Bergmans Mechatronics LLC

LabVIEW-Based Instrumentation for Large-Scale Combustion Diagnostics

John Bergmans

Bergmans Mechatronics LLC

www.bergmans.com

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1616 Bedford Lane, Unit A
Newport Beach, CA 92660

Phone: 714-474-8956
Fax: 949-646-1429

Introduction

BML

- Bergmans Mechatronics LLC specializes in the development of custom LabVIEW software and instrumentation products

- Current BML products for large scale combustion diagnostics
  - LTS-100 Laser Temperature Sensor and
  - Laser Alignment System

- Objective of presentation: Illustrate use of LabVIEW and NI hardware for specialized instrumentation applications

LTS-100 Laser Temperature Sensor BML

Processing Unit in
Power Plant Terminal Room

- Employs Tunable Diode Laser Absorption Spectroscopy (TDLAS) for Measurement of gas temperatures up to 3000 °F
- Designed for temperature measurements in power plant boilers and refinery heaters
- Testing performed along 48 foot path at Ameren Sioux Station near St Louis, MO
- LabVIEW-based software
- Core TDLAS technology developed by MetroLaser, Inc., Irvine, CA

Theory of Operation

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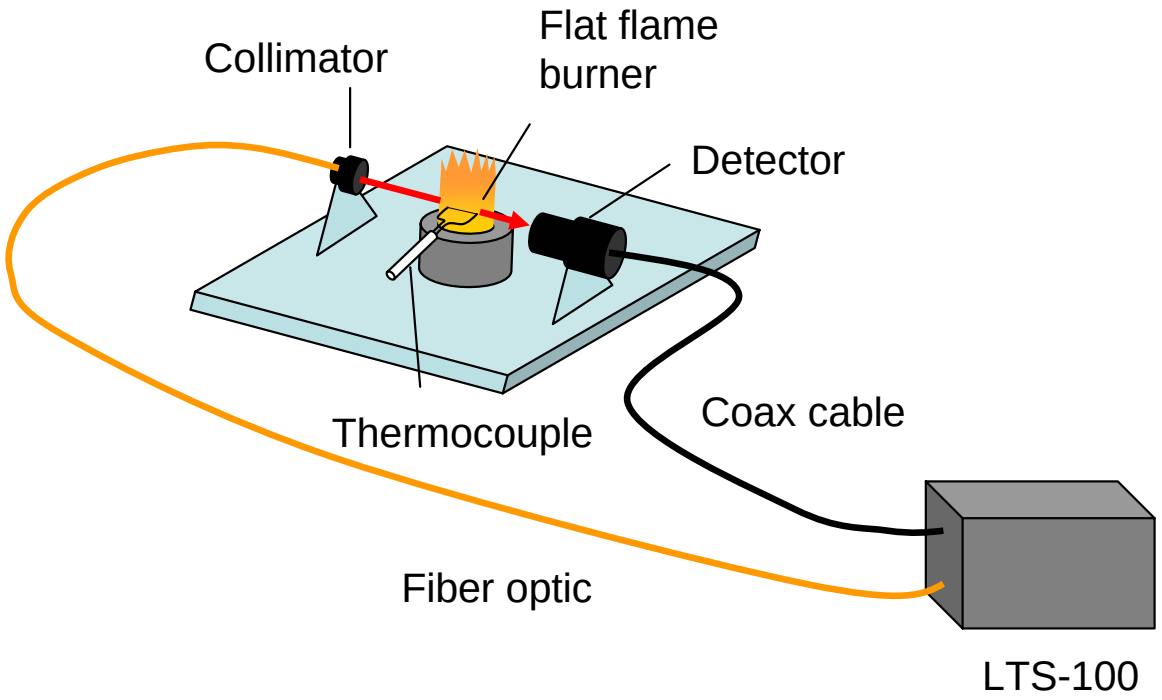
LTS-100 Laser Temperature Sensor employs two-line TDLAS to measure temperature and H_2O concentration

Calibration testing using flat flame burner:



Theory of Operation

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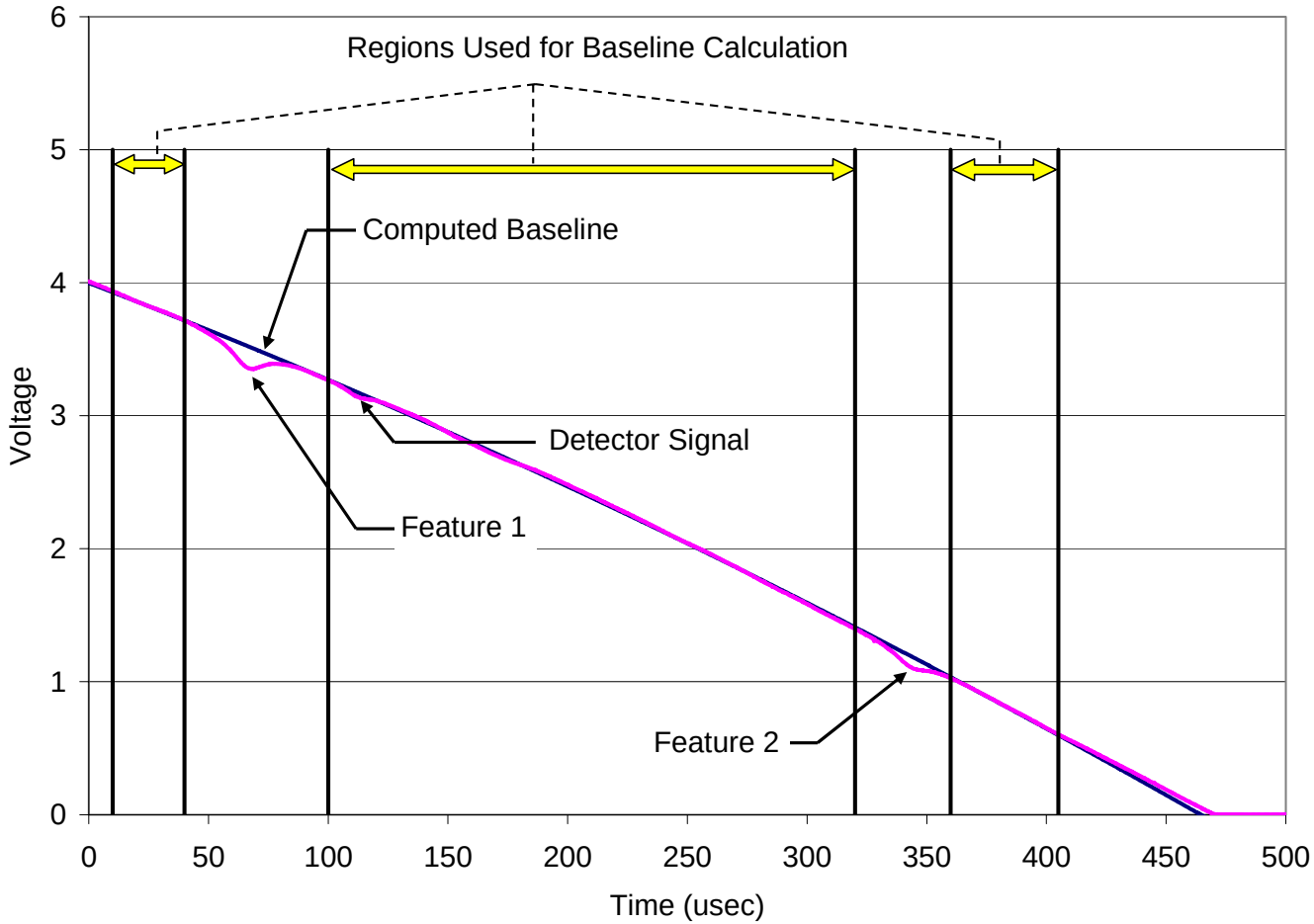
Detector signal during calibration (TC = 2578 °F)



Absorbance:

$$\alpha_\lambda = -\ln\left(\frac{I(\lambda)}{I_o(\lambda)}\right)$$

Theory of Operation

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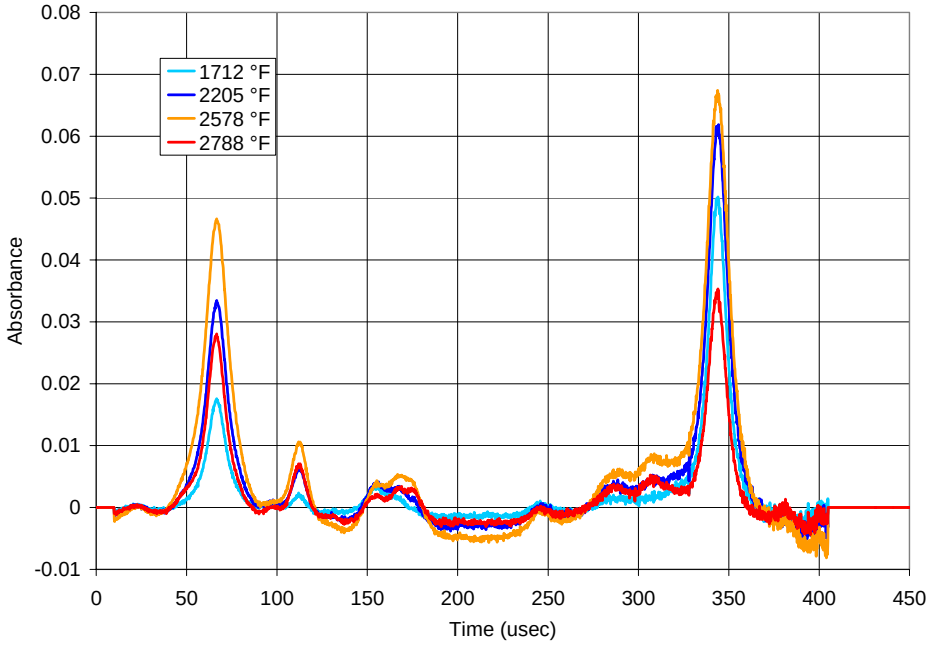
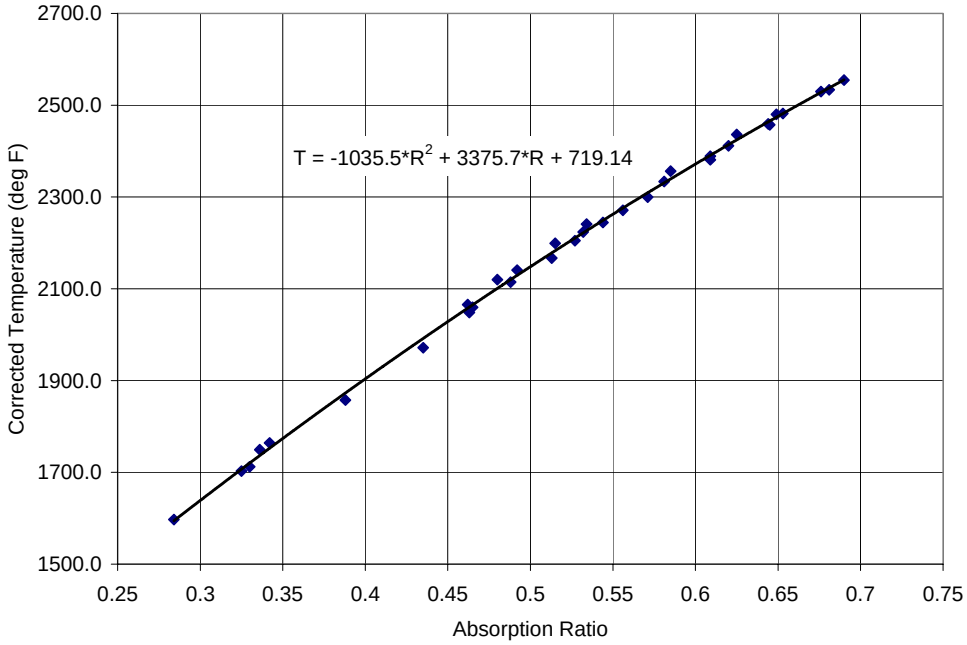
With constant temperature along beam path, ratio of absorbance under two absorption peaks is a function of temperature:

$$R = \frac{A_1}{A_2} \approx \frac{S_1(T)}{S_2(T)}$$

Typical Calibration Spectra



Calibration Curve



Combustion Laboratory

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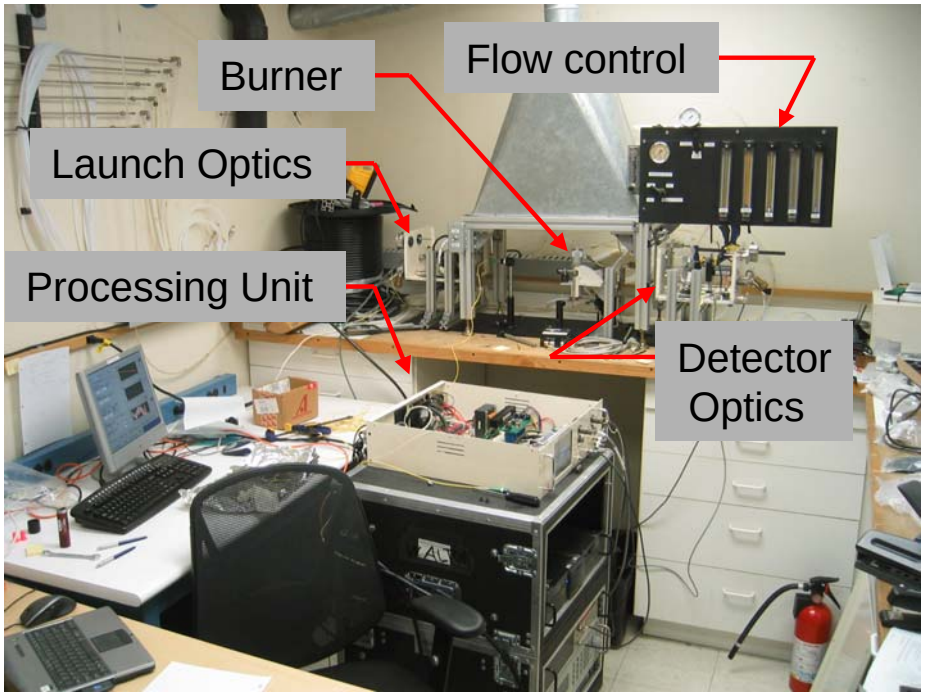
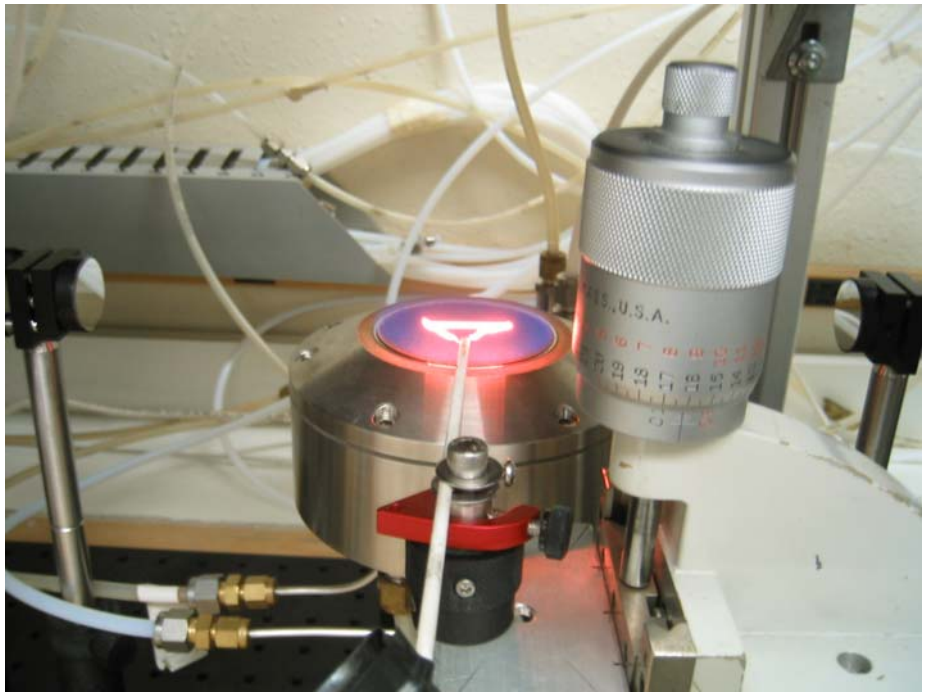


LTS-100 and
Calibration Apparatus



Temperature Measurements
on Flat Flame Burner

Laser Alignment System

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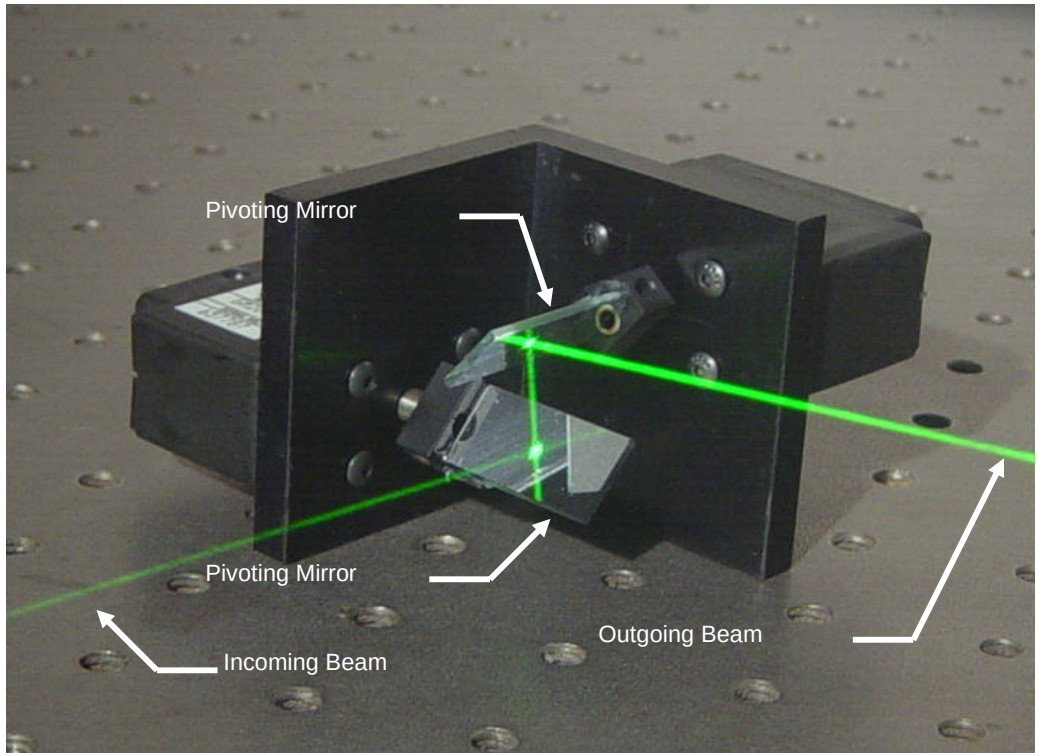
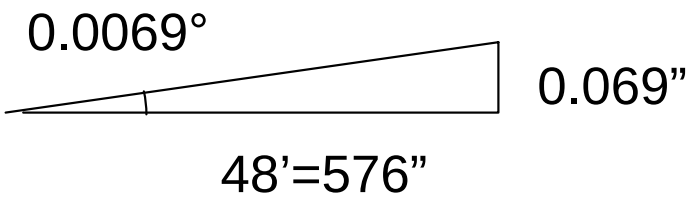
- Computer controlled two-axis scanner
- Angular resolution: 0.0069° (0.069” at 48 feet)
- Range of motion: ±13.7°
- Two operating modes: Raster Scan and Optimization





User Interface

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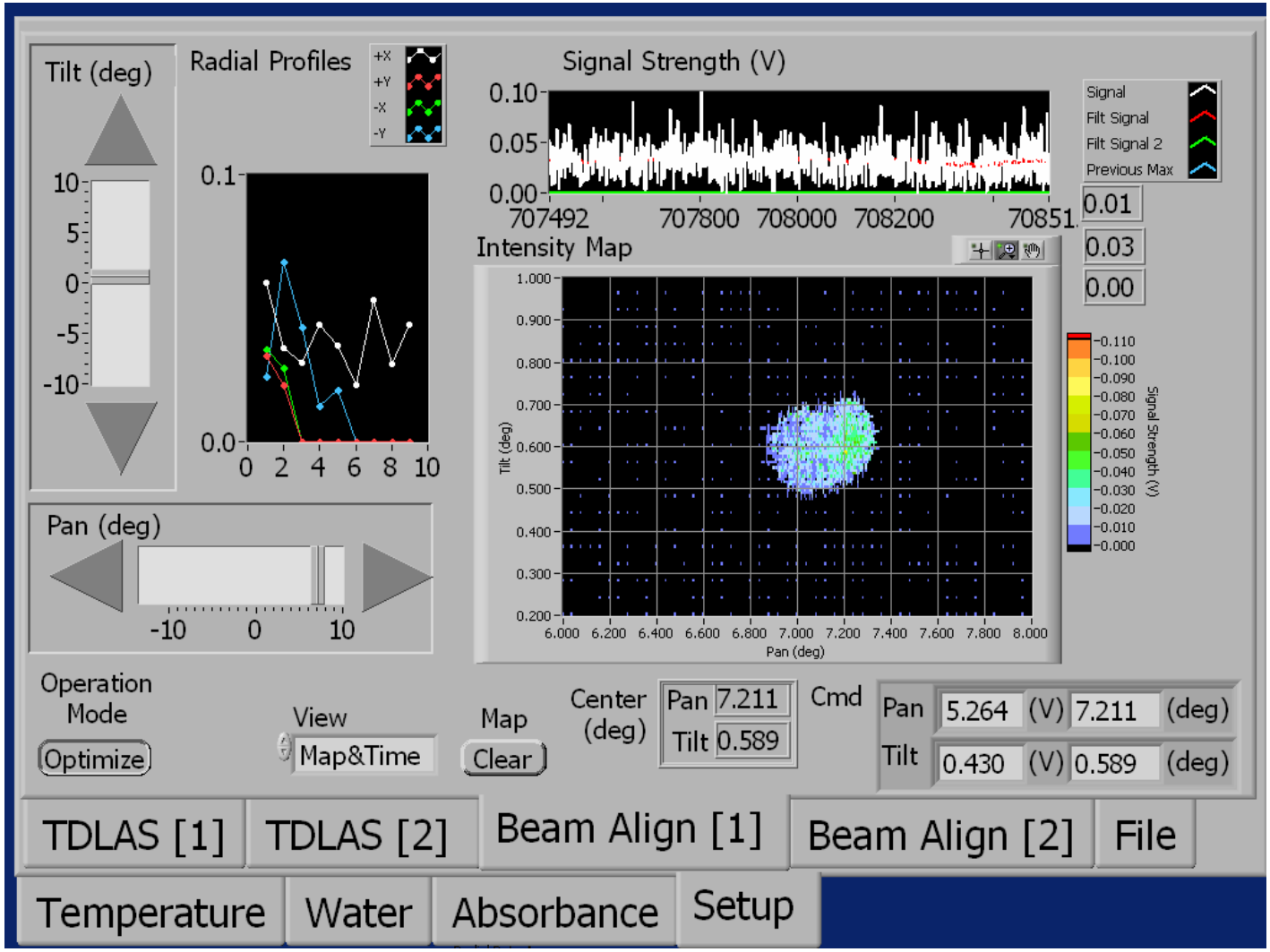
- 6.4” touch screen display
- Multi-layer tabs allows easy access to all system controls and displays
- Intensity plot for visualization of alignment process



