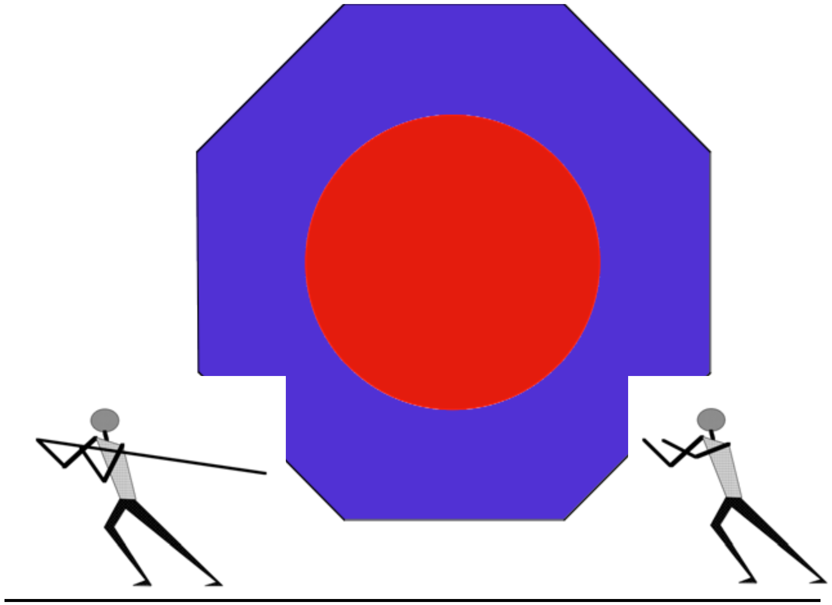
Detector Services Design for push-pull option



Andrea Gaddi, CERN Physics Dept.

Introduction

This talk has been given at last ILC Interaction Region workshop at SLAC (IRENG07). It includes some general consideration on designing detector infrastructures in a push-pull scenario, along with a proposal for ILC experimental area infrastructures design.

Contents

- ❑ Integrated design of infrastructures with detectors and civil engineering
- ❑ List of detector services (powering, cooling & cryogenics, ventilation)
- ❑ Platform concept
- ❑ Remote vs all-on-board services
- ❑ Cavern ventilation
- ❑ Proposal for ILC Experimental Area

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, the design of services must be integrated with the design of the detector and the civil engineering plans from the beginning.

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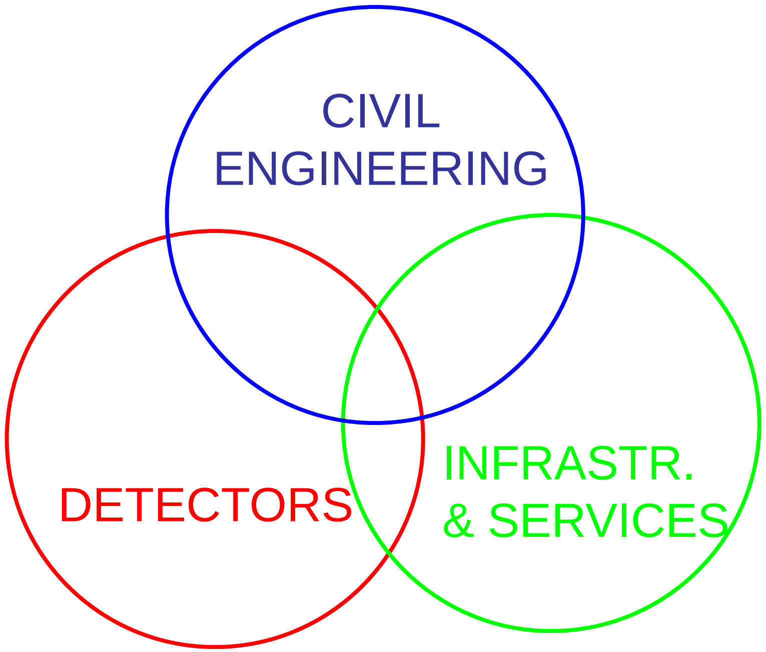

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Primary services

Facility	Output	Users
Water chillers	Water at 6 - 10 deg C	HVAC Electronics racks cooling Detector specific cooling (chilled fluids in range -30 / +25 deg C)
High to medium voltage power transformers	18 kV / 400V AC tri-phase	Lifts, cranes, general services Cooling & HVAC stations 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 Compressed-air	Detectors chambers Process control valves, moving systems, ...

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

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Secondary services

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

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 secondary service cavern, on the side opposite to the main one, has been proposed to serve the second detector.

Platform concept

The idea of having a mobile platform, in a push-pull scenario, was driven essentially by the consideration that the engineering of the interaction region can proceed almost independently from the design of each detector, giving only a few parameters to be respected (overall weight, overall dimensions, beam-high).

The platform plays also the role of interface between the detector and its services, whilst all the cables and hoses run inside dedicated cable-chains.

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)

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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 (examples: L-He transfer line serving superconducting magnets, LV power cables).
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.

