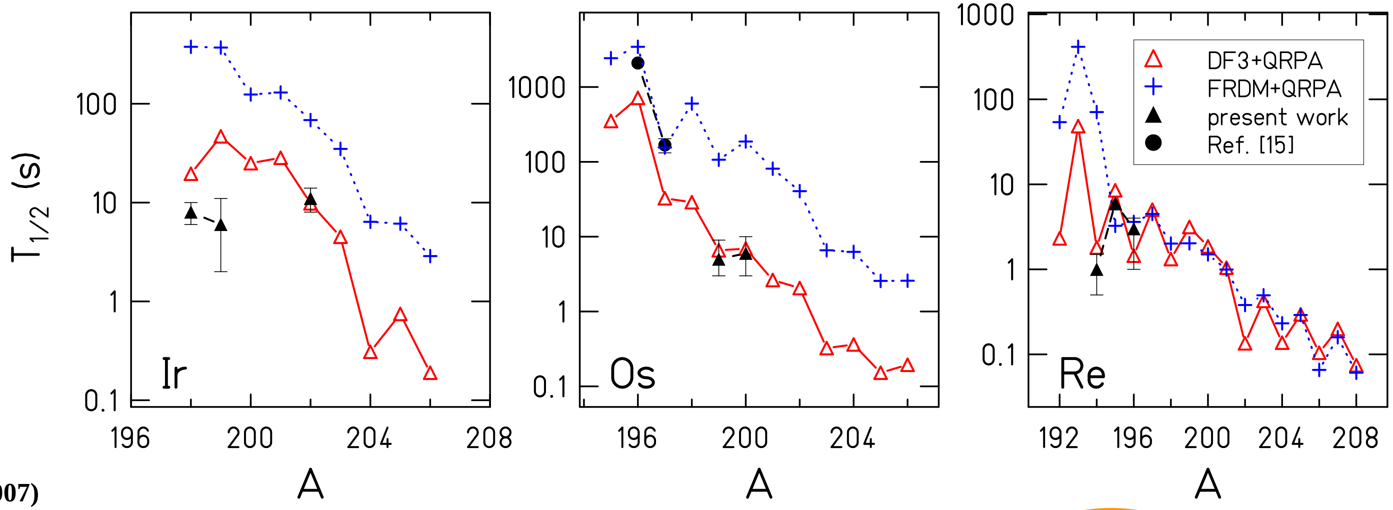
$^{198}Hf_{72}$

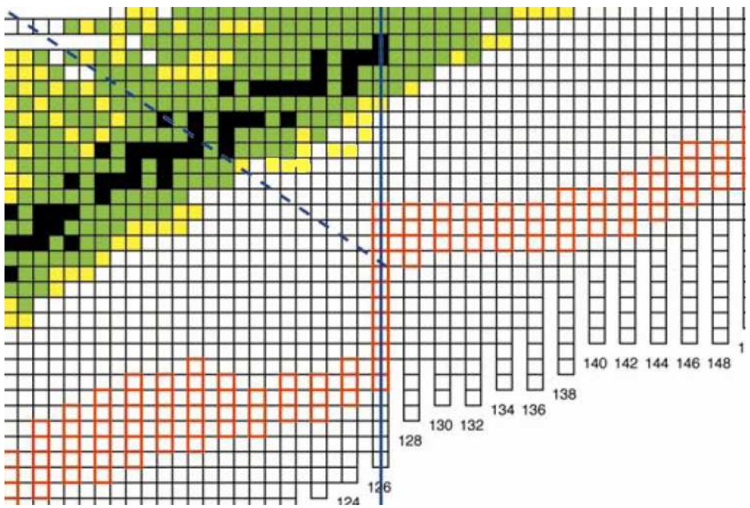
$^{197}Lu_{71}$

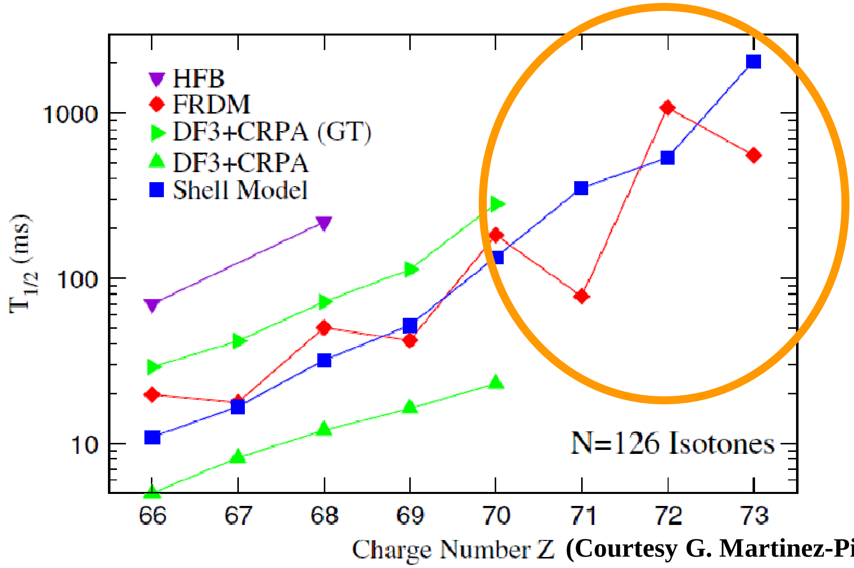
N=126 Half-lives



(T. Kurtukian-Nieto, PhD Thesis, 2007)

