ALBA light source synchrotron

Barcelona(Spain)

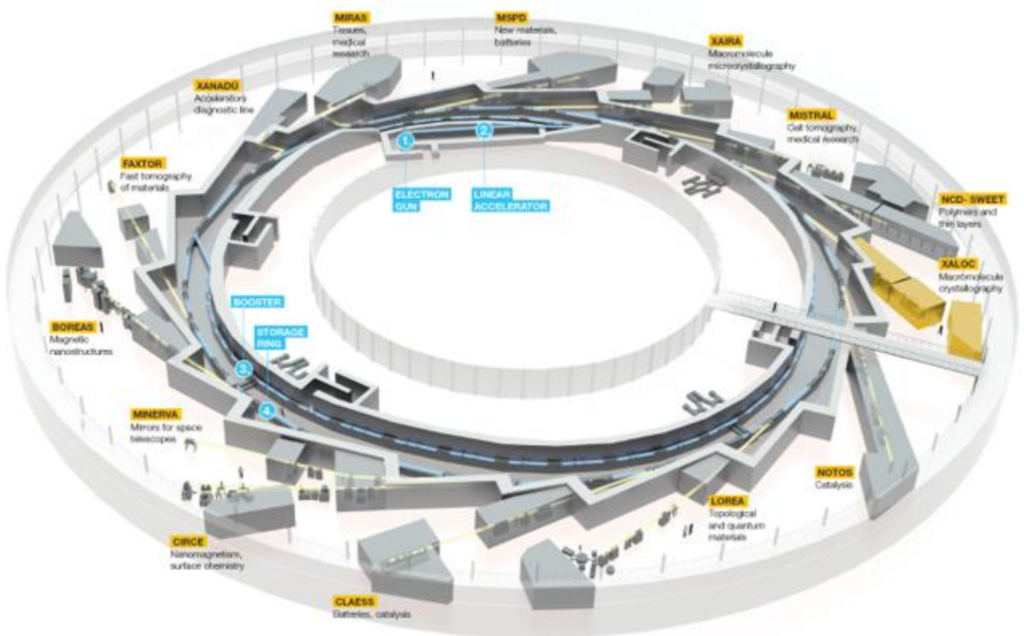
MOCRAF'25 attendees:

- Xavier Serra-Gallifa

ICALEPCS'25 CHICAGO

ALBA is a 3rd generation synchrotron light source (foreseen an upgrade to 4th generation):

- 14 beamlines in operation
- 1 new BL in construction
- BL are working 24h/7 with only Mondays morning for maintenance. And a 24h OnCall service for incidents.



Organization of Motion Team

- Motors and encoders are purchased by Mechanical engineers. Engineering division
- Controllers are provided by Electronics Section, which configure it
- Controls section programing the control, trajectories

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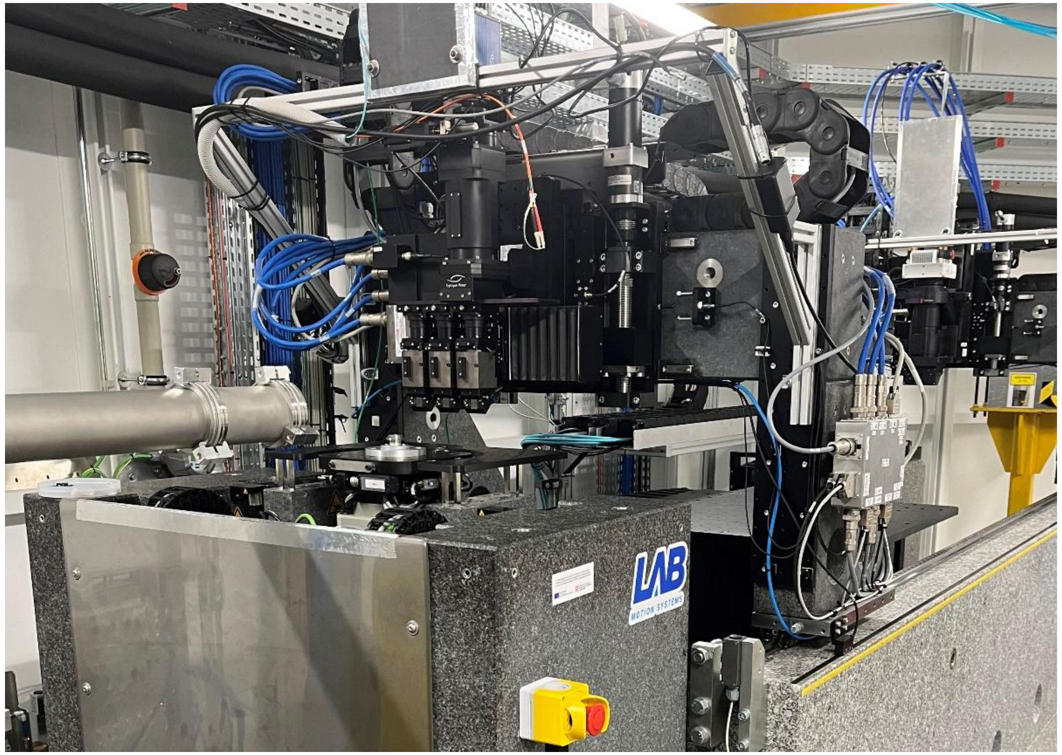
MOTION CONTROLS AND ROBOTICS

Motion in numbers

- ALBA is using Tango and Sardana control system
- 90% of the motors are steppers and controlled by ICEPAP controller developed in Collaboration with ESRF (~850axis)
- 80% of the motors have encoder feed-back, and many has close-loop control



Maintenance and incident management

- Use of a standard controller, for an easy replacement
- Controller configuration tool saves the configuration changes done by each user
- During summer shutdown copy of configuration and position are saved and checked during the power off.
- Incidents. Mechanical in never though as a root of the problem. First suspect is always Controller. Despite aging is affecting more the mechanics.
- There is no maintenance plan. No mechanical lubrication plan.
- Use of chains to guide the cabling avoid cabling brokes

Present and future Highlights

Innovations

- We have a new Nanomotion lab which is a white room equipped with Instrumentation to test and develop new capabilities.

Challenges

- New standard controller for Servo Motors.

Advanced Photon Source

Lemont, Illinois, United States

MOCRAF’25 attendees:

- Nick Marks

ICALEPCS’25 CHICAGO

The newly upgraded Advanced Photon Source at Argonne National Laboratory

- 72 beamlines
  - Our group (BC) manages controls for around 45 of them
- 41 beamlines accepted users during the first run of 2025, the rest still in commissioning phase

Organization of Motion Team

- Beamline controls group
- Accelerator controls group

Motion control at our Facility

- 1000s of motors
  - Stepper motors (majority)
  - Piezoelectric stages
  - DC motors
- Most new installations have encoder feedback, some using closed-loop
- Preferred controllers:
  - ACS Motion (steppers, servos)
  - PI (piezos)
- Many other controllers in use at the APS
- EPICS
  - Our group maintains synApps; A collection of EPICS support modules (including the motor record) which are useful at synchrotron facilities

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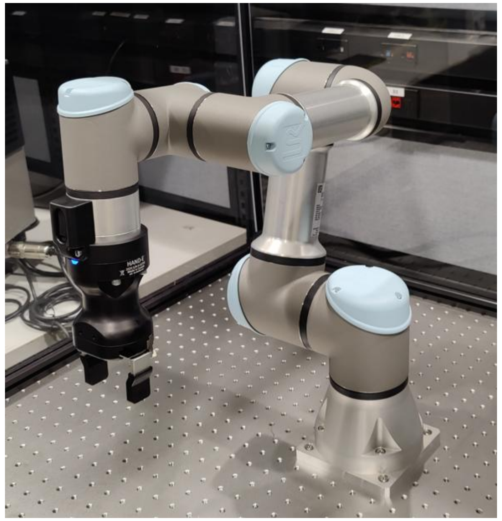
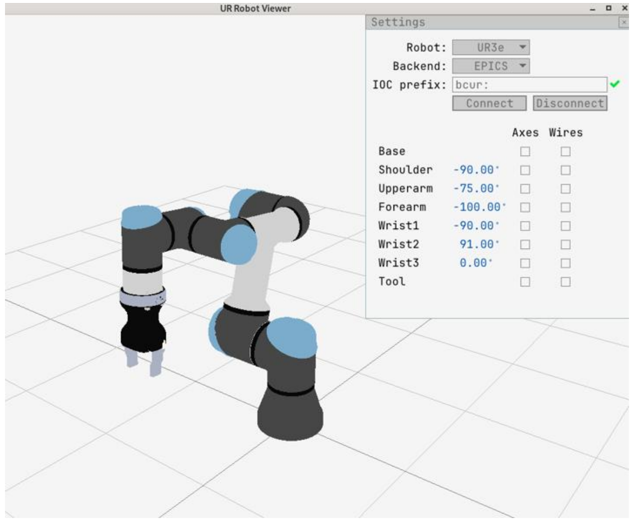
MOTION CONTROLS AND ROBOTICS

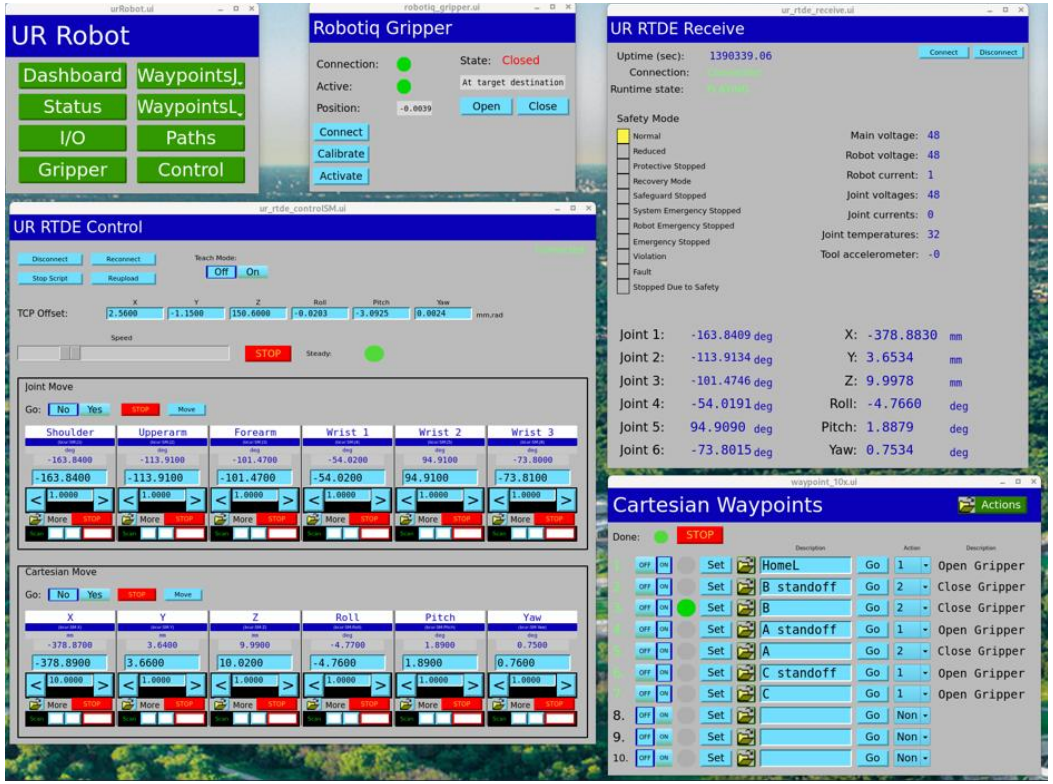
Present and future Highlights

Innovations

- We develop EPICS support software for new devices as they are needed
- I've recently been developing EPICS support for robotic arms from Universal Robots







CERN

MOCRAF'25 attendees:

- Alessandro Masi – Controls, Electronics and Mechatronics Group Leader
- Mario Di Castro – Mechatronics, Controls and Operations Section Leader
- Giuseppe Pezzullo

ICALEPCS'25 CHICAGO

CERN - European Organization for Nuclear Research

Goal

Uncover what the universe is made of and how it works.

