Search for a Josephson-like effect in the $^{116}Sn + ^{60}Ni$ system
&
Lifetimes in Ca and Ar isotopes

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The Josephson Effect

Physics of matter:

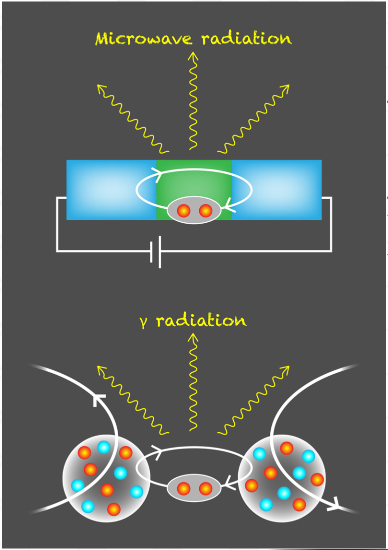
- Cooper pairs of electrons (phonon exchange with lattice)
- Josephson junction: S|I|S
- Voltage difference V
- Correlation length $\xi \approx 10^4$ Å

$\longrightarrow$ **ACJE:** supercurrent + microwave radiation

Nuclear physics:

- Cooper pairs of nucleons (**Pairing** interaction)
- Below-barrier reaction: SN|E|SN
- Reaction Q-value
- Correlation length $\xi_N \approx 13.5$ fm

$\longrightarrow$ **Nuclear ACJE:** enhancement of transfer probability + predicted γ-ray dipole emission



P. Magierski, "The Tiniest Superfluid Circuit in Nature", physics.aps.org American Physical Society (2021)

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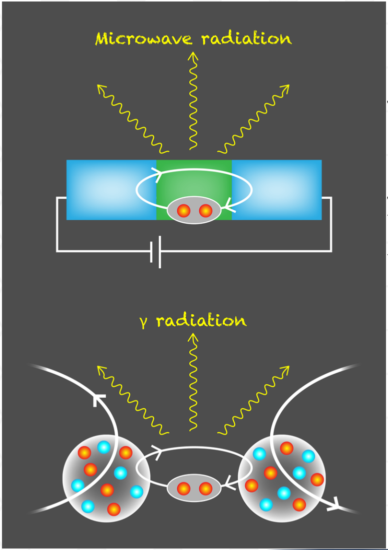

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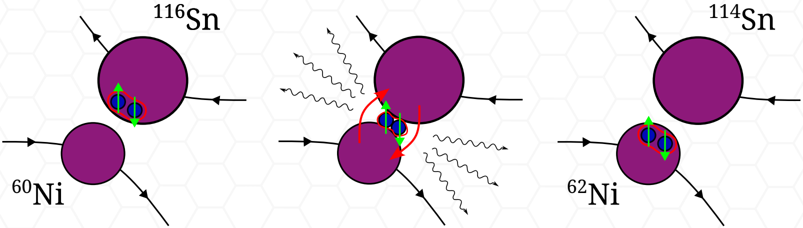
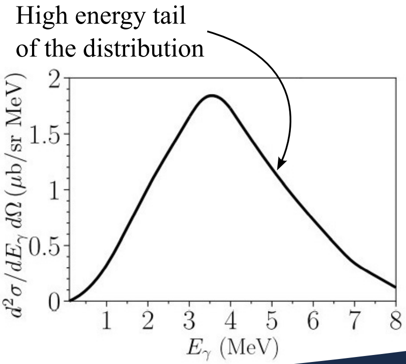
The experiment





Expected γ-ray distribution for the ACJE dipole emission in the 2n-transfer reaction

$^{116}Sn + ^{60}Ni \longrightarrow ^{114}Sn + ^{62}Ni$

[G.Potel et al., PRC 2021]

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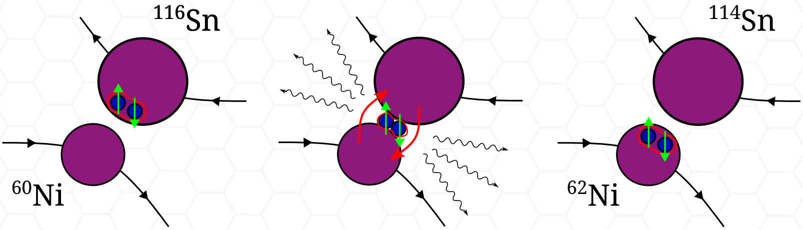

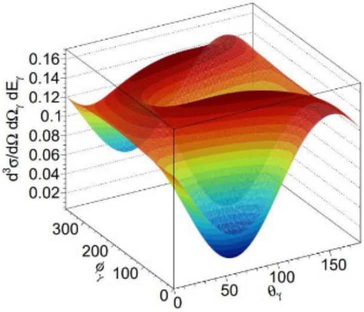

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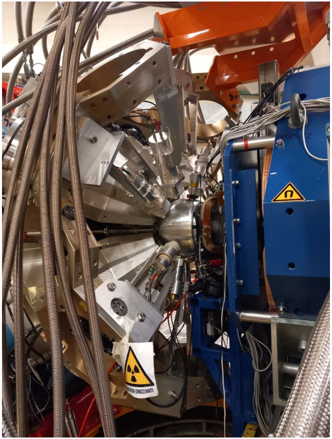
The experiment

