XENONnT: an upgrade of XENON1T to reach 10^{-48} cm^2 sensitivity by 2022

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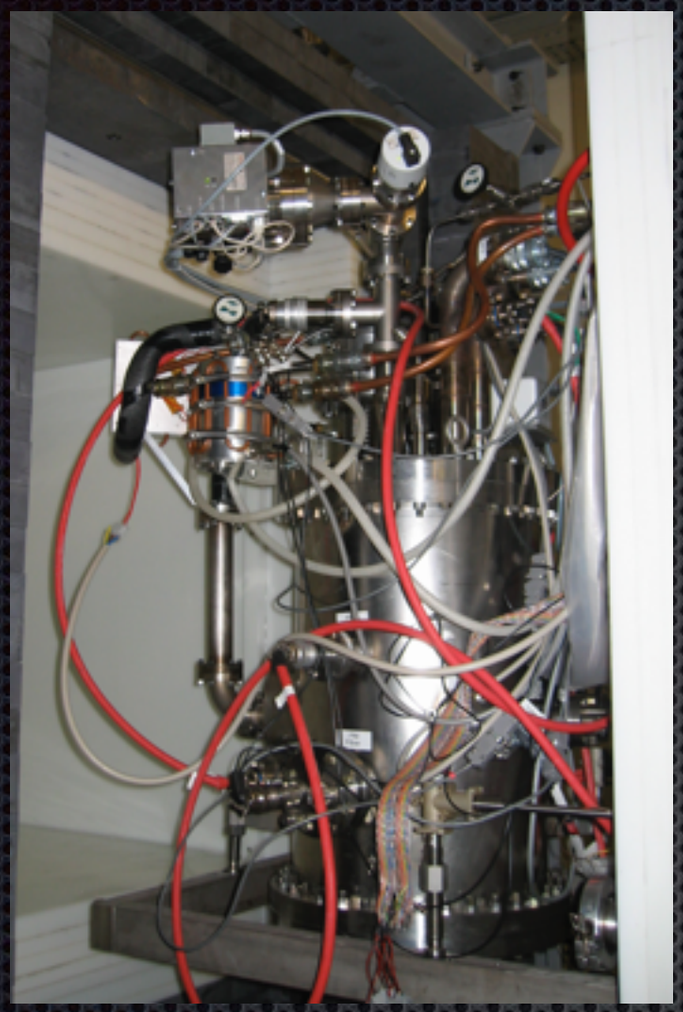
on behalf of the XENON Collaboration

