Istituto Nazionale di Fisica Nucleare

Octupole Collectivity in ^{96}Zr from Low-Energy Coulomb Excitation with the AGATA+SPIDER Setup

Federica Ercolano

Young GAMMAs Meeting

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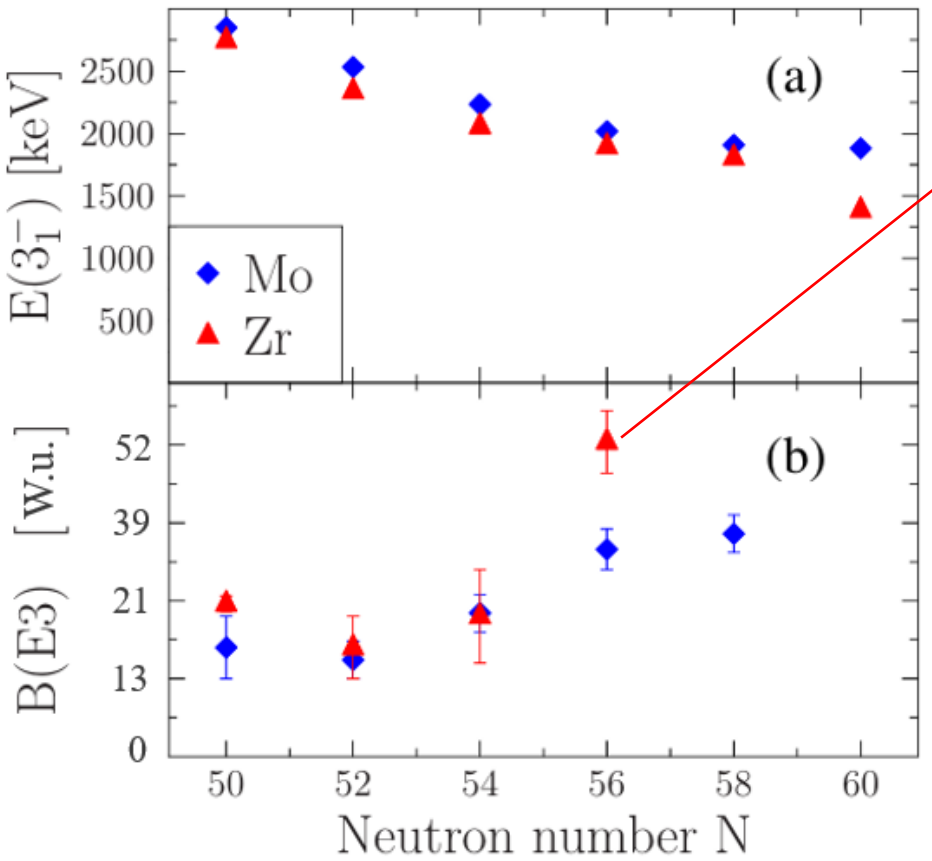
Octupole collectivity in Zr isotopes



Adapted from T. Kibédi and R.H. Spear, At. Data Nucl. Data Tables 80, 35 (2002).

$B(E3, 3_1^- \rightarrow 0_1^+)$ value in ^{96}Zr strikingly high (evaluated value: 53(6) W.u.), long-standing challenge for theory

The revised value B(E3) = 42(3) W.u. resulting from a new measurement of E1/E3 branching ratio in ^{96}Zr (Ł. Iskra *et al*, Phys. Lett. B 788 (2019)) is in better agreement with the experimental trend

The present work aims to extract for the first time the $3_1^- \rightarrow 0_1^+$ γ–ray transition probability **directly**, via the **low-energy Coulomb excitation technique**.

