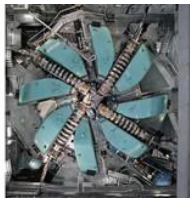
PAUL SCHERRER INSTITUT

Markus Janousch:: Paul Scherrer Institut (PSI) for the Controls group

Overview and Status of the SwissFEL Project at PSI

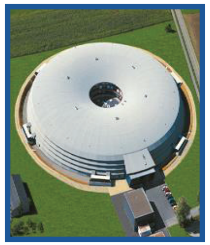
ICALEPCS 2015 in Melbourne, October 23, 2015

PSI Accelerator Environment



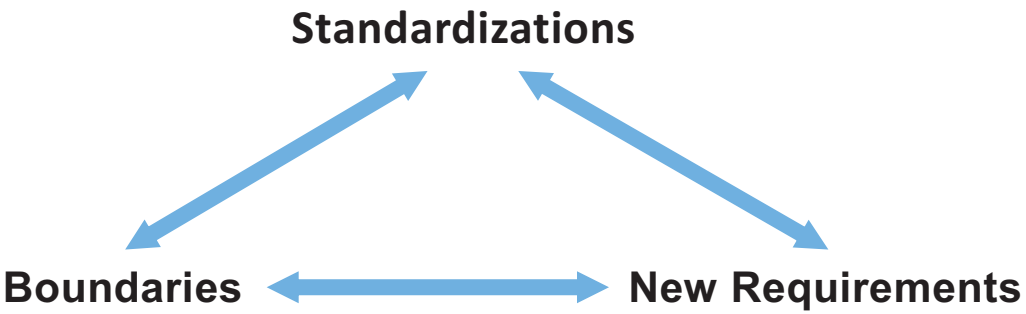
High Intensity Proton Accelerator (HIPA). Machine, different beamlines and experiments. SINQ is not in the scope of Controls group. See **MOPGF127**

Comet, support of machine and 4 beamlines only, no treatment area. (CPT) See **TUC3O04**



Swiss Light Source (SLS), support of machine and 18 beamlines.

The Controls group has to support a diverse and complex range of accelerator facilities with a rather *interesting* historical background.



Existing Standards

- All accelerator control systems use EPICS (3.14.12)
- Fast I/O, scalers, etc, are mainly based on the VME bus
- IOCs are to a large extend Motorola's MVME(5,6)100 series boards
- On these runs VxWorks 5.
- Timing system based on the 230 series of Micro-Research Finland Oy (MRF)
- Motion controller from Pro-Dex (MaxV)

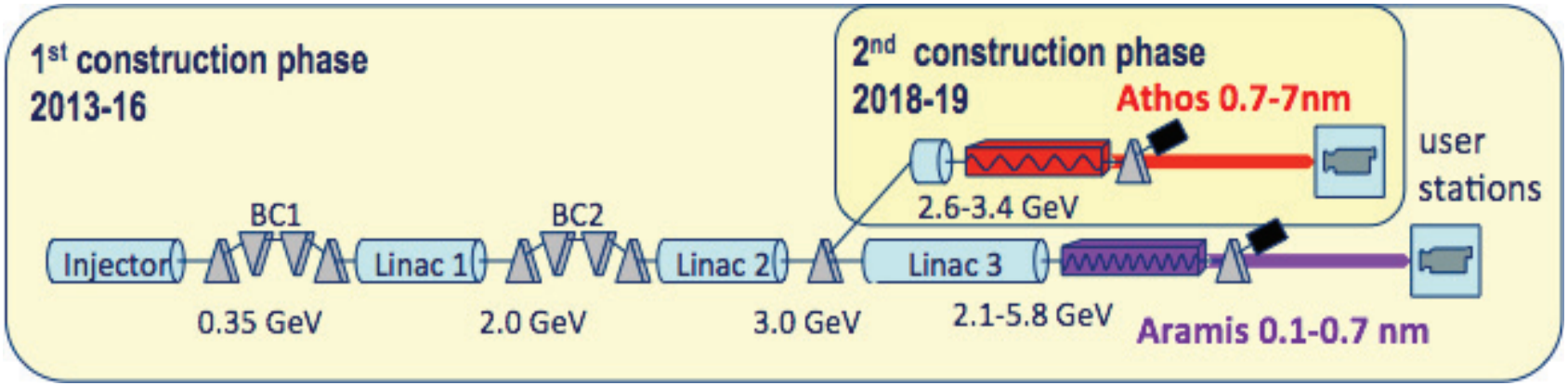
- Consoles and most servers run Scientific Linux 6.4. SW distributed with Puppet.

