The next generation dark matter hunter: XENON1T status and perspective

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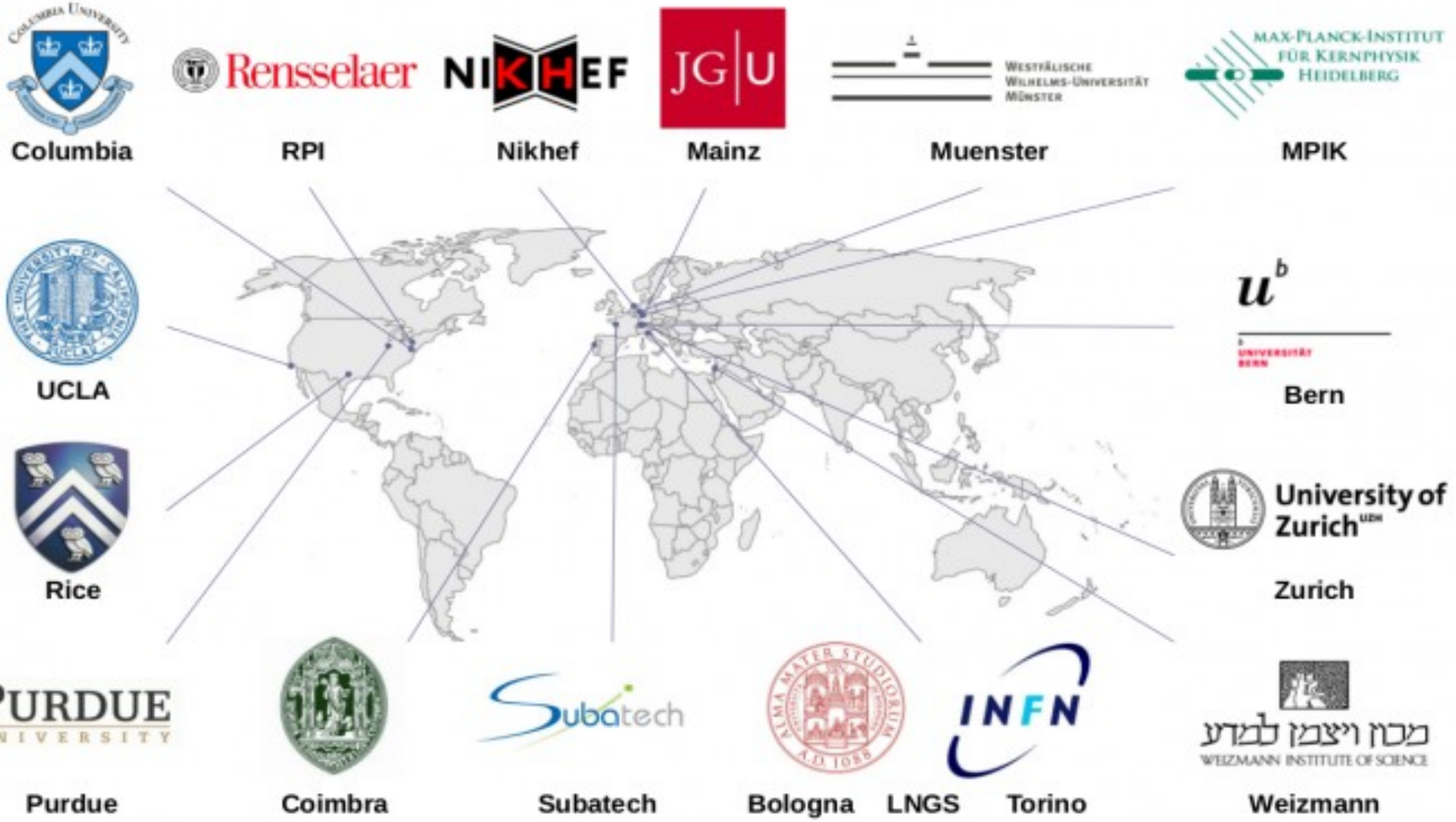
for the XENON Collaboration

RICAP-14, Noto (Italy)
30 September 2014

XENON1T Collaboration : world map



XENON1T Collaboration : people

The Dark Matter Hunter's path

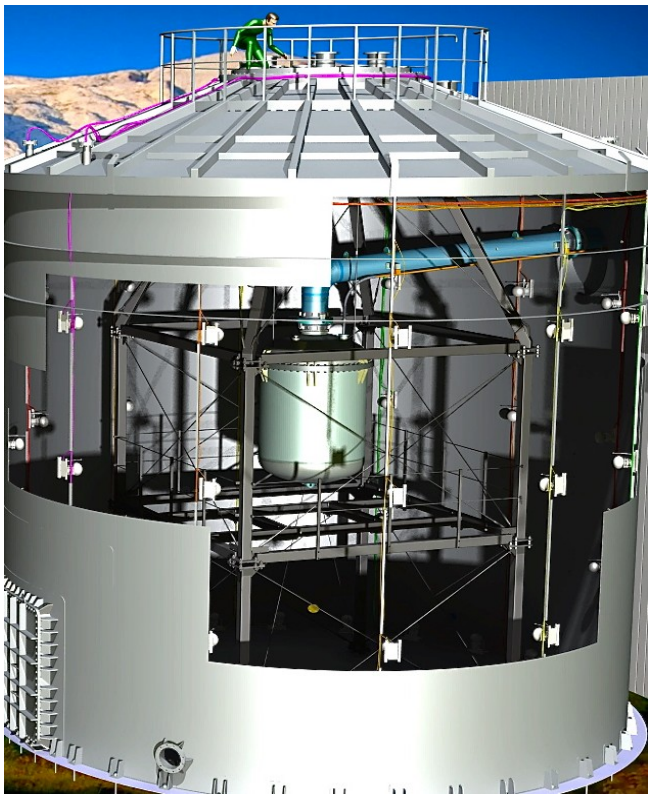
The Past (2005-2007)
XENON10

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

The Present (2005-2014)
XENON100

$\sigma_{SI} < 2 \times 10^{-45}$ cm^2 (2012)
(see S. Orrigo Talk)

