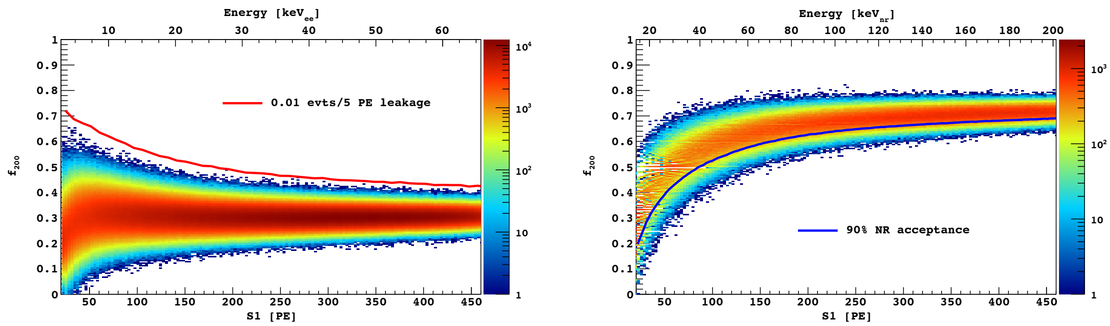


FIG. 112. **Left:** Distribution of f_{200} as a function of S1 for ^{39}Ar betas. The red line on the left plot shows the leakage curve for β's generated from the requirement of 0.01 events/(5-PE bin). **Right:** Distribution of f_{90} as a function of S1 for NRs. The blue curve delimits the 90 % NR acceptance region.

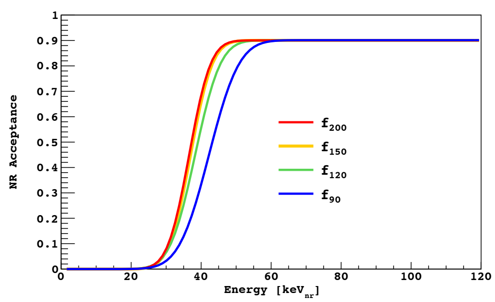


FIG. 113. Comparison of nuclear recoil acceptance bands for f_{90}, f_{150}, and f_{200}.

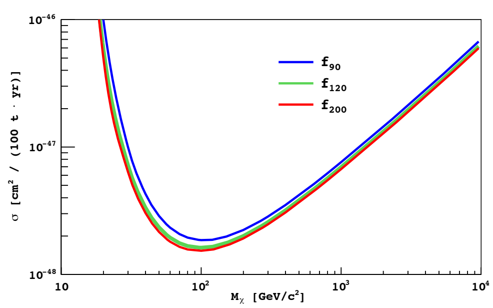


FIG. 114. Comparison of the projected sensitivity for DarkSide-20k as a function of the choice of f_{90}, f_{150}, and f_{200}as main PSD parameter.

XVII. FACILITIES, ASSEMBLY, ACCESS, AND INTEGRATION

A. Introduction

The DarkSide-20k facility consists of the LAr TPC and its cryostat and cryogenics and purification system; the surrounding active shielding and its fluid handling plants; the readout, data acquisition, high-voltage, and monitoring electronics; the calibration systems; and the availability of the cleanrooms with low radon content for parts preparation, assembly, and installation. A new water tank and a new stainless steel sphere must be built from scratch to host the WCV and the LSV: the prior experience of the DarkSide-50 construction will guide this process. Fig. 115 shows a 3D rendering of the major infrastructures required for DarkSide-20k.

Is WCV and LSV define somewhere else?

A key element in the strategy for rejecting background in DarkSide-20k is the use of high-efficiency neutron and muon vetoes. Based on the success of the current veto configuration for DarkSide-50 in maintaining a background free environment, the proposed detector design calls for deployment of the DarkSide-20k cryostat inside a newly constructed veto system.

The new stainless steel water tank will have a cylindrical shape 15 m in diameter and 8.5 m tall, with a dome-shaped ceiling having a radius of 7.5 m, and will be lined ~~in~~ Tyvek to improve the Cherenkov light collection. The total height of the water tank is 16 m. The new LSV will be 8.0 m in diameter, lined with Lumirror reflective foil to increase light collection. Both the WCV and the LSV will be equipped with 20″ diameter MCP-PMTs, as described in the Sec. X B. The WCV will be filled with ultrapure water and the LSV will be filled with the same boron-loaded liquid scintillator as was used in DarkSide-50, but with the TMB concentration optimized for the new detector.

with

For DarkSide-50, we built stainless steel-lined clean rooms and equipped them with an active radon abatement system to reduce the radon content in the air to the record level of 5 mBq/m^3, a factor 2×10^4 below the activity in the air of the Hall C of LNGS. For DarkSide-20k, we plan to use as a clean assembly space the floor of the water tank. The flow of radon-suppressed air will be provided by the radon abatement system of the DarkSide-50 clean rooms.

FIG. 115. 3D rendering of the DarkSide-20k detectors superimposed inside Hall C of LNGS.

FIG. 116. Geographic location of LNGS.

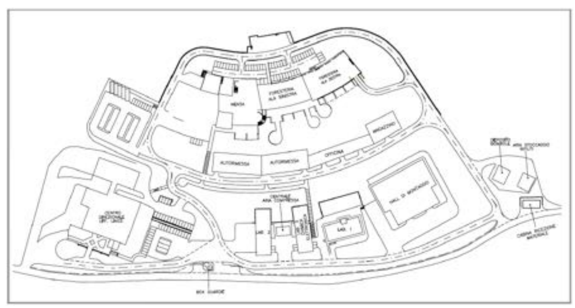


FIG. 117. Map of the LNGS External Laboratory.

I do not like saying "Most Important". What is the most important underground lab if I measure by Noble Prizes? Better to say "World's Premier"

B. The LNGS ~~External~~ Laboratory *

The Gran Sasso National Laboratory (LNGS) of the Italian National Institute of Nuclear Physics (INFN) is one of the most important worldwide underground laboratories. It comprises two main areas:

LNGS External Laboratory: Located in Assergi, a small village in the municipality of L'Aquila town in the Abruzzo Region, about 130 km East of Rome, at the foot of the Gran Sasso massif, with an altitude of approximately 900 m above sea level at its main entrance;

LNGS Underground Laboratory: Located at the km 124.2 of the highway A24 conencting Teramo and L'Aquila, in the middle of the 10.5 km long Gran Sasso Tunnel, with an altitude of 967 m above sea level at its main entrance, approximately 1400 m ~~under the~~ below the Monte Aquila peak of the Gran Sasso massif.

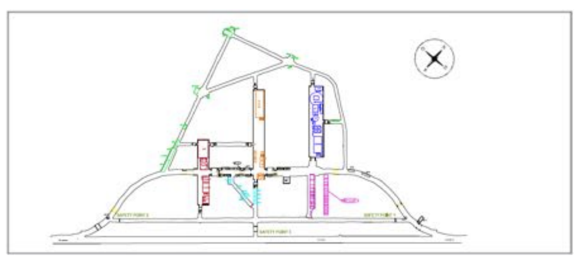


FIG. 118. Map of the LNGS Underground Laboratory and access highway tunnel.

