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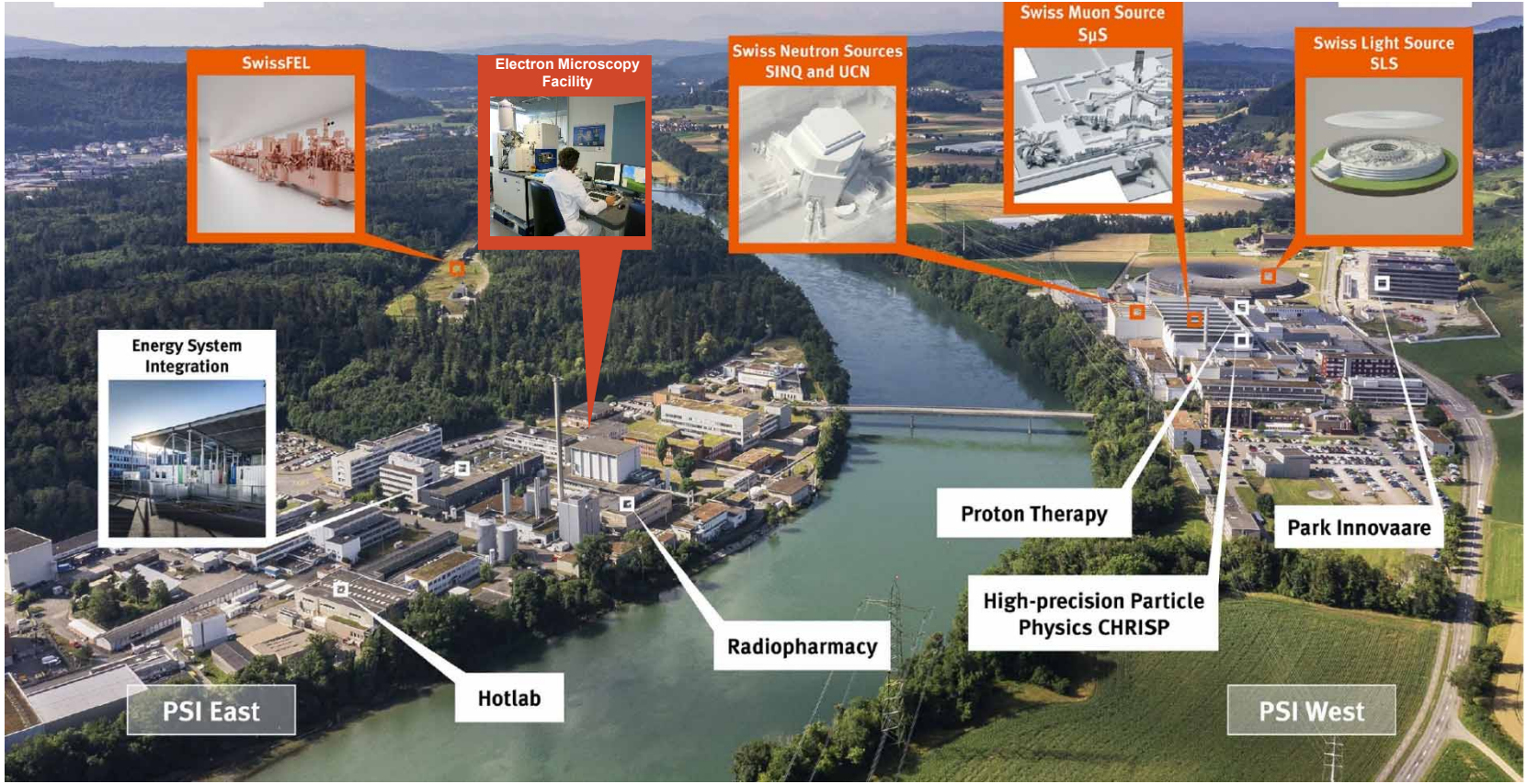
PSI

Alun Ashton, Head of Science IT and SLS 2.0 Subprject for Controls and Science IT, PSI

THE CONTROLS AND SCIENCE IT PROJECT FOR THE SLS 2.0 UPGRADE

ICALEPCS'19 2023, Cape Town, SA

Facilities at the PSI Campus



The SLS 2.0 upgrade project on the SLS

- On the 30th of September 2023 the dark time for the Swiss Light Source (SLS) facility began. SLS 2.0, a project to upgrade the storage ring and selected beam-lines now enters the construction phase. With the advent of the next generation of synchrotron light sources, called diffraction-limited storage-rings (DLSRs), that yield an emittance and brightness improved by up to two orders of magnitude, it has become equally imperative to upgrade the SLS to accommodate the new developments. The storage ring is undergoing its upgrade in 2023/2024 with a planned reduction of emittance by a factor of 40, before the facility returns to user operations in 2025.

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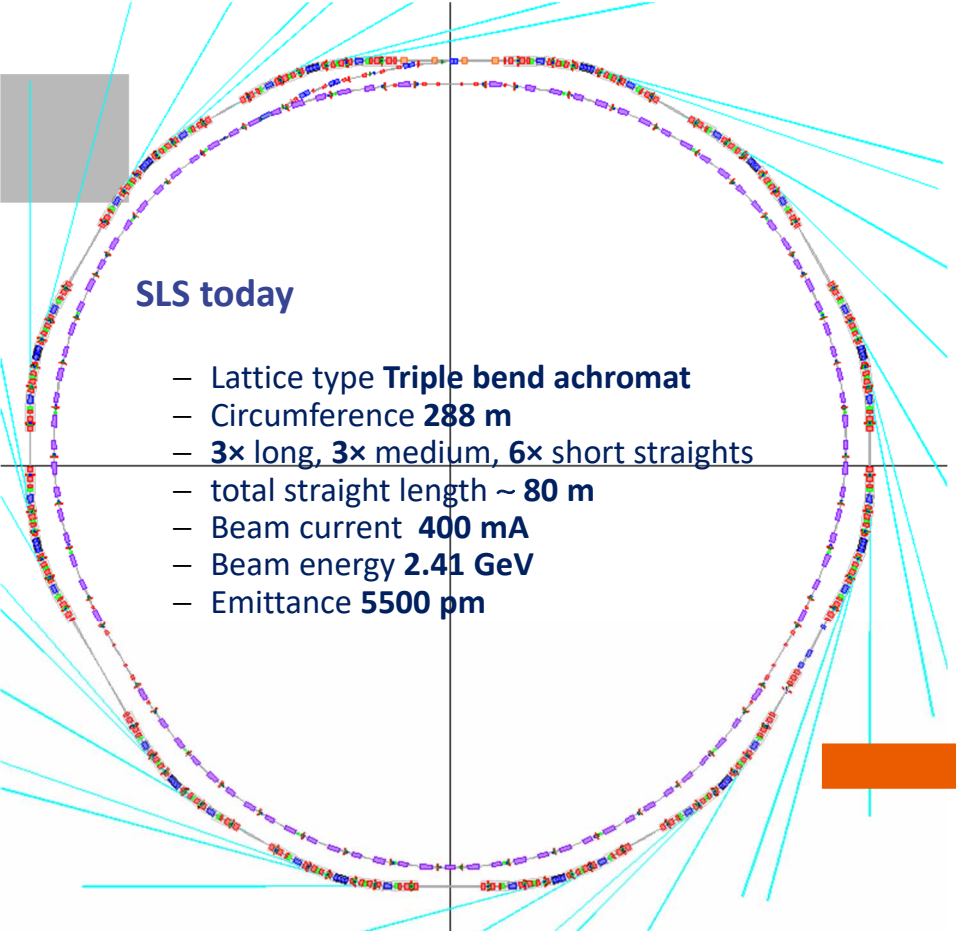
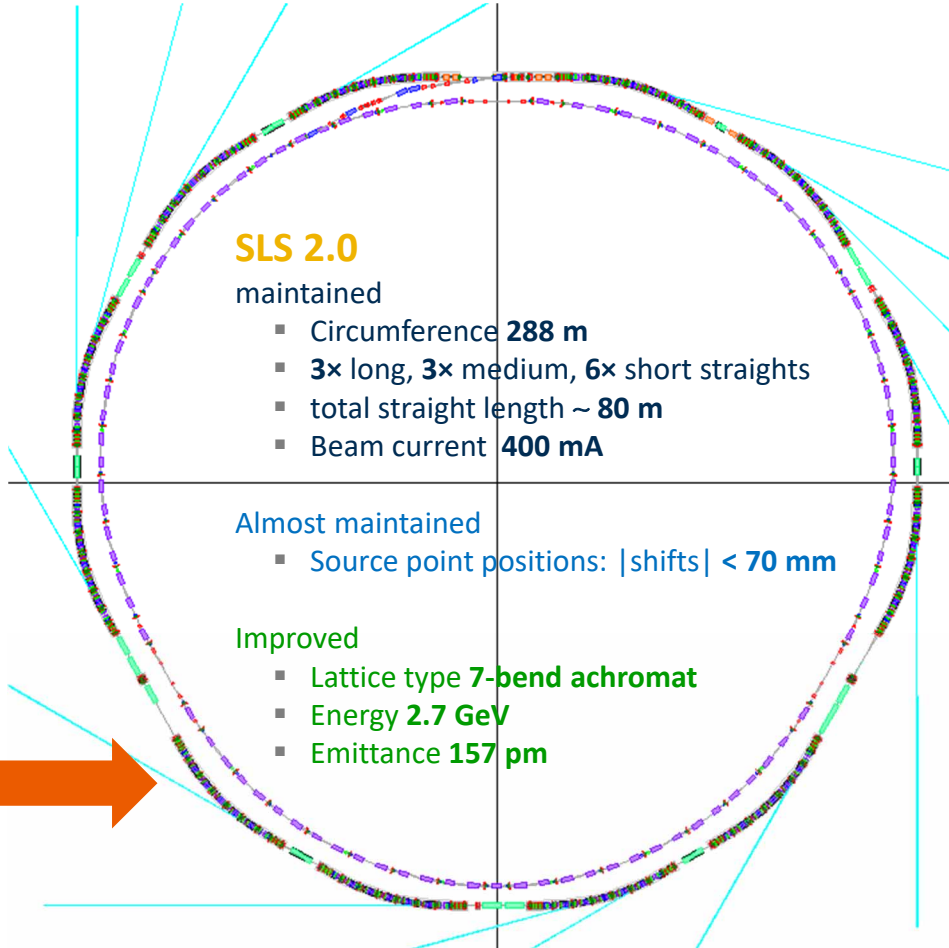
SLS → SLS 2.0



