Neurophysiology-guided programming

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Disclosures

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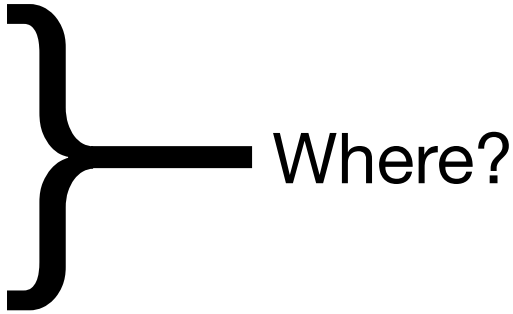
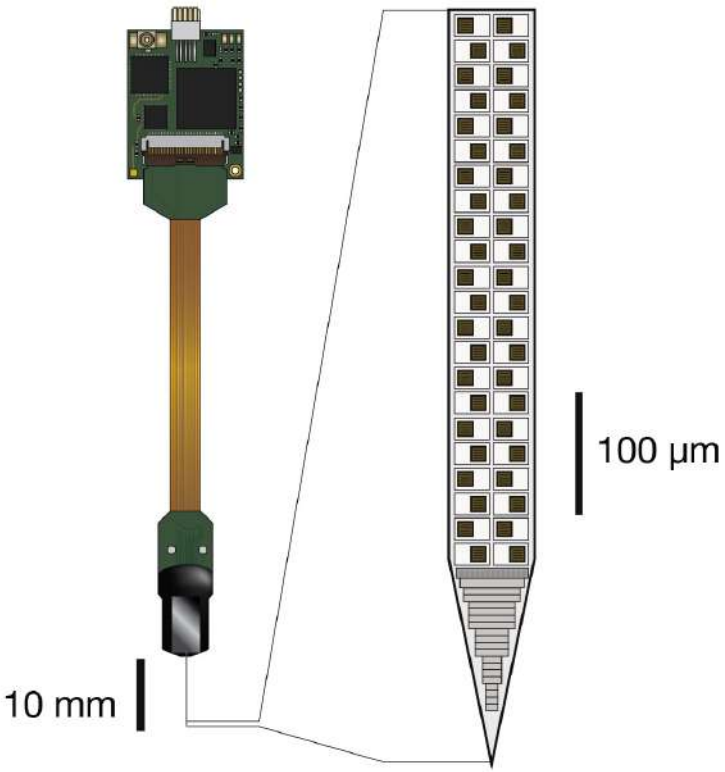
Outline: Neurophysiology guided programming

