Annular Core Research Reactor Instrumentation & Control Systems

SAND2007-6062C

Pulse Diagnostics System Upgrade

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Abstract

Sandia National Laboratories (SNL) and PrimeCore Systems have developed a pulse diagnostic measurement system for the SNL Annular Core Research Reactor based on PXI instrumentation and leveraging ZTEC ZT410PXI modular oscilloscopes. The power and flexibility of the PXI platform and the ZT410PXI 16-bit, 400 MS/sec instrument enabled SNL and PrimeCore to replace and decidedly improve an aging system based on 8-bit benchtop scopes, amplifiers, and long cable runs. The SNL Annular Core Research Reactor allows scientists to perform experiments and test components under extreme radiation exposure. The research reactor is used to perform in-pile experiments for radiation effects, reactor development, and safety requirements. These experiments are conducted by "pulsing" the reactor, which allows for extremely high power levels to be achieved for short periods of time. This power then decays exponentially over time.

To ultimately capture the power measurements, Self Powered Neutron Detectors (SPND) are placed just outside of the reactor core. They generate currents that are proportional to the neutron flux of the reactor, which can be related to the reactor power. The system employed by SNL and PrimeCore then amplifies and converts the current to voltage using termination resistors, a PXI current amplifier, and an external programmable current amplifier. This method allows them to capture many different ranges and conditions. Finally, the high-resolution ZTEC ZT410PXI modular oscilloscopes acquire the voltage measurements and transfer the data to a control computer for processing.

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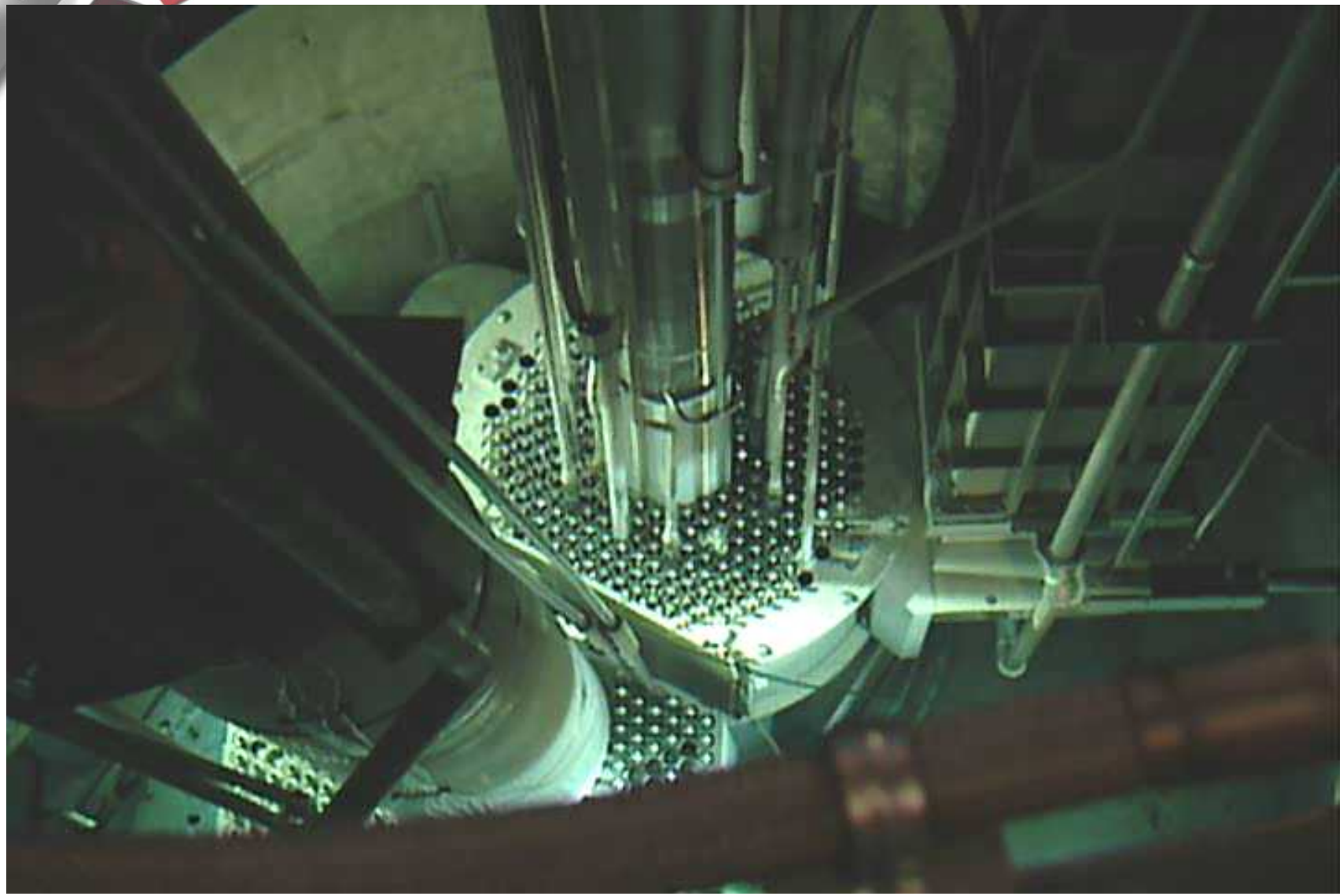

Need to include mpeg file on thumb drive to make video work.

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Pulse Diagnostics System Upgrade

Annular Core Research Reactor

- ~500 pneumatic operations/yr
- ~380 reactor pulses/yr
- Pulses: 30,000 MW peak power, 7-7.5 msec pulse width, 280-310 MJ (Safety Limit: 500 MJ, 60,000 MW)
- Steady State: Currently limited to 2.0 MW, have run as high as 4.0 MW.

