

# DarkSide-50 an update

SC Committee II  
LNGS  
16 April 2013

Gioacchino Ranucci  
**On behalf of the DarkSide Collaboration**

# DarkSide Collaboration

Augustana College, USA

APC Paris, France

Black Hills State University, USA

Fermilab, USA

IHEP, China

INFN Laboratori Nazionali del Gran Sasso, Italy

INFN and Università degli Studi Genova, Italy

INFN and Università degli Studi Milano, Italy

INFN and Università degli Studi Napoli, Italy

INFN and Università degli Studi Perugia, Italy

INFN and Università degli Studi Roma 3, Italy

IPHC Strasbourg, France

Jagiellonian University, Poland

Joint Institute for Nuclear Research, Russia

Princeton University, USA

RRC Kurchatov Institute, Russia

SLAC, USA

St. Petersburg Nuclear Physics Institute, Russia

Moscow University, Russia

Institute for Theoretical and Experimental Physics, Russia

Institute of Nuclear Research, Ukraine

Temple University, USA

University College London, UK

University of Arkansas, USA

University of California at Los Angeles, USA

University of Chicago, USA

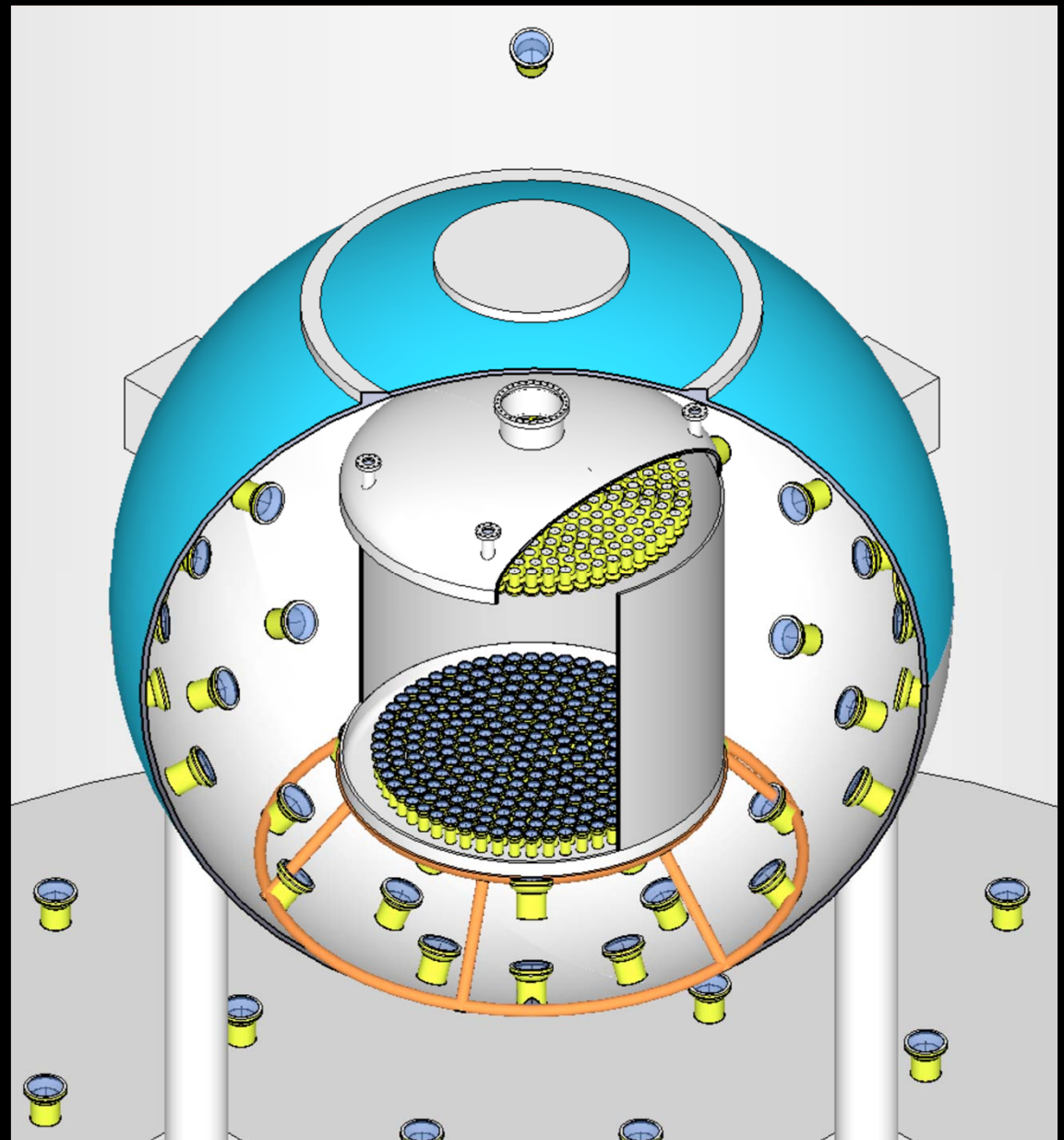
University of Hawaii, USA

University of Houston, USA

University of Massachusetts at Amherst, USA

Virginia Tech, USA

University of Virginia, USA





# General framework

- ✓ After the end of the full approval process, the preparation and installation activities of the detector progressed at “full steam”
- ✓ While each group maintained its specific responsibilities for the realization of the various subsystems, the group acted as a unique entity for the management of the underground works, under a centralized top-down organization scheme (already illustrated to the Committee and borrowed from the Borexino experience)
- ✓ Over the past months the preparation of the various subsystems went ahead significantly (PMT's, Electronics, parts of the TPC, cryostat, argon procurement)
- ✓ Meanwhile important installation and integration jobs have been completed underground: Clean rooms, cryogenic system installation, TMB delivery, cleaning and preparation of the SSS for subsequent installations, neutron veto PMT's installation
- ✓ The integration of the TPC is in progress since a couple of weeks-just completed
- ✓ I report here the status of each subsystem preparation and of the overall system integration underground

