Laboratori Nazionali di Legnaro

INFN
Istituto Nazionale di Fisica Nucleare

Study of shell evolution around the doubly magic ^{208}Pb, via a multinucleon transfer reaction at MINIBALL

A. Illana Sison

On behalf of the IS572 collaboration

HIE-ISOLDE

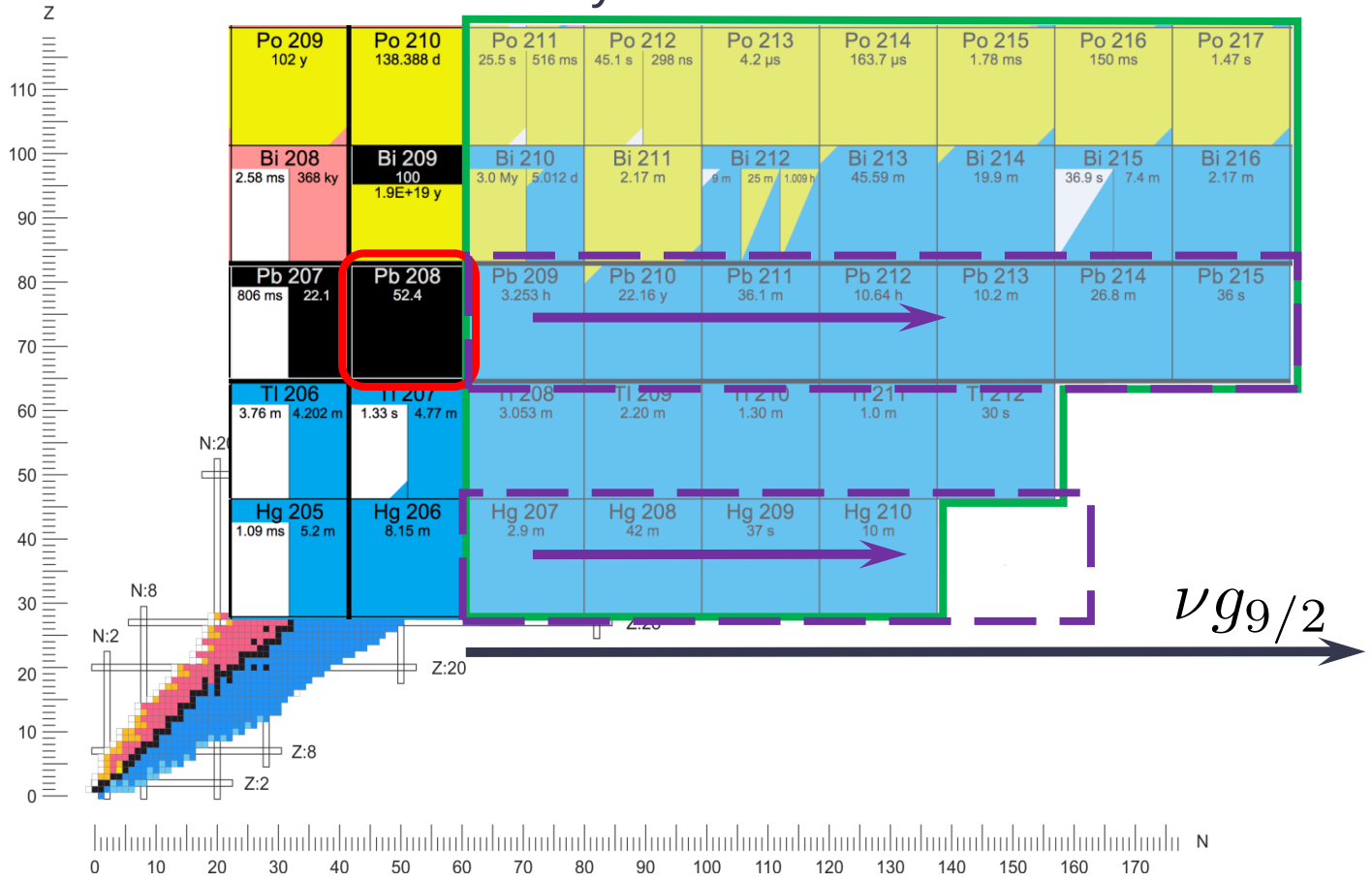
MINIBALL

OUTLINE

- Physics motivation
- Multinucleon Transfer (MNT) technique
- Experimental Setup
- Preliminary results
- Outlook and future perspectives

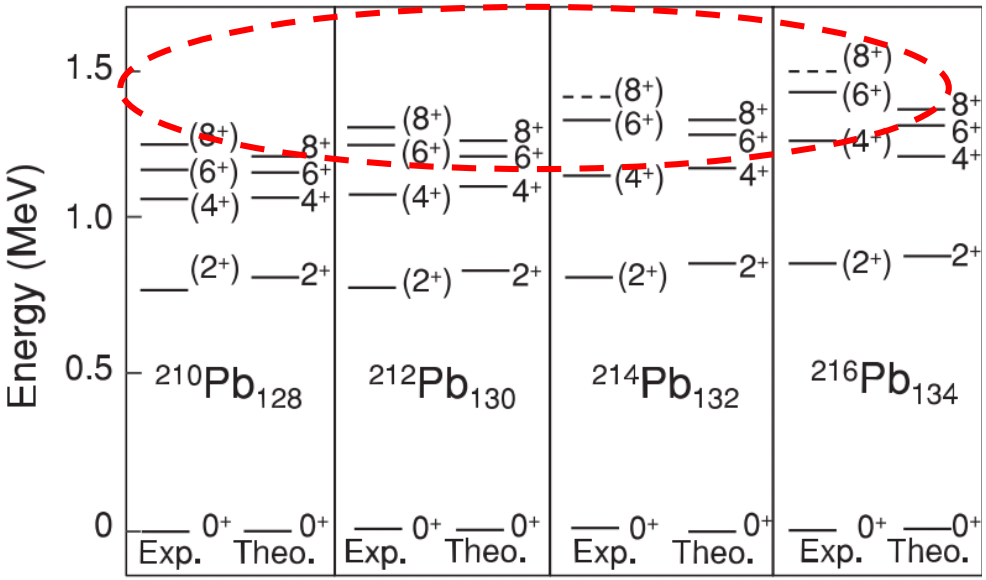
PHYSICS MOTIVATION

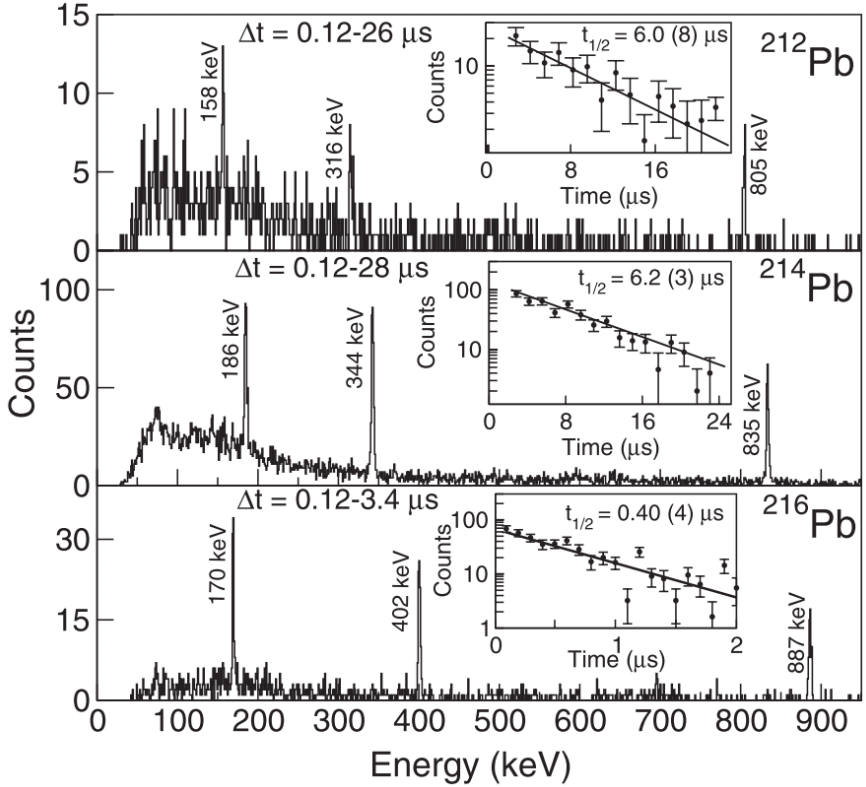
The region around ^{208}Pb has been very difficult to populate experimentally due to its large A and Z. We would like to study the nuclear structure evolution beyond N = 126.