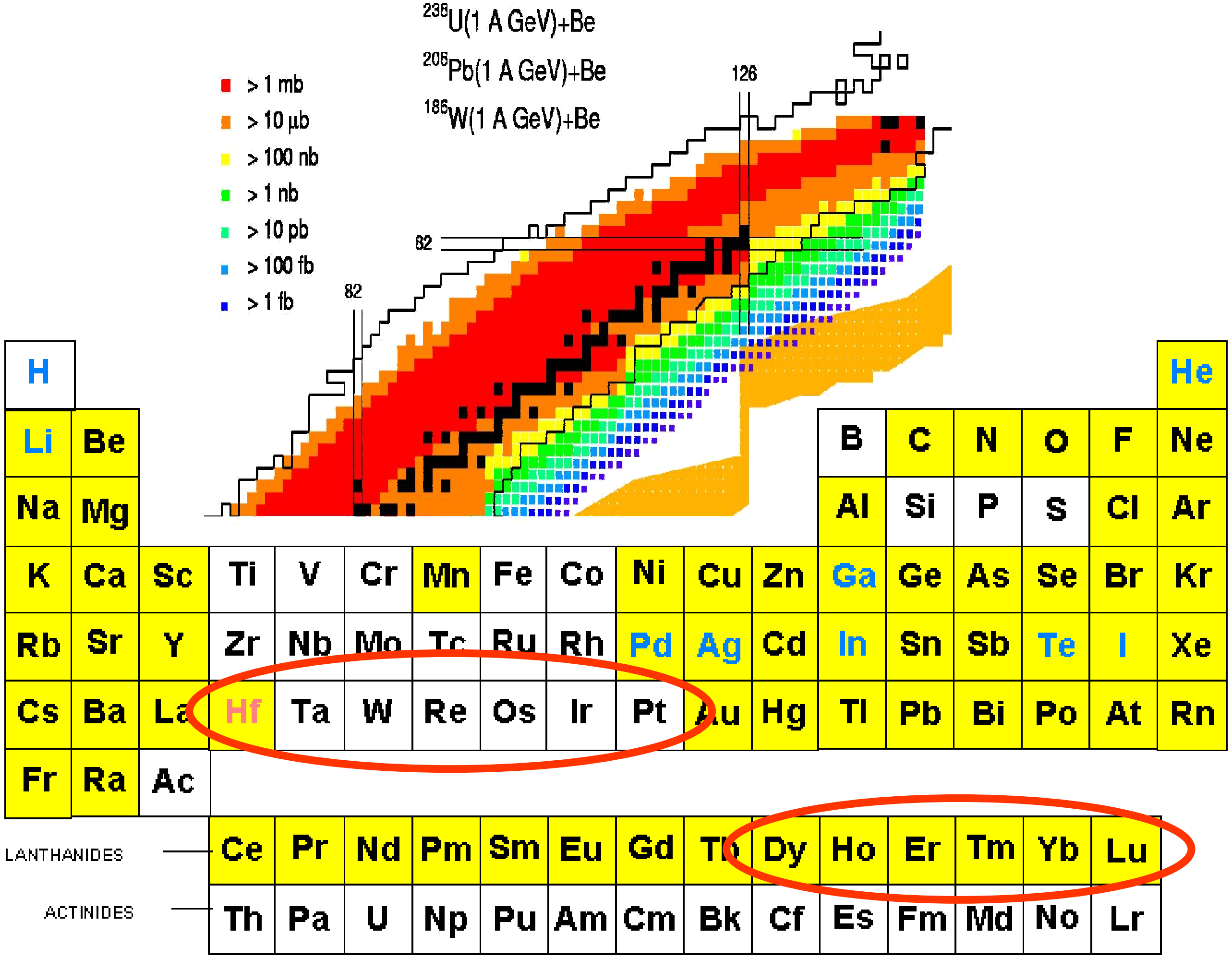






(Courtesy G. Martinez-Pinedo)

ISOL or In-flight

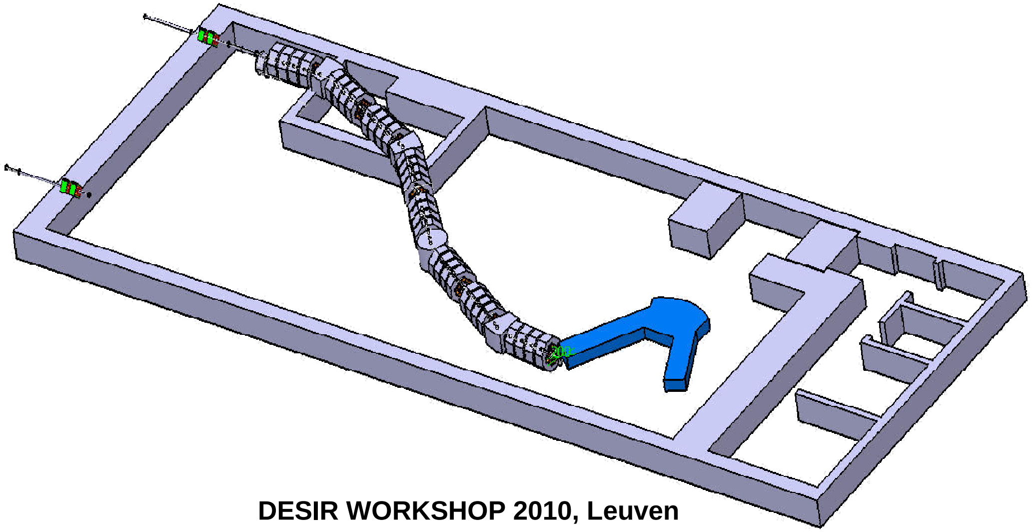


Production at S3

Spiral2	Conseil Scientifique IN_2P_3 30 Mars 2009	**S3 Spectrometer**

Production of neutron rich nuclei with transfer/Deep inelastic reactions

Very high primary beam intensities open also the possibilities of producing neutron rich exotic nuclei in large numbers, either through the transfer of few nucleons on light nuclei, or with massive transfer for heavier ones. The physics topics addressed here have been largely presented and discussed in the SPIRAL2 project. Undoubtedly, the neutron rich beam intensities produced by SPIRAL2 through U fission will be much higher in all the regions covered by the fission peaks, but it could be possible with S^3 to produce nuclei outside these zones, either lighter or heavier. For examples multiple nucleon transfer in a $^{136}Xe+^{208}Pb$ reaction can produce neutron rich nuclei on the ^{208}Pb region and with $^{48}Ca+^{208}Pb$ reaction, neutron rich nuclei can be significantly produced in the N=28 region. On the light side, reaction like $^{12}C(^{13}C,2p)^{11}Be$ can give high yields of exotic nuclei with energies from 6-14 MeV/u, competitive for some cases with an ISOLDE type facility.

