CRYOGENICS OPERATIONS 2008

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Safety aspects concerning the operation of liquid krypton and liquid argon calorimeters in underground areas

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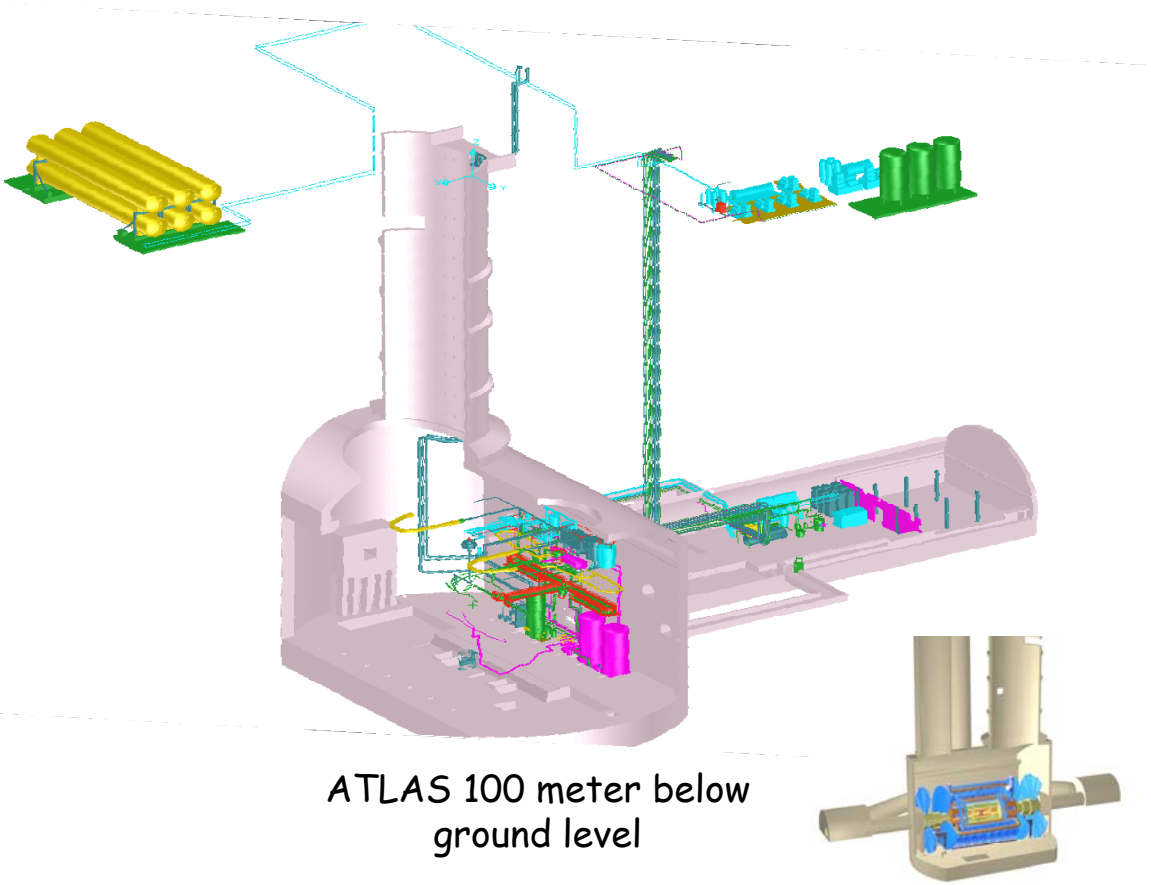
Introduction

Two experiments at CERN are equipped with a liquefied noble gas calorimeter: NA62 (krypton), and ATLAS (argon), and both these experiments are installed in an underground area.

