

Accelerator Data Foundation: How It All Fits Together

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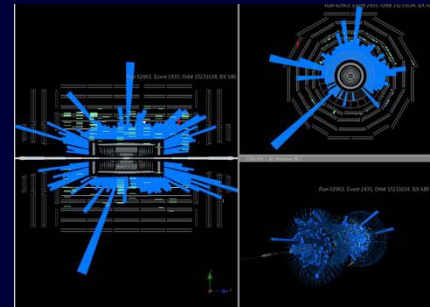
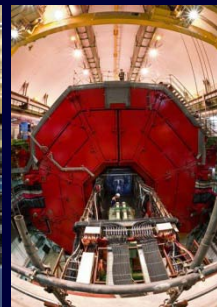


CERN, Beams Department
Controls Group
Data Management Section

The 12th International Conference on Accelerators and
Large Experimental Physics Controls Systems
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Kobe International Conference Center
Kobe, Japan

Outline

- ✧ Introduction
- ✧ A Vision, a Strategy and some Tactics
- ✧ Accelerator Data Management Domains
- ✧ Data Federation
- ✧ Covering the CERN Accelerator Complex
- ✧ Human Resources
- ✧ Conclusions



Introduction

Two major events can be considered as turning points in data management in CERN's Accelerator Sector:

① Purchase of a commercial RDBMS in 1983



- ⇒ Aimed to address **complex technical** aspects of LEP
 - Project planning, cabling, documents, magnet data,...
- ⇒ Since then, many successful **database driven** systems were implemented, but in a dispersed way
 - PS Controls, LEP Alarms,...

② Reunification of “Accelerators & Beams” activities in 2003

- ⇒ Single groups for *Operation*, *Controls* and *Equipment* for the complete CERN accelerator complex
- ⇒ Unification of *accelerator data management* was proposed...and accepted by the hierarchy

The Vision

★ Data Management Team in the Controls Group

- ⇒ Dedicated team of 8-10 database software engineers
- ⇒ Senior members having also accelerator domain knowledge
- ⇒ Junior members proficiently up-to-date in database development
- ⇒ Ambitious technical and human objectives for the team

★ Need for a clear vision

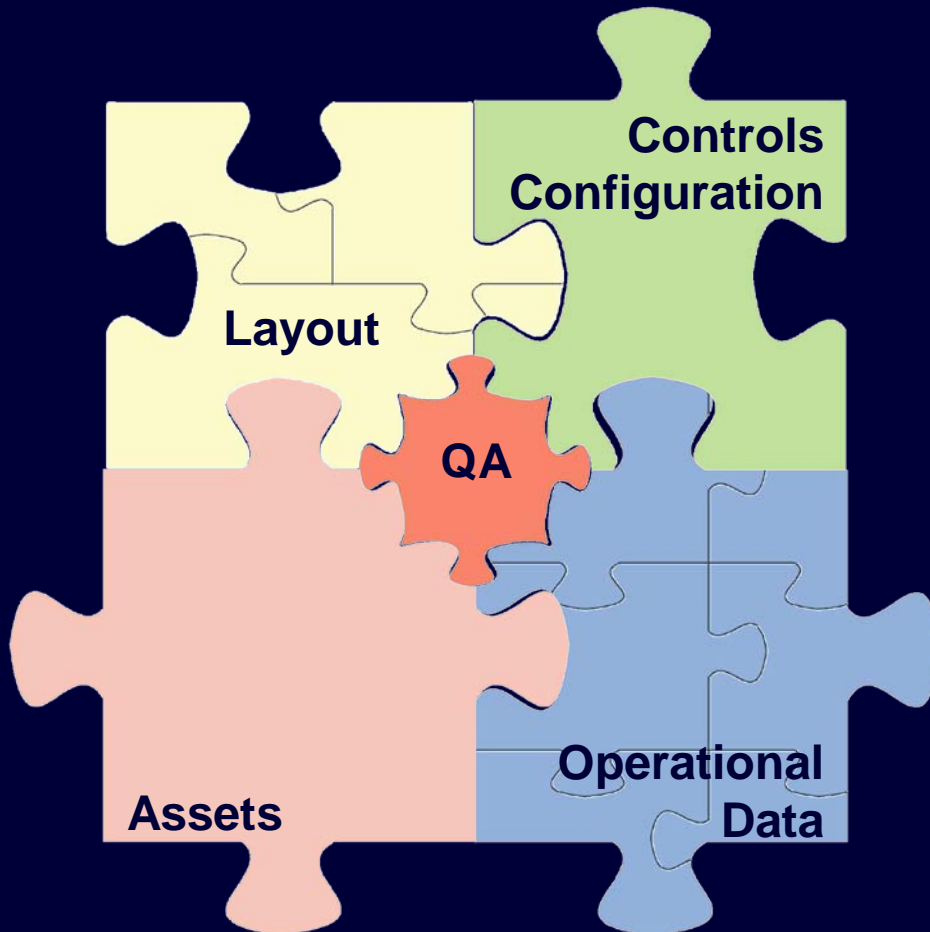
- ⇒ Highest importance attributed to LHC
 - huge complexity, but starting from a relatively clean sheet
- ⇒ Rationalize, improve and federate the existing data on the older accelerators
- ⇒ Break up the vast domain into manageable areas
 - Typically a senior and junior team member in each area

