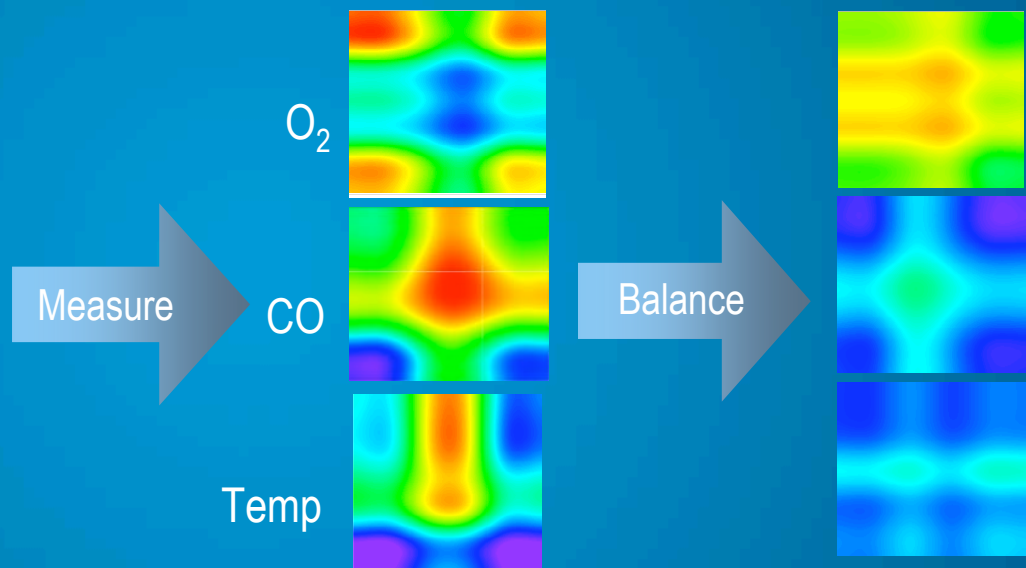
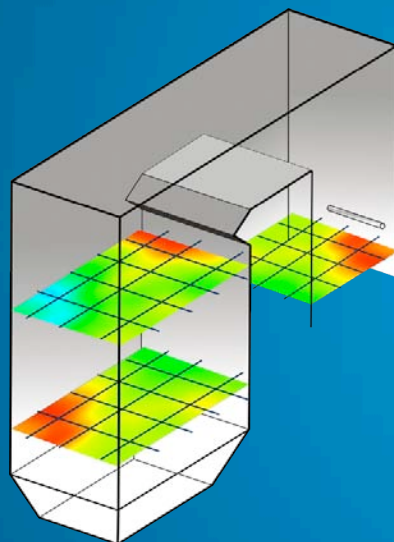


Laser-based Sensors for Real-time Combustion Optimization



Henrik Hofvander
President and CEO
Zolo Technologies, Inc.



Agenda

Overview

The Zolo**BOSS**

Combustion Balance / Optimization

- Manual tuning
- DCS tuning
- Combustion Optimizers

Summary



Customer Needs

- Enhance availability
- Reduce emissions
- Improve efficiency
- Increase fuel flexibility
- Minimize slagging



Key Priority: Combustion Balance / Optimization

Challenges

- Difficult to achieve & maintain optimized combustion
- Lack of combustion zone data
- Large number of variables
- Constantly changing conditions & fuels
- Traditional “tuning” is a one-time event

