Studying structure near the neutron emission threshold using the detector TETRA at ALTO

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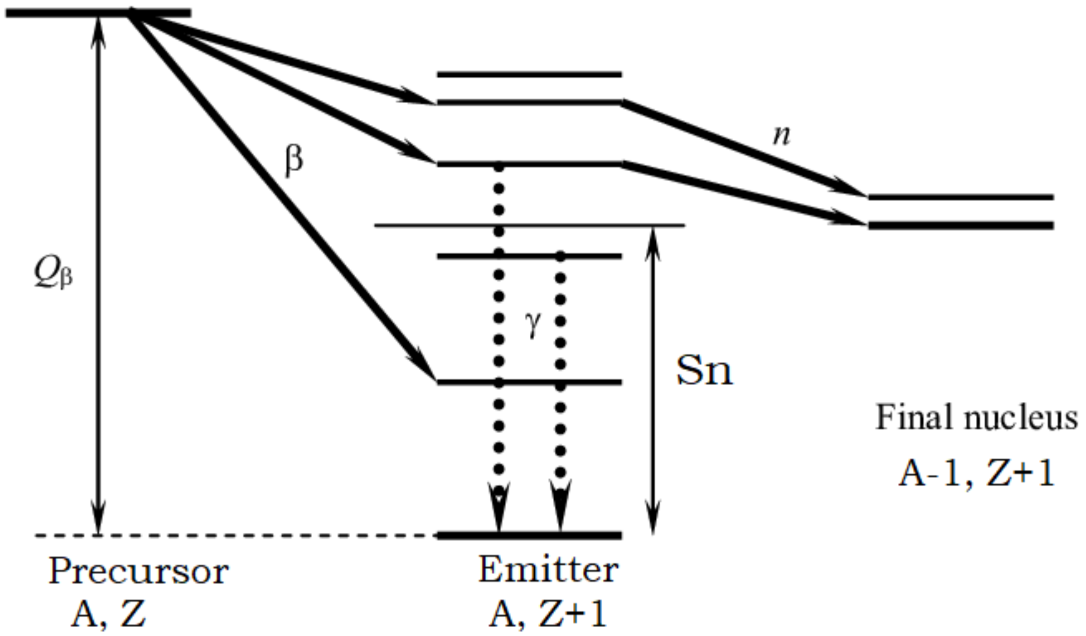
Outline

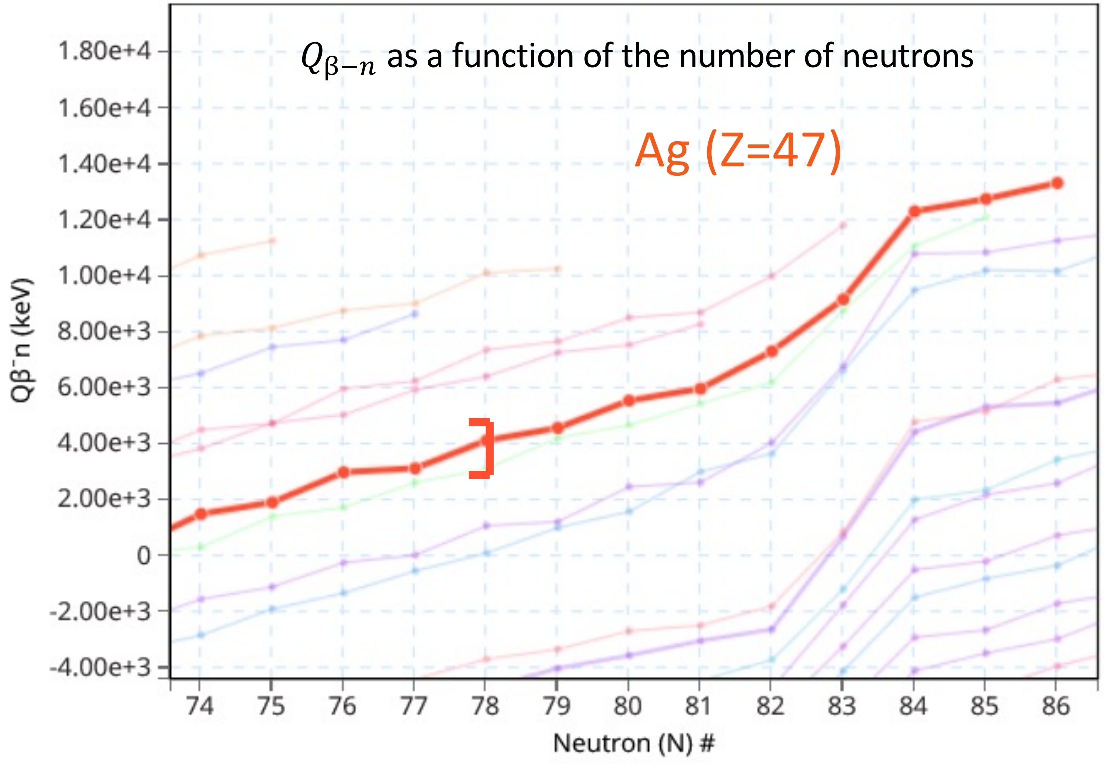
I. Structure near the neutron emission threshold

II. Experimental setup

III. Pn measurement of 84Ga

IV. Ring ratio method to measure mean neutron energy



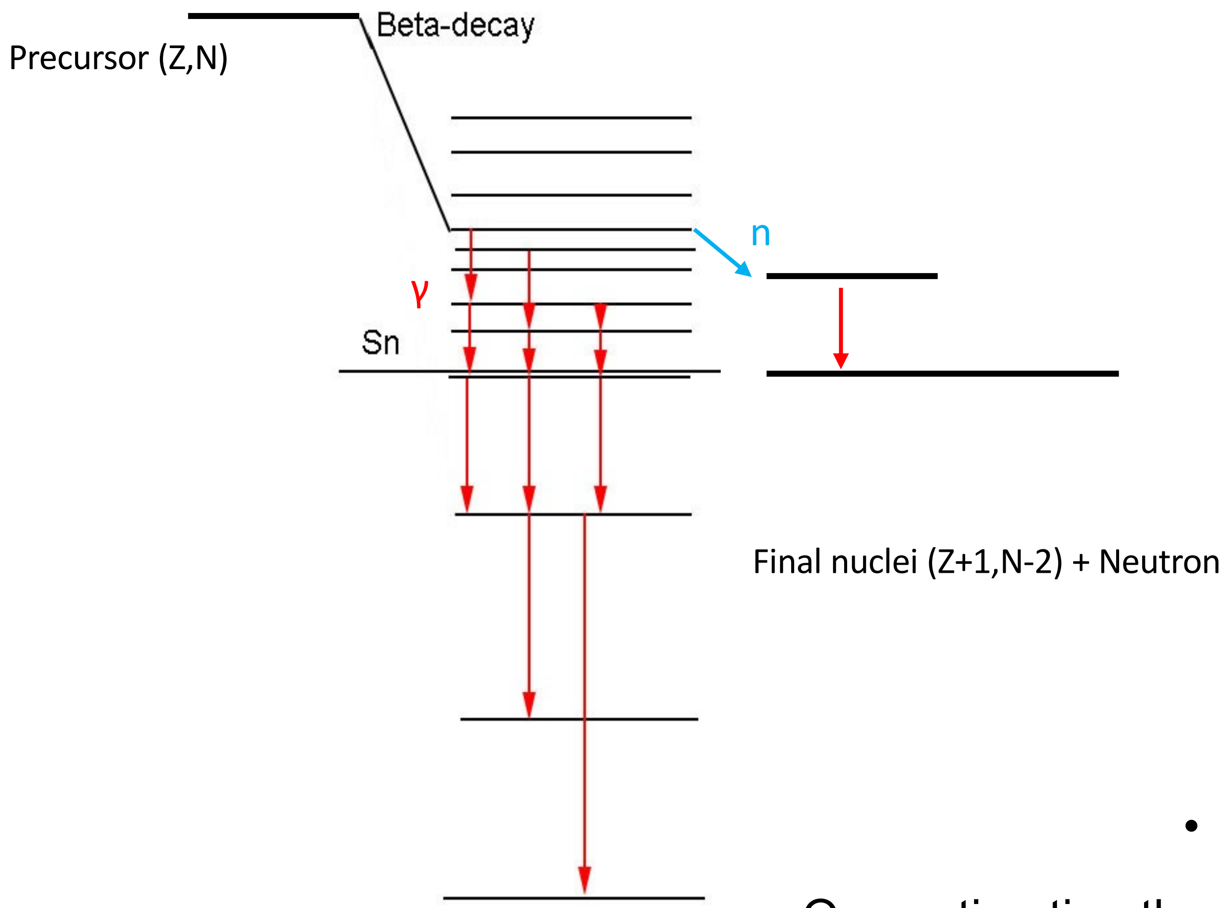


- $Q_{\beta-n} = Q_\beta - S_n$ ➡ Available energy for neutrons
- P_n: Probability for the daughter nucleus to emit at least one neutron after the beta decay

