XENON1T



Elena Aprile, Columbia University

on behalf of the XENON Collaboration

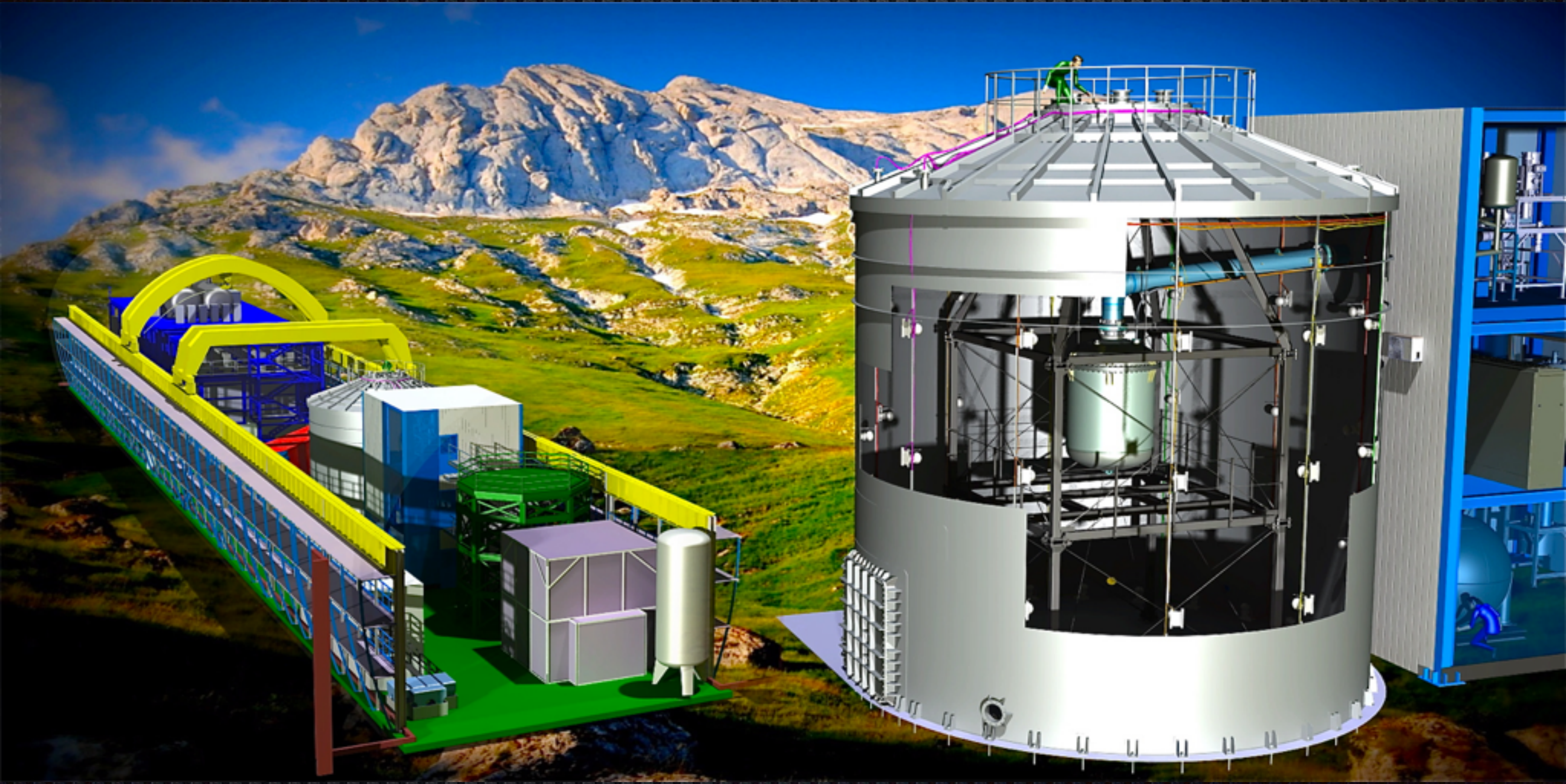
LNGS Scientif Committee, April 29, 2015

XENON1T

XENON1T

- **Location:** LNGS - Hall B.
- **Detector:** 1m- drift dual-phase TPC with 3.3 t LXe viewed by 250 PMTs
- **Shield**: water Cherenkov muon veto. **Back goal::** *3 x 10^{-2} events/(t-d-keV)*
- **Status:** In commissioning. Detector installation by Summer 15. Science data start by late 2015.
- **Projected Sensitivity:** 10^{-47} cm^2 for 50 GeV WIMP with 2 ton x yr data