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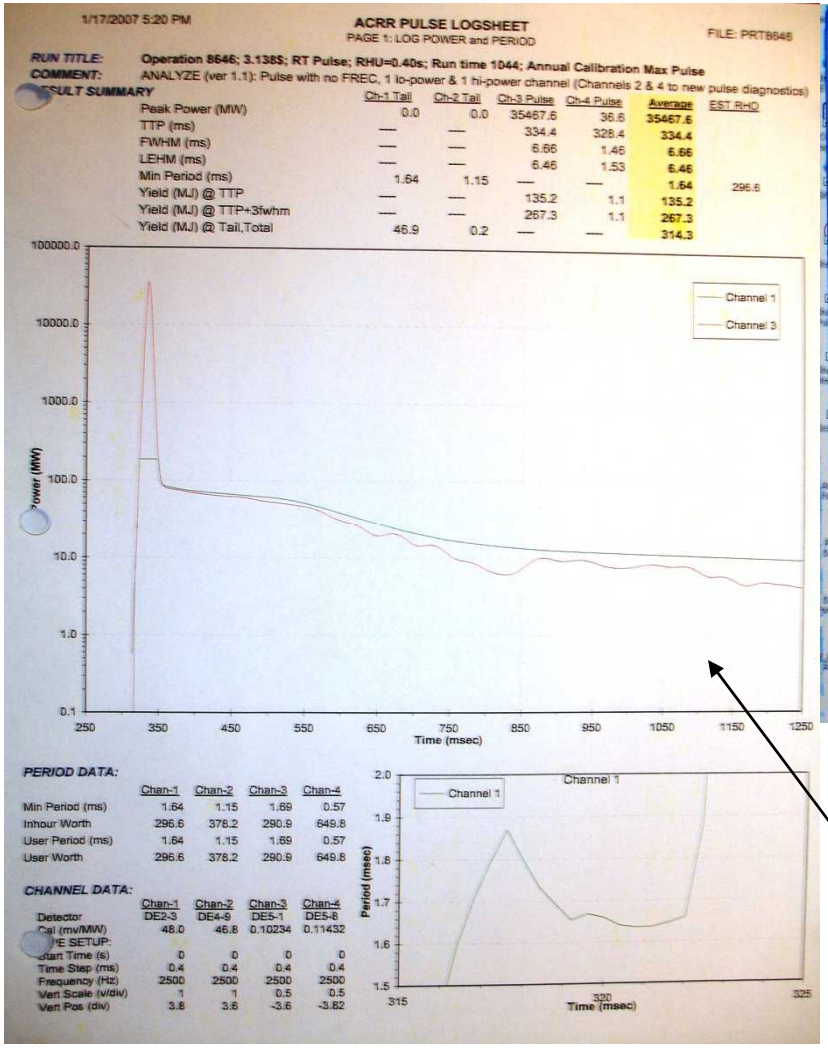
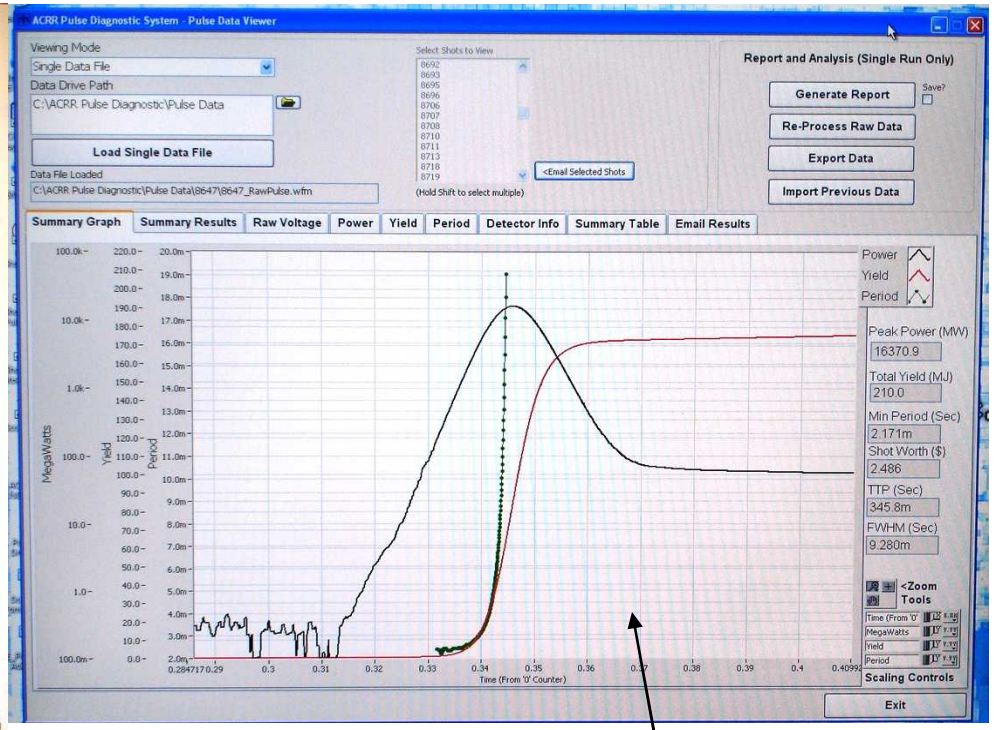
Pulse Diagnostics System Upgrade

- Why upgrade old system?
  - Replace Aging system
  - Upgrade Instrumentation
  - Improve Resolution and Accuracy, Reduce Noise
  - Improve and simplify user interface
  - Provide simple system calibration

