EUROPEAN
SPALLATION
SOURCE

The Integrated Control System at ESS

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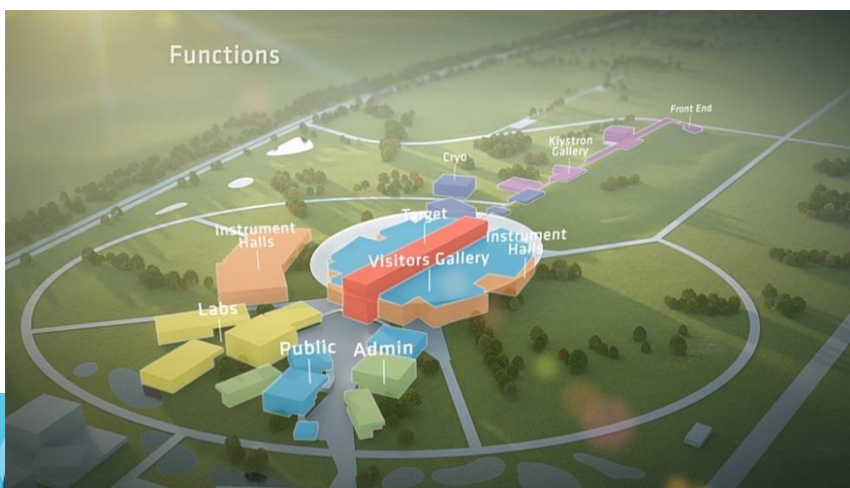
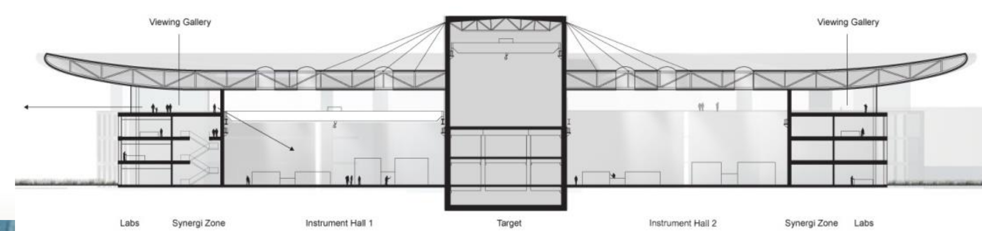
ESS Overview

- The European Spallation Source (ESS) will host the most powerful proton linac currently planned...
  - The average beam power will be 5 MW
- Built in Lund, Sweden with first neutrons in 2019
- End of construction in 2025 with 22 instruments online

What Will ESS Look Like?





ICS Programme and Organization evolution

- Organizational structure

[2010] Team

[2011] Group

[2013] Division

- Project structure

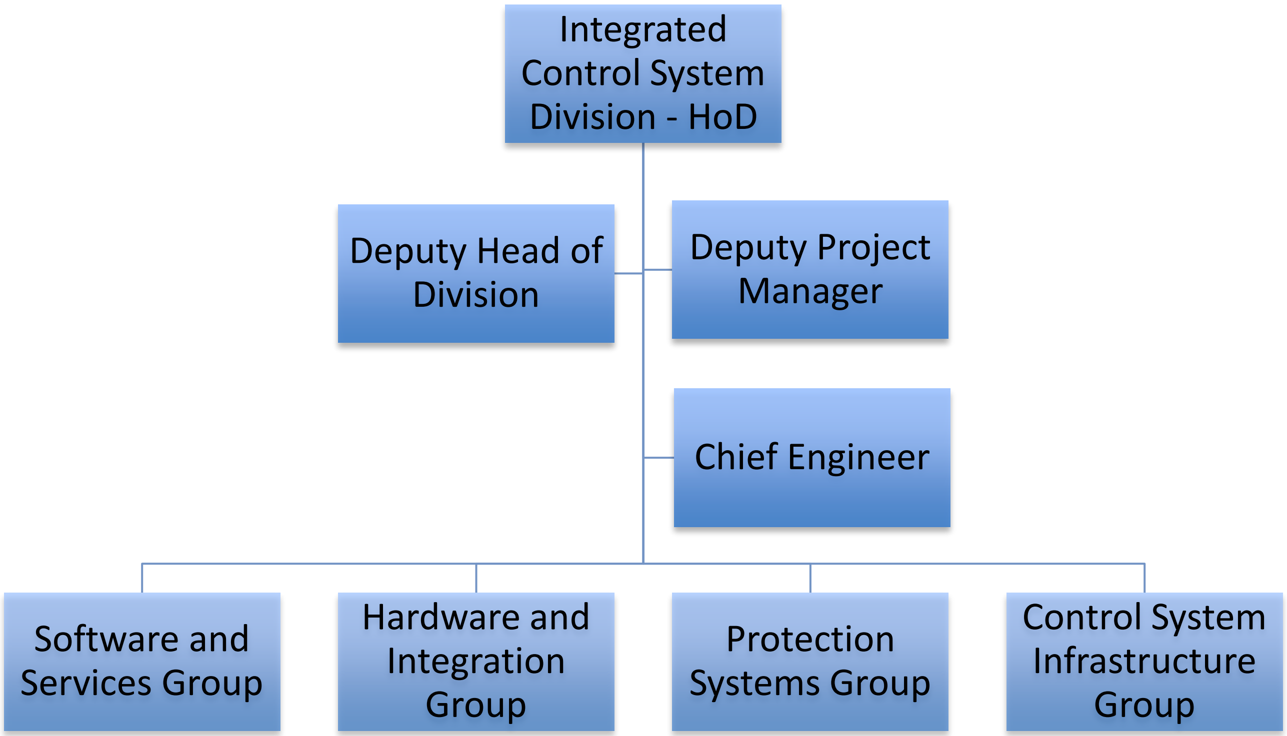
[2010] Activity

[2012] Project

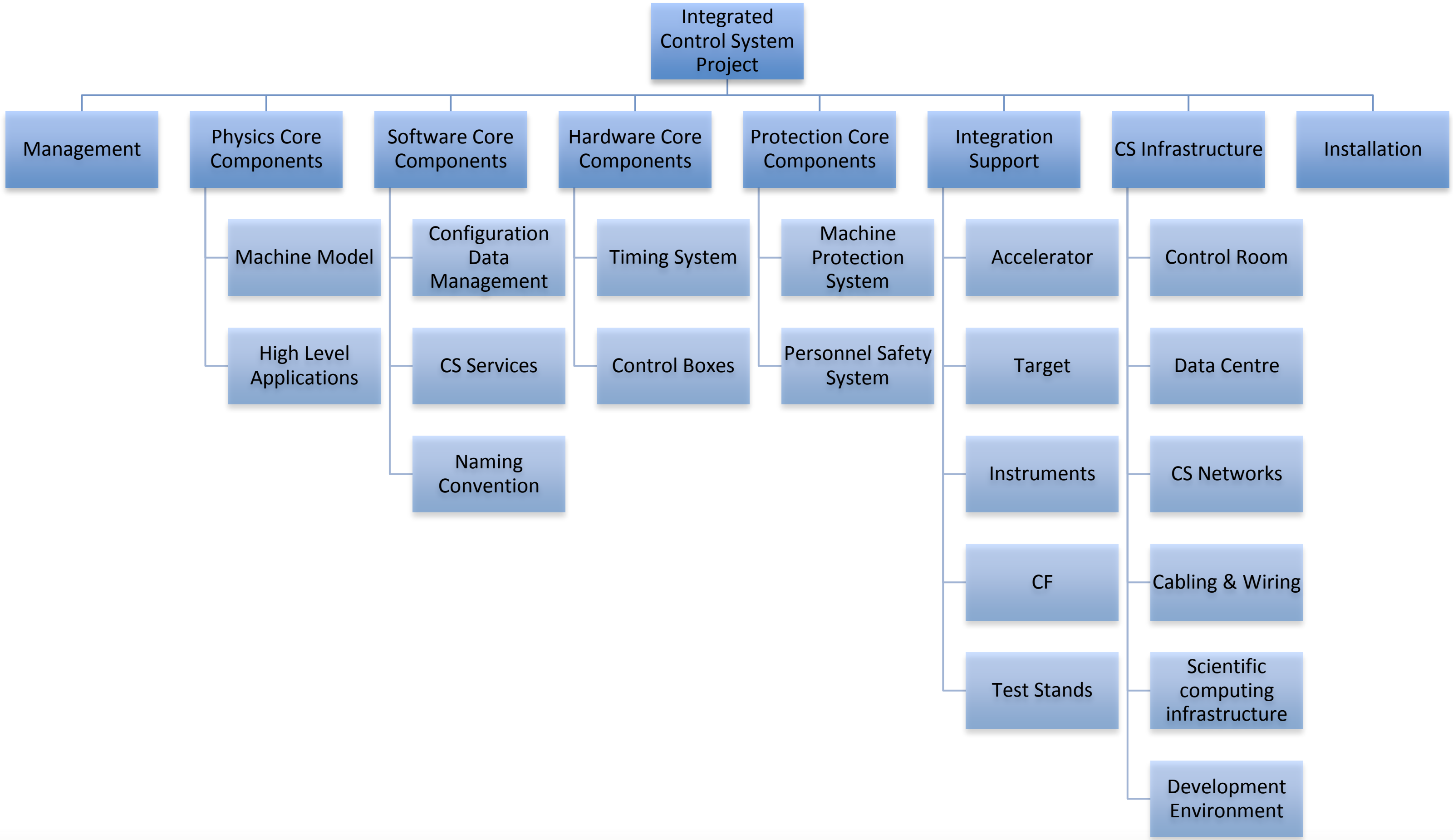
Top Level Requirements

- Provide the following to ESS:
  - Control system framework for monitoring and control of **accelerator**, **target**, **instruments** and **CF**
  - Timing service for **generating events**, **synchronization** of devices and **time stamping** (in the ns range)
  - Control system services and applications to perform **commissioning** and **operations**
  - **Control Boxes** and **Integration Support** to stakeholders
  - **Machine Protection** and **Personnel Safety** systems
  - Control Room(s)
- Constraining requirements
  - High reliability and availability (**>95%**)!

