2002 Conference on Unburned Carbon on Utility Fly Ash

A collaborative project for the improvement of combustion efficiency in utility boilers

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Outline of presentation

- Project aim and objectives
- Project participants
- The main project areas
- Progress so far

Project aim

- To develop new tools for the reliable and rapid prediction of combustion efficiency of coals in pf-fired utility boilers
- This will give the ability to improve fuel selection and chose the most appropriate burner and boiler design for a given fuel

Project Objectives

- Review previous work to predict combustion efficiency
- identify how prediction can be made quick and more reliable than in existing methods
- develop the ability to predict how a coal will perform on a given boiler
- provide a predictive tool which can be used to quantify combustion improvement from proposed plant modifications.

Project participants

- UK-based utilities - Innogy, PowerGen, Scottish Power and TXU Europe
- UK-based manufacturers - Alstom Power and Mitsui Babcock
- UK universities - Imperial College, London, and Nottingham University
- Project management by Innogy
- Parallel project on coal modelling at Leeds University

Acknowledgement

- Financial support from the UK Department of Trade and Industry’s Cleaner Coal Technology Programme.

Main project areas

- Review of existing information, including creating a data base
- Conducting new tests on power stations, large scale rigs and laboratory scale equipment
- Developing a new carbon-in-ash predictor

Review of existing information (1)

- Review of existing information concerning plant experience, to include (ideally) the plant arrangement, dimensions, coal analysis, operating conditions and performance (including carbon-in-ash).
- Data base created to store these data in an easily accessible form

Review of existing information (2)

- A review has also been made of methods for modelling coal combustion
- Modelling coal combustion must take into account inter-related phenomena (heat transfer, drying, devolatilisation, chemical reaction of volatiles and char).
- The most widely used models of devolatilisation and char combustion have therefore been reviewed.

Conducting new tests

- Laboratory-scale tests
- Rig tests
- Power station tests
- Some coals studies on all three scales of test to enable results to be compared.
- Data added to data base created from existing data

Laboratory-scale tests

- Imperial College, London
- University of Nottingham

Imperial College activities

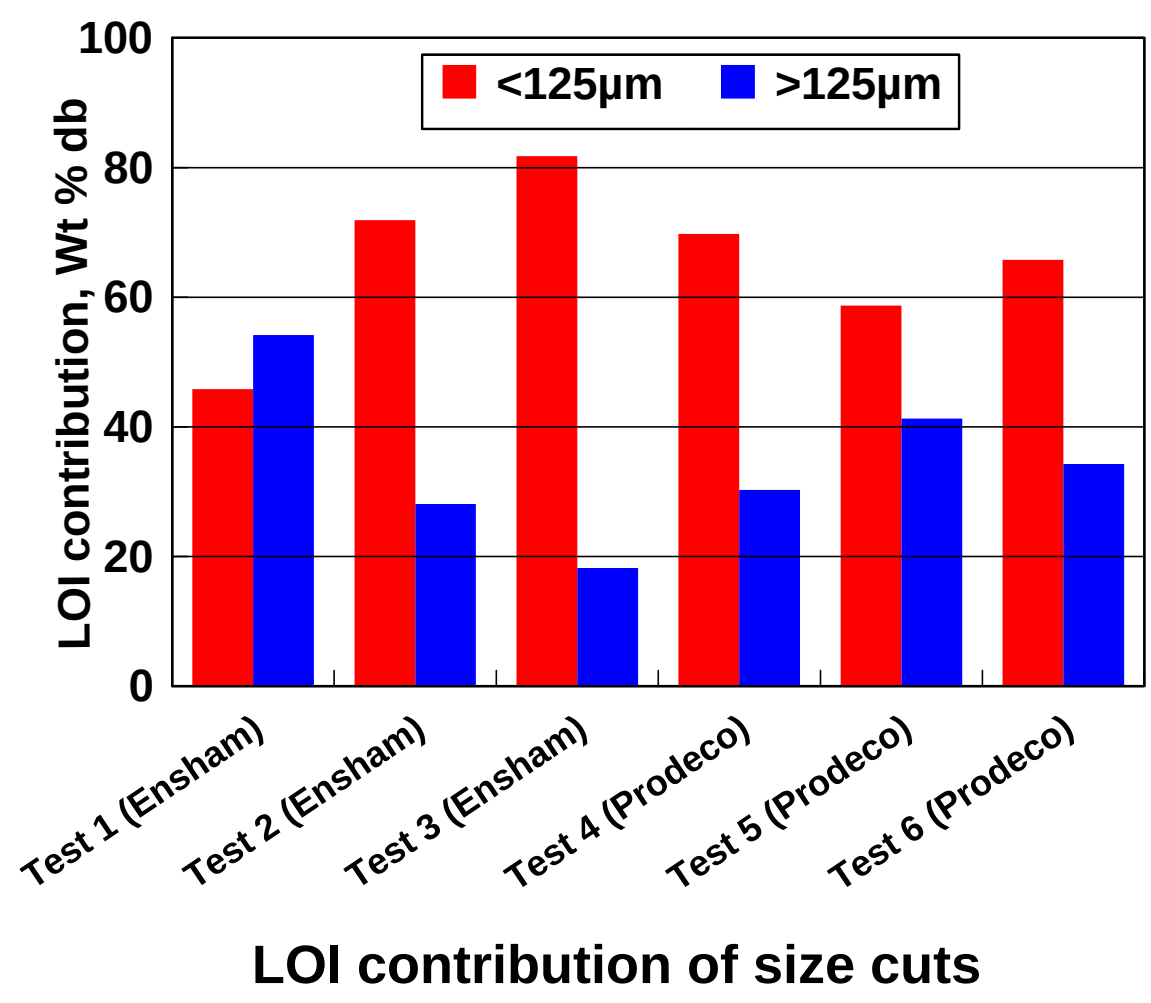
- Char production from high temperature wire mesh (HTWM) plus elemental analysis plus measuring char reactivity
- Particle heterogeneity assessments by optical analysis techniques
- Sonic sieving of char plus analysis to establish carbon distribution
- TGA reactivity on char sub-samples

