Diamond Light Source

- Diamond Light Source is the UK's national synchrotron facility, located at the Harwell Science and Innovation Campus in Oxfordshire. By accelerating electrons to near light-speed, Diamond generates brilliant beams of light from infra-red to X-rays which are used for academic and industry research
- Opened in 2007, Diamond is being developed in three phases. Phase I investment of £263 million included Diamond's buildings and the first seven photon 'beamlines'. Phase II funding of £120 million enabled the construction of 15 more beamlines between 2007 and 2012. In October 2010, the government confirmed further funding for Phase III expansion, for an additional 10 advanced beamlines between 2011 and 2017, which will bring the total to 32
- A total of 20 beamlines are now operational, with three more in commissioning phases.

diamond

Motion Control at Diamond Light Source

- There are currently over 1800 operational motorised axes in use at Diamond with more being added every day.
- Over 90% are DC stepper motors. Other motors include DC servo, Brushless servo, Pico motor, Nano motor, Piezo legs and Smaract.
- Feedback devices include incremental encoders, both digital and analogue, resolvers and absolute encoders using SSI, EnDat and BissC protocols. The latest device uses a 40 bit parallel output.
- Motors are commissioned using Vendors interfaces. The engineering interface is via EPICS. The experimental interface is via openGDA. Occasionally added functionality is embedded into the controller to increase productivity

Motion Challenges at Diamond Light Source

- Monochromators; Increase resolution and stability. Currently we operate at between 50-200nR rms. Aim to reduce further towards 5-10nR.
- Beam Conditioning; Increase resolution and stability to better than 10% beam size. With reducing beam size encoder feedback resolution has gone from1u to 20 nm.
- Detector Stages; Implementing complex scanning trajectories on a 6 circle diffractometer as we migrate from one motion controller to our standard geoBrick-LV.
- Commonality; Increasingly vendors are offering higher precision devices , but at the same time reducing the availability of common control inputs. Particularly true of ceramic motor vendors. This increases the difficulty of incorporation into the overall control system and providing detector trigger signals for fly scanning.

MOCRAF Workshop 2013

- Validate what we are doing is sensible
- Hear what other Facilities are attempting
- Create a mailing list for year round interaction rather than just at these workshops.
- Help others with our learning where we can.

GANIL

SPIRAL 2 Project

GANIL, (National Large Heavy Ions Accelerator), is installed in Caen, Normandy, France.

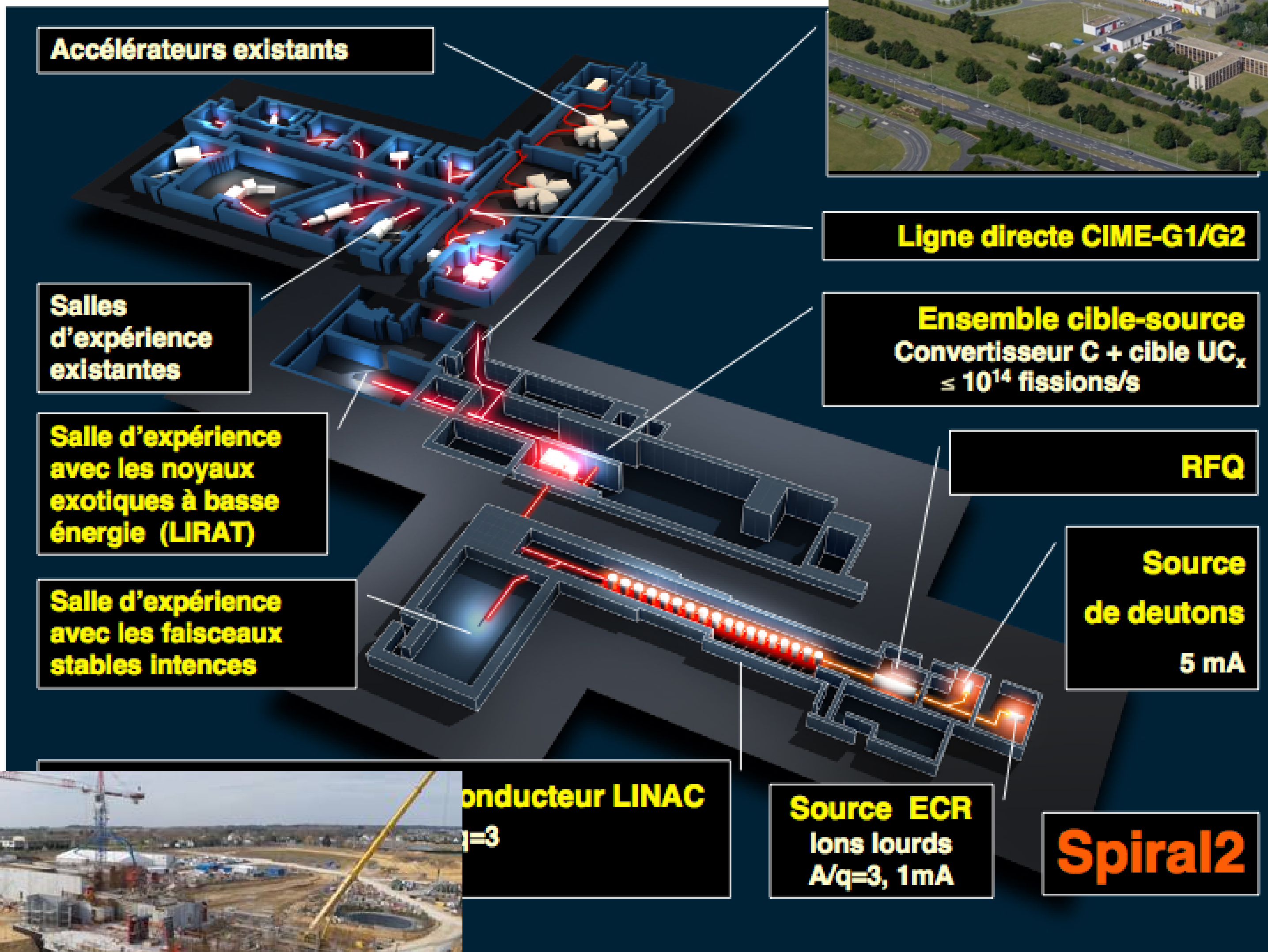
- **Nuclear physics** is the field of physics that studies the constituents and interactions of atomic nuclei.

