IMPLEMENTATION OF CONTINUOUS SCANS USED IN BEAMLINE EXPERIMENTS AT ALBA SYNCHROTRON

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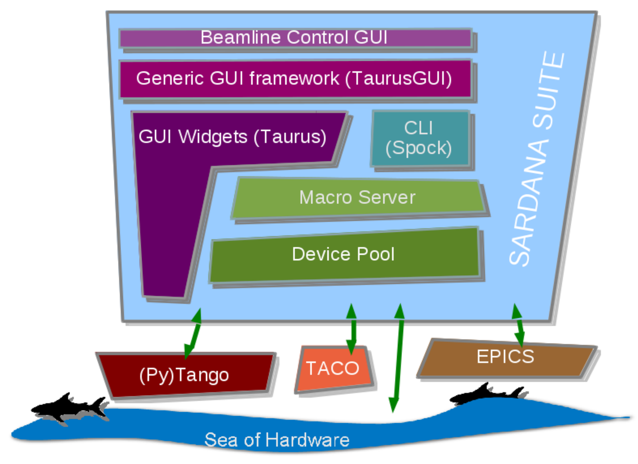
Alba - 3rd generation synchrotron

+) located near Barcelona, Spain
+) 1st construction phase = accelerators + 7 beamlines
+) designed, built and commissioned by 2012
+) 7 beamlines host user experiments regularly

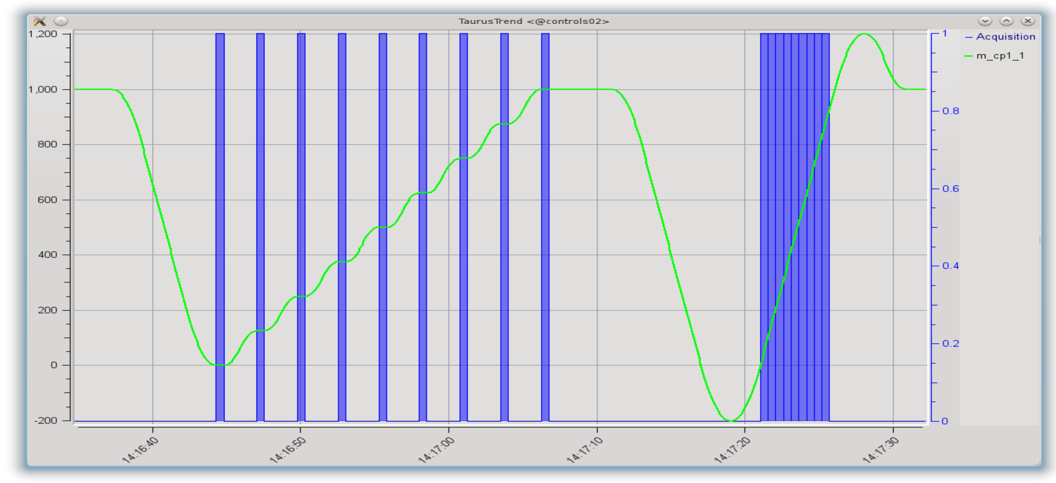
Sardana (on top of Tango) – CS of Alba

+) software package for building a distributed CS
+) easy plug-in solution for the hardware controllers
+) comprehensive interfaces for the common elements: motors, experimental channels, pseudo-axes, etc
+) python based macro and sequence environment
+) modern GUI front-ends
+) generic scan framework (GSF)



Why continuous scans?

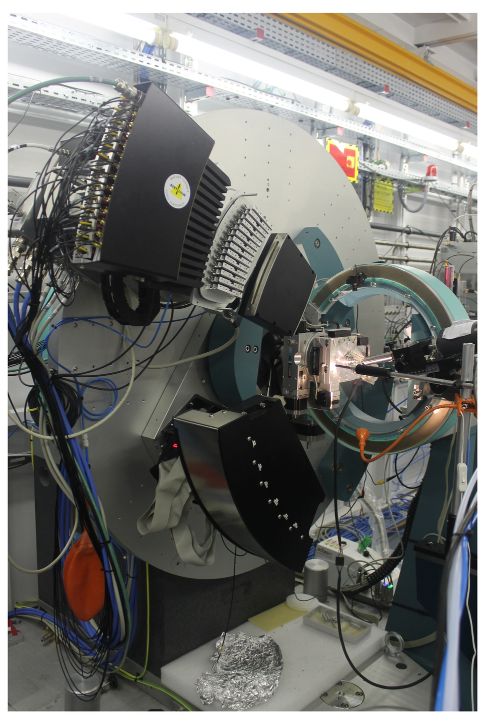
+) step scan = sequential execution of motion and acquisition
multiple accelerations/decelerations
extra software overheads
mechanical vibrations
+) continuous scan = simultaneous motion and acquisitions
scan time reduction
difficulties in abstract design and implementation



BL04 – MSPD

High energy beamline (8 - 50 keV), comprises two experimental stations:
+) high resolution powder diffraction (HRPD)
+) high pressure powder diffraction (HPPD)
The main instruments of HRPD:
+) three circle diffractometer
+) MAD26 detector resides on the OC
+) 6 x Mythen 1D mounted on the MC

Scans the OC rotational axis on a total range of 40 – 120 degrees. Diffraction pattern is gathered with 13 channels of the MAD26 & the monitor channel.

