
CERN

WAO 2018
Operator-made Tools and Software

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CERN – SPS / LHC Operator

Outline

- Introduction
- **F**ront-**E**nd **S**oftware **A**rchitecture
- **L**HC **S**oftware **A**rchitecture
- Tools use case
- Conclusion

Introduction to CERN complex

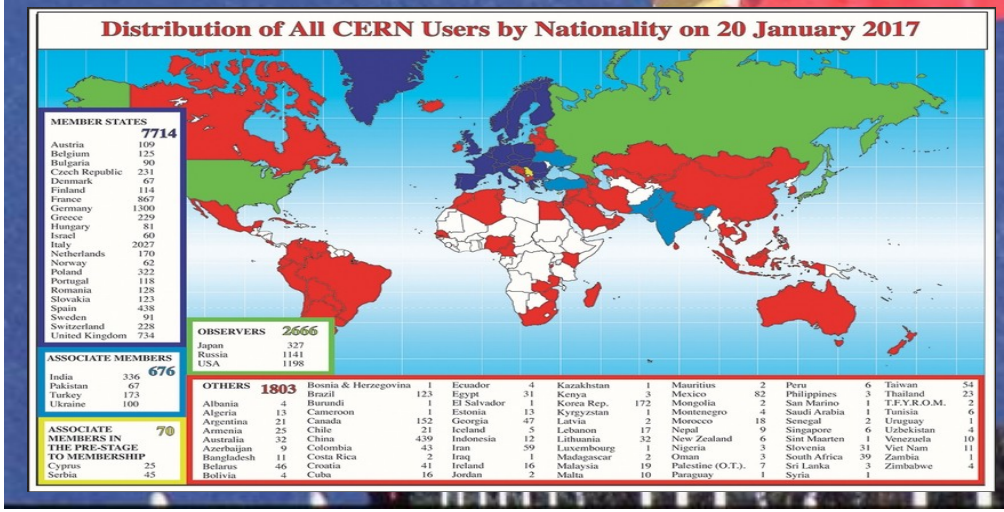
CERN was founded 1954: 12 European States

"Science for Peace"

