Radon background/s in LUX-ZEPLIN

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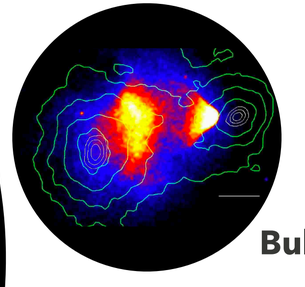
Cosmological Universe

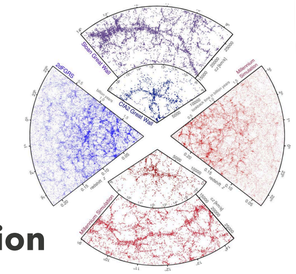
Baryonic Matter
5%

Dark Matter
26%

Galaxy Cluster Observations

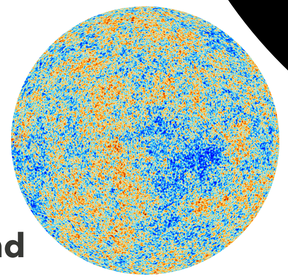


Bullet Cluster Observation



Large Structure Formation

Dark Energy
69%

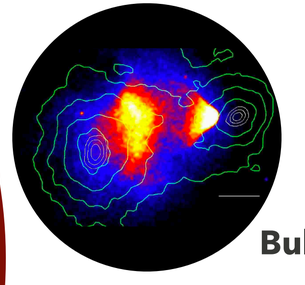


Cosmic Microwave Background

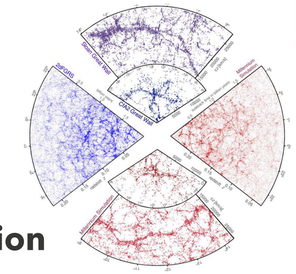
Cosmological Universe

Baryonic Matter
15%

