INSTITUT MAX VON LAUE - PAUL LANGEVIN

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FPGA Implementation Of A Digital Constant Fraction For Fast Timing Studies In The Pico Second Range

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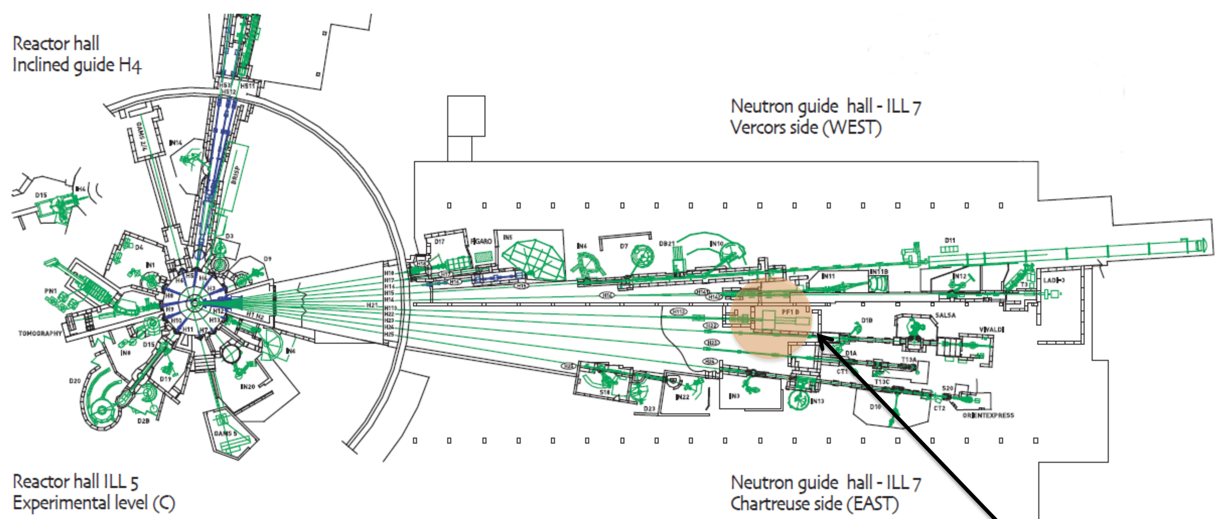
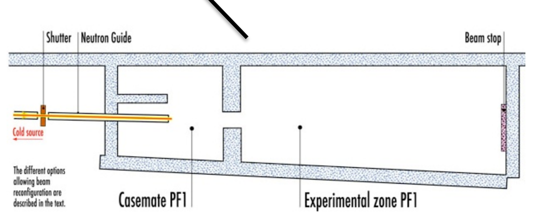
Abstract: Thermal or cold neutron capture on different fission systems is an excellent method to produce a variety of very neutron-rich nuclei. Since neutrons at these energies bring in the reaction just enough energy to produce fission, the fragments remain neutron-rich due to the negligible neutron evaporation thus allowing detailed nuclear structure studies. In 2012 and 2013 a combination of clover and standard coaxial Ge detectors plus very fast $LaBr_3$(Ce) scintillators has been installed at the PF1B cold neutron beam of the Institut Laue-Langevin (ILL). The present paper describes the digital acquisition system used to collect information on all gamma rays emitted by the decaying nuclei. Data have been acquired in a trigger-less mode to preserve a maximum of information for further off-line treatment with a total throughput of about 10 MByte/sec. Special emphasis is devoted to the FPGA implementation of an on-line digital constant fraction algorithm allowing fast timing studies in the pico second range.

Experimental Setup

PF1B Cold Neutron Beam



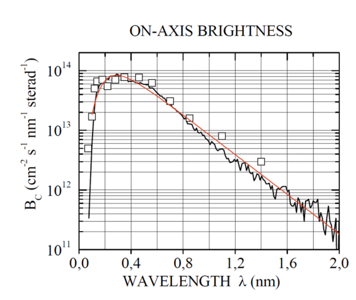
Maximum flux at the wavelength of 4 Å of about 2 x 10^{10} neutrons/cm²/s on a total beam size of 20 cm x 12 cm.