The whole LNGS complex is sited inside the Gran Sasso and Monti della Laga National Park. Figs. **??**, 117, and 118 show the geographic position and the planimetric maps of the LNGS External and Underground Laboratories.

LNGS was conceived, designed, and built to provide large experimental halls well shielded by cosmic rays. The Underground LNGS Halls provide a

* Add a footnote reference to the LNGS website

What is meant by quiet? Cosmic ray quiet?

quiet place ideal to mount experiments dedicated to the study of neutrino physics, to searches of dark matter, and to precision measurements for nuclear astrophsyics.

New Section "External Laboratory"

The External Laboratory comprises several facilities and services, as described in the next paragraphs:

Chemistry Laboratory: The Chemistry Laboratory provides support to LNGS users for chemical and instrumental analysis. The services that it provides include precision cleaning of metals, components of plants or devices, and other kinds of materials. The Chemistry Laboratory also provides support for measurements with the following techniques: atomic absorption spectrometer (AAS); gas chromatography (GC); gas chromatography-mass spectrometry (GC-MS); UV-VIS spectrophotometry; spectrofluorometry; thermal ionization mass spectrometry (TIMS); inductively coupled plasma mass spectrometry (ICP-MS); high resolution inductively coupled plasma mass spectrometry (HR-ICP-MS). We note that the trace sensitivity for elemental (*e.g.*, U, Th, K, Pb) analysis can reach the level of 10^{-15} g/g with the ICP-MS and HR-ICP-MS units, which are both located inside a clean room. The Chemistry Laboratory can also provide support for development of new analytical techniques for preparation of samples with complex matrices.

This is somewhat contrary to the what is said in Sec. XV-D LNGS only reached ppb, where BHSU and PNNL reach ppt

"service" not "Service"

Low Radioactivity Service: The Low Radioactivity Service runs, in a dedicated room sited in the Underground Laboratory, the most sensitive HPGe counters in the world [174] and some of the most sensitive detectors for other forms of radioactivity [155, 175]. In addition, the Service provides support for: measurement of intrinsic radioactivity for selection of materials for the experiments under construction; measurement of natural radioactivity in environmental samples and building and construction materials; radon monitoring; development of ad-hoc detection techniques for ultra-low levels of radioactivity and rare nuclear processes.

Electronics Workshop: The Electronics Workshop provides users support for the following range of activities: design and implementation of analog and digital electronic devices; design and realization of programmable logic circuits; development of detectors and related front-end electronics; development of acquisition, monitoring and control systems; development of control systems with the LabView framework; design and management of monitoring and calibration devices for detectors; design and development of amplifier under Cryogenic environment; CAD support for the design and implementation of electronic circuits; support for the design, construction, and operation of data acquisition systems for the experiments; maintenance of electronic devices.

Comp. and Network Service: The Computing and Network Service is in charge of: management of the LNGS LAN network, its infrastructure, and security; management of the wireless network; connection to the external networks; electronic mail service mailing lists service; the "U-Lite" infrastructure providing central computing resources to the LNGS scientific community (public login, batch, backup); development and management of cloud and ad-hoc hosting services for experiments and groups; management of the web hosting system for the official web sites of services and experiments; management of the public videoconference and streaming systems; development and management of the official timing system. The Service also coordinates the Helpdesk service for computers support (including configuration, upgrades and antivirus installation). The Service is also continuously in contact with the experiments and organizes periodic meeting with the experiments' representatives to discuss and decide the evolution of the computing resources and services.

"Workshop" not "WorkShop"

Mechanical WorkShop: The Mechanical WorkShop provides support for the design and manufacturing of mechanical structures, mechanical components, vacuum and cryogenic circuits. The manufacturing is carried with a number of traditional manual and/or modern computer numerical control (CNC) machine tools. The design specializes with the 3D CAD CATIA V5 software.

Nuova Officina Assergi: The "Nuova Officina Assergi" is a new micro-fabrication and nano-fabrication laboratory conceived specifically to support the development and construction of the photodetector modules of DarkSide-20k. The facility and the equipment included in it are described in the companion document.

Is this an appendix? Needs better reference

C. The LNGS Underground Laboratory

The Underground Lab, whose map is show in Fig. 118, consists of three large experimental Halls, Hall A, Hall B, and Hall C, and a series of small interconnecting tunnels and service galleries. The main galleries are also known as the Interferometer Gallery, the Car Gallery, and the TIR Gallery. The Underground Laboratory is equipped with central services for distribution of fresh air, power, cooling water, and compressed air. ~~As mentioned above~~, Hall C is one of the three main Halls and currently hosts the experiments Borexino, OPERA, DarkSide-50 and the MiBeta test facility. Hall C has been identified by LNGS as the site candidate for the installation of DarkSide-20k. Hall C is 100 m

Not mentioned

long, 20 m wide, and has a vaulted ceiling with 20 m height. Fig. 119 shows the general layout of Hall C. Fig. 120 shows the current view from the Borexino building.

Hall C is equipped with the following devices and sub-systems: a double-hook (vaulted type) 20+20 t crane; a 25 t crane; a 5 t crane. a system of liquid sensors covering the perimeter of the Hall; a system of smoke detectors; a volatile organic carbon detector with multiplexed sampling points; a fixed foam fire extinguish system.

The ground floor of the Hall C is waterproofed, and a curb on its perimeter mitigates any possible flooding due to the release of ~~filling~~ fluids from the experiments. A metal grid placed on the floor "A collection of" at the south side of Hall C allows ~~to collect~~ up to $\sim$1000 m^3/h of liquid into a containment pit placed beneath the pavement. The ventilation system ensures $\sim$7000 m^3/h of fresh air and keeps the Hall C overpressure at a few mbar. Fresh air is delivered on the south side and removed from the north side. A ~~fan coils~~ system can help control the temperature in case of need. The north, south, and east entrances to Hall C are all equipped with fire-proof stainless steel doors.

~~Should~~ the experiment ~~be approved by LNGS, it~~ will likely be located in the South part of the ", which is" Hall C, currently housing OPERA experiment in decommissioning phase; the area will host also SABRE experiment. This location would be optimal from a logistics standpoint as it grants direct access to the TIR tunnel through the South entrance of Hall C, equipped with a double-containment fire-proof door that allows for truck~~s~~ access.

Fig. 121 shows a possible layout of the south part of the Hall C, ~~under the hypothesis of approval for installation of DarkSide-20k from LNGS.~~ In addition to the 15 m diameter and 16 m tall water tank, on the Hall C floor will be installed two argon recovery tanks. The core of the cryogenic system (cooling tower) as well as all DAQ electronics will be placed on a structure on the side of the water tank.

Fig. 122 shows a cross section of the apparatus with dimensions of the main detector. Fig. 4 and 123 show a 3D rendering of the DarkSide-20k detector. The large manhole that allows access to the water tank is shown in Fig. 124.

Fig. **??** shows the frontal view of the water tank, and allows to check the clearance between the tank itself and the vaulted crane. The bottom of the water tank will be equipped with a 8 cm thick stainless steel slab in order to provide additional shielding against γ-rays from the Hall C floor. The water tank "have" will also ~~be provided with~~ a $7.5 \times 6.0\,\mathrm{m}^2$ manhole, to provide maximal access within the tank itself.

