Background model for the nEXO neutrinoless double beta decay experiment

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Introduction

The nEXO neutrinoless double beta decay experiment[1] uses the Geant4 radiation transport simulation toolkit to estimate relative probabilities to produce events due to decay of trace isotopes in detector materials.

This poster presents the simulation geometry and physics listed use to produce the background model, based on the methods used successfully for EXO-200.

Sensitivity goal: $T_{½} \approx 10^{28}$ years in 10 years of operation

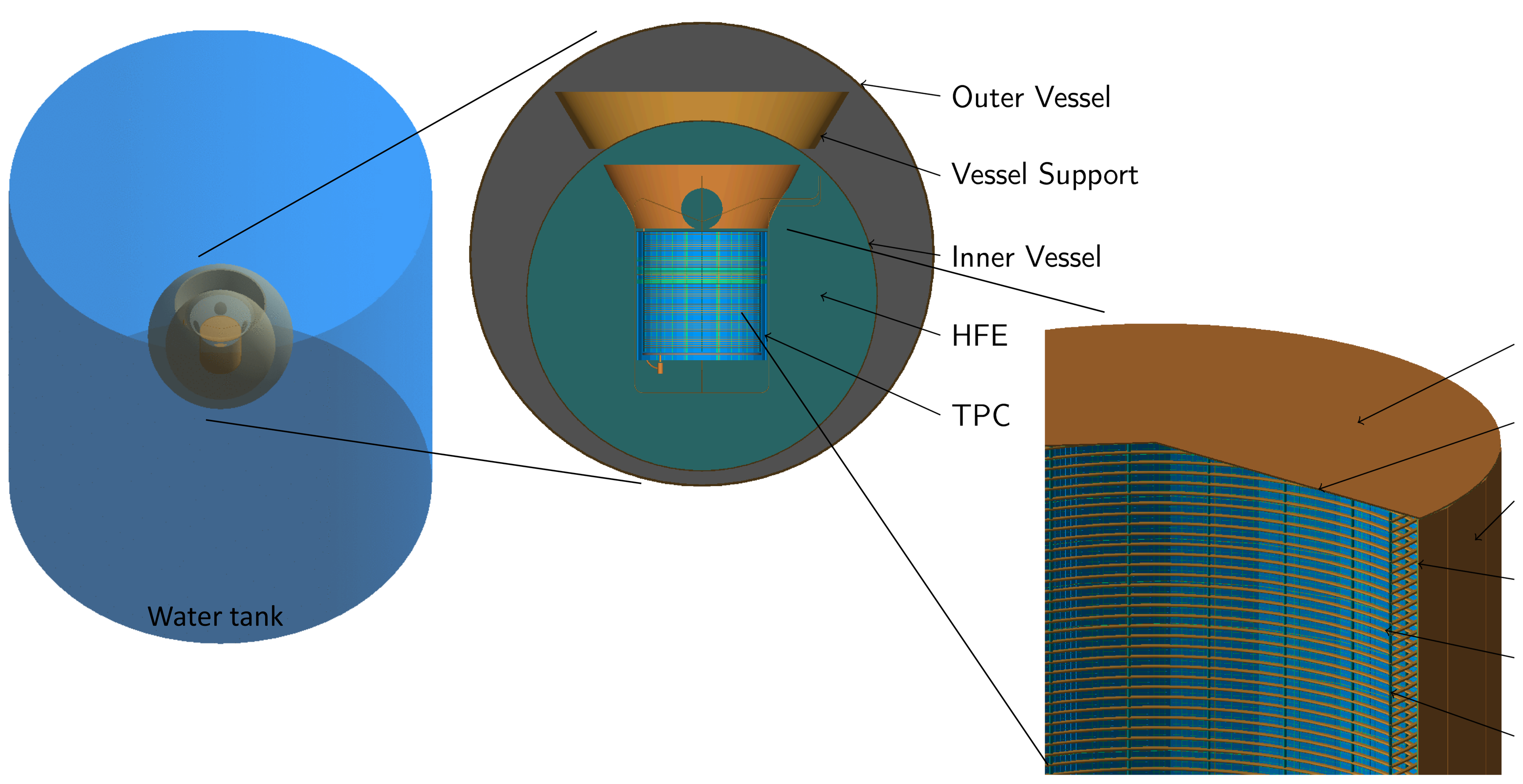
Physics lists

Key physics processes for nEXO background simulation include radioactive decay and interactions of emitted radiation. Processes and energy ranges are list here:

Particle	Process	Energy range
γ	Livermore EM	< 1GeV
e^-, e^+	Urban Multiple Scattering	< 100MeV
	Wentzel-VI Multiple Scattering	> 100MeV
	Coulomb Single Scattering	> 100MeV
e^-	Livermore Ionization	< 100keV
	Livermore Bremsstrahlung	< 1GeV

