# COATING BASED RADON BARRIERS FOR FUTURE LIQUID XENON DETECTORS

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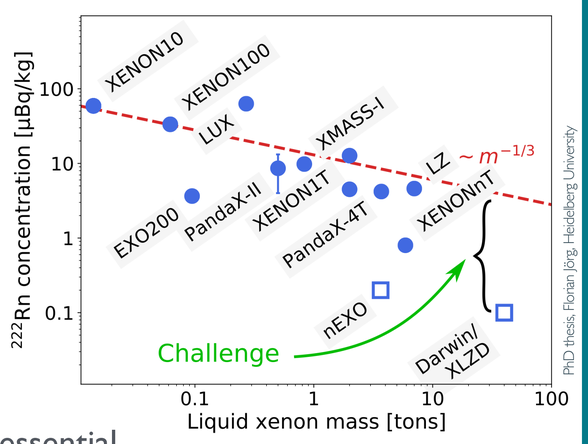
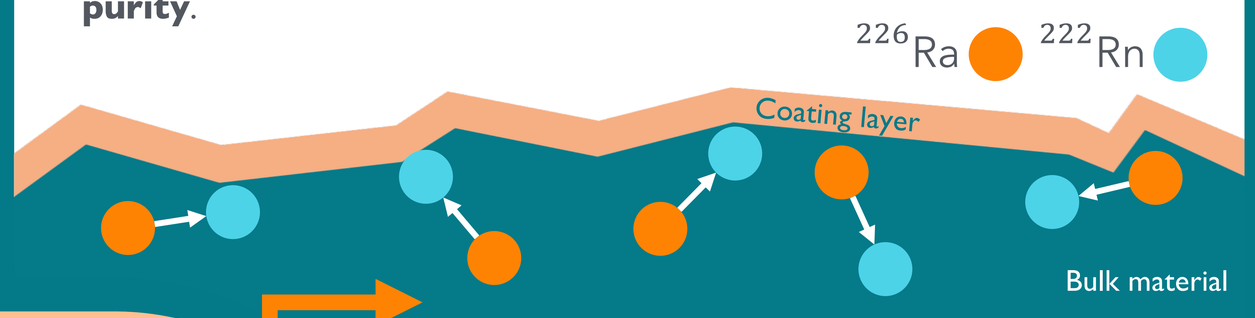
## RADON BACKGROUND

- Decays induced by $^{222}$Rn, limit sensitivity for direct dark matter search in liquid xenon (LXe).
- Radon is continuously released into the xenon from trace impurities present in the detector materials.
- Since radon emanation is a surface effect, the radon concentration decreases proportional to $1/\sqrt[3]{m}$ .
- Advancing radon mitigation techniques is essential for current and future LXe experiments.



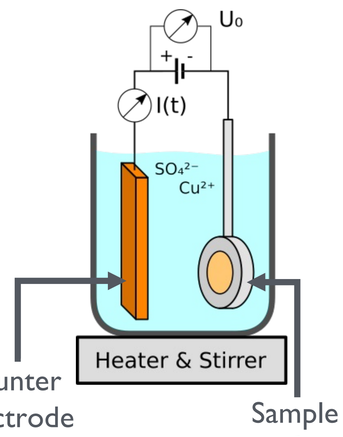

## BASIC CONCEPT OF COATING

- Basic concept: Apply a thin coating to seal the surface, reducing radon release from bulk material.
- There are two processes responsible for radon release: recoil and diffusion.
- The coating must be at least **thick** enough to contain the radon recoil range, be sufficiently **tight** against radon diffusion and must feature a high degree of **radio purity**.