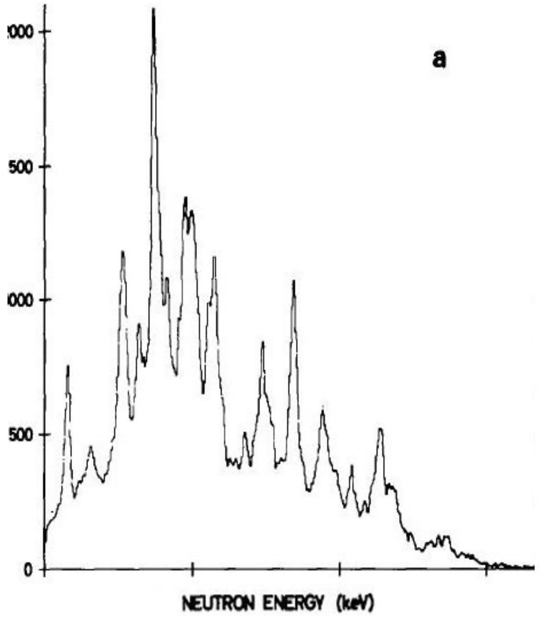
$$P_n = P_{1n} + P_{2n} + \cdots \quad \neq \quad < n > = P_{1n} + 2P_{2n} + \cdots$$

The statistical models

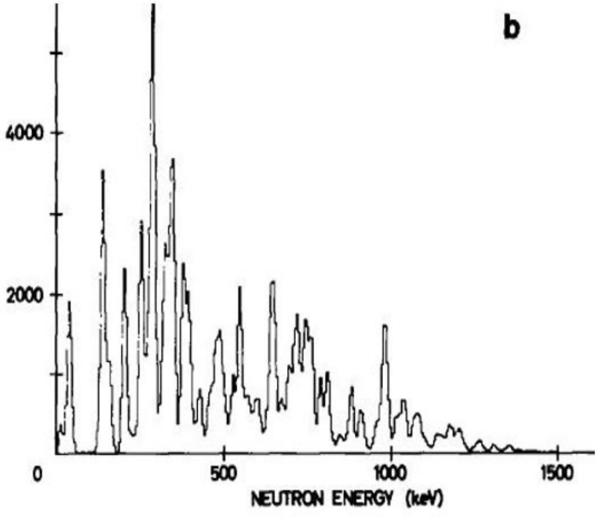
Hardy et al. "The essential decay of pandemonium: β-Delayed neutrons" 1977



Emettor (Z+1,N-1)



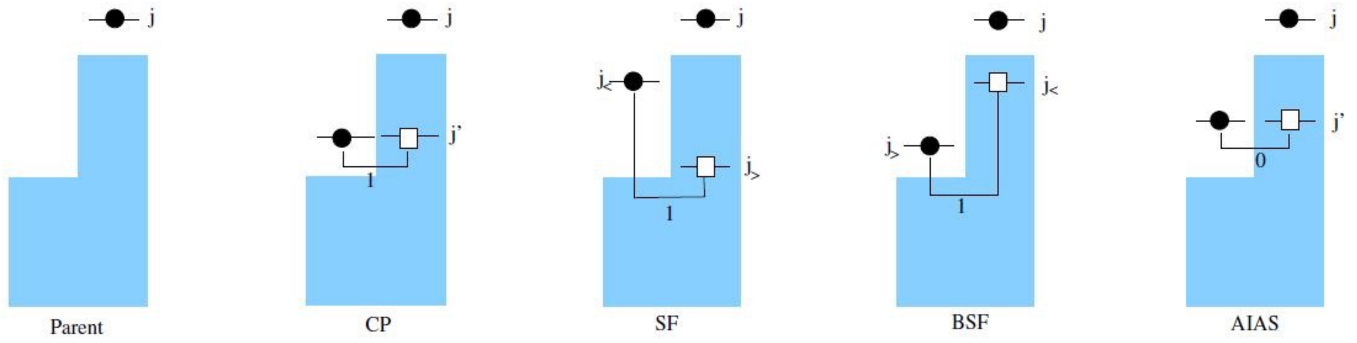
Experimental spectrum

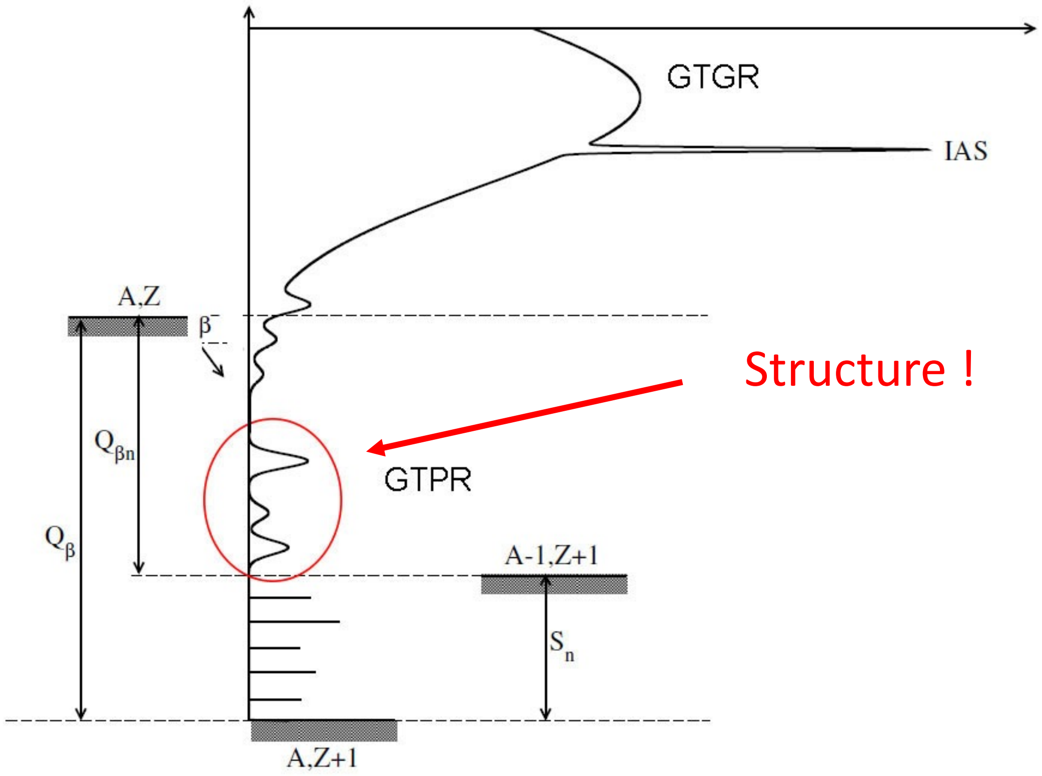


Pandemonium simulation

- Discret spectrum but bad prediction of P_n and $T_{1/2}$
- Overestimating the probability to populate levels under S_n : Pandemonium effect

