

Using “Big Data” to help understand NPP challenges

Advanced Sensors and Instrumentation
Annual Webinar

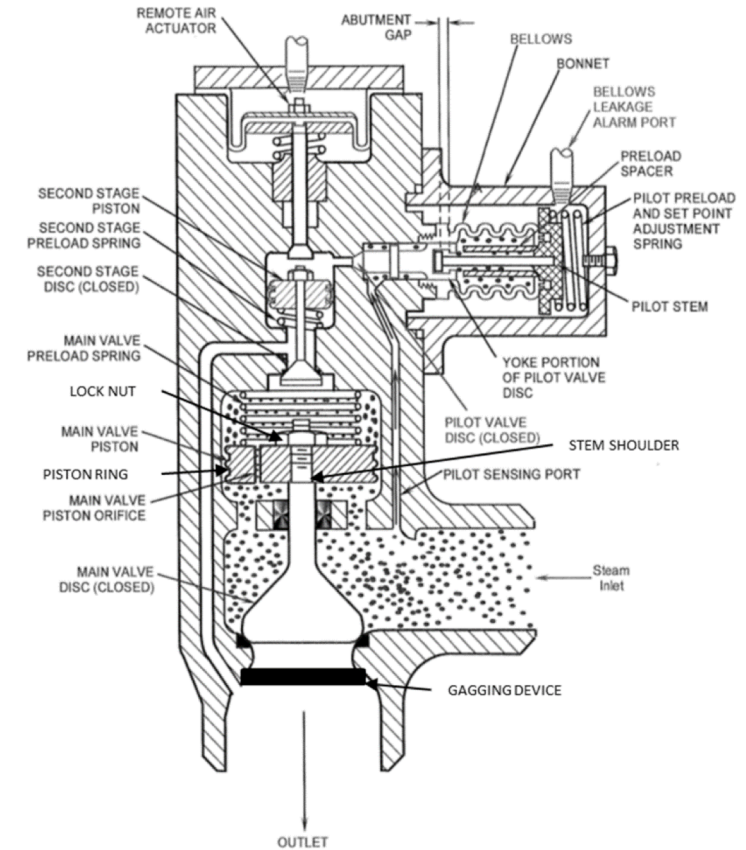
October 31 – November 1, 2018

Tom Gruenwald
Blue Wave

Project Overview

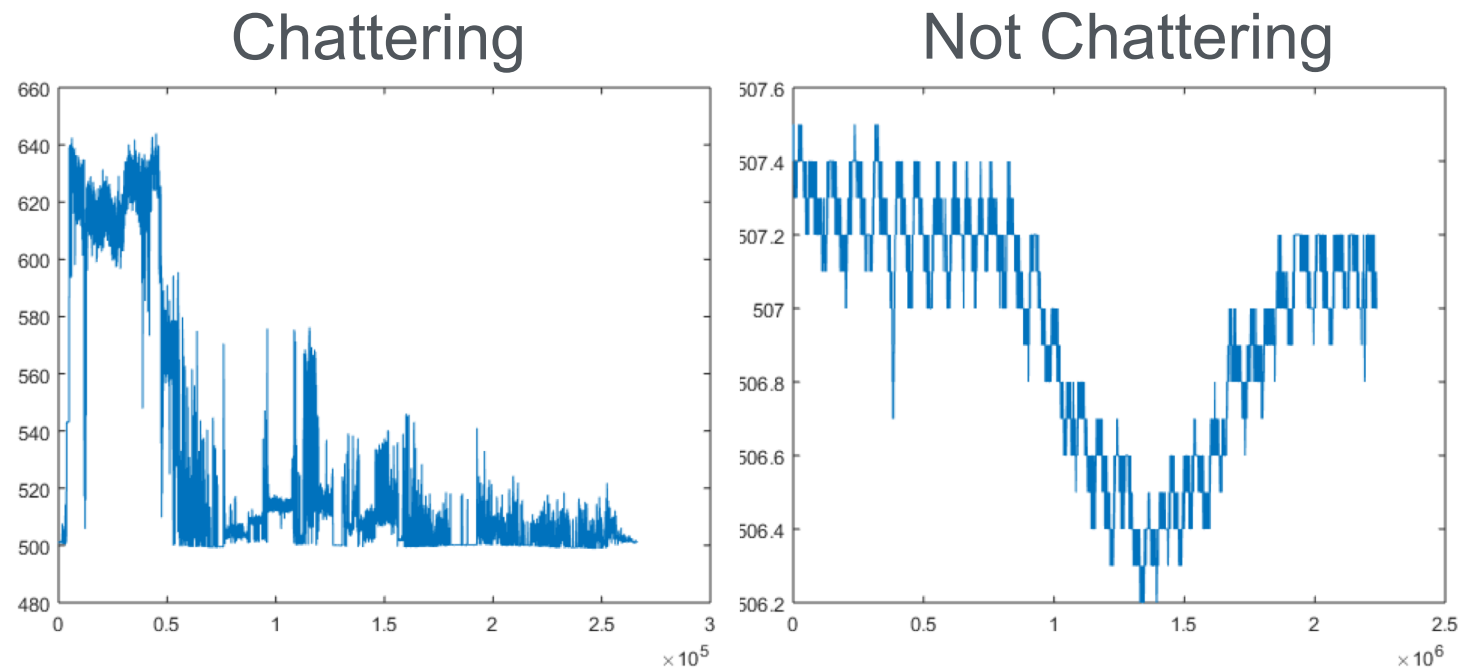
Chattering Valve

- Problem:
 - Hatch 1 observes sporadic $\sim 0.2\text{Hz}$ chattering in Safety Relief Valves (SRVs)
 - Hatch 2 (very similar reactor) does not chatter
 - Chattering valves moved from Hatch 1 to Hatch 2 do not chatter
- Goal:
 - To quickly and autonomously identify chattering valves
 - Create a model which predicts chattering and identify its root cause



Chattering Valve

- 1.8 TB of data provided for Hatch 1
- There are 32 million data points per year, per valve.
- There are eleven three-stage valves at SNP's Hatch1
- There are about 3 years worth of data (100 million points per valve)

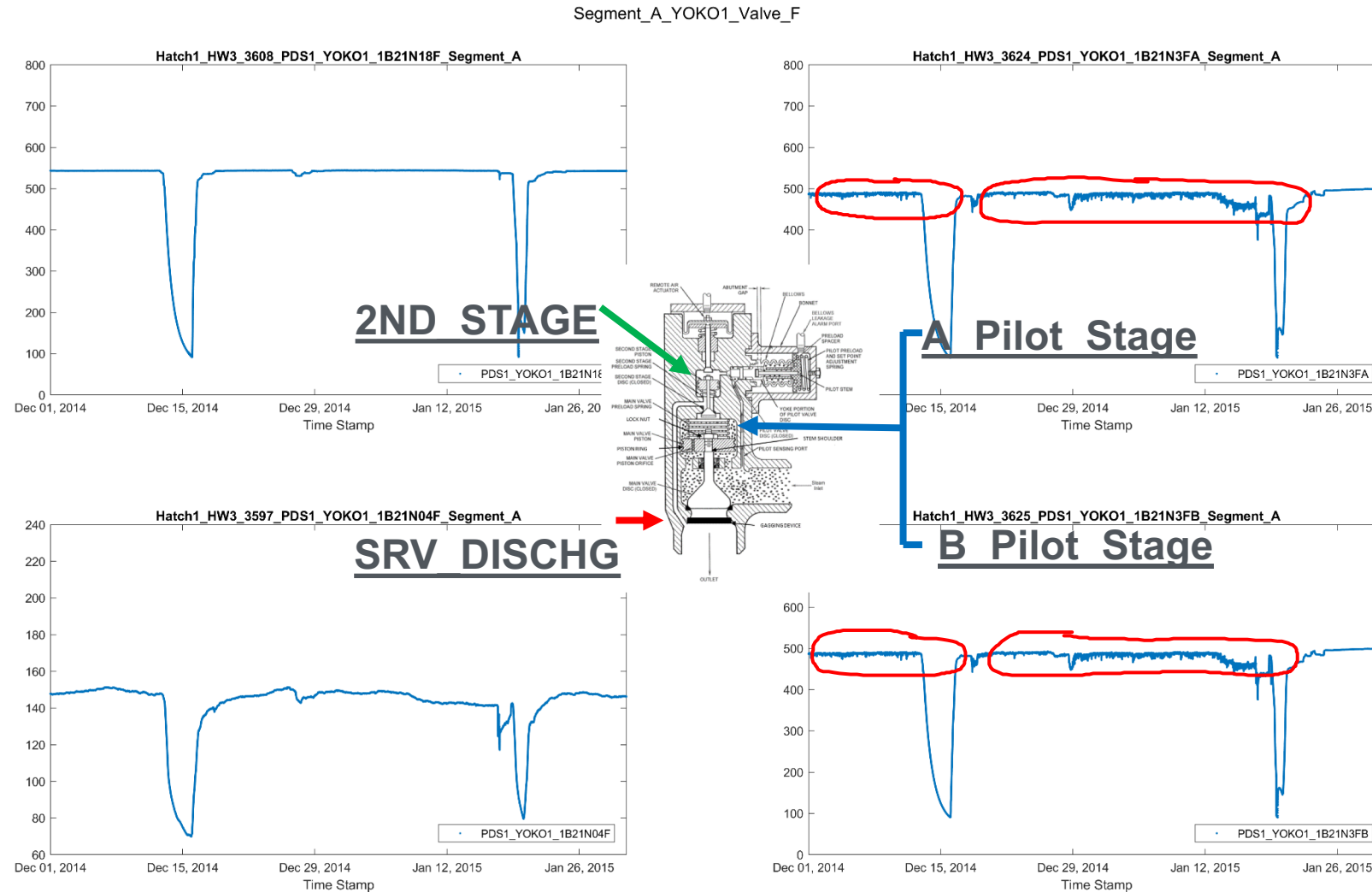


Chattering Valve

- 5 Batches, 1.81 TB
 - Earliest date: 03/01/2014
 - Latest date: 04/30/2017
 - 1Hz time log
- 3,722 Sensor-Check pairs
 - 28 Service Groups;
 - “YOKO1”: 44 Variables, 11SRVs × 4 Thermocouple sensors per SRV
 - Other Groups: Plant Variables
- 6,000 CPU hours to format the data into processable format.

