



SYNCHRONIZATION OF MOTION AND DETECTORS AND CONTINUOUS SCANS AS THE STANDARD DATA ACQUISITION TECHNIQUE

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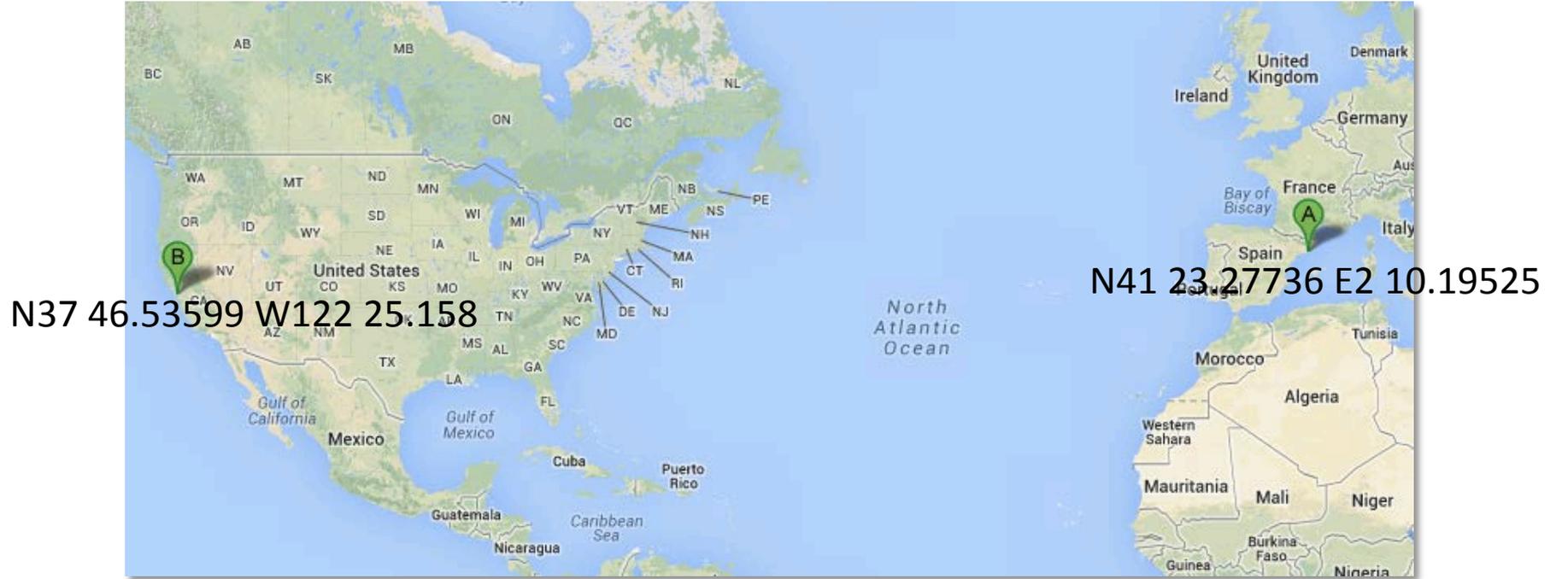
5949 miles / 9573.99 km / 5169.54 nautical miles



N37 46.53599 W122 25.158

N41 23.27736 E2 10.19525





WECOAB03. Continuous scans as the standard data acquisition technique

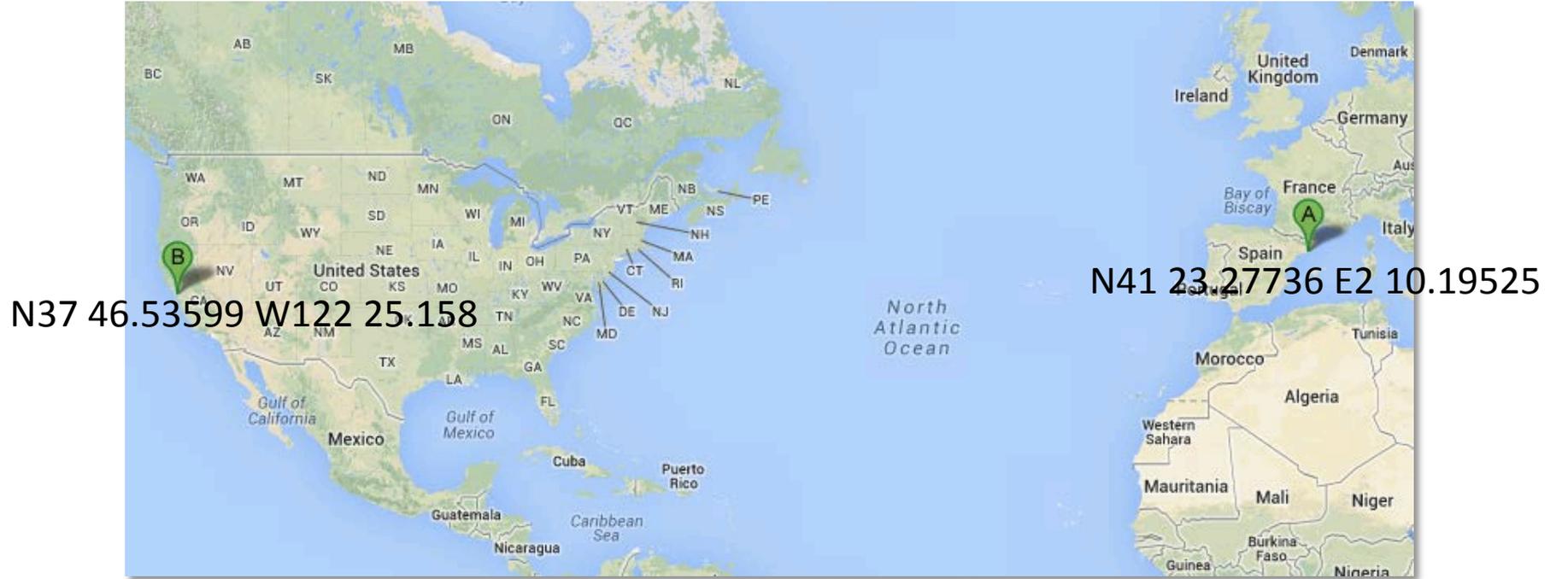


N37 46.53599 W122 25.158

N41 23.27736 E2 10.19525



WECOAB03. Continuous scans as the standard data acquisition technique



WECOAB03. Continuous scans as the standard data acquisition technique

- **3GeV Accelerators Commissioned in 2011**

- Ethernet as a fieldbus. Linux Diskless cPCI IOCs B&R PLCs
- Firsts Tests of TOP-UP and FOFB in progress (2013)



- **7 Beamlines commissioned in 2012: Official Users since then.**

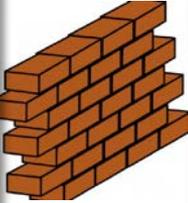
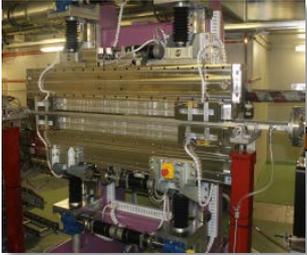
- Electrometers, VTF Counters, CCD cameras (Rayonix, PCO, Princeton...)
- Pixel detectors: Pilatus, Mythen, ImXPAD1400...



