Study of the neutron-rich region in vicinity of ^{208}Pb via multinucleon transfer reactions

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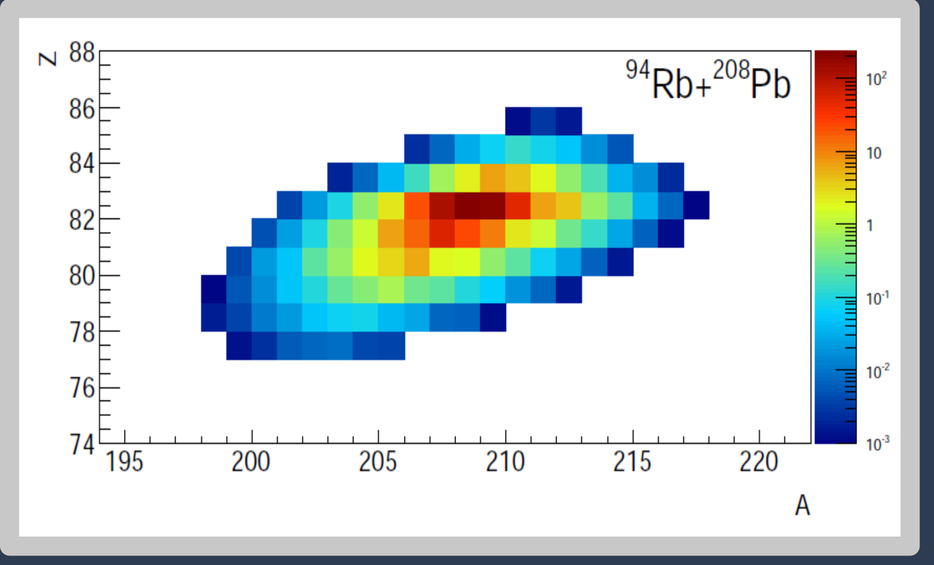
Towards neutron-rich heavy nuclei

- **aim**: to exploit the multinucleon transfer reaction mechanism in the **production of the neutron-rich heavy binary partners**
- **focus**: region **south-east** of the doubly-magic ^{208}**Pb** nucleus in the Segré chart
- we employed this reaction mechanism in the ^{94}Rb+ ^{208}Pb reaction studied with the MINIBALL γ-array at ISOLDE

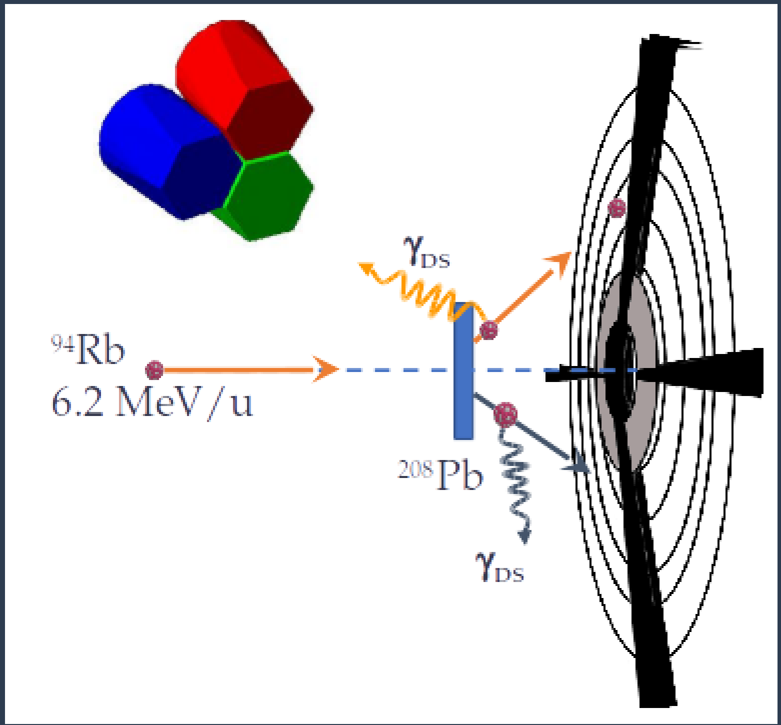


^{94}Rb+^{208}Pb cross section distribution [mb]
calculated by GRAZING

Program GRAZING [http:/www.to.infn.it/~nanni/grazing]

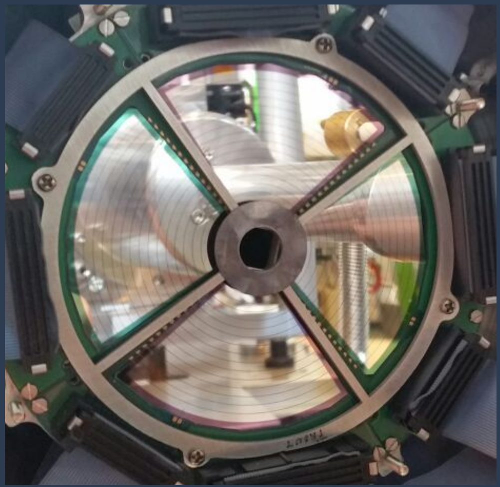
The ^{94}Rb+^{208}Pb experiment

Beam: ^{94}Rb at 6.2 MeV/A, delivered by HIE-ISOLDE
Target: ^{208}Pb, 1 and 13 mg/cm^2 thickness

