The XENONnT Dark Matter Experiment

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(on behalf of the XENON collaboration)

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Phases of the XENON program

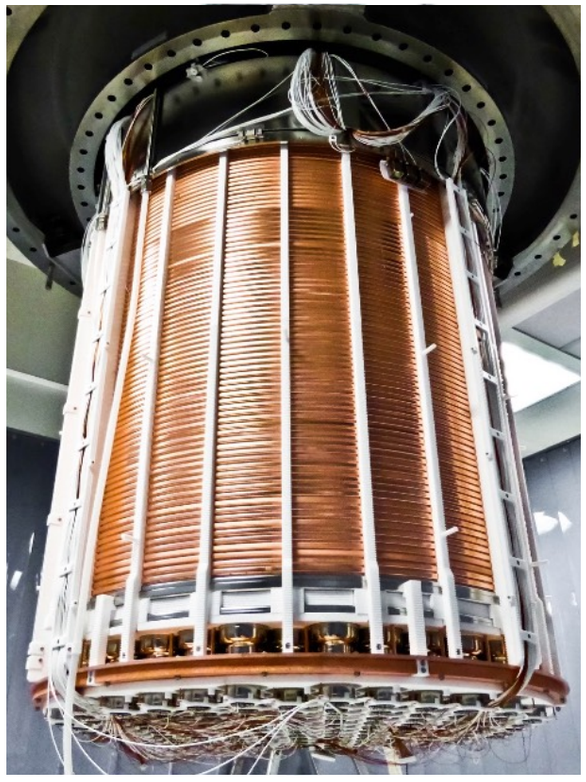
XENON10

2005-2007
15 cm drift TPC
25 kg
Achieved (2007)
$\sigma_{SI} = 8.8 \times 10^{-44}$ cm^2

XENON100

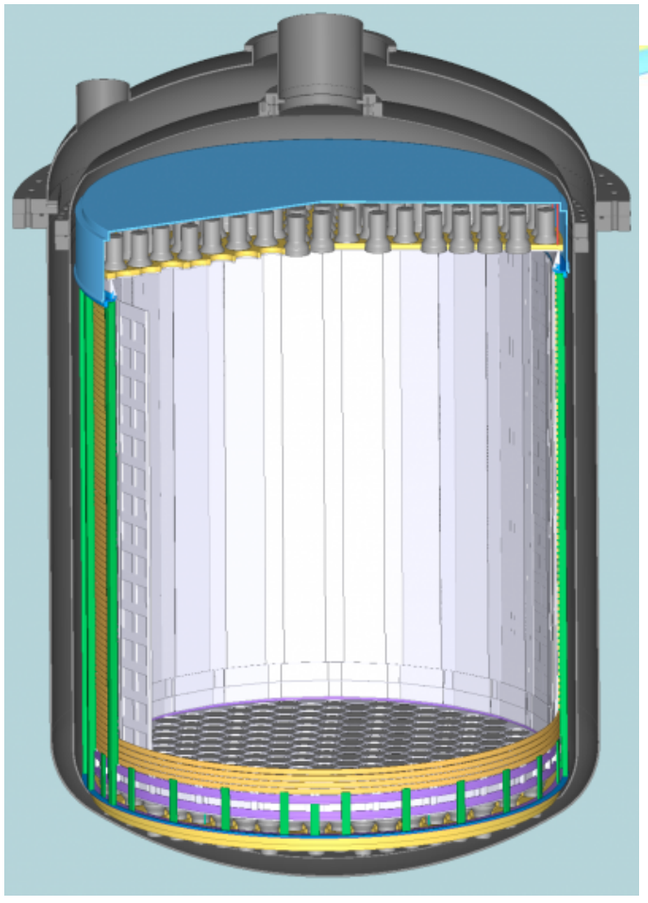
2008-2016
30 cm drift TPC
161 kg
Achieved (2016)
$\sigma_{SI} = 1.1 \times 10^{-45}$ cm^2

XENON1T



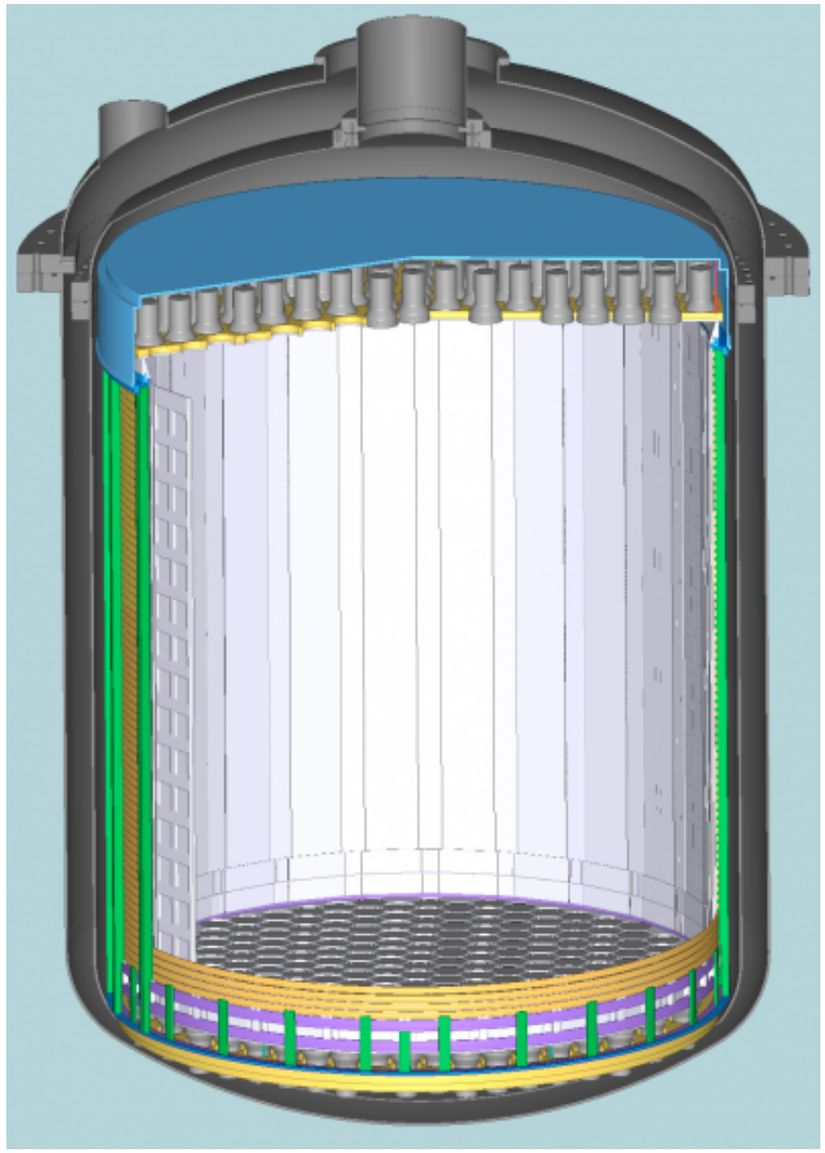
2013-2018
~100 cm drift TPC
3200 kg
Projected (2018)
$\sigma_{SI} = 1.6 \times 10^{-47}$ cm^2

XENONnT
(XENON1T Upgrade)



2019-2025
~144 cm drift TPC
~8000 kg
Projected (2025)
$\sigma_{SI} = 1.6 \times 10^{-48}$ cm^2

