

Data Acquisition and Instrument Control @ ILL



Outline

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

The Source



58 MW reactor \longrightarrow $2 \cdot 10^{15}$ n/cm²/s

Main Research Fields

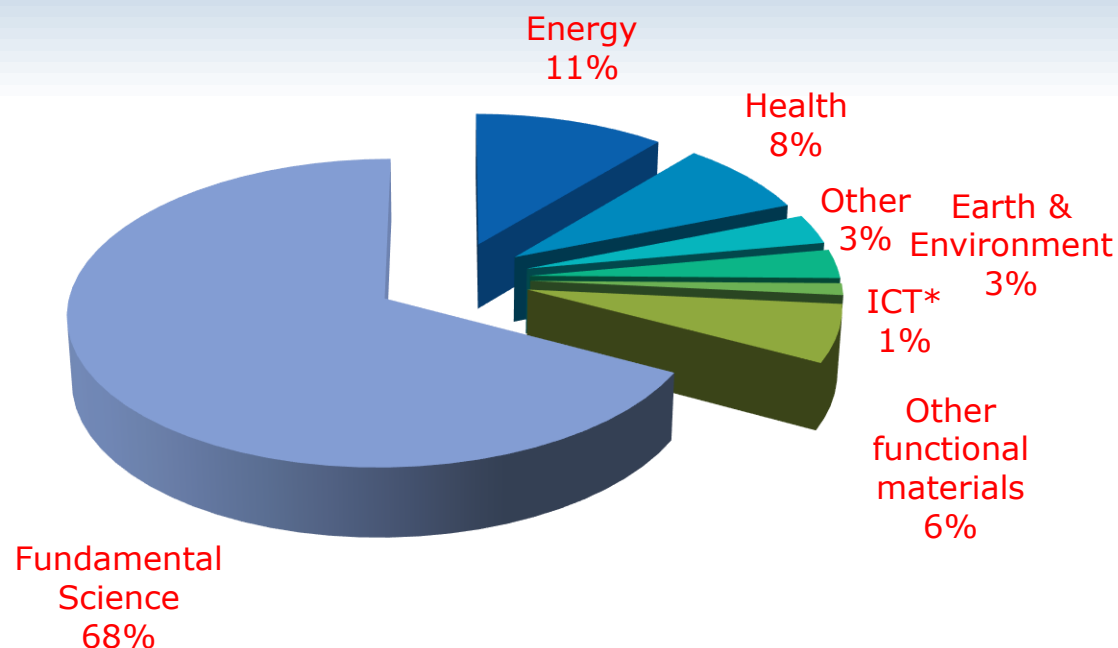
850 experiments/year

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

- ^3He , ^{10}B , scintillators
- HPGe, $\text{LaBr}_3(\text{Ce})$, 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

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

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

Acquires energy spectra from peak-sensing ADCs

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

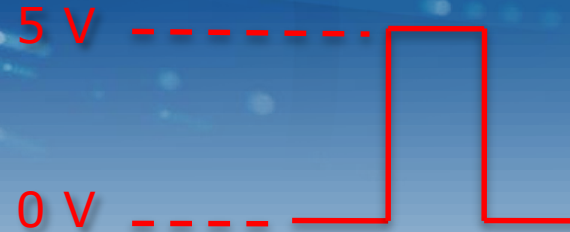
DAC - Requirements

- 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**

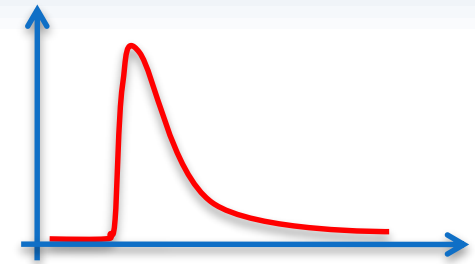
TTL:



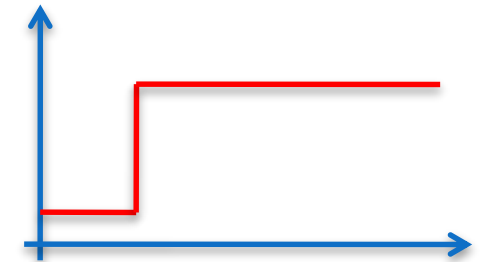
Address: 0x7f66

◆ **Analog**

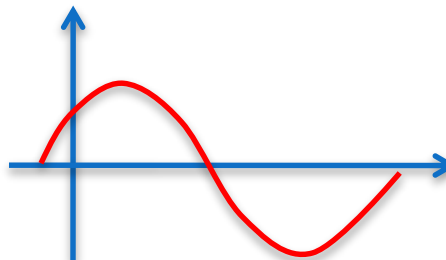
Pulse-Shape:



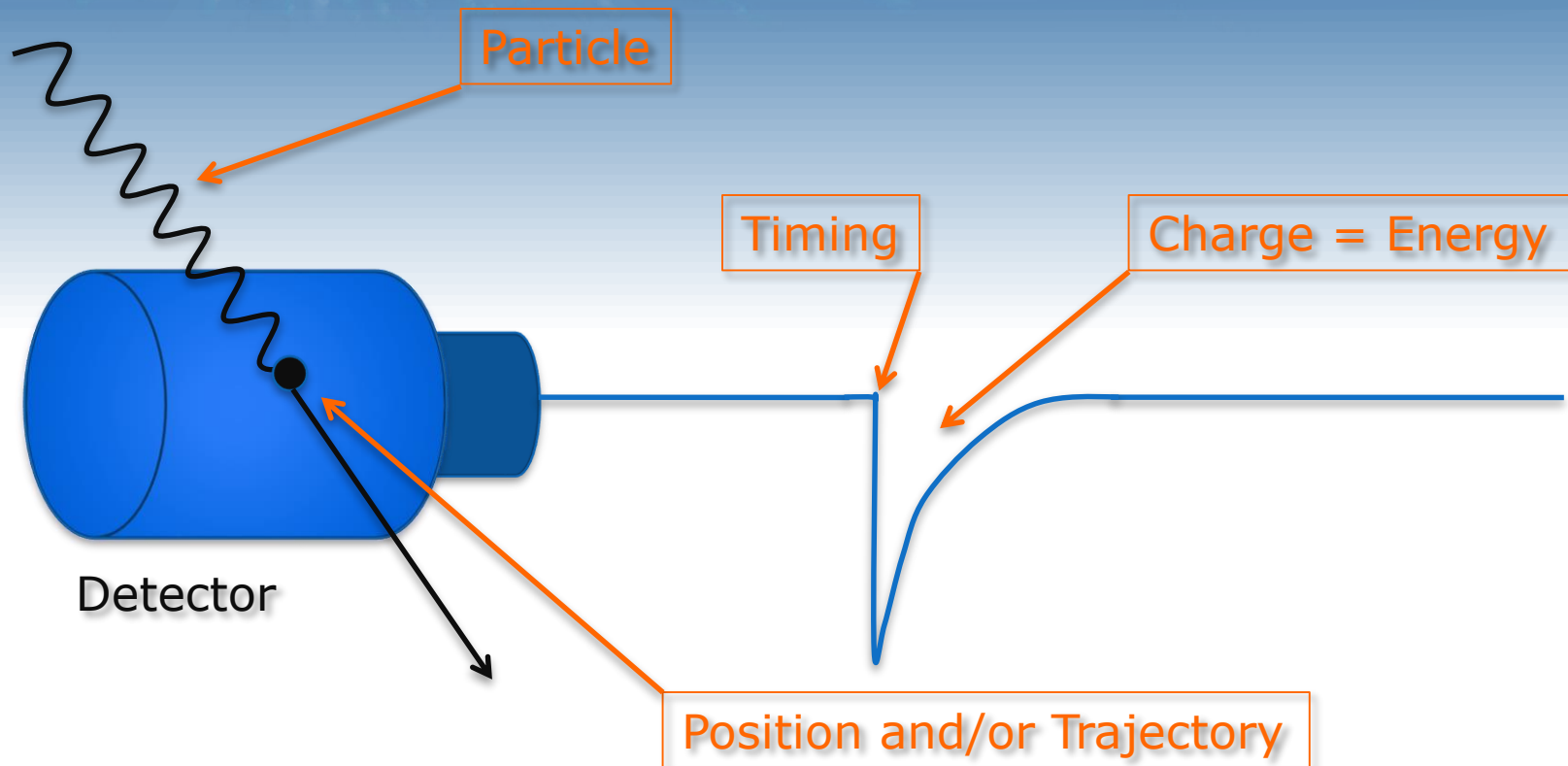
Current/Voltage:



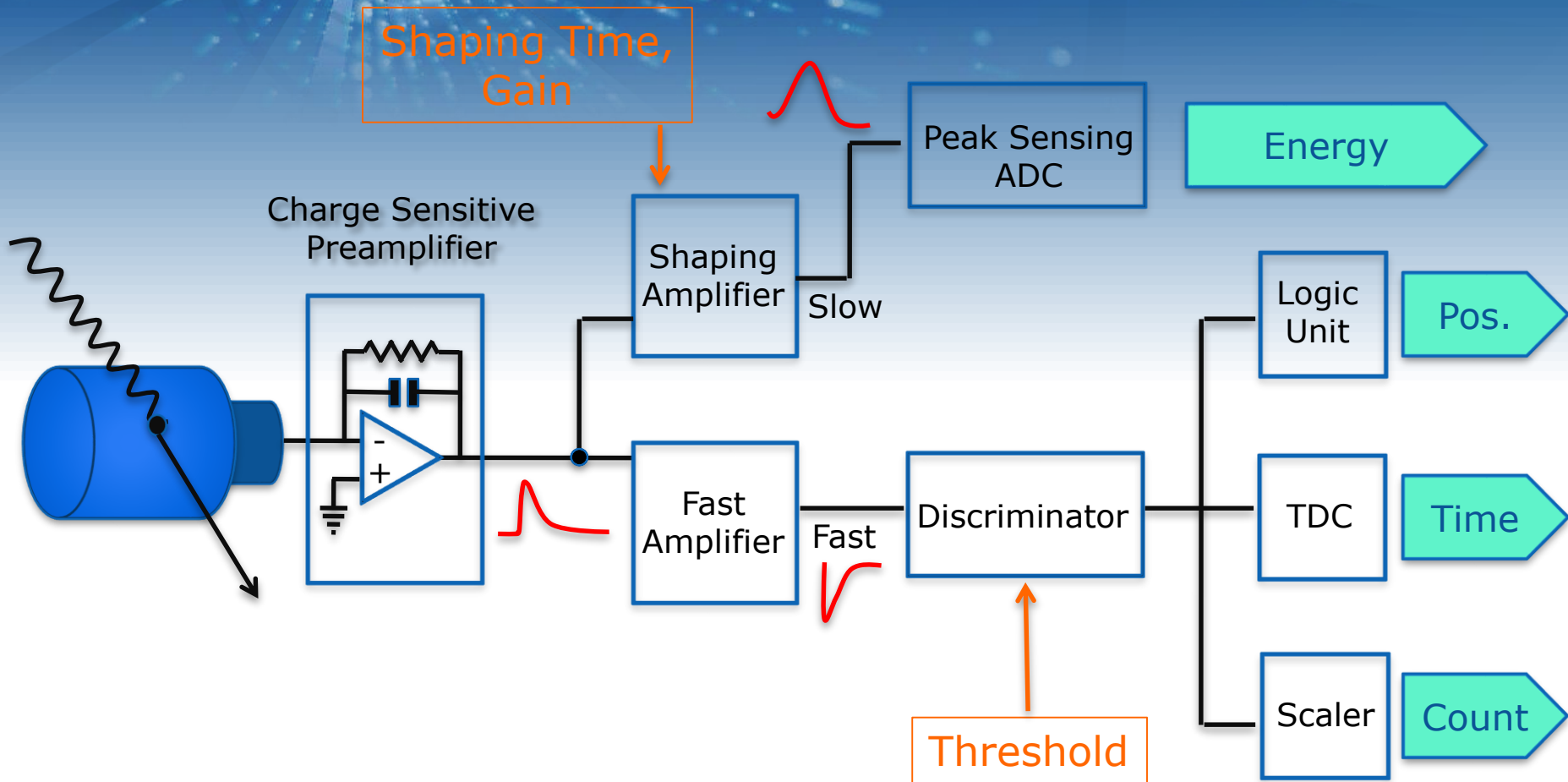
Phase:



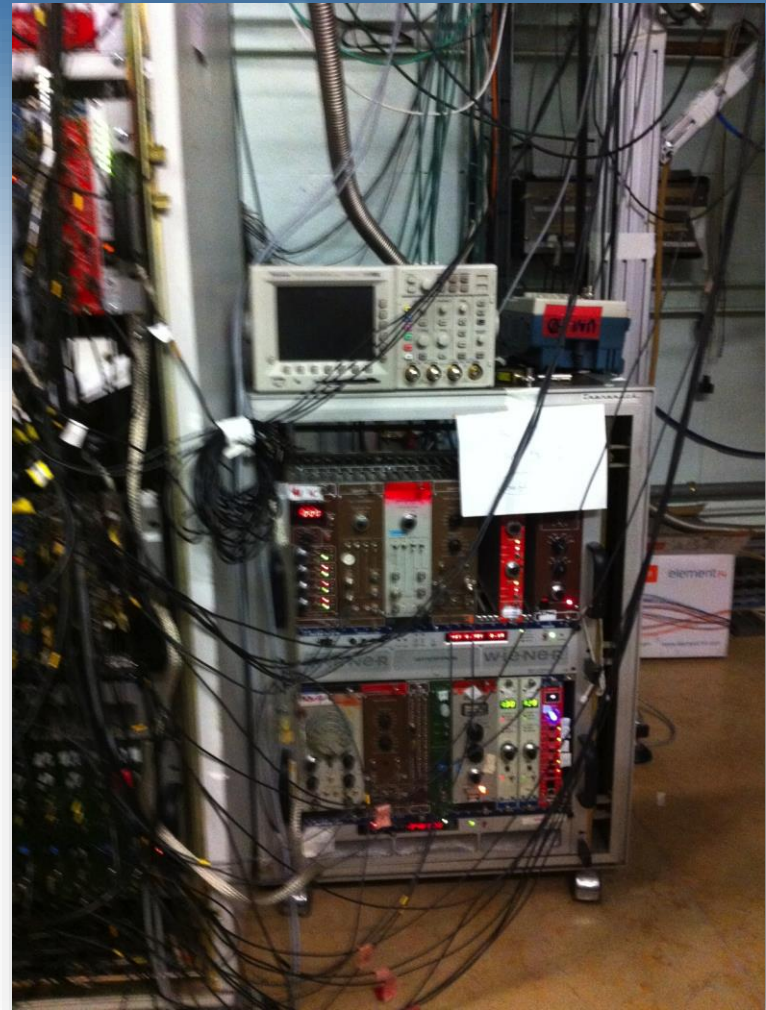
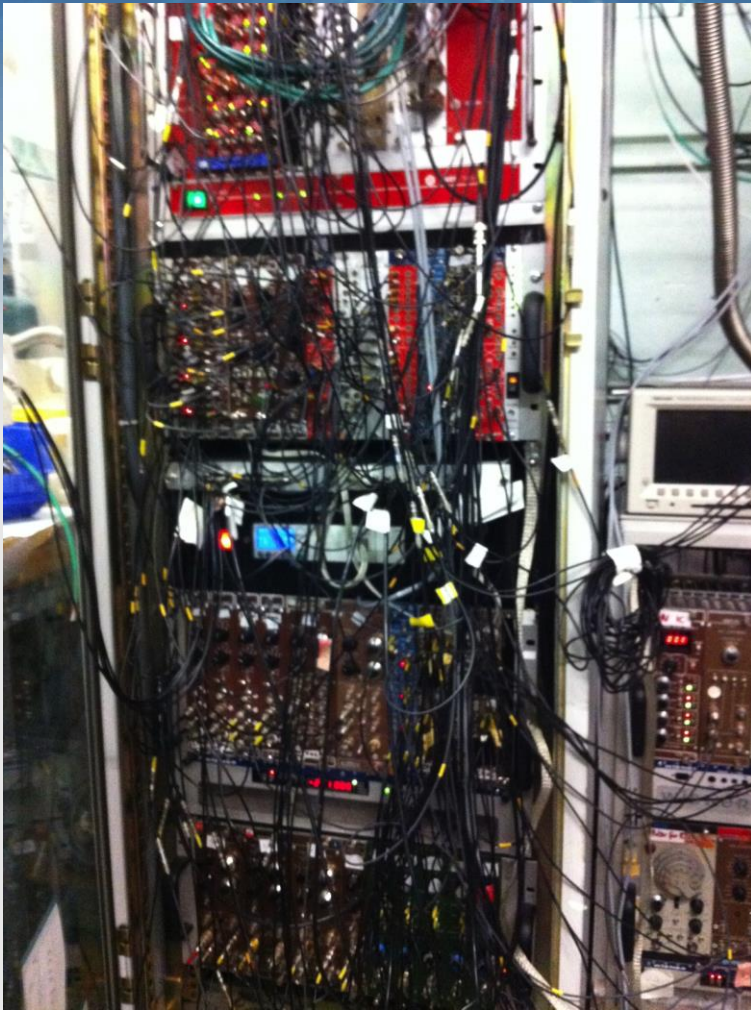
The Relevant Quantities



