NvDEx - A Se TPC detector for neutrinoless double beta decay

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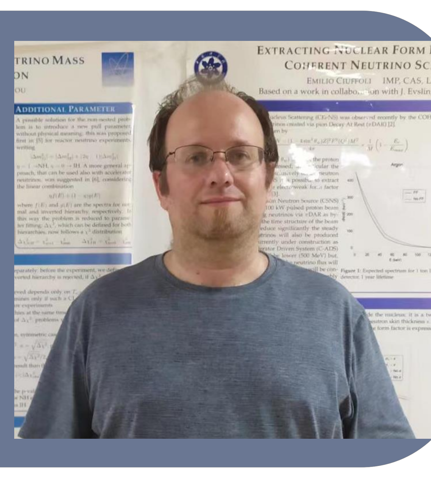
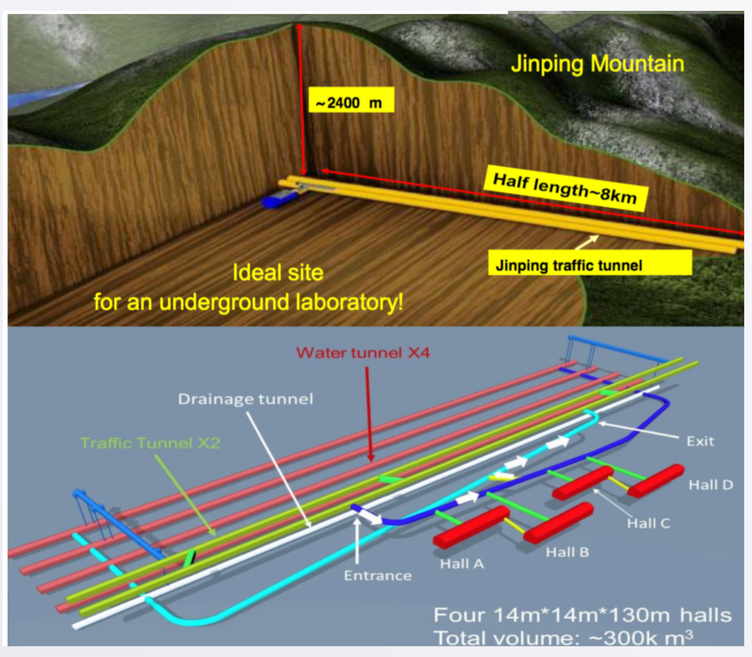


NvDEx

(No Neutrino Double beta decay Experiment)

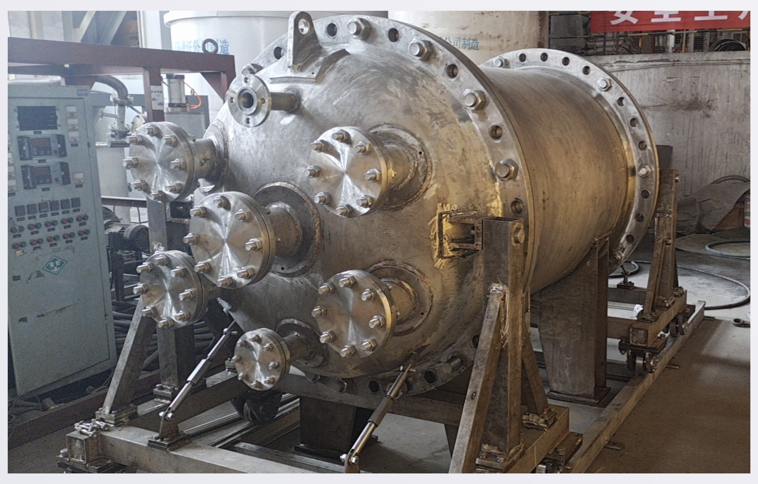
HP SeF_6 TPC [1] looking for neutrinoless double beta decays



Advantages

- ^{82}Se high Q-value, 2.996 MeV
- Placed at CJPL → 2.4 km rock overbuden
- TPC → topology used to veto bg

Very low bg index estimated <2x10^{-5} evts/(kg yr keV) for NvDEX-100 → excellent prospects for scalability!



