Study of cosmogenic background in JUNO Te-LS

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[1] JUNO physics and detector, JUNO Collaboration Prog.Part.Nucl.Phys. 123 (2022), 103927
[2] Neutrinoless Double-Beta Decay: a Probe of Physics Beyond the Standard Model, Int.J.Mod.Phys.A 30 (2015) 04n05, 1530001
[3] Neutrinoless Double-Beta Decay: Status and Prospects, Ann.Rev.Nucl.Part.Sci. 69 (2019), 219-251

JUNO

Jiangmen Underground Neutrino Observatory (JUNO) is a 20-kton liquid scintillator detector. The main physics purpose is to determine the neutrino mass ordering (NMO) [1].

- **High energy resolution $3\%/\sqrt{E}$**
- **17,612 20-inch PMTs and 25,600 3-inch PMTs in CD**
- **~1345 p.e./MeV**

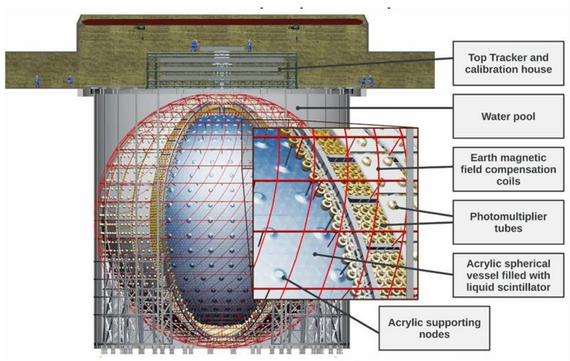


Fig.1 JUNO detector[1]

Neutrinoless Double Beta Decay

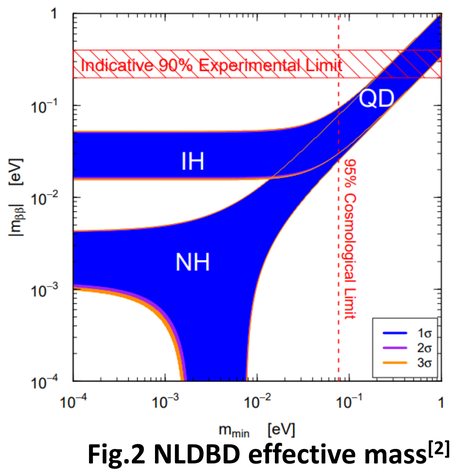


Fig.2 NLDBD effective mass[2]

- **NLDBD is a mechanism beyond the SM.**
- **Absolute mass will be constrained by accurate measurement of the effective mass[2].**
- **This study discusses the potential of JUNO with ^{130}Te.**

Isotope	$T^{0\nu}_{1/2}$ ($\times 10^{25}$ y)	$\langle m_{\beta\beta}\rangle$ (eV)	Experiment
^{48}Ca	$> 5.8 \times 10^{-3}$	$< 3.5 - 22$	ELEGANT-IV
^{76}Ge	> 8.0	$< 0.12 - 0.26$	GERDA
	> 1.9	$< 0.24 - 0.52$	MAJORANA DEMONSTRATOR
^{82}Se	$> 3.6 \times 10^{-2}$	$< 0.89 - 2.43$	NEMO-3
^{96}Zr	$> 9.2 \times 10^{-4}$	$< 7.2 - 19.5$	NEMO-3
^{100}Mo	$> 1.1 \times 10^{-1}$	$< 0.33 - 0.62$	NEMO-3
^{116}Cd	$> 1.0 \times 10^{-2}$	$< 1.4 - 2.5$	NEMO-3
^{128}Te	$> 1.1 \times 10^{-2}$	—	—
^{130}Te	> 1.5	$< 0.11 - 0.52$	CUORE
^{136}Xe	> 10.7	$< 0.061 - 0.165$	KamLAND-Zen
	> 1.8	$< 0.15 - 0.40$	EXO-200
^{150}Nd	$> 2.0 \times 10^{-3}$	$< 1.6 - 5.3$	NEMO-3

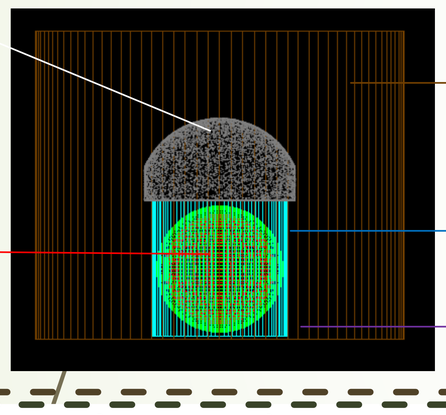
Table 1 Current NLDBD experiment[3]

