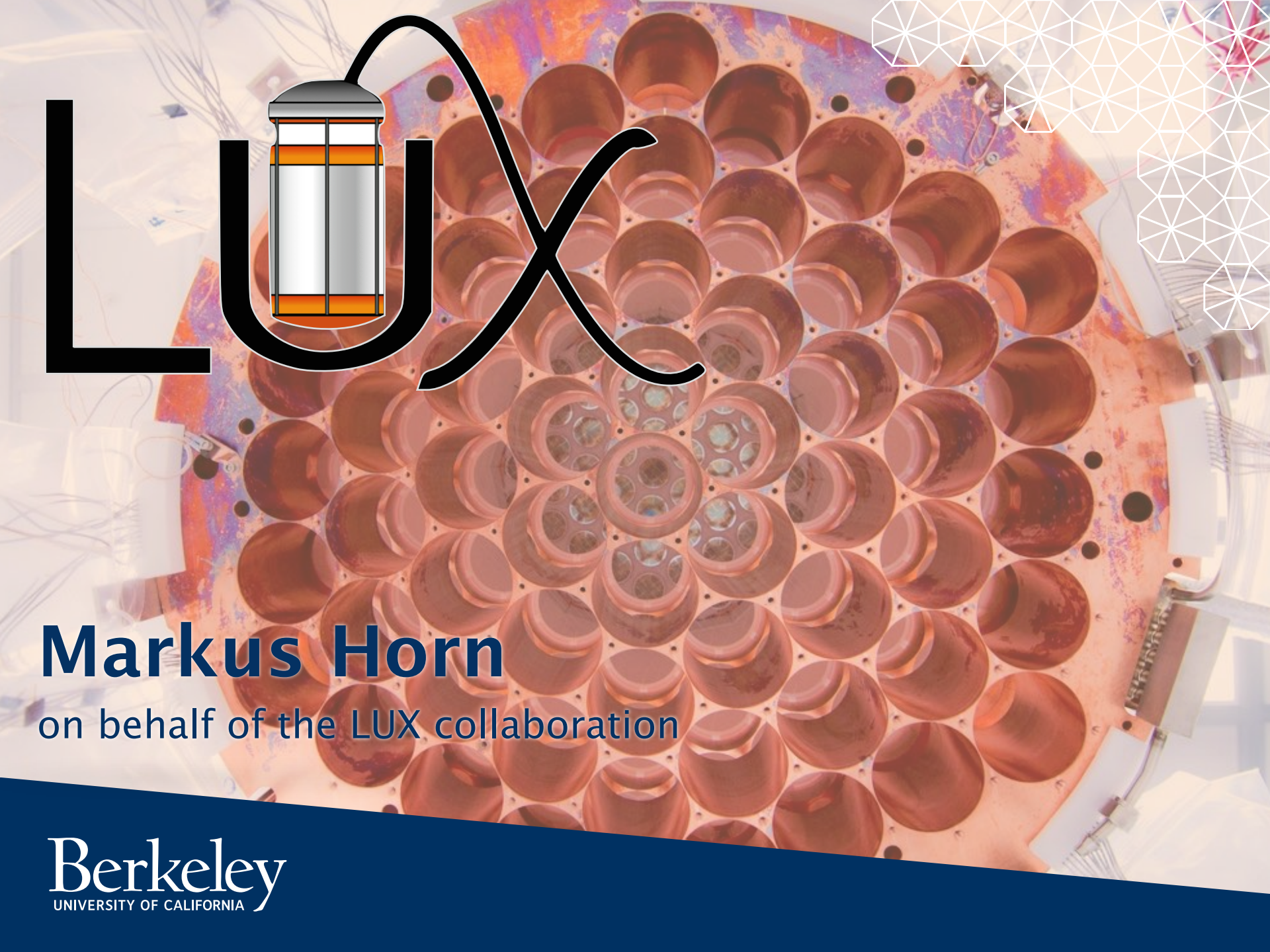


Markus Horn

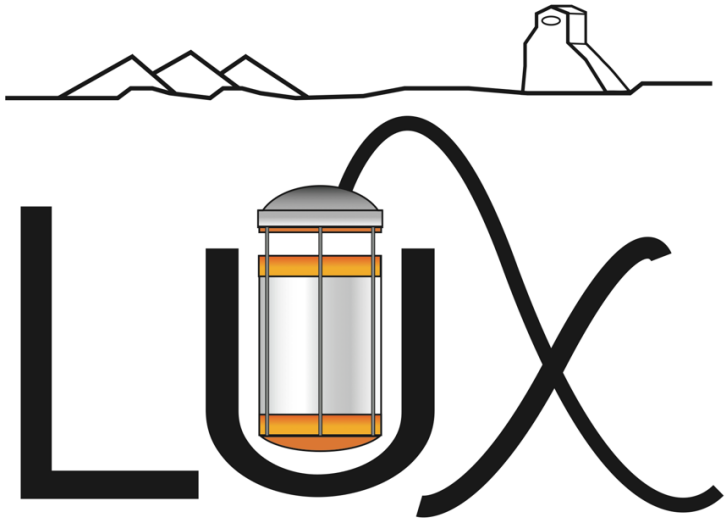
on behalf of the LUX collaboration

Berkeley
UNIVERSITY OF CALIFORNIA

Overview

- Direct Dark Matter search with LUX
  - collaboration, implementation, u/g operation
- LUX first results
  - WIMP sensitivity: PRL 112, 091303 (2014)
- Calibrations
  - tritiated methane
  - neutron (DD) calibrations
- What's coming next?
  - Run 4 and re-analysis of 2013 data