Pulse Diagnostics System Upgrade

- **System Output Comparison**





~ 640,000 data points

~ 12,000 data points

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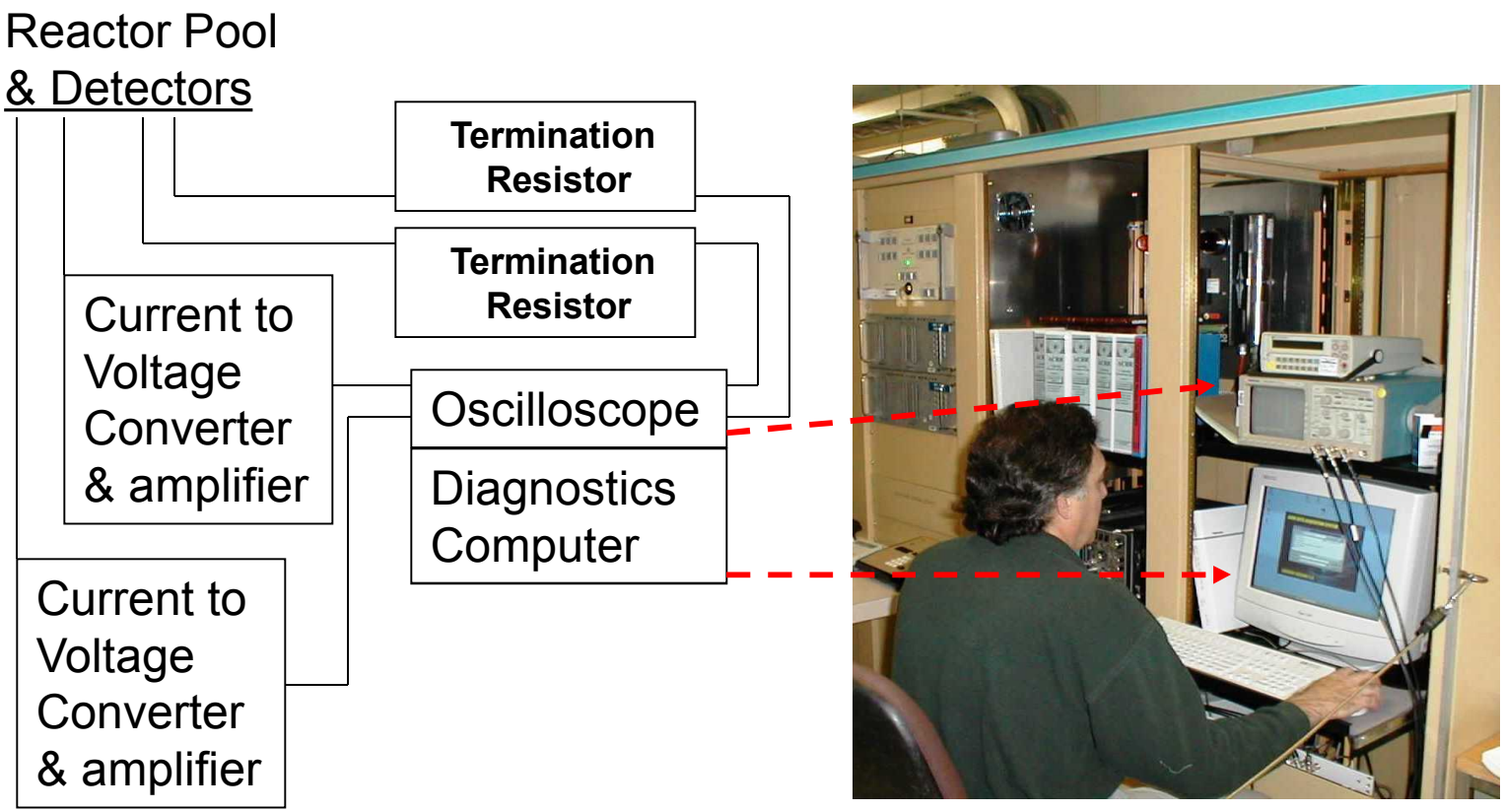
Previous Pulse Diagnostic System



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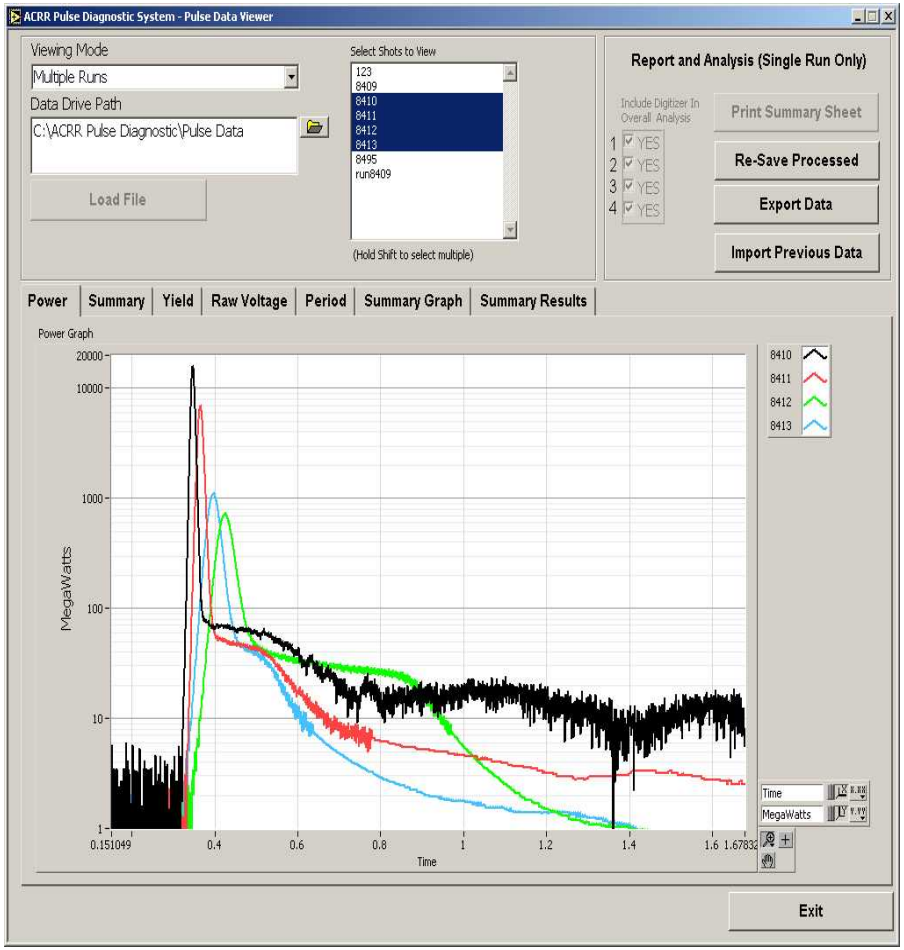
Pulse Diagnostics System Upgrade