★ Communicate, communicate, communicate



The Puzzle

Breaking up the data domain into several pieces



★ Advantages

- ⇒ Logical break-down
- ⇒ Organized
- ⇒ Manageable

★ Inconveniences

- ⇒ Integration not considered at the outset

★ Therefore

- ⇒ Emphasize common **understanding** and good **communication** between developers
- ⇒ Federation work began in 2007

Strategy

★ Development work

- ⇒ Major effort: requirements gathering, analysis and development work
- ⇒ Legacy DB showed lack of *Quality Assurance* at DB and data levels
 - ⇒ Introduced integrity constraints and naming conventions

★ Technology

- ⇒ Use of Oracle technology stack (huge in-house expertise)
- ⇒ Use of Java, J2EE, JDBC deployed in 3-tier architecture
- ⇒ On-line usage of database services for accelerator control

★ Responsibilities

- ⇒ Acceptance of competence shift with clear limits of responsibilities
 - 1 DM team developers
 - 2 Application developers
 - 3 Data owners
 - 4 DB infrastructure service

Some Tactics

★ The important aspects to make the strategy successful

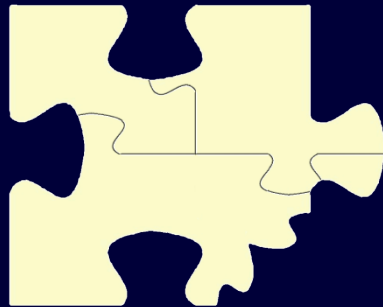
- ⇒ **Involve end-users** right from the start, throughout the design and development process
- ⇒ **Communicate** constantly on scheduled interventions and their anticipated impact
- ⇒ **Iterate rapidly** based on end-user feedback
- ⇒ Provide adequate **environments** for development, unit testing, system testing and production
- ⇒ Push **data ownership** to the experts, assist and guide the usage of the data maintenance interfaces



Layout Data



Icalepcs'07
RPPA03



① Machine Layout

- ⇒ Accelerator design, magnetic model, beam optics by machine physicists
- ⇒ Mechanical installation & integration work; establishing the as-built model

② Controls Electronics Layout

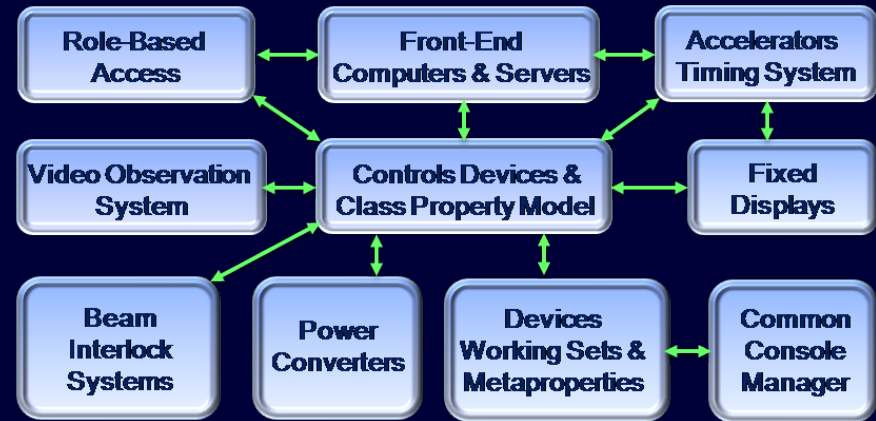
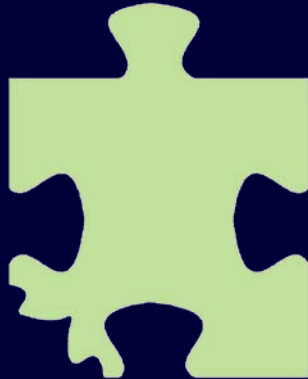
- ⇒ Racks, crates, modules, fieldbus connections
- ⇒ 9,000+ racks for LHC
- ⇒ Essential during installation
- ⇒ Starting point for automatic *configuration* of front-end computers