Gamow-Teller « Doorway » transitions



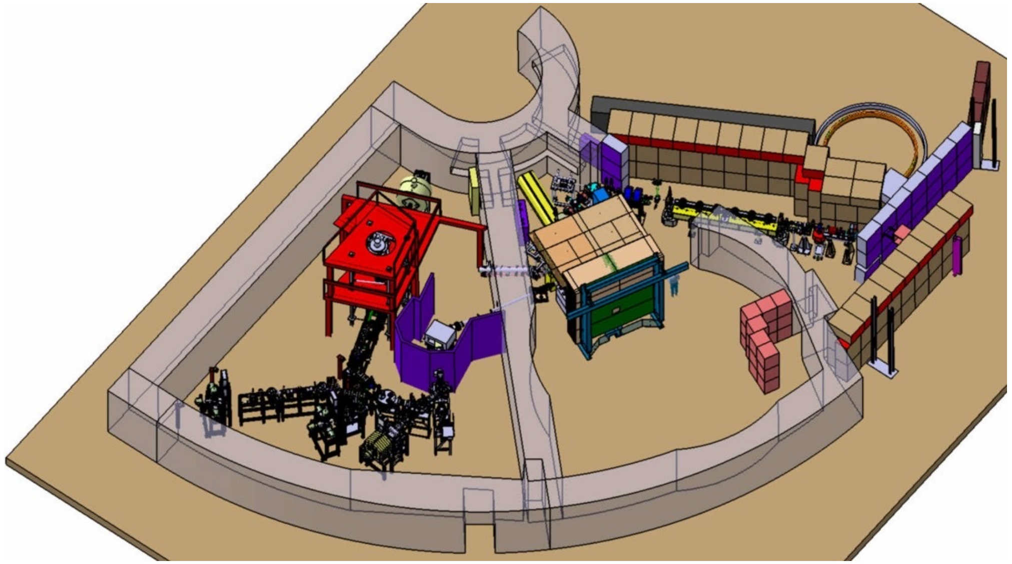


$$\Delta L = 0 \quad \Delta J = 0,1$$

- Better results for integrated properties in N = 50 region
- No overestimation of the population of levels under S_n

Statistical and Non Statistical Models for Delayed Neutron Emission : Application to nuclei near A=90 Z.M. De Oliveira (1980)

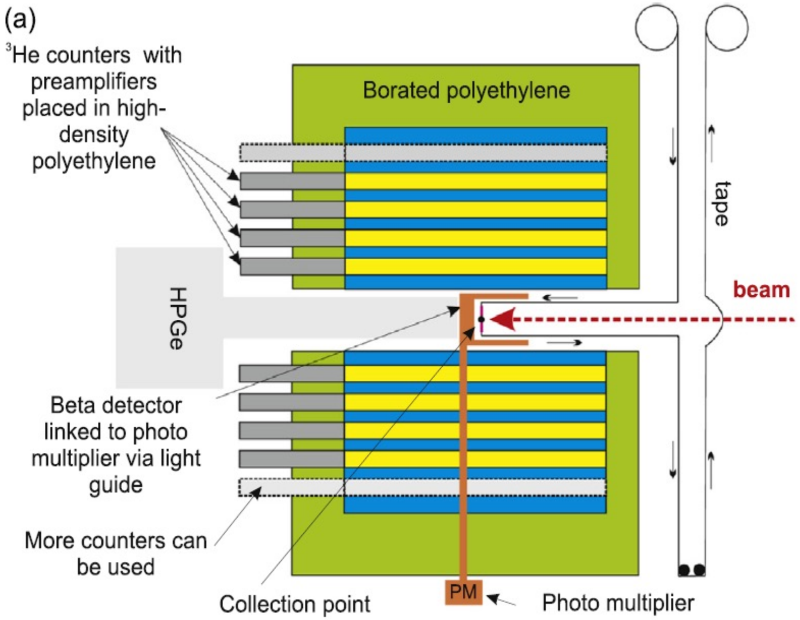
ALTO - LEB

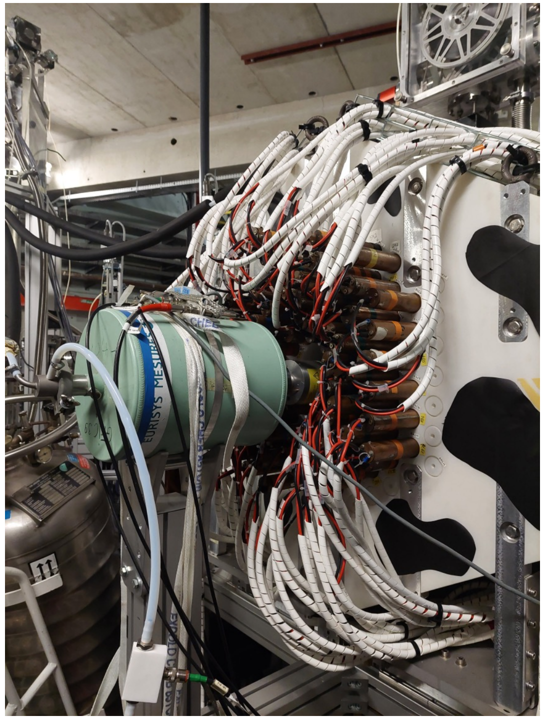


Beam production using ISOL technique

- Photofission
- Laser ionization
- Mass separation

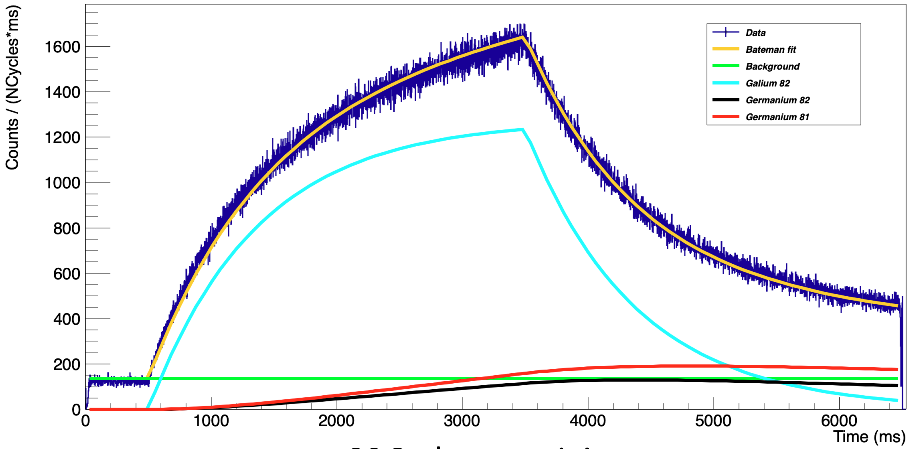
Neutron counter : TETRA



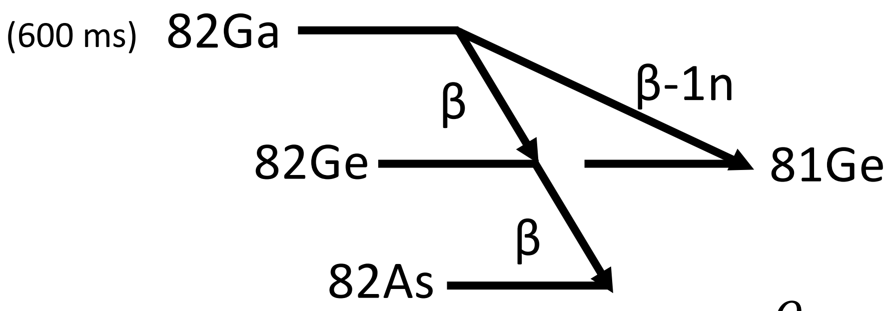


$$^{3}\mathrm{He} + \mathrm{n} \rightarrow \ ^{3}\mathrm{H} + \mathrm{p} + 765\ \mathrm{keV}$$