LTS-100 Hardware Overview

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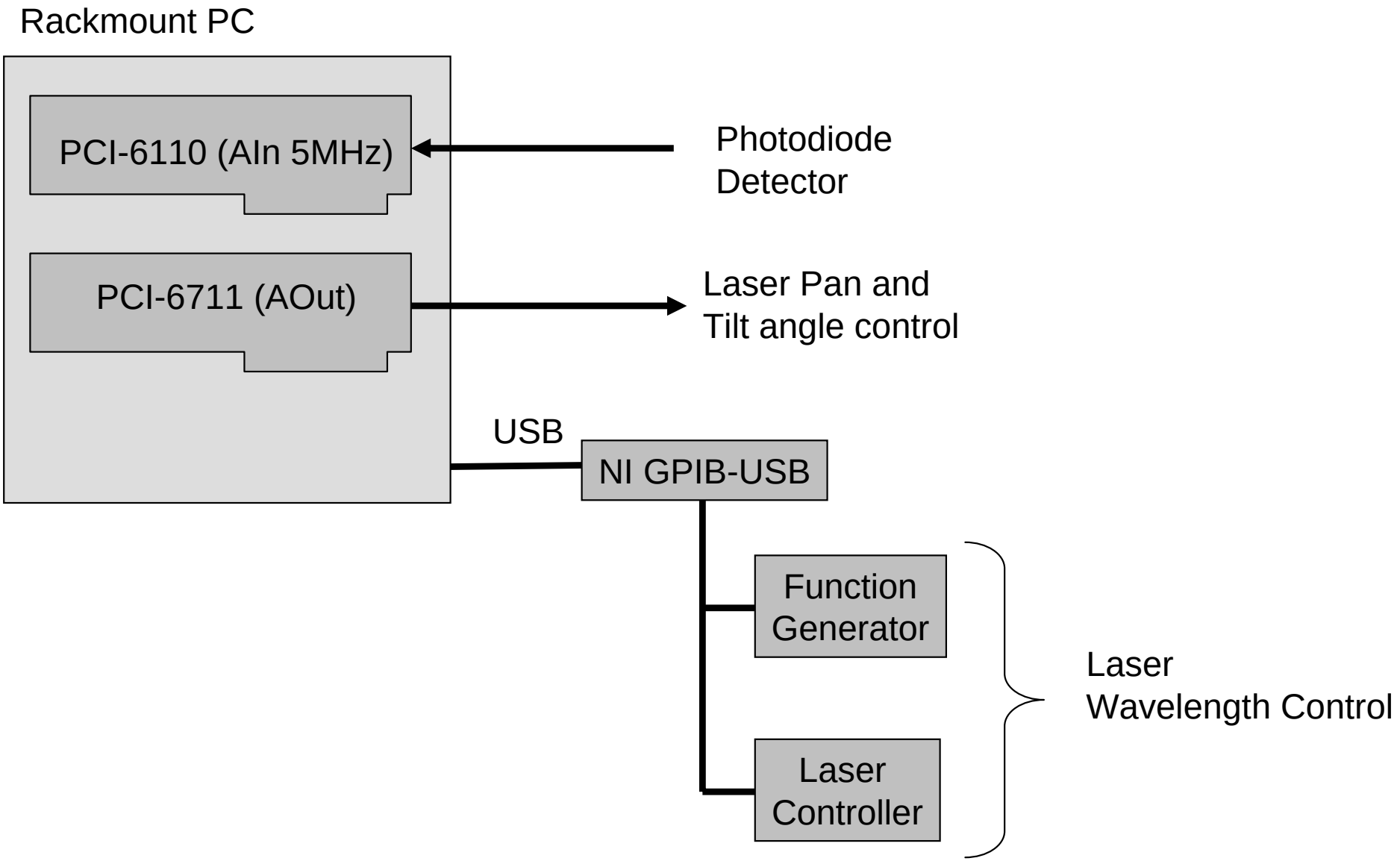

States of Main Software Loop

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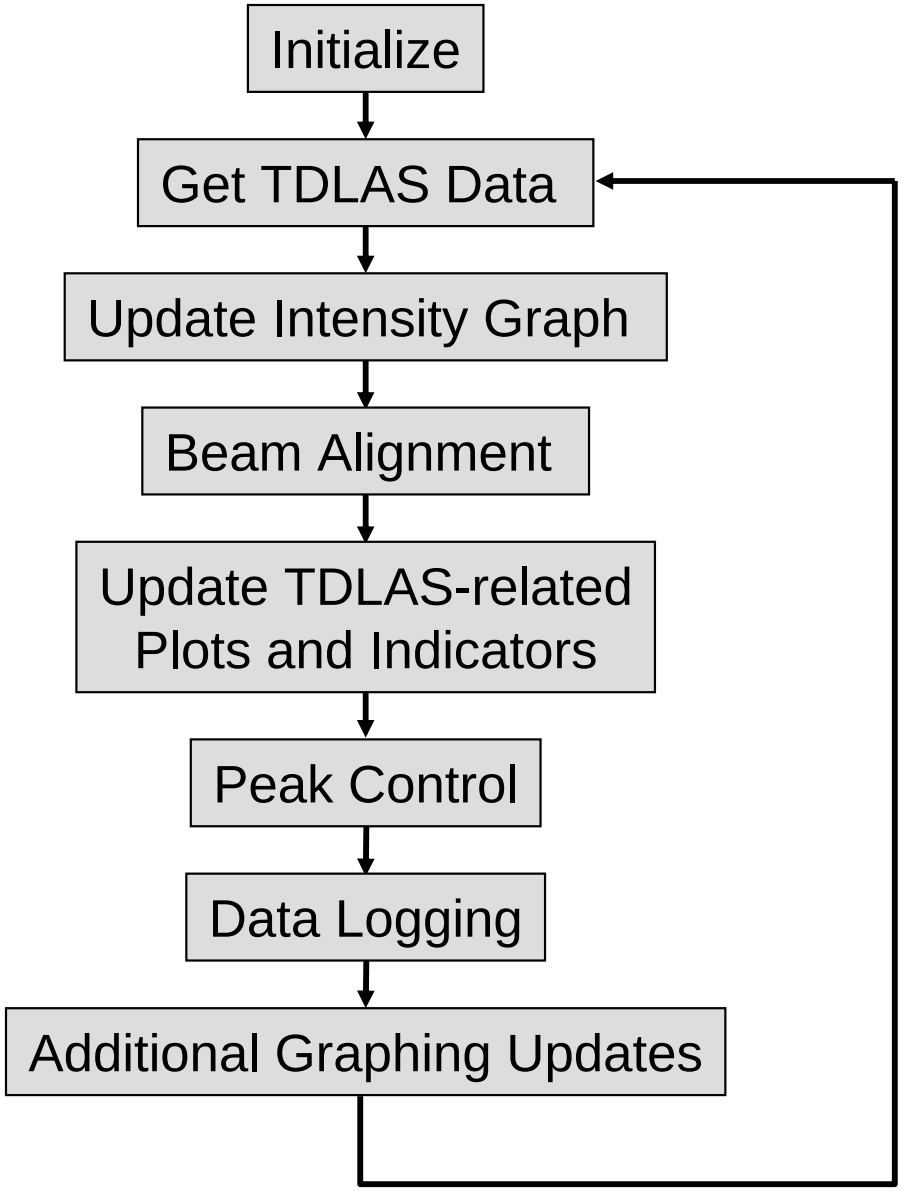

Ameren Sioux Station Testing

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- Located north of St Louis, MO, on Mississippi river
- Two, coal-fired, cyclone units
- Each unit nominally rated at 485 MW

Ameren Sioux Station Overview

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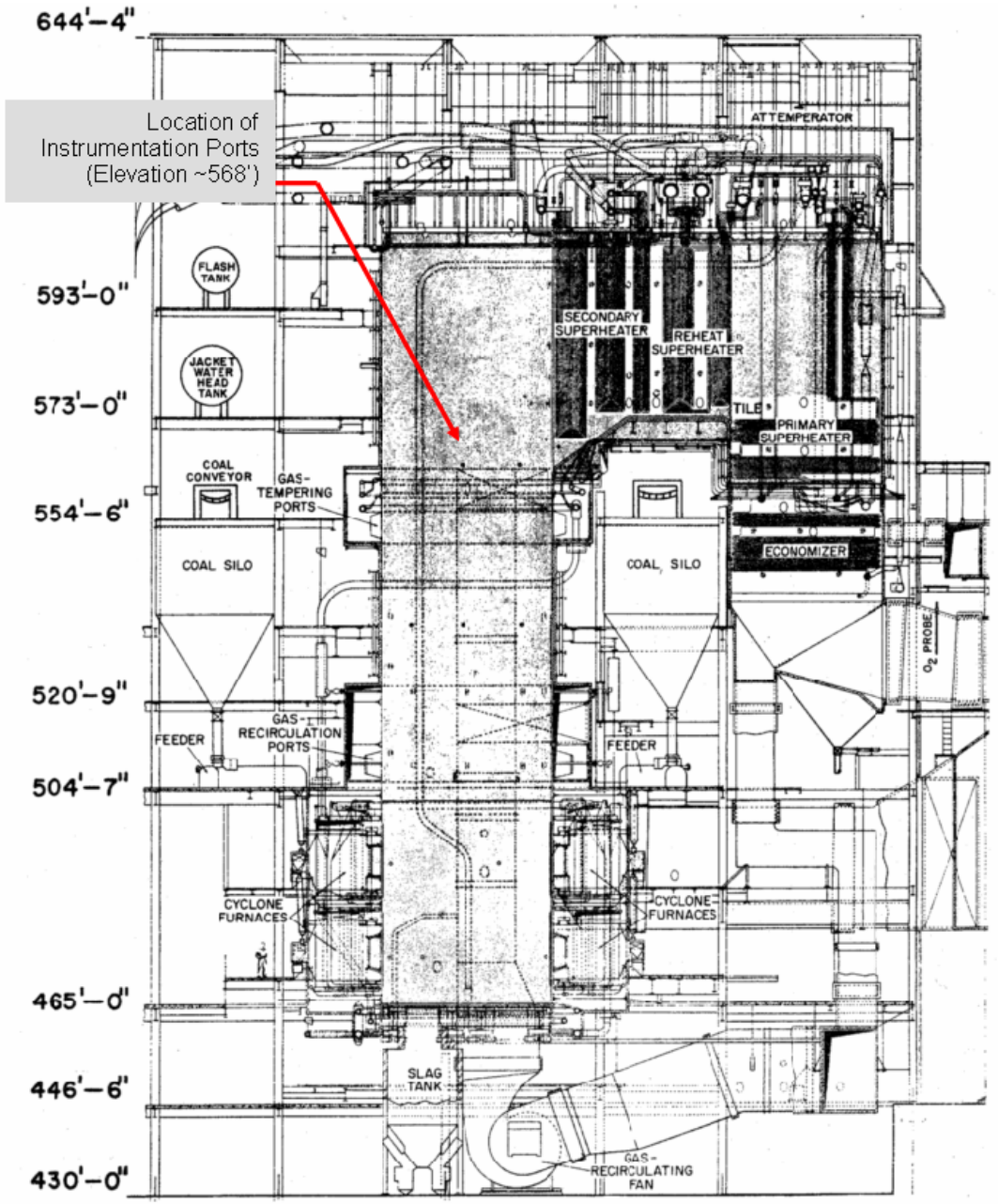
- LTS-100 tested on Unit 1
- Beam passed from side to side over 48 foot width of boiler
- Testing performed from end of Aug 2007 to beginning of Sep 2007
- Possible applications for temperature measurement - slag prevention and SNCR support