LUX Collaboration



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Dongqing Huang	Graduate Student
Casey Rhyne	Graduate Student
Will Taylor	Graduate Student
James Verbus	Graduate Student

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Tim Sumner	Professor
Alastair Currie	Postdoc
Adam Bailey	Graduate Student
Khadeeja Yazdani	Graduate Student

Lawrence Berkeley & UC Berkeley

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Kevin Lesko	Senior Scientist
Peter Sorensen	Scientist
Victor Gehman	Scientist
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Kate Kamdin	Graduate Student
Kelsey Oliver-Mallory	Graduate Student

Lawrence Livermore

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Kareem Kazkaz	Staff Physicist
Brian Lenardo	Graduate Student

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Jose Pinto da Cunha	Assistant Professor
Vladimir Solovov	Senior Researcher
Francisco Neves	Auxiliary Researcher
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Mark Hanhardt	Support Scientist

SLAC Nation Accelerator Laboratory

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John Thmpson	Development Engineer
Dave Herner	Senior Machinist
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Dean White	Engineer
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Curt Nehrkorn	Graduate Student
Melih Solmaz	Graduate Student

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Maria Francesca	Graduate Student

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Richard Knoche	Graduate Student

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Yale → UC Berkeley / LBNL

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Markus Horn	Research Scientist
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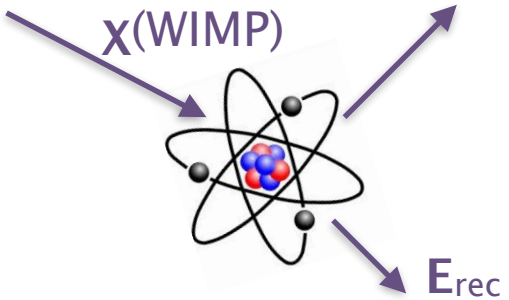
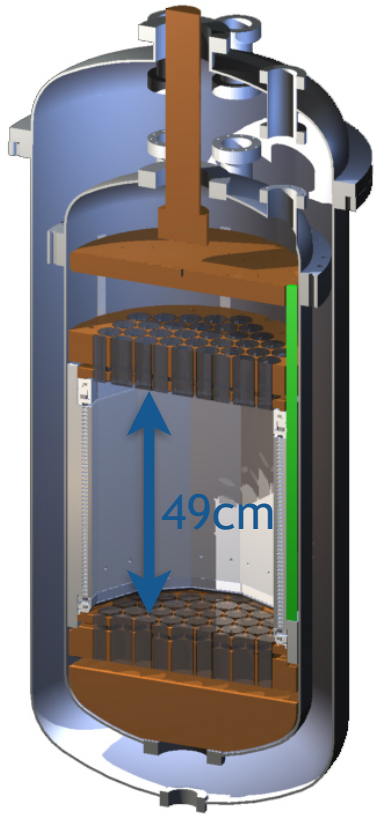
Kevin O'Sullivan	Postdoc
Elizabeth Boulton	Graduate Student
Nicole Larsen	Graduate Student
Evan Pease	Graduate Student
Brian Tennyson	Graduate Student
Lucie Tvrznikova	Graduate Student