The Future (2017- ..2023)
XENON1T .... XENONnT

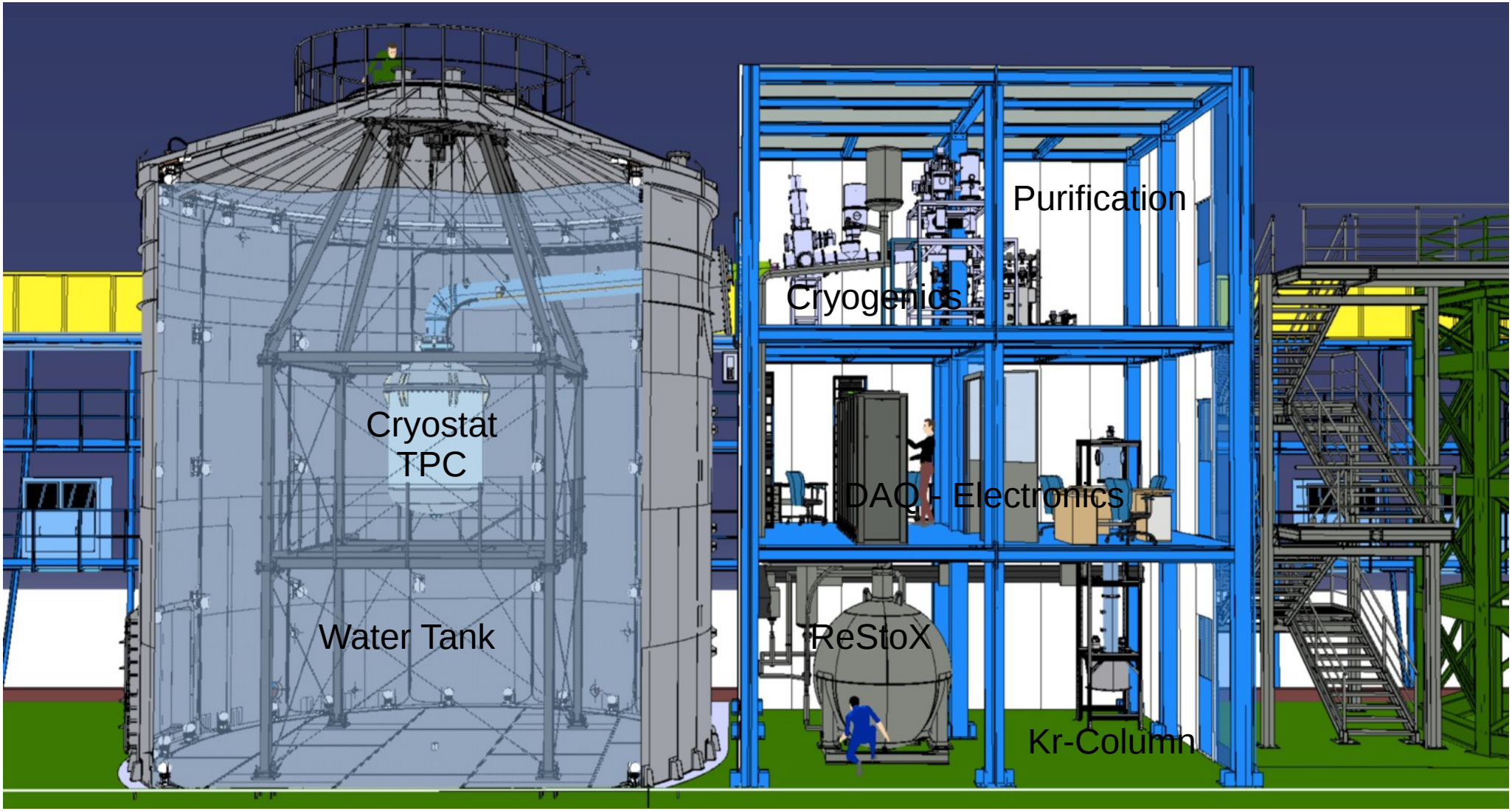


$\sigma_{SI} < 2 \times 10^{-47}$ cm^2 (XENON1T)
$\sigma_{SI} < 3 \times 10^{-48}$ cm^2 (XENONnT)

Goals!

