# The DarkSide Experiment

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# DarkSide Collaboration

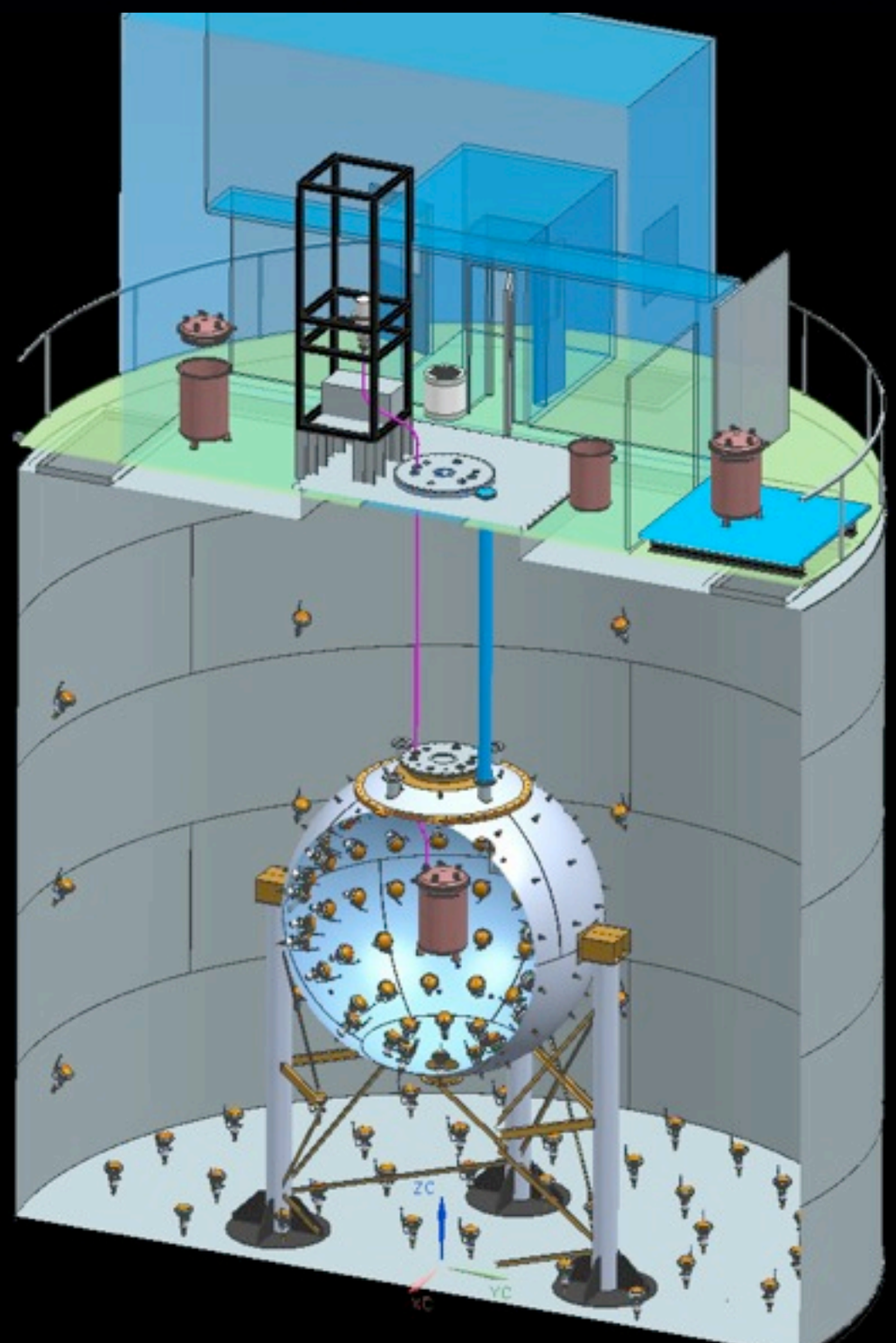
Augustana College, USA
APC Paris, France
Black Hills State University, USA
BNL, USA
FNAL, USA
IHEP, China
LNGS, Italy
INFN and Università Genova, Italy
INFN and Università Milano, Italy
INFN and Università Napoli, Italy
INFN and Università Perugia, Italy
INFN and Università Roma 3, Italy
INR, Ukraine
IPHC Strasbourg, France
Jagiellonian University, Poland
JINR, Russia
LLNL, USA

Lomonosov MSU, Russia
LANL, USA
PNNL, USA
Princeton University, USA
RRC Kurchatov Institute, Russia
SLAC, USA
St. Petersburg NPI, Russia
Temple University, USA
University of Arkansas, USA
UCD, USA
UCLA, USA
The University of Chicago, USA
University of Hawaii, USA
University of Houston, USA
UMass Amherst, USA
Virginia Tech, USA

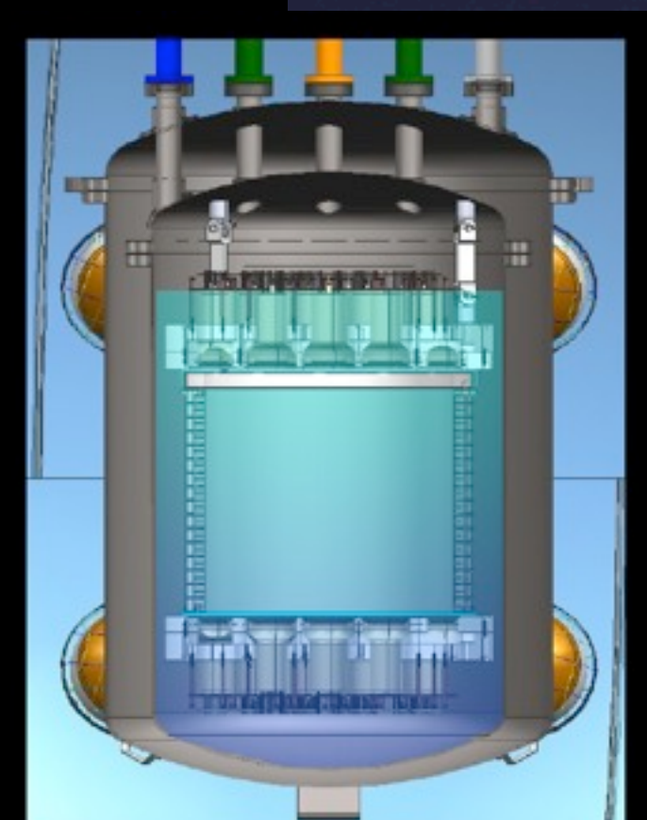
# Outline

- DArkSide 50 description
- Techniques used to reach low background
- Status
- Future plan