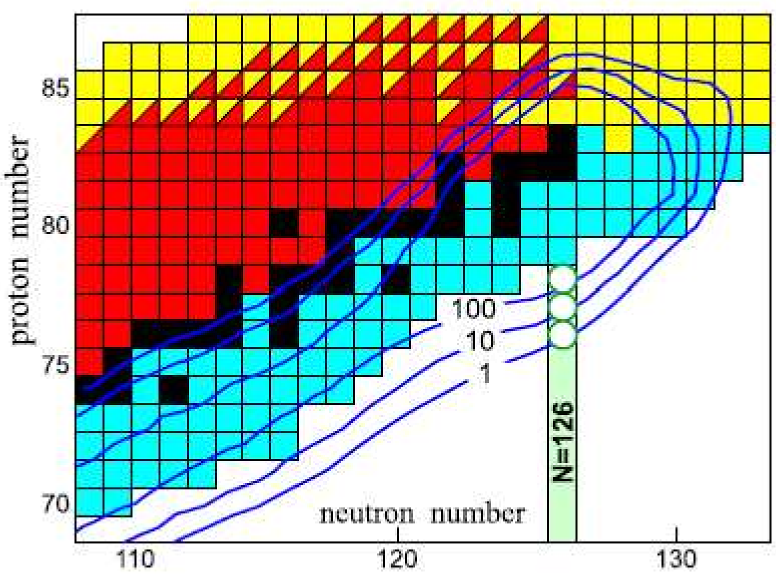


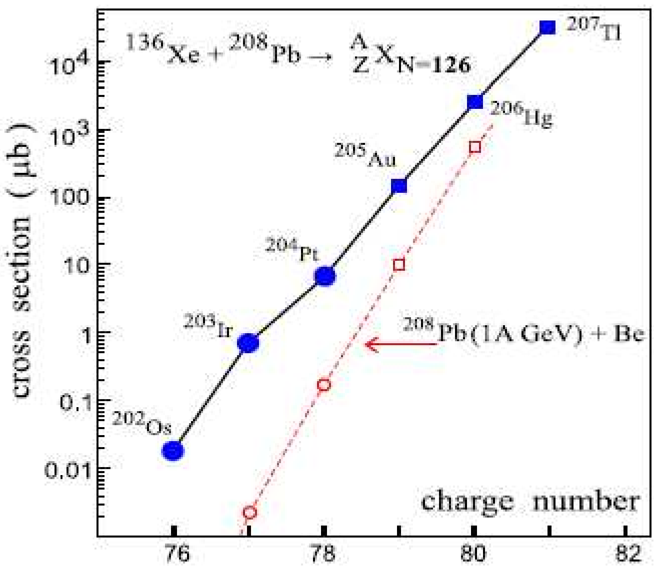
Reaction mechanism to be studied: multi-nucleon transfer

Landscape of the cross sections (µb, numbers near the curves) for the production of primary heavy fragments in collisions of ^{136}Xe with ^{208}Pb at Ec.m. =450 MeV

V. Zagrebaev, W. Greiner / Nuclear Physics A 834 (2010) 366c–369c

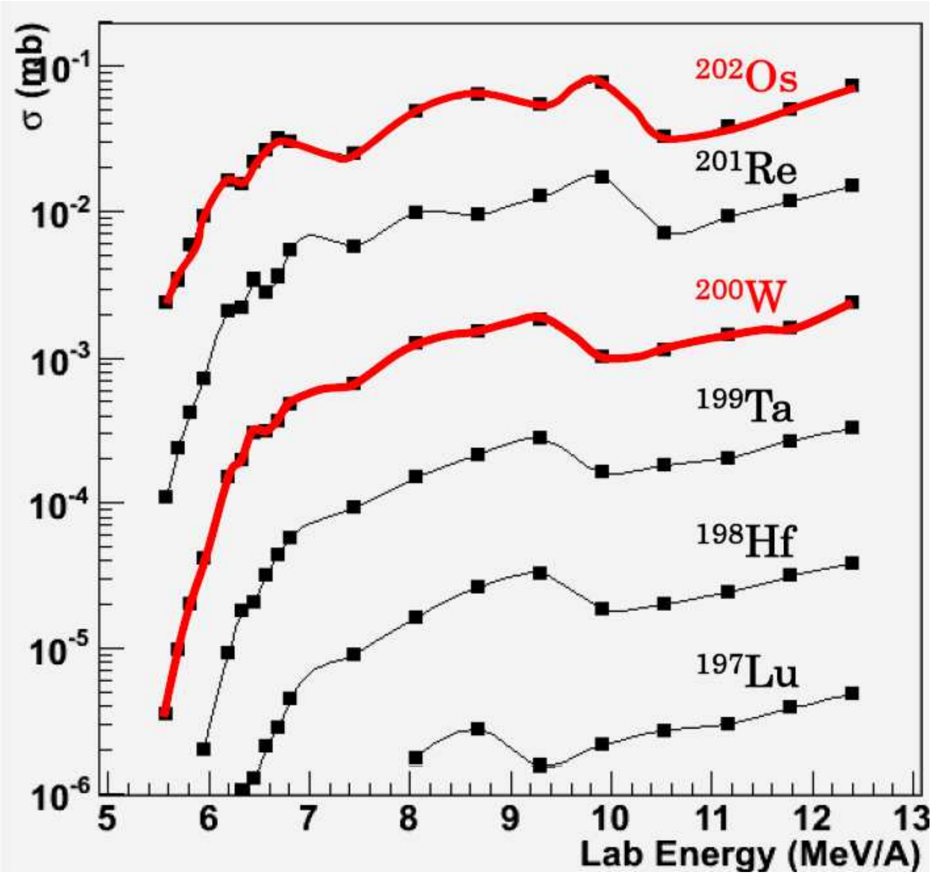
Nuclei with the closed neutron shell N = 126 produced in this reaction and in high-energy collisions of ^{208}Pb with beryllium target (T. Kurtukian-Nieto, PhD Thesis, 2007)





