The LZ Dark Matter detector

28th Texas Symposium on Relativistic Astrophysics

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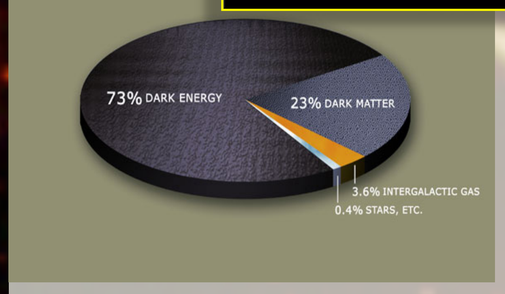
on behalf of the LZ collaboration

LZ is a second-generation dark-matter experiment designed to achieve unprecedented sensitivity to weakly interacting massive particles (WIMPs) of masses from a few GeV/c^2 to hundreds of TeV/c^2. With total liquid xenon mass of about 10 tonnes, LZ is planned to achieve a sensitivity to WIMP-nucleon spin-independent cross section approaching 2X10^{-48} cm^2 in 3 years of operation. This represents an improvement of almost three orders of magnitude over current results, covering a substantial range of theoretically-motivated dark matter candidates. We will present aspects of LZ's designs that permit achievement of this planned sensitivity.

Introduction

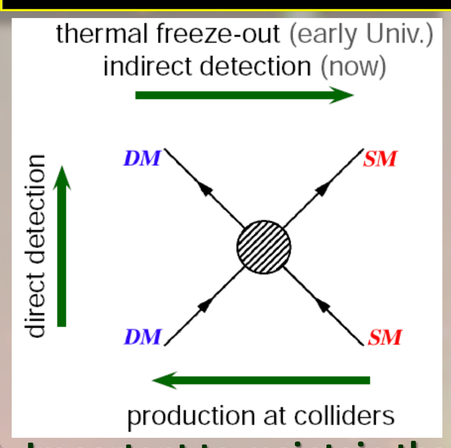
The Dark matter Problem



A real challenge for experimentalists to study this known energy denisty

- There is a known effect looking for an answer.. as opposed to a known solution looking for an experimental effect.
- **Postulate–1**:DM is a particle.
- **Postulate–2**:DM and SM particles interact with some force that is very weak but much stronger than gravity.

Detection Techniques

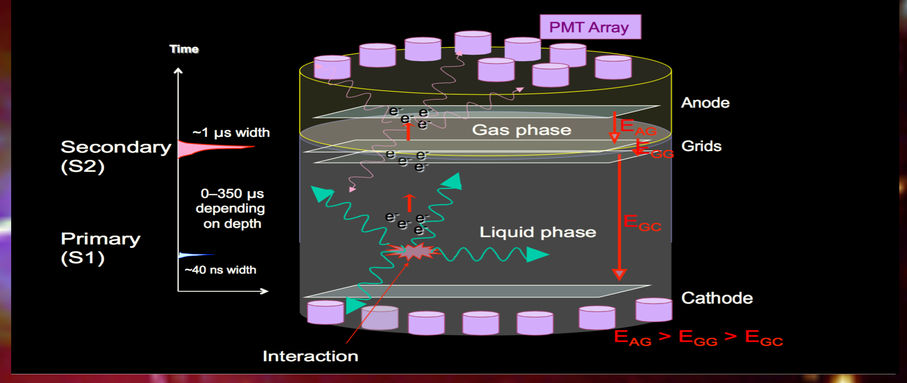


- Important to maintain the theoretical conenction between these 3 approaches

Direct Detection

- ✓ **Basic goal:** Search for nuclear recoil from DM elastic scattering
- ✓ Simple dynamics: Cross section α (form factor)^2

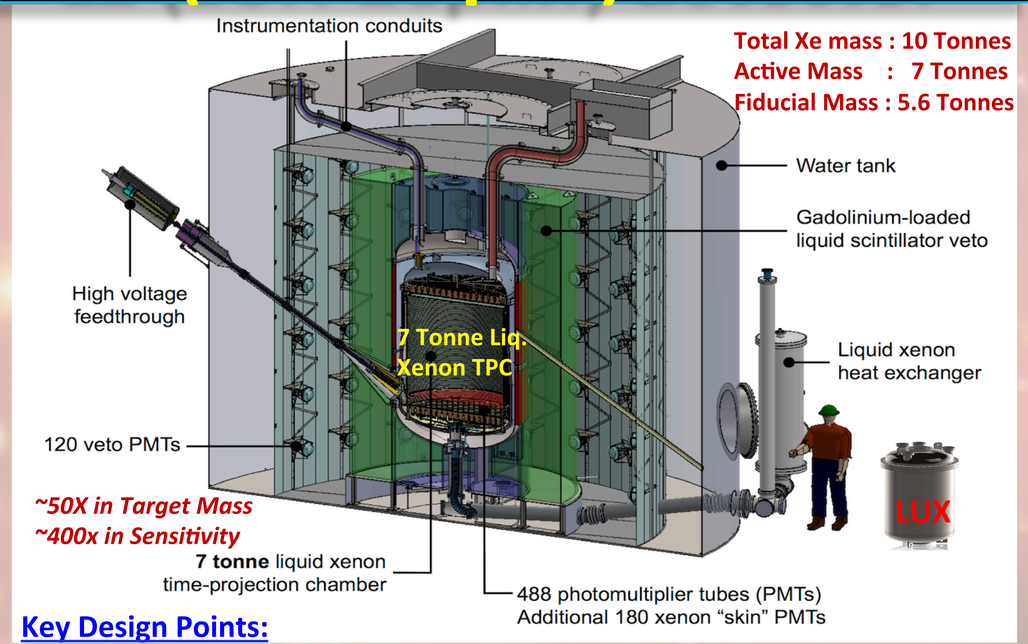
Two-phase Xenon TPC (Time projection Chamber): Two Signal technique



