LZ overview and needs for future

Luke Kreczko

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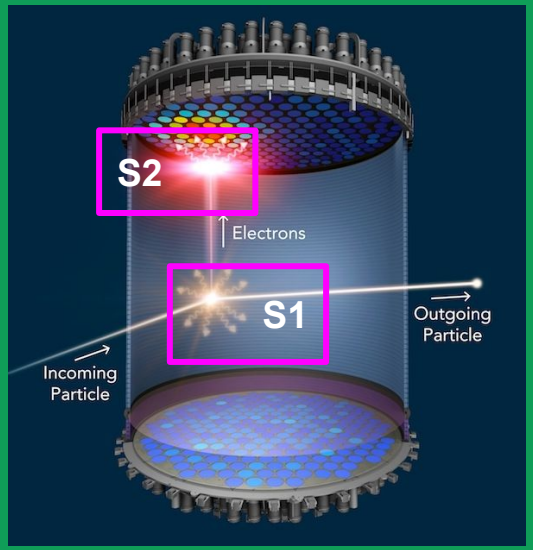
DANCE 2019

University of BRISTOL

Outline

- The Lux-Zeplin (LZ) experiment
- Current computing overview
- Future needs

Lux-Zeplin



Two-phase Xenon TPC experiment for direct Dark Matter (DM) detection (technical design report)

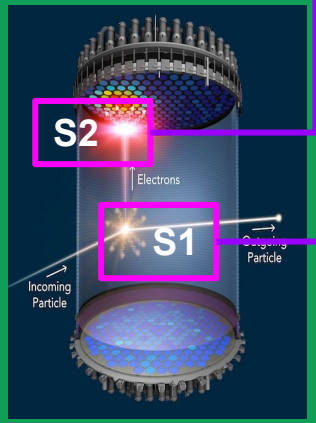
- ~500 PMTs
- 7 tonnes (5.6t fiducial) volume
- Typically looking for two signals (S1 & S2)

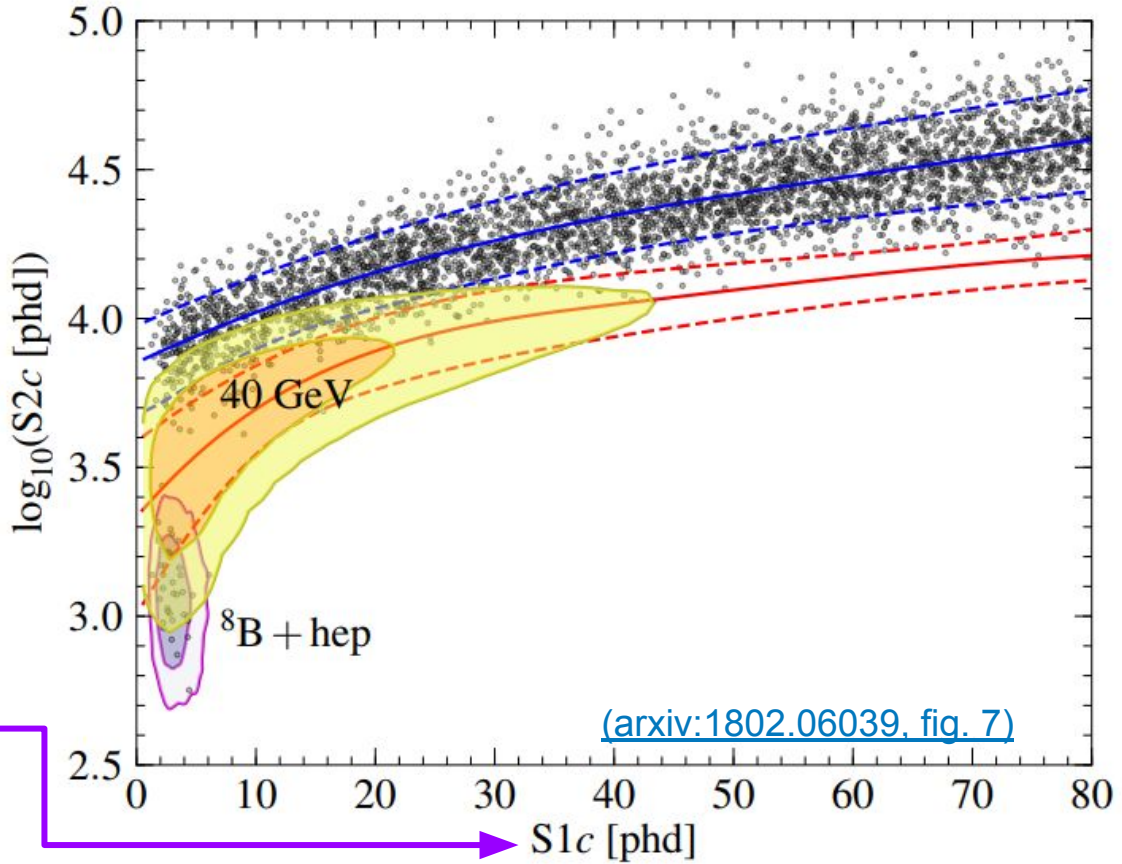
Located at Sanford Underground Research Facility (SURF) in Lead, SD

