Napoli, February 20th, 2003
ICARUS Collaboration Meeting

T600 @ LNGS

Cryogenics and Safety

Very recent fundamental progresses for the T600 installation in Hall B:

- **Air Liquide "definitive" Site Project for Hall B was completed at the end of 2002** and was presented and delivered to LNGS Technical Authorities (Director and all the Heads of the Technical Services) on December 11th 2002 (next part of the talk).

- **NIER** Engineering Company completed and delivered the "**S**afety **R**isk **A**nalysis" **(SRA)** for the ICARUS plant (T600 and future expansions) **to LNGS on November 14th 2002** (First version) **and on February 5th 2003** (Second version).

- SRA has been developed thank to a strict and productive correlation between NIER and Air Liquide. Many improvements were inserted in the project by AL engineers coming from suggestions in matter of safety given by NIER.

➢**Air Liquide Site Project for Hall B was discussed with LNGS Technical Authority on February 5th 2003**

➢No specific problems arose in the discussion

➢The opinion of the Services on the Documentation and the Project was very positive

➢Necessity to ask for the authorisation for the use of the anti-seismic shock adsorbents to "Consiglio Superiore dei Lavori Pubblici" Authority (request that has to be presented by INFN President/LNGS Director)

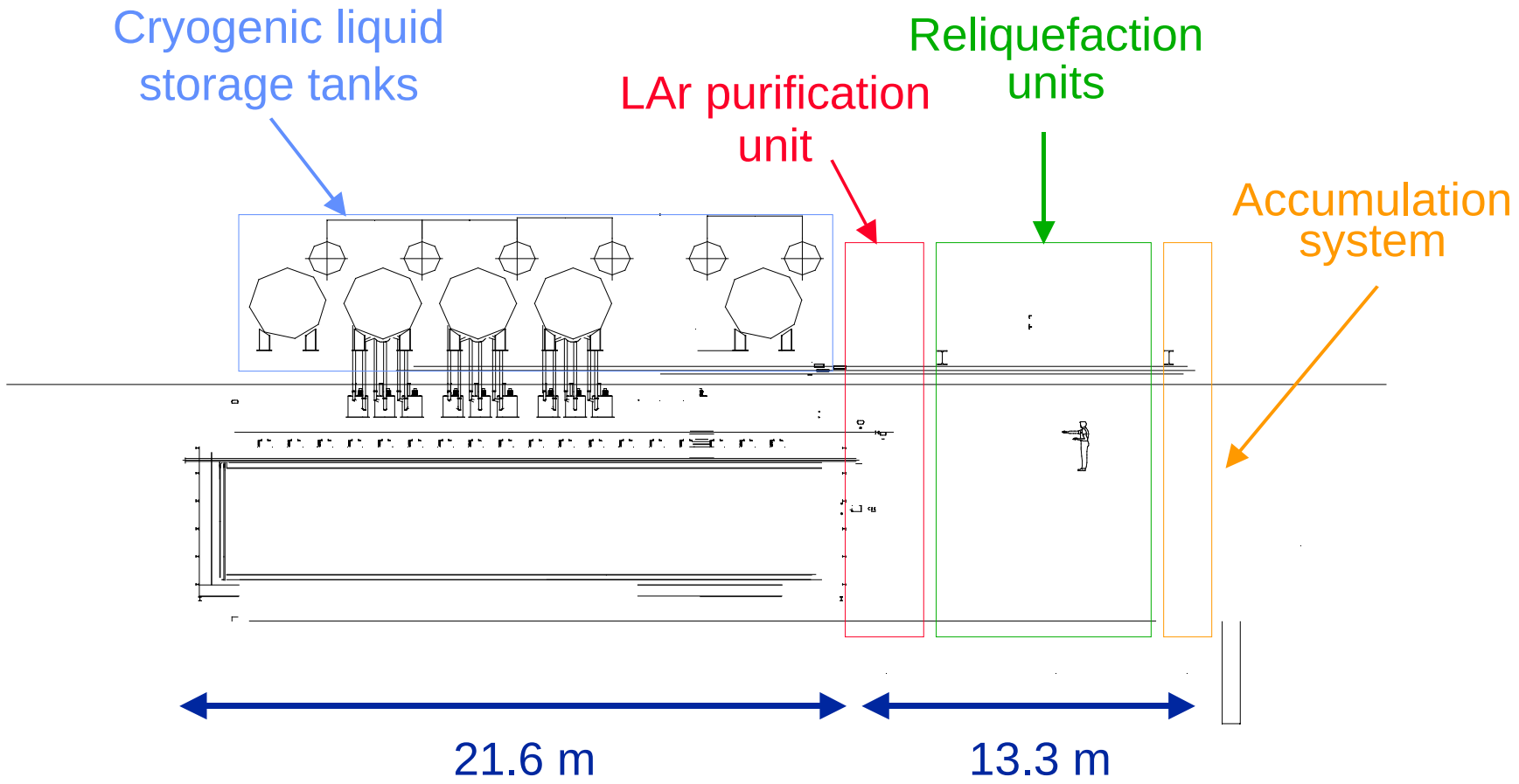
➢Different seismic spectra ("Bettini MCE")

➢Particular apparatus (experiment)

➢The Director prepared a letter to certify his positive answer to the AL documentation (February 13th, 2003)

☞ **approved by the LNGS technical Authorities**

T600 & Auxiliary services (I)

