Study of background from tritium and ^{37}Ar decays in LZ using Monte Carlo simulations

LABORATÓRIO DE INSTRUMENTAÇÃO
E FÍSICA EXPERIMENTAL DE PARTÍCULAS

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Dark Matter

- Observations of gravitational effects show that 85% of the matter content of the universe does not emit or absorb electromagnetic radiation
- We call this contribution “dark matter”
- Cannot be explained in terms of known elementary particles from the Standard Model
- Evidence for Physics beyond the Standard Model

Weakly interacting massive particles (WIMPs)

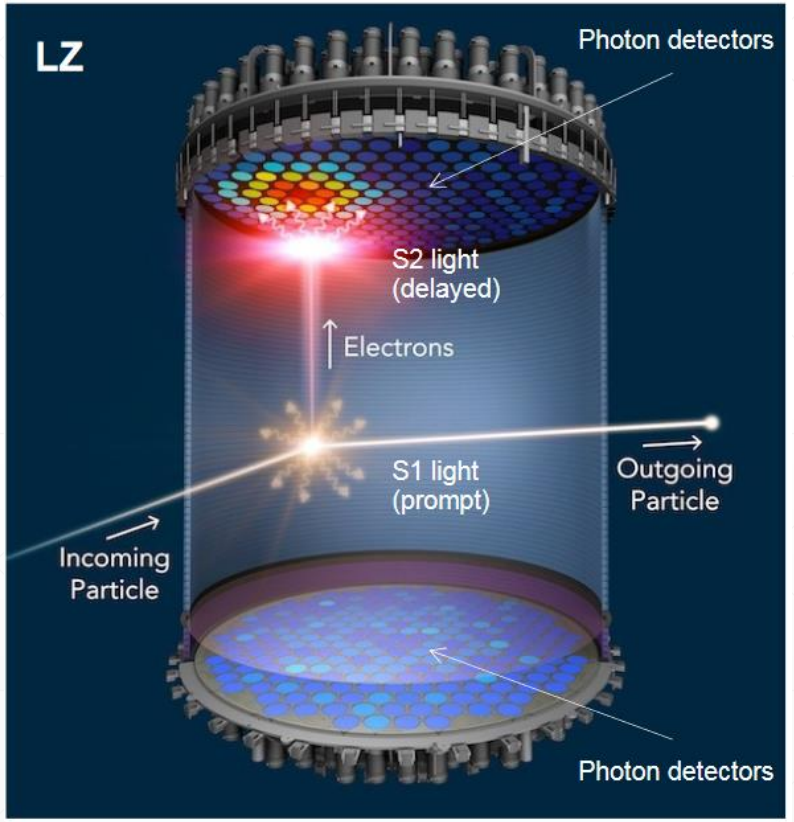
- Proposed candidate for dark matter
- Standard Model's weak interaction with matter
- Mass between 10 and 100 GeV

Direct Search for Dark Matter

- Detecting recoil of dark-matter particles off target nuclei (which is in the keV range)
- Radioactivity and cosmic rays are a common source of background in that energy range
- Accurately describing backgrounds is of extreme importance for sensitivity

LUX-ZEPLIN (LZ) experiment

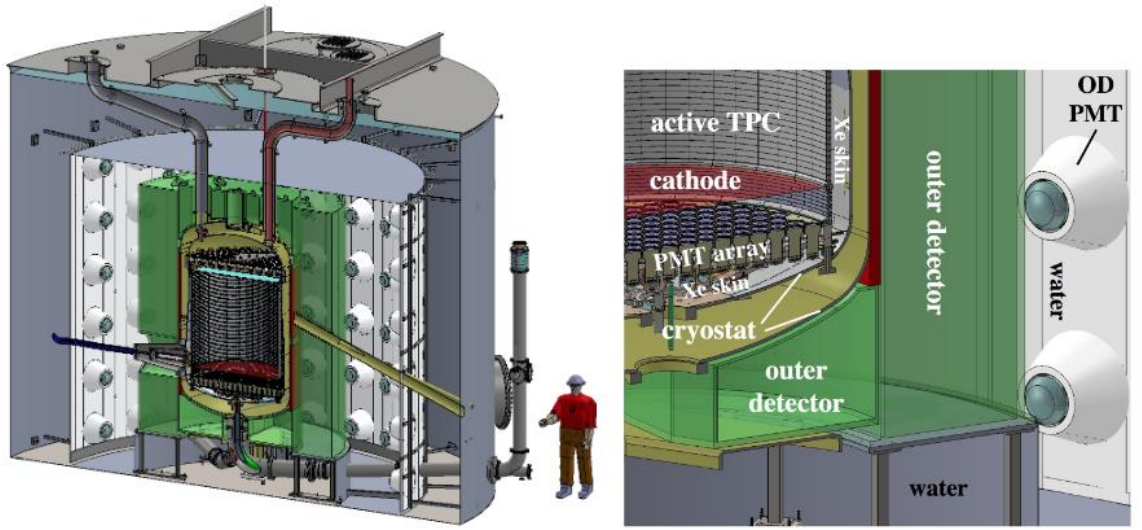
- WIMP detector
- Formed in 2012 by combining the LUX and ZEPLIN groups
- Collaboration of 30 institutes in the US, UK, **Portugal** and Russia



