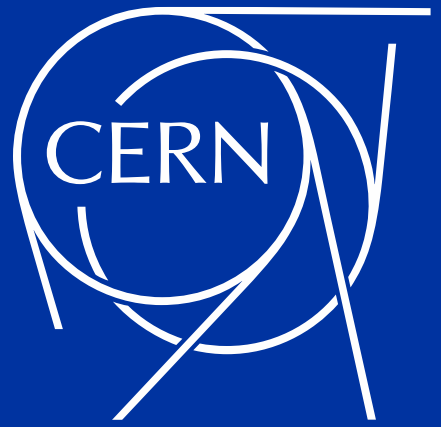


2023 EIROforum Workshop on Configuration Management - CERN

Thomas Birtwistle (EN dept.), Giulia Romagnoli (BE dept.), Stephane Bally (CMS experiment)

25 April 2023

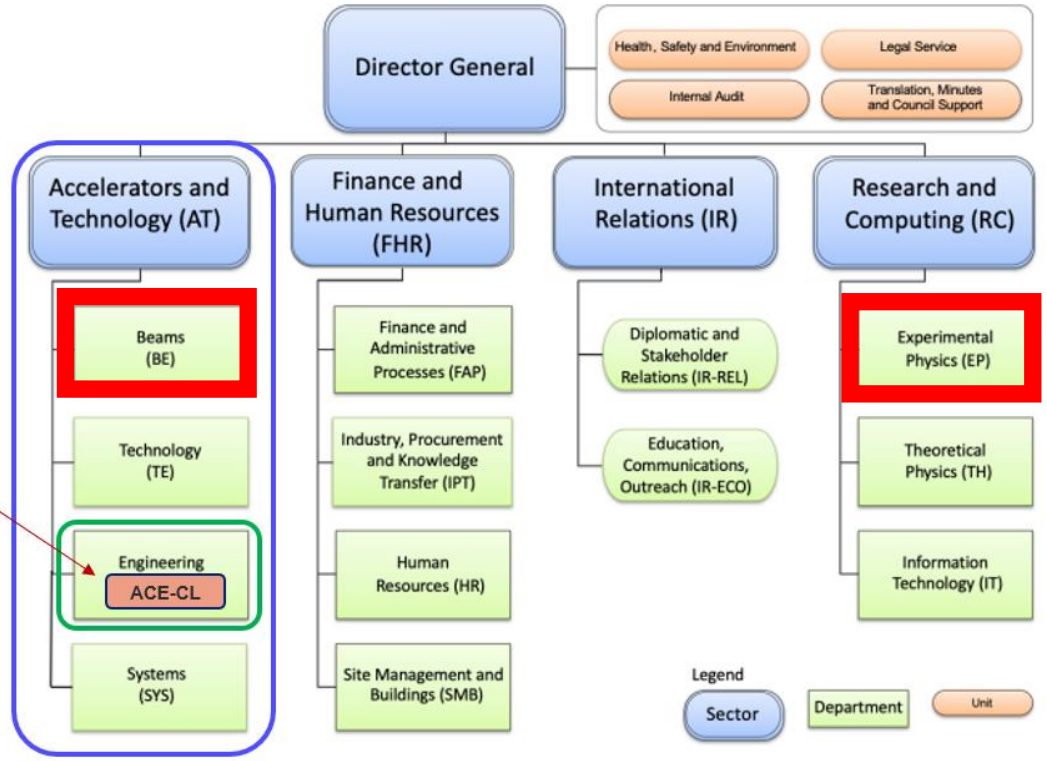
Outline

- **CERN Configuration Management Organisational Structure**
- **Configuration Management Mission**
- **Accelerators Perspective on Configuration Management**
  - Naming, Layout Database, Hardware Baselines, Change Management, Panoramas, Overall Process
- **Accelerators' Sector Experimental Areas Configuration Management (Giulia Romagnoli)**
- **CMS Experiment Configuration Management (Stephane Bally)**

CERN Configuration Management Organisational Structure

- **Accelerators**
  - Centralise configuration management processes.
  - Located in the **Engineering** Department – **Accelerator Coordination and Engineering** Group – **Configuration and Layout** Section.

Configuration & Layout Management team

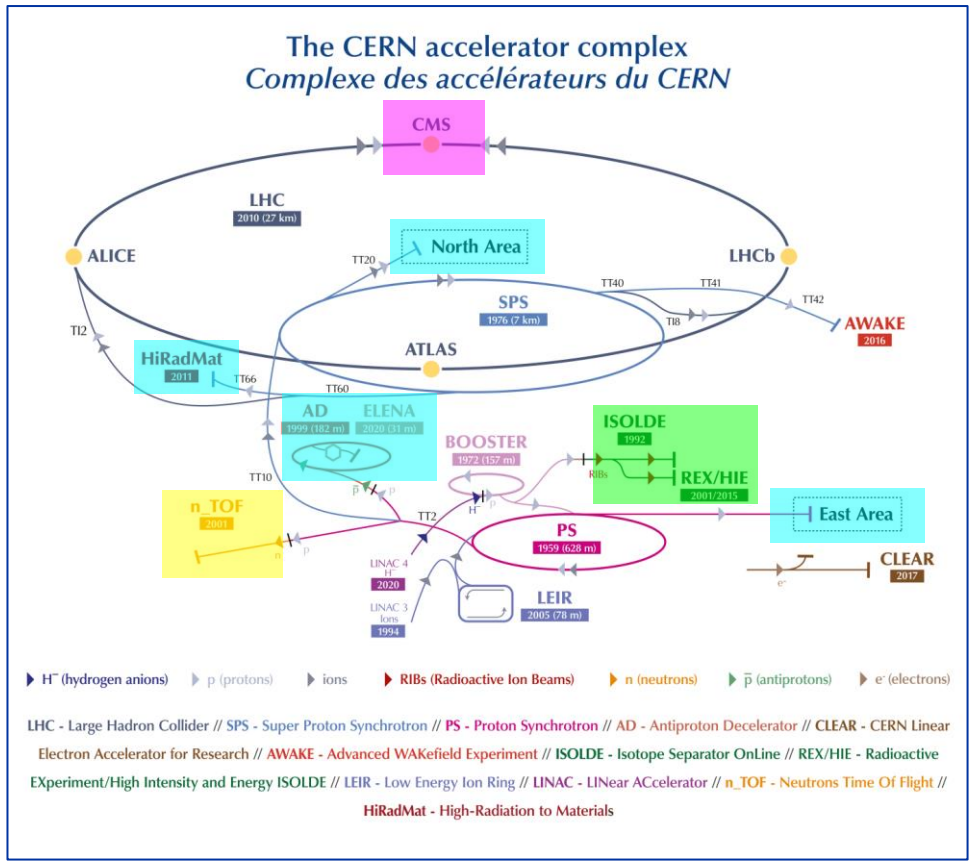


  - Ensure the configuration management of all primary beam lines (~50km of beam line)

- **Accelerators' Sector Experimental Areas**
  - East Area, North Area, AD etc. = **BE-EA group.** Activities to be presented by **Giulia Romagnoli**

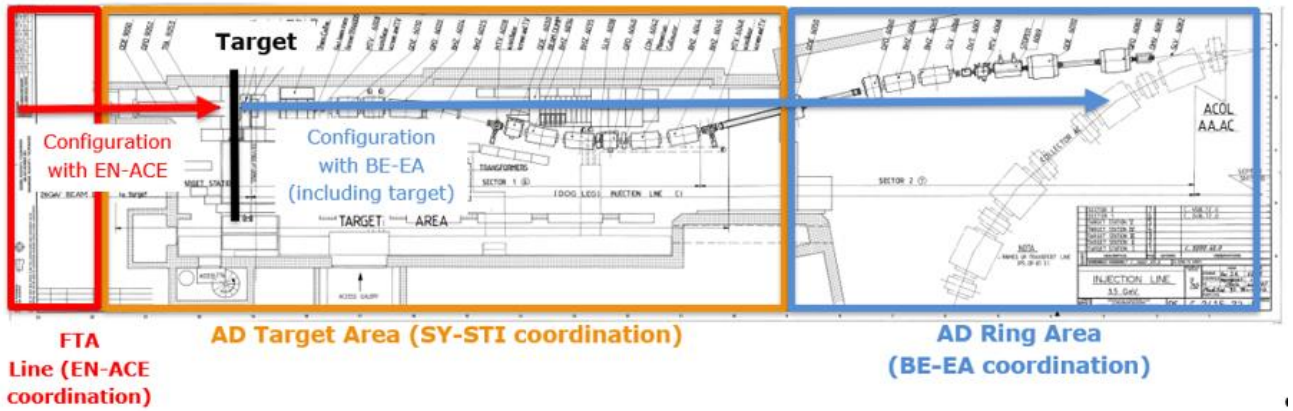
- **LHC Experiments (example today from CMS)**
  - LHC experiments - CMS = **EP-CMX group.** Activities to be presented by **Stephane Bally**

CERN Configuration Management Organisational Structure



Several actors for configuration management

- Primary beam lines: EN-ACE-CL
- Experimental areas (North Area, East Area…): BE-EA
- nTOF: SY-STI
- ISOLDE: BE-OP
- LHC experiments - CMS



AD target area example - Configuration management responsibilities sharing

Slide courtesy of A.L. Perrot (EN-ACE)

Configuration Management Mission

Provide a clear and coherent representation of the CERN accelerators, experiments and facilities at a given point in time.

Using various engineering tools, databases, and processes.

Working with various stakeholders across the organisation.

Accelerators Perspective on CM

Hardware Baselines / Product Breakdown Structures

- Linac 3 Hardware Baseline
- Linac4 Hardware Baseline
- LEIR Hardware Baseline
- PS Booster Hardware Baseline
- ISOLDE Hardware Baseline
- HIE-ISOLDE Hardware Baseline
- PS Ring Hardware Baseline
  - PS Ring LS2 Work Package Analysis
  - Layout
  - Integration
  - Magnets
  - Injection/Ejection Systems
  - Vacuum System
  - DC Powering
  - Radiofrequency System
  - Beam Instrumentation
  - Beam Intercepting Devices
  - Supports
  - Transfer Lines
  - Infrastructure

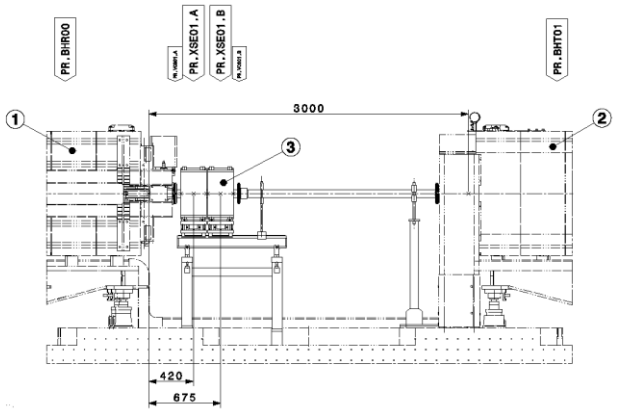
EDMS

Configuration Items

- PXMQNAAIAP (v.0) PXMQNAAIAP - Quadrupole magnet, type 401
- PXMQNABIAP (v.0) PXMQNABIAP - Quadrupole magnet, type 402
- PXMQNBAFAP (v.0) PXMQNBAFAP - Quadrupole magnet, type 406
- PXMQNBCAWP (v.0) PXMQNBCAWP - Quadrupole magnet, type 407
- PXMQNBDAAP (v.0) PXMQNBDAAP - Quadrupole magnet, type 408
- PXMQNCAAWP (v.0) PXMQNCAAWP - Quadrupole magnet, type 409
- PXMQNCHAWP (v.0) PXMQNCHAWP - Quadrupole magnet, type 414

Documentation

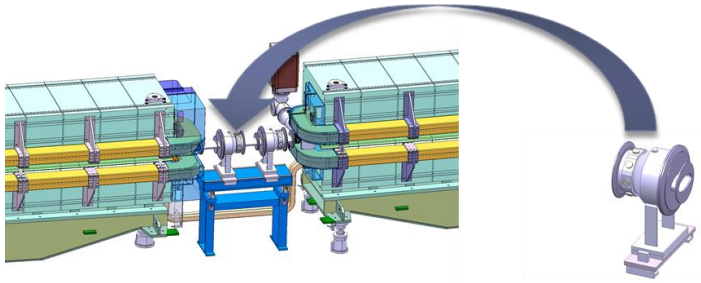
Layout – sequence of functional positions



- LEIR Complex
- PS Ring (PR)
  - SECTOR 1
    - SECTION 01
      - **PR.SD01**
        - PR.XSE01.A
        - PR.VCS01.A
        - PR.XSE01.B
        - PR.VCS01.B
      - PR.UA01
    - SECTION 02

Layout

Change Management



Naming

QUALITY ASSURANCE DEFINITION

Conventions for Layout Components of the PS Ring and F16, F61, FTN, FTA, ZT8, ZT9, ZT10, ZT11 Transfer Lines

Panoramas

Accelerators Perspective on CM

Naming Portal

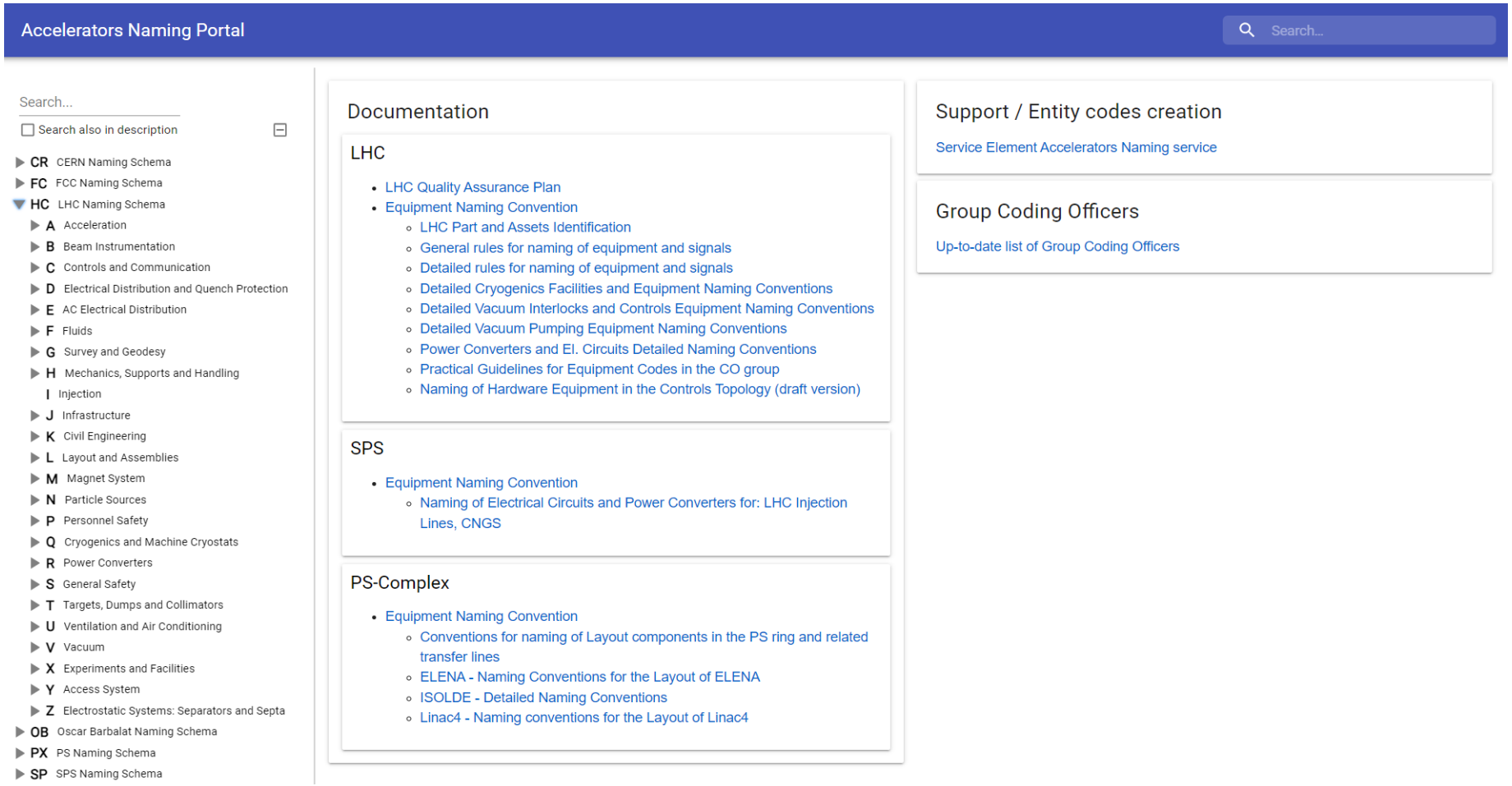
Accelerators Naming Portal

Link to Naming Database

Stores the names/codes of all accelerator equipment.

