Status update

Simulation setup & Loss map anomaly detection

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Acknowledgements: M.Schenk, R. Bruce, R. De Maria, A. Mereghetti, D. Mirarchi, T. Persson

Context

Optimize particle losses in the LHC.

- Data driven surrogate model of the losses
- **Simulation based loss rates & loss maps**
- **Operational loss maps**

Simulations

Framework

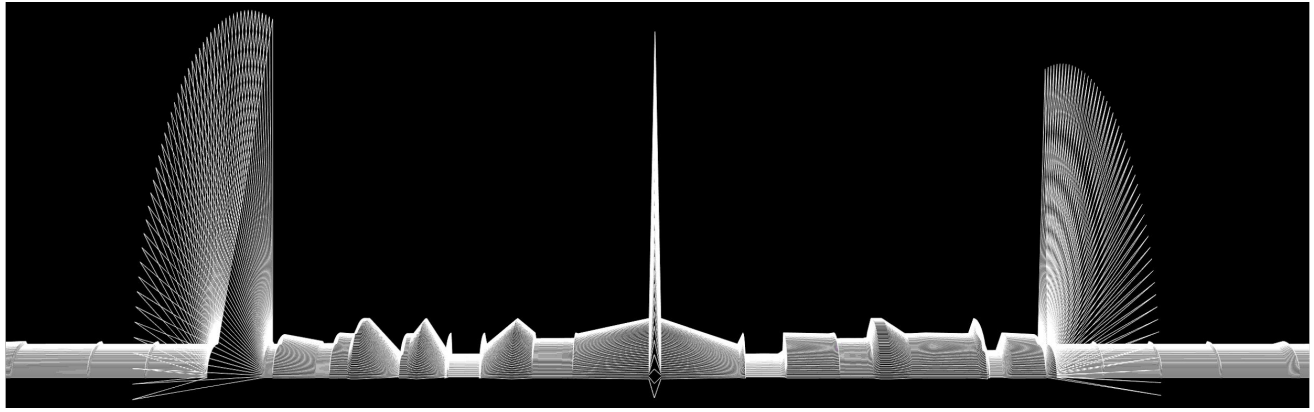
Pysixdesk: https://github.com/SixTrack/pysixdesk

Python madx/sixtrack particle tracking simulation handler.

Can run simulations with aperture / collimators.

Can run on the BOINC (LHC@Home) system.

Result collection to sqlite/mysql backend.

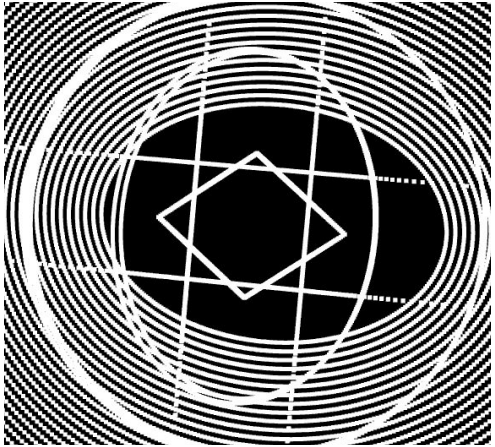


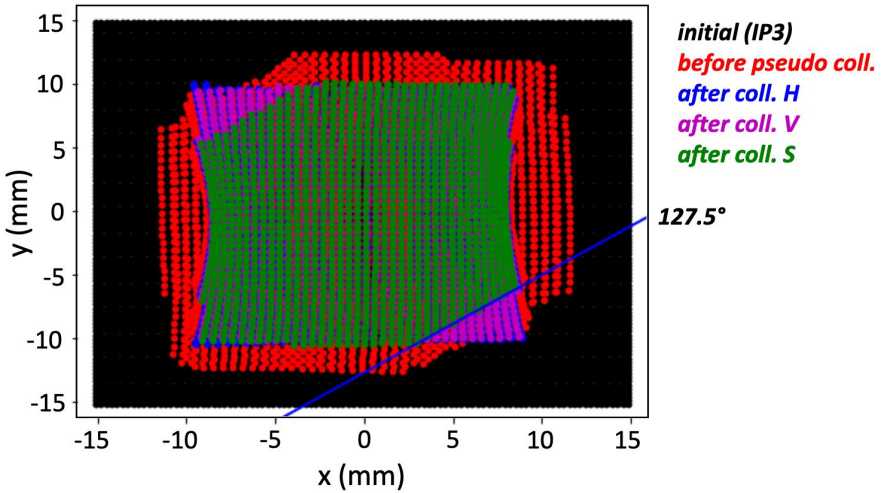
Modification

Use a custom aperture model, with just the primary collimators.

Black hole particle absorbers, no scattering → faster simulations.

Still some open questions regarding the input particle distribution, but the infrastructure has for the most part been setup.



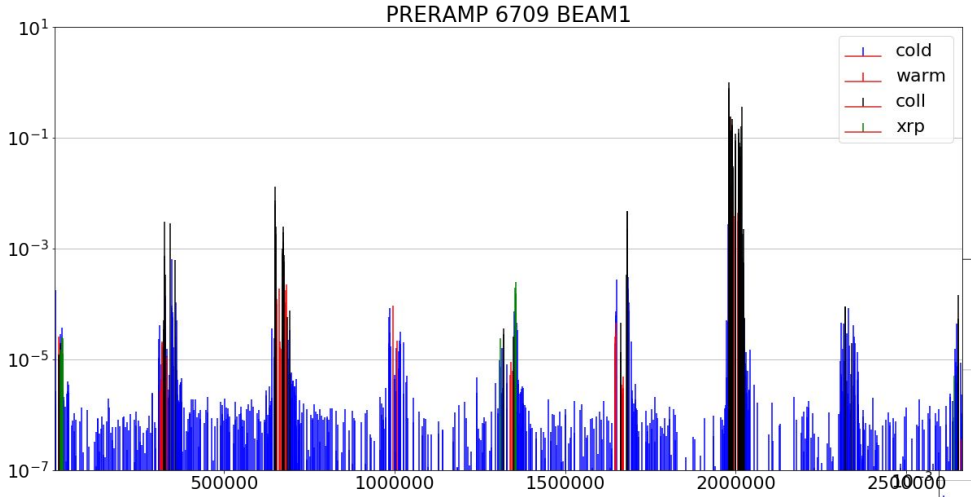


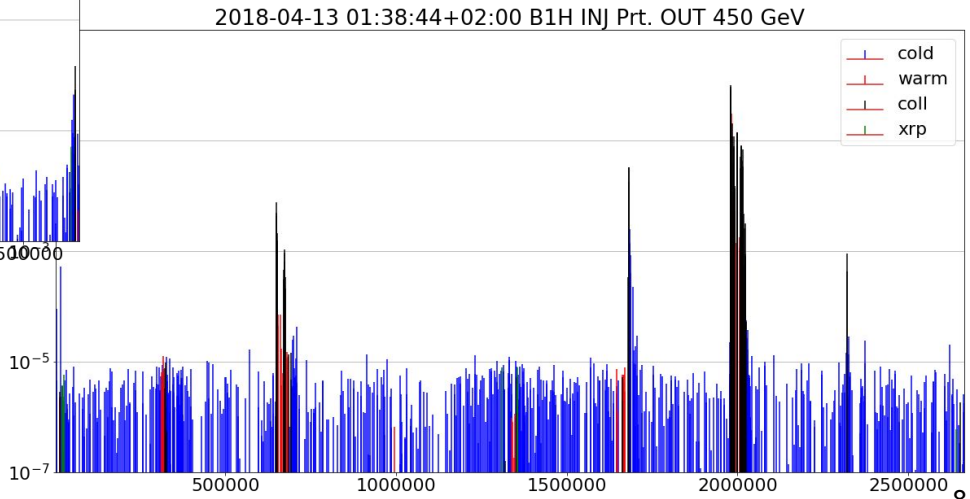
Loss Maps

Context

Loss distribution is another observable with which to benchmark simulations.

Interesting idea: get commissioning loss maps from operational data.



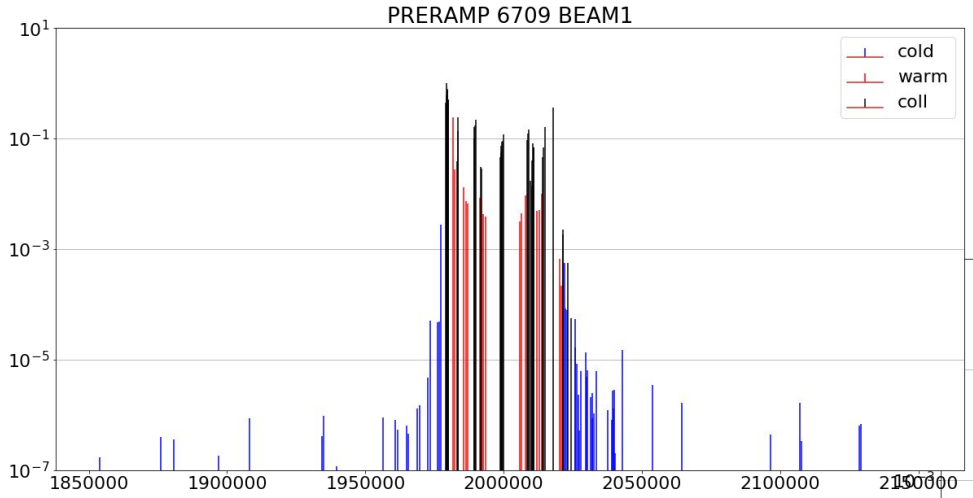


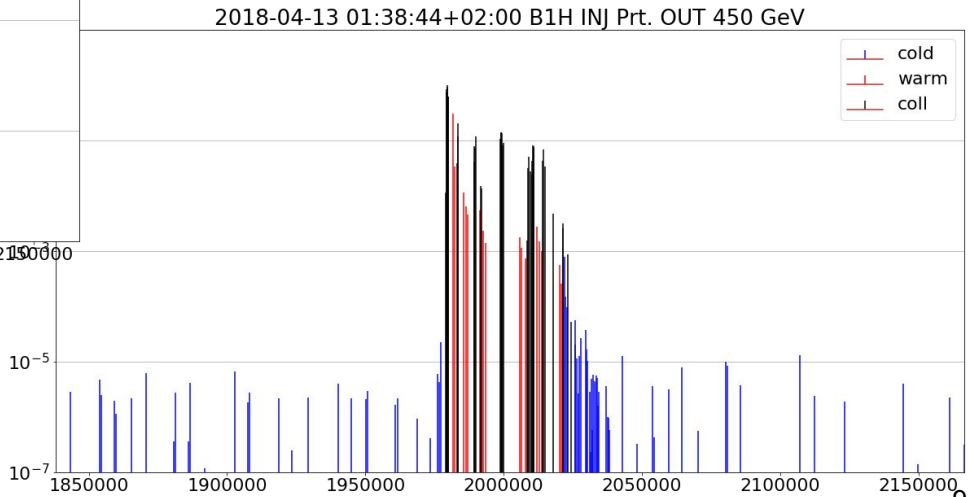
Is this information already in the operational loss distribution ?

Context

Loss distribution is another observable with which to benchmark simulations/models.

Interesting idea: get commissioning loss maps from operational data.





Is this information already in the operational loss distribution ?

Keep it simple

Set a ~simple but related problem **loss pattern anomaly detection**. Can we detect anomalous loss distributions in operational BLM data ?