The main upgrade: Time Projection Chamber



XENONnT TPC

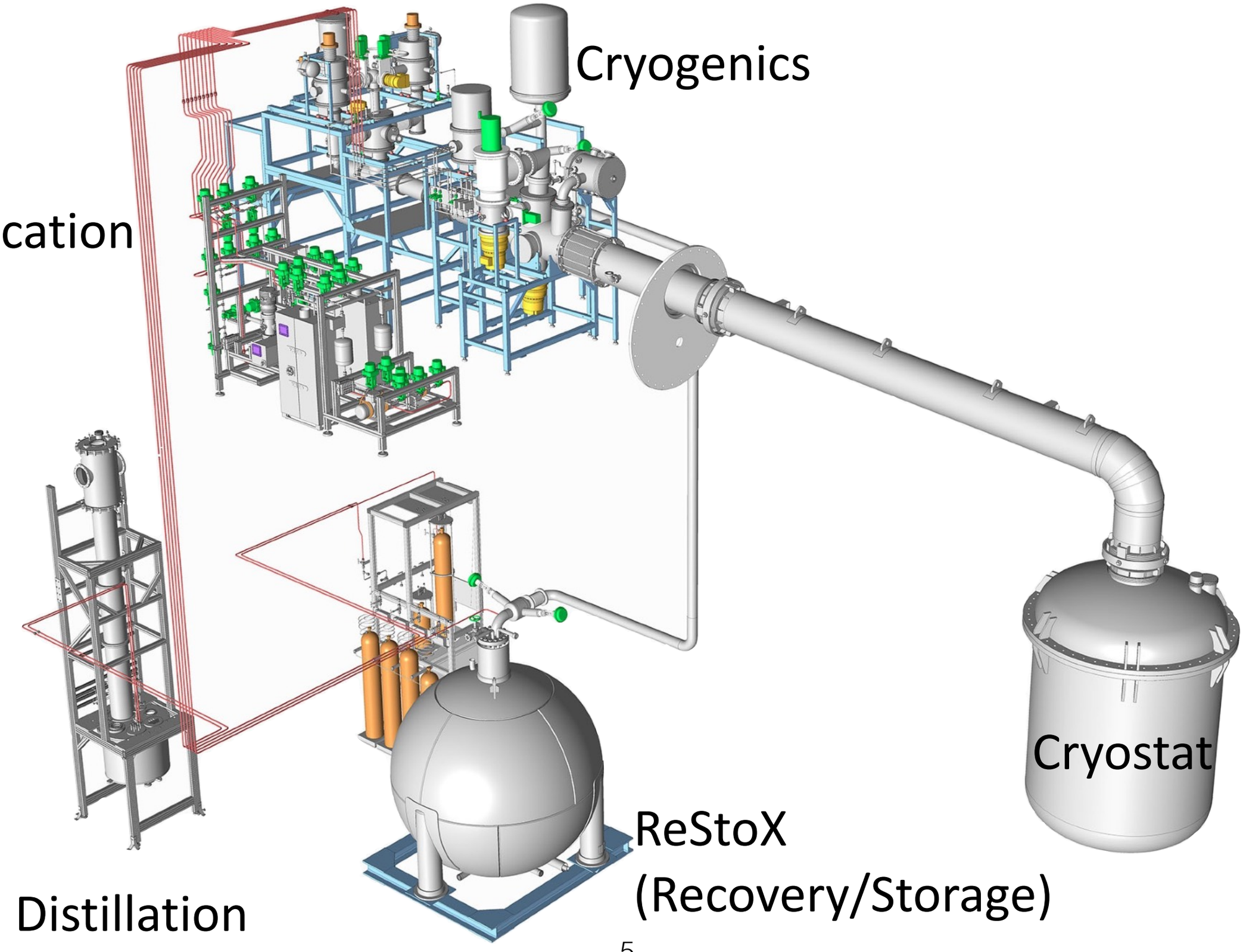
Basic characteristics of XENON1T & nT TPCs

	XENON1T	XENONnT*
Drift (cm)	97	144
Diameter (cm)	96	137
# Top PMTs	127	223
# Bottom PMTs	121	253
Active Mass (tonne)	2.0	6.0
Total Mass (tonne)	3.2	8.0

* baseline design

XENON1T/nT Sub-Systems

Major systems are already in operation for XENONIT

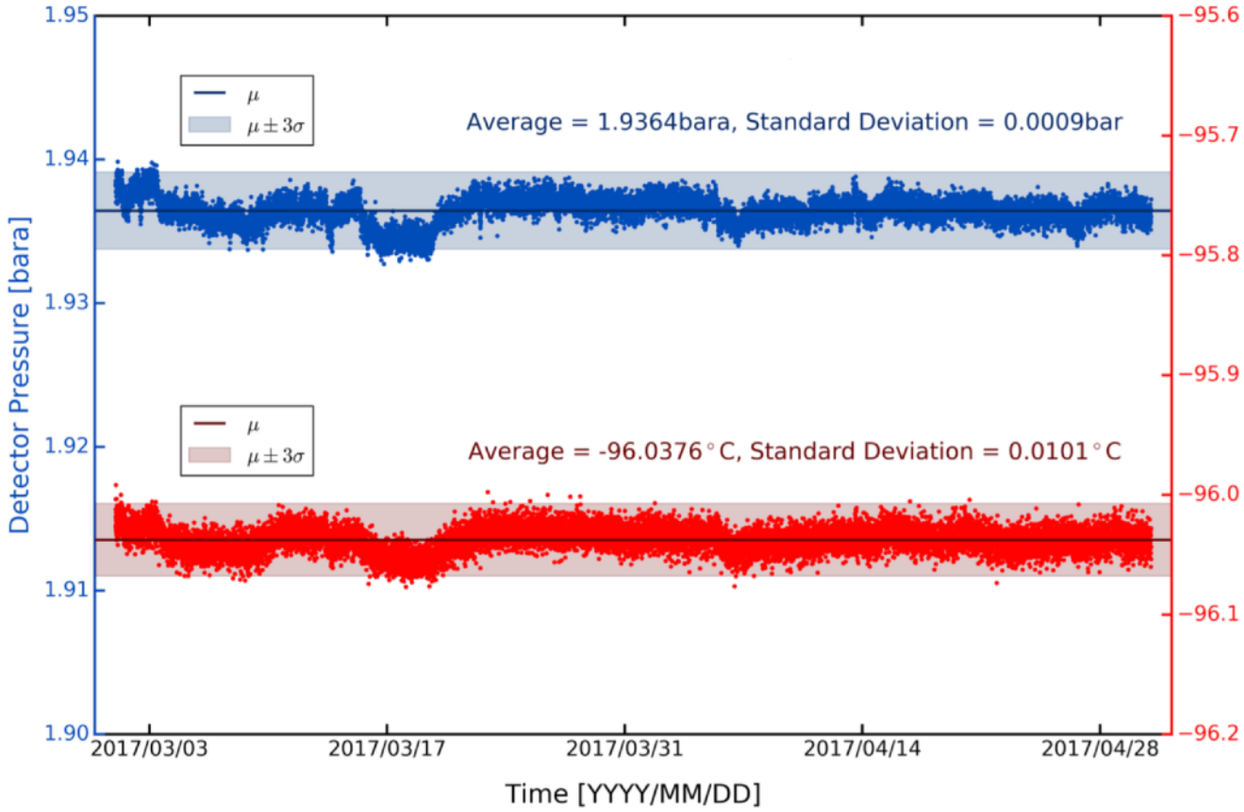


Status of XENONnT Sub-Systems

	XENON1T	status for XENONnT
Muon Veto	operational	ready
Outer cryostat	existing	ready
Cryogenic system	operational	ready
Screening facilities	operational	ready
Distillation column	operational	ready
Calibration system	operational	ready
Slow control	operational	ready
DAQ & electronics	operational	all electronics in hand
Xenon gas	3.2 tonne in use	ready (>8t in hand)
LXe Storage	ReStoX1 operational	ReStoX2 extra safety & storage
PMTs	260 existing	+230 being delivered & tested
TPC & inner cryostat	operational	upgrade design
Purification system	operational	upgrade design
Rn reduction	tested	study on-going
n-veto system	no	study on-going