XENON1T



The XENON Collaboration

currently 124 scientists from 20 institutions

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XENON Dark Matter Project

currently 124 scientists from 20 institutions

Columbia · RPI · Nikhef · Mainz · Stockholm · Muenster

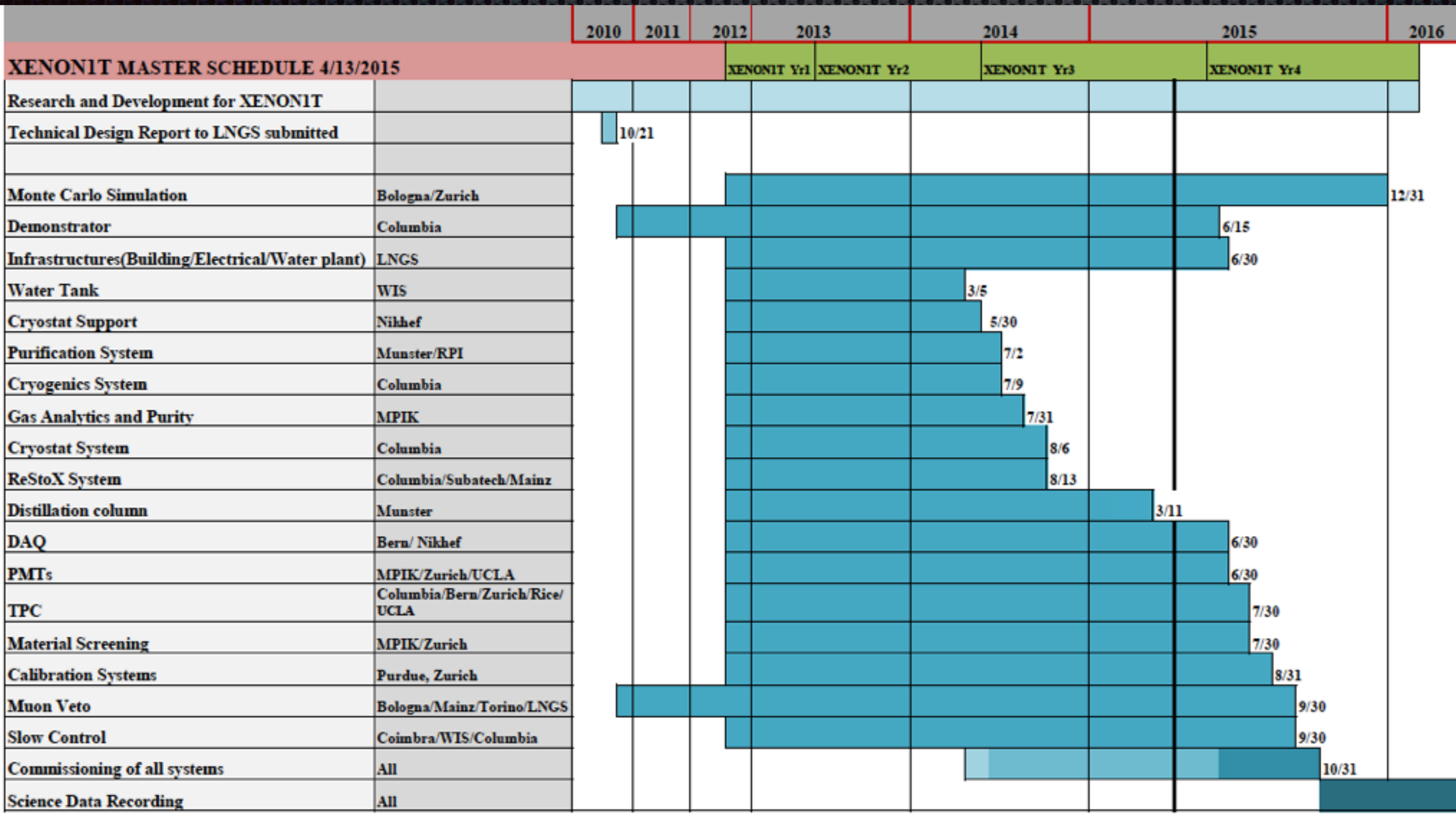
Chicago · MPIK

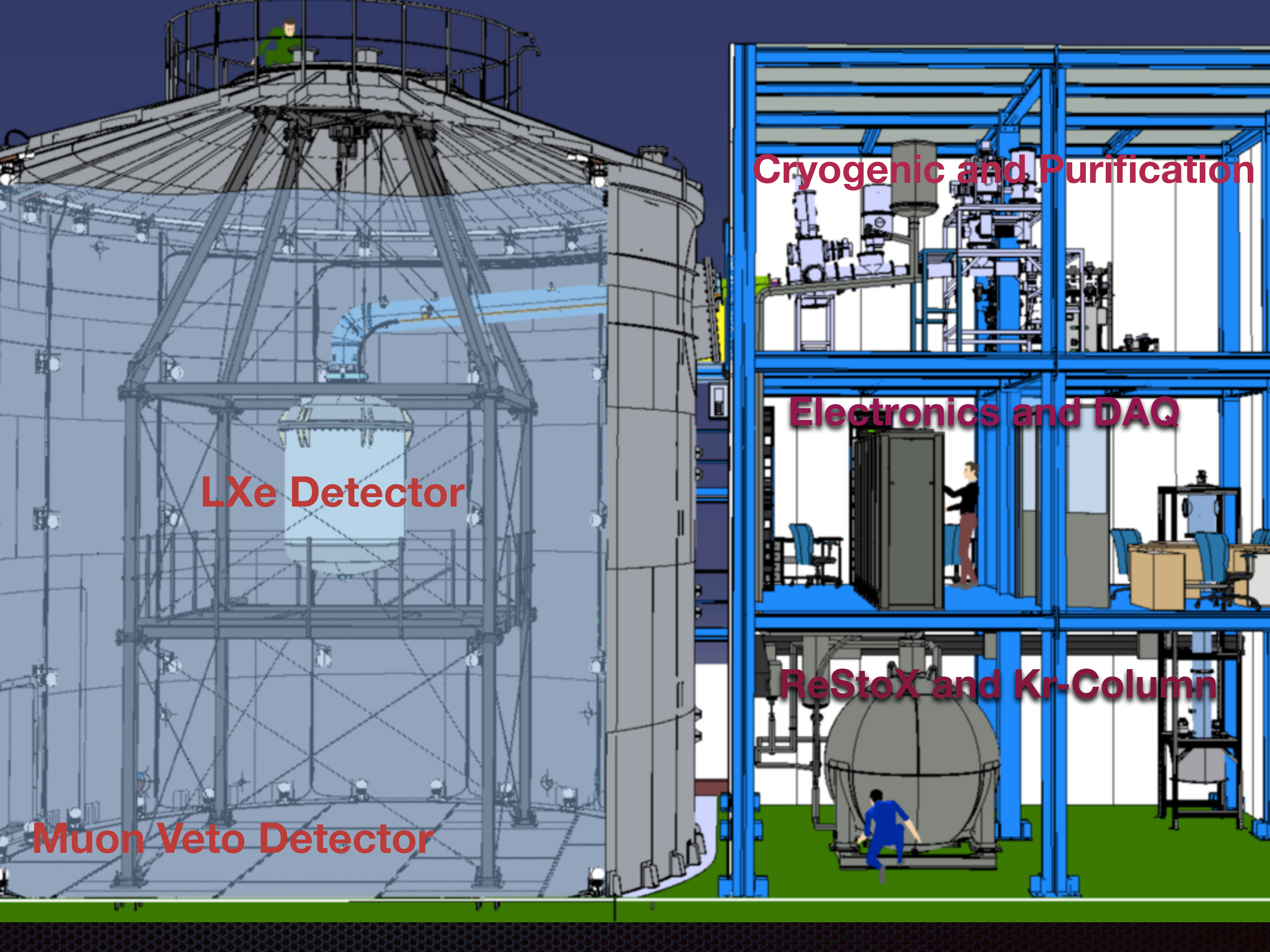
UCLA · Bern

Rice · Zurich

Purdue · Coimbra · Subatech · Bologna · LNGS · Torino · Weizmann · NYUAD

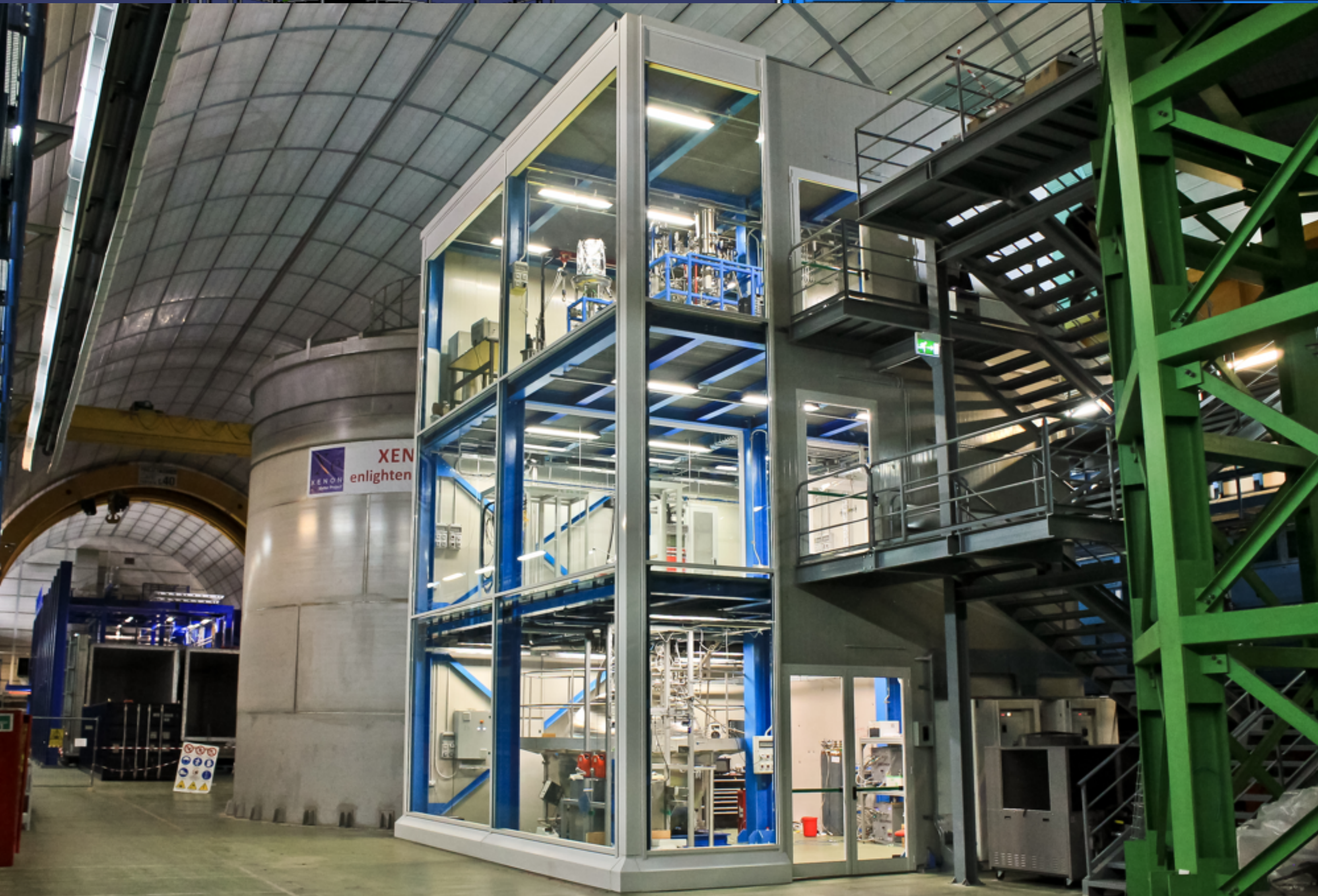
Schedule


2010
2011
2012
2013
2014
2015
2016
XENON1T MASTER SCHEDULE 4/13/2015
XENON1T Yr1
XENON1T Yr2
XENON1T Yr3
XENON1T Yr4
Research and Development for XENON1T
Technical Design Report to LNGS submitted
10/21
Monte Carlo Simulation
Bologna/Zurich
12/31
Demonstrator
Columbia
6/15
Infrastructures(Building/Electrical/Water plant)
LNGS
6/30
Water Tank
WIS
3/5
Cryostat Support
Nikhef
5/30
Purification System
Munster/RPI
7/2
Cryogenics System
Columbia
7/9
Gas Analytics and Purity
MPIK
7/31
Cryostat System
Columbia
8/6
ReStoX System
Columbia/Subatech/Mainz
8/13
Distillation column
Munster
3/11
DAQ
Bern/ Nikhef
6/30
PMTs
MPIK/Zurich/UCLA
6/30
TPC
Columbia/Bern/Zurich/Rice/UCLA
7/30
Material Screening
MPIK/Zurich
7/30
Calibration Systems
Purdue, Zurich
8/31
Muon Veto
Bologna/Mainz/Torino/LNGS
9/30
Slow Control
Coimbra/WIS/Columbia
9/30
Commissioning of all systems
All
10/31
Science Data Recording
All



Cryogenic and Purification
Electronics and DAQ
LXe Detector
ReStoX and Kr-Column
Muon Veto Detector