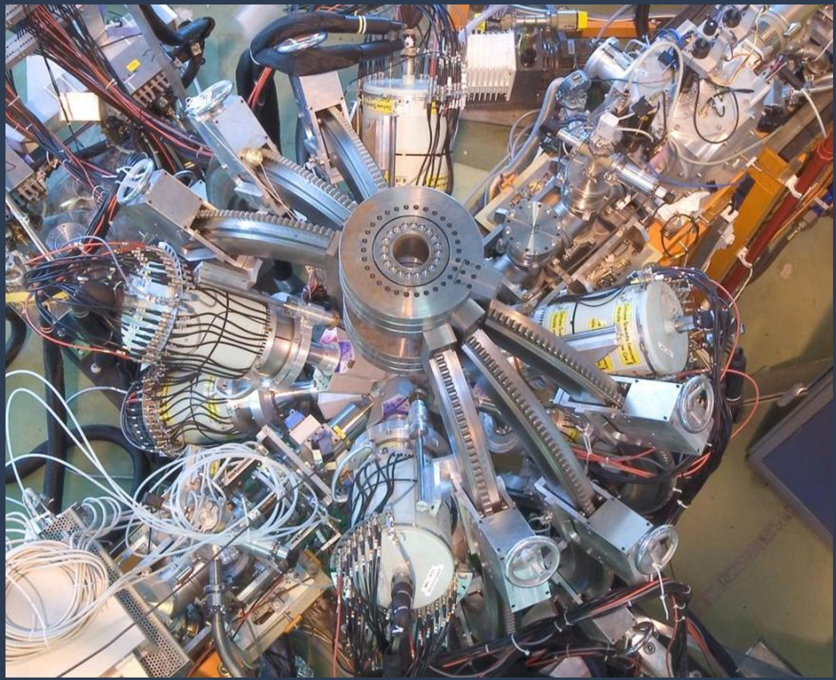


N. Warr et al., Eur. Phys. J. A, 49 40 (2013)

CD particle silicon detector



γ-spectrometer MINIBALL



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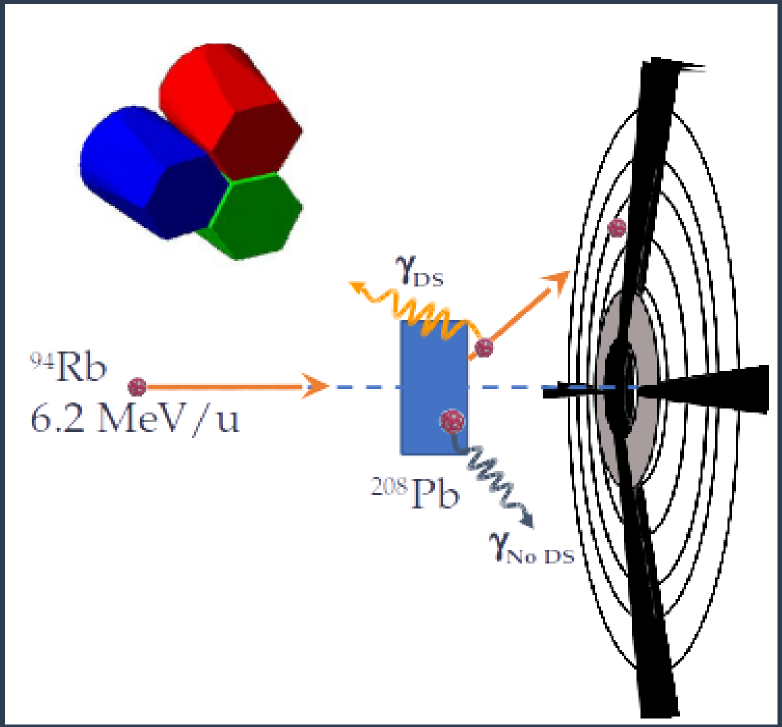