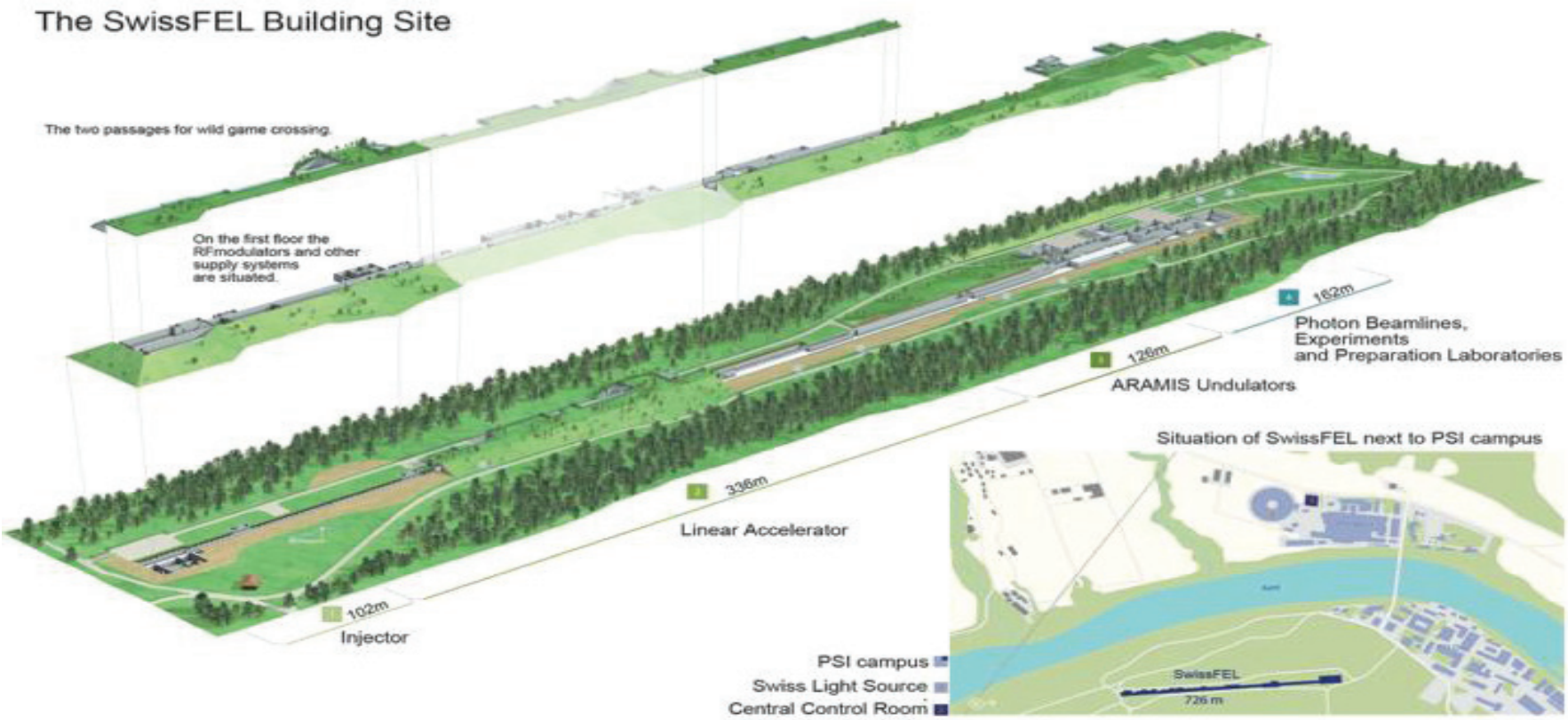
- Common SW deploy system for EPICS-SW
- Inventory DB

- Group works in a matrix structure. Single point of contact for our customers.