XENONIT/nT Cryogenic System

Dual PTR+LN2 system for enhanced safety and cooling



Superb performance demonstrated in XENONIT

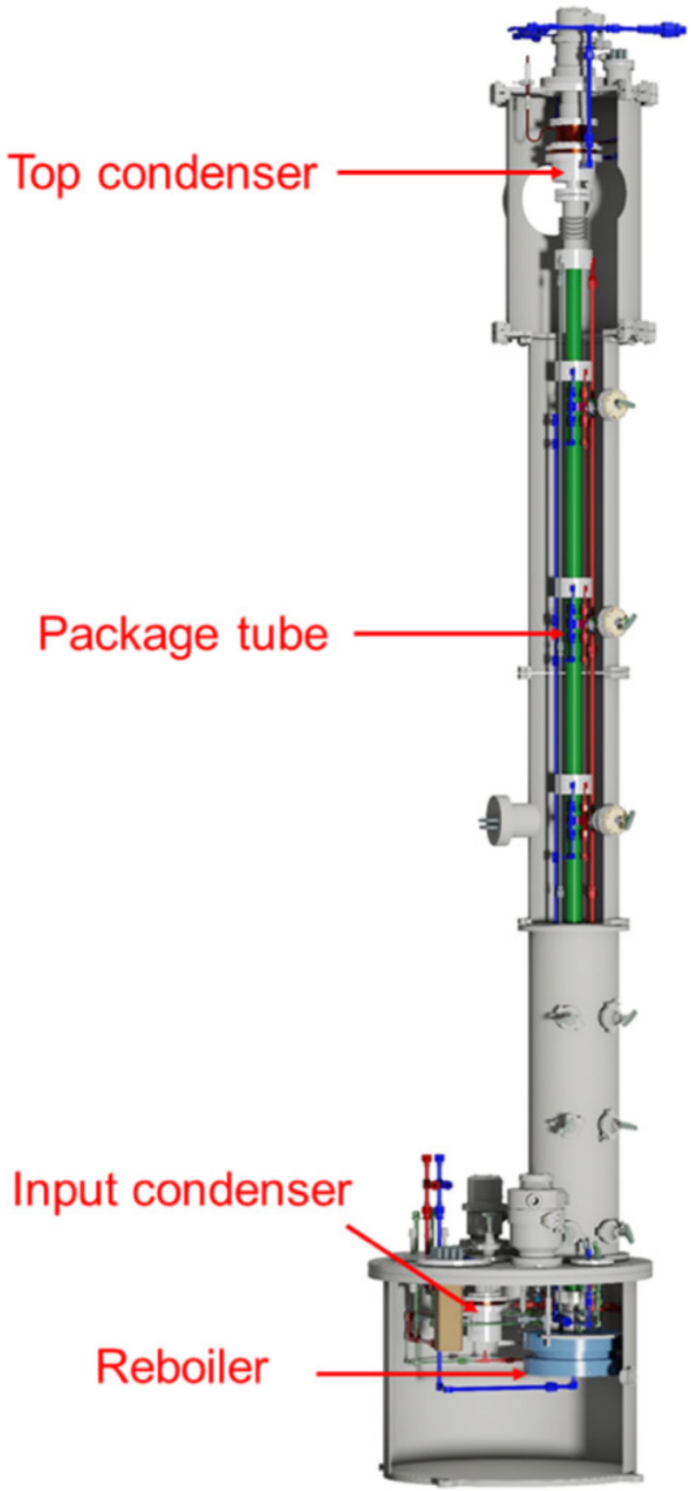
XENONIT heat load

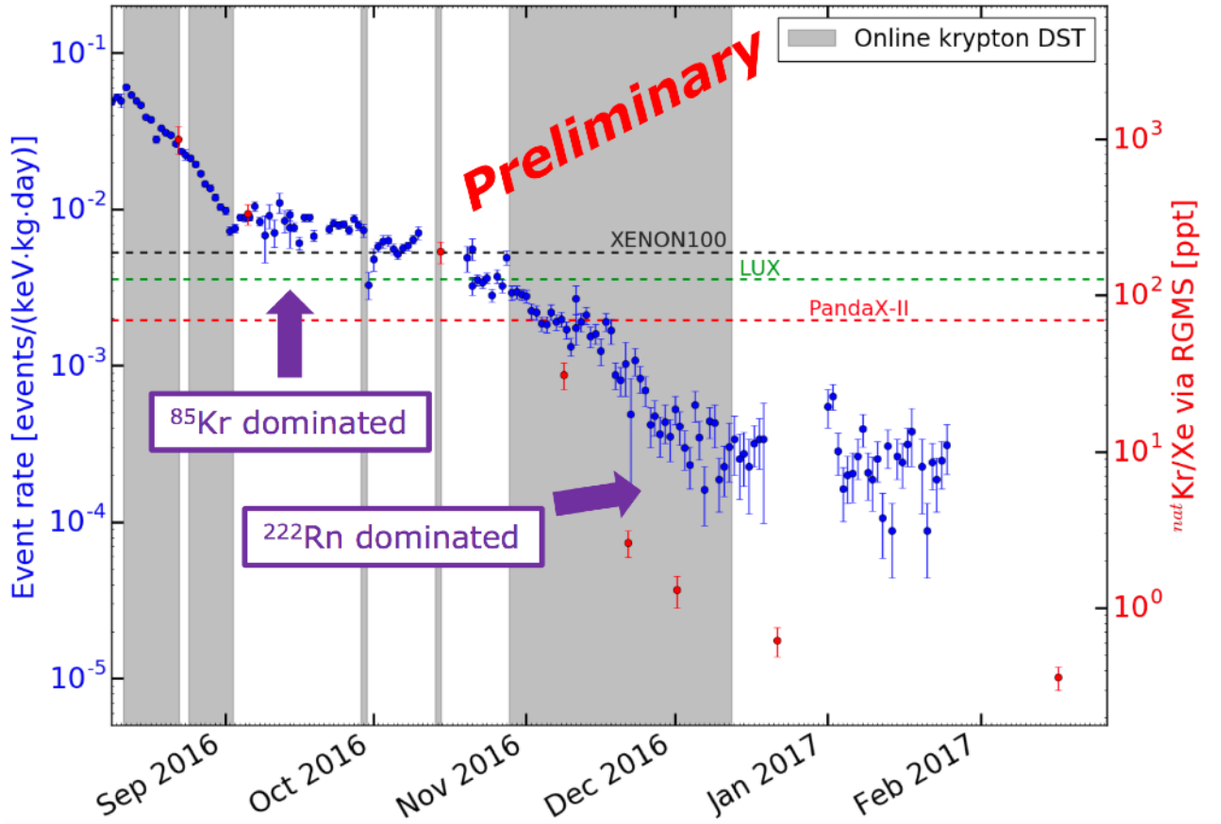
Total heat load (nominal operation)	150 W
Vessel (static)	~75 W
Circulation (@55 slpm)	~40 W
Heat pipe loss (dynamic)	~30 W
PMT arrays	5 W

XENONnT heat load estimate: ~230 W

(increased circulation, etc.)