- Permanent staff of 250 (physicists, engineers, technicians, administrators …)

- GANIL has **700 visiting scientists**, from laboratories located all over the world

- **1983** : First experiment

The FACILITIEs



Motion For

- GANIL (old Facility)
  - Motors used for:
    - ✓ Slits (~50) and Diagnostics: ⇒ Stepping motors
    - ✓ Cyclotrons [Injection /Ejection and probes] (~10 /cyclotron) : ⇒ stepping motors
    - ✓ RF cavities: variable capacitances, mobile panels : (~10 /cyclotron):
      - ⇒ Stepping motors ⇒ DC motors
    - ✓ Ions sources: electrostatic lenses
      - ⇒ Stepping motors ⇒ DC motors

- SPIRAL2 Project (New Facility)
    - ✓ Slits (~50)
      - ❑ stepping motors with a local control by a microcontroller
    - ✓ RF Superconducting cavity [28] and Diagnostics [emittance-meters.. Probes]
      - ❑ Brushless motors: SINAMICS S110 SIEMENS

The control is made by

- VME Crate through: a Modbus-RTU fieldbus (with a local feedback)
- PLC through :
  - ✓ Modbus-RTU / Analog drive / Profibus for Brushless motors
- Always a local feedback by an encoder:
  - ✓ Mechanical (hold) / Potentiometer: linear or rotary / shaft encoder (optic)
- Local control made by:
  - ✓ A HCS12 microcontroller / PLC / servo drive [Simatics S 110]