Reaction mechanism to be studied: multi-nucleon transfer

$^{136}Xe + ^{198}Pt$



^{202}Os ($^{136}Xe+^{208}Pb$ @ 5.5 MeV/u)

σ = 2E-5 mb

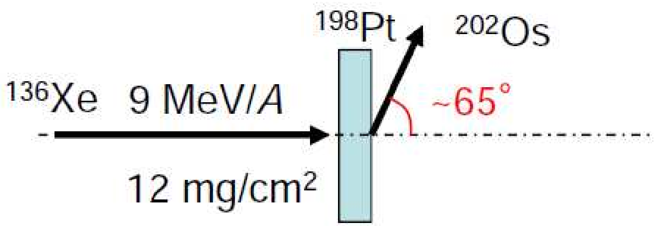
^{202}Os ($^{136}Xe+^{198}Pt$ @ 5.5 MeV/u)

σ ~ 2E-3 mb

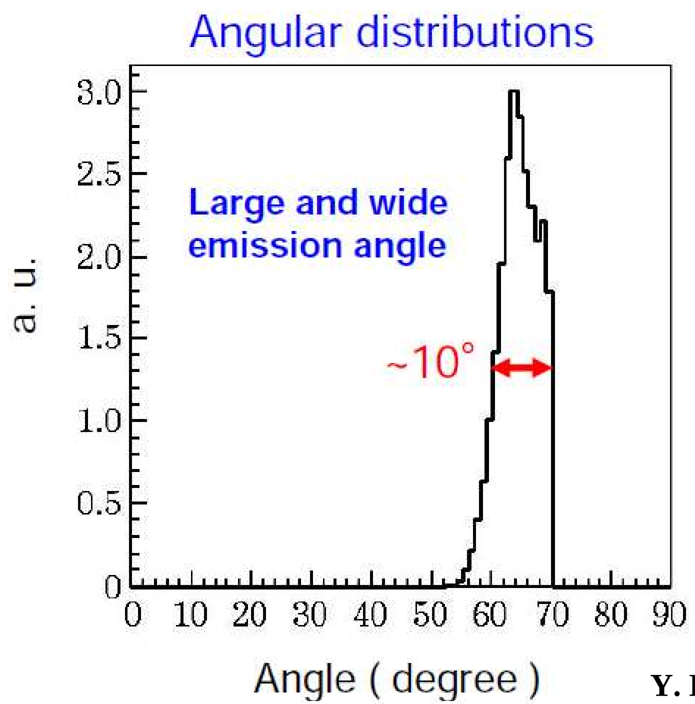
Y. Hirayama et al.