# DarkSide 10

7x 3" PMTs



TPB + ITO coated quartz window



Acrylic cylinder  
with TPB-coated reflector

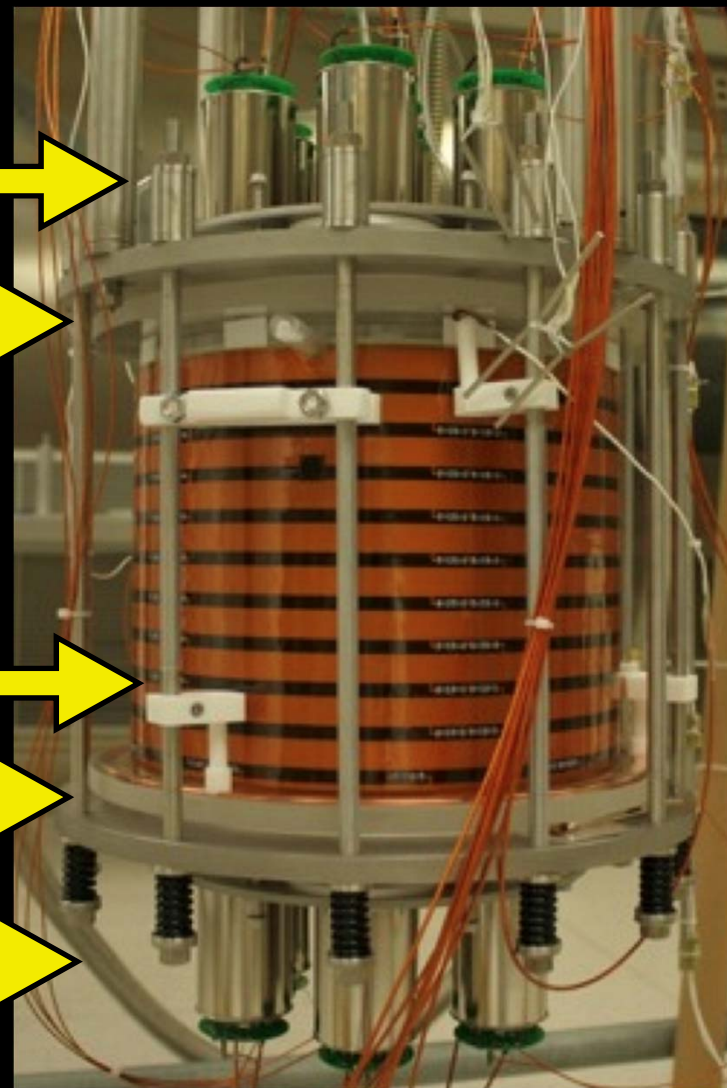
Flexible PCB field cage



TPB + ITO coated quartz window



7x 3" PMTs

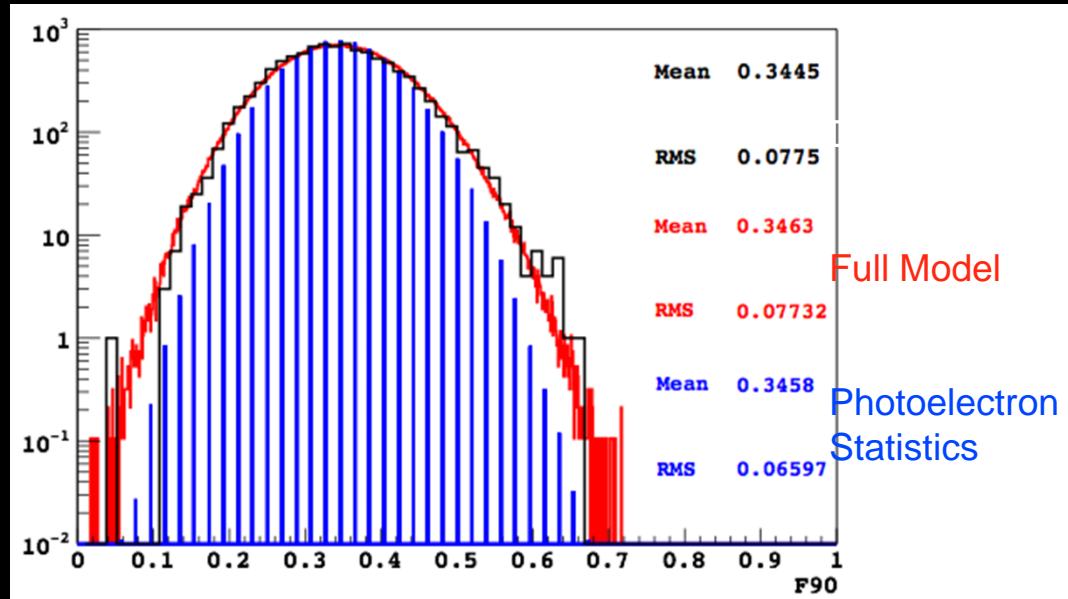


**Completed its technological tasks - run stopped**

# DarkSide-10 Activities and Results

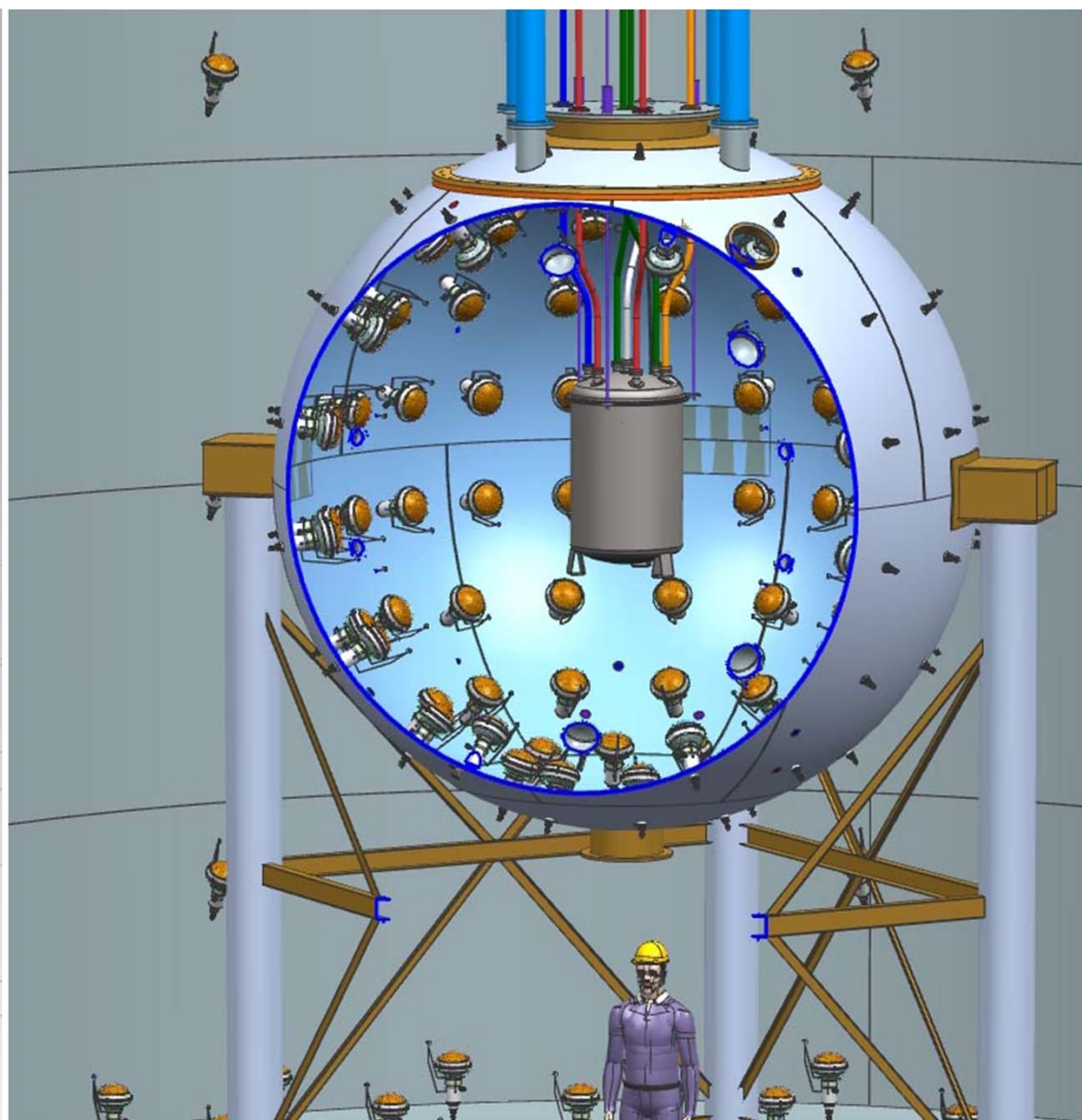
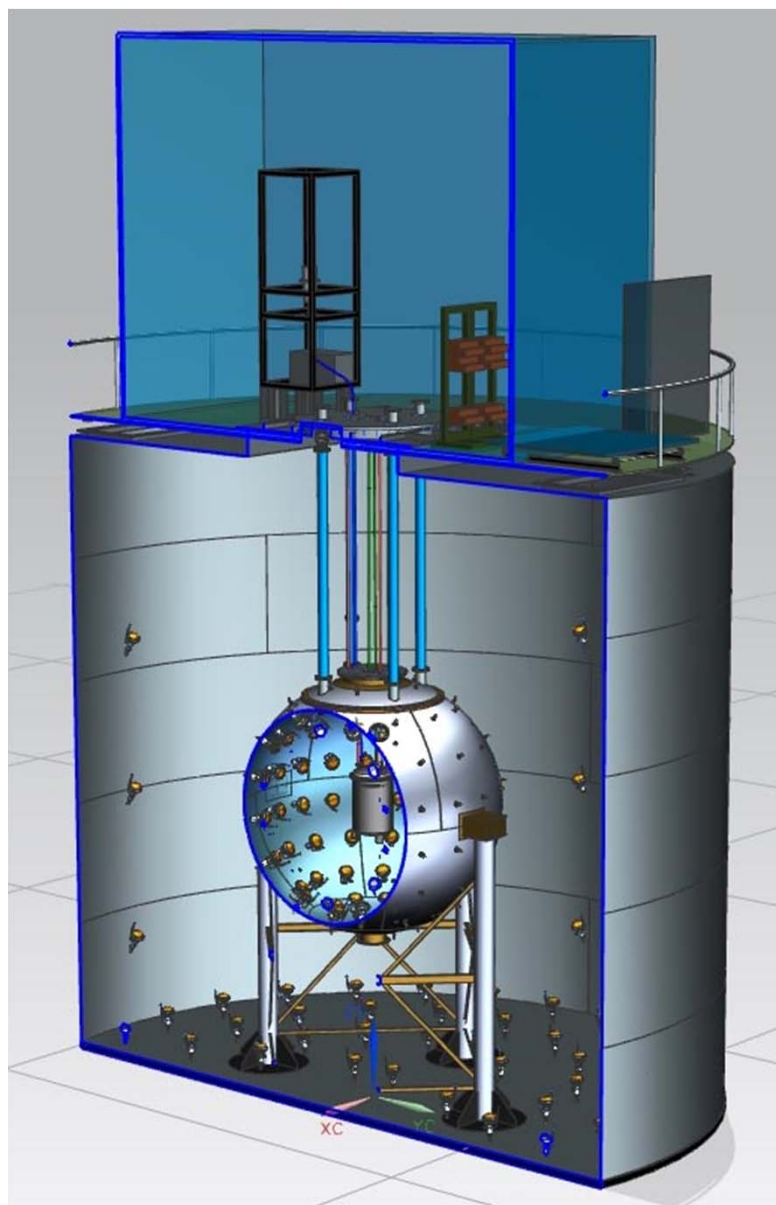
- Not physics capable (a fraction of a neutron per day due to cryostat, feedthroughs, and shield)
  1. Compare performance of different reflectors for light collection
    - Obtained record light yield of 8.9 pe/keV<sub>ee</sub>
  2. Perform long-term test of HHV system
    - Stainless steel-cryofitted HDPE HHV feedthrough reached required 36 kV and operated stably for over 8 months

# PSD studies and modeling



- Good agreement between DS-10 data and the developed model describing F90 distribution for electron recoils, down to energies equivalent to 20-25 keV<sub>rec</sub> (~40 p.e.);
- Model predicts significant differences in electron leakage compared to simple Binomial Model;
- Confirmed the expected sensitivity of  $10^{-45}$  cm<sup>2</sup> in 0.1 ton\*year for a 100 GeV WIMP;

# 3D full view of the detector



# Hardware breakdown

- ✓ Infrastructures: Clean rooms, Radon suppression system
- ✓ Vetoes (muon and neutron)
  - Supporting and Containment Stainless Steel Sphere
  - Diffusive panels (Tyvek and Lumirror)
  - PMTs, support parts, cables, fibers for monitoring of the devices
  - Electronics & DAQ
  - Liquid scintillator (TMB+PC+PPO)
  - New purification system
  - Insertion systems for source calibration (valid also for TPC)

## Hardware breakdown (cont'd)

### Inner detector

- ✓ Cryostat
- ✓ TPC
  - Teflon support structure for the PMTs
  - Reflector
  - field cage rings
  - Silica windows
  - Feedthroughs
  - evaporator
  - Cryogenic PMTs
- ✓ Read-out electronics & DAQ
- ✓ Cryogenic system



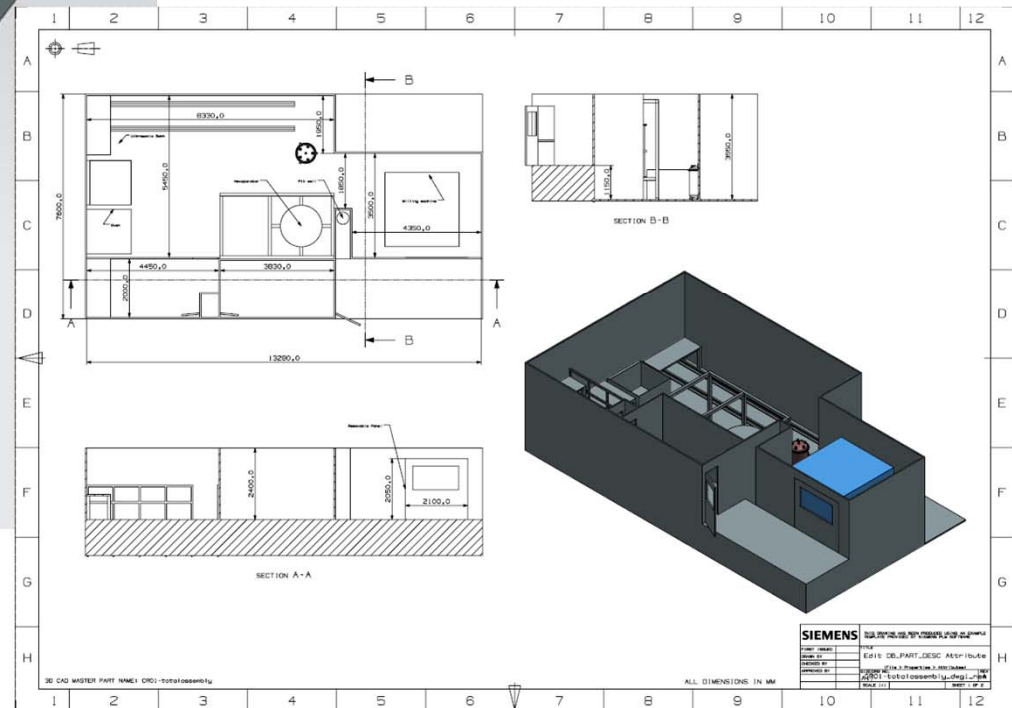
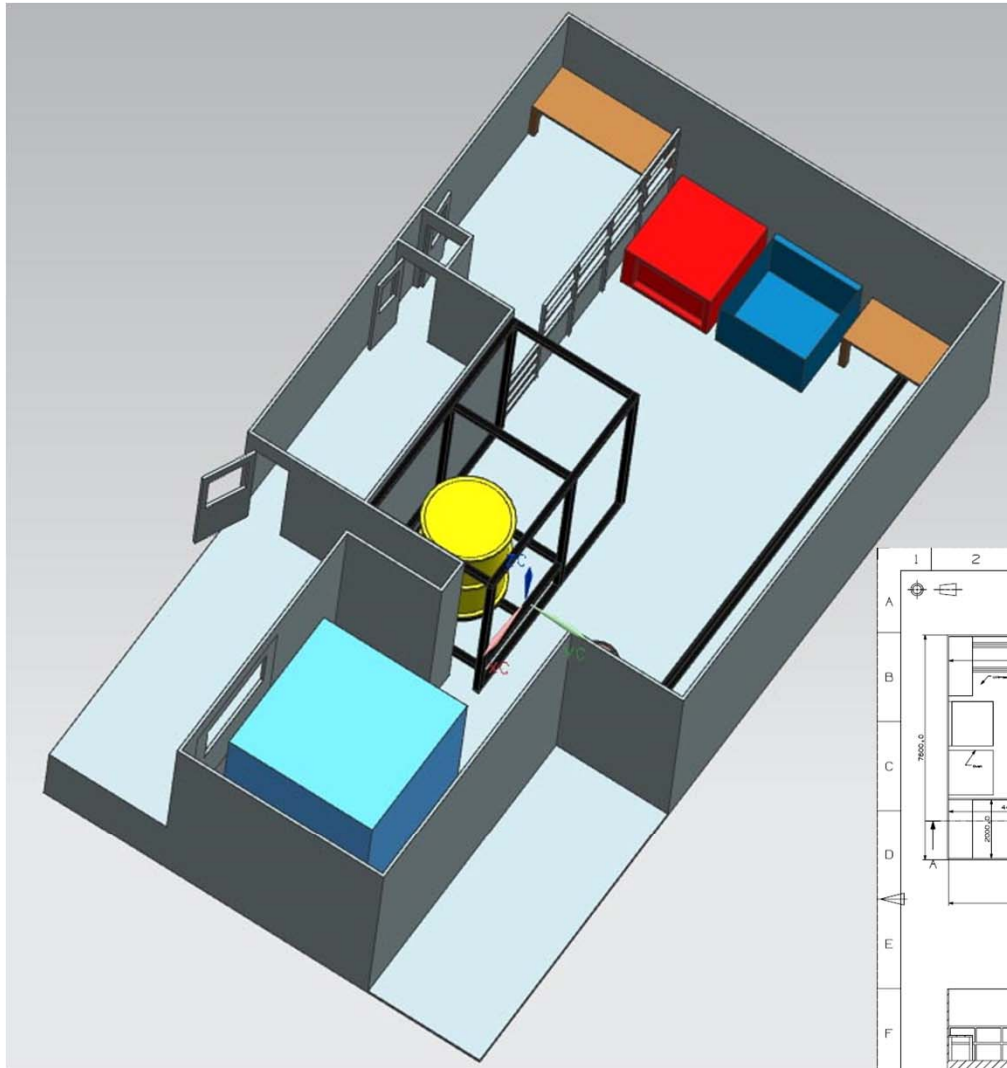
## Other items