→ this could give hints as to if we drift away from the validated loss patterns

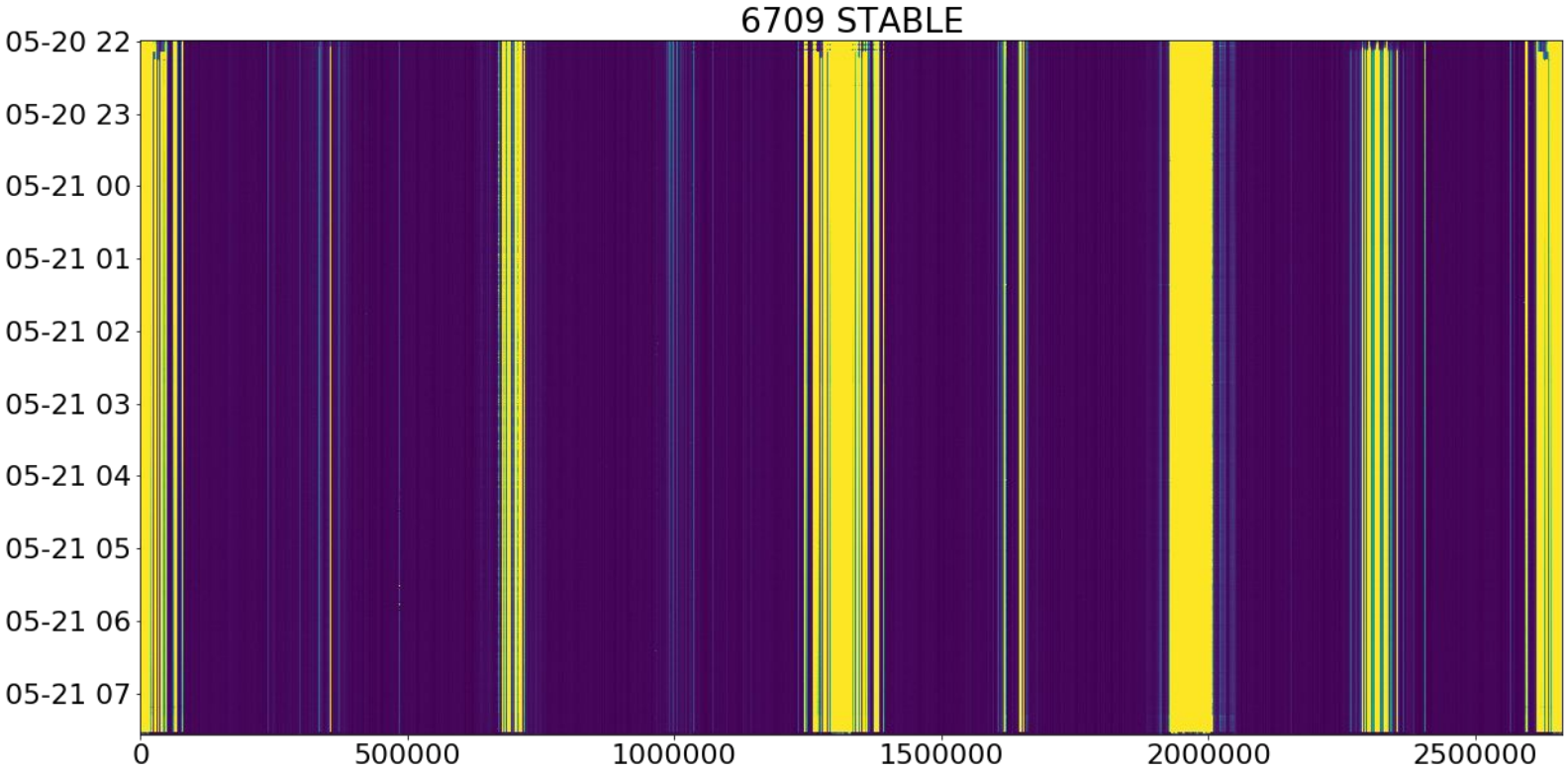
Downloaded all **STABLE** operational BLM data → ~120Gb 😱

Select all BLMs at **Primary & Secondary** collimators → 82 BLMs → ~3Gb 🎊

Rolling 1min sum

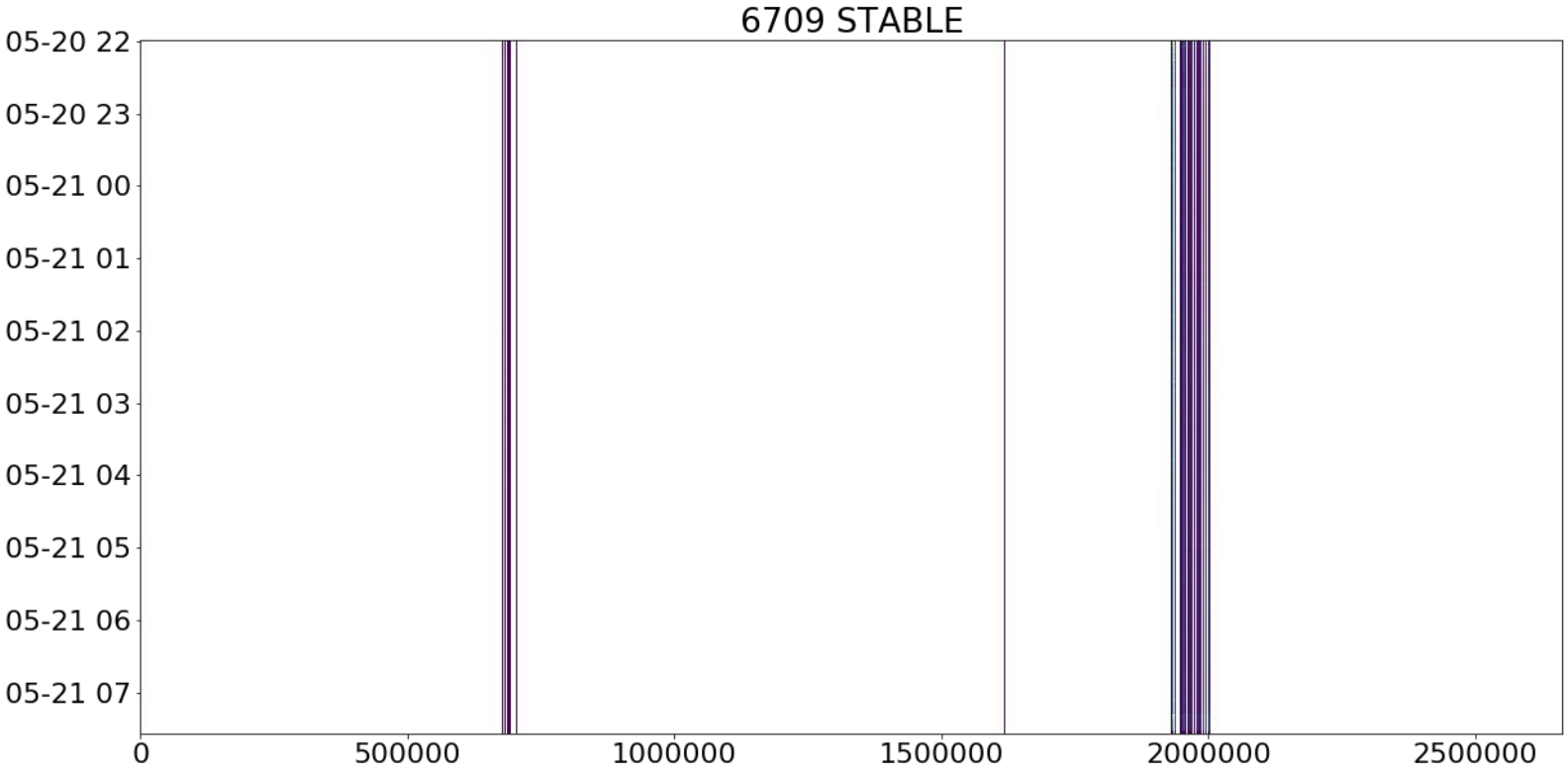
Keep it simple

Raw data

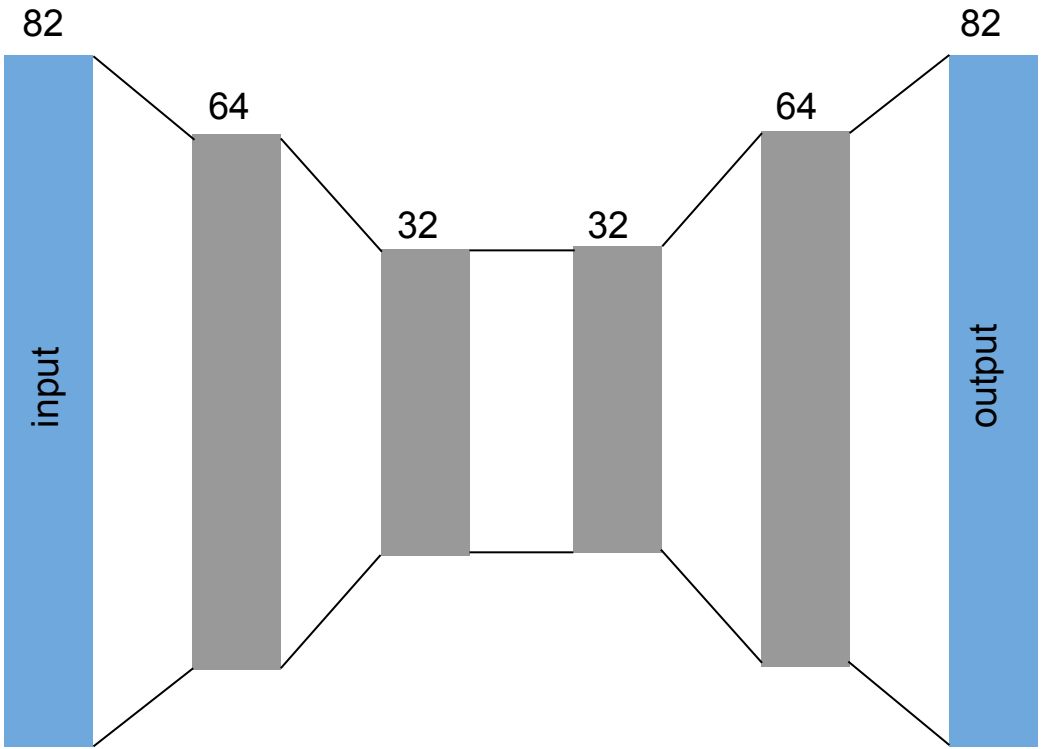


Keep it simple

What the model sees:
BLMs at primary & secondary collimators



The model - AutoEncoder



Anomaly score = RMS(input, output)

AEs learn to recreate the input while reducing the dimensionality through a bottleneck.

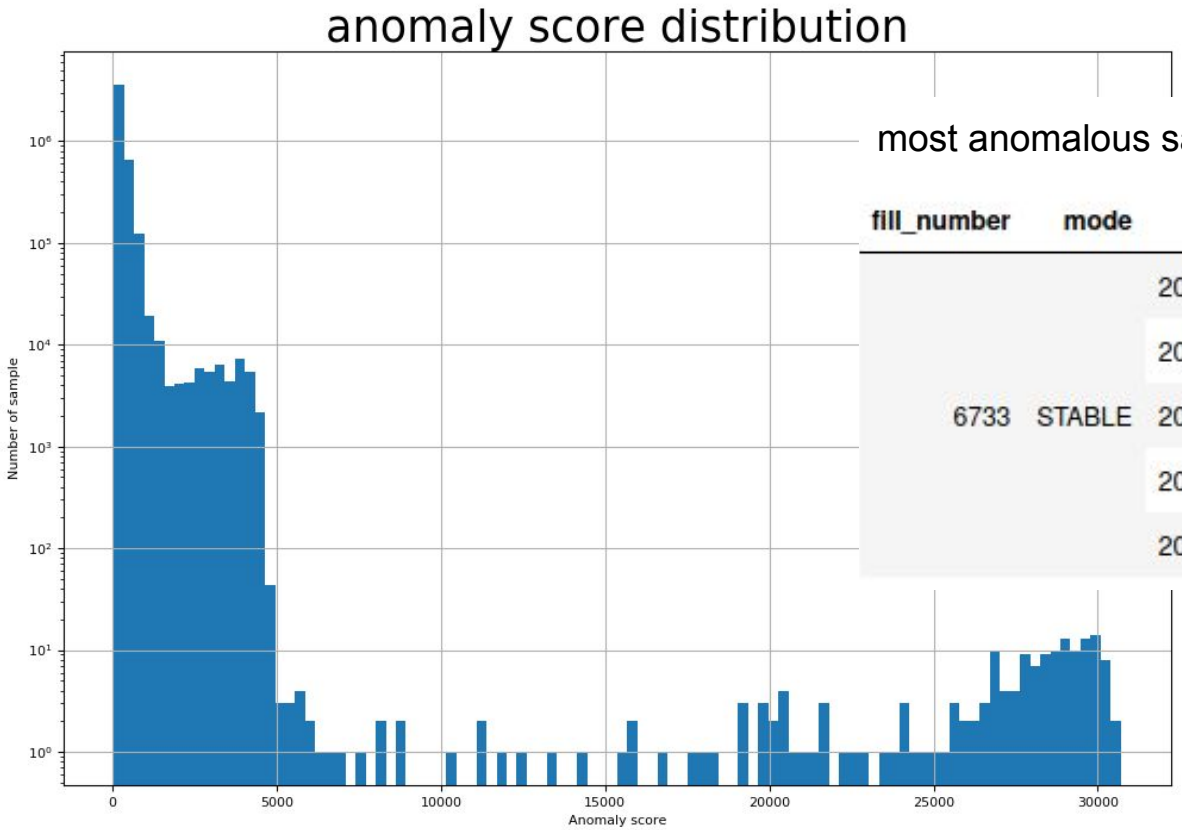
AE can recreate inputs they see more often better than inputs they see less often → anomaly detection !