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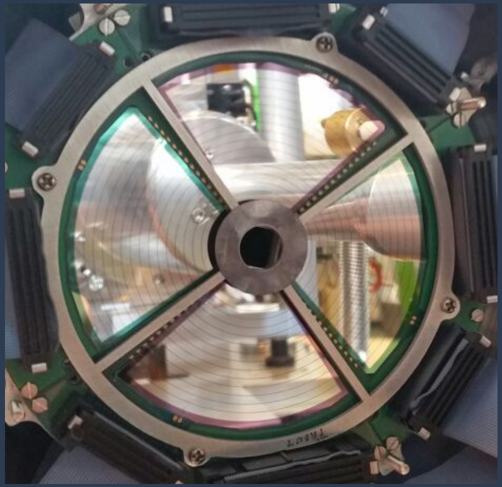
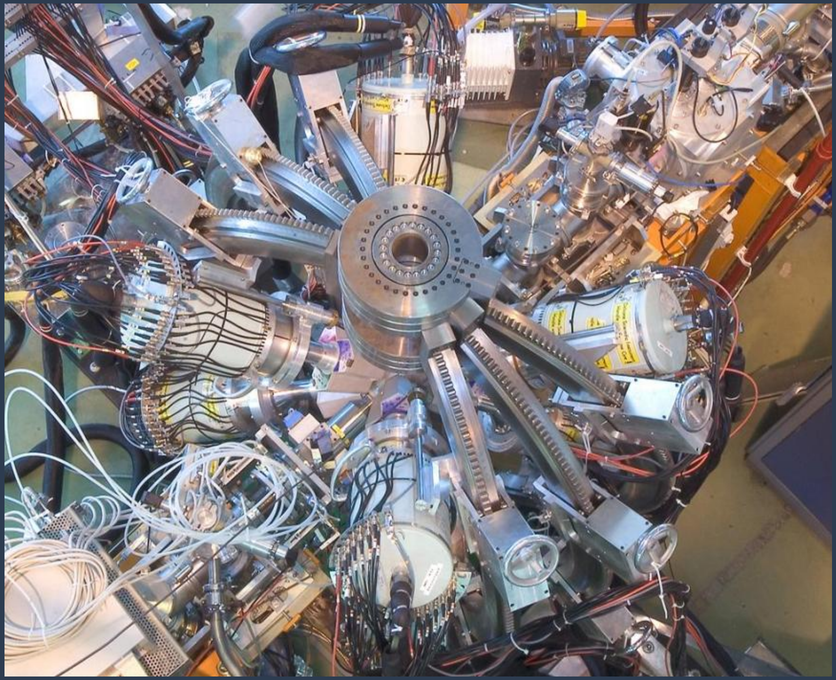
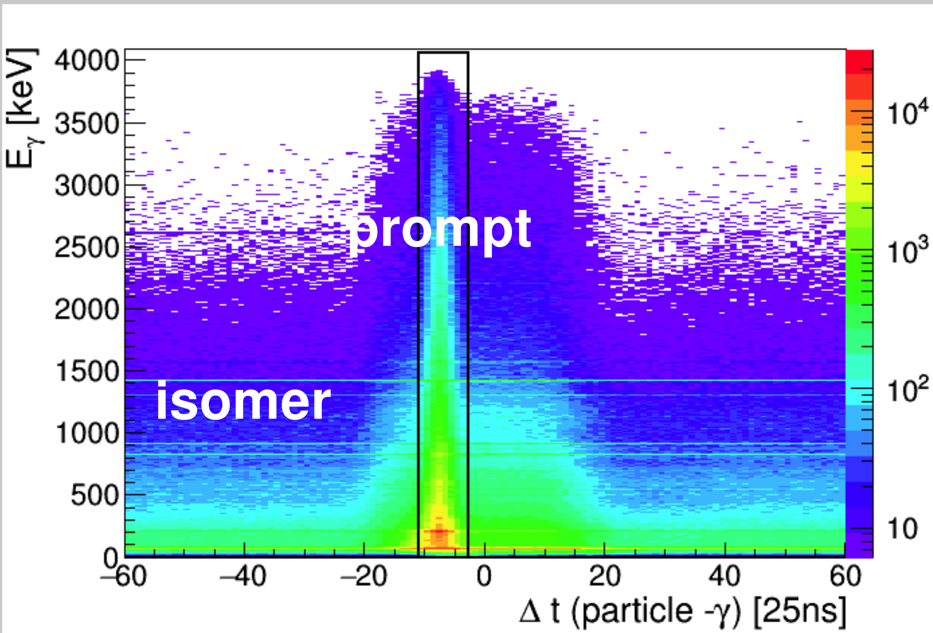


γ-spectrometer MINIBALL



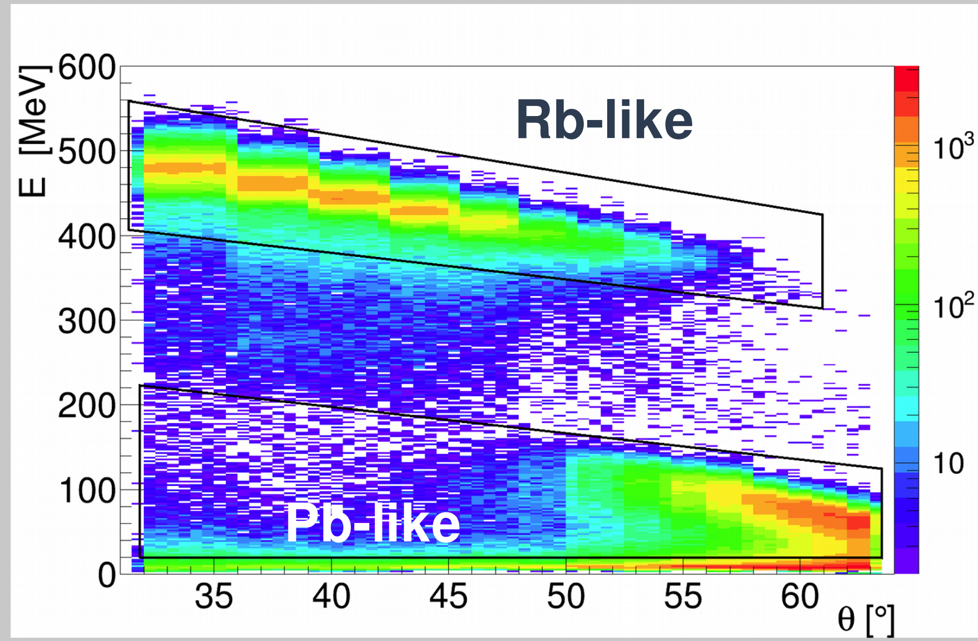
Experimental results

time vs. energy



- prompt γ-rays within Δt ~ 250 ns
- isomer contribution
- background: strong presence of ^{94}Rb ($\tau_{1/2}$~3 s) β-decay chain