- 4850 feet (0.9 miles, 1.48 km)
- At the final stages of assembly, main vessel going underground soon (check @lzdarkmatter for latest news)

Physics

Two photon signals separated in time (S1, S2)





(arxiv:1802.06039, fig. 7)

Electron recoils

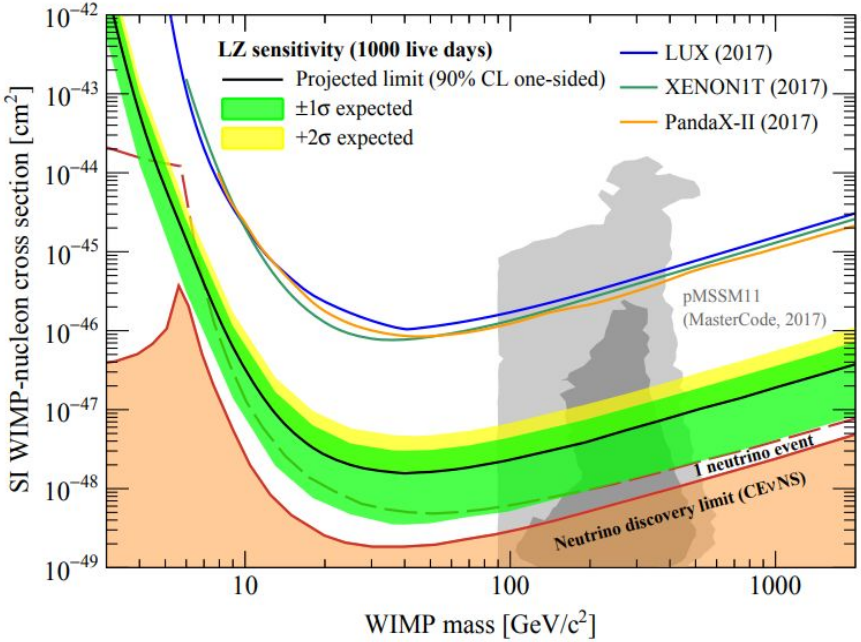
nuclear recoils

Physics

Discover Dark Matter

Measure solar neutrinos

Background	σ/N
^{222}Rn (ER)	10%
pp+^{7}Be+^{14}N ν (ER)	2%
^{220}Rn (ER)	10%
^{136}Xe $2\nu\beta\beta$ (ER)	50%
Det. + Env. (ER)	20%
^{85}Kr (ER)	20%
^{8}B solar ν (NR)	15%
Det. + Env. (NR)	20%
Atmospheric ν (NR)	25%
hep ν (NR)	15%
DSN ν (NR)	50%



(arxiv:1802.06039, fig. 8)