No tuning of hyperparameters done

implementation: keras/tensorflow

Useful anomaly detection library: https://github.com/yzhao062/pyod

First results



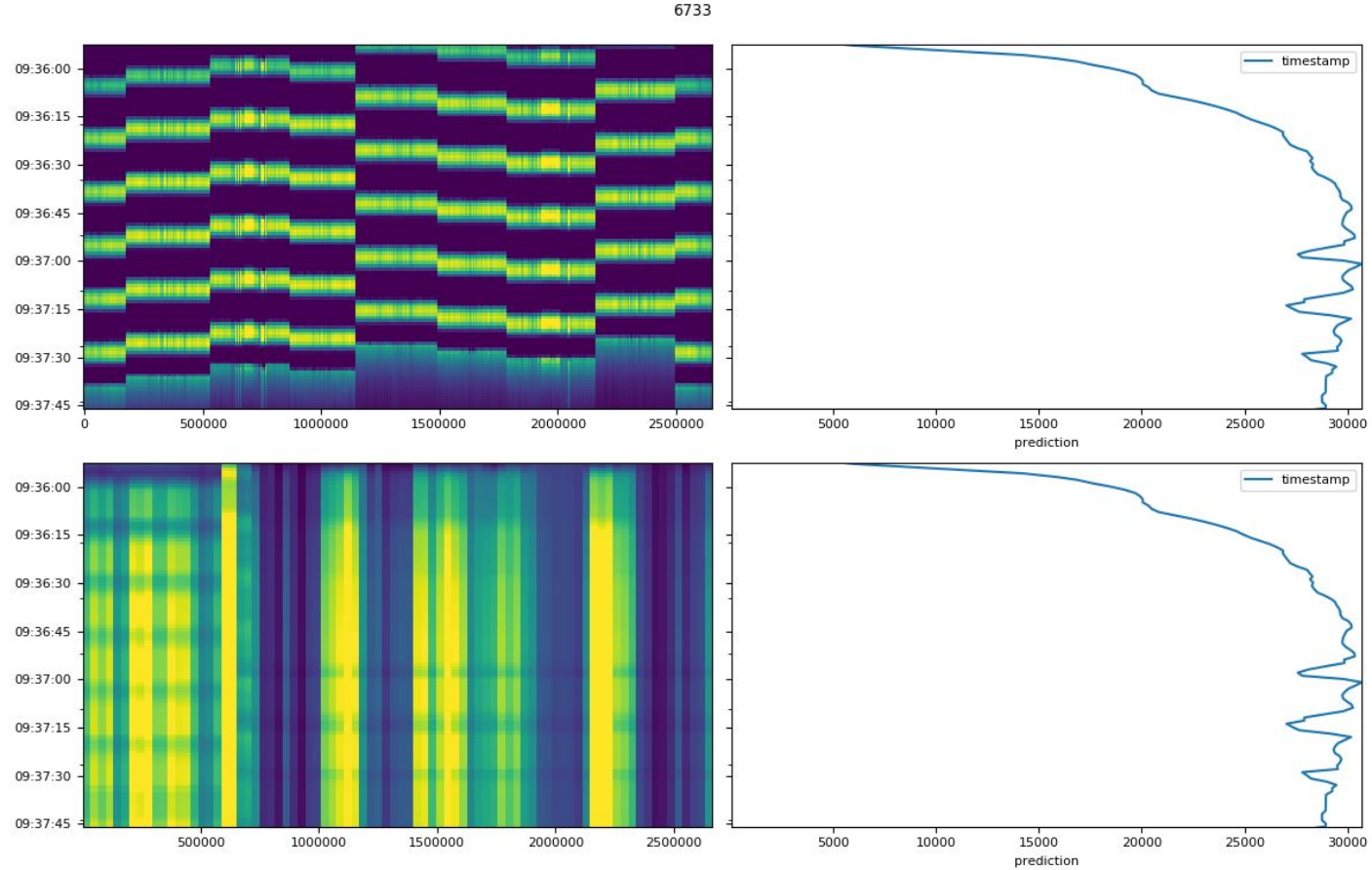
most anomalous samples:

fill_number	mode	timestamp	
		2018-05-28 11:37:00.851000071+02:00	30698.336310
		2018-05-28 11:37:01.792999983+02:00	30417.244596
6733	STABLE	2018-05-28 11:36:52.809000015+02:00	30356.008133
		2018-05-28 11:36:51.772000074+02:00	30333.256499
		2018-05-28 11:37:08.789000034+02:00	30270.357412

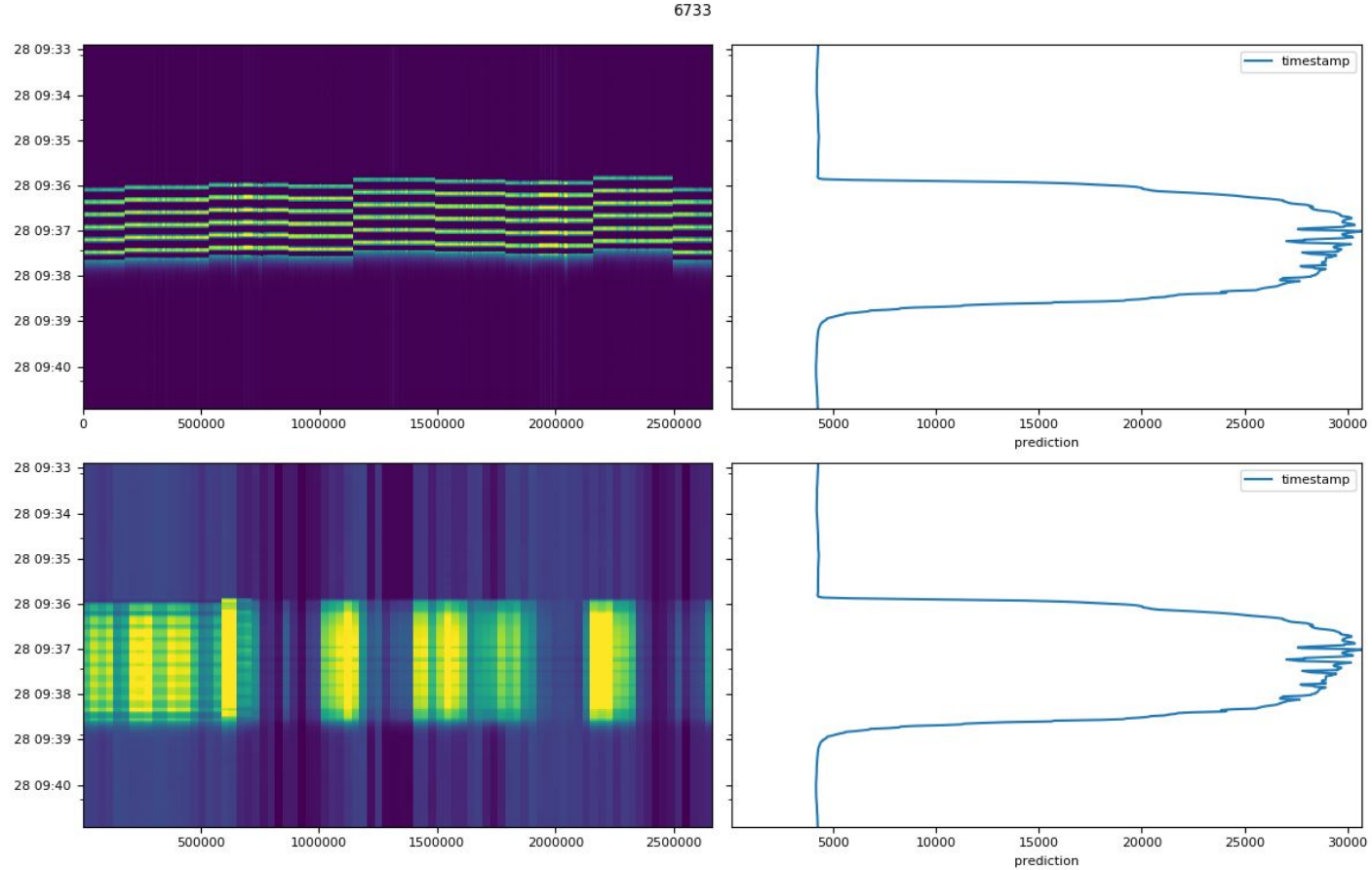
All of the super anomalous samples are in fill 6733...

Let's investigate...

