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Control System in the SwissFEL Injector Test Facility

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for M. Dach and PSI Controls Team

Outline

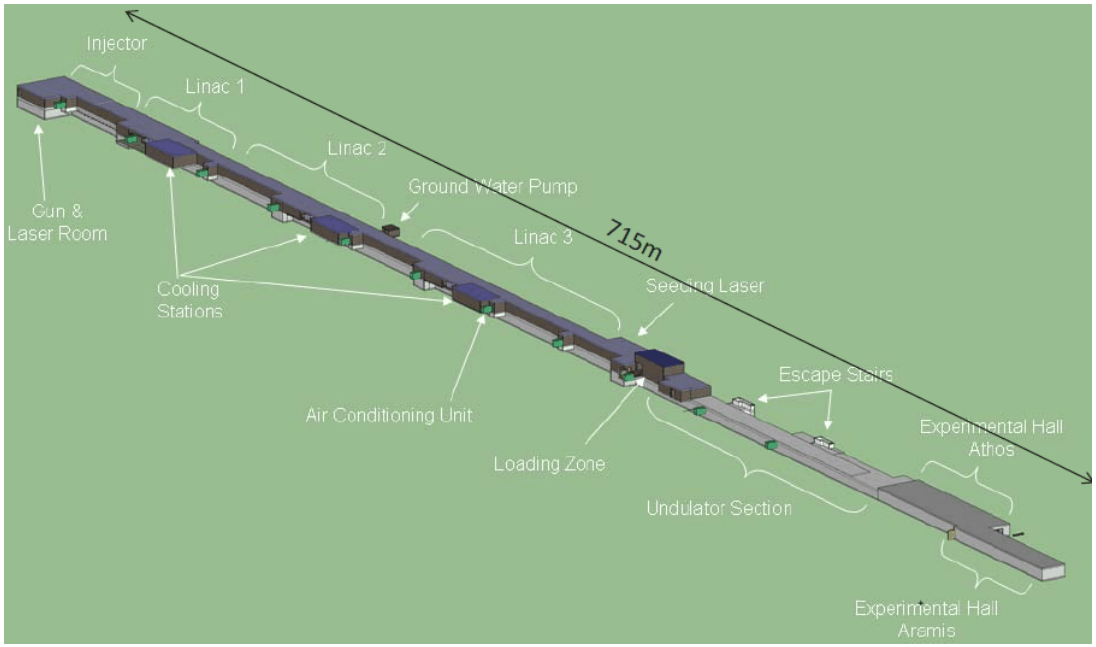
- **Introduction** (SwissFEL)

- **SwissFEL Injector Test Facility Controls Overview**

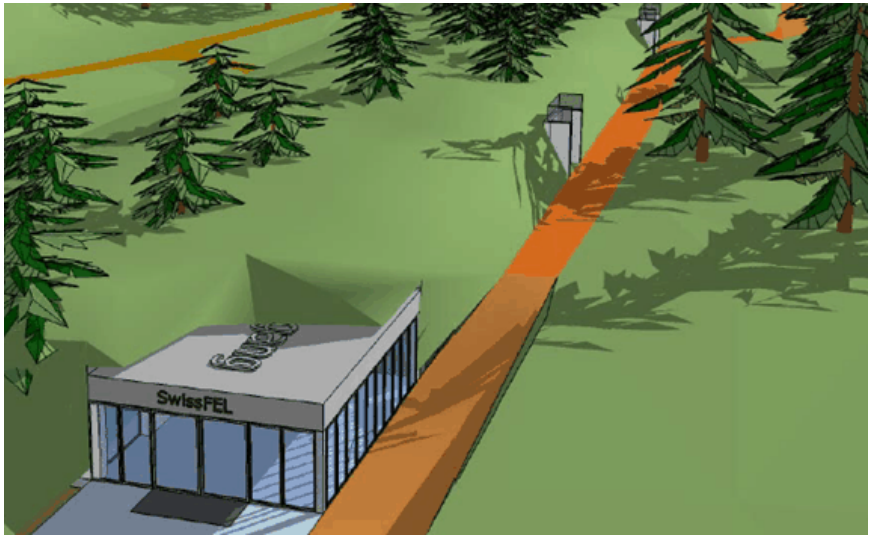
  - Control System Concept
  - Controls/Computing Infrastructure
  - Test Facility Subsystems support
    - *Timing*
    - *Magnets*
    - *Advanced Beam Diagnostics*
  - Operations support

- **Conclusions**

SwissFEL project at PSI



SwissFEL key parameters	
Wavelength range	1 Å - 70 Å
Pulse duration	1 fs - 20 fs
e^- Energy	5.8 GeV
e^- Bunch charge	10-200 pC
Repetition rate	100 Hz



SwissFEL 250 MeV Injector Test Facility was built at PSI and officially put into operations on August 24, 2010.