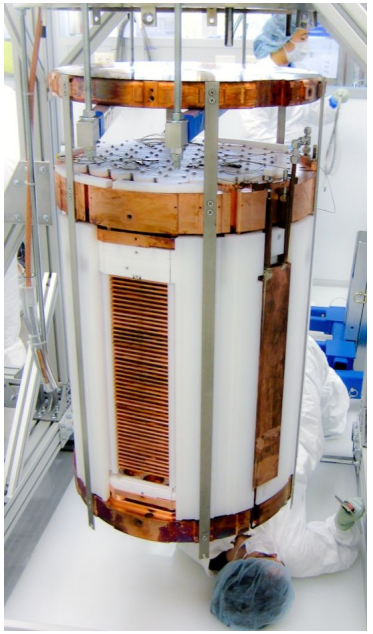
LUX direct Dark Matter search



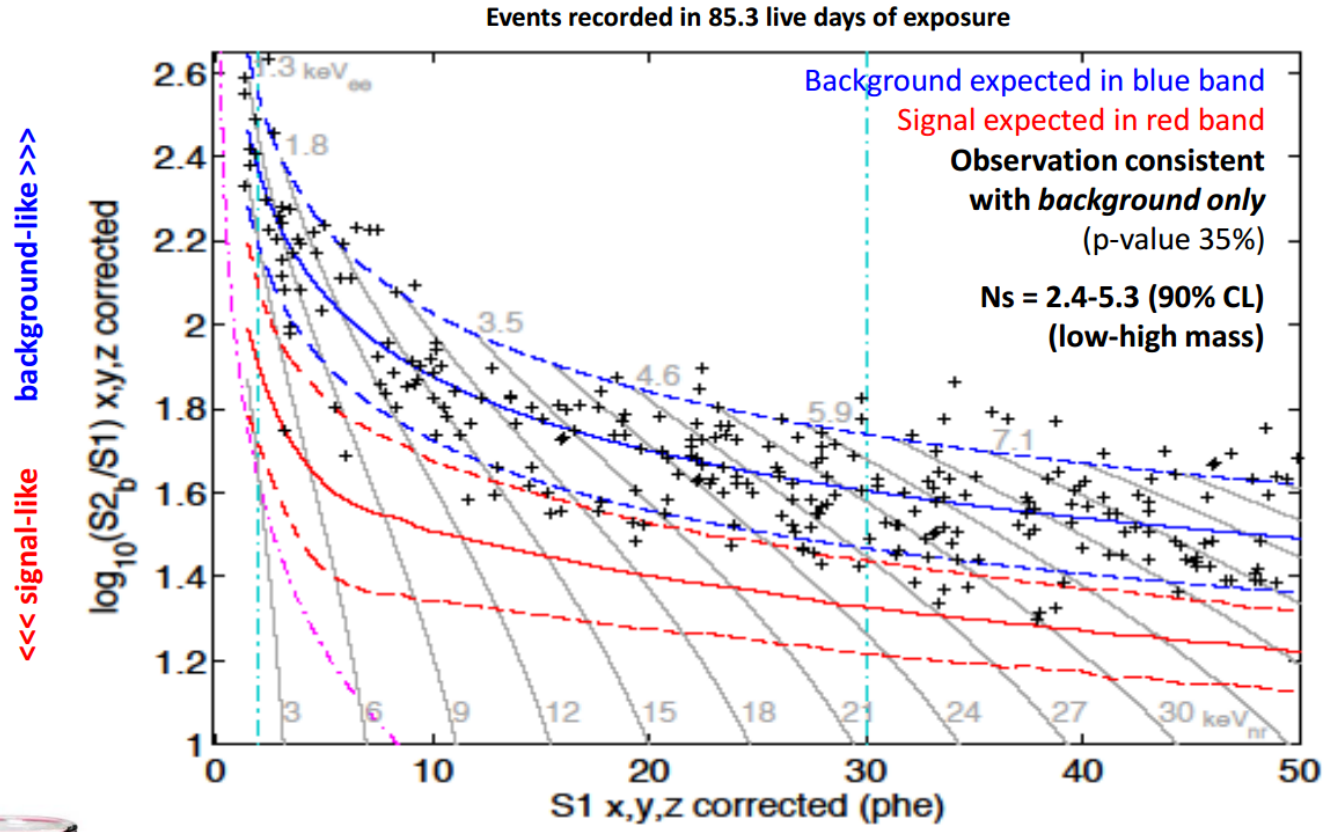
- Elastic scattering of WIMPs off target nuclei
- Two phase liquid xenon time projection chamber
  - scintillation (S1) and ionization (S2) signal
  - 350 kg of xenon, ~120 kg fiducial
  - Ti cryostat, 122 PMT, PTFE paneling
  - 49 cm max drift length
- LUX @ Sanford Underground Research Facility Lead,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



LUX in pictures



LUX first results (2013)



The Economist

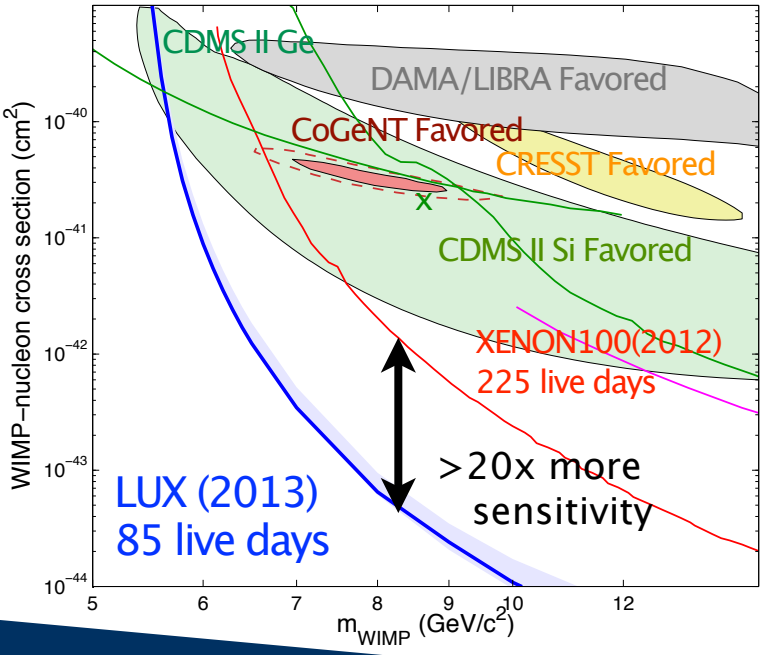
"Absence of evidence, or evidence of absence?"

