Lawrence Berkeley National Laboratory

LBL is a multi–purpose National Lab:

- Chemistry
- Physics
  - Nuclear
  - High Energy
  - Plasma
  - Accelerator
- Photon Science (Advanced Light Source)
- GeoPhysics
- AstroPhysics / Astronomy
- Life Sciences
- Material Science
- Energy Sciences
- Applied Mathematics / Computation
- Engineering

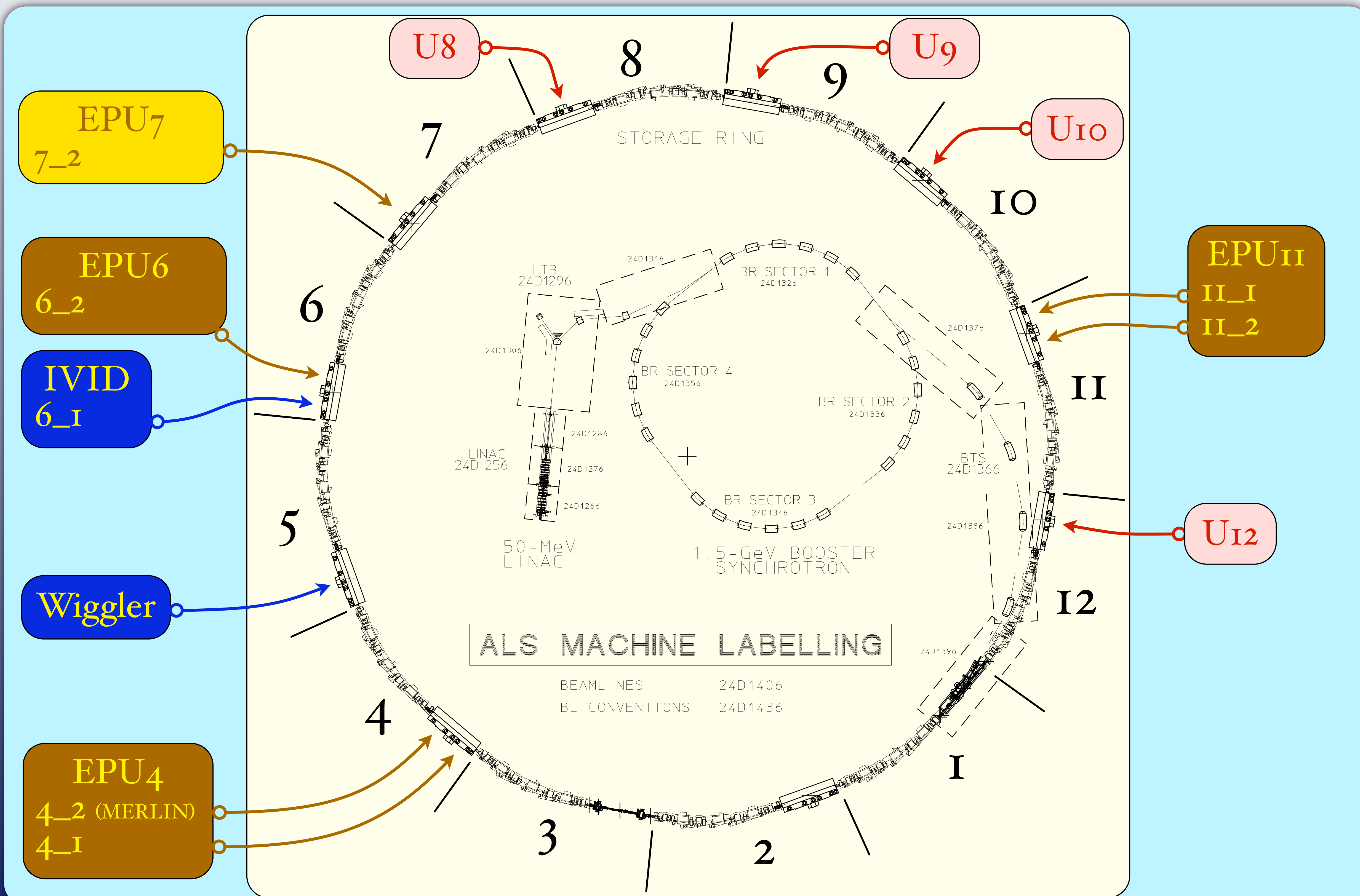
Motion Control at ALS

Accelerator / Storage Ring:
- Insertion Devices (gap & phase control)
- Chicane Magnets
- Beam Scrapers

