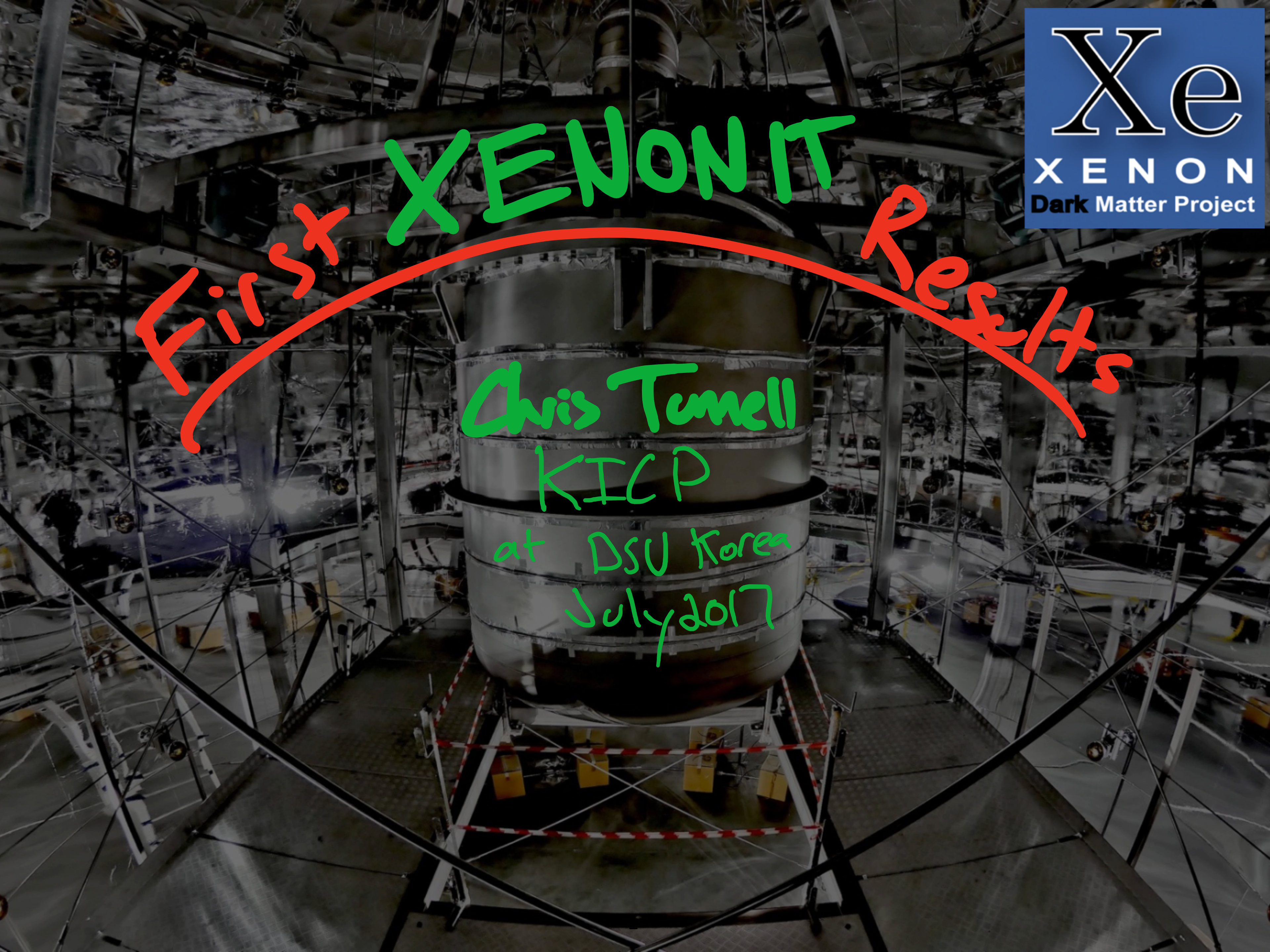


First XENON1T Results

Chris Tunnell

KICP

at DSU Korea

July 2017

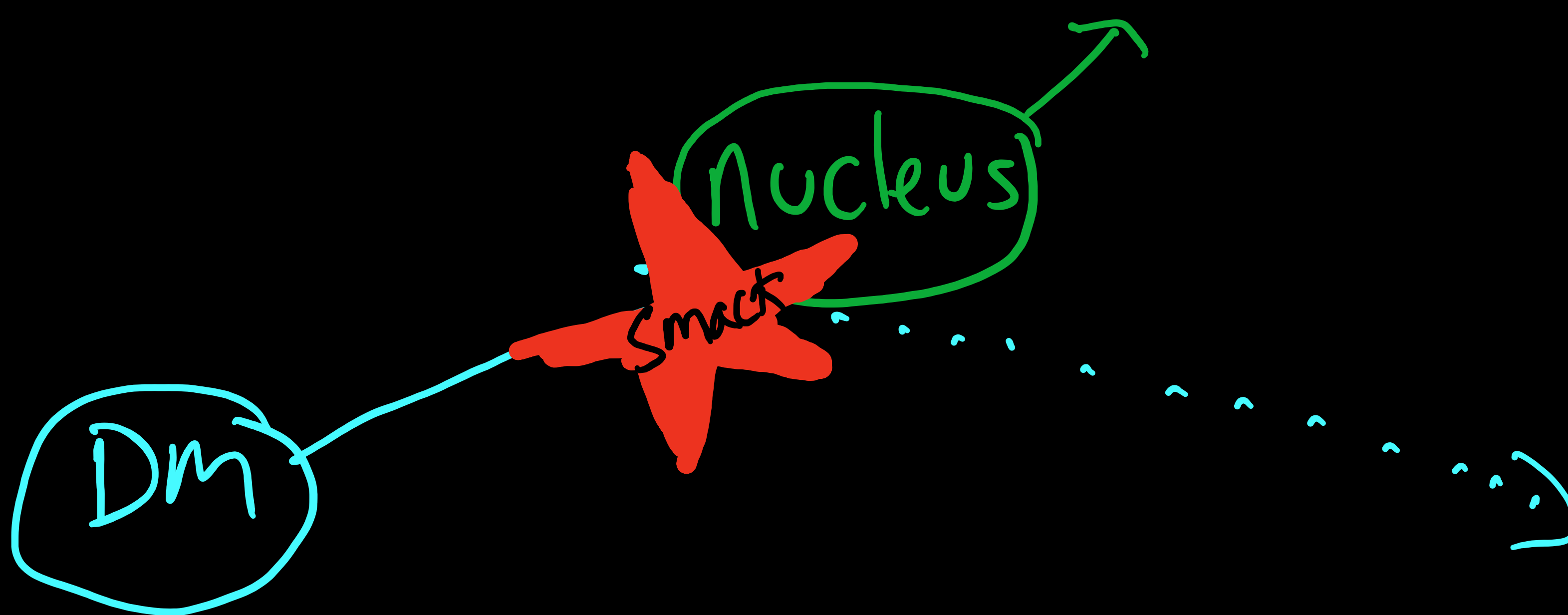
Xe XENON Dark Matter Project

PHYSICAL REVIEW D VOLUME 31, NUMBER 12 15 JUNE 1985

Detectability of certain dark-matter candidates

Mark W. Goodman and Edward Witten
Joseph Henry Laboratories, Princeton University, Princeton, New Jersey 08544
(Received 7 January 1985)

We consider the possibility that the neutral-current neutrino detector recently proposed by Drukier and Stodolsky could be used to detect some possible candidates for the dark matter in galactic halos. This may be feasible if the galactic halos are made of particles with coherent weak interactions and masses $1-10^6$ GeV; particles with spin-dependent interactions of typical weak strength and masses $1-10^2$ GeV; or strongly interacting particles of masses $1-10^{13}$ GeV.