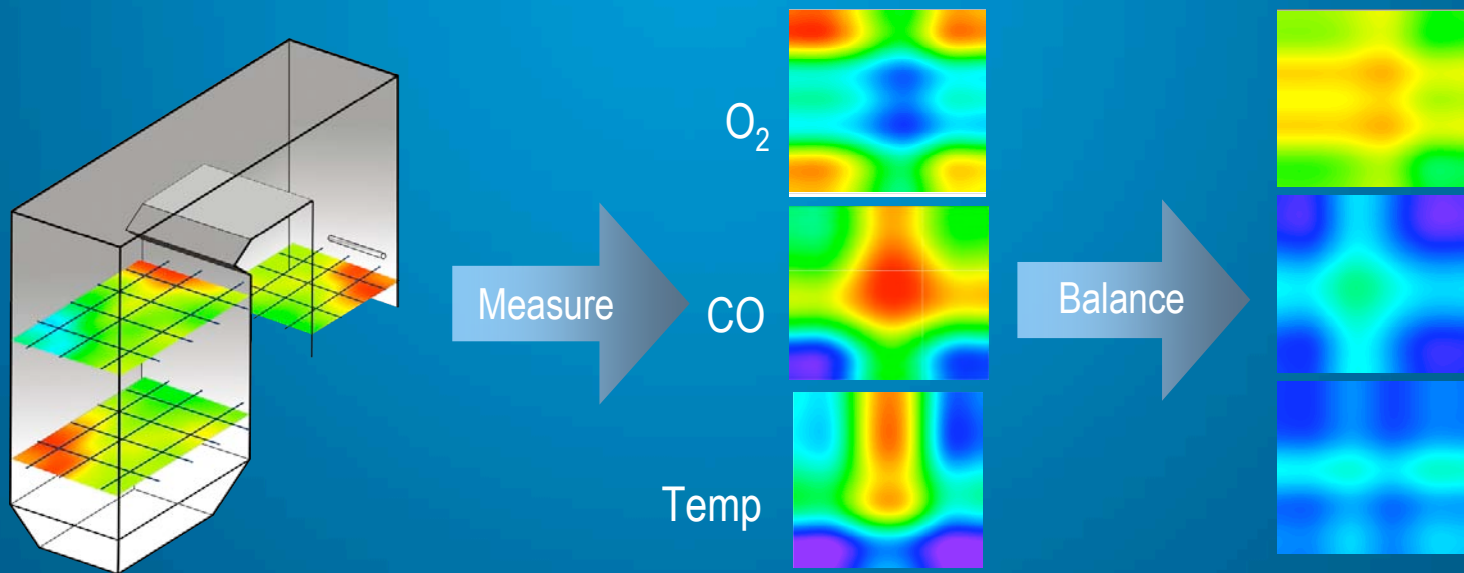
The Solution

Accurate combustion zone data

The appropriate combustion optimization system

- Man-in-the-loop
- DCS
- Combustion Optimizers

Integration of data + control system





Agenda

Overview

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The ZoloBOSS

Accurate, *in-situ*, combustion zone data

Designed for ultra-harsh environments

Temp, O₂, CO, CO₂, H₂O

No calibration

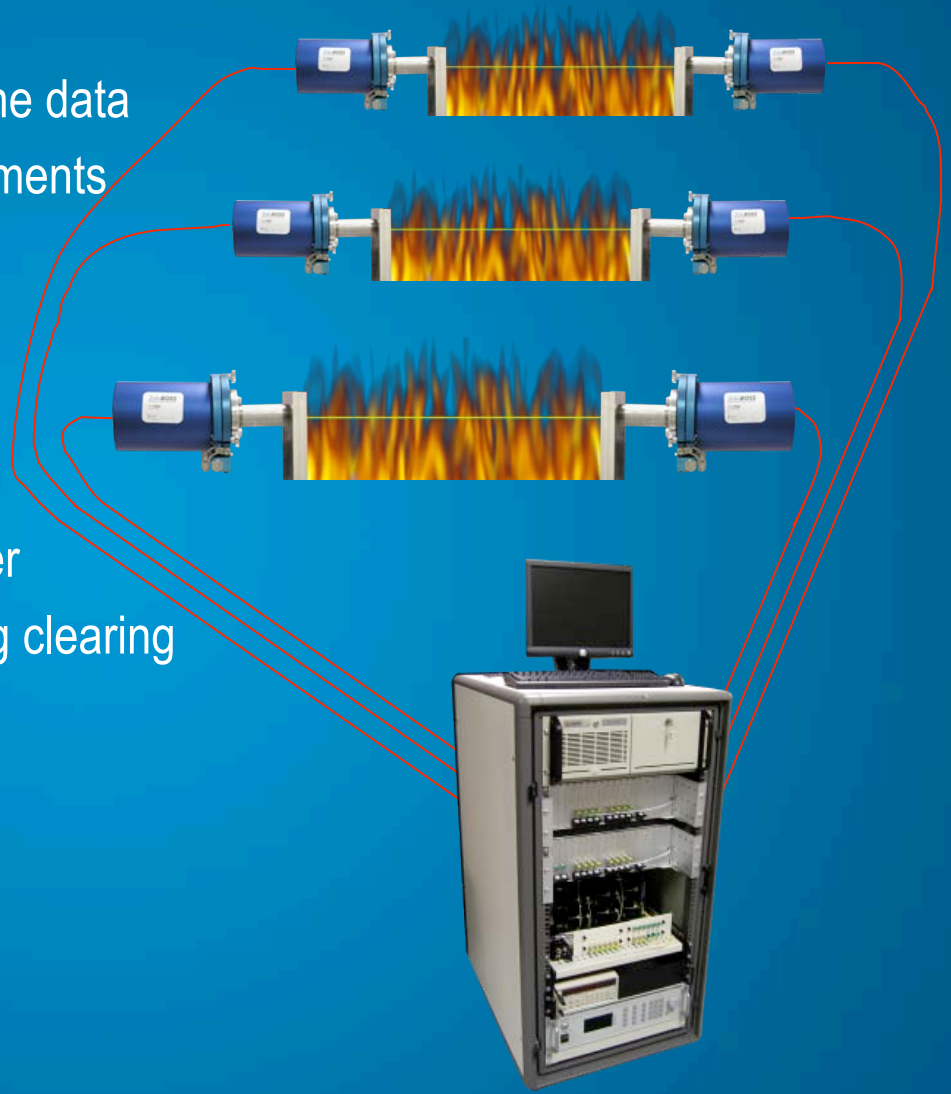
15 paths per instrument

Laser-light routed via fiber-optics

Auto-aligned transmitter / receiver

Automated "port-rodders" for slag clearing

Installed since 2005



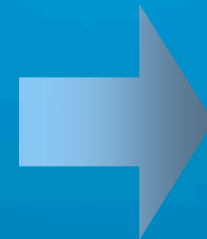
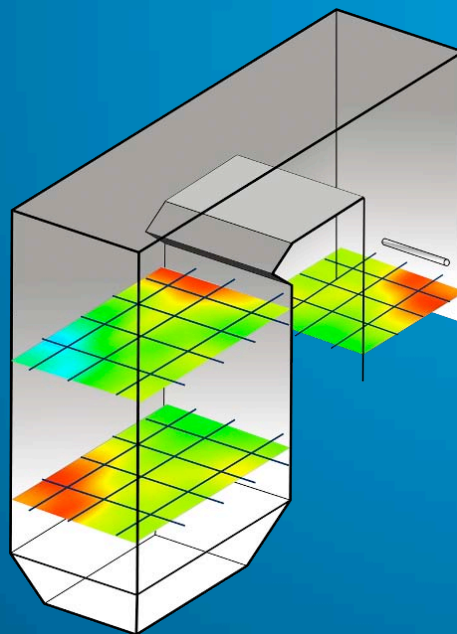
The ZoloBOSS

Measure where it counts

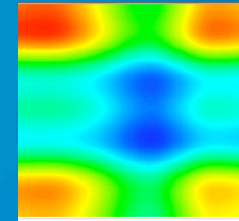
Measure at several locations

Multiple paths generate “CAT” scan images

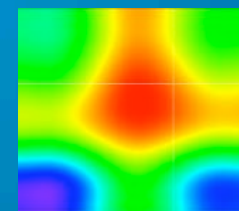
Better Measurements, Better Results



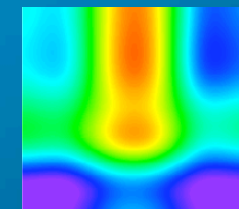
O₂



CO



Temp





Agenda

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Summary

Man-in-the-loop: Opacity Control

Situation:

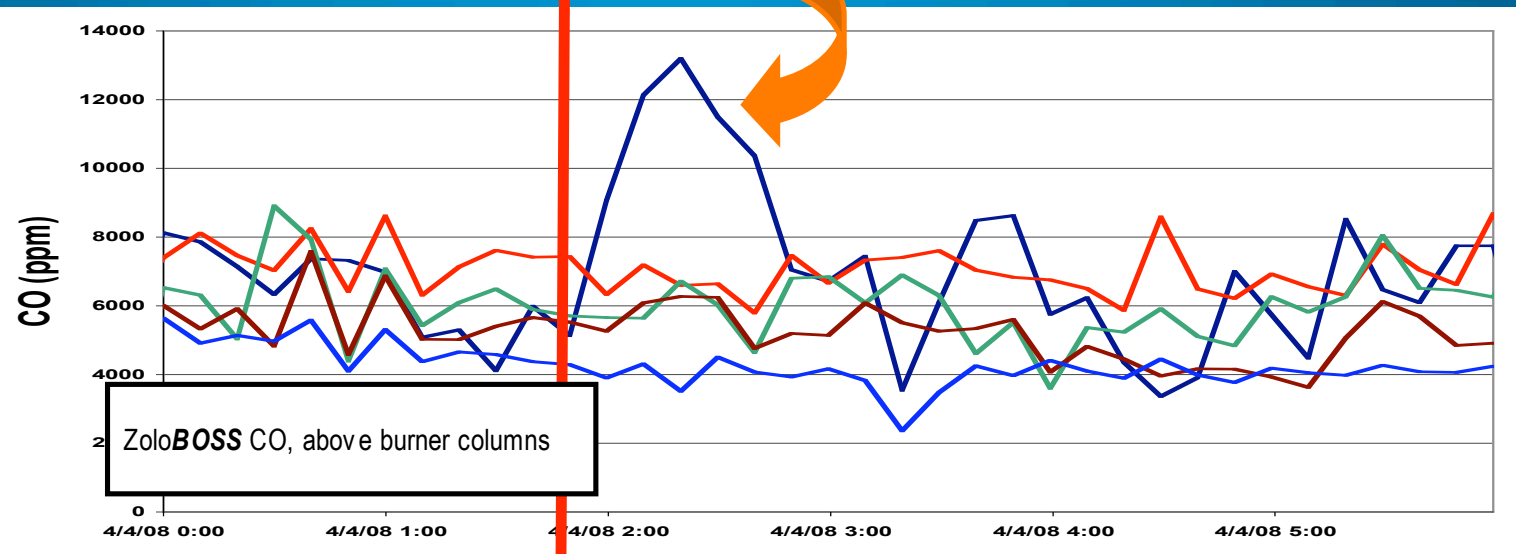
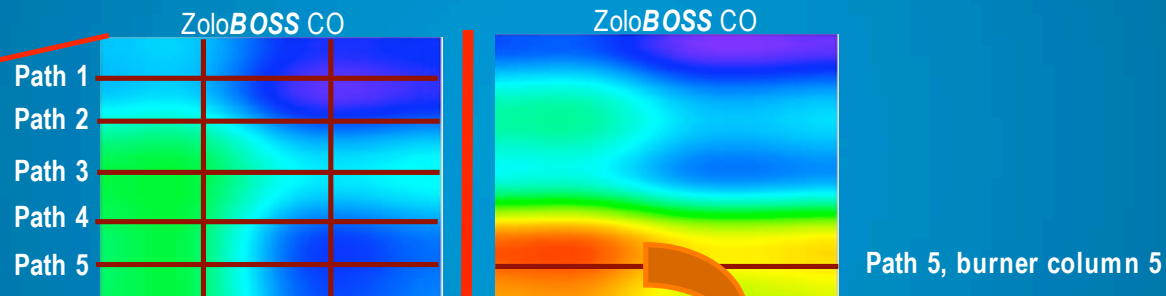
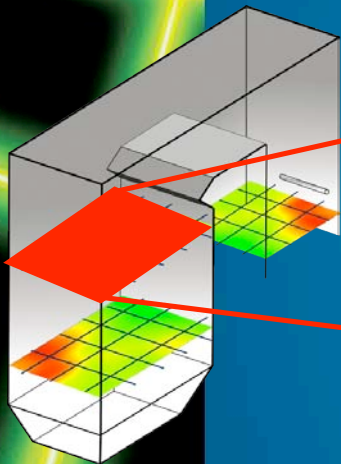
500 MW wall-fired. 5 columns of Low NO_x Burners
ZoloBOSS paths aligned on top of LNB columns