SLS today

- Lattice type **Triple bend achromat**
- Circumference **288 m**
- **3×** long, **3×** medium, **6×** short straights
- total straight length ~ **80 m**
- Beam current **400 mA**
- Beam energy **2.41 GeV**
- Emittance **5500 pm**



SLS 2.0

maintained

- Circumference **288 m**
- **3×** long, **3×** medium, **6×** short straights
- total straight length ~ **80 m**
- Beam current **400 mA**

Almost maintained

- Source point positions: |shifts| **< 70 mm**

Improved

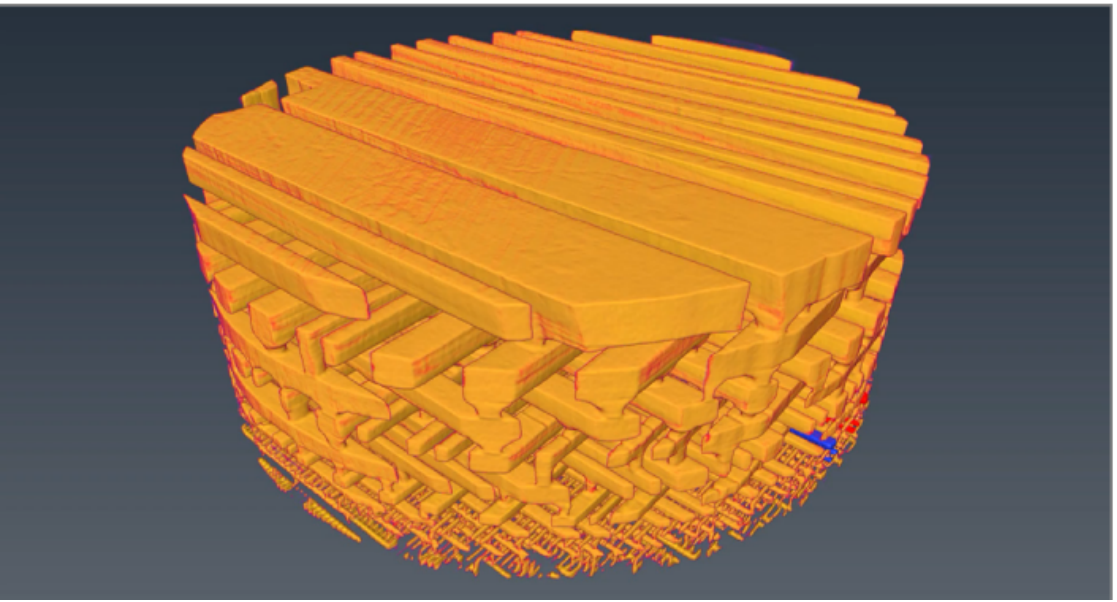
- Lattice type **7-bend achromat**
- Energy **2.7 GeV**
- Emittance **157 pm**

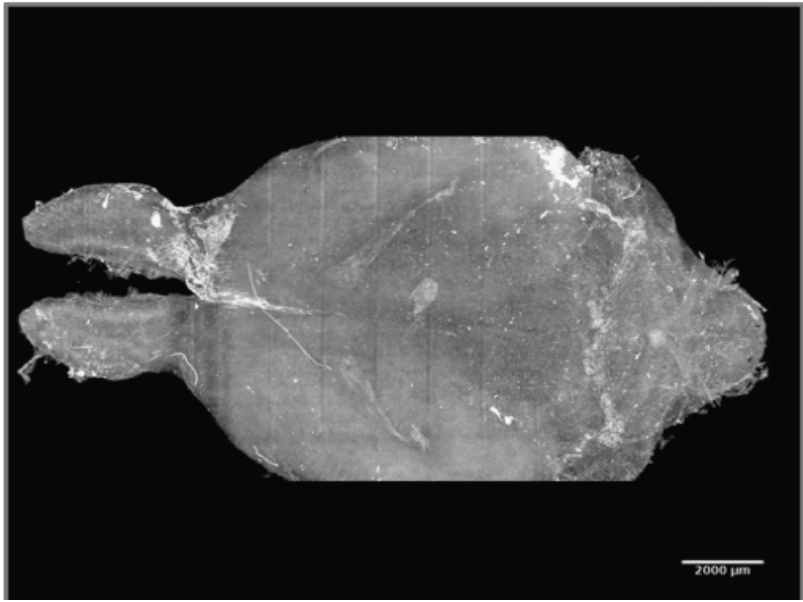
Large-volume, high-resolution Tomography at SLS

22-nm & 100-nm Intel processor
Holler *et al*.

3D mouse brain
Miettinen *et al*.