The current technical challenges

- We try to use industrial devices to reduce the workload
- Strength to neutrons

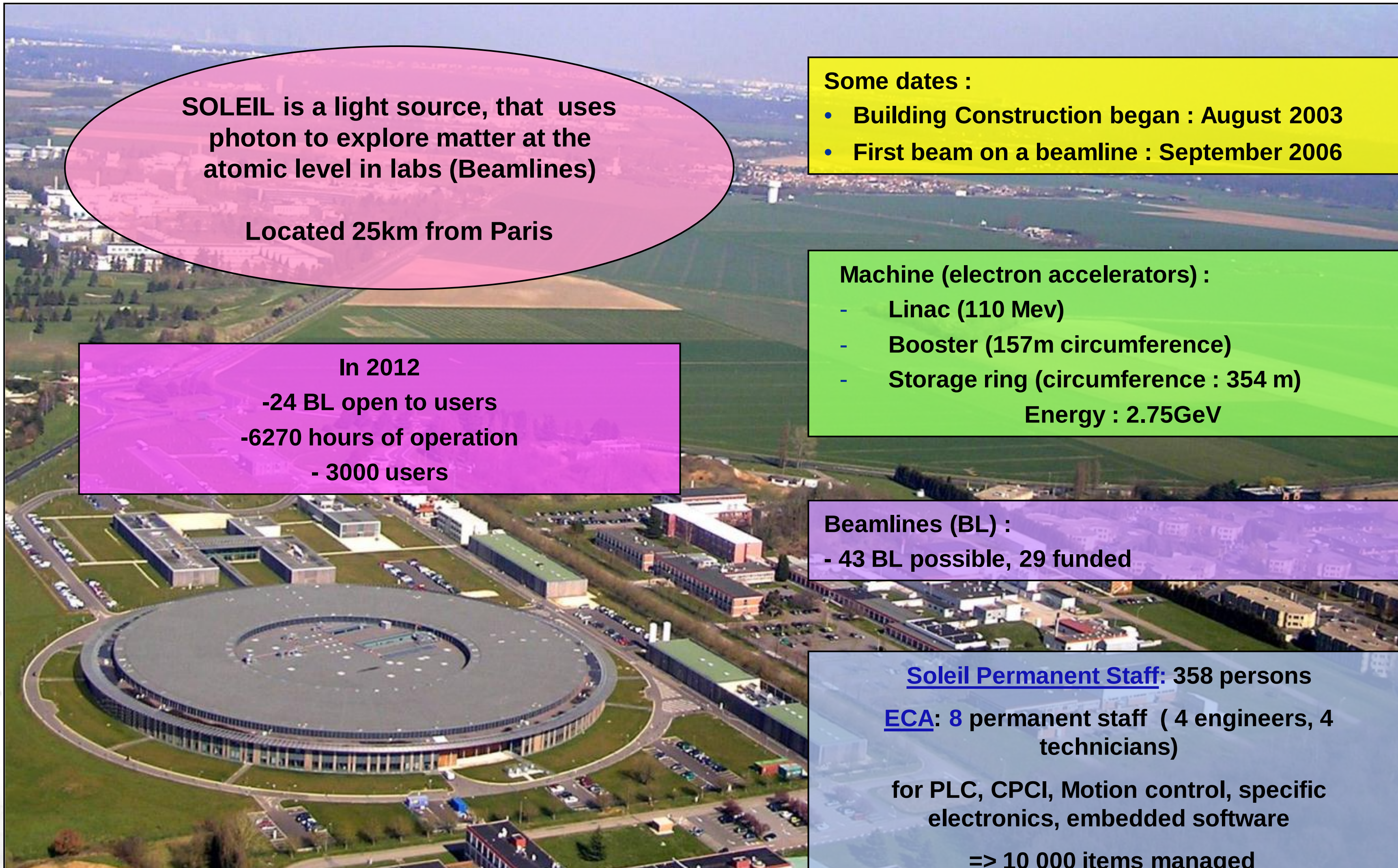
Expect to hear from other attendees

- Examples of the use of industrial solutions
- Examples of use in neutron environment

Motion Control in SOLEIL

Pascale Betinelli
on behalf of the Control and Data Acquisition Electronics team

SOLEIL in a few figures



SOLEIL is a light source, that uses photon to explore matter at the atomic level in labs (Beamlines)

Located 25km from Paris

Some dates :
- Building Construction began : August 2003
- First beam on a beamline : September 2006

In 2012
- -24 BL open to users
- -6270 hours of operation
- - 3000 users

Machine (electron accelerators) :
- Linac (110 Mev)
- Booster (157m circumference)
- Storage ring (circumference : 354 m)

Energy : 2.75GeV

Beamlines (BL) :
- 43 BL possible, 29 funded

Soleil Permanent Staff: 358 persons

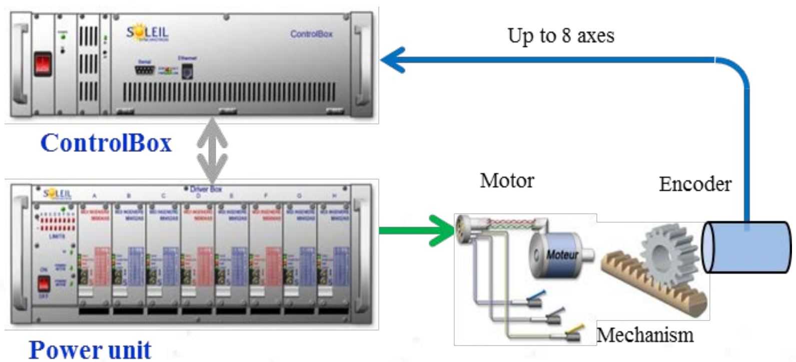
ECA: 8 permanent staff (4 engineers, 4 technicians)