NA62 12 meter below ground level



ATLAS 100 meter below ground level

Oxygen deficiency risk

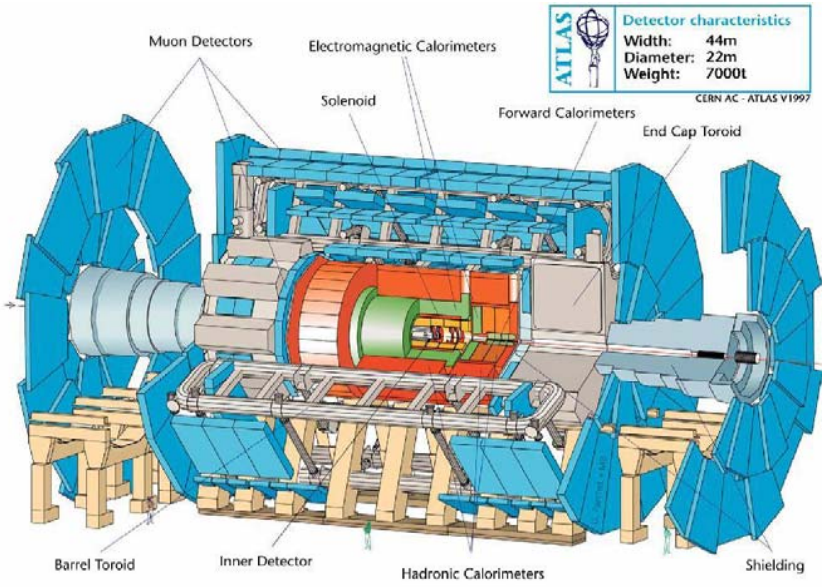
Gas density at room temperature:

He	0.16	kg/m3
N2	1.12	kg/m3
Air	1.18	kg/m3
Ar	1.60	kg/m3
Kr	3.37	kg/m3

An eventual leak of argon or krypton inside an underground area will create an increasing layer of this gas at the bottom of the cavern, pushing out the air present.