XENON smack detection team

Columbia, RPI, Nikhef, Stockholm, Muenster, Mainz, MPIK

Chicago, UCLA, UCSD, Rice

Freiburg, Zurich, NYUAD, Weizmann

Purdue, Coimbra, Subatech, LPNHE, LAL, Bologna, LNGS, Torino

Phases of the XENON program

XENON10

2005-2007
15 cm drift TPC – 25 kg

Achieved (2007)
$\sigma_{SI} = 8.8 \times 10^{-44}$ cm^2

XENON100

2008-2016
30 cm drift TPC – 161 kg

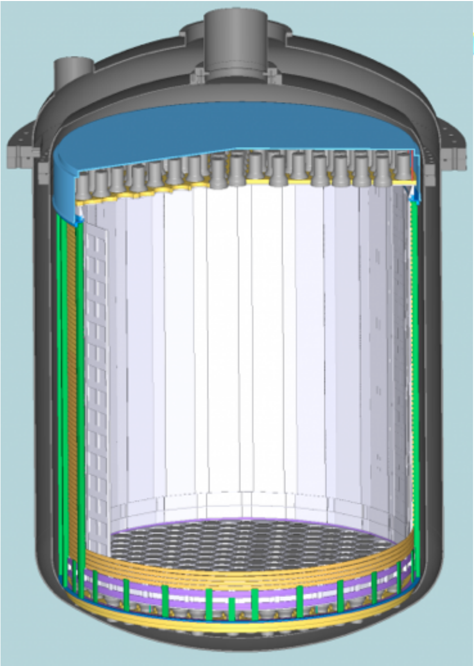
Achieved (2016)
$\sigma_{SI} = 1.1 \times 10^{-45}$ cm^2

XENON1T

2013-2018
100 cm drift TPC - 3.2 t

Projected (2018)
$\sigma_{SI} = 1.6 \times 10^{-47}$ cm^2

XENONnT



2019-2023
144 cm drift TPC - 8 t

Projected (2023)
$\sigma_{SI} = 1.6 \times 10^{-48}$ cm^2

1512.07501

Principle sometimes easy

But practice hard

E.g. yesterday angular momentum
v.s. pole dancing

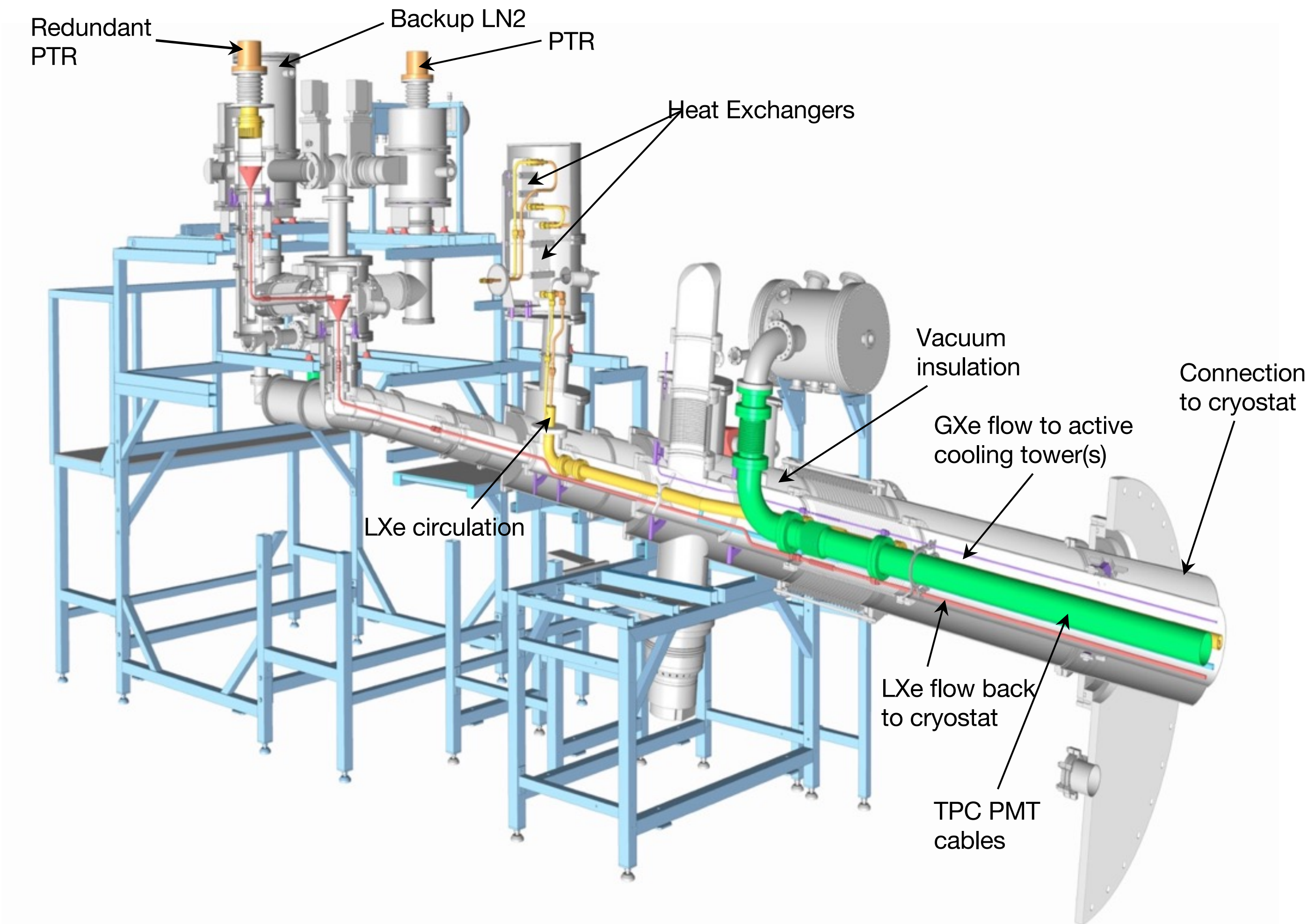

Direct detection cookbook

- Build it
- Fill it
- Clean it
- Record it
- Analyze it

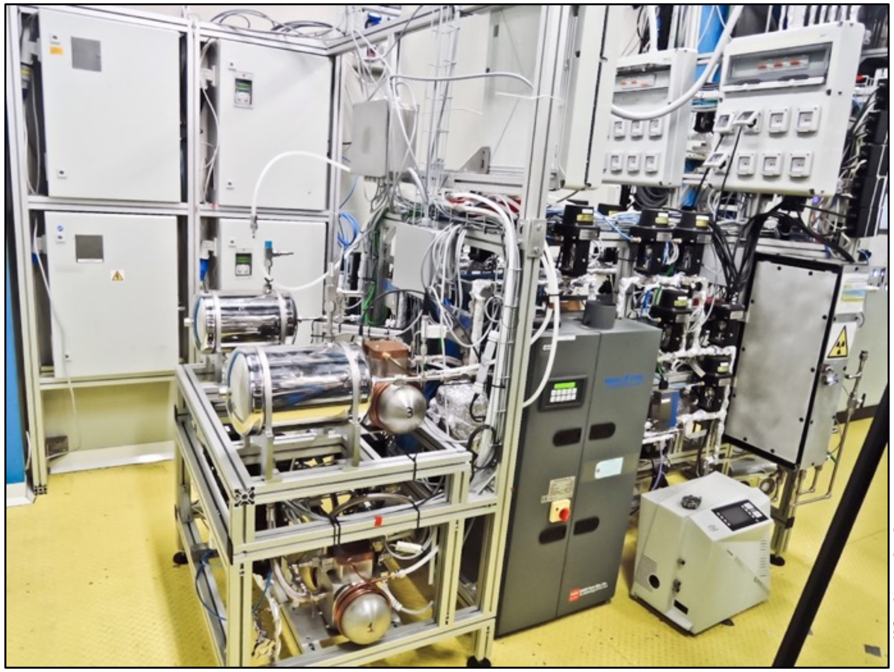
Build it

Cool it

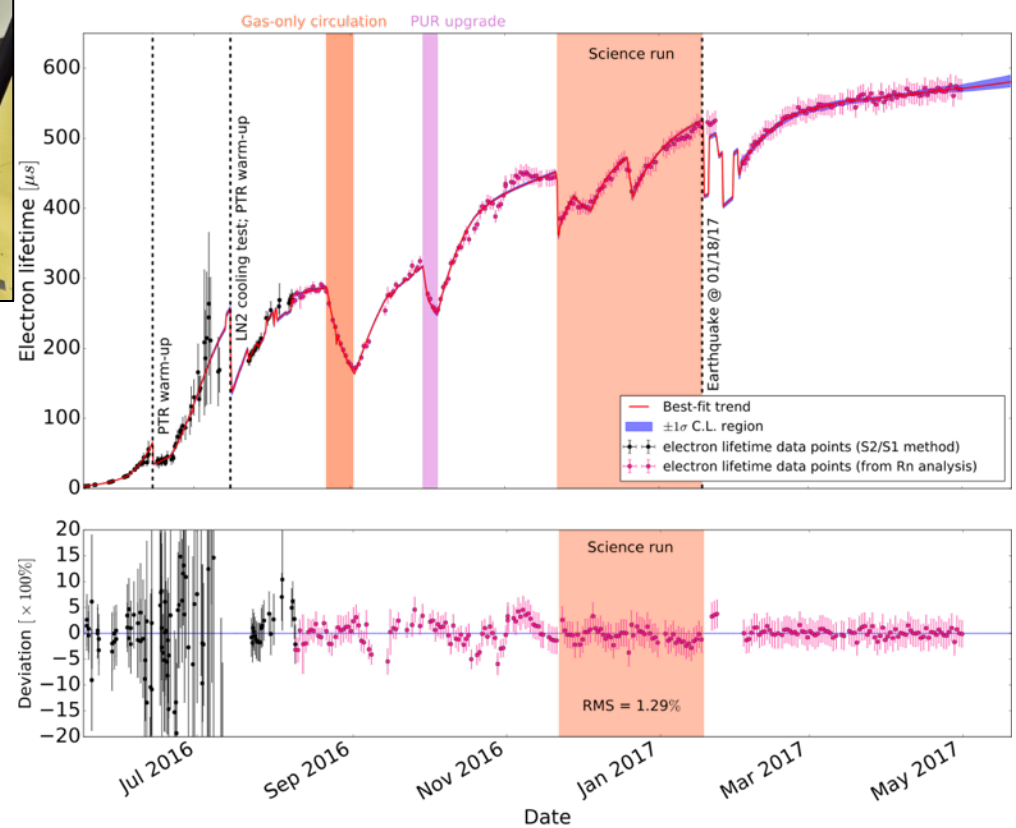
Goal: liquefy 3300 Kg of Xe and maintain the xenon in the cryostat in liquid form, at a constant temperature and pressure, and so for years without interruption.



