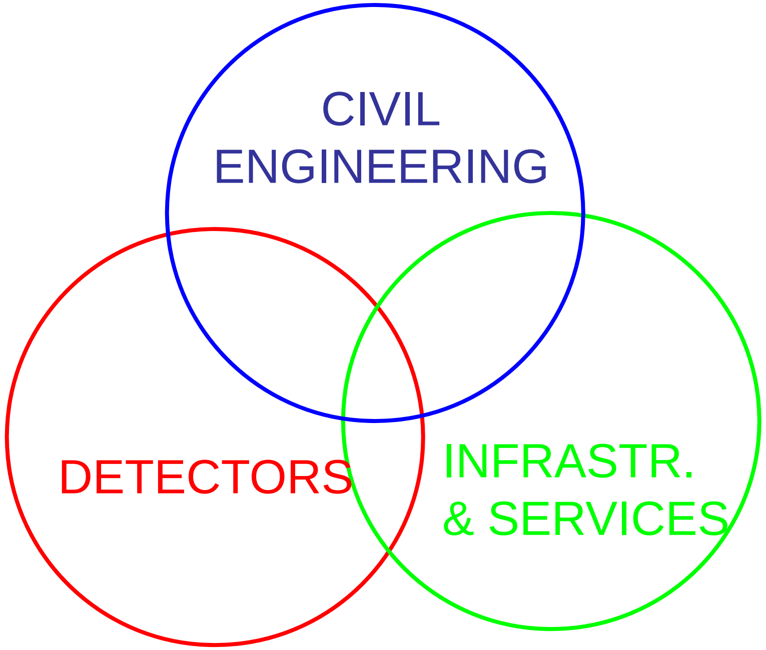
Part II: Integrated Design of Infrastructures

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 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.

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

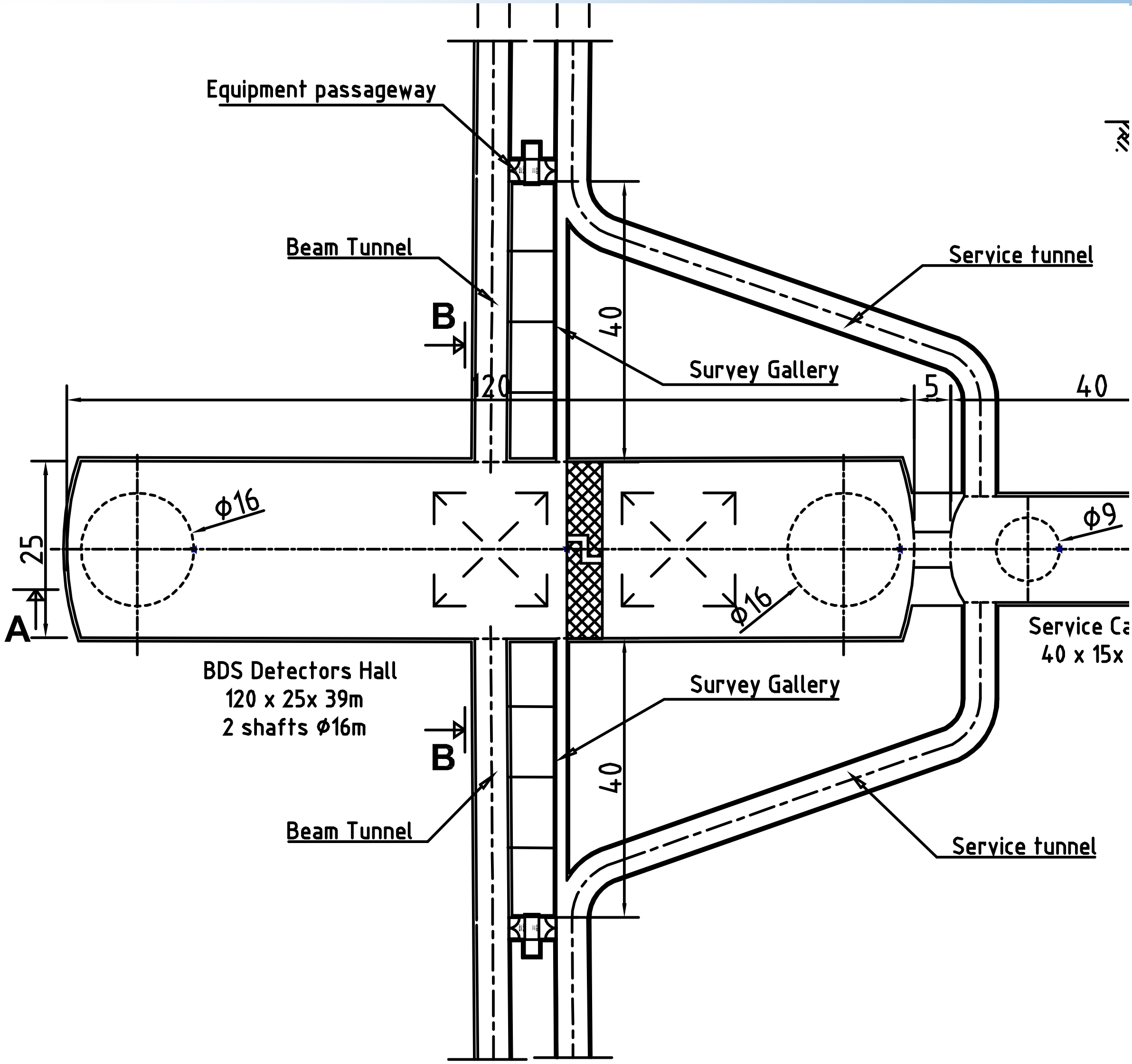
Some secondary services must be situated close to the detector as well, if the connection lines through the cable-chains is technically difficult or too expensive.
However this makes the size of the moving detector bigger with risks of inducing vibrations and electrical noise and should be limited to a few special utilities, in a push-pull scenario, where detectors move every month or so.

