HIGH-SPEED DATA ACQUISITION OF SENSOR SIGNALS FOR PHYSICAL MODEL VERIFICATION AT CERN HIRADMAT (SHC-DAQ)

C. Charrondière, M. Guinchard, S.D. Marques Dos Santos, CERN, Geneva, Switzerland

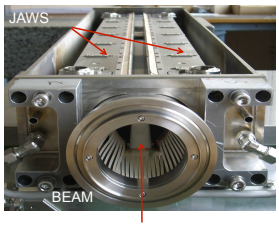
ABSTRACT

A high-speed data acquisition system was successfully developed and put into production with the sensors in a harsh radiation environment in a couple of months to test new materials impacted by proton beams for future use in beam intercepting devices. A 4 MHz ADC with high impedance and low capacitance was used to digitize the data at a 2 MHz bandwidth. The system requirements were to design a full speed data streaming on a trigger during up to 30 ms and then reconfigure the hardware in less than 500 ms to perform a 100 Hz acquisition for 30 seconds. Experimental data were acquired, using LabVIEW real-time, relying on extensive embedded instrumentation (strain gauges and temperature sensors) and on acquisition boards hosted on a PXI crate. The data acquisition system has a dynamic range and sampling rate that are sufficient to acquire the very fast and intense shock waves generated by the beam impact. This presentation covers the requirements, the design, development and commissioning of the system. The overall performance, user experience and preliminary results will be reported.

HiRadMat is a facility to study materials intense pulsed beam impact:

- Thermal management
- Radiation Damage to materials
- Thermal shock – beam induces pressure waves

The Collimators intercept the external halo of particles of the LHC beam, therefore are the parts of the machine closer to the beam.



- Installation of setup by remote control.
- No electronic devices inside the critical area.
- All validations measurements done at the surface.

DAQ characteristic

Sensor type	Quantity	Sampling Frequency
Strain gauges	244	4 MHz
Vibrometer	2	5 MHz
PT100	36	100 Hz
Pirani gauges	1	100 Hz

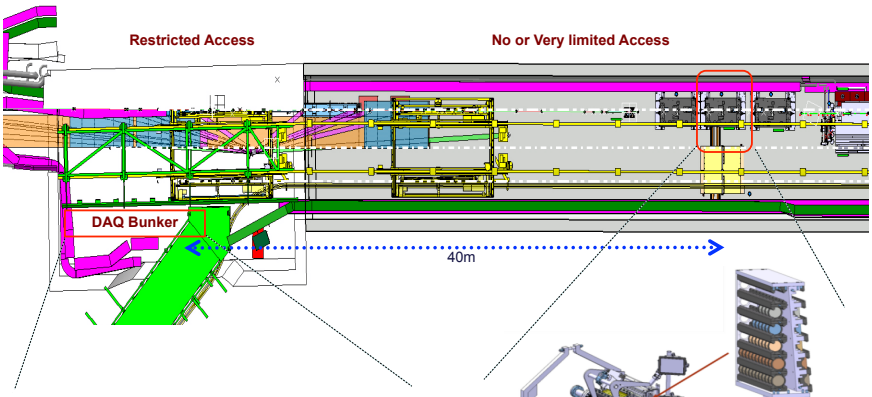
Tight Schedule

Project study	March 2012
Purchase DAQ hardware	June 2012
First Measurement	July 2012
Real Measurements	September 2012

NI products fast delivery such as PXIe-6124 and PXIe-4357
Using LabVIEW allows to design the application in stages:

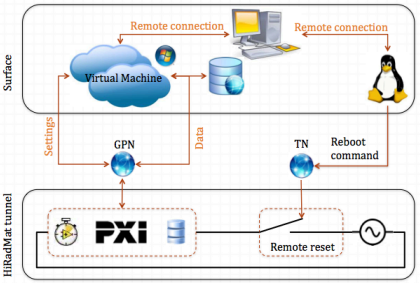
1. using 2 PXIe-6124 cards to validate the system and the synchronization.
2. using all the fast channels changing only the configuration file.
3. adding voltages and temperature read out changing little to the application.

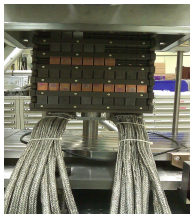
Secure installation:
Using RealTime environment.
Using remote reset in case of major failure like single event.



SHC-DAQ Monitoring system structure

The system is build using a PXI express and controller running LabVIEW Real-Time on PharLap operating system, to address the deterministic requirement of such an application. A remote computer is used to configure the real time system and receive the data online. As a safety system, a remote reset is added to be able to power cycle the entire chassis in case of major issue.

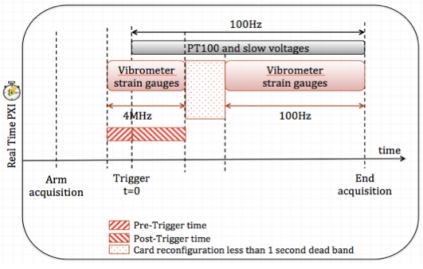




Sample Holder
Instrumentation installed

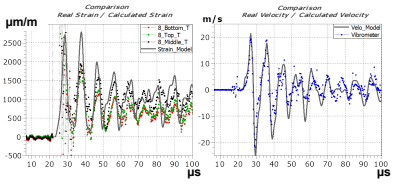
SHC-DAQ data acquisition

As soon as the PXIe-6124 running at 4MS/s using "reference trigger" has finished his task, the cards have to be reconfigured to record data at 100Hz for 30seconds. This reconfiguration of the hardware results in a dead band where no data will be acquired using these cards. This time can be up to 1second.



Results

- The experiment was successful from all points of view.
- All measurement systems (DAQ, electronics, mechanics) worked properly in spite of the very harsh environment and the technological challenges.
- Preliminary results on "standard" materials match very well advanced simulations.
- A huge quantity of data is ready to be processed to derive constitutive models for the less known materials.
- Post-irradiation analysis is to be done in order to complete the picture and provide additional valuable information.



CONCLUSIONS

During the entire tests the application never failed to read a trigger and save the data. In a single occasion the remote reset had to be used. This was when the real time system was not answering to any command. In this particular situation a single event has been suspected, as the system restarted very easily following the power cycle. A large amount of data is being treated and will hopefully help deriving constitutive models for the less known composite materials.

Industrial Controls Engineering Department

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