Gamma-ray spectroscopy of neutron-rich Sb isotopes by cluster transfer reactions

Simone Bottoni

Università degli Studi di Milano and INFN

for the IS595 collaboration

ISOLDE workshop

30 November 2023

IS595 MINIBALL and T-REX collaboration

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Special thanks

- ISOLDE team
- IS702 collaboration (P. Reiter at al.)

Status of the IS595 experiment

Simone Bottoni

approved in 2014

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Spectroscopy of particle-phonon coupled states in ^{133}Sb by the cluster transfer reaction ^{132}Sn on ^{7}Li: an advanced test of nuclear interactions

[8th October 2014]

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M. Kowalska[14]

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run in October 2023

ISOLDE workshop

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run in October 2023

advanced γ-ray spectroscopy around ^{132}Sn

triton transfer from ^{7}Li

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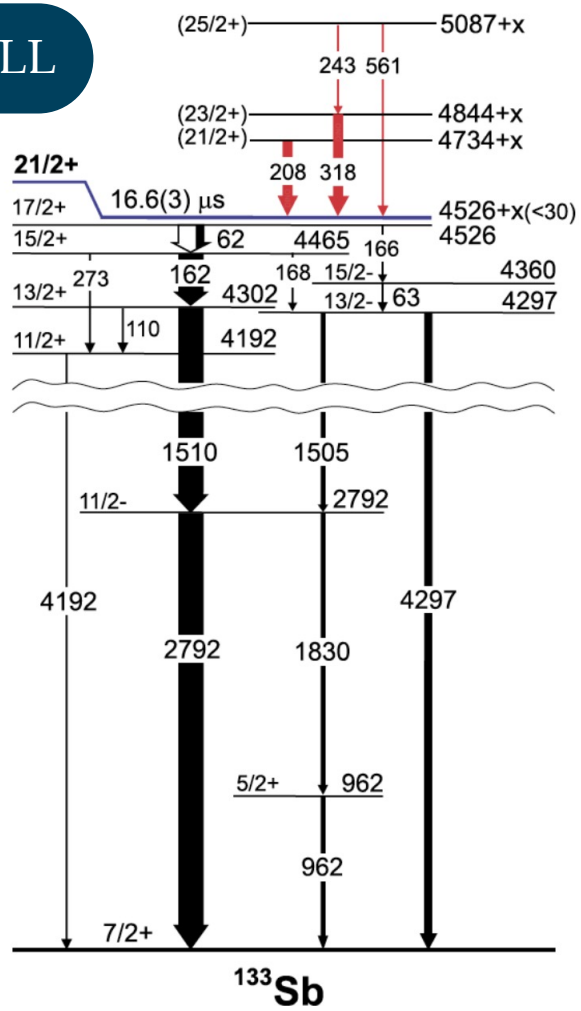
Valence proton-phonon couplings in ^{133}Sb

Simone Bottoni

$$^{133}\mathbf{Sb} = {}^{132}\mathbf{Sn} \otimes \mathbf{1\pi}$$

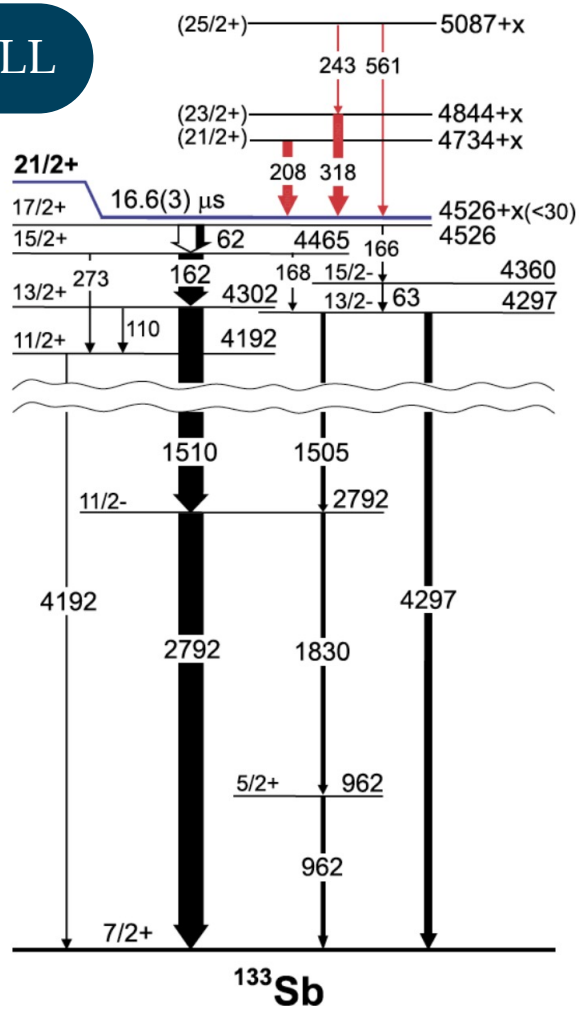
EXILL



G. Bocchi *et al.*, Phys. Lett. B **760**, 273 (2016)

^{133}Sb = ^{132}Sn ⊗ 1π

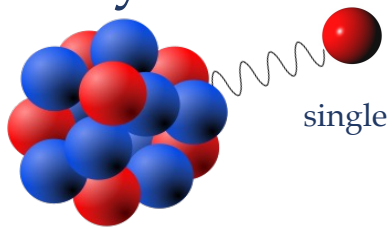
EXILL



G. Bocchi *et al.*, Phys. Lett. B **760**, 273 (2016)

The Hybrid model

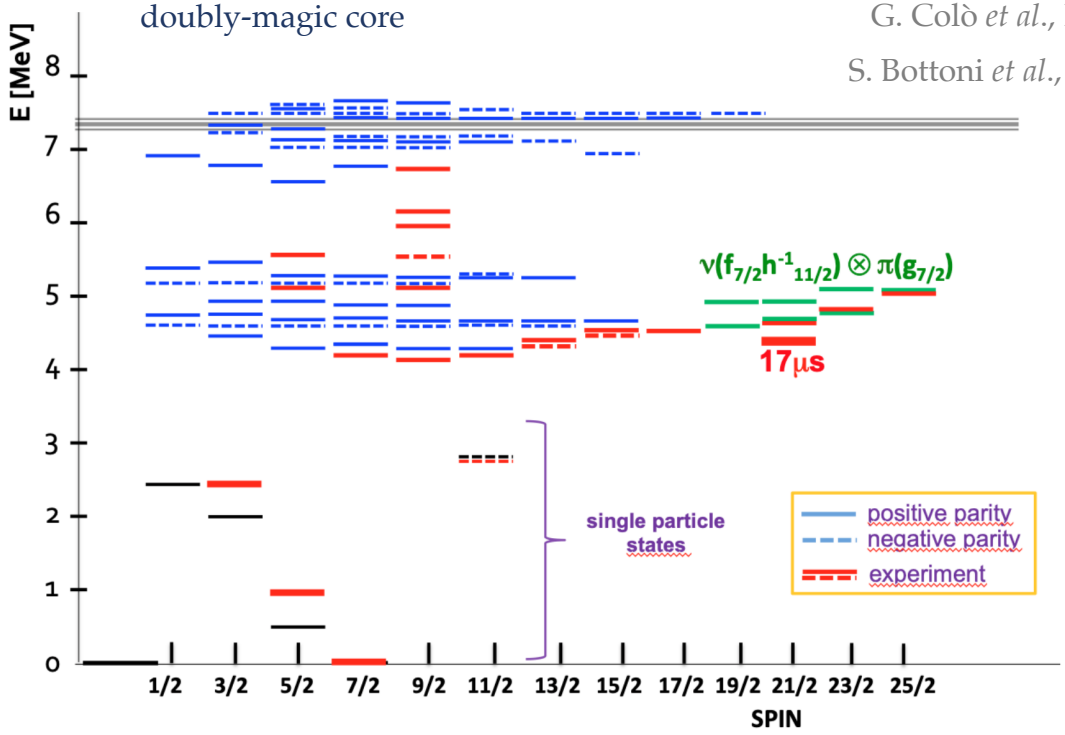
A+1 system



$$H = H_0 + V,$$
$$H_0 = \sum_{jm} \varepsilon_j a^\dagger_{jm} a_{jm} + \sum_{NJM} \hbar\omega_{NJ} \Gamma^\dagger_{NJM} \Gamma_{NJM},$$
$$V = \sum_{jmj'm'} \sum_{NJM} h(jm; j'm', NJM) a_{jm} \left[a^\dagger_{j'} \otimes \Gamma^\dagger_{NJ} \right]_{jm}$$