Large Hadron Collider

Located 100m Underground

27 km in Circumference

99.9999% the Speed of Light

Temperatures of -271°C

4 Detectors

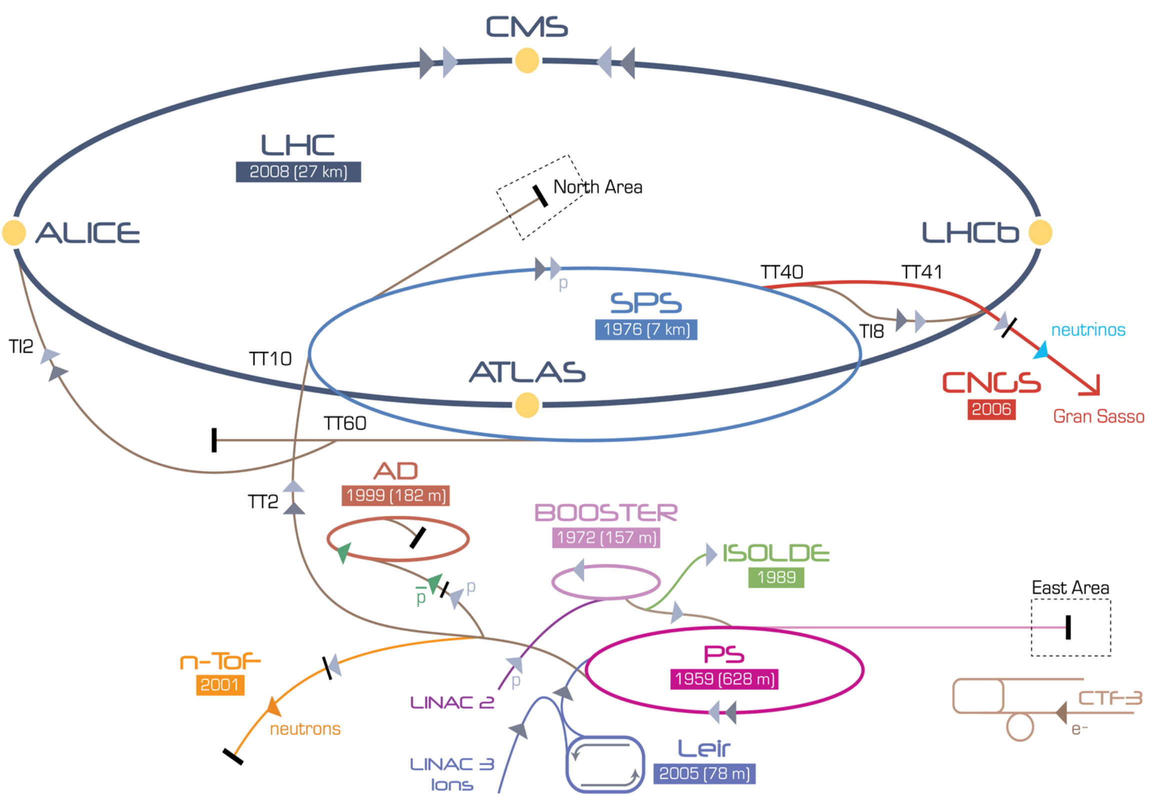
Best Model

The Standard Model of Particle Physics

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + i\bar{\psi}\not{D}\psi + h.c + \psi_i y_{ij}\psi_j\phi + h.c + |D_\mu\phi|^2 - V(\phi)$$

INCOMPLETE

FACILITIES



Director General

Fabiola Gianotti

CERN in Numbers

16,950 Member of Personnel

700+ Buildings

23 Member States

1.2 GCHF/year Budget

Impact & Return

Medical Imaging

Cancer Treatment

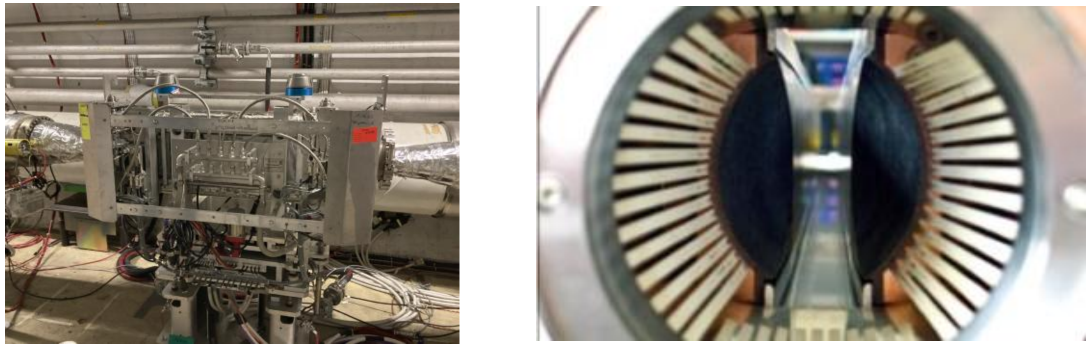
Superconducting Magnets

Data Processing

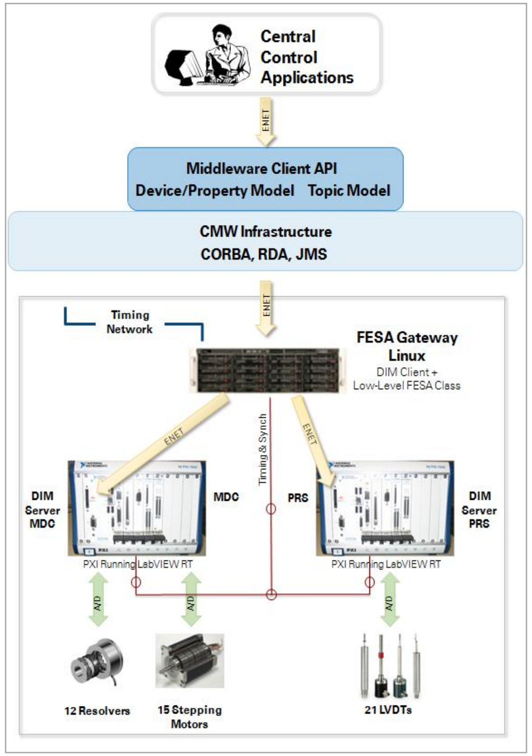
...

Motion control at our Facility

- **Motion Control @ CERN** — precision actuation for Beam Intercepting Devices, beam diagnostics and robotics. High precision (~ 1um) in extremely radioactive environments with millisecond synchronisation.
- From Beam Intercepting Devices to beamlines: standardisation, synchronisation, sustainability.
- Remote-controlled stages providing the possibility to position the DUT with ±0.005mm precision in the transversal plane (X-Y) with respect to the beam axis
- **Control stack (typical):** Drives/PLCs (safety) → real-time edge/HIL → SCADA/HMI → EPICS/FESA gateways → timing/trigger fan-out.
- **Synchronisation for experiments:** fly-scans, detector coupling via triggers/time-stamps; cross-brand jitter/latency



LHC Collimator (left) and internal view of the 2 jaws (right)



LHC Collimators control system block diagram architecture.

Maintenance and incident management

- **Planned maintenance + diagnostics:** preventive schedules in planned technical stops, with condition monitoring (drive/axis telemetry, temperature/vibration) and periodic re-qualification of critical axes.

- **Spares & obsolescence control:** criticality-based stock, last-time buys for EOL items, form-fit-function replacement policy, and documented interchangeability. In house developments.

- **RAMS:** availability targets, spares/obsolescence, predictive diagnostics.

- **Work execution & safety:** work orders with risk assessment, RP checks/ALARA; pre-job briefs and post-job sign-off with as-built updates to EDMS/config DB.

- **On-call & escalation (piquet):** 24/7 duty rota with clear ownership; first-line recovery playbooks, escalation paths (controls/mech/RP), and service KPIs (MTTR, availability).

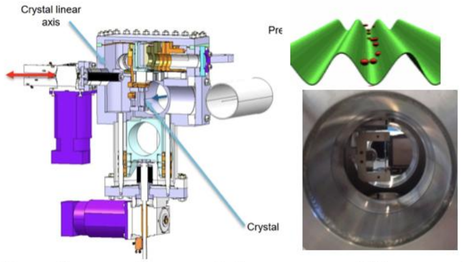
- **Incident lifecycle:** immediate logging, stabilization, root-cause analysis (5-Whys/FMECA), corrective & preventive actions (CAPA), and a short **blameless post-mortem** shared within days.

Present and future Highlights

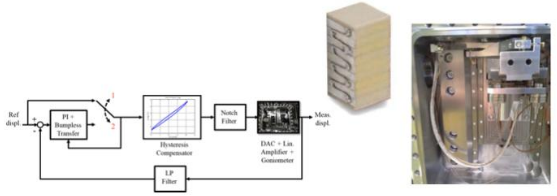
Innovations

- Precise motion control of silicon crystal strips to steer the beam with 1 urad precision
- Precise Wire scanners (1 um) for beam diagnostics

LHC Piezo goniometers: crucial for ion beams cleaning !



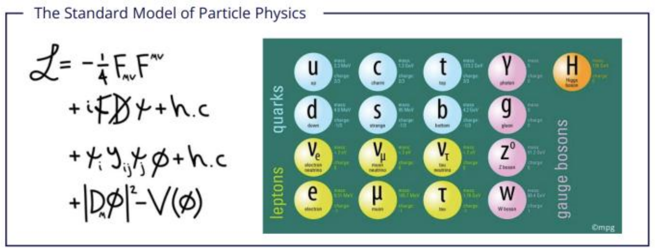
➢ *1 μrad precision over 20 mrad*



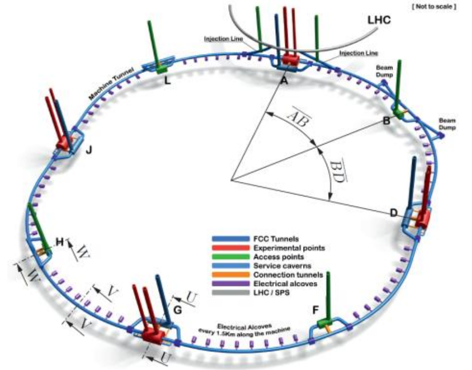
➢ *Piezo technology in the LHC vacuum !*

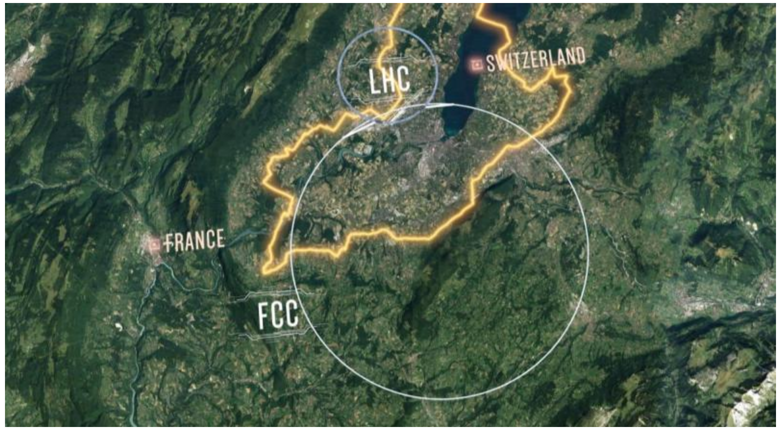
Robotics

- In-house robotic service to improve maintainability and safety
- Setting up the future for FCC automation

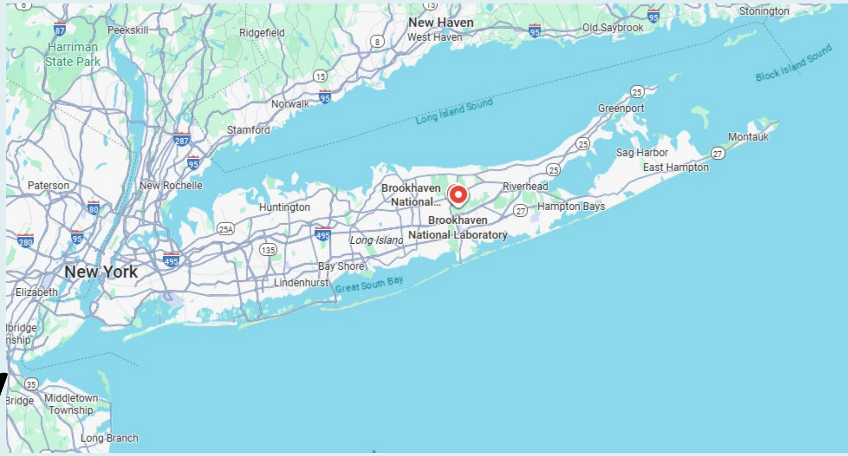


Best Model not complete





NSLS2 Brookhaven National Laboratory



Long Island NY, USA

MOCRAF’25 attendees:

- Oksana Ivashkevych oksana@bnl.gov

ICALEPCS’25 CHICAGO

- NSLS2 is a 3rd generation synchrotron
- Electron Beam Energy: 3 GeV
- Beam Current: 500 mA
- 29 operating beamlines (0.6 meV - 117 keV)
- 8 beamlines are funded and currently being built (4 beamlines are under construction, 4 are in the design phase)

Organization of Motion Team

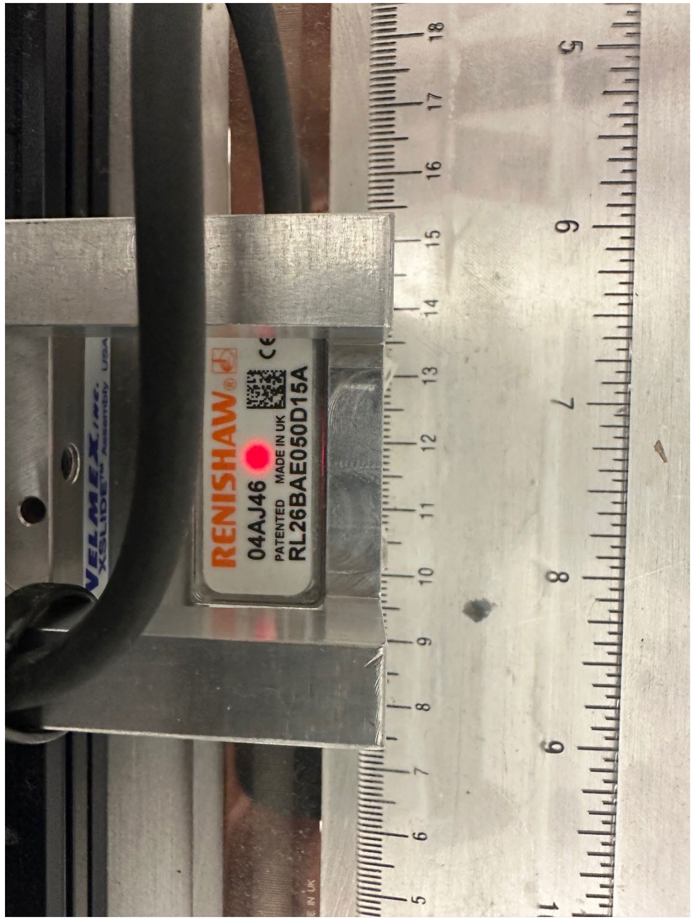
- Motion tasks are performed by Integrated Controls (IC) group withing Data Science and Systems Integration (DSSI) division.
- IC rep is involved in equipment purchases
- We have a list of supported hardware

Motion control at NSLS2 BNL

- ~3,500 motors and ~1,000 encoders on the beamlines
- 90% is driven by DeltaTau controllers
  - Moving from GeoBrick LV(obsolete) to Power Brick LV
  - Majority are Incremental encoders
  - New beamlines are built with Absolute Renishaw encoders.
- SmarAct is the most common piezo system used
- NSLS2 is an EPICS user facility

Maintenance and incident management

- We use Jira tool to handle repair requests
- Every beamline has an assigned support engineer to handle emergencies
- If not an emergency, the requested Jira request must be elevated on the program level and selected for development



Present and future Highlights

Innovations

- To manage and maintain that many IOCs we are moving to Ansible deployment of IOCs and screens.
- The Ansible deployment is applied to the new beamline constructions
- We are looking at Liberty M-drive as a cheaper standard motion control solution and are designing a custom in-house power supply solution for it.