LNGS beyond 2020 Meeting
LNGS, April 28, 2015

Xe
XENON
Dark Matter Project

The XENON Dark Matter Program

2005 - 2007



XENON10

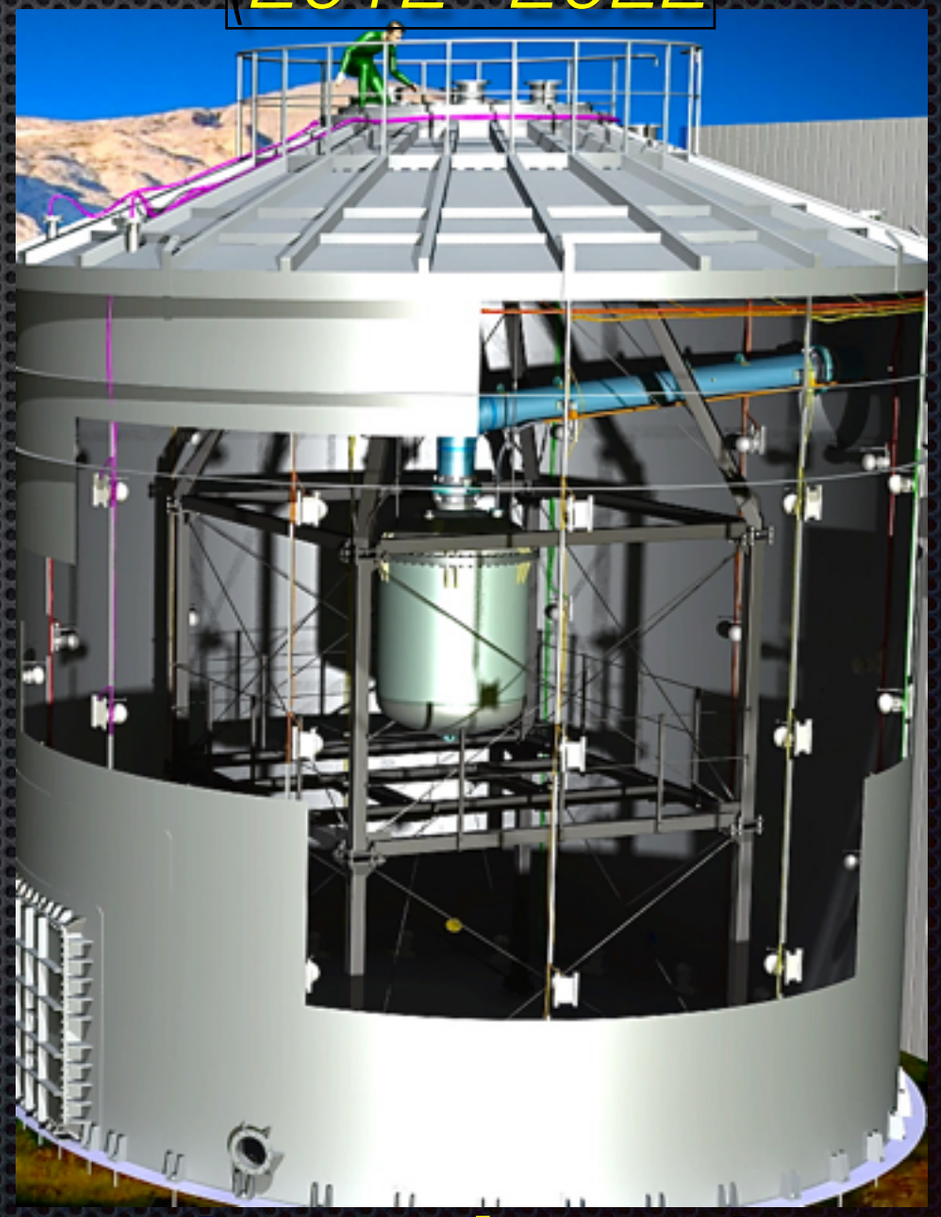
15 cm drift TPC - 25 kg

2007-2015

XENON100

30 cm drift TPC - 161 kg

2012- 2022



XENON1T/XENONnT

100 cm drift TPC - 3300 kg/7000 kg

The XENON Collaboration

currently 124 scientists from 20 institutions

Columbia

RPI

Nikhef

Mainz

Stockholm

Muenster

Chicago

MPIK

UCLA

Bern

Rice

Zurich

Purdue

Coimbra

Subatech

Bologna

LNGS

Torino

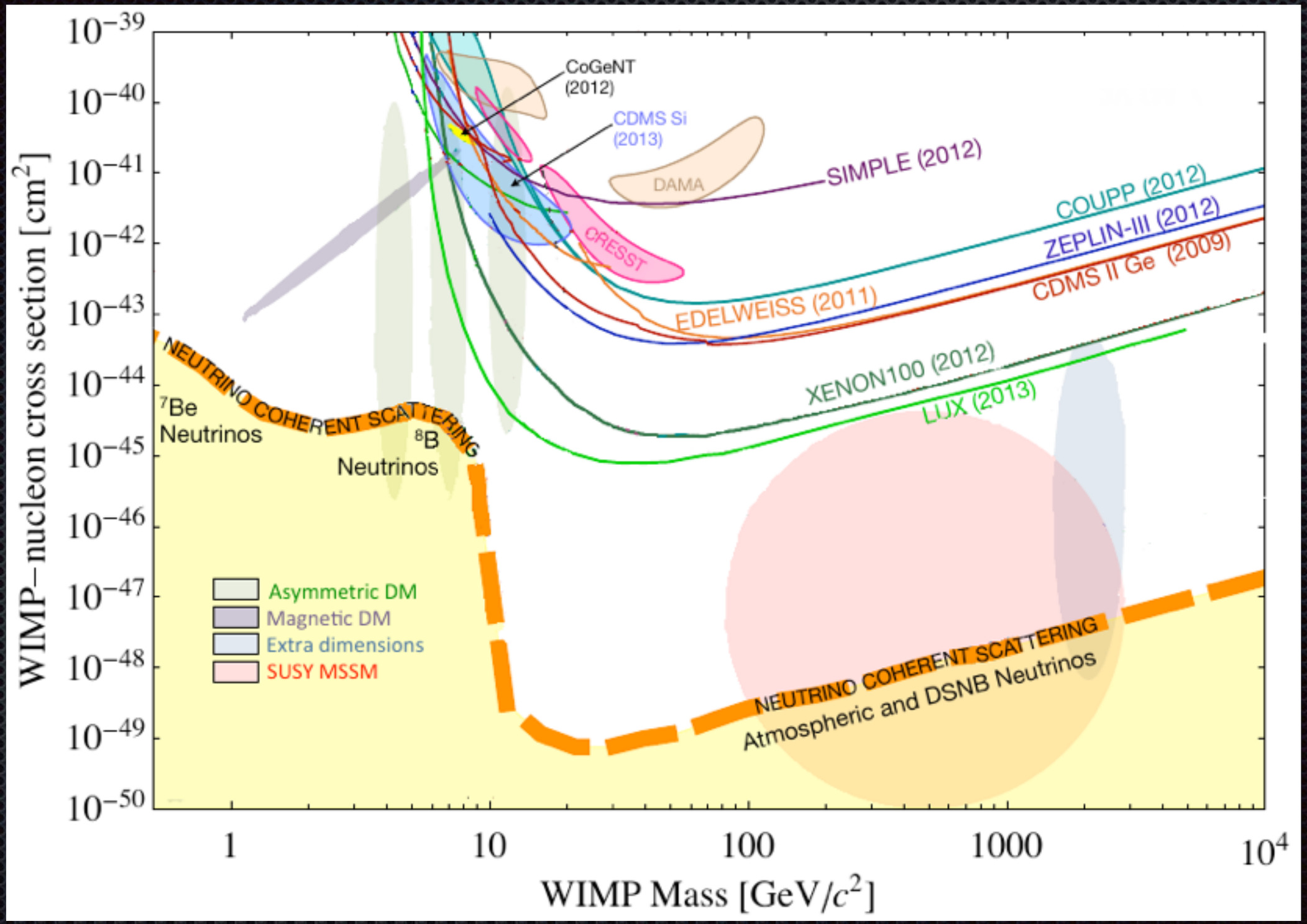
Weizmann

NYUAD

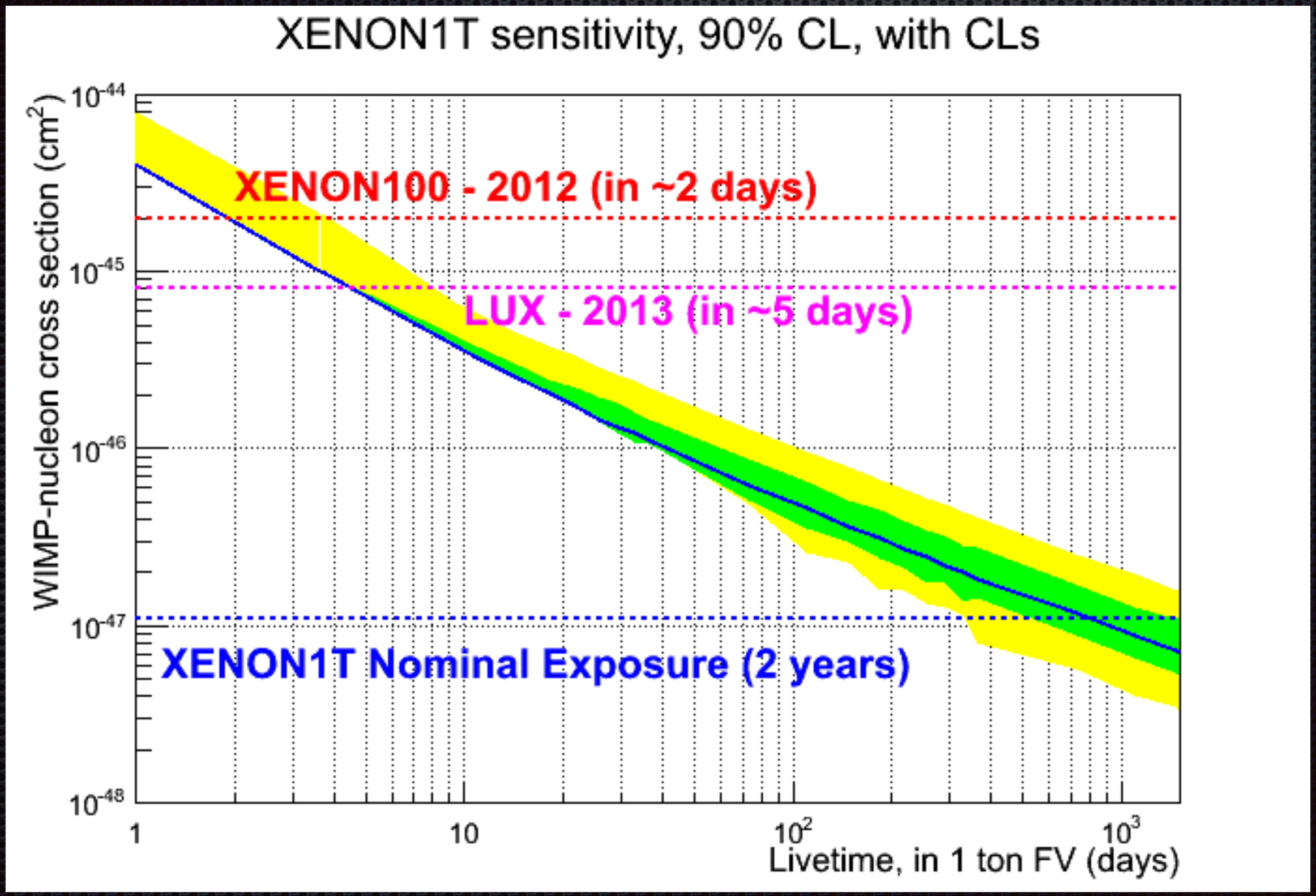
Motivation for XENONnT

- LXe experiments have led the search for DM placing the most stringent limits on WIMP-nucleon cross sections, down to 10^{-8} pb. Unlike other targets, LXe has shown about a factor 10 improvement in sensitivity every two years.
- The XENON program has established the double phase XeTPC technology with the realization of XENON100 as one of the lowest background DM detector. The power of the technology has been confirmed with the 2013 LUX result.
- By the end of 2015 XENON1T will become the first and only multi-ton LXe DM experiment worldwide. Its design sensitivity is 100 times lower than that achieved by XENON100 after 2 ton x year exposure.
- This large step in physics reach is made possible by the technological advances in purification/cooling/storage of large quantities of Xe and by innovative solutions to achieve unprecedented ultra-low level of intrinsic radioactivities.
- A rapid upgrade path is built in the design of XENON1T, with the goal of achieving another factor of 10 in sensitivity. A larger mass (7000 kg) new detector is planned for installation in 2018, using the same cryostat, cryogenic plants and muon veto built for XENON1T.