Layout for ILC detector services

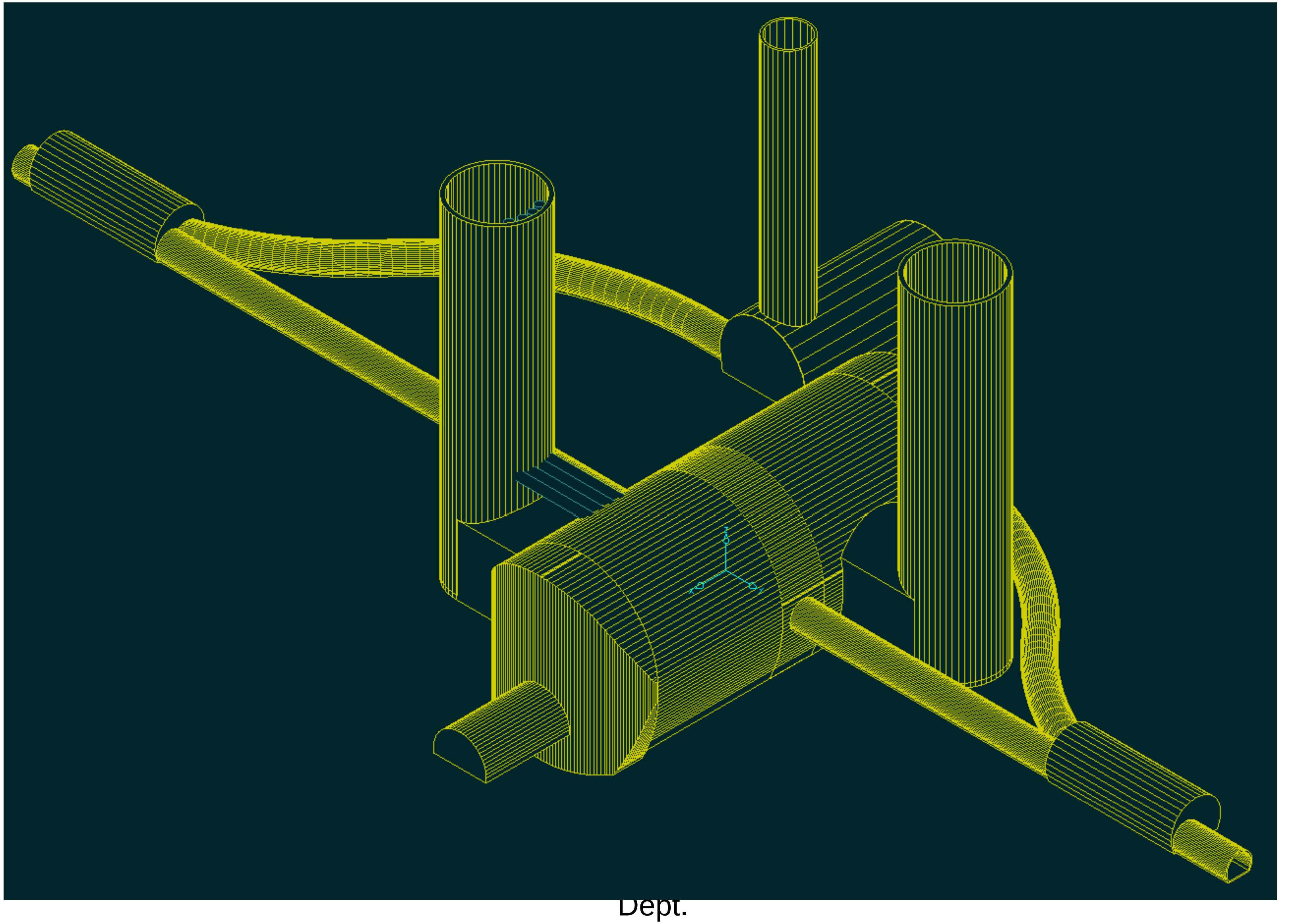
The following slides present a proposal to arrange services for ILC detector in the experimental area. The criteria taken into account are:

- Minimum impact on civil engineering cost with respect to the RDR baseline (reduced main cavern length)
- Enhanced safety by removing shafts from cavern ceiling
- Better logistic and easier installation of services by adding two small alcoves at main cavern ends
- Optimization for push-pull scenario

Interaction Region Baseline

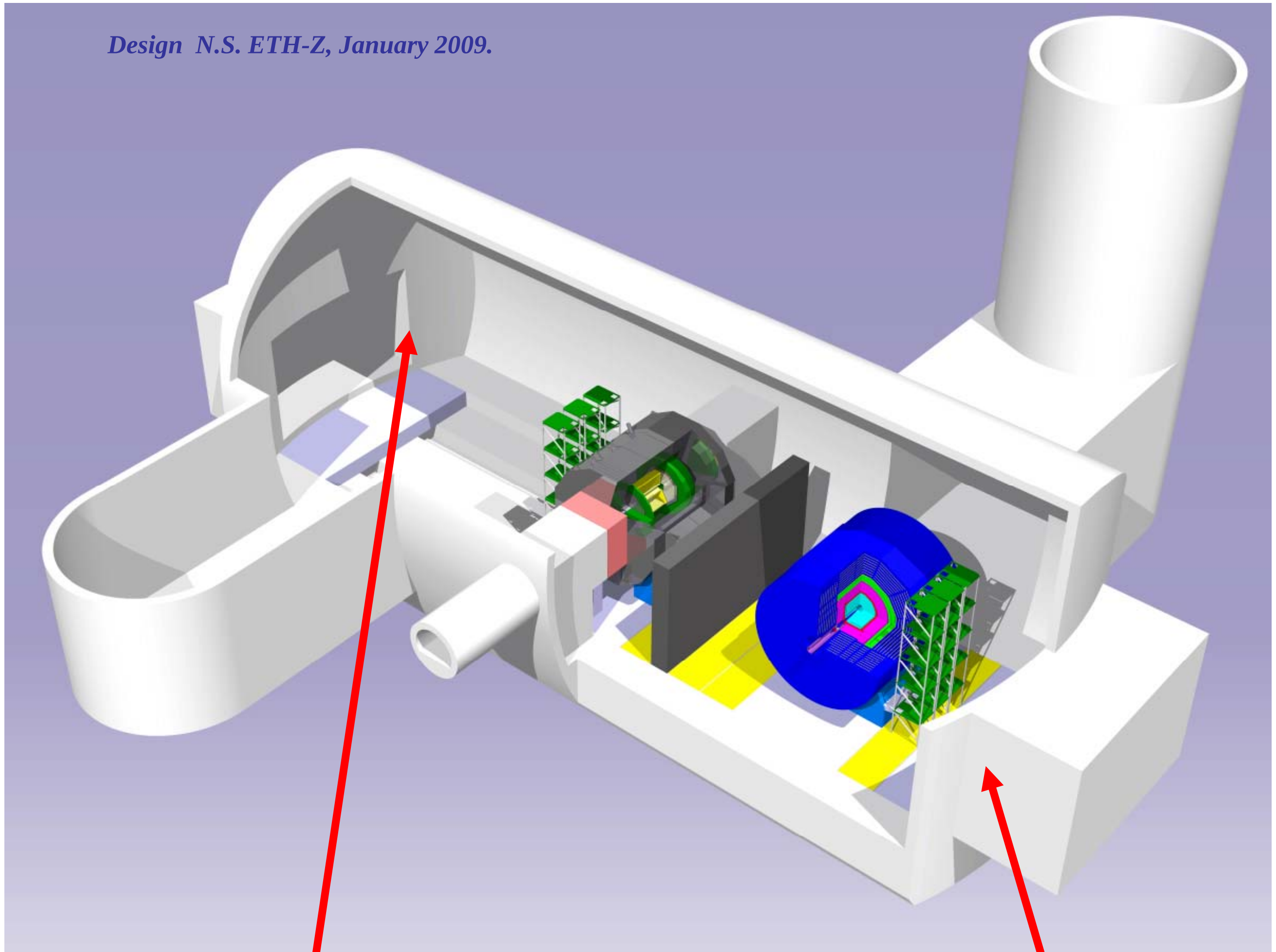


Layout with two offset shafts and alcoves



Dept.