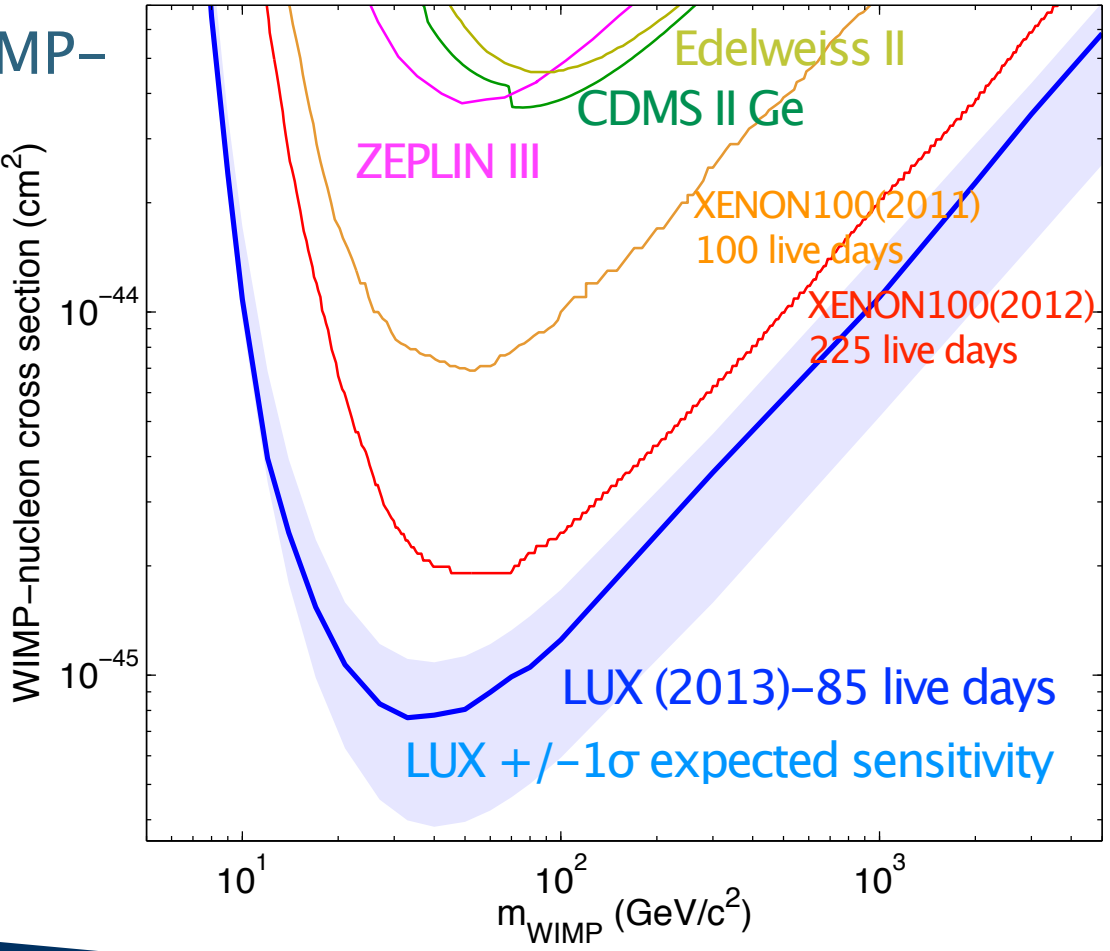
New York Times

"Dark Matter Experiment Has Detected Nothing, Researchers Say Proudly"

LUX first results (2013)

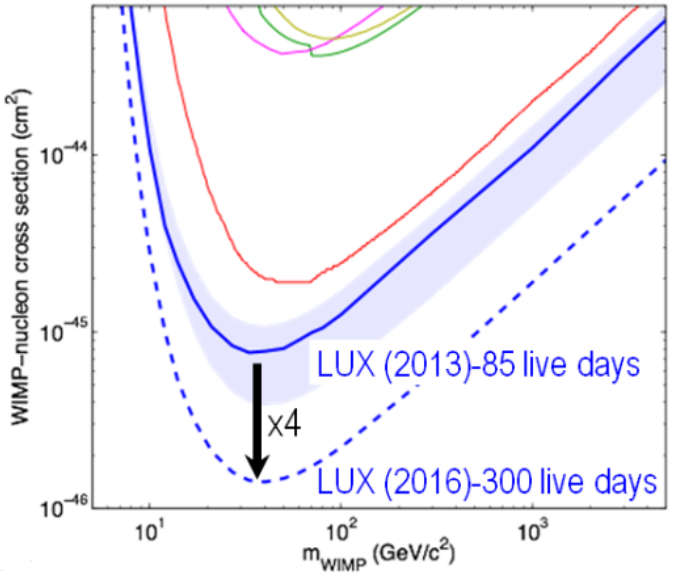
- PRL **112**, 091303 (2014)
  - 7.6×10^{-46} cm^2 @33 GeV/c^2
- unprecedented low-WIMP-mass sensitivity