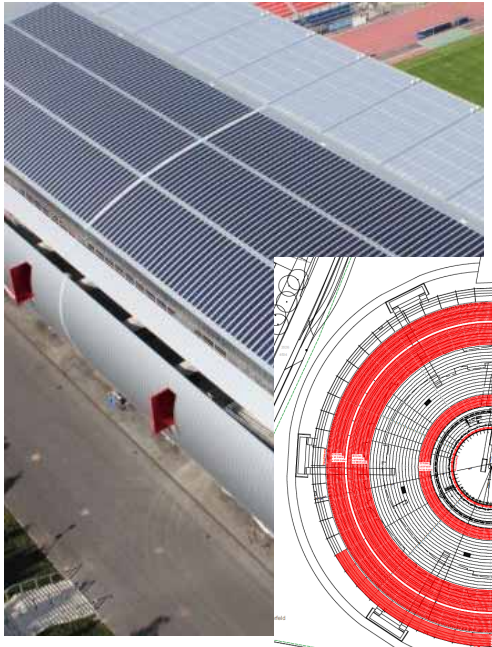
Human Brain Project

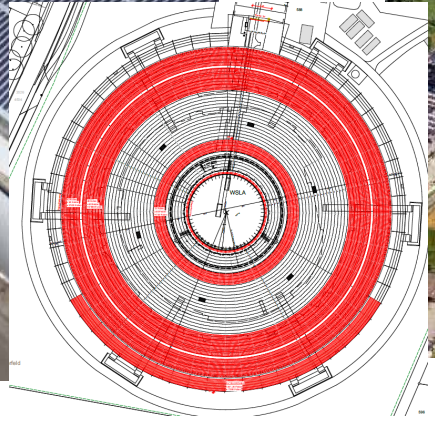




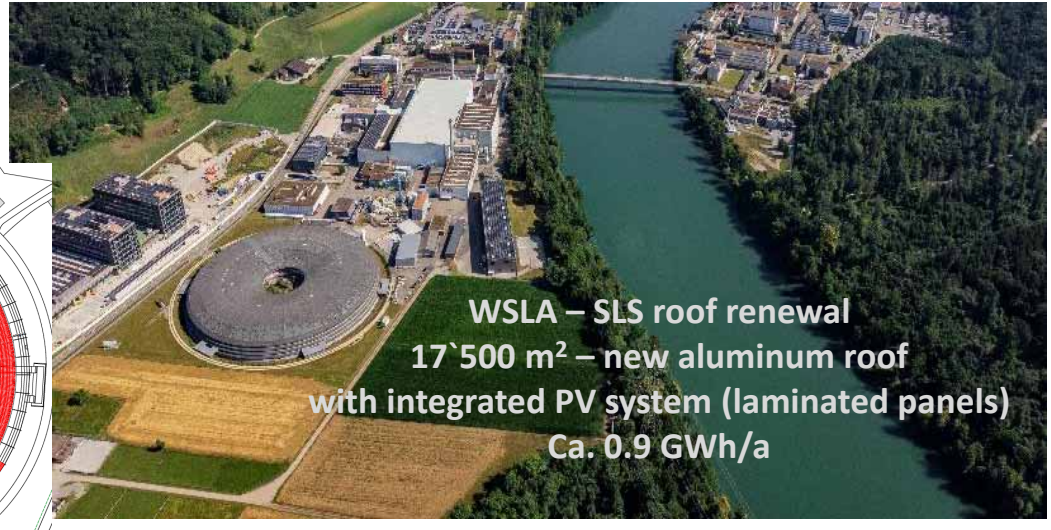
Green credentials.....

The use of permanent magnets for all bending magnets enables a densely packed lattice and contributes most to a reduction of total power consumption of the facility by 30%.





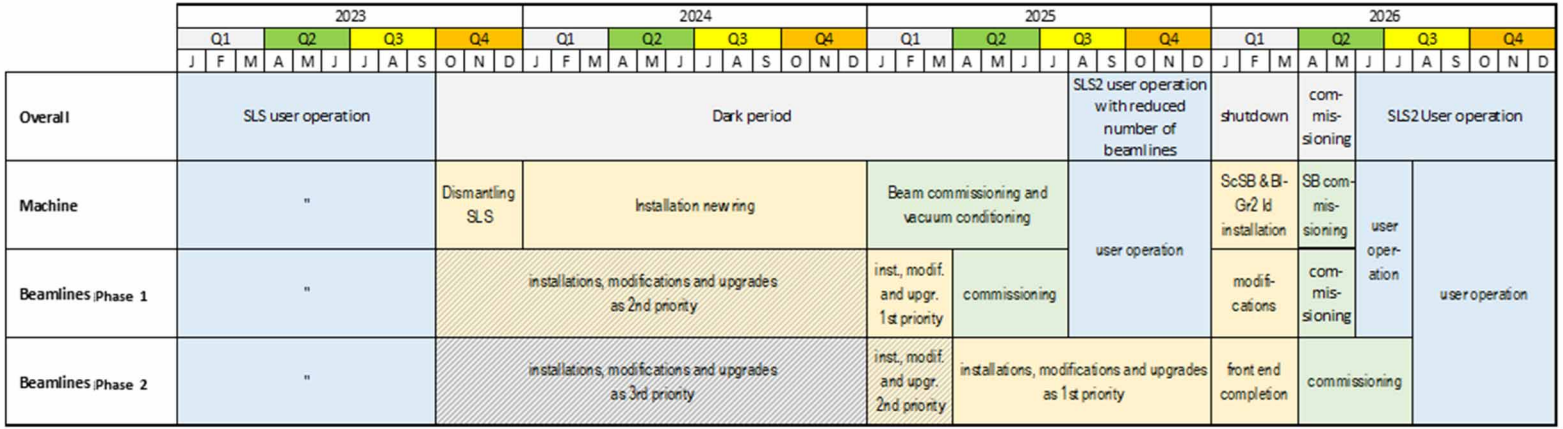
Roof renewal and PV system



Summary of key milestones

	Milestone	Date
1	Definition of ring lattice	30/06/2020
2	Beamline and positions defined	30/09/2020
3	SLS 2.0 funding secured*	01/01/2021
4	Ready for dark time	17/10/2022
5	Start of dark time	30/09/2023
6	Tunnel closure	20/12/2024
7	First beam available	01/05/2025
8	Start of user operation on first beamlines	01/08/2025
9	Start of shutdown phase 2	21/12/2025
10	Re-start user operation	01/06/2026

What are the beamline upgrades?



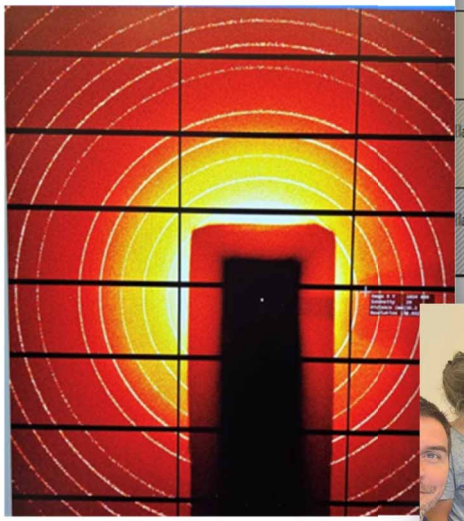
- Phase 0 (pre Dark period): PX III (incl. FE, present 2.9-T SB), Debye, (incl. FE, normal "SLS-1" 1.4-T bend), S-TOMCAT (present 2.9-T SB), SIM optics, partially I-TOMCAT, X01DD diagnostics (hutch)
- Phase 1: Finish I-TOMCAT, PX1, PX2, MS, remaining SIM (front end), cSAXS, SuperXAS (2-T RT-SB), PolLux/nanoXAS 3 x diagnostics BLs (X01DD, X05DB, X08DA). All FEs for Phase-1 BLs
- Group 2: Replace 2-T magnets @ Debye and S-TOMCAT with 3 - 5-T ScSBs, X-Treme/PHOENIX, RIXS, SX-ARPES, XIL, microXAS, QUEST, VUV, All FEs for Phase-2 BLs

Correct in 2021, minor updates occurred.

