

Investigating the presence of a Nuclear Josephson Effect in sub-barrier reactions with the AGATA+PRISMA setup

G. Andretta - INFN-LNL & UNIPD
GAMMA Science Collaboration Workshop



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

INFN
LNL
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro



Outline

- Josephson Effect: Solid state and Nuclear case
- Experiment
- Strength decomposition
- Simulations
- Perspectives



The Josephson Effect

- Superconductors (Left & Right)

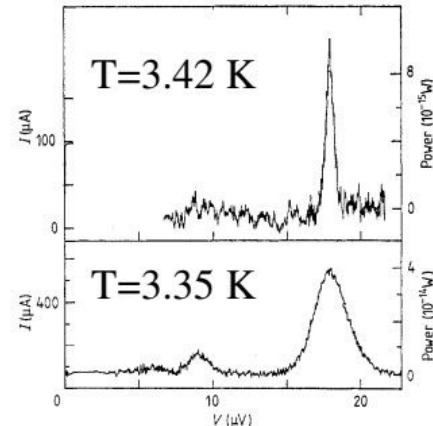
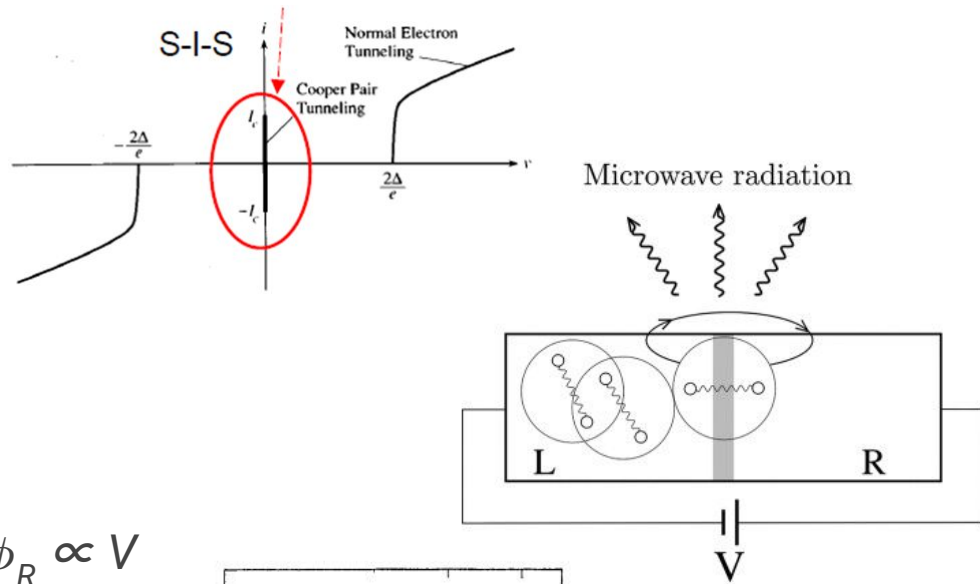
$$\psi = \psi_0 e^{i\phi(t)}$$

- Voltage difference & Supercurrent

$$I(t) = I_0 \sin \Delta\phi(t) \quad \Delta\phi(t) = \phi_L - \phi_R \propto V$$

- If $V \neq 0 \rightarrow$ AC
- If $V = 0 \rightarrow$ DC
- AC: Microwave radiation at specific frequency

$$f = 2eV/h$$



P.E.Lindelof,
Rep.Prog.Phys.44:
60,1981

The *Nuclear* Josephson Effect

- Superfluid nuclei (e.g. ^{116}Sn , ^{60}Ni) in a cold transfer (transfer at Q_{gg})

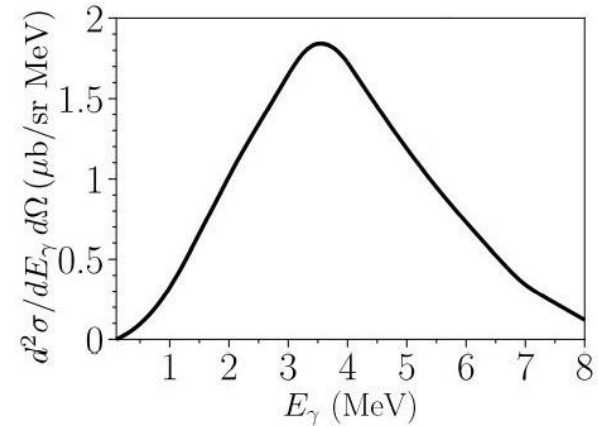
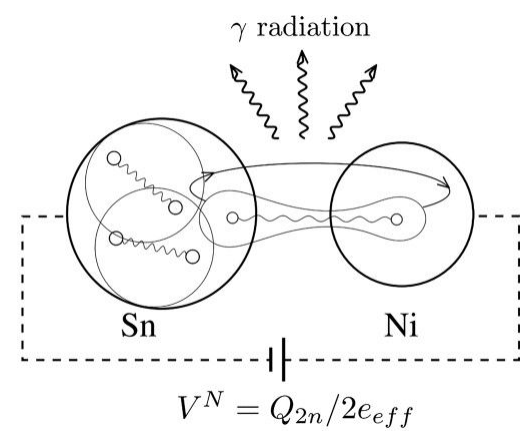
$$Q < 2\Delta$$

- Voltage difference & Supercurrent

$$I(t) = I_0 \sin \Delta\phi(t_{coll}) \quad \Delta\phi(t) \propto Q$$

- Gamma radiation at frequency

$$f = Q_{2n}/h$$



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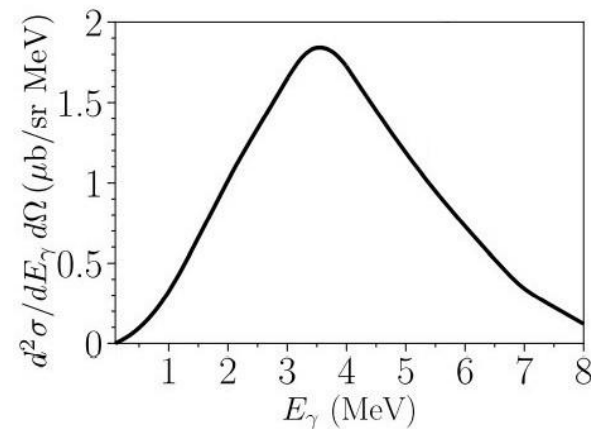
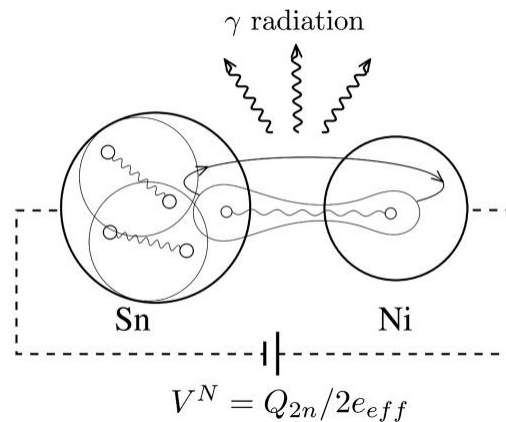
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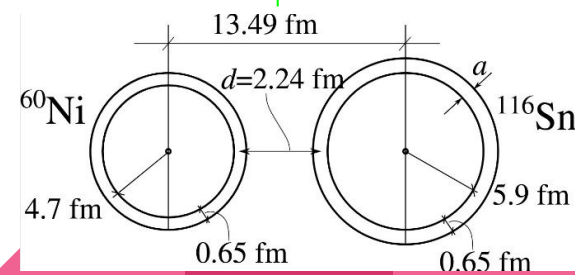
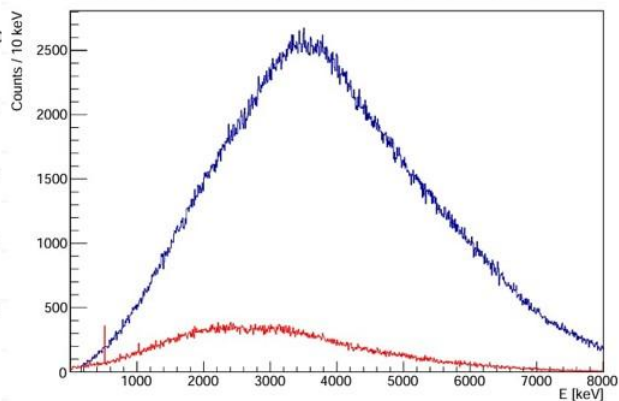
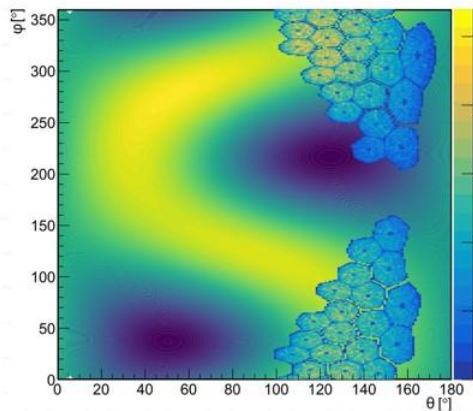
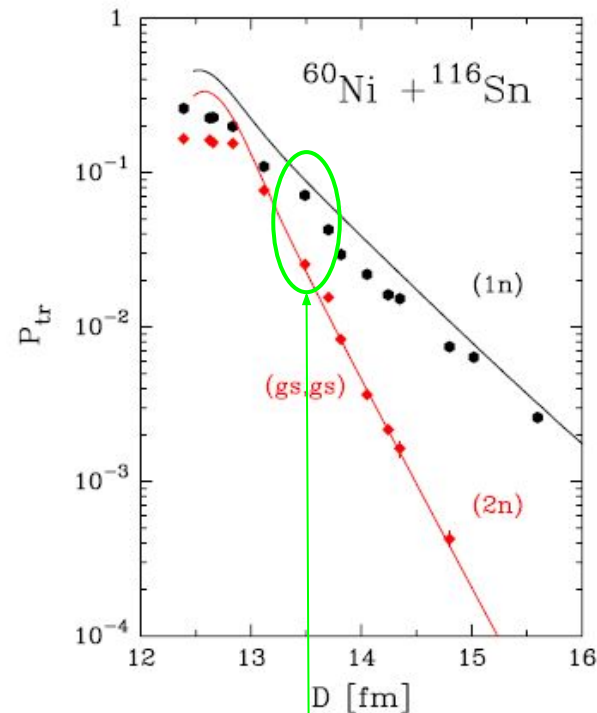
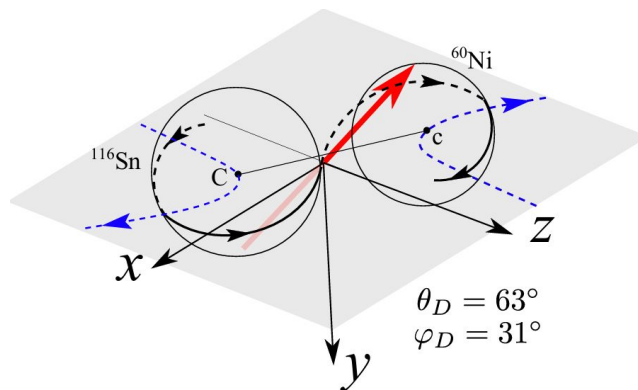
$$f = Q_{2n}/h$$

