

1st Accelerators Technology Sector Workshop

Engineering Design Tools and Processes
Project Management Methodologies and Tools

Chair: Mike Lamont

Interconnecting knowledge, experience, methods,
people & data to foster learning & collaboration



ATS
Accelerators and
Technology Sector

Managing physical configurations of CERN accelerators with Layout

Pascal Le Roux

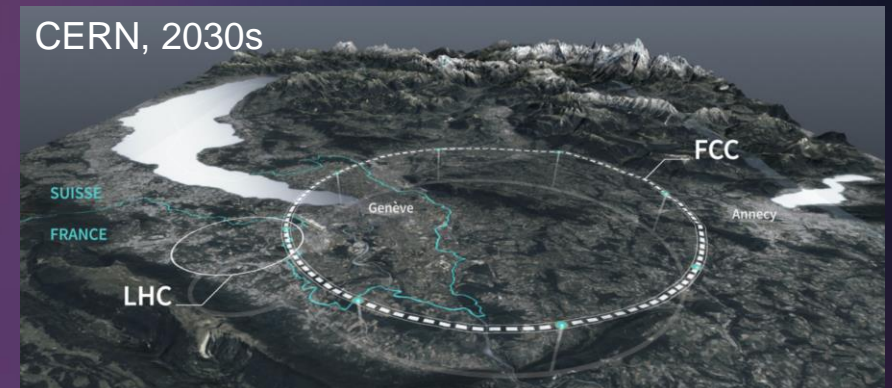


ATS
Accelerators and
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Introduction

CERN's infrastructure is constantly evolving over space and time

- Maintenance, renovations, upgrades, new facilities...
- From a simple local change (e.g., moving a crate) to **complex long-term projects** like HL-LHC or FCC, involving hundreds of experts from **many diverse domains** at CERN and beyond
- Major activities planned during **intense and challenging stop periods** (LS, EYETS) interleaved with run periods
- From design to operation phases, **documenting the CERN physical configuration is essential**
- **Resulting cross-domain** applications, analysis, understanding and coordination are **indispensable** to the **decision-making process**



What is Layout?

- A comprehensive **centralised collaborative platform** designed to manage the physical configuration of CERN facilities **over time**
- Aims to provide the **unified, coherent** and **controlled** source for **functional positions** and their **layouts**
- Answering questions: "**What** is installed, **Where** and **When** and **Interacting/Interfacing with...**"
- Initial development **started in 2003**, in EST/IC group, to facilitate installation and commissioning of LHC
- **21 years later**, Layout supports the physical configuration over time, of:
 - **Most CERN beam lines**
 - Potentially, any infrastructure in **underground and surface buildings**
 - e.g. SM18 IT STRING



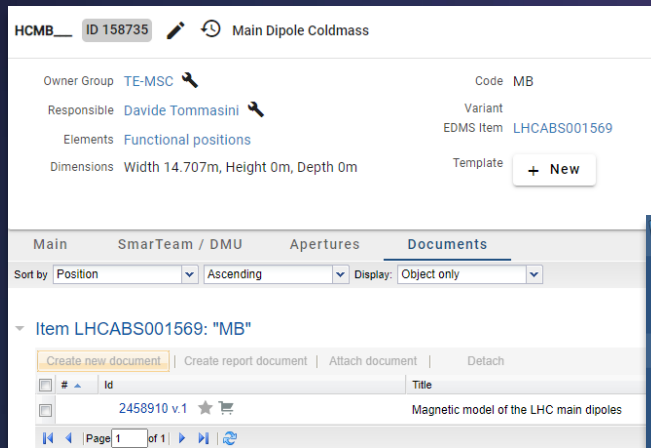
What can you do with Layout ?

7 main concepts

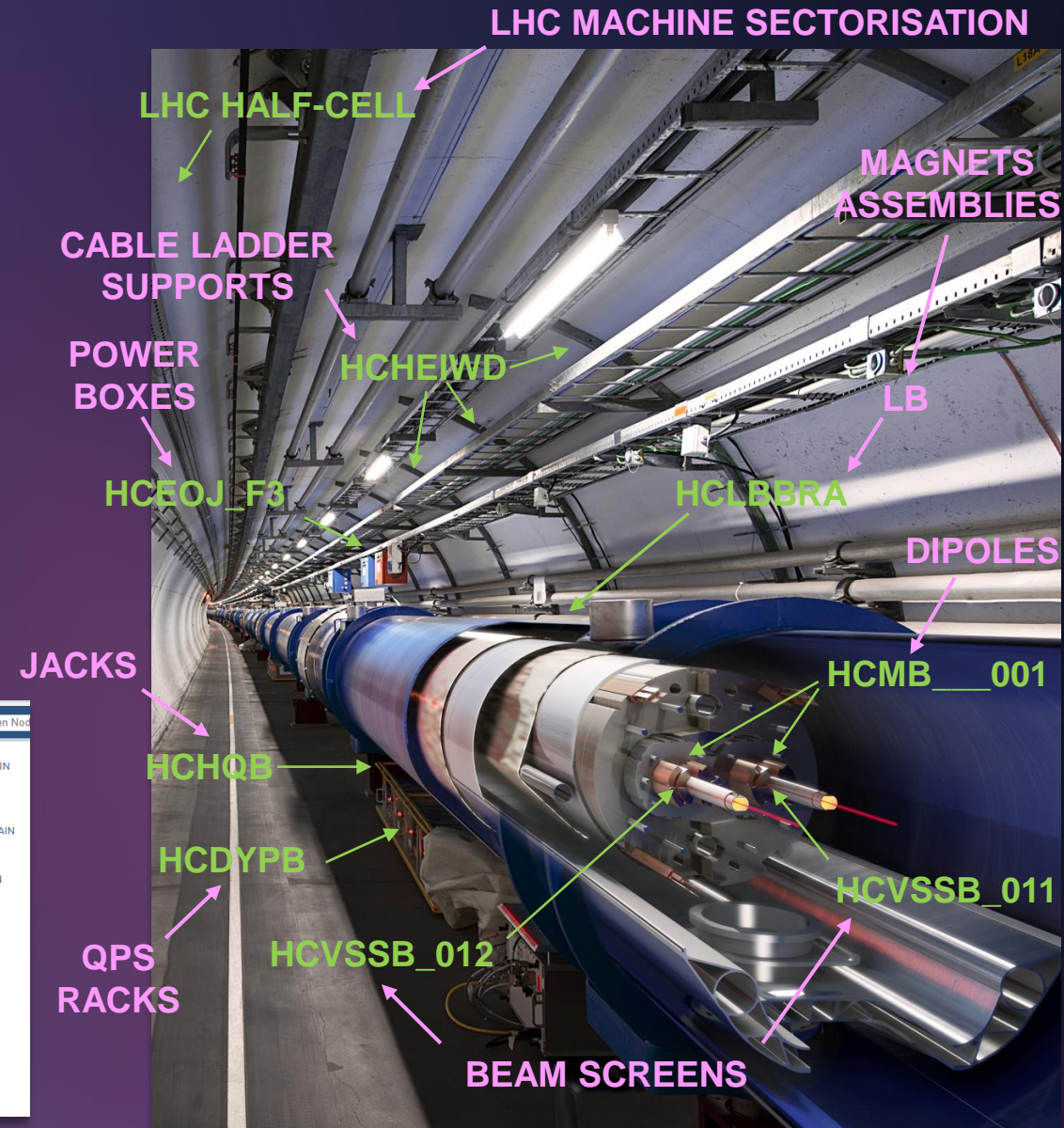
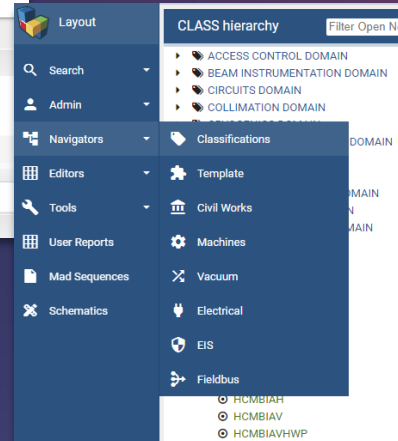
1. Types & Classes