Detection in the LZ experiment

LUX-ZEPLIN (LZ) experiment

- Two-phase xenon detector
- 1.5 km underground at the Sanford Underground Research Facility (SURF)
- Active mass of 7 tonnes
- 5.6 tonne fiducial mass
- Will observe for 1000 days
- Construction underway as of 2020!



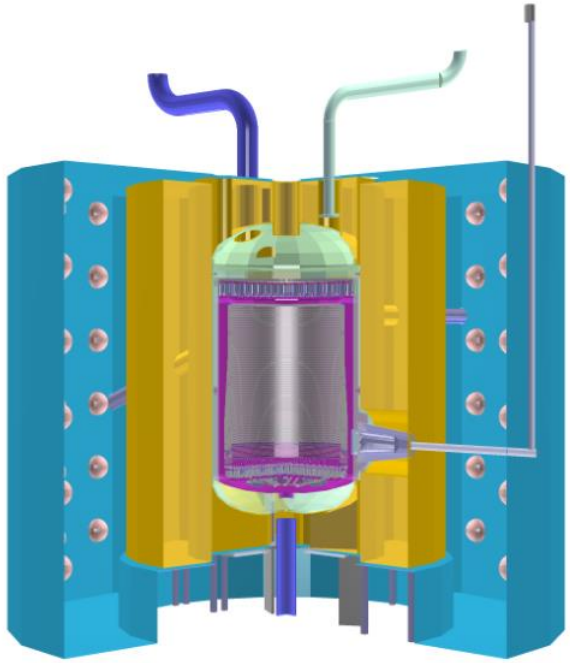
The LZ experiment

GEANT4

- Widely used simulation toolkit in particle physics
- Simulates the interaction of radiation with matter with Monte Carlo methods
- Also has applications in medical physics, nuclear engineering and astronautics

