

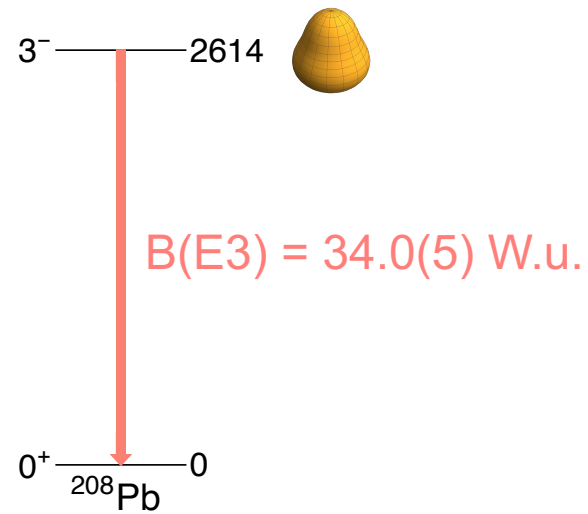
Investigation of Coupled States near ^{208}Pb

Carlotta Porzio

5th February 2025, INTC Meeting

Motivation

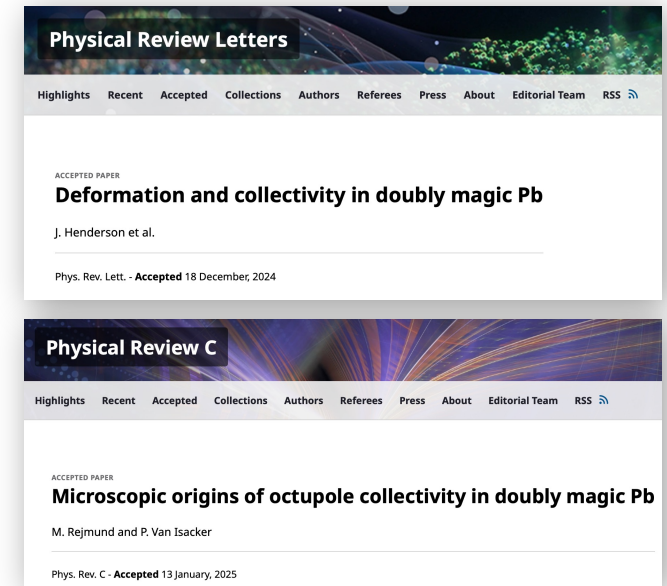
The doubly magic ^{208}Pb region



^{208}Po	^{209}Po	^{210}Po	^{211}Po	^{212}Po
^{207}Bi	^{208}Bi	^{209}Bi	^{210}Bi	^{211}Bi
^{206}Pb	^{207}Pb	^{208}Pb	^{209}Pb	^{210}Pb
^{205}Tl	^{206}Tl	^{207}Tl	^{208}Tl	^{209}Tl
^{204}Hg	^{205}Hg	^{206}Hg	^{207}Hg	^{208}Hg

Shell model reproduces 3⁻ octupole strength.

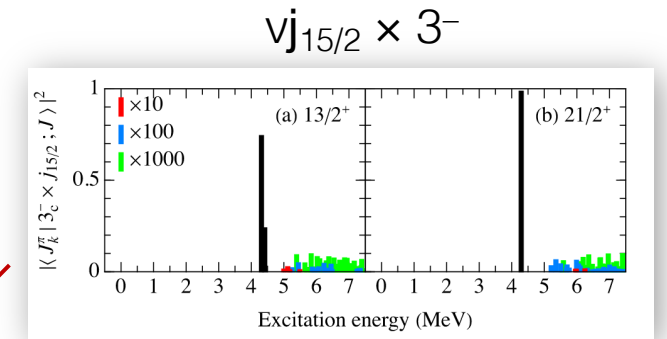
► Van Isacker and Rejmund, Phys. Rev. Res. 4, 2022