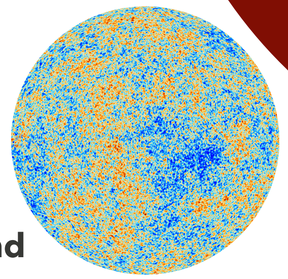
Galaxy Cluster Observations



Bullet Cluster Observation



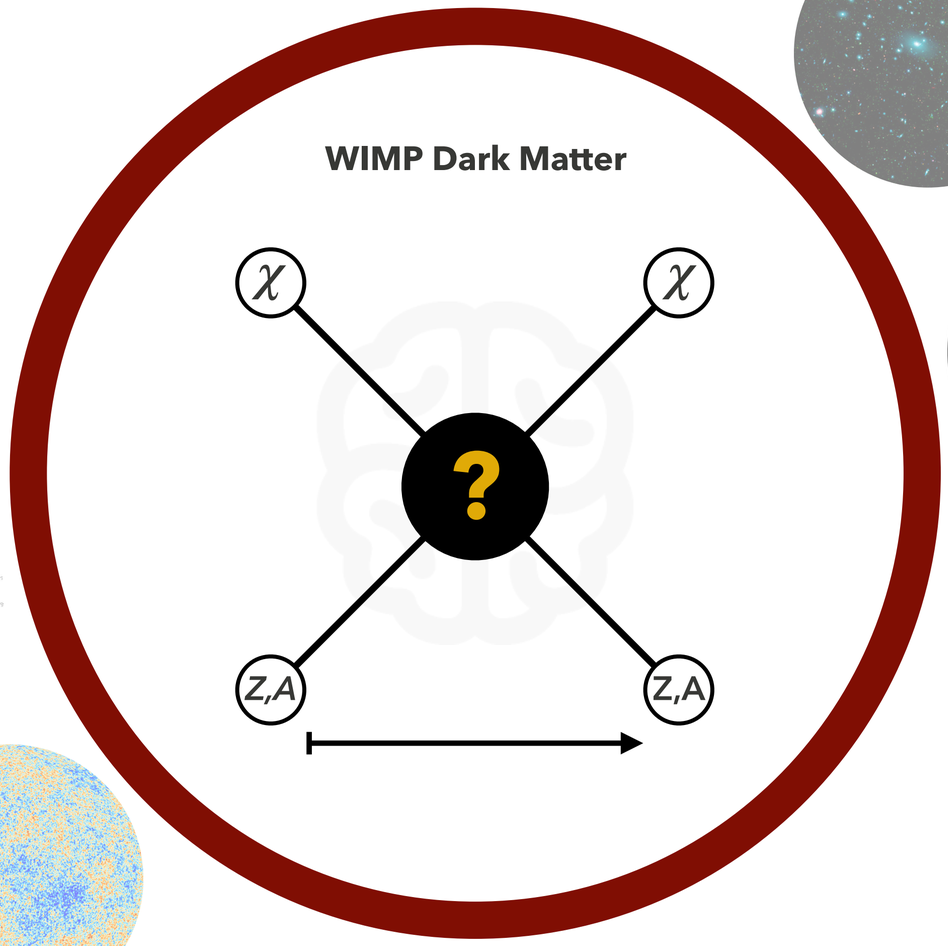
Large Structure Formation



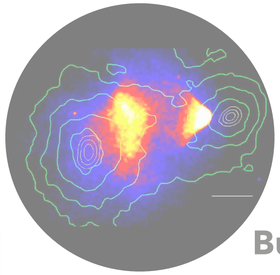
Cosmic Microwave Background

Dark Matter
85%

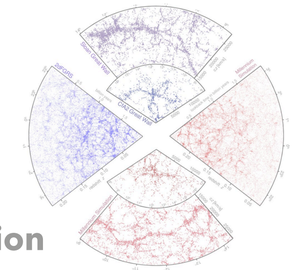
WIMP Dark Matter



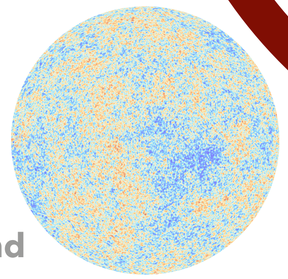
Galaxy Cluster Observations



Bullet Cluster Observation



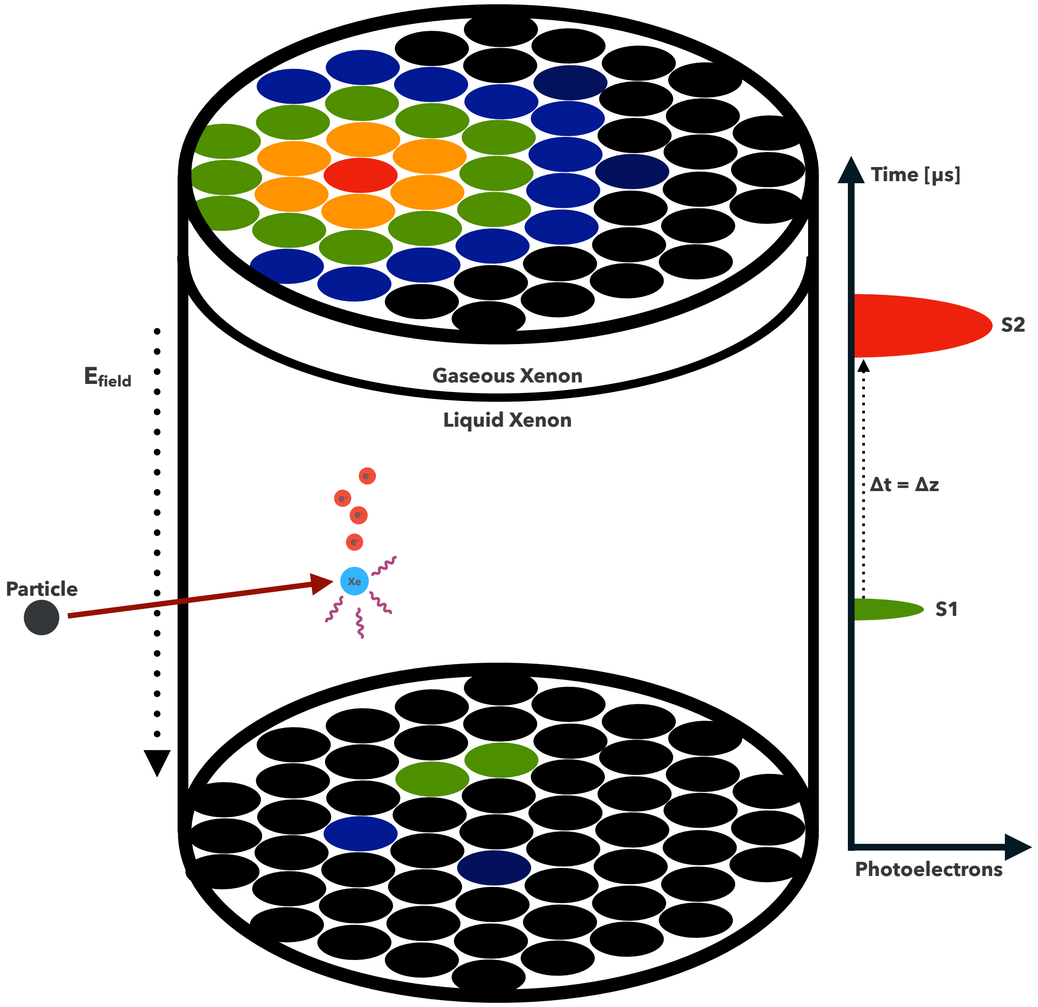
Large Structure Formation



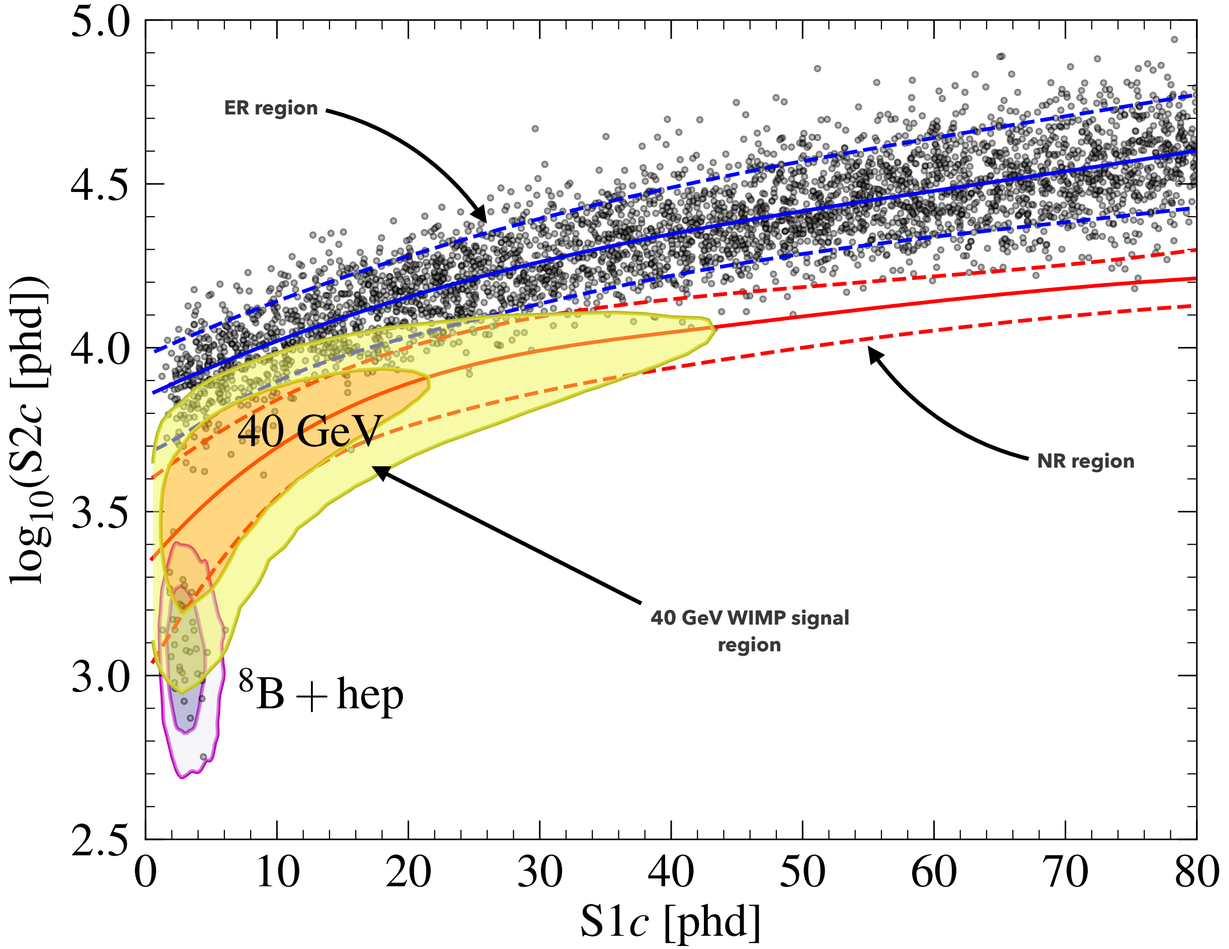