G. Colò *et al.*, Phys. Rev. C **95**, 043403 (2017)

S. Bottoni *et al.*, Phys. Rev. C **103**, 014320 (2021)



single particle

^{132}Sn(λ) ⊗ π

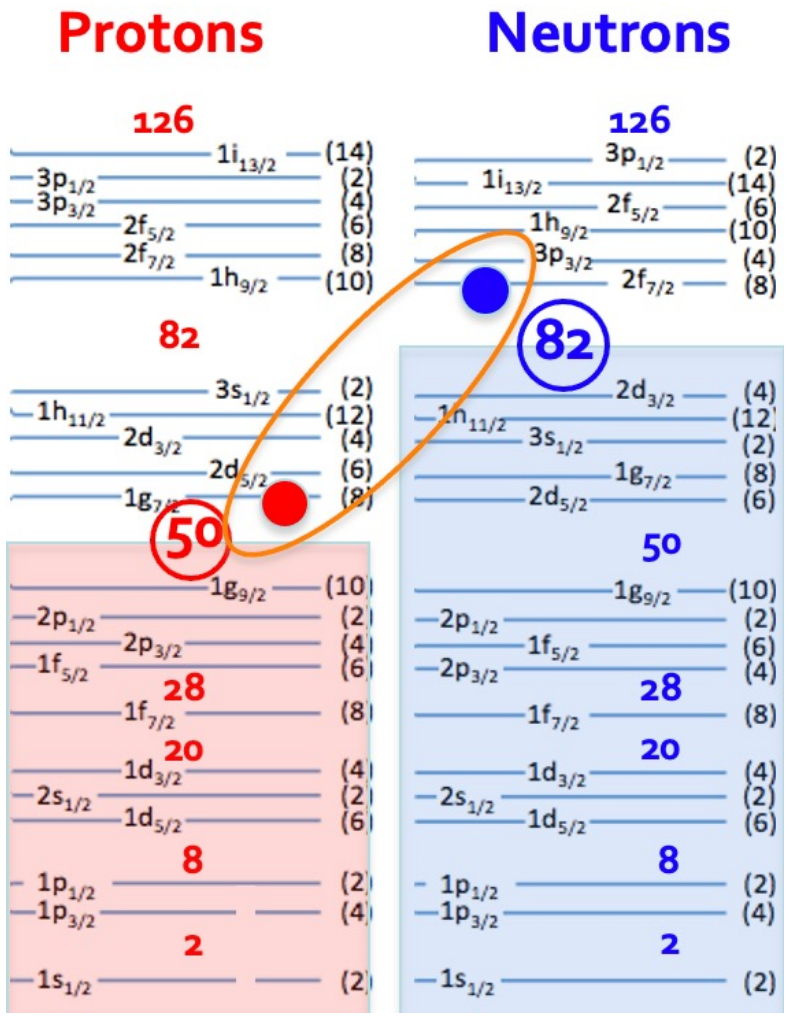
^{132}Sn(1p1h) ⊗ π

complex excitations not fully treated within standard shell model

Valence proton-neutron couplings in ^{134}Sb

Simone Bottoni

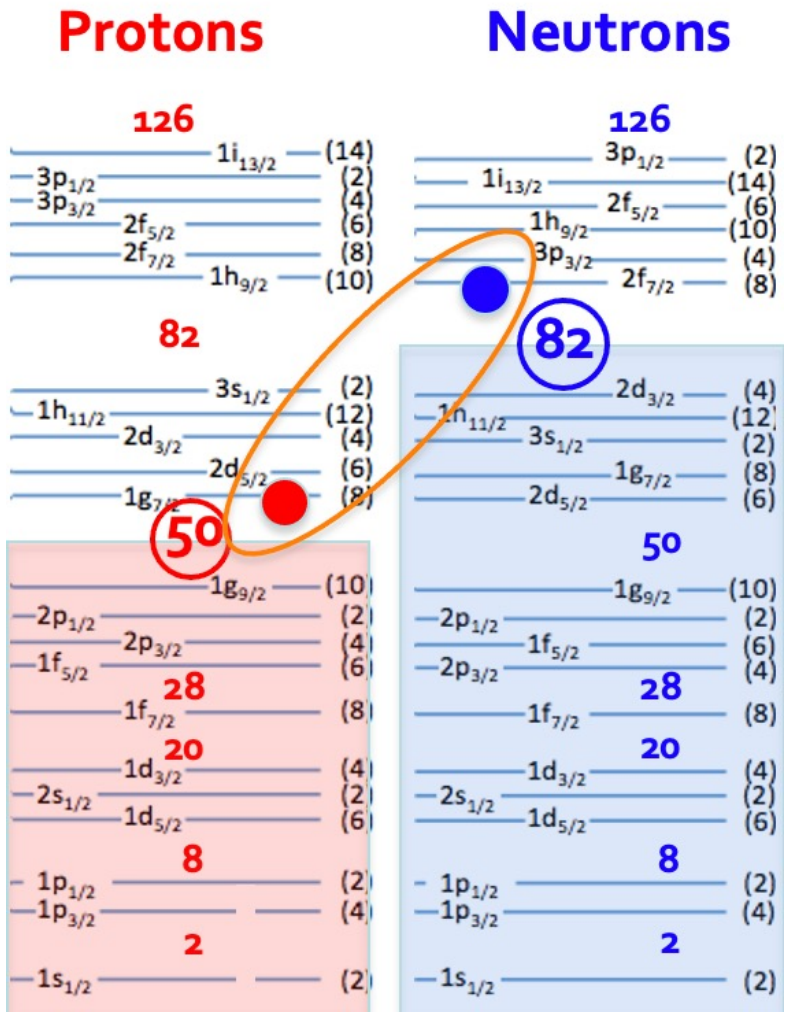
$$^{134}\mathrm{Sb} = {}^{132}\mathrm{Sn} \otimes (1\pi + 1\nu)$$

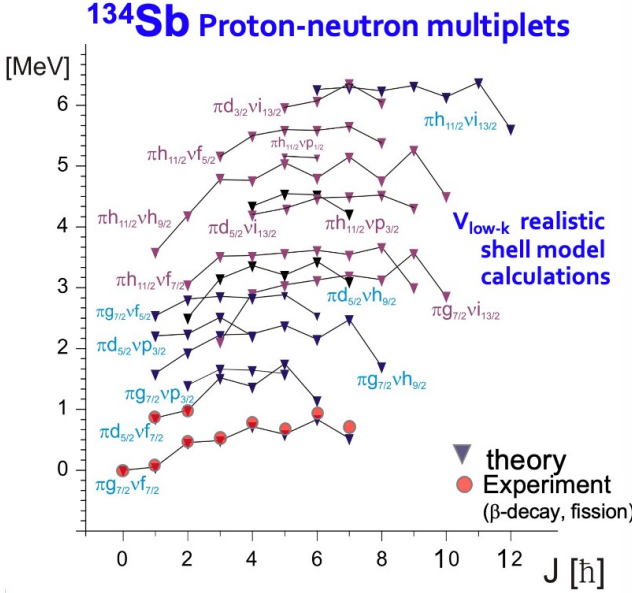


Realistic shell model

L. Coraggio *et al.*, Phys. Rev. C **80**, 021305(R) (2009)

$^{134}Sb = {}^{132}Sn \otimes (1\pi + 1\nu)$

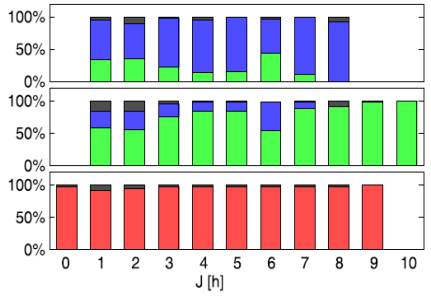


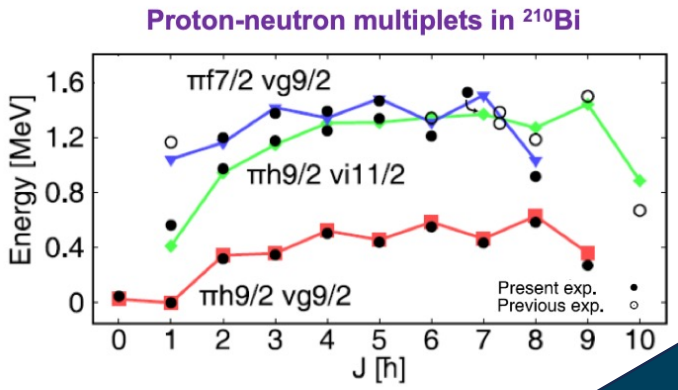


test of two-body matrix elements

$$\begin{pmatrix} H_{11} & H_{12} & H_{13} & \cdots \\ H_{21} & H_{22} & H_{23} & \cdots \\ H_{31} & H_{32} & H_{33} & \cdots \end{pmatrix}$$

