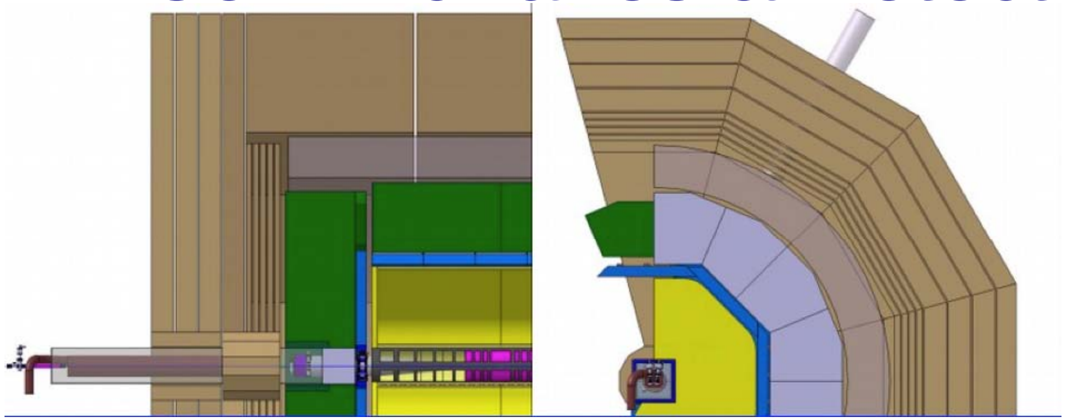
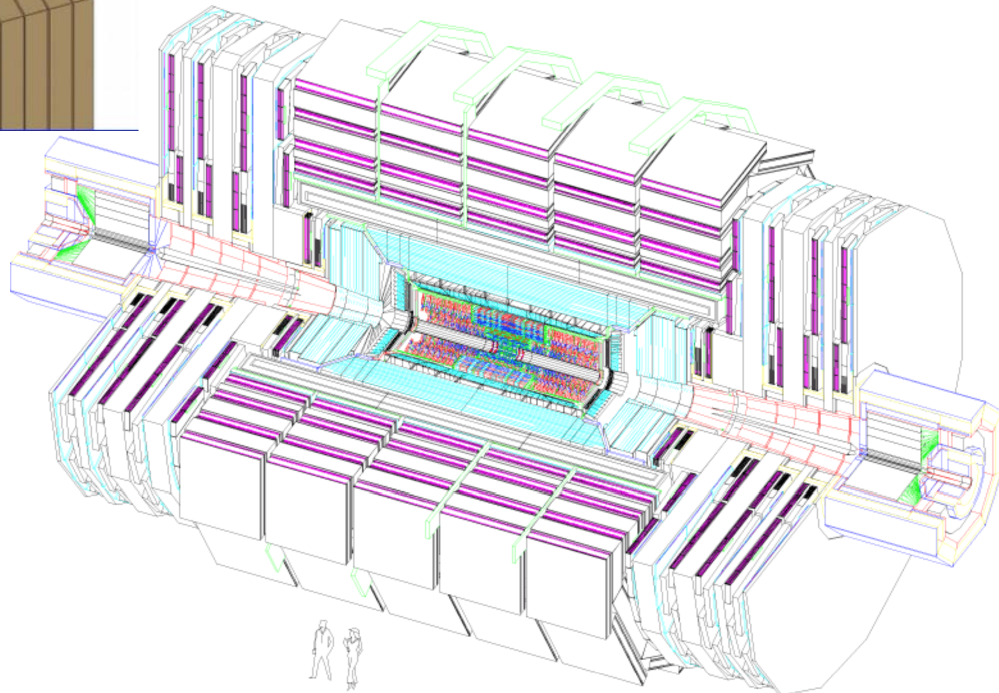
# CMS-ILD Engineering Workshop 2009

# Coil Ancillaries & Detector General Services





Compact Muon Solenoid

Andrea Gaddi, CERN Physics
Dept.

# Part I: Typical Coil Ancillaries

Powering:

Coil Power Supply (20kA, 24V, 200x160x240H cm, 4 units)
Circuit Breakers (265x160x275H cm, 2 units)
DCCT (Current Gauge) (200x200x275H cm)
Discharge Resistors
Powering Lines

Cryogenics & Vacuum:

Vacuum Primary Pumps (100x140x120H cm, 2 units)
Vacuum Pumping Line
Vacuum Secondary Pumps (1 $m^3$)
Cold-box (He liquifier) (500x180x180H cm)
Cryogenic Trasfer Lines
LHe dewar for transient states (6 $m^3$)
Phase Separator/Valve box (3 $m^3$)

# Cryogenics at CMS

The cryogenic plant at CMS site has the function to cool down and keep at 4.5 K the 230 tons of the CMS Superconducting Coil.

