FALL 2014 EPICS Collaboration Meeting
Mon 20th - Thu 23rd October 2014
CEA Saclay, France

METHODOLOGY FOR THE DEVELOPMENT OF INTELLIGENT DATA AND IMAGE ACQUISITION SYSTEMS USING EPICS AND FLEXRIO TECHNOLOGY

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Outline

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- RIO & FlexRIO Devices
  - Reconfigurable hardware based on FPGA
  - Interchangeable physical front ends for FlexRIO devices
- NIRIO-EPICS Device Support
  - I-RIO Driver
  - EPICS Device support for every RIO/FlexRIO configuration
- Design Methodology
  - Procedure
  - Example of FPGA implementation
- Applications
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  - ESS Bilbao
- Conclusions
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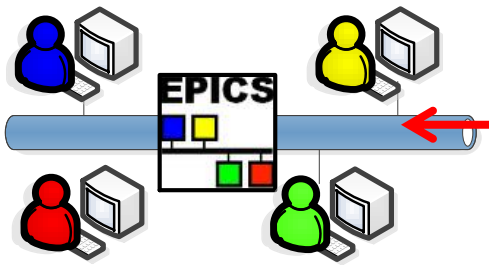
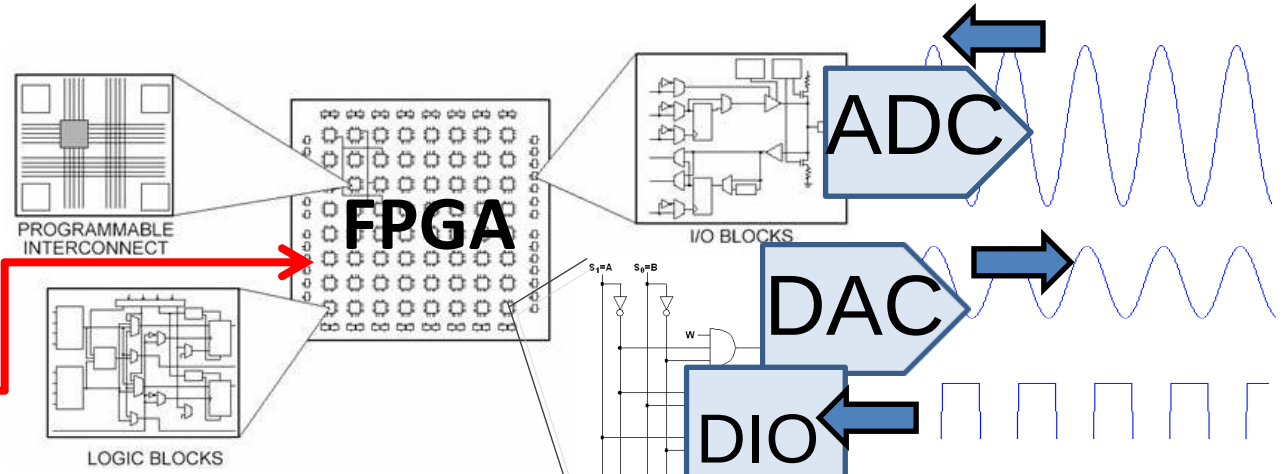
Introduction

- Nowadays large scale experiments require EPICS and reconfigurable DAQ devices based on FPGA.
- EPICS provides a powerful software framework.
- FPGAs provide reconfigurable hardware with deterministic data preprocessing capabilities.



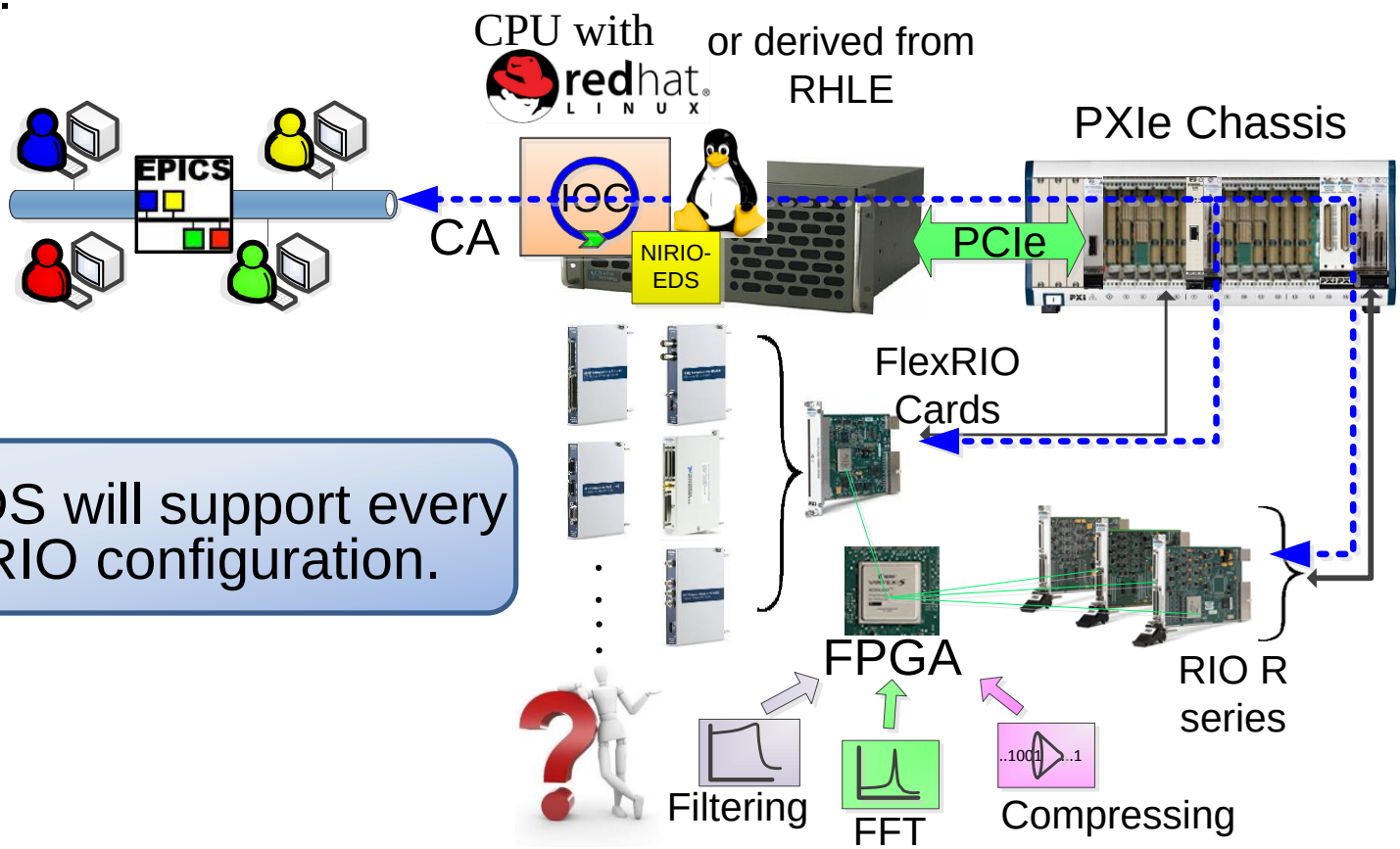
Distributed control and monitoring systems



Reconfigurable hardware: Logic gates, flip-flops, RAM memory, I/O registers etc..