# DarkSide 50



- TPC: 50 kg Argon as active mass seen by 38 3” PMTs
- Neutron Veto: 30 ton of scintillator seen by 110 8” PMTs
- Muon Veto: 1000 ton of water seen by 80 8” PMTs

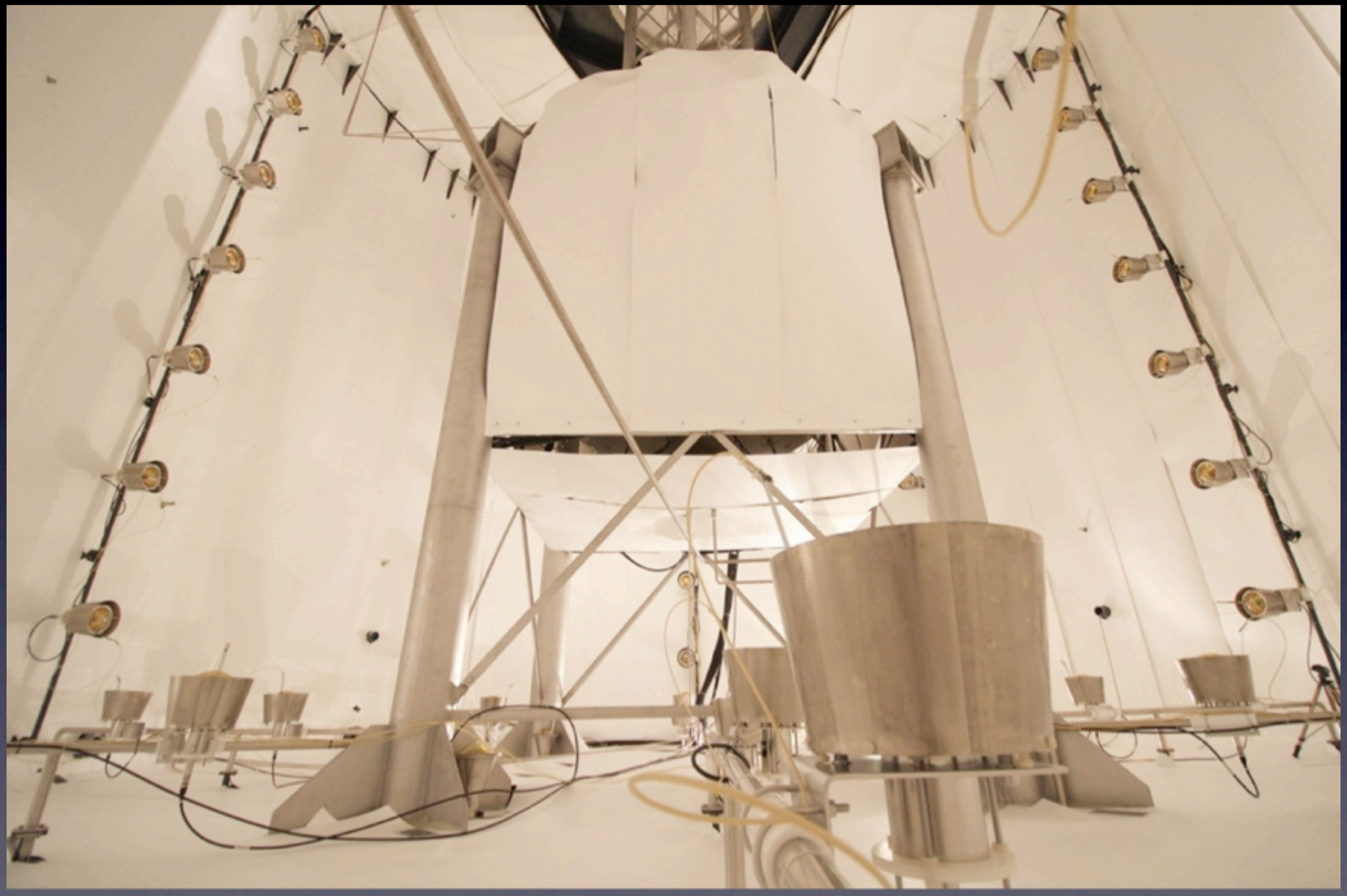


# DarkSide 50

Neutron veto

TPC Cryostat

# DarkSide 50



Muon veto tank

# Material selection at LNGS

- All material and all components close to the TPC have been screened with a low background Ge detector
- The selection was done on the basis of contamination limits set by Monte Carlo simulations

Low background Lab

# Material selection at LNGS

GeMPI detector

# Material selection at LNGS

# Material selection at LNGS

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sample:          AISI304L, 5 mm (lot 0502467, SA240TP304L), Darkside
                 4 sheets (249 x 249 x 5) mm  each
weight:          9.6966 kg
live time:               696483 s
detector:                GeMPI2

radionuclide concentrations:

Th-232:
Ra-228:          < 1.1 mBq/kg             <==>    < 2.7 E-10 g/g
Th-228:          (0.8 +/- 0.3) mBq/kg             <==>    (1.9 +/-
0.6) E-10 g/g

U-238:
Ra-226           (0.4 +/- 0.2) mBq/kg             <==>    (3.2 +/-
1.6) E-11 g/g
Th-234           < 0.10 Bq/kg             <==>    < 8.3 E-9 g/g
Pa-234m          < 51 mBq/kg              <==>    < 4.2 E-9 g/g