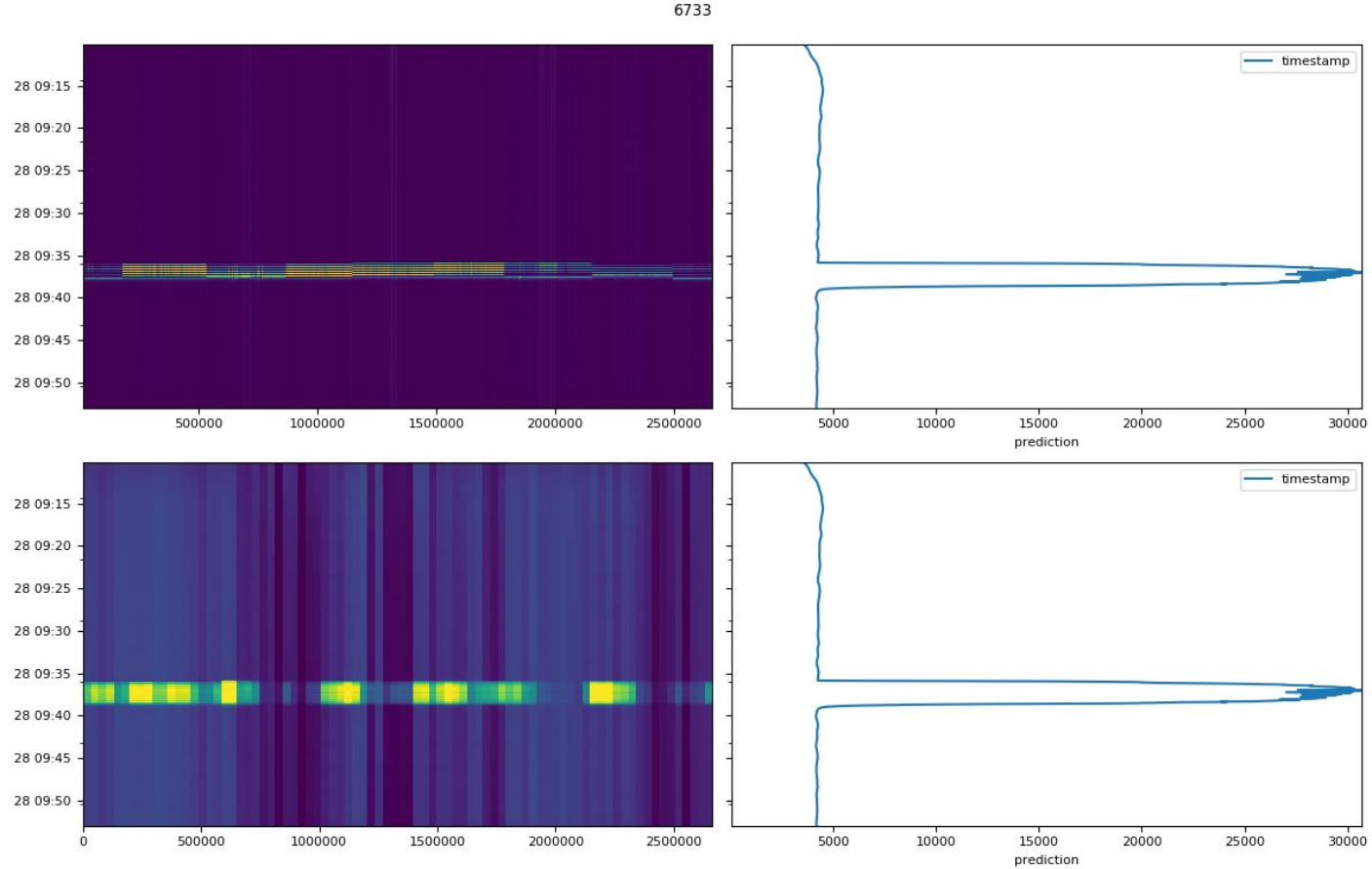
First results



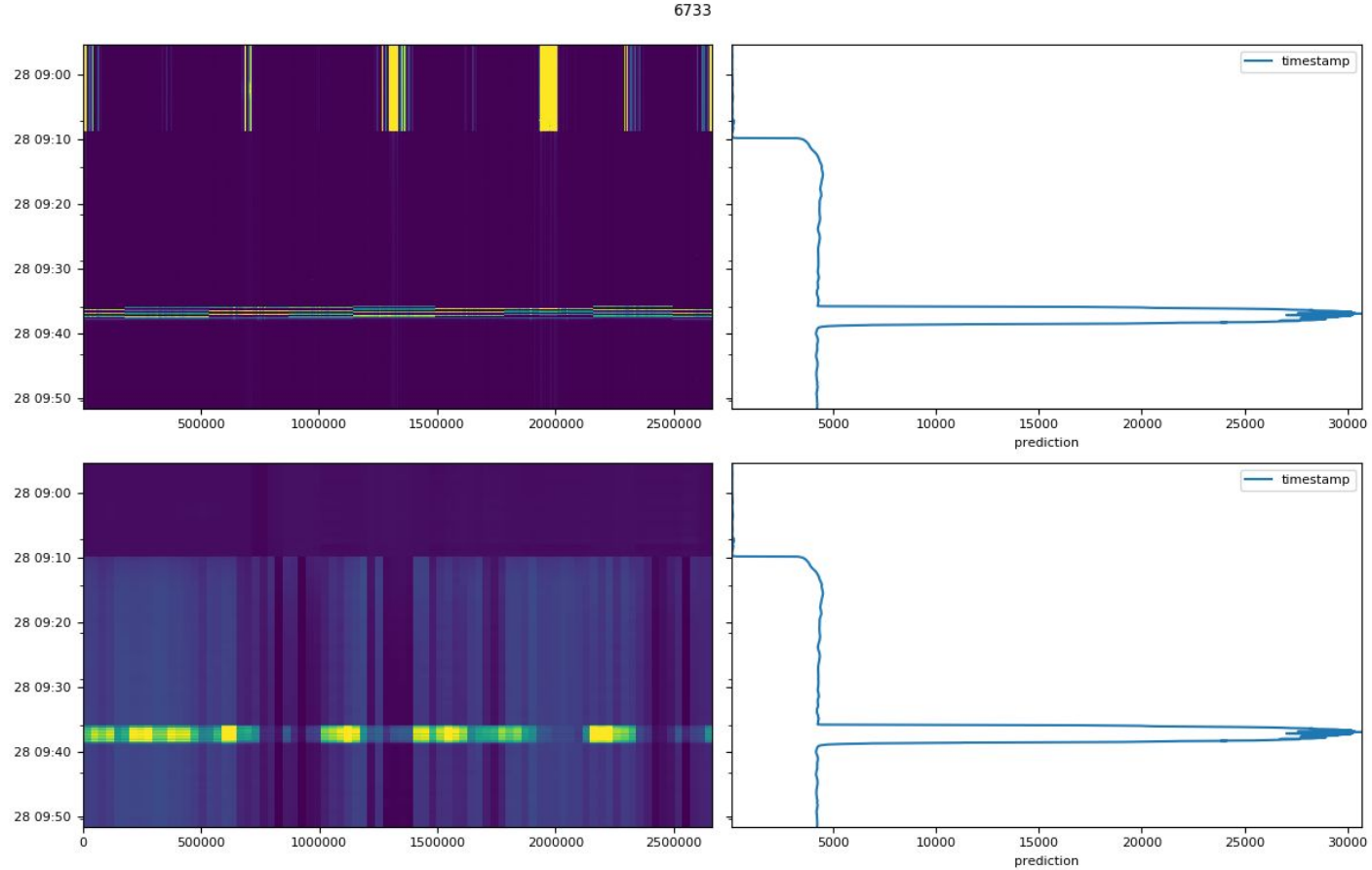
First results



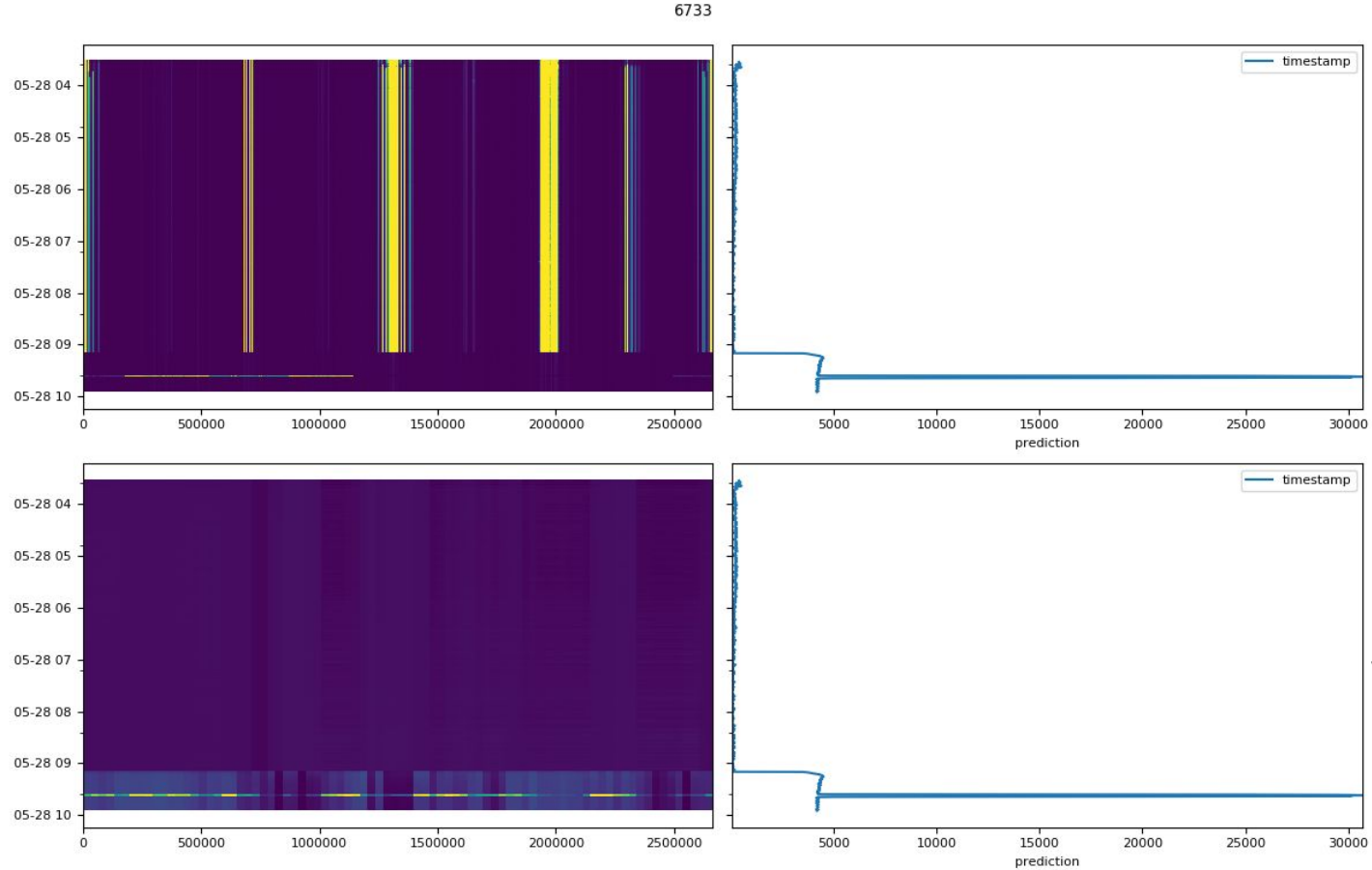
First results



First results



First results



Beam dumped but still in STABLE beam mode…

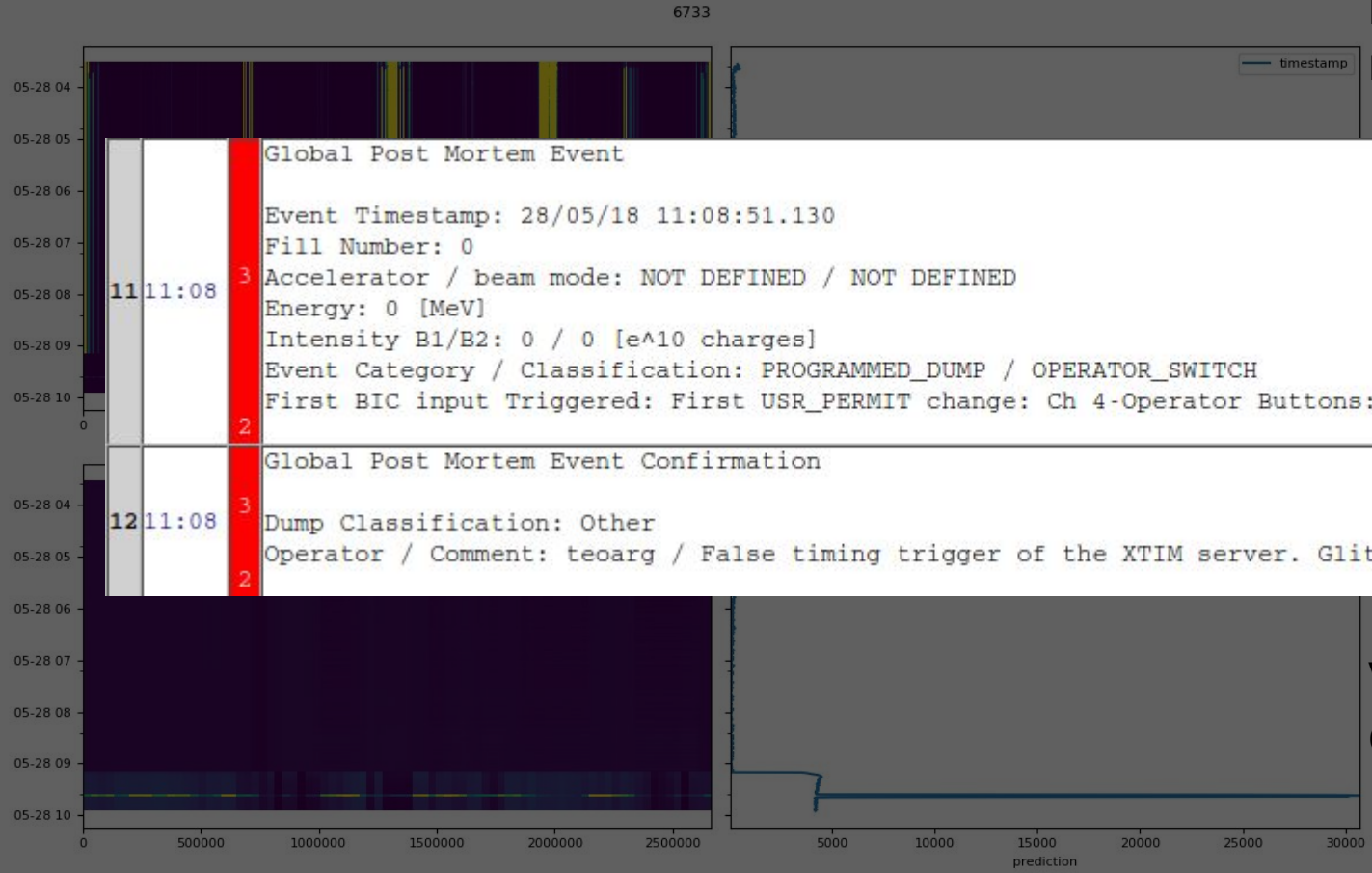
Sharp increase in anomaly score for dump data…