Analogies with ^{208}Pb region



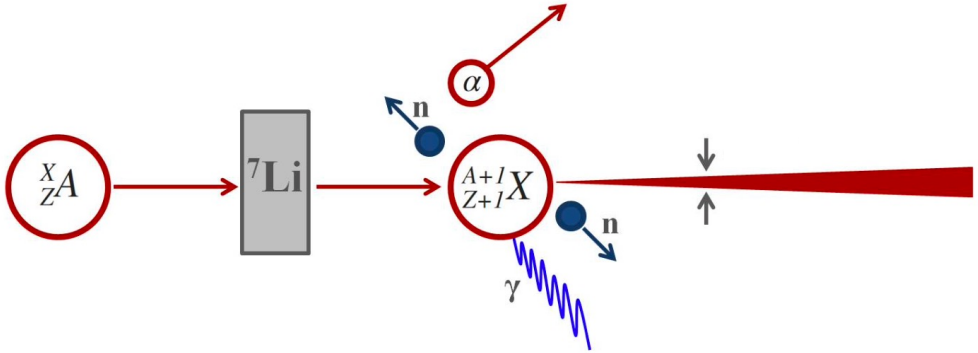


N. Cieplicka-Oryńczak *et al.*, Phys. Lett. B **802**, 135222 (2020)

FIPPS

The ^{98}Rb/^{98}Sr + ^{7}Li experiment

S. Bottoni *et al.*, Phys. Rev. C **92**, 024322 (2015)



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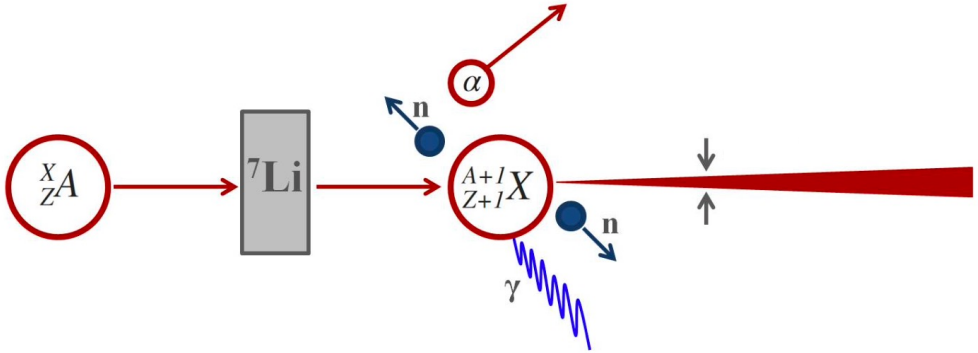
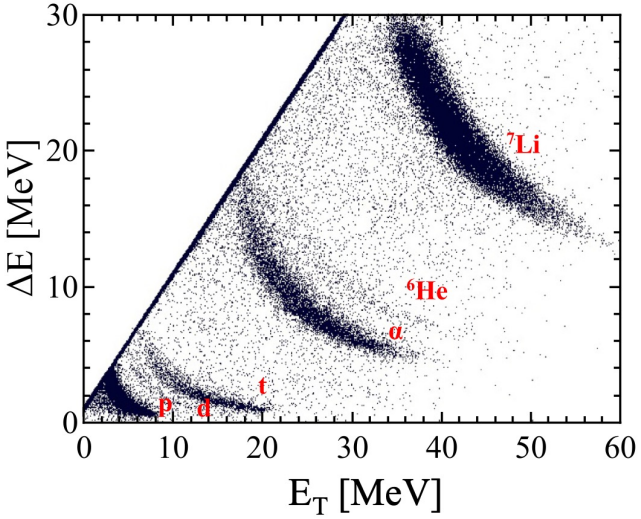
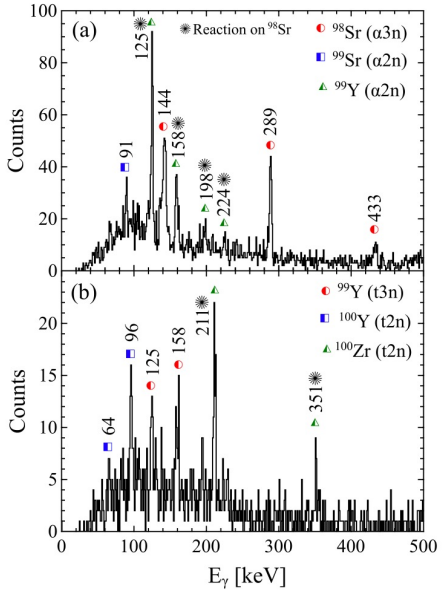


Selectivity on α- and t-transfer channels





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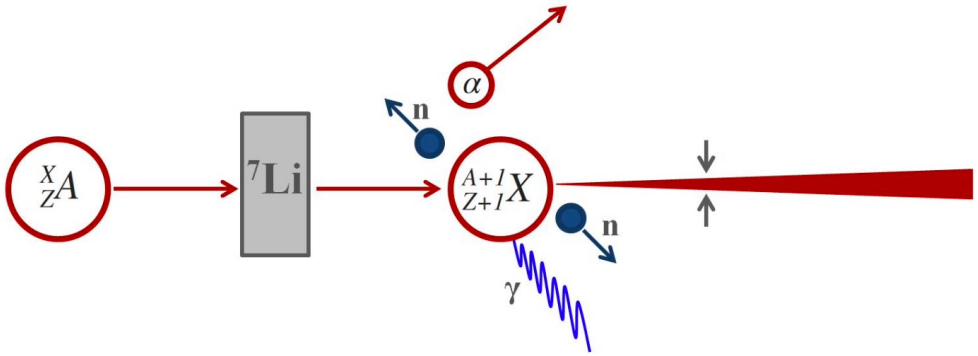

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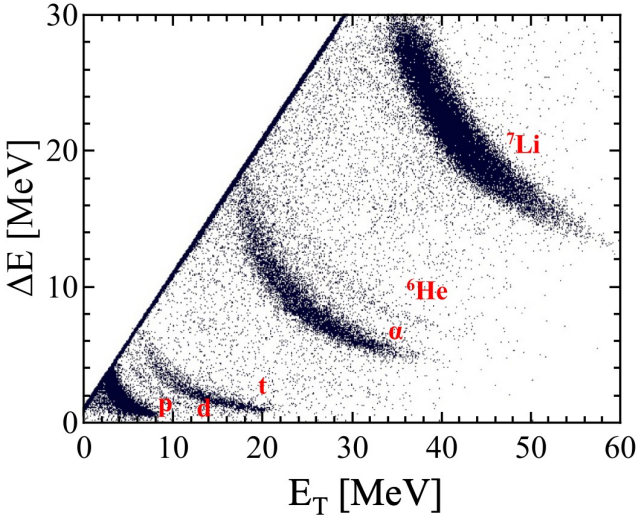
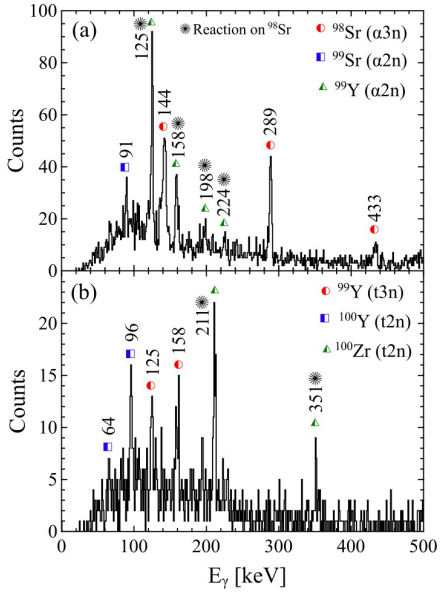
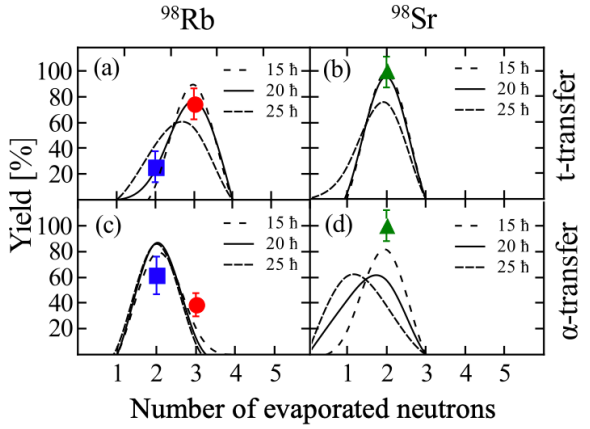
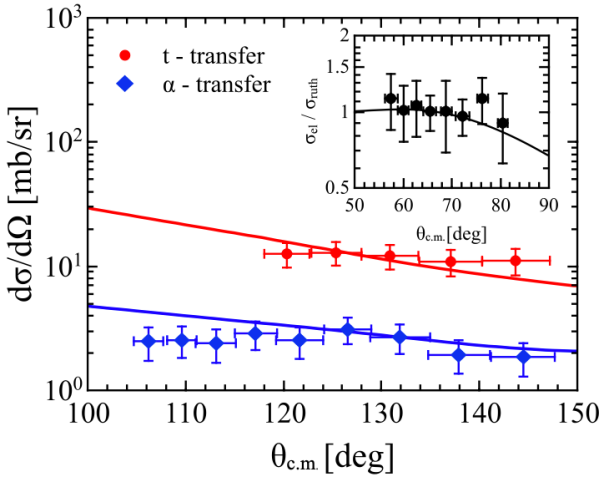
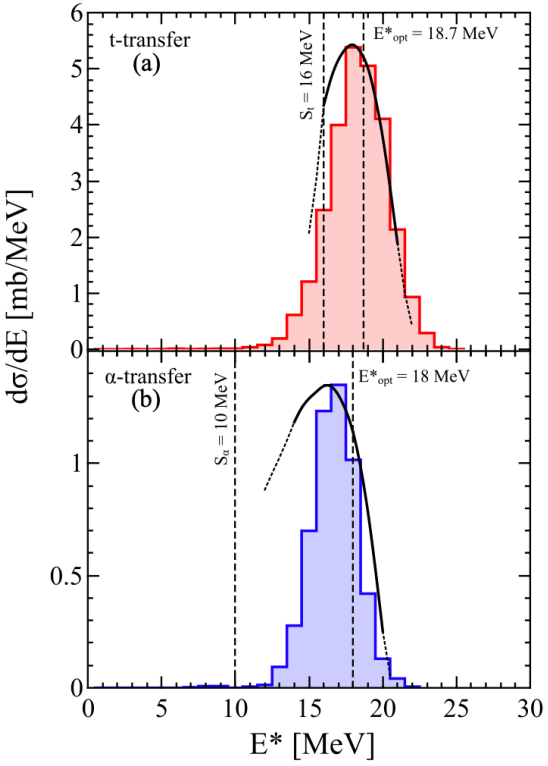