Xe
XENON
Matter Project


XEN
enlighten

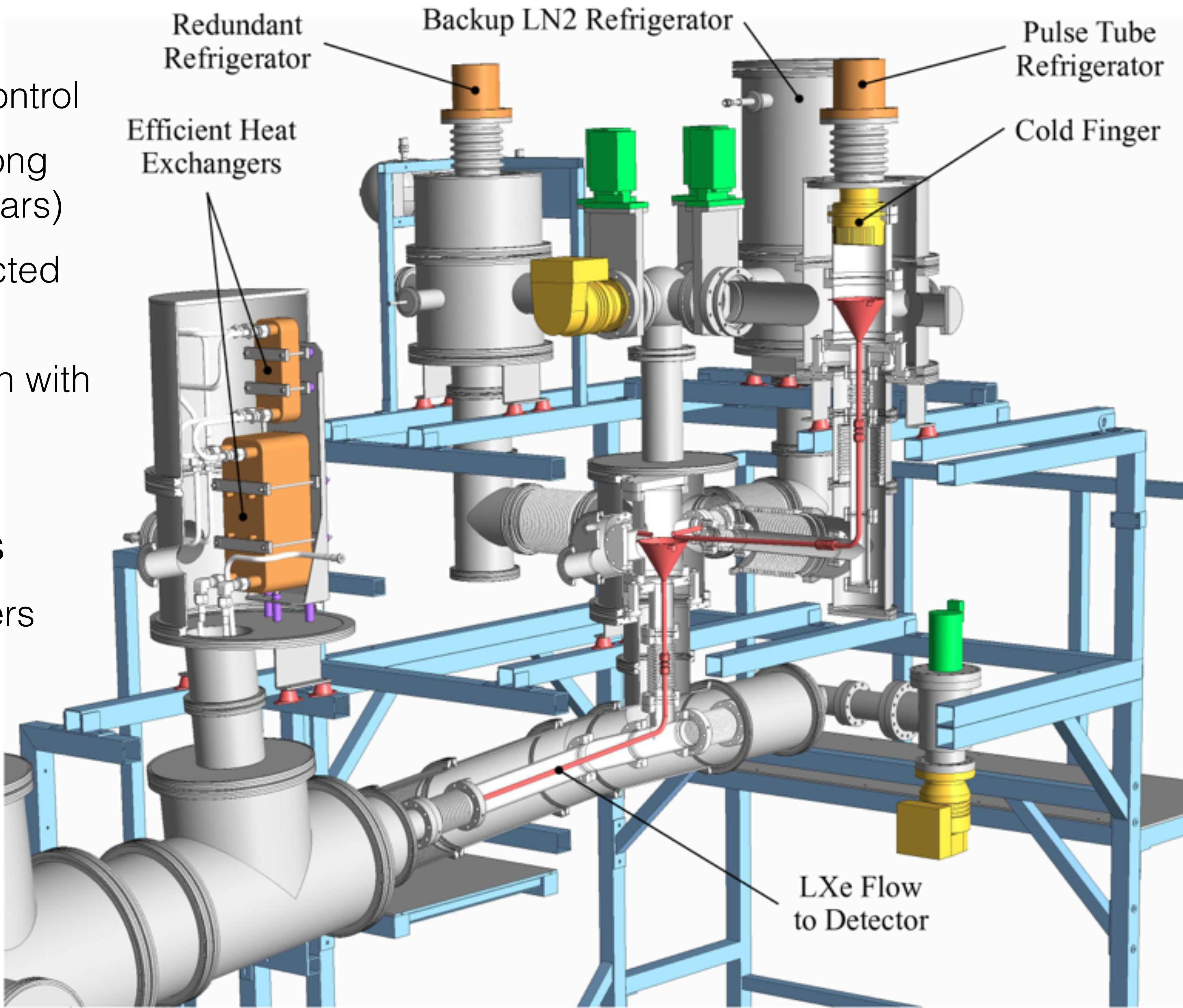
XENON1T Cryogenic System

✦ Design goals

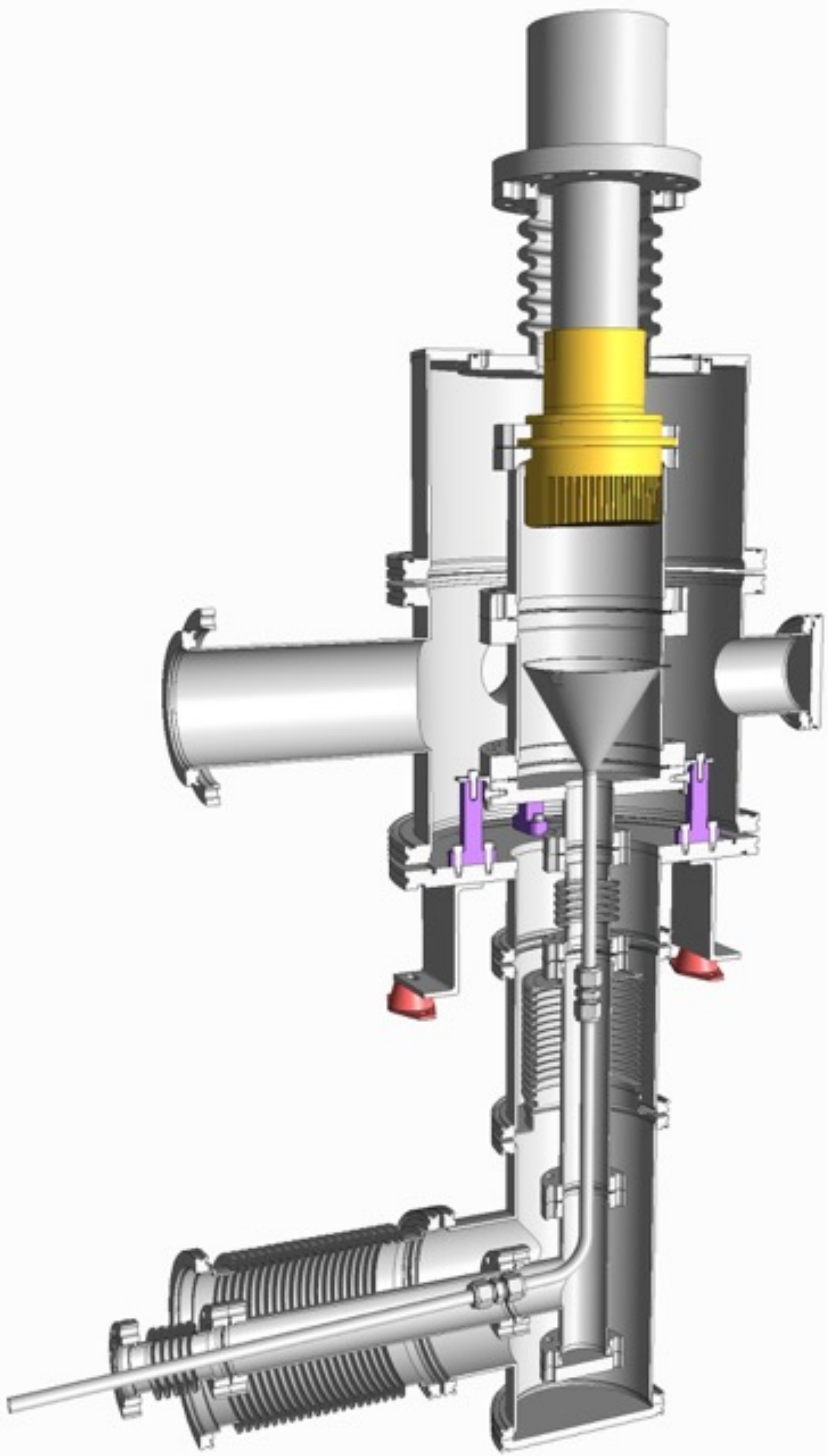
- Stable temperature control
- Reliable continuous long term operation (3+ years)
- Resilience to unexpected failures
- High speed circulation with low heat load

✦ Main Components

- Two PTR cooling towers
- One backup LN2 cooling tower
- Efficient heat exchangers



PTR Cooling Tower



- PTR designed to deliver a cooling power of at least 200W at 170K.
- Total heat load (including Cryostat) with no gas circulation estimated to be below 50W.
- Detector gets cooled down through continuous liquefaction and evaporation.
- Temperature control loop with a precision <0.005°C.
- Two identical PTR cooling towers and associated equipment provide necessary redundancy.

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IN THE CITY OF NEW YORK

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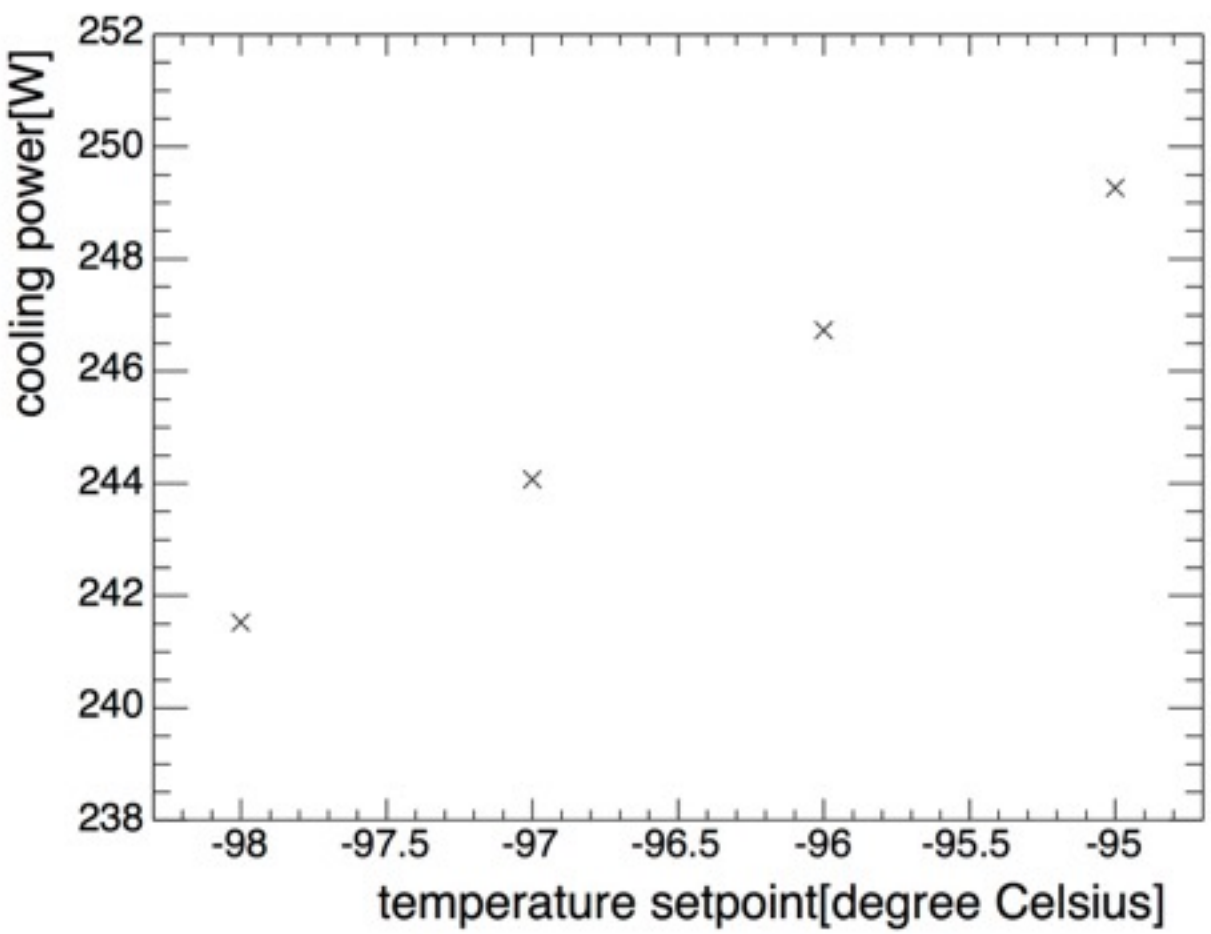
PTR Cooling Power Test

- ✦ Measured achievable cooling power over range of operating temperatures
- ✦ Heat load measurement in June 2015 after transferring ~300 kg of Xe from ReStoX into cryostat