Basic dimensions for the stainless steel sphere are reported in Fig. 122. The sphere will ~~be provided~~ "have" at the top with a 1.0 m diameter flange to allow the passage of all the cryogenics lines, process tubing, and LAr TPCcables. At the bottom, a large, 6.6 m diameter flange ~~to~~ provide maximal access for the insertion of the DarkSide-20k LAr TPC and for all installation purposes. At the very bottom of this flange, a smaller 1.0 m diameter flange is equipped with the feedthroughs for the penetration in the stainless steel sphere of the liquid cryogenic lines. Support of the stainless steel sphere will be provided by three legs welded on the WCV floor. A system of reinforced beams reaching from the top of the sphere to the top of the water tank dome will be included to handle the load in the off-case scenario in which the LSV is accidentally drained while the WCV is full of water.

The cryostat holding and leveling system will mirror the successful experience of DarkSide-50: the cryostat will be suspended from a system of three rods, penetrating through the stainless steel sphere via a leak-tight connection, and connected to the cryostat with rotatable joints. Leveling of the cryostat will be adjusted by turning the rods, with the precision of a fraction of a mm over the diameter of the LAr TPC. We are performing a study of the response of the system to seismic events, and are prepared ~~for the possibility~~ to introduce support tendons on the side and on the bottom of the cryostat if necessary to guarantee full compliance with the anti-seismic regulations.

DarkSide-20k will also host several calibration systems interfacing with the mechanical structures as described in Chapter XI.

The DarkSide detectors require extraordinarily low background levels. NSF funding augmented by considerable contributions of equipment and manpower from INFN and DOE and an ongoing major commitment by the LNGS have enabled the Borexino and DarkSide Collaborations to build a set of facilities in Hall C of LNGS that support development and operation of such low background detectors, and which were already ~~critical~~ for the success "crucial" of DarkSide-50. We will utilize anew many of the facilities listed below for DarkSide-20k:

High Purity Water Plant: For the filling and runtime purification of the DarkSide-~~50~~ 1000 t muon "20k" veto water tank we plan to use, as we did for DarkSide-50, the Borexino water purification plant. This consists of a special low pressure degassing system, a cascade of reverse osmosis columns, a deionizer, a set of ultra-Q filters, and a radon stripping column. It is capable of producing ultra-high purity water at the rate of 1 m^3/h. In addition, the Princeton group recently added a smaller water purification unit, consisting of a reverse osmosis column, a deionizer, and a small distillation column, capable of

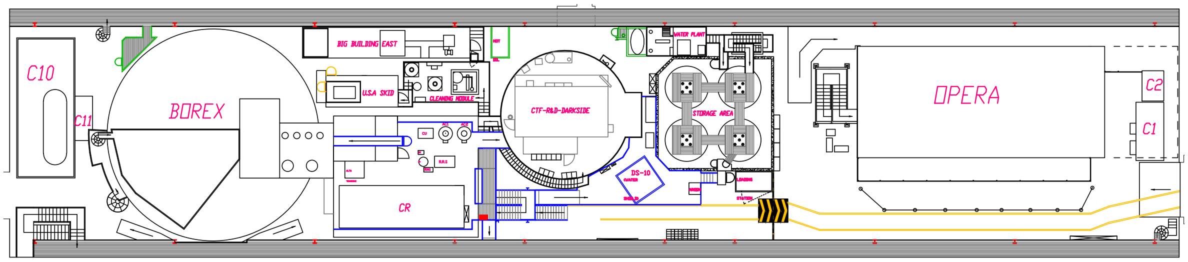


FIG. 119. General layout of LNGS Hall C.

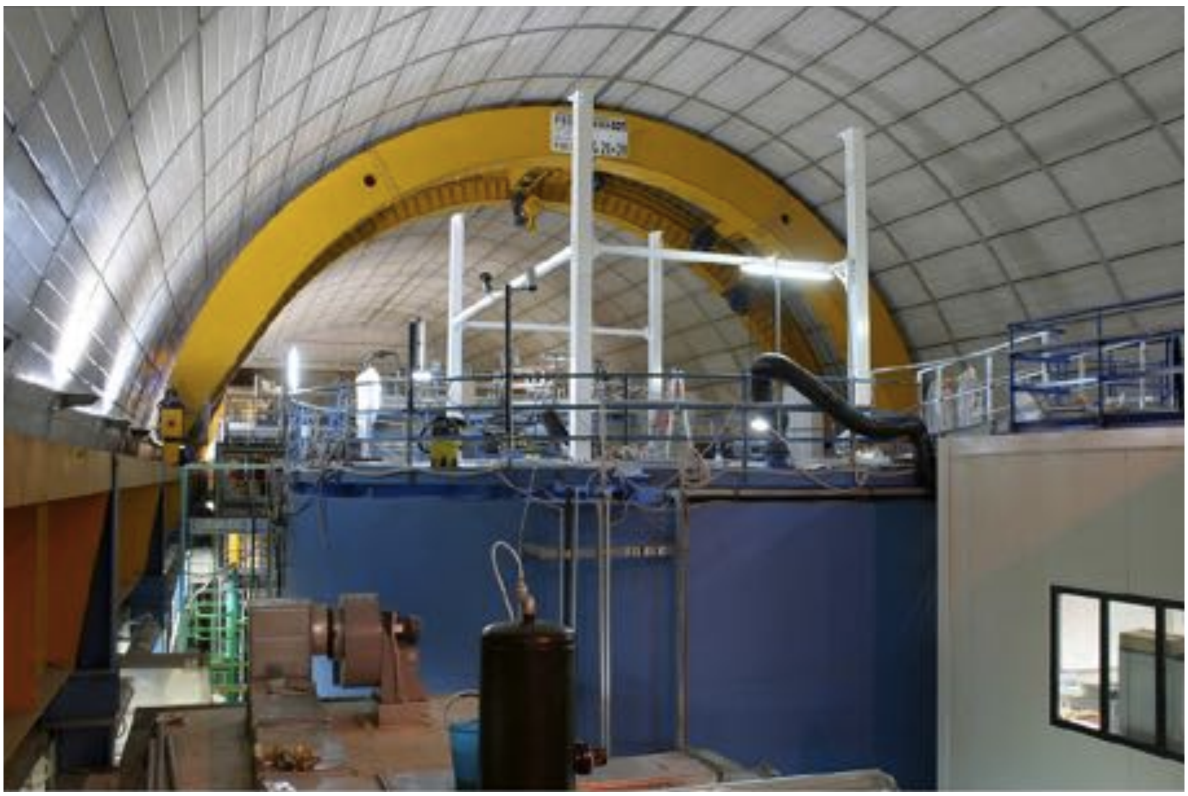


FIG. 120. The current view of Hall C from the Borexino building. The blue CTF water tank hosts the DarkSide-50 experiment.

treating a flow rate of about $0.1\,\mathrm{m}^3/\mathrm{h}$. Feeding the Princeton unit with ultra-high purity water from the main plant we achieved very low levels of contamination in ^{210}Po and ^{210}Pb, which will be useful in "DarkSide-20k" ~~DSk~~ for on-site precision cleaning of process lines, tanks, and detector parts (see below).