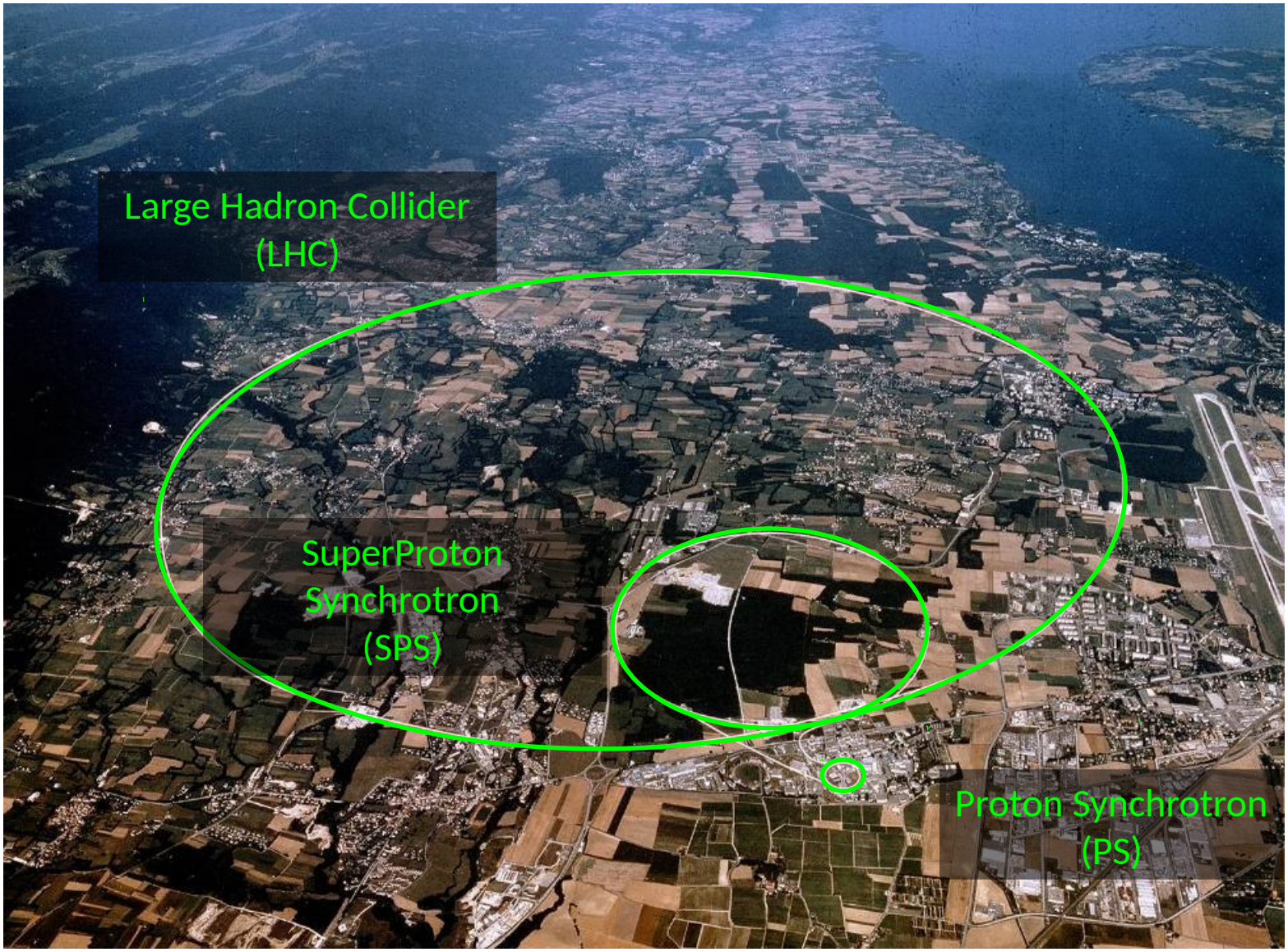
Today: 22 Member States

~ 2600 staff
~ 1280 other paid personnel
~ 11000 users

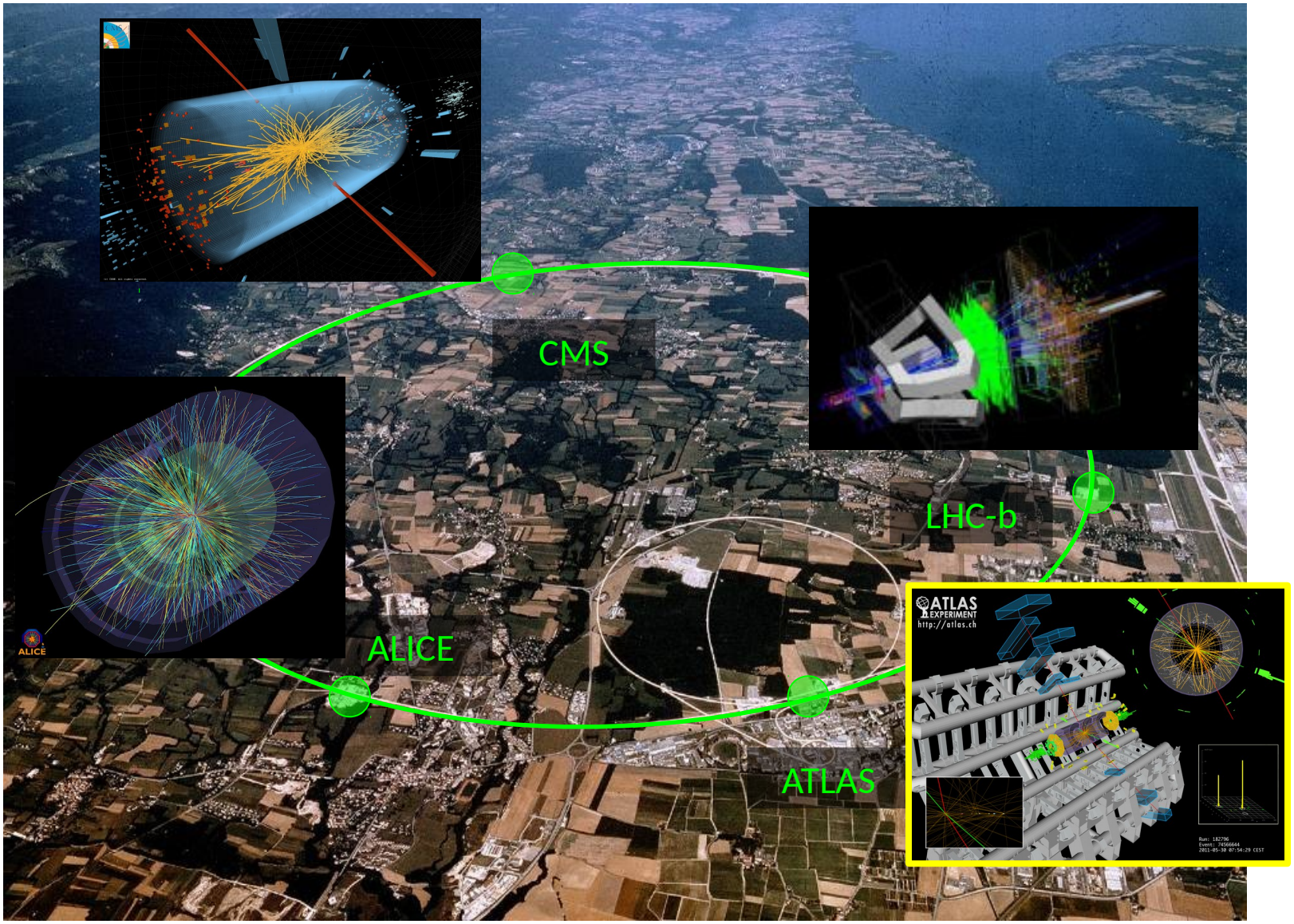