NB: we are at the limits of PRISMA sensitivity! (~30 $\mu\text{b}/\text{sr}$)

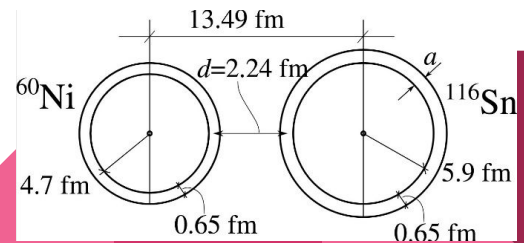
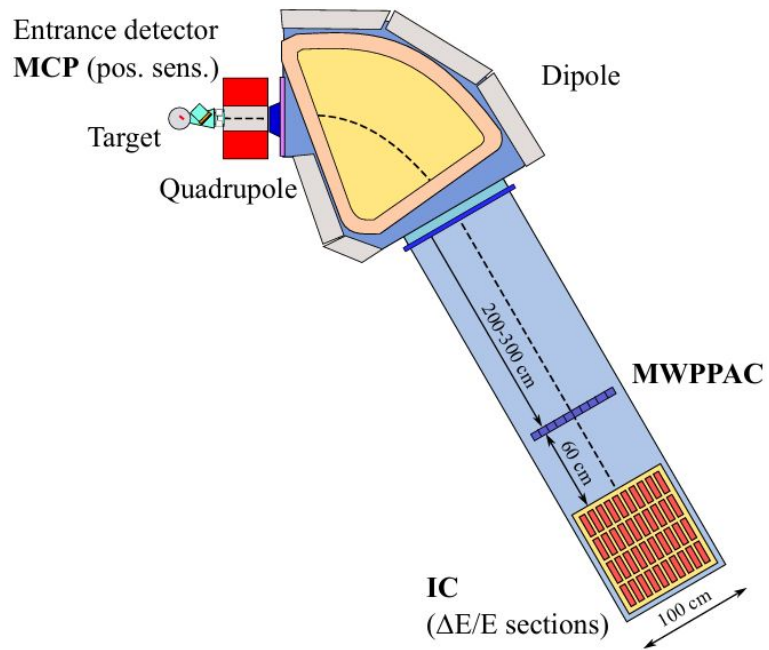


Geometrical properties and JE Simulations

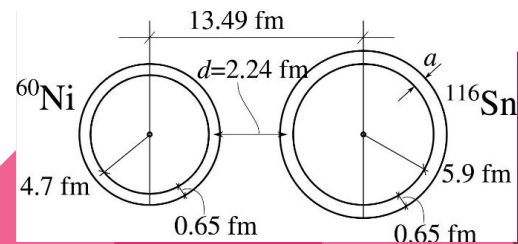
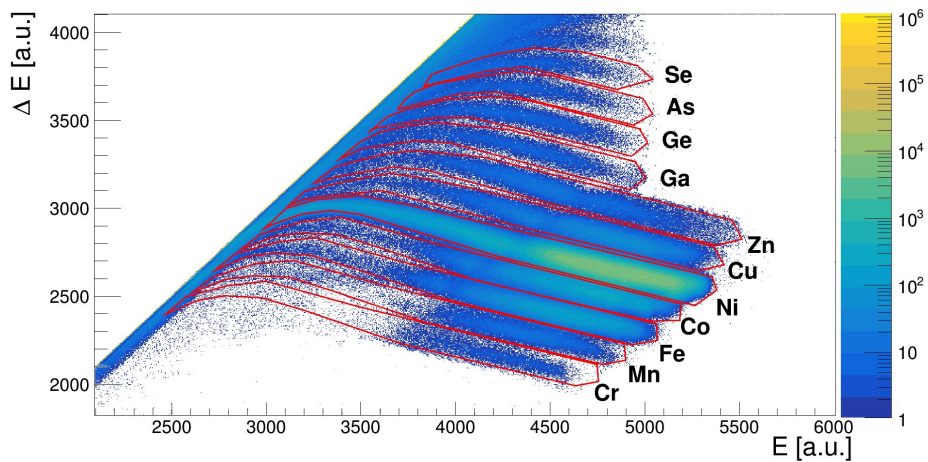
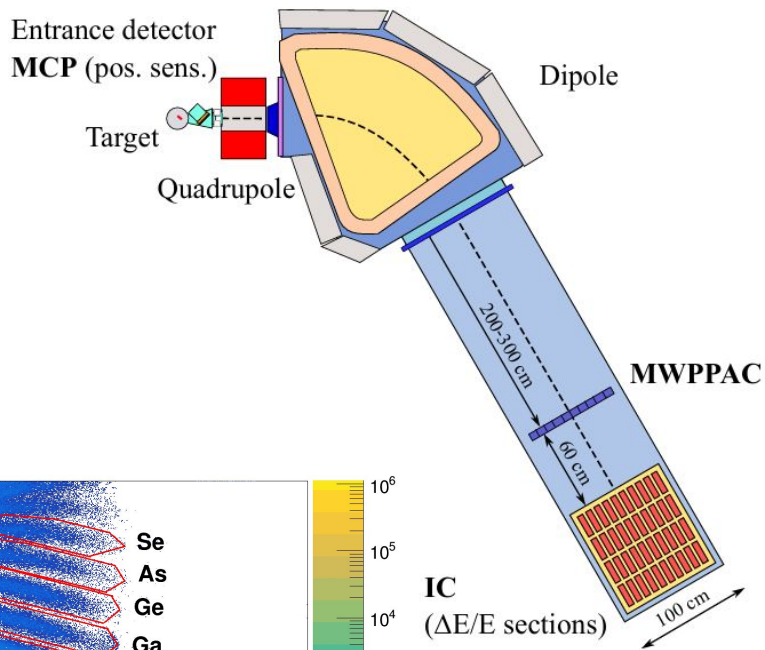
- dipole distribution
- dipole angle
- AGATA acceptance and response function



