

PBU Detection Task

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DATASET

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Objectives

SECTION 1

Downhole Pressure Buildup
Detection

SECTION 2

Reservoir Pressure Estimation

Nature of The Dataset: Challenges

- 3-18 million entries
- DHP in time series with non-uniform sampling intervals
- Long-duration buildups (hours → months)
- No explicit markers for other events

Outlier handling

1) Remove negative, infinity values

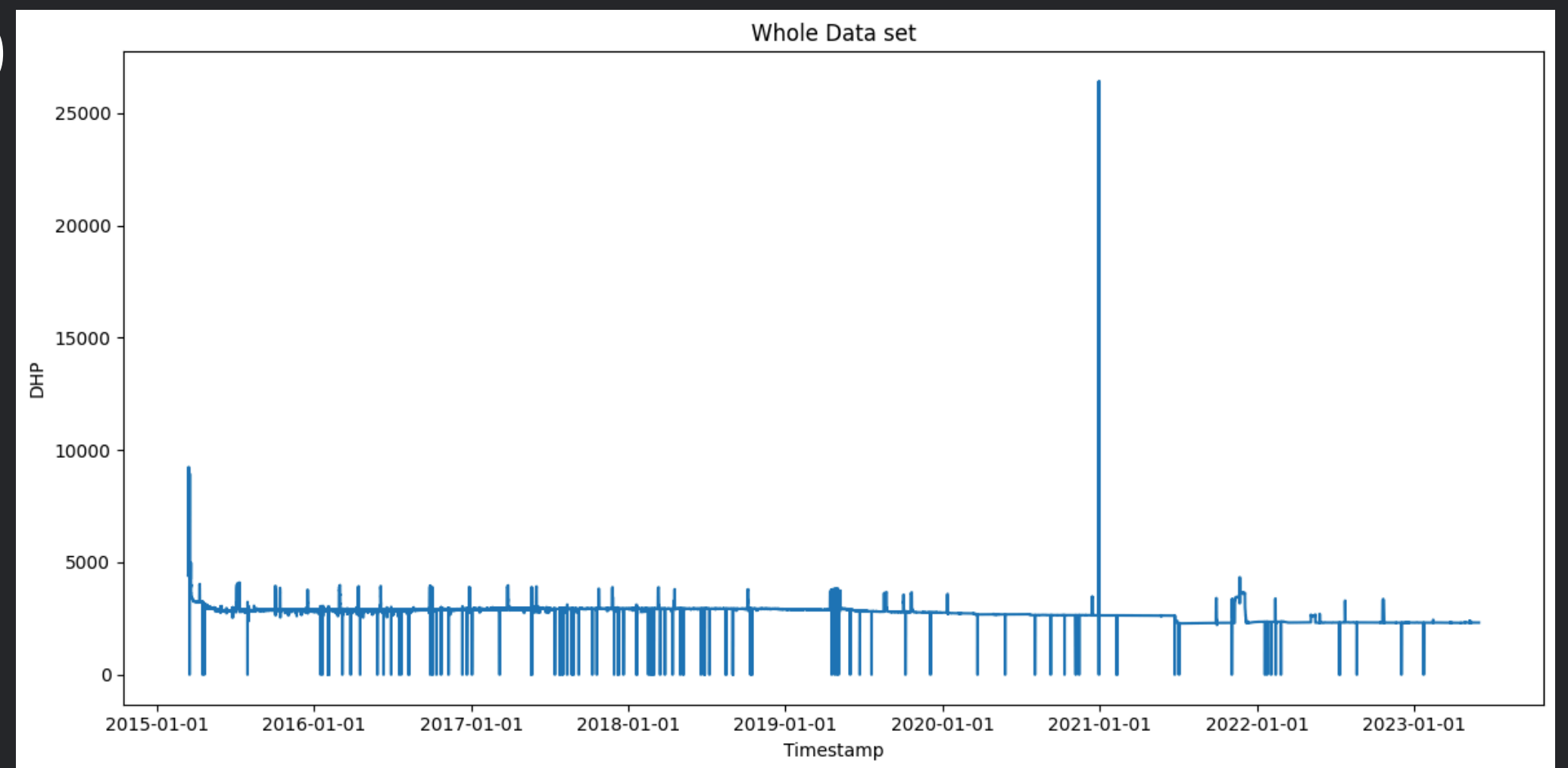
2) Data entry error (decimal shift)

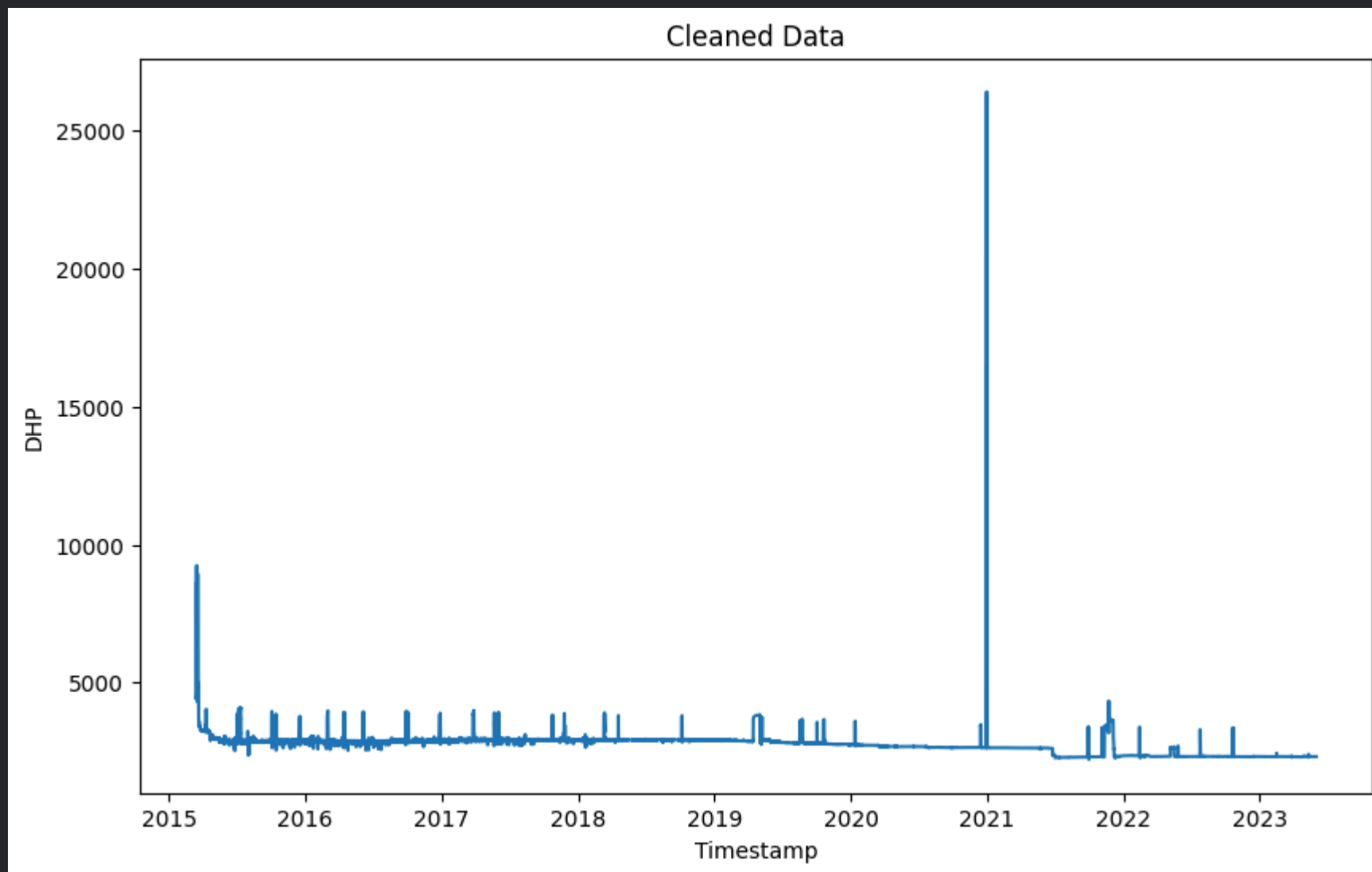
Compare mean log with individual +
remove based on big deviation from
neighboring values ($<\text{neighbors} \times 5>$)

```
7213642 2020-12-29 23:48:47.900000+00:00 2640.85000
7213643 2020-12-29 23:56:09.600000+00:00 26410.00000
7213644 2020-12-29 23:56:09.666000+00:00 2641.00200
```