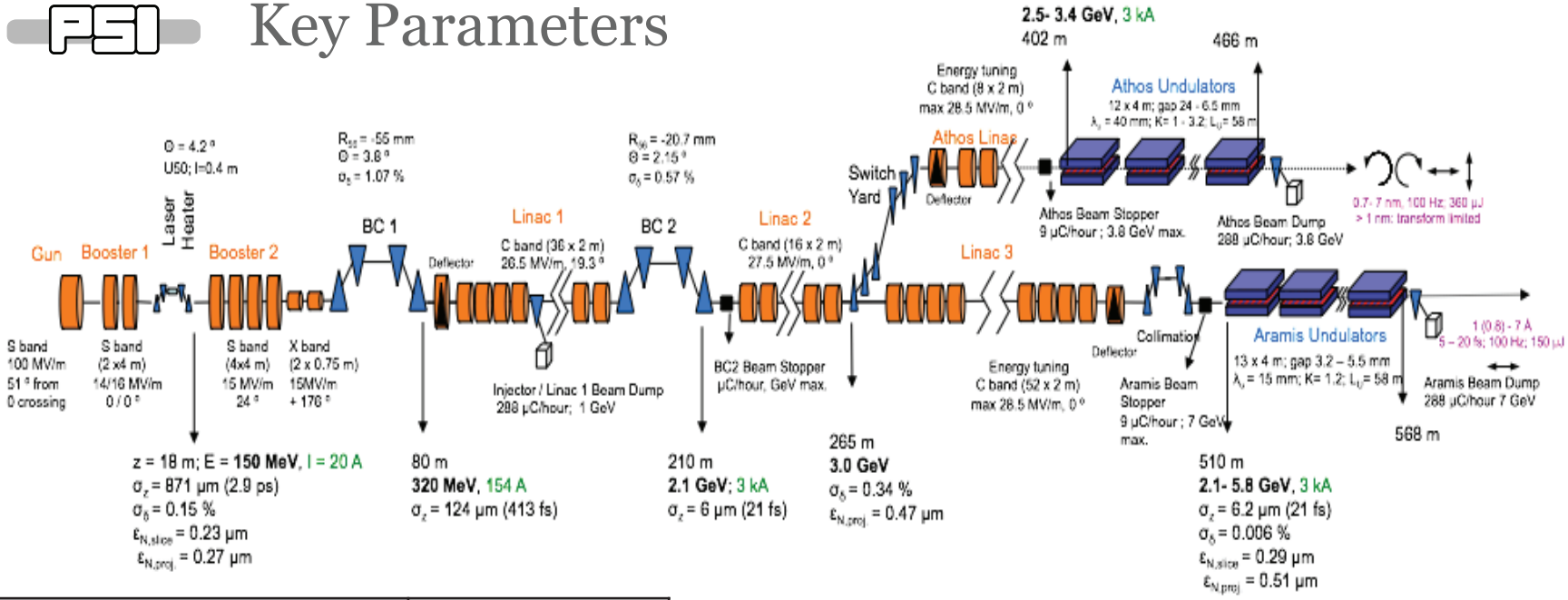
- …

Overview and Location





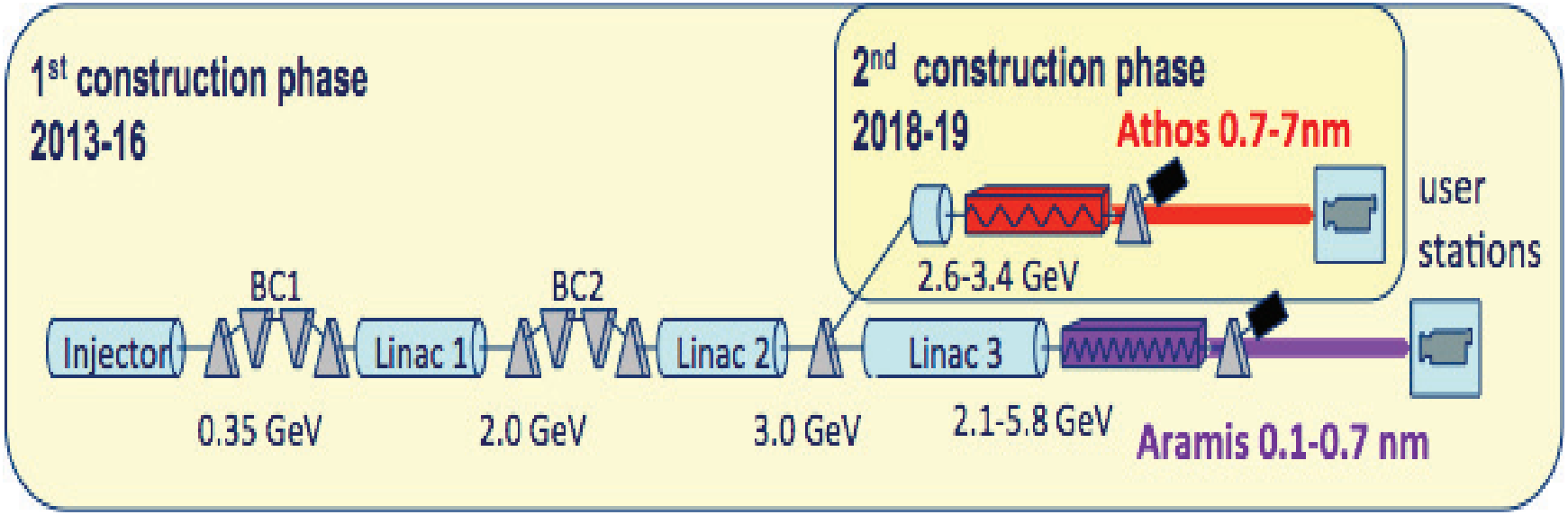
Key Parameters

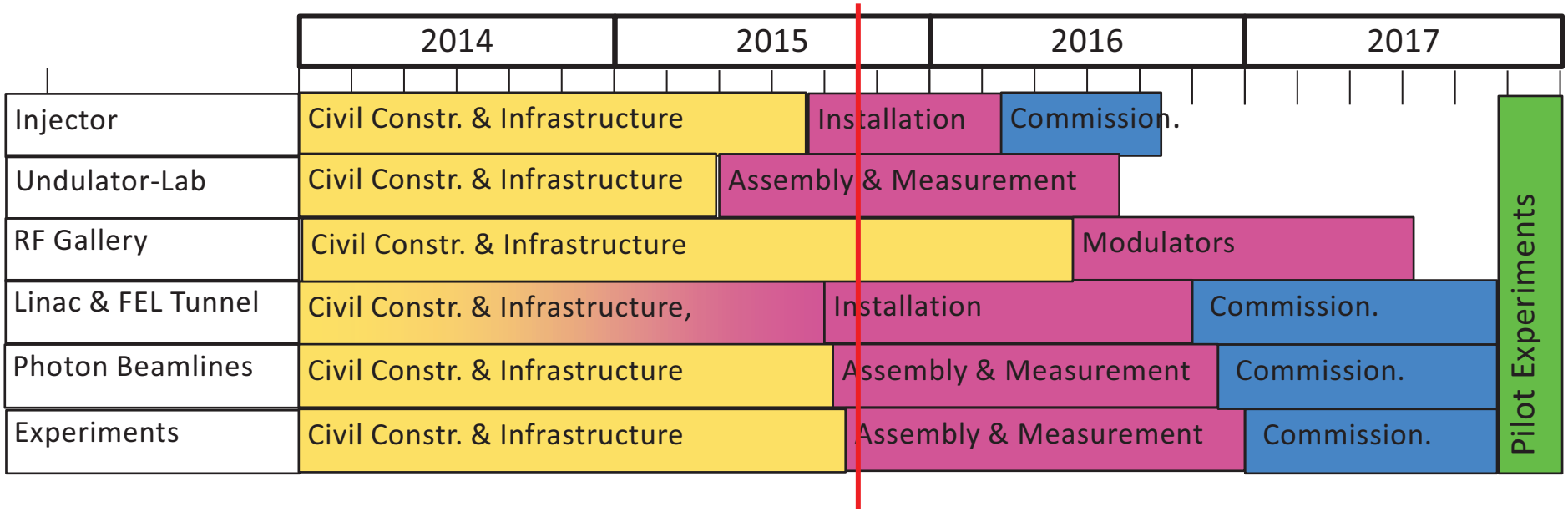


Overall Length	720 m
Total electrical power	5.2 MW
Maximum electron beam energy	5.8 GeV
Number of FEL lines	2
Wavelength	1 - 7 Å, 7 - 70 Å
Repetition Rate	100 Hz
Number of Endstations	2 + (1)
Cost	280 MCHF

Aramis 1 Å	**Long Pulses**	**Short Pulses**
