# Power Distribution for NSS Instrumentation

IKON 13

Lund, 26th September 2017

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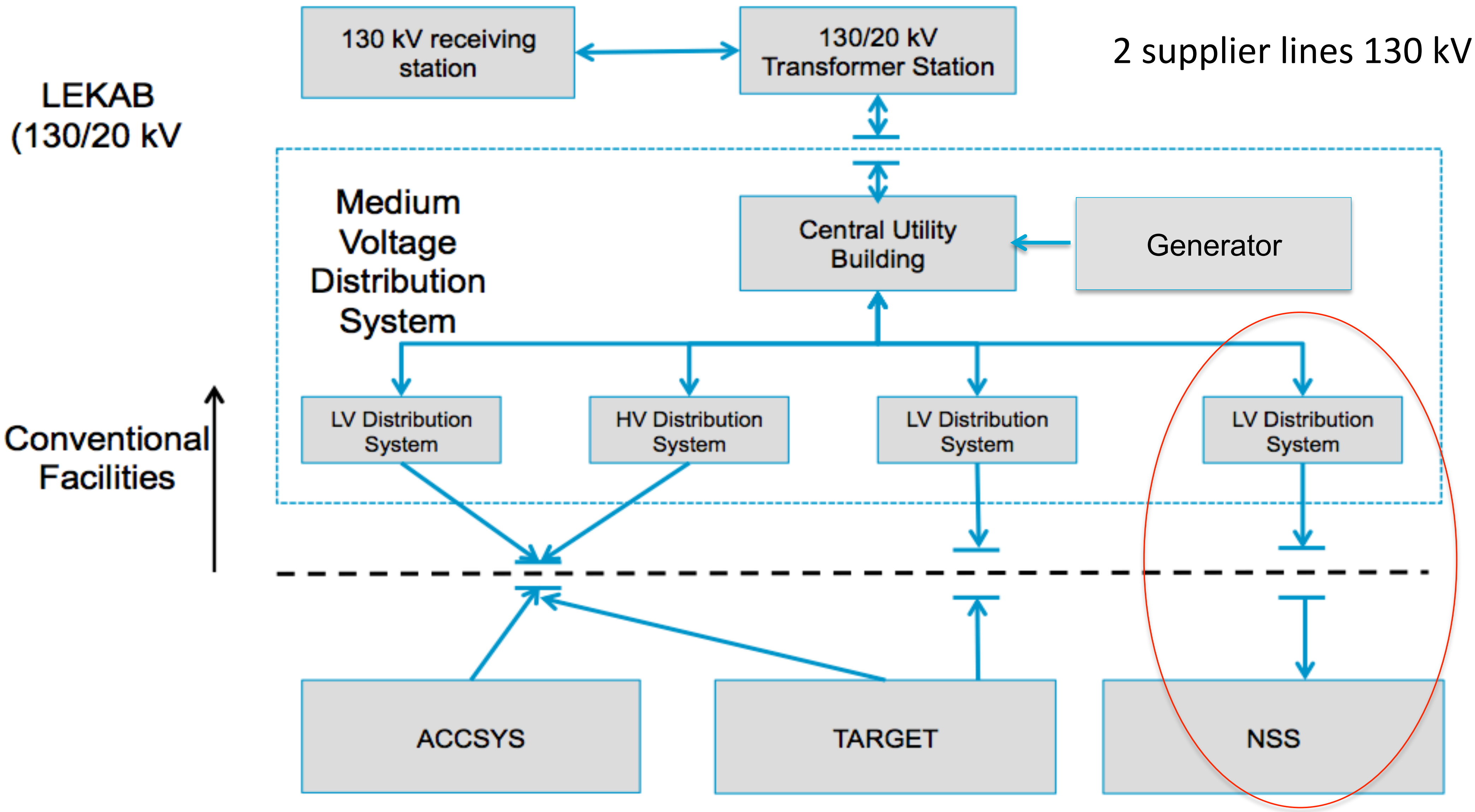
# Overview

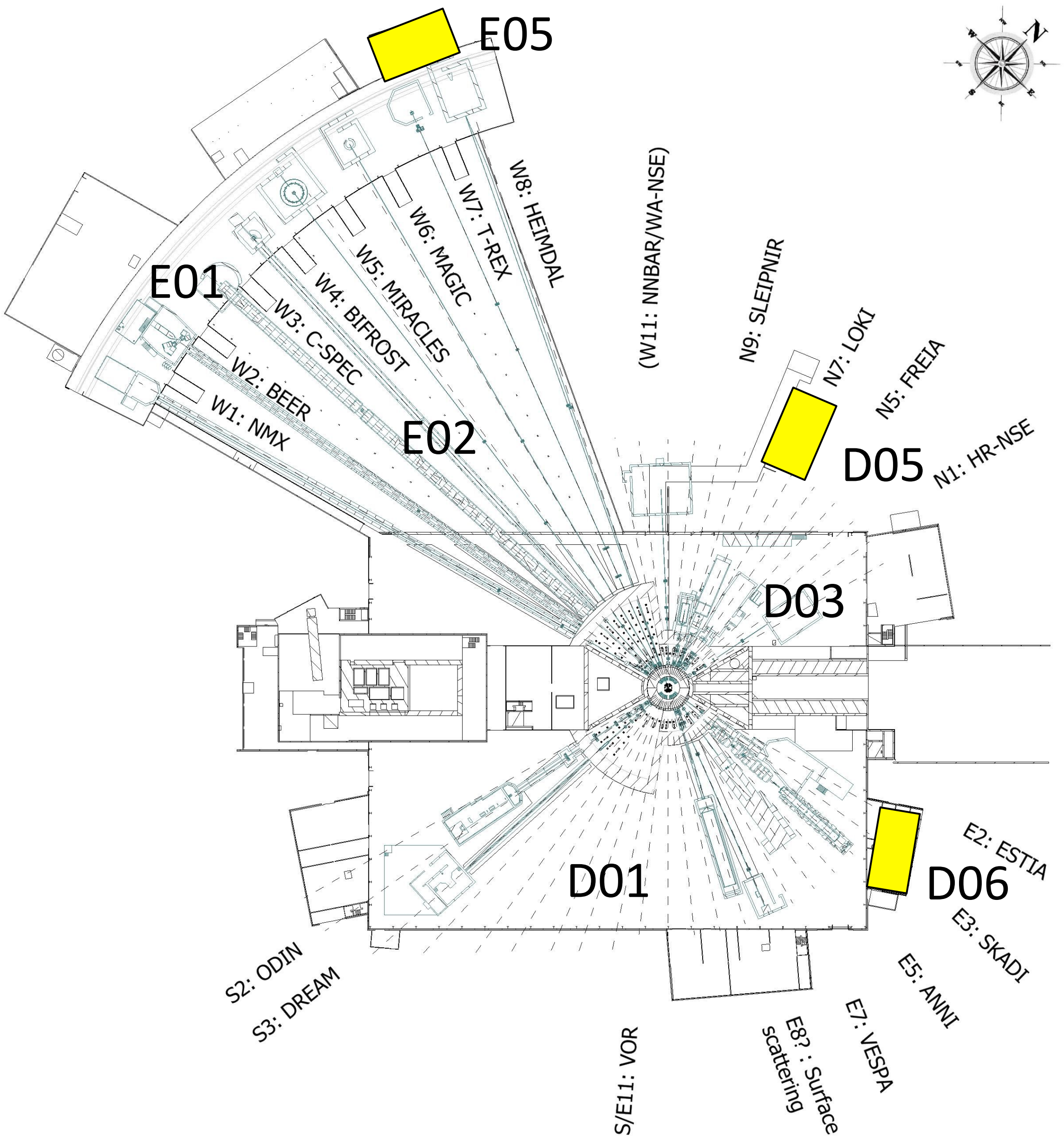
- Power Distribution Strategy
  - Topology, power supply zones
  - CF planning: Load list, design of transformer substations
  - Cable routing, 3D planning
- Instruments power distribution
  - Connection point
  - Power distribution cabinet
- NSS power failure strategy
  - Detectors
  - Choppers
  - Other control electronics etc.
- ESS project interfaces to Instrument Teams
- Additional Slides
  - Halls infrastructure ("vacuum cleaner sockets")
  - Labs and workshops in D04, D07, D08, E03 and E04
  - Summary power needs for NSS