Introduction

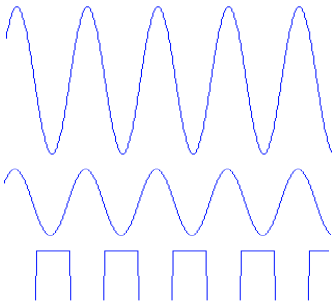
- We propose a design methodology for **RIO/FlexRIO** devices, to be supported by a **NIRIO EPICS Device Support** (**NIRIO-EDS**) based on asynDriver.



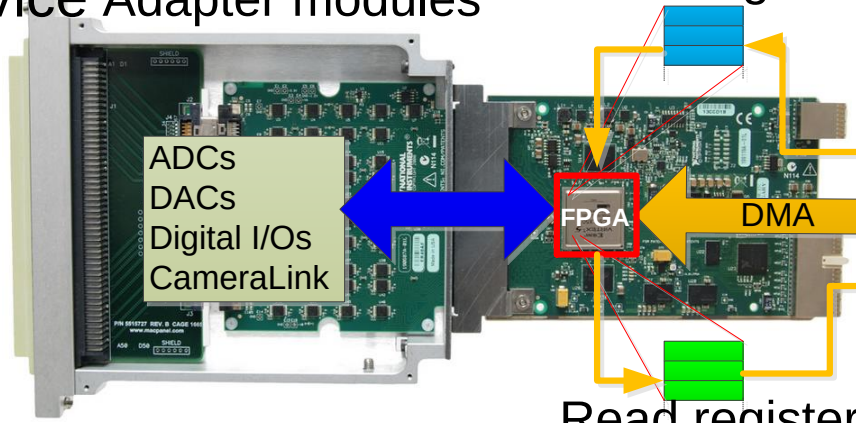
- NIRIO-EDS will support every RIO/FlexRIO configuration.

RIO/FlexRIO Devices

FlexRIO device



Interchangeable Adapter modules



Write registers

Read registers

HOST

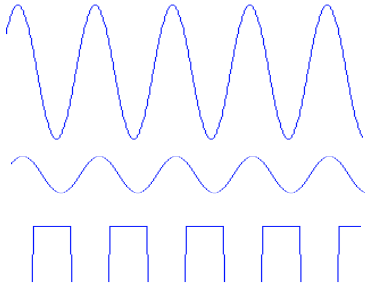
IOC

NIRIO-EDS

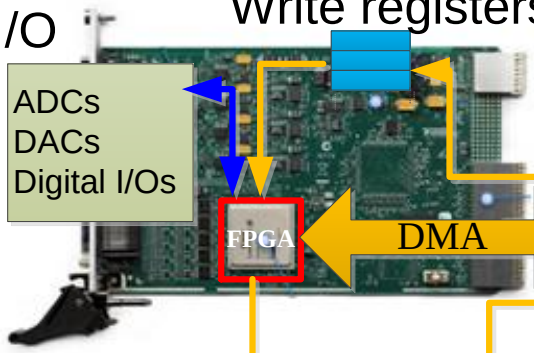
PVs

ai
ao
di
do
mbbi
Mbbo
string
Waveforms
...

RIO device



Fixed I/O



Write registers

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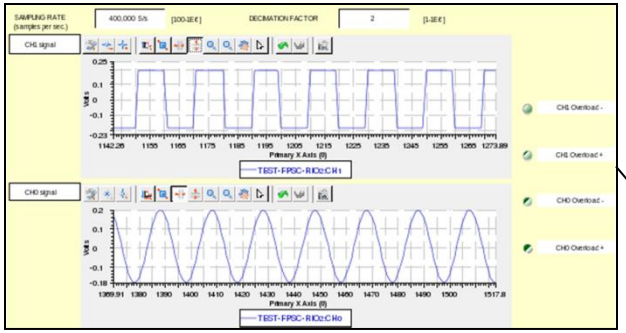
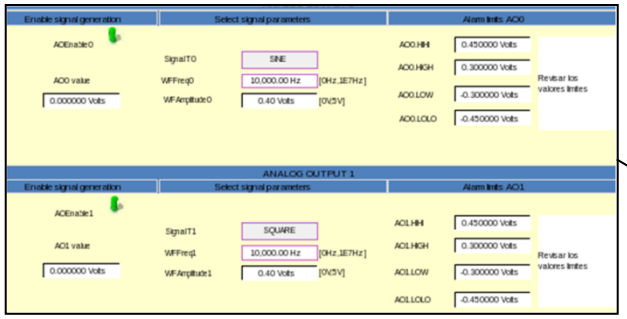
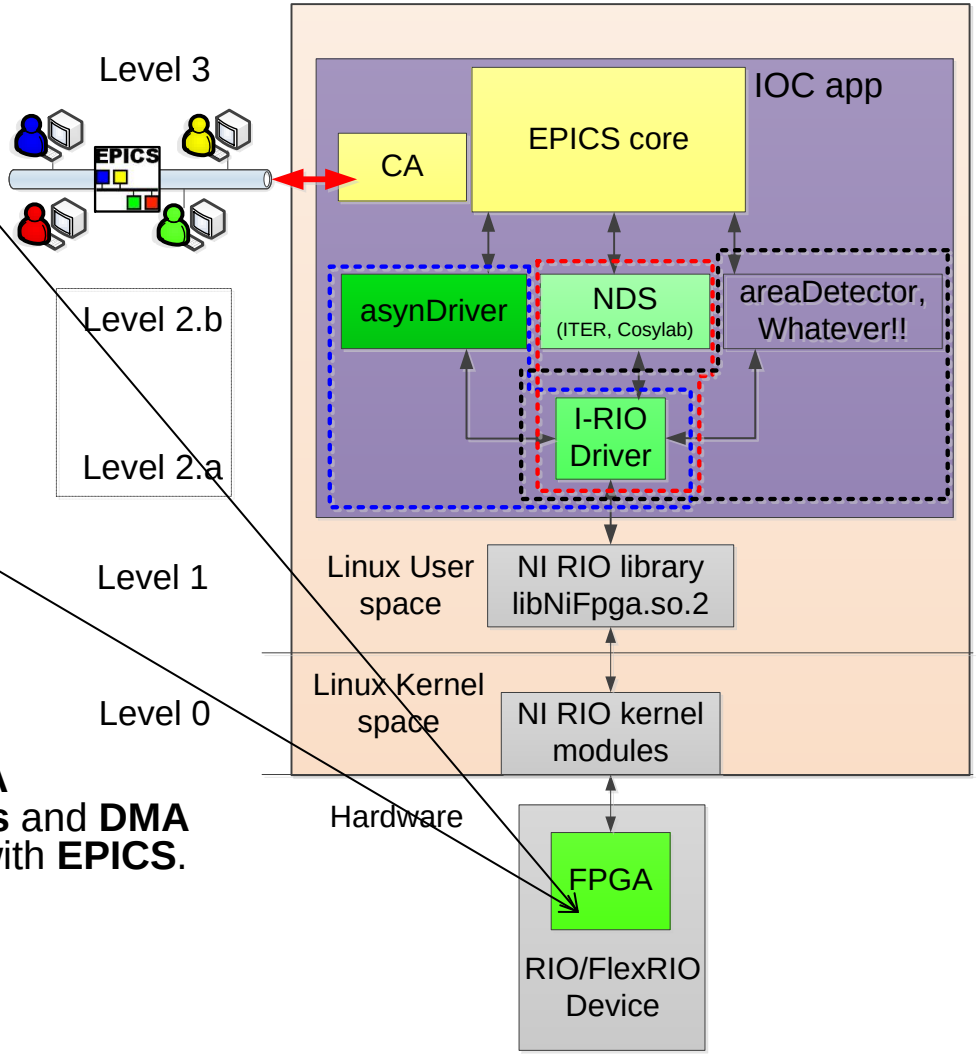
NIRIO-EDS based on asynDriver