Challenges

- GeoBrick LV is obsolete, we own controllers since 2014.
- DeltaTau still repairs the units
- Failures we see :
  - limit switch boards
  - Communication board
- GeoBrick LV and power Brick LV are similar but not identical
- Though majority of motor controllers are GeoBrick LV and Power PMAC LV, we do have motion diversity.

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MOTION CONTROLS AND ROBOTICS

Canadian Light Source (CLS)

Saskatoon, Canada

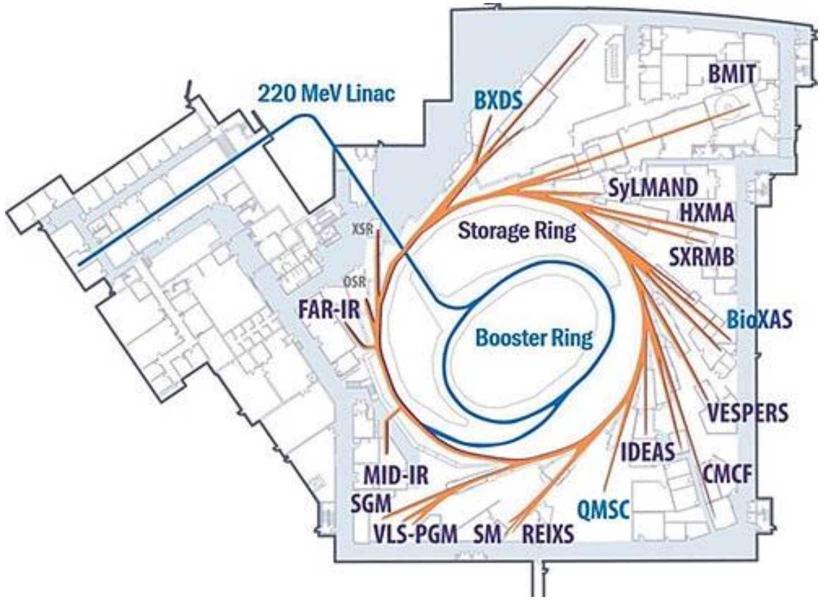
MOCRAF’25 attendees:

- Augusto Y. Horita
  (augusto.horita@lightsource.ca)

ICALEPCS’25 CHICAGO

CLS is a 3rd generation synchrotron light source

- 22 beamlines
- BLs performs shift working 24h/6, with Mondays for maintenance
- 24h OnCall duty (EE, EM, CTRL, IT)
- Currently No User Beam: Upgrading LINAC

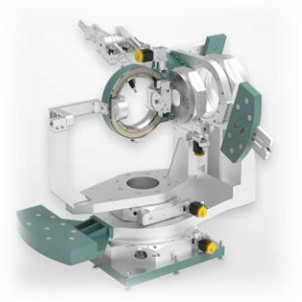


Organization of Motion Team

- Motors and Encoders purchased by EEE or CTRL groups
- Non-PLC Controllers purchased by 'all' groups configured by CTRL
- PLC Controllers purchased and configured by EEE
- Tuning of PLC Controllers in hands of EEE

Motion control at our Facility

- CLS uses EPICS for the Control System
- MOCR standard was to use:
  - MaxV (VME bus) controller
  - Deltatau
  - Customized board
- Those are being updated to:
  - Beckhoff systems using ecmc
  - Deltatau for more complex systems
  - Some piezos (PI, Smaract,Newport)



Present and future Highlights

Innovations

- Currently trying to update to Beckhoff
- Update OS (SL7/SL54 to Debian 12)
- Update EPICS version
- Use of new build environment (require)
- GUI tool is also being updated

Challenges

- Update of multiple levels of the Control System at scale and at the same time
- Training staff with new tools /env

Diamond Light Source

Oxfordshire UK

MOCRAF'25 attendees:

- Brian Nutter Motion systems engineer
- Ronaldo Mercado. Senior Software Systems engineer-ID group

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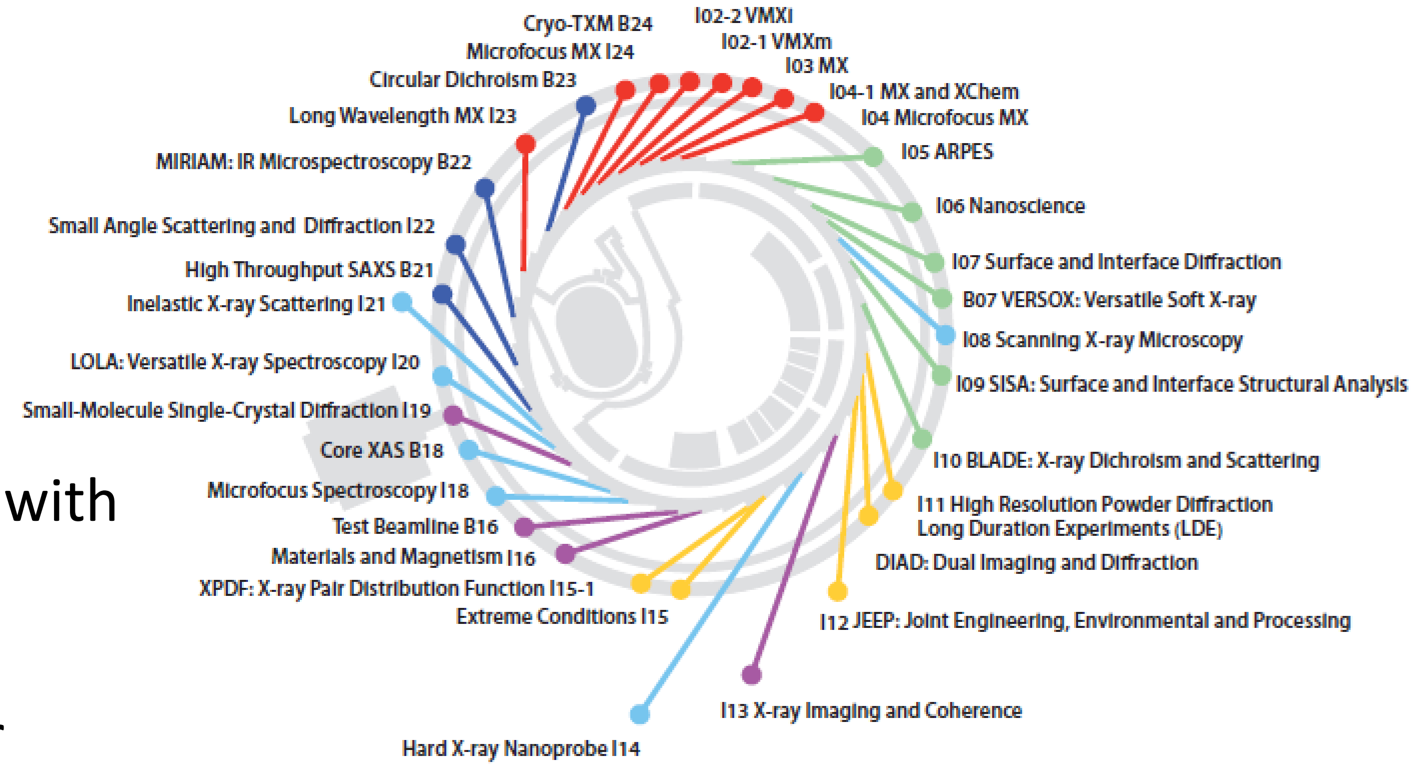
MOTION CONTROLS AND ROBOTICS

- Diamond Light Source is the UK national synchrotron facility.
- It has been open to users since 2007, now offering 31 beamlines with a wide range of techniques and specialties.
- We are now preparing for a major upgrade project to deliver a low emittance storage ring and build 3 new flagship beamlines.
- Every existing beamline will need some upgrades to their beamline optics with some motion changes.



Organization of Motion Team

- Motion team at Diamond is a dedicated team of 4 engineers and 2 technicians. Formerly part of Controls it is now part of Engineering.
- Engineers buy motion hardware. Must(?) be compatible with standard motion controller.

Motion control at our Facility

- Beamline Motion controller is Delta Tau PMAC controller; evolving via GeoBrick into PowerBrick controller/amplifier.
- DT software used for initial set up and commissioning. Files now stored and managed using GIT.
- On-line ‘tweaks’ can be made using Diamond written DLS_MotorControl.py which detects which version of PMAC it is connecting to and presents the appropriate interfaces.
- There are over 3000 motors; > 80% stepper. All new installations encoded and used in closed loop position control
- Alternatives are piezo actuator or brushless servo.

Maintenance and incident management

- Standardisation is the key to rapid response and recovery.
- Motion team take it in turns to respond to the emergency phone for 1 full day per week.
- Standardisation allows every team member to be able to resolve most incidents that arise.
- Fauty kit can be quickly replaced. And depending upon its age repaired in house or returned to manufacturer.
- There is no planned (motion) maintenance at present.
- High precision requirements are often compromised prior to catastrophic failure
- Encoded stepper motors can run open loop (with lower precision) until shutdown and replacement. Very useful in vacuum.
- Radiation tolerance of encoders is becoming a more prevalent issue.

Present and future Highlights

Innovations

- Flexure driven stages delivering nanometer level precision , accuracy and stability.
- ‘Gantry Control’ over ‘cascaded servo loops’ on aging hardware restoring 18 YO diffractometers to ‘as delivered’ performance levels.
- Modular code configuration delivering rapid commissioning for beamline upgrades. 24 axes in 3 days during the last shutdown.

Challenges

- Even higher levels of precision and stability driven by ptycography and imaging beamlines…
- Leading to projects for High dynamic motion control and Machine learning using FPGA hardware.
- Cross hardware integration to enable 10,000 MX diffraction sets per day.
- Diamond-2 upgrade.

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MOTION CONTROLS AND ROBOTICS

ESRF

Grenoble

MOCRAF’25 attendees:

- Vicente REY BAKAIKOA

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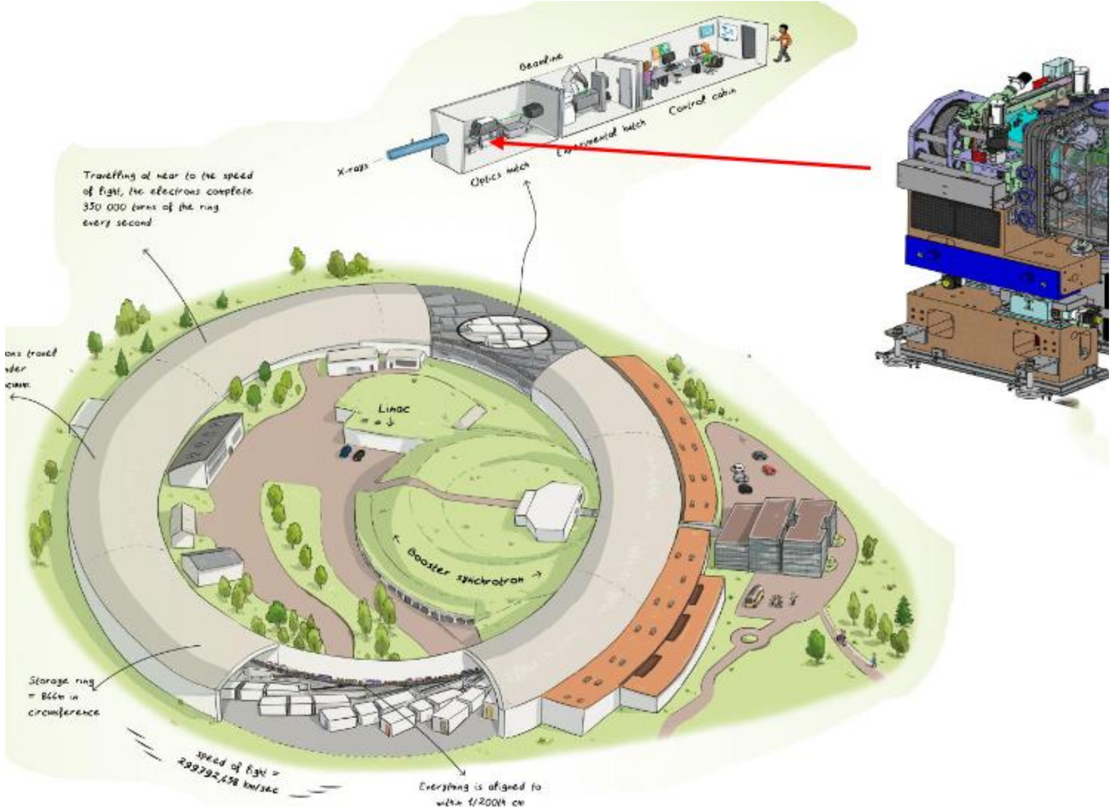
- ESRF - The European Synchrotron was one of the first 3rd generation synchrotrons. It was first opened to users in 1994.