Budget (2016) ~1000 MCHF



CERN Accelerator Complex



CERN Accelerator Complex



Operational tools

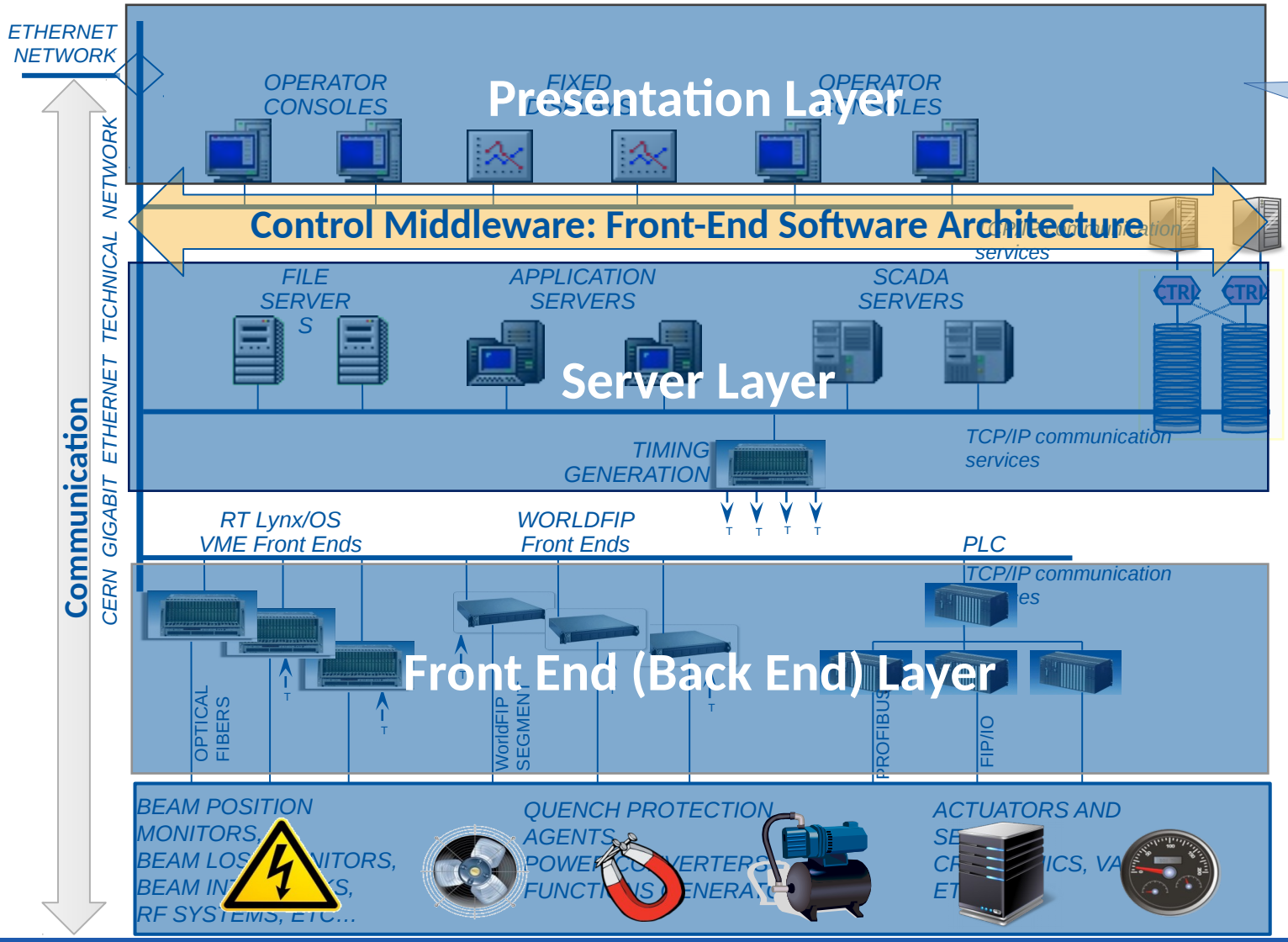
CERN control infrastructure is composed of:

- 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

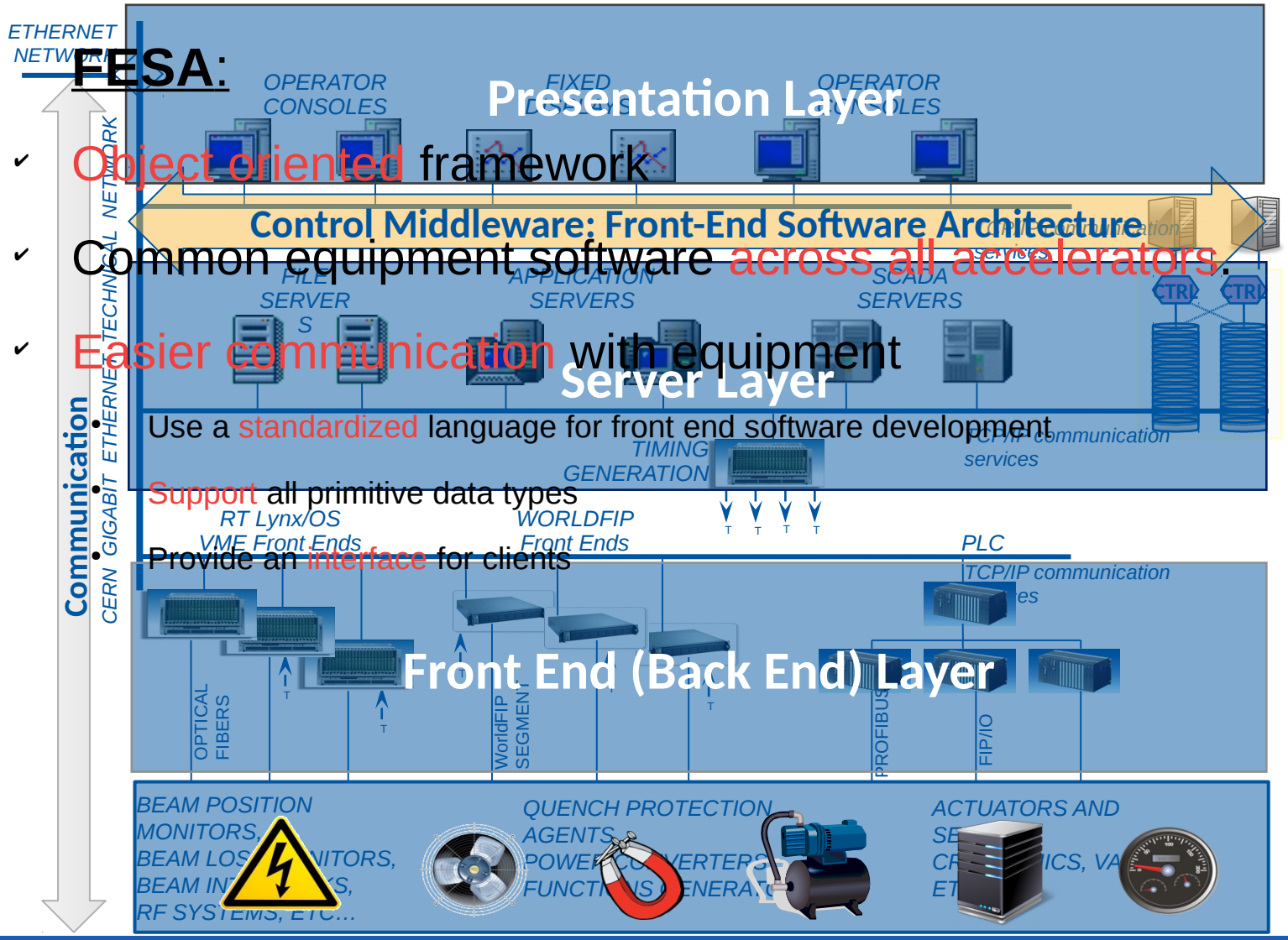


Front-End Software Architecture

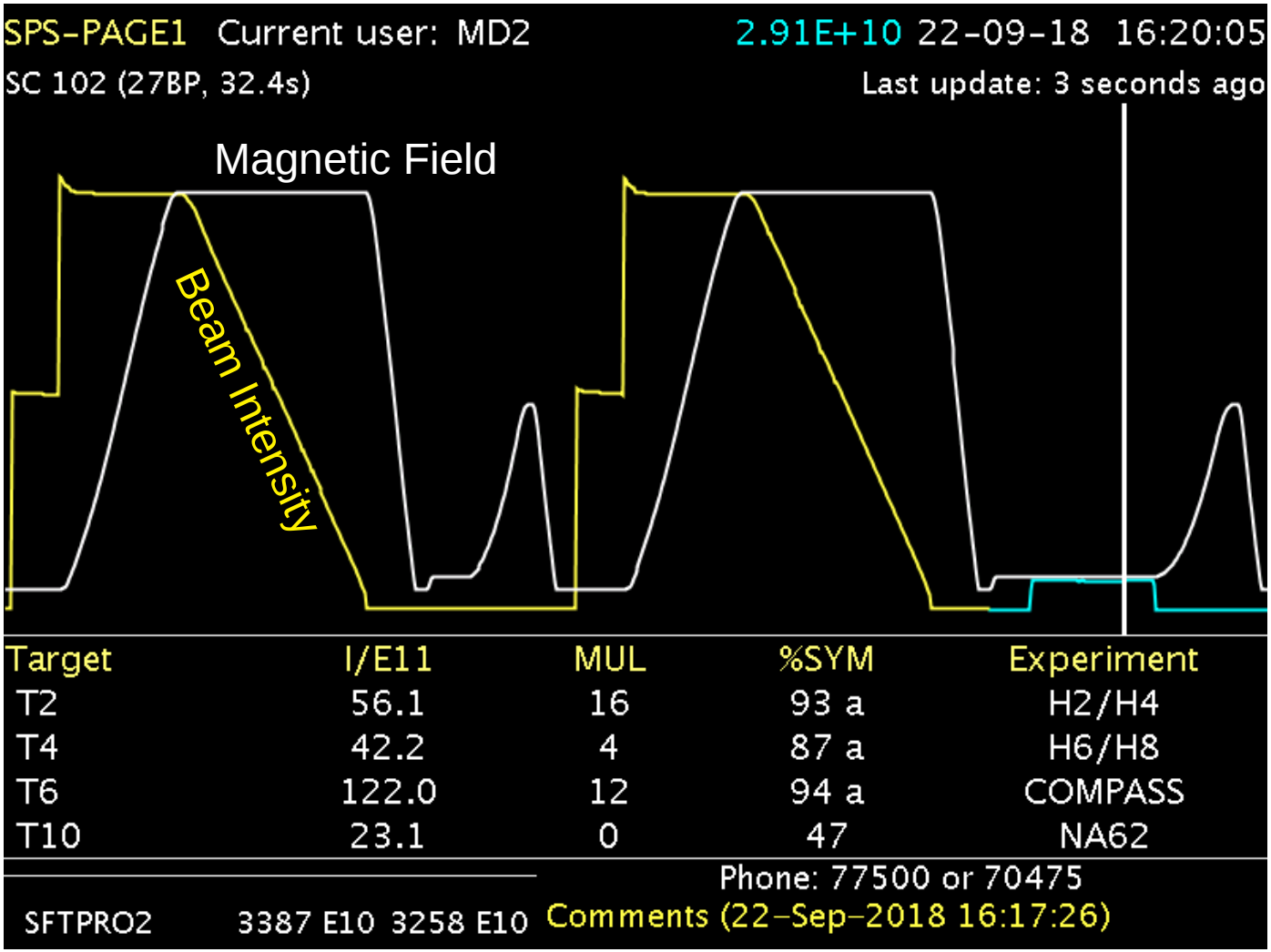
FESA:

- ✔ Object oriented framework
- ✔ Common equipment software across all accelerators.
- ✔ Easier communication with equipment

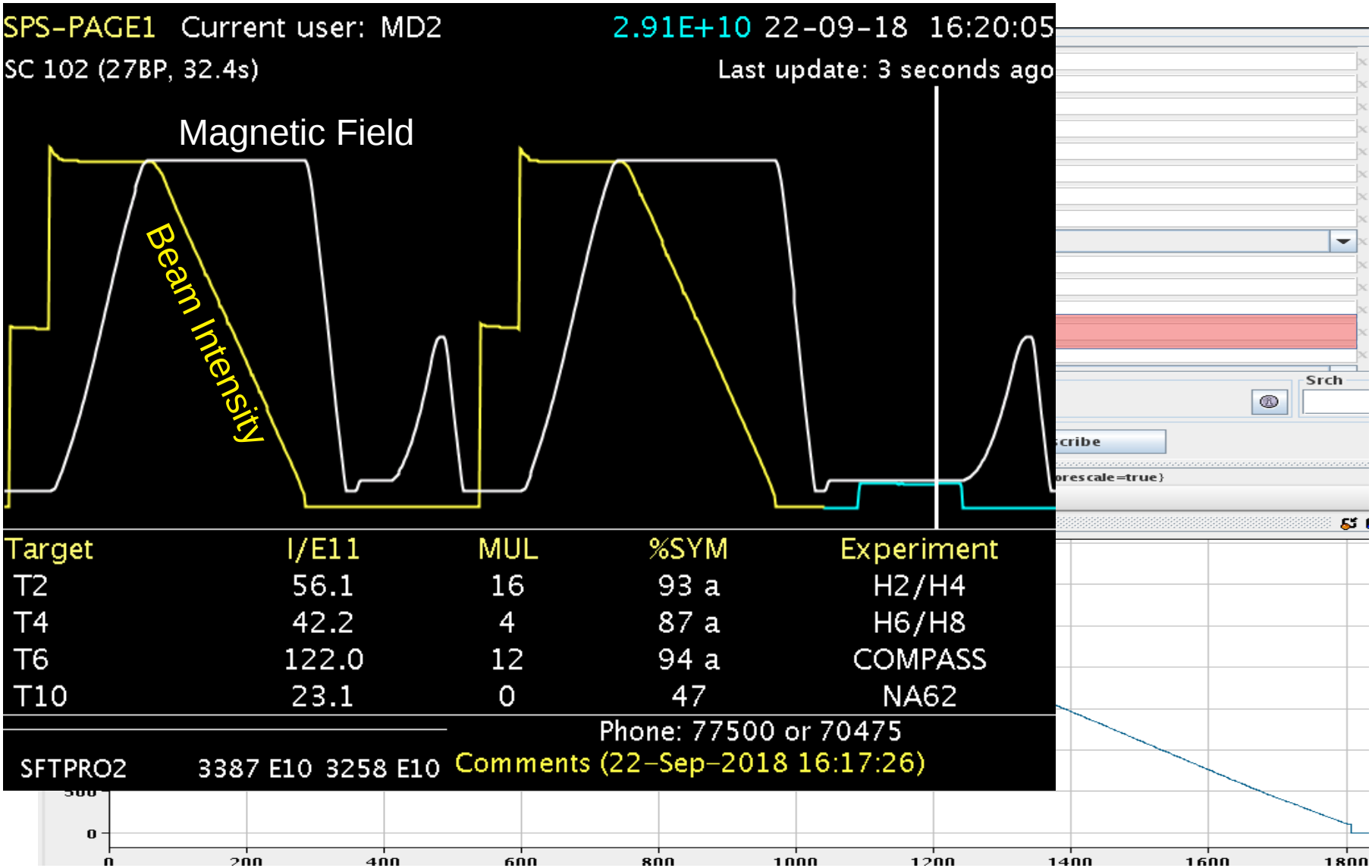
- Use a standardized language for front end software development
- Support all primitive data types
- Provide an interface for clients