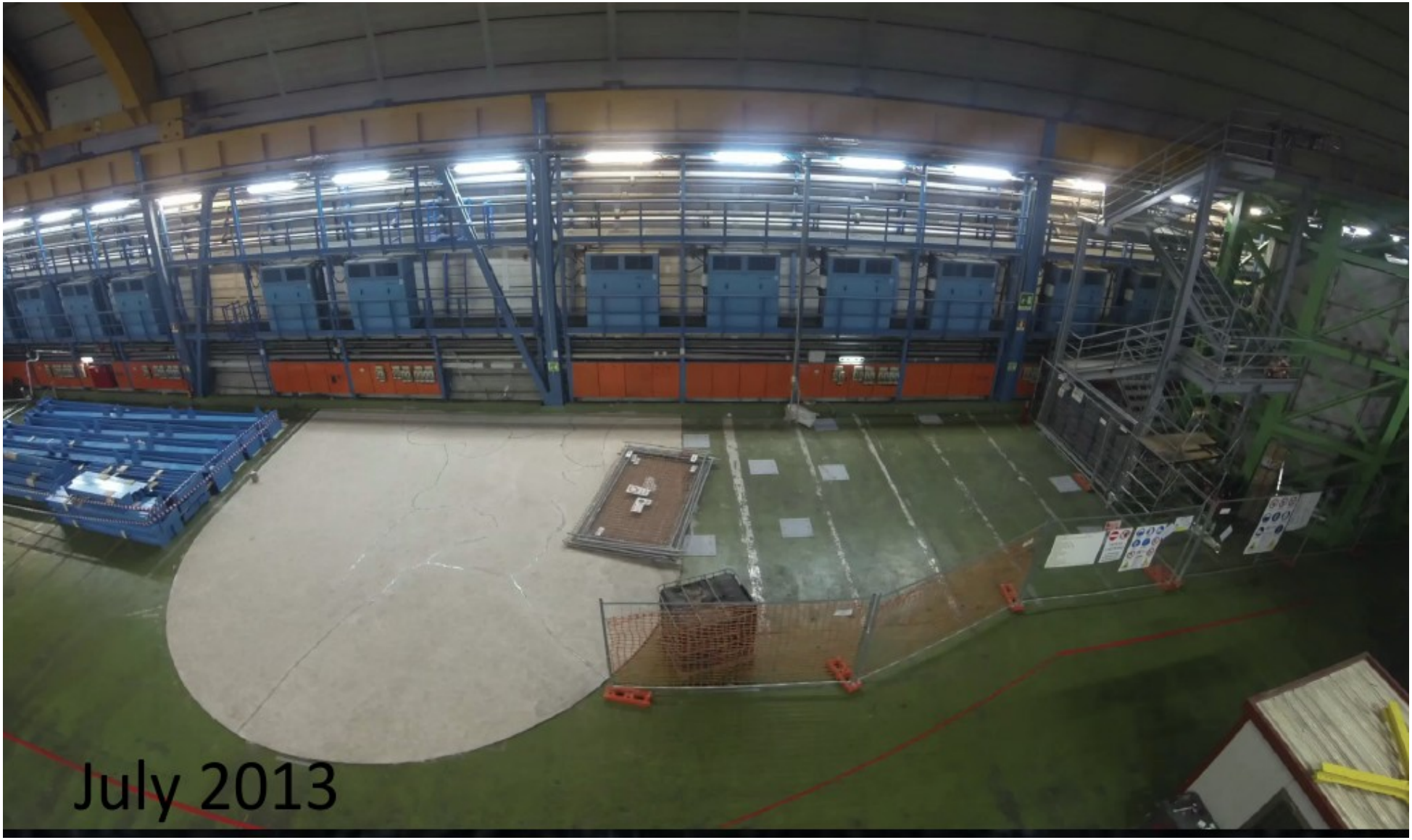
XENON1T @ LNGS

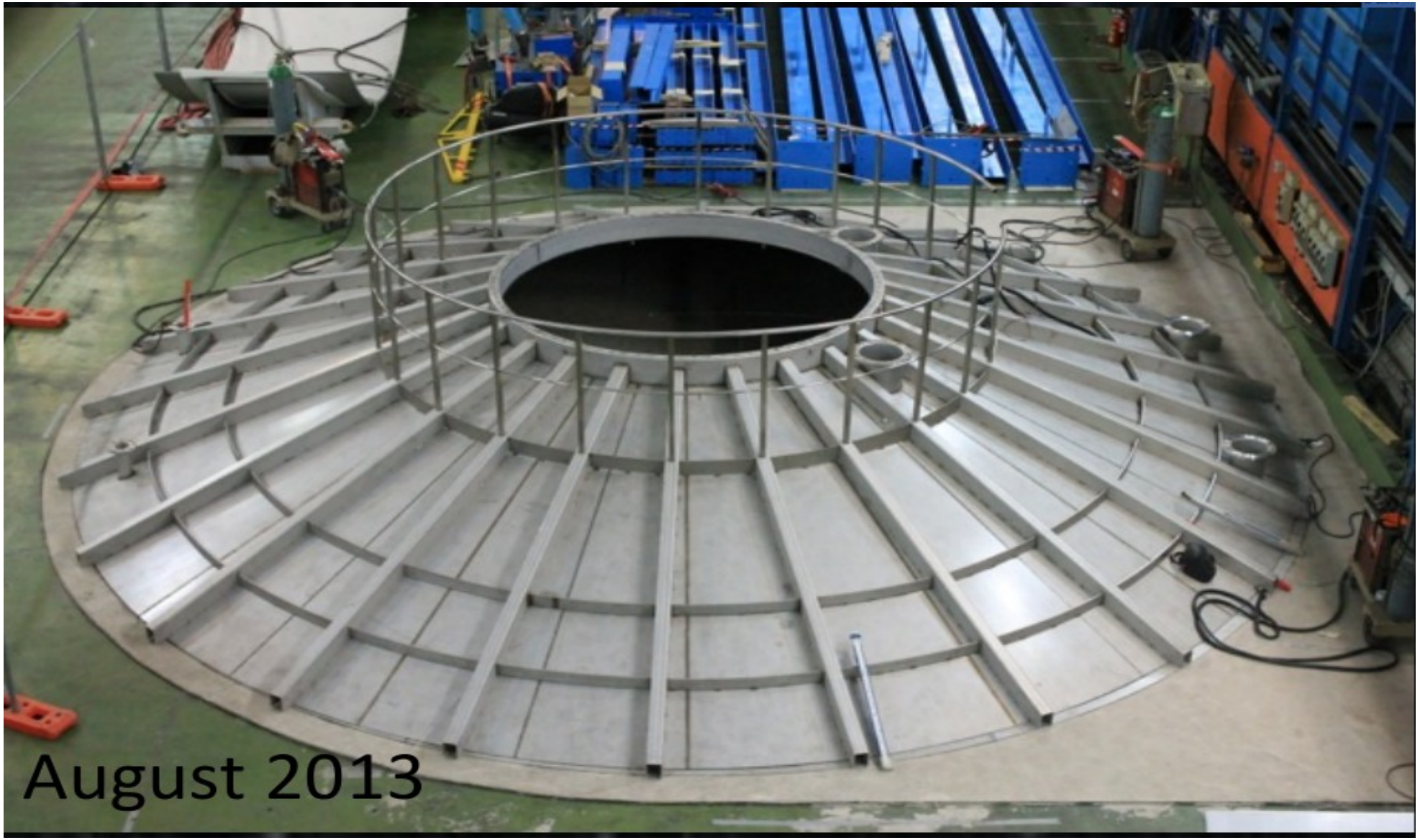
XENON1T Sketch



XENON1T Construction Steps

XENON1T

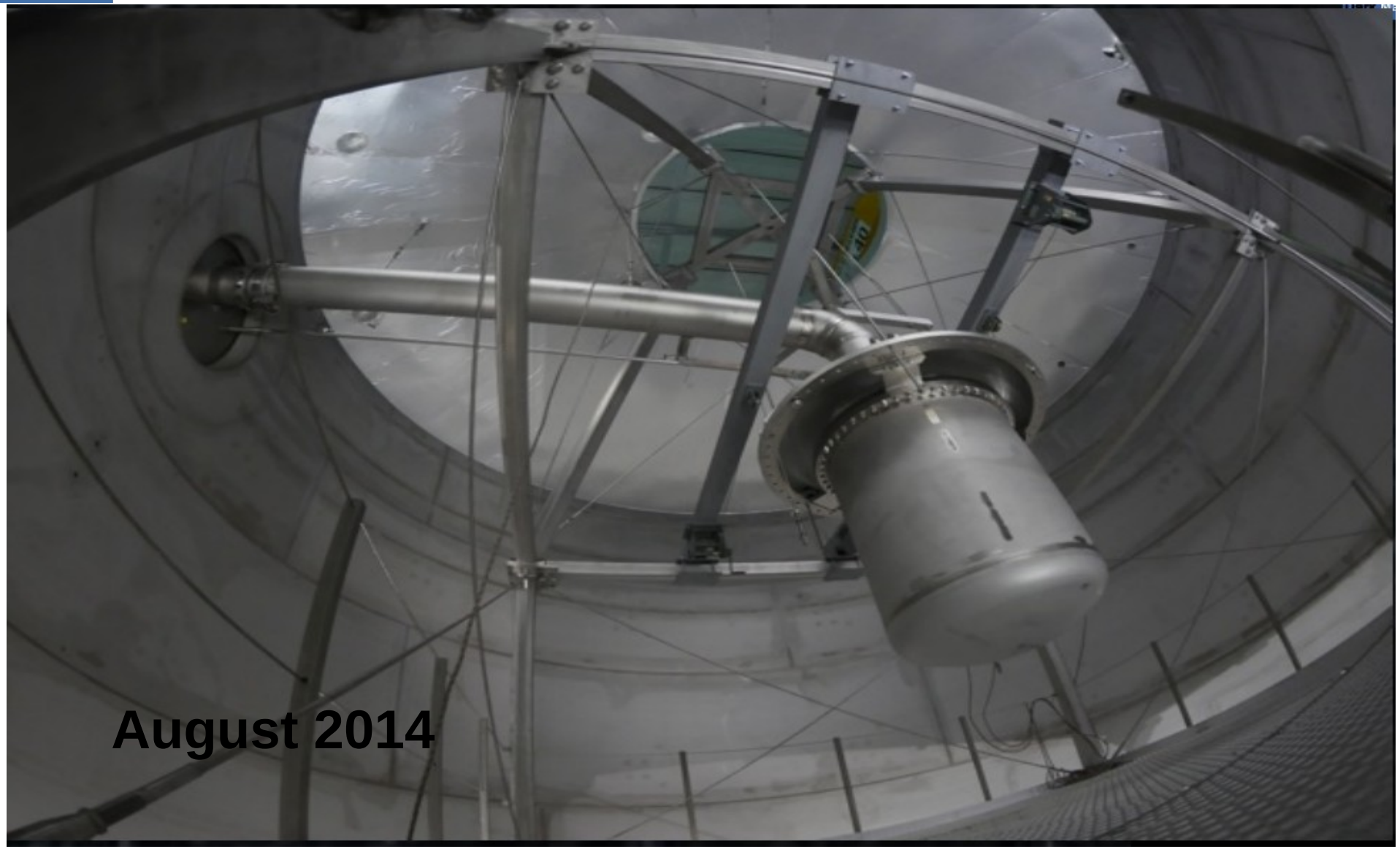



August 2013

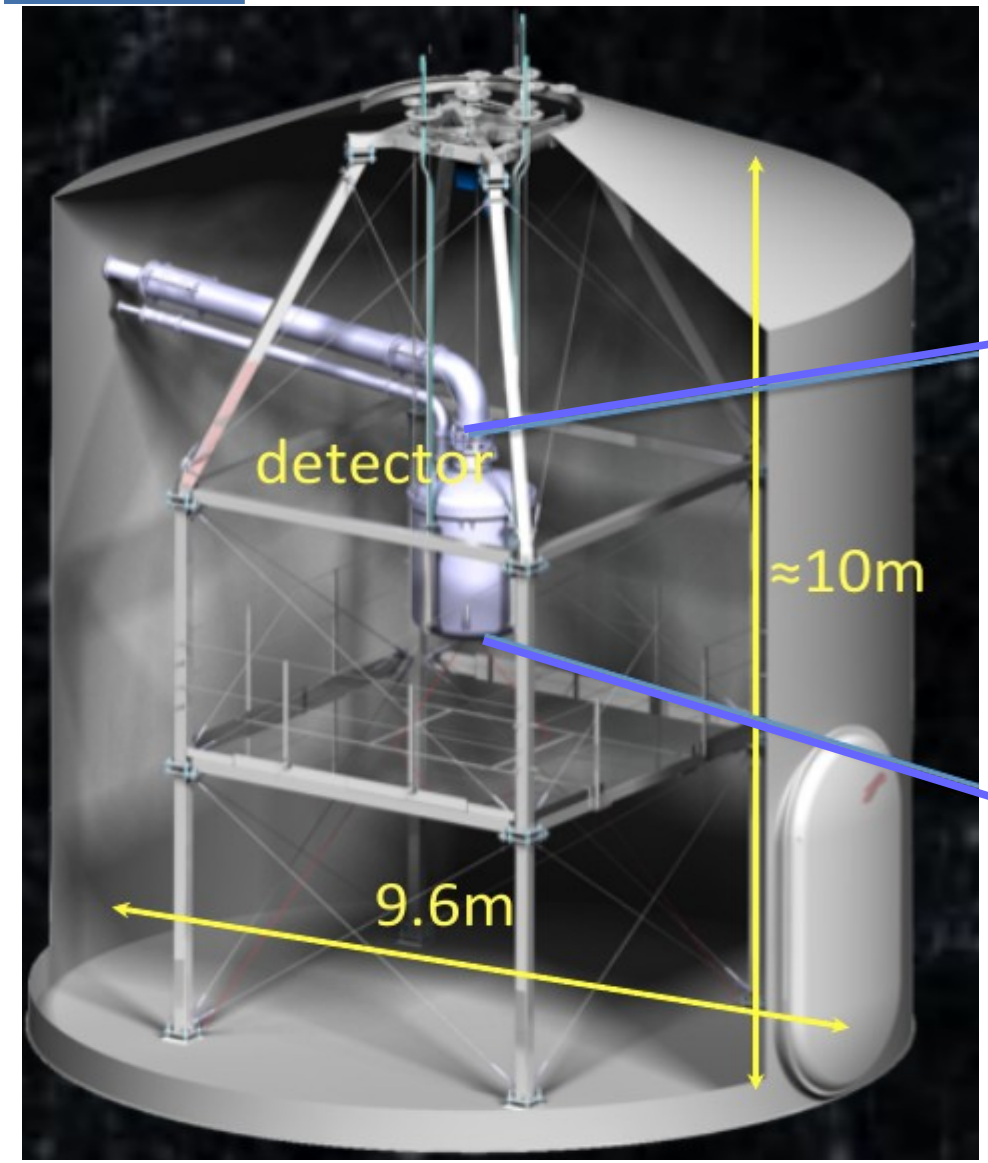
Water Tank

Main Pipe

Support and Cryostat



Cryostat Zoom

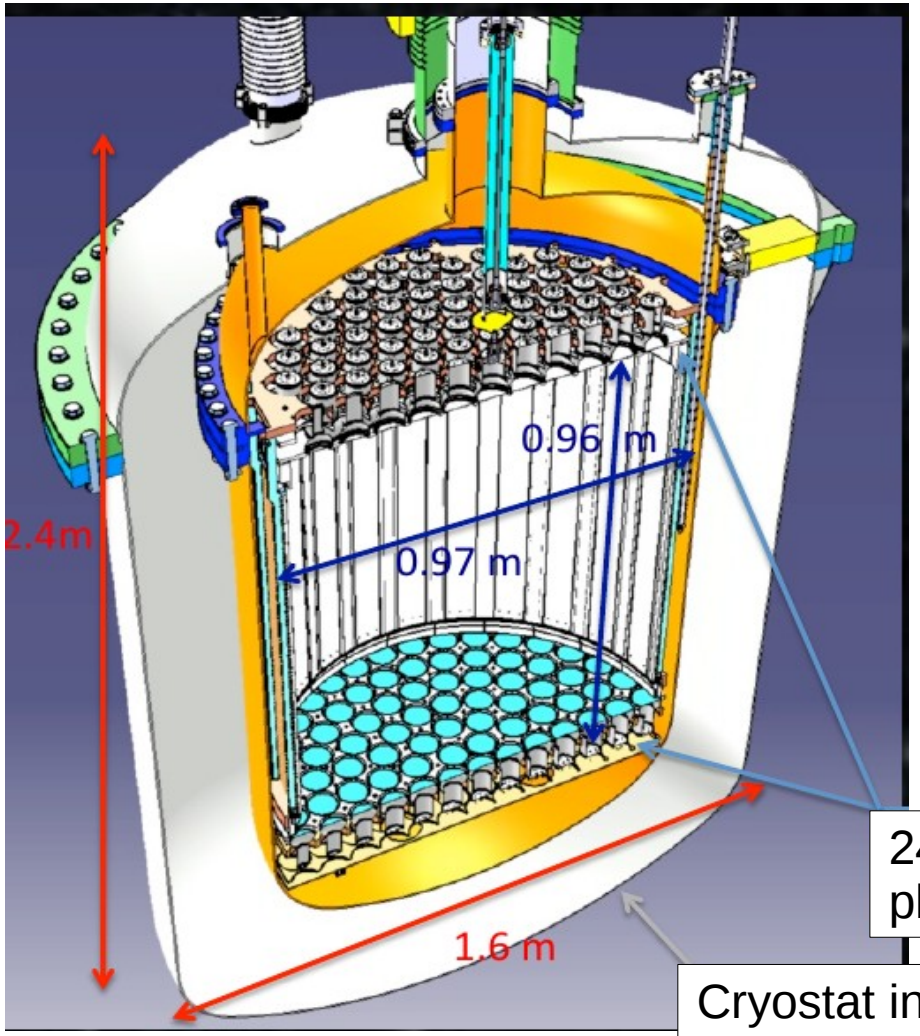


Xe Storage and Recovery: ReStoX

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

XENON1T Building