The Facility repetition rate is 10 Hz
(a driving laser operates at 100 Hz)

Test Facility goals

- **Demonstrate a high-brightness electron beam required to drive the SwissFEL main linac.**

- **Act as a platform for new developments and validation of accelerator components needed for the SwissFEL project.**

Injector Test Facility Control System Concept

-A very limited manpower available for the project support

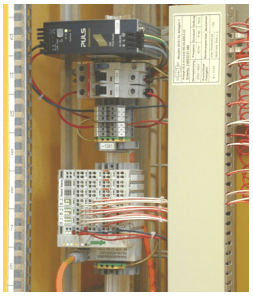
-A very good performance of the existing Swiss Light Source (SLS) control system based on a lot of investment in VME64x solutions (e.g. BPMs, motion controls, timing system)

Basic development tool is

Controls Hardware

1. Use **VME64x** *where dedicated electronics and/or real time processing needed*

2. Use small embedded systems for applications with a limited number of I/O channels in isolated locations



3. Work on modular PLC-type control solutions (e.g. WAGO) for slow I/O

Some non-VME controls solutions

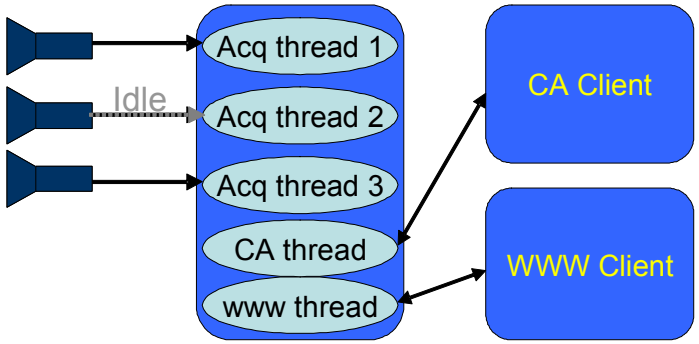
Video Cameras

- More than 40 FireWire (*IEEE 1394*) cameras are used, mostly for beam diagnostics applications.

- Video images are handled by camera servers running on Linux PCs.

- Servers provide EPICS CA and web video streaming.

- Multiple cameras can be supported on one PC.