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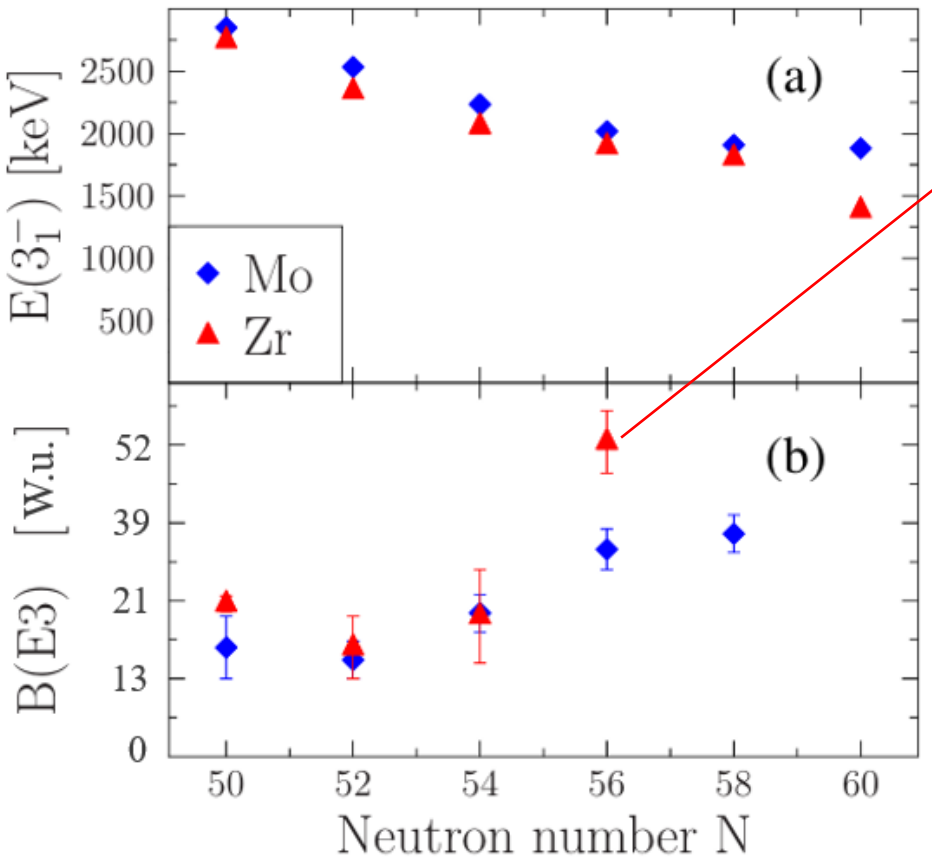

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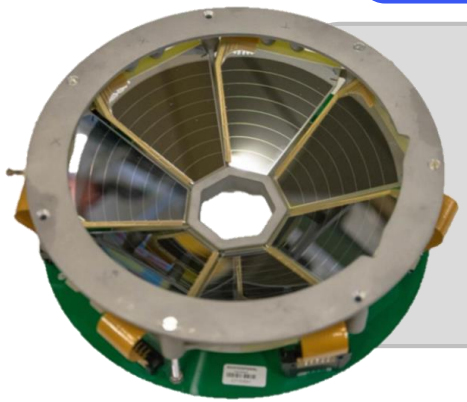
Coulomb Excitation Semi-Classical Treatment, First-Order Perturbation Theory:

$$\sigma = \sum_{\lambda} \sigma_{E\lambda} \longrightarrow \sigma_{E\lambda} \propto \left(\frac{Z_P\, e}{\hbar v_P}\right)^2 a^{-2\lambda+2}\, B(E\lambda)$$

Coulomb-Excitation Setup at LNL

- Data taking: October 21-25, 2022
- Beam: ^{58}Ni 160 MeV, 3 pnA
- Target: self-supporting ^{96}Zr

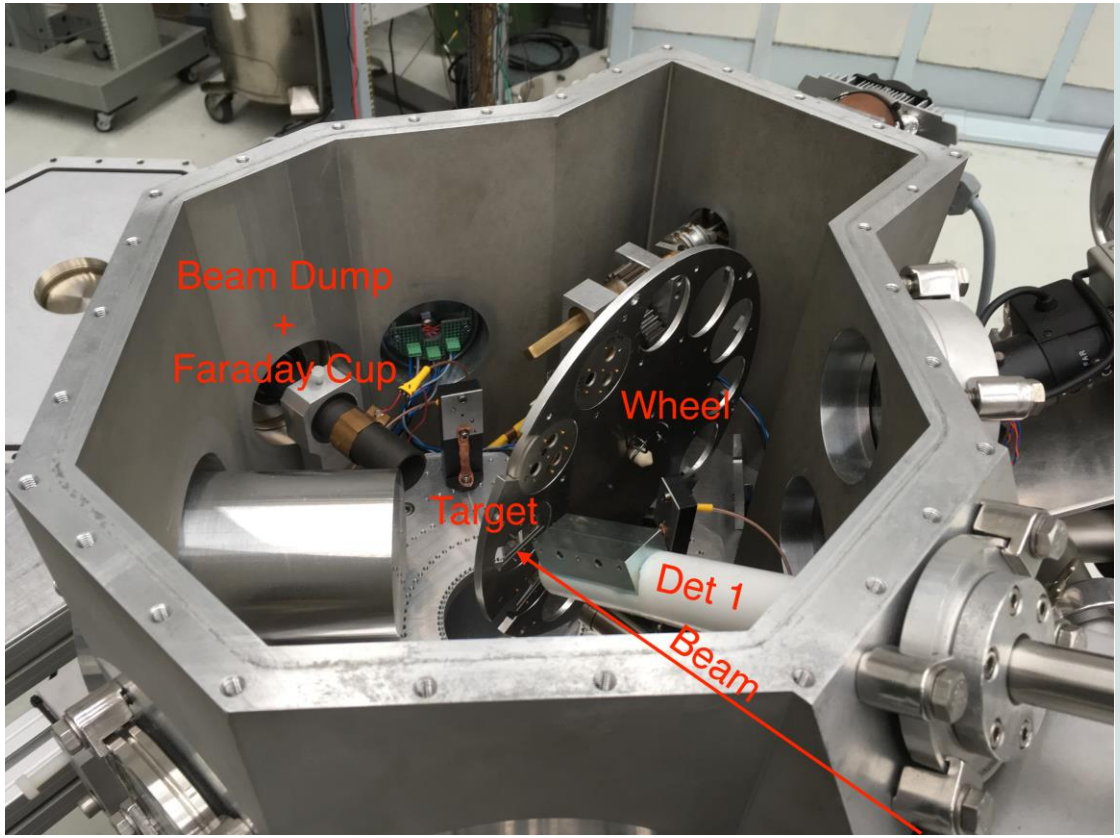
AGATA array (11 ATCs), close-up position