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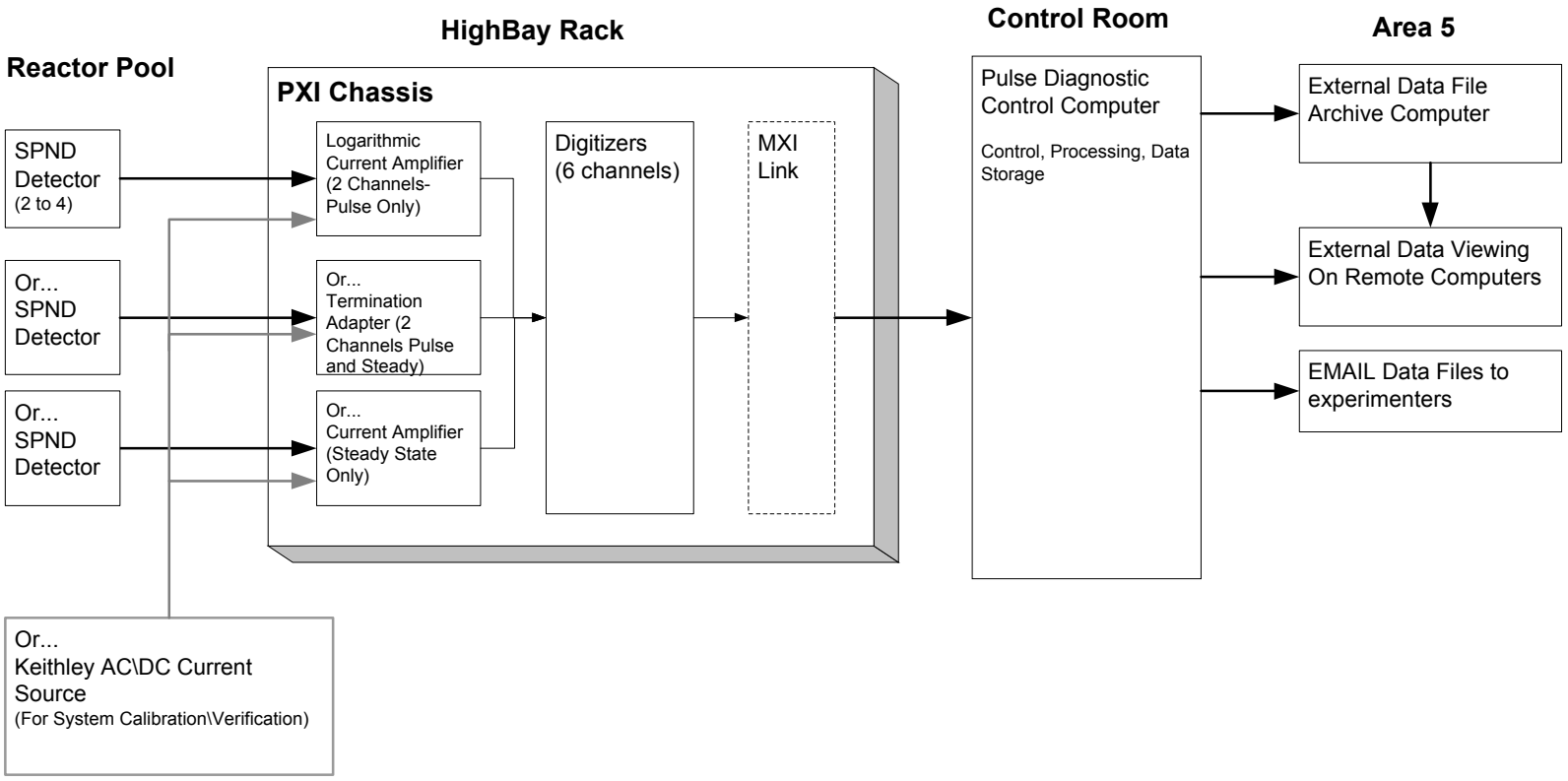
System Overview



