Neutron-rich heavy nuclei explored via multinucleon transfers

S. Szilner[1], J. J. Valiente Dobón[2], D. Montanari[3]

[1] *Ruđer Bošković Institute and University of Zagreb*
[2] *Istituto Nazionale di Fisica Nucleare - Sezione di Legnaro*
[3] *Institut d'Etudes Avancés - Université de Strasbourg and IPHC-CNRS*

L.o.I. for the SPES radioactive beam project at LNL

Main objective

Radioactive SPES beams to:

- **produce neutron-rich nuclei (Z $\geq$ 50)**,
- **study their structure**.

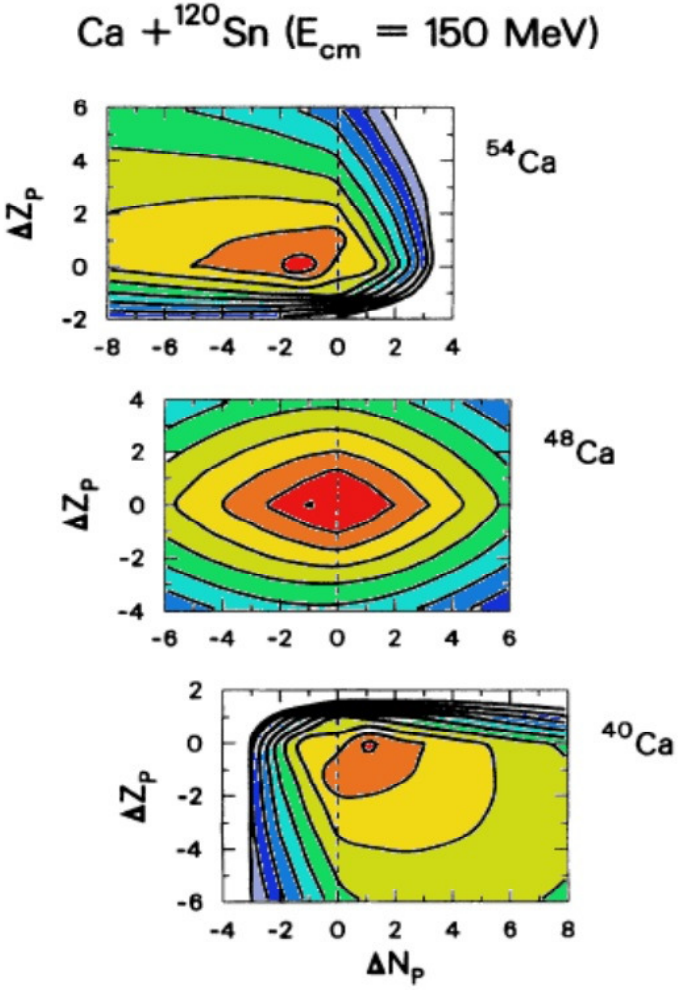
Experimental setup:

- high efficiency γ-detector arrays **GALILEO** and **AGATA**,
- in suitable cases coupled with the large solid-angle spectrometer **PRISMA**.

Transfer reactions with heavy ions

- Ruled by structure properties (form factors) and **optimum Q-value**,
- the process is **mostly controlled by the light partner**.
- Possibility to populate different regions of the nuclide chart.

Heavy ion transfer reactions



C.H.Dasso, G. Pollarolo, A. Winther
Phys. Rev. Lett. 73, 1907 (1994)

with neutron rich beams

- neutron stripping and proton pick-up
- **Heavy** partner to the **(neutron-rich side)** of the stability valley

with stable beams

- neutron pick-up and proton stripping
- **Heavy** partner to the **"left"** of the stability valley

Experimental methods

Studying heavy target-like reaction products

Experimental difficulties for ion detection

At energies close to the Coulomb barrier

- Low kinetic energies of fragments,
- Low mass (A), charge (Z) and energy resolution
- Secondary processes limit the final yield

particle-γ coincidence

Thin targets, detecting **projectile-like partner** with the magnetic spectrometer and **studying γ's of the heavy partner**.