Installation at Sioux Station

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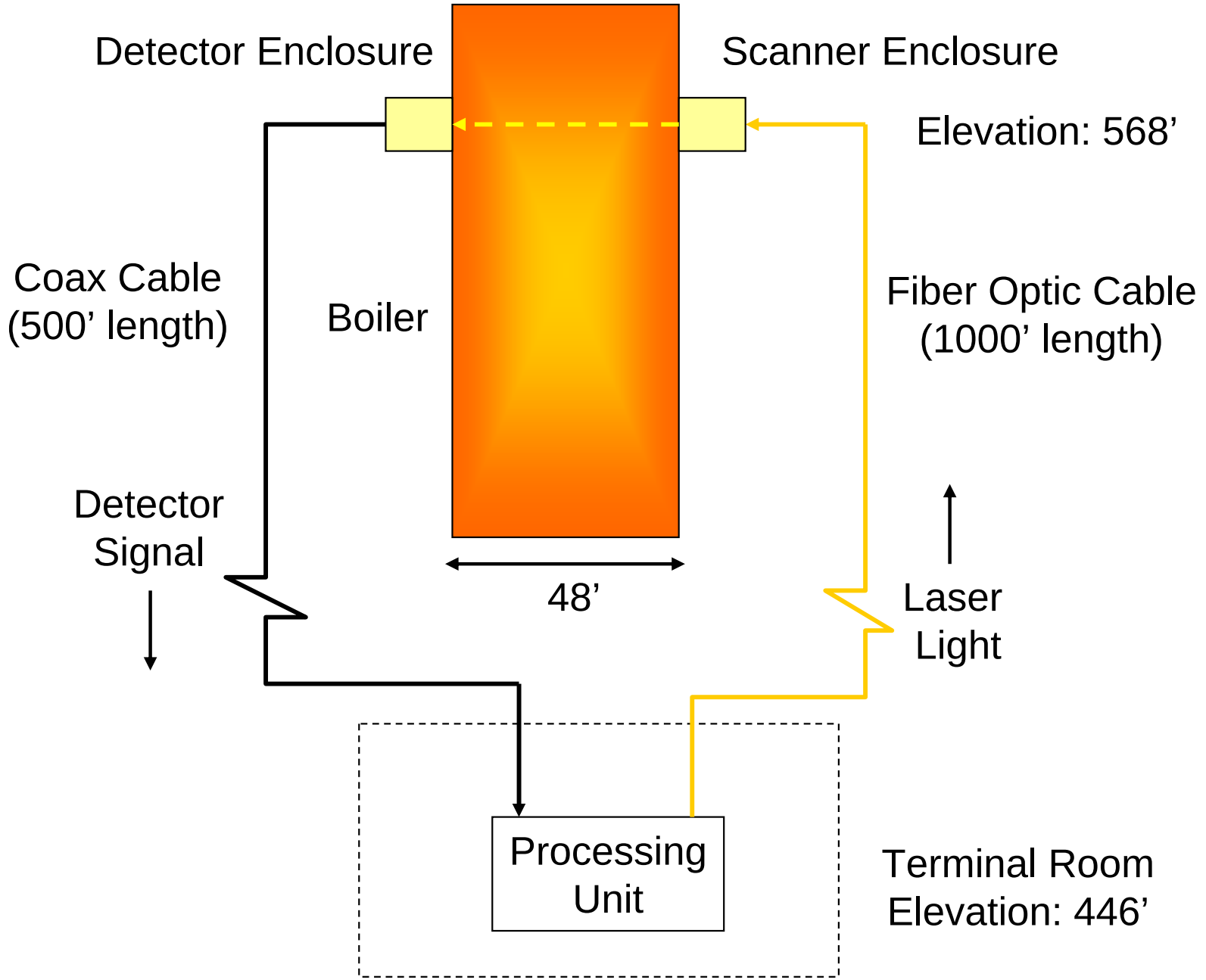

LTS-100 Hardware

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Processing Unit in
Terminal Room

Detector Optics Enclosure
on Boiler

Temperature and Load Data

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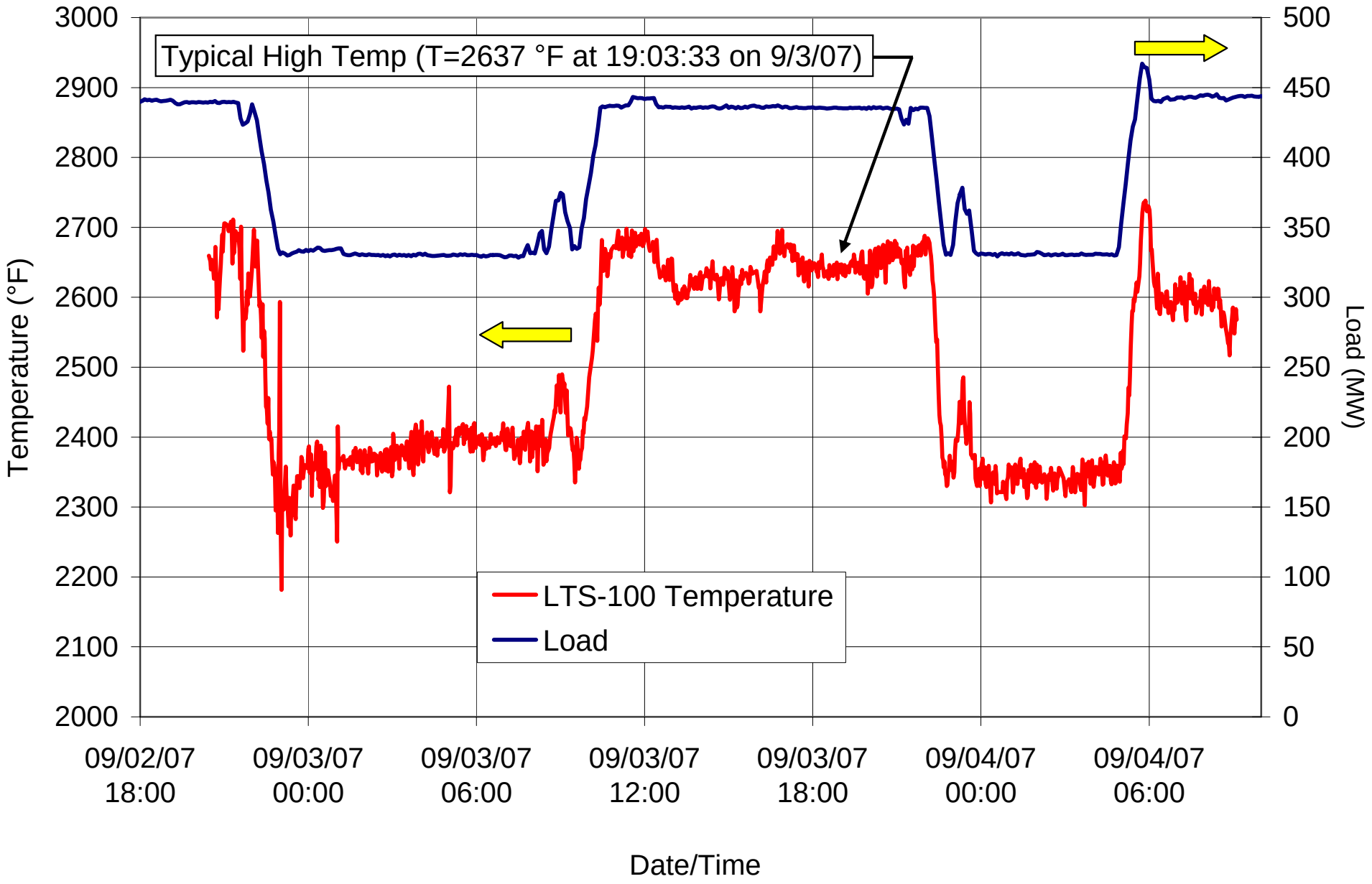
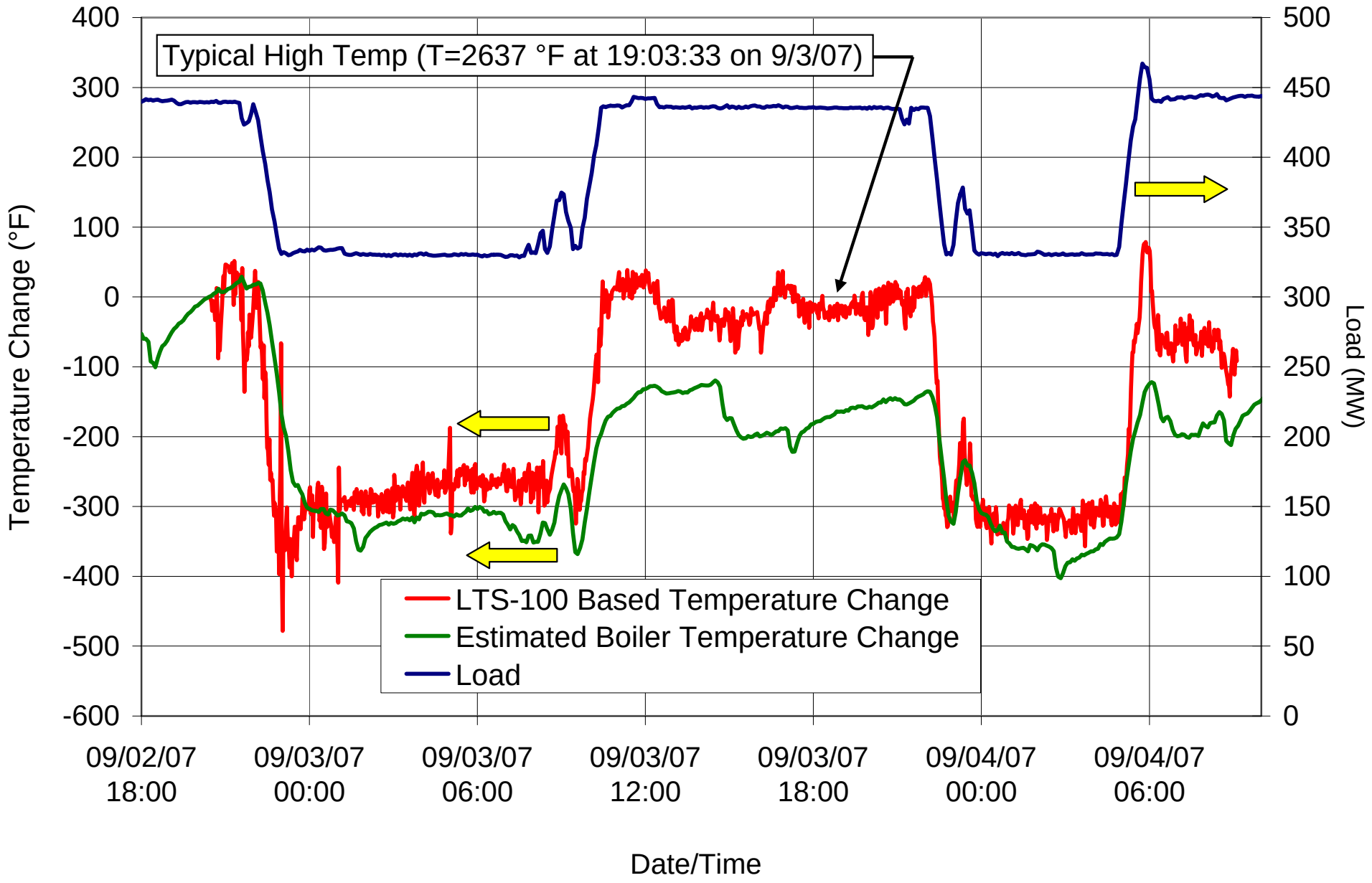


