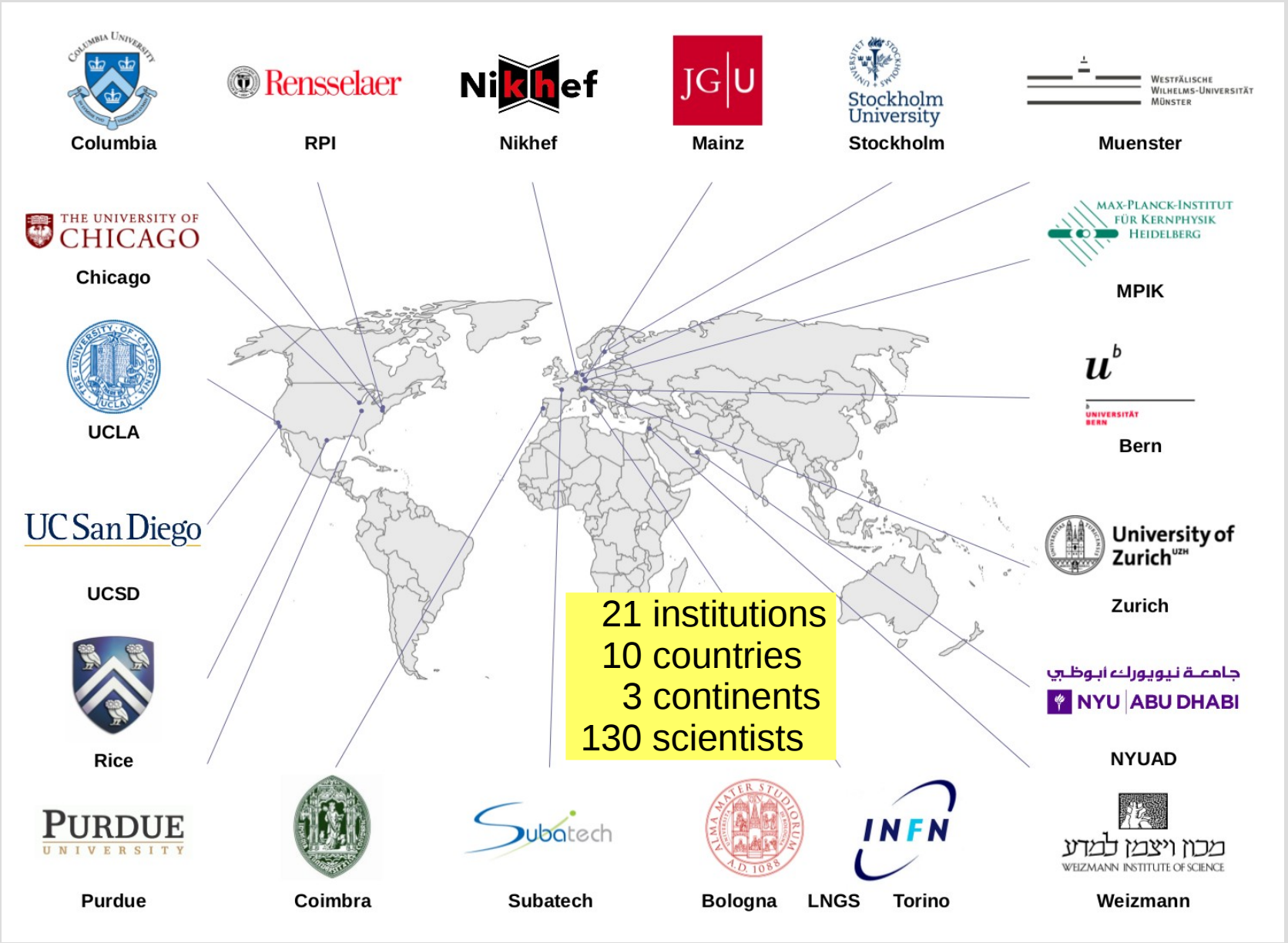
XENON1T

Marc Schumann (AEC Bern)
on behalf of the Collaboration

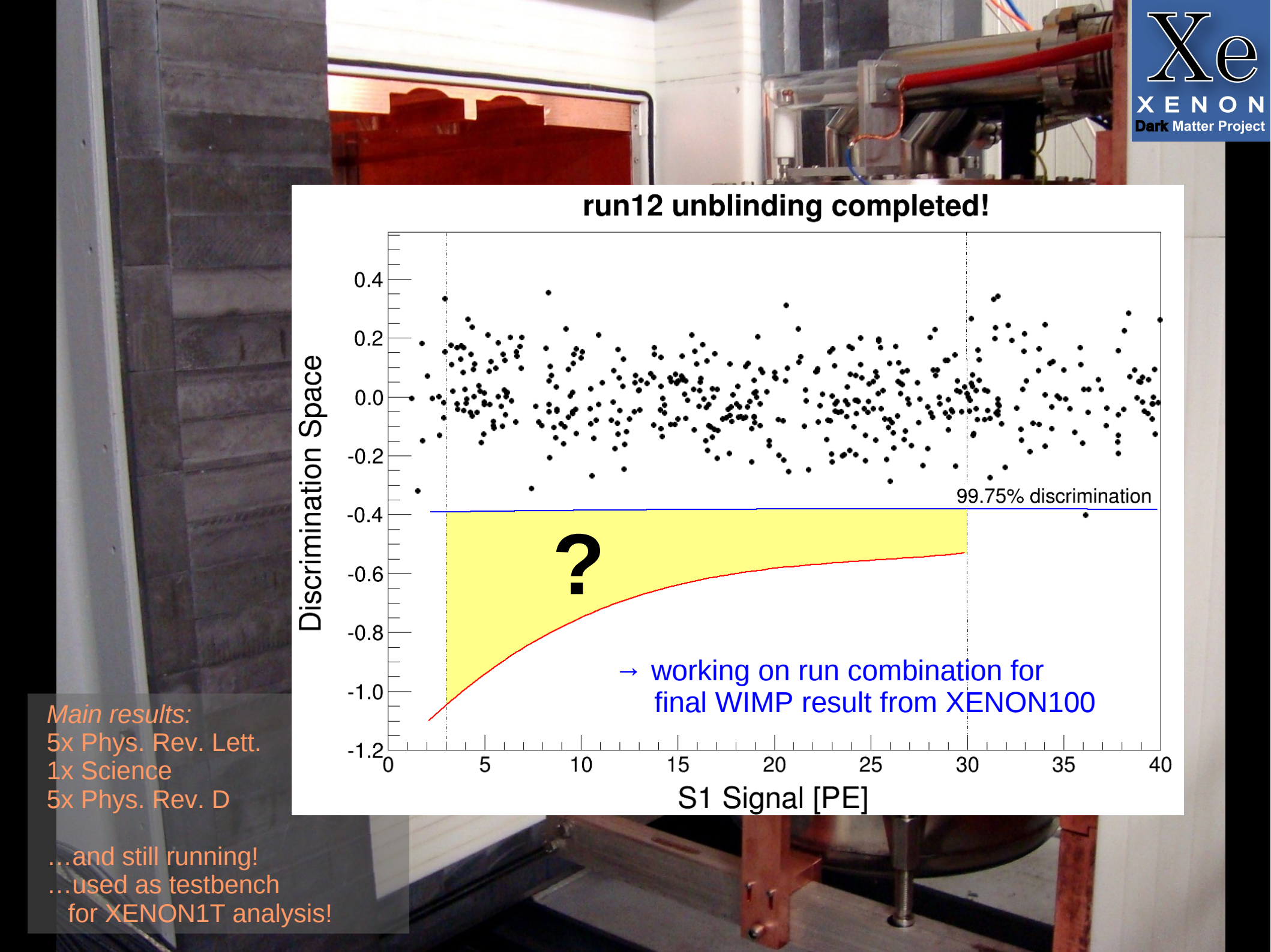
LNGS Open Session, 11.04.2016

The XENON Collaboration



Main results:
5x Phys. Rev. Lett.
1x Science
5x Phys. Rev. D

…and still running!
…used as testbench
for XENON1T analysis!



Main results:
5x Phys. Rev. Lett.
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…and still running!
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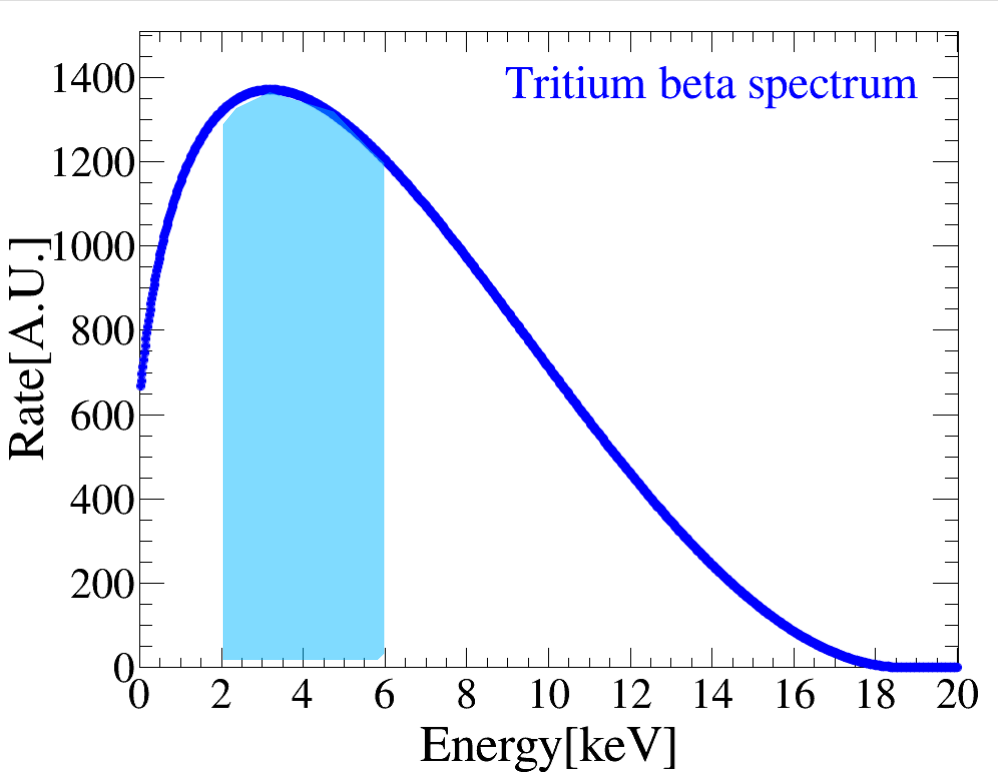
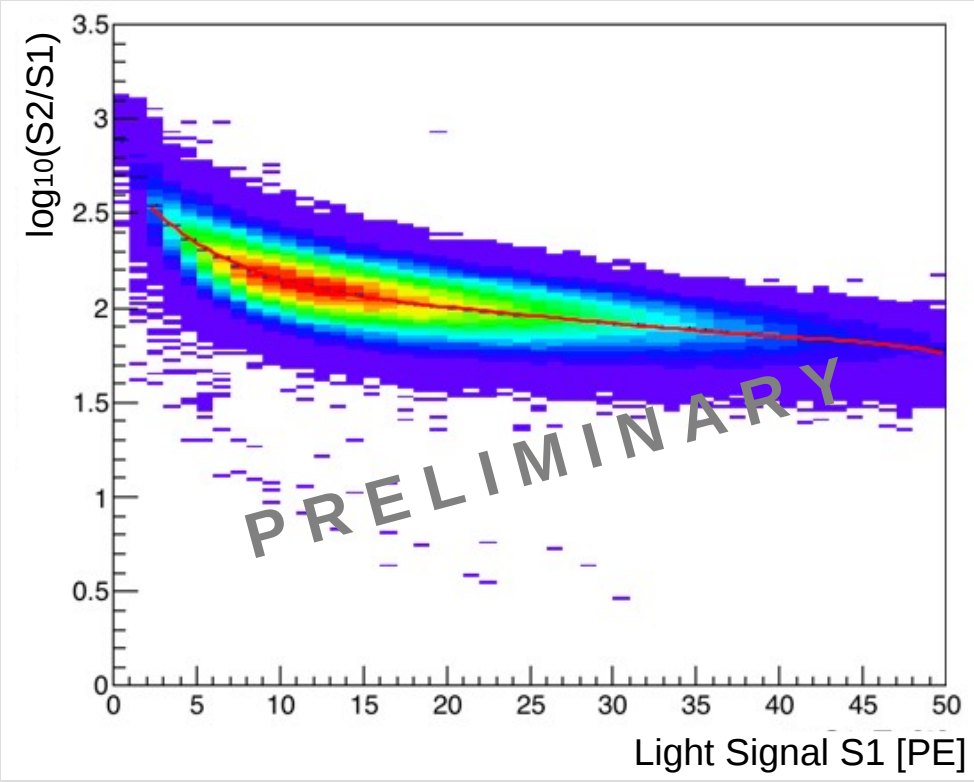
XENON100 – CH_3T Studies

Intrinsic ER calibration with tritiated methane: pioneered by LUX *arXiv:1512.03133*



