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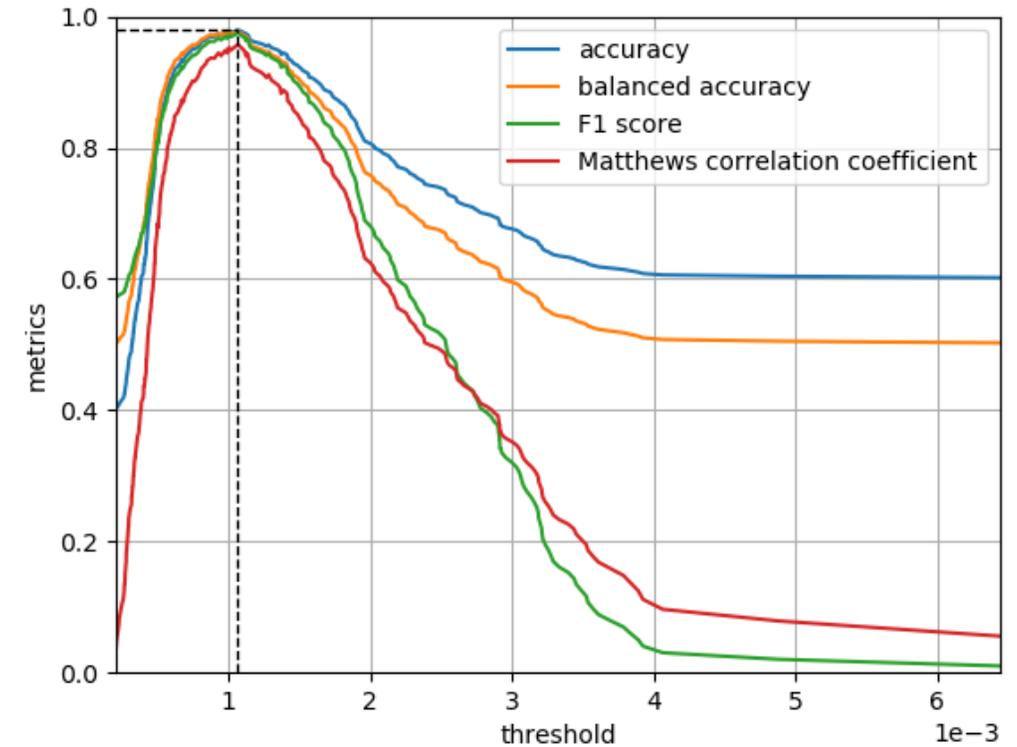
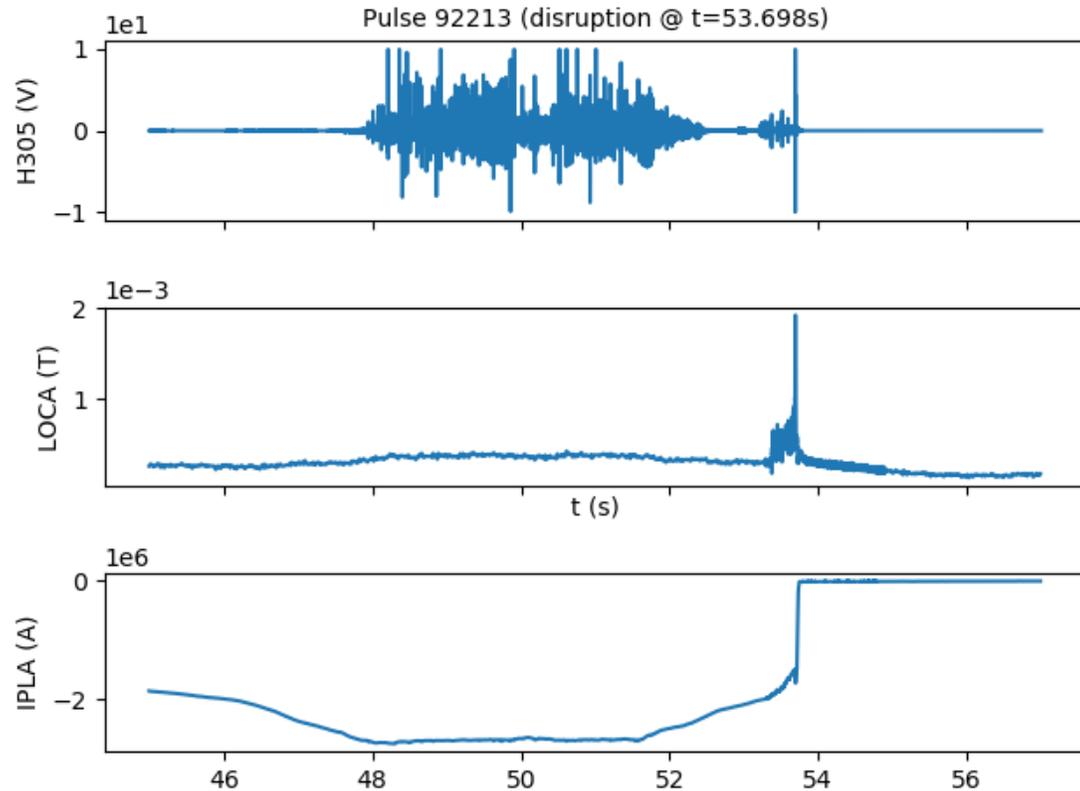
Predicting locked-mode disruptions with explainable deep learning on MHD spectrograms

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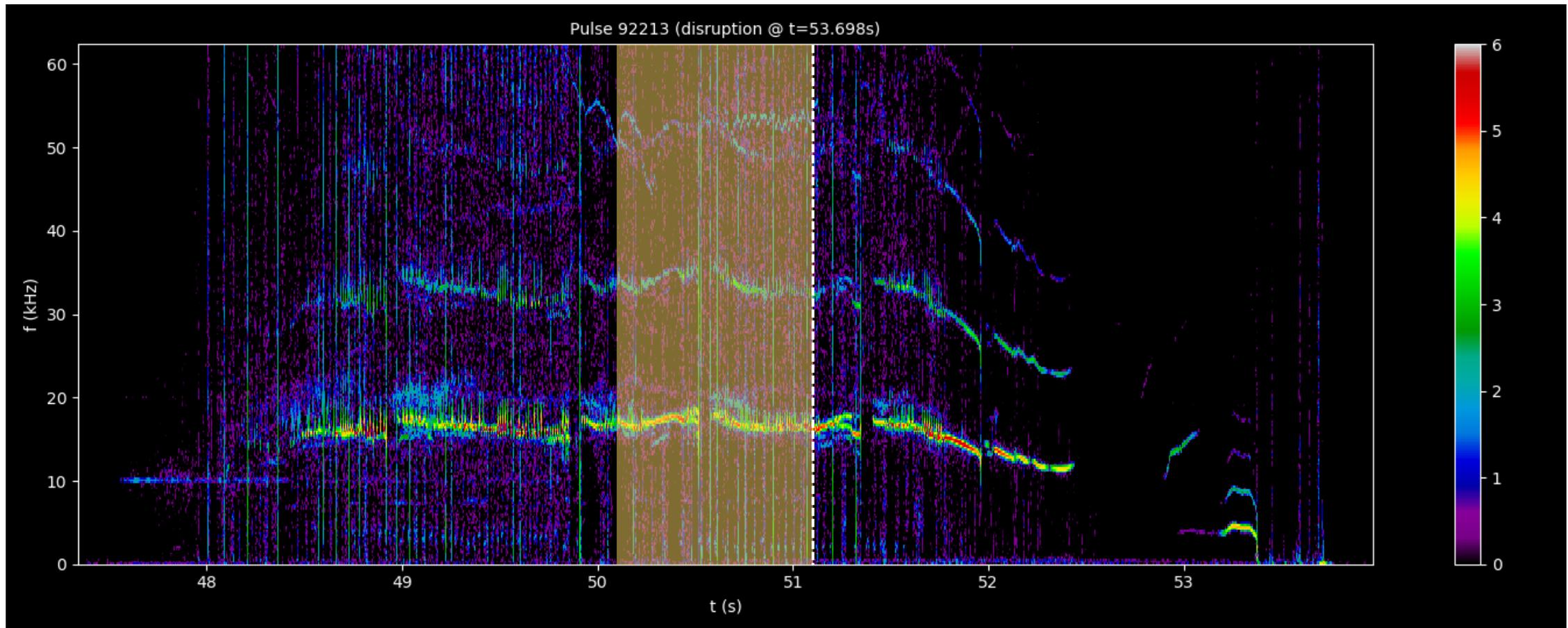