# ESS Power Distribution - Overview

2 supplier lines 130 kV



# Power Distribution NSS – Instruments Halls

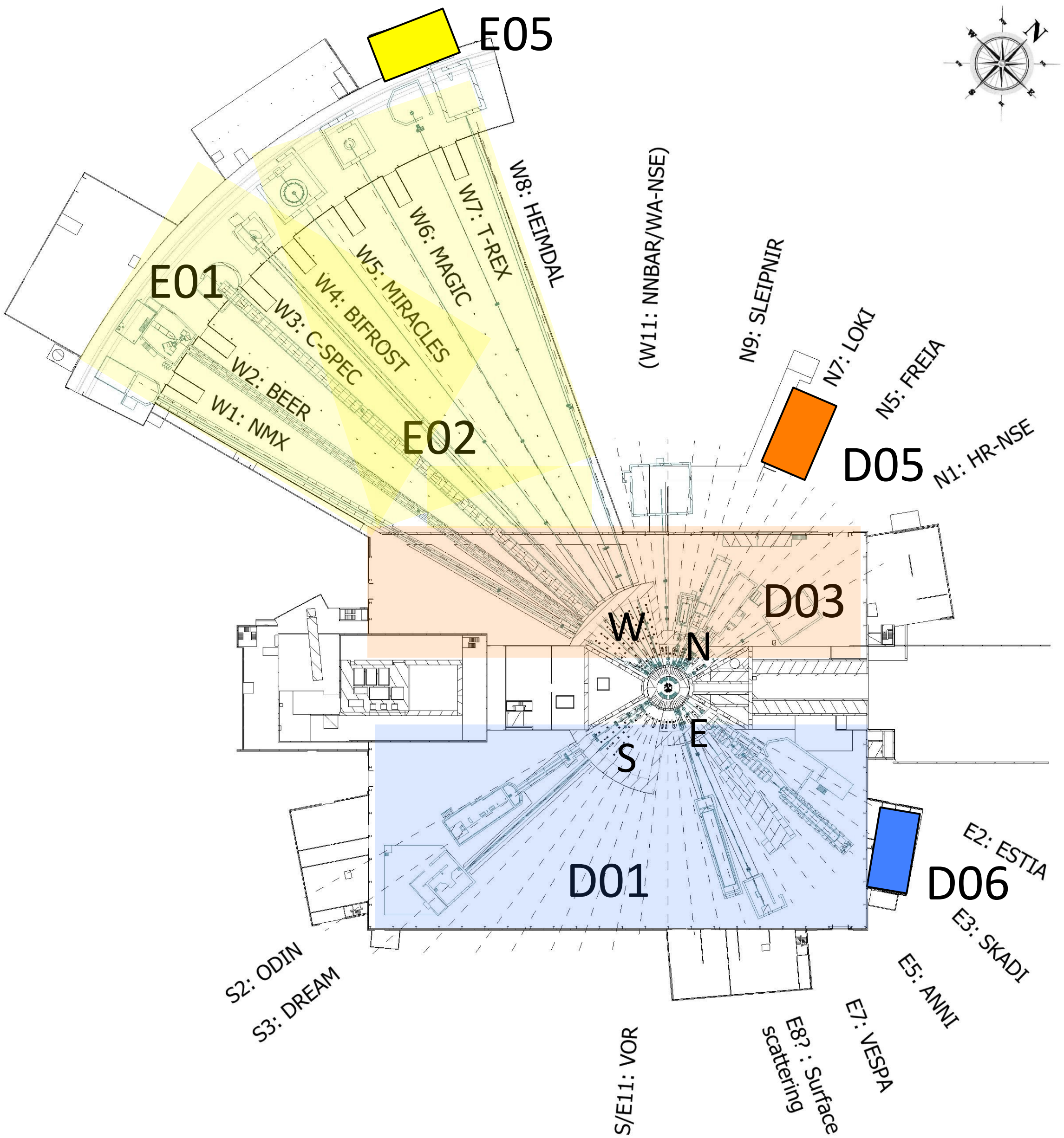



Interface Control Document CF-NSS (ESS-0058274) - Requirements

- No installation of instruments power by CF
- Substations have outlets for future 22 instruments
- The bunker area is included in the instrument numbers
- Outlets and transformers are dimensioned according to an estimated average power need distributed over the 4 halls

- NSS-CF-23: 20 standard instruments (30 kW)
- NSS-CF-24: 2 high-power instruments (100 kW)
- Auxiliary generator power 100 kW

# NSS Power supply zones– Instruments Halls




- E05
  - Supply of the cave areas of instruments W1 to W8 in E01
  - Supply of instruments installations in the guide-hall E02
- D05
  - Supply of the Instruments N1 to N11 in D03
  - Supply of parts of the instruments W1 to W8 in D03
  - Supply of the bunker areas W and N
- D06
  - Supply of the instruments S1 to S10 and E1 to E11
  - Supply of the bunker areas S and E

# CF planning – Load list for instruments

| ocatior | Equipment | Connection point | Voltage [V] | Curren t [A] | Rated Powe[r] [kVA] | Actual Power [kVA] | Outlet # | Instrument distribution v1 | Instrument distribution v2 |
|---|---|---|---|---|---|---|---|---|---|
| D03 | NSS equipment | =63C:01- | 400 | 56 | 39 | 39 | GEN14 | | |
| D03 | NSS equipment | =63C:01- | 400 | 130 | 90 | 37 | 1 | Loki | Loki |
| D03 | NSS equipment | =63C:01- | 400 | 130 | 90 | 37 | 2 | Freia | Freia |
| D03 | NSS equipment | =63C:01-N53 | 400 | 130 | 90 | 37 | 3 | Instrument 16 | Testbeamline (#16) |
| D03 | NSS equipment | =63C:01-N54 | 400 | 130 | 90 | 37 | 4 | NMX | NMX, BEER, C-SPEC, BIFROST |
| D03 | NSS equipment | =63C:01-N53 | 400 | 130 | 90 | 37 | 5 | BEER | MIRACL,MAGIC, T-REX, HEIMD |
| D03 | NSS equipment | =63C:01-N54 | 400 | 130 | 90 | 37 | 6 | C-Spec | SLEIPNIR (#18) |
| D03 | NSS equipment | =63C:01-N53 | 400 | 130 | 90 | 37 | 7 | Bifrost | Aux |
| D03 | NSS equipment | =63C:01-N54 | 400 | 130 | 90 | 37 | 8 | Miracles | Aux |

Standard, Generator: max. 160A, Hi-Power: max 400A

## E05

- Outlets: 34 Standard, 2 Generator
- Current: 214 kVA actual, 397 kVA rated

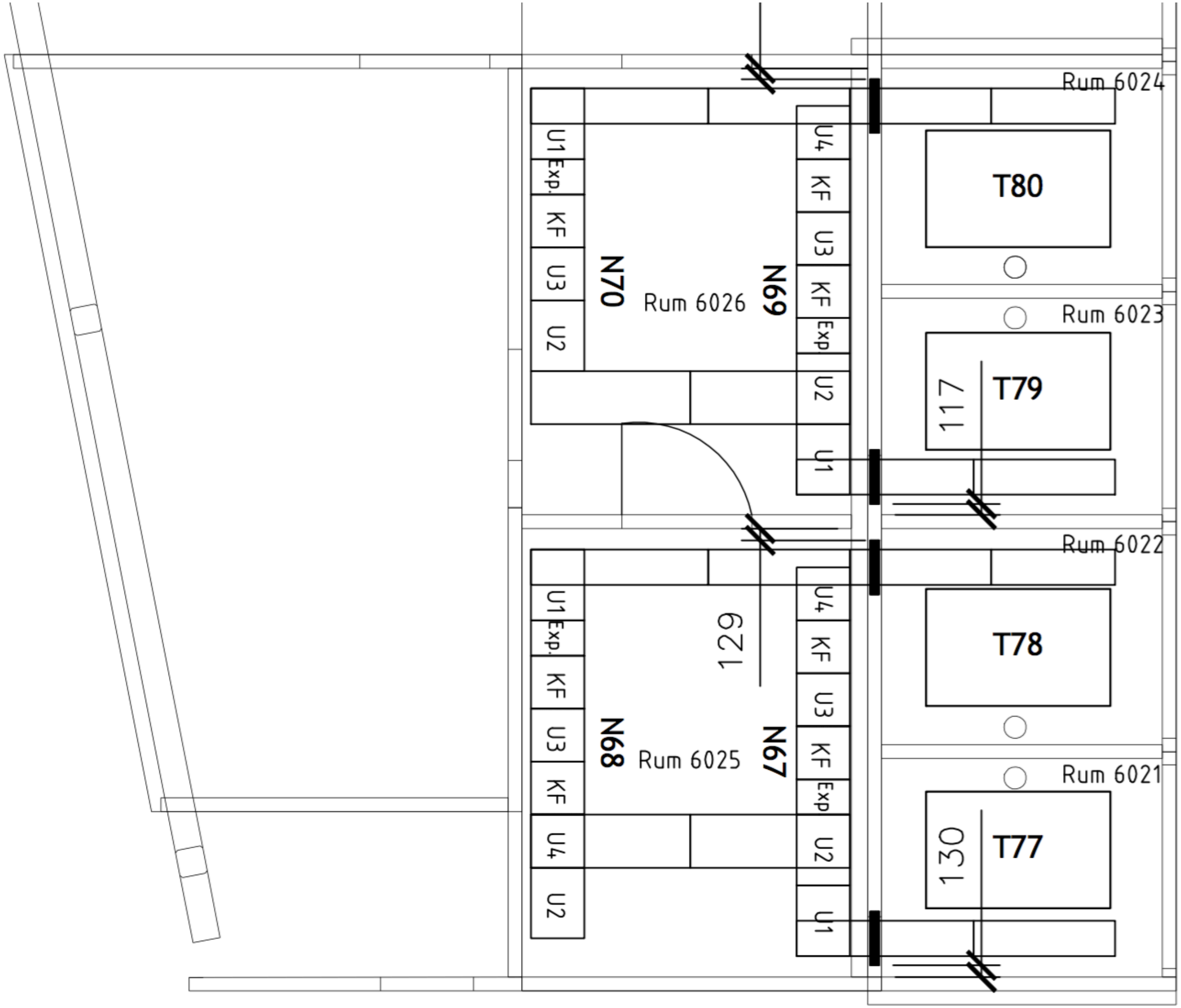
## D05

- Outlets: 13 Standard, 2 Hi-Power, 1 Generator
- Current: 590 kVA actual, 1762 kVA rated