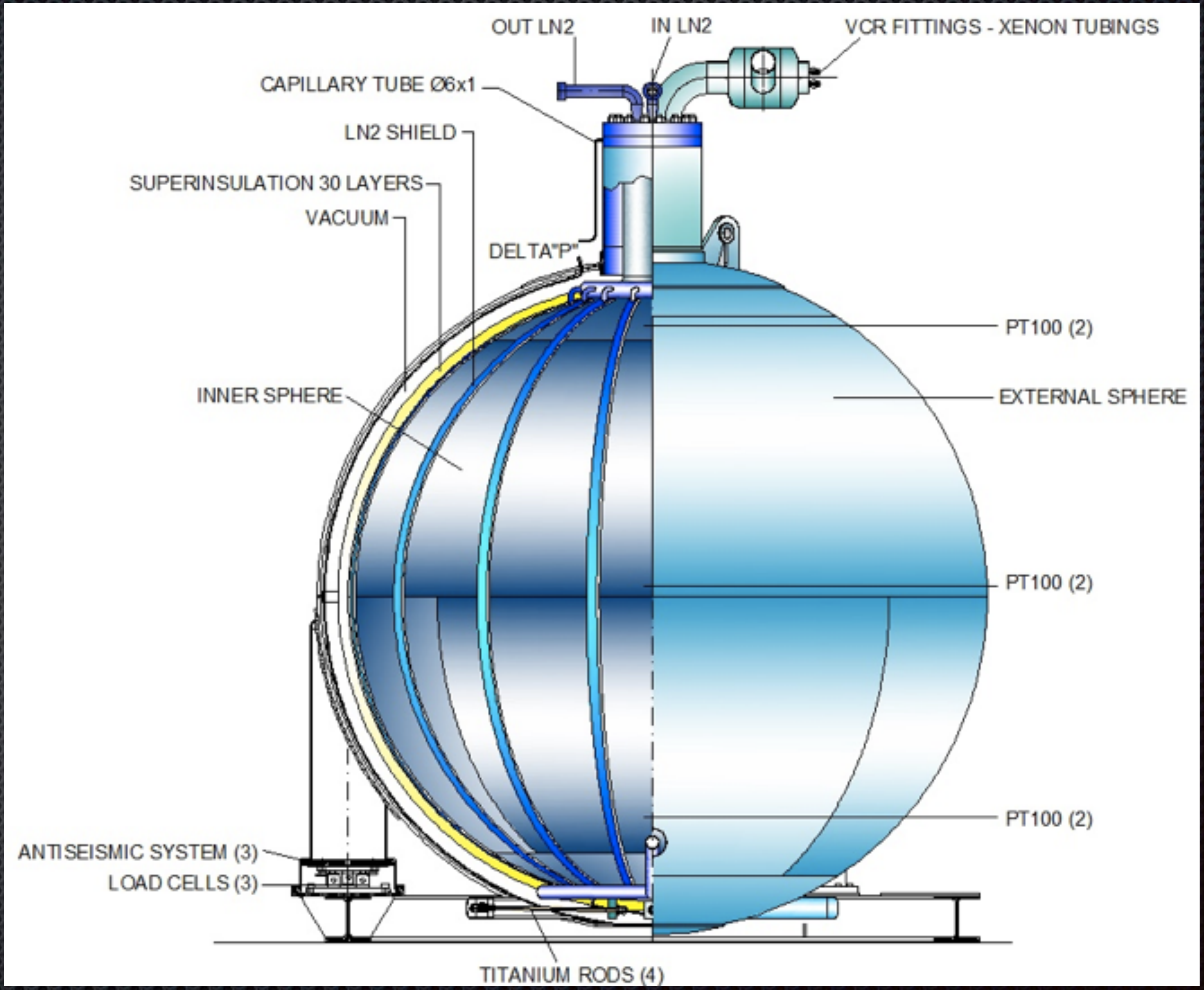



Xe
XENON
Dark Matter Project
XENON1T
enlightening the Dark

XENON1T Purification System

XENON1T/nT ReStoX System (Recovery & Storage of Xe)

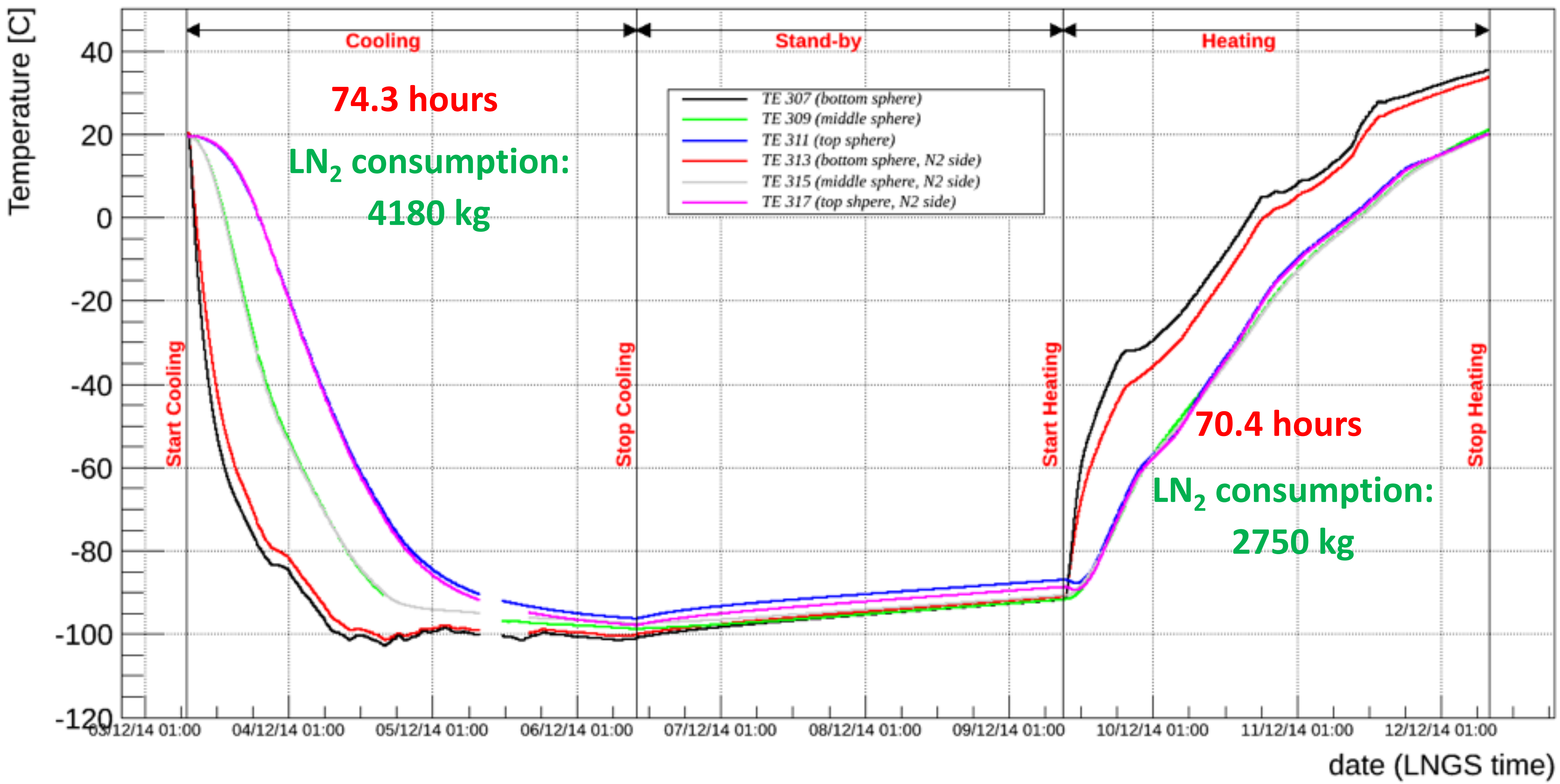
- Double-walled, high pressure (70 atm), vacuum-insulated, LN2 cooled sphere of 2.1 diameter
- To store 7.6 tons of Xe either in gas or liquid/ solid phase under high purity conditions
- To recover in a safe and controlled way LXe from detector. In case of emergency all LXe is recovered in a few hours



Cooling Tests

- 3rd – 12th December 2014

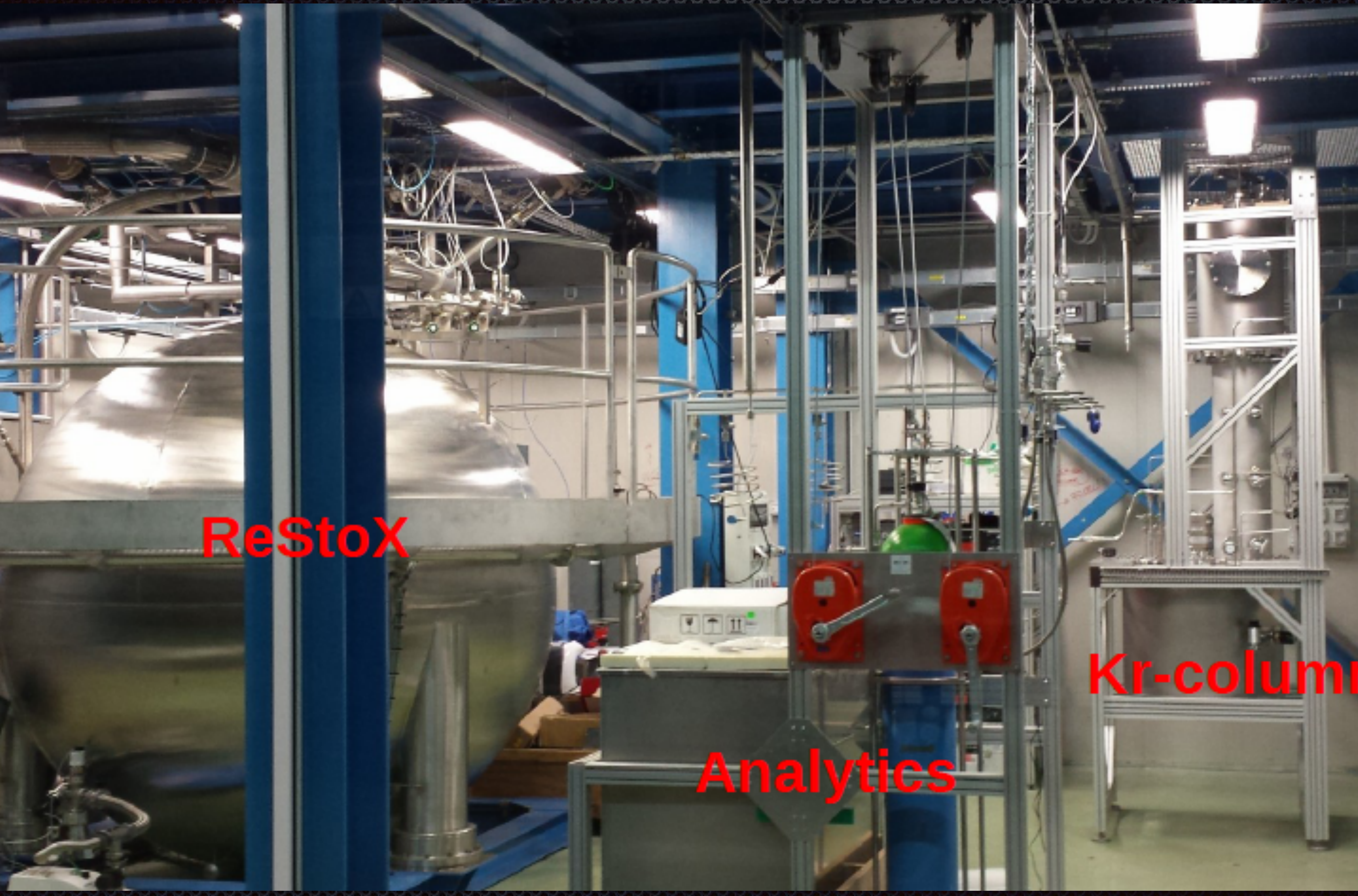
Evolution of the six temperatures on the sphere



