Multi-Sensor Data Acquisition System for Process Monitoring

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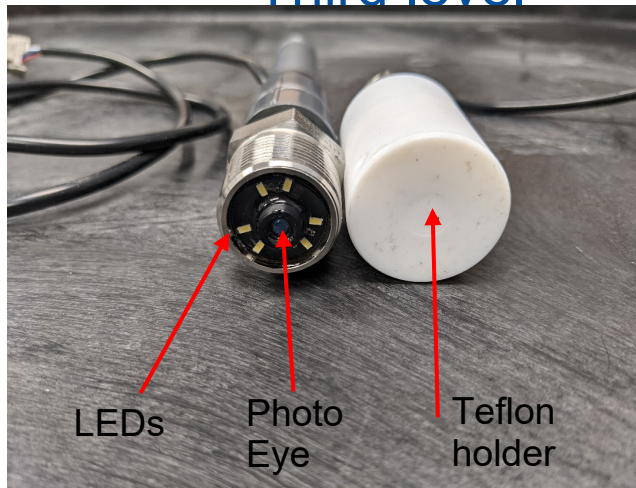
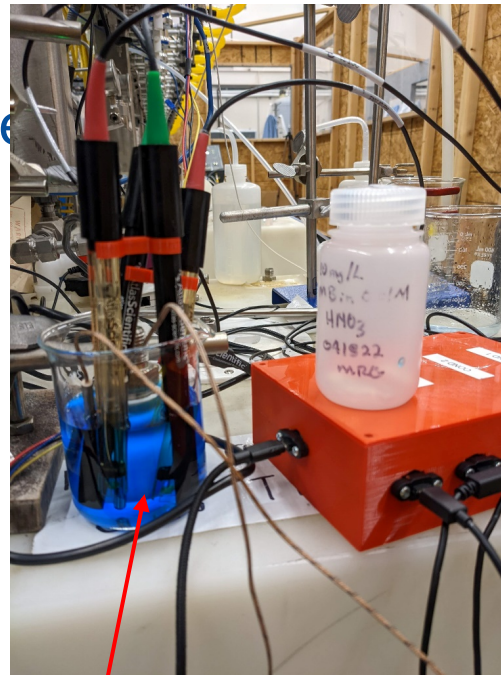# Multi-Sensor Data Acquisition System for Process Monitoring

- Idaho National Laboratory (INL) is building a research test bed called Beartooth to help advance research in nuclear fuel cycle reprocessing.

- Beartooth will give researchers the ability to study the solvent extraction process and deploy several innovative technologies.

- Beartooth will use centrifugal contactors designed for the recovery and purification of special nuclear material.

- As a part of the initiative, this project will integrate non-traditional sensors into the systems which have the potential to enhance nuclear safeguarding efforts and other process activities.

Multi-Sensor Data Acquisition System for Process Monitoring

- Some non-traditional sensors include, accelerometers, acoustic microphones, colorimetric, pH, conductivity, viscosity, density, and infrared cameras.

LEDs   Photo Eye   Teflon holder

Acoustic Microphone

RGB Color Sensed

pH, Conductivity, Temperature, RGB

Accelerometer

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Multi-Sensor Data Acquisition System for Process Monitoring

- One of the challenges behind deploying all the sensors, is the need for a fast and reliable data collection process.

- The data acquisition system (DAQ) needs to be capable of recording multi-sensors simultaneously at rates up to 12.8kS/s/ch.
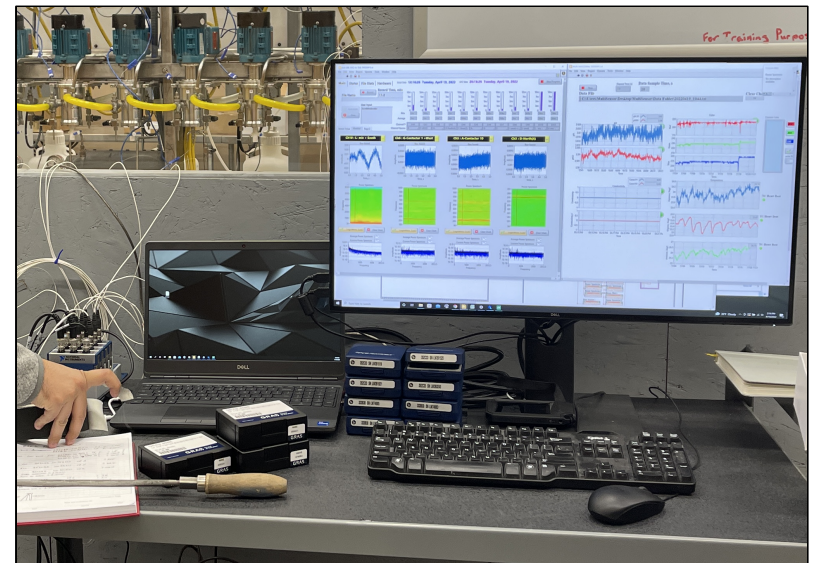
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Multi-Sensor Data Acquisition System for Process Monitoring