## D06

- Outlets: 36 Standard, 2 Generator
- Current: 380 kVA actual, 650 kVA rated

# CF planning – Transformer in D06, level 100

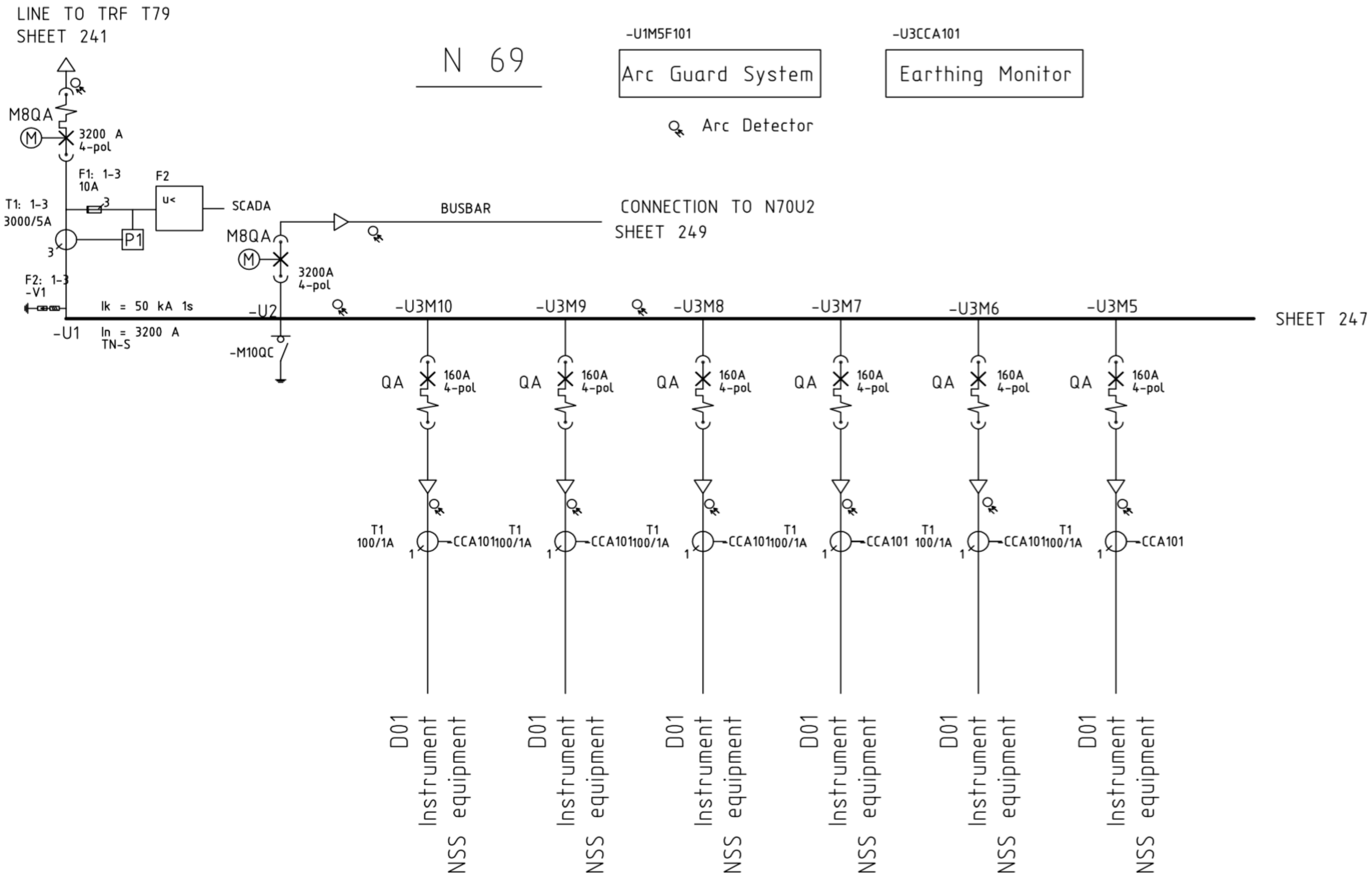



D06

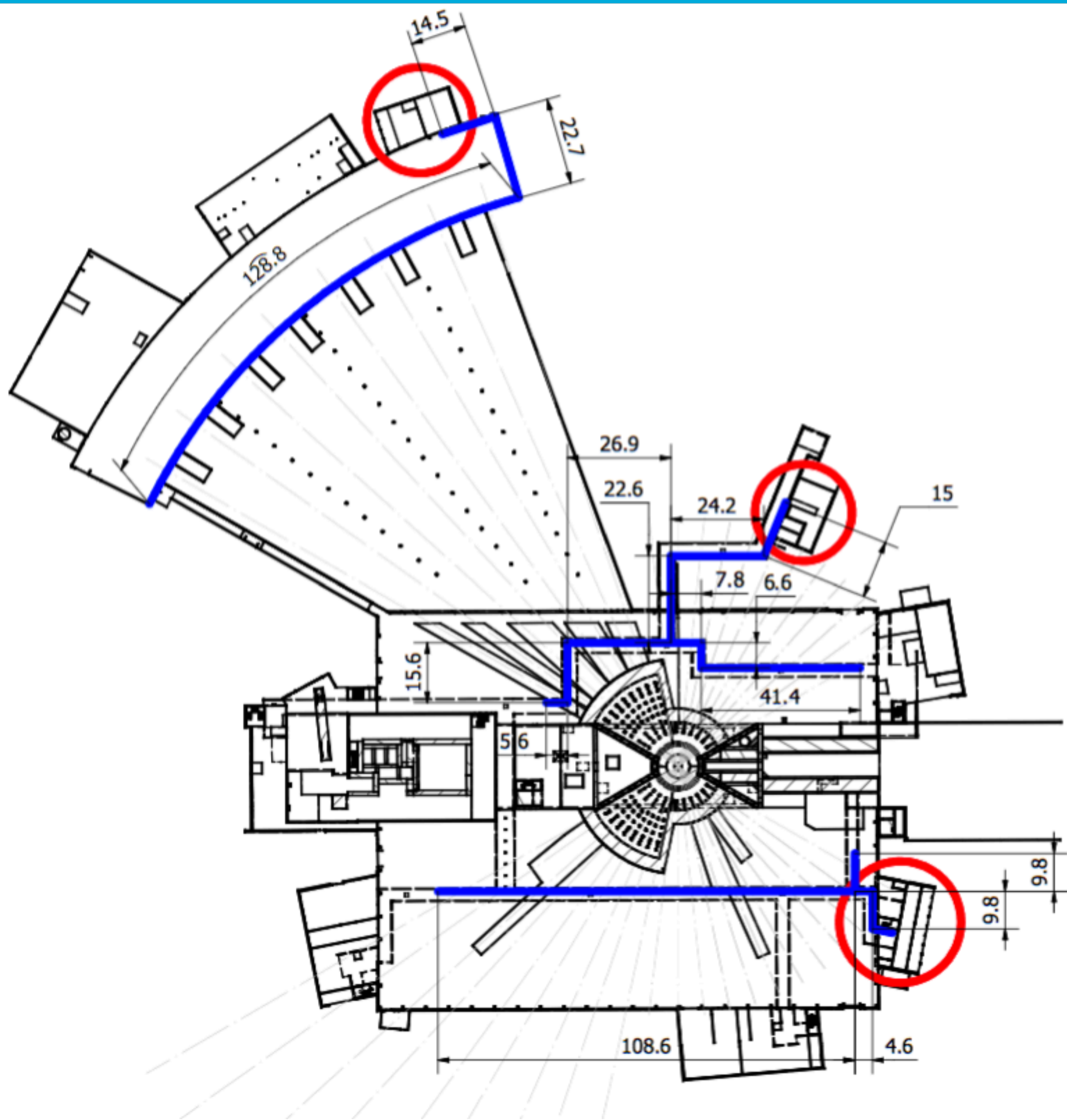
Power distribution panels for NSS:
N67, N68, N69 + N70

Transformers for NSS:
T77, T78, T79 + T80

# CF planning – Transformer wiring diagram



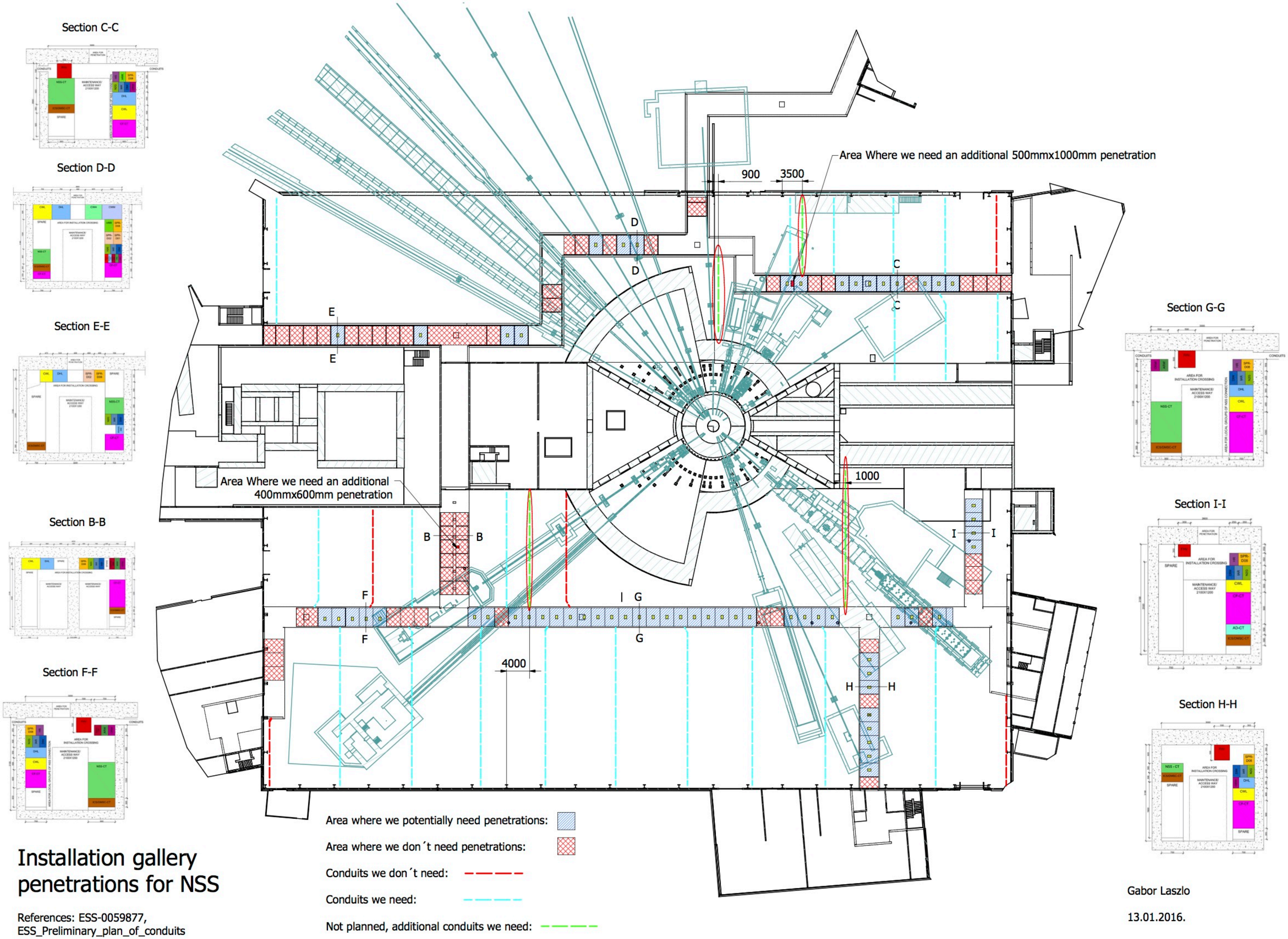
# Cable routing – Overview




Interface Control Document CF-NSS (ESS-0058274) – Load list

- Instruments will be connected to the substation through the gallery (D0x) or installations along the columns (E0x)

- Preliminary distribution of actual power needs over the halls and substations:
- D01: 360 kW (substation D06)
- D03: 551 kW (substation D05)
- E01: 170 kW (substation E05)
- E02: Will be supplied from E01
- Auxiliary generator power (distributed over all halls) : 103 kW