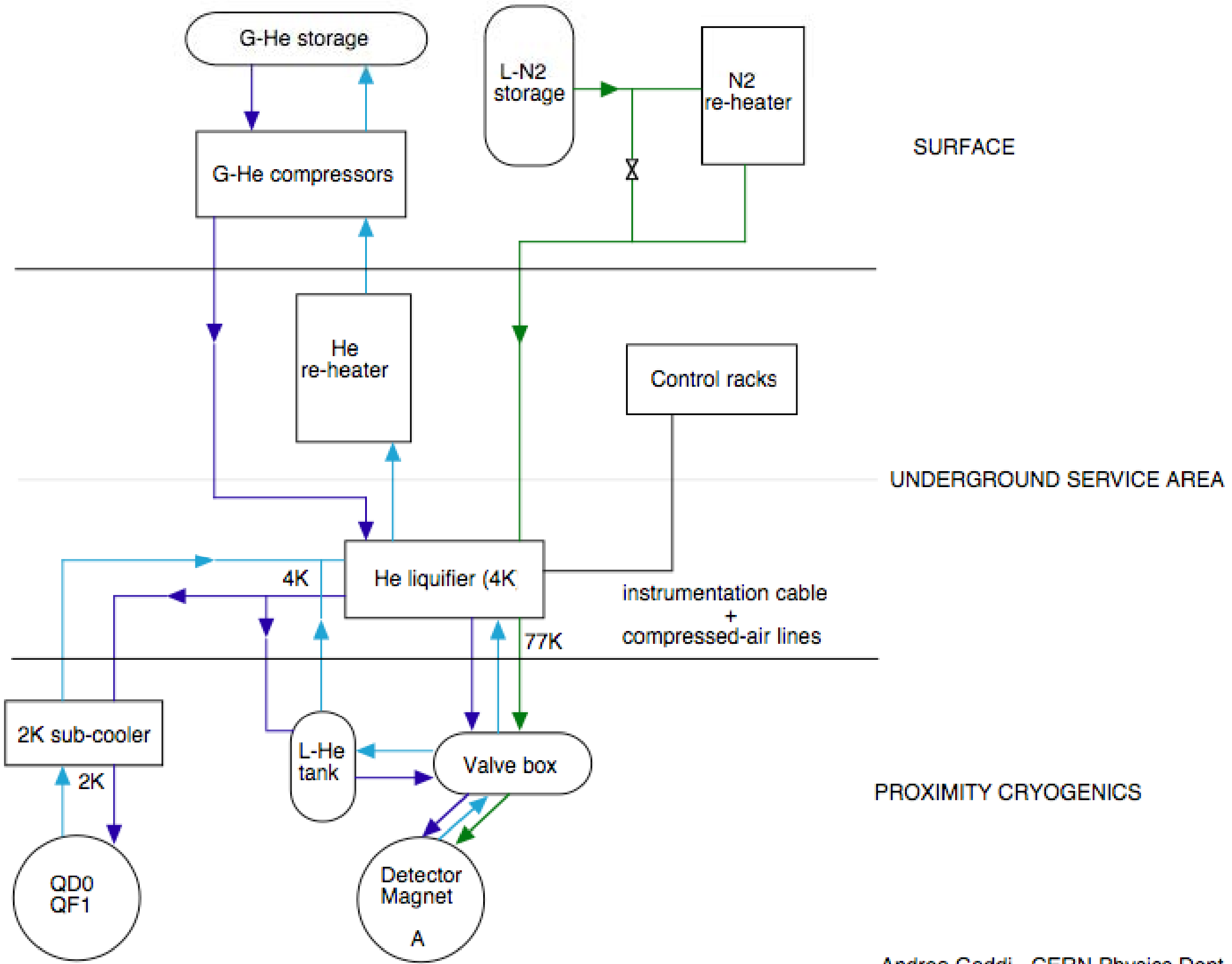
The refrigerator system can deliver a cooling power of 800 W at 4.5 K, plus 4500 W at 60 K to cool the Coil thermal screens and in addition to that 4 g/sec of L-He to cool the 20 kA Coil Current Leads.

Cooling the Coil down from ambient temperature takes 3 weeks, with a maximum thermal gradient inside the cold mass of 40 deg.

In case of quench, the temperature rises up to 70 K and 3 days are necessary to bring the cold mass down to 4.5 K

A 6,000 lt L-He storage tank sits close to the cold mass to allow a slow-discharge from full current without warming up the coil, in case of fault of the Coil power converter or the Cold-box.

# Cryogenics block diagram




Andrea Gaddi - CERN Physics Dept.

# Coil Services in Alcove

Powering:
Coil Power Supply (20kA, 24V)
Circuit Breakers
DCCT (Current Gauge)
Discharge Resistors
Powering Lines

Cryogenics & Vacuum:
Vacuum Primary Pumps
Vacuum Pumping Line
Vacuum Secondary Pumps
Cold-box (He liquifier)
Cryogenic Trasfer Lines
LHe dewar for transient states
Phase Separator/Valve box

These services are specific to each detector and can be arranged into a dedicated service alcove at both ends of the main cavern. They are typically heavy & noisy.

# Coil Services on Detector

Powering:

Coil Power Supply (20kA, 24V)
Circuit Breakers
DCCT (Current Gauge)
Discharge Resistors
Powering Lines

These components have to be on the detector.
They require short connection lines to the coil.
They are static devices, passive to vibration noise.

Cryogenics & Vacuum:

Vacuum Primary Pumps
Vacuum Pumping Line
Vacuum Secondary Pumps
Cold-box (He liquifier)
Cryogenic Trasfer Lines
LHe dewar for transient states
Phase Separator/Valve box