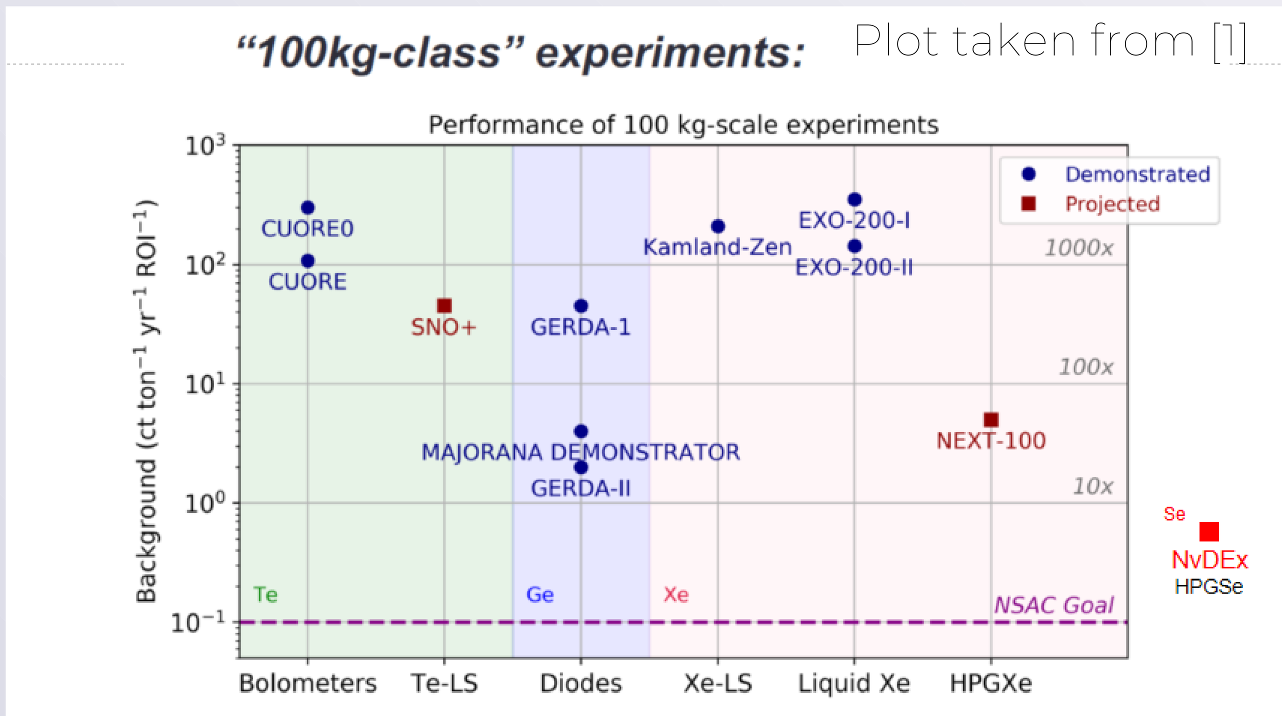
Challenges

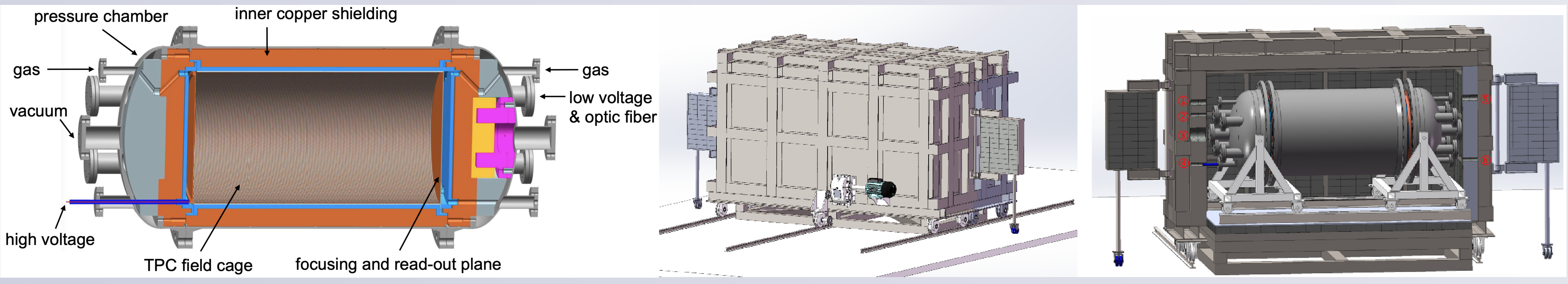
- SeF_6 is toxic → security measures must be implemented
- SeF_6 highly electronegative → negative ions are drifting → new sensor (Topmetal-S) to detect negative ions; good energy resolution without electron avalanche multiplication

NvDEx-100 [2]