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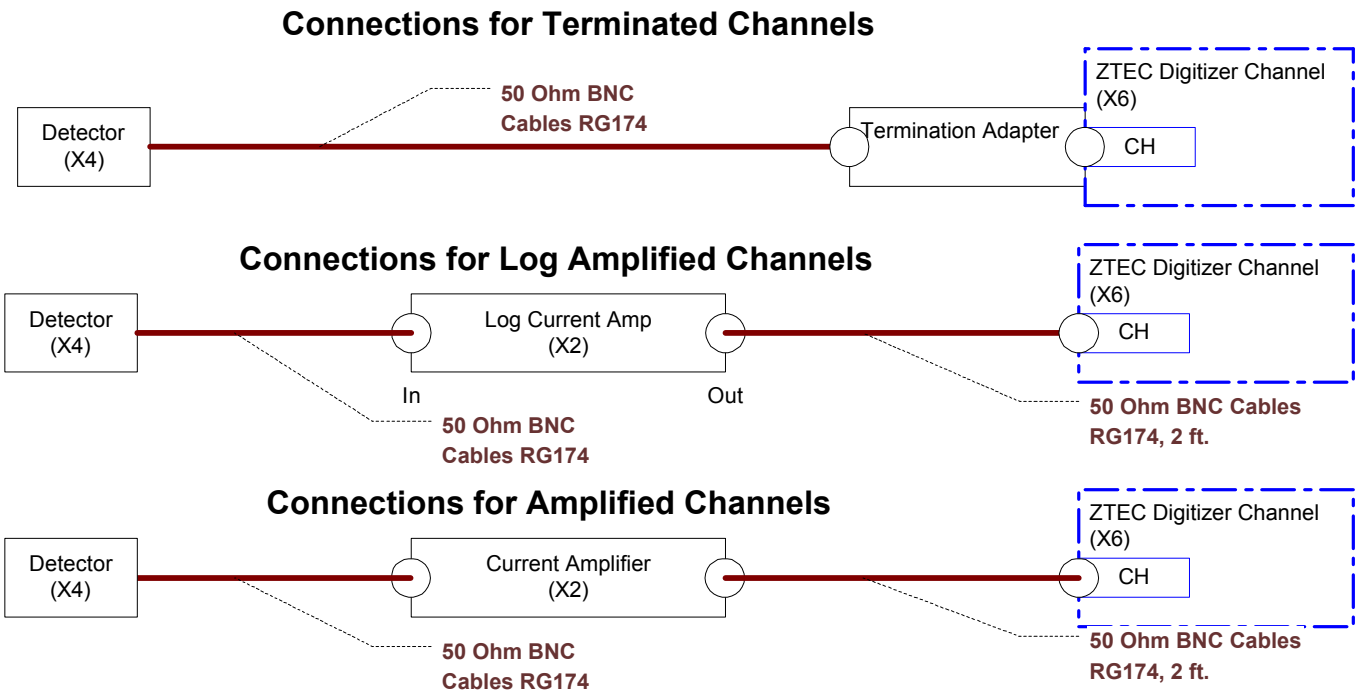
Key Hardware Improvements

- **Reduced Cable Run**
  - Instrumentation is located in High Bay.
  - Cable run is reduced, reducing system noise and capacitance.
  - Fiber optic connection from instruments to computer in control room.
- **Improved Digitizers**
  - 8 bit scope replaced by 16 bit digitizer.
  - Digitizer accuracy approximately 0.25% compared to >2%.
  - Modular Instruments, Installed spare.
- **Log Amplifiers**
  - Converts 10 na to 10 ma to .4 to 1.4 Volts
  - Provides even resolution across 6+ decades of range. Approximately 5000 bits\decade of resolution compared with 512 bits (in 2 separate ranges) of resolution in the old system.

Interconnect Diagram



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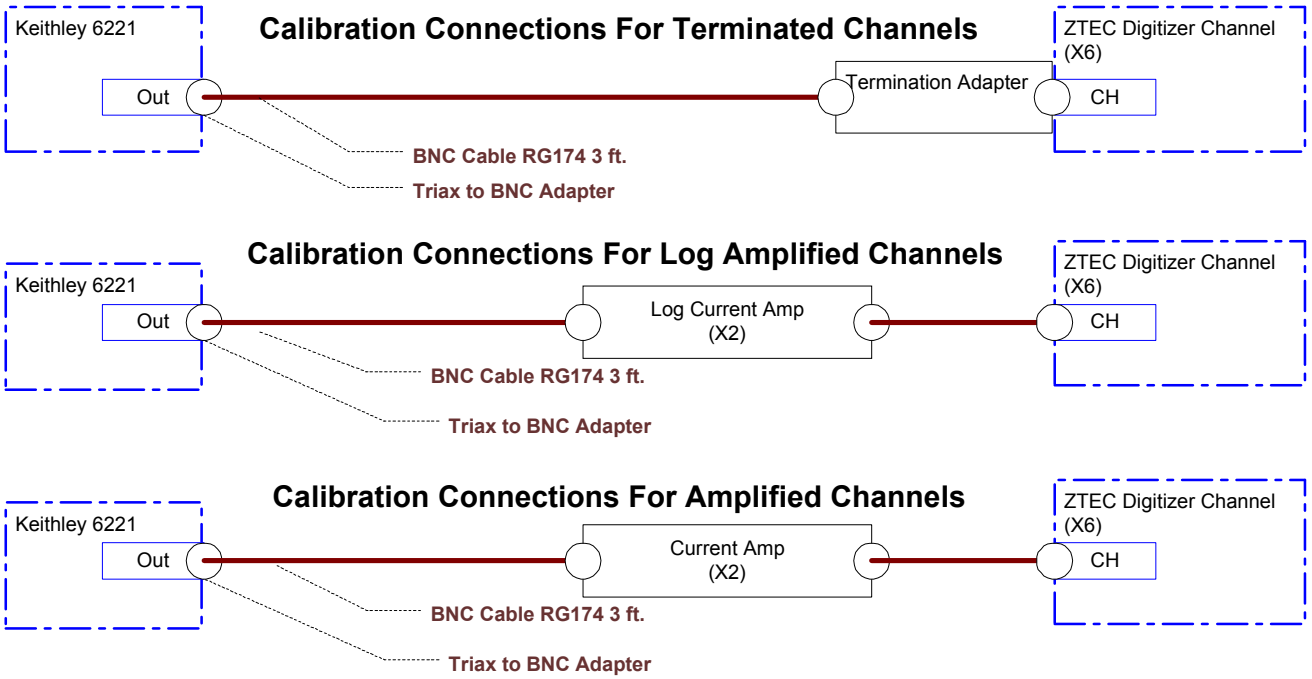
Calibration Interconnect Diagram



