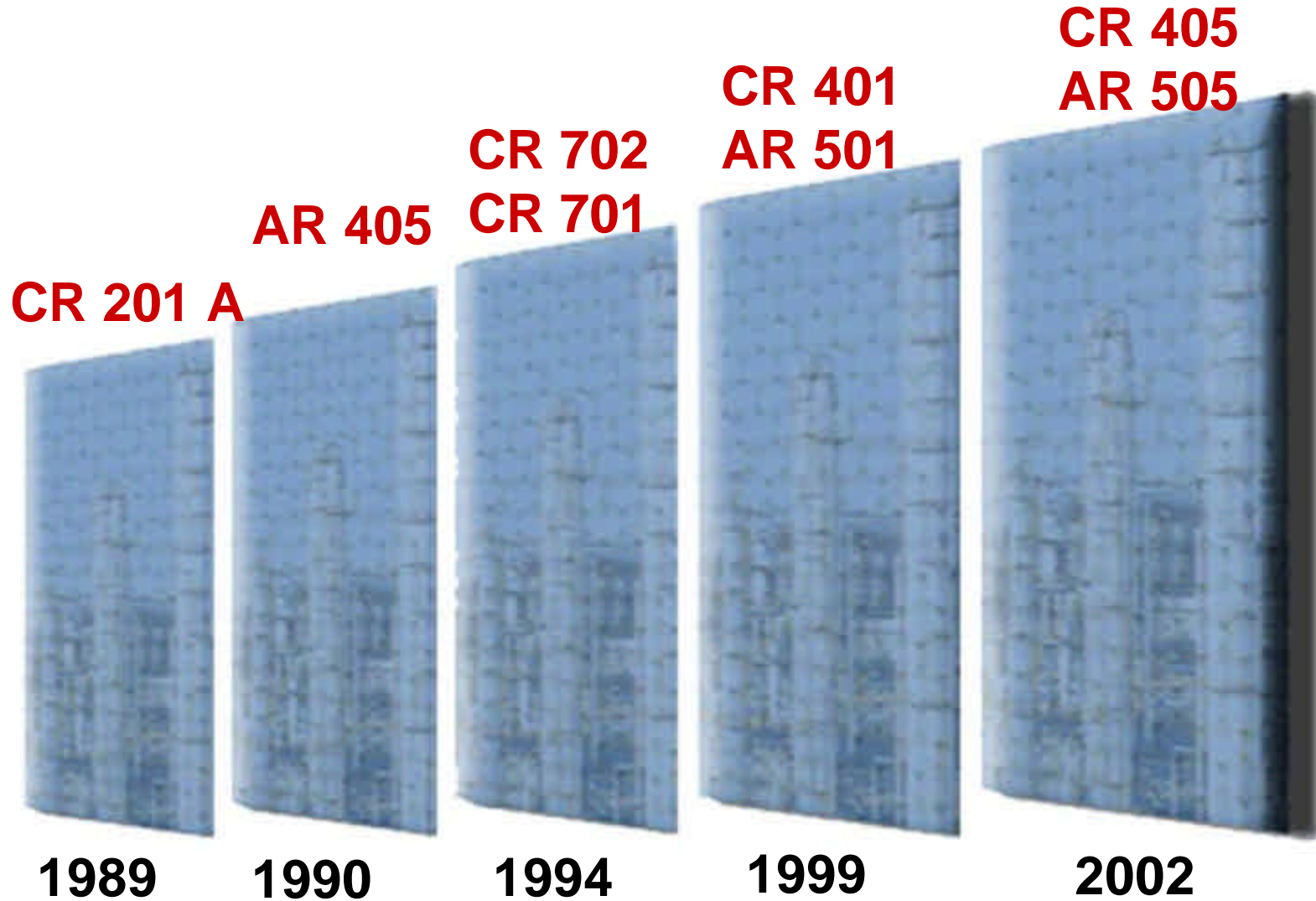


Increasing Reformer Performance through Catalytic Solutions

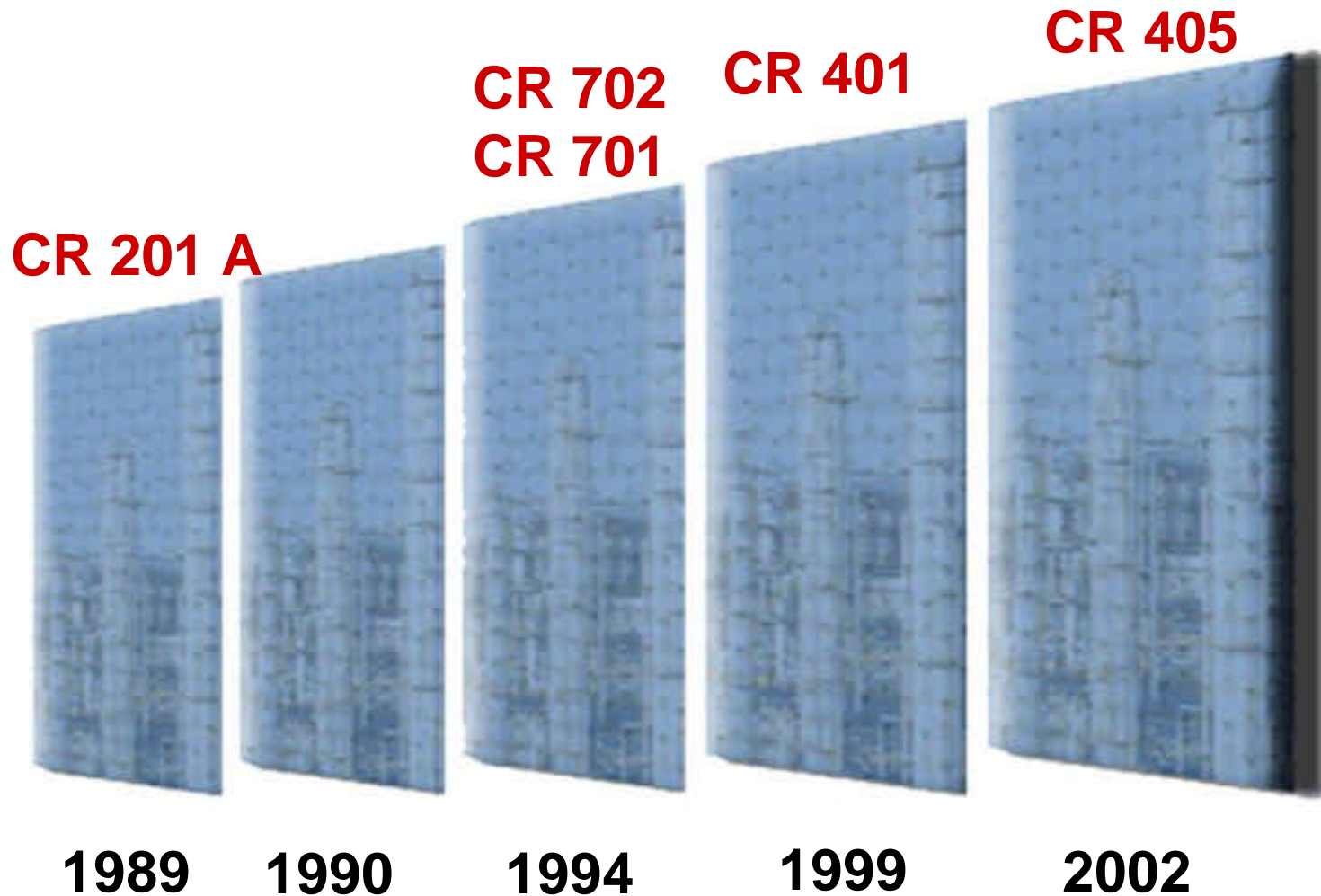
P.-Y. Le Goff, F. Le Peltier
Axens

- **CCR Catalyst Portfolio**
- **Reforming Approaches**
- **Industrial Feedback**
- **Conclusion**