XENON1T TPC

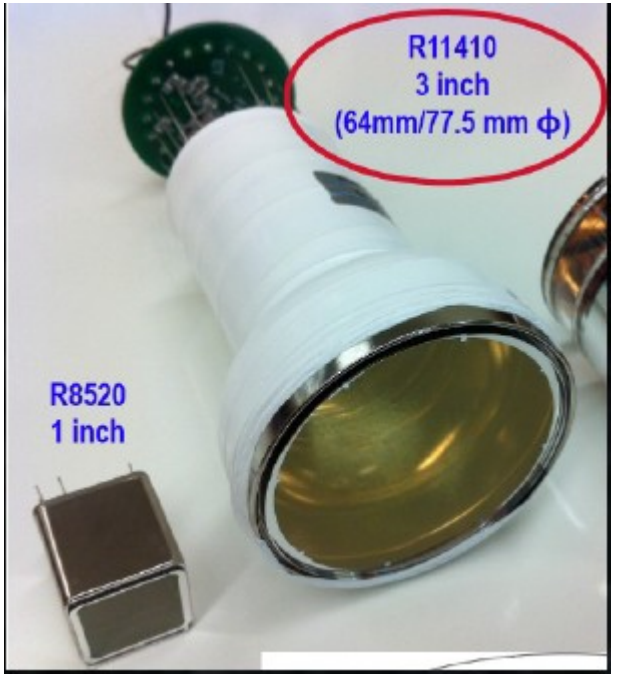


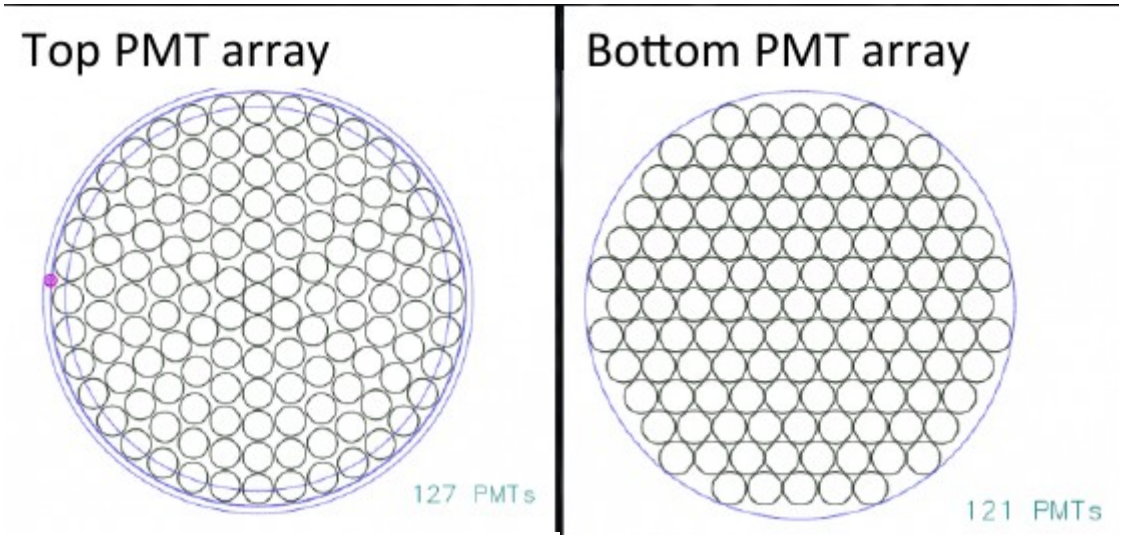
- In total ~ 3.3 ton of LXe, 2 ton active inside TPC, part of the LXe used as active veto.
  Fiducial Volume >= 1 ton
- ~ 1 m drift inside TPC, E_d > 500 V/m, HV >- 50kV
- Improved LCE, better PTFE reflector coverage, electrode transparency
- Lower background (10 cm self shielding and low radioactivity components)
  Background goal: <1 event / 2 years x 1 ton

