Data Acquisition and Instrument Control @ ILL

NEUTRONS FOR SCIENCE

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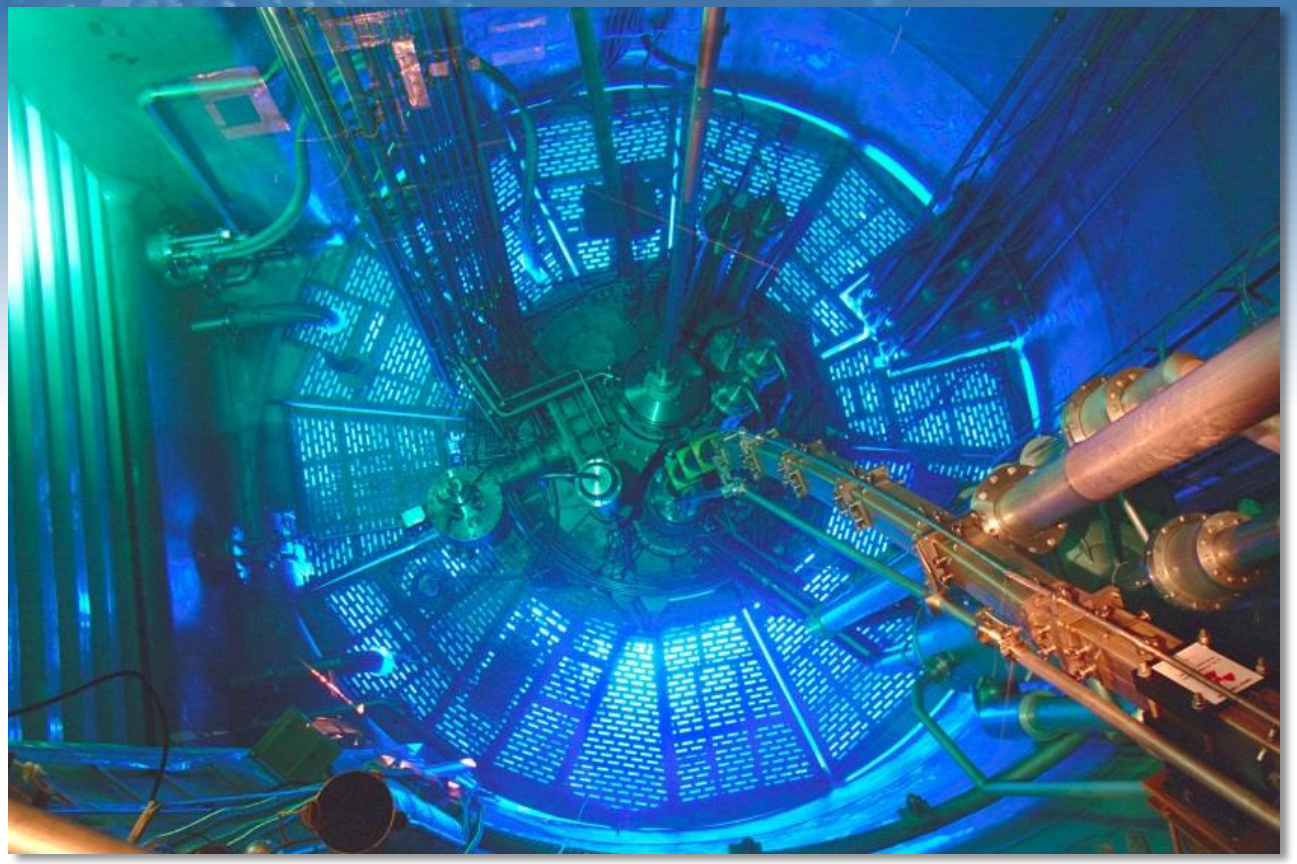
ESI - 18 June 2015

Outline

- Physics @ ILL
- Detectors
- DAC electronics
- NOMAD - Instrument control software
- Coming soon

The Source



58 MW reactor ⟶ $2 \cdot 10^{15}$ n/cm^2/s

Main Research Fields

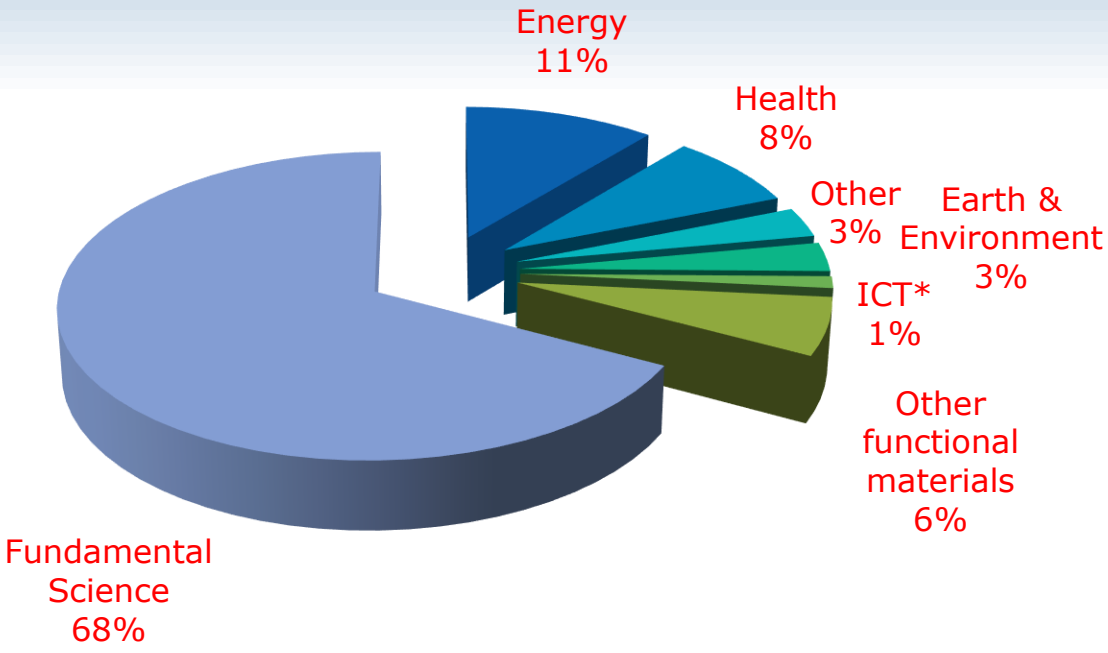
850 experiments/year

2000 users

38 countries

40 instruments

- Condense matter physics
- Material science
- Chemistry
- Biology
- Nuclear and Particle physics



Which Particles

- Neutrons (fast, epithermal, cold, UCN)
- Gammas
- Charged particles (β, α, ions)
- Photons

Which Detectors

- ^{3}He, ^{10}B, scintillators
- HPGe, $LaBr_3(Ce)$, BGO, NaI, etc …
- Ionization chamber, Si, TPC
- CCD and CMOS cameras

Acquisition Modes

- Simple Count
- Time-of-Flight
- Kinetic
- ToF - Kinetic
- ToF - Extern
- Doppler
- Energy
- DPP

Simple image of the detector with or without a pixel binning mask

Events are arranged as a function of the travel time from the source to the detector in channels from 100 *ns* to 100 *ms*

Events are arranged as a function of time from an initial TOP in channels from 100 *ms* to 100 *s*

For each kinetic time slice the events are arranged in ToF

Events are arranged in ToF and a number of slices are generated by an external signal

Events are arranged in speed slices according to the information delivered by the Doppler drive

Acquires energy spectra from peak-sensing ADCs

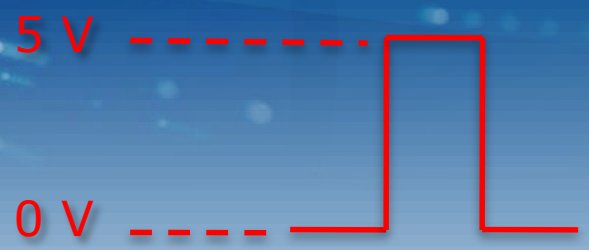
Full digital acquisition, energy and time are recorded in list-mode

DAC - Requirements

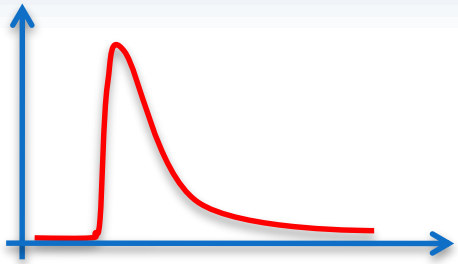
- Handle high event rate (up to 10 MHz)
- Minimize dead-time and pileup
- Accurate timing (10 ps)
- High data throughput (up to 80 MB/s)
- Synchronization with complex instrument operations

A Variety of Signals

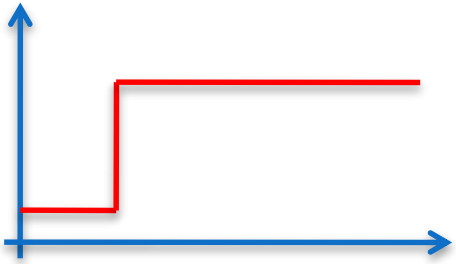
- Digital
  - TTL:



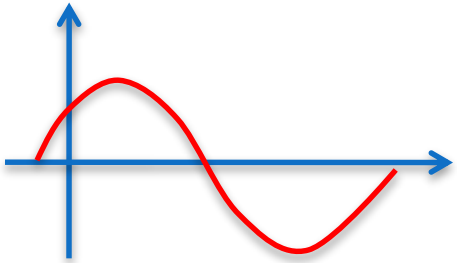
  - Address: 0x7f66
- Analog
  - Pulse-Shape:



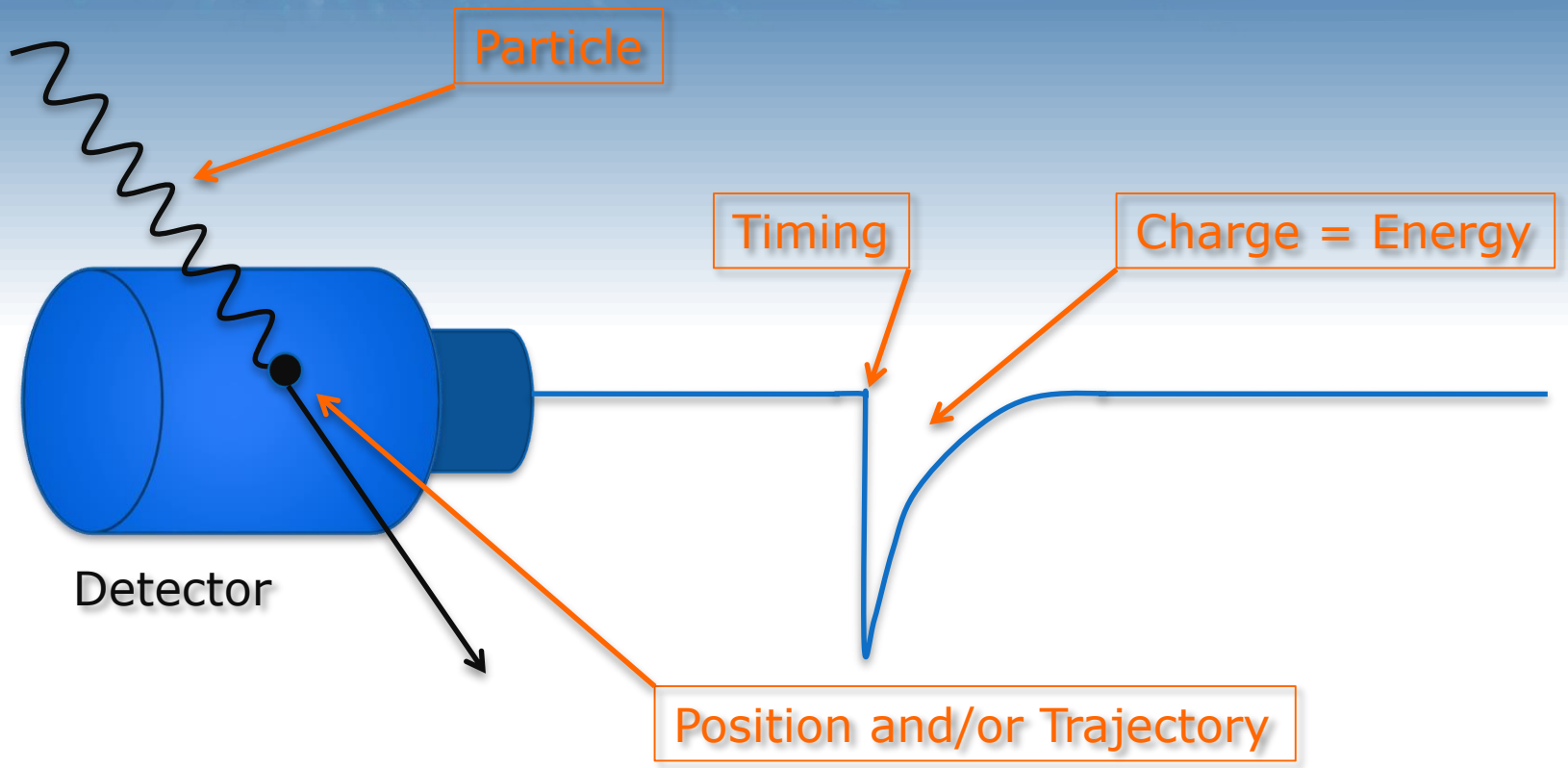
  - Current/Voltage:



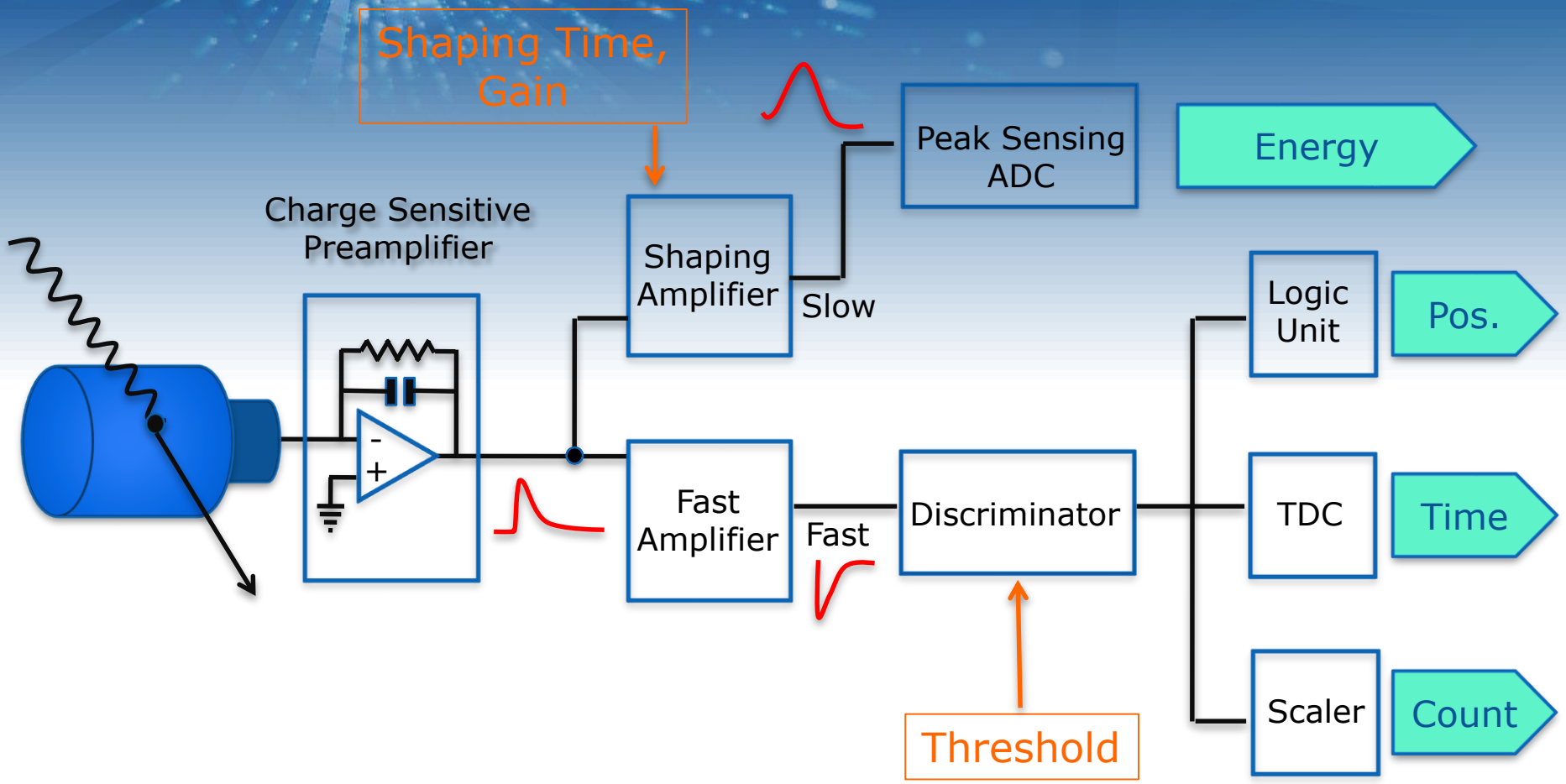
  - Phase:



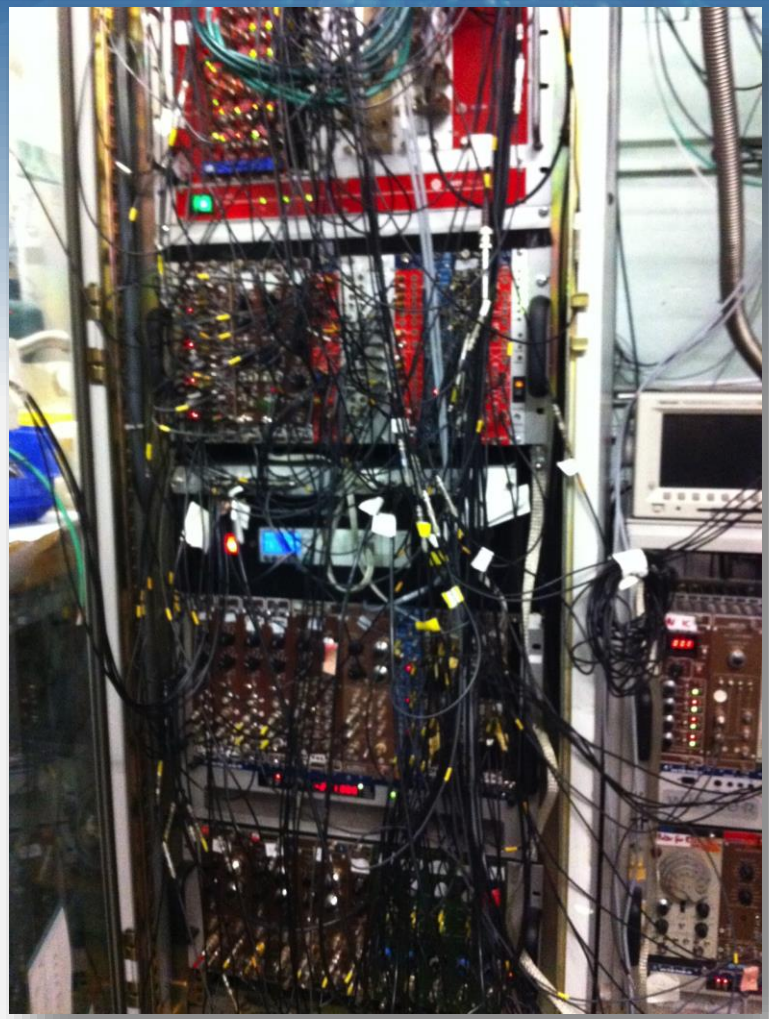
The Relevant Quantities

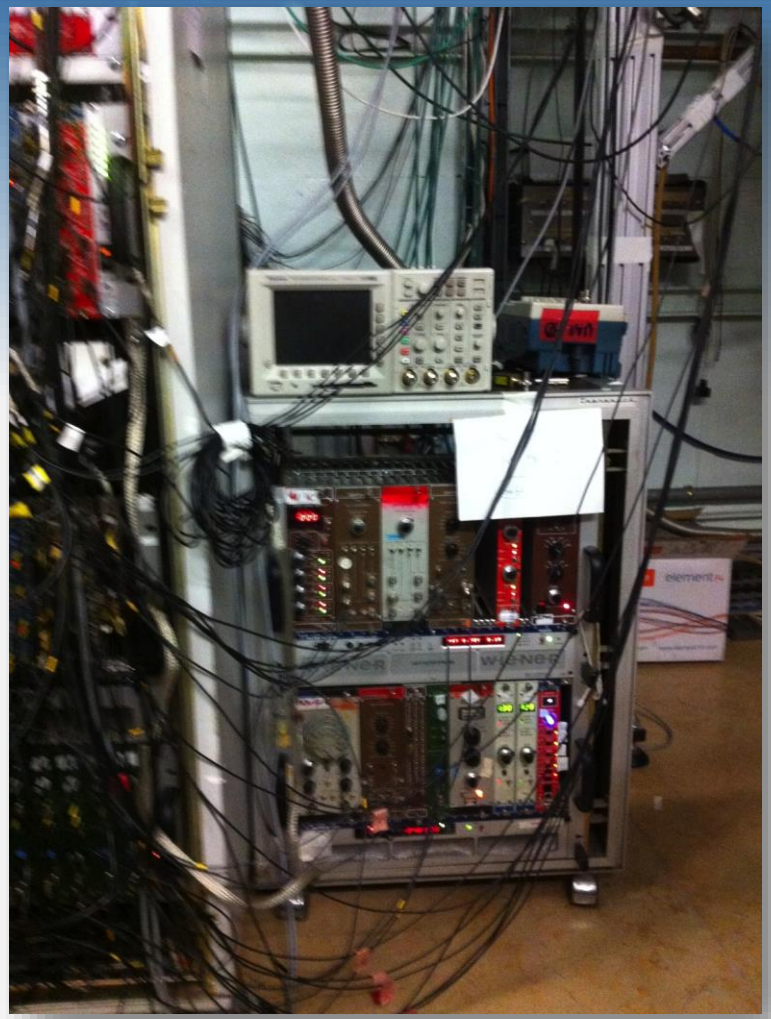


Analogue Approach

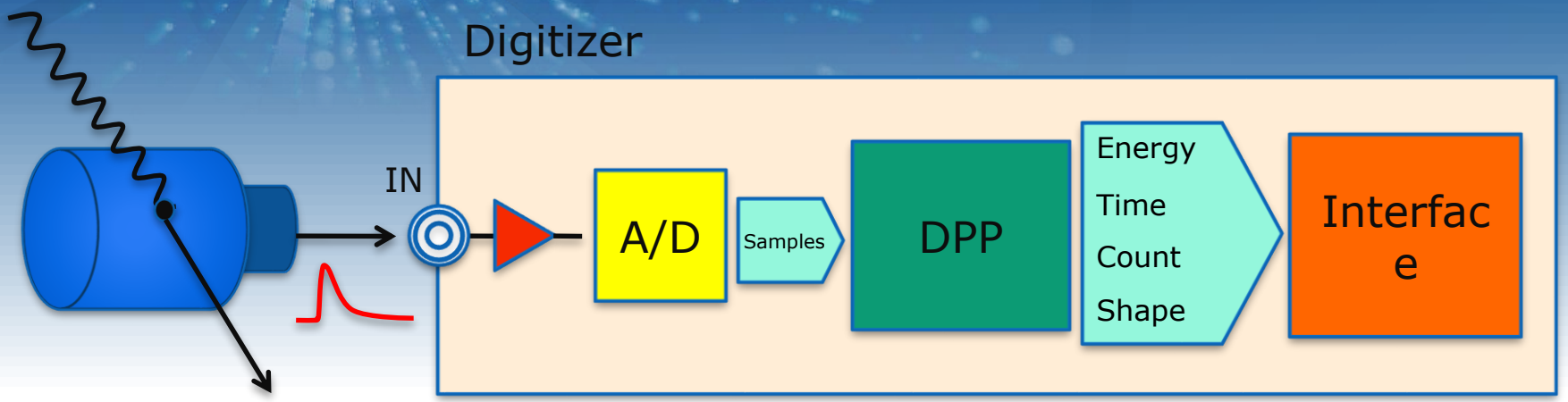


Analogue Complexity



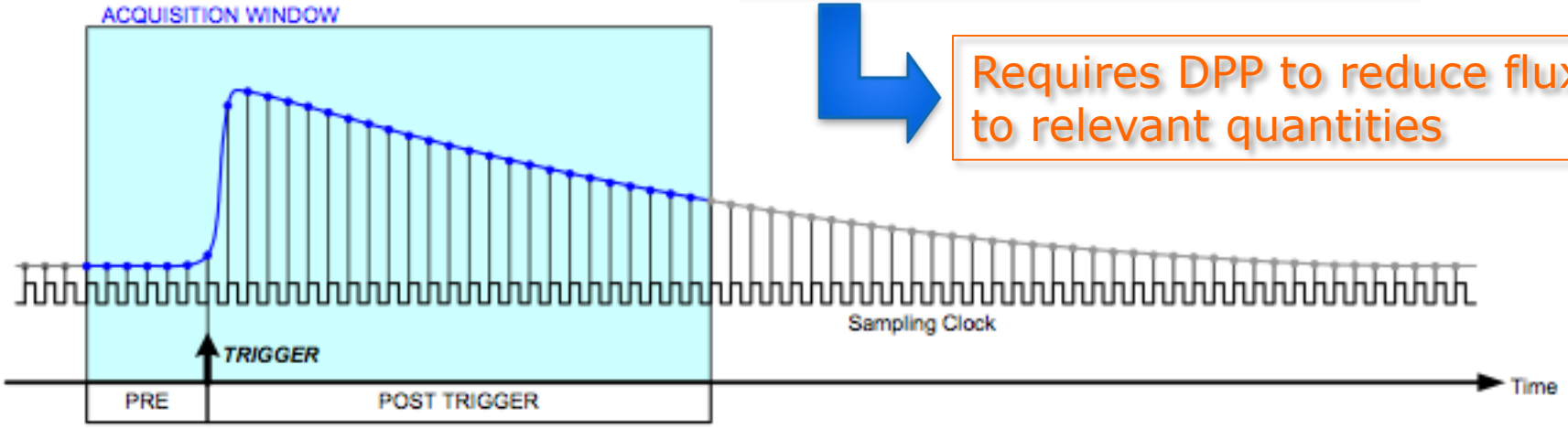


Digital Approach



Very high throughput of data

Requires DPP to reduce flux to relevant quantities



A/D Comparison

ADVANTAGES

- One single board can do energy, timing and pulse shape analysis.
- Low cost per channel and reliability.
- Low dead-time in the acquisition.
- Synchronization and correlation among several channels (coincidence).
- All in FPGA, flexibility in tuning and calibration.