PHYSICS MOTIVATION

Why the neutron-rich Pb region?



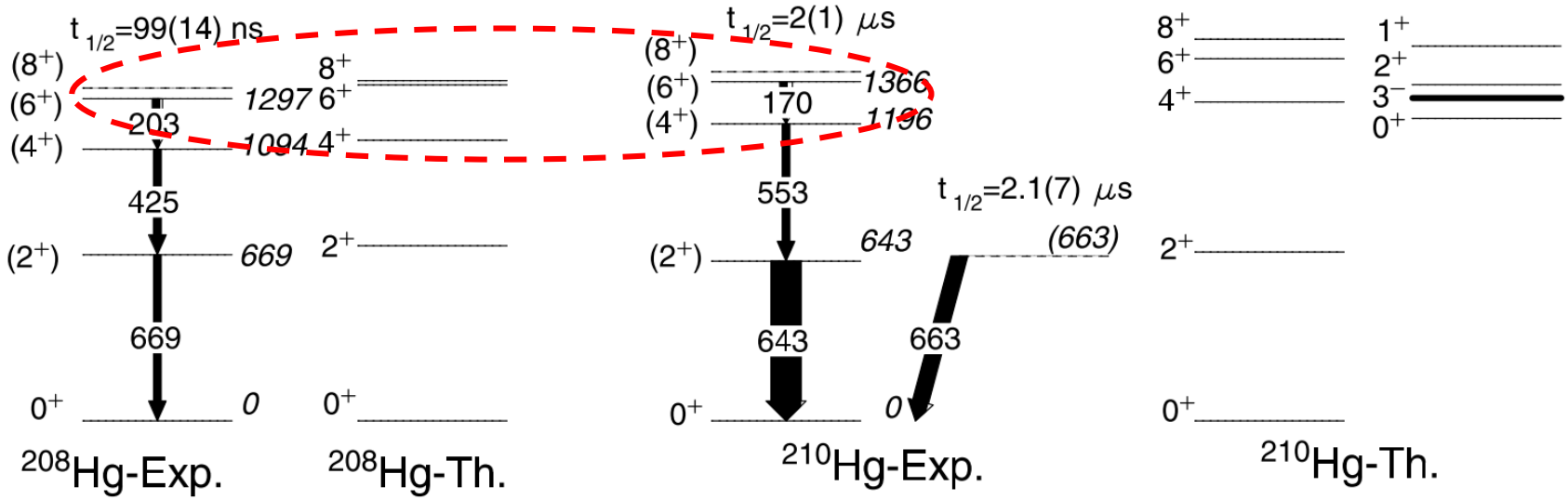


Where is above the 8+ isomer? and the negative states?

A. Gottardo et al., *Phys. Rev. Lett.* **109** (2012) 162502

PHYSICS MOTIVATION

And why the neutron-rich Po region?

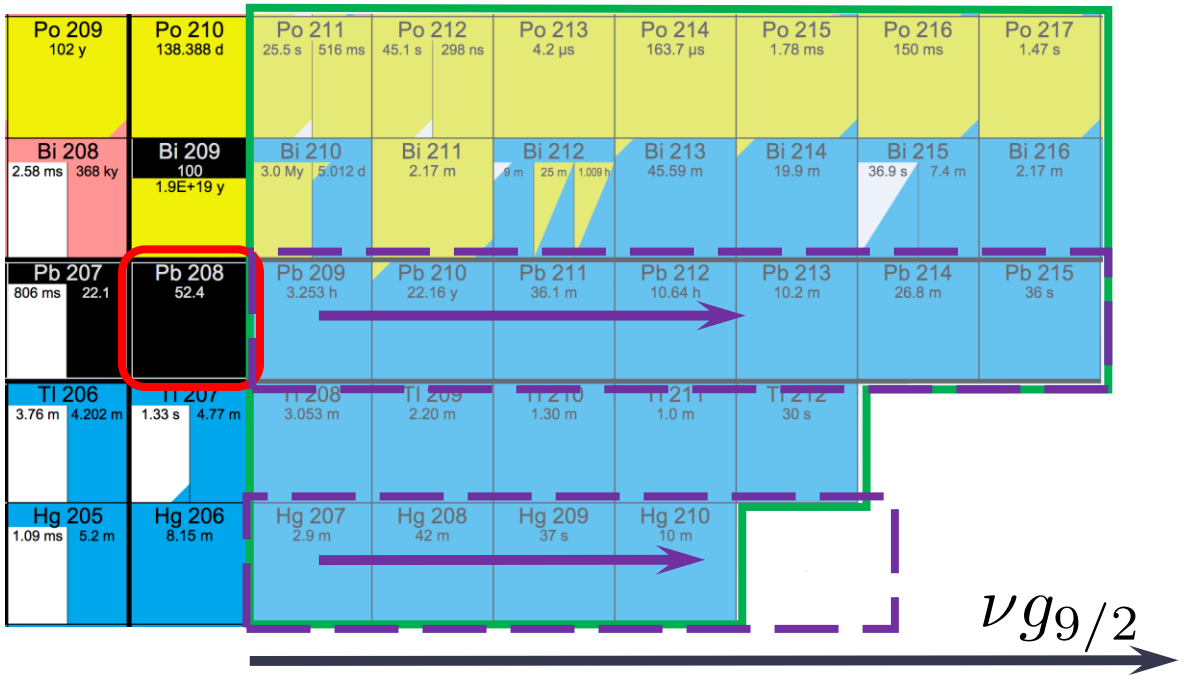


Where is above the 8+ isomer? and the negative states?

A. Gottardo et al., *Phys. Lett. B* **725** (2013) 292-296

PHYSICS MOTIVATION

The region around ^{208}Pb has been very difficult to populate experimentally due to its large A and Z. We would like to study the nuclear structure evolution beyond N = 126.



How can we study this region?