Big spike →BLM calibration → still erroneously in STABLE beam mode

Very accurate beam dump detector ! 🎉

First results

Beam dumped but still in STABLE beam mode…



11	11:08	3 2	Global Post Mortem Event Event Timestamp: 28/05/18 11:08:51.130 Fill Number: 0 Accelerator / beam mode: NOT DEFINED / NOT DEFINED Energy: 0 [MeV] Intensity B1/B2: 0 / 0 [e^10 charges] Event Category / Classification: PROGRAMMED_DUMP / OPERATOR_SWITCH First BIC input Triggered: First USR_PERMIT change: Ch 4-Operator Buttons: A T -> F on CIB.CCR.LHC.B1
12	11:08	3 2	Global Post Mortem Event Confirmation Dump Classification: Other Operator / Comment: teoarg / False timing trigger of the XTIM server. Glitch on a rack

Very accurate beam dump detector ! 🎉

Second try - with filtering

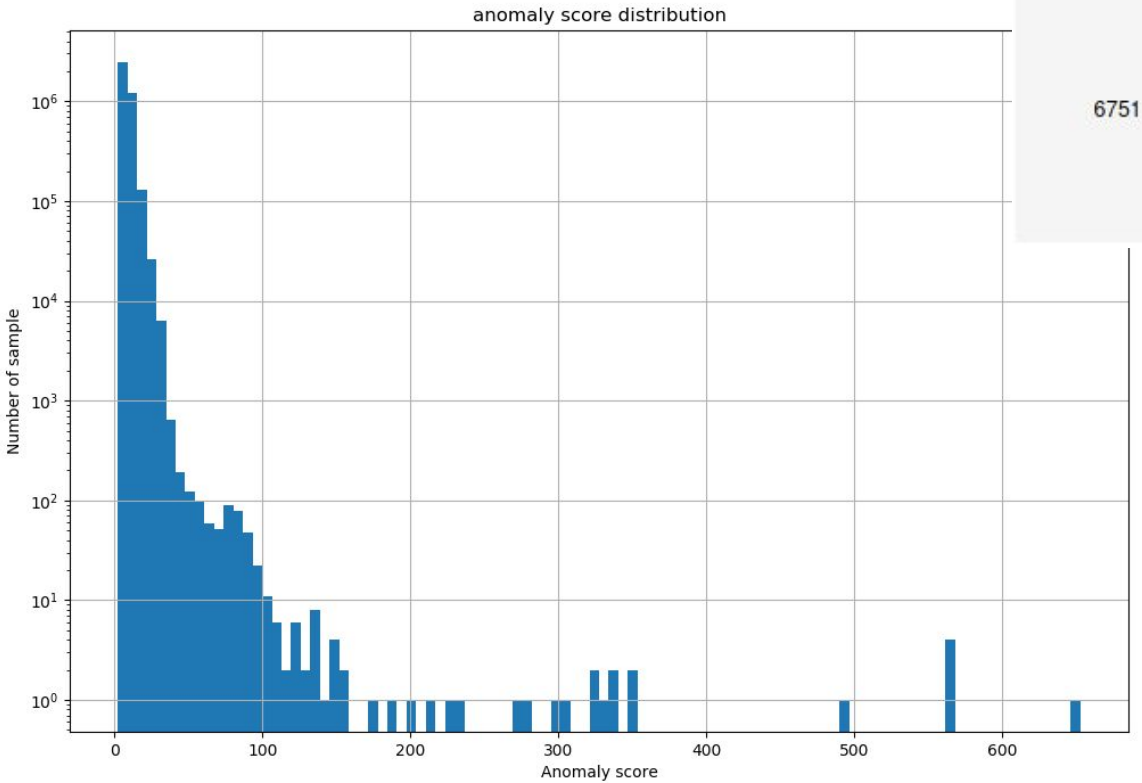
Filter out samples where intensity < 1e11

Remove fills where the starting intensity < 1.5e14 → remove low number of bunch fills

Remove rolling sum → just blurred out the details

Same blms, same model.

Second try



most anomalous samples:

fill_number	mode	timestamp	
6751	STABLE	2018-06-02 00:01:36.148000002+02:00	652.499088
		2018-06-02 00:01:38.123000145+02:00	564.841354
		2018-06-02 00:01:41.150000095+02:00	564.751117
		2018-06-02 00:01:37.117000103+02:00	564.612878
		2018-06-02 00:01:40.118000031+02:00	563.182124

Lower anomaly score maxima

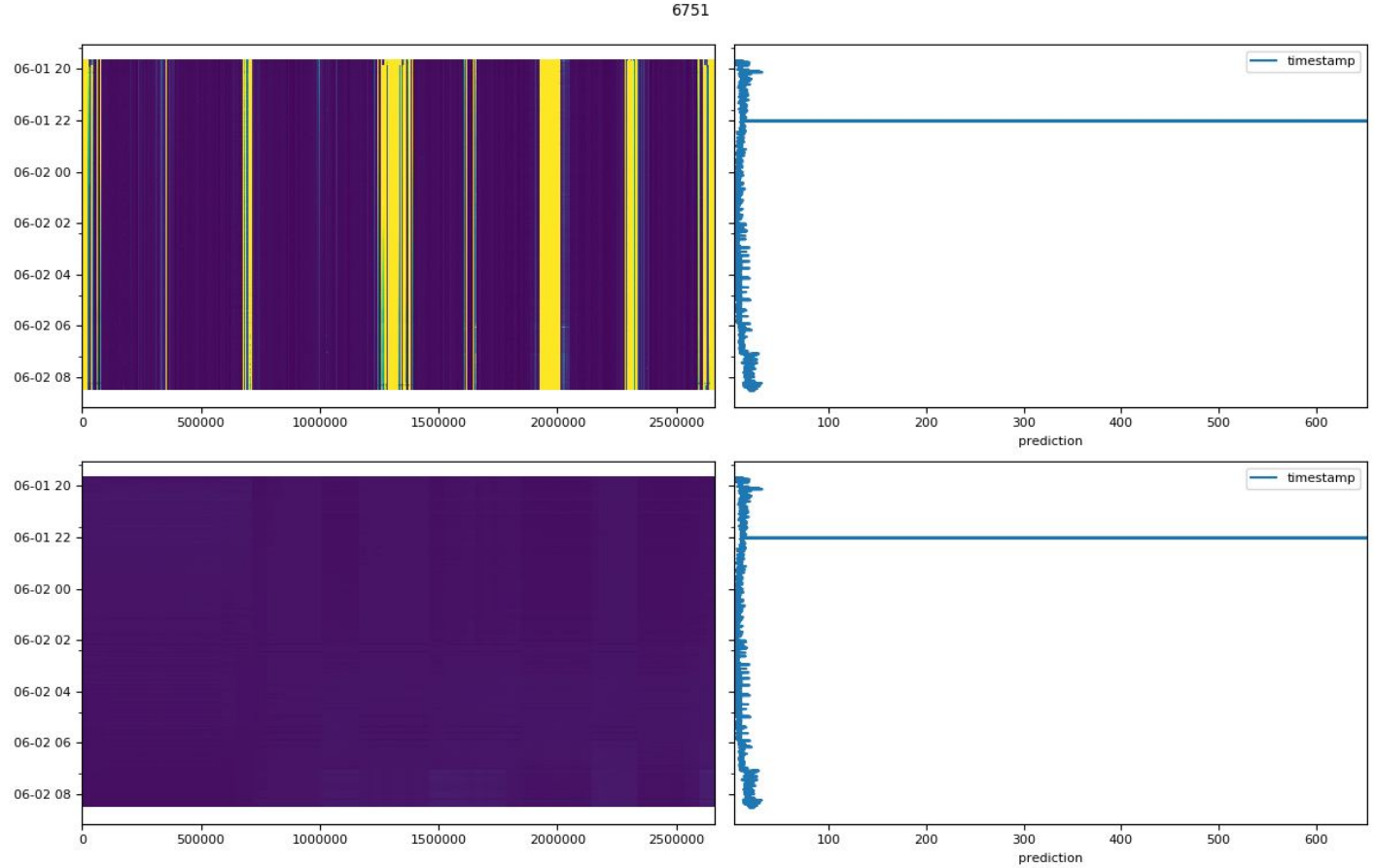
No real clear cut off → could potentially change with model tuning

5 most anomalous sample in 6751

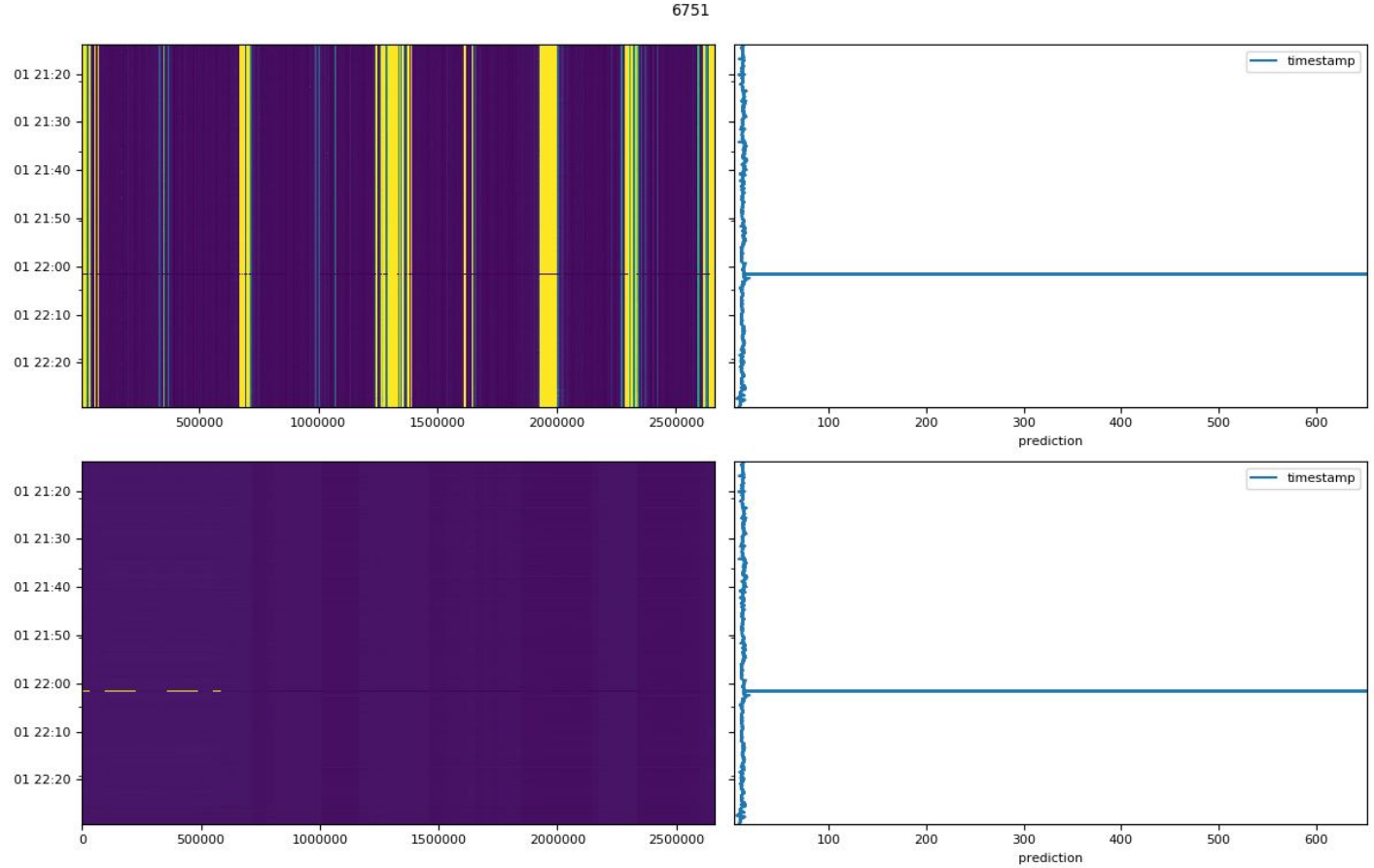
Fills orders by most anomalous sample: **6751, 6648, 6763, 6672**

Let's investigate...