for PLC, CPCI, Motion control, specific electronics, embedded software

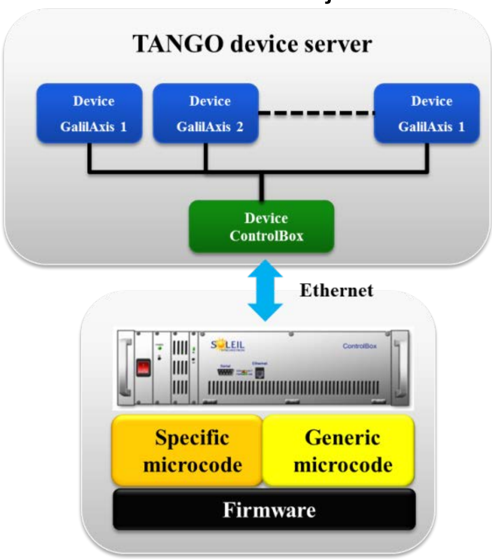
=> 10 000 items managed

Motion control status

- Hardware
  - Standardized hardware architecture
  - Separation of control unit and power units
  - **Industrial boards integrated in racks** (Boxes) designed by SOLEIL
  - ControlBox integrates a GALIL(1) DMC-2182 controller



- Software: **Hide motion complexity inside the controller**
  - Firmware with options
  - Generic and specific embedded user application (microcode)
  - Tango devices : a set of software objects



Installed base of motion controller, in September 2013:

- **320 ControlBox & 2000 single axis** power board are operational
- **85%** of axes controlled by a ControlBox
- **300 axes out of standard**

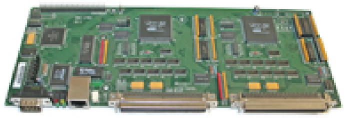
First goals achieved : Flexible & Easy to implement, to use and to maintain

- Flexible architecture open to other technologies by using standard signals
- Need only few staff to support motion control issues in a wide installed base

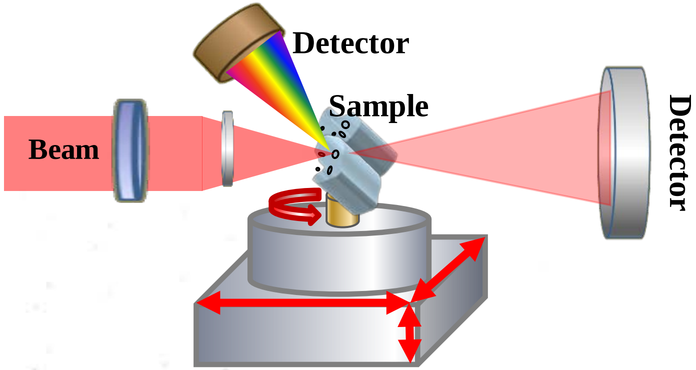
(1) GALIL company : http://www.galilmc.com

Current Upgrade

- What's happening after 10 years?
  - In 2009 GALIL released a new generation of motion controller (Accelera)
  - DMC2182 product becomes outdated product in comparison of the new generation of Galil controller
  - What is the state of the market?



To increase electron beam stability and photon energy accuracy



To synchronize detectors with optics that select photon energy to acquire only useful data

To perform fastest continuous acquisition to save time

- New motion control applications become more complex and request more advanced functionalities and a faster controller.

REconsider Various contrOLlers for oUr moTION

See technical presentation: Revolution project

Expectation for the workshop

Small team requests efficiency:

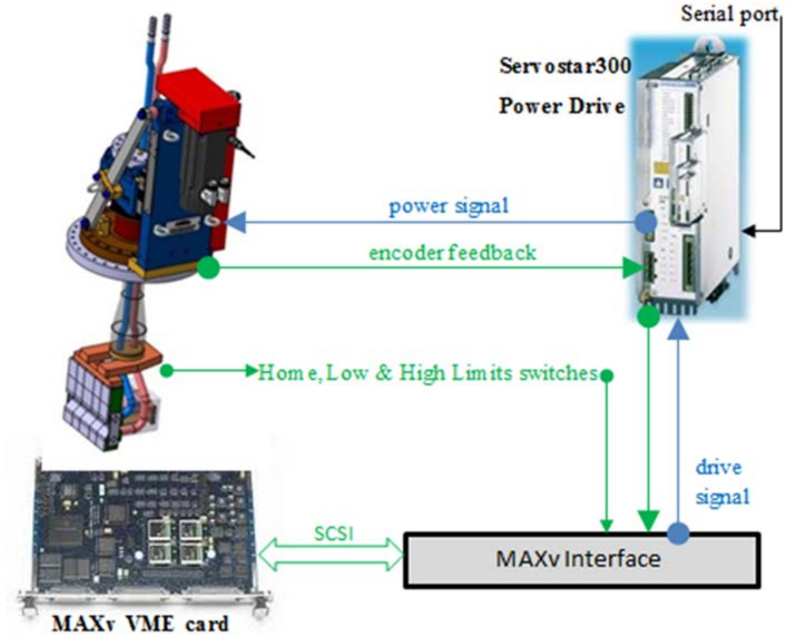
- To work in collaboration in order to learn faster
  - $\Rightarrow$ to build a community around motion control