Coherence ensured by the naming service (EN-ACE-CL), in conjunction with equipment groups.

Equipment codes defined according to naming conventions that are agreed and defined through Quality Assurance Plans / with Quality Assurance teams



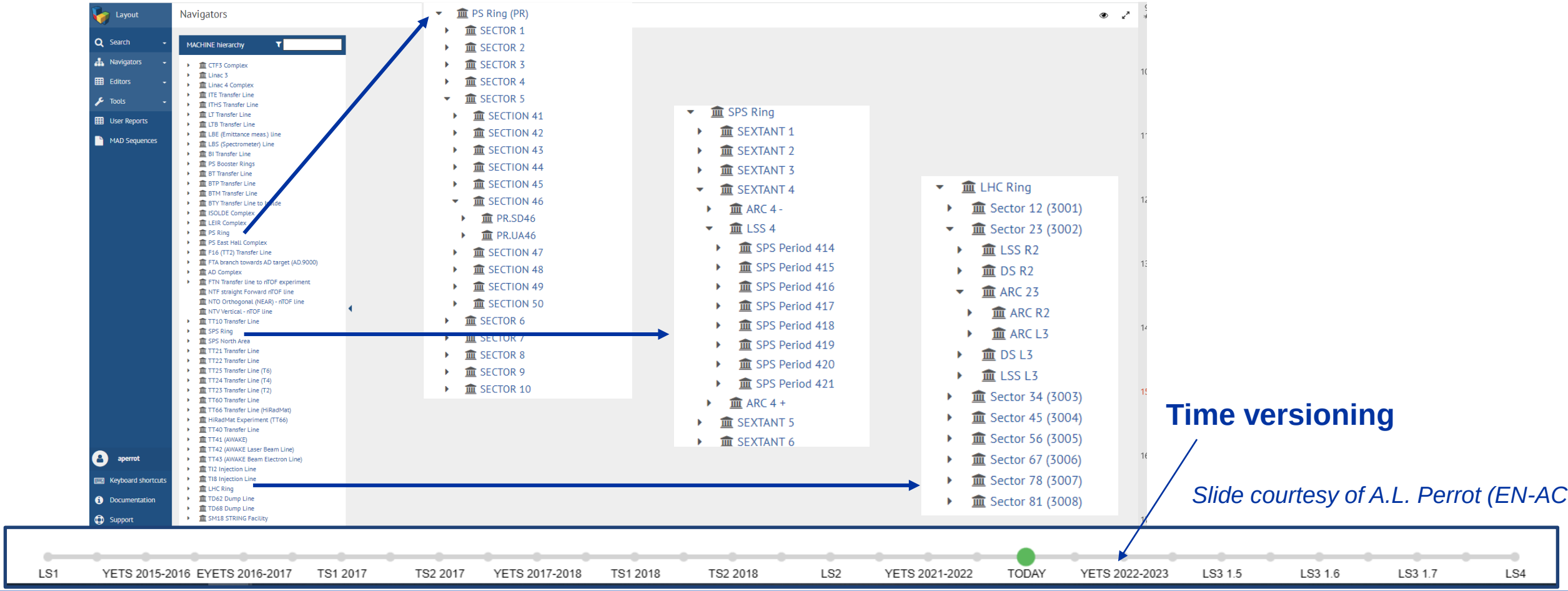
Accelerators Perspective on CM

Layout Database

Layout

Development by BE-CSS

Stores the sequence of the accelerators and transfer lines components

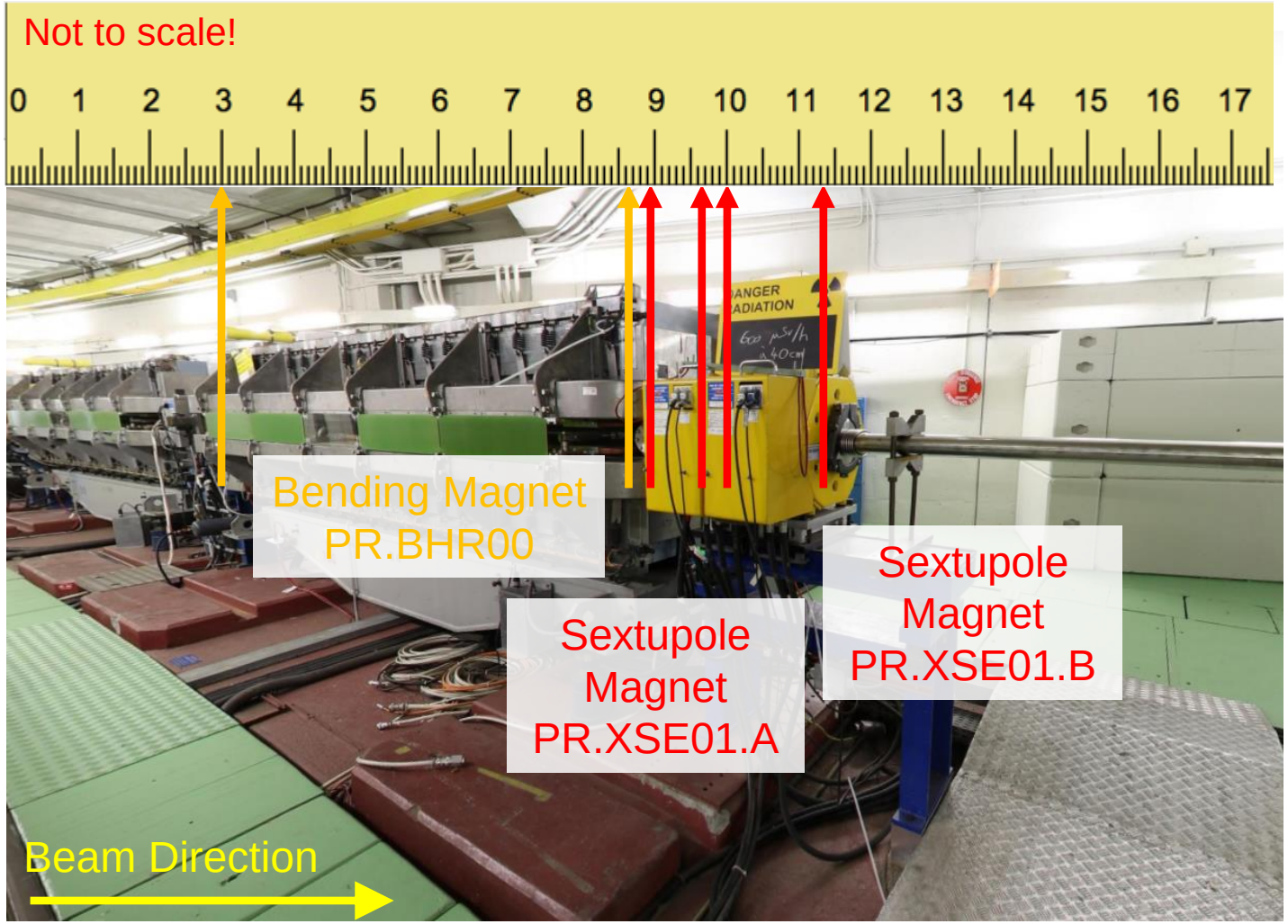


Time versioning

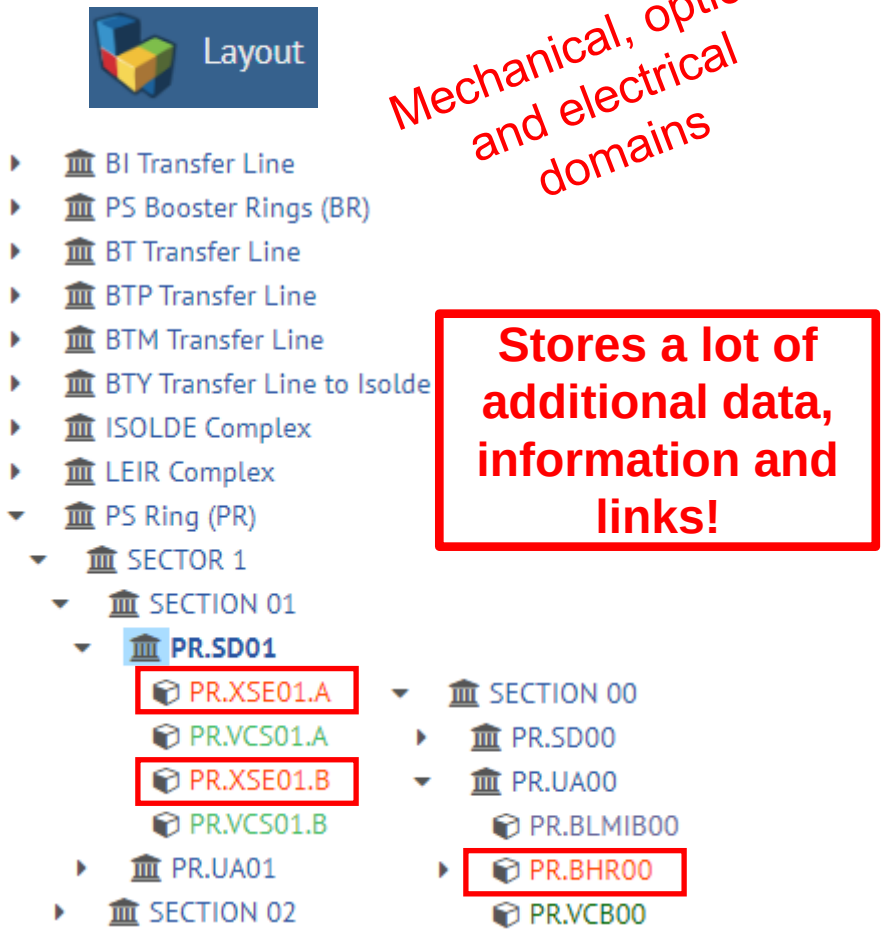
Slide courtesy of A.L. Perrot (EN-ACE)

Accelerators Perspective on CM

Layout Database

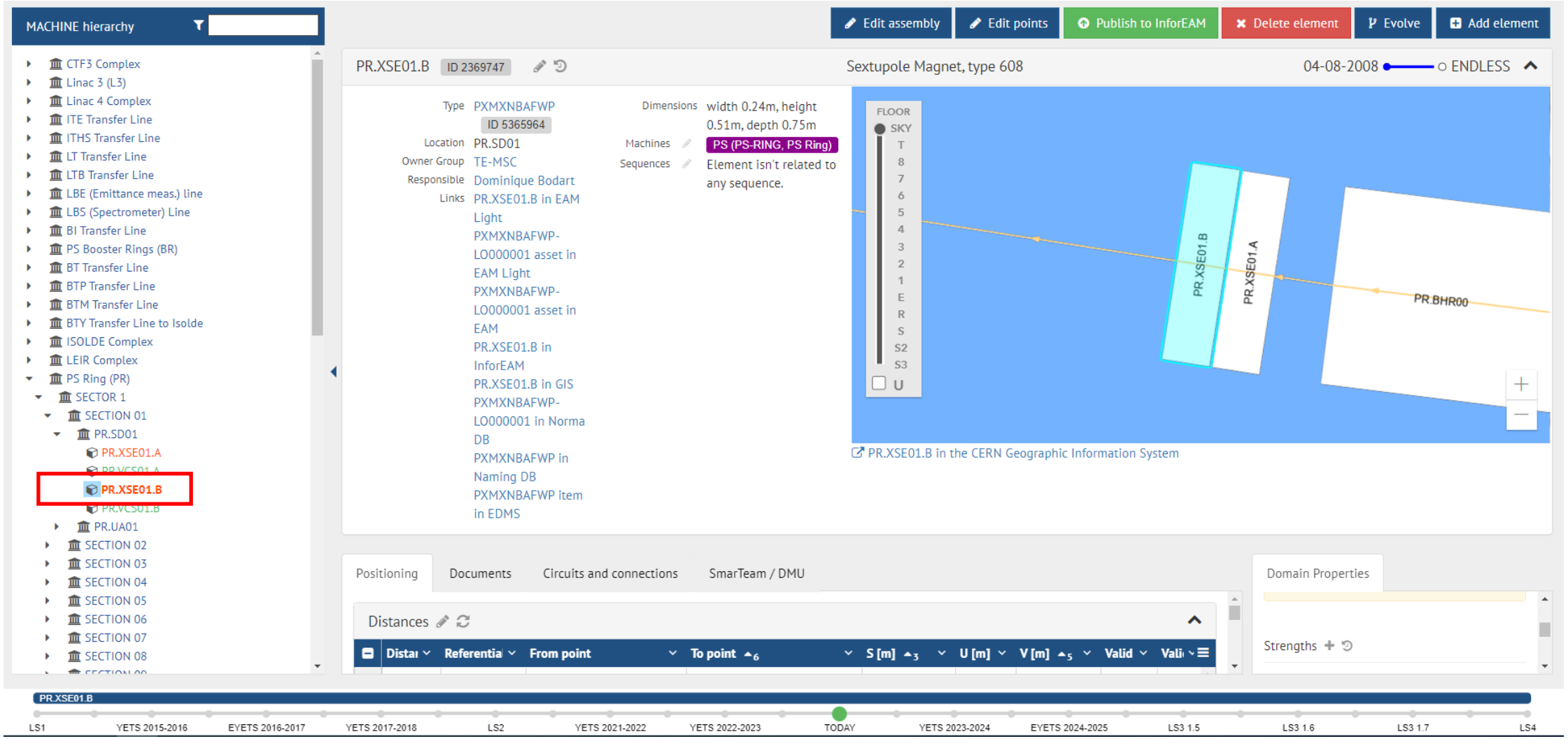


Layout – sequence of functional positions



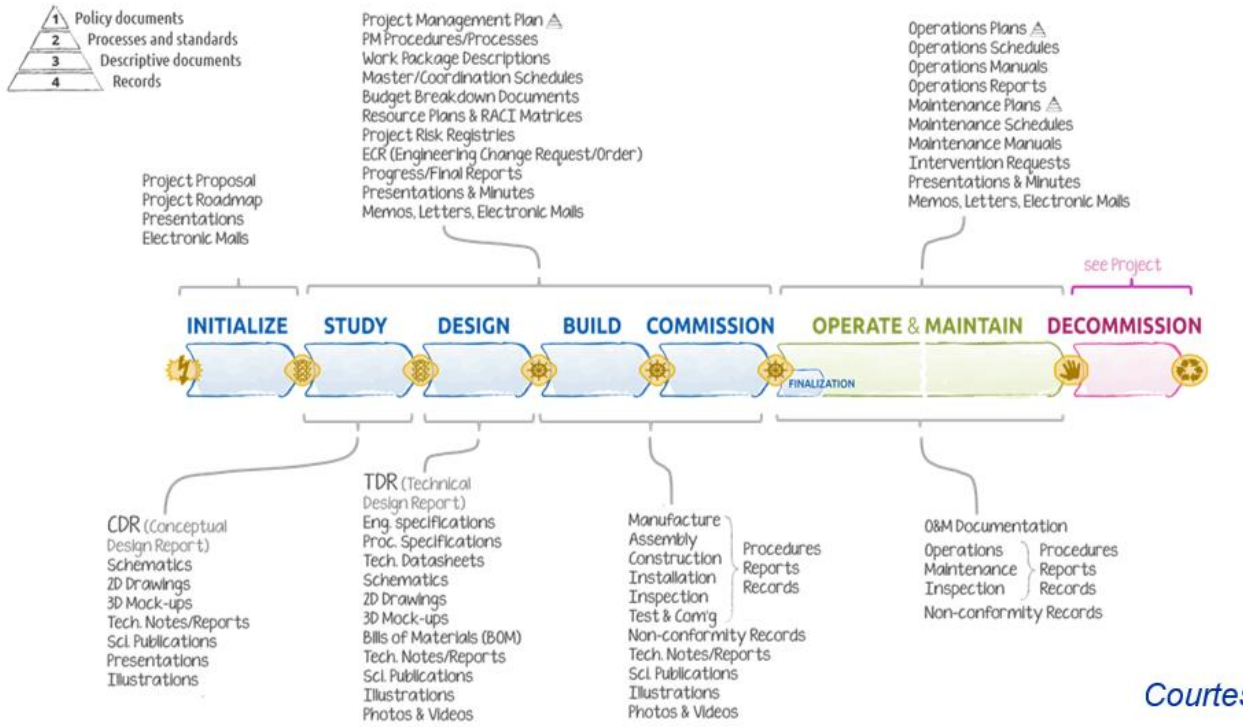
Accelerators Perspective on CM

Layout Database

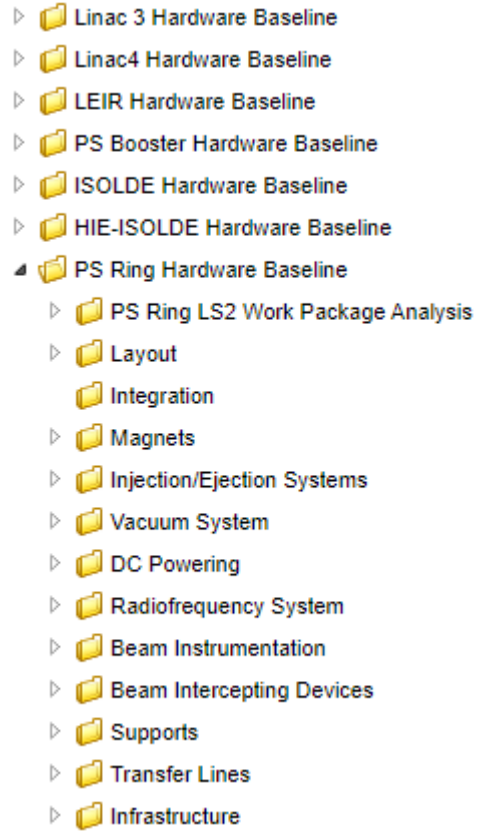


Accelerators Perspective on CM
Hardware Baselines / Configuration Items

- Hierarchy of classes, sub-classes and configuration items
- Stores approved documentation over the full life-cycle

