Selecting Transients Automatically for the Identification of Models for an Oil Well

IFAC Workshop on Automatic Control in Offshore Oil and Gas Production

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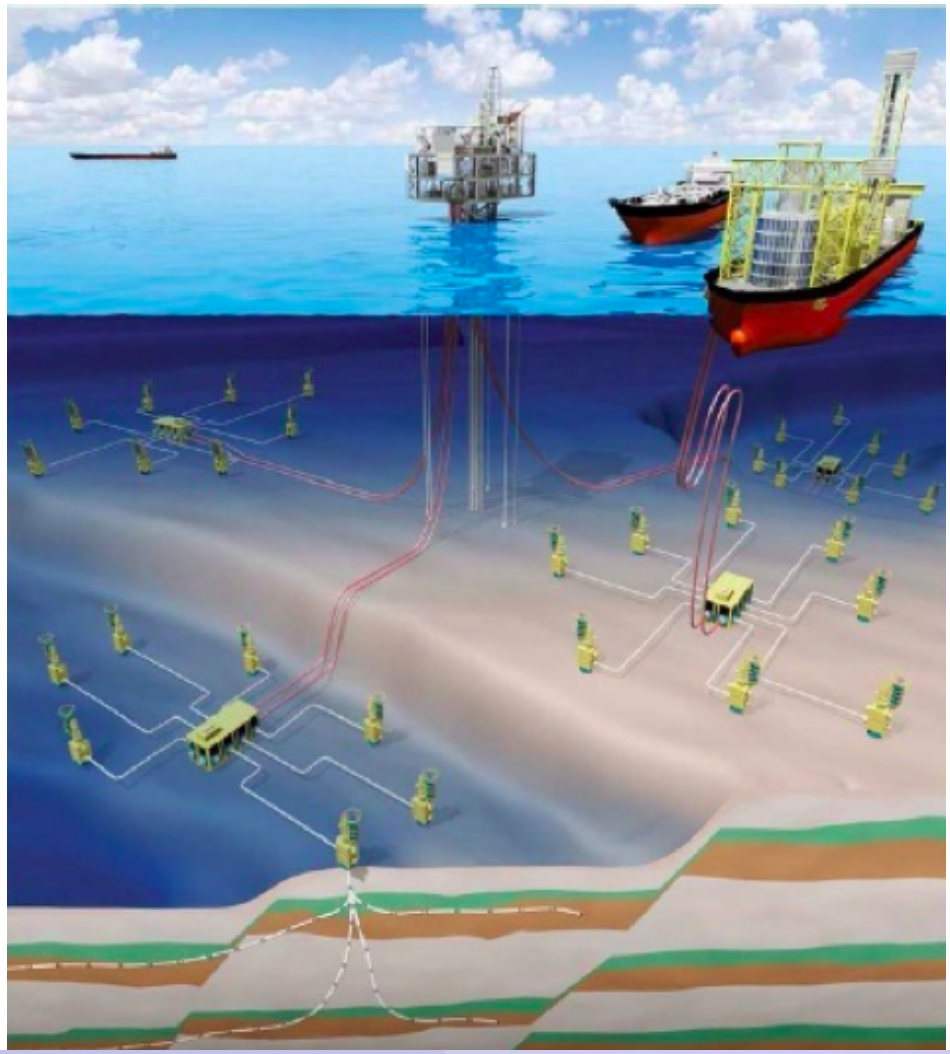
Florianópolis, 2nd IFAC Oilfield, 2015

Offshore Oil Production Process

Introduction

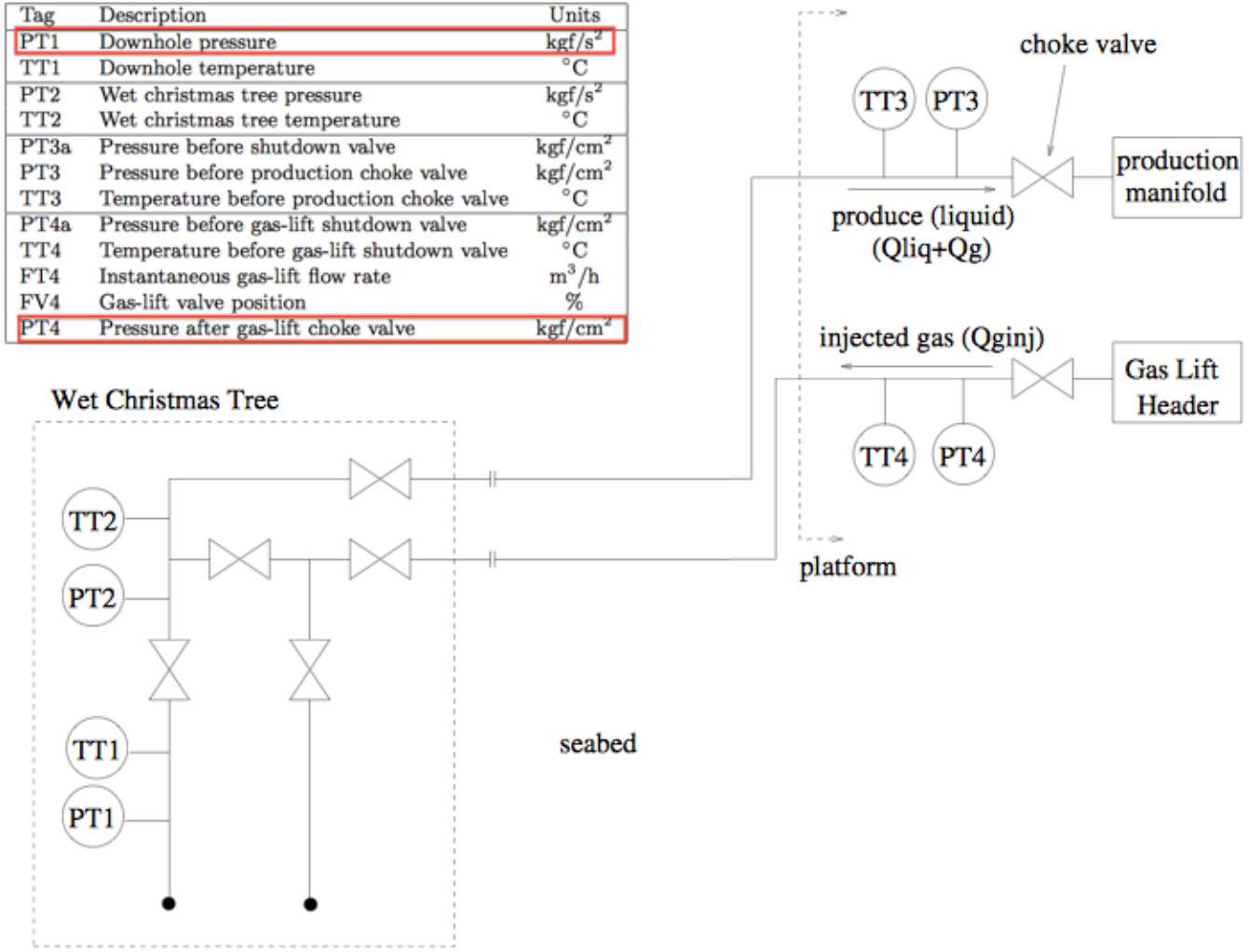


- Stacionary Production Unit;
- Riser;
- Flow Line;
- Manifold;
- Wet Christmas Tree;
- Wellhead;
- Gas Lift;
- Soft Sensors.

P&ID diagram

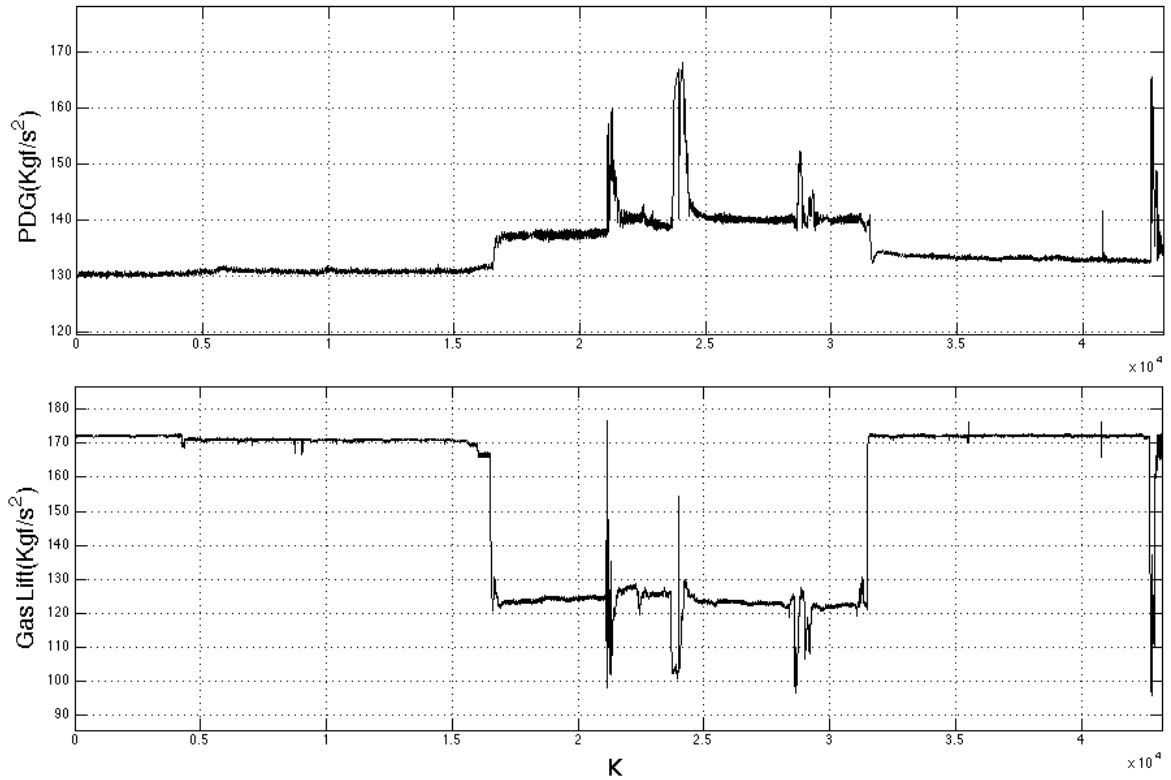
Introduction

Tag	Description	Units
PT1	Downhole pressure	kgf/s^2
TT1	Downhole temperature	°C
PT2	Wet christmas tree pressure	kgf/s^2
TT2	Wet christmas tree temperature	°C
PT3a	Pressure before shutdown valve	kgf/cm^2
PT3	Pressure before production choke valve	kgf/cm^2
TT3	Temperature before production choke valve	°C
PT4a	Pressure before gas-lift shutdown valve	kgf/cm^2
TT4	Temperature before gas-lift shutdown valve	°C
FT4	Instantaneous gas-lift flow rate	m^3/h
FV4	Gas-lift valve position	%
PT4	Pressure after gas-lift choke valve	kgf/cm^2