Cross sections







direct process (DWBA)

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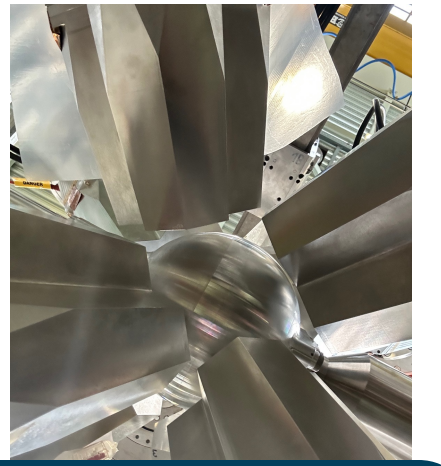
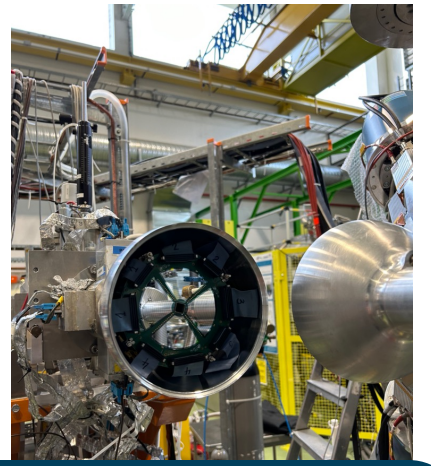
$^{132}Sn + ^{7}Li$ @ 3.5 MeVA

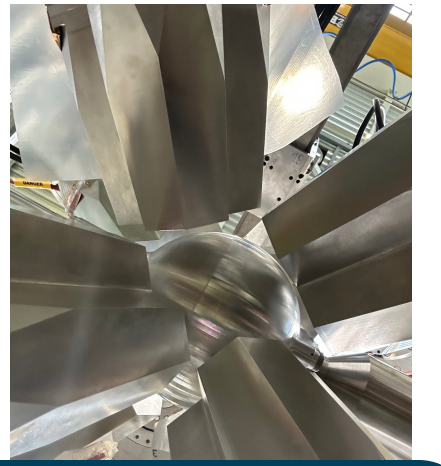


MINIBALL



CD (140 μm)+PADS

^{132}Sn + ^{7}Li @ 3.5 MeVA



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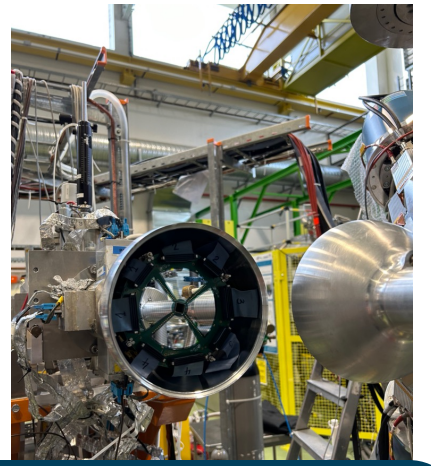

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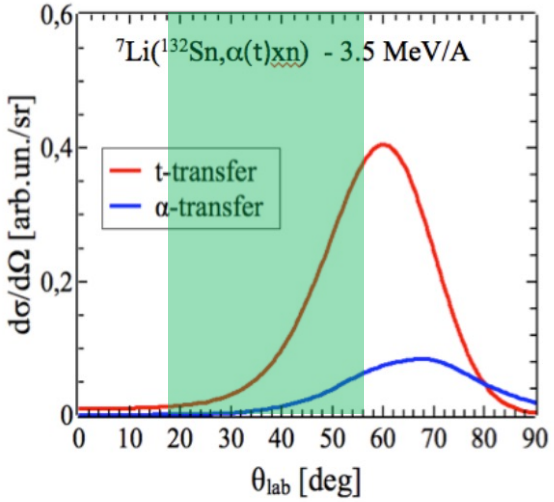

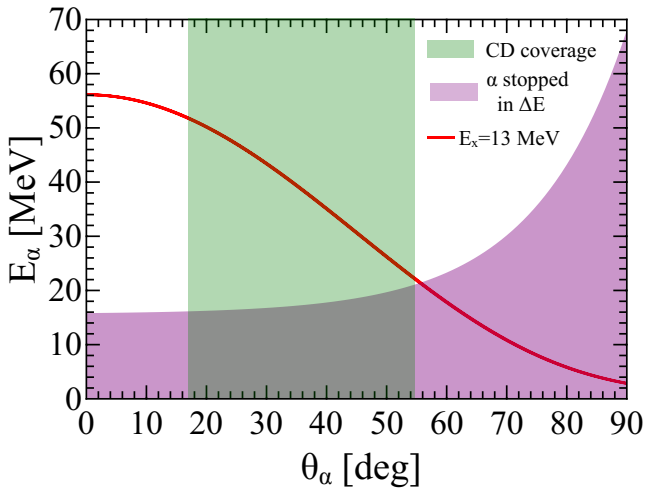

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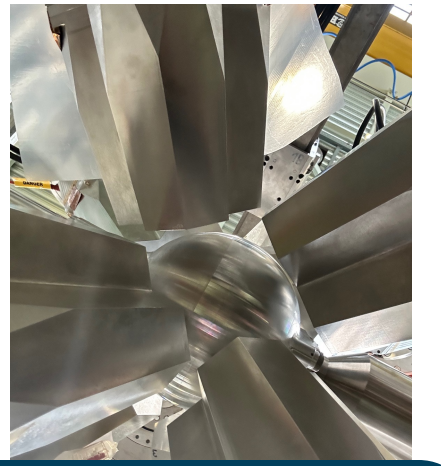

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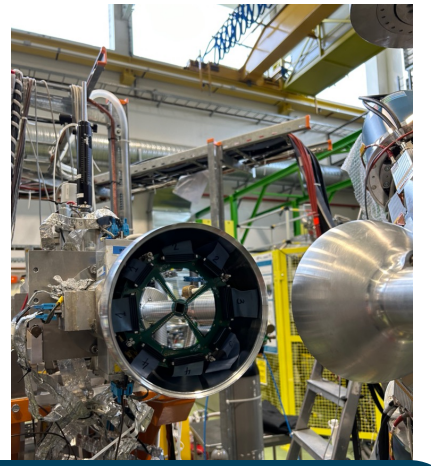
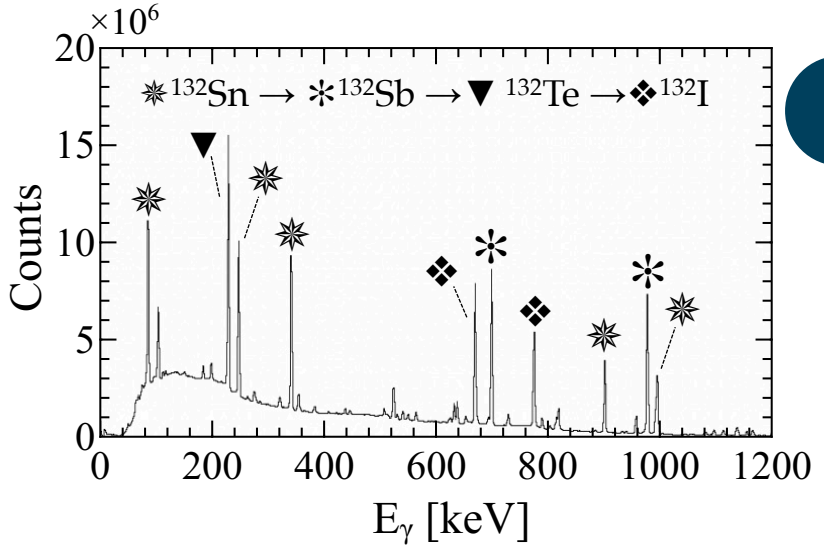