Detector Simulation

Geometry

Experimental hall (air)
- N: 75.50%
- O: 23.21%
- C: 0.01%
- Ar: 1.28%

TeLS:
- C: 85.16018%
- H: 11.7758%
- O: 0.03298%
- N: 0.02619%
- S: 0.00485%
- Te: 3.0%



Rock
- O: 48.5%
- Si: 34.3%
- Al: 8.0%
- Fe: 2.0%
- Mg: 0.1%
- Ca: 0.2%
- Na: 2.4%
- K: 4.5%

Water (H_2O)

Acrylic:
- C: 59.984%
- H: 8.055%
- O: 31.961%

Physics list

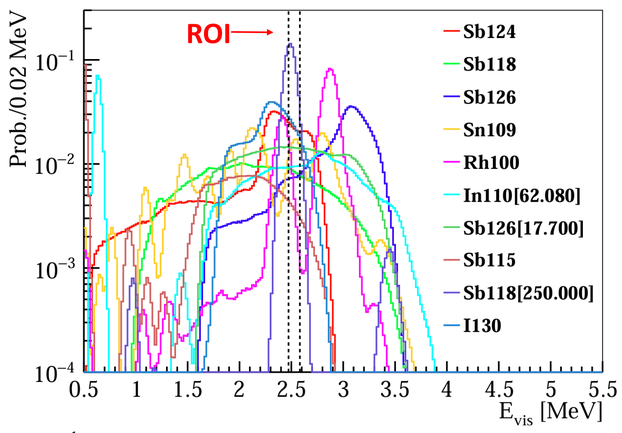
GEANT4 version: 11.0.p03

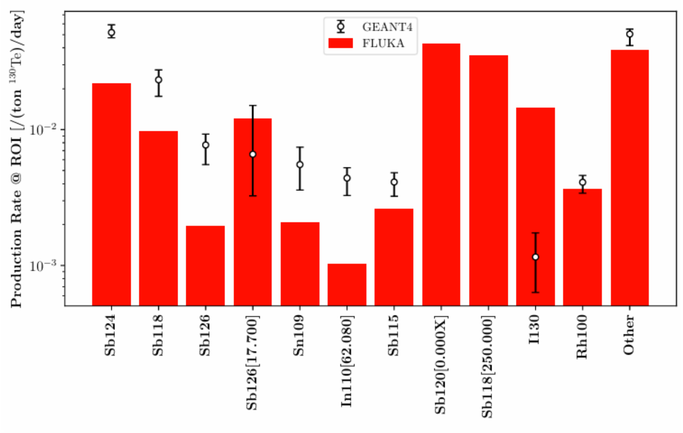
EM process: G4EMLivermorePhysics, G4EmExtraPhysics
Decay process: G4DecayPhysics, G4RadioactiveDecayPhysics
Ion process: G4IonPhysicsPHP
Hadronic (in)elastic process: G4HadronPhysicsQGSP_BERT_HP
G4HadronElasticPhysicsHP

FLUKA version: 4-4.0

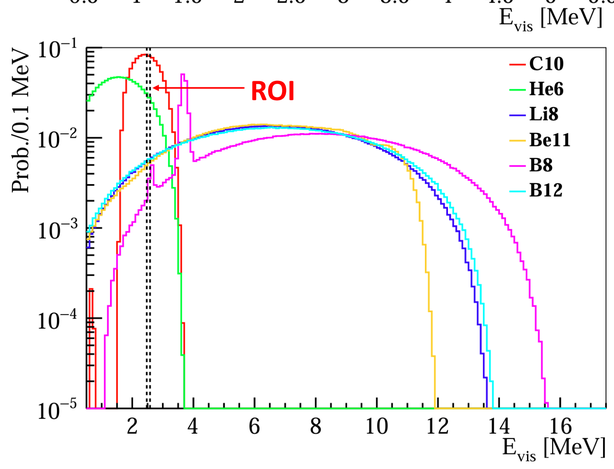
Default: PRECISIOn PHOTONUC
PHYSICS: COALESCE
PHYSICS: EVAPORAT, New evaporation model, with heavy fragment evaporation
RADDECAY: semi-analogue mode with isomer production activated