- **I-RIO Driver** detects in run time **FPGA** configuration, and **FPGA I/O registers** and **DMA** channels are dynamically interfaced with **EPICS**.

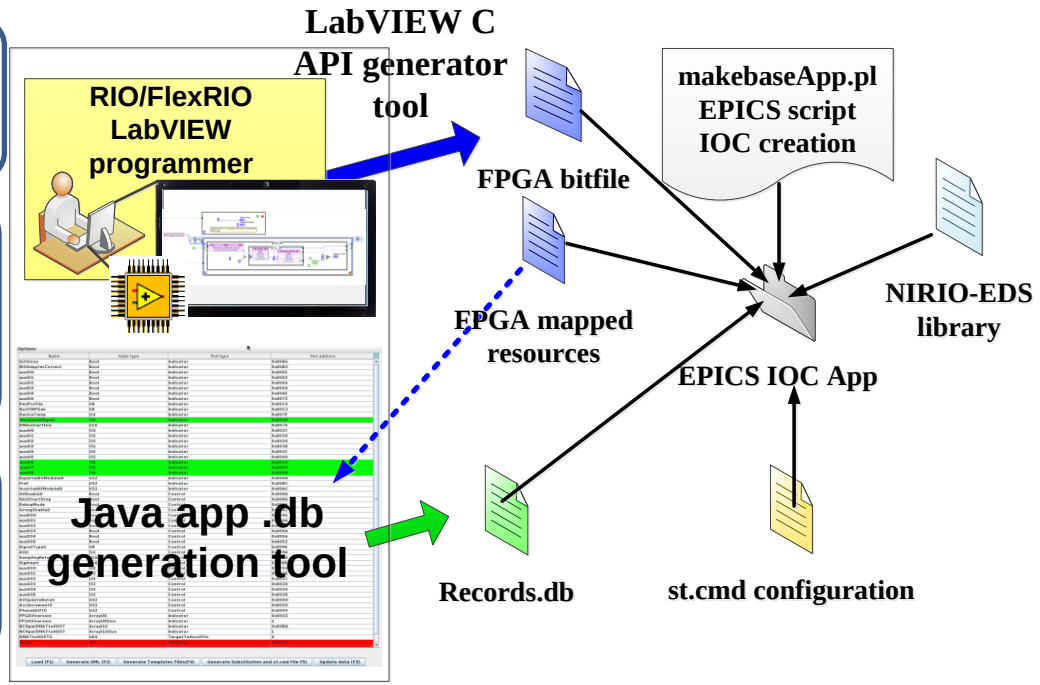
Design **Methodology** for **RIO/FlexRIO** devices

- Records database file is **generated automatically** using FPGA mapped resources. Including all files in EPICS software unit, the IOC is ready to control & monitor the RIO/FlexRIO