U-235:           < 15 mBq/kg              <==>    < 2.7 E-8 g/g

K-40:            < 2.5 mBq/kg             <==>    < 8.2 E-8 g/g

Cs-137:          < 0.29 mBq/kg

Co-60:           (13.3 +/- 1.0) mBq/kg            @ start of
measurement

Mn-54:           (1.1 +/- 0.3) mBq/kg             @ start of
measurement

Co-58:           < 0.59 mBq/kg            @ start of measurement


Be-7:            < 3.4 mBq/kg             @ start of measurement

upper limits with k=1.645,
uncertainties are given with k=1 (approx. 68% CL);

Ra-228 from Ac-228;
Th-228 from Pb-212 & Bi-212 & Tl-208;
Ra-226 from Pb-214 & Bi-214;
U-235 from U-235 & Ra-226/Pb-214/Bi-214

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sample:          AISI321, 40 mm (lot 7707-2301, #411690, SA240TP321),
Darkside
                 1 sheet (246 x 245 x 42) mm
weight:          19.5778 kg
live time:               435462 s
detector:                GeMPI2

radionuclide concentrations:

Th-232:
Ra-228:          < 2.3 mBq/kg             <==>    < 5.7 E-10 g/g
Th-228:          < 0.87 mBq/kg            <==>    < 2.1 E-10 g/g

U-238:
Ra-226           < 0.51 mBq/kg            <==>    < 4.1 E-11 g/g
Th-234           < 0.22 Bq/kg             <==>    < 1.7 E-8 g/g
Pa-234m          (0.12 +/- 0.04) Bq/kg            <==>    (9 +/- 3)
E-9 g/g

U-235:           < 74 mBq/kg              <==>    < 1.3 E-7 g/g

K-40:            < 1.0 mBq/kg             <==>    < 3.3 E-8 g/g

Cs-137:          < 0.69 mBq/kg

Co-60:           (24.6 +/- 1.9) mBq/kg            @ start of
measurement

Mn-54:           (1.8 +/- 0.4) mBq/kg             @ start of
measurement

Co-58:           (0.6 +/- 0.3) mBq/kg             @ start of
measurement

Be-7:            < 6.4 mBq/kg             @ start of measurement

upper limits with k=1.645,
uncertainties are given with k=1 (approx. 68% CL);

Ra-228 from Ac-228;
Th-228 from Pb-212 & Bi-212 & Tl-208;
Ra-226 from Pb-214 & Bi-214;
U-235 from U-235 & Ra-226/Pb-214/Bi-214

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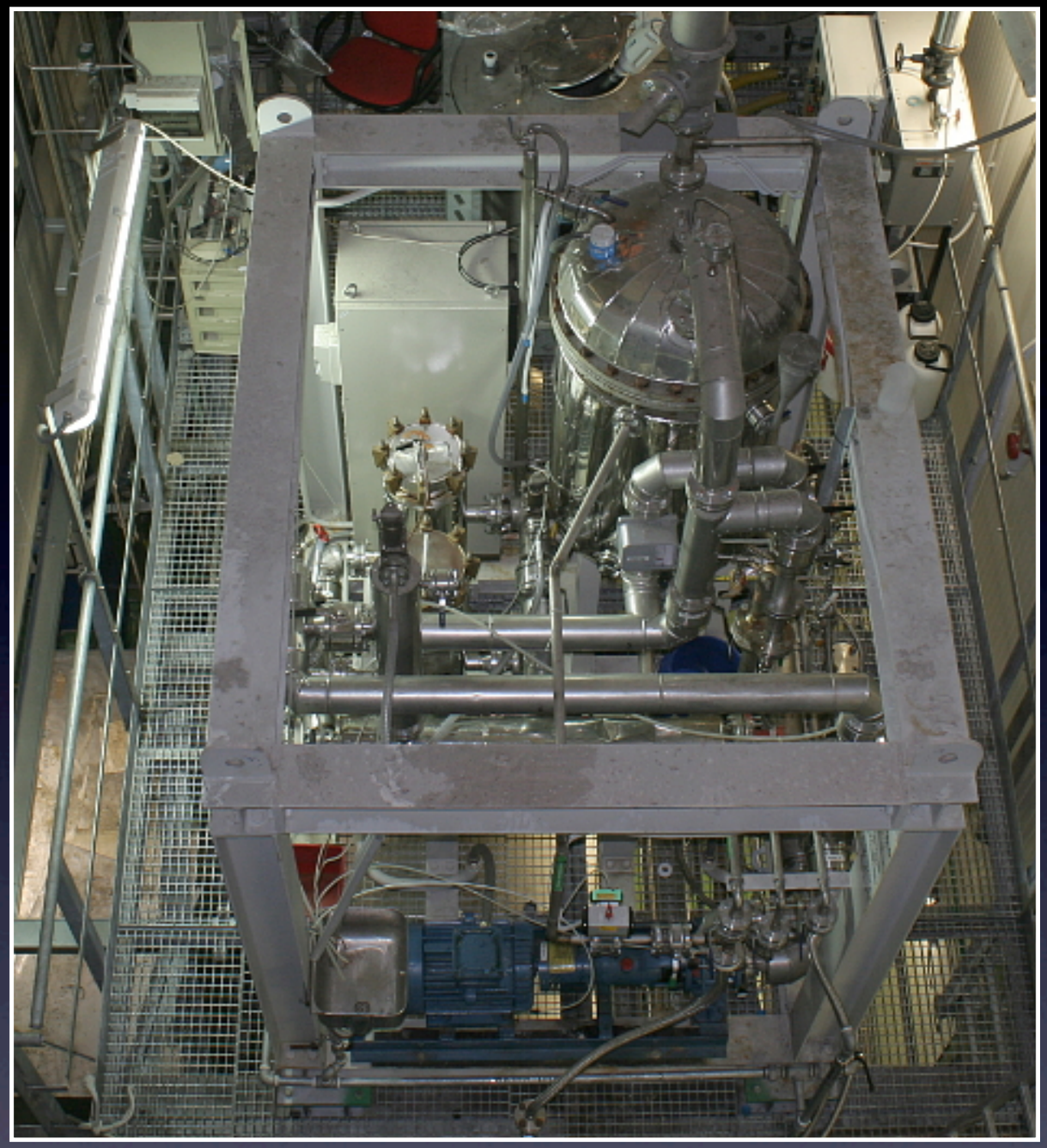
# Cleaning at LNGS