Charge per Bunch	200 pC	10 pC
Bunch length	25 fs	6 fs
Peak Brightness	$7 \cdot 10^{32}$ ph/s/mm^2/mrad^2 /0.1%	$1 \cdot 10^{32}$ ph/s/mm^2/mrad^2 /0.1%
Number of Photons	$73 \cdot 10^9$	$1.7 \cdot 10^9$

Overview and Schedule





Requirements and Challenges

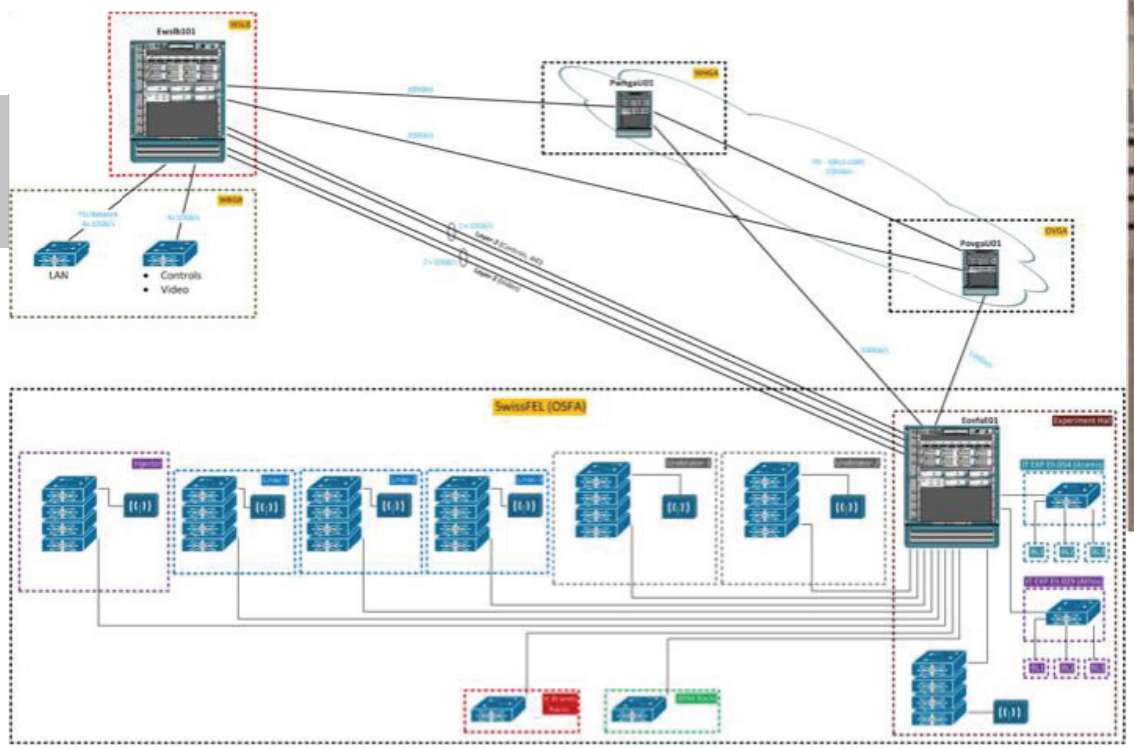
- Going from circular to a long linear machine means a **highly distributed** system.
  - ➢Smaller and more VME crates
  - ➢Other buses like EtherCAT