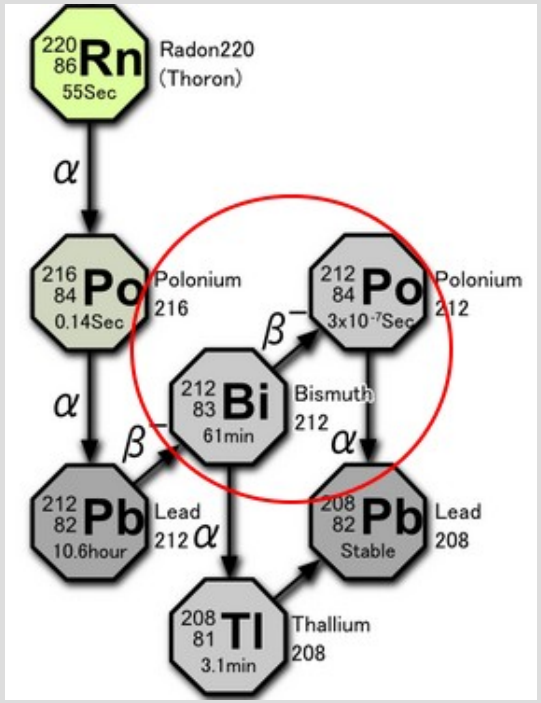


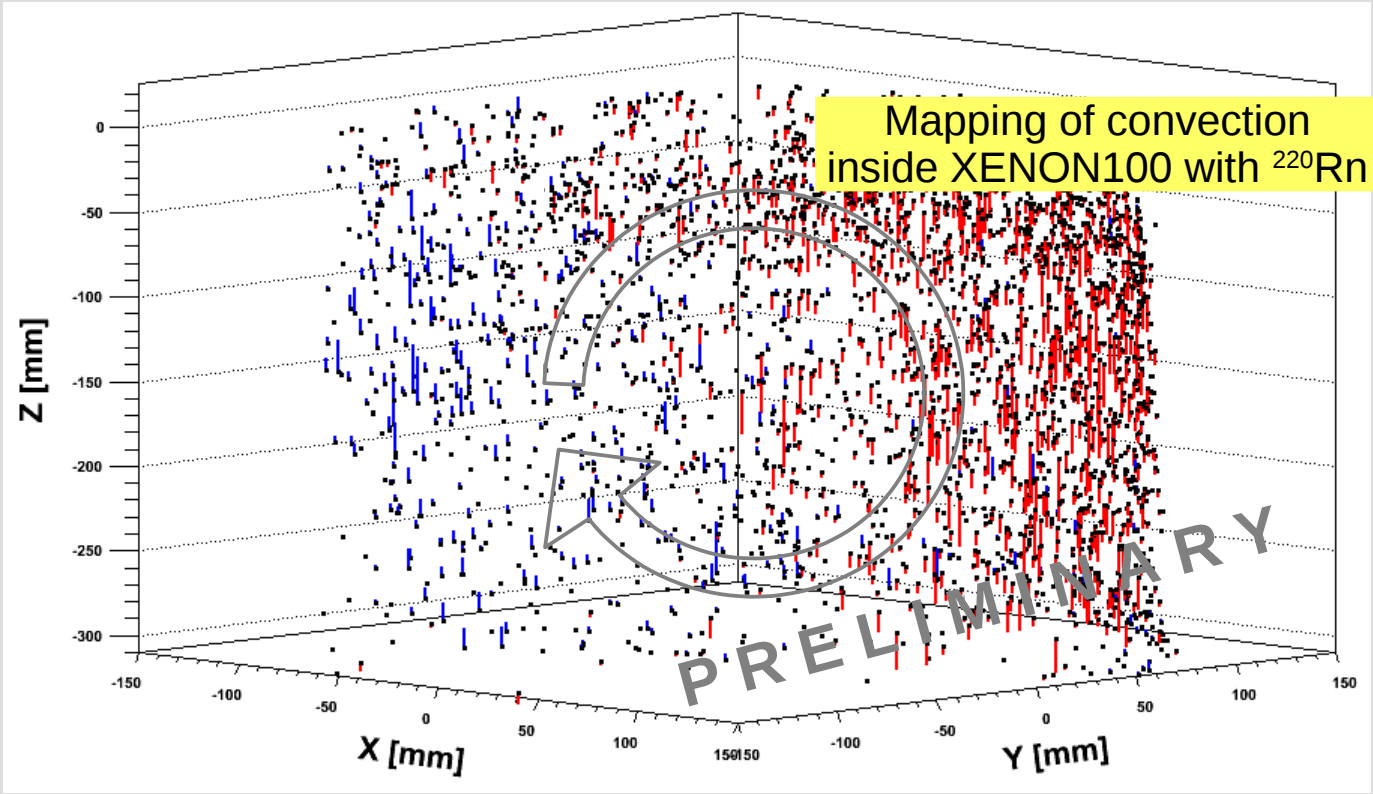
- high-stats calibration of XENON100 successfully performed twice
- ongoing: data analysis, removal strategies, application to XENON1T

→ electron lifetime unaffected

XENON100 – ^{220}Rn Studies

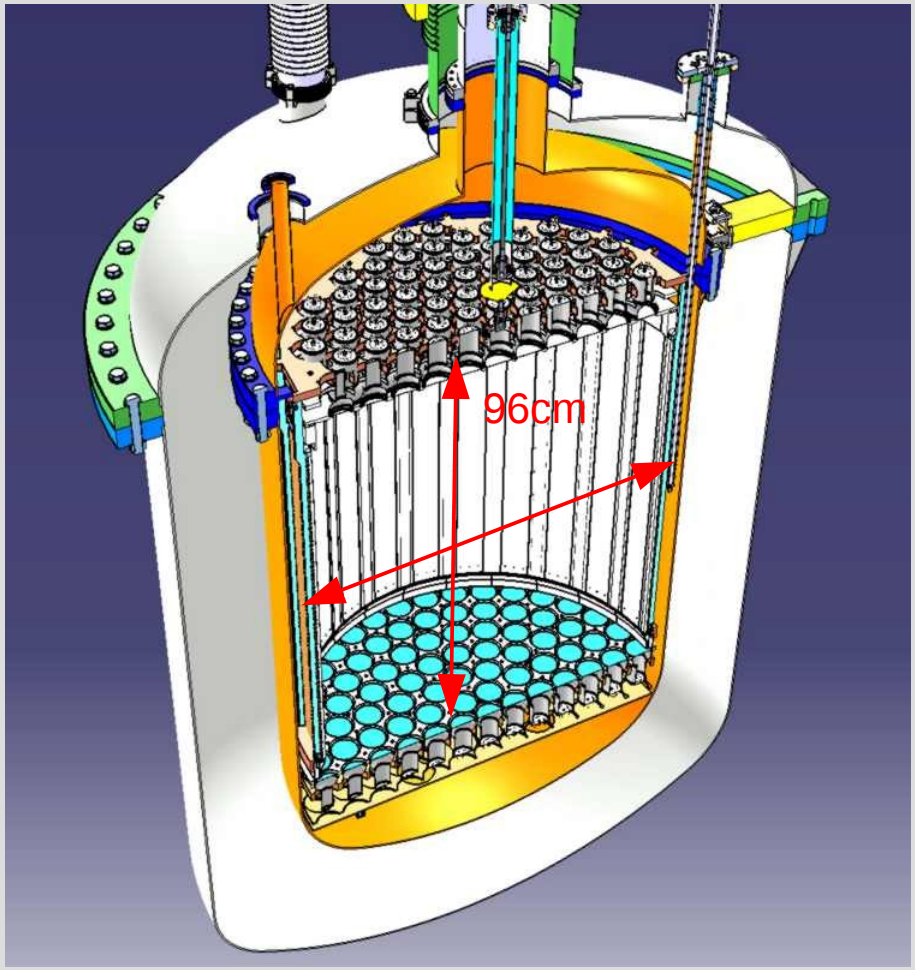
- ^{228}Th source emanates ^{220}Rn
- ^{220}Rn is very short-lived (55 s)
- use beta-decays following ^{220}Rn to characterize low-E ER response
- prepare XENON1T use



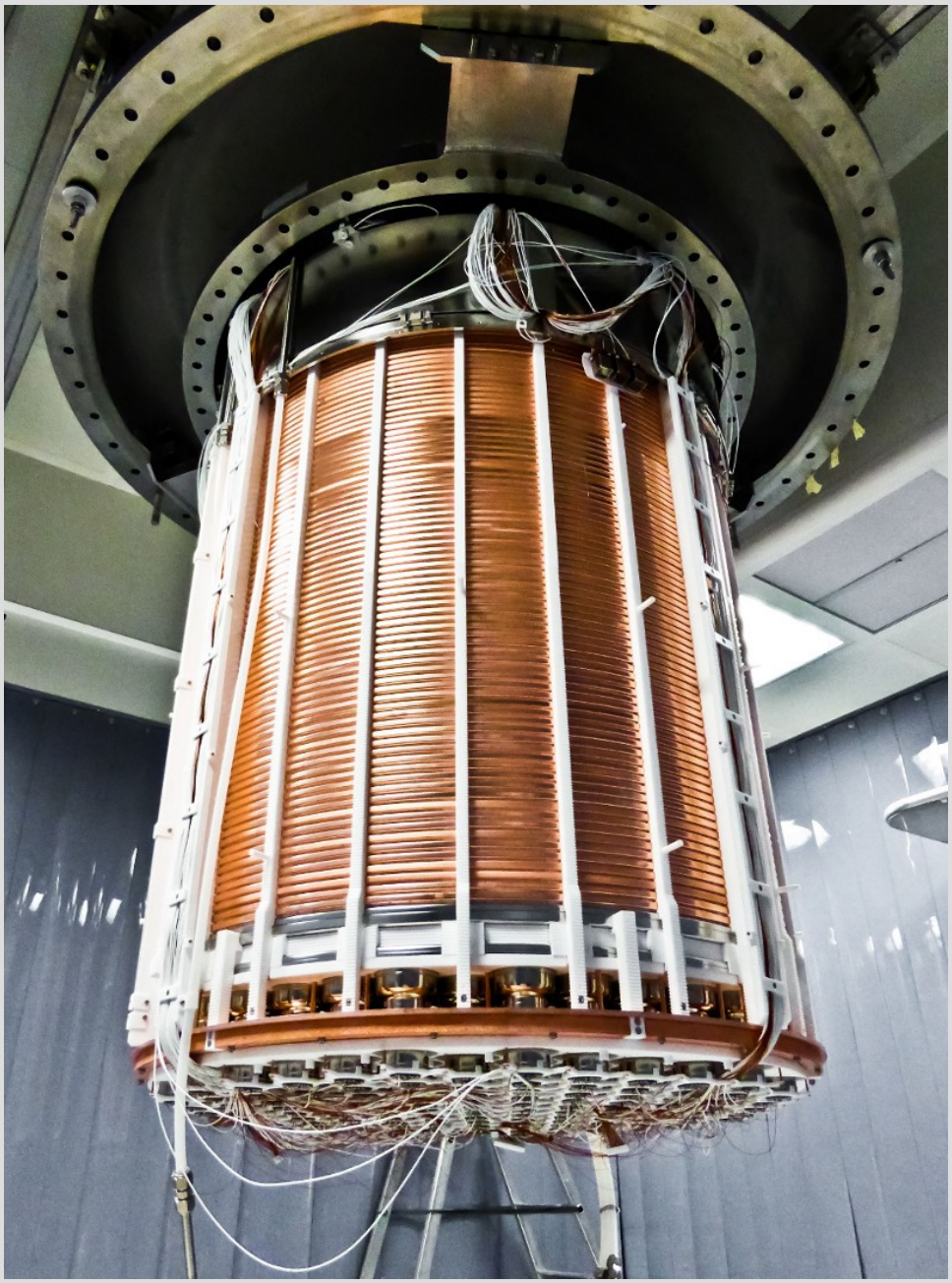



XENON1T
Xe
XENON
Dark Matter Project

XENON1T



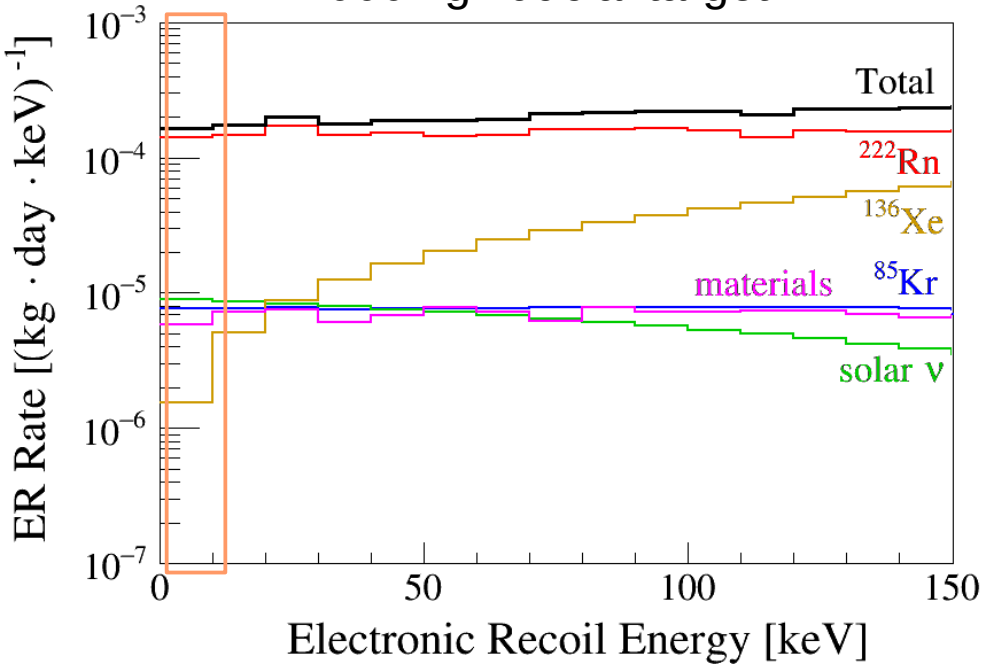
- 3.5 t liquid xenon in total
- **2.0t active target**
- ~1t after fiducialization
- 248+6 PMTs



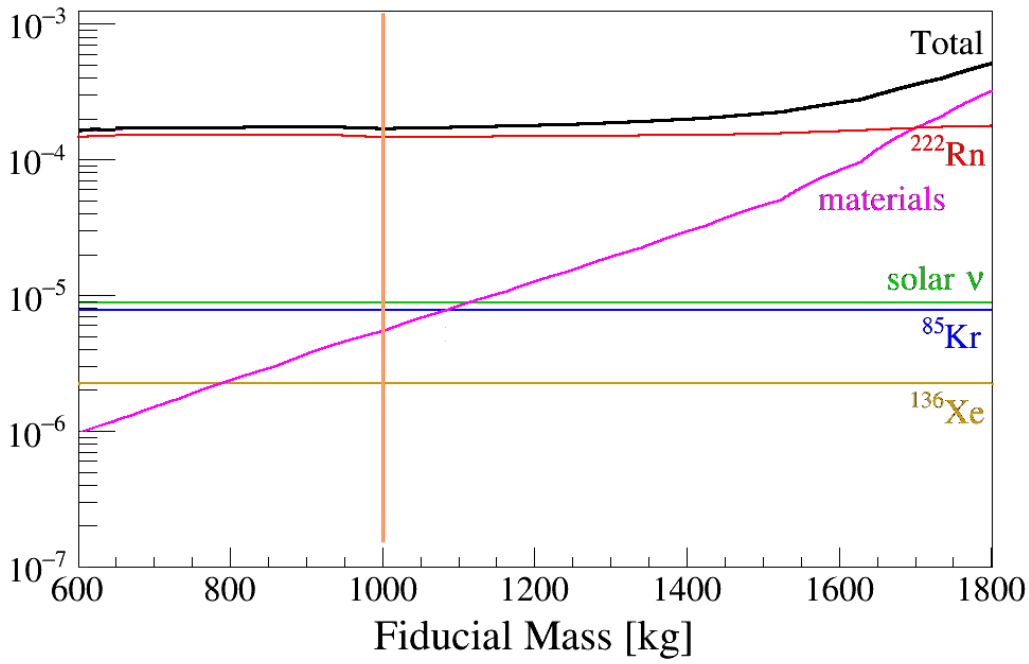
Background: Electronic Recoils

arXiv:1512.07501, accepted by JCAP

1000 kg fiducial target



1–12 keV interval

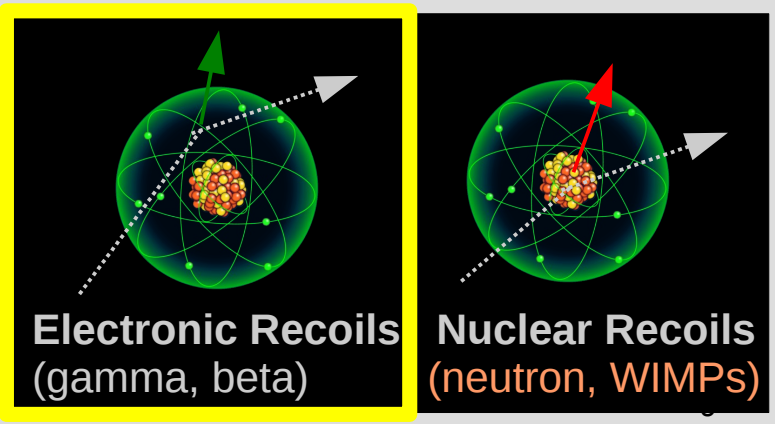


Assumed contamination:

^{222}Rn: 10 µBq/kg

^{nat}Kr: 0.2 ppt

^{136}Xe: 8.9% natural abundance



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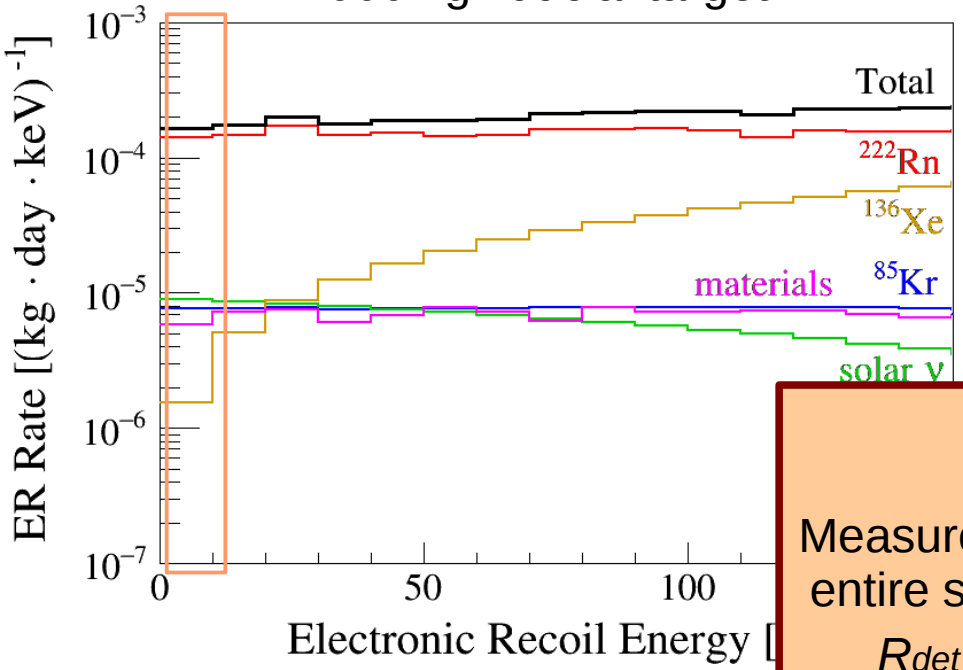

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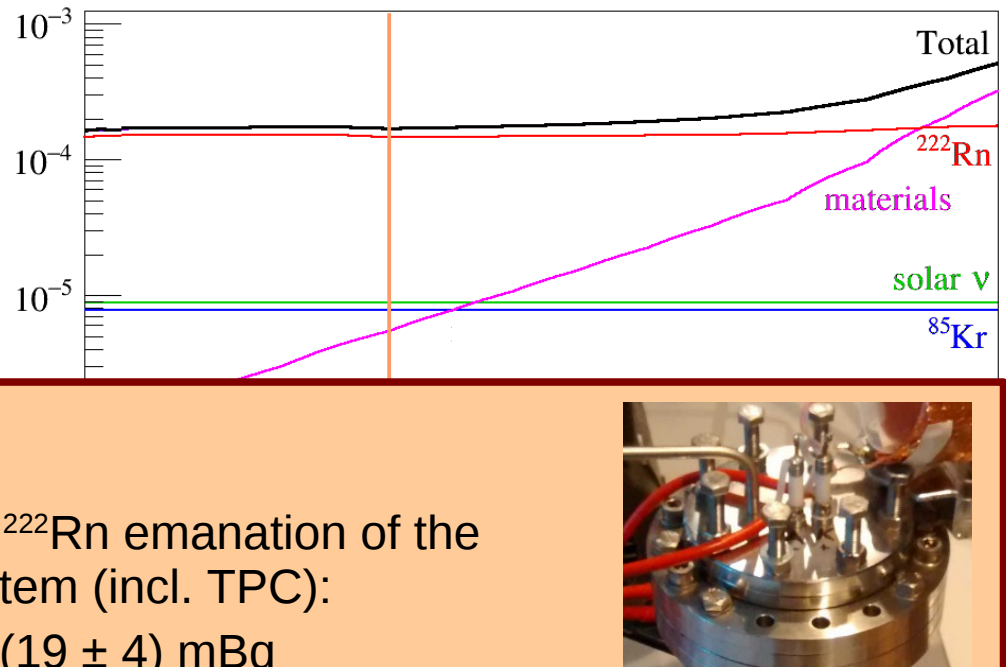

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Measured ^{222}Rn emanation of the entire system (incl. TPC):

R_{det} = (19 ± 4) mBq

Contribution from purification system:

R_{PUR} ~ 10 mBq (depends on pump)

→ expect **8 µBq/kg** in LXe

→ this conservatively assumes uniform mixing

→ **design goal achieved!**

Kr Distillation

Design goals

- High throughput: 3 kg/h (3.5t in ~50d)
- High separation: $>10^4$
- Online monitoring of performance

Successful commissioning

- Operation at 3 kg/h @ 99% Xe recovery (even 6 kg/h could be operated stably)

Kr-in: 0.34 ppm = 3.4×10^{-7} (very high Kr content! gas chromatography)

Kr-out: 0.73 ppt = 7.3×10^{-13} (RGMS)

→ **reduction factor ~5×10^5**

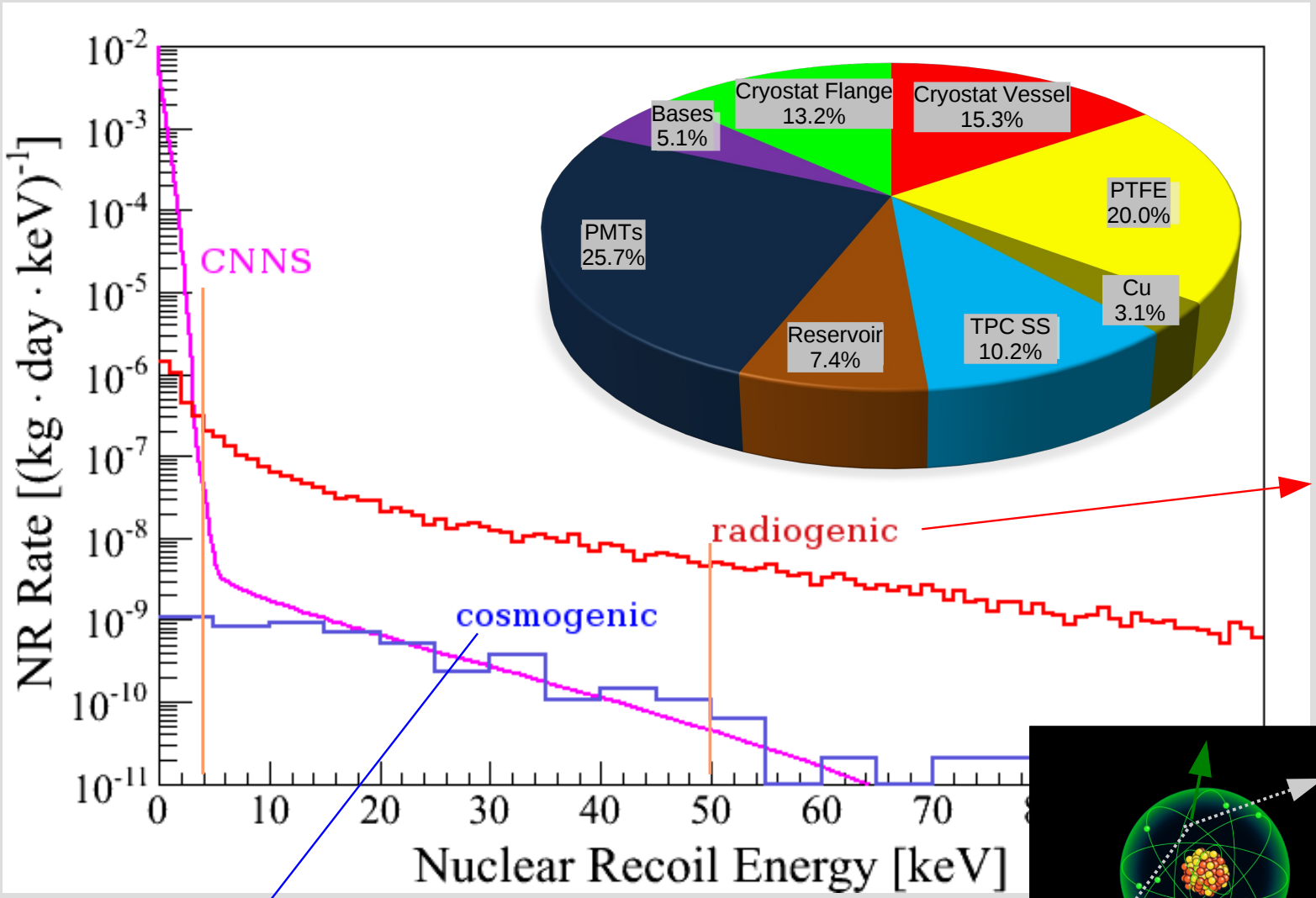
→ **exceeds the design goal of 10^4!**

- 3 distillation runs so far (with O(100)kg each) to purify highly contaminated gas (with Kr, He)
- column has already delivered a concentration of **<0.026 ppt** = 2.6×10^{-14} (90% CL)

→ **better than required for XENON1T**

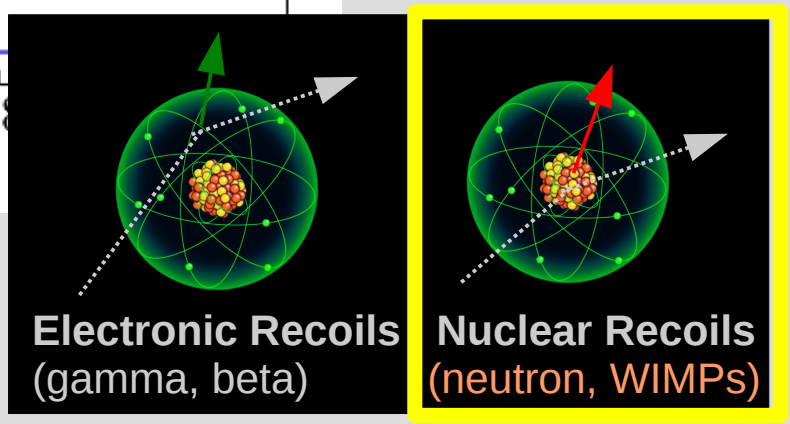
Background: Nuclear Recoils

arXiv:1512.07501, accepted by JCAP



material screening, e.g. EPJ C 75, 546 (2015)

Muon veto design and performance: XENON1T, JINST 9, P11006 (2014)



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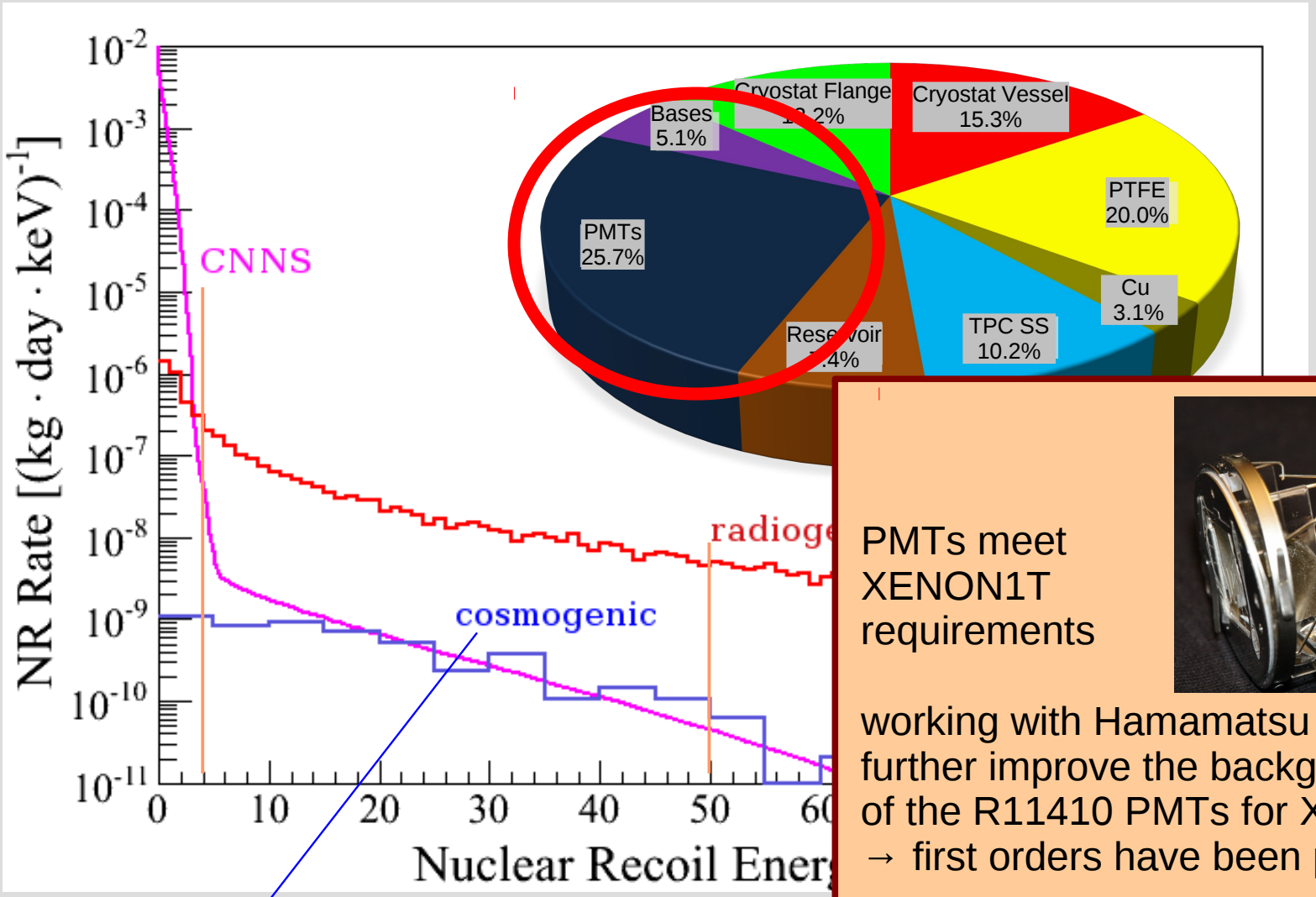