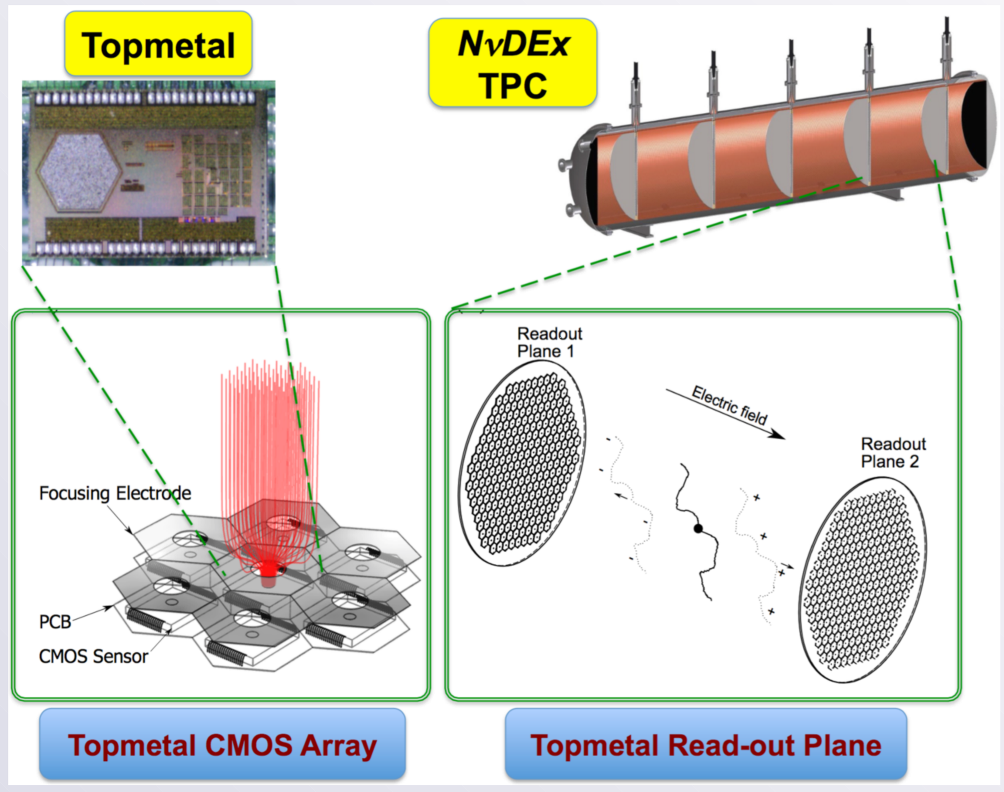
- First phase: NvDEx-100, 100 kg of SeF_6
- Expected FWHM: 1% at 3 MeV
- Expected sensitivity: 3x10^{25}(3x10^{26}) yrs with nat (enr.) Se

2024	Completing TPC construction & testing
2025	Installation in CJPL
2026	Start data taking

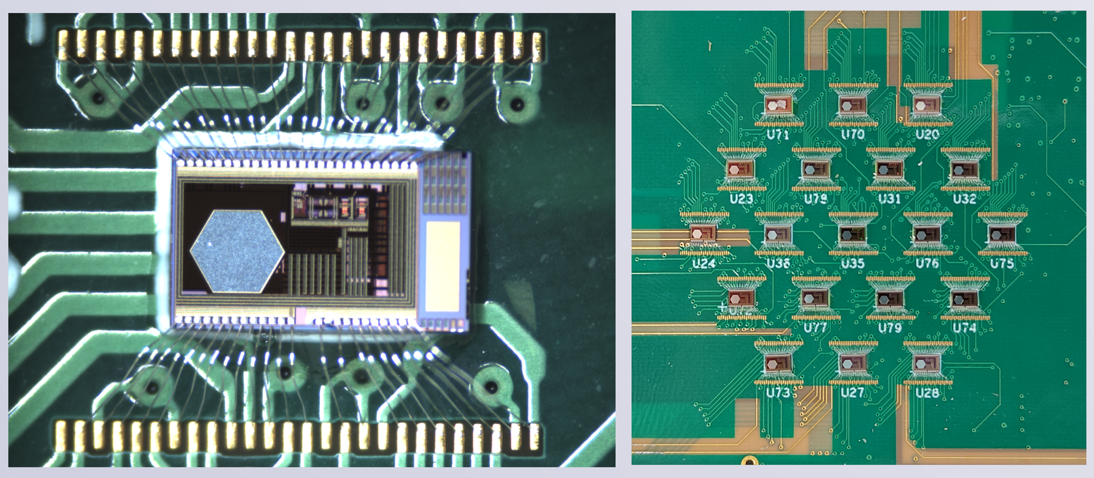




Topmetal-S [4,5]