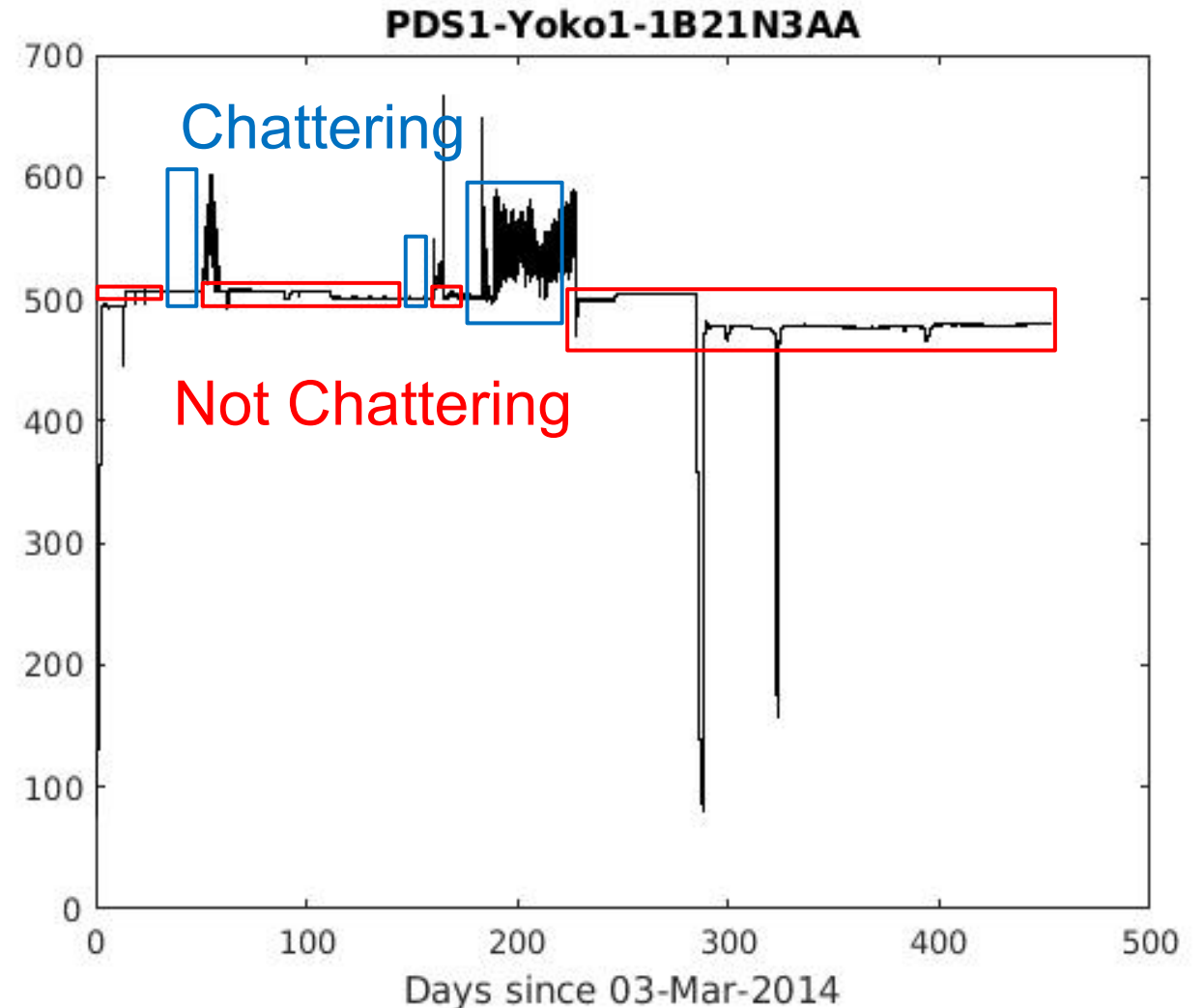
Service Name	Service Name
asdcalca	rtp4
asdcalcb	rtp5
calc	rtp6
calpush	rtp7
inter	rtp8
modbus1	rtp9
modbus2	rtp10
modbus3	rtp11
plasma	valves
ppc	yoko1
relay	yoko2
rtp1	yoko3
rtp2	yoko4
rtp3	yoko5

Chattering Valve

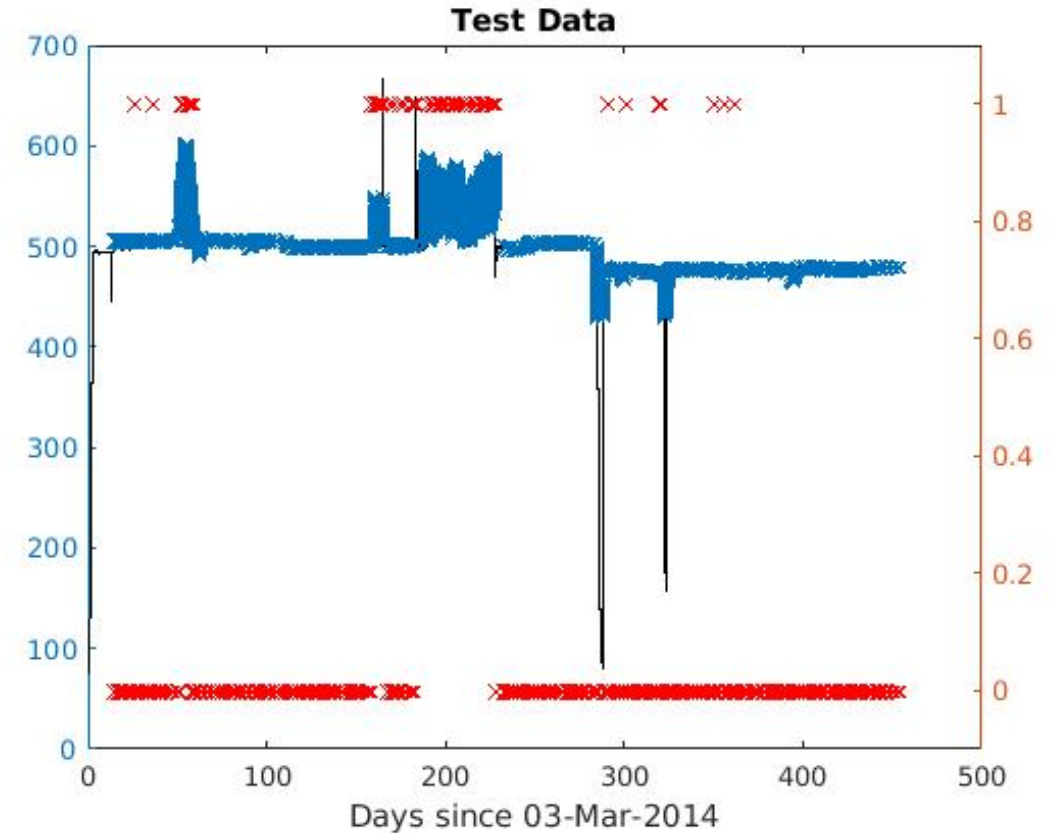
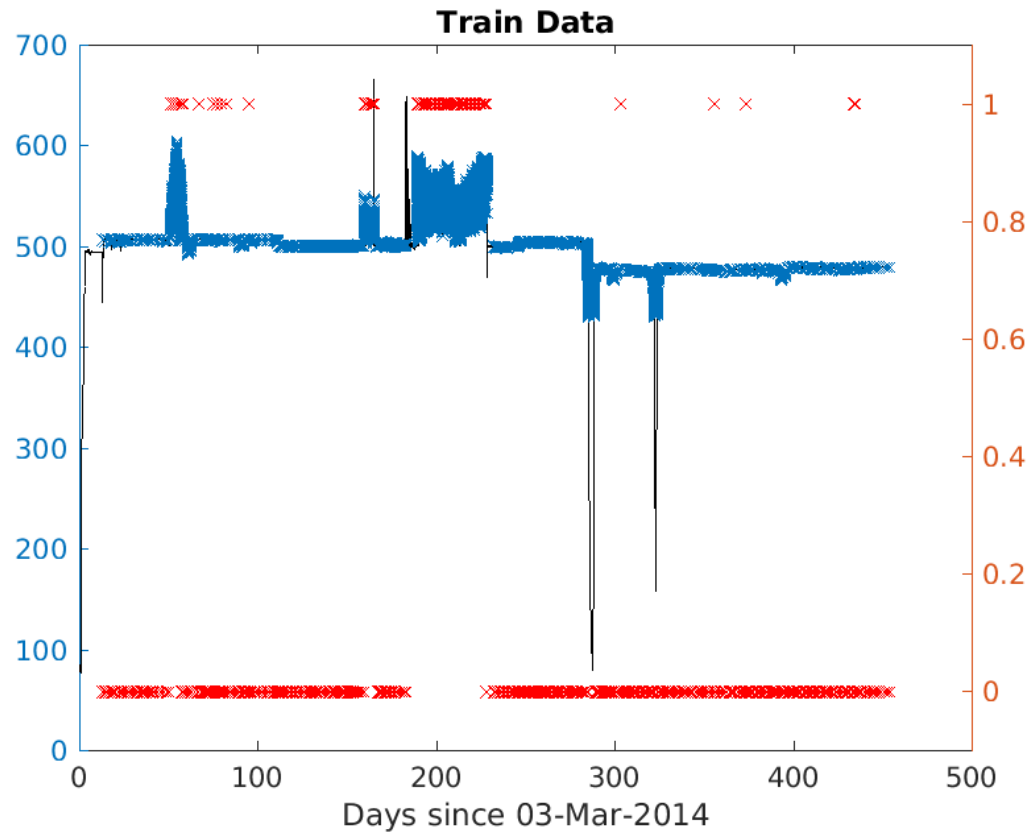


Classifying chattering

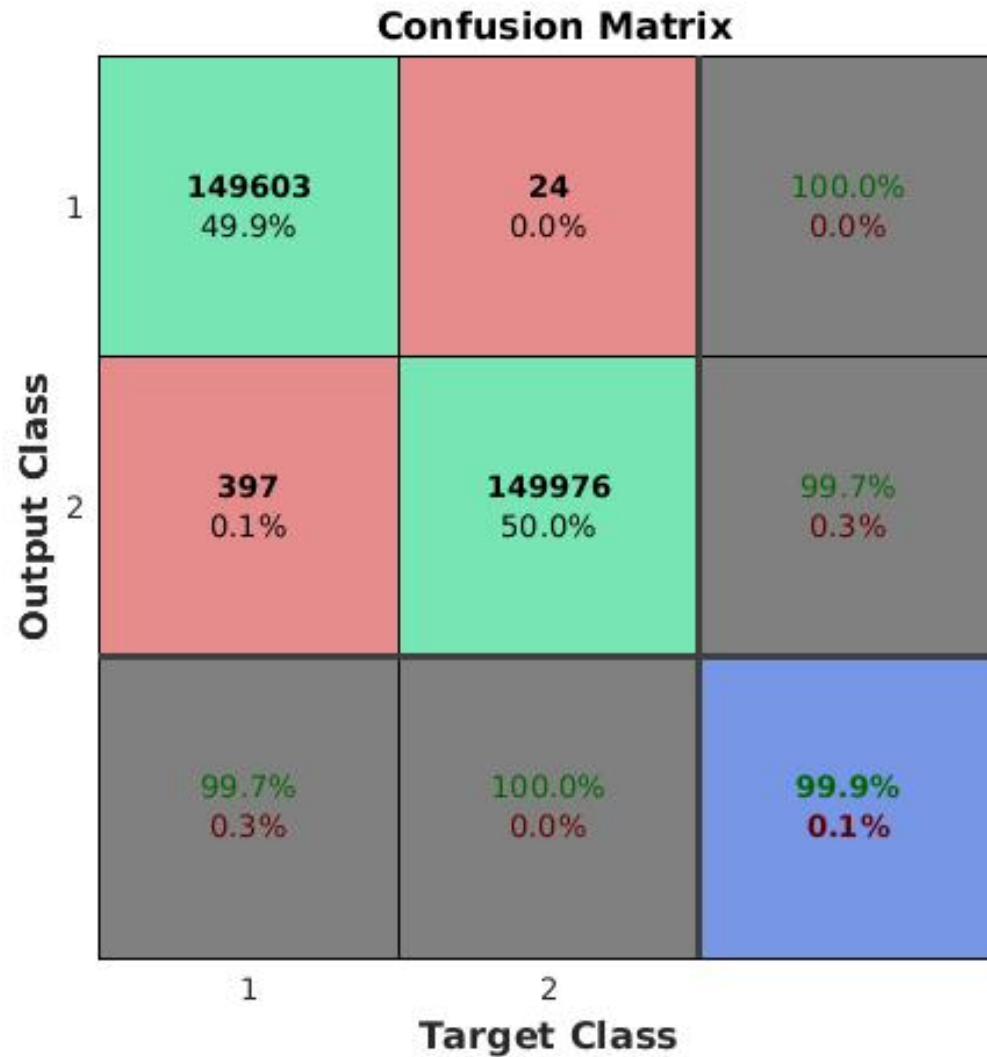
1. Hand classify chattering
2. Split train and test data
3. Generate 9 Features
 1. 10 minute moving window
 2. 7 wavelet variances
 3. 1 Fast Fourier Transform
 4. Peak to Valley Height
4. Train Classifiers - Bagged Tree Model
 1. 2 million points
5. Validate Model
 1. 99.8%