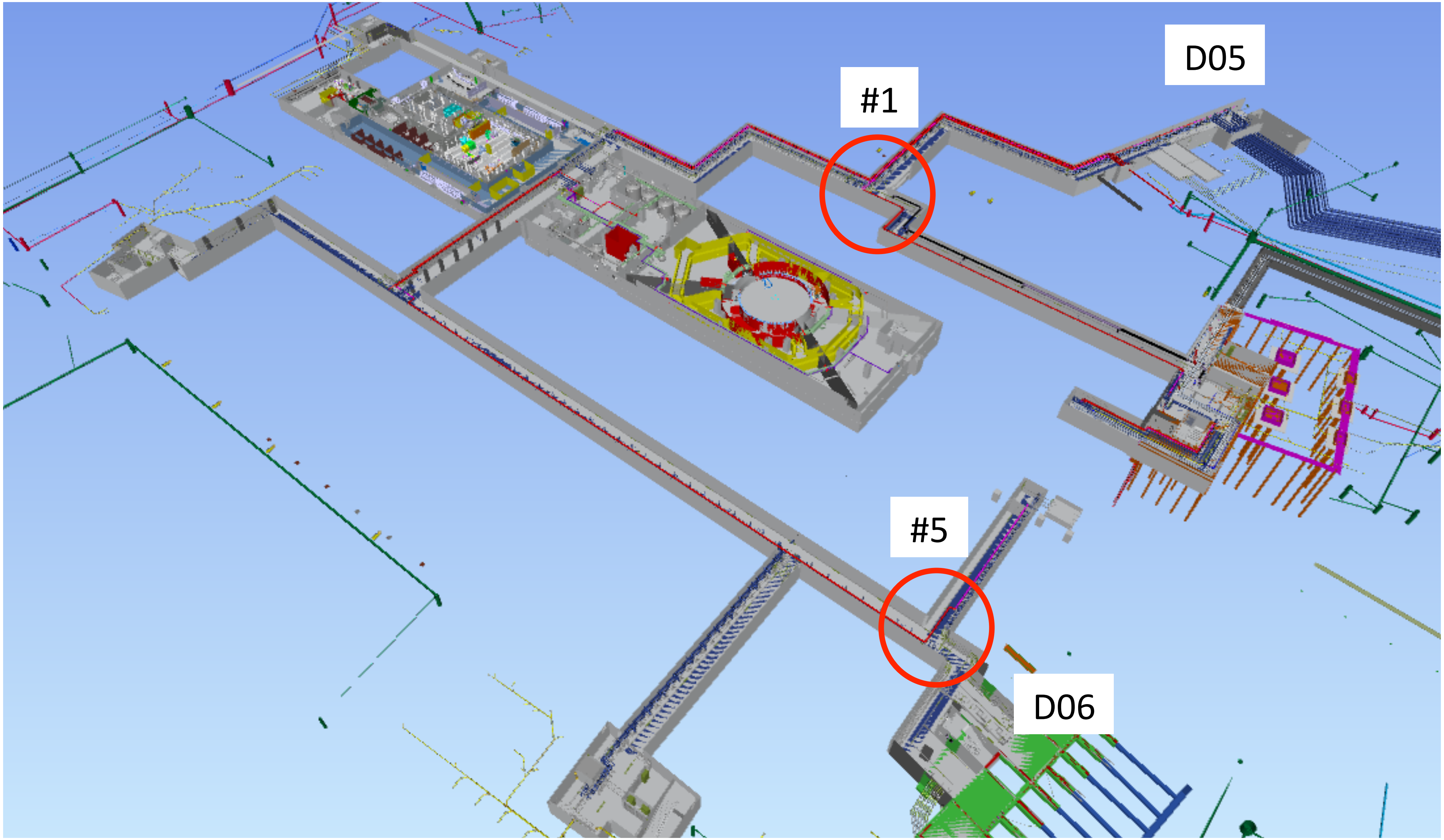

# Installation gallery penetrations for NSS

References: ESS-0059877,
ESS_Preliminary_plan_of_conduits

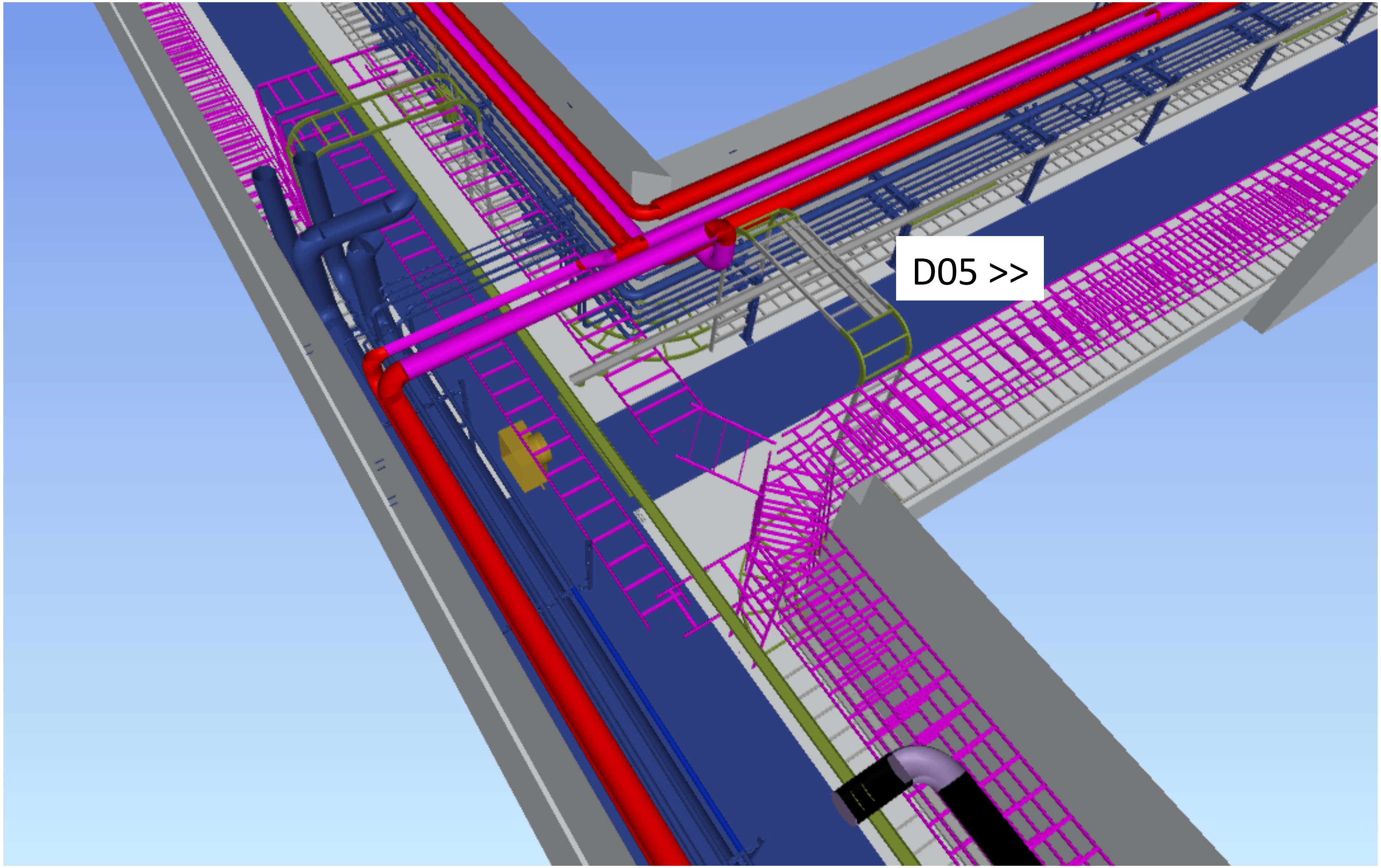
Gabor Laszlo

13.01.2016.