BACCARAT

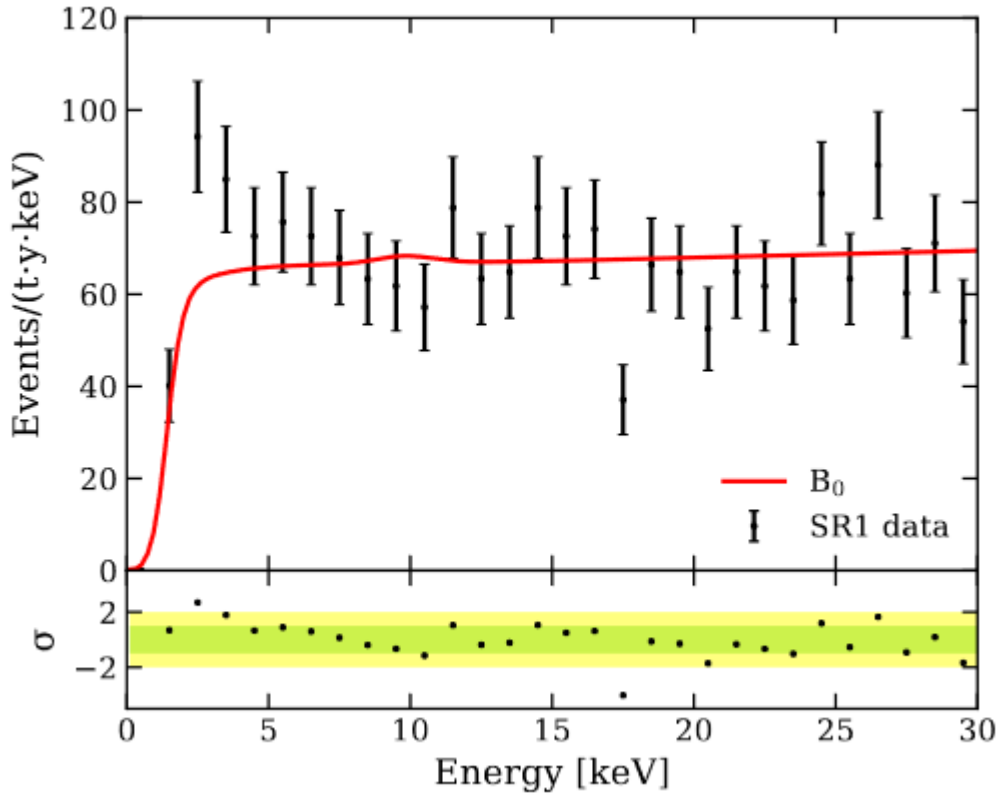
- **B**asically **A** **C**omponent-**C**entric **A**nalog **R**esponse to **A**ny**T**hing
- In-house software package that brings an interface for Geant4 with optimized organization for experiments like LZ
- Focus towards individual volumes in the geometry



LZ as seen in BACCARAT

XENON1T excess

- XENON1T was a smaller two-phase xenon detector also built for the search for dark matter
- Recently reported an excess of electron recoil events below 5 keV
- Several possibilities:
  - New physics
  - ^{37}Ar
  - Tritium



Measured and predicted background in XENON1T

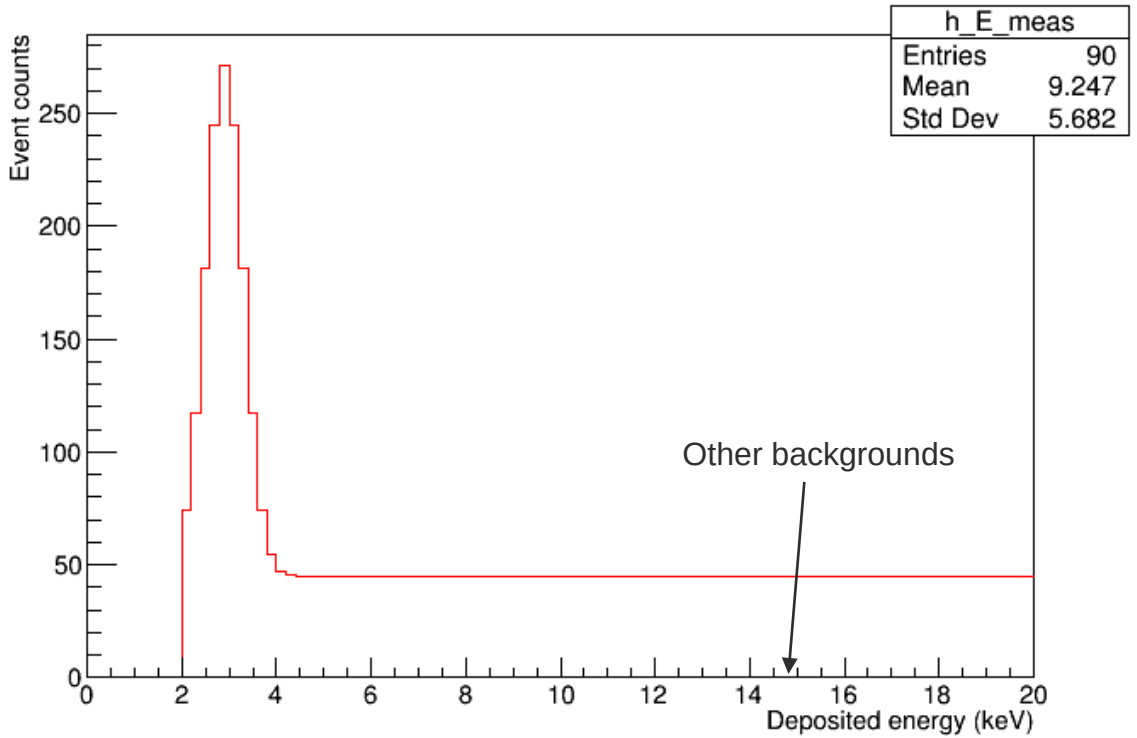
Simulations

- We simulated 10000 events for the decay of ^{37}Ar and Tritium
- Normalization assuming same levels observed in the XENON1T excess
- Added contribution from the rest of the backgrounds produced by the LZ collaboration