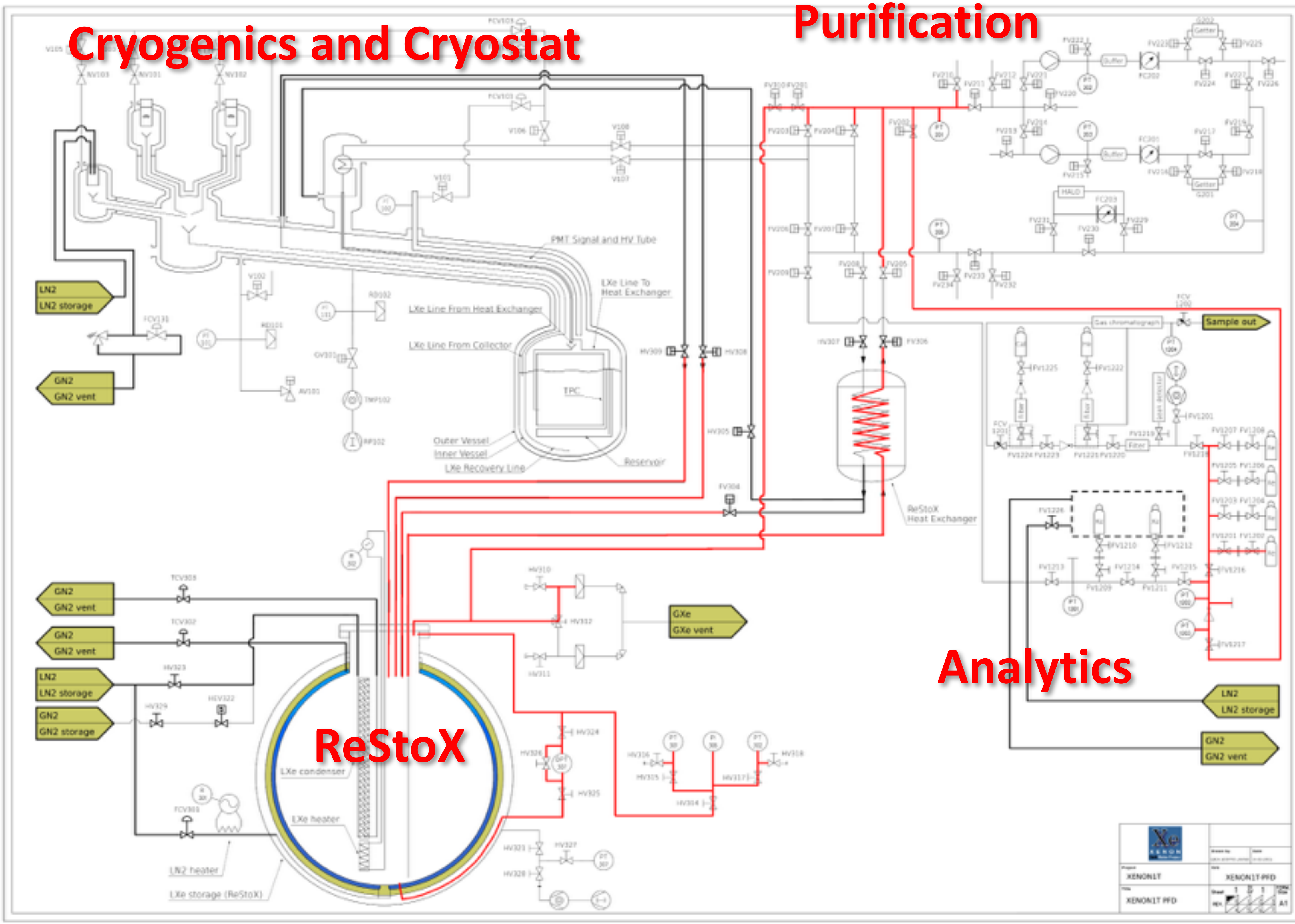
XENON1T/nT: Kr Distillation Column

- 1ppt Kr/Xe contributes ~ 4×10^{-5} cts/keV/kg/d hence XENON1T sensitivity demands ~ 0.2 ppt
- Custom-designed 5m distillation column with 3kg/hr @ 10^{5} separation
- 3m version successfully used to reduce Kr in Xe below 1 ppt as measured by RGMS
- 3m column used on XENON100 to test Radon purification in LXe through cryogenic distillation - the proof of principle is quite successful
- two systems developed to measure ^{nat}Kr/^{nat}Xe and infer ^{85}Kr/nat from known ^{85}Kr/^{nat}Kr: RGMS at MPIK (S. Lindemann and H. Simgen Eur. Phys. J. C (2014) 74:2746) and an Atom Trap at Columbia (Aprile et al. : Rev. Sci. Instrum. 84 (2013))