PMTs meet XENON1T requirements

working with Hamamatsu to further improve the background of the R11410 PMTs for XENONnT
→ first orders have been placed

Muon veto design and performance: XENON1T, JINST 9, P11006 (2014)

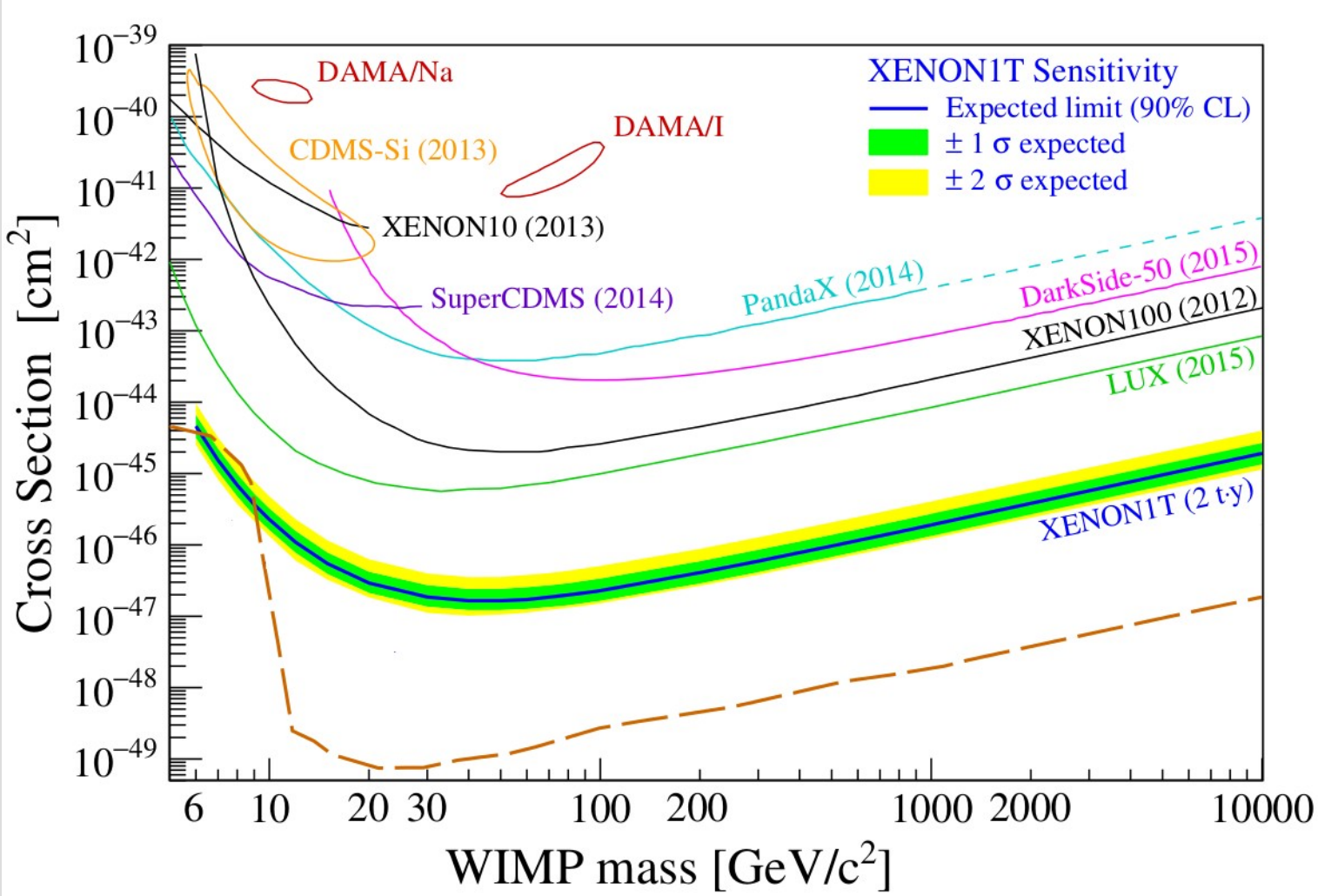
Electronic Recoils (gamma, beta)

Nuclear Recoils (neutron, WIMPs)

XENON1T Sensitivity

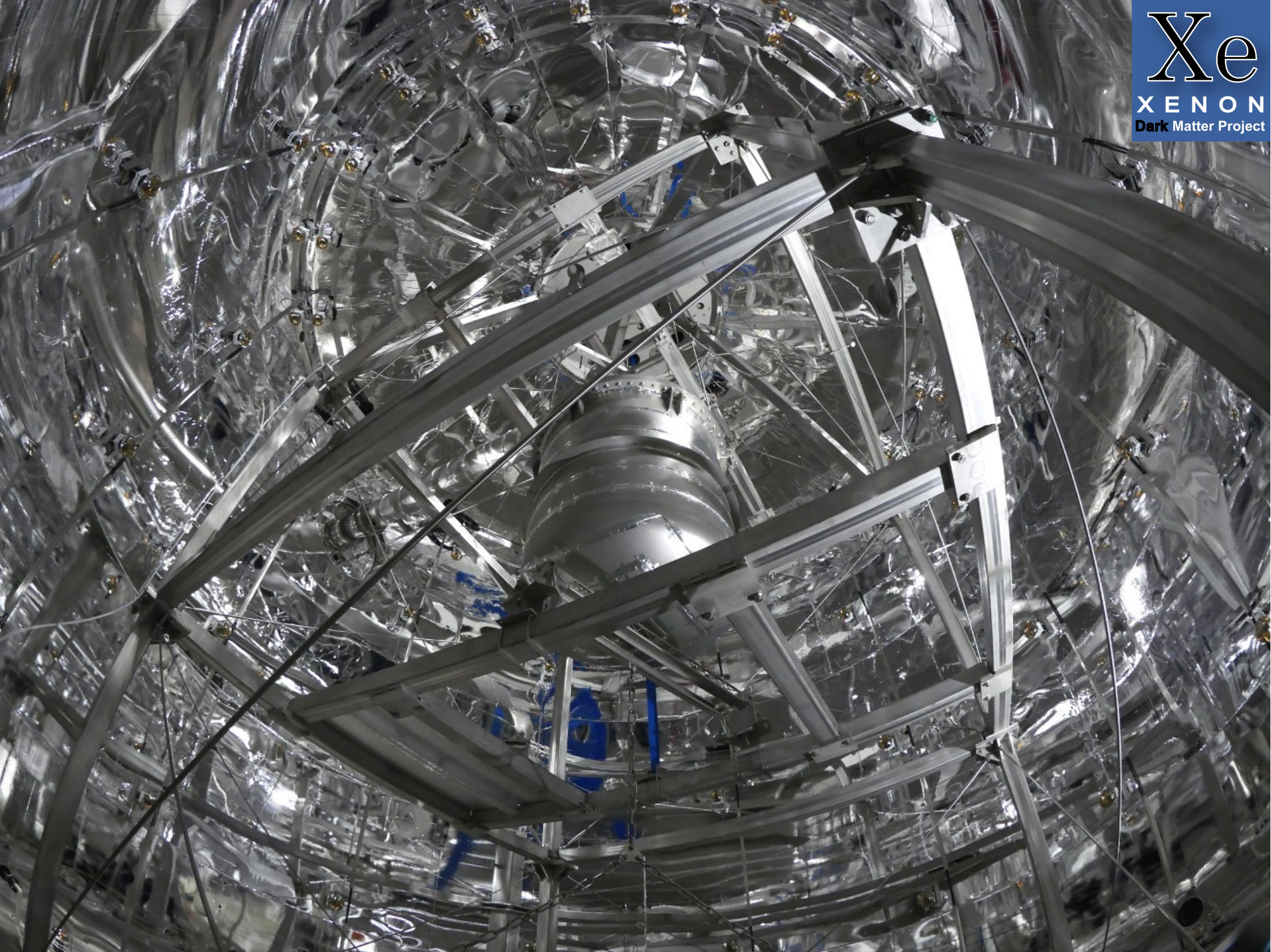
arXiv:1512.07501, accepted by JCAP

based on background predictions shown before, 2 t×y exposure:

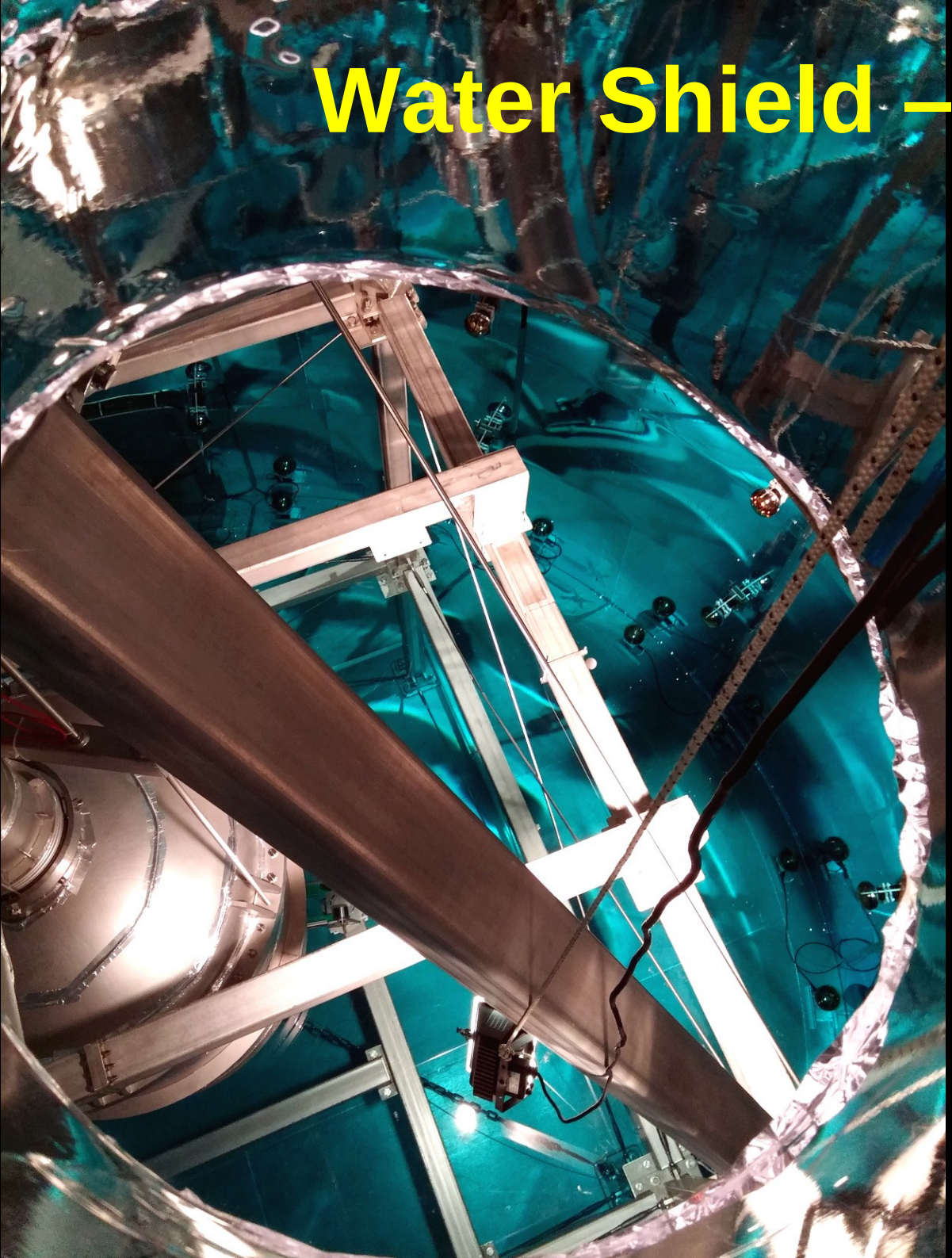


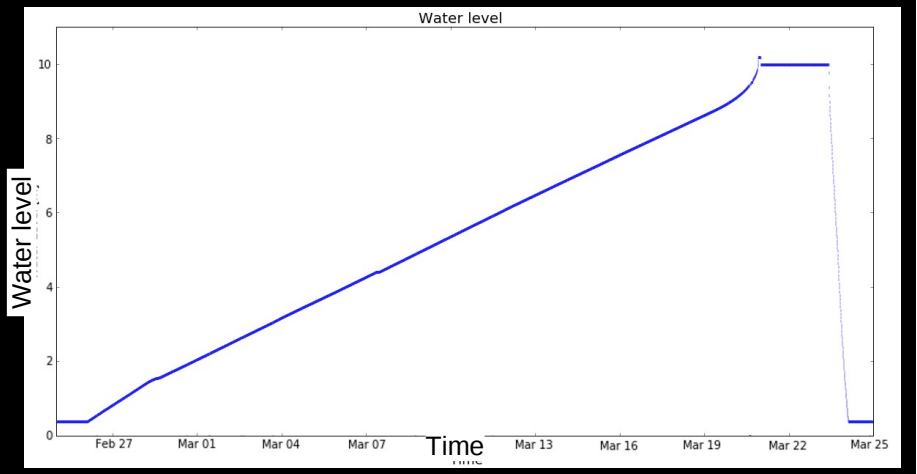
assumptions: energy interval: 4 – 50 keV, ER rejection as XENON100: 99.5% @ 50% NR acc.

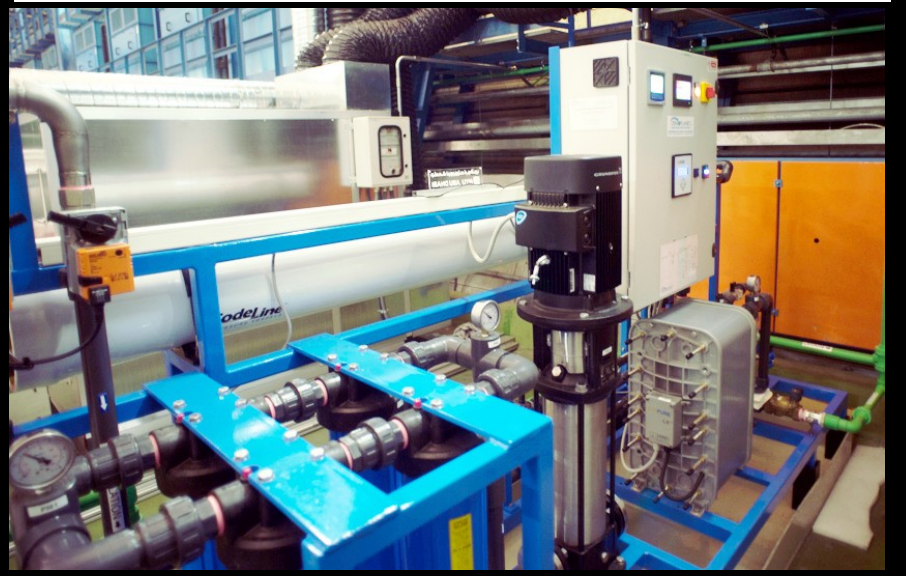
→ expected LY is 2x higher than in XENON100!