Motivation

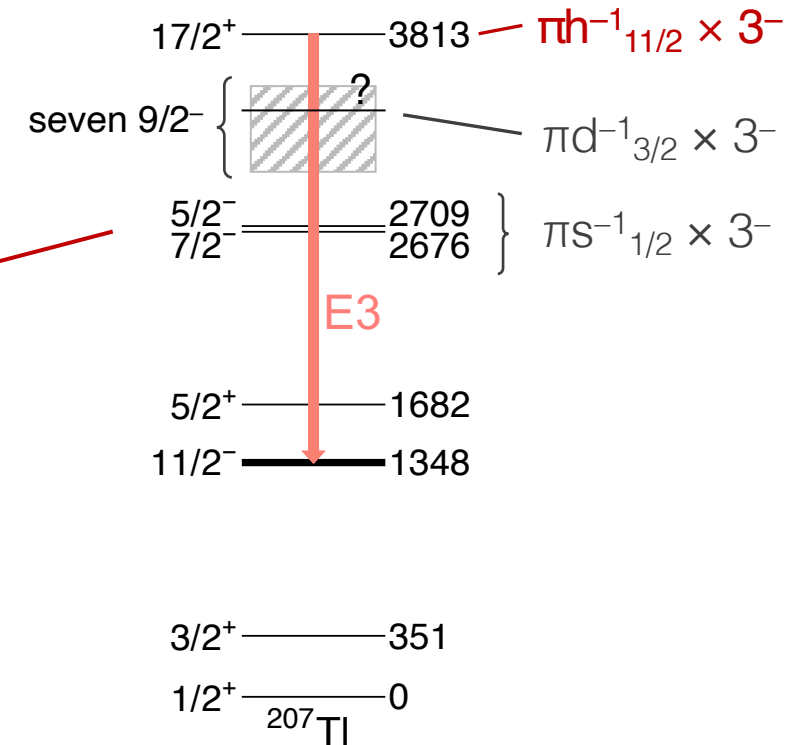
Proton hole-octupole phonon coupling in ^{207}Tl

Multiplets of states from coupling of $^{208}\text{Pb } 3^- \times$ valence particle/hole.



Van Isacker and Rejmund, Phys. Rev. Res. 4, 2022

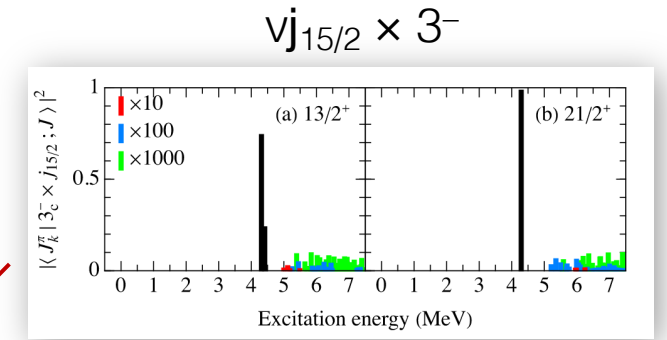
^{208}Po	^{209}Po	^{210}Po	^{211}Po	^{212}Po
^{207}Bi	^{208}Bi	^{209}Bi	^{210}Bi	^{211}Bi
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^{205}Tl	^{206}Tl	^{207}Tl	^{208}Tl	^{209}Tl
^{204}Hg	^{205}Hg	^{206}Hg	^{207}Hg	^{208}Hg