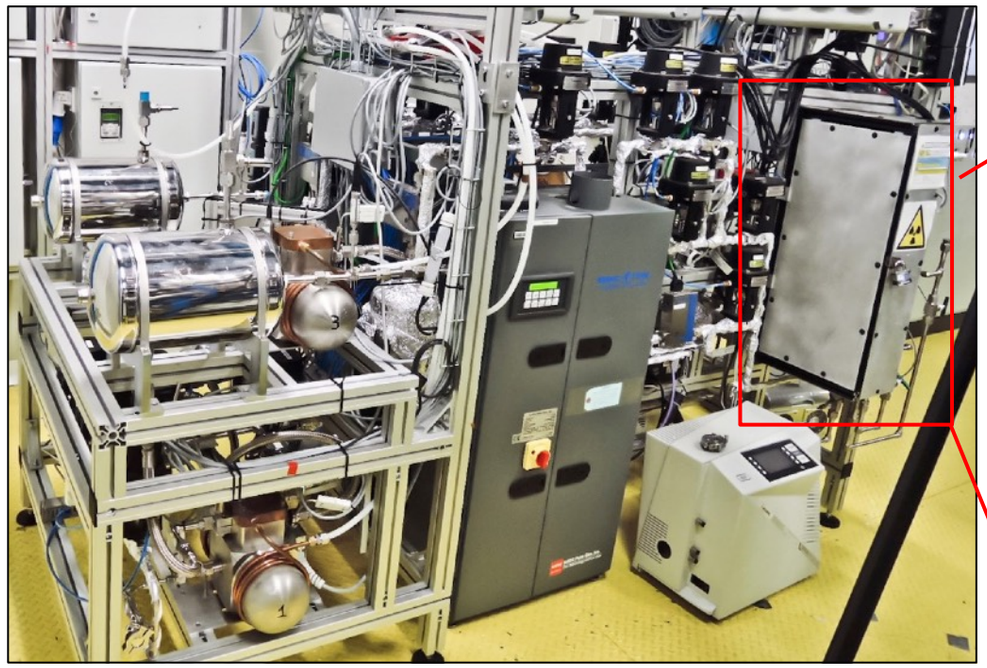
XENONIT/nT Distillation Column





- through-put up to 6.5 kg/hr
- output concentration <0.05 ppt (Eur. Phys. J. C77, 275, 2017)
- sub-ppt Kr/Xe achieved for XENONIT with online distillation (further reduction not needed due to Rn)
- XENONnT goal: 0.02 ppt Kr/Xe

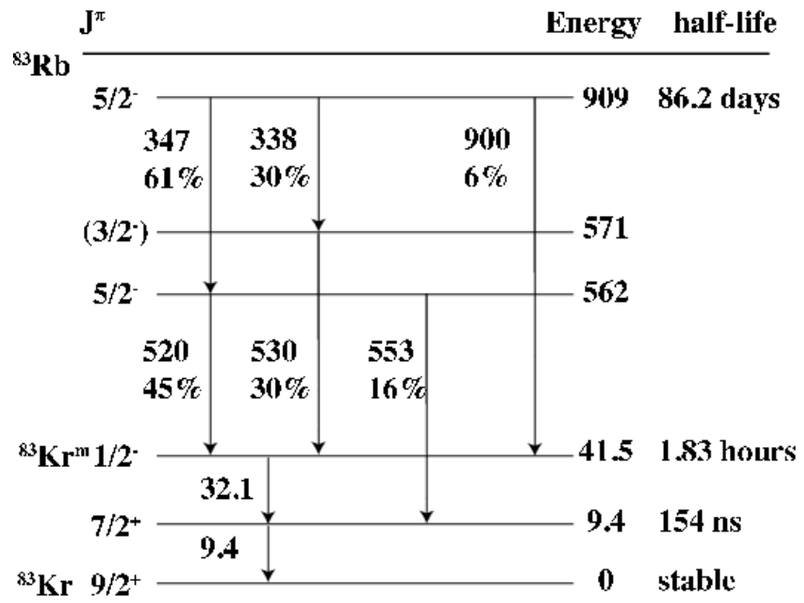
XENONIT/nT Calibration System



AmBe neutrons

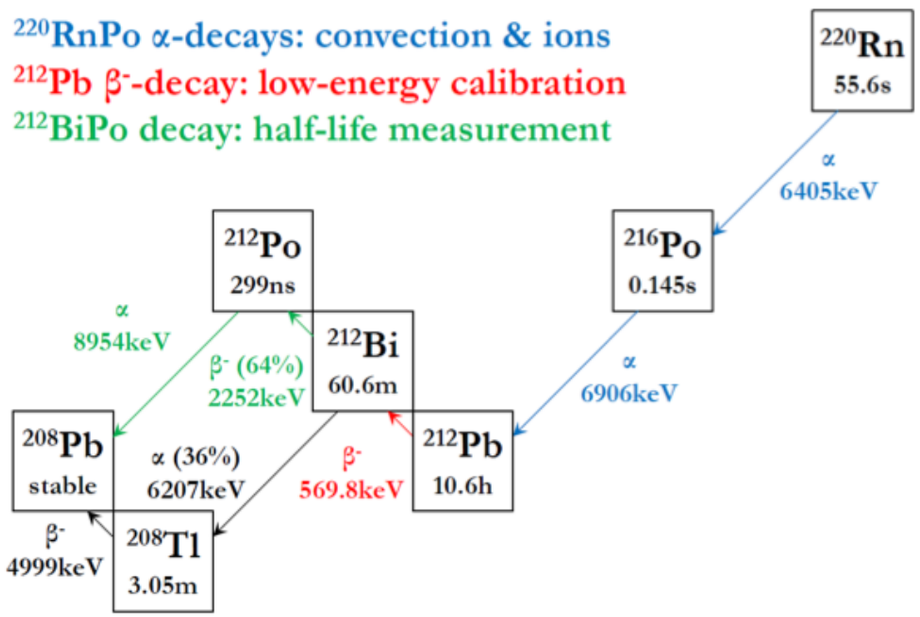
use neutrons to calibrate the dark matter signals

^{83m}Kr: to calibrate the energy response



(sorry, tritium is forbidden for good reasons)

^{220}Rn: to calibrate the dominant background ^{222}Rn

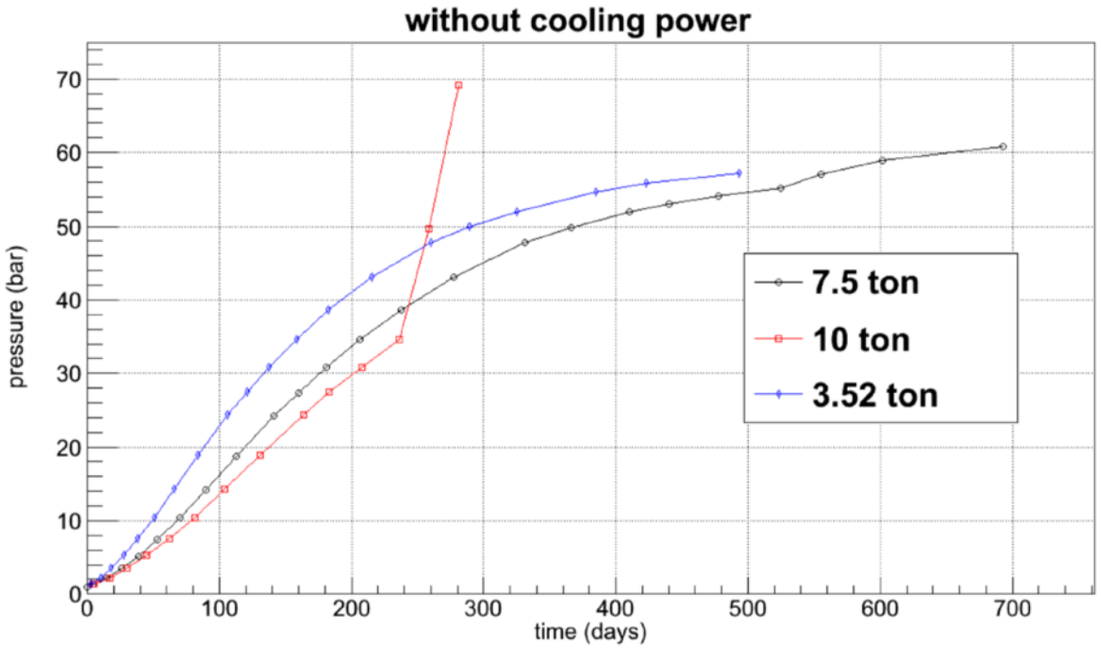


Other sources being investigated (the more, the merrier😊)