Bagged tree classifier

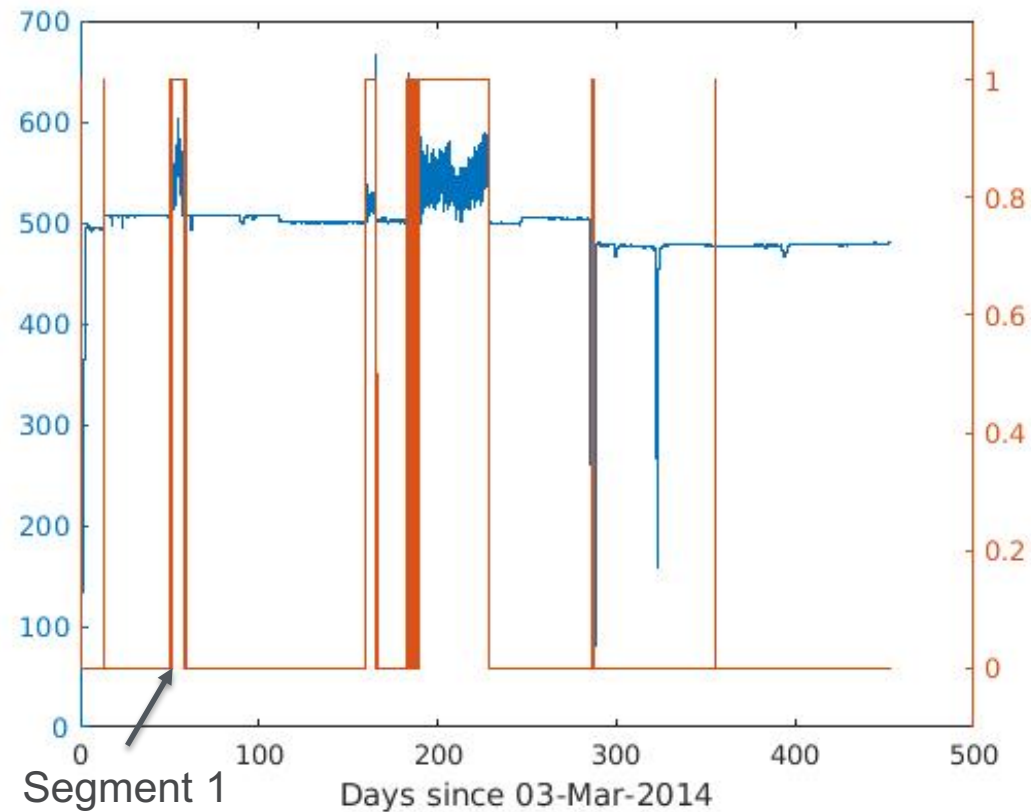


Bagged Tree Classifier – Confusion Matrix

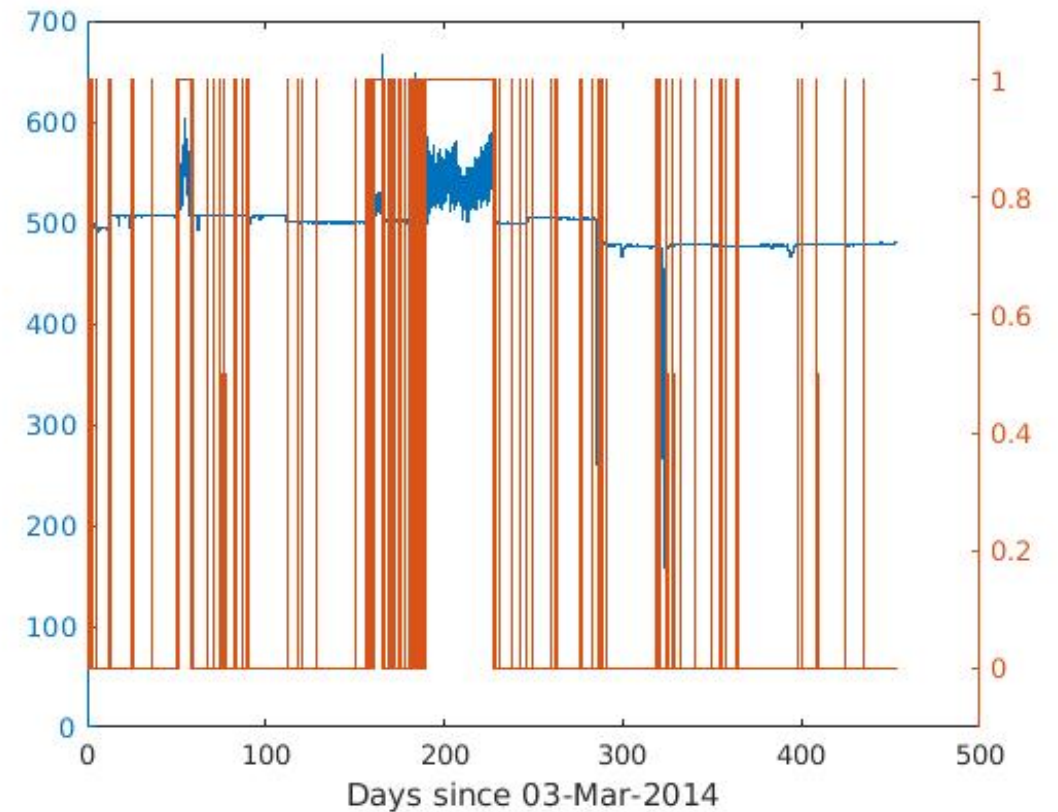


Smoothed Classifier

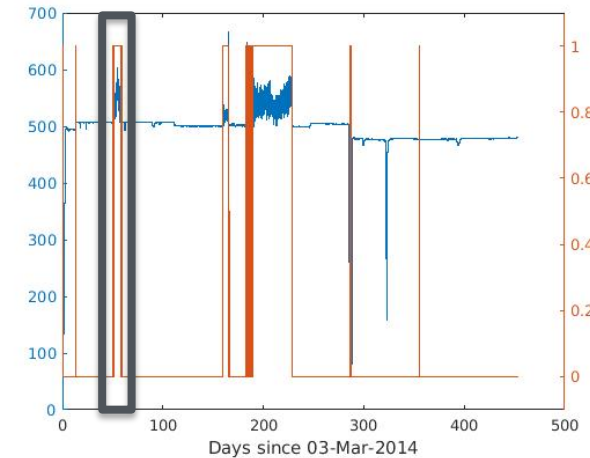
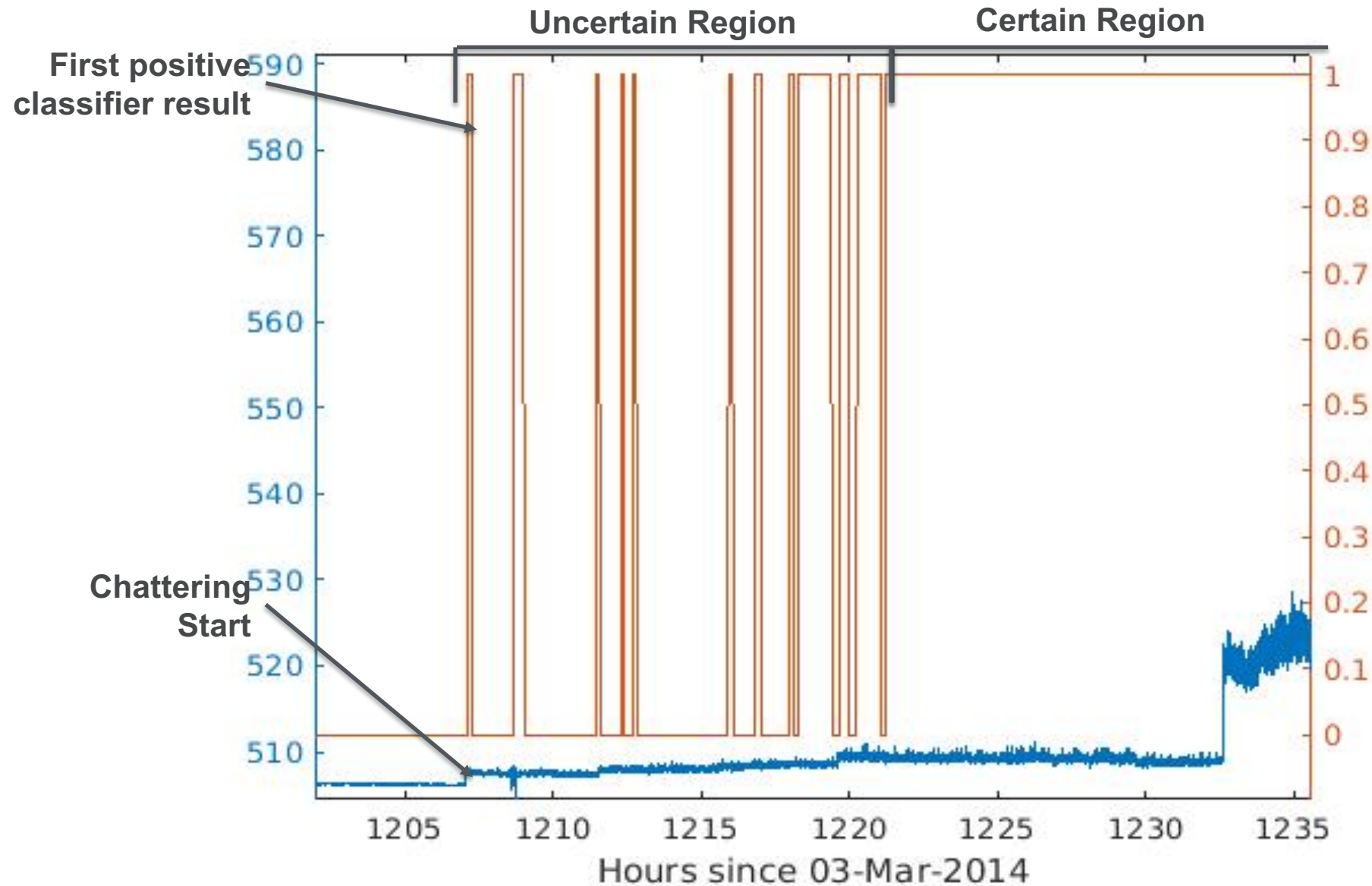
10 point smoothing