DISADVANTAGES

- Setting up the system requires time and a knowledge of the relevant parameters.
- Loss of resolution with fast signals. We are limited by the bit resolution and sampling rate.

A Digital Example

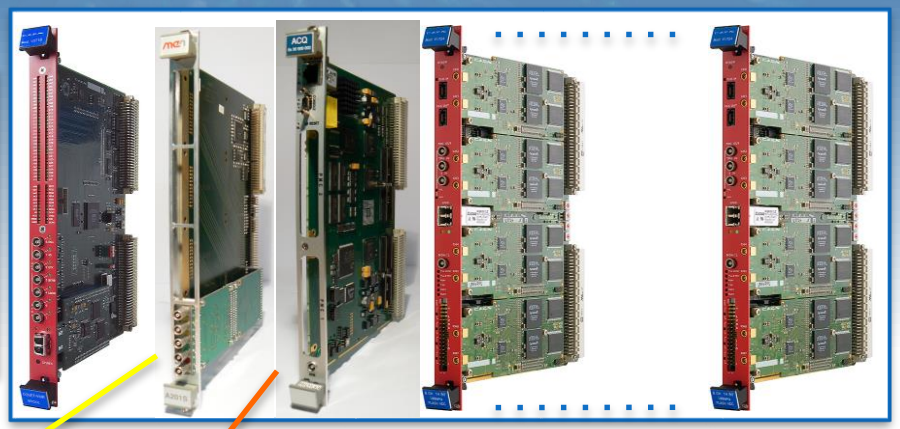
- 18 month preparation (administration…)
- 20 (hard) days installation
- 100 days (and nights) of beam-time
- More than 200 people
- New digital DAC electronics
- New data storage (60 TB)
- 3 different detector's configuration

More details on next video!

A Unique DAC Solution

Data acquisition performed fully in hardware

Optical link to storage



Event rate: ~ 10 MHz

15 bit resolution

Up to 2 GS/s

Data Concentrator (event-mode, histogram, coincidence)

General clock for data taking (100 ns)