Time Series

Introduction



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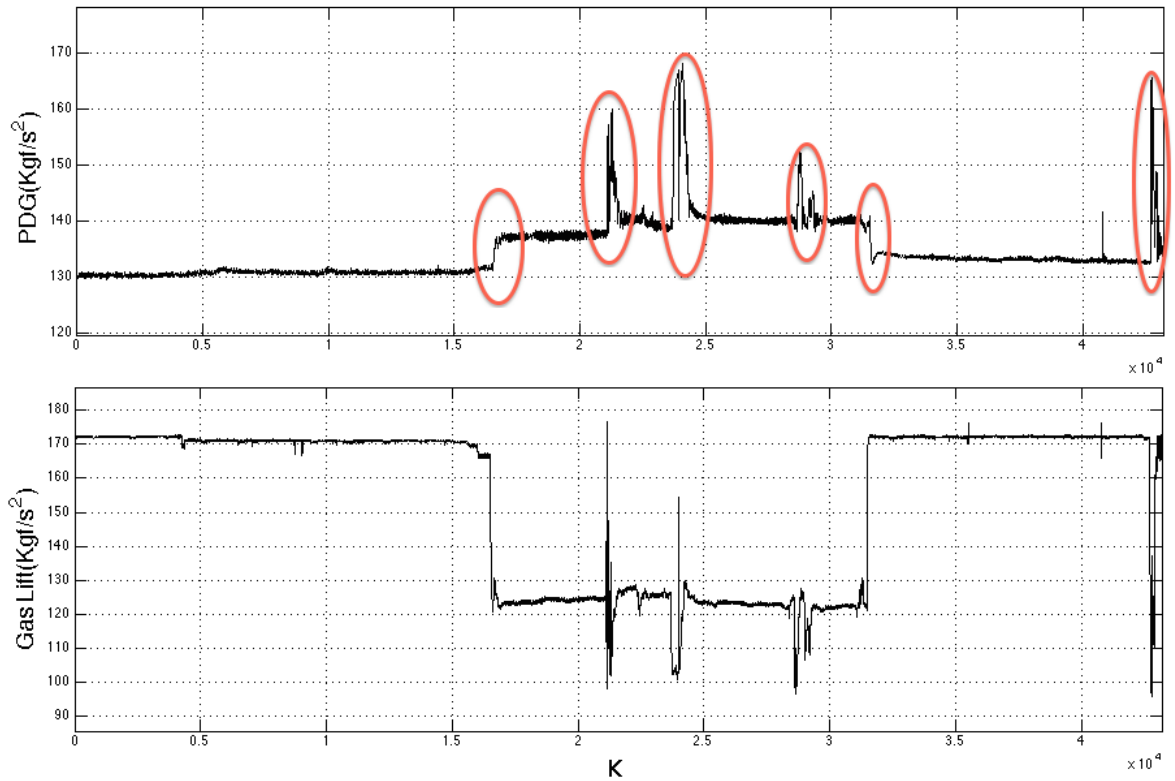

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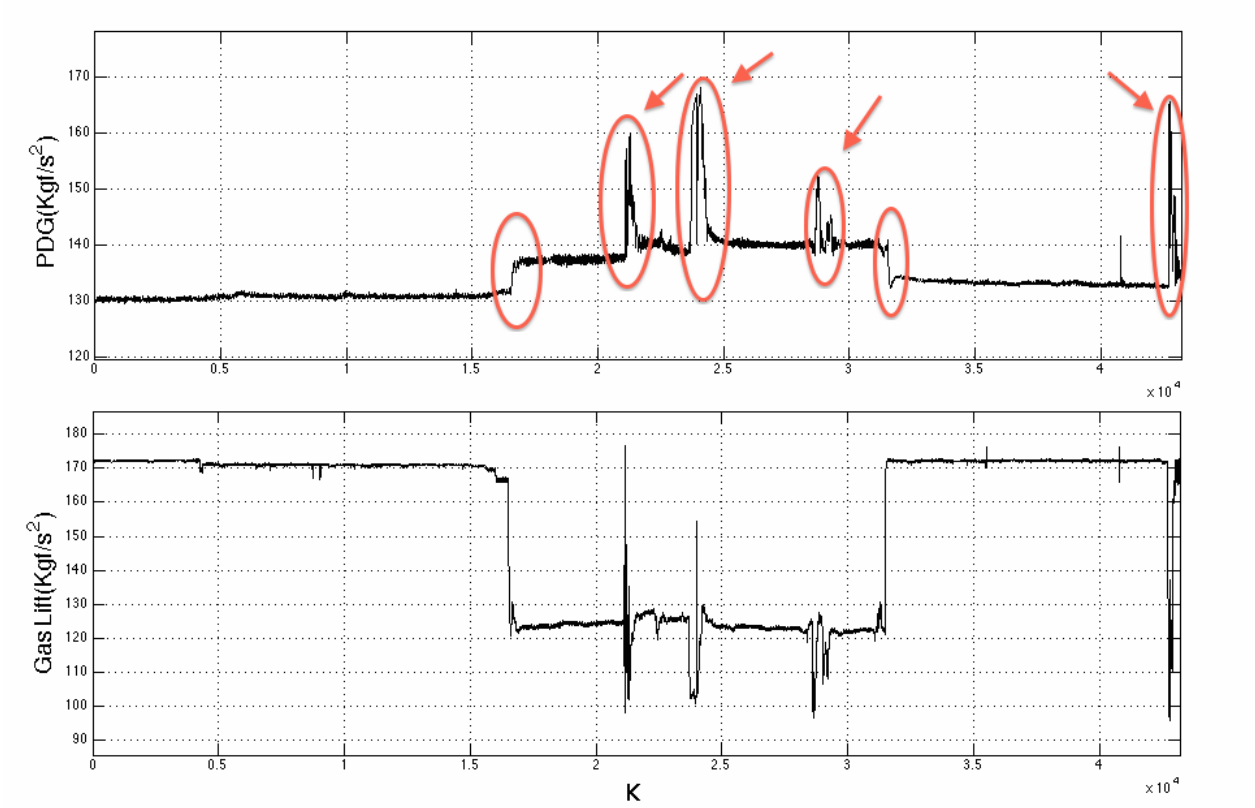

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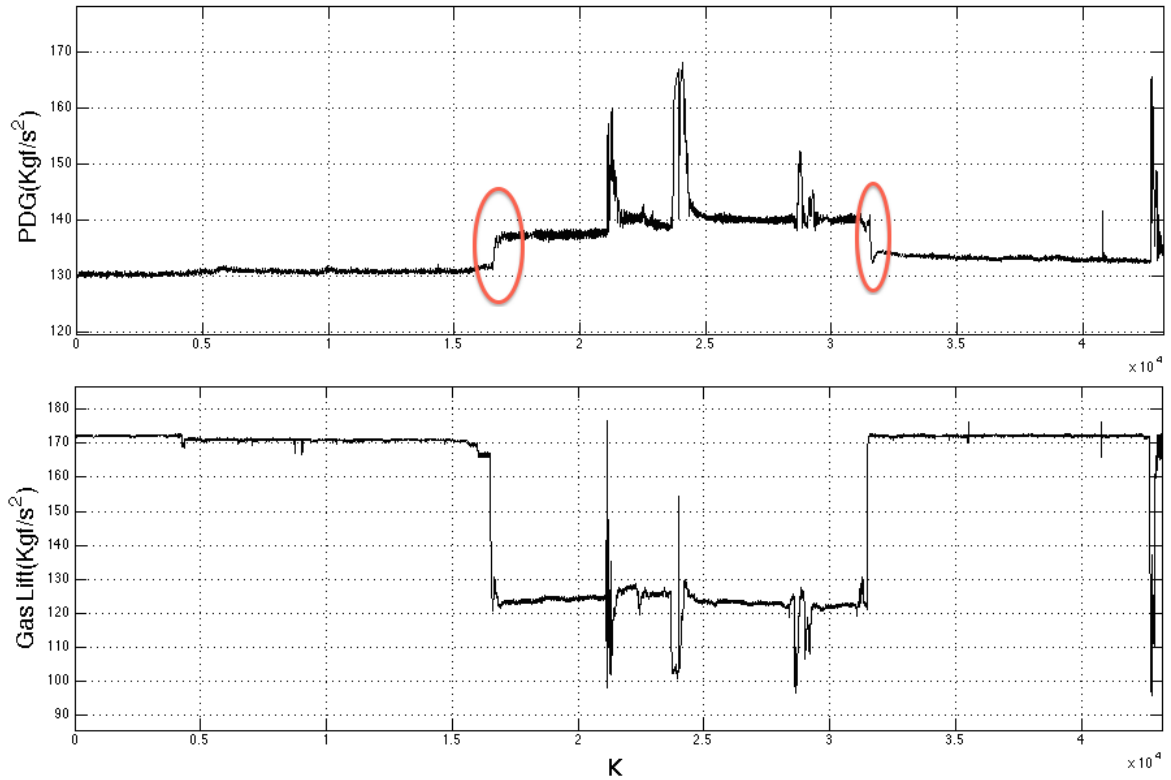


Goals and Objectives

Selecting Transients Automatically

- Define a quantitative way to measure how suitable a window is for system identification;
- Define a quantitative measure that can be used to discard windows where the output is not correlated with the input;
- Use these metrics to automatize the process of finding suitable windows for system identification.

