

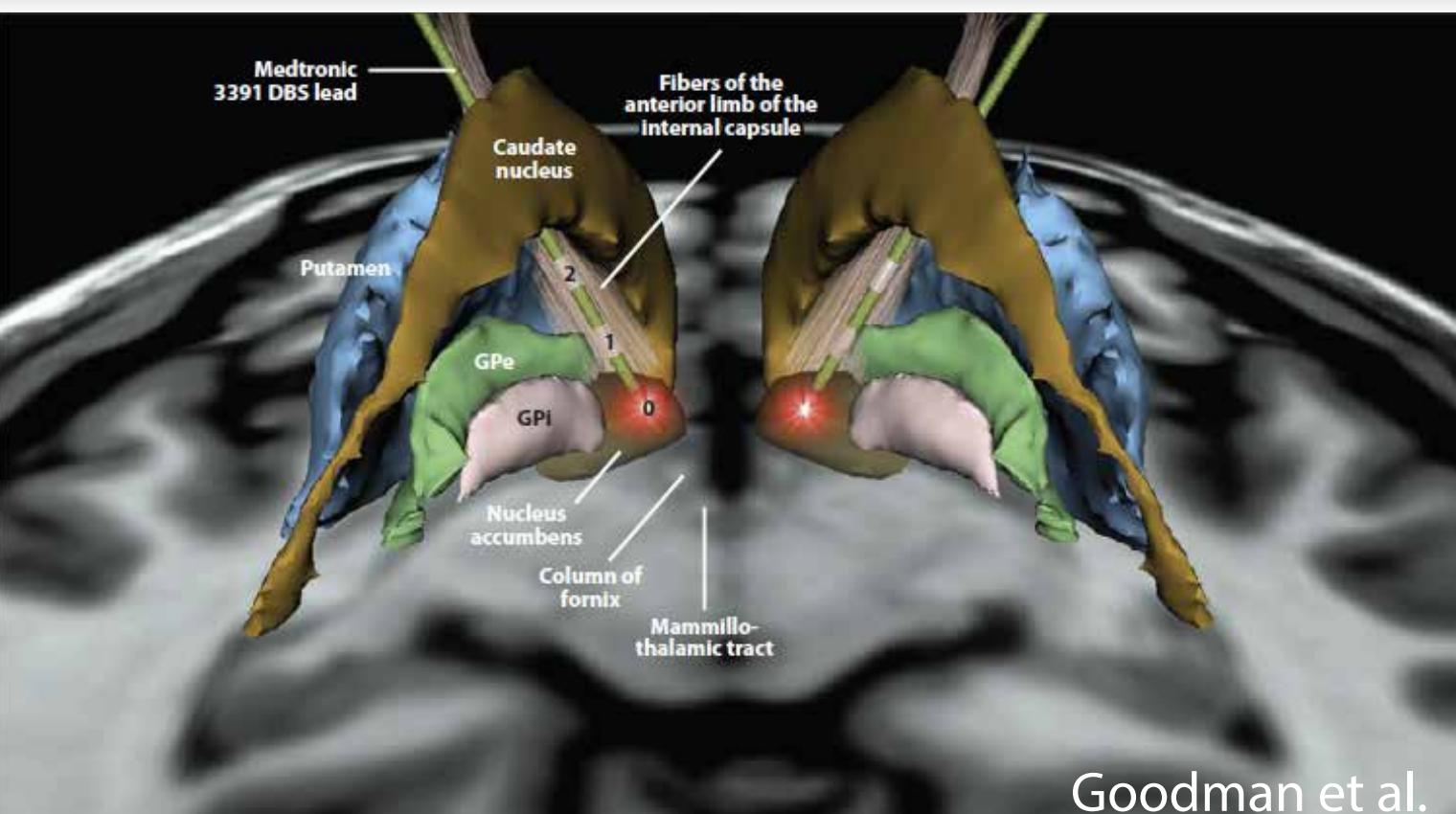
Artifact removal from Local Field Potential Recordings during Deep Brain Stimulation