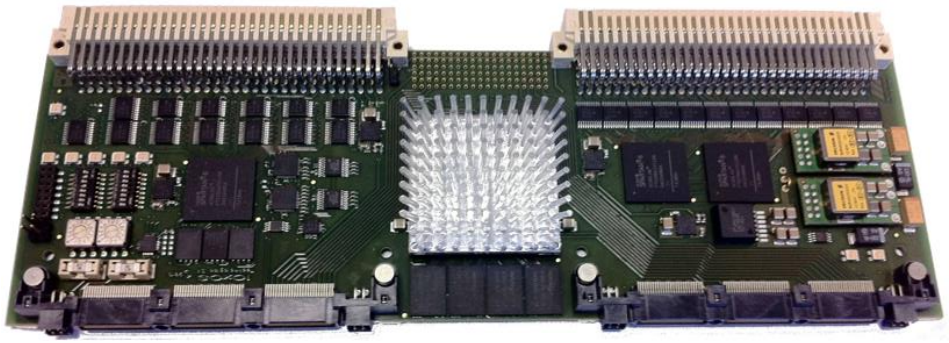
- Fully Digital CFD

Time resolution: 14 ps

Virtex 6 + 1 GB ram

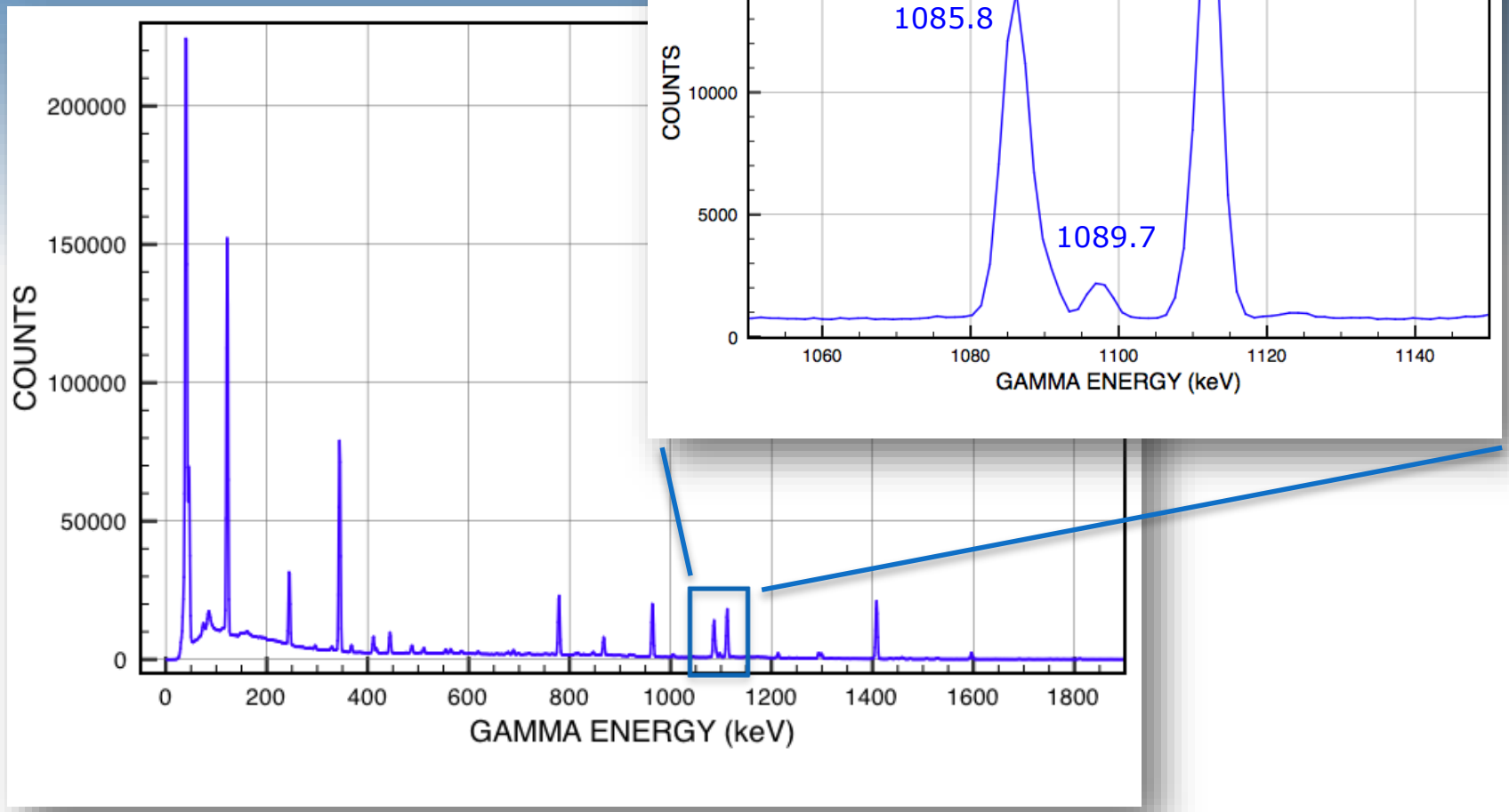
12 bit – 1 Gs/s

Perfect for $LaBr_3(Ce)$



Digital System Performances

^{152}Eu source



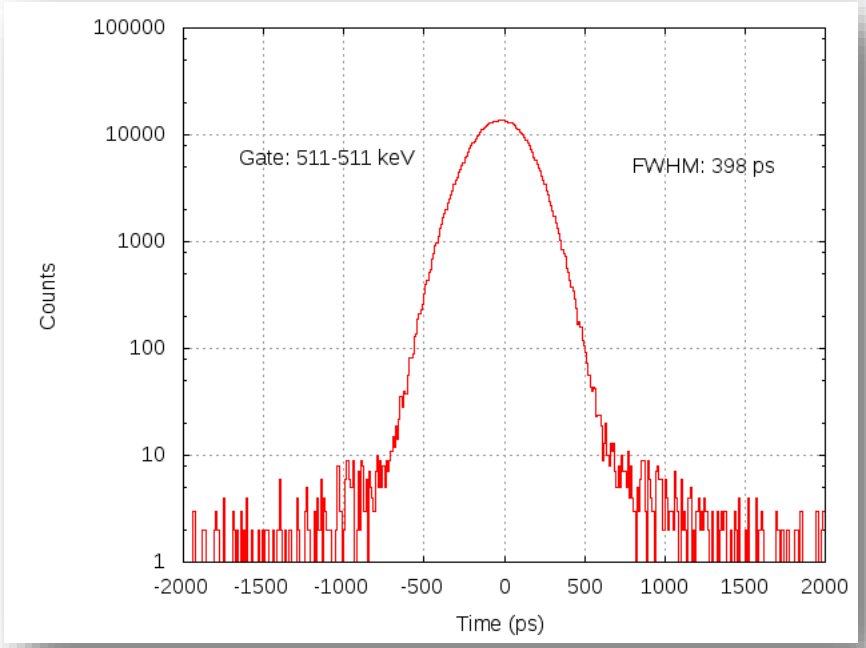
FWHM = 2.0 keV @ 1408 keV

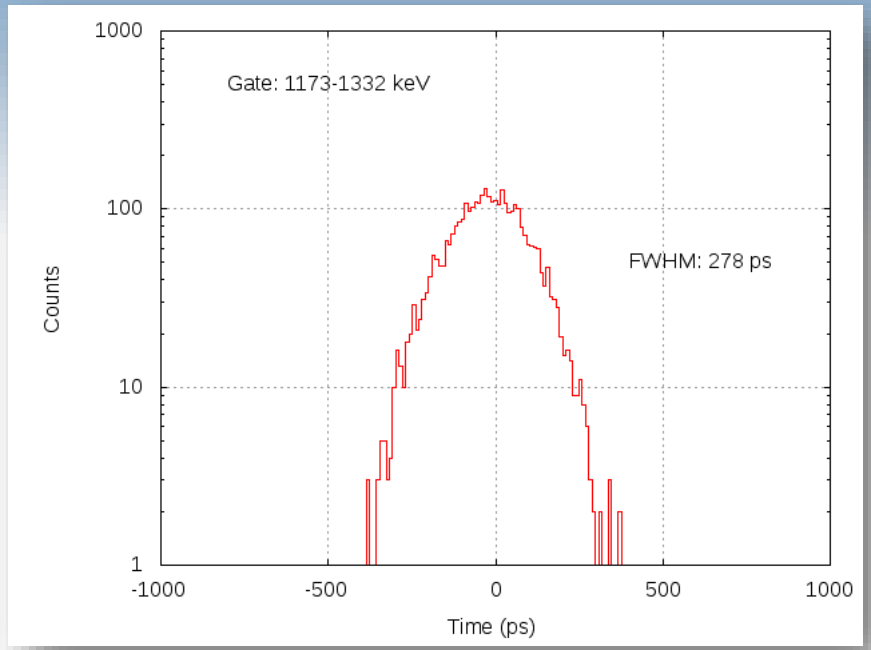
Digital System Performances

^{22}Na & ^{60}Co source – timing resolution

Electronic time resolution : 14 ps

511-511 keV prompt





1173-1332 keV prompt

NOMAD

Instrument Control Software

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- ☑ Team project to optimize resources
- ☑ Facilitate development and maintenance
- ☑ Unique interface to facilitate user's operations
- ☑ Abstraction to hide technical complexity
- ☑ Tools to help setting up and evaluating results
- ☑ Unique for all ILL instruments

NOMAD Architecture

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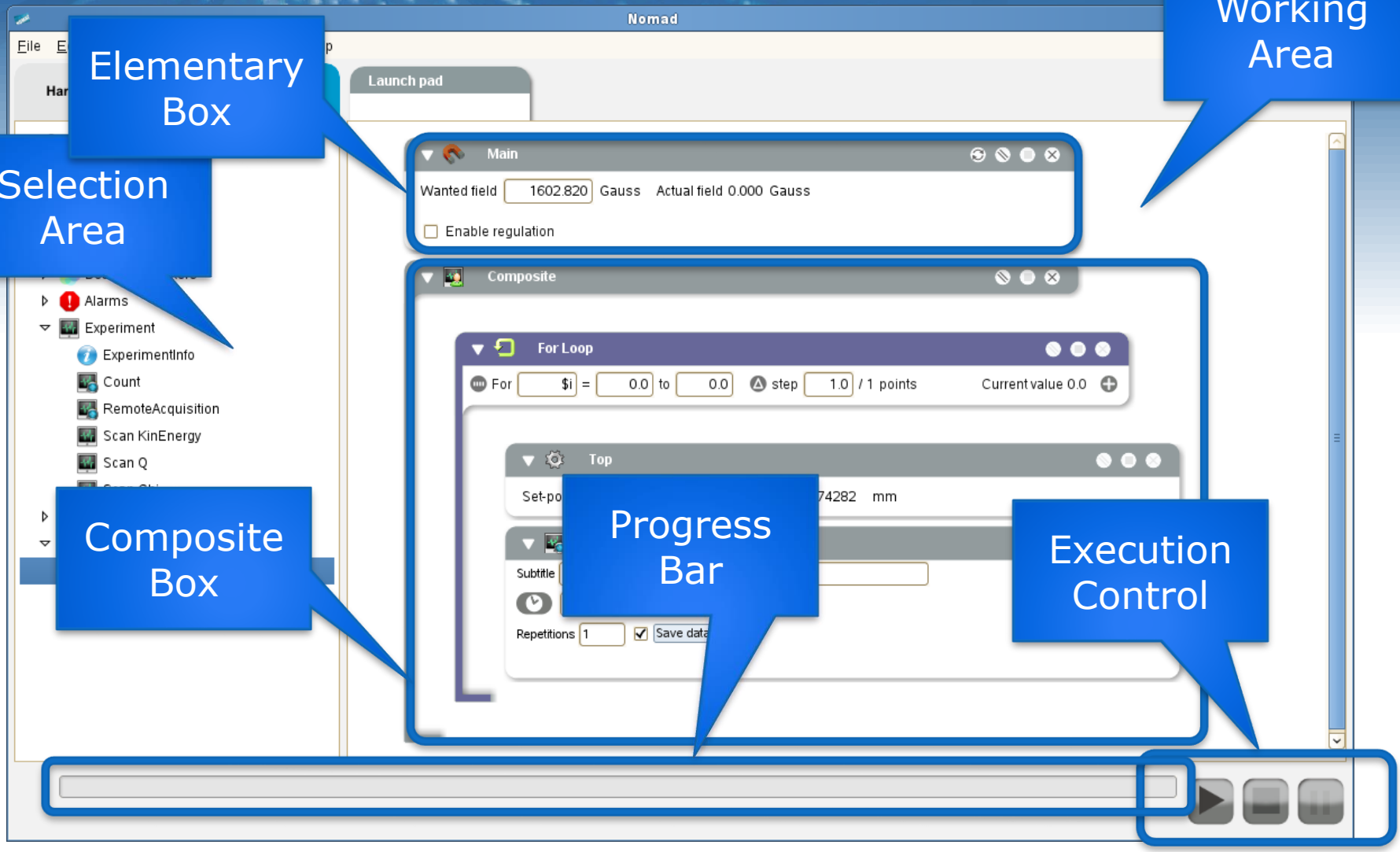
Java + SWT
Dynamic interface engine
Real time visualization (OpenGL)

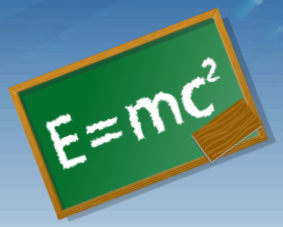
OMNIORB

C++
Drivers and controllers
Scheduler: sequential and parallel execution
File system: data, logs, rules, etc…