Defining a taxonomy of functional position types

- Identifying the **type** of components
 - Naming, description, dimensions, responsible
 - Uniquely mapped to
 - CERN Naming code
 - EDMS item → Access to EDMS document



- Categorising the **types** by **classes**
 - organised by shared attributes
 - nature, function, usage



2. Functional positions

- Defining individual components as **functional positions**
 - Placeholder for a component (not assets)
 - Generally named according to its type and localisation/position
- Generated **Layout names**, mostly following **naming conventions** defined in the QA plan of each machine

QUALITY

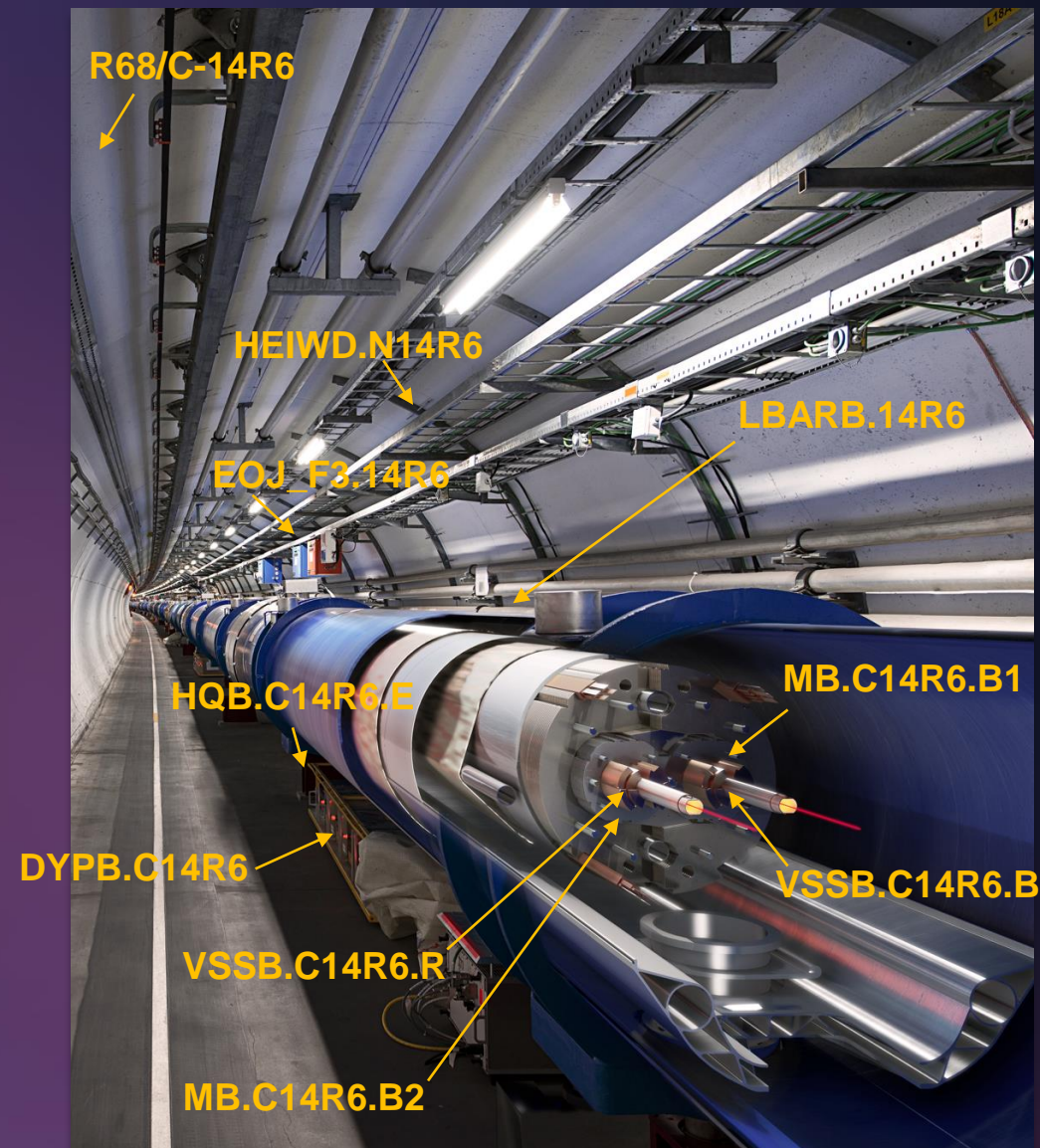
Quality Management Support
for the
Accelerators & Technology Sector