- Pulsed machine. Need very **good distributed timing**.
  - ➢Timing System with reprogrammable patterns

- **Synchronization** of different detectors and actuators is needed
  - ➢Coordinated and timed motion
  - ➢Beam-Synchronous data-acquisition (BSDAQ)

- **Large data** from new detectors (Jungfrau, Gotthard) and many cameras
  - ➢Large bandwidth
  - ➢New schemes of DAQ

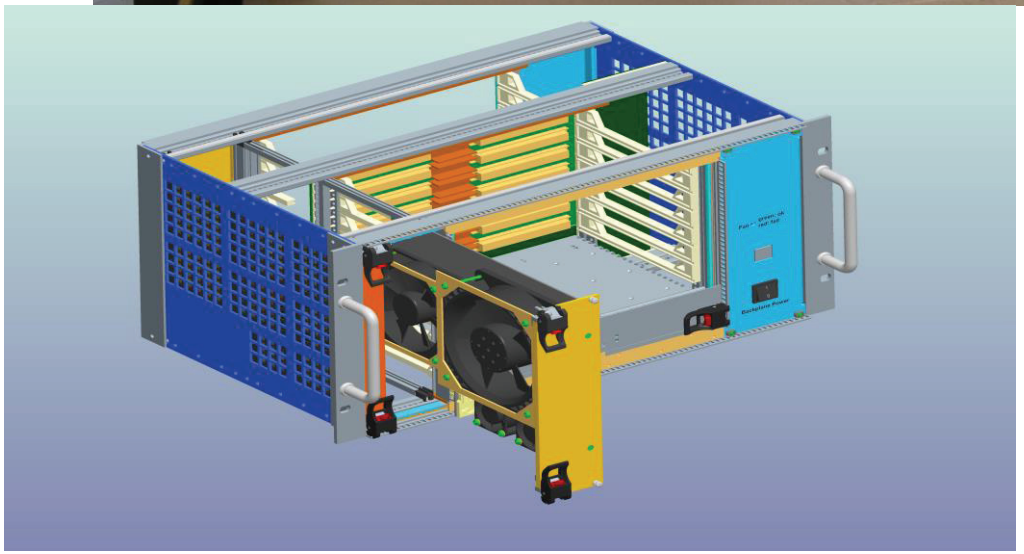
Network (from Central IT)



- 100 Gbit between SwissFEL,

  Control Room, and Computing Centers
- LAN, 10 Gbit SwissFEL, special devices VLAN
- WLAN in technical galery