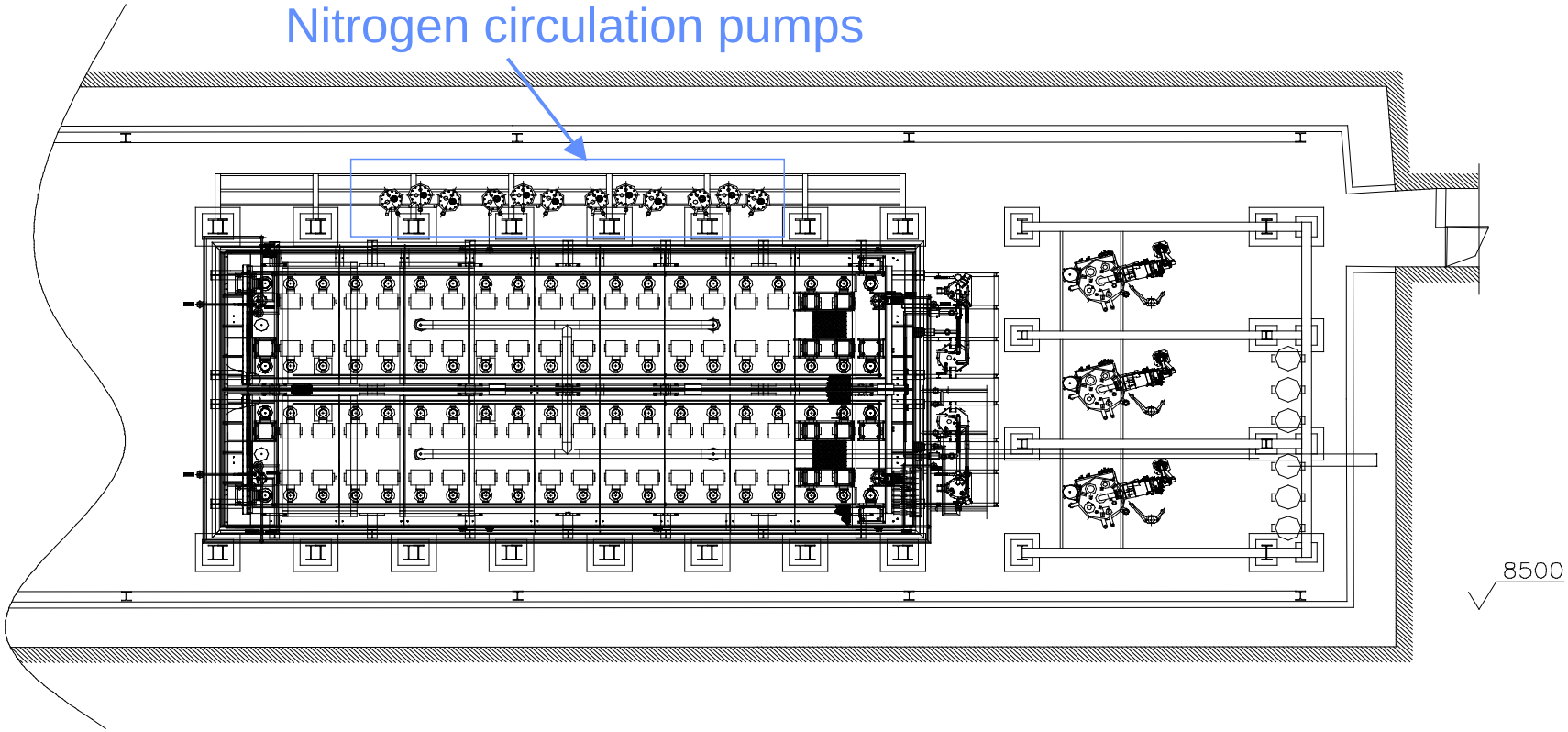


In Hall B 58 m are left for the T600 construction and run (Phase 1)

All the auxiliary services for the T3000 are located in the T600 area:

- **At the end of the Hall: 3 reliquefaction units + 2 or 3 accumulator systems**
- **Over the top of T600: 4 LN2 (1xT600, 2x2T1200, 1 back-up) + 1 LAr storage tanks (25000 l each) + 12 Nitrogen circulation pumps (3xT600, 6x2T1200, 3 back-up)**

T600 & Auxiliary services (III)



The Nitrogen circulation pumps for cooling the whole T3000 are located in the T600 area:

- **3xT600, 6(2x3)x2T1200, 3 back-up**
- **For each triple 2 pumps are for the 300 t cryostats' cooling (alternatively working) + 1 for the cooling of the Argon purification systems**