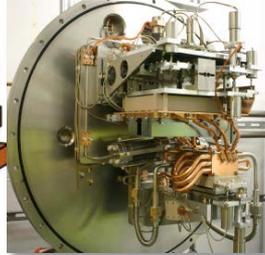
...preparing for time resolved experiments...



ID



DCM



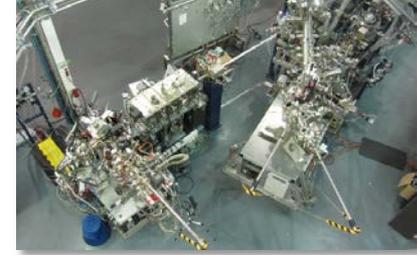
MAD



XMCD



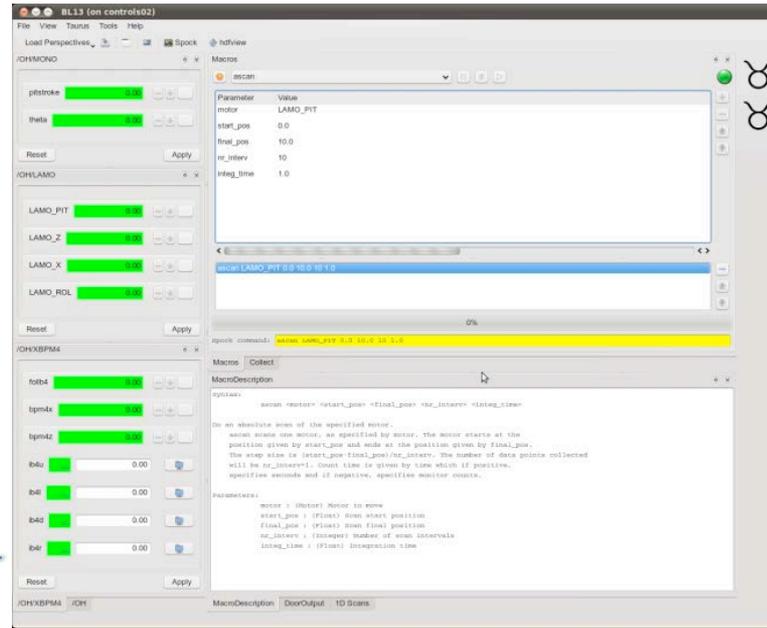
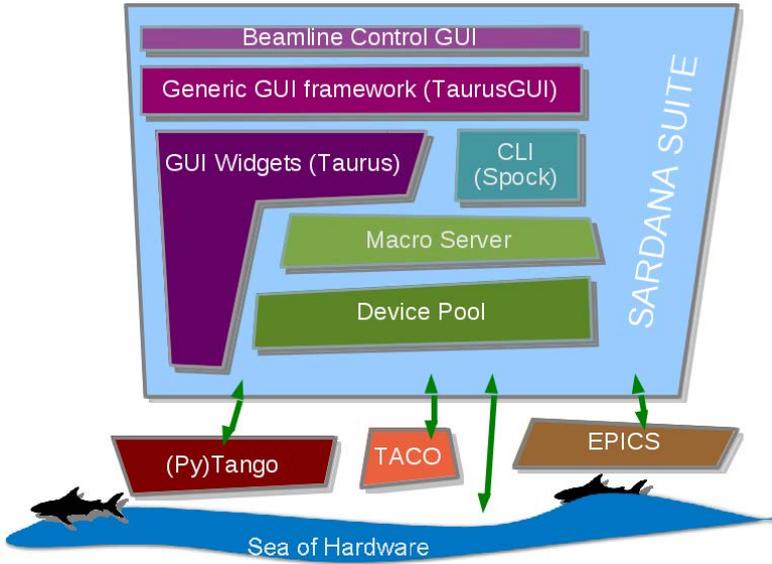
PEEM, KNAPP



(...)

- **Insertion devices:** e.g. helical undulator (6 motors) and 6 pseudomotors
- **Monochromators:** e.g. Double crystal monochromator (direct drive 4 DEG/s)
- **Experimental station:** scalars, counters, 0D, 1D, 2D,
 - Counters, Electrometers, Cameras, etc.
 - Slow channels and fast channels

Need a “scanning machine” having **movable channels** and **experimental channels**.
:Configure any combination of motors and counters + detectors in a step scan.
:Write my own sequences “macros” and scans,
:have pseudo-motors and pseudo-counters as a combination of several channels



- Generic, configurable Graphical User Interfaces. Trends, plots, forms, channels, synoptics, ...
- Interfaces with PLCs, databases, and different fieldbuses.
- Historical archives for supervision data.
- Configuration management. Configuration tool and state snapshots capabilities.
- Alarm handling, states, notification, acknowledgement and archiving.
- Self diagnostics and management tools

...

WECOAB03. Continuous scans as the standard data acquisition technique



Sardana: towards the scientific SCADA



FLEXIBILITY

- Simple to download, install and startup.
- . and above all: well documented.

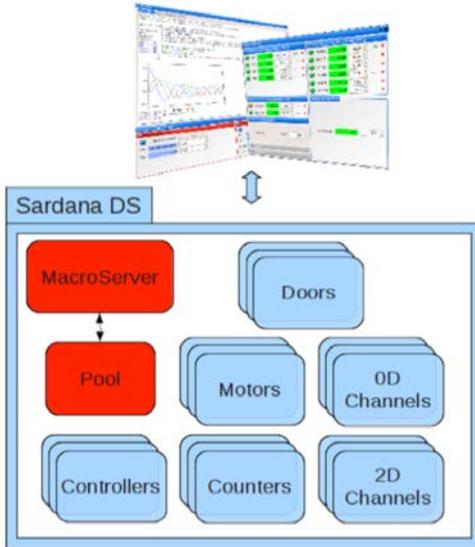
www.sardana-controls.org

www.tango-controls.org/static/sardana/latest/doc/html/

The screenshot displays the Sardana SCADA interface with several key components:

- Left Panel:** A parameter list with columns for 'Parameter' and 'Value'. Below it is a 'History Viewer' showing a list of energy scan events.
- Top Center:** 'Experiment Config' and 'Sardana Elements' sections. The 'Sardana Elements' section shows a tree view of 'MS_BL09' containing 'Motors' (wbd_uj, wbd, m3_x, m3_pitch) and a list of elements to be dragged (machine_current, fe_xbpm_v, fe_xbpm_h, fez, fe_x, fe_v_offset).
- Right Panel:** A control panel for 'gr_pitch', 'm3_pitch', 'm3_x', 'gr_x', 'EnergyCf12.25', 'Cff', 'Energy', 'Cff_enc', 'Energy_enc', 'gr_selection', and 'm3_stripe'. Each parameter has a numerical value, a range, and a unit.
- Bottom Left:** A 3D schematic of the mistral-3D beamline with various components highlighted in red and blue.
- Bottom Center:** A 'Limits_M1' panel showing current ranges and filters for I1 and I2.
- Bottom Right:** A 'Limits_M2' panel showing numerical values for parameters like jj_d, jj_u, es_d, and es_u.