No smoothing

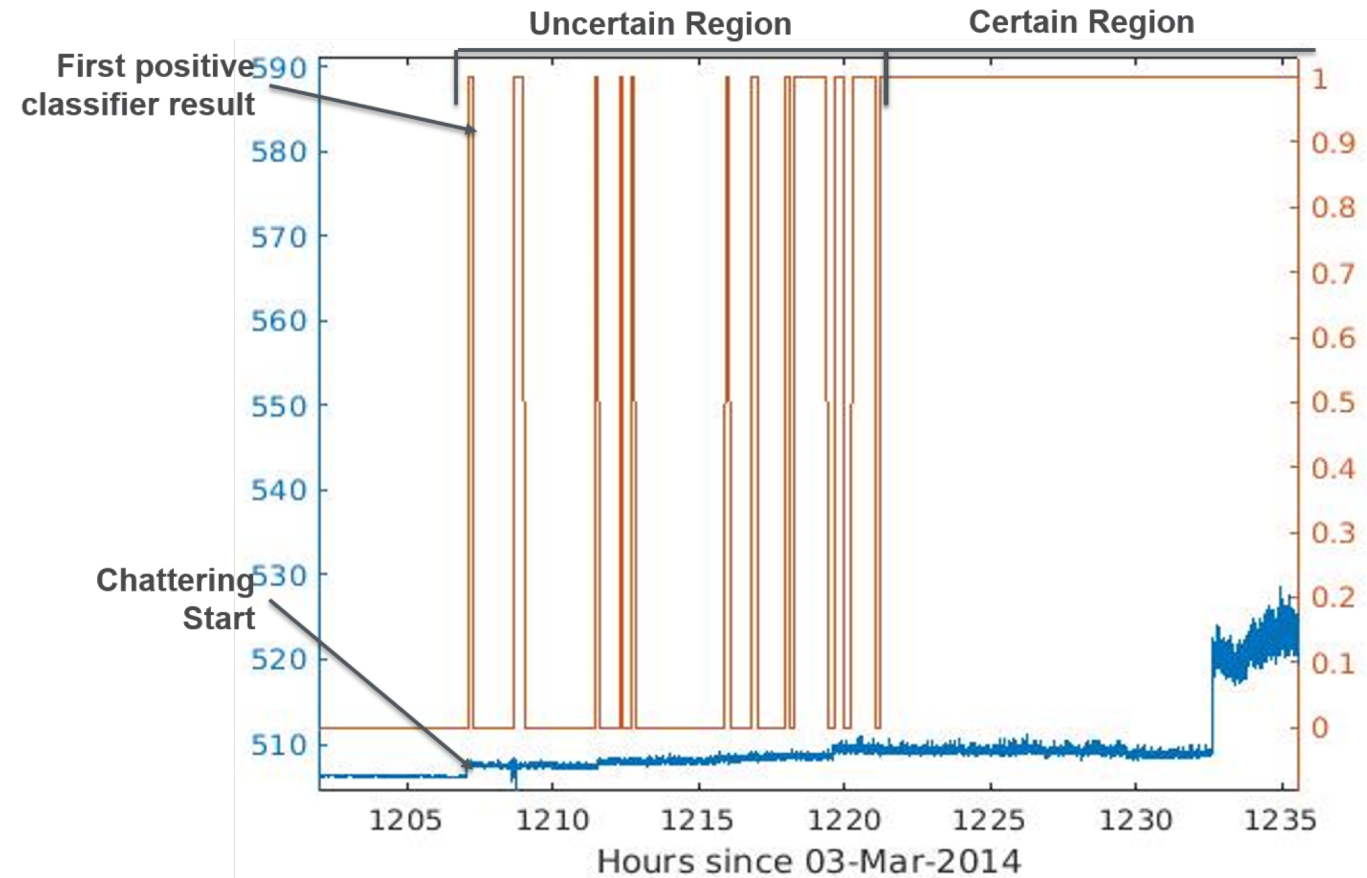


Segment 1 – Time Response



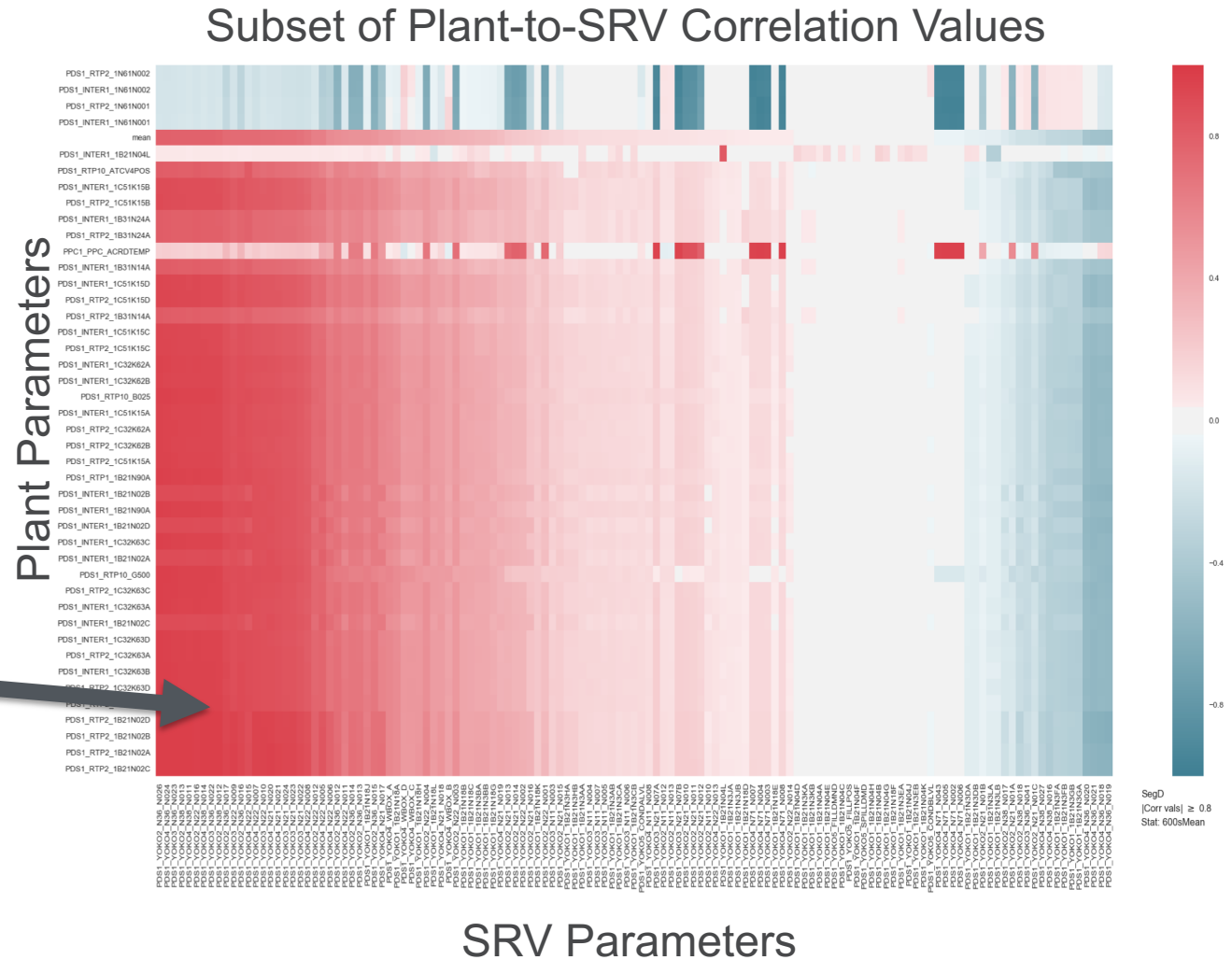
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2. Uncertain region 10-15 hrs
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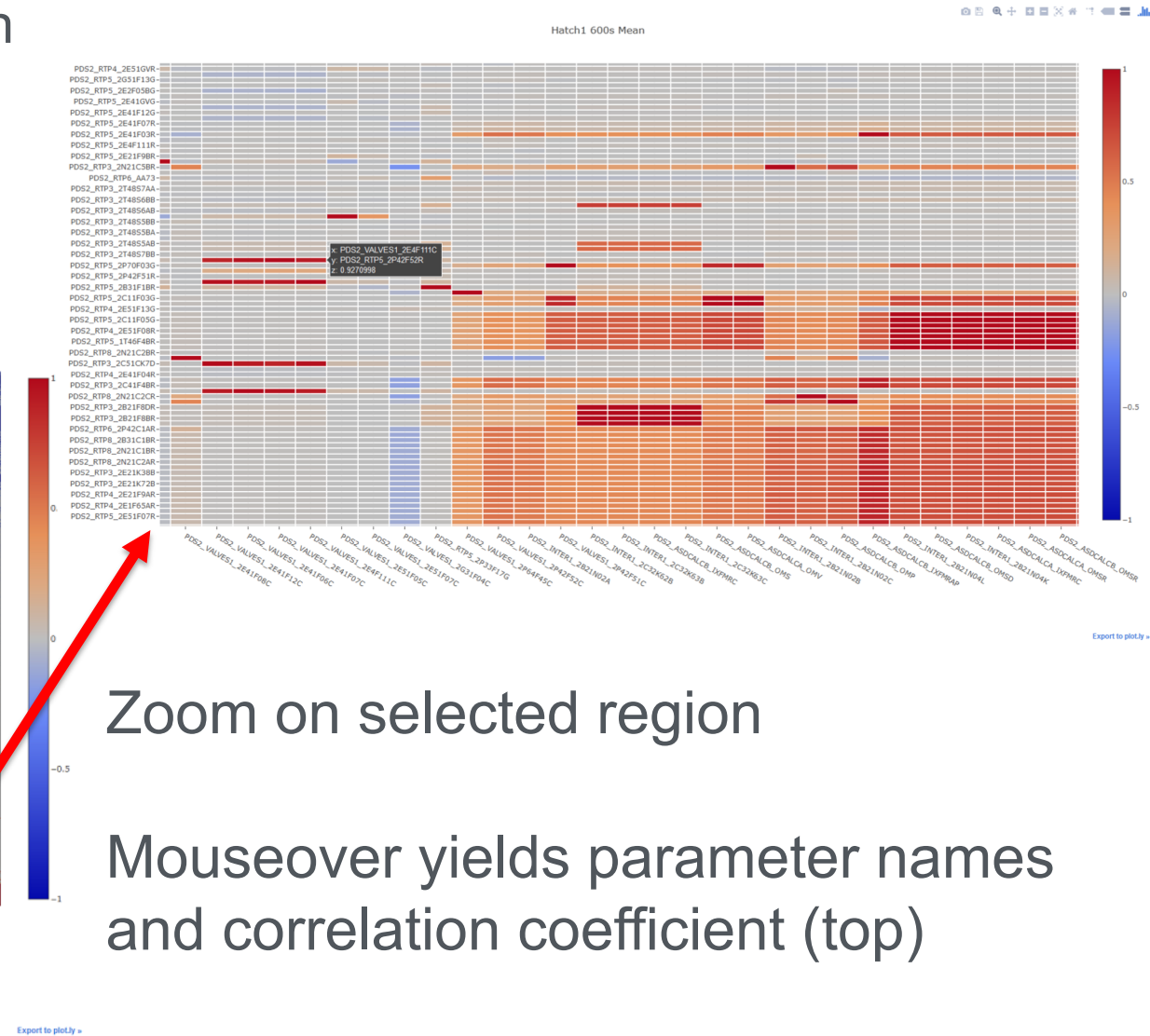
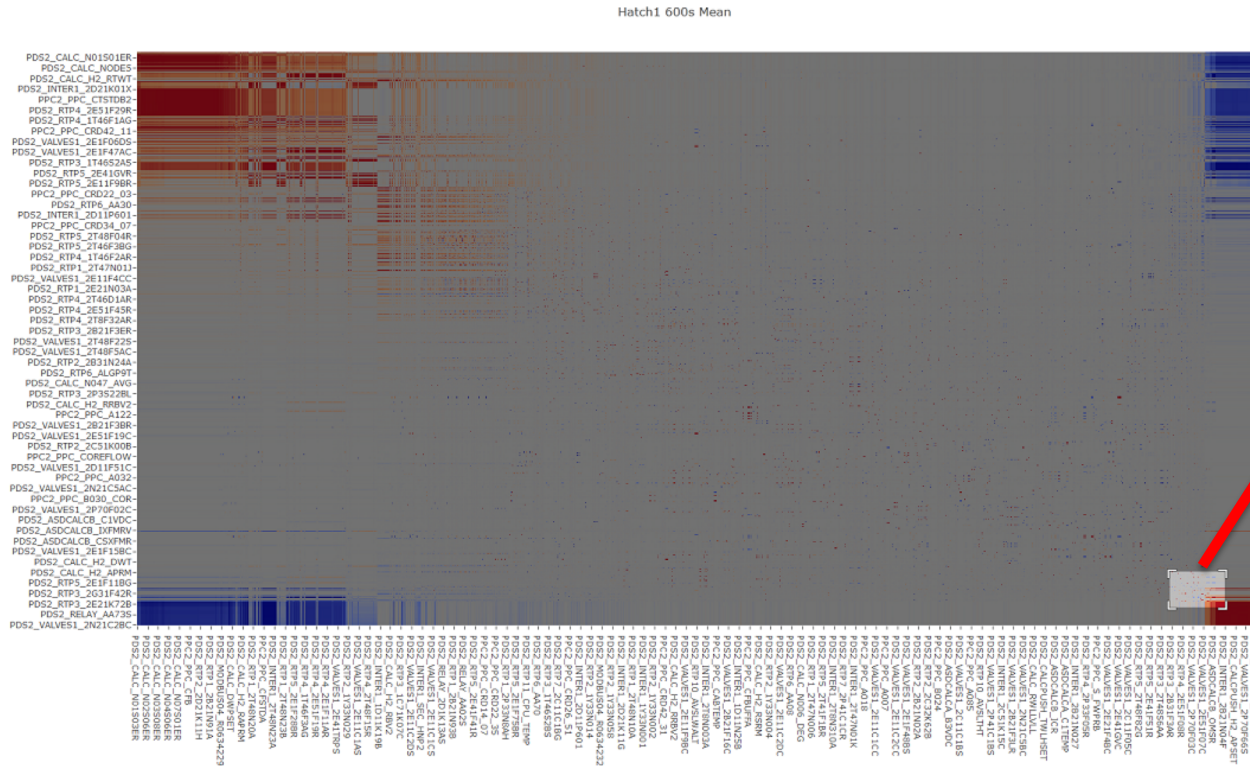
Pearson Correlations

- Search for *plant* parameters with behavior correlating to SRV behavior.
- Explore statistical characteristics and time periods over which to correlate the behavior.
- Filter and sort correlation results to isolate most highly-correlated (+ or -) parameters.