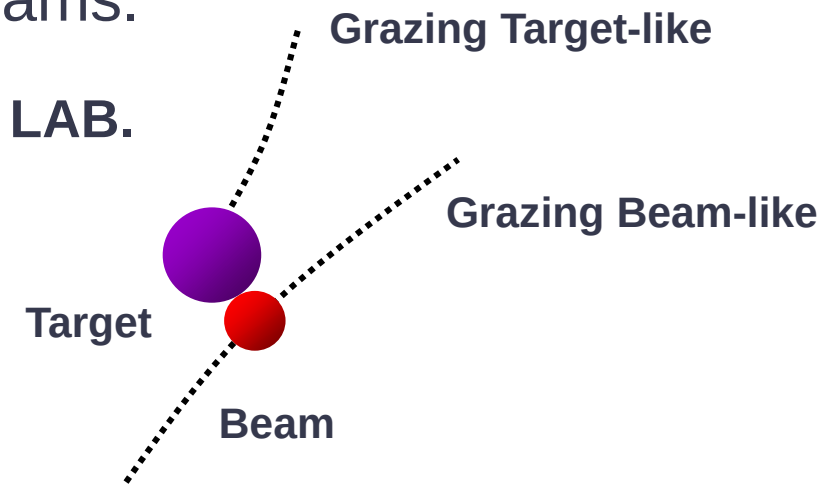
Fragmentation, Transfer reaction, Multinucleon transfer with stable beams or ISOL beams.

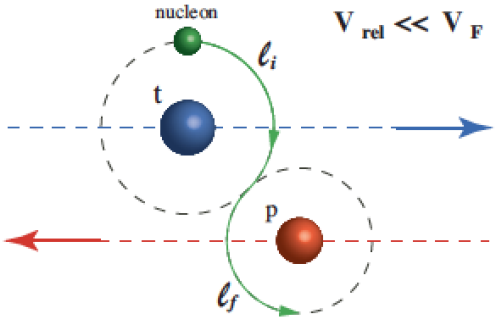
OUTLINE

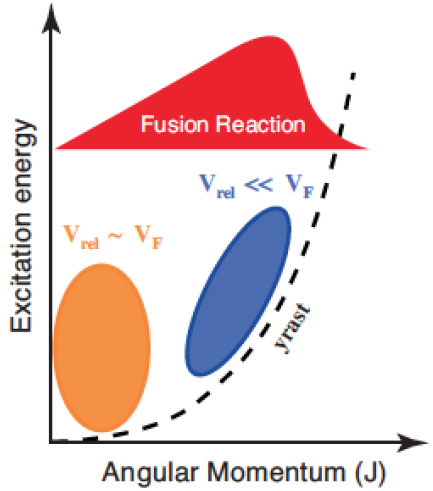
- Physics motivation
- Multinucleon Transfer (MNT) technique
- Experimental Setup
- Preliminary results
- Outlook and future perspectives

MULTINUCLEON TRANSFER

- It is possible to transfer several nucleons and large angular momentum between the projectile and the target.
- It has been proved as a fantastic mechanism with stable beams.







L. Corradi et al., *J. Phys. G* **36** (2009) 113101.
J.J Valiente-Dobon, *Basic Concepts in Nuclear Physics: Theory, Experiments and Applications* (2016).

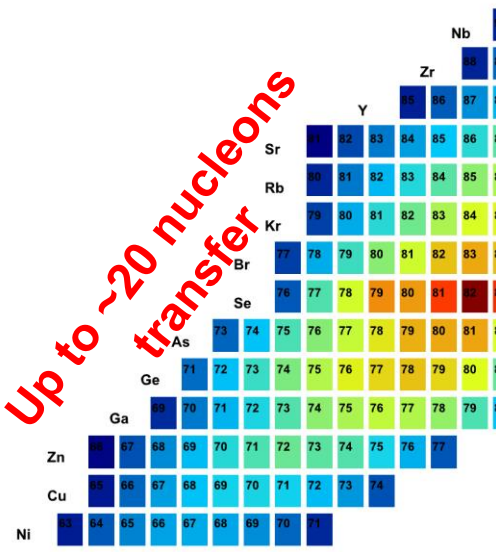
MULTINUCLEON TRANSFER

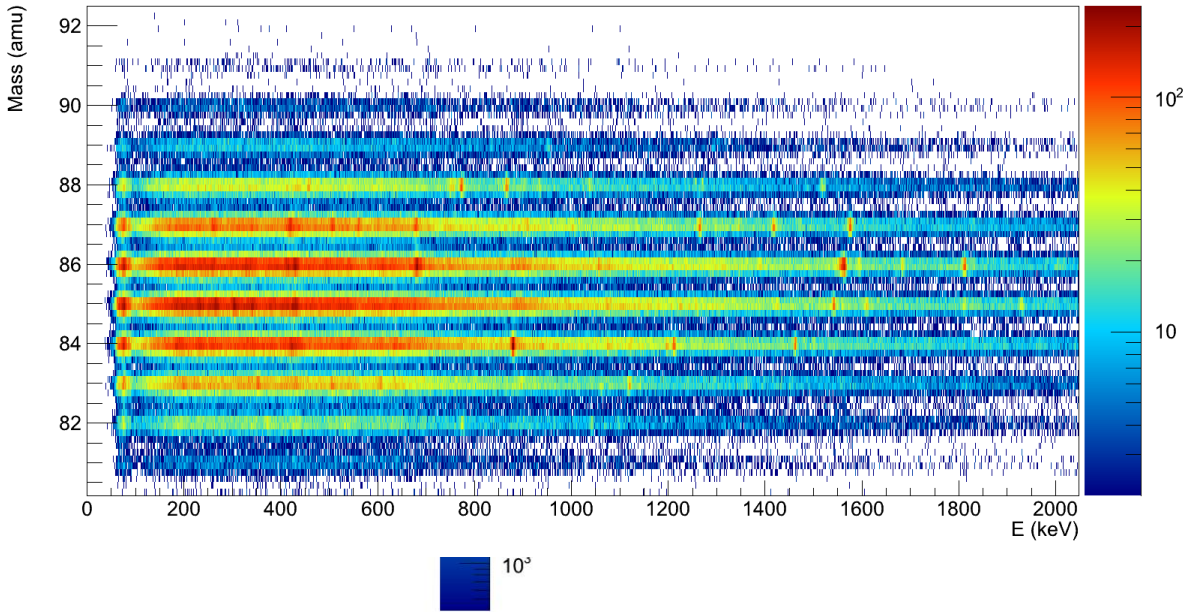
With stable beams:

^{82}Se onto ^{198}Pt

BLF measured in P

Yield (bea

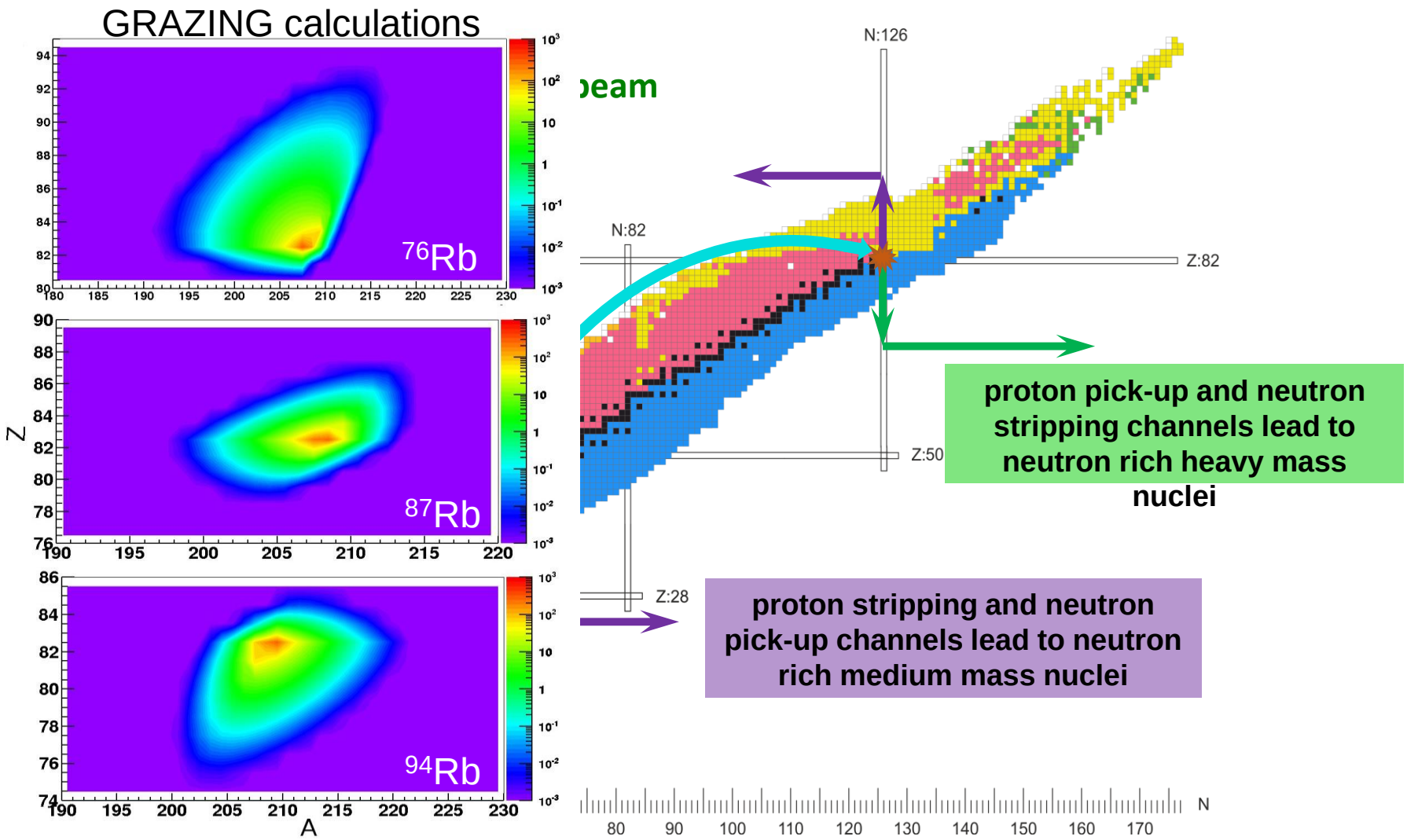




In-beam gamma coincidence with recoils → Gamma spectrometer (AGATA) + magnetic spectrometer (PRISMA/VAMOS)

Courtesy of J.J. Valiente-Dobon

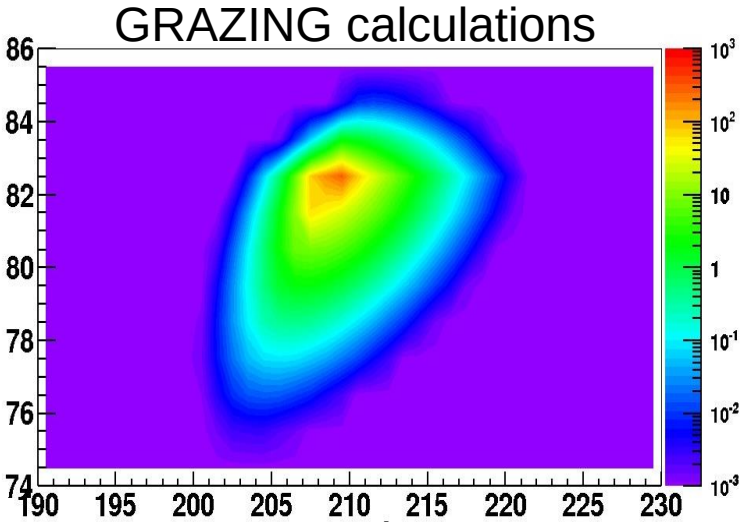
MULTINUCLEON TRANSFER



C. H. Dasso et al., *Phys. Rev. Lett.* **73** (1994) 1907

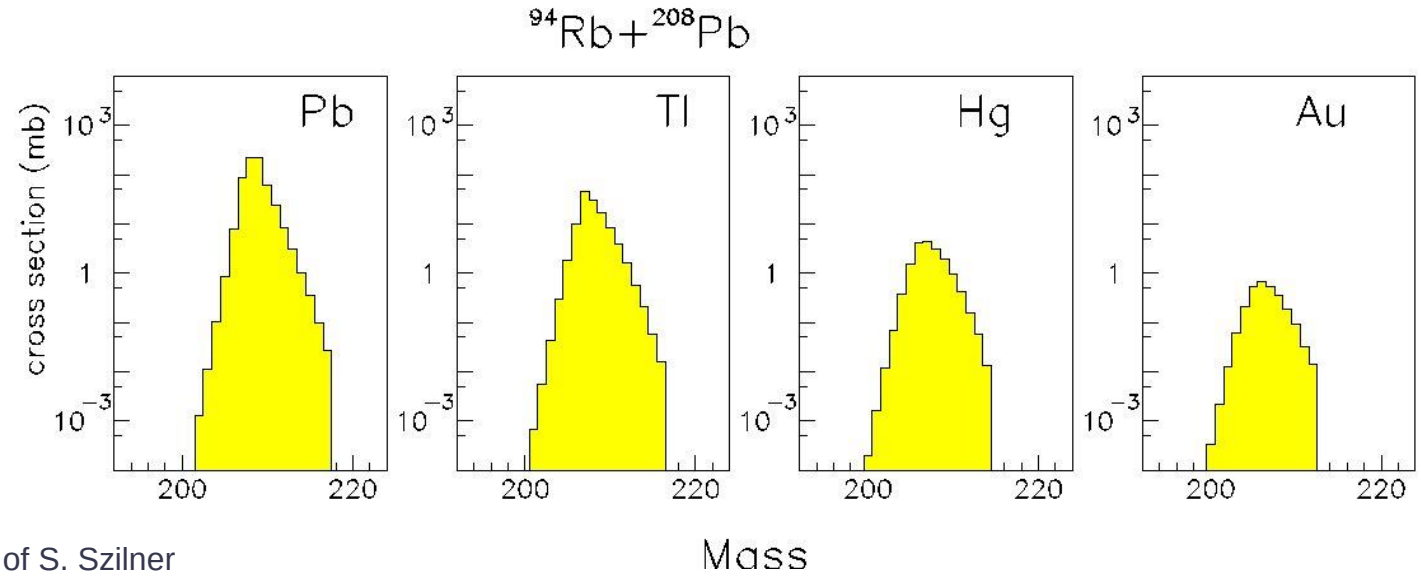
Courtesy of S. Szilner

MULTINUCLEON TRANSFER



With this technique is possible to do:

- In-beam spectroscopy of several nuclei at the same time.
- We can investigate isomers between 25 ns and 5 μs.