Home Processes Roles Conventions

</> Naming Conventions

Global Naming Conventions

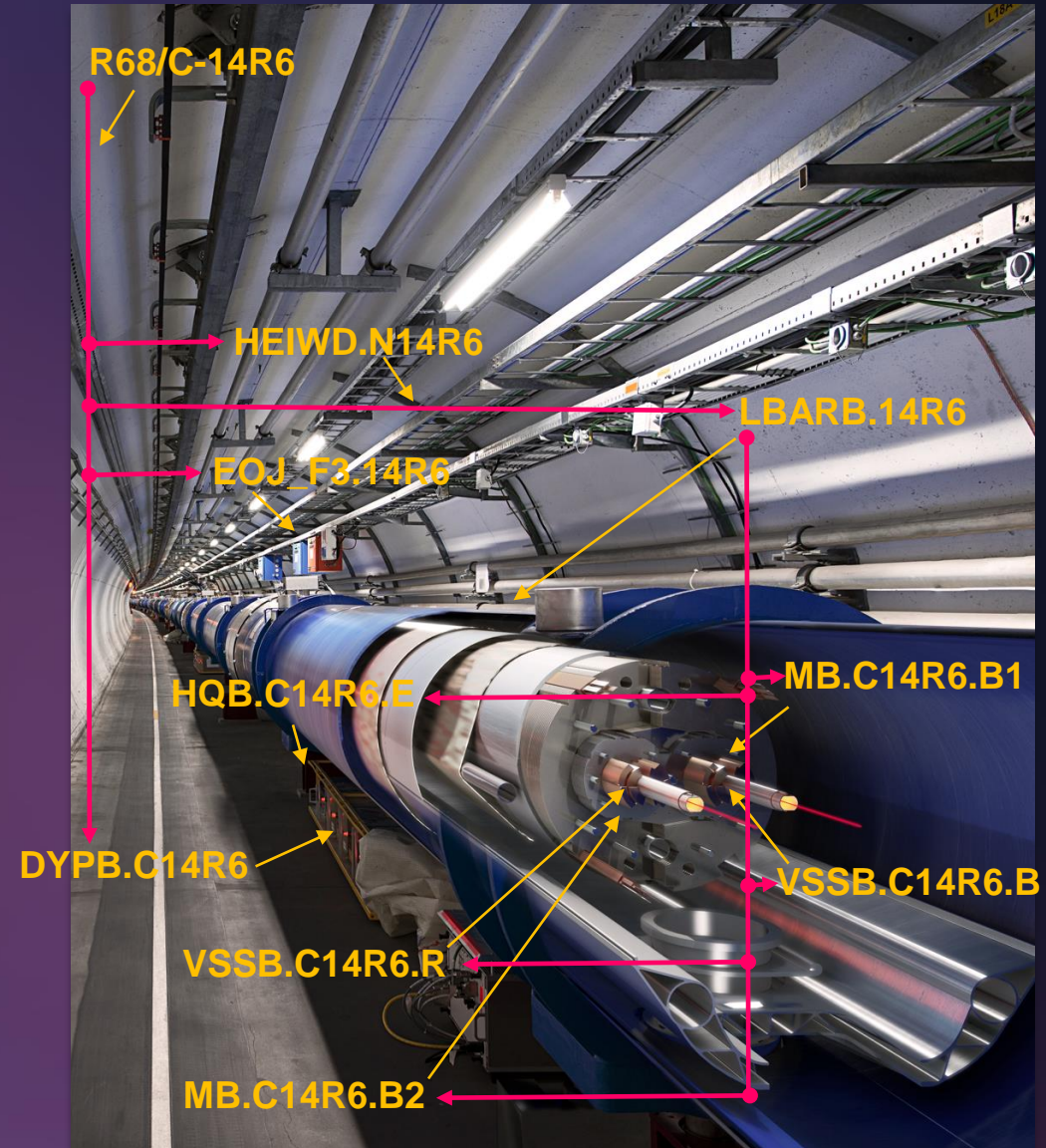
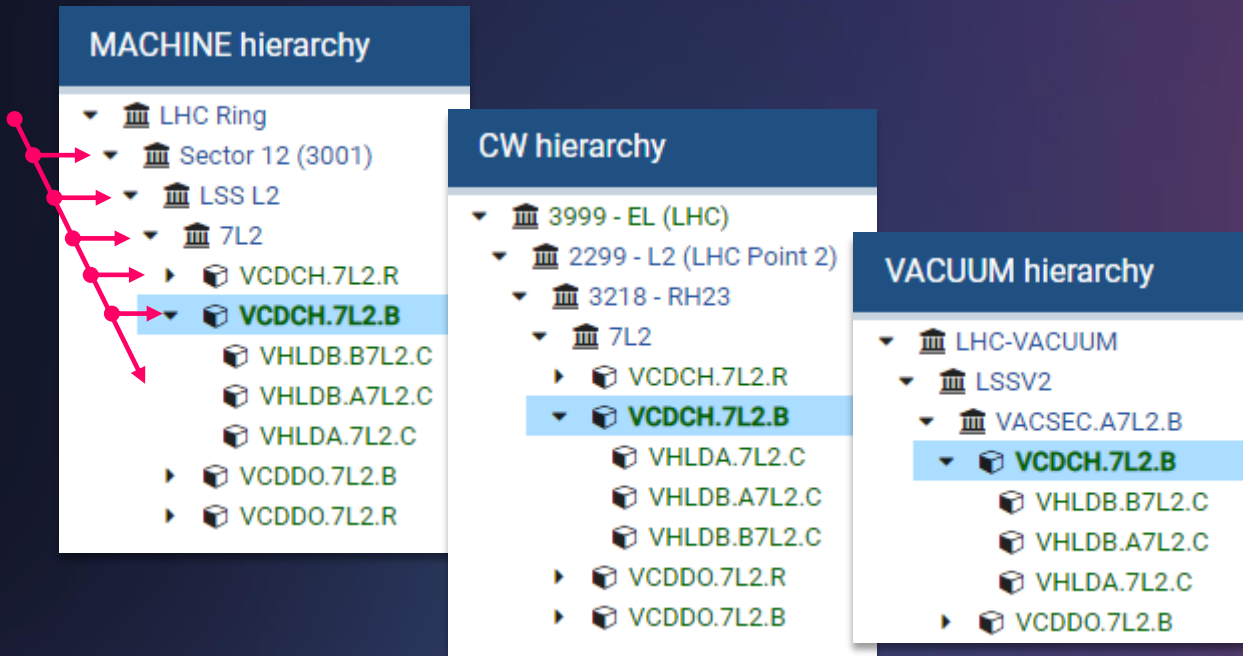
- CERN Equipment Identification (EDMS)
- General rules for naming of equipment and signals (EDMS)
- Detailed rules for naming of equipment and signals (EDMS)
- Practical Guidelines for Equipment Codes in the CO Group (EDMS)
- Naming Conventions for Shielding Installations (EDMS)



See talk of Giulia Romagnoli, "Managing Beamline Configurations in the Experimental Areas"

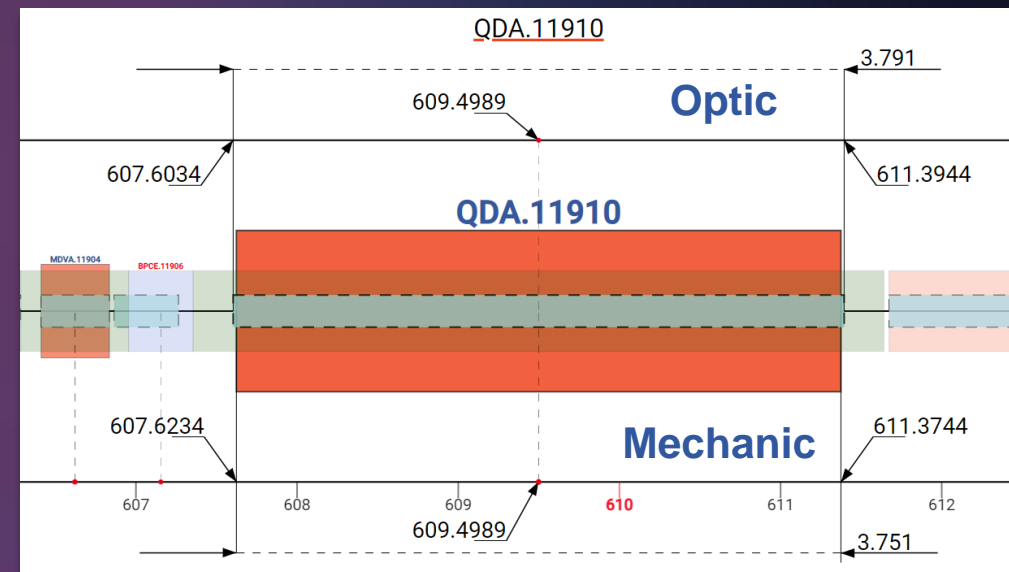
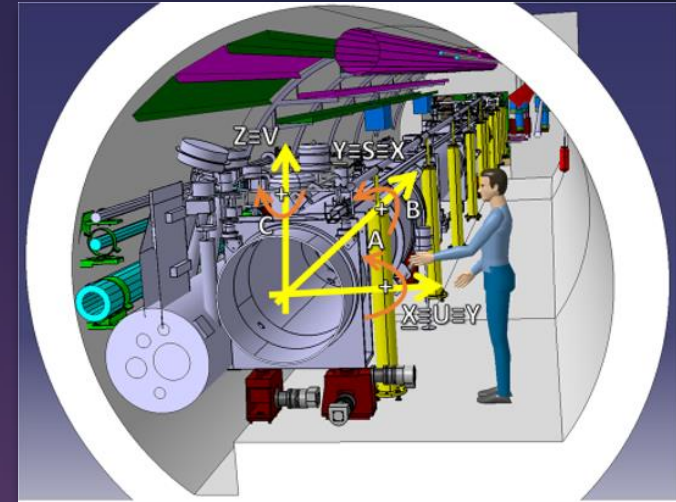
3. Assembly Breakdown Structures