LZ Computing

LZ Computing

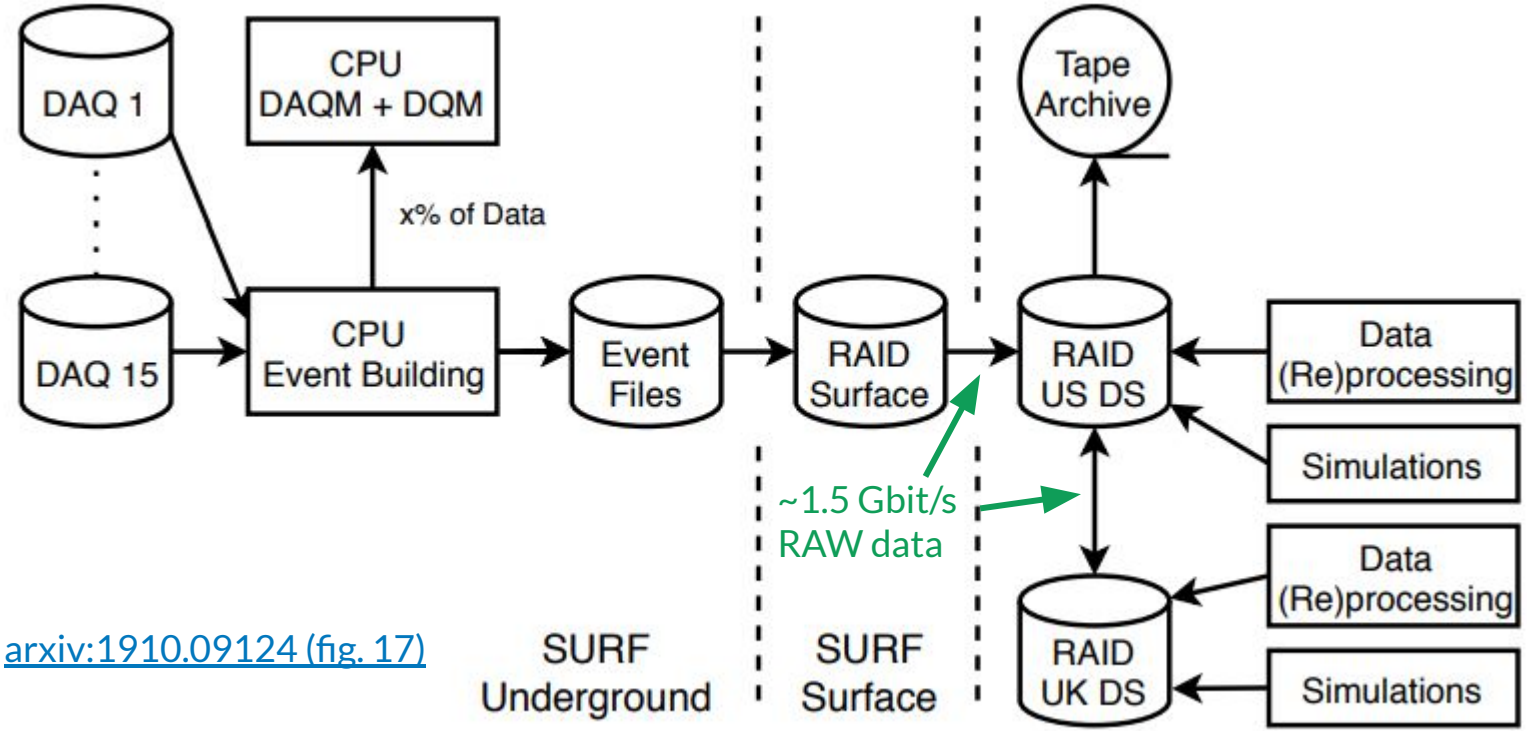
Two main computing and storage locations:

- USDC (NERSC) & UKDC (Imperial College London)
- Using SPADE for data transfers USDC↔UKDC

Software on **CVMFS** (hosted by U. Wisconsin)