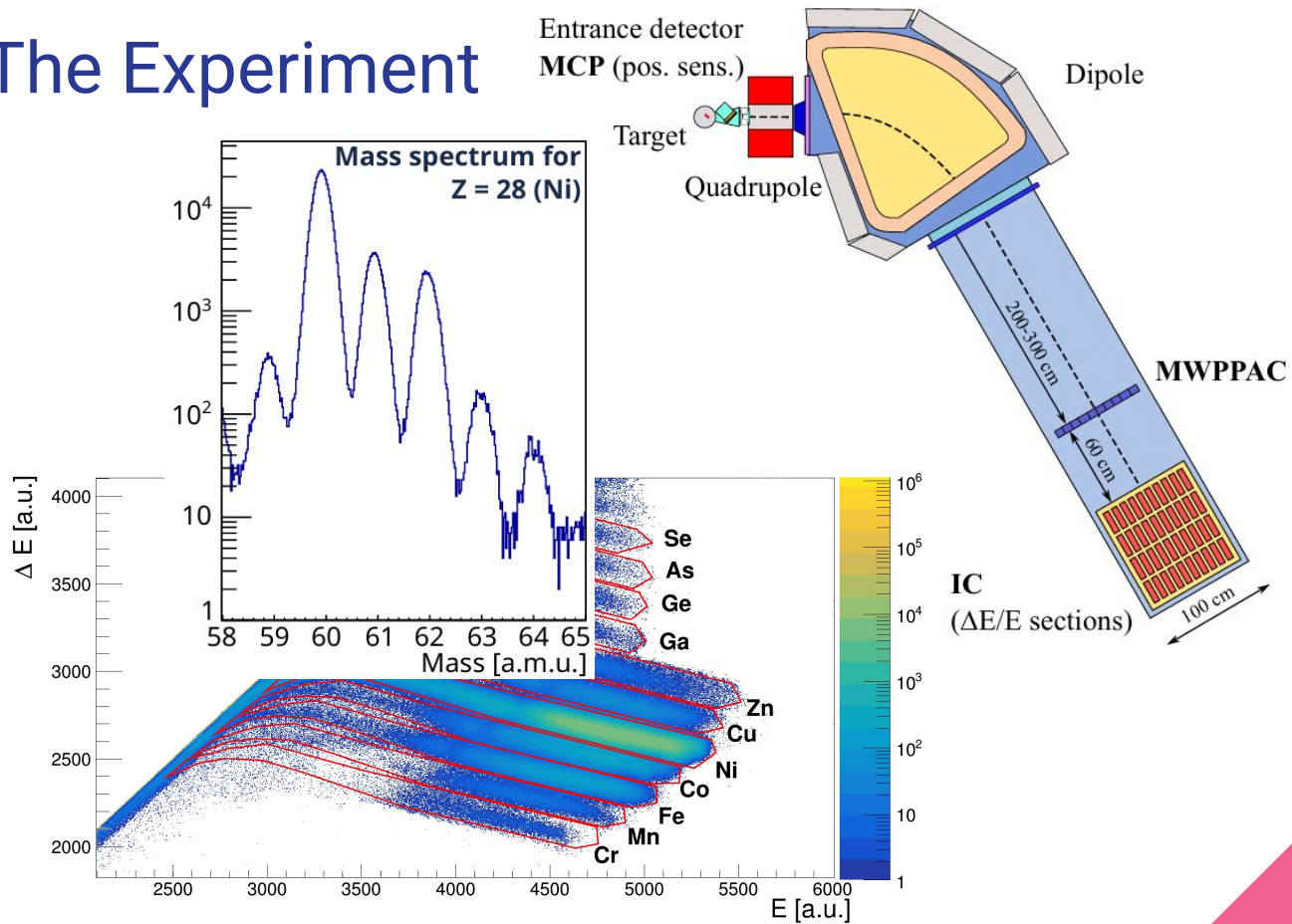
The Experiment



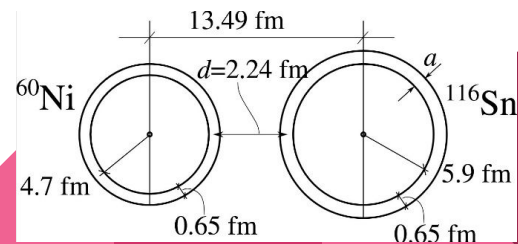
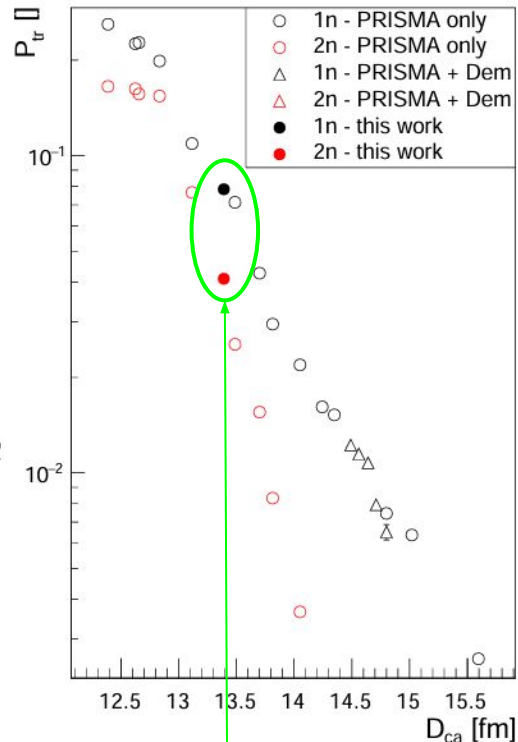
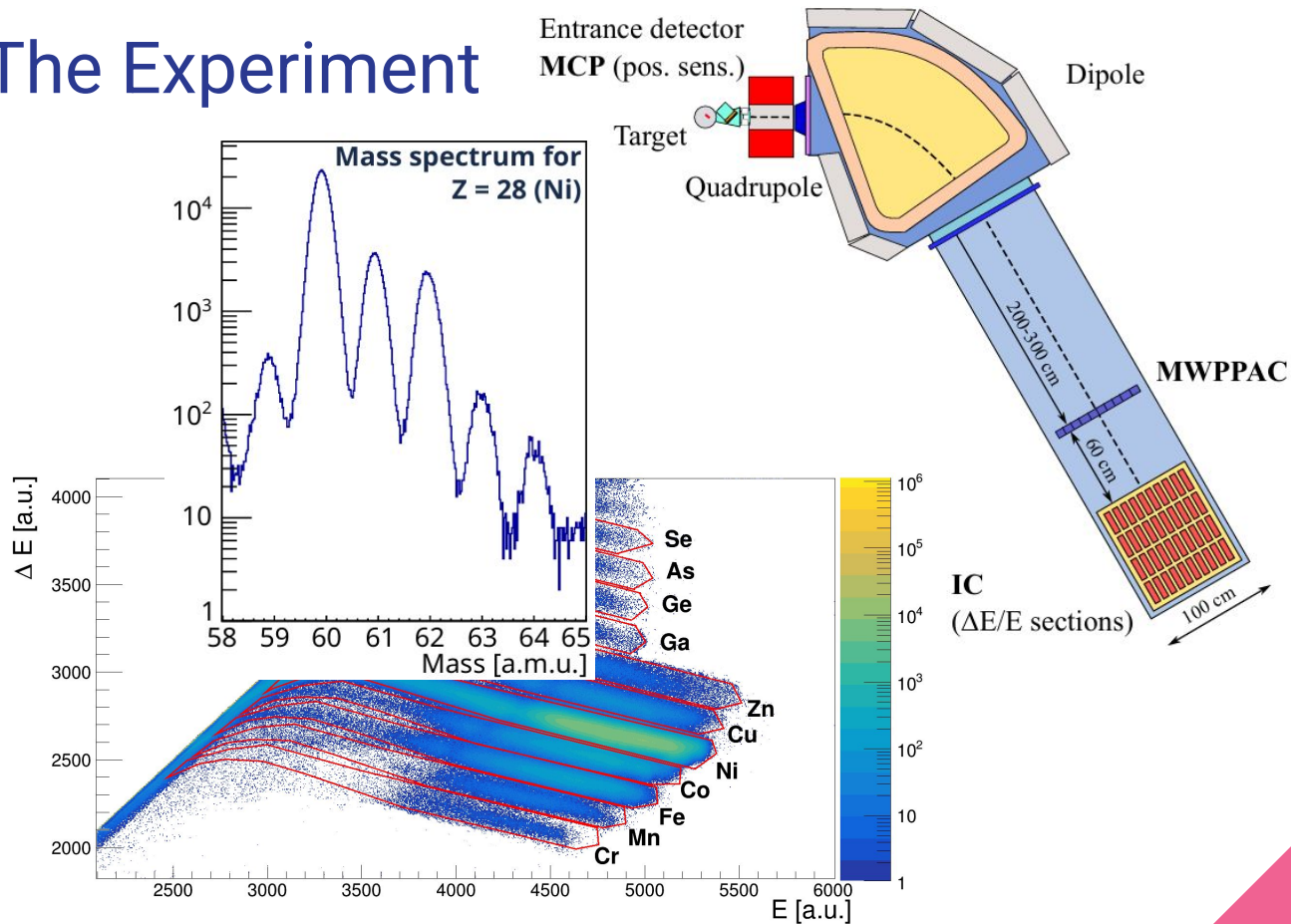
The Experiment



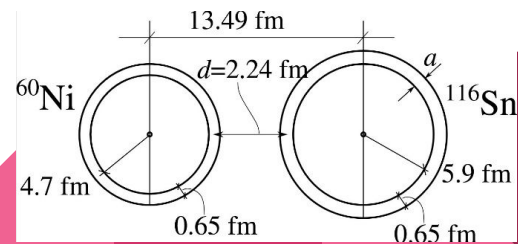
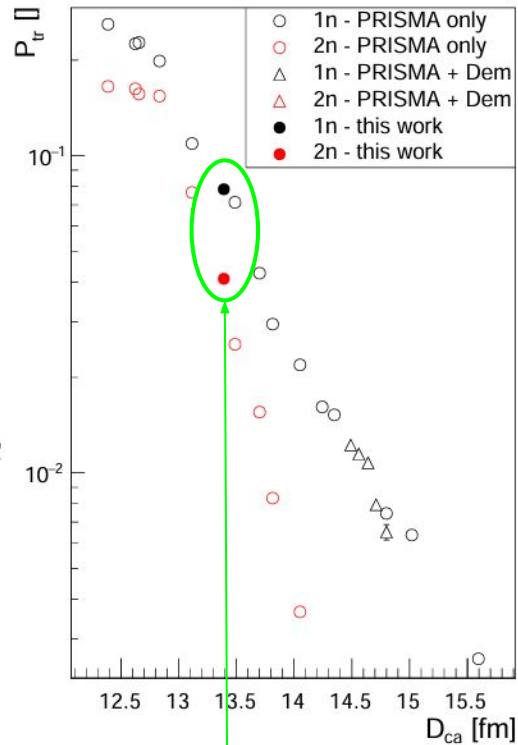
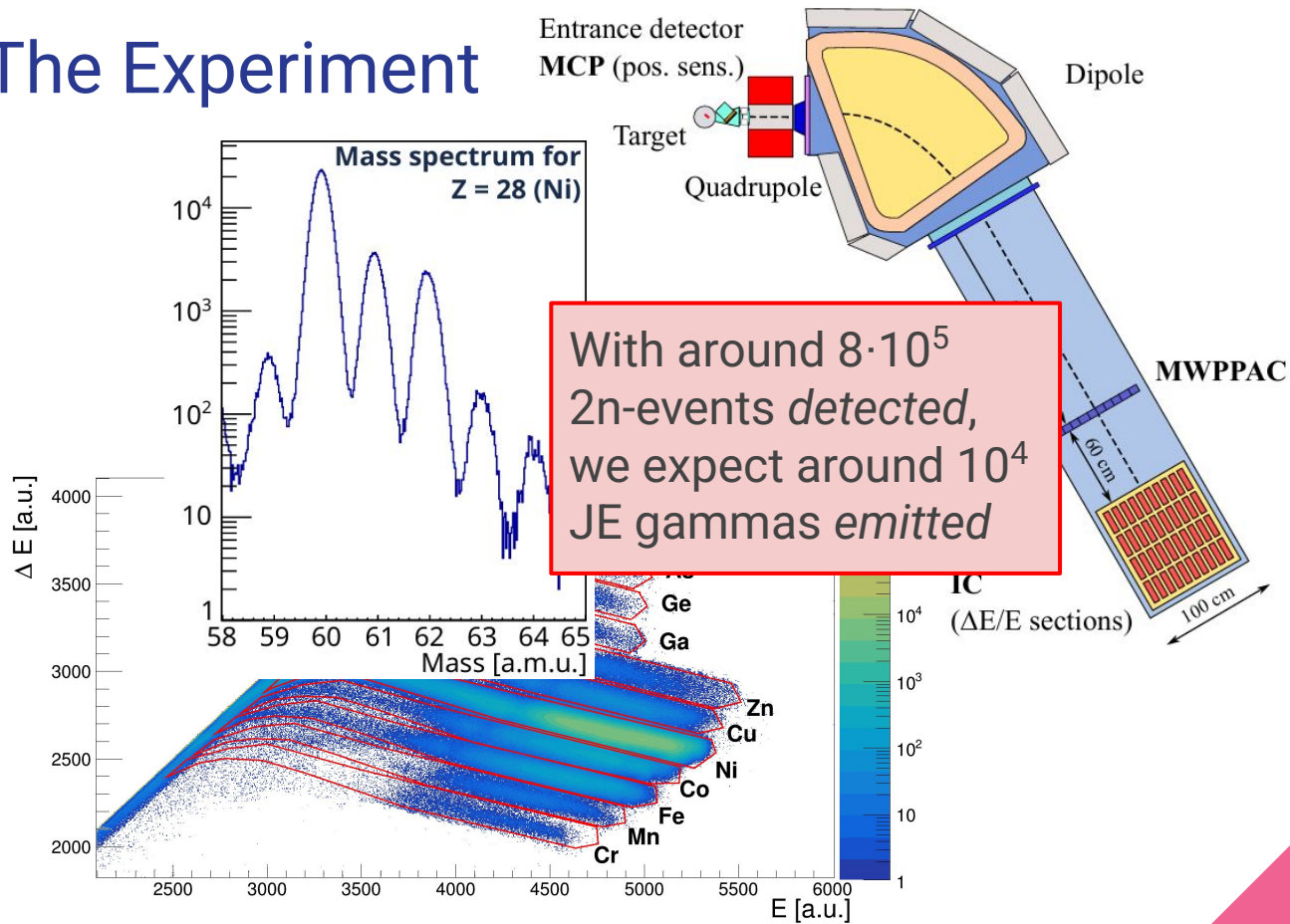
The Experiment