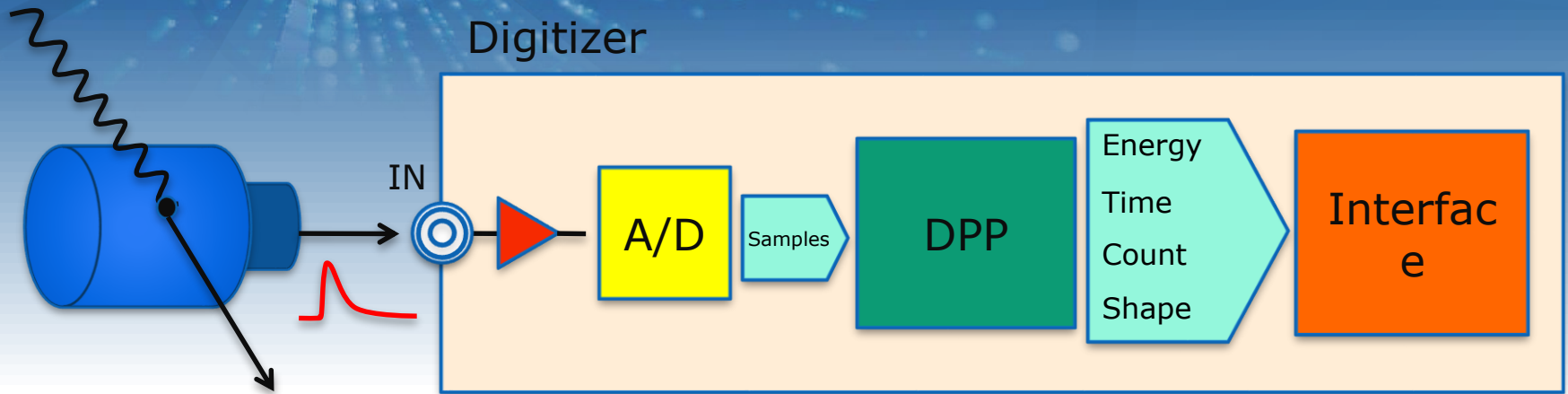
Analogue Approach



Analogue Complexity



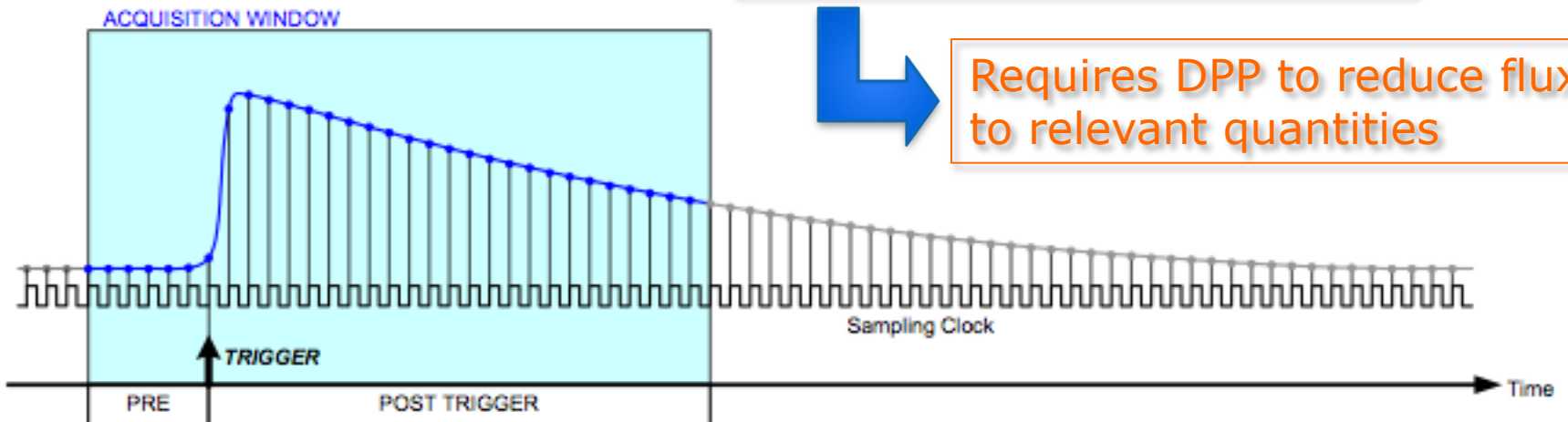
Digital Approach



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

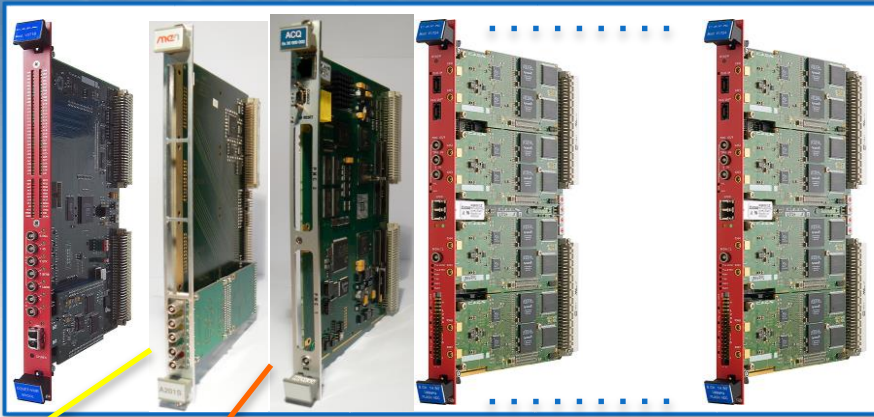
- 18 month preparation (administration...)
- 20 (hard) days installation
- 100 days (and nights) of beam-time
- More than 200 people
- New digital DAC electronics
- New data storage (60 TB)
- 3 different detector's configuration

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)