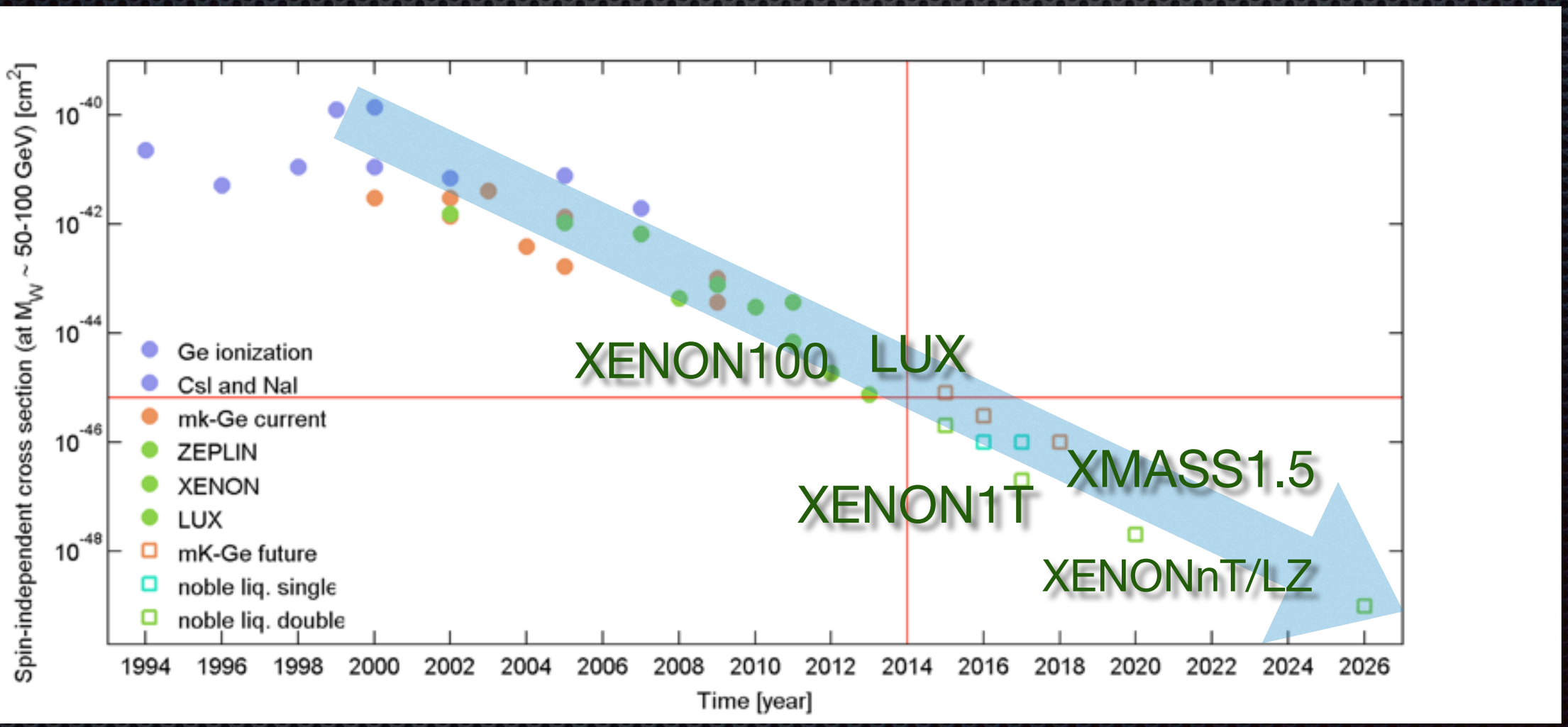
WIMP Direct Detection: Situation Today



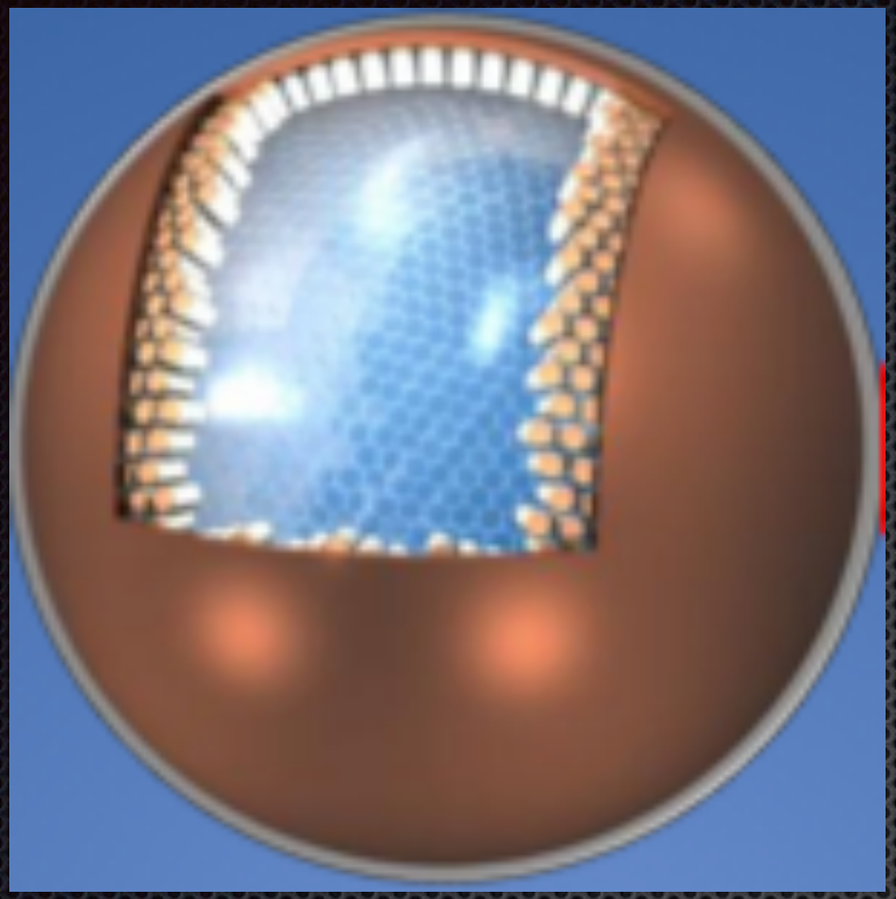
WIMP Direct Detection: Situation by 2019



WIMP Direct Detection: Situation by 2025?