- Designed to detect negative ions
- Three tape-outs already conducted (V0, V1 and V2)
- Noise: ~110 e$^-$ for V1, V2 currently being tested
- NvDEx goal: <45 e$^-$
- Pixel dimension: ~ 8 mm
- Readout plane: ~10,000 sensors

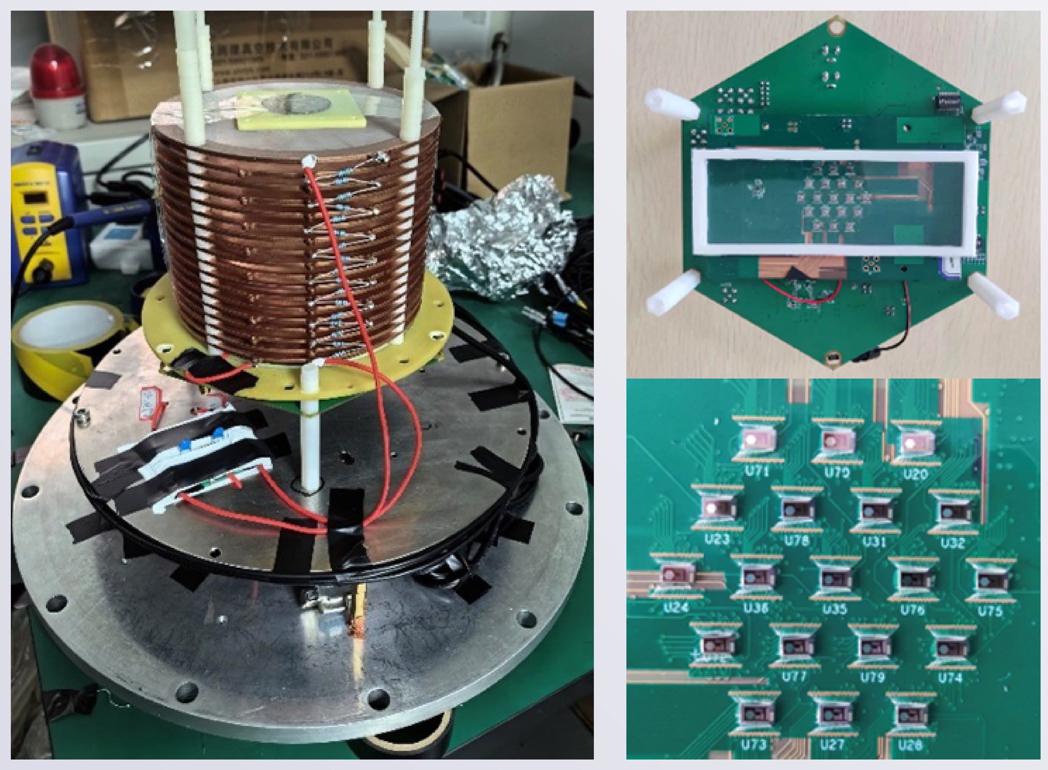


TPC Surface Test