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 ■

Low voltage to front-end electronics

The distribution of low voltage / high current power to front-end electronics is by far the most critical issue when designing the powering and cooling system of a modern HEP detector. As electronics evolves very quickly, people tend to make their choice at the very last moment, when the overall design of the detector is consolidated and often infrastructures on site have already been built.

Modern custom electronics may require even lower voltages than in the past.

It is essential to keep low voltage power cables as short as possible, possibly installing AC/DC converters and LV regulators into racks on the detector itself.

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.

Typical temperature/humidity distribution

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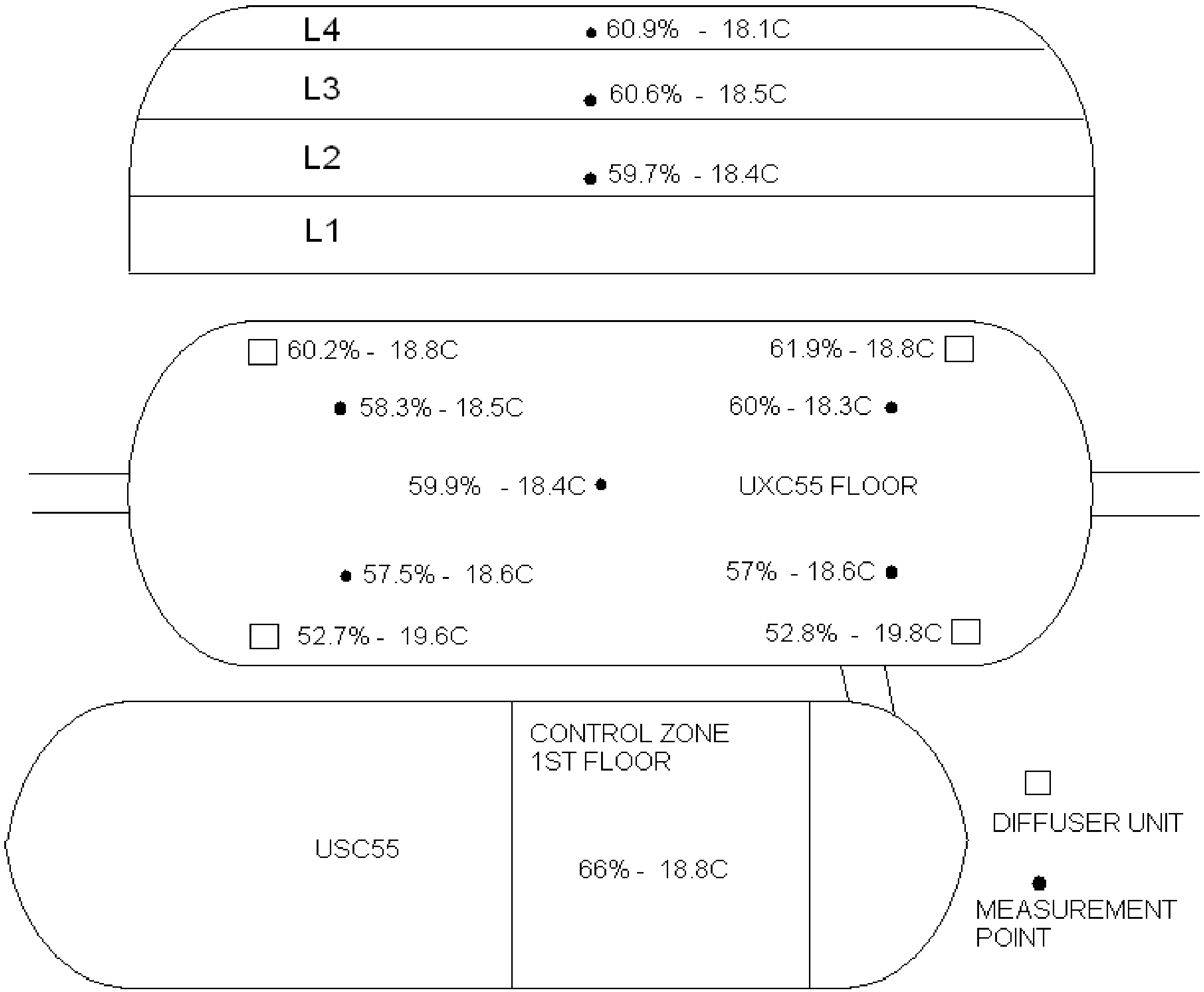
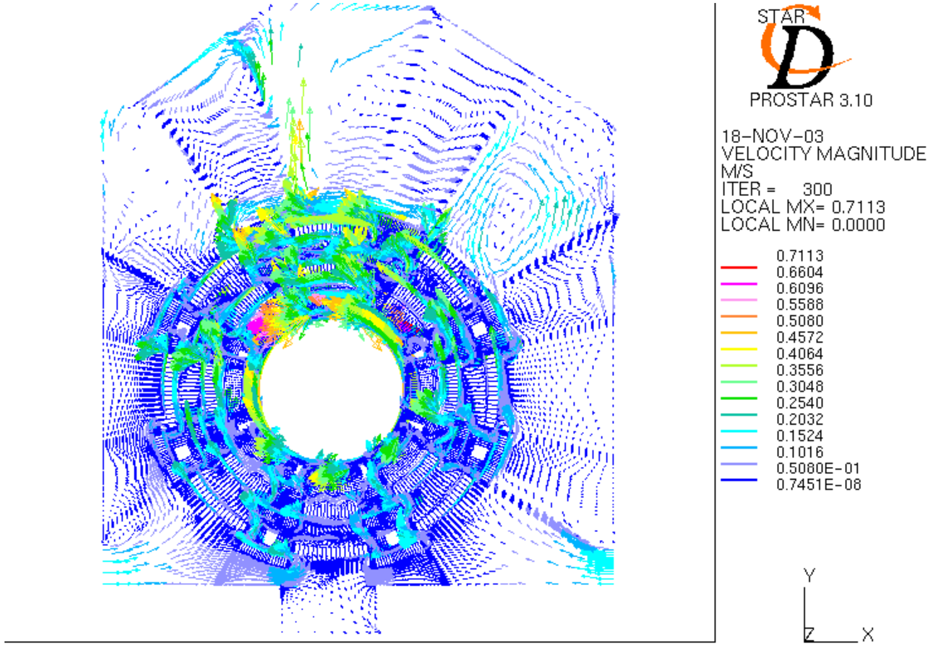
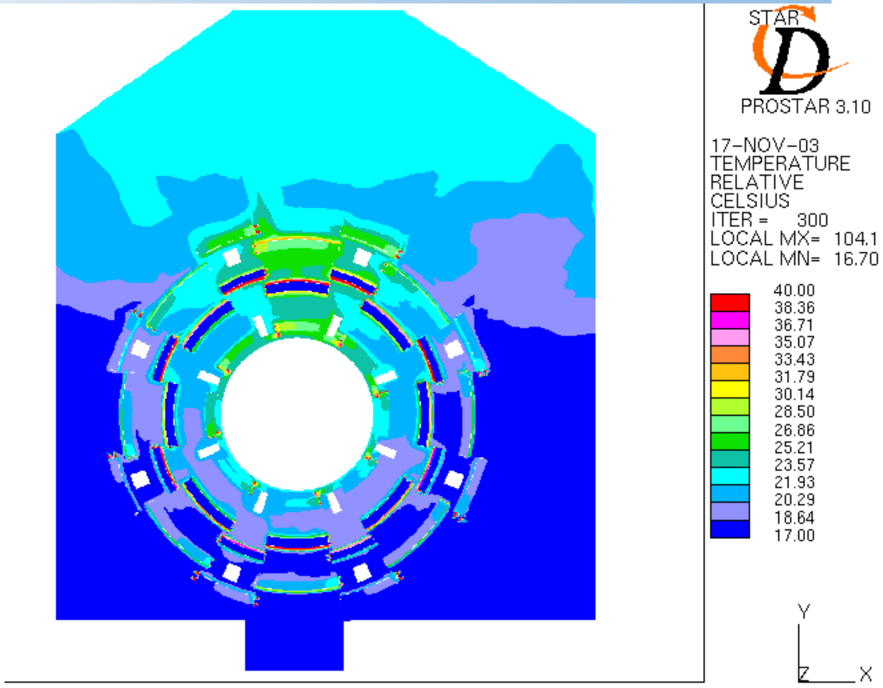