What are the beamline upgrades?

	2023				2024				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
	J F M	A M J	J A S	O N D	J F M	A M J	J A S	O N D	J F
	Dark period								
	Installation new ring								Beam c vacu
	lations, modifications and upgrades as 2nd priority								inst., mod and upg 1st priori
	lations, modifications and upgrades as 3rd priority								inst., mod and upg 2nd prior

- Mono light 01.09.2023

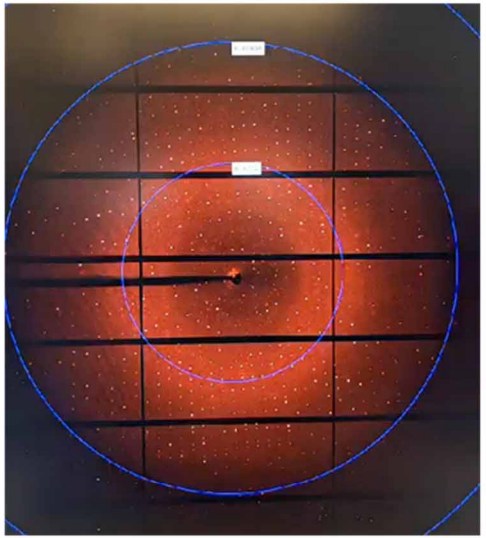


LaB_6 powder standard

- Group 2: Replace 2-T magnets @ D

microXAS, QUEST, VUV, All FEs for Phase-2 BLs

- Lyzosyme 04.09.2023



Pilatus4 1M, 150 µm pixel size,
fast readout
Real research data now being recorded,
industry included!!

Correct in 2021, minor updates occurred.

PSI Divisions involved in SLS 2.0

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Prof. Dr. Andreas Pautz
Prof. Dr. Gebhard F. X. Schertler
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Prof. Dr. Mike Seidel
Dr. Thierry Strässle*

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Center for Proton Therapy	Prof. Dr. Damien Weber

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- **Neutron Scattering and Imaging** — Prof. Dr. Michel Kenzelmann
- **Muon Spin Spectroscopy** — Dr. Thomas Prokscha a.i.
- **Neutron and Muon Instrumentation** — Prof. Dr. Marc Janoschek
- **Multiscale Materials Experiments** — Prof. Dr. Thomas Lippert

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- **Reactor Physics and Thermal Hydraulics** — Hakim Ferroukhi
- **Hot Laboratory** — Dr. Marco Streit
- **Waste Management** — Prof. Dr. Sergey Churakov
- **Nuclear Materials** — Dr. Manuel Pouchon
- **Radiochemistry** — Prof. Dr. Robert Eichler

Energy Systems Analysis
Prof. Dr. Russell McKenna

Research Division
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- **Bioenergy and Catalysis** — Prof. Dr. Oliver Kröcher
- **Electrochemistry** — Dr. Felix Büchi a.i.
- **Atmospheric Chemistry** — Prof. Dr. Claudia Mohr
- **Environmental Chemistry** — Prof. Dr. Margit Schwikowski
- **Catalysis and Sustainable Chemistry** — Prof. Dr. Jeroen van Bokhoven

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- **Macromolecules and Bioimaging** — Dr. Oliver Bunk
- **X-ray Nanoscience and Technologies** — Dr. Yasin Ekinci
- **Condensed Matter** — Prof. Dr. Frithjof Nolting
- **Femtochemistry** — Prof. Dr. Christoph Bostedt
- **Advanced Spectroscopy and X-ray Sources** — Prof. Dr. Luc Patthey
- **Nonlinear Optics** — Prof. Dr. Adrian Cavalieri
- **Nano and Quantum Technologies** — Prof. Dr. Kirsten Moselund

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- **Theoretical and Computational Physics** — Prof. Dr. Andreas Läuchli
- **Materials Simulations** — Prof. Dr. Nicola Marzari
- **Science IT Infrastructure and Services** — Dr. Alun Ashton

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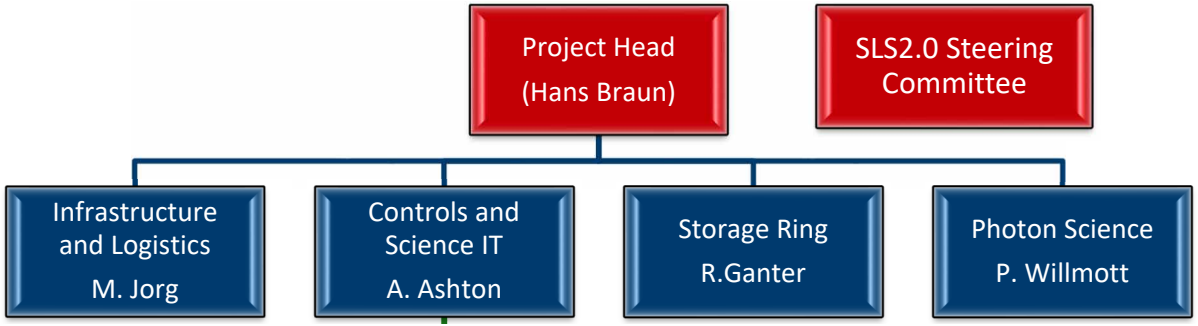
- **Accelerator Operation and Development** — PD Dr. Daniela Kiselev
- **Electronics and Control Systems** — Dr. Thomas Schilcher
- **Engineering and Coordination** — Kilian Rolli
- **Accelerator Technologies** — Dr. Hans-Heinrich Braun

Division
Logistics (LOG)
Dr. Peter Allenspach

- **Finance and Administrative Services** — Dr. Frank Behner
- **Real Estate and Services** — Lilian Jakob
- **Infrastructure and Electrical Installation** — Markus Jörg
- **Information Technology** — Ronny Peterhans
- **Radiation Safety and Security** — Dr. Sabine Mayer
- **Communications** — Dr. Mirjam van Daalen

