ESS Integrated Control System Progress Report

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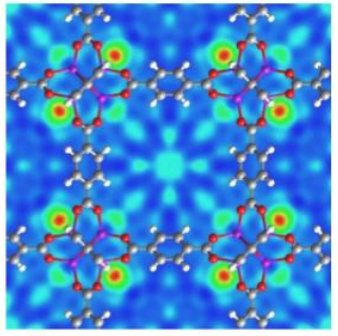
Overview

- Recap of ESS
- Project status update (pictures)
- ICS organisation
- ICS technologies
- EPICS activities
- Tools and status
- About growing pains
- Summary and outlook

The European Spallation Source

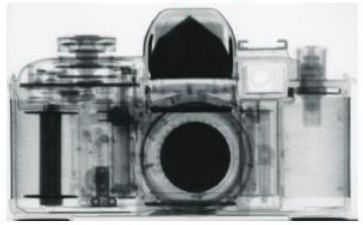
- ESS is a neutron spallation source for neutron-based multi-disciplinary science.
- Neutron scattering can reveal the molecular and magnetic structure and behavior of materials:
  - Structural biology and biotechnology, magnetism and superconductivity, chemical and engineering materials, nanotechnology, complex fluids, etc.
  - Often complementary to light sources
- The European Spallation Source (ESS) consists of :
  - a pulsed accelerator that shoots protons into
  - a rotating metal (tungsten) target to produce neutrons
  - (up to) 22 neutron instruments for various experiments
- The European Spallation Source (ESS) will house the most powerful proton linac ever built.
  - When we (one day) reach the specification: one beam pulse has the same energy as a 7.2kg shot traveling at 1100 km/hour (Mach 0.93). 14 times a second.



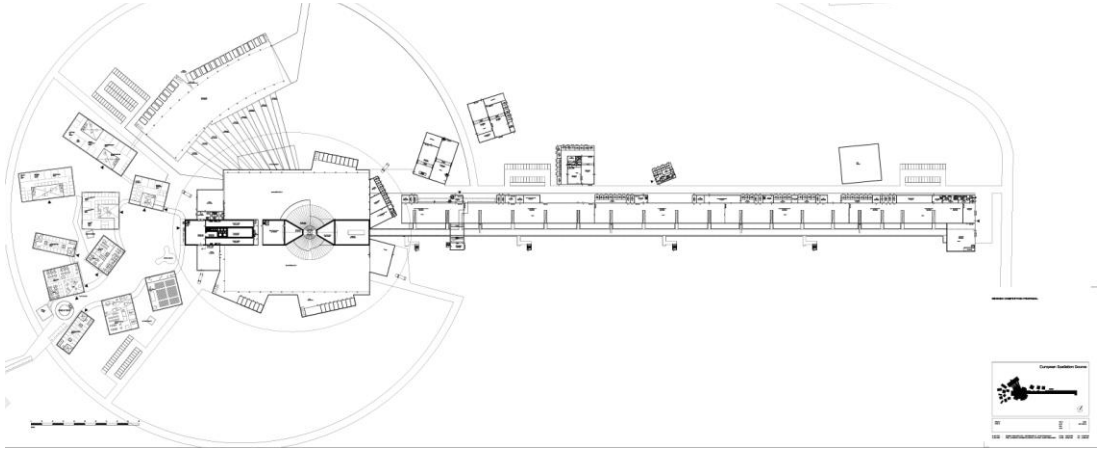
Neutron scattering of hydrogen in a metal organic framework

