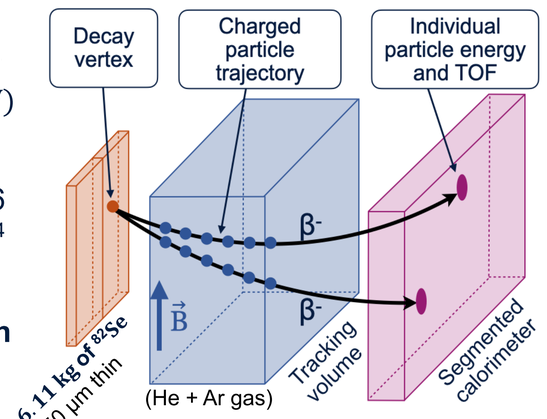
Study of radon background in the SuperNEMO demonstrator

#632

SuperNEMO Demonstrator

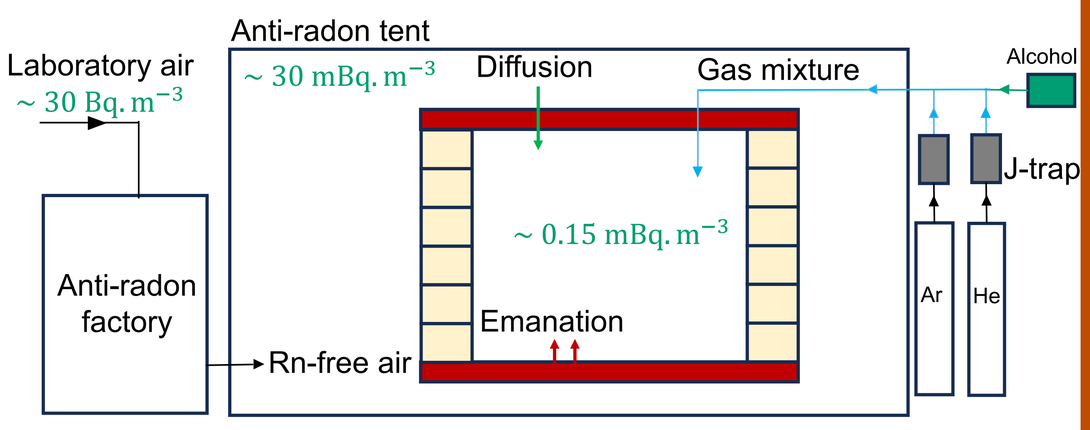
- **Goal of SuperNEMO :** to search for $0\nu\beta\beta$ process with ^{82}Se ($Q_{\beta\beta} \sim 3$ MeV)
- **Preliminary SuperNEMO demonstrator sensitivity:** $T_{1/2} > 4.6\ 10^{24}$ years (Bayesian), $T_{1/2} > 3.6\ 10^{24}$ years (Frequentist)
- Able to **track and measure electron energy independently**
- **Data taking in autumn 2024**



→ **Radon (Rn) is the main background in the tracker**

Anti-radon strategy

^{222}Rn decay to **^{214}Bi** (Q_{β^-} = 3.272 MeV) → background for $0\nu\beta\beta$ search



Anti-radon strategies:

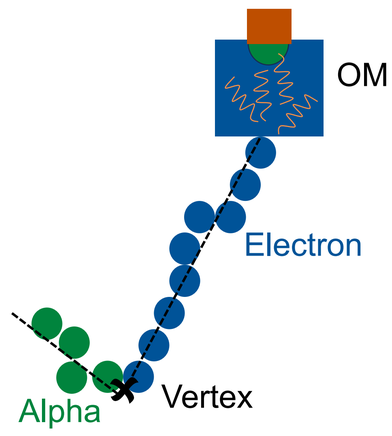
- **Material screening for radiopurity** → very low Rn emanation ✓
- **J-Trap facility** → ultra high Rn purification of the gas (He+Ar)
- **Anti-Rn tent** → Buffer volume against the air from the LSM lab ✓
- **Anti-Rn factory** → to inject Rn-free air in the tent

Measuring radon activity with ^{214}Bi-^{214}Po decay events

Measuring Rn activity ⟺ measuring BiPo activity

Golden ^{214}Bi-^{214}Po channel: 1 **electron** + 1 delayed **alpha** ($T_{^{214}Po}$ = 164 µs)

- **Electron identification**:
  - 1 Optical Module (OM) triggered
  - ≥ 1 associated Geiger cell near the OM
  - Temporally correlated with the OM
- **Alpha identification**:
  - ≥ 2 close Geiger cells triggered
  - Delayed alpha below 1.6 µs after electron
  - Short track (≤ 12 Geiger cells)



Additional BiPo selection:

Electron energy	>300 keV
e^-/α vertex distance in xy plane	≤6 cm
e^-/α vertex distance on z axis	≤10 cm
Delay between α and e^-track	[300-1600] µs

Efficiency selection of 3.1%
From 10^6 events simulated on the surface of the grounds wires