ATLAS is in an even more critical situation. The argon calorimeters are placed inside the detector volume and leaks can create local areas with a very low oxygen content.

From the design phase onwards measures have been implemented to diminish the probability of leaks, and to diminish the consequences of an eventual leak.



NA62 safety considerations

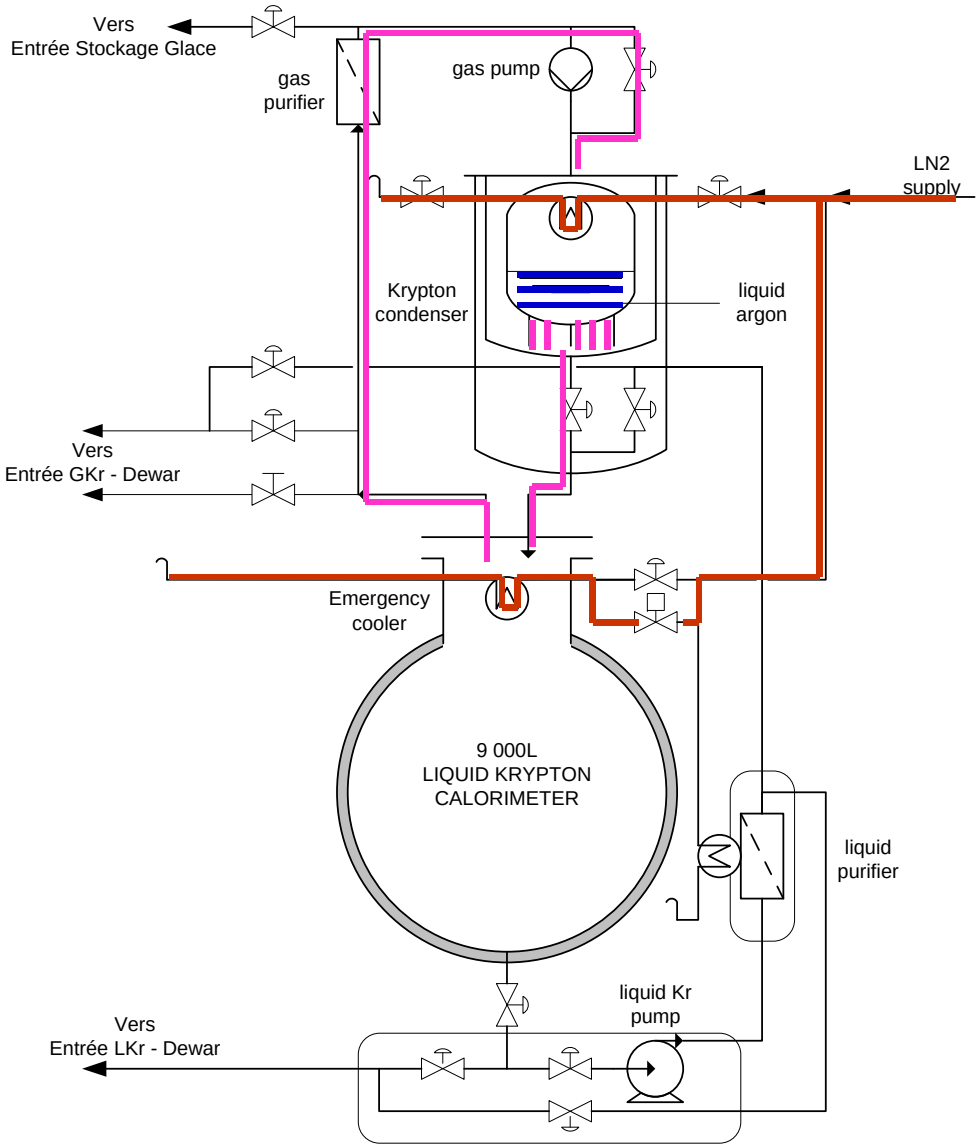
Design features concerning safety:

- Liquid nitrogen in cooling circuit is transferred by gravity only. No external pumps or compressor systems needed.

- Cooling back-up layer: in case of a rising krypton pressure the control is taken over by a hardwired redundant system backed-up by an independent UPS

- It is always possible to empty the content of the cryostat into a 10000 litre storage dewar. Transfer line between dewar and cryostat is always kept cold.

- The liquid krypton is by an eventual rupture of the cryostat cold vessel transferred from the vacuum vessel into an insulated "swimming pool". The low evaporation rate of the liquid in this container gives the time to the personnel to leave the cavern.



NA62 safety considerations

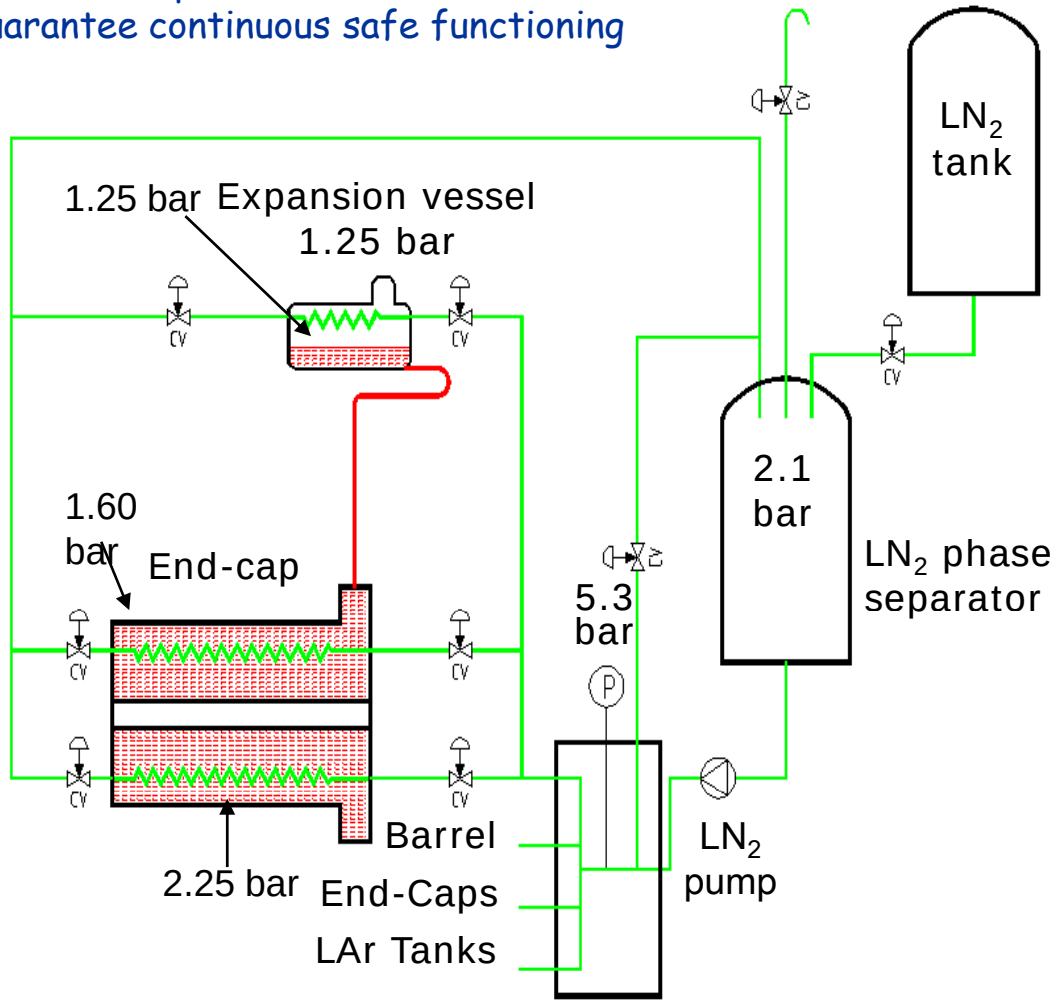
- Electrical power:
  - » Norma network
  - » Diesel generator
  - » UPS covering for up to ten hours
- Cooling water (diffusion pump):
  - » Local dedicated system;
  - » Normal cooling water circuit;
  - » Tap water;
- Compressed air:
  - » Compressor station
  - » Batteries
- ODH detection system directly connected to CERN fire-brigade
- One of the first installations to be "restored" in case of a CERN wide failure (computer network, electrical power etc.)

During 12 years of operation:
No records of danger for personnel and/or equipment
No krypton lost

ATLAS general safety

The cooling principle of the calorimeter has been explained in an earlier presentation. Measures implemented to guarantee continuous safe functioning of this system:

- Nitrogen refrigerator is used as main cooling source
- Two 50000 liter nitrogen storage tanks can take over its function in case of failure (10 days reserve)
- Liquid nitrogen is transferred via an underground phase separator, but it can also be by-passed
- Liquid is circulated through heat exchangers by liquid pump (2 on standby), but they can also be by passed
- If necessary system can "survive" with a nitrogen circulation driven by gravity



ATLAS general safety

Services needed to guarantee safe continuous operation:

- Electrical power:
  - EDF / EOS/ Diesel 1 / Diesel 2 / UPS
- Cooling water:
  - cooling tower I, cooling tower II, tap water
- Compressed air:
  - compressor I, compressor II, buffer, batteries

The services needed for the ATLAS calorimeter will have a very high CERN-wide priority to be restored in case of failures

Control system:

- PLC based control system
- Spare PLCs are "pre-programmed" ready to be installed
- PLC automatic re-start in correct mode is being implemented

ATLAS general safety

The installation goes into fail safe condition in case of problems with the cryogenic system or one of the services