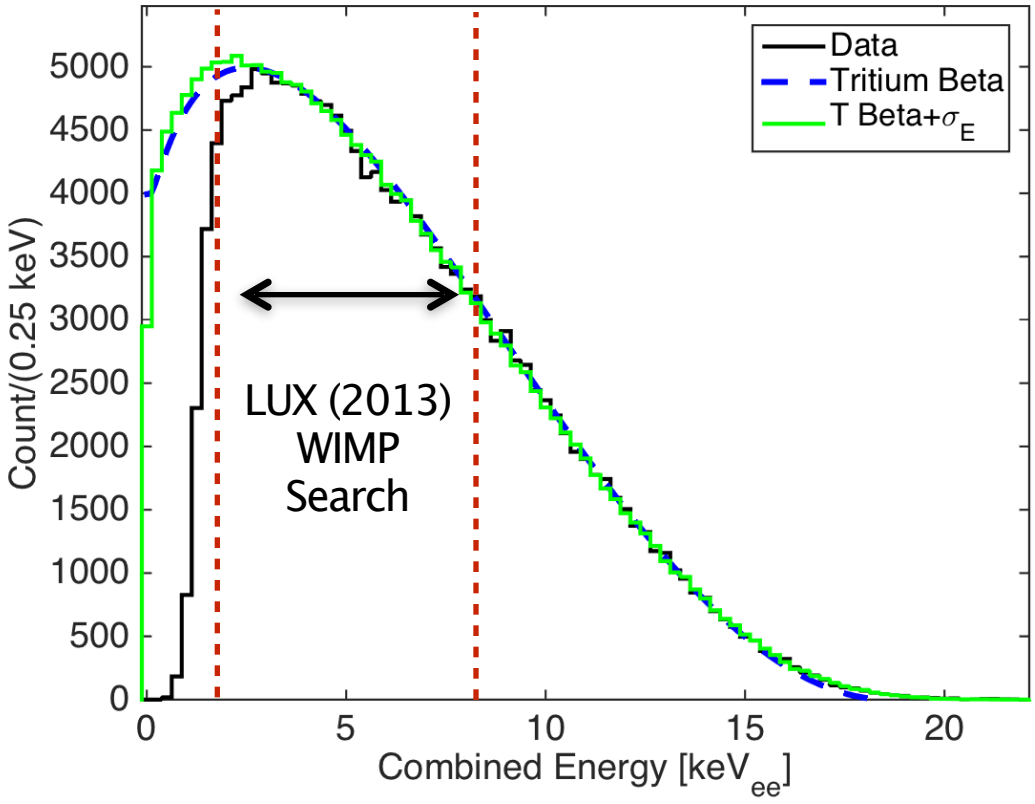
What has happened since?

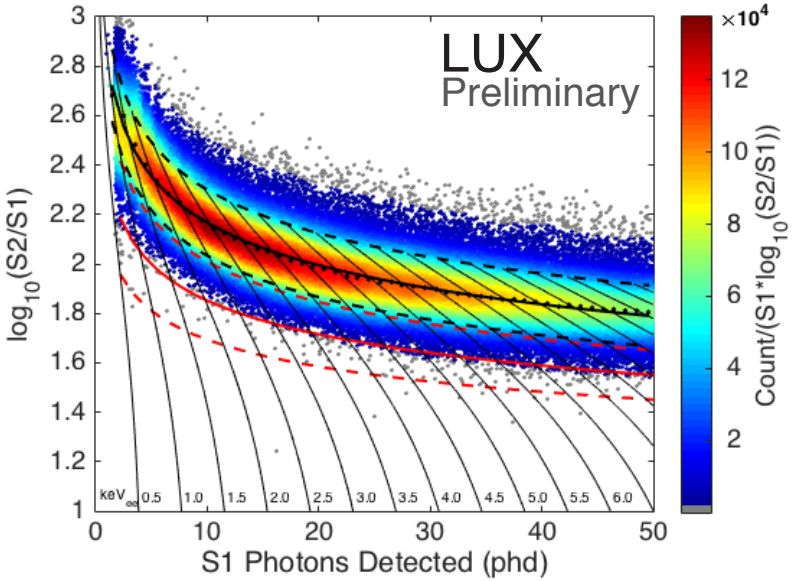
- End of 2013: high-stats calibration (see next)
- Early 2014: optimizing grids HV, "conditioning"
  - Increased extraction field by 17%
- Run 4 started in Sep 2014, with multiple high-stats calibrations throughout the 300-live days WIMP search data run.
- ~100 live-days accumulated so far, continue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