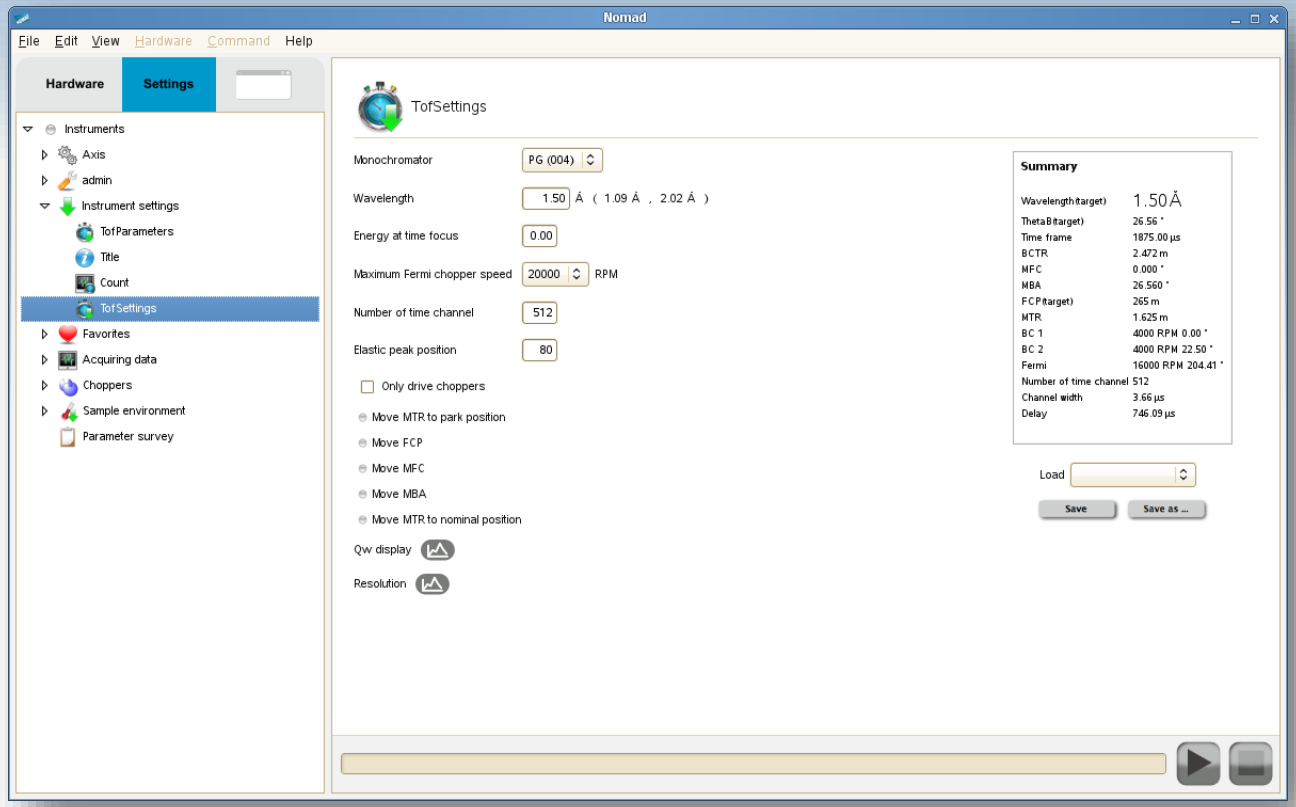
A Graphical Control



Scientific Controllers



Allow user to work directly with the relevant physical quantities (e.g. λ, Q_{range}, hkl, Energy)



Scientific Controllers