Xe
XENON
Dark Matter Project

Water Shield – Filling







Muon Veto – Commissioning

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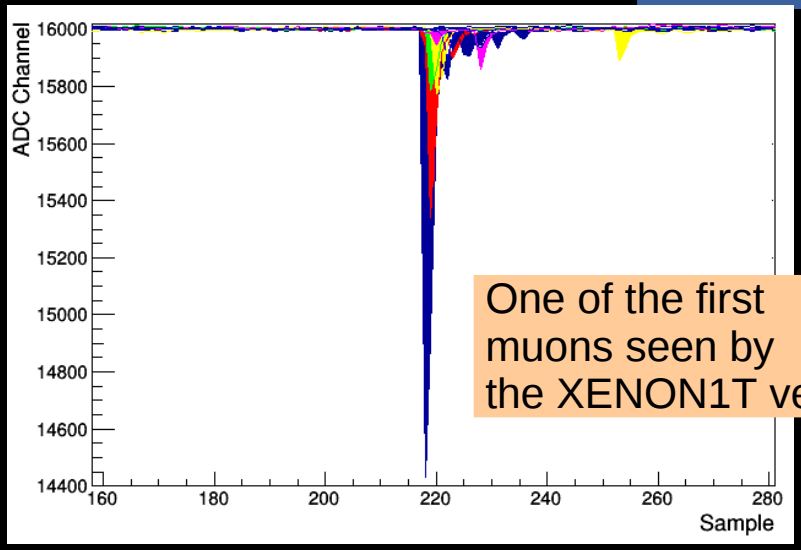
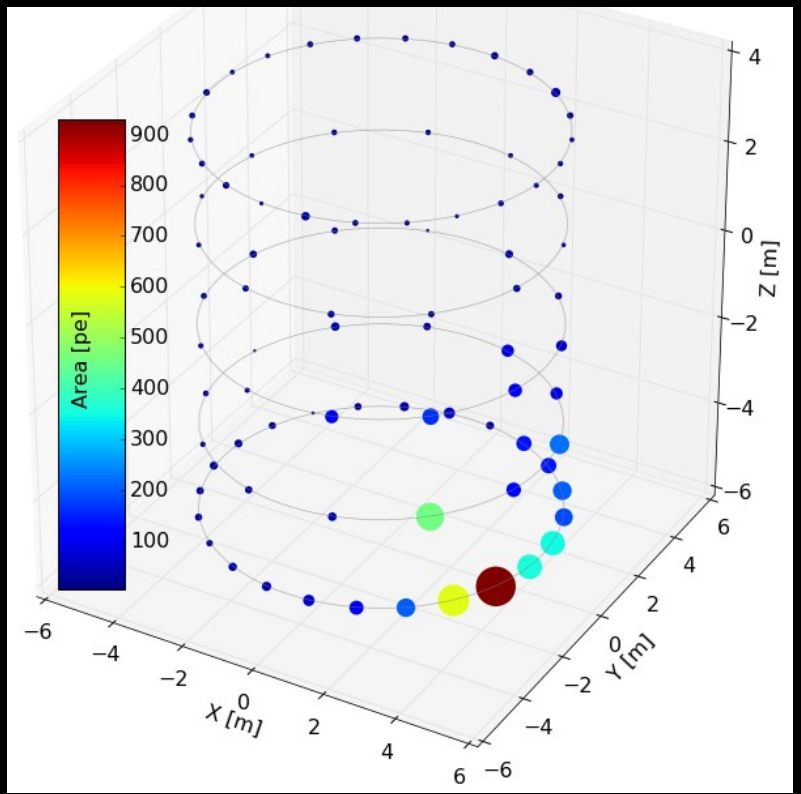
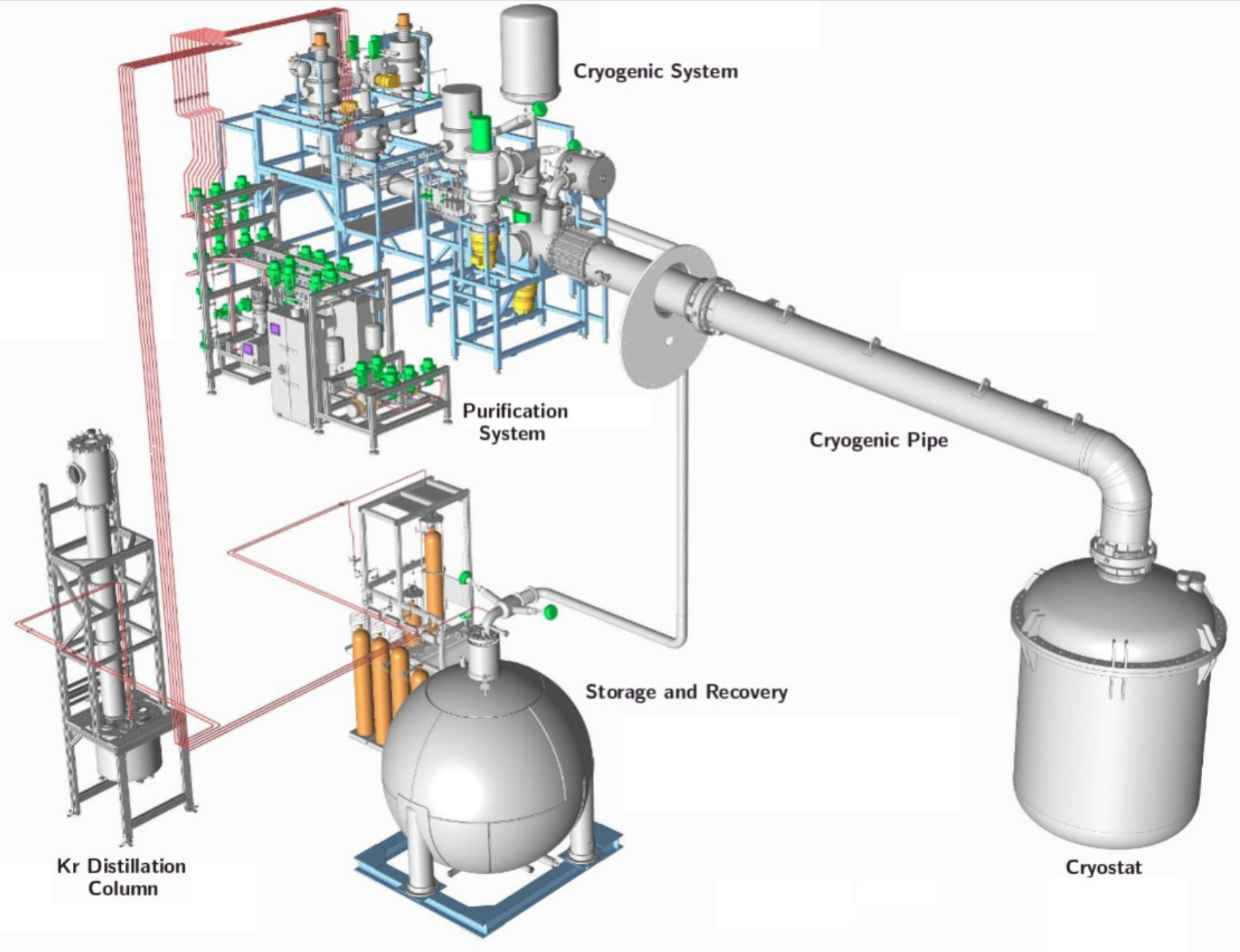


One of the first muons seen by the XENON1T veto



Cryo-Systems



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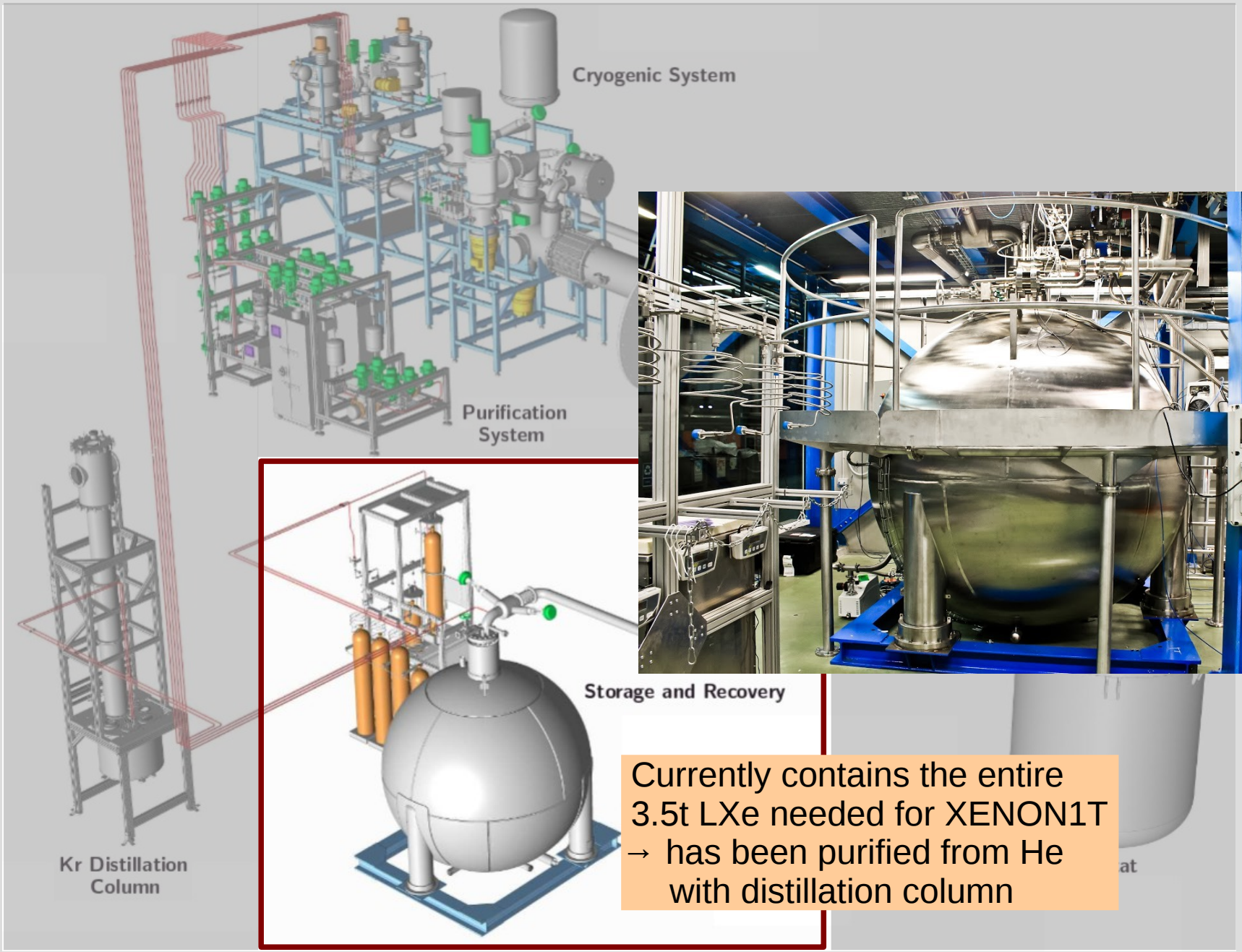
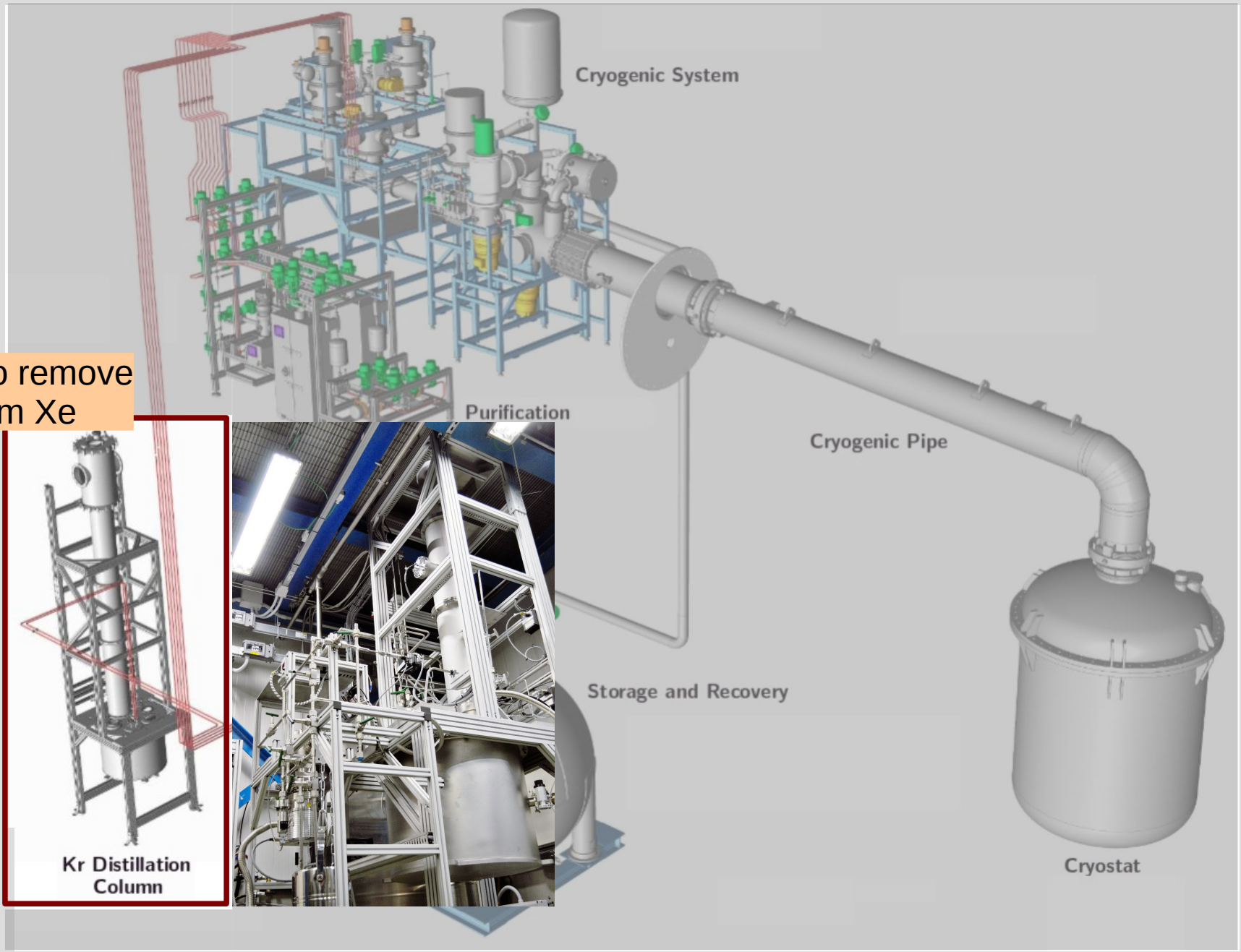