Cleaning Module: The water purification plants feed a cleaning module, which can prepare and filter heated acidic and chelating solutions for pickling, passivation, and precision cleaning of components. The combination of the ultrasonic cleaning bath ($61 \times 66 \times 46\,\mathrm{cm}^3$) and a properly sized HDPE tank will permit the use of the cleaning module for precision cleaning of some of the DarkSide-20k components, as it was done for DarkSide-50.

What does "properly sized" mean? suggest removing

Scintillator Storage: As we did for DarkSide-50, we will use two or three of the four $100\,\mathrm{m}^3/\mathrm{h}$ storage vessels formerly used for storage of the Borexino scintillator to store the DarkSide veto scintillator. The scintillator has already been delivered and is used now in ~~use for~~ DarkSide-50.

Purification Plants: Over the span of ~~twenty~~ "20" years, the Borexino collaboration has developed a very sophisticated set of process-plants for scintillator purification. In order to prevent possible con-

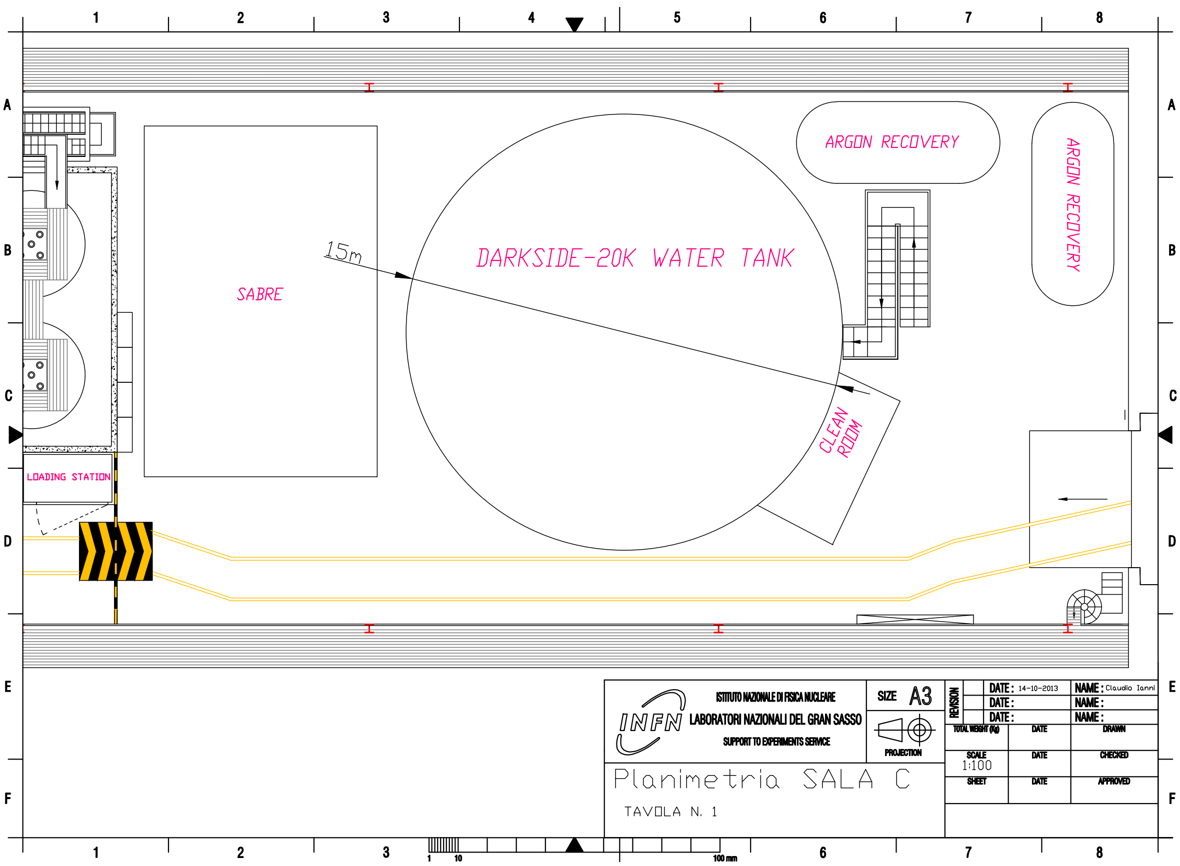


FIG. 121. Possible layout of the south part of Hall C for DarkSide-20k installation at LNGS.

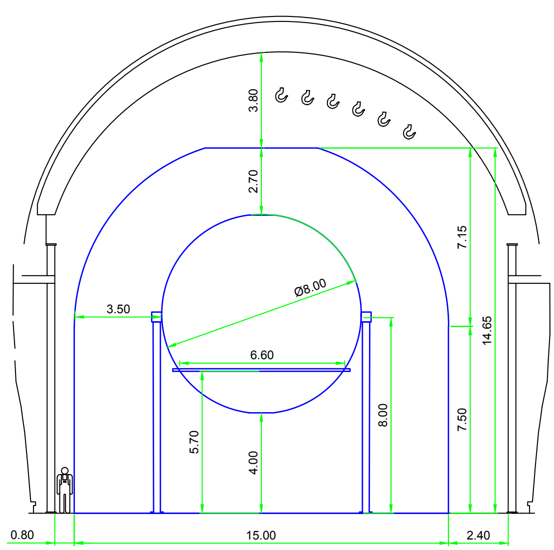


FIG. 122. Cross section of DarkSide-20k with dimensions of WCV and LSV. All ~~quotes~~ “units” in m.

tamination of these delicate Borexino systems, we procured for use in DarkSide-50 an independent small set of purification units (distillation, N_2 stripping) capable of treating the DarkSide-20k scintillator (or its individual components) at a rate of $0.1\,m^3/h$. We plan to keep using the same unit for scintillator purification in DarkSide-20k, with the possibility for upgrading the present system. Should “the” addition of fluors to the scintillator be required, we plan on using the Borexino mixing unit as we did for DarkSide-50.

LN_2 Systems: The $30\,m^3$ Borexino system for storage of liquid nitrogen, including storage of high-purity LN_2 with reduced contamination of ^{39}Ar and ^{85}Kr, is available for use by DarkSide-20k. For DarkSide-50, we built an LN_2 line to provide automated feed to all end user points. For DarkSide-20k, we plan to complement it with a recondensing unit, capable of liquefying and recovering the N_2 vapor.