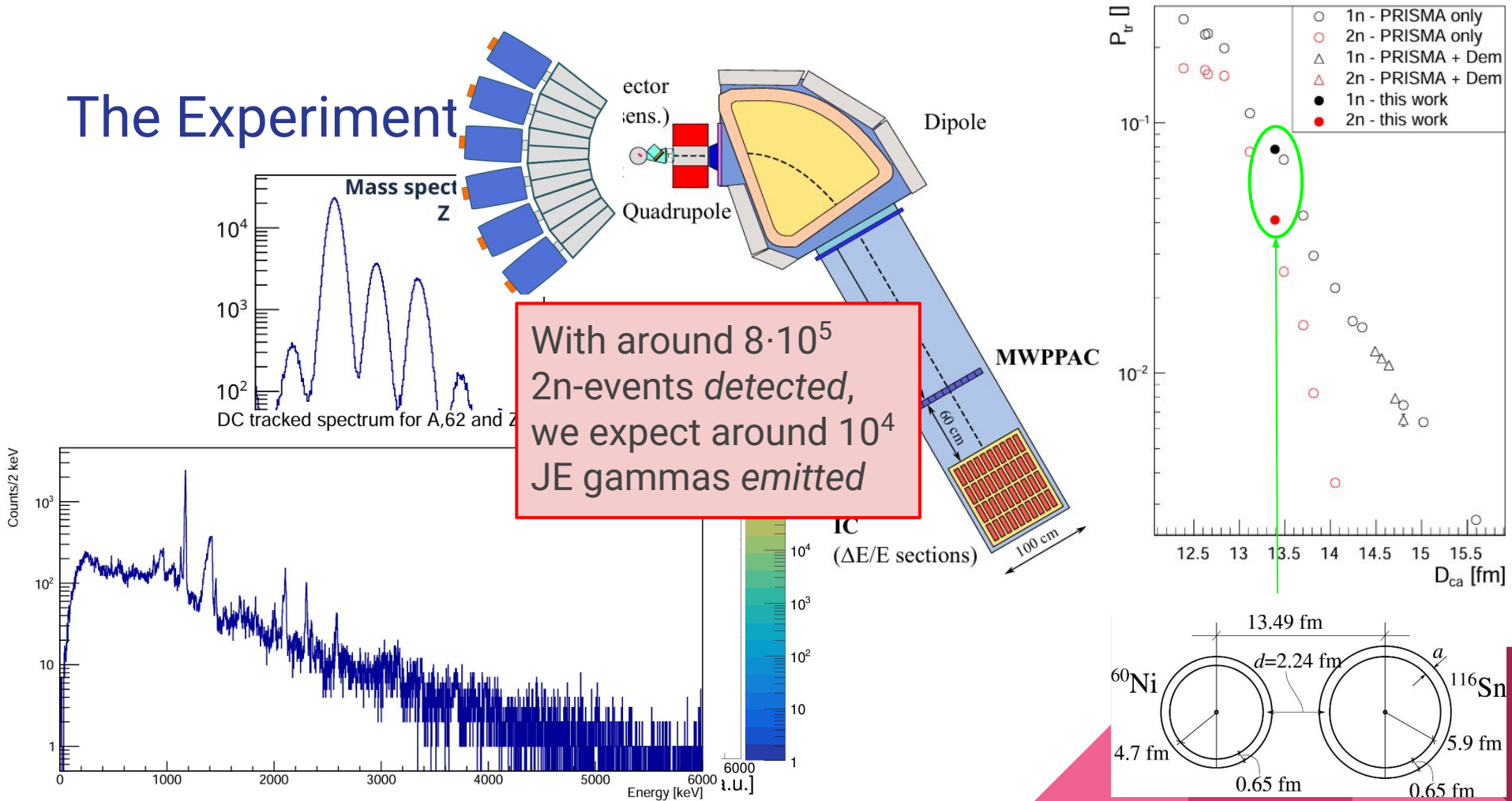
The Experiment



The Experiment



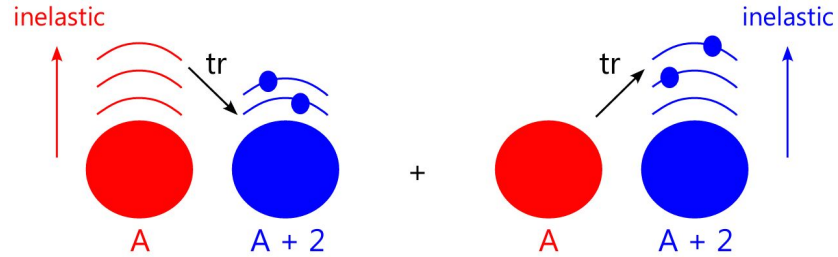
The Experiment



Subtraction procedure scheme

$$S_Y = S_{tr} + S_{inel}$$

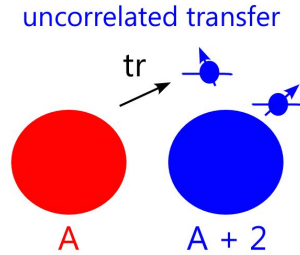
$$= S(0n) \cdot N2/N0$$



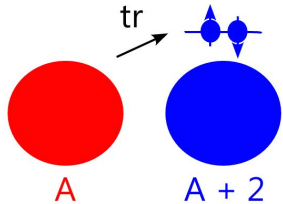
$$S_{tr} = S_{tr-corr} + S_{tr-uncorr}$$

$$= 2 \cdot S(1n)_{tr-corr} \cdot N2/N1 =$$

$$= 2 \cdot [S(1n) - S(1n)_{inel}] \cdot N1/N0 \cdot N2/N1$$



correlated transfer



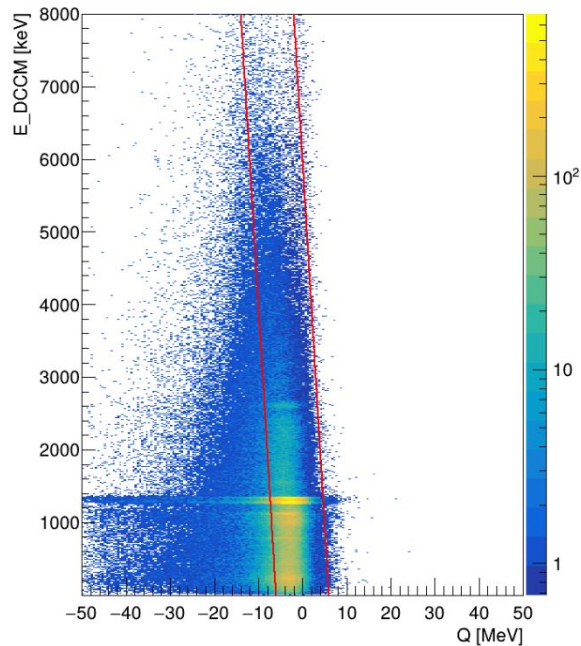
$$= S_Y - S(0n)_{inel} - S(0n)_{tr-uncorr} =$$