Depleted Argon extraction

Depleted Argon distillation

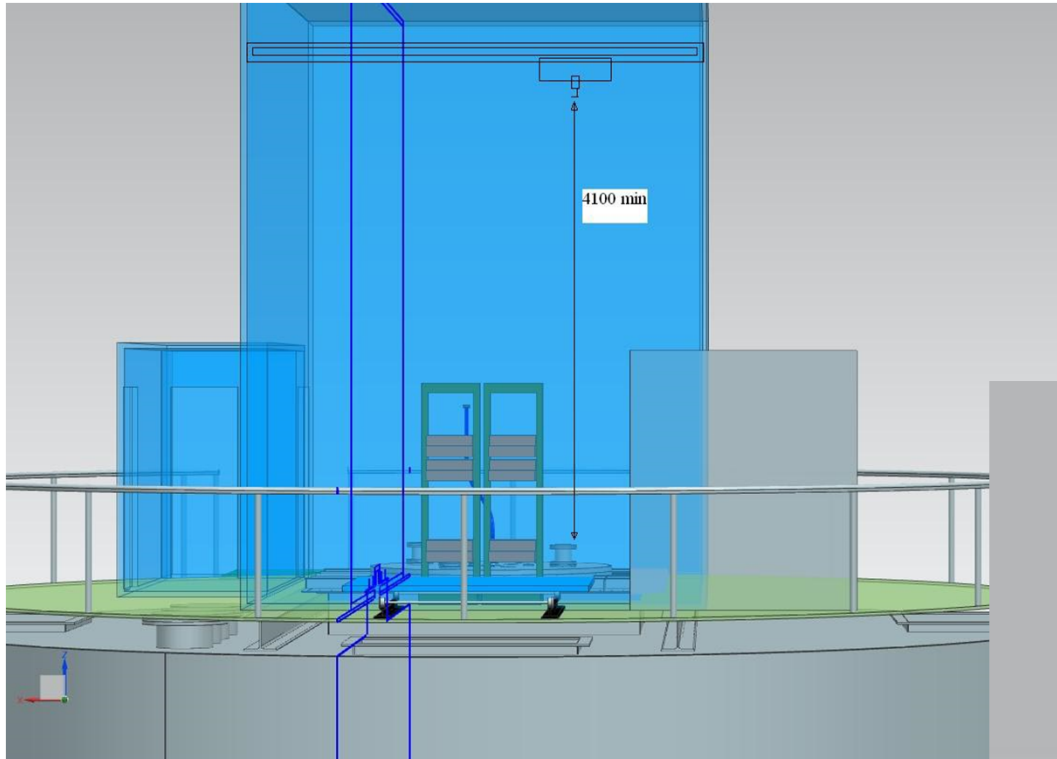
MC & Analysis

# Conc. design of Radon free CR1

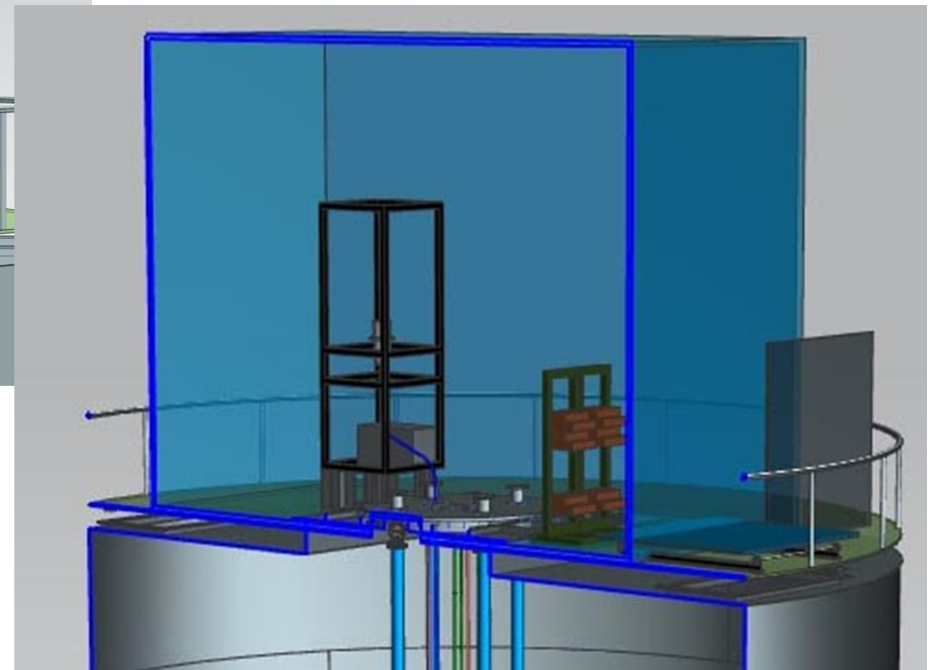


# Conc. design of Radon free Hanoi CR

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Class of both clean rooms : 10-100



## Interior of CR1 completed





## Interior of CR1 completed



CR on top completed





CR on top completed - interior





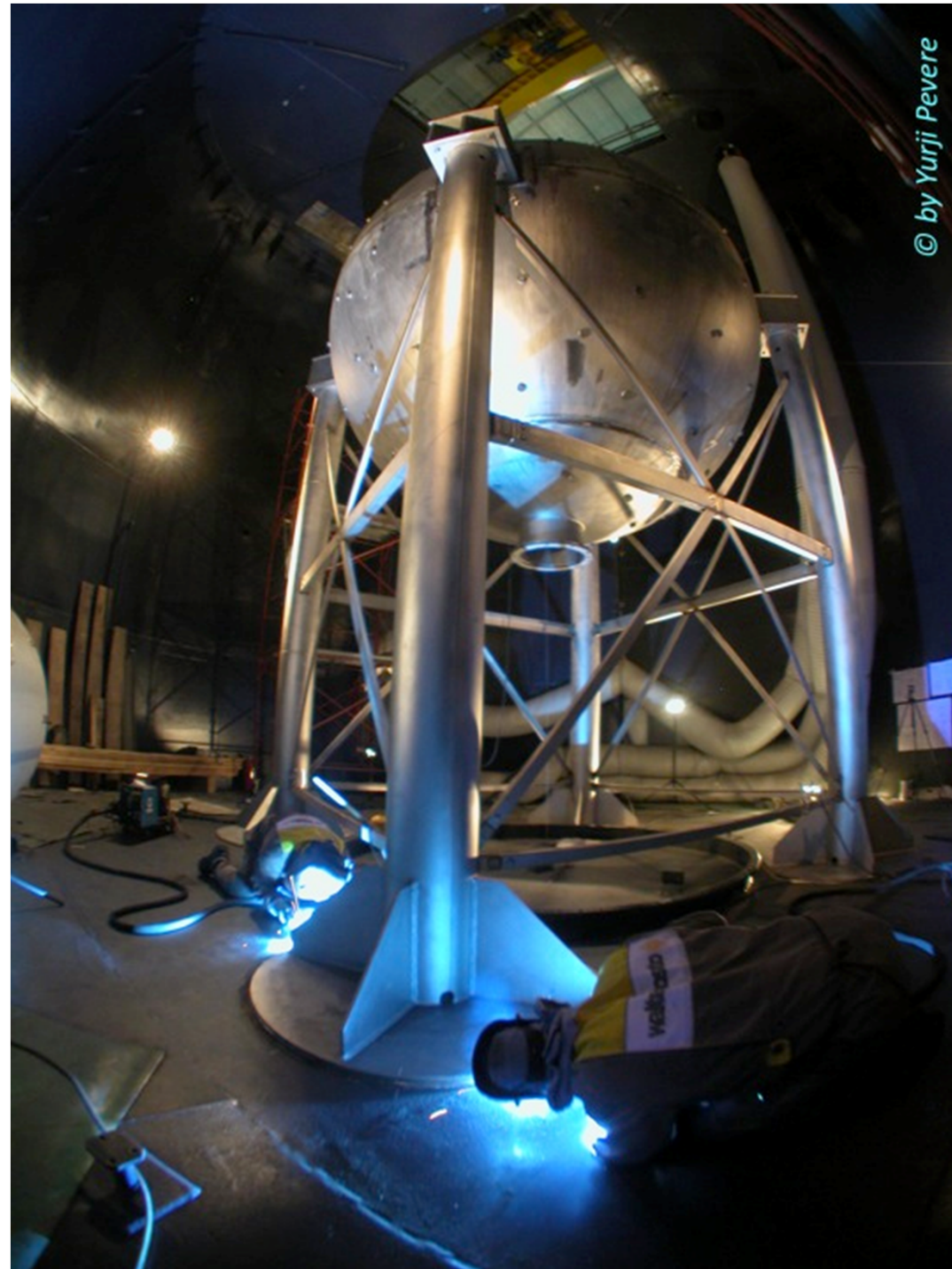
## Radon reduction system installed and tested



Obtained  $\lesssim 30 \text{ mBq/m}^3$  in  $>100 \text{ m}^3 \text{ CRH}$

Neutron veto  
sphere «artistic»  
view during  
welding

Now completed  
and cleaned





## Installation of the Lumirror diffusive panels

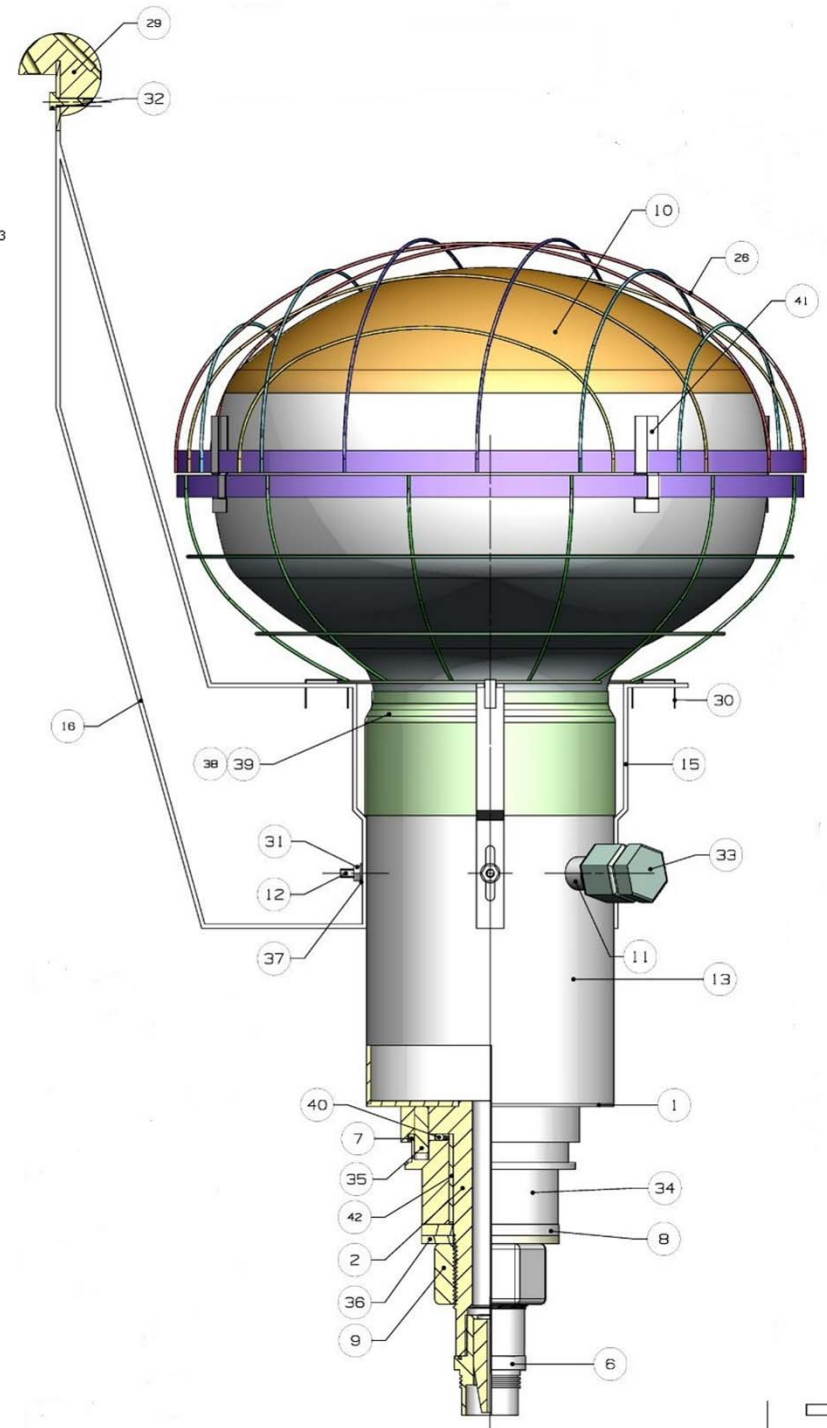
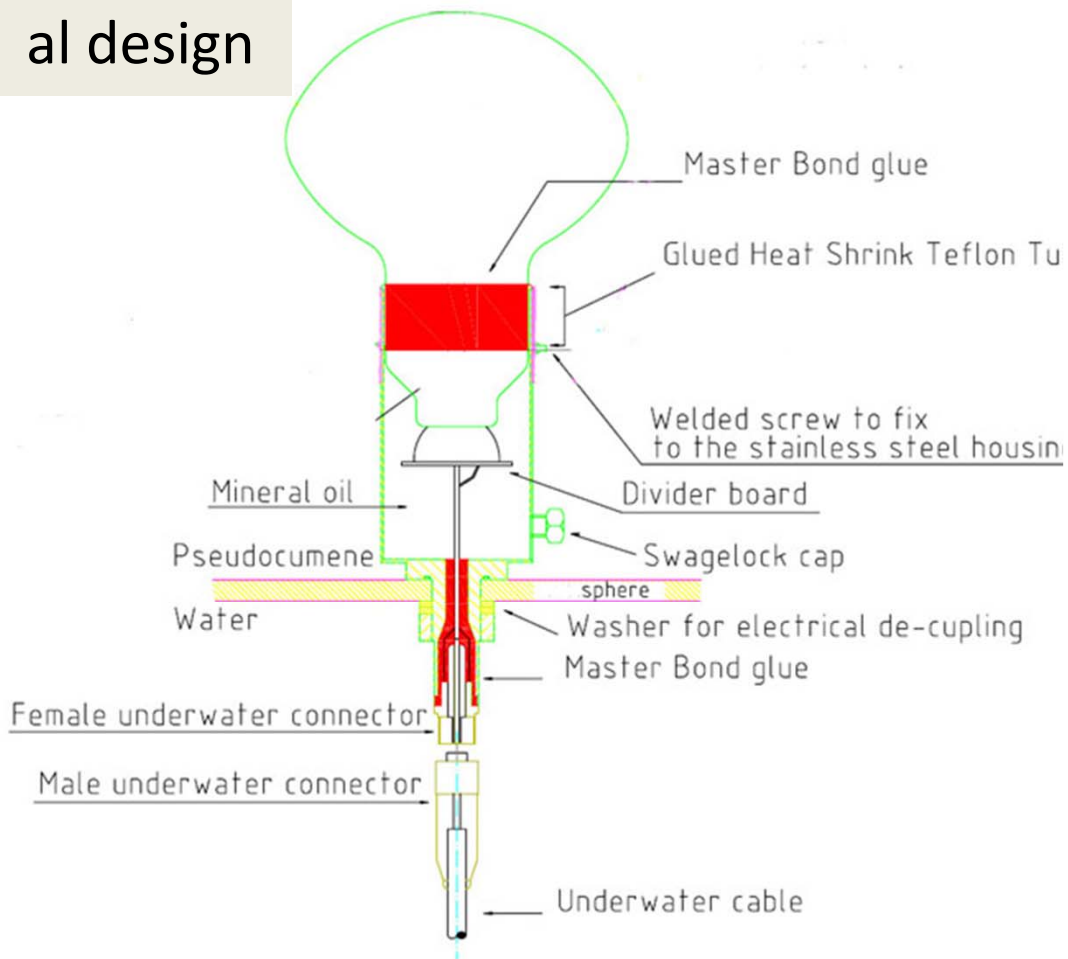
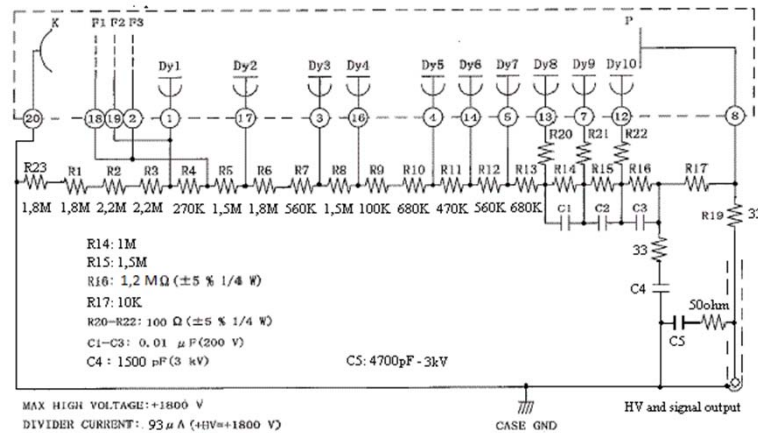