Trajectory Matrix

Dynamic Based Metric

Trajectory Matrix

If you have a set of data containing values of y from $k = 0$ to $k = m + n$, you may write: $\mathbf{y} \in \mathbb{R}^m$ and $\mathbf{x} \in \mathbb{R}^n$:

$$\mathbf{A} = \begin{bmatrix} y(n-1) & y(n-2) & \dots & y(0) \\ y(n) & y(n-1) & \dots & y(1) \\ \vdots & \vdots & \ddots & \vdots \\ y(m+n-2) & y(m+n-3) & \dots & y(m-1) \end{bmatrix};$$

Rank of Trajectory Matrix

Dynamic Based Metric

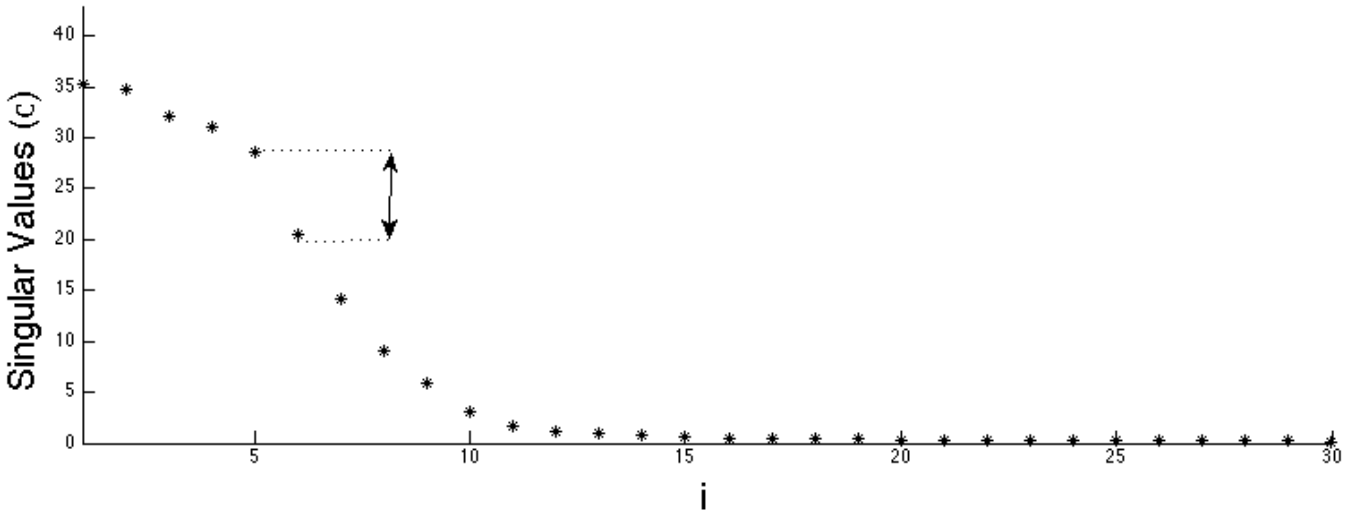
- Deeply related with how strong a transient is;
- Equals the number of parameters one can estimate for an autoregressive model.
- Depends only on signal y evolution.

Effective Rank of Trajectory Matrix

Dynamic Based Metric

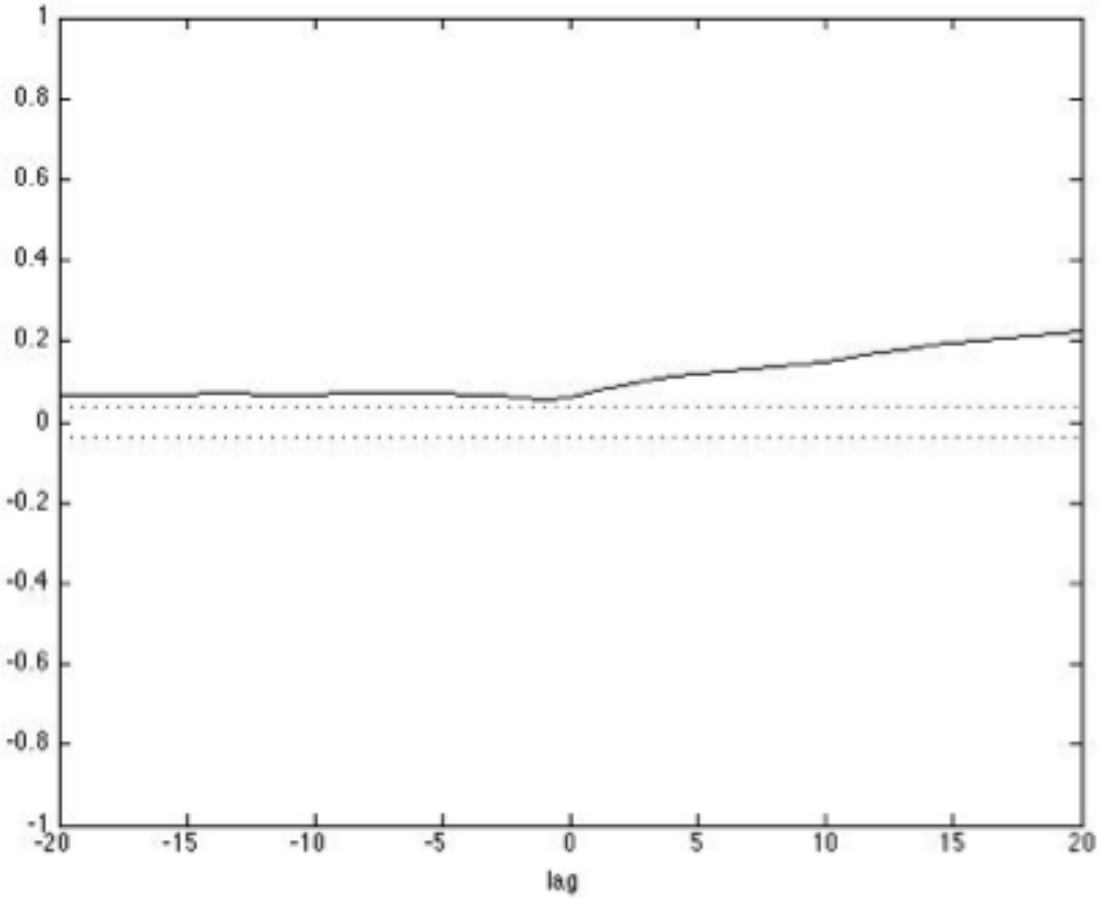
The effective rank r will be calculated as the maximum value of i, so that:

$$\sigma_i - \sigma_{i-1} > l$$



Correlation Based Metric - Definition

Correlation Based Metric



Correlation Based Metric

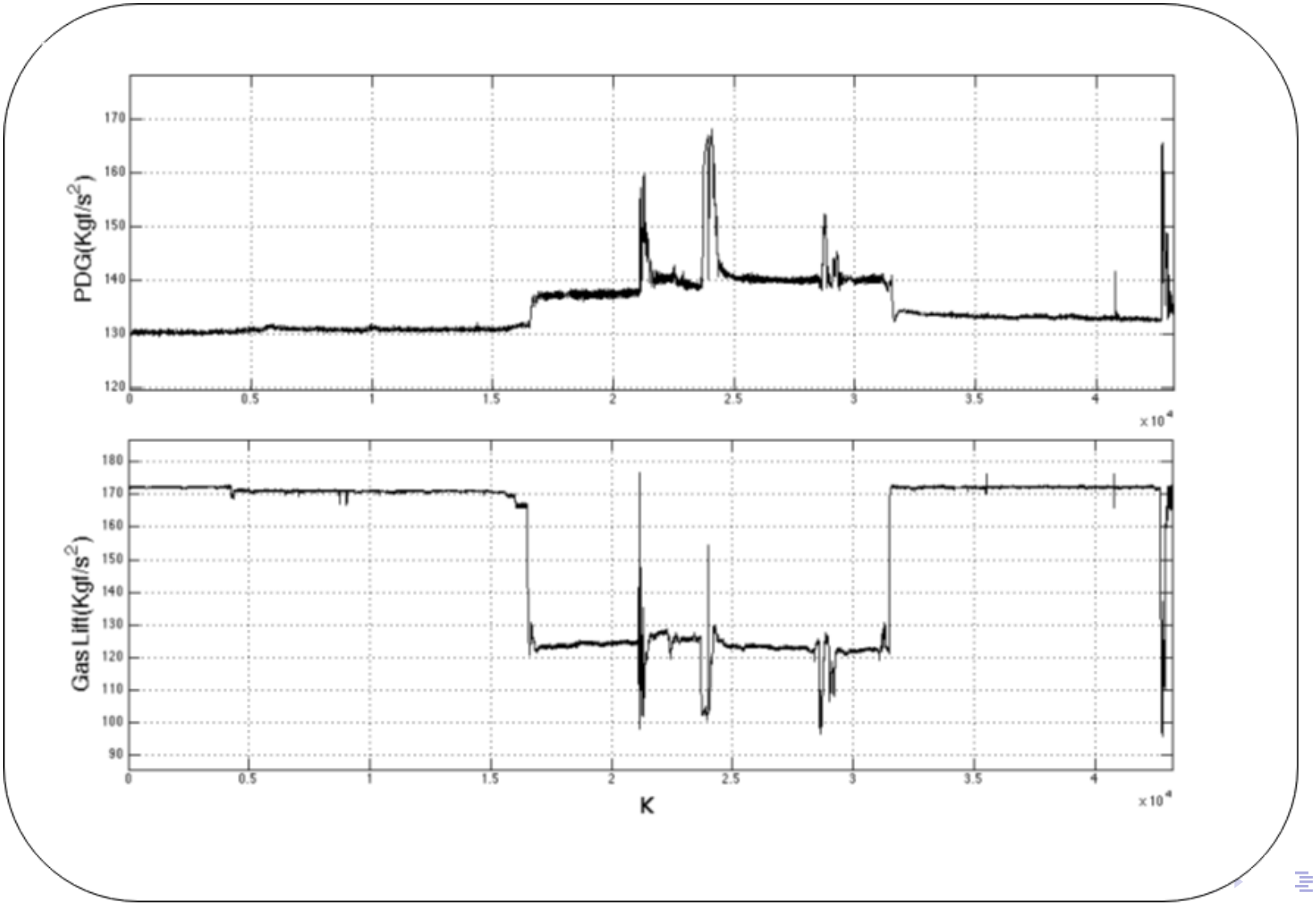
The following scalar metric is proposed:

$$s = \sum_{\tau=-\tau_{\max}}^{\tau_{\max}} \frac{|\rho(\tau)| - p}{|\tau|}, \quad (1)$$

$\rho(\tau)$ is the normalized CCF and confidence interval is given by $\pm p$.