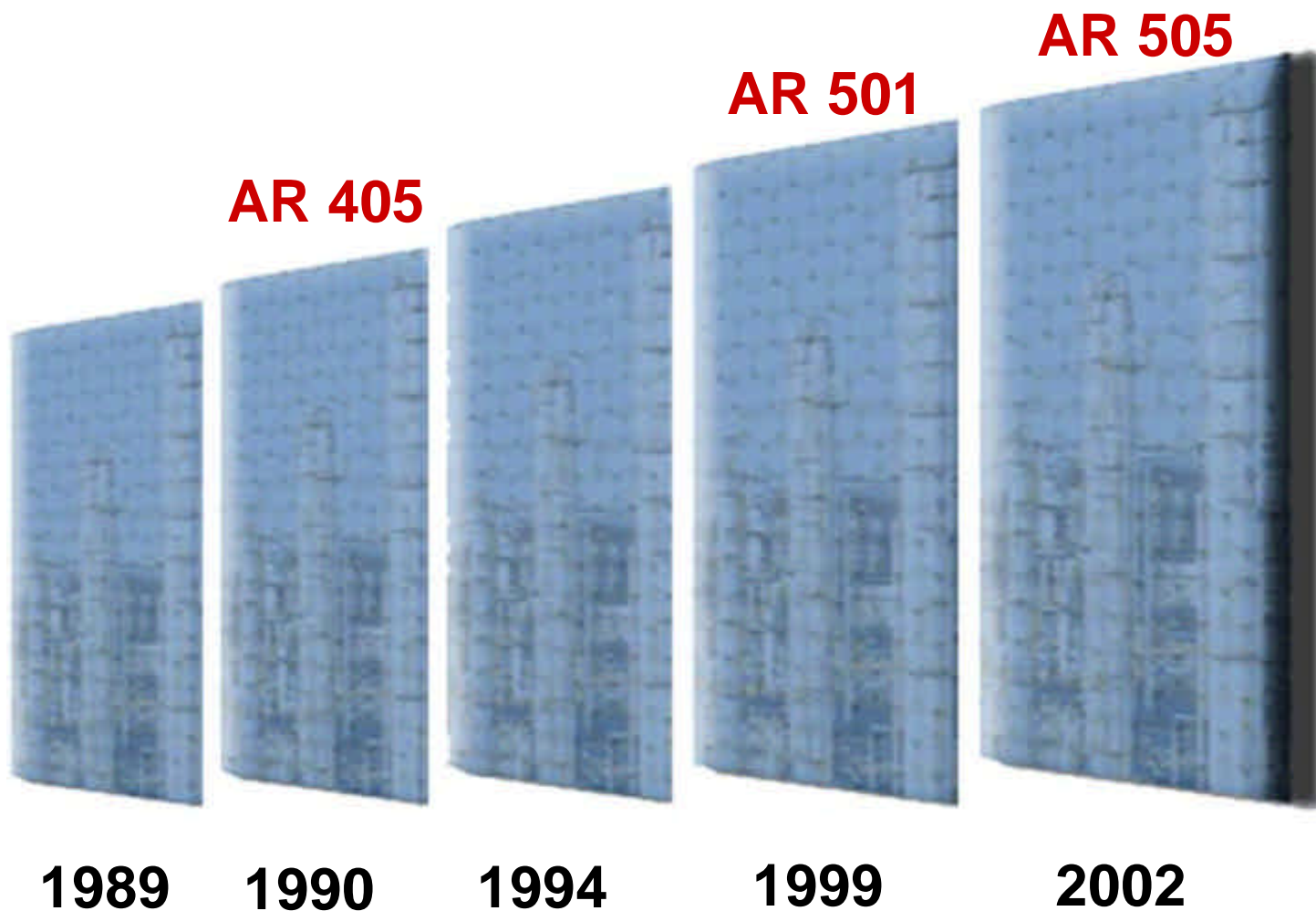
CCR Reforming Catalyst Launch Dates



CCR Reforming Catalyst Launch Dates



CCR Reforming Catalyst Launch Dates



Catalyst Tuned to Operating Conditions (Pressure)

CR 401

CR 405

... Max H₂ and C₅+

AR 501

AR 505

... Max Aromatics; *high severity operation*

3

6

11

barg

All in Commercial Operation

- **Adjustments achieved through:**
 - metal-to-acid balance
 - metal dispersion & distribution
 - platinum loading
- **Benefits:**
 - Higher selectivity and activity
 - Lower coke make

Customer Tests

Pressure 4 barg; N+2A = 55 wt %

**CR 401 compared to
CR 405**

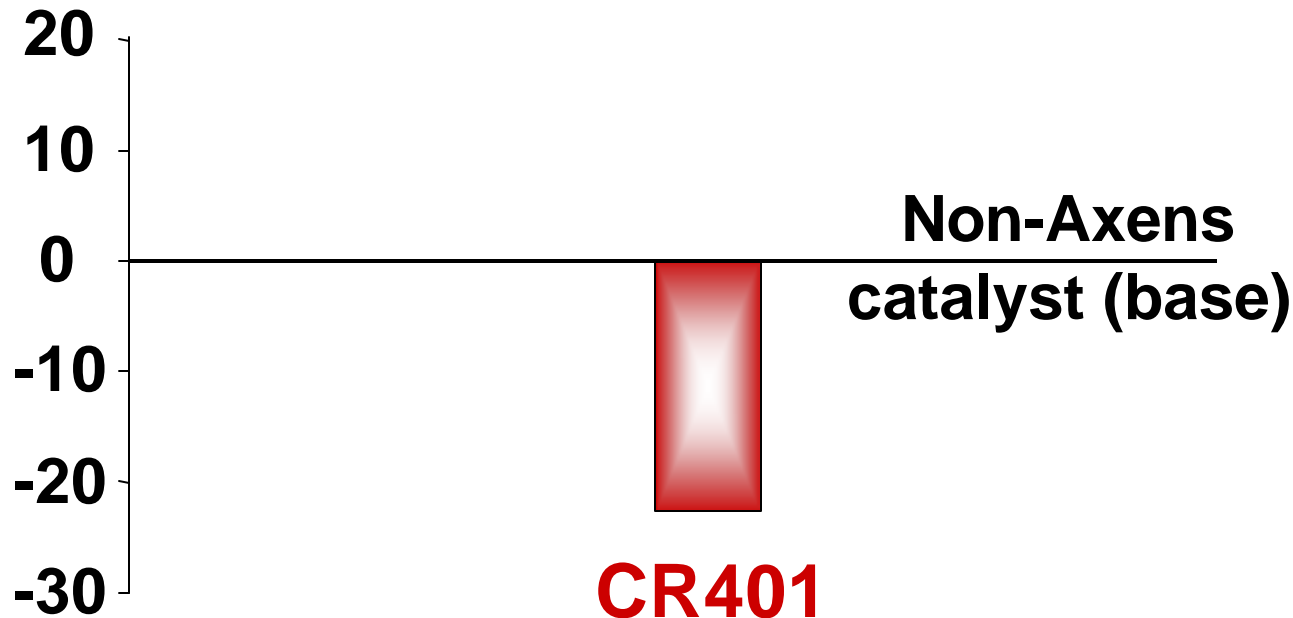
- activity, + 4°C
- selectivity C₅₊,
+0.5 to +0.6 wt %