3) Set boundaries for DHP

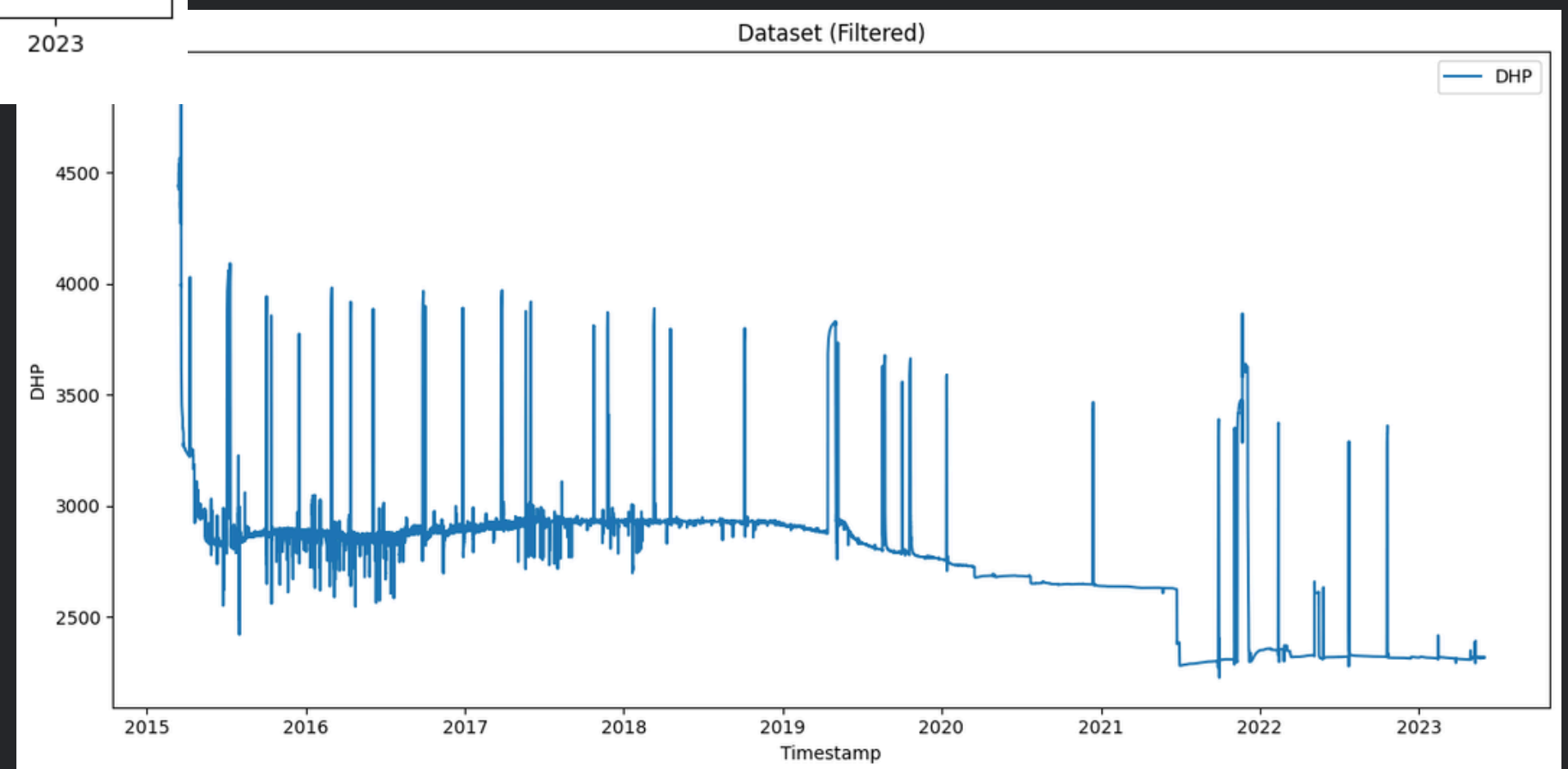
Manually set $1000 < \text{dhp} < 5000$ based
on visual analysis of data





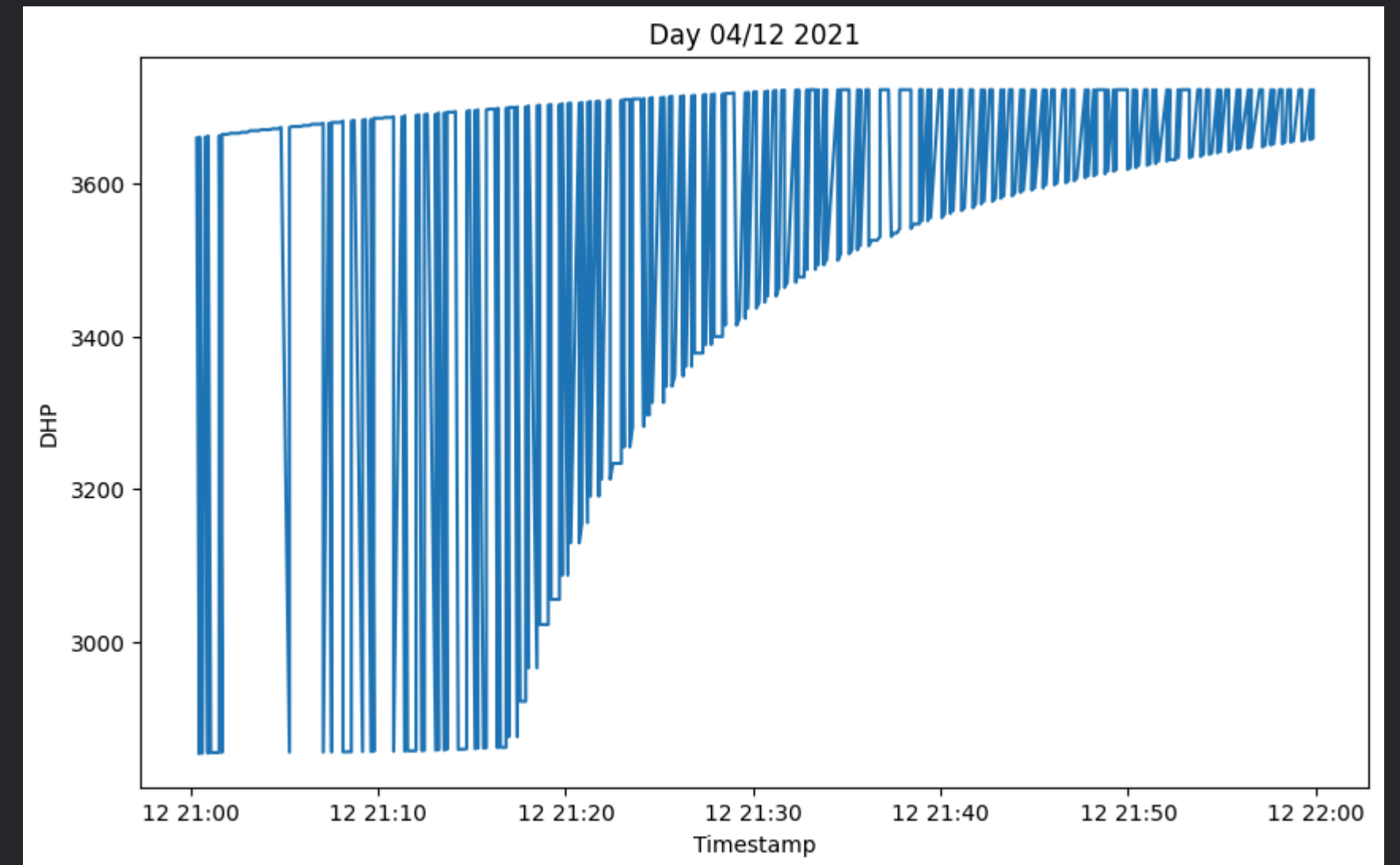
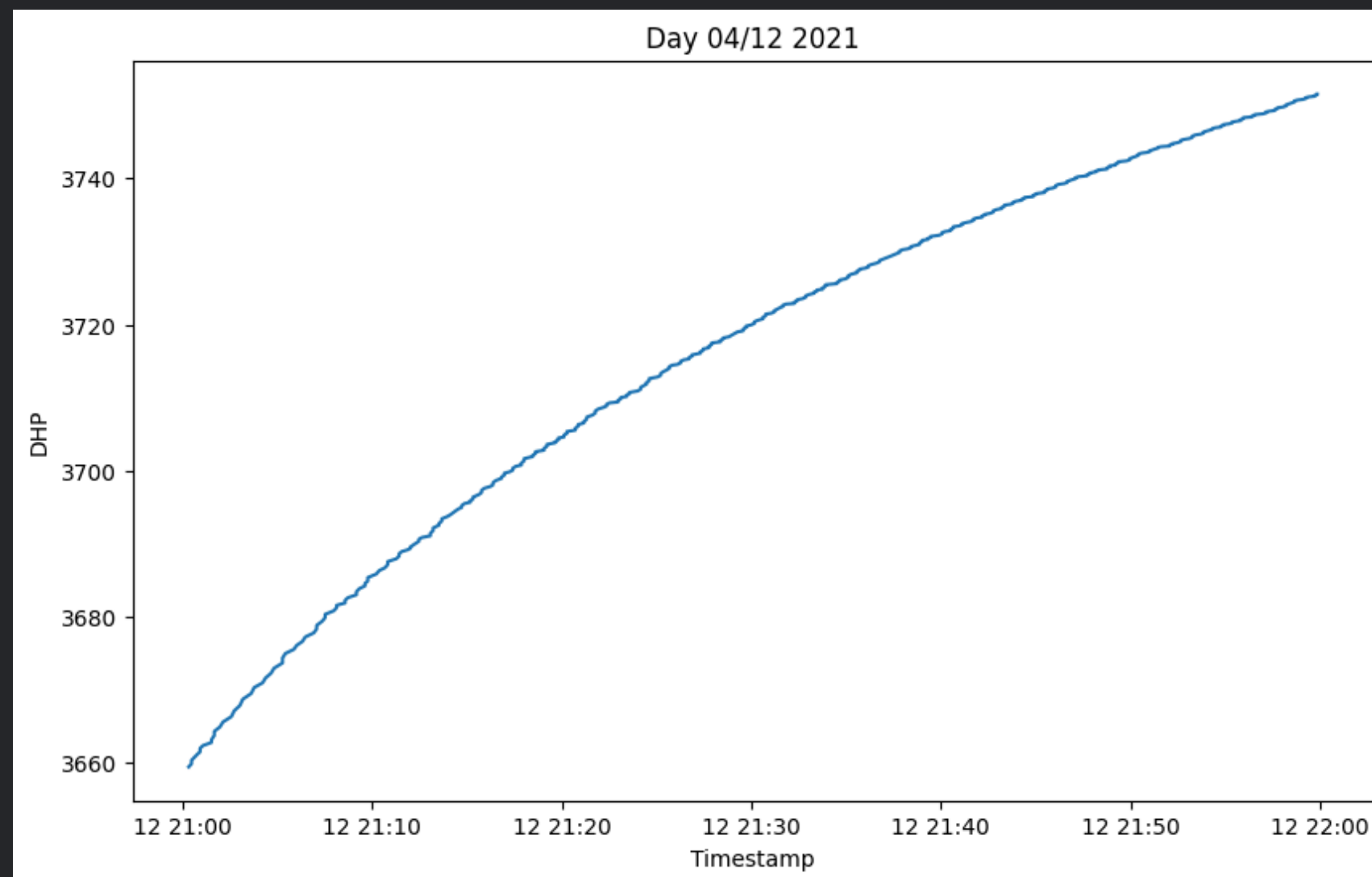
After cleaning and before
fixing decimal shift

