LZ : DARK MATTER EXPERIMENT

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ON BEHALF OF LZ COLLABORATION
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COMPONENTS OF OUR UNIVERSE

DARK MATTER: one of the GREATEST UNSOLVED MYSTERIES of the UNIVERSE!!!
UNDERGROUND DARK MATTER EXPERIMENTS

LUX + ZEPLIN = LZ

ZEPLIN DRIFT
EDELWEISS
KIMS

CDMS CoGENT

LUX LZ
DEAP - 3600 & MiniCLEAN
PICASSO COUPP SuperCDMS

DAMA/LIBRA DarkSide
XENON1T XENONnT

PandaX CDEX
XMASS
Located 4,850 ft underground in Sanford Underground Research Facility (SURF), Lead, South Dakota
LZ Collaboration meeting at Rutherford Appleton Laboratory, UK (6 - 10 January 2020)
WORKING PRINCIPLE

- Uses 7 tons of liquid Xenon as target for collisions with dark matter (DM) particles
- DM particles scatter target nuclei (billiard ball collision) producing scintillation photons ‘S1’ signal and recoil electrons
- Ionization electrons are accelerated to the liquid surface by the electric field
- Ionization electron excites and ionizes gaseous Xe atoms creating a secondary scintillation signal ‘S2’ signal
- Signals are detected by Photomultiplier tubes (PMTs)
INSTRUMENT OVERVIEW

The LZ Detector

- 7 tonne liquid xenon time-projection chamber
- Instrumentation conduits
- Existing water tank
- Gadolinium-loaded liquid scintillator
- 120 outer detector PMTs
- Liquid Xe heat exchanger
- High voltage feedthrough
- 494 photomultiplier tubes (PMTs)
- Additional 131 xenon “skin” PMTs
- Neutron beam pipes
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TOP & BOTTOM ARRAY OF PMTs
Skin & Outer Detector — operates as an integrated veto system — rejecting gammas and neutrons that mimic DM particle signals.
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To mitigate cosmogenic backgrounds
TIME PROJECTION CHAMBER

- Core of the LZ experiment ~ TPC is 150 cm tall and 150 cm wide, containing 7 tonnes of ultra-pure cryogenic liquid Xe.
- Highly reflective PTFE panels ~ efficient measurement of the initial S1 scintillation signal.
PMTs

BOTTOM PMT ARRAY
SKIN & OUTER DETECTOR

- Instrumented Xe ‘skin’ to veto gamma rays
- Outer detector to veto neutrons

Liquid scintillator is doped with 0.1% Gd (Gd-LS) and held in large acrylic vessels

Acrylic vessel containing liquid scintillator
A fish-eye view of the water tank

Height: 5.92 m
Diameter: 7.62 m
Dark Matter Experiment’s Central Component Takes a Deep Dive – Nearly a Mile Underground

LUX-ZEPLIN experiment’s time projection chamber is successfully moved to its research cavern

News Release • October 29, 2019
LZ simulation for a background-only 1000 liveday run and a 5.6 tonne fiducial mass

**BACKGROUNDS**

**External Sources**

- Cosmogenic & Radiation from experiment cavern

**Mitigation:**
- Will operate underground at SURF in Lead, SD
- Measure rock backgrounds: ArXiv:1904.02112
- Instrumented Xe skin region
- Gd-LS outer detector
- High purity water shield

**Internal Sources**

- Radioactive materials in detector components
- Emanation of Radon from detector components
- Rn daughters & dust on surfaces
- Xenon contaminants- Kr, Ar, Rn

**Mitigation:**
- Radio-assay campaign
- Gamma-screening, ICPMS, NAA
- TPC assembly in Rn-reduced cleanroom
- Dust < 500 ng/cm³ on all LXe wetted surfaces
- Rn-daughter plate-out on TPC walls < 0.5 mBq/m²
- Charcoal chromatography at SLAC, California
LZ projected sensitivity to SI WIMP-nucleon elastic scattering for 1000 live days and a 5.6 tonne fiducial mass

A minimum sensitivity of $1.4 \times 10^{-48}$ cm$^2$ is expected for 40 GeV/c$^2$ WIMPs


Physics sensitivity beyond WIMPs: LZ projected sensitivity to $^{136}$Xe $0\nu\beta\beta$ decay as a function of detector live time

SUMMARY

Dark matter - one of the greatest unsolved mysteries of the Universe

LZ - will be the most sensitive & the largest direct detection dark matter experiment!!!

LZ construction is nearly done and it will be entering its operations phase soon!!!

“I’ve either discovered dark matter, or I’ve left the lens cap on.”

STAY TUNED . . .
THANK YOU!