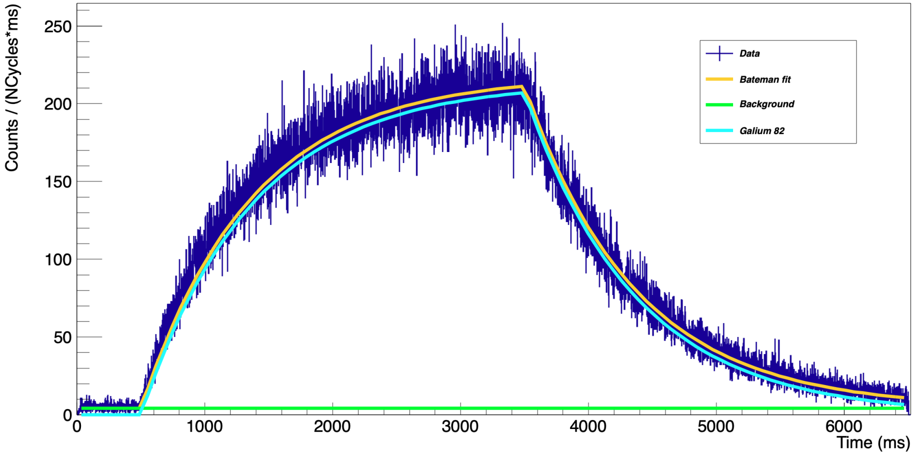
Around 5400 barns at thermal energies



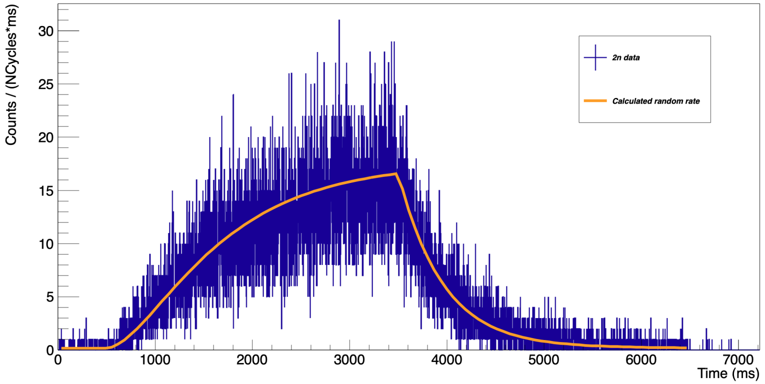
82Ga beta activity



$$Q_{\beta-1n} = 5.290\ MeV$$
$$Q_{\beta-2n} < 0\ MeV$$



82Ga neutron activity

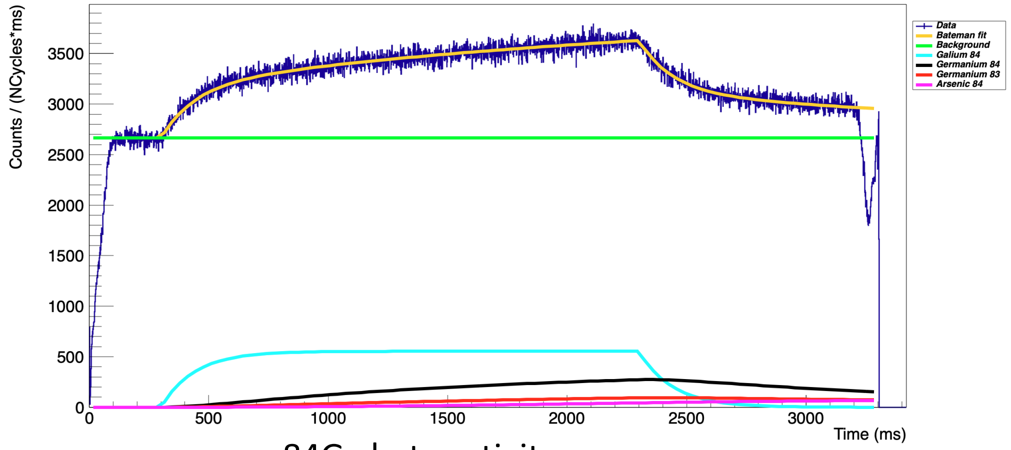


82Ga 2-neutron activity

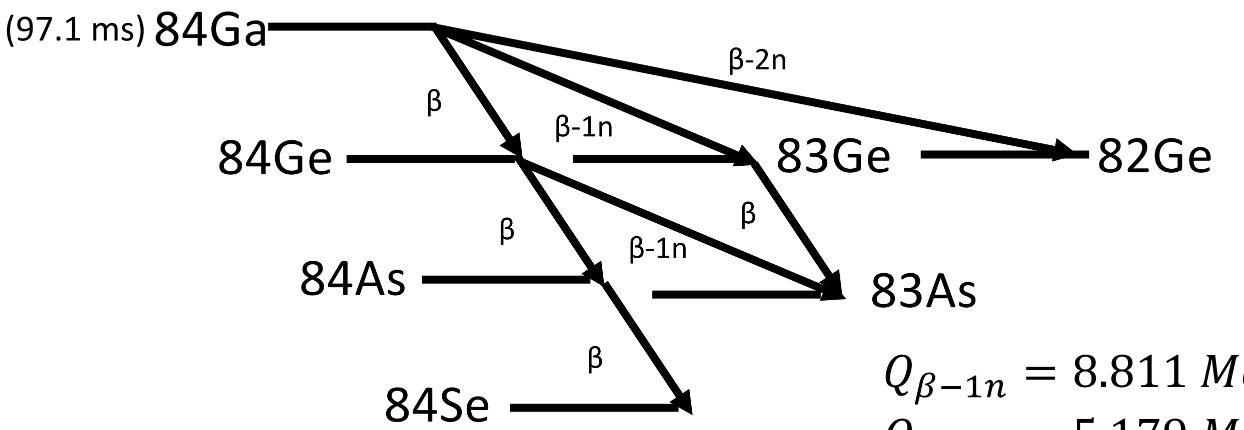
$$P_n = \frac{N_n}{N_\beta} \times \frac{\varepsilon_\beta}{\varepsilon_n} = 22.6\%$$