- All components, purification and filling plants have been cleaned with a cleaning module, following procedures developed for Borexino Experiment
- The small parts have been cleaned in a ultrasonic bath in a Radon free Clean Room (CR1)

# Cleaning at LNGS

- Washing: Ultrapure water + 3% Alconox Detergent 8 for 2-4 hours at 80 C
- Pickling: Ultrapure water + 2% glycolic acid + 1% for 3 hours at 80 C
- Passivation: Ultrapure water + 4% citric acid for 4 hours at 70 C
- Chelation: Ultrapure water + 0.1% EDTA for 3 hours at 60 C
- Final rinsing: Ultrapure water  for a final resistivity >17 Mohm/cm
- Particle counting: class better than 20 according to MIL-STD-1246C



Cleaning module

# Cleaning at LNGS

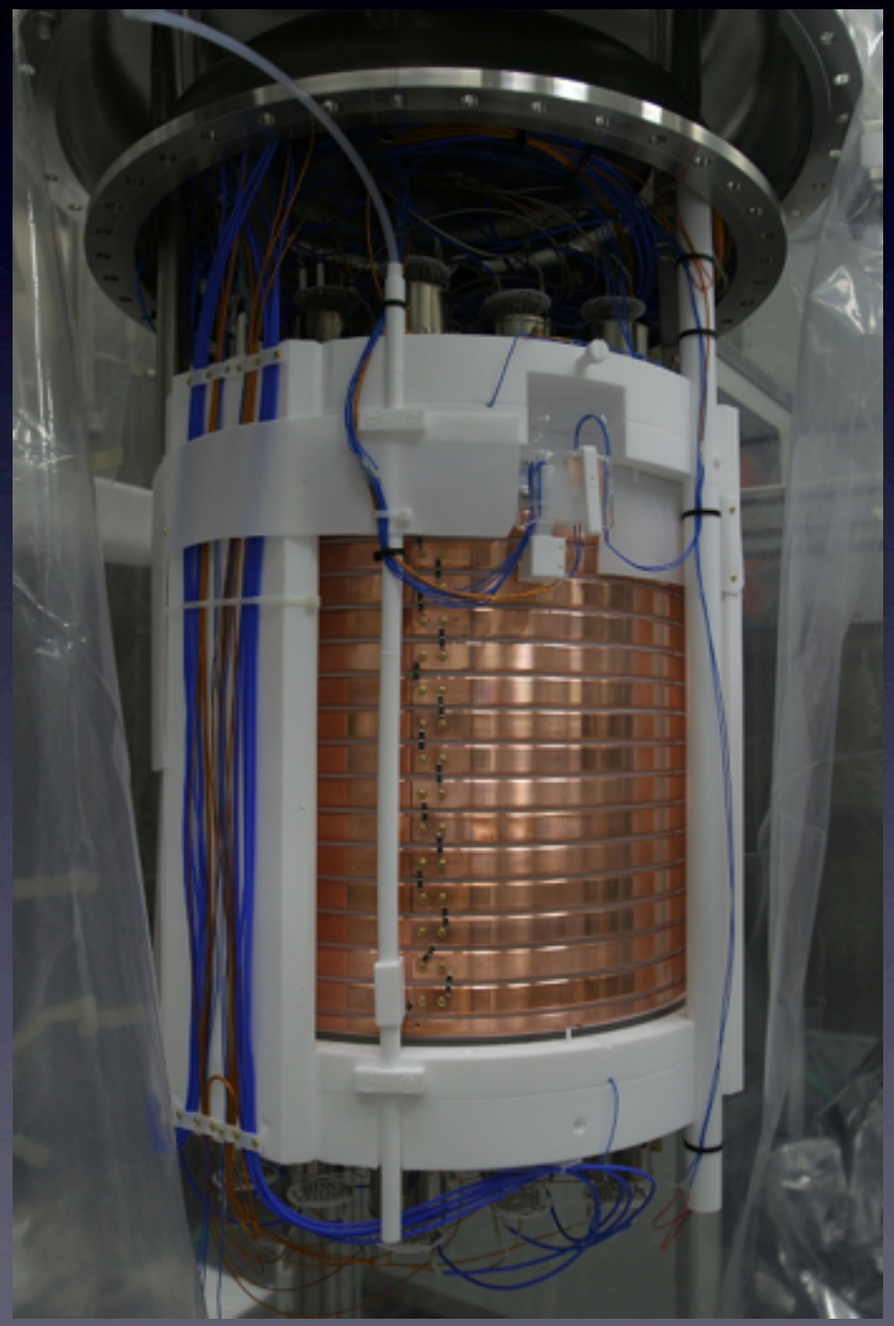
Ultrasonic bath and vacuum oven in CR1

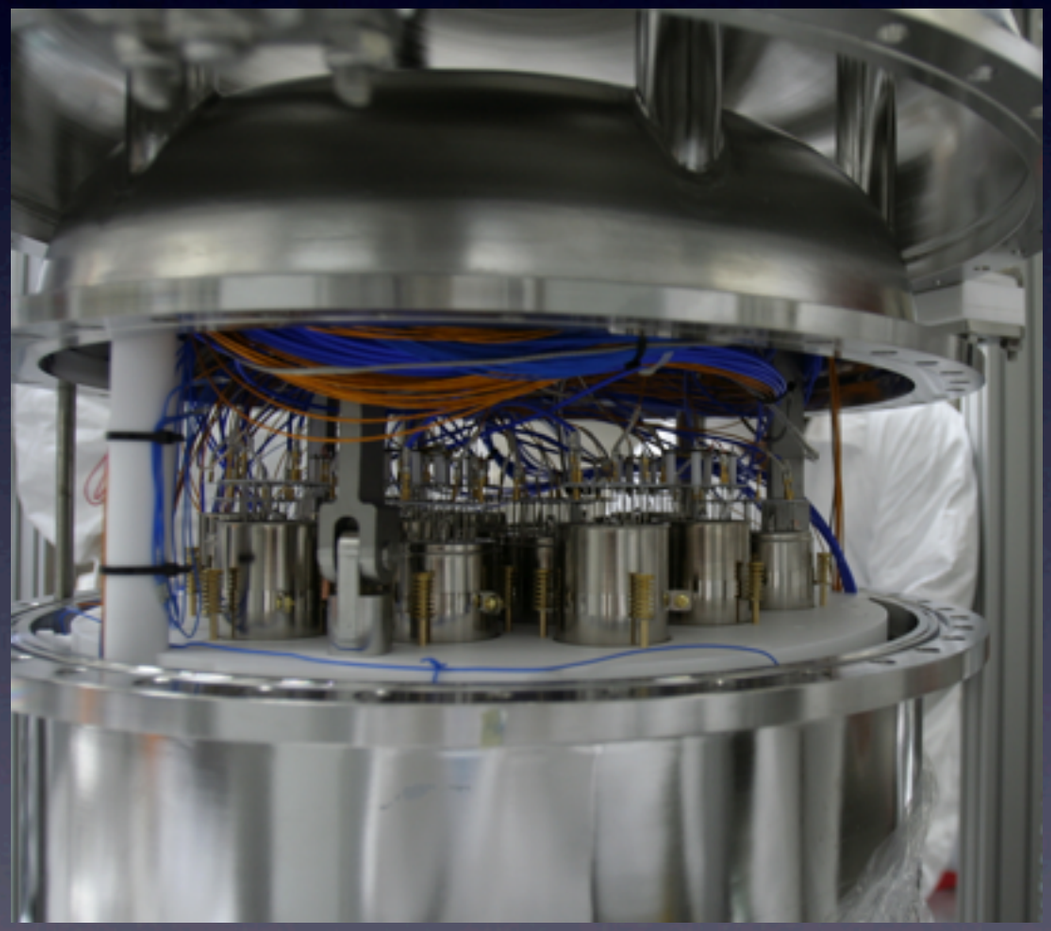
# Cleaning at LNGS

# Assembly in Rn free Clean Room

- The TPC has been assembled in a RN free Clean Room (CRH) in order to reduce the background induced by Rn daughters on the surfaces
- CR1 and CRH are fed by a Rn reduction plant that reduces the RN from 80 Bq/m3 to 1 mBq/m3