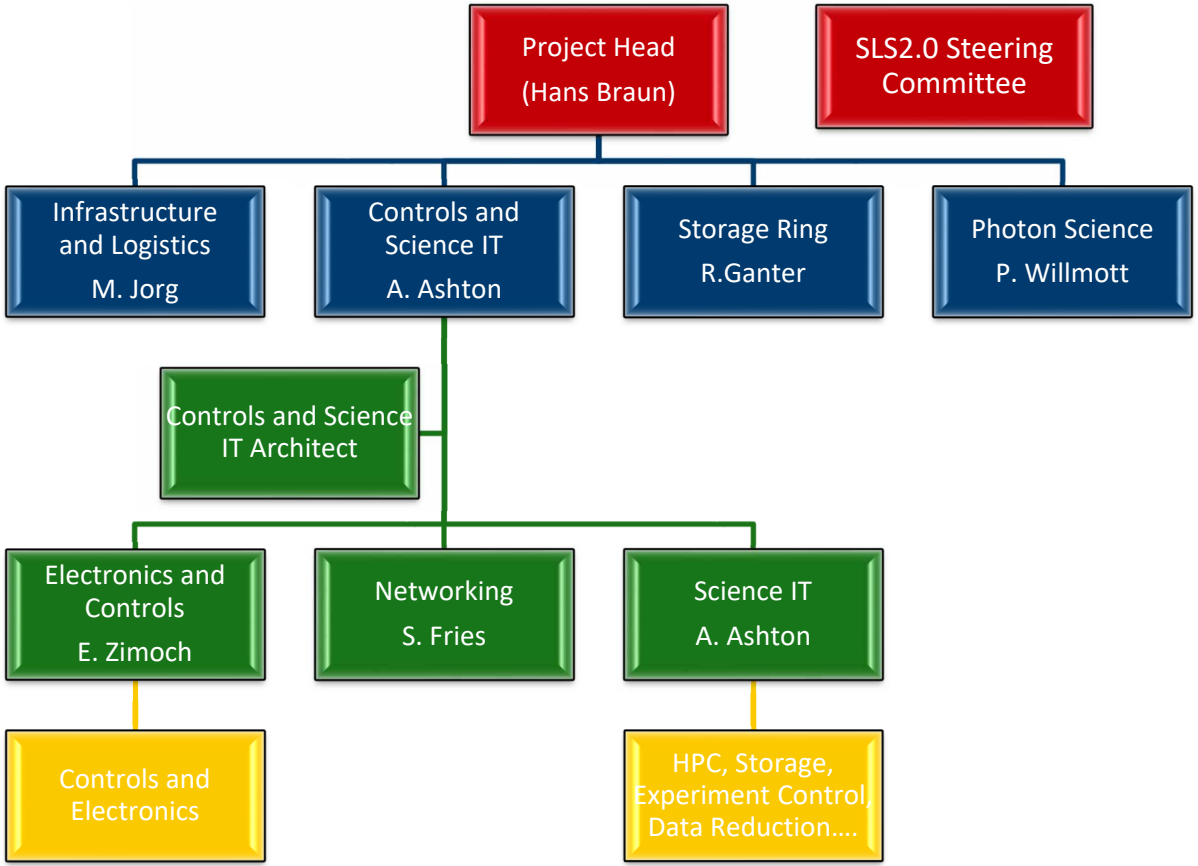
SLS2.0 Project Structure and Visibility of IT



Based on lessons learnt and increasing challenges/opportunities

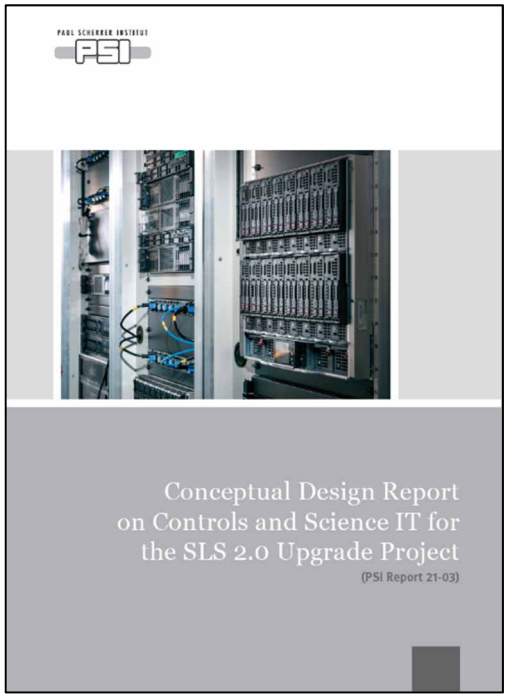
- Controls and Science IT represented at the highest level of the project management.
- Increased communication/reporting, visibility, impact consideration, budget negotiation, accountability.

SLS2.0 Project Structure and Visibility of IT



SLS 2.0 CaSIT Conceptual Design Report

- 21 authors, 82 pages
- Virtual review on 19th and 20th of May 2021
  - 16 talks
  - 6 reviewers from ESRF, APS, BESSY, Diamond, and SKA
- Variations in the level of detail in the report highlight the level of maturity of different services
- Published and available open access (Nov 2021): https://www.dora.lib4ri.ch/psi/islandora/object/psi%3A39514



SLS vs SLS2.0 Network Upgrade

SLS Services - Overview

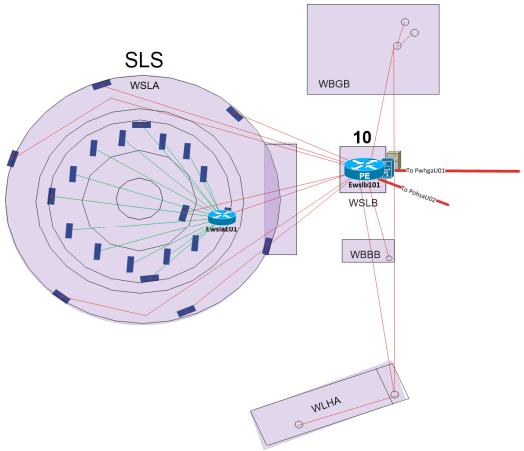
Core 1/10Gb/s

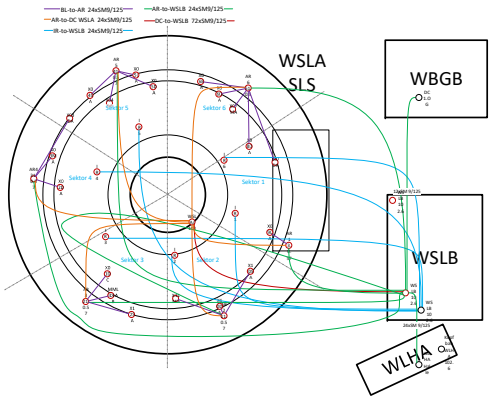
Machine network
- Cu 1Gb/s

BeamLine network
- Cu 1Gb/s, few 10Gb/s

WLAN (not in Tunnel)
- corp
- guest/eduroam

Cabling
- Fibre Multimode
- Fibre Singlemode





SLS2.0 Services - Overview

- Core 100Gb/s
- Machine network
- 1/10/25/100Gb/s
- BeamLine network
- Cu 1/10Gb/s
- Fibre 10/25/100Gb/s

WLAN in Tunnel as well
- corp/infra
- guest/eduroam

Cabling
- Fibre Singlemode

Thanks to: Stefan Fries

SLS2.0 Network Planning

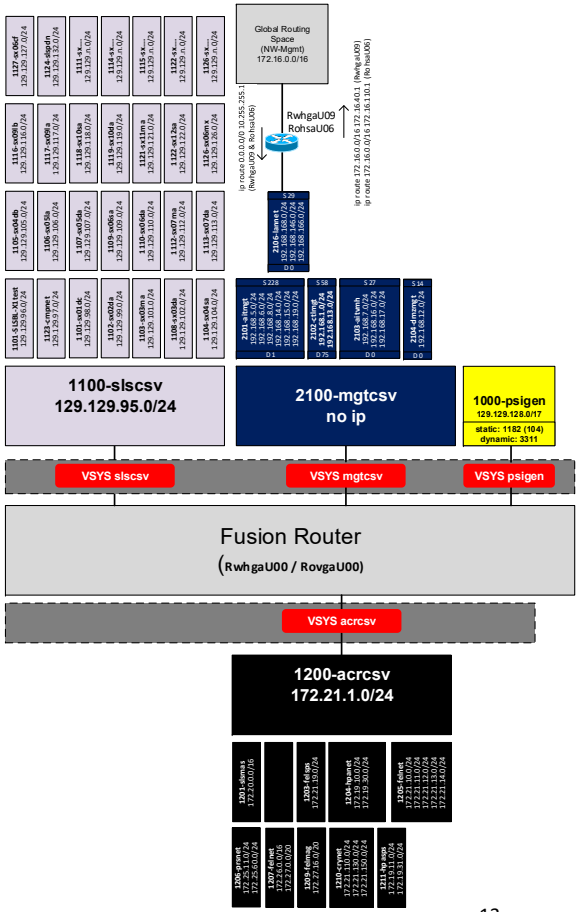
Zone concept will stay as it is today within SLS