ESS Integrated Control Systems Division Organization

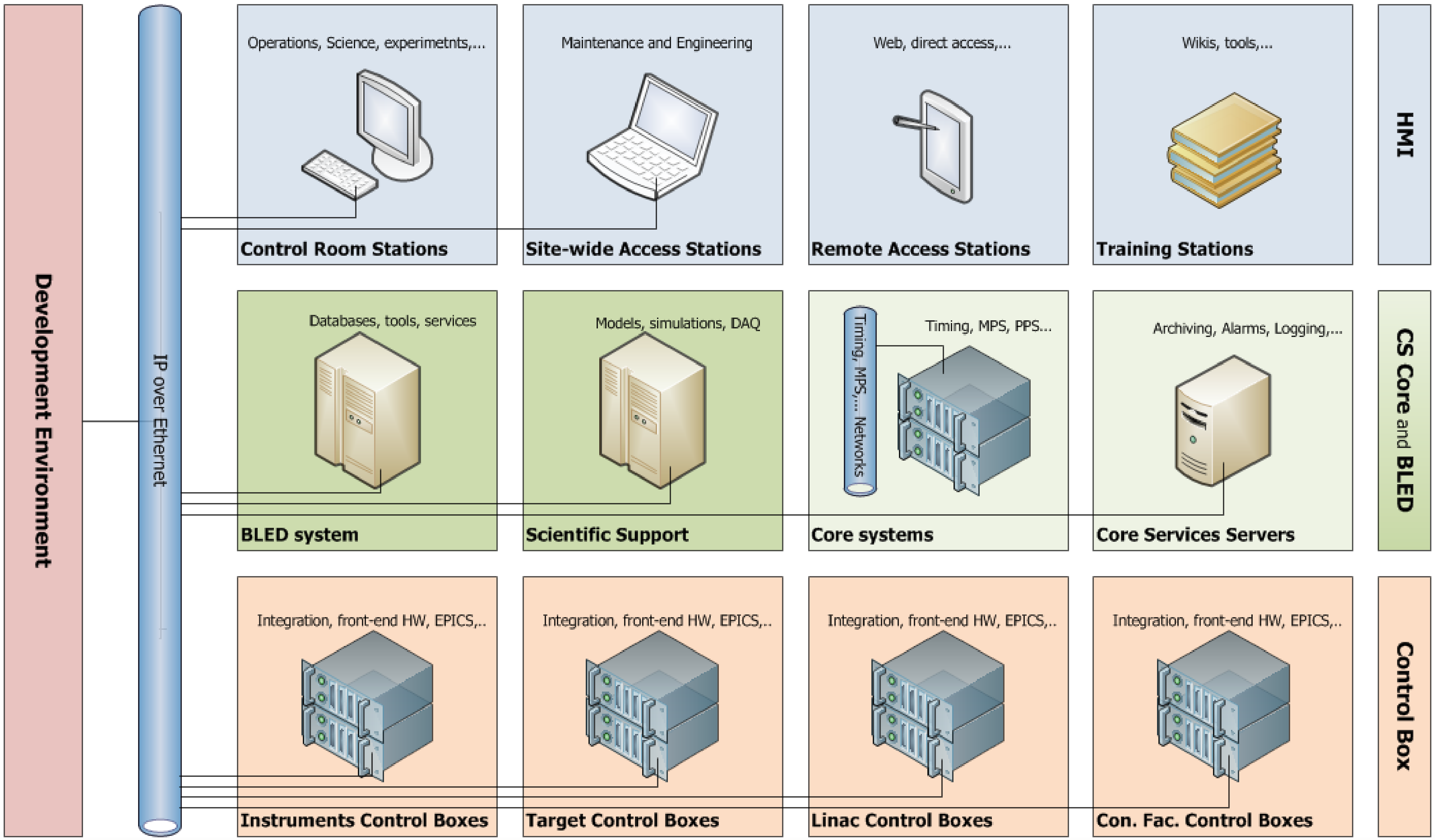


ESS Integrated Control Systems Project Organization

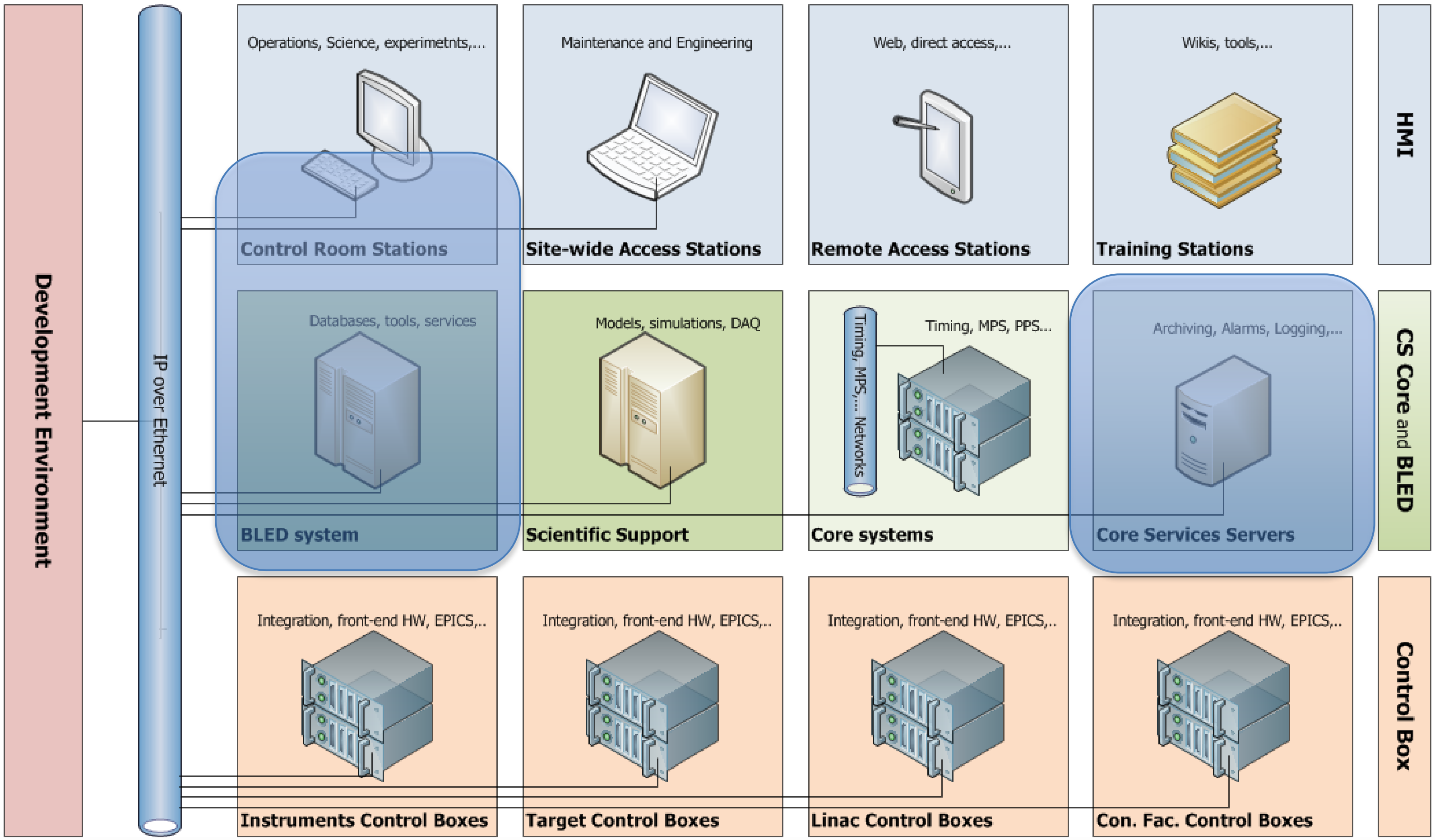


ICS Architecture

- **The three-tier architecture**



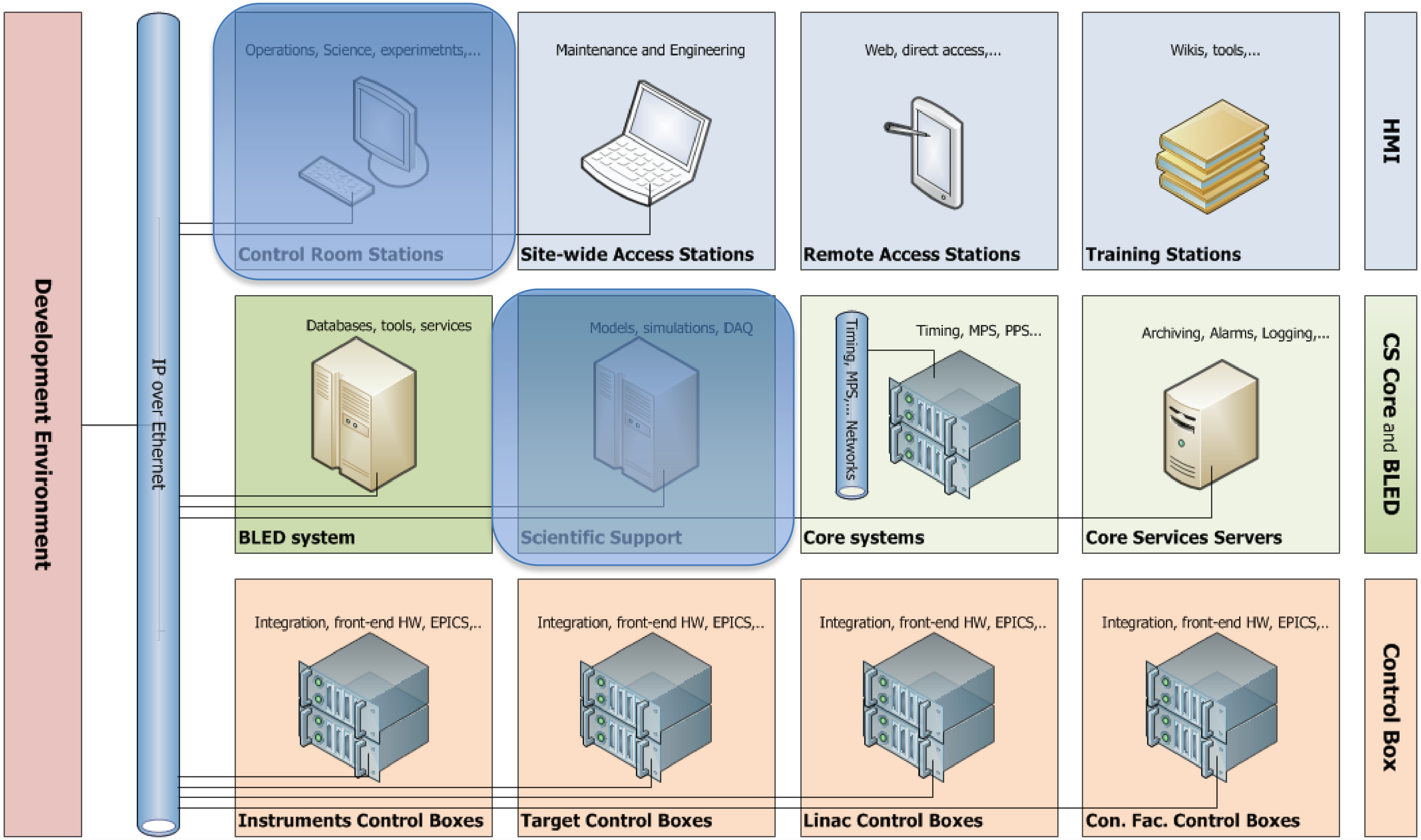
Software Core Components



Software Core Components

- **Configuration Data Management**
  - The collection, storage, and distribution of configuration, calibration, location … data
- **Control System Services**
  - Alarm handling Archiving, logging, long term storage, CSS, Logbook, Role Based Access Control (RBAC) …
- **Naming Convention**
  - *SSSS-BBBB:DDDD-III:TTTIIIXXX*
- **Scope**