- Sensing basics

- Pathophysiologic biomarker localization
- Evoked potentials

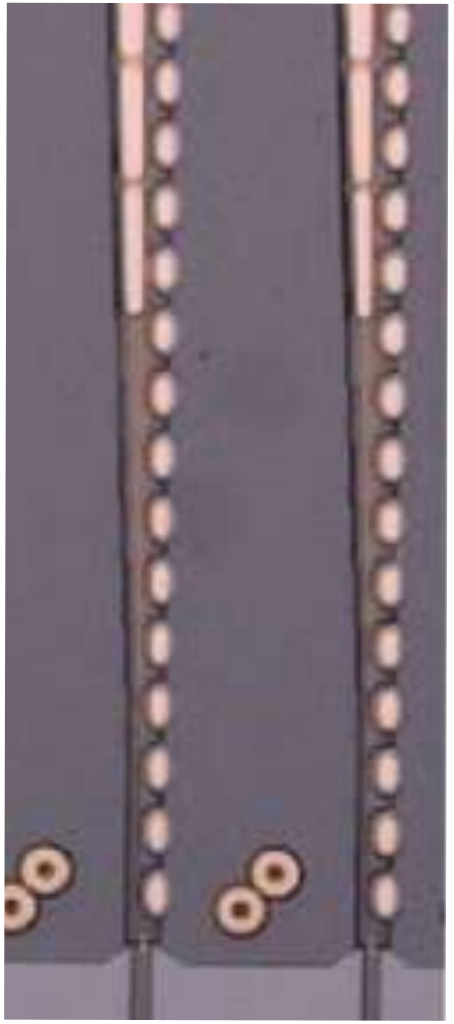


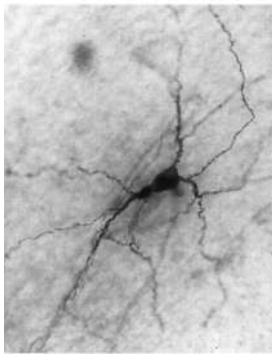
- Adaptive deep brain stimulation



Neuropixel

Neuropixel, brain-map.org



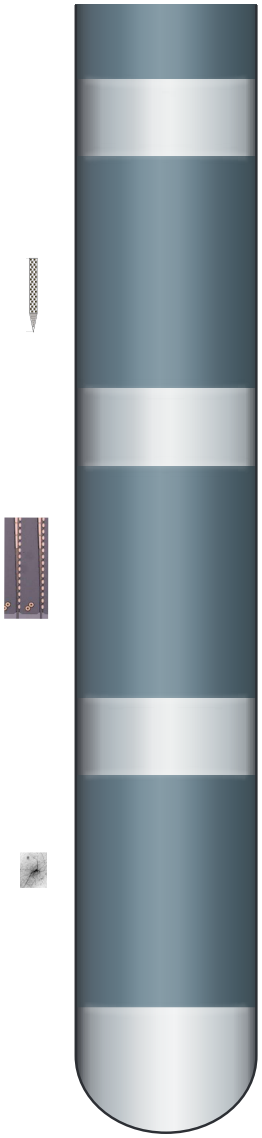


Neuralink thread

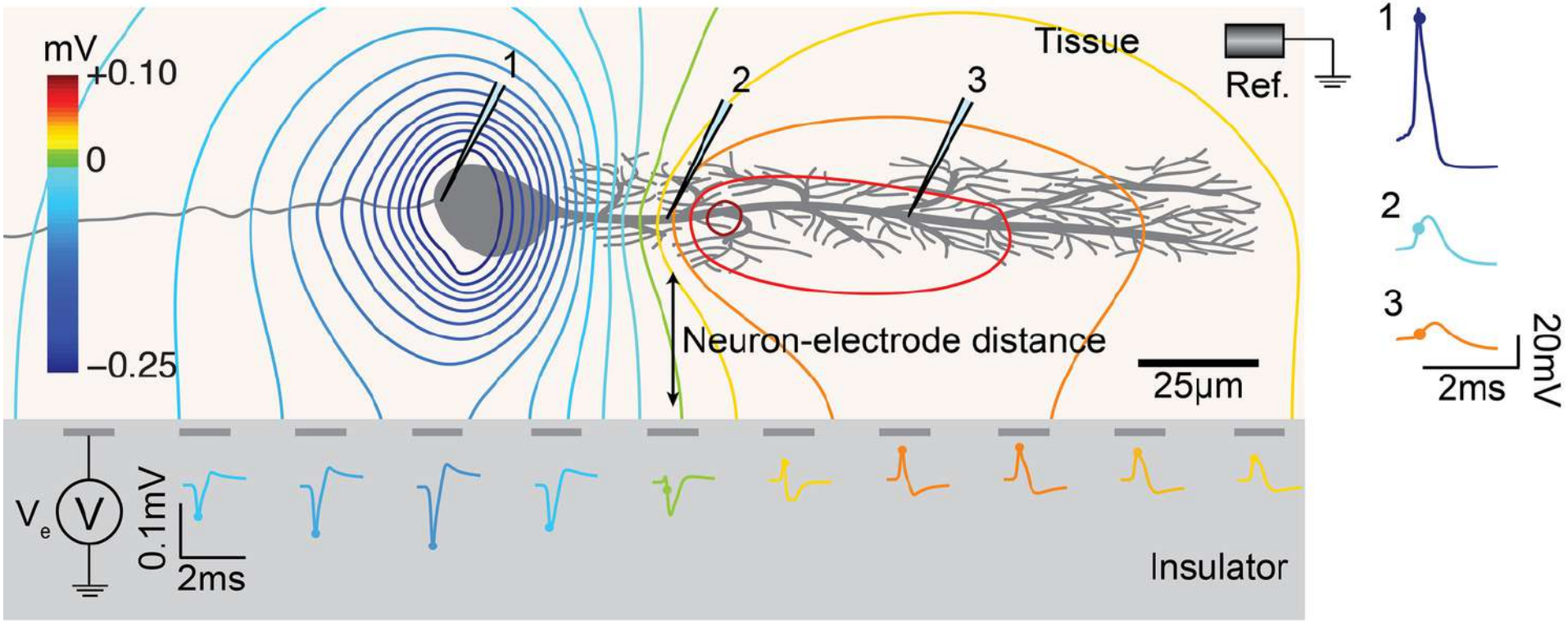
Musk E, Neuralink J Med Internet Res 2019;21(10):e16194

C **Wilson, S. (1914, Brain). An experimental research into the anatomy and physiology of the corpus striatum.**
From the site of the lesion in the putamen there is very well marked and easily followed fine degeneration in numerous bundles or pencils of fibres, all, without exception, degenerating in a ventral, caudal, and mesial direction, towards the mesial plane.