Cavern space for detector infrastructures

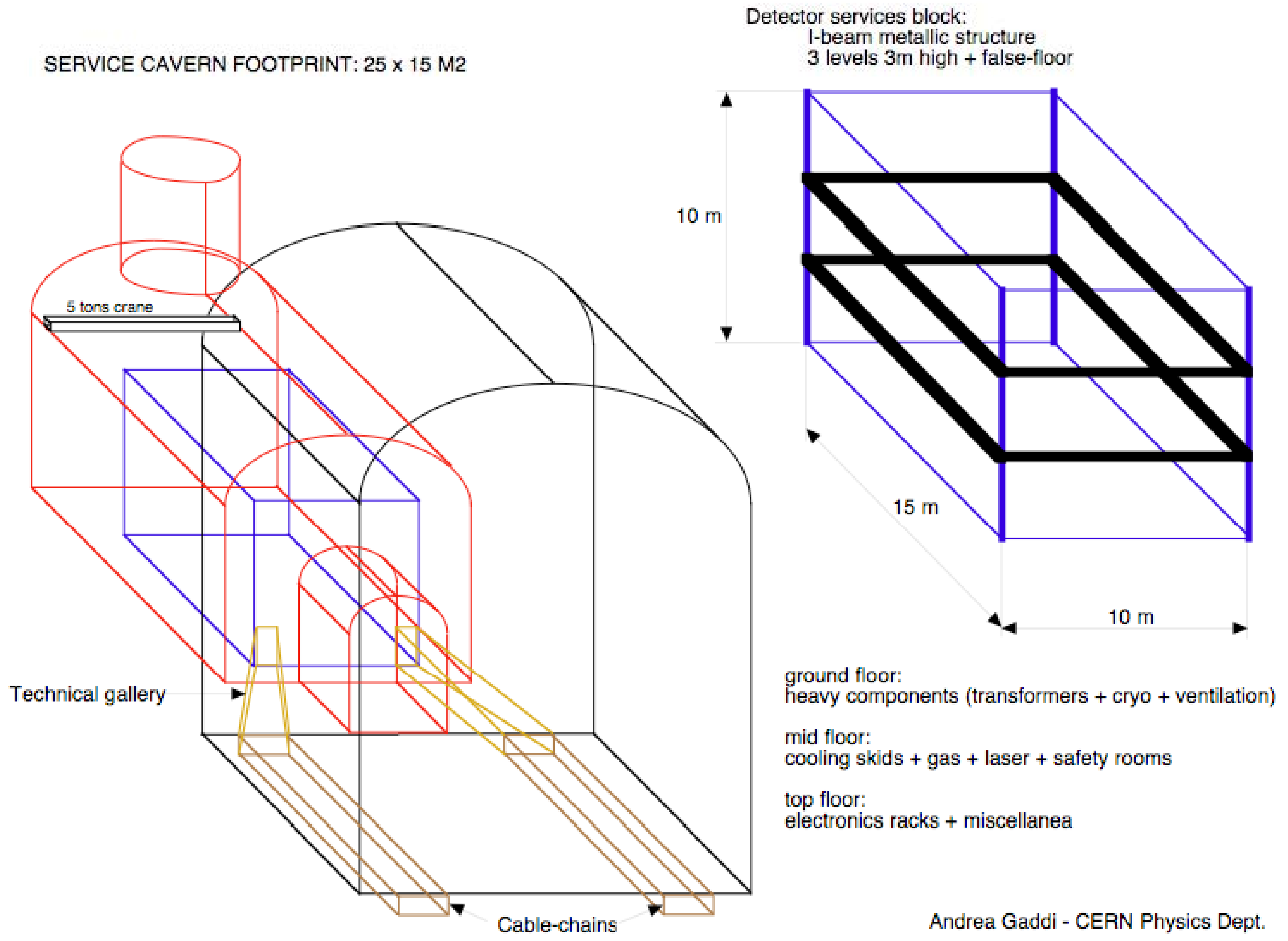


No crane coverage. Only for light weight infrastructures (electronics racks)

Service alcove with light crane

Andrea Gaddi, CERN Physics Dept.