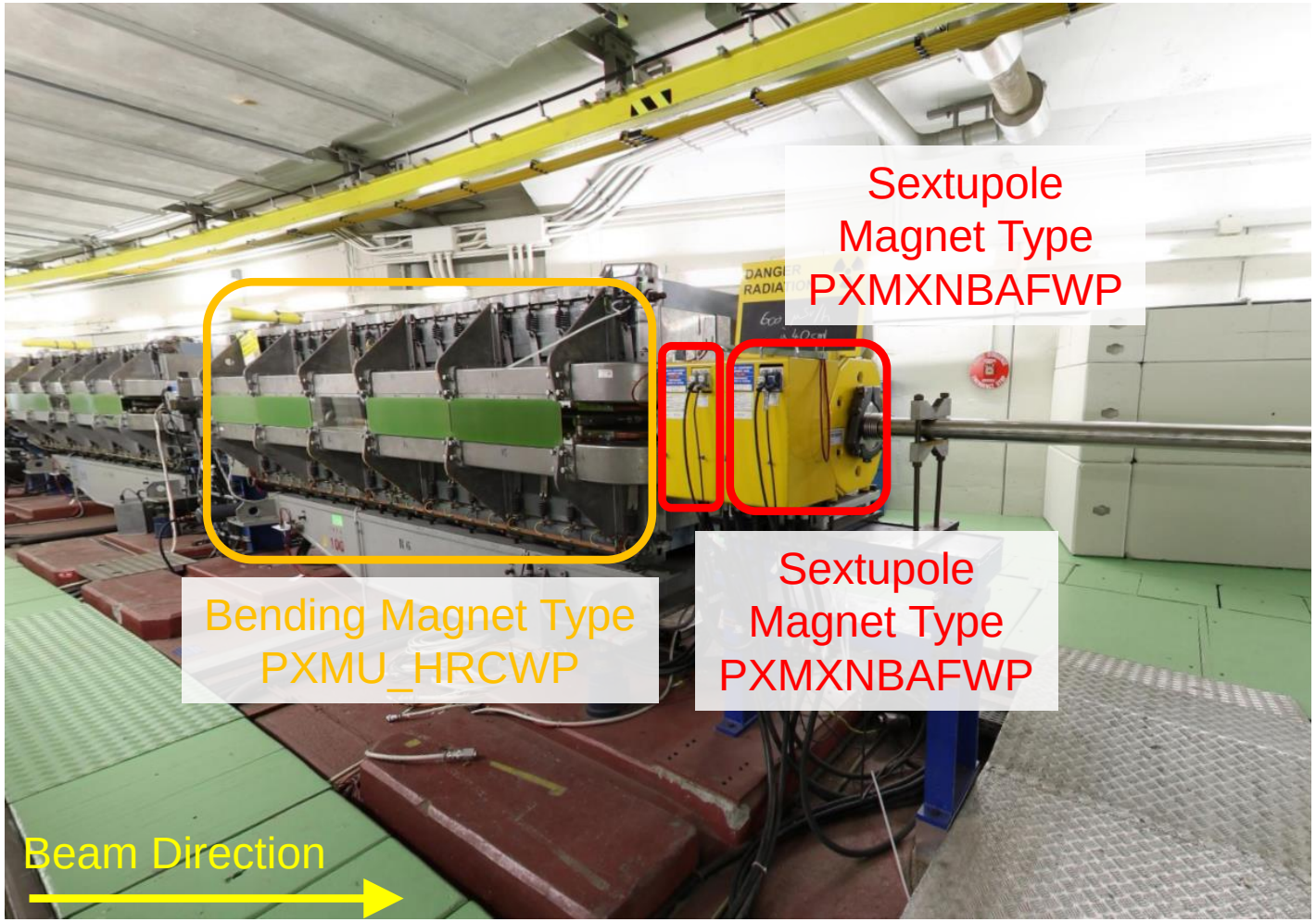


Courtesy S. Chemli & P. Bonnal
(ATS quality service)



Accelerators Perspective on CM

Hardware Baselines / Configuration Items



Hardware Baselines / Product Breakdown Structures

EDMS

- Linac 3 Hardware Baseline
- Linac4 Hardware Baseline
- LEIR Hardware Baseline
- PS Booster Hardware Baseline
- ISOLDE Hardware Baseline
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  - Layout
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  - Magnets
    - PXMQNAAIAP (v.0) PXMQNAAIAP - Quadrupole magnet, type 401
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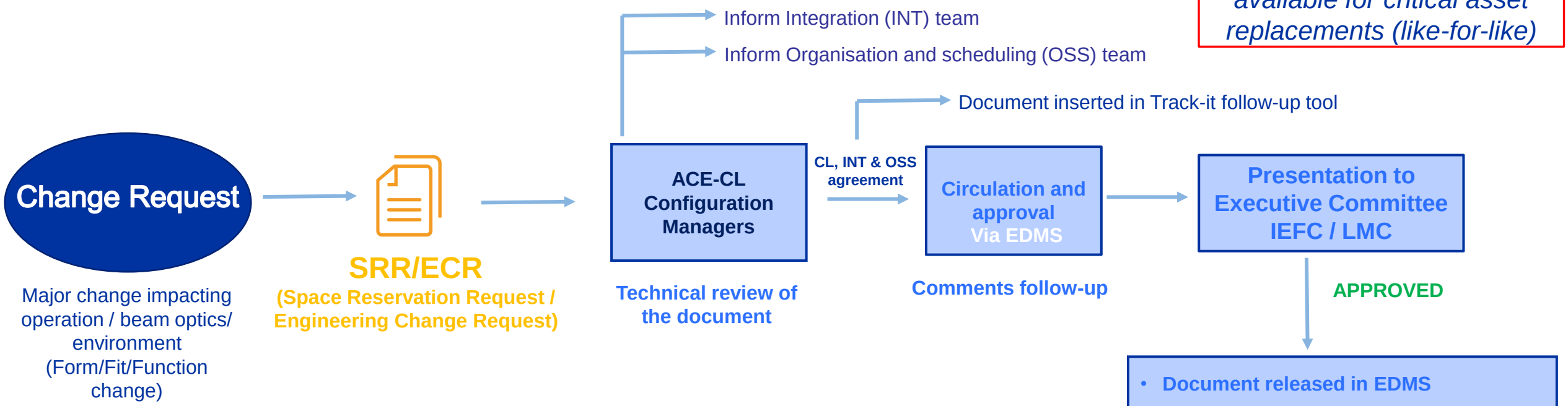
  - Vacuum System
  - DC Powering
  - Radiofrequency System
  - Beam Instrumentation
  - Beam Intercepting Devices
  - Supports
  - Transfer Lines
  - Infrastructure

Handling Changes in the Accelerators

Process

Separate Asset Replacement Request Process (ARR) also available for critical asset replacements (like-for-like)



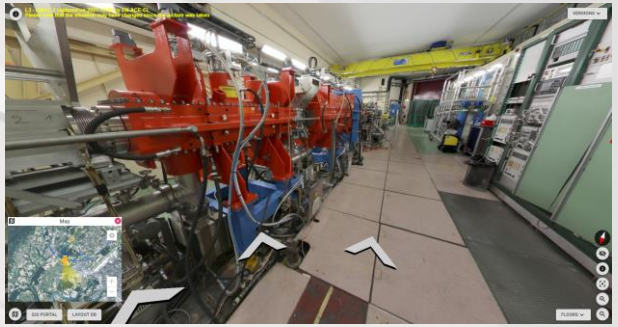
- Activity by ACE-CL
- Activity by other teams

Slide courtesy of A.L. Perrot (EN-ACE)

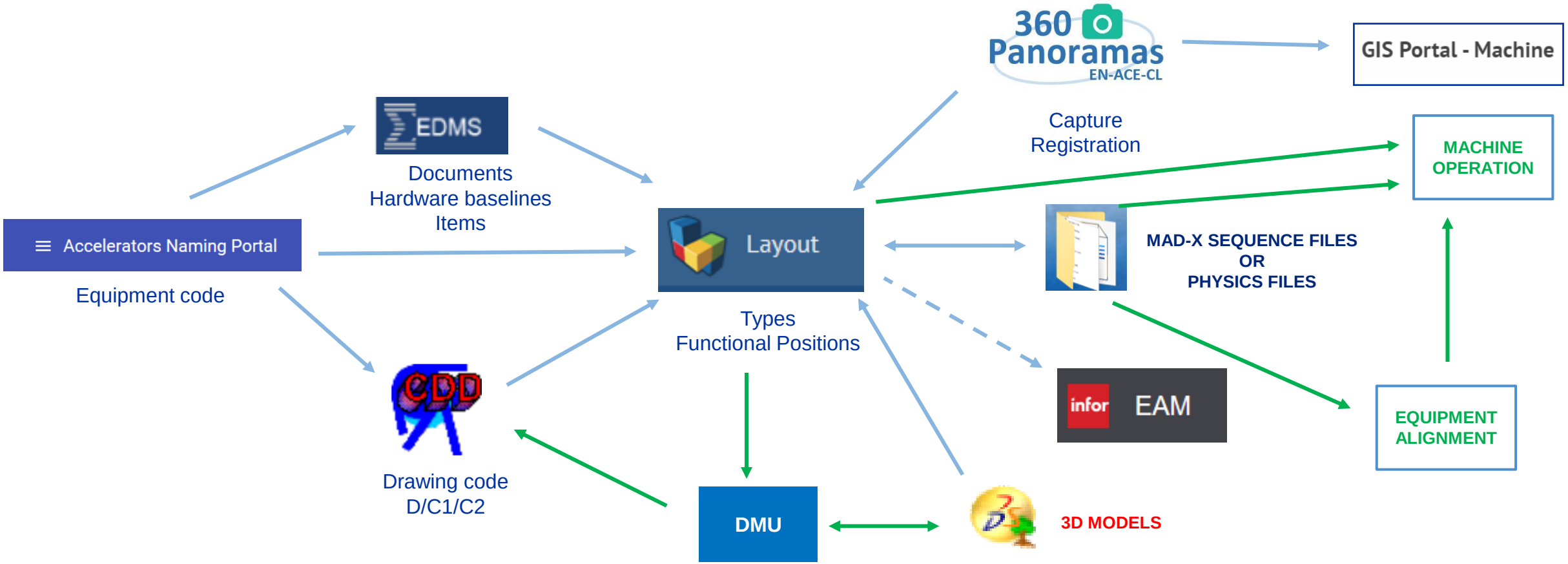
Panoramas

Panoramas (CERN internal)
Outreach version

- 360-degree visualisation of the CERN accelerators and facilities.
- Started in 2013 by EN-ACE-CL.
- Initially covered only primary beam lines. Now extended to many surface buildings, service tunnels, and experiments.
- Used by many groups across CERN for preparing interventions, checking layouts etc. (minimize radiation exposure, save time etc.)



Configuration Management Process



Slide courtesy of A.L. Perrot (EN-ACE)

Some Associated Reading

T. Birtwistle et al., “360 Degree Panoramic Photographs During the Long Shutdown 2 of the CERN Machines and Facilities”, IPAC 2021, Campinas, Brazil, WEPAB315 - https://accelconf.web.cern.ch/ipac2021/papers/wepab315.pdf

S. Bartolomé Jiménez et al., “CERN Accelerators Topology Configuration: Facing the Next LHC Long Shutdown”, IPAC 2017, Copenhagen, Denmark, THPAB145 - https://accelconf.web.cern.ch/ipac2017/papers/thpab145.pdf

M. Barberan Marin et al., “Integration, Configuration and Coordination: from Project to Reality, at CERN”, IPAC 2016, Busan, S. Korea, TUPMW003 - https://accelconf.web.cern.ch/ipac2016/papers/tupmw003.pdf

Conclusion

Coherence is key!

Thank-you for your attention

Acknowledgements

Special thanks to:

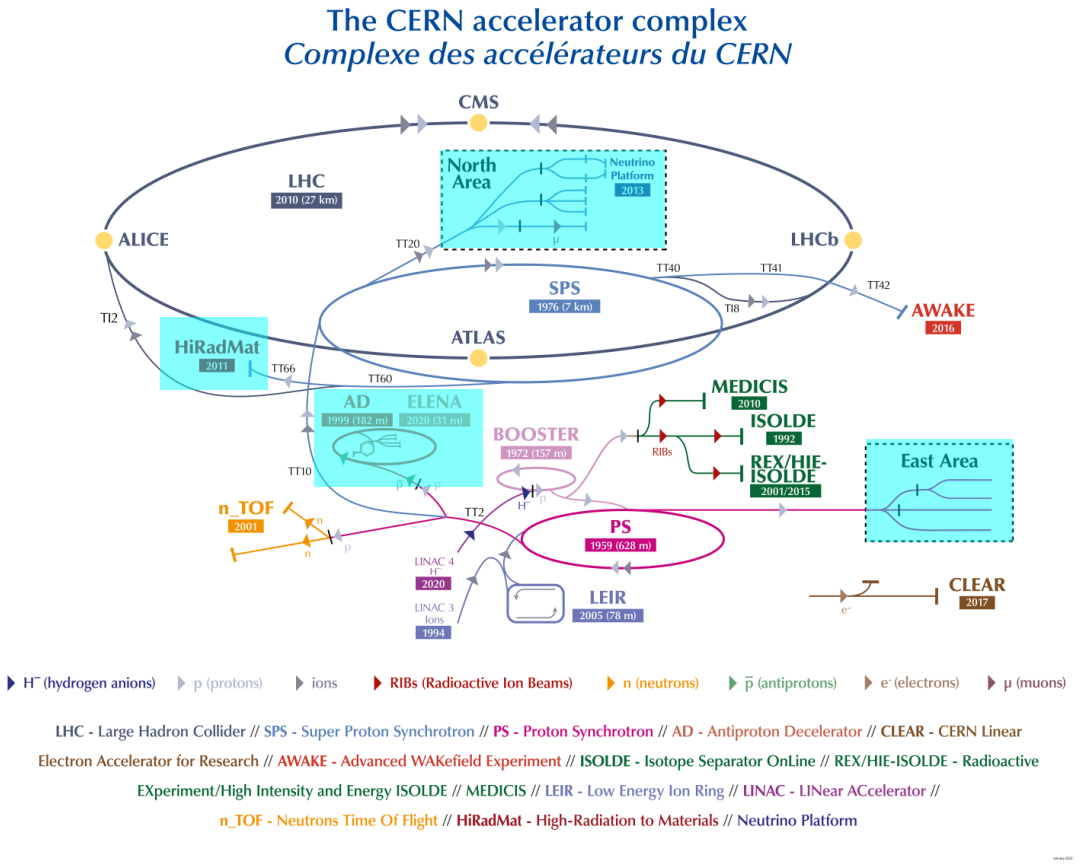
S. Petit - ATS Quality Service

P. Le Roux - BE-CSS

C. Scoero, A. Ortiz - EN-IM

A. L. Perrot, S. Bartolomé Jiménez, B. Feral, S. Chemli - EN-ACE

Configuration Management for Experimental Areas



Experimental areas started adopting the CM strategy in 2019 following the strategy in place and already implemented by EN-ACE for the accelerators:

- **NEW** CM for East Area: completely renewed with East Area Renovation Project (2019-2021)
- AD and ELENA with Transfer lines CM started by EN-ACE and taken over by BE-EA in 2019
- HiRadMat CM started by EN-ACE and taken over by BE-EA in 2019
- **NEW** CM for North Area: Configuration Management implementation in the framework of the NACONS project.

EXPERIMENTAL AREAS CHALLENGE →
Beamlines subject to **frequent modifications** following requirements of the Users and Experiments

BE-EA Group is responsible for CM, coordination and for **beamline equipment**!!