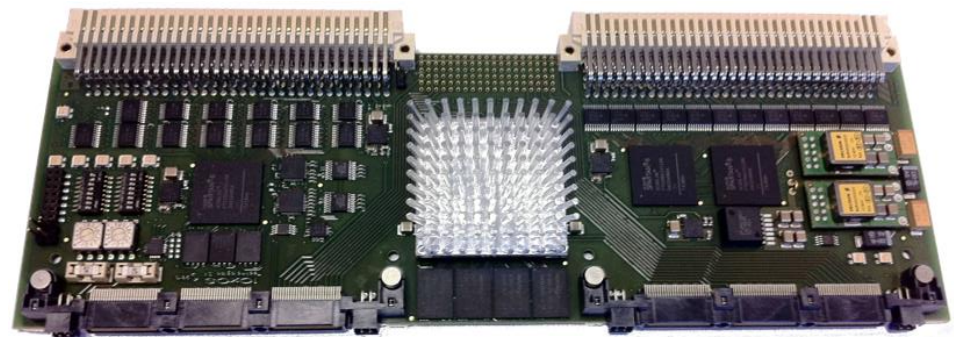
- Fully Digital CFD

Time resolution: 14 ps

Virtex 6 + 1 GB ram

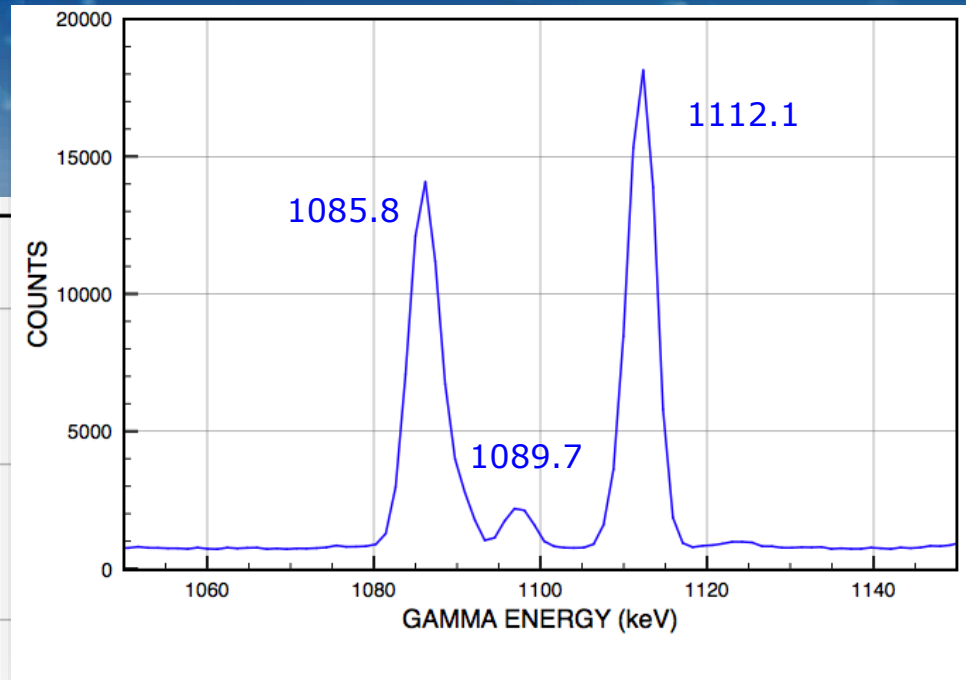
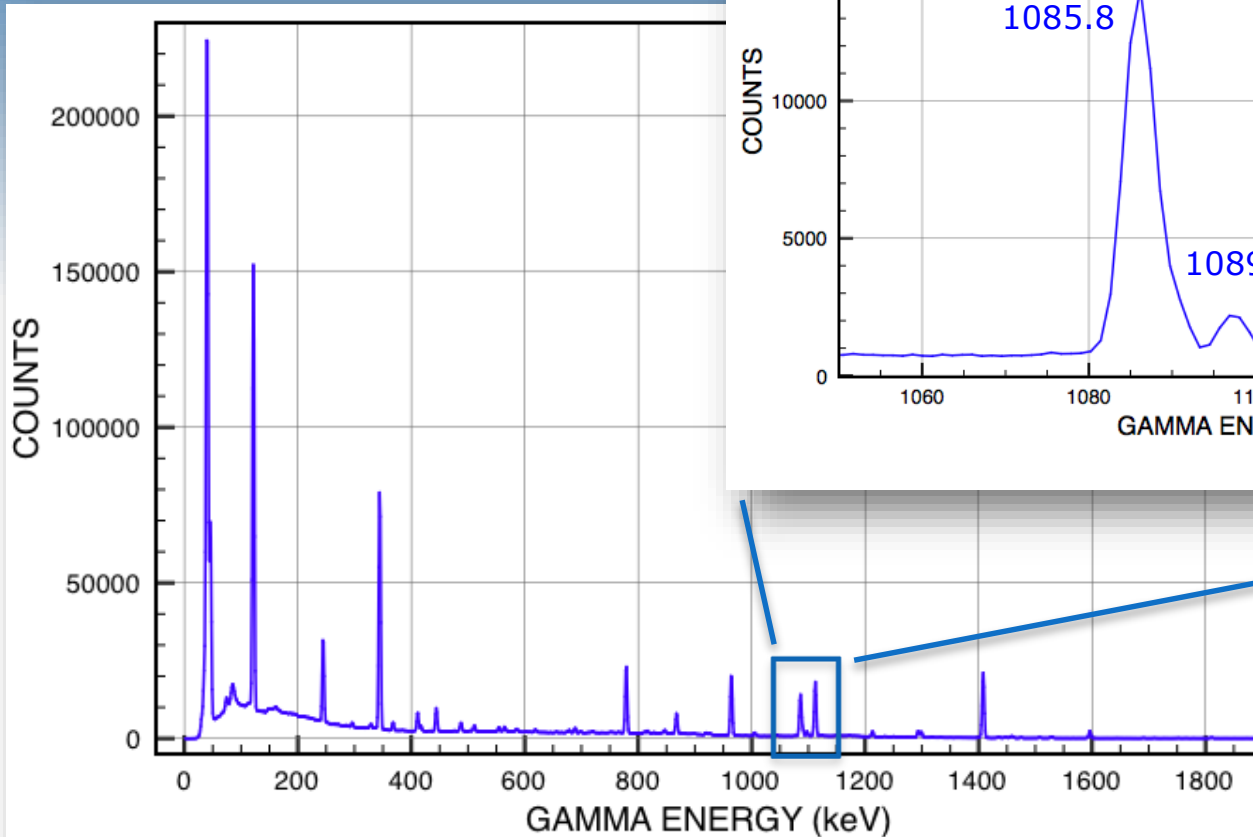
12 bit – 1 Gs/s

Perfect for $\text{LaBr}_3(\text{Ce})$



Digital System Performances

^{152}Eu source



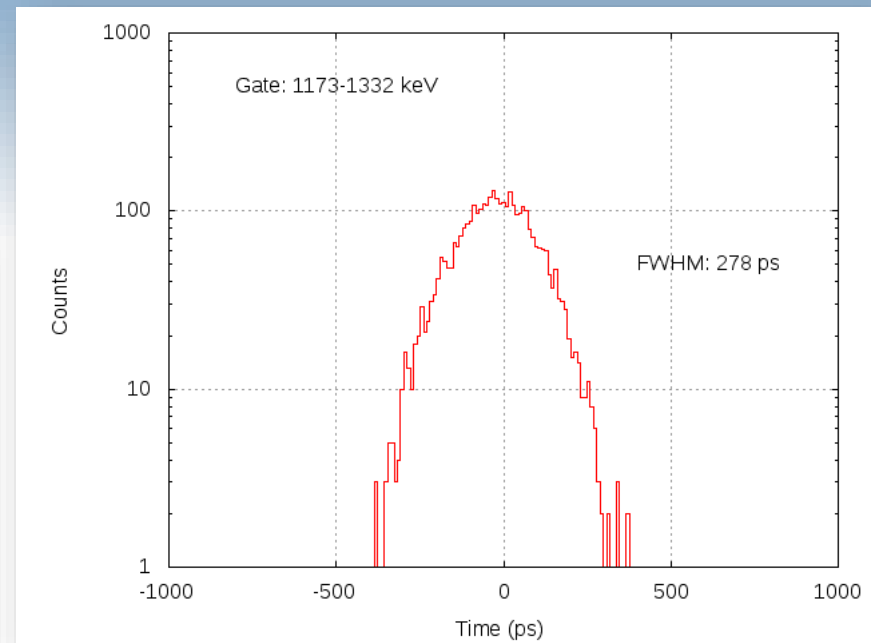
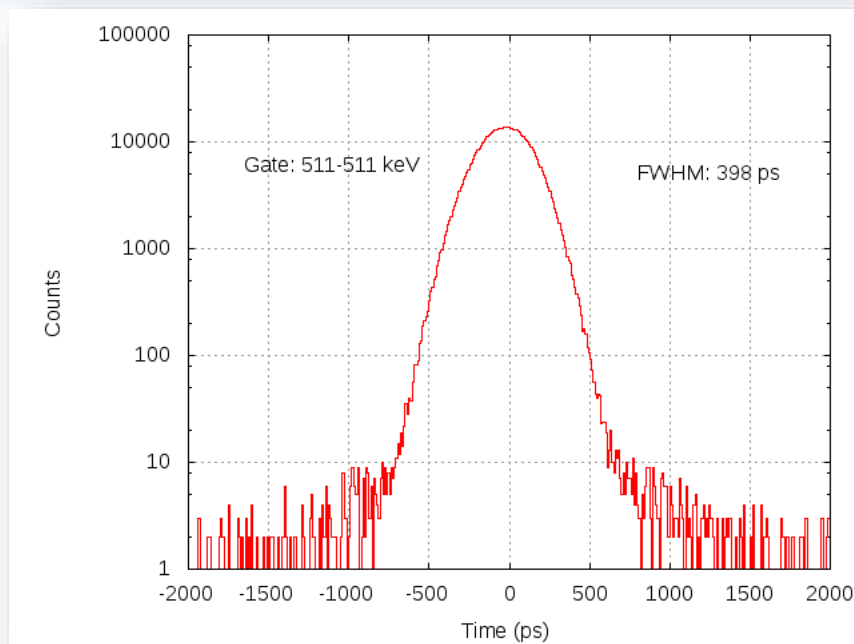
FWHM = 2.0 keV @ 1408 keV