Problem:

Single LNB causes opacity event
De-rate of 20 MW
8 - 12 hours to identify and fix

Solution:

ZoloBOSS paths above each column
CO identifies "bad" LNBs
Quickly return to full capacity



Man-in-the-loop: Slag Control

Situation:

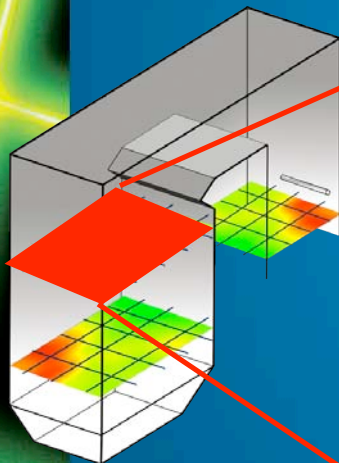
578 MW T-fired boiler
Mine mouth plant, high sodium coal
ZoloBOSS grid right above OFA

Problem:

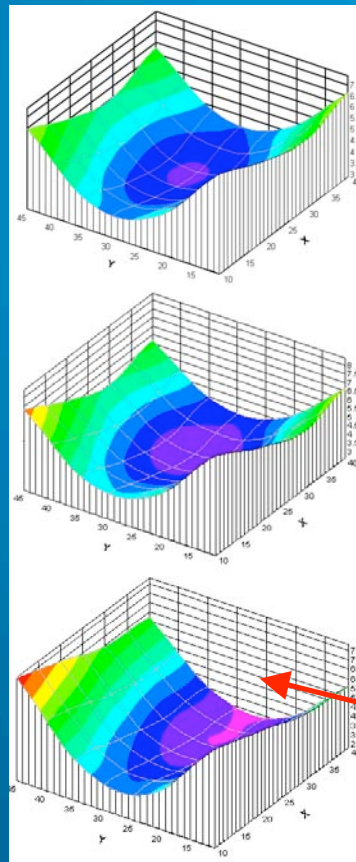
Major slag on one wall, coal seam dependent

Solution:

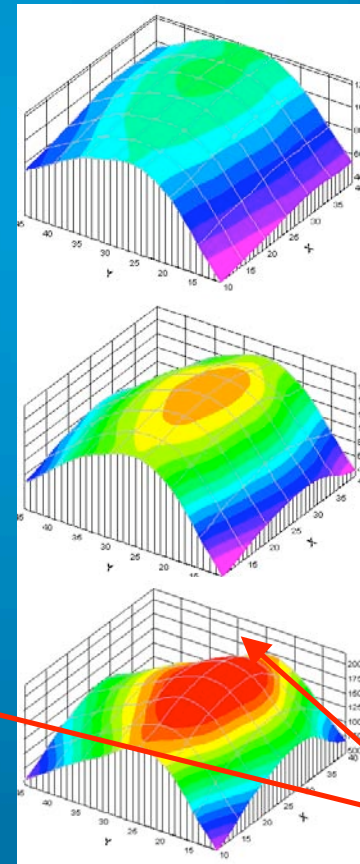
Accurate temperature, O_2 and CO profile
Parametric testing of burner and OFA tilts, yaws
Manual set-points for burner and OFA tilts



ZoloBOSS O_2



ZoloBOSS CO



OFA at -20°

OFA at -10°

OFA at 0°

High slagging wall



Agenda

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Combustion Balance / Optimization

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- **DCS tuning**
- Combustion Optimizers

Summary

DCS Tuning: Intelligent Sootblowing

Situation:

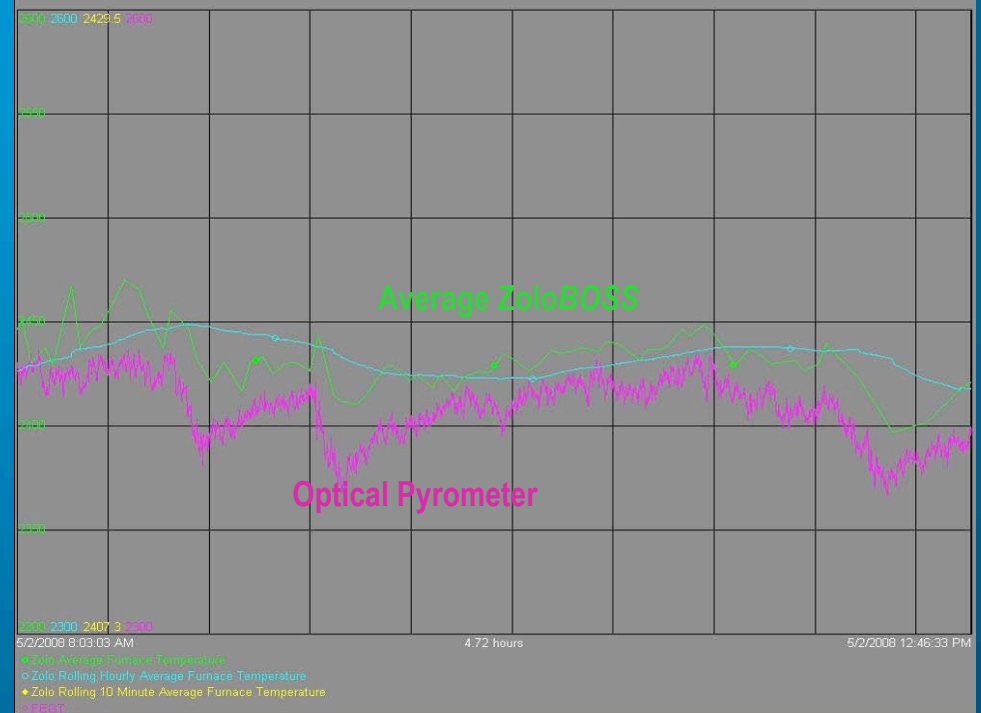
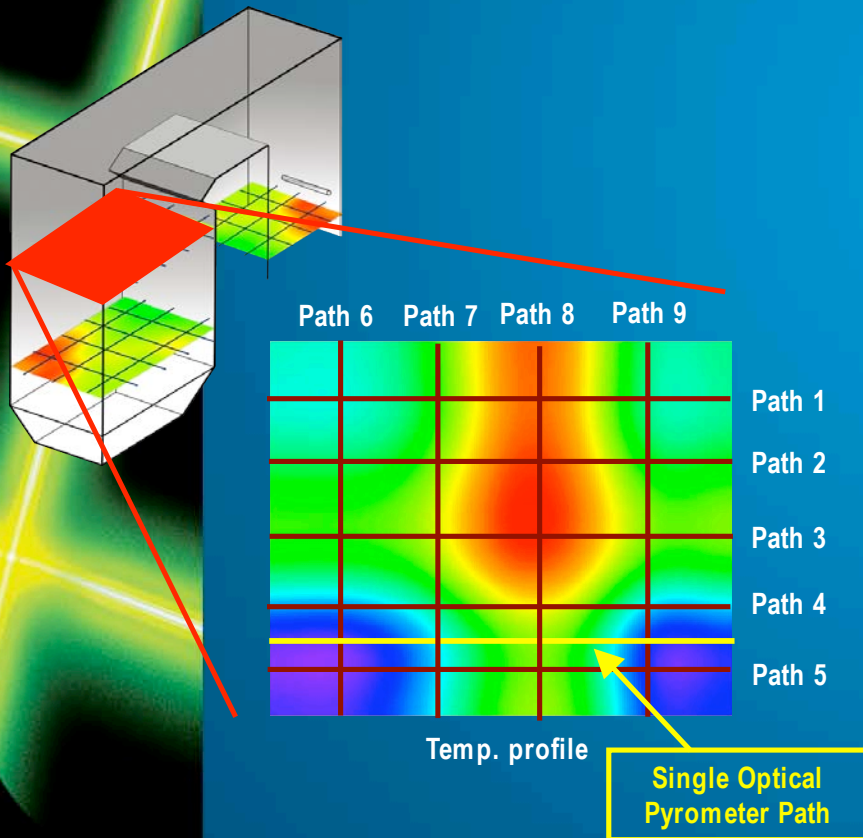
270 MW T-fired boiler
Single optical pyrometer for FEGT
ZoloBOSS grid above OFA

Problem:

Single temperature measurement
Single sensor failure

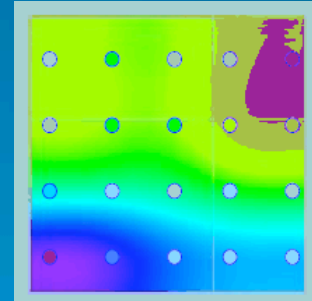
Solution:

Accurate temperature profile
Average furnace temperature calculated
Data via OPC to DCS
Closed-loop control of soot blowing

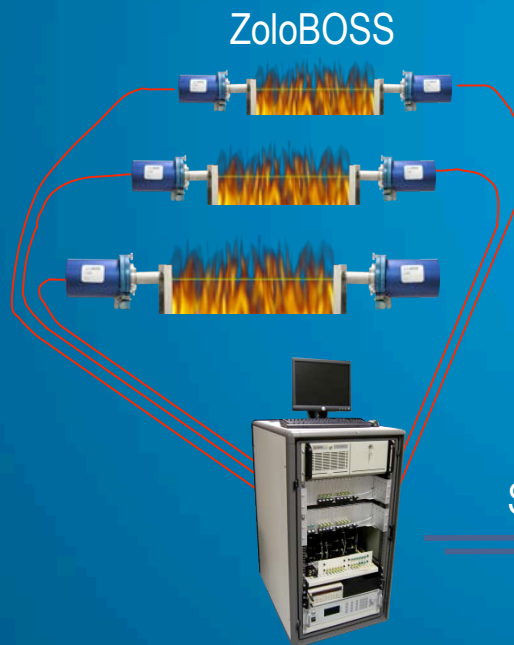


DCS Tuning: Integration

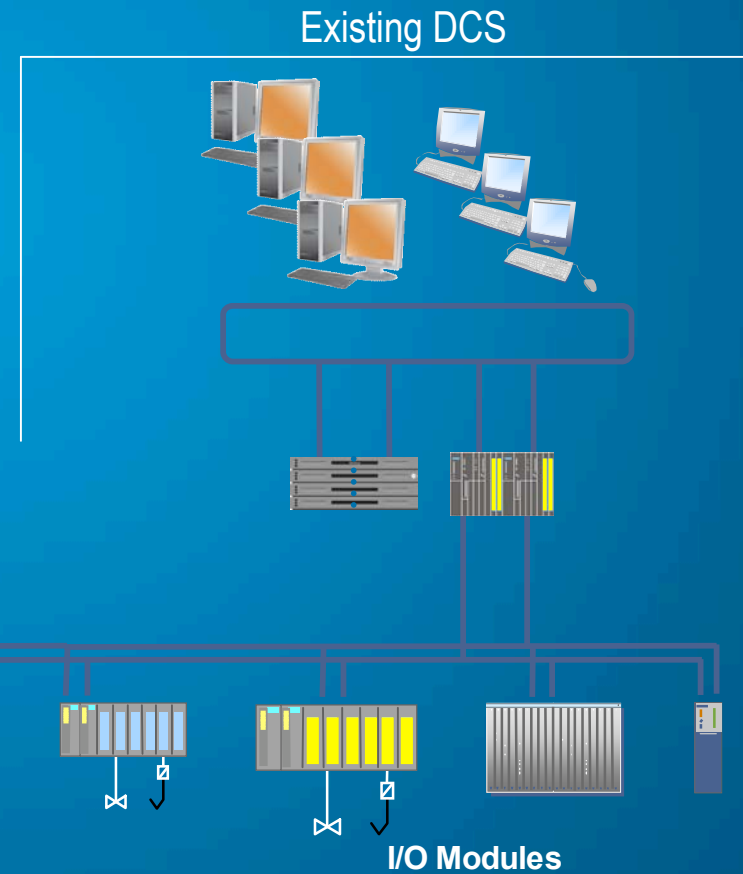
CAT scan images → data grid



→ DCS



Standard OPC





Agenda

Overview

The Zolo**BOSS**

Combustion Balance / Optimization

- Manual tuning
- DCS tuning
- **Combustion Optimizers**

Summary

Combustion Optimizers: Balancing

Situation:

446 MW T-fired boiler
ZoloBOSS grid above OFA

Problem:

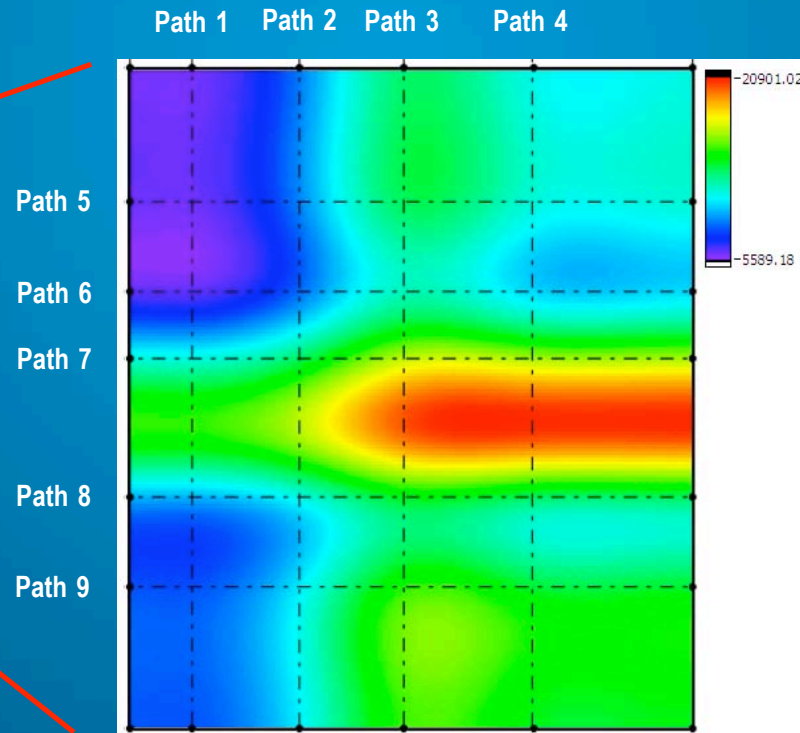
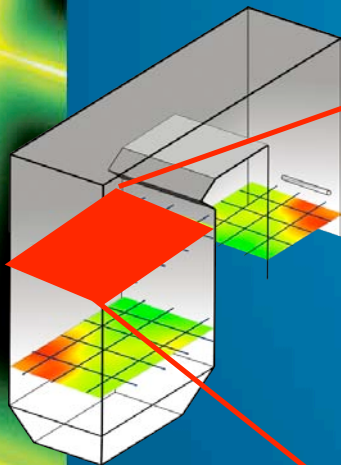
NOx reduction
Heat rate improvement

Solution:

Accurate temperature, O₂ and CO profile
Balance O₂ and CO distribution in combustion zone

Approach

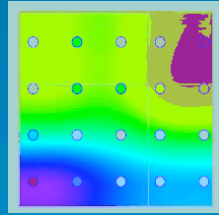
1. Minimize delta between path O₂'s and furnace average O₂
2. Build models. Neural net &/or model predictive controllers
3. Verify models
4. Closed loop control / bias