SPIDER modular array of Si detectors segmented into 8 annular strips (junction side).
$\vartheta_{LAB} = 126° - 162°$ (detection of back-scattered ^{58}Ni ions).

Target Characterization

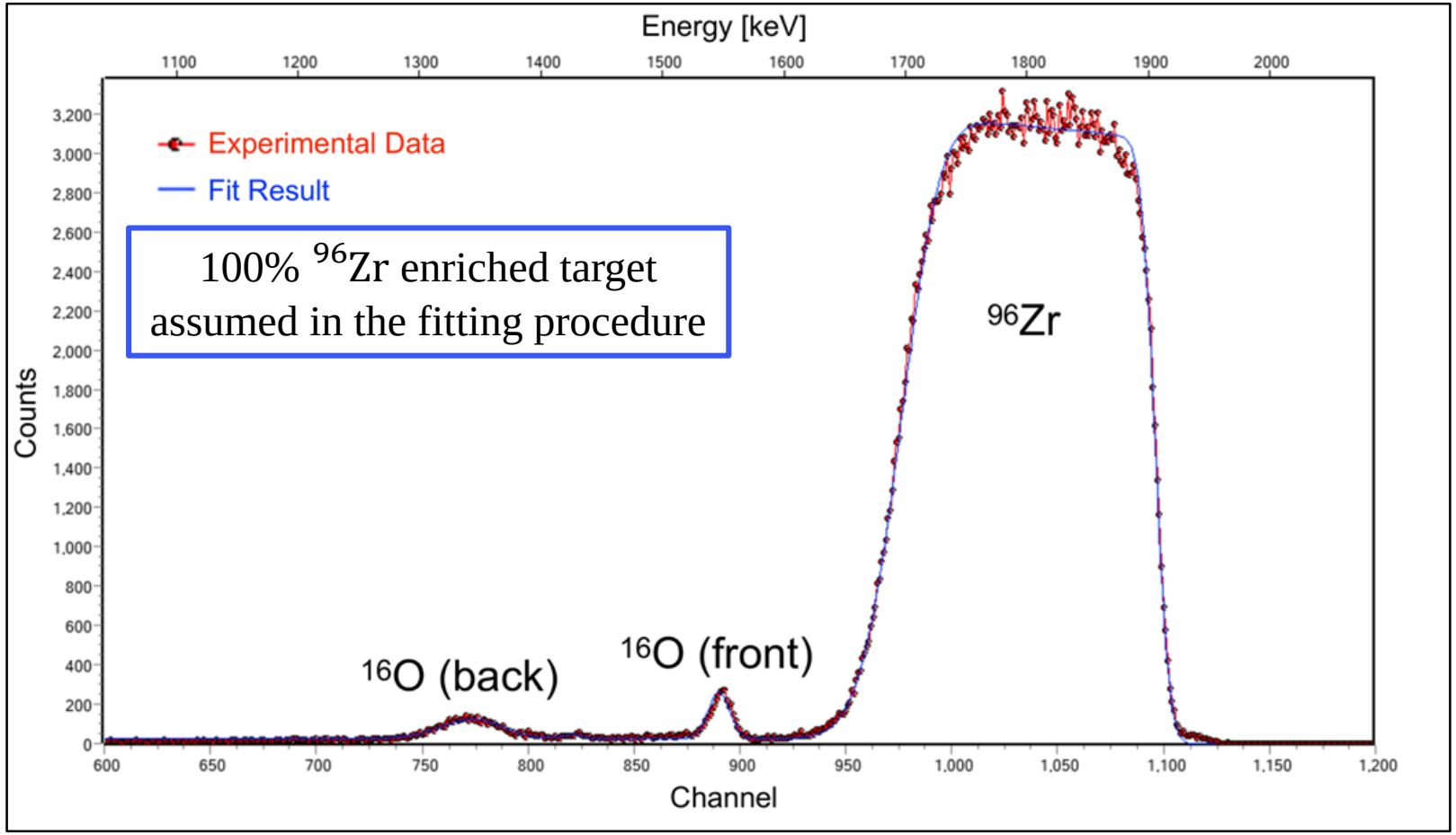
The ^{96}Zr target employed in this work was characterized using the Rutherford Backscattering Spectrometry (RBS) method at the INFN LABEC laboratory in Florence.