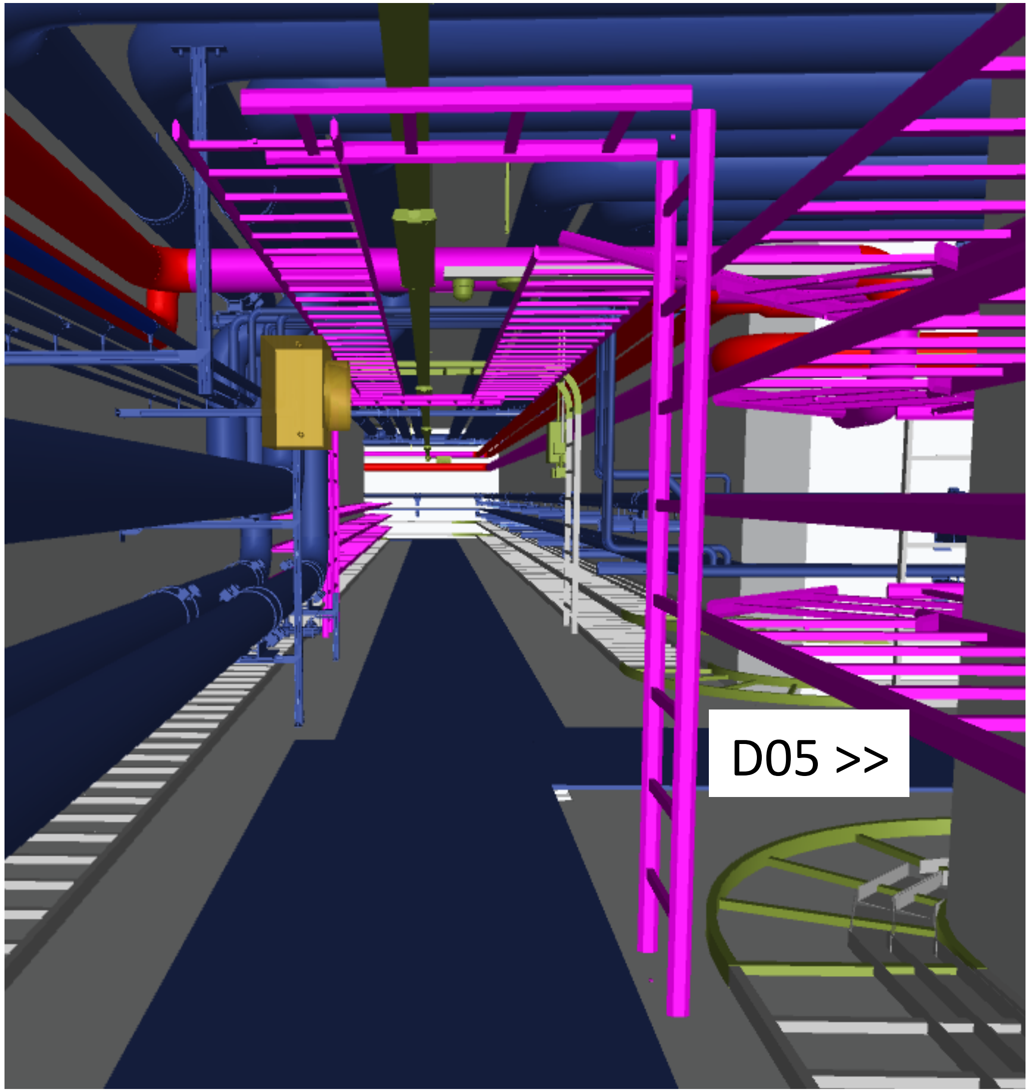
# Cable routing – 3D planning overview

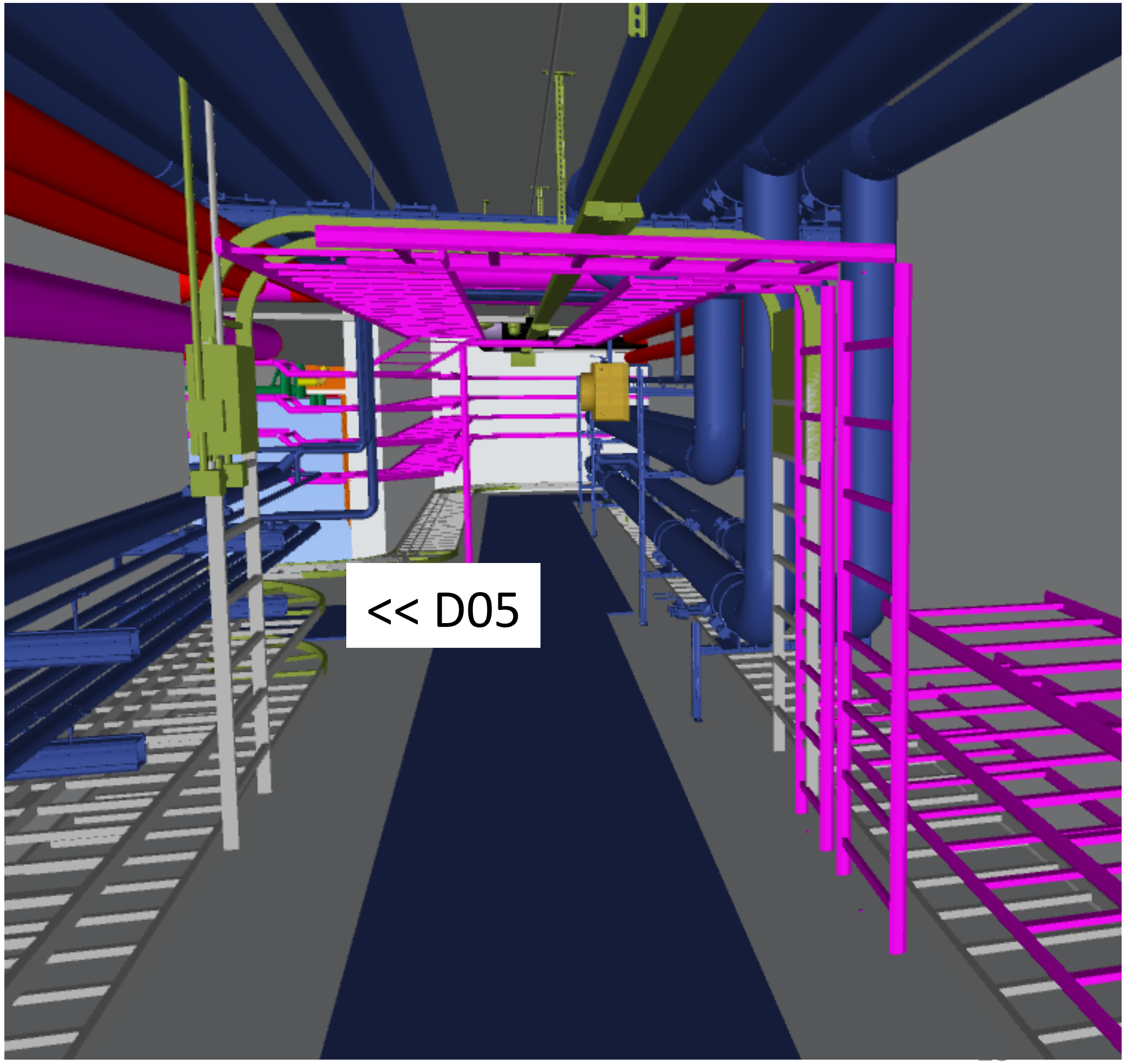


# Cable routing – 3D planning junction #1

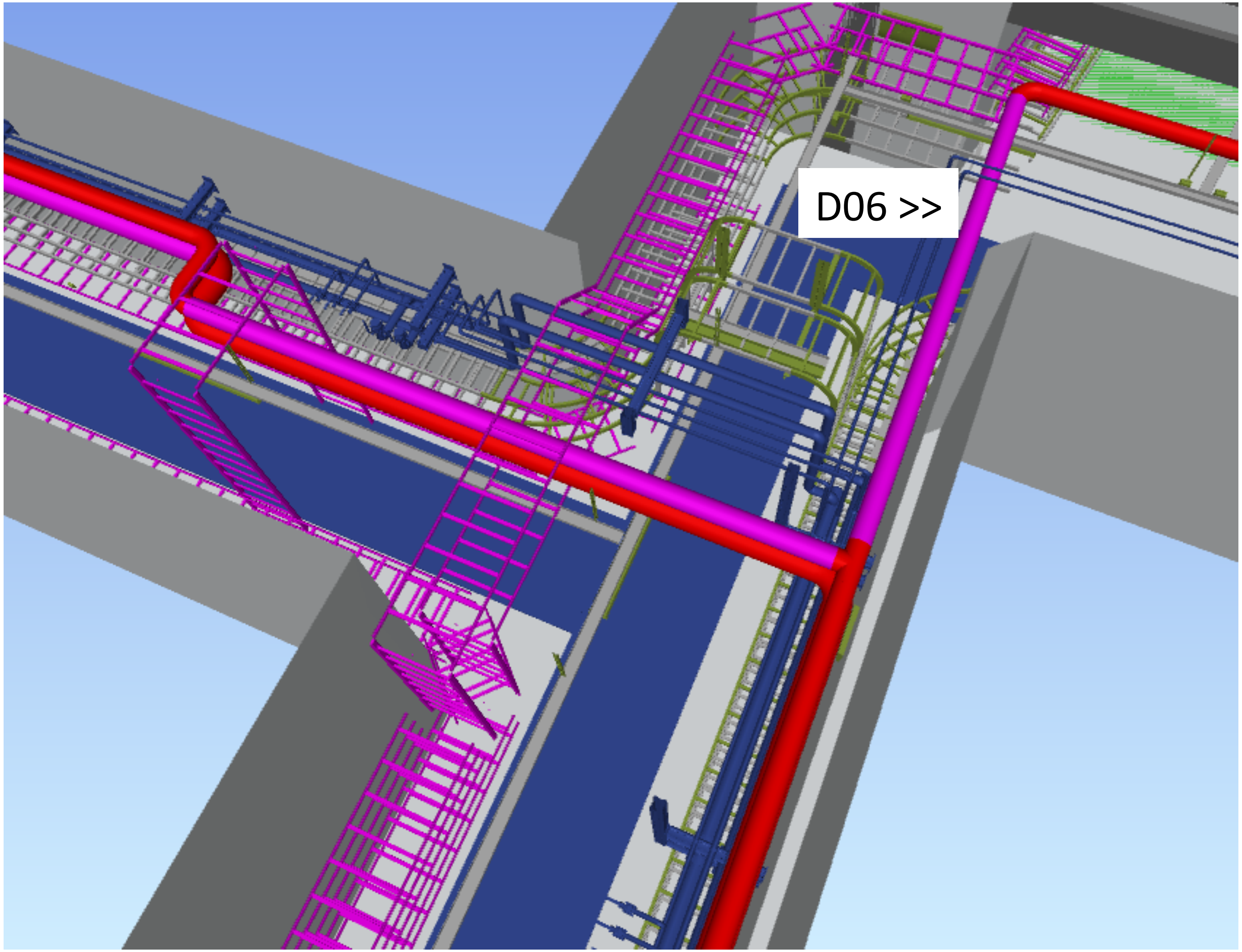


# Cable routing – 3D planning junction #1

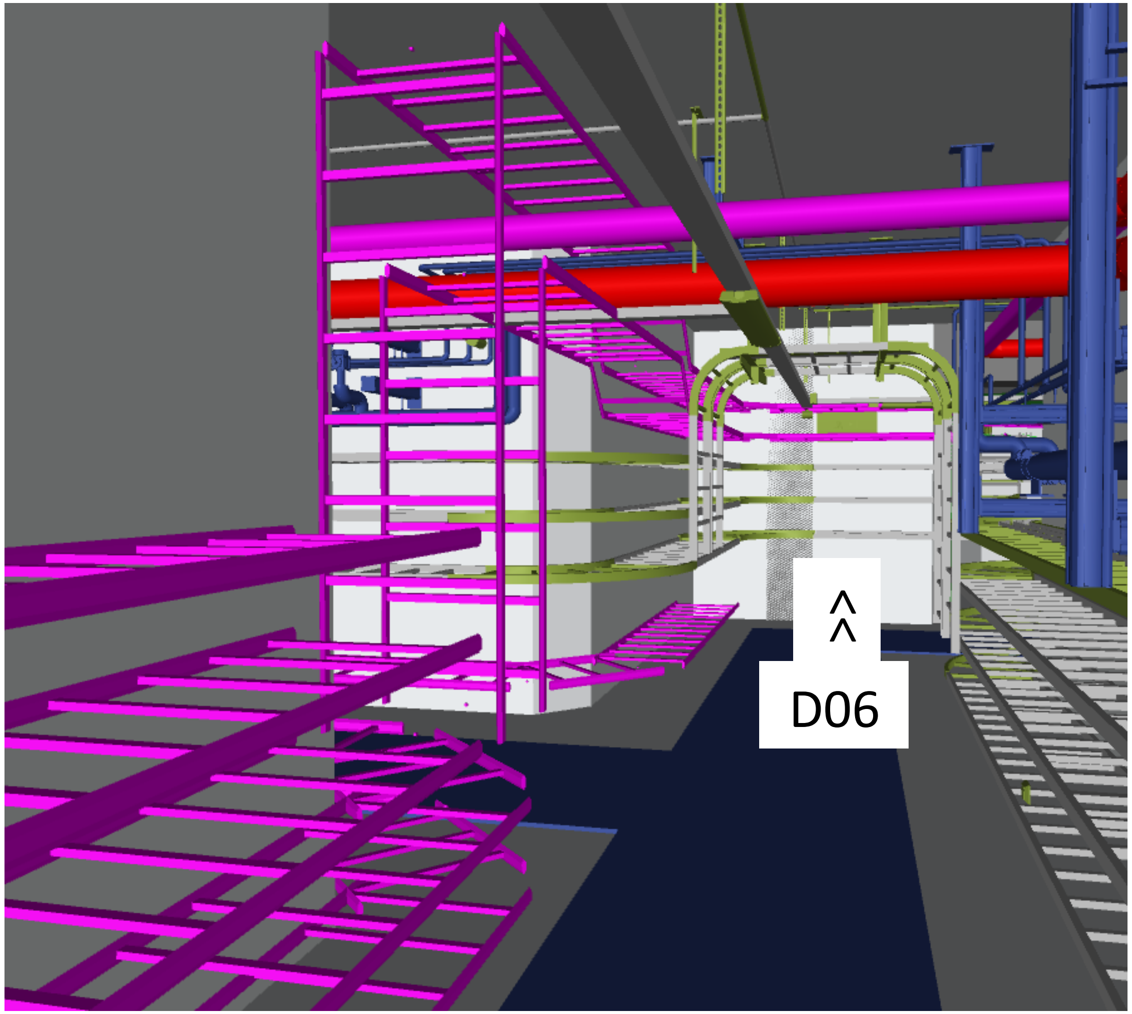


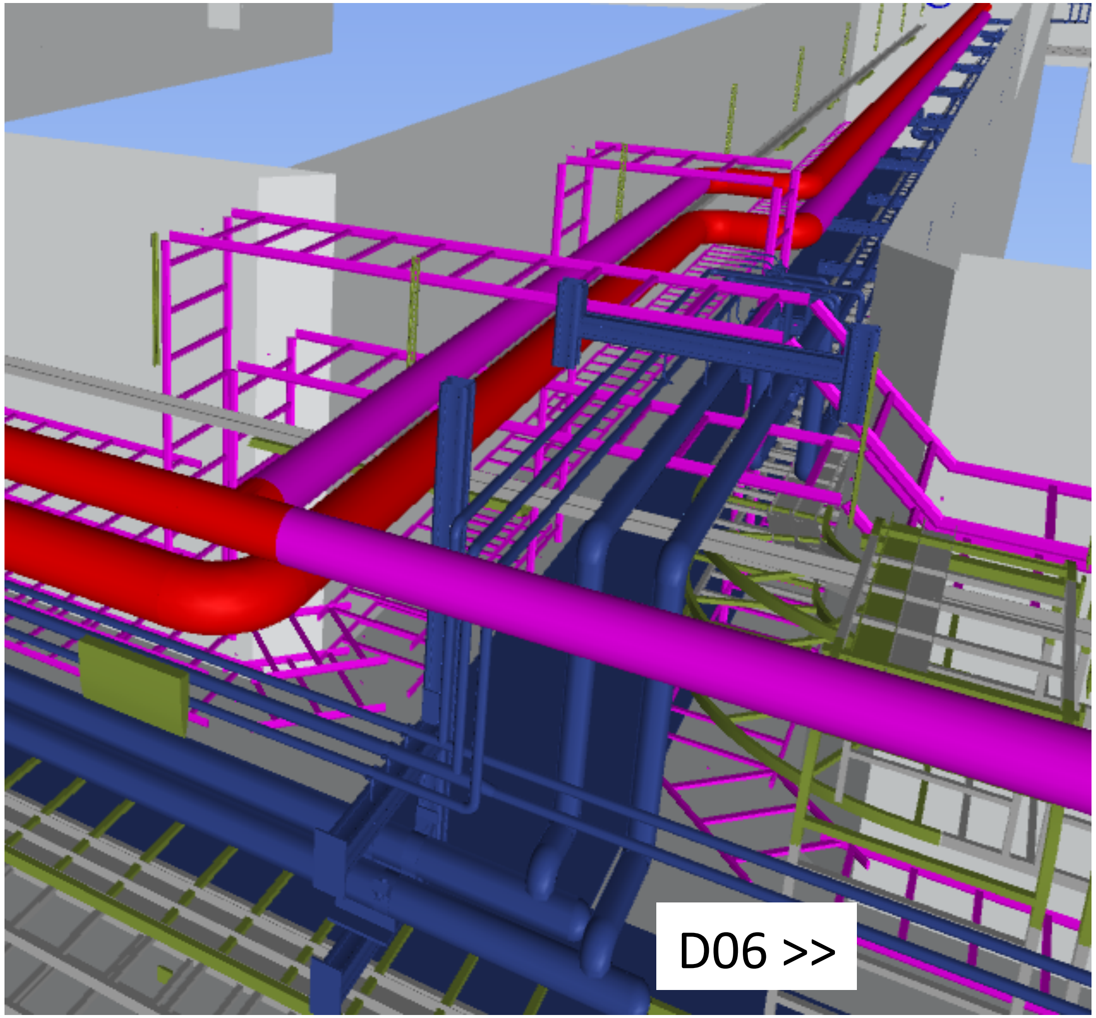



# Cable routing – 3D planning junction #5

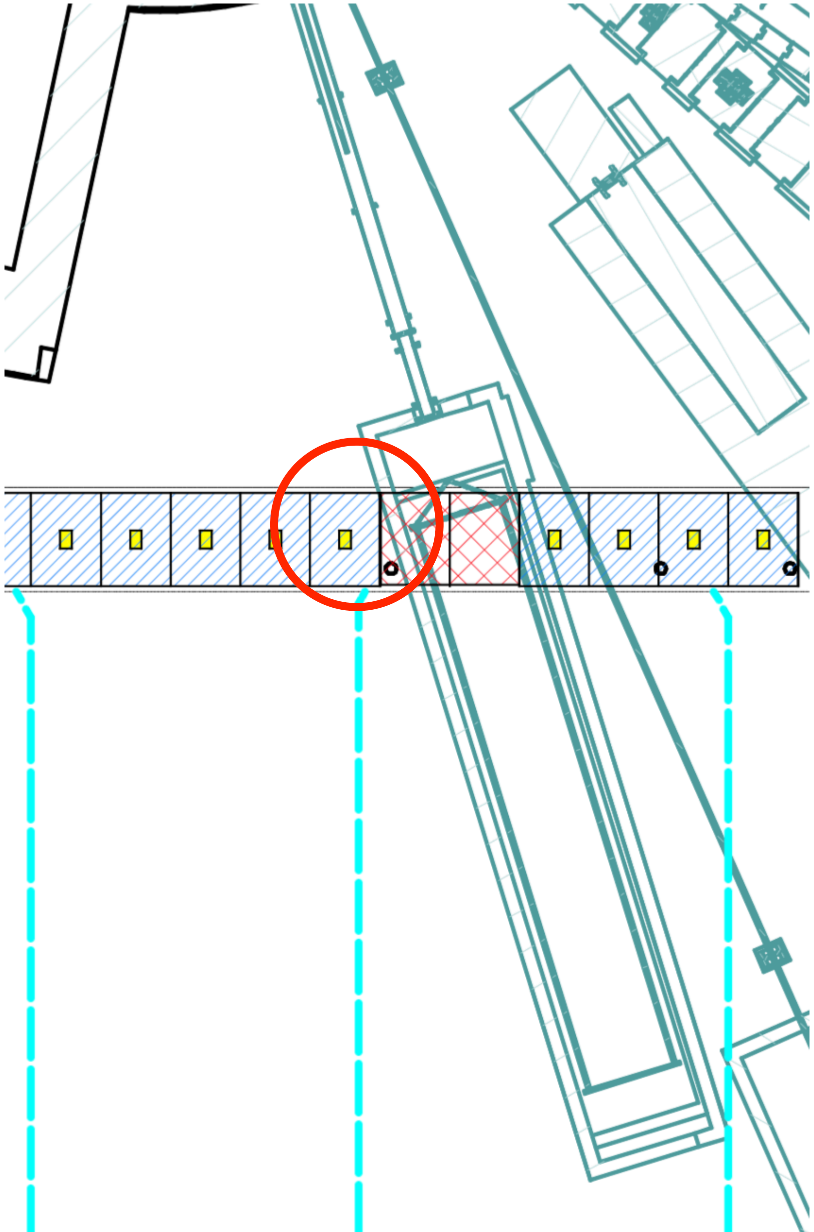


# Cable routing – 3D planning junction #5



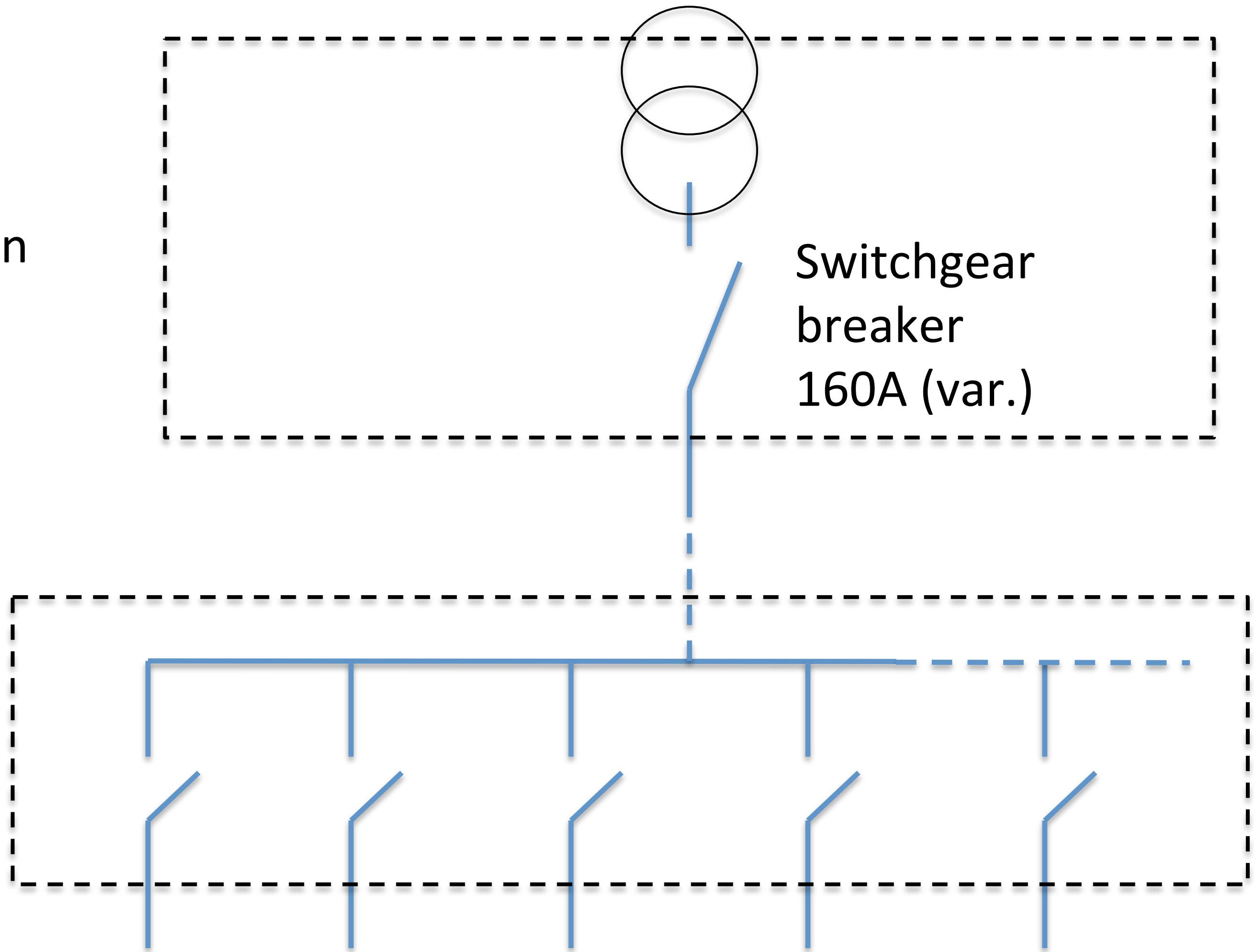



# Instruments power – connection point

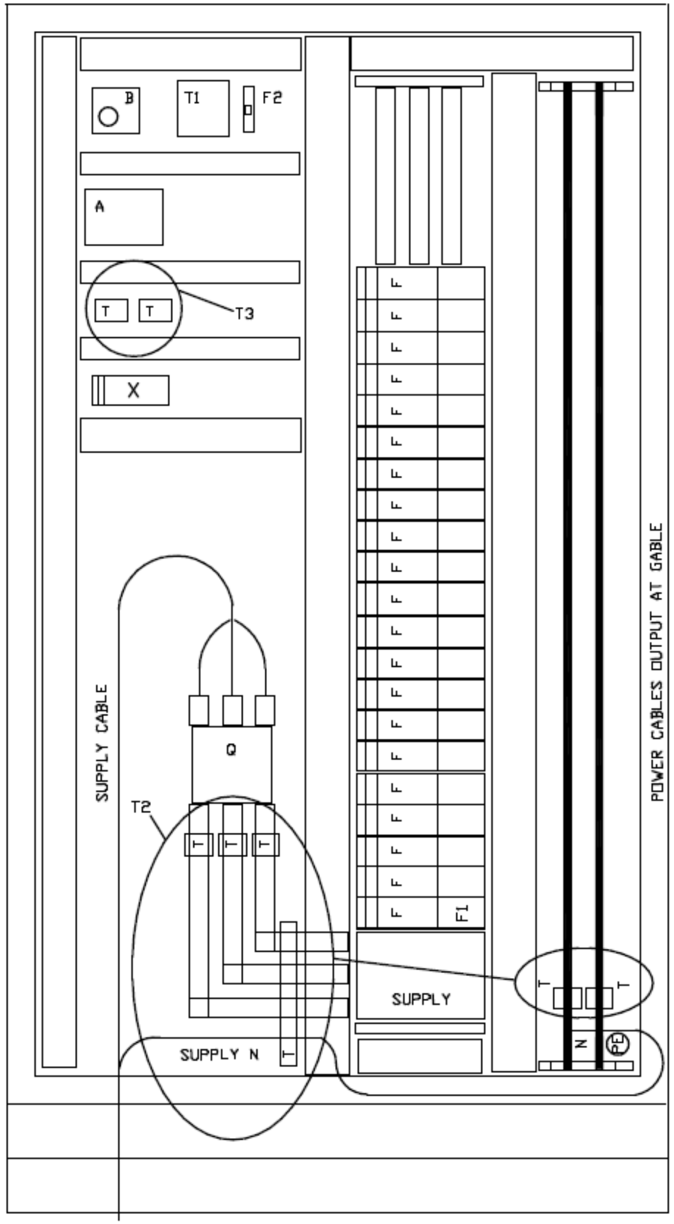


- Crossing area of the gallery with the instrument is connection area
- The instruments power distribution will be installed near this point
- Connection area also for IT and other utilities
- There will only be one connection point per instrument zone

# Instrument zone low voltage distribution




# Instrument power panel – First ideas




## Requirements:

- 1 cabinet 2m high + wide as necessary
- 1 cable input (from substation), max peak power 40 kW
  - Circuits out:
  - 1 for light (1 phase)
  - 3 for sockets 230V (1 phase)
  - 1 for CEE sockets 400V, 16A (3 phase)
  - 1 for CEE socket 400V, 32A (3 phase)
  - 6 for control cabinets 16A (3 phase)
  - 4 for control cabinets 32A (3 phase)
- Internal lightning protection (over voltage) SPD2
- Mains input filter
- Mains diagnostics and earth leaking measurement

# NSS Power Fail Strategies

1. Permanent UPS for EMC Class-1 power supply
   – Detector electronics
2. 15 min UPS for safe shutdown of machinery
   – Magnetic bearings of neutron chopper
3. Non-volatile memories to continuously store status of control systems for safe recovery