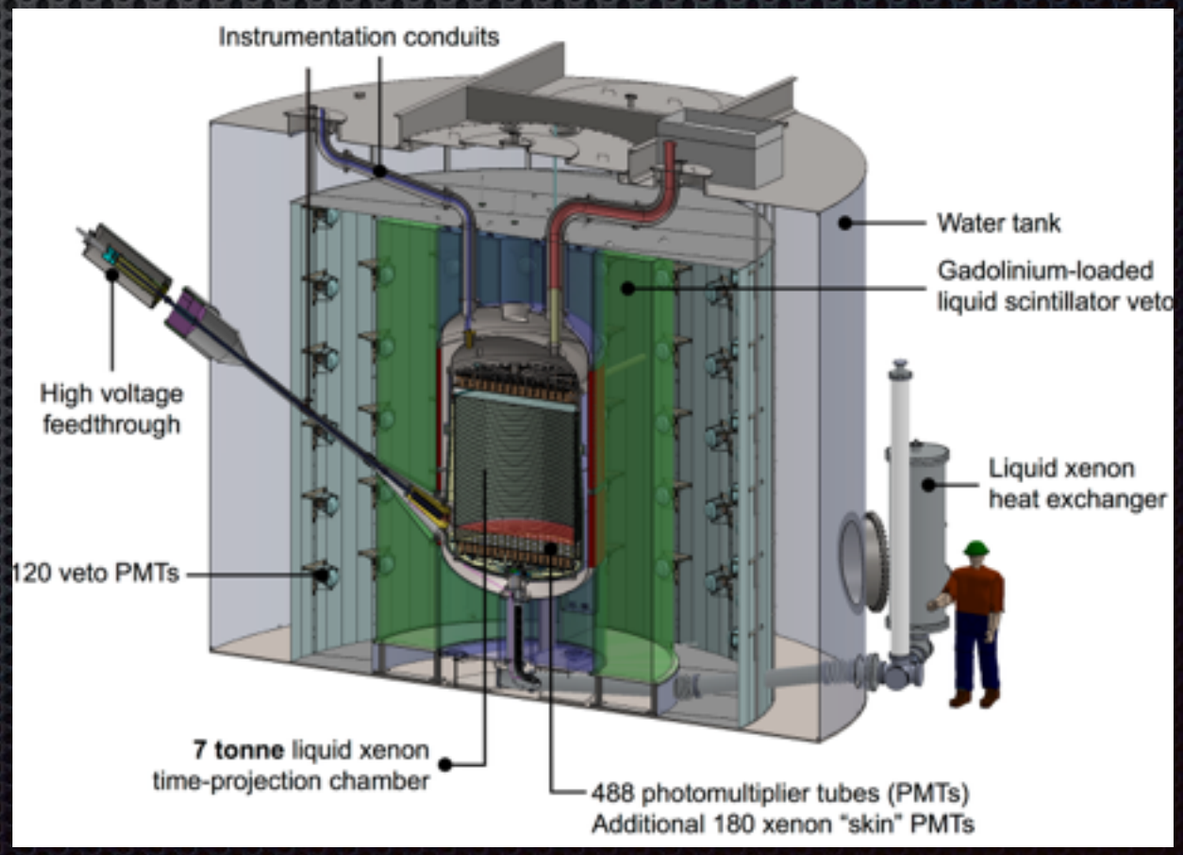


The competition: XMASS and LZ

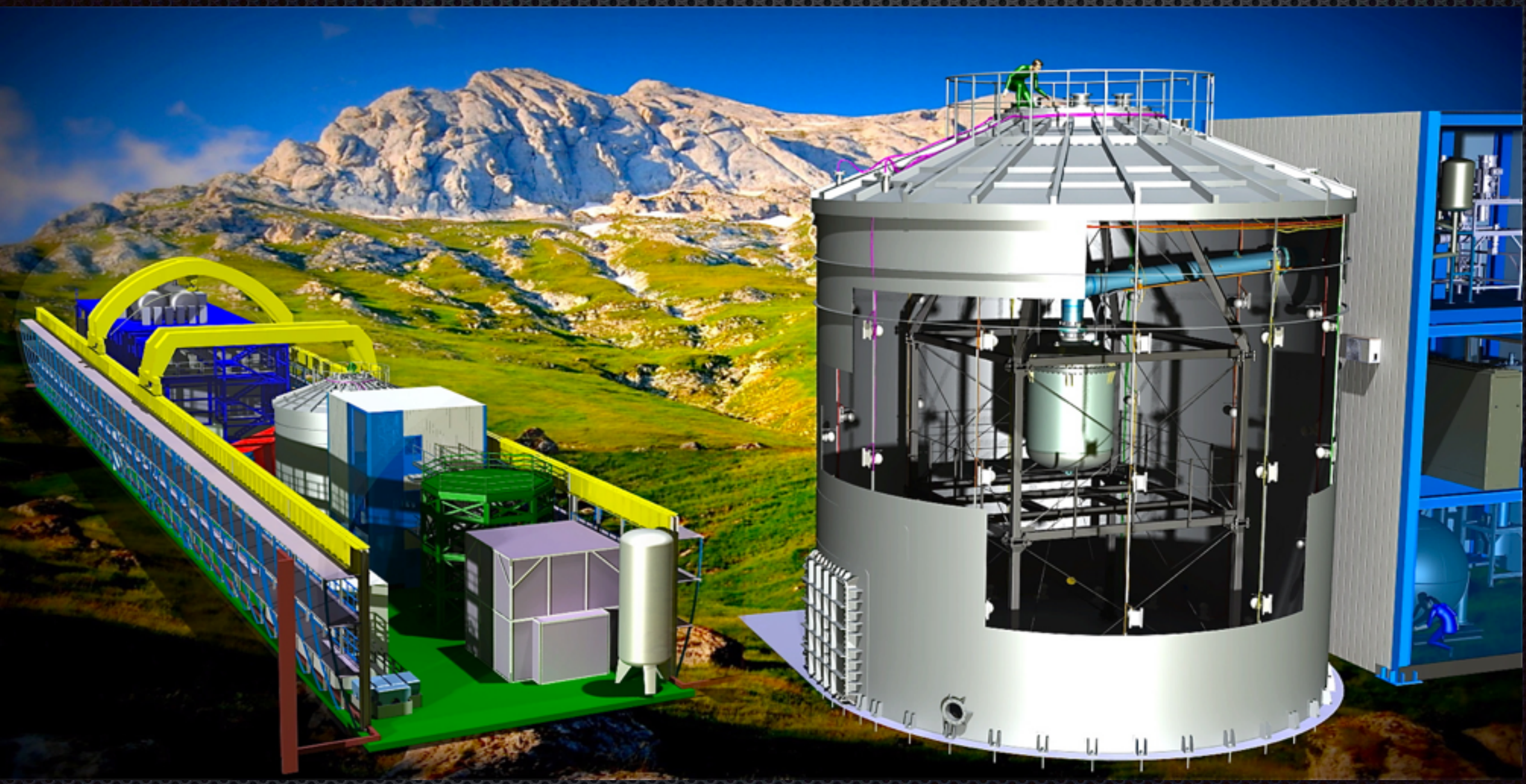


- XMASS1.5: single-phase LXe (5 ton total)
- New PMTs to achieve 10^{-5} ev/keV/kg/day
- Projected Sensitivity: $\sigma_{SI} = 10^{-47}$ cm^2 @ 50 GeV and for 3 ton FV @ 2 keVee thresh
- Status: start in ~2017 ?
- XMASSII → 24 ton total mass (10 ton fiducial)

- LZ: dual-phase TPC (7 ton total) viewed by 488 3-inch PMTs
- Gd-loaded liquid scintillator and LUX water shield
- Projected Sensitivity: 10^{-48} cm^2 for 50 GeV WIMP with 1000 live days
- Satus: start in 2018? Approved in mid-2014 as DOE-only project.