  - Accelerator, Target, Neutron Instruments, and Conventional Facilities

Physics Core Components

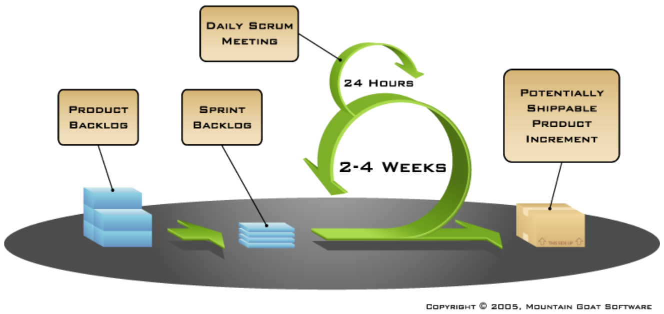


Physics Core Components

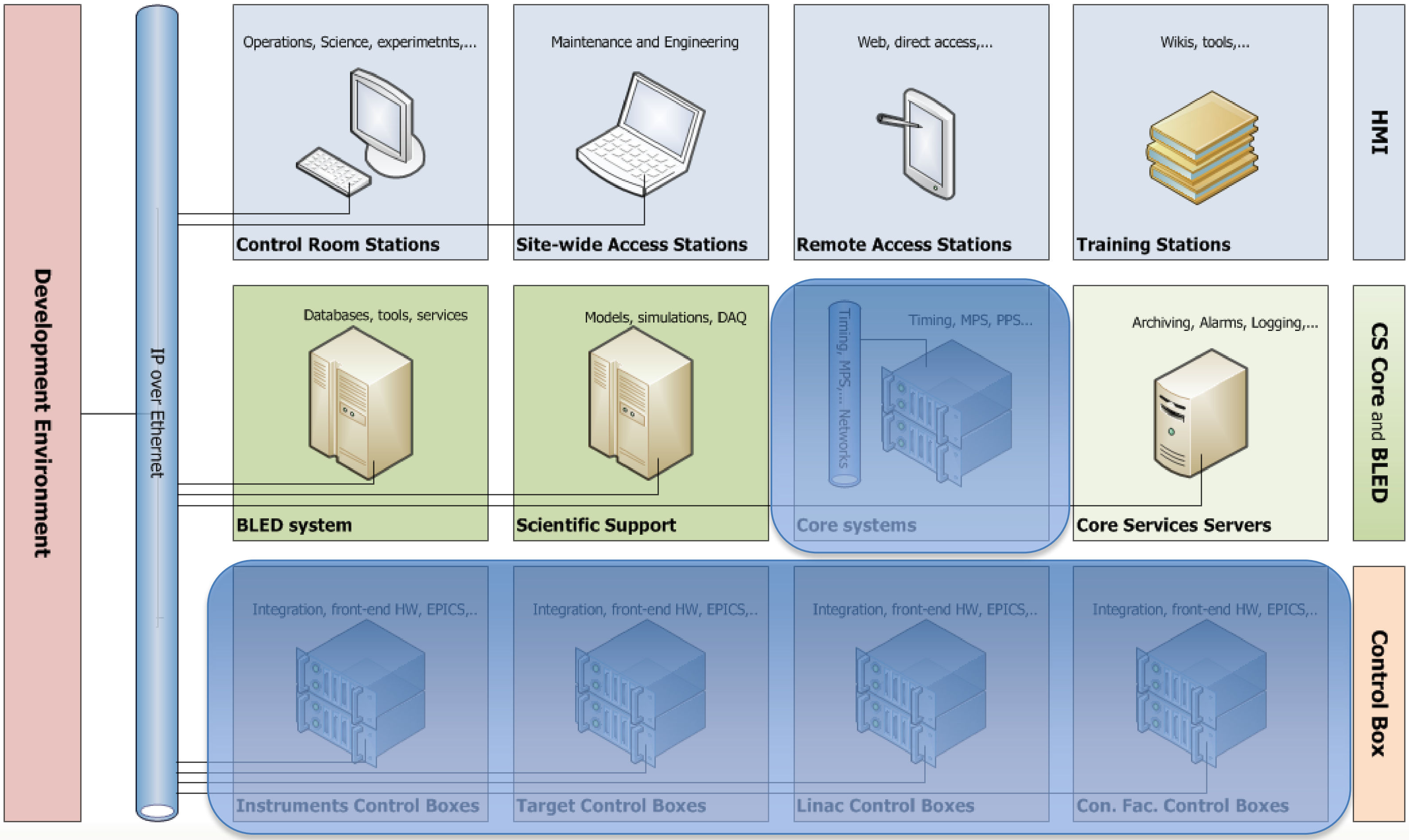
- **Purpose**
  - Model the machine and provide users the access to the control system and models
- **Machine Model**
  - Online models: OpenXAL, ELS, (JELS) …
  - Offline models: TraceWin, MadX …
- **High level applications**
  - Everything interfacing the users, operators, engineers, integrators, physicists, scientists, observers, innocent bystanders …
    - GUIs, Applications, Scripts, Tools …
- **Scope**
  - **Accelerator, Target, Neutron Instruments, and Conventional Facilities**