ICSTM High Temperature Wire Mesh

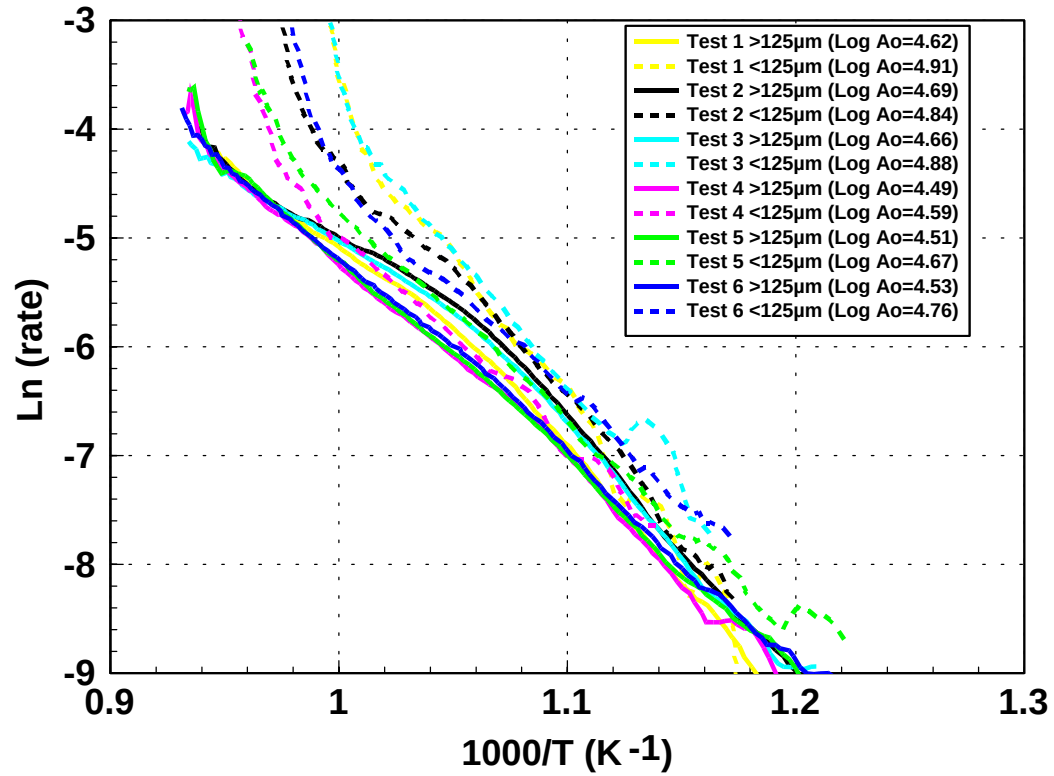
Devolatilisation Conditions

Initial Coal Temperature 25ºC
Heating Rate 10000ºC/s
Final Temperature 1600ºC
Hold Time 2s