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BACKGROUND

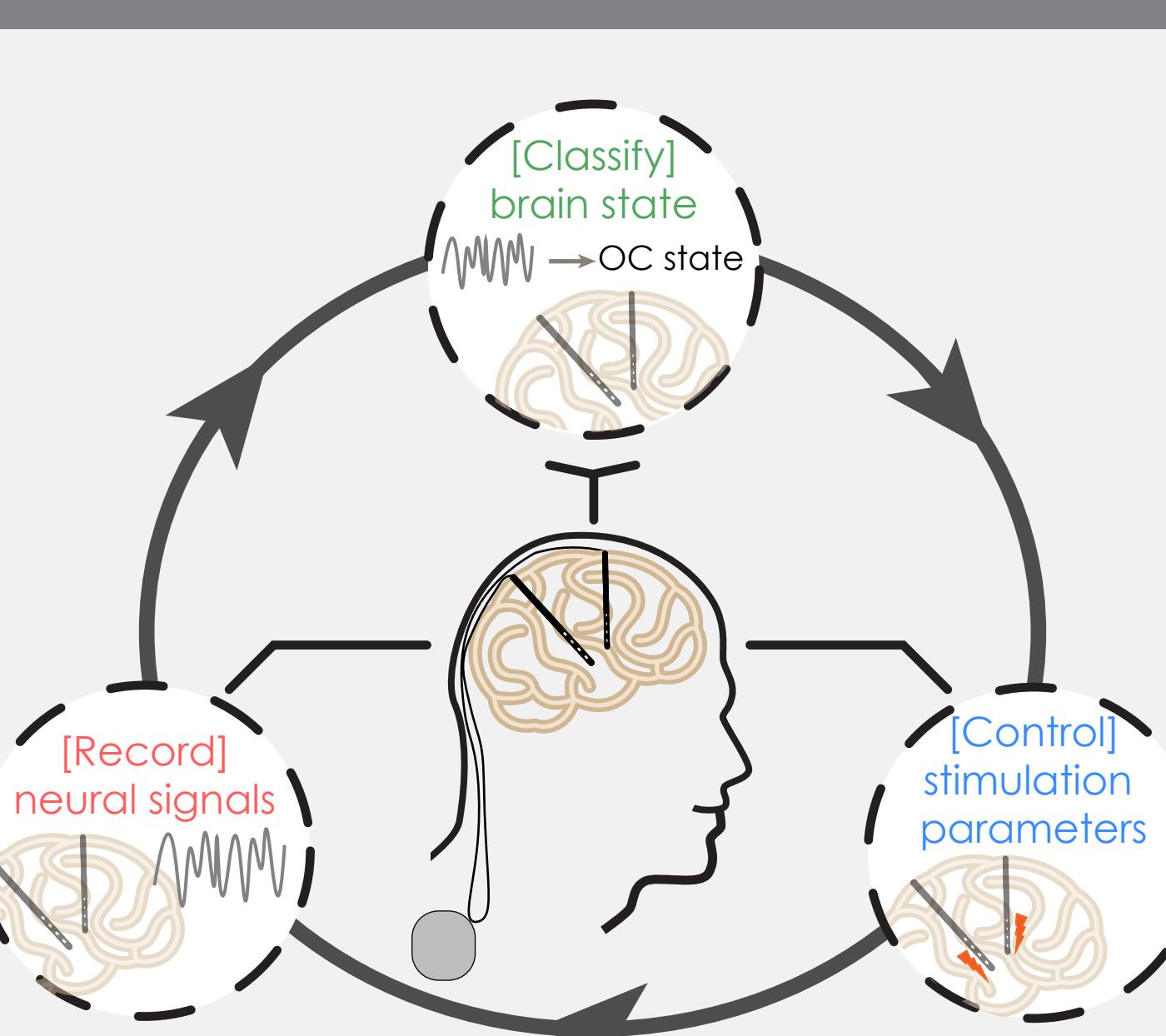
- OCD is a psychiatric illness marked by:
 - (1) Obsessions: recurrent unwanted or distressing thoughts
 - (2) Compulsions: repetitive, ritualistic behaviors
- OCD affects ~2% of the US population, and 10-20% of cases are treatment resistant
- DBS in the ventral capsule/ventral striatum (VC/VS) improves symptoms in 46-73% of patients



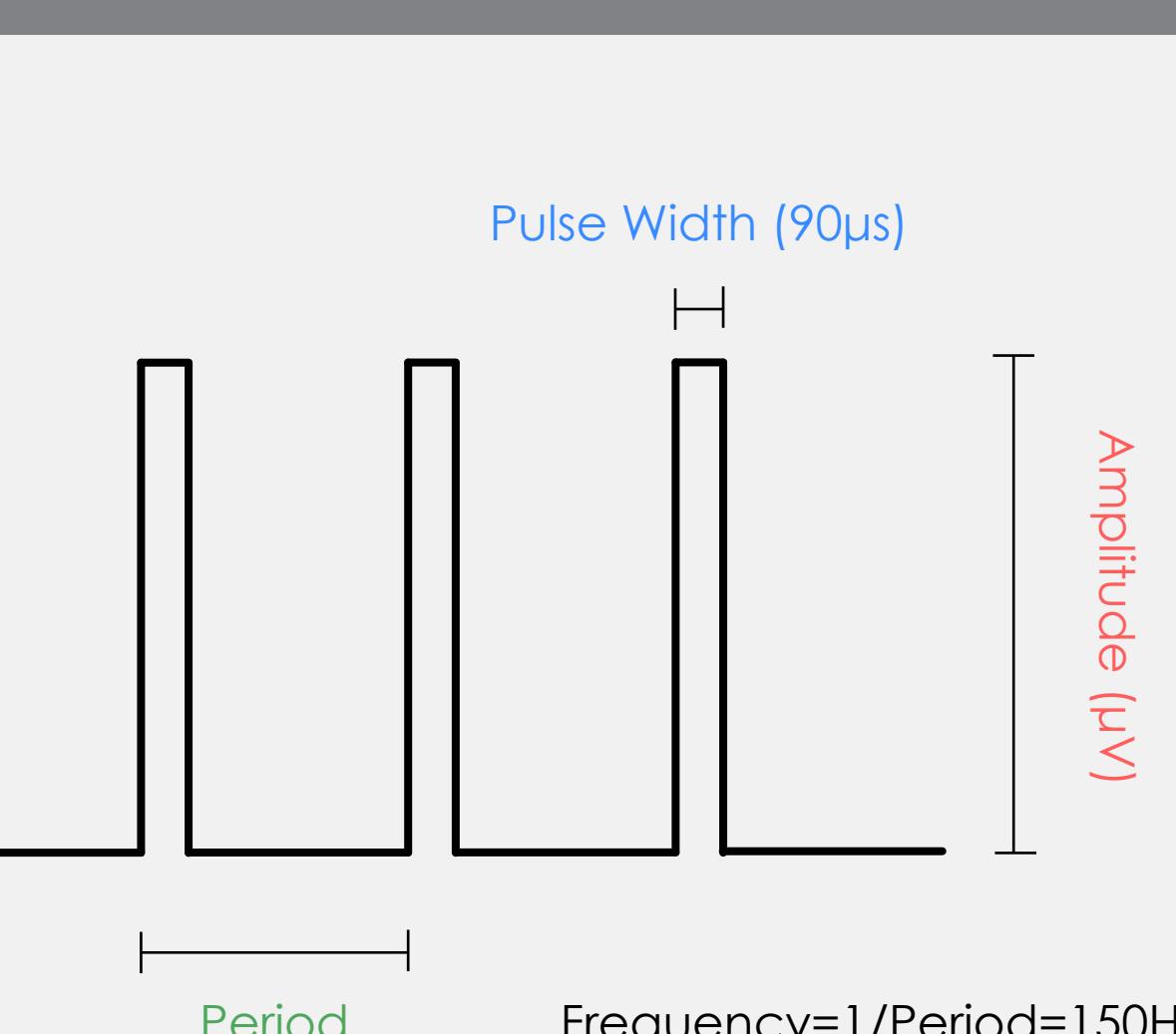
Goodman et al.