Neutron radiograph of a flower corsage

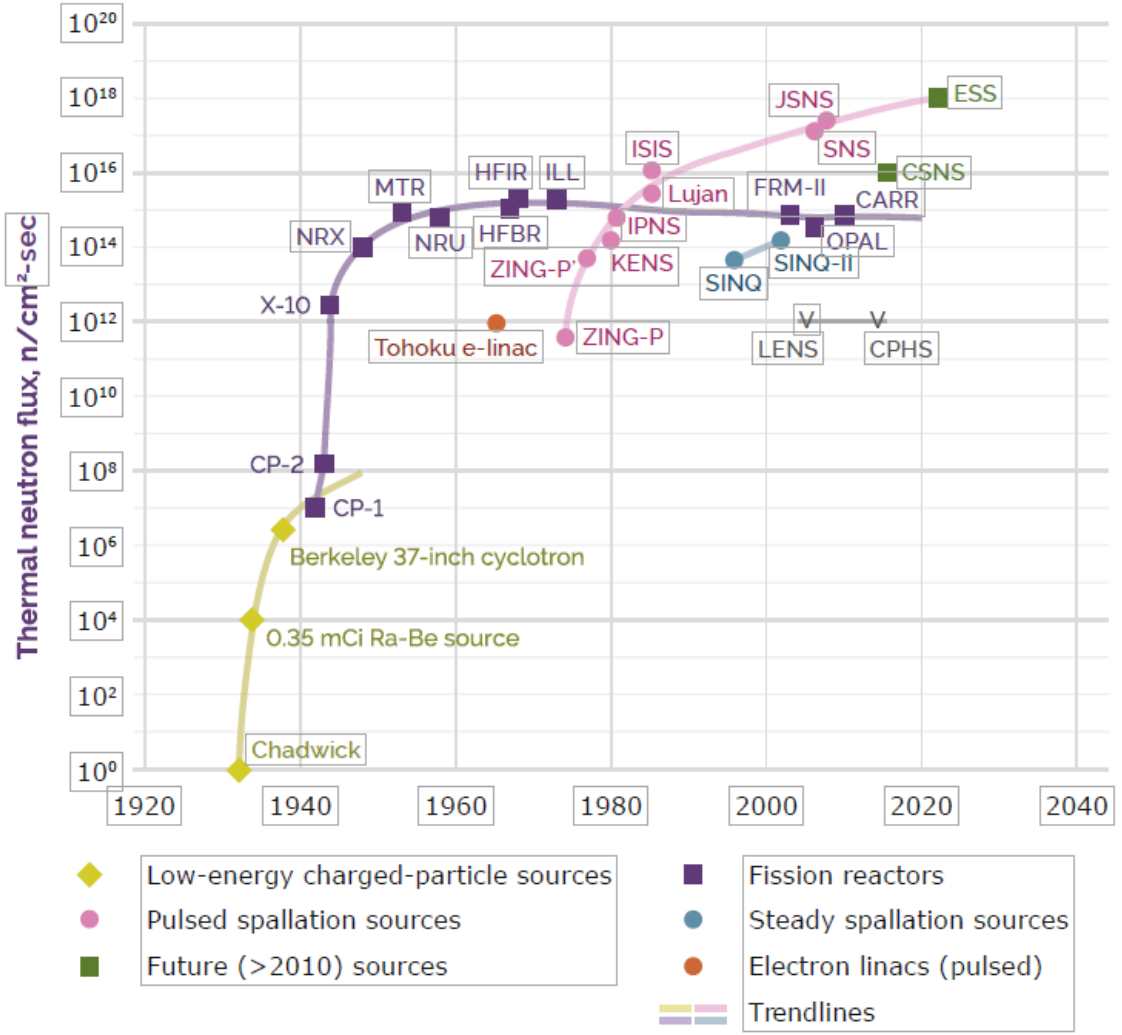
X-Ray Image



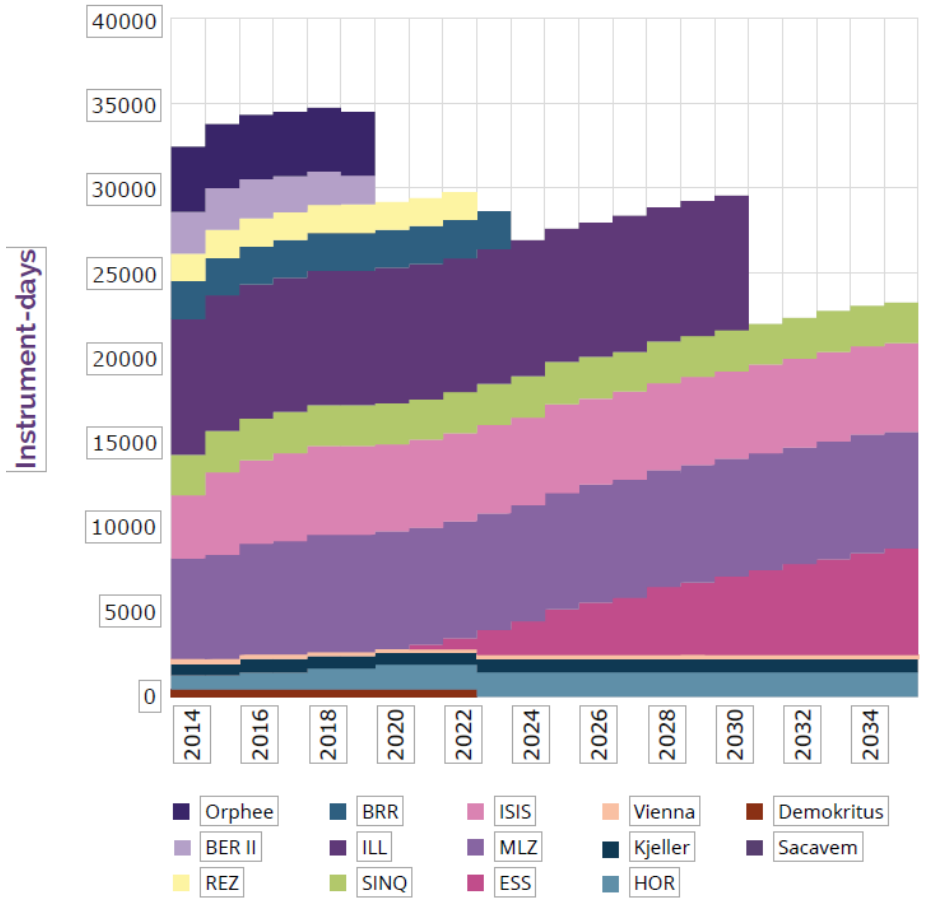
Neutron radiograph



Why is ESS being built?