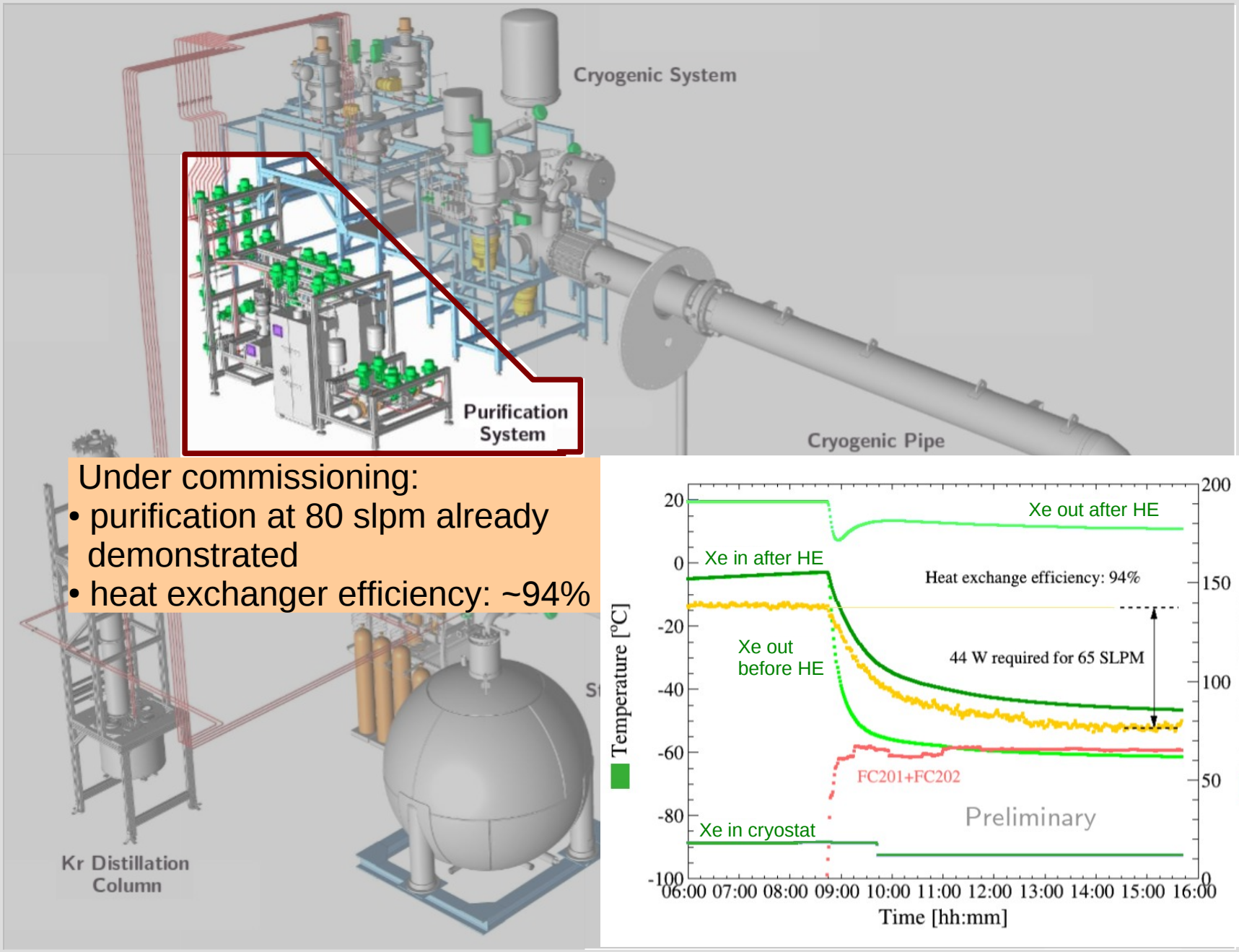
Currently contains the entire 3.5t LXe needed for XENON1T
→ has been purified from He with distillation column

Cryo-Systems



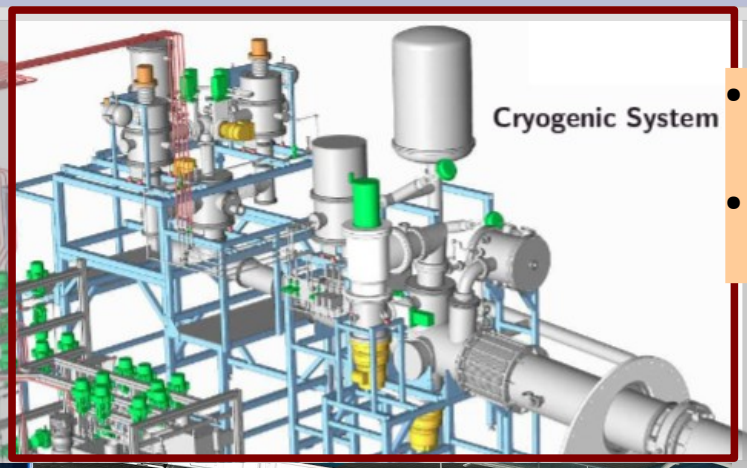
ready to remove ^{nat}Kr from Xe

Cryo-Systems



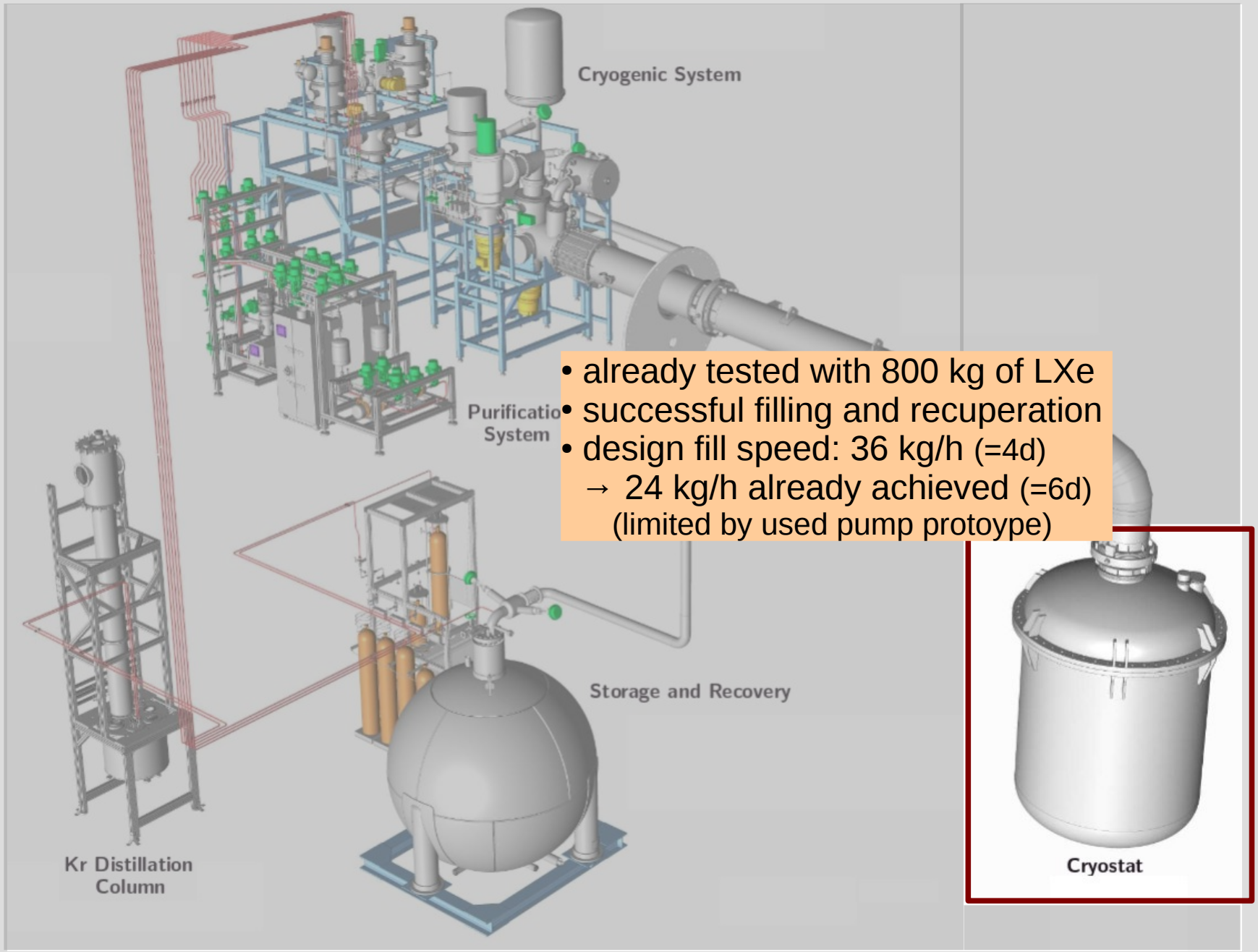
Under commissioning:
- purification at 80 slpm already demonstrated
- heat exchanger efficiency: ~94%

Cryo-Systems



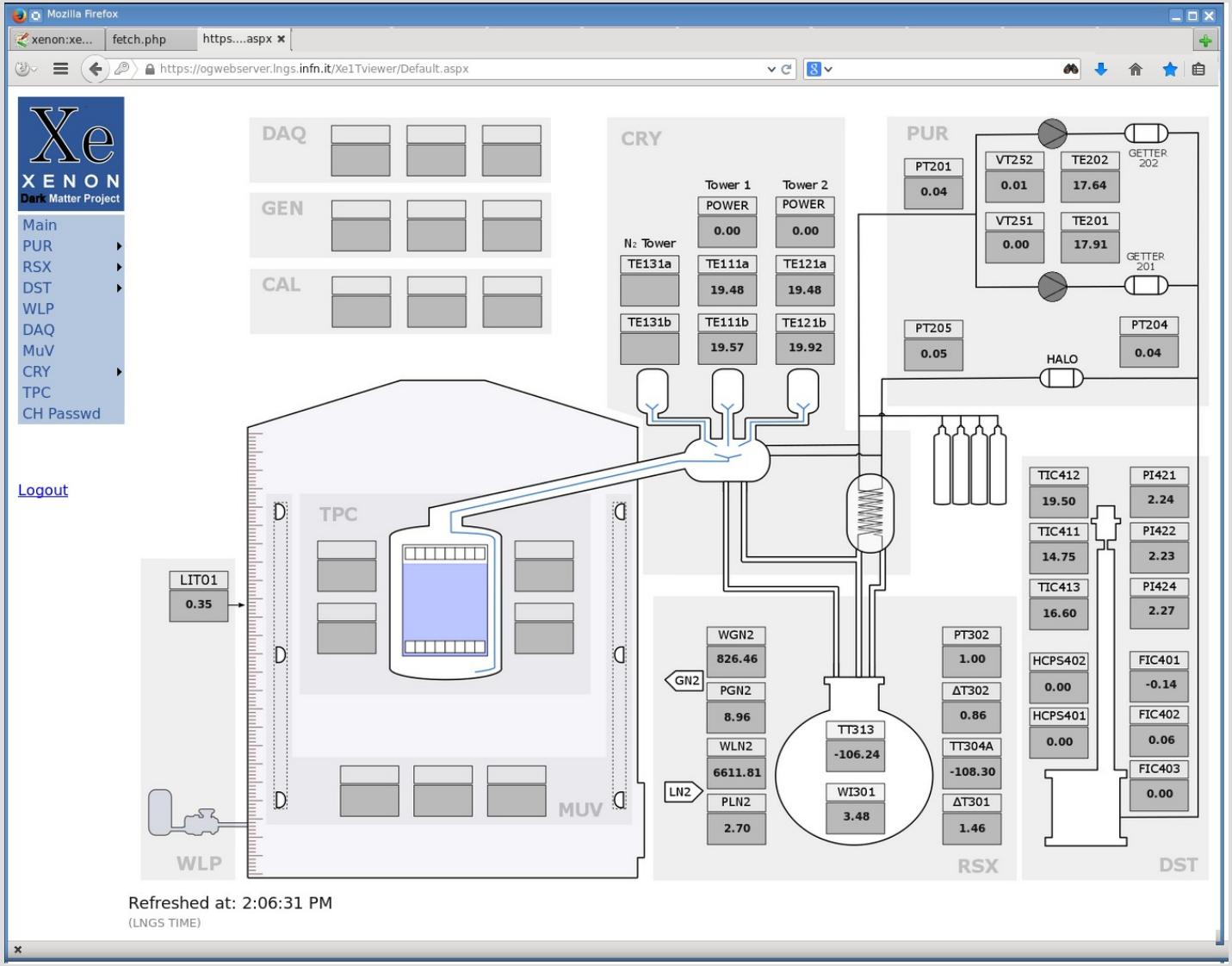
- 3 redundant cold-heads
  (2 PTR, 1 LN2)
- sufficient cooling power
  for $\gg$100 slpm purification

Cryo-Systems



- already tested with 800 kg of LXe
- successful filling and recuperation
- design fill speed: 36 kg/h (=4d)
  → 24 kg/h already achieved (=6d)
  (limited by used pump protoype)