STUDY OVERVIEW

Adaptive DBS

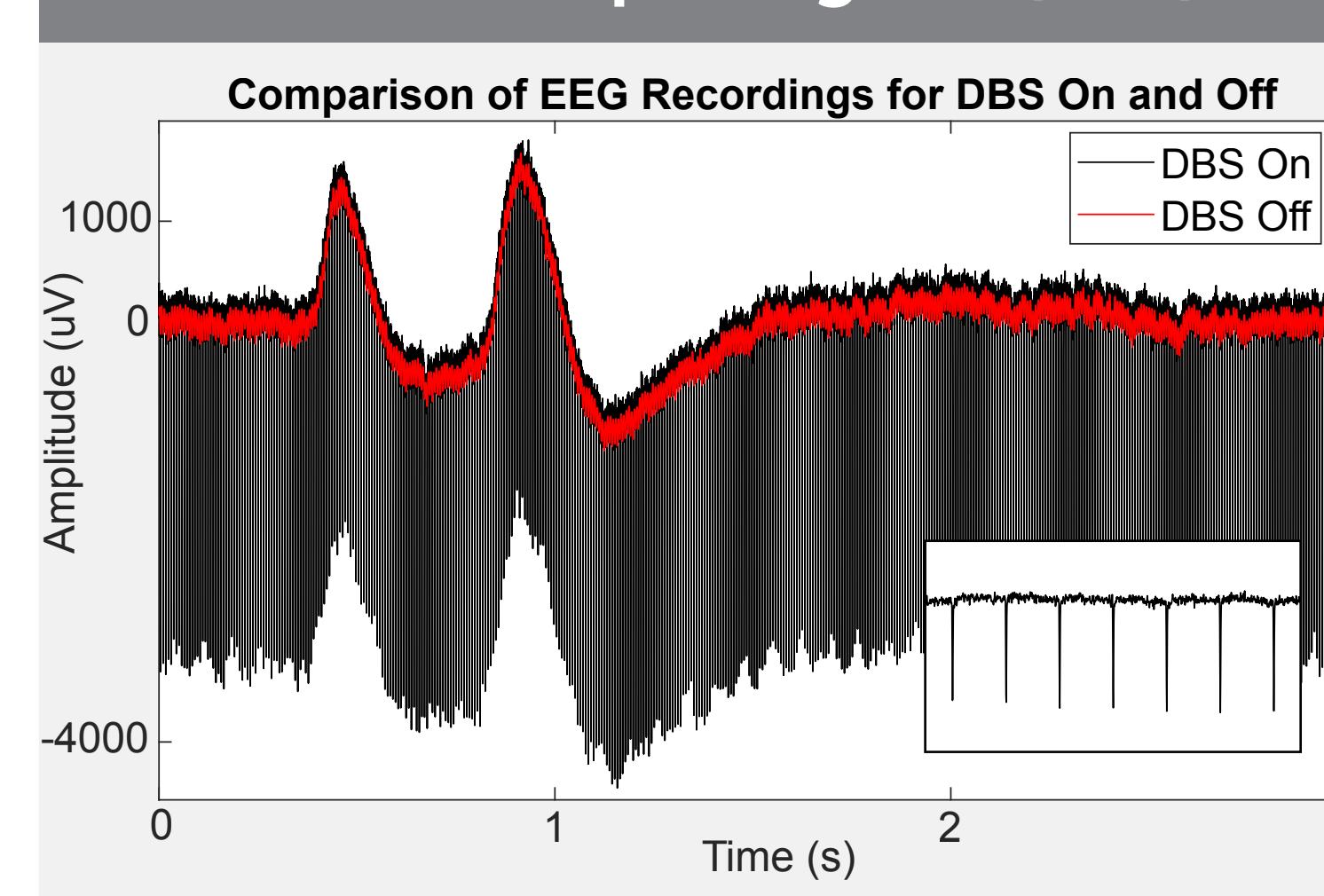


DBS Signal



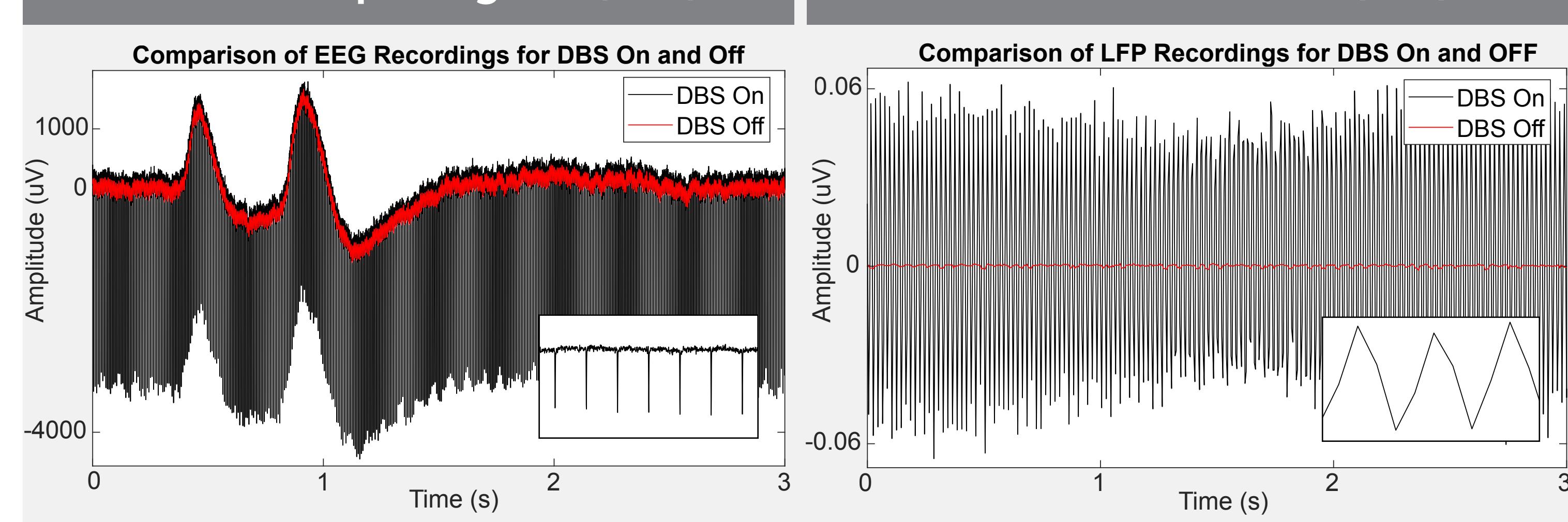
Recording Methods

Electroencephalogram (EEG)



- Records neural activity from electrodes attached to the scalp
- 20 total channels across the front of the scalp
- High resolution (30kHz sampling rate)