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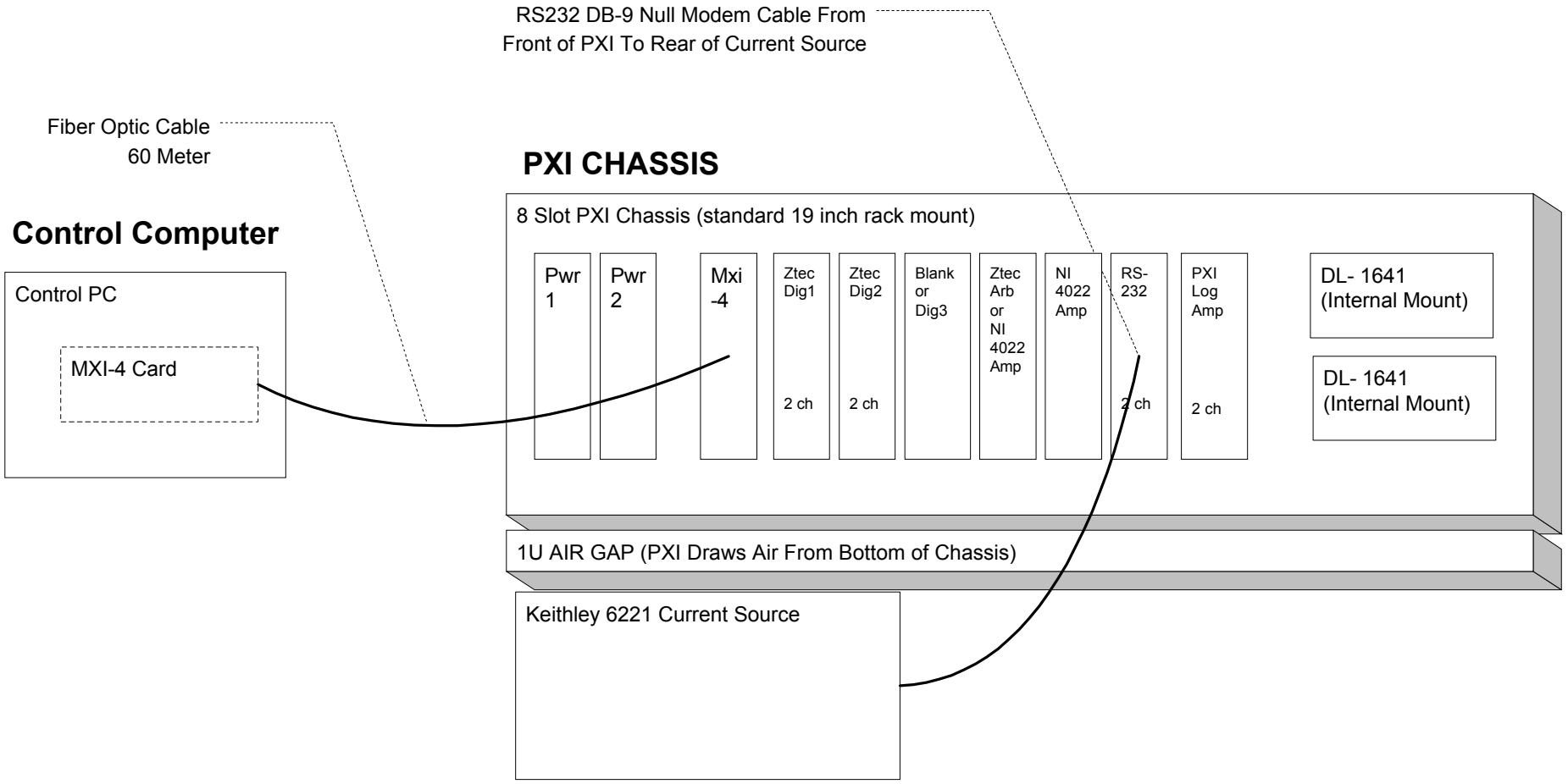
PXI Instrument Layout