- Organising functional positions as physical Assembly Breakdown Structures
- Several hierarchical structures superposed (like layers)
 - Machine, Civil work (CW), Vacuum, EIS chain



4. Positioning in machines

- A **functional position** is placed relative to its **parent assembly** using 3D transformations
- Using relative positions, we compute **cumulated distances** (DCUMs) and **orientations** of **functional positions** in the machine



6. Domain specific data

- Defining **domain specific data** associated to **types** and **functional positions**
 - e.g. for Optic, Magnet, Vacuum, Aperture, Circuit, Power converter, BLM, Cryogenic instrumentation and EIS domains

EIS ELEMENT IMPORTANT SECURITE

Safety Elements: EIS-Beam or EIS-Machine

EIS Name: **L4.SOURCE**
As given to ASN/DFSP

Comments: **EIS in PROTON MODE**

EIS Type

Element: **L4 SOURCE**

Magnetic: Beam Stopper: Other:

EIS Responsible

Group Owner: **BE-ABP**

Interventions done by CERN Staff:

Interventions done by Contractor/FSU:

Tech Contact Note:

Technical Contact 1: **Jacques Letry**

Technical Contact 2: **Michael O'Neil**

Technical Contact 3:

Responsible of the Element Interlocked with EN/AA

Type: **POWER SUPPLY**

Code: **L4L.NFH.011**

Group Owner: **TE-EPC**

Responsible 1

Technical Contact 1: **Christophe Machado**

Technical Contact 2: **Nicolas David**

Interventions done by CERN Staff:

Interventions done by Contractor/FSU:

Edit the Magnet Type Properties for HCMB___ (ID 158735)

Magnet coil length [m]*: 0

Magnet iron length [m]*: 0

Magnetic length [m]*: 14.3

Aperture separation at operating condition [mm]: 194

Nominal operating temperature [K]*: 1.9

Magnetic aperture*: TWIN

Aperture individually powered

Inductance per aperture [H]:

Inductance per magnet [H]: 0.102

Resistance per aperture at 293K [Ω]:

Resistance per magnet at 293K [Ω]:

Magnet family: B1

Polarity change if turned

Polarity for LHC beam 1: -

Polarity for LHC beam 2: -

Polarity for LHC external beam: +

Polarity for LHC internal beam: -

stream/Downstream):

Polarity flag: +1

Edit the Cryogenics Instrument Properties

Channel Status*: EQUIPPED

Sensor Type: 500W

Override Generate Flag*: NOT_FORCE

Override Enable Flag*: NOT_FORCE

DP Address:

PA Address:

Instrument is active?: YES

Is Instrument a Beam Screen Heater?: YES

Assigned sector: S23

Comment:

0 / 1000

Edit the Optic Type Properties for HCMBW_ (ID 297705)

Offset between mechanical and optic middles*: 0.0675

Magnetic length defined with Lrad, used for LHC MAD sequence

Optic length for MAD sequence*: 3.4

K max at 1.9K: 1.42

K min at 1.9K: 0.036

I max at 1.9K: 720

I min at 1.9K: 18

K max at 4.5K:

K min at 4.5K:

I max at 4.5K:

I min at 4.5K:

7. Managing data over time

- **Functional positions** and their **relationships** all have a **Validity Period** (lifetime)
 - physical breakdown structures, relative positions, distances, connections, etc.
- A Layout **version** is a snapshot of the configuration at a **specific date**
 - Using **end dates of shutdown periods** (approx.) (YETS, EYETS, LS) + intermediate weekly dates
- **Enabling continuous and consistent change management over time**
 - Editing all versions included in the lifetime simultaneously

QF.11810's Validity Period
Start date/version <= lifetime < End date/version



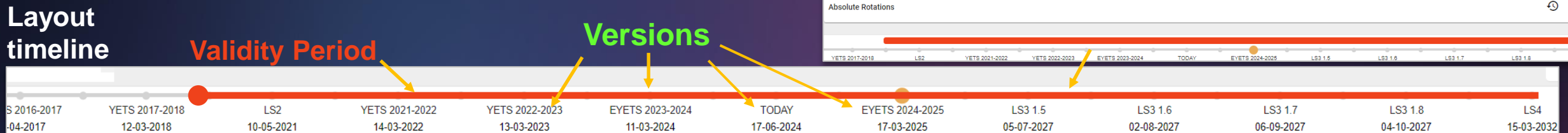
QF.11810 ID 43343503 focussing quadrupole

Type SPQF 2360491
Location 118
Owner Group TE-MSC
Responsible Jeremie Bauche

Dimensions width 3.045m, height 0.95m, depth 1.04m
Machines SPS (SPS Ring)
Sequences SPS BEAM LINE

Referential	From point	To point	S [m]	U [m]	V [m]	Valid from	Valid till
Distance type = DISTANCE CUMULATED							
SPS.START	SPS START	QF.11810 START OPTIC	575.9587	0	0	24-09-2018	ENDLESS
SPS.START	SPS START	QF.11810 START	575.9787	0	0	24-09-2018	ENDLESS
SPS.START	SPS START	QF.11810 MIDDLE OPTIC	577.5012	0	0	24-09-2018	ENDLESS
SPS.START	SPS START	QF.11810 MIDDLE	577.5012	0	0	24-09-2018	ENDLESS
SPS.START	SPS START	QF.11810 END	579.0237	0	0	24-09-2018	ENDLESS
SPS.START	SPS START	QF.11810 END OPTIC	579.0437	0	0	24-09-2018	ENDLESS

From point	To point	S [m]	U [m]	V [m]	B [Deg]	A [Deg]	C [Deg]	Valid From	Valid till
SPS START	TS1 START	0	0	0	0	0	0	30-06-2008	ENDLESS
TS1 START	TS15 START	447.9678	0	0	0	0	0	30-06-2008	ENDLESS
TS15 START	118 START	127.6379	0	0	0	0	0	30-06-2008	ENDLESS
118 START	QF.11810 START	0.373	0	0	0	0	0	24-09-2018	ENDLESS