Configuration Management Definition

The Configuration Management is a strategy applied to the Experimental Areas with the final goal of:

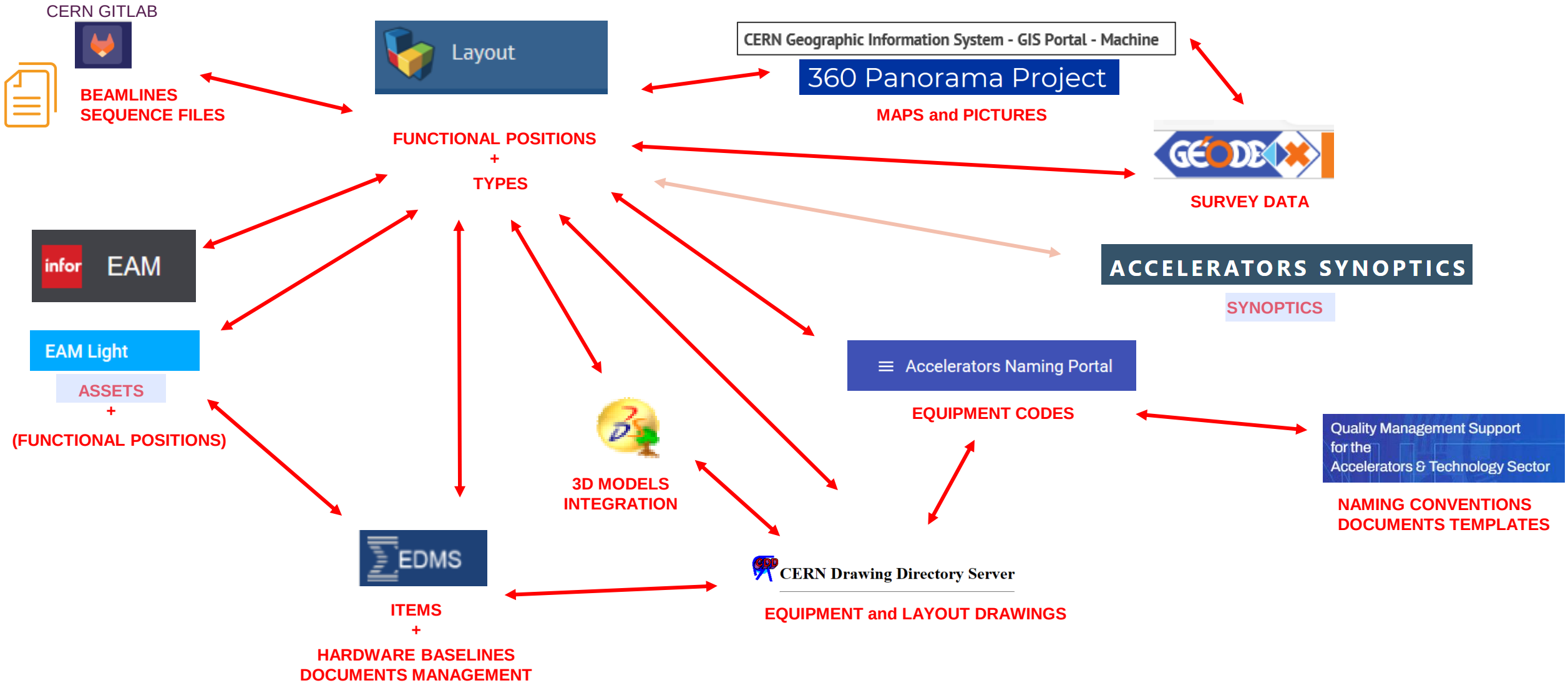
Provide a clear and coherent picture of the status of a BEAMLINE at a given point in time.

The main elements used by the BE-EA group to develop the CM strategy are:

- **Hardware Baseline:** Product Breakdown Structures in EDMS (DOCUMENTS Quality Control)
- **Layout Database:** Sequence of functional positions = space management
  (Integration and Installation Drawings + Survey Data)

  → Automatic generation of the sequence file to import in MADX for beam optics
- **Naming:** verify and registering all equipment codes on Naming Portal (ATS Sector Quality)
- **Infor and EAM Light:** ASSET Management

BE-EA Configuration Management Tools



Beamline Configuration - Studies

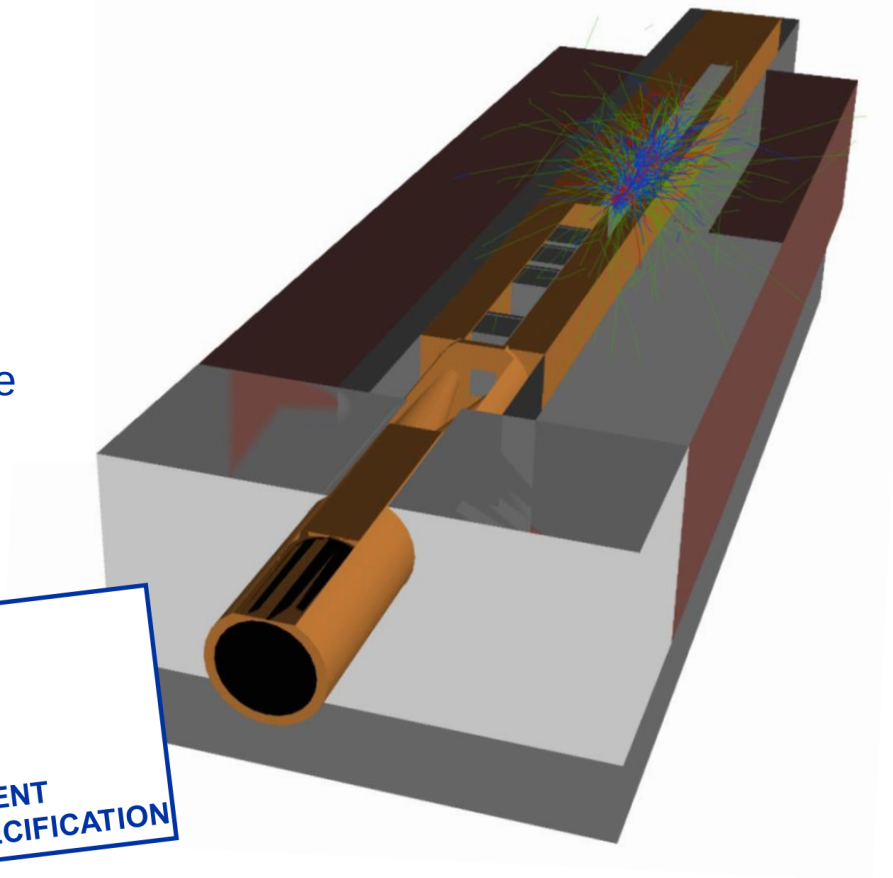
The Experimental Areas are hosting a large variety of experiments/users asking different setting and special configuration of beamlines. To cope with these request, beamline physicists are running simulations and calculating beam trajectories and optics.

The NEED could be of a different nature:

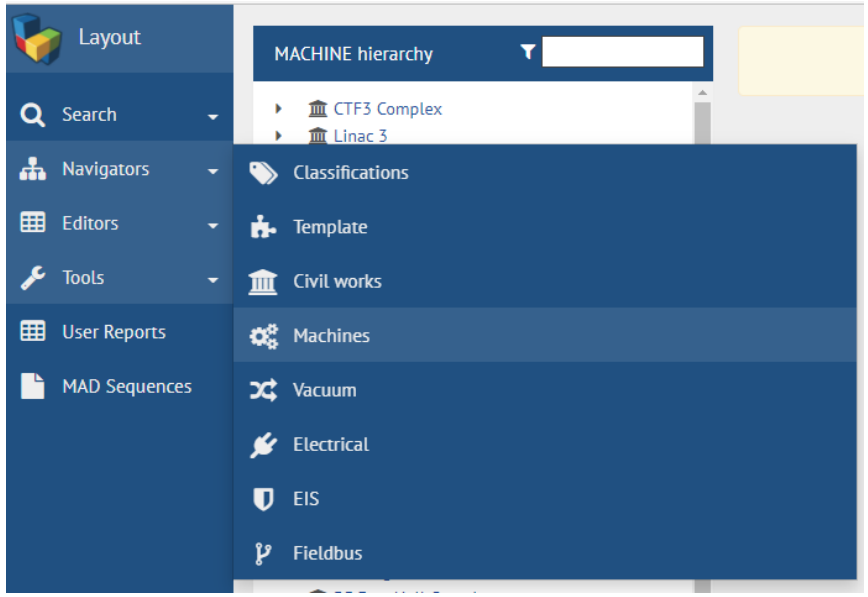
- New component
- Functional change (different configuration)
- Layout change
- Beam-matter interactions

The physicists may also help in designing and modifying existing beamlines for future experiments.

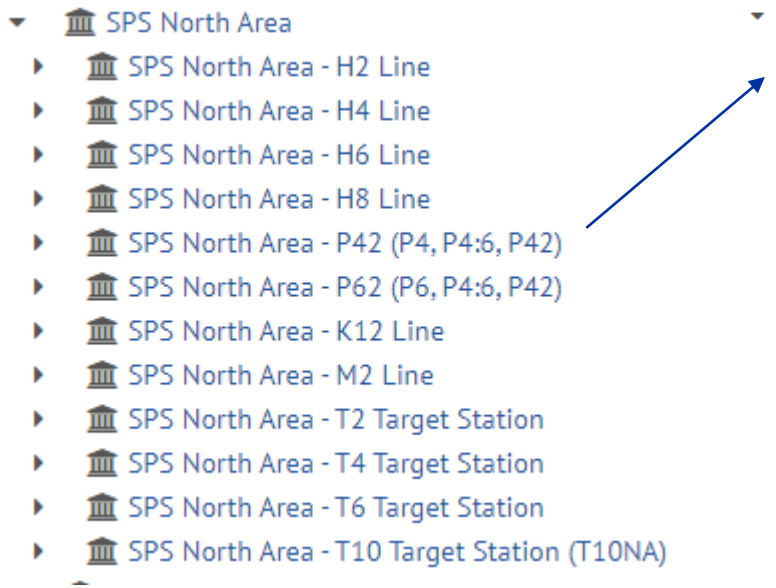
Physics simulations → BDSIM (Geant4) / FLUKA model

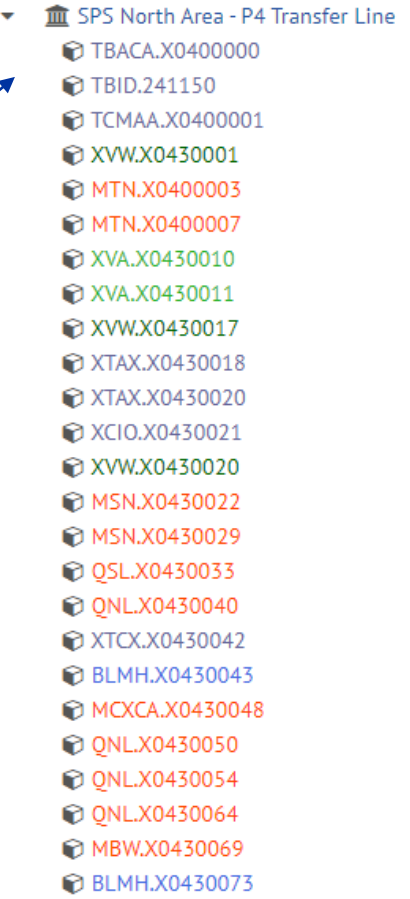


Functional Positions – Beamline Structure



Beamlines functional position structure is stored time dependently on Layout Database (LD) tool. LD is the reference tool that centralize all information and data with links to the other database.



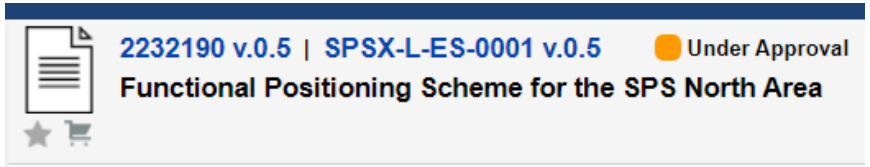


Accelerators Naming Portal

EQUIPMENT CODES

Quality Management Support for the Accelerators & Technology Sector

NAMING CONVENTIONS
DOCUMENTS TEMPLATES



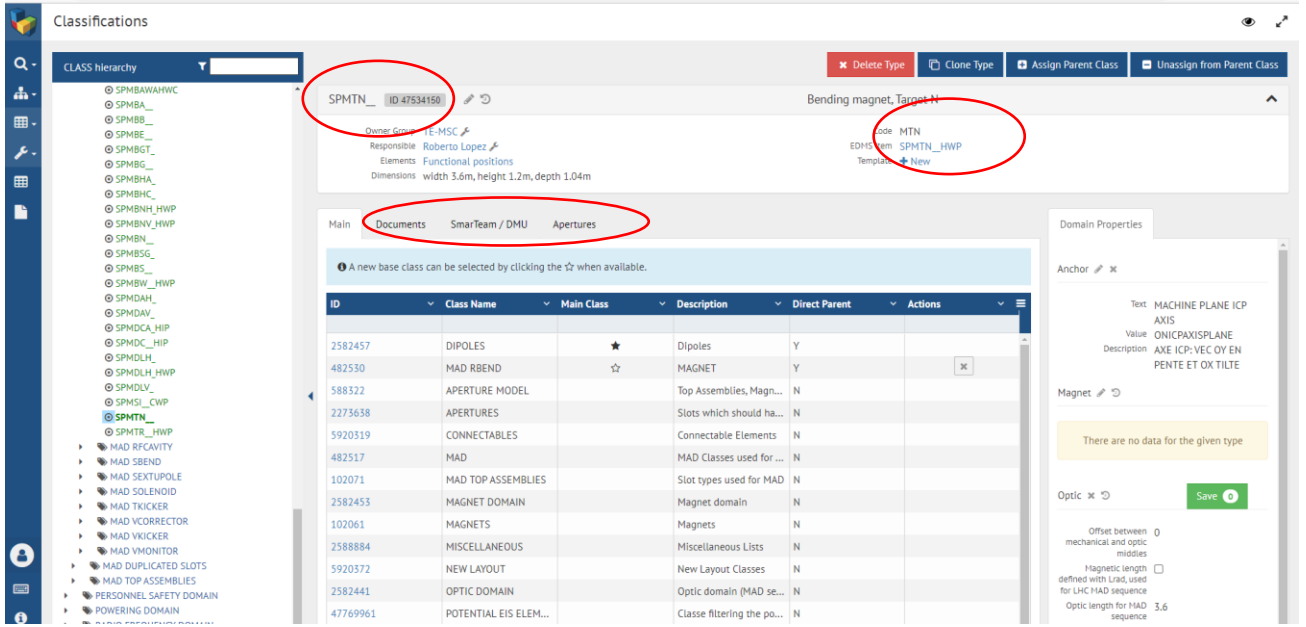
All positions and equipment codes follow a specify convention agreed with the different equipment groups and stakeholders

Hardware Baseline - ITEMS

- SPS NA HARDWARE BASELINE
  - SPSX - Beam Instrumentation
  - SPSX - Beam Intercepting Devices
  - SPSX- Integration
  - SPSX - Layout
  - SPSX - Magnets
  - SPSX - Supports
  - SPSX - Controls
  - SPSX - Beam Parameters
  - SPSX - Infrastructure
  - SPSX - General Services
  - SPSX - Power
  - SPSX - Vacuum system
  - SPSX - Safety and Access
  - SPSX - Experiments
  - SPSX - Mechanical Supports
  - SPSX - Electrical Systems

The hardware baseline is a breakdown structure on EDMS of the components of the beamline collecting all ITEMS there present and all important documents.
All ITEMS are linked to the functional positions in Layout database defining the nature of the positions, the dimensions, the responsible, …

