Background Modeling of AMoRE-I

Poster Session 2 /414

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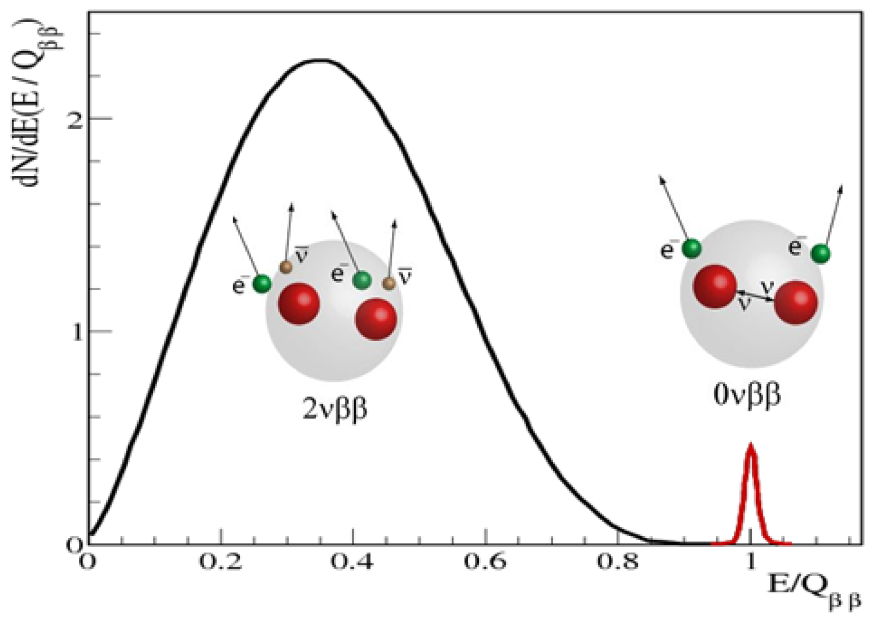
Motivation

- Understanding the background is crucial in neutrinoless double-beta decay (0νββ) search

Introduction

2νββ

- Allowed in the Standard Model
- Only in even-even nuclei
- ΔL = 0 (lepton number conservation)