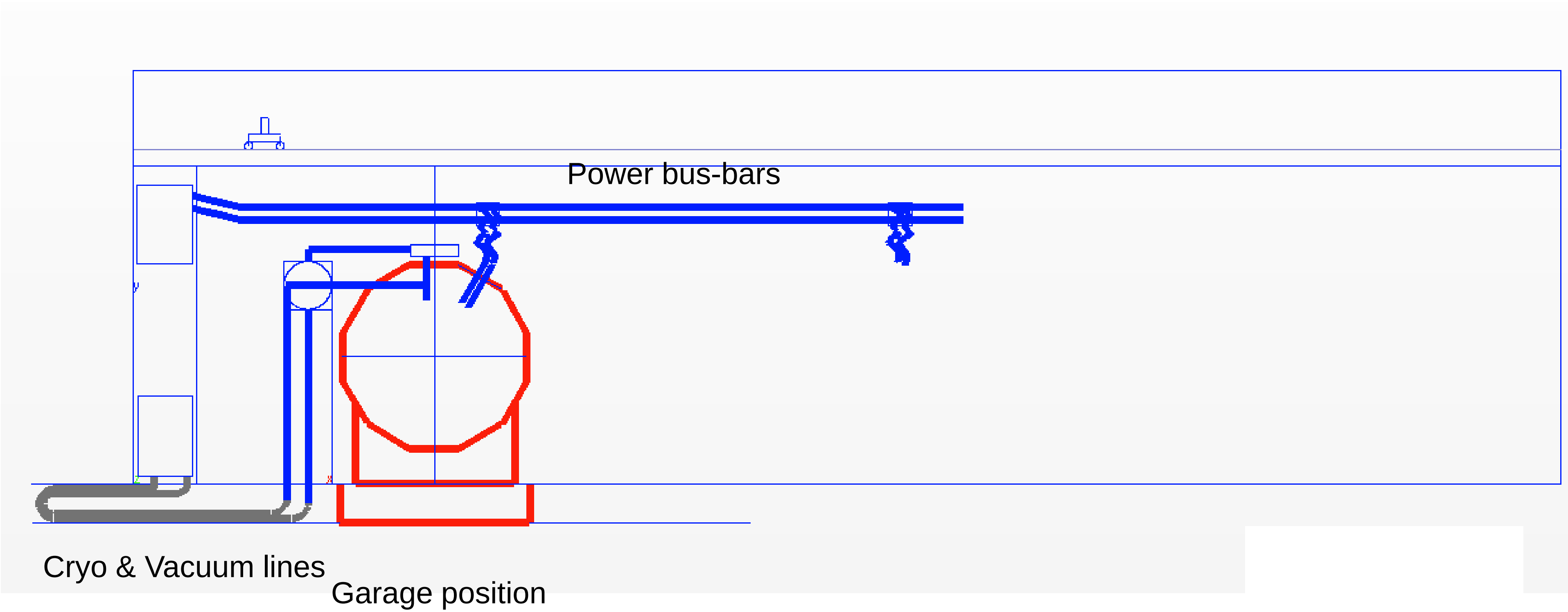
# Transfer Lines

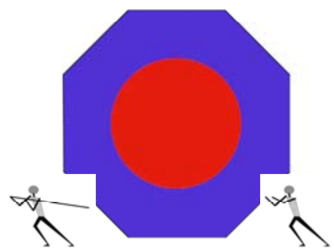
Powering:
Coil Power Supply (20kA, 24V)
Circuit Breakers
DCCT (Current Gauge)
Discharge Resistors
Powering Lines

Cryogenics & Vacuum:
Vacuum Primary Pumps
Vacuum Pumping Line
Vacuum Secondary Pumps
Cold-box (He liquifier)
Cryogenic Trasfer Lines
LHe dewar for transient states
Phase Separator/Valve box

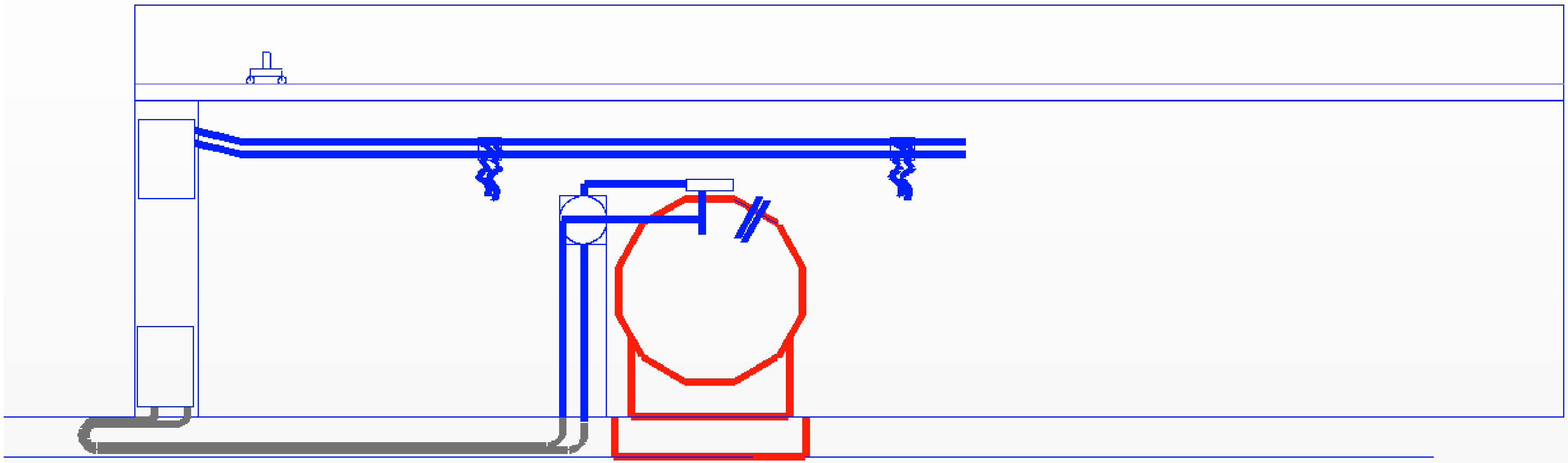
These transfer lines connect the Coil services in the alcove to the detector ones.They have to be engineered to allow the smooth movement of the Detector from its garage position to the beam-line. Their diameter depends on the lenght and can rea 500mm for the vacuum and cryo lines.
Powering bus-bars could be attached on the caver wall, at adequate high. Flexible connections to Detector's current-leads chimney can be envisage in different positions.

