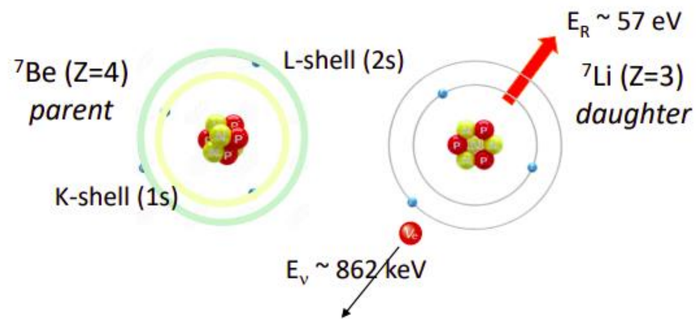
Estimation of the Electron Shaking Probability of Low-Energy ^{7}Be Decay Spectra in Superconducting Quantum Sensors for the BeEST Sterile Neutrino Experiment

S. Nuñez[1†], G.B. Kim[2], K. G. Leach[3] for the BeEST Collaboration

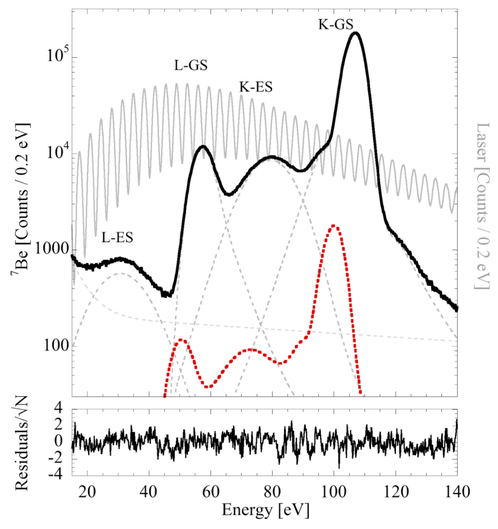
[1]Facultad de Ciencias, Universidad Nacional de Ingeniería, av. Tupac Amaru s/n, Lima, Rímac 15333, Perú
[2]Nuclear and Chemical Sciences Division, Lawrence Livermore National Laboratory, Livermore, CA 94550, USA
[3]Department of Physics, Colorado School of Mines, Golden, CO, 80401, USA

†snunezs@uni.pe

Neutrinos Studies with the EC decay of ^{7}Be



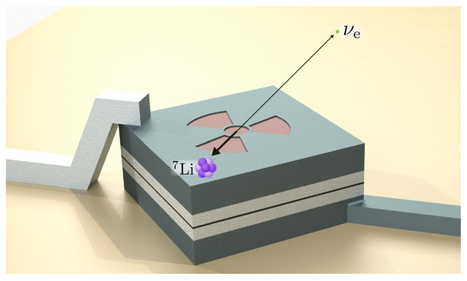
$$T_d = \frac{Q_{EC}^2 - m_\nu^2 c^4}{2(Q_{EC} + m_d c^2)}$$

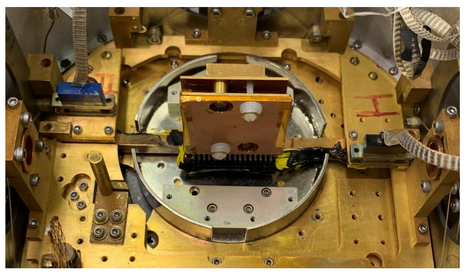


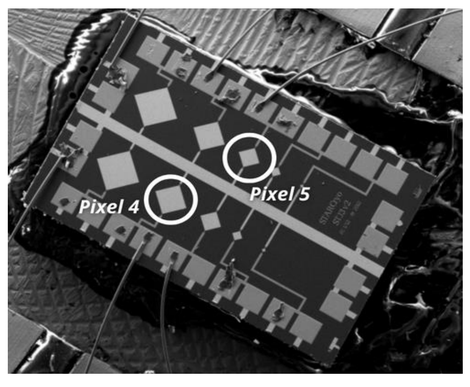
Electron Shaking Effect

- Phenomenon of purely physical origin → Useful for studying systematic errors.
- e^- excited to a new orbital or continuum caused by a sudden change in the central potential of the atom:
  - Alpha or beta decay
  - Electronic capture
  - Photoionization
  - Auger process.
- Previous work: between 1.2% and 31.5%.