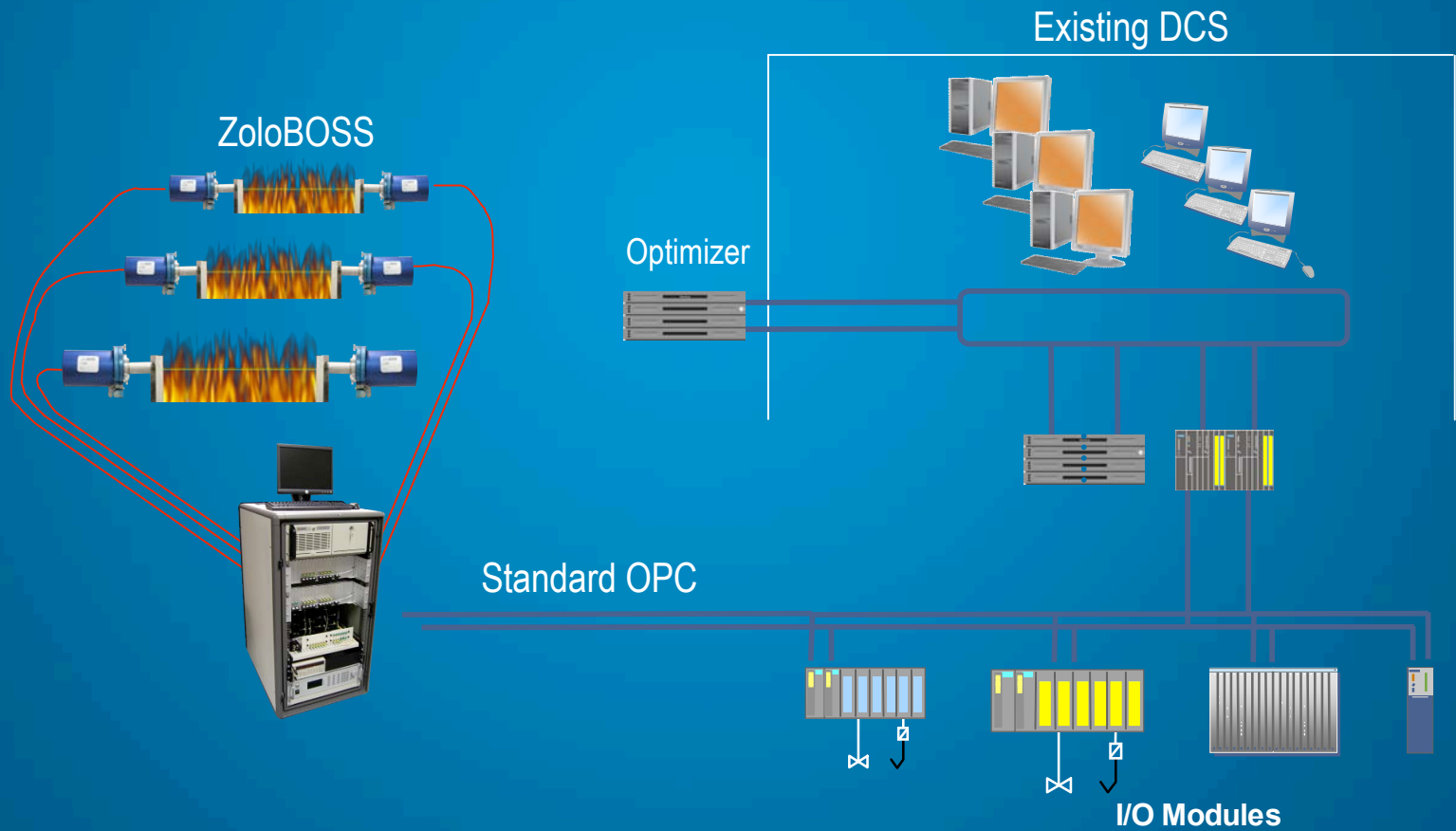
ZoloBOSS CO profile

Combustion Optimizers: Integration

CAT scans → data grid



→ DCS → Optimizer



Neural Net Tuning: Siemens Neural Network

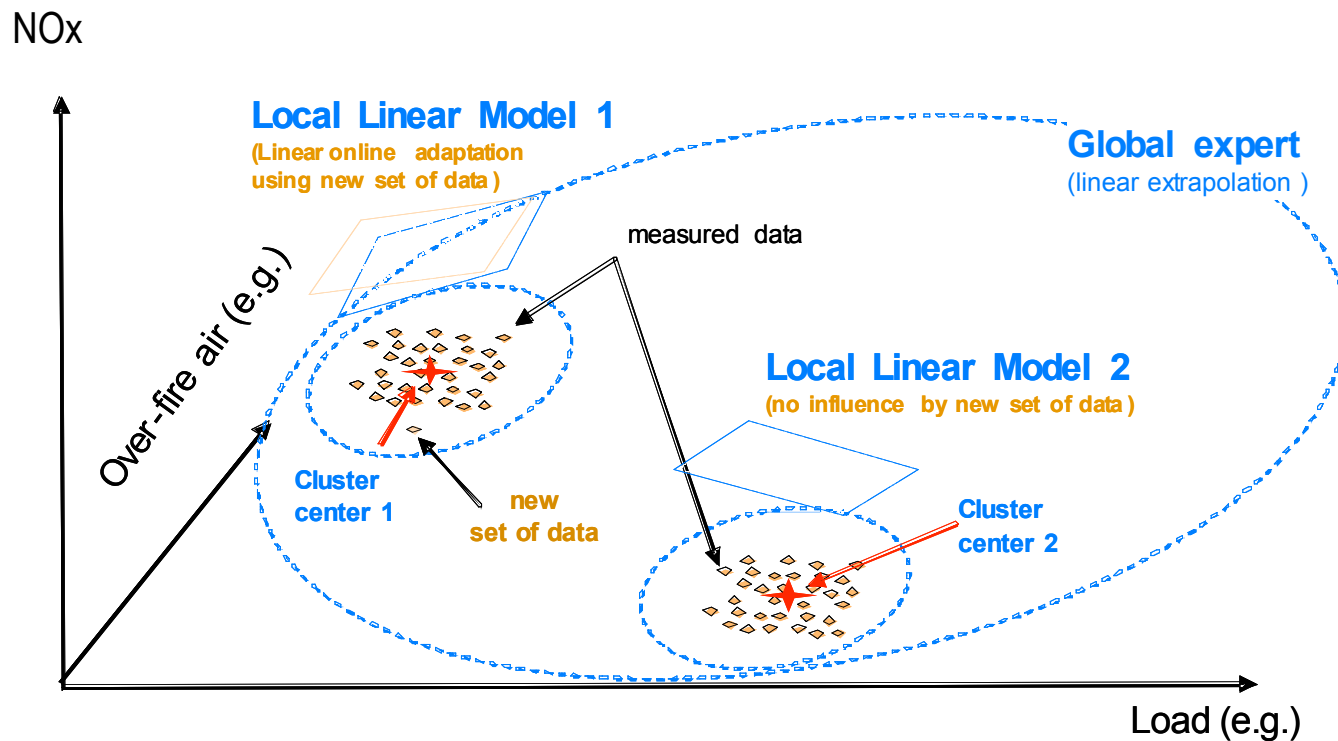
Partition model space into smaller “local” areas

Local areas use Local Linear Models, LLMs

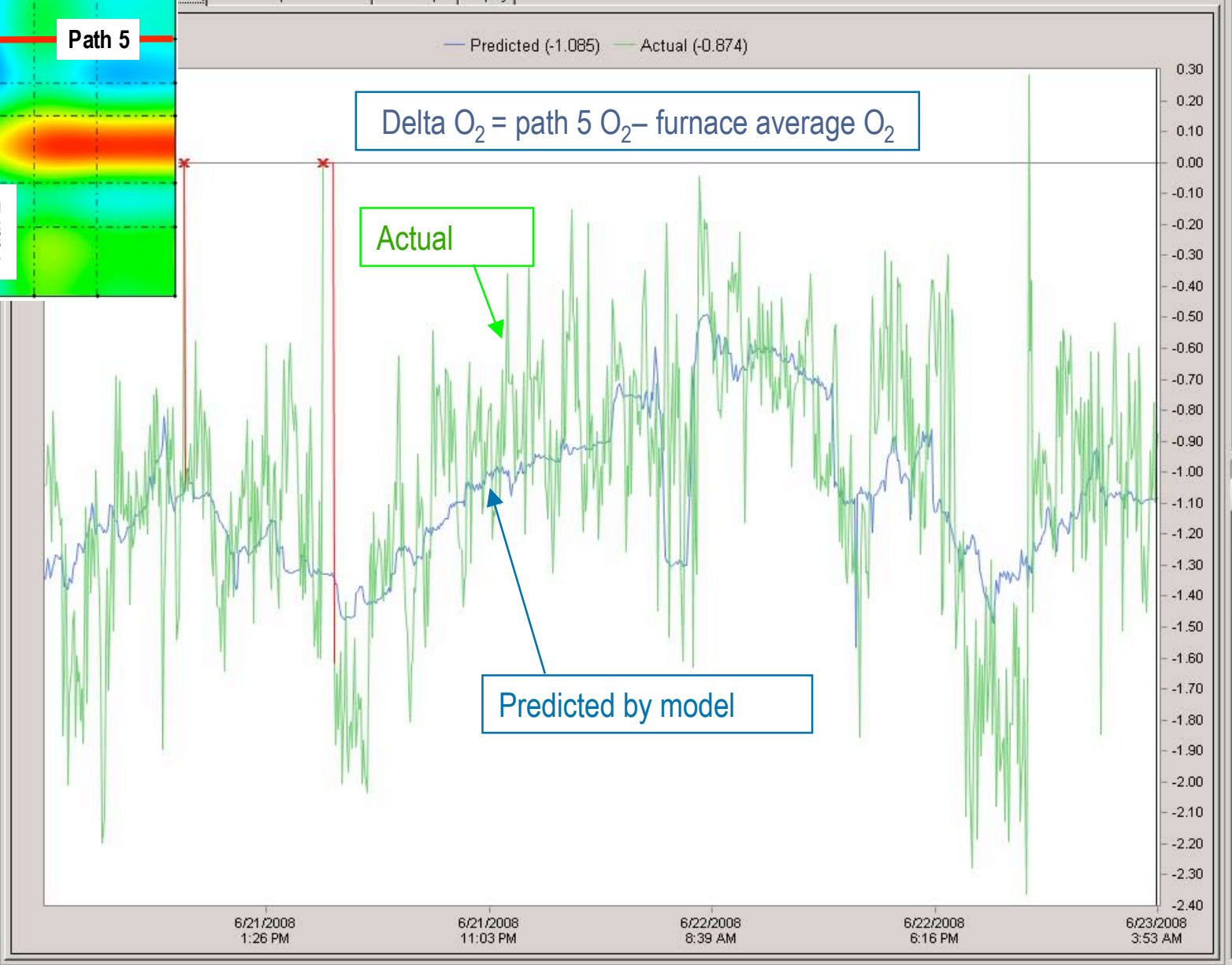
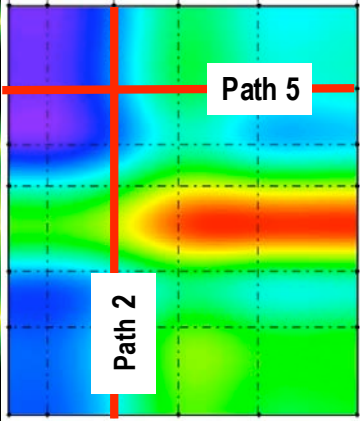
Smooth transition between LLMs

Individual LLMs can be changed online → on-line adaptation

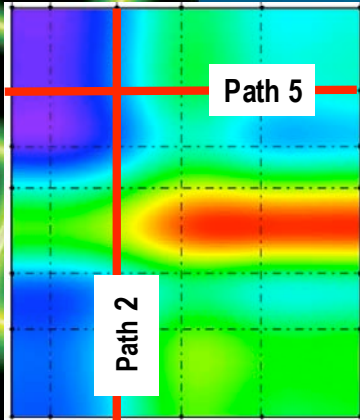
Model and optimization reflects actual boiler state, not state at time of learning