- Since 2020 we operate the EBS with a complete new lattice (hybrid 7-bend achromat) and horizontal emittance down to 150pm (30 fold improvement)

- 45 beamlines in operation



Organization of Motion Team

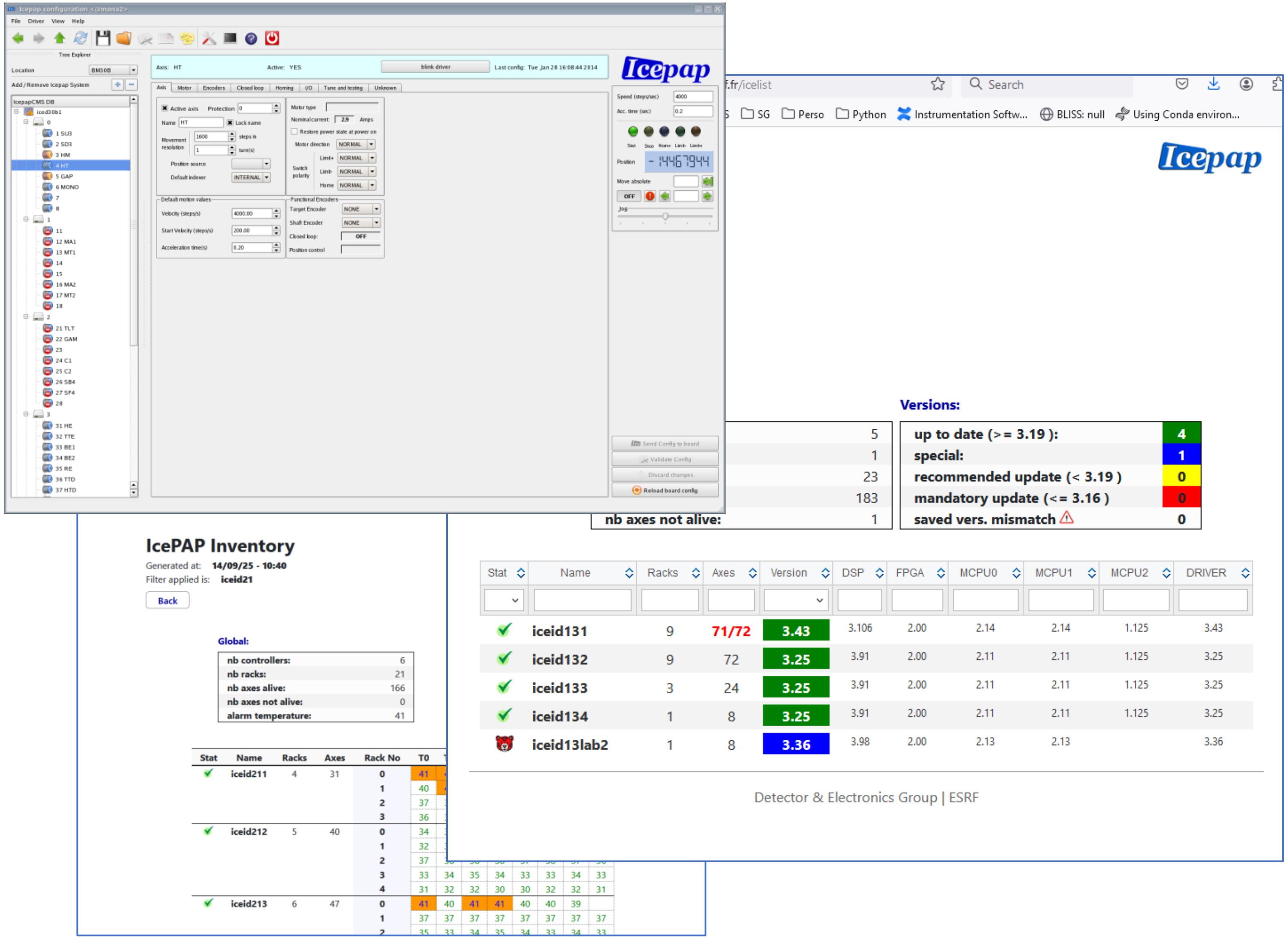
- No dedicated team. Three groups of the ISDD division intervene in motion aspects:
  - Mechanical Engineering
  - Electronics Group
  - Software Group

Motion control at our Facility

- IcePAP was developed at the ESRF and constitute now the standard solution for the vast majority of motion needs: standard movement, trajectory generation, synchronous movements.
- Many other various motion solutions present if required: commercial: Aerotech, Symetrie, LabMotion, piezo controllers.
- PEPU is the solution developed at ESRF for high-accuracy position encoders supporting (SSI, BiSS-C, EnDat and HSSL and quadrature signals)
- Also developments for specific cases: see later.
- ESRF control is based on Tango and BLISS. The integration of motors at beamlines is mainly done through BLISS controllers. Tango solution for accelerator and some BLs.
- BLISS has extensive features for driving and synchronizing motors on top of IcePAP features: calc. motors, continuous scans
- We have today 7900 axes (292 controllers) controlled by IcePAP

Maintenance and incident management

- IcepapCMS tool (developed by ALBA)
- We also have a web tool to survey all IcePAP controllers in the facility (connection, responsiveness, firmware version, temperature of axes).
- Standby system during user-mode



Present and future Highlights

Innovations

- Mechatronics developments have been used and they are now deserving special attention for complex systems.
- Using speedgoat / matlab
    - DCM (Double Crystal Monochromator)
    - Hexapods
- Special project for Mono-Undulator synchronization

Challenges

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MOTION CONTROLS AND ROBOTICS

Mechatronics at ESRF

- DCM (Double Crystal Monochromators) in operation at 2 beamlines and planned for 4 more
- Hexapod over IcePAP with trajectories
- Speedgoat (developing Linux solution, free of Matlab license)

Forschungszentrum Jülich JCNS (Jülich Center for Neutron Science)

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MOTION CONTROLS AND ROBOTICS

Jülich, Germany

MOCRAF’25 attendees:

- Harald Kleines

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MOTION CONTROLS AND ROBOTICS

- Forschungszentrum Jülich
  - Interdisciplinary research center (information, energy, bioeconomy)
  - Ca. 7500 employees
- JCNS
  - neutron scattering (neutron instrument development and operation, science with neutrons)
  - Main outstation: research reactor FRM-II (14 neutron instruments)
  - Instruments also at ILL, SNS, NIST (Gathersburg), ESS
  - Ca. 200 employees

FRM II experimental hall

FRM II neutron guide hall

Organization of Motion Team

- Common team for instrument control (motion, vacuum, personal safety,…..)
- FRM II: core development of top level SW NICOS, administration of SW packets (TANGO servers,….), "first level" service

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MOTION CONTROLS AND ROBOTICS

Motion control at JCNS

- Mainly Stepper motors, some AC synchronous servos, some Piezo motors, few DC motors, mostly closed loop
- Average number of motors/instrument: 25
- Motion control mainly based on Siemens PLCs: S7-1500; older S7-300 being replaced
- Motion controllers from Phytron and Siemens (for ET200S, ET200SP, ET200MP Sinamics)
- Encoder readout: SSI, NDAT, Incremental or BissC with Siemens modules (for ET200S, ET200SP, ET200MP,…)
- Instrument control SW: NICOS
- Middleware: TANGO
- Proprietary motion application protocol on top of PROFINET (between Tango Servers and PLCs)
- Instruments at ESS: Beckhoff / EPICS / NICOS

Examples of motion racks

Present and future Highlights

Innovations

- Started two projects with robots for sample change
- Gitlab for Siemens PLC software (for basic common motion and communication SW)

Challenges

- Project HBS-I on the BMFTR shortlist for German national large research infrastructures
- HBS-I (High Brilliance Source Phase I) is a High Current Accelerator Based Neutron Source (HiCANS)
  - 20 MeV pulsed proton Linac with 100 mA peak current
  - Target Station
  - 5 Neutron instruments + radioisotope production for medical applications

Prototype for HBS Targetstation Example: Target Handling Tool

Decentral racks

- Extraction/insertion of target plug with target
  - servo axes for target plug movement, 3 shieldings, 2 supports
  - Decentral cabinets with parker servo drives and 24V power distribution + ET200SP
  - PLC + AC power distribution in main cabinet (shared with cooling, vacuum, personal safety,…….)

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MOTION CONTROLS AND ROBOTICS

Helmholtz-Zentrum Berlin (HZB)
BESSY II

Berlin, Germany

MOCRAF’25 attendees:

- Maxim Brendike (maxim.brendike@helmholtz-berlin.de)
- Parvathi Sreelatha Devi (parvathi.devi@helmholtz-berlin.de)

ICALEPCS’25 CHICAGO

HZB is one of 19 Helmholtz centers in Germany

- BESSY II is a 3rd generation synchrotron at HZB
- We operate about 40 beamlines
- Additional to BESSY II the HZB has many smaller research labs

Organization of Motion Team

- Traditionally there was no motion team at HZB
- We are currently in the process of creating one

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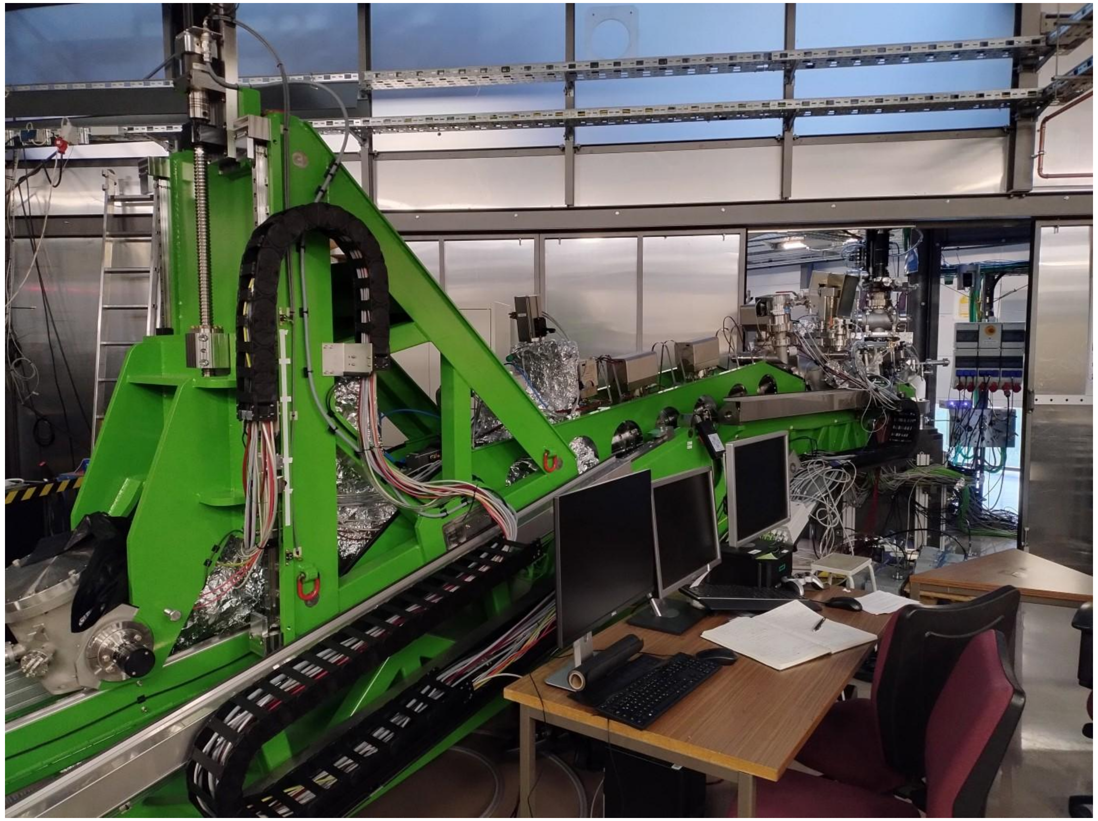
MOTION CONTROLS AND ROBOTICS

Motion control at our Facility

- ~1000 motors at BESSY II:
  - Mostly stepper motors (>90 %)
  - Of which most are open-loop steppers
- We currently have no “standard motion controller” at BESSY II
- BESSY II uses EPICS as the standard control system



Present and future Highlights

Innovations

- Wider integration of new software and development tools for motion control in general:
  - Gitlab CI/CD pipelines and containers for EPICS and Motion Control applications
  - AI-tools for motion control and beamline automation

Challenges

- We are in the process of finding a HZB standard motion controller
- Creating a HZB-wide motion control group
- BESSY II+ project - refurbishment of old beamline equipment and development of new Beamlines
- BESSY III design

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MOTION CONTROLS AND ROBOTICS

MAX IV Laboratory

Lund (Sweden)

MOCRAF’25 attendees:

- Peter Sjöblom
- Marcelo Alcocer
- Vanesa Da Silva
- Aureo Freitas
- Yimeng Li
- Aleko Lilius
- Lin Zhu
- Carla Takahashi
- Mirjam Lindberg