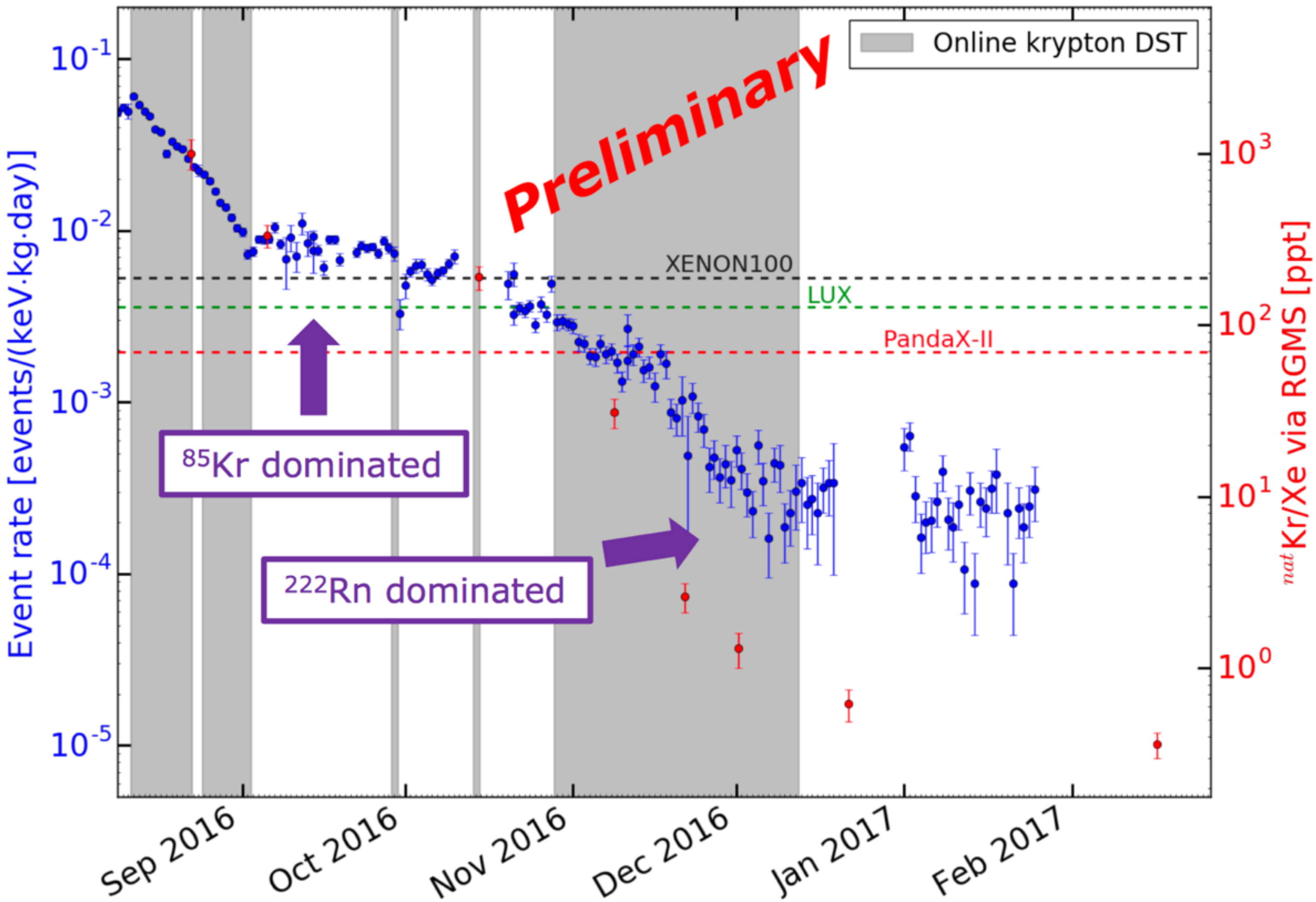
Clean it



Goal: remove electronegative impurities below 1 ppb (O2 equivalent) in the Xe gas fill and from outgassing of detector's components with continuous circulation of Xe gas at high speed through hot getters



Clean it

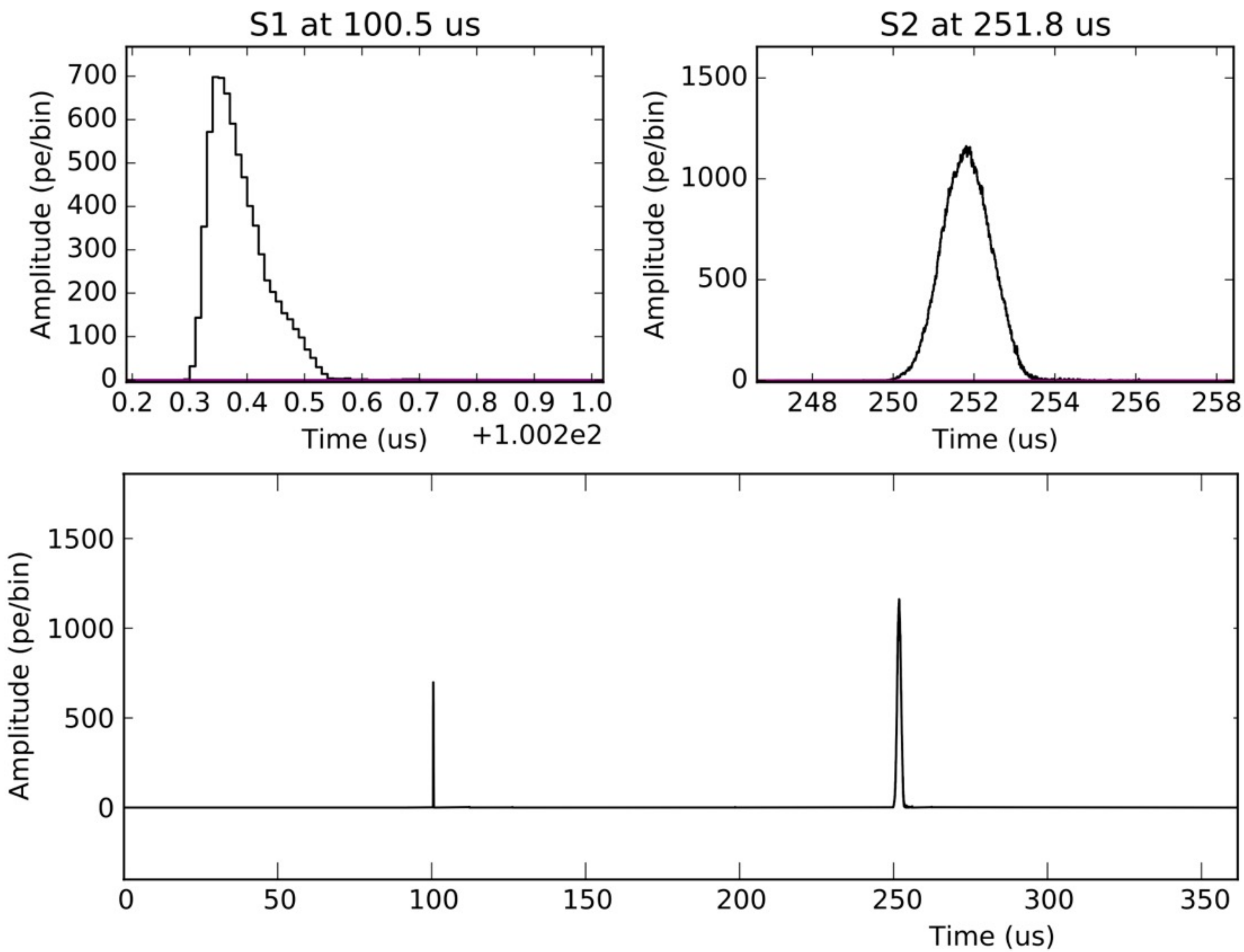


Eur. Phys. J. C77 (2017) no.5, 275 & arXiv:1702.06942

Record it


DAQ
Triggerless Readout
300MB/s
MongoDB
Software Trigger
pickle files
1 PB/year
Processing
Distributed processor
Chicago/OSG
Distributed Storage
Nikhef
Lyon
Weizmann
Bologna
Chicago
OSG
Tape
Analysis
Common Storage
Chicago
50TB
Reduce
GB
Table
Ipython notebook