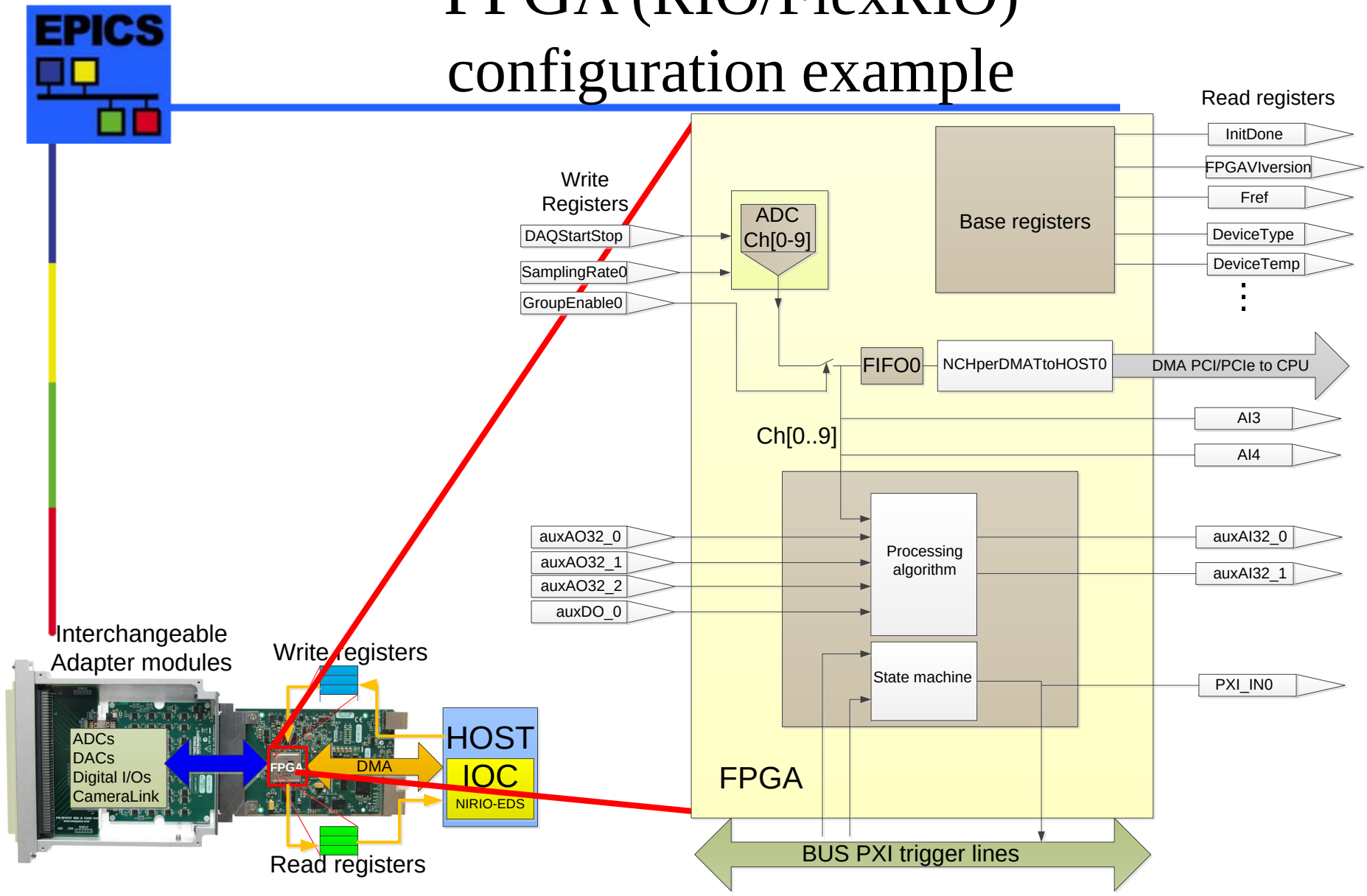
Step 1 Scientific requirements

Step 2 Electronics specifications: Signal conditioning, AI/O, DI/O sampling rates, preprocessing algorithms, etc.

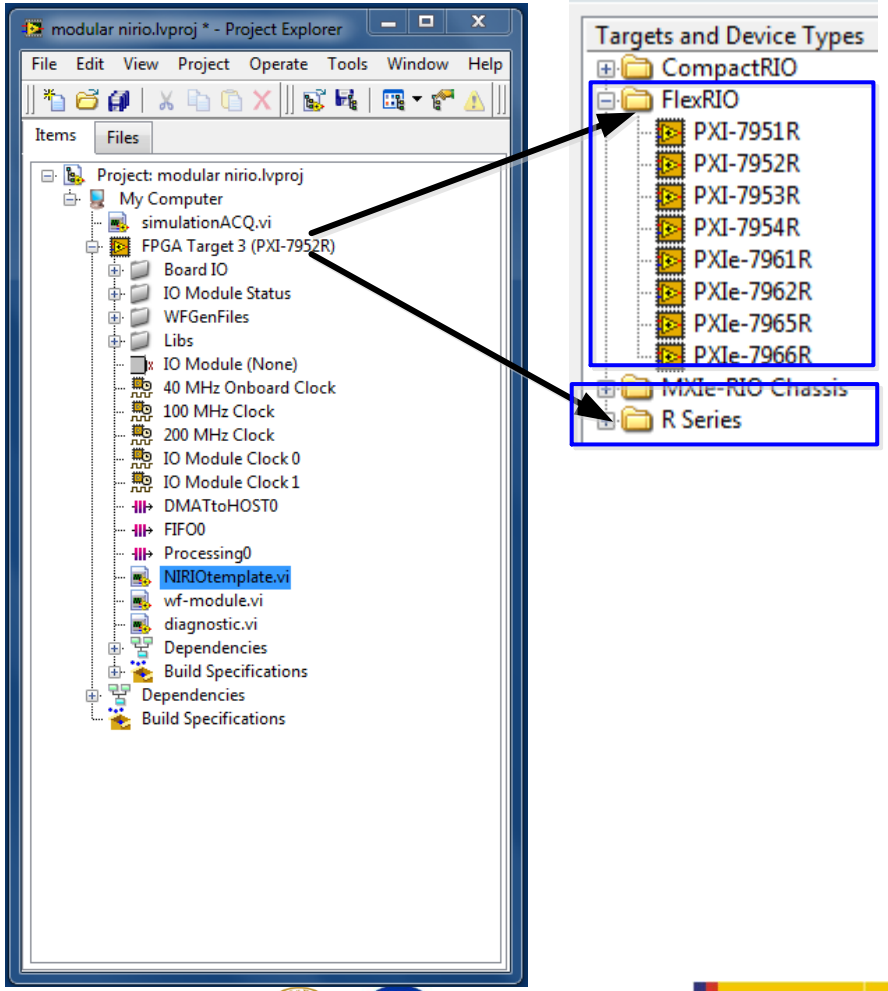
Step 3 RIO/FlexRIO configuration with LabVIEW FPGA templates



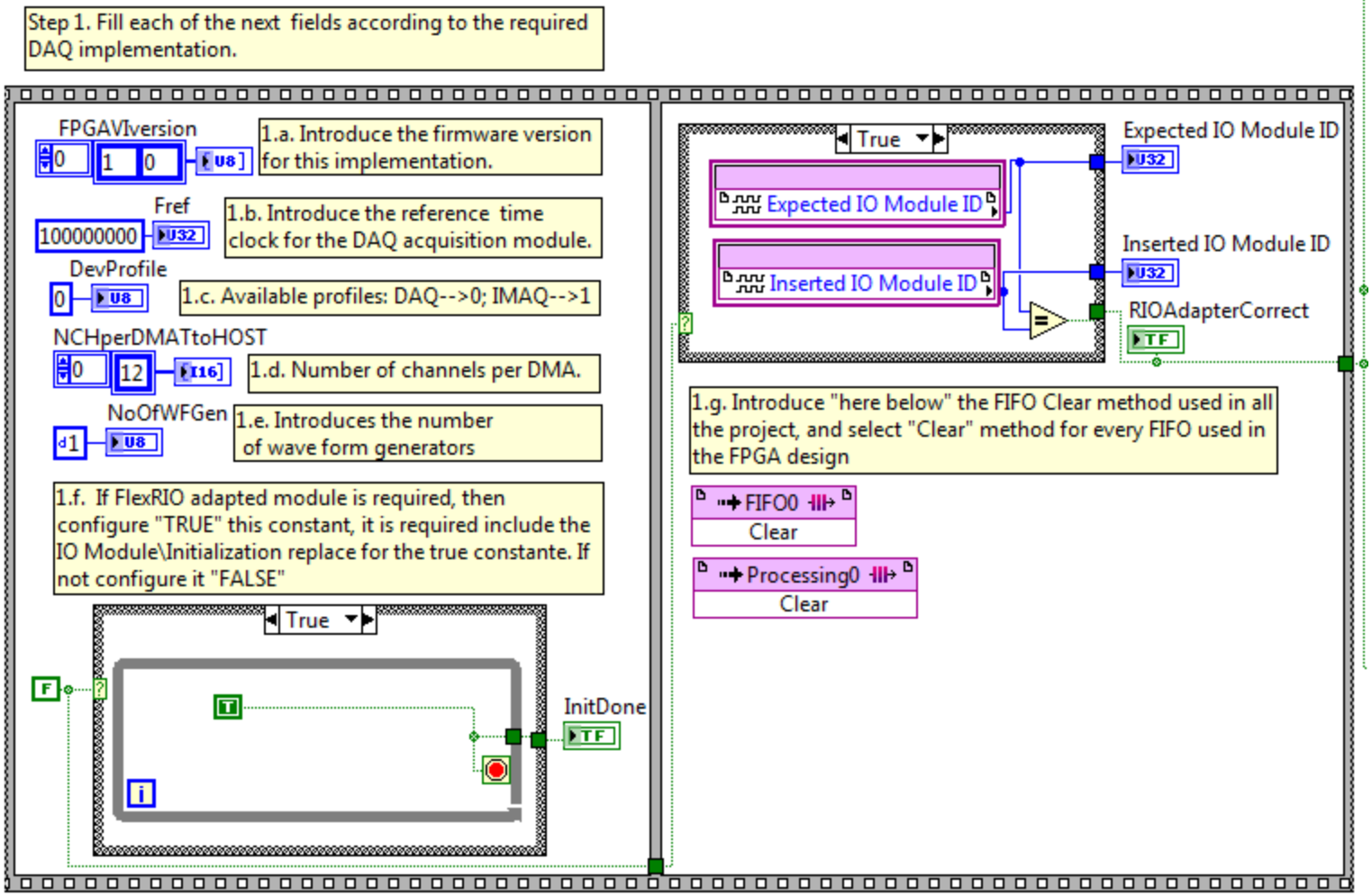
FPGA (RIO/FlexRIO) configuration example