Neutrons for science in Europe



The European Spallation Source

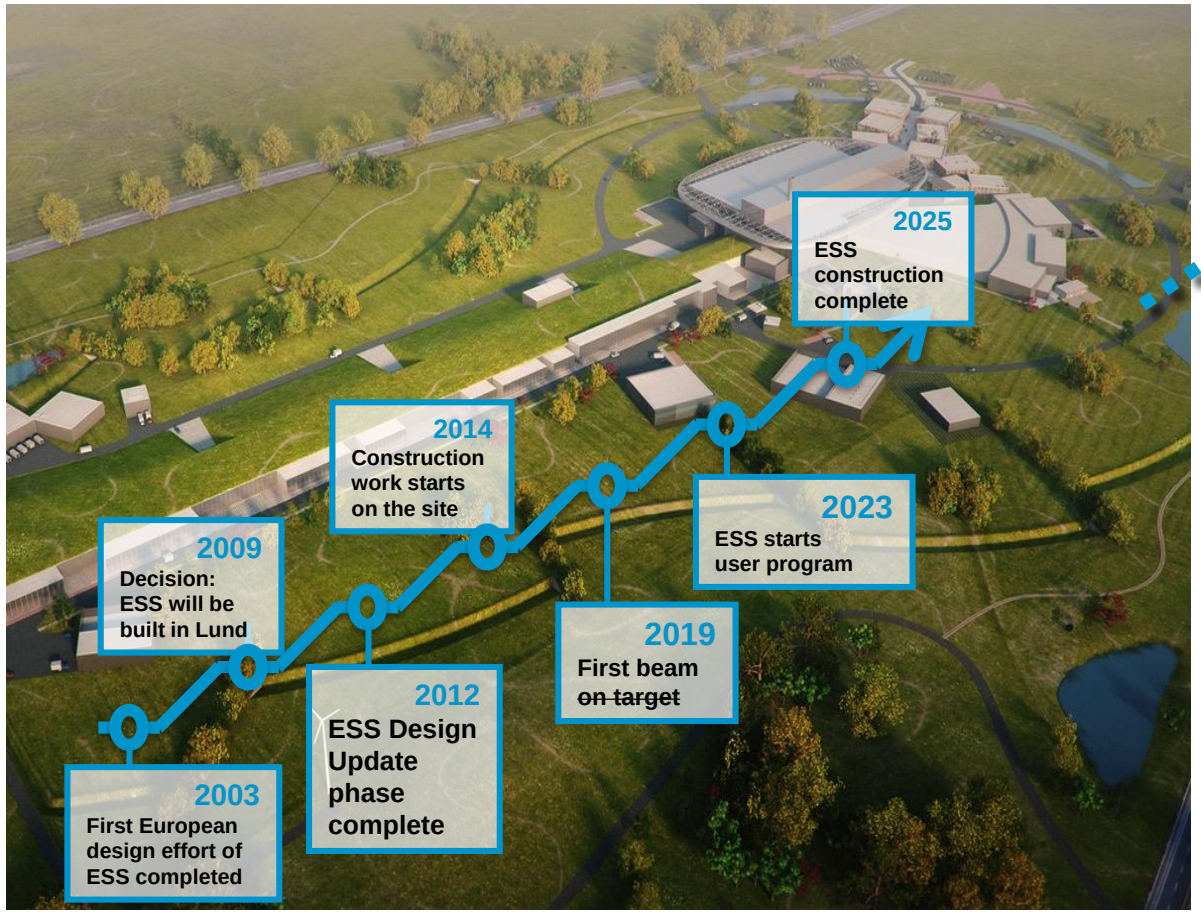
Artist's view…

ESS Site, a recent aerial photo

For some reason always brings to my mind this…

Timeline for the ESS facility

A few years old picture, just needed a very small update to show that we are still on track.



2067
Decommissioning

A lot of equipment arriving and installed…

Cryogenic plants delivered, installed and commissioned

Commissioning the first parts of the accelerator