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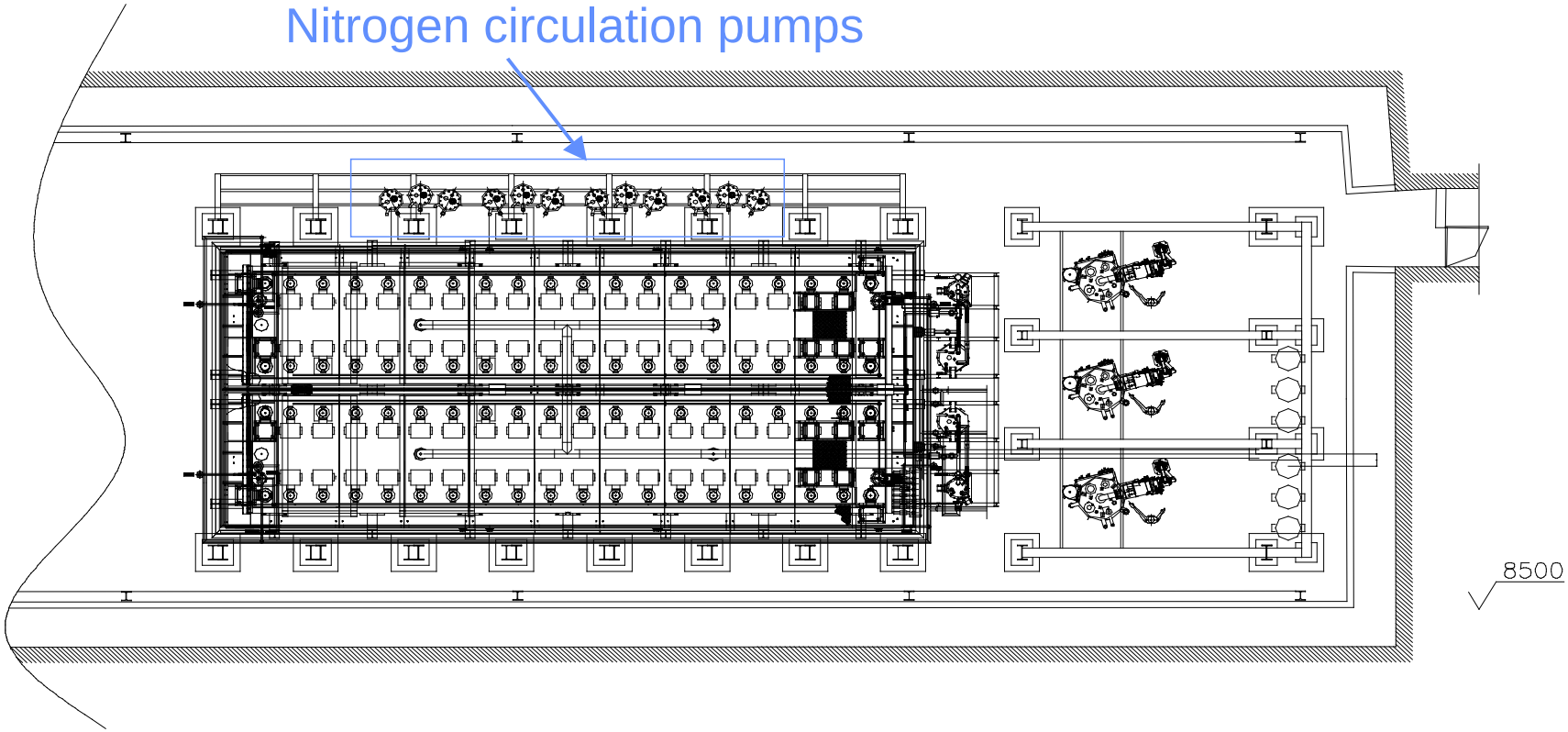