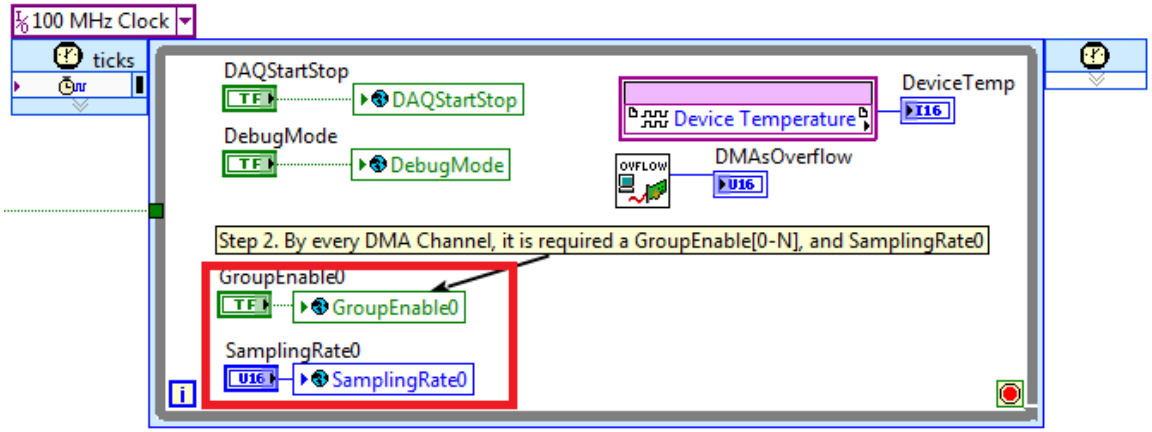
FlexRIO configuration

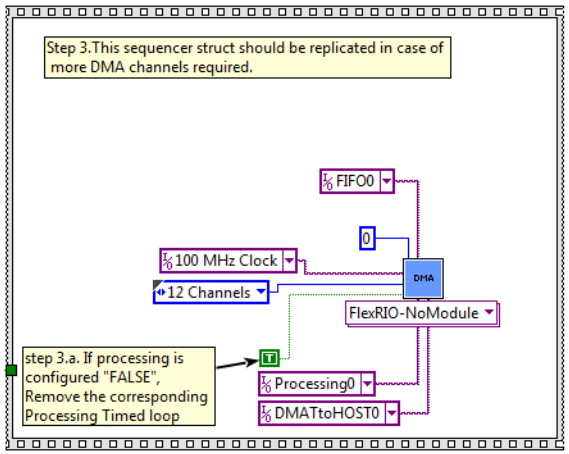


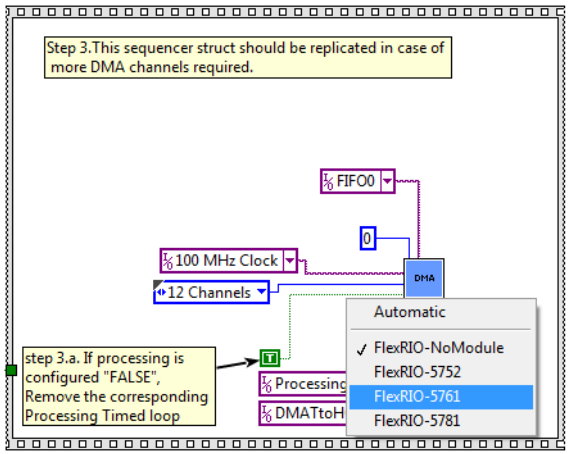
FlexRIO configuration

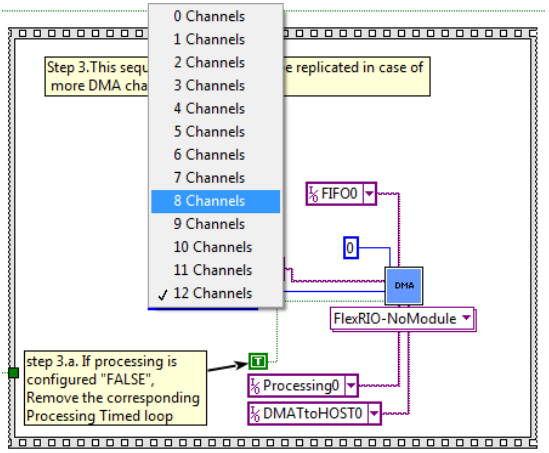


FlexRIO configuration

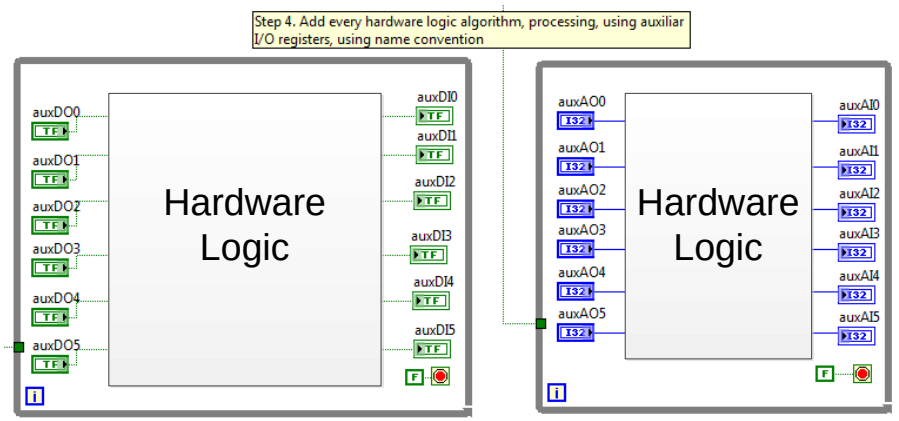


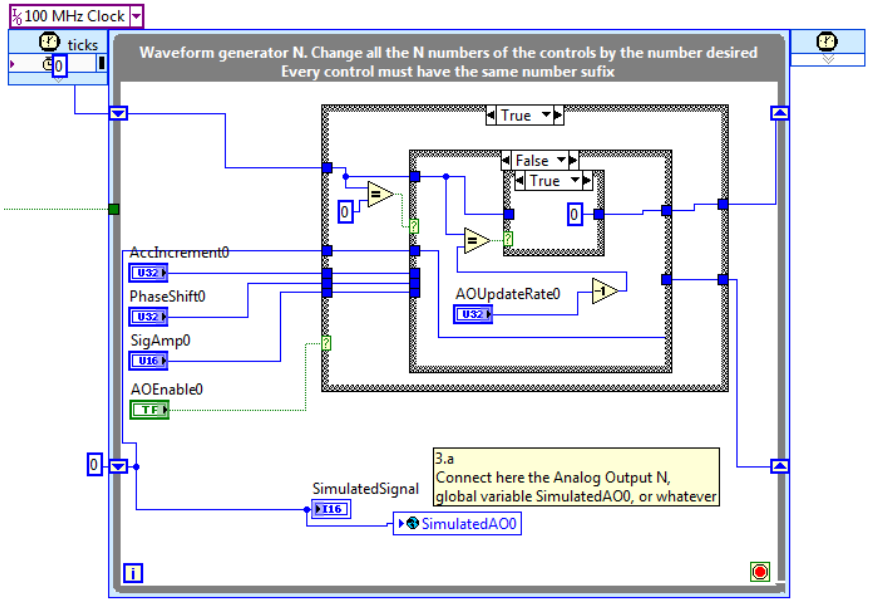