WECOAB03. Continuous scans as the standard data acquisition technique



```

IPython
File Edit View Kernel Magic Window Help
Spock 1.0.0 -- An interactive laboratory application.

help      -> Spock's help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

Spock [1]: wa
Positions (user, dial) on 2012-10-02 15:58:05.472332

gap01    ice08    mot01    mot02    mot03    mot04    offset01
100.0000 100020.0000  50.0000  50.0000  0.0000   0.0000   0.0000
100.0000 100020.0000  50.0000  50.0000  0.0000   0.0000   0.0000

Spock [2]: ascan gap01 0 100 8 0.25
Operation will be saved in /tmp/BL99 scans.h5 (v5)
Scan #5 started at Tue Oct 2 15:58:10 2012. It will take at least 0:00:02.250000
Moving to start positions...
#Pt No   dt   gap01    ct01    ct02    ct03    ct04
0       2.40239  0       0.25    0.5    0.75    1
1       3.47745 12.5    0.25    0.5    0.75    1
2       4.56185  25      0.25    0.5    0.75    1
3       5.67741  37.5    0.25    0.5    0.75    1
4       6.77876  50      0.25    0.5    0.75    1
5       7.88055  62.5    0.25    0.5    0.75    1
6       8.97808  75      0.25    0.5    0.75    1
7       10.0703  87.5    0.25    0.5    0.75    1
8       11.1666  100     0.25    0.5    0.75    1
Operation saved in /tmp/BL99 scans.h5 (v5)
Scan #5 ended at Tue Oct 2 15:58:21 2012, taking 0:00:11.451502. Dead time 80.4% (motion dead time 77.1%)

Spock [3]: mesh
gap01
ice08
mot01
mot02
mot03
mot04
offset01
    
```



- Flexible, present in beamlines in “virtually” all synchrotrons. Extensively used in the day-to-day: Alignment, data acquisition, day-to-day operation in the Beamline.
- They are at the center of the control system:
 - Require motion, counter-timers, often a scripting-macro language,
 - Integrated with data formats, detectors, experimental channels, sample environment...

...very robust ...although ...slow ...

- A **step scan**, depending on the experiment, exposure times and number of points can be **time consuming**.
- In some cases (**time resolved**), the experiment itself needs to be done on certain time constraints.
- The longer the scan takes, the more vulnerable is to changes in the environment (thermal drifts, machine current, orbit, etc...)
- Occasionally, it is more convenient (or mandatory) **taking data during the motion**:
 - **The data is taken at given intervals while the motor(s) are moving.**
- Acquisitions can be synchronized in different ways:
 - Time (pulses given at certain time) usually by a time frame generator or a timer
 - Position (reading encoder positions and producing pulses at the given points)
- ...what if non linear trajectories or non equal intervals?

- Running in most Beamlines synchrotrons
 - Overcome the “slow” issue of step scans

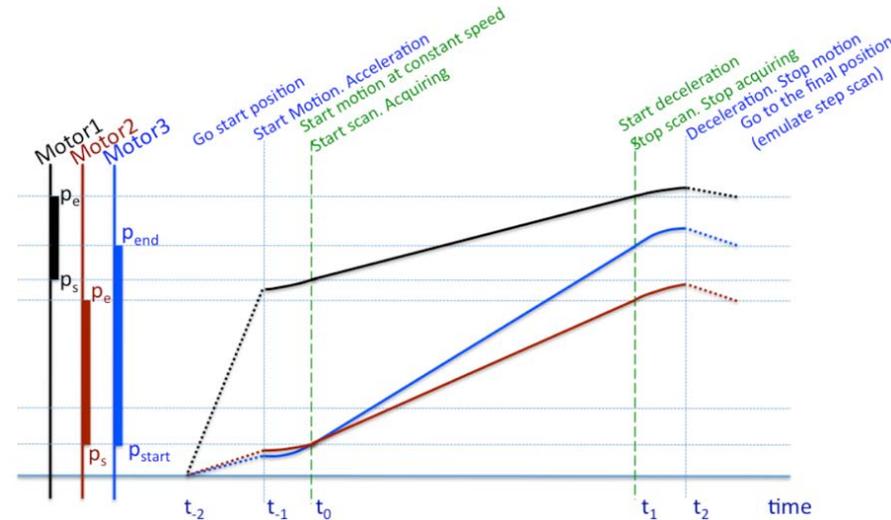
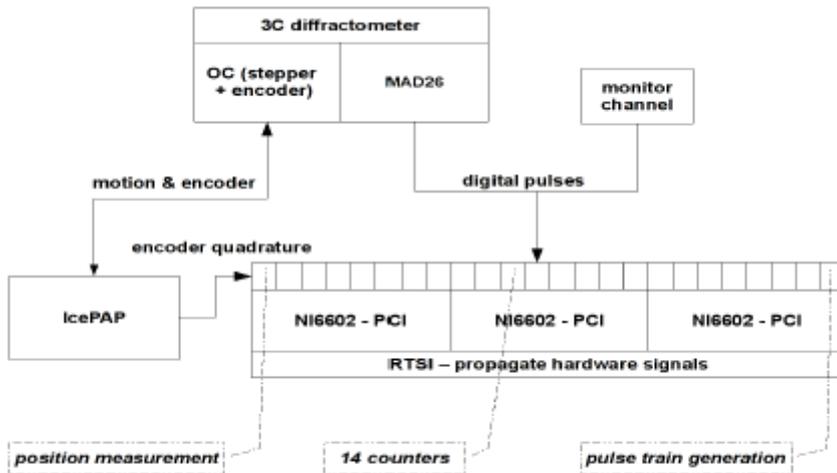
Need dedicated hardware with dedicated cabling for a particular purpose.