Simulation Geometry

Simulation geometry includes both large components and fine levels of part details to assess background contributions from detector construction materials.



nEXO presentations at TAUP 2017:

1.	Talk: “nEXO: a tonne-scale next-generation double-beta decay experiment”	13:00 Mon, July 24
2.	Talk: “Progress in Barium tagging at the single atom/ion level for nEXO“	13:15 Mon, July 24
3.	Talk: “Results of nEXO detector development”	14:15 Mon, July 24
4.	Talk: “3D digital SiPM for large area low background experiments”	13:00 Tues, July 25
5.	Poster: “The nEXO radioassay program”	19:00 Tues, July 25

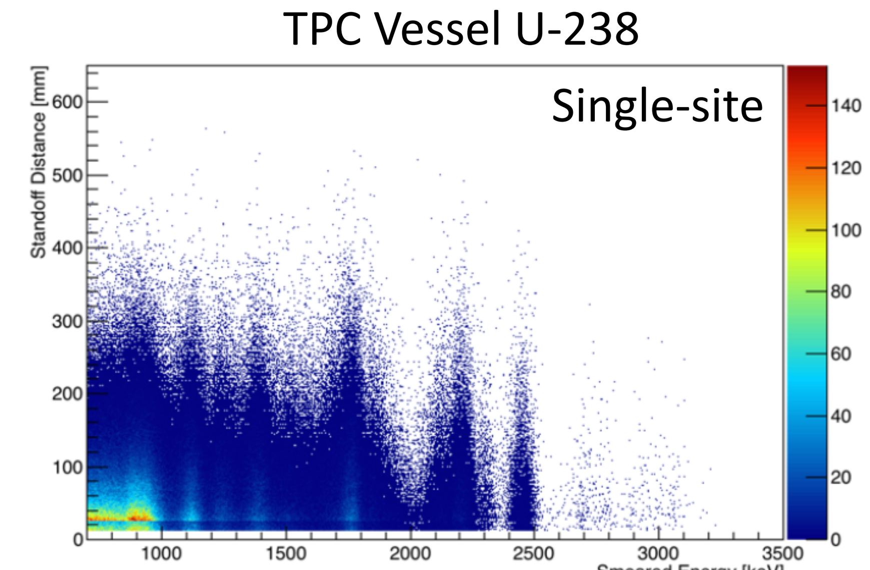
Components and Source Terms

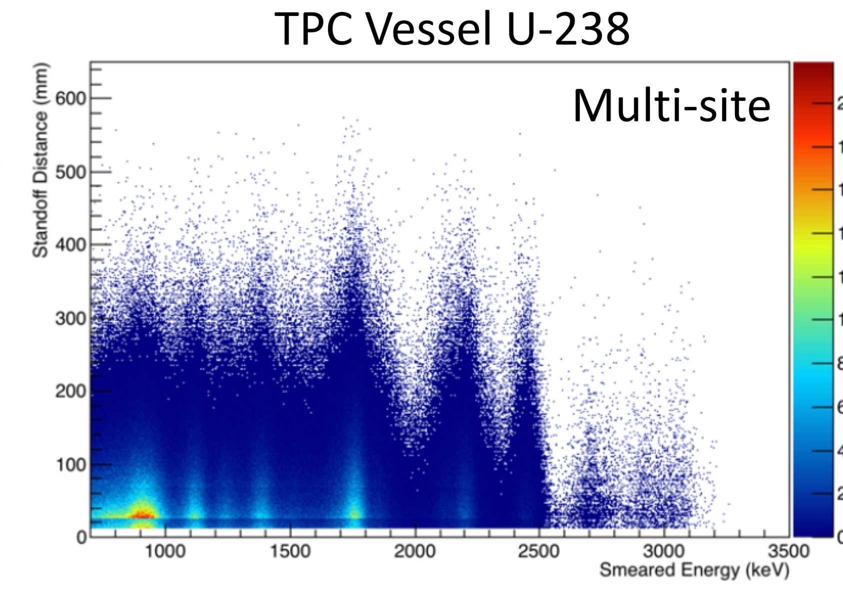
Full decay chains for U and Th as well as ^{60}Co and ^{40}K are simulated in the geometry volumes as listed here:

Component	Isotopes	Material
Outer Cryostat	^{238}U, ^{232}Th, ^{60}Co, ^{40}K	Carbon Composite
Inner Cryostat	^{238}U, ^{232}Th, ^{60}Co, ^{40}K	Carbon Composite
Inner Cryostat Liner	^{238}U, ^{232}Th, ^{60}Co	Titanium
HFE	^{238}U, ^{232}Th	HFE-7000
TPC Vessel	^{238}U, ^{232}Th	Copper
Cathode and bulge	^{238}U, ^{232}Th	Copper
Field Rings	^{238}U, ^{232}Th	Copper
FR Support Leg	^{238}U, ^{232}Th, ^{40}K	Sapphire
FR Support Spacer	^{238}U, ^{232}Th, ^{40}K	Sapphire
SiPM	^{238}U, ^{232}Th, ^{40}K	SiPM
SiPM Support	^{238}U, ^{232}Th	Copper
SiPM Module Backing	^{238}U, ^{232}Th	Quartz
SiPM Electronics	^{238}U, ^{232}Th	Silicon
SiPM Glue	^{238}U, ^{232}Th, ^{40}K	Silicone
SiPM Cables	^{238}U, ^{232}Th	Kapton
Charge Module Cables	^{238}U, ^{232}Th	Kapton
Charge Module Chip	^{238}U, ^{232}Th	Silicon
Charge Module Glue	^{238}U, ^{232}Th, ^{40}K	Silicone
Charge Module Support	^{238}U, ^{232}Th	Copper
Charge Module Backing	^{238}U, ^{232}Th	Quartz
LXe	^{137}Xe, $2\nu\beta\beta$, ^{222}Rn, $0\nu\beta\beta$	Xenon

Simulation Output

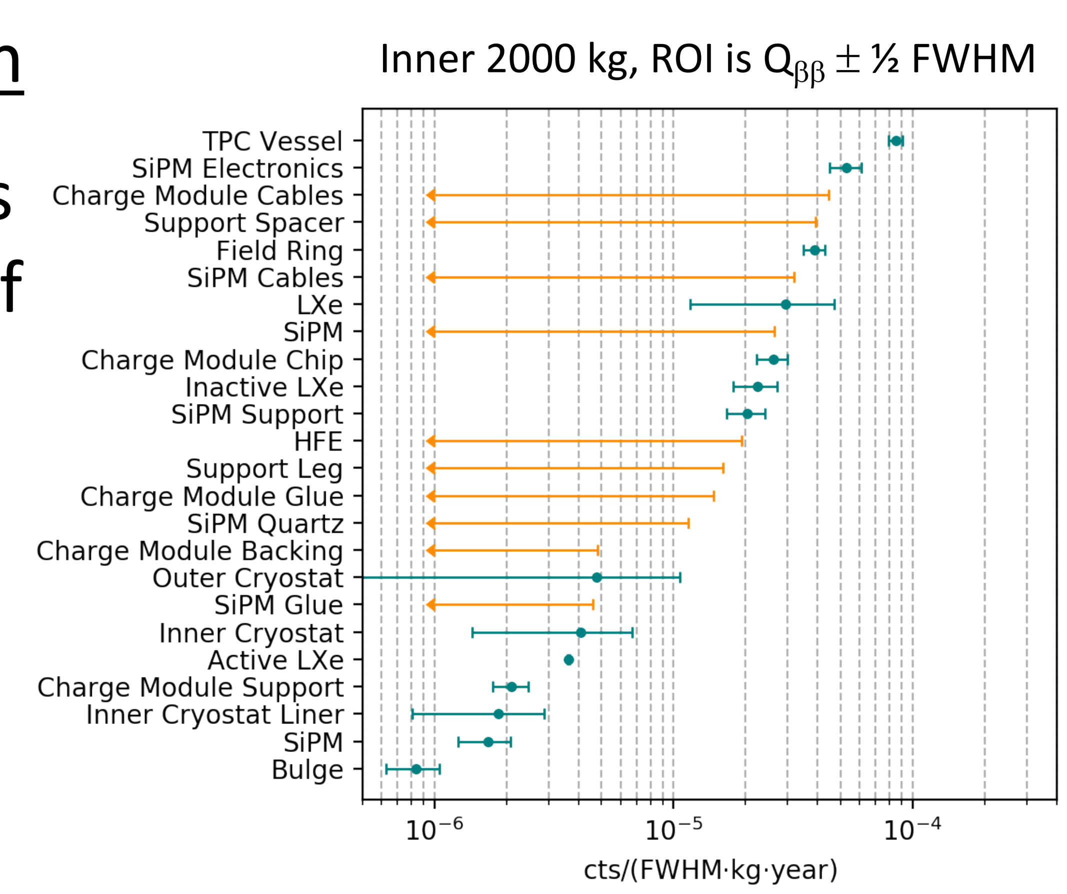
Geant4 simulation output is post-processed to include division into single-site and multi-site events. Results are stored in 2D-histograms of standoff distance (distance from nearest material). Half-life sensitivity reach is calculated using entire parameter space, gaining from fitting to background shapes.





Background Evaluation

Combined with results from *measurements* of the radio-impurity levels in all potential detector materials[5] a predicted background rate is generated for evaluation.



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