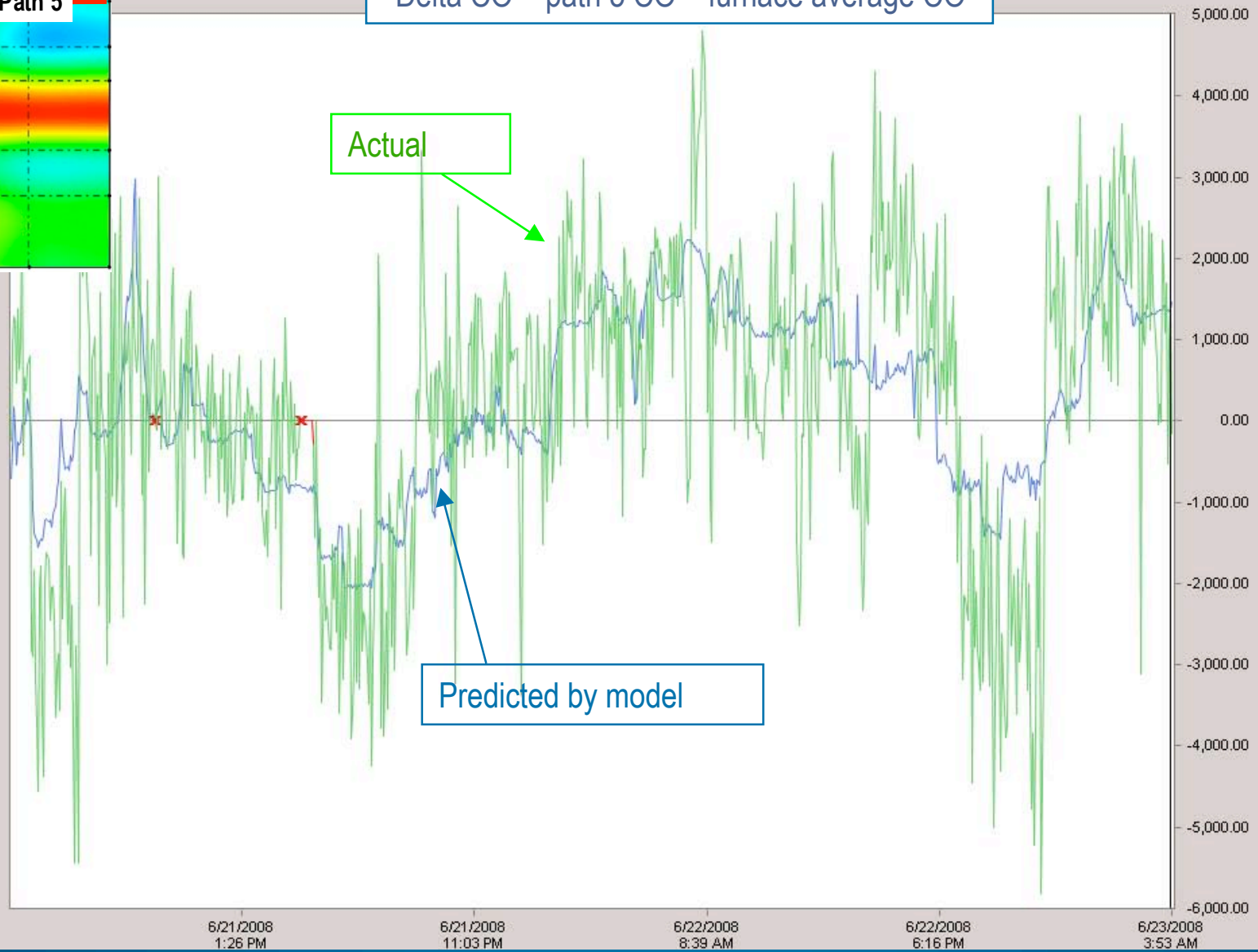
Build / Verify Models



Build / Verify Models



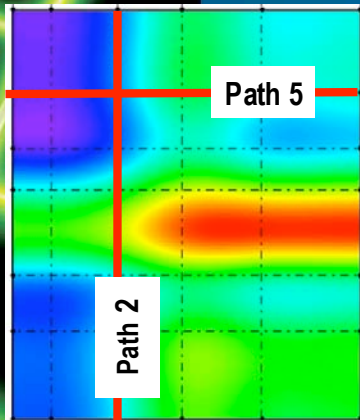
$$\text{Delta CO} = \text{path 5 CO} - \text{furnace average CO}$$