Locked mode and disruptions

- A locked mode is present in most disruptions in the JET baseline scenario
- The locked mode amplitude is one of the most used signals for disruption prediction
- Using a simple threshold yields a binary classifier (disruption / no disruption) with over 95% accuracy



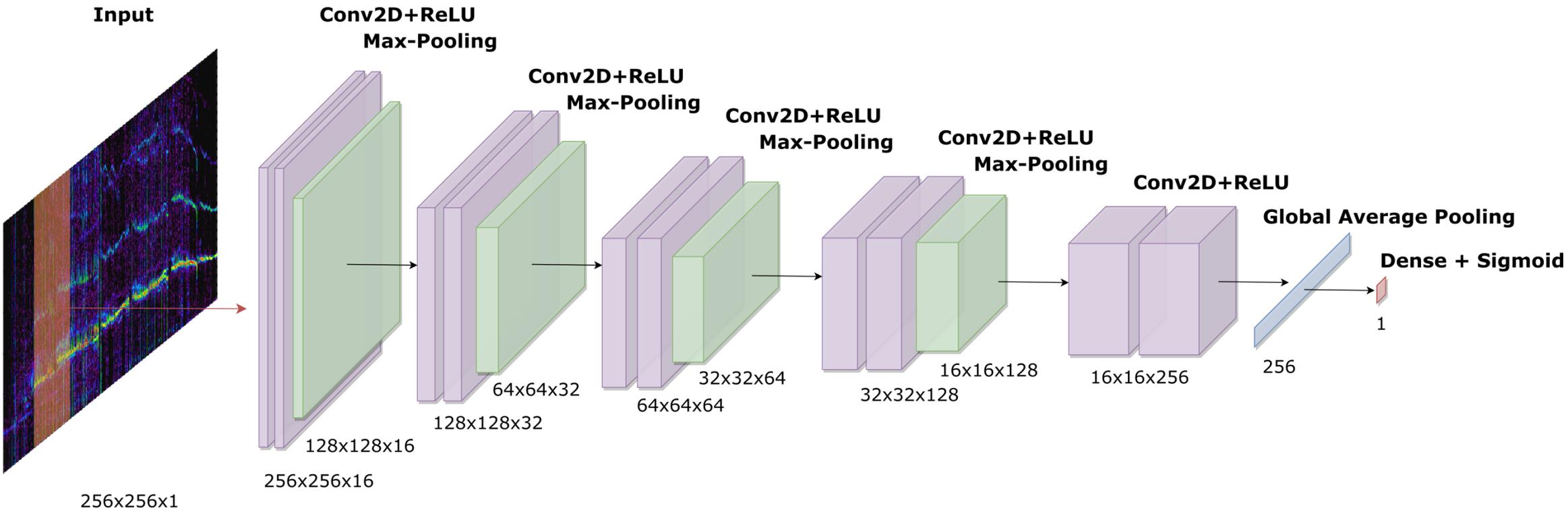
MHD spectrograms

- We use MHD activity to predict the locked mode (and therefore infer that disruption will occur)
- A deep learning model is applied on a time window (~ 1 s) from the MHD spectrogram
- Model predicts whether locked mode will occur