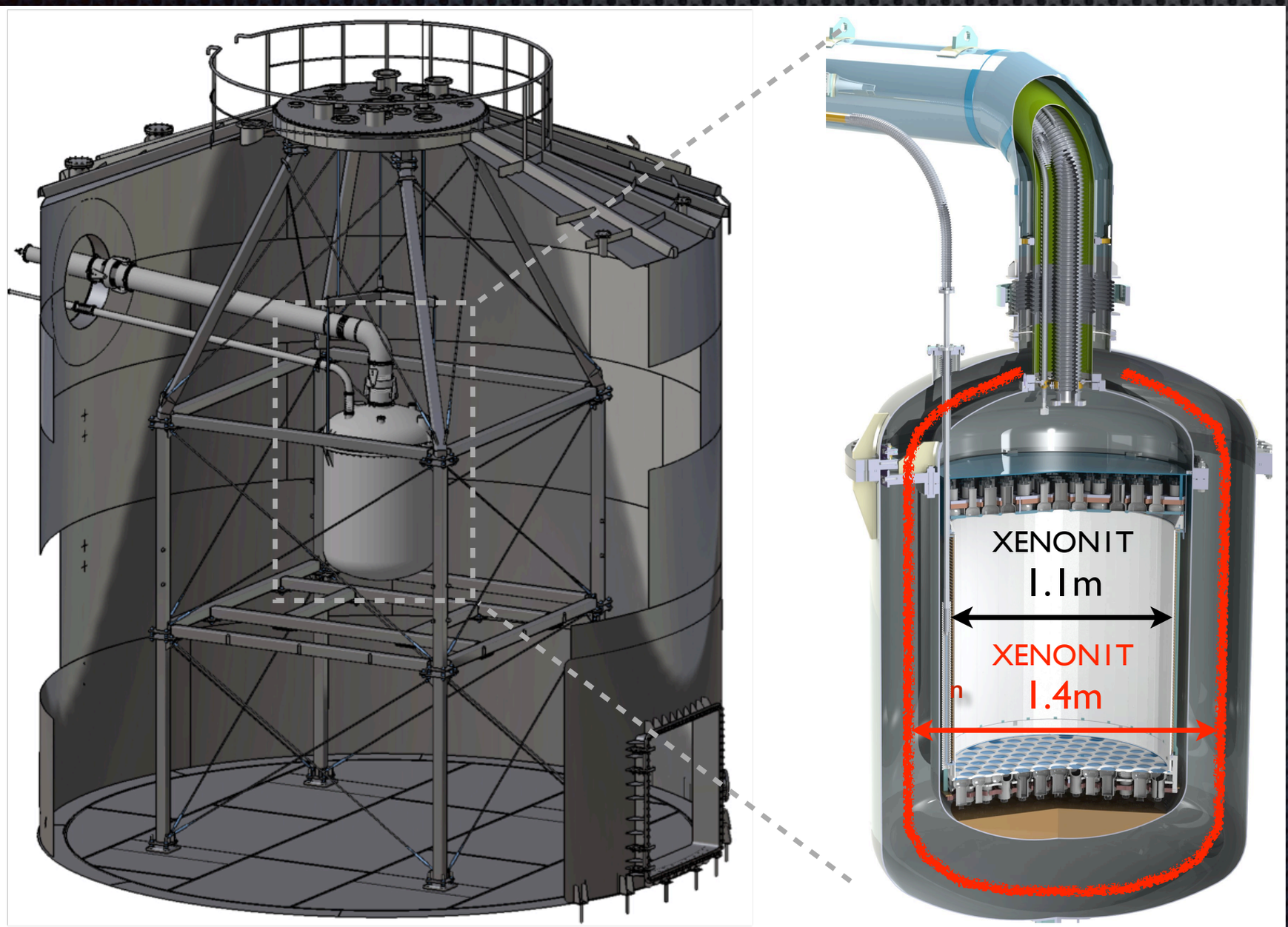


XENON1T/ XENONnT



XENONnT: 2018 - 2022

- XENONnT will be serviced by the same infrastructures and sub-systems developed for XENON1T:

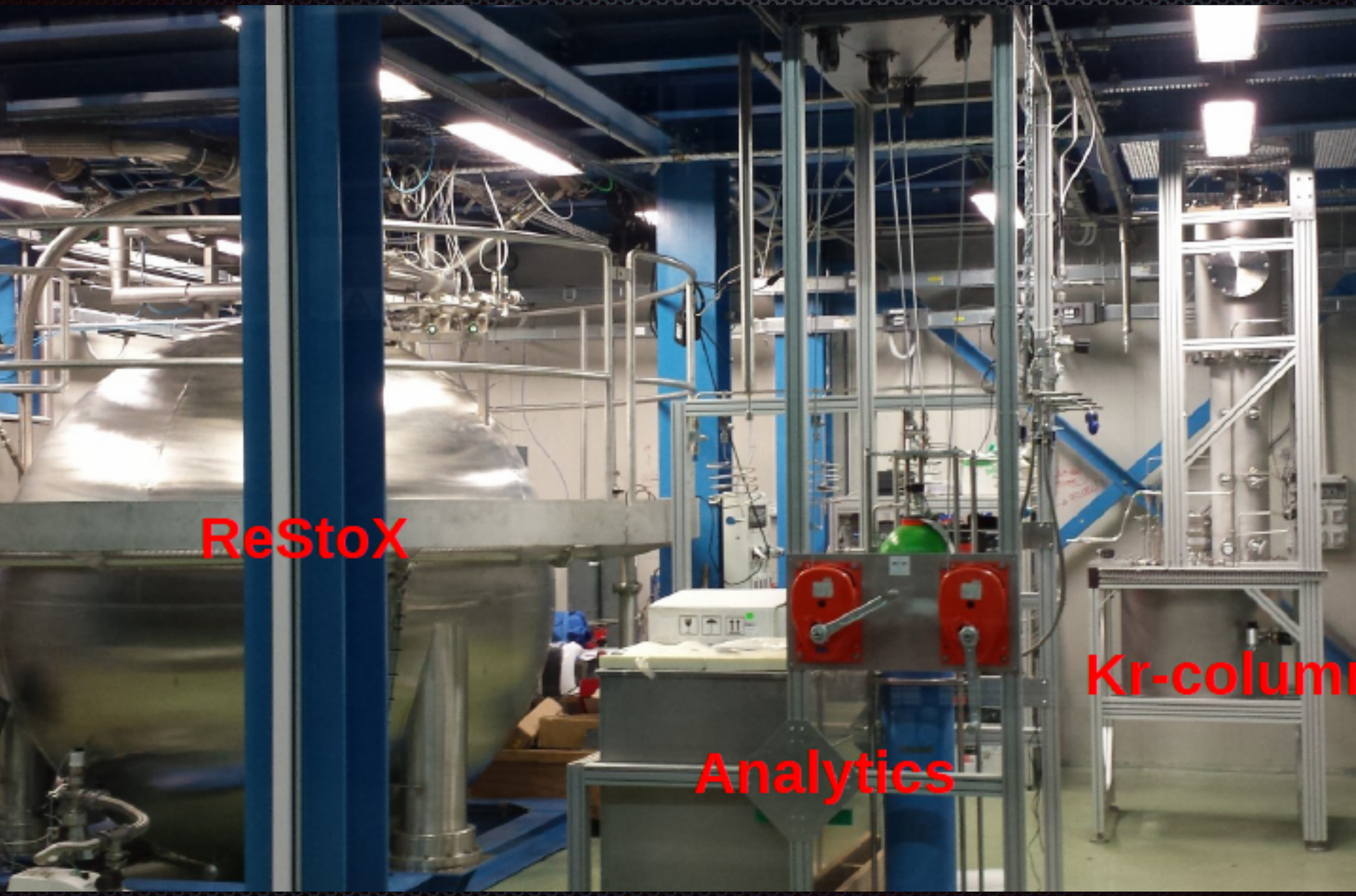


- Water tank + muon veto
- Outer cryostat and support structure
- Cryogenics system
- Purification system (with new circulation pumps for lower Rn)
- LXe storage /recovery system
- Kr/Rn columns