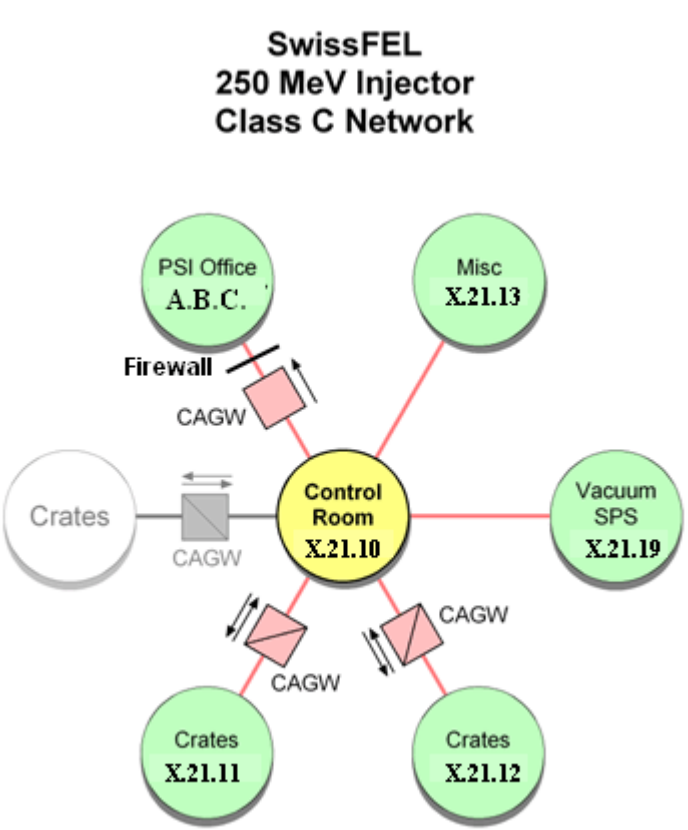
Firewire server

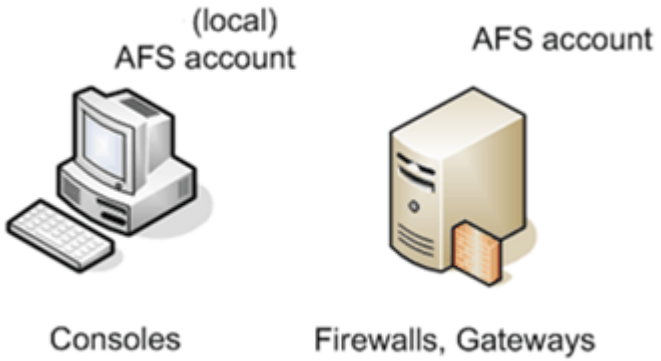
Serial (RS232) Devices

Serial (RS232) devices are mostly handled by custom made embedded controllers based on Virtex-4 FPGA

Controls/Computing Infrastructure

computer network structure





More than 20 consoles are set up including 4 in the main control room.

VME IOCs

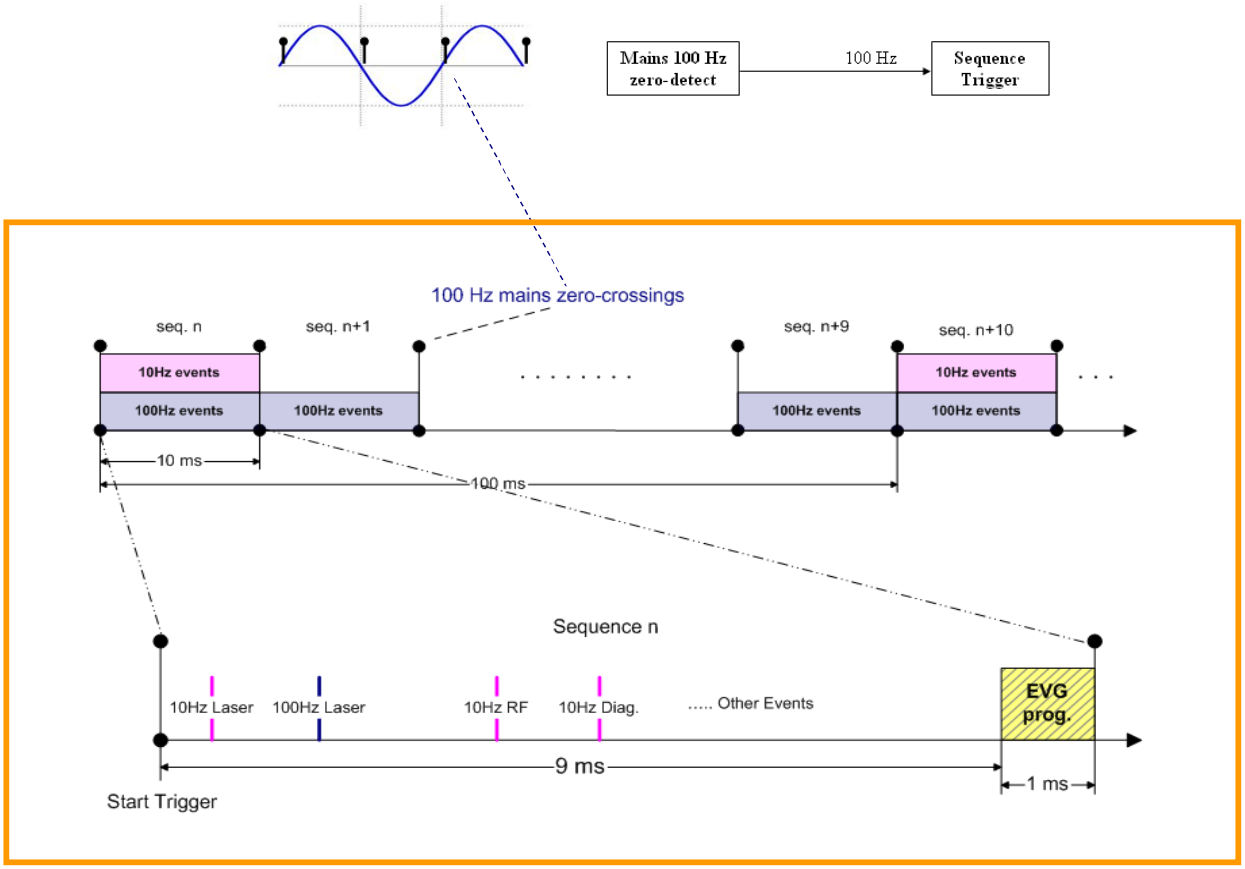
RF IOCs:	21
Magnet IOCs:	2
Timing IOC:	1
Diagnostics IOCs:	26