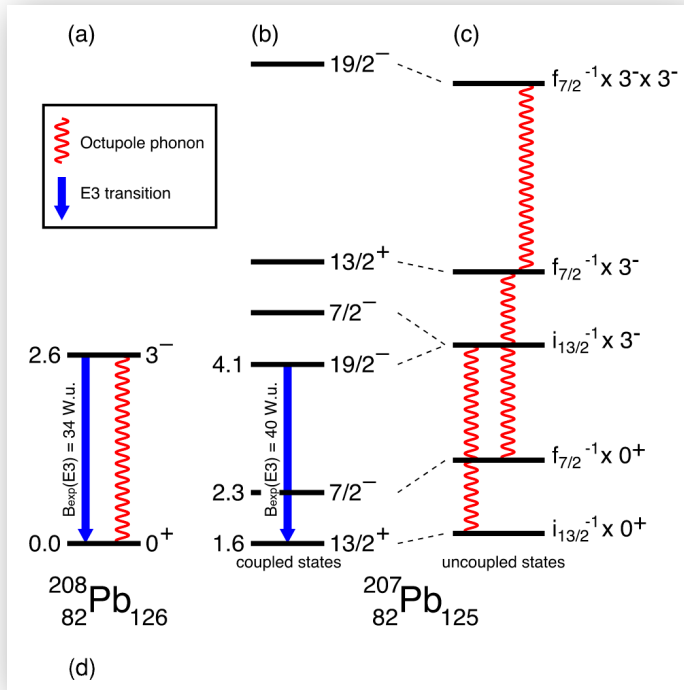
Motivation

Proton hole-octupole phonon coupling in ^{207}Tl

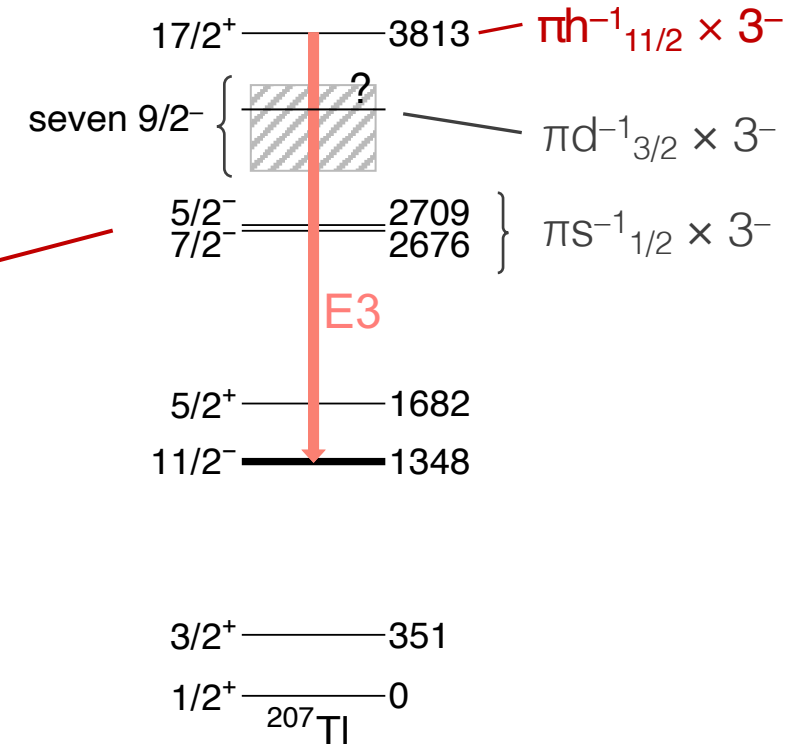
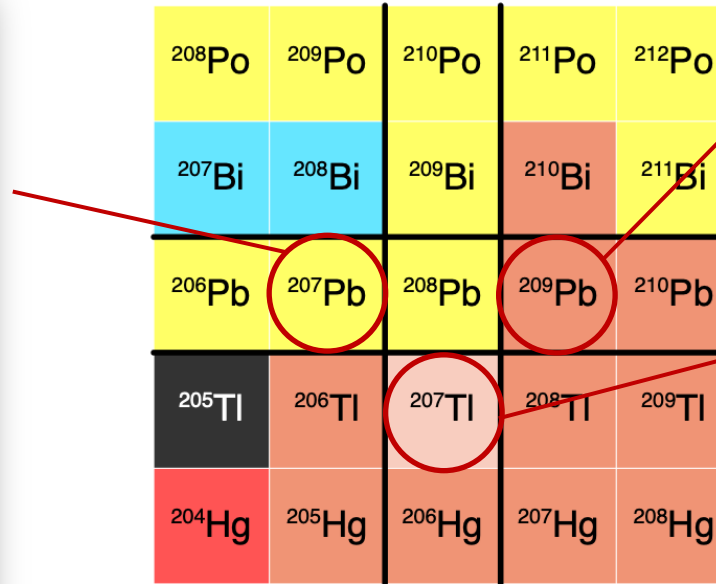
Multiplets of states from coupling of $^{208}\text{Pb } 3^- \times$ valence particle/hole.



Van Isacker and Rejmund, Phys. Rev. Res. 4, 2022

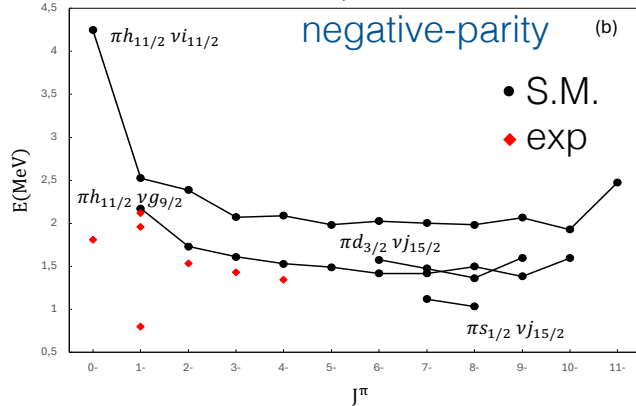
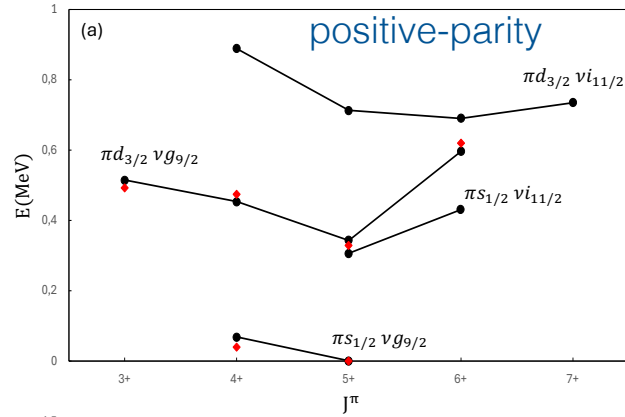