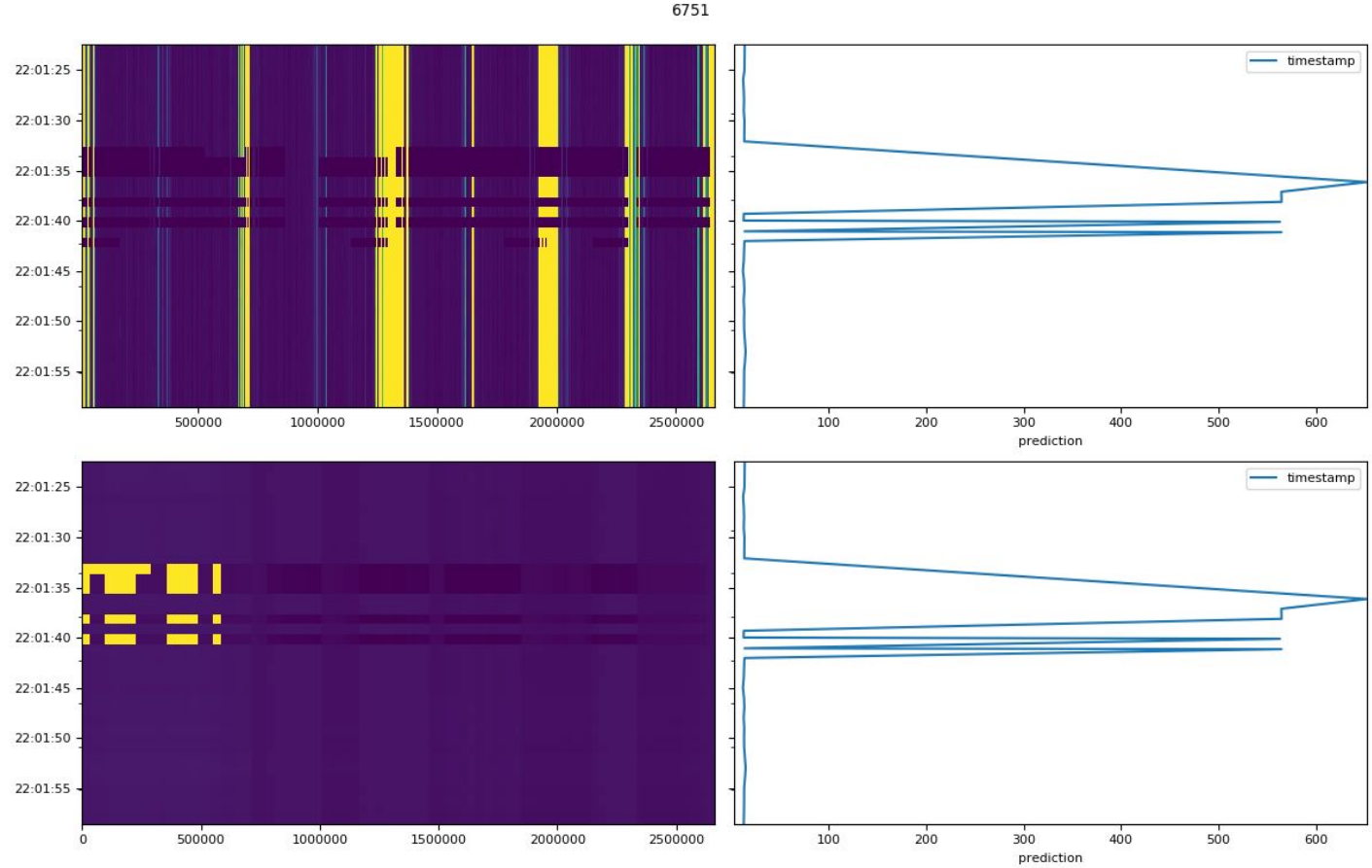
Second try


6751
06-01 20
06-01 22
06-02 00
06-02 02
06-02 04
06-02 06
06-02 08
0
500000
1000000
1500000
2000000
2500000
timestamp
100
200
300
400
500
600
prediction
06-01 20
06-01 22
06-02 00
06-02 02
06-02 04
06-02 06
06-02 08
0
500000
1000000
1500000
2000000
2500000
timestamp
100
200
300
400
500
600
prediction

Second try


6751
01 21:20
01 21:30
01 21:40
01 21:50
01 22:00
01 22:10
01 22:20
500000
1000000
1500000
2000000
2500000
timestamp
100
200
300
400
500
600
prediction
0
timestamp
prediction

Second try

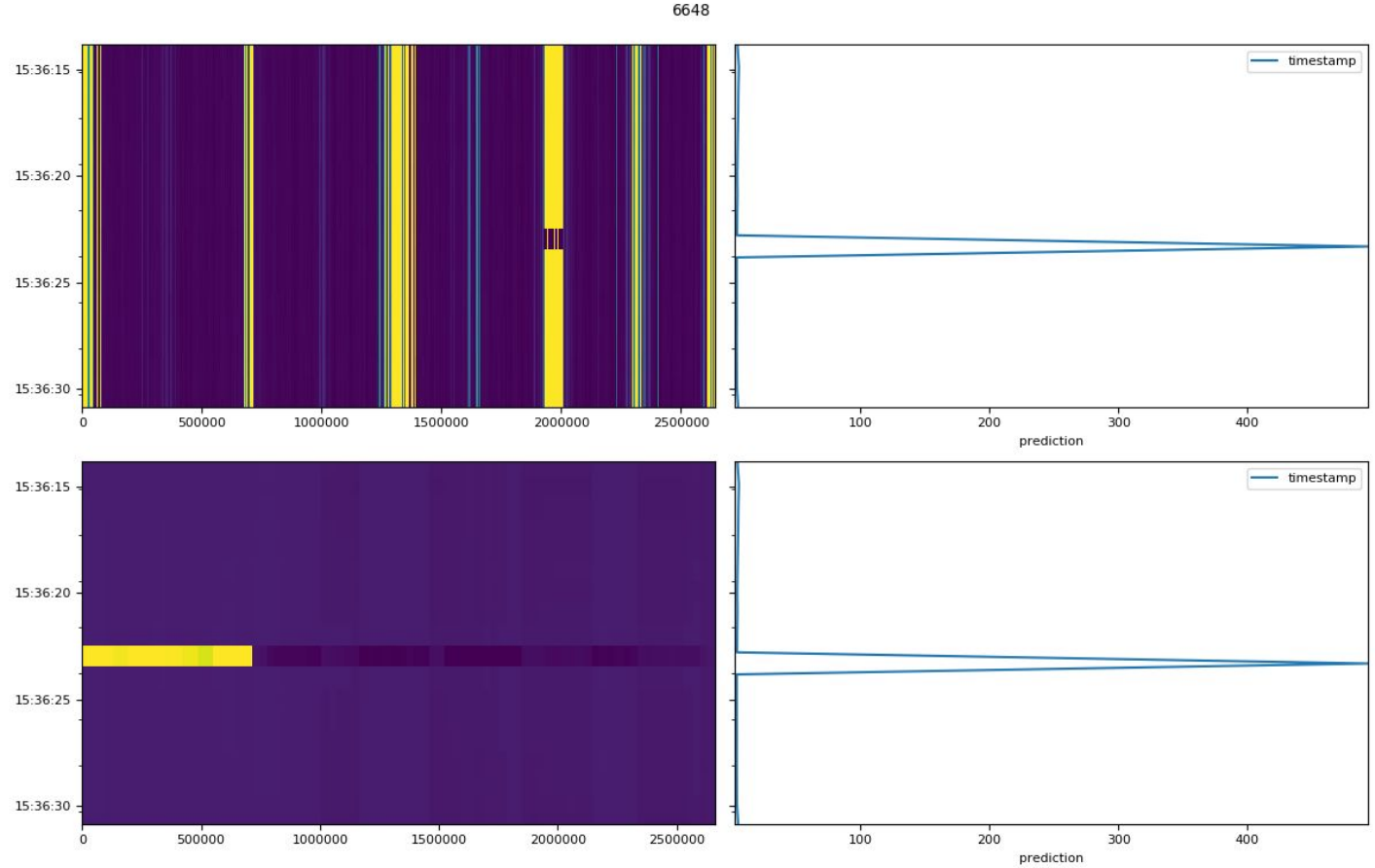


Looks very much like a technical glitch…

No entry in logbook

How about fill 6648 ?

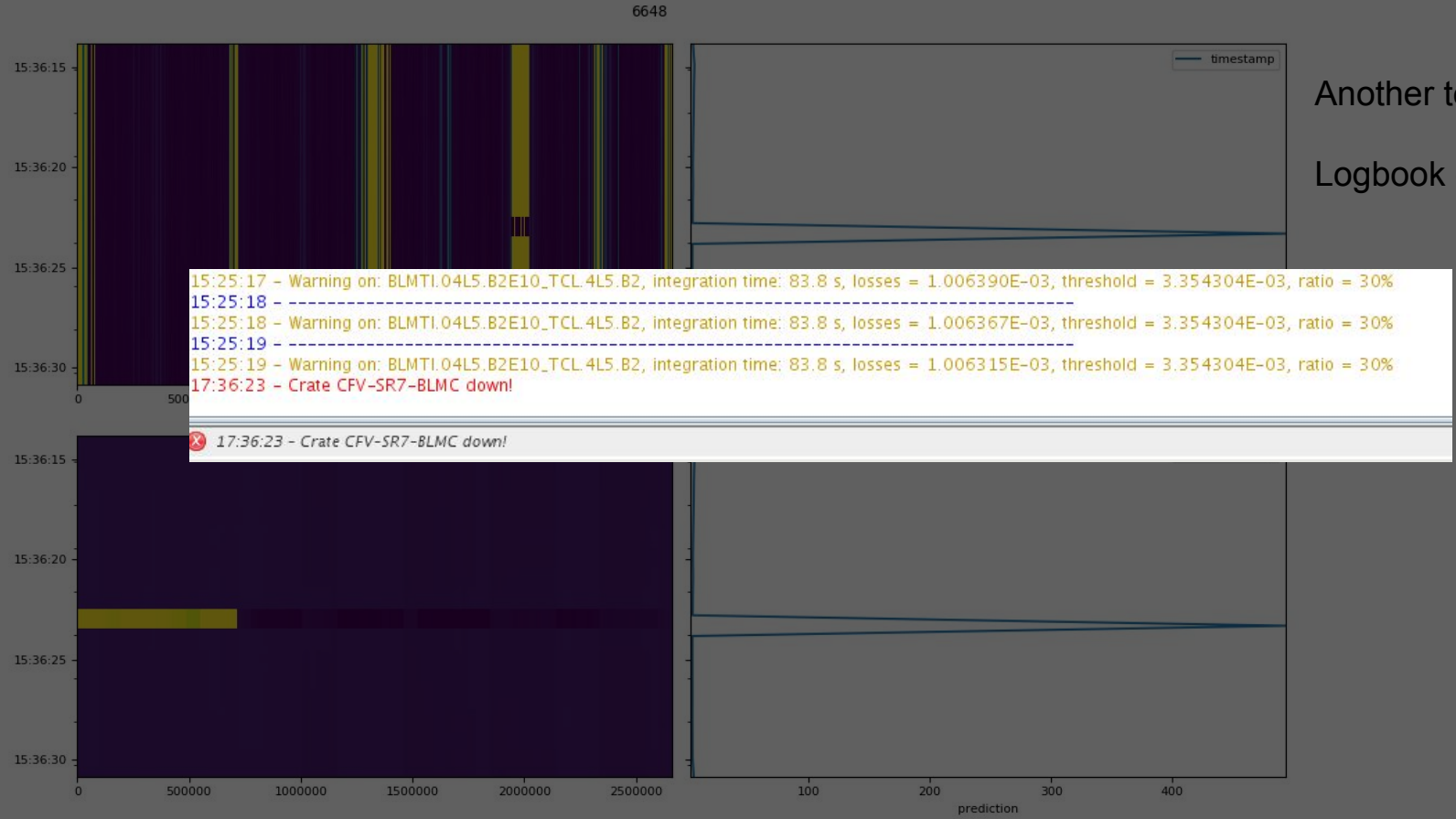
Second try



Another technical glitch ?