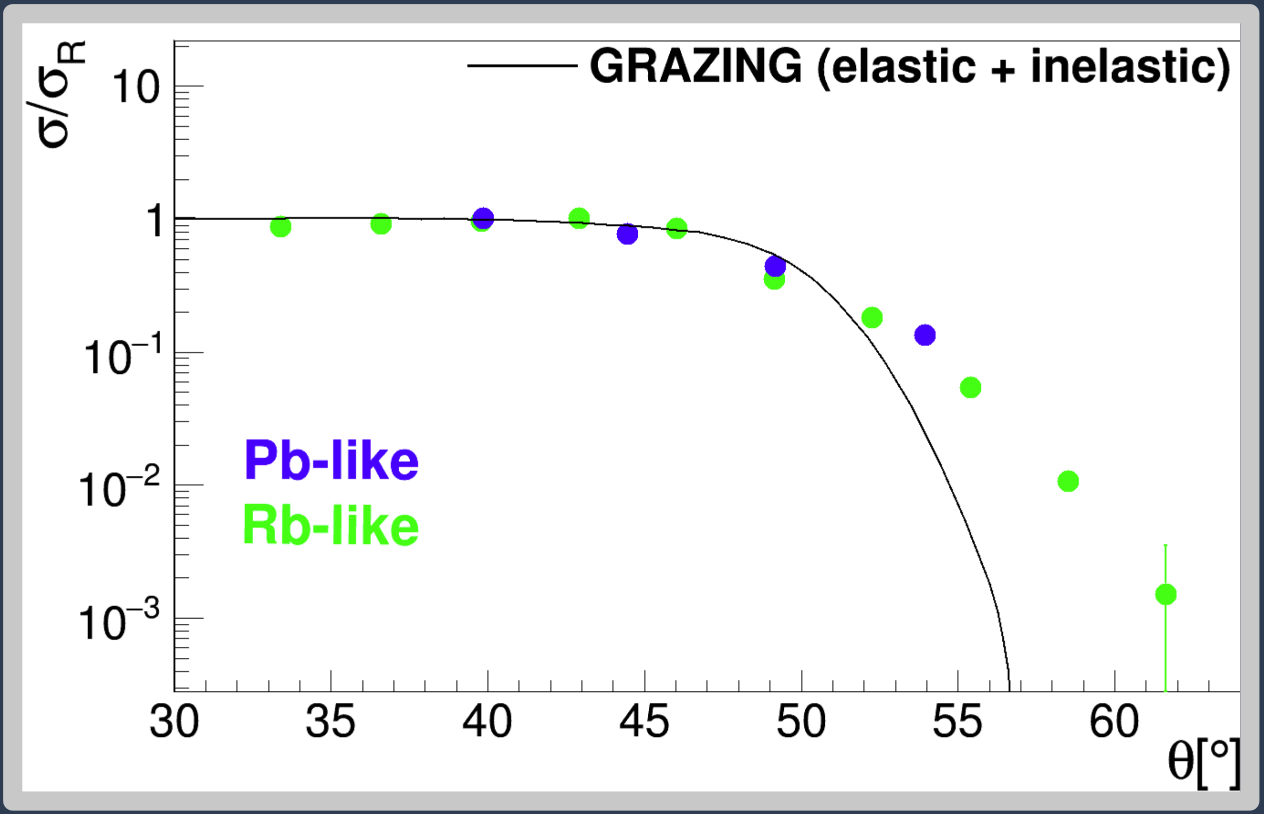
scattering angle vs. energy



- **E-θ matrix**: separation of Rb-like and Pb-like reaction fragments
- **E-θ cuts**: fragments used for the angular distribution construction

