



# WAO 2018

## Operator-made Tools and Software

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CERN – SPS / LHC Operator

# Outline

- Introduction
- **Front-End Software Architecture**
- **LHC Software Architecture**
- Tools use case
- Conclusion



# Introduction to CERN complex

CERN was founded 1954: 12 European States

“Science for Peace”

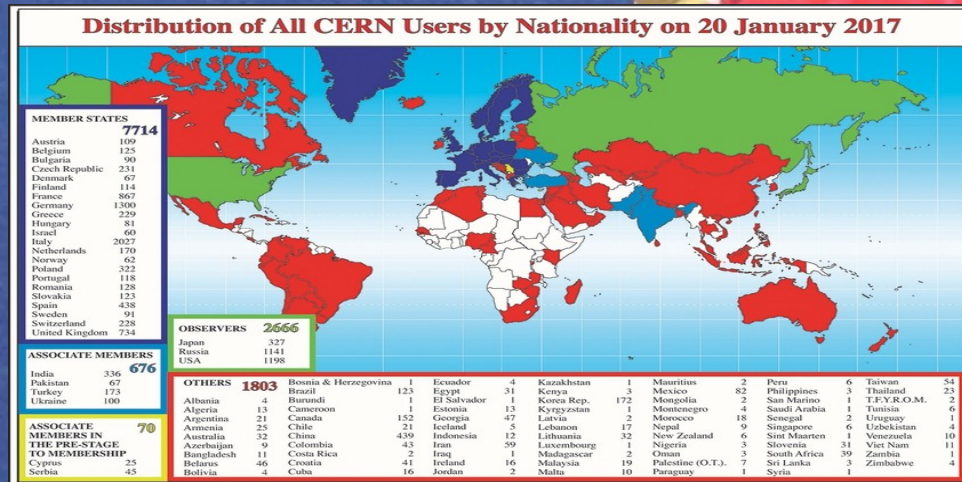
Today: 22 Member States

~ 2600 staff

~ 1280 other paid personnel

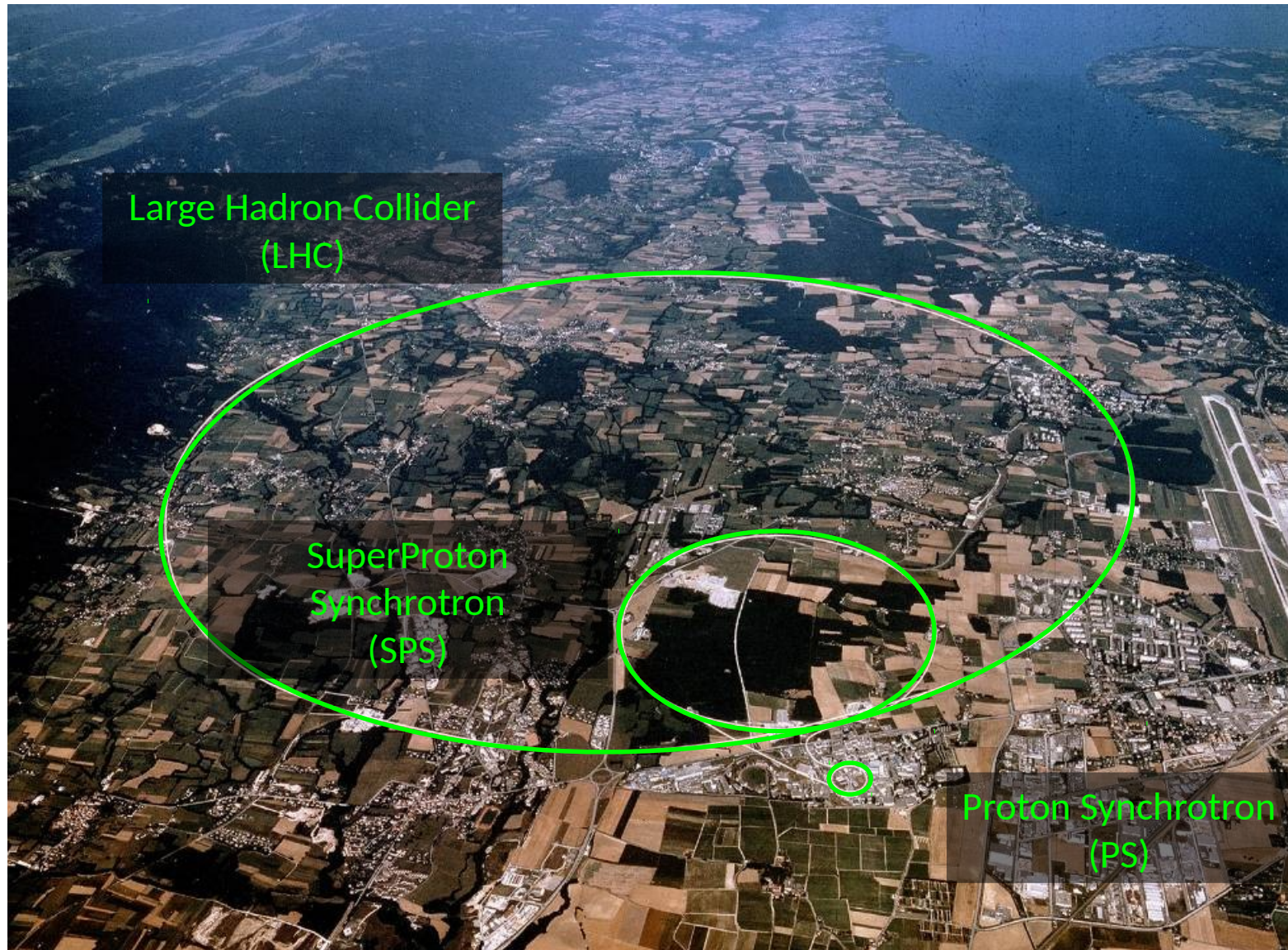
~ 11000 users

Budget (2016) ~1000 MCHF



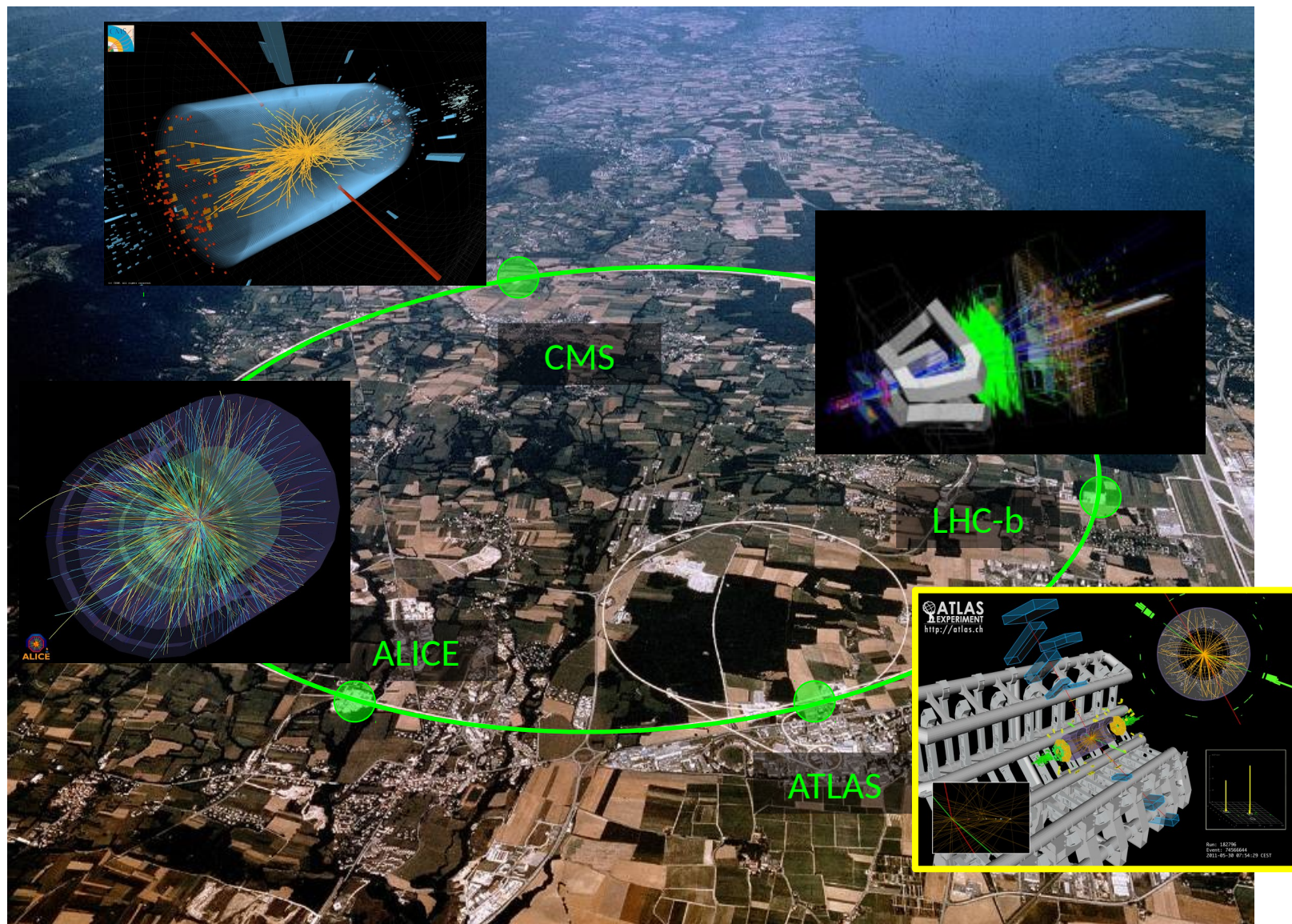


# CERN Accelerator Complex





# CERN Accelerator Complex



# Operational tools

CERN control infrastructure is composed of:

- ✓ A large number of **Front-End computers** > 800
- ✓ A huge **equipment diversity** > 500
- ✓ A big number of **physical devices** to control ~45000