Accelerator:

- EPICS machine Network will subneted and therefore built with /24 networks, instead of /16 as in SLS today,
- Beside EPICS Machine Network we will have noneEPICS machine network (as in SwissFEL)

Beamline

- Each Beamline will have it’s own network. Beamline networks do not see each other.
- There will be a shared network between all beamline, Common Service VLAN network
- Detector Ethernet switches/networks are covered by Science IT
- Networking boundaries between accelerator and beamlines need to be agreed

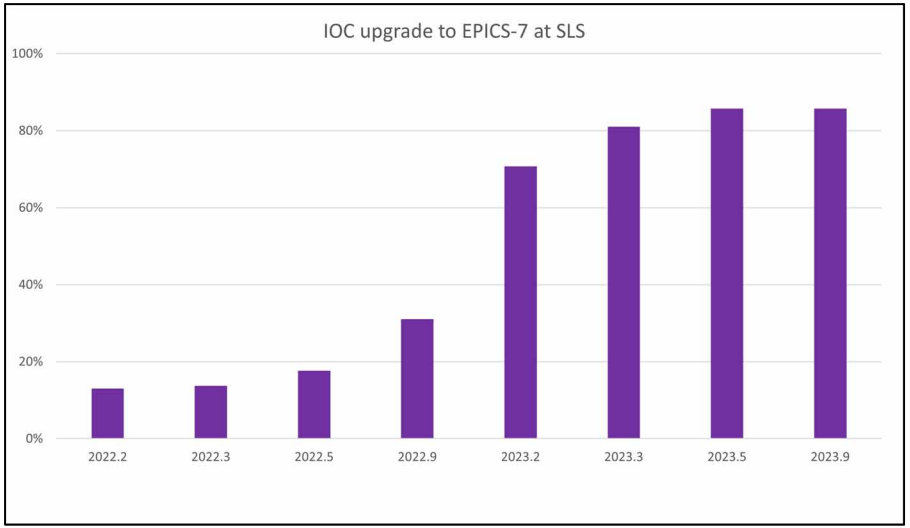


Controls Software Upgrades

Key challenge is mixing legacy and new generational systems, mitigation:

Goal: upgrade before the dark time if possible

- VxWorks upgraded to Version 6 (100% of VME systems SLS)
- EPICS upgraded to Version 7 (86% of IOCs upgraded – including everything that stays after the dark time)



Motion System

- New motion system for SLS 2.0 installations based on EtherCAT
- Slaves from Beckhoff
- Use of ECMC as EtherCAT Master
- Reasons:
  - Fast feedback loops can be relized (ms)
  - Easy to integrate new motors
  - Approx. 160 slaves currently supported
  - Core developer at PSI

ECMC
(EtherCAT Motion Controller)

EtherCAT®

Beckhoff slave modules

Motion System

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  - Core developer at PSI

New shipment of Beckhoff motion control hardware has arrived

ECMC
(EtherCAT Motion Controller)

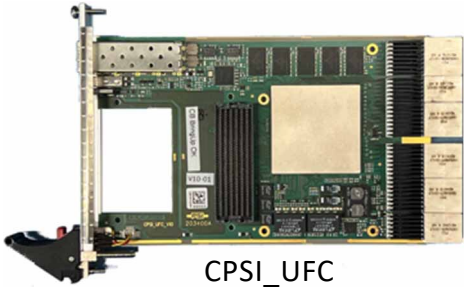
EtherCAT®

Beckhoff slave modules

Hardware Toolbox

Hardware Solution	Use Case
CPCI-S Toolbox	Fast ADC/DAC or DIO Signals, if needed with specific FPGA (Field Programmable Gate Array) Development. An example are the LLRF Systems
Embedded systems (Zynq UltraScale+)	Special developments for PSI where CPCI-Serial or a commercial solution does not fit the requirements. An example is the DBPM3 system.

CPCI-S Crate



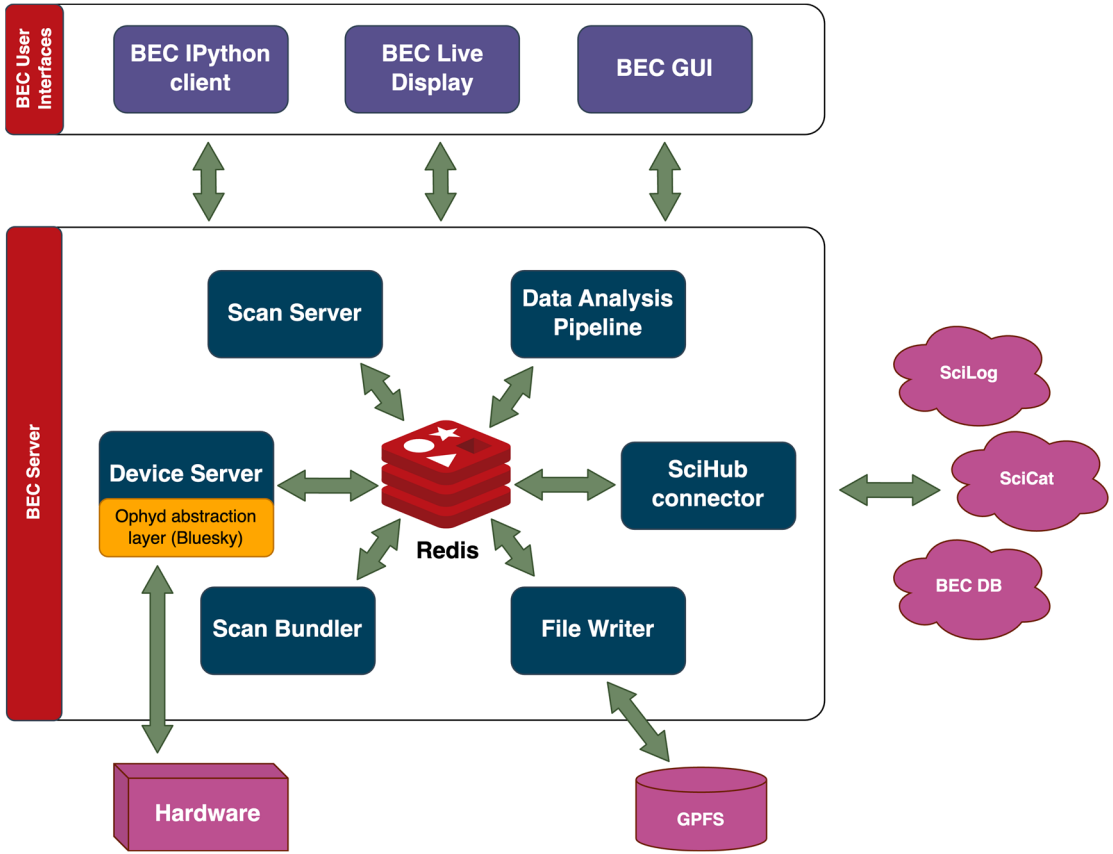
CPSI_UFC

CPSI_CIO

BPM Electronic

Beamline Experiment Ccontrol Architecture

K. Wakonig et. al., “A Beamline and Experiment Control System for the SLS 2.0.”, presented at ICALEPCS’19, Cape Town, South Africa, October 2023, paper MO2AO02