③ Electrical Circuits Layout

- ⇒ Description of electrical objects in powering circuits
- ⇒ Relationship between power converters, current leads, bus bars, magnets,...
- ⇒ Exploited in *operational data* domain



Controls Configuration



TUA004

★ Control system topology

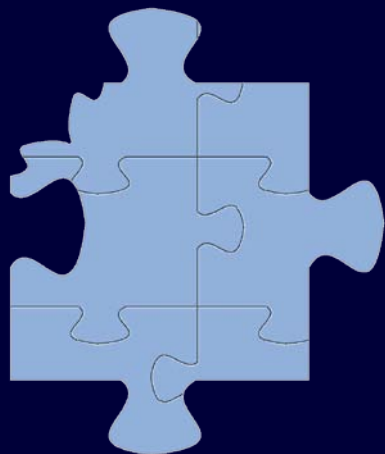
- ⇒ From front-end computers to control room consoles
- ⇒ 65,000+ controls devices
- ⇒ 5 device-property models
- ⇒ Rejuvenated legacy DB

★ Interactive interfaces and APIs

- ⇒ 200+ re-developed Oracle ADF interfaces (Java-based forms)
- ⇒ 150+ Oracle APEX reports
- ⇒ Java APIs for control room apps
- ⇒ Pro*C APIs are being replaced