Cosmic Microwave Background

Detection Principles & Reconstruction

3D Position Reconstruction

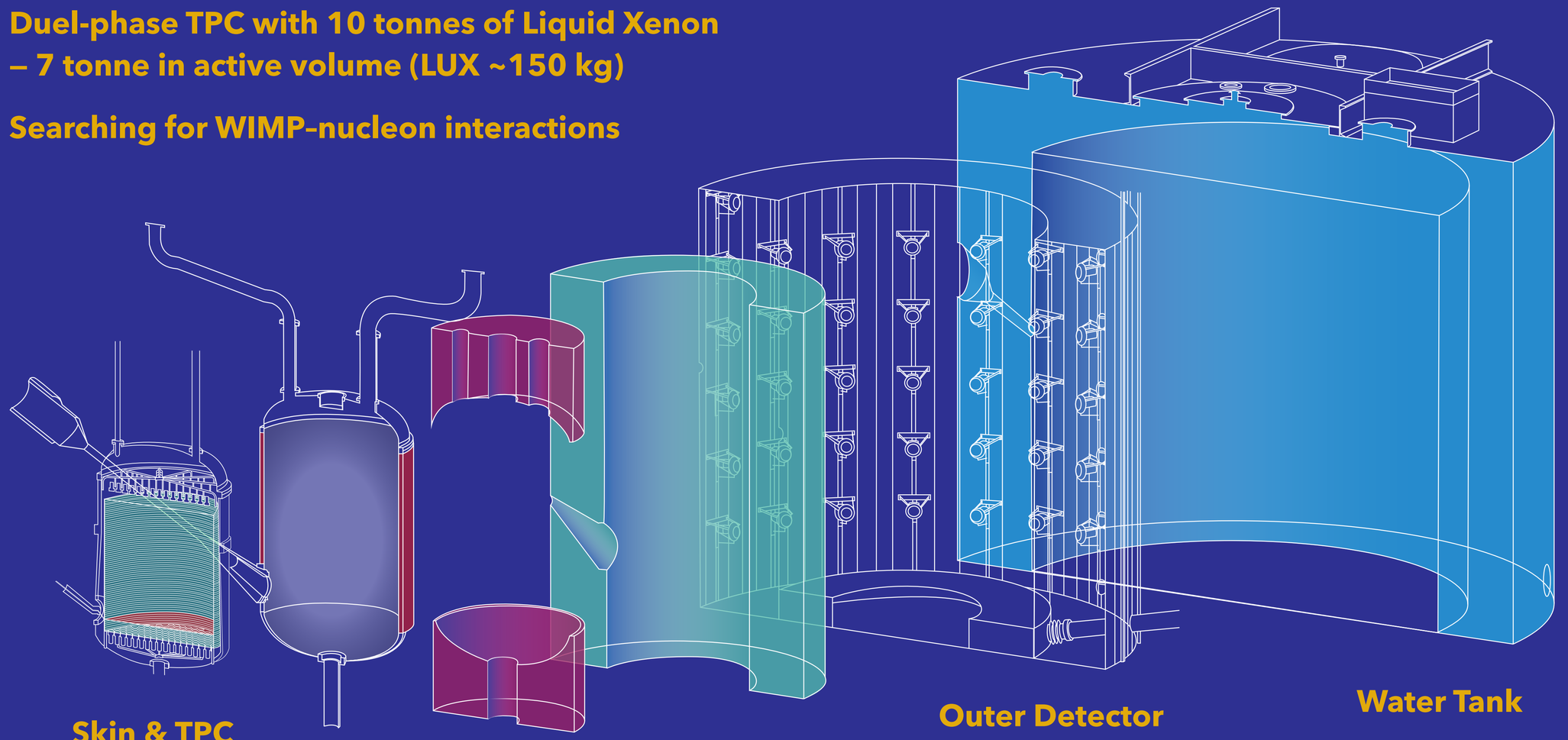


Energy Reconstruction



The LZ Detector/s (GEANT4 model)

- Duel-phase TPC with 10 tonnes of Liquid Xenon – 7 tonne in active volume (LUX ~150 kg)
- Searching for WIMP-nucleon interactions



The LZ Detector (Less virtual)

LZ Inner Cryostat Vessel

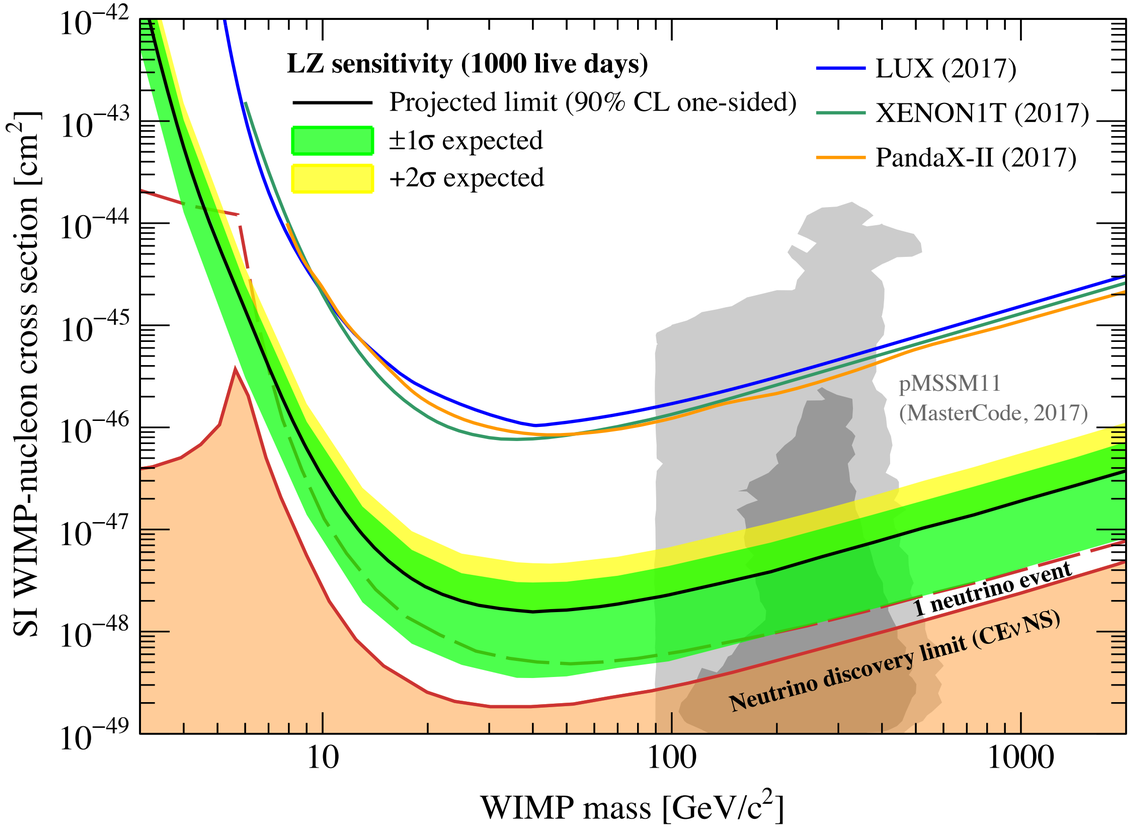
Ongoing war with backgrounds

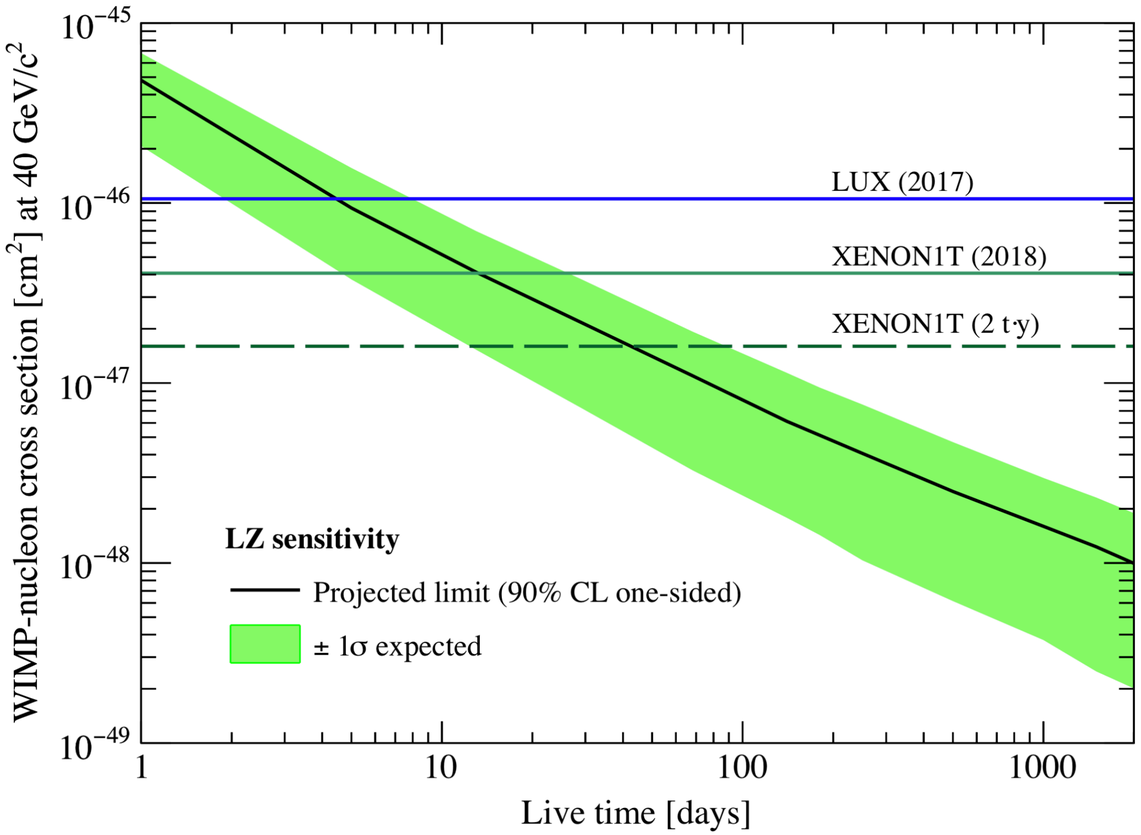
The LZ Detector (Less virtual)