# Cable-chains and power bus-bars

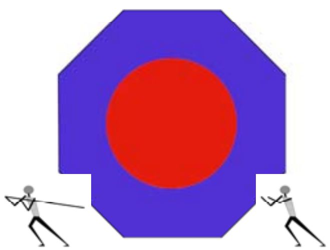


# Cable-chains and power bus-bars

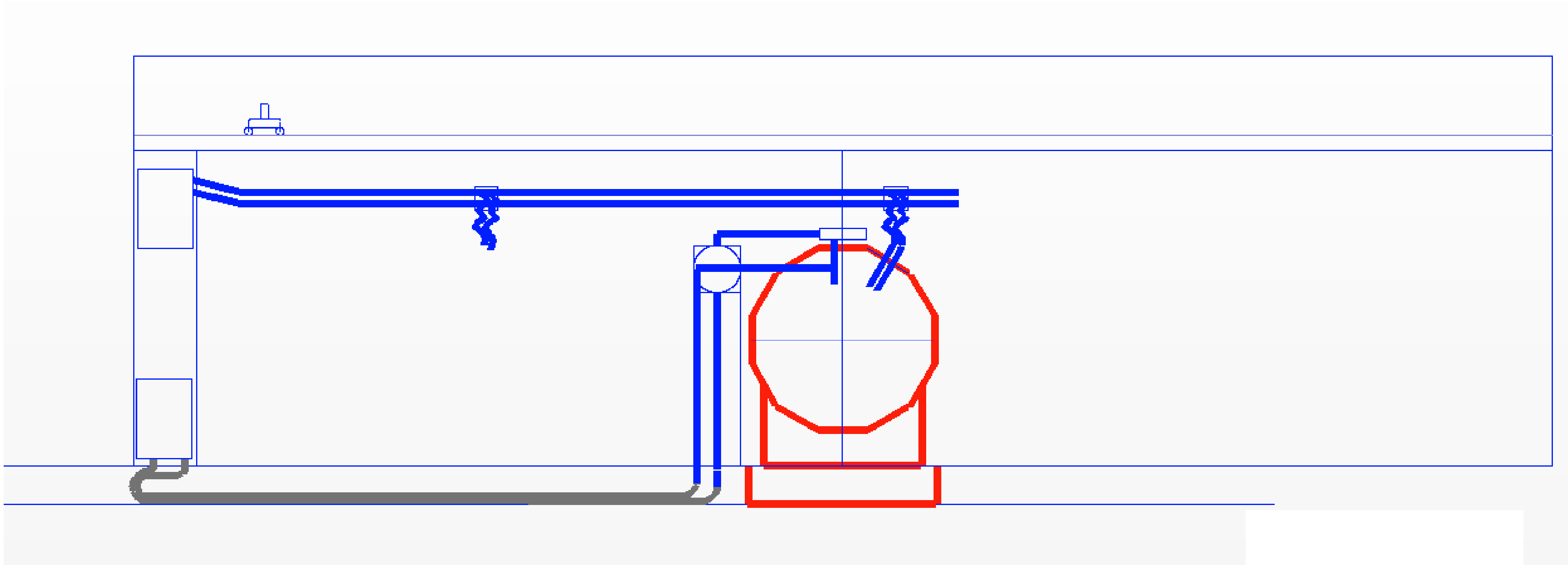


Moving toward IP

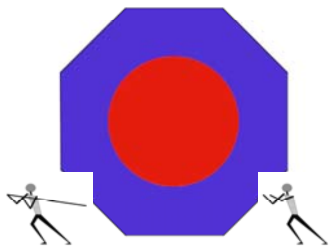


Andrea Gaddi, CERN Physics
Dept.

# Cable-chains and power bus-bars

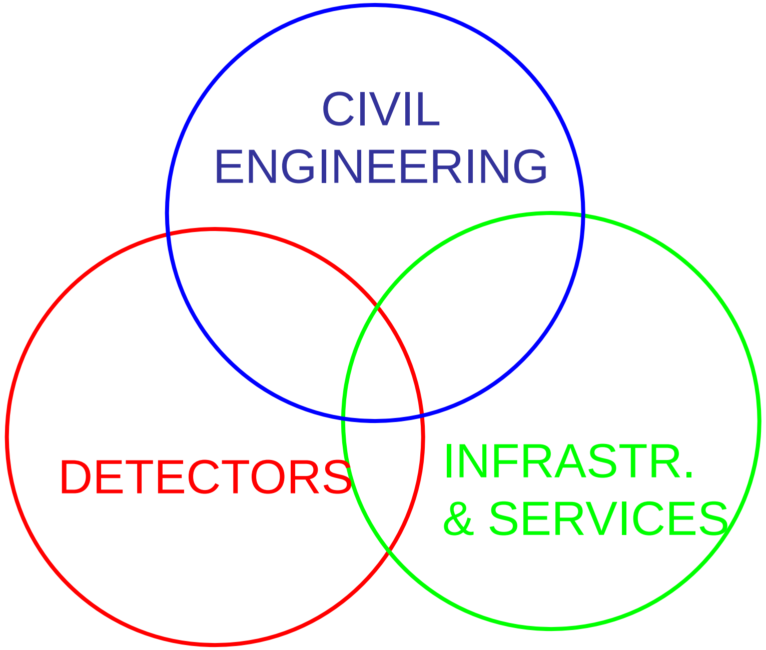


IP position



# Part II: Integrated Design of Infrastructures

The choice made by ILC to have two detectors on the same interaction region has led to the push-pull concept. This has a great impact on the layout of detectors infrastructures, because they have to be designed for a "moving" detector. Consequently, <u>the design of services must be integrated with the design of the detector and the civil engineering plans for the cavern from the beginning.</u>



# Primary services

| Facility | Output | Users |
|---|---|---|
| Water chillers | Water at 6 - 10 deg C | HVAC<br>Electronics racks cooling<br>Detector specific cooling<br>(chilled fluids in range -30 / +25 deg C) |
| High to medium voltage power transformers | 18 kV / 400V AC tri-phase | Lifts, cranes, general services<br>Cooling & HVAC stations<br>Primary power to detector electronics |
| Diesel & UPS facility | Secured power for valuable systems | |
| He storage & compressor plants | High pressure He at room temperature | He liquifier |
| Gas & compressed-air plants | Gas mixtures<br>Compressed-air | Detectors chambers<br>Process control valves, moving systems, … |

Plants providing these services are usually located on surface, due to their dimensions and related risks.

# Secondary services

- Temperature-stable cooling water for sensitive detectors
- Low Voltage/High Voltage supply for front-end electronics
- Gas mixtures for drift-chambers
- UPS power for valuable electronics
- AC-DC power converters for superconducting coil(s)
- Cryogenics & Vacuum services

Secondary service plants need often to be close to the detector (low-voltage/high-current lines, cryogenics lines, etc…) and they are located in the underground areas. Due to the push-pull design of the Interaction Region, these services are permanently connected and run into cable-chains toward the detector, regardless of their position in the Hall. To keep flexible pipes and cables in the chains within a reasonable length (< 50m), a service alcove for each detector is proposed at the main cavern ends.