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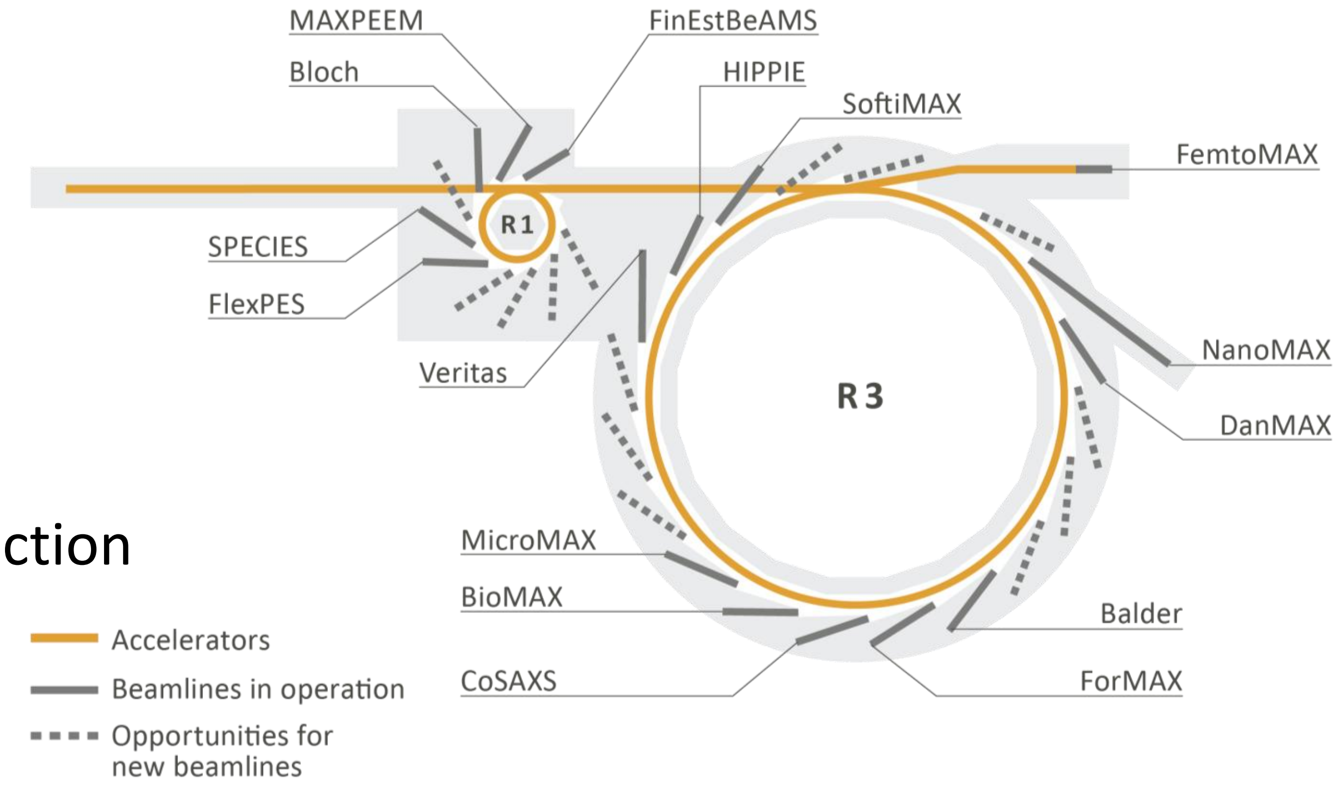
- 4^{th} gen synchrotron
- 1.5 and 3.0 GeV storage rings
- 16 beamlines in operation
- 1 new Tomowise beamline in construction
- Planning an upgrade Max4U



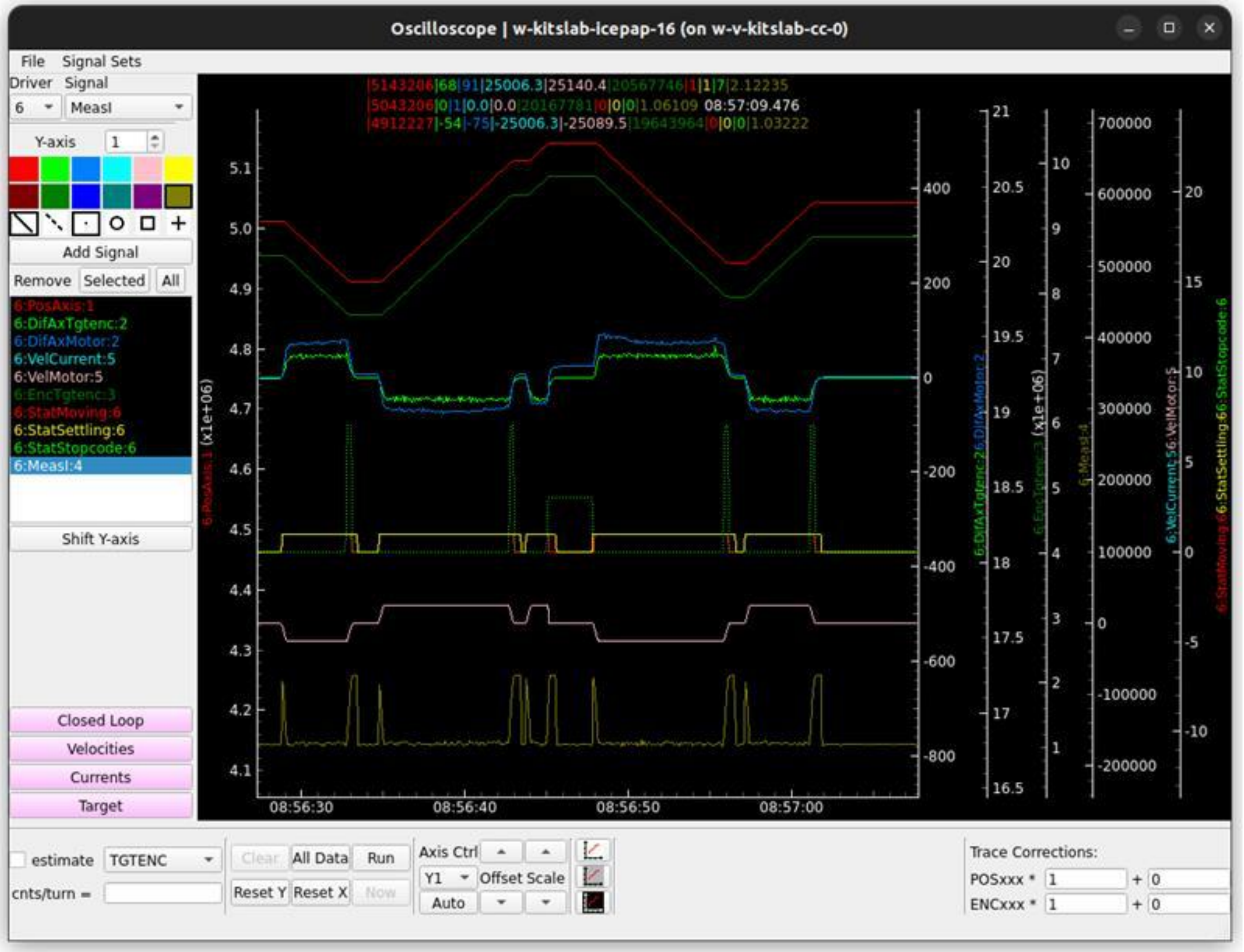
Organization of Motion Team

Motion is a collaboration between

- Electronics, that integrate controllers and drivers
- Mechanics, that design motion solution
- Software, that orchestra the measurement where motion is a part
- Scientists that do…

Motion control at our Facility

- Tango and Sardana control system
- About 2000 axis in operation in the facility
- Vast majority is stepper motors
- IcePAP controller, ESRF ALBA collaboration
- Favorite encoder: Renishaw RL32BAT001
- Most motors in closed loop
- Many systems in trajectory mode with multiaxis linking
- Own developed tuning tool



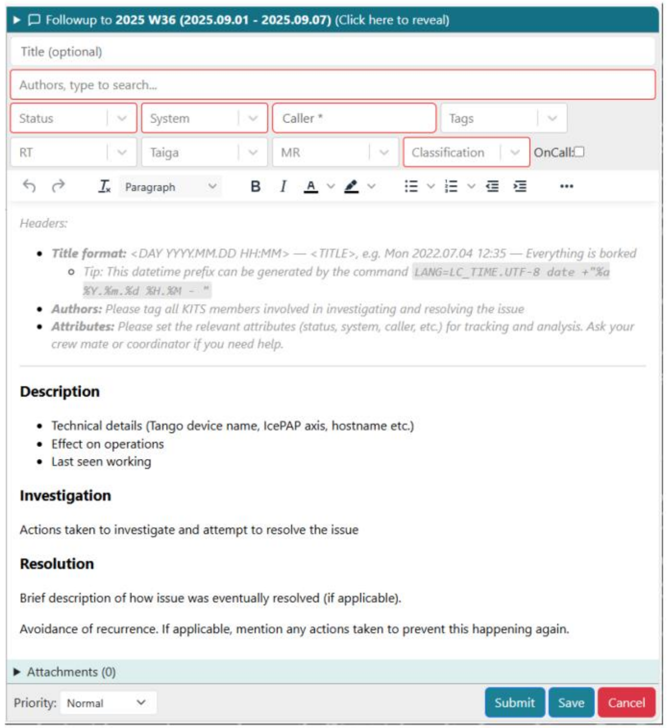
The “Osilloscope” lets us tune and diagnose multiple axis in IcePAP

Maintenance and incident management

- Working on a facility wide maintenance plan. Tool: J5
- Hard work add all equipment into the tool. Long term project.
- Rapid response during office hours through KITOS, dedicated persons to handle beamline and accelerated
- Evening and weekend oncall support where 1 SW and one from either electronics/infra/detector responds

WECR002 Mirjam Lindberg *et al.*

The MAX IV KITOS experience: organizing rapid response operation support in a user facility



Present and future Highlights

Innovations

THAG002 Vanessa Da Silva *et al.*

- MULTIMODAL DATA ACQUISITION SYSTEM
- The combined XAS–XRD experiment at Balder executed as a sequential, repeated measurement program

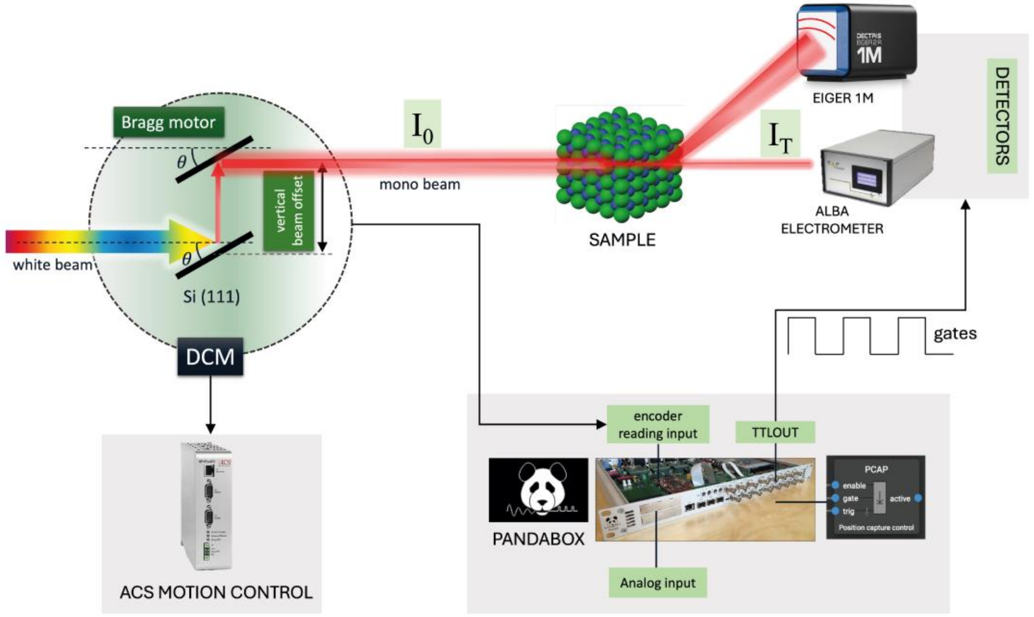
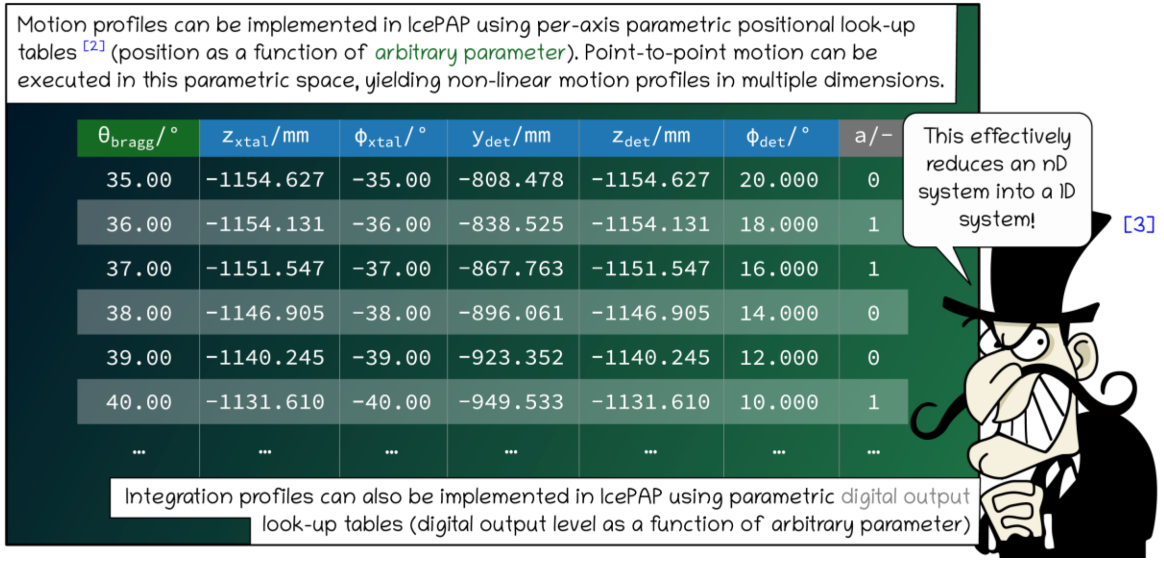


Figure 1: XAS-XRD experiment general setup overview.

Innovations

THPD052 Marcelo Alcocer *et.al*

- Hardware orchestrated, multidimentional, continuous scans with IcePAP motion controller



$\theta_{bragg}/°$	z_{xtal}/mm	$\phi_{xtal}/°$	y_{det}/mm	z_{det}/mm	$\phi_{det}/°$	a/–
35.00	-1154.627	-35.00	-808.478	-1154.627	20.000	0
36.00	-1154.131	-36.00	-838.525	-1154.131	18.000	1
37.00	-1151.547	-37.00	-867.763	-1151.547	16.000	1
38.00	-1146.905	-38.00	-896.061	-1146.905	14.000	0
39.00	-1140.245	-39.00	-923.352	-1140.245	12.000	0
40.00	-1131.610	-40.00	-949.533	-1131.610	10.000	1
...	...	...	...	...	...	...