4. All experiment data storage and data treatment in the server room of the Central Utility Building (CUB)
5. Safety critical components (shutter) shall de designed fail safe
6. Proposal UPS for PSS: Generator power + UPS to bridge the 20s time to start the generators
7. UPS for Sample environment: to be discussed

# UPS for detector electronics

### 3.1.2. Double Conversion UPS

This type of UPS is constructed from a Rectifier / Filter, DC-link with batteries, followed by a DC / AC converter stage. In the Double Conversion UPS, there is no direct connection from the upstream power system; even the Neutral connection is created inside the UPS.

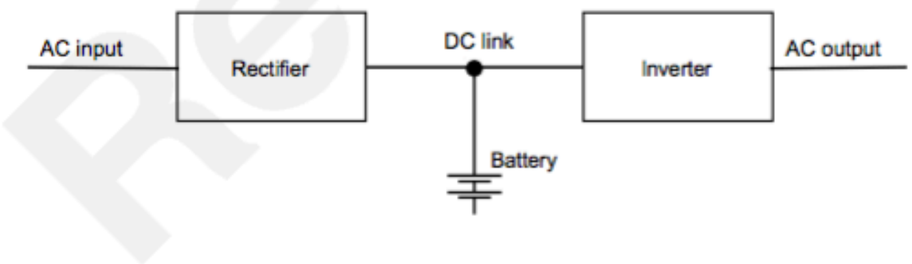



**Figure 4: Double conversion topology (SS-EN 62040-3)**

Because of the double conversions and the fact that all the power provided to the loads are flowing through the UPS, these systems are not quite so efficient. Typically, a quality system will operate at around 95% efficiency.

The main advantage is the total isolation between the upstream power grid and the UPS loads. Upstream transients or EMI cannot be transported through the UPS. It acts like a perfect filter.

Double Conversion UPS according ESS-0016586

- Local UPS system in each of the detector electronics rack
- Measure to achieve a protected power supply with EMC-Class 1 as defined in SS-EN 61000
- The same might apply for sensitive measuring equipment in sample environment
- Detailed design of standardised detector electronics racks are ongoing in the work package of the Detector Group

- Standard automation equipment at NSS instruments like motion control, vacuum pumps, furnaces etc. generally requires EMC-Class 2.

# UPS for magnetic bearings of chopper

Hybrid Systems UPS according ESS-0016586