# Cable-chains

The main benefits of having connections via cable-chains are:

- The detector is permanently connected to all its services and readout cables
- Services are located in a separated area, easy to access, with independent ventilation and lifting equipments (crane)
- No vibration or electrical noise close to detector
- Chains can be equipped with cables and hoses when the detector is still under construction on surface
- The cavern floor is clean and without obstructions (no flying cables/hoses around)

# On-board services

Some secondary services must be situated close to the detector as well, if the connection lines through the cable-chains is technically difficult or too expensive.

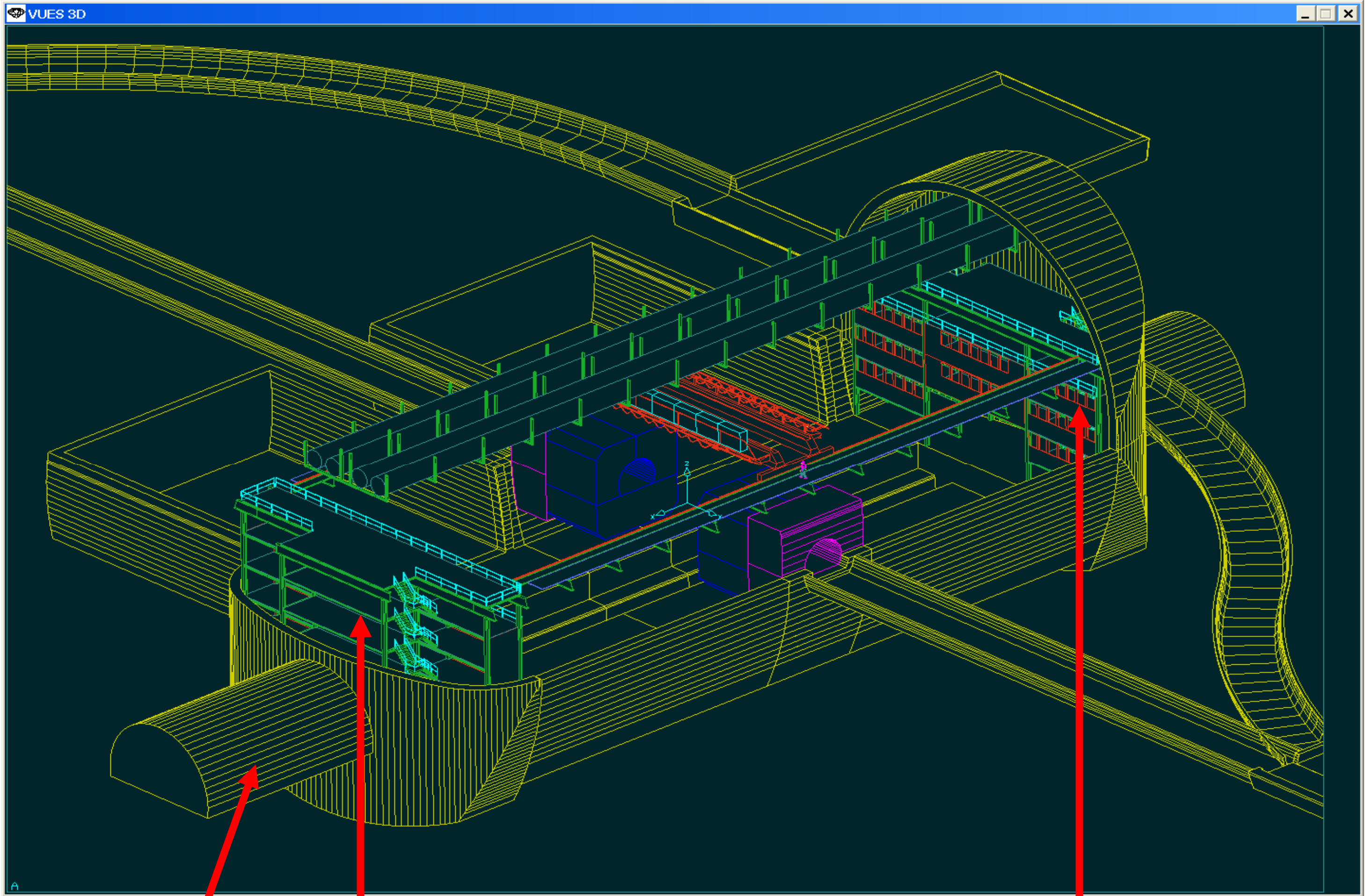
However this makes the size of the moving detector bigger with risks of inducing vibrations and electrical noise and should be limited to a few special utilities, in a push-pull scenario, where detectors move every month or so.

# Layout for ILC detector services

The following slides present a proposal to arrange services for ILC detector in the experimental area. The criteria taken into account are:

- Minimum impact on civil engineering cost
- Better access and easier installation of systems
- Optimization for push-pull scenario