PC IOCs

Vacuum IOC:	1
Diagnostics IOCs:	7 + 15 video camera servers

Timing System

Based on the global event distribution technology provided by Micro-Research Finland



- Sequence triggering is **100 Hz** with real-time sequence masking:
  - **10 Hz** machine rep rate + **100 Hz** events

Some Important Implementations

- **Reduced beam rate operation**
  - ➢ beam rate **< 10 Hz** while machine runs at **10 Hz**
    - ✓ means having events @ 100 Hz + 10 Hz + e.g. 2 Hz

- **Beam Synchronous Data Acquisition (BS-DAQ)**
  - ➢ **1 Hz** synchronous PV archiving (data trending)

*(details are in **MOPKS011,** B. Kalantari)*

Magnet Controls

Magnet Controls

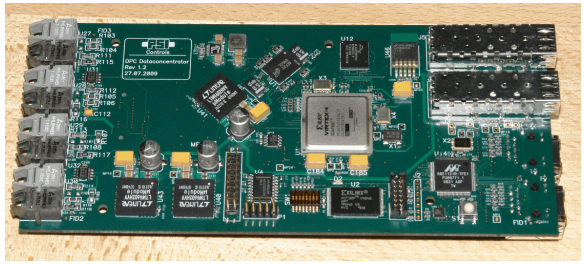
- **Magnet controls is based on PSI digital power supply controllers**

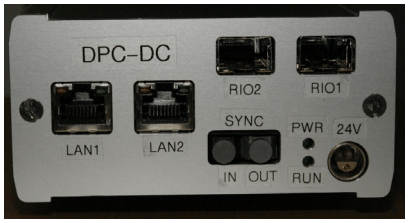
- **Magnet controls software is currently hosted by two VME based EPICS IOCs.**

- **Automated cycling (degaussing) is supported for select magnets.**

- **EPICS support for the PSI Digital Power electronic Control system (DPC) "Data Concentrator" is ready.**

  - **10 DPCs can replace two currently used VME based IOCs.**





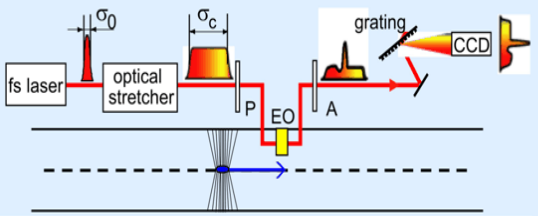
Advanced Beam Diagnostics Support

SwissFEL beam parameters are challenging, which requires advanced beam diagnostics systems to be implemented.

Diagnostics at 250 MeV Test Injector: Longitudinal Profiles

- *online monitoring* of longitudinal electron beam profiles (bunch length / peak current) along injector

Schematic Set-Up of EO BL Measurements – Spectral Decoding



Time Resolution (Gaussian bunches)

$$\sigma_{lim} \geq \sqrt{\sigma_0 \, \sigma_c}$$

σ_0 - laser beam duration

σ_c - chirped laser pulse duration

Example (250 MeV Injector)