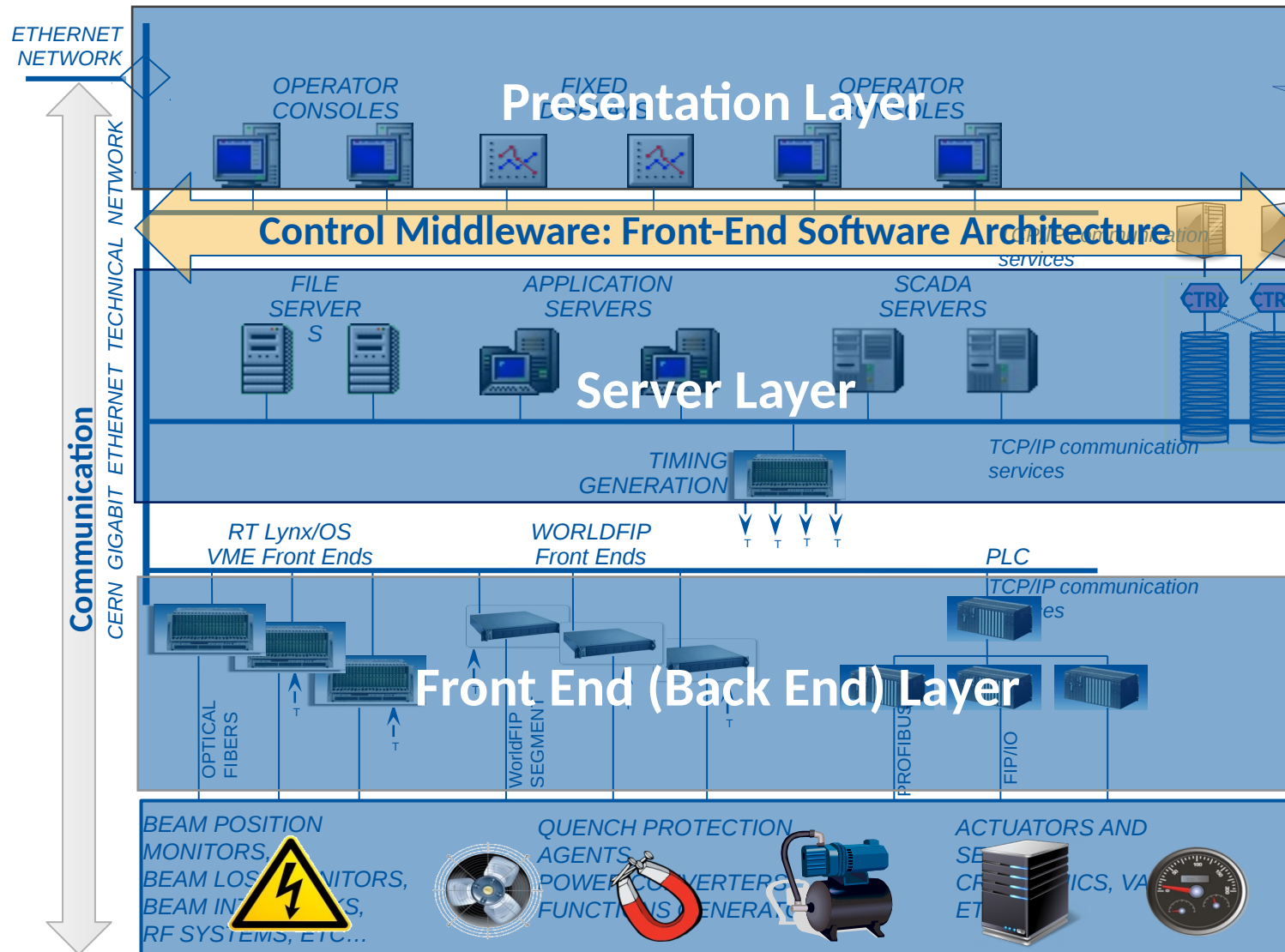


Operator is not expert, he should diagnose faults, if the problem persist an equipment specialist will intervene and hopefully solve the problem.

Efficient operation tools are extremely **helpful for operators** and are **essential for machine reliability**.