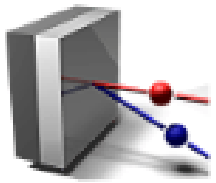
Setup used for the RBS measurement at LABEC:

- Proton beam with 2 MeV energy
- ^{96}Zr target mounted on a rotating wheel
- Silicon detector placed at 165° degrees

Target Characterization



Experimental RBS spectrum resulted from the ^{96}Zr target analysis at LABEC.



SIMNRA

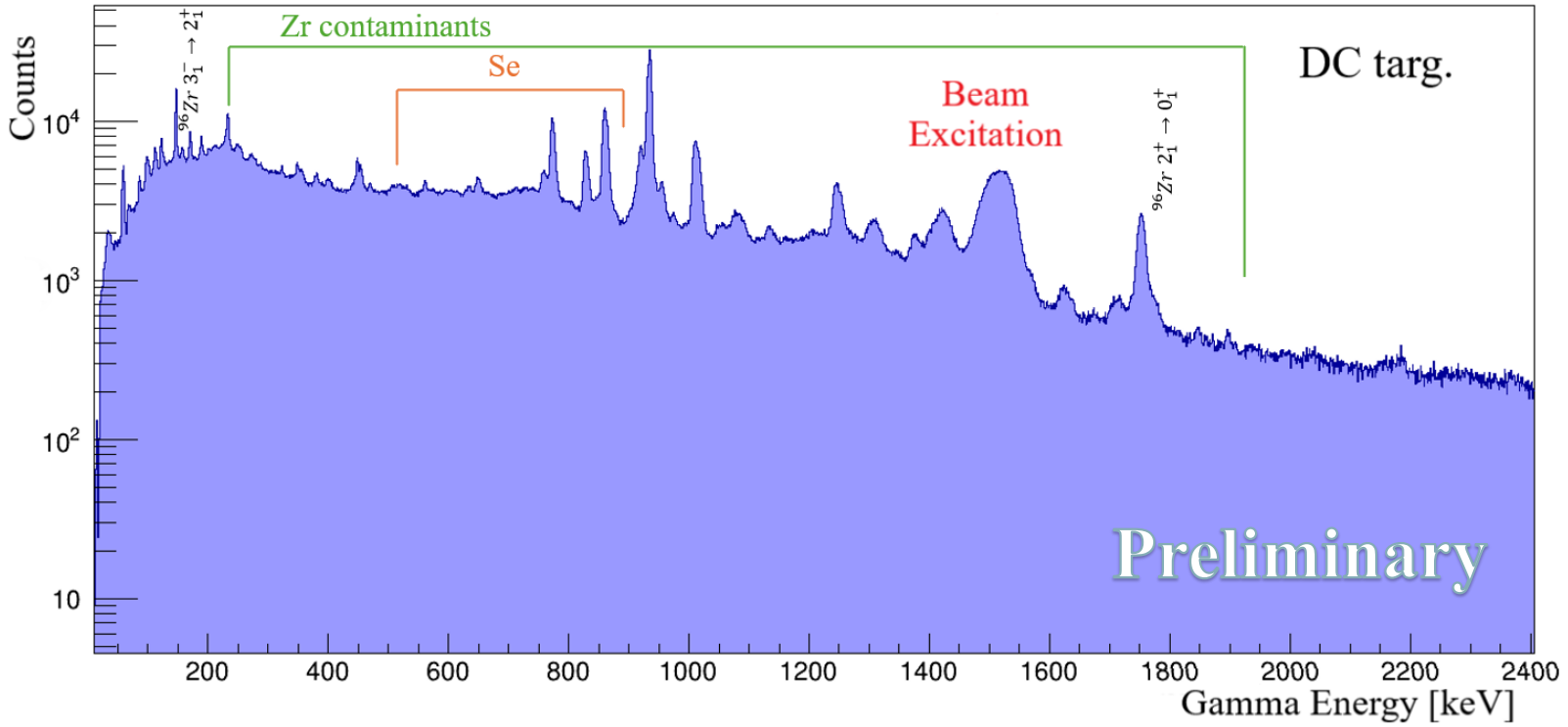
Computer simulation of RBS, ERDA, NRA, MEIS and PIGE by Matej Mayer