- DBS artifact can be removed using a simple low-pass filter

Local Field Potential (LFP)

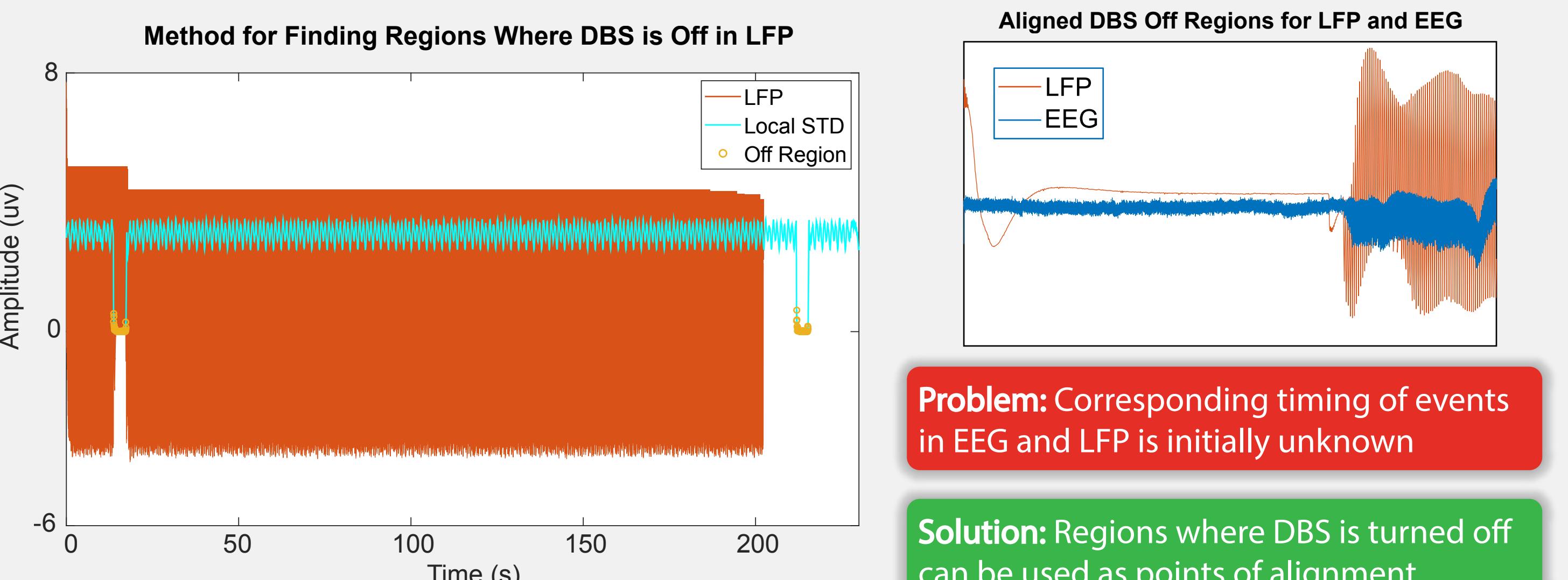


- Records neural activity from implanted electrodes
- Two channels, bilaterally in the nucleus accumbens
- Low resolution (200Hz or 800Hz sampling rate)
- DBS artifact can not be removed using standard filtering approaches