Ralet *et al.*, PLB 797, 134797 (2019)



Motivation

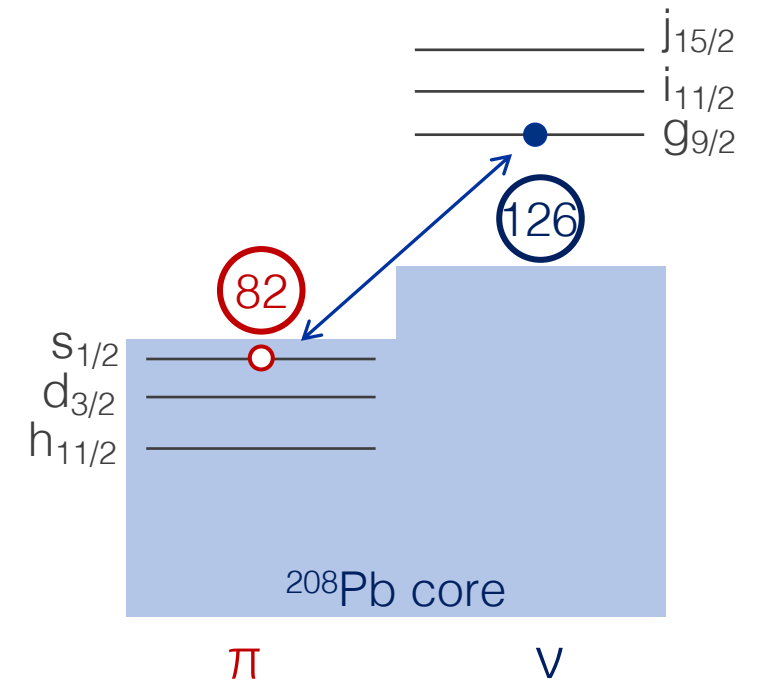
Proton hole-neutron particle coupling in ^{208}Tl



realistic effective Hamiltonian $V_{\text{low-k}}$
 derived from CD-Bonn nucleon-nucleon potential
 ▶ Fornal *et al.*, Journal of Physics 267, 2011

Multiplets of states from coupling of valence particles.

^{208}Po	^{209}Po	^{210}Po	^{211}Po	^{212}Po
^{207}Bi	^{208}Bi	^{209}Bi	^{210}Bi	^{211}Bi
^{206}Pb	^{207}Pb	^{208}Pb	^{209}Pb	^{210}Pb
^{205}Tl	^{206}Tl	^{207}Tl	^{208}Tl	^{209}Tl
^{204}Hg	^{205}Hg	^{206}Hg	^{207}Hg	^{208}Hg



Proposed Experiment

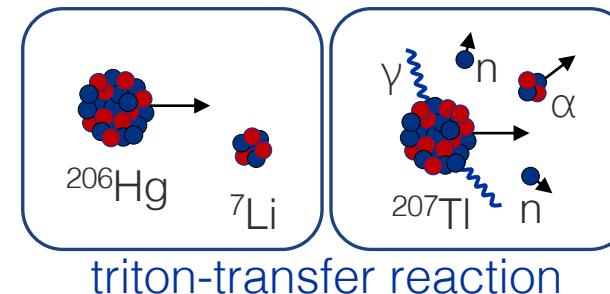
Goal of the experiment:

- Investigate octupole nature of $17/2^+$ state ($\pi h^{-1}_{11/2} \times 3^-$) in ^{207}Tl
- Probe the microscopic character of members of $\pi s^{-1}_{1/2} \times 3^-$ and $\pi d^{-1}_{3/2} \times 3^-$ multiplets in ^{207}Tl
- Search for proton hole-neutron particle coupled states in ^{208}Tl