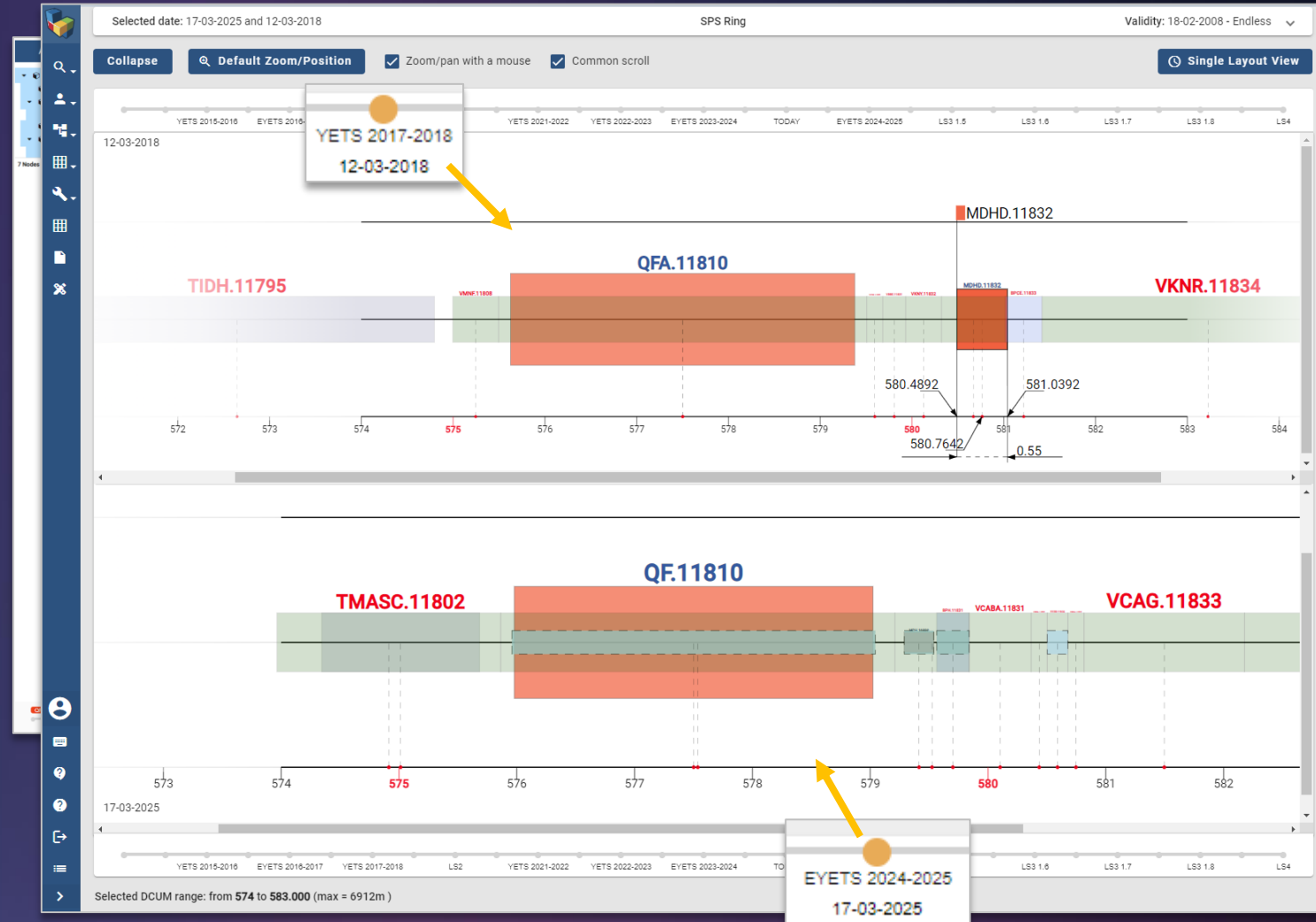


7. Managing data over time

From the Layout UI, users can seamlessly

- **Navigate** through the **past**, **present**, and **futures layouts** of the facilities
- **Edit** and **clone** certain layout data over time
- **Compare two versions** of a beam line configuration

SPS Chronological Layout Comparison

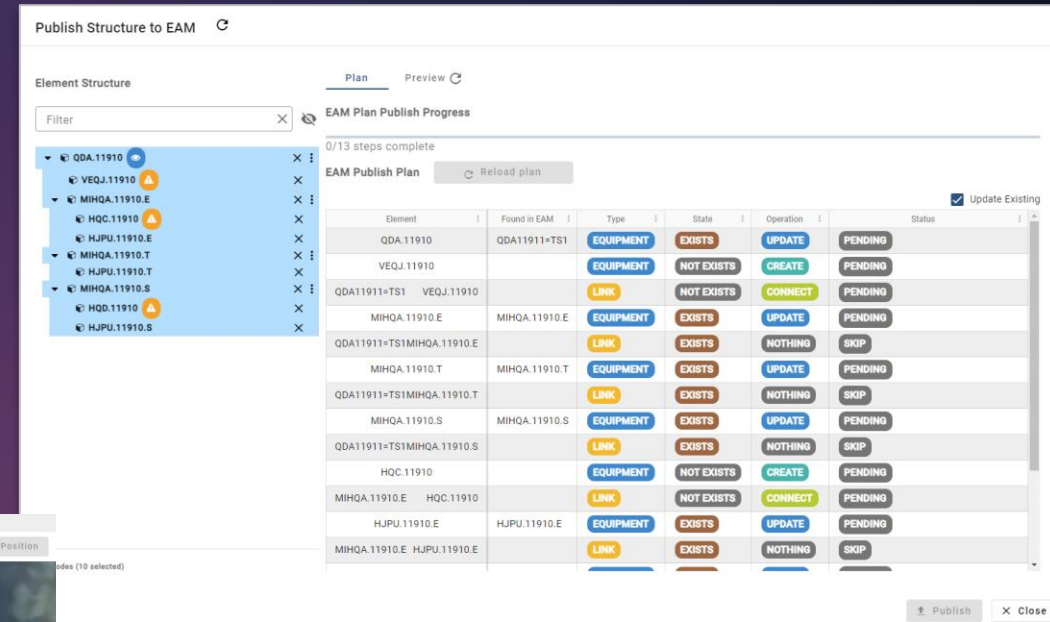
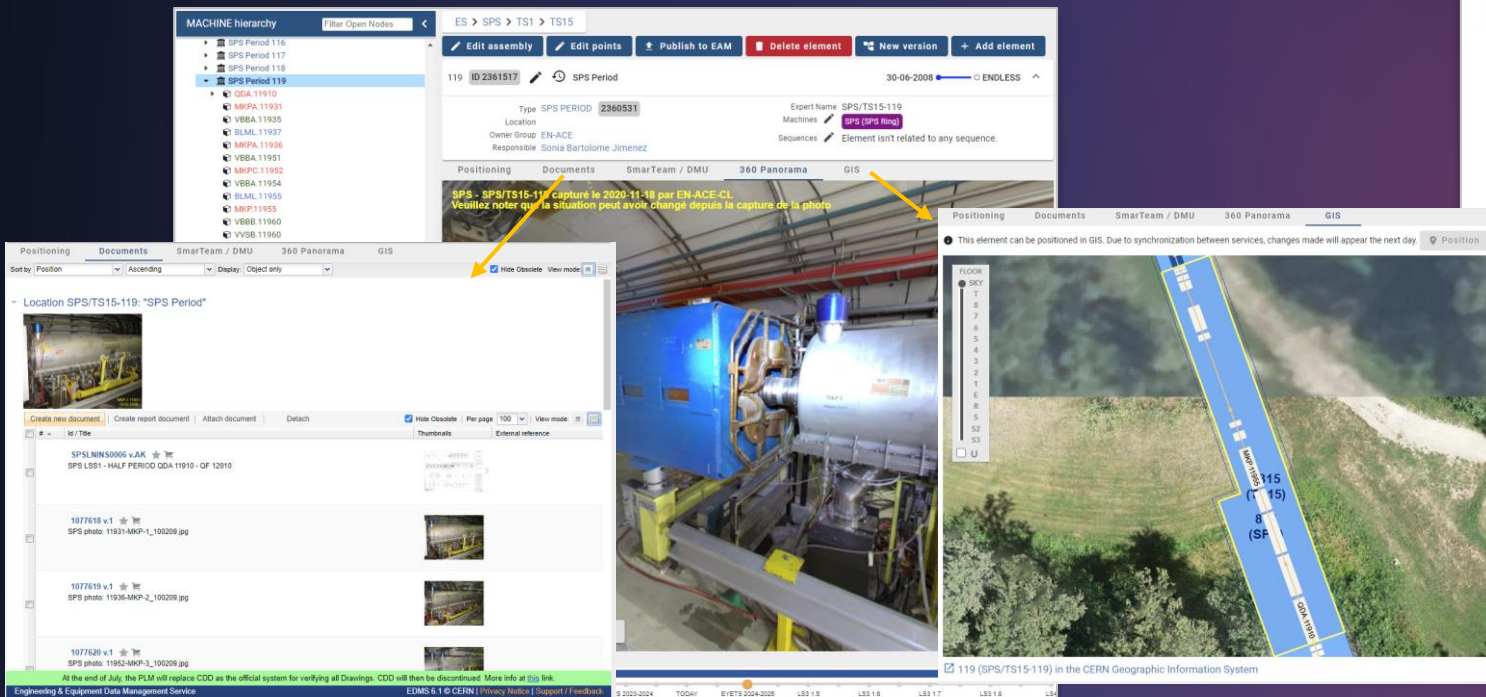