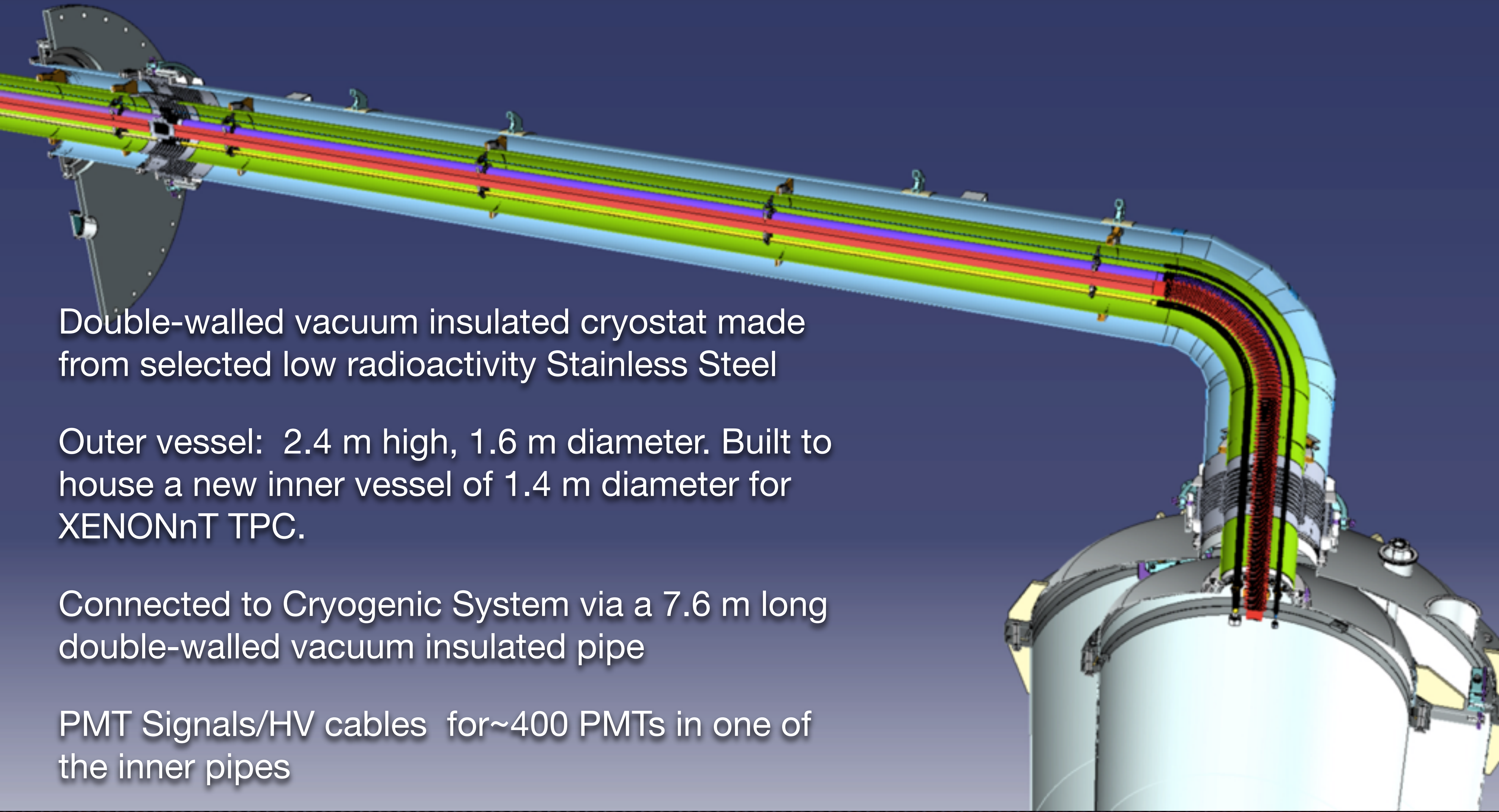
XENON1T/nT: Kr Distillation Column



ReStoX filled with Xe



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

XENON1T Cryostat

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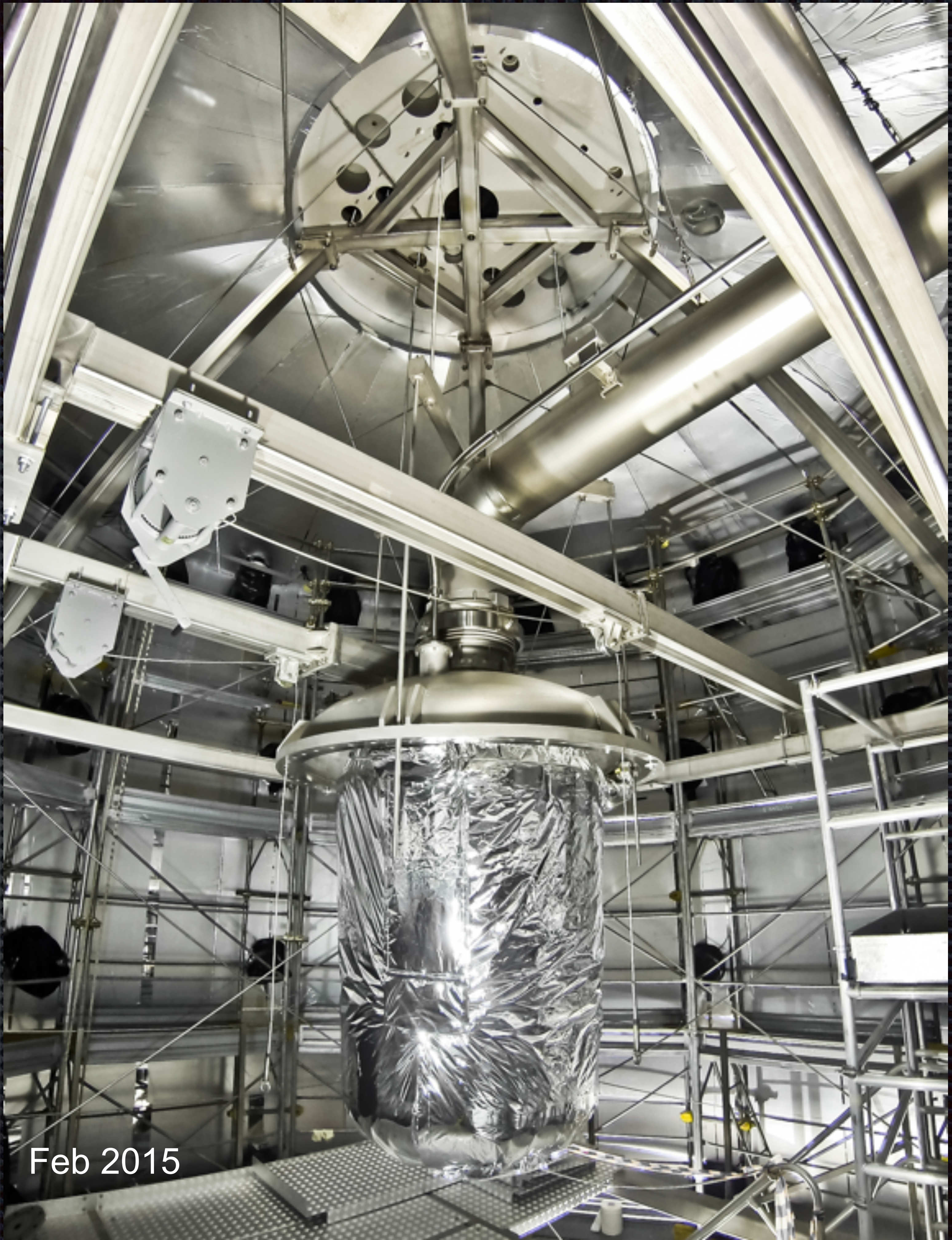
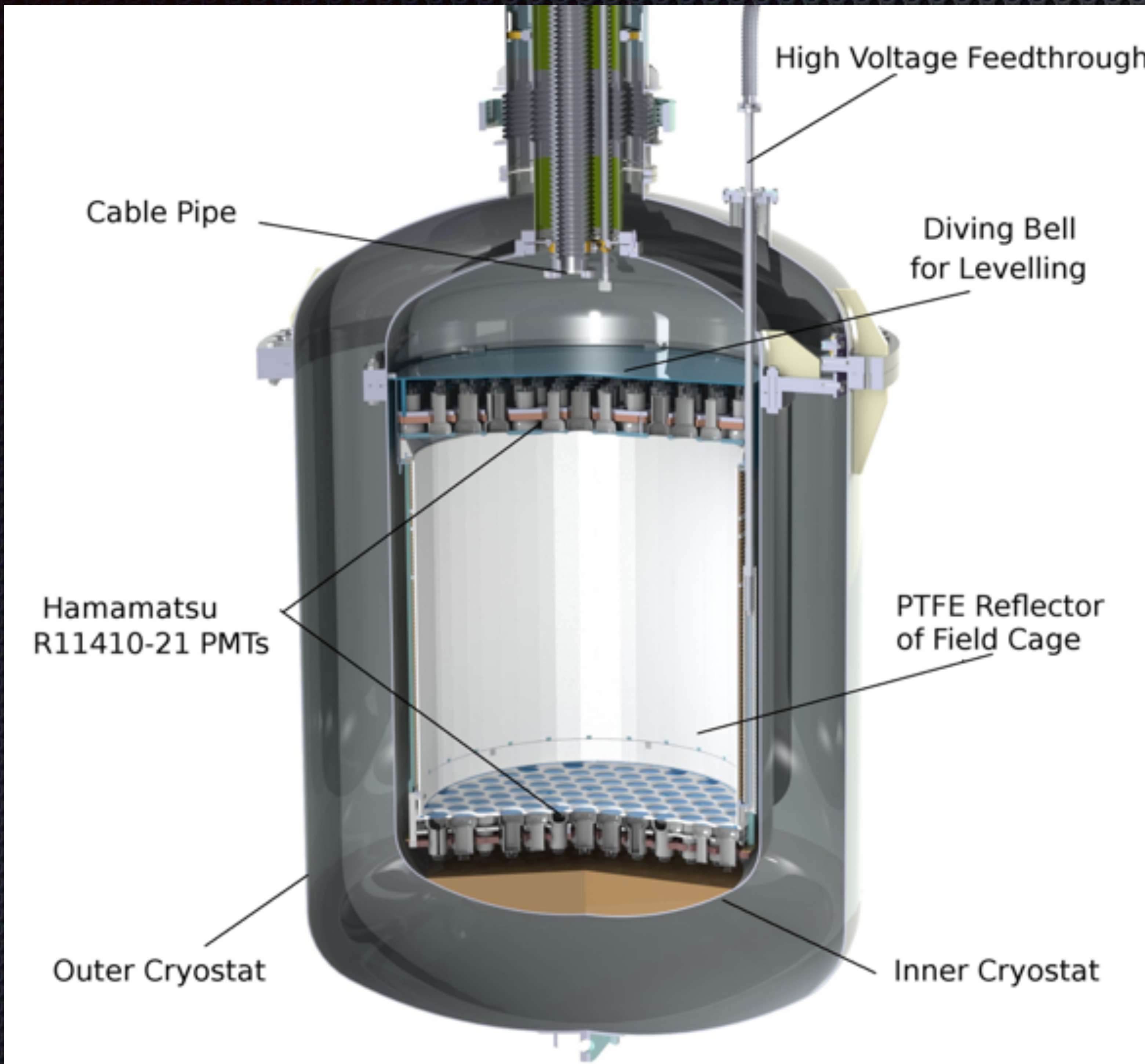

Feb 2015

XENON1T TPC



a larger and improved version of the XENON100 detector

More extensive materials selection to control background, particularly from Rn

248 x R11410-21 (3 inch PMTs) with average QE (178nm) of 34%

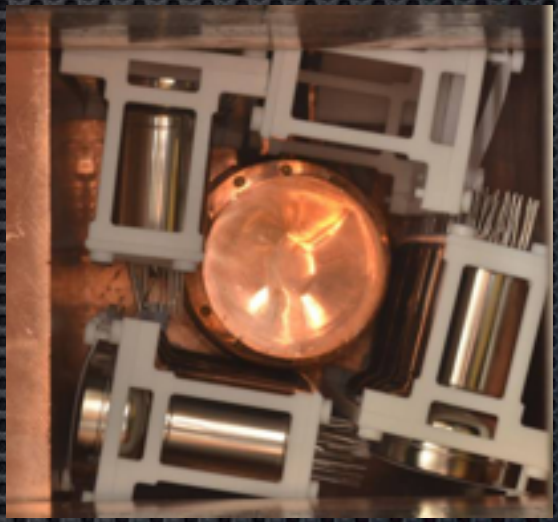
Design completed. Assembly procedure in place. Construction of components ongoing (grids/ PMT supports/HV FT/E-shaping)

Schedule: start assembly in Lab2 Clean Room in July 2015

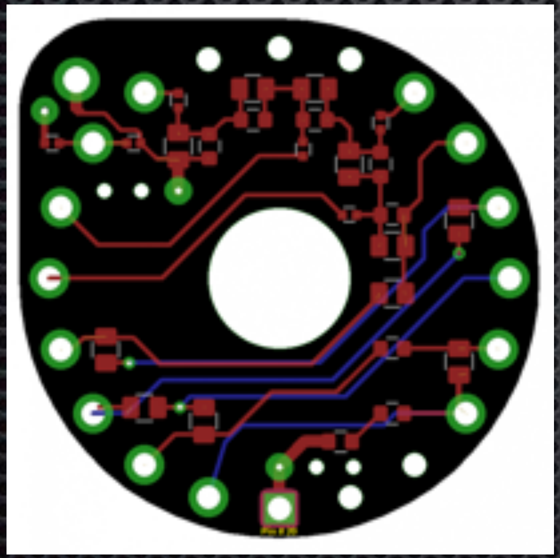
R11410-21 PMTs for XENON1T

- Hamamatsu has delivered 255 PMTs (248 needed for TPC)
- 227 tubes have been screened with HPGe (paper submitted to EPJ-C)
- All tested in cold N vapour (MPIK) and in LXe (UZurich)
- Average QE at 178 nm: 34%
- Low-radioactivity, voltage-divider tested and in production