XENON1T/nT Gas Storage and Recovery

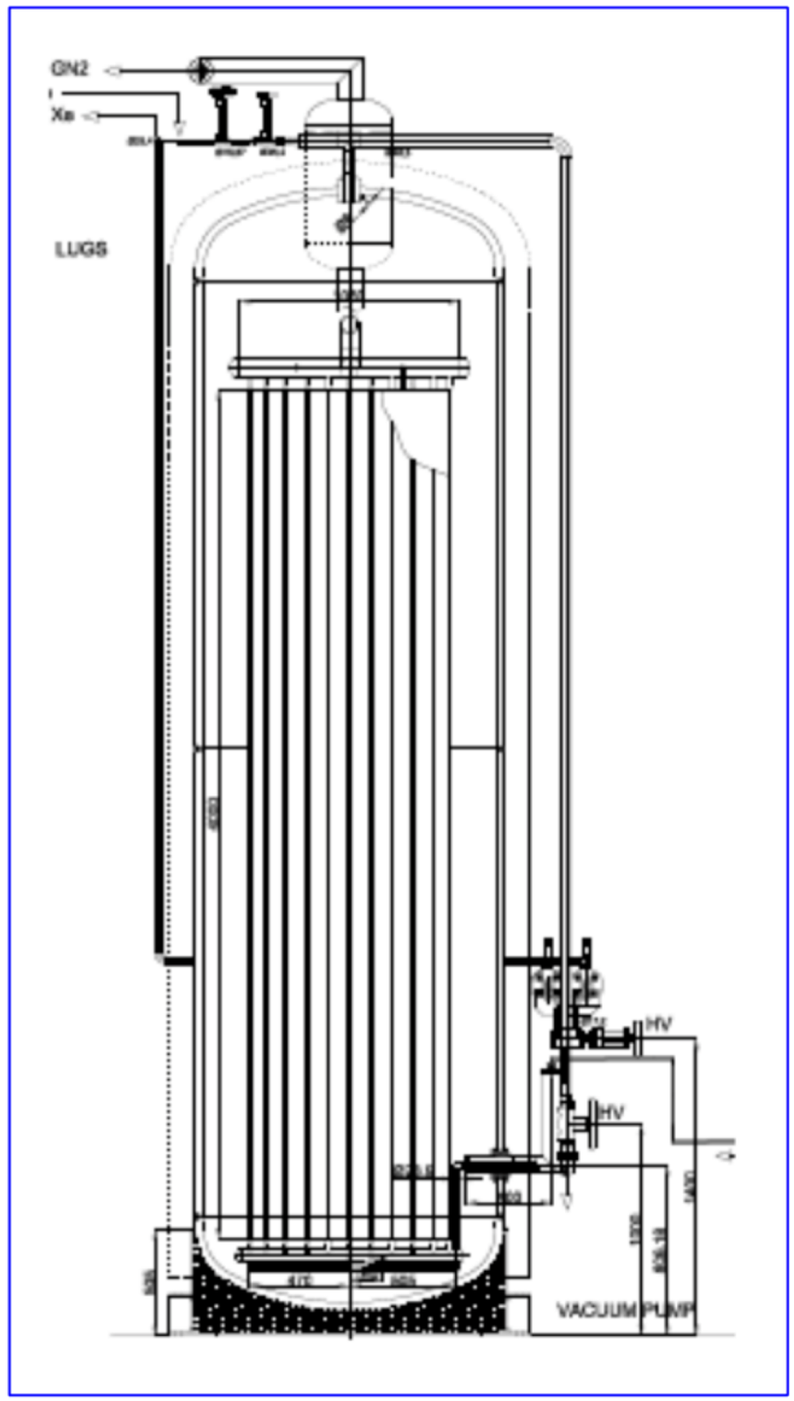
ReStoX1 (operational for 1T)

- safe for filling & recovery <7.5 tons;
- ok for primary storage >7.5 tons

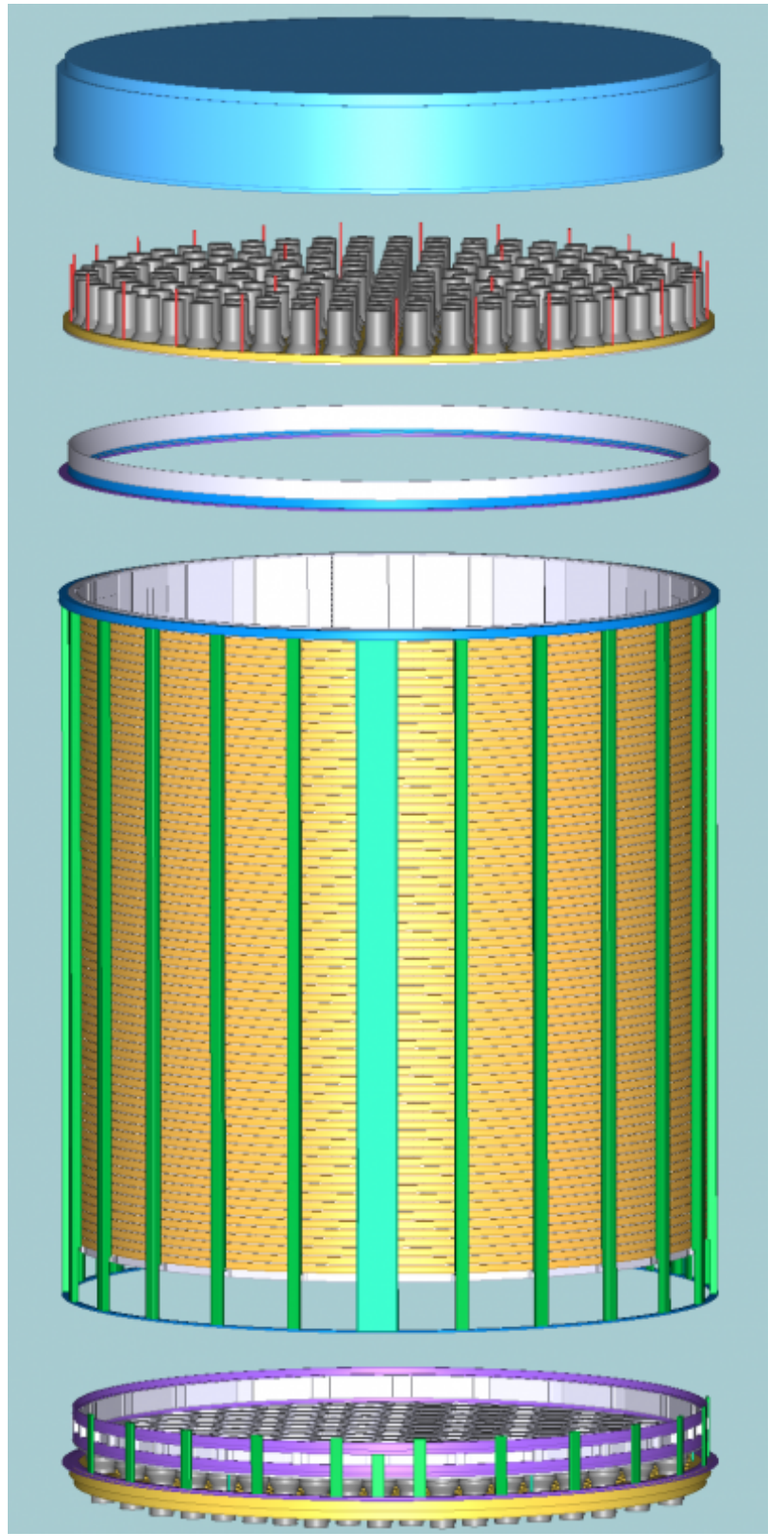


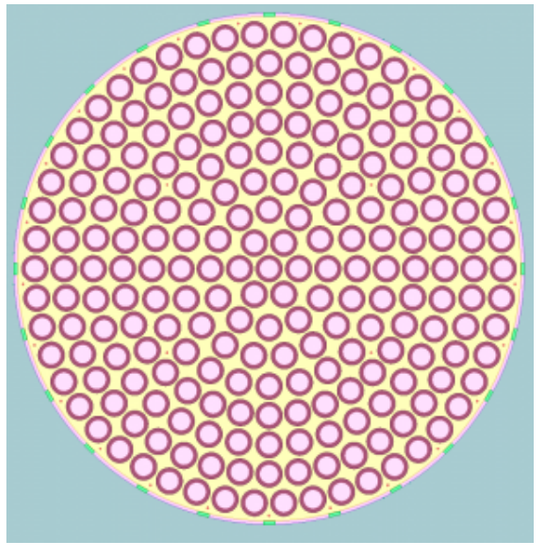
ReStoX2 (to be added for nT)