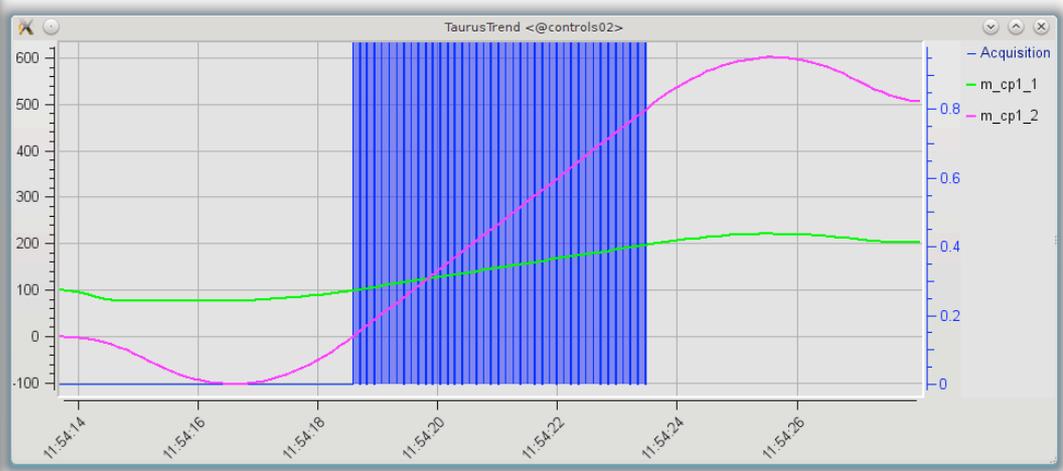
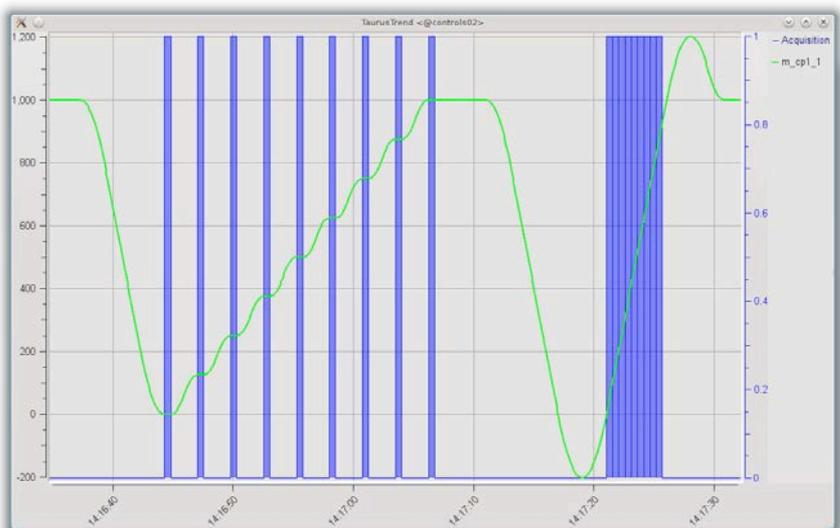
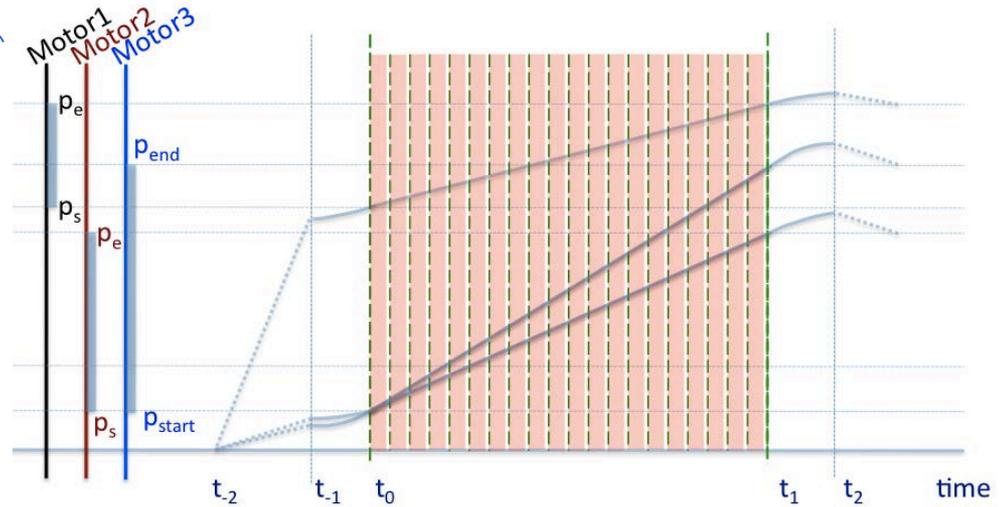
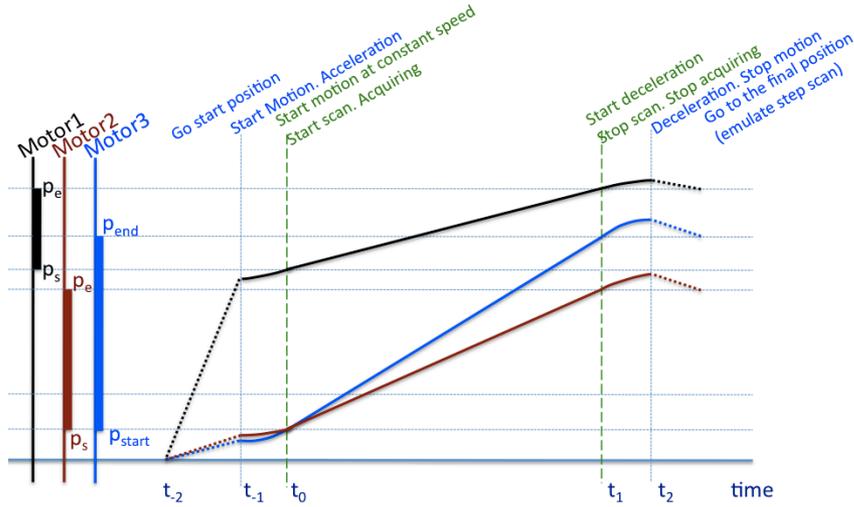
: Solve the problem for a particular type of experiment.

: Adapted to the purpose.

: Fast, optimized.

They do not solve all problems, being necessary to reprogram the beamline for other experiments using another hardware.





- Do *continuous scans in a generic way as if they were step scans*
 - Share the **same syntax**, have the same flexibility. Have the same motors, pseudomotors, channels and detectors available
- Trigger objects
 - Produce triggers (a timer or any particular axis at the given positions)
 - All motors shall be prepared to act as input for synchronization.
 - This means having encoder signals or indexers routed multiplexed and feed to the triggering hardware
- Buffering
 - Different data rates need different buffer capabilities.
 - Slow data from sample environment, accelerators, etc. do not need/can not achieve the same data rate. Interpolated
- Timestamps:
 - Having a accurate enough timestamp would make eventually unnecessary hardware triggers in several applications.
 - In the case of a spectroscopy moving the energy with a motorized Bragg angle (4 degrees per second, taking 4000 points in one second), we would need a precision of about 13 microseconds (not achievable by NTP)