-> Only random 2n counting

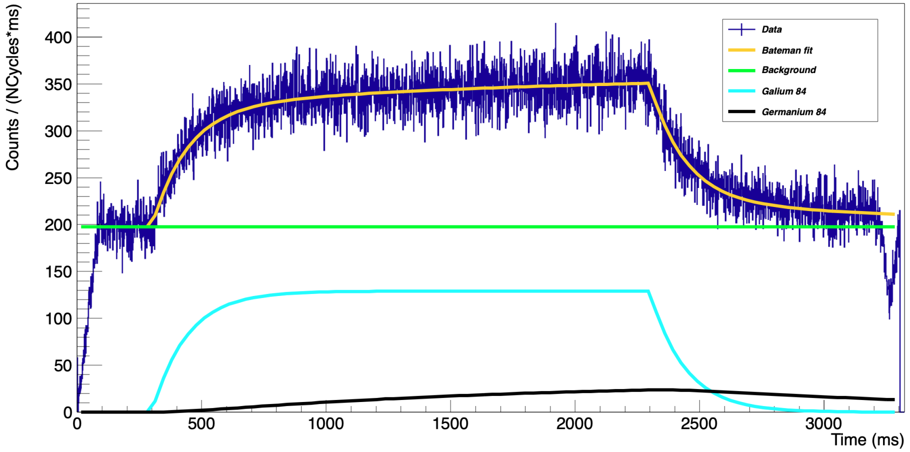
84Ga data analysis



84Ga beta activity

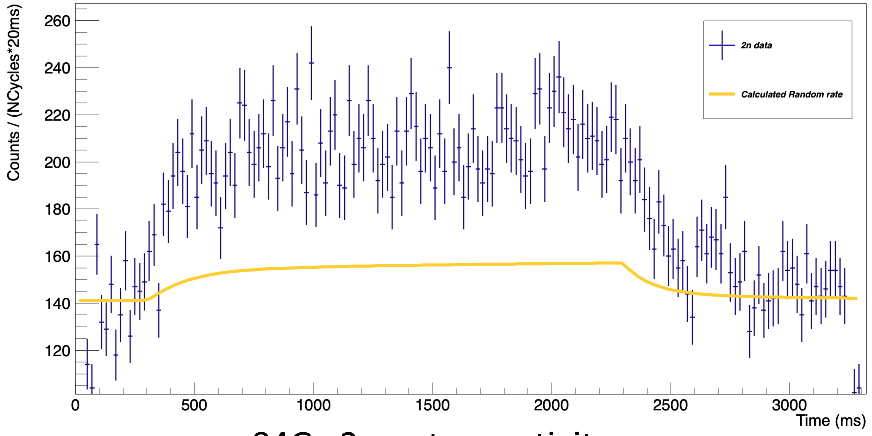


$$Q_{\beta-1n} = 8.811\ MeV$$
$$Q_{\beta-2n} = 5.179\ MeV$$



84Ga neutron activity

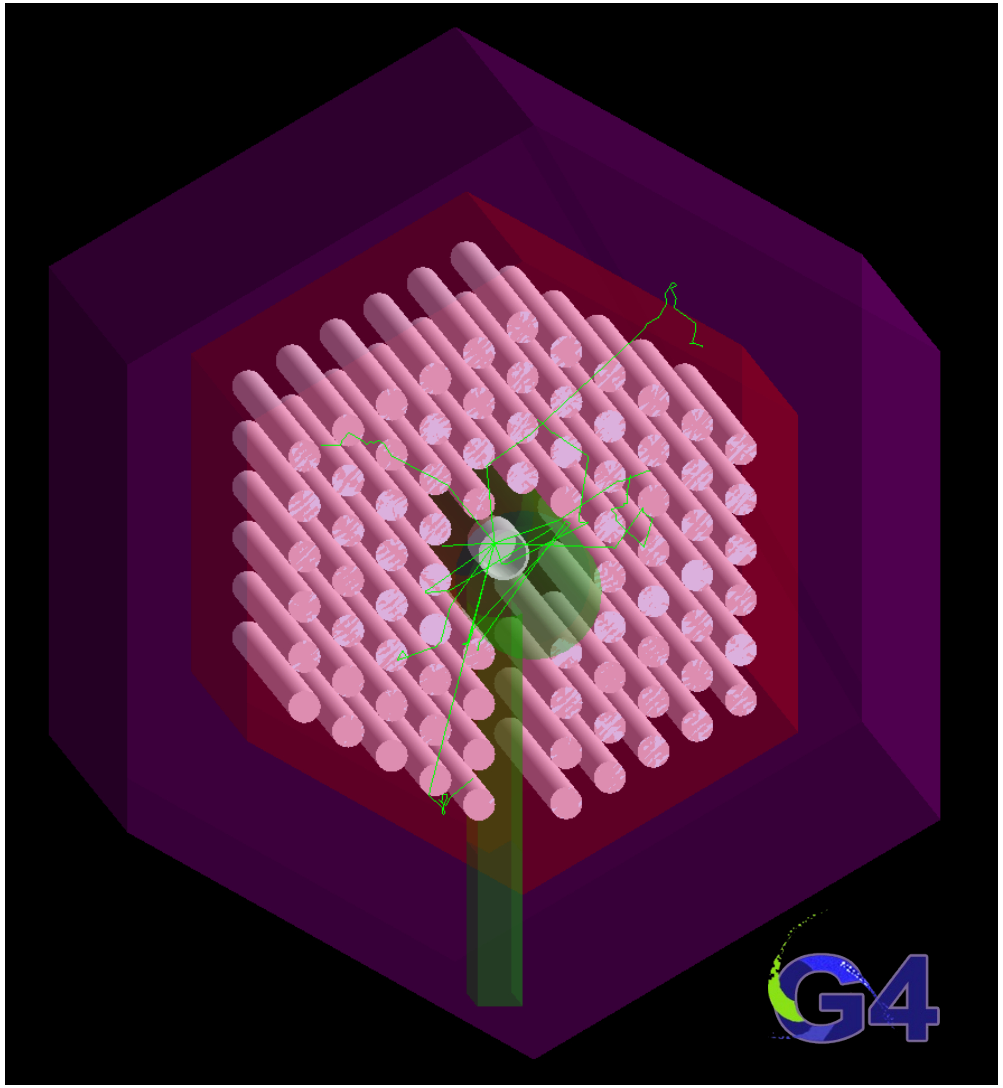
$$< n >^{*} = P_{1n} + (1 + \varepsilon_n)P_{2n} = 37.5\ \%$$



84Ga 2-neutron activity

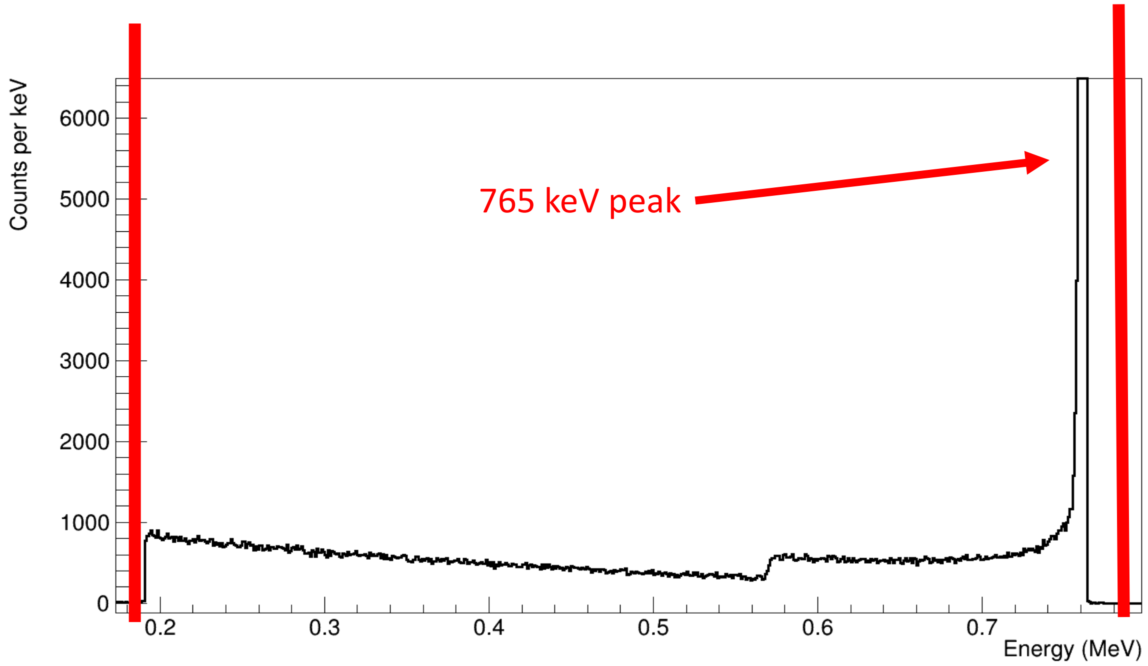
$$P_{2n} = \frac{\varepsilon_\beta}{\varepsilon_n^2} \times \frac{N_{2n}}{N_\beta} = 1.2\ \%$$

Geant4 TETRA simulation



High energy threshold : Sparks, alphas, neutrons

Low energy threshold: gamma pile-up, noise



Energy deposition in tetra cells

Low energy tail ➡ Events were the secondary particles left the cell before depositing all their energy

*Thermal neutrons physics list included

Different energy distributions

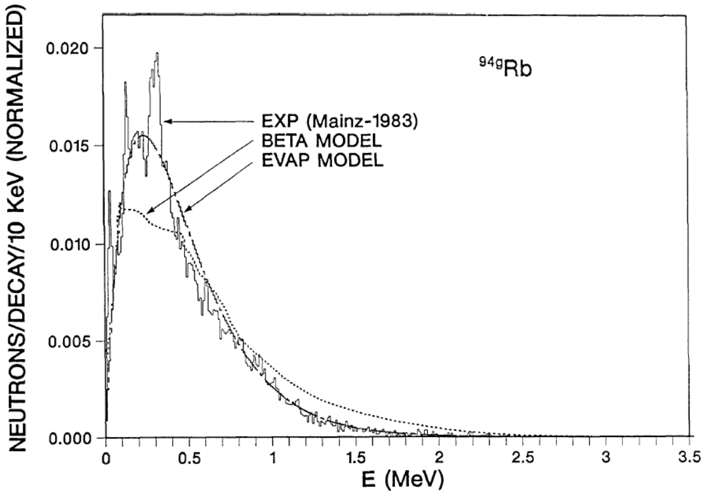


Fig. 58. Comparison of spectra for ^{94}Rb.