Temperature and Load Data

BML



Potential Error in Baseline Fit

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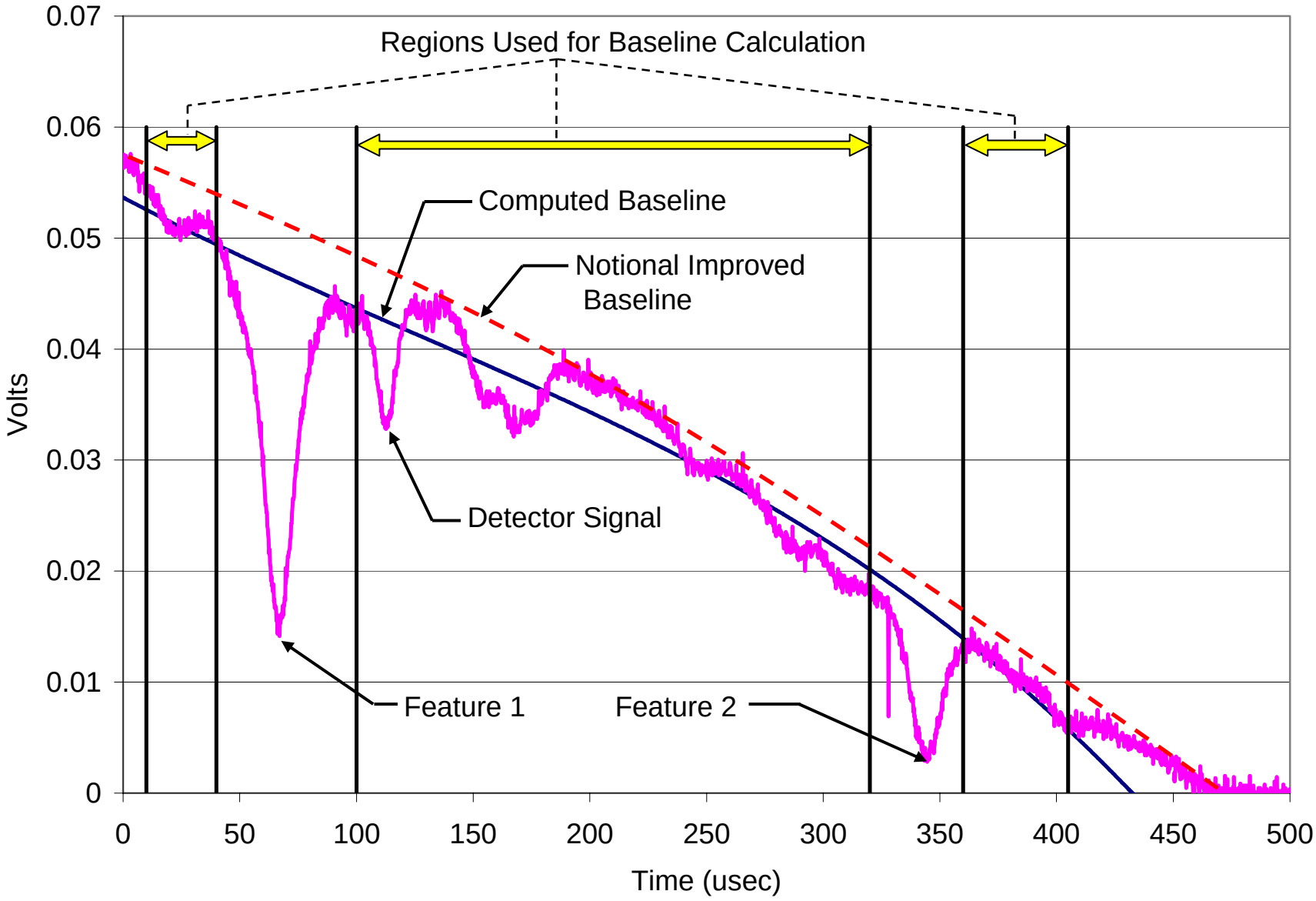
Full scale detector signal and baseline at 2637 °F



Recent Progress in Baseline Fitting

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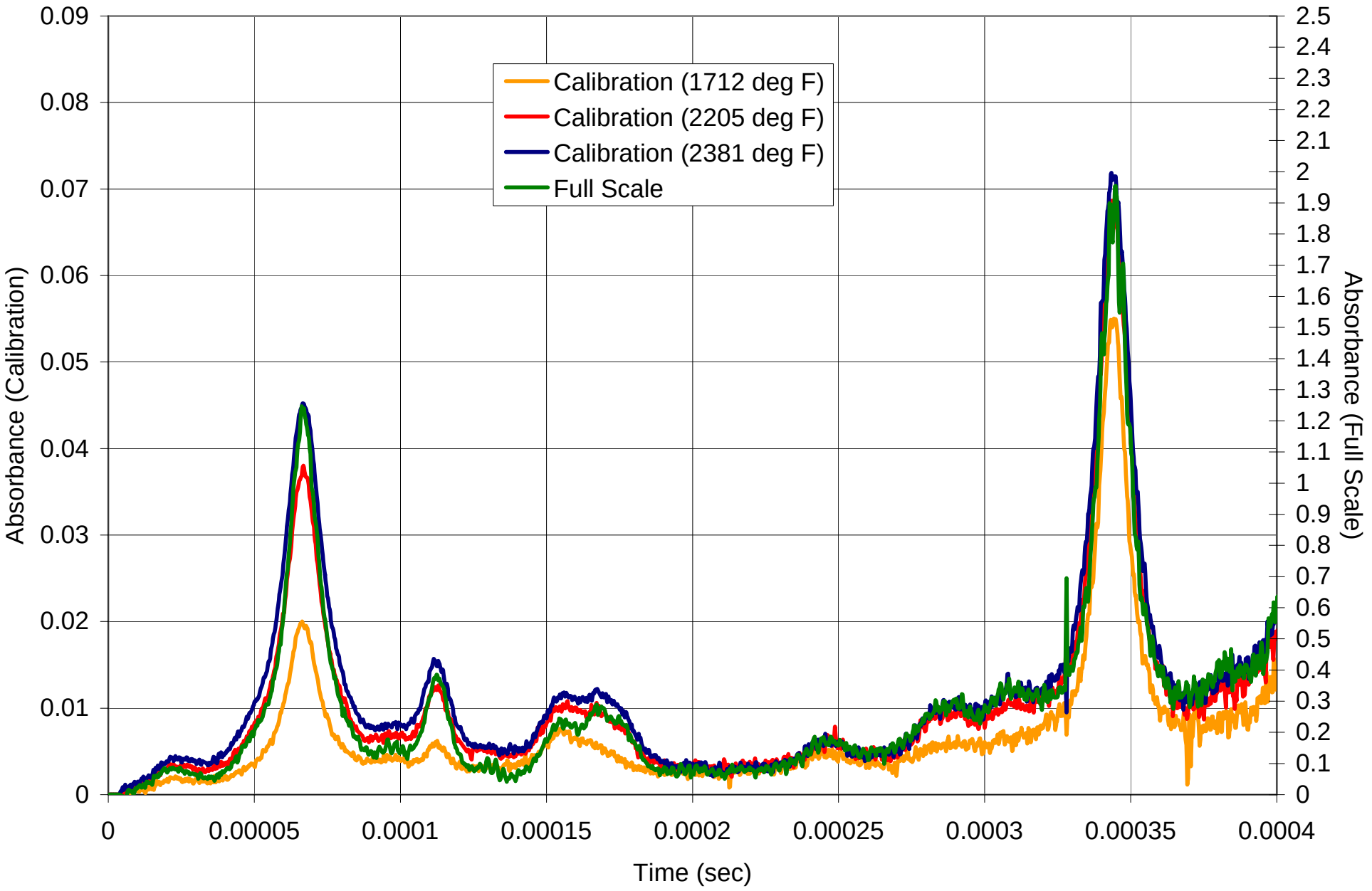
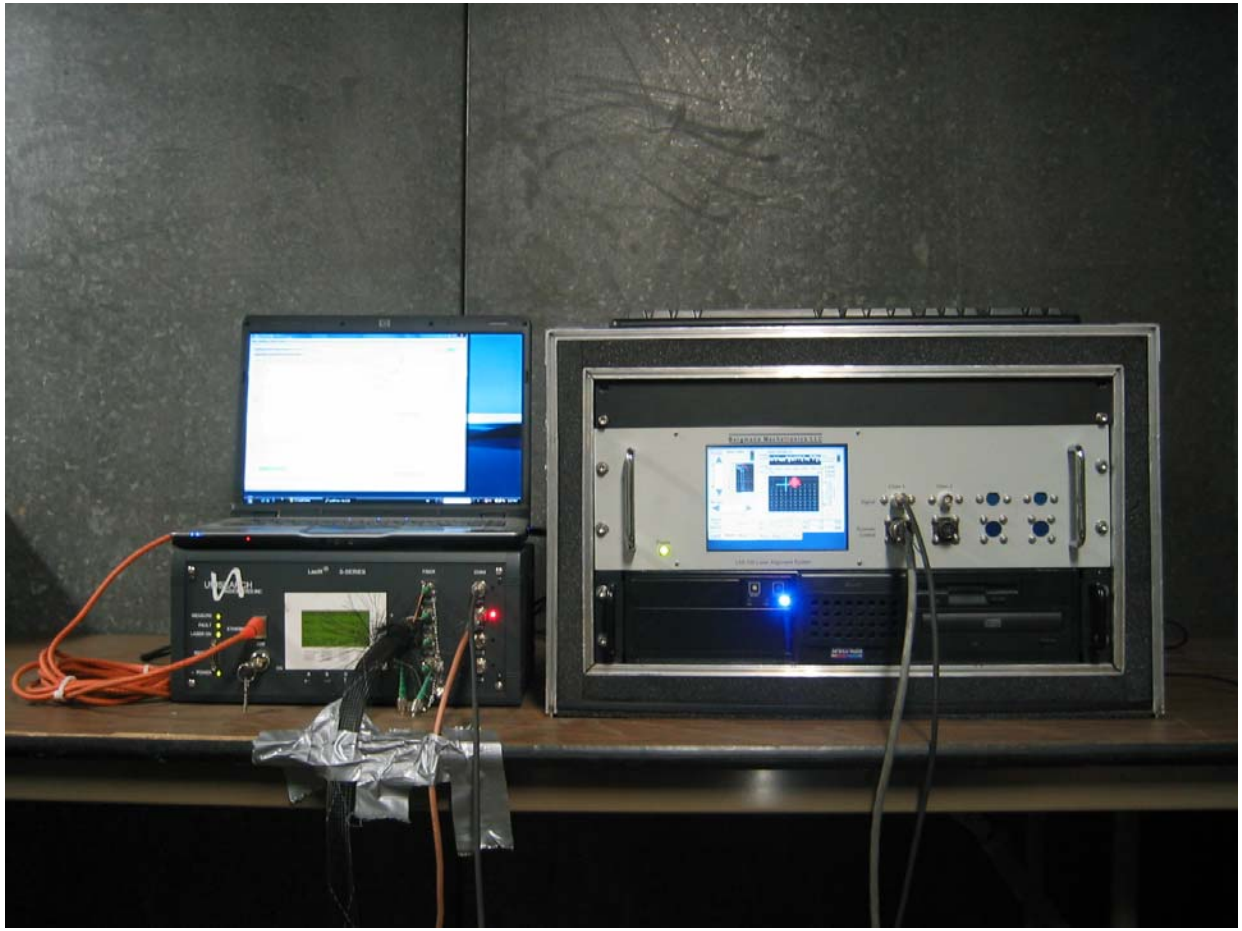