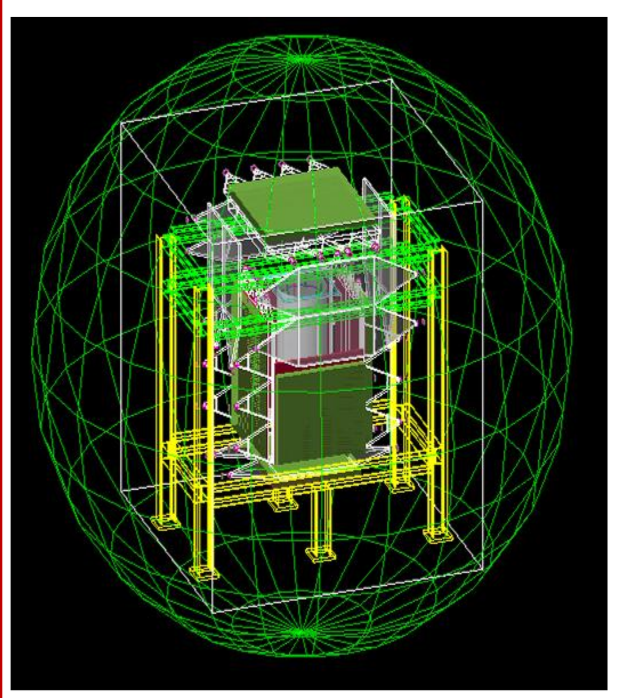


0νββ

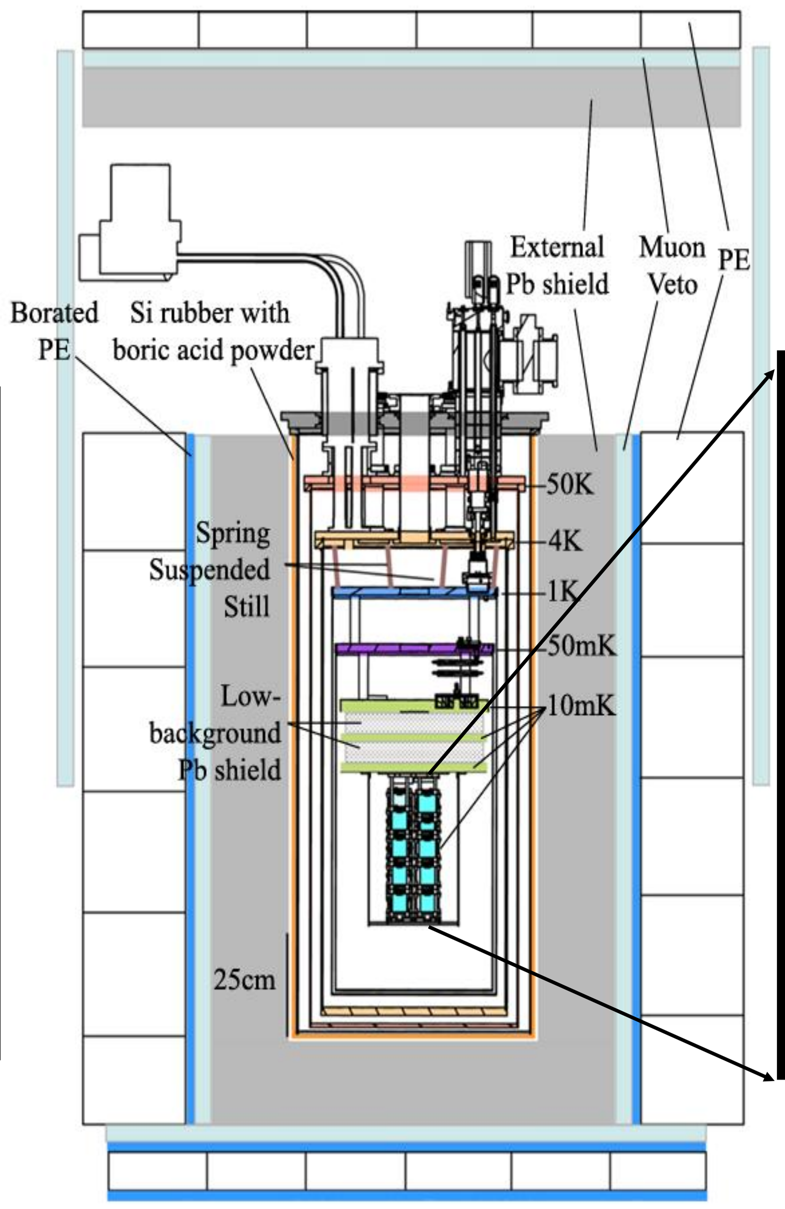
- Beyond the Standard Model
- Δ L = 2
- No experimental evidence observed so far