## Final configuration Lumirror diffusive panels



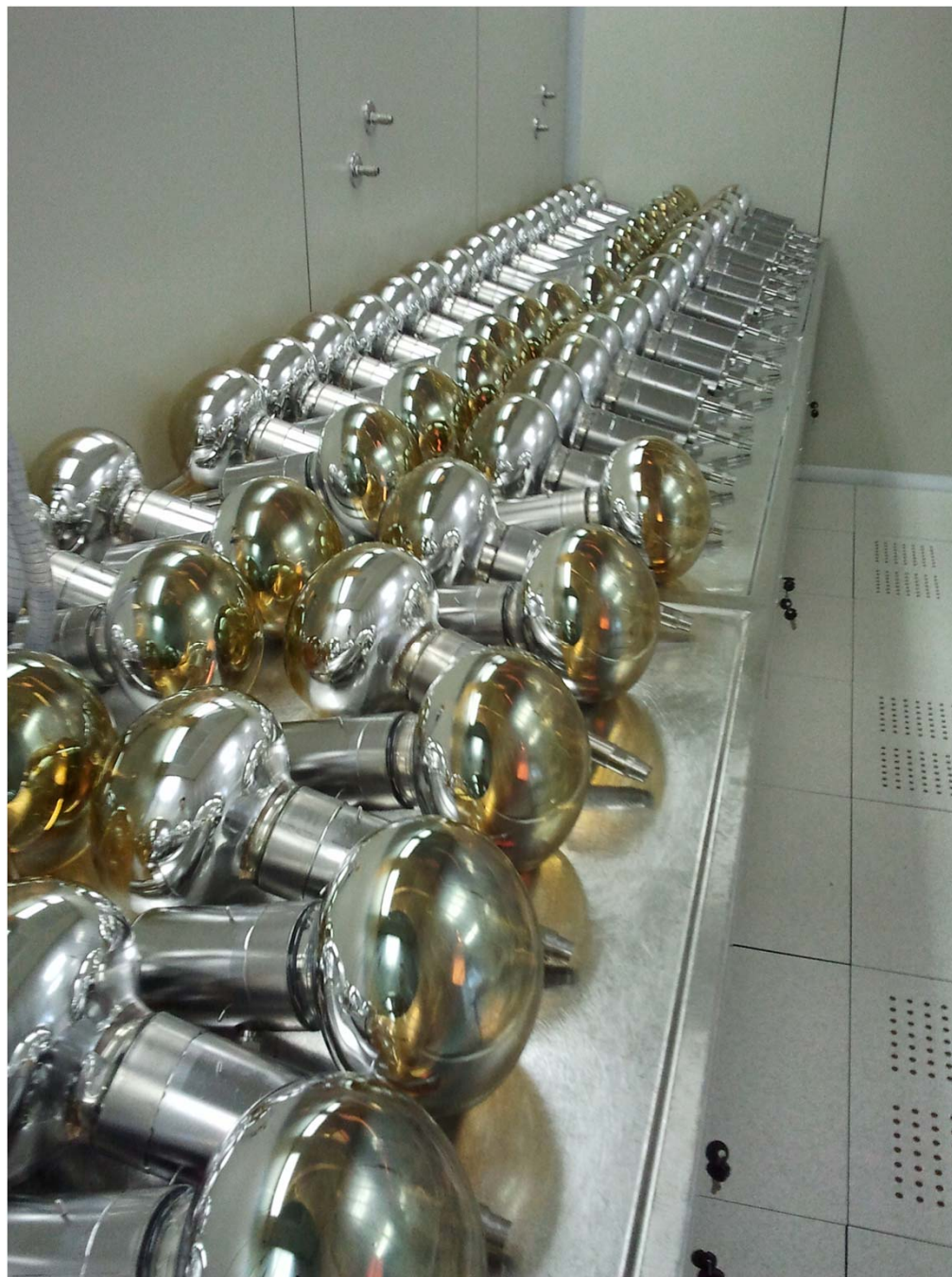


# Muon veto PMT electrical sealing and mechanical design













Total inventory of the devices  
110 new PMTs for the neutron veto  
80 old PMT from CTF for the muon veto  
plus a few spares