- To work closely with industry in order to have smart solution
  - $\Rightarrow$ to be identified as a market with special needs
  - $\Rightarrow$ to get what we need

Not reinvent the wheel, just realign it!

Motor control issues

Françoise Gougnaud
CEA Irfu/SIS



The Irfu institute

- Involved in numerous physics projects

- In large facilities through collaborations
  - Accelerators
  - Large physics experiments
  - Telescopes

- VME OMS MaxV
  - for servo motors
  - Allison scanner emittance-meters
  - Wire scanners
  - doesn’t answer to our new requirements

- Newport XPSC8 motion controller
  - for a telescope simulator

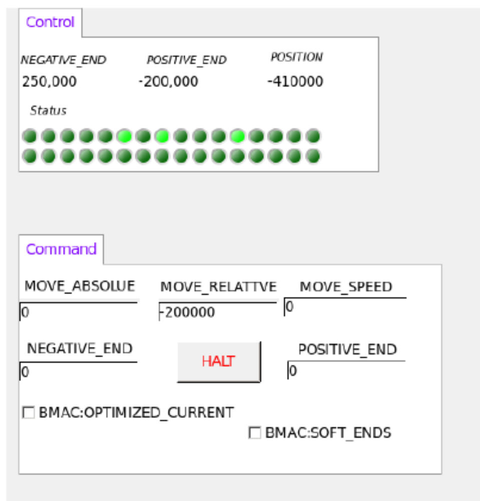
- Ganil GEM in-house electronics for slits

Stepper drive: our current requirements

- COTS boards from a sound company
- Remote intelligence, not on the IOC
- Independant of the hardware platform
- Ethernet communication if possible, Tcp/Ip
- Easily scalable and configurable for hardware and software
- Existing EPICS support
- Or the possibility to use « EPICS streamdevice »
- Inexpensive

A first candidate for a Phyton motor in a cryogenics environment

- Test bench based on a BMAC and EPICS is running
  - With a MIDI-INGENIERIE BMAC module version
  - Tcp/Ip communication
  - EPICS interface based on streamdevice



- BMAC board version
  - Up to 12 boards on a crate, Tcp/Ip communication

Paul Scherrer Institut

Guido Janser

Short introduction

The Paul Scherrer Institute in brief

The Paul Scherrer Institute, PSI, is the largest research centre for natural and engineering sciences within Switzerland, with its research activities concentrated on three main subject areas: *Matter and Material*, *Energy and the Environment*, and *Health*. The PSI develops, constructs and operates complex large-scale research facilities. Every year, more than 2000 scientists from Switzerland and other countries travel to PSI in order to perform experiments at our unique facilities.

Main areas of research

Researchers in the area of **Matter and Material** study the internal structure of a wide range of different materials

The goal of activities in the **Energy and Environment** area is to develop new technologies to facilitate the creation of a sustainable and secure supply of energy, as well as an uncontaminated environment.

PSI has about 1500 staff, with an annual budget of approximately CHF 365 million, and is primarily financed by the Swiss Confederation.

Large research facilities

PSI operates large scientific research facilities, such as the **SINQ neutron source**, the **Swiss Light Source (SLS)** and the **SμS muon source**, which offer out-of-the-ordinary insights into the processes taking place in the interior of different substances and materials. These are the only such facilities within Switzerland, and some are the only ones in the world.