Stimulation artifacts must be removed from LFP recordings in order to identify neural biomarkers of OCD symptoms and side effects of DBS

TEMPORAL ALIGNMENT OF EEG AND LFP

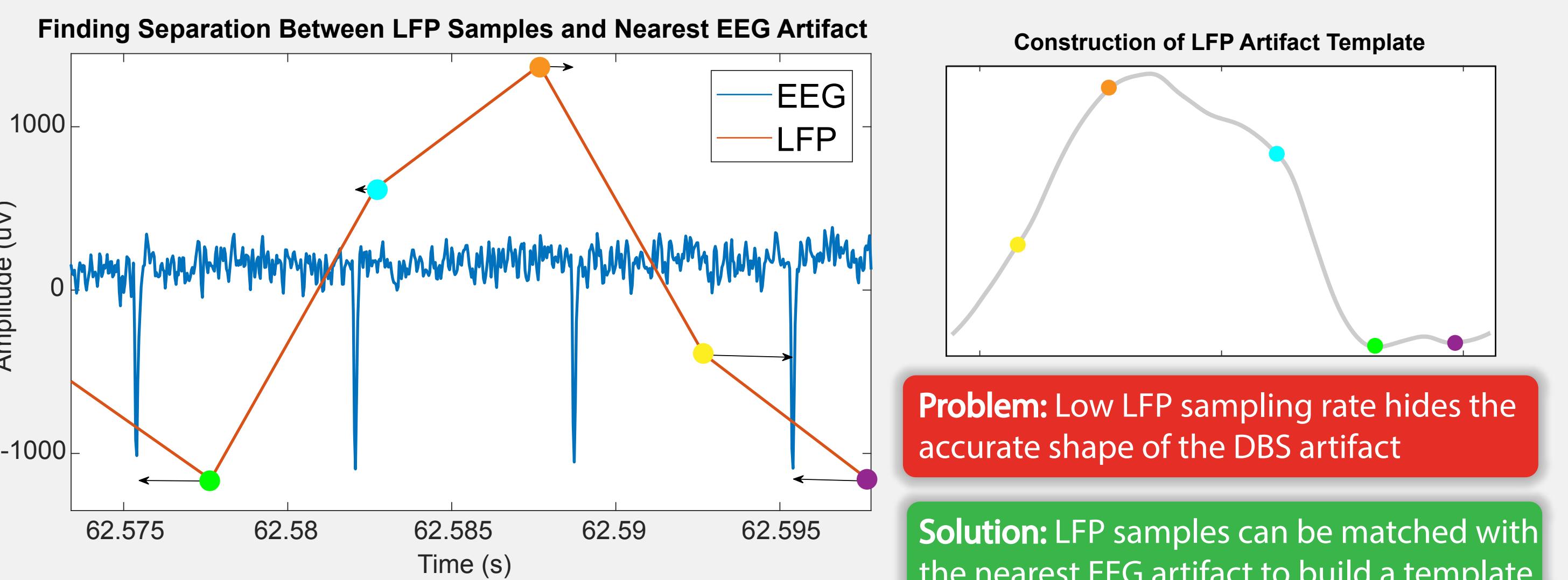
Alignment of Periods When DBS is Off



Problem: Corresponding timing of events in EEG and LFP is initially unknown

Solution: Regions where DBS is turned off can be used as points of alignment

Alignment of LFP to EEG Artifacts

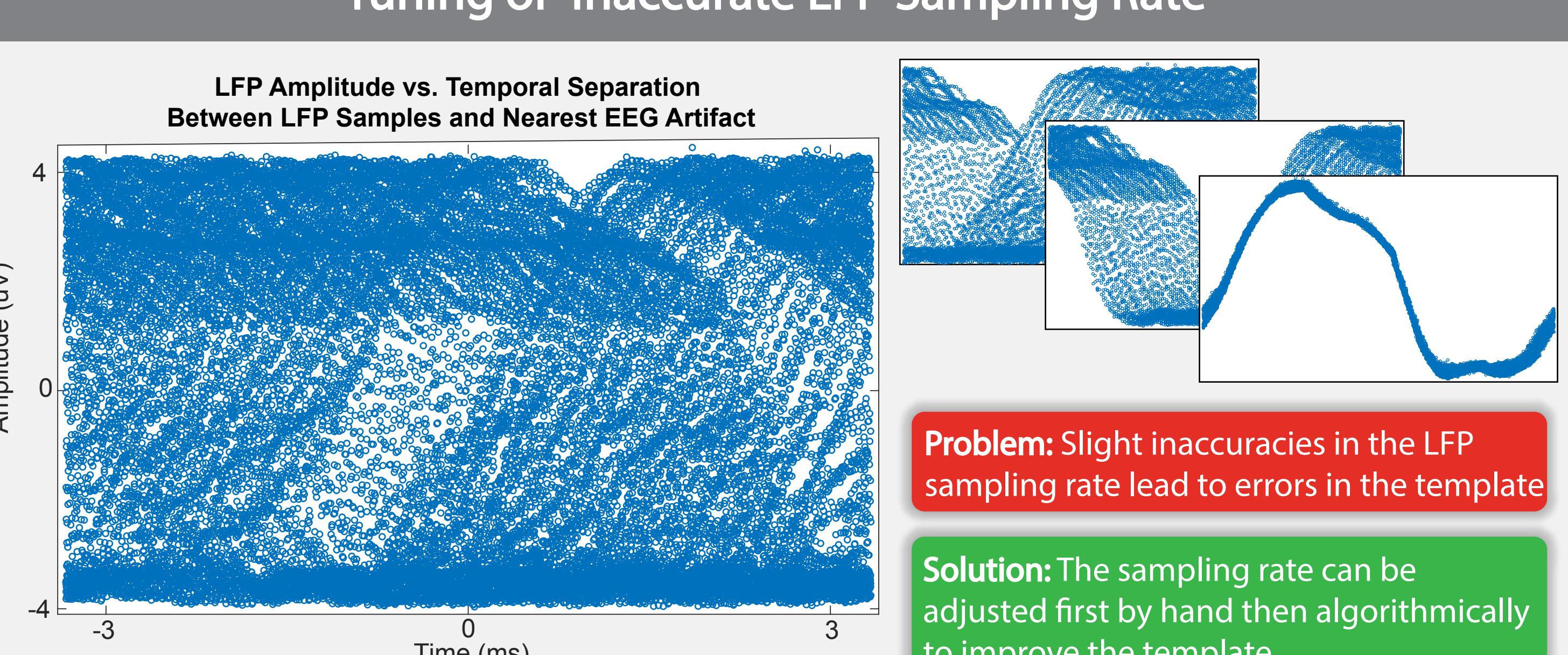