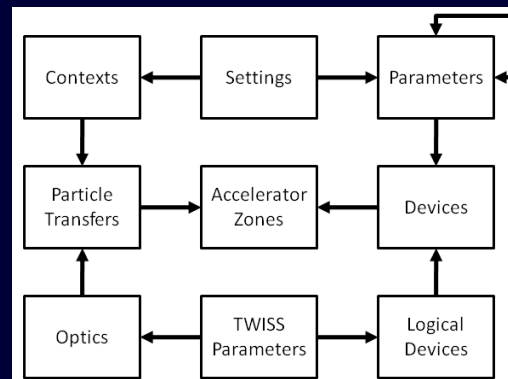
THP108

Operational Data



① Settings

⇒ Parameter space for LSA



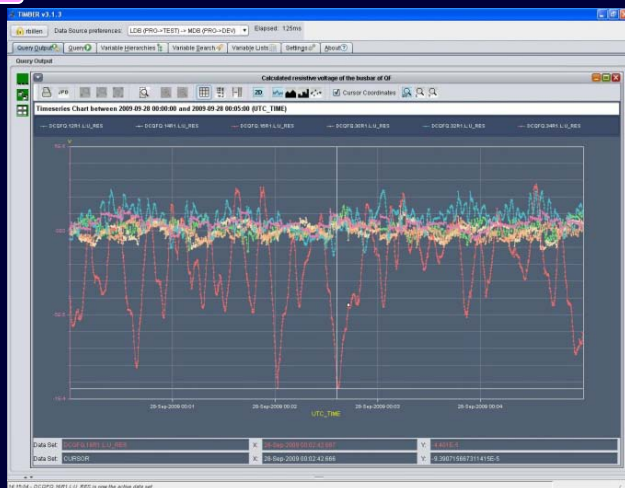
WEP006

② Measurements & Logging

⇒ Store time-series data, keep on-line

⇒ Beam and equipment measurements

WEP005

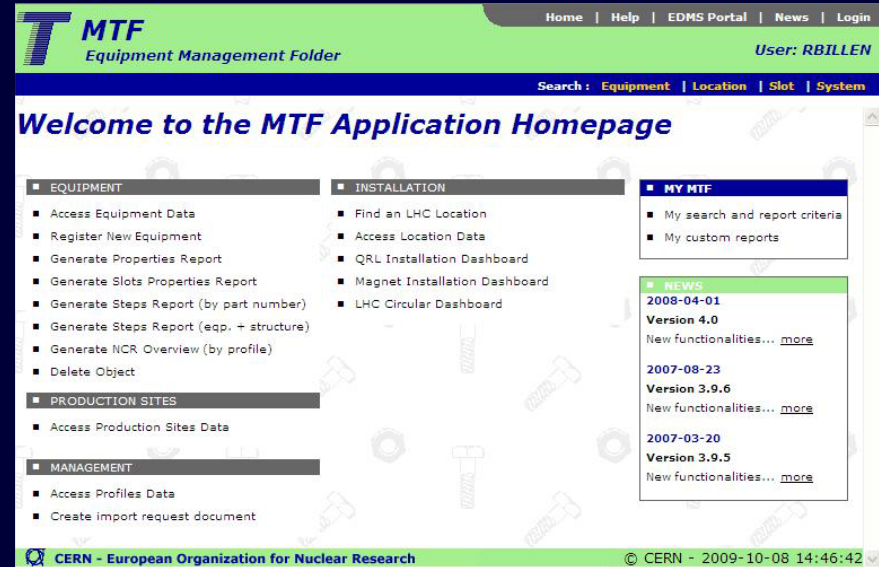


Time	Source	Message	Severity	Category	Details
28/09	14:42:28	1	CMW ALARM ...	SPS SPMT-BAS	Alarm state not known
31/09	22:29:18	1	CMW ALARM ...	SMA-B87-CERF01	Alarm state not known
31/09	22:29:18	1	CMW ALARM ...	SMA-B87-CERF02	Alarm state not known
30/09	15:10:51	1	COMPUTER	RESCE	Missing or misbehaving process : At least [hw.p...
02/10	07:30:28	1	COMPUTER	CFV-BAS-SLMHC	Disk space or disk usage problem : Pb with [space...
N	12:09:27	1	COMPUTER	CS-COR-TXT	Contact lost
N	12:09:28	1	COMPUTER	RAD3A3	Contact lost
01/09	17:22:22	2	RF-SPS-REAMC...	RECAPT-FREQ	Measurement time-out
16/09	11:32:56	2	TDX CFV-BAS-CTSNF5		Bus Error
16/09	11:32:56	2	TDX CFV-BAS-CTSNF6		Bus Error
21/09	14:20:13	2	BOSTIP	BOSTIP-SVE-4372	Alarm raised when the motor is moved in.
25/09	08:58:28	2	TDX CFV-BAS-CTSNF3		Bus Error
25/09	13:29:00	2	SPS5PTAmiW...	M5 LS56-SEPTA	Actual unequal demanded
26/09	14:40:52	2	FAU-DEM-SPS	FDXB-0003-REDBES	DEFAULT GENERAL CIRCUIT ADDRESS/SPS
29/09	17:12:53	2	BetsCrisSps	MKE MCA4.MKCS.LINC	Remote/Controls device: RDA error occurred.
29/09	17:12:53	2	BetsCrisSps	MKE MCA4.MKCS.CNCS	Remote/Controls device: RDA error occurred.
01/10	18:28:54	2	SPS SIS	JAPC	PARAMETER SUBSCRIPTION CAUSED EXCEPTION
01/10	17:11:39	3	SPS SIS	TT20	SIS PERMIT test masked
01/10	17:11:39	3	SPS SIS	SPS	SIS PERMIT test masked
01/10	17:11:39	3	SPS SIS	SPS	Default
02/10	10:19:35	3	SPS SIS	SPS	DIC Channel masked

③ Alarms - LASER

⇒ Capture, store, notify anomalies

Assets Data



★ Physical components

- ⇒ CERN-centralized **asset management**
- ⇒ CERN-wide **part identifier**
- ⇒ Commercial system enriched with home-made interfaces
- ⇒ Keep track of complete **lifecycle** of the asset

TUB004

Quality Assurance



★ Fitting the pieces of the puzzle

⇒ QA starting point: identification of objects

⇒ Equipment code catalogues as official references

⇒ Supporting QA tools

⇒ Including a Naming database

★ Basis for Data Federation

⇒ Imposed naming conventions

⇒ Clear procedures, standards and instructions to be followed by all

CERN
CH-1211 Geneva 23
Switzerland



the
**Large
Hadron
Collider**
project

LHC Project Document No.
LHC-PM-QA-001.00 rev 1.0

CERN Div./Group or Supplier/Contractor Document No.