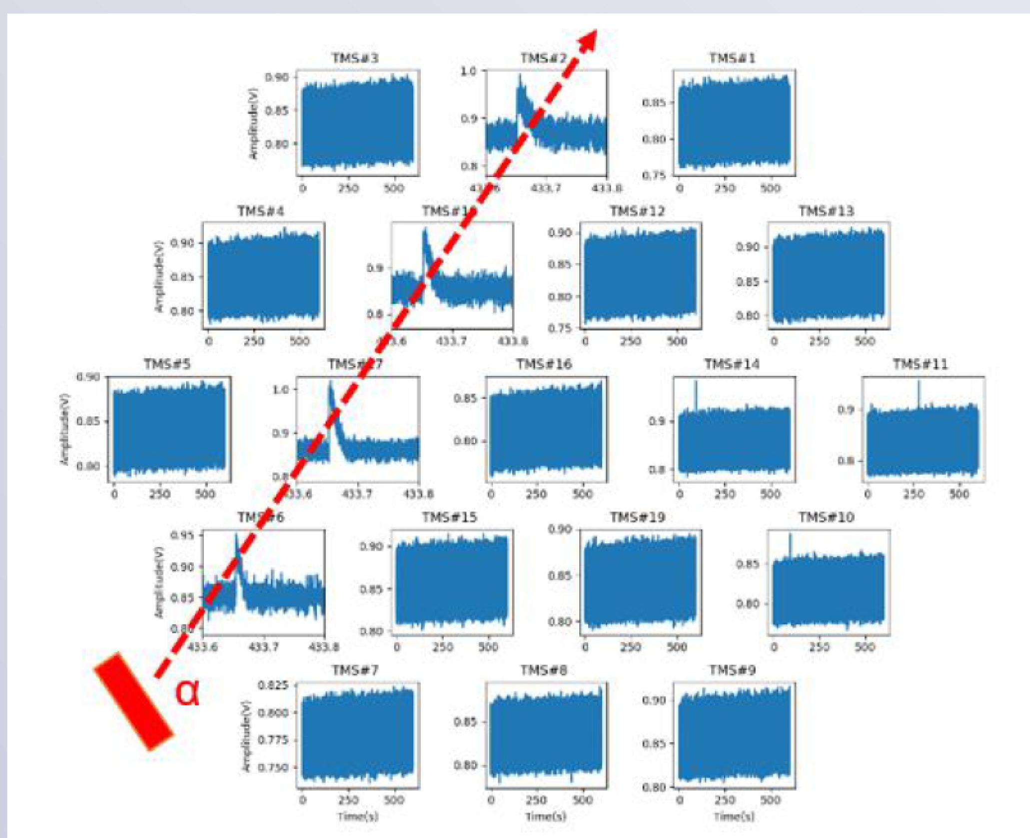
A prototype of the TPC is being currently tested at IMP, in Lanzhou

Main goals

- Test Topmetal-S
- Energy reconstruction
- Track detection



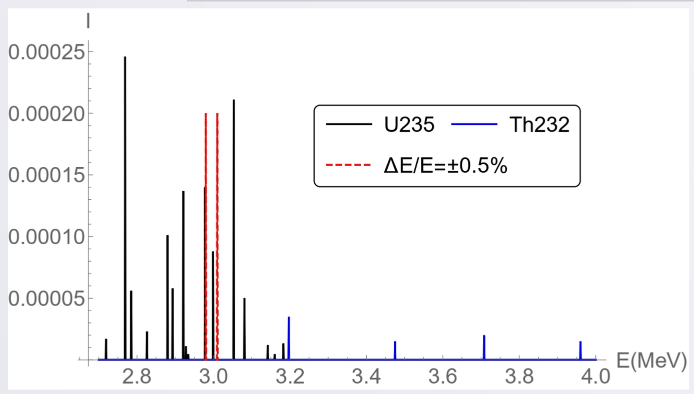
Currently α sources are being used, γ sources will be considered as well