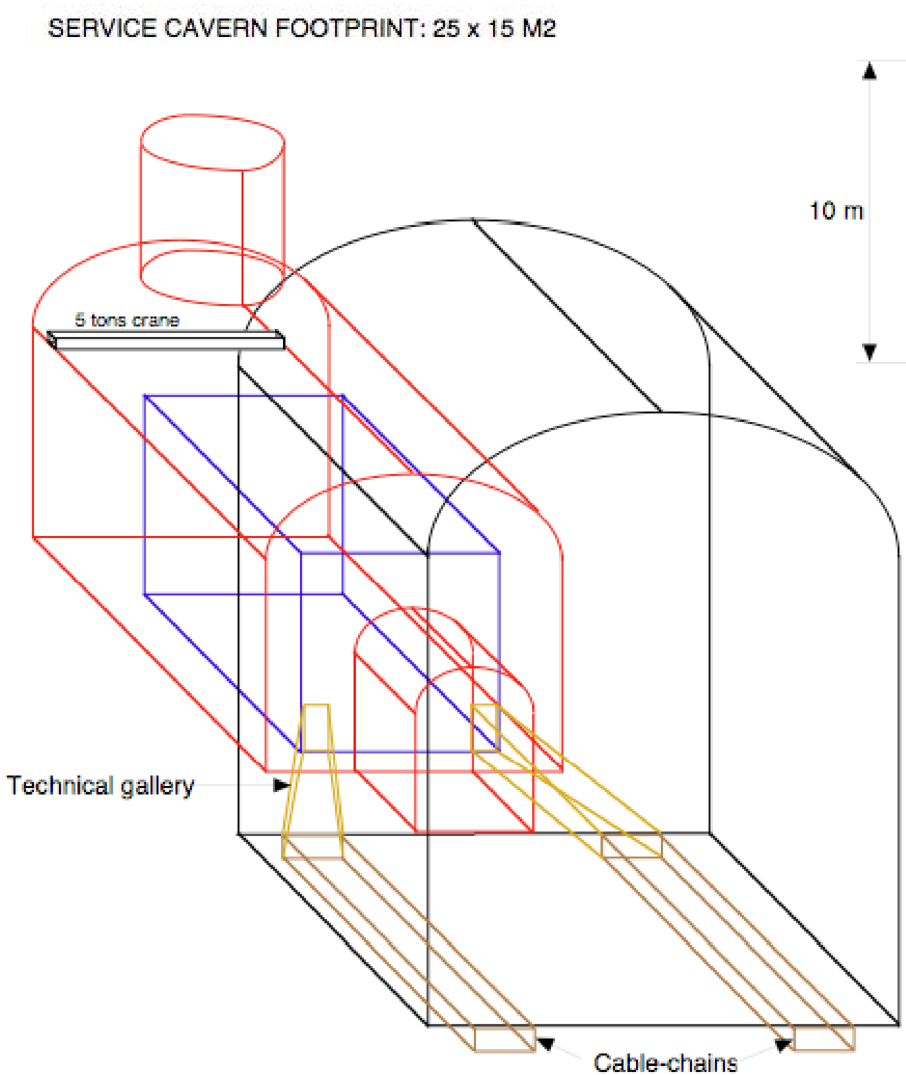
# Cavern space for infrastructures

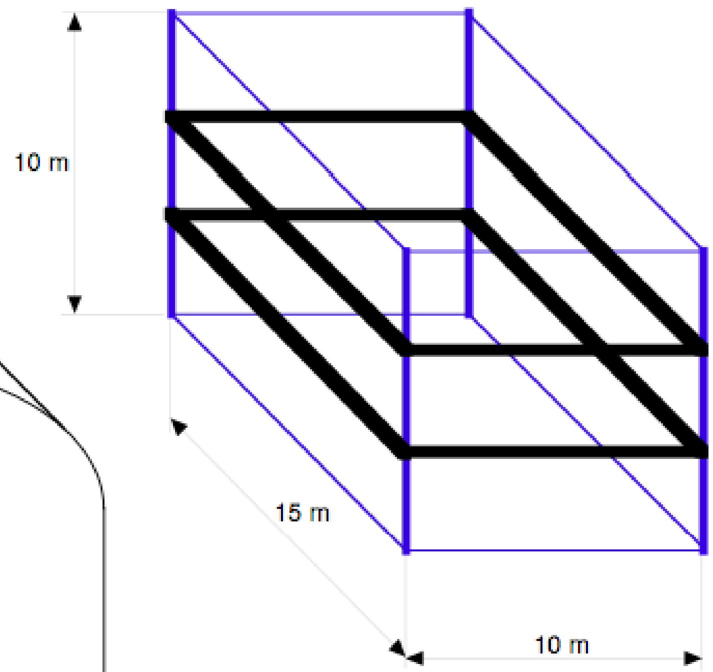



No crane coverage. Only for light weight infrastructures (electronics racks)

Service alcove with light crane

# Service cavern layout




ground floor:
heavy components (transformers + cryo + ventilation)

mid floor:
cooling skids + gas + laser + safety rooms

top floor:
electronics racks + miscellanea

# List of systems housed in the "service-block"

Detector facilities located into the service cavern (not exhaustive list…):

- Electrical room for transformers & switchboards: LV system, electronics racks, UPS
- Cryogenics & vacuum system for magnet: He liquefier, rough vacuum pumps, …
- Electrical room for magnet power circuit: AC/DC power converter, breakers, …
- Ventilation & air-treatment skids
- Cooling skids for detector circuits: heat-exchangers, pumps, controls
- Gas room for gas mixture distribution/regulation
- Laser room for detector calibration
- Safety room: radiation monitoring, smoke detection, fire-fighting, …

# Conclusions

The push-pull scenario leads to an integrated design of detectors infrastructures.
A compromise between on-board services and a remote “service block” has to be found, making use of cable-chains that assure permanent connections with the service block, allowing a smooth movement of the detector during the push-pull operation.

Most of the secondary services are detector specific, that implies a dedicated service area at each cavern end. Installation of services can proceed in parallel with detector assembly, assuring great flexibility to overall schedule.

# Back-up slides

# CMS Infrastructures

These slides give an overview of the CMS Infrastructures and can be used as a basis to define ILC detectors needs.

# Detector Powering

Different power utilities:

- ❑Power to Front End Electronics (FEE) - specific to detector
- ❑Power to Counting Rooms and Site Control Centres - specific to detector
- ❑Power to auxiliaries & services - common to detectors

Different power sources:

- ❖Uninterruptible Power (battery back-up) - specific to detector
- ❖Secured Power (diesel-generator back-up) - common to detectors
- ❖Non-secured Power - common to detectors