POINT 5 CAVERN TEMPERATURE/HUMIDITY VALUES
DATE 19/09/06 RECORDED BY: RDE
TIME 14:00

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.

Layout for ILC detector services

The following slides present a proposal to arrange services for ILC detector in the experimental area.

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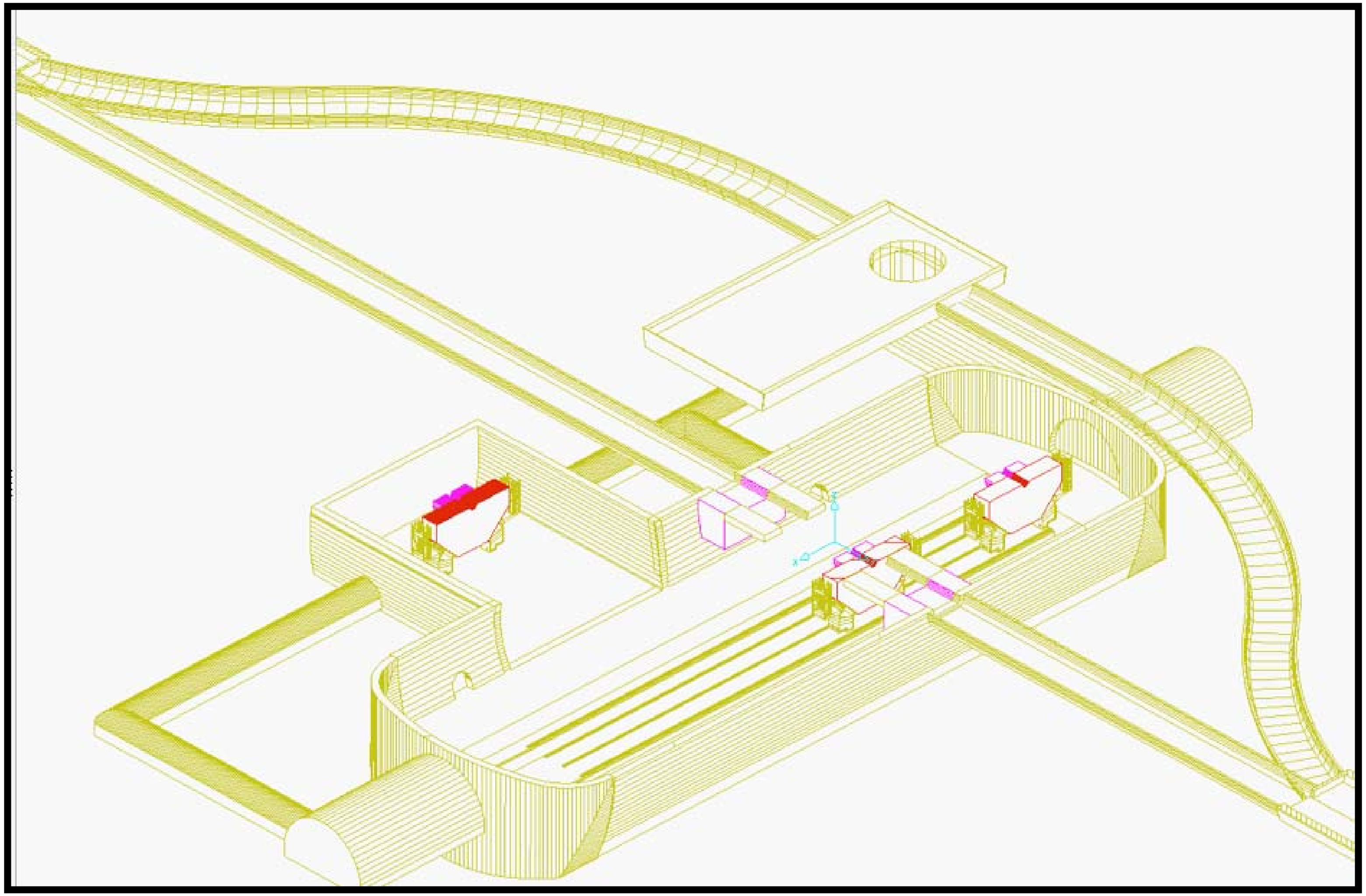
Service caverns



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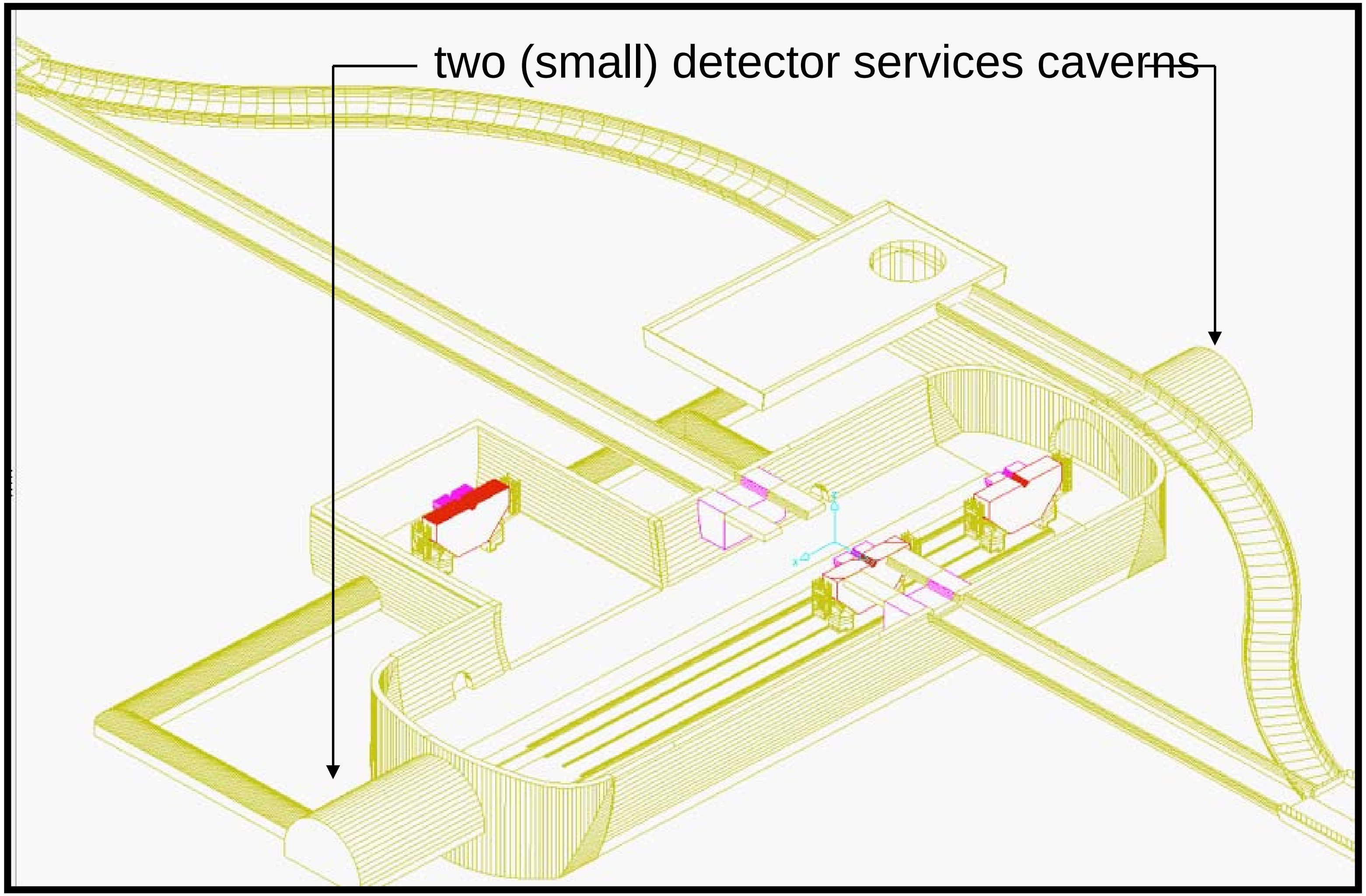
Service caverns