**CR 401 compared to
reference (non Axens)
catalyst:**

- more active, + 4°C
- highest selectivity
- lowest coke make

Customer Tests Relative coke make vs. reference catalyst

Relative to reference, %



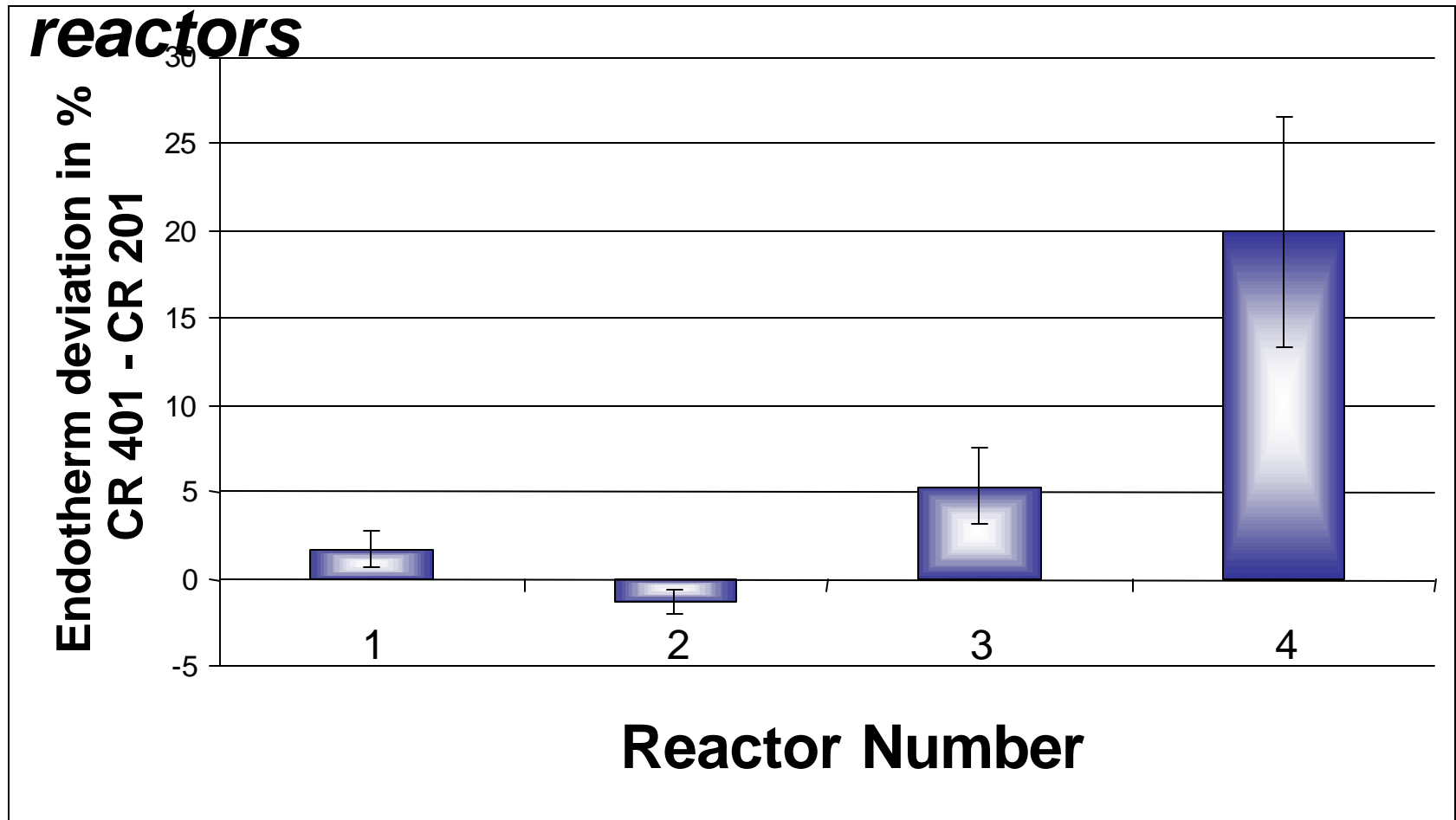
- **Feed Composition, N+2A: 73 wt %**
- **Feed Boiling Range, IBP/FBP: 100/180 °C**
- **Product Octane, RON: 102**
- **Space velocity, WHSV: 3.1 h⁻¹**