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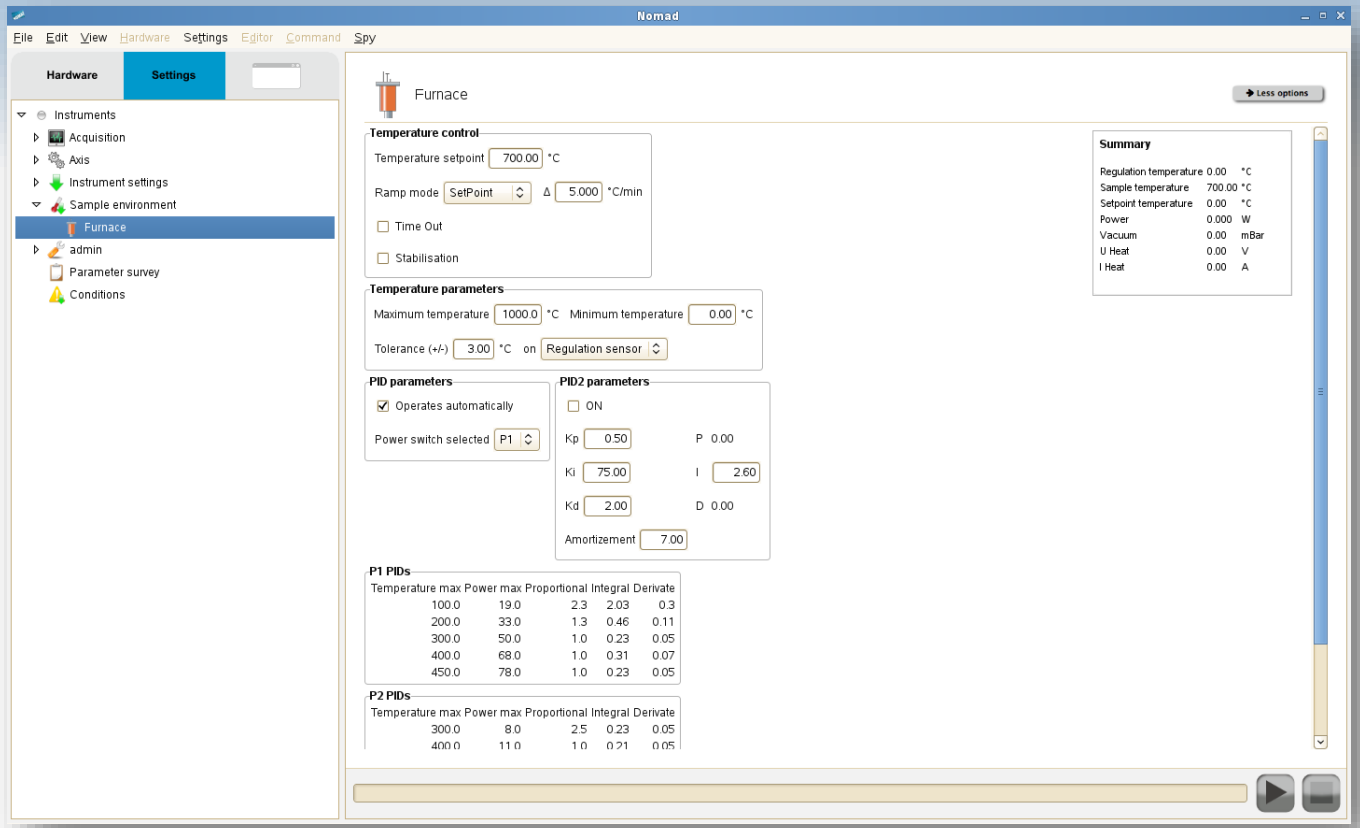
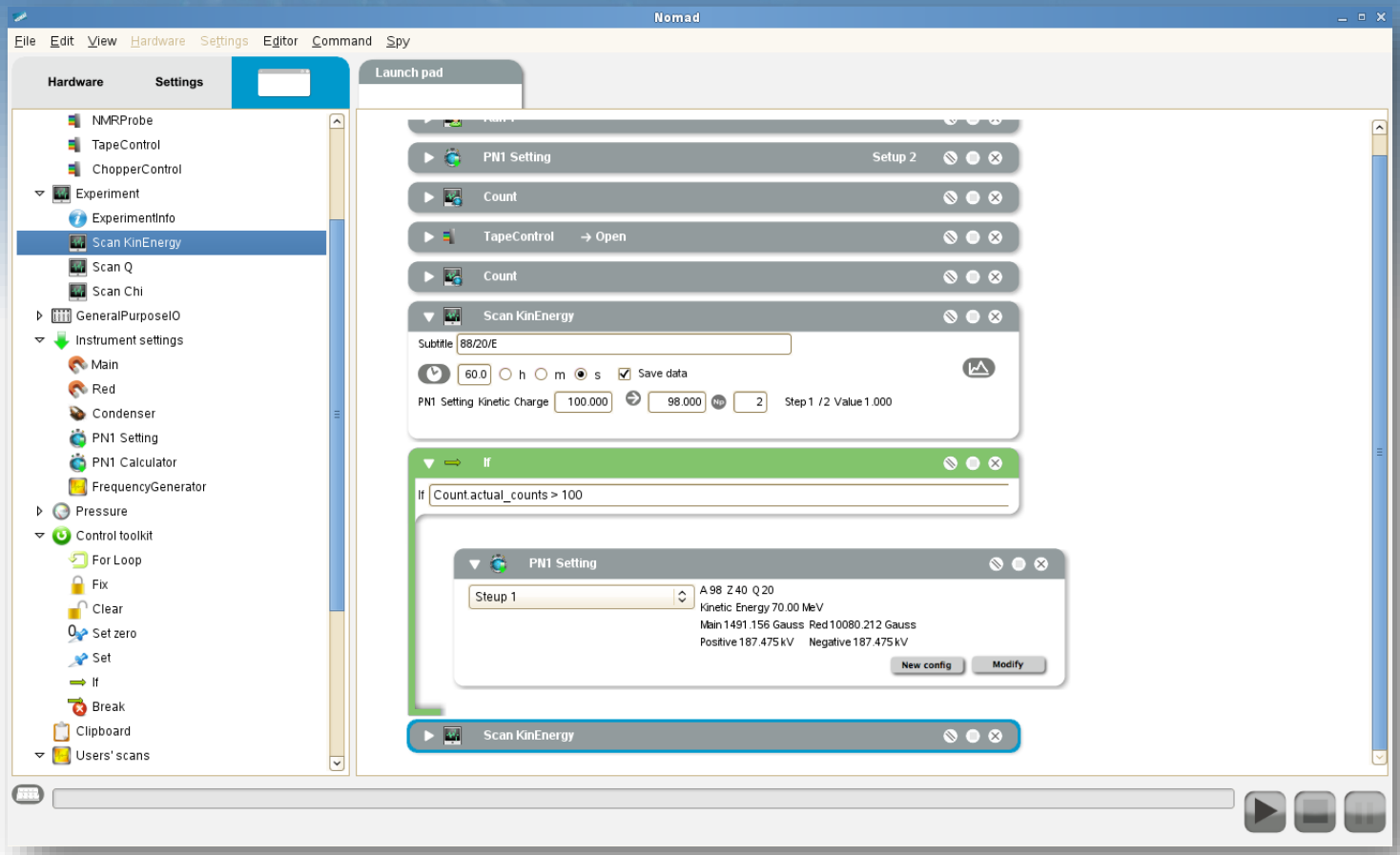
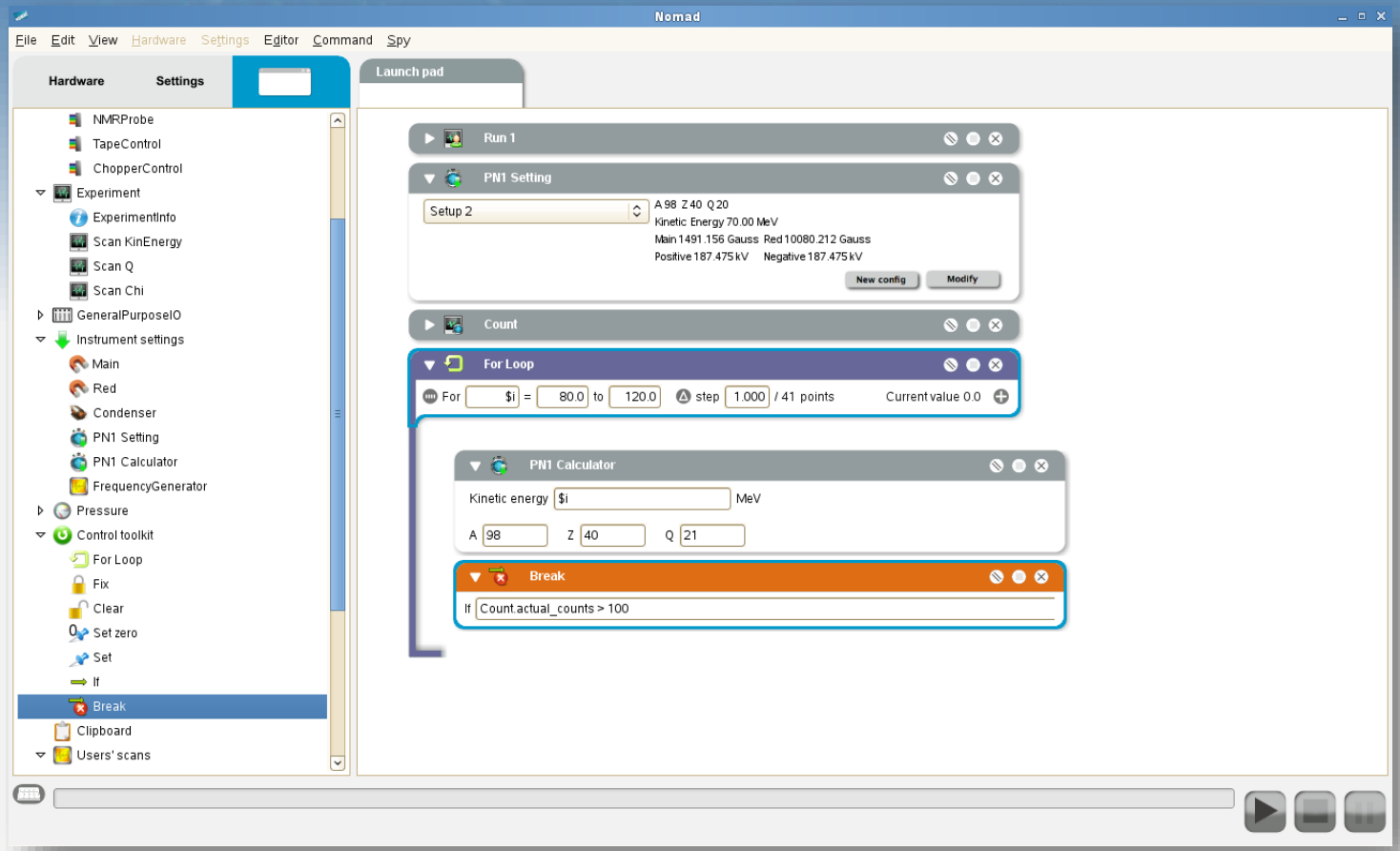
Instrument performance optimizer for fine adjustments or advanced regulations