Slow Control & Safety

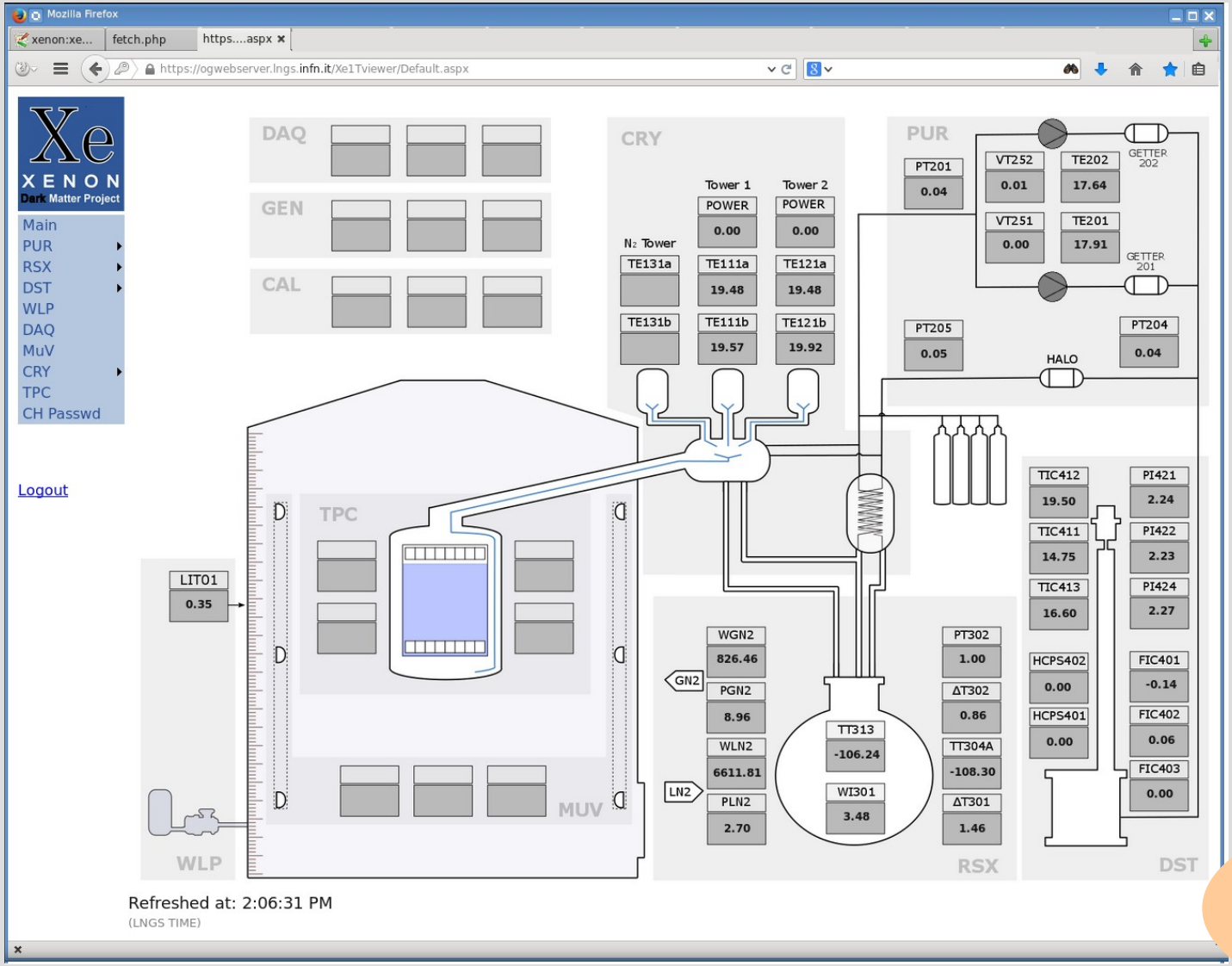


- XENON1T Slow Control system (SCADA) based on GE industry standard
- controls all cryo-systems, calibration, high voltages
- monitoring, alarms
- expert and user mode

Operation Risk Review

- an internal evaluation panel has reviewed all cryogenics operations
  → recommendations to mitigate risks already implemented

Slow Control & Safety



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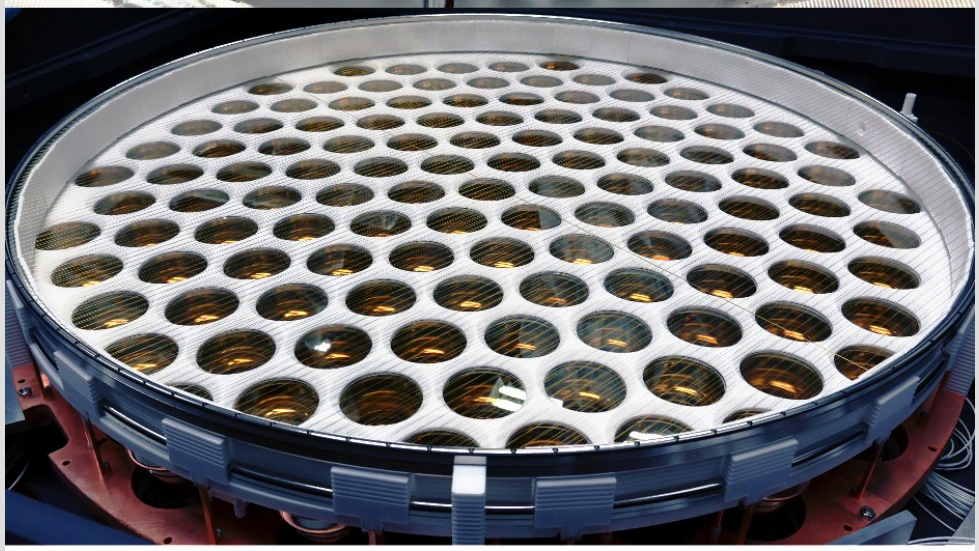
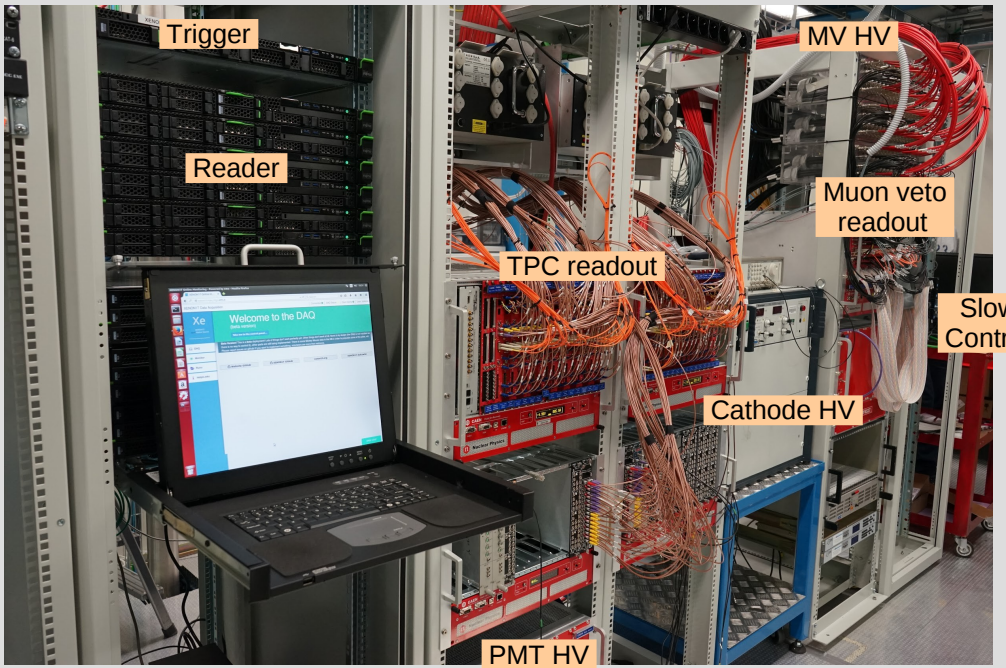
Started 2nd filling of cryostat last week (now with TPC)!

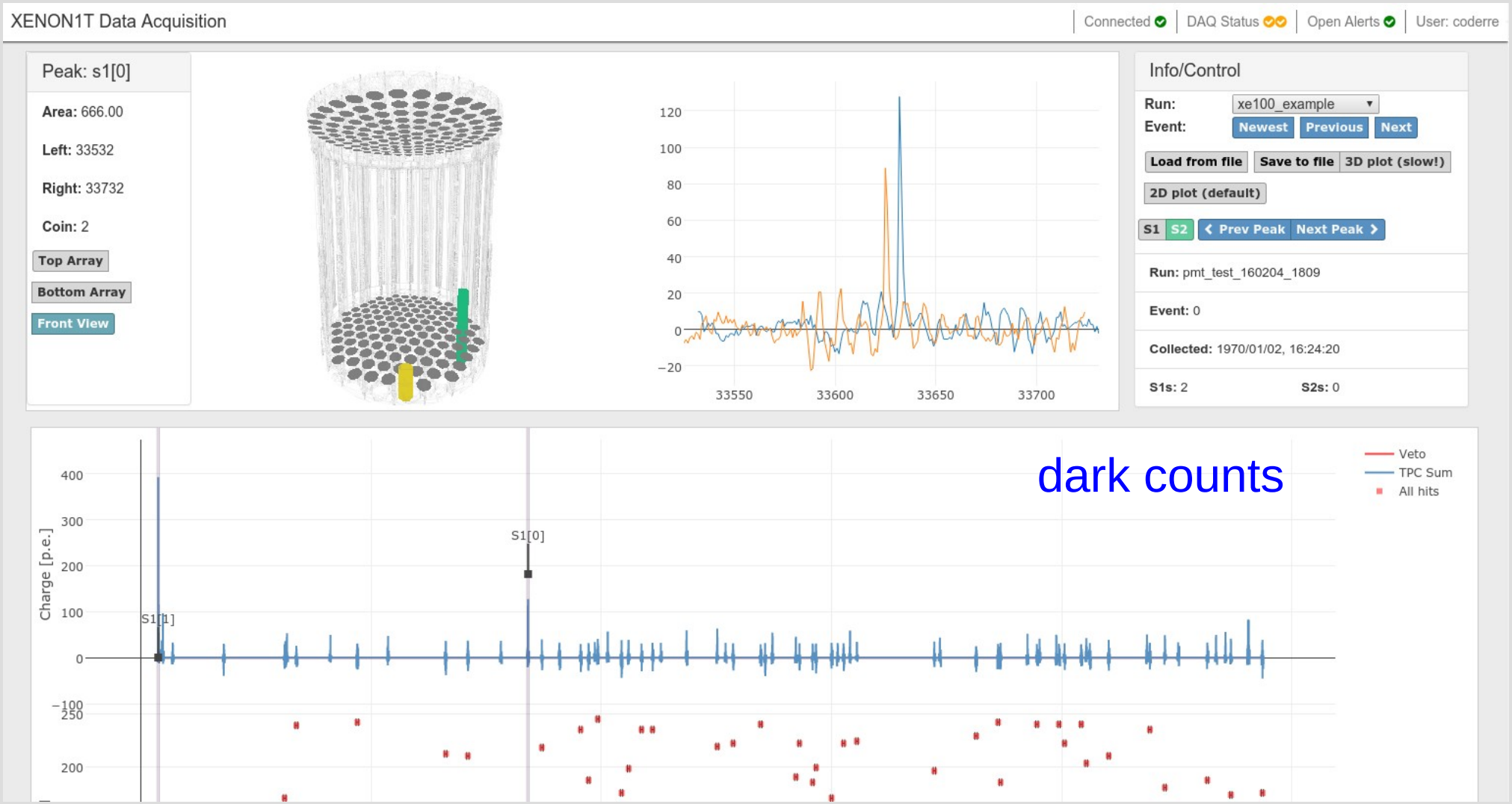
PMTs, DAQ and Electronics



- **all 254 PMTs operational**
- DAQ electronics for TPC and muon veto installed in T-stabilized DAQ room
- detectors can be operated simultaneously (and time-synced) or independently
- PMT/DAQ commissioning ongoing