Angular distributions

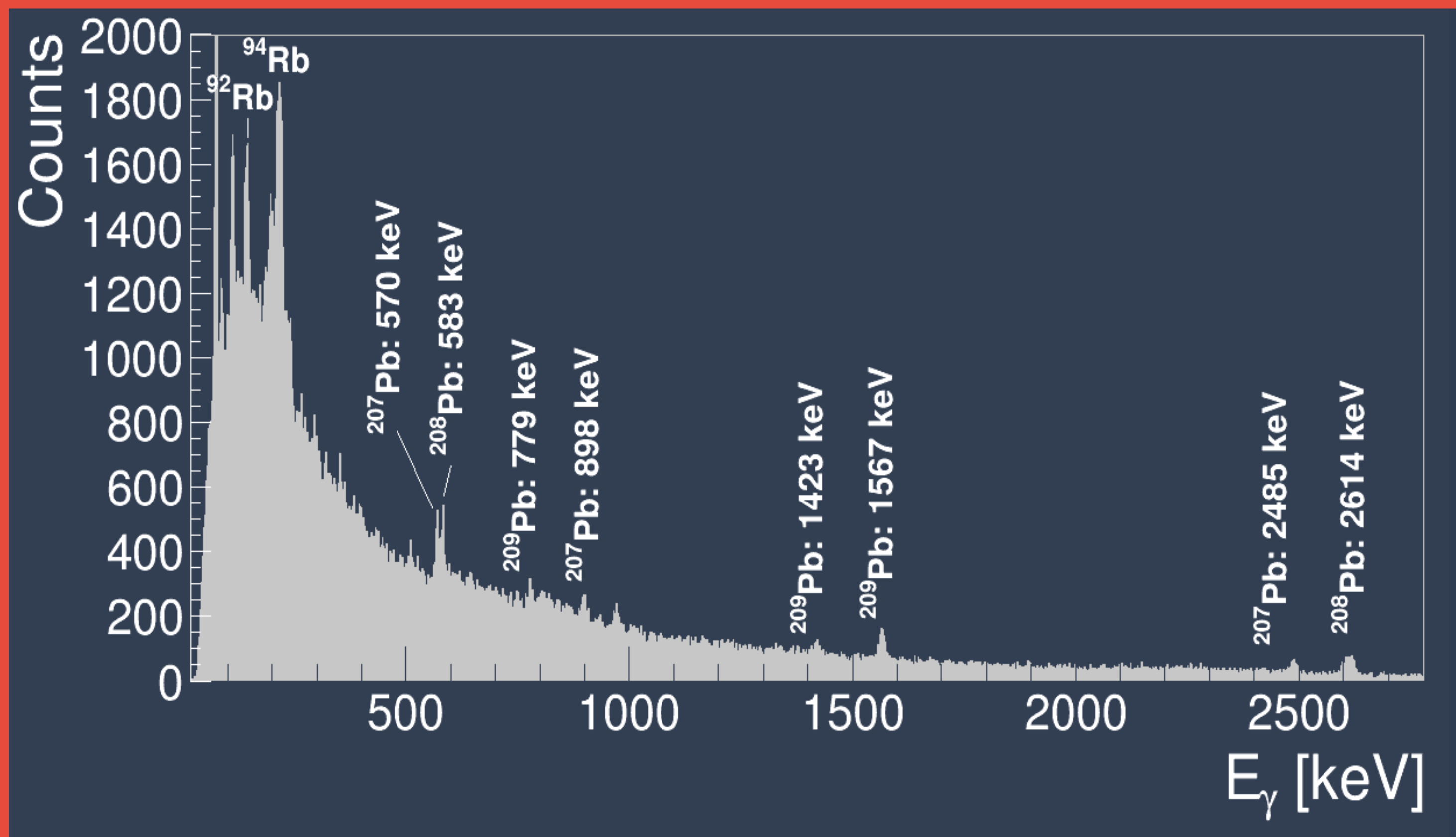
σ/σ_R comparison with GRAZING code



- **σ/σ_R** was obtained gating on **fragments without γ in coincidence**
- experimental distribution: elastic + inelastic + transfer
- normalization at the most forward θ → Rutherford scattering

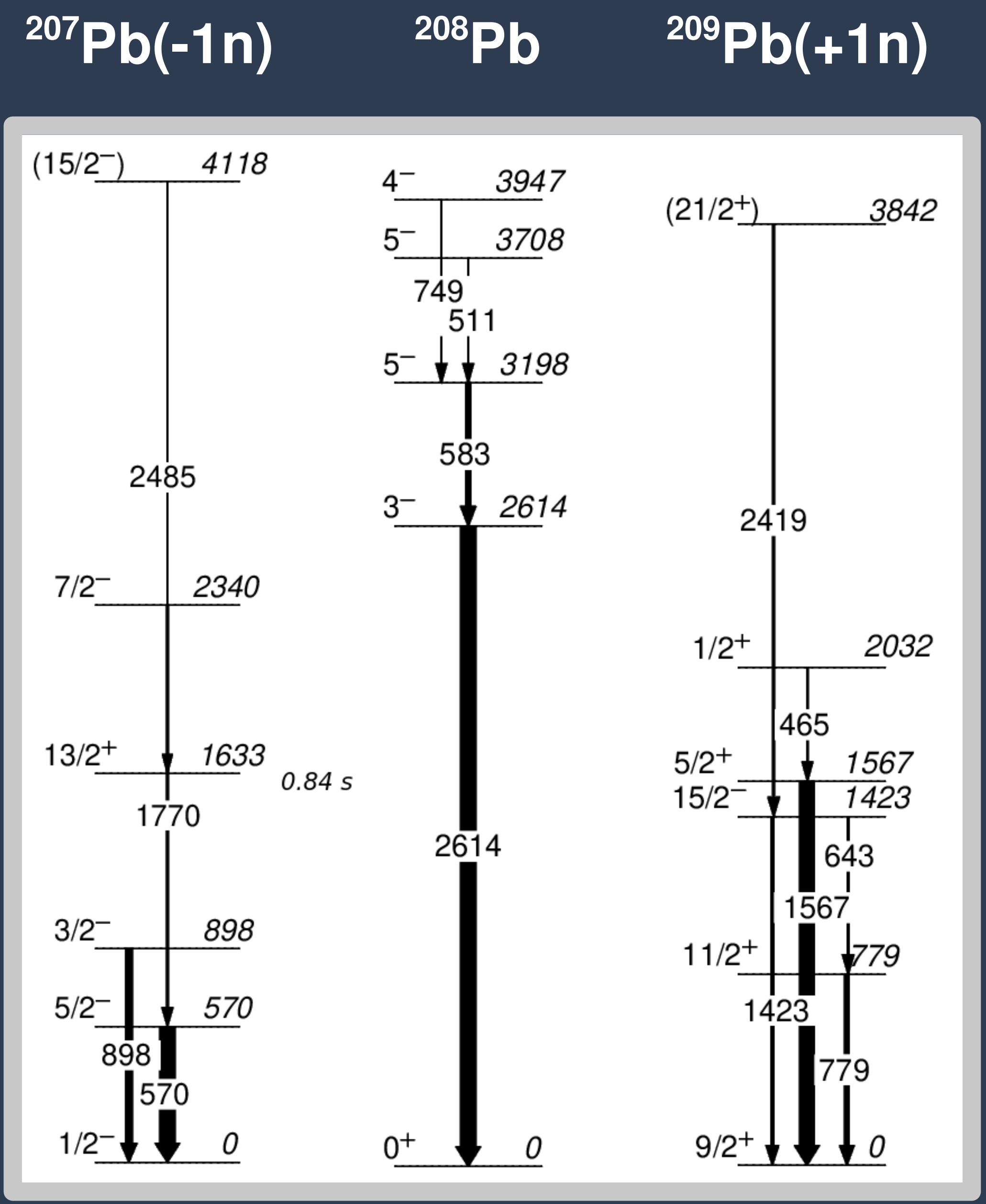
Inelastic and neutron transfer channels

“Thin” (1 mg/cm^2) target



- fragment-γ coincidence with Rb-like products
- γ-rays emitted in-flight → Doppler correction with resolution of 1.2% at 1.5 MeV