Temporary Control Room
(Final control room will be in target building, not ready yet)

Ion Source & Low Energy Beam Transport (ESS, INFN Catania and CEA Paris collaboration)

Tunnel installations

Waveguides installed in stubs. Many concerns (space, installation, etc.) but the end result looks quite neat.

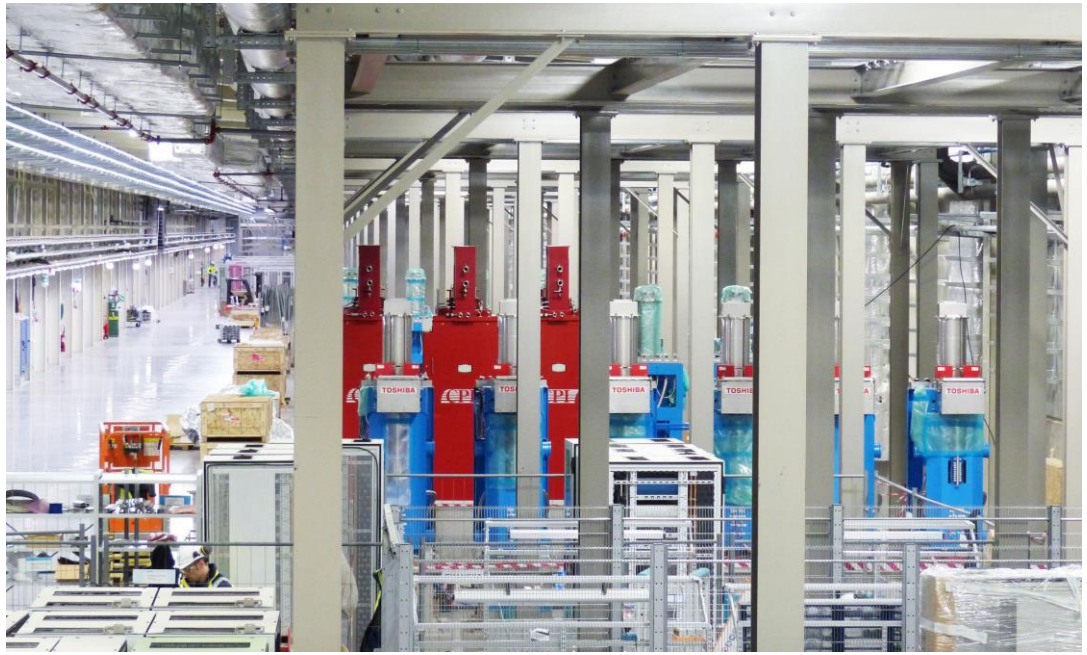
Cryo distribution lines being installed. The tunnel starts to feel tight…

Cool stuff

Cryomodules also start to arrive (first unit)

Coldboxes of the cryogenic systems.

