Virtual depth by active background suppression: The cosmic muon induced background of GERDA Phase II

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• non-standard background sources have to be considered in next generation background-free 0νββ searches
  "Only background-free experiments make efficient use of 0νββ searches"
  background index [cts/(keV yr)]

GERDA Phase II 1.0 ± 0.5 × 10^3 [1]
next generation 0 (1 ± 10^-6) [2]

• deep underground in-situ production of radioactive isotopes by cosmic muons generates non-negligible background [3]
  "How deep is deep enough?"

76Ge: ground state decay dominates
1.6% ground state transition is spin suppressed

• 34(56)Ge(76) has been identified as critical cosmogenic component for 0νββ searches with germanium [4]

76Ge production: 2 mm 90% energy deposition cluster radius for pulse shape discrimination (PSD).

2) Cosmic muon induced 77(m)Ge production

• underground muon flux in Hall A of Lxos is obtained by MuSun [6]
• simulation of 1 × 10^10 muons with mean energy of 270 GeV and angular correlation
• 43.4 yr or 1544 kg-yr of GERDA Phase II data

neutron production/propagation in GERDA setup
• cosmic muon induced neutron flux at germanium array is 1.6 m^11/h
  "Only neutrons from inner cryostat volume contribute to the 77(m)Ge production"

• recent measurements [7] show that ENDFB-VII.1 does not include full 77Ge production, increased Monte Carlo cross section is used
• at higher neutron energies 77Ge is favored, equal 1.8 Ge to 77Ge production is assumed
  "Captures appear mainly prompt and at non-thermal neutron energies"

77Ge production rate (0.21 ± 0.01) nuclei/(kg yr)

3) 77(m)Ge rejection by delayed coincidence

• (85 ± 2)% of 77Ge events show prompt coincidences (<10 μs) between muon veto and germanium detectors
• 6 min dead-time leads to ~4% life-time reduction

• (60 ± 7)% of 77(m)Ge events show delayed coincidences
• sequence of prompt and delayed tagging combined with "standard" prompt coincidences rejection

4) Virtual depth by active background suppression

• active suppression can be translated into an effective muon flux reduction for a certain cosmogenic background
• other cosmogenics than 77Ge have only minor contribution
  "The virtual overburden of Gerda Phase II corresponds to about 5000 m.w.e."]
• early stage design considerations open up possibilities for further improvements

77Ge isotope production...