Courtesy of S. Szilner

OUTLINE

- Physics motivation
- Multinucleon Transfer (MNT) technique
- Experimental Setup
- Preliminary results
- Outlook and future perspectives

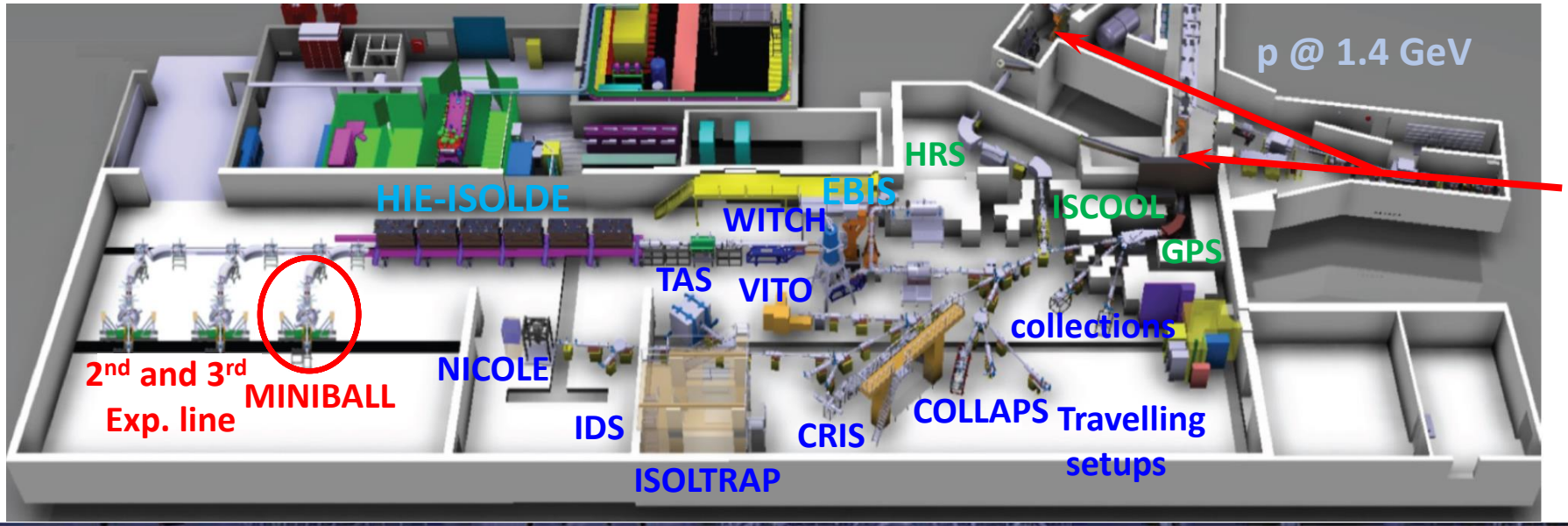
EXPERIMENTAL SETUP

To be consider:

- High beam intensity into a thick target: High γ-rate and contamination.
- High instantaneous beam intensity.

First MNT experiment with RIB.

- Beam Intensity required 1.5 10^7pps.
- First Exp. @ HIEISOLDE with:
  - All cavities used (6.2 MeV/u)
  - The RF pulse length of 1.6 ms.

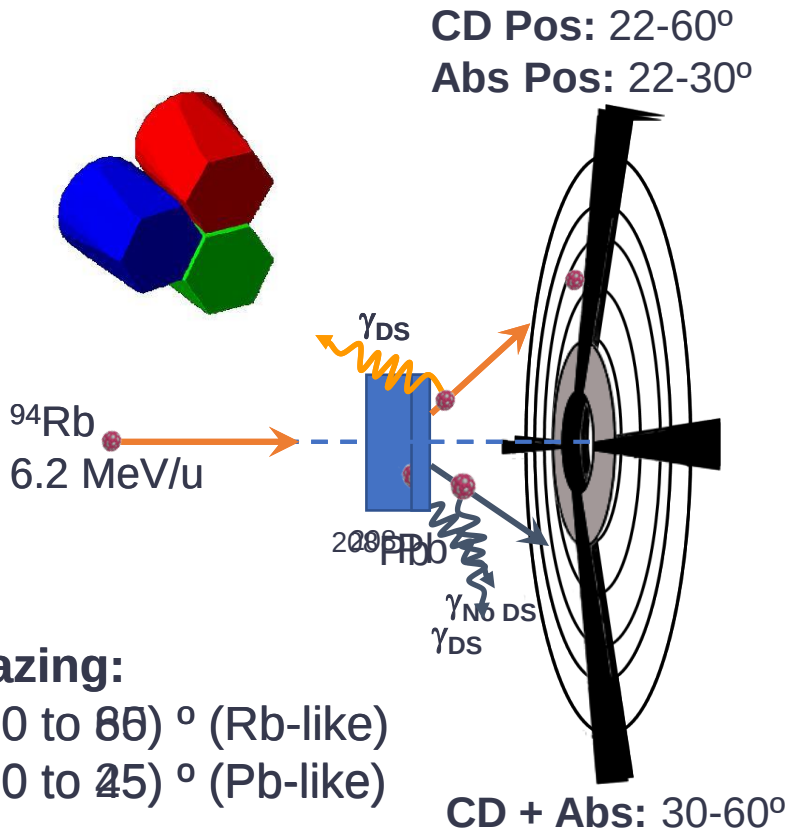


EXPERIMENTAL SETUP

Solutions:

- Very slow extraction.
- CD + Absorbers for particle detection.
- New trigger for MINIBALL.
- Target size must be optimized.

Target	Thickness [mg/cm^2]	Intensity [pps]	Total hours
^{208}Pb	1.0	~ 1.0 10^6	~ 15
^{208}Pb	13.0	~ 1.0 10^6	~ 120



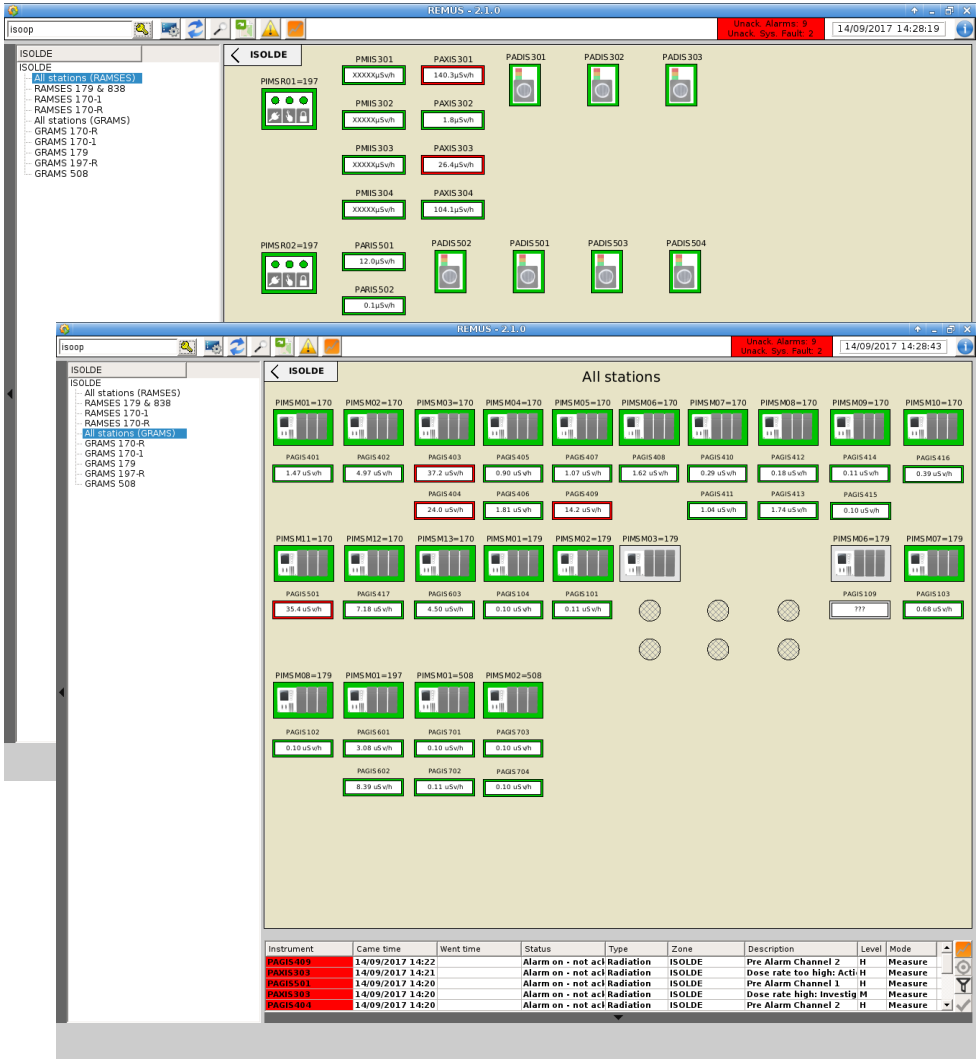
Different trigger modes (γ-γ, γ-p, γ-γ-γ, γ-γ-p, …) have been implemented in the DAQ.