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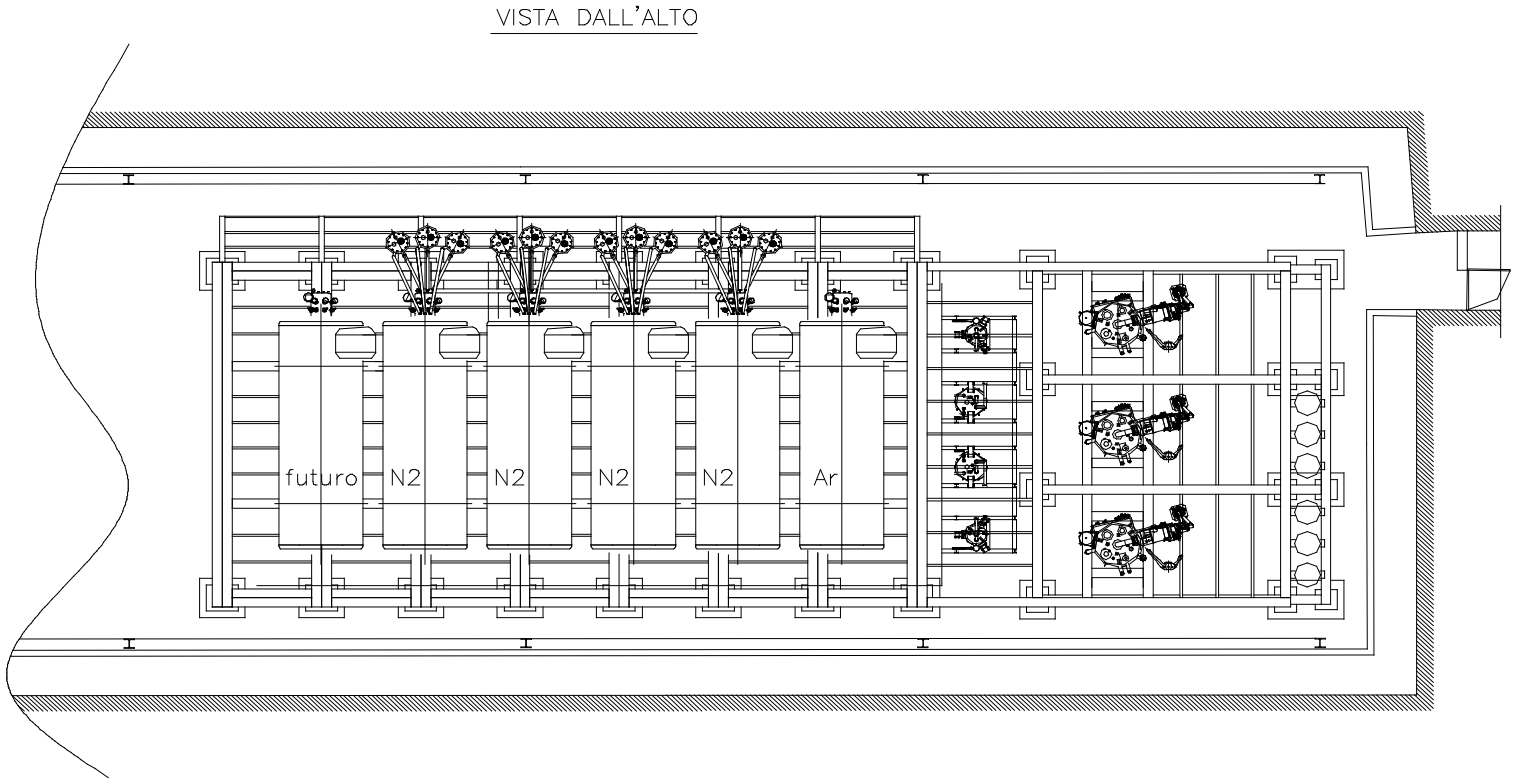