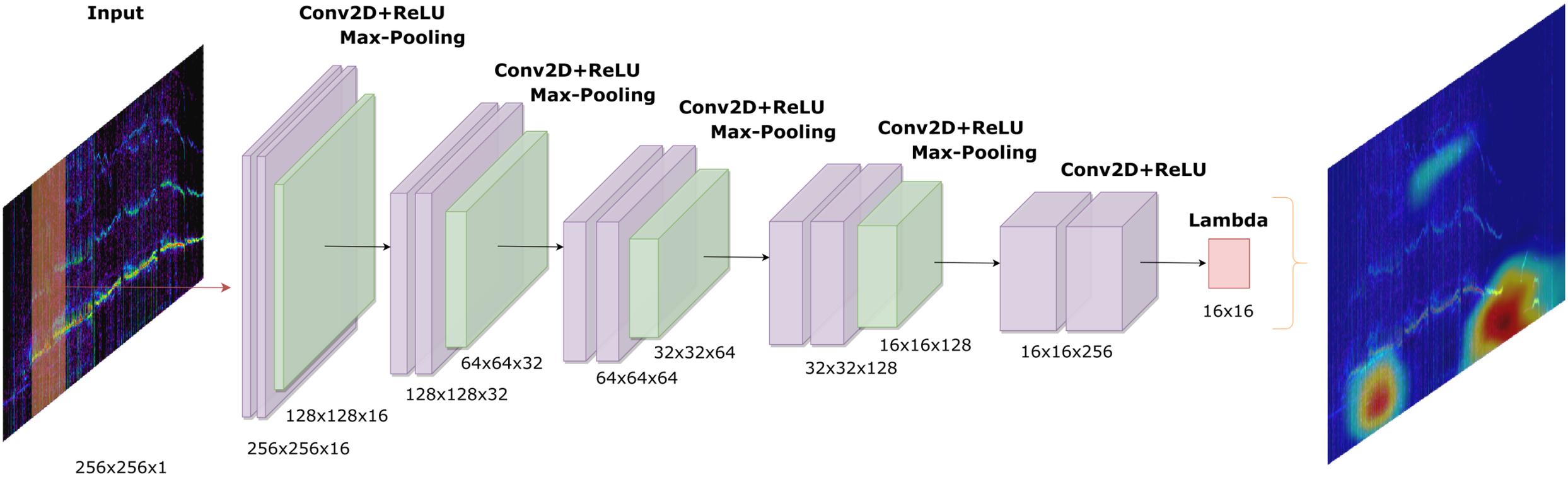
Deep learning model

- The model is a **fully** convolutional neural network (CNN)
- It receives a 256×256 input (image) and produces a single output (prediction)
- Model can be modified to provide a **class activation map** (CAM) of the most important features in the input