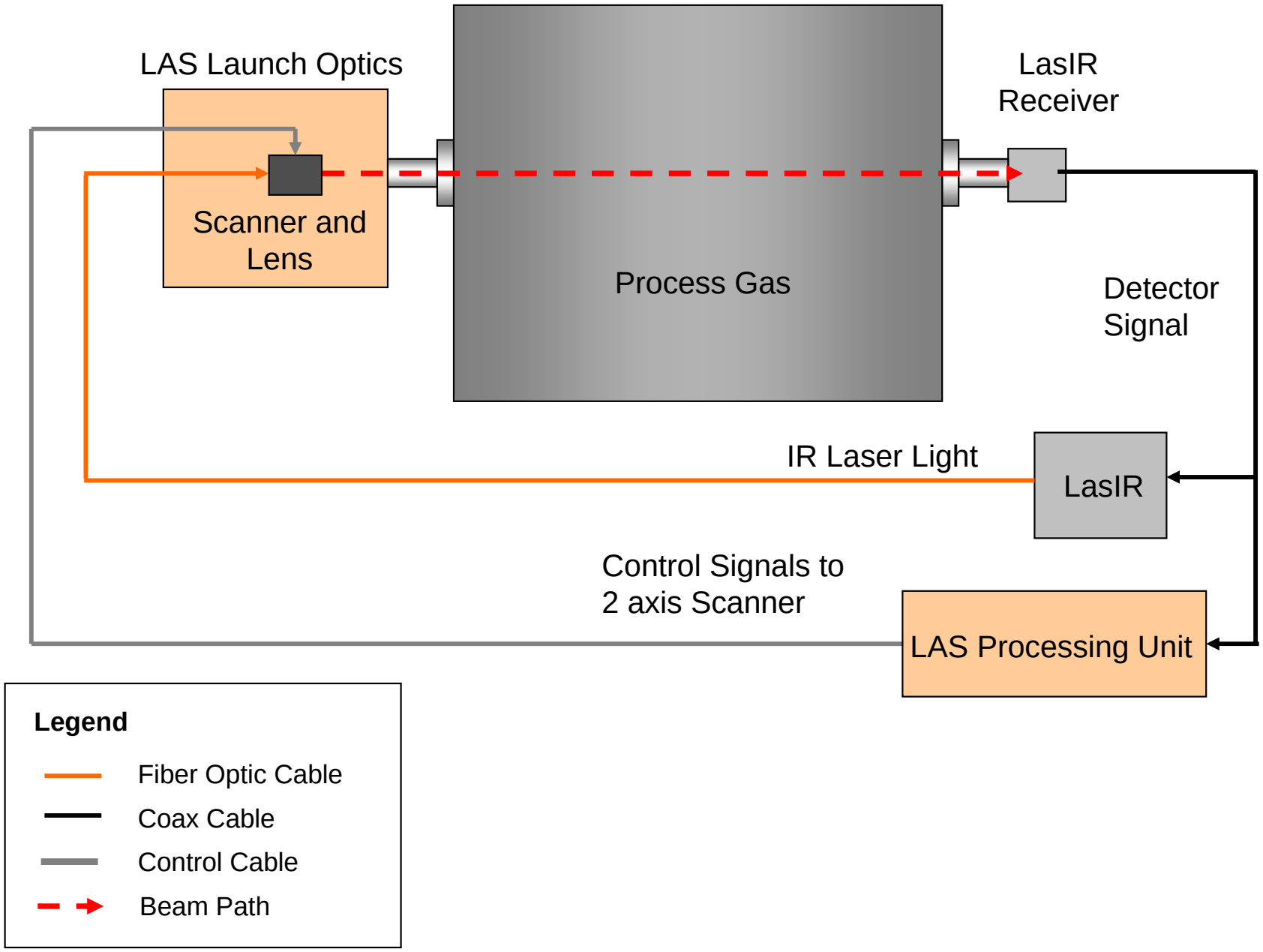
Laser Alignment System for TDLs BML

- Interfaces to a Unisearch Associates LasIR TDL-based NH3 monitor
- Enables continuous beam alignment despite duct wall movement
- Based on LTS-100 hardware and software