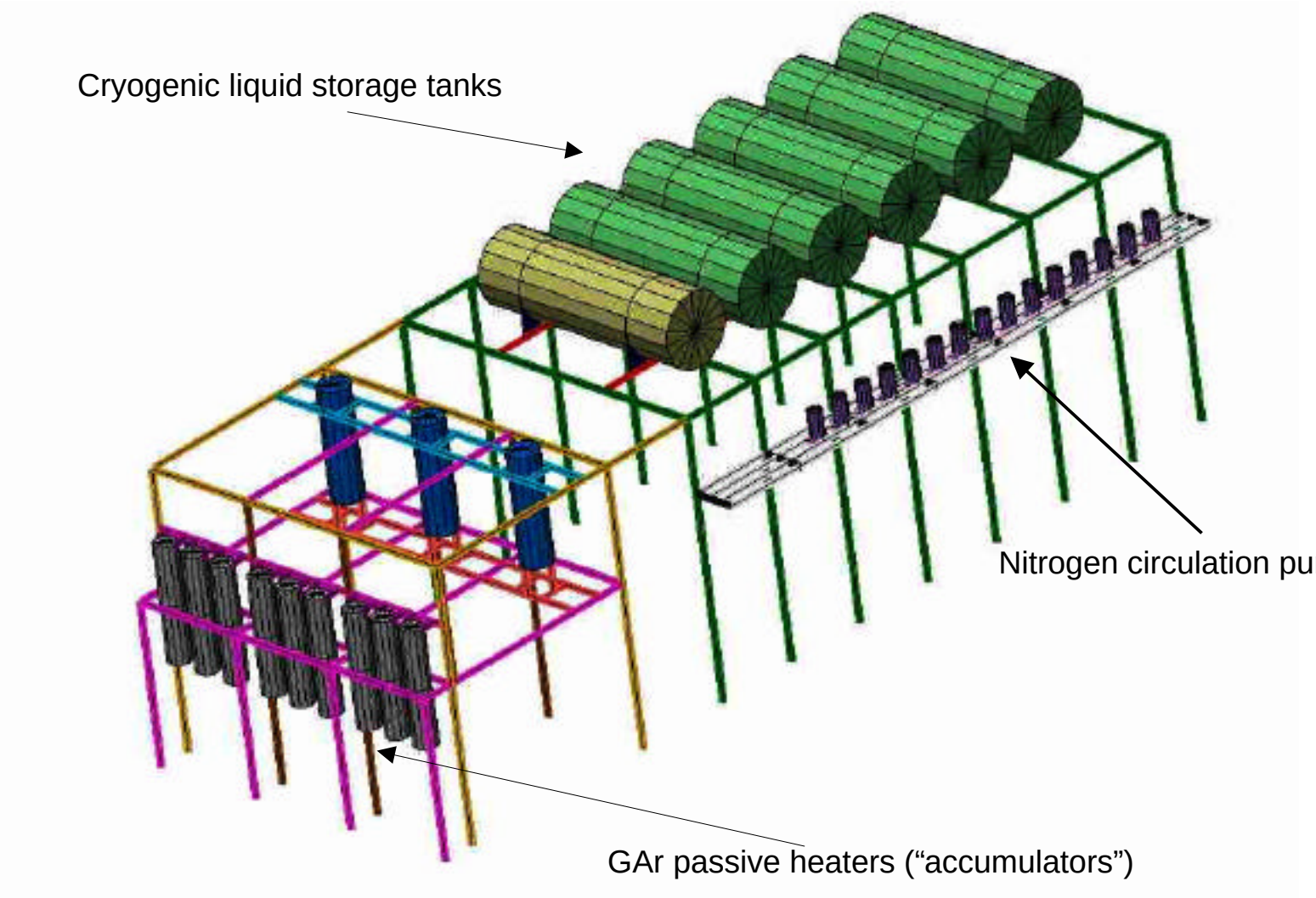
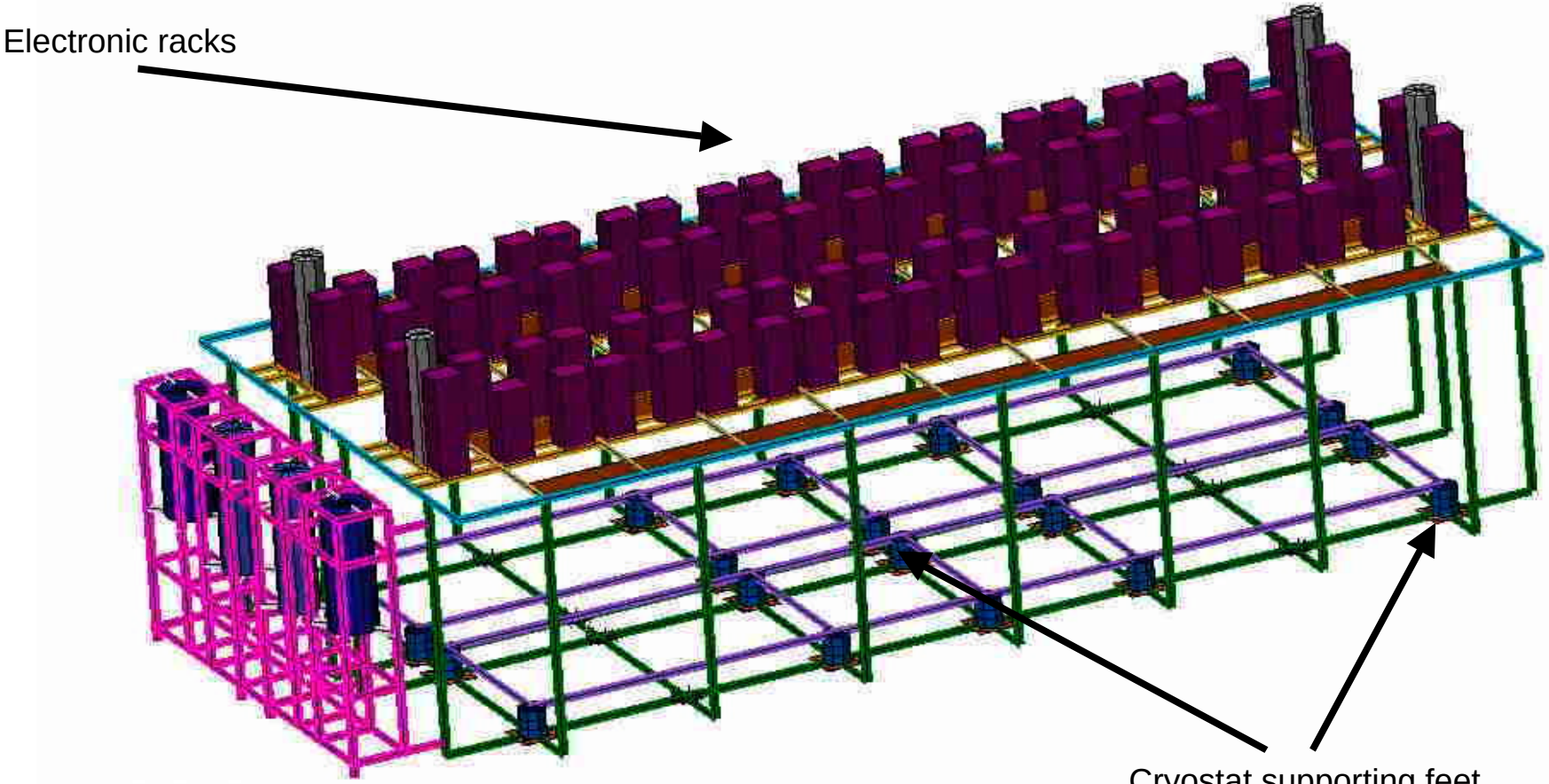
T600 & Auxiliary services (IV)