Global View of the Algorithm

Selecting Transients Automatically



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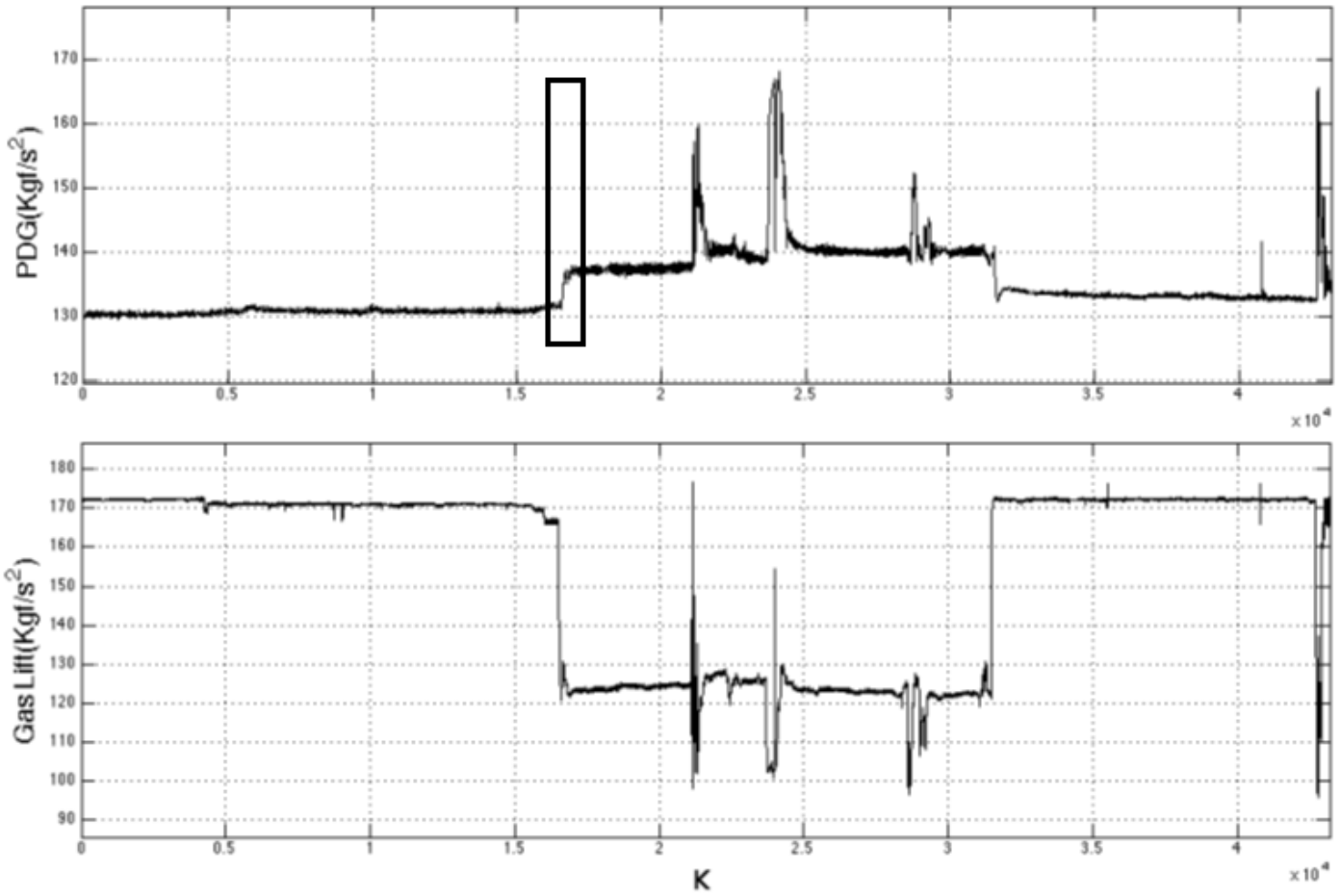

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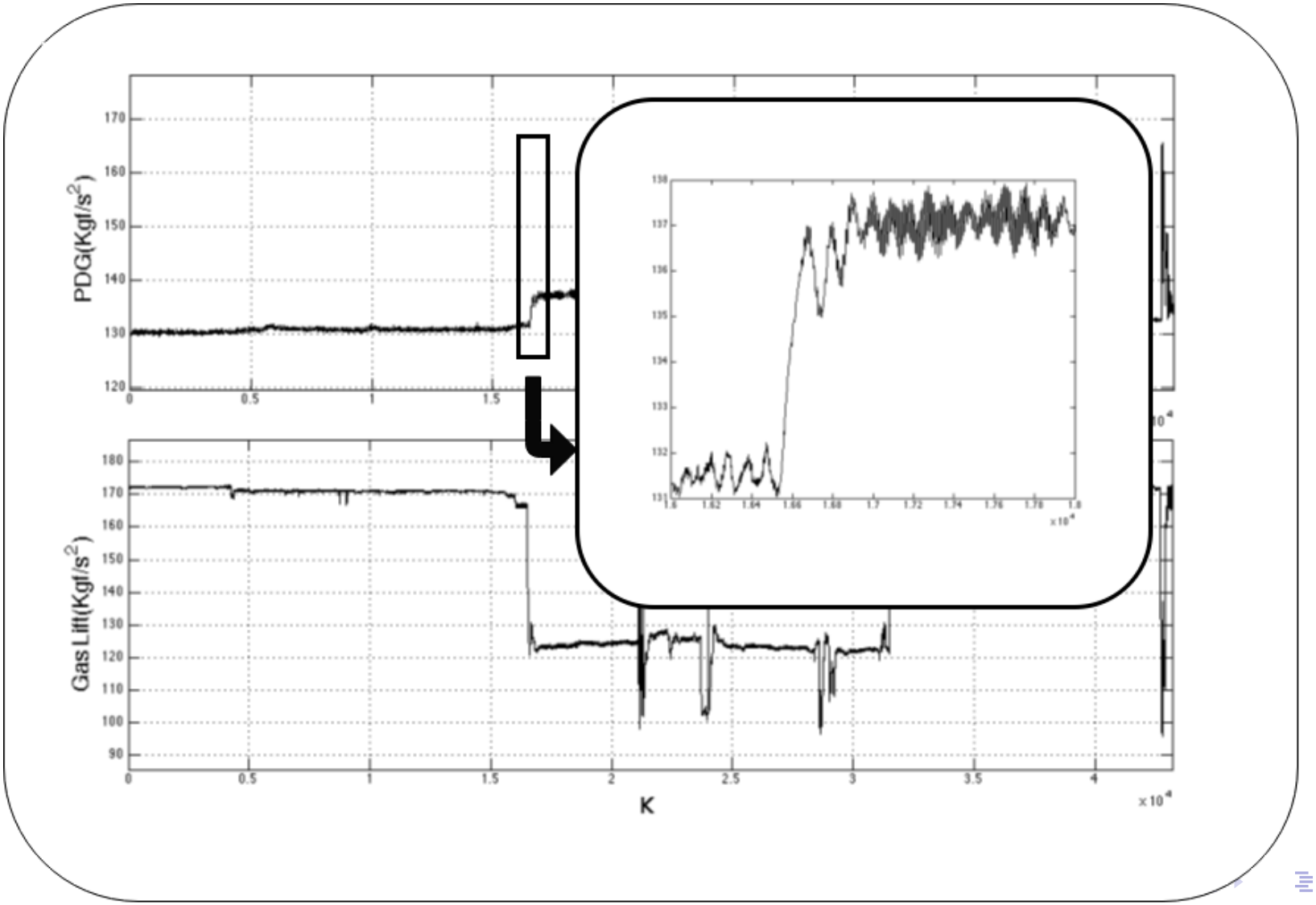