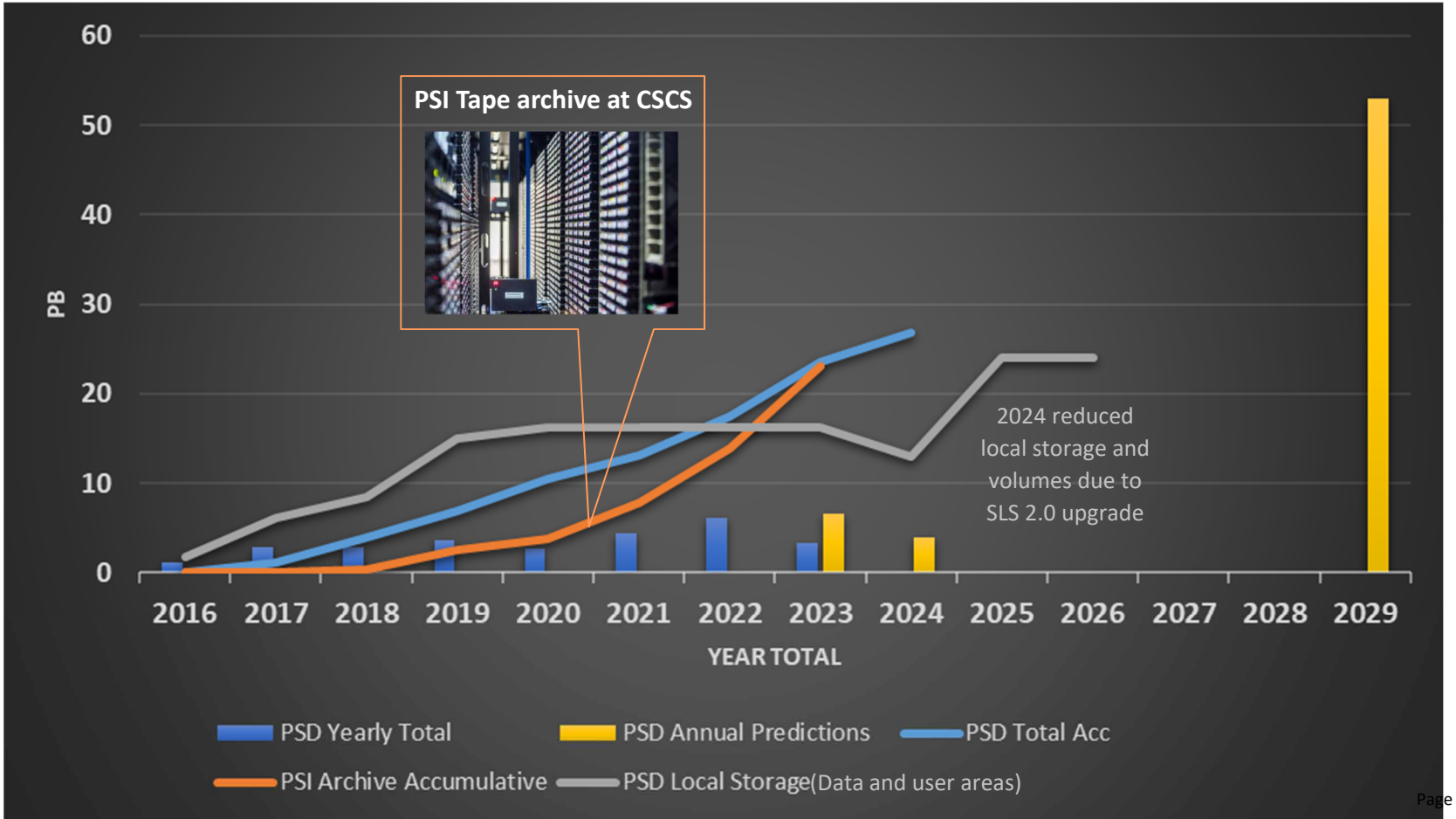


“Tiered” experiment measurement stream/capture

All currently under development:

- Lowest rates (low hundred MB/s (100-400 MB/s)
  - Directly back into the Redis of the BEC
- High rates (stdDAQ: circa 8 GB/s)
  - stDAQ, developed originally for JF detectors on SwissFel and recently being tested on SLS before shutdown
- Highest rates (currently tested up to 2 kHz (36 GB/s), THMBCMO38)
  - Filip Leonarski, et al. “Jungfraujoch: Hardware-Accelerated Data-Acquisition System for Kilohertz Pixel-Array X-Ray Detectors.” Journal of Synchrotron Radiation 30, no. 1 (January 1, 2023): 227–34. https://doi.org/10.1107/S1600577522010268.

PSI Data Volumes



SLS Data Reduction, Reconstruction and Analysis

DA+ data acquisition and analysis software at the Swiss Light Source macromolecular crystallography beamlines

Justyna Aleksandra Wojdyla, Jakub W. Kaminski, Ezequiel P
Simon Ebner, Xiaoqiang Wang, Jose Gabadinho and Meitiar

Swiss Light Source, Paul Scherrer Institute, 5232 Villigen, Switzerland.
*Correspondence e-mail: meitian.wang@psi.ch

Data ac quisition soft essential component of modern
crystallo graphy (enabling efficient use of
synchro tron facilities. Develo at the Paul Scherrer Institut
acquisit ion software is im at all three Swi Light
beamlin es. D of distributed services and com
Python and Ja communities, and stre
The majo r com DA+ are the acquisition
processi ng and database. Immediate feedbac
distribut e analysis tools software
explorat ential of the latest instrumentati
beamlin es, such as marcom goniometer and the EIGER X
and dev data collection methods.

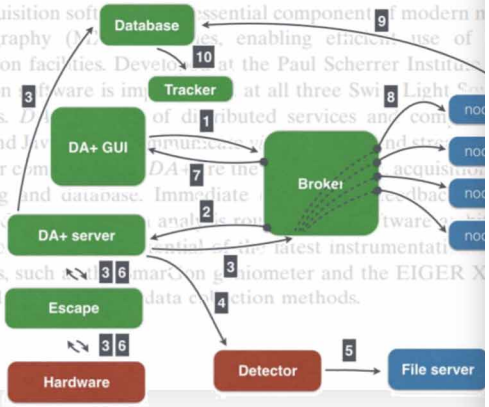


Figure 1
Schematic representation of the software infrastructure at the SLS MX be
components are shown in green boxes, hardware components in red boxes, a
computing nodes in blue boxes. Lines indicate interactions between different
numbers show the order of workflow (a detailed description is given in in §3.1)
message broker is a major communication hub used by *DA+* daq software compon
experiment parameters in the *DA+* GUI, while *DA+ server* carries out da
communicates with detector and hardware *via* basic state machine *escape*. *Adp*
message from the broker, start data processing and send results to the *mxdb* database. Results of *adp*
are displayed in the web-based *adp-tracker*.

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Research at PSI | Research Divisions and Labs | Facilities and Instruments

cSAXS beamline software packages

Base package

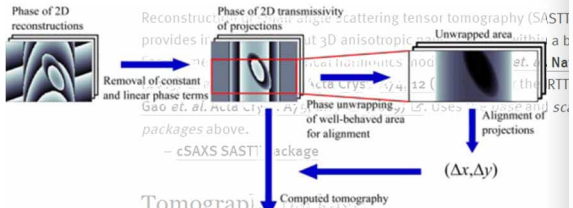
Basic functionalities for file reading and radial integration and plott
provides a lot of functions used in the other packages.
– cSAXS base package

Scanning SAXS package

Analysis and plotting of scanning SAXS, main orientation of scatter
orientation. Please cite Bunk *et. al.* New J. Phys. 11, 123016 (2009)
base package above.
– cSAXS scanning SAXS package

SASTT package

Reconstruct SAXS scattering tensor tomography (SASTT
provides i ut 3D anisotropic
Acta Crys 12 (
Gao *et. al.* Acta Cry
packages above.
– cSAXS SAST ackage



Tomograp

Beamline c nt of projections and reconstruction for
and laminog n alignment methods by 3D consistenc
sub-pixel ac ded. If used cite Odstrčil *et al.* Opt. Exp
36637 (201 ase package* above.
– cSAXS tomography package