Photon Beamline Components:
- Monochromators (gratings, crystals)
- Mirrors
- Entrance & Exit Slits

End Stations:
- Sample Manipulators
- Scanning Stages
- Specialized Sample and Optical Component Positioning Systems

ALS Insertion Devices



ID Control Objectives

- Accuracy
- Reliability
- Low maintenance
- Consistency among devices
- Cost effective installation
- Adaptability to evolving requirements

SESAME Motion Control System

Abdallah Ismail Ibrahim Saleh

Introduction

- SESAME is a synchrotron light source located in Allan, Jordan. It is currently under construction. It consists of a 22MeV Microtron, an 800MeV Booster Synchrotron, and a 2.5 GeV Storage Ring.

- SESAME succeeded in commissioning the Microtron in October 2012. The Booster is expected to be commissioned by the end of 2013, the storage ring by the end of 2015, and the first beam line in 2016.

- *Machine Control System:*

- EPICS Control System
- Scientific Linux 6.4 OS
- SIEMENS PLC for Interlocks
- MOXA for Serial Devices
- VME for Timing System
- Git Version Control System
- Libera Electron for beam Diagnostics.

Beamlines Motion System

Beamline	Energy Range	Source Type	Donation
Protein Crystallography	4 – 14 keV	Wiggler	Daresbury DL – 14.1 & 14.2
XRF-XAFS	3 – 30 keV	Bending Magnet	Donated by ESRF
Infra-red Spectro-microscopy	0.01 – 1 eV	Bending Magnet	New Design
Soft X-ray, Vacuum Ultra Violet (VUV)	0.05 – 2 keV	Elliptically Polarizing Undulator	-
Small and Wide Angle X-ray Scattering (SAXS/WAXS)	8 – 12 keV	Bending Magnet	Daresbury DL – 16.1
Powder Diffraction	3 – 25 keV	Multi-pole Wiggler (SLS)	SLS
Extreme Ultraviolet (EUV)	10 – 200 eV	Bending Magnet	LURE

Day One Beamlines (first three rows)

Table 1: Phase One Beamlines

- Sesame received different beam lines as a donation from other light sources shown in the above table.
- Many of the beamlines are not complete and they are missing some devices.
- The existing motion system includes many motors but there is no controller.
- Many parts such as motor drivers include old electronics which will not be suitable to be used.
- Different solutions are available to define a new motion control system.

Motion Controller Selection

- Choices are limited because we want a system which will be compatible with our EPICS control system.
- A controller which is used before in other light sources is preferred so we can get help and support and learn from their experience.
- Two options have been selected, VME controller or integrated motion controller.
- After comparison, we decided to use the integrated motion controller because it is newer, cheaper and used in other light sources while the VME is getting older and more complex.
- Newport XPS-Q8 controller is selected because it has EPICS support, and it is recommended by Mark Rivers from APS who wrote the EPICS support for this controller.
- XPS-Q8 includes the motor drivers and the controller in the same unit and it can control different types of motors. It has digital and analog ports.

