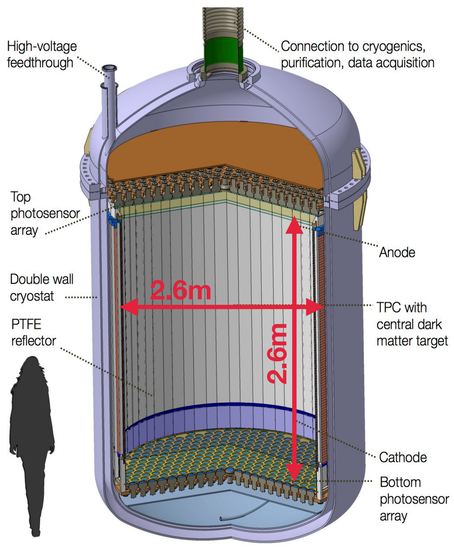
1. Neutrinoless double-beta ($0\nu\beta\beta$) decay in DARWIN

DARWIN Baseline Design

Its primary goal is to search for particle dark matter

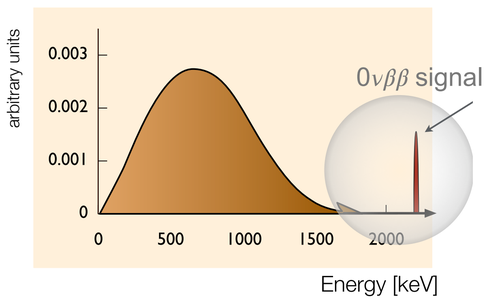


- Dual-phase Time Projection Chamber (**TPC**).
- **40 t active** of liquid xenon.
- Dimensions: **2.6 m diameter and 2.6 m height.**
- Two arrays of photosensors (top and bottom).
- Low-background double-wall cryostat.
- Outer shield filled with water (14 m diameter).

Why Look for the $0\nu\beta\beta$ Decay with DARWIN ?

DARWIN offers the possibility of looking for this rare process for FREE

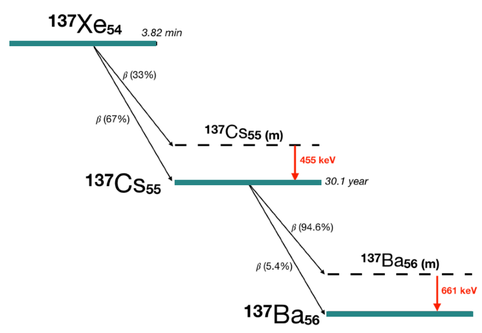
- ^{136}Xe excellent candidate:
  - **8.9% abundance** in natural Xe.
  - Q-value = 2.458 MeV
- DARWIN will have more than **3.5 t** of active ^{136}Xe.
- Energy resolution of ~0.8% at 2.5 MeV
- Ultra-low background environment dominated by intrinsic sources

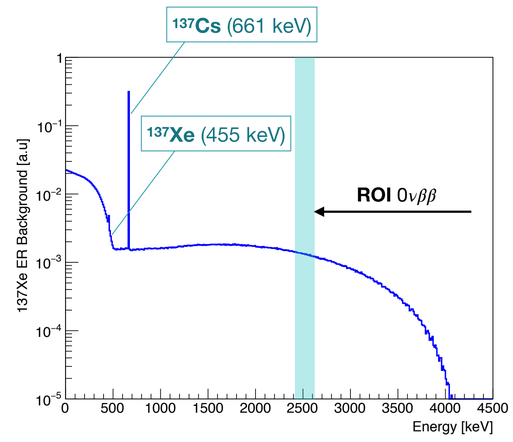


2. ^{137}Xe from cosmogenic activation underground

^{137}Xe: an Intrinsic Background

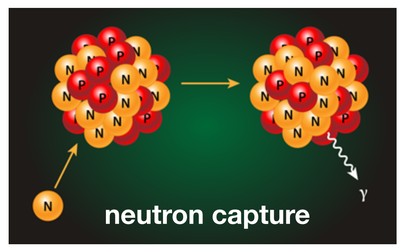
- ^{137}Xe beta decays with a Q-value of 4173 keV.
- The half-life is 3.82 min.
- Background uniformly distributed in the detector volume.





^{137}Xe Production Underground

^{137}Xe is mainly produced when muon-induced neutrons are captured by ^{136}Xe.



Cosmic Muons underground

↓

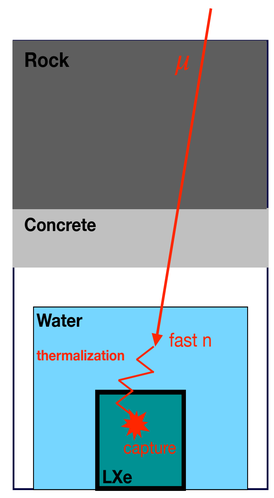
Fast Neutrons

↓

Thermalize by collision

↓

Neutron Capture



IDENTIFICATION OF ^{137}Xe LIKE A BACKGROUND FOR $0\nu\beta\beta$ SEARCHES IN DARWIN

Patricia Sanchez-Lucas

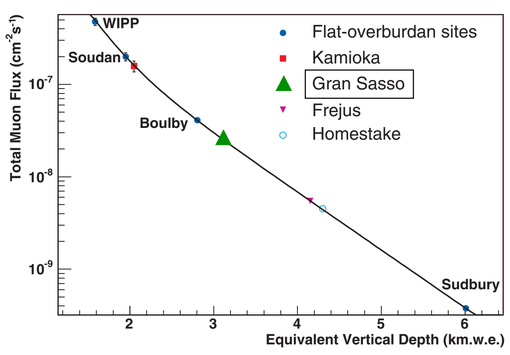
— University of Zurich —

3. Simulations

Muon Flux at LNGS

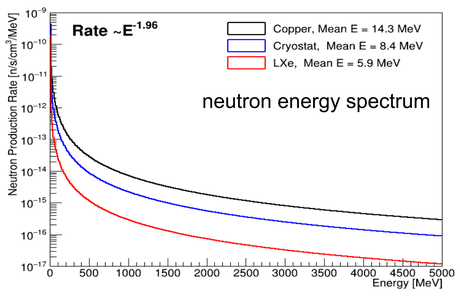
The muon flux underground depends on the depth of the lab