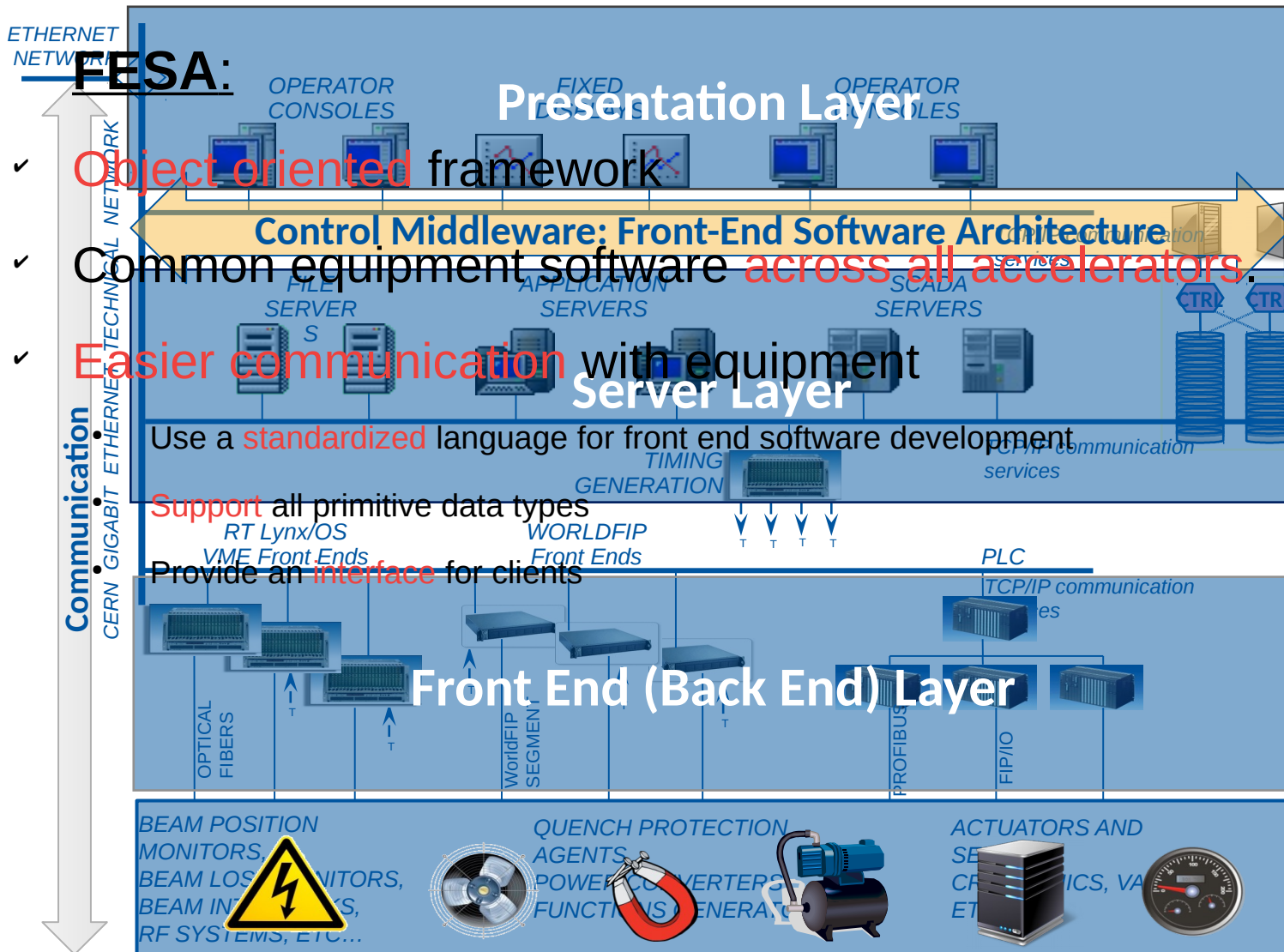


# Front-End Software Architecture

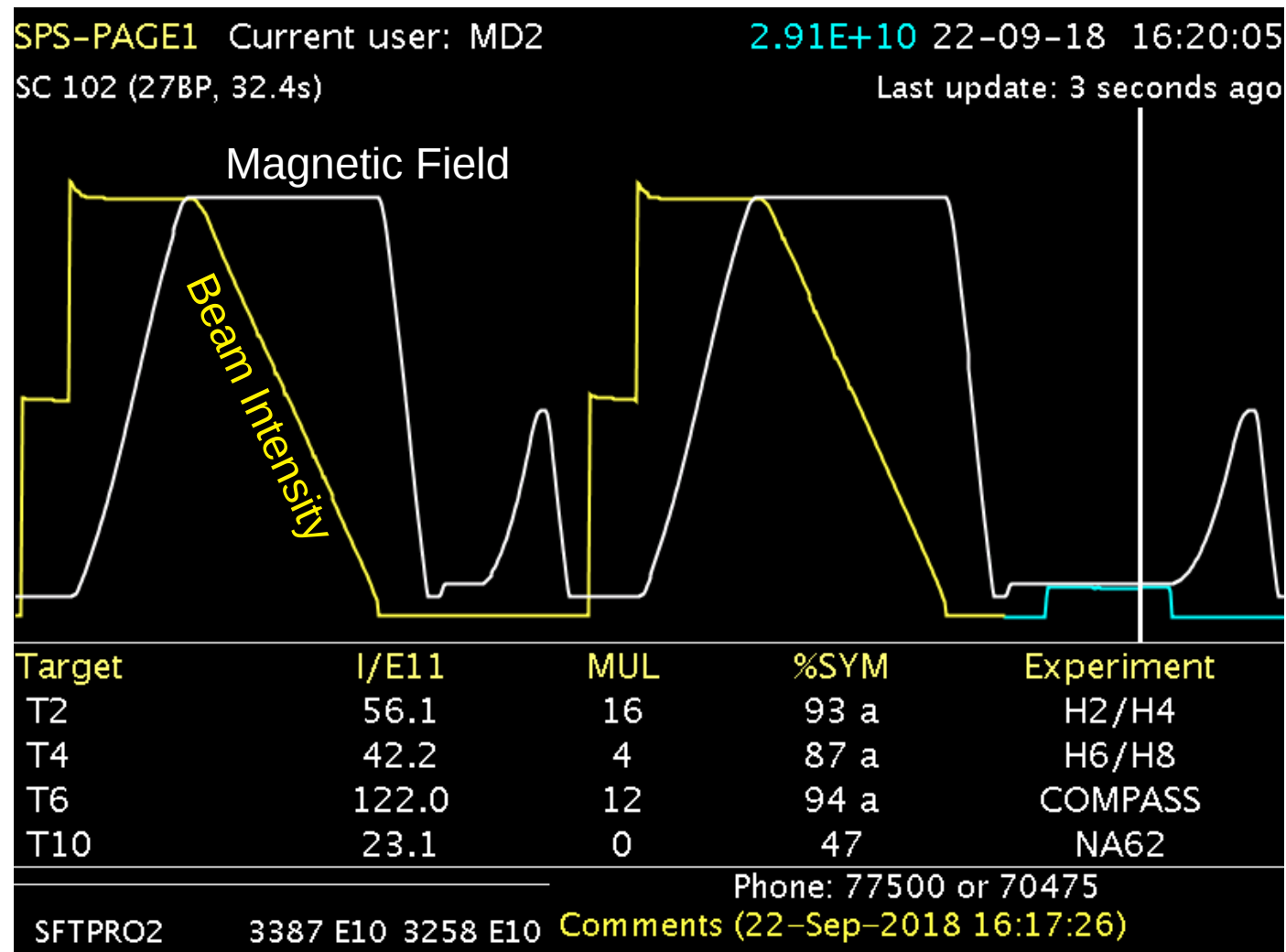




# Front-End Software Architecture



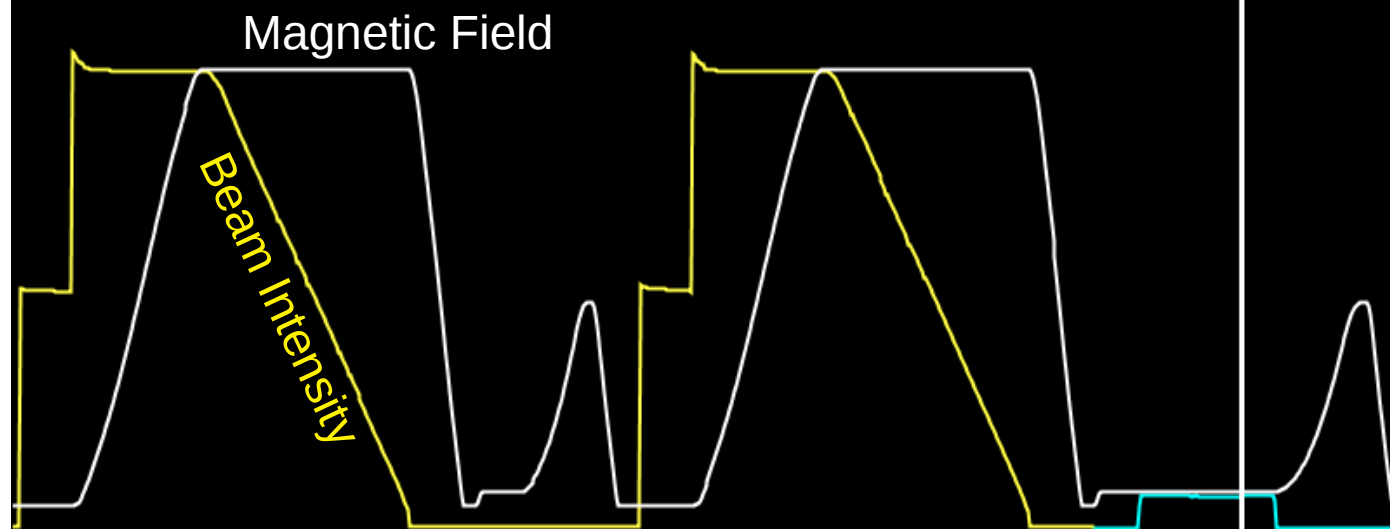
# Client interface





# Client interface

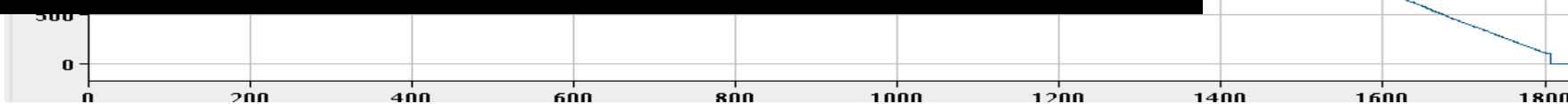
SPS-PAGE1 Current user: MD2 2.91E+10 22-09-18 16:20:05  
 SC 102 (27BP, 32.4s) Last update: 3 seconds ago