- SPSX - Magnets
  - ECR and ARR Magnets
  - PXMBHHEHWC (v.0) PXMBHHEHWC - Bending magnet, type M200, straight poles
  - PXMBHHJHWC (v.0) PXMBHHJHWC - Bending magnet, type M200, tappered poles
  - PXMBHGGHWC (v.0) PXMBHGGHWC - Bending magnet, type M100, straight poles
  - PXMBXFACWP (v.0) PXMBXFACWP - Bending magnet, H or V, type VB3, 1m gap 108mm
  - PXMBXGDCWP (v.0) PXMBXGDCWP - Bending Magnet, H or V, type MCW
  - PXMBXHACWP (v.0) PXMBXHACWP - Bending Magnet, H or V, type VB1, 2.5m gap 108mm
  - PXMBXHCCWP (v.0) PXMBXHCCWP - Bending Magnet, H or V, type HB1, 2.5m gap 80mm
  - PXMBXHDCWP (v.0) PXMBXHDCWP - Bending Magnet, H or V, type HB2, 2.5m gap 80mm
  - PXMCXCAHWC (v.0) PXMCXCAHWC - Corrector magnet, H or V, type MDX
  - PXMCXCDHWC (v.0) PXMCXCDHWC - Corrector magnet, H or V, type MNPA30
  - PXMQNEETWC (v.0) PXMQNEETWC - Quadrupole magnet, type Q100, 1m
  - PXMQNEGTWP (v.0) PXMQNEGTWP - Quadrupole magnet, type QFS, 0.8m
  - PXMQNFBTWC (v.0) PXMQNFBTWC - Quadrupole magnet, type Q200, 2m
  - SPLSE__FWP (v.0) SPLSE__FWP - Sextupole lens, extraction
  - SPLSX__FWP (v.0) SPLSX__FWP - Sextupole lens, north area
  - SPMBNH_HWP (v.0) SPMBNH_HWP - Bending magnet, secondary beams, horizontal, north area
  - SPMBNV_HWP (v.0) SPMBNV_HWP - Bending magnet, secondary beams, vertical, north area
  - SPMBW__HWP (v.0) SPMBW__HWP - Bending Magnet, main, type B2, 1000A



TYPES - ITEMS

DESIGN - STUDY

Items are the “virtual objects”, results of the design studies collecting all technical information, specifications, drawings, 3D assembly models,…

TYPE = ITEMS – What? Shape and Color / Family Name

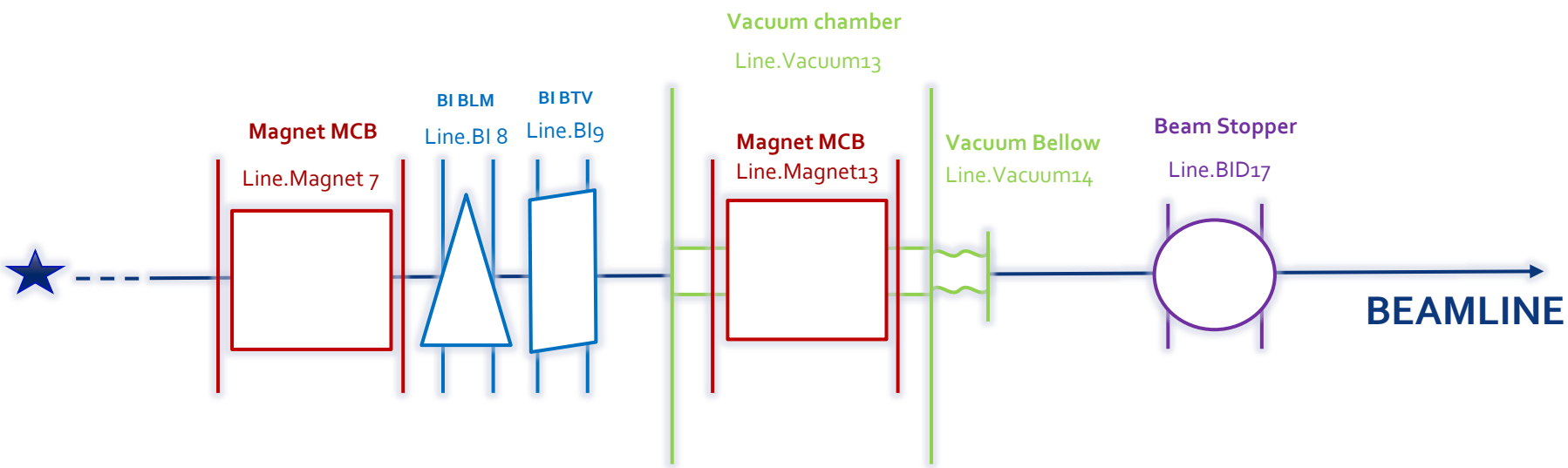
FUNCTIONAL POSITION –Where? Place / Where it is located?

Layout

TYPES

infor EAM

PART



ENGINEERING SPECIFICATION

3D Model (.stp)

2D Drawings

EDMS

ITEM

Accelerators Naming Portal

ASSETS

PRODUCTION - TESTING

ASSETS are the physical instances of a specific ITEM
All ASSETS are linked to the functional positions in Layout Database

ASSET – Who? — Filling / First Name + Family Name

TYPE = ITEMS – What? — Shape and Color / Family Name

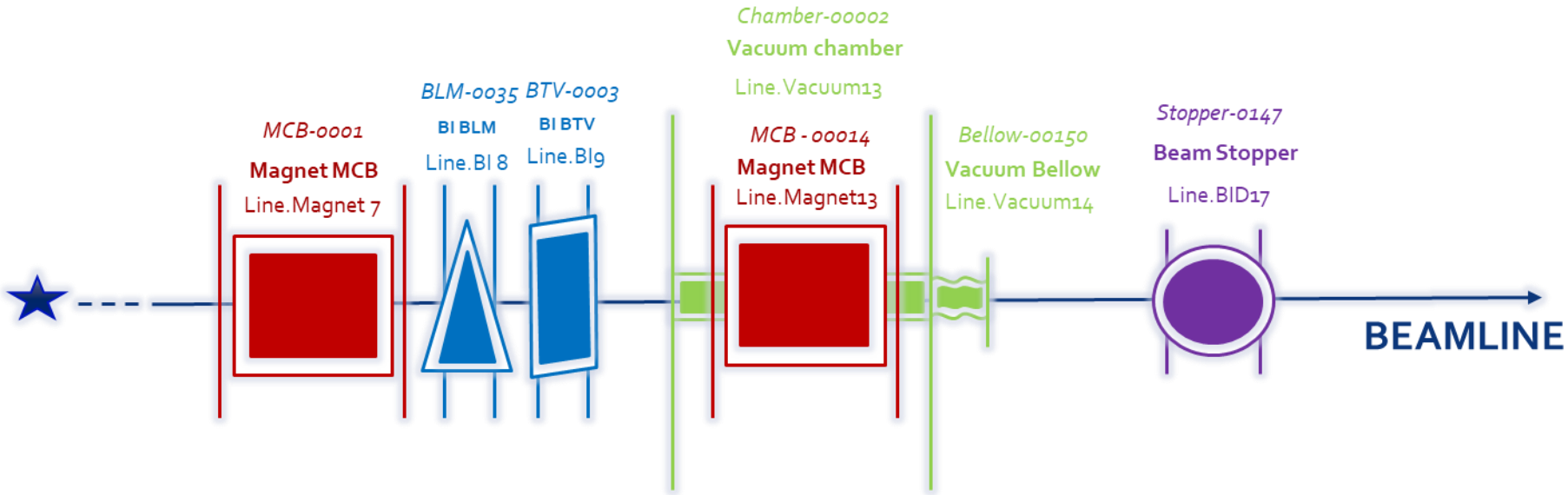
FUNCTIONAL POSITION – Where? — Place / Where it is located?

The assets management tool used is Infor EAM used also for work orders, preventive maintenance, …

infor EAM

EAM Light

ASSET



Make or buy?
Technical Specification

MTF Equipment Management Folder

Manufacturing workflow

Test reports
Material certificates

Installation

INSTALLATION

Layout

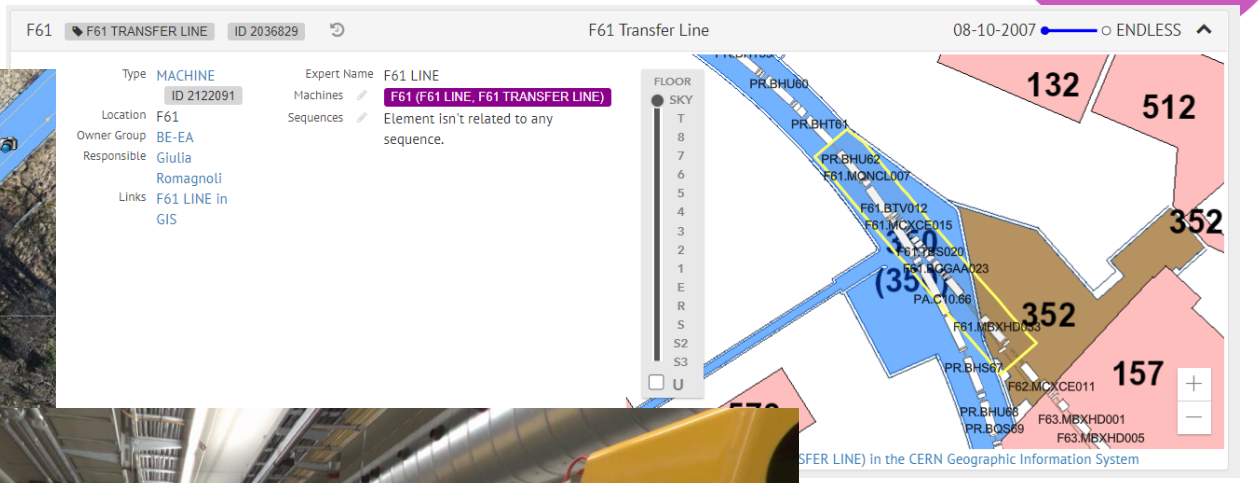
- PS East Hall Complex
  - F61 Transfer Line
    - F61.MQNCL007
      - F61.HMQAD007
    - F61.BLM008
    - F61.BTV012
    - F61.MCXCE013
    - F61.MQNEL014
    - F61.HLMAC014
    - F61.MCXCE015
      - F61.HMCAD015
    - F61.TBS016
    - F61.TBS017
    - F61.TBS018
    - F61.TBS019
    - F61.TBS020
    - F61.MQNEF021
      - F61.HMQAN021
    - F61.BCTF022
      - F61.HBCTF022
    - F61.BCGAA023
    - F61.XSEC0.23

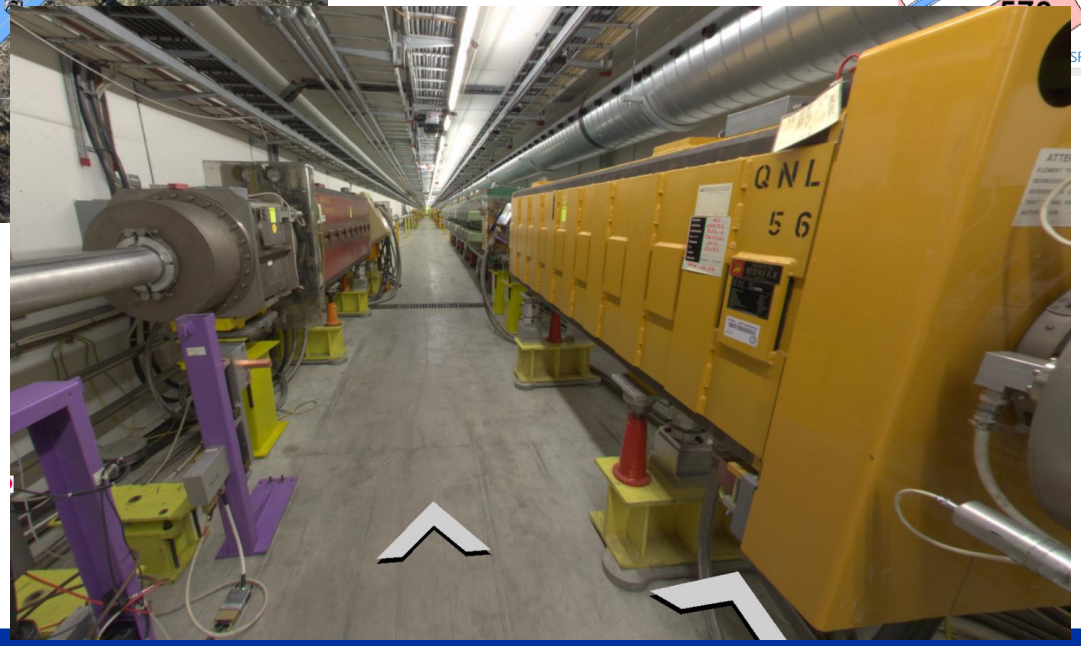
CERN Geographic Information System - GIS Portal - Machine

360 Panorama Project

Panorama contact person: T. Birtwistle, EN-ACE-CL

MAPS and PICTURES





All positions DCUMs are exported to the survey database to allow the alignment and positioning of the elements

GEODE

SURVEY DATA

Beamline Sequence File

From Layout Database is possible to automatically extract (and save in Gitlab) the beamline sequence file containing:

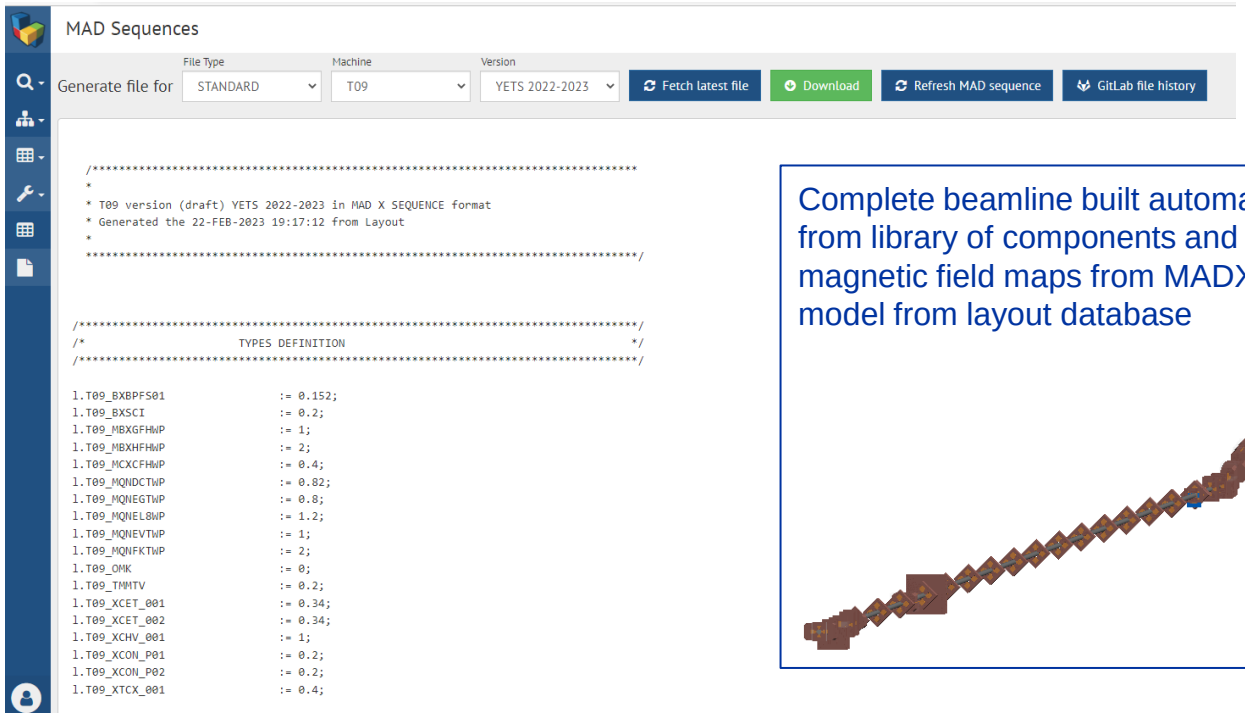
- Functional positions and expert names
- DCUM (cumulative distances) and optical lengths of elements
- Strength/angles variables and values

The sequence file is used as input into MADx software that is used for optics studies.