EXPERIMENTAL SETUP

Problems during the run:

- Radiation problems in ISOHALL. Test at 2.0 μA → the highest value registered was 146 μSv/h!!!!
- We couldn't run with high proton beam intensity. Some actions were carried out without any success.
- Proton Beam intensity limited.
- Therefore we had a very Low beam intensity (> factor 10).

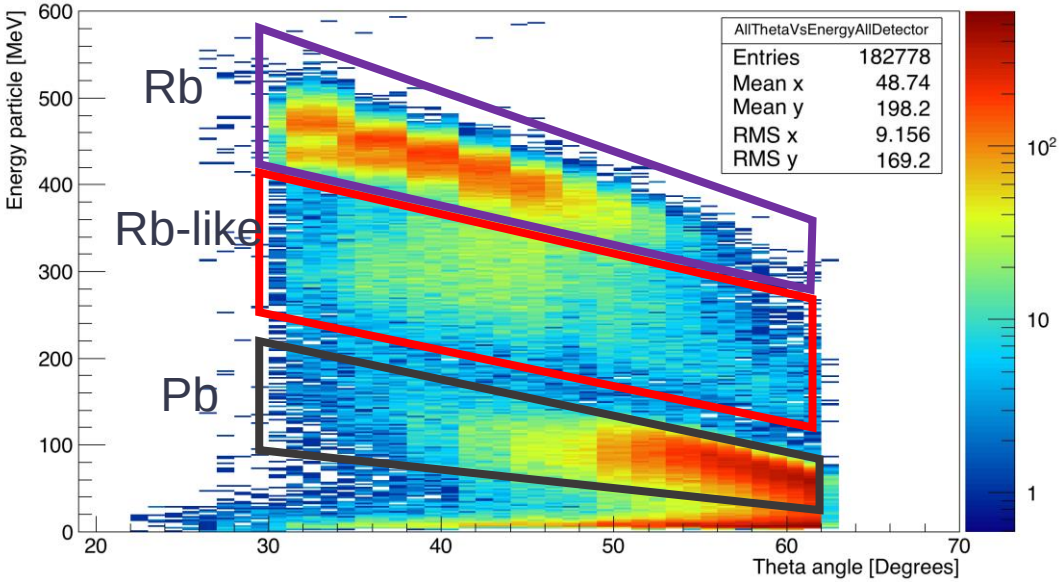
What will we be able to extract from this run?

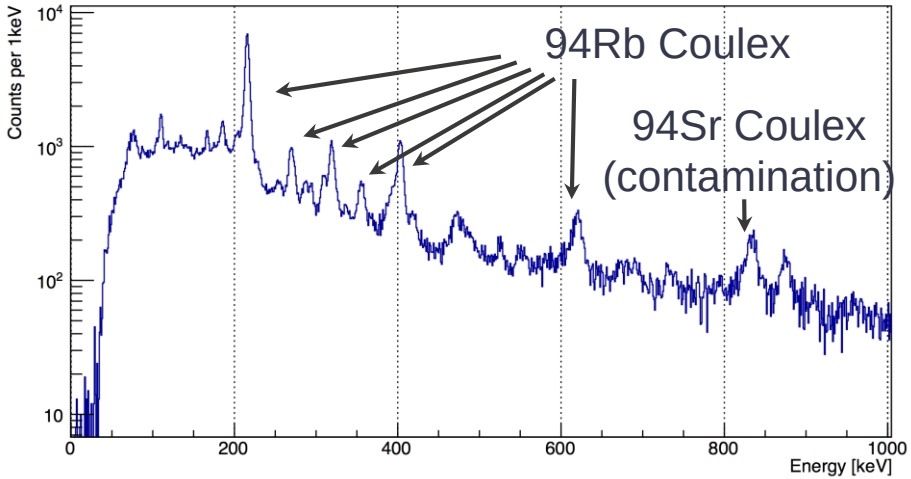


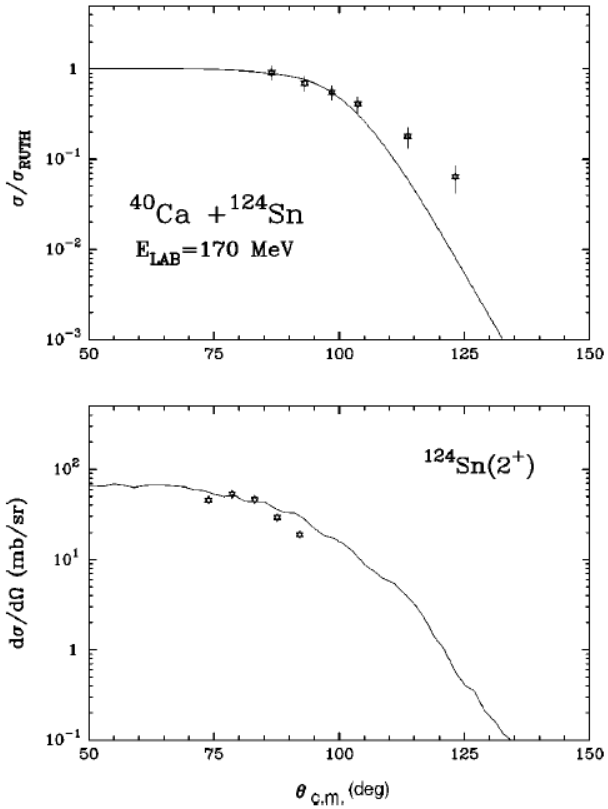
OUTLINE

- Physics motivation
- Multinucleon Transfer (MNT) technique
- Experimental Setup
- Preliminary results
- Outlook and future perspectives