Target	I/E11	MUL	%SYM	Experiment
T2	56.1	16	93 a	H2/H4
T4	42.2	4	87 a	H6/H8
T6	122.0	12	94 a	COMPASS
T10	23.1	0	47	NA62

Phone: 77500 or 70475

SFTPRO2 3387 E10 3258 E10 Comments (22-Sep-2018 16:17:26)



# Equipment state and control

AP2CAV0.12.0 Global

**Equipment Selection**

Device Selection

- AP2CAV\_DU.cfc-crc-allgspss
  - CAV3
  - CAV4
  - GD\_AP2CAV
  - CAV1
  - CAV2

**Cycle Selection**

- ALL
- SPS.USER.AWAKE1
- SPS.USER.HIRADMT1
- SPS.USER.HIRADMT2
- SPS.USER.LHC1
- SPS.USER.LHC2
- SPS.USER.LHC25NS
- SPS.USER.LHC3
- SPS.USER.LHC4
- SPS.USER.LHC5ONS

**Status and Control property selection**

Property Selection (dbl-clk = new)

- ExpertStProperty
- OperStProperty
- AlarmDetails
- Alarm
- ResetProperty
- ExpertCmdProperty
- OperCmdProperty

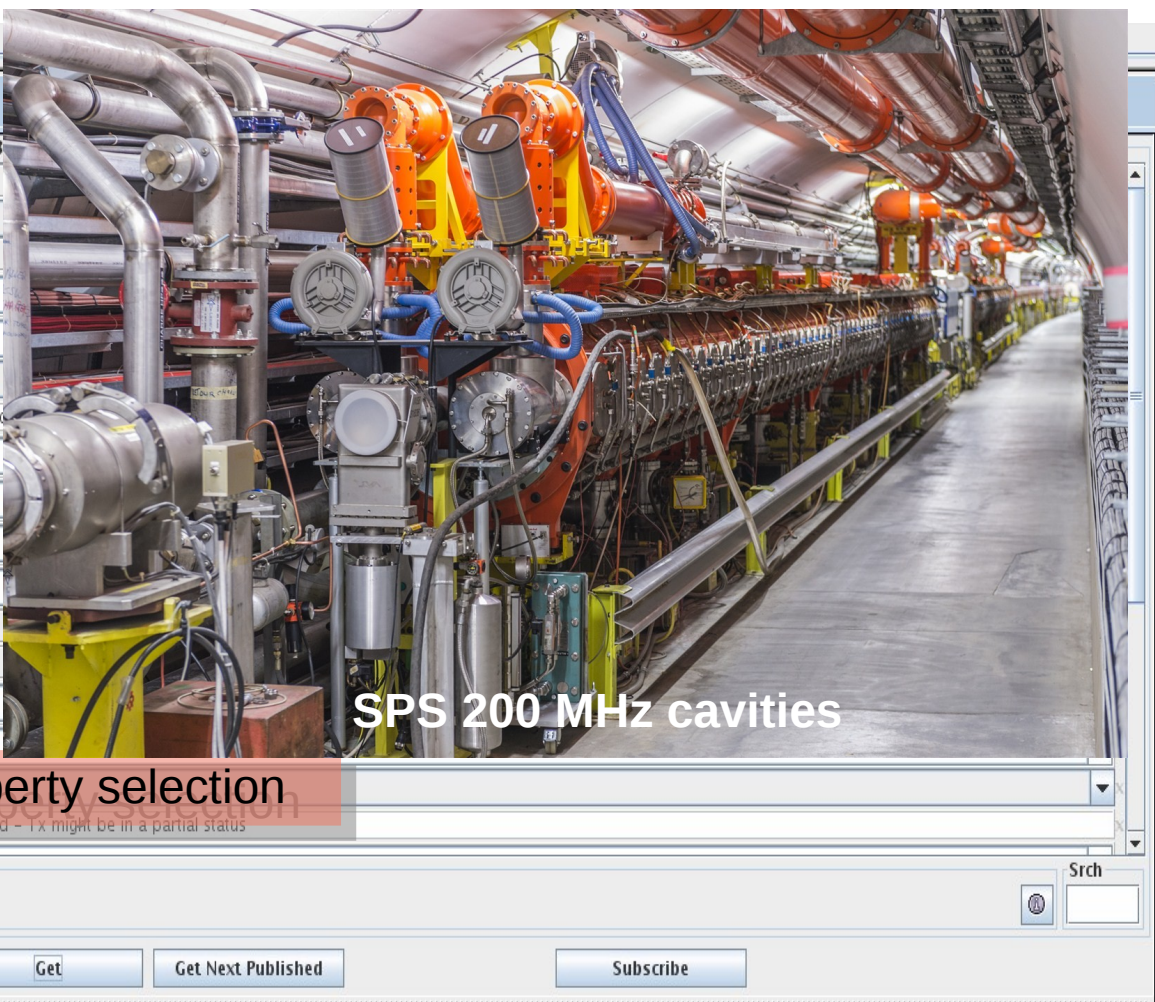
Property Value (210 b) - Mon Aug 06 01:43:09 CEST 2018

<input type="checkbox"/> Cavity_faults	00000000
<input type="checkbox"/> Line_ST	RF_ON
<input type="checkbox"/> TxATubes_ST	00000000
<input type="checkbox"/> TxA_Online	true
<input type="checkbox"/> TxA_Remote	true
<input type="checkbox"/> TxA_ST	RF_ON
<input type="checkbox"/> TxA_ST_info	Number of retries exceeded
<input type="checkbox"/> TxA_Summary_ST	true
<input type="checkbox"/> TxA_Timeout	false
<input type="checkbox"/> TxA_busy	false
<input type="checkbox"/> TxA_faults	00000000
<input type="checkbox"/> TxBTubes_ST	00000000
<input type="checkbox"/> TxB_Online	true
<input type="checkbox"/> TxB_Remote	true
<input type="checkbox"/> TxB_ST_info	Number of retries exceeded - Tx might be in a partial status