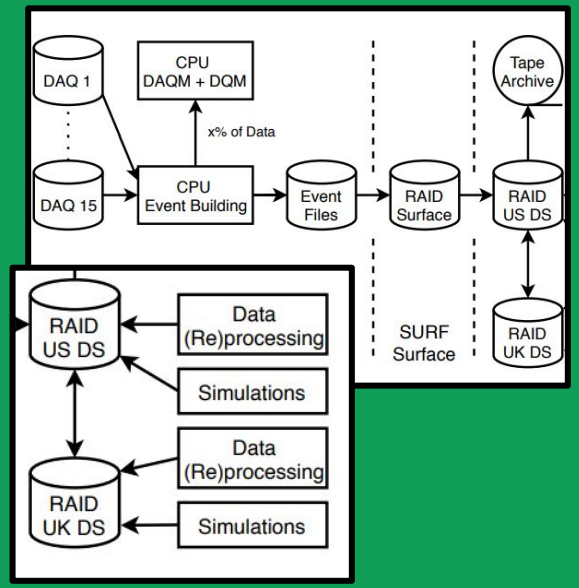
- Using bits of /cvfms/sft.cern.ch
- Building own packages on /cvmfs/lz.opensciencegrid.org

Using **GitLab** (U. Alabama) & **Continuous Integration** (U. Bristol) for building, testing, documentation & validation



arxiv:1910.09124 (fig. 17)

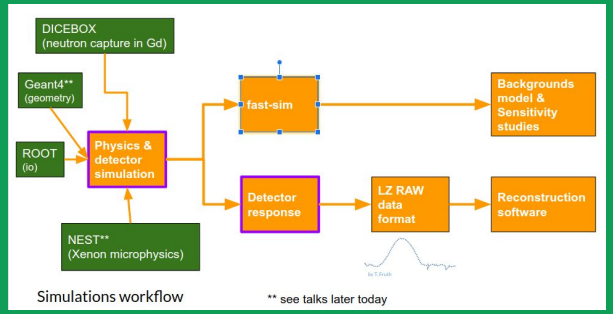
Data acquisition and processing



LZ data acquisition & processing based on Gaudi Framework

- Particle and event reconstruction
- Calibration & applying corrections from conditions database
- Parallel data streams in input → used for Salting
- Offline DQM with Gaudi Histogram Services
- Reduced Quantities with Gaudi ConversionSvc

Simulations
(more details tomorrow)



Describe low-energy liquid Xenon interactions with

- Electrons → electron recoils (ERs)
- Nuclei → nuclear recoils (NRs)
- WIMPs → similar to NRs

Photon (175 nm) & low-energy electron propagation

- Drifting low-energy electrons in electric field
- Millions of photon through a transparent medium

Accurate **P**hoto**M**ultiplier **T**ube (PMT) response

- Photon pulses as close to real data as possible

Mock Data Challenges

Testing computing infrastructure with MDCs

- Both data centres tested independently & compared
- 6 months of simulated data
- Treated as real data for processing & analysis
- Resource use monitored & compared against estimates
- First experiences for analysts with LZ data

Data analysis

uproot

FAST HEP

Data analysis requirements:

- Easy to set up, reproducible, quick iterations

C++ packages based on ROOT, RooFit and RooStats for data analysis & statistical evaluation

Processing fast-sim, full-sim & data (reduced quantities)

Looking into Python analysis with FAST-HEP

Machine learning: See Scott's talk this afternoon

Future needs / whishlist

Saving personpower for “standard tasks”