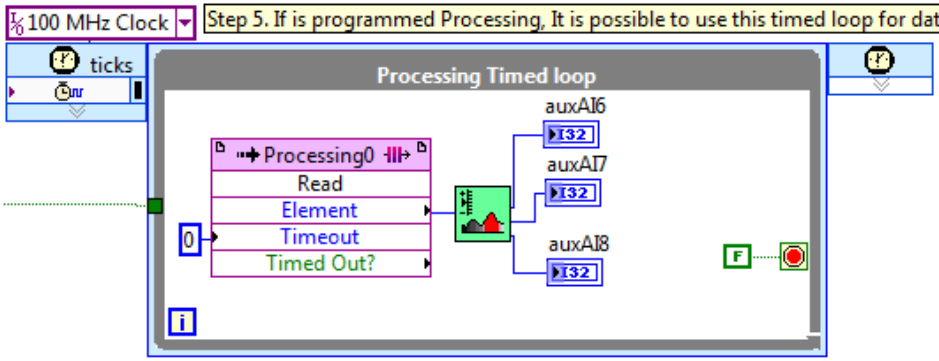




FlexRIO configuration

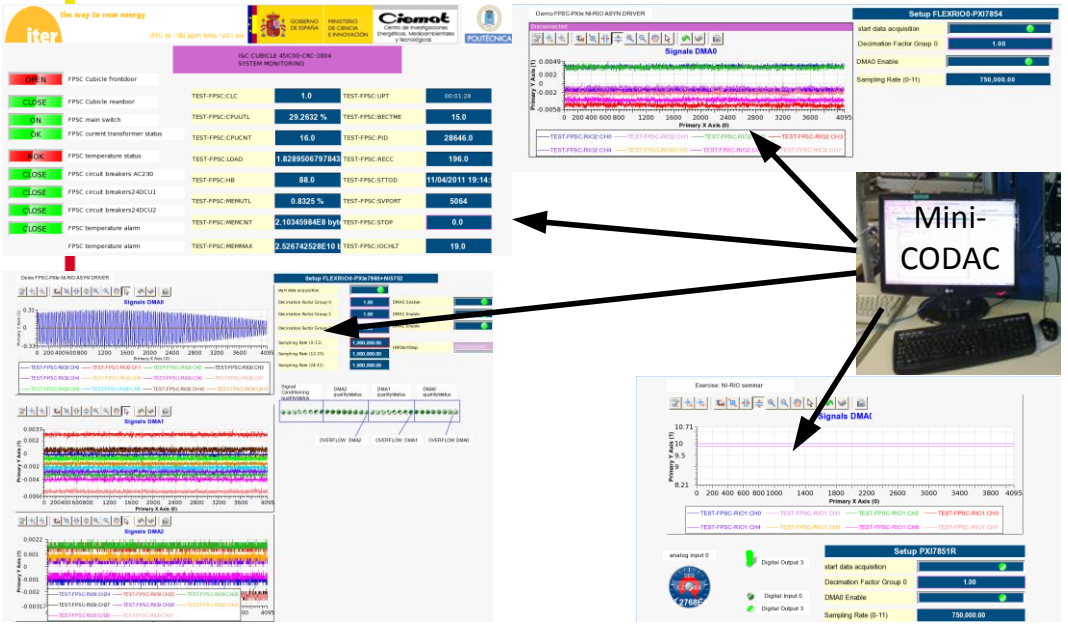


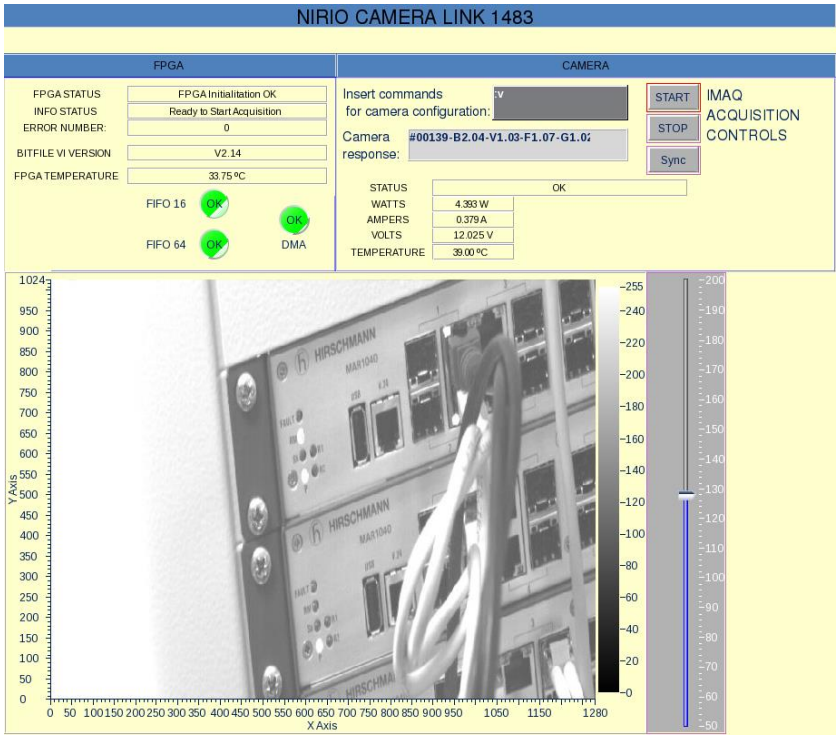




Use case applications

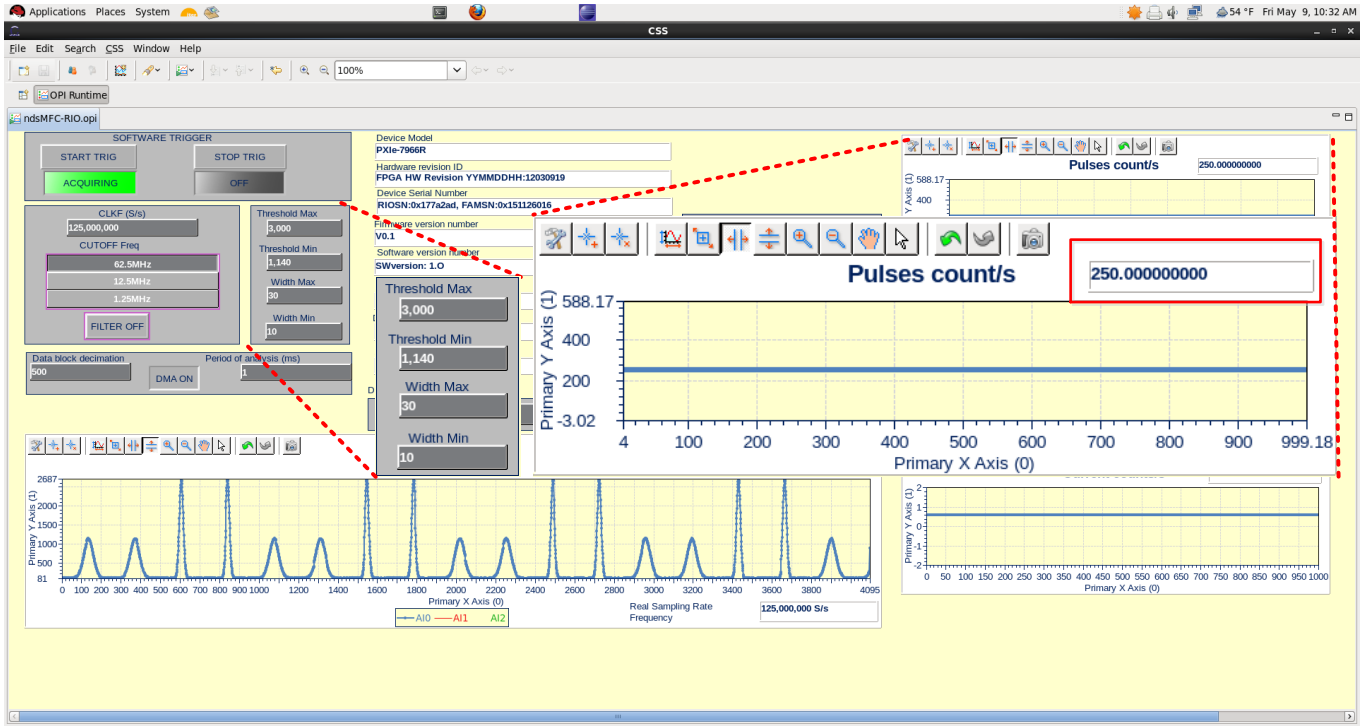
- ITER PXIe Fast controller prototype for data and Image acquisition (cameralink).