After fixing decimal shift



Noise Handling

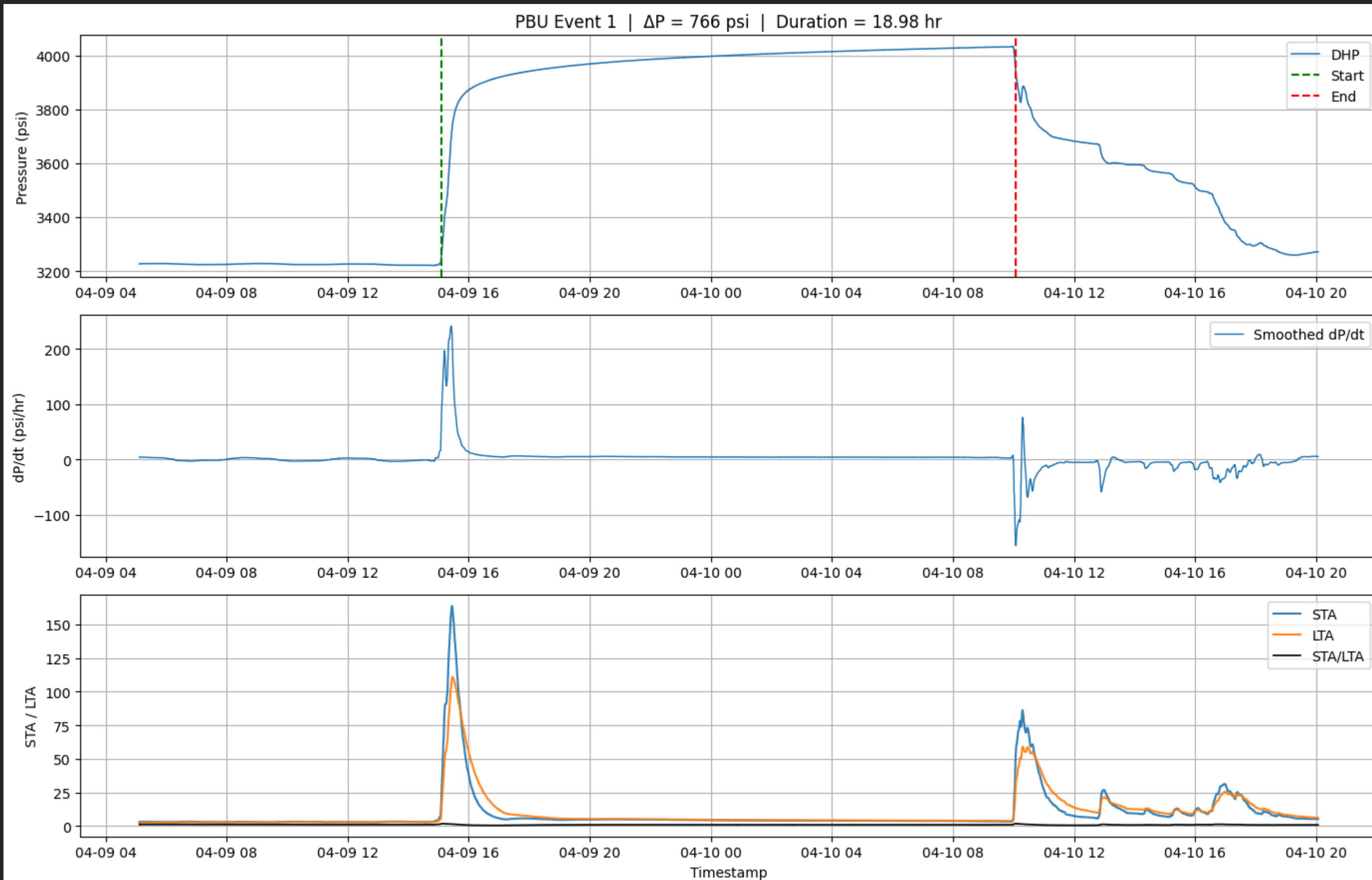
Impulsive, spike noise with dropouts



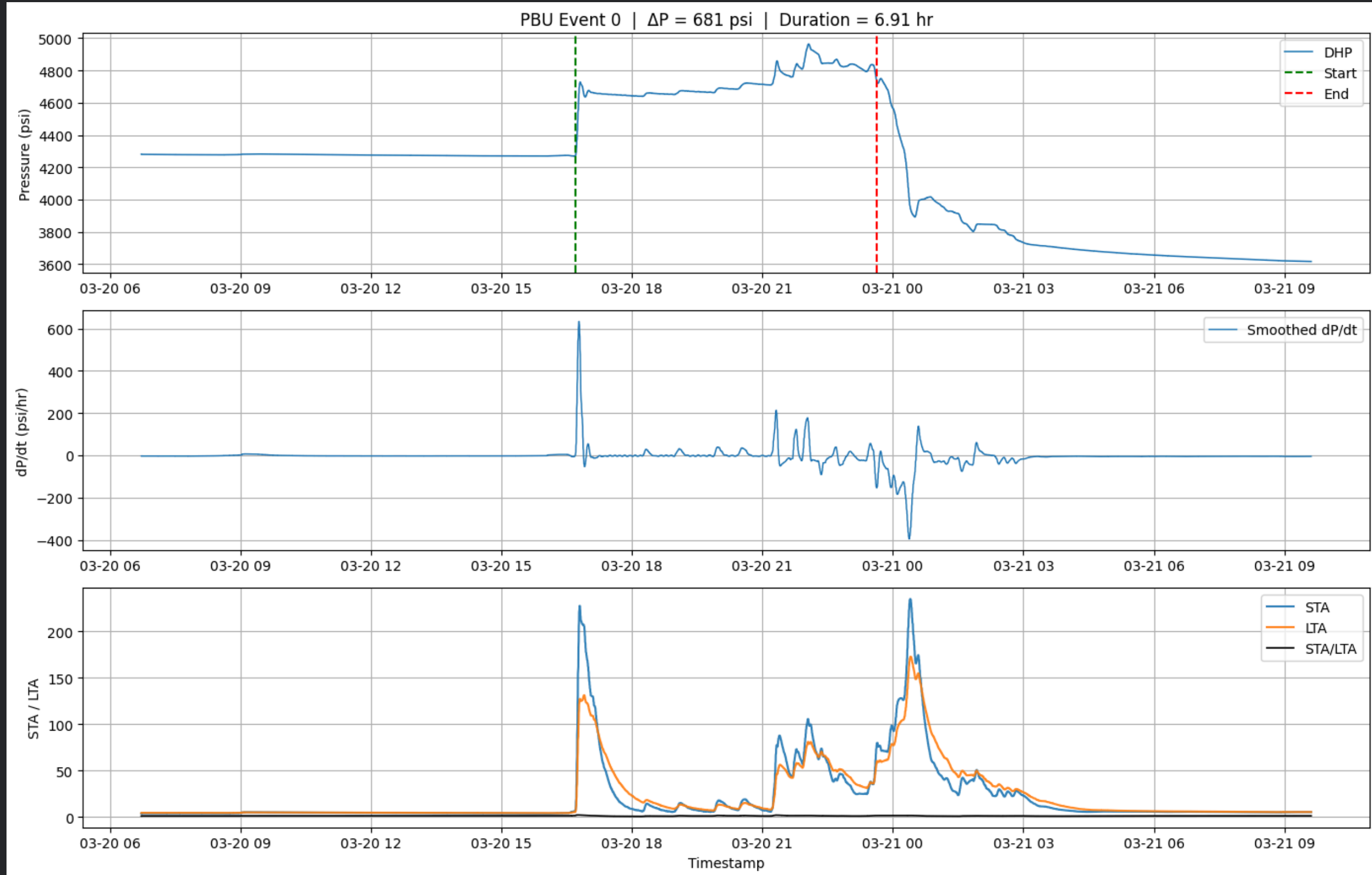
Applied techniques: morphological filtering (follow top of the curve: more reliable shape) + Savitzky-Golay filter for smoothing