Pearson Correlations

- Also interest in finding substitute indicators in the event a given instrument malfunctions
- Created fully interactive heatmap of plant-to-plant correlation coefficients



Zoom on selected region

Mouseover yields parameter names and correlation coefficient (top)

Pearson Correlations

- From the correlation analysis, we have produced lists of top correlation pairs during various operational segments.
- We are now working to integrate the chattering-classified data to probe for differences in parameter behavior between chattering and non-chattering states
- We will work with partner to help guide focus in drilling down on components of highest utility

Next Steps

- FFT/Wavelet of every plant variable, and then take the correlation coefficient between the output FFT of each
 - Correlate valves with each other-chatter same time?
 - Does one of the four always go first?
 - Identify Plant Variables highly correlated to chattering states
- Deeper analysis of Chattering
 - Examine length of chattering states and whether continuous or with breaks
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- Further test Chattering classifier on data already provided
 - Develop code with User Interface for SNP to use to detect chattering
- Build Machine Learning model to predict chattering from data

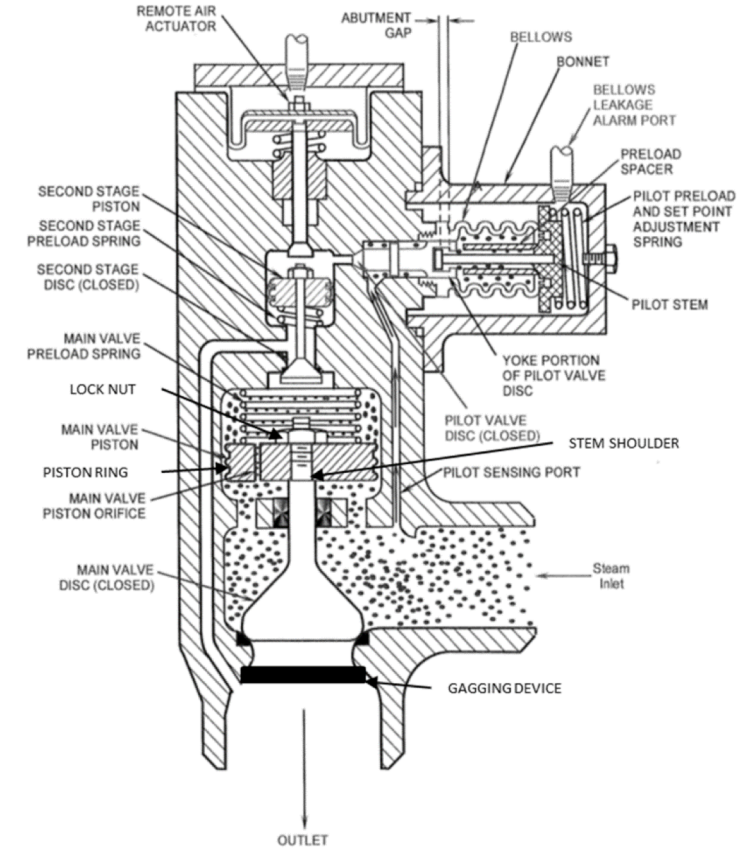


Clean. **Reliable. Nuclear.**

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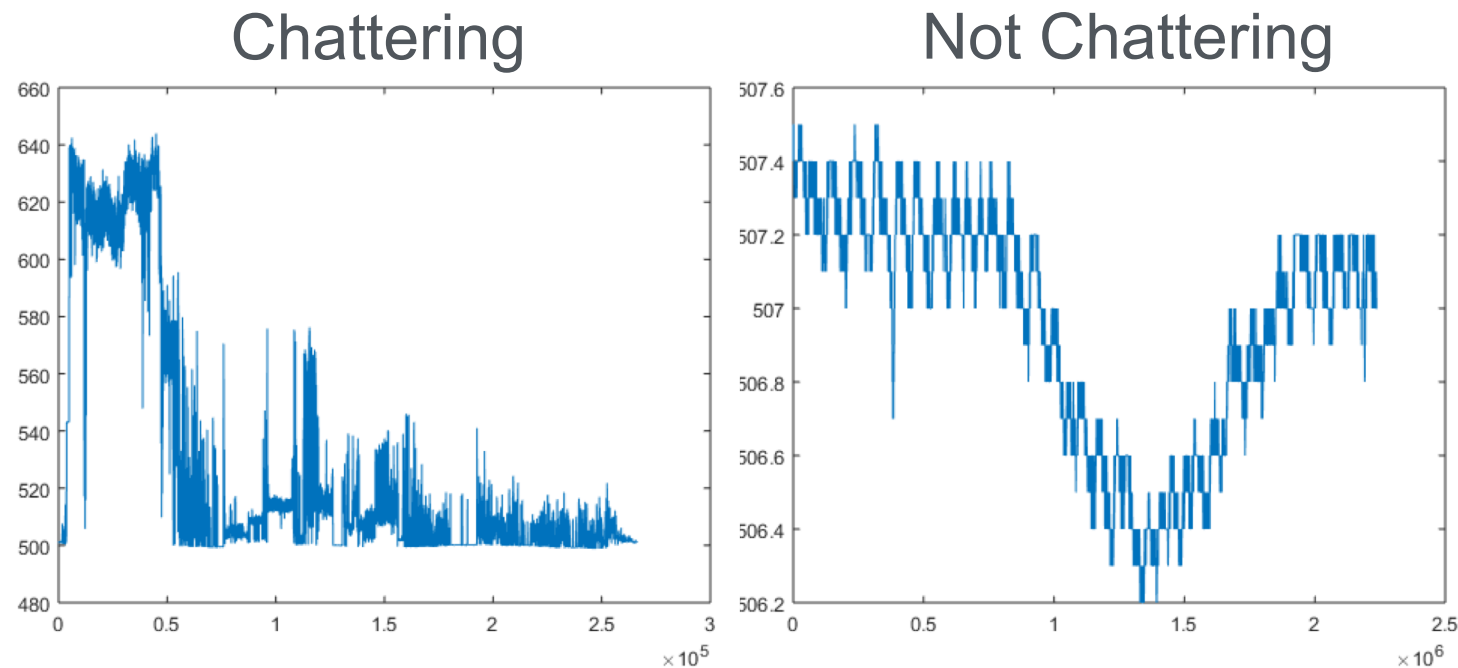
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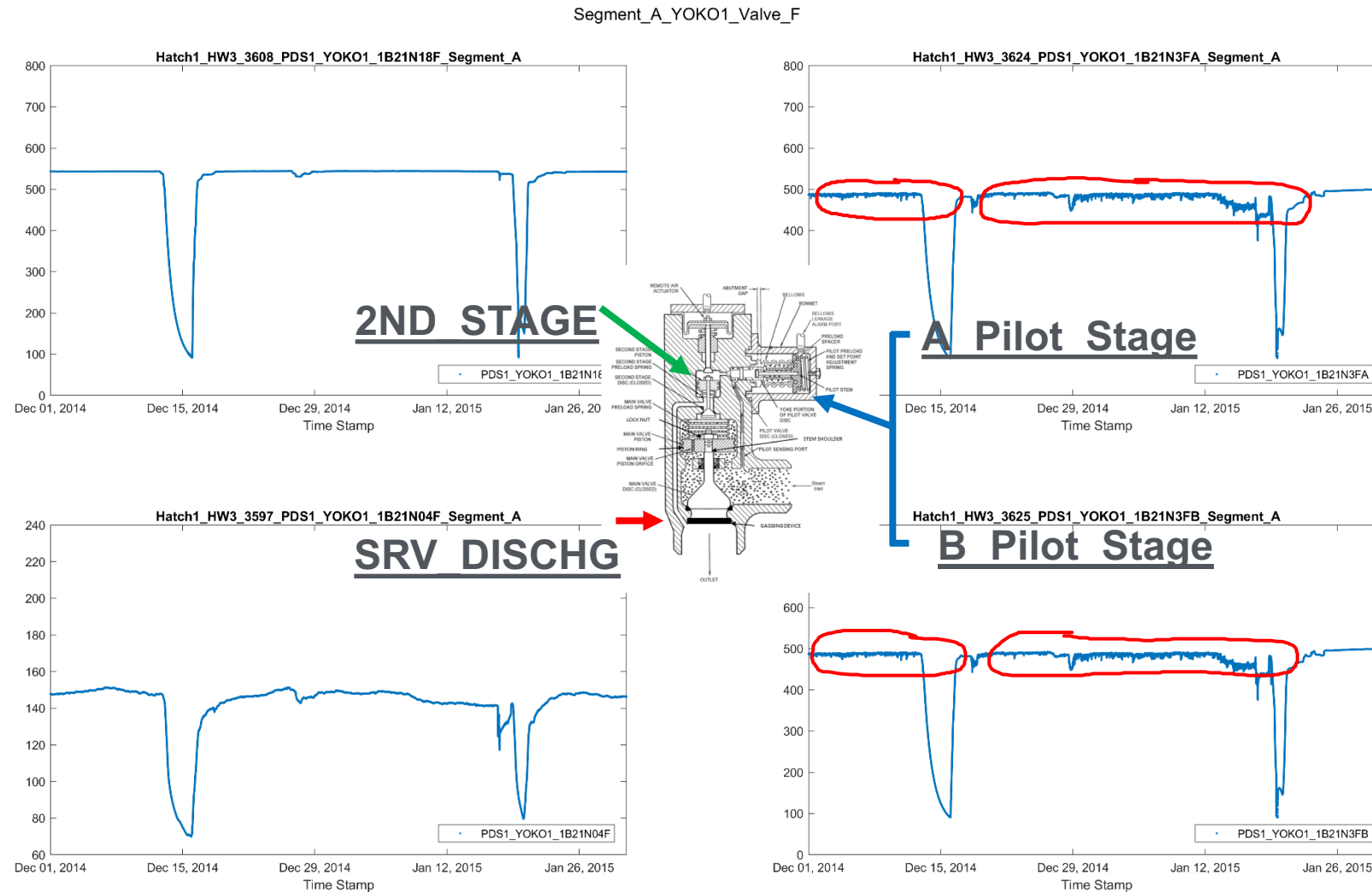