LOI contribution of size cuts

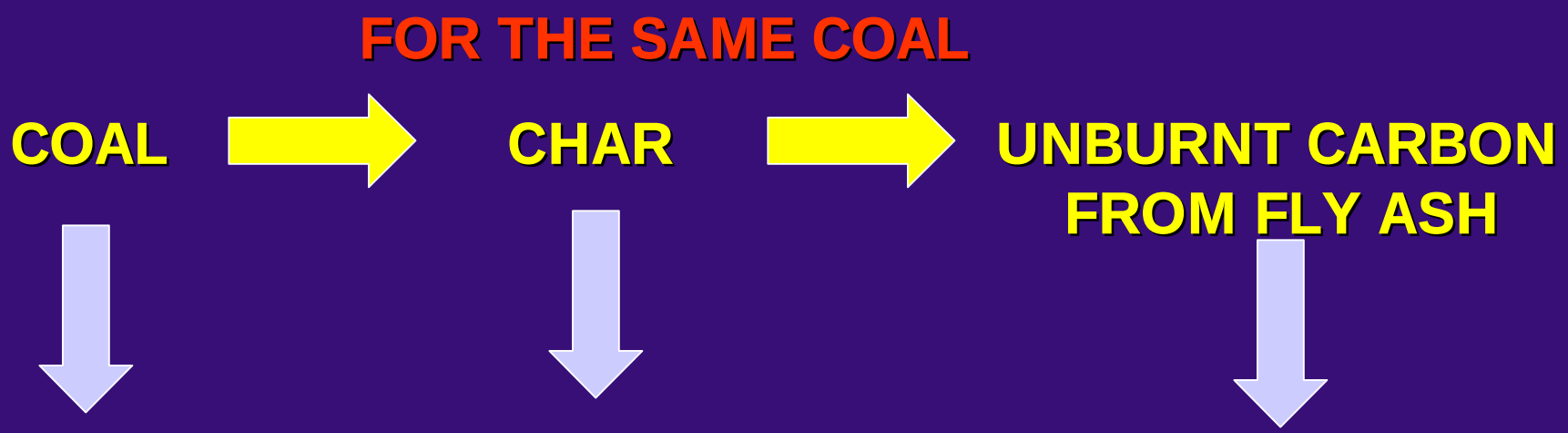


Comparison of char reactivities

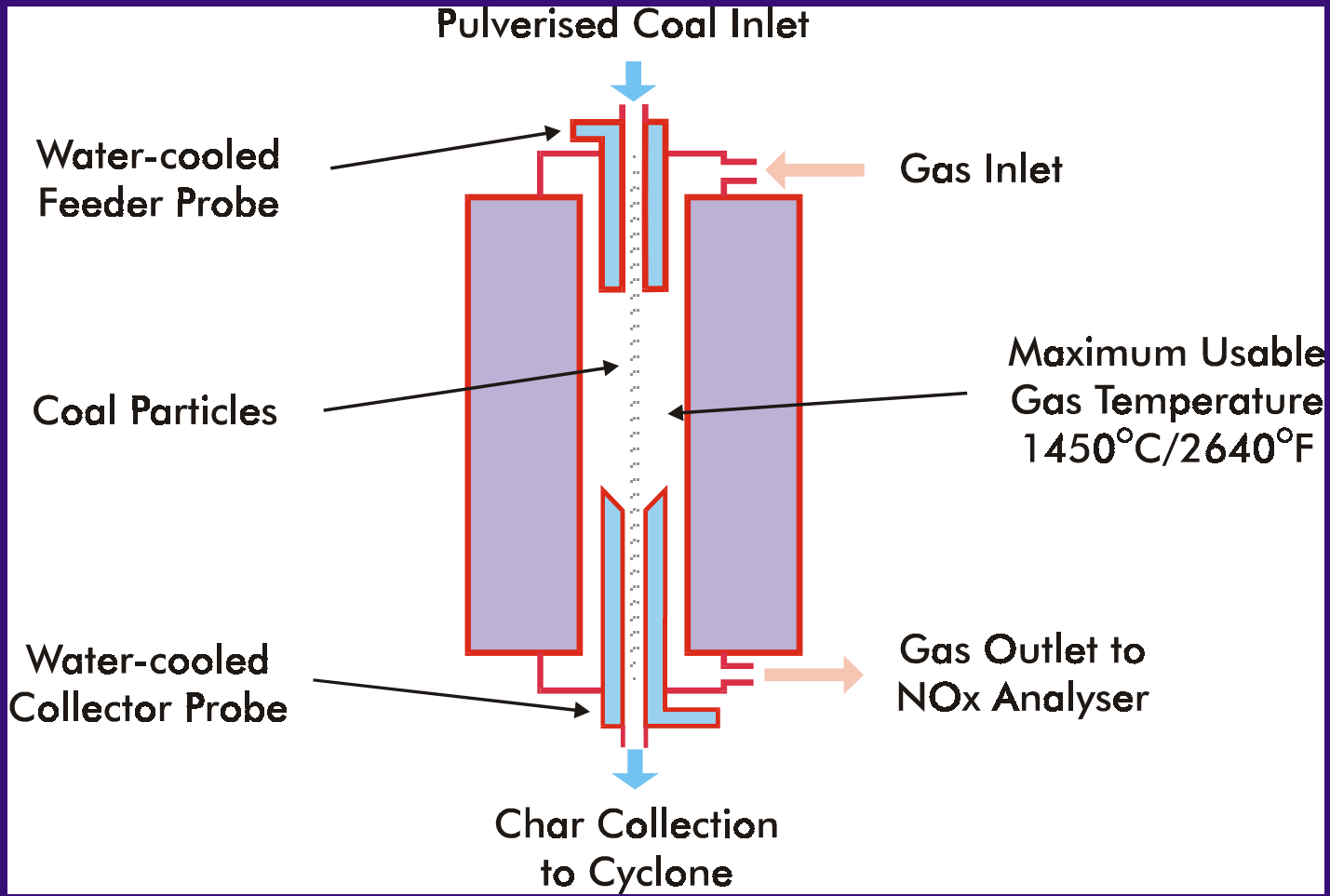


Comparison of char reactivities of sieved PFA (B mech) samples

Nottingham University activities



Drop Tube Furnace (Alstom, Nottingham, PowerGen)



DTF Objectives

- Develop a more realistic procedure to evaluate the effects of coal quality on unburned carbon
- Operate the DTF with a gas mix containing CO_2 to compare the effects of Furnace atmosphere
- Compare the burnout of char made in the DTF with char from a CTF
- Evaluate the DTF data and compare the results with reactivity correlations in various burnout models