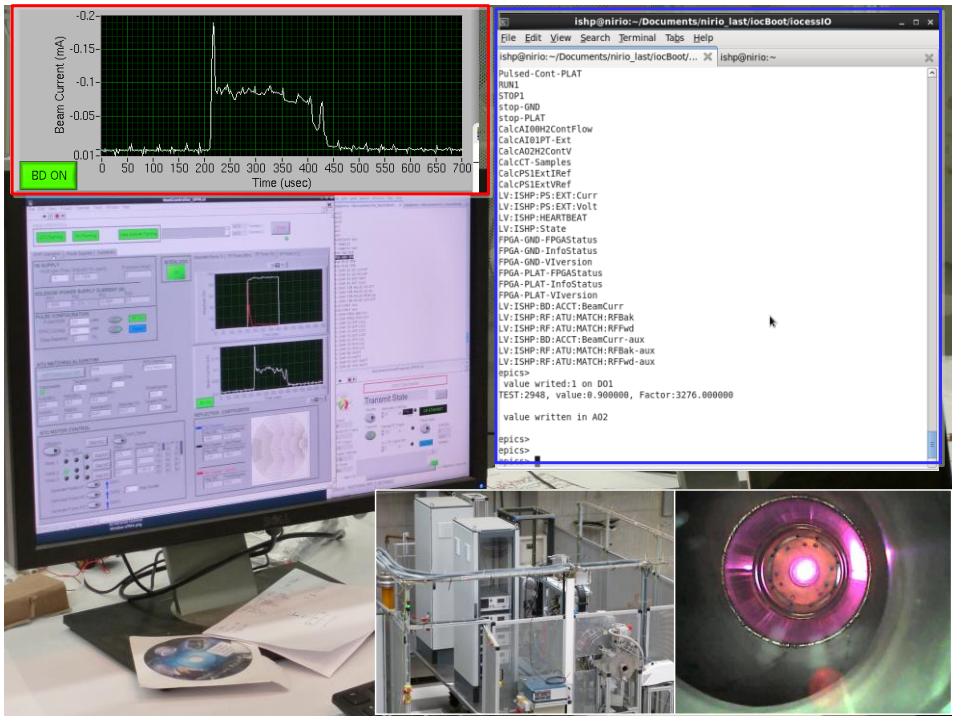
Use case applications

- ITER Fission chamber diagnostic use case application based on FlexRIO technology: It integrates deterministic diagnostic into the FPGA (4 ADC sampling at 125MS/s). Processing to obtain counts, RMS and cambelling implemented in the FPGA.