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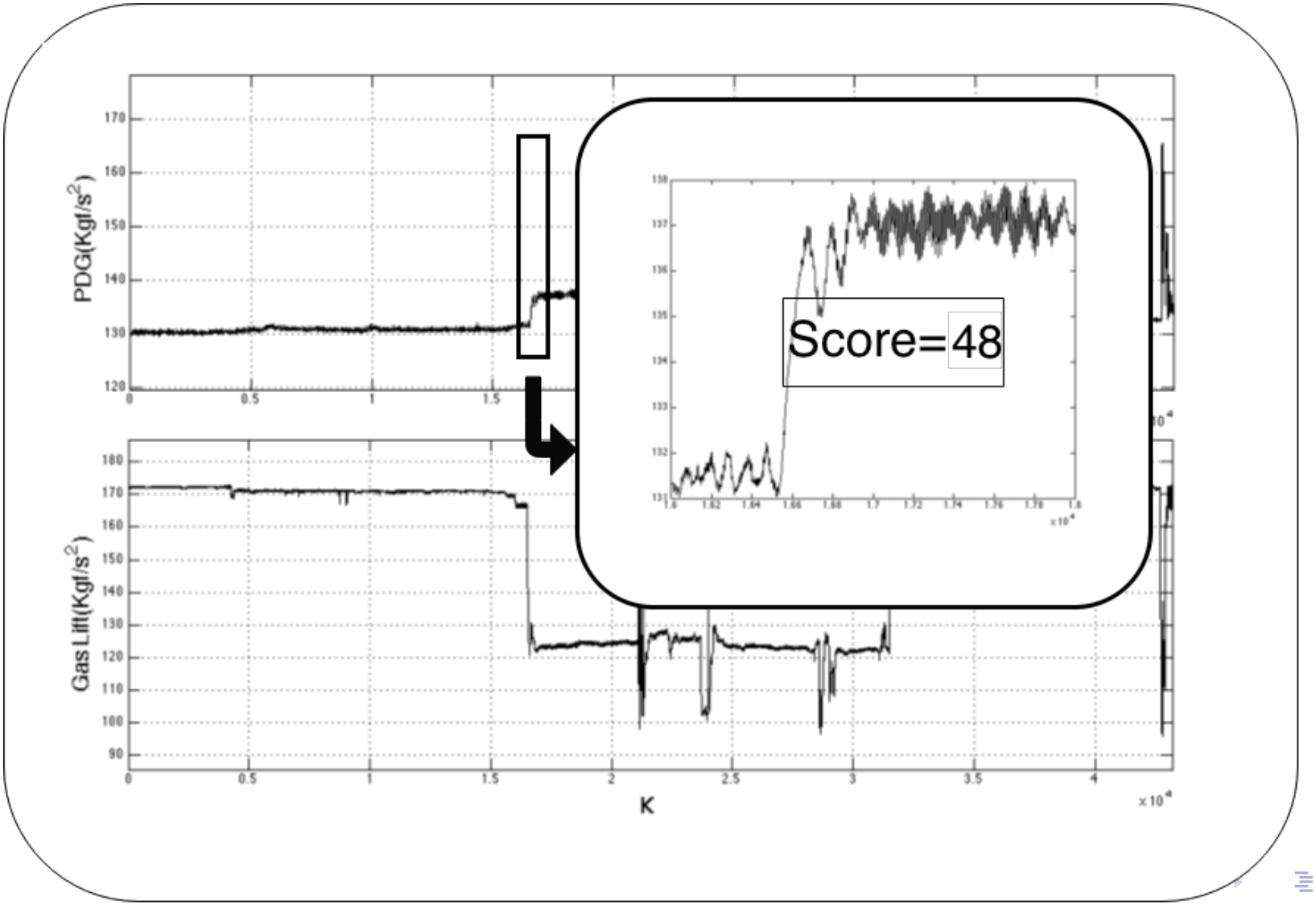

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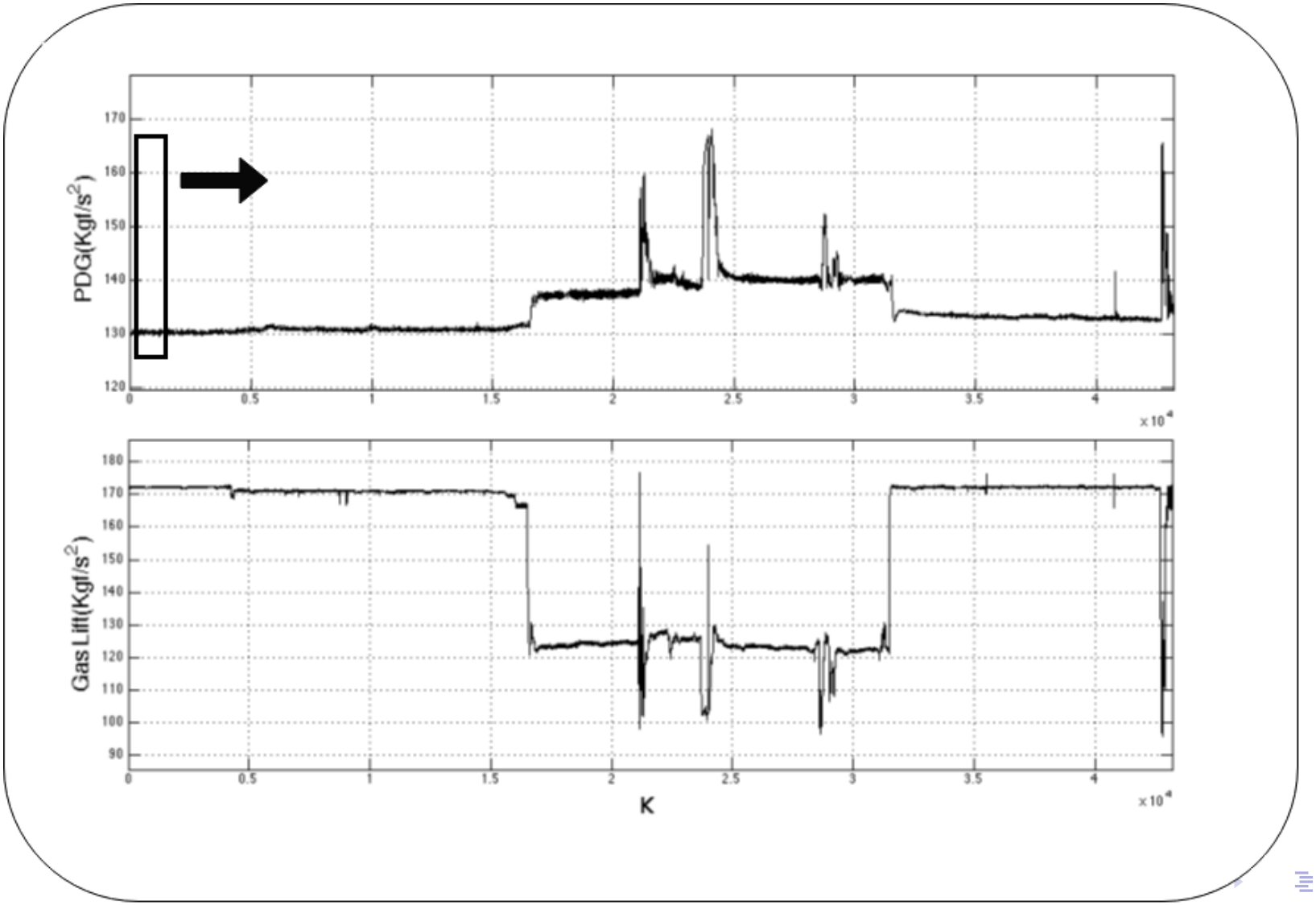

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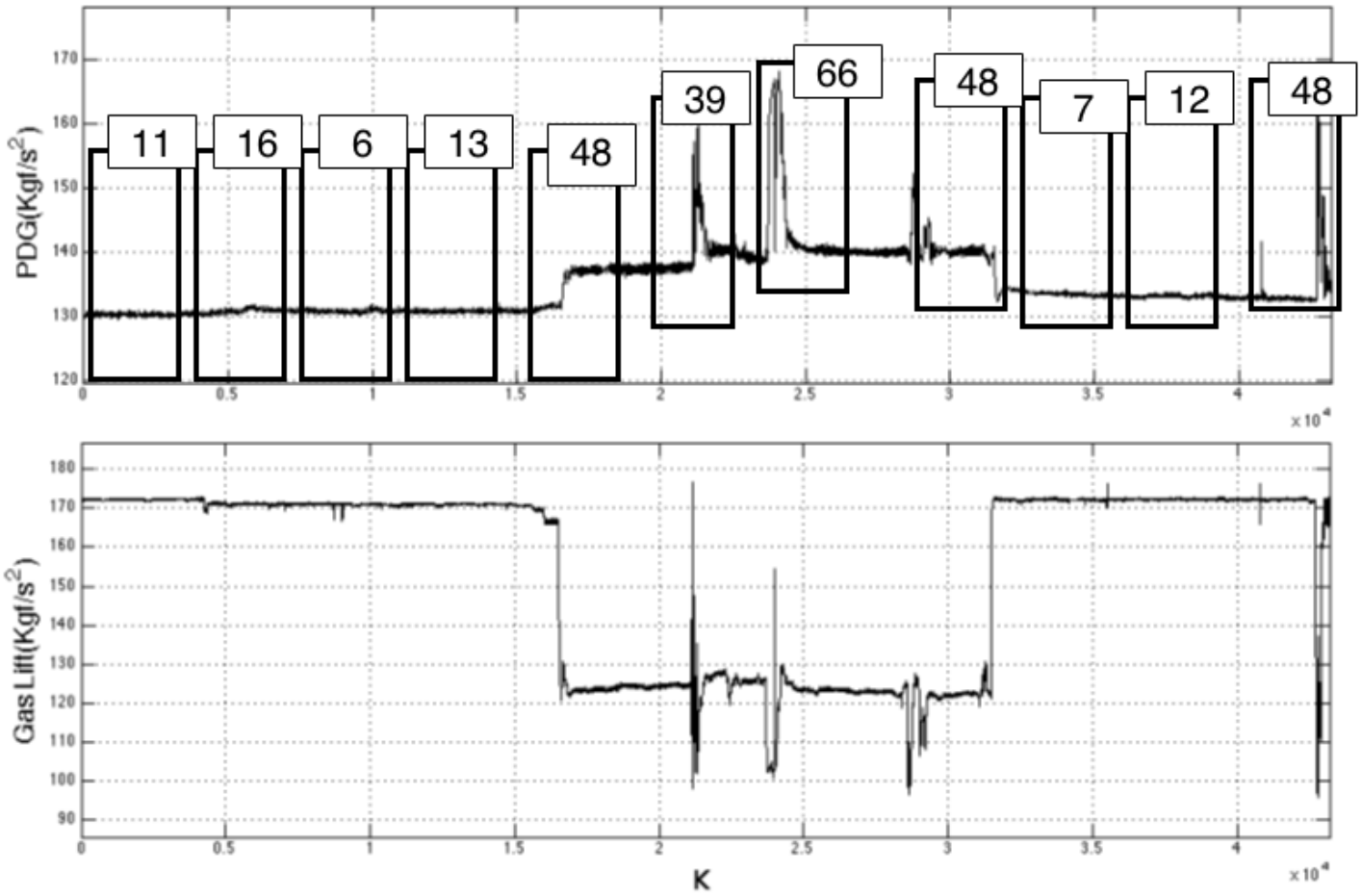