XPS-Q8 controller

Challenges and Needs

We need help for the following:

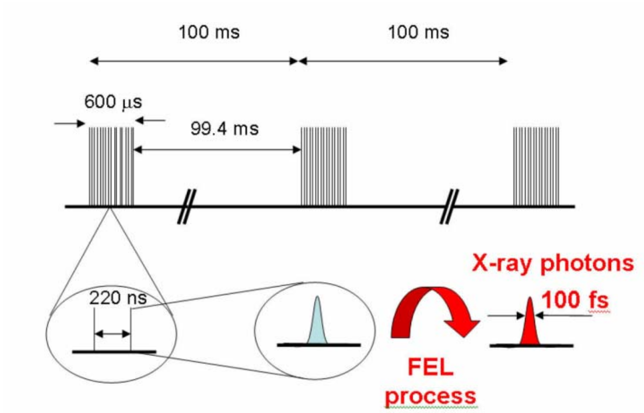
- More training using XPS-Q8
- Advantages / Disadvantages of XPS-Q8
- Pseudo Motors Implementation
- Recommendations for other controllers

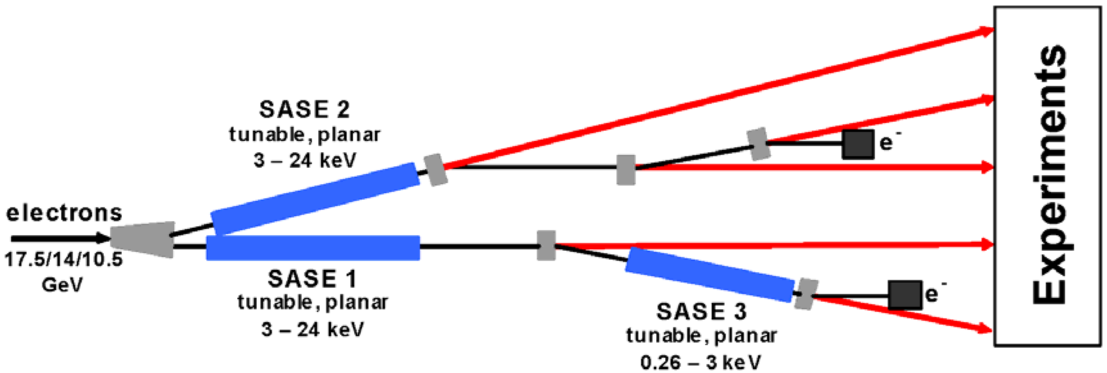
Motion Control at European XFEL

Nicola Coppola, Suren Karabekyan
European XFEL

The aim of the European XFEL

- The European XFEL project is a 4th generation light source.
- The first beam will be delivered at the end of 2015
- Spatially coherent <100fs short photon pulses
- Peak brilliance of 10^{32}-10^{34} photons/s/mm^2/mrad^2/0.1% BW
- Energy range from 0.26 to 29.2 keV at electron beam energies of 10.5 GeV, 14 GeV, or 17.5 GeV
- Electron bunch time pattern with 10 Hz repetition rate and up to 2700 bunches in a 0.6 ms bunch train





- 5 photons beams produced by means of undulator systems
- Photon beam transport and diagnostics
- 7 broad scientific experiments and R&D on X-ray instrumentation
- 4 specific XFEL experiments instrumentation

Motion control at European XFEL

- **The motion control system at European XFEL is based on industrial components produced by Beckhoff Automation GmbH and a PLC implemented in the TwinCAT system.**
  - State of the art motion control
  - Widely used in Automation Industry
  - EtherCAT Fieldbus - fast and truly open communication standard
  - TwinCAT based software with mighty diagnostic tools
  - Wide variety of control terminals and motors available off the shelf (servos, steppers, ADCs (til24 bit), DACs, encoders, I/O…..
  - Growing scientific use: FLASH, PETRA III, EMBL, ELBE, planned to be used at Pohang Light Source, LCLS II…
  - Provides a possibility for cost effective solutions