- **Comparison between CR 401 vs. CR201**
 - ✘ ***C₅⁺ yield: +0.7 wt %***
 - ✘ ***More active: - 4 °C WAIT****
 - ✘ ***Coke production: - 20 wt %***
- **Test run results vs. Guaranteed performance**
 - ✘ ***C₅⁺ yield: + 1.27 wt % (absolute)***
 - ✘ ***H₂ yield: + 7.8 wt % (relative)***

*** WAIT = Weighted Average reactor Inlet Temperature**

- **Selectivity Improvement**
 - **Naphthenes conversion already satisfactory**
 - **Objective: improve paraffins conversion**
 - **Evidence: higher endotherm in the last reactor**
 - ✘ ***Main reactions of the tail reactor are linked to paraffins conversion***
 - » Endotherm: dehydrocyclisation
 - » Exotherm: cracking

Large endotherm improvement in the tail

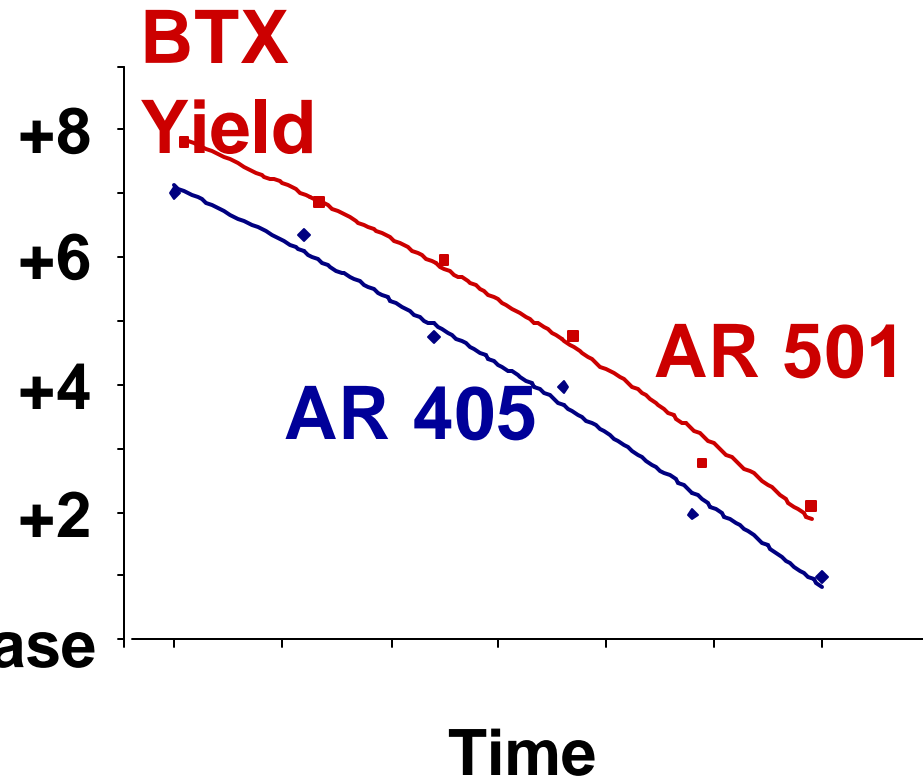


AR 501 compared to AR 405

- Pressure 3.2 barg
- N+2A: 37.3 vol%

-AR 501

- ⊠ More active, +10°C
- ⊠ Improved selectivity, +0.7 total aromatics
- ⊠ Less coke, -20%
- ⊠ Less platinum, -20 %



**Formulation tuned for low pressure CCR
operation affords:**

- ❑ ***Improved commercial performance***
 - » Lower coke make
 - » Improved activity
 - » Higher selectivity
- ❑ ***Pilot results confirmed in commercial unit***