Buildings: The Borexino Big Building West (BBW) houses the DarkSide control room and the counting room for the muon and neutron veto. The Borexino Big Building East (BBE) houses the DarkSide scintillator purification units, the main

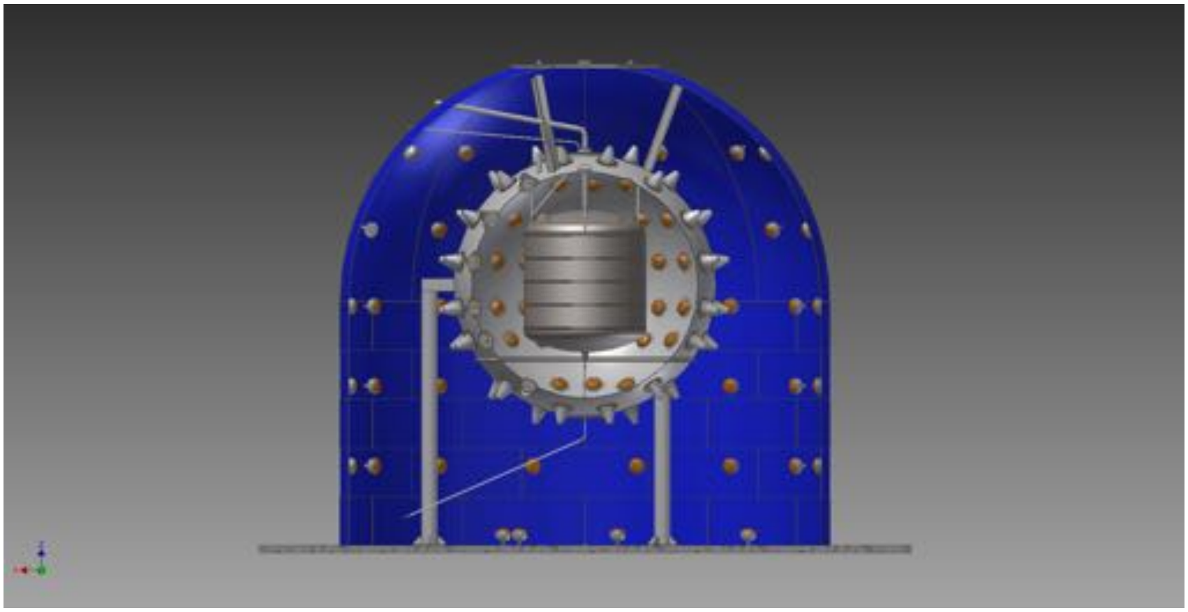


FIG. 123. Cross sectional view of DarkSide-20k through a plane in front of the DarkSide-20k LAr TPC, showing the water tank and the WCV detector, the stainless steel sphere and LSV detector, and the DarkSide-20k cryostat and LAr TPC.

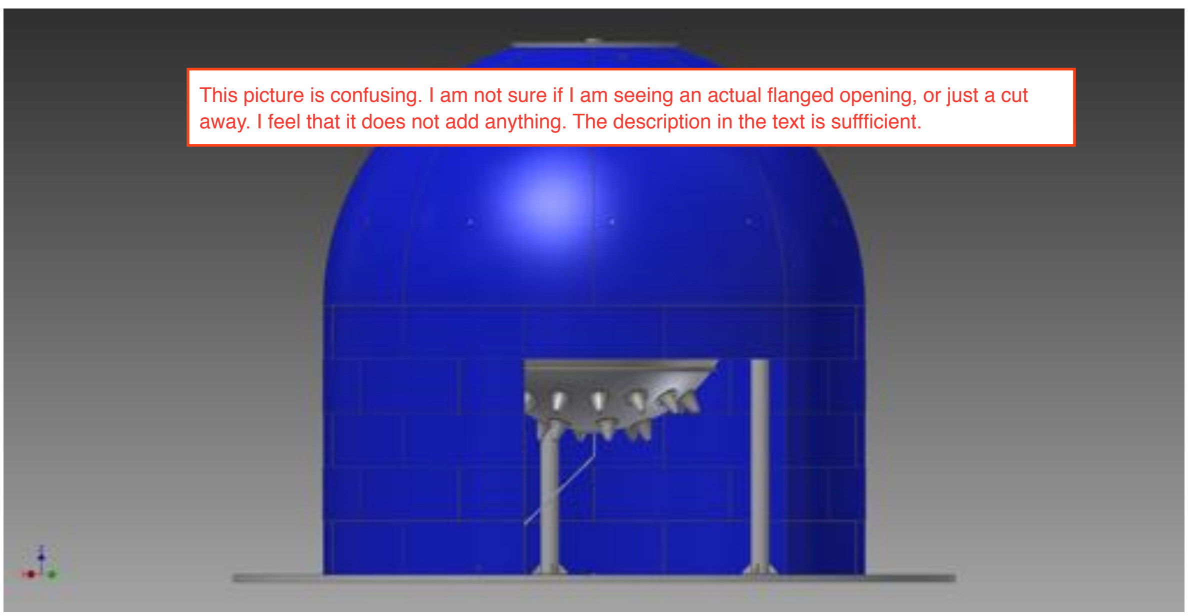


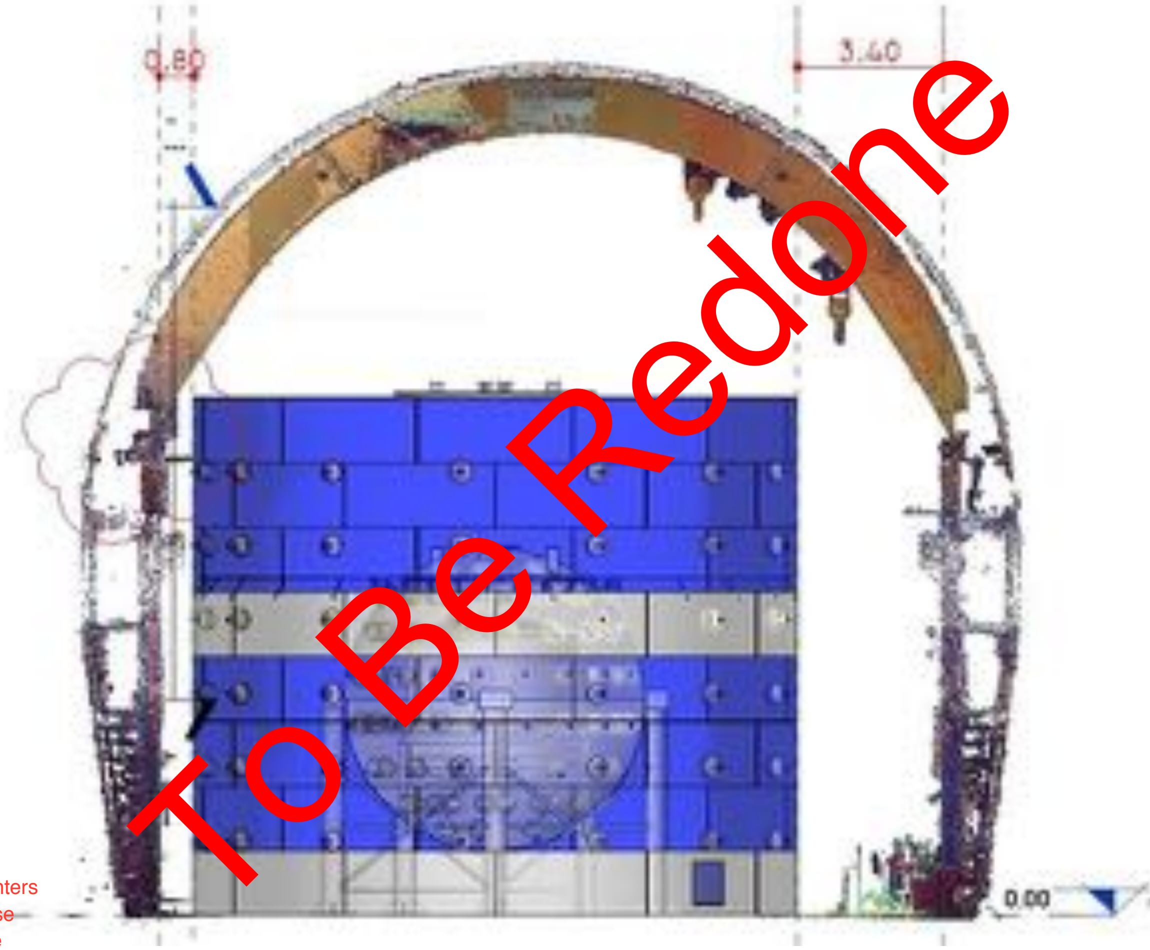
FIG. 124. 3D rendering of DarkSide-20k with detail of the man hole allowing access inside the water tank.