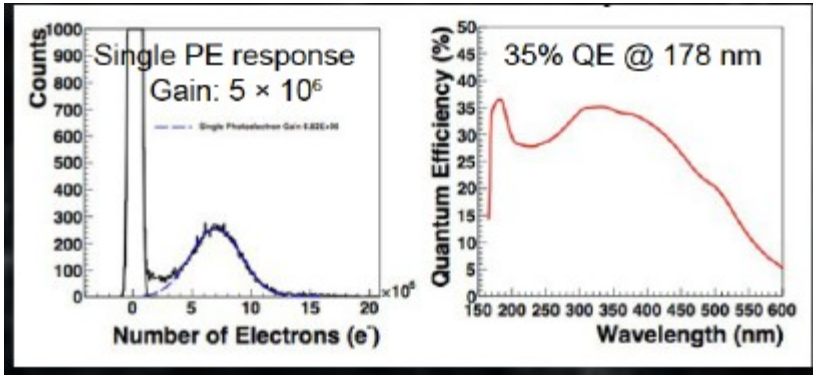
248 low radioactivity photon detectors

Cryostat in low radioactivity stainless steel

XENON1T PMTs





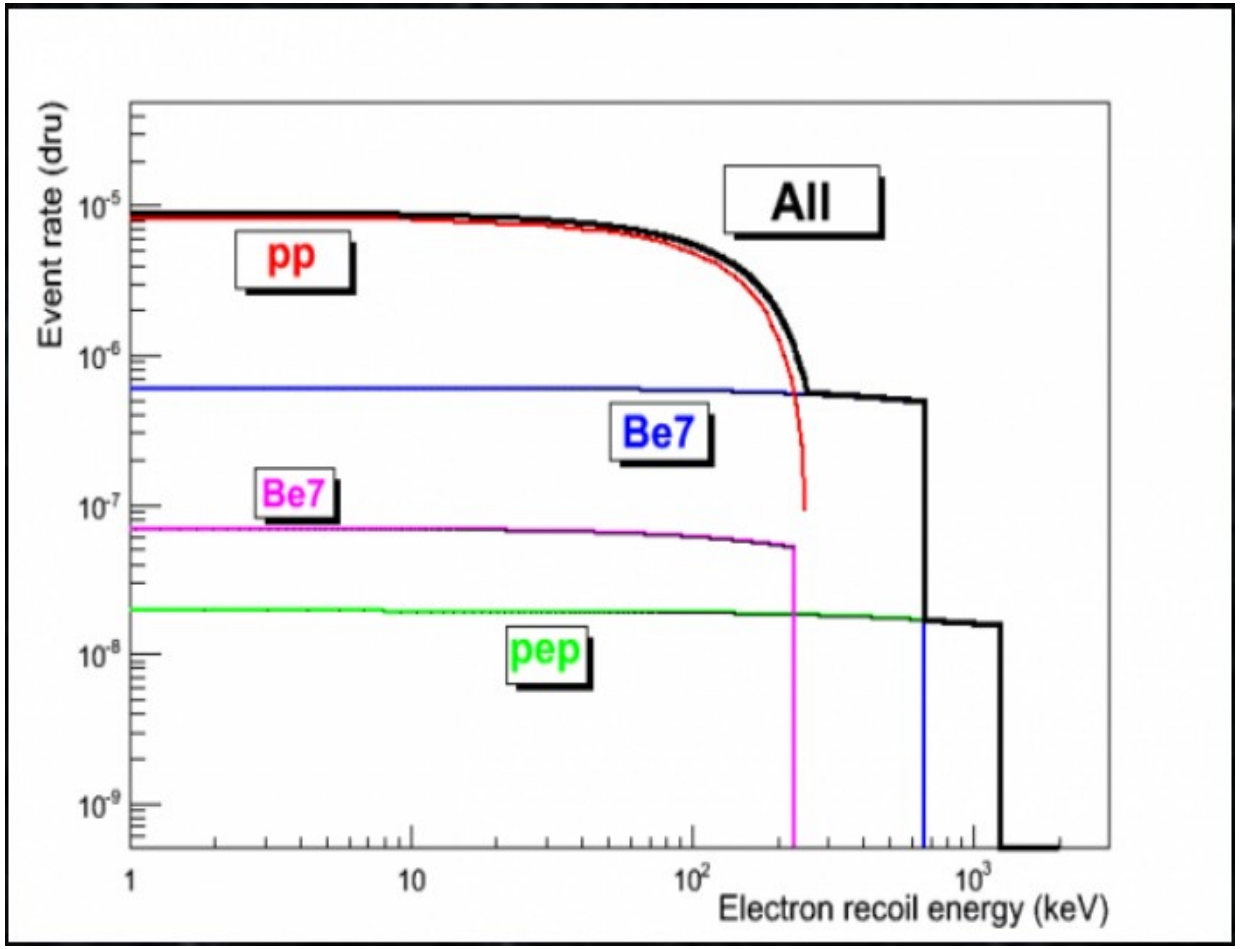


- 3" PMTs: Hamamatsu R11410-21
- Two Arrays of PMTs (127+121)
- QE: 28% min., >35% achieved
- Ongoing program for screening and test in LXe

Intrinsic background reduction

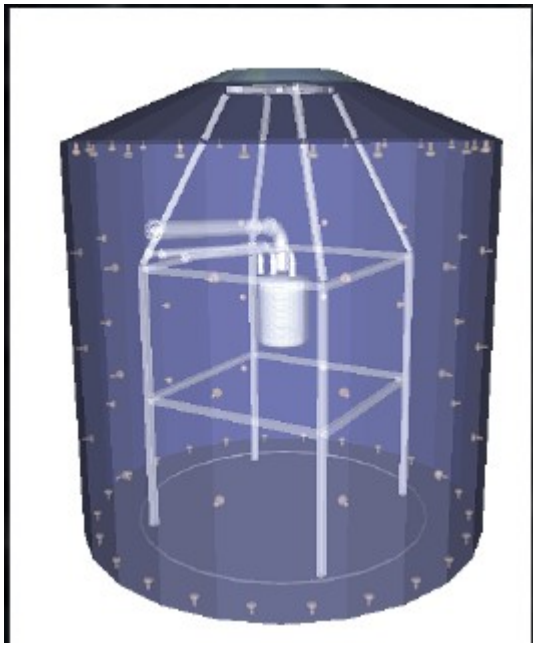
- Cryogenics distillation column for ^{85}Kr removal, aim Kr/Xe < 0.1 ppt
- High throughput: 3kg / h (3.5 ton in ~ 1.8 months)
- Custom gas purity diagnostics (online&offline) (^{83m}Kr tracer, ATTA, RGMS, RGA + cold trap