CR 405 compared to CR 201

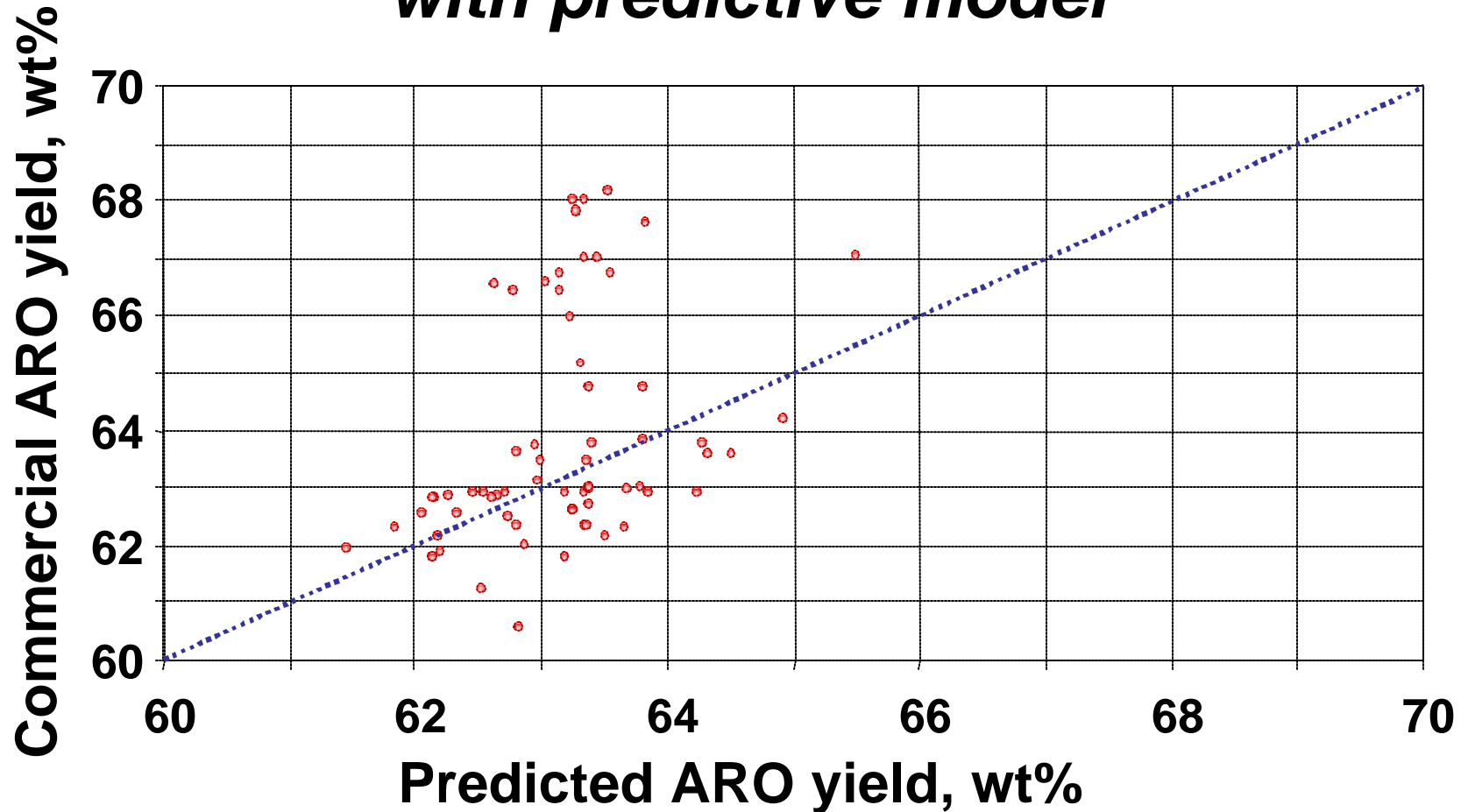
Conditions	Unit A	Unit B
Pressure, barg	6	10
N+2A, wt%	67.6	67.6
Product RON	103	104
Results		
Activity, °C	+4	+2
Reformate Yield, wt%	+1	+0.5