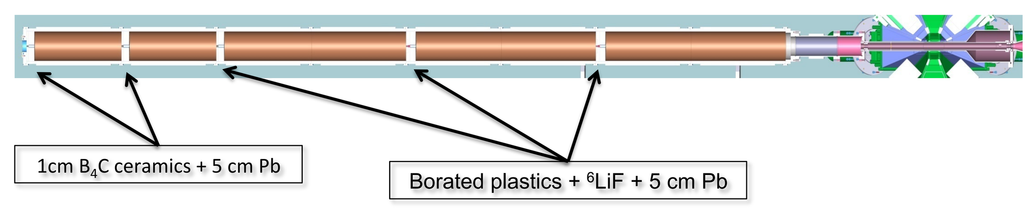


Collimation system

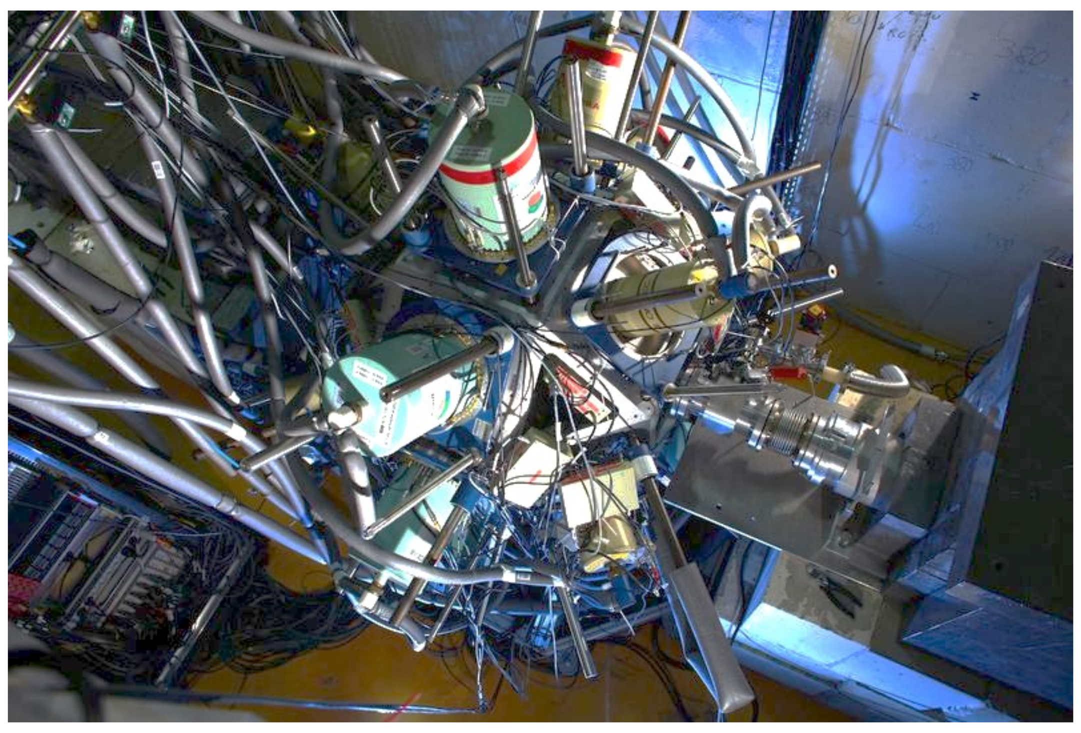
To reduce the beam size to match a diameter of about 1 cm at the sample position, we have introduced a series of boron and lithium collimators upstream.

24 different samples have been irradiated in a neutron beam of 10^8 n/cm²/s





Detector array



Spectroscopy measurements:

- **8 EXOGAM segmented clovers**
- **6 GASP n-type coaxial**
- **2 Ge clovers**

Fast timing measurements:

- **16 $LaBr_3$(Ce) scintillators**

+ BGO suppression shield

68 (spectroscopy) to 72 (fast timing) separate channels

Target chamber

Sample holder capable of keeping the sample in a stable and reproducible position. The target material was suspended to the sample holder using a Teflon bag consisting of a foil of 25 mg/cm².

Evacuated inner chamber for the ^{241}Pu measurements.