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MOTION CONTROLS AND ROBOTICS

Paul Scherrer Institute

Switzerland

MOCRAF'25 attendees:

- Anders Sandström

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- 4 Machines/Facilities
  - SLS: Synchrotron, major upgrade ongoing SLS 2.0
  - HIPA: Proton Accelerator (Cyclotron). Upgrade project started.
  - SwissFEL: Free Electron Laser
  - Proscan: Medical treatment (protons)

Organization of Motion Team

- No dedicated group. Distributed resources in several groups (but too few)
- In Controls section 2 dedicated motion control engineers.
- Motion is also the job of Integrators
- ElNet motion forum

Motion control at our Facility

- PSI uses EPICS and the (in)famous motor record
- New motion standard: EtherCAT hardware and ECMC software.
- "Legacy" motion systems MaxV, Delta Tau PowerBrick,…
- Standard setup: Steppers and BISS-C
- Ramping up use of servos now, maybe 150+ motors (with the new EtherCAT and ECMC standard).

Total axes count estimation:

- SLS: approx. 2000+ axes (600+ EtherCAT and ECMC based)
- HIPA: 500 axes
- SwissFEL: 1200 axes
- Proscan: ?

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Present and future Highlights

Innovations

- Inventory (hardware and drawings)
- Continue to develop our motion platform

Challenges

- Support of 40 years old hardware (for instance CAMAC)
- Motion Safety
- Make people aware that software cannot fix everything
- Phase out of VxWorks and VME

SLAC National Accelerator Laboratory LCLS

Menlo Park, California, USA

MOCRAF'25 attendees:

- Nicholas Lentz
- Christian Tsoi-A-Sue

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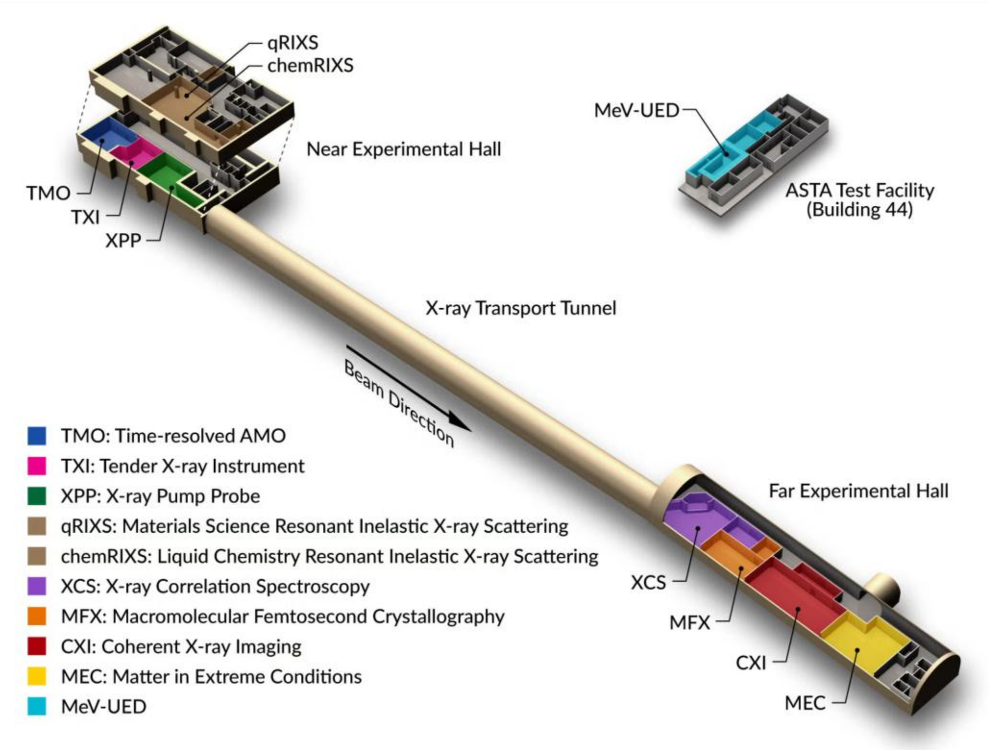
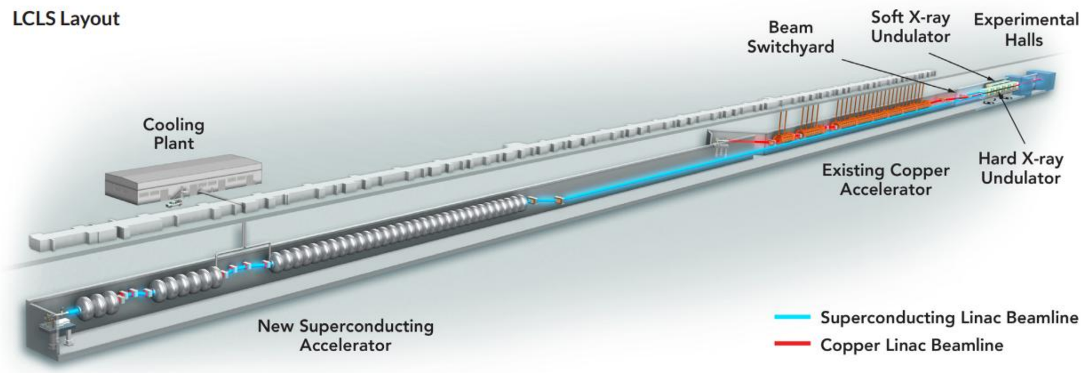
- 10 instruments
- The existing Cu-linac will provide photon energies up to 25 keV, and multi-mJ pulses from the soft X-ray undulator (SXU) at 120 Hz
- LCLS-II will generate soft X-ray pulses from 0.25 to 5 keV (2.5 Å) at repetition rates up to 1 MHz
- LCLS-II-HE will double the electron beam energy to 8 GeV and thus increase the spectral reach of the hard X-ray undulator (HXU) to more than 12 keV at repetition rates up to 1 MHz





Organization of Motion Team

- Motors, encoders and stages procured by Mechanical Engineering team.
- Software and electronics design, maintenance, and procurement by controls system team.
- Responsibility split into accelerator controls and experiment controls as separate groups.

Motion control at our Facility

- Real-time PLCs produced by Beckhoff and using TwinCAT for real-time software with EtherCAT fieldbus.
- We still support some legacy systems with IMS and Newport motors/controllers.
- Numerous Smaract piezos and controllers (although we have a lot of problems with them)
- We also use PI and Micronix piezos and controllers
- ~600+ stepper motors, ~50+ piezos, ~300+ encoders, ~10+ DC motors, a few DC servos.
- EPICS SCADA

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Present and future Highlights

What we are working on now

- Rapidly reconfigurable TwinCAT motion systems without the TwinCAT XAE.
- Synchronous fly scanning at the rep-rate of the X-ray beam.
- Better diagnostics and logging support.
- Better motion libraries for easier unit testing.

Challenges

- Reliability of piezo systems.
- Constant reconfiguration of motion systems to support different experiments.
- Synchronous motion with XFEL.

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SLAC National Accelerator Laboratory

California, U.S.A.

MOCRAF’25 attendees:

- Ziyu Huang (zyhuang@slac.Stanford.edu)

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The LCLS-II at is a next-generation X-ray free-electron laser in SLAC.

- Delivers ultrafast, ultra-bright X-ray pulses at up to a million pulses per second
- 2 independent undulator lines:
  - Soft X-ray Undulator lines
  - Hard X-ray Undulator lines

Organization of LCLS-II Motion Team

- Undulator motion group for SXR and HXR undulator motion control
- General motion group for wire scanner, collimator and other motor control

Motion control at LCLS-II

- 20 **Fast Wire Scanners** controlled by Aerotech Ensemble motion controller
- 26 **Soft X-ray Undulator** segments, controlled by Aerotech controller
- 32 **Hard X-ray Undulator** segments controlled by MVME3100 VME board
- All controllers has been upgraded into EPICS 7 based IOC.

Present and future Highlights

Innovations

- We developed a new data streaming pipeline for acquiring high-resolution motion scope profile
  - ➢ Aims to analyses fast wire scanner motion performance in real-time
  - ➢ Display motion scope data automatically post each scan

Challenges

- Commissioning a **Cavity-Based X-ray Free Electron Laser (CBXFEL)**
  - ➢ 4 High-precision flexure stages with Newport Picomotors
  - ➢ Capacitive sensors from Lion Technologies for absolute position feedback
  - ➢ 2 linear stages for positioning
  - ➢ 2 rotational stages for pitch and roll adjustments

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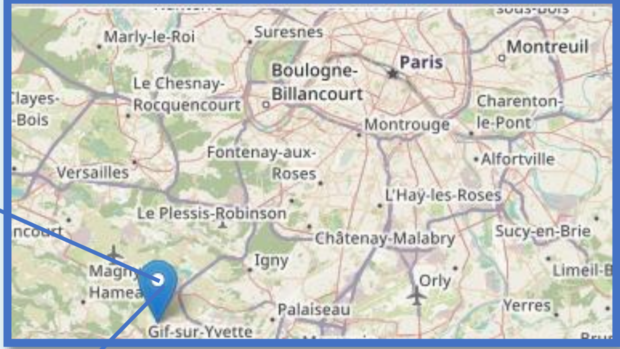
SOLEIL SYNCHROTRON



Paris

MOCRAF’25 attendees:

- Yves-Marie ABIVEN on behalf of all teams involved on Mechatronics and Robotics developments

- Contacts :
  - laura.munoz-hernandez@synchrotron-soleil.fr
  - yves-marie.abiven@synchrotron-soleil.fr

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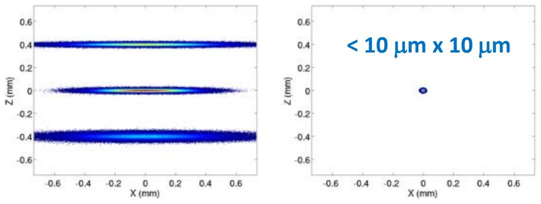
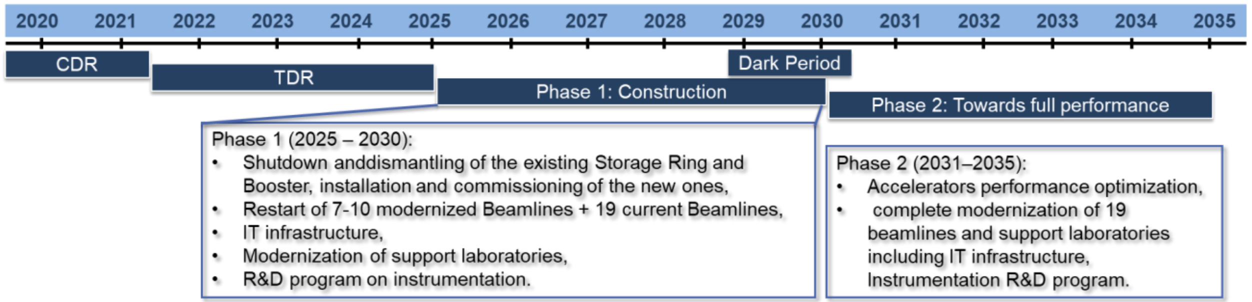
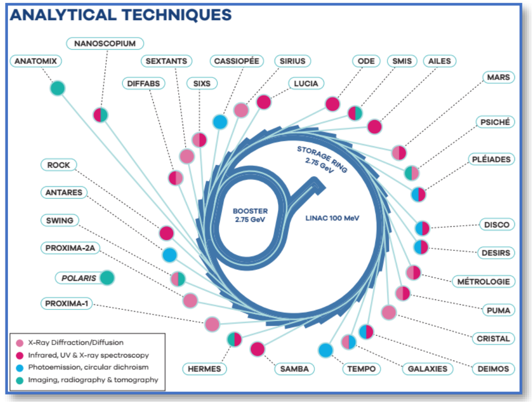
- SOLEIL
  - Storage ring 354m, 2.75GeV
  - 29 beamlines
  - 9 orders of magnitude in energy from far IR to hard X-rays
  - Open to external users in 2008
  - ~ 450 staff members

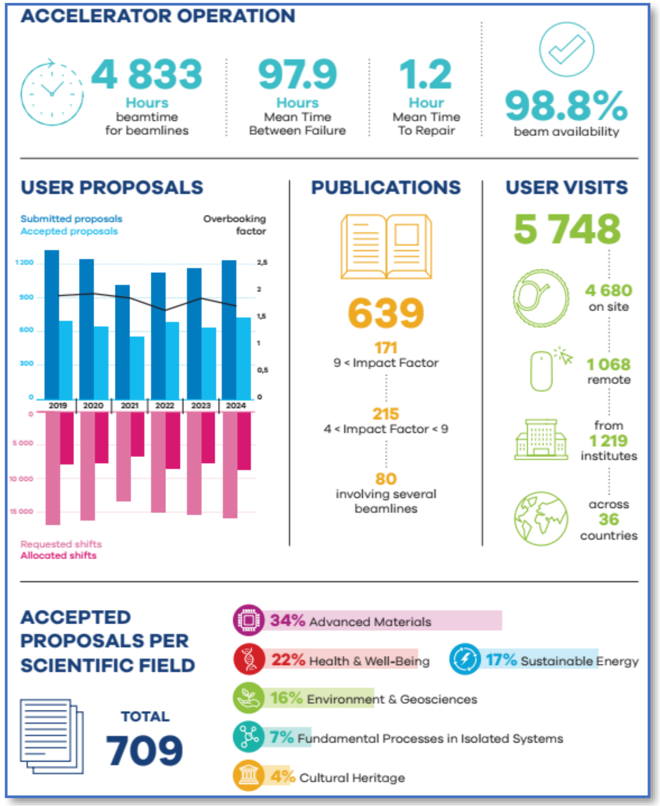


Beam SIZES

- SOLEIL II
  - Reaching an emittance **< 100 pm.rad.**
  - Keeping the same electron beam energy : **2.75 GeV**
  - Preserving a maximum current of **500 mA** in the multi- bunch mode.