Technical challenges and concerns

- Historically many commercial implementations exist:
  - PI, piMicos, Galil, Phytron, Newport, attocube, DeltaTau, etc
- By using a single standard XFEL 's implementation is simplified (man power, scalability, interchangeability)
- Many commercial solutions are
  - vendor centric, they want to sell a full solution,
  - no longer state-of-the-art.
- Friendly vendors accept selling motors and controllers separately:
- XFEL is not alone requiring solutions of this type.
- Vendor entrapment problem exists for sub-micron to nanometer precision stages
- A common vendor problem is the I/O interface to the control system:
  - serial interface (rs232) i.e. slow, limited cable length
  - USB interface: limited geographical range, non identificability of port
  - non scalability both at H/W and S/W (library: for specific Operating systems, not thread safe) levels
  - vendor specific protocols (if they are open at all)
- Most commercial solutions are reasonable for:
  - table top applications,
  - slow or non-synchronized systems
  - large latency between move operations with very limited position monitoring
- but not :
  - for distributed system within a wide area (from 50 m to ~km distances),
  - middle to fast synchronization needs,
  - ~1 kHz position/velocity read out operations,
  - move and while moving "do something"

Wish list and expectation from other institutions

- **The community should push vendors:**
  - **to use modern interfaces in a modern fashion**
  - **to use common protocols**
  - **to use open-software solutions**
  - **to use modern standards (i.e. EtherCAT or similar) for controllers**
  - **allow for interchangeability of motors-stages and controllers**

Motion Control at FRIB

Martin Konrad
Control System Engineer

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661, the State of Michigan and Michigan State University. Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.

Motion Control at NSCL

- Mainly using out of date Parker PC6K motor controllers
- Controllers run a custom program
  - Provides local control of motors (via switches)
  - Provides scan functions etc.
  - Breaks compatibility with other PC software
- In-house developed EPICS records for controller access
  - No standard interface
  - Make upgrade to new controllers very difficult

FRIB Motion Control Applications

- Beam profile monitors
  - 26 small aperture monitors
    - » 1 motor each
  - 17 large aperture monitors
    - » 2 motors each (one moving at a time)
  - 3 flipper type monitors
    - » 2 motors each (one moving at a time)
    - » Non-linear motion (rotating)
- Selecting slits systems
  - TBD (synchronized motion of the two sides of the slit?)
- Emittance scanners
  - TBD

→ ~100 axes in total

Challenges

- FRIB uses different complex beam pulse patterns
  - Synchronize data acquisition with motor position and beam pulses
- FRIB is planned to be in operation for 30 years
  - A controller lifetime of 10 years results in two upgrade cycles
  - Need a clean solution that allows to upgrade with minimum effort
    - Motor Record?
- Minimize costs, risk, and maintenance effort
  - Use a single type of motor controllers for everything?
  - Share development effort with other labs