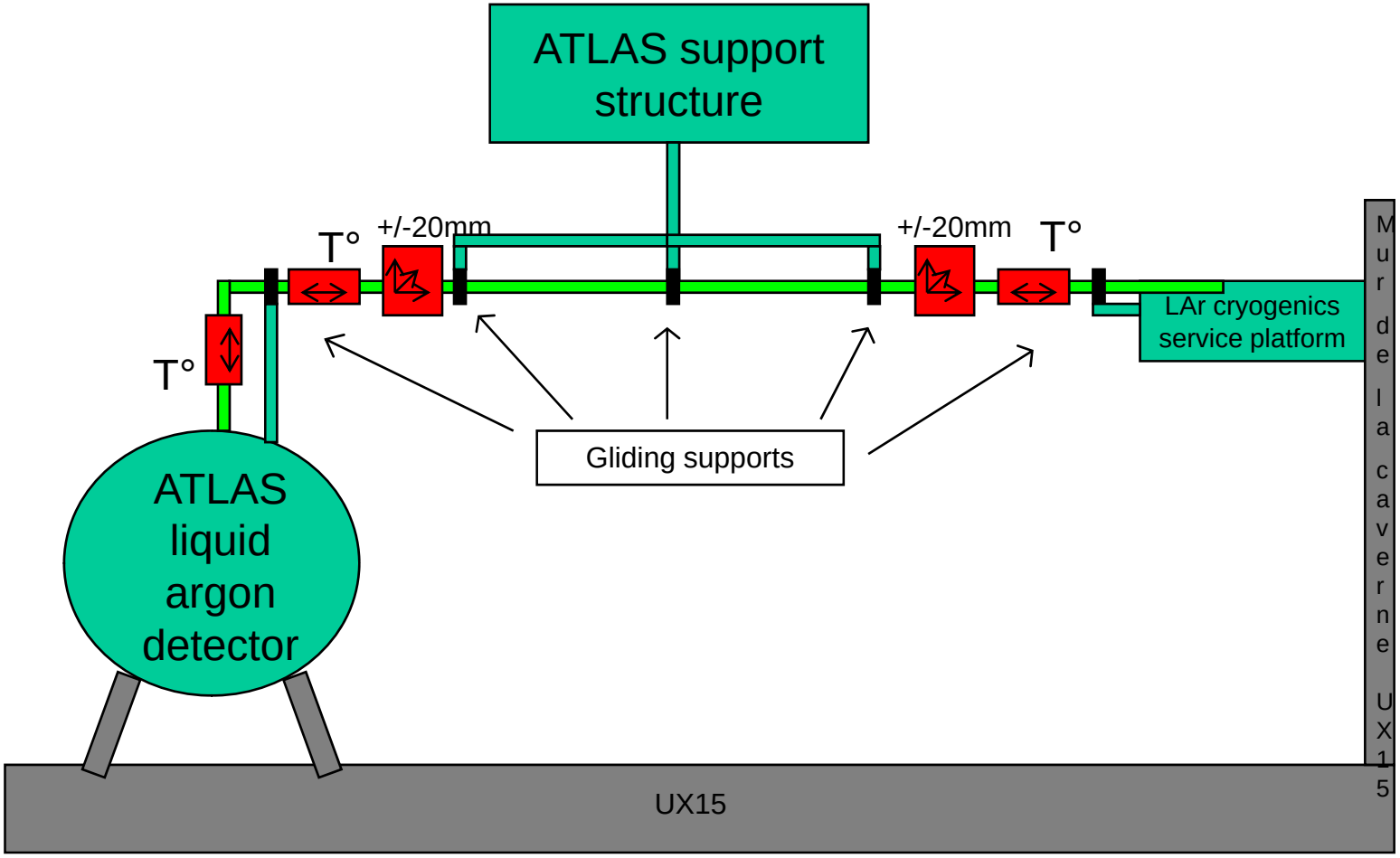
- Detector control system is informed and electronics present in the argon bath is switched off
- Depressurization of liquid argon calorimeters via a dedicated exhaust line to the surface
- Depressurization of complete nitrogen system via nitrogen vent line

The sub-systems are independently protected by mechanical safety valves, also venting at the surface.

In case of emergemcy, the liquid argon in the calorimeters can be transferred into two underground 50000 liter liquid argon storage tanks. These tanks are placed such that the transfer can be made by gravity only. They are constantly on standby (cold) for an eventual transfer.