Calibrations: CH3T

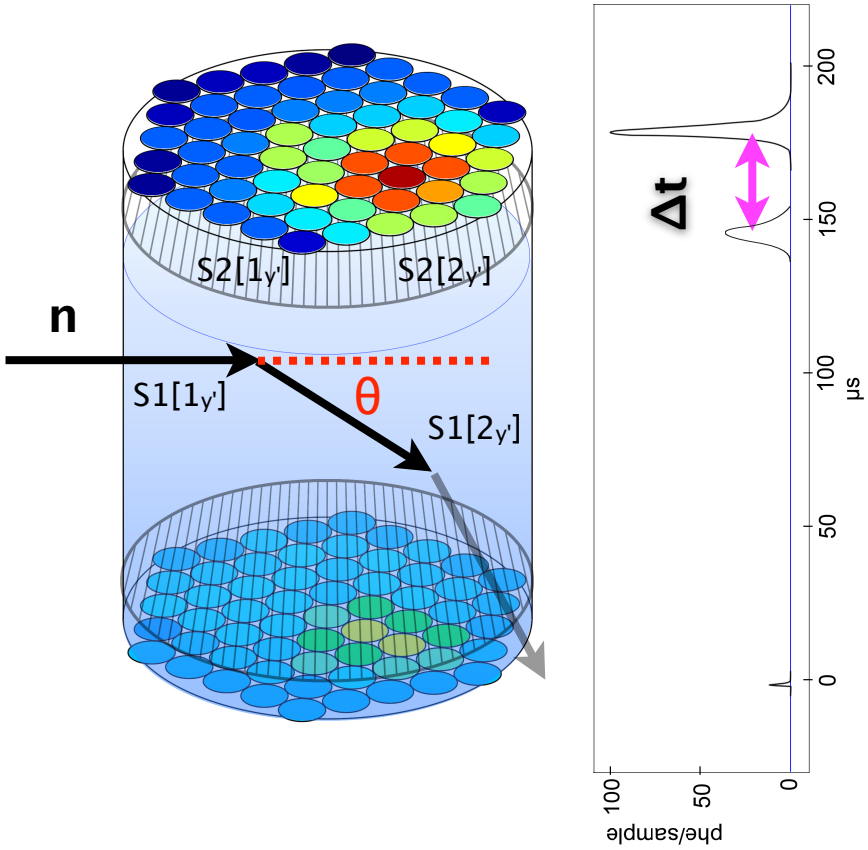
- Tritiated methane – an excellent electron recoil calibration source





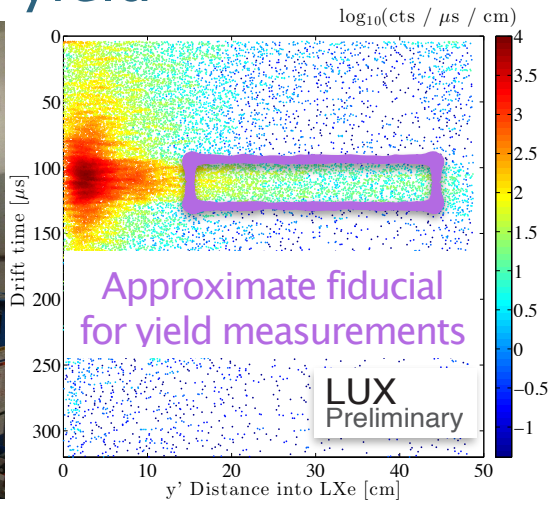
- low energy ER
- light & charge yield measurement (in situ)
- high statistics calibration (~150k)
- detector efficiency
- ER/NR discrimination studies

Calibrations: DD neutrons



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

- 2.45 MeV neutrons from external (D–D) generator
- x–y position reconstruction from hit pattern
- Δt: z' separation
- θ: energy calculation
- double scatters → charge yield
- single scatters (incl. charge yield) → light yield



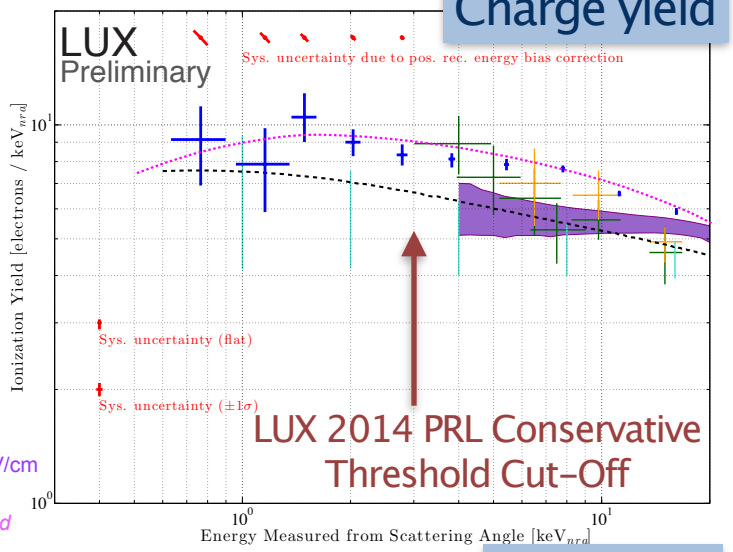
Calibrations: DD neutrons

- 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

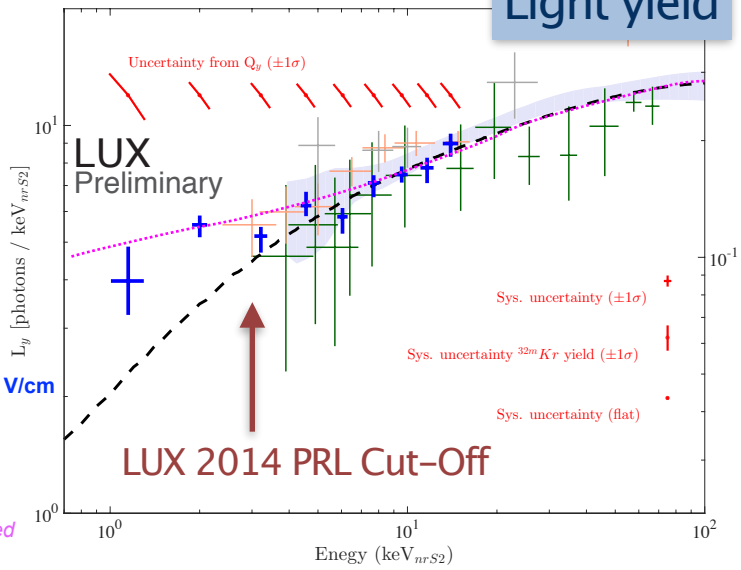
LUX Measured Qy; 180 V/cm
Manzur 2010; 1 kV/cm
Manzur 2010; 4 kV/cm
Z3 Horn Combined FSR/SSR; 3.6 kV/cm
Sorensen IDM 2010; 0.73 kV/cm
Szydagis et al. (NEST v1.0) - *updated*