Section 1

STA/LTA Algorithm

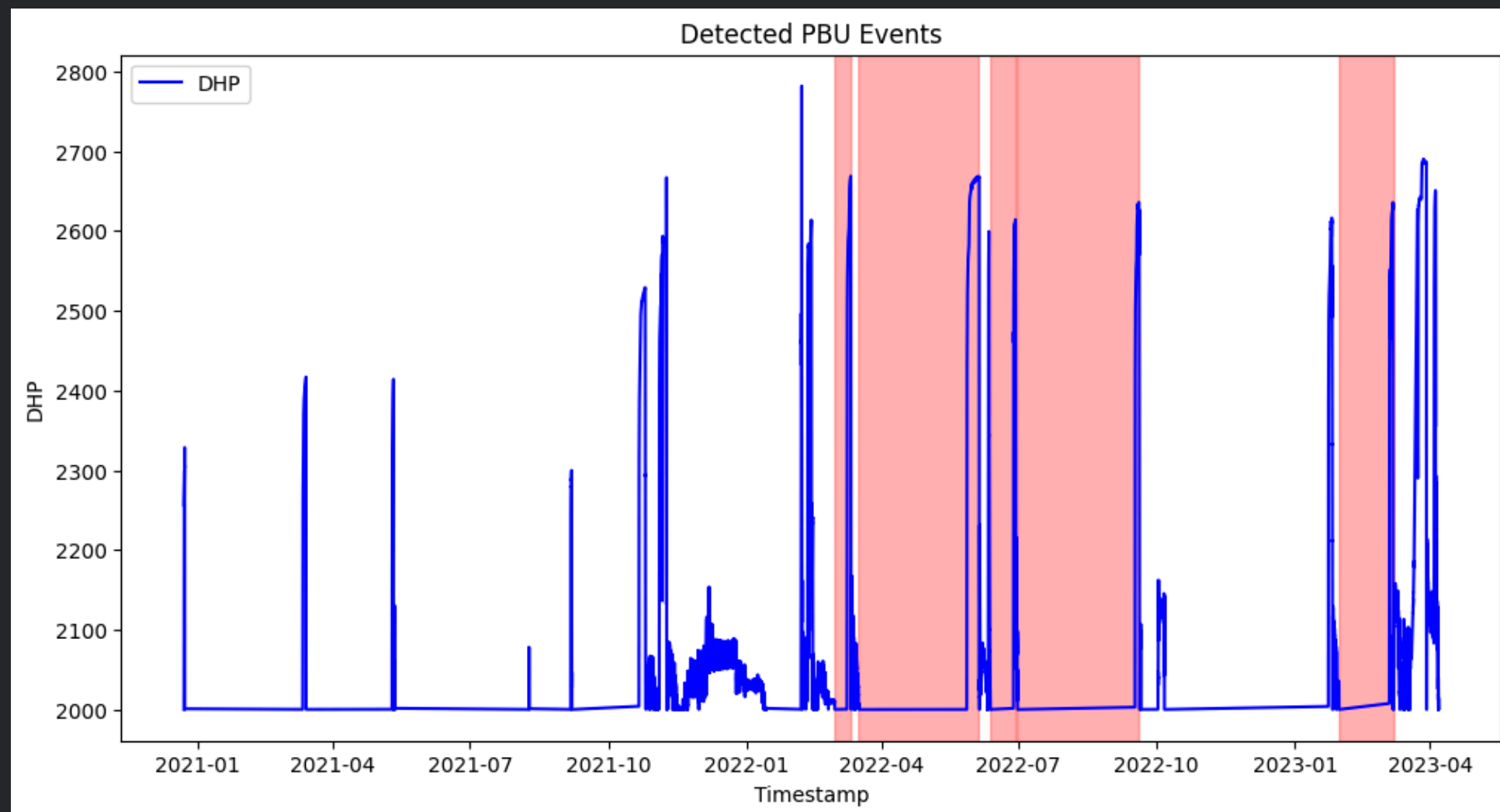


STA/LTA Algorithm



Early Solutions: Logic and Issues

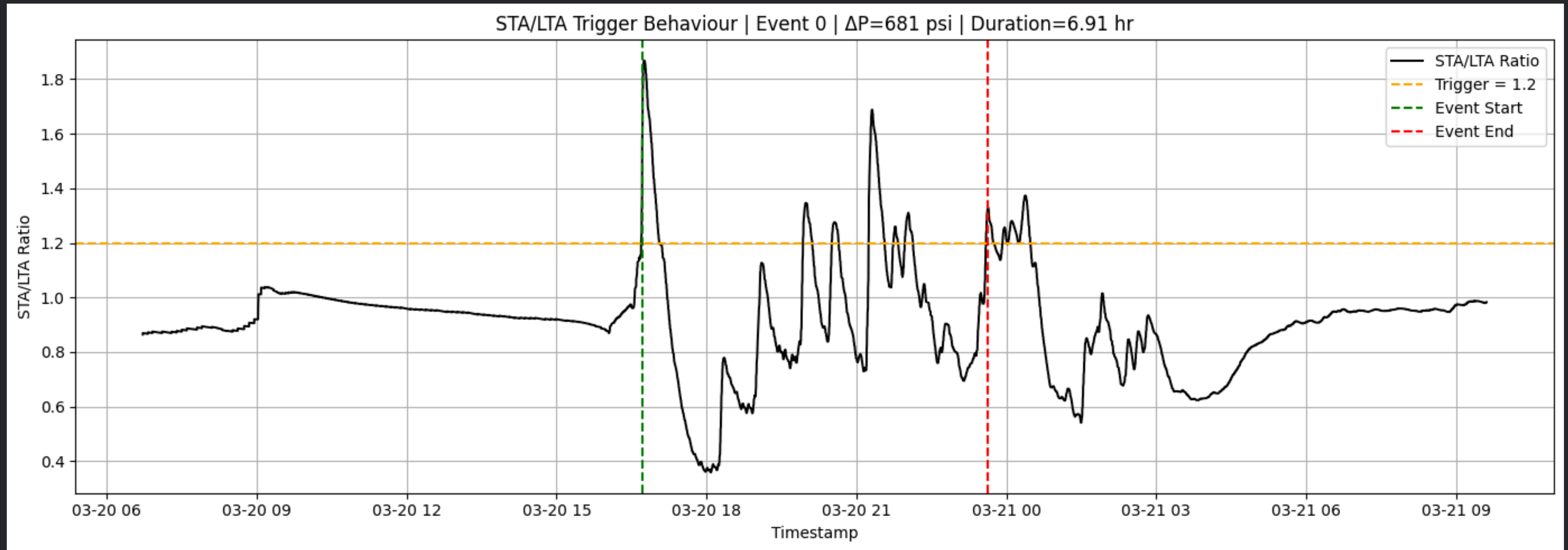
1. Detect strong positive slope → declare start
2. Detect strong negative slope → declare end
3. Apply duration + ΔP filters