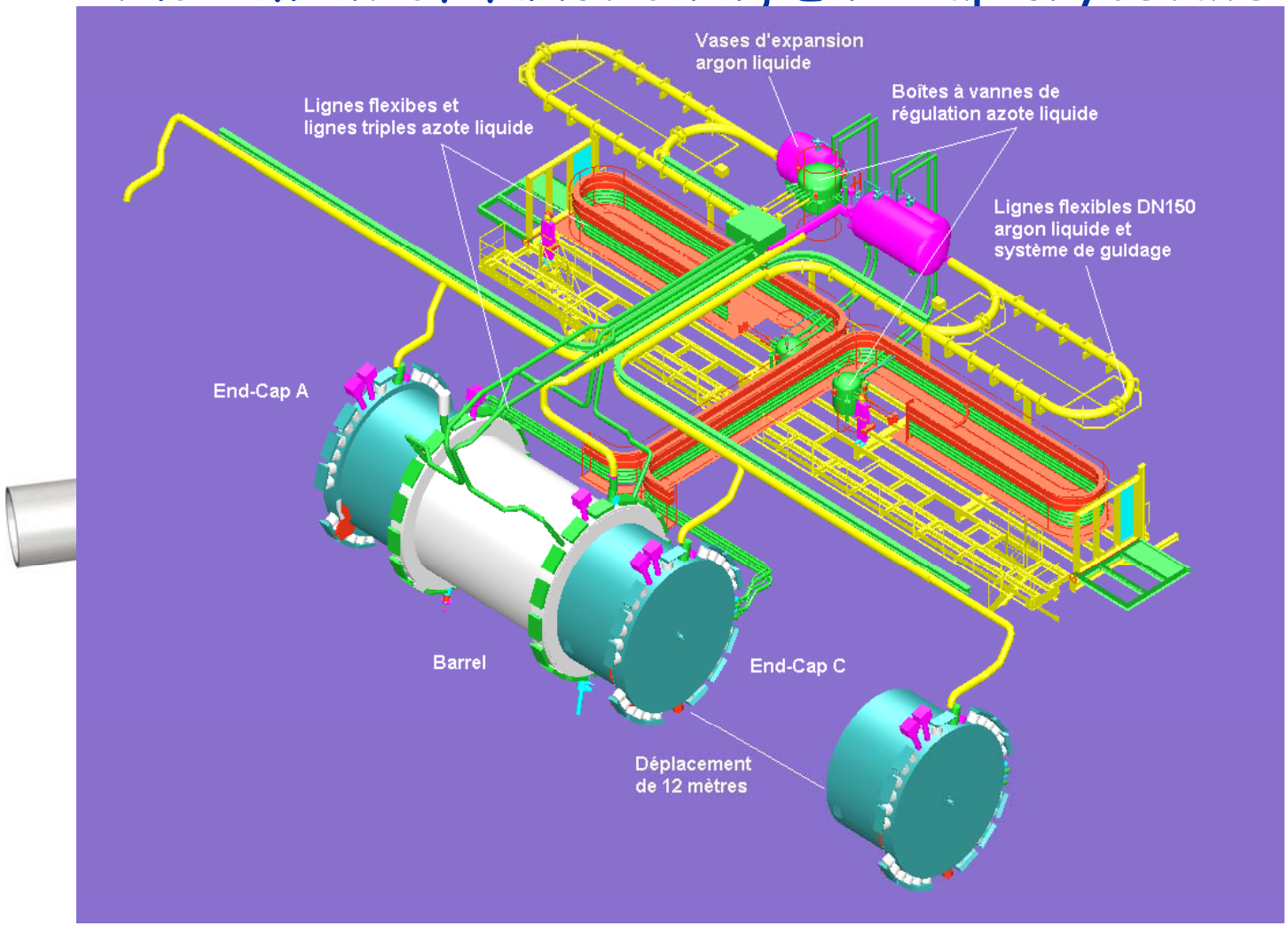
ATLAS special safety

Resistance to seismic movements



ATLAS special safety

Movement of functioning End Cap cryostats



ATLAS special safety

In case of emergency

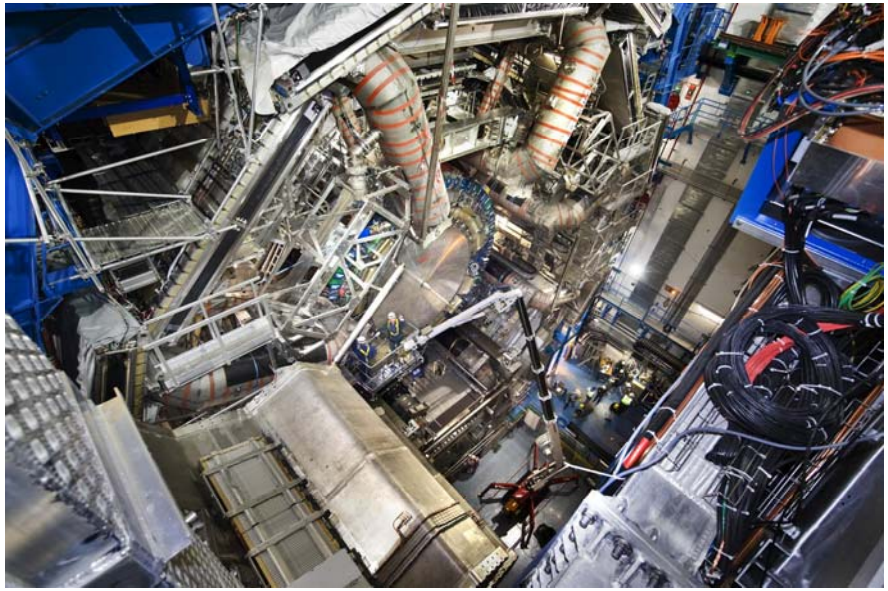
- Alarm level 3, evacuation of personnel and tripling of ventilation in cavern directly triggered by:
  - insulation vacuum level of cryostats (3)
  - insulation vacuum level of main transfer lines (15)
  - temperature of bayonet connections on cryostats (15)