Inelastic and neutron transfer channels

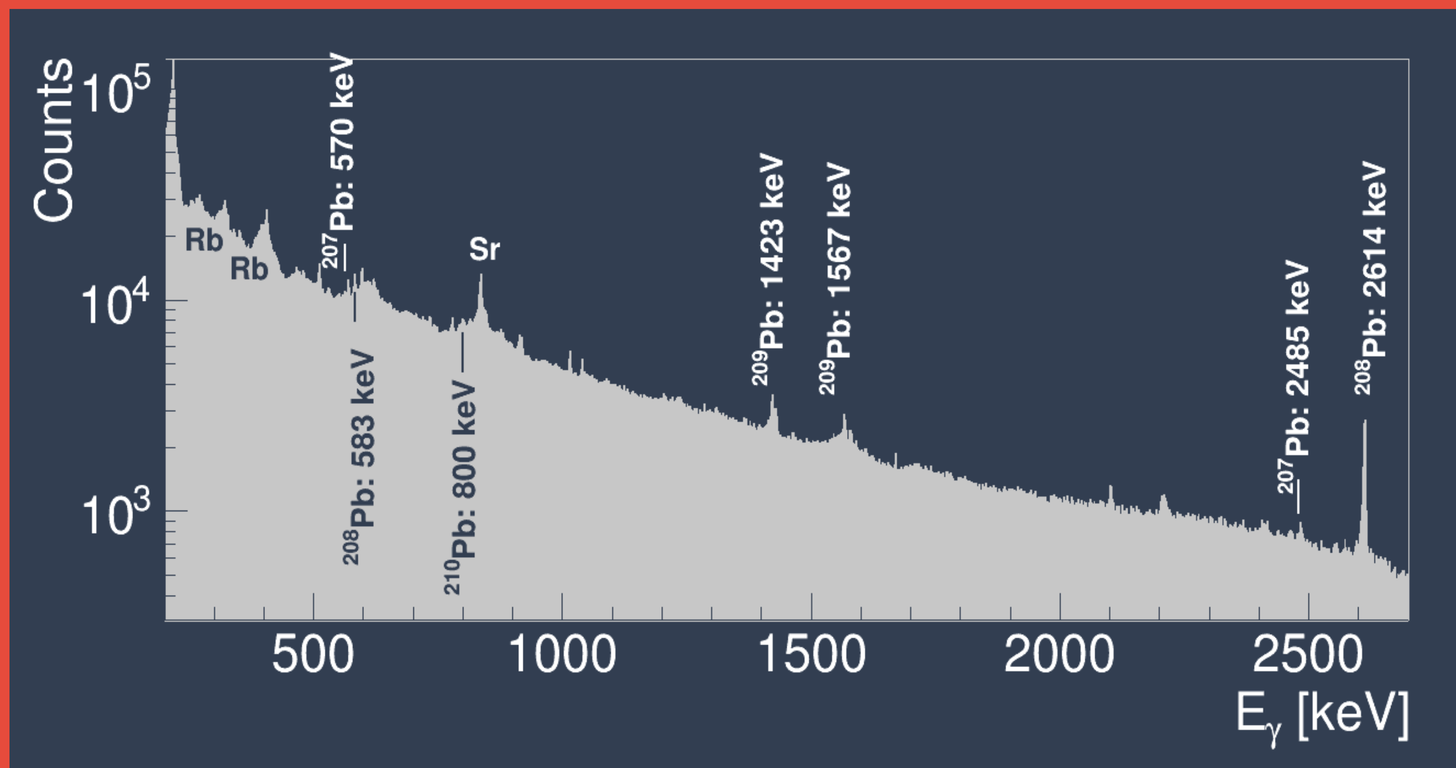


Selective population

- **yrast states**
- **^{208}Pb**: **strong 3$^-$** octupole excitation
- **^{207,209}Pb**:
  - →single-particle states
  - →particle (hole) and 3$^-$ coupling scheme