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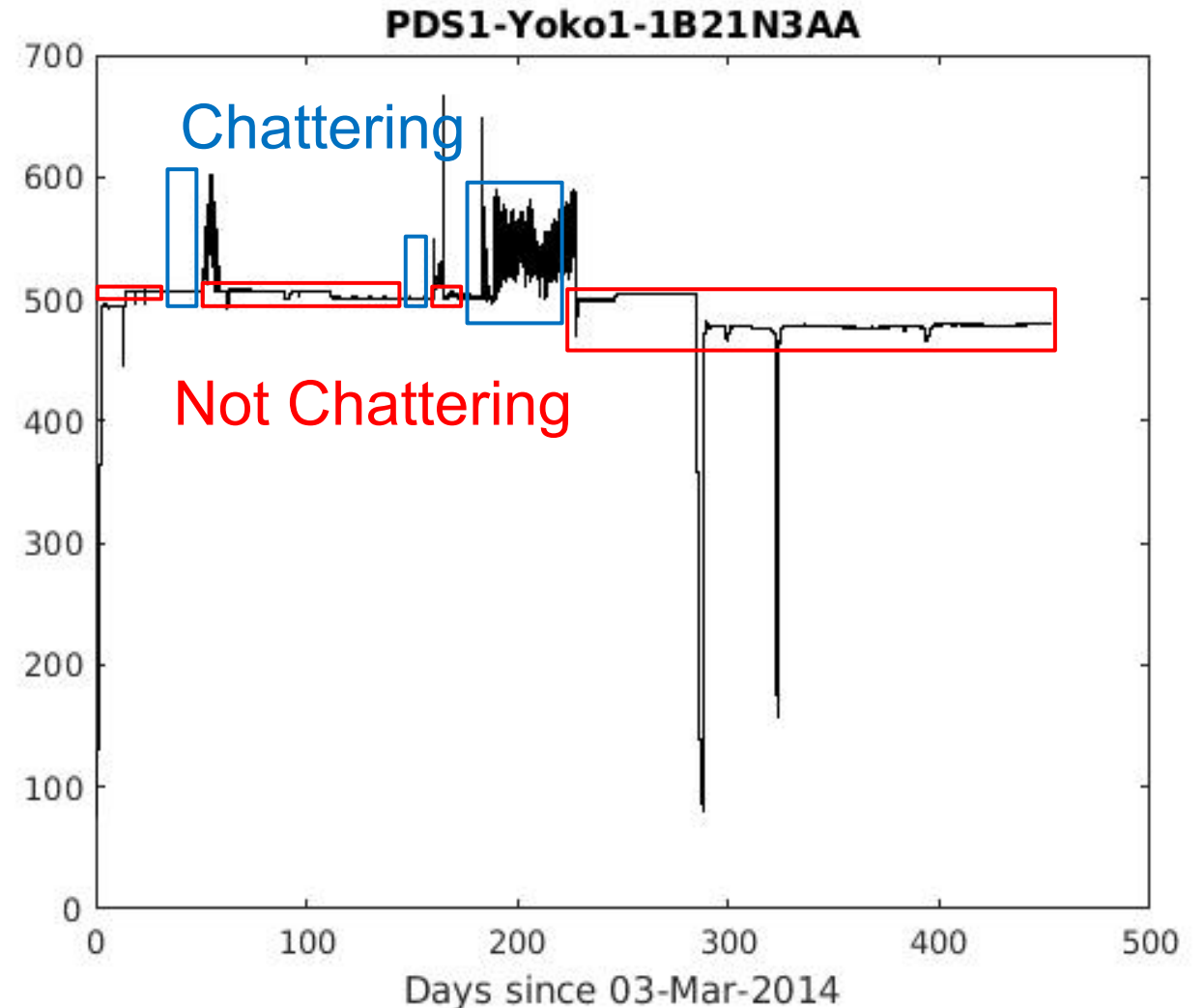
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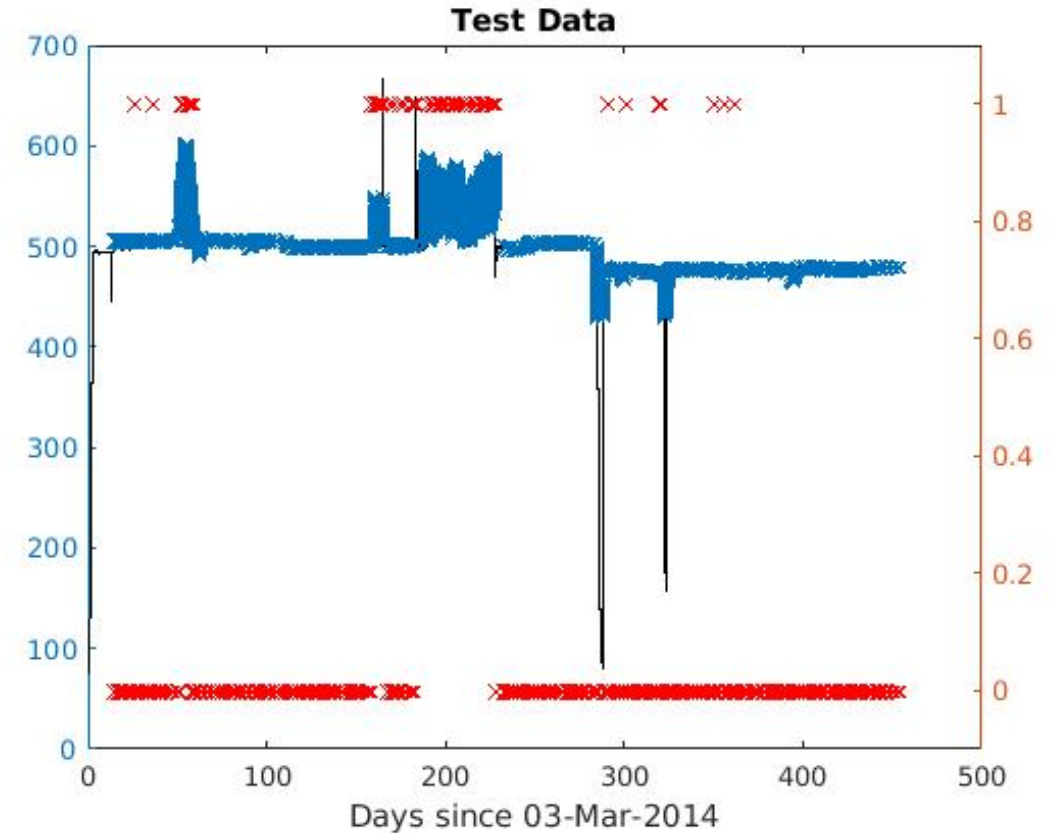
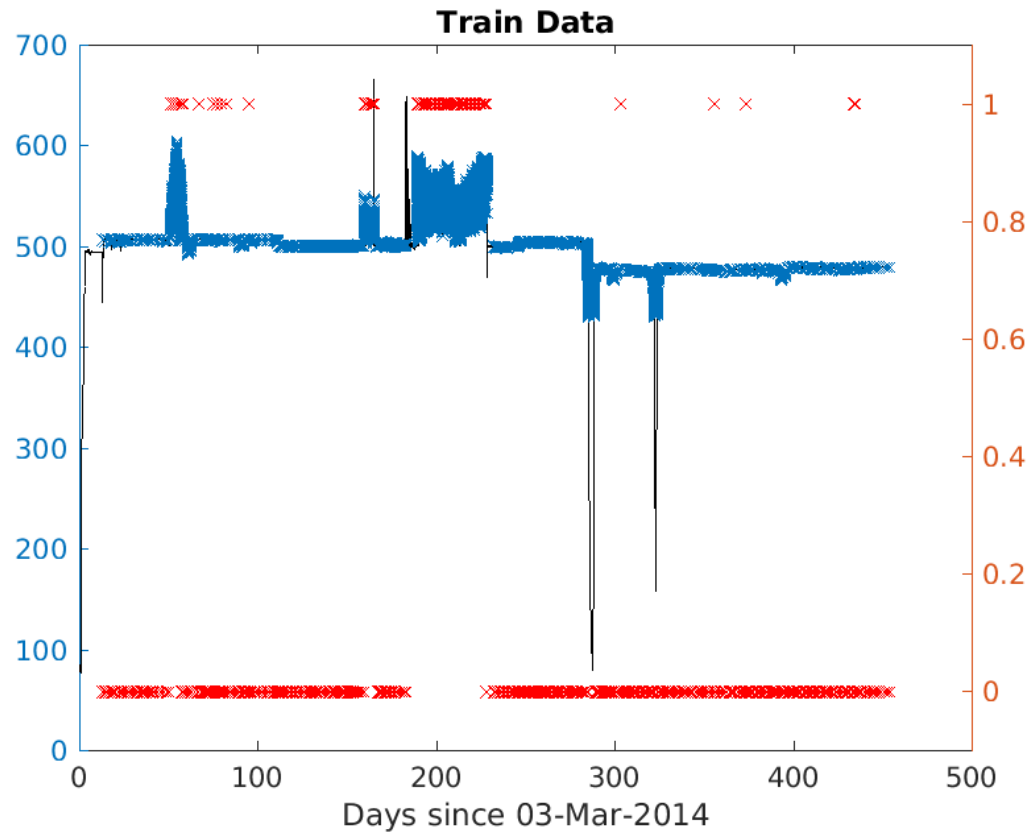


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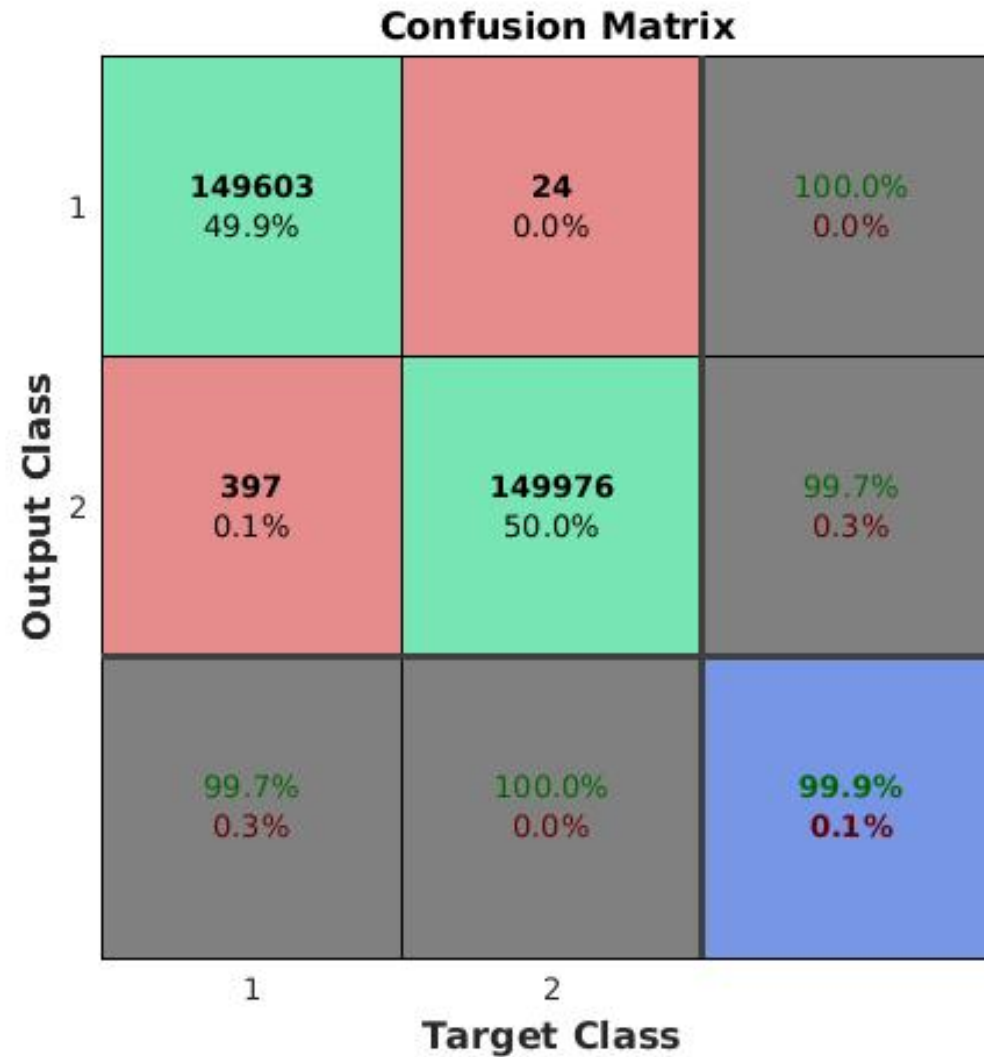
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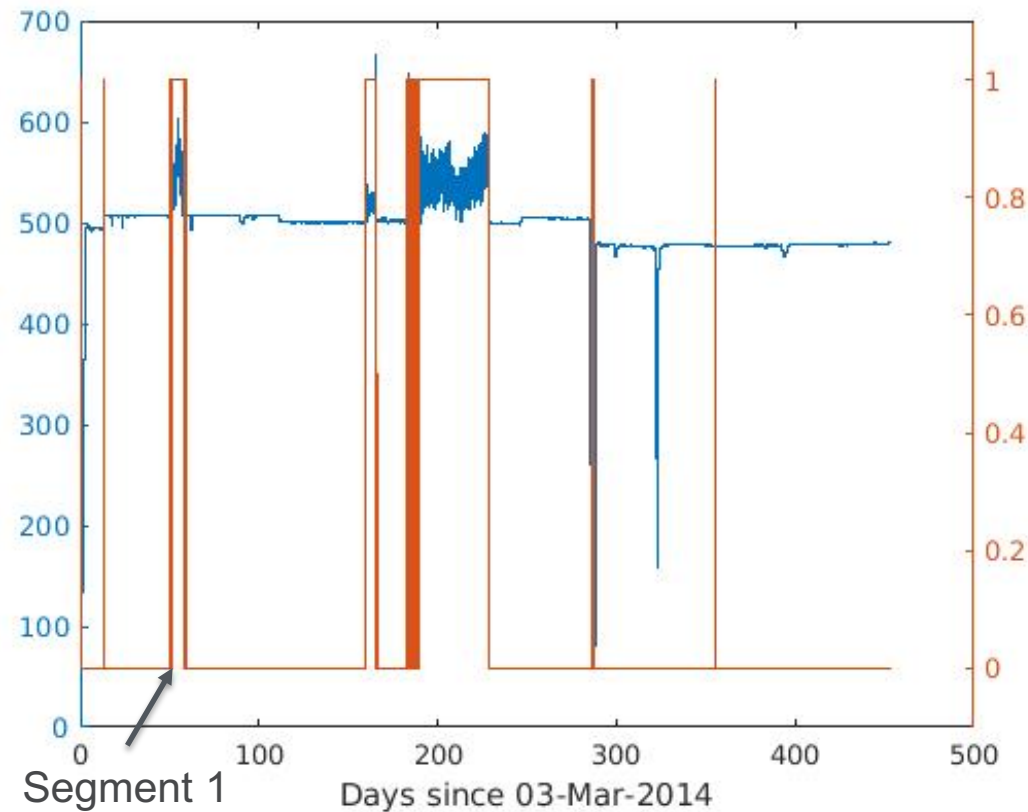