Issues and challenges

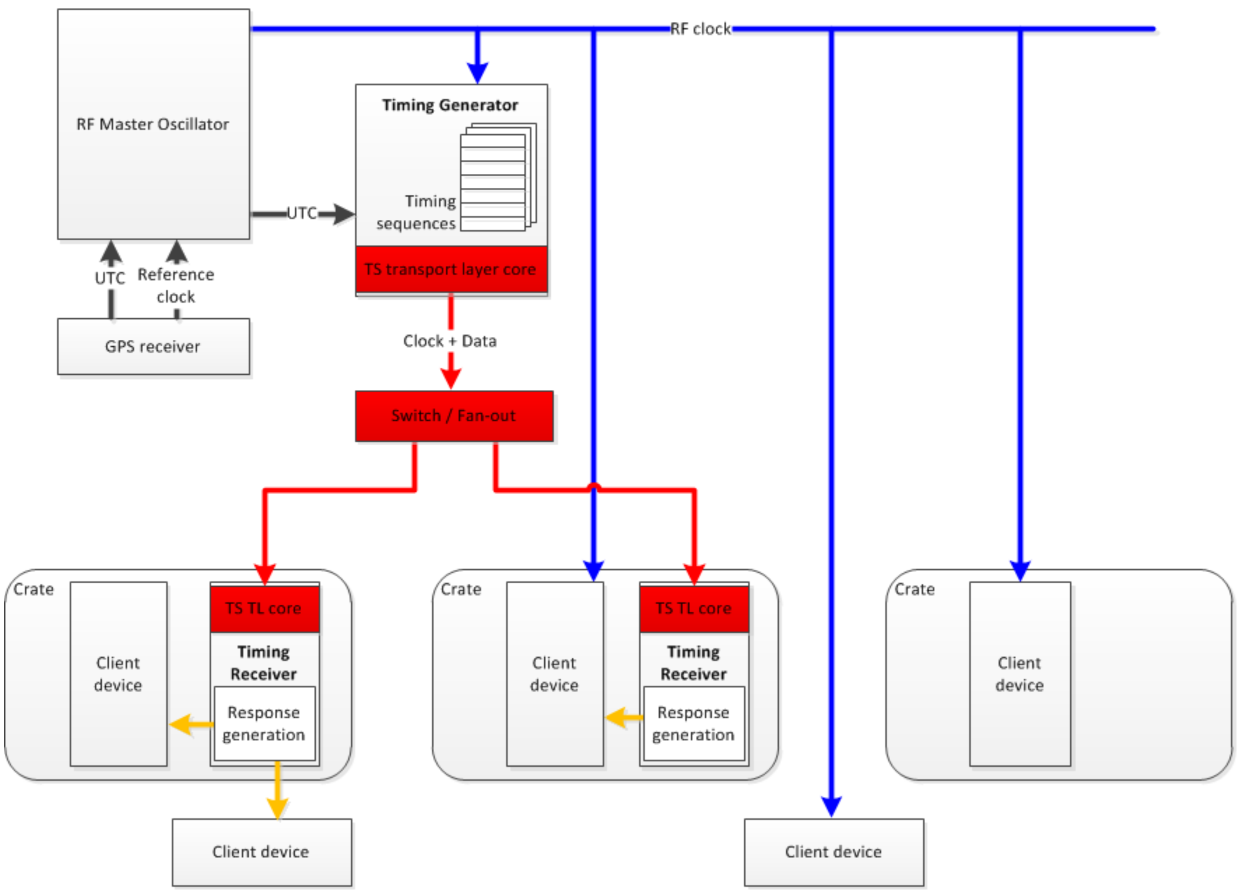
- Structuring of High-Level apps and Physics core
  - Scope of modelling, machine models as services?
  - What is (High level) Applications layer?
- (Re)usability
- Collaborations
  - DISCS (Distributed information Services for Control Systems)
  - OpenXAL
- Getting users on-board
  - Agile approach
    - Scrums, sprints, backlogs



Hardware Core Components

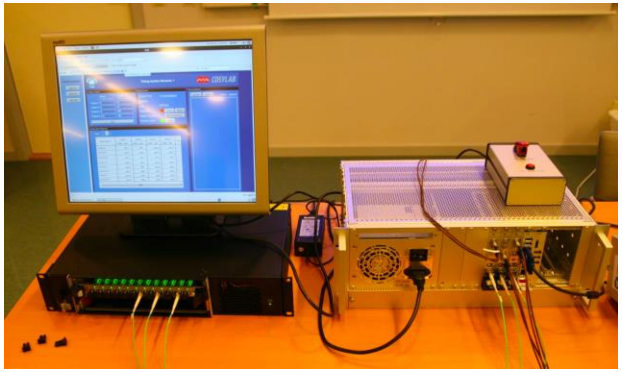


ESS Timing System



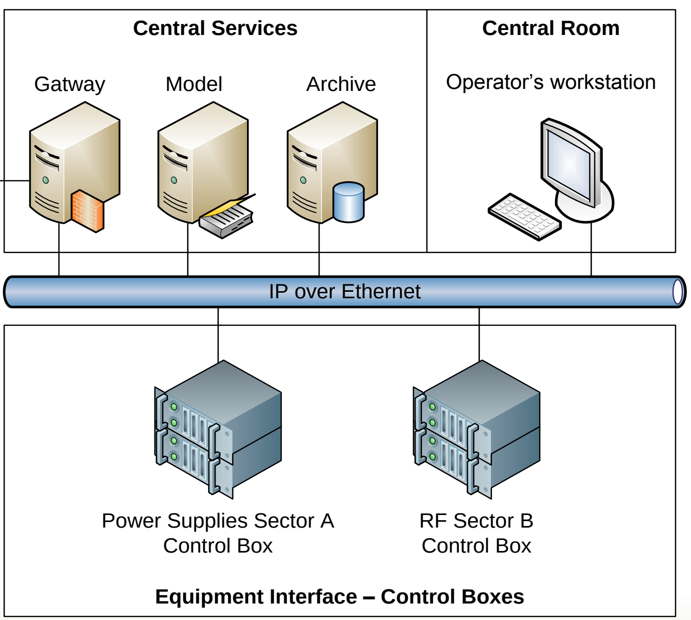
Characteristics

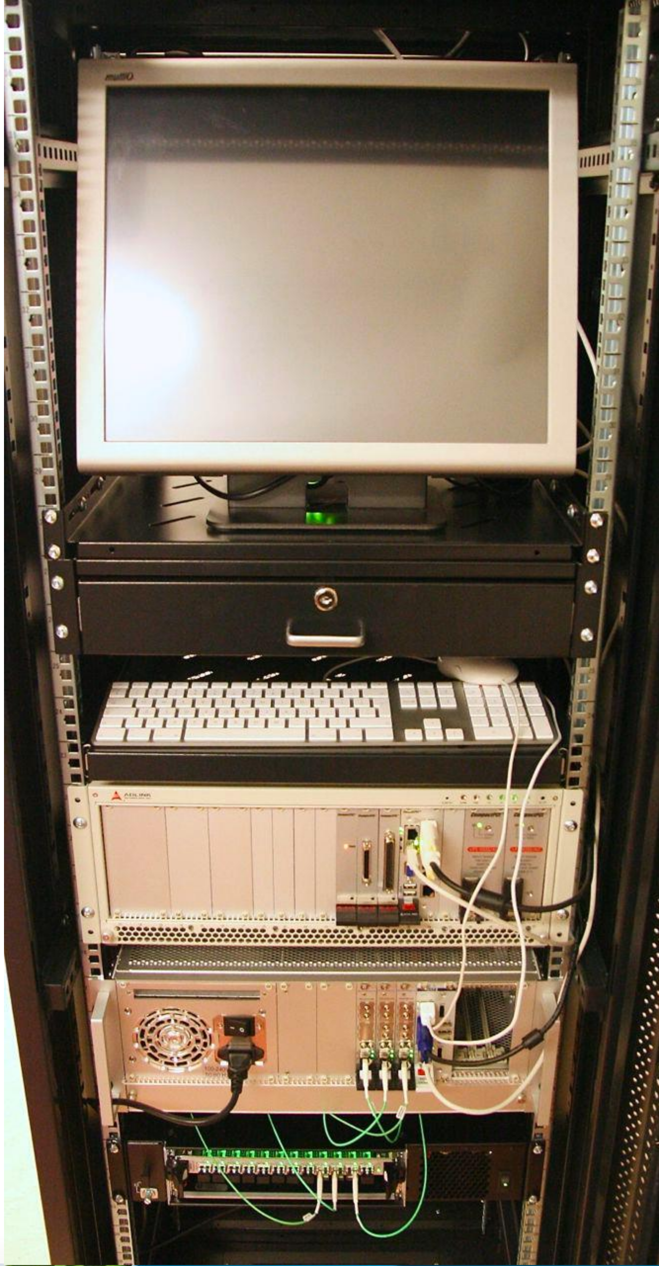
- Clock frequency: **88 Mhz**
- Event Granularity: **20 ns**
- Jitter: **40 ps**
- Prototype platform: **MRF**
- Uni-directional system



Control Boxes

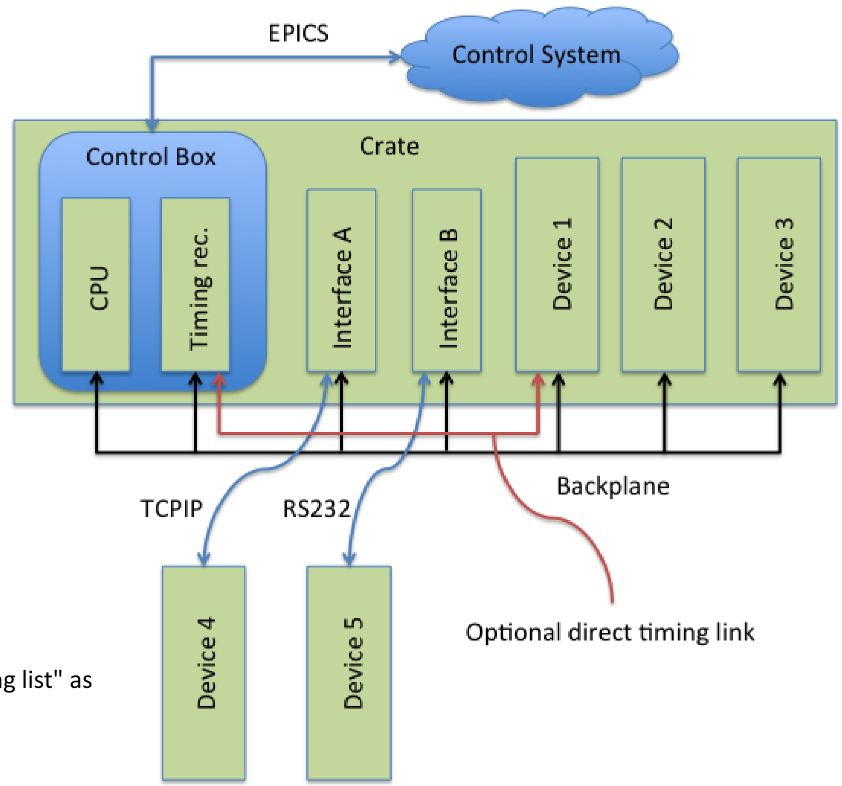
- "Servers controlling a collection of equipment"
- Also, HW Standardization





Control Boxes, the scope and responsibilities

- Fact:
  - “ICS provides control boxes to **ALL** the stakeholders”!
  - … Well accepted
  - … **But**, what <u>really</u> is a control box?