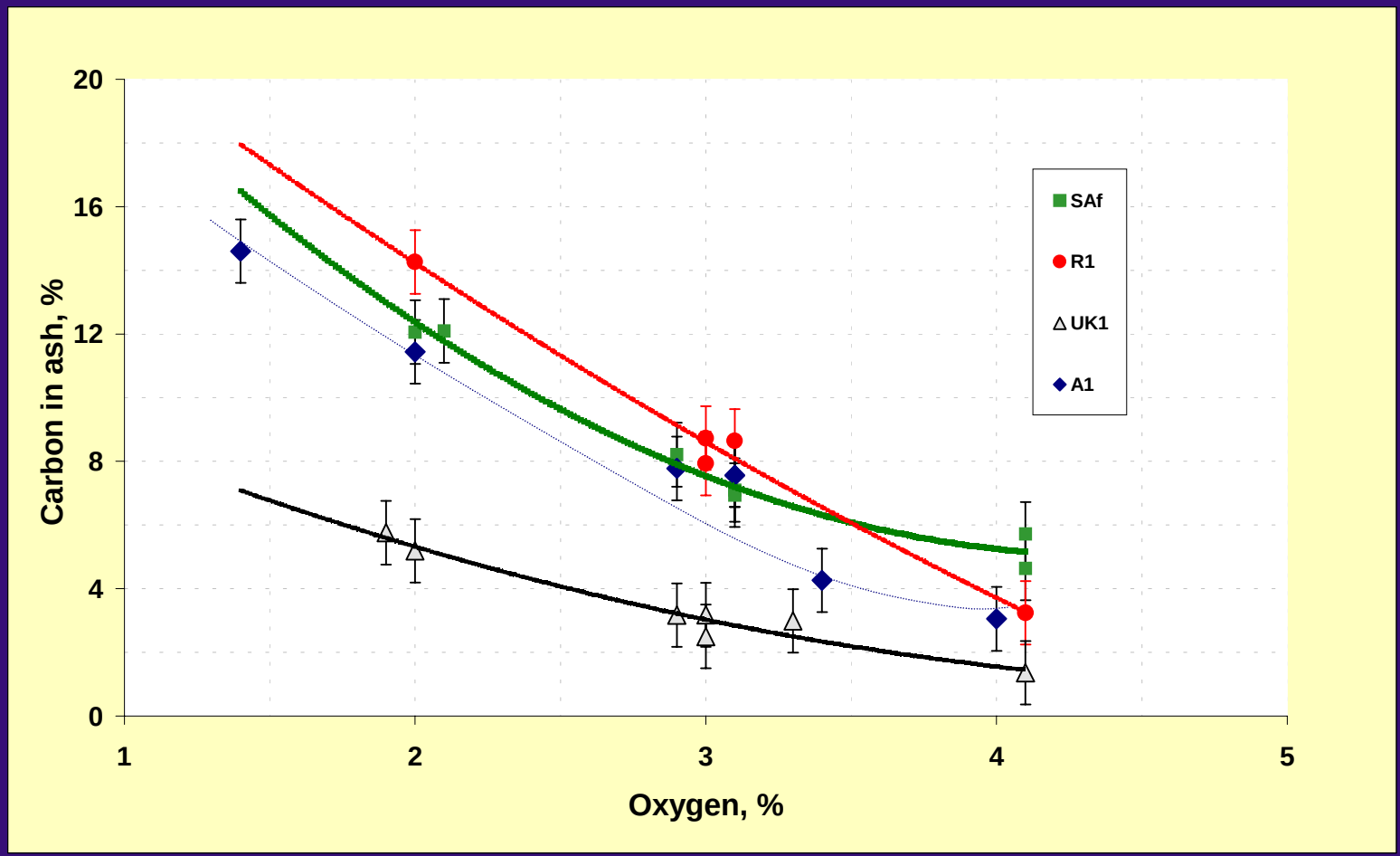
Rig tests

- Innogy’s 0.5 MW Combustion Test Facility
- PowerGen’s 1.0 MW Combustion Test Facility