Problem: Low LFP sampling rate hides the accurate shape of the DBS artifact

Solution: LFP samples can be matched with the nearest EEG artifact to build a template

ARTIFACT RECONSTRUCTION

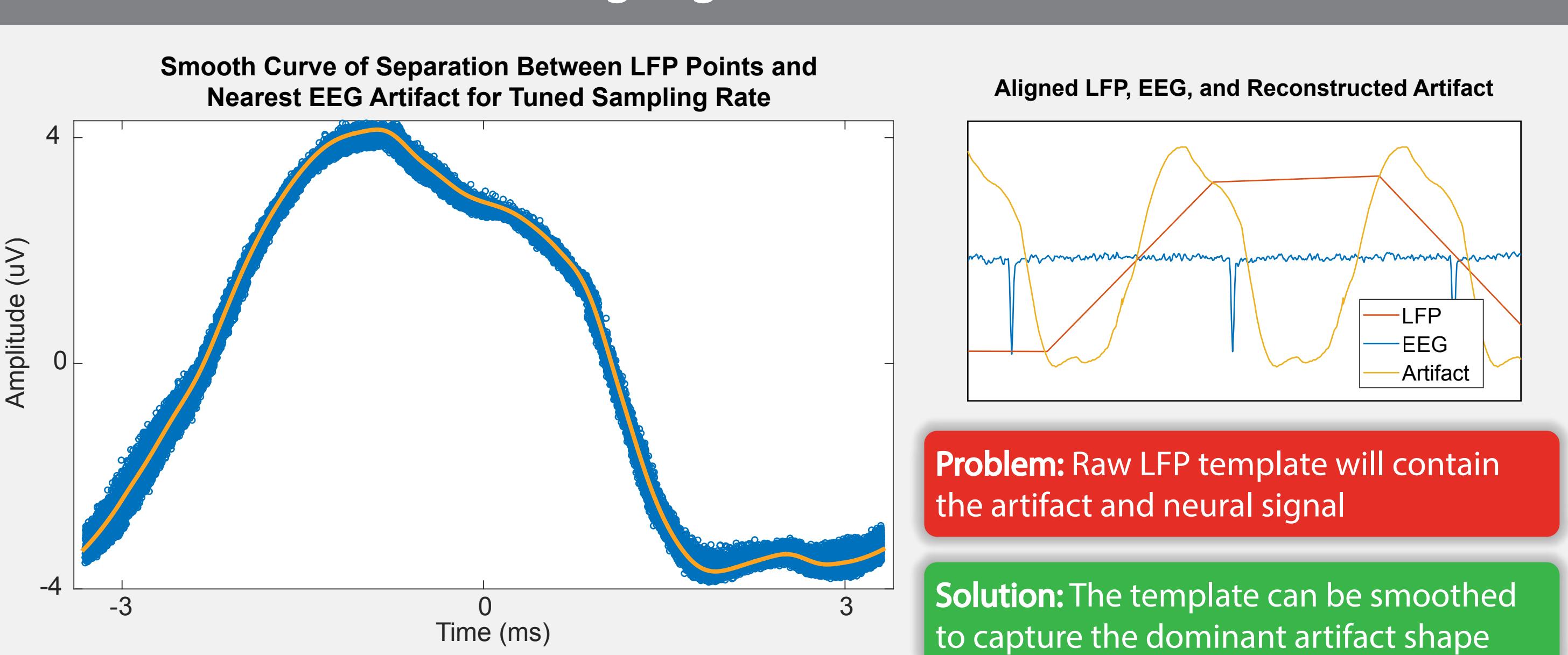
Tuning of Inaccurate LFP Sampling Rate



Problem: Slight inaccuracies in the LFP sampling rate lead to errors in the template

Solution: The sampling rate can be adjusted first by hand then algorithmically to improve the template