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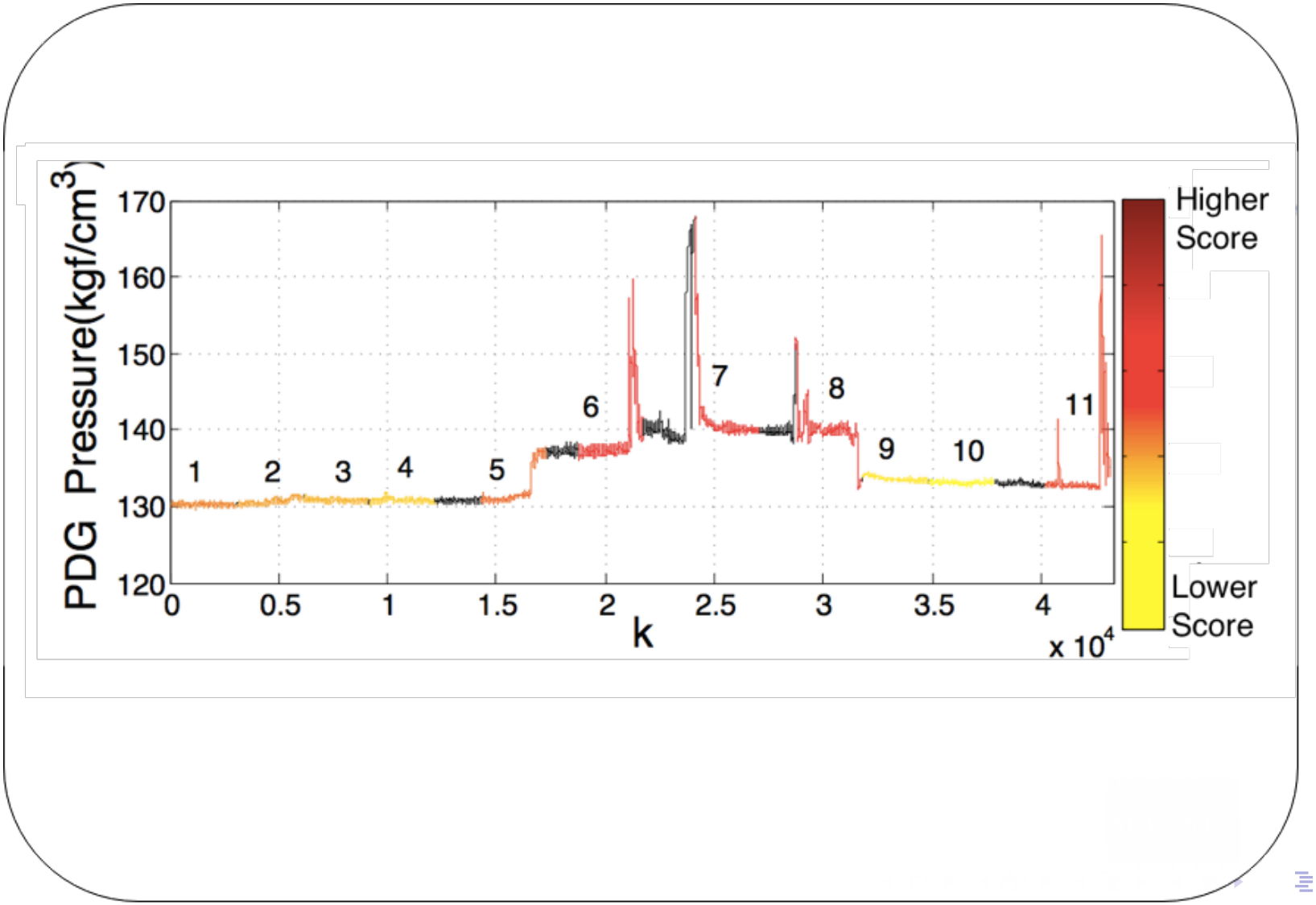

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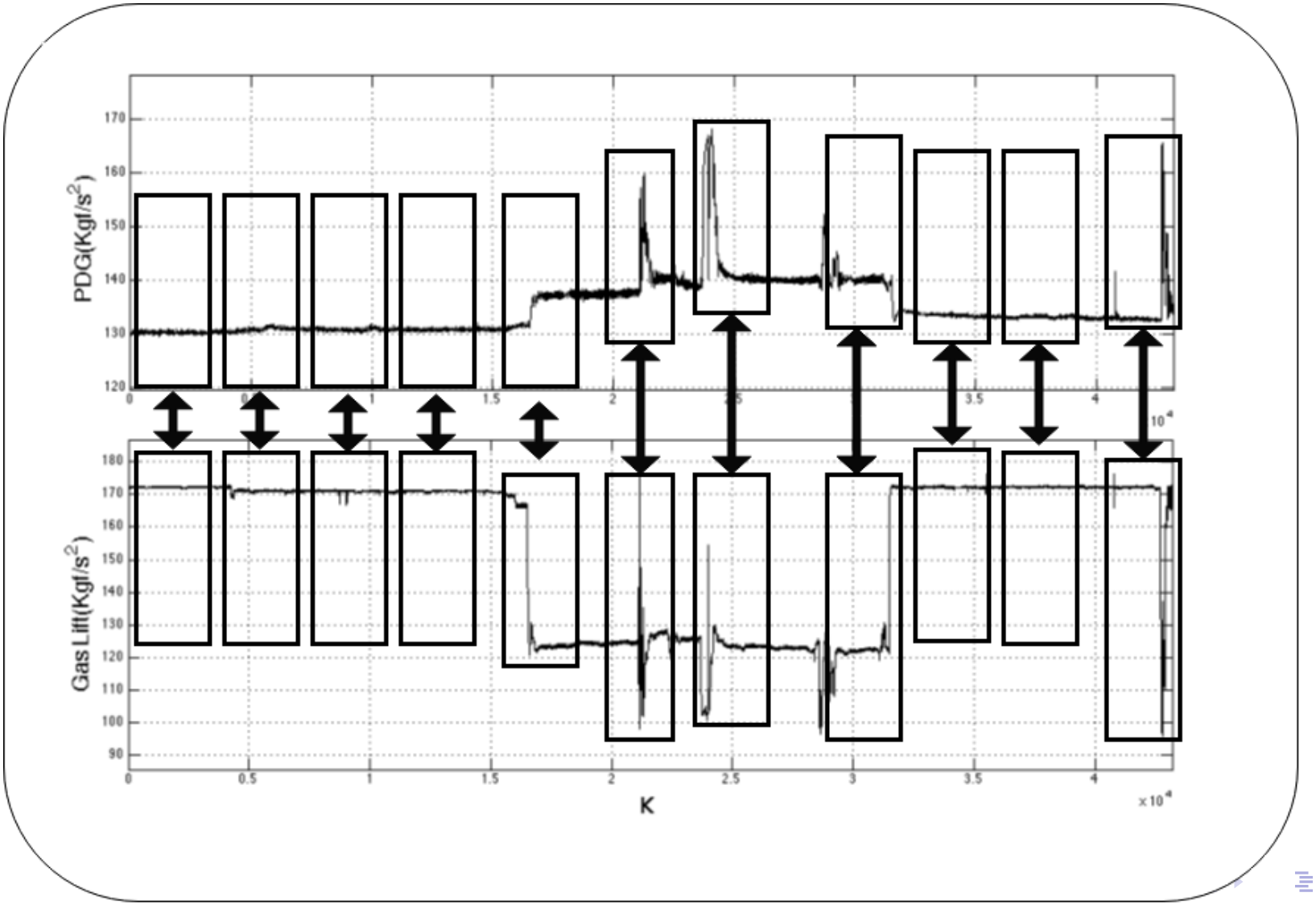

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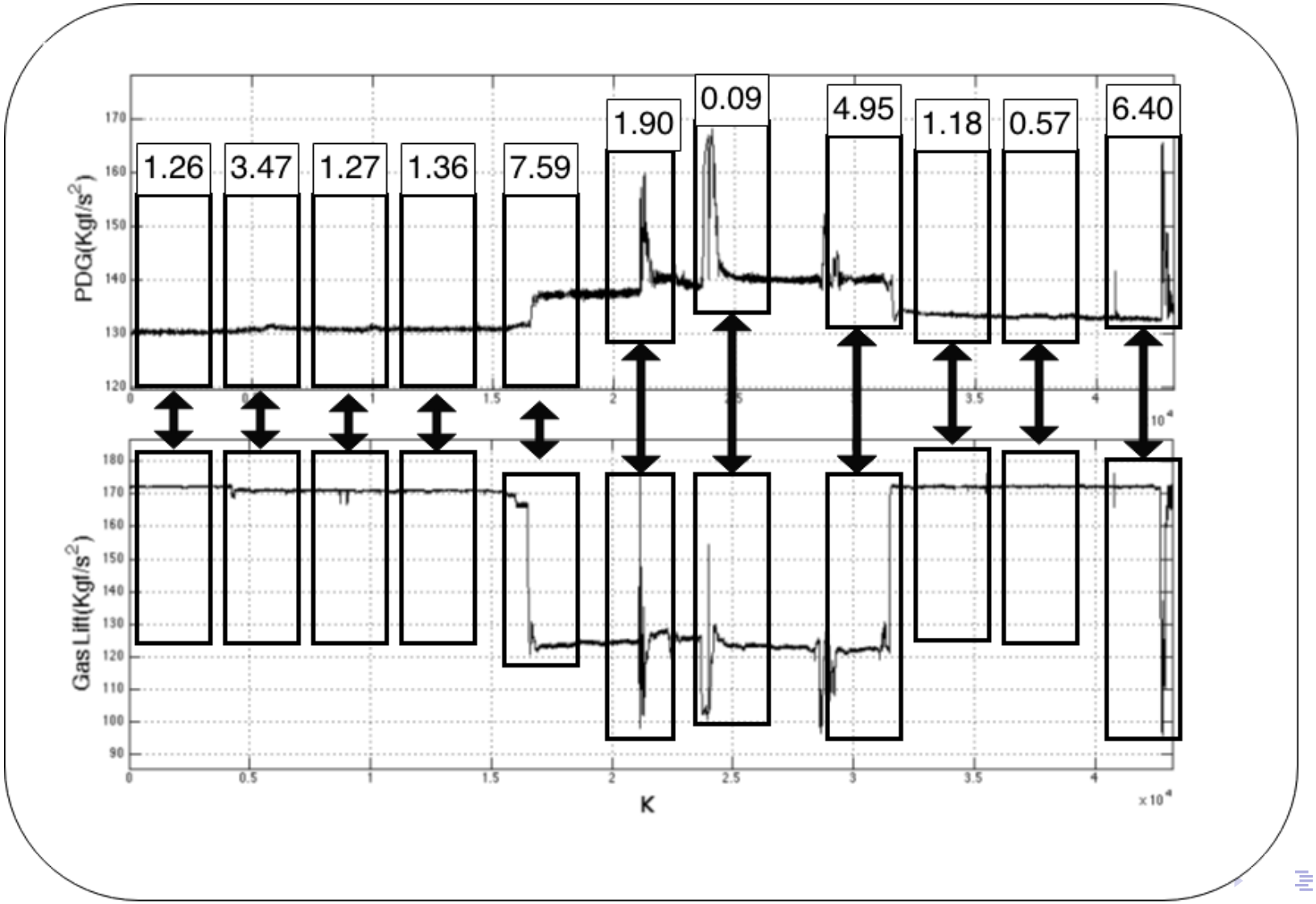