Horn A, et al. Neurology. 2019;92(14):e1663-e1664

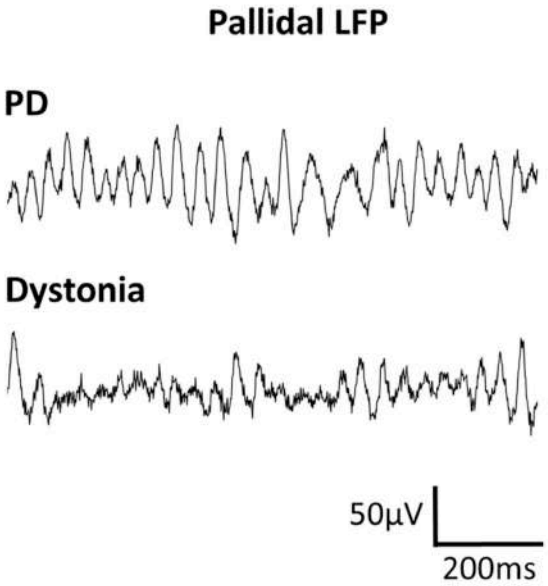


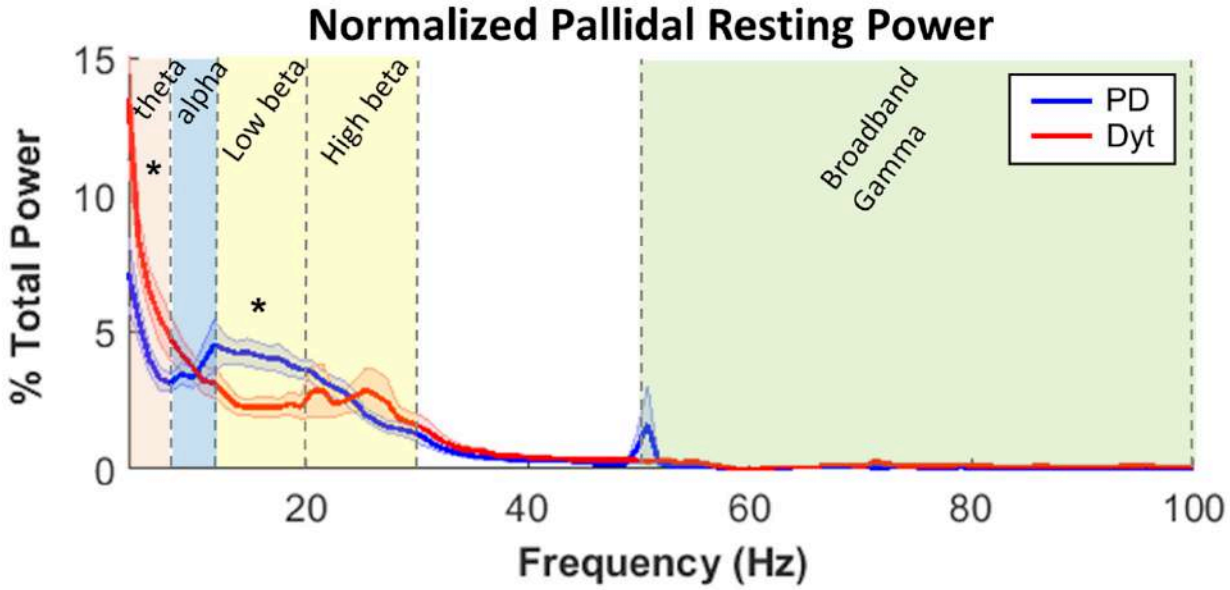
Single neuron potentials