vessels of the DarkSide scintillator loop, and the interconnection system between the DarkSide scintillator loop and the Borexino scintillator purification plants.

Radon Abatement System: The DarkSide collaboration has installed and commissioned an air treatment unit which processes air from the LNGS Hall C at a rate of $230\,\mathrm{m}^3/\mathrm{h}$, reducing radon by a factor greater than 1×10^5 and delivering radon-suppressed air to the DarkSide clean rooms with residual ^{222}Rn activity below the level of $1\,\mathrm{mBq}$.

Radon-Suppressed Clean Rooms: Nuclear recoils from α decays on the innermost surfaces of

To Be Redone



“, and the daughters of radon on these surfaces are the biggest source for this background.”

FIG. 125. Front view of the DarkSide-20k water tank and of the Hall C vaulted crane.

dark matter detectors are a pernicious source of background for direct dark matter searches. The DarkSide collaboration has built in Hall C of LNGS two radon-suppressed clean rooms (Fig. ??). These rooms receive all their make-up air from our radon abatement system and are almost completely lined with stainless steel panels to limit radon emanation from the walls. The concentration of radon in the clean rooms is below 5 mBq/m^3 (a factor 2×10^4 suppression relative to the Hall C air). The first ^{222}Rn suppressed clean-room (<1 Bq/m^{3}of air) in the world was built at Princeton University in 1998–99 for the construction of the Borexino nylon vessels, achieving surface activities of <10 α's/(m^2·d) [176], later also achieved for the SNO NCD detectors [177]). The DarkSide clean rooms have reached a ^{222}Rn level lower than the Princeton clean room by more than two orders of magnitude. The clean room CR1 contains the equipment used for the cleaning and preparation of the DarkSide-50 LAr TPC parts: the already mentioned HDPE tank and ultrasonic cleaning bath; an Ultra-High-Vacuum (UHV) evaporator (vacuum chamber: 127 cm diameter, 84 cm height, baseline vacuum: 10^{-8} mbar) to coat the innermost surface of the LAr TPC with TPB wavelength shifter; and a vacuum oven ($66\times66\times66$ cm^3). The clean room CRH is located on top of the CTF tank and gives direct access into the muon and neutron vetoes through their top flanges. It has a 6 m vertical clearance, and is served by a 5 t crane to permit assembly and installation of the DarkSide-50 LAr TPC in a radon-free environment.

It seems wrong to not mention the NEMO system

Radon Detector The DarkSide collaboration, with funding from the NSF G2 R&D and from the Jagiellonian University of Krakow, Poland, has installed and commissioned an electrostatic ^{222}Rn detector, inspired by Refs. [178, 179]. The detector consists of a stainless steel chamber in which a silicon diode α detector is electrically biased to act

Is this my diode?

as an ion collection electrode, attracting mobile α-emitting radon daughters. Samples are introduced via intake and exhaust plumbing, a sampling pump (which can also be run in recirculation mode) and a drier for the input air stream. The care in design and construction allowed the sensitivity goal of about 100 µBq/m^3 needed to monitor the Radon-suppressed air to be achieved. The chamber is connected through a manifold to the output of the radon abatement system and to the CR1 and CRH clean rooms, so that it can continuously monitor ^{222}Rn levels at the output of the radon abatement system or directly in the two clean rooms.

What gas? Hall C gas?

Gas Exhaust Plant: All gas exhausts are connected to a negative pressure which directs all the exhaust gases through a carbon filter and purified before being released to the environment (motor way tunnel).

change "PC" to "liquid scintillator"

Blow Down: ~~All~~ PC vapors from bursting discs of PC storage tanks and other containers are collected and recovery into a tank filled with ~8 m^3 of water and a no-structural packing metal ring.

Nitrogen Supply System: Hall C is equipped with three different nitrogen supplies, shared by the experiments Borexino and DarkSide-50: Regular Nitrogen (RN2), High Purity Nitrogen (HPN), Low Ar/Kr Nitrogen (LAKN). All the previous N2 System are ~~hosted in the Tir Gallery~~.

Replace with "housed just outside of Hall C in the underground lab"

Regular Nitrogen (RN$_2$): This is a conventional liquid nitrogen storage tank with a heater to provide boil off nitrogen for pneumatic instrumentation, routine purging of gas lines. Regular nitrogen is standard grade liquid nitrogen from Linde;

High Purity Nitrogen (HPN): This is mainly used for the gas blankets in the Borexino/DarkSide-50 PC storage area, in the gas stripping operations of the water and for other operations. Radon is being removed from the regular nitrogen by adsorption onto a low temperature adsorber (LTA), *i.e.* high purity activated carbon adsorbent at 77 K, to reduce the ^{222}Rn concentration in the nitrogen by approximately a factor of 100. The LTA facility is installed in the entryway to Hall C;

Low Ar/Kr Nitrogen (LAKN): This is special nitrogen supplied by the SOL group that was tested to have much lower levels of Ar and Kr than found in standard commercial liquid nitrogen. The nitrogen does not need any further purification and is supplied to the Hall C gasified by an heater. This nitrogen is used for blanketing of the scintillator, for gas stripping of pseudocumene, during Bx/DS-50 purification and as a service nitrogen for the DarkSide-50 cryogenic system.

D. Detector Assembly and Installation Sequence

Any kind of construction will start in accordance with LNGS, and after a deep review of the project with all the technical documentation available.

The complete assembly of the detectors (water tank, stainless steel sphere, and cryostat) will start with the realization of all the foundation anchor points for the water tank, followed by the construction of the water tank itself. As was done for DarkSide-50, the collaboration will try to minimize the quantity of dust during all construction and assembly phases.

WHY?

The LSV stainless steel sphere will be then be built inside the water tank, by welding in place pre-formed stainless steel sheets brought into the water tank through the man hole, like we did for DarkSide-50. The material for the stainless steel sphere will be carefully screened, as done for DarkSide-50, including the legs and reinforced beams on top. Particular care will be devoted to the realization of the large flange that will allow the insertion of the cryostat (usually any flange is done using forged steel from waste material, which requires particular care to identify radio-pure material).