Viewers

☐ All -viewers- ☐ Global tab

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SPS 200 MHz cavities

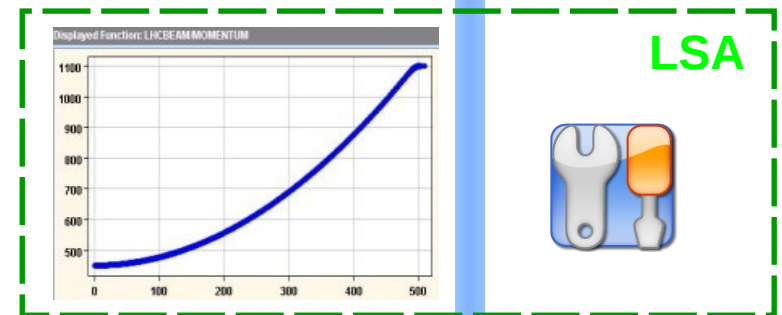


# Equipment state and control

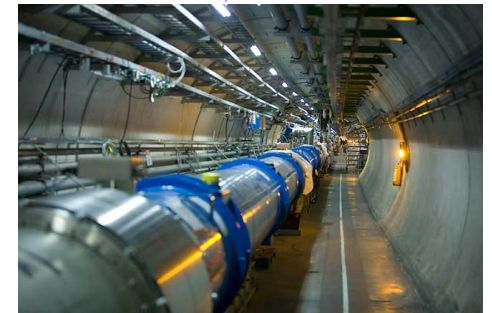


# LSA (LHC Software Architecture)

- ✓ Around the ring, we have **thousands of different devices**
- ✓ In order **to work they need** to be given **settings**
  - They need to know what to do



LSA does it: **manage settings**

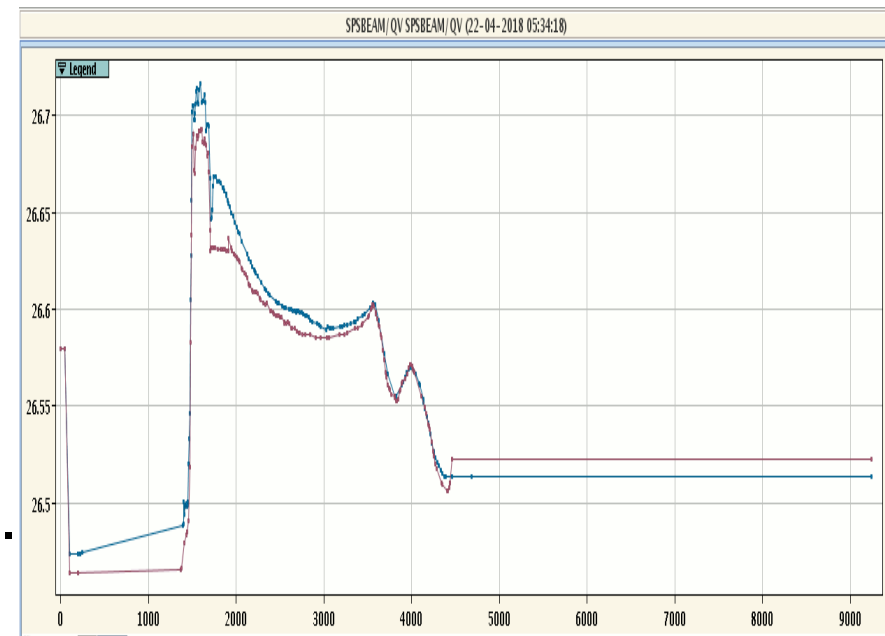




# LSA (LHC Software Architecture)

LSA is a database:

- ✓ Every change is **registered**.
- ✓ Allow **reloading** of previous settings **at any time**.
- ✓ Provide **physics model-based** controls for operation.
  - MBI/IREF - **hardware** level parameter
  - TUNE/QH - high level **physical** parameter
- ✓ Parameters organized by **hierarchies**.



# Hierarchy and calculation

How to calculate main magnets current in SPS from a momentum function ?

MOMENTUM

Machine design:

Machine run energy: 400 GeV

Dipole magnet field: 1.8 T

Calibration factor is specific to dipole magnets

$$B = \frac{MOMENTUM * 1.8}{400}$$

B

Example with a LHC beam:

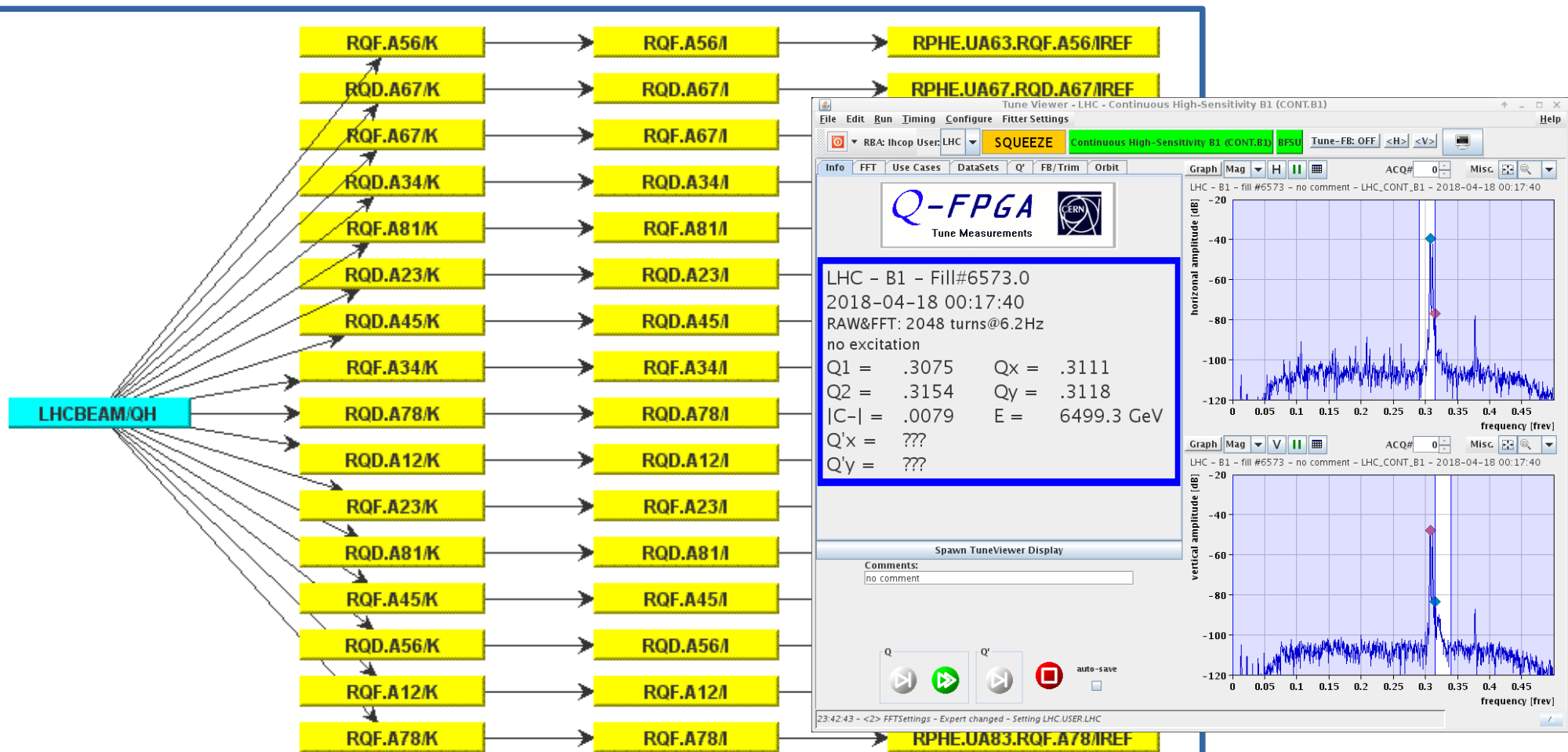
$$B = \frac{450 * 1.8}{400} = 2.025 \text{ T}$$