Control Box: CPU board + Timing Receiver + ICS Software

ICS Software: ICS CODAC* distribution and support for items from the "ICS shopping list" as defined by the list

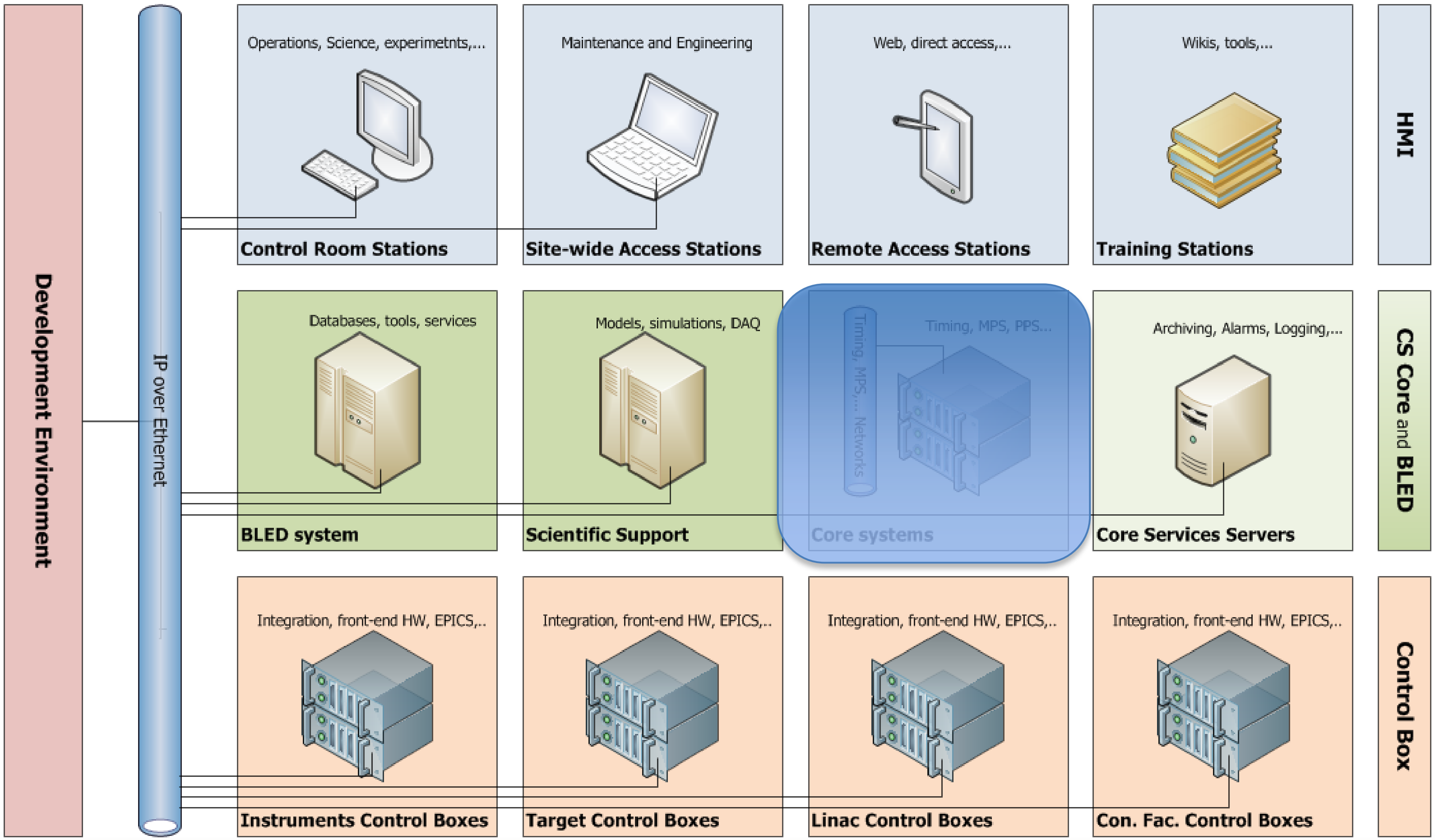
Ownership, responsibility and costing for Control Box: **ICS**

Example: uTCA CPU board, Operating system (Scientific Linux 6.0), ICS CODAC 3.0 distribution (EPICS 3.14 including Struck SIS8300 kernel drivers, EPICS device support, CSS etc.), uTCA Timing Receiver with EPICS device support.

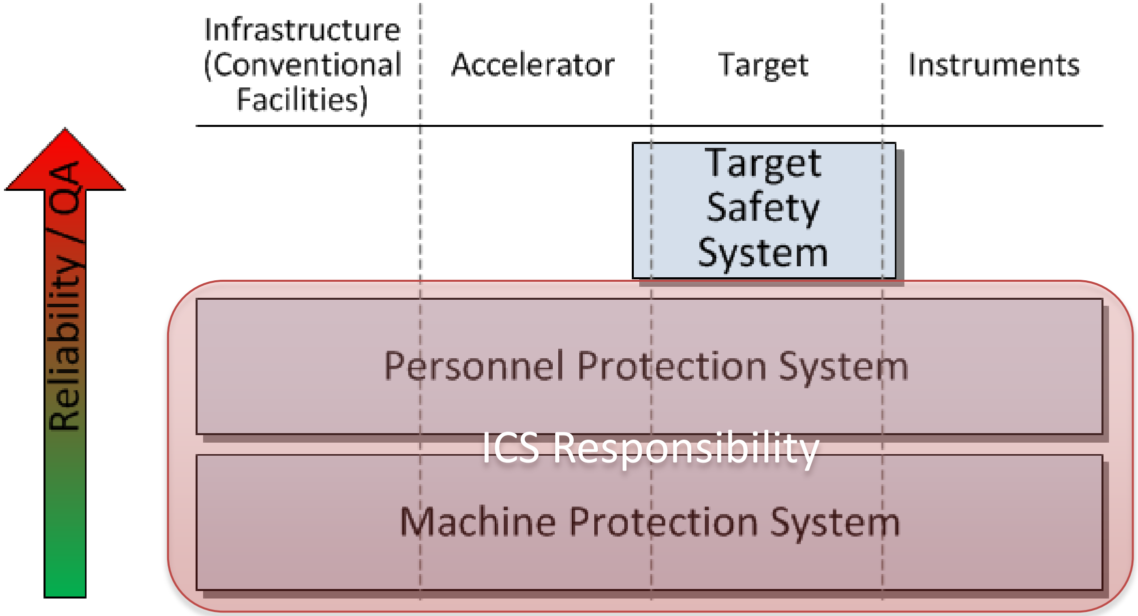
HW issues and challenges

- Interface control
  - ICS <-> Stakeholder,
  - Control Box <-> Stakeholder System
- Enforcing and maintaining responsibility
- Support and knowledge transfer
- Compliance to “standards”
  - HW, SW, tools etc.
- HW Platform(s)
  - cPCI, uTCA for Physics (MTCA.4)