EXILL campaign 2 cycles → 100 days

1st cycle: spectroscopy on both stable and ^{235}U targets

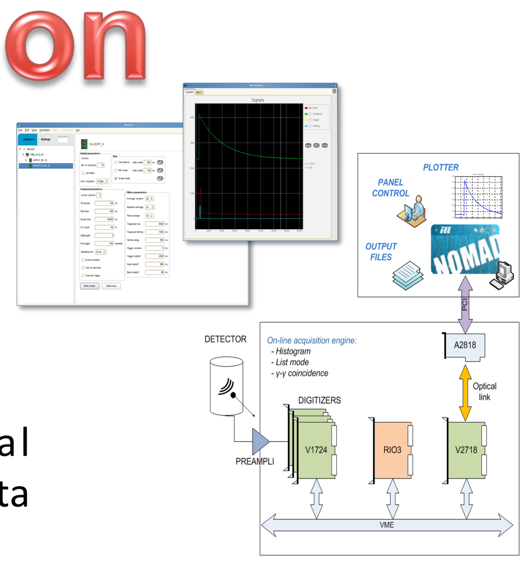
2nd cycle: fast timing with ^{235}U and spectroscopy with ^{241}Pu

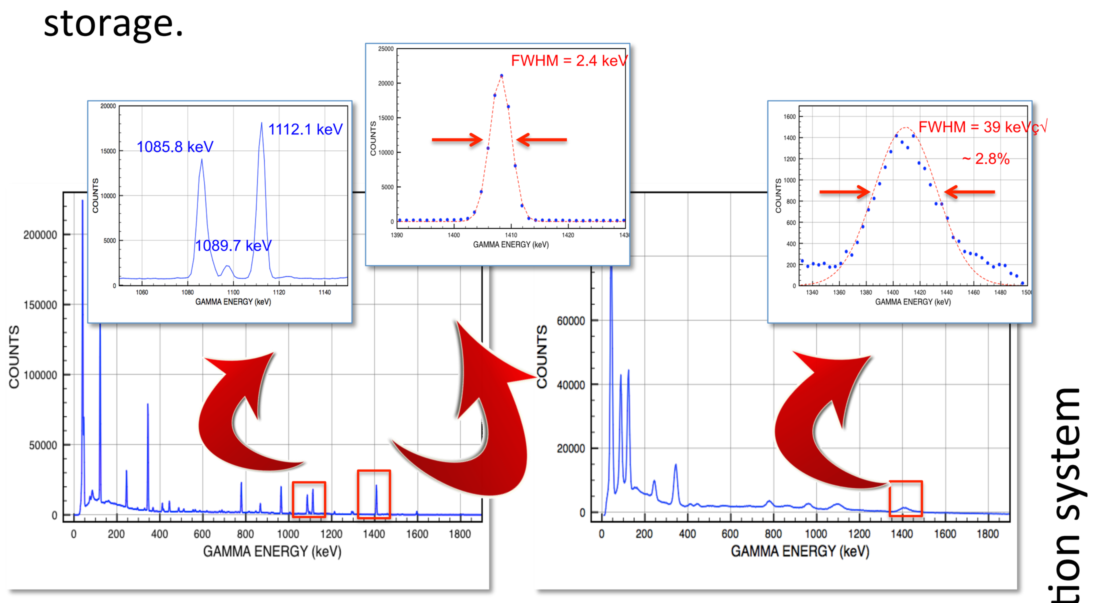
Digital Acquisition

Digitizers: 10 digitizers CAEN v1724, 8 channels, 100MS/s 14 bits.

Processor board: 2 power PC based VME board computer equipped with 256 MB of memory.

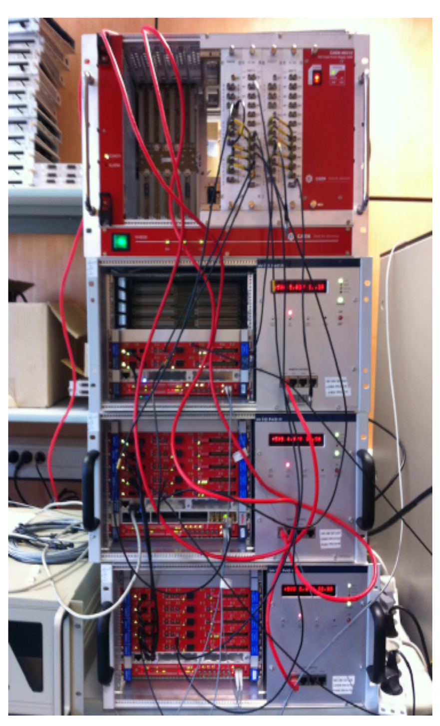
Instrument control software: full graphical configuration interface, on line display and data storage.