Obien MEJ, et al. Front Neurosci. 2015

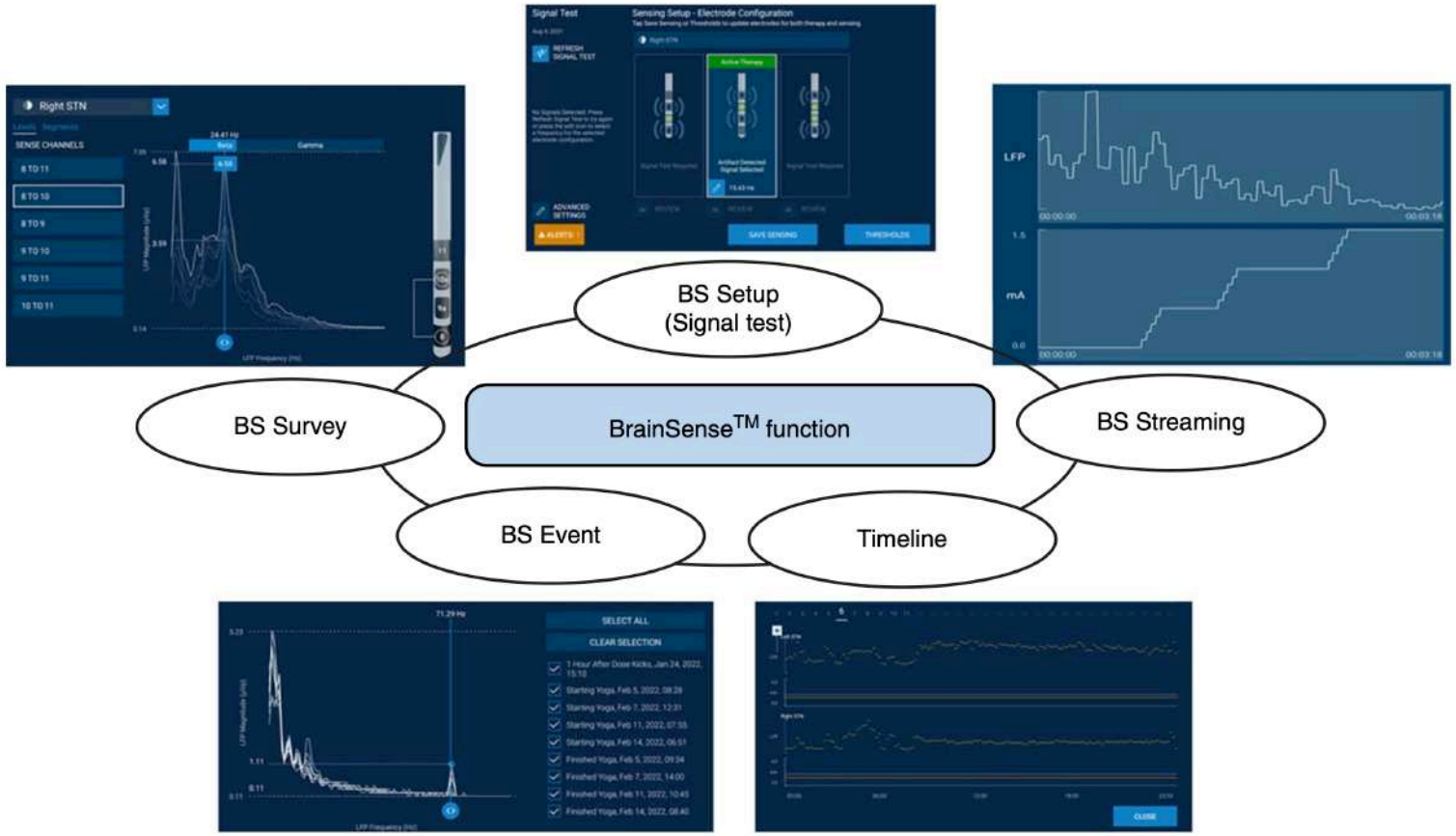
Local field potentials





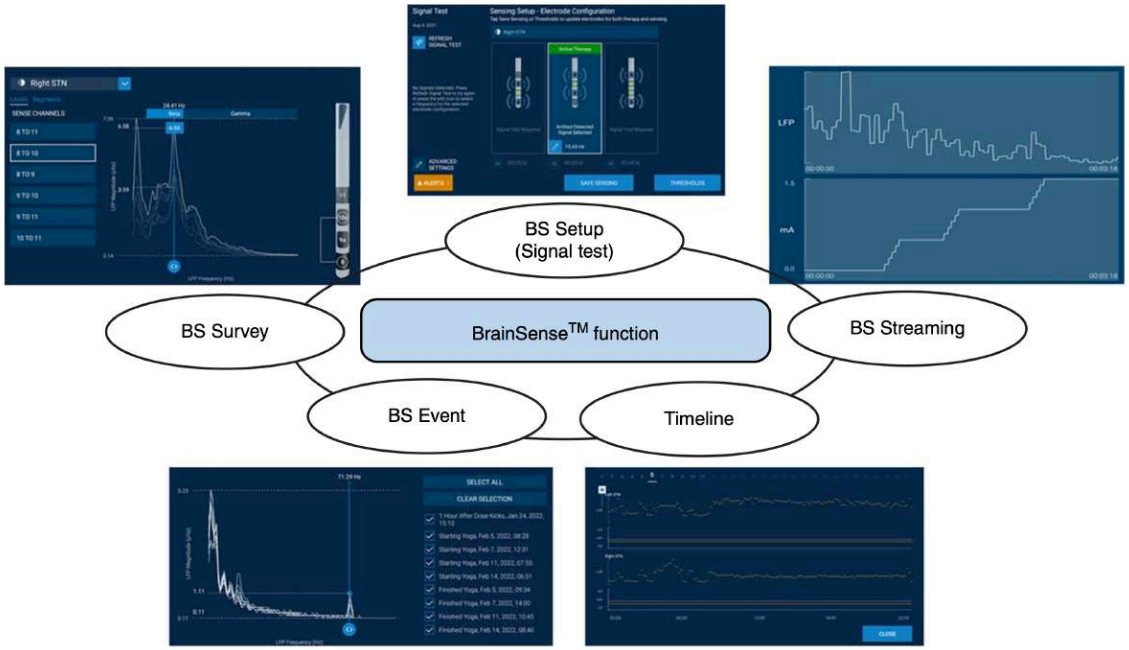