After a month in Lead, SD

Skin PTFE Tiling & Skin PMT Array

LZ Spin Independent WIMP Sensitivity





- **One-sided profile likelihood ratio method used to obtain WIMP sensitivity**
- **Sensitivity is defined as the 90% CL upper limit on WIMP-nucleon cross-section**

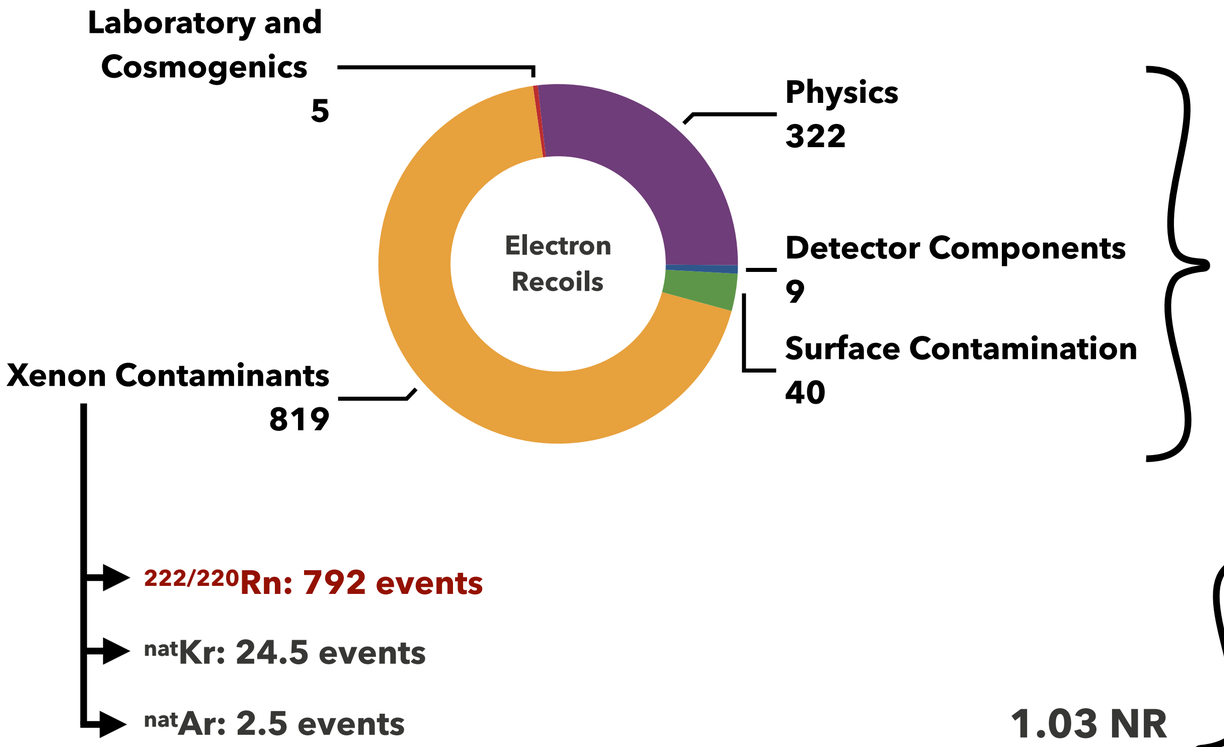
- **Minumum point: 1.6x10^{-48} cm^2 @ 40 GeV/c^2**
- **LUX sensitivity ~4–5 days**
- **XENON1T (2018) sensitivity ~2 weeks**

[Projected WIMP sensitivity of LZ, arXiv:1802.06039v1 – 2018]

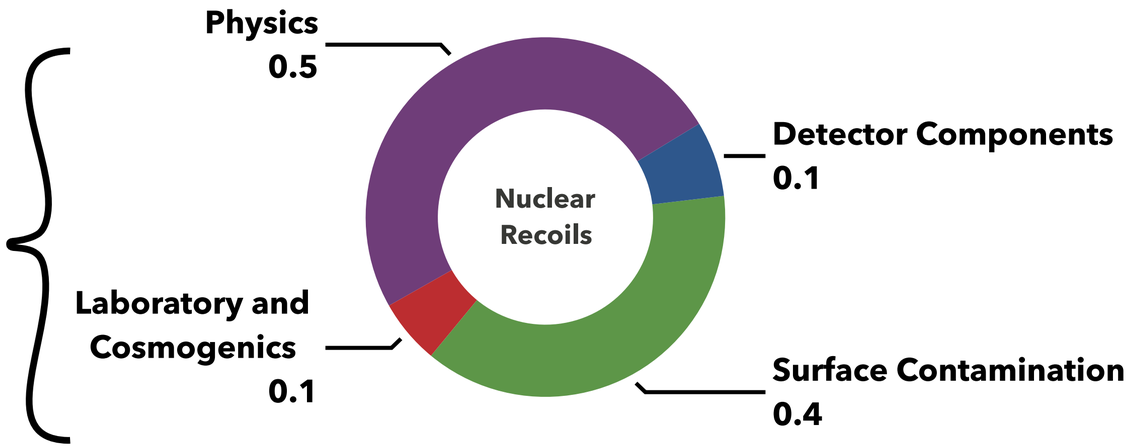
[XENON1T result, arXiv:1805.12562 – 2018]

LZ Background Expectations

Estimated background from a 1000 live day exposure in WIMP ROI (FV: 5.6 tonnes, ER: 1.5-6.5 keV, NR: 6-30 keV)