^{208}Po	^{209}Po	^{210}Po	^{211}Po	^{212}Po
^{207}Bi	^{208}Bi	^{209}Bi	^{210}Bi	^{211}Bi
^{206}Pb	^{207}Pb	^{208}Pb	^{209}Pb	^{210}Pb
^{205}Tl	^{206}Tl	^{207}Tl	^{208}Tl	^{209}Tl
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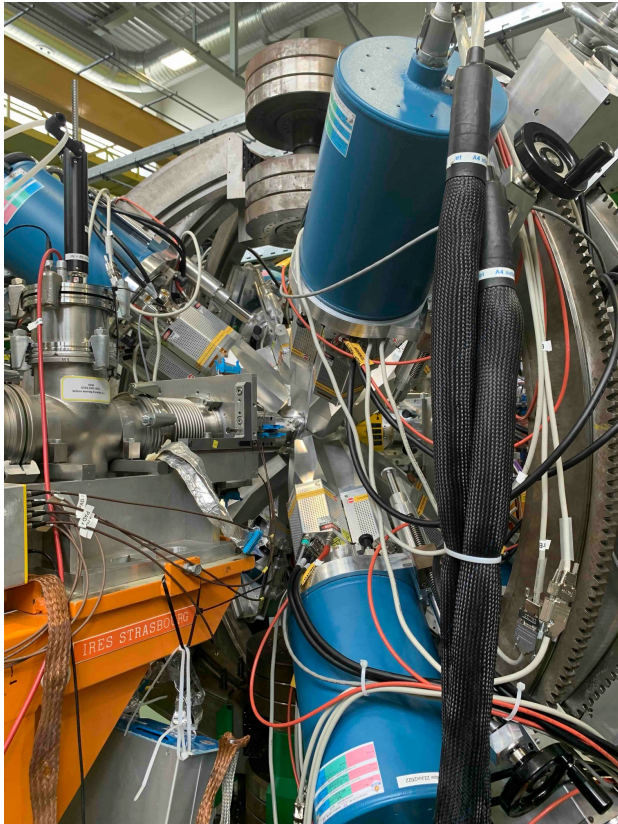
Proposed Measurement:

- Population of $^{207,208}\text{Tl}$ via cluster transfer reaction $^7\text{Li}(^{206}\text{Hg}, \alpha xn)$
technique successfully employed in IS536 and IS595
► Bottoni *et al.*, PRC 92, 2015
- Lifetime measurement of $17/2^+$ state in ^{207}Tl :
B(E3; $17/2^+ \rightarrow 11/2^-$) and upper limits on lifetimes of other multiplet member candidates
- Spectroscopic study to identify short-lived states belonging to other multiplets in ^{207}Tl and ^{208}Tl

