Markus Horn
on behalf of the LUX collaboration
Overview

• Direct Dark Matter search with LUX
  – collaboration, implementation, u/g operation

• LUX first results

• Calibrations
  – tritiated methane
  – neutron (DD) calibrations

• What’s coming next?
  – Run 4 and re–analysis of 2013 data
**LUX Collaboration**

### Brown University
- Richard Gaitskell: PI, Professor
- Simon Fiorucci: Research Associate
- Samuel Chung Chan: Graduate Student
- Dongqing Huang: Graduate Student
- Casey Rhyne: Graduate Student
- Will Taylor: Graduate Student
- James Verbus: Graduate Student

**Imperial College London**
- Henrique Araujo: PI, Reader
- Tim Sumner: Professor
- Alastair Currie: Postdoc
- Adam Bailey: Graduate Student
- Khadeel Yazdani: Graduate Student
- Lawrence Berkeley & UC Berkeley
  - Bob Jacobsen: PI, Professor
  - Murdock Gilchriese: Senior Scientist
  - Kevin Losko: Senior Scientist
  - Peter Sorensen: Scientist
  - Victor Gehman: Scientist
  - Attila Dobi: Postdoc
  - Daniel Hogan: Graduate Student
  - Mia Ihm: Graduate Student
  - Kate Kamdin: Graduate Student
  - Kelsey Oliver-Mallory: Graduate Student

**University at Albany, SUNY**
- James White: PI, Professor
- Robert Webb: PI, Professor
- Rachel Mannino: Graduate Student
- Paul Terman: Graduate Student

### Lawrence Livermore
- Adam Bernstein: PI, Leader of Adv.
- Kareem Kazkaz: Staff Physicist
- Brian Lenardo: Graduate Student

### LIP Coimbra
- Isabel Lopes: PI, Professor
- Jose Pinto da Cunha: Assistant Professor
- Vladimir Solovov: Senior Researcher
- Francisco Neves: Auxiliary Researcher
- Alexander Lindote: Postdoc
- Claudio Silva: Postdoc

### SLAC Nation Accelerator Laboratory
- Dan Akerib: PI, Professor
- Thomas Shutt: PI, Professor
- Kim Palladino: Project Scientist
- Tomasz Biesiadzinski: Research Associate
- Christina Ignarra: Research Associate
- Wing To: Research Associate
- Rosie Bramante: Graduate Student
- Wei Ji: Graduate Student
- TJ. Whitis: Graduate Student

### Texas A&M University
- Harry Nelson: PI, Professor
- Mike Witherell: Professor
- Susanne Kyre: Engineer
- Dean White: Engineer
- Carmen Carmona: Postdoc
- Scott Haselschwantz: Graduate Student
- Curt Nehrkorn: Graduate Student
- Melih Solmaz: Graduate Student

### UC Santa Barbara
- UC Santa Barbara
  - James White: PI, Professor
  - Robert Webb: PI, Professor
  - Rachel Mannino: Graduate Student
  - Paul Terman: Graduate Student

### UC Davis
- Mani Tripathi: PI, Professor
- Brit Holbrook: Senior Engineer
- John Thompson: Development Engineer
- Dave Herner: Senior Machinist
- Ray Gerhard: Electronics Engineer
- Aaron Manalaysay: Postdoc
- Scott Stephenson: Postdoc
- Jacob Cutter: Graduate Student
- James Morad: Graduate Student
- Sergey Uvarov: Graduate Student

### University of Maryland
- Carter Hall: PI, Professor
- Jon Balazh: Graduate Student
- Richard Knoche: Graduate Student

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Markus Horn – The LUX experiment
LUX direct Dark Matter search

- Elastic scattering of WIMPs off target nuclei
- Two phase liquid xenon time projection chamber
  - scintillation (S1) and ionization (S2) signal
  - 350 kg of xenon, ~120 kg fiducial
  - Ti cryostat, 122 PMT, PTFE paneling
  - 49 cm max drift length
- LUX @ Sanford Underground Research Facility Lead, South Dakota, USA
LUX in pictures

Markus Horn – The LUX experiment
LUX first results (2013)

The Economist
“Absence of evidence, or evidence of absence?”