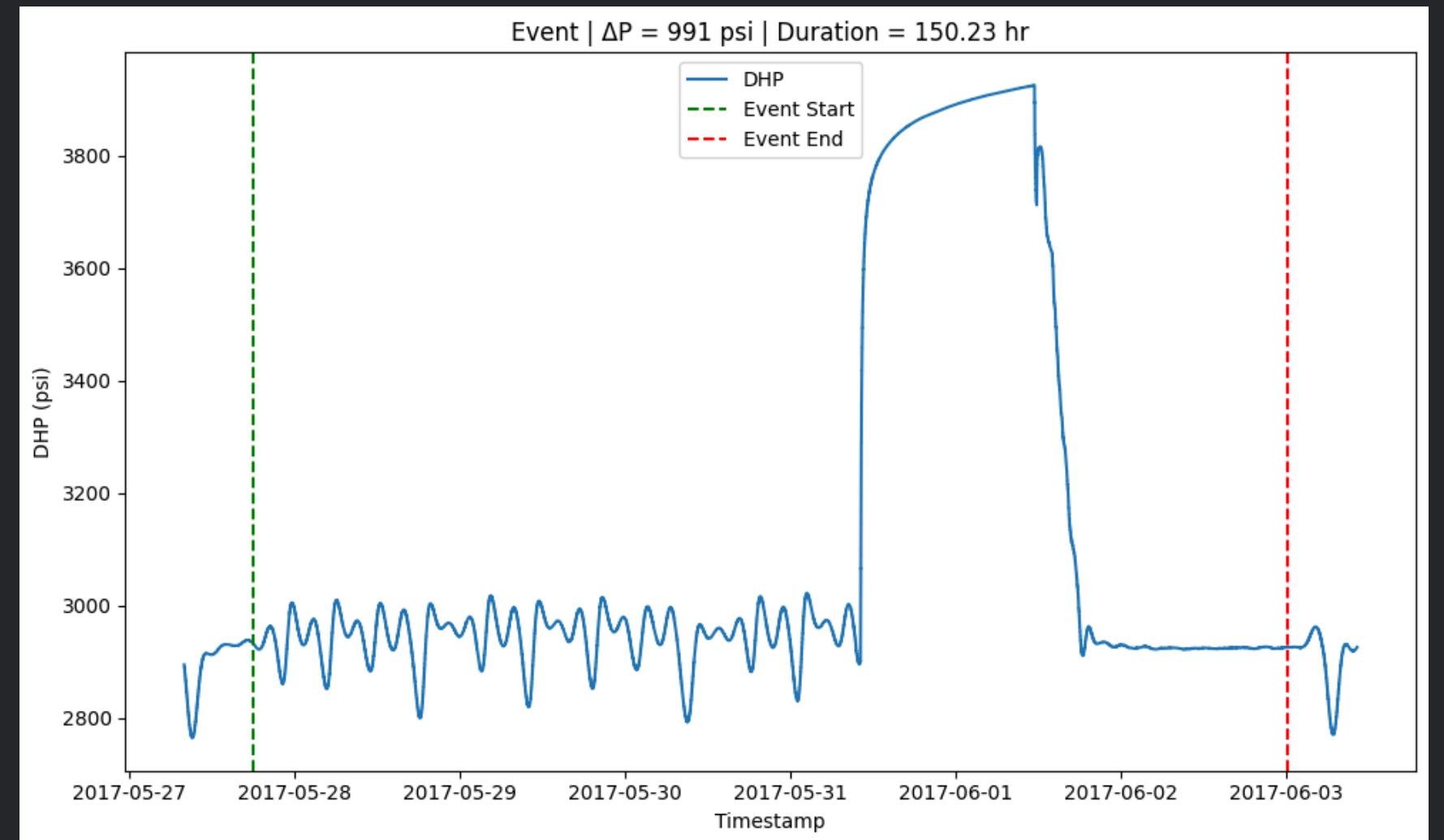
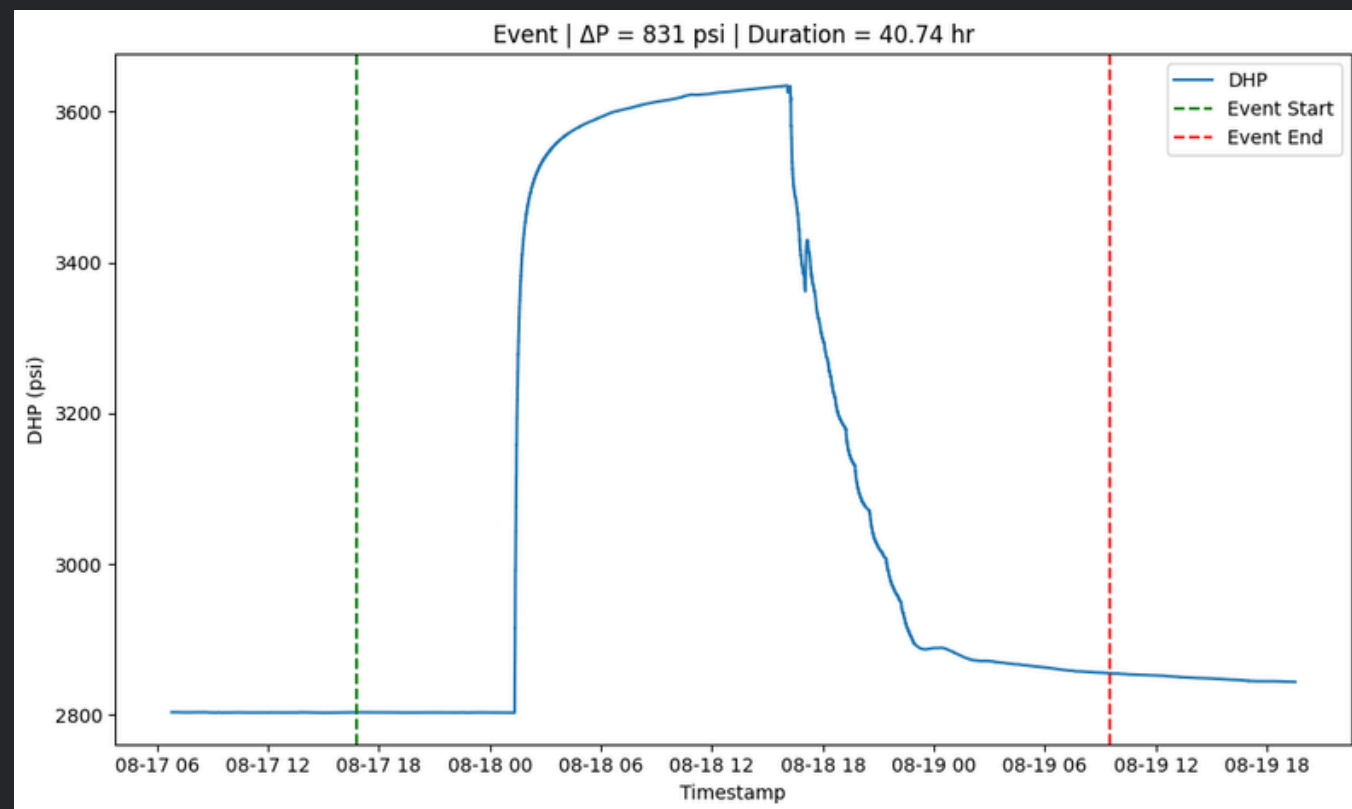
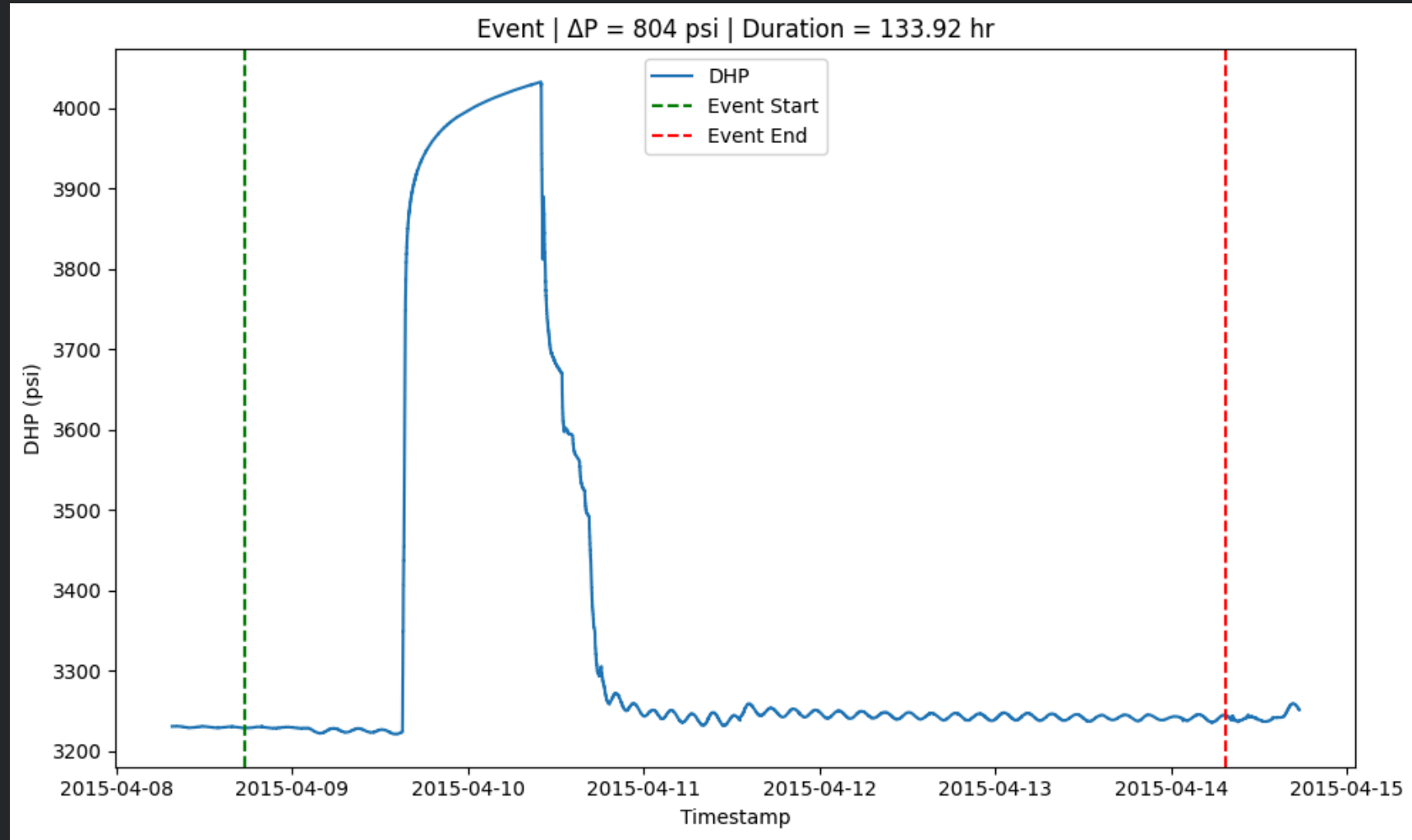
This lead to