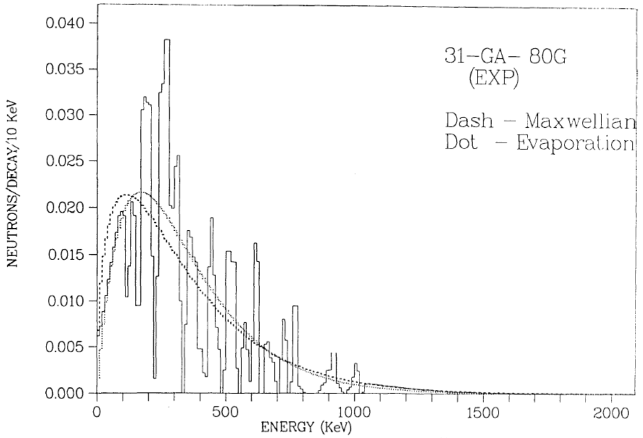


Fig. 47. Comparison of model spectra for ^{80}Ga.

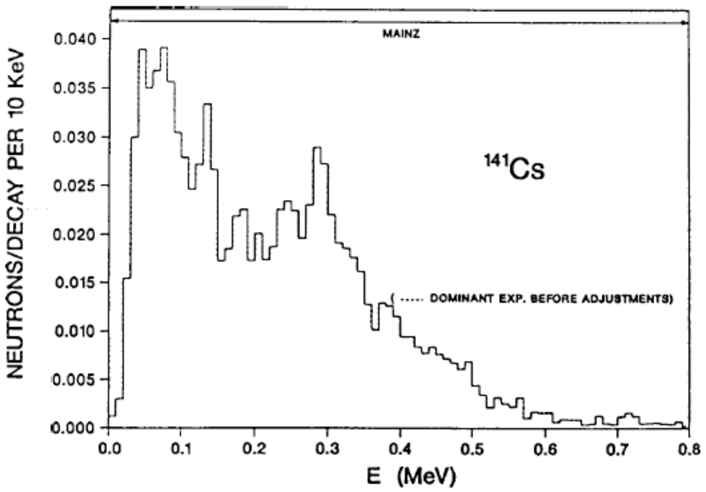
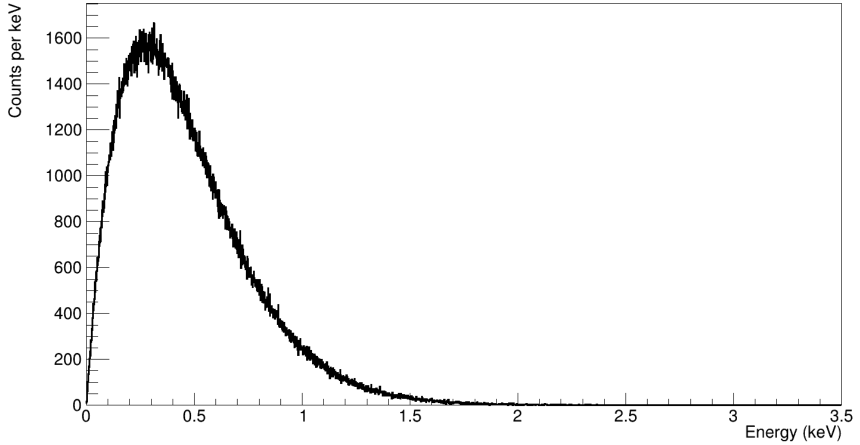


Fig. 39. Normalized delayed neutron spectra for ^{141}Cs.

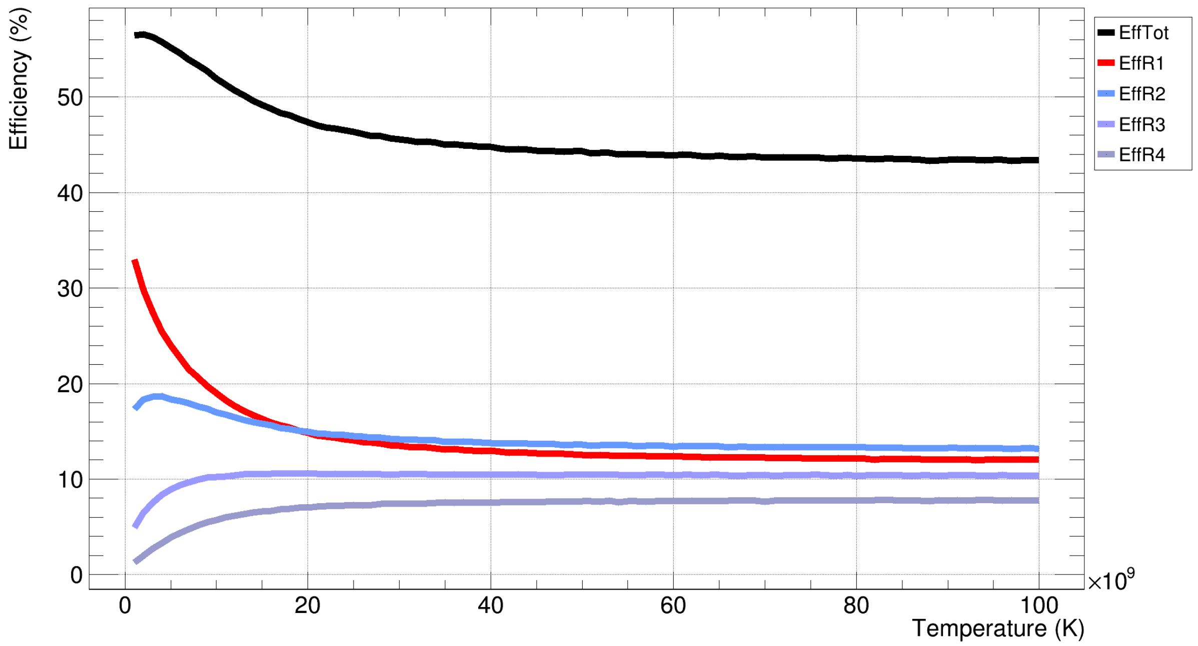
« Evaluation and Application of Delayed Neutron Precursor Data » Michaele Clarice Brady