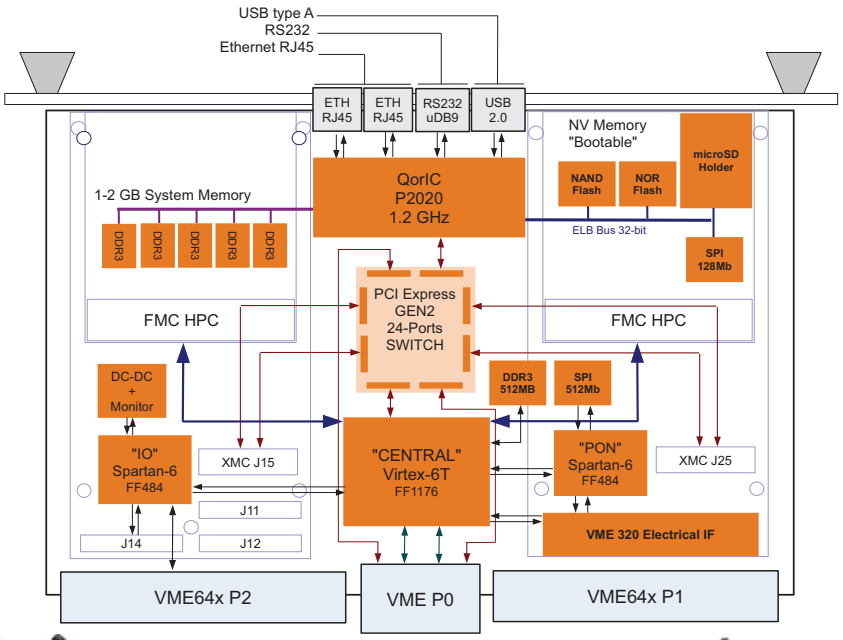
VME Crates

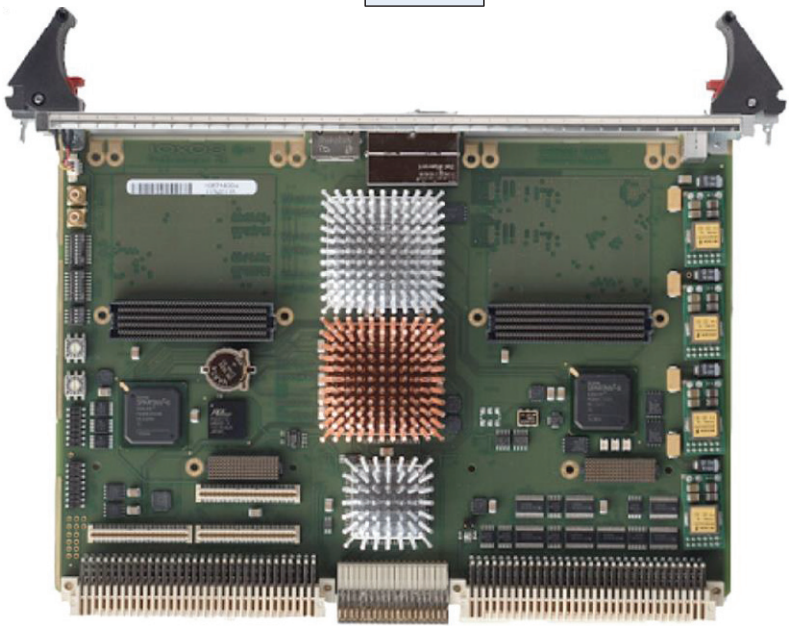


7-Slot VME Crates provided by Trenew

- Dual power supplies in parallel operation
- Cooling from side to side for improved airflow
- Plug-in power supplies, fan units, air filter etc. for easy maintenance.
- Very low noise ripple and cross-talk on PS voltage
- Integrated crate monitoring with Ethernet connection (I^2C)
- ~ 180 Crates delivered

IFC 1210





The board of choice as a VME bus controller and for fast D/A signal processing, timing, power-supply control and connection to EtherCAT-systems.

- 6 U VME64x single board computer (Freescale Power PC P2020 dual core, Xilinx Virtex-6 central and Spartan-6 IO FPGAs).
- Co-developed by Controls, LLRF, and IOxOS Technologies SA in Switzerland.

Extension slots

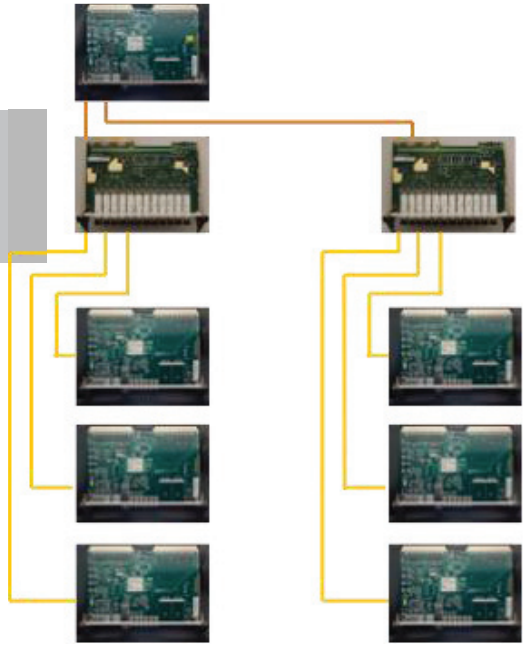
2 XMC, 1 PMC, 2 FMC mezzanine

Operating system

RTLinux

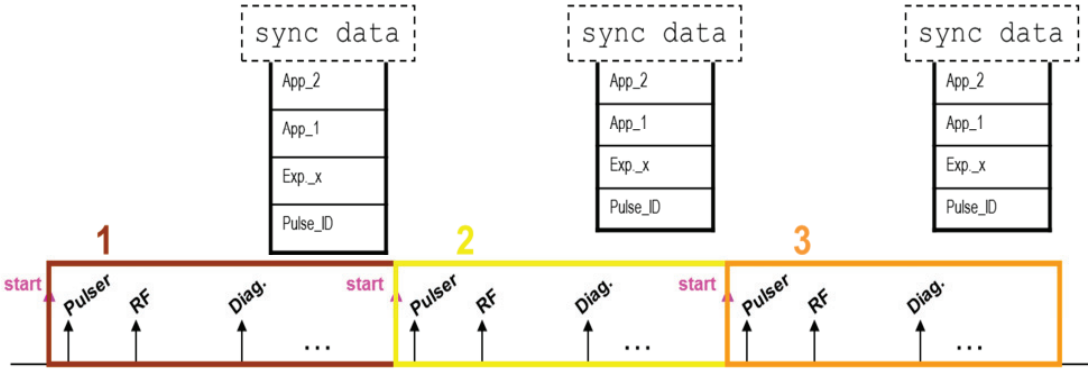
~250 boards delivered

Timing and Event System from MRF



- Based on Series 300 from MRF
- Reference clock runs at 142.8 MHz
- 5 ps RMS jitter
- Automatic delay and drift compensation
- Sequence reprogrammable with 100 Hz
- Event tagging of all synchronous data
- Also used in the Machine Protection System through instant delay shift
- 70 VME Event Masters, 120 VME, 69 PCIe Event Receivers and numerous level adaptors and delay adjusters

Event Sequencing:



100 Hz synchronized with mains

New version of mrfioc2-driver developed with help of Cosylab. Also for PCIe.