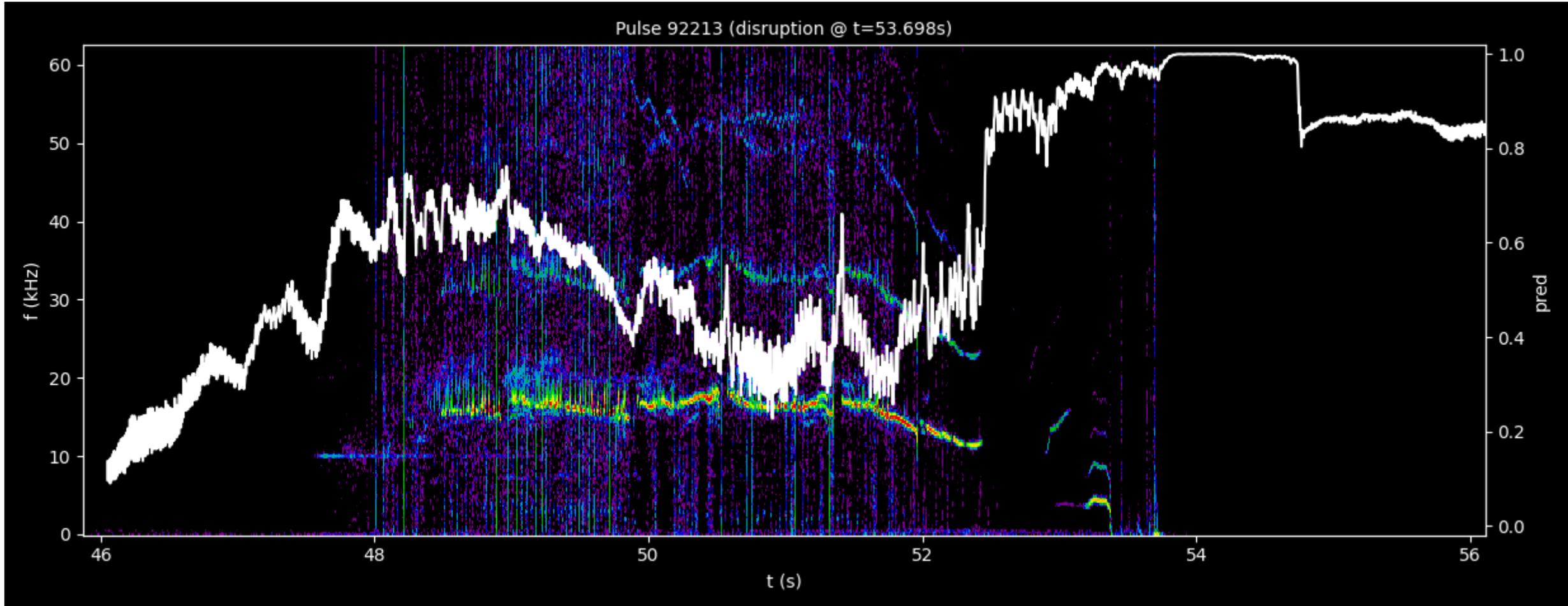
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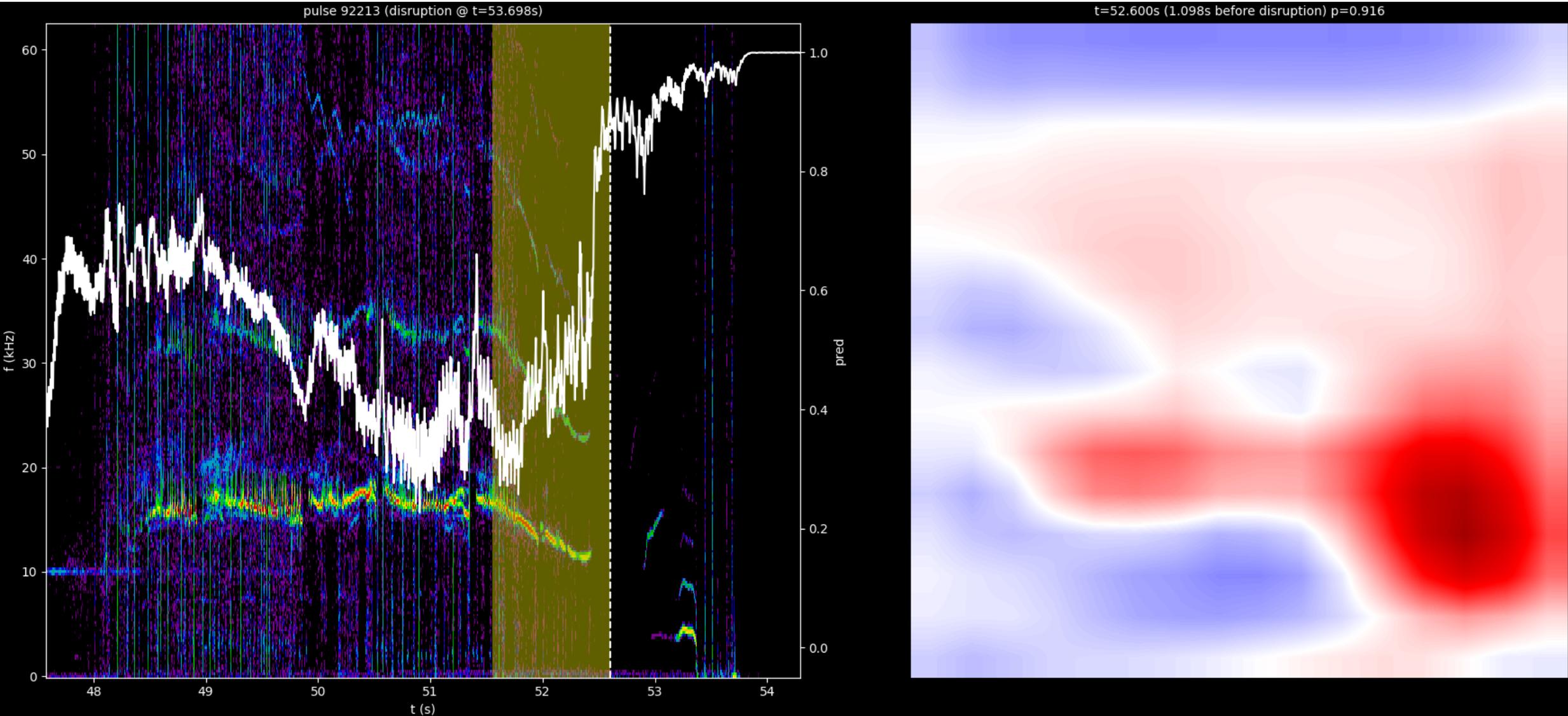
Model prediction

- Prediction on a test pulse based on (1 second) sliding window from beginning to end