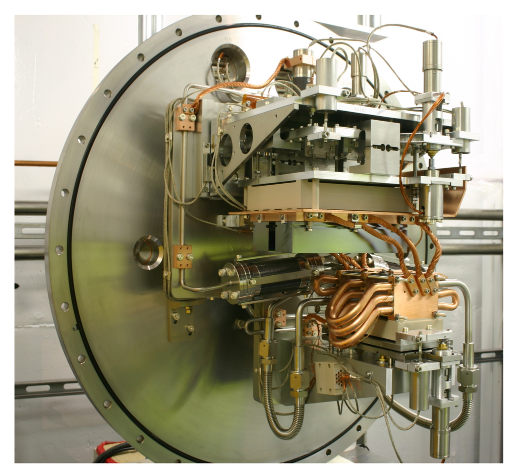


3C diffractometer and its MAD26 and Mythen detectors

BL22 - CLAESS

High energy beamline (2.4 - 65 keV), implements X-ray absorption & emission spectroscopic techniques.
Its main instruments are:
+) double crystal monochromator (DCM)
+) ionization chambers
+) position sensitive detector
+) fluorescence detector

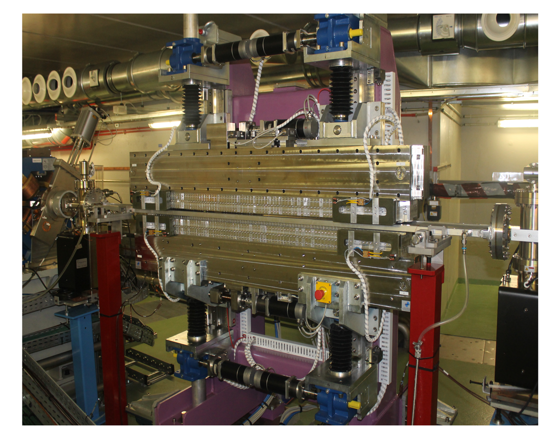
Scans the beam energy using a DCM, at the same time maintaining the fixed exit offset.
Reduction of the scan time to range of fraction of a second is required.



Si crystal stages of the DCM

BL29 – BOREAS

Soft X-ray beamline (80 - 3000 eV), implements magnetic circular and linear dichroism: XMCD/XMLD.
T wo cutting edge end-stations:
+ high-field vector magnet (HECTOR) for absorption methods
+) UHV reflectometer (MARES) for scattering and reflection approaches.

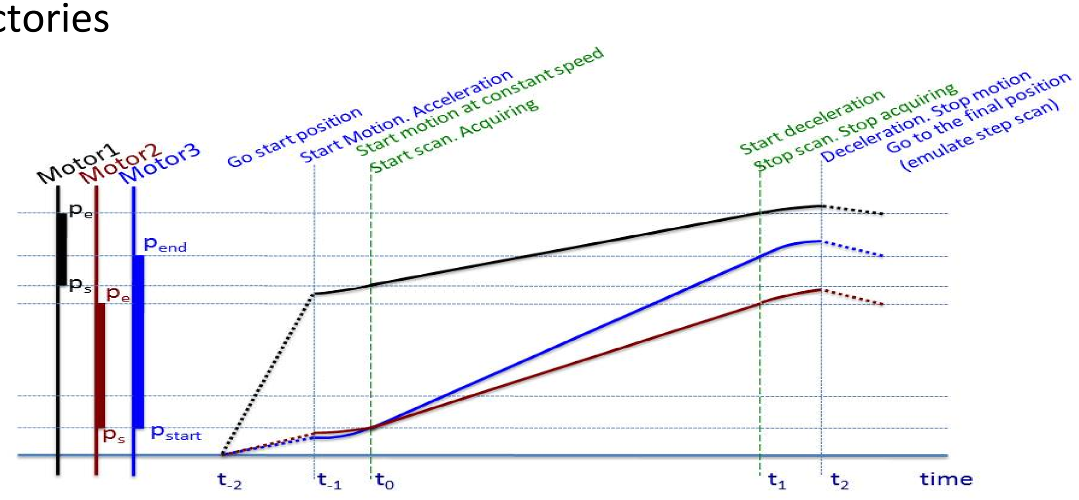


ID (undulator) located in the accelerator's tunnel

Scans the beam energy using a plane grating monochromator (VLS-PGM). ID (undulator) must follow the energy change. XMCD absorption method detection achieved by total electron/fluorescence yield measurements (measured with low current ammeters).