# PMT test facility

4x32 channels electronics



4 tables x 16 PMT each



Picosecond laser

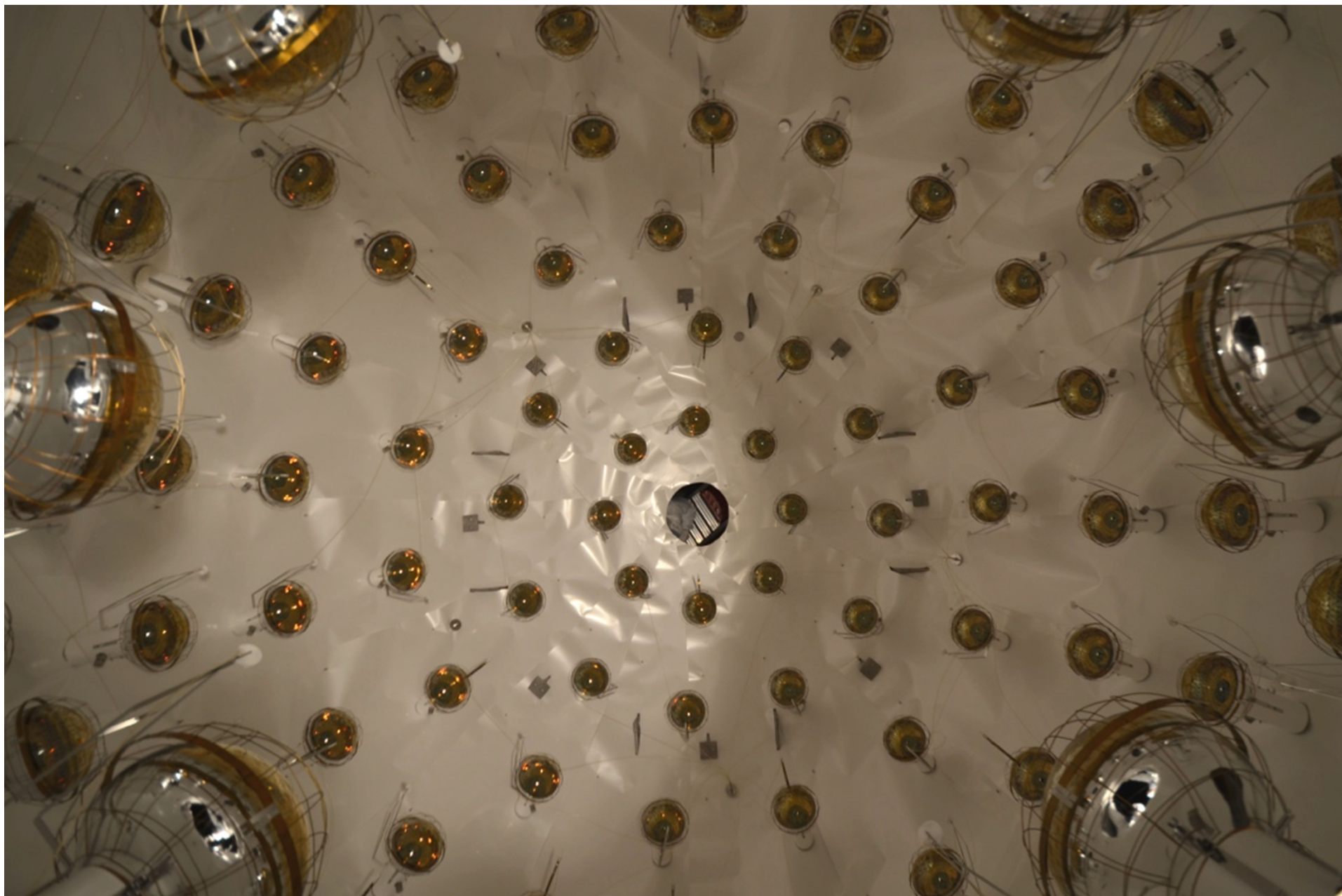


Earth Magnetic Field compensation system





## Neutron veto completed



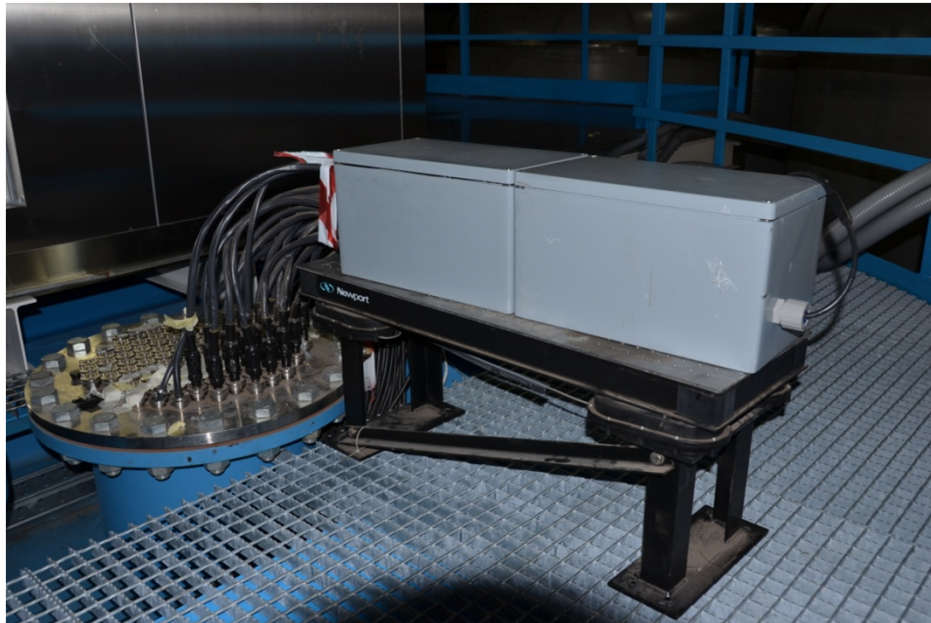
All cables deployed





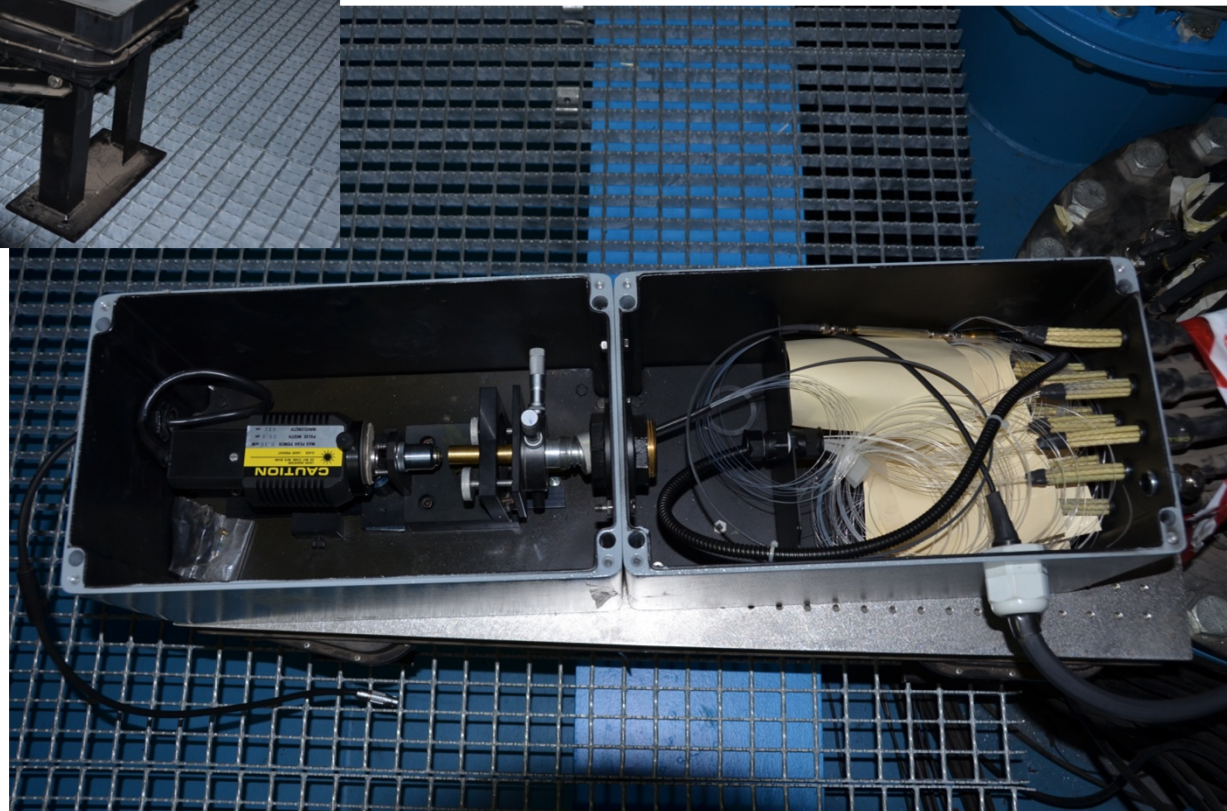
# Optical fibers and laser for PMTs monitoring

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110 new fibers for neutron  
veto + 20 spare

80 old fibers for muon veto +  
10 spare





# Optical fibers installation

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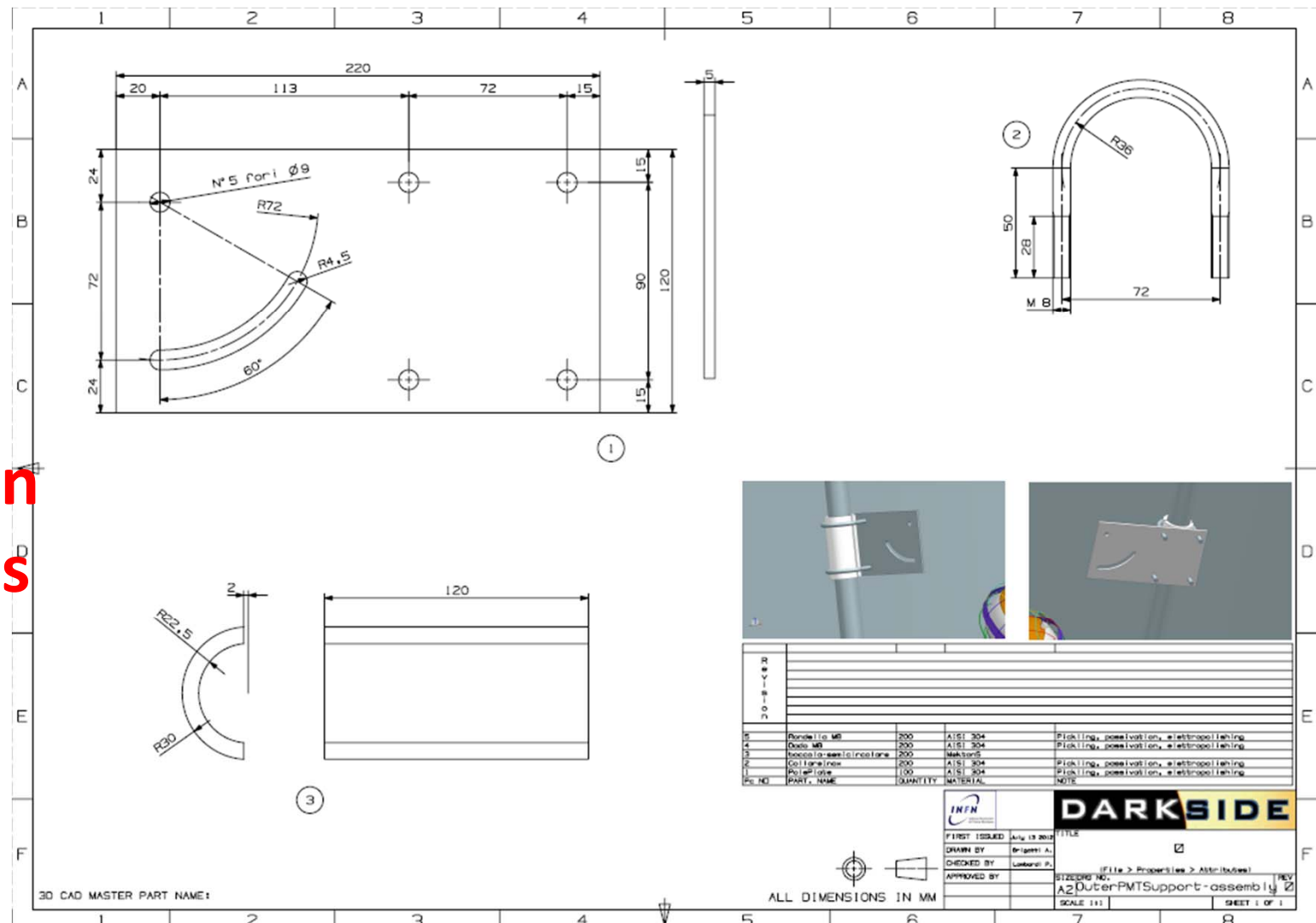


## External muon veto

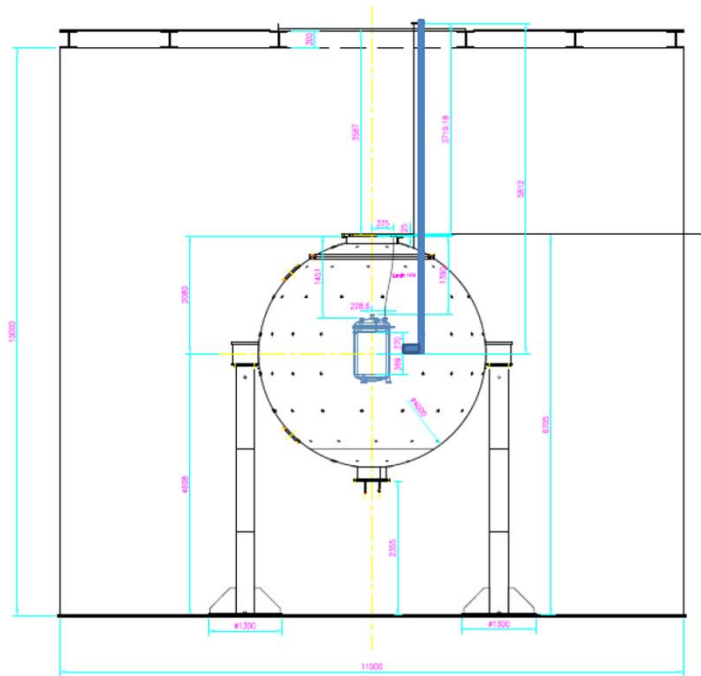
The support structures of the Tyvek and of the external PMT's have been completely designed and constructed – ready to be mounted

This is the design for the outer PMTs support

# Installation in progress







Movable arm to deploy the source in the LSV and close to the TPC

Testing on a building terrace

Pre-installation test





# Veto Electronics



- **Options**

- FADC commercial boards, 1-2 GHz, 8-10 bit

- CAEN (e.g. V1731)
- **National Instruments (e.g. NI-PXI 5162)**
- Agilent Technologies



Selected after  
the bid

- The NI-PXI 5162 will work at 1.25 GHz sampling rate and 10 bits

- **System under implementation:** 190 channels will be assembled for both vetoes

120 channels already available, assembled and being tested

Purchase of the remaining 70 plus spares channels **almost** completed!

- Suited for the full upgrade of the Borexino electronics
- **Front end electronics: design completed and construction started**
- **High Voltage modules procured**