AR 505 compared to AR 405

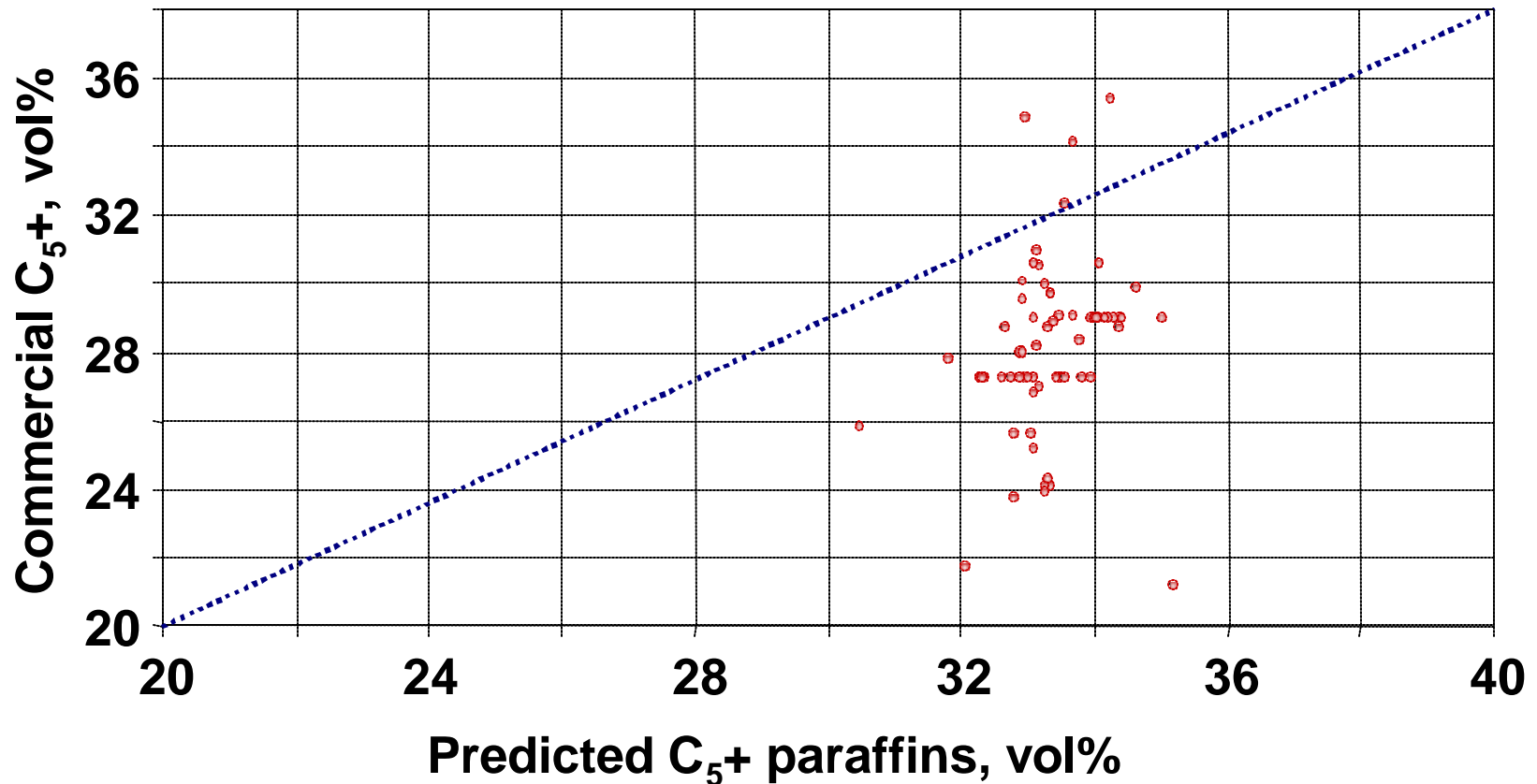
- **Operating conditions**
 - **Pressure: 10 barg**
 - **N+2A: 37.5 wt %**
- **Results**
 - **Activity same**
 - **Selectivity same**
 - **Pt inventory, -20%**

More homogeneous Pt distribution enables a reduction in the Pt inventory at constant activity