PRELIMINARY RESULTS

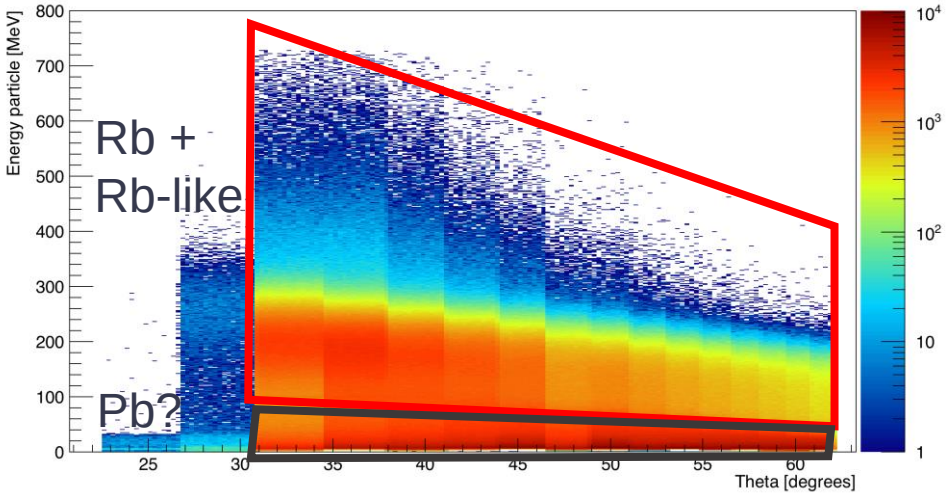


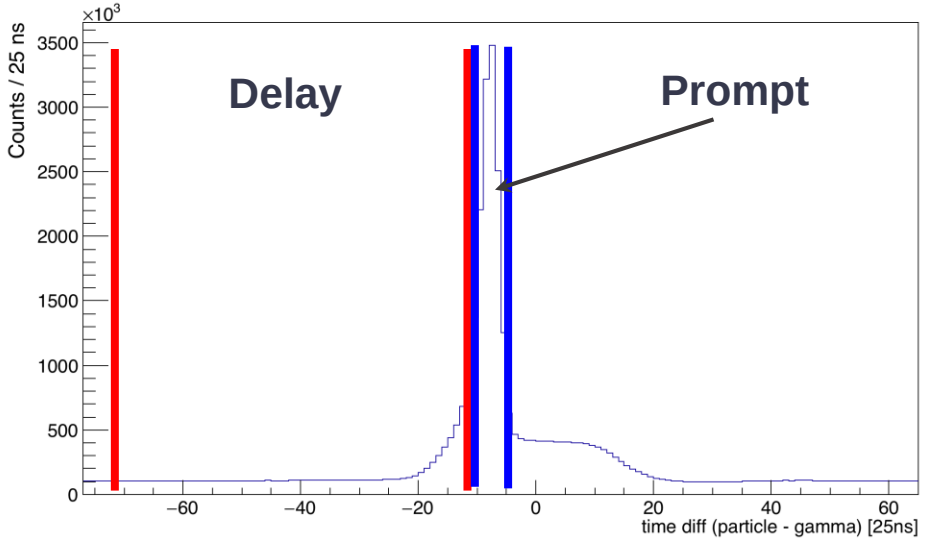


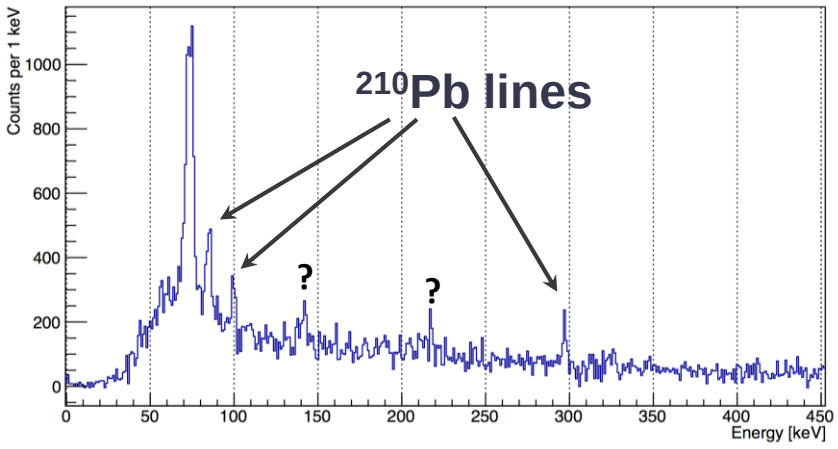


Cross-section for MNT will be extracted using the elastic + inelastic excitation, and the 3^- inelastic excitation.
L. Corradi et al., Phys. Rev. C 61 (2000) 024609

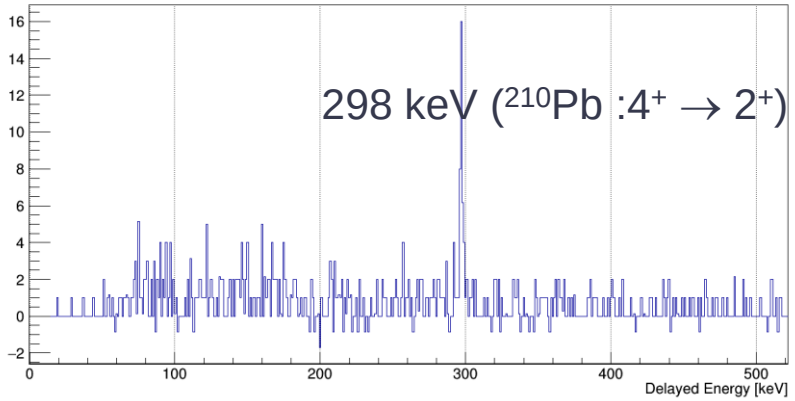
PRELIMINARY RESULTS







Gate in 799 keV (^{210}Pb :$2^+ \rightarrow 0^+$)



OUTLINE

- Physics motivation
- Multinucleon Transfer (MNT) technique
- Experimental Setup
- Preliminary results
- Outlook and future perspectives

OUTLOOK AND FUTURE PERSP.

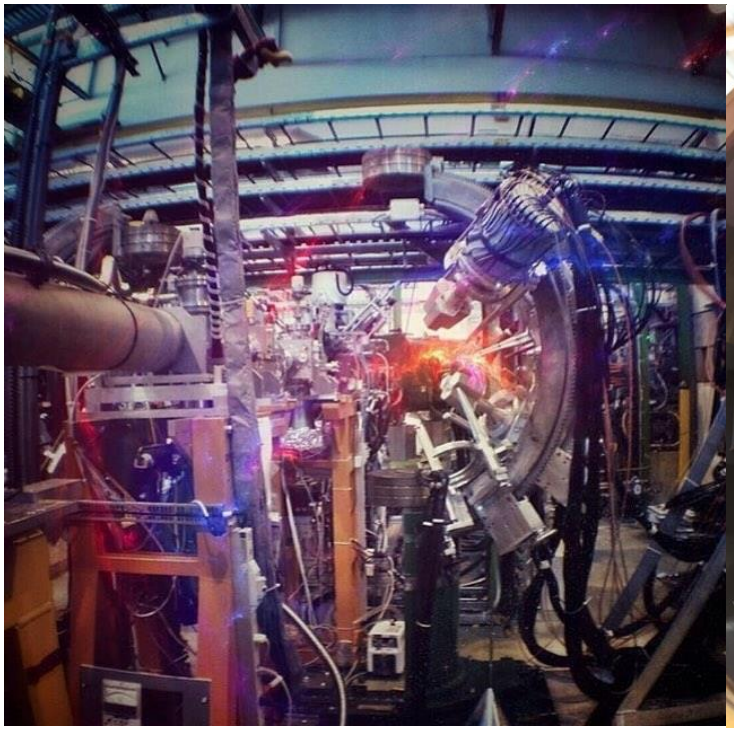
- The experiment was successful despises of the Radiation problem inside ISOLDE-HALL.
- Cross-sections for MNT using the thin target will be extracted. Theory Vs Experiment.
- In-beam γ spectroscopy will be performed with the thick target:
  - To identify all the nuclei produced, like 210Pb, …
  - Isomer spectroscopy (with lifetimes between 25 ns to 5 μs).