Linear interpolation of B  
in a lookup table.

I MAINS (Dipoles)

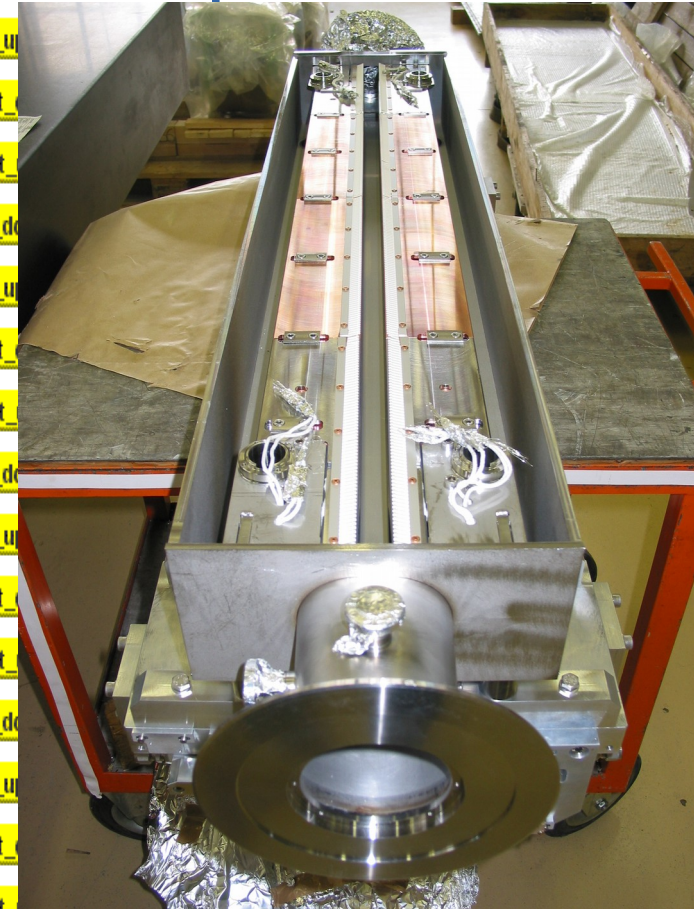
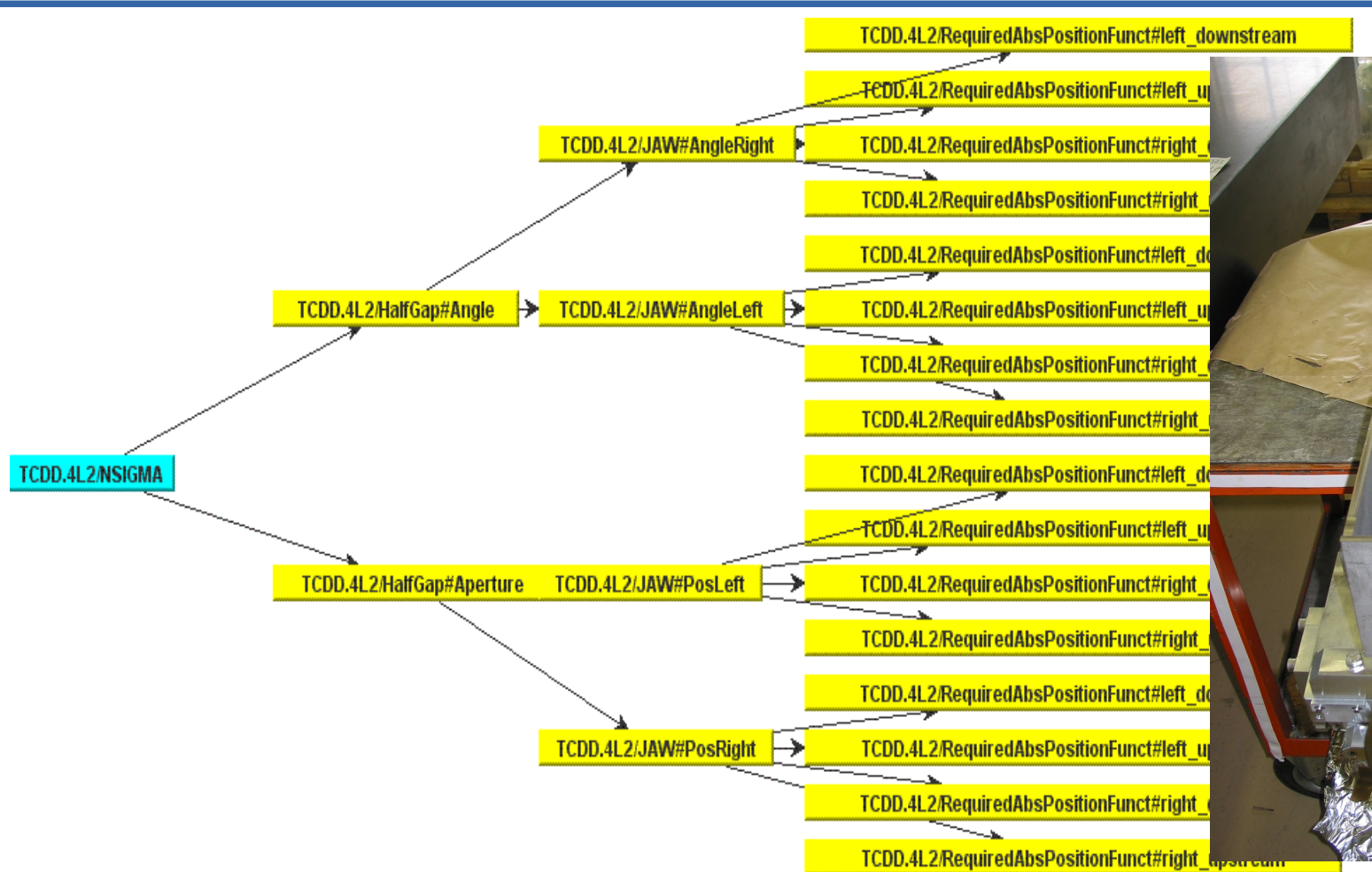