Inelastic and neutron transfer channels

"Thick" (13 mg/cm^2) target

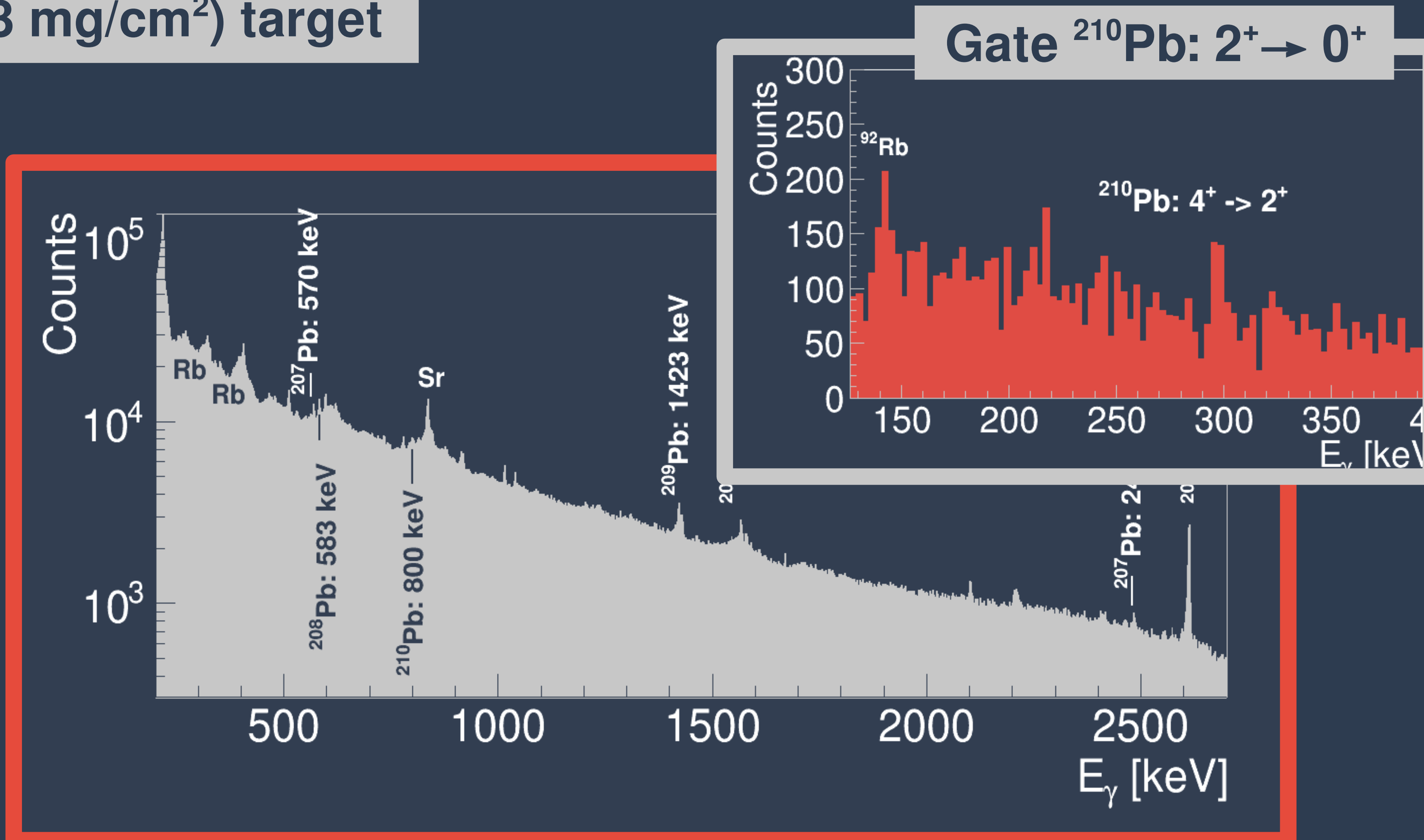


- γ-γ coincidences $\rightarrow$ structure of excited states and isomers
- ^{210}**Pb**: $10^+ \rightarrow 8^+$ ($\tau_{1/2}$ = 201 ns) $\rightarrow 6^+$ ($\tau_{1/2}$ = 92 ns) $\rightarrow 4^+ \rightarrow 2^+ \rightarrow 0^+$

$\tau_{1/2}$ from R. Broda et al, Phys. Rev. C 98, 024324 (2018)

Inelastic and neutron transfer channels

“Thick” (13 mg/cm^2) target



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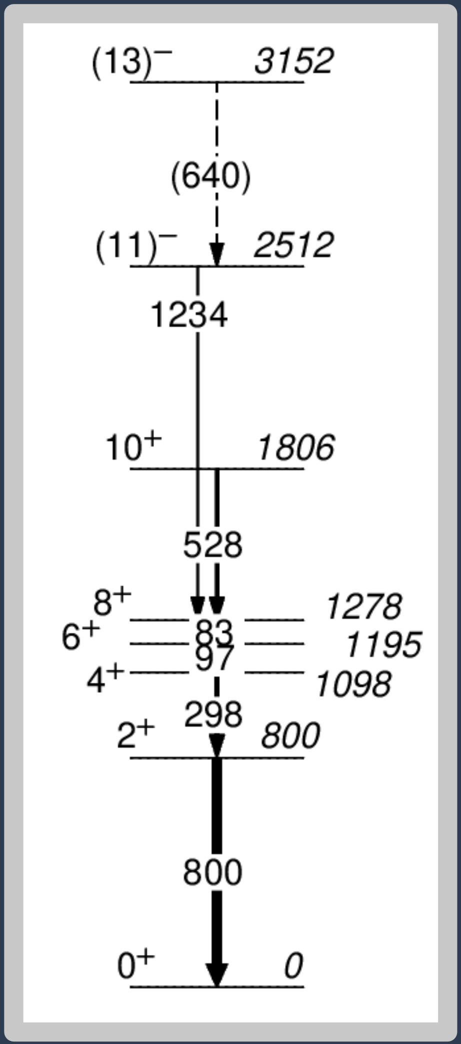
Inelastic and neutron transfer channels

^{210}Pb(+2n)