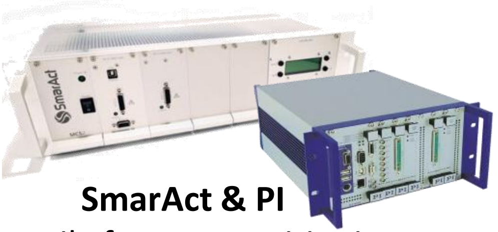
- Organization of Mechatronics and Robotics Teams
- Collaborative work across facilities, with strong cooperation between :
  - Control Engineering
  - Mechanical Engineering
  - Metrology Group
  - Experimental control Engineering

Motion Control & Robotics at SOLEIL

Platforms for Motion Control/Robotics Solutions

ControlBox (Galil)
Standard motion control requirements

Powerbrick
Complex kinematics, trajectory generation, synchronous motion



SmarAct & PI
Primarily for nanopositioning applications

STAUBLI robots
Standardized for task automation

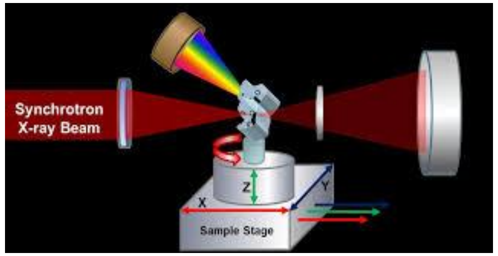
Schneiders Insertion devices

Other controllers
Aerotech, Newport XPS

PandABox Synchronizes mechatronic instruments with acquisition

Control Systems

SOLEIL control is based on Tango for accelerators and beamlines.
All motion controller and robot applications are fully integrated into the TANGO framework



Experimental control is developed around a ***SOLEIL Flyscan ecosystem***

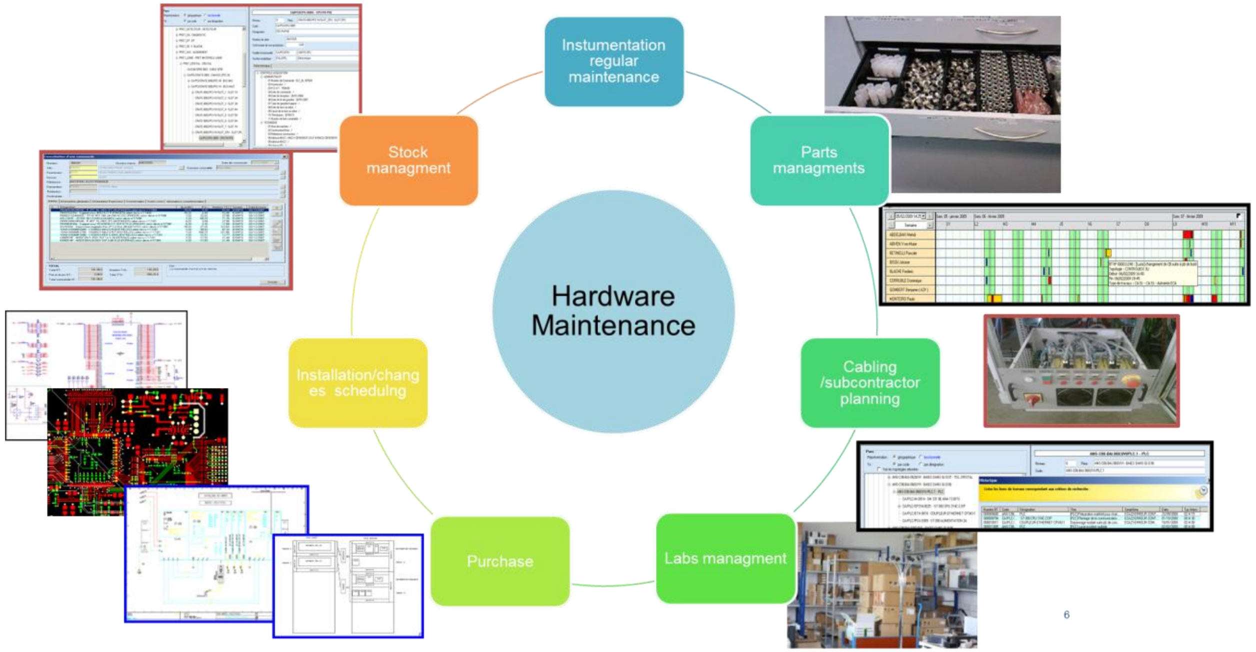
Motors & Sensors

Steppers, brushed , brushless & nanopositioners
We have today ~2700 axes (~450 controllers) controlled by our 2 standardized controllers (ControlBox & Powerbrick)

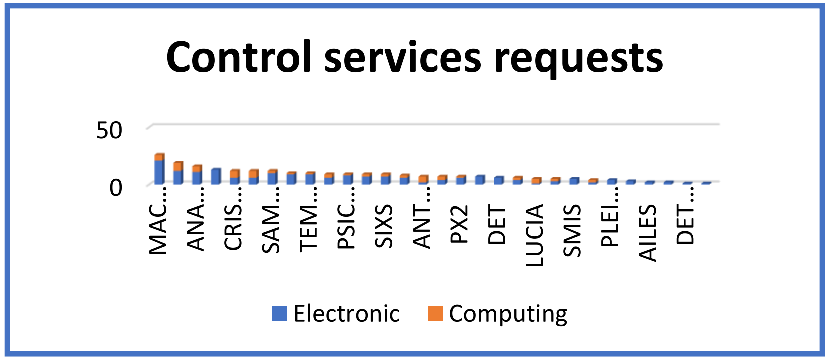
Supporting high-accuracy position encoders (ex: SSI, BiSS-C, Sin-Cos & AquadB signals)

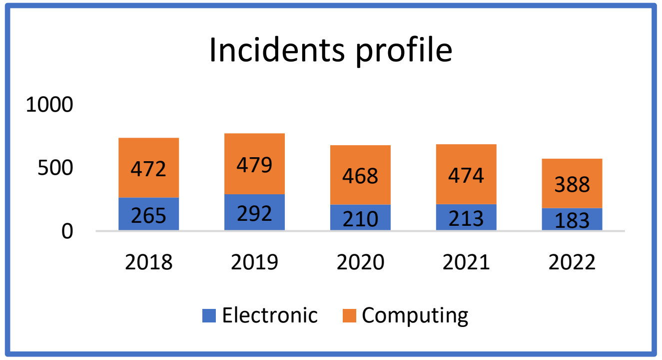
Interferometers

Maintenance and incident management



- 24/7 on-call support
- Annual backup of system configurations
    - Partial automation in place
    - Need for a centralized configuration management system
- Significant obsolescence management after 20 years of operation
- Regular root-cause analyses
    - On-going improvements through log analysis





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Present and future Highlights

Innovations

TUPD098 Poster

- Mechatronics and Robotics are increasingly approached as integrated developments, since complex systems demand a global vision to support advanced automation processes.
- 5 applications using 6-axis robots developed in the last 5 years. Two more are under development.
- 9 high-performing applications using Powerbrick controllers with multi-axial kinematics and low-level functionalities (motor/actuator securities, advance control network handling, anti-collision algorithms, buffered trajectories).
- Proof of Concept (POC) for sensor data fusion to enhance closed-loop control capabilities.
- Hardware-in-the-Loop (HIL) with Speedgoat / MATLAB: first use-case for nanopositioner validation.
- Development for EXAFS-Flyscan: enhancing synchronization between Insertion Device and Monochromator
- Magnetic Levitation actuator developed in the scope of LEAPS INNOV
- Metrology test bench for nanopositioning stages (automated measurement to be enhanced)

TUMR017Poster

Present and future Highlights

Challenges

- Management of encoder obsolescence
- Defining a suitable control architecture for Insertion Devices for SOLEIL II
- Complex sample environments integration.
- Advancing experiment automation with the goal of optimizing:
  - Beam alignment
  - Sample alignment
- Meeting high requirements for accuracy, stability, and robustness
- Preventing collisions between systems
- Manage "dynamic" environments.

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SPring-8

Hyogo (Japan)

MOCRAF’25 attendees:

- Kosei Yamakawa

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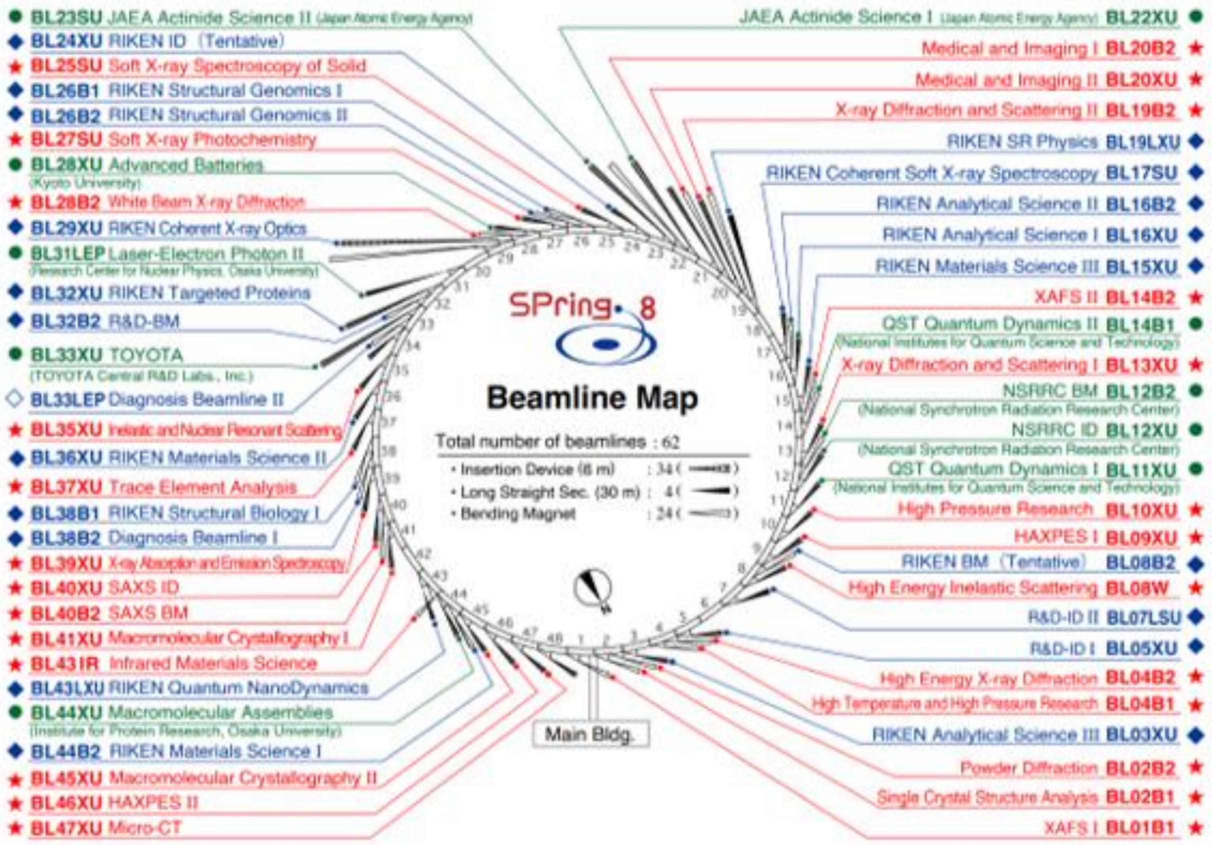
SPring-8: a 3rd generation light source

Upgrading to 4th generation SPring-8-II

- 57 operational beamlines (BLs)
    - 34 insertion device (ID) BLs
    - 23 bending magnet BLs
- A new BL under construction
    - Operations start in Jan. ’26

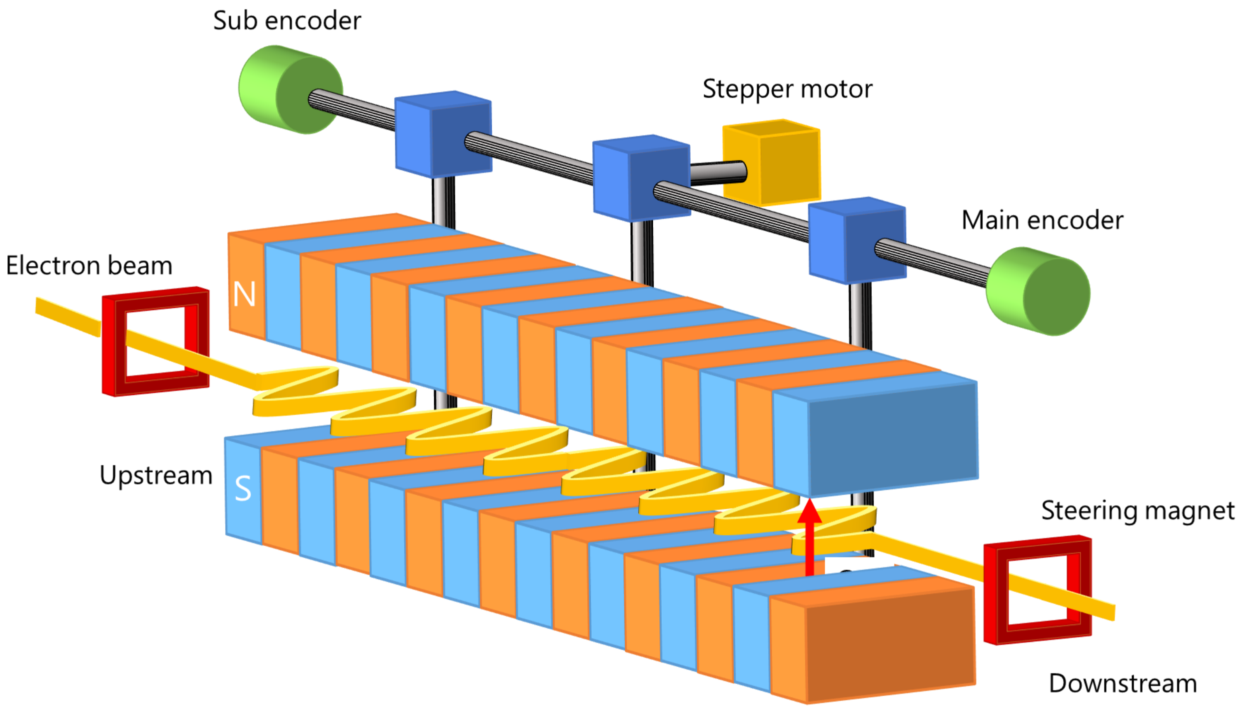


Organization of Motion Team

- There is no dedicated motion team.
- Accelerator Division: ID controls
- Beamline Optics Division: BL systems

Motion control at our Facility

- Control framework: MADOCA 4.0
- Standard ID: In-Vacuum Undulator (IVU)
- IVU motion control setup consists of:
  - 1 stepper motor
  - 2 encoders
- 60 stepper motors,
  120 encoders, and 12 resolvers for IDs
  - Other ID types included
  - Helical-8, new IVU, etc.