- Premature event starts
- Overtriggering in noisy ramps
- False PBUs
- Unstable event boundaries
- Mislabeling

STA/LTA Trigger: Limitations



Imprecision



Final Solution

Small minimum timestep: 1 minute

First derivative of pressure vs time +
STA/LTA ratio

A point is flagged as a possible PBU start
when:

- the STA/LTA ratio exceeds a
threshold, and
- the smoothed slope is clearly positive

State variable:

State	Meaning
IDLE	No event in progress
PROBATION	Possible beginning of a buildup
IN_EVENT	Confirmed buildup event
COOLDOWN	Post-event waiting period

Final Solution

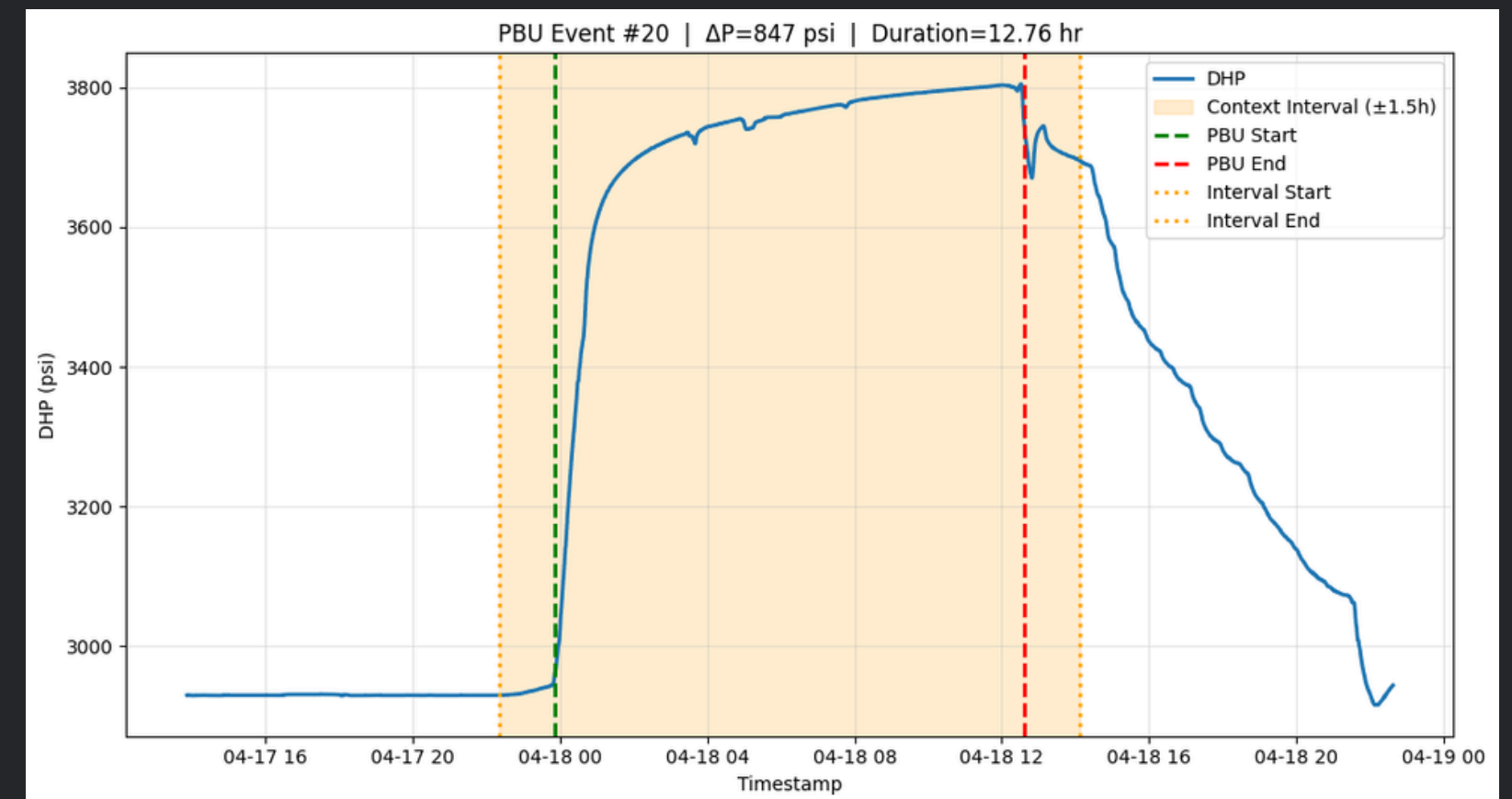
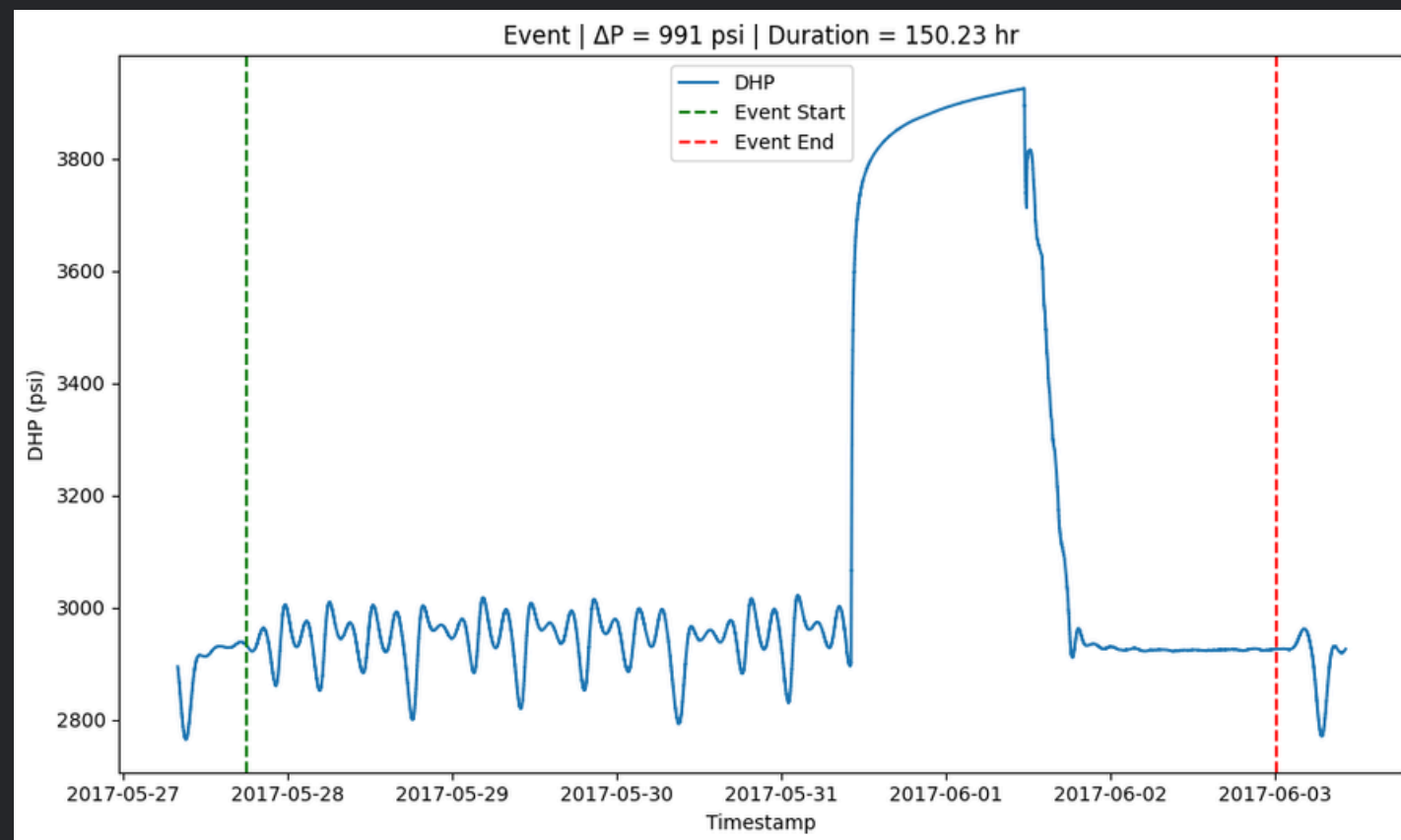
Start validation — preventing false starts

Evaluate current slope and compare with global:

If the slope is weak → reject.

Projection

Projected increase is too small → the candidate is discarded.



Final Solution

Baseline vs forward pressure comparison

Once a candidate passes projection checks, the script compares:

1. The mean pressure before the candidate from the previous PBU end up to the candidate time.
2. The mean pressure in the forward window after it

If the average pressure ahead is not meaningfully higher than the baseline, the candidate is rejected.