# Assembly in Rn free Clean Room

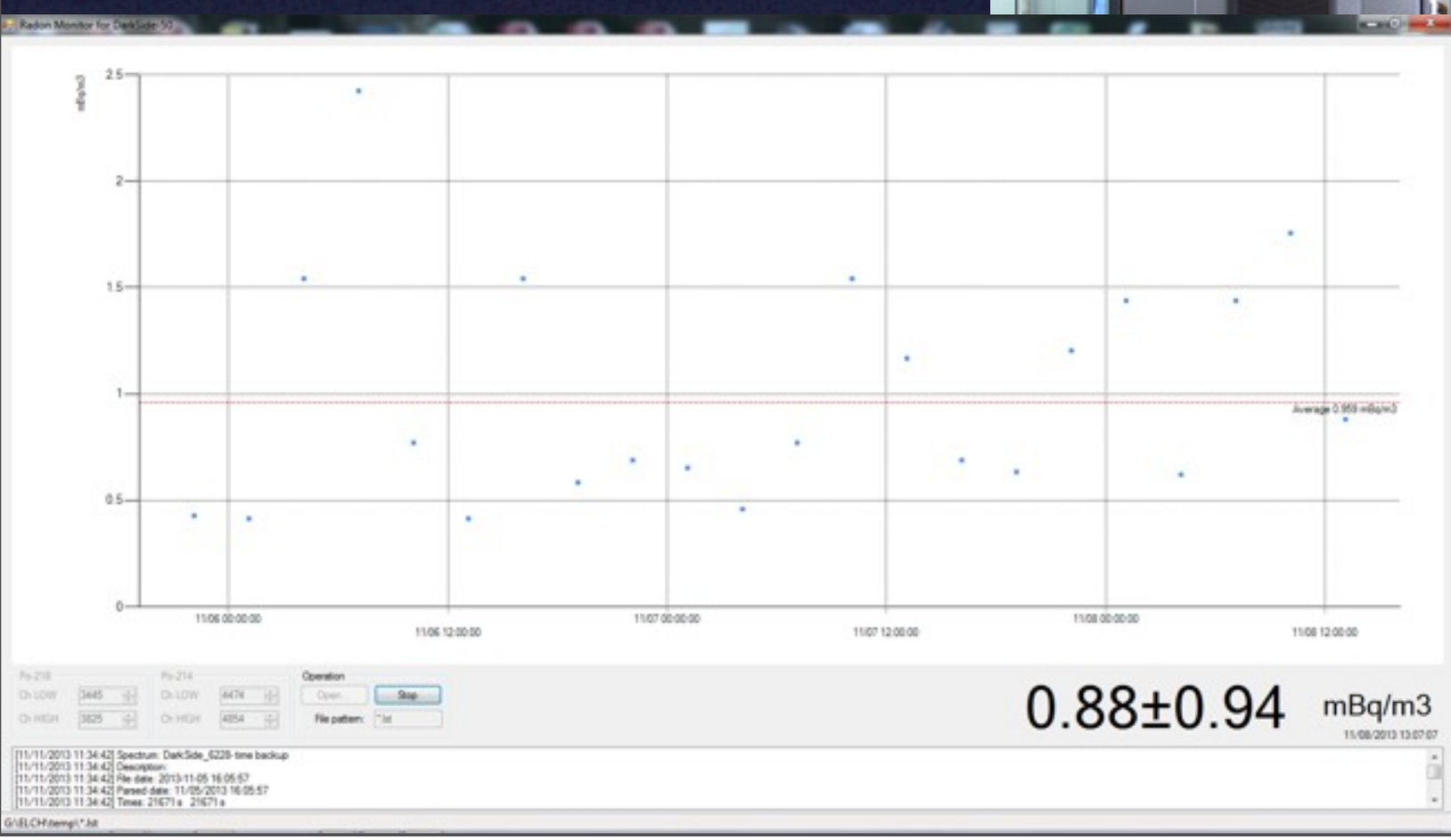




TPC assembly in CRH

# Assembly in Rn free Clean Room

- Flow rate 230 m3/h
- Rn activity 1 mBq/m3



Radon Reduction System

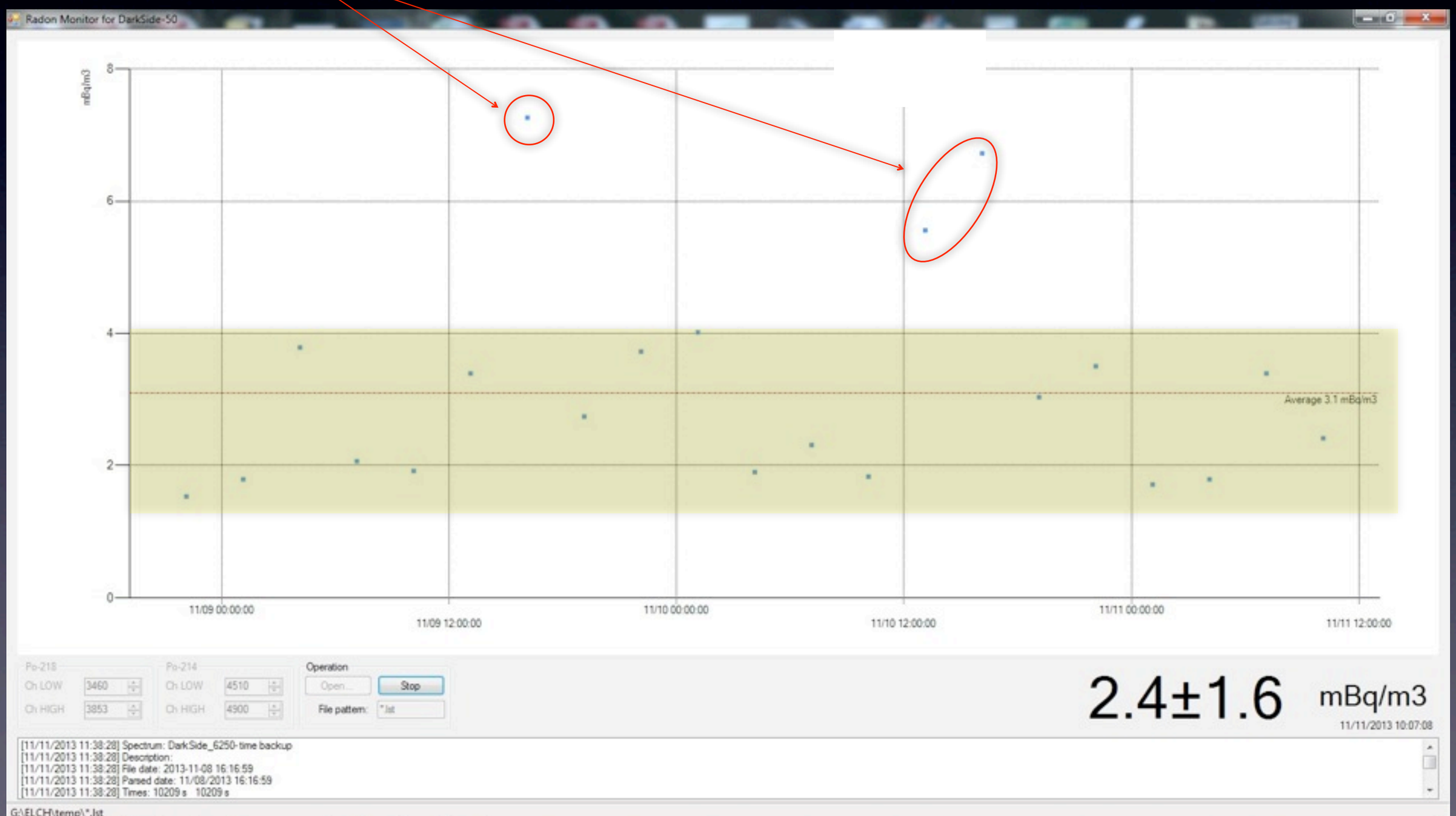
# Assembly in Rn free Clean Room

Internal view of CR1

External view of CRH

# Assembly in Rn free Clean Room

Measured over the weekend (little activity in CRH): 08.11.2013 – 10.11.2013
Average concentration $^{222}Rn \sim 3.5$ mBq/m$^3$ (no activity in CRH)