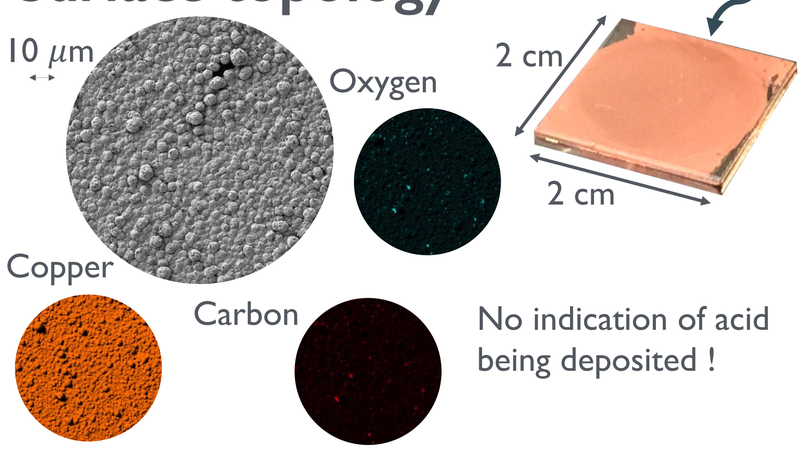



## ELECTROCHEMICAL PLATING

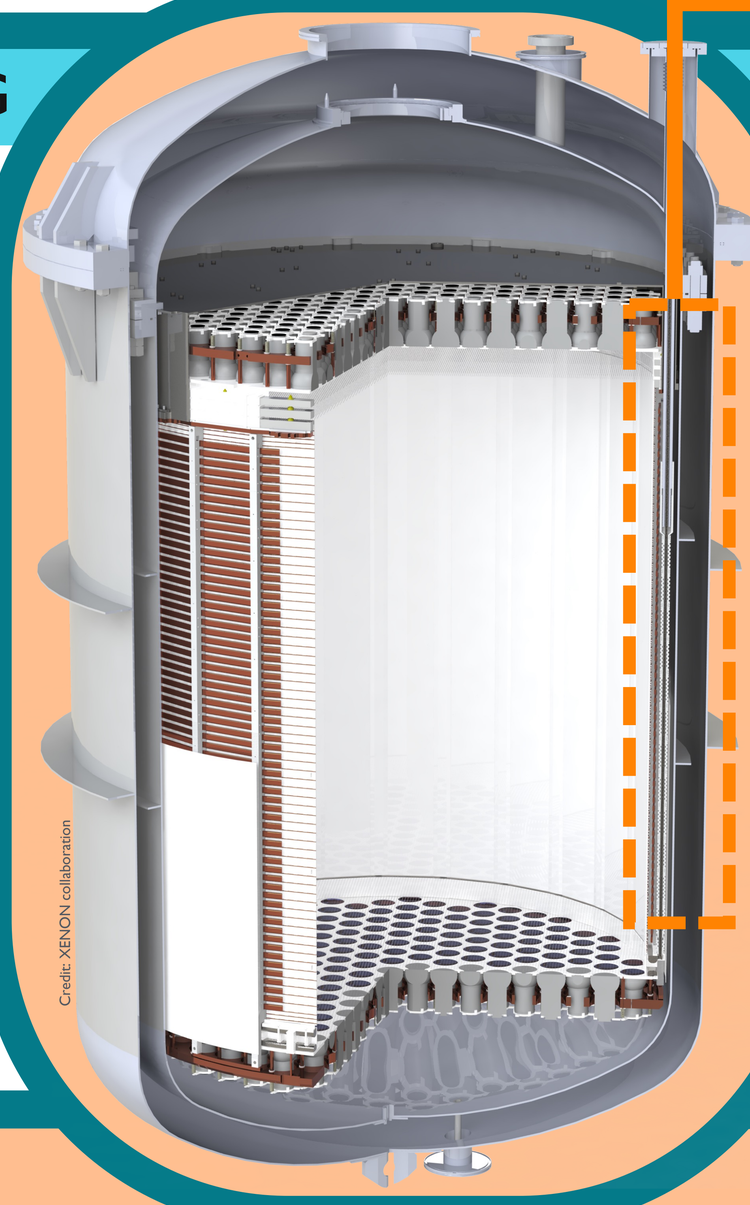
- Electrochemical plating (ECP) is performed locally. at MPIK.
- Solution heated to ~ 45°C and continuously stirred.
- Reduction occurs at sample: $Cu^{2+} + 2e^- \rightarrow Cu_s$




### Surface topology



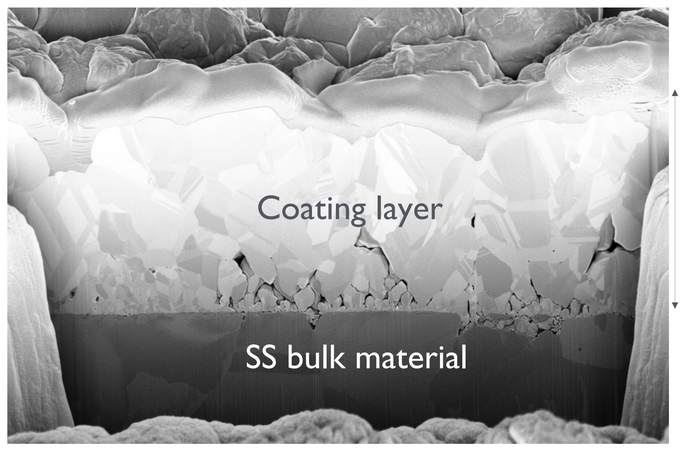

No indication of acid being deposited !