CD (140 μm)+PADS

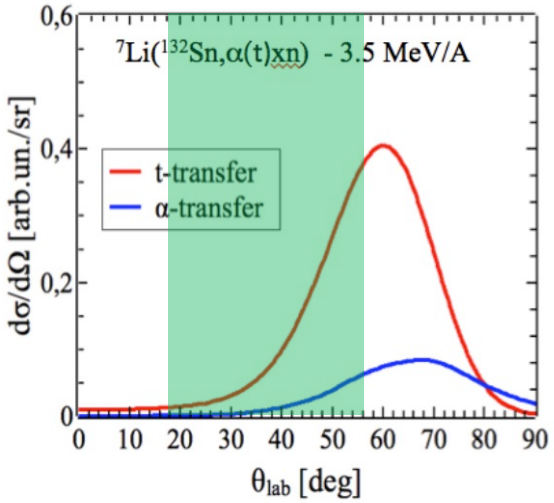
BEAM

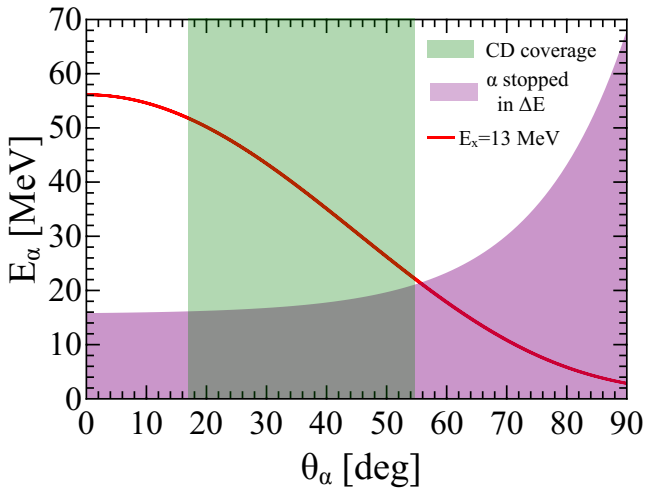


~ 1.4 μA protons
molecular beam
~ 5·10^{6} pps of ^{132}Sn on target
~ 100% pure

TARGET

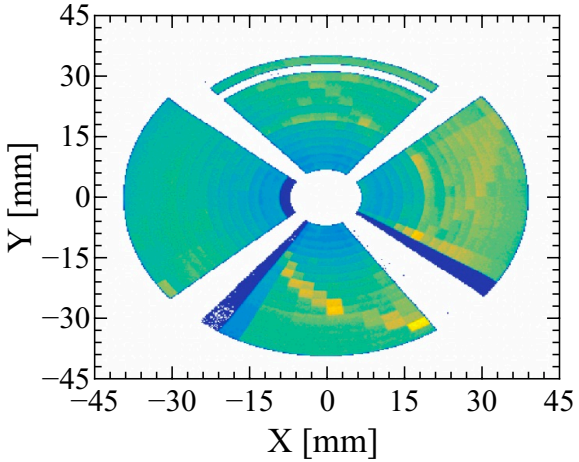
^{7}LiF – 1.5 mg/cm^{2}

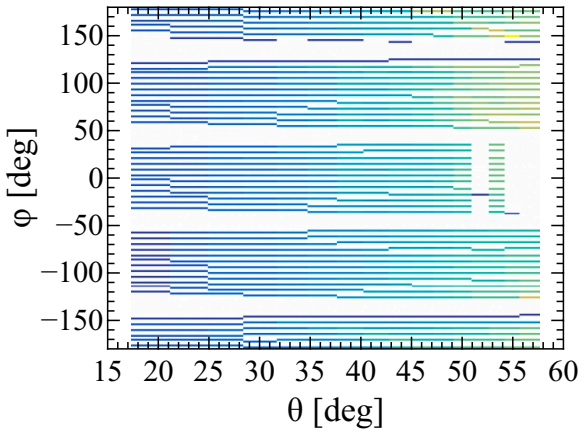




very smooth run
over ~ 7 days

Particle detection





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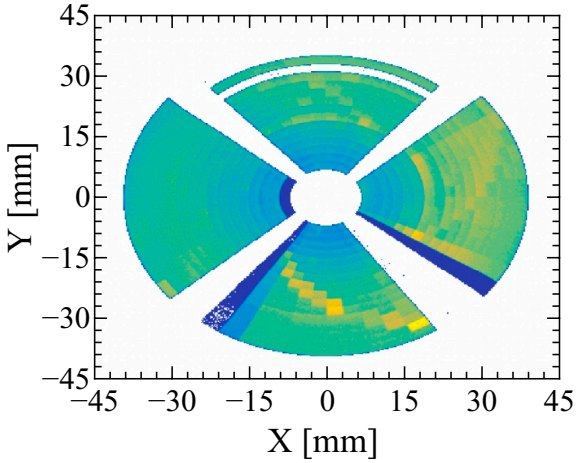
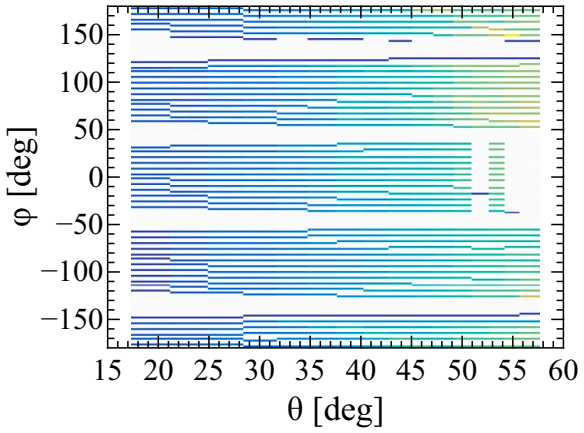
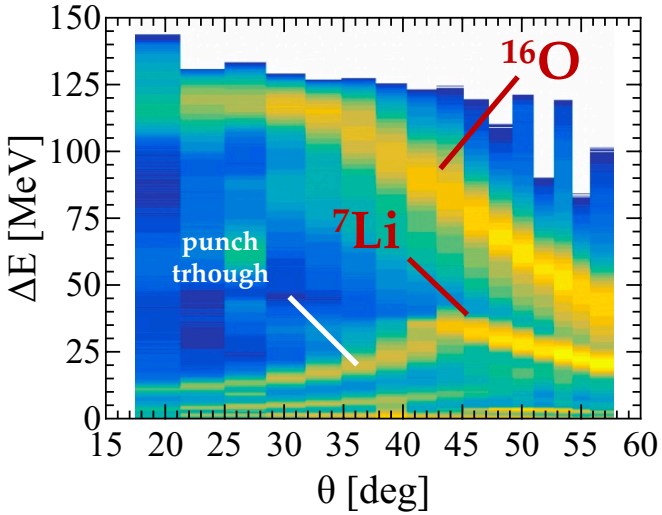
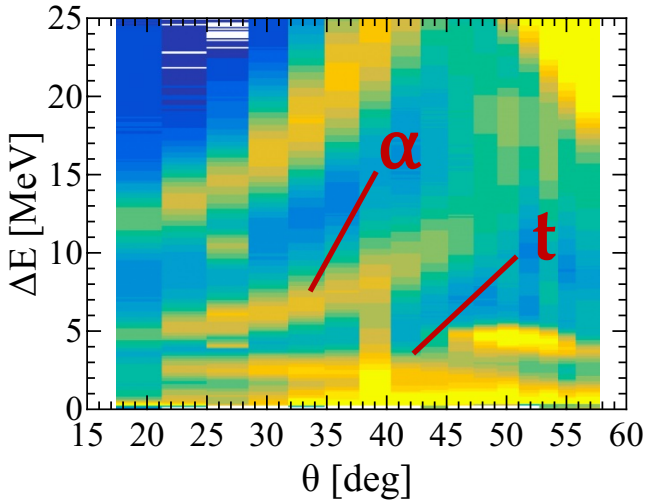