Digital System Performances

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

Electronic time resolution : 14 ps

511-511 keV prompt



1173-1332 keV prompt

- ✓ 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

NOMAD Architecture

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

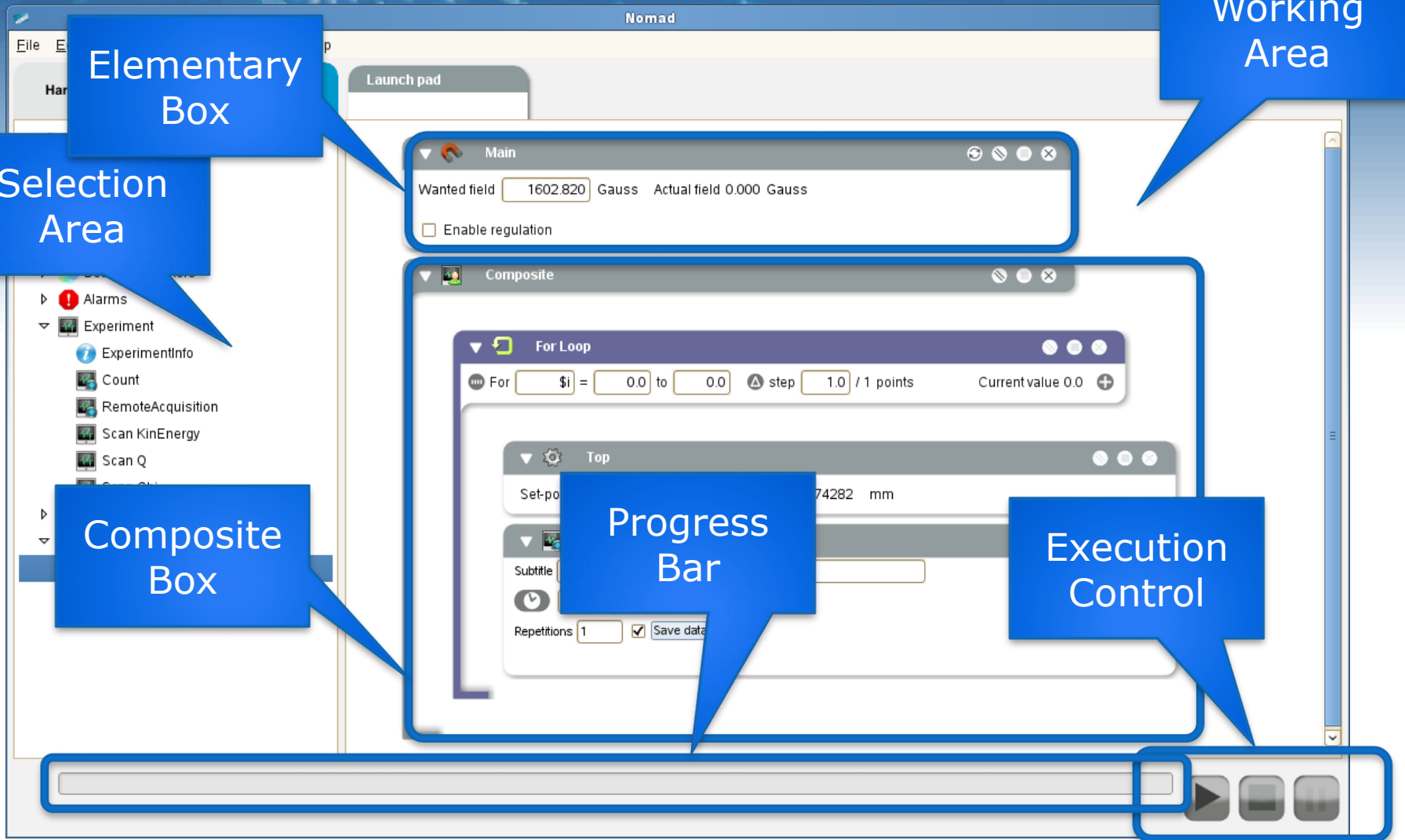


OMNIORB



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

A Graphical Control

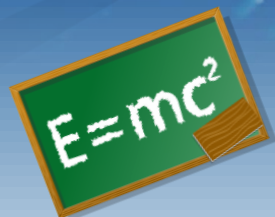


The image shows a screenshot of the Nomad graphical control interface. The interface is divided into several sections, each highlighted by a blue callout box:

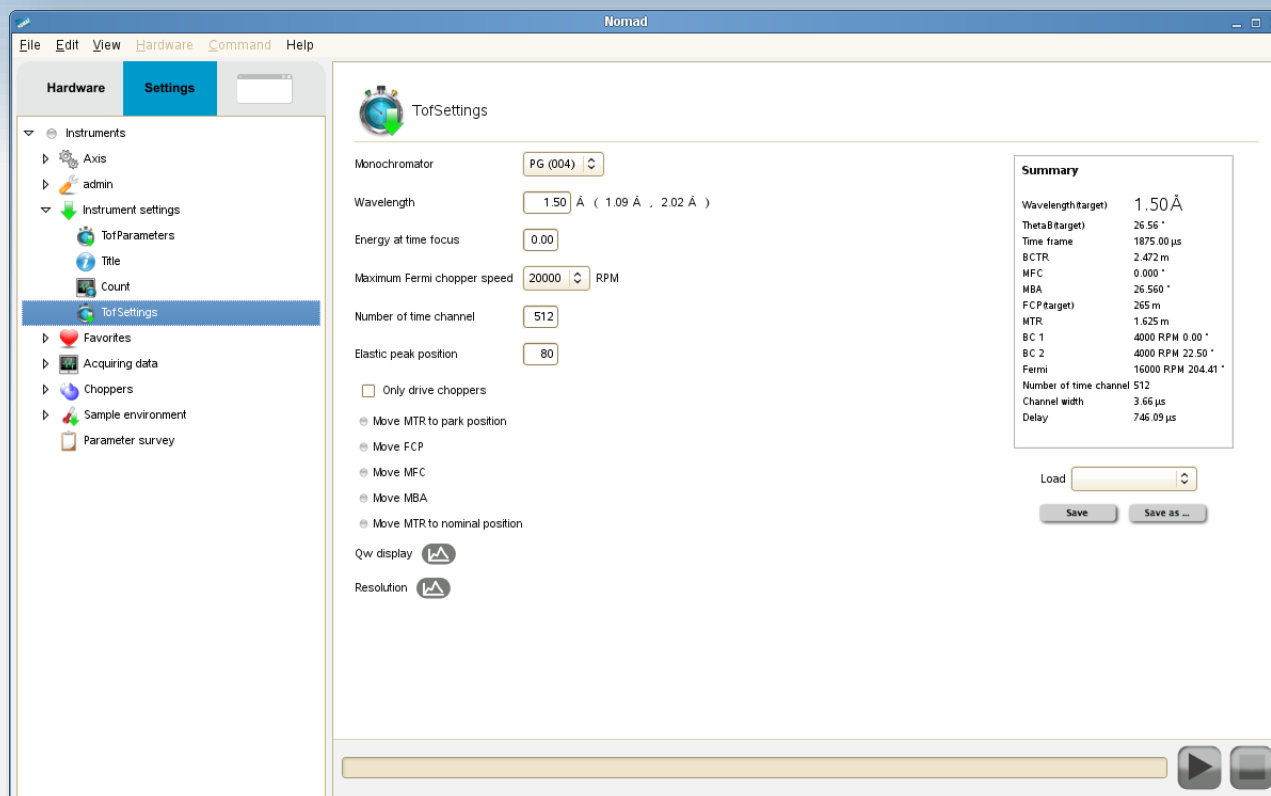
- Elementary Box:** Points to the 'Main' control panel, which displays 'Wanted field' (1602.820 Gauss) and 'Actual field' (0.000 Gauss), along with an 'Enable regulation' checkbox.
- Selection Area:** Points to the left sidebar containing a tree view of the system hierarchy, including 'Alarms', 'Experiment', 'ExperimentInfo', 'Count', 'RemoteAcquisition', 'Scan KinEnergy', and 'Scan Q'.
- Composite Box:** Points to the 'Composite' control panel, which contains a 'For Loop' section with a 'For' loop (0.0 to 0.0, step 1.0 / 1 points) and a 'Top' section with a 'Set-point' (74282 mm) and a 'Subtitle'.
- Working Area:** Points to the main display area where the control panels are shown.
- Progress Bar:** Points to the 'Progress Bar' section within the 'For Loop' control panel.
- Execution Control:** Points to the 'Execution Control' section within the 'For Loop' control panel, which includes a 'Repetitions' field (1) and a 'Save data' checkbox.

The interface also features a status bar at the bottom with a progress indicator and control buttons.