Motion Control at the LNLS

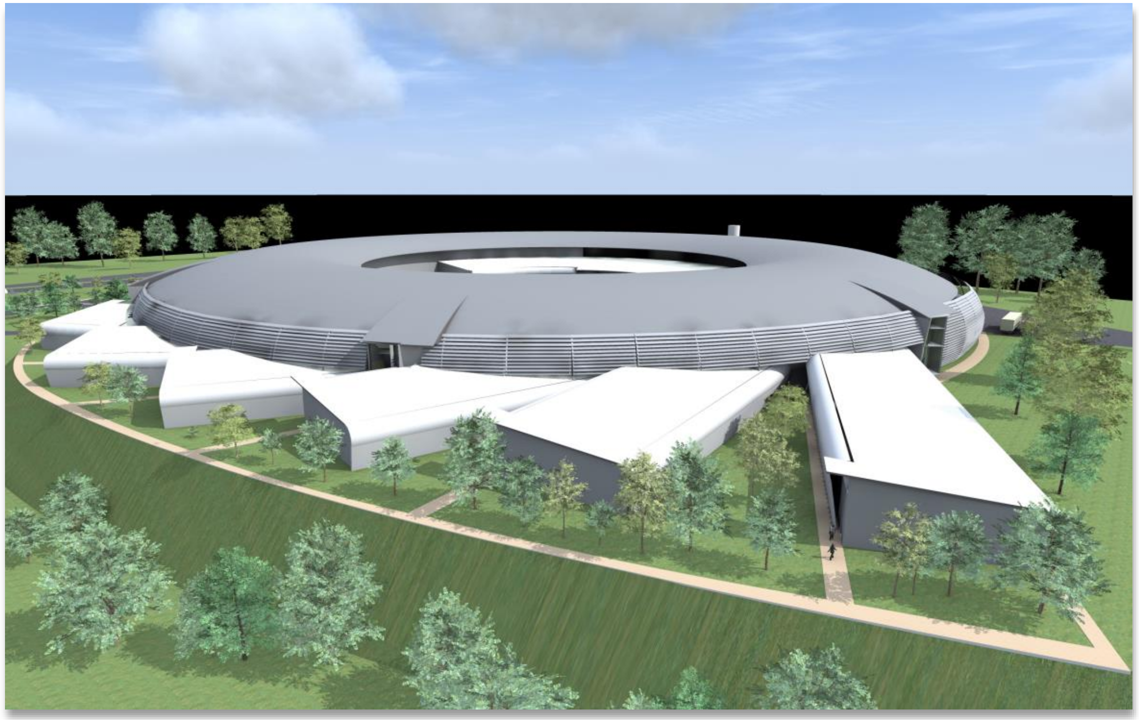
Status and Perspectives

Lucas Sanfelici

On behalf of the LNLS Instrumentation Groups for Beamlines

MOCRAF 2013

LNLS: UVX and SIRIUS Storage Rings



- Operations started on 1997
  - 1.37 GeV, 100 nm.rad emittance
  - Currently 16+2 beamlines
  - 1 EPU, 1 W (2T) and 1 SCW (4T)
  - Home made controls (hw/sw) for accelerators and beamlines
  - Today ~1200 users/year

- Operations start on 2017
  - 3 GeV, 0.28 nm.rad emittance
  - Initial phase (2017/2018) with 13 beamlines
  - 6 IVU, 2 EPU, 1 SCW and 5 BM
  - On pursuit of standard solution for basic and advanced applications

Motion Control at the LNLS

PAST	PRESENT	FUTURE
1997		2017

– LOCO Control System:
- Proprietary software
- Proprietary hardware (scalers, digitizers, DIO, AIO, low power <u>motion controllers</u>, etc.)

– Difficulties to maintain and support

– In Course Control System Update Effort:
- EPICS-base at all beamlines by 2014
- Hardware fully replaced by NI-PXI/cRIO by 2014 (LNLS Hyppie)
- Galil DMC-41x3 (+Phytron option/Powerpack) and Parker OEM650 as the supported controllers/drivers
- Work group recently set to respond to some advanced applications (fly scans and EPU/PGM synchronization)
- Actions to consolidate the area at the LNLS

– Extrapolate current requirements also to our future requirements at SIRIUS;
– Reevaluate our current standard options based on the experiences presented at MOCRAF
– Define standard solutions for SIRIUS
– Split solutions for ordinary motion control and advanced motion control
– Stay consistent with community developments

Challenges

- Standardize, communicate and control development and procurement
- Develop support for fly-scanning using Galil on EPICS
- Multi-axes and multi-devices synchronization (as for experiment triggering and ID/Monochromator coordination, for instance)
- Specify motion controllers for the SIRIUS IDs
- Complex trajectory support
- Control of robotic arms
- Nanopositioning
- Consolidate area and team competence

Immediate Interest

- Long term experience with Galil controllers
- Fly-scanning support on EPICS
- Multi-axes and multi-devices synchronization
- Common limitations on ID motion control
- REVOLUTION collaboration
- Motion control exhibitors

Groundwork for SIRIUS

September 10th

CLS Motion Control

ICALEPCS 2013

MOCRAF Workshop

Canadian Light Source Centre canadien de rayonnement synchrotron

Why are we here?

What is the aim of the institute/vendor?