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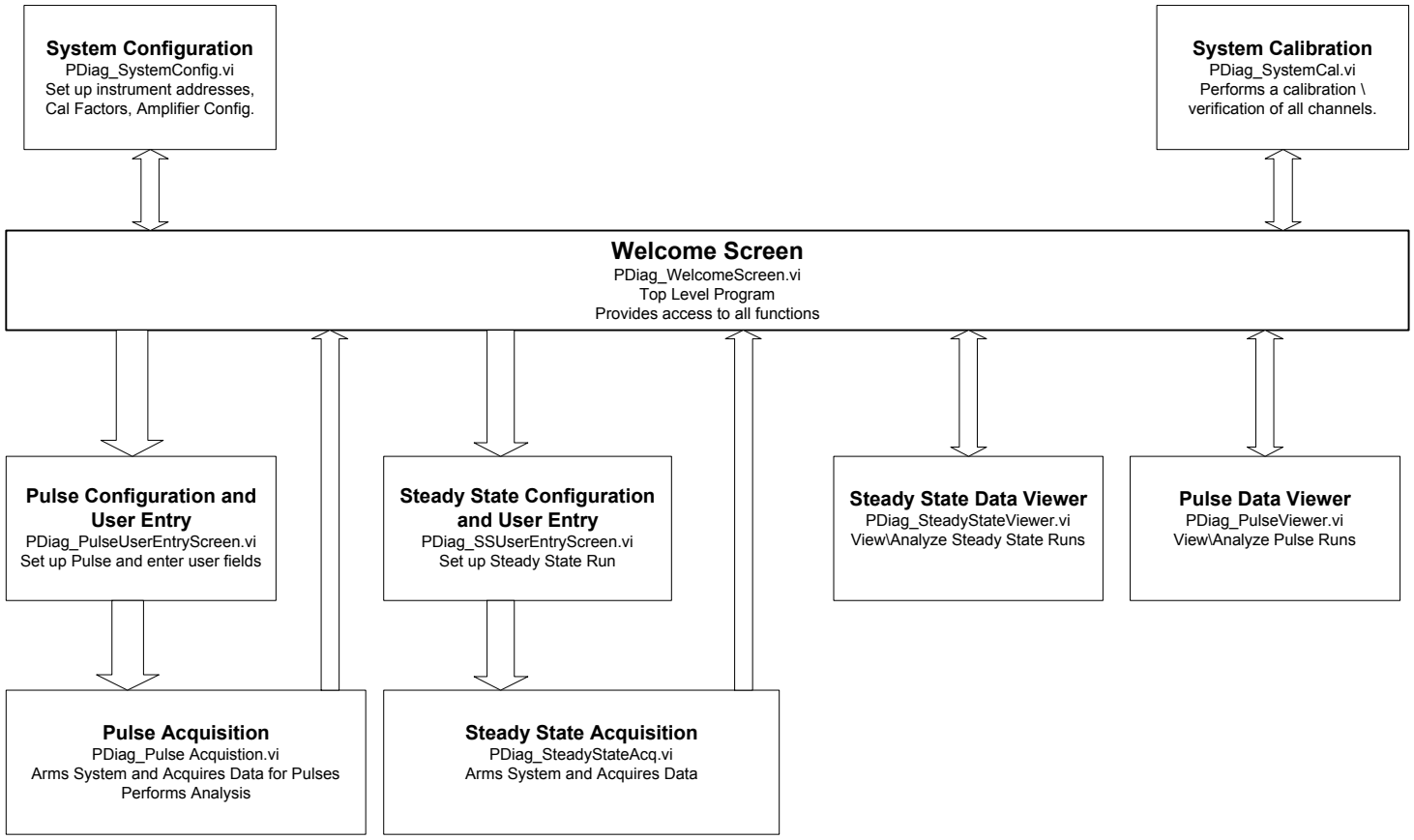
Key Software Improvements

- **Integrated System**
  - Single application runs the system, processes the data, views and manages data.
  - System calibration \ verification is built into the software package.
  - Excel is used as a post analysis and printing tool. It is not used for signal processing and calculation.
  - Predictive Calculations embedded in program.
- **Source Code Control and Installation**
  - System will be an executable program with an installation package for recovery.
  - Algorithms will be “locked” with the executable. Can only be changed with a new revision and release.

Software Flow Diagram



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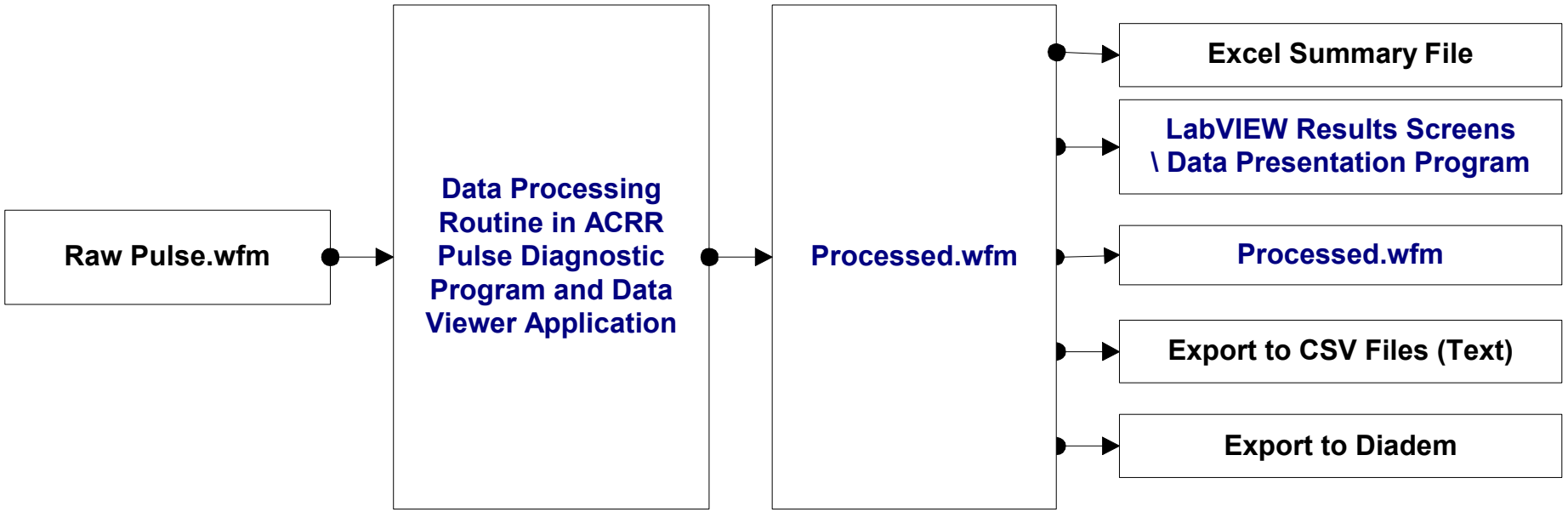
Data Processing Flow

Logic Flow for Data Processing



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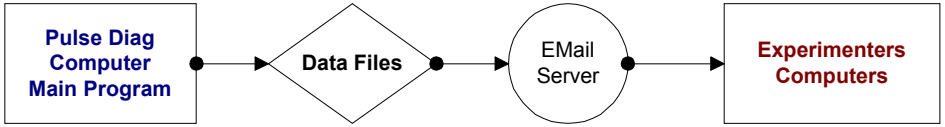
Data Viewing Methods