Record it



S1 at 100.5 us
Amplitude (pe/bin)
700
600
500
400
300
200
100
0
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Time (us)
+1.002e2
S2 at 251.8 us
Amplitude (pe/bin)
1500
1000
500
0
248 250 252 254 256 258
Time (us)
Amplitude (pe/bin)
1500
1000
500
0
0 50 100 150 200 250 300 350
Time (us)

Direct detection cookbook

- Build it
- Fill it
- Clean it
- Record it
- Analyze it

First Dark Matter Search Results from the XENON1T Experiment

E. Aprile, J. Aalbers, F. Agostini, M. Alfonsi, F. D. Amaro, M. Anthony, F. Arneodo, P. Barrow, L. Baudis, B. Bauermeister, M. L. Benabderrahmane, T. Berger, P. A. Breur, A. Brown, A. Brown, E. Brown, S. Bruenner, G. Bruno, R. Budnik, L. Bütikofer, J. Calvén, J. M. R. Cardoso, M. Cervantes, D. Cichon, D. Coderre, A. P. Colijn, J. Conrad, J. P. Cussonneau, M. P. Decowski, P. de Perio, P. Di Gangi, A. Di Giovanni, S. Diglio, G. Eurin, J. Fei, A. D. Ferella, A. Fieguth, W. Fulgione, A. Gallo Rosso, M. Galloway, F. Gao, M. Garbini, R. Gardner, C. Geis, L. W. Goetzke, L. Grandi, Z. Greene, C. Grignon, C. Hasterok, E. Hogenbirk, J. Howlett, R. Itay, B. Kaminsky, S. Kazama, G. Kessler, A. Kish, H. Landsman, R. F. Lang, D. Lellouch, L. Levinson, Q. Lin, S. Lindemann, M. Lindner, F. Lombardi, et al. (62 additional authors not shown)

(Submitted on 18 May 2017 (v1), last revised 23 May 2017 (this version, v2))

We report the first dark matter search results from XENON1T, a ~2000-kg-target-mass dual-phase (liquid-gas) xenon time projection chamber in operation at the Laboratori Nazionali del Gran Sasso in Italy and the first ton-scale detector of this kind. The blinded search used 34.2 live days of data acquired between November 2016 and January 2017. Inside the (1042±12) kg fiducial mass and in the [5, 40] $\mathrm{keV_{nr}}$ energy range of interest for WIMP dark matter searches, the electronic recoil background was $(1.93 \pm 0.25) \times 10^{-4}$ events/(kg × day $\times \mathrm{keV_{ee}}$), the lowest ever achieved in a dark matter detector. A profile likelihood analysis shows that the data is consistent with the background-only hypothesis. We derive the most stringent exclusion limits on the spin-independent WIMP-nucleon interaction cross section for WIMP masses above 10 GeV/c^2, with a minimum of 7.7 $\times 10^{-47}$ cm^2 for 35-GeV/c^2 WIMPs at 90% confidence level.

Comments: 6 pages, 4 figures, submitting to PRL, v2 data upload Fig 2/4

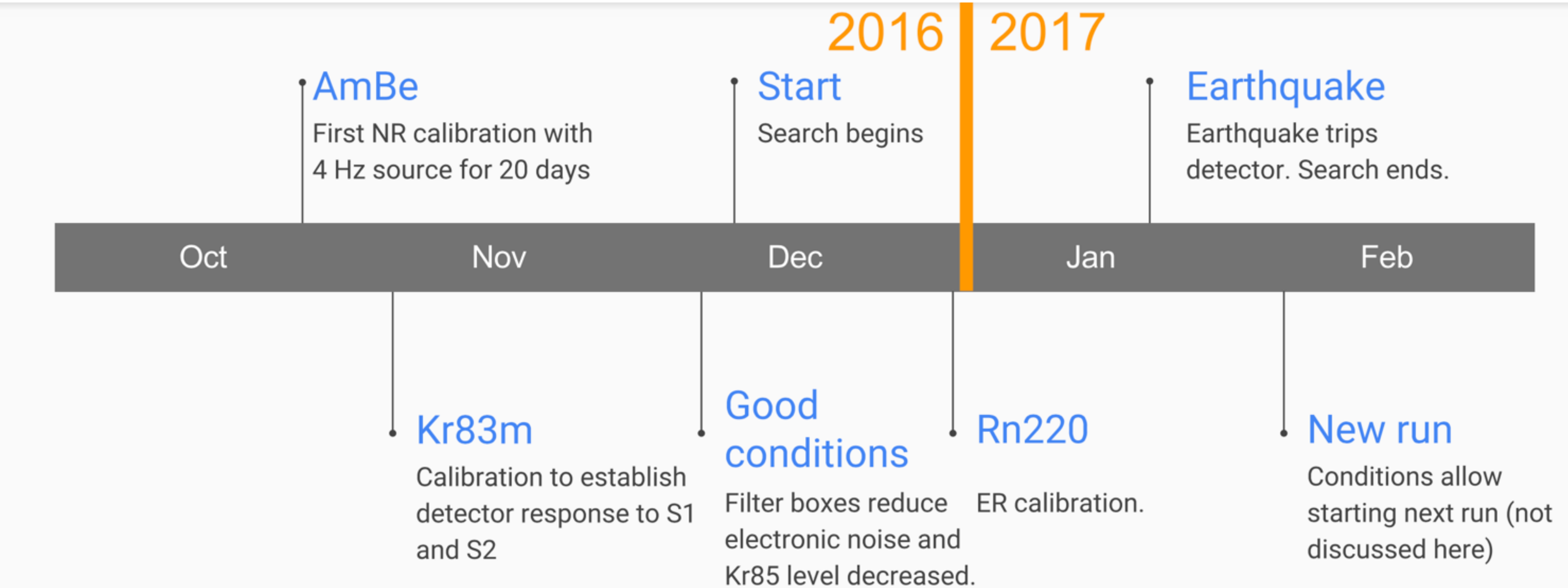
Subjects: **Cosmology and Nongalactic Astrophysics (astro-ph.CO)**; Instrumentation and Methods for Astrophysics (astro-ph.IM); High Energy Physics – Experiment (hep-ex)

Cite as: arXiv:1705.06655 **[astro-ph.CO]**
(or **arXiv:1705.06655v2 [astro-ph.CO]** for this version)

Submission history

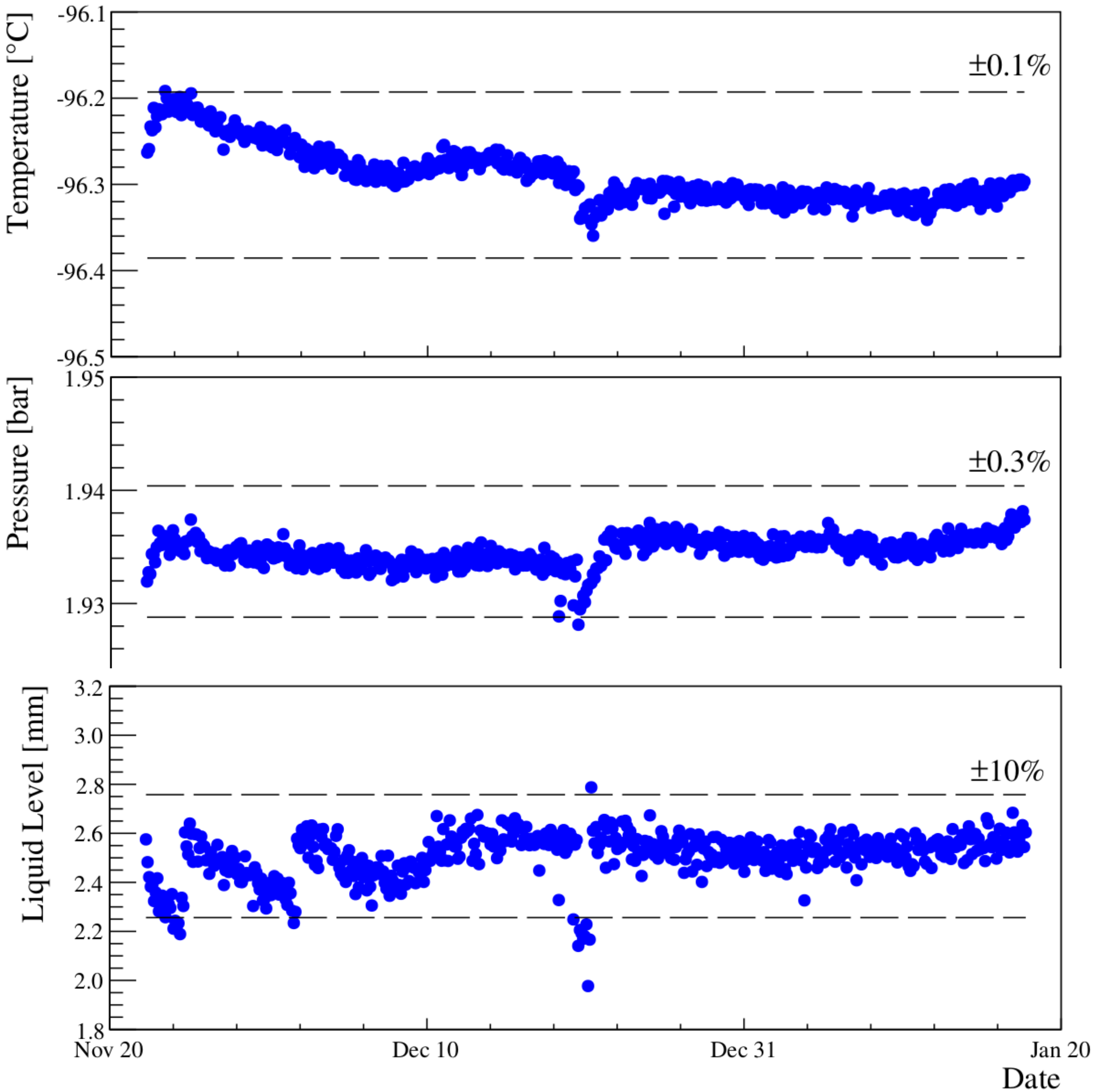
From: Christopher Tunnell [view email]
[v1] Thu, 18 May 2017 15:36:12 GMT (2006kb,D)
[v2] Tue, 23 May 2017 16:59:26 GMT (2084kb,D)