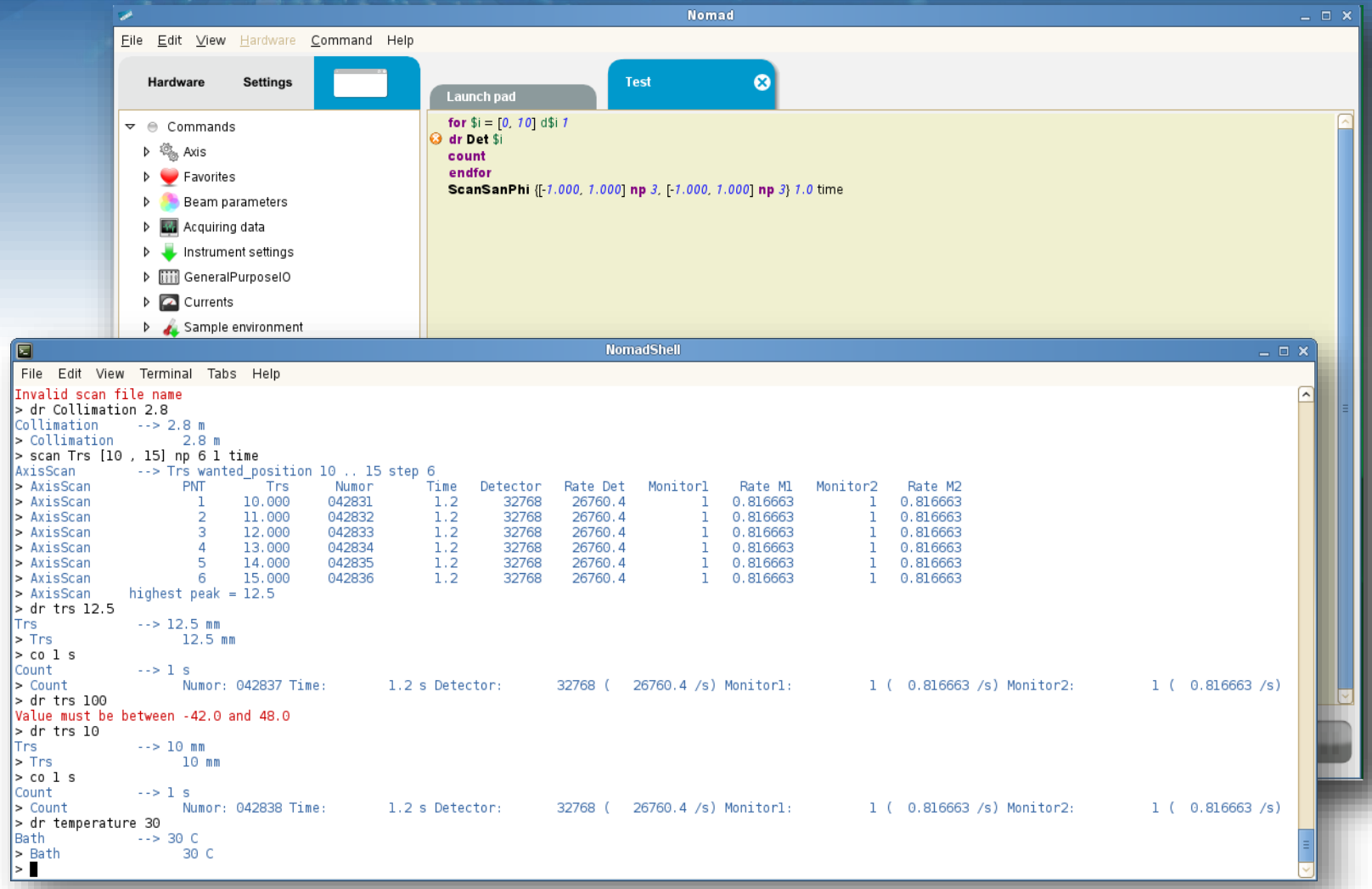
Take Decisions - IF



Flow Control – IF BREAK



Different Interfaces



NOMAD Mobile

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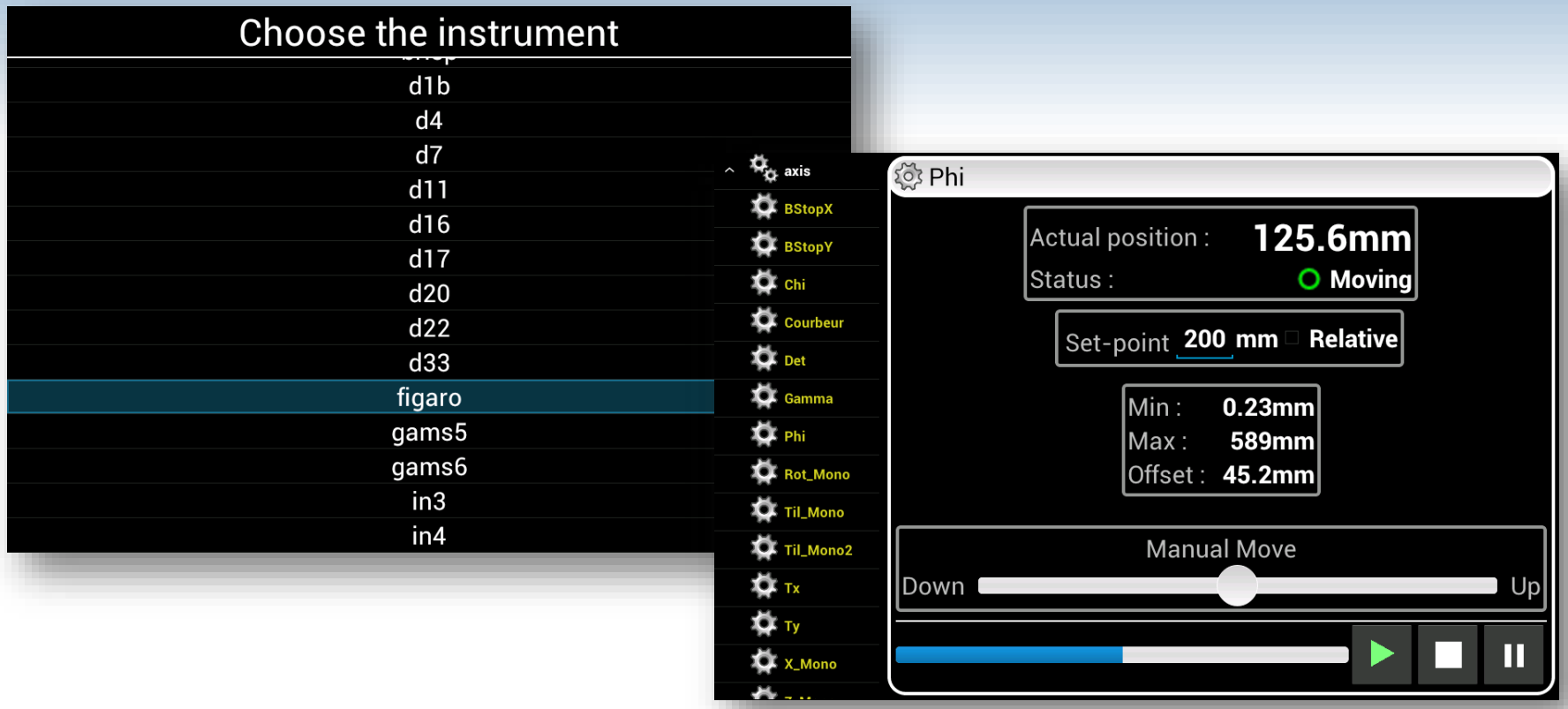
Tablet support allows a dedicated very powerful remote control for instrument operations

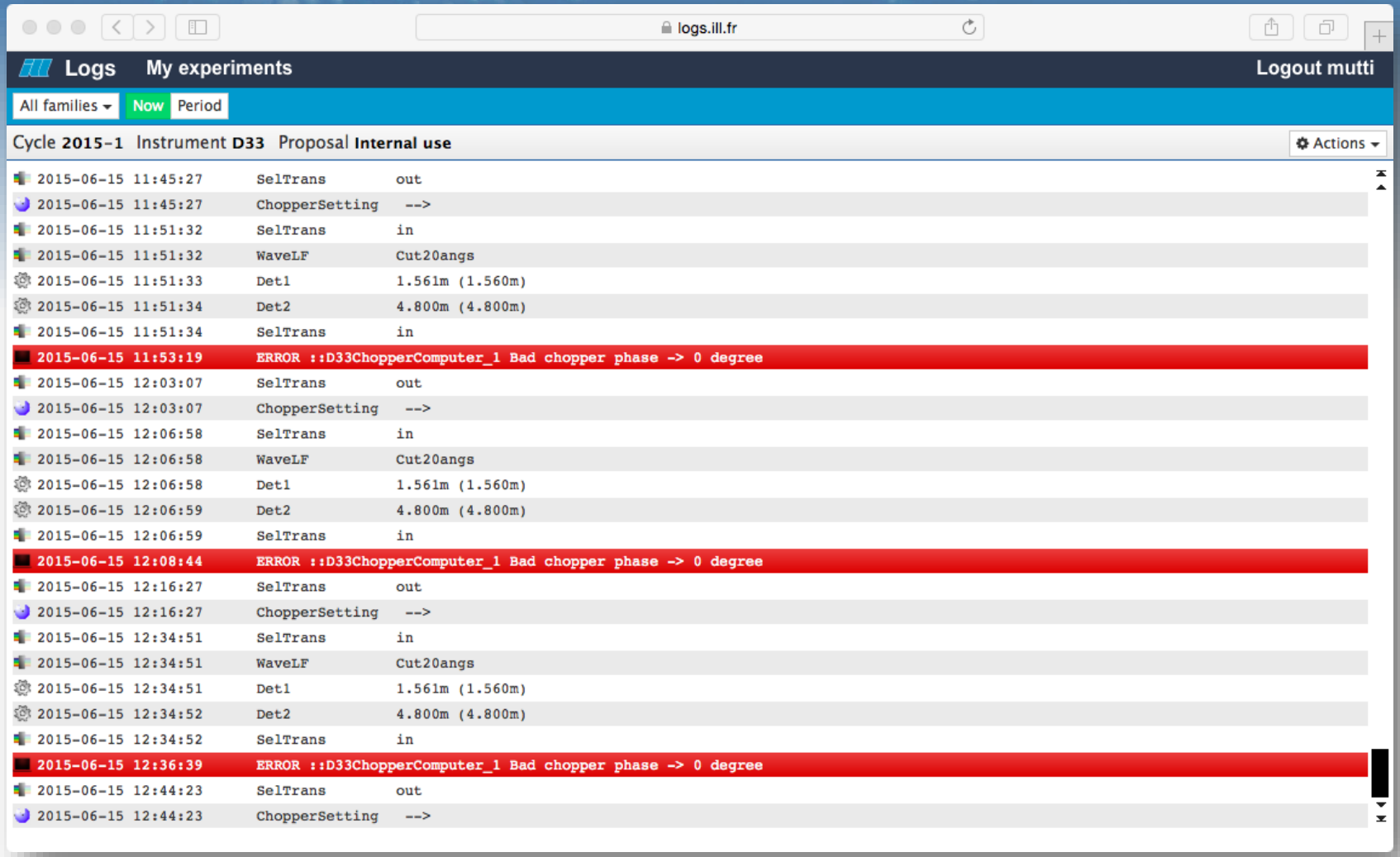


On The WEB

http://nomad.ill.fr/

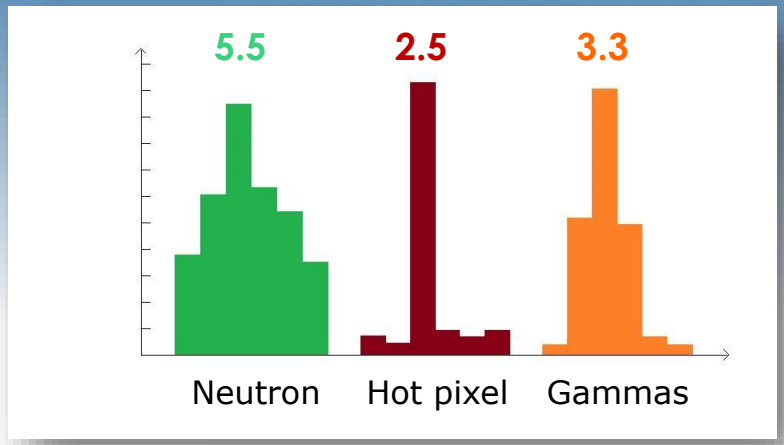
On The WEB

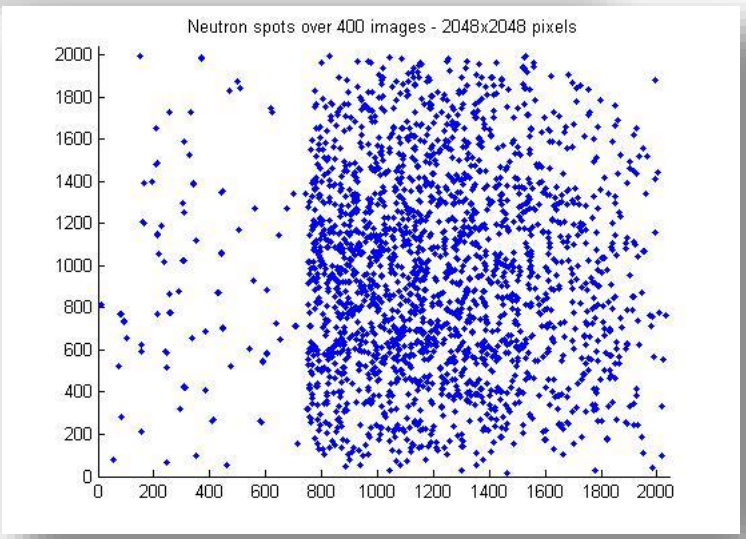
http://logs.ill.fr/



Coming Soon

Counting single neutron with cameras





Coming Soon

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Live data reduction within the sequencer

NOMAD

Request Methods (with parameters)

Data files (one or many)

Check if finished (status)

Results (data arrays or values)

Scientific Methods