Scientific Controllers



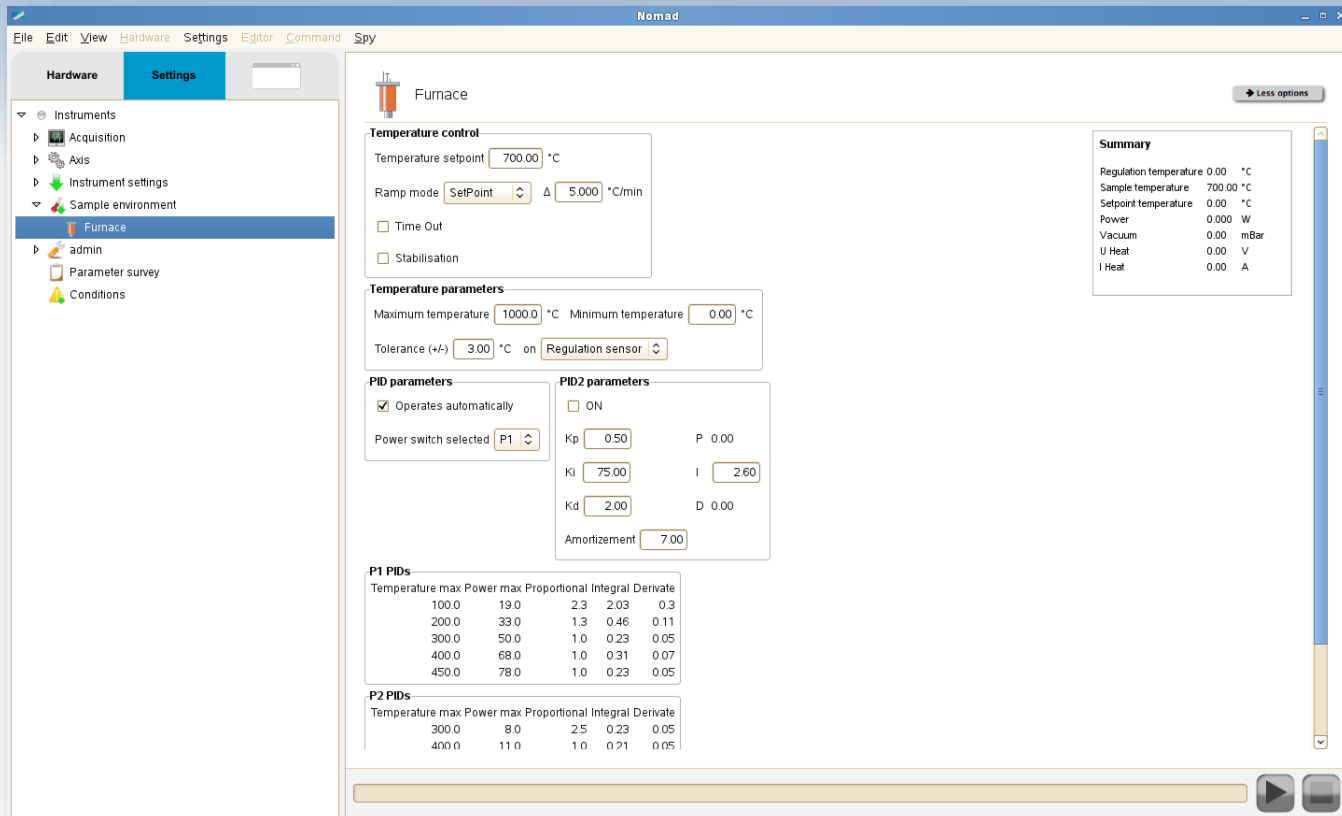
Allow user to work directly with the relevant physical quantities (e.g. λ , Q_{range} , hkl, Energy)



Scientific Controllers



Instrument performance optimizer for fine adjustments or advanced regulations



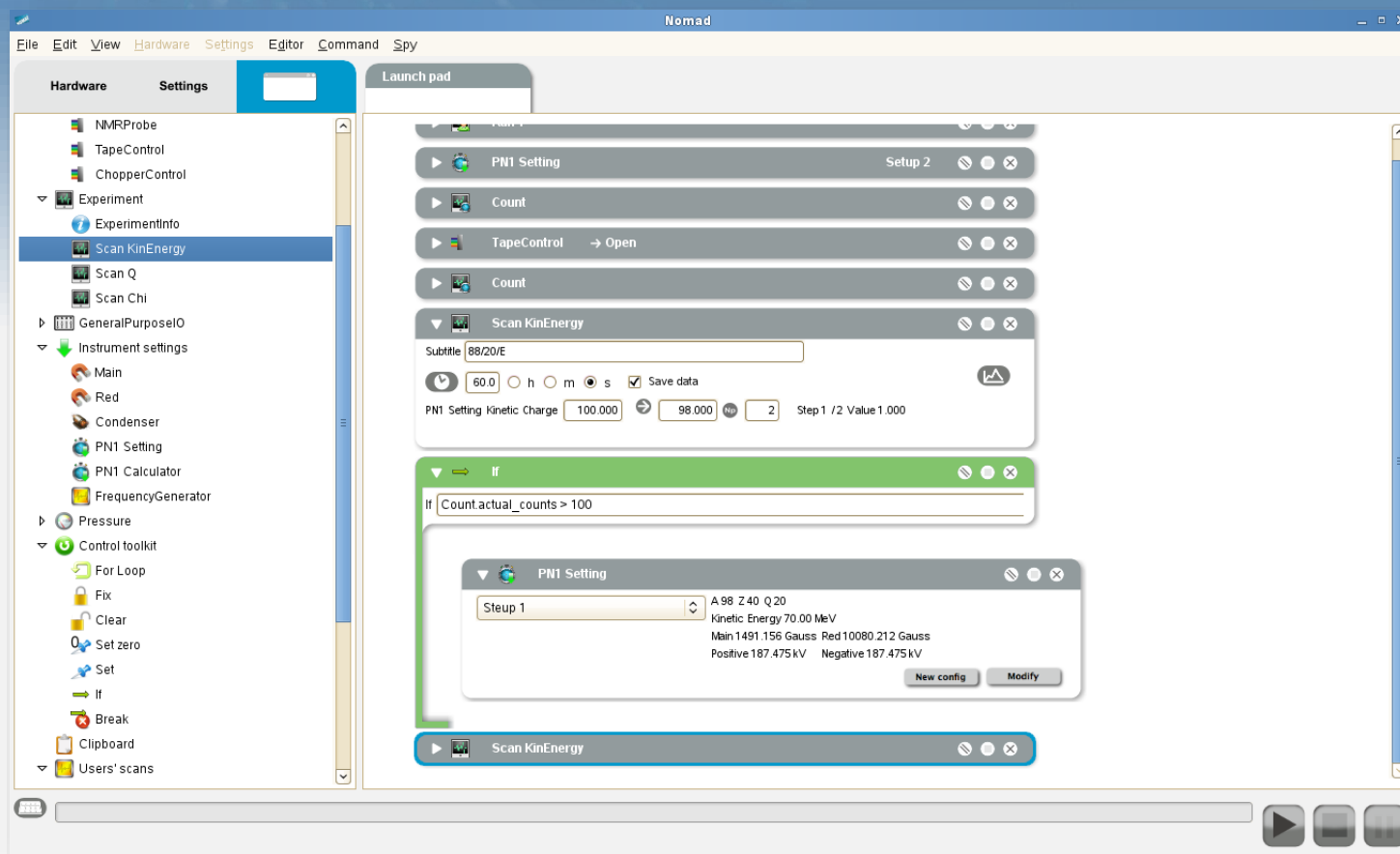
The screenshot shows the Nomad software interface for a 'Furnace' instrument. The interface is divided into several sections:

- Hardware/Settings:** A sidebar on the left shows a tree view with 'Furnace' selected under 'Instruments'.
- Temperature control:**
 - Temperature setpoint: 700.00 °C
 - Ramp mode: SetPoint Δ 5.000 °C/min
 - Time Out: ☐
 - Stabilisation: ☐
- Temperature parameters:**
 - Maximum temperature: 1000.0 °C
 - Minimum temperature: 0.00 °C
 - Tolerance (+/-): 3.00 °C on Regulation sensor
- PID parameters:**
 - ☒ Operates automatically
 - Power switch selected: P1
 - PID2 parameters:**
 - ☐ ON
 - Kp: 0.50, P: 0.00
 - Ki: 75.00, I: 2.60
 - Kd: 2.00, D: 0.00
 - Amortizement: 7.00
- P1 PIDs:**