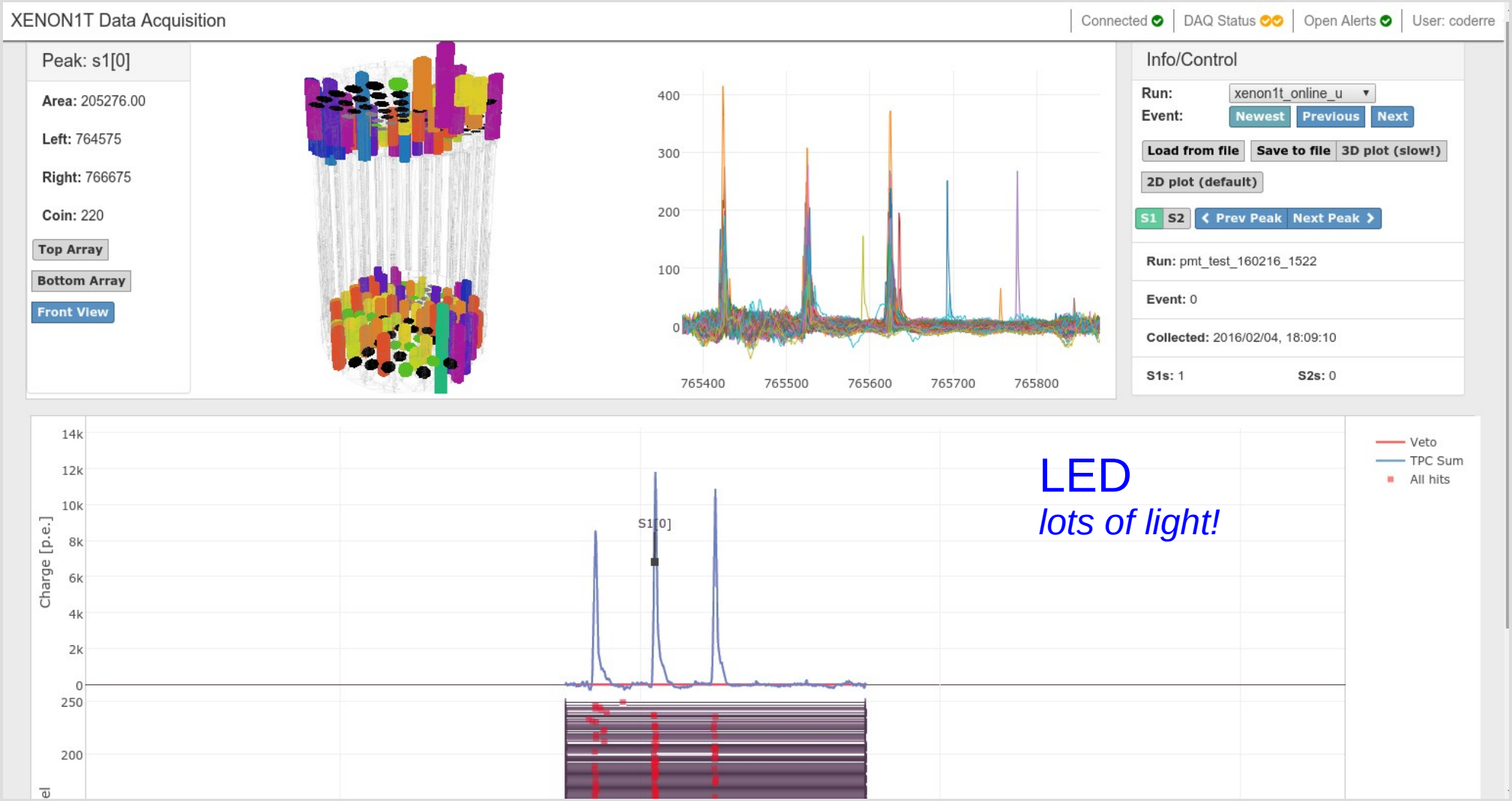


PMT / DAQ Commissioning



grounding/noise optimization, DAQ system, data analysis, PMTs

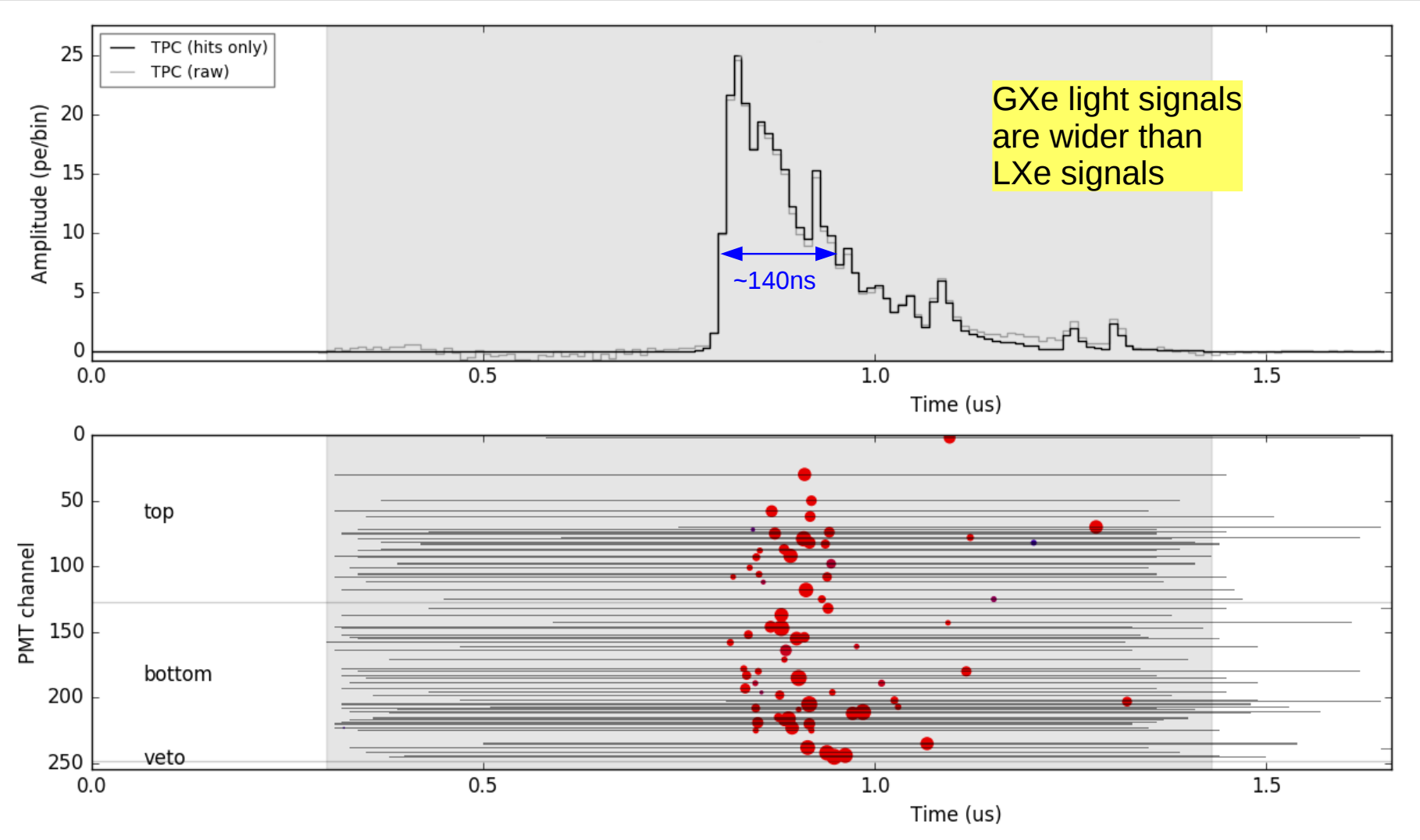
PMT / DAQ Commissioning



grounding/noise optimization, DAQ system, data analysis, PMTs, **light calibration system**

The first GXe Event

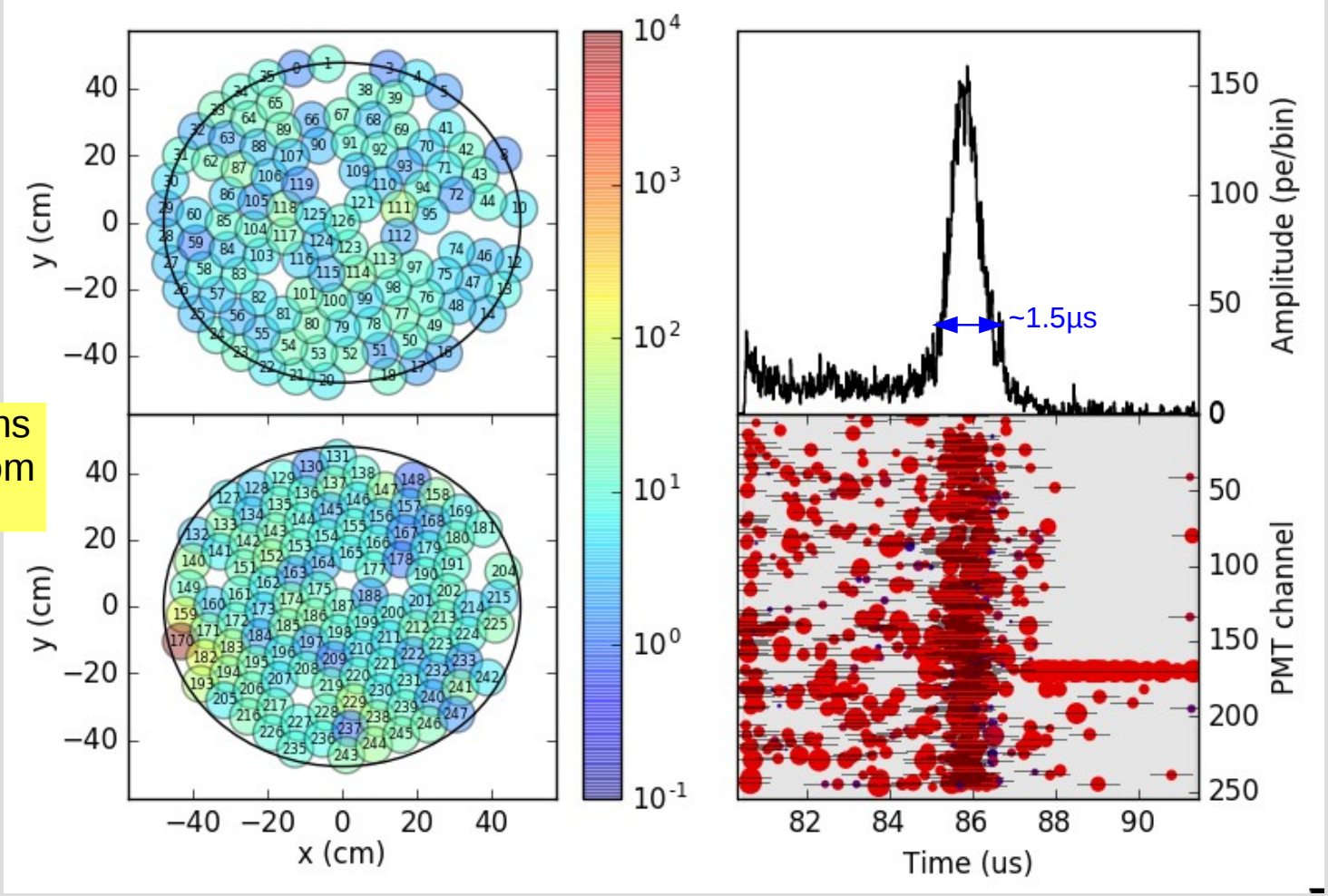
March 2016: TPC filled with GXe
→ start commissioning of **PMTs**, **DAQ** and **analysis** with particle interactions



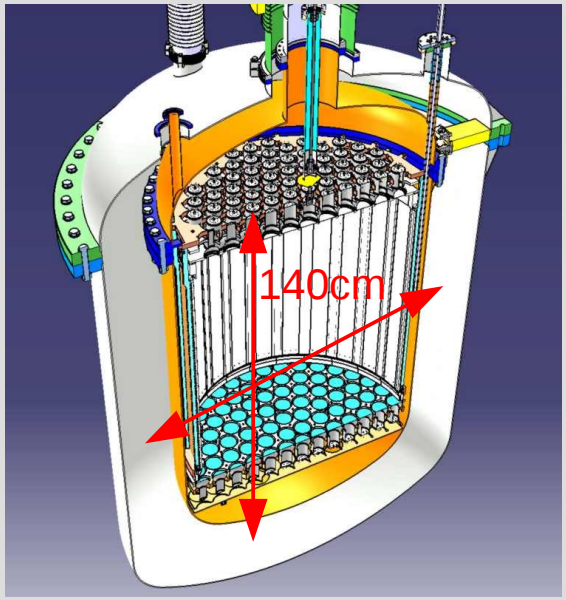
Our first charge signals...

the main TPC electrodes were not yet biased
→ we still see first S2 peaks, thanks to the fields
between the PMTs and the screening electrodes (~2.1 kV/cm)

Event happens close to bottom PMT array

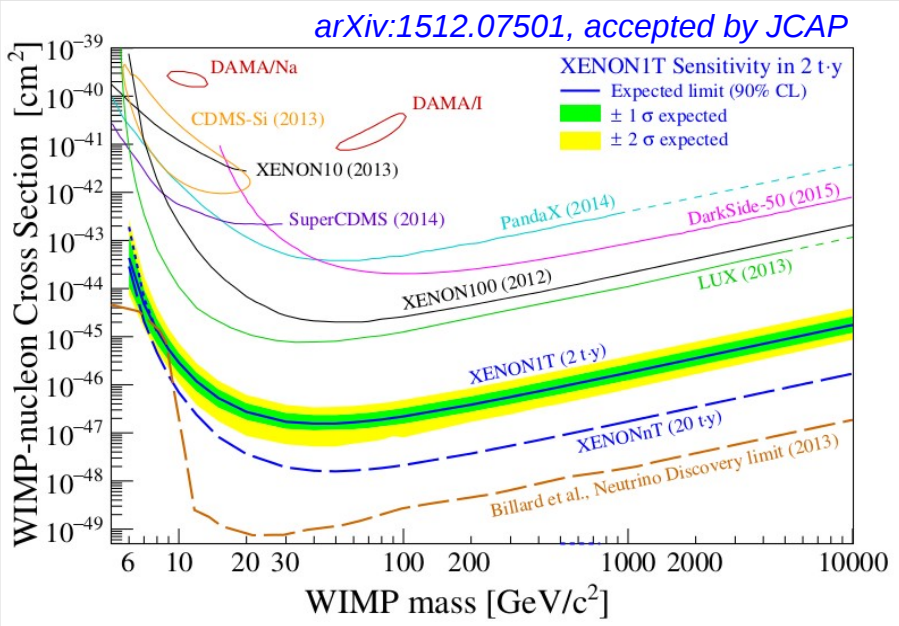


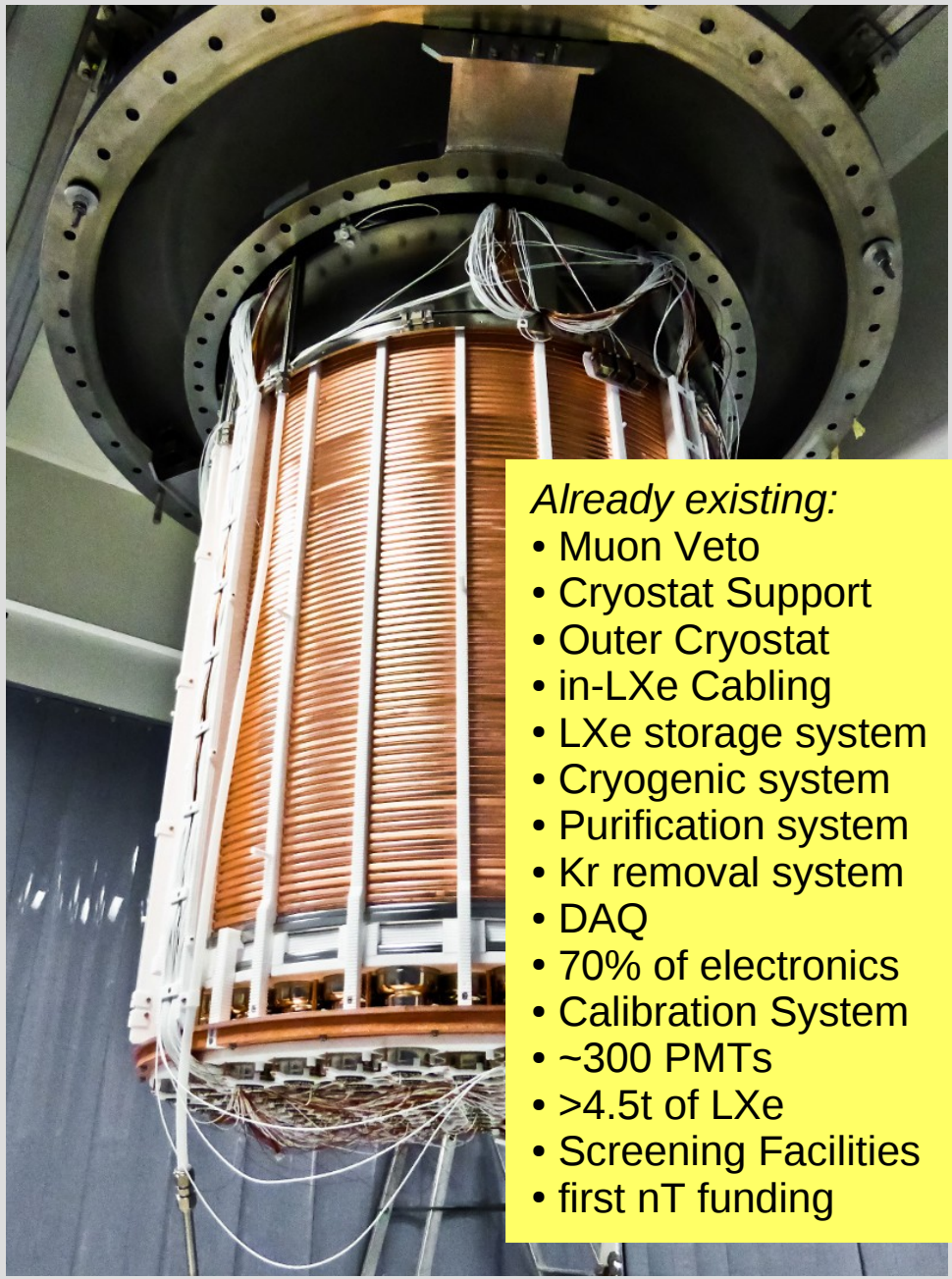
XENON1T → XENONnT



XENON1T
- **2t** active LXe target
- @commissioning
- science data in mid 2016

XENONnT
- **multi-ton** target
- projected to start data taking 2018





Already existing:
- Muon Veto
- Cryostat Support
- Outer Cryostat
- in-LXe Cabling
- LXe storage system
- Cryogenic system
- Purification system
- Kr removal system
- DAQ
- 70% of electronics
- Calibration System
- ~300 PMTs
- >4.5t of LXe
- Screening Facilities
- first nT funding