LZ (LUX-Zeplin) detector

LZ: Evolution of LUX and ZEPLIN

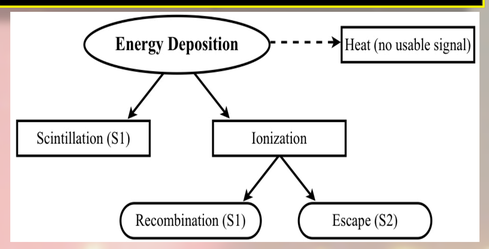
- LUX water shield and an added liquid scintillator active veto.
- Instrumented "skin" region of peripheral xenon as another veto system.
- Unprecedented levels of Kr removal from Xe.
- Radon suppression during contruction, assembly and operations.
- Photomultipliers with ultra-low natural radioactivity.
- Cryogenics and Xe purification systems made external to the mai detector in a unique design.



Key Design Points:

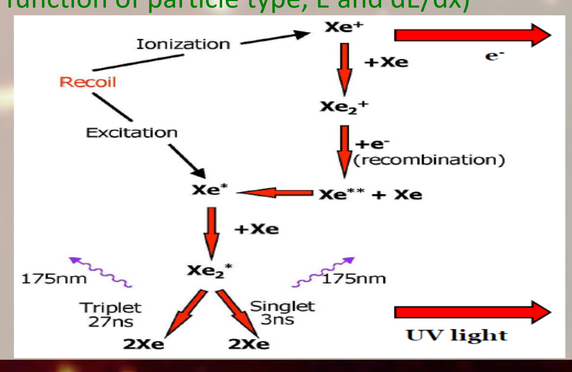
- Xe detector – Good light collection, background rejection (ER discrimination) and signal detection efficiency.
- Sophisticated Veto System – Skin (outside active Xe region) + scintillator/water allows maximum fiducial volume to be obtained, maximize use of Xe and substantially increases reliability of background measurements
- Control backgrounds, both internal (within the Xe) and external from detector components/environment.

Scintillation process in LXe



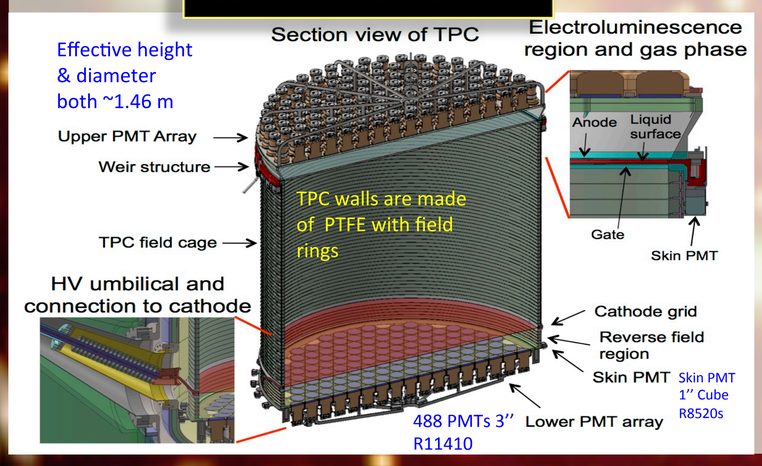
- Difference in recombination efficiency used to discriminate between electron and nuclear recoil.
- Xenon is transparent to its own scintillation light.
- Figure of merit derived from plots of Log (charge escaping recombination/total primary light produced).