- It rises when MHD activity is interrupted, and approaches 1.0 near the locked mode / disruption



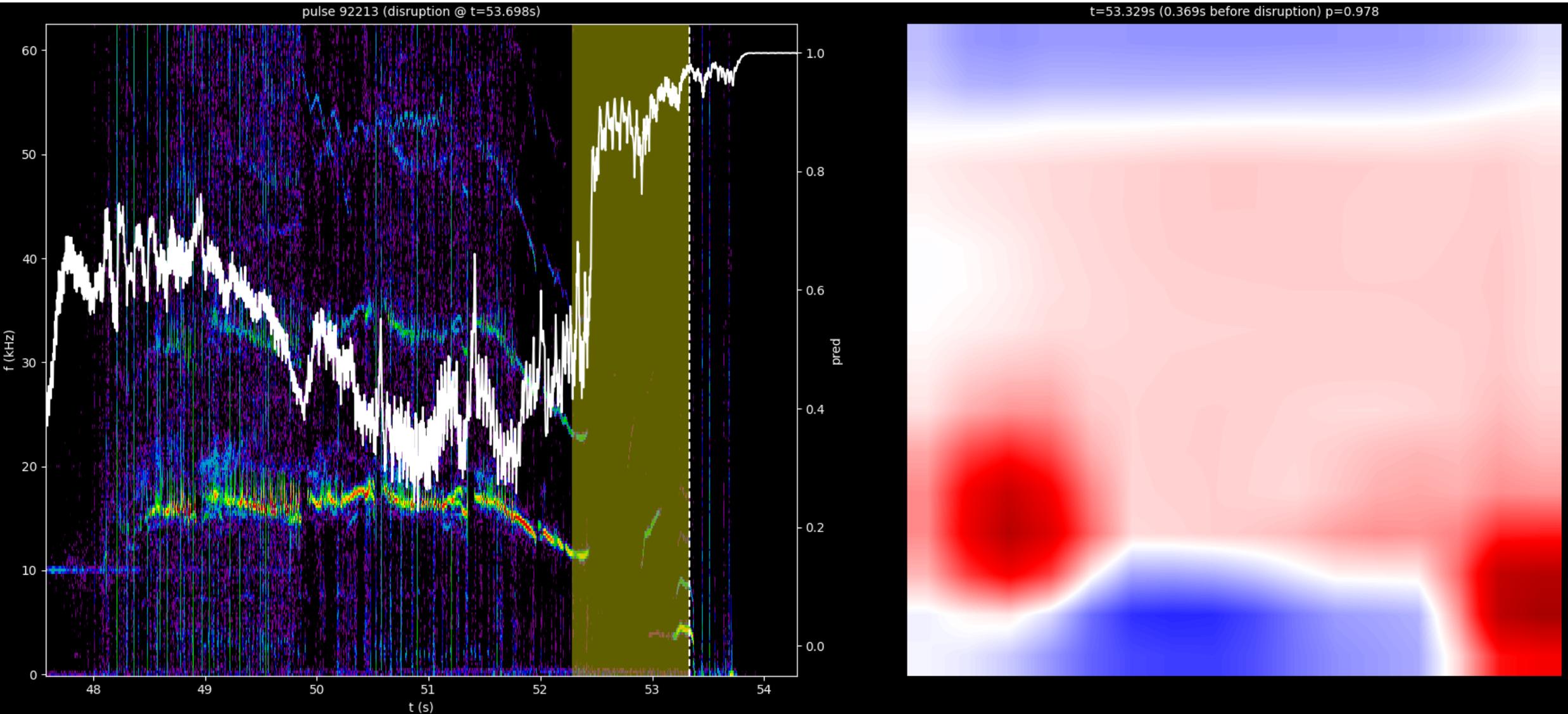
Model interpretability

- Class activation map when approaching locked mode / disruption



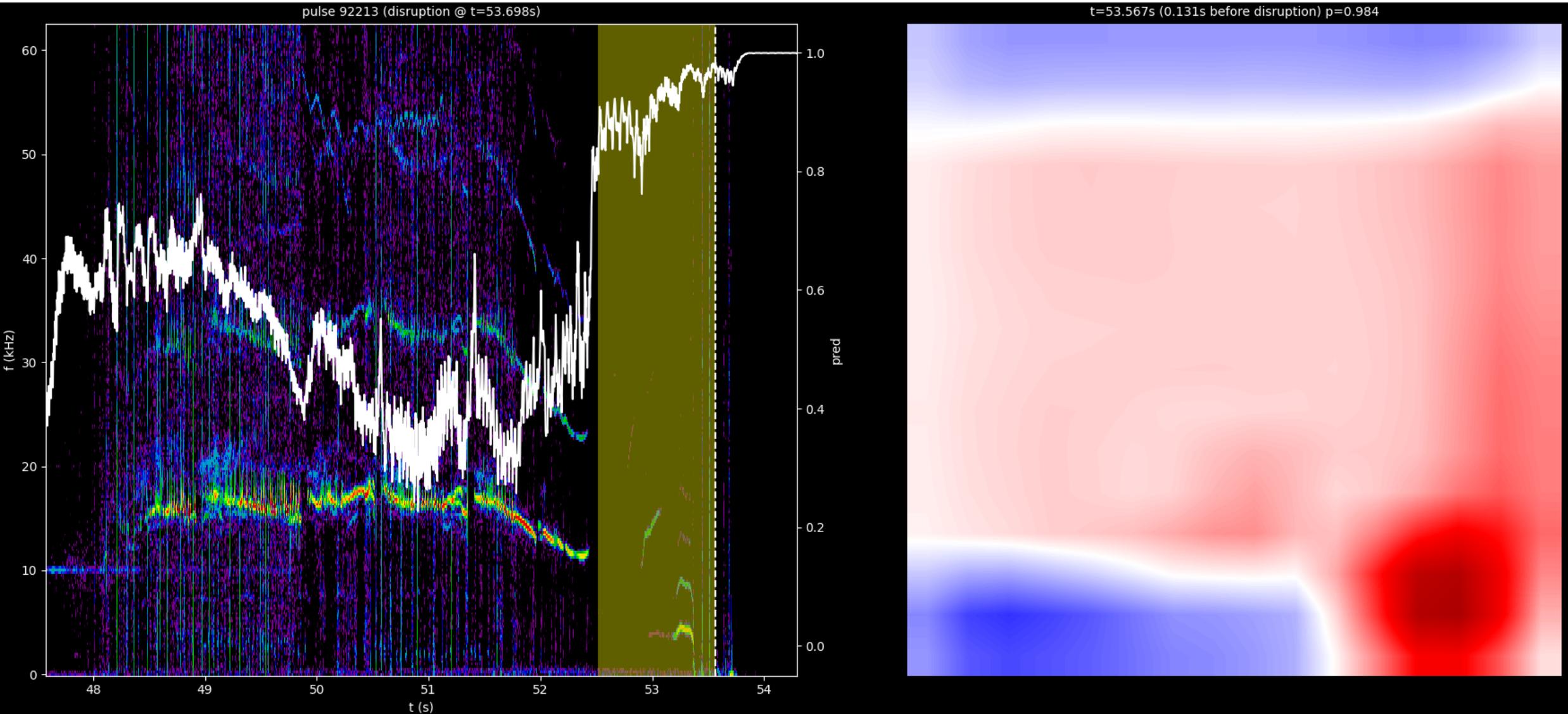