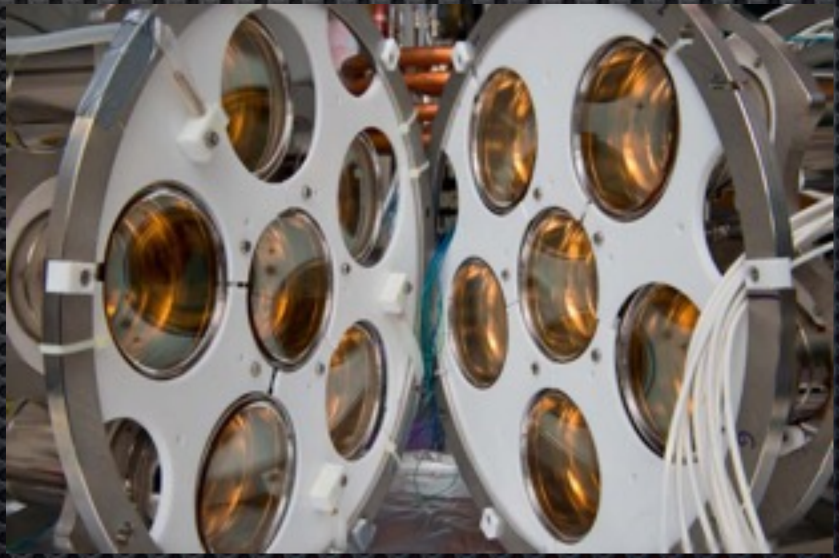
Gator at LNGS



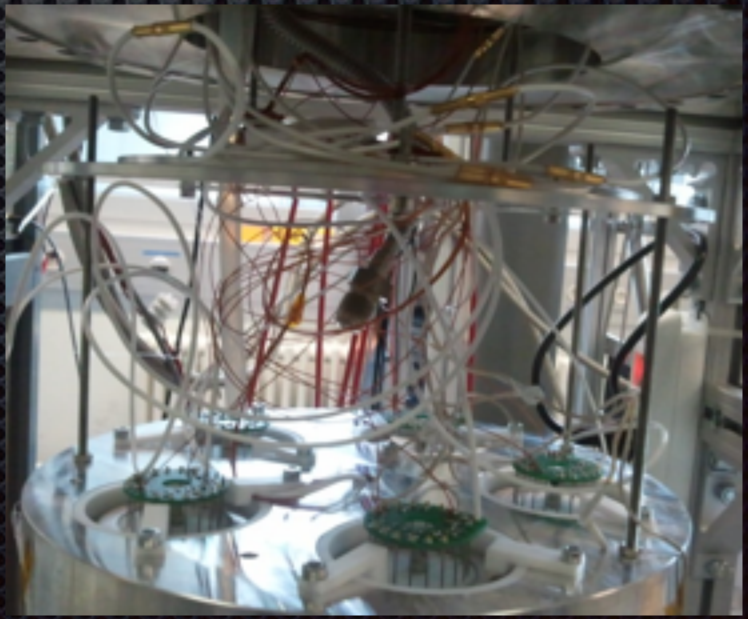
<1mBq/PMT U/Th/Co



voltage-divider



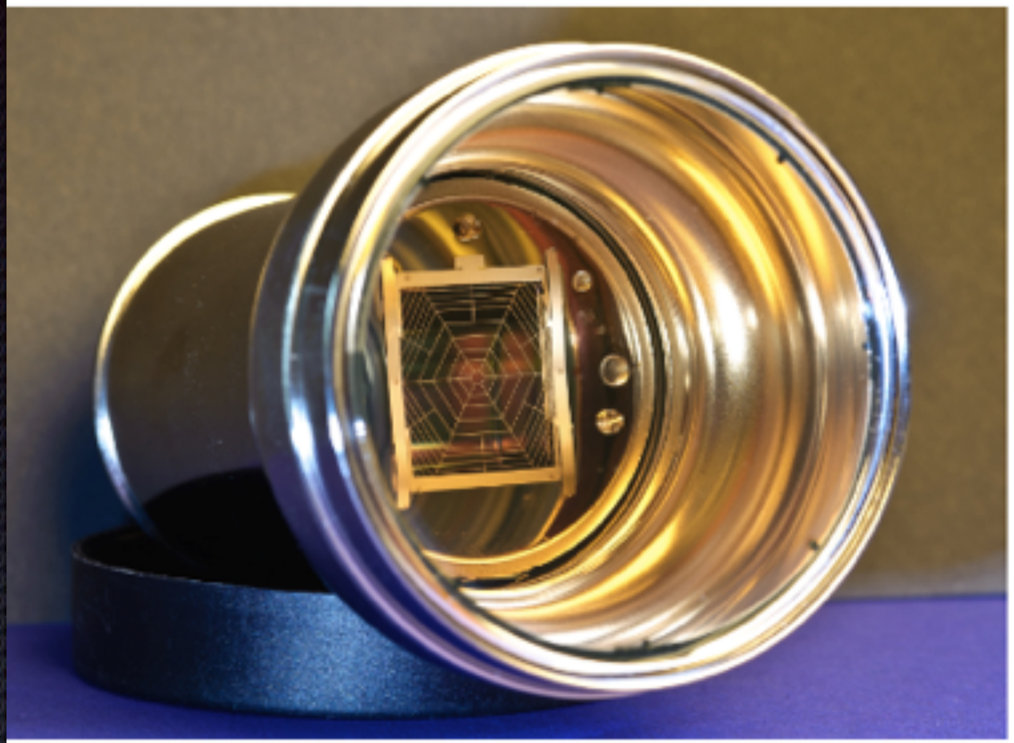
tests in cold N gas



tests in LXe

R11410-21 PMTs for XENON1T

Low radioactivity photosensor for XENON1T

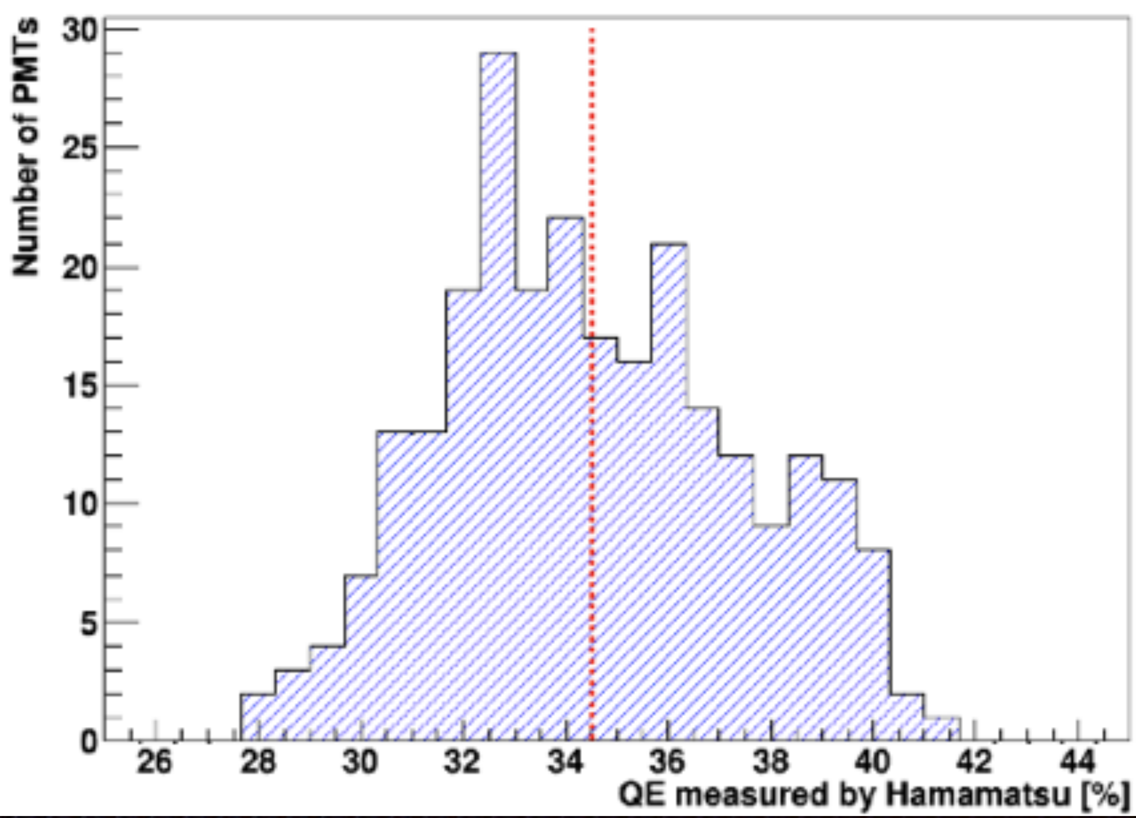


Component	Radioactivity
^{238}U	< 10 mBq/PMT
^{228}Th	~ 0.5 mBq/PMT
^{226}Ra	~ 0.6 mBq/PMT
^{235}U	~ 0.3 mBq/PMT
^{60}Co	~ 0.8 mBq/PMT
^{40}K	~ 12 mBq/PMT