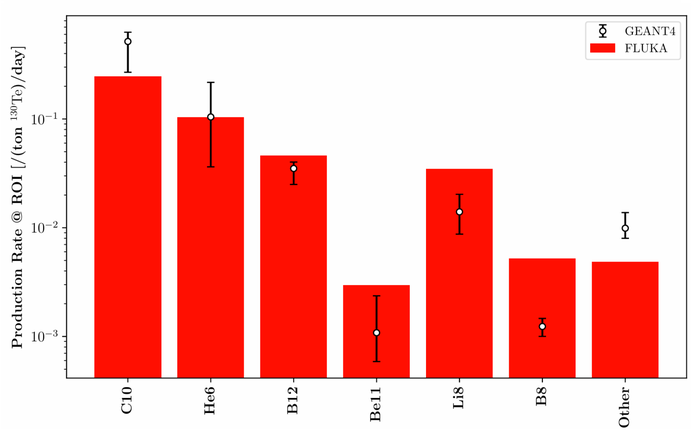
Long-lived





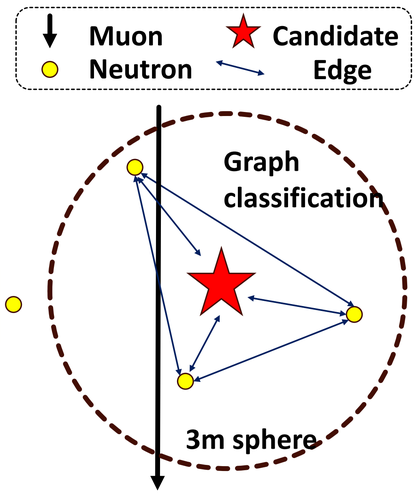
Short-lived





- **Q_{0vbb}= 2.527MeV, ROI = (2.473, 2.582) MeV**
- **Isotopes are divided into two groups long-lived (lifetime > 30s) and short-lived (lifetime < 30s).**
- **Long-live isotopes are mainly from Sb while short-lived are mostly C10.**

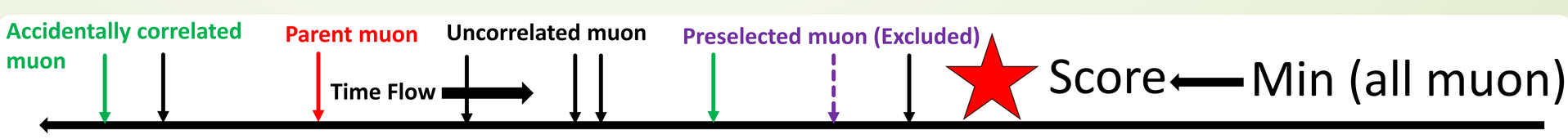
GNN



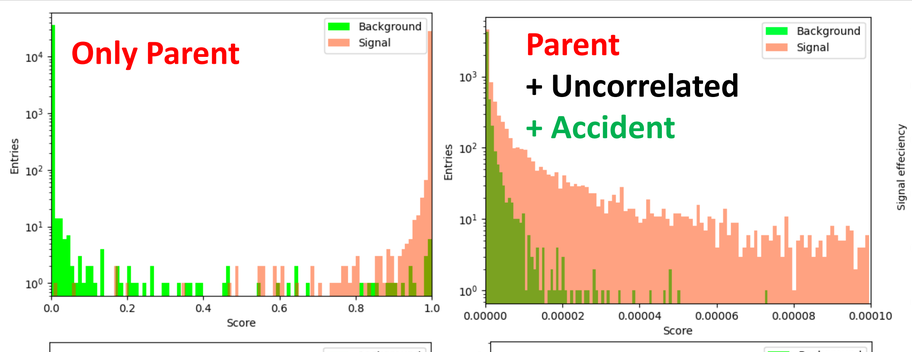
Node feature
- (x, y, z)
- (d, t) to muon
- (E, L, multiplicity) of muon

Edge feature
- Assign no physics quantities to edge
- Only assign edge index

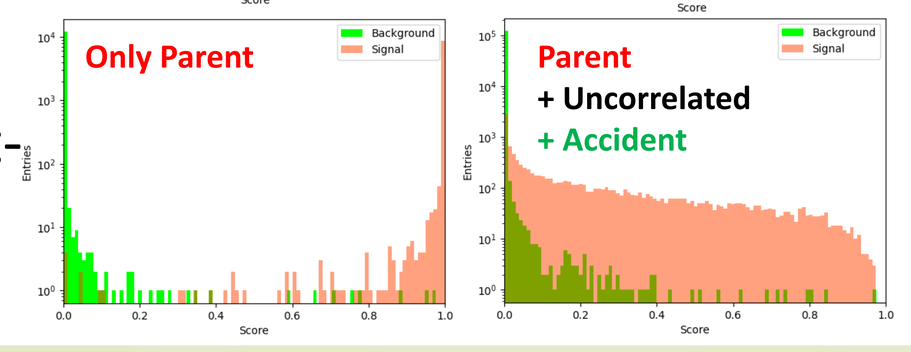
Background rejection



Long-lived



Short-lived



- **Preselected muon**
  - **E_dep = 0 / L_track = 0**
  - **Distance to muon > 10m**
- **Short-lived**
  - **99.9% background rejection with ~50% signal efficiency**
- **Long-lived (~hour)**
  - **Accidentally muons "smear" the signal**
  - **99.9% background rejection with ~20% signal efficiency**
- **Long-lived (~day)**
  - **Still study in progress**