Final Solution

Monitoring the buildup for the event end

An end candidate is considered only when:

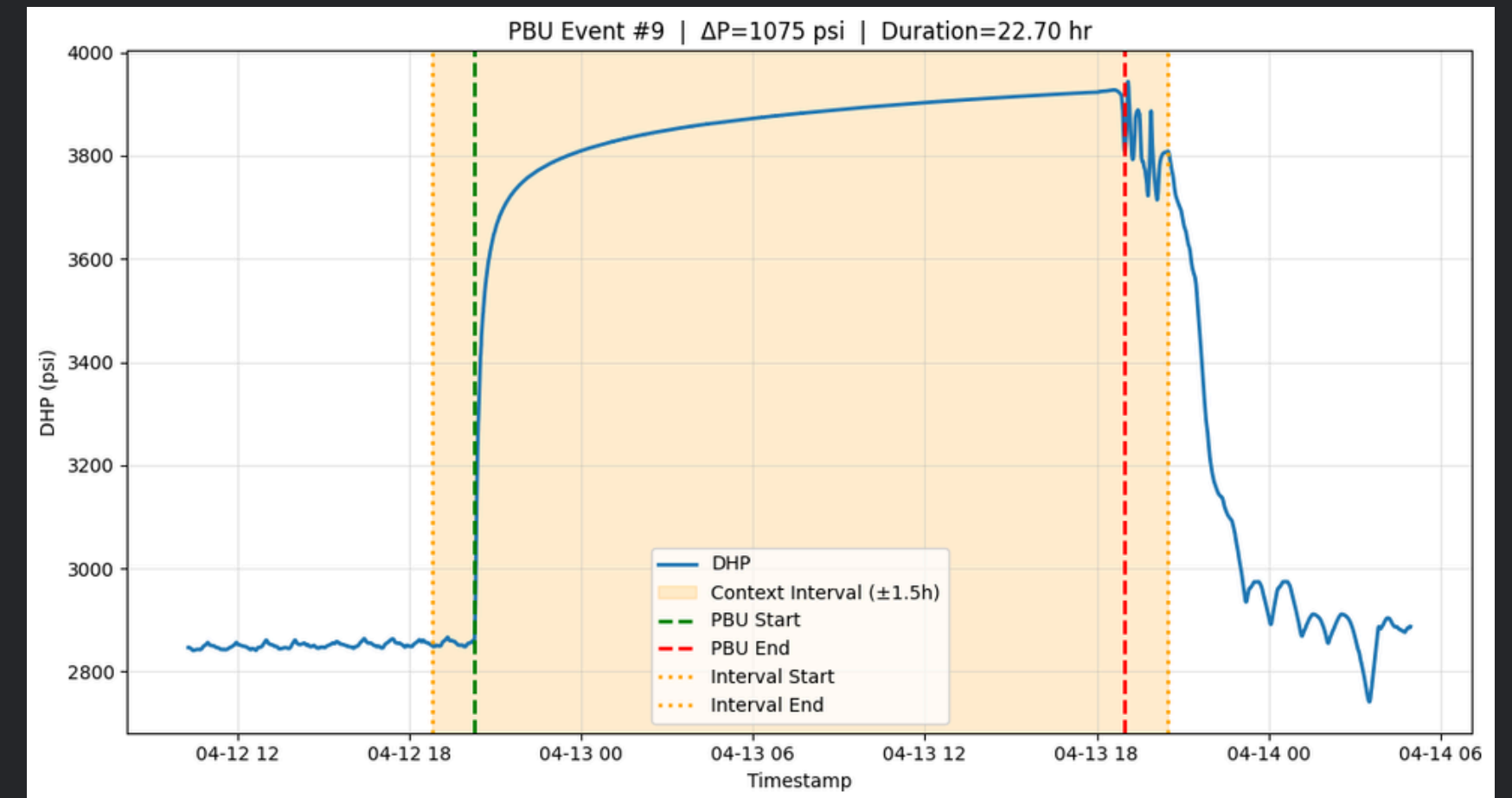
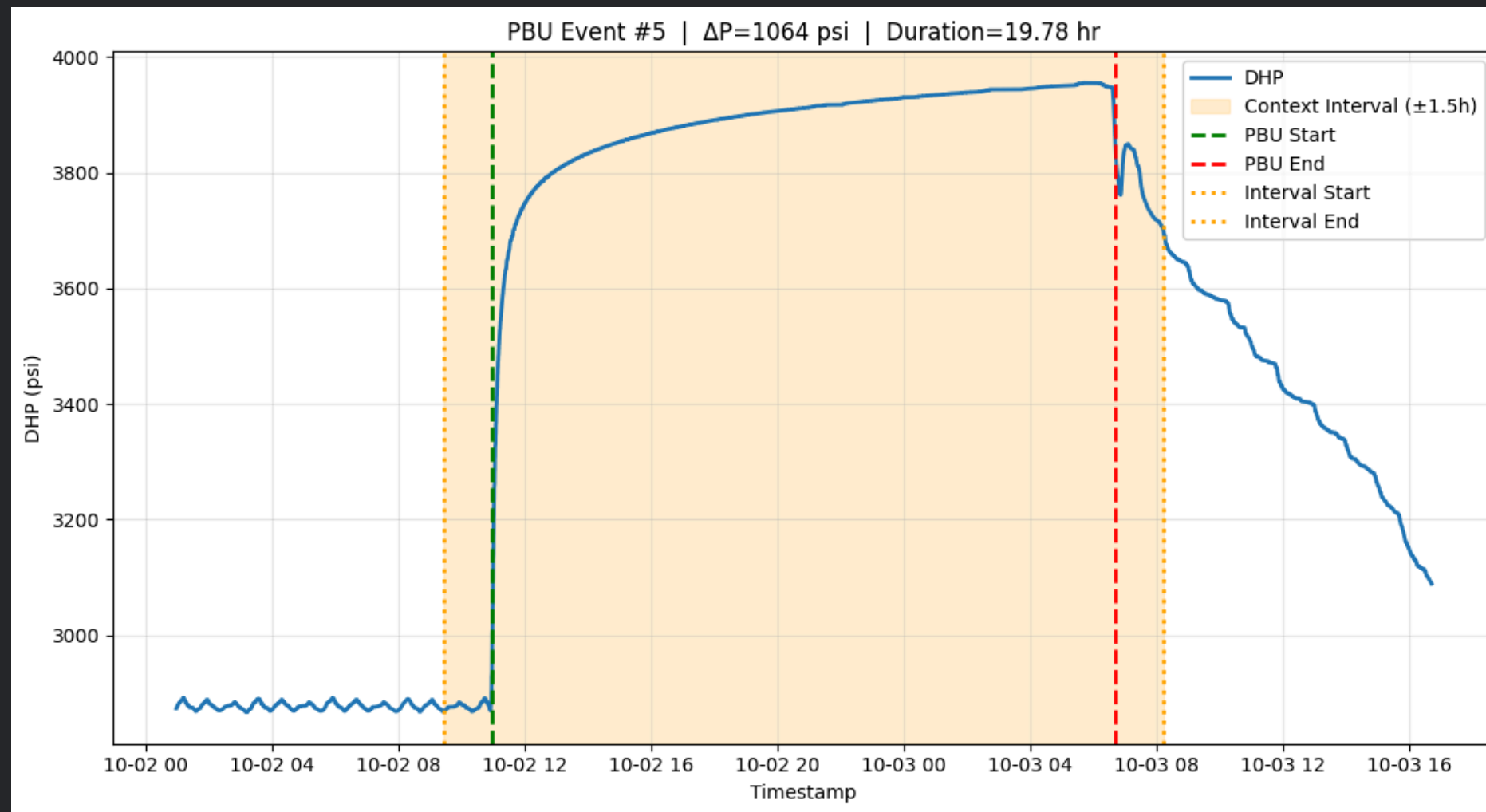
- negative slope persists long enough, and
- the decline slope is sufficiently strong

Short slope reversals or noise blips are ignored.

Final event acceptance criteria: ΔP , Δt

```
[START] 2022-10-19T21:38:47.339000000 P=2334.7 psi slope=26.75 psi/hr Δmean=237.1 psi (adaptive ok)
[PASS] Event confirmed
[END?] Candidate end at 2022-10-20T23:08:24.128000000 P_end=3321.8 psi
[REJECT] Noise dip (11.8 psi)
[END?] Candidate end at 2022-10-21T13:50:38.714000000 P_end=3263.5 psi
[ACCEPT] PBU event 2022-10-19T21:38:47.339000000 → 2022-10-21T13:50:38.714000000 duration=40.20 hr ΔP=1026.6
```

Final Solution: Results



Major Leftover Questions

1. Are all detected events PBUs?

2. Are all PBUs detected?

3. Is this model versatile / suitable for various noise?

4. What are possible optimization steps?

Section 2

Loading and Conditioning the Reservoir Pressure Reference Table

The code loads an external file containing historical a few reservoir pressure estimates. **Median pressure** is used as prior reference value

Well	PBU date (approximate date, m/d/yyyy)	Estimated Reservoir Pressure, psi
3	5/1/2024	3970
3	3/3/2023	3974
3	3/11/2021	4073
3	5/14/2020	4033
3	10/14/2019	3937
3	7/29/2018	3864
3	8/21/2017	3812
3	6/2/2016	3824
3	2/26/2015	4014