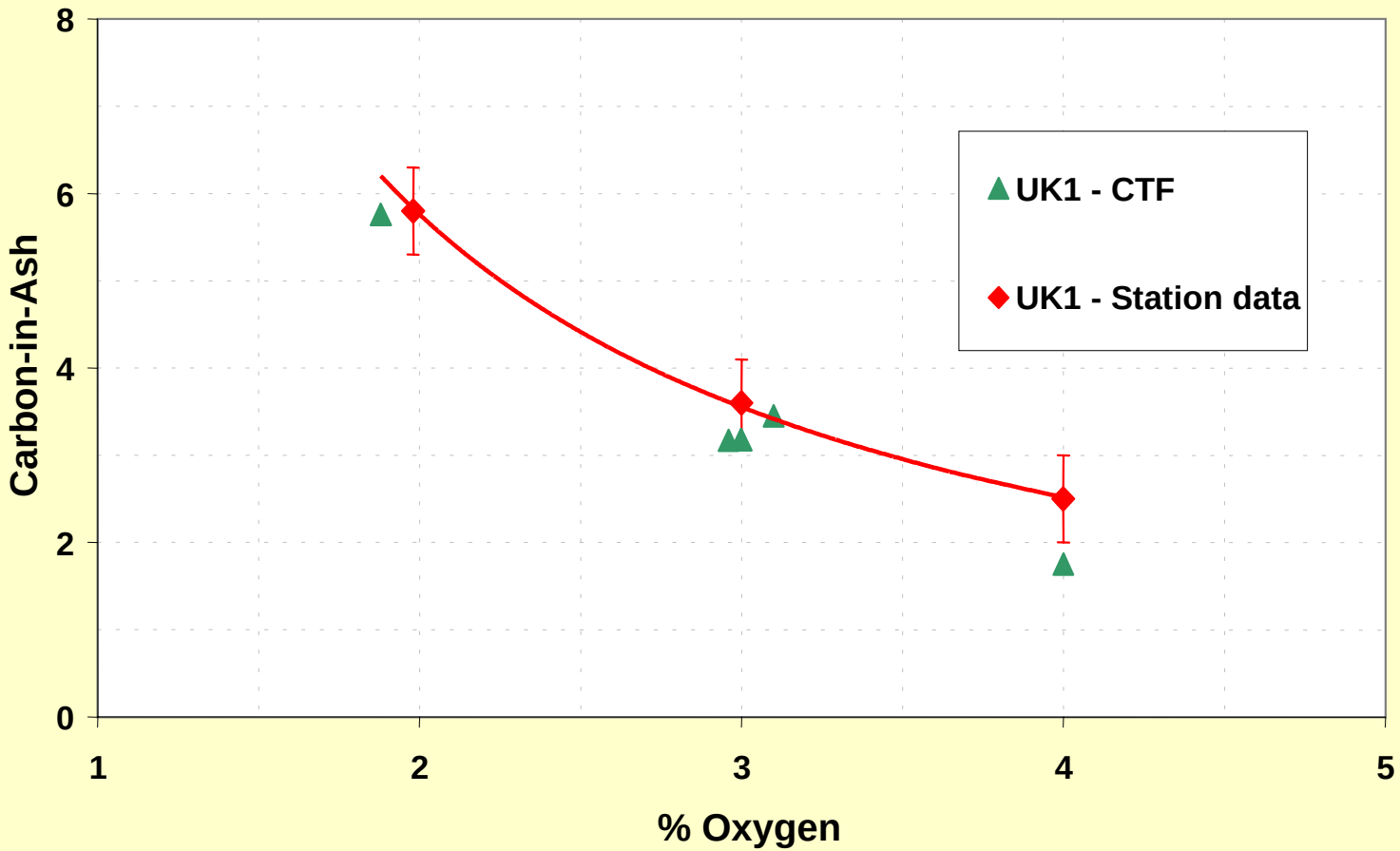
General view of Innogy's CTF

Scaled low NOx burner

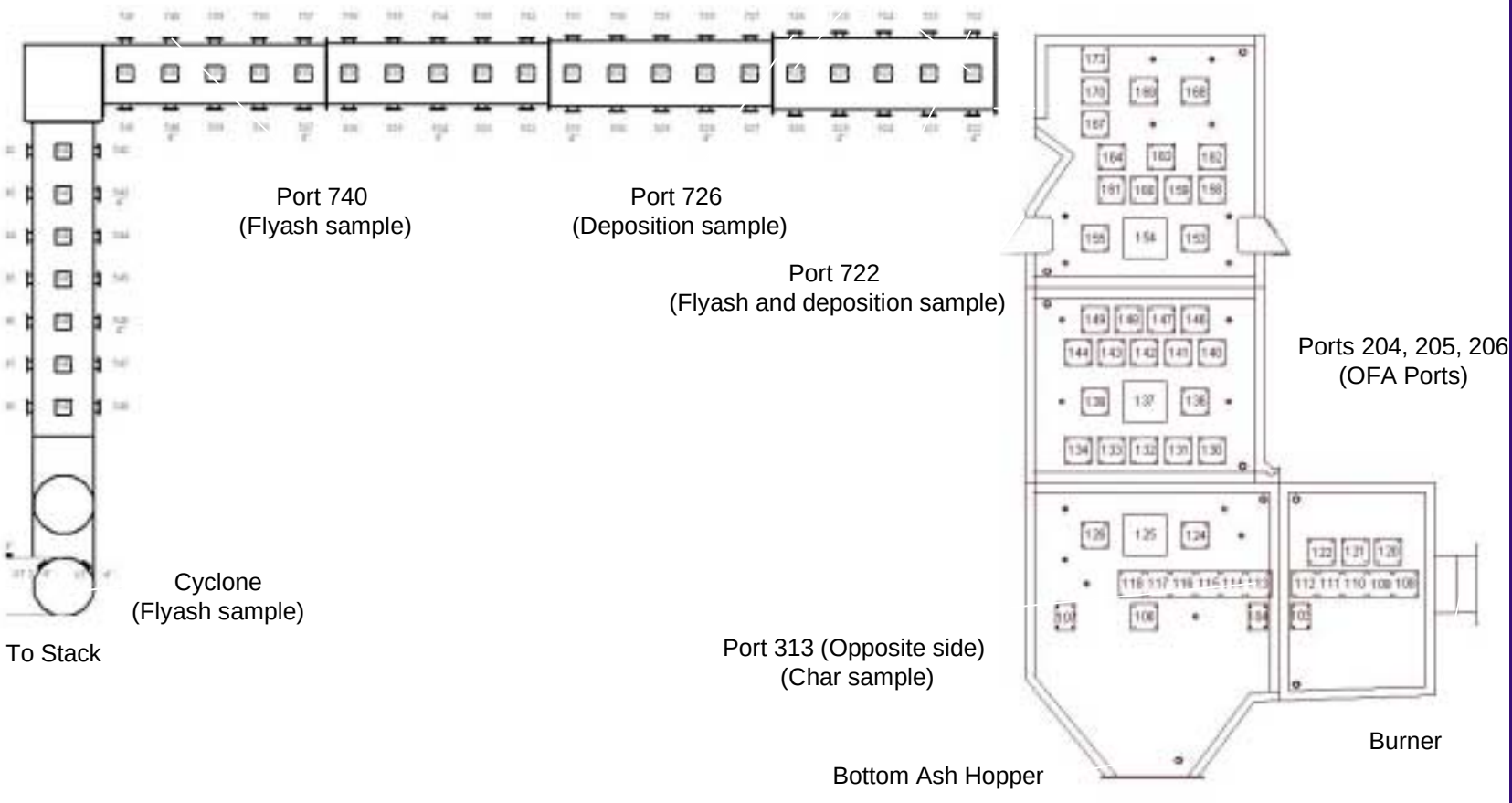