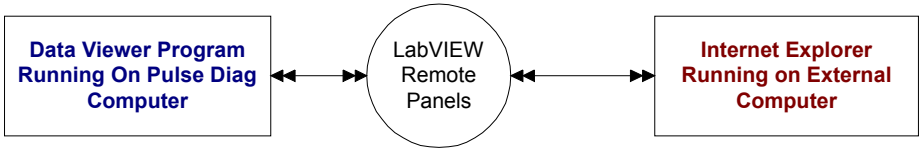
Data Viewing Methods

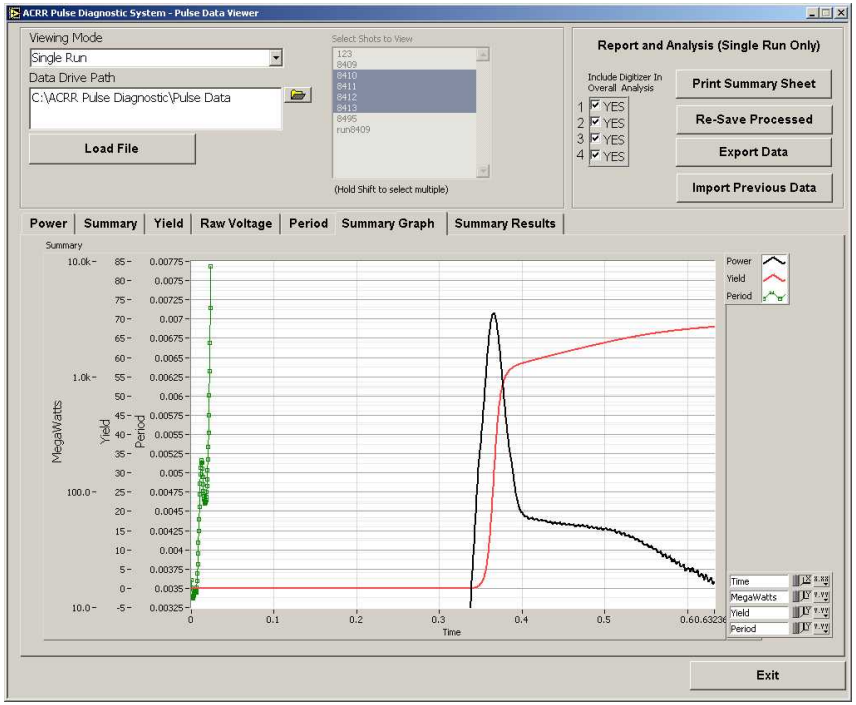
Use Pulse Diagnostic Machine or Network drive as a file server: The data viewer application can be installed on other machines and use the data files from the pulse diagnostic computer. .



EMail Excel files to experimenters.

OPTIONAL????





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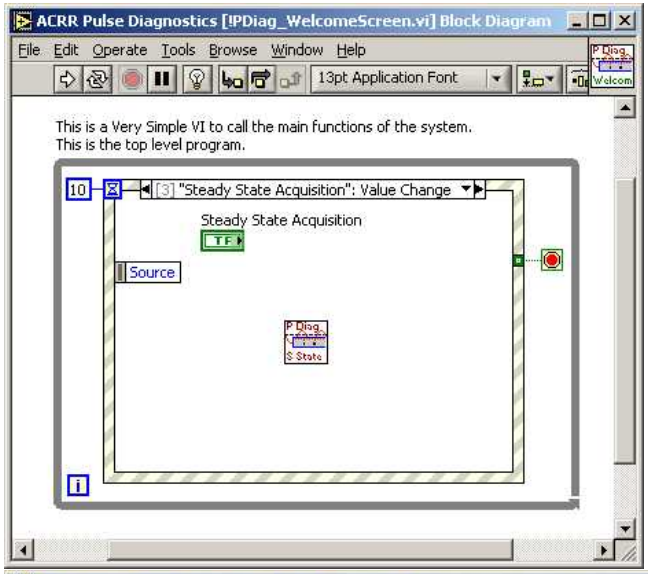
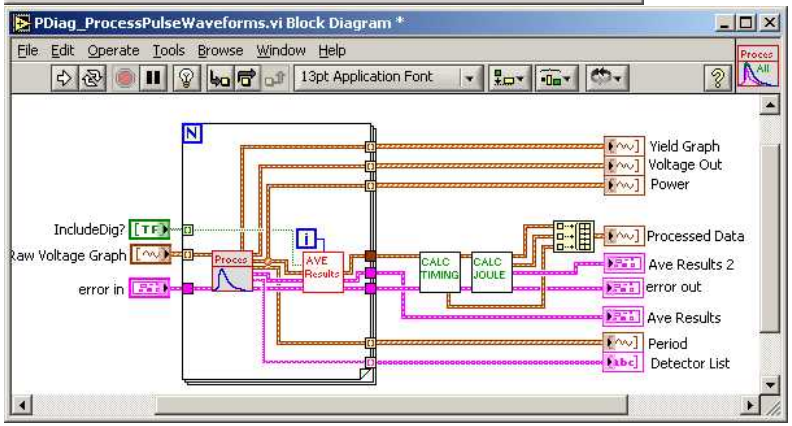
Software Design\Implementation

- Simple Architecture, Clean Program. Basic event driven interfaces with simple state machines.
- Object based data flow.
- Modular programming.
- Basic Documentation in Code
- Source Code Delivered to ACRR
- LabVIEW 7.1





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Pulse Diagnostics System Upgrade

- Acceptance Testing Results to Date? Not sure if we need this slide?

Pulse Diagnostics System Upgrade

- **Future Work**
  - **Allow for measurement in Transient Rod Withdraw Submode.**
  - **Obtain better results for Steady-State operations <5% Rx Power.**
  - **Procure new larger SPND, install, and configure.**

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End result:
Pulse Diagnostics
Operational!!!

A job well done to all involved!!!

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Questions???

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