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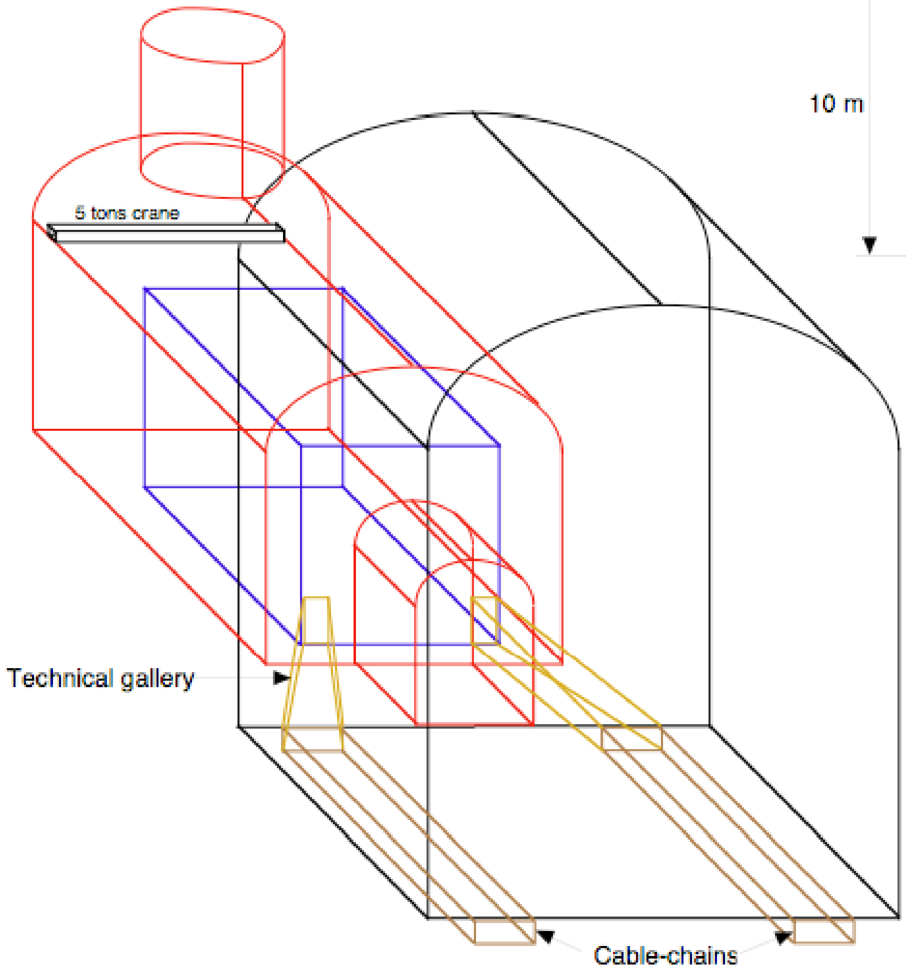
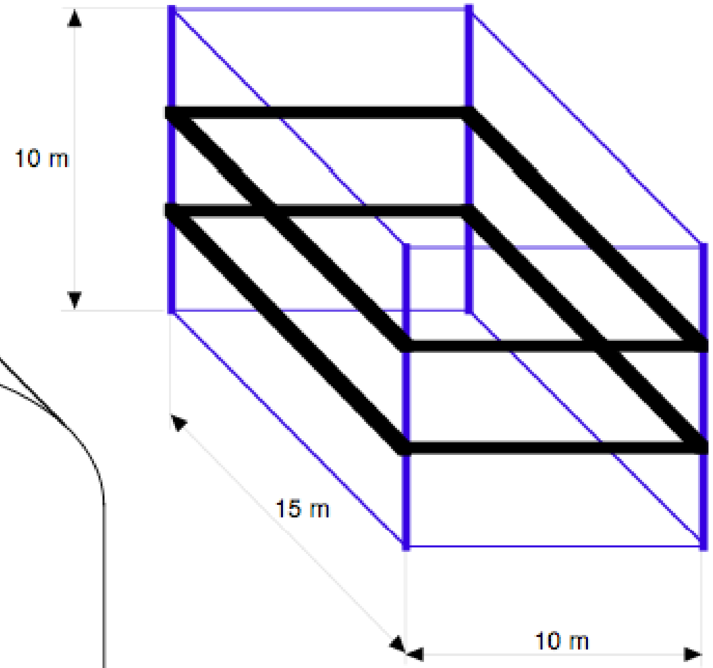
Service cavern layout