EDMS Document No.
107132

Date: 1999-09-09

LHC Quality Assurance Plan

Foreword

The LHC Project represents an unprecedented challenge for CERN in several respects: the purpose of it is to build a world-class hadron collider making use of the most advanced techniques in several fields such as superconducting magnets, cryogenics, vacuum, powering, etc. The LHC is intrinsically complex as the different systems that make it interact with each other and require careful definitions of their mutual interfaces. Also and contrary to the former accelerators built at CERN, maintenance and machine consolidation after running in will almost be impossible in the long continuous cold parts of the LHC.

In addition to technical constraints, some systems and components will be entirely under the responsibility of external Institutes and Collaborations and will be supplied ready for installation. Finally, the construction phase extends over a rather long period, in a context of constant annual budget and of declining human resources.

One way for taking up this challenge is to implement a Total Quality Management System, based on defect prevention and continuous process improvement. To this end, I have asked Paul Faugeras, Head of Technical Coordination and Planning in the LHC Project Team, to act as my deputy for Quality Assurance and to prepare a Quality Assurance Plan in collaboration with all interested parties. A QAP Working Group, chaired by M. Mottier was then set up with members coming from project management and hardware groups.

I am glad to introduce the resulting Quality Assurance Plan, which defines the overall structure for quality activities and responsibilities for LHC and contains all related procedures and standards. The QAP has been made available on the Web for some time, procedures and standards being added when they were introduced. However, it has been found essential to distribute a paper copy of the QAP to each project engineer not only for easy reference, but mainly to make project engineers realise that the QAP is now put into force.

It is part of the professional duties of each project person to ensure that material, components and assemblies of their systems are fully compliant with all applicable requirements of the QAP and that the procedures described herein are implemented in an effective manner. The management is ultimately responsible for Quality, by ensuring that each project individual is made responsible for the quality of the work he is performing, from the design stage to the final installation through the whole construction process.

Quality is essential to make the LHC a great success.

Lyndon Evans
Director,
LHC Project Leader

Data Federation

★ The perfect solution for data integration...

⇒ Unique identifier (i.e. primary key) for each object throughout all data domains

★ ...was not put in place, so...

⇒ How do we solve this problem?

★ Exchange of keys between the domains

⇒ Object Identifiers are truly **unchangeable** primary keys

- Not the object name! It may change over time

⇒ Several implementations on a case-by-case basis

- Database views, materialized views
- Use of 'grant select' or database links
- PL/SQL code for more complex data propagation
- Execution on manual, semi-automatic or automatic basis

★ Best illustrated by example



Assets Installed in Layout Slots

LAYOUT DATABASE

Advanced Search : Functional Positions | Interfaces | Systems | Electrical | Classifications | Utilities

Version: STUDY

LHC MACHINE BY SECTOR (STUDY)

- S12
 - LSSR1
 - DSR1
 - ARC12
 - ARCR1
 - 12R1
 - LBARA.12R1**
 - QOB1.11R1
 - MCD0.A12R1.B1
 - MCD0.A12R1.B2
 - QBAA.A12R1
 - GIWCA.A12R1
 - GIMBA.A12R1
 - GIMSA.A12R1
 - GIMVA.A12R1
 - HQB.A12R1.E
 - GIMBB.A12R1
 - GIMSA.B12R1
 - GIMVA.B12R1
 - HQBC.A12R1.M
 - MB.A12R1
 - QIHEW.A12R1.EH821
 - QITES.A12R1.TT821
 - MBA.A12R1
 - VSSB.A12R1.B
 - VSSB.A12R1.R
 - GIWCT.A12R1
 - GIMBH.A12R1
 - GIMSA.C12R1
 - GIMSA.D12R1
 - GIMVB.A12R1

IDENTIFICATION

Machine: LHC Ring
 Type: LBARA (Type ID : 101624, Quality Assurance : HC)
 Description: Arc Dipole, Type A Cryo-Assembly, Annealed on the Right, Cryo-Magnet Extremity Type A
 Official Name: LBARA.12R1 ID:10212 [Link to MTF Slot](#)
 Expert Name:
 Vacuum Name: LBARA.78.12R1
 Beam: This slot is on both beams (B1, Blue; B2, Red) [E]
 Equipment (MTF PART ID): **HCLBARA000-IN001352** [Link to MTF Equipment](#)
 Classification:
 Related Electrical object:
 Log:

DIMENSIONS

Length	Width	Height
15.66 m	0 m	0 m

LOCALISATION

Location: LHC HALF-CELL - 12R1 (CIVIL WORK : RI18)

MTF Equipment Management Folder

Actions : [Show NCR Report](#)

Assembly Tree

- Arc Dipole LBARA
 - Cryo Dipole LBARA
 - Cold Mass MBAR
 - Cryostat Assembly
 - Assembled beam screen - R
 - MB upstream
 - MB upstream (V1)
 - Flexible K-long (v1)
 - Flexible K-long
 - Long Sleeve

Top Assembly Folder : Main Info

Top Assembly Identifier: HCLBARA000-IN001352
Other Identifier: None
Description: Arc Dipole LBARA

Slot identifiers are imported

Asset identifiers are imported

Asset-to-Slot assignment done by the equipment owner via this interface

Main

Actions : [View summary](#)

Physical	
Manufacturer	
Project Engineer	
Status	Manufacturing
Other Identifier	
Parent Equipment	
Parent Slot	LBARA.12R1
Location	RI18
State	Good
MRC	MTF1

Design

Item in ABS: LBARA Arc Dipole Variant (ver.0)

Audit

Created on	Last modified on	by
2005-11-16	2007-03-22	DIPCOOR

Other Examples of Data Propagation

★ Beam loss monitoring electronics

⇒ Module data needed for beam interlocks

★ Commissioning sets of circuits

⇒ Electrical layout needed to drive settings

★ Configuring front-end computers

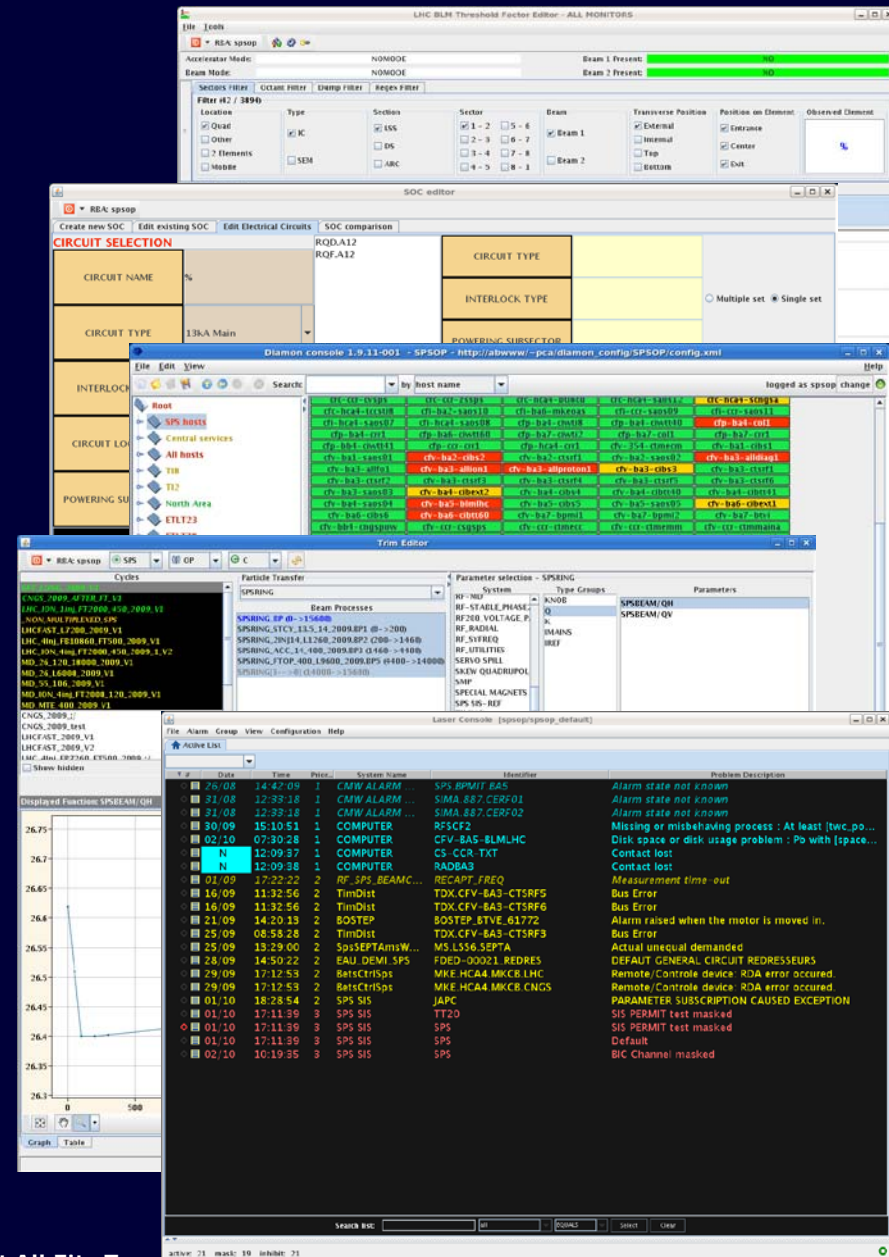
⇒ HW/SW configuration derived from layout data