AMoRE-I

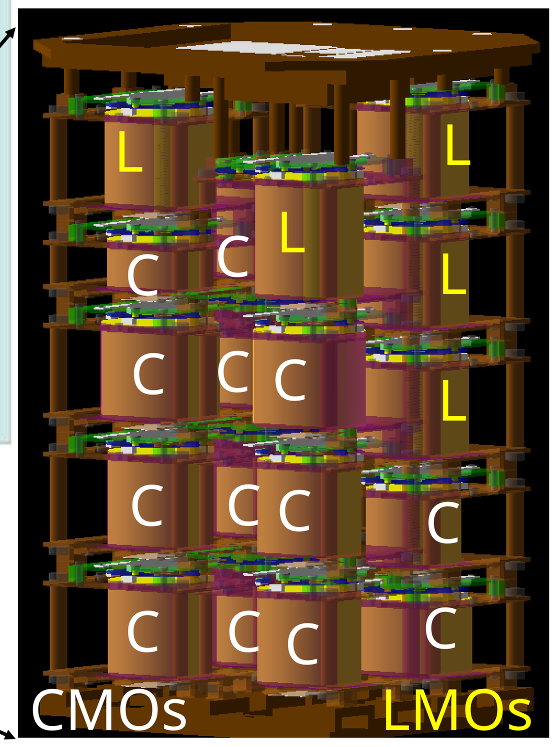
- 13 $^{40}CaMoO_4$ (CMO) and 5 Li_2MoO_4 (LMO) crystals
- Yangyang Underground Laboratory, depth of 700 m, during 2020-2023
- Background at ROI (Region of Interest) ~0.025 counts/keV/kg/yr[ckky]
- $T_{\frac{1}{2}}^{0\nu} > 2.9\times 10^{24}$ yrs (90% CL)[1]
- ^{100}Mo Target with Q-value: 3.034 MeV, high natural abundance (~9.7%)
- 6.2 (3.0) kg of CMO & LMO (^{100}Mo)
- Simultaneous measurement of phonon and scintillation light at ~12 mK



Externals



Shielding & Detector Setup



Detector Tower

Background Sources

Background Components	Sources	Activities
Internal	Bulk	Based on Measured Alpha Spectrum
	Surface	Based on Alpha Modeling
2νββ		$T_{\frac{1}{2}}^{2\nu\beta\beta}$ (7.12×10^{18} yr)[2]
Near components		^{238}U/^{232}Th [mBq/kg]
	Vikuiti Reflector[3]	0.6/<0.6[3]
	NOSV Copper	<0.016/<0.025[3]
	Heater	<2/<2[4]
Neutron		Different flux depending on energy[5]
Far Components	Boric Acid Rubber	^{40}K/^{228}Th/^{226}Ra [mBq/kg]: <9.2/<1.6/14.2[6]
	Air Radon	RRS ON/OFF [Bq/m^3]: 5/35
	Superconducting Shield	^{40}K/^{238}U/^{232}Th [mBq/kg]: <8/<3.5/4
	Outer Vacuum Chamber	^{40}K/^{238}U/^{232}Th/^{60}Co [mBq/kg]: 2.2/0.62/0.82/2.1
Rock		^{40}K/^{238}U/^{232}Th [Bq/kg]: 1418/52/64.2