XENON collaboration, arxiv:1503.07698

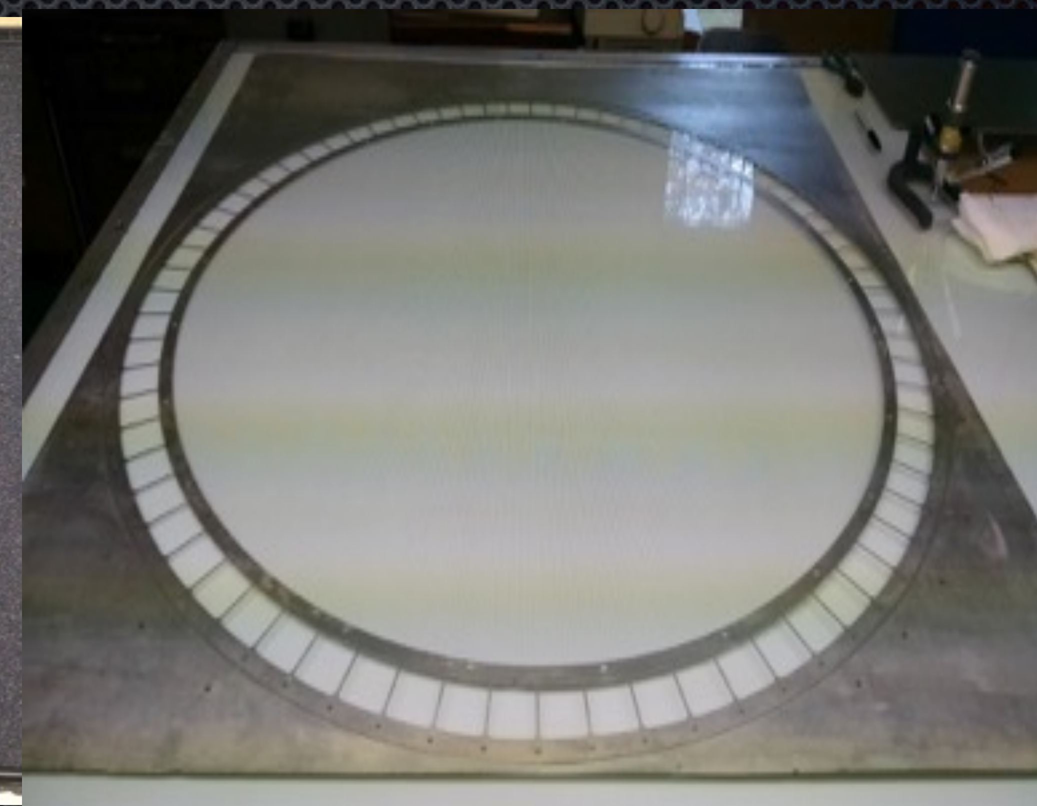
Hamamatsu values:

- High QE: 34.5 % at 175 nm average for 250 PMTs
- Gain average @1500 V: 5.0×10^6 (for 250 PMTs)



Electrodes for XENON1T

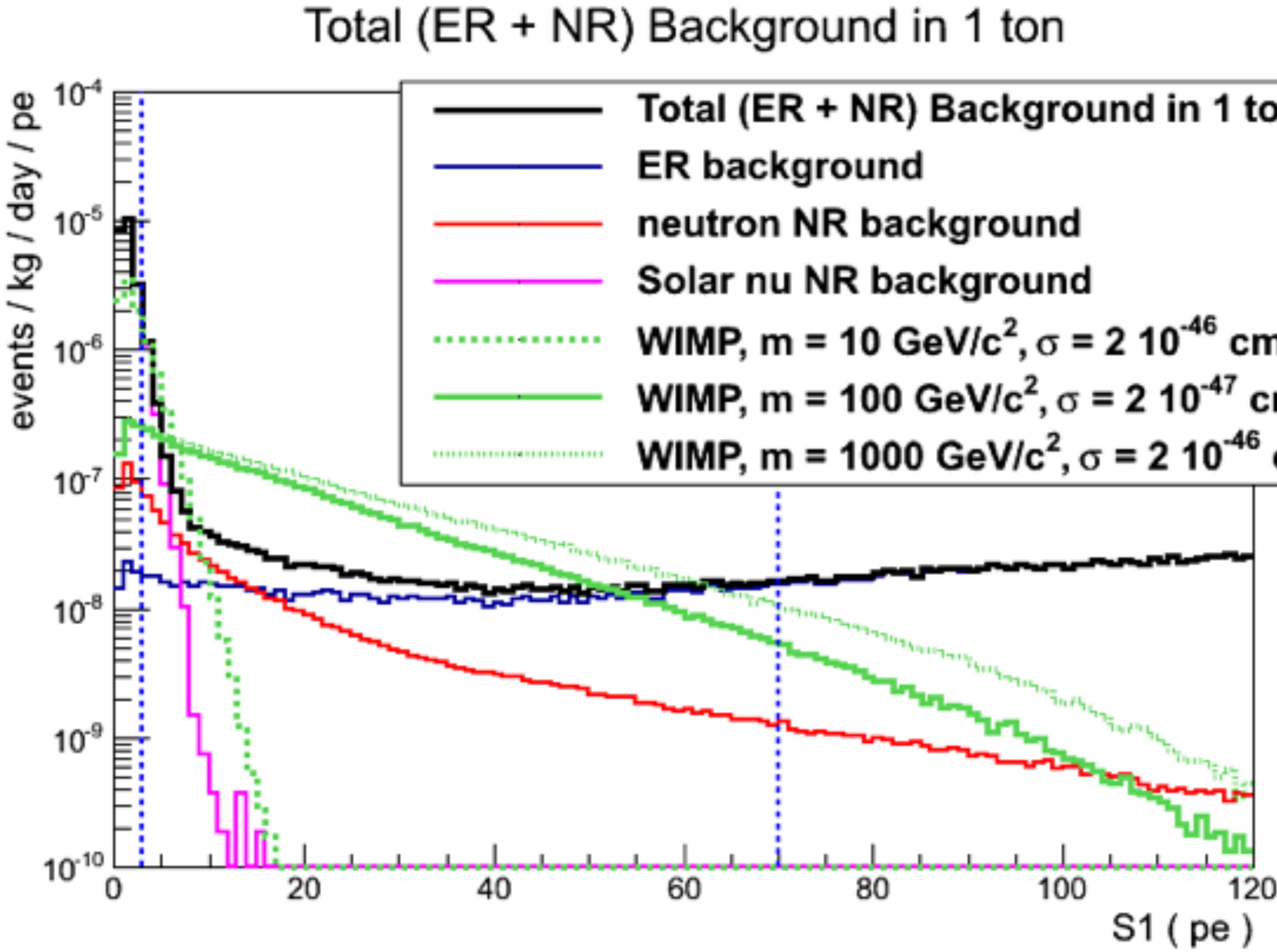
Anode ring:
L-Shaped to min. mass
OD = 1004.0 mm ID = 966.0 mm
H = 18.0 mm W= 19.0 mm
Mass = 4.5 kg of Low Rad SS
Flatness better than 150 μm



Anode mesh:
Hexagonal shaped cell for the best
Stretching uniformity
OD = 1002.0 mm ID = 968.0 mm
Thickness – 187 μm;
Optical transparency - 92%
Mass = 125 g

Cathode electrode:
OD = 985.0 mm ID = 963.0 mm;
200 μm diameter wires; 7 mm
spacing
Mass = 5 kg of Low Rad
Stainless Steel

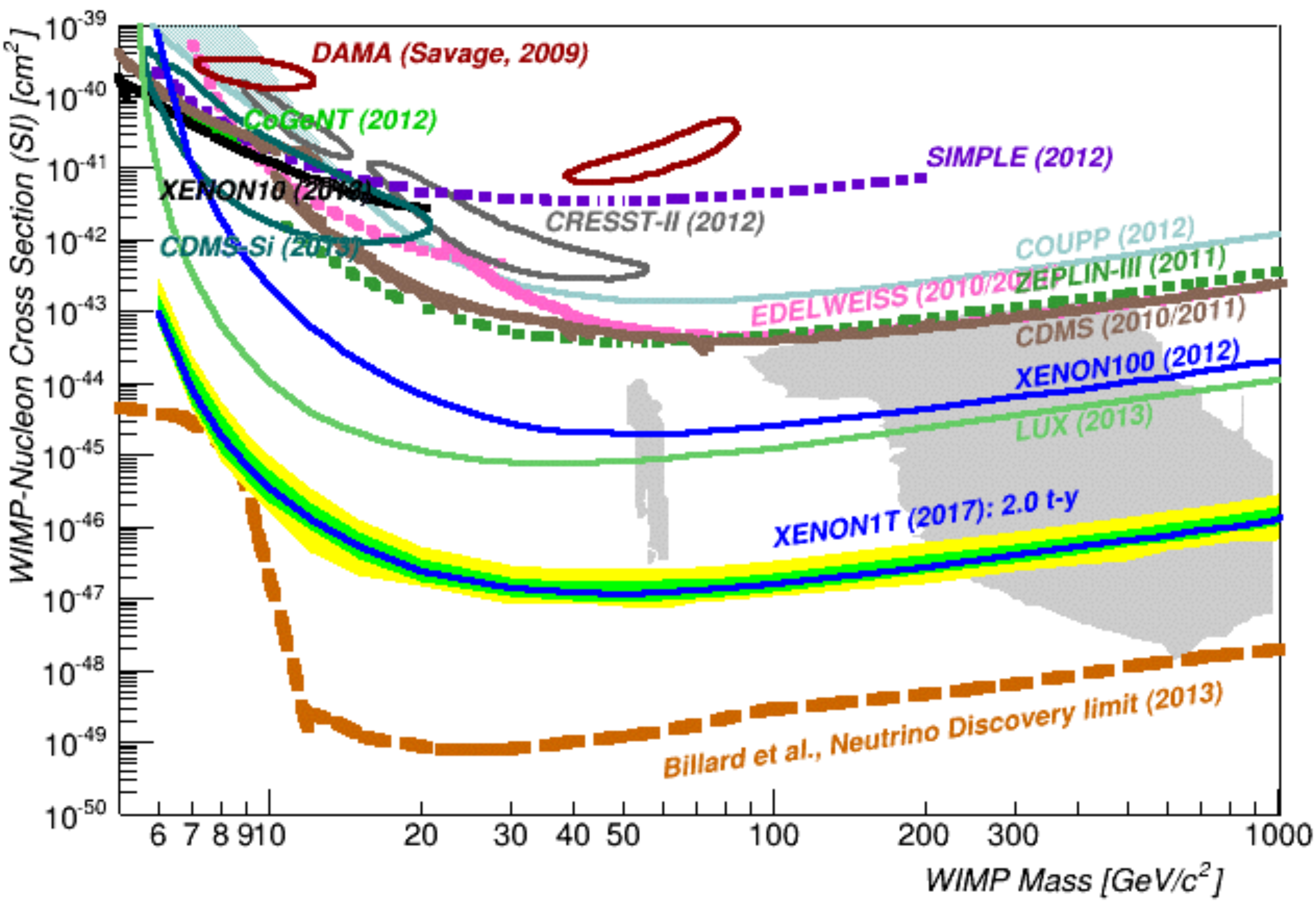
XENON1T Backgrounds



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

Source	Background (ev. / ton /y)
ER (materials + intrinsic + solar ν)	*0.32*
NR from radiogenic neutrons	*0.22*
NR from neutrino coherent scattering	*0.55*
Total	*1.1*

XENON1T sensitivity



XENON1T Sensitivity vs Exposure