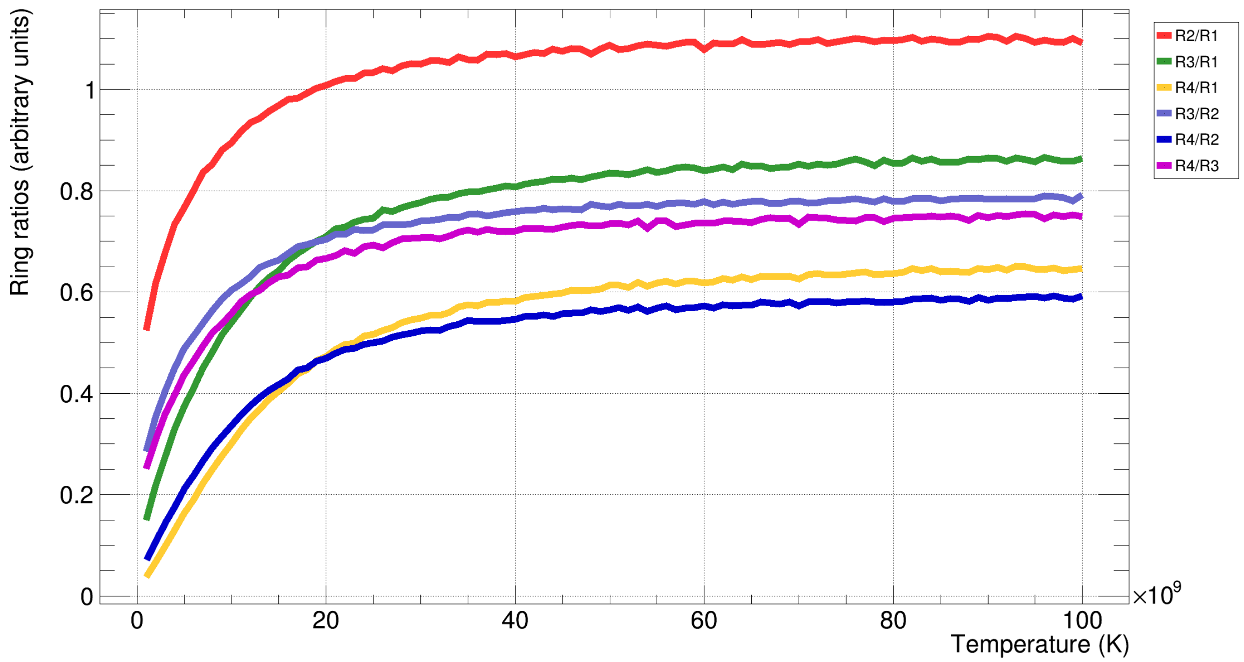
Maxwellian approximation -> Parameter : Temperature

**S.-T. Park, "Neutron Energy Spectra of 252 Cf, Am-Be source and of the D(d,n)3 He Reaction,"*

TETRA efficiency per ring



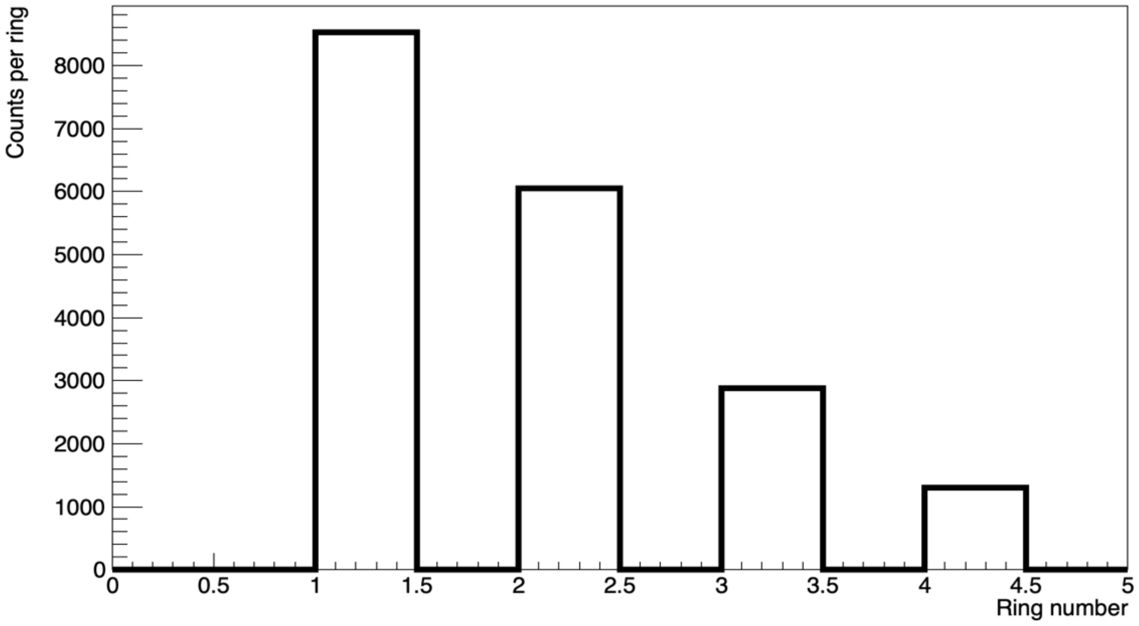
Efficiency as function of Maxwellian temperature parameter



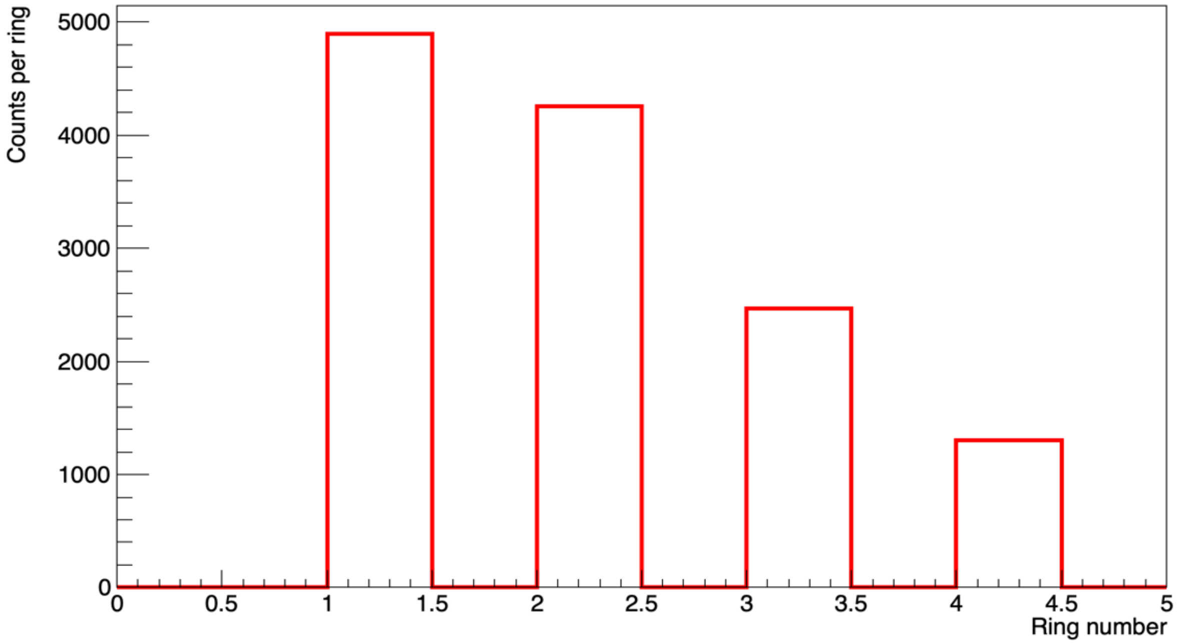
Ring ratios as function of Maxwellian temperature parameter

- The efficiency per ring changes with the neutron energy
- Can a link between ring efficiency and mean neutron energy be made ?