Protection Core Components



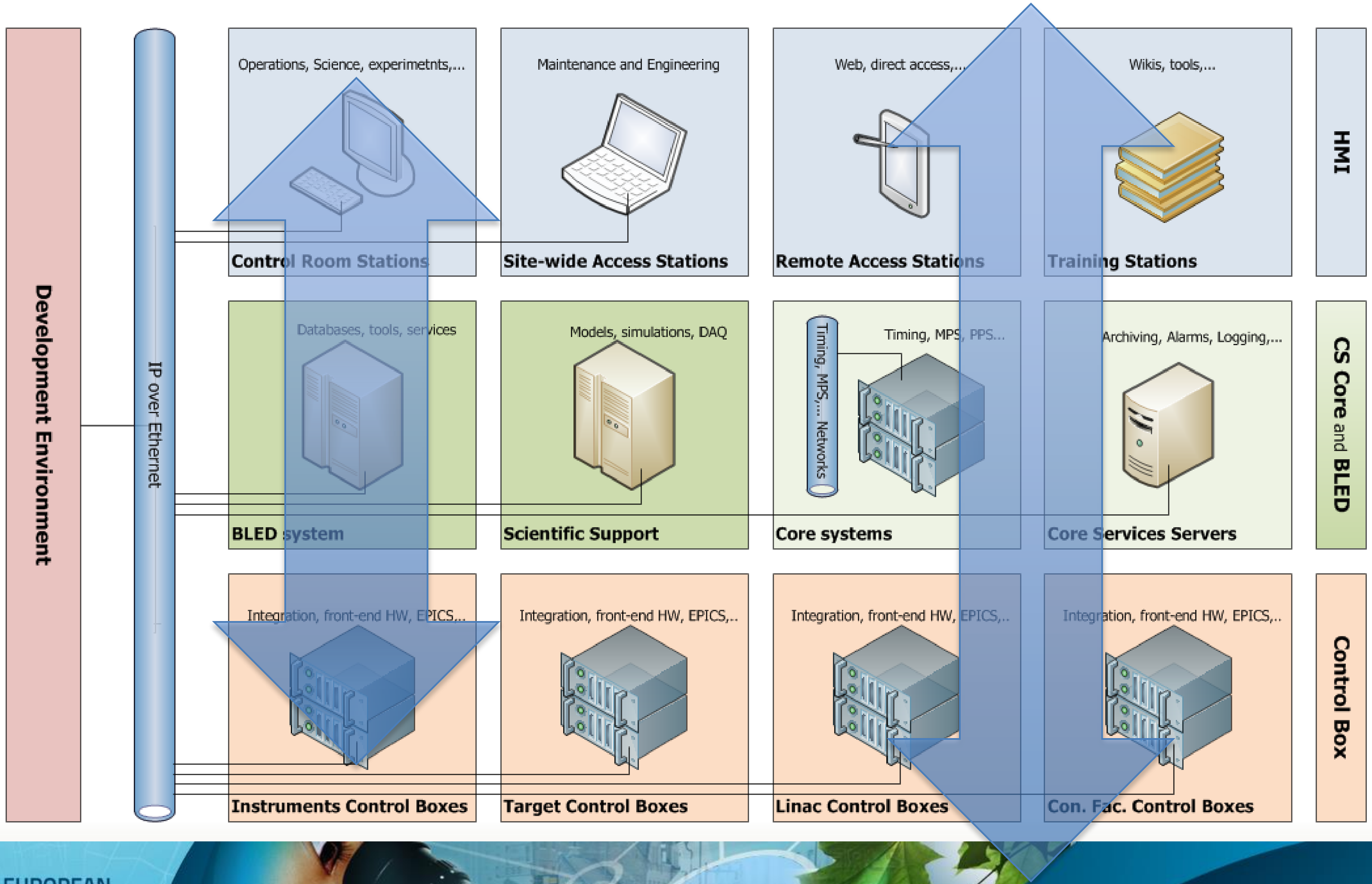
Protection Core Components



Machine Protection System

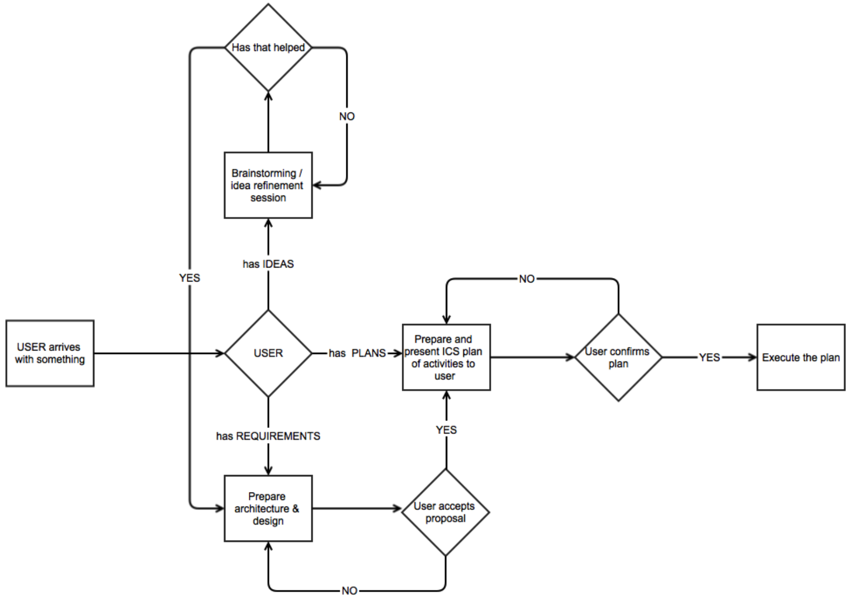
- **Scope of MPS**
  - Protect the machine's equipment from damage due to
    - Beam losses
    - Malfunctioning equipment.
- **MPS Design Function**
  - Initiate beam stop upon detection of non-nominal conditions.
- **MPS Design Approach**
  - Follow IEC61508 standard, where applicable.
  - Optimize integrated machine performance according to ESS overall goal of reaching 95% reliability and high beam availability.

Integration Support

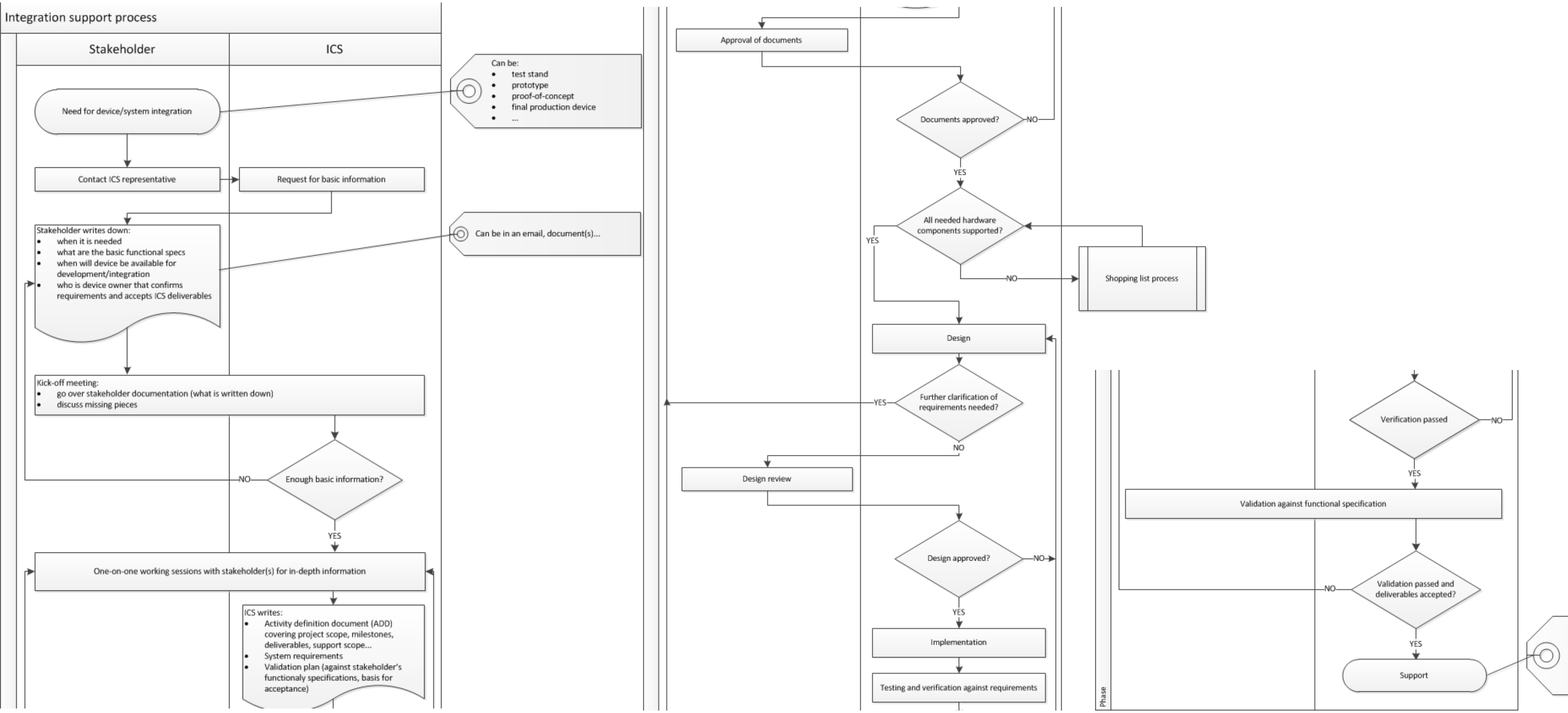


Integration Support, motivation

- A standards-based way to meet stakeholder requirements
- Stakeholders approach ICS with:
  - Requirements
  - Plans
  - Orders
  - Money
  - Equipment
  - Ideas
  - Other