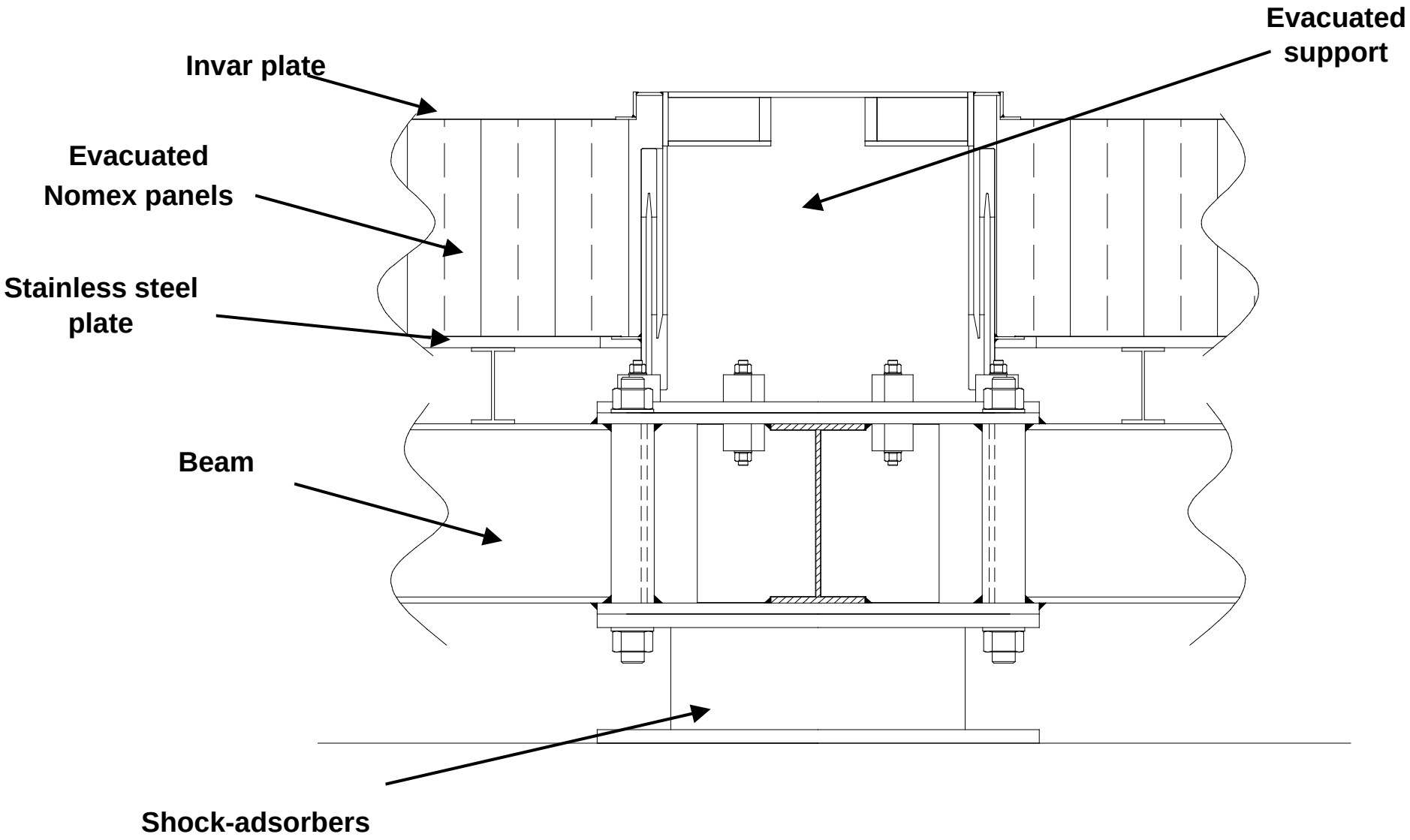
T600 Auxiliary services sustaining structure