$$= S(2n) - 2 \cdot S(1n) \cdot N2/N1 + S(0n) \cdot N2/N0$$

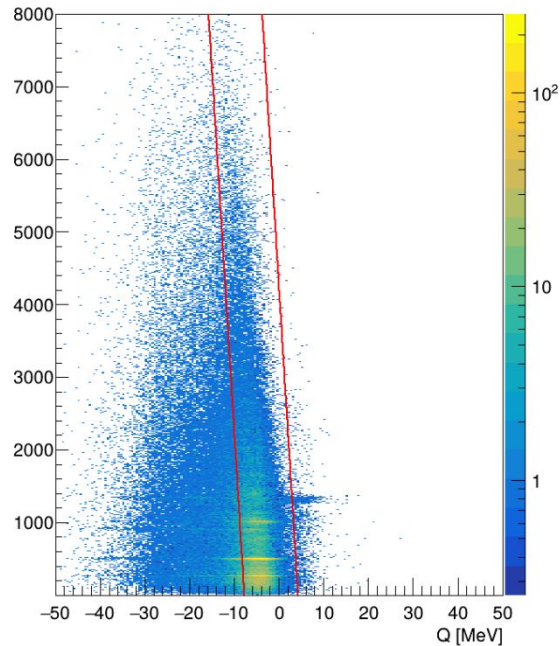
Q-value gate

Cold-transfer requirement \rightarrow Q-val condition: $E_\gamma + Q = Q_{gg}$

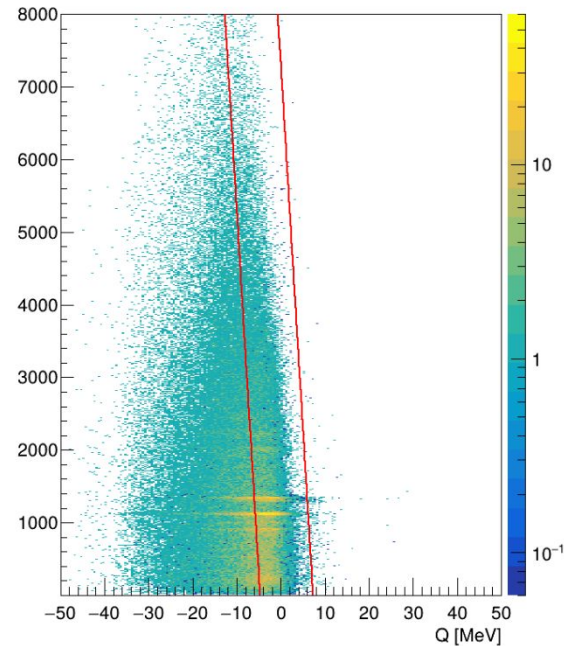
Calorimeter Data - 0n



Calorimeter Data - 1n



Calorimeter Data - 2n

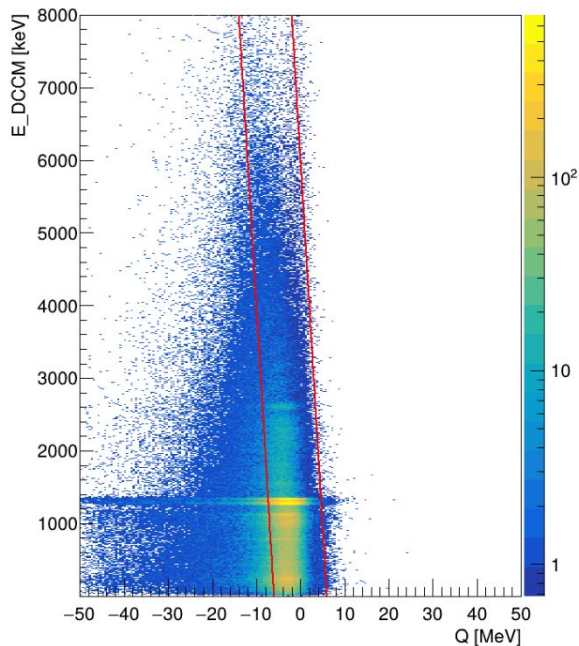


Q-value gate

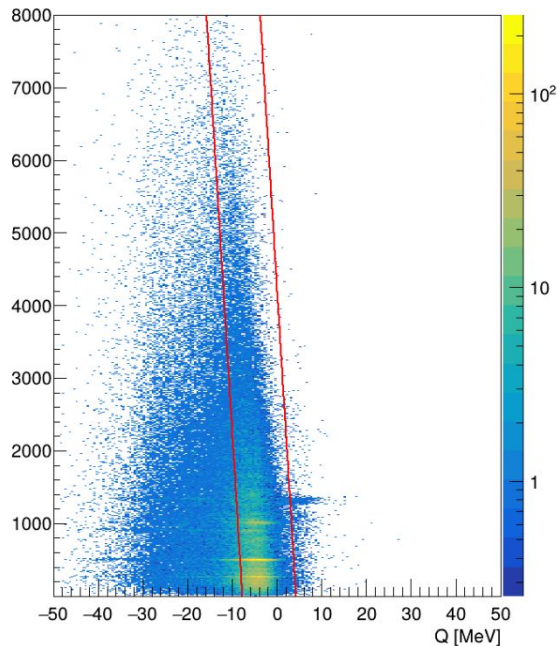
Cold-transfer requirement \rightarrow Q-val condition: $E_\gamma + Q = Q_{gg}$

JE should
somewhere stay
here

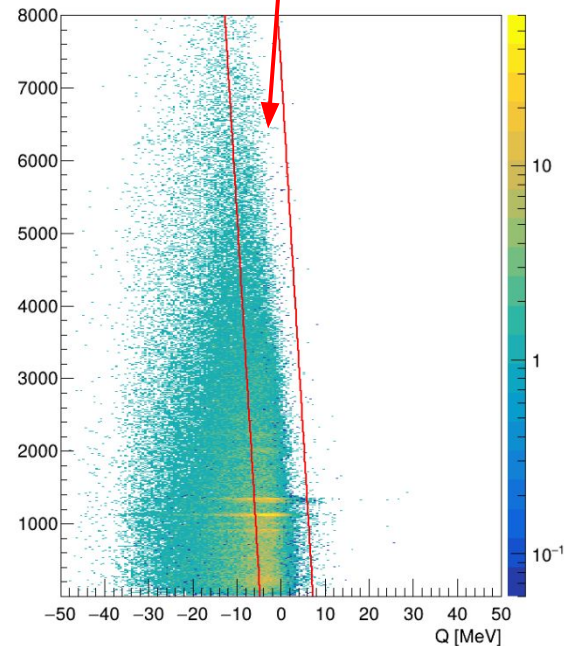
Calorimeter Data - 0n



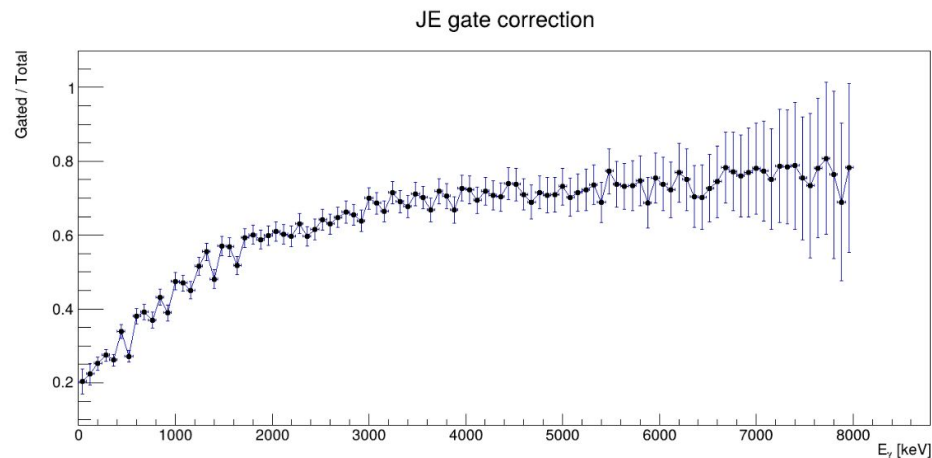
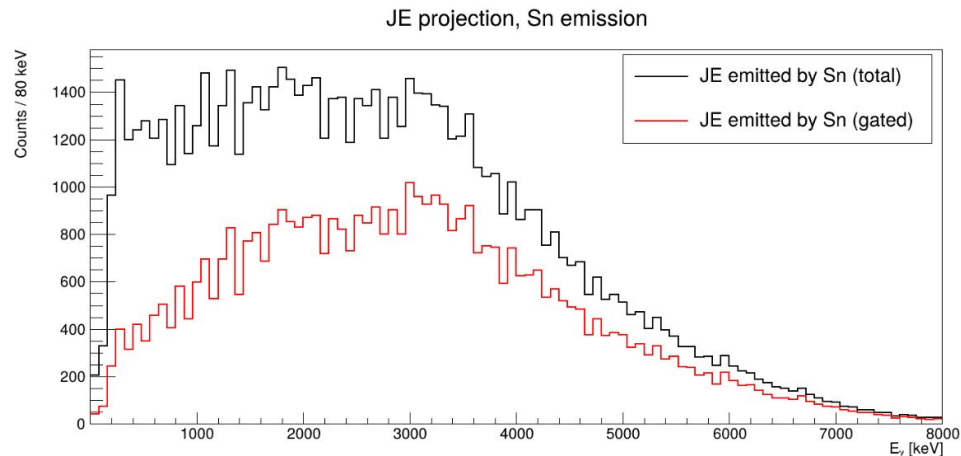
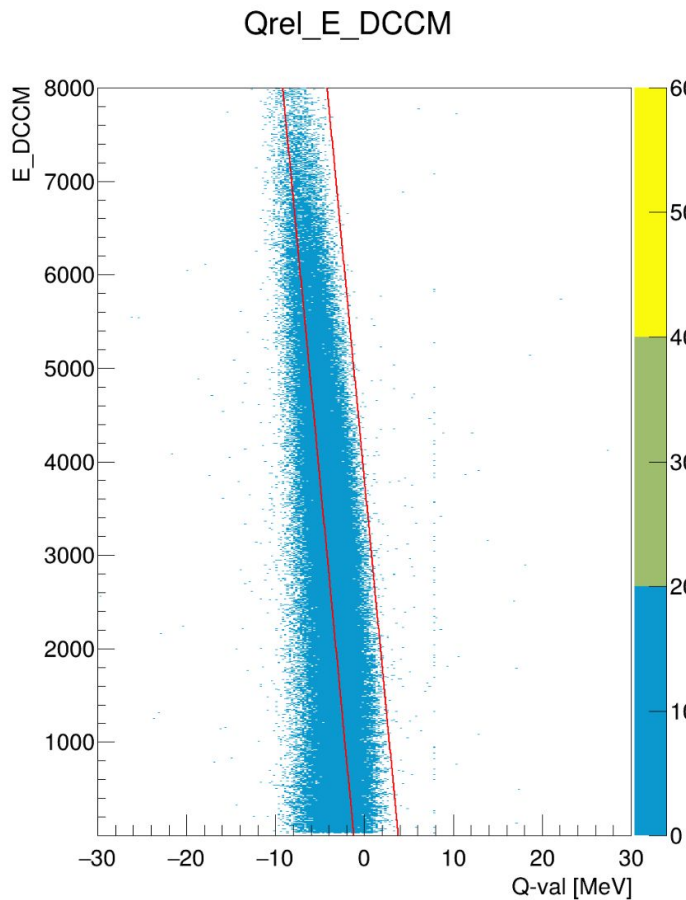
Calorimeter Data - 1n