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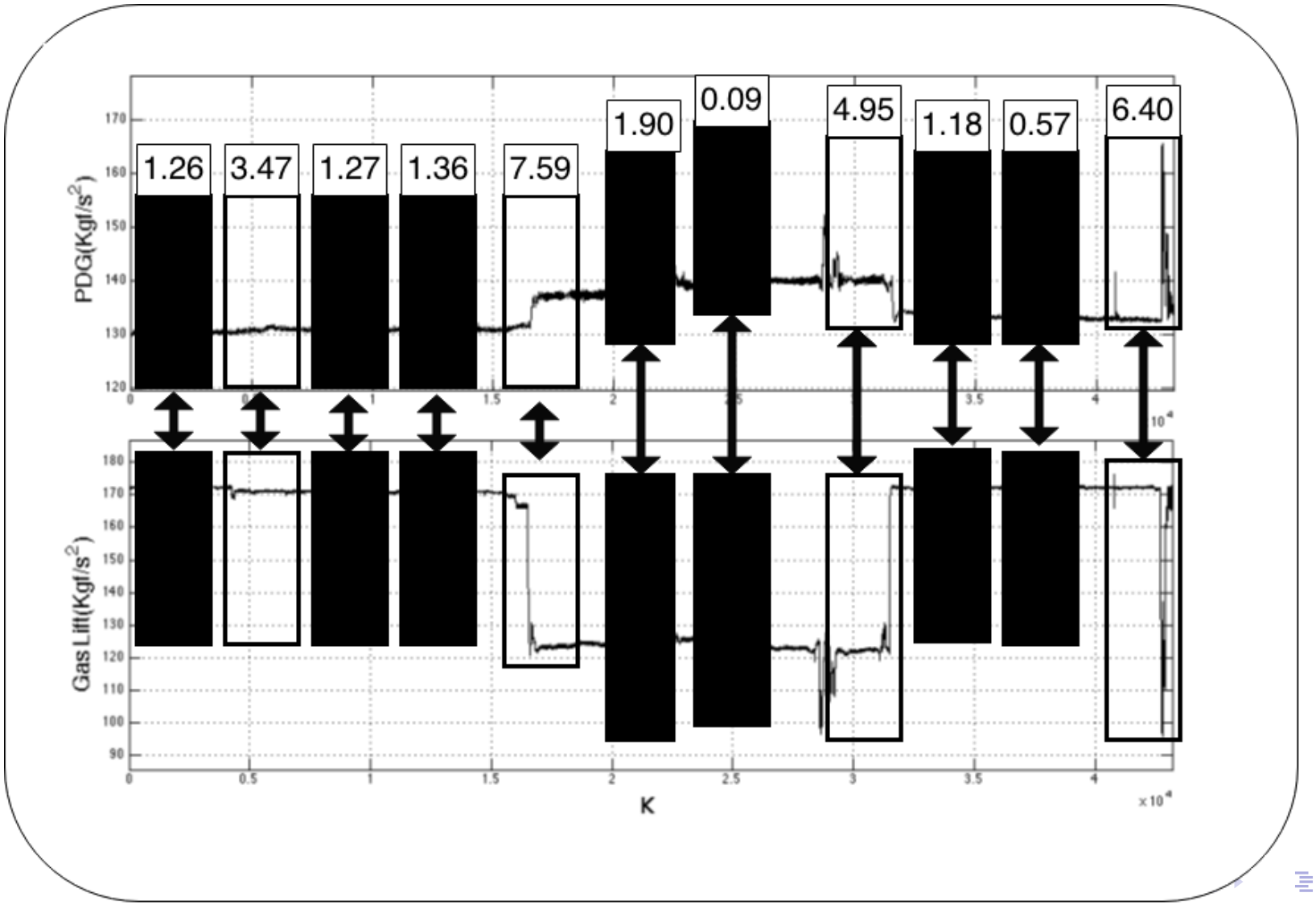

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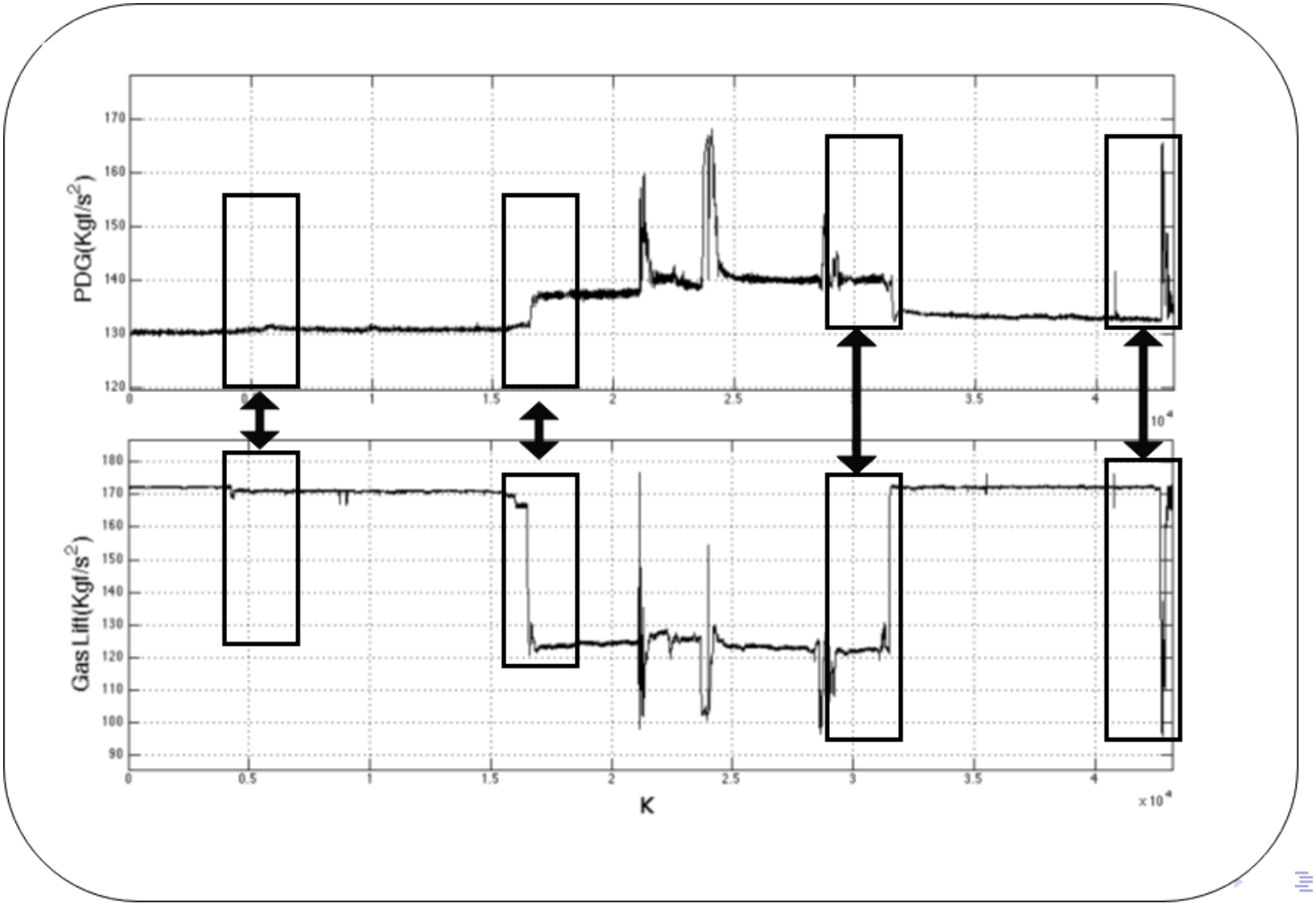