$$\sigma_{lim} \geq \sqrt{20\ fs \cdot 500\ fs}$$

$$\geq 100\ fs$$

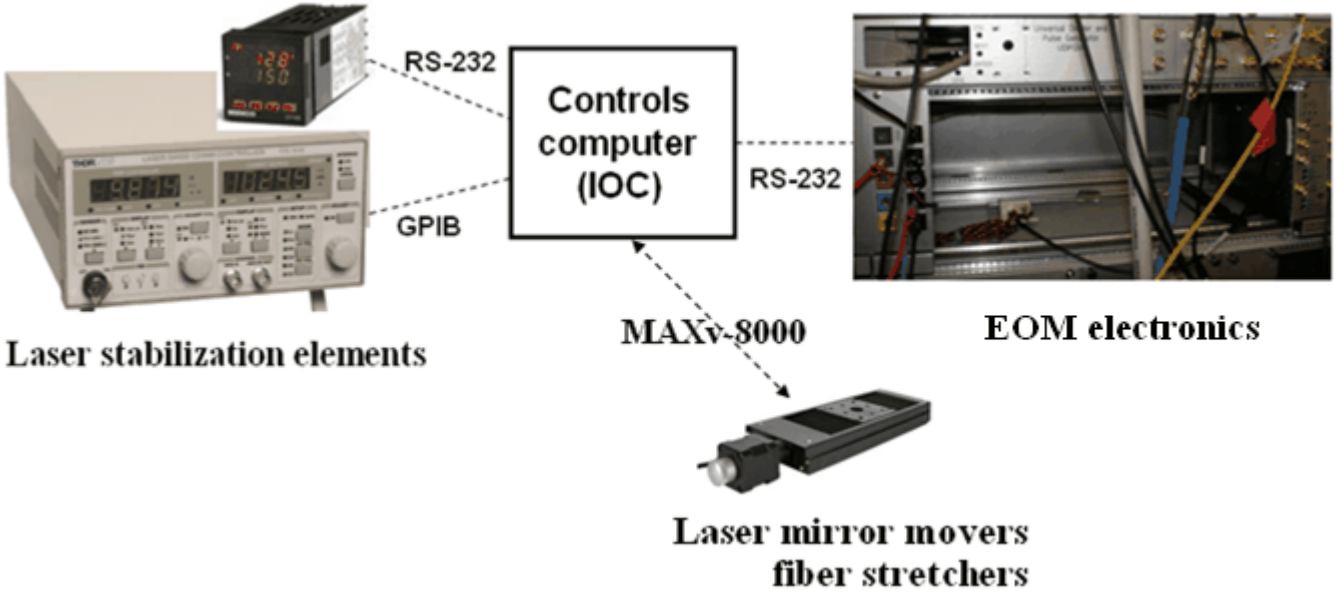
Electro Optical bunch length Monitoring (EOM) Systems

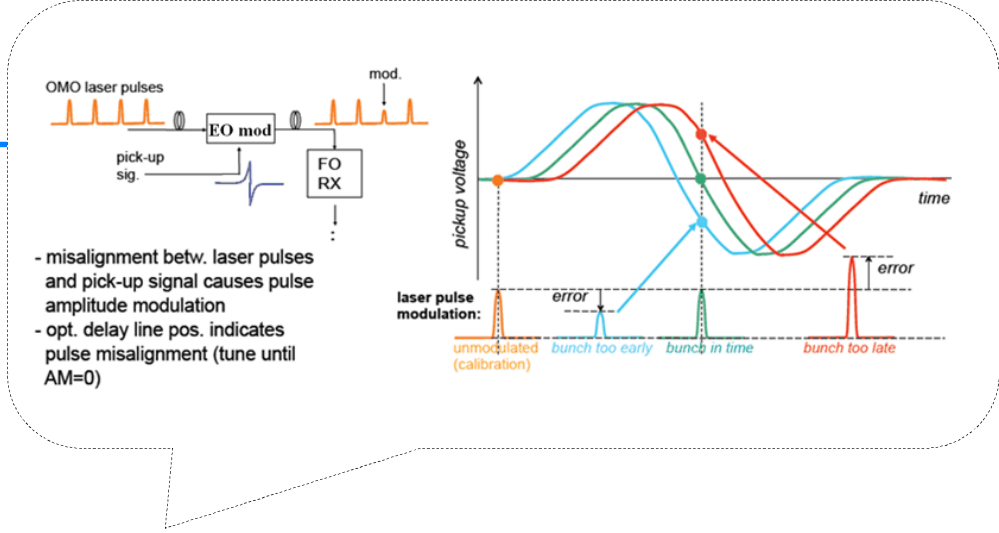
- EOM are designed and built at PSI.

- Working principle:
the electron bunch field profile is transferred onto the laser pulse (or pulses) co-propagating in an electro optical crystal (e.g. ZnTe).