**3.1.3. Hybrid Systems**

Due to concerns over rising energy costs, most new UPS systems are now Hybrids of the Line Interactive and Double-Conversion UPS. These are equipped with an "Energy Saver System"-feature, which allows the UPS to be switched between Double Conversion and Line Interactive operation using a solid-state bypass switch.

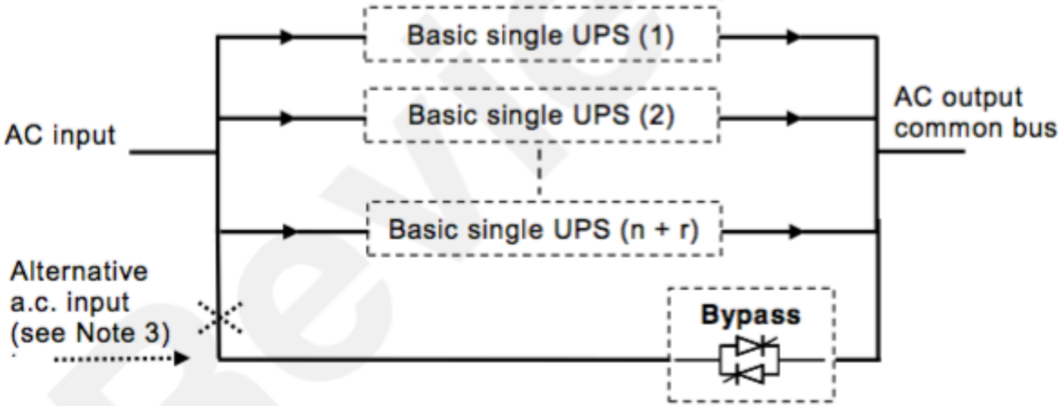



**Figure 5: Hybrid systems - Parallel UPS with common bypass.**



- Magnetic bearings need to be further supplied in cases of power failure (15min)
- Around 100 chopper axes with magnetic bearings will be installed
- EMC-Class 2 as defined in SS-EN 61000 required
- Local UPS (control rack or instruments power distribution) foreseen as the distances to the substations are quite large.
- No space in the galleries for additional power cables
- Technical risk analysis/reliability evaluation needs to be done

# Project interfaces to Instruments teams

EUROPEAN SPALLATION SOURCE

1. Power distribution is part of the ESS infrastructure and strongly linked to CF, Swedish installation rules etc.
2. NSS will take over to coordinate, design and deliver the power distribution for all instruments.
3. An Electrical Engineer in a coordinating role will soon be available in the Science Directorate to act as a point of contact for all electrical power and grounding matters for each instrument team.
4. Job definition is currently ongoing, the hiring process will be started in the next weeks.
5. The engineer will be in place in Q1 2018.
6. In the meantime the most urgent tasks driven by the progress of construction (space claim by 3D planning, grounding guidelines, UPS planning) are covered by consultants (Group of Jonas Widing, E&IS Division) and by my group (Markus Larsson).