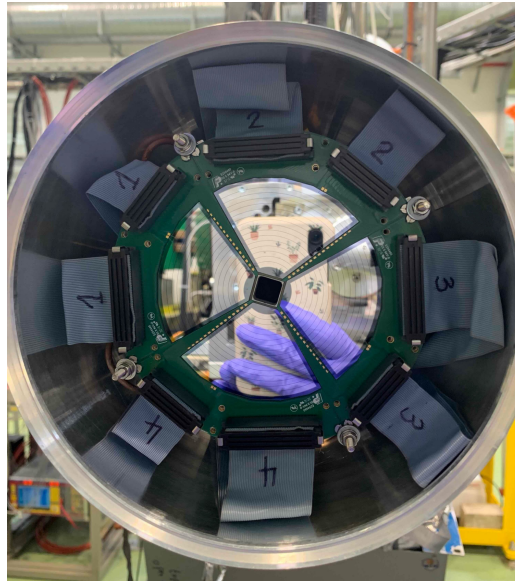


Experimental Setup

Detectors

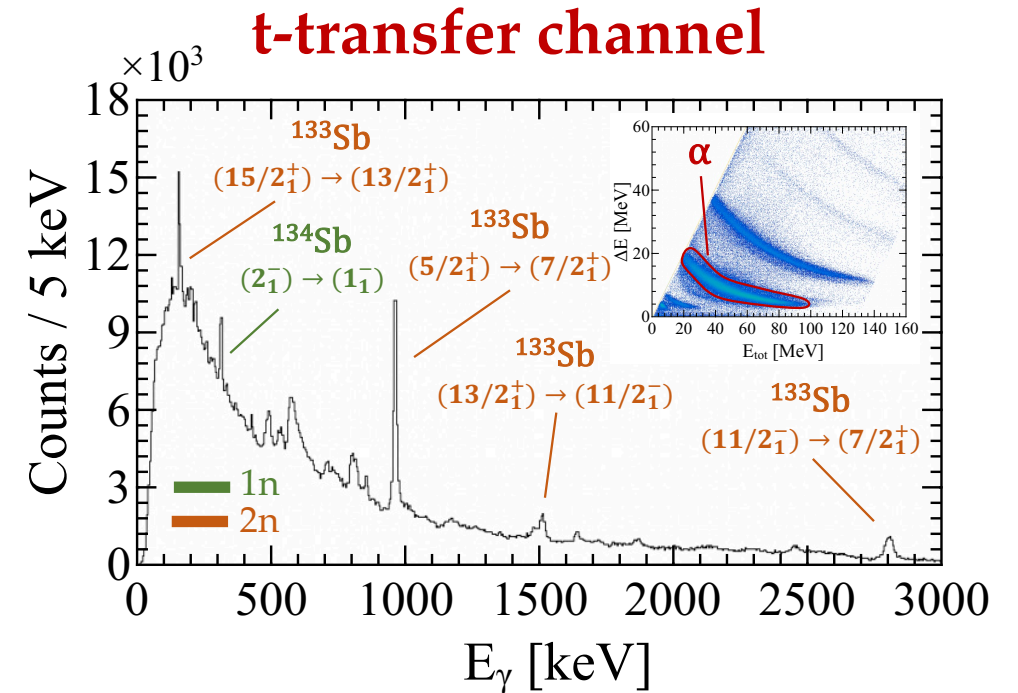


Miniball array
(gamma rays)



CD+PAD Si detectors
in telescope mode
(light ions identification)

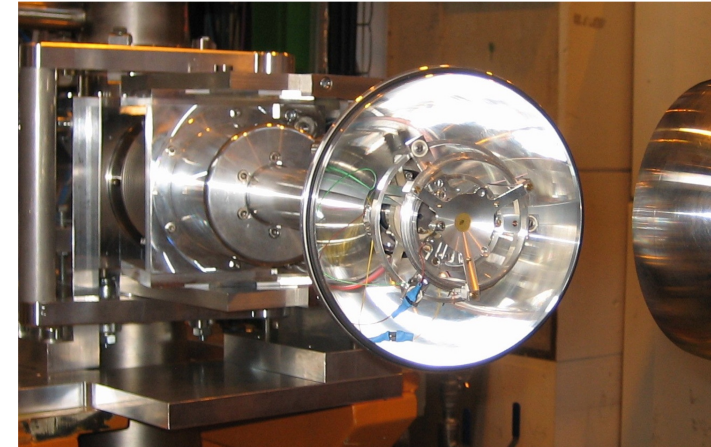
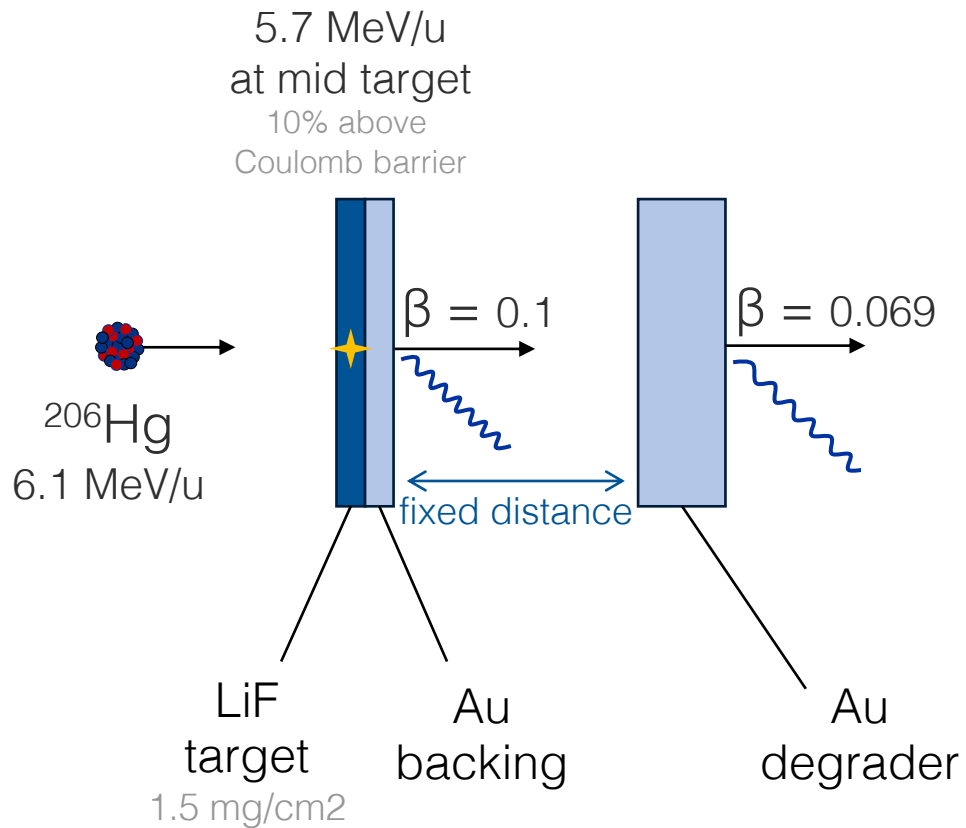
$20^\circ \lesssim \theta_{\text{lab}} \lesssim 60^\circ$
at 25 mm target distance