# Outer Detector: review of DAQ

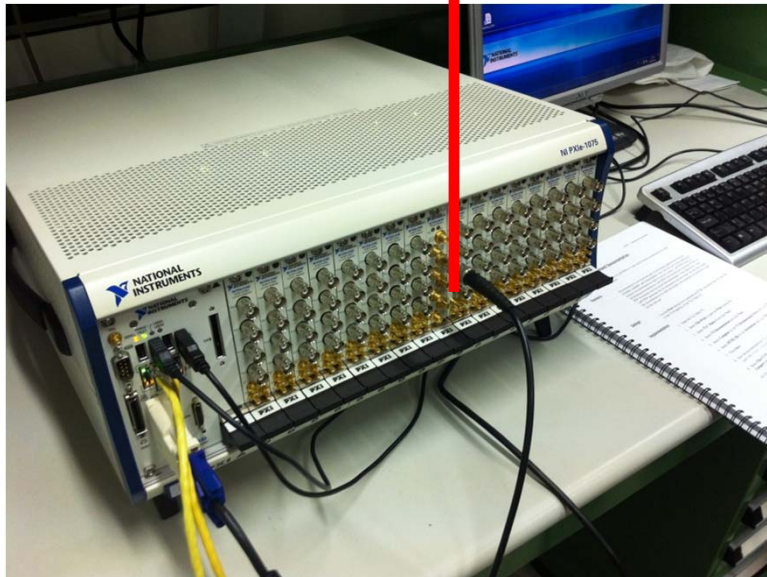


NI PXIe-6674T

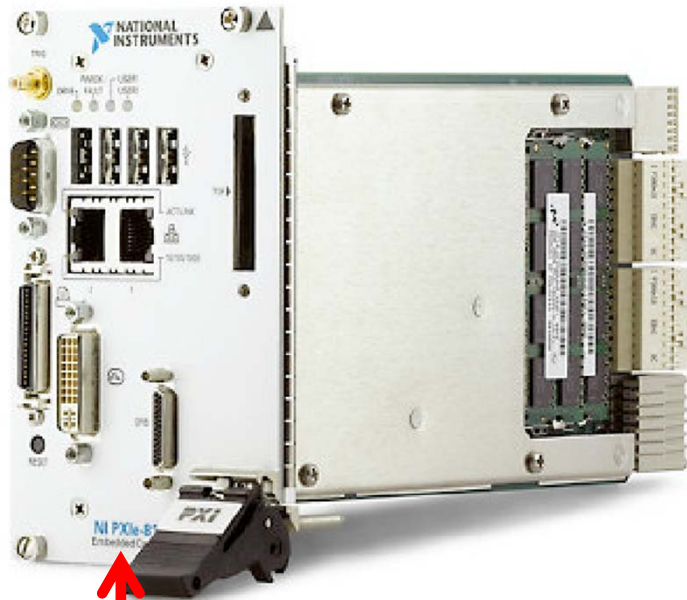
Trigger and Synchronization Module

**Multi-chassis synchronization**

**Trigger Routing in the chassis**



# Outer Detector: review of DAQ



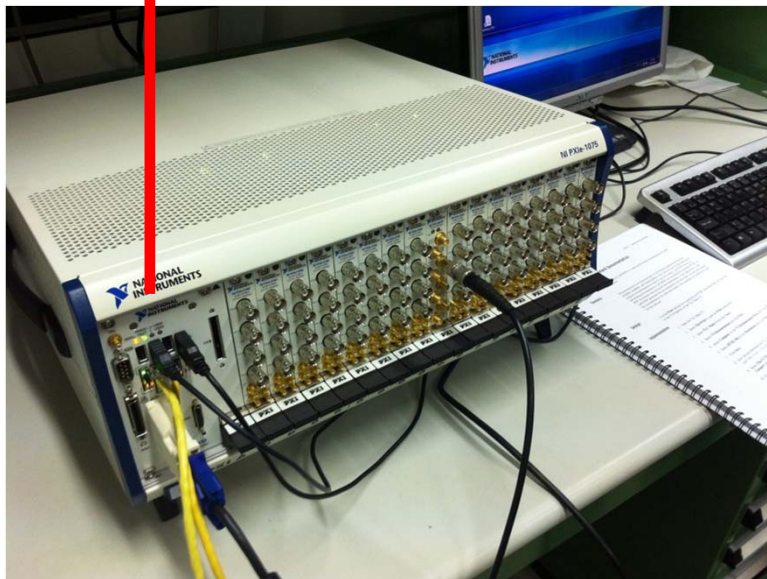
NI PXIe-8133 controller

**High-performances** embed controller

1.73 GHz Quad-Core

Windows/RealTime **OS**

**Gigabit Ethernet** (2 ports)



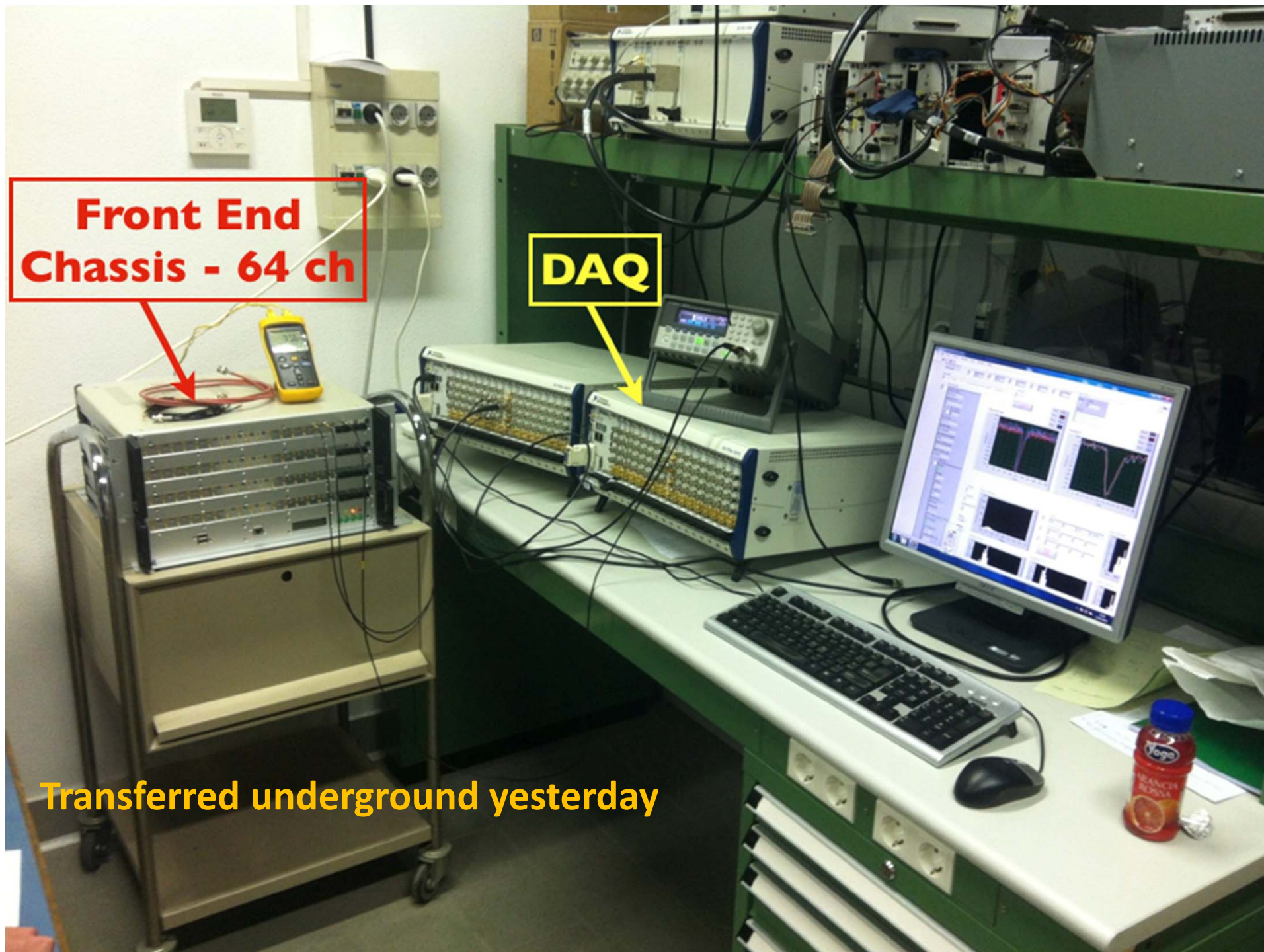
**Readout code** installed and **runs**  
in the **controller** of each chassis



**Front End  
Chassis - 64 ch**

**DAQ**

**Transferred underground yesterday**





# Liquid scintillator – delivery of the TMB

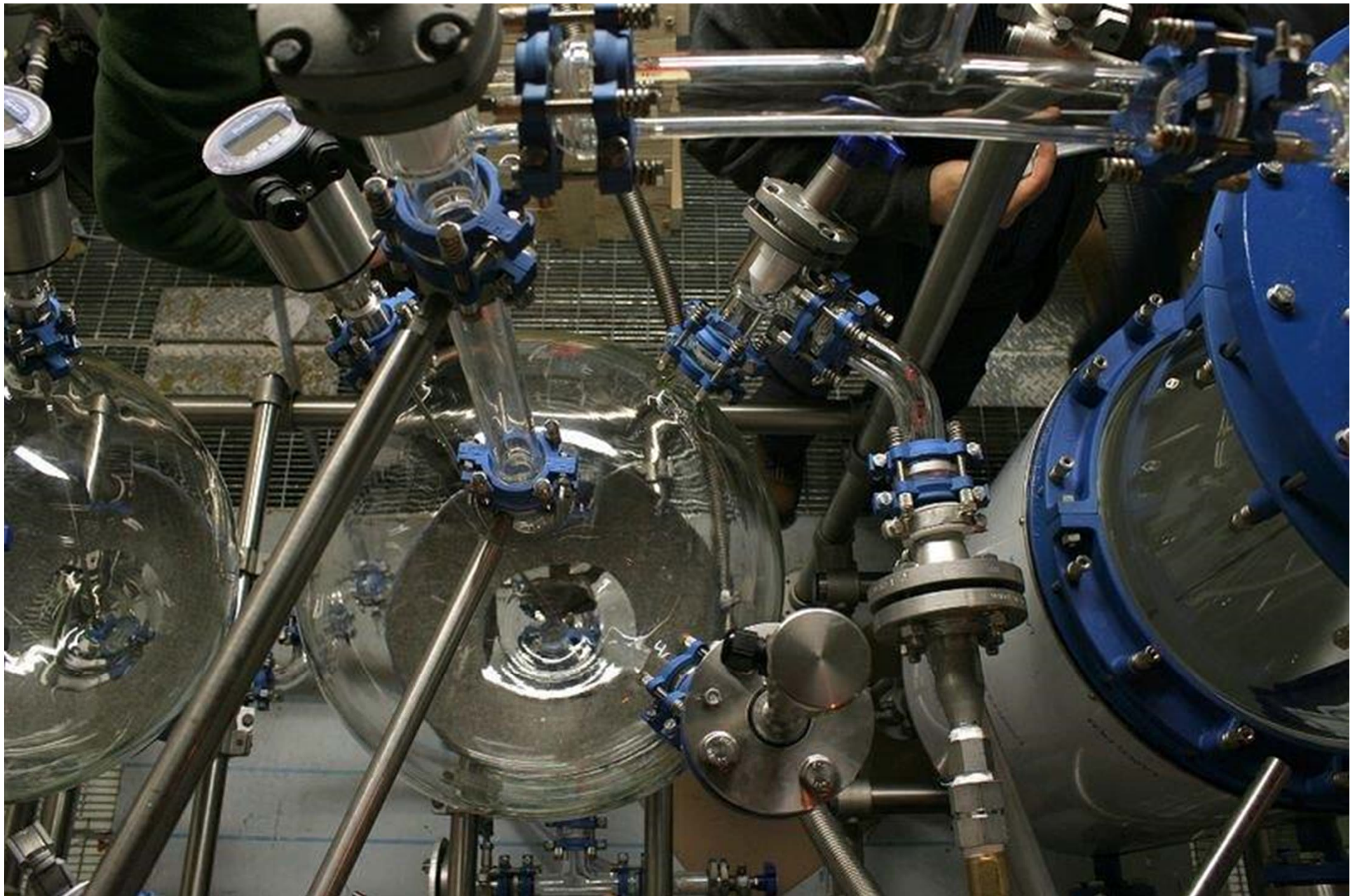






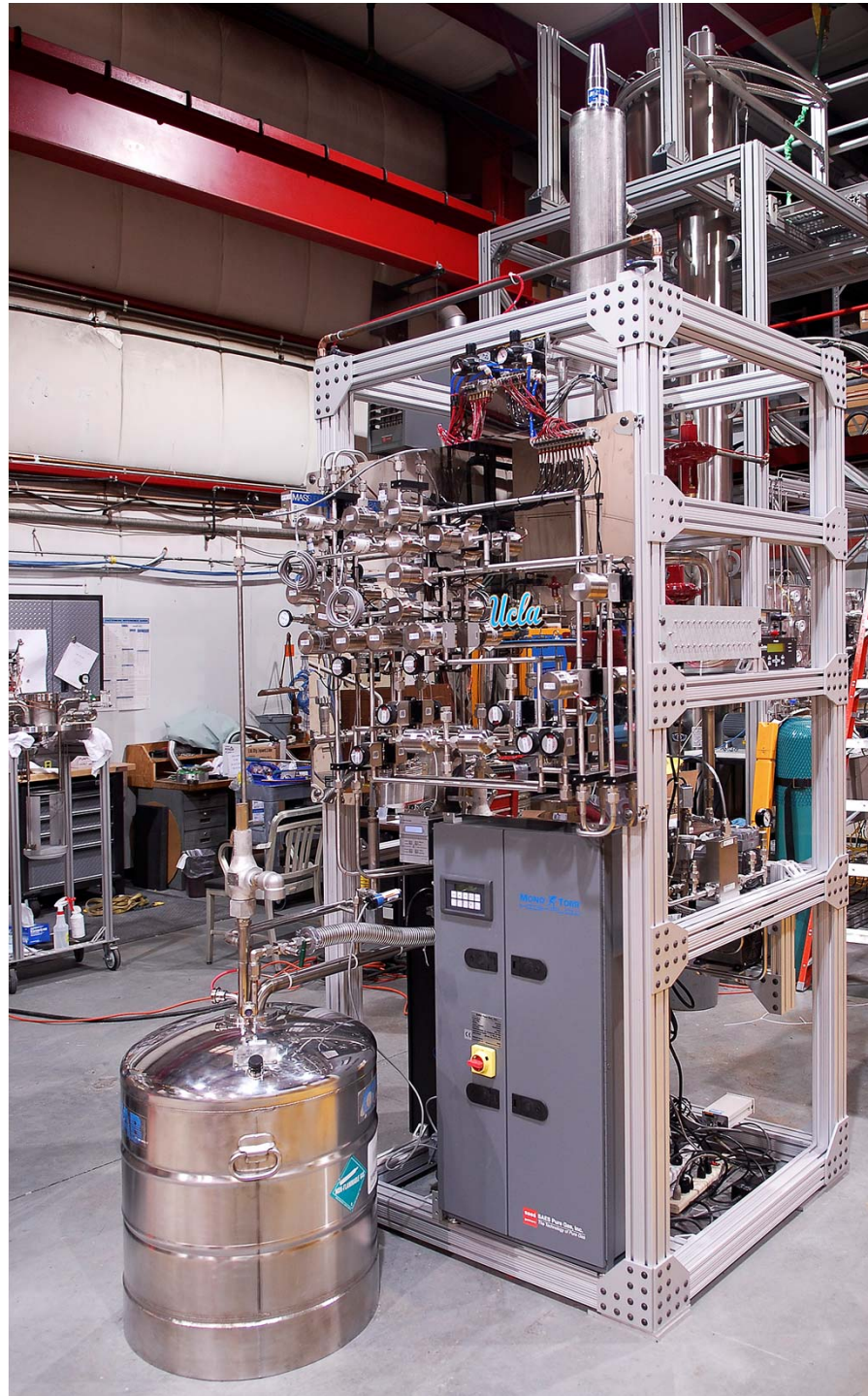


## Dedicated purification system





**Argon handling  
system was built  
at Fermilab and  
shipped to Gran  
Sasso in  
November**



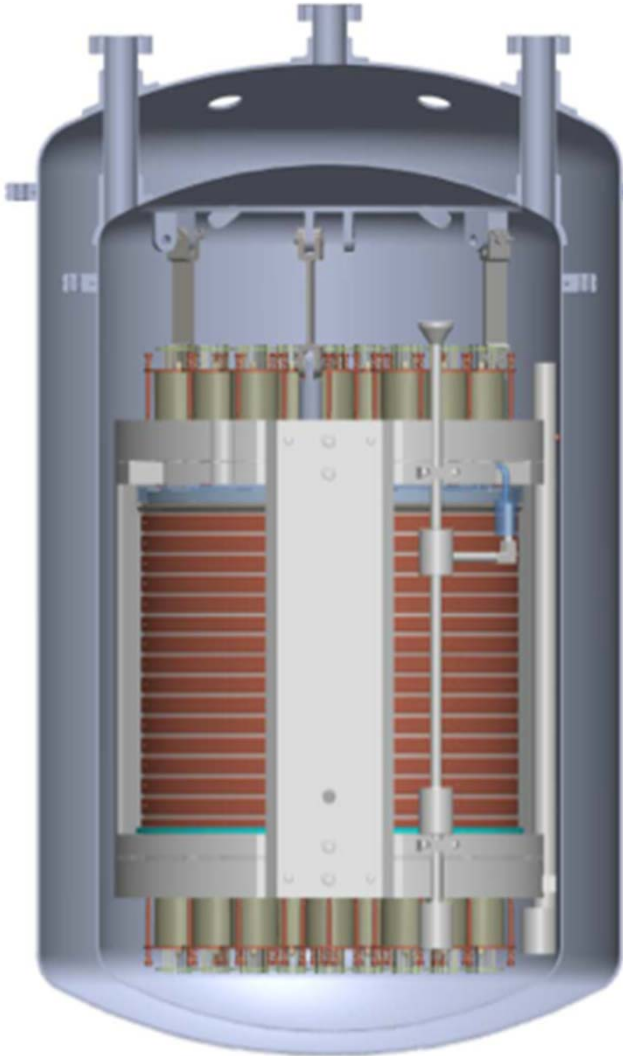








# DS-50



- Low rad Stainless Steel cryostat (138 kg);
- Active Volume diameter 35.6 cm;
- Active Volume height 35.6 cm;
- Gas Pocket 1.0 cm;
- Active LAr mass 49.4 kg;
- Total LAr mass ~145 kg;