## COATING LAYERS

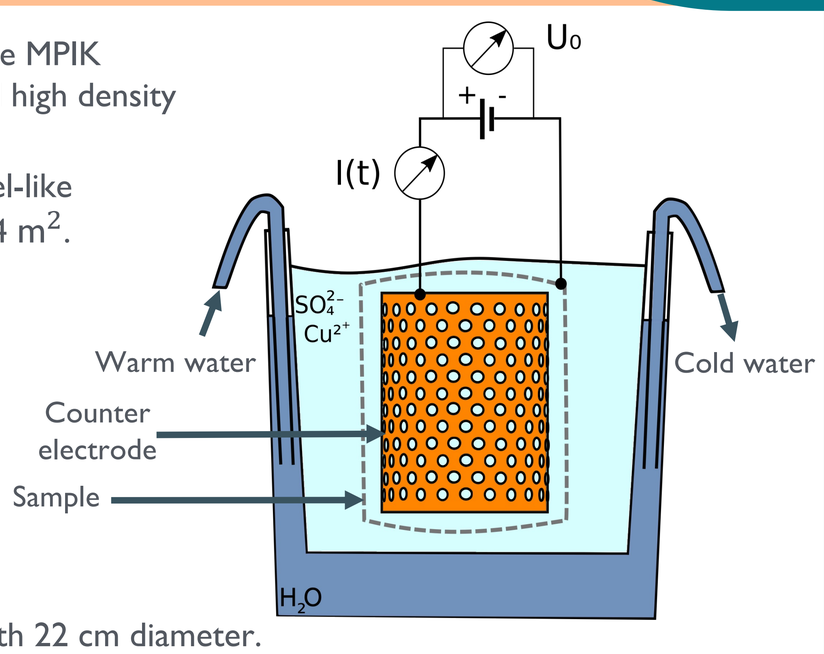
- The surface current density j influences the coating's properties.
- At j ≈ 10 mA/cm$^2$ : $^{222}$Rn reduction is highest.
- At j ≈ 50 mA/cm$^2$: Layer showed good adhesion.
- Final coating of 5 µm combines properties of both layers, leading to a radon reduction of a factor **1500!**

1 µm at 50 mA/cm$^2$ → 4 µm at 10 mA/cm$^2$




## UPSCALING

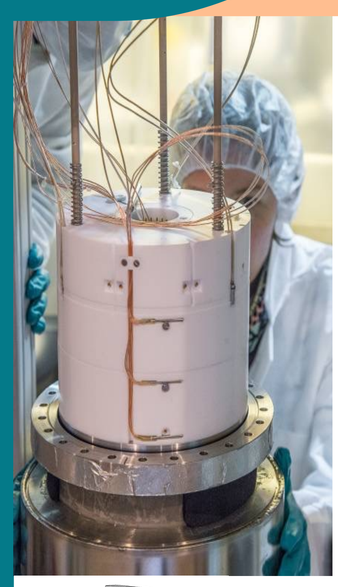
- New coating setup at the MPIK features a double walled high density polyethylene vessel.
- Capable of coating vessel-like geometries up to ~ 0.14 m$^2$.

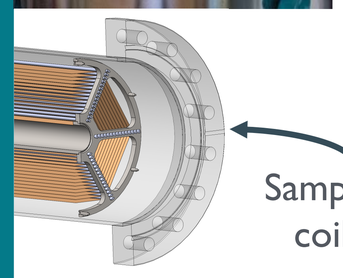




- First test: SS cylinder with 22 cm diameter.
- Dual-sided copper coated SS foil: 50 µm thick SS foil coated on both sides.
- Samples show high resistance to mechanical stress and temperature shocks in liquid nitrogen.




## PERFORMANCE TEST

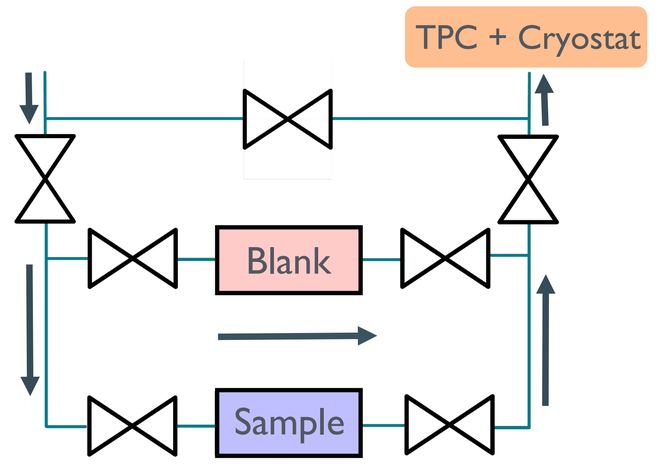




Sample will be coiled up !

### Local liquid xenon TPC

- Dual phase TPC with 350 grams of active liquid xenon.
- Ideal detector for testing novel background mitigation techniques under realistic operating conditions!
- The coating's effects on the chemical purity of xenon can be investigated through electron drift lifetime.

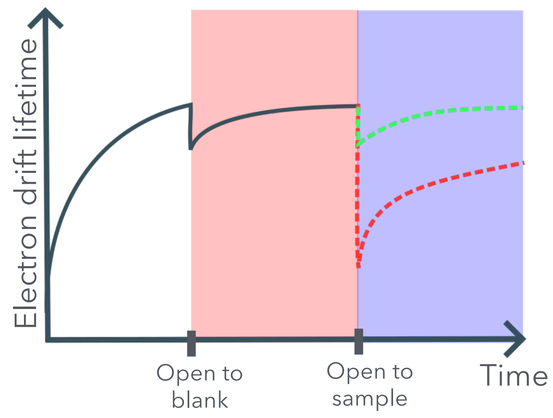



### Upcoming performance test in GXe

- 0.7 m$^3$ of dual-sided copper coated SS foil will be introduced into the GXe system.
- Two vessels: one blank with uncoated SS foil and one with coated sample.

Green curve: coating doesn't affect the chemical purity of xenon.

Red curve: coating reduces the chemical purity of xenon.



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