IPP Max-Planck-Institut für Plasmaphysik

Results of the RBS measurement:

- oxidized front and back surfaces of the target
- ^{96}Zr target thickness: 690 $\mu g/cm^2$

Experimental results

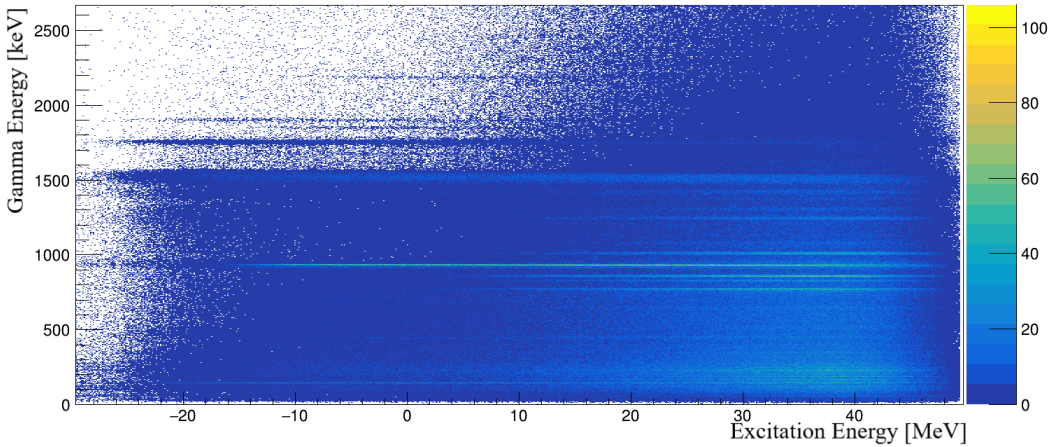


γ–ray energy spectrum acquired in coincidence with the back-scattered ^{58}Ni ions Doppler corrected for the target nuclei.

Excitation lines from other Zr isotopes ($A = 90, 92, 94$) present in the target

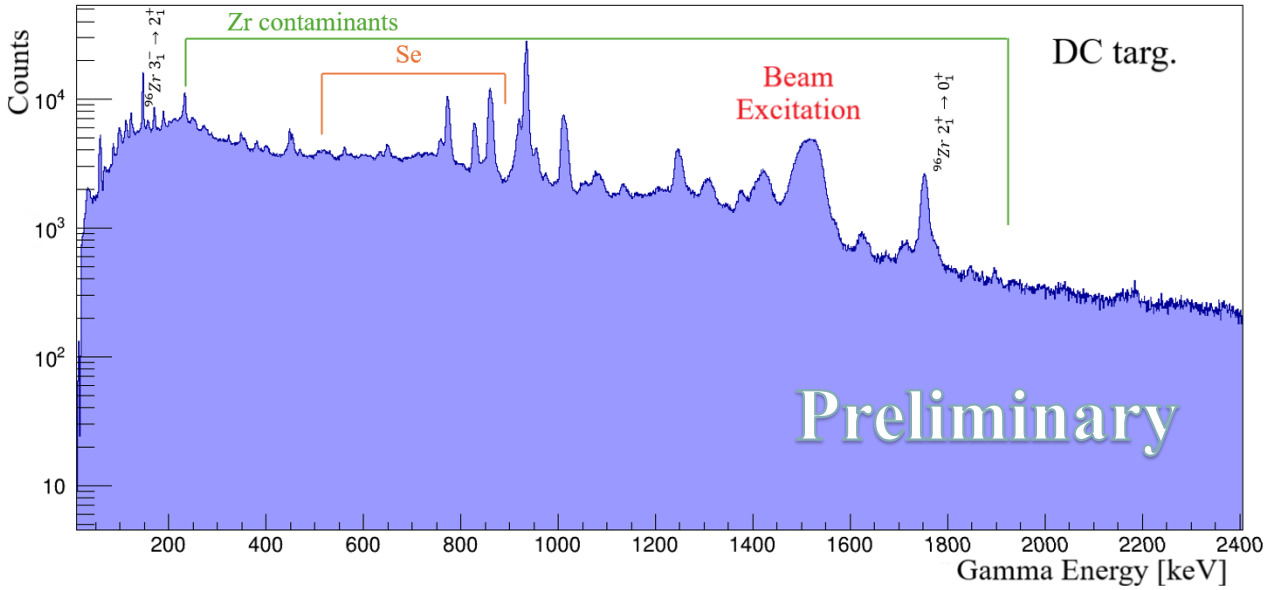
Contribution from the products (^{72}Se, ^{72}Br, ^{69}As) of the fusion-evaporation reaction ^{58}Ni + ^{16}O at 160 Mev