The control system. Block diagram

```

terminal
File Edit View Terminal Tabs Help

spock
tcour1sh@pc131:~$ spock
Setting spock environment... [DONE]
Setting global environment... [DONE]
Connecting to door...
79 new macro(s) available

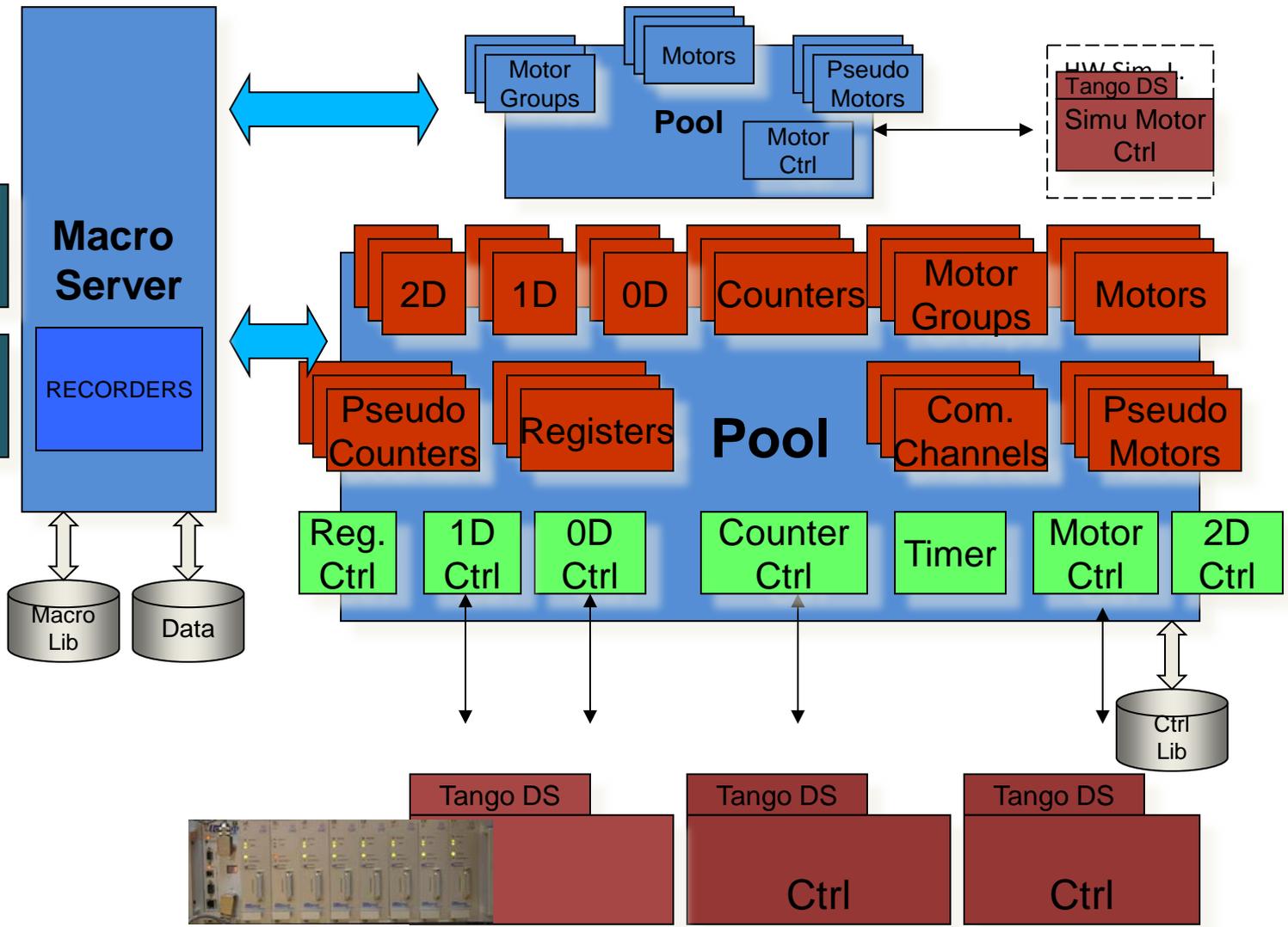
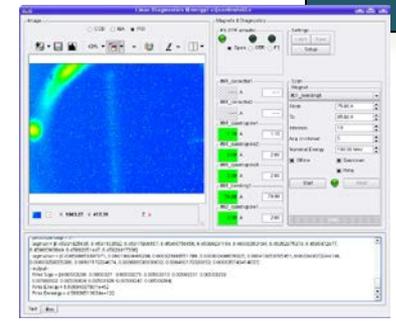
Spock 0.1.0 -- An interactive Macro Server client.
Running on top of Python 2.5.2 and Ipython 0.8.4
Using Door BL90/Door/001 to access Macro Server BL90/MacroServer/001.

I:SPCK: wa
Current Positions (user, dial)

BL90 gapt1 BL90 offset1 BL90 SimMot1 BL90 SimMot2 BL90 SimMot3
200.00000000 74.50000000 274.50000000 25.50000000 0.00000000
260.00000000 74.50000000 174.50000000 25.50000000 0.00000000

BL90 SimMot4
200.00000000
200.00000000
  