The BeEST Experiment

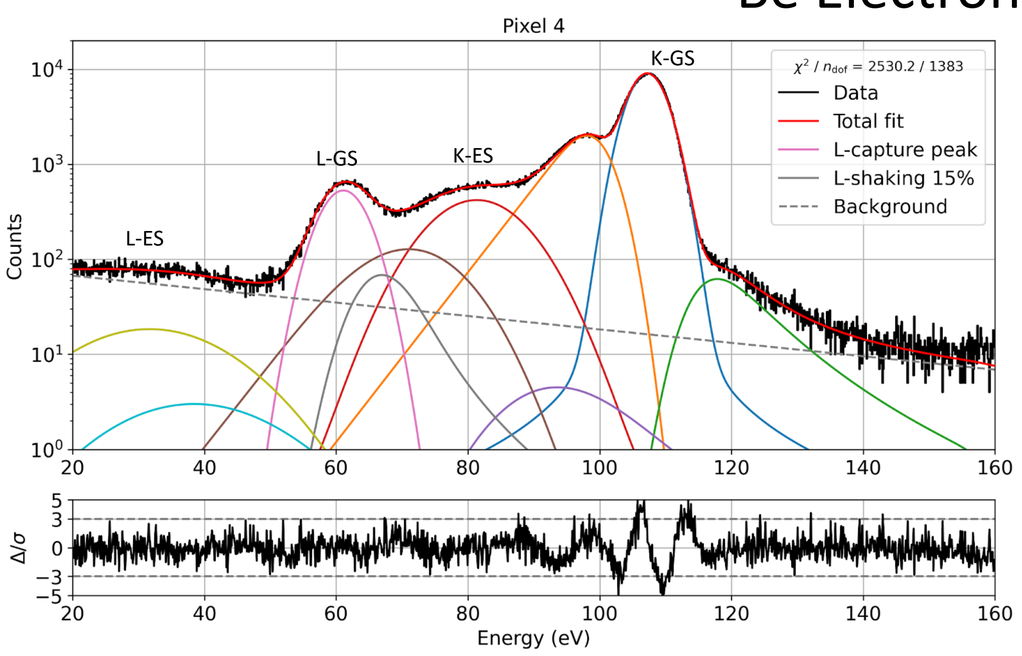


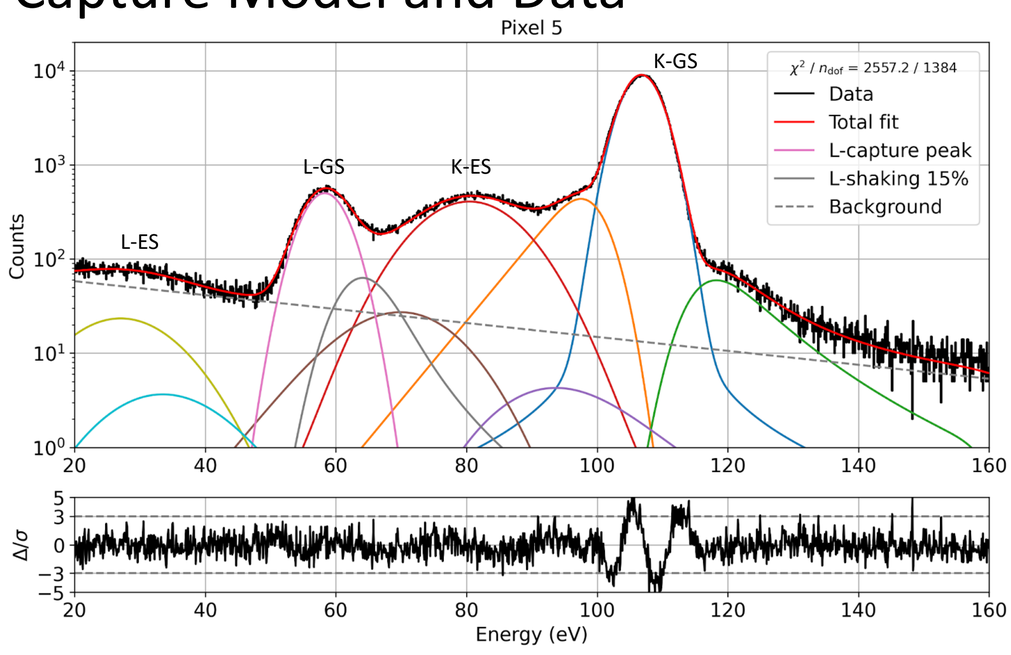




- EC nuclear decay offers a model-independent way to study neutrinos.
- BeEST studies the decay-momentum reconstruction of ^{7}Be→^{7}Li EC decay into STJ radiation detectors to search for keV sterile neutrinos.
- 7Be+ ion were implanted in Ta based superconducting Tunnel Junctions (STJs) at TRIUMF
- Measurements at Lawrence Livermore National Laboratory
- Cooled to 100 mK in an adiabatic demagnetization refrigerator (ADR).
- 10 pixels. This work was done over pixels 4 and 5.

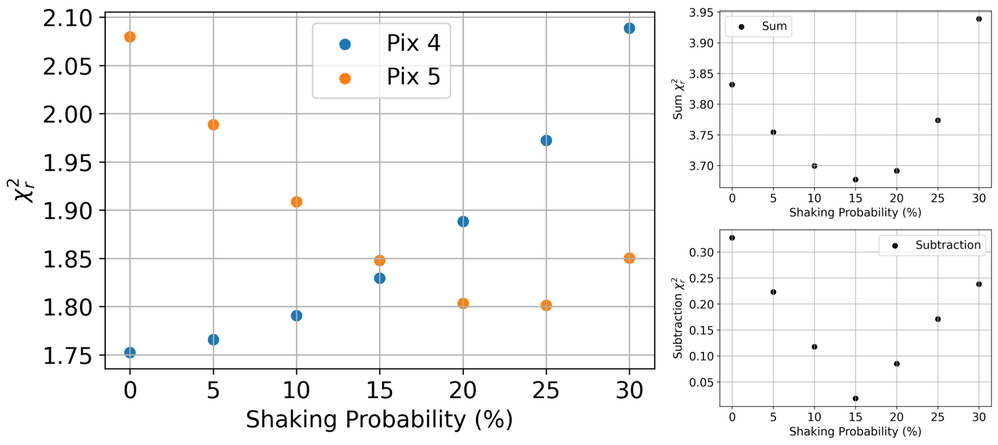
^{7}Be Electron Capture Model and Data





- K/L: K/L capture peak
- GS/ES: Ground/Excited state

A 15% of ESE gives consistency to our data



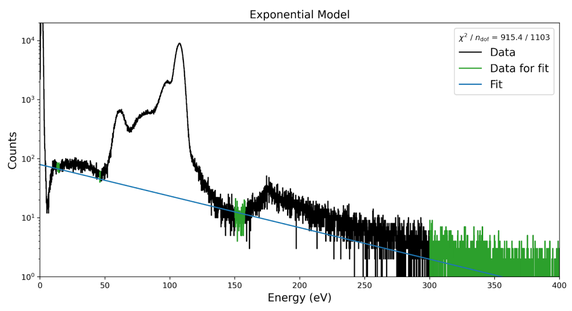
Model considerations:

- Background: Exponential function.
- K/L Peaks: Gaussian functions.
- Auger e^-: Complementary error and exponential functions.
- Shaking effect: Sign and exponential functions.

$$ESE = \frac{N(shaking\ events)}{N(total\ events\ in\ L-GS\ peak)}$$

Fitting considerations:

- Runned using iMinuit.
- Background pre-fitted in regions with dominance.



Conclusions

- A 15% of ESE gives consistency into both pixels and goes according to prior BeEST works (between 1.2% and 31.5%) [1].
- Poor K-GS fitting generates high χ^2_ν. In contrast, L-GS fitting area have a better fitting (<3 standard deviations).
- There is a high variation of the K-ES Auger e^- peak between pixels. This needs to be further study.
- BeEST Phase-III in underway and this results have been considering for the next analysis..

[1] S. Fretwell et al., Phys. Rev. Lett. 125, 032701 (2020)
[2] S. Friedrich et al., Phys. Rev. Lett. 126, 021803 (2021)
[3] BeEST's articles: https://beest.mines.edu/publications-talks-theses/
[4] R. Adhikari et al., JCAP01 (2017)025

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