- Improve motion control for synchrotron-based data acquisition
- Share what we know
  - EPICS without APS motor record
  - Experience with fast scans (1d)
- Learn what we don't know
  - 2d fast scans

- How is motion control integrated into the activities of your institute (organization, technologies, installed base…)?
- Stepper Motors (lots), Servo Motors (few), Piezos (few), Hand Cranks (I just can’t get the software to work for these)
- CLS custom EPICS interface
- Hardware expertise in Engineering Group, Software expertise in Controls Group

- What are your current technical challenges or concerns in the motion control area?
- Different applications having different interface requirements – EPICS isn't always the answer!
- Unusual applications (Sylmand chopper, SGM fast shutter)
- Precise co-ordination with detectors (fast scanning)

Please Help!

- What do you expect to hear from other attendees and what questions do you have for them?
- Motion Synchronization – multiple motors and motors to detectors
- Experiences with newer/faster/better/cheaper hardware
- Stepper motor vs Server motor applications

Canadian Light Source · Centre canadien de rayonnement synchrotron

Observatory Sciences Limited

Andy Foster

Who are we?

- A UK based software consultancy company who specialise in the design, development and commissioning of control systems for telescopes, instrumentation, synchrotrons and other large Physics facilities.

- We have expertise in EPICS, LabVIEW, C, C++ and Java.

- Who is here this week?
  - Alan Greer and Andy Foster

Motion Control

- From the 1990's, when we worked on several of the subsystems for the Gemini Telescopes, to the present day, we have a long history of being closely involved with motion control.

- In particular, we have worked, extensively, on-site, at Diamond Light Source, helping with the commissioning of various beamline components.

- We have developed several Telescope Control Systems, including for the:
  - ATST (Advanced Technology Solar Telescope). At 4m, soon to be the world's largest Solar Telescope, using their Common Software Framework.
  - DCT (Discovery Channel Telescope) using LabVIEW.

- We have worked closely with our colleagues at Delta Tau UK on several projects including:
  - verifying the compatibility of the Geobrick LV controller with EPICS (for Diamond's Phase II motion tender).
  - Producing a TANGO device server for the Power PMAC.

What do we expect to hear/Questions?

- How is motion control being implemented and supported at various facilities?
- Novel approaches to particular motion control problems.
- What are the latest demanding requirements for typical motion control systems?
- Can we help with our experience and expertise?

Motion Control Downloads

- On our web-site, we have several free downloads relevant to motion control:

- EPICS
  - Device and Linux 2.6 Driver support for the **PMAC2 PCI Ultralite** motion controller.
  - ASYN (Model 3) driver support for the **PowerPMAC.**
  - Driver and Motor record support for the Attocube **ANC350** Piezo Motion Controller.
  - Driver and Motor record support for the Attocube **ECC100** Motion Controller
  - Support for the Attocube **FPS3010** Interferometric Displacement Sensor

- LabVIEW
  - **Turbo PMAC** VI's.

http://www.observatorysciences.co.uk

Galil Motion Control

MOCRAF Workshop Introduction

Background

Established Reputation and Long History of Success

- Founded in 1983 by Jacob Tal and Wayne Baron
- Introduced 1st microprocessor-based servo controller
- Profitable for over 110 consecutive quarters
- Delivered over 750,000 motion controllers and PLCs

Excellent Technical Support and Service

- World-wide network of factory-trained reps & distributors
- Technical support team with over 100 man-years of motion control experience
- On-line support tools at www.galil.com

Workshop Objectives

- Introduce Galil to the Big Physics community
- Better understand challenges facing physics research applications
- Participate in dynamic discussions about improving the capabilities at the installations
- Face-to-face meetings with key individuals in the industry

Galil = Motion Control

We manufacture motion and I/O controllers that are:

Easy to Use

- 2 letter, English-like instructions
- Software tools for servo tuning

Cost Effective

- 100 qty price guarantee; as low as $100/axis

Flexible

- Available in 1 through 8-axis configurations
- Configurable for steppers and servos on any axis
- Box-level or card-level; PCI, RS232, and Ethernet

Easy to Customize

- Firmware & hardware customized to specifications

Workshop Expectations

- Find out how to enhance interaction with other components of the installation
- Learn more about motion requirements of new applications
- Collect feedback on future product enhancements
- General networking