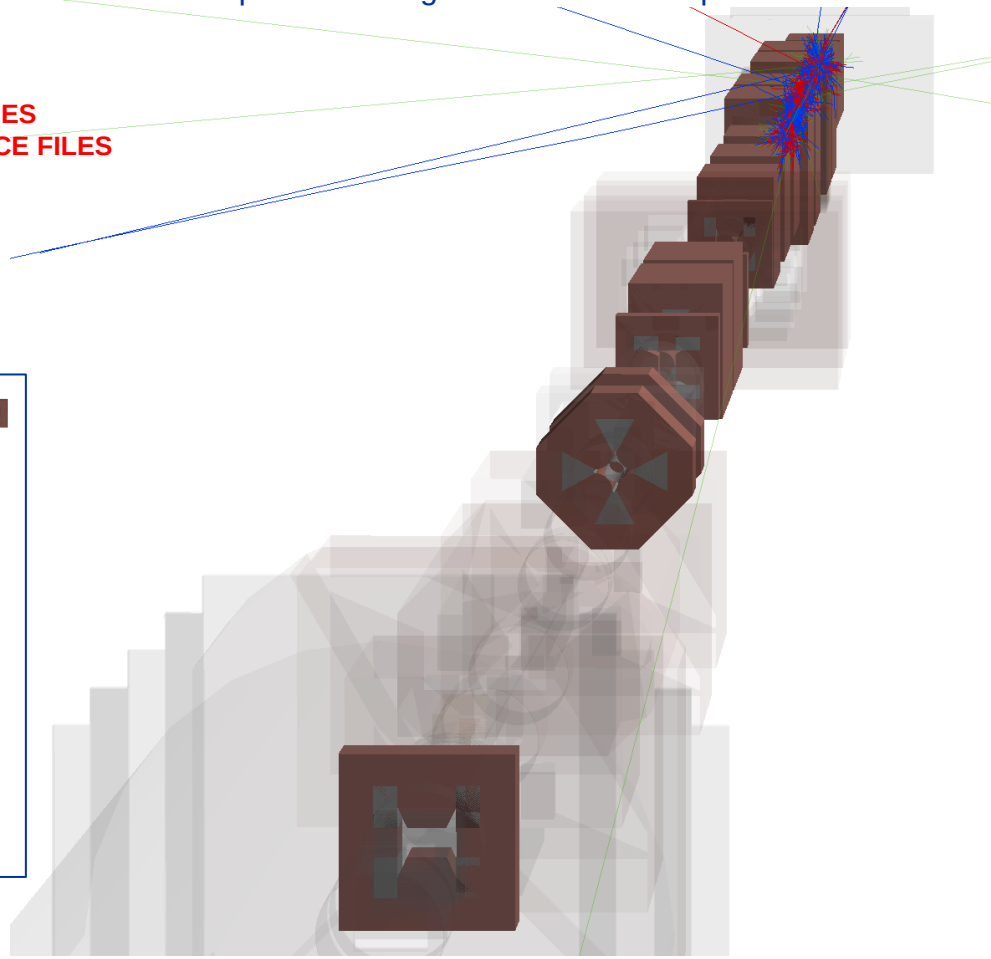
CERN GITLAB

BEAMLINES SEQUENCE FILES

BDSIM / Fluka software is used for beam-matter interactions, radiation protection studies, and to provide background fluxes for experiments



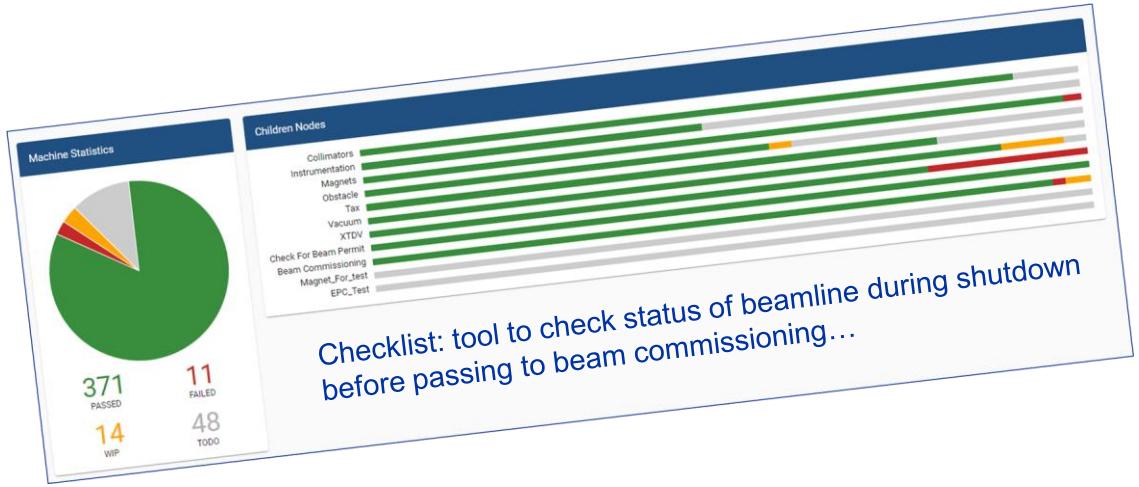
Complete beamline built automatically from library of components and magnetic field maps from MADX model from layout database



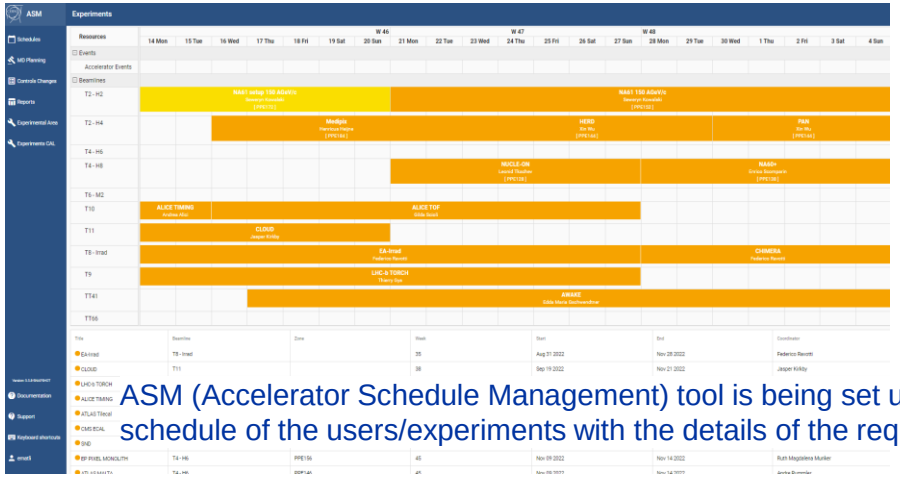
Beamline Operation

OPERATION

AFT (Accelerator Faults Tracking), Checklist and ASM are used to monitor the status of the beamline during operation and shutdowns.

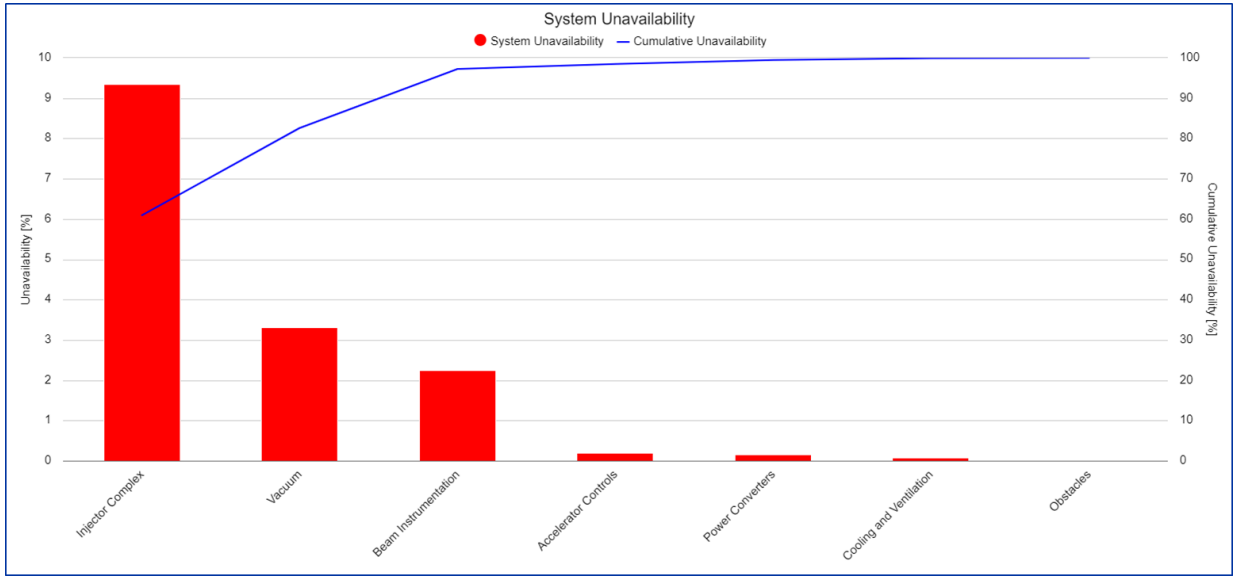


Checklist: tool to check status of beamline during shutdown before passing to beam commissioning…



ASM (Accelerator Schedule Management) tool is being set up to have the schedule of the users/experiments with the details of the requests

Accelerator Fault Tracking

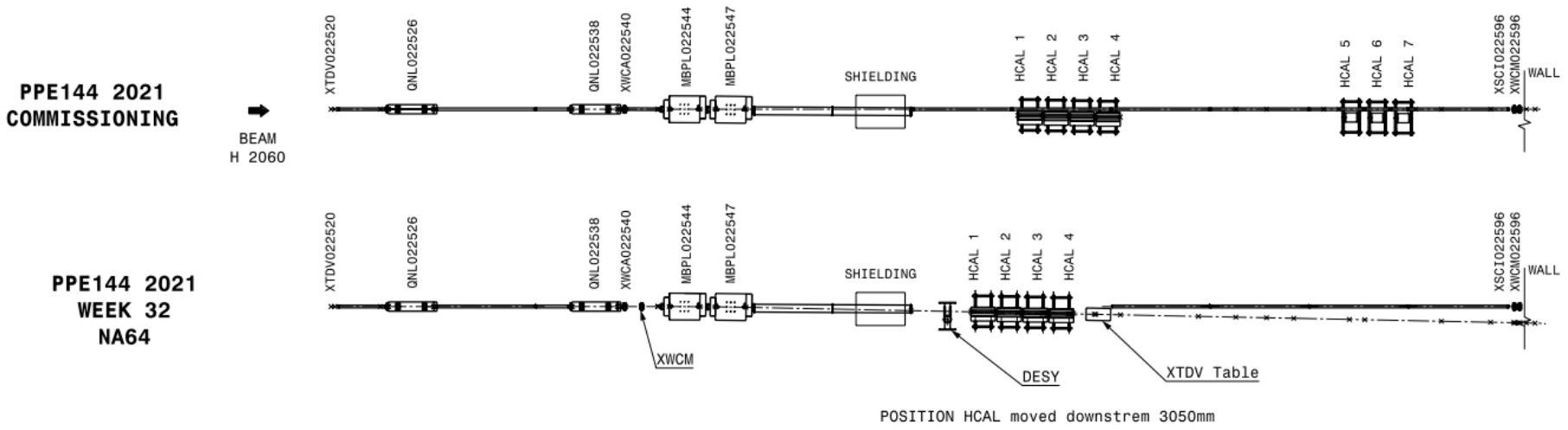


AFT used to declare faults and monitor availability and performance of the machine. The faults are linked to the functional positions in Layout and to the ASSETS

Synoptic – Beamline Configuration

NEED
- Schematic representation different configuration of beamlines
- Long term configurations, weekly changes….

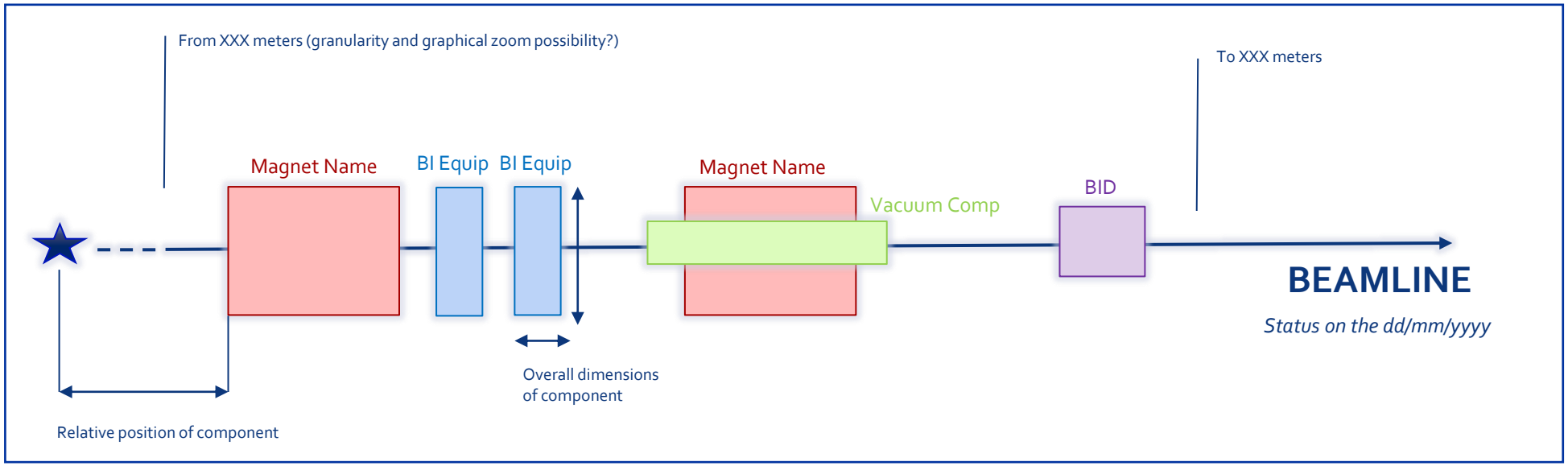
POSSIBLE APPLICATIONS
- User/experiments requests with hystorical trace of configuration
- Vacuum layout with “live” pump and valve status
- CESAR status of beamlines elements
- Coordination meetings: layout drawings or 3D models
- Documents: schematic missing often reducing clarity of the document



Beamline Synoptic (Under Development)

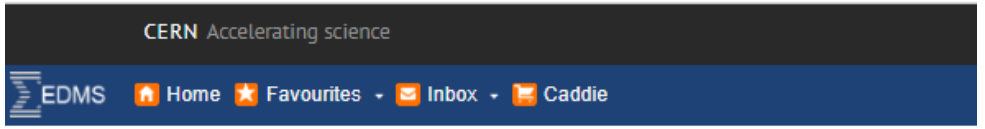
Future development: since experimental beamlines areas are continuously evolving, to facilitate beamlines coordination and changes of physical configurations, a data-driven time-dependent schematics is under study to provide a intuitive overview of the beamline automatically linked to Layout Database structure.

Configuration XX at time XX:



Work in progress of BE-CSS, BE-EA group
In collaboration with EN-ACE

Document Quality Management



At CERN documents are stored and organized inside:

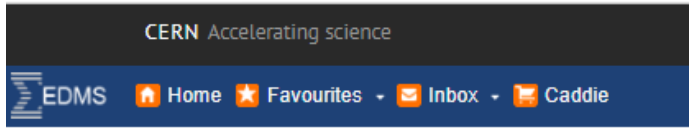
EDMS CERN's Engineering Data Management Service

→ The important documents are circulated and approved trough official EDMS process by **DOCUMENTS MANAGERS** in the framework of the configuration management strategy

Procedures ad quality processes are listed inside the Quality website at CERN

TEMPLATES are available inside the Quality CERN website: Templates (cern.ch)

Document Quality Management



Document managers of BE-EA are helping authors to correctly treat/circulate/store their documents

NEED FOR A CHANGE

Author wanting to create/save/register a document in EDMS

HB Documents, ECRs, Specifications

BE-EA Documents Managers

Official circulation of document with EDMS processes

EATM
APPROVAL

IEFC
APPROVAL
Document involves discussions on:
Budget, Resources, Operation constraints
Conflicting experiment requirements

EATM
For information

IEFC
Informed
Document approved with minor implications

Other "official approval process" documents

BE-EA Documents Managers

Official circulation of document with EDMS processes

DOC-Owner Documents

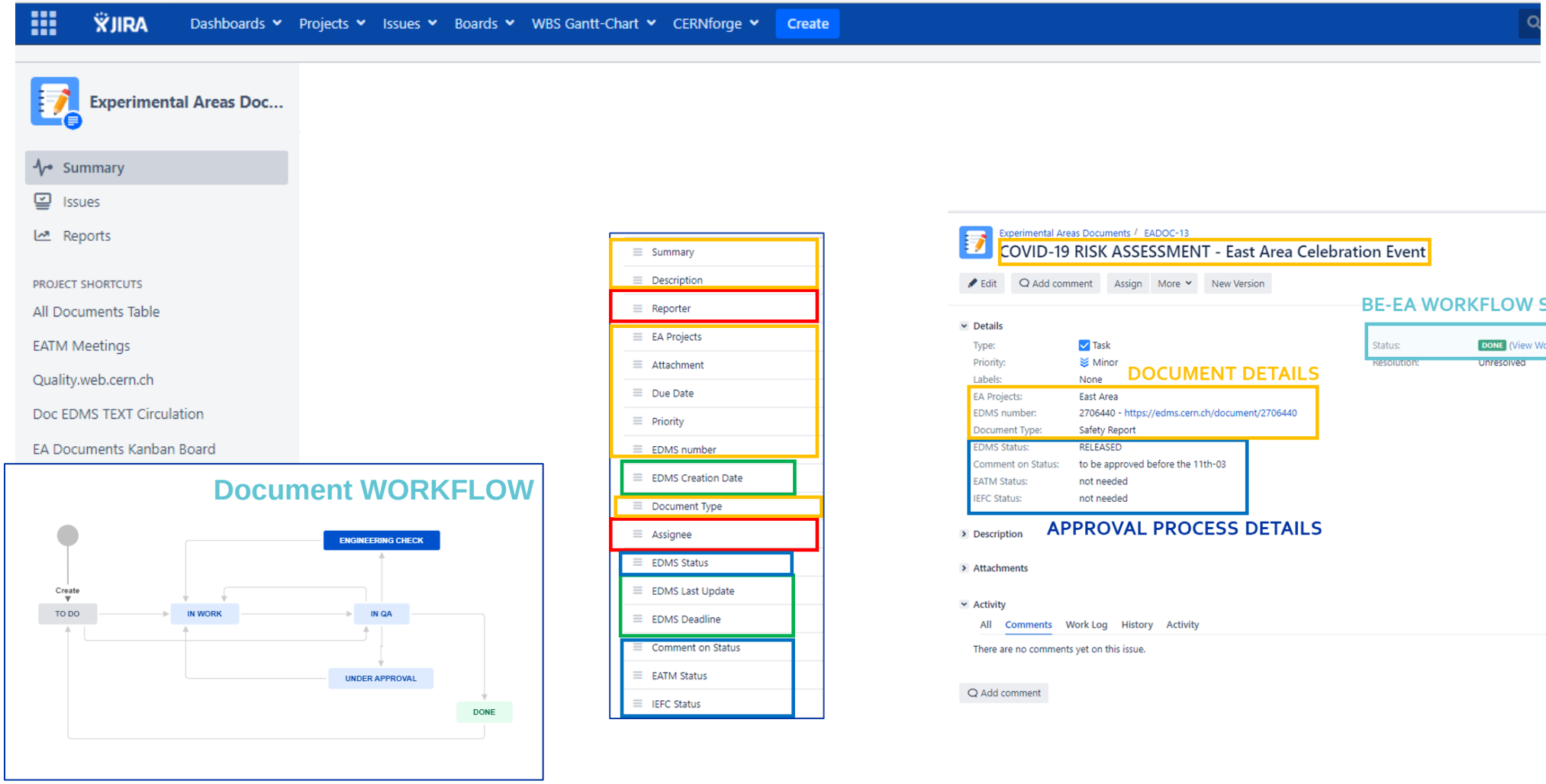
Registration of document on EDMS by document authors
Possible help of Document Managers to know where to save and how to register the document…