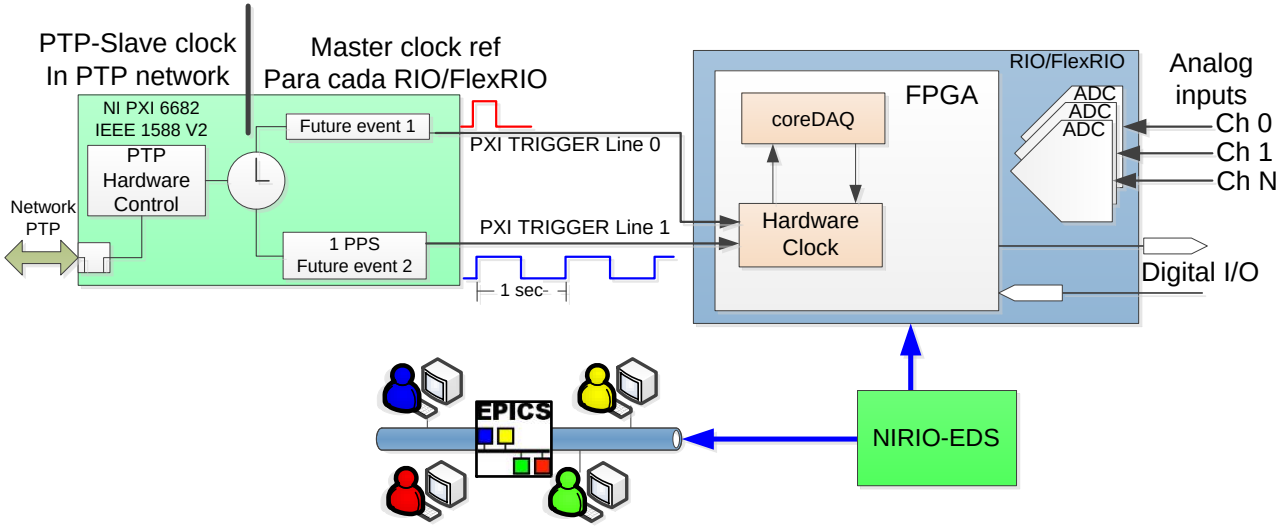
Use case applications

- ESS Bilbao. NIRIO-EDS will support the RIO PXI-7852R for the control and monitoring of the Ion Source Hydrogen Positive (ISHP).



Other Applications

- Integration of Hardware clock into the RIO/FlexRIO devices synchronized with IEEE1588-V2 (tenth of nanoseconds accuracy)
  - It allows real-time timestamping in the DAQ for all acquired data (or blocks) without CPU intervention. Very useful for timestamped data streaming.
  - It requires a PXI device compliant with PTP-V2.

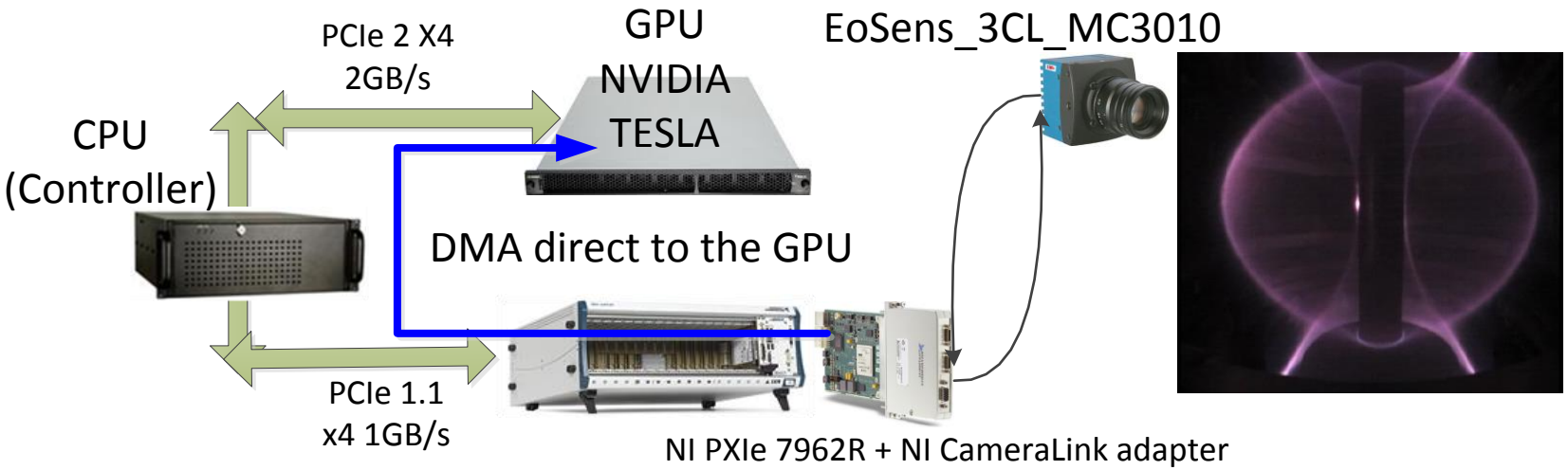


Conclusions

- We have defined a design methodology for implementing intelligent data and image acquisition into RIO/FlexRIO devices, supported by the NIRIO-EDS.
- We have developed LabVIEW patterns and libraries, that permit configure RIO/FlexRIO devices in an easy way.
- The NIRIO-EDS will support every RIO/FlexRIO configuration (implementation), without rewriting the device support.

Next Steps

- We will communicate soon to EPICS community the availability of this EPICS device support, and all RIO/FlexRIO hardware description templates and libraries (in LabVIEW for FPGA code).
- We are implementing direct data transfer communication among FlexRIO devices and GPUs without CPU intervention. This application will also include an EPICS device support to use the GPU.



References

- [1] D. Sanz, M. Ruiz, R. Castro, J. Vega, J. M. Lopez, E. Barrera, N. Utzel and P. Makijarvi, "Implementation of Intelligent Data Acquisition Systems for Fusion Experiments Using EPICS and FlexRIO Technology," *Nuclear Science, IEEE Transactions on,* vol. 60, pp. 3446-3453, 2013.
- [2] D. Sanz, M. Ruiz, J. M. Lopez, R. Castro, J. Vega and E. Barrera, "IEEE 1588 clock distribution for FlexRIO devices in PXIe platforms," *Fusion Eng. Des.,* vol. 89, pp. 652-657, 5, 2014.
- [3] E. Barrera, M. Ruiz, D. Sanz, J. Vega, R. Castro, E. Juárez and R. Salvador, "Test bed for real-time image acquisition and processing systems based on FlexRIO, CameraLink, and EPICS," *Fusion Eng. Des.,* vol. 89, pp. 633-637, 5, 2014.

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Technical University of Madrid

Thank you very much for your attention!!

questions?

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