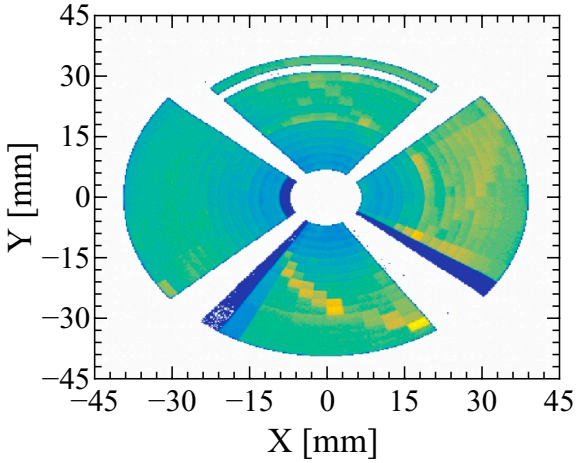


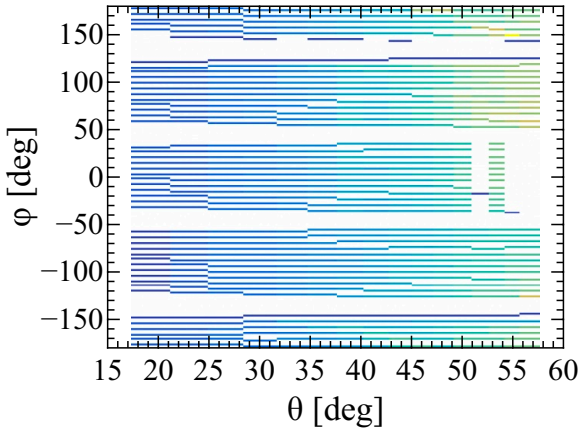
Particle kinematics



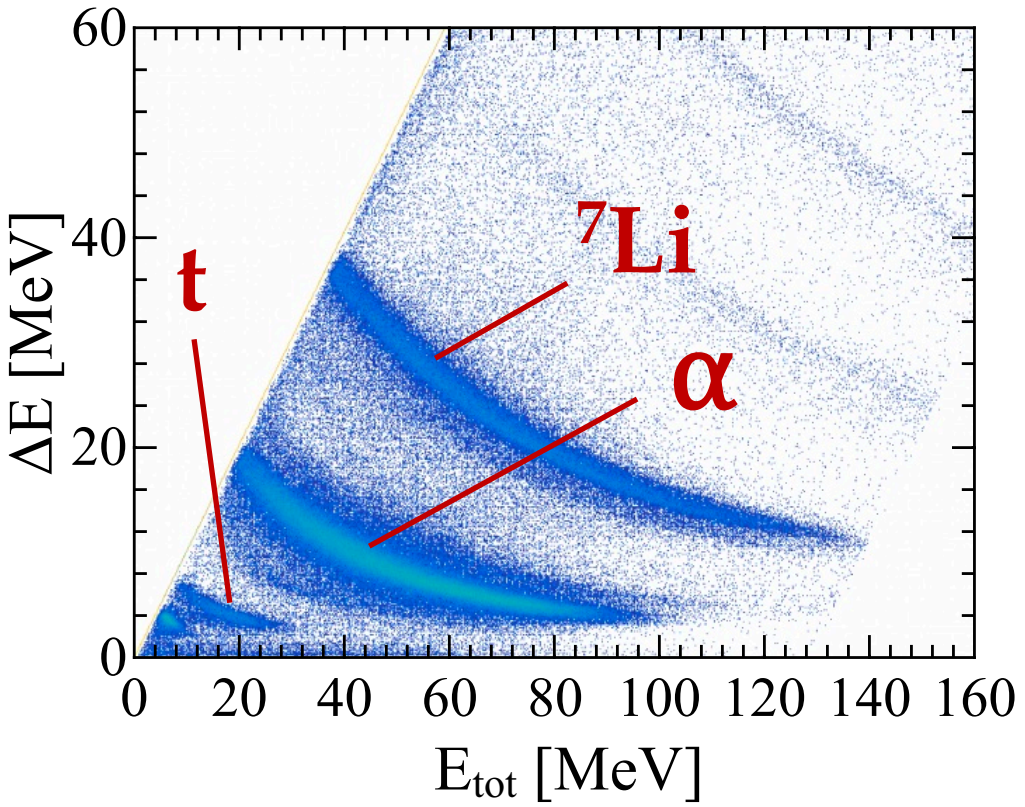


Particle detection

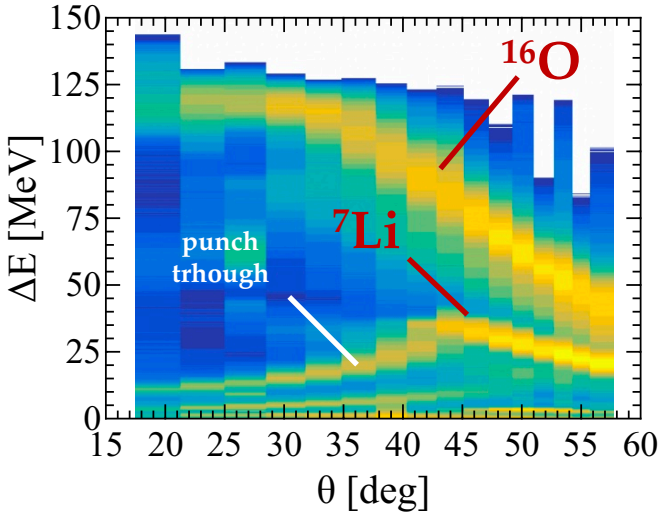


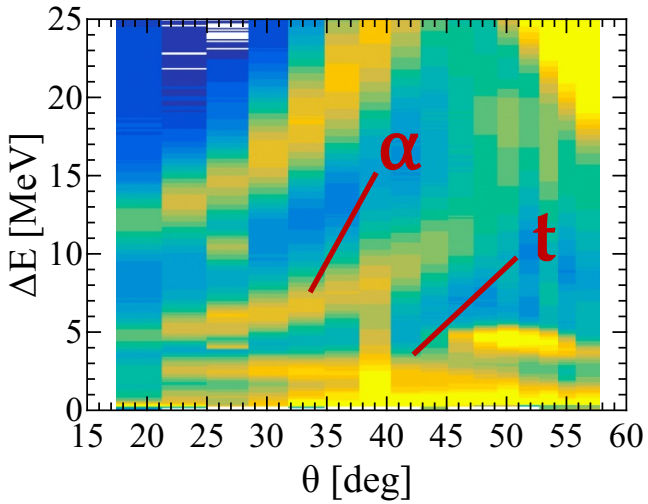


Particle identification



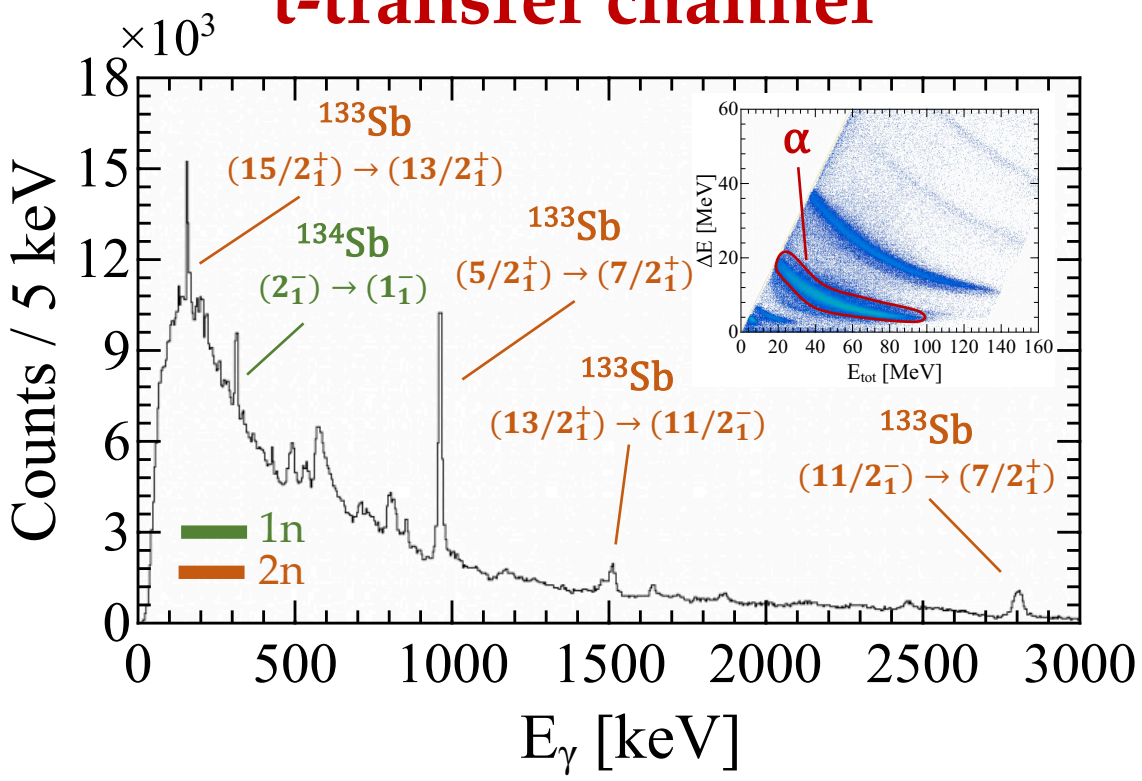