Klystron Gallery installations



Klystrons waiting for test and installation.

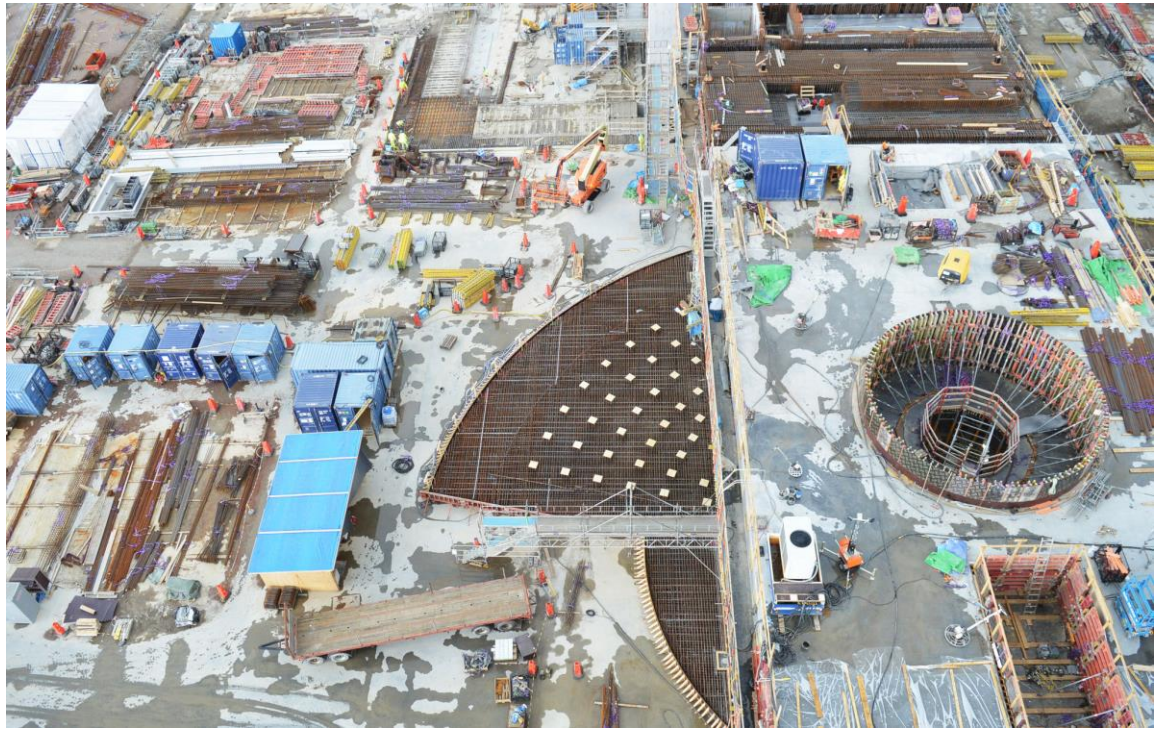
RF Waveguides and loads are being installed

Not only RF…

Equipment racks installed and populated

Pre-assemblies of “linac warm units” with magnets.

The massive target station



Integrated Control System (division)

- Is responsible for all control system integration for
  - The accelerator
  - Target station
  - Neutron instruments (up to, but not including experimental data processing)
  - Conventional Facilities integration (water, power, HVAC, etc.)
- Provides EPICS integration for subsystems in all of the above
- Provides facility-wide services
  - Timing system, machine protection, networking, archiving, configuration services, etc.
  - Also Personnel Protection systems
- Is a division in the ESS Machine Directorate (Accelerator, Target)
  - But also serves the Science Directorate (for neutron Instruments integration)