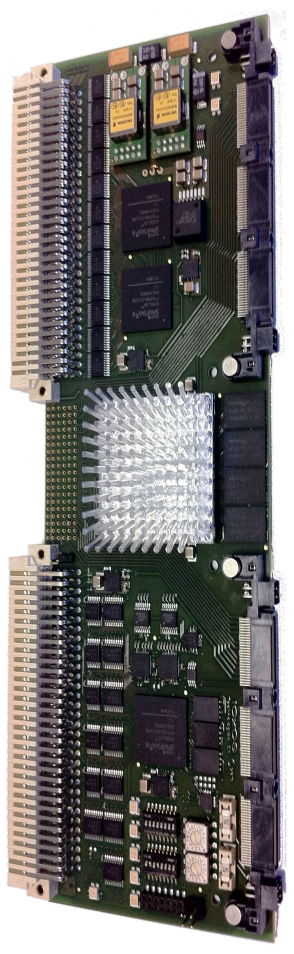
The resolution obtained with Ge (left) and $LaBr_3$(Ce) (right) detectors.

Acquisition system



Event rate ≈ 900kHz → Data rate ≈ 7.2 MB/s

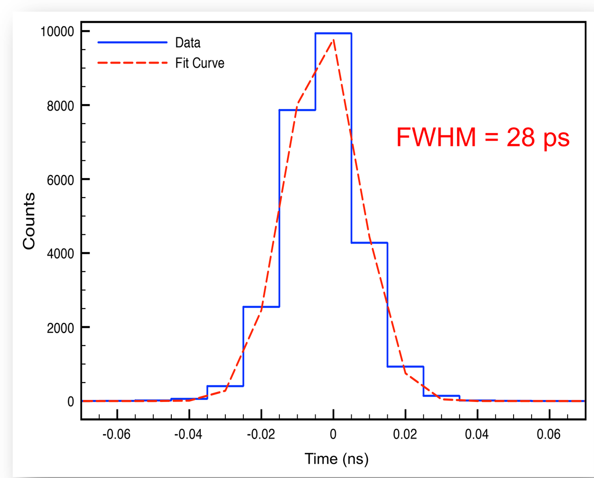
Constant Fraction Discriminator



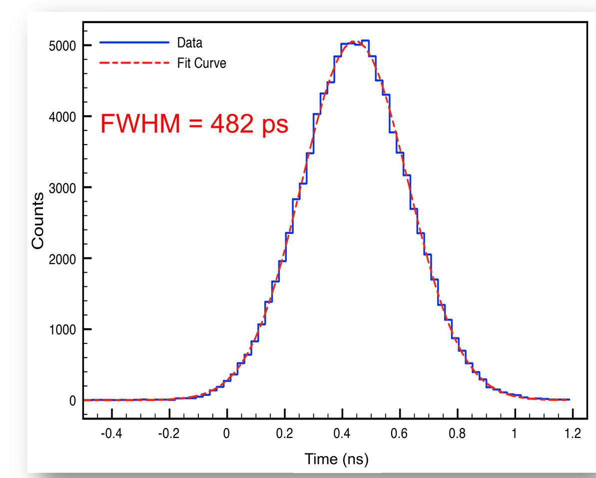
Features:

- 6U VME64x board with 2eSST support.
- Based on latest XILINX Virtex-6T 40mn FPGA.
- Modular IO Expansion with full front panel access (MPF – Multi-Purpose Front IO).
- 5V tolerant VME64x P2 user IO with Spartan-6 IO Support.
- On-board DDR3 Memory.
- Native PCI Express GEN2 support over VME64x P0 and/or front-end MPF.
- TOSCA II FPGA architecture:
  - Optimized for XILINX Virtex-6 FPGAs.
  - PCI Express GEN2 EP/RC.
  - Network on Chip (NoC) architecture.
  - Shared Memory.

FPGA implementation of a CFD algorithm in combination with fast digitizers (1GS/s 10 bits) has shown its potential to replace complex analogue chain for fast timing measurements.



Time dispersion obtained using a pulse generator sending the same pulse on 2 different digitizer channels.



Time dispersion obtained with two $LaBr_3$(Ce) detectors placed in front of a ^{22}Na source.

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