The Temperature Dependence of Electron Captures in Supernovae

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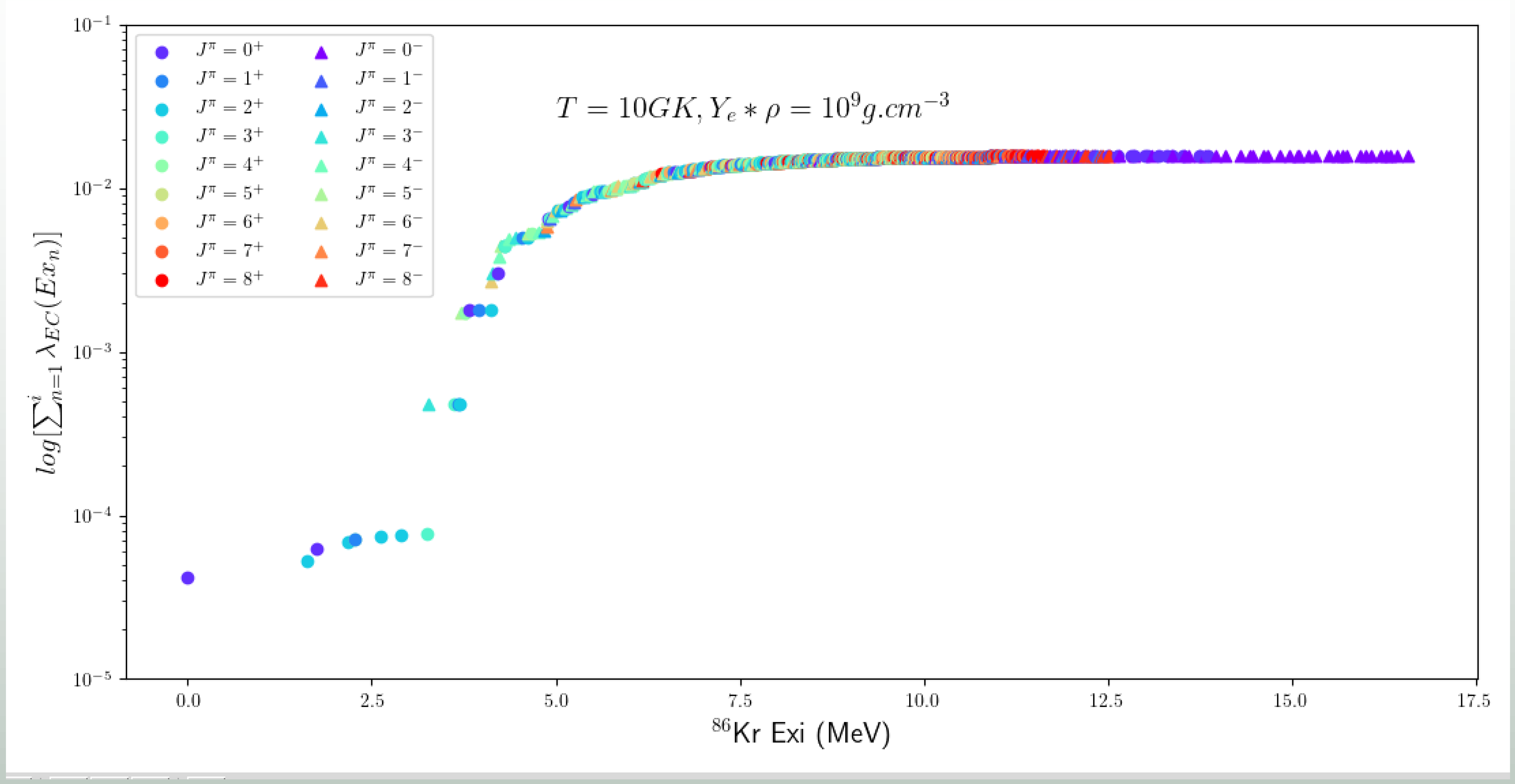
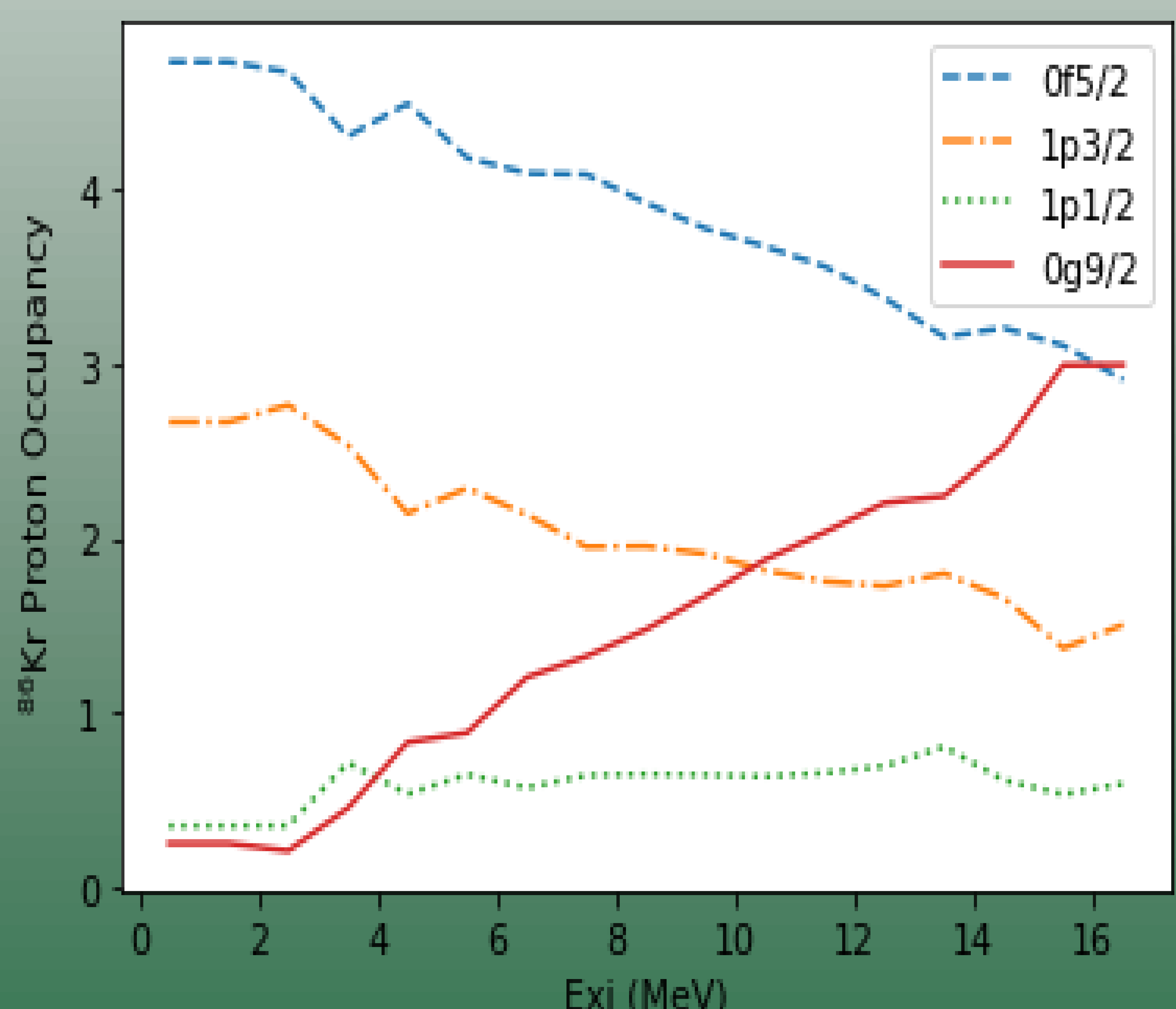
- Electron-capture (EC) play an important role in the late evolution of core-collapse supernovae.
- Because stellar temperatures are high, EC on excited states are important
- Nuclei near N=50 particularly important[1]
- By using shell model calculations for ^{86}Kr, we demonstrate the importance for transitions at high initial excitation energy, driven by the increasing population of protons in the $g_{9/2}$ shell