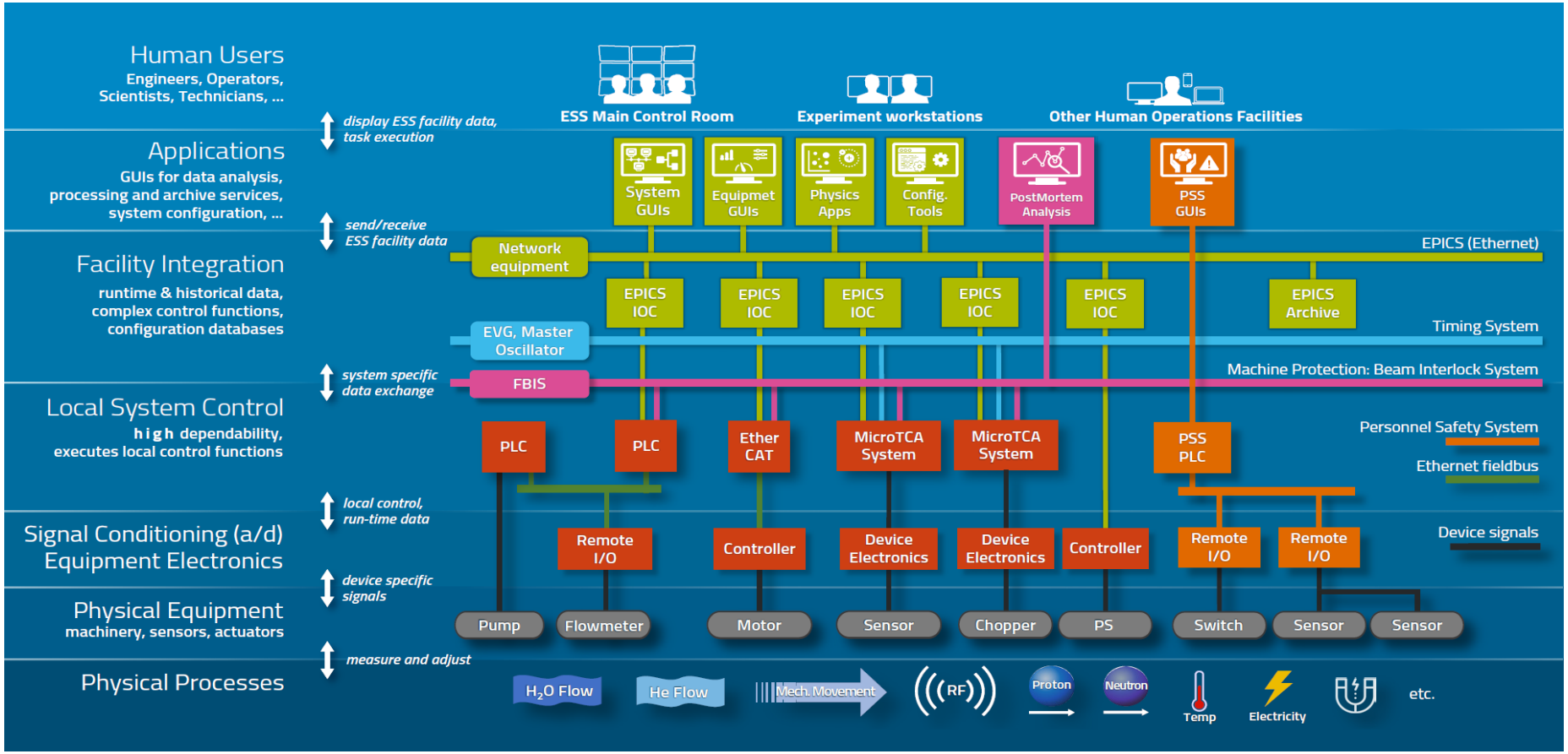
ICS Organization
2019-05

Permanent employees	45
Temporary employees	6
On-site consultants	25
Off-site consultants	8
Open positions	2