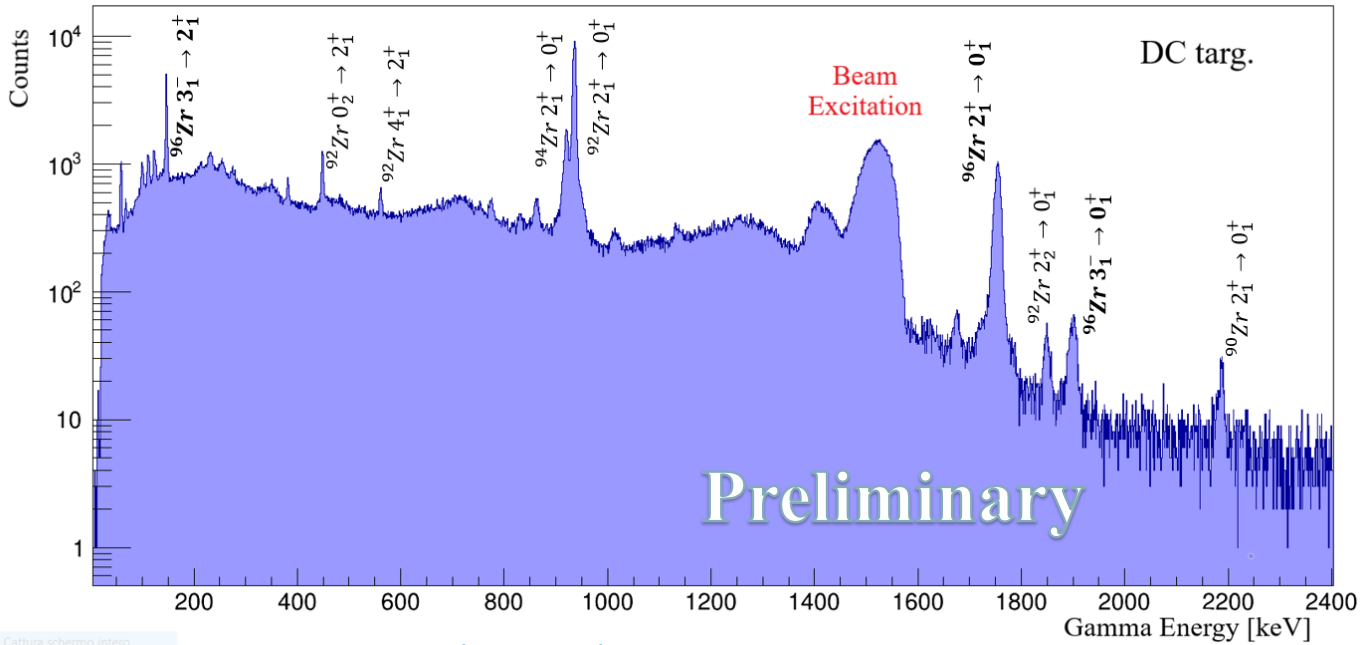
Experimental results



γ–ray energy Doppler-corrected for the target nuclei as a function of the total excitation energy of the ^{58}Ni + ^{96}Zr system.