- Shell-model calculation using NUSHELLX[2], assuming an inert ^{88}Sr core using the jj44pna interaction
- Only Gamow-Teller (GT) transitions from initial states with J^{π}=1-8$^{+/-}$; EC rates calculated with well-established code[3]
- Increasing population of the proton $g_{9/2}$ shell with increasing excitation energy of the mother state in ^{86}Kr results in increased GT strengths and thus enhanced EC rates
- Favorable Q-value conditions (high excitation energy in EC mother, low excitation energy in daughter results in a strong increase in EC rates for certain initial J^{π} states, in spite of unfavorable temperature dependent population

1 . R._Titus et al, Phys. Rev. C 2019; 2.. B.A. Brown ., et al (2004), NSCL Report No. MSUCL-1289-2004; 3. S. Gupta et al. *Astrophys. J. 662, 1188 (2007)*

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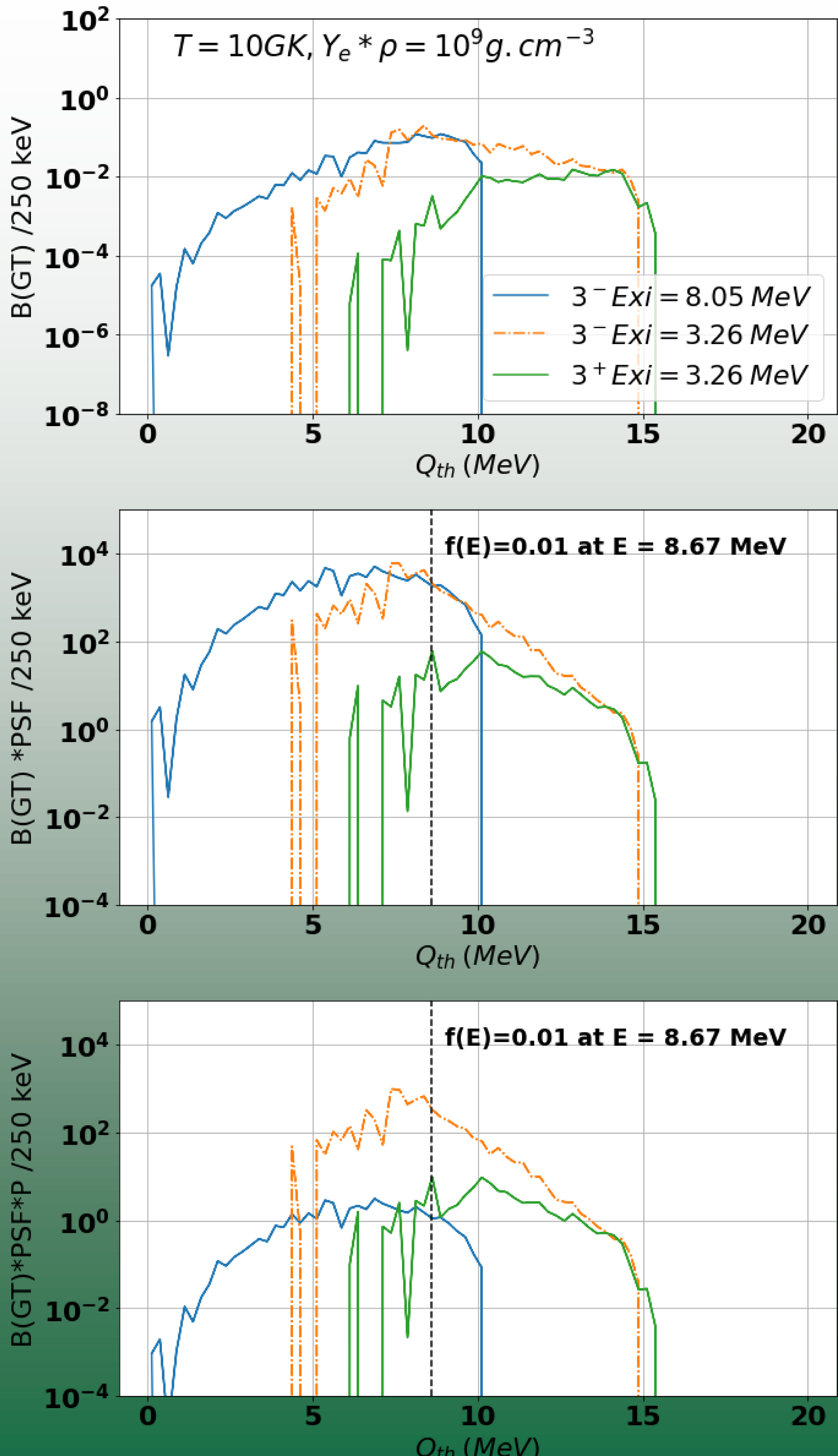
^{86}Kr B(GT) Comparison



$$\lambda_{EC} = \frac{ln(2)}{K} \sum_i \varphi_i \sum_j B_{ij} \Phi_{ij}^{EC}$$

$$\varphi_i = \frac{(2J_i+1)e^{-E_i/(k_b T)}}{\sum_{i=1}^{n} (2J_i+1)e^{-E_i/(k_b T)}} = Population\ Factor$$

B_{ij} = Gamow teller strength

Φ_{ij}^{EC} = Phase Space Factor

$$Q_{threshold} = (Mf + Ex_f - M_i - Ex_i)$$

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Nushell details: ^{86}Kr. The first calculation used NUSHELLX [1 nushell] with jj45 model space for the core and valence structure and jj45a residual interactions which describes the assumed single-particle energies (SPE) and the two-body matrix elements (TBME) [2]

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