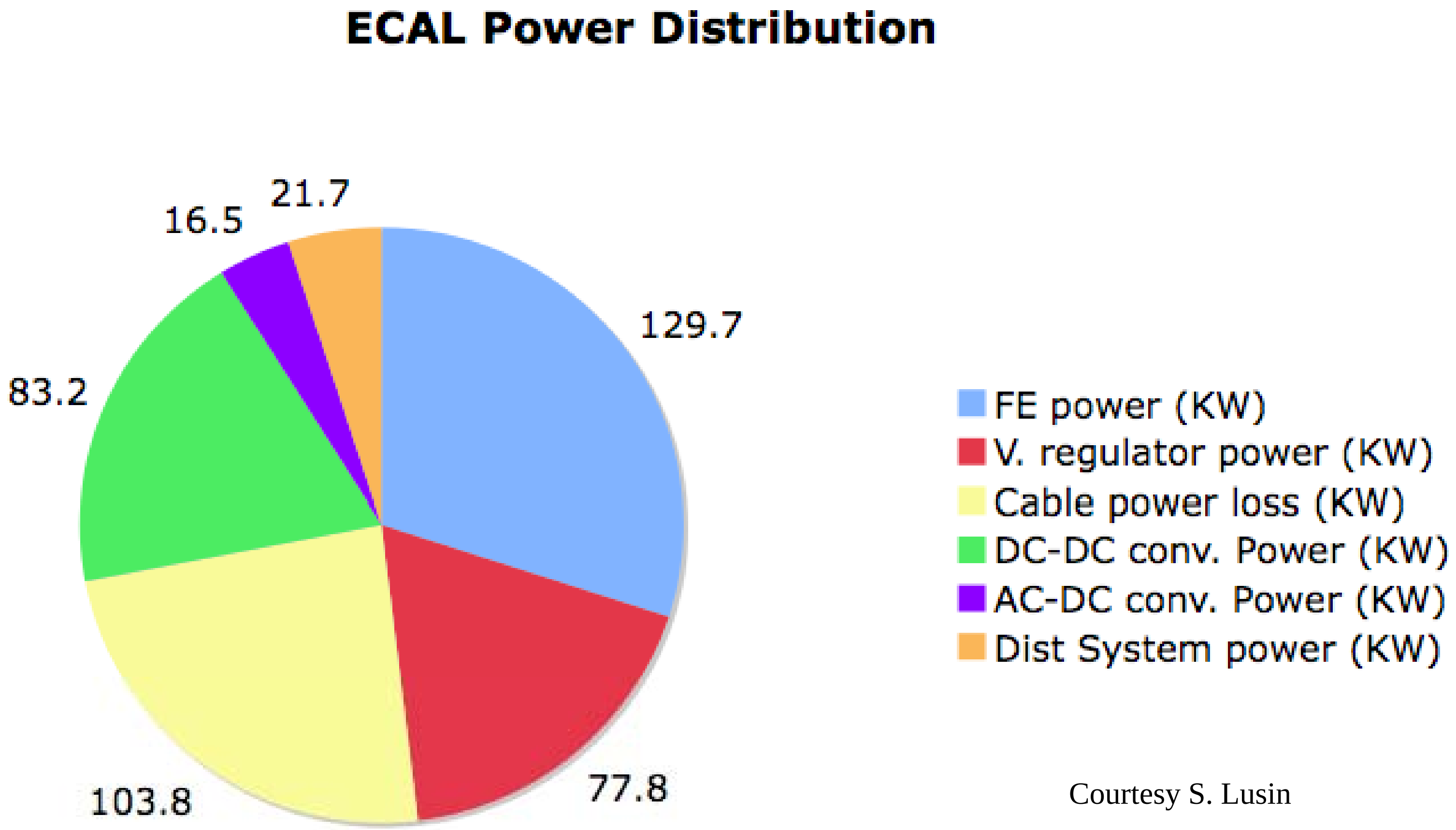
# How much power

| System | Rated power (kW) |
|---|---|
| General services on site (lifts, cranes, lights, …) | 1,200 |
| Electronics racks | 1,300 |
| Low Voltage to front-end electronics | 1,000 |
| Magnet + Cryogenics | 800 (1,250)* |
| Ventilation units (inc. smoke extraction) | 1,250 (3,000)* |
| Surface cooling stations | 3,000 |
| Underground cooling stations: | |
| (water) | 600 |
| (C6F14) | 600 (900)* |
| Total | 9,750 (12,250)* |

(*) refers to transient operations (cooling down, powering up, etc.)

# Power Losses

Consider a factor 2 wrt final end user to design transformers and power lines.
As an example, CMS Ecal use 207 kW over a total available of 432 kW




Courtesy S. Lusin

# FEE Cooling at CMS

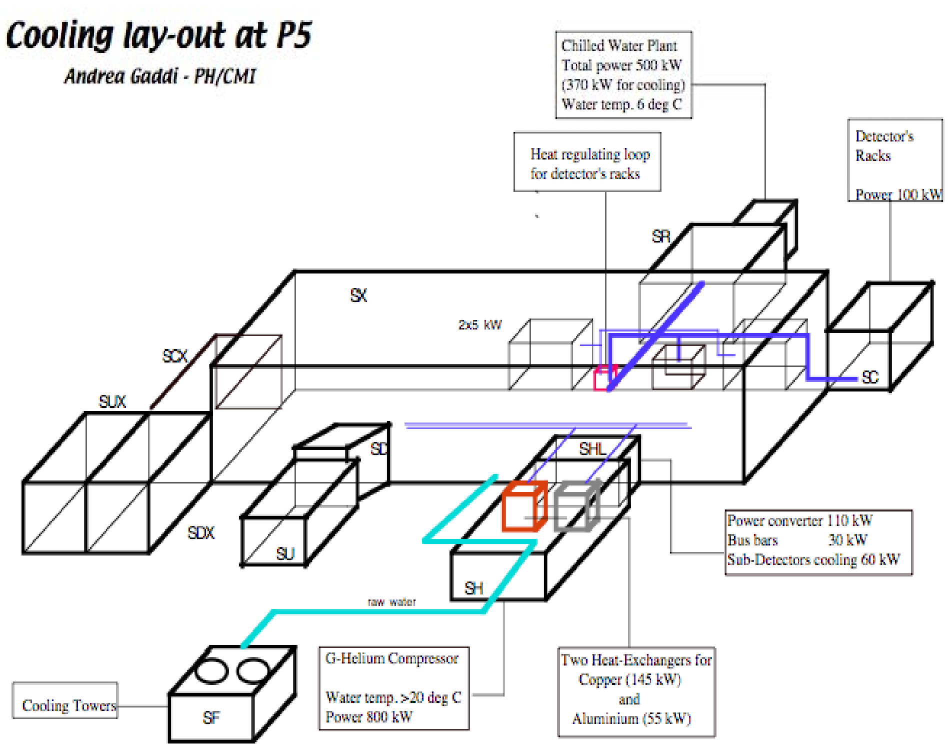
More than 1 MW is dissipated into heat by CMS Front Electronics boards.
This large amount of heat needs to be transferred away from the Detector
via appropriate cooling fluids (water or CxFy, depending on working temperature).