# Dewar suspension and alignment system

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Test at the  
Company site

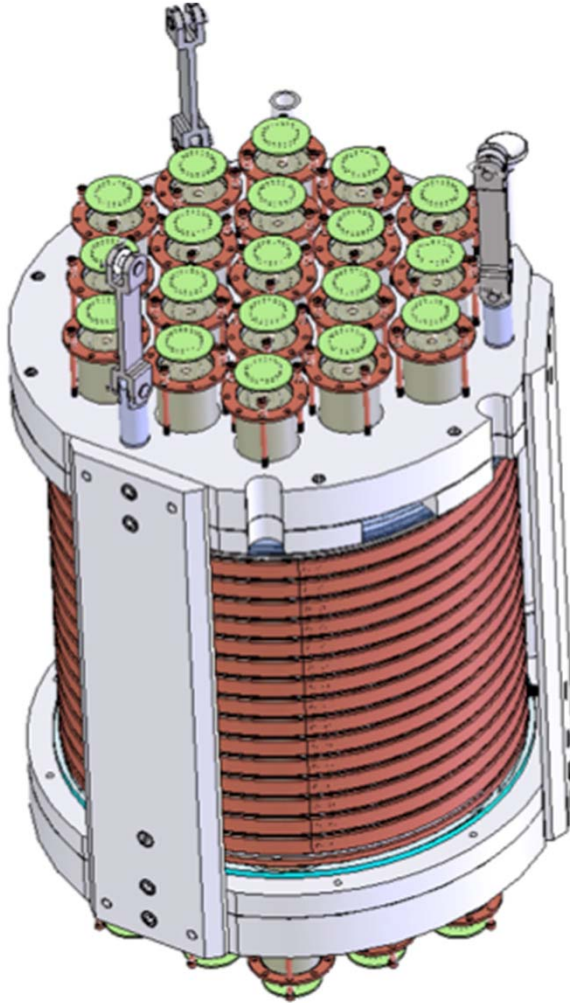




Dewar  
in clean  
room  
CRH



# DS-50 TPC



- 38 PMT R11065;
- Drift field (typical) 1.0 kV/cm;
- Extraction field (typical) 3.8 kV/cm;
- Multiplication field (typical) 5.7 kV/cm;
- HHV voltage -43.2 kV

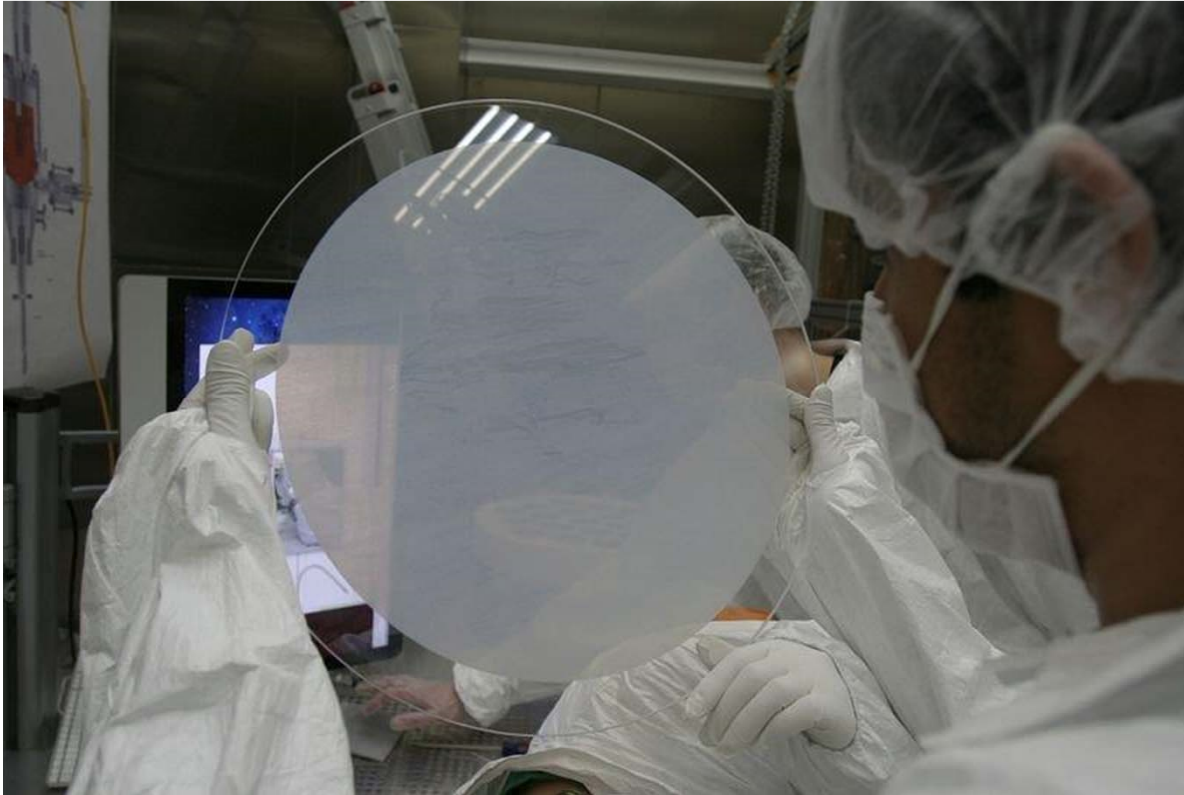
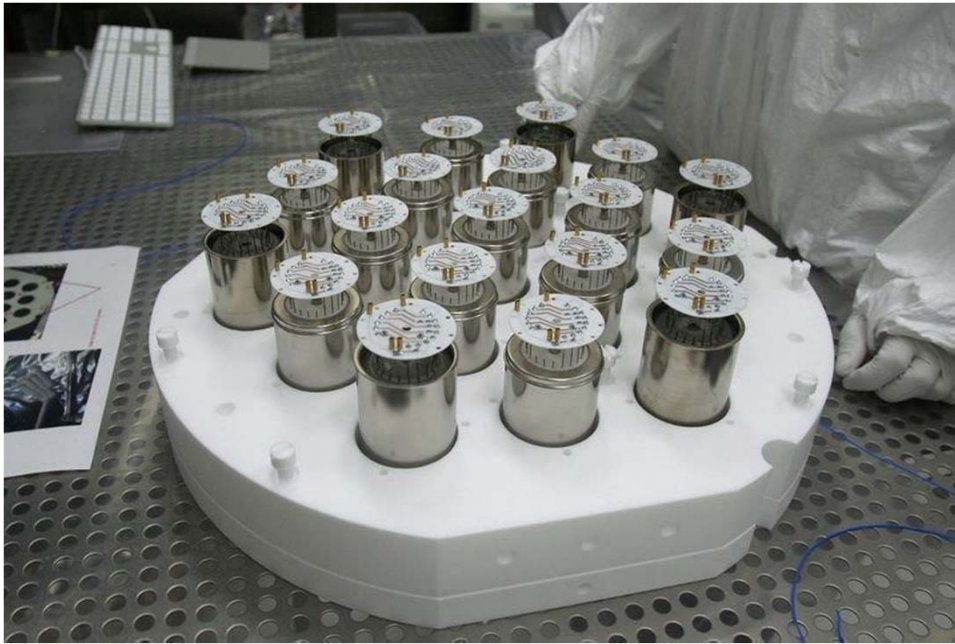
Procurement of parts completed

Cleaning and TPB evaporation in CR1 done

Final assembly in CRH completed

- Quartz windows + ITO
- High reflectivity Teflon
- Deposition of the wavelength shifter (Tpb) in CR1
- Low radioactivity copper rings for field cage
- Diving bell
- Metal cryogenic PMTs
  - R11065, R11065-10, R11065-20
- low rad dividers