★ Driving settings from SW devices

⇒ From device-property to Device-parameter

★ Generating alarm definitions

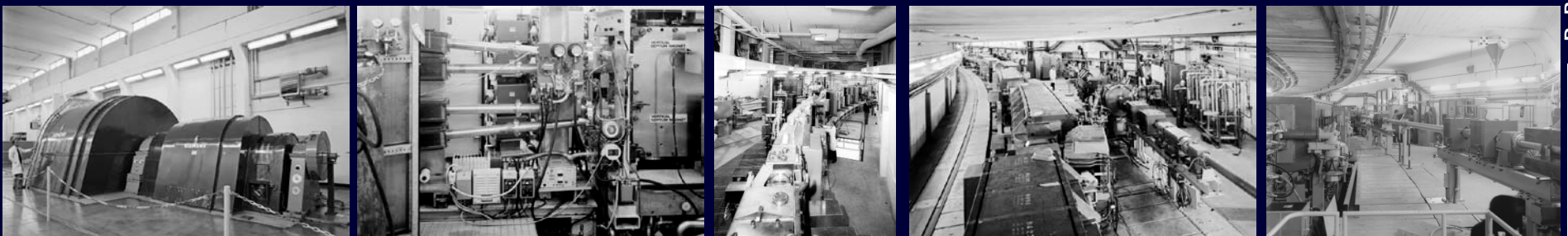
⇒ Based on controls configuration



Covering the CERN accelerator Complex

- ★ Architecture, design and implementation was set out with LHC in mind
- ★ Retrofit to existing accelerators is in progress
 - ⇒ **Integrate** the existing data into the current model
 - ⇒ **Extend** the model to cater for specifics of other accelerators
 - ⇒ High level controls and settings management of the **PS-complex** is the most difficult challenge
 - ⇒ **Renovation project** with convergence towards LHC has been launched

TUP019



Human Resources

- ★ The people are the most important assets in the process of *analysis, design, development and maintenance*
- ★ The core team of database engineers have to:
 - ⇒ Follow and use the **technology** effectively
 - ⇒ Acquire specific **domain knowledge**
 - ⇒ Show flexibility in adapting to the **changing user requirements**
 - ⇒ Impose **data access methods** to application developers
- ★ Their *responsibility* is **proportional to the database complexity**




	tables	constraints	code	volume
Layout	134	495	55,602	5.3 GB
Configuration	514	1,524	30,326	9.7 GB
Settings	281	1,392	9,026	14.6 GB
Logging	55	103	14,431	+17 TB
Alarms	207	191	24,915	62.8 GB

Conclusions

What's the important message here?

- ⇒ Data management is an **organizational** issue
- ⇒ The accelerator domain is a **very wide area**
 - Legacy, in-house developments, commercial systems are part of our environment
- ⇒ Ensure **single source** of maintained, consistent data
 - Avoid confusion, doubt and errors
- ⇒ In case of data propagation
 - **Procedures** for **execution** and **verification** of the data synchronization are mandatory (i.e. Quality Assurance)

 A database is only as good as the correctness of the data it contains

 Software comes and goes, data stays forever

Questions?