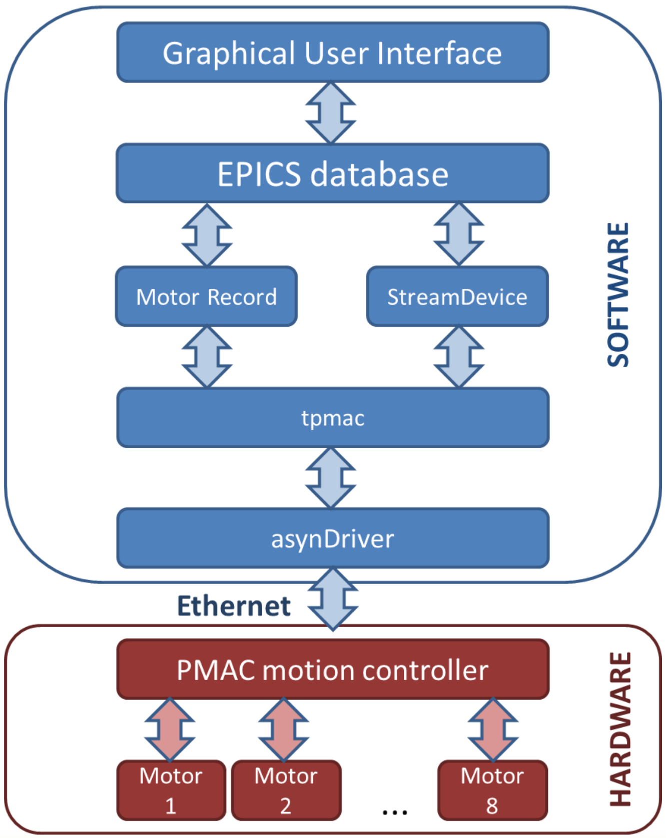


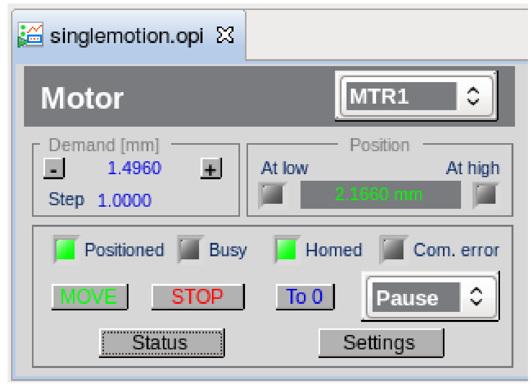
ICS Integration support flow chart

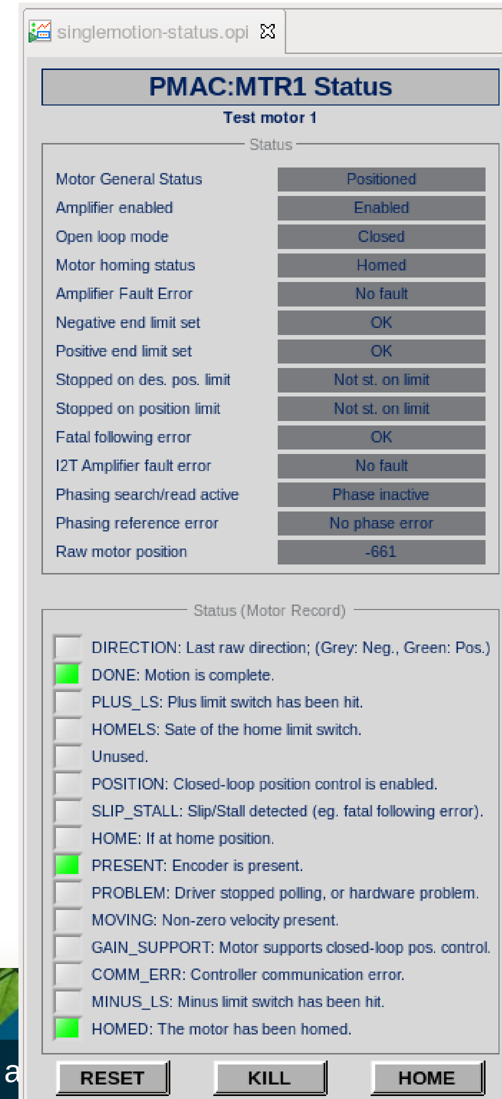


Integration support examples

- DeltaTau GeoBrick motion control

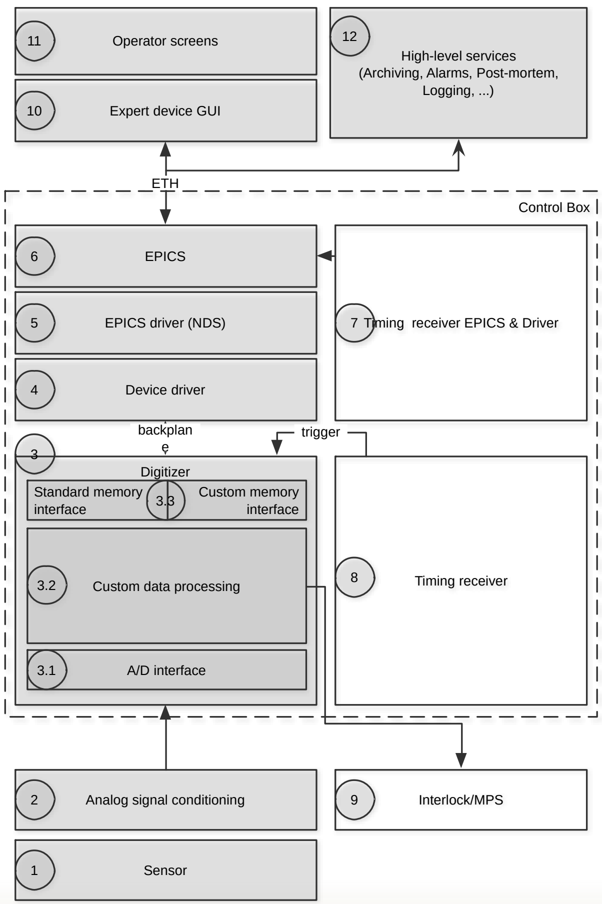


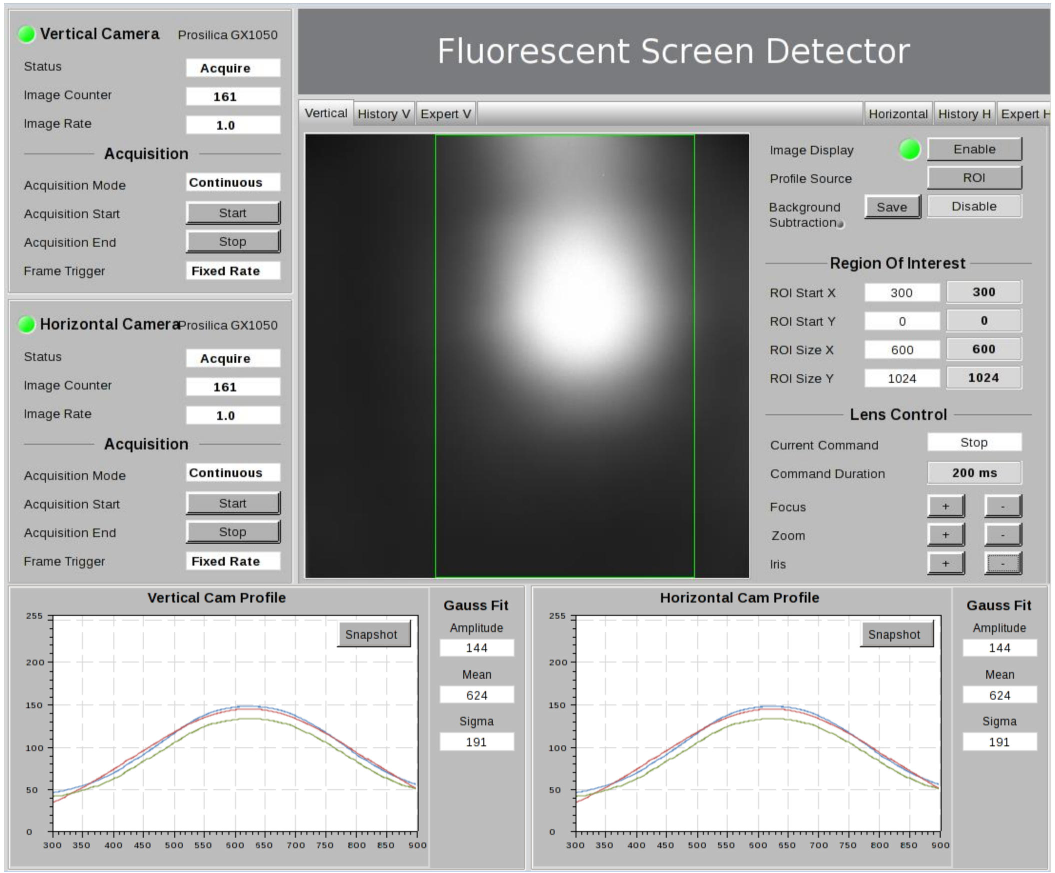




Integration support examples

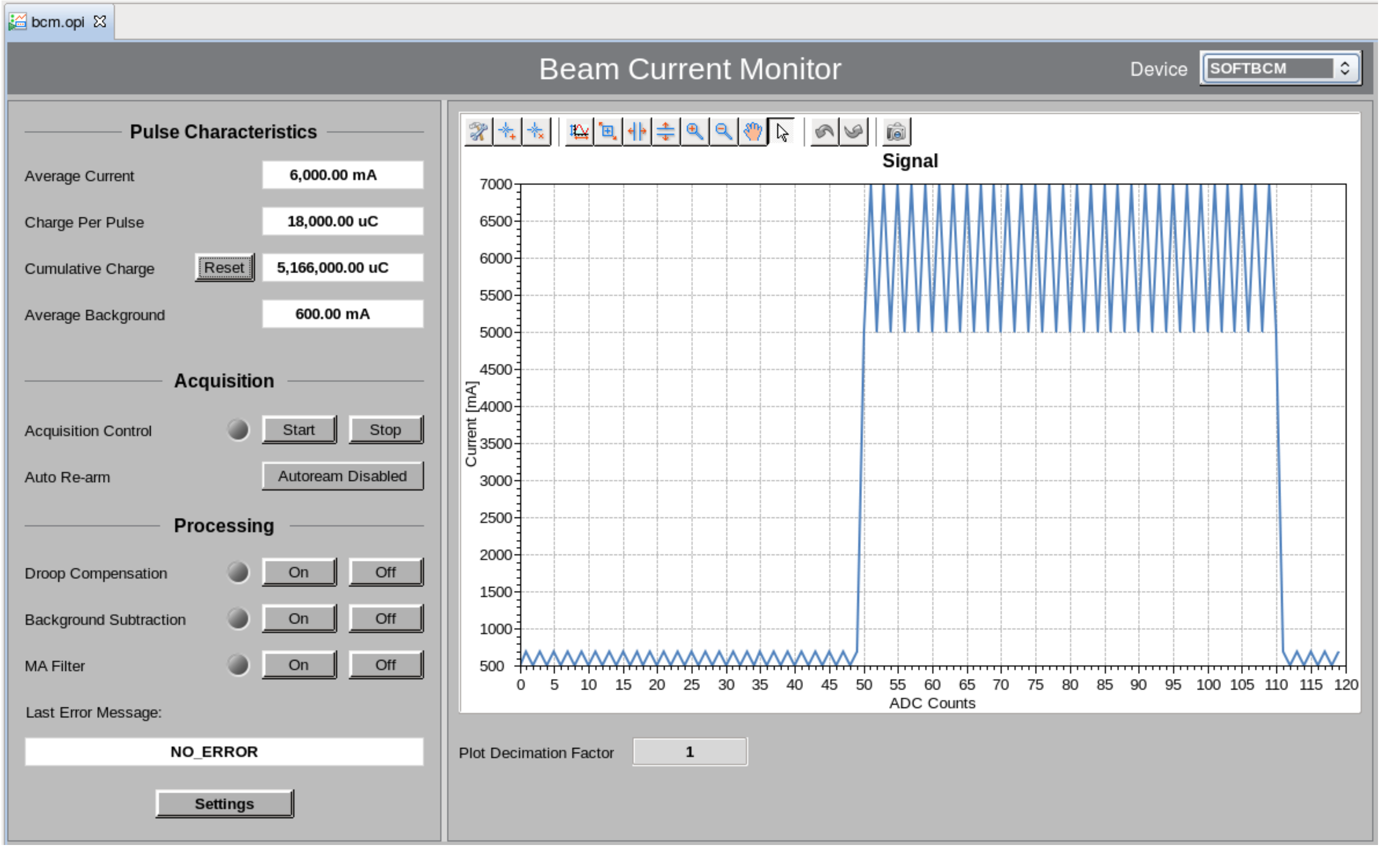
- Beam diagnostics





Integration support examples

- Beam diagnostics (uTCA.4)