Science Run: Timeline



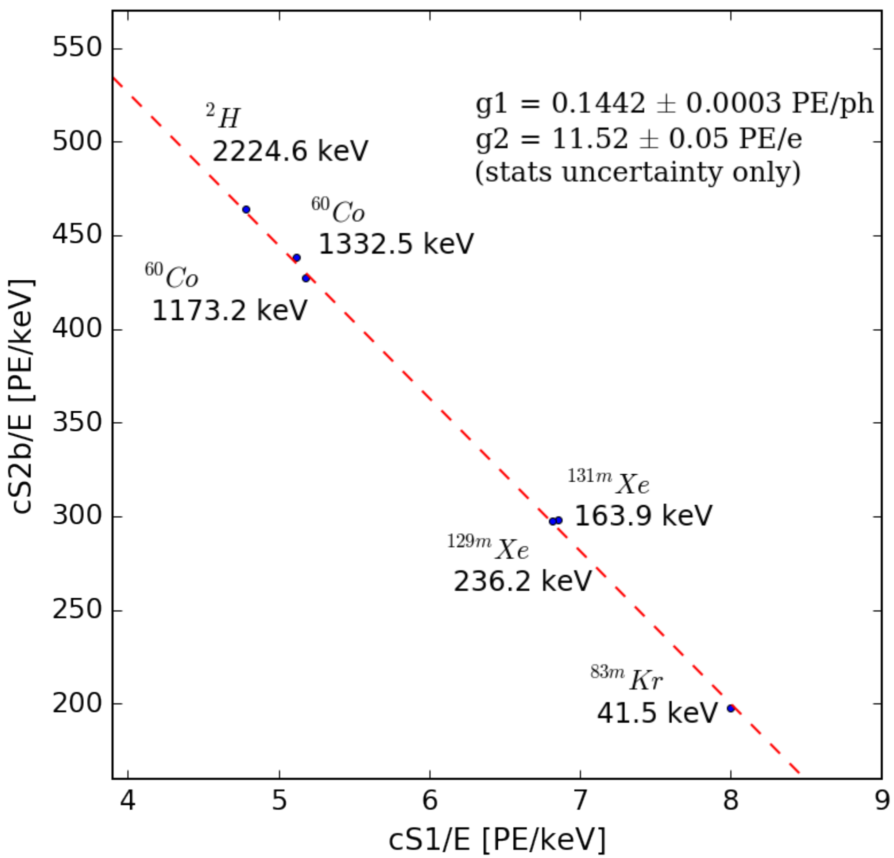
- Average DAQ lifetime = 92%

Detector Stability



Energy response

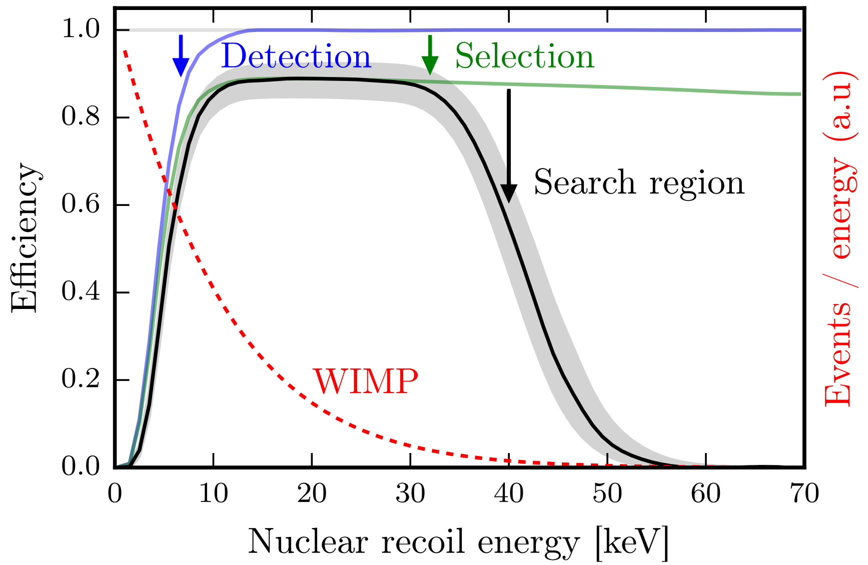
$$E = (n_{ph} + n_e) \cdot W = (\frac{S1}{g1} + \frac{S2}{g2}) \cdot W$$



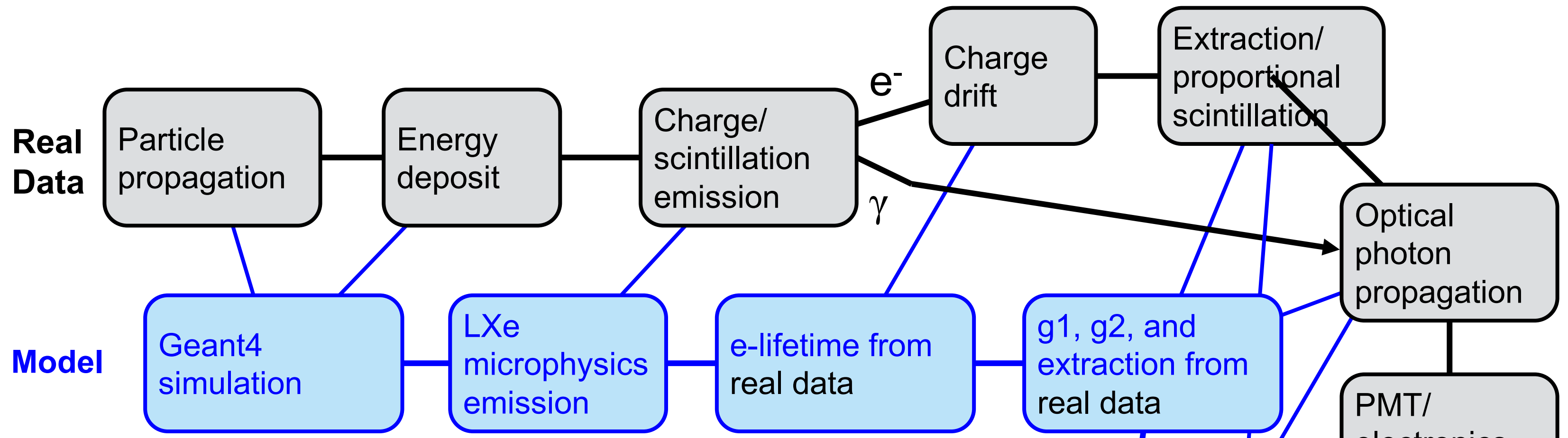
- Excellent linearity with electronic recoil energy from 40 keV to 2.2 MeV
- g1 = 0.1442 ± 0.0068 (sys) PE/photon corresponds to a light detection efficiency of 12.5 ± 0.6%
  - Assumptions of past MC sensitivity projected 12.1%.
- The amplification in gas (g2) corresponds to ~100% extraction of charges from the liquid.
- Feeds into (later) NR model

Efficiencies

- Detection efficiency dominated by 3-fold coincidence requirement
    - Estimated via novel waveform simulation including systematic uncertainties
- Selection efficiencies estimated from control samples or simulation
- Search region defined within 3-70 PE in cS1