Client interface



Client interface



Equipment state and control

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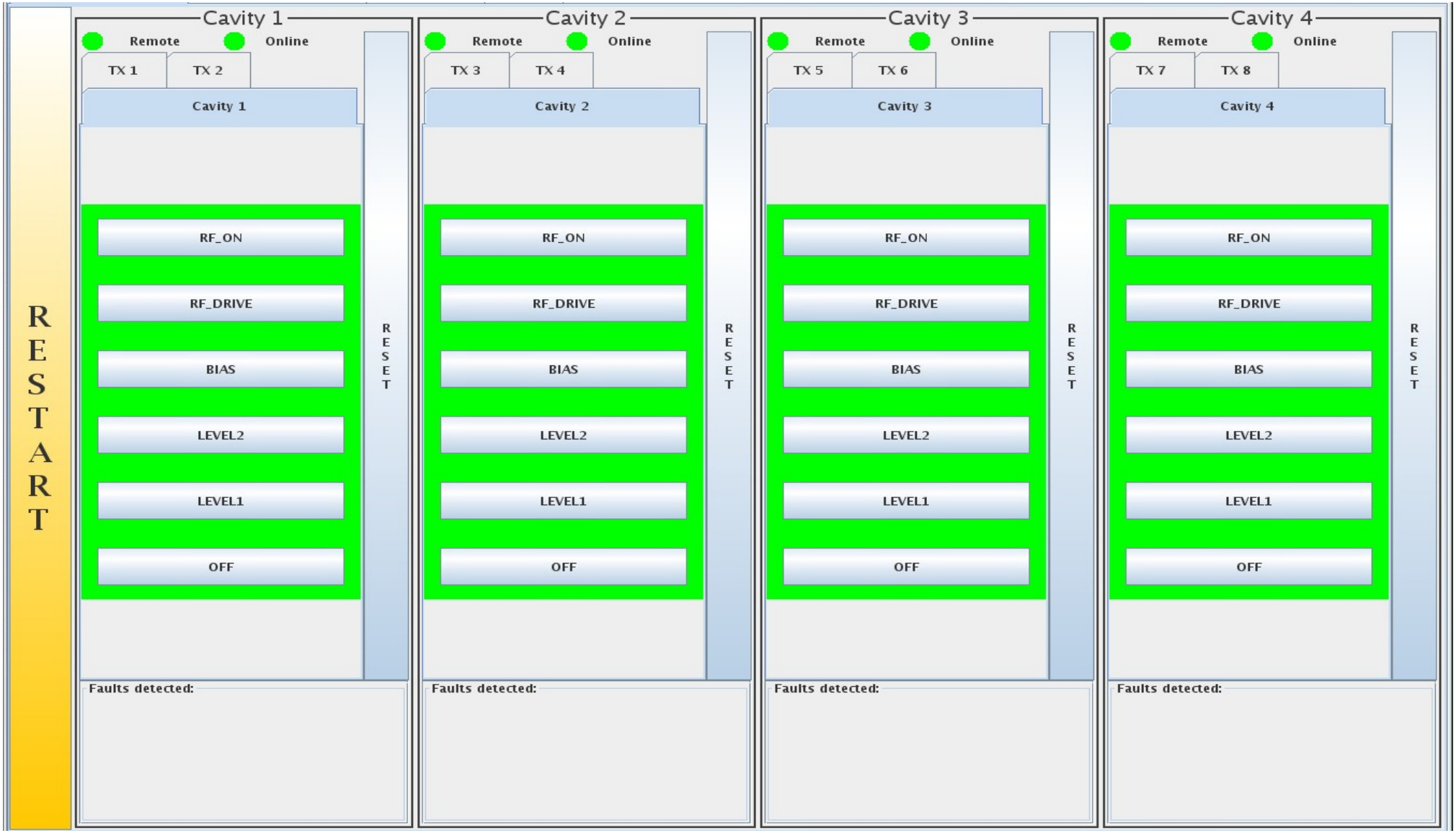
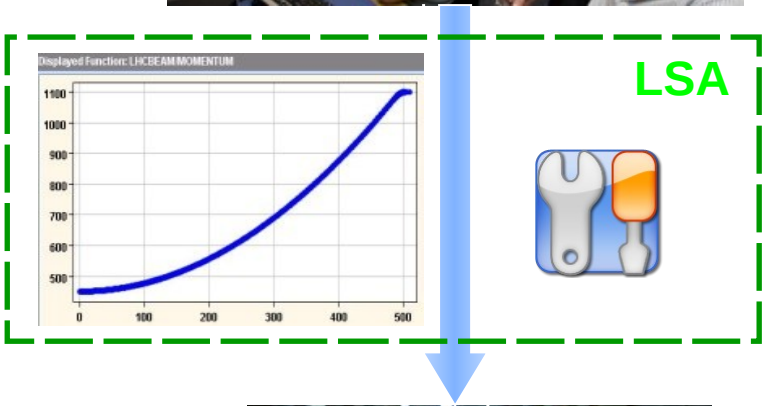


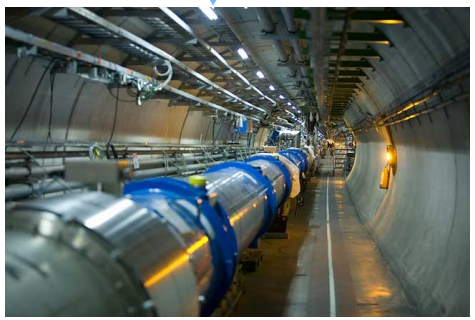
LSA (**L**HC **S**oftware **A**rchitecture)