EATM (Experimental Areas Technical Meeting)

LHC Injector and Experimental Facilities Committee (IEFC)

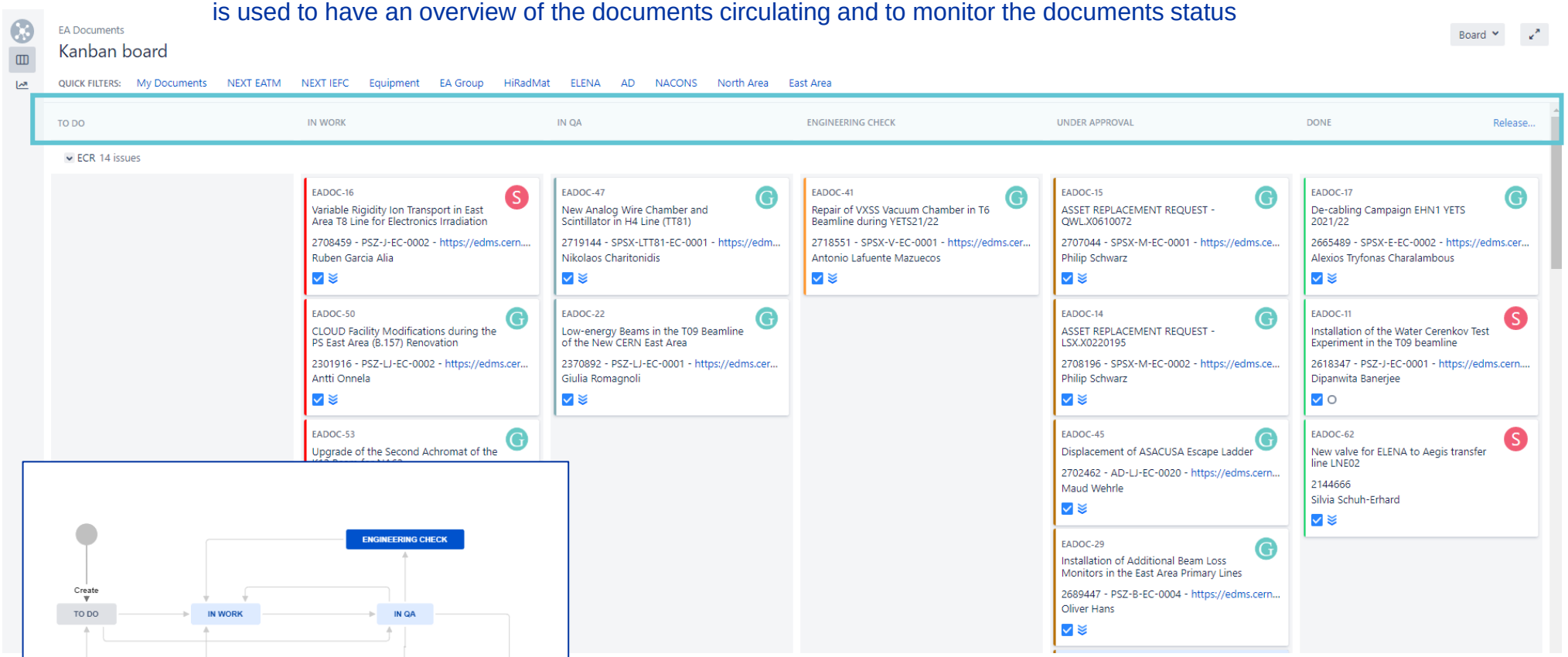
Document Approval Process Management

JIRA project considering each EDMS document as a JIRA ISSUE to be treated by the Document Managers



Document Approval Process Management

All documents treated by the document managers are stored inside a JIRA project, where a Kanban board is used to have an overview of the documents circulating and to monitor the documents status



DOCUMENTS WORKFLOW

See DEMO tomorrow morning at 9.00!!

JIRA PROJECT for EA Document Circulation

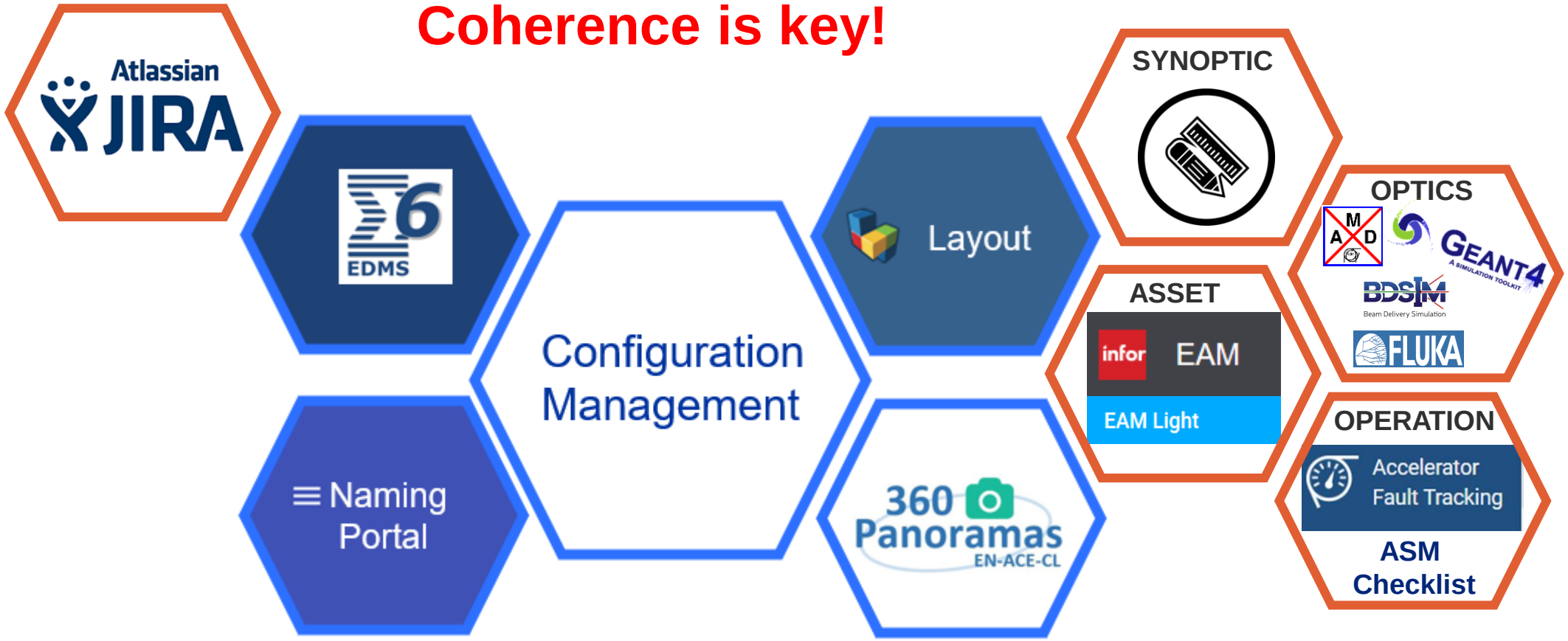
Experimental Areas Documents - CERN Central Jira

Conclusion

Coherence is key!

Thank-you for your attention

Conclusion



Thank-you for your attention

Acknowledgements

Special thanks to:

S. Petit - ATS Quality Service

P. Le Roux - BE-CSS

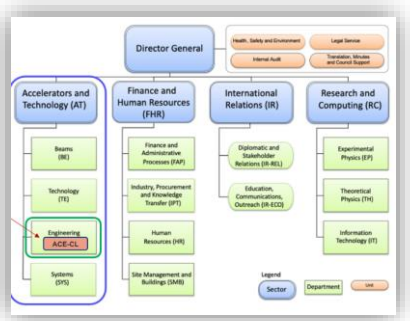
C. Scoero, A. Ortiz - EN-IM

T. Birtwistle, A. L. Perrot, S. Bartolomé Jiménez, B. Feral, S. Chemli - EN-ACE

C. Vendeuvre - BE-GM

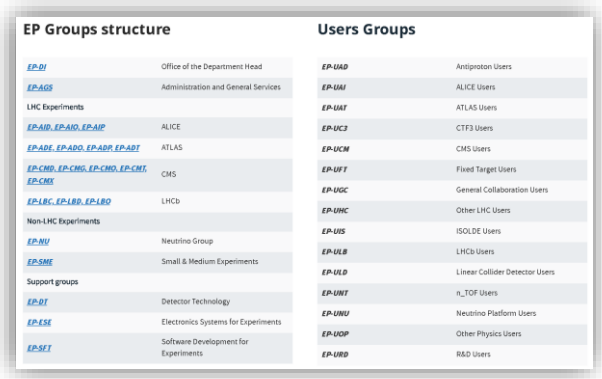
D. Banerjee, N. Mandal, J. Buesa, S. Schuh - BE-EA

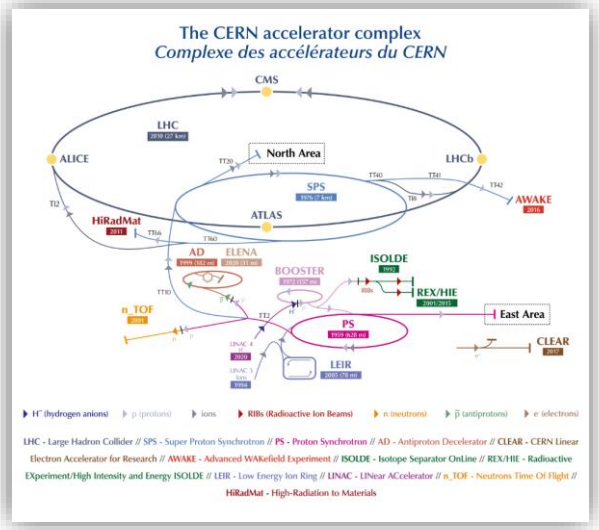
CMS Experiment Configuration Management
Organizational Structure



Experimental Physics (EP) **Department**

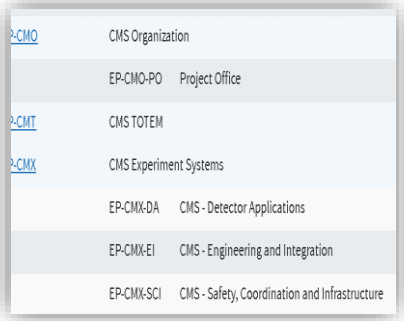
- 800 **Members** of **personnel**
- 12000 **Users** from their **Home Institutes**
- 4 LHC **Experiments** (ALICE, ATLAS, CMS, LHCb)
- 3 **Support** Groups
  - **Detector Technology**
  - **Electronics Systems** for Experiments
  - **Software Development** for Experiments

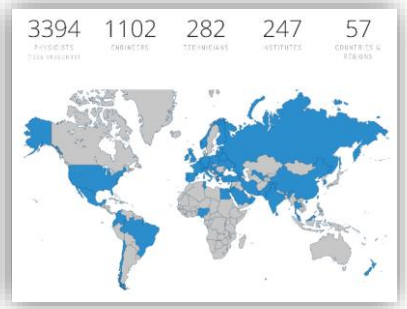




CMS Experiment **Groups**

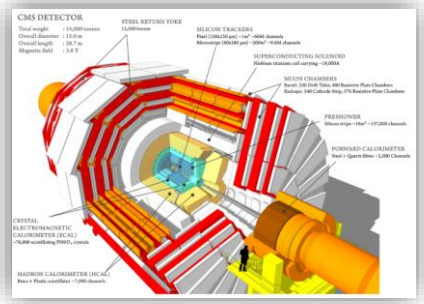
- **DAQ** & **Trigger**
- **Physics**, **Software** & **Computing**
- **Organization**
- **TOTEM**
- Experiment **Systems**
  - **Safety**, **Coordination** and **Infrastructure**
  - **Engineering** & **Integration**
  - **Detector Applications**





CMS Experiment Configuration Management
Project Management

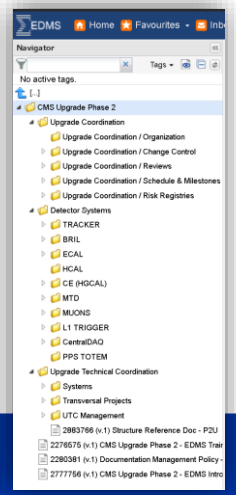
Detector Systems

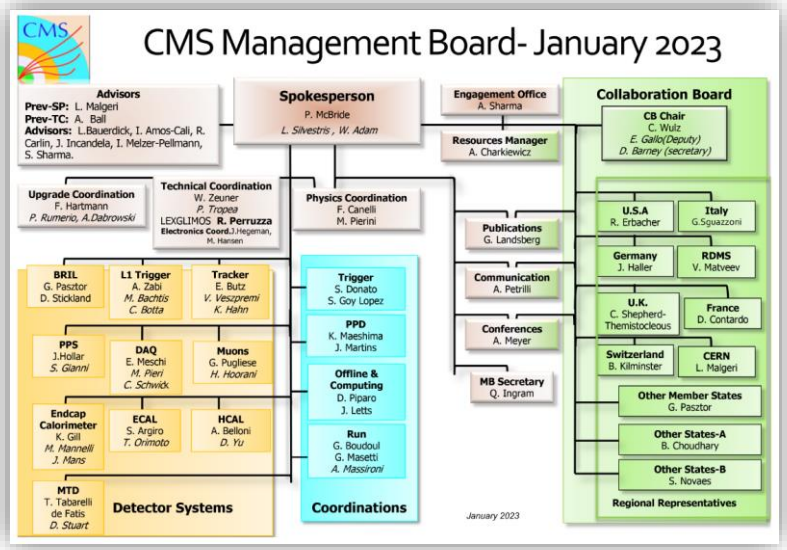


Future Configurations
- ➢ *Study & **Design***
- ➢ ***Build** & Commission*

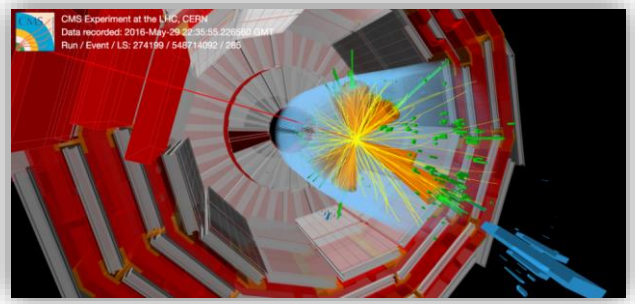
Present Configuration
- ➢ ***Operate***
- ➢ ***Maintain***