Calorimeter Data - 2n

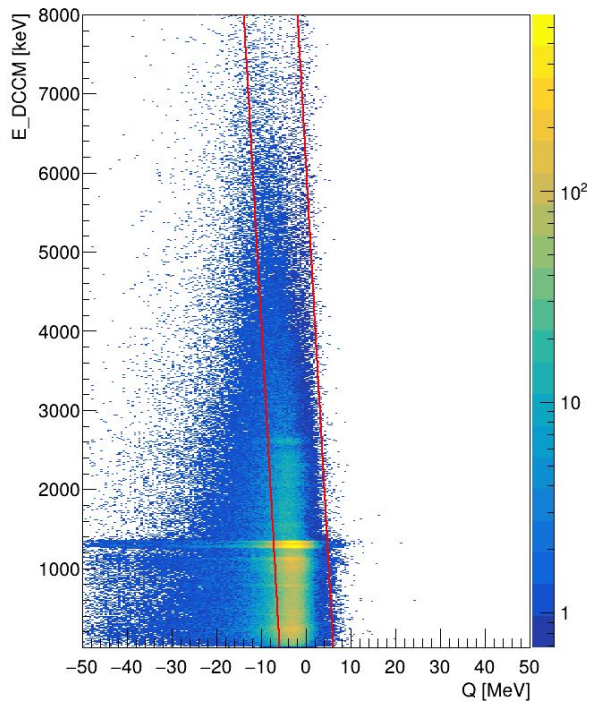


JE simulation - Q-value distribution and Gate effect

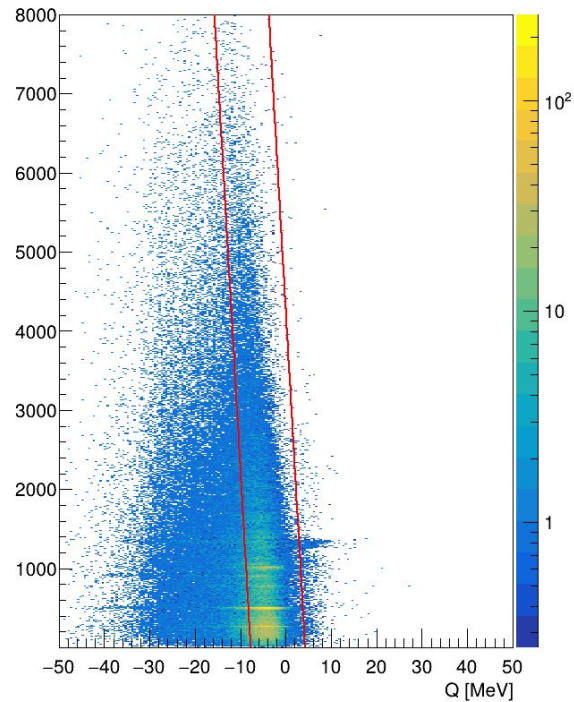


Q-value gate

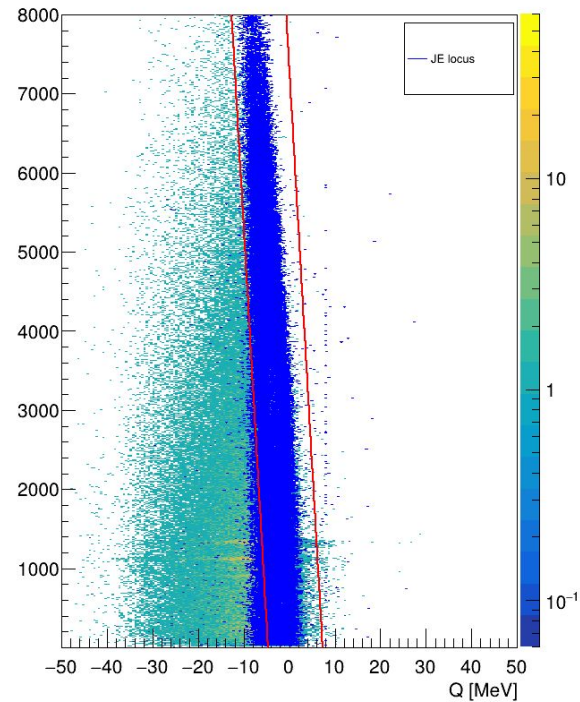
Calorimeter Data - 0n



Calorimeter Data - 1n

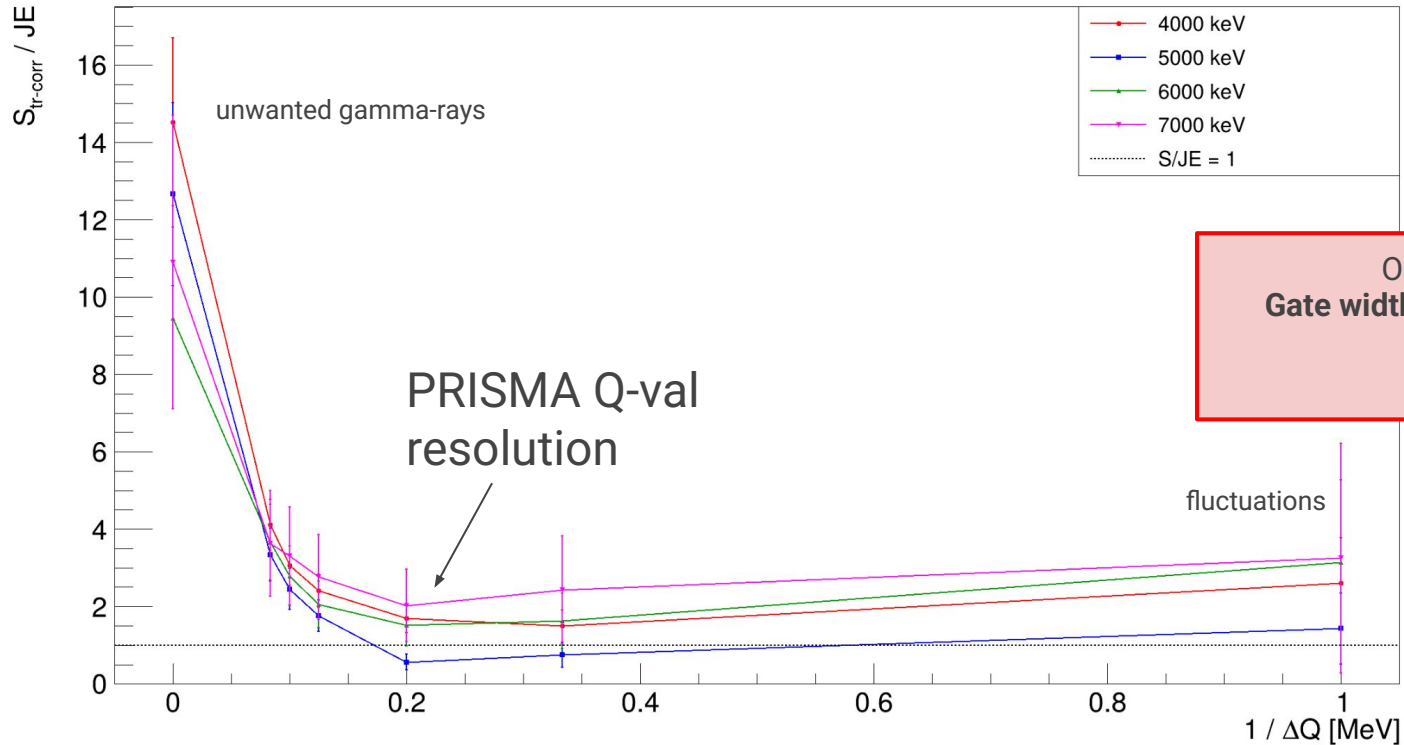


Calorimeter Data - 2n



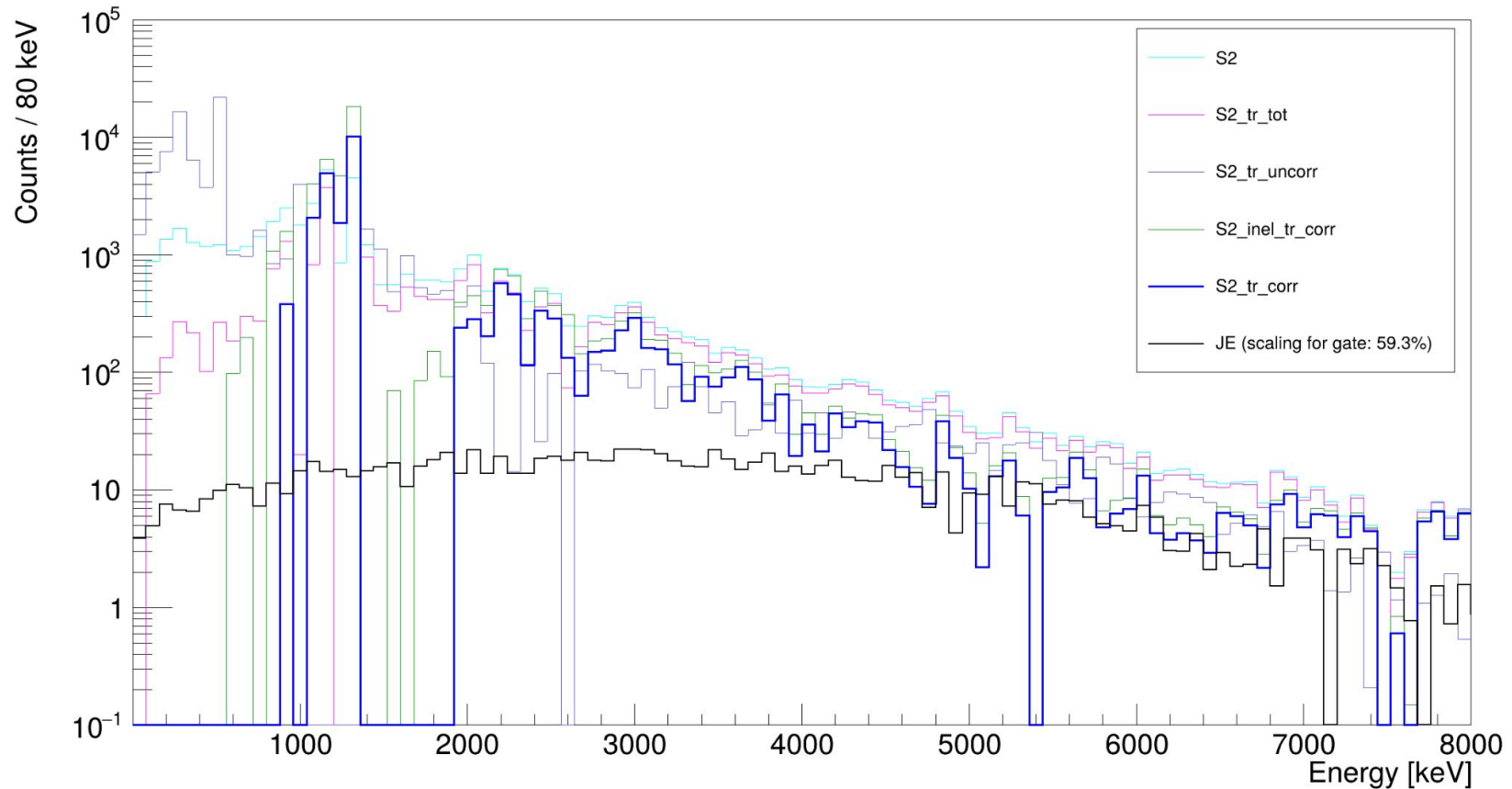
Sensitivity study - Effect of the Gate

Ratio Data/Simu vs Gate Width