Experiment 22.28, February 2023, LNL

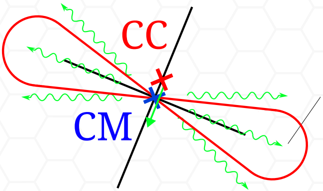
- ^{116}Sn beam @ $E_{lab} = 460$ MeV (ALPI-PIAVE), 1.5 pnA
- ^{60}Ni target: 100, 200, 300 μg/cm^2 + 20 μg/cm^2 C "fronting"
- PRISMA @ 20°, AGATA+LaBr opposite to PRISMA
- Si-det @ 55° for back-scattered C and Ni ions

Based on L. Corradi and S. Szilner, proposal n. 28, LNL PAC 2021



Main idea

- center of charge oscillates against CM
- the "preferential" reference frame is the CM
- energy conservation in CM:



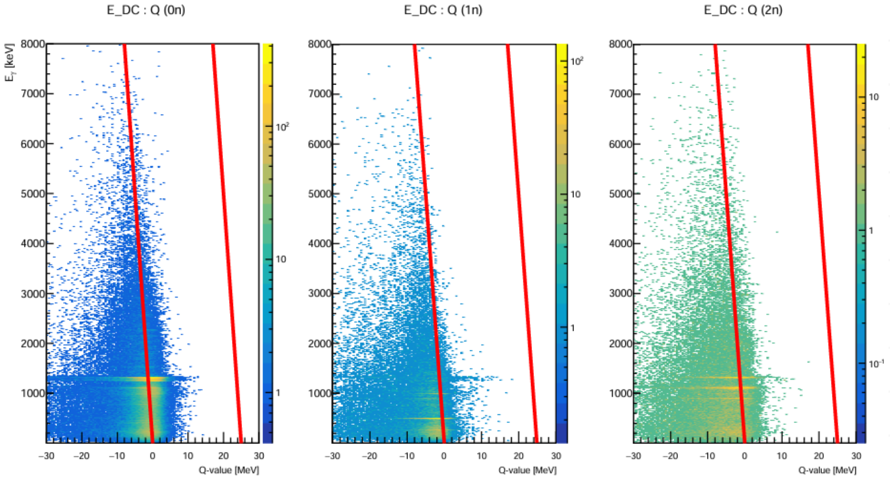
$$K + Q_{gg} = K' + E_x + E_{JE}$$

- measured Q-value:

$$Q = Q_{gg} - E_x - E_{JE} = K' - K = -TKEL$$

- plot E_γ vs Q-value (NB: Doppler correction done with CM velocity) to gate on the region where the JE is expected to occur

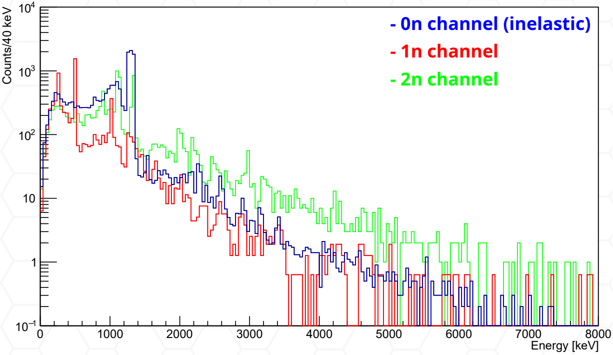
AGATA results: E-Q

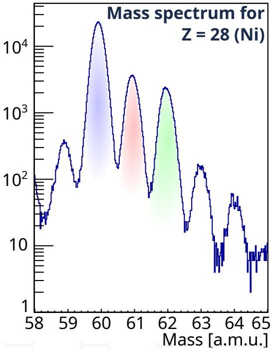


E_γ vs $Q - value$: in principle the JE will lay on the right edge of the distribution, where $E_\gamma + Q \approx Q_{gg}$ ($E_x \approx 0$)

AGATA results: Q-gated spectra

Q-gated spectra for 0n-, 1n- and 2n-transfer channels, normalized using the ratio of production yields (PRISMA mass spectrum in coincidence with AGATA)





AGATA results: Q-gated spectra

Good (maybe) news:

- number of counts in the region of interest above 3 MeV (to almost avoid discrete lines) is ~ 340, compatible with the expected amount of JE gammas
- in the other channels, the normalized counts are 60 for the 0n and 40 for the 1n transfer