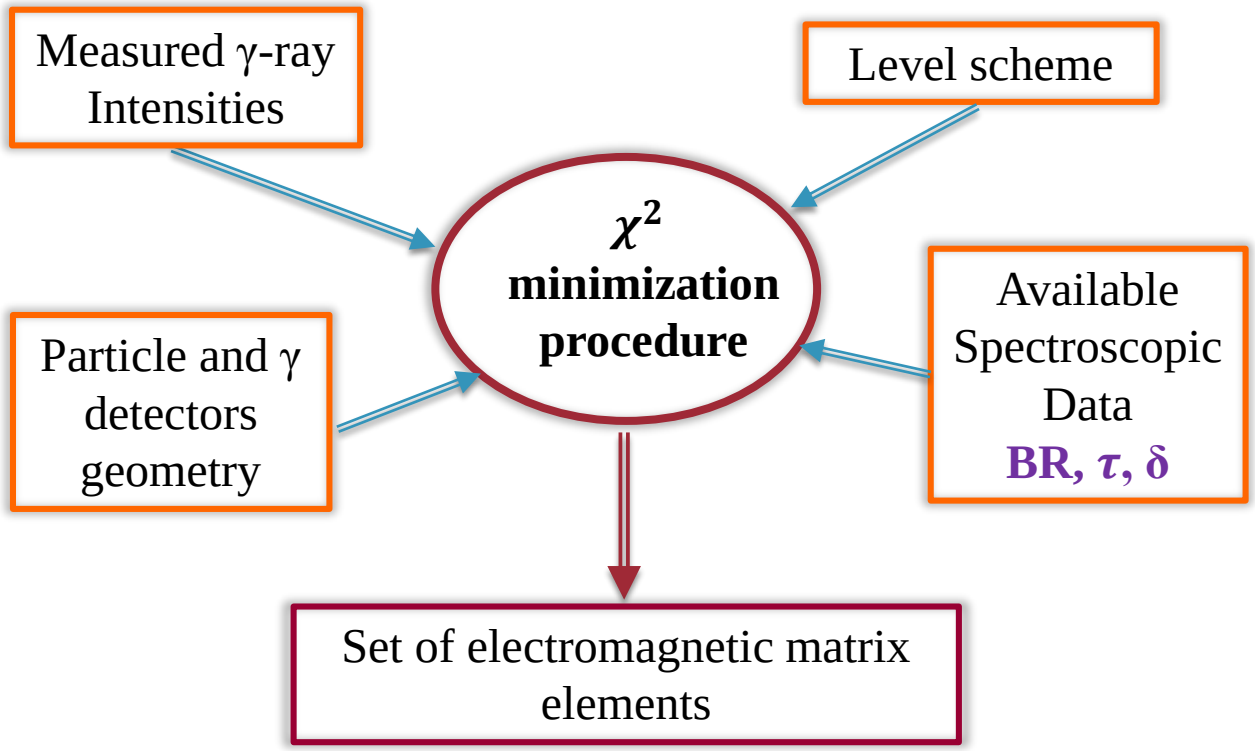
Excitation Energy Selection to remove the fusion-evaporation background

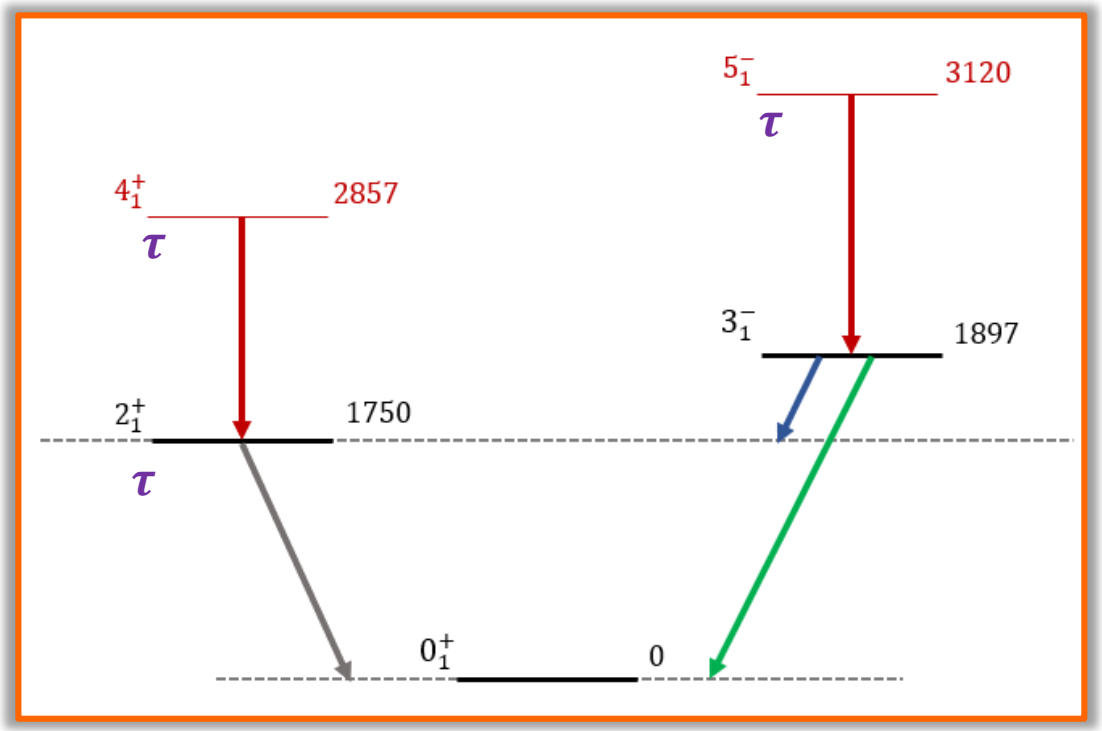




Coulomb-Excitation Analysis - GOSIA code

GOSIA exploits the semi-classical Coulomb-excitation treatment to evaluate the excitation cross-sections and to extract the observables of interest.