**Total aromatics yield in good agreement
with predictive model**



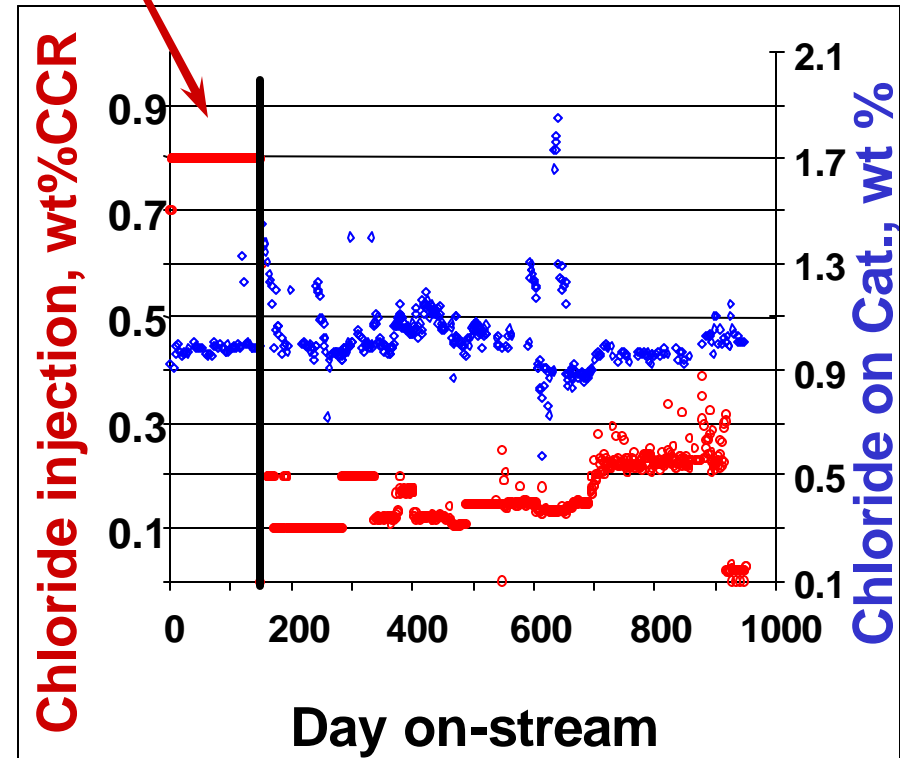
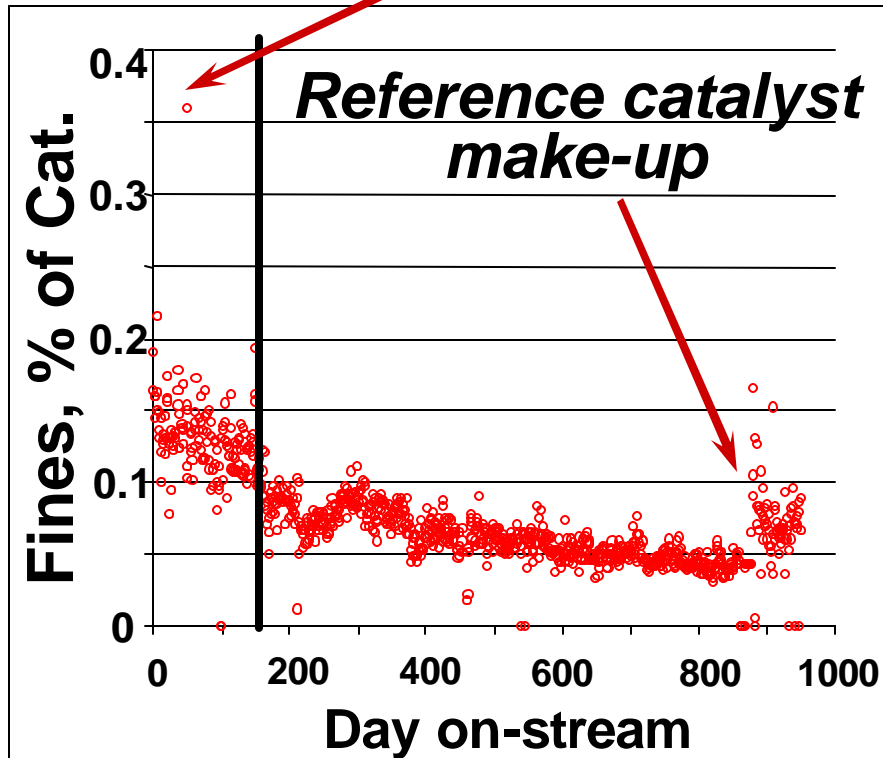
***Lower paraffins in reformat,
confirms higher aromatics yield***



- **New impregnation technology**
 - ❑ ***Higher uniformity of metal dispersion***
 - ❑ ***Combined advantage of activity, selectivity and reduced Pt inventory***
 - ❑ ***Better commercial performance than predicted by direct modeling from pilot testing***

Mechanical and chloride retention properties

Reference catalyst in unit



wt% CCR = wt% of chlorine per weight of circulating catalyst

CR 702 versus reference catalyst

- Reduction of “fines make” by 70 %, at higher catalyst circulation rates
- Reduction of the chloride addition by 80 %
- Activity gain: +8°C
- C₅+ Selectivity Improvement: 1.3 vol%

***New, catalyst technology applied to
fixed bed catalyst - RG 682***

- **Commercial performance of RG 682 compared to RG 482 (current formulation)**
 - **Activity improvement: + 7 °C**
 - **Selectivity Boost: + 2.1 wt%**
 - **Actual C₅+ yield vs. estimated: +0.1 wt %**

- **New manufacturing methodology**
 - affords better control:
 - ✘ *Metal to acid site balance*
 - ✘ *metal dispersion & distribution*
 - enables customized catalysts for:
 - ✘ *Specific operational parameters: pressure*
 - ✘ *Targeted objectives: RON, Aromatics*
 - ✘ *Reduction in Pt loading*
- **Predictive model estimates (conservatively) commercial performance based on pilot testing of commercial products**