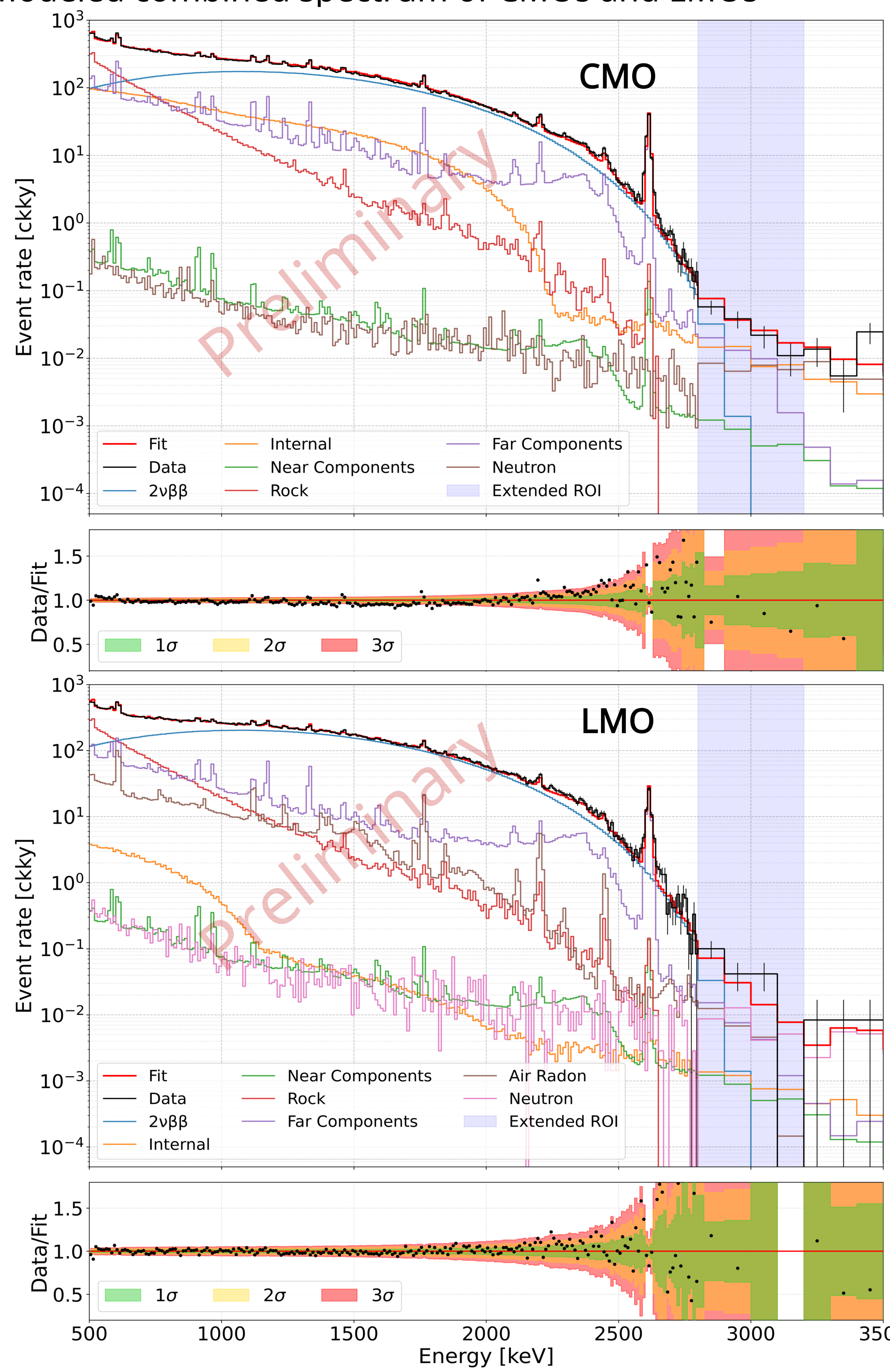
Measurement values in the table are used to normalize the simulation spectrum and serve as prior values in the modeling.

Simulation

- Implemented GEANT4 simulations
- Simulated the entire decay chain of ^{232}Th, ^{238}U, ^{235}U, ^{40}K for major background sources
- Assigned distinct activity rates to non-equilibrium segments
- Detector resolution effect applied using AMoRE-I data.
- **Event selection:** Only single-hit beta-gamma events(events depositing energy in a single crystal) were selected for this modeling
- Events within 30 minutes of ^{212}Bi alpha decay (6207±50 keV) can be classified as alpha-tagged and rejected with 98% efficiency
- **Alpha Modeling:** Simulated ^{232}Th, ^{238}U, ^{235}U on surface of crystal and nearby materials with different depths
- Fitted measured alpha spectrum with simulated surface spectra

Results & Summary

Modeled combined spectrum of CMOs and LMOs



- The current background model provides an initial qualitative framework
- Preliminary results indicate that, around ROI, both internal and external sources contribute to the background in CMO, whereas external events are the leading contributor in LMO crystals
- We plan to perform a simultaneous fit of single-hit, double-hit (beta/gamma), and alpha spectra

References: [1] A. Agrawal et al., Phys. Rev. Lett. 134, 082501 (2025)
[2] E. Armengaud et al. Eur. Phys. J. C 80:674 (2020)
[3] A. Agrawal et al., Astropart. Phys. 162 102991 (2024)
[4] A. Agrawal et al., Front. Phys. 12:1362209 (2024)
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