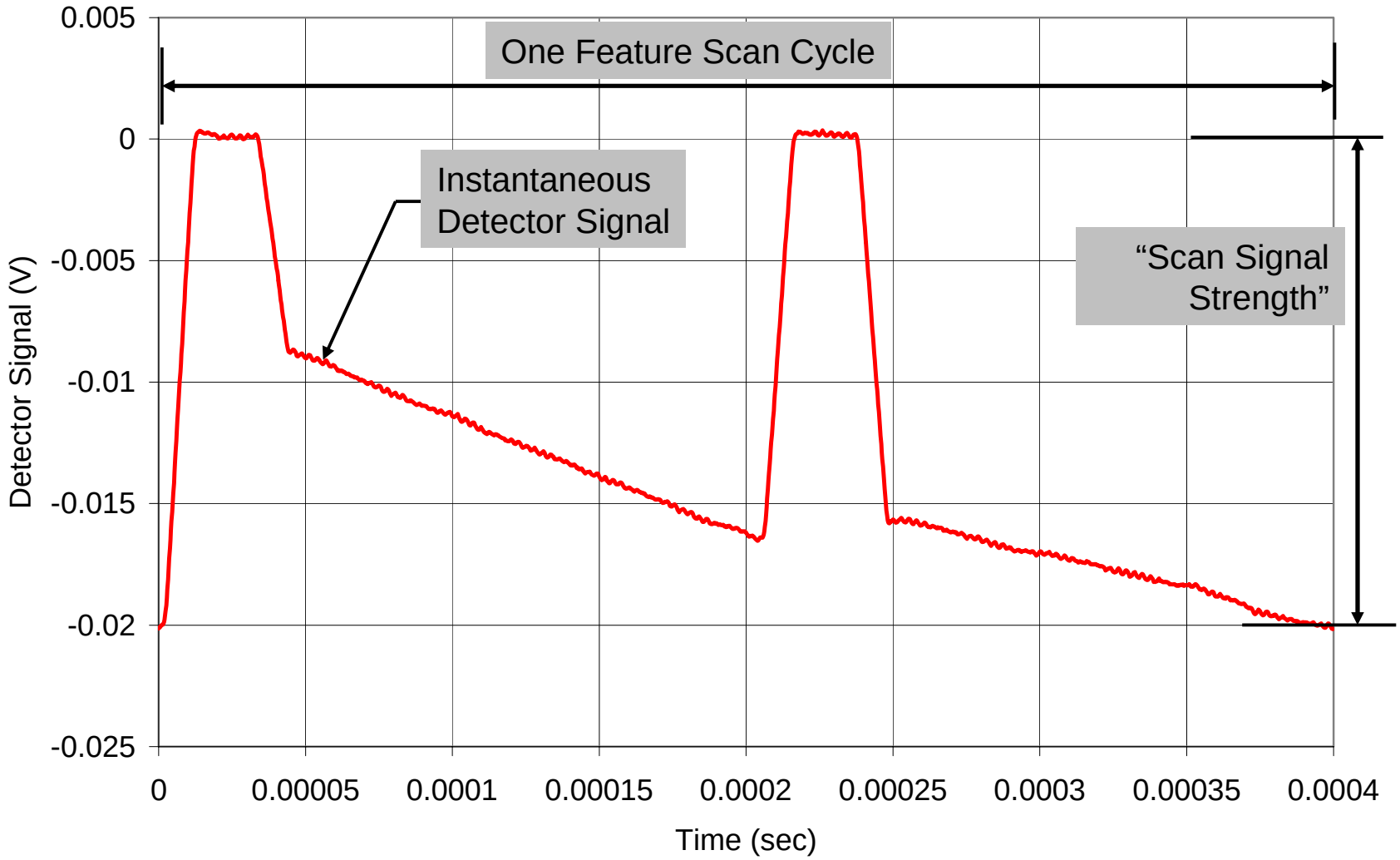


System Schematic

BML



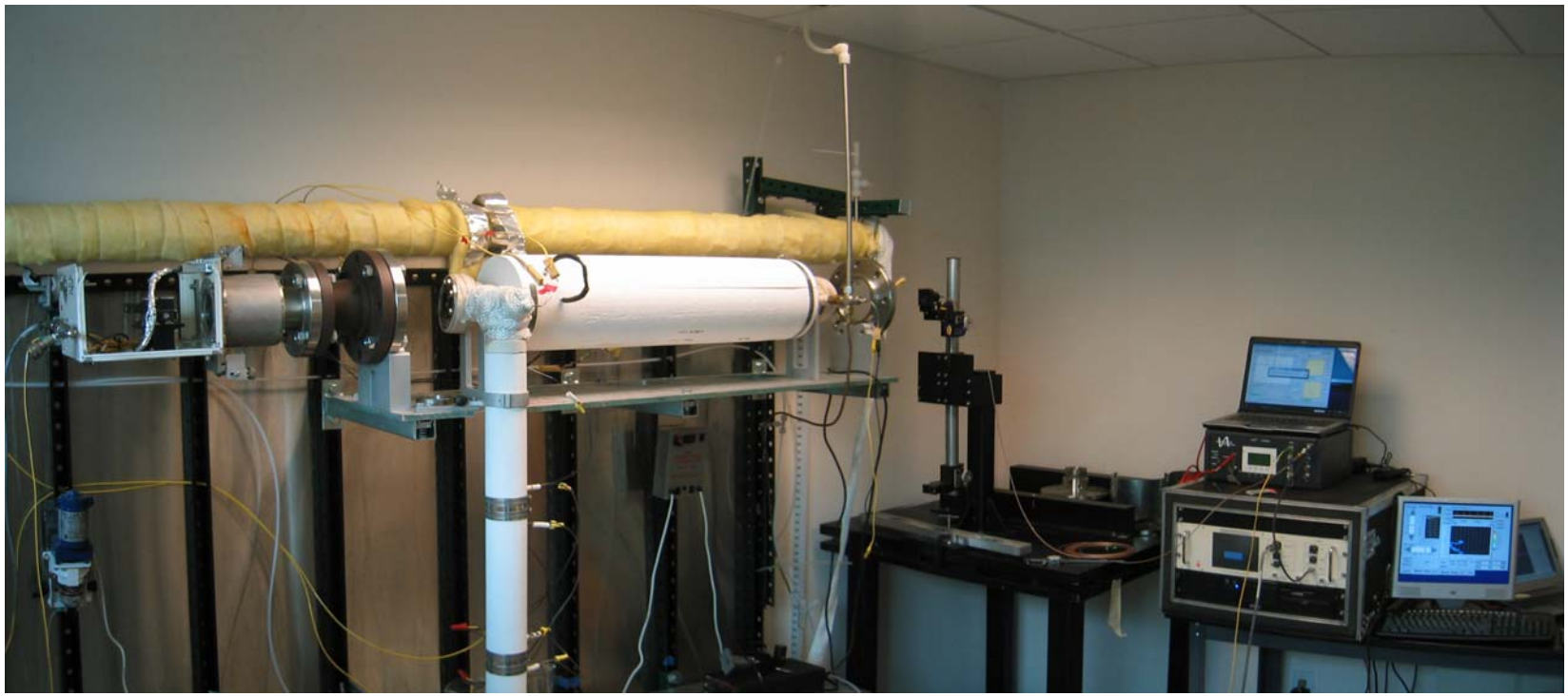
LasIR Signal Strength Measurement



Laser Alignment System BML

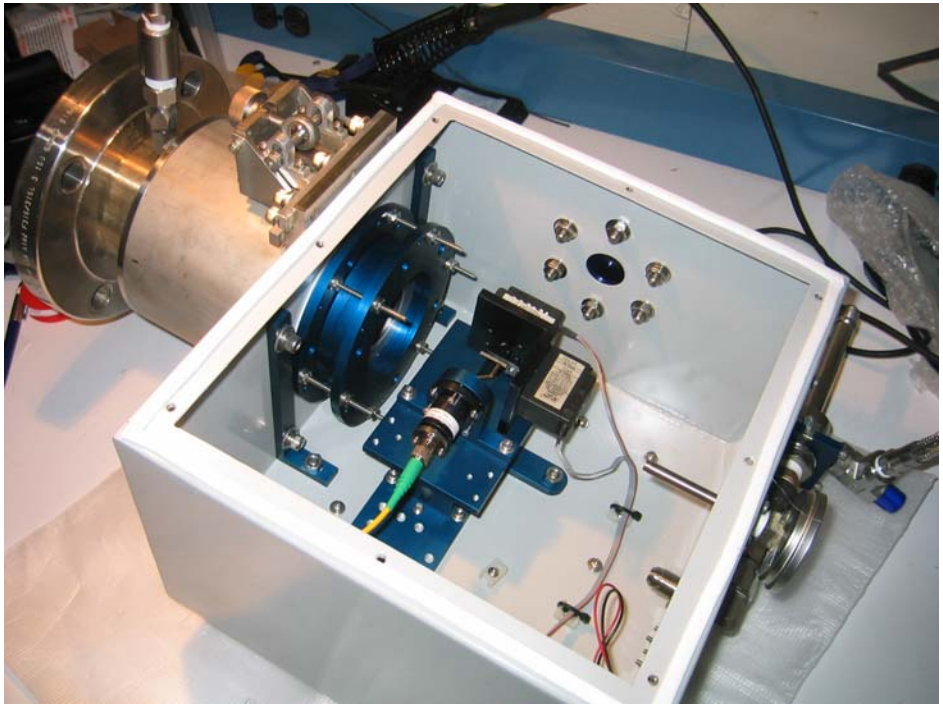
System testing with NH_3 test cell at University of California Riverside, CE-CERT

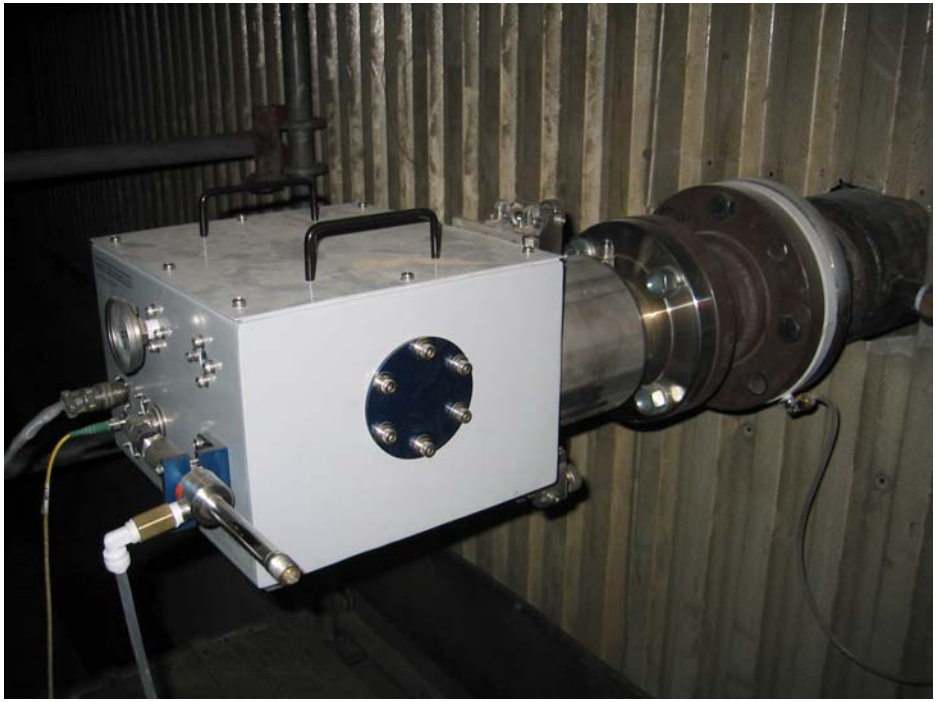
- Sponsored by Electric Power Research Institute (EPRI)
- Results:
    1) System can maintain alignment in presence of large detector movements
    2) LAS does not interfere with LasIR measurement accuracy



Launch Optics Enclosure

BML

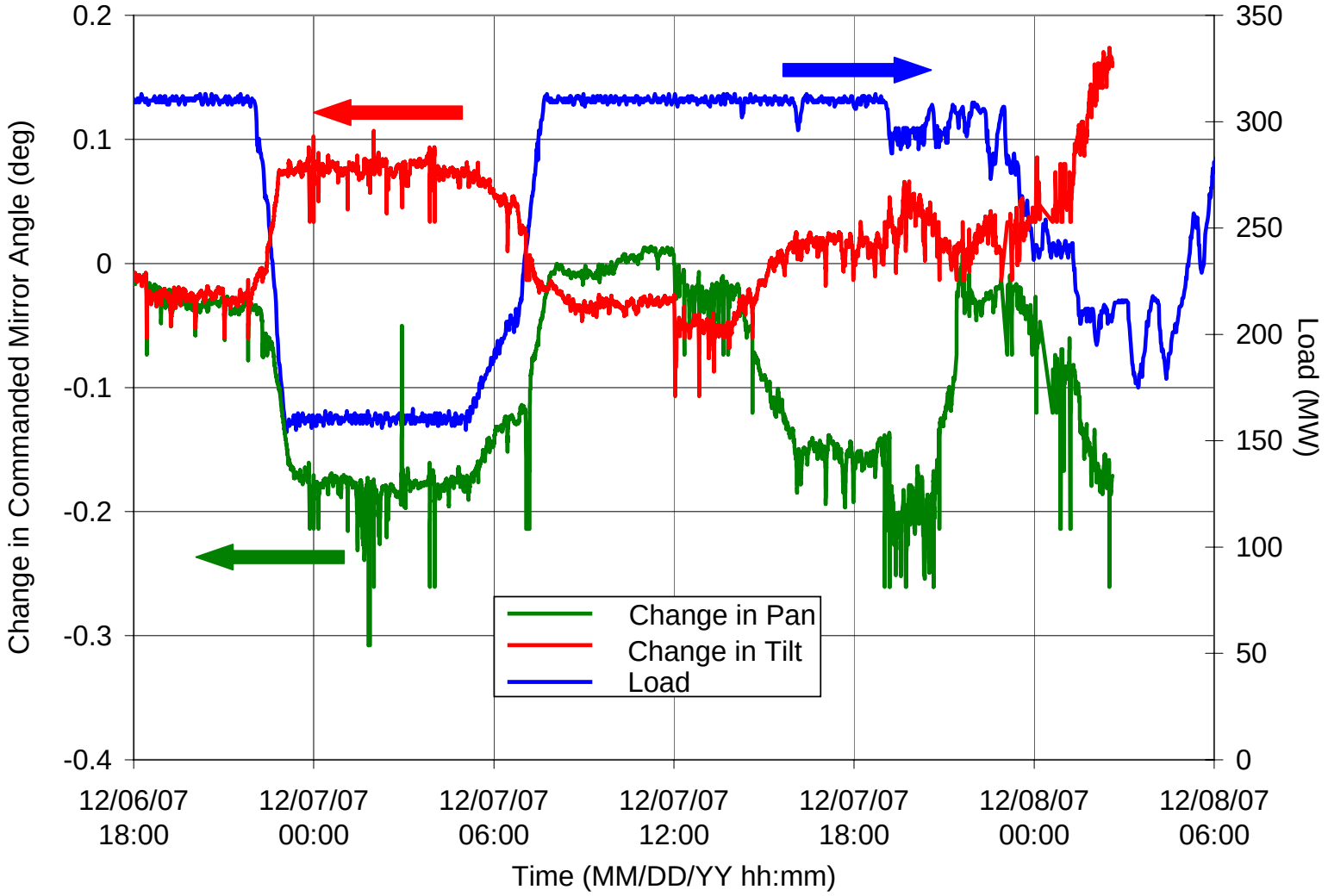




Full Scale Testing

BML

- 28’ foot path downstream of boiler at mid-western power plant
- Sample beam movement: 0.2 ° = 1.2” at 28’
- Sponsored by EPRI