Visible a short increase to up to ~ 7 mBq/m$^3$ after $LN_2$ refilling (Opened CRH door)



# Low 39Ar

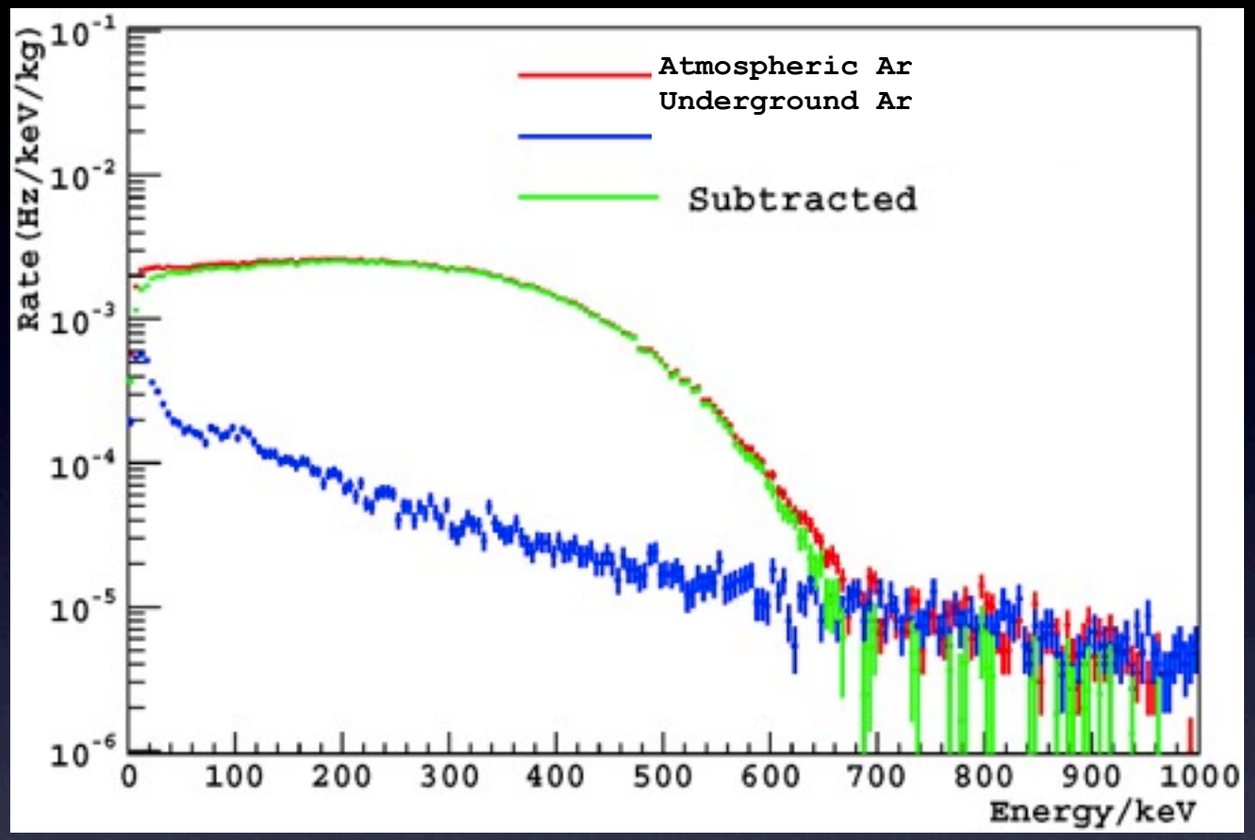
- The internal background would be dominant using atmospheric Argon
- Argon is present in very small fractions in underground CO2 wells
- A plant to extract the 100-500 ppm of Argon in a CO2 stream has been built and operated @ Doe canyon - Colorado (production rate about 0.7 kg/day, final concentration 4-5%)
- A cryogenic distillation plant to obtain pure Argon has been built and operated @ FermiLab