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

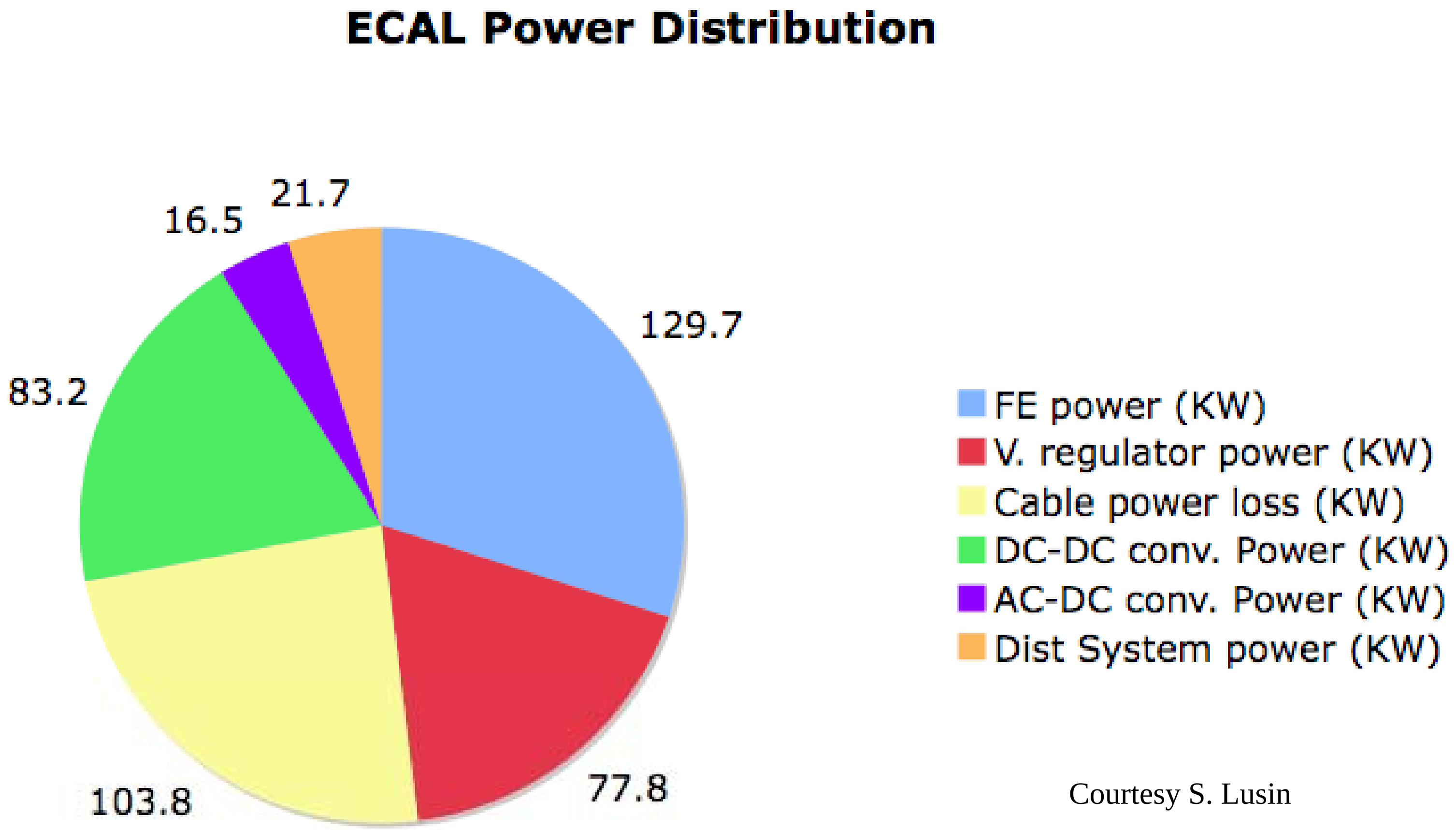
How much power

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

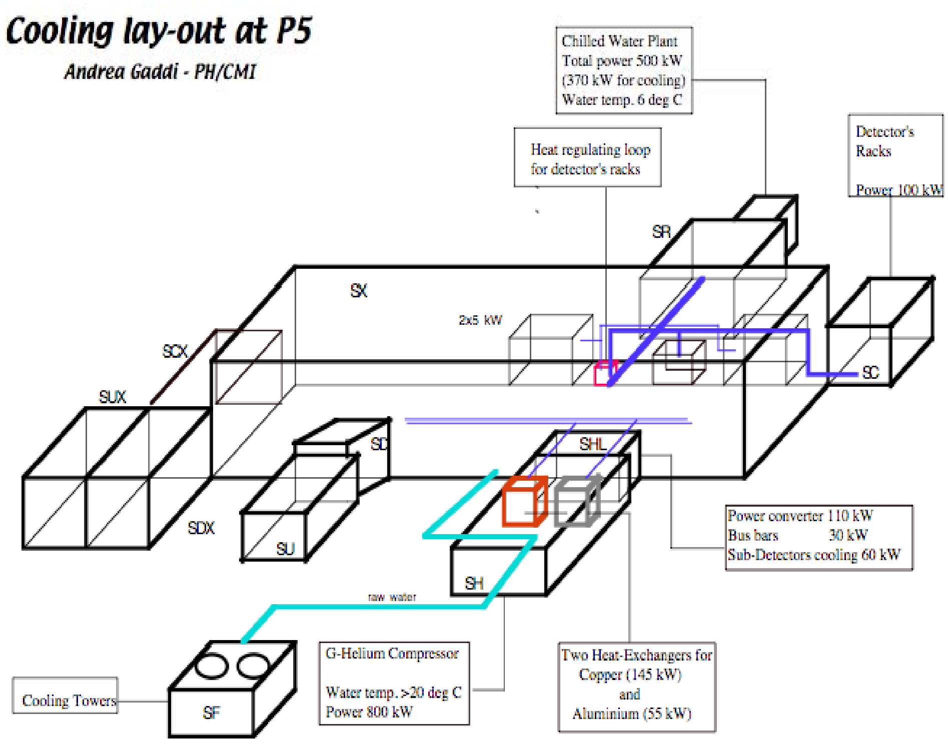
More than 1 MW is dissipated into heat by CMS Front Electronics boards.
This large amount of heat needs to be transferred away from the Detector
via appropriate cooling fluids (water or CxFy, depending on working temperature).

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. 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.