∑=84

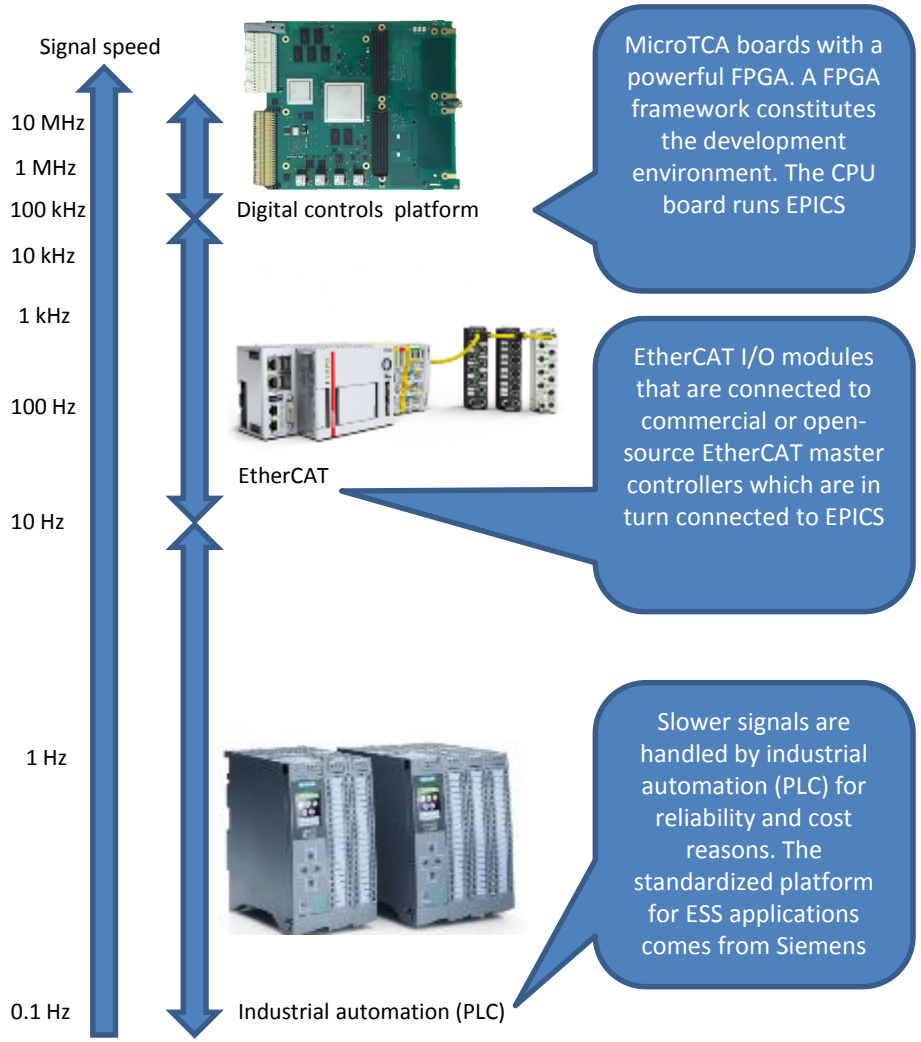
ESS-0081625

Control system overview



This is roughly the scope of ICS

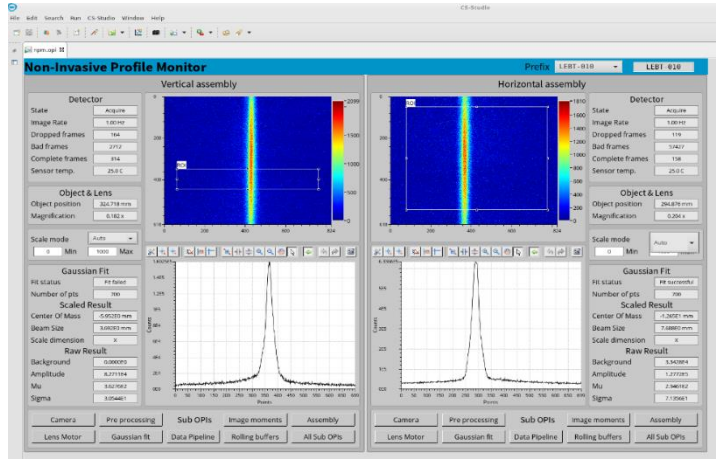
Three layer strategy - control systems hardware at ESS