Particle kinematics



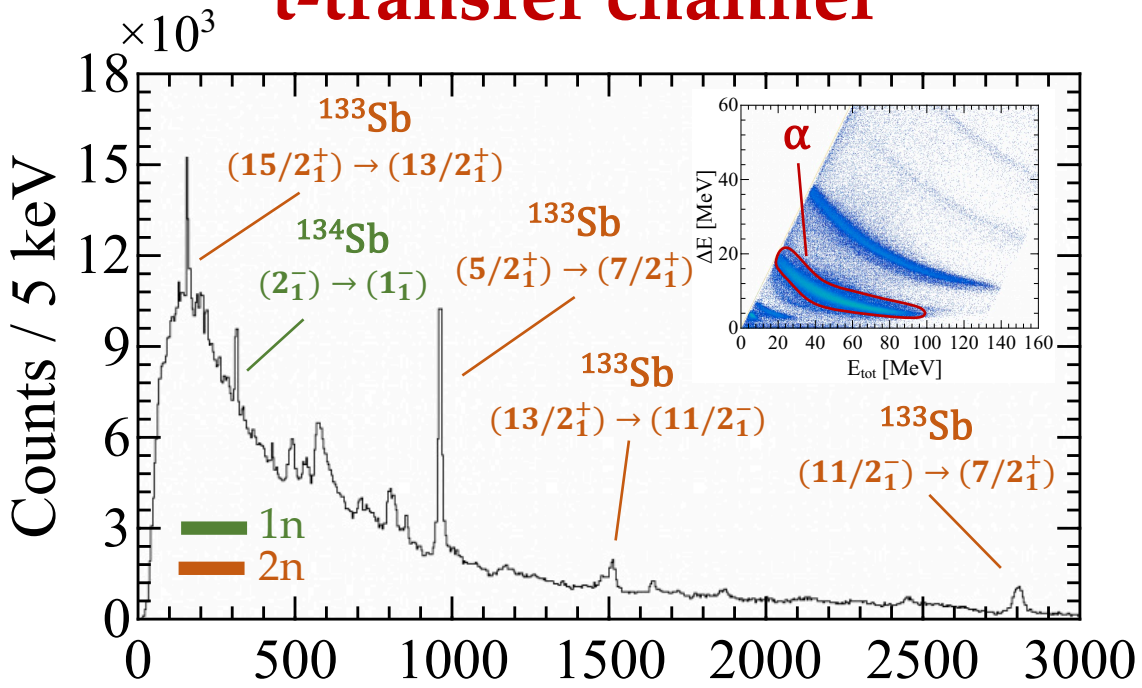


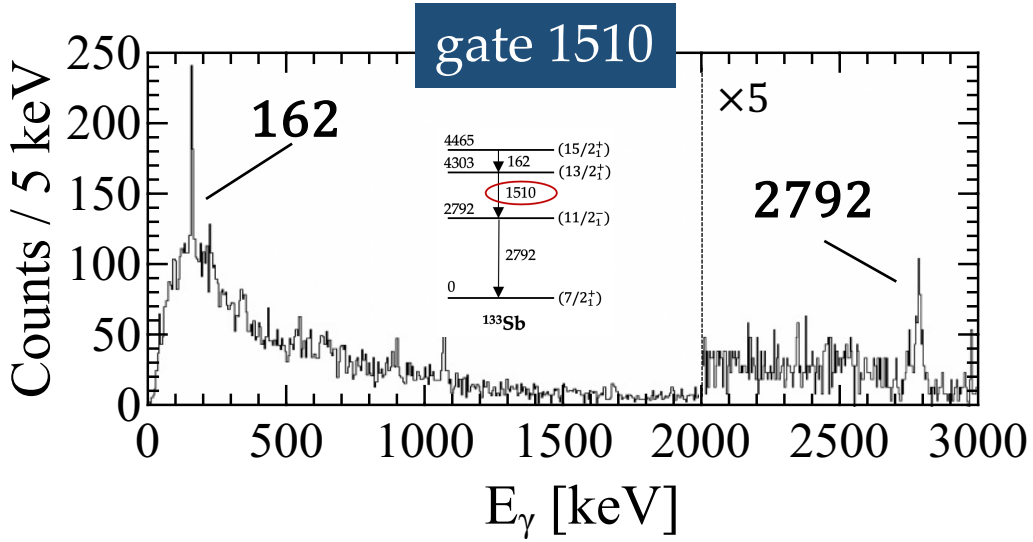
clean particle selection

t-transfer channel

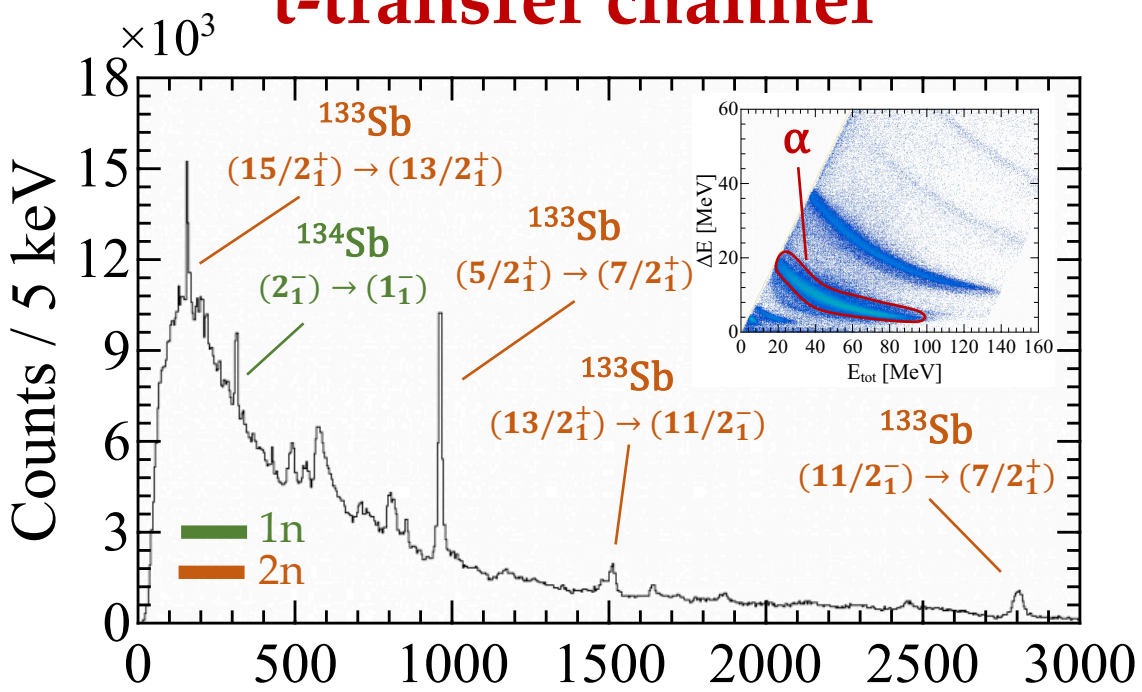


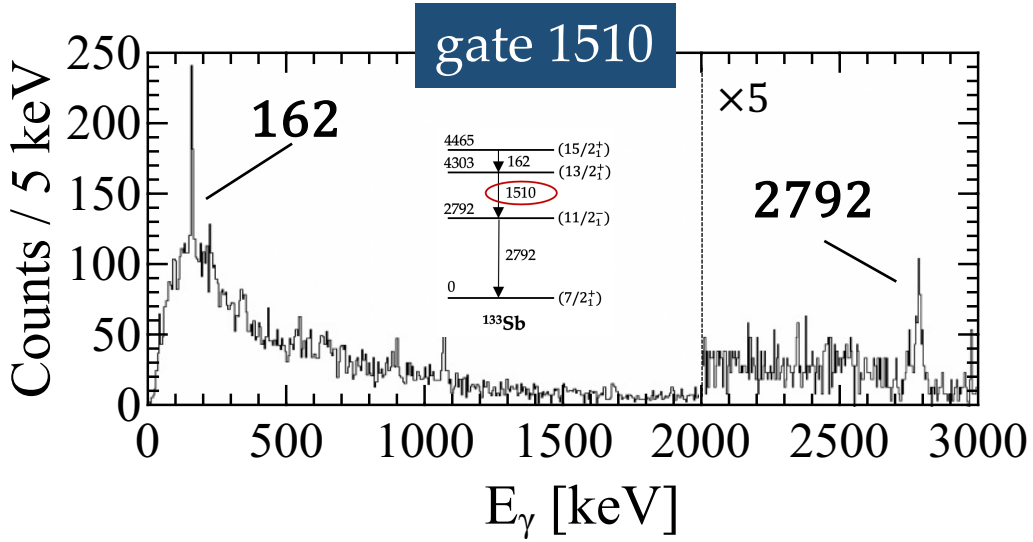
t-transfer channel



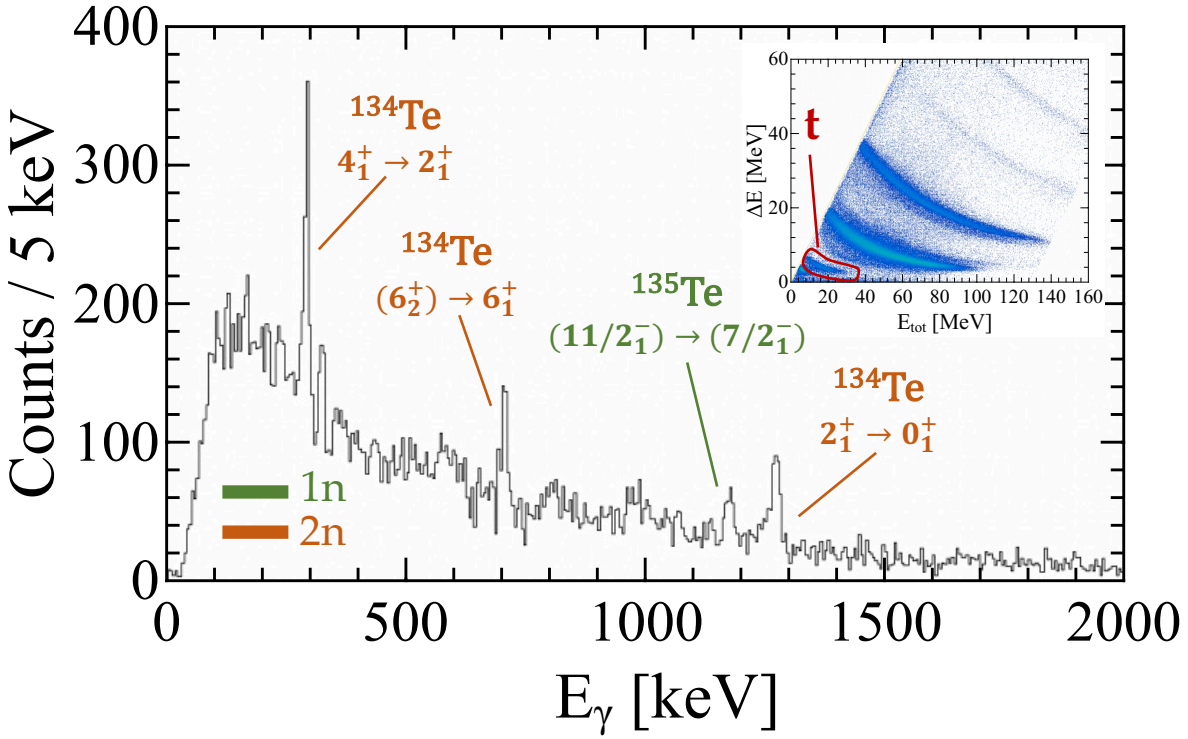


t-transfer channel