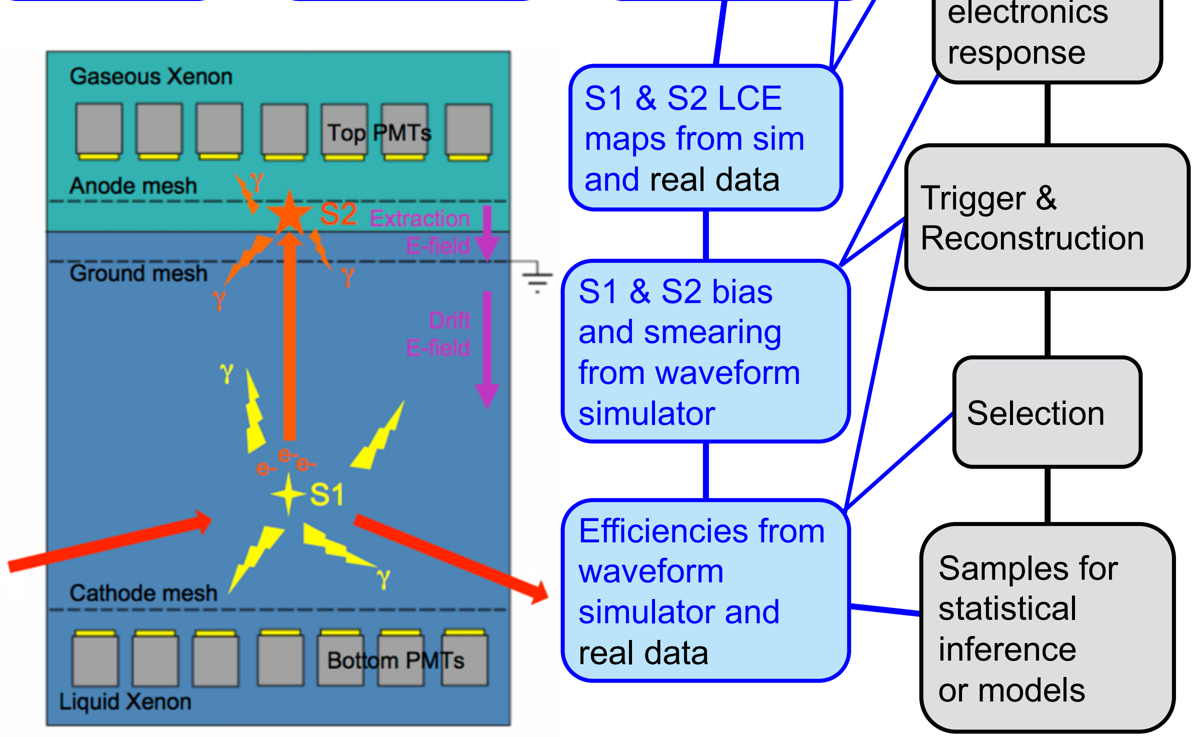


The ER and NR Models

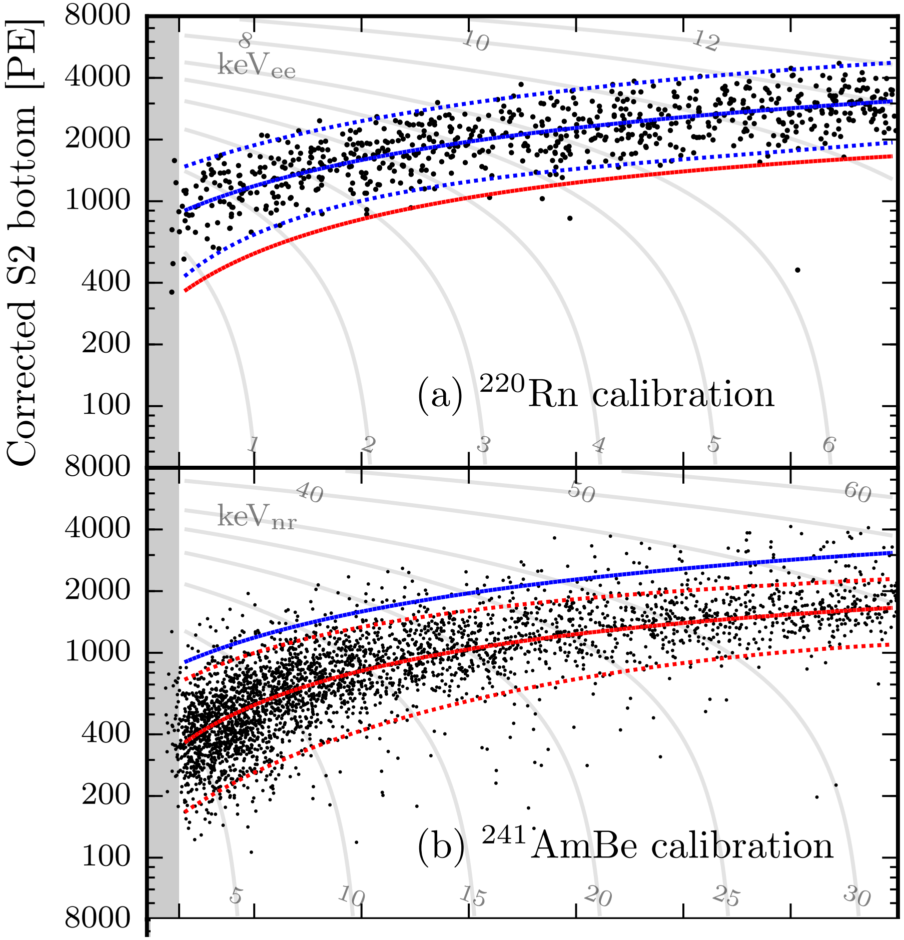


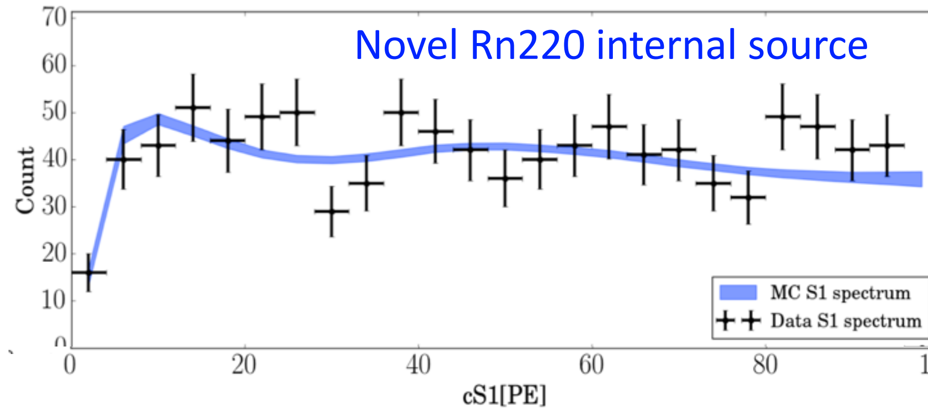
- Simulate LXe microphysics & detector response to fit Rn220 and AmBe calibration data

- Background and signal predictions from tuned models

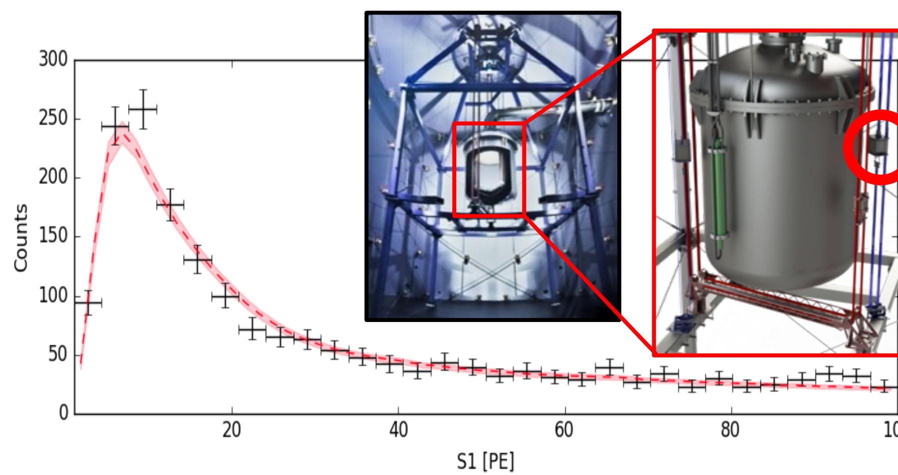


Fitting Models to Calibration



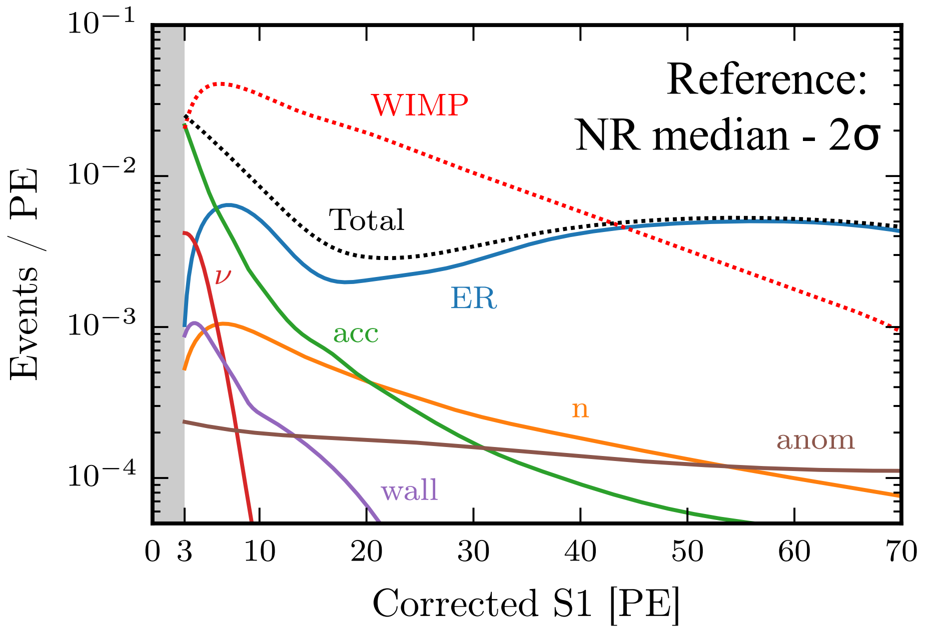


- Full modeling of LXe and detector response in $cS2_b$ vs cS1 space
- All parameters fitted with no significant deviation from priors