SERVICE CAVERN FOOTPRINT: 25 x 15 M2



Detector services block:
I-beam metallic structure
3 levels 3m high + false-floor



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

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

top floor:
electronics racks + miscellanea

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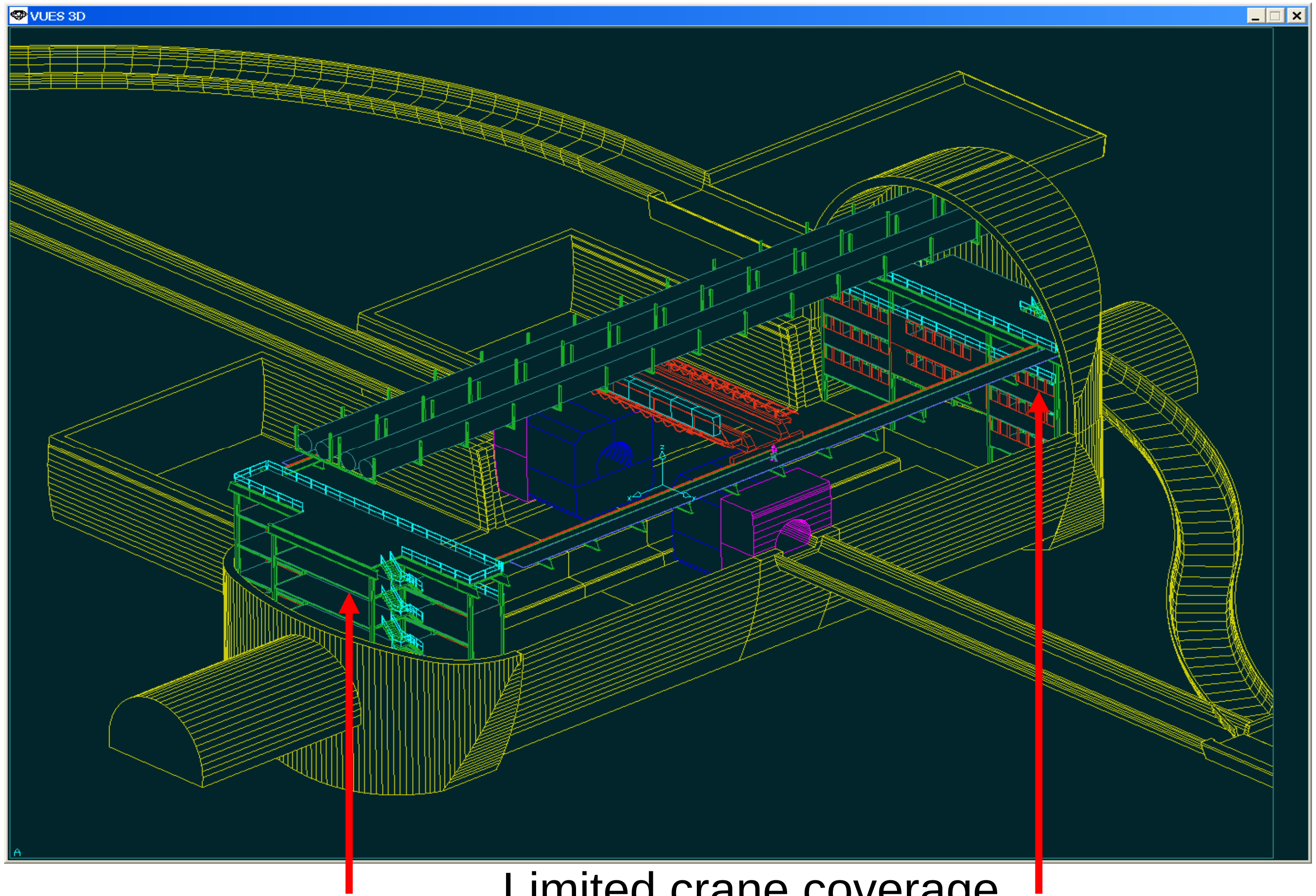
List of services housed in the “block”

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, …

Cavern balconies



Limited crane coverage

Only for light weight infrastructures (electronics racks)

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 have been presented during one of the phone meetings preparatory to this workshop. They give an overview of the CMS Infrastructures and can be used as a basis to define ILC detectors needs.