Irreducible background: Solar ν

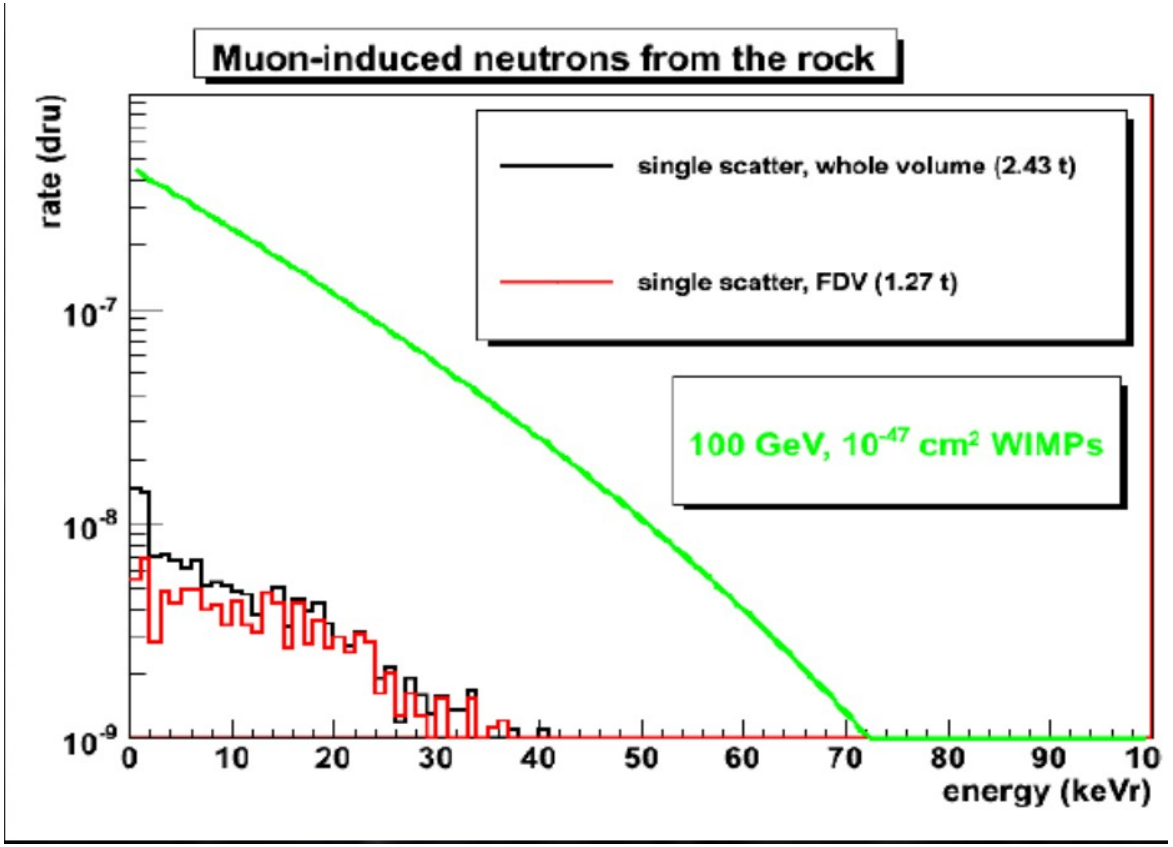


- Elastic scattering of Solar ν (mainly from pp chain) off electrons produces ~ 40 events per ton per year in the energy ROI, before NR selection.
- Assuming 99.75% S2/S1 discrimination, the surviving events are 0.08 per ton per year

Water Cherenkov Muon Veto



- Muon-induced neutron background: 0.01 per year, negligible w.r.t. WIMP signal

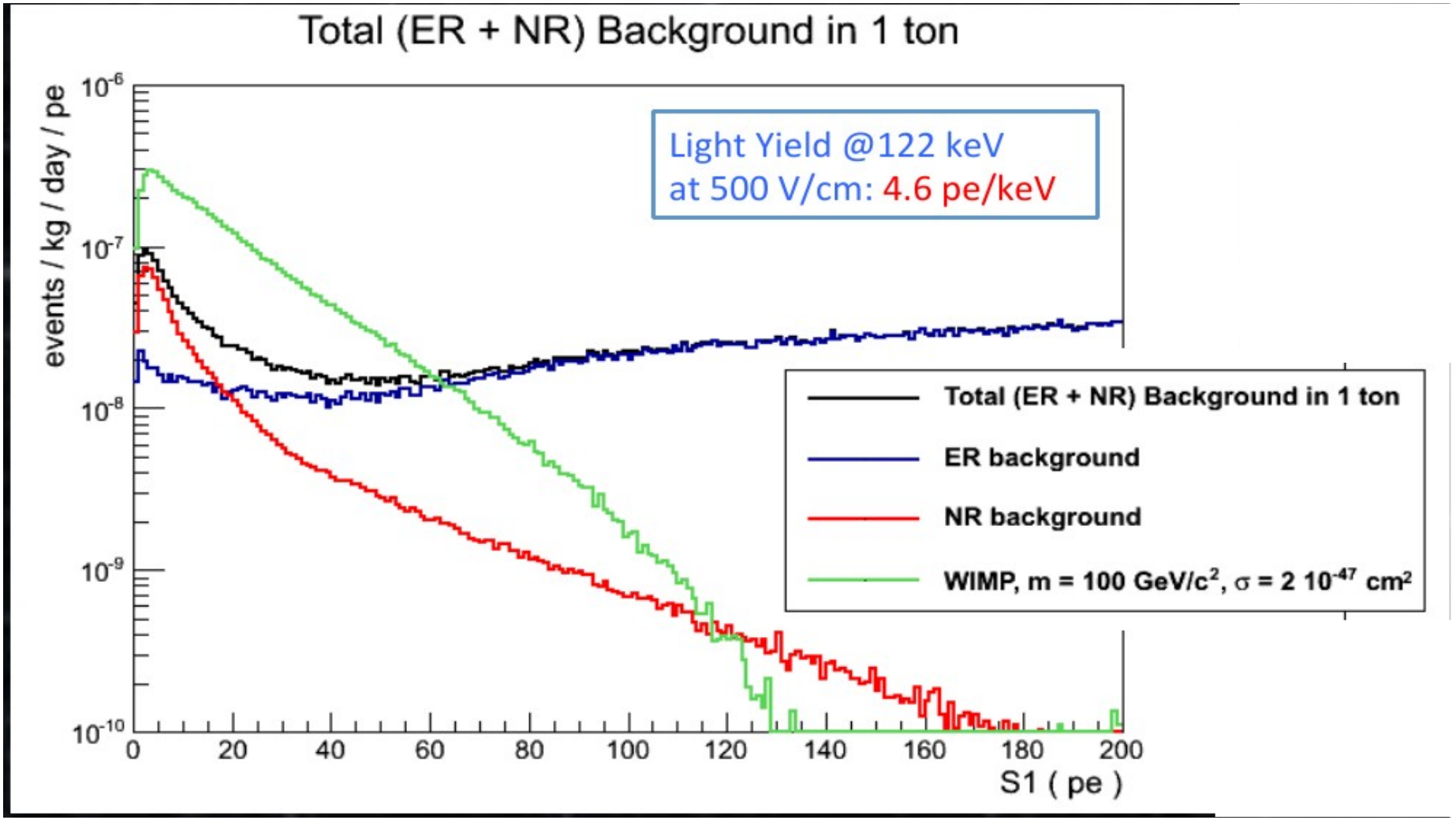


- Water Tank: 10 m high, 9.6 m diameter
- 84 HQE 8” PMTs Hamamatsu R5912
- Specular reflector: foil DF2000MA 3m