Dedicated radon injection runs

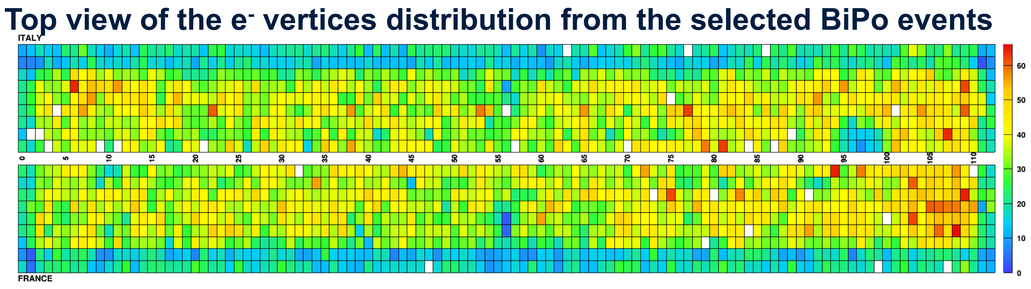
Radon source

- Emanation rate: 95 ± 5 Rn atoms per second
- Injected in the tracker at 5 L.min^{-1}

Objectives

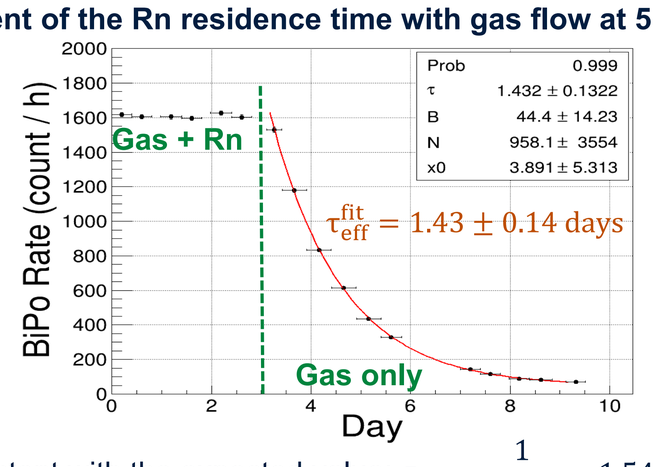
- To optimize the BiPo selection criteria with high statistics
- To study the spatial radon uniformity in the detector
- To study the radon residence time in the detector

Top view of the e$^-$ vertices distribution from the selected BiPo events



→ Spatial Rn uniformity in the bulk of the tracker
→ Small side effects and left-right asymmetry under study

Measurement of the Rn residence time with gas flow at 5 L.min^{-1}



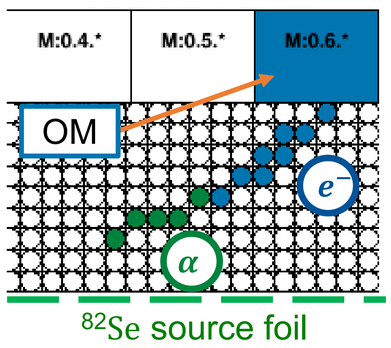
→ Consistent with the expected value: $\tau_{eff} = \frac{1}{\frac{\phi}{V} + \frac{1}{\tau}} = 1.54$ days

→ **Radon and the tracker gas mixture have the same flow dynamics**

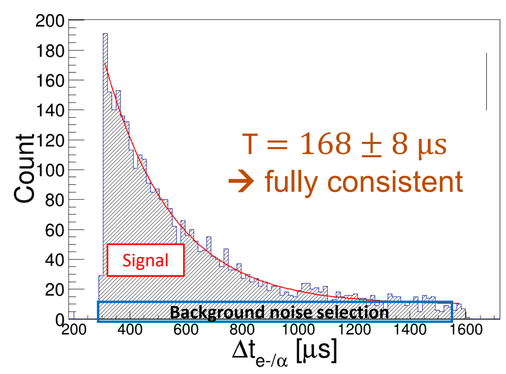
Radon background

- 58 h of Rn background measurement in March 2024 at different gas flow

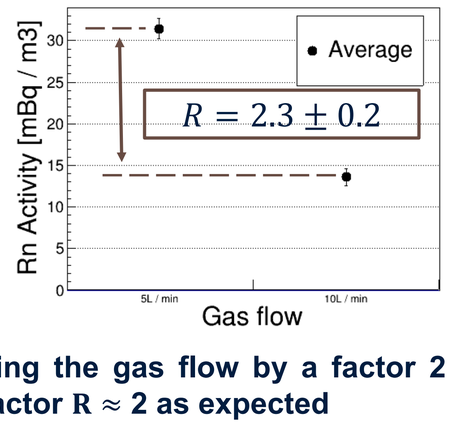
Real BiPo event



Time between e^- and α



Two Rn measurements performed at 5 and 10 L.min^{-1}



→ **Increasing the gas flow by a factor 2 decreases the BiPo rate by a factor R ≈ 2 as expected**

→ **First Rn background activity**
in current operation mode at 10 L.min^{-1} : [10-15] mBq.m^{-3}

New Radon activity updated soon with anti-radon factory, gas purification and nominal gas flow at 20 L.min^{-1}, stay tuned !

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