- The molten-salt sensor system employs National Instruments (NI) hardware to digitize the signals.

Hardware	Item Number	Sample Rate
Compact DAQ Chassis	CDAQ-9174	0-10Mhz
C-Series Acquisition module	NI-9230	12.8kS/s/ch

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Multi-Sensor Data Acquisition System for Process Monitoring

- The software architecture was developed using NIs LabVIEW.

- LabVIEW is used to control and record sensor data.

- The Technical Data Management Solutions (TDMS) function inside LabVIEW was utilized to stream the data to disk, without any loss or dropout of information.

- TDMS is a binary file structure.

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Multi-Sensor Data Acquisition System for Process Monitoring

- The binary file structure consists of three levels of architectural hierarchy.
- File, Group, and Channel
- The file level can contain an infinite number of groups, with each group being able to store an unlimited number of channels.
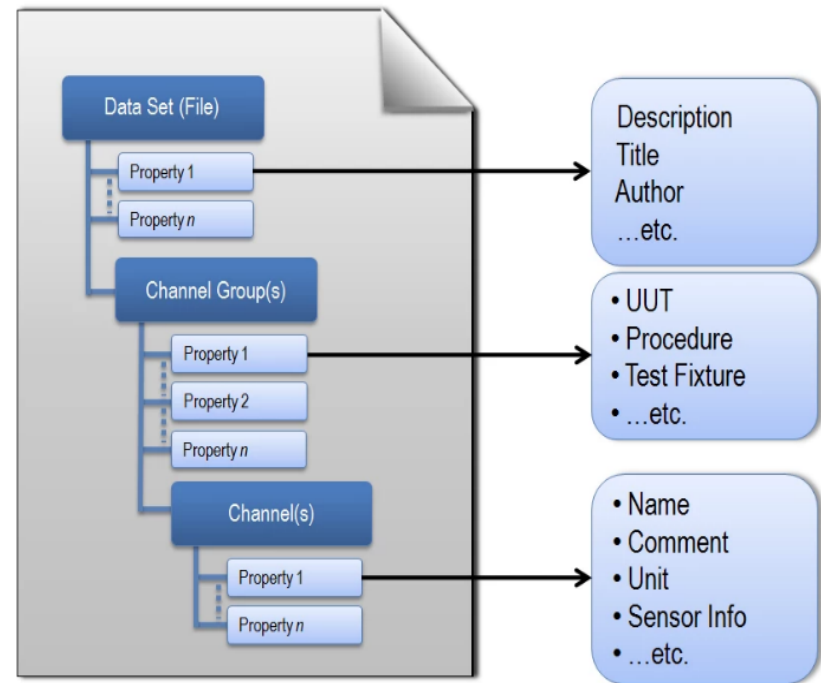
Data Set (File)
- Property 1
- Property n
→ Description / Title / Author / …etc.

Channel Group(s)
- Property 1
- Property 2
- Property n
→ • UUT • Procedure • Test Fixture • …etc.

Channel(s)
- Property 1
- Property n
→ • Name • Comment • Unit • Sensor Info • …etc.

Multi-Sensor Data Acquisition System for Process Monitoring

- Sensors deployed for DAQ test and evaluation

Measurement	Sensor	Sensing Range
Vibration	PCB Piezotronics high sensitivity accelerometer	0.5 Hz-10 kHz
Vibration	PCB Piezotronics modal array accelerometer	0.5-3 kHz
Acoustics	GRAS Sound & Vibration ½" Rugged Free-Field microphone	3.15-20 kHz @ 2dB
Acoustics	GRAS Sound & Vibration ¼" Free-Field microphone	4-80 kHz @ 2dB
Acoustics	GEM Infrasound logger	0.05-25 Hz
Seismic-acoustic	Raspberry Shake and Boom	Infrasound 1-44 Hz Seismic 0.7-44 Hz
Color	Atlas Scientific EZO-RGB Embedded Color Sensor	~425- ~750 nm wavelength
pH	Atlas Scientific pH 101P	0-14
Conductivity	Atlas Scientific Conductivity K 10	10 µS/cm-1 S/cm