- For the simulations we assume the depth of LNGS.
- 1 muon per hour and per m^2



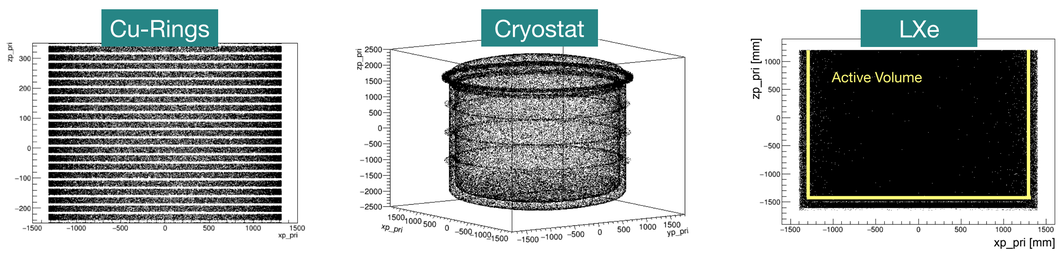
Neutron Simulations and ^{137}Xe Production Rate

- Moun-induced neutron production rate from MUSIC and MUSUN [1]



Material	Neutron production rates [10^{-8} n/s/cm^3]	Mean neutron energy [MeV]
Polyethylene	0.15	34.3
Copper	0.47	14.8
Pb	1.04	6.8
Cryostat	0.39	8.3
Others	NA	NA
LXe	0.19	5.7

- Simulation of neutrons in the different materials, propagate them and counting of ^{137}Xe isotopes produced by neutron capture



Simulation Details				
Material	**Volume [m^3]**	**Sim. Neutrons**	**^{137}Xe Isotopes**	**^{137}Xe Prod. Rate [atoms/kg/y]**
Cu-Shaping Rings	0.076	10^6	234 ± 15	(6.7 ± 0.4)×10^{-5}
Cryostat	1.076	10^6	89 ± 9	(2.9 ± 0.3)×10^{-4}
LXe (~50 ton)	16.976	10^6	252 ± 16	(6.5 ± 0.4)×10^{-3}

[1] XENON100 Collaboration, internal note (2010)

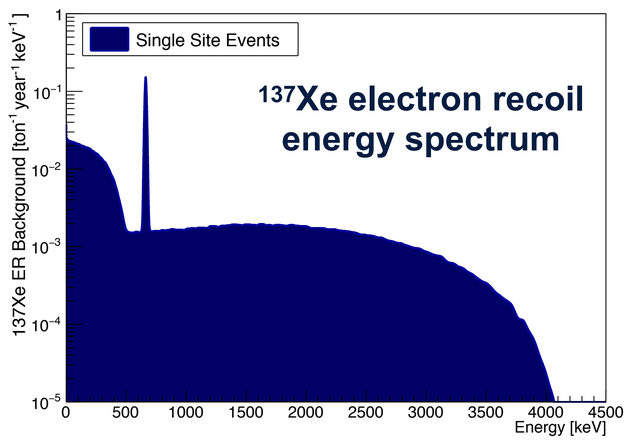
4. Results

^{137}Xe: Comparison with other experiments

Experiment	Location	Depth [m.w.e]	^{137}Xe Production Rate [atoms/kg/year]
DARWIN	LNGS	3600	7.71×10^{-2}
nEXO [2]	SNOLAB	6011	2.44×10^{-3}

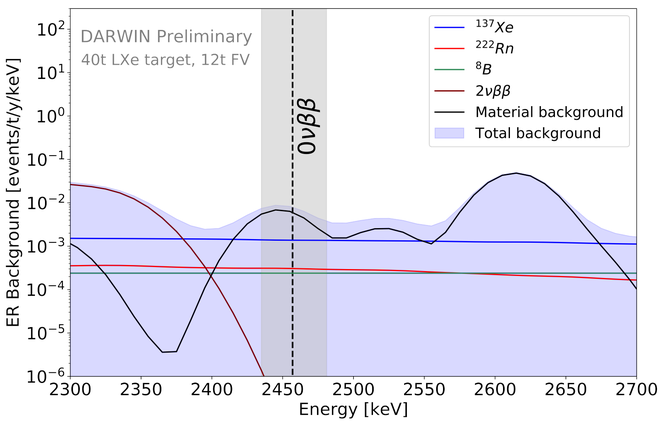
[2] nEXO Collaboration, Phys. Rev. C 97, 065503 (2018).

values normalized per kg of ^{136}Xe



- Simulation of 10^7 events of ^{137}Xe uniformly distributed in the detector.
- Normalization taking into account the previous production rates
- 3D-clustering 15 mm
- Single site selection

Contribution in the ROI of the 0vbb decay



Component	Events_ROI/(ty) 2435 - 2481 keV
Detector materials in 6t FV	0.24 (73%)
^{137}Xe background	**0.067 (20%)**
^{222}Rn in LXe (0.1μBq/kg)	0.014 (4%)
8B (ν-e scattering)	0.011 (3%)
^{136}Xe ($2\nu\beta\beta$)	0.00002 (<0.1%)

The ^{137}Xe accounts for 20% of the total ER background in the scenario of 12t FV