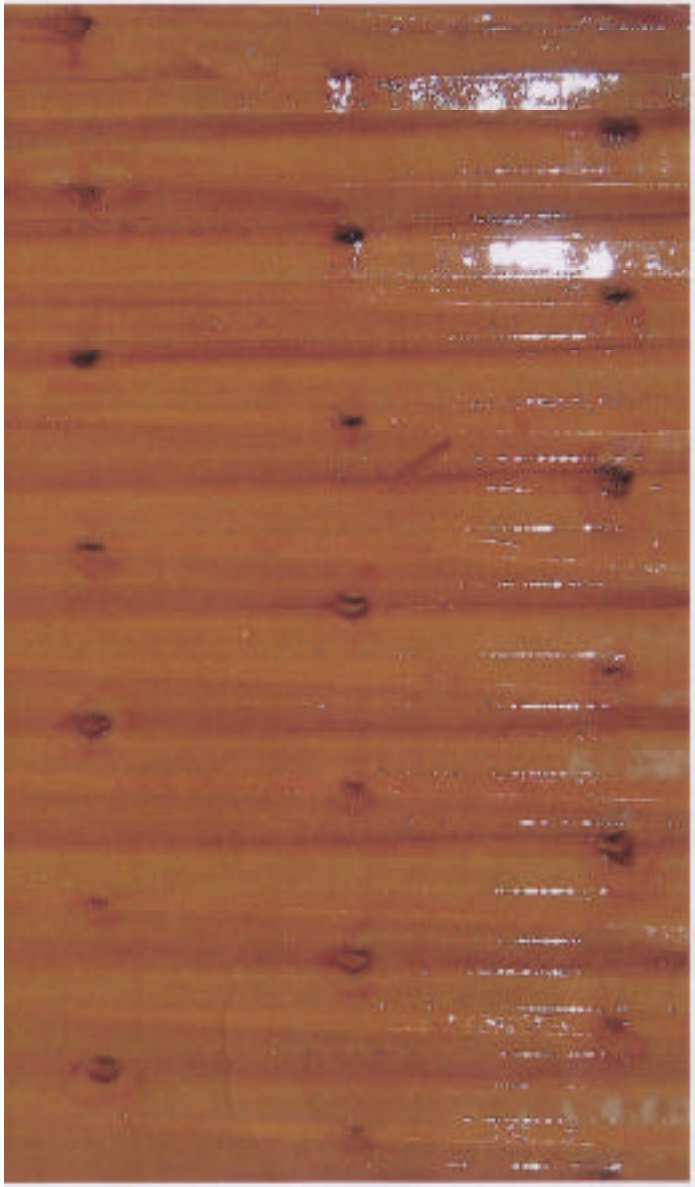


T600 electronics sustaining structure

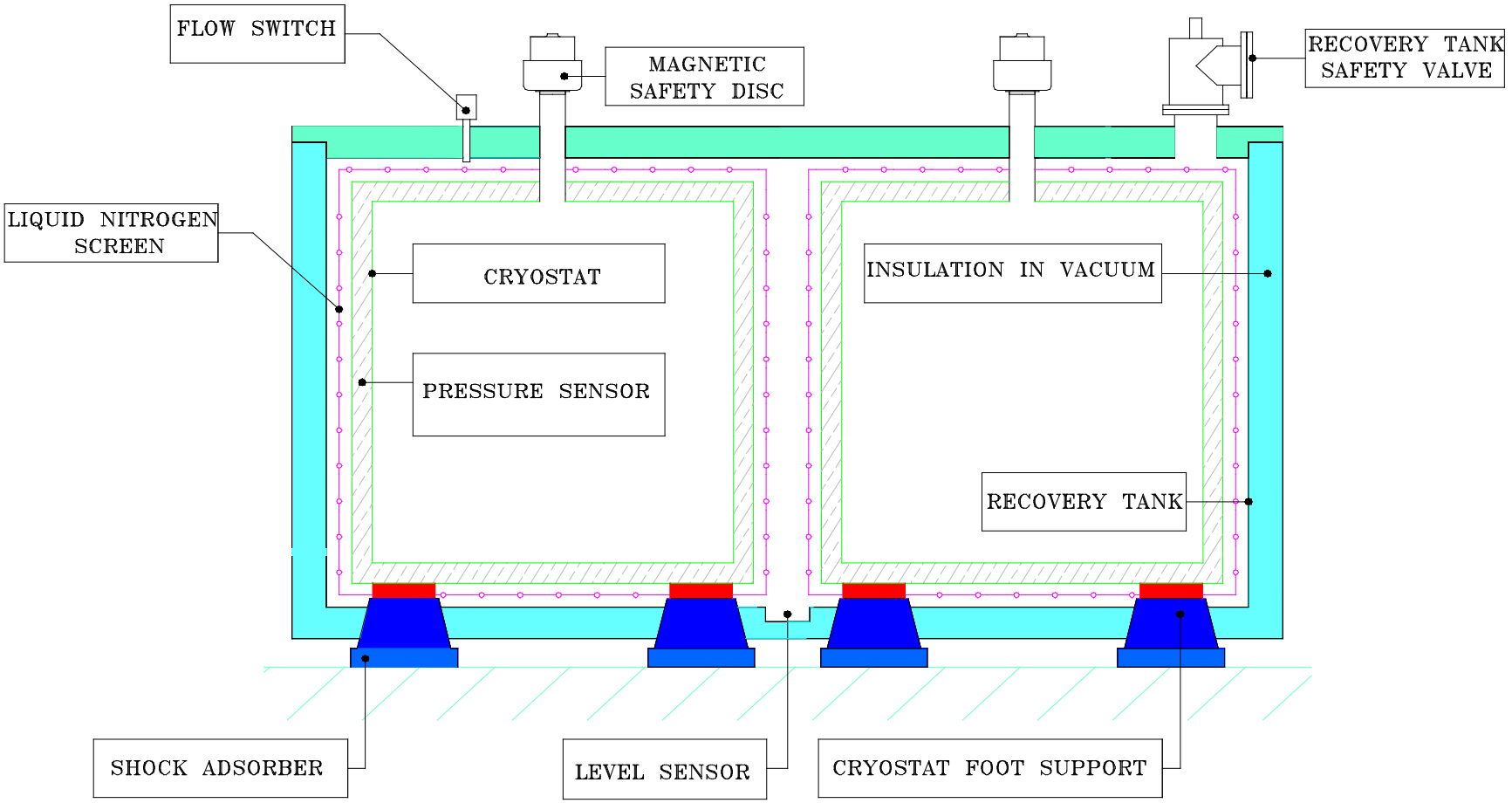


T600 cryostat supports





T600 insulation box



The insulation is a vacuum-tight welded box:

- Improving of the insulating performance (no thermal convections)
- Third cold containment box (hydrostatic + 50 mbar overpressure) instrumented with sensors detecting leaks and liquid presence

Insulation & LN2 reliquefaction systems

–Air Liquide is improving the insulation performance with respect to the Pavia test in order to maintain the **heat incoming ≤ 10 W/m^2**:

- ✓The insulation box is welded in order to ensure vacuum-tightness and to avoid air convection due to panel shrinking during the cooling phase. The Nomex panels are evacuated in order to strongly reduce the gas conduction effect (vacuum is maintained by getter pumps)
- ✓In this way the **LN2 consumption** will be reduced to **≈ 6600 l/d** for the insulation losses and the nitrogen circulation (new system of pumps: 1600 l/h biphasic Nitrogen circulation), **plus** the consumption (**≈7500 l/d**) due to Ar purification circuits (gas + liquid) when activated

–To avoid gas exhaust in underground environment a Nitrogen reliquefaction system has to be installed.

- ☛The electrical consumption is a fundamental parameter to maintain as low as possible!

–In case of emergency (electrical black-out) the LAr purification systems will be stopped and the LN2 storage will allow to go on cooling for some days!