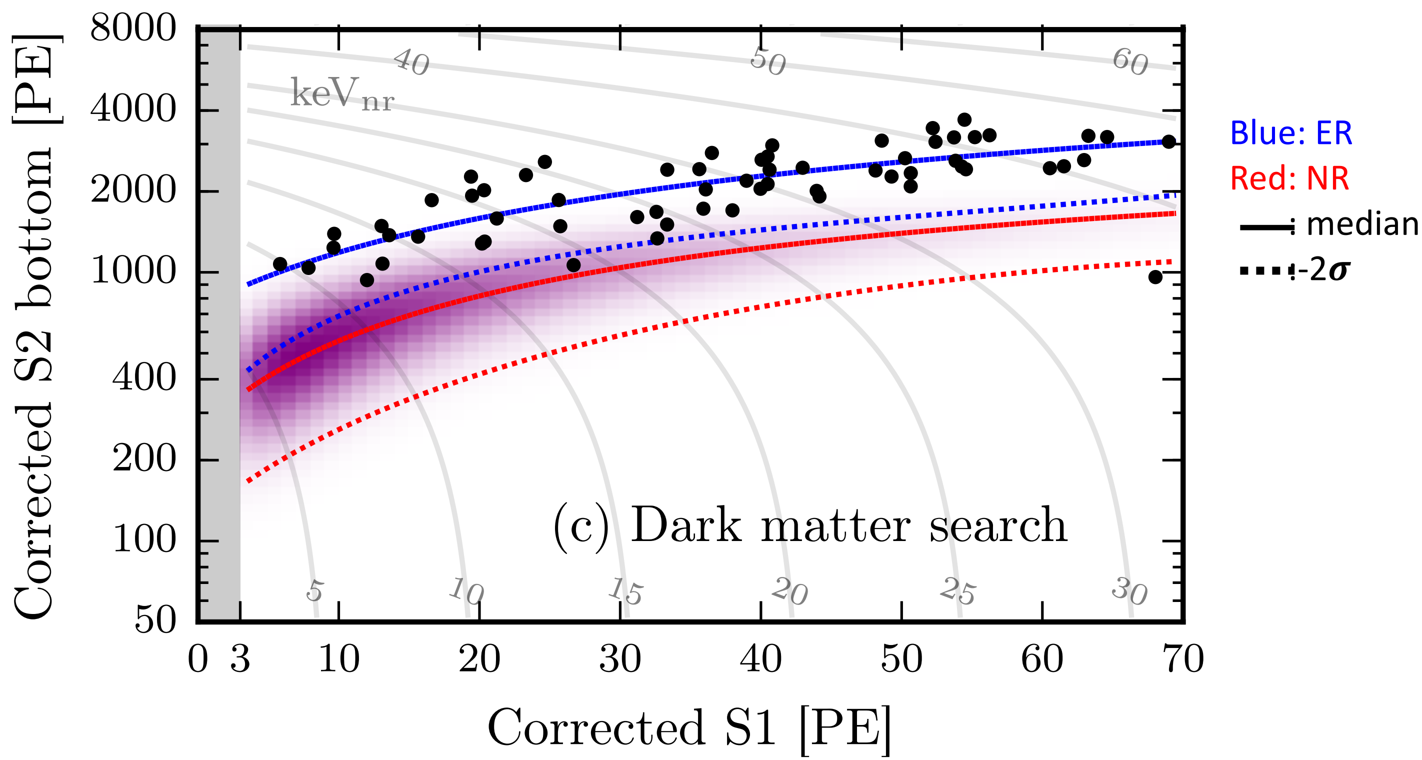
Background model

- ER and NR spectral shapes derived from models fitted to calibration data
- Other background expectations are data-driven, derived from control samples

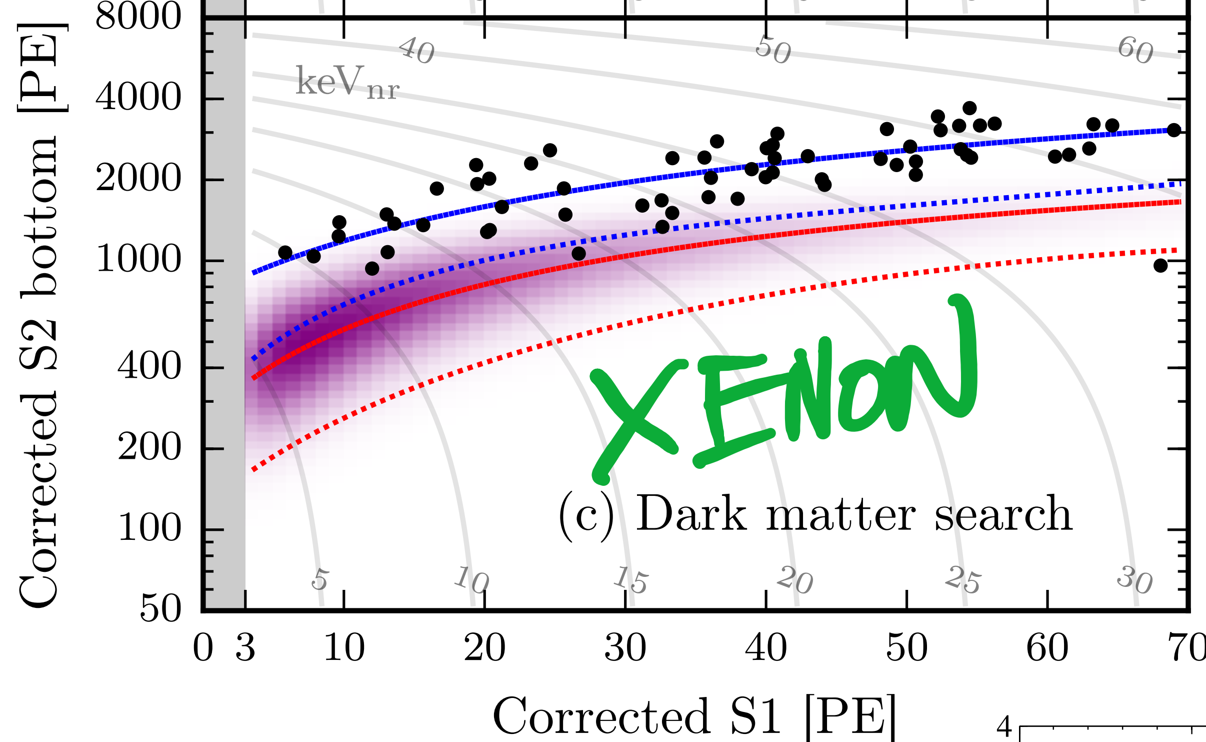


Background & Signal Rates	Total	Reference
Electronic recoils *(ER)*	62 ± 8	0.26 (+0.11)(-0.07)
Radiogenic neutrons *(n)*	0.05 ± 0.01	0.02
CNNS (ν)	0.02	0.01
Accidental coincidences (*acc*)	0.22 ± 0.01	0.06
Wall leakage (*wall*)	0.52 ± 0.32	0.01
Anomalous (*anom*)	0.09 (+0.12)(-0.06)	0.01 ± 0.01
Total background	**63 ± 8**	**0.36 (+0.11)(-0.07)**