- 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



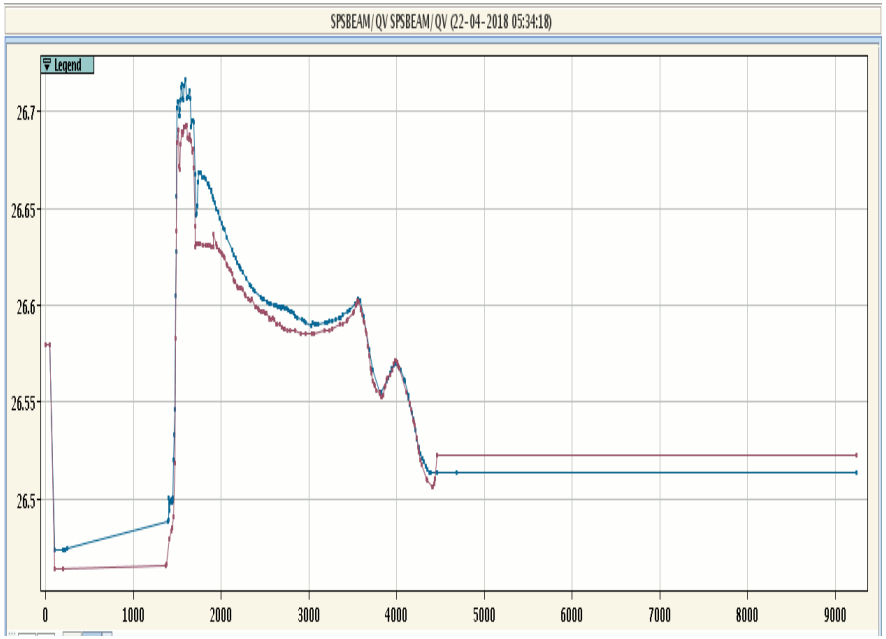
LSA (**L**HC **S**oftware **A**rchitecture)

LSA is a database:

- Every change is registered.
- Allow reloading of previous settings at any time.
- Provide physics model-based controls for operation.

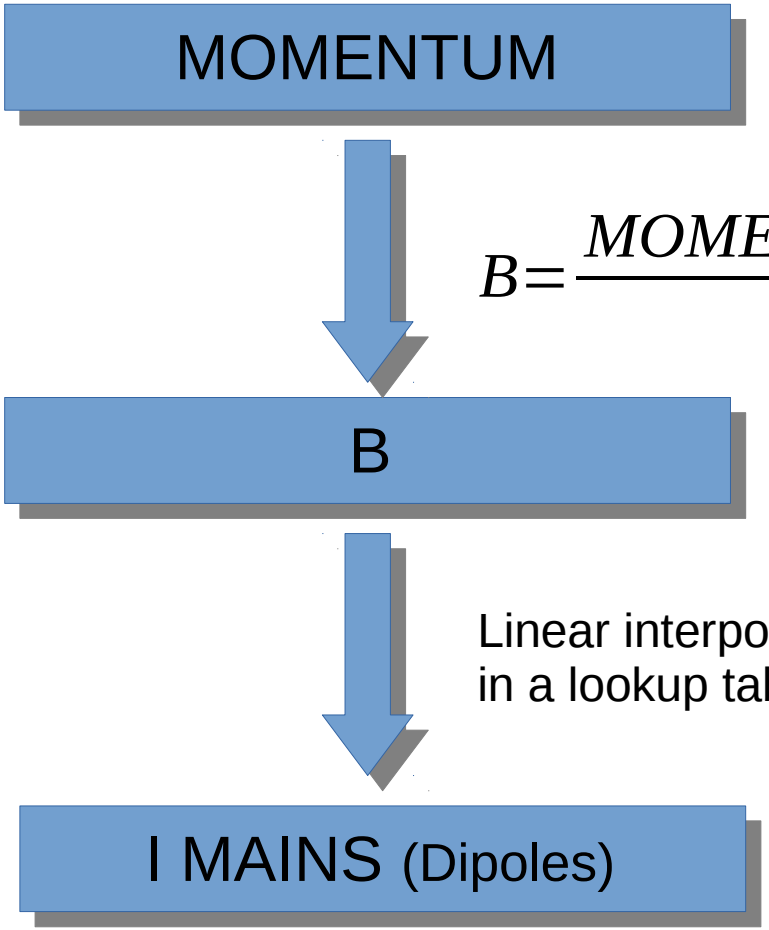
  - MBI/IREF - hardware level parameter
  - TUNE/QH - high level physical parameter

- Parameters organized by hierarchies.