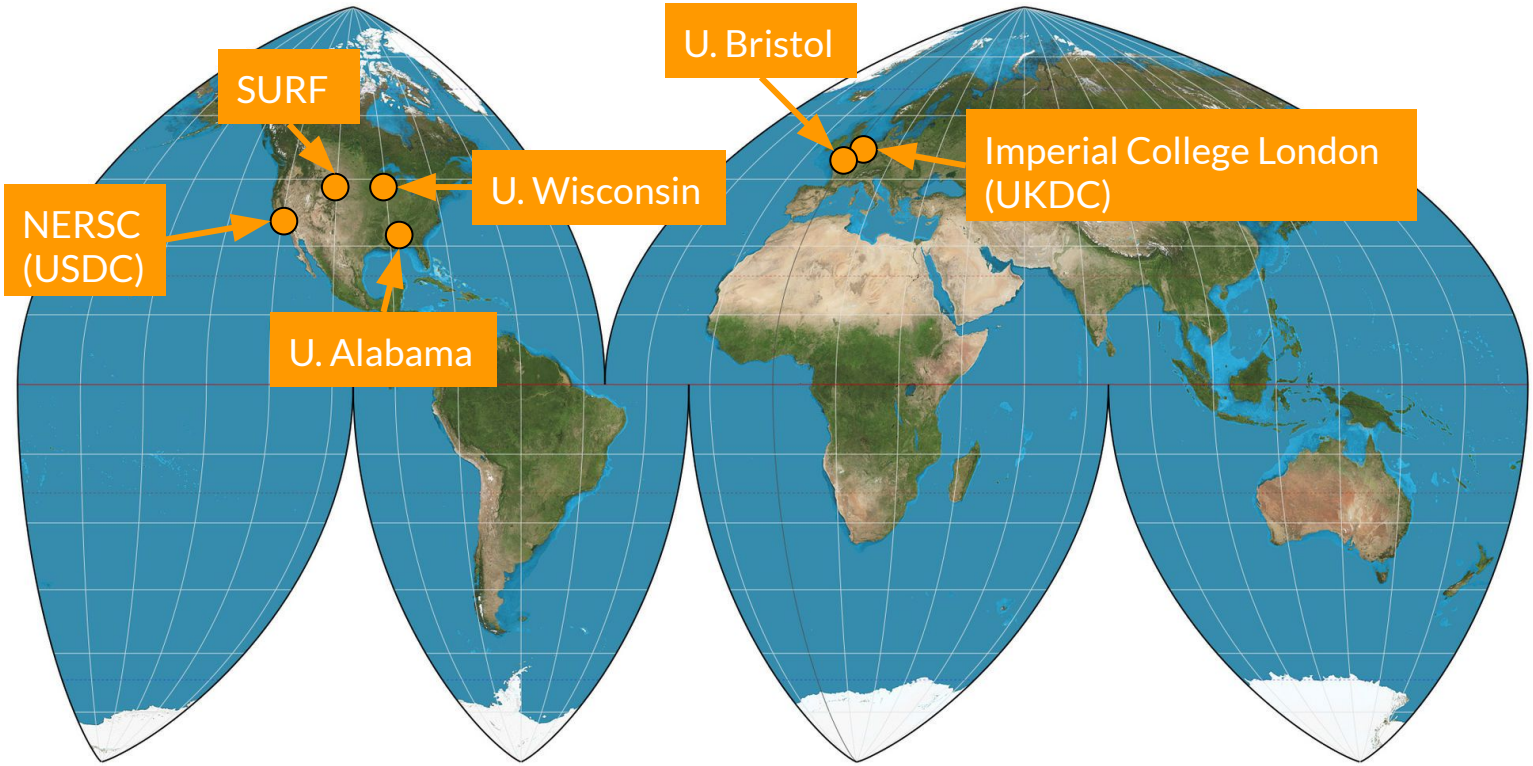
- specialize code for specific architectures & many cores
  - HPC: Perlmutter cluster at NERSC in 2020
  - GPUs? FPGAs?
- sharing high-level tools
  - Rucio seems a good example in other experiments
  - What else can we share in the future?
  - What can we do to strengthen collaboration?
- Related: curated list of “standard”
  - Complete with “this worked, this failed because of XYZ”
  - Computing “How-to for new experiments”