Schematic view of IVU motion control

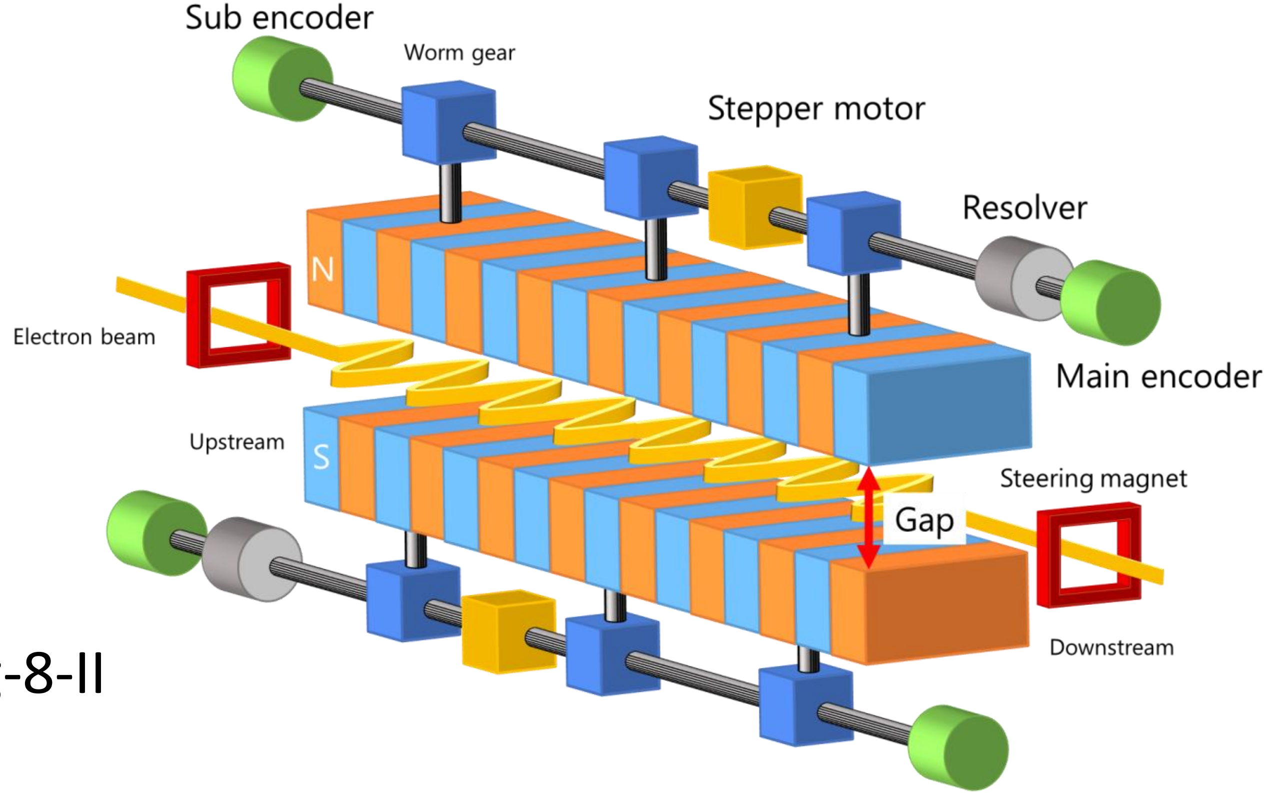
Present and future Highlights

Innovations

- New protocol: EtherCAT for ID control
- Upgrades began with the new IVU implementation
  - called IVU-II
  - 6 systems already installed
- The setup of IVU-II motion control is:
  - 2 stepper motors
  - 4 encoders and 2 resolver
- This will be the next standard at SPring-8-II

Challenges

- Synchronised 2-axis control with linear interpolation, achieving an accuracy of better than 50 µm



Tekniker

Eibar (Spain)

MOCRAF’25 attendees:

- Ismael Ruiz de Argandoña
- Pello Usabiaga

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- R&D Centre
  (not-for-profit Private Foundation) |
- Applied research spanning 44 years
- Our mission is to deliver growth and wellbeing to society at large via R&D&I and to further the competitiveness of the business fabric in a sustainable manner
- 320 employees (83% university degrees), around 35M€ revenue
- Specialised in Manufacturing

Organization of Motion Team

- Automation and Control Unit focused on the development of control systems for Big Scientific Installations

Motion control at our Facility

- Unless otherwise specified, we use Siemens and Beckhoff motion solutions
- Used to handle high precision and high dynamics multi-drive axes with multi head encoders, hydrostatic bearings, etc (telescopes, big machine tools, etc.).

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European XFEL GmbH

Schenefeld Germany

MOCRAF'25 attendees:

- Dr. Nicola Coppola
- Dr. David Hickin
- Dr. Mikail Yakopov

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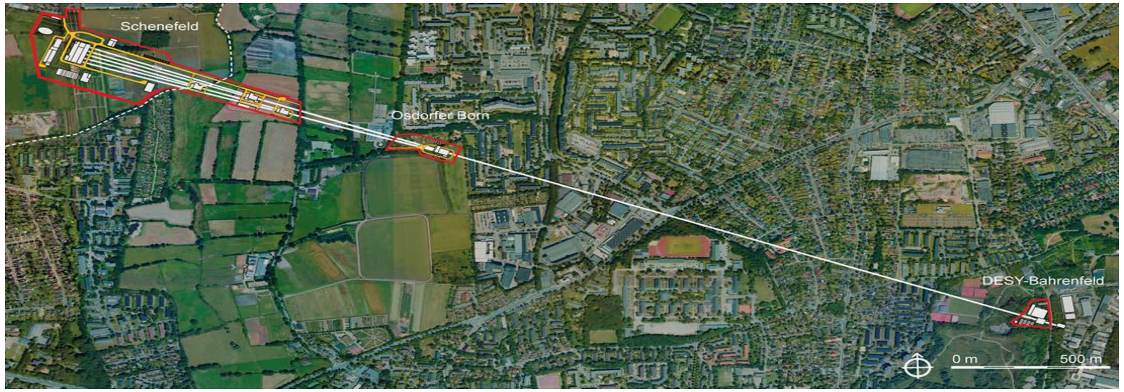
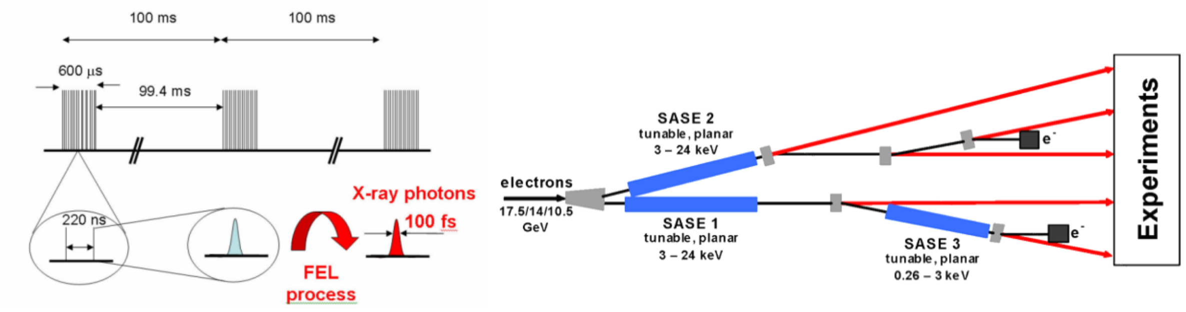
- European XFEL is a 4th generation light source.
- Spatially coherent <100 fs short photon pulses
- Photon energies range from 0.26 to 29.2 keV
- Electron bunch time pattern with 10 Hz repetition rate and up to 2700 bunches in a 0.6 ms bunch train
- **8** (was 7) broad scientific experiments and R&D on X-ray instrumentation (installed and taking data, some 10-25% components still to be installed & commissioned)
- BLs are performing shift working (either 24h/6 or 7-23/6), with Tuesdays for maintenance, liaison with accelerator via Photon Run Coordinator (OnCall duty)
- 24h OnCall duty (EEE, CTRL, IT, VG) via Data Operation Control shift (7-23/6) and Data Run Coordinator (DRC) OnCall duty





Organization of Motion "Team"

- No dedicated group/team
- Motors and Encoders are purchased by 'all' groups
- Non-PLC Controllers purchased by 'all' groups partially configured by CTRL
- PLC Controllers purchased and partially configured by EEE
- Tuning of PLC Controllers in hands of 'all' group
- Except for the UND group (<0.25 FTEs), most of actuators are managed by EEE-PLC (~2.5 FTEs). Most of piezo actuators are managed via Eth-controller directly via CTRL/Karabo (~1 FTEs)

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Motion control at our Facility

- MOCR @European XFEL based on industrial components produced by Beckhoff and a PLC implemented with TwinCAT and EtherCAT based (more and more exceptions for piezo, in the past controlled over Step/Dir signals & encoders).
- Wide variety of control terminals and motors available off the shelf (servos, steppers, ADCs, DACs, encoders, I/O…..)
- Piezo Actuators mainly from Smaract ✓ but many from: PI, Newport, Nanomotion, Xeryon ✓
  (✓ indicates EC interface has been tested)
- >2200 2-Phase Stepper, >240 piezo*, 500 3-Phase Servo(UND), 200 5-Phase stepper(UND) , ~15 linear, 6 3-phase, 3 DC , >1400 encoders
- Day2 components & 1 new instrument on SASE2 still to come
- Using Karabo as SCADA

Maintenance and incident management

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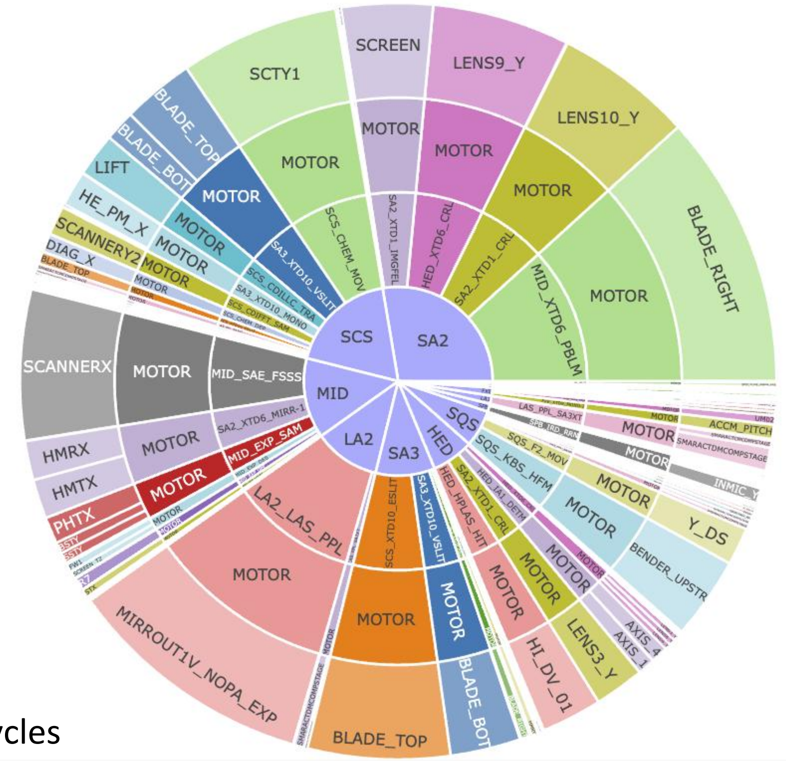
- OCD (24h/7) in place with members of EEE-PLC and CTRL. These are called by DOC or DRC.
- Incidents are tracked via Redmine tickets (fully tagged: which source, what, how…)
- At the moment we are starting a project: *Hard- and Software Life Cycle Management for Data Infrastructures*
- This shall, among other, ensure consistent and efficient life cycle management (need of experiments feedback from experiments and instrument department), write up maintenance rules/protocols which we will apply in our facility
- First discussions have already taken place also with the help of colleagues of IT group
- We are in the process to save time series for all devices from our online Grafana DB (3 years' worth) to offline HDF5 this enables longer period of keeping data and easier access and analyses.



Motor Cycles