Innogy CTF Results



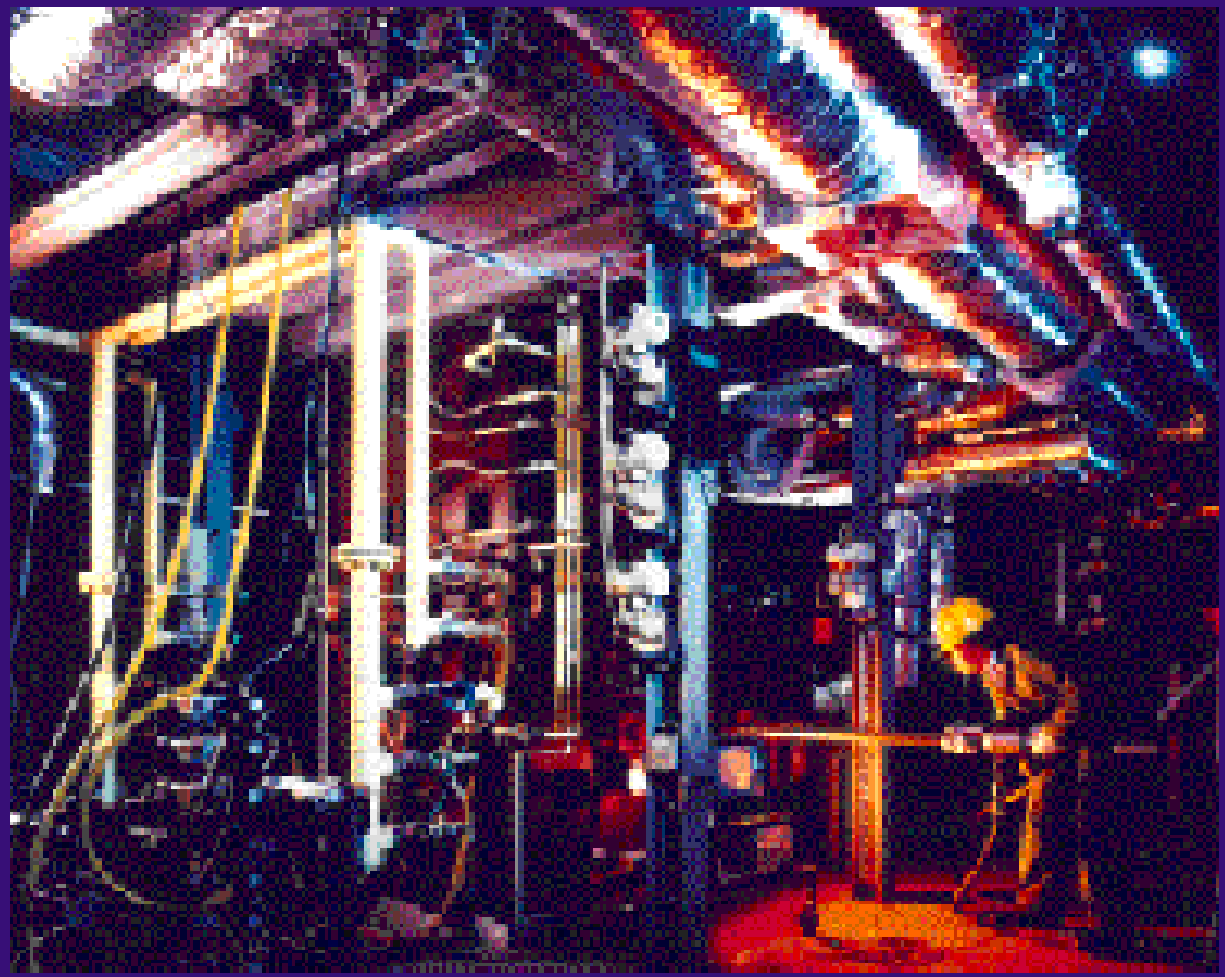
Comparison of Station and Innogy CTF results