Motion Controller

- **PowerBRICK** LV IMS PSI based on Delta Tau's PowerPMAC.
- PCIe timing card from MRF integrated.
- For coordinated and synchronized movements.

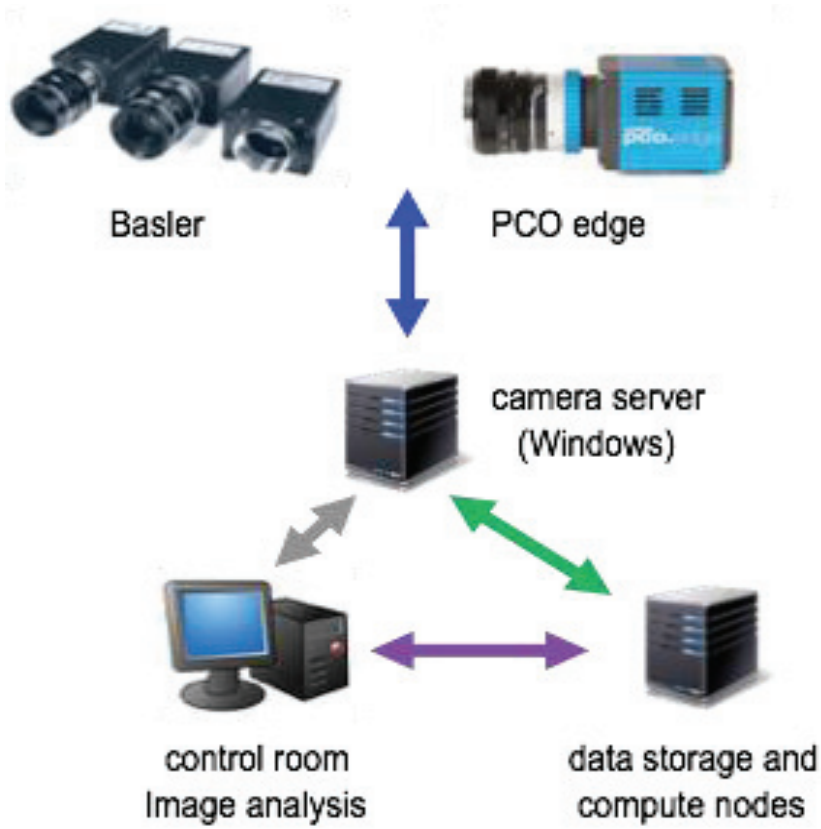
MDrive from Schneider-Electric

Ethernet communication interface

Incremental, SSI, and BISS encoders. A few special systems have to be supported.

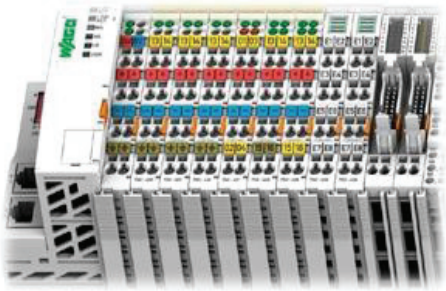
New support of motorRecord for PowerPMAC written with help of Cosylab.

Camera Support



- Cameras are used for
  - Electron beam diagnostics
  - Lasers
  - Photon beam diagnostics
  - Experiments
- MS Windows based system
  - Timing system (MRF) included
  - Fast analysis of data with 100 Hz
  - Dedicated storage for 5 cameras running simultaneously.
- Many GigE-Cameras

Serial and Low Demand Systems



Serial and slow signals do not need VME

WAGO system

- Slow digital I/O
- Slow analog I/O
- Temperature measurement with low accuracy
- Connected with Ethernet to an EPICS softIOC