- storage capacity: 10 tons
- recovery solution for emergency events

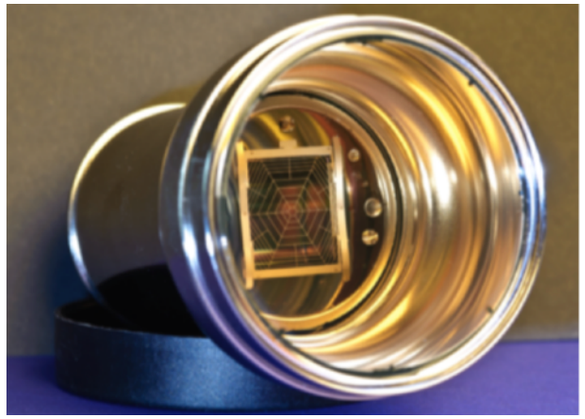


XENONnT TPC & PMTs





223 Top PMTs (radial distrib*)



Hamamatsu R11410-21

high QE: 35% at 175 nm

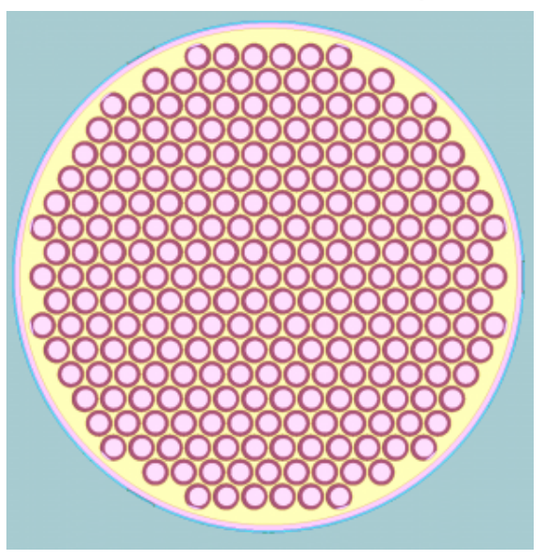
(476 needed, 490 exist/ordered)

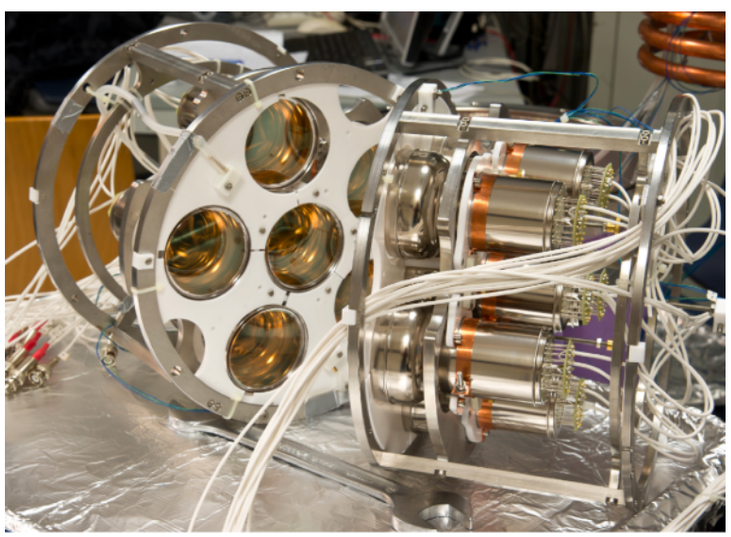
Stability, light emission etc. being tested in LXe at three test facilities & radioactivities screened before installation in XENONnT

Field Cage

Drift field (100 - 500 V/cm)

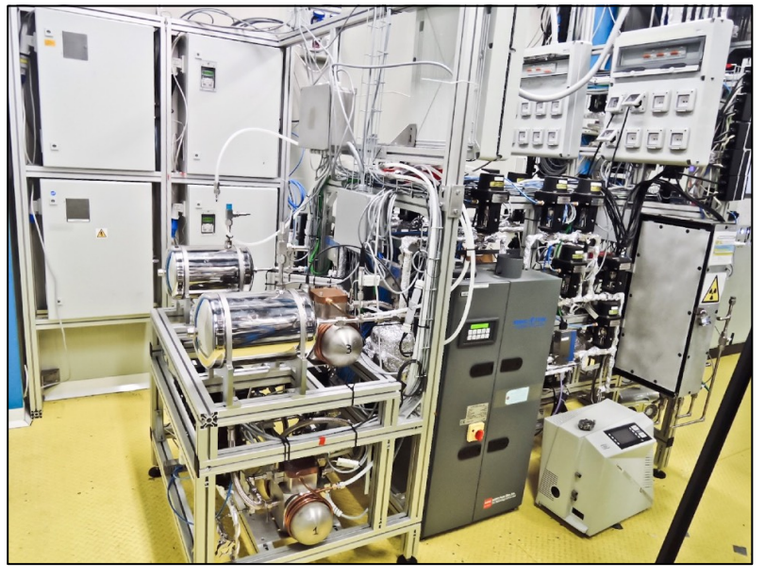
253 Bottom PMTs (max packing)