Logbook entry !

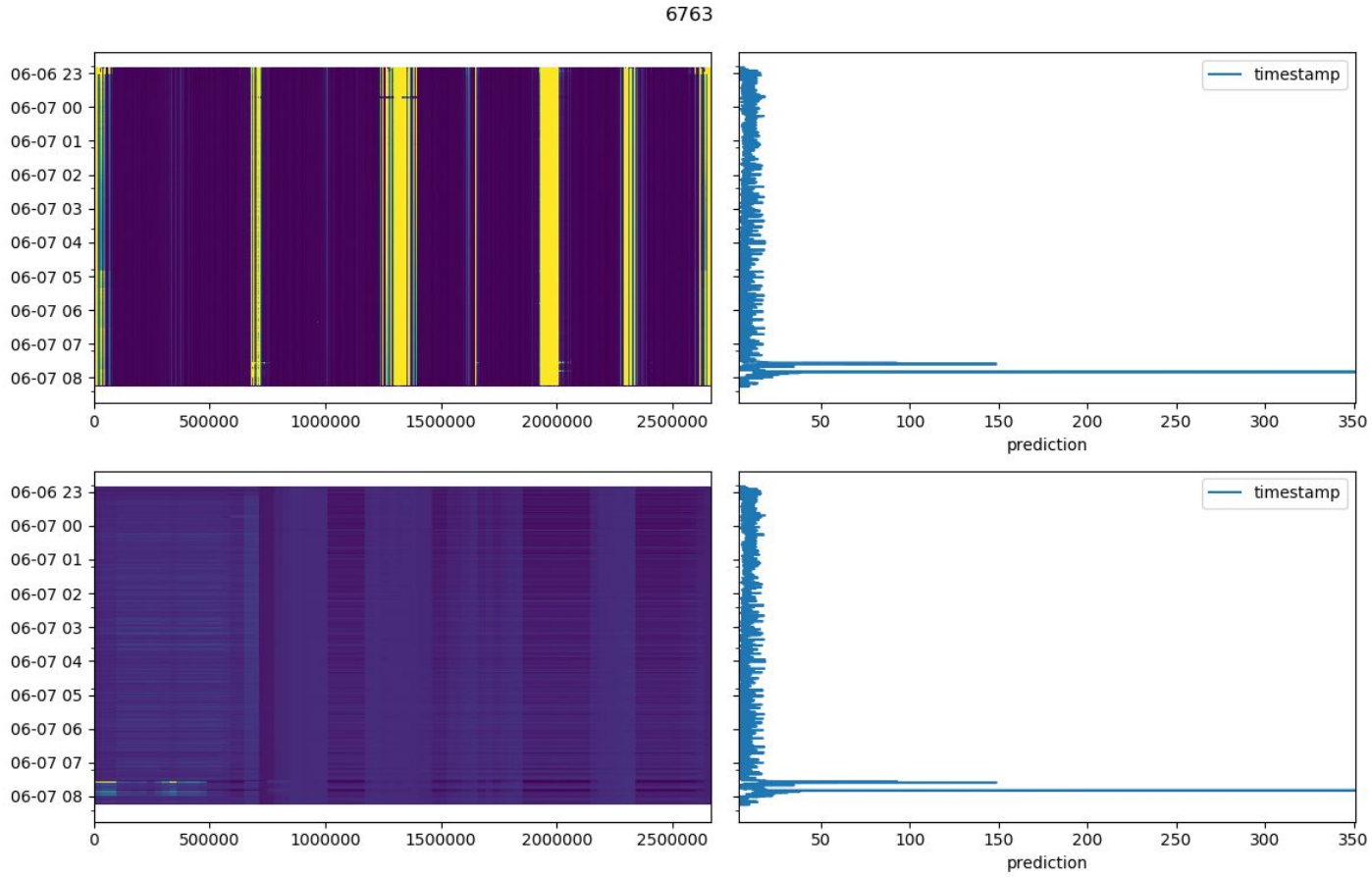
Second try



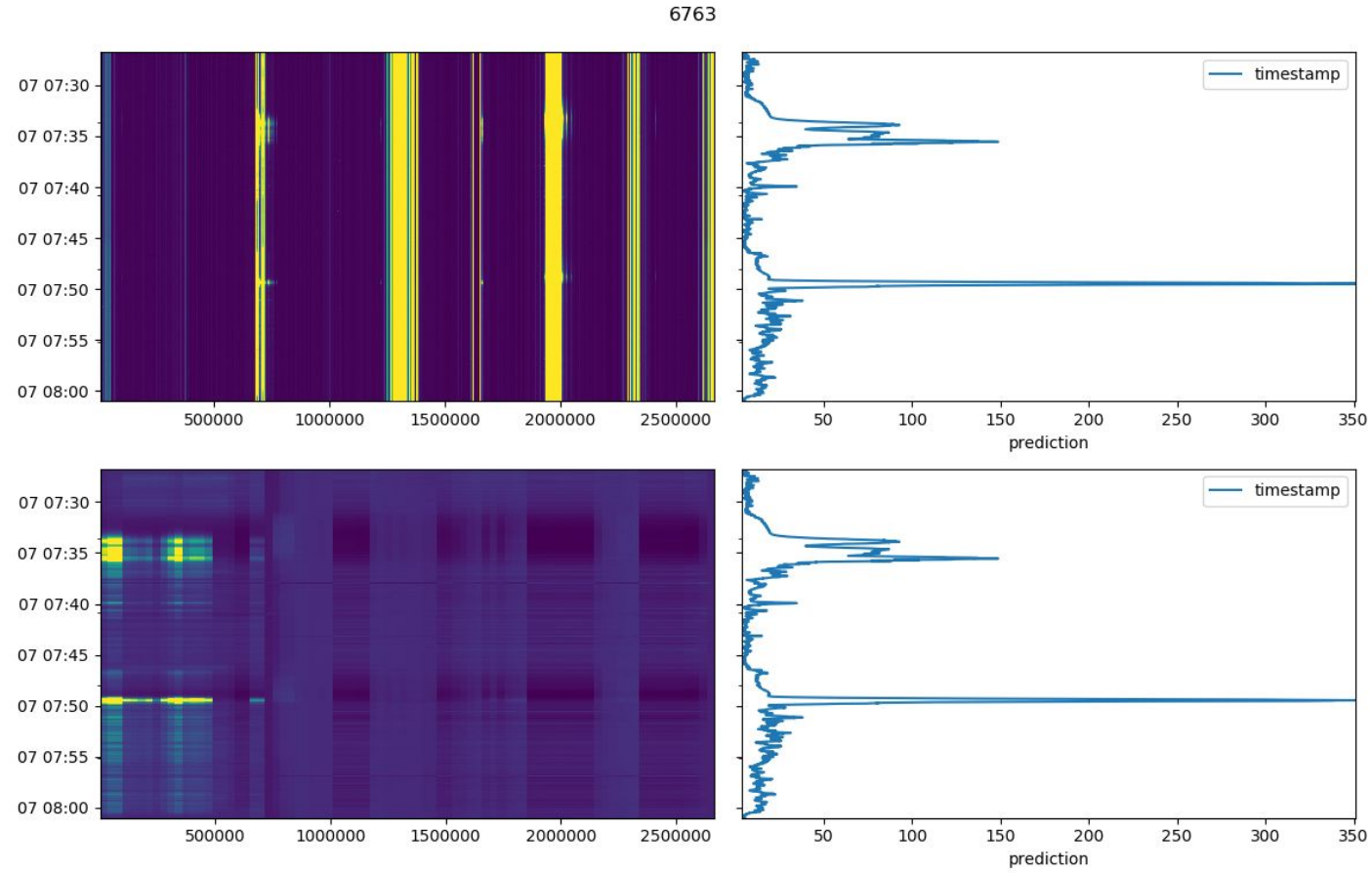
Another technical glitch ?

Logbook entry !

Second try


6763
06-06 23
06-07 00
06-07 01
06-07 02
06-07 03
06-07 04
06-07 05
06-07 06
06-07 07
06-07 08
0
500000
1000000
1500000
2000000
2500000
timestamp
50
100
150
200
250
300
350
prediction
06-06 23
06-07 00
06-07 01
06-07 02
06-07 03
06-07 04
06-07 05
06-07 06
06-07 07
06-07 08
0
500000
1000000
1500000
2000000
2500000
timestamp
50
100
150
200
250
300
350
prediction

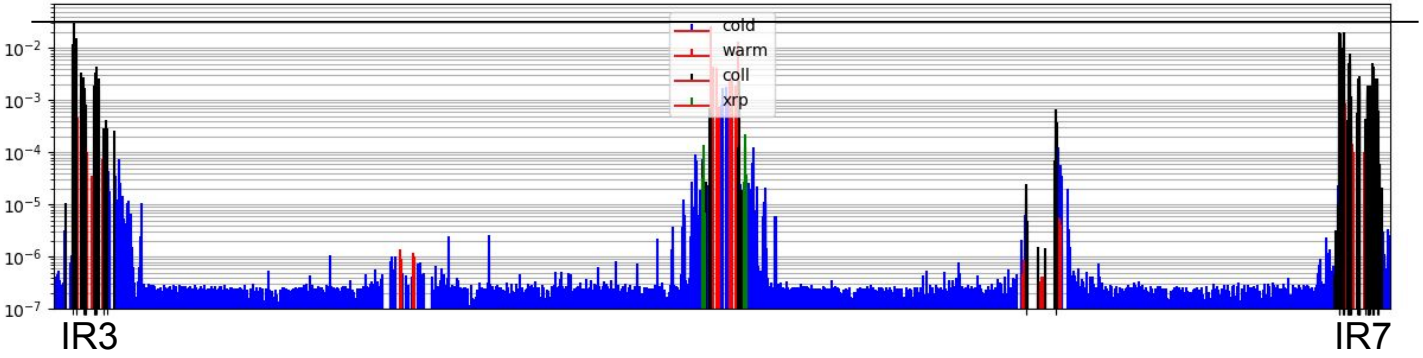
Second try



Already looks much more physical.

What about the loss map ?

Second try



Losses in IR3 > IR7

Logbook entry:

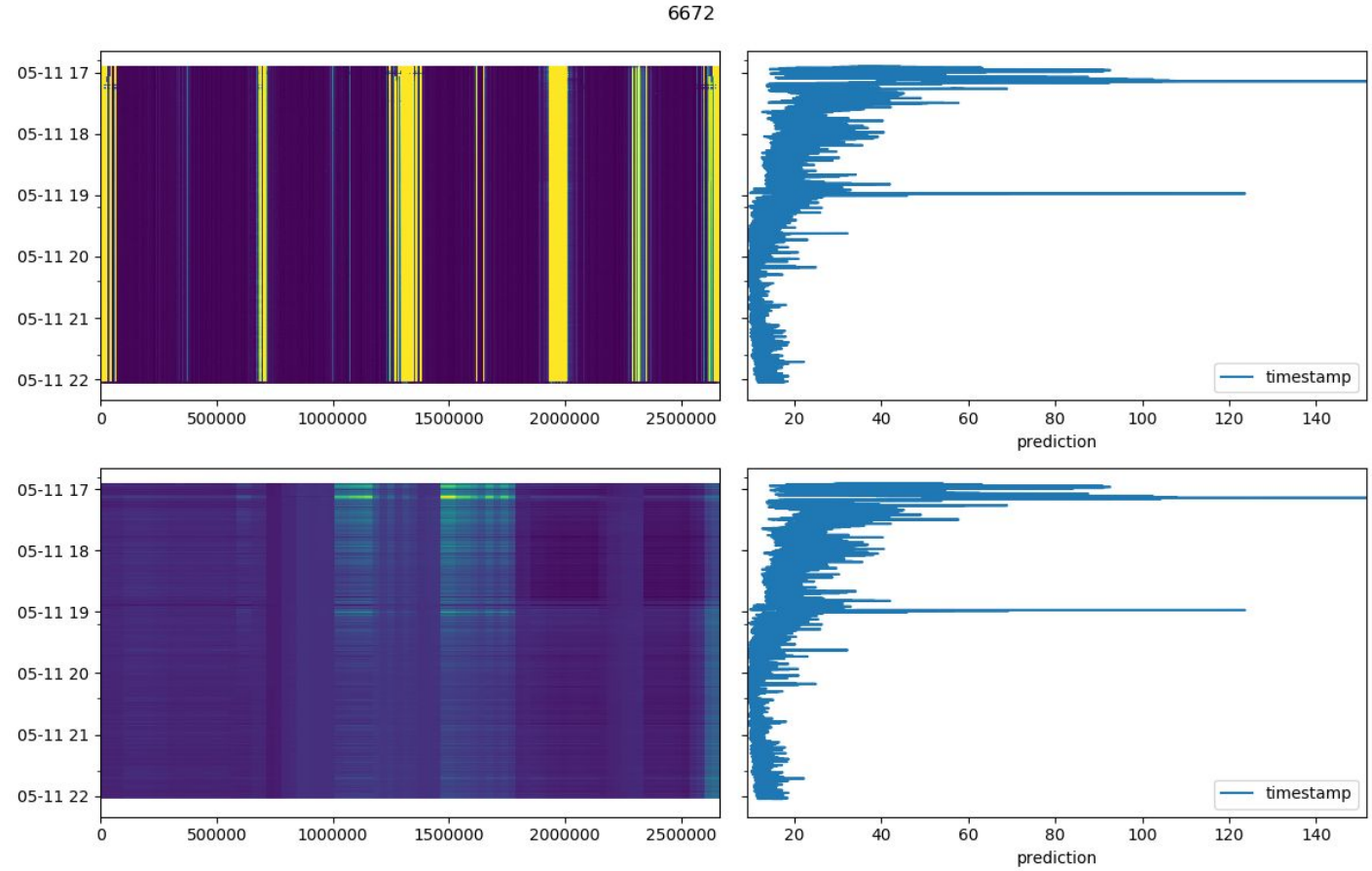
Announcer signalled: B1 RF clock generator STATUS is not OK. This was followed by beam leaking to the abort gap which triggered the cleaning.

Then, B1/B2 RF Beam Control synchro loop NOISE above limits.
The problem can be seen as well on the bunch length.

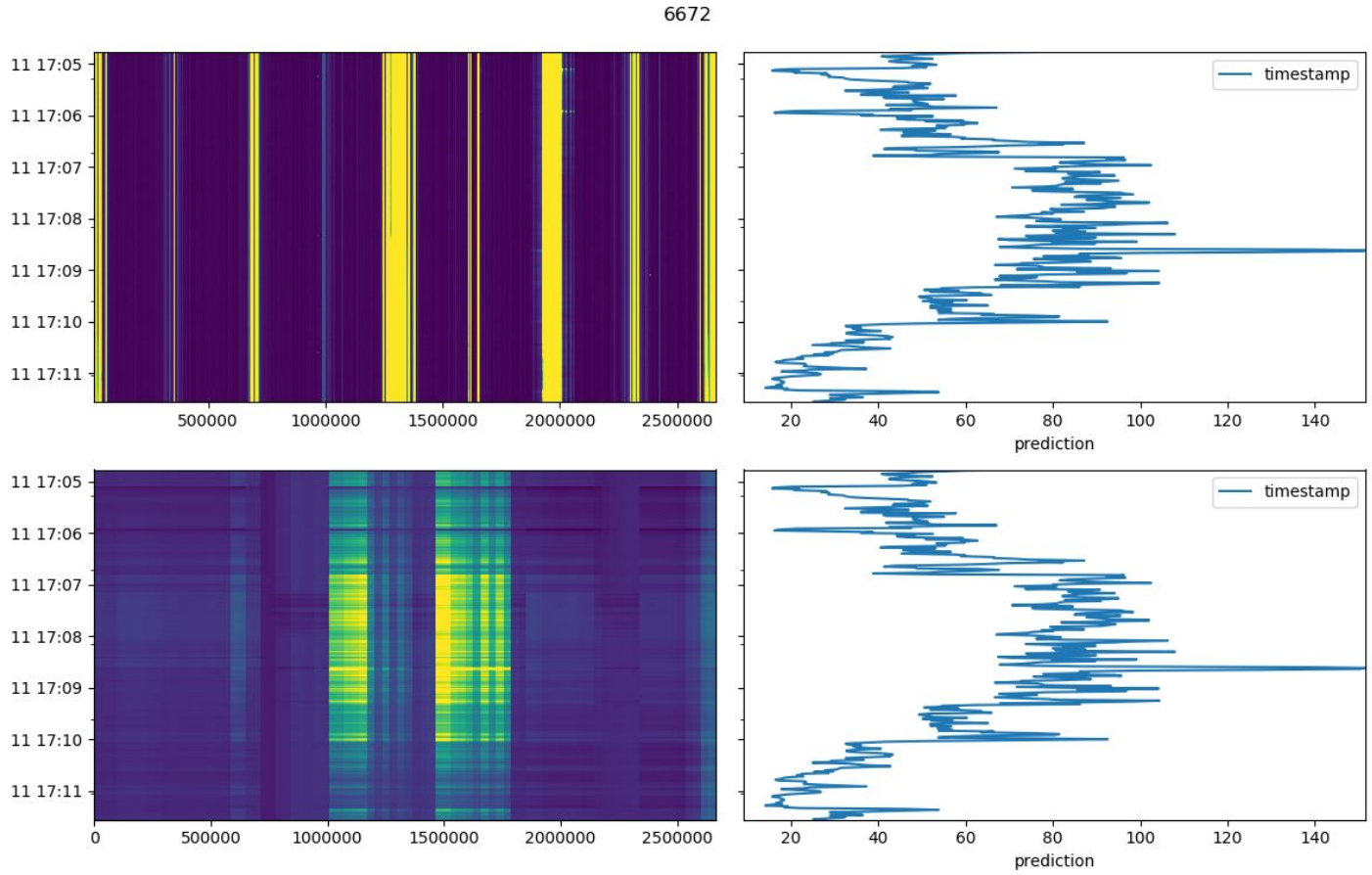
It recovered on its own within 5min. RF expert checking.

RF problem ! → a real anomaly

Second try


6672
05-11 17
05-11 18
05-11 19
05-11 20
05-11 21
05-11 22
0
500000
1000000
1500000
2000000
2500000
timestamp
20
40
60
80
100
120
140
prediction
05-11 17
05-11 18
05-11 19
05-11 20
05-11 21
05-11 22
0
500000
1000000
1500000
2000000
2500000
timestamp
20
40
60
80
100
120
140
prediction

Second try

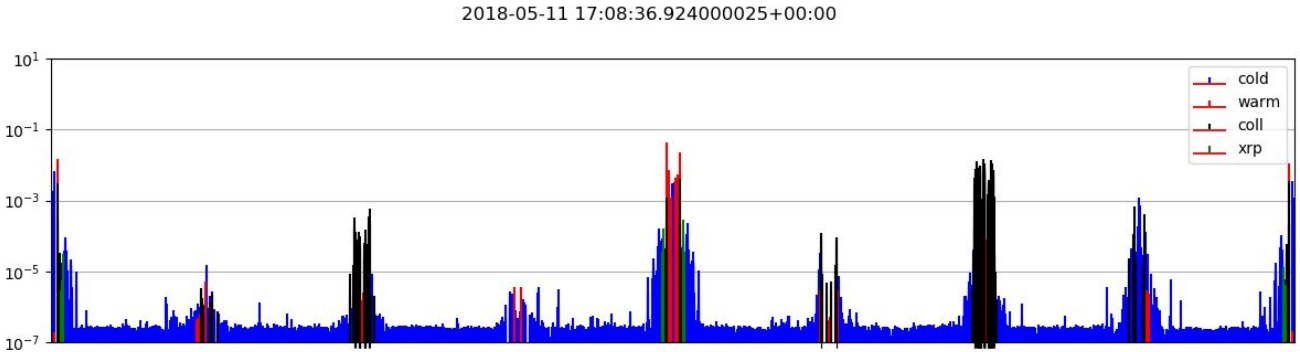


Hard to tell what is going on… the colours are hiding a lot.

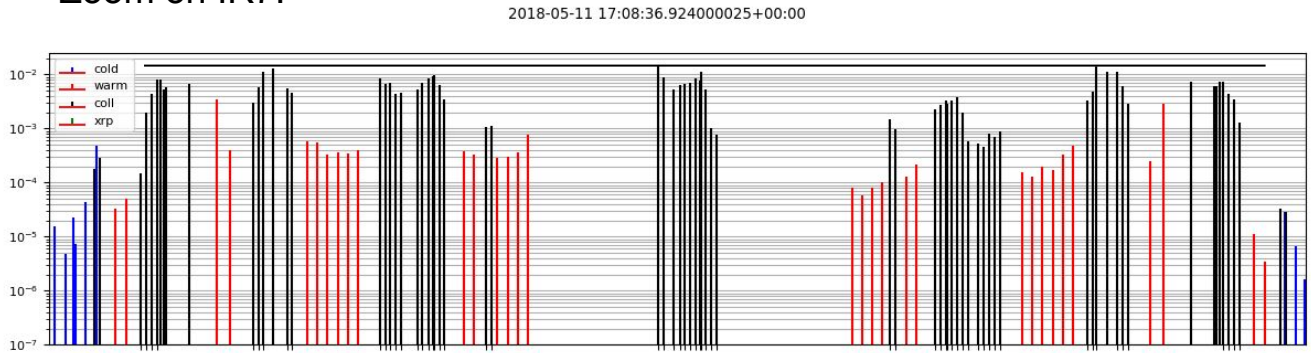
The model clearly sees something changing.

What about the loss distribution ?

Second try



Zoom on IR7:

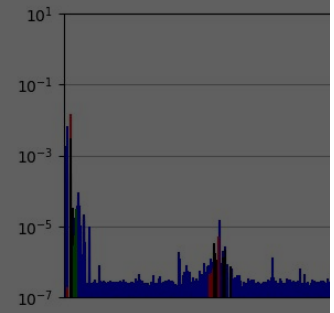


Flat losses

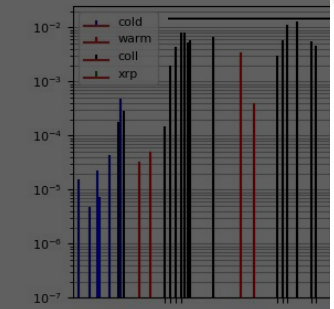
Higher losses in secondaries than in primaries

Relevant logbook entry ?

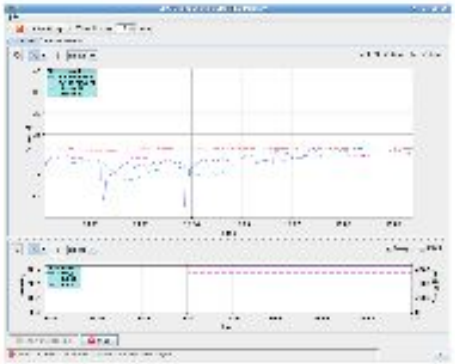
Second try



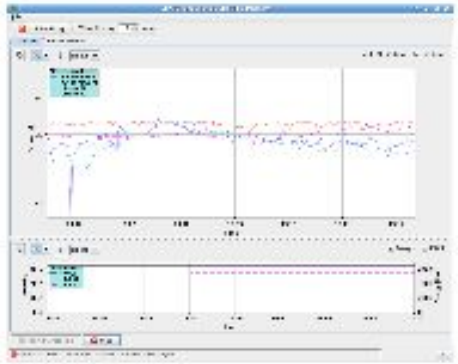
Zoom on IR7:



72	19:04	SB	Tune scan for lifetime optimisation B1H: +2e-3 B1V: -3e-3 B2H +2e-3 B2V -1e-3



20180511190811.png



20180511191220.png

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ndaries than in
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gbook entry ?

Conclusion

Surrogate model of the losses:

- Dataset exploration
- Formulating the problem

Simulations:

- Machinery mostly setup
- First test results coming in as we speak

Loss maps:

- Infrastructure up and running
- Some very compelling results, needs fine tuning.