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*

Charge yield



Light yield



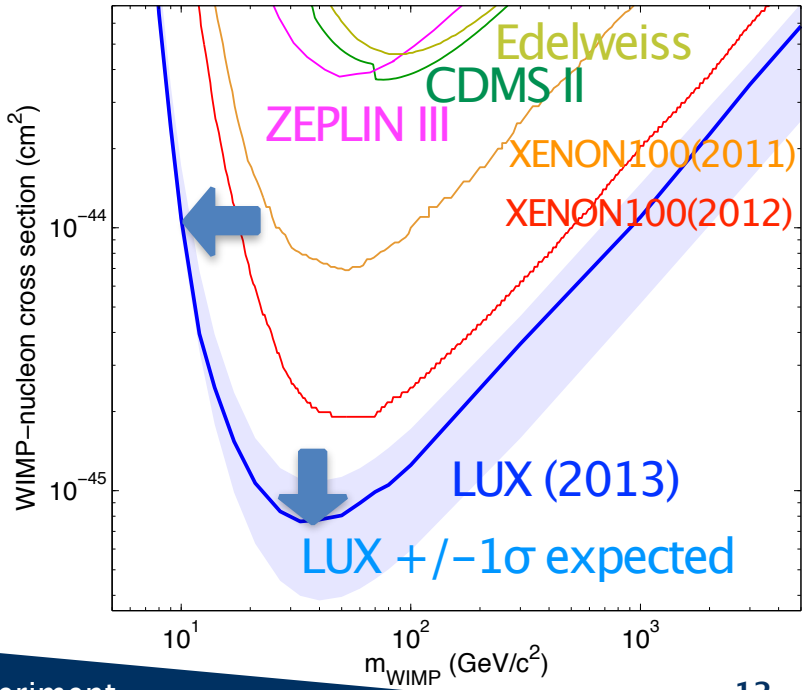
Run 3 re-analysis & Run 4

- 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!**

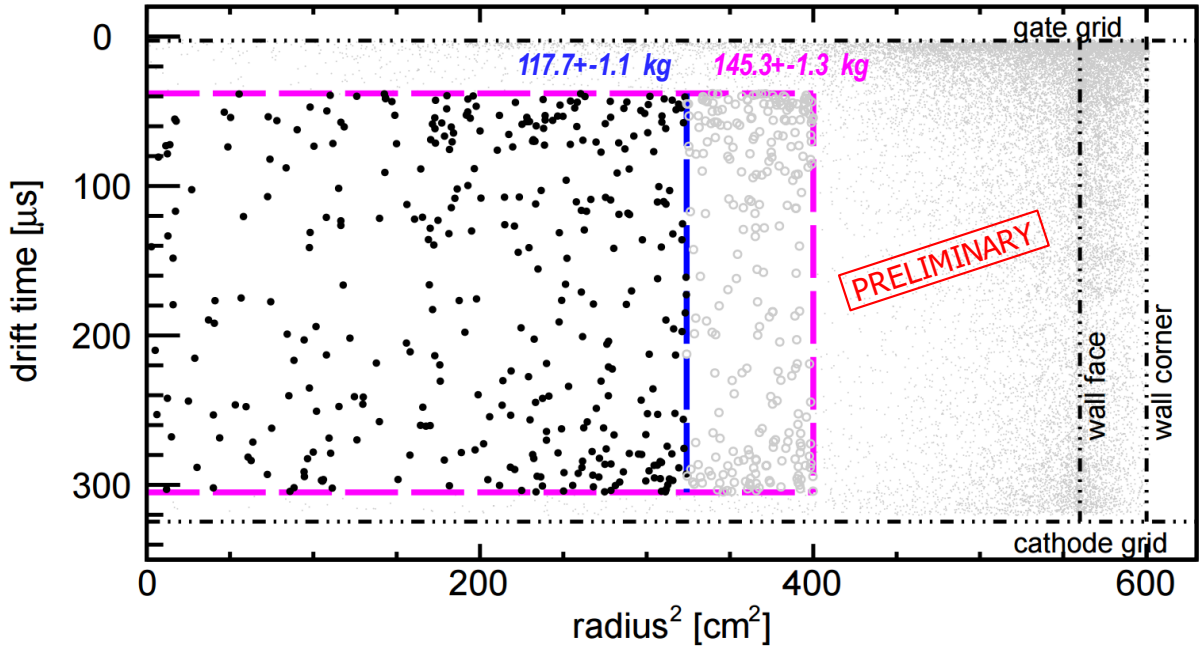


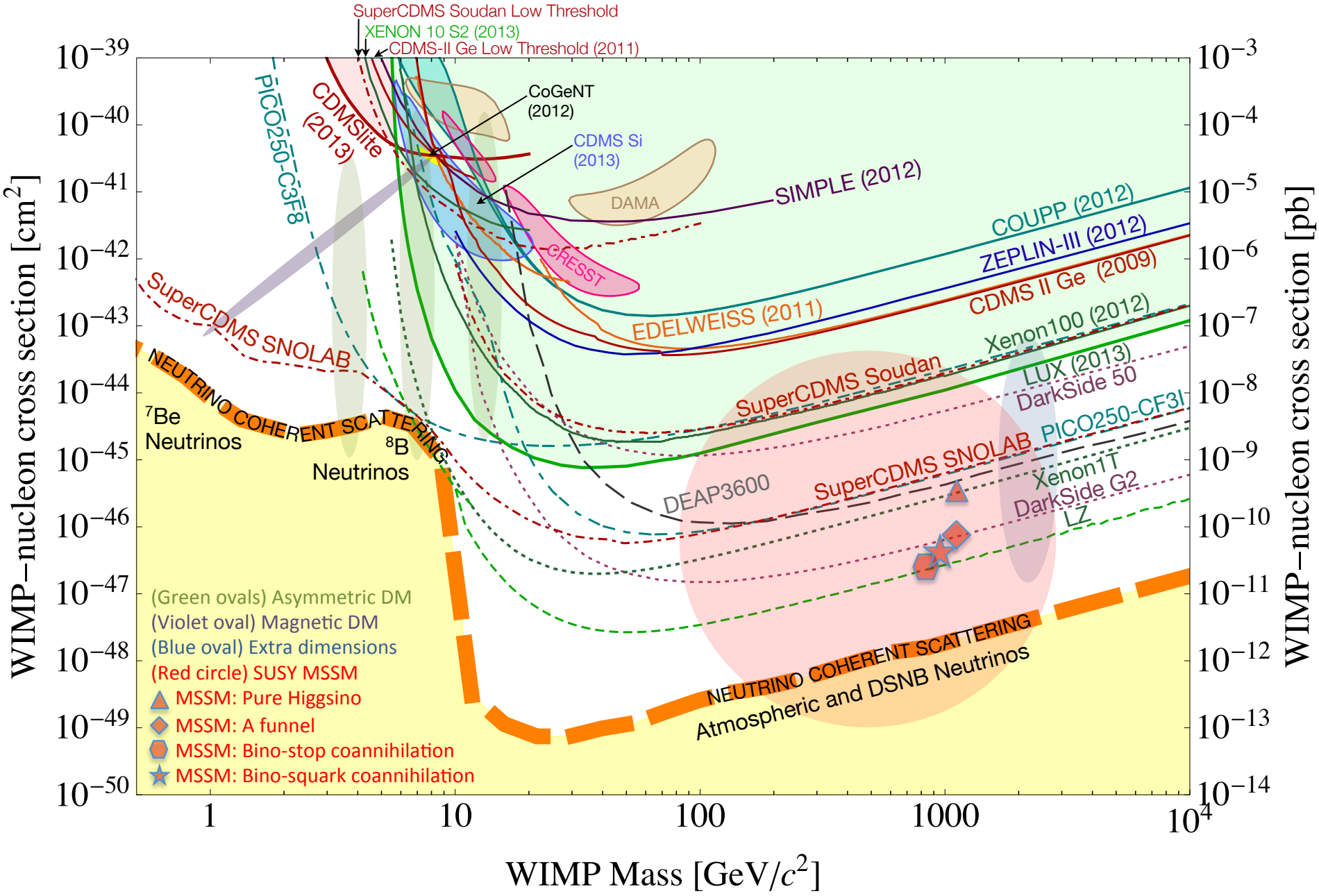
Thank you!

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




SuperCDMS Soudan Low Threshold
XENON 10 S2 (2013)
CDMS-II Ge Low Threshold (2011)
CoGeNT (2012)
CDMS Si (2013)
CDMSlite (2013)
PICO250-C3F8
DAMA
SIMPLE (2012)
CRESST
COUPP (2012)
ZEPLIN-III (2012)
CDMS II Ge (2009)
EDELWEISS (2011)
Xenon100 (2012)
SuperCDMS SNOLAB
NEUTRINO COHERENT SCATTERING
SuperCDMS Soudan
LUX (2013)
DarkSide 50
PICO250-CF3I
^{7}Be Neutrinos
^{8}B Neutrinos
DEAP3600
SuperCDMS SNOLAB
Xenon1T
DarkSide G2
LZ
(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
NEUTRINO COHERENT SCATTERING
Atmospheric and DSNB Neutrinos
WIMP–nucleon cross section [cm^2]
WIMP–nucleon cross section [pb]
WIMP Mass [GeV/c^2]
10^{-39}
10^{-40}
10^{-41}
10^{-42}
10^{-43}
10^{-44}
10^{-45}
10^{-46}
10^{-47}
10^{-48}
10^{-49}
10^{-50}
10^{-3}
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10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
1
10
100
1000
10^4