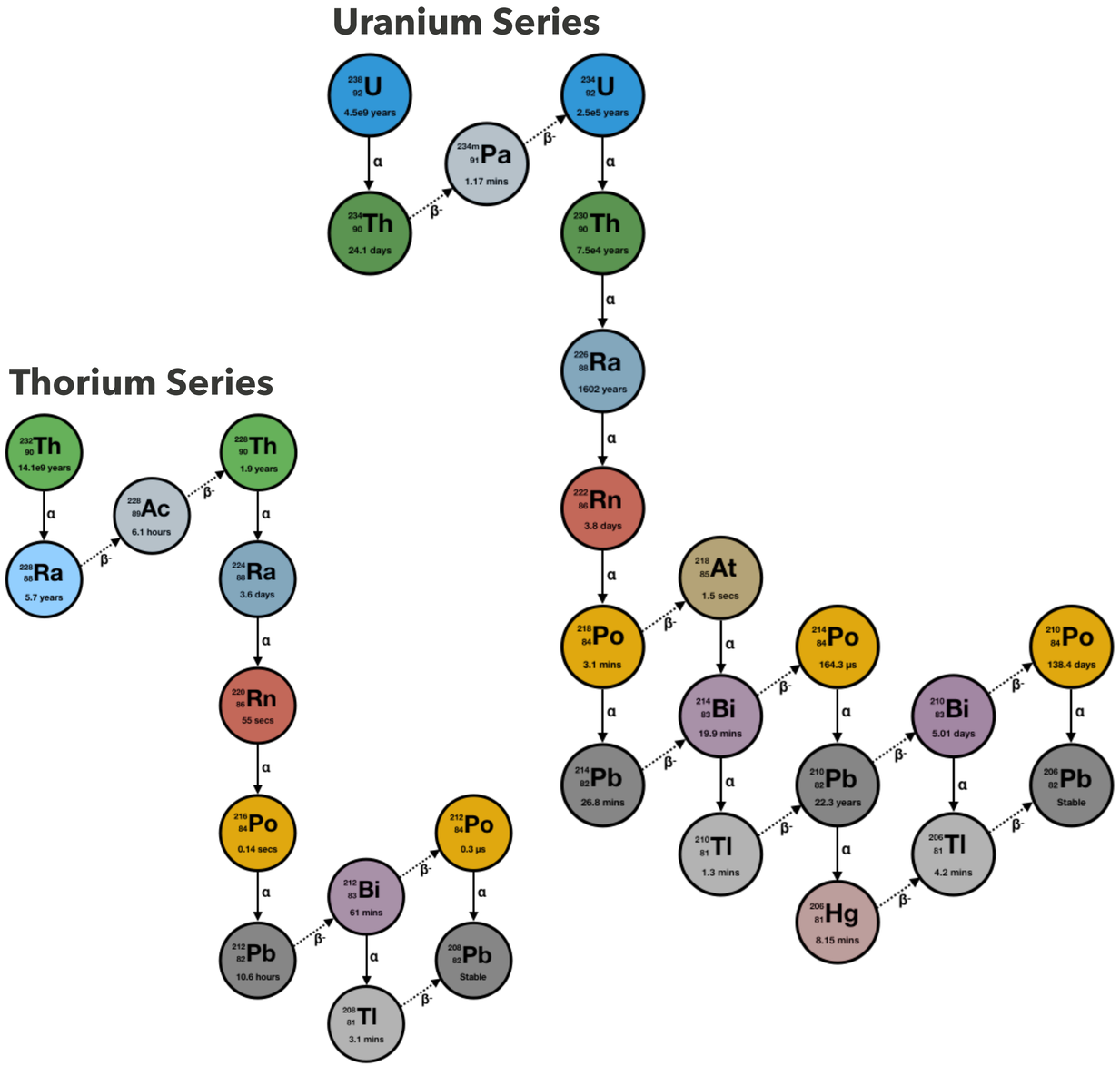


1195 ER events → **5.97 events will leak into the signal region**

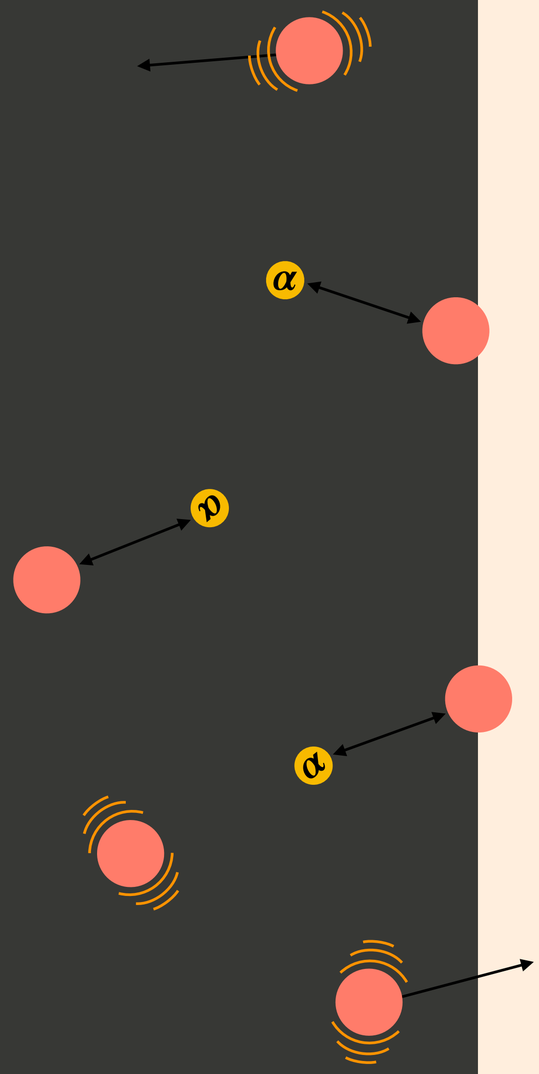


[Projected WIMP sensitivity of LZ, arXiv:1802.06039v1 – 2018]

Origin of Radon



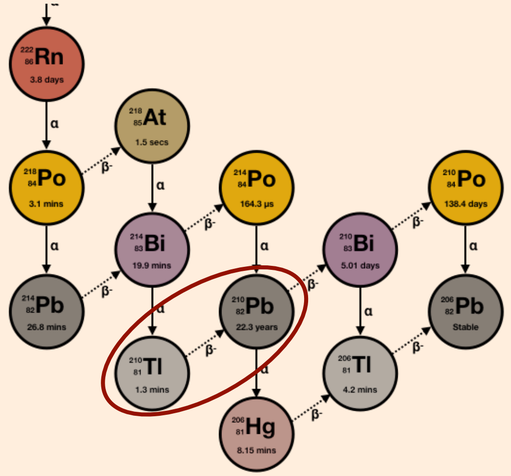
- Traces of ^{238}U & ^{232}Th found in everything
- Including material/components used in low background experiments
- Background contributions from different regions of the chain – **betas & gammas**
  - Betas/Gammas –> Electron Recoil
- Alphas from the chain can undergo **(alpha, n)** reactions and produce neutrons
  - Neutrons –> Nuclear Recoil
- **Radon** is the decay product of radium



Radon in LZ

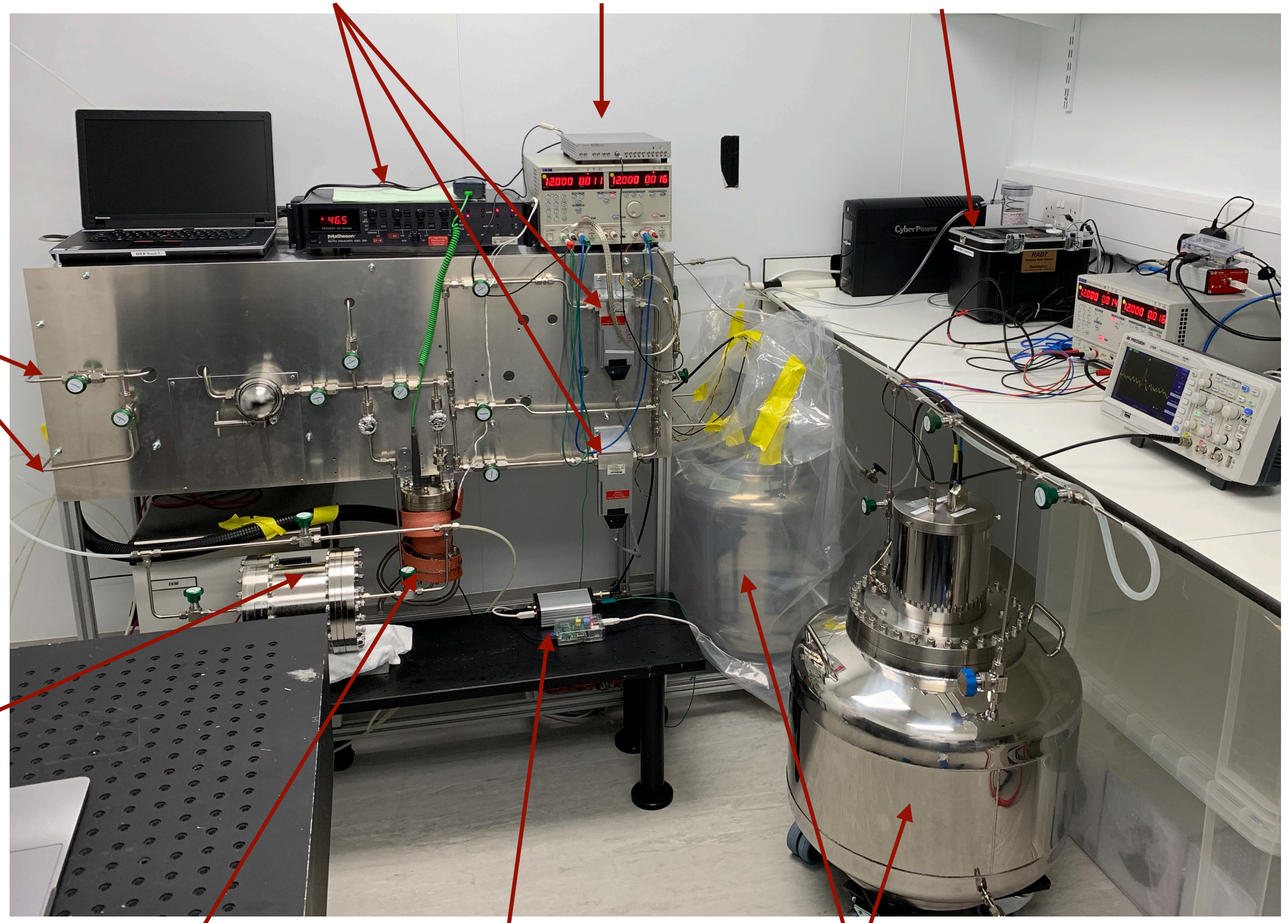
(& other low-background experiments)

