Gamma-ray emission in competition with neutron emission in the β decays of $^{87-91}$Br

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De-excitation of nuclear states populated in β decay with energies exceeding the neutron separation energy (S_n) typically proceeds via neutron emission. However, this is not the only available decay channel. Neutron emission can be hindered by the increasing centrifugal barrier associated with higher angular momenta carried by the emitted neutron; hence, γ-ray emission becomes a viable alternative. The processes by which the nucleus "chooses" between neutron and γ-ray emission are known as neutron-γ competition.

As early as 1972, Slaughter et al. [1] reported evidence of γ-ray emission approximately 80 keV above S_n in the β decay of ^{87}Br. More recent studies have revealed cases where γ-ray emission occurs from states up to 3 MeV above S_n [2]. Typically, neutron-γ competition is discussed in a general sense, where known γ-ray transitions above S_n are compared with the total number of delayed neutrons emitted (P_n). A more precise comparison is only possible when the full decay path of the β-n transition is known, including β-feeding intensities and energies of neutron-emitting intermediate levels in the daughter nuclei.

Modular Total Absorption Spectrometer (MTAS) can detect full decay paths of β-γ and β-n transitions. MTAS consists of 19 NaI(Tl) hexagonal modules, each 21" long and 6.93" wide (side-to-side). The total active NaI(Tl) mass is approximately one ton. Its large volume allows for direct neutron measurements through neutron scatterings and captures inside NaI(Tl) crystals. An example of MTAS-derived ^{89}Br β-γ and β-n transitions in competition is presented in the figure below. The left vertical axis corresponds to a histogram of $I_{\beta\gamma}$ / ($I_{\beta\gamma}$ + $I_{\beta n}$) and indicates neutron-γ competition in 200 keV bins above $S_n(^{89}\mathrm{Kr})$ = 4916(3) keV. The right veritcal axis corresponds to squares, which represent MTAS-obtained neutron emission intensities.

Neutron-γ competition in the β decays of $^{87-91}$Br will be discussed. Results will be compared to shell model calculations across the entire accessible energy region.

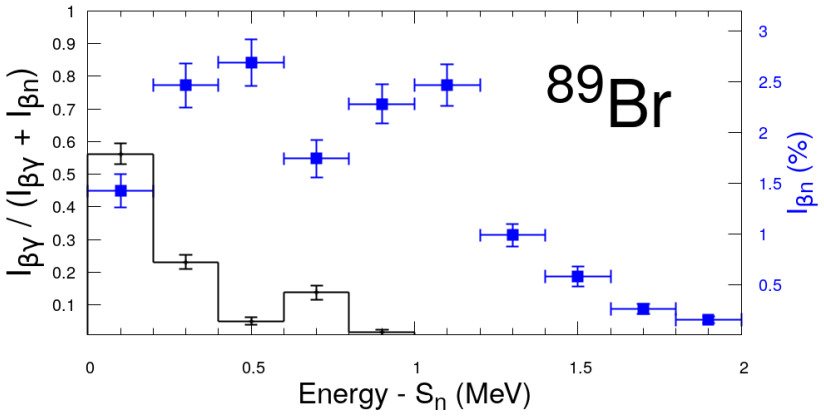

FIG. 1: Competition between neutron and γ-ray emission in the β decay of ^{89}Br. See the text for details.

[1] D. R. Slaughter *et al.*, Phys. Lett. B **38** (1972) 22-24.
[2] V. Vaquero *et al.*, Phys. Rev. Lett. **118** (2017) 202502.