"Manhole" not "man hole"

reference sec. XV

I do not understand what this means. What waste?

Given the larger size of the TPC, it is foreseen that the new water tank itself will be turned into a clean room that could house the final assembly of the DarkSide-20k TPC. Thus, once the water tank and the stainless steel sphere will be ready for beginning of detector assembly, they will be connected with radon abatement system already installed in Hall C. Special removable tent and HEPA filters will be utilized to create a clean environment before entering the two main vessels. The installation of the cryostat and any other kind of operation that will involve the assembly of the LAr TPC will be performed using the two volumes contained within the water tank and the stainless steel sphere as radon-abated clean room spaces.

At this point, reflective Tyvek sheets will ~~be~~ line the interior walls of the water tank and the interior and exterior walls of the stainless steel sphere.

The cabling installation, the water tank 20″ PMTs the Tyvek installation to cover the internal surface and all the remaining components will be installed during the final phase of installation and before starting the liquid fill tests.

The main flange of the LSV will be located on the bottom of the vessel, allowing for the TPC assembly to be done at the ground level of the water tank. After its completion, the LAr TPC will be shifted to ~~on~~ the bottom of the stainless steel sphere and then raised in place at the center of the sphere. The installation sequence for the cryostat is pictured

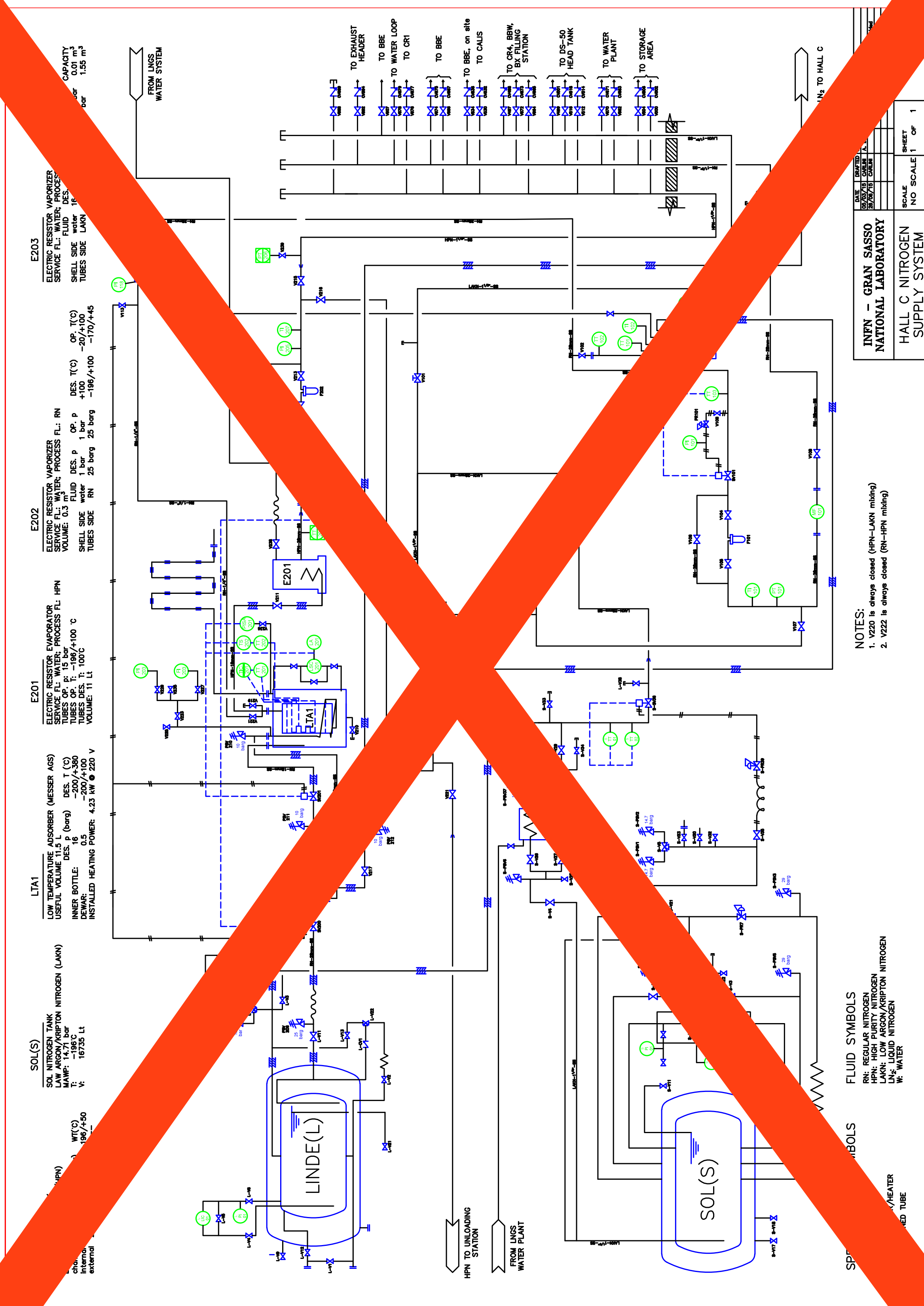


FIG. 126. Flow diagram for the nitrogen storage and supply system underground at LNGS.

I don't see that this diagram is referenced anywhere, and I think it is far more detail than is required. If it will not be referenced, then it should be removed.