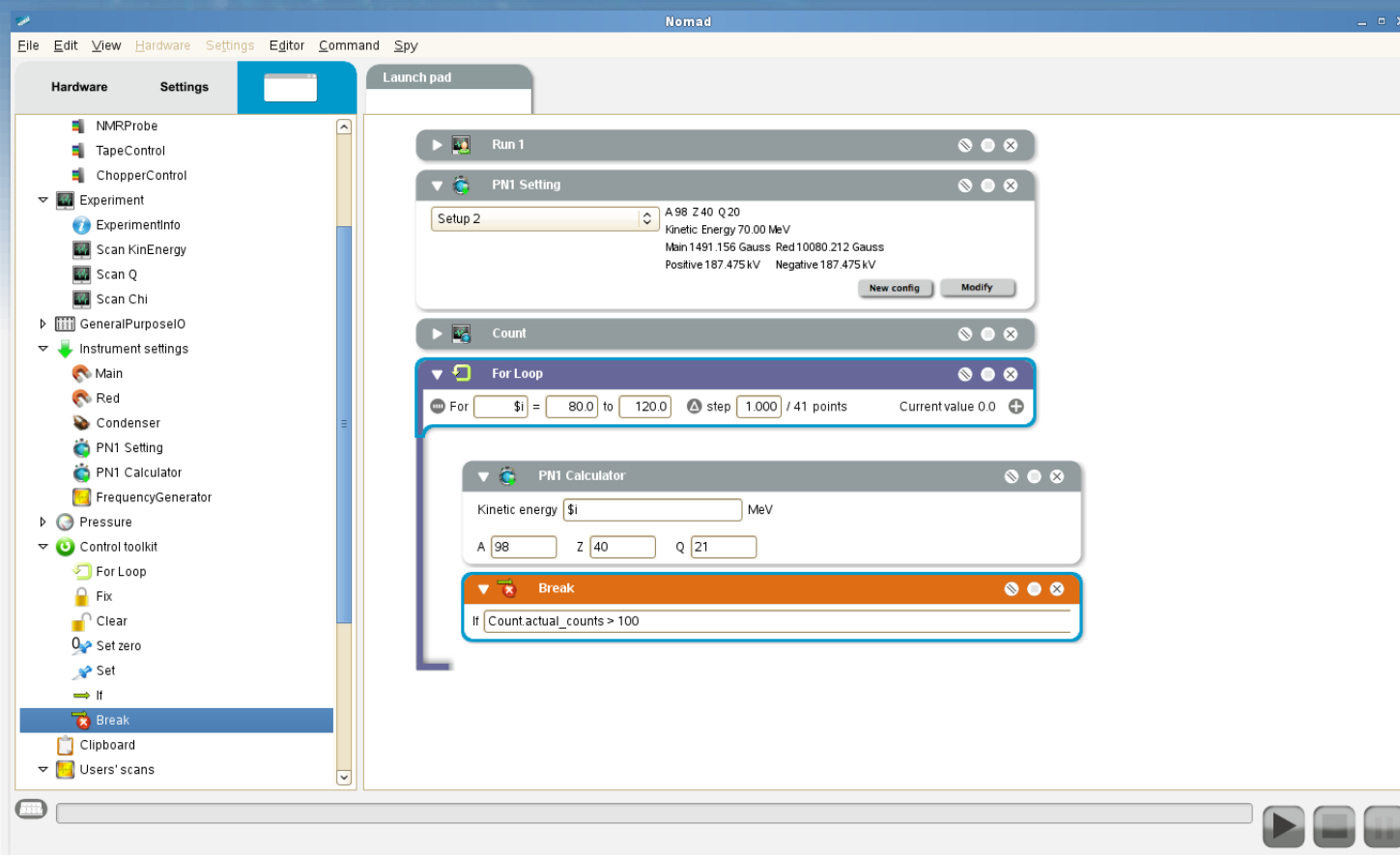
Temperature	max	Power	max	Proportional	Integral	Derivate
100.0	19.0	2.3	2.03	0.3		
200.0	33.0	1.3	0.46	0.11		
300.0	50.0	1.0	0.23	0.05		
400.0	68.0	1.0	0.31	0.07		
450.0	78.0	1.0	0.23	0.05		
- P2 PIDs:**

Temperature	max	Power	max	Proportional	Integral	Derivate
300.0	8.0	2.5	0.23	0.05		
400.0	11.0	1.0	0.21	0.05		
- Summary:**
 - Regulation temperature: 0.00 °C
 - Sample temperature: 700.00 °C
 - Setpoint temperature: 0.00 °C
 - Power: 0.000 W
 - Vacuum: 0.00 mBar
 - U Heat: 0.00 V
 - I Heat: 0.00 A

Take Decisions - IF



Flow Control – IF BREAK



The screenshot displays the Nomad control interface. The top window, titled "Nomad", has a menu bar with "File", "Edit", "View", "Hardware", "Command", and "Help". The "Hardware" panel is active, showing a tree view of settings: Commands, Axis, Favorites, Beam parameters, Acquiring data, Instrument settings, GeneralPurposeIO, Currents, and Sample environment. The "Launch pad" tab is selected, showing a script for "dr Det \$i" with a "count" loop and a "ScanSanPhi" command. The bottom window, titled "NomadShell", is a terminal window showing the execution of commands. It starts with an error "Invalid scan file name", followed by "dr Collimation 2.8" which sets "Collimation" to "2.8 mm". Then "scan Trs [10, 15] np 6 1 time" is executed, showing a table of scan parameters and results. The table has columns: PNT, Trs, Numor, Time, Detector, Rate Det, Monitor1, Rate M1, Monitor2, and Rate M2. The results show a "highest peak = 12.5". Finally, "dr trs 12.5" is executed, setting "Trs" to "12.5 mm".

NomadShell Terminal Output:

```
File Edit View Terminal Tabs Help
Invalid scan file name
> dr Collimation 2.8
Collimation --> 2.8 mm
> Collimation 2.8 mm
> scan Trs [10, 15] np 6 1 time
AxisScan --> Trs wanted_position 10 .. 15 step 6
> AxisScan
PNT Trs Numor Time Detector Rate Det Monitor1 Rate M1 Monitor2 Rate M2
> AxisScan 1 10.000 042831 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan 2 11.000 042832 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan 3 12.000 042833 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan 4 13.000 042834 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan 5 14.000 042835 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan 6 15.000 042836 1.2 32768 26760.4 1 0.816663 1 0.816663
> AxisScan highest peak = 12.5
> dr trs 12.5
Trs --> 12.5 mm
> Trs 12.5 mm
> co 1 s
Count --> 1 s
> Count Numor: 042837 Time: 1.2 s Detector: 32768 ( 26760.4 /s) Monitor1: 1 ( 0.816663 /s) Monitor2: 1 ( 0.816663 /s)
> dr trs 100
Value must be between -42.0 and 48.0
> dr trs 10
Trs --> 10 mm
> Trs 10 mm
> co 1 s
Count --> 1 s
> Count Numor: 042838 Time: 1.2 s Detector: 32768 ( 26760.4 /s) Monitor1: 1 ( 0.816663 /s) Monitor2: 1 ( 0.816663 /s)
> dr temperature 30
Bath --> 30 C
> Bath 30 C
>
```

NOMAD Mobile



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

Choose the instrument

d1b
d4
d7
d11
d16
d17
d20
d22
d33
figaro
gams5
gams6
in3
in4

- axis
- BStopX
- BStopY
- Chi
- Courbeur
- Det
- Gamma
- Phi
- Rot_Mono
- Til_Mono
- Til_Mono2
- Tx
- Ty
- X_Mono