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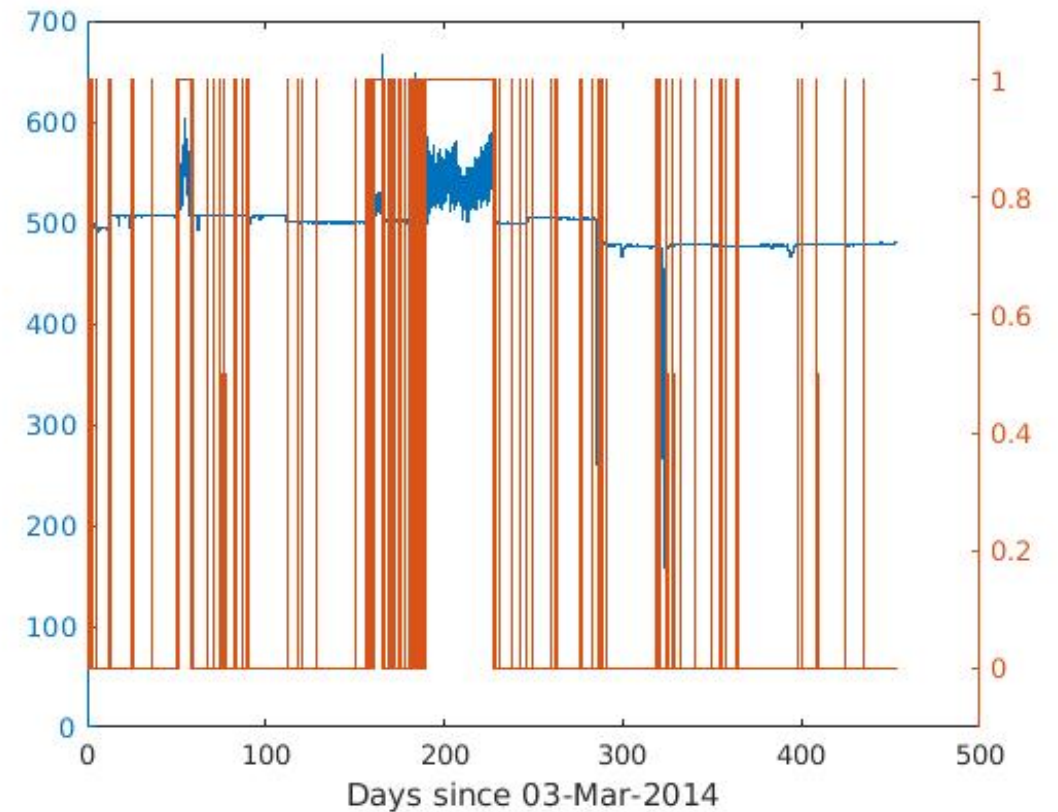


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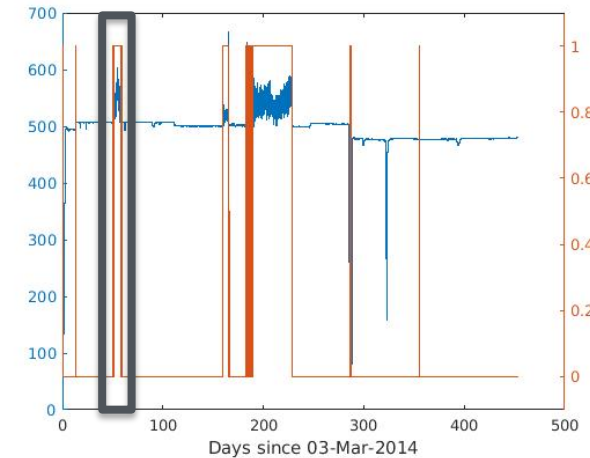
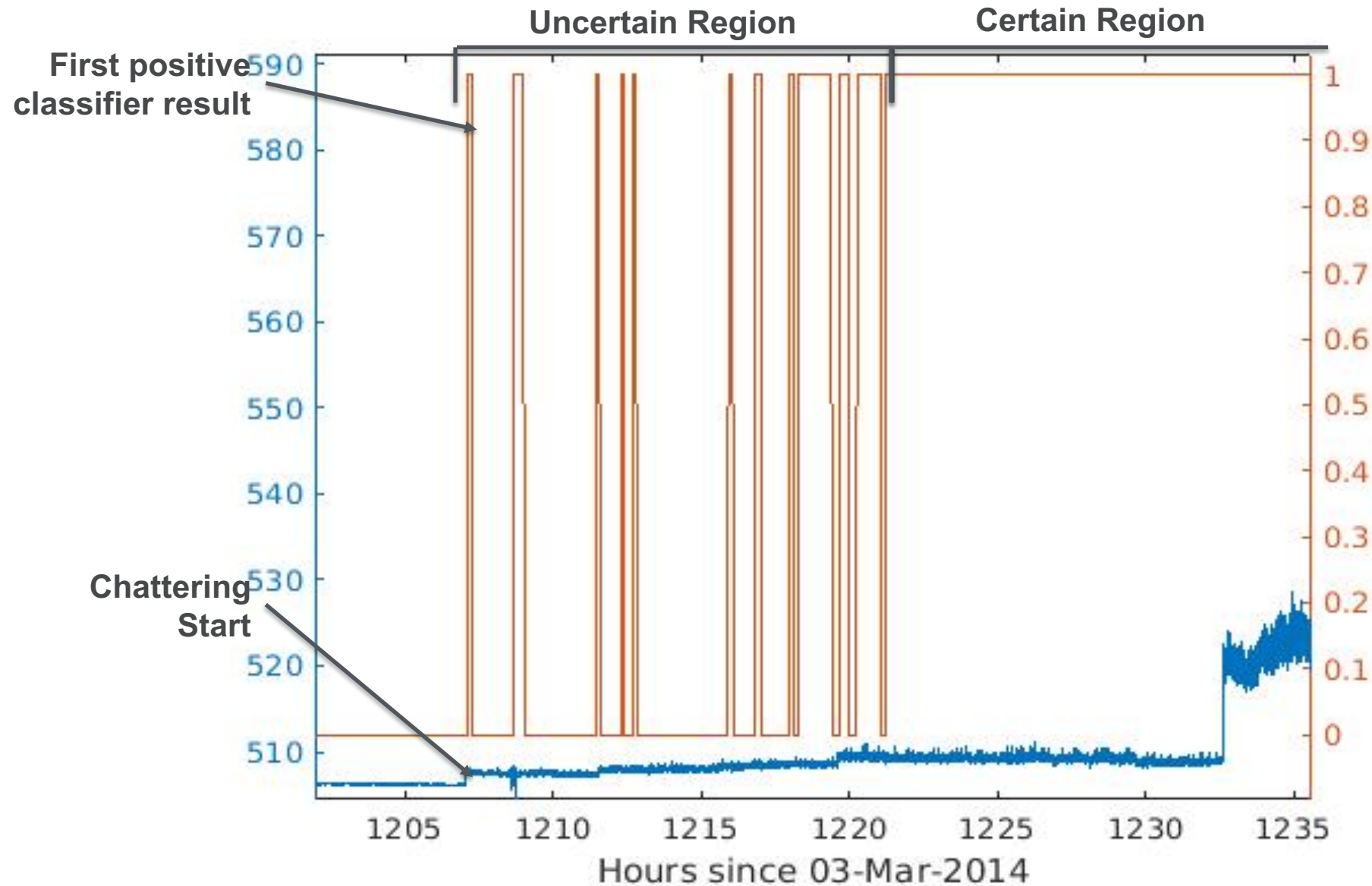
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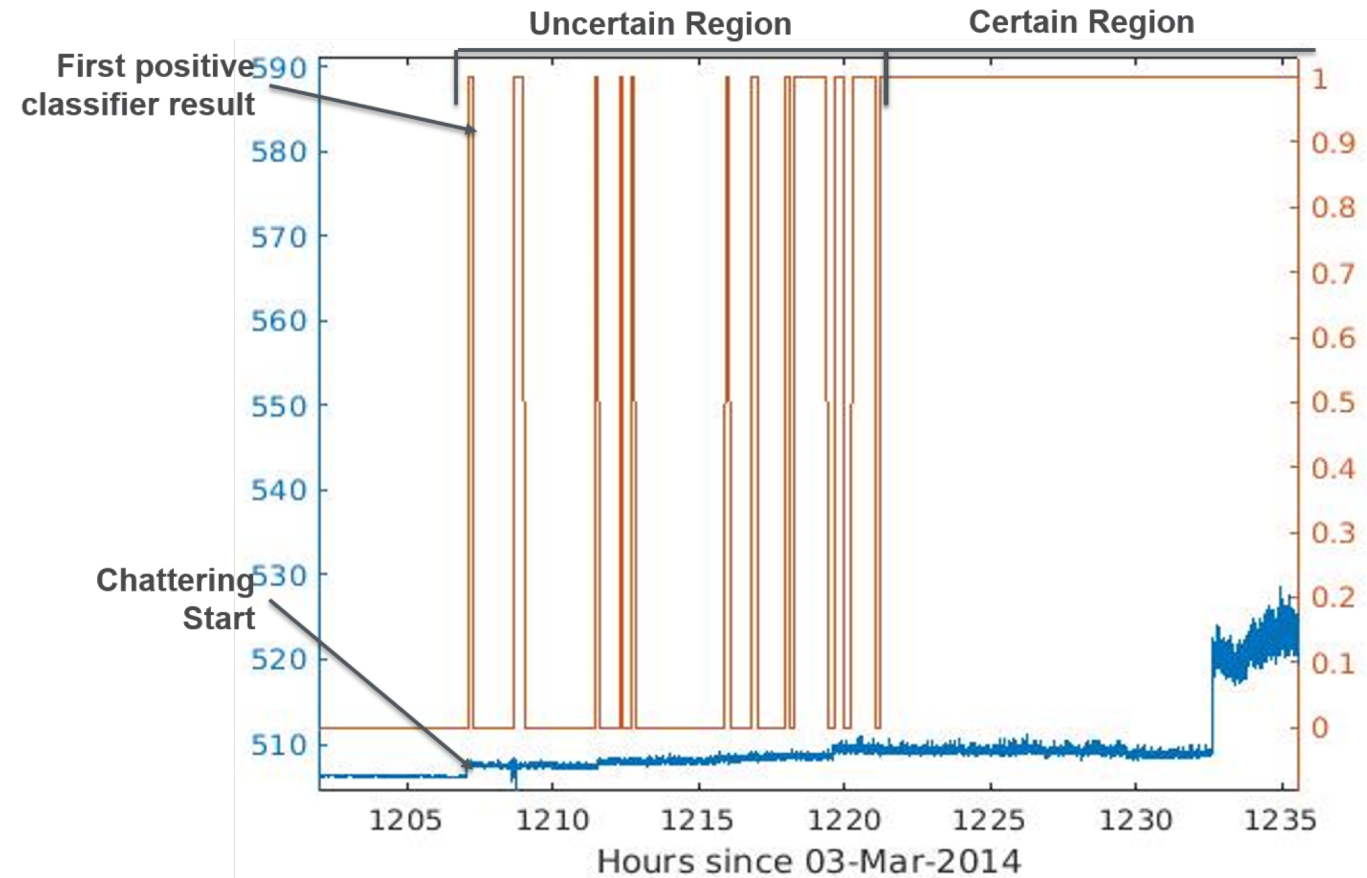