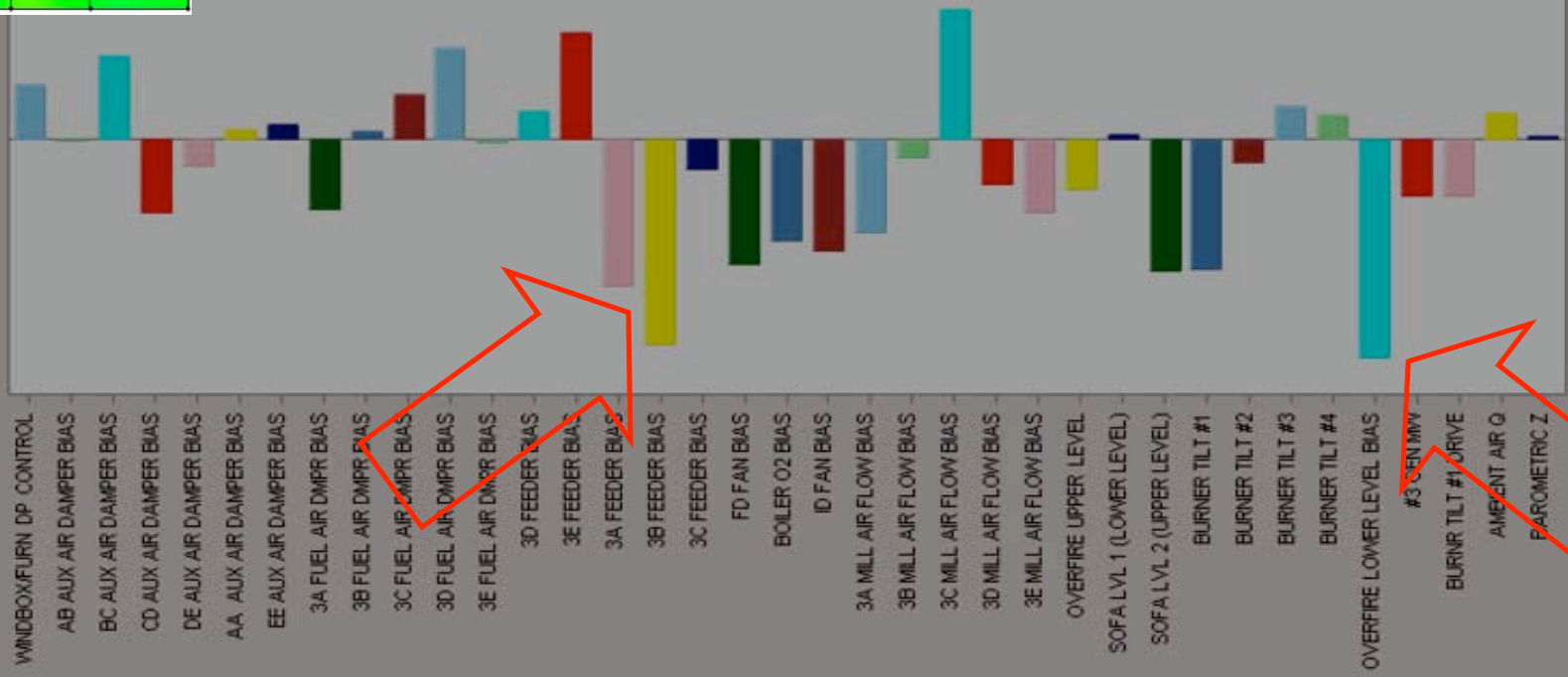
Combustion Optimizers: Modeling

37 controlled variables

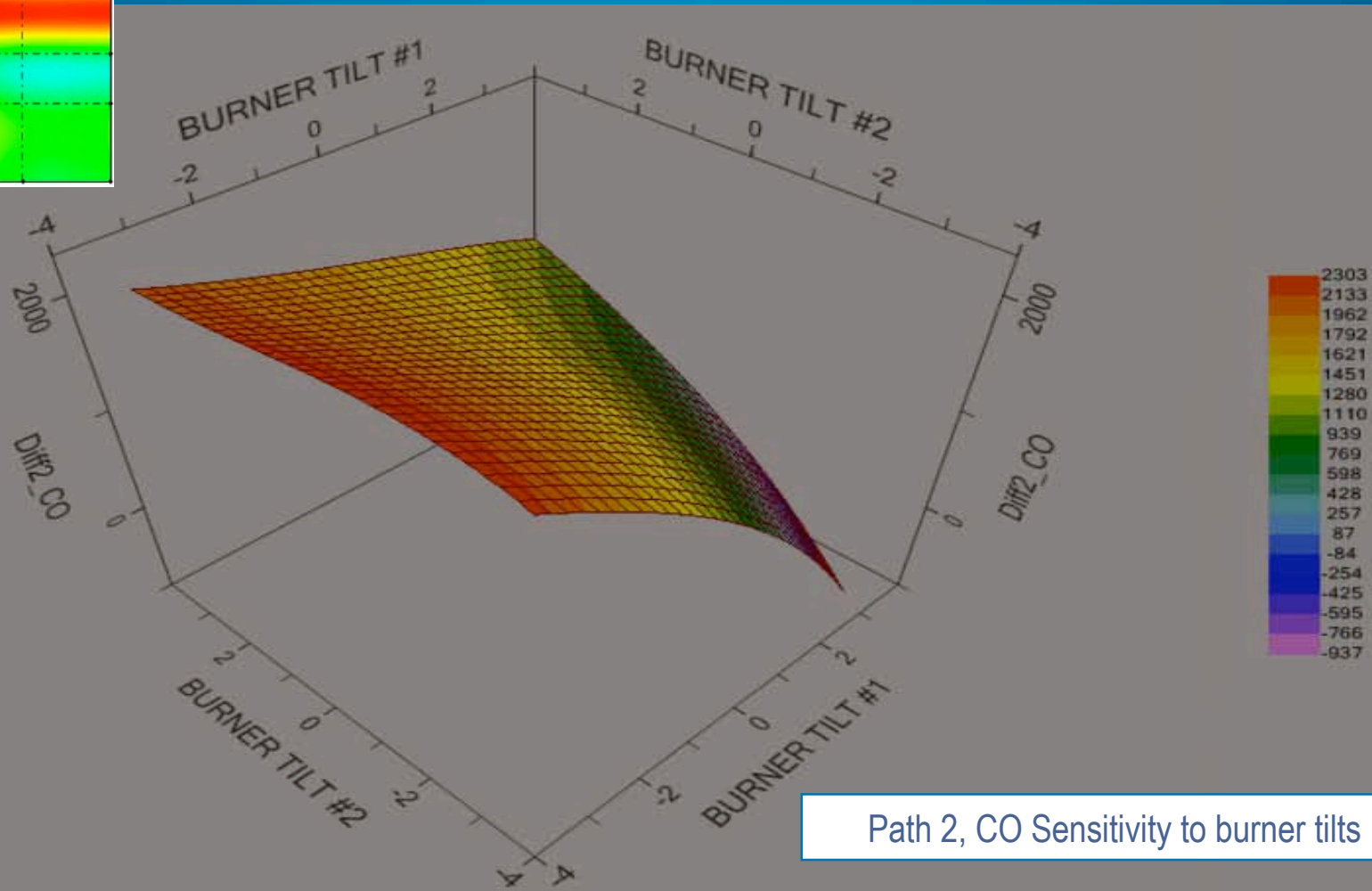
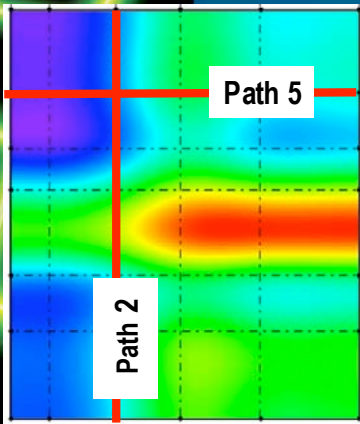
Graph shows how each variable affects path 5 ΔCO



Path 5, CO Sensitivities



Combustion Optimizers: Modeling



Path 2, CO Sensitivity to burner tilts

Combustion Optimizers: Summary

Standard OPC integration

Zolo**BOSS** data consistent with manual testing/observations

Optimizer builds models using Zolo**BOSS** data

- Individual paths
- Deltas between furnace average and each path

Large number of variables affect CO distribution

High model quality

Models appear robust and accurate

Preliminary resulting are very encouraging

ROI results to follow...

Agenda

Overview

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- Manual tuning
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Summary

Summary

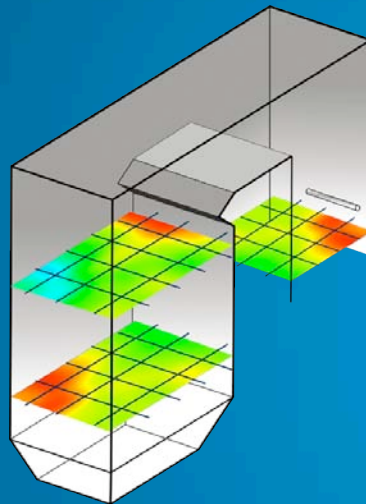
Balanced / Optimized combustion requires

- Accurate, real-time, combustion zone data
- The appropriate combustion optimization system
 - Man-in-the-loop
 - DCS
 - Combustion Optimizers
- Integration of data + control system

Balanced / Optimized combustion leads to

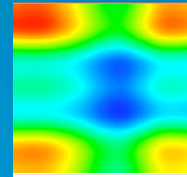
- Enhanced availability
- Decreased emissions
- Improved heat rate

Questions?

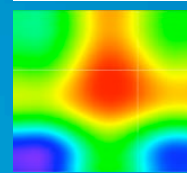


Measure

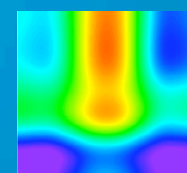
O₂



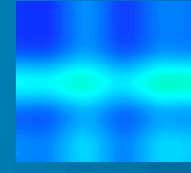
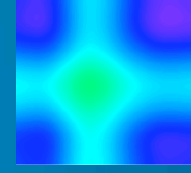
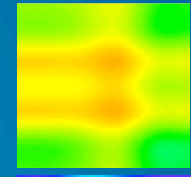
CO



Temp



Balance



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