^{96}Zr Level scheme used in the GOSIA analysis

Coulomb-Excitation Analysis - Preliminary Results

The E1 and E3 electromagnetic matrix elements extracted in the present work have been used to calculate the reduced transition probabilities:

$$\mathrm{B(E1}, 3_1^- \rightarrow 2_1^+) = 114(13) \cdot 10^{-4}\, W.u.$$

$$\boxed{\mathrm{B(E3}, 3_1^- \rightarrow 0_1^+) = 41(3)\, W.u.}$$

This value confirm the results of the indirect determination of the $\mathrm{B(E3;}\ 3_1^- \rightarrow 0_1^+) = 42(3)$ W.u. value in ^{96}Zr from Ł. Iskra *et al*, Phys. Lett. B 788 (2019)

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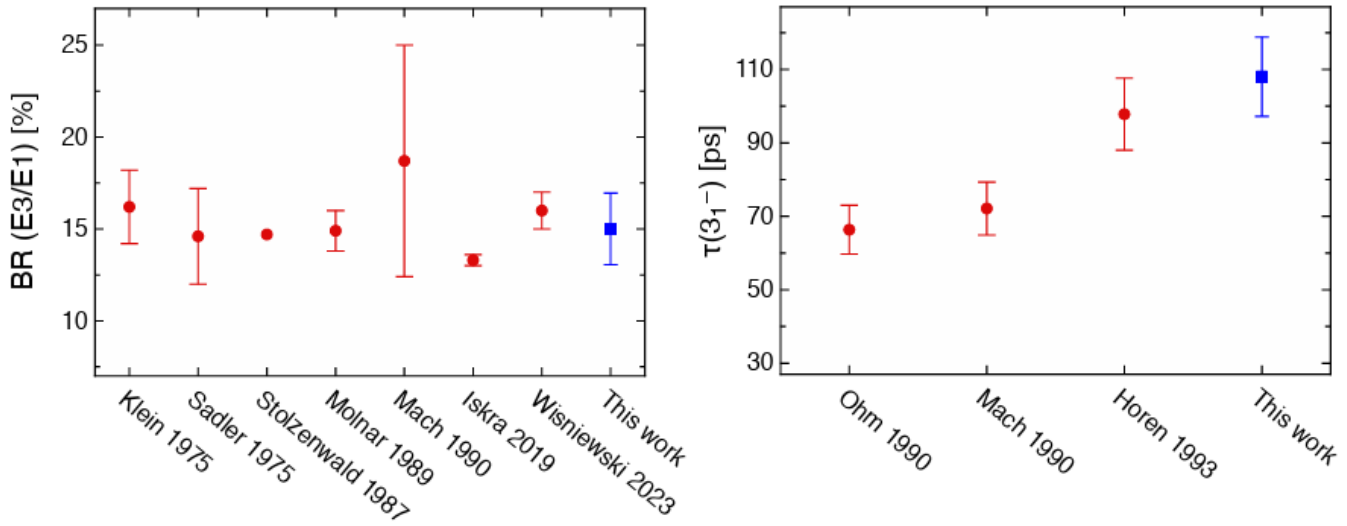

The matrix elements extracted in this work are in agreement with the most recent measurements of the $3_1^- \rightarrow 0_1^+ / 3_1^- \rightarrow 2_1^+$ branching ratio and the lifetime of the 3_1^- state.

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THANK YOU FOR THE ATTENTION

Collaboration

F. Ercolano[1], N. Marchini[2], D.T. Doherty[3], M. Zielińska[4], M. Rocchini[2], A. Nannini[2], P.E. Garrett[5], K. Hadyńska-Klęk[6], M. Balogh[7], P. Aguilera[7], F. Angelini[7], D. Bazzacco[7], J. Benito[7,9], G. Benzoni[8], D. Brugnara[7], S. Buck[5], F. Camera[8], R. Coleman[5], R. Escudeiro[7,9], A. Ertoprak[7], G. de Angelis[7], F. Galtarossa[7,9], N. Gelli[2], A. Goasduff[7], B. Gongora[7], A. Gottardo[7], A. Gozzelino[7], D. Kalaydjieva[4], W. Korten[3], Md. S. R. Laskar[8], M. Matejska-Minda[10], D. Mengoni[7,9], D. Napoli[7], M. Ottanelli[2], G. Pasqualato[11], J. Pellumaj[7], R.M. Pérez-Vidal[7], S. Pigliapoco[7,9], E. Pilotto[7], F. Recchia[7,9], K. Rezynkina[9], K. Stoychev[11], J. J. Valiente Dobón[7], K. Wrzosek-Lipska[6], L. Zago[7], G. Zhang[9],1. Zanon[7], T. Zidar[5]

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