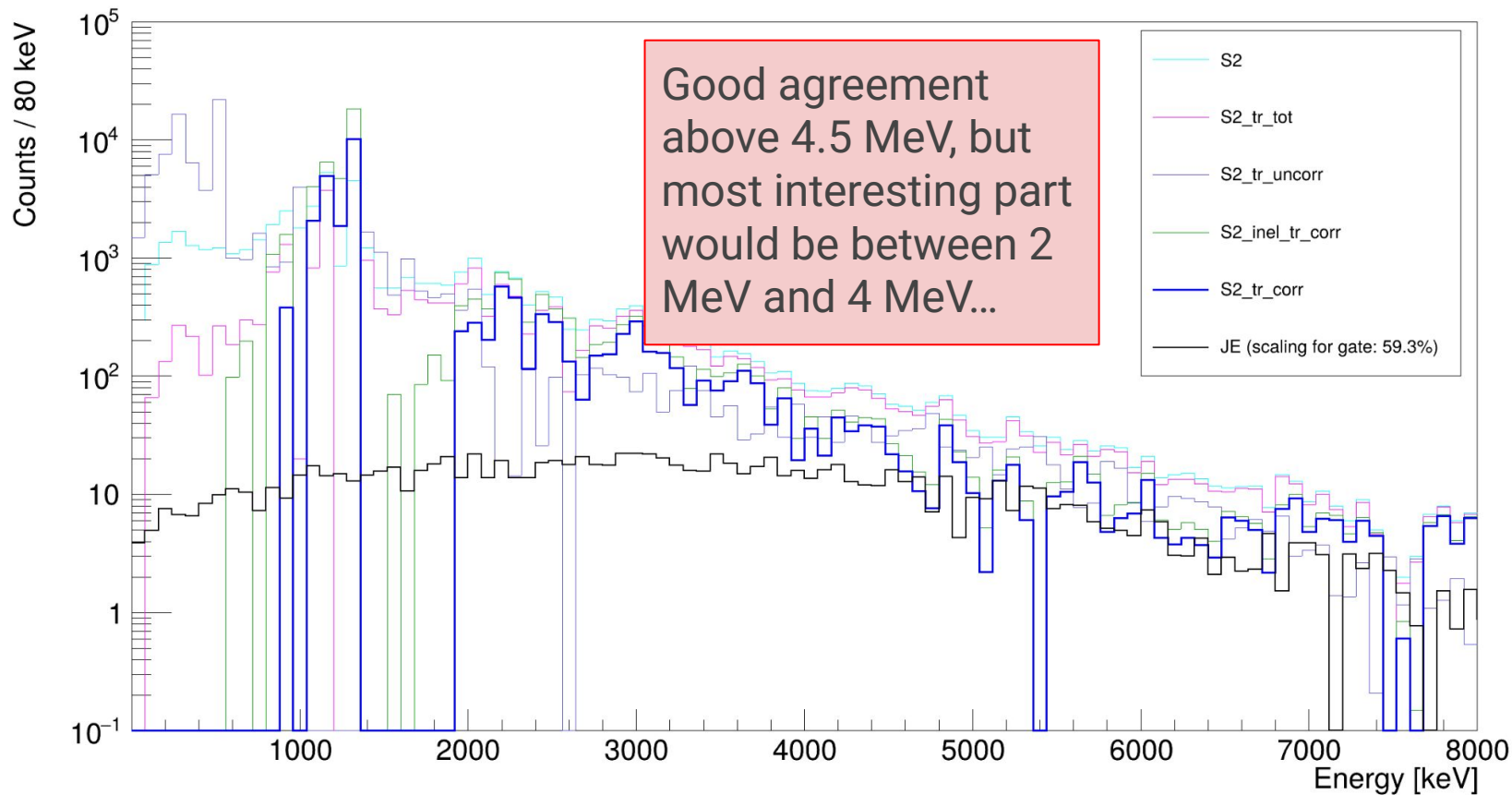


Optimal condition:
Gate width = PRISMA Q-resolution
 $\Delta Q = 5$ MeV

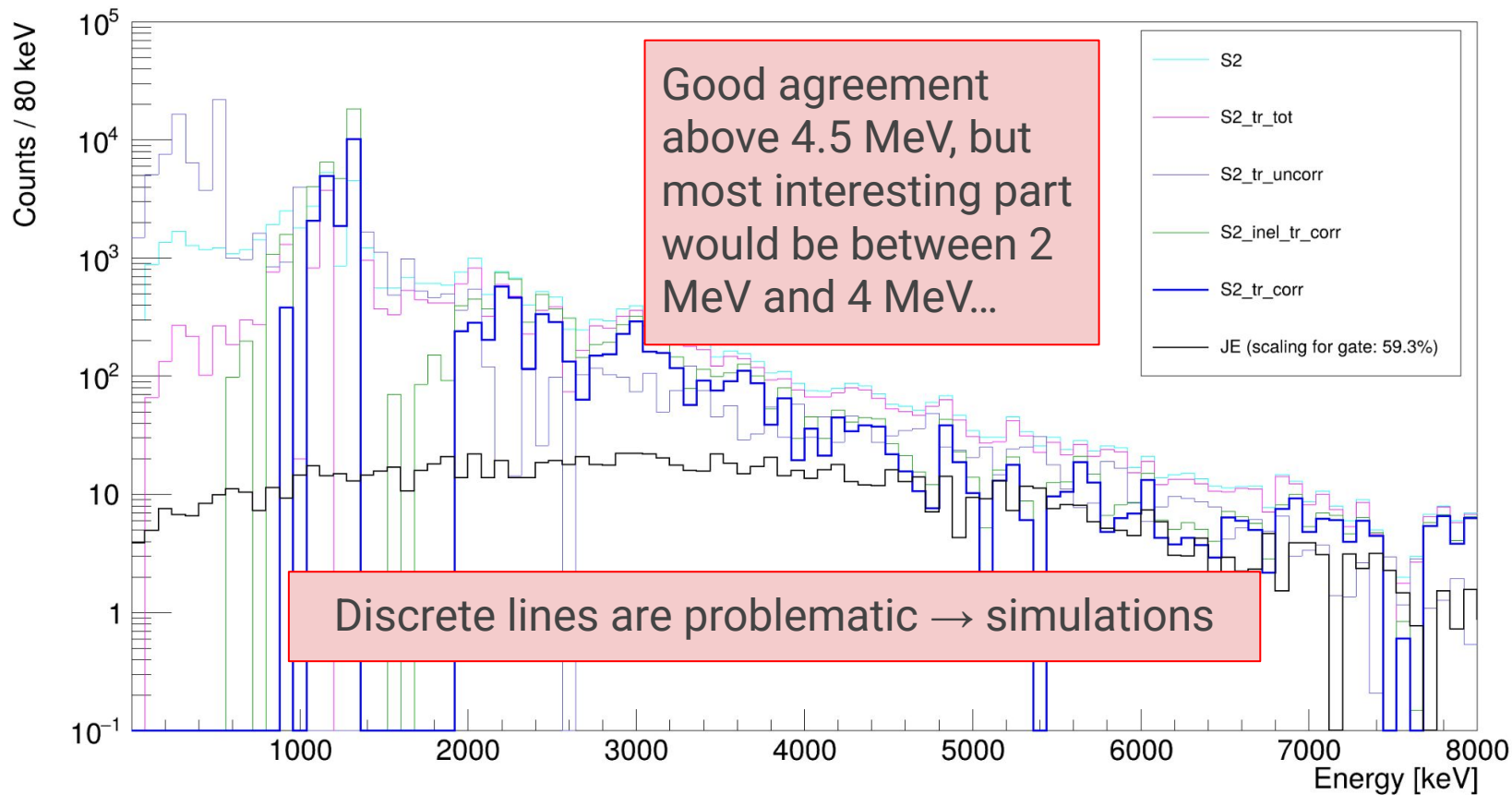
Results of the subtraction procedure



Results of the subtraction procedure

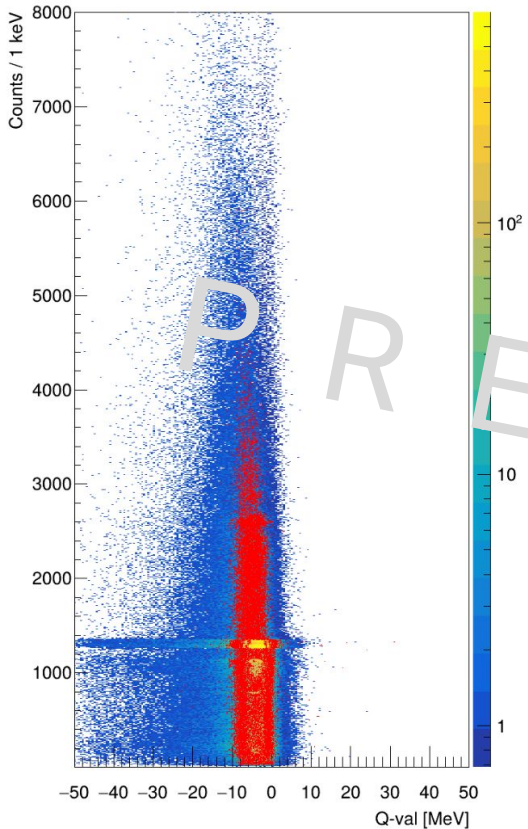


Results of the subtraction procedure

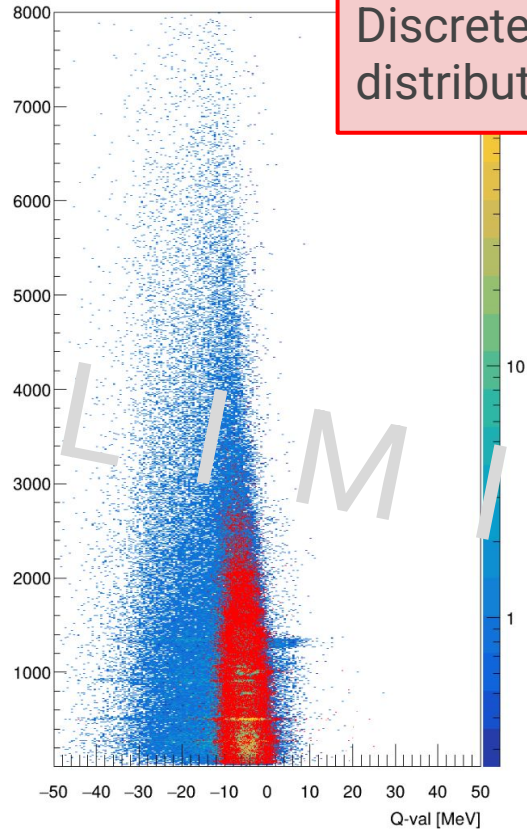


Discrete lines simulation vs Data

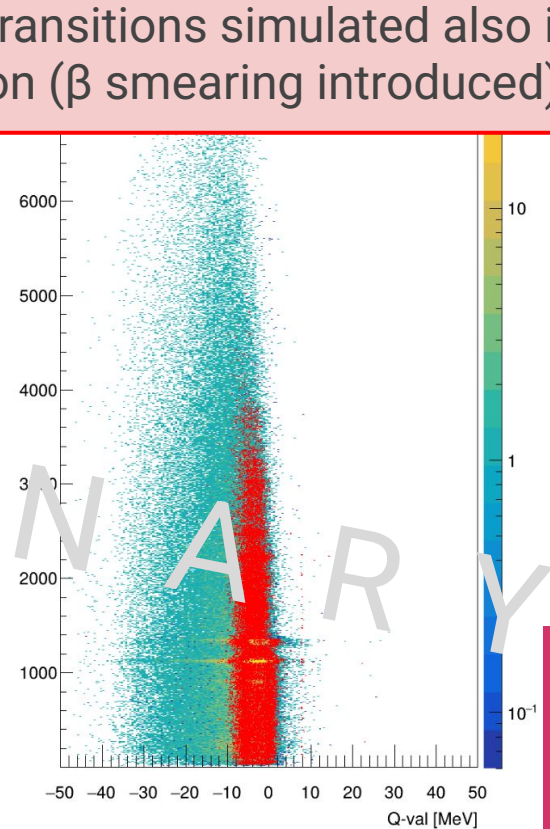