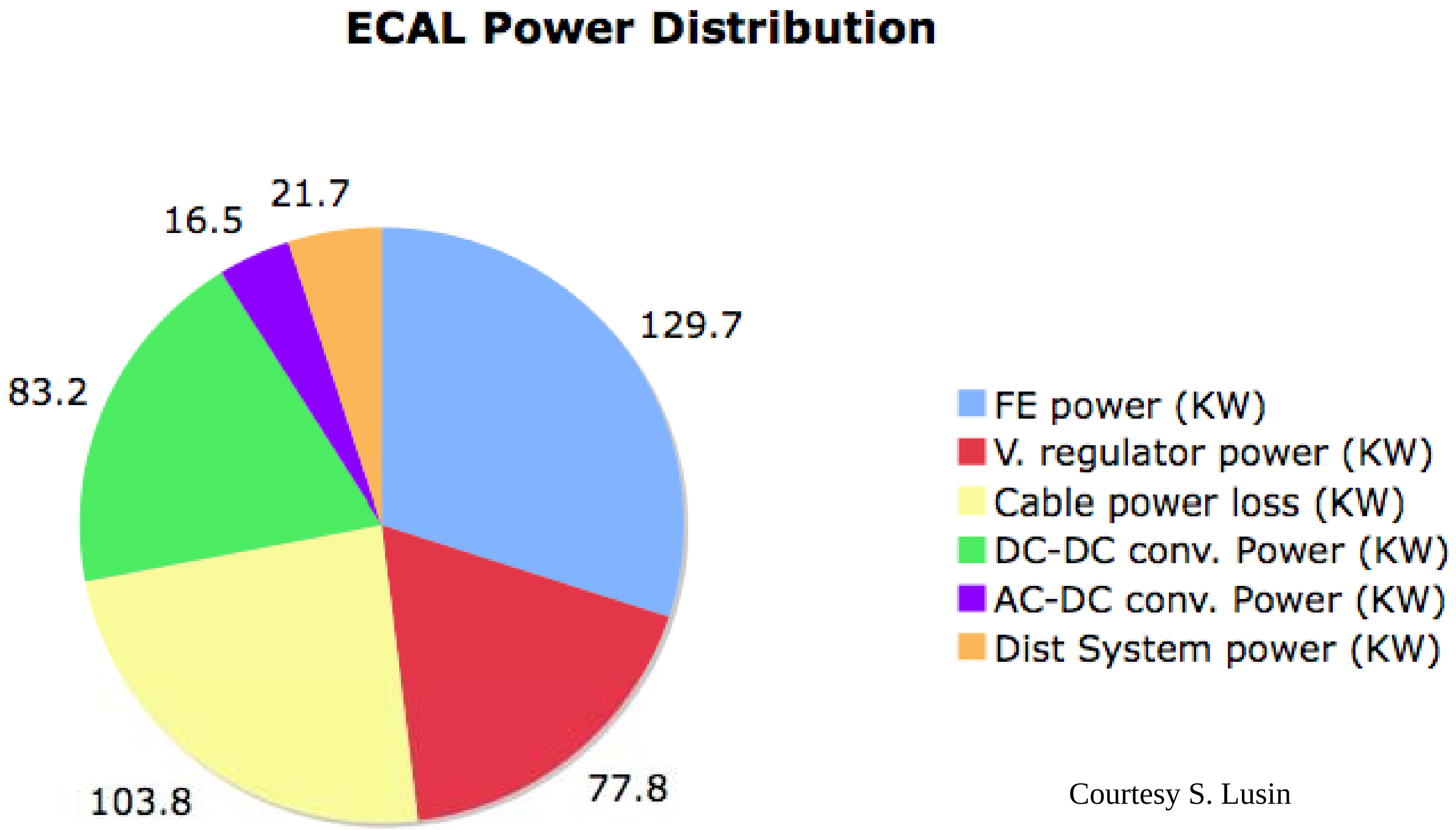
How much power

System	Rated power (kW)
General services on site (lifts, cranes, lights, …)	2,200
Electronics racks	2,300
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	4,000
Underground cooling stations:	
(water)	600
(C6F14)	600 (900)*
Total	12,750 (15,250)*

(*) 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 Barrelwater	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

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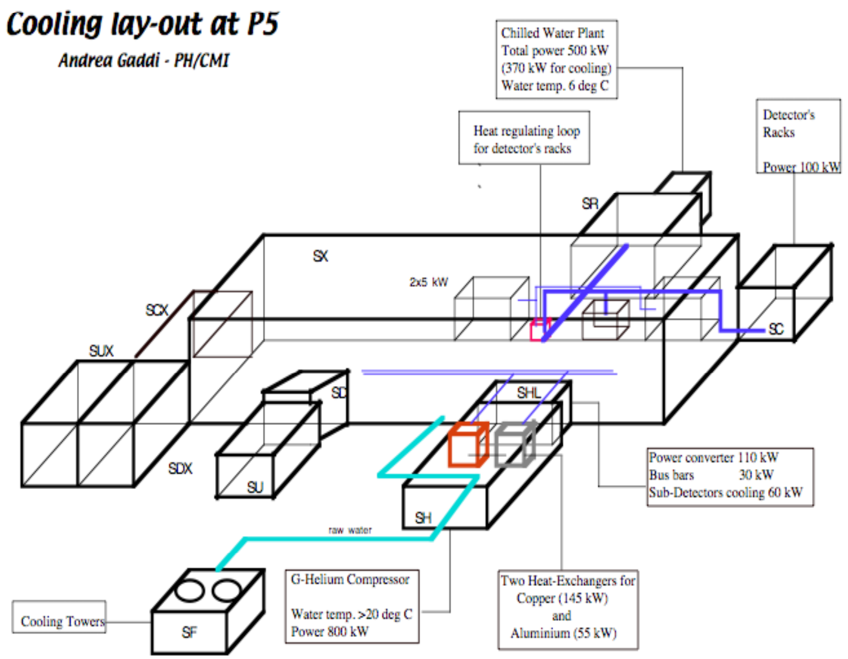
Cooling Infrastructures at CMS

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. 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.