CMS has 6 independents cooling loops, serving the following systems:

| | | | |
|---|---|---|---|
| Muon Endcaps | water | 16 deg | 100 kW |
| Muon Barrel | water | 16 deg | 50 kW |
| HCal + Yoke Barrel | water | 16 deg | 60 kW |
| ECal | water | 16 deg ( ±0,05) | 300 kW |
| Racks system | water | 16 deg | 1600 kW |
| Si-Tracker, Pixels, ES | C6F14 | -15/-30 deg | 150 kW |

# Cooling Infrastructures at CMS

Chilled water at 6 deg is produced on surface and dispatched to the different cooling stations present on site (above and below ground) that finally produce water at 16 deg for the different cooling loops.
<u>This arrangement has made possible to test a significant part of CMS on surface, before lowering the Detector down into the cavern without having a large impact on infrastructure costs.</u>



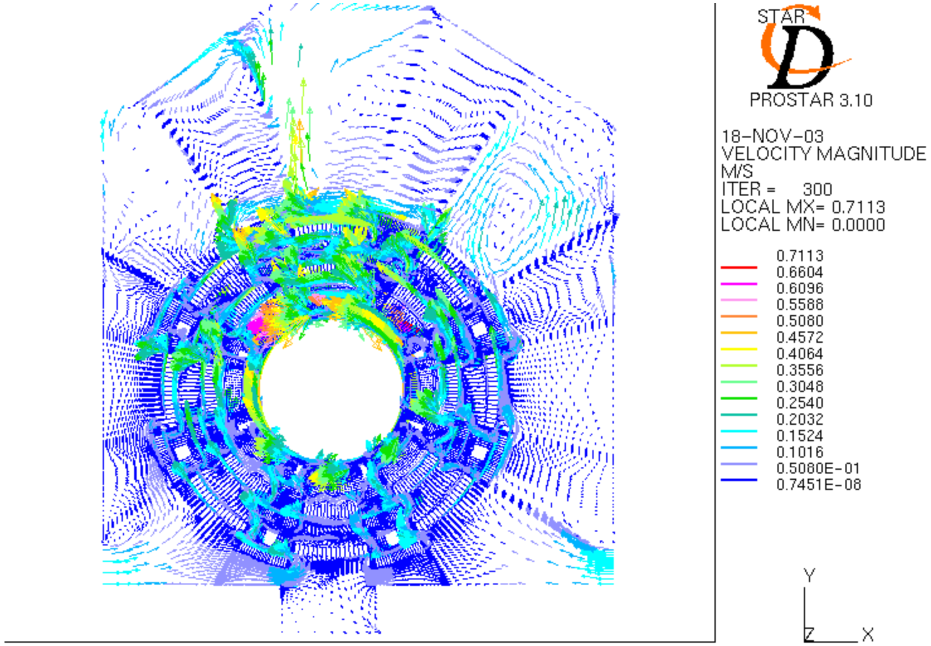
# Cavern ventilation

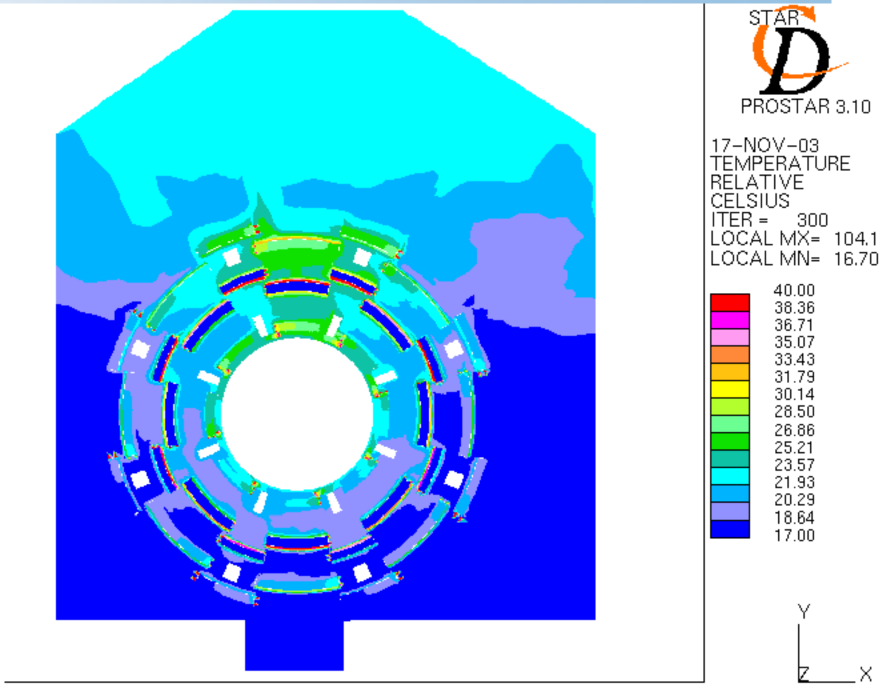
Temperature stability of the cavern air plays a role in the calibration of most of the detectors. Vertical gradients are usually accepted, but not large temperature fluctuations.

Low humidity (dew-point) is also important to prevent water condensation on cold surfaces (typically water pipes)

The biggest the cavern, the most difficult the problem is.

# Example of temperature distribution




L.Vila Nova Goncalves, CERN TS Deptm.

- Intercept heat with water at the source rather than heat-up the cavern.
- Be aware of chimney effect of large pits, there a cover helps.
- Consider also the huge transversal dimension of the cavern.