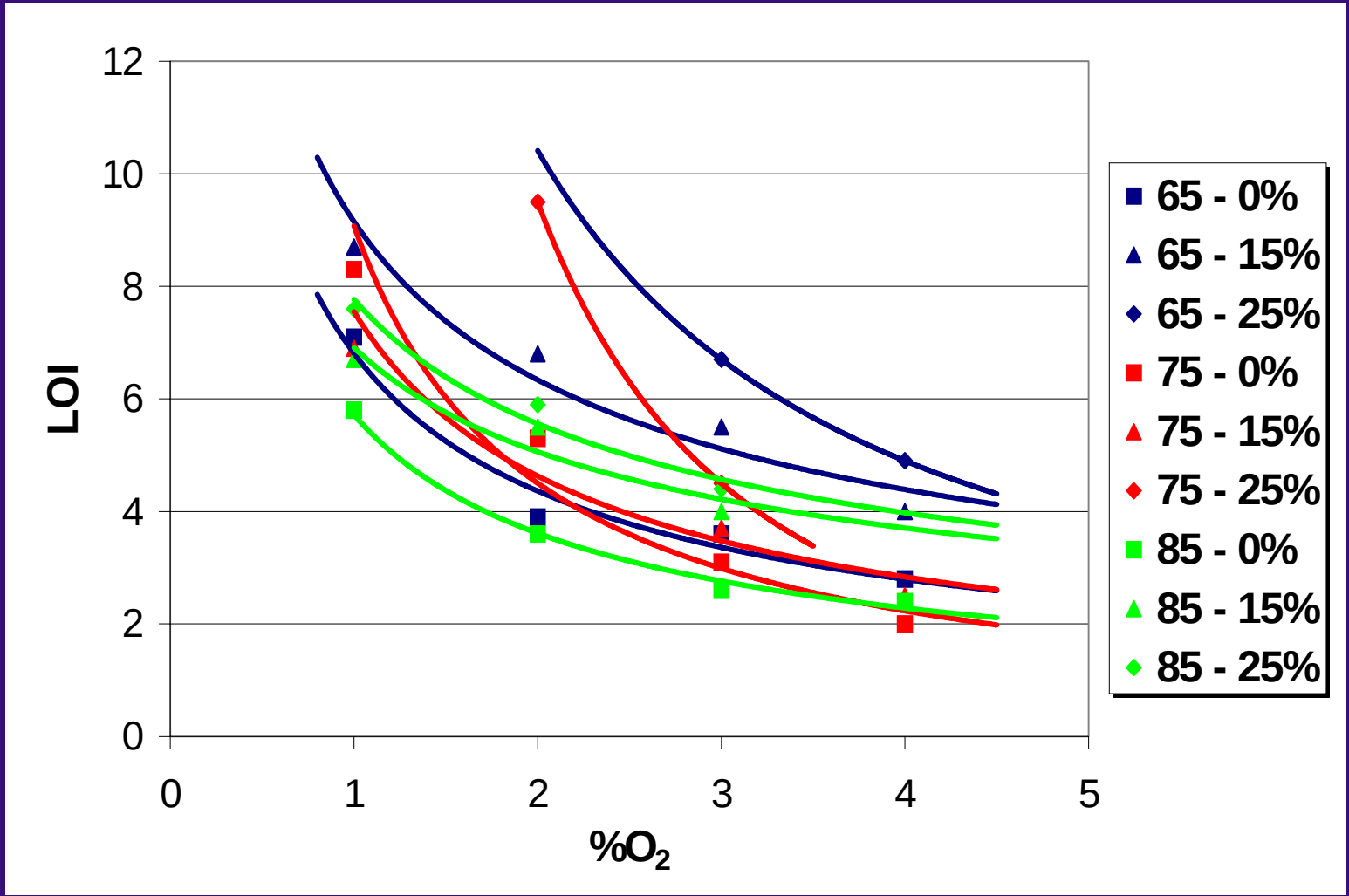
PowerGen Combustion Test Facility



PowerGen's CTF



PG CTF - Effect of grind size on LOI



65/75/85=%<75 microns, 0/15/25=% OFA

Power station tests

Innogy's Didcot A PS

4 x 500 MW front wall fired with low NOx burners

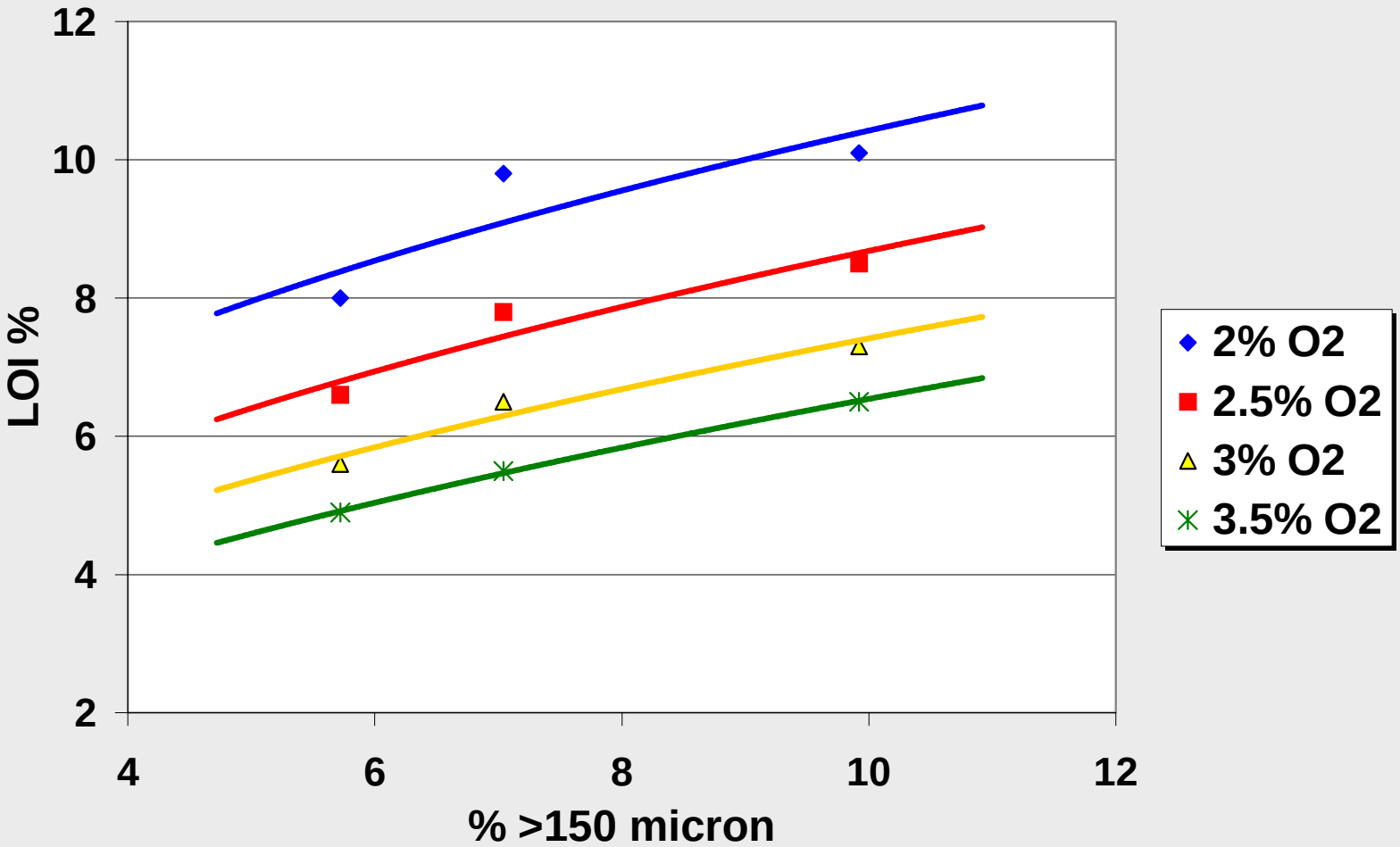
PowerGen's Kingsnorth PS

4 x 485 MWe tangentially fired with low NOx concentric firing system and over fire air

Castle Peak A and B

4 x 350 MW and 4 x 667 MW opposed fired

Typical PowerGen station data - LOI v pf grind



Development of a carbon-in-ash predictor

- Aim
- Possible approaches
- Method adopted

Aim of the c-in-ash predictor

- To be able to predict how a given coal will perform in a given boiler
- To provide a method that is quicker and more reliable than existing methods
- To be able to quantify possible combustion improvements (eg by predicting the best performance that can reasonably be expected)

Possible methods for c-in-ash predictors

- Empirical correlations - useful especially if ‘tuned’ to a particular boiler but suspect for ‘unusual’ coals
- CFD - time consuming and requires a lot of coal-specific data
- Challenge of modelling accurately the final stages of char burn out