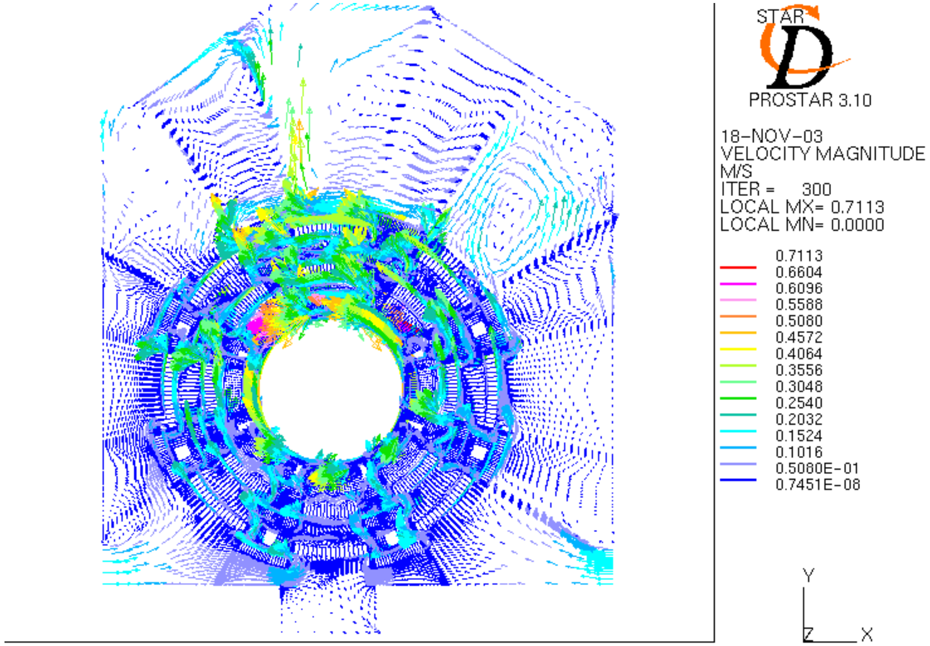
Cavern ventilation

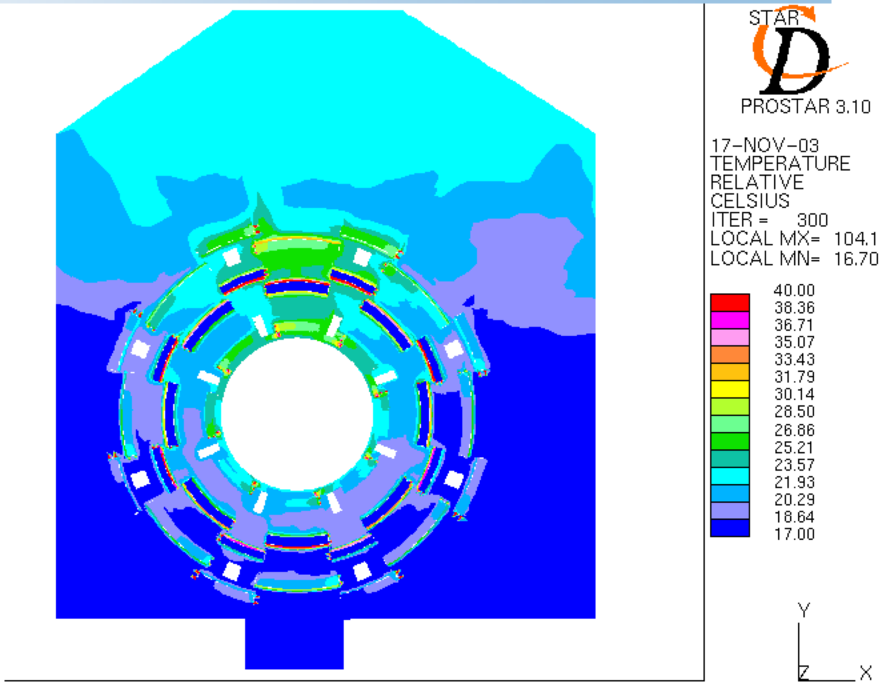
Temperature stability of the cavern air plays a role in the calibration of most of the detectors. Vertical gradients are usually accepted, but not large temperature fluctuations.

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





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- 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.