Layout Ecosystem

EAM, EDMS, Panorama, GIS integrated into Layout UI

- **Publication** from **Layout** to **EAM**
 - Functional positions, physical breakdown structures
 - Using **EAM API** (EN-IM)
- **Panorama** (EN-ACE), **EDMS** (EN-IM), **GIS** (SCE-SAM)



Linked to applications

- **Controls Configuration** (BE-CSS)
- **Network.cern.ch** (IT-PW)
- **Normal Conducting Magnets** (TE-MS)
- **Power converters DB** (SY-EPC)

Interconnecting services, data

- **Exchanging data** with multiple groups, databases (40+ databases)

TE-VSC (VACUUM) BE-GM (SURVEY)
TE-MPE (ELQA, MP)
FAP-BC (LOCATIONS)
BE-CEM (RADMON, HIT)
TE-CRG (CRYO UNICOS)
EN-ACE (PANORAMA, NAMING, DMU)
SY-BI (BLM) EN-IM (EAM, EDMS, SMARTTEAM)
EN-EL (CABLOTHEQUE)
BE-CSS (AFT, CCDB, LSA)
BE-OP (OPWEBTOOLS)
TE-MSC (NORMA)
SY-EPC (ALIM) SCE-SAM (GIS)



Collaborative layouts

From beam line to control electronics (Simplified examples)

Building up LHC base layouts

1. EN-ACE-CL Configuration managers define FPs acting on the beams, collecting information from ECR, specifications, drawings... authored by equipment groups

2. TE-VSC-BVO Vacuum managers build up the base vacuum layouts (chambers, modules..) to complete the gaps using LHC Beam Vacuum Editor

3. Add child components Vacuum instrumentation, supports...

6. Vacuum data delivered to TE-VSC-ICM Vacuum DBs to configure their controls, generate their SCADA synoptics

LHC Long-Straight Section - LSS5

Gap Threshold: 0.005 | Overlap Threshold: 0.005

Element name | Expert name | Positions | Length | Transformations | Flanges | Element name | Expert name | Positions | Length | Transformations | Flanges

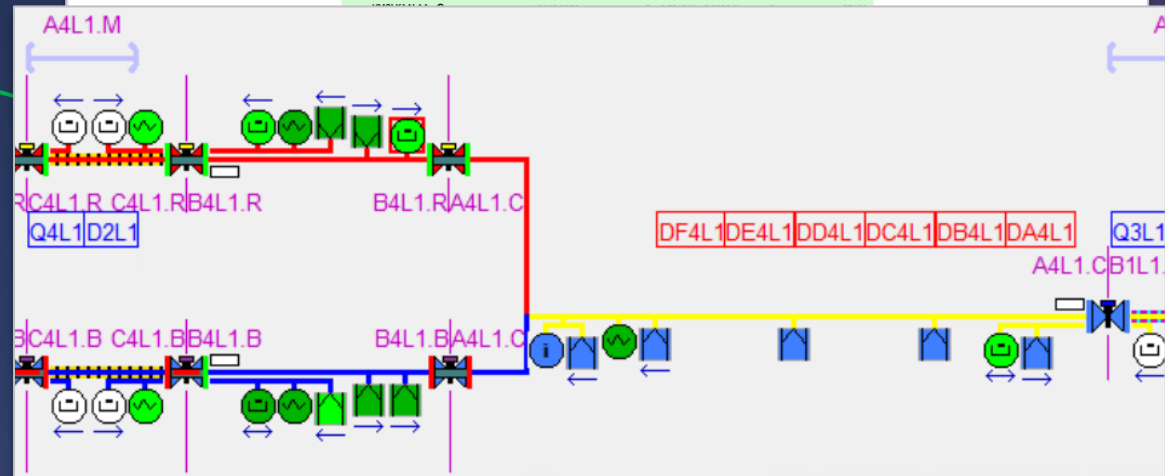
Inner beam						Outer beam					
IP-162.0003	VAVG_EA.883	13167.7343	0.293	S 24.0132 U 0.097 V 0	CF100	IP-162.0003	VAVG_EA.883	13167.7343	0.293	S 24.0132 U 0.097 V 0	CF100
VAVGSA_M... IP-159.1748	VAVGSA_854	13170.2668	0.293	S 24.0132 U 0.097 V 0	CF100	VAVG_SA... IP-159.1748	VAVG_SA_854	13170.2668	0.293	S 24.0132 U 0.097 V 0	CF100
VAPH_C.A... IP-158.9819	VAPH_C.850	13171.1798	0.62	S 24.9262 U 0.097 V 0	CF100	VAPH_B.A... IP-158.9819	VAPH_B.850	13171.1798	0.62	S 24.9262 U 0.097 V 0	CF100
VMWIAAA... IP-158.2622	VMWIAAA.846	13171.1794	0.22	S 25.1458 U 0.097 V 0	CF100	VMWIAAA... IP-158.2622	VMWIAAA.846	13171.1794	0.22	S 25.1458 U 0.097 V 0	CF100
VAVG_PH.4... IP-158.0422	VAVG_PH.843	13171.3994	0.293	S 25.4388 U 0.097 V 0	CF100	VAVGSA_M... IP-158.0422	VAVGSA_843	13171.3994	0.293	S 25.4388 U 0.097 V 0	CF100
VAVGH_R.A... IP-155.2167	VAVGH_R.815	13174.2249	0.293	S 28.2643 U 0.097 V 0	CF100	VAVGHE_... IP-155.2167	VAVGHE_815	13174.2249	0.293	S 28.2643 U 0.097 V 0	CF100
VMBKIAAA... IP-154.9237	VMBKIAAA.812	13174.5179	0.2	S 28.4643 U 0.097 V 0	CF100	VMBKIAAA... IP-154.9237	VMBKIAAA.812	13174.5179	0.2	S 28.4643 U 0.097 V 0	CF100
VCKKAAAA... IP-154.7237	VCKKAAAA.803	13174.7179	1.701	S 30.1653 U 0.097 V 0	CF100	VCKKAAAA... IP-154.7237	VCKKAAAA.803	13174.7179	1.567	S 30.0313 U 0.097 V 0	CF100
VAVFEUEJ... IP-153.157	VAVFEUEJ.792	13176.2846	0.774	S 30.895 U 0.097 V 0	CF100						
LBKDC.ALS... IP-152.383	LBKDC.ALS.1016	13177.0586	15.043	S 30.895 U 0.097 V 0	CF100						
VAVEAOAO... IP-137.34	VAVEAOAO.633	13192.1016	0.939	S 46.787 U 0.097 V 0	CF100						
VCKKAAAA... IP-137.3398	VCKKAAAA.637	13192.1018	0.134	S 0.8048 U 0.0942 V 0	CF100						