Multi-Sensor DAQ Acquisition System for Process Monitoring

- During testing and evaluation, there were 12 inputs to the program.
  - 8 accelerometers
  - 4 microphones
- The limits of the hardware was pushed by setting the upper bound to the max sampling rate of 12.8kS/s/ch.
  - Tested data throughput
  - Tested data dropout
- This sample rate also gives the highest possible measurement fidelity.

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Multi-Sensor Data Acquisition System for Process Monitoring
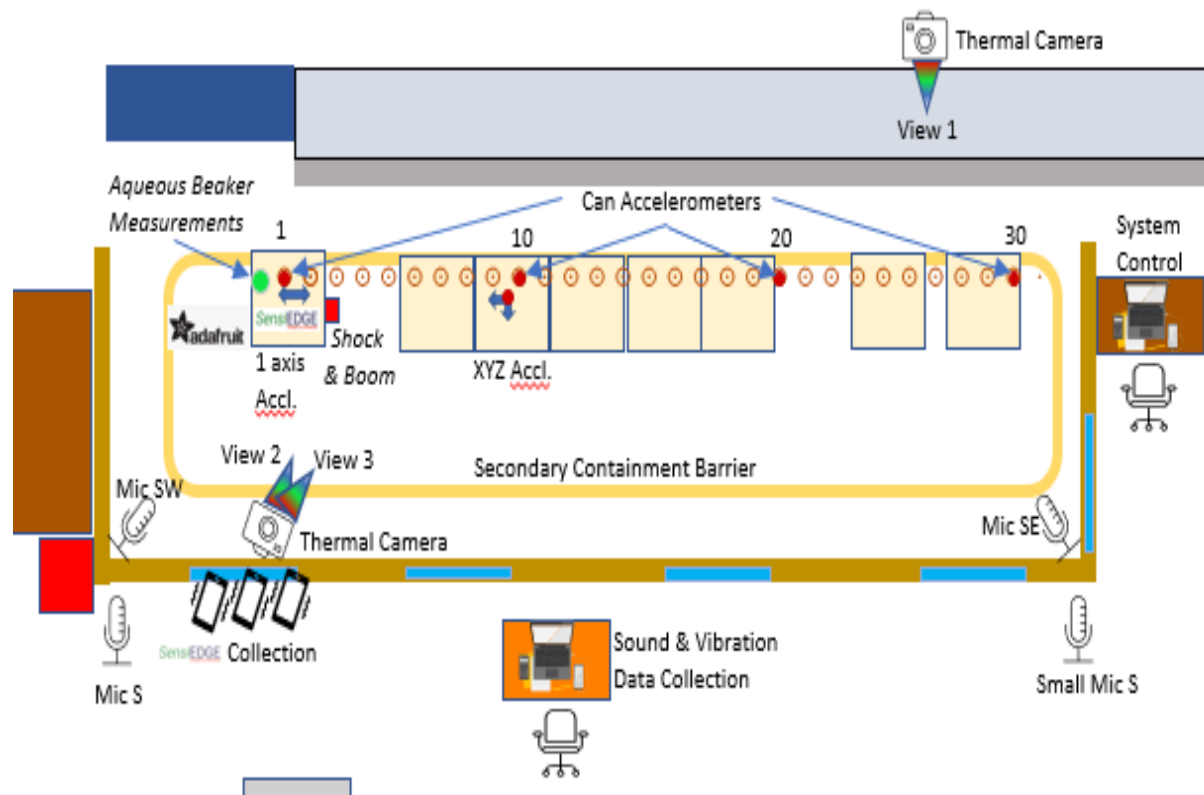
Testing and Evaluation set up

Multi-Speed DMA Acquisition System for Process Monitoring

- This accollected allowed the data to be buffered then saved to memory without any signal drops or loss of data.
  - Second level
- This was determined by confirming the delta between saved points which was 78.125us or 12.8S/s/ch.
  - Third level
  - Fourth level
- This sampling rate matched the vendors max sampling rate of the NI-9230 module.
  - Fifth level

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Multi-Sensor Data Acquisition System for Process Monitoring

- This software has also been written to be modular for allowing the addition or removal of sensors depending on experimental needs.