–The not reliquified cold GN2 exhaust is convoyed through a heater (40 kW) to a dedicated emergency vent system or is diluted with a fan into the tunnel

Electrical power/heat dissipation

- Each **reliquefier** will be dimensioned for about **30 kW (cold power)**: 1W per 11W liquefaction system efficiency is foreseen
  - ❋ 1 reliquifier for the T600 (over dimensioned), 3 units are foreseen for the whole T3000
- This means for each system a heat dissipation (at the maximum power) that has to be exchanged with water cooling system: 9 l/s, $\Delta T = 10°C$
  - ❋ The heat dissipation or the T600 is compatible with the LNGS (Italian rule: $\Delta T = 3°C$) but for the T3000 we have to implement a dedicated dissipation system
- **For the whole T600 the electrical request** with the Nitrogen consumption described before for (with all the LAr purification system on, pessimistic case!) is about **500 kW (maximum) for the cryogenics + about 80 kW for the electronics + about 10 kW for other systems (sensors, HV, monitors,PCs, PMs,..)**
  - ❋ The LNGS still claim that the total power needed for the T3000 is a problem...
- In case of electric black-out a back-up (motorgenerator) system together with a UPS system are foreseen for temporary power supply of fundamental parts of the plant (N2 pumps, PLC, sensor/regulation/control system, HV control, heaters,...).
  - ❋ The emergency electrical power (cryogenics) is about 55 kW for the T600, 550 kW for the T3000 (1 reliquefier unit will maintained on back-up power supply)

- **NIER SRA Document for ICARUS in Hall B will be soon discussed with LNGS Technical Authority (first attempt failed)**

- The identified hazards are connected with the huge quantity of cryogenic liquids used in Hall B that may cause:
  - reduction of O2 content
  - reduction of temperature

- The FermiLab standards (Oxygen Deficiency Hazard and Equivalent Chill Temperature) have been chosen

- **The conclusion of the SRA is that the global level of risk is Class 0: there is no accidental event that has as a consequence a decrease of the Oxygen content to values less than 18% with a probability greater than 10-7 ev/h (ODH standard)**
  - Other events related to minimum O2 content < 18% are possible (for short periods) although with a global probability < 10-7 ev/h

- The identified accidental situations that require emergency procedures are:
  - Serious increase of Argon pressure inside the cryostats due to Nitrogen refrigeration stop for t>4h due to electrical power supply and/or compressed air supply; as a consequence: Argon loss through SM Disks and not liquefied Nitrogen loss, both conveyed, heated and diluted in Hall B (17%<O2<18%, p ≈ 7.7x10-7 ev/y)
  - Liquid loss by a pipe during the liquid transfer from a truck, point not yet defined (O2≤17% in a not negligible area around the point, p≈ 2.4x10-7 ev/y)
  - Cryostat “big” crack (2mx5mm along a horizontal reinforcing frame) with GAr loss through the insulation box vent valve, conveyed, heated and diluted in Hall B (17%<O2min<18%, Hall B has to be rinsed by the emergency ventilation, p≈ 8.7x10-7 ev/y)
  - LAr purification connection crack/cut with Argon loss, that can be intercepted (O2min=17.4%, p≈ 3x10-6 ev/y for crack; 8.7x10-7 ev/y for cut or impact)
  - Connection crack between the cryostat and the storage LN2 tank with Nitrogen loss, that can be intercepted (on the cryostat top O2=16.8% , p≈ 8.7x10-6 ev/y)
  - Connection crack between the cryostat and the storage LAr tank with Argon loss, that can be intercepted (on the cryostat top O2=16.5% , p≈ 8.7x10-6 ev/y)

- The precedent emergency situations are in any case widely manageable
- **The risks are compatibles with the adopted international standards of acceptability**

- **The minimal safety requirements / specifications for the ICARUS plant** are listed in the following:
  - Compliance with standards, with test and verifications, and with LNGS Safety Management manual
  - Minimisation of the number of flanges
  - Introduction of cut off valves to intercept the liquid/gas flow
  - Availability of cooling in case of emergency (emergency power supply)
  - Collection and treatment of the cold liquid/gas outputs

- **The minimal safety requirements/specifications concerning the LNGS management of the ICARUS plant** are listed in the following:
  - Electrical power supply required for normal and emergency operation
  - Power supply availability (in middle and long time)
  - Conformity of the heat dissipation into water with the potentiality of the underground laboratory
  - Ventilation system (to be better evaluated: minimal throughput in normal and emergency conditions, minimal time to commutate between the two conditions, possible extra ventilation to mix and dilute cold nitrogen into air)
  - Predisposition of DPI for cryogenics and devices for emergency monitoring (O2 sensors, alarms, light guides,..)

From now on:

- On the basis of the SRA document and suggestions **the LNGS has also to state the specifications for underground cryogenic plants** that have to be followed to install ICARUS in the Hall B.

  ☛Then we can start the call for tenders for the **final "executive" Site Project together with the installation**

- Updates of SRA and verifications will be necessary after the executive project redaction and in the precommissioning and commissioning phase.

☛ The SRA document will be used to complete the "big risk documentation" of the Labs (DDL 334/99) . As the ICARUS plant does not involve dangerous substances (flammable, toxic, irritating, harmful substances), the add-on documentation will be a "variation without rising risk".

☛ Only documentation (as foreseen for DDL 334) for CPVVF (and CTR, if does exist) has to be prepared.

☛ **It's a LNGS job.**

Conclusions

- **LNGS have approved Air Liquide "definitive" installation project.**
- **We probably need to ask authorisation to CSLLPP for the use of seismic shock adsorbents**
- **We will soon discuss the NIER Safety Risk Analysis with LNGS Authority. We are confident to be approved also from the point of safety as the conclusions of the RSA Document are positive.**
- **We can start soon the call for tenders for the**
  - T3000 auxiliary system supporting structure (by now)
  - T600 executive site project and installation
  - Nitrogen re-liquefaction (1 or 2 units by now?) + storage tanks (T3000)
  - LAr (for the second half-module + first h.m. integration)
  - Hall B infrastructures (electrical power supply system, ventilation, ...)
  - T600 transportation
  - T1200