4. Define the apertures

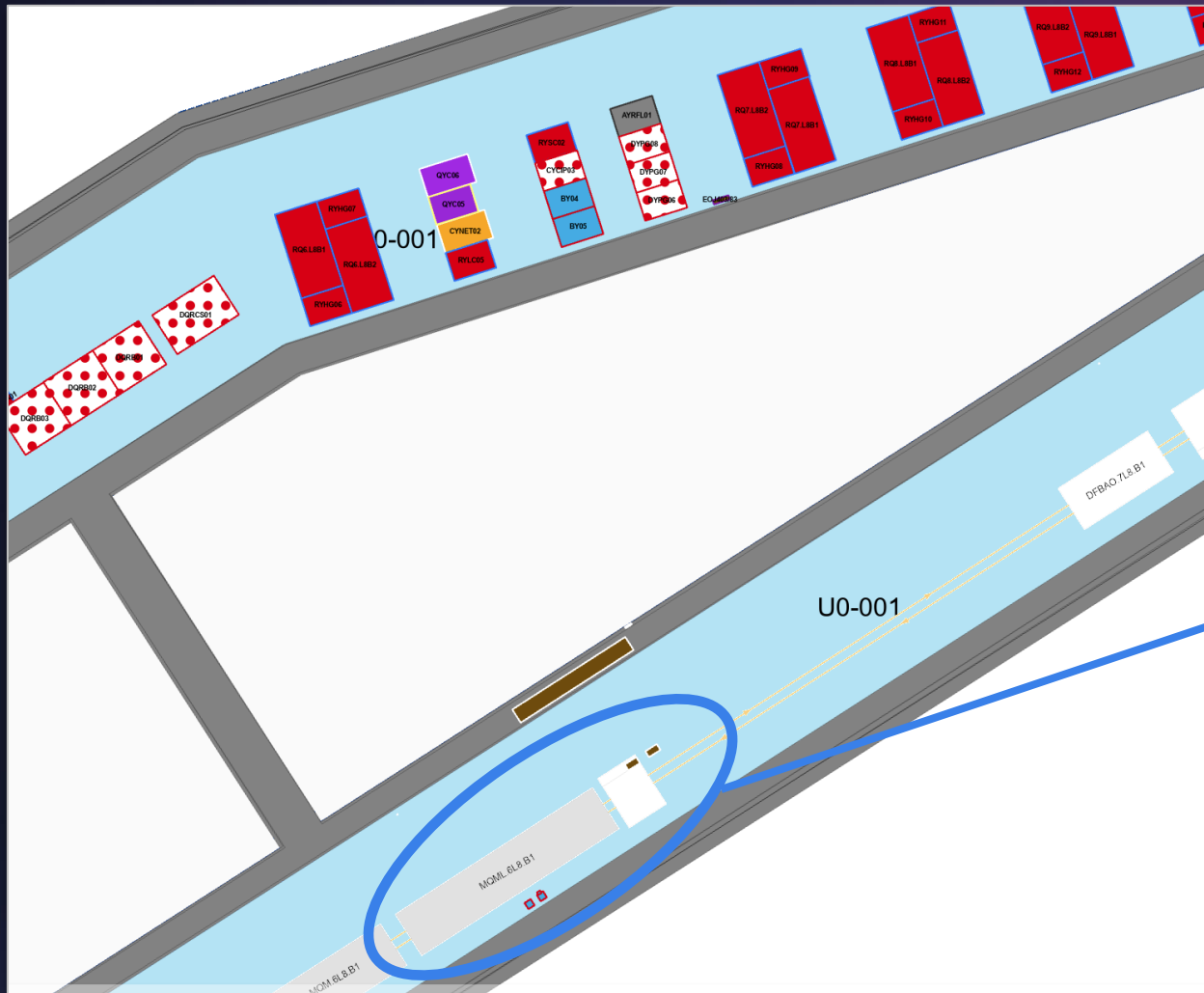
Edit aperture profiles | Add aperture

Offs. X	Offs. Y	Offs. Z	Profile AL	Shape	Inner Ø V	Inner Ø Z	A	B	C	D	Actions
0	-0.0884	0	AP223	CIRCLE	0.085	0.085	0.0425	0.0425	0.0425	0.0425	
0	0.0885	0	AP223	CIRCLE	0.085	0.085	0.0425	0.0425	0.0425	0.0425	
0.0183	-0.0884	0	AP029	CIRCLE	0.09	0.09	0.045	0.045	0.045	0.045	
0.0183	0.0885	0	AP029	CIRCLE	0.09	0.09	0.045	0.045	0.045	0.045	
0.1618	-0.0902	0	AP029	CIRCLE	0.09	0.09	0.045	0.045	0.045	0.045	
0.2958	0.0896	0	AP029	CIRCLE	0.09	0.09	0.045	0.045	0.045	0.045	

5. Perform elementary aperture checks with the LHC aperture graph



Cryogenic instruments, Control electronics...