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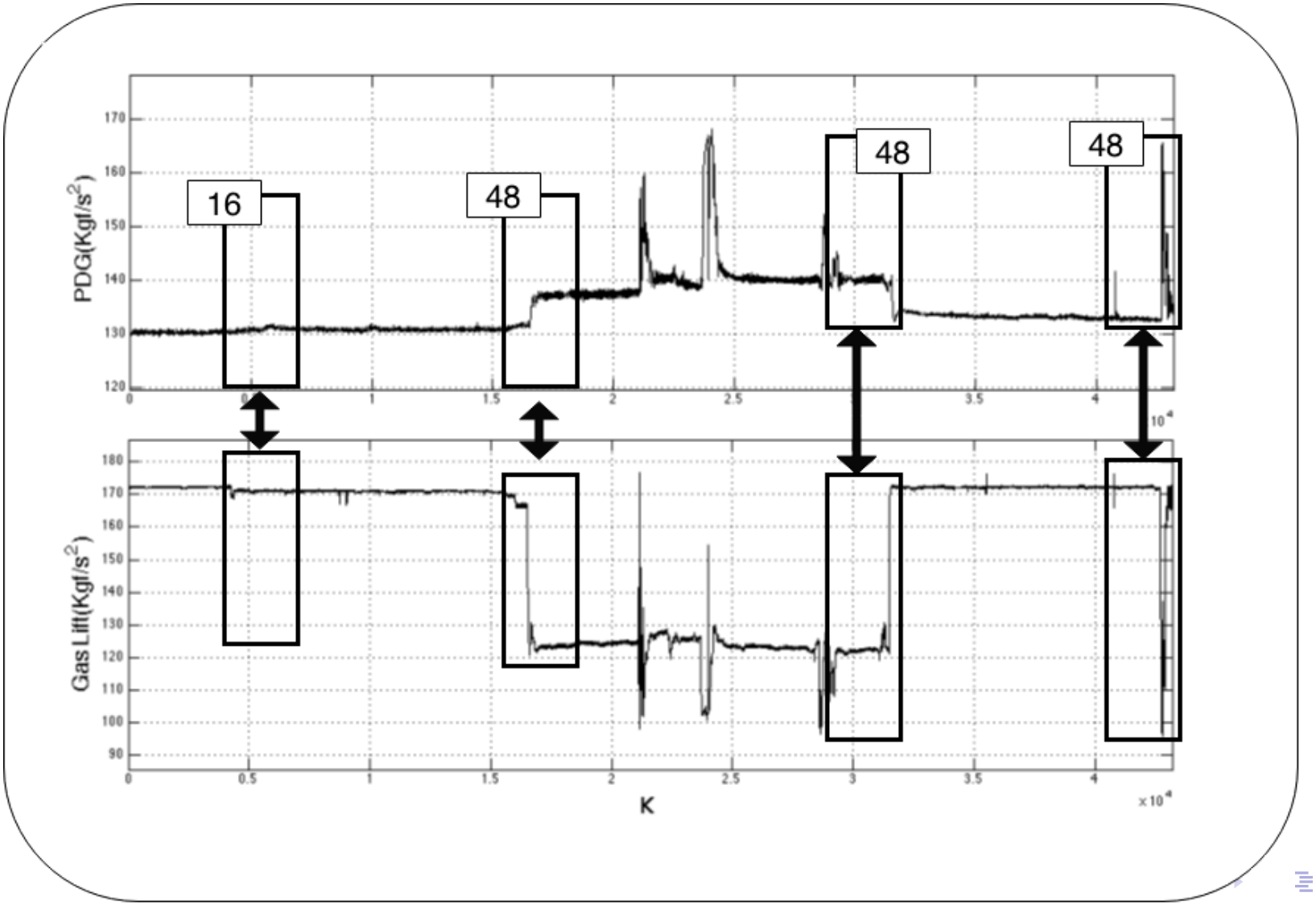

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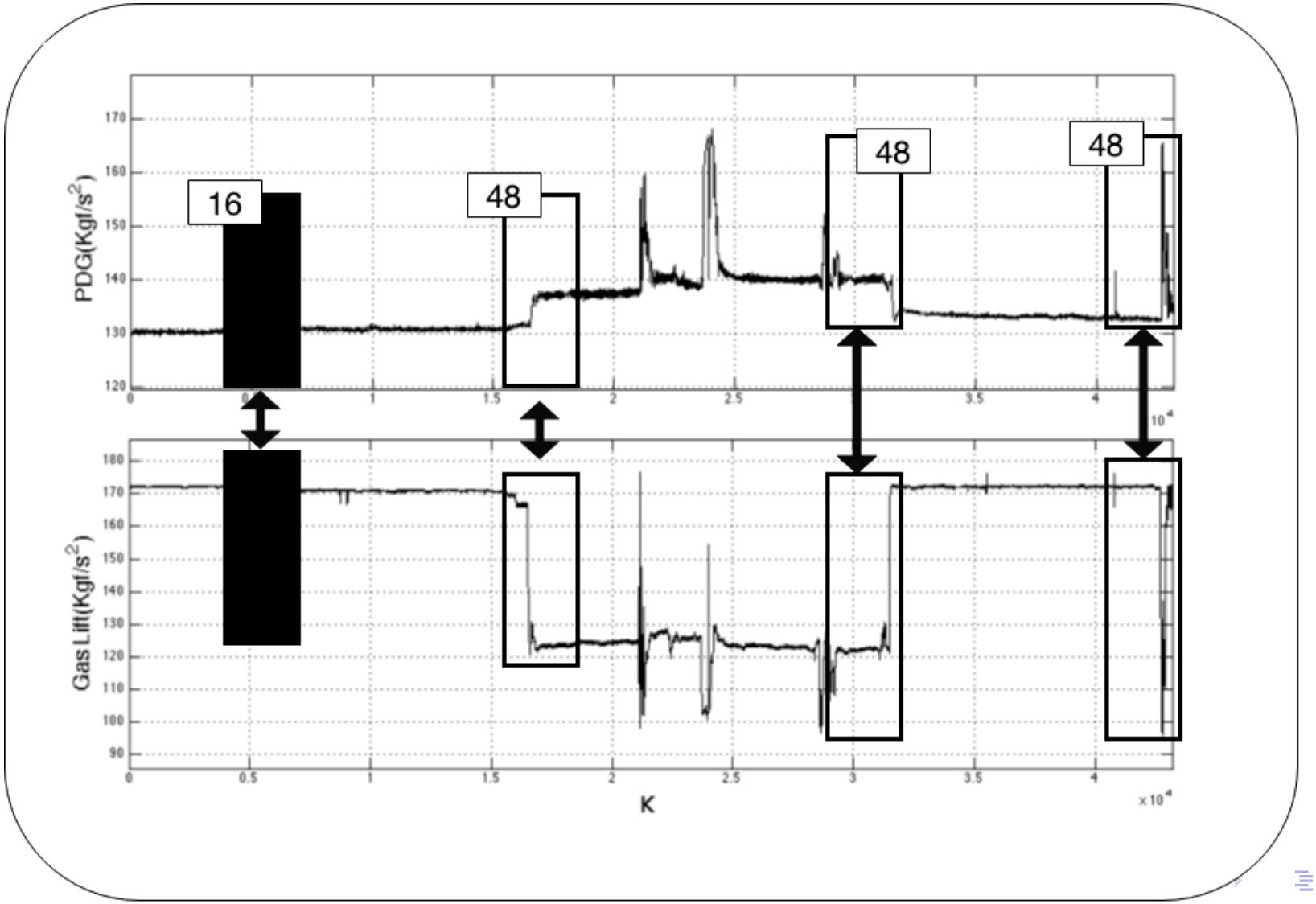

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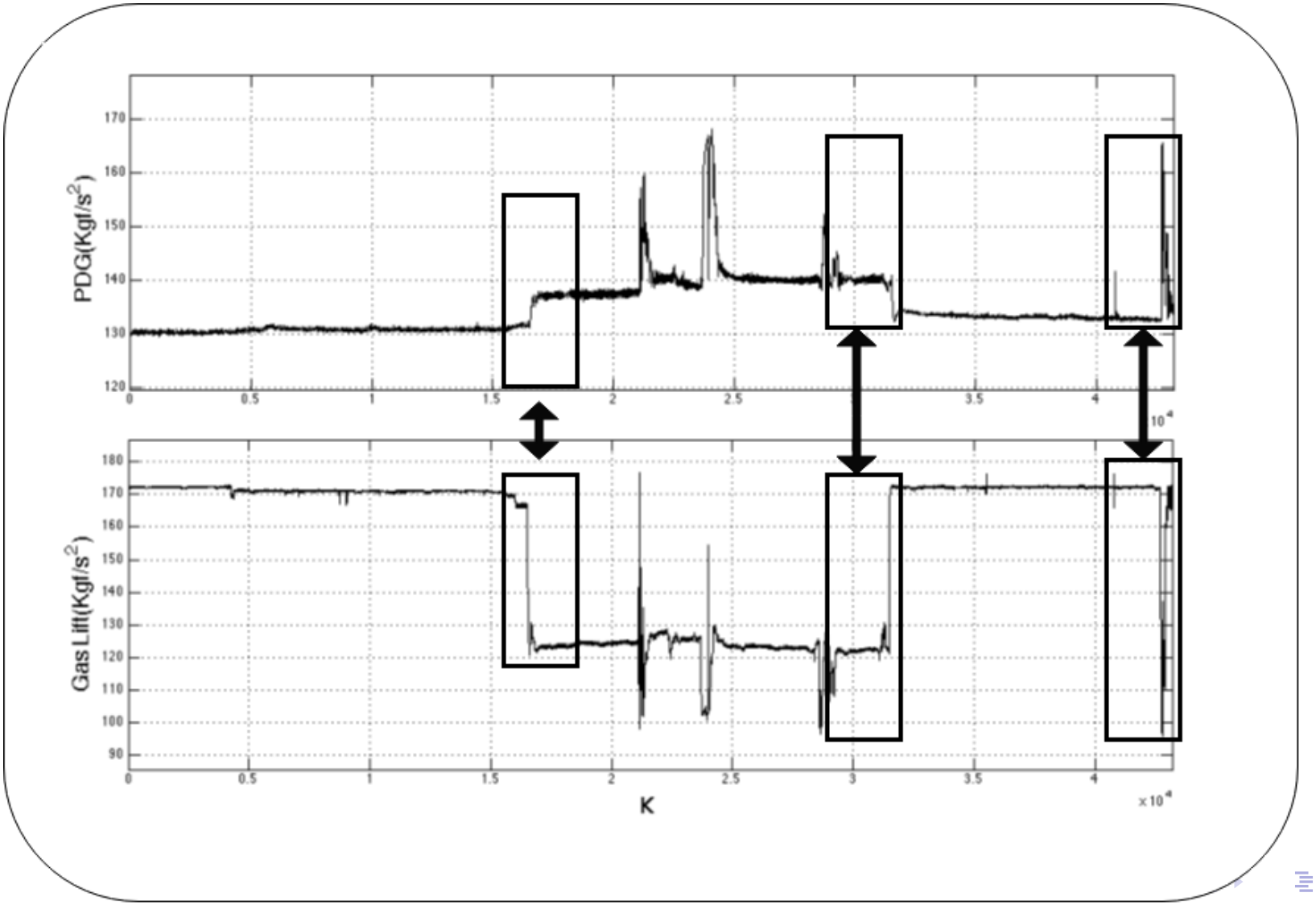

Concluding Remarks

Conclusion

- Daily operation data vs Creating Tests;
- Easily extended for the multivariated case;
- Some adjustments may be done aftewards;
- Time saving.