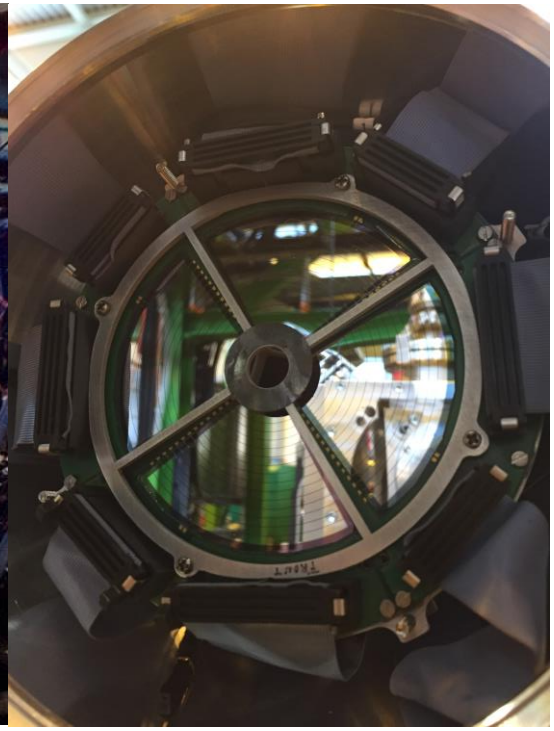
Multinucleon transfer technique with Radioactive Ions Beams has been proved. New opportunities!

COLLABORATION

A. Illana, J.J. Valiente-Dobón, G. de Angelis, L. Corradi, E. Fioretto, F. Galtarossa, D.R. Napoli
I*NFN, Laboratori Nazionali di Legnaro, Legnaro, Italy*
S. Szilner, P. Colovic
Ruder Boskovic Institute, Zagreb, Croatia
A. Boso, R. Menegazzo, D. Mengoni, F. Recchia
Dipartimento di Fisica and INFN, Sezione di Padova, Padova, Italy
M. Jurado-Gomez
IFIC, CSIC, Valencia, Spain
Th. Kröll
Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
S. Ceruti, T. Marchi
Instituut voor Kern- en Stralingsfysica, KU Leuven, Leuven, Belgium
L.P. Gaffney
ISOLDE, CERN, Switzerland
G. Benzoni
Dipartimento di Fisica and INFN, Sezione di Milano, Milano, Italy
M.J.G. Borge
Instituto de Estructura de la Materia CSIC, Madrid, Spain
Zs. Podolyack
Department of Physics, University of Surrey, Guildford, United Kingdom
J.G. Cubiss
Department of Physics, University of York, York, United Kingdom

Thanks to the ISOLDE and HIE-ISOLDE collaboration





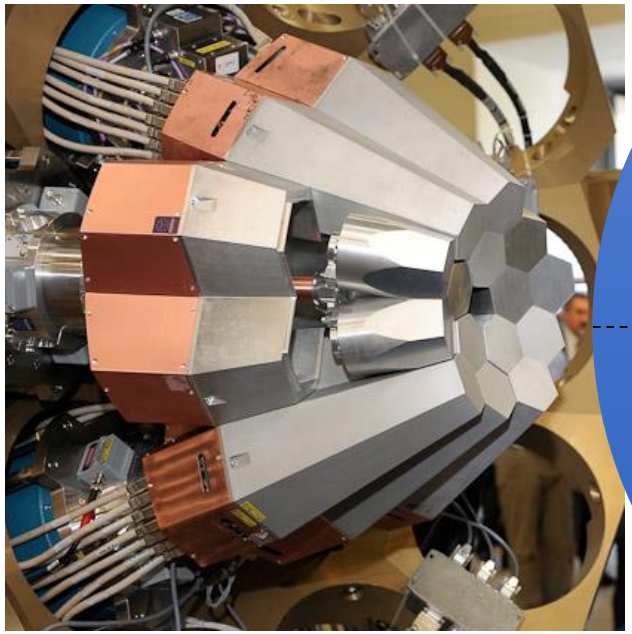
THANKS FOR YOUR ATTENTION

MNT WITH STABLE BEAMS

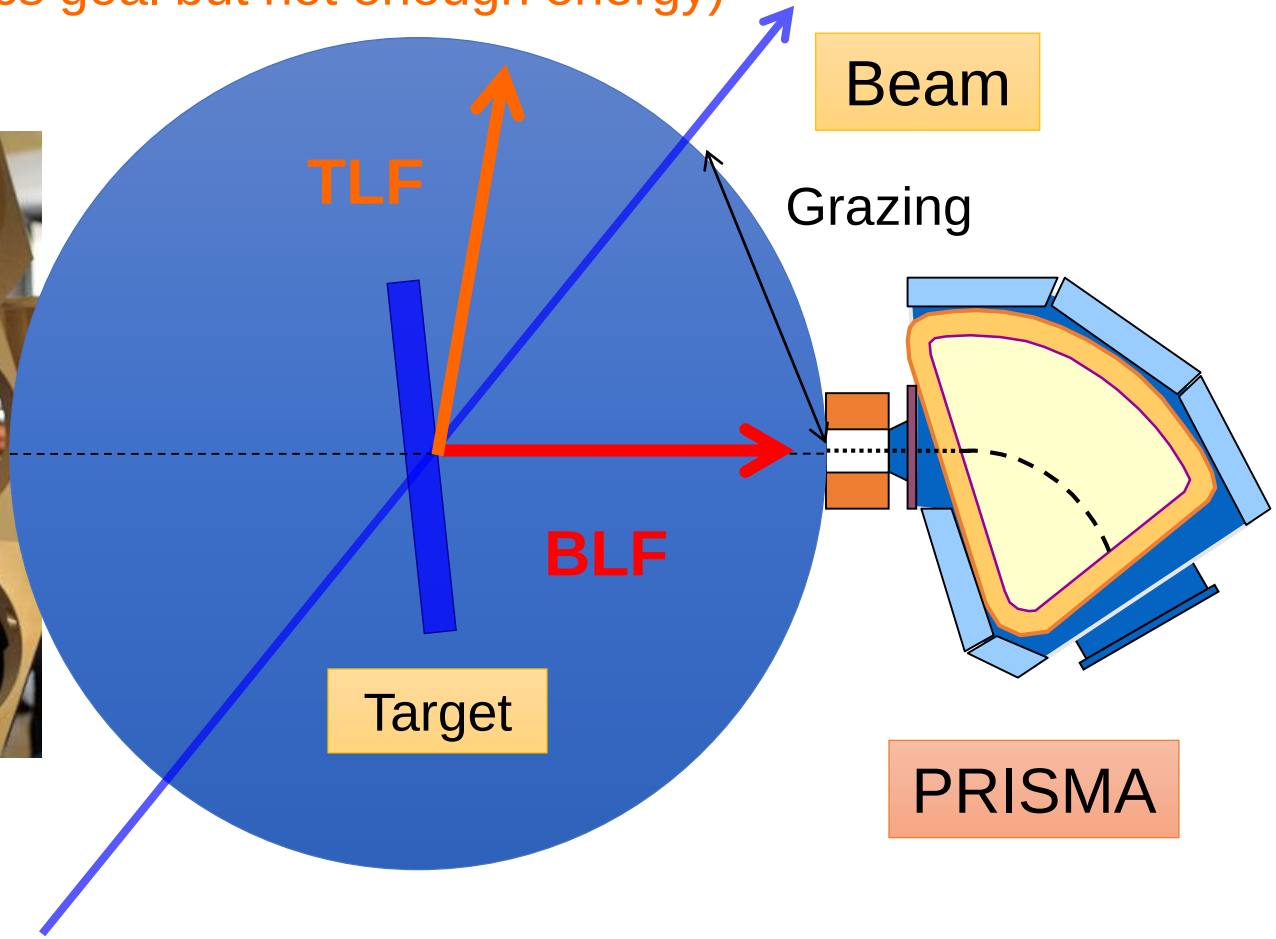
Direct kinematics, binary reaction:

BLF lighter (enough energy for identification)

TLF heavier (physics goal but not enough energy)



AGATA



RADIATION @ ISOLDE