- The sampling rates can also be changed as needed.

- The picture to the right demonstrated how the TDMS filer was configured in this project.

- Click to edit text
  - Second level
    - Third level
      - Fourth level
        - Fifth level

File Parameters
File Name
Title & Author
Date & Time
GPS Time
Location
Experiment Notes

Sensor Parameters
Channel 0 Info
Channel 1 Info
Channel n Info

Sensor Data
Channel 0 Data
Channel 1 Data
Channel n Data
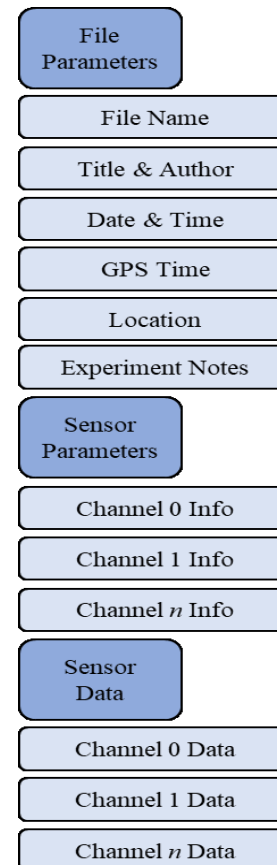
Multi-Sensor Data Acquisition System for Process Monitoring
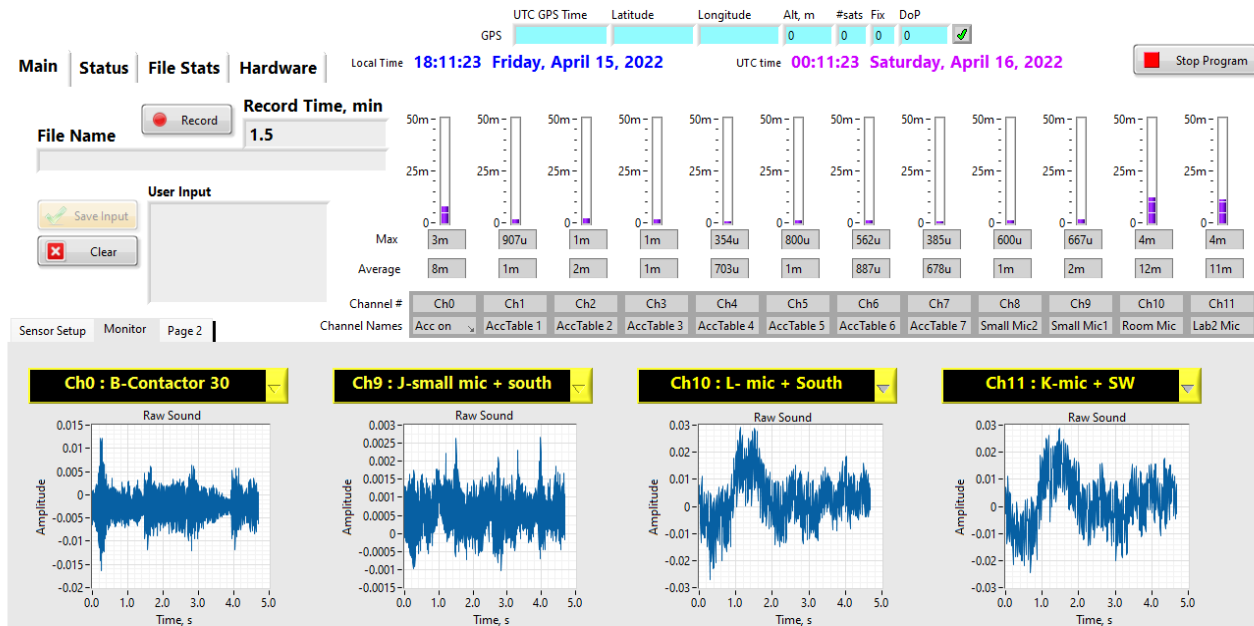
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- The GUI was also built to be user friendly.

- The GUI includes multiple tabs that show controls and indicators.

- This provides the operator with real time measurement data.

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Multi-Sensor Data Acquisition System for Process Monitoring

- As part of the fuel reprocessing test bed, this project is exploring the use of non-traditional sensors to monitor the solvent-extraction process.

- A robust DAQ system is necessary to allow for the collection and storage of large data sets.

- The robust DAQ system is essential, not only due to the multiple sensor types, but also for the high sampling rates of each sensor.

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