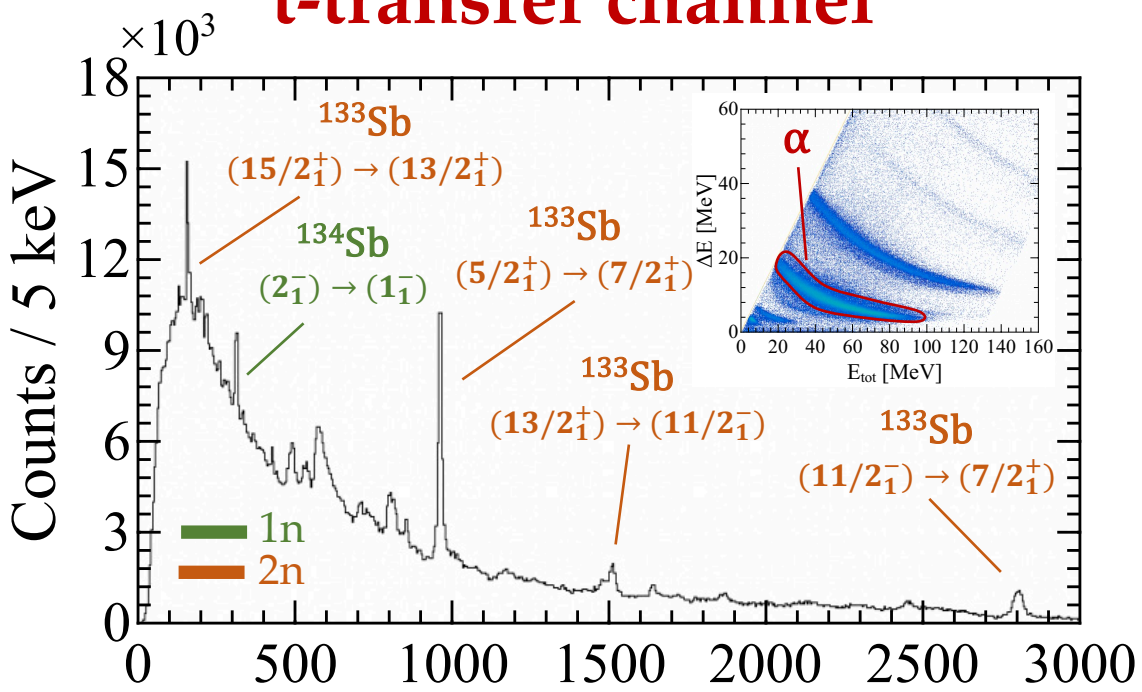


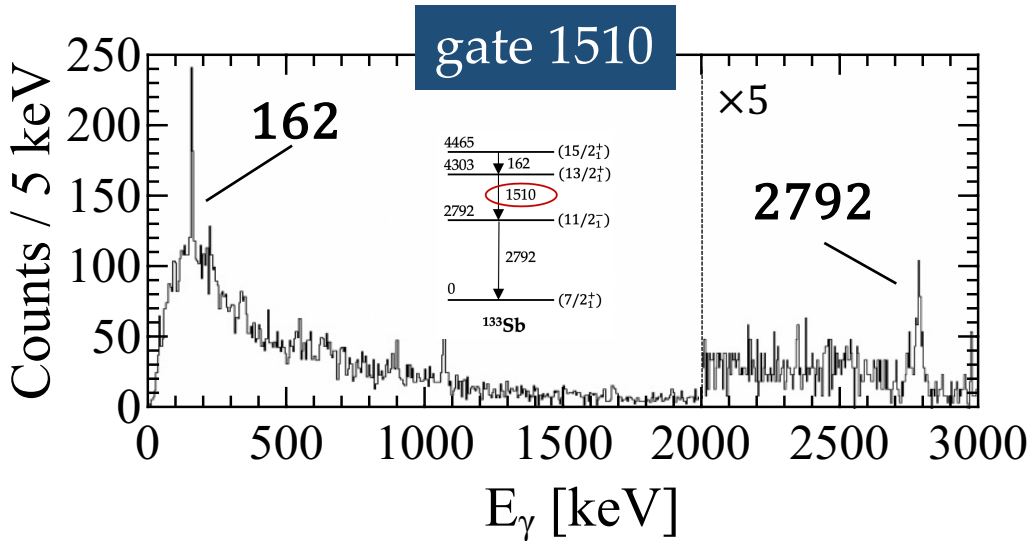


α-transfer channel

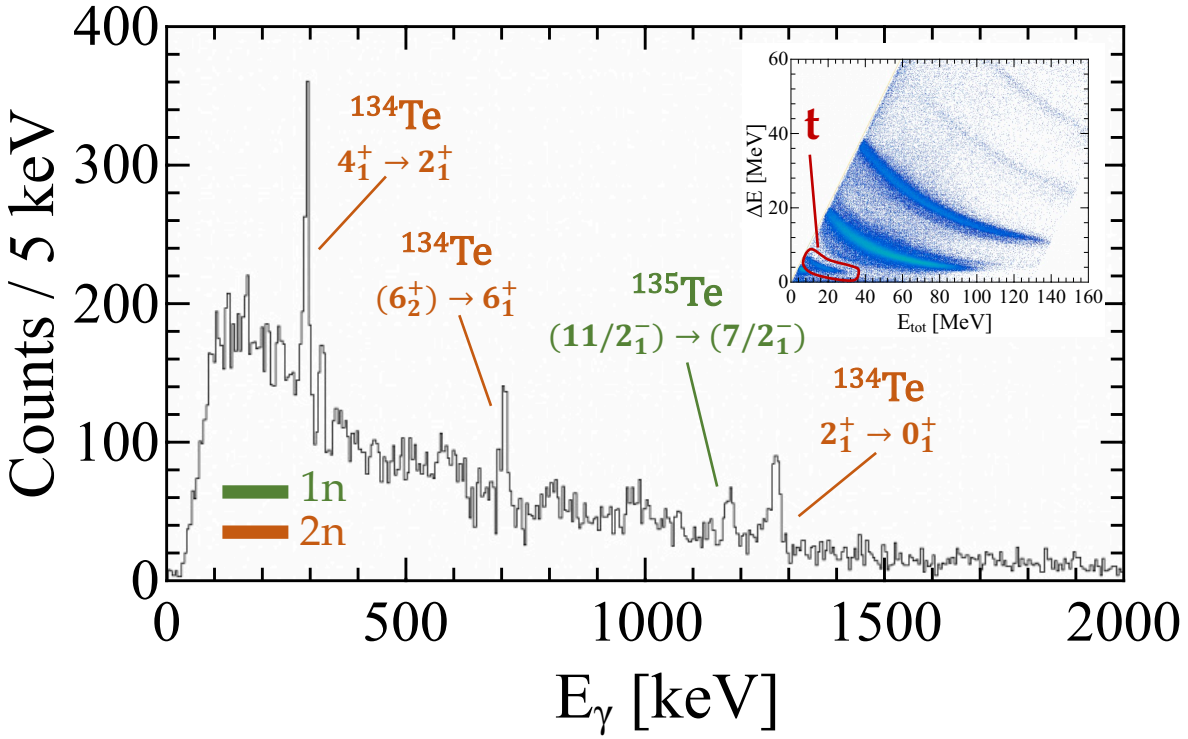


t-transfer channel





α-transfer channel



particle-γ selectivity

p-γ-γ coincidences

IS595 MINIBALL and T-REX collaboration

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Thank you!