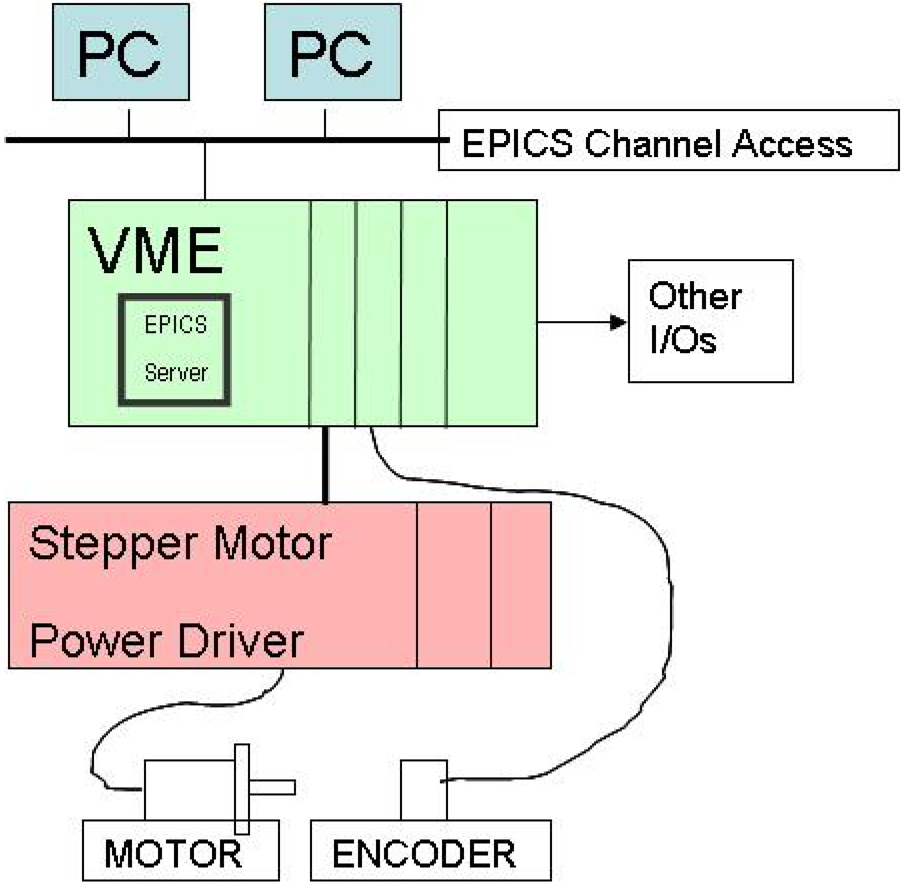
Proton therapy

In addition to its research activities, the Institute operates Switzerland's sole facility for the **treatment of specific malignant tumours using protons.** This particularly sensitive procedure allows tumours to be destroyed in a targeted manner, leaving the surrounding tissue largely undamaged.