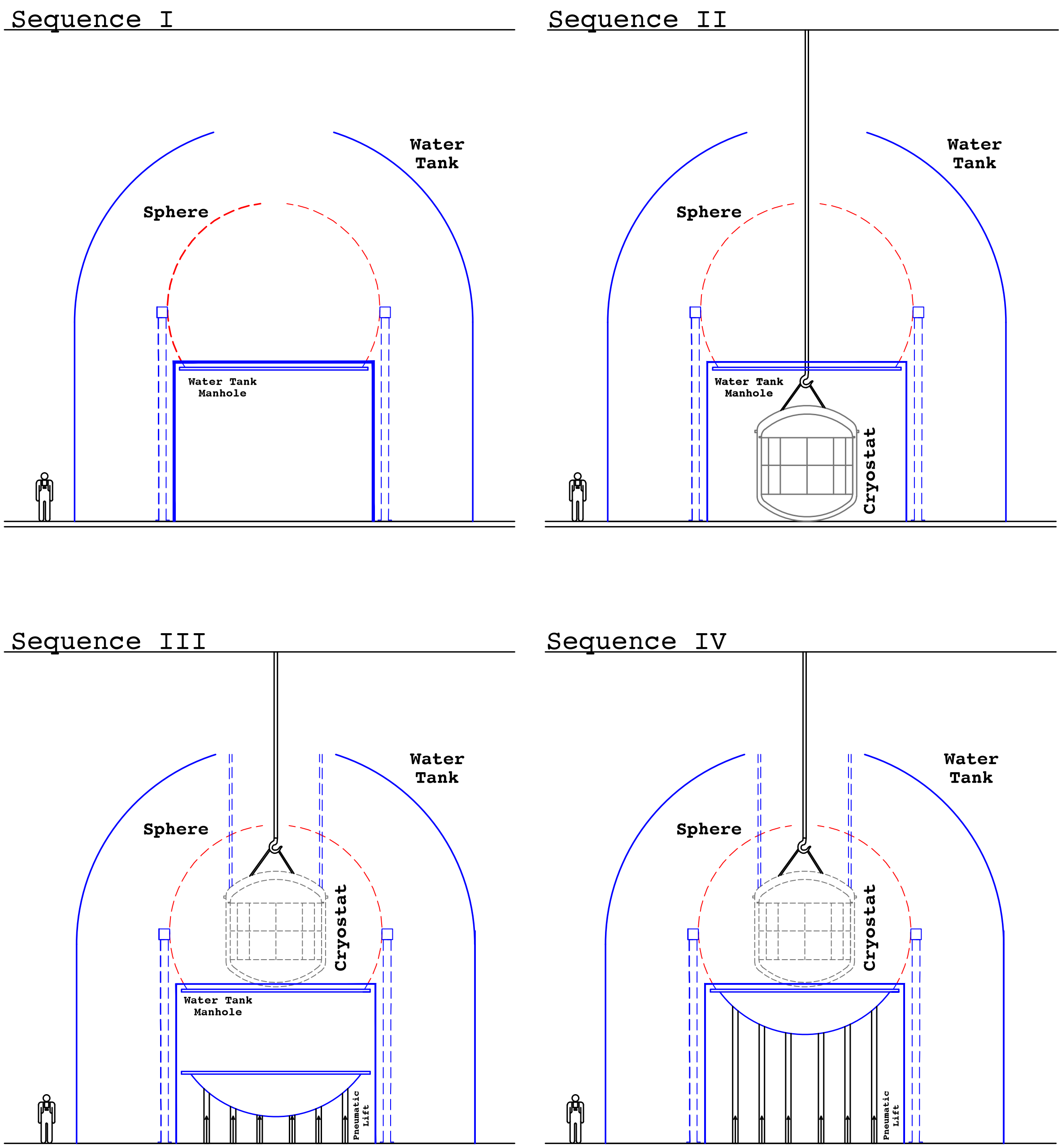


FIG. 127. Schematic drawing of the cryostat installation sequence.

“system”

in Fig. 127. In order to move the cryostat, we envision using a temporary rail to transport the cryostat first into the water tank, then under the stainless steel sphere, where it would then be anchored to the main 20+20 t crane, to be lifted in its position at the center of the stainless steel sphere. At that point the connections of the LAr TPC with the cryogenics, process, and signal lines, will be completed. The mounting scheme of the LSV PMTs allows for the LSV PMTs to be mounted (and their connection to the LSV leak checked) after all other work has been performed inside the LSV and the main flange has been sealed.

TABLE XVII. Scintillator Inventory Required ~~for the LSV.~~

PC	TMB	PPO
250 t	13 t	580 kg

E. Scintillator Procurement and Purification

DarkSide-20k scintillator will be the same solution in ~~use for~~ DarkSide-50, composed ~~by~~ of 1,2,4-TriMethylBenzene (PseudoCumene or PC), TriMethylBorate (TMB), and 2,5-DiPhenylOxazole (PPO). Table XVII reports the inventory required for each scintillator component, under the assumption that the solution will contain 95 % of PC, 5 % of TMB, and about 2 g/L of PPO. The inventory in Table XVII also accounts for a 10 % possible loss during purification and a 5 % contingency margin.

Apart from ~~for~~ the presence of TMB, the scintillator is the same used in the Borexino Experiment [129] and the purifications of the scintillator could be performed using the same Borexino plants [180]. The DarkSide-20k and Borexino management are discussing various possible agreements to use the Borexino plants and possibly also the Borexino scintillator. At the moment there are three possible scenarios ~~are possible~~:

1. In the first case, the DarkSide Collaboration is allowed to use both the Borexino scintillator and purification plants. This could happen if, for example, Borexino were already decommissioned at the time of DarkSide-20k filling. In this case, the DarkSide Collaboration could use the PC from Borexino and store the ultra-pure scintillator in three of the four Borexino storage vessels. The Borexino scintillator will Text not need any re-purification, and could be used straight to fill the DarkSide-20k LSVafter mixing inline with the TMB (and adding PPO if required). DarkSide-20k would have to procure the necessary TMB, following tests to verify the ^{14}C content in the TMB, and the TMB could be either stored in a Borexino storage vessel or directly purified from the delivery tank. The TMB would be added inline, after being distilled in the Borexino plants. The scintillator could ~~be~~ eventually be purified by recirculating it from the LSV through the Borexino plants and back into the LSV. The Borexino scintillator has a PPO concentration of 1.5 g/L: if need be, the PPO can be first prepared in a highly concentrated solution ("Master Solution") with the Borexino dedicated plant, then added inline, or during recirculation.
2. In the second case, the DarkSide Collaboration is allowed to use the Borexino purification plants but not its scintillator. In this case, the DarkSide Collaboration will have to procure the PC, the TMBand the PPO. Procurement and preparation of the TMB and of the PPO follows as per the previous case. Nowadays, PC is produced only in China but it is commercialized by few European and American companies. If PC were to be delivered in 20 m^3 iso-tanks, as it happened for Borexino, 8 to 13 shipments will be needed. Mindful of the Borexino experience, it is practical to receive at LNGS 3 shipments per week, thus the delivery can be completed within one month. Contacts with some PC distributors are being established. Once the PC enters the Lab, it will be unloaded using the Borexino unloading station and stored in three of the four Borexino storage vessels. The DarkSide-20k filling would be done by distilling the PC in the Borexino skids and adding PPO and TMB inline, following the same prescriptions and recipes in use for the first case.
3. In the third and last case, the DarkSide Collaboration is not allowed to use neither the Borexino purification plants nor its scintillator. As for the second case discussed above, the DarkSide Collaboration will need to procure the PC, the TMB and the PPO. We would still plan to use the Borexino storage vessles and unloading station to receive and store the scintillator components. For their purification, we will make use of the multipurpose distillation, able to process PC and PC-based solutions, built by the DarkSide Collaboration for DarkSide-50. The plant was designed to handle the small quantities of scintillators typical of DarkSide-50 and its use on a larger scale would need a detailed assessment, and possibly a major upgrade with a larger unit.

XVIII. SAFETY AND ENVIRONMENTAL ASPECTS

A. Introduction

The DarkSide Collaboration aims at establishing outstanding performance in matters of Health, Safety and Environment (HSE). The whole experimental collaboration is involved in the effort to achieve these targets. During the DarkSide-50 installation at LNGS, the collaboration acquired a strong safety background. We can rely on skilled researchers, technicians and professionals with proven experience in the design, construction, commissioning and operation of complex plants. All aspects of the experiment, both technical and managerial, are handled in conformity to all applicable US, European and Italian HSE Regulations and Standards, as well as the LNGS internal guidelines and proce-

If there is a real possibility that only the DS-50 scintillator purification system will be used, then more detail is needed.
- How long will it take to purify the scintillator for DS-20k?
- What is needed to upgrade the system?
- etc..