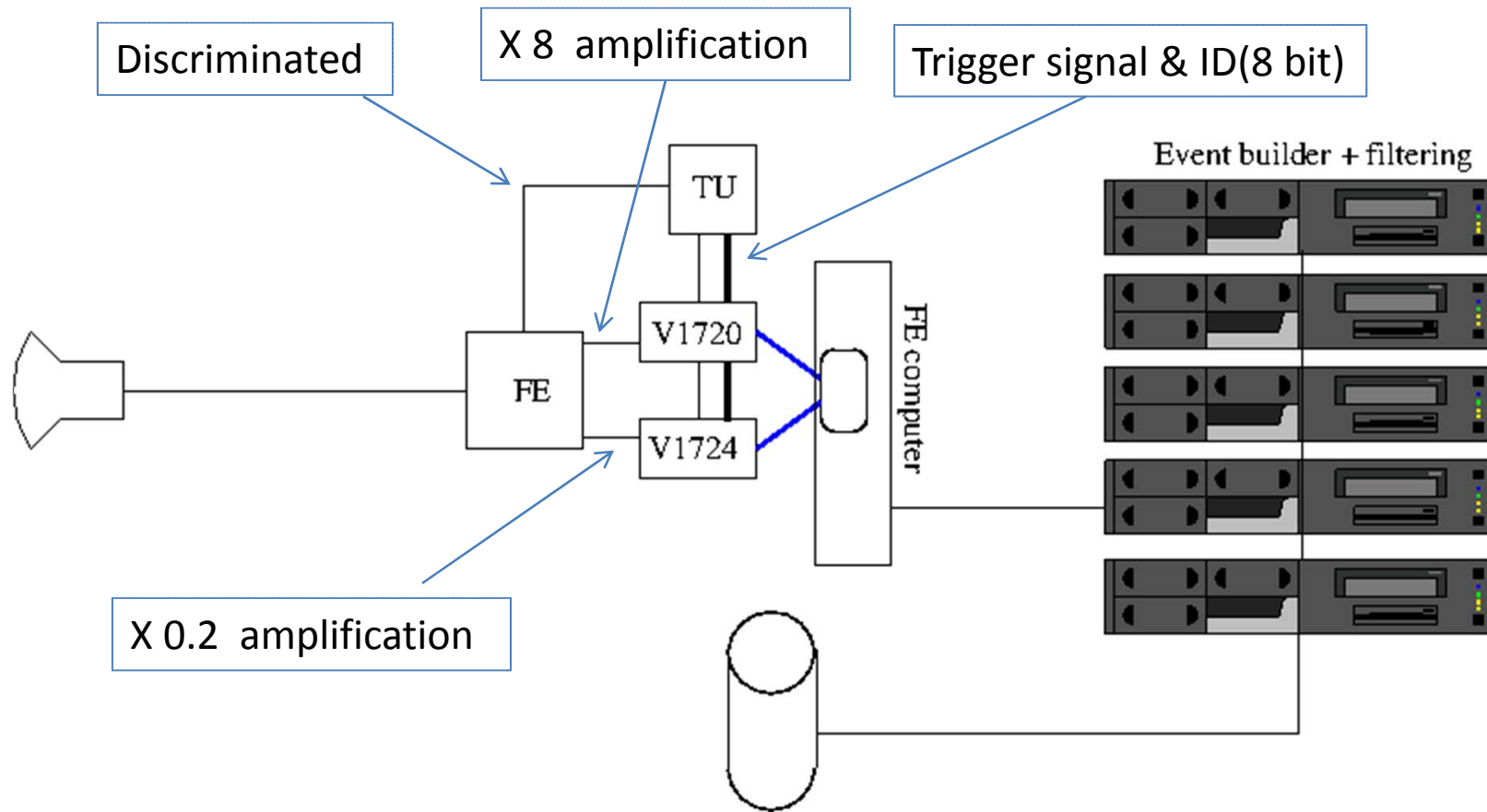








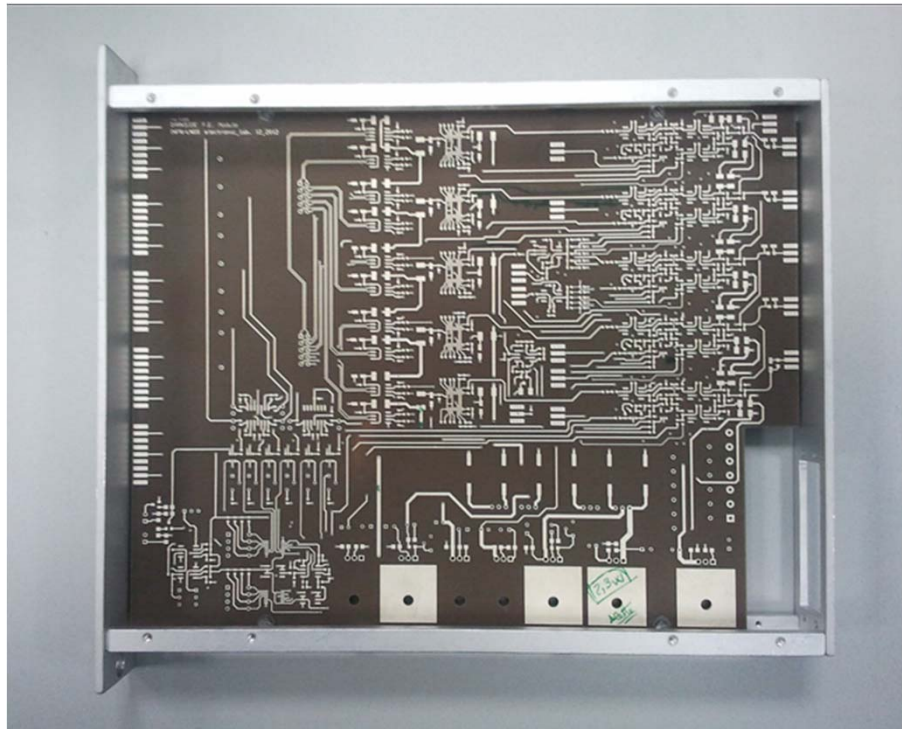
# TPC ReadOut



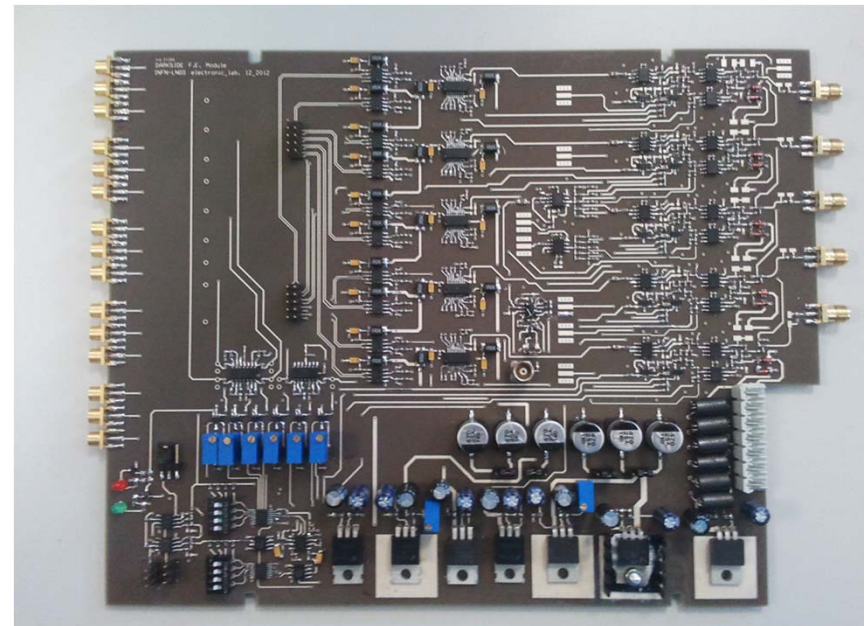


# Activities well in progress

- Cabling
- Front-end developed and realized
- Digitizers procured
- DAQ software
  - Developed
- Acquisition cluster
  - Procured and under installation
- Trigger unit
  - Developed
- Entire system ready to be transferred underground



Front-end circuit







Ready to be transferred underground



## Underground Argon



Extraction (Montezuma  
County, Colorado, USA)



Distillation (Fermilab, USA)

1. Extraction: underground Ar concentrated by  $>10\times$  in well gas  
150 kg Ar extracted to date; rate 0.5 kg/day
2. Distillation;  $\sim 5\%$  Ar  $\rightarrow > 99.95\%$ , full operation since February  
20-25 kg Ar distilled to date; batch rate  $\sim 1$  kg/day, efficiency 99%
3. Final Purification to  $< 1$ ppb impurities using getters
  - 0.65 kg purified for  $^{39}\text{Ar}$  counting test  $\rightarrow$   $^{39}\text{Ar}$  limit  $< .005$  Bq/kg



# DarkSide-50kg MonteCarlo

Geant4:

- studies for the definition of the dimensions of the detector
- Evaluation of the background due to material contaminations

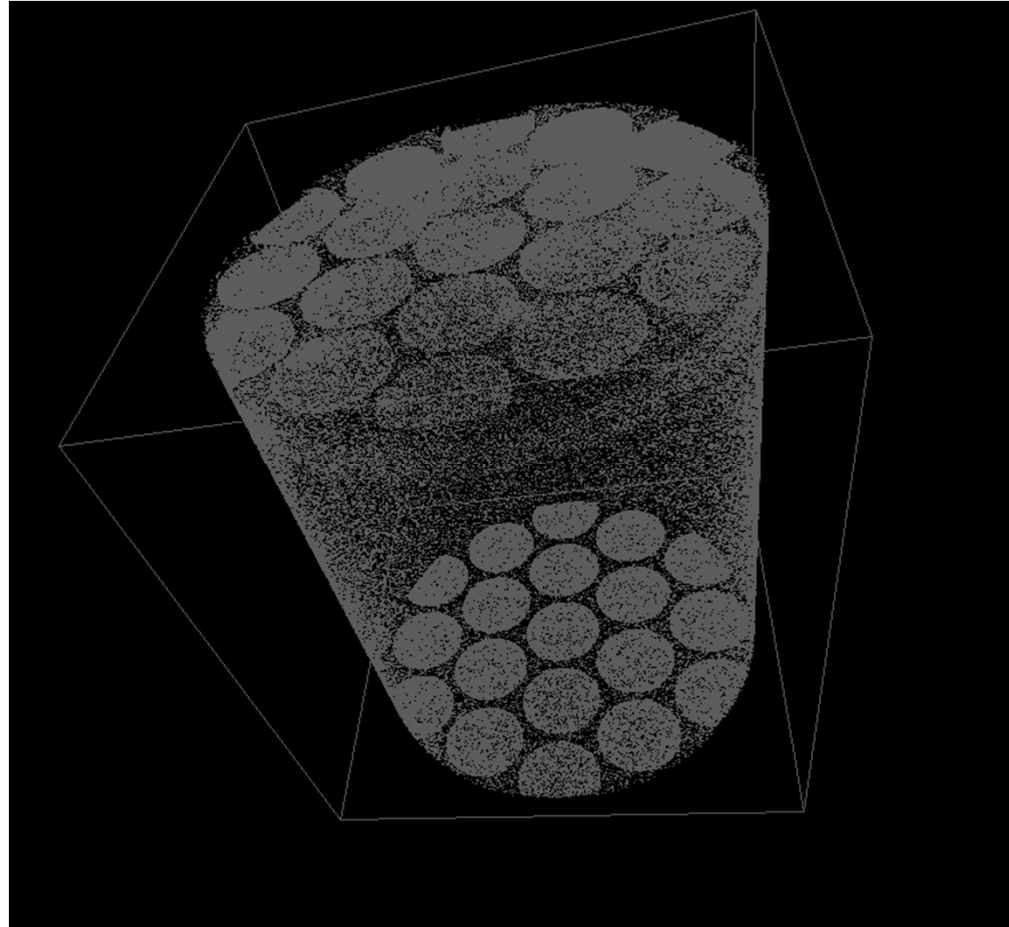
Fluka + Geant4:

- study of the background in Hall C from cosmic rays and from neutrons

Geant4 + custom photon tracing + effect of the electronics:

- Investigation of the background rejection through pulse shape discr.
- tuning and efficiency evaluation of the reconstruction algorithms

# DarkSide-50kg MC event



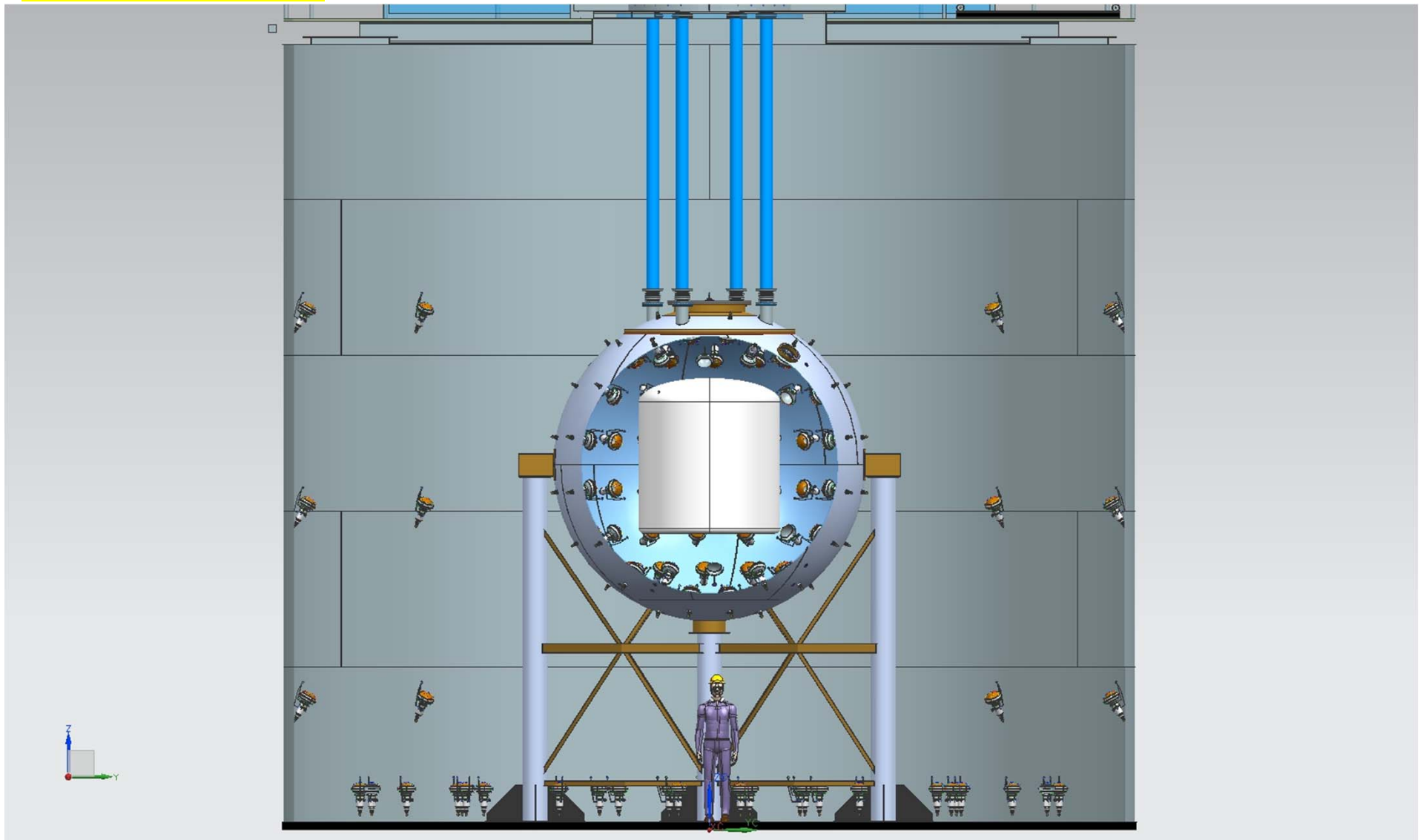
Argon scintillation light (128 nm) shifted by TPB and collected on Top and Bottom PMT arrays



## Imminent DS-50 next steps

- TPC final assembly within the cryostat and deployment in the center of the Sphere
- First cooldown and calibration campaign with normal argon
- Completion of underground installation of both electronics systems
- Completion of muon veto
- Replacement of the models R11065 with the R11065-20 PMT's
- Fill of the Sphere with boron-loaded scintillator (end of May) finalization of the authorization being worked out together with LNGS Directorship
- Fill of the muon veto with ultra-pure water by middle of June
- July: fill of the TPC with depleted argon and start-up of data taking

## Outlook DS-5000





## Conclusions

The installation of the DarkSide-50 set-up is progressing at “full steam” with an impressive record of achievements over the past few months

The detector is ready to enter the full operative mode and data taking with the Depleted Argon will commence in the Summer