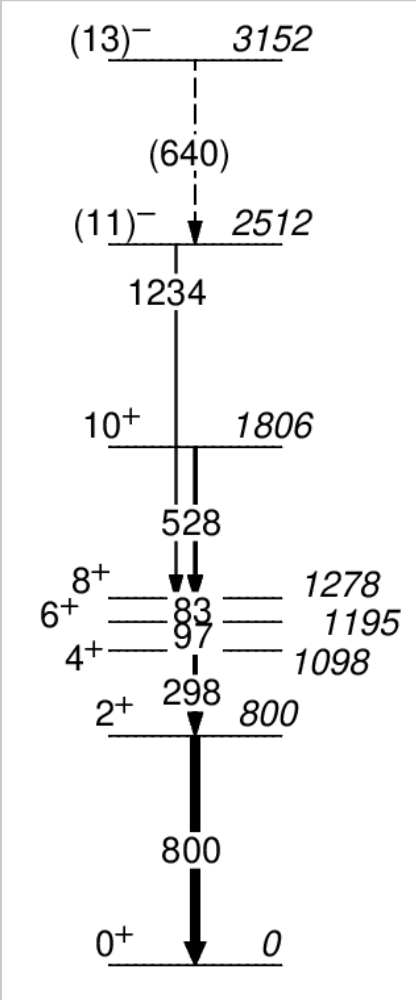


Ongoing analysis: cross section extraction

- extraction of excited states yields
- cross check via γ-γ coincidences
- normalization factor:
  $\rightarrow$ angular distribution of $3^- \rightarrow 0^+$ in ^{208}Pb
  $\rightarrow$ comparison with reaction models (DWBA)

Inelastic and neutron transfer channels

^{210}Pb(+2n)



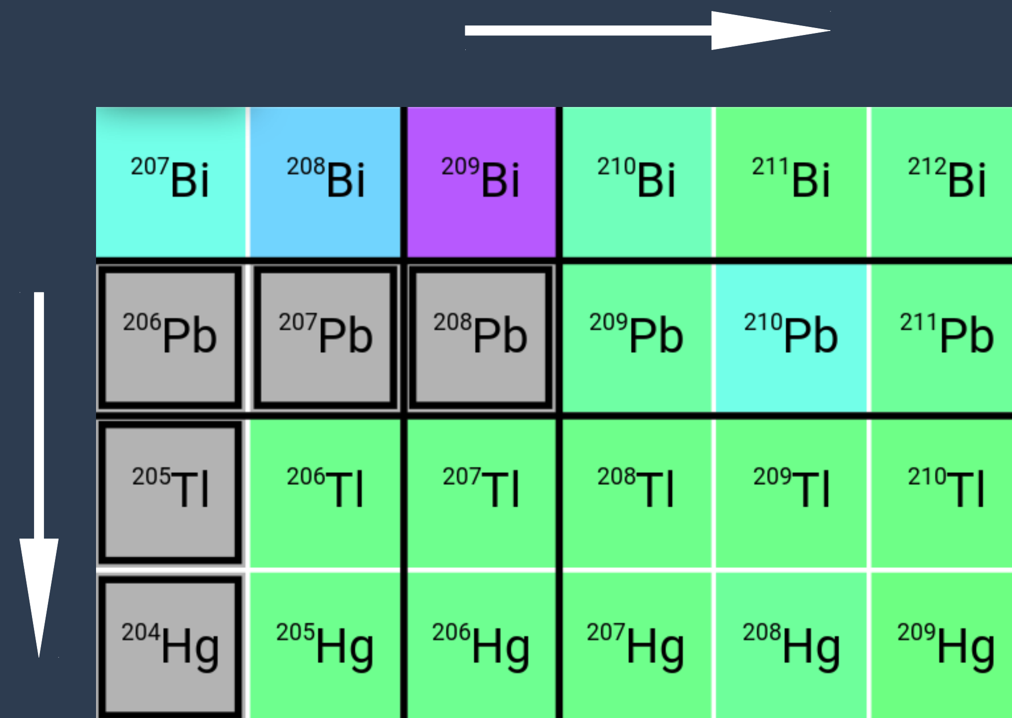
Ongoing analysis: cross section extraction

- extraction of excited states yields ✓
- cross check via γ-γ coincidences *ongoing*
- normalization factor:
  $\rightarrow$ angular distribution of $3^- \rightarrow 0^+$ in ^{208}Pb ✓
  $\rightarrow$ comparison with reaction models (DWBA)

Perspectives

- degrees of freedom that influence the evolution of MNT reaction (transfer strength)
- the optimal experimental conditions for the production of neutron-rich heavy nuclei (different systems, bombarding energies)

The preliminary results show larger cross sections of channels where neutrons are added to the ^{208}Pb target. MNT reactions with the neutron-rich unstable beam is an efficient reaction mechanism for the production of the neutron-rich heavy nuclei.



Thank you!

P. Čolović[1], A. Illana[2], S. Szilner[1], J. J. Valiente-Dobon[2] ,L. Corradi[2], T. Mijatović[1], G. Benzoni[3], M. J. G. Borge[4], J. G. Cubiss[5], G. de Angelis[2] , E. Fioretto[2], F. Galtarossa[2], L. P. Gaffney[5], M. L. Jurado-Gomez[6], Th.Kröll[7] , T. Marchi[2] , R. Menegazzo[2], D. Mengoni[8] , D. R. Napoli[2] , Zs. Podolyak[9], F. Recchia[8], D. Testov[8] in collaboration with MINIBALL and ISOLDE

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