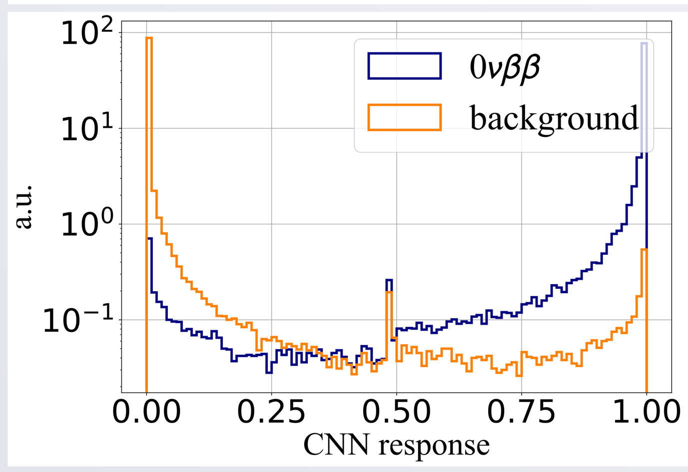


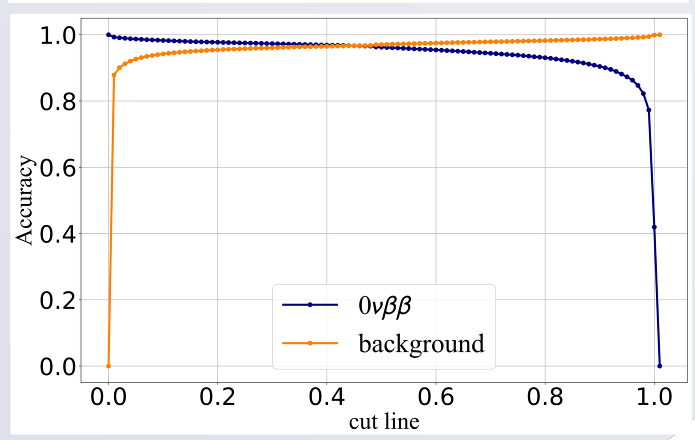
Background

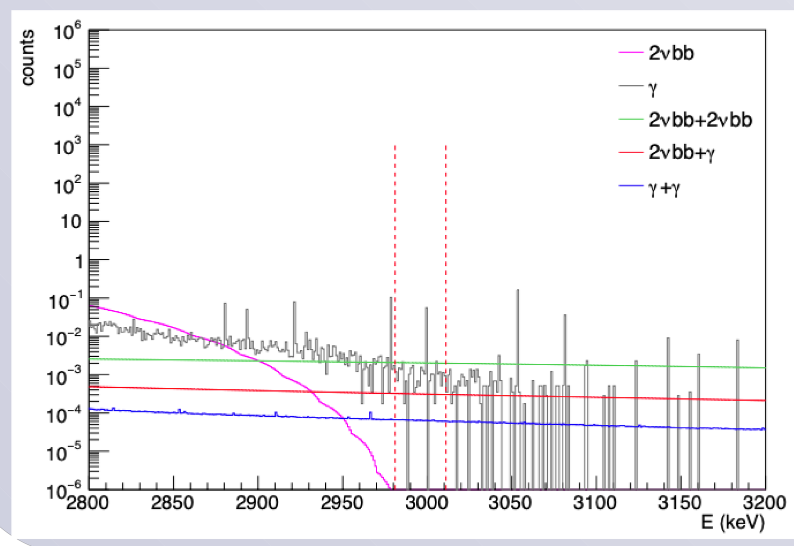
- **ϒ from natural radioactivity** → suppressed with 20 cm lead shield. Main contribution comes from radioactive contamination in the detector (cannot be suppressed by additional shielding). Estimated rate (w/o topological veto): ~0.4 evts/yr [2]
- **Fast neutrons** [3]: main contribution from neutron-induced γ Using HDPE rate can be reduced down to 0.15 evts/yr
- **Cosmogenic background**: cosmic rays can activate nuclei while the detector is manufactured on the surface, in particular ^{56}Co created in ICS could be an issue, after 3 years cooldown rate can be reduced to 0.18 evts/yr
- **Pile-up**: since the ions drift slowly (~ 7 s to cross the entire detector) pile-up background could be a concern. PMT placed at the HV plate can be used to identify these events
- **Radon**: currently under study
- **Topological cuts**: from MC simulations, using CNN rejection efficiency: 98.6%, signal loss ~10%

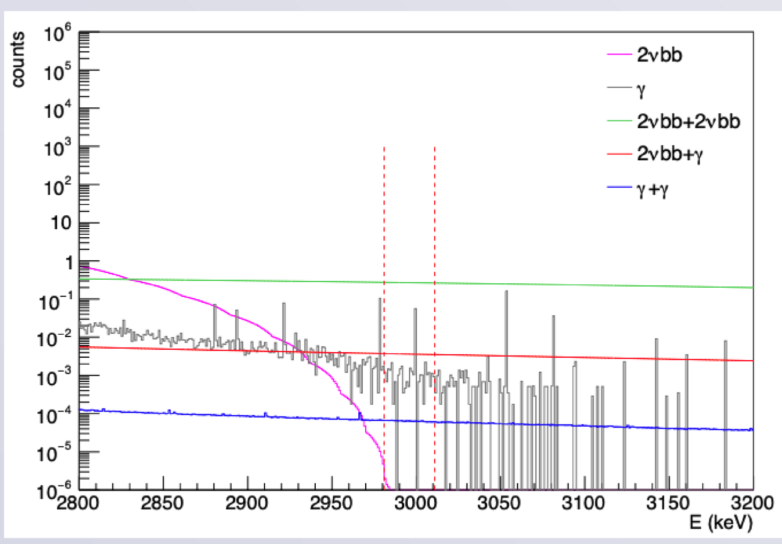
ϒ Background	
Source	Evts/yr
Walls	0.004
SSV	0.026
ICS	0.050
FC	0.330
Total	0.42











References

[1] JINST 13 (2018) 03, P03015 [2] Nucl.Sci.Tech. 35 (2024) 1, 3 [3] arXiv: 2307.12785 [physics.ins-det] [4] JINST 19 (2024) 03, C03031 [5] JINST 19 (2024) 04, C04004