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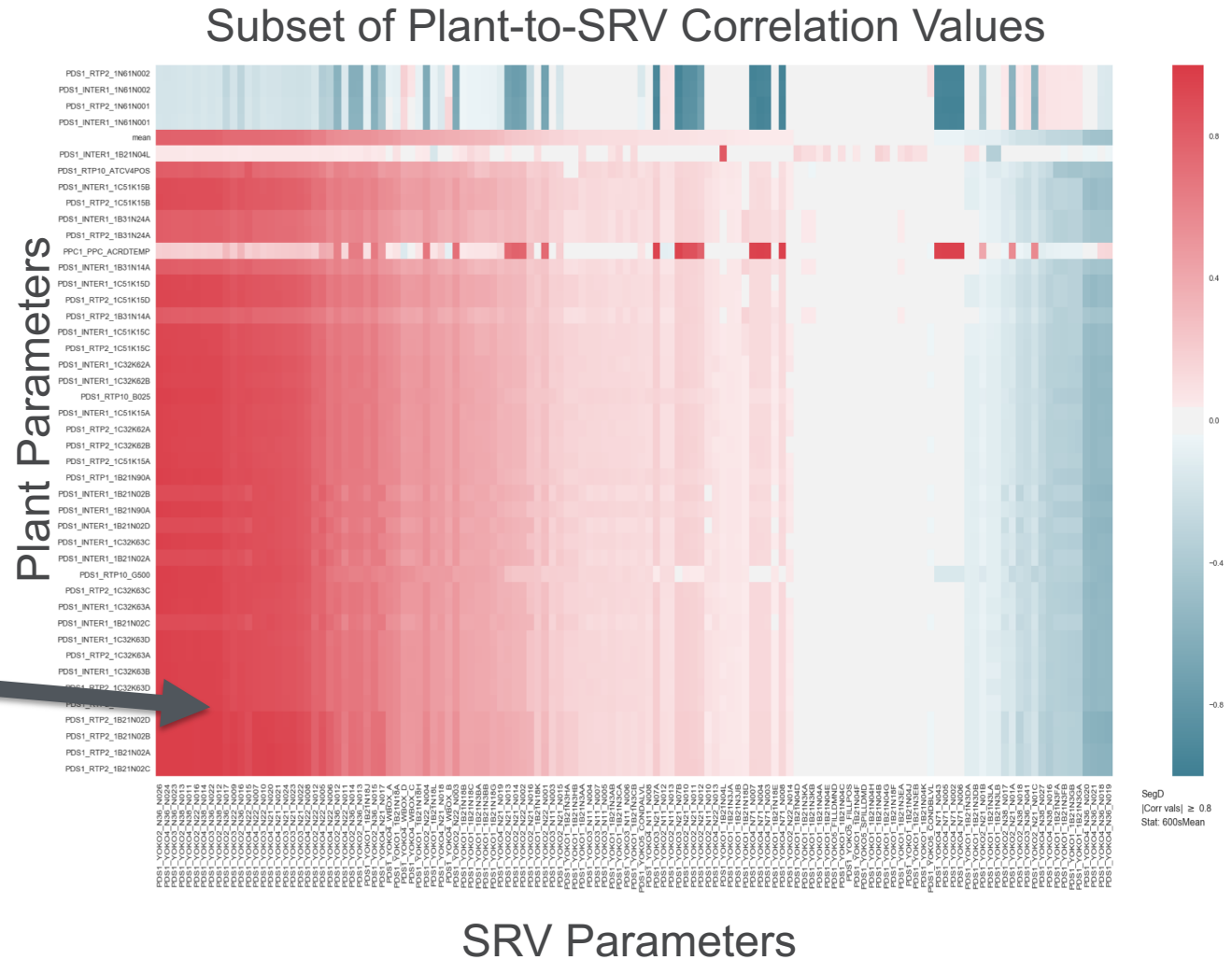
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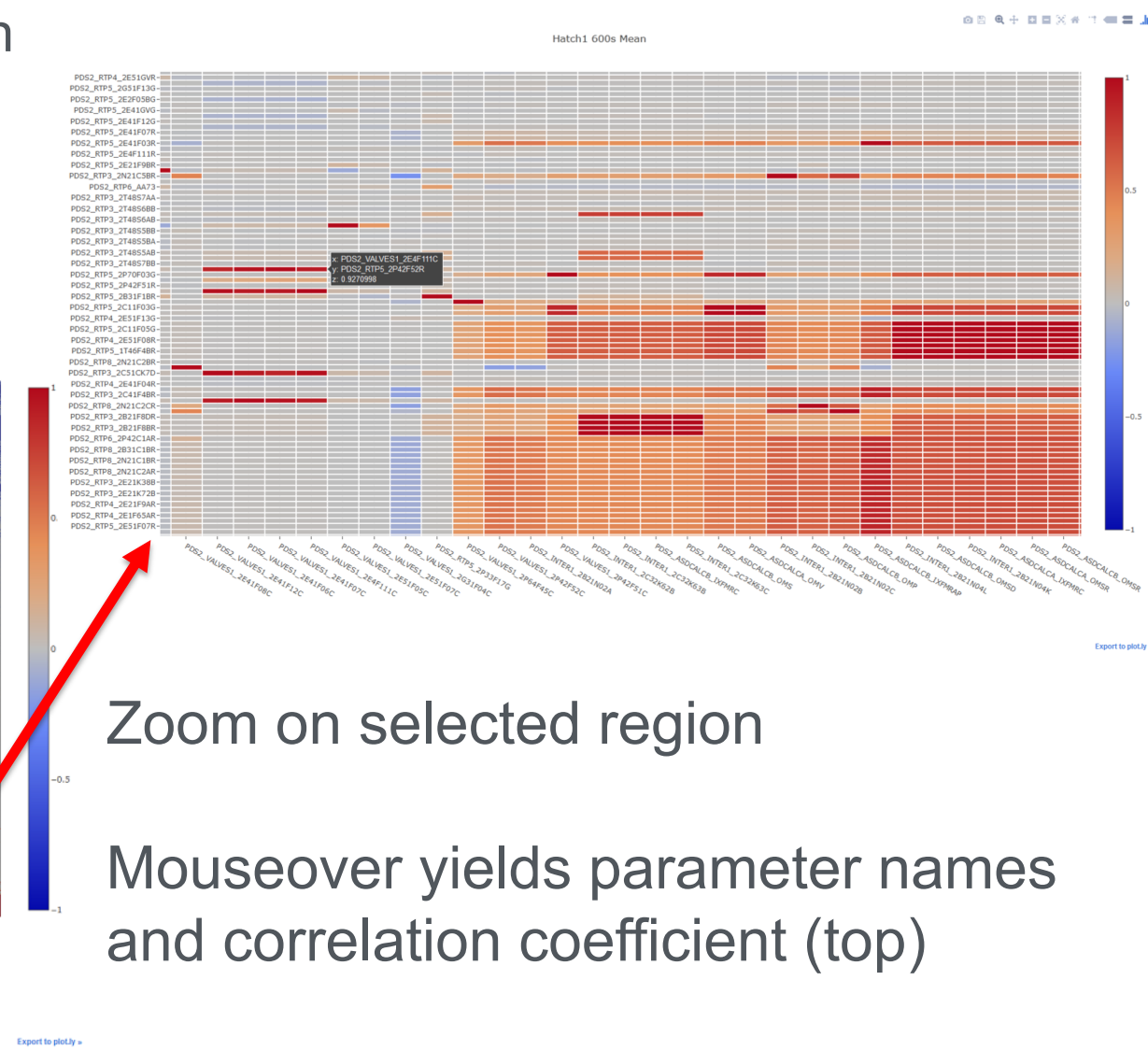
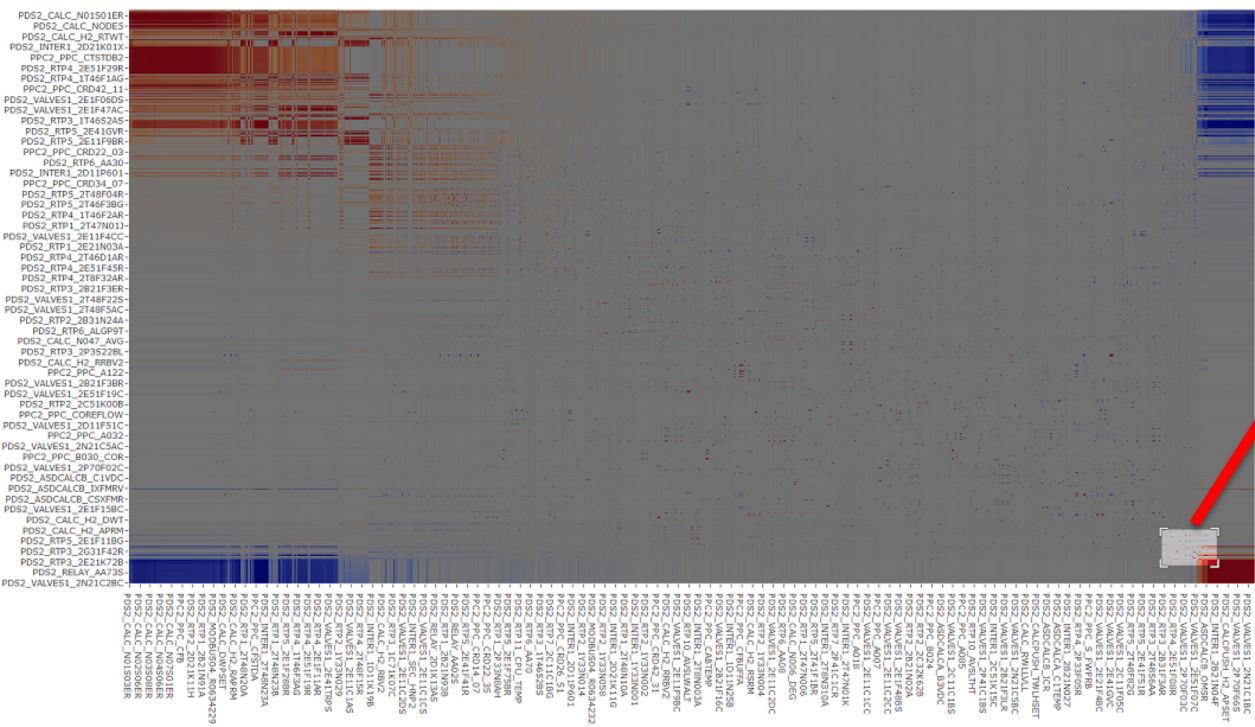
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