# Interface responsibilities

1. Instrument teams:
   - Load list: Number of power circuits
   - Load list: Actual power need for each circuit
   - Requirements for light/socket installations (cave, hutch etc.)
   - Special requirements to power distribution panels
   - ….
2. Common responsibilities
   - Define and design instrument zones
   - Define the positions of the distribution panels, control cabinets and racks
   - Define commissioning procedure
   - ….
3. ESS
   - Coordinate power needs of instruments, contact to CF
   - Design and install power and grounding connections between the substations and the instruments distribution panel
   - Design, procure and install instruments distribution panel
   - Commission the whole low voltage electrical power installation
   - ….

# Thanks!

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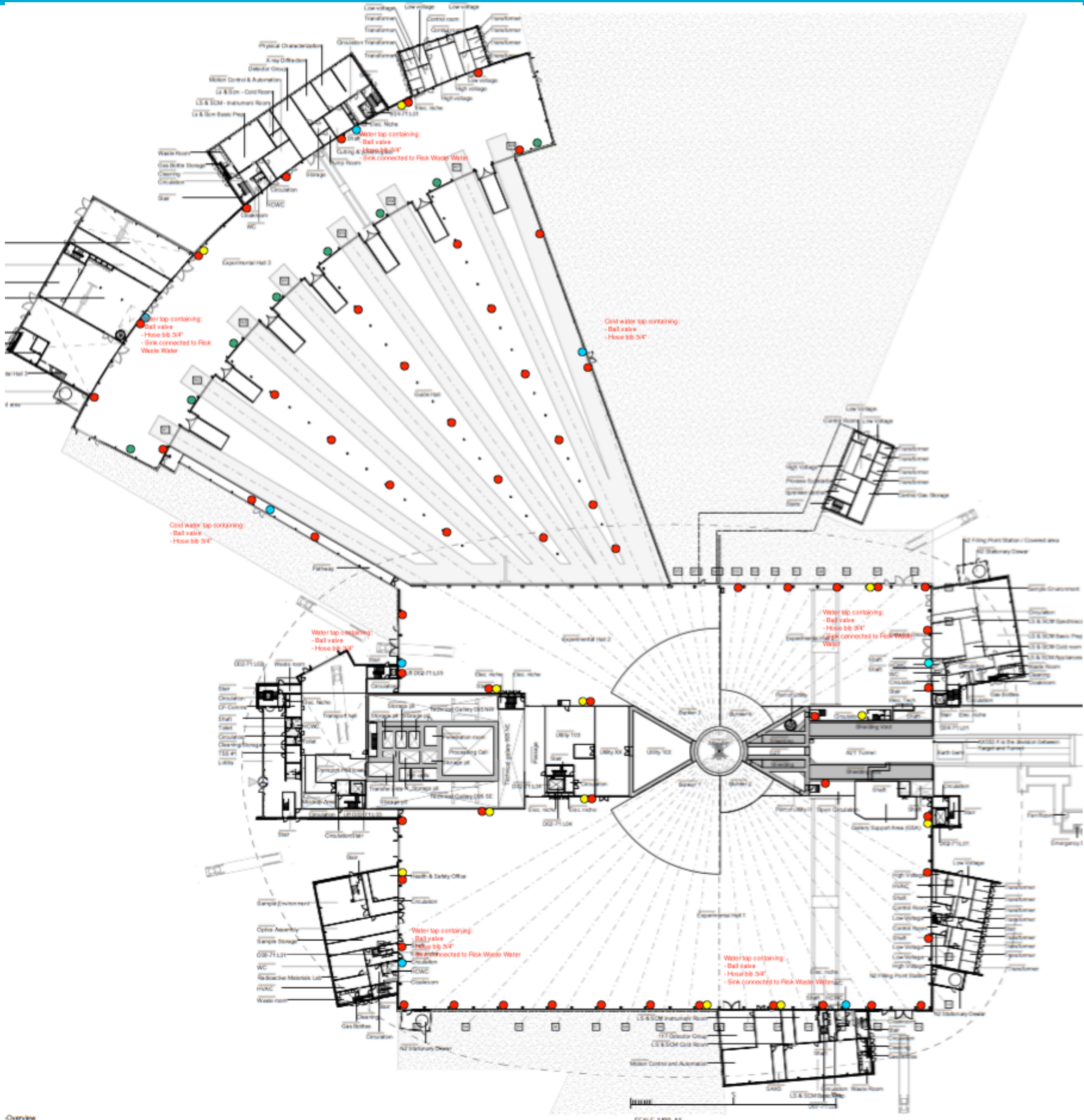
# Power Distribution CF – Infrastructure



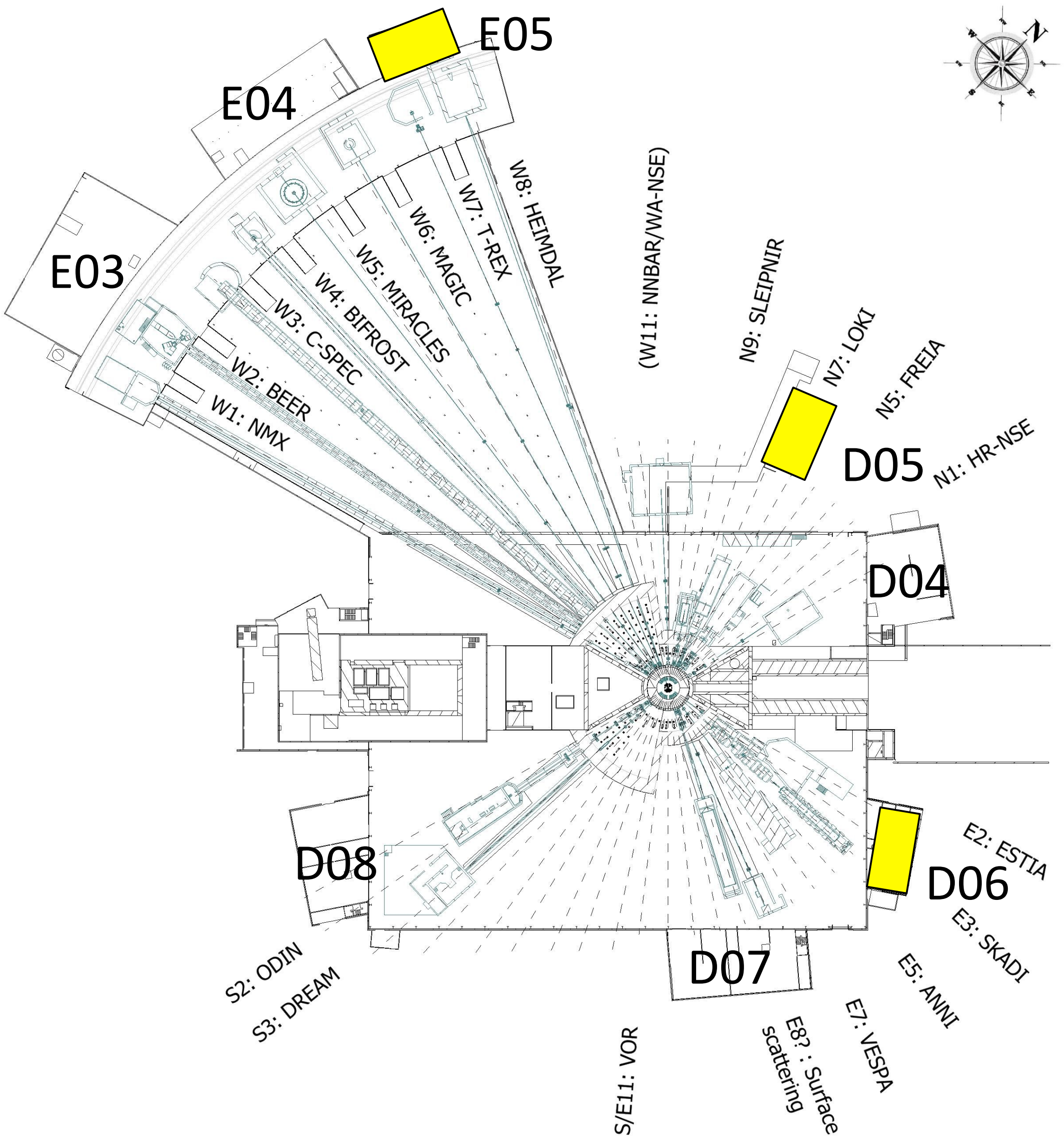
Outlets in D & E halls
(ESS-0046984) – Power sockets

- Red dots are power outlets with a combination of 1- and 3-phase sockets
- As hall infrastructure they are supposed to be used for maintenance, cleaning etc. ("vacuum cleaner sockets").

- No connection of any equipment of the instruments or the control hutches is allowed
- Separate grounding scheme

# Power Distribution CF/NSS – Labs & Workshops

EUROPEAN SPALLATION SOURCE




Room Book
(ESS-0018817) - Requirements

- Power installations as part of the requirements for NSS labs and workshops
- Combined Server/Switch rooms for DMSC and ICS are included as they are part of the buildings
- Detailed design and installation coordinated by CF

- D04: 106 kW (substation D05)
- D07 + D08: 201 kW (substation D06)
- E03 + E04: 333 kW (substation E05)

# Summary Power Needs NSS

EUROPEAN SPALLATION SOURCE

NSS power inventory submitted in February 2017 to ES&H (Erica Lindström)

Total power need: ≈ 1.5 MW

| Number of Instruments | peak power (kW) each | average power (kW) each | Total average power (kW) | Produced heat (kW) each | Heat to water cooling system (kW) | Total heatload to water cooling systems (kW) |
|---|---|---|---|---|---|---|
| 20 | 55 | 30 | 600 | 30 | 27 | 540 |
| 2 | 600 | 100 | 200 | 100 | 90 | 180 |
| **22** | | | **800** | | | **720** |
| | | | | | | |
| **Full operation** | | | | | | |
| **Component** | **Peak power needed (kW)** | | | **Total Produced heat (kW)** | | **Heat to cooling water system (kW)** |
| ICS/DMSC | 10 | | | 10 | | 0 |
| Sample Environment | 170 | | | 170 | | 92 |
| Chopper Labs | 30 | | | 30 | | 27 |
| MCA | 50 | | | 30 | | 25 |
| Neutron Optics | 20 | | | 20 | | 4 |
| Detector Labs | 100 | | | 100 | | 70 |
| User Labs | 276 | | | 276 | | 123 |
| | **646** | | | | | **341** |