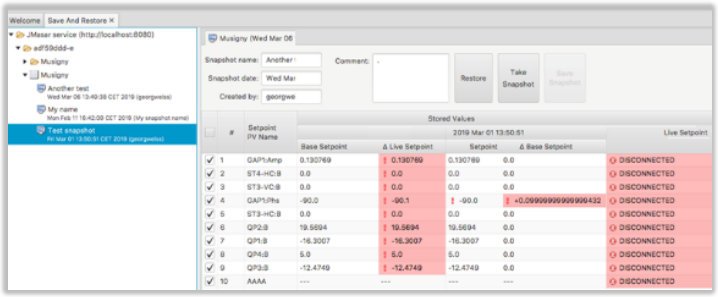


- **ICS has adopted a three layer strategy for implementing the control system based on signal speed**
  - A custom made platform based on microTCA for applications with data acquisition exceeding 100 kHz
  - Fast data processing happens in FPGA, augmented by ample CPU power. Timing included in every system.
  - For slower signals, EtherCAT will be used as a real-time fieldbus with good price/performance ratio
  - Synchronization and event information are key for applications where a full custom platform solution would be too costly
  - Low speed signals are handled with commercially available PLC systems from Siemens
  - This is a cost-effective solution that addresses ESS reliability and maintainability requirements
  - The PLCs will be connected to EPICS for further integration into the control system

Software components/tools/services

- EPICS, of course
- Archiving: Archiver Appliance
- Control System Studio
  - Display Builder, etc.
  - Going for Phoebus (replacing Eclipse RCP)
- Channel Finder
  - Starting to put this in real use – now that we have hardware to control
- OpenXAL for accelerator physics modelling
- Calibration service
  - Handling of unit conversions – measurement data to conversion coefficients
    - Actual conversion happens in the IOC (obviously)
- Configuration management tools (databases, EAM)
- Logbook
- Etc.





EPICS at ESS

- Committed to use EPICS 7 with pvAccess fully throughout the facility
  - IOCSs, even 3.15 are equipped with PVA modules
    - even if people often forget this…education needed.
    - More education needed to start using the new features – this is underway
  - All tools support pvAccess
    - CS-Studio tools all support PVA
    - Archiver Appliance can archive Normative Types
    - Channel Finder supports PVA
    - OpenXAL (our accelerator physics code) has (basic) PVA support built-in
    - pvaPy is our official Python interface
- Supported EPICS versions in our (E3) environment, as of now
  - Base 3.15.5 / 3.15.6
  - Base 7.0.1.1 / 7.0.2 / 7.0.2.1

EPICS activities at ESS – Community and internal

- Development and deployment tools (Thursday talk on “E3”)
- Control System Studio
  - Display Builder, etc. Active participation in development group
- EPICS7 development - support
  - Funding projects to support developments in EPICS Core
    - Project funds will not last forever, though…
  - ESS Developers working on core technologies (pvAccess)
  - We plan to organize a “Documentathon”, in ~August this year
    - To address documentation “debt” that has accumulated
    - Please consider joining if you would like to contribute – for your own or the community’s sake

Configuration Tools

- Like every self-respecting EPICS project, we also have ambitious configuration tools
  - CCDB (Controls Configuration Database), CableDB
  - IOC Factory, PLCFactory
- While there are challenges with these tools, I keep claiming they will eventually pay off, provided that:
  - We keep our expectations realistic
  - Tools will only get us so far; do not even try to fully cover the EPICS setup
  - Do not let the tools limit use of EPICS good features
    - Herein lies the biggest challenge
  - EPICS database is a programming tool. Auto-creating algorithms is still beyond our skills.
- Jury is still out. Final verdict will be in a few years
  - But “IOC management by emacs” is not going to be realistic either…

Growing pains

Building up a new lab from the ground…

- Steep learning curve, project-wide
  - Most of the project staff is building their first accelerator – and a big one
  - Many different backgrounds – people have to learn to work together
- Complicated project setup
  - Many in-kind activities to be supported and followed up, and finally integrated
- Staff increase has been really fast
  - Which is a good thing but not unproblematic
- EPICS “awareness”
  - Not many people know EPICS when they start at ESS
  - Available possibilities of EPICS and related tools not realized or utilized – or even misunderstood.
- First commissioning experience has started to bring the teams together
  - In ICS but also (and more importantly) from different organizations.

Summary and outlook

- ESS has become an accelerator lab – from a paper lab. Real beam, real issues.
- ESS, including ICS division has grown very rapidly. With its pros and cons.
- Hardware is appearing at the site, at a growing speed
  - Nice but sometimes very hectic.
- We are still on the learning curve in many issues
  - But situation is constantly improving – even if we tend to forget it.
- ESS has a strong will and commitment to work with the community
  - But (even) our resources are limited – we need the community to reach our goals.
- Next couple of years will be very busy – but exciting!