E_DC : Q (0n)



E_DC : Q (1n)

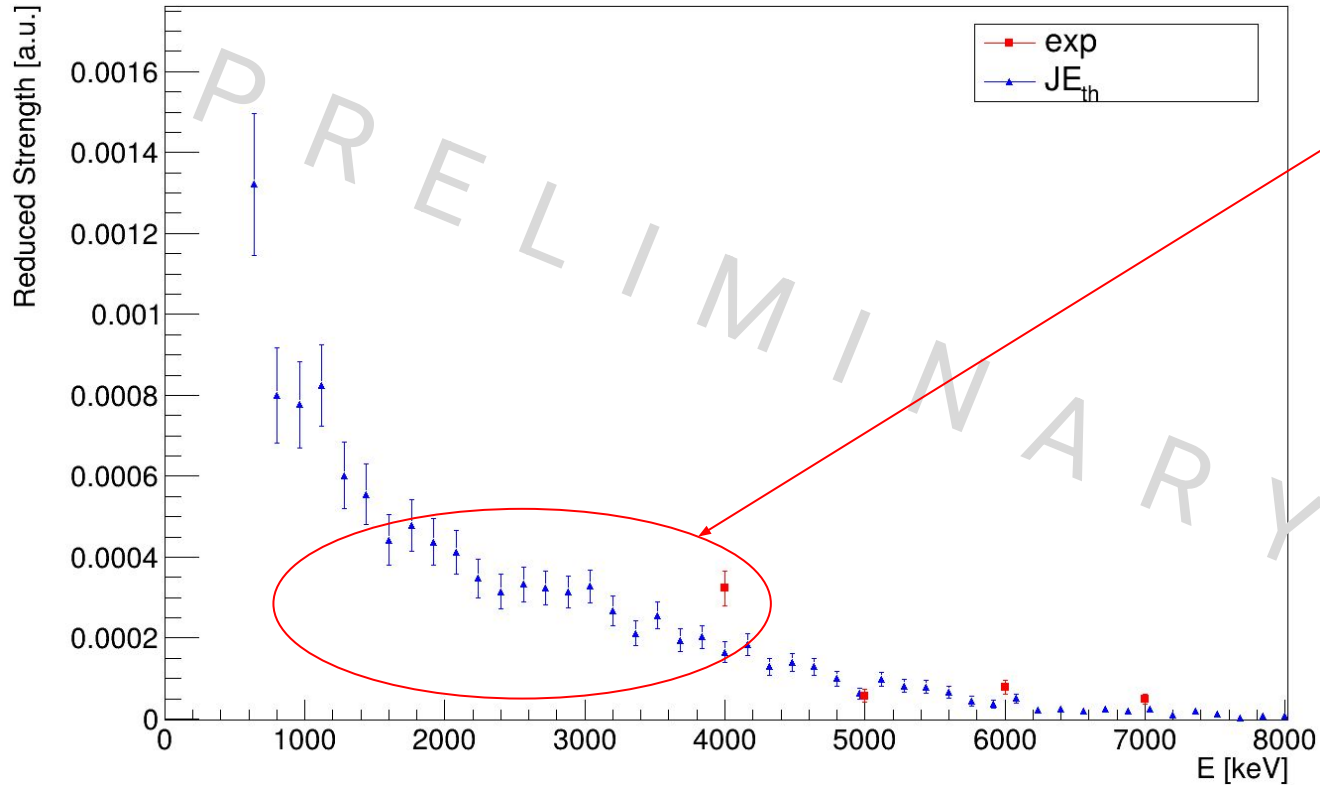


E_DC : Q (2n)



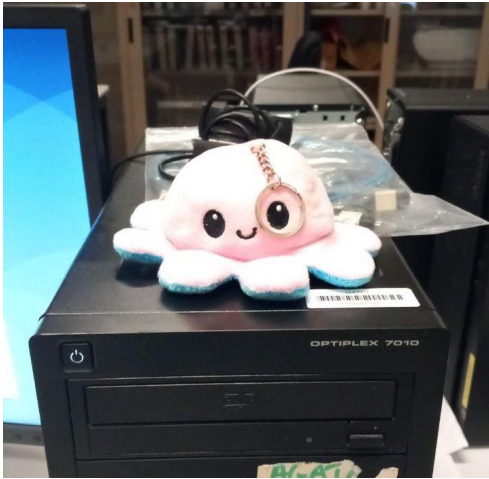
Discrete transitions simulated also in Q-val distribution (β smearing introduced)

Reduced Strength



Ultimate goal: fill up
the region between
1 MeV and 4 MeV

Thanks



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+ many people from all the “local” group (LNL, PD, MI, FI...)