Motion

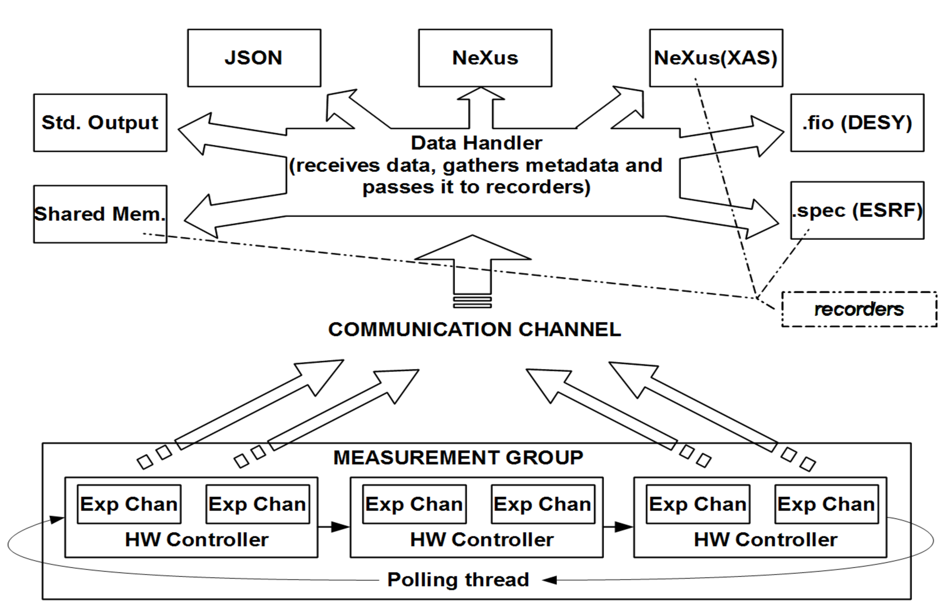
+) start of the multiple axes achieved by the Icepap multiple motion command and the Turbo Pmac 2 motion programs
+) pseudomotors resolved by the top-down inspection of the hierarchy of the all involved moveable axes
+) common acceleration times but separated velocities and trajectories



Theoretical trajectories of motors involved in the continuous scan: constant velocity represent an "effective" scan region.

Acquisition

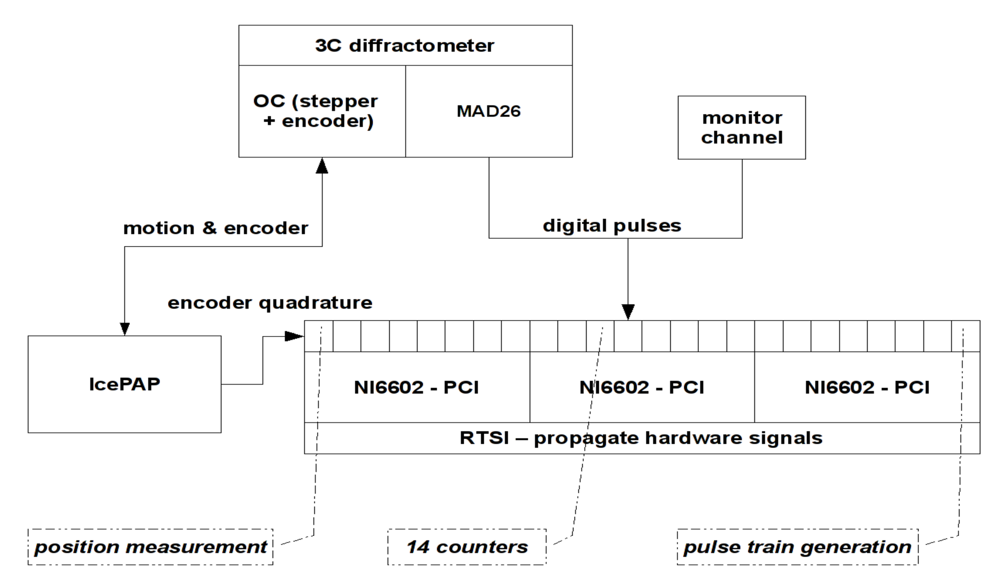
MAD26 → Cyberstart X2000 PPU → NI6602 counters:
3 Ni6602 PCI cards (32 bit counter and 80MHz clock) with RTSI used for routing signals.
Low current measurements:
+) AlbaEM: 1kHz sampling and 12 bits digitization
+) AlbaEM + Adlink2005 (external ADC): 500 kHz sampling and 16 bits digitization