Past Configuration
- ➢ ***Recycle / Dispose***



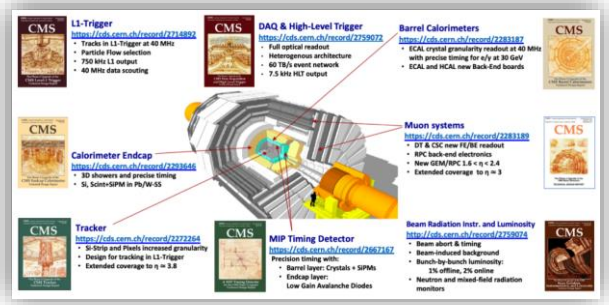


Offline & Computing Coordination



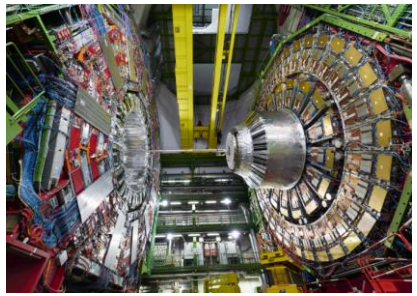
Past, **Present** & **Future** Configurations
- ➢ ***Simulation** (Digital Twin)*

Upgrade Coordination



Future Configurations
- ➢ *Study & **Design***
- ➢ ***Build** & Commission*

Technical Coordination



Future Configurations
- ➢ *Study & **Design***
- ➢ ***Build** & Commission*

Present Configuration
- ➢ ***Maintain***

Run Coordination

Present Configuration
- ➢ ***Operate** (DAQ System)*

CMS Experiment Configuration Management

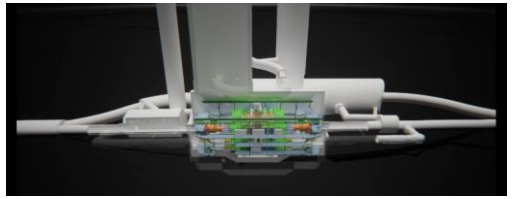
Product Management

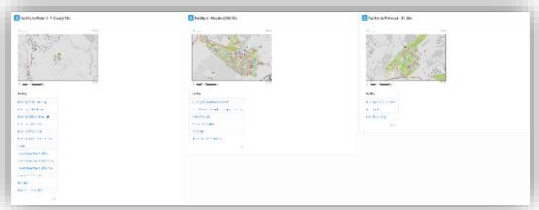
Product Representations
(Digital Twins)

Virtual (Past/Present/Future) **Product**

Physical (Present) **Product**

Surface Sites & **Underground** Tunnel / Caverns

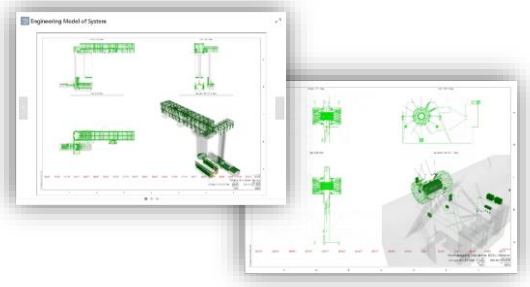


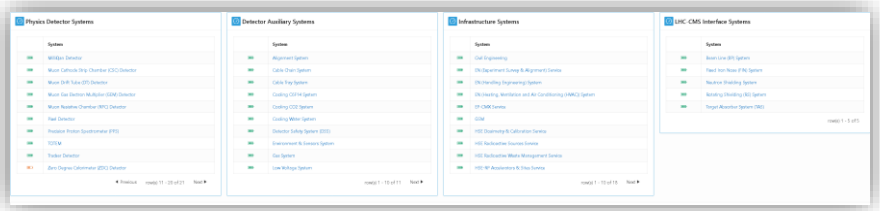


Facility Level Products

Geographic Naming

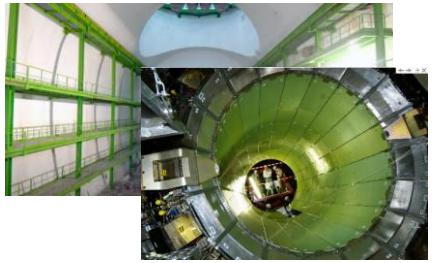
Physics **Detectors**, Detector **Auxiliary Systems**, **Infrastructure** & Machine-Experiment **Interfaces**





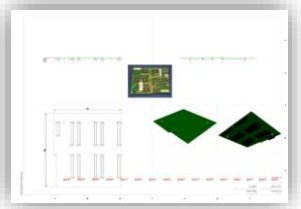
System Level Products

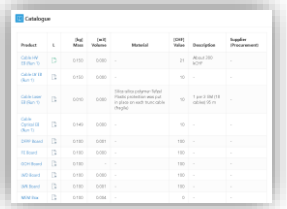
Functional Naming



Equipment Level Products

Cables, **Electronics**, **Equipment** & **Tools**





Catalogue of Product Items

Functional Naming

Inventory of Product Assets

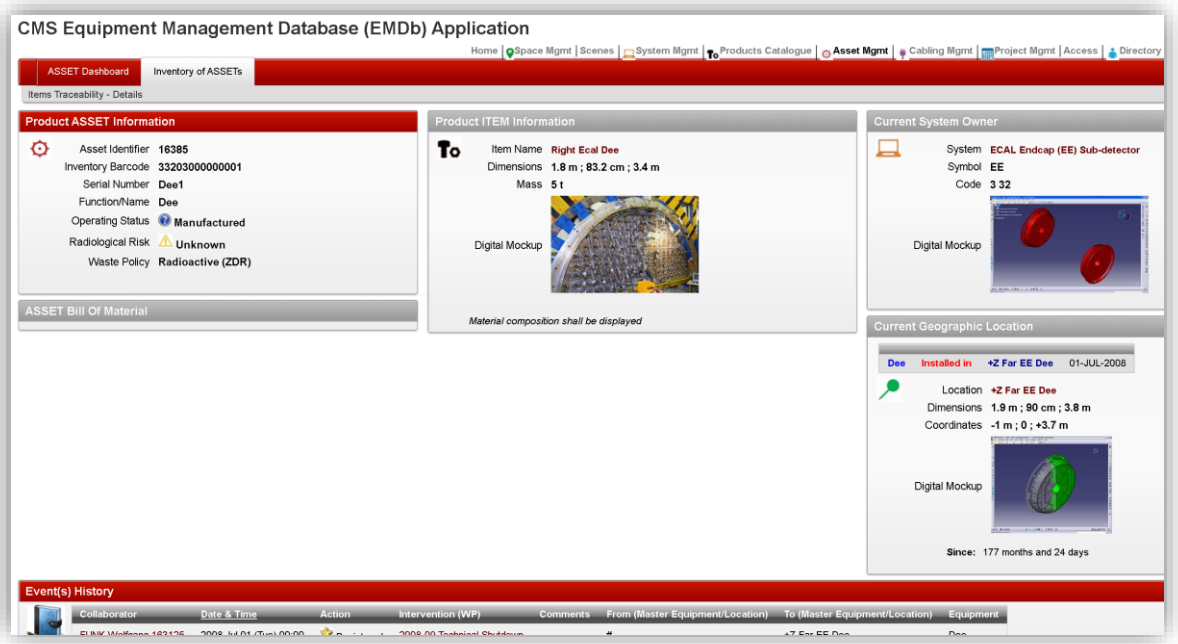
Serialized Naming

Asset Management

Asset
Data & History

Item
Specifications

Functional Position
Data

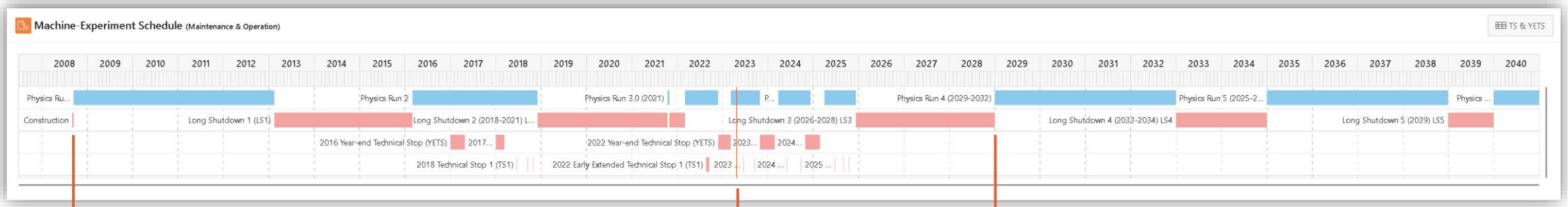


CMS Experiment Configuration Management

Product Lifecycle Management

CMS Experiment **Program/Project Schedule**

- **Product Operation** (Physics Run) & **Maintenance** (Technical Stop) **Lifecycle Timeline**

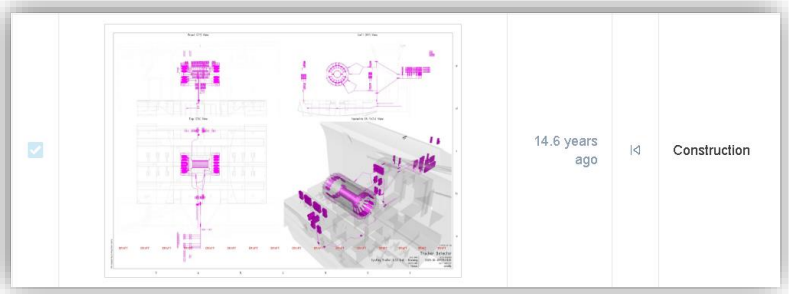


Present Validity

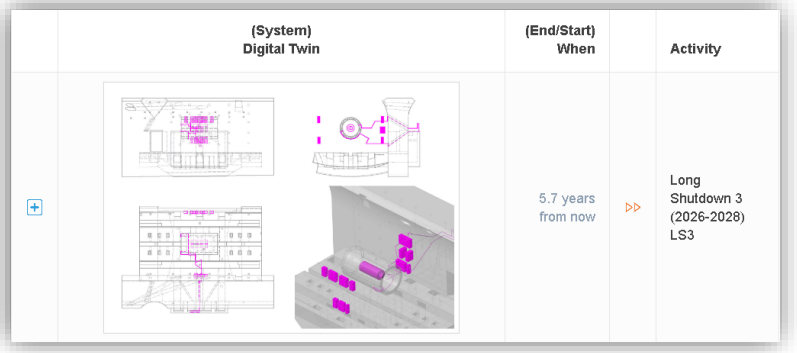
- **System of Systems**

System (Tracker Detector) **Validity** & **Versioning**

Past configuration



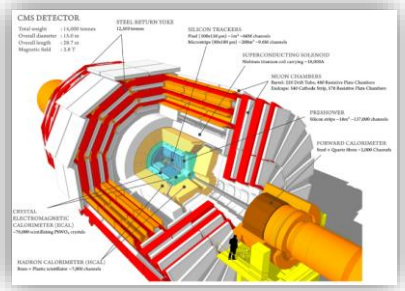
Future configuration



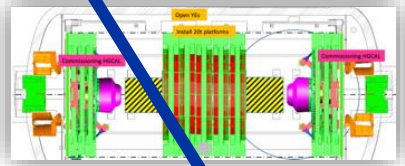
CMS Experiment Configuration Management

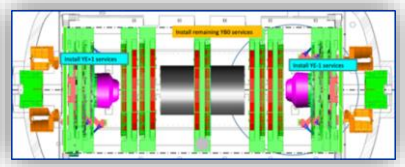
Long Shutdown 3 (2025-2028) Maintenance Project

Initial LS3 Configuration



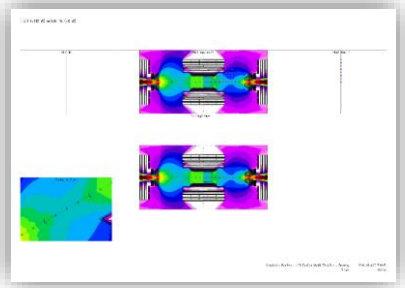
Intermediate LS3 Configurations





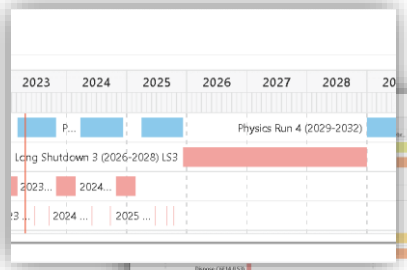
Final LS3 Configuration

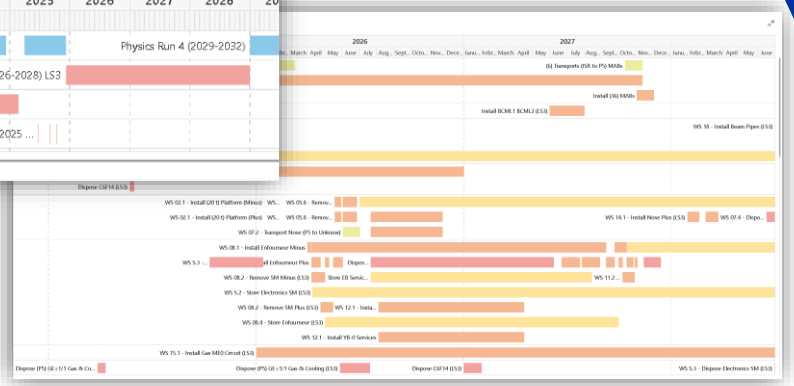
Facility/Activity Safety Map



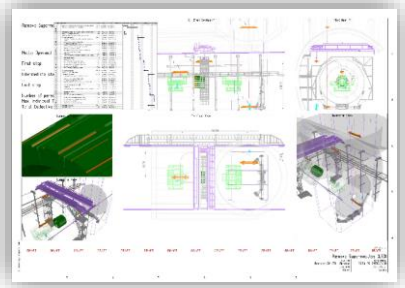
LS3 Maintenance Schedule

by Systems, by Activity Types





Maintenance Activity Procedure

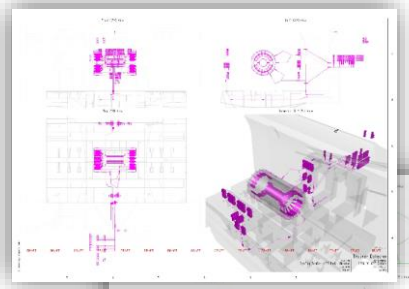


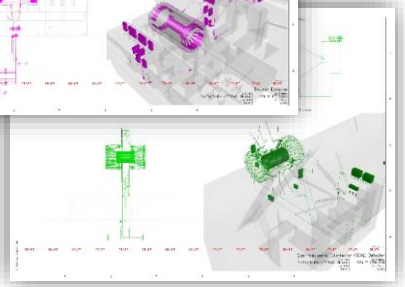
Bill Of Materials

Bill of materials

RP	Quantity	Product	L	Description	[kg] Mass	[m3] Volume
	18	Water		2 [l] per SM	36	0.036
	18	Super Module EB		-	54'000	19.440
	36				54'036	19.476

Systems' Configurations





CMS Experiment Configuration Management
Information Systems Architecture

CERN
INDICO, EDMS Tool

Upgrade, Technical, Safety meetings
CMS **Projects**

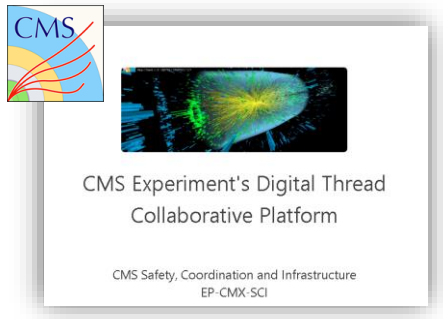
Safety, Quality, Project Management, Product Engineering and IT
CMS **Roles** & **Persons**

CERN
HR

CERN
IMPACT Tool

Design, Manufacturing, Operation, Maintenance, Transport, Storage, Disposal
CMS **Activities**

Radiation Protection
CMS **Safety**



Surface and Underground
CMS **Facilities**

CERN
GIS Portal

CERN Geographic Information System - GIS Portal - Machine

CERN
QA Policy

Naming Conventions
CMS **Standards**

Physics Detectors, Detector Auxiliary, Infrastructure, Machine-Experiment Interface
CMS **Systems**

Cables, Electronics, Equipment, Tools
CMS **Inventory**

Cable Types, Equipment Types
CMS **Catalogue**

CERN
InforEAM, TREC Tools

CERN
EDMS, SmarTeam Tools

infor EAM

EDMS

Conclusion

Coherence is key!

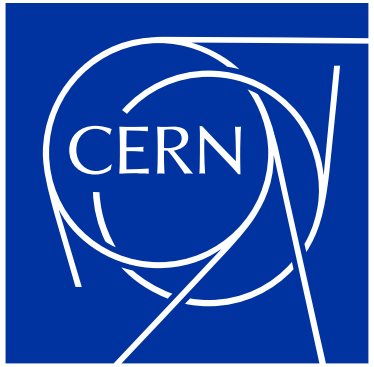
Thank-you for your attention

Acknowledgements

Special thanks to:

CMS - Safety, Coordination and Infrastructure Section members - EP-CMX-SCI

CMS - Engineering and Integration Office members - EP-CMX-EI



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