Summary

Thank You

Backup slides

LZ Computing Infrastructure



Solar neutrinos ^{8}B & *hep*

$$p + p \rightarrow {}^2\mathrm{H} + e^+ + \nu_e \ (99.75\%) \qquad p + e^- + p \rightarrow {}^2\mathrm{H} + \nu_e \ (0.25\%)$$

$$\downarrow$$

$${}^2\mathrm{H} + p \rightarrow {}^3\mathrm{He} + \gamma$$

$$\downarrow$$

$${}^3\mathrm{He} + {}^3\mathrm{He} \rightarrow \alpha + 2p \ (86\%) \qquad {}^3\mathrm{He} + \alpha \rightarrow {}^7\mathrm{Be} + \gamma \ (14\%) \qquad {}^3\mathrm{He} + p \rightarrow \alpha + e^+ + \nu_e$$

$$\downarrow$$

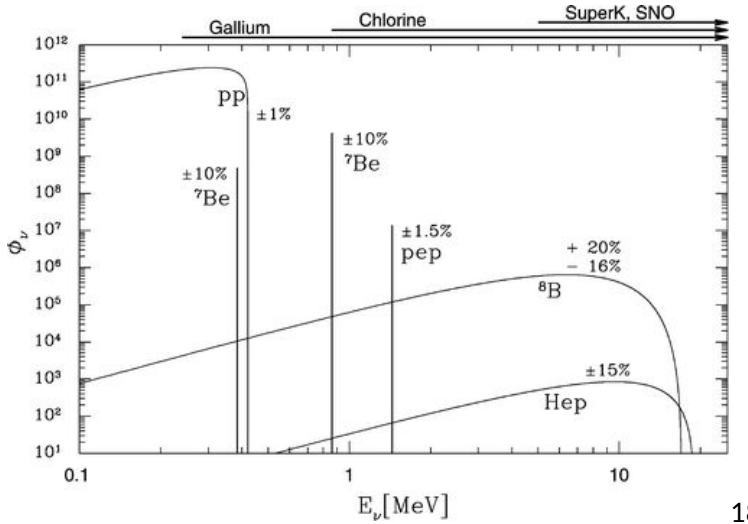
$${}^7\mathrm{Be} + e^- \rightarrow {}^7\mathrm{Li} + \nu_e \ (99.85\\%) \qquad {}^7\mathrm{Be} + p \rightarrow {}^8\mathrm{B} + \gamma \ (0.15\%)$$

$$\downarrow \qquad\qquad \downarrow$$

$${}^7\mathrm{Li} + p \rightarrow 2\alpha \qquad {}^8\mathrm{B} \rightarrow {}^8\mathrm{Be}^* + e^+ + \nu_e$$

$$\downarrow$$

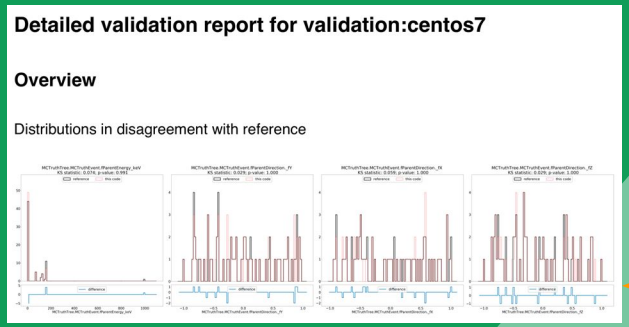
$${}^8\mathrm{Be}^* \rightarrow 2\alpha$$



https://www.annualreviews.org/doi/full/10.1146/annurev.nucl.54.070103.181239

Continuous Integration

Validation powered by scikit-validate



lzbot @lzbot · 3 days ago

BACCARAT CI Report

Pipeline summary

Current pipeline: https://lz-git.ua.edu/sim/BACCARAT/pipelines/9292

name	status	log	software versions
quick-checks:centos7	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
build:centos7	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
unit-tests	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
build:docs	✅	log (raw)	python=3.6.5, gcc=7.3.0, geant4=10.3.2, root=6.16/00
build:debug	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
test:centos7	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
validation:centos7	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00
build:profile	✅	log (raw)	python=2.7.15, gcc=7.3.0, geant4=10.3.2, root=6.16/00

Validation report

job	status	summary	details	mismatch
validation:centos7	failed	4/3773 distributions differ (10 unknown)	details	▶ Display the names of the 4 differing distributions