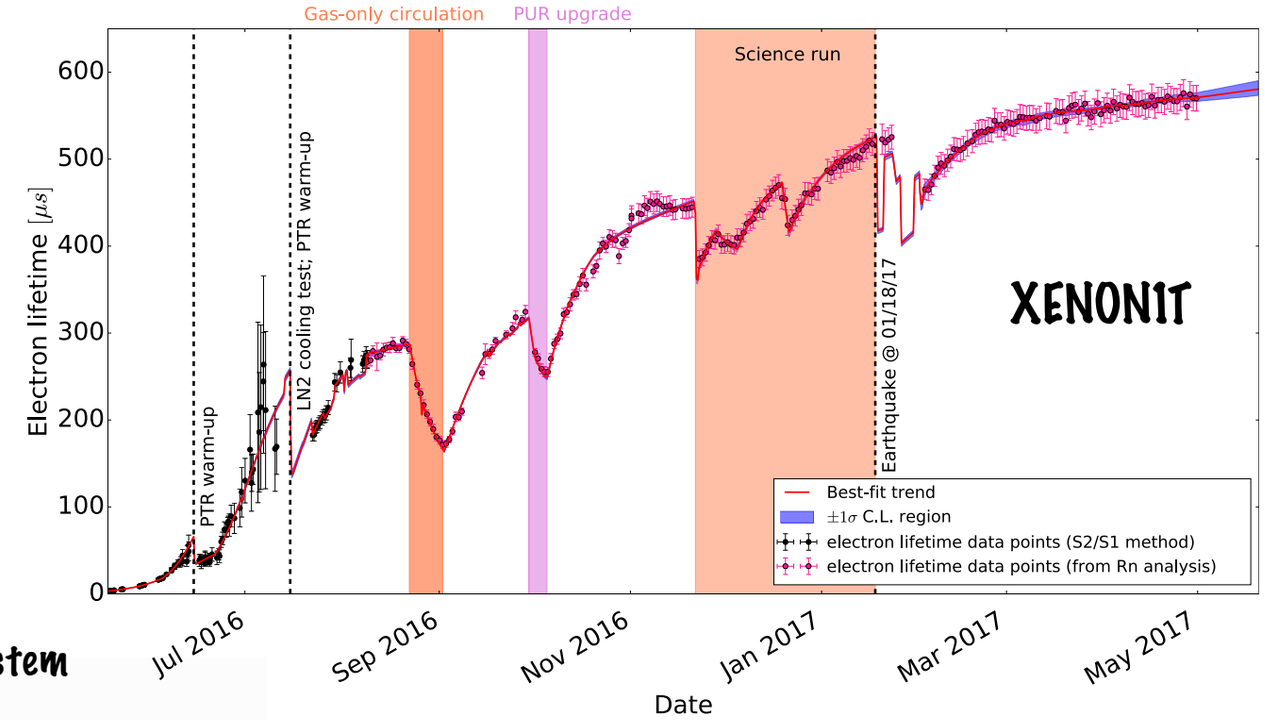


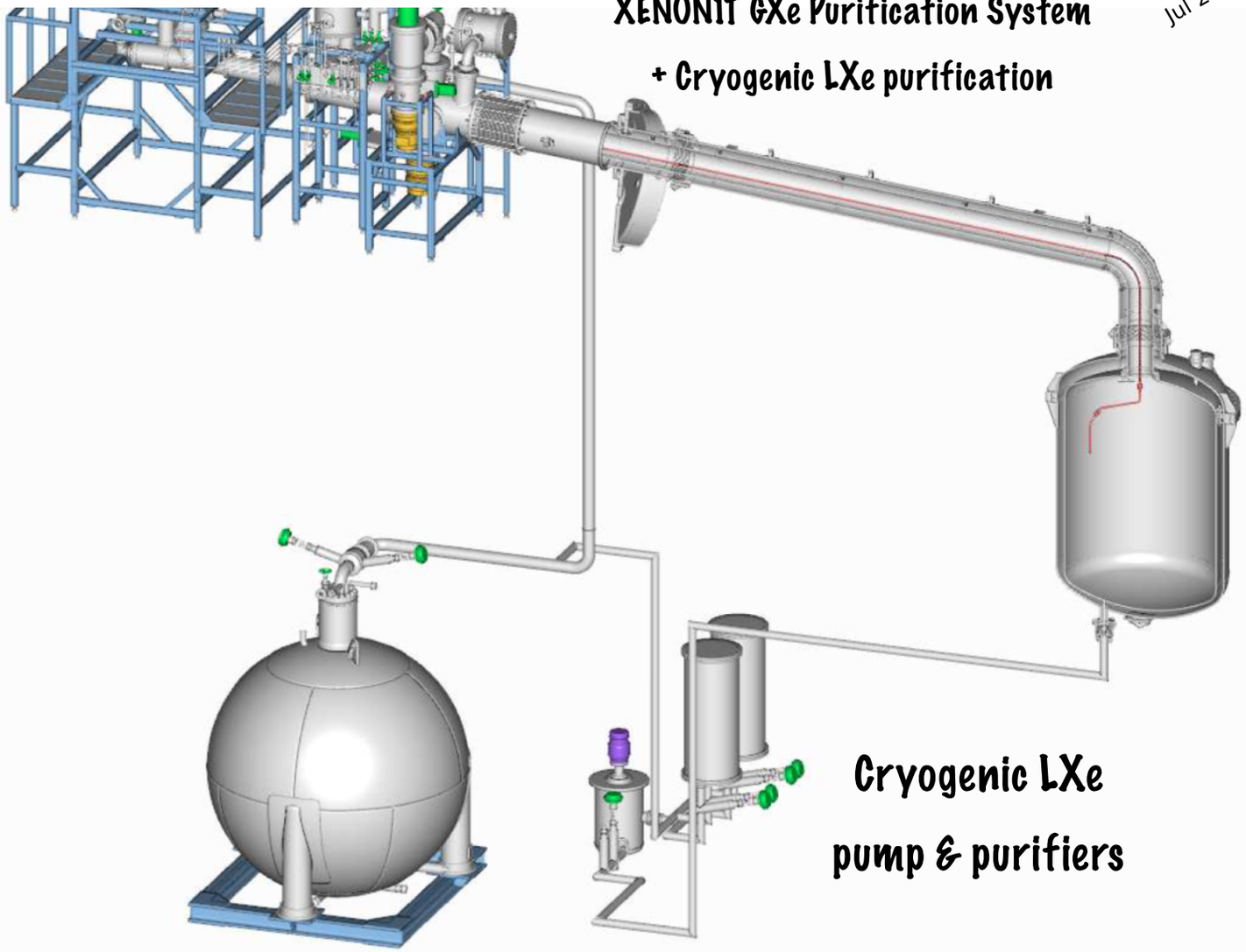


* baseline design

Purification System Upgrade for XENONnT



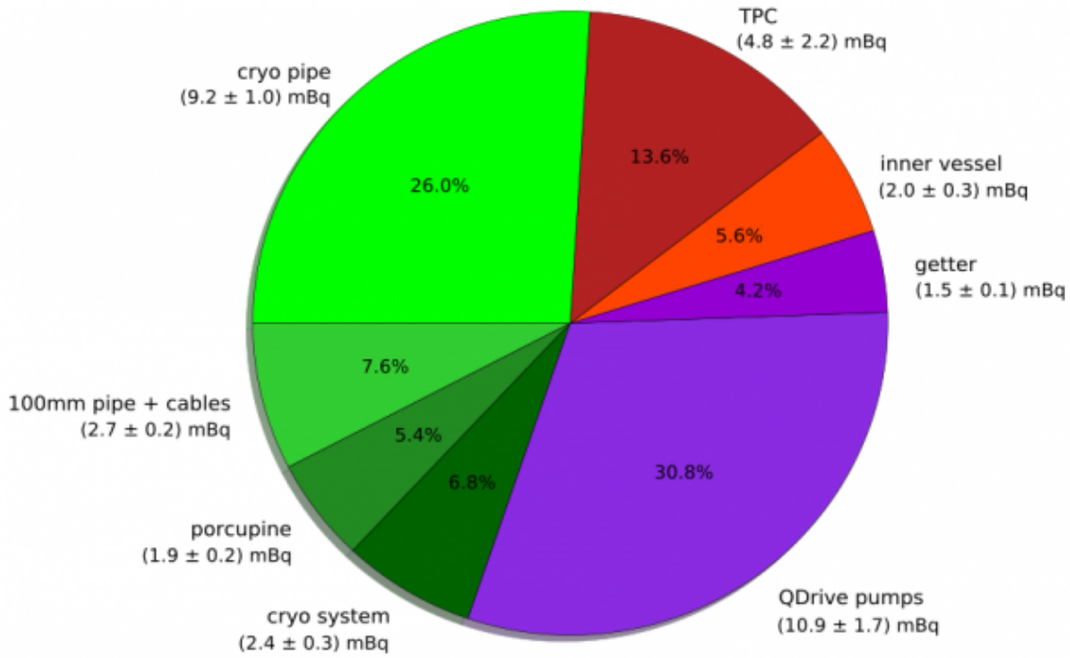




- XENON1T GXe purification:
  - 55 SLPM gas purification
  - >500 μs e- lifetime achieved