Wang D, et al. J Neurosci 2018

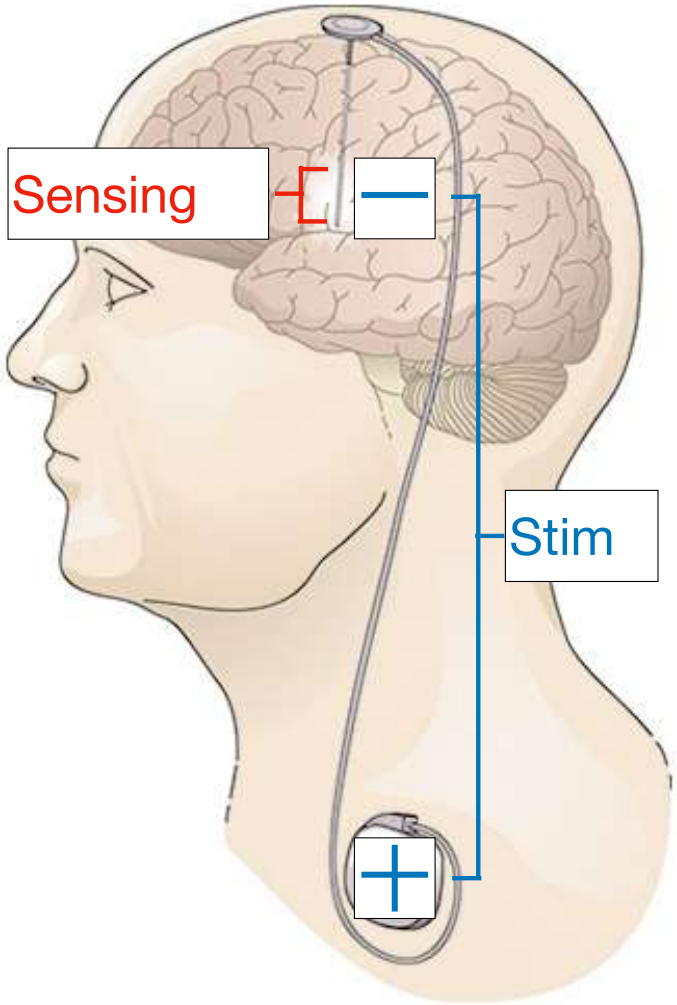
Sensing data modes



Saengphatrachai W, et al., Neurodegener Dis Manag. 2024