- Radon is a noble/inert gas –> emanate out of material via recoil or diffusion
- Half-life of 3.82 days –> once in xenon (liquid or gas), mixes uniformly
- Background mainly from the “naked” beta emission from lead-214 (in radon-222 subchain)
- All LZ components that are in contact with GXe & LXe are screened



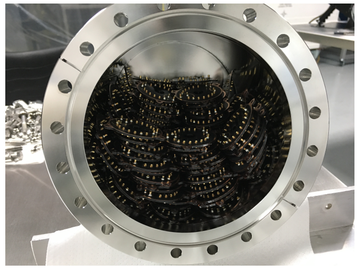
Liquid/Gaseous Xenon

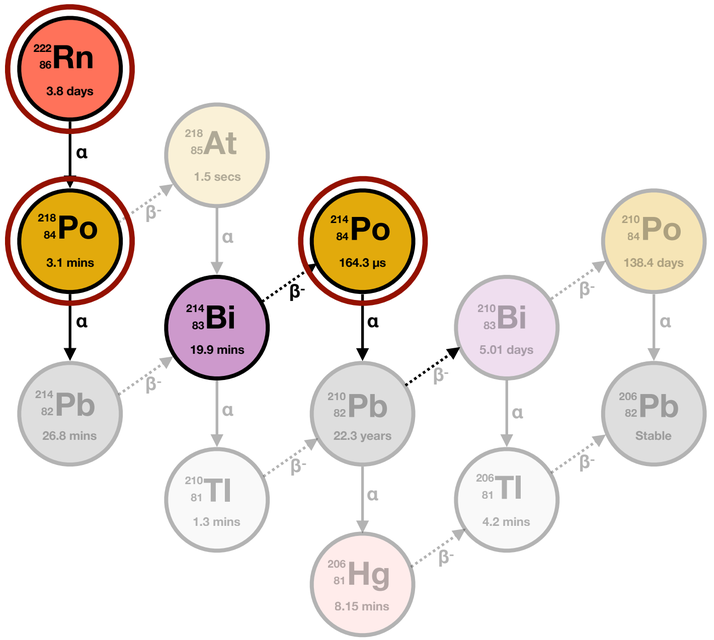
Radon Screening @ UCL

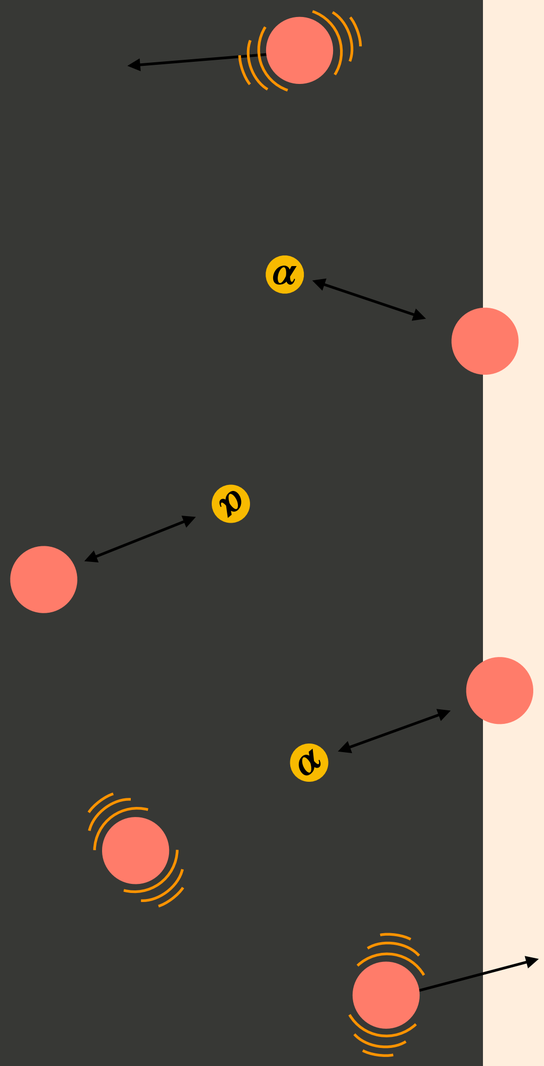


LZ HV Components

LZ 1" & 3" Bases