Different energy distributions



82Ga Ring Ratios



84Ga Ring Ratios

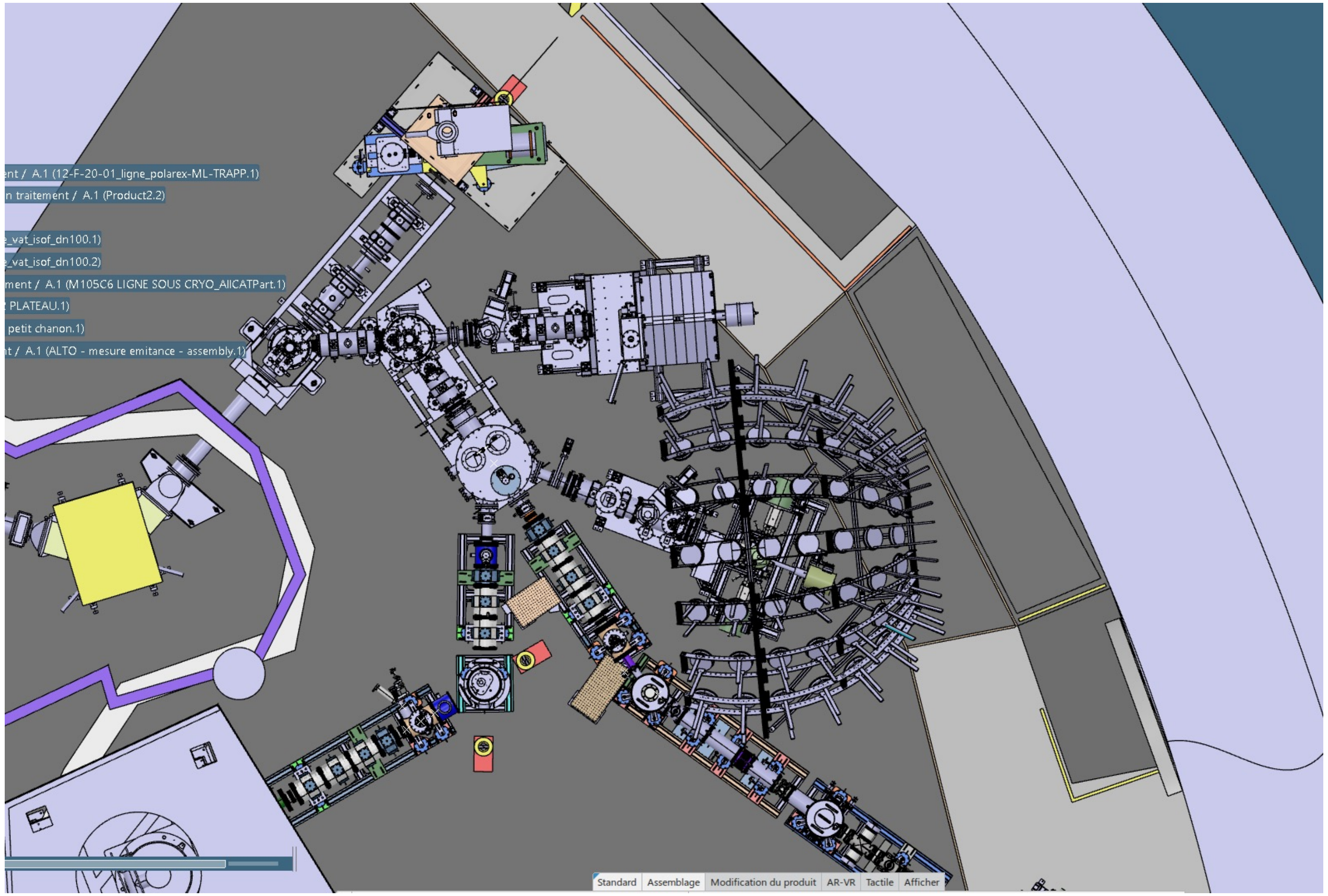
0.93 MeV mean energy

2.1 MeV mean energy

MONSTER @ ALTO

> Structure installation in Juin 2024

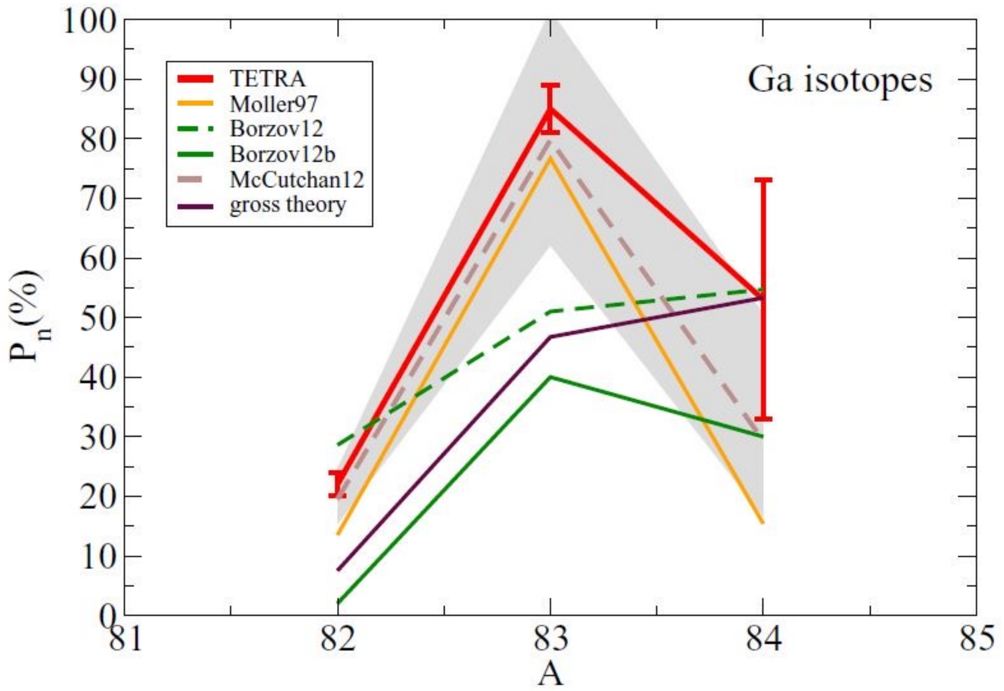
> Experiment MONSTER + BEDO planned in Autumn 2024

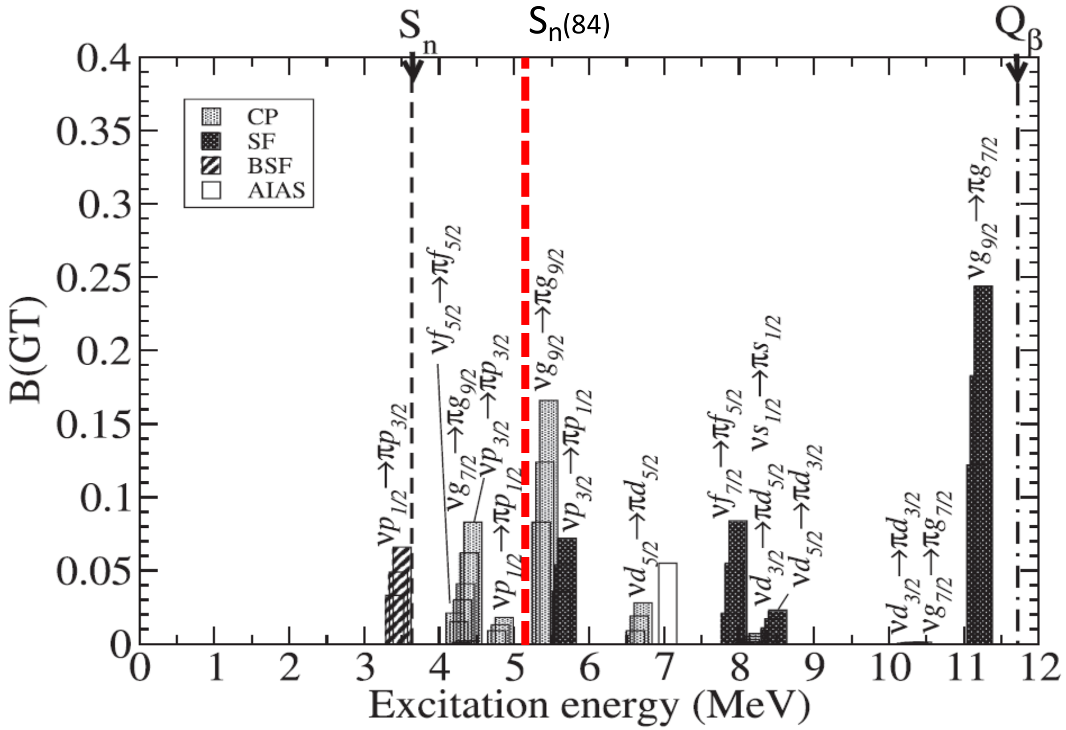


Thank you for your attention

Back up slides

Galium (Z=31) systematics





Verney et al. “Pygmy Gamow-Teller resonance in the N = 50 region: New evidence from staggering of β-delayed neutron-emission probabilities” 2017

Structure revealed