Online data collection and storage mechanism

Synchronization

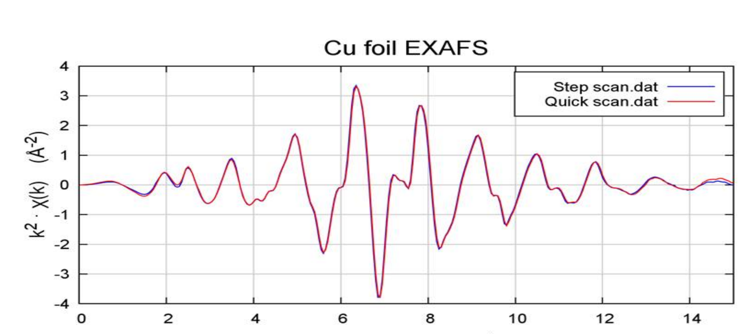
Time driven hardware trigger used to synchronize experimental channels.
Position measurement as an experimental channel:
+) Turbo Pmac 2 position capture feature
+) Ni6602 position measurement application



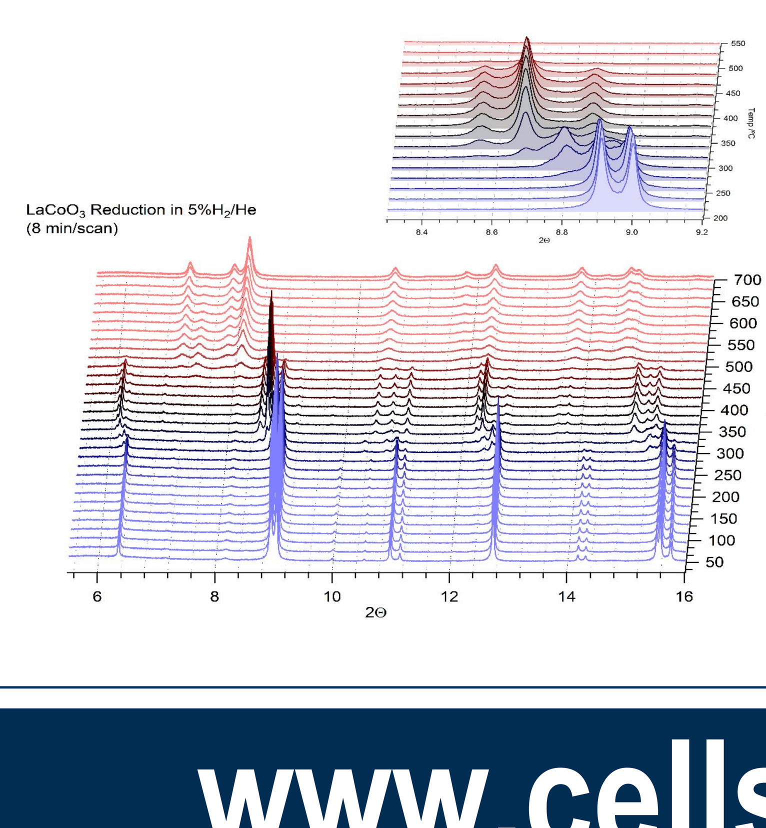
Instruments and controls hardware involved in HRPD experiment

Performance and results

Set-up	Step scan time	Continuous scan time
BL04 - MSPD angular range: 100° integ. time: 0.025s nr of points: 100 000	~ 9h 26min	~ 42min
BL22 - CLAESS energy range: 1keV (8969keV - 9969keV) integ. time: 0.0291s nr of points: 4000	~ 1h 3min	~ 3min
BL29 - BOREAS energy range: 65eV (755eV - 820eV) integ. time: 0.0124s nr of points: 4000	~ 1h 25min	~ 3min



EXAFS: step scan (45 min) vs quick scan (30 s)



HRPD: consecutive short scans (8 min) allows to resolve sharp diffraction peaks while changing the sample environment

Future development

Flexibility of selection the experimental channels implementing various triggering modes: hardware triggering and/or gating as well as software triggering must be provided.
Correlation of the data, produced by the channels of the different nature, should be also implemented.

The **1D** and the **2D** experimental channels are very common in the experimental set-ups. Normally they generate much more data than 0D experimental channels. GSF should be able to handle experimental channels producing data at the **high rate** and of **considerable size**.

Various approaches for implementing hardware triggering in the continuous scans exists. The most common are **position** driven and **time** driven. **Generalization** and **transparency** in implementation and usage should be achieved.

An approach of using software/hardware synchronized **timestamps**, redistributed to all the participant devices seems to be the future standard of the continuous scans. Each data acquired during the scan would have a timestamp and higher software layers could then manage this data to be easily interpreted by the end user.