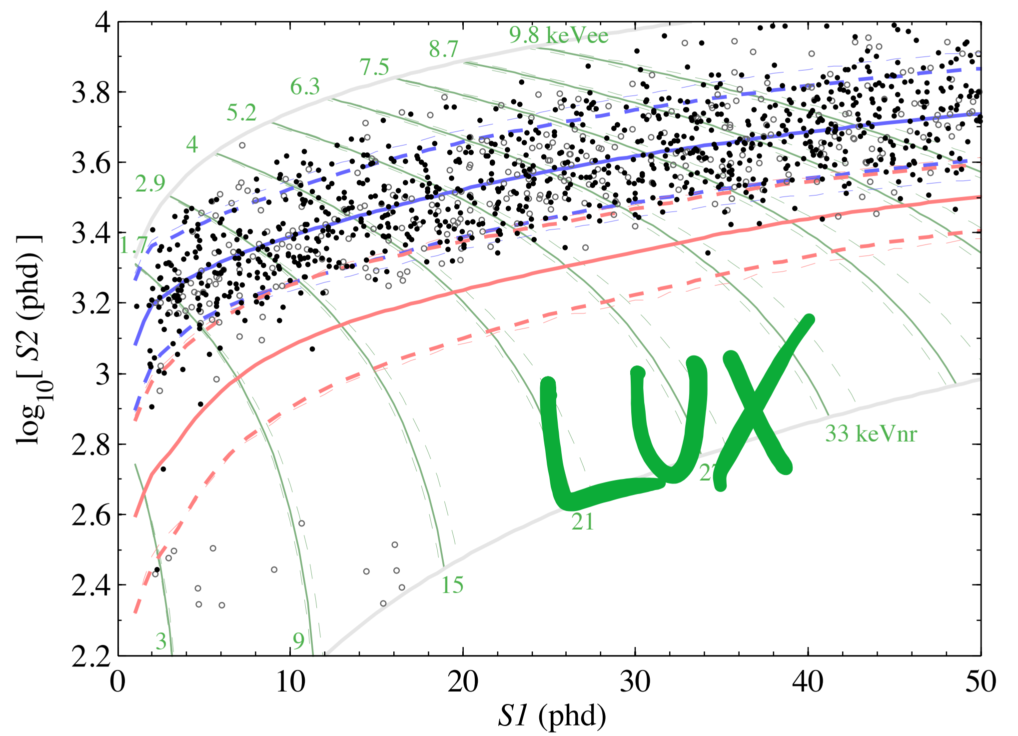
Dark Matter Search



- Extended unbinned profile likelihood analysis
- Most significant ER & NR shape parameters included from cal. fits
- Normalization uncertainties for all components
- Safeguard to protect against spurious mis-modeling of background

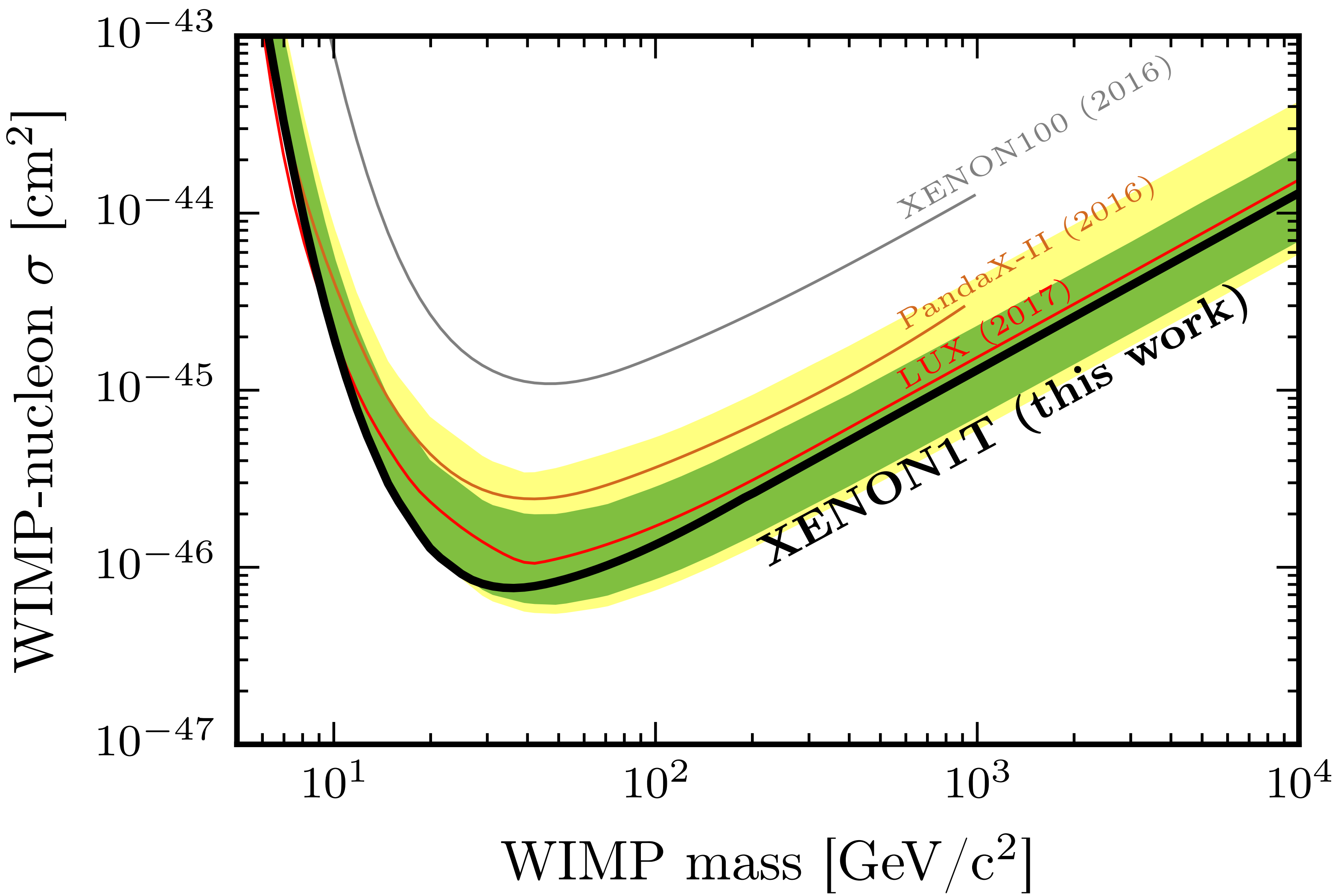


Compare
Same
exposure



Take-away messages

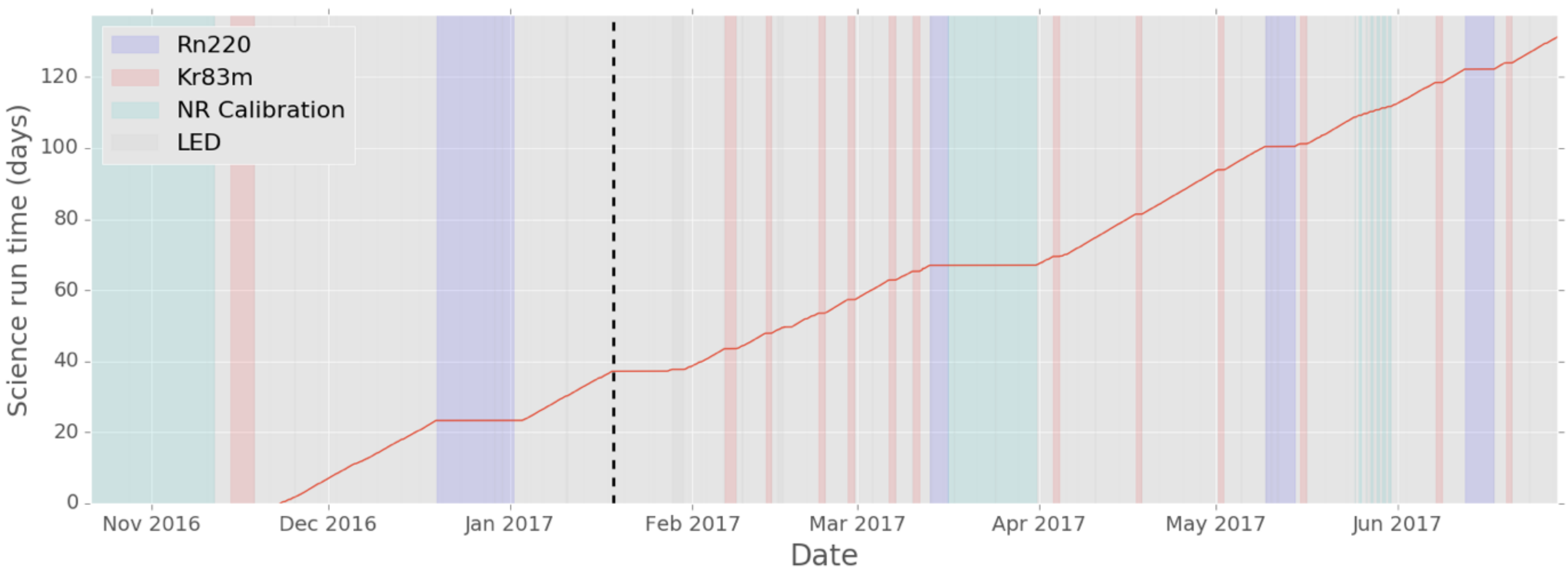
#1: First ton-scale xenon TPC, XENON1T, demonstrated



Take-away messages

#1: First ton-scale xenon TPC, XENON1T, demonstrated

#2: Significant additional (blinded) exposure



Take-away messages

#1: First ton-scale xenon TPC, XENON1T, demonstrated

#2: Significant additional (blinded) exposure

#3: Work for XENON1T upgrade, XENONnT, underway