Multi-nucleon transfer reaction

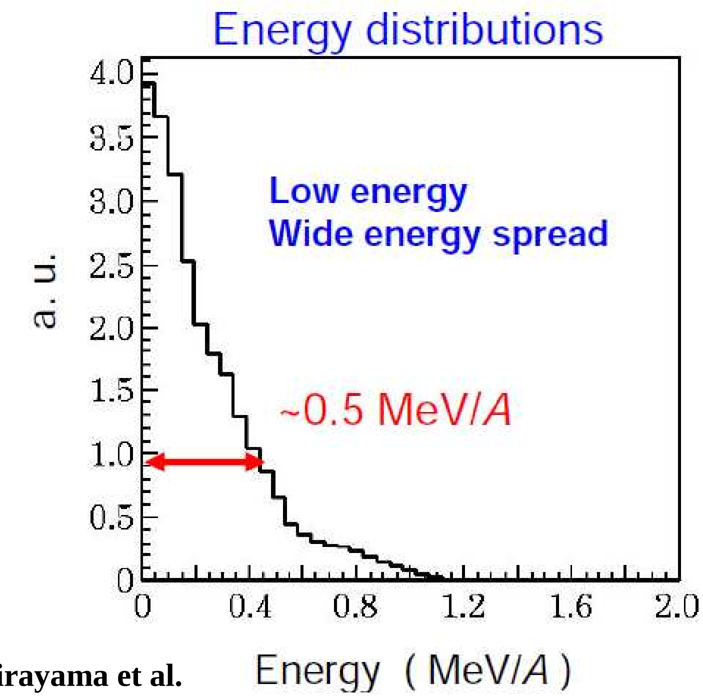
Kinematics of ^{202}Os



It would be difficult using a spectrograph.

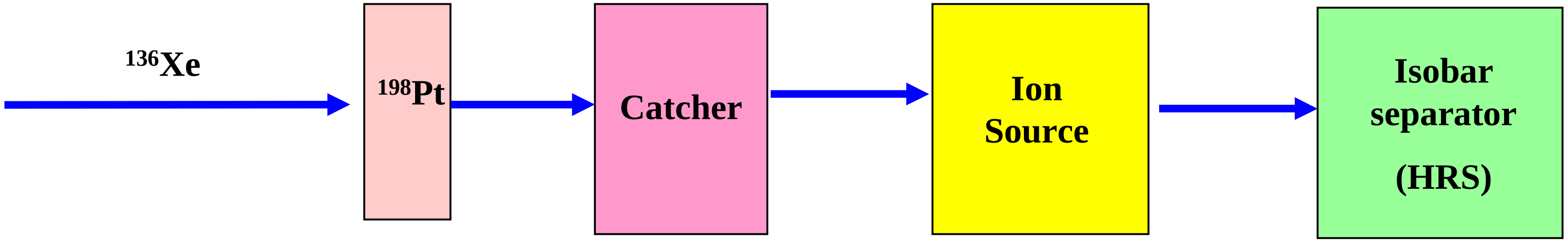


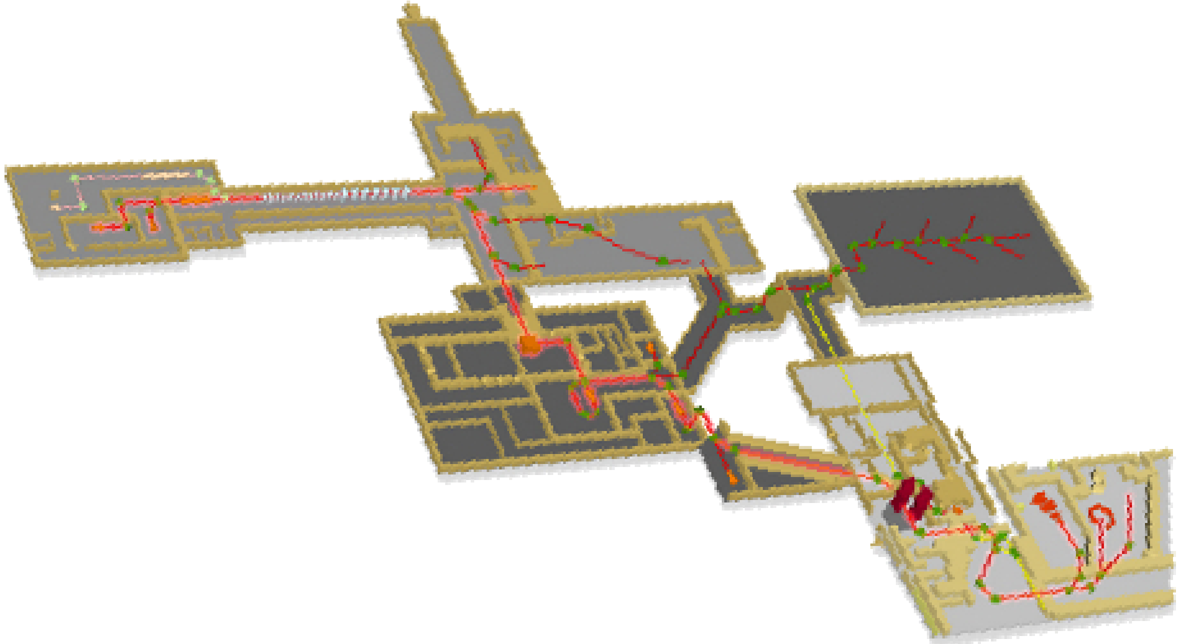
Y. Hirayama et al.