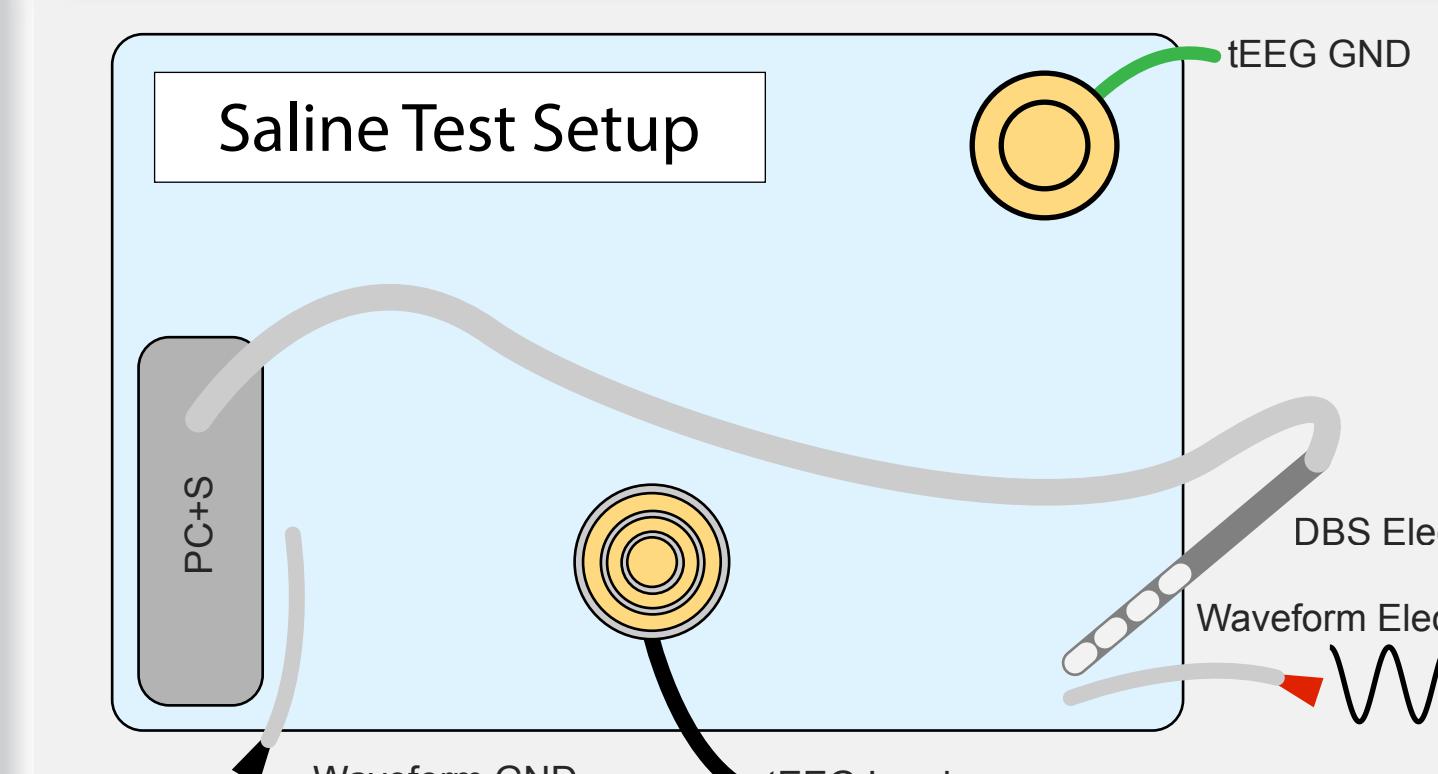
Smoothing High Resolution Artifact



Problem: Raw LFP template will contain the artifact and neural signal

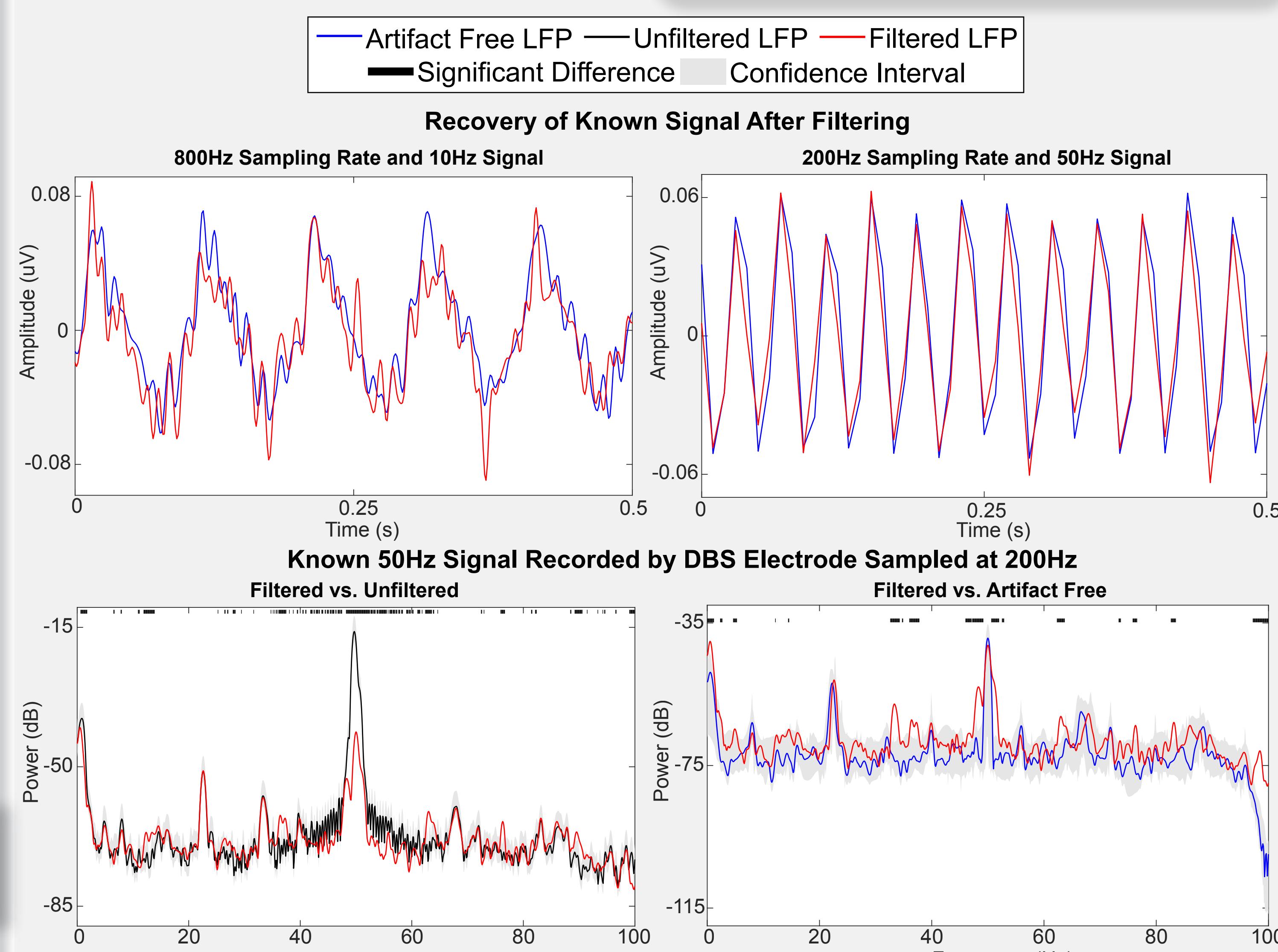
Solution: The template can be smoothed to capture the dominant artifact shape