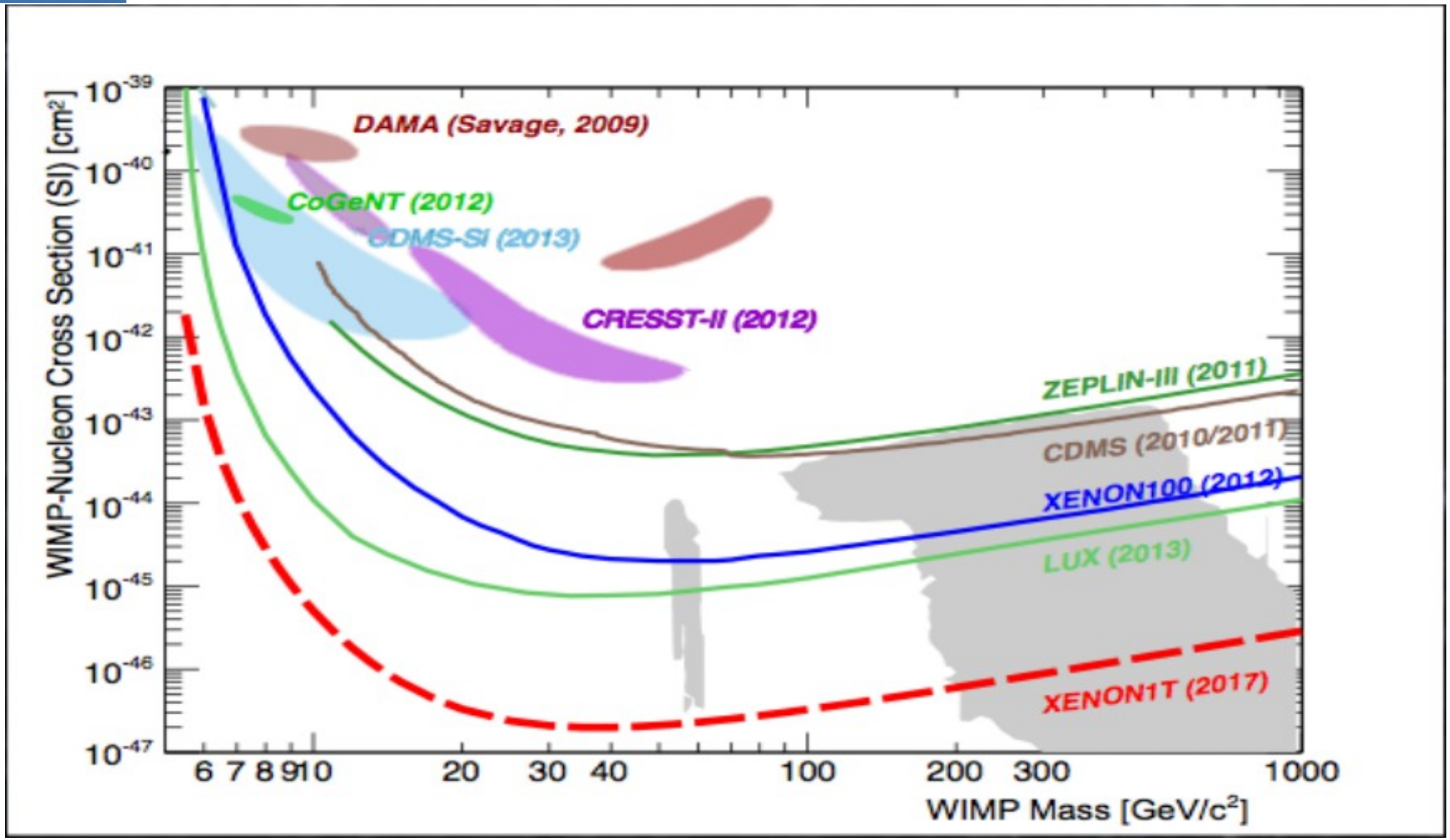
“Conceptual design and simulation of a water Cherenkov muon veto for the XENON1T experiment”
Arxiv: 1406.2374 (accept. by JINST)

Background Summary

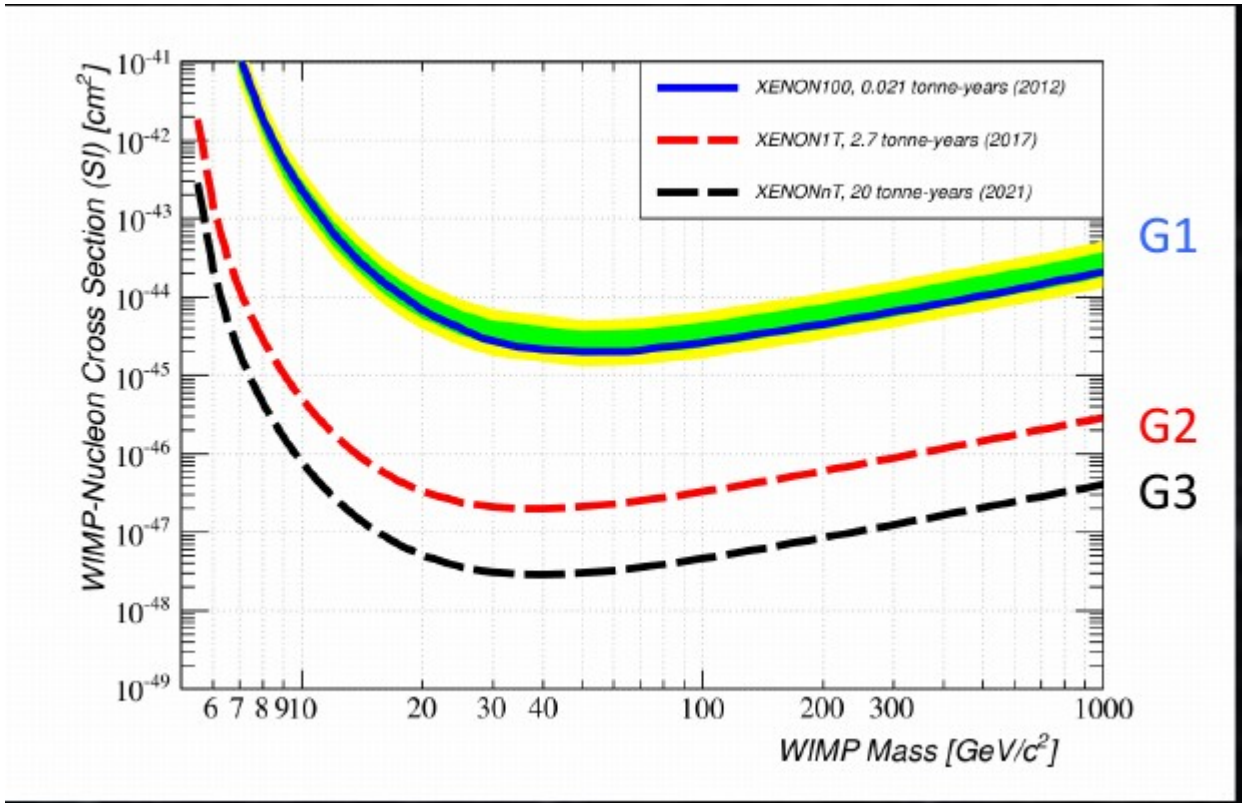
- Single scatter, 1 ton FV, 99.75% S2/S1 discrimination, 50% NR acceptance