Hierarchy and calculation

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



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

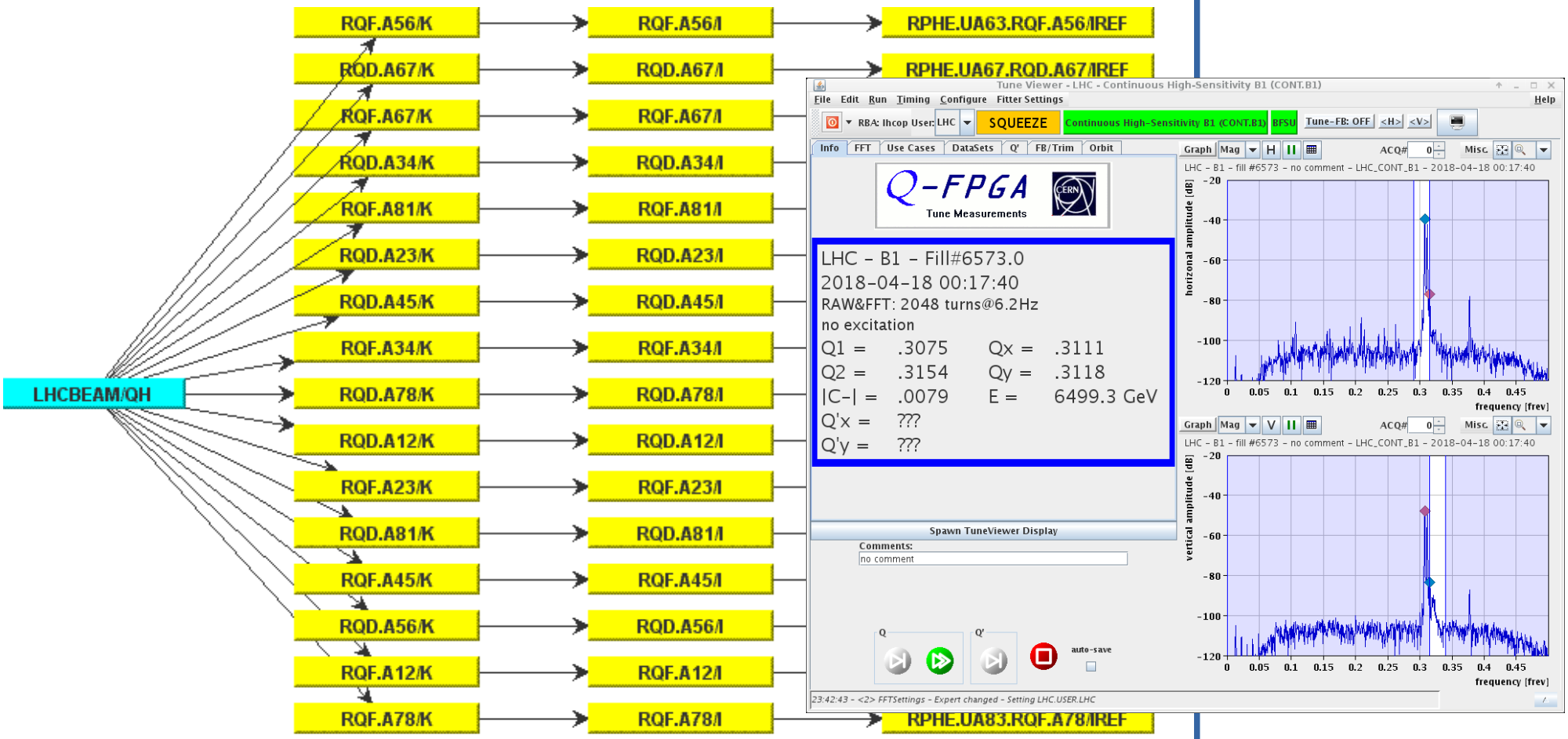
Linear interpolation of B
in a lookup table.

Machine design:
Machine run energy: 400 Gev
Dipole magnet field: 1.8 T
Calibration factor is specific to dipole magnets

Example with a LHC beam:

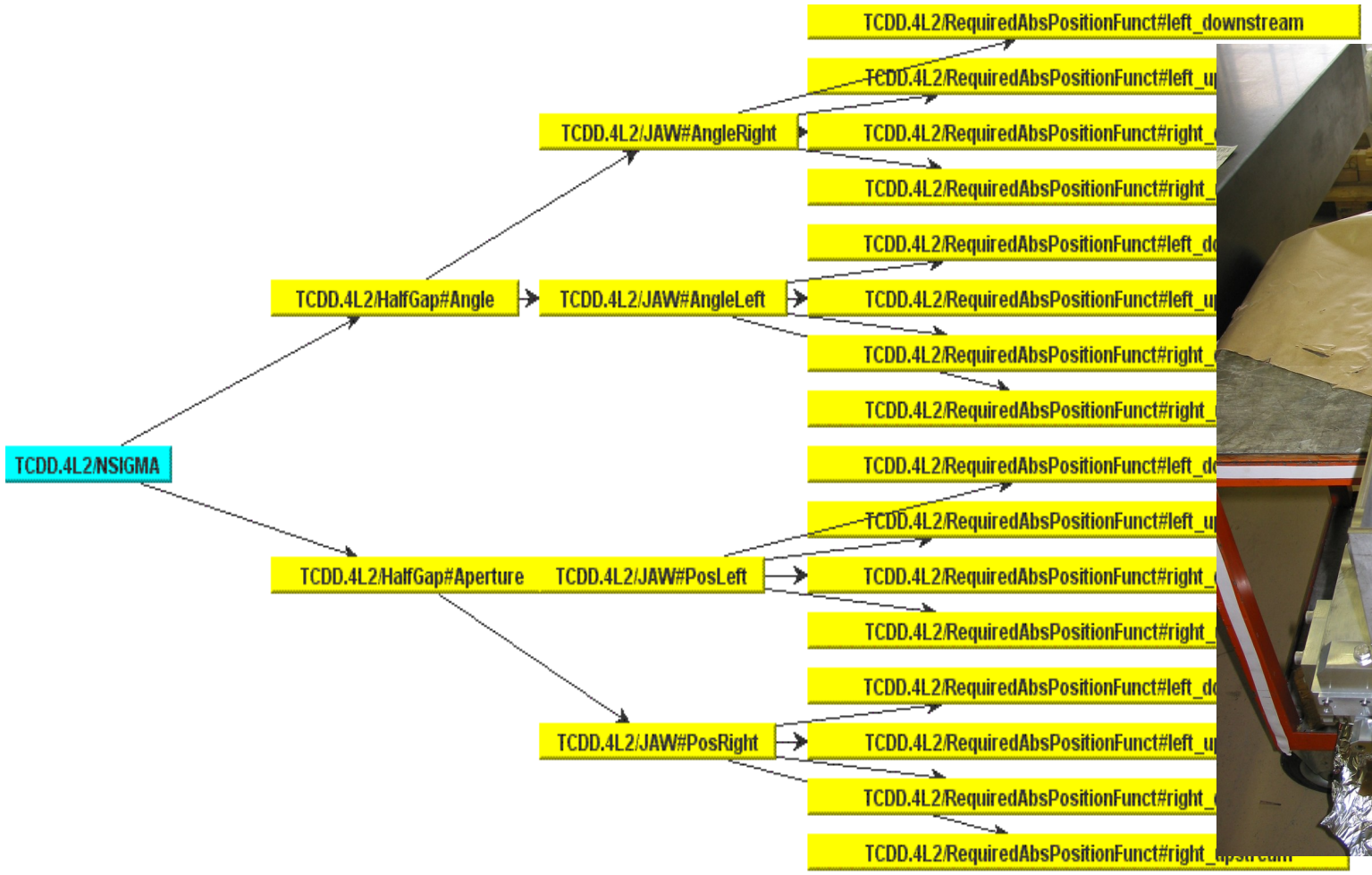
$$B = \frac{450 * 1.8}{400} = 2.025\,T$$