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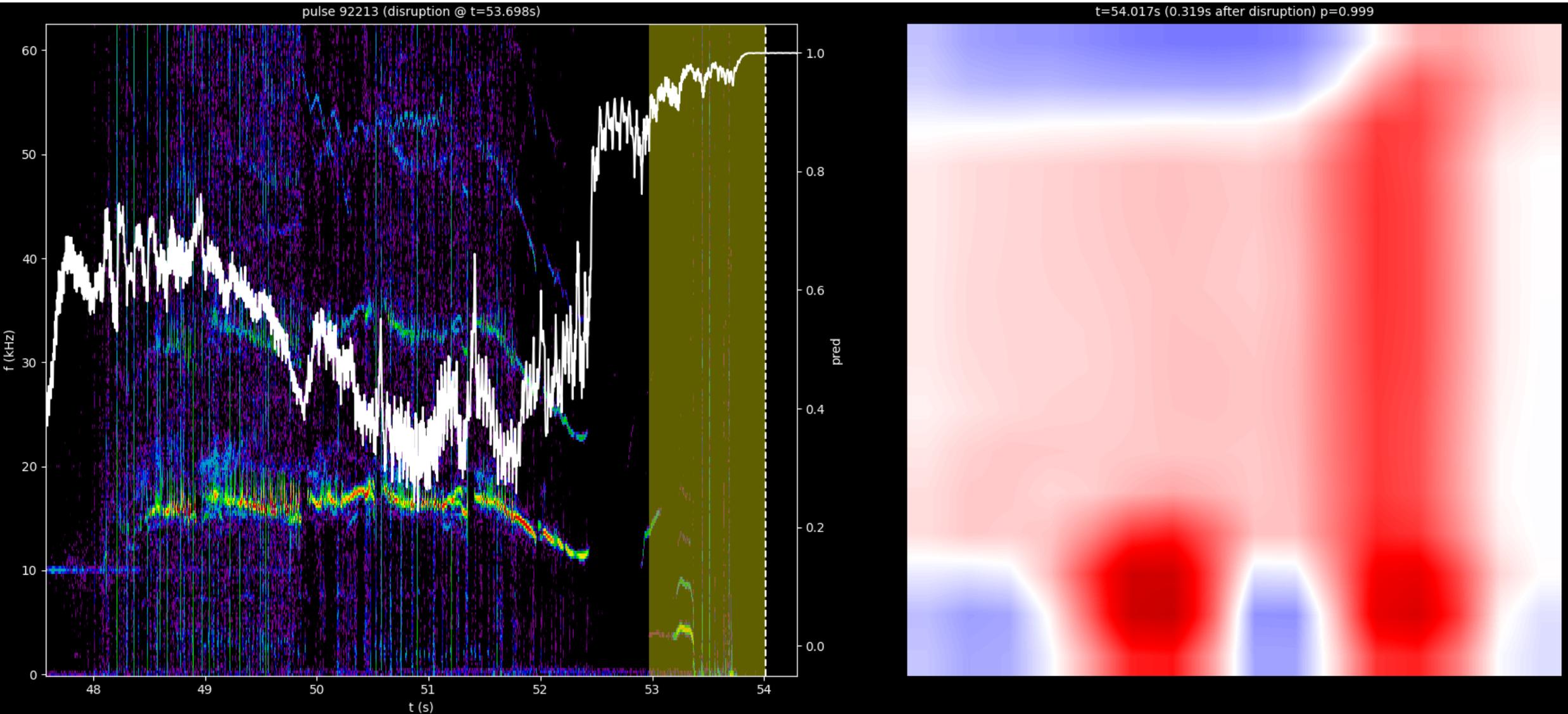
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Conclusion

- Proposed model emphasizes the following behaviors:
 1. interruption of MHD activity at any point during the pulse (well before locked mode)
 2. resurgence of MHD activity, e.g. in the form of a 2/1 mode (when locked mode is about to occur)
 3. occurrence of locked mode before disruption (locked mode has occurred, but no disruption yet)
 4. occurrence of disruption (disruption has occurred)
- Use of locked mode signal provides access to 3. and 4., but not 1. and 2.