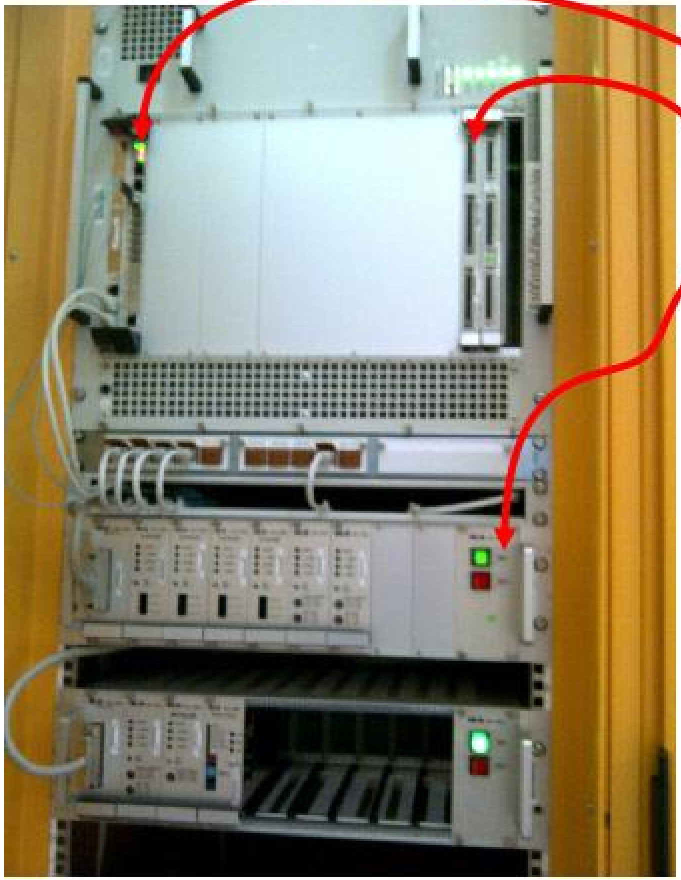
Pro-Dex MAXv

VME bus based

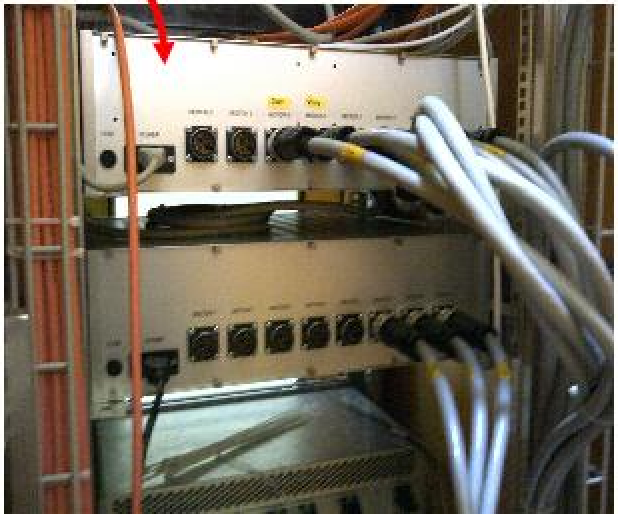
PSI current standard



Pro-Dex MAXv



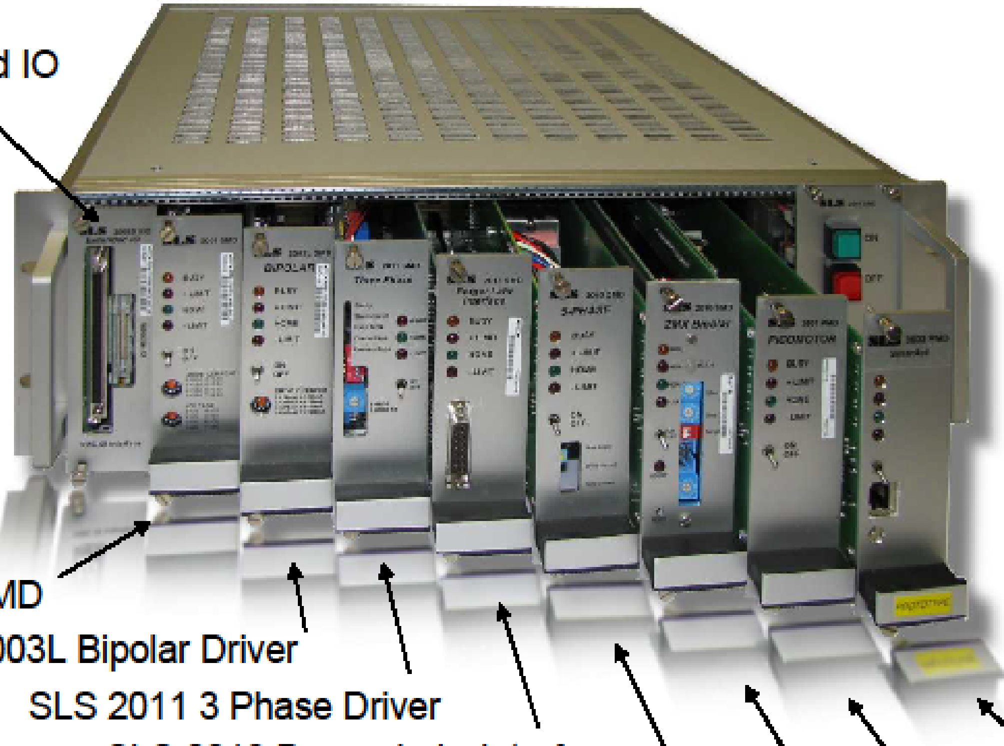
- VME cpu running EPICS IOC server
- OMS MAXv motion controller
- Motor Driver Unit



The SLS 2001 Motor Drive Unit (MDU)

Keeping the beamline in motion.

SLS 2009 Extended IO Module



SLS 2001 SMD

SLS 2003L Bipolar Driver

SLS 2011 3 Phase Driver

SLS 2013 Berger Lahr Interface

SLS 2015 5-Phasen Driver

SLS 2019 ZMX Driver

SLS 3601 Picomotor Driver

SLS 3603 SmarAct Driver

One rack

One cable

One GUI

Any kind of motor

Motion systems under evaluation

• Controllers

- VME based
  - Pro-Dex MAXv
- Ethernet
  - Icepap
  - Galil
  - Delta Tau
- EtherCAT modular
  - Beckhoff
  - PSI "slave" motion controller
- "All-in-One"
  - Schneider-Electric MDrive23

Thank you for your attention

Elettra Sincrotrone Trieste

Motion Control @FERMI

Alessandro Abrami

Presented by Marco Lonza

- ✓YAMS Controller, a description
- ✓FERMI & Elettra Installations
- ✓Issues

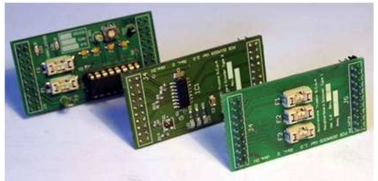
Yams - *Yet Another Motor Subrack*

Elettra
Sincrotrone
Trieste

Subrack 19" - 3U
Built-in 350W 24VDC PSU
Galil DMC 2183 board
with ethernet (... and TANGO)
Simple front panel commands
Up to 8 Eurocard size Motor board with power & Encoder interface