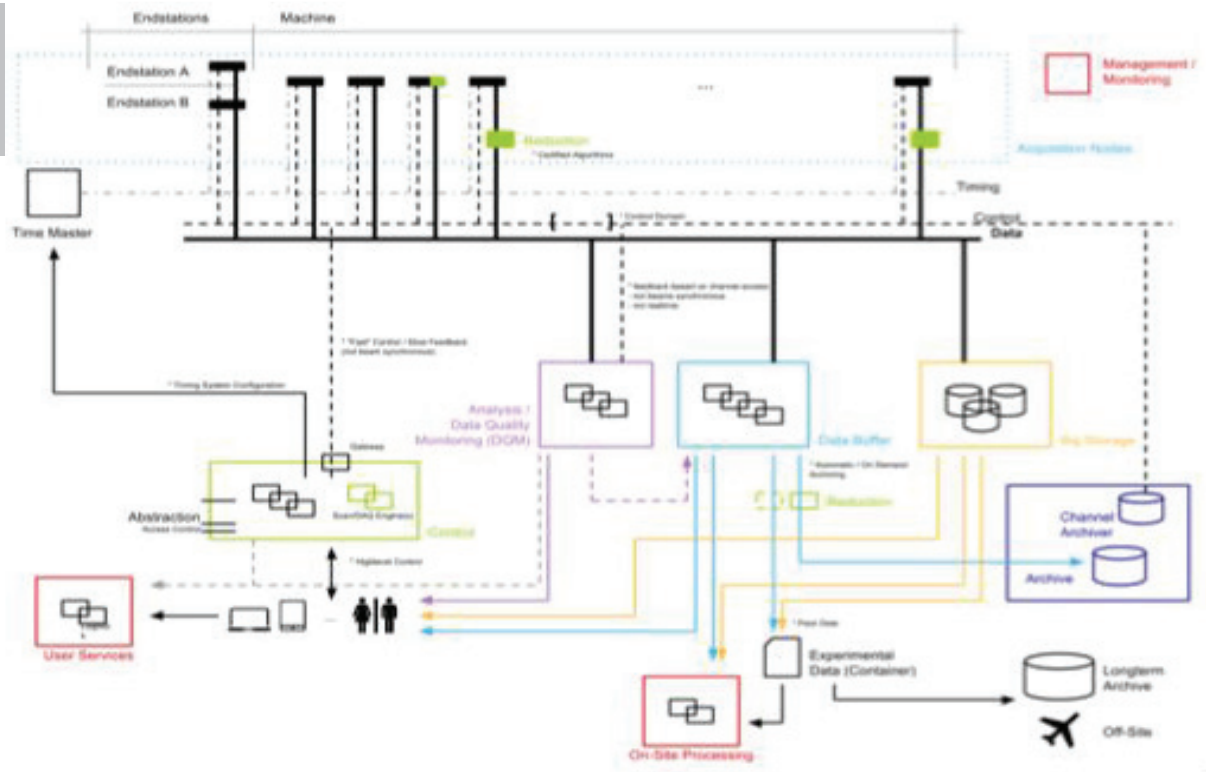
MOXA Serial Server

- 16 serial ports
  (configurable RS232, RS485, RS422)
- Runs Linux and EPICS softIOC on the device

EtherCAT

See **MOPGF027**

Beam Synchronous and High Volume DAQ



- Based on EVR or FPGA decoding of events.
- CA or JSON for configuration
- Streaming of data with ZMQ
- Storage of data in HDF5 format
- Data rates of up to a few Gbyte/s

See **WED3O06**, **MOPGF059**, and **TUA3O02**

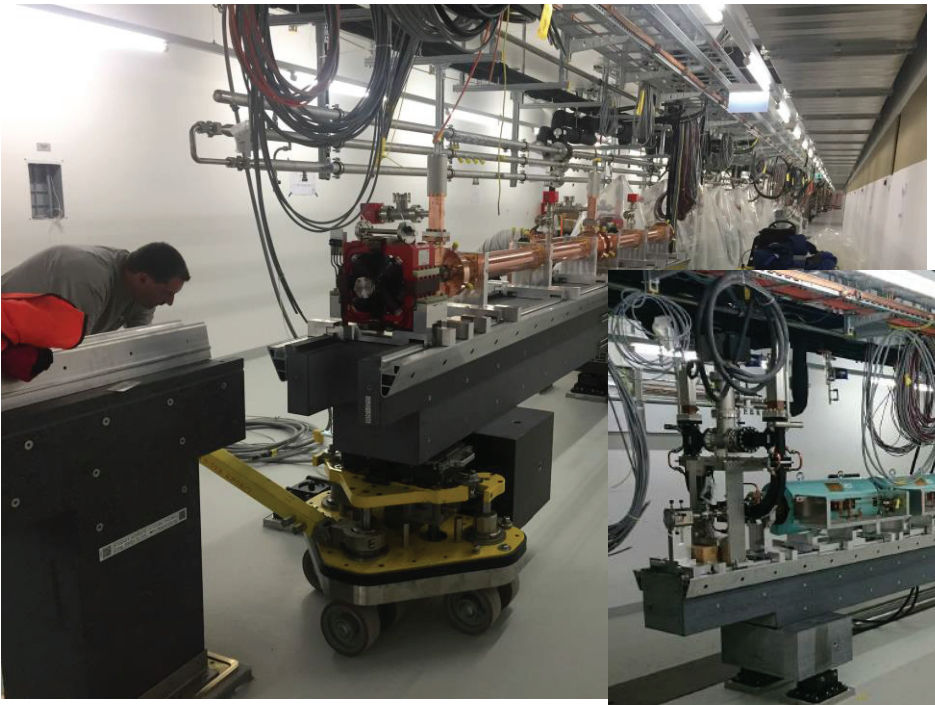
Summary

The SwissFEL facility introduces new requirements and challenges to the Controls group of PSI.

All of them could be met with new standards in hardware or in software.

Controls will be ready for beam commissioning of the SwissFEL injector that starts in March 2016.

For the other PSI facilities we will gradually replace the old standards with the new ones were appropriate.



Acknowledments

- To the members of the **Controls section**

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