Phi

Actual position : **125.6mm**

Status : ● Moving

Set-point 200 mm ☐ Relative

Min : 0.23mm

Max : 589mm

Offset : 45.2mm

Manual Move

Down

 Up

▶
■
⏸

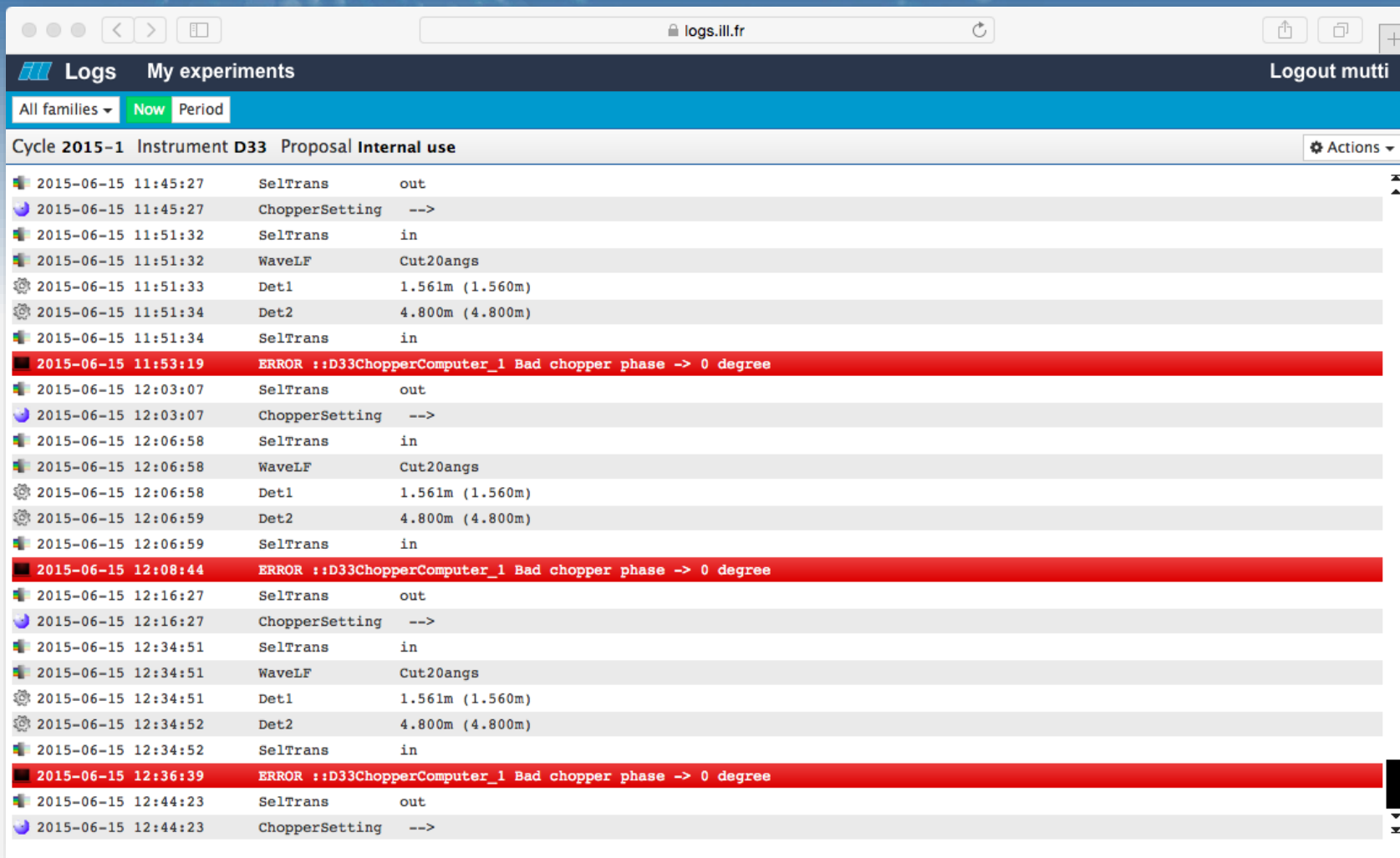
On The WEB

<http://nomad.ill.fr/>



On The WEB

<http://logs.ill.fr/>



Logs My experiments Logout multi

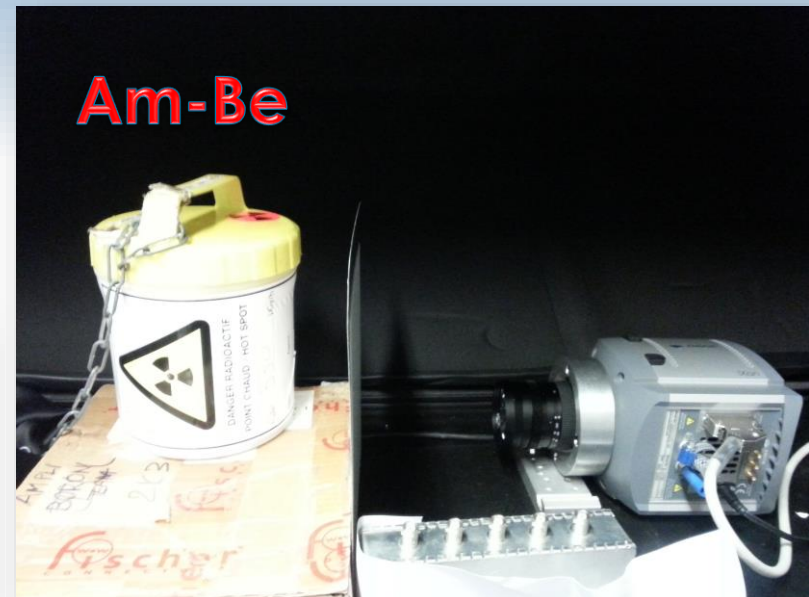
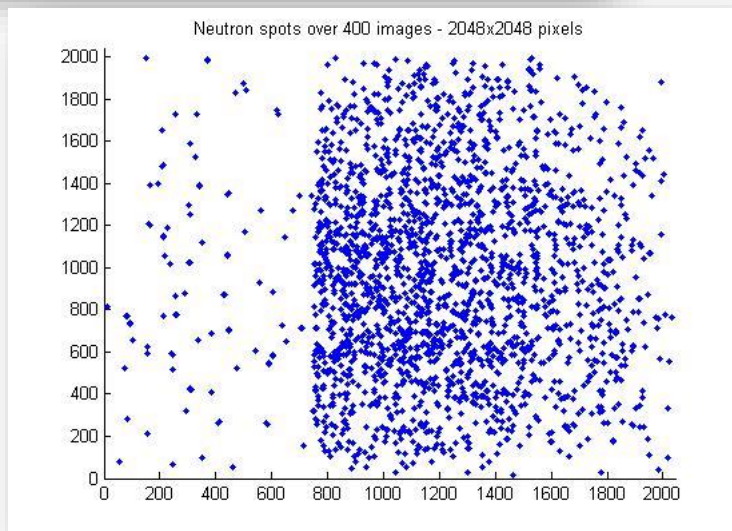
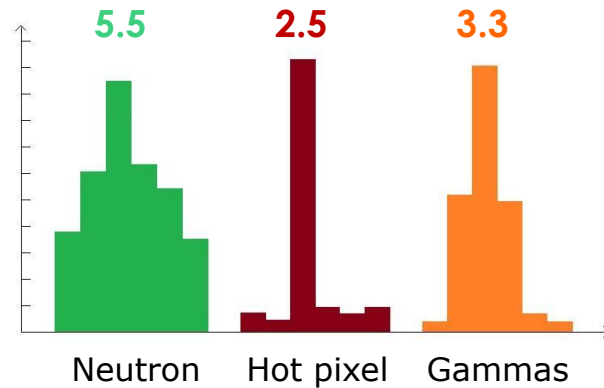
All families ▾ Now Period

Cycle 2015-1 Instrument D33 Proposal Internal use Actions ▾

2015-06-15 11:45:27	SelTrans	out
2015-06-15 11:45:27	ChopperSetting	-->
2015-06-15 11:51:32	SelTrans	in
2015-06-15 11:51:32	WaveLF	Cut20angs
2015-06-15 11:51:33	Det1	1.561m (1.560m)
2015-06-15 11:51:34	Det2	4.800m (4.800m)
2015-06-15 11:51:34	SelTrans	in
2015-06-15 11:53:19	ERROR ::D33ChopperComputer_1 Bad chopper phase -> 0 degree	
2015-06-15 12:03:07	SelTrans	out
2015-06-15 12:03:07	ChopperSetting	-->
2015-06-15 12:06:58	SelTrans	in
2015-06-15 12:06:58	WaveLF	Cut20angs
2015-06-15 12:06:58	Det1	1.561m (1.560m)
2015-06-15 12:06:59	Det2	4.800m (4.800m)
2015-06-15 12:06:59	SelTrans	in
2015-06-15 12:08:44	ERROR ::D33ChopperComputer_1 Bad chopper phase -> 0 degree	
2015-06-15 12:16:27	SelTrans	out
2015-06-15 12:16:27	ChopperSetting	-->
2015-06-15 12:34:51	SelTrans	in
2015-06-15 12:34:51	WaveLF	Cut20angs
2015-06-15 12:34:51	Det1	1.561m (1.560m)
2015-06-15 12:34:52	Det2	4.800m (4.800m)
2015-06-15 12:34:52	SelTrans	in
2015-06-15 12:36:39	ERROR ::D33ChopperComputer_1 Bad chopper phase -> 0 degree	
2015-06-15 12:44:23	SelTrans	out
2015-06-15 12:44:23	ChopperSetting	-->

Coming Soon

Counting single neutron with cameras



Coming Soon

Live data reduction within the sequencer