- 2 Phase Stepper Board with IMS hybrid circuit

IM481H (≤ 1.5 A_{RMS}/phase)
IM483H (≤ 3 A_{RMS}/phase)
IM805H (≤ 5 A_{RMS}/phase)

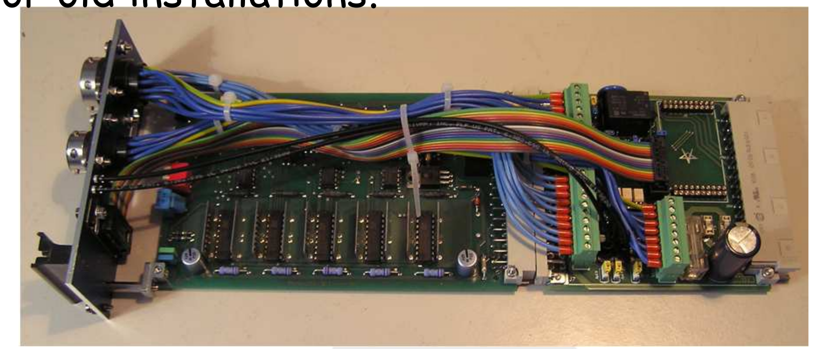


- Encoder daughter boards

Type 1 No conditioning is performed.
Type 2 RS422 digital encoders
Type 3 4-20mA analog encoders

- 3 & 5 Phase Stepper Adapter

It adapts the YAMS bus interface to the old "Berger-Lahr" D450 (5phase) and D920 (3phase) stepping motor cards, thus allowing the "retro-fit" issue for old installations.



Yams - Installations

FERMI

Installations:
63 YAMS subracks
256 stepper motors

used in:
bunch compressor, sled cavities, laser stages,
cavity beam position monitors,
quadrupoles, phase shifters, X band cavity, collimators,
mirrors & gratings, double-slits, beam position / intensity monitors,
gas regulation valves, etc...

Future:
(1) a hundred more stepper motors...
(2) brushless motor integration

ELETTRA

Installations:
4 YAMS subracks
30 stepper motors

Yams - Issues

Technical issues

Integration of new motor types
Hardware evolution (due to natural obsolescence)

What in the Community?

What is going on about: “Advanced diagnostics and tests”?

At Mocraf 2012 in the ELI-Beamline (Prague) presentation
the following interesting issue was pointed out:
“User end stations – LEGO style reconfigurable motion control system required”

Any news?

For any question please contact

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www.elettra.eu

Australian Synchrotron

Turning bright ideas into brilliant outcomes

Motion Control at the Australian Synchrotron

Emma Shepherd

BACKGROUND

- Beamline control systems delivered ‘turn-key’
  - Delta Tau PMAC (PCI, VME, Ethernet)
  - Galil
  - Newport
- EPICS control, but many different solutions
- New projects now adopting the Delta Tau Geobrick
  - Great community collaboration / support (thanks, Diamond Light Source!)
  - Co-ordinated motion done using inverse kinematics on the brick
  - *tpmac* and *pmacCoord* EPICS drivers

COMPARISON OF APPROACHES

Feature	XAS implementation (ACCEL)	XFM implementation (IDT)	PD/MX implementation (Oxford Danfysik)	New implementation (DLS model)
Client interface	Multiple standard EPICS records per axis	Single motor record per axis	Multiple standard EPICS records per axis	Single motor record per axis
PMAC communications	DPRAM and ASCII PCI	ASCII PCI	ASCII Ethernet	ASCII Ethernet
EPICS driver	pmacpci (Observatory Sciences)	pmacpci (Observatory Sciences)	M-comm (Cosylab)	tpmac, pmacCoord (APS, DLS)
Axis co-ordination (e.g. DCM Energy transform)	C code running in the EPICS IOC	EPICS database layer running in the IOC	SNL code running in the EPICS IOC	Inverse kinematics running on the PMAC

CHALLENGES

- Complex system:
  - Steep learning curve
  - Difficult to identify configuration errors
  - Important to start from a well understood baseline configuration

- Reliable closed loop control still proving difficult to achieve
- Wiring standards...
- Some work required on co-ordinate system support

FOR DISCUSSION

- How do different facilities organise motion control?
- What processes do you follow?
- How do you acquire the necessary skills?
- How do we best share experiences and information?