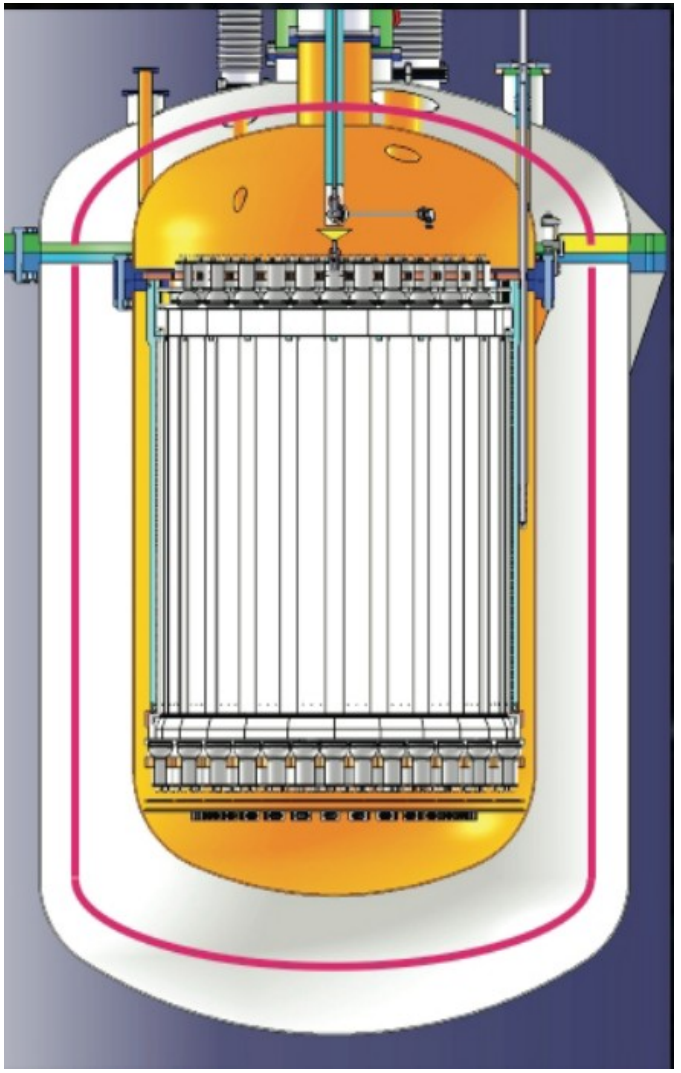


XENON1T Sensitivity



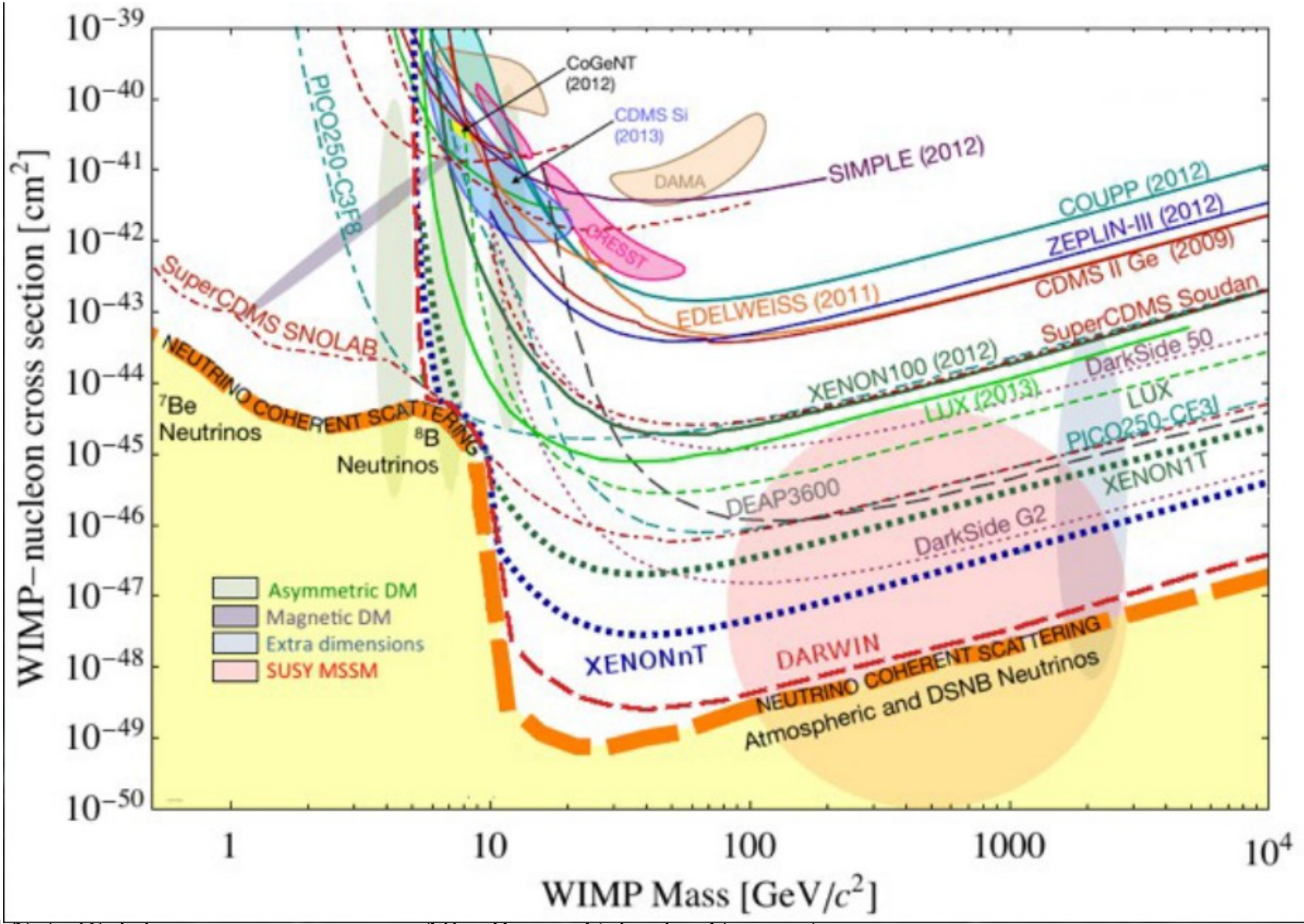
XENONnT: XENON1T Upgrade





- XENONnT will have a larger TPC and inner cryostat, but the same XENON1T setup (outer cryostat, support structure, cryogenics, purification, etc.)
- Amount of LXe, PMTs and electronics almost doubled
- Aimed exposure: 20 tons year from 2018

XENON1T and the Next Generation



Summary

- XENON1T is currently under construction @ LNGS in Hall B; the water tank, support structure, main pipe, cryostat are mounted.
- The service building with the cryogenics plants, purification and recovery system are installed and currently under commissioning
- Whole detector installed in mid 2015, commission and first science run by the end of 2015, with 2 x 10^{-47} cm^2 sensitivity from 2017 with a 2 ton y exposure
- With modest modifications, we can operate a larger detector in the same setup: XENONnT, with a potential sensitivity of 3 x 10^{-48} cm^2 with 20 ton y exposure

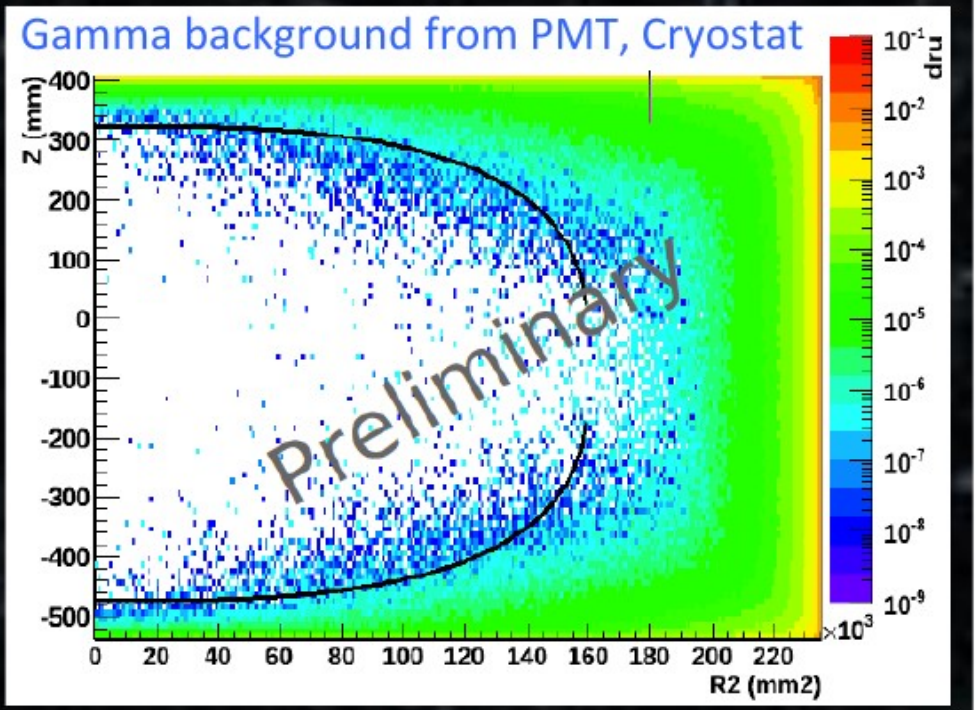
XENON1T: backgrounds

Full Monte Carlo simulation of the detector (TPC, PMTs, cryostat, water shield, …) in GEANT4.
Neutrons from (α,n) predicted with SOURCES-4A.
Breaking of secular equilibrium is taken into account both for γ and n induced background.

Background rejection through:

- single scatter requirement
- position in the TPC (fiducialization)
- S2/S1 discrimination
- Tagging events due to muons thanks to the 10m x 10 m water Cerenkov muon veto

Intrinsic backgrounds pass through most of the selection requirements:
it's mandatory to keep very low the internal impurities ^{85}Kr and ^{222}Rn



Background Summary

Single Scatter, 1 ton Fiducial Volume, [2, 12] keVee, [5, 50] keVr,
99.75% S2/S1 discrimination, 40% NR acceptance

Source	Background (ev/y)
ER from materials	0.05
Kr85 (0.2 ppt of ^{nat}Kr)	0.07
Rn222 (1 μBq/kg)	0.08
Solar neutrinos	0.08
2ν2β	0.02
NR from materials	0.24
Total	**0.54**