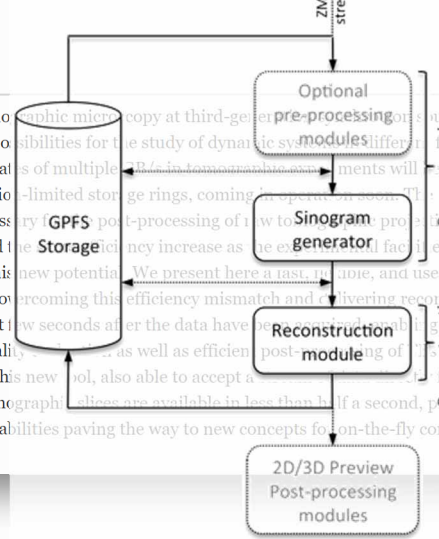
Towards on-the-fly data post-processing for real-time tomographic imaging at TOMCAT

Federica Marone ✉, Alain Studer, Heiner Billich, Leonardo Sala & Marco Stampanoni

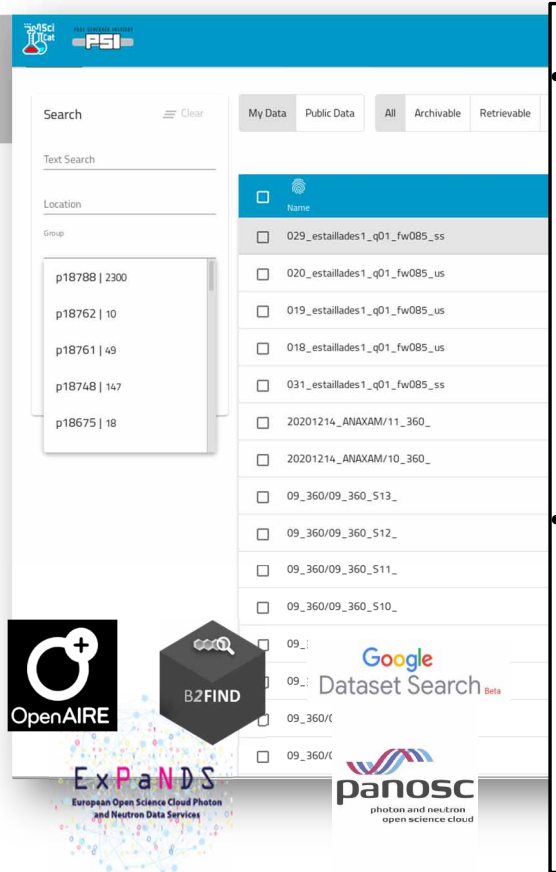
Advanced Structural and Chem ical Imaging 3, Article number: 1 (2017) | Cite this article

Abstract

Sub-second full-field tomo graphic micr copy at third-ge ers
reality, opening up new po sibilities for t e study of dynamic s differ
Sustained elevated data rat s of multiple ments will
more common at diffractio limited stor ge rings, coming
computational tools necess ry f post-processing of
generally not experienced f e
optimal exploitation of this new potentia We present here a fast, n ote, and user-fri
post-processing pipeline o ercoming this efficiency mismatch and c livering
tomographic datasets just f w seconds af er the data have
parameter and image quali as well as efficien post-
tomographic data. With thi new ol, also able to accept a
detector, few selected tomo graphi eliesare available in less than
advanced previewing capa bilities paving the way to new concepts fo n-the-fly contro
dynamic experiments.



Data Catalogue and Lab Notebook



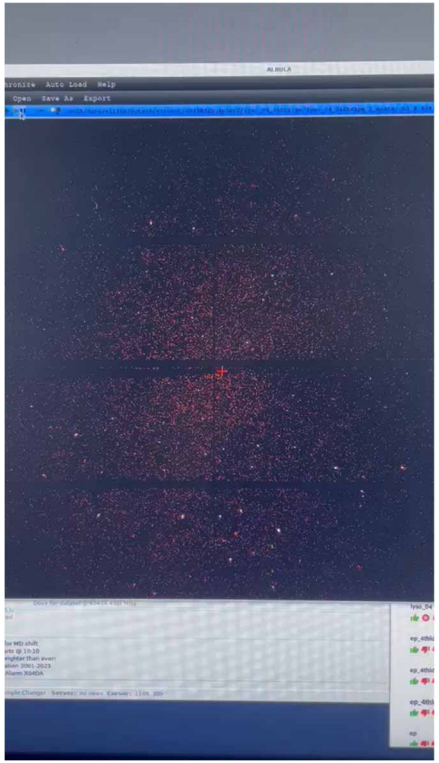
- C. Minotti et. al., “Enhancing Data Management With SciCat: A Comprehensive Overview of a Metadata Cata-logue for Research Infrastructures.”, presented at ICALEPCS’19, Cape Town, South Africa, October 2023, paper THMBCMO02

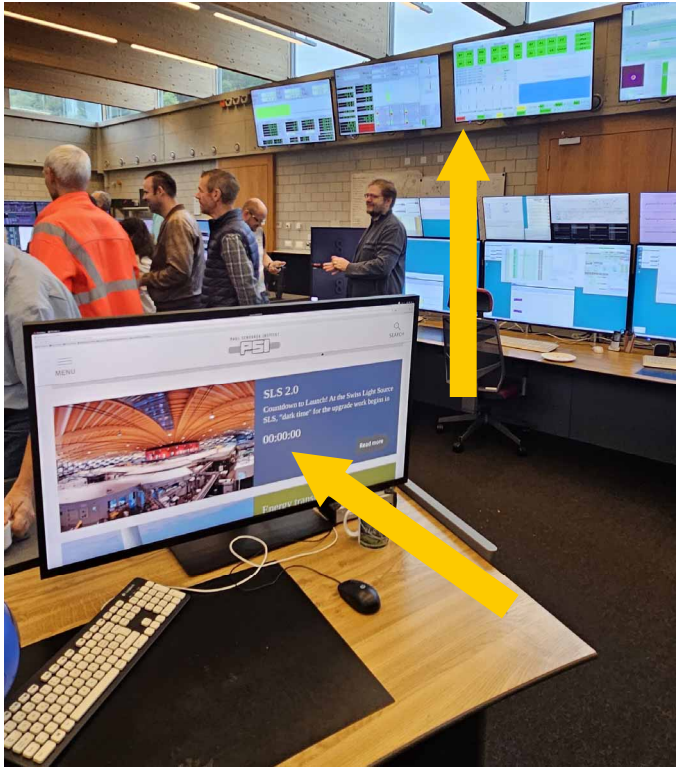
- K. Wakonig et. al., “Scilog: A Flexible Logbook System for Experiment Data Management.”, presented at ICALEPCS’19, Cape Town, South Africa, October 2023, paper THPDP073.

Some experience that come as no surprise….

- The immediate consideration and impact on CaSIT activities, availability and schedule when any scope changes were being considered.
- A dedicated budget line that was ringfenced (circa 4% of the overall upgrade budget).
- Direct communication line to the workgroups in CaSIT both from the SLS 2.0 management board or to the management board for any matters needing escalation.
- Increased and simplified processes for standardisation.
- Gathering and agreeing requirements and prioritisation.
- Identifying budgets that were historically embedded with other activities and ensuring none were over-looked or double accounted.
- Establishing, documenting and communicating clear responsibilities and decisions in a resource stretched environment where other external pressures persist on the involved units.
- The critical nature of involving and delegating decisions and priorities to a combination of technical and scientific expert stakeholders.

Dark Time Started





Many thanks and…

- All involved,
  – see paper!