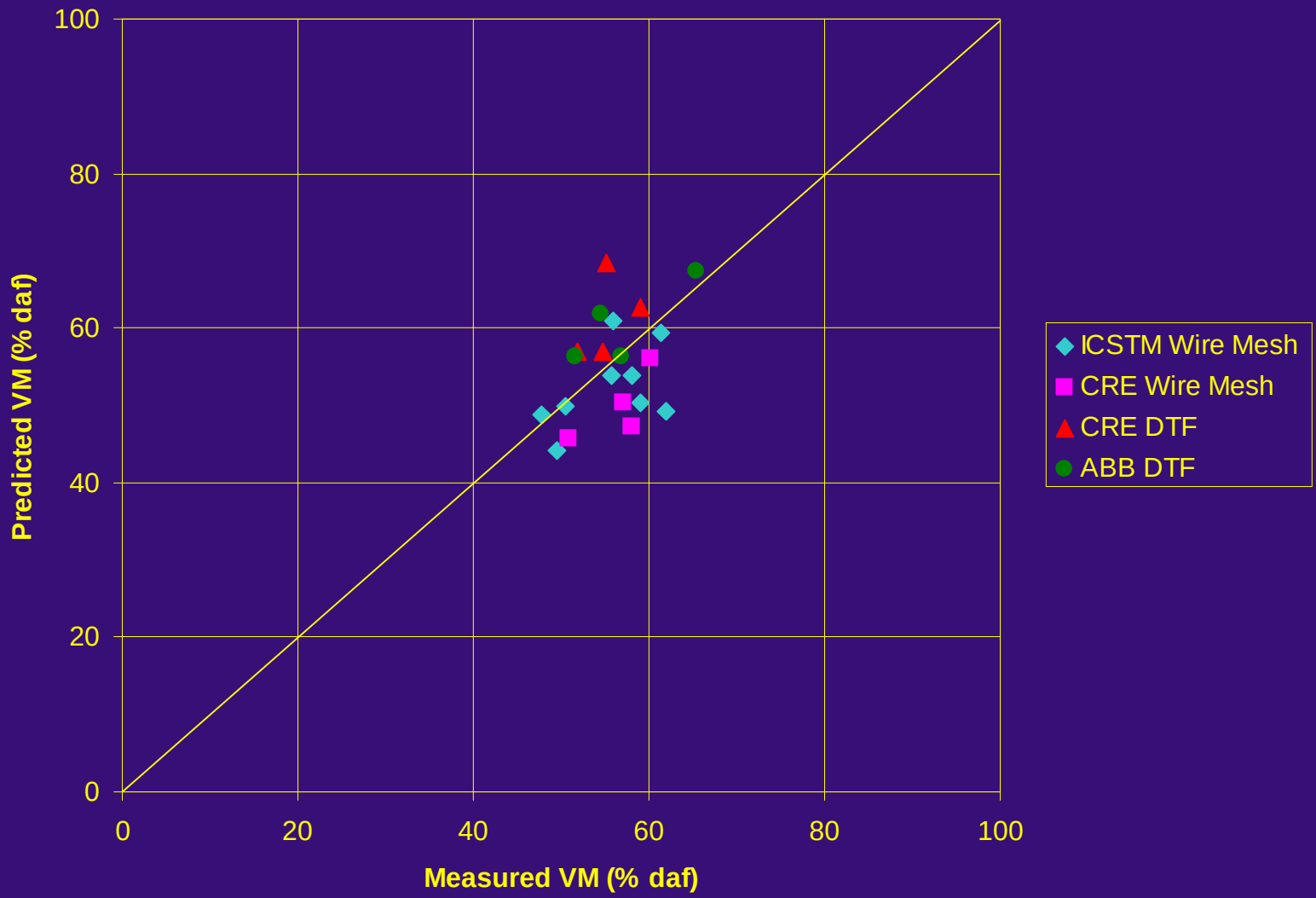
Method adopted for c-in-ash predictor

- Use detailed models (eg CPD, Flashchain, CBK8) to model devolatilisation and char burnout
- Use a simplified furnace model to obtain temperature-time curves for each burner
- These furnace models can be created once and for all for each PS boiler, so that models can be quickly run for a new coal
- Parallel project “Advanced Coal Combustion Modelling” at Leeds University delivering a more fundamental approach to carbon burnout

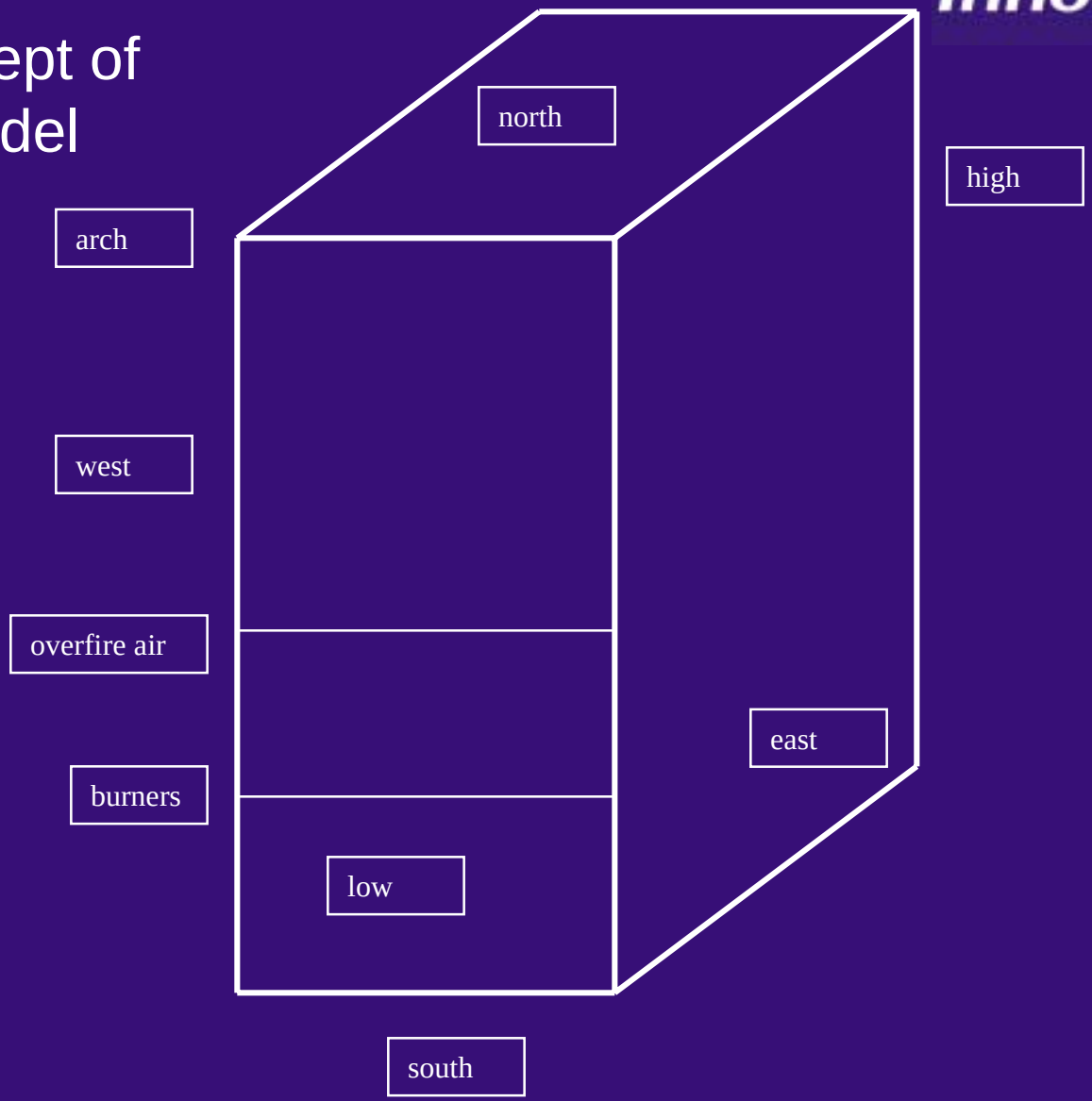
Testing coal combustion models

- Testing models against laboratory data
- PC Coal Lab (Flashchain) v high temperature volatile yield
- CBK8 compared against DTF burnout measurements

Predicted vs. Measured



Basic concept of furnace model



Progress to date (1)

- Review of existing information on burnout data and burnout models completed
- Data base created for existing and new rig and plant data. This includes data for around ten power stations with up to five coals per station, plus a range of rig data (including effects of grind size and OFA). Around 40 world traded coals included

Progress to date (2)

- Most of the laboratory scale, rig and power station tests have been completed
- Devolatilisation and char burnout models have been checked against measurements
- The c-in-ash predictor is partly developed

Remaining activities

- Analysing and reporting all the experimental data
- Reporting the tests of devolatilisation and char burnout models
- Comparing data for the same coal across different scales or rigs or power station
- Completion and validation of the c-in-ash predictor
- Project completion due November 2002!