VPSA at Doe Canyon - Colorado

# Low 39Ar

Argon cryogenic distillation plant at FermiLab

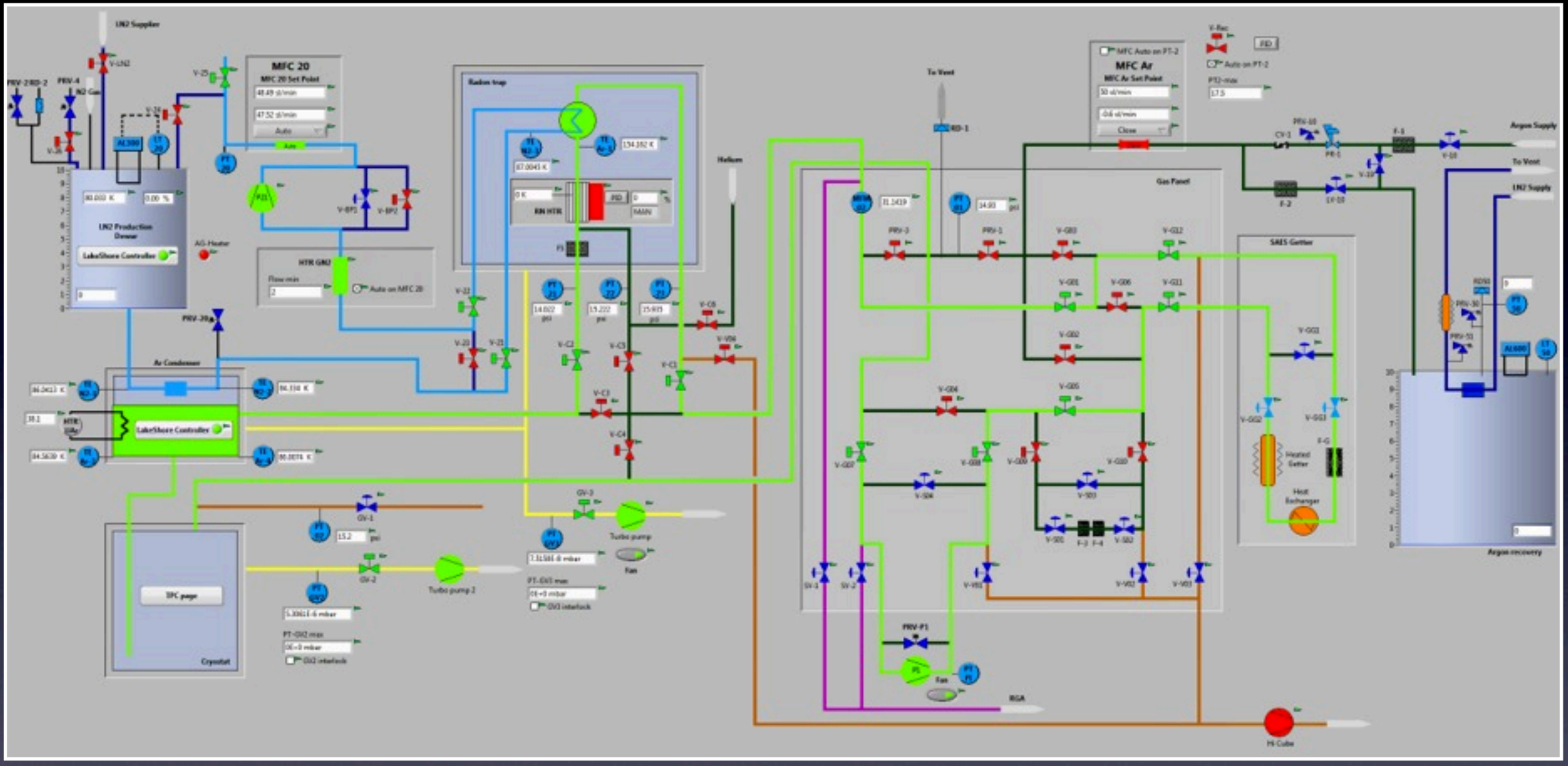
# Low 39Ar




Jingke Xu Ph.D. thesis, 2013

Our measurements give an **upper limit** of 6.5 mBq/kg, a factor of >150 reduction in 39Ar.