(details are in **MOPKS019,** P. Chevtsov)

Main EOM controls components



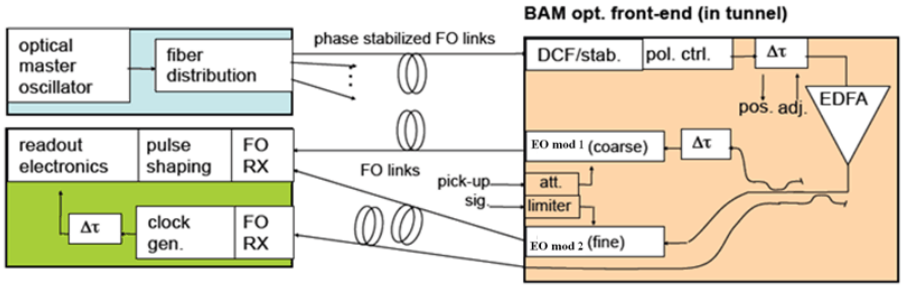


Beam Arrival time Monitors (BAM)

- **BAM systems are (also) based on electro optical effects.**

- **They can determine the beam arrival time with the resolution of ~10 fs.**

- **BAM signals can be used, for example, in feedback loops preventing beam energy drifts and stabilizing RF amplitudes of the injector linac structures.**



Key BAM elements

- stepper-motors remotely handled by

  - VME motor drivers

    and

  - standing alone high precision motor controllers talking via serial (RS232) communication lines

- signal synchronization devices (VME and RS232)

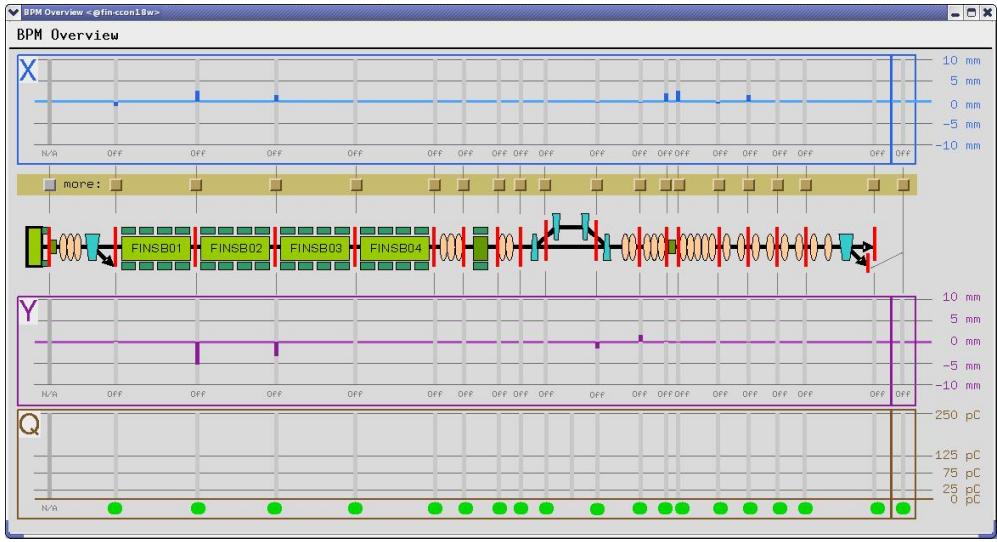
Work on their integration into EPICS is in progress.

Operations Support

Operations Tools

Standard EPICS tools are provided for the Test Facility operations:

- **medm**
- **Alarm Handler**
- **Data Archiver**



Controls team is currently looking for other solutions:

QT based, CSS, etc.

Physics Applications

- **MATLAB with the MCA interface to EPICS is supported.**

- **Some applications need more robust interface provided by a Channel Access interFacE (CAFE) library developed at PSI.**

(see poster **WEPKS024,** J. Chrin)

Conclusions

- **The SwissFEL Injector Test Facility has been providing us with an unique opportunity to develop and evaluate new ideas for the future SwissFEL project.**

- **Successful Test Facility commissioning (phases 1 and 2) and operations have revealed some points for improvements:**

  - The stability and performance of the Channel Access gateway is questionable.

  - The choice of the FireWire camera standard seems to be far from optimal for a highly distributed SwissFEL environment. GigE cameras were chosen to improve the stability and reliability of video systems in the future.

  - The fast feedback system is under investigation.

Contributors

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