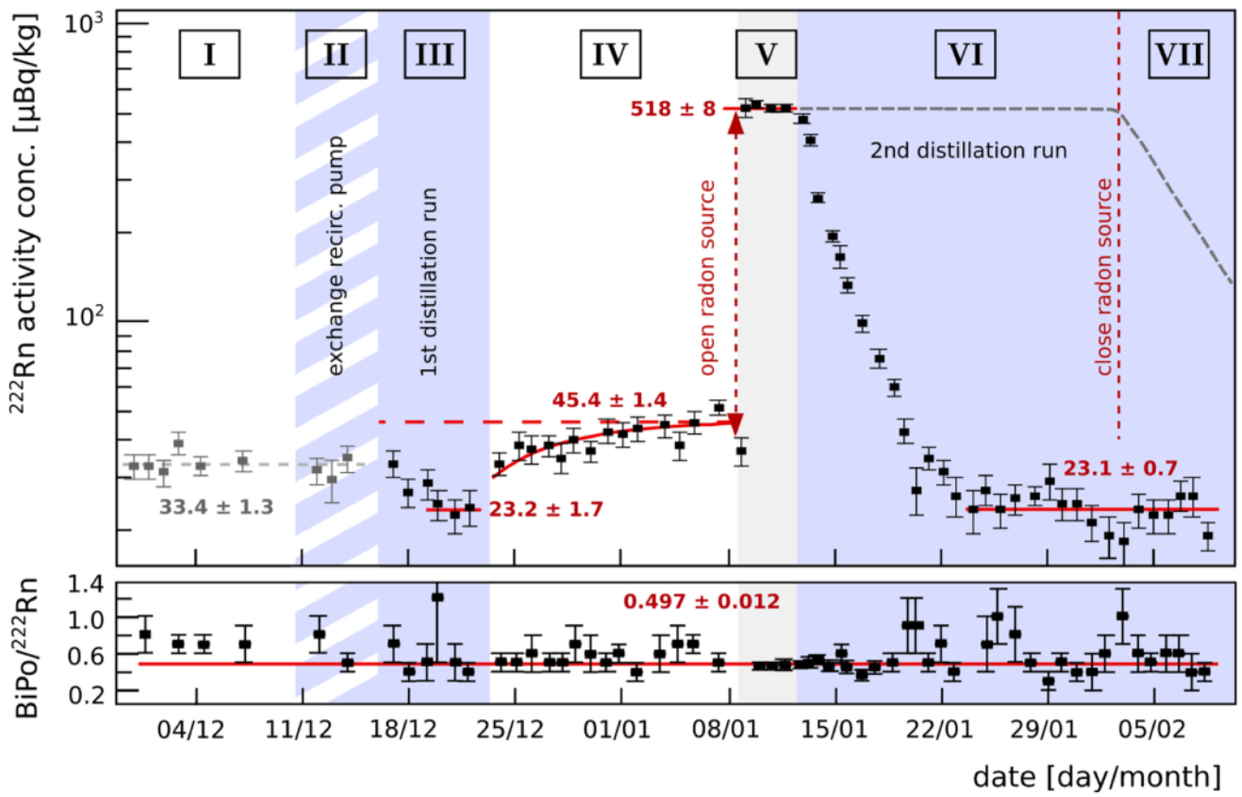
- XENONnT purification: combining GXe and a cryogenic LXe purification system
  - 10 L/min LXe (~5000 SLPM gas)
  - ~5 L/min GXe (from gas phase only)
  - estimates >10 ms e- lifetime within a week
  - system being designed

Radon Reduction for XENONnT



Radon source identified in XENON1T

- Material selection with ^{222}Rn screening
  - screening facilities with few atoms/probe sensitivity
- Replace parts with large Rn contribution
- Post-manufacturing surface treatment
- Reduction with high through-put online distillation
- Goal: 1 µBq/kg



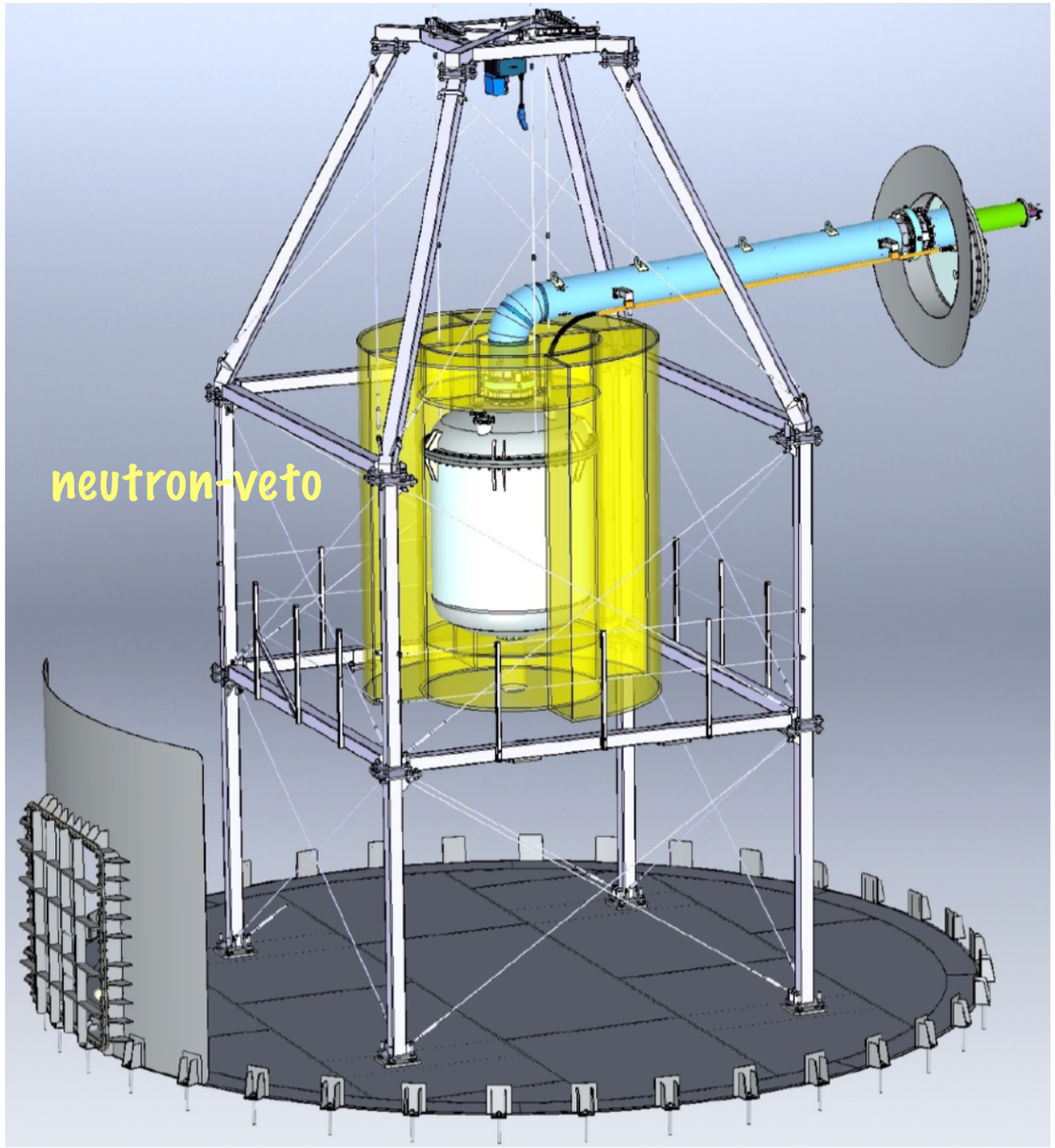
Online Rn removal with distillation in XENON100 (Eur. Phys. J. C, 77:358, 2017)

Rn screening facility @ MPIK

Backgrounds for XENONnT

Estimated Background in RoI for XENONnT

Events/4-ton/year	ER*	NR
^{222}Rn (1μBq/kg)	248	-
^{85}Kr (0.02 ppt Kr/Xe)	12	-
^{136}Xe (nat. abund.)	36	-
solar neutrinos electron scattering	144	-
CNNS (mainly ^{8}B)		2.4*
rad. neutrons (no veto)		1.1
rad. neutrons (w/ veto)		<0.3**
99.75% ER rejection with 40% NR acceptance	~1	~1



* scaled from the uniform backgrounds in XENON1T, JCAP 04 (2016) 027

** preliminary study

Great discovery potential for WIMPs in the coming years