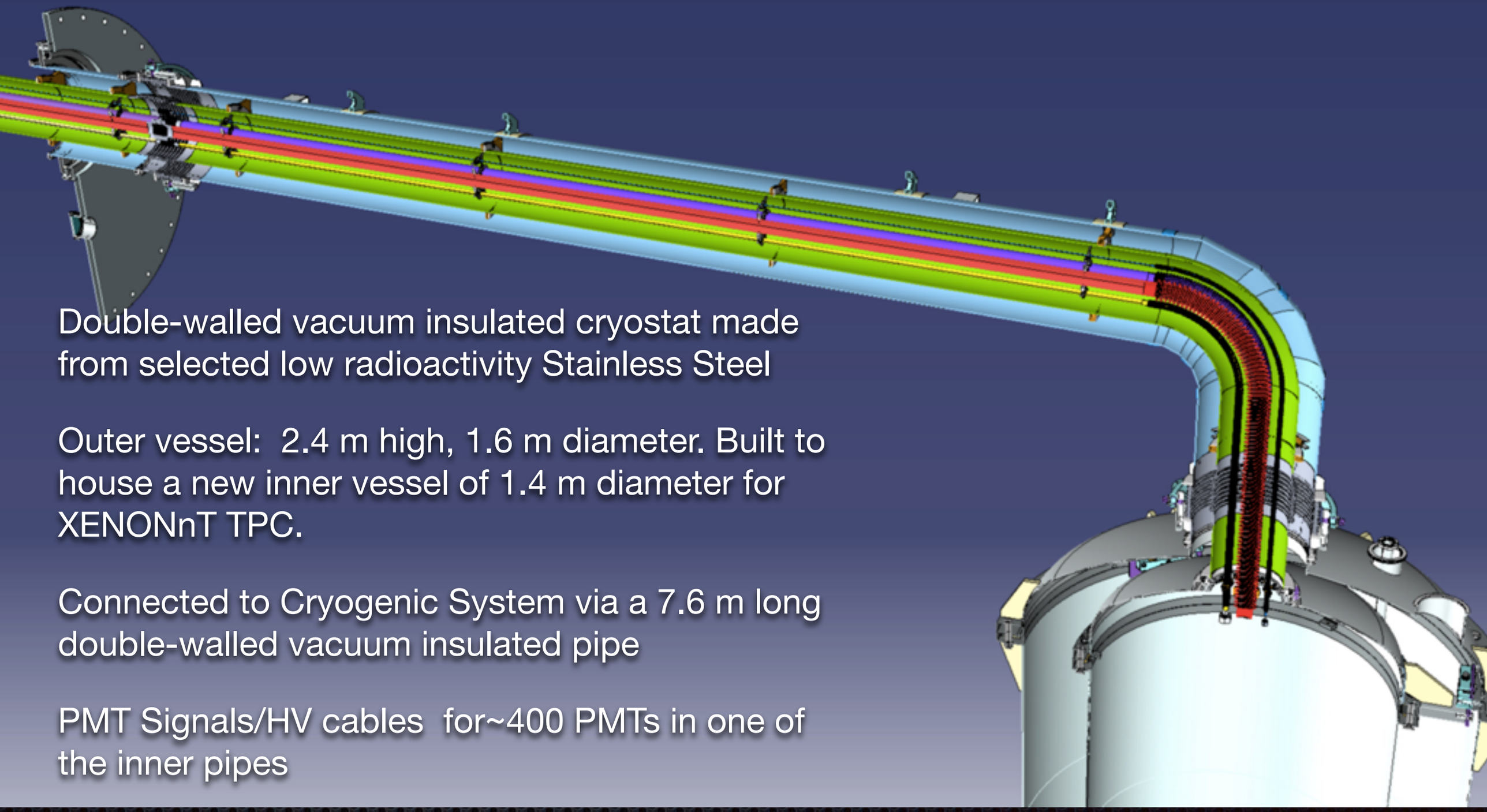

XEN
enlighten

XENON1T / nT Cryogenic System

XENON1T/nT: Kr Distillation Column



XENON1T/nT Cryostat & Cryopipe



Double-walled vacuum insulated cryostat made from selected low radioactivity Stainless Steel

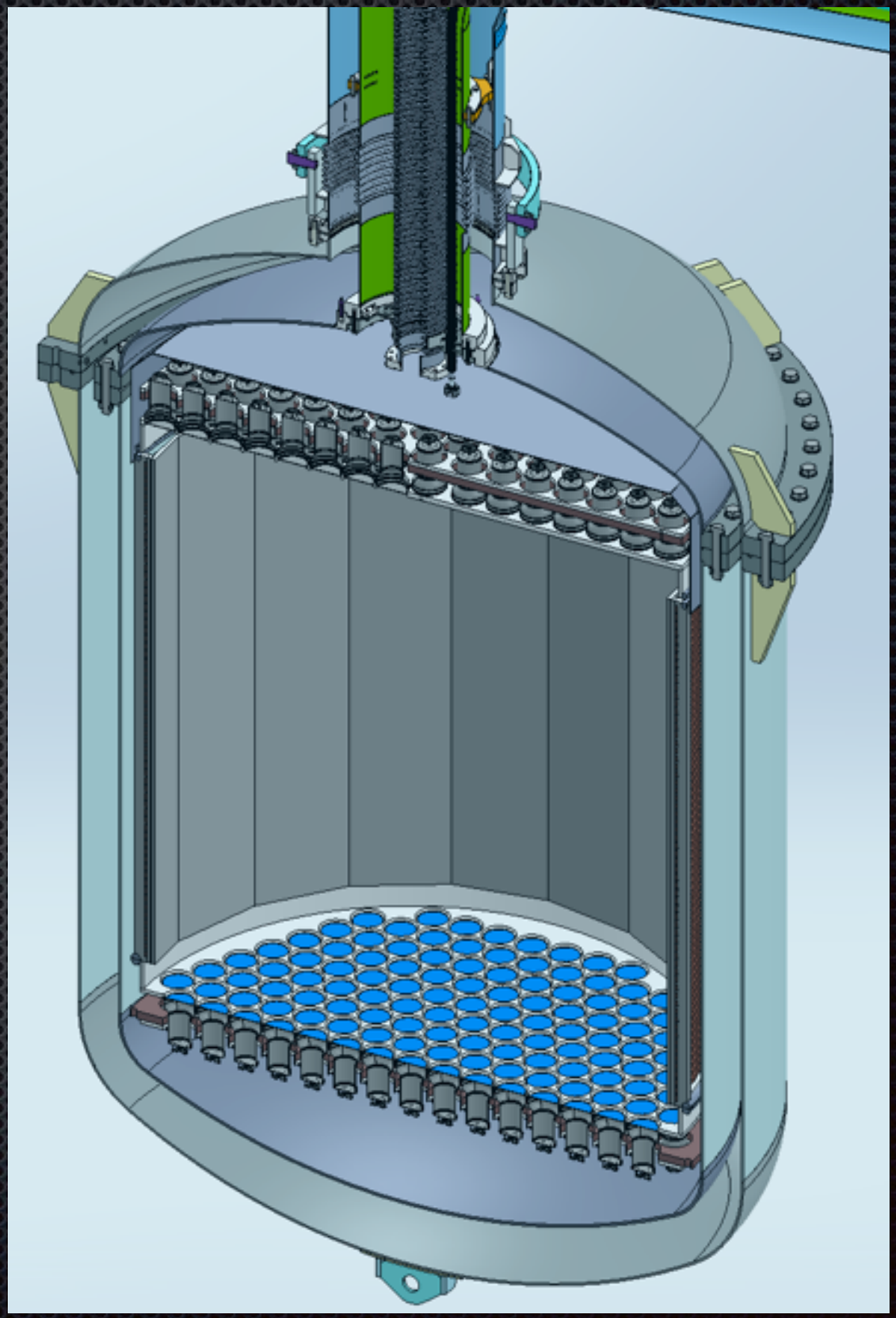
Outer vessel: 2.4 m high, 1.6 m diameter. Built to house a new inner vessel of 1.4 m diameter for XENONnT TPC.