  - ODH measurement by about 200 sniffer pipes installed inside the detector
  - ODH measurements on ground level and in retention pits

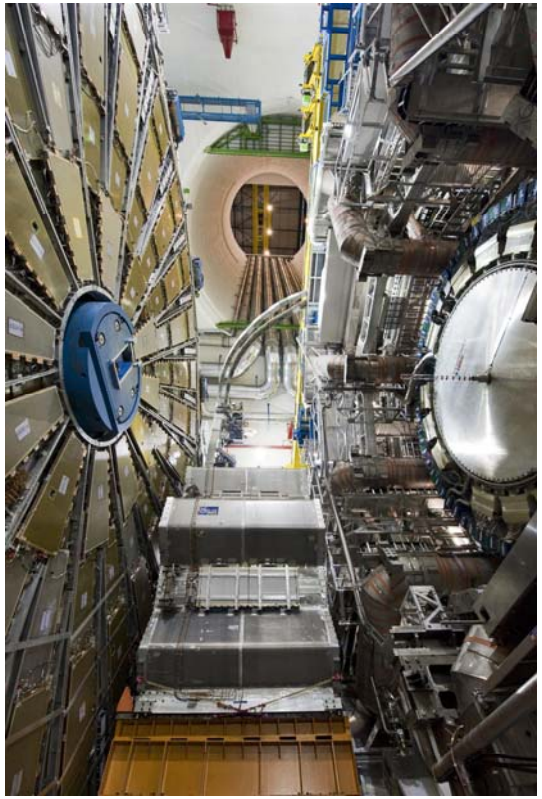
ATLAS safety

Actual status

ATLAS calorimeters in operation since about two years.

Since then we have had only one major accident, which forced us to empty one of the End Cap calorimeters. Safety equipment has been functioning as foreseen following this accident caused by an external system.





ATLAS actual situation