```

Door
Door



WECOAB03. Continuous scans as the standard data acquisition technique

The control system. Block diagram

```

terminal
File Edit View Terminal Tabs Help

10: spock
tcour1@hp1311:~$ spock
Setting spock environment... [DONE]
Setting global environment... [DONE]
Connecting to door...
79 new macro(s) available

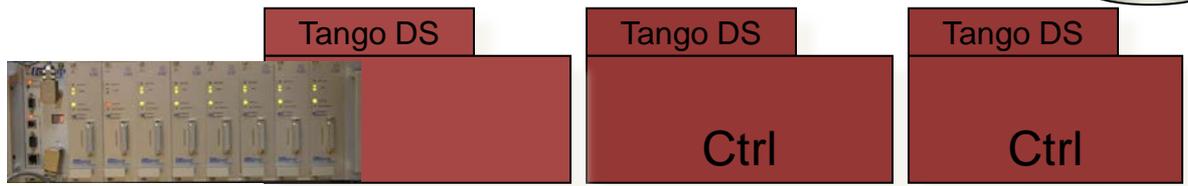
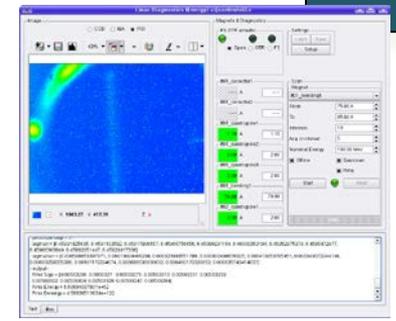
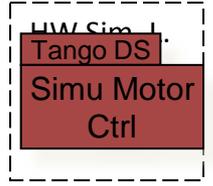
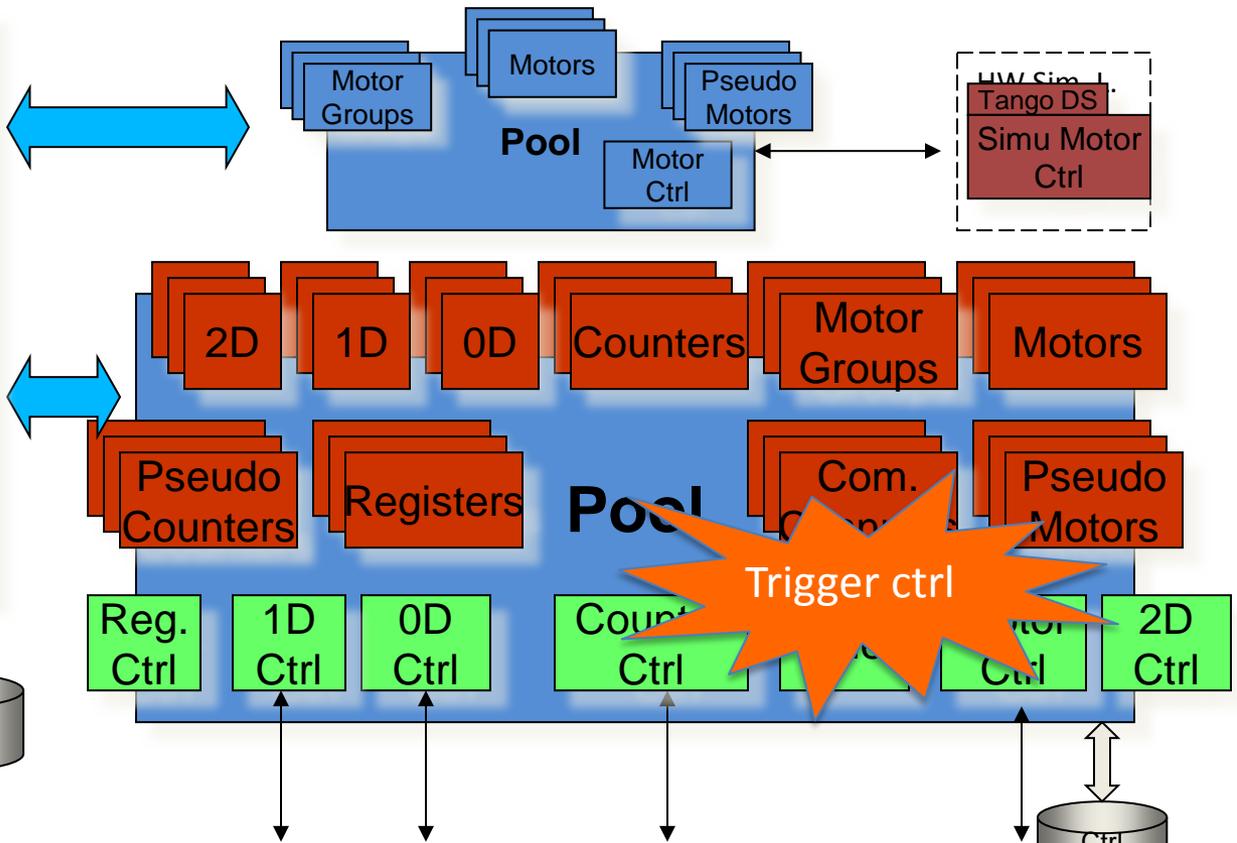
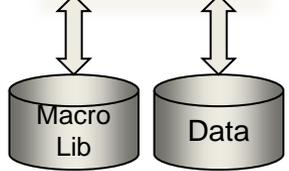
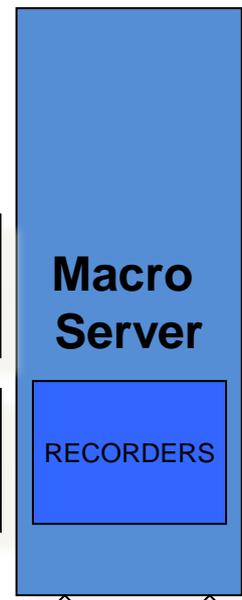
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Running on top of Python 2.5.2 and Python 6.8.4
Using Door BL90/Door/001 to access Macro Server BL90/MacroServer/001.

1: SPCK: wa
Current Positions (user, dial)

BL90 gapt1 BL90 offset1 BL90 SimuMot1 BL90 SimuMot2 BL90 SimuMot3
200.00000000 74.50000000 274.50000000 25.50000000 0.00000000
260.00000000 74.50000000 174.50000000 25.50000000 0.00000000

BL90 SimuMot4
200.00000000
260.00000000
1: SPCK:
  