Spectrum from IS595 (under analysis)
using $^7\text{Li}(^{132}\text{Sn}, \alpha xn)$.

Experimental Setup

The Miniball plunger for half-life measurements



- **3 distances** (200 μm -2 mm):
for half-life measurement
expecting $T_{1/2} \sim 25$ ps
from $B(E3; 3^- \rightarrow 0^+)$ in ^{208}Pb
- **1 long distance** (~ 5 mm):
for systematic error estimate and
identification of short-lived states

referee's question

4 distances

Shift request

- ^{206}Hg beam at 6.1 MeV/u, 4×10^5 ions/s at Miniball
 already successfully delivered from molten Pb target with VADIS+RILIS in IS547 and IS631;
 operation at 0.6 μA p^+ current
 - Tang *et al.*, PRL 124, 2020
 - Morrison *et al.*, PLB 838, 2023
- Population of states in ^{207}Tl with $\sim 8\text{h}$ and up to 6 MeV excitation energy

Total σ	$\sigma_{\alpha 2n}$	^{207}Tl total production rate	CD count rate for $\alpha 2n$ channel	Population probability $17/2^+$ state in ^{207}Tl	$\epsilon_{\gamma}(2.5 \text{ MeV})$ with one Miniball ring	2.5 MeV γ rays observed in 1 8-hour shift	2.5 MeV γ rays observed in 5 8-hour shifts
100 mb	80 mb	1 pps	0.3 pps	20%	2%	40	200

referee's question

To ensure clear identification of the two peak components in the γ -ray spectrum. Minimum **$\sim 30\text{-}40$ counts per component** required.

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100 mb	80 mb	1 pps	0.3 pps	20%	2%	40	200

→ 4 plunger distances \times 5 shifts = **20 shifts**
 → **1 shift** for beam tuning optimization

} **21 shifts in total**

Summary

Motivation

- Investigate particle-phonon coupled states in $^{207}\text{Tl} \rightarrow \text{B}(E3)$
- Investigate proton hole-neutron particle coupled states in $^{208}\text{Tl} \rightarrow$ probe shell model description

Proposed experiment

- Cluster transfer reaction ${}^7\text{Li}({}^{206}\text{Hg}, \alpha xn)$ at Miniball
- Lifetime measurement of $17/2^+$ state in ^{207}Tl and upper limits for other multiplet member candidates
- Identification of other multiplet members in $^{207,208}\text{Tl}$

→ **21 shifts requested**

Thank You

C. Porzio¹, S. Leoni², B. Fornal³, S. Bottoni², A. D. Ayangeakaa⁹, G. Benzoni², A. Bracco², F. Browne⁴, M. Ciemala³, N. Cieplicka-Oryn zak³, G. Col ², G. Corbari², D. Duda³, C. Fransen⁵, S. Freeman^{1,4}, L. P. Gaffney⁶, A. Gargano⁷, D. Genna², A. Giaz², A. Gottardo⁸, Ł. Iskra³, R. V. F. Janssens⁹, C.-D. Lakenbrink⁵, M. Luciani², A. Maj³, N. Marginean¹⁰, M. Matejska-Minda³, D. Mengoni¹¹, S. Meyer¹², C. M ller-Gatermann¹³, R. Raabe¹⁴, P. Reiter⁵, P. Spagnoletti⁶, S. Stegemann¹, T. Kr ll¹², N. Warr^{5,6}, L. Zago^{2,8}