ARTIFACT REMOVAL

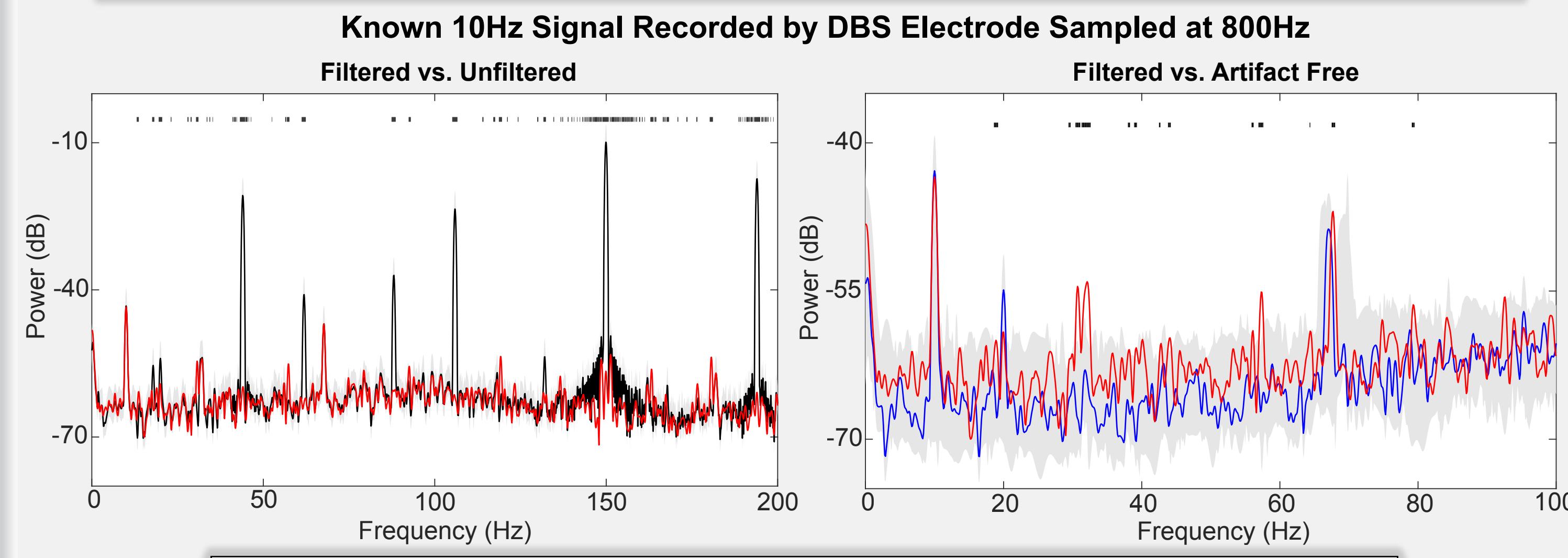


- Performance of the filtering approach was evaluated by recording signals in saline
- Both stimulation from the PC+S and known signals from a waveform generator were recorded on tEEG and DBS electrodes

By recording stimulation and a known signal in tandem, the performance of the filtering method can be evaluated by comparison to a ground truth



At 200Hz some aspects of the artifact are not sufficiently attenuated and filtering adds noticeable artifacts



At 800Hz all aspects of the artifact are well attenuated and filtering adds minor artifacts

CONCLUSIONS

- EEG and LFP can be aligned using regions when DBS is off
- Timing of artifacts in EEG can be used to reconstruct a high resolution LFP artifact
- True LFP sampling rate can be found through maximizing the convergence of the artifact
- This method can effectively remove artifacts at higher sampling rates with reduced performance at lower sampling rates
- Further work on developing the methods for choosing the exact point for alignment of EEG and LFP and algorithmically converging and smoothing the template will improve attenuation of the artifact and quality of the filtered signal

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