```

Door
Door



WECOAB03. Continuous scans as the standard data acquisition technique

The control system. Block diagram

```

terminal
File Edit View Terminal Tabs Help

spock
tcour1sh@pc151:~$ spock
Setting spock environment... [DONE]
Setting global environment... [DONE]
Connecting to door...
79 new macro(s) available

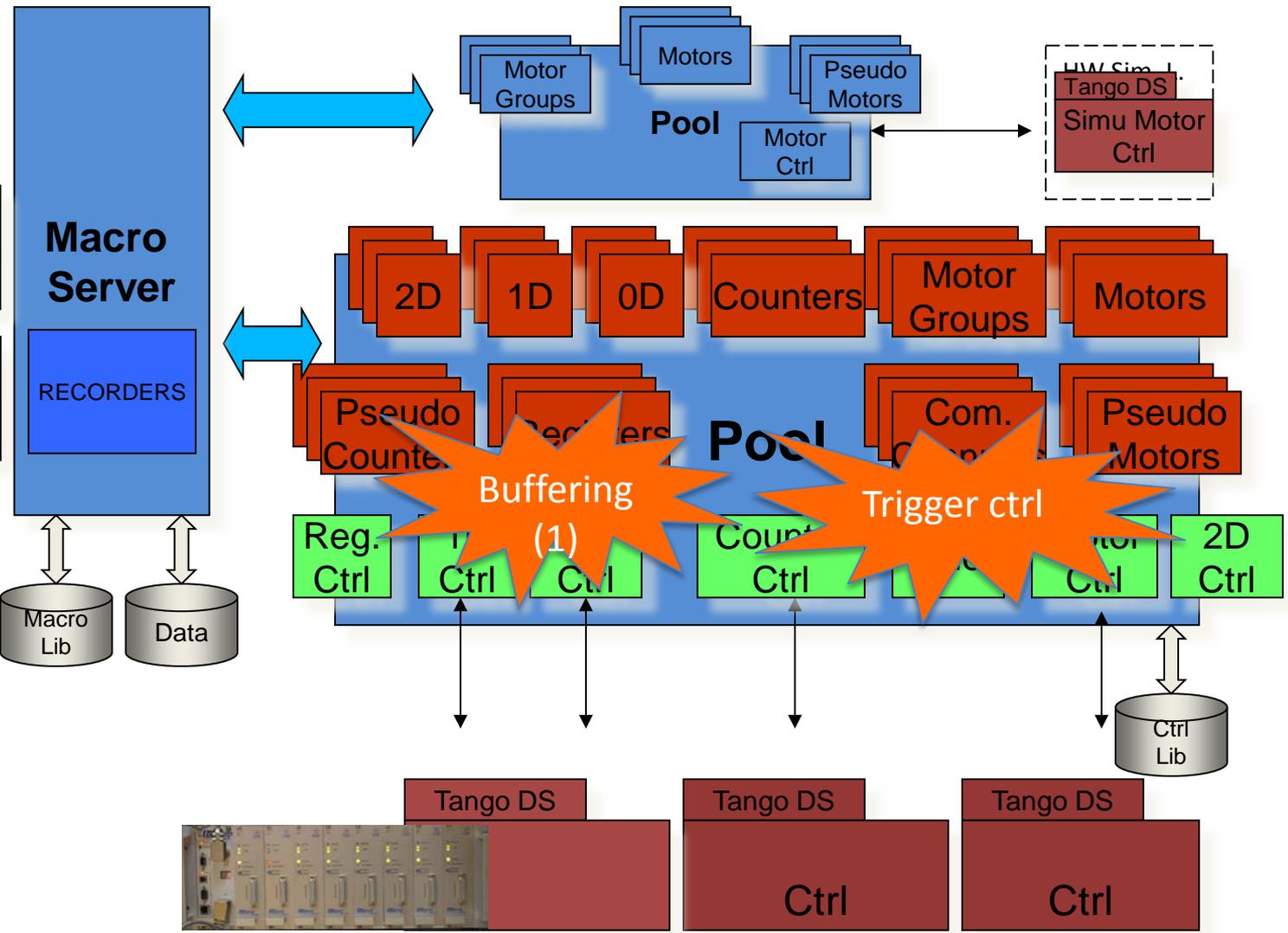
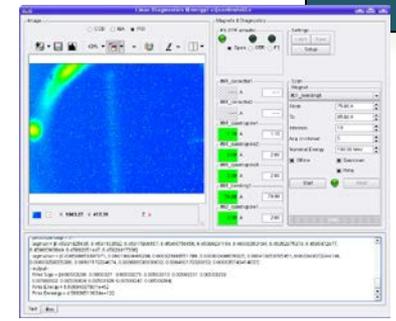
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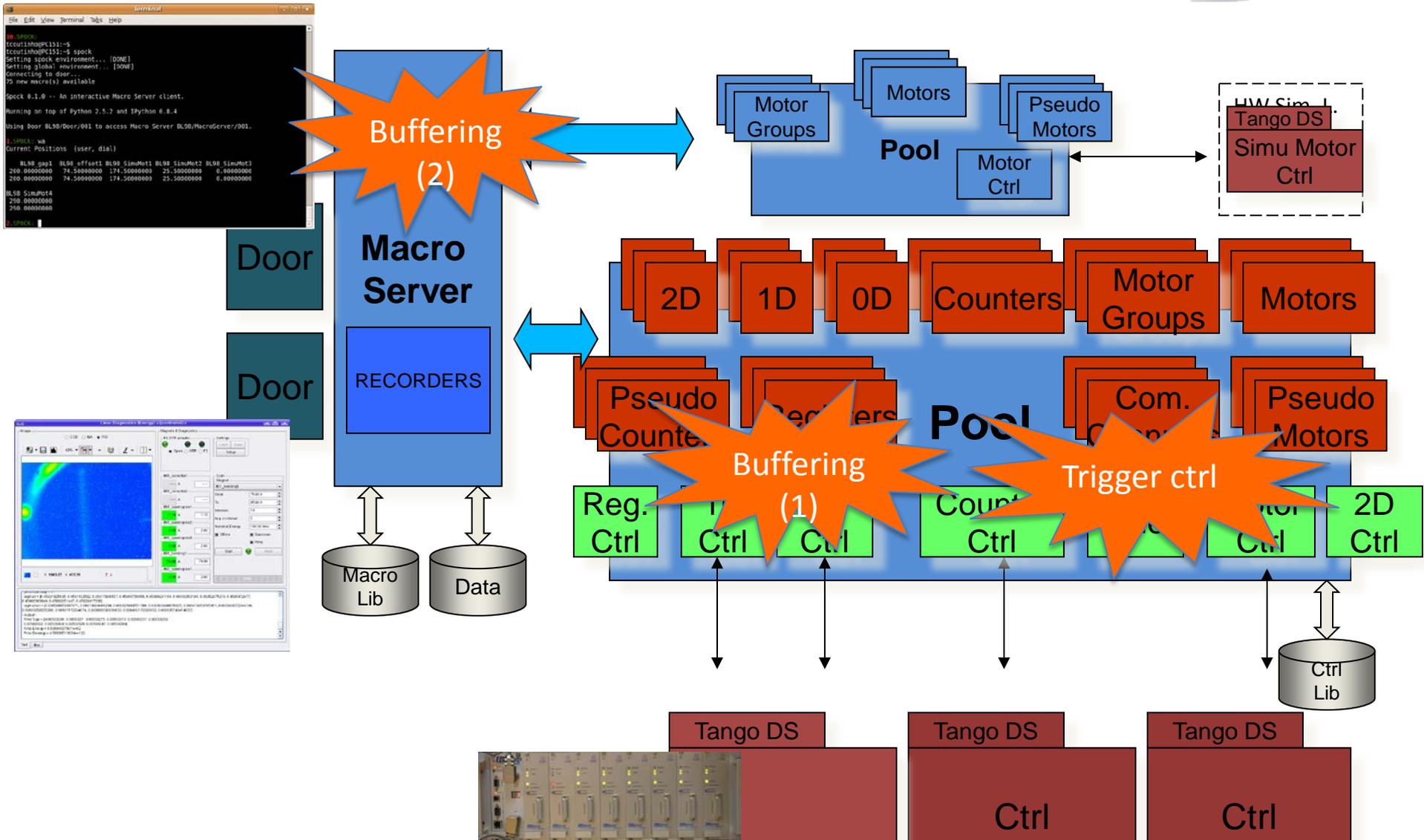
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BL90 SimuMot4
200.00000000
200.00000000
  