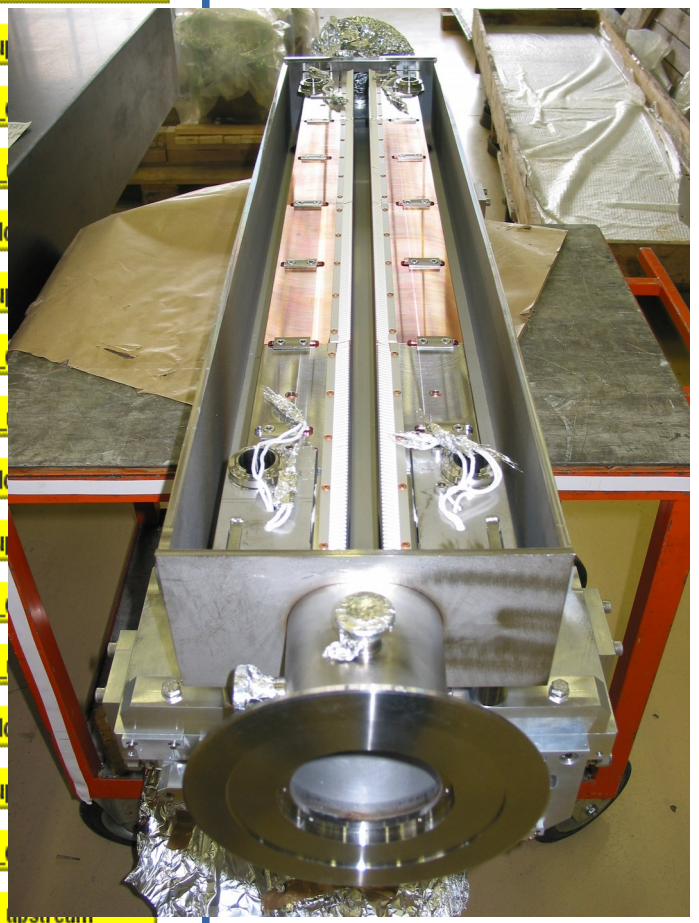
Hierarchy and calculation



LHC Horizontal Tune Hierarchy

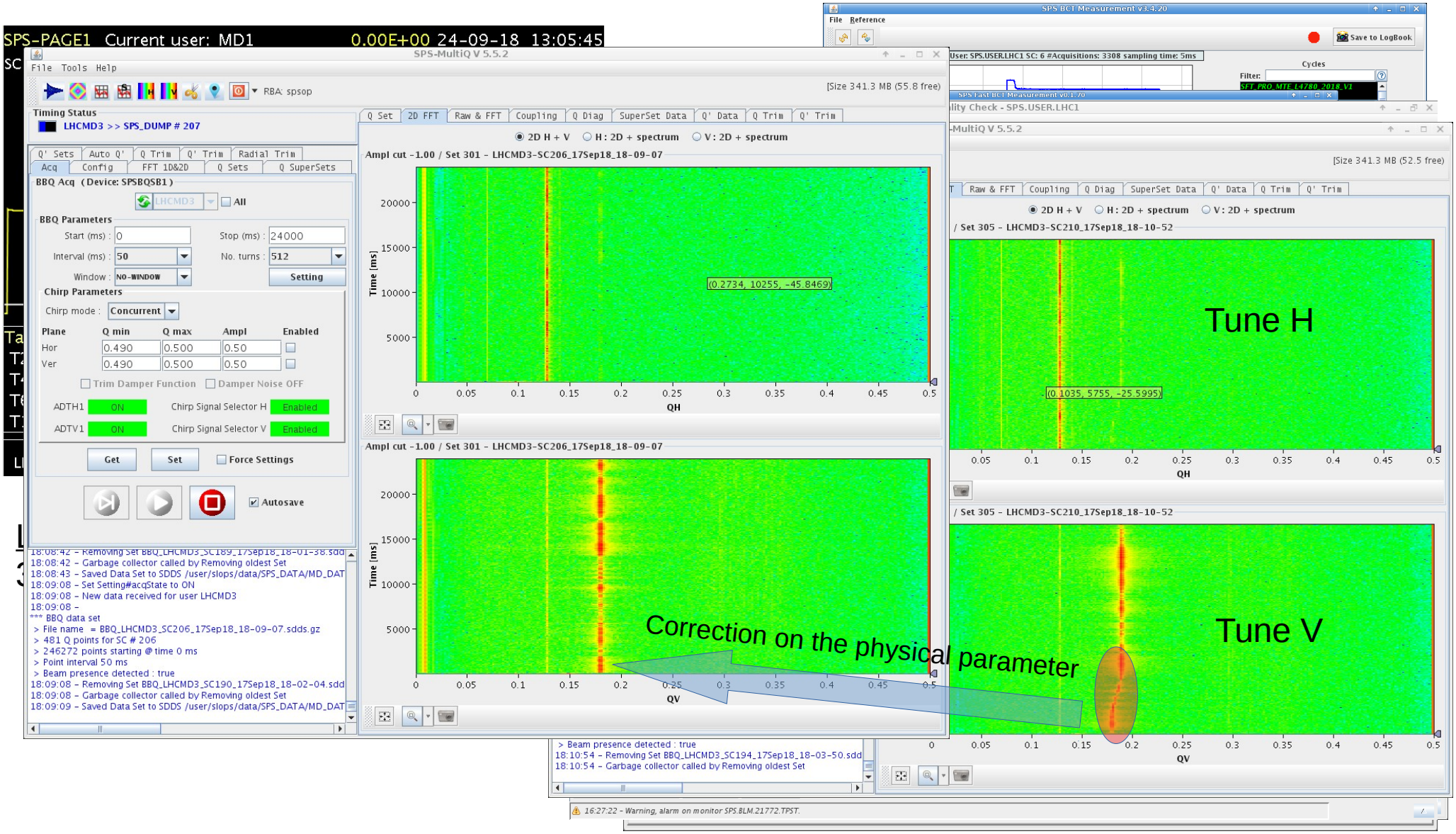
Hierarchy and calculation





LHC Collimator aperture Hierarchy

Tools use-case



Conclusion

Front-**E**nd **S**oftware **A**rchitecture and **L**HC **S**oftware **A**rchitecture 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!