Target-Ion source

^{136}Xe at 12.5 MeV/u, 10^{13} pps on 450 μg/cm^2 Pt





Expected yields

^{136}Xe at 12.5 MeV/u, 10^{13} pps on 450 μg/cm^2 Pt

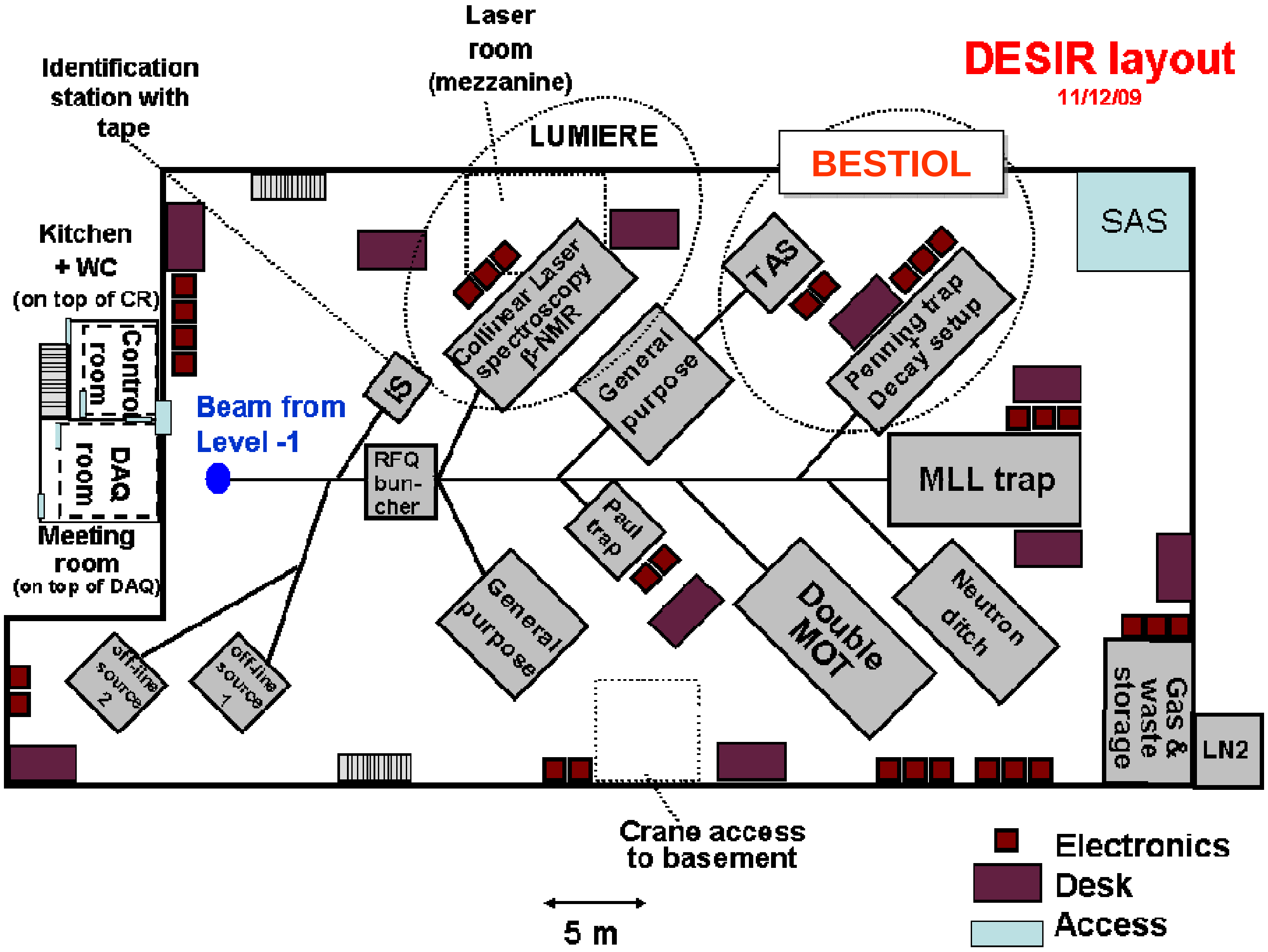
Yields at Target

Isotope	σ (mb)	Yield (pps)
^{202}Os	8E-2	1.11E3
^{201}Re	1E-2	1.39E2
^{200}W	2E-3	2.78E1
^{199}Ta	3E-4	4.17E-0
^{198}Hf	2E-5	2.78E-1
^{197}Lu	4E-6	5.56E-2