Noble Element Simulation Technique (NEST):
Data driven model – Explain scintillation and ionization yields of noble elements (as function of particle type, E and dE/dx)

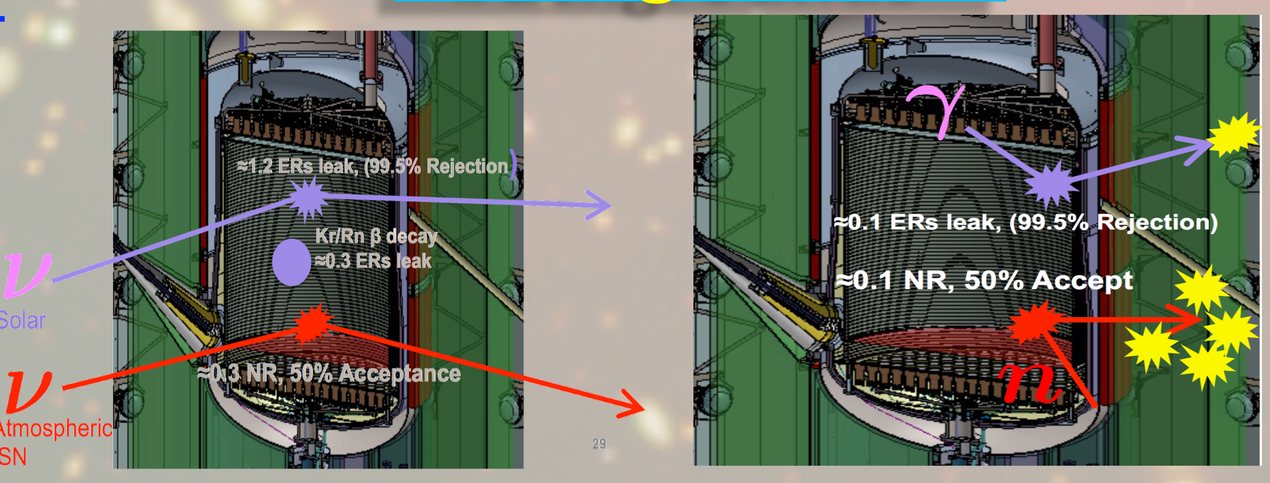


Liquid detectors : "easy" scaling

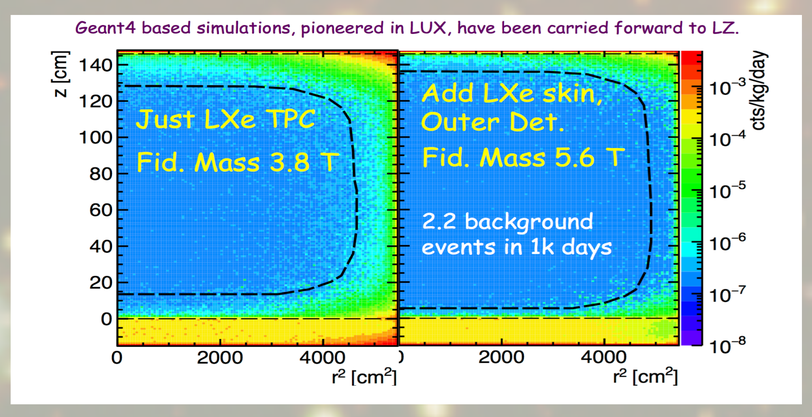
Section View of TPC



Backgrounds



- Maximize WIMP Target mass
- Self-shielding necessary
- Two component outer detector



Results

Expected Limit for 5.6 T fiducial ~ 1000 days

2X10^{-48} cm^2

Expected background for 5.6 T fiducial ~ 1000 days

Item	Mass kg	U mBq/kg	Th mBq/kg	^{60}Co mBq/kg	^{40}K mBq/kg	n/yr	ER cts	NR cts
R11410 PMTs	93.7	2.7	2.0	3.9	62.1	373	1.24	0.20
R11410 bases	2.7	74.6	29.1	3.6	109.2	77	0.17	0.03
Cryostat vessels	2,140	0.09	0.23	≈0	0.54	213	0.86	0.02
OD PMTs	122	1,507	1,065	≈0	3,900	20,850	0.08	0.02
Other components	-	-	-	-	-	602	9.5	0.05
Total components							11.9	0.32
Dispersed radionuclides (Rn, Kr, Ar)							54.8	-
^{136}Xe 2νββ							53.8	-
Neutrinos (ν-e, ν-A)							271	0.5
Total events							391.5	0.82
WIMP background events (99.5% ER discrimination, 50% NR acceptance)							1.96	0.41
Total ER+NR background events							2.37	

LZ holds the promise to be the ultimate WIMP search experiment, limited by neutrino – induced background. Projected commissioning in Feb. 2019

1915 – 2015

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International Conference Centre Geneva

References

[1] M. Szydagis et al., JINST 8 (2013) C10003. arxiv:1307.6601

[2] *LUX-ZEPLIN (LZ) Conceptual Design Report, arxiv: 1509.02910*

Acknowledgement

Thanks to Texas conference committee for accepting my abstract