# Hierarchy and calculation



LHC Horizontal Tune Hierarchy

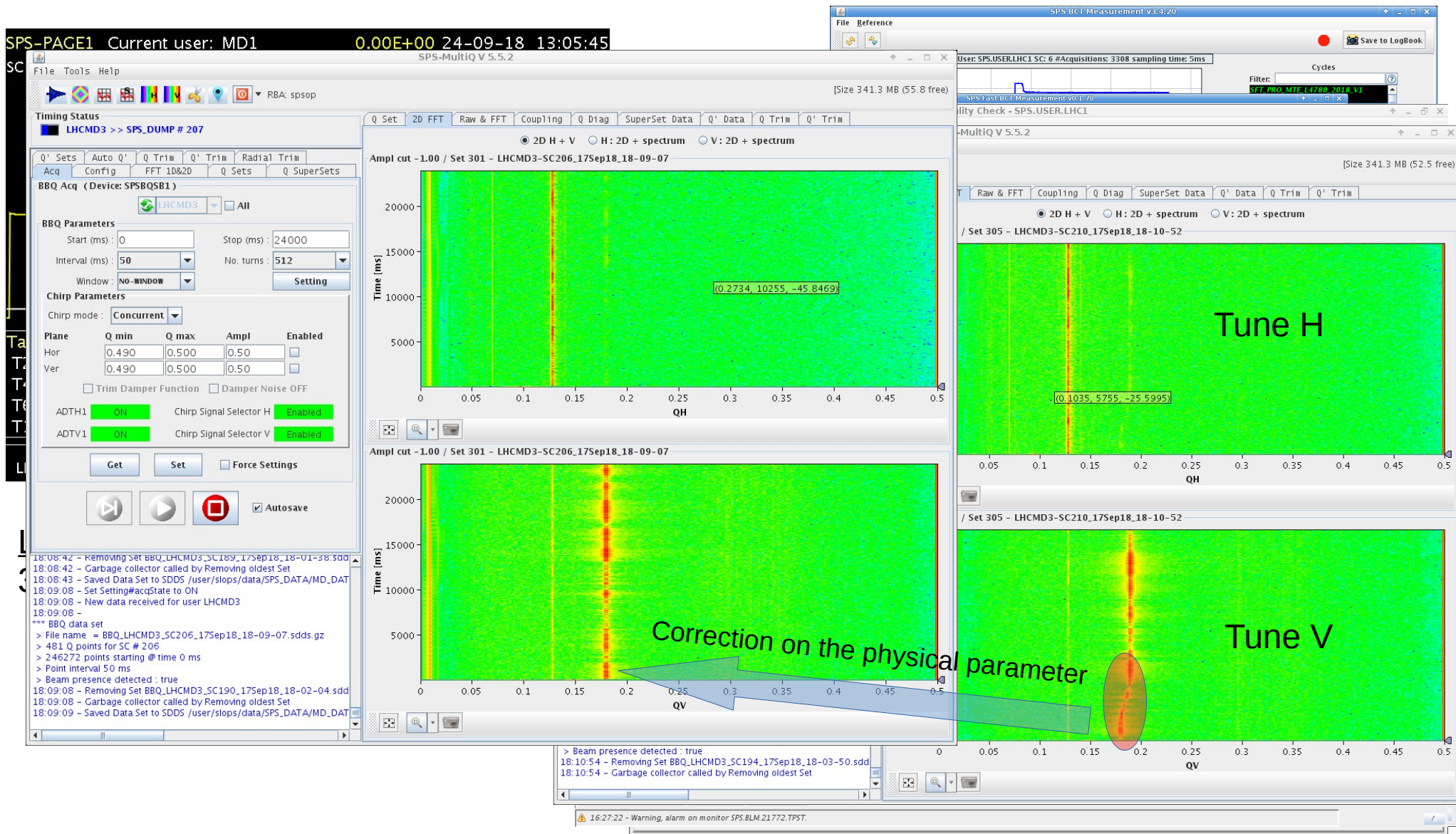
# Hierarchy and calculation



LHC Collimator aperture Hierarchy



# Tools use-case





# Conclusion

**Front-End Software Architecture** and **LHC Software Architecture** are two essential tools for operation at CERN:

- Adapted to a **huge number of devices** to control
- Provide **high level** accelerator machine **parameters**
- Optimized **for expert and operator** work



These **powerful tools** combined with good **operation skills** contributed to achieve high performance and reliable operation.

Thanks to CERN BE/CO group,  
and specially to the FESA team, LSA / INCA team and G. Kruk

Thanks for your attention!