¹CERN-ISOLDE, Gen ve, Switzerland

²Universit  degli Studi di Milano and INFN Milano, Milano, Italy

³Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland

⁴University of Manchester, Manchester, UK

⁵Universit t zu K ln, K ln, Germany

⁶University of Liverpool, Liverpool, UK

⁷INFN Napoli, Napoli, Italy

⁸INFN Legnaro, Legnaro, Italy

⁹University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA and Triangle Universities Nuclear Laboratory, Duke University, Durham, North Carolina, USA

¹⁰IFIN-HH, Magurele, Romania

¹¹Universit  degli Studi di Padova and INFN Padova, Padova, Italy

¹²TU Darmstadt, Darmstadt, Germany

¹³Argonne National Laboratory, Lemont, USA

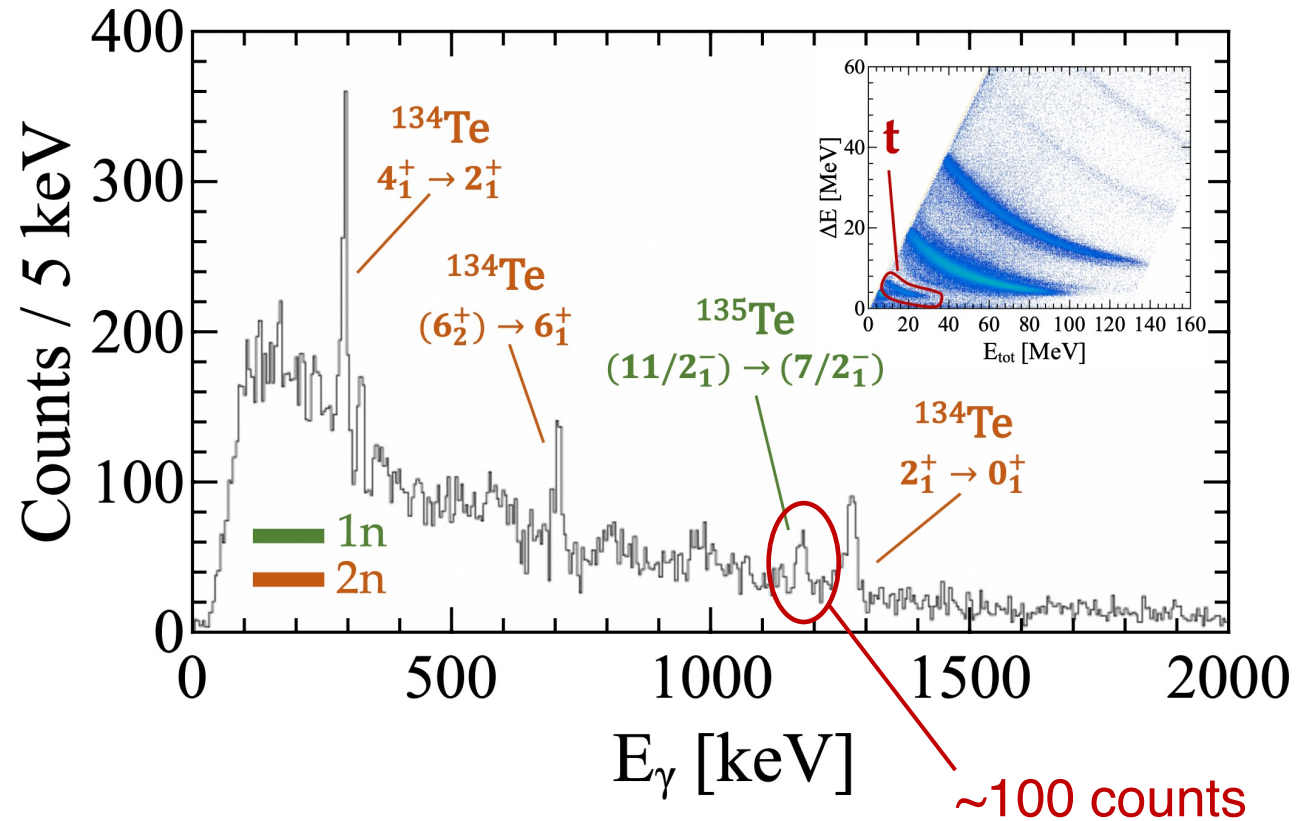
¹⁴KU Leuven, Leuven, Belgium



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Backup Slides

α -transfer channel



Spectrum from IS595 (under analysis).