Connected to Cryogenic System via a 7.6 m long double-walled vacuum insulated pipe

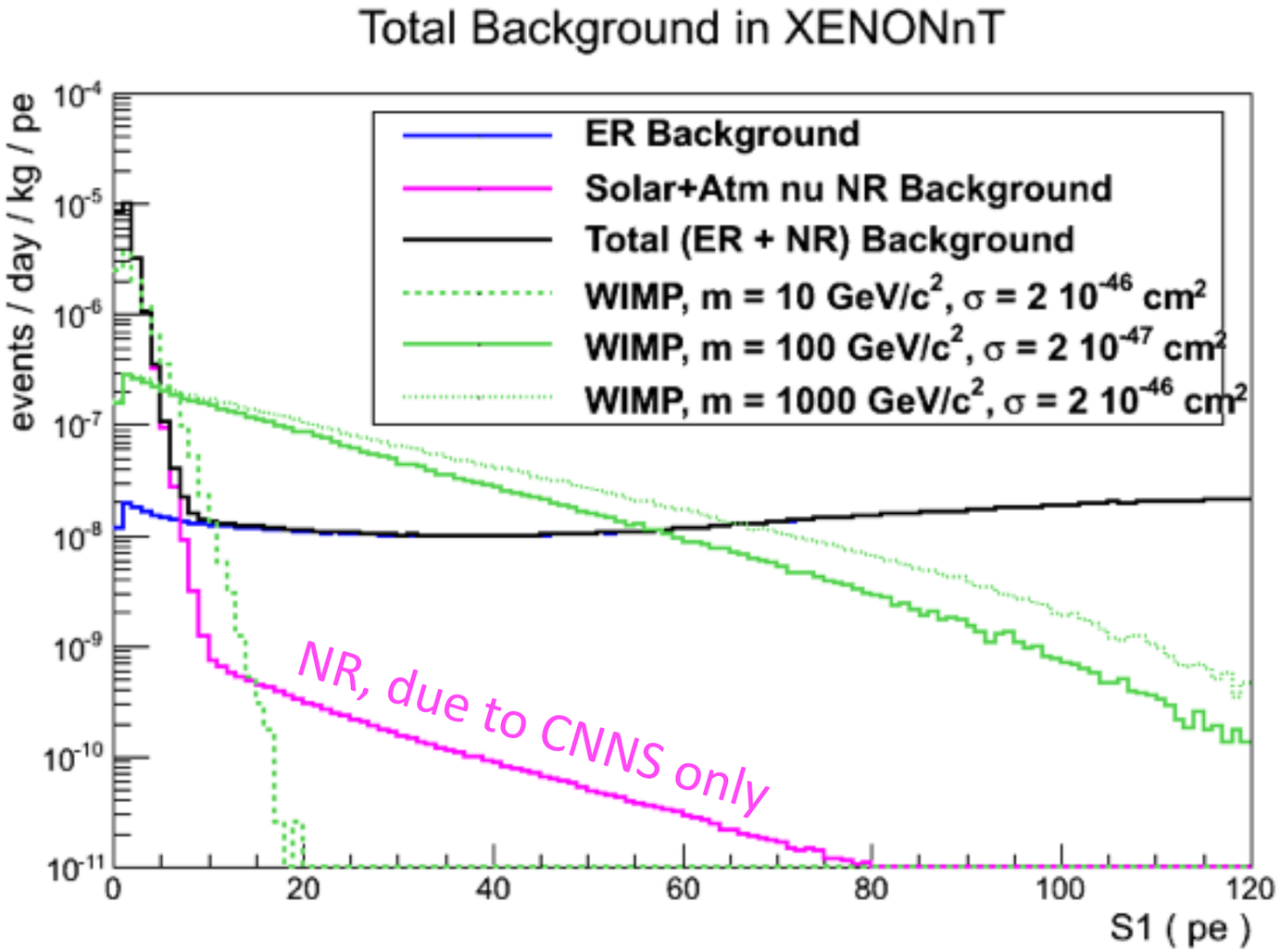
PMT Signals/HV cables for~400 PMTs in one of the inner pipes

XENONnT TPC

- New inner vessel with ~7 tons of LXe
- More extensive materials selection to mitigate background, particularly from Rn
- New TPC structure with larger number of the same R11410-21 PMTs with 35% QE average at 178 nm: 192 PMTs top array and 211 PMTs bottom array
- Cables for the additional PMTs already installed in the Cryogenic Pipe
- New HV Feedthrough port already added to outer cryostat vessel
- Space for additional Readout Channels already allocated in DAQ racks



XENONnT Backgrounds



S1 in [3, 70] pe,
ER discrimination 99.75%,
NR acceptance 40%.

ER:
- negligible materials radioactivity
- 0.2 ppt Kr/Xe and 1 microBq/kg Rn-222, as in XENON1T
- solar neutrino elastic scattering

NR:
- negligible n-background
- neutrino coherent scattering

Source	Background (ev. / ton / y)
ER (intrinsic + solar ν)	***0.27***
NR from neutrino coherent scattering	***0.55***
Total	***0.82***

XENONnT Sensitivity: 20 ton x year Exposure