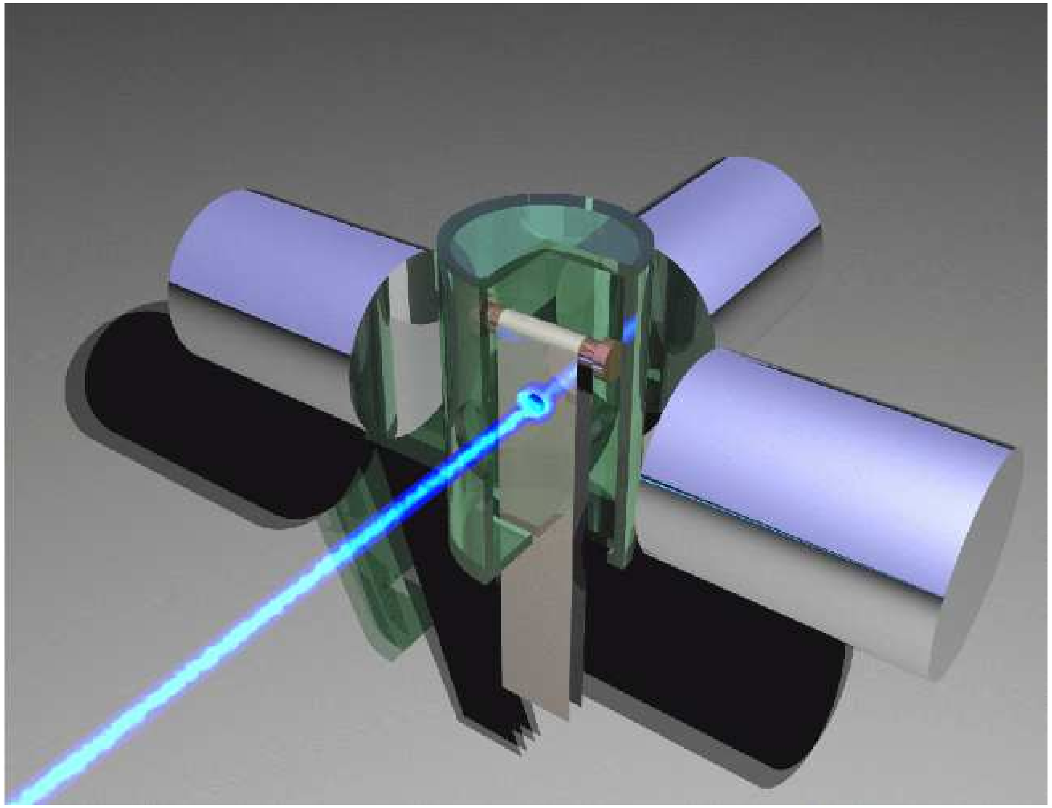
Considering 10% efficiency

Isotope	Yield (pps)
^{202}Os	1.11E2
^{201}Re	1.39E1
^{200}W	2.78E0
^{199}Ta	4.17E-1
^{198}Hf	2.78E-2
^{197}Lu	5.56E-3

Experimental setup



Experimental setup



- Tape transport system
- Beam-on/off time-sequence for accurate lifetime measurements
- β-γ, γ-γ coincidence for β-decay spectroscopy

Thank you