Integration support examples

- RF

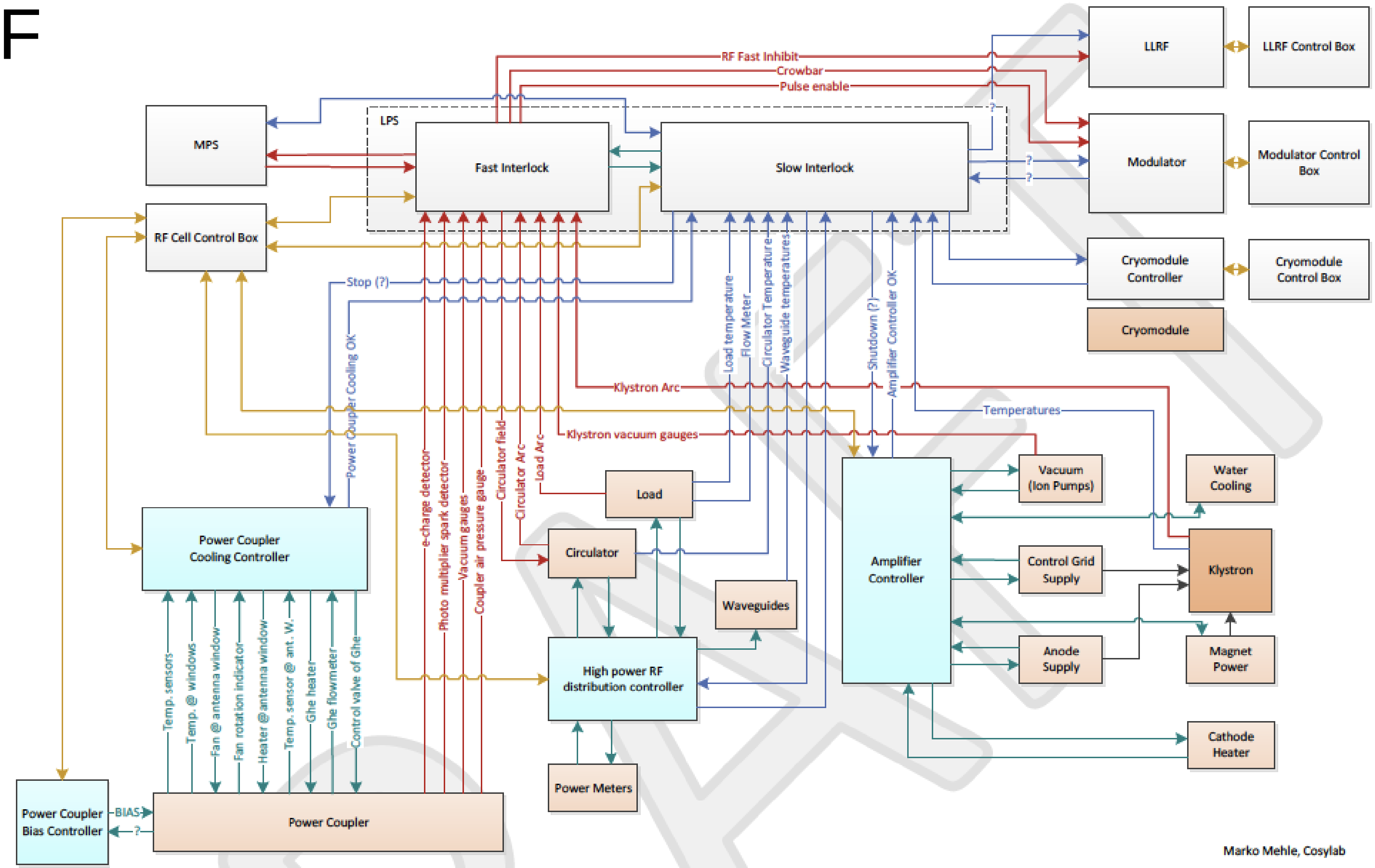
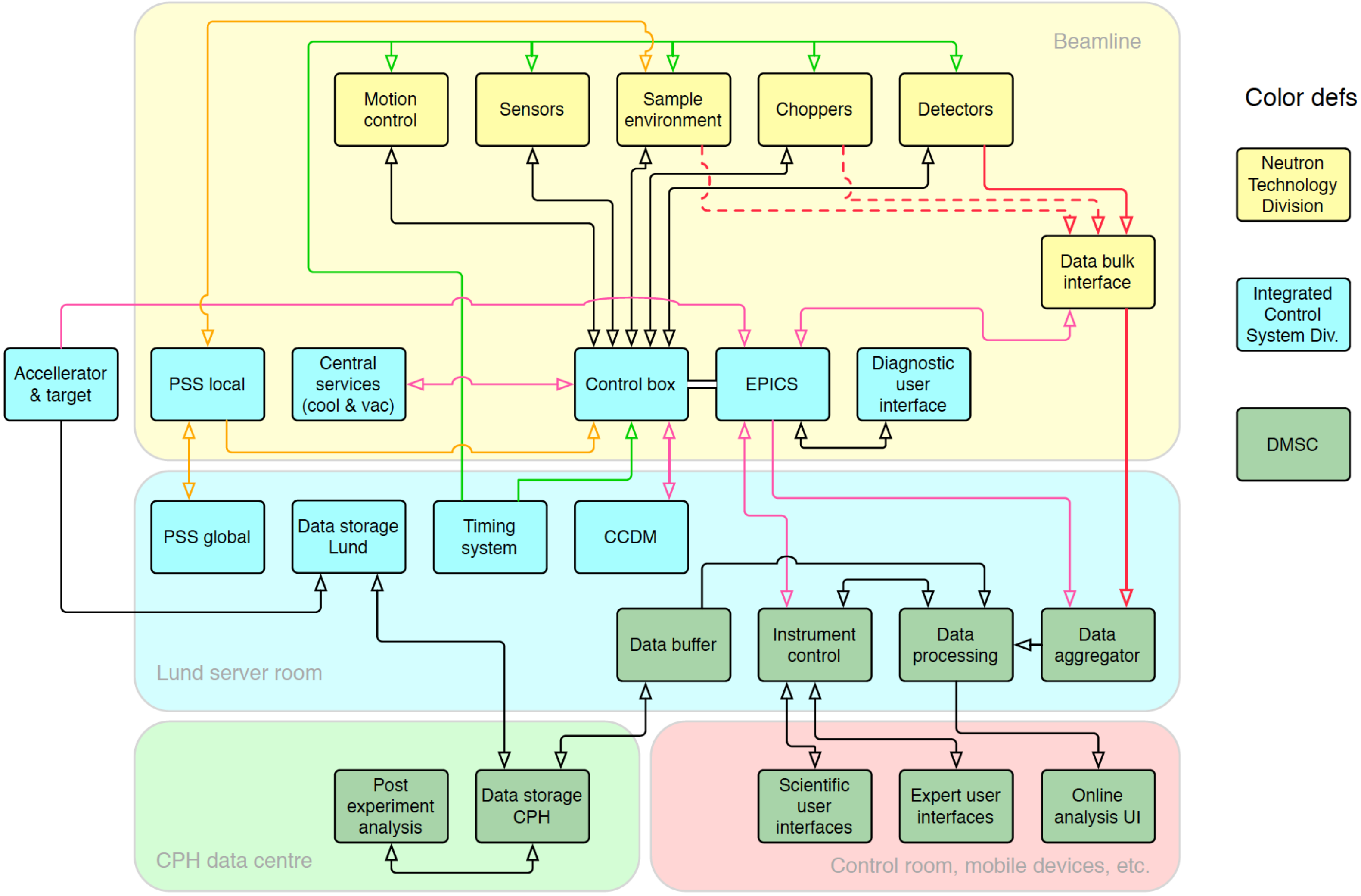


Figure 1: RF Cell Control & Protection systems

Integration support examples
Scientific Projects Division (Neutron Instruments)



Integration issues and challenges

- Establishing and driving the process
- Communication and transparency
  - Who is responsible for what, who does what, at what meeting we discuss what?
- Costing
- Bringing the users on-board
- Leveraging solutions developed for one system to others

Facts

[2013] Today

[2014] Intensive start of development and prototyping

[2015] Major test stands online, major integration start

[2016] Should be up and running

[2017] Must be up and running!

Conclusions

- Building Integrated Controls at ESS will be challenging
- Adopting a standards based strategy for core hardware, software and integration support is critical to completing the project on schedule