```

Door
Door



The control system. Block diagram



WECOAB03. Continuous scans as the standard data acquisition technique

The control system. Block diagram

```

terminal
File Edit View Terminal Tabs Help

spock
tcour1nh@pc151:~$ spock
Setting spock environment... [DONE]
Setting global environment... [DONE]
Connecting to door...
79 new macro(s) available

Spock 0.1.0 -- An interactive Macro Server client.
Running on top of Python 2.5.2 and Python 6.8.4
Using Door BL90/Door/001 to access Macro Server BL90/MacroServer/001.

1-SPICK: wa
Current Positions (user, dial)

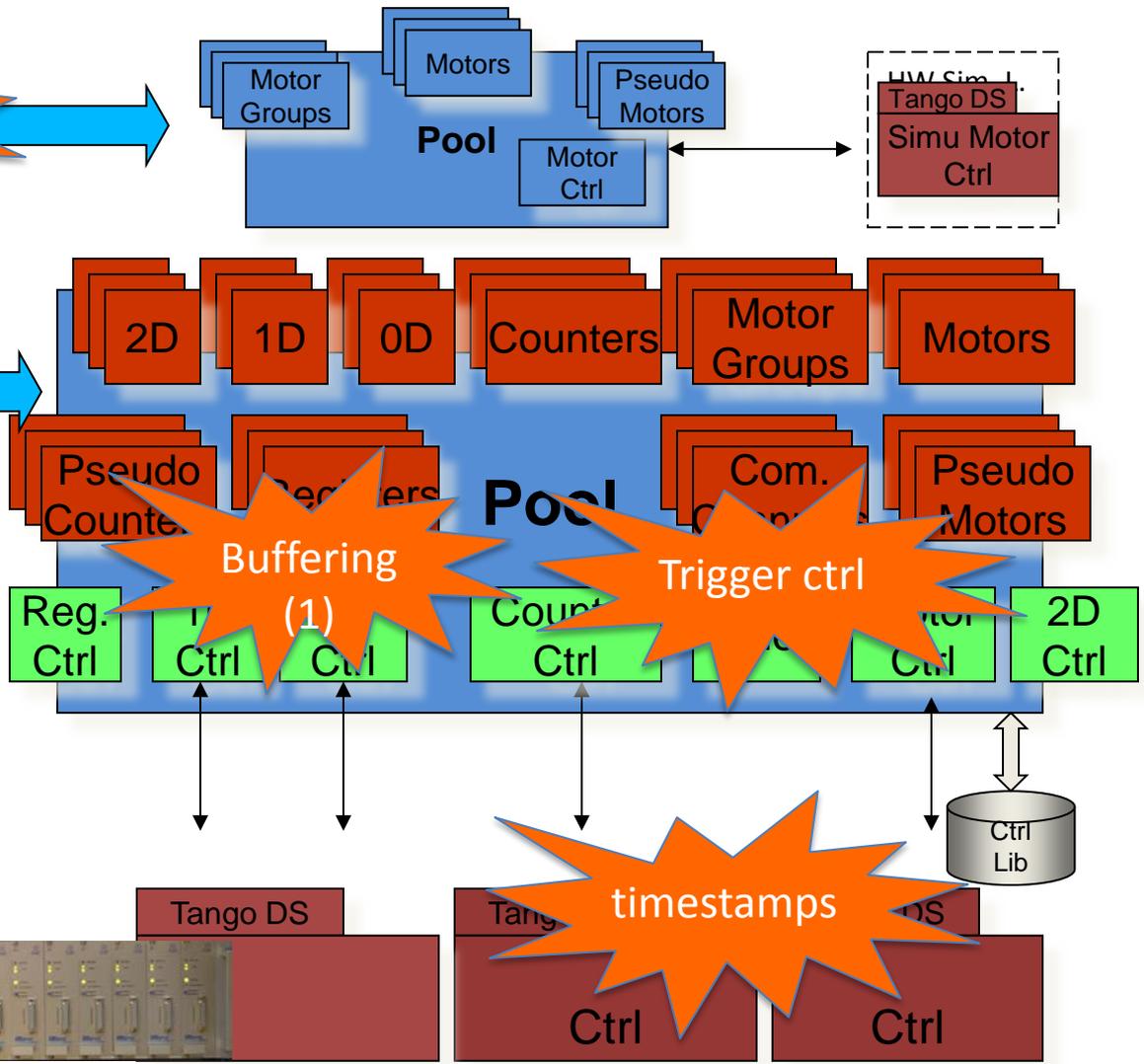
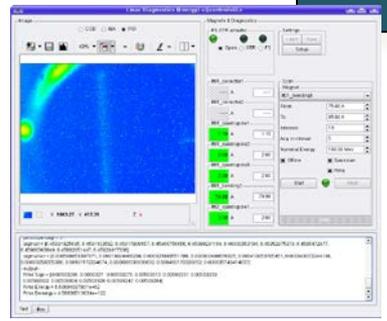
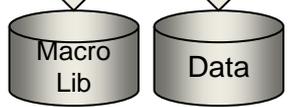
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200.00000000 74.50000000 274.50000000 25.50000000 0.00000000
200.00000000 74.50000000 174.50000000 25.50000000 0.00000000

BL90 SimuMot4
200.00000000
200.00000000
  
```

Door
Door

Macro Server

RECORDERS



WECOAB03. Continuous scans as the standard data acquisition technique

- **Triggering at time** intervals occasionally is simpler and more convenient than getting the motor position. Motor encoders treated as experimental channels.

- **Buffers** manage fast acquisition combined with local buffers and slow acquisitions managed directly.



- **Scalers, 0D,**

- **1D, 2D ... LIMA (ESRF)**

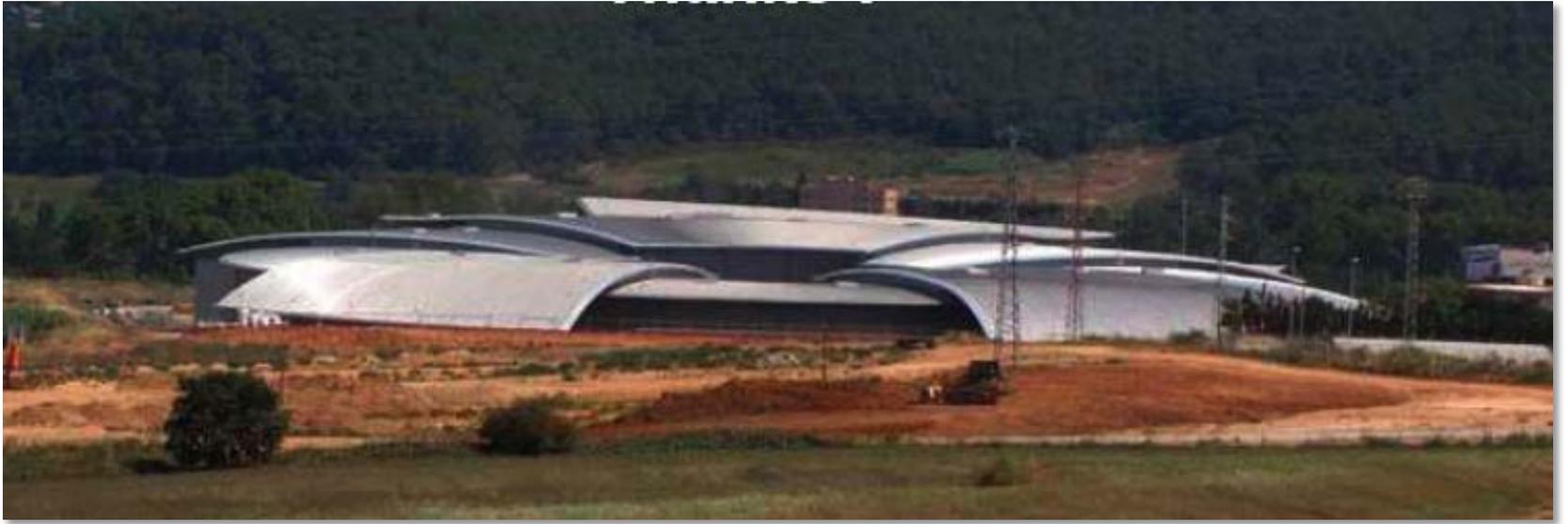


- **Timestamps**

- Timing system (MRF) from the Accelerators distributed to the Beamlines.
- IOCs synchronized by NTP (10 ms offsets)
 - PTP to be considered.
- Data is timestamped when acquired, the closest to the hardware.

- **Generic scientific SCADAS require a tighter integration of software components,**
 - Sequencer (friendly (powerful) (scripting) language (python))
 - Users write their own sequences/macros. Standard macro library.
- **Hardware easy to install and plug in. Flexible software**
 - Motion control, and fast detectors/channels triggered/configured with no hardware/cabling re-installation.
- **Triggering and buffering**
 - Central trigger object and device managing multiple motor inputs (potentially all in a beamline) and detectors.
 - Slow channels and fast channels, archived and interpolated
- **Timestamps**
 - Close to hardware. Detectors must have an accurate timestamp which attach to the data.
 - Accurate, but feasible with standard technologies, (microsecond range).
 - Triggers are the first option when available:
 - Timestamps do not avoid triggers.

TUPPC094 X. Serra et al.



Thank you for your attention.