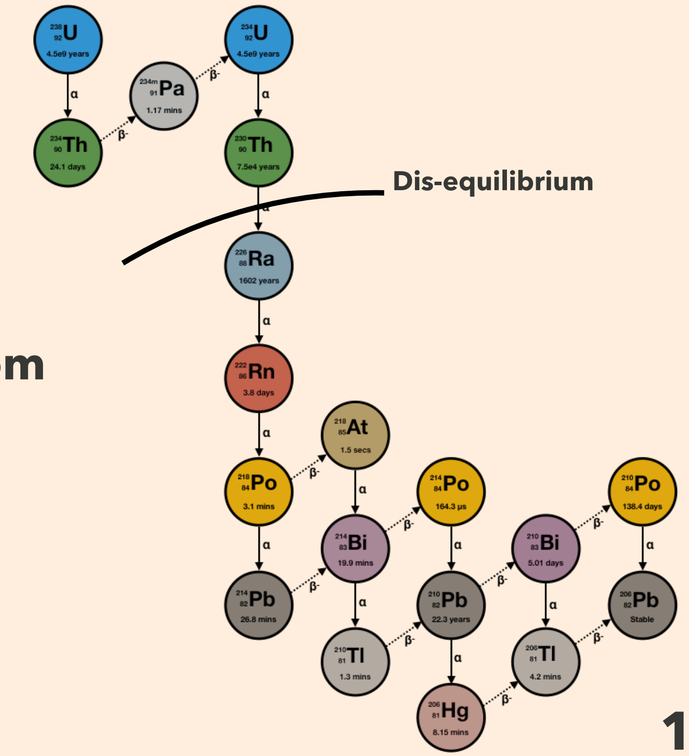




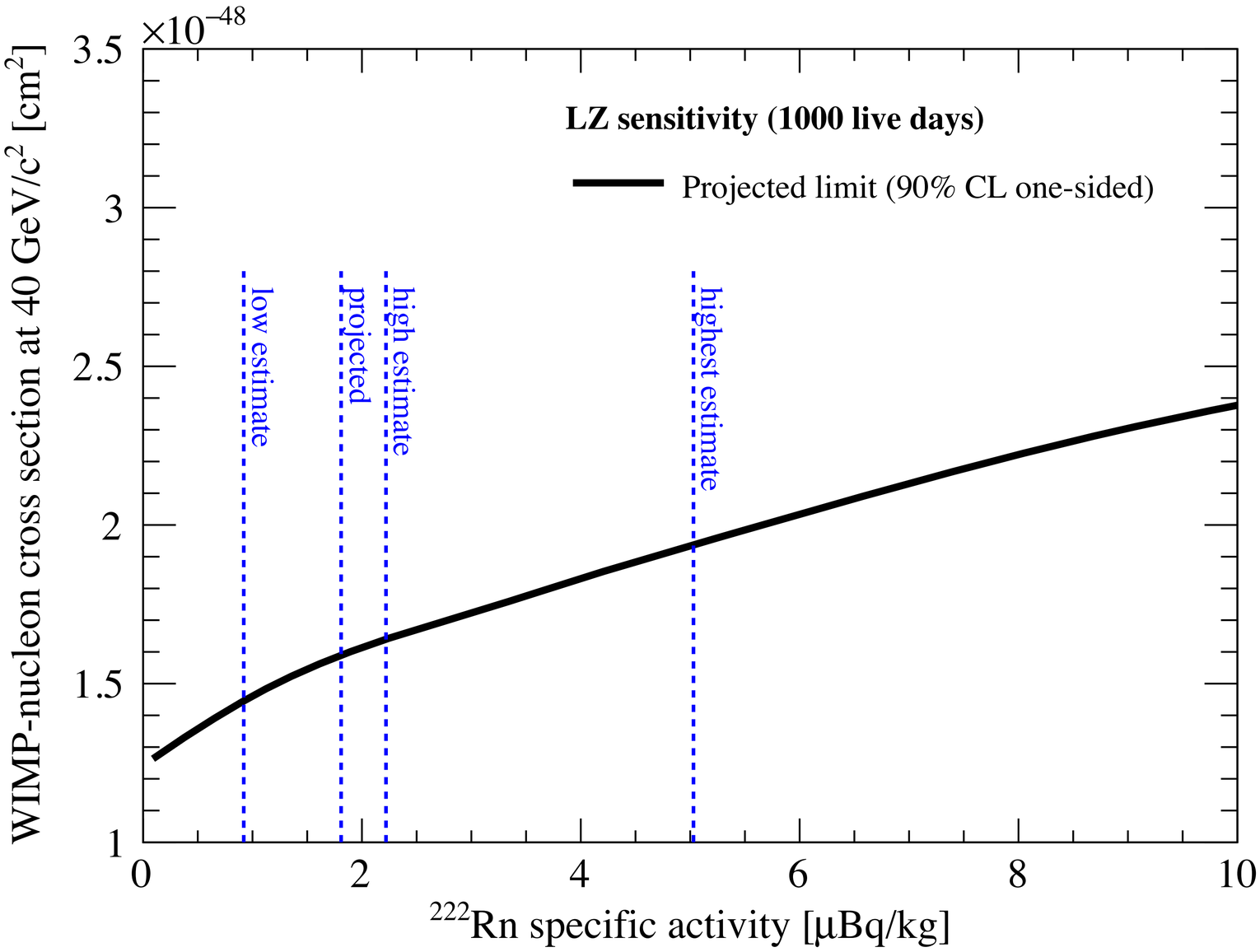


The Issues…

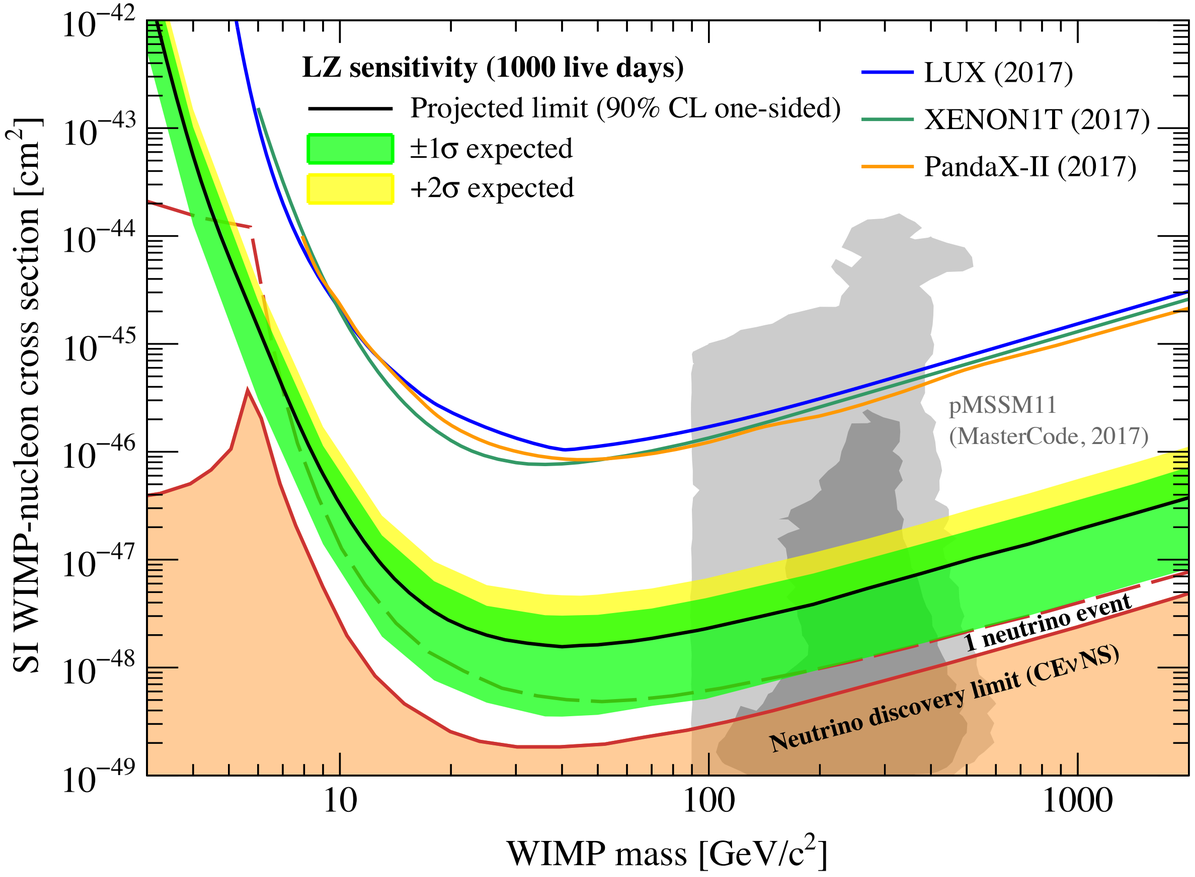
- Despite all the screening efforts, there remains large sources of uncertainty in interpreting emanation results as background rates in detector…
  - Emanation rates depend on:
    - Temperature – diffusion is temperature dependent
    - Emanation medium – gas vs liquid
    - Surface geometry
    - Material structure & density
  - Chain is often broke
  - Roughly 1/2 of radon in LZ is expected from dust (500ng/cm²)