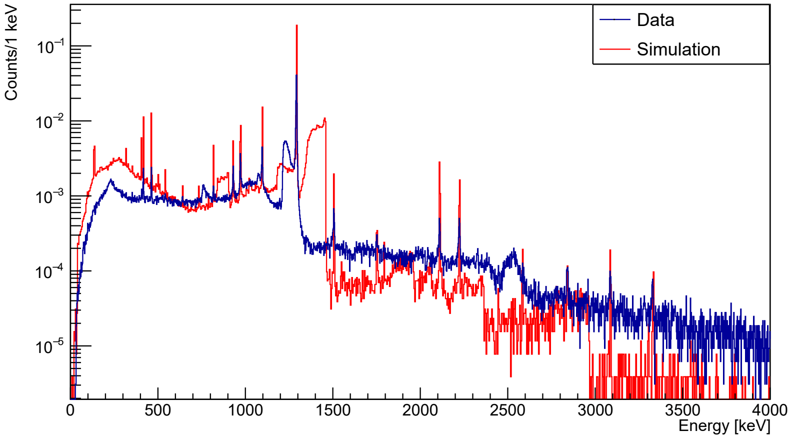
Bad news:

- very much gate dependent
- Q-value resolution very poor (few MeV)
- discrete gammas still present, so this comparison is very very qualitative

$\longrightarrow$ **simulations** are needed

Simulations

Work on simulation started, 1^{st} step is to reproduce the discrete lines



Example of comparison between simulated spectrum (red, DC for ^{116}Sn) and experimental data (blue)

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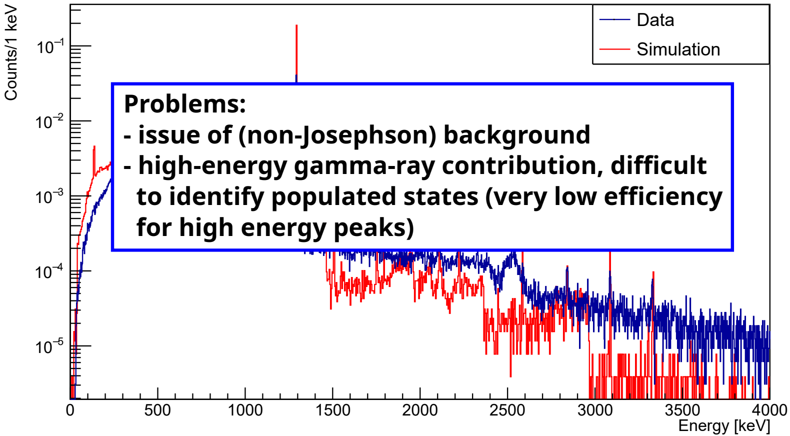

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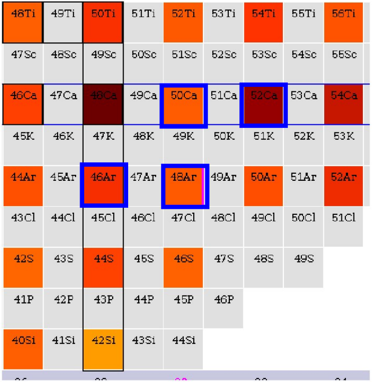
Conclusions

To summarize:

- **High energy tail:** normalization issue, but could be the best way to see something
- **Q-value resolution:** still to be understood, maybe energy losses to be better evaluated?
- **Simulations:** on going
- **Angular distribution:** very low statistics, pretty impossible to see a pattern

Lifetimes in Ca and Ar isotopes



Spokepersons: C. Fransen, A. Gottardo, D. Mengoni,

Investigation of $^{50\text{-}52}$Ca

- **→ large charge and matter radii observed**
- **→ also hints for subshell closures N=32 ($\nu p_{3/2}$), N=34 ($\nu p_{1/2}$); mass measurements**

Investigation of $^{46\text{-}48}$Ar

- **→ Weakening of N=28 shell closure in ^{46}Ar**
- **→ explanation from shell structure: depletion of $\pi s_{1/2}$?**

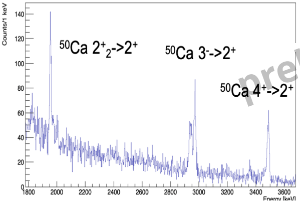
E(2+) = 700 – 800 keV

E(2+) = 1000 – 1500 keV

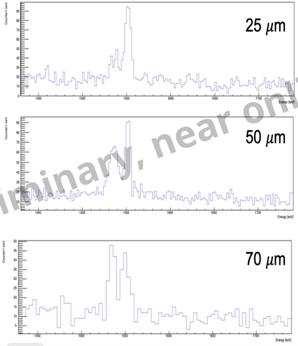
E(2+) > 2500 keV

^{48}Ca @ 305 MeV onto ^{238}U,
Nb degrader
AGATA + PRISMA
RDDS and DSAM

DSAM



^{46}Ar 2^+->0^+



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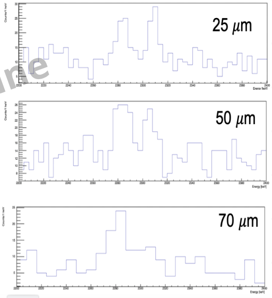

RDDS

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PRISMA analysis on-going