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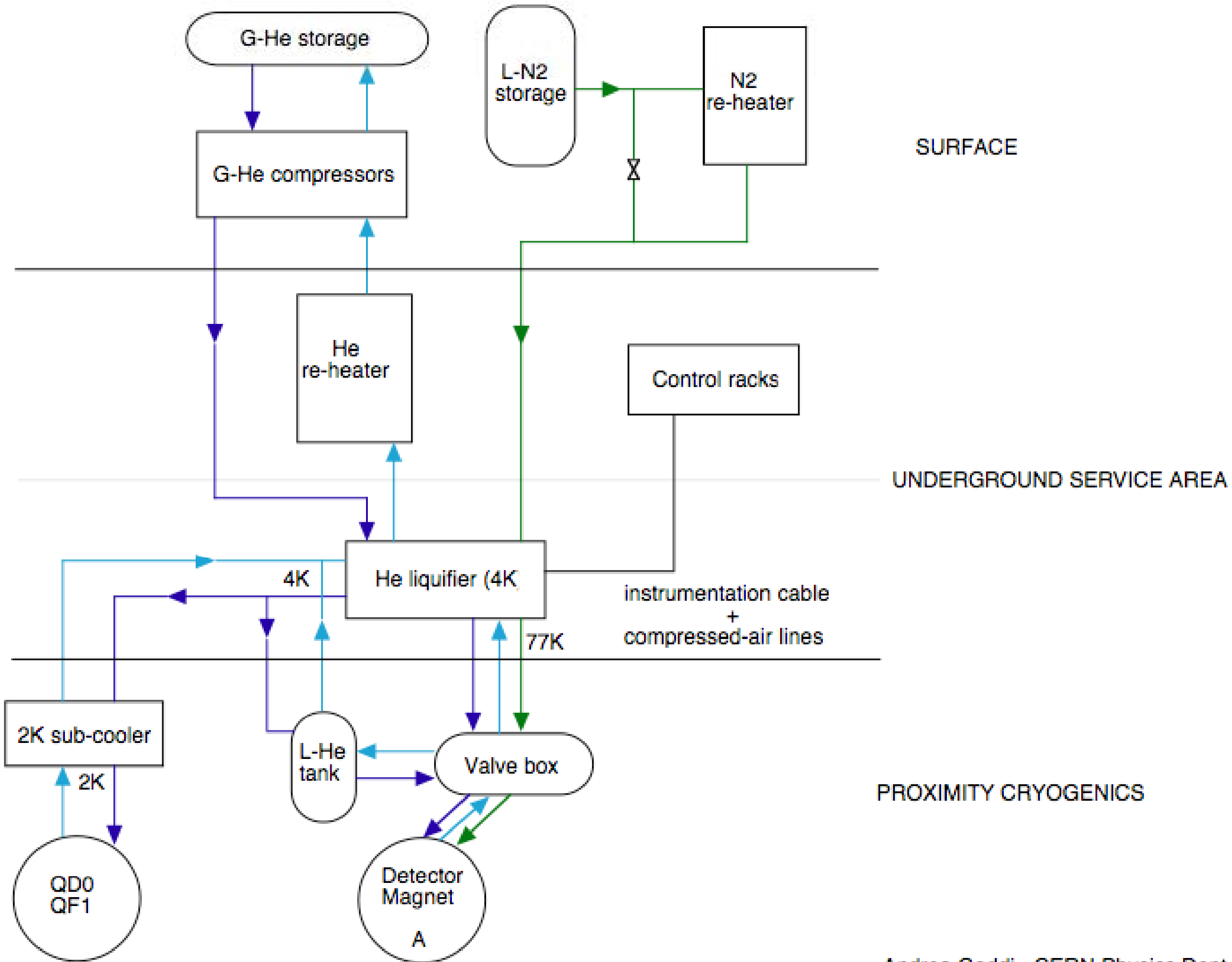
Cryogenics block diagram



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 15 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.

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Coil system components (20kA)

Equipment	Dimensions (cm)	Notes
DCCT ⇨	200x200x275(H)	
CP1-CP2 ⇨	265X160X275(H)	per unit (2)
TRANSFORMER	185X270X270(H)	
MAIN BREAKER	70X285X270(H)	
COIL HEATER	90X280X270(H)	
POWER CONVERTER ⇨	200X160X240(H)	per unit (4)
PRIMARY PUMPS ⇨	100X140X120(H)	per unit (2)
48V BATTERIES		
CONTROL RACK	60X90X210(H)	per unit (12)

More than 25m² required on the detector if on-board