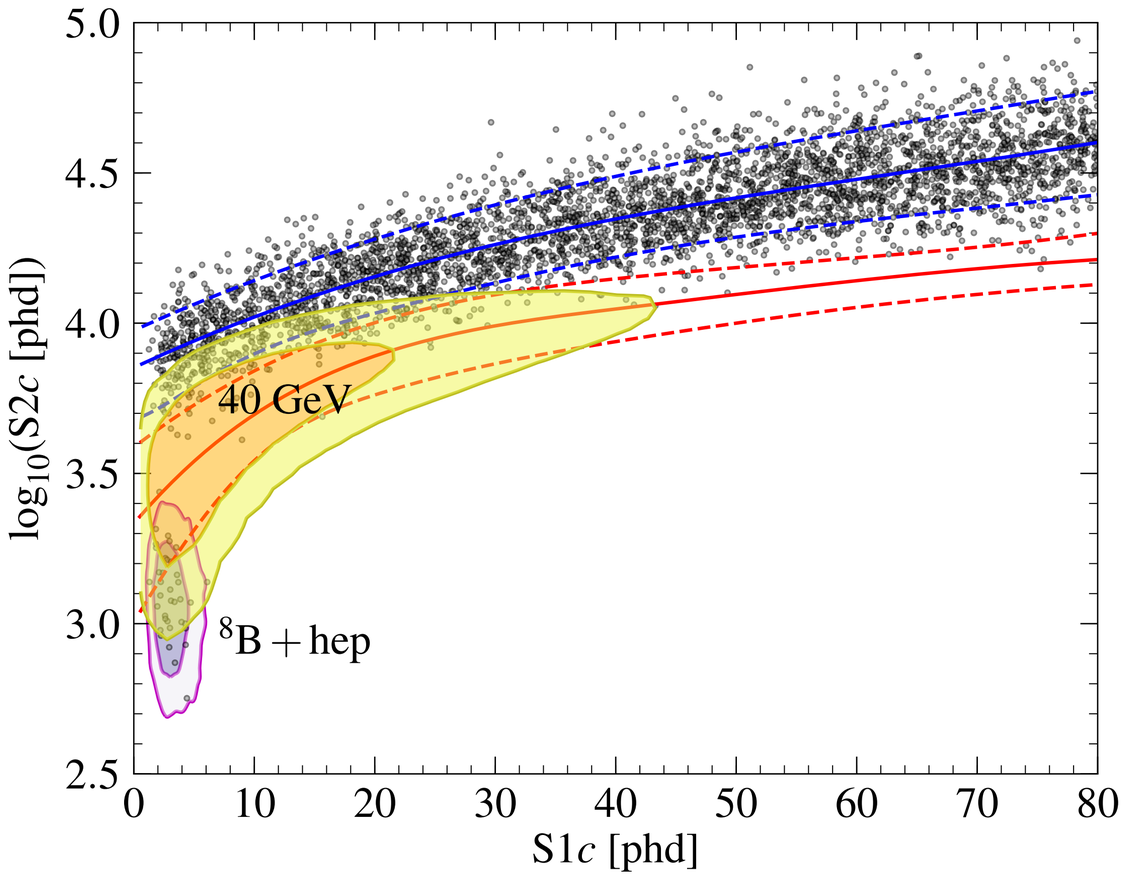


LZ SI WIMP Sensitivity vs Radon



Towards G3 Dark Matter (and more)



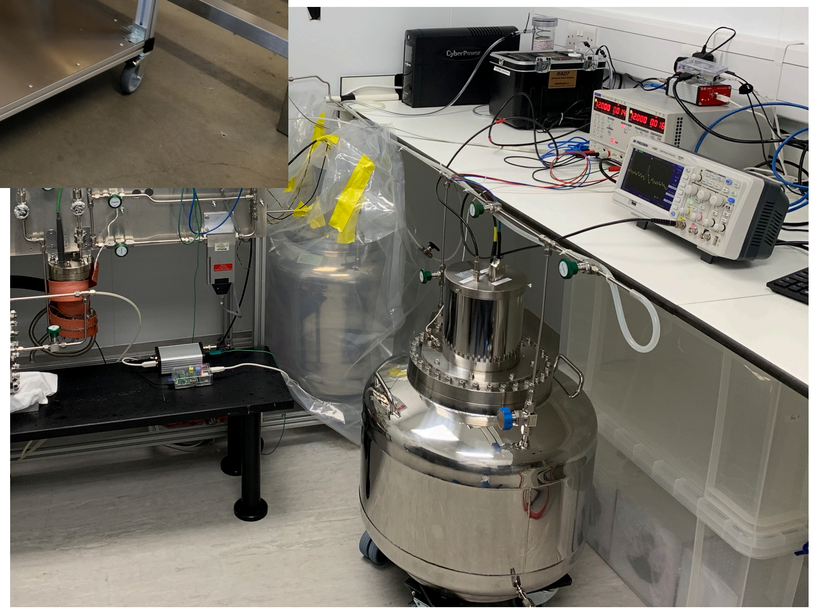


Understanding radon is vital for any G3 DM & 0νββ experiments

Cold Radon Emanation @ UCL/RAL

Concentration line

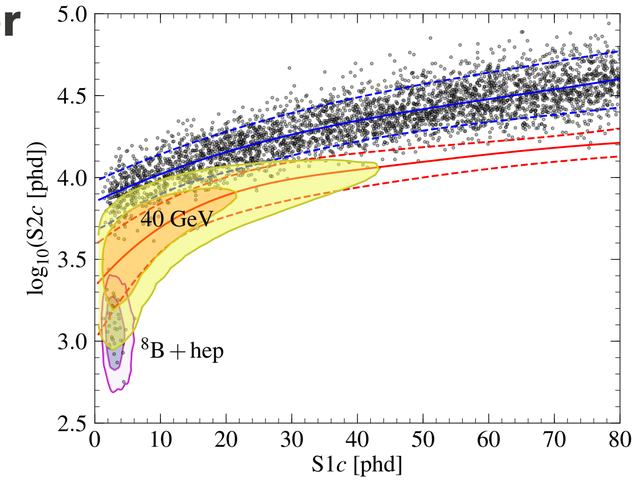
Si PIN-diode detector

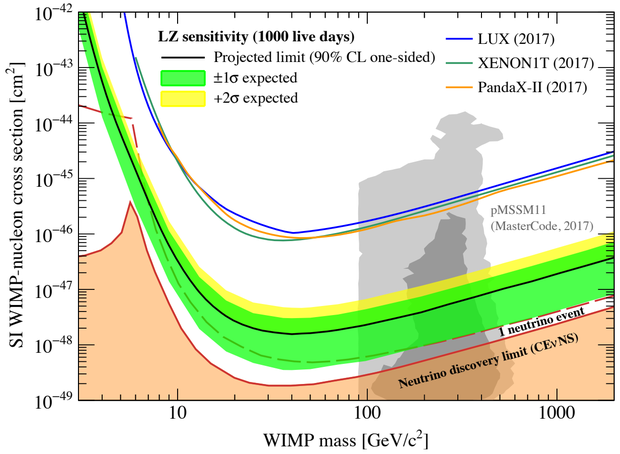


- New gas system with added capabilities
- ULB detector with reduced intrinsic radon background
- Goal is to understand and reduce uncertainties…
  - radon emanation rates vs temperature
  - emanation from diffusion vs recoil for different detector material
  - better material selection and background estimation

Conclusion

- Radon is the largest background for LZ WIMP ROI – making up ~66% (819) of all ER events
- Uncertainty on radon mainly due to lack of data/modelling
- Radon emanation at low temperatures (LXe) is not understood –> room for investigation with new ULB radon system!
- G2: dark matter detectors are mainly focused on WIMPs
  – ER band physics is a lot more challenging with radon!
- G3: radon needs to better understood and reduced in order achieve
  - WIMP sensitivities down to neutrino floor
  - Solar neutrino physics with ER band
  - 0νββ more accessible





Thanks for listening!
Questions?