Effect on Beam Power Density

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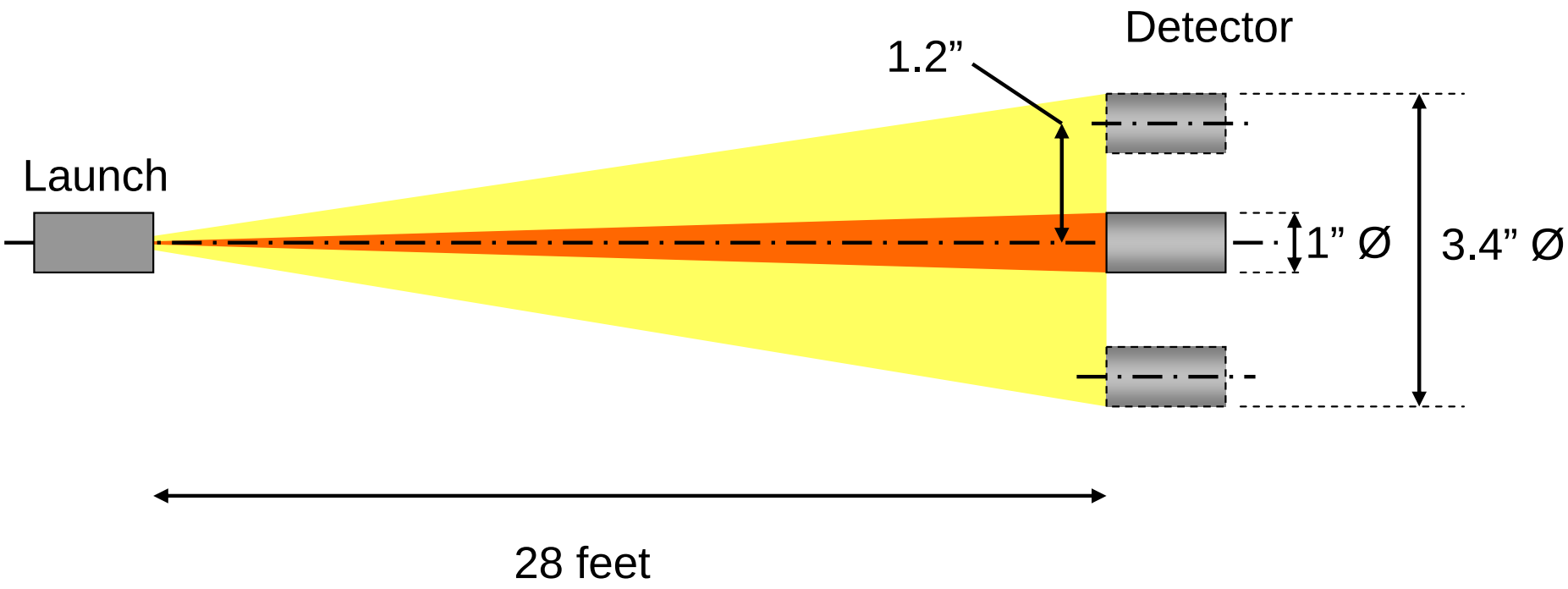
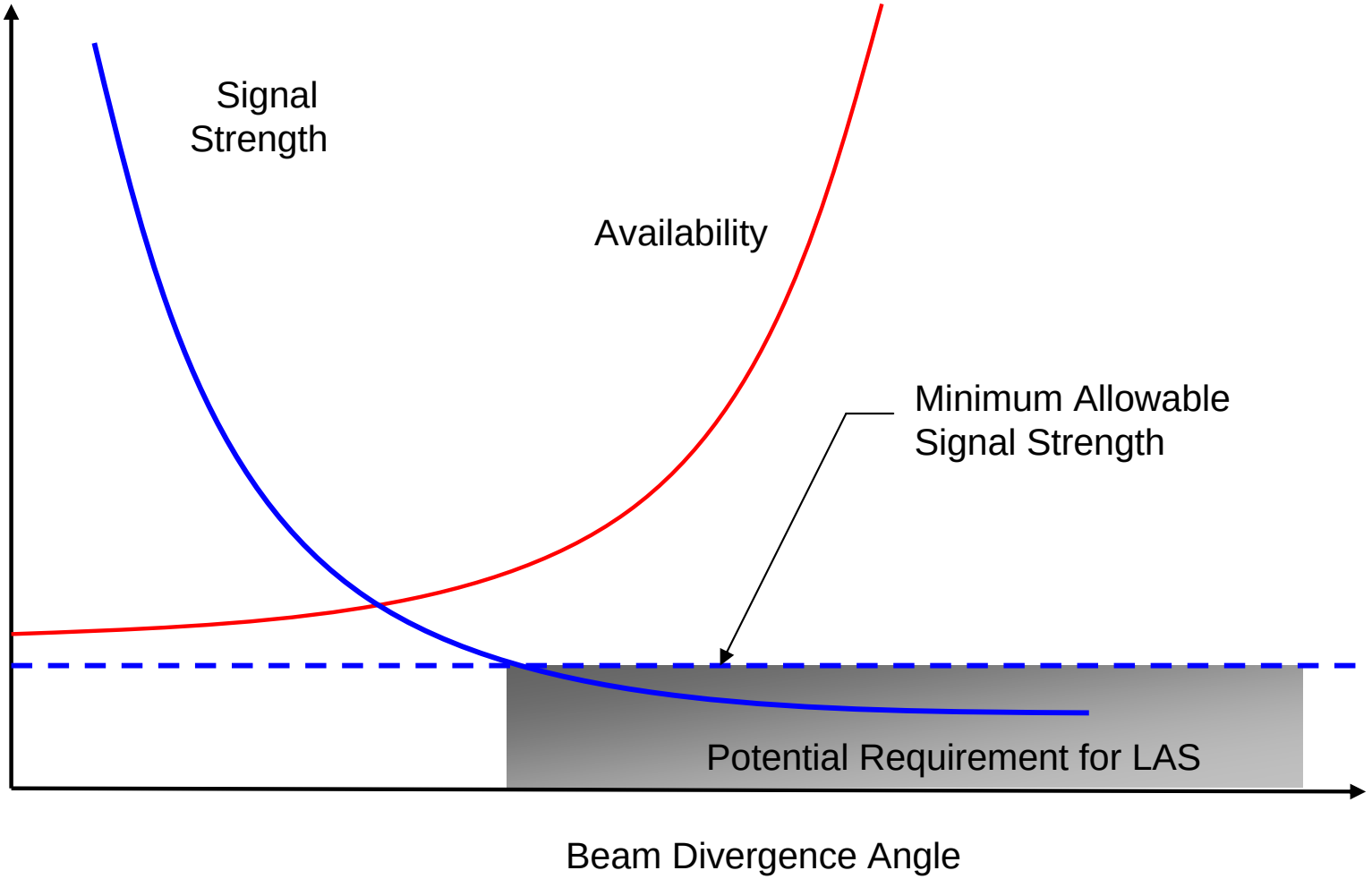
- For manually aligned system with 1.2” of detector movement, spot size must be 3.4” diam (9.1 in^2 area)
- Auto-aligned system, spot size can be 1” diam (0.8 in^2 area)
- Resulting power density of manually aligned system is 8.6% of auto-aligned system



Laser Alignment System for TDLs BML

- For manually aligned system, increasing divergence angle increases availability
- Divergence angle is limited by minimum allowable signal strength



Summary and Comments

BML

- LabVIEW development environment and PC and NI hardware are well-suited for rapid prototyping of instrumentation products
  - straightforward development of robust, user-friendly code
  - readily available, high-performance hardware
  - easy to interface software to hardware

- For mass production / cost sensitive applications, consider
  - Hardware: microcontroller, DSP
  - Software: C code or LabVIEW Embedded modules for Blackfin / ARM / DSP

Backup Slides

LTS-100 Hardware Overview

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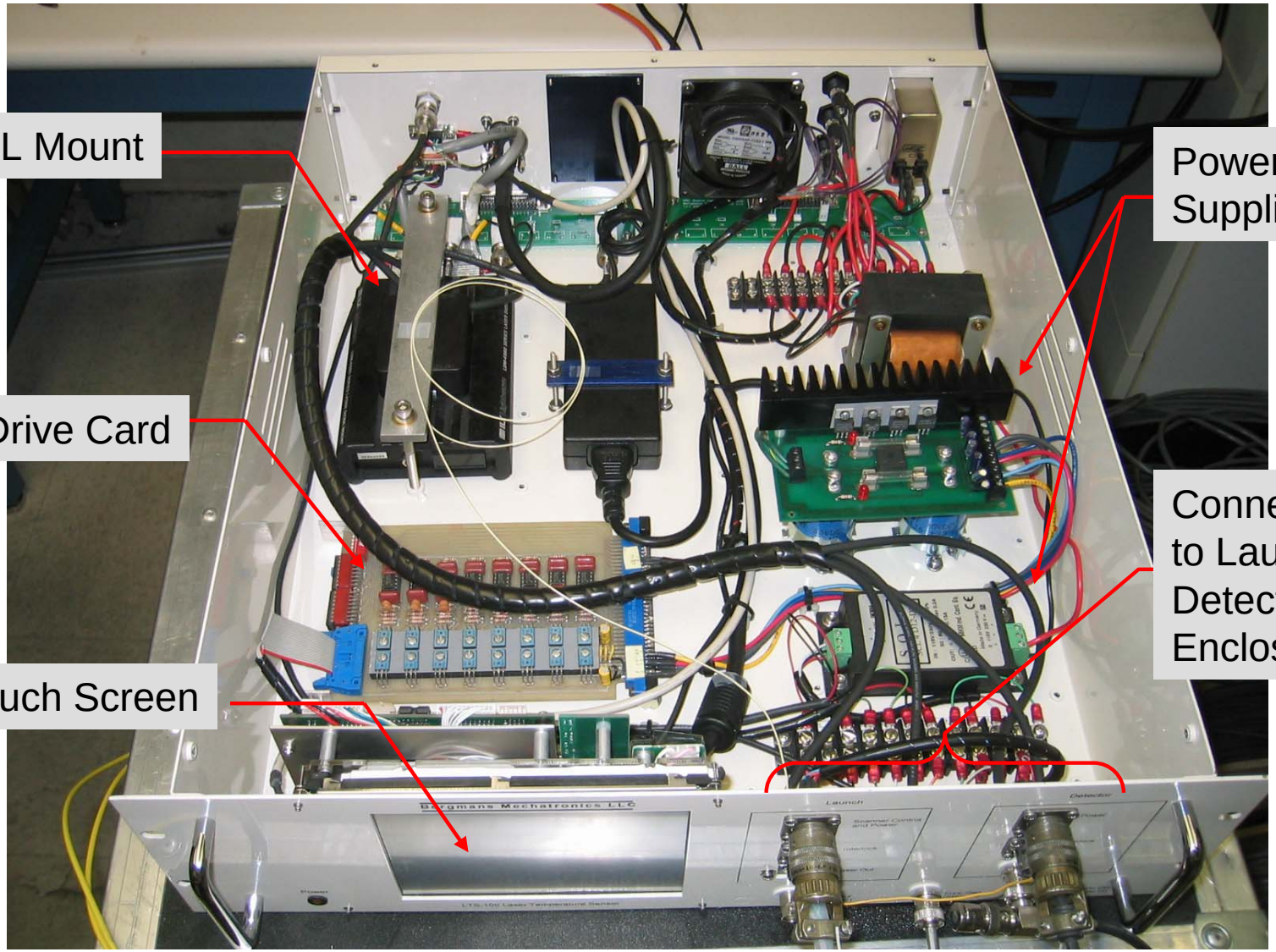
Interior of Interface Unit



LTS-100 Hardware Overview

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Custom, low-cost DAQ breakout board