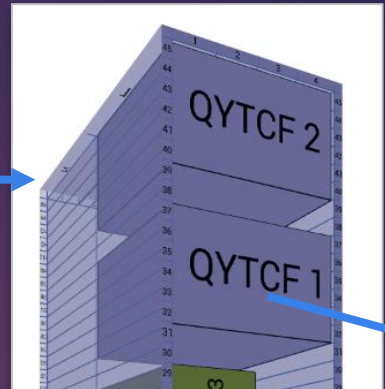
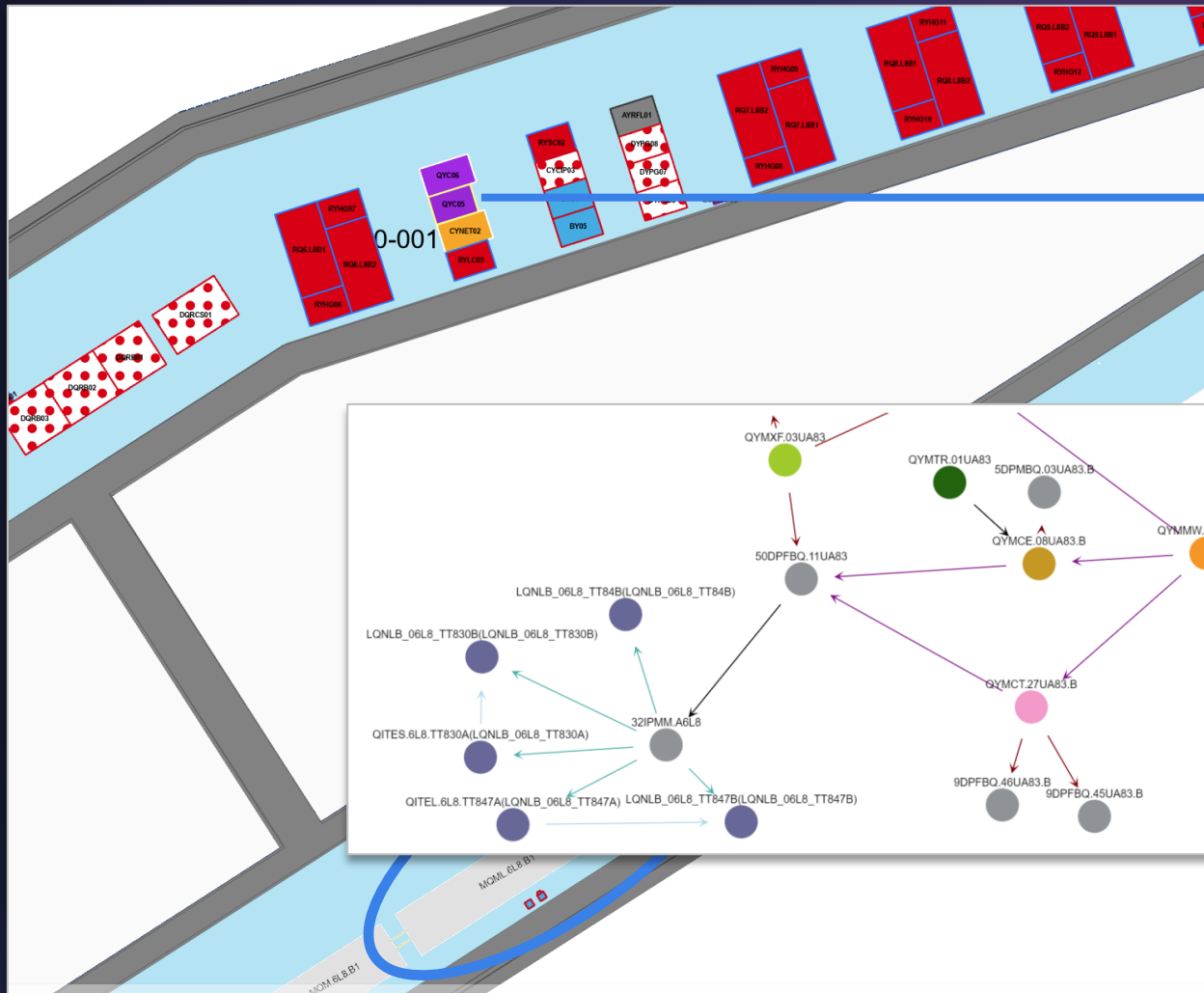


8. EN-ACE-CL Configuration managers maintain the QRL line (TE-CRG inputs) and cryo-assembly layouts

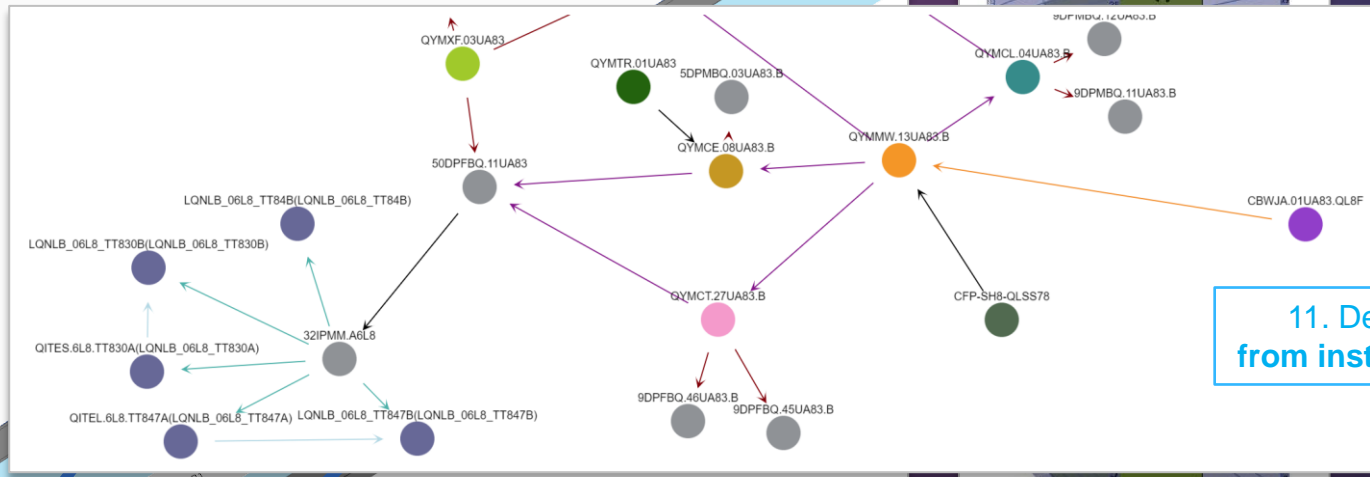
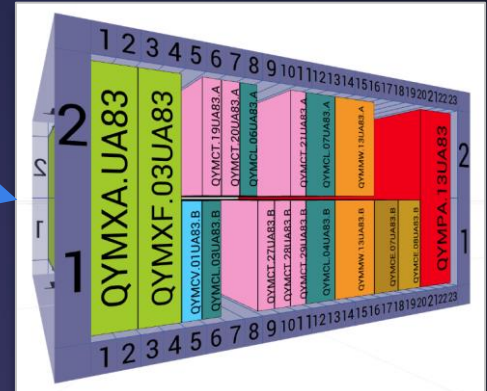
9. TE-CRG-IC define the cryogenic instrumentation (Thermometers, valves...)

- Sector 78 (3007)
 - LSS L8
 - 7L8
 - QRLDF.7L8 (QRLDF.7L8.Q)
 - QITEL.7L8.TT950 (QRLDF_07L8_TT950)
 - QITEL.7L8.TT951 (QRLDF_07L8_TT951)
 - QITEL.7L8.TT901 (QRLDF_07L8_TT901)
 - QITEL.7L8.TT961 (QRLDF_07L8_TT961)
 - QITEL.7L8.TT991 (QRLDF_07L8_TT991)
 - 6L8
 - LQNLB.6L8 (Q6L8)
 - QITES.6L8.TT830A (LQNLB_06L8_TT830A)
 - QITES.6L8.TT830B (LQNLB_06L8_TT830B)
 - QITEH.6L8.TT84B (LQNLB_06L8_TT84B)
 - QITEL.6L8.TT847B (LQNLB_06L8_TT847B)
 - QITEL.6L8.TT847A (LQNLB_06L8_TT847A)

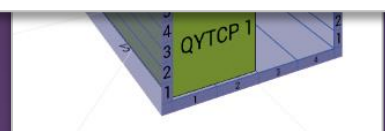
Cryogenic instruments, Control electronics...



10. TE-CRG-IC, helped by BE-CEM-IN, defined all their electronics (racks, crates, modules, connectors, pins...)



11. Define all connections from instruments to electronics



Summary

- Centrally **documenting** and **maintaining** the **physical configuration** of CERN infrastructures is **essential** to cope with its **complex evolution** over space and time
- **Layout** provides necessary **features to model** this **global physical configuration over time** and **interoperate** with its **ecosystem**
- **Teams** can **share** and **assemble** their **specific expert data** in **Layout** to enable various **cross-domain applications** across **ATS**



Thank you for
your attention

Questions ?