# Low 39Ar




# Argon loop purification

# Argon loop purification

Scintillator purification plant

- The scintillator is composed by 50% pseudocumene 50% trimethyl borate + 2.5 g/l PPO
- During the neutron veto filling, all the scintillator has been distilled and nitrogen stripped

# Scintillator purification

# High purity water

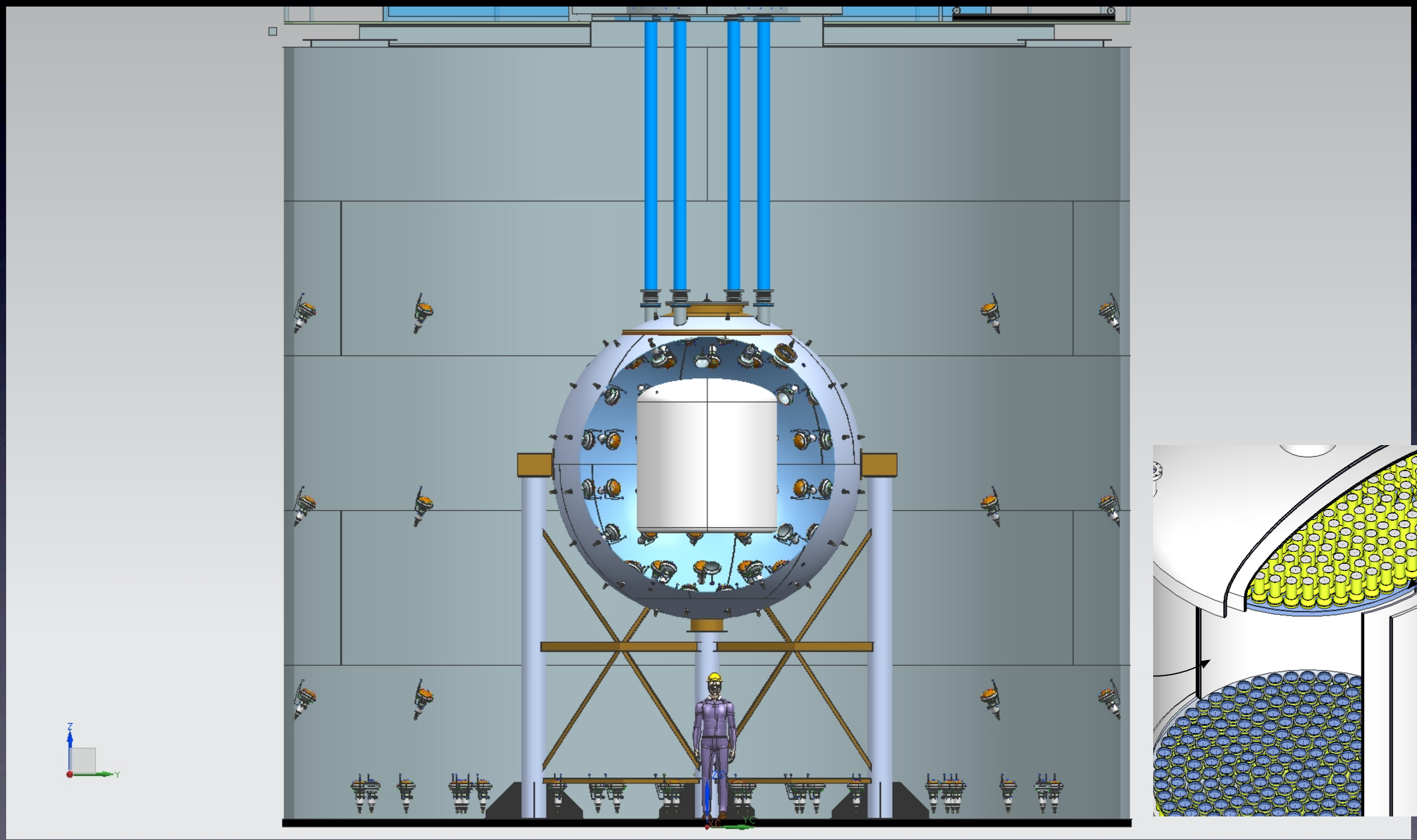
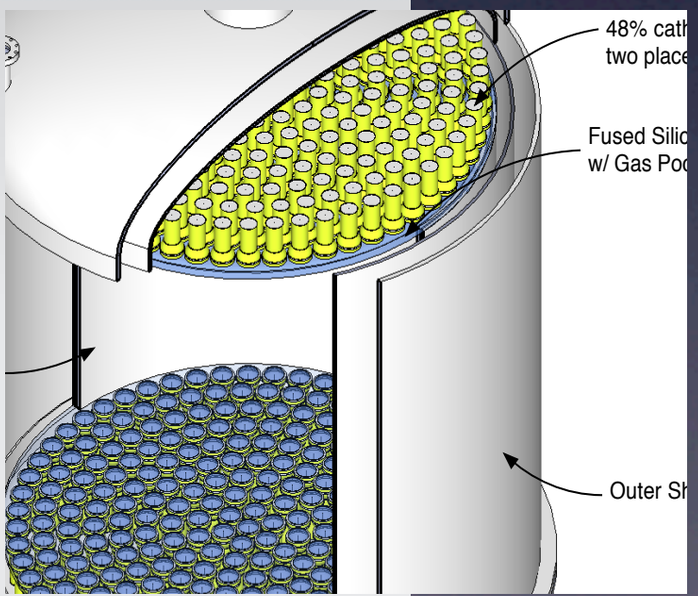
- All the cleaning and the filling of the muon veto has been done with 18 Mohm/cm water produced at LNGS
- The water production plant is composed by a degassing system, 2 reversal osmosis, a deionizer, 4 UltraQ cartridges and a nitrogen stripping column
- The production rate is 1 m3/h
- The water quality is 18 Mohm/cm

# High purity water

Water plant at LNGS

# DarkSide 50 status

- TPC deployed in neutron veto tank Sep. 13
- TPC cryostat cool and fill Sep. 16-20 (atmospheric argon)
- Neutron veto filled Sep. 30 - Oct. 13
- Muon veto filled Oct. 2 - Nov. 11

DATA TAKING IS ONGOING !!

# It is possible to host a multi-ton TPC inside the DS-50 neutron veto: DarkSide G2