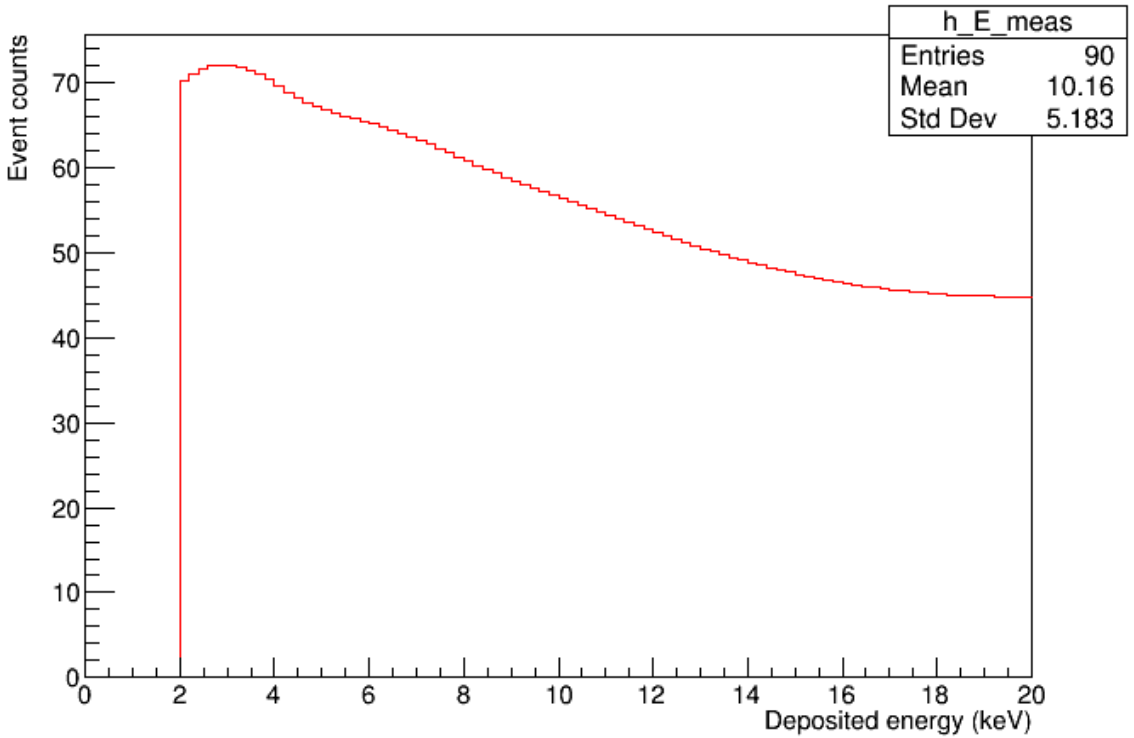
(reference 1)

- Smeared the resulting spectrum by the energy resolution function measured by XENON1T assuming a gaussian distribution

Results



Simulated ^{37}Ar



Simulated Tritium

Conclusion

- This work represents the first study of background from Tritium and ^{37}Ar decays in LZ
- Additionally, our simulations seem support the hypothesis that the decay of ^{37}Ar could be the cause of the excess observed in XENON1T

References

- arXiv:1802.06039 Projected WIMP sensitivity of the LUX-ZEPLIN
- arXiv:2001.09363 Simulations of Events for LUX-ZEPLIN
- arXiv:1806.07043 Production Rate Measurement of Tritium and Other Cosmogenic Isotopes in Germanium with CDMSlite
- arXiv:2006.09721 Observation of Excess Electronic Recoil Events in XENON1T
- arXiv:2007.00528 Investigating the XENON1T Low-Energy Electronic Recoil Excess Using NEST