Function Fitting

Physical Model Components

Radial flow transient

$$\Delta P = -m \times \ln\left(\frac{tp}{\Delta t} + 1\right)$$

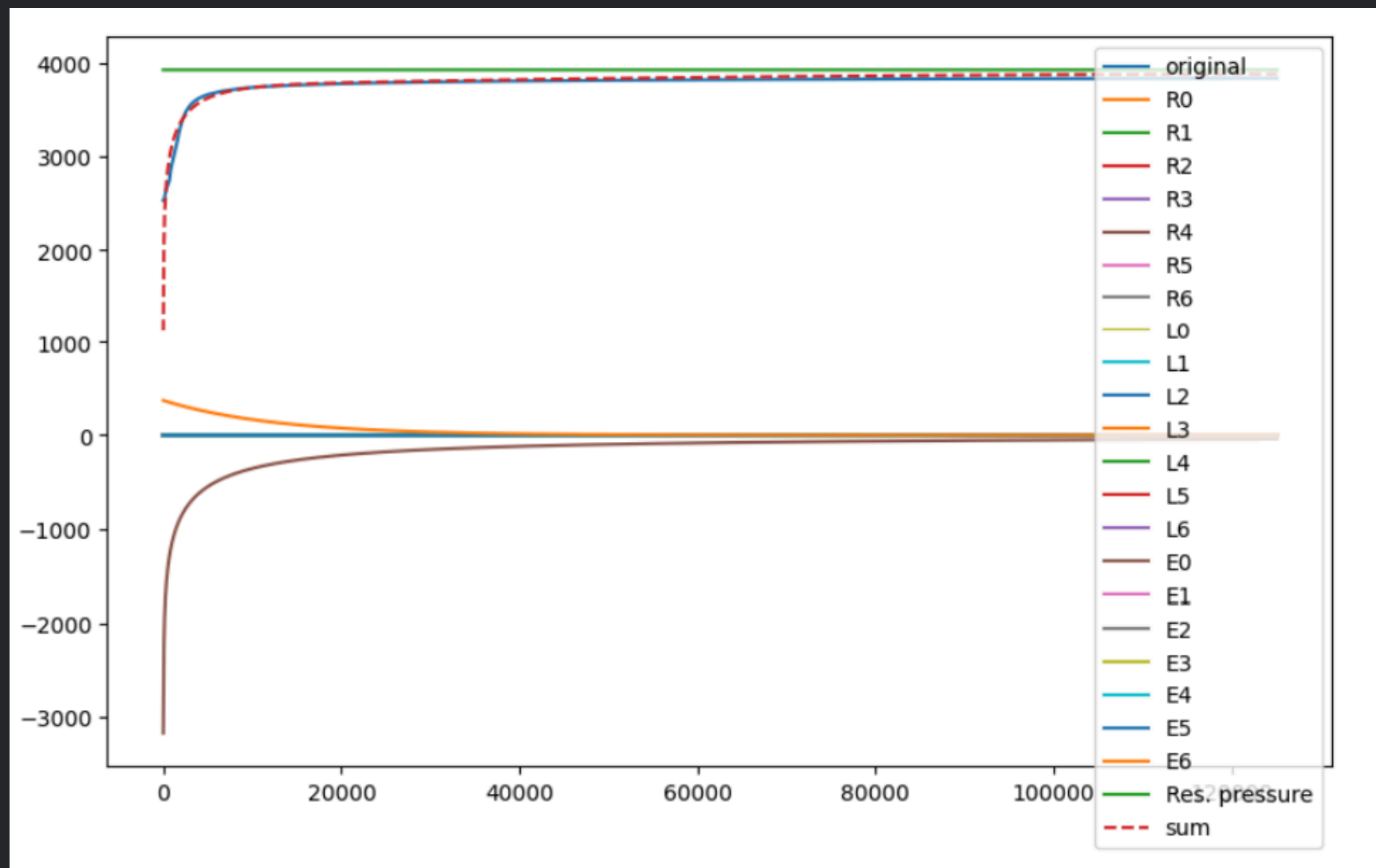
Linear flow transient

$$\Delta P = m \left(\sqrt{tp} + \sqrt{\Delta t} - \sqrt{tp + \Delta t} \right)$$

Exponential (Residual) Function

Should converge to 0 by the end of the interval

$$A_1 e^{-k_1 t} + A_2 e^{-k_2 t}$$



Final Pressure Term

$$P = P_{res} + A_1 e^{-k_1 t} + A_2 e^{-k_2 t} + P_{rad}$$

or

$$P = P_{res} + A_1 e^{-k_1 t} + A_2 e^{-k_2 t} + P_{linear}$$

===== FINAL FITTED MODEL =====

Selected flow regime: LINEAR

$P_{\text{model}}(\Delta t) = P_r + m(\sqrt{tp} + \sqrt{\Delta t} - \sqrt{tp + \Delta t}) + A_1 \cdot \exp(-k_1 \Delta t) + A_2 \cdot \exp(-k_2 \Delta t)$

Substituted parameters:

$P_r = 3548.506$ psi

$m = 10.000$

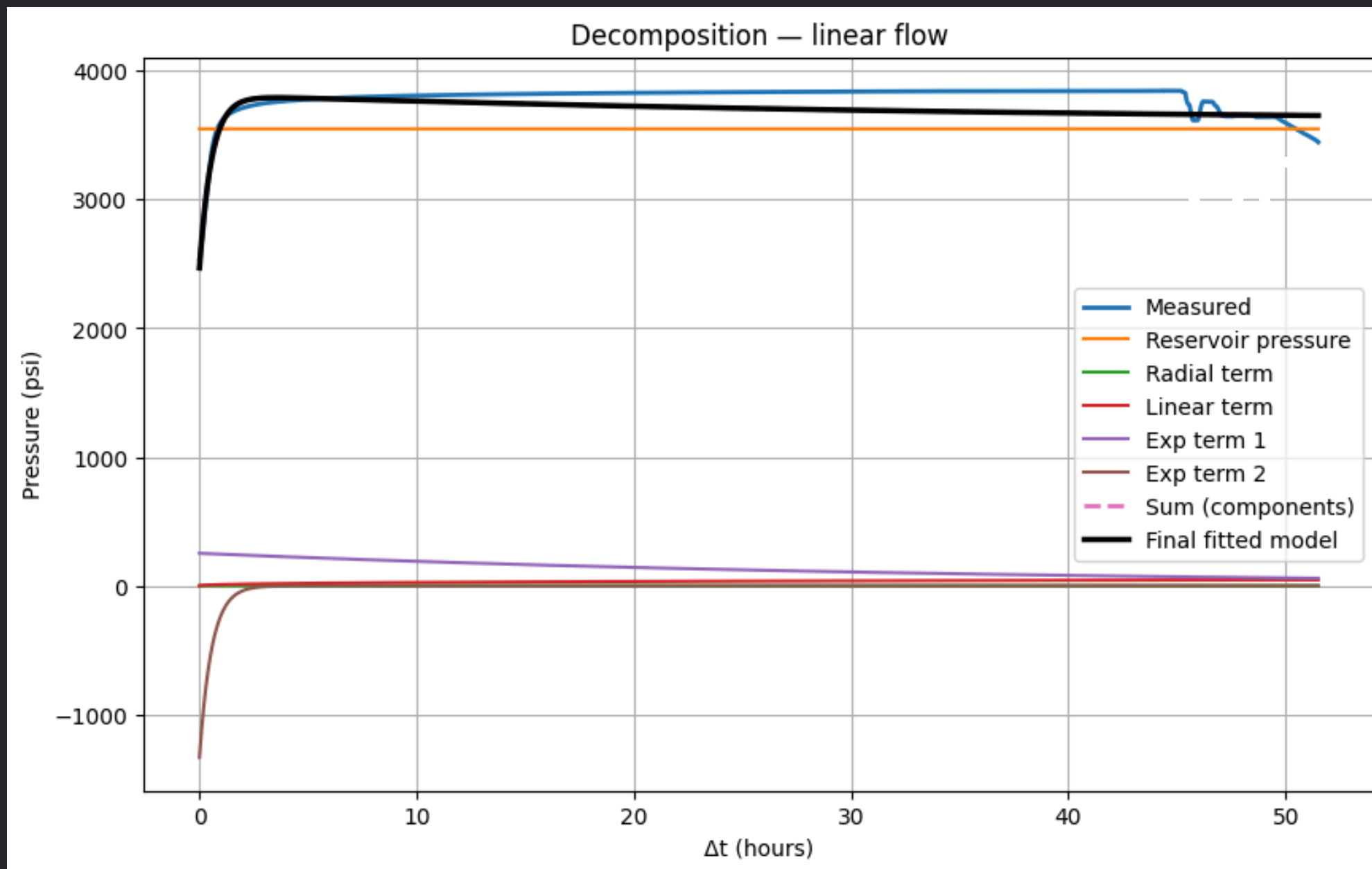
$tp = 72.000$ hr

$A_1 = 252.341, \quad k_1 = 0.028570$

$A_2 = -1332.483, \quad k_2 = 1.776999$

Compact substituted function:

$P(\Delta t) = 3548.506 + 10.000(\sqrt{72.000} + \sqrt{\Delta t} - \sqrt{72.000 + \Delta t}) + 252.341 \cdot \exp(-0.028570 \Delta t) - 1332.483 \cdot \exp(-1.776999 \Delta t)$



1. Defined composite model
2. Components fitted using constrained least-squares
3. Each regime assumed
4. Lowest RMSE chosen

**Thank You for
Attention**