New York Times
“Dark Matter Experiment Has Detected Nothing, Researchers Say Proudly”
LUX first results (2013)

- PRL 112, 091303 (2014)
  - $7.6 \times 10^{-46} \text{ cm}^2$ @33 GeV/c$^2$
- unprecedented low–WIMP–mass sensitivity

![Graph showing WIMP-nucleon cross section vs. WIMP mass for different experiments.](image-url)
What has happened since?

- End of 2013: high-stats calibration (see next)
- Early 2014: optimizing grids HV, “conditioning”
  - Increased extraction field by 17%
- Run 4 started in Sep 2014, with multiple high-stats calibrations throughout the 300-live days WIMP search data run.
- ~100 live-days accumulated so far, continue until June 2016
- We also had more than a year to look at the data and improve our analysis (see next)
Calibrations: CH₃T

- Tritiated methane – an excellent electron recoil calibration source

- low energy ER
- light & charge yield measurement (in situ)
- high statistics calibration (~150k)
- detector efficiency
- ER/NR discrimination studies
Calibrations: DD neutrons

- 2.45 MeV neutrons from external (D–D) generator
- x–y position reconstruction from hit pattern
- $\Delta t$: $z'$ separation
- $\theta$: energy calculation
- double scatters $\rightarrow$ charge yield
- single scatters (incl. charge yield) $\rightarrow$ light yield

$$E_r = E_n \frac{4m_n m_{Xe}}{(m_n + m_{Xe})^2} \frac{1 - \cos \theta}{2}$$
Calibrations: DD neutrons

- Low-energy yield measurements
  - $Q_Y$ down to 0.8 keV$_{nr}$
  - $L_Y$ down to 1.2 keV$_{nr}$
- 105 live hours data
- in depths studies of systematics
- Publication in preparation
- NEST update to follow with physics motivated fit
- to be included in Run3 re-analysis

**LUX Measured $Q_Y$: 180 V/cm**
Manzur 2010; 1 kV/cm
Manzur 2010; 4 kV/cm
Z3 Horn Combined FSR/SSR; 3.6 kV/cm
Sorensen IDM 2010; 0.73 kV/cm
Szydagis et al. (NEST v1.0) - updated

**LUX Measured $L_Y$: reported at 180 V/cm**
Manzur 2010; 0 V/cm
Horn Combined Zeplin III FSR/SSR; 3.6 kV/cm, rescaled to 0 V/cm
Plante 2011; 0 V/cm
Aprile 2009
Szydagis et al. (NEST v1.0) - updated
Run 3 re-analysis & Run 4

- Higher dataset acceptance (increase statistics)
- Change from non-zero response for low nuclear recoil events
- Updates to pulse finding algorithm
- Updates to position reconstruction algorithm
- Explored potential larger fiducial volume range (for PLR)
- Taking into account non-uniformity of electric field
- Improved fit to calibration data for energy scales
- Update to background model
- Additional nuisance parameters (PLR)

- Run 4 started in Sept 2014
- Expected improvement over 2013 sensitivity: x2 – x4

Stay tuned for new publications!
Thank you!
BACKUP
WIMP Search Events and Fiducial Volume

- These are all events before ER/NR discrimination
- Comparing result to 2013 analysis (118 kg)
- Some small changes to position reconstruction, S2 energy
- Explored larger fiducial volume range as a function of background model prediction for PLR
- Potential gain in total kg.days exposure
Markus Horn - The LUX experiment

WIMP Mass [GeV/c^2]

WIMP-nucleon cross section [cm^2]

WIMP-nucleon cross section [pb]

(Green ovals) Asymmetric DM
(Violet oval) Magnetic DM
(Blue oval) Extra dimensions
(Red circle) SUSY MSSM

MSSM: Pure Higgsino
MSSM: A funnel
MSSM: Bino-stop coannihilation
MSSM: Bino-squark coannihilation

Neutrinos

atmospheric and DSNB Neutrinos