γ-γ and γ-γ-γ measurements

To be done with heavier systems with **thick targets**. Possible only if performed with **very efficient γ-detectors arrays**.

Proposed reaction

Thin target

- Beams close to Z=50, A=132 (^{132,134}Te and $^{128.130}$Sn)
- Target ^{208}Pb (or U)

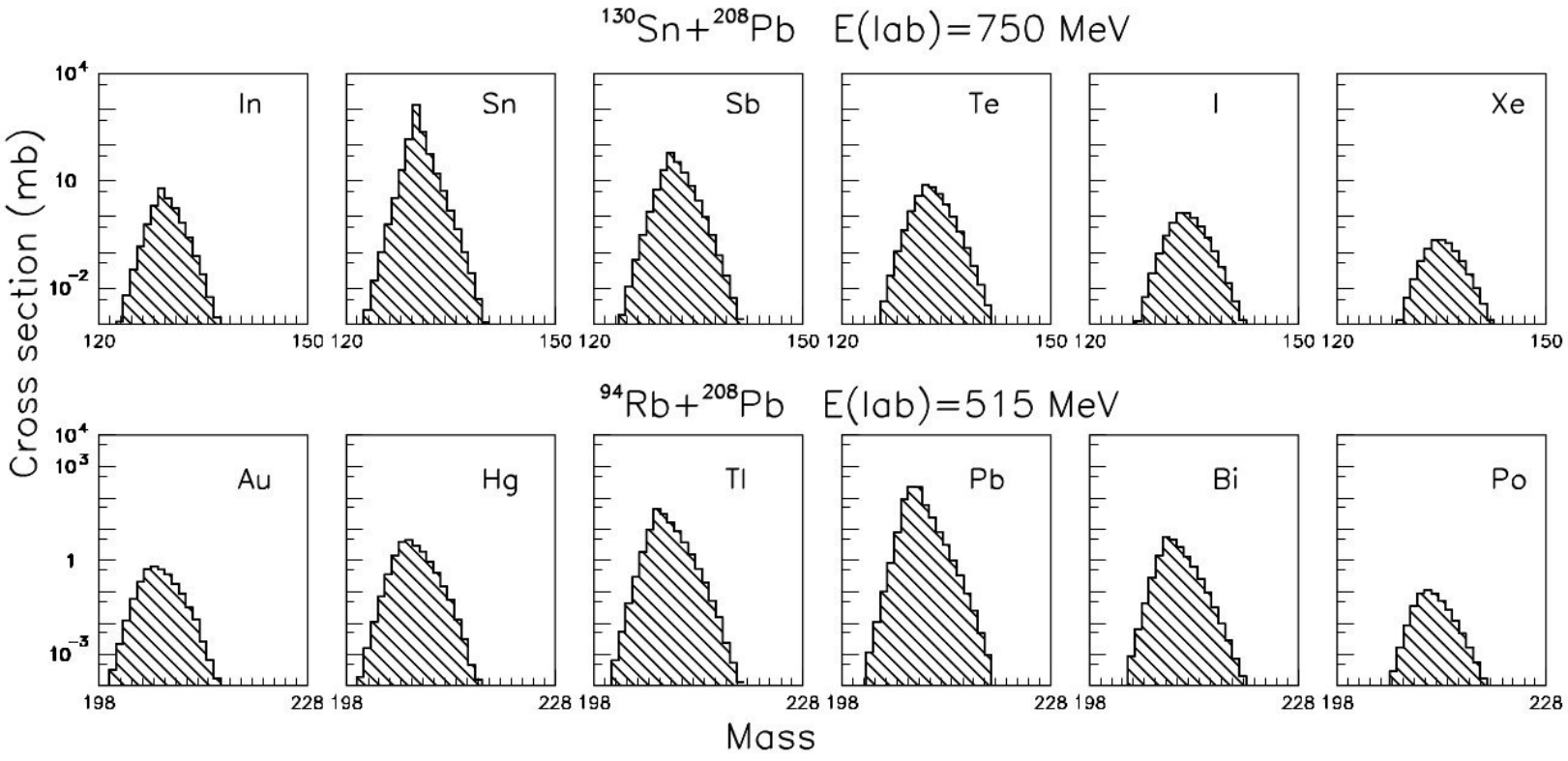
Measurement performed detecting the **light partner** with the **PRISMA** spectrometer coupling γ-arrays (**GALILEO** and **AGATA**)

Thick target

- Intense A$\sim$95 (^{93,94}Rb)
- Target ^{208}Pb
- Possibility to use other targets (Os, Pt, Au)

Measurement performed using high efficient γ-arrays **GALILEO** and **AGATA** to perform γ-γ and γ-γ-γ coincidences

Proposed reaction



Calculation performed with GRAZING code: cross section

projectile-like reaction products in ^{130}Sn+^{208}Pb

target-like reaction products in ^{94}Rb+^{208}Pb

Structure studies

Around double shell closure

Region around ^{208}Pb experimentaly difficult to be explored

Present studies

Multi-nucleon transfer reactions. Ions populated up to A=211

Nucl. Part. Phy. 32R151 (2006)

Fragmentation. Ions populated up to A=216

PRL 109 162502 (2012), PLB 725 (2013) 292

Pilot experiment

Accepted by the ISOLDE and Neutron ToF Committee.

Important to understand:

- the possibility of populating the n-rich heavy-mass region through transfer reactions.
- the **existence** of the predicted 16^+ state isomer in Pb isotopes
- the nature of the **very low** $(3^-?)$ state in ^{210}Hg.

Summary

We propose to study the **n-rich heavy mass region (Z$\geq$50)** via **multinucleon transfer (MNT) reactions**

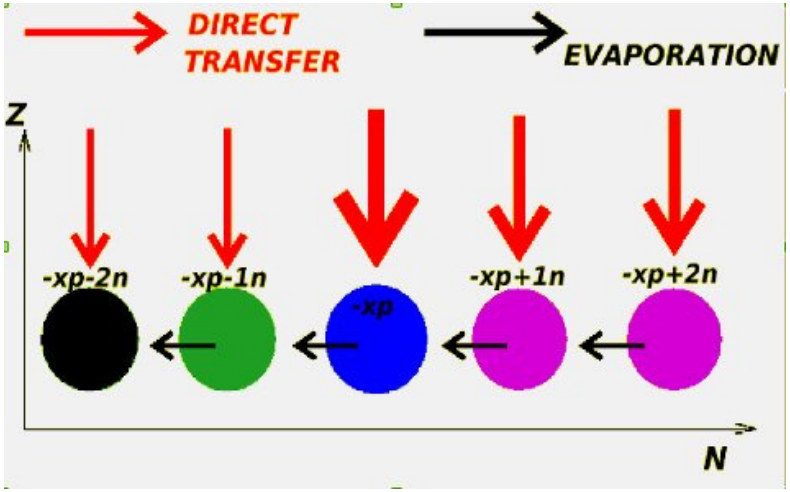
- To explore the possibility of producing n-rich nuclei via MNT
- To perform studies of their structure to shed light on some still open questions.

Two kinds of experiment:

- **thick target** exploiting the high efficiency γ-arrays GALILEO and/or AGATA to perform γ-γ and γ-γ-γ coincidences,
- **thin target** coupling GALILEO and/or AGATA to the PRISMA spectrometer.

Pilot experiment already approve at ISOLDE

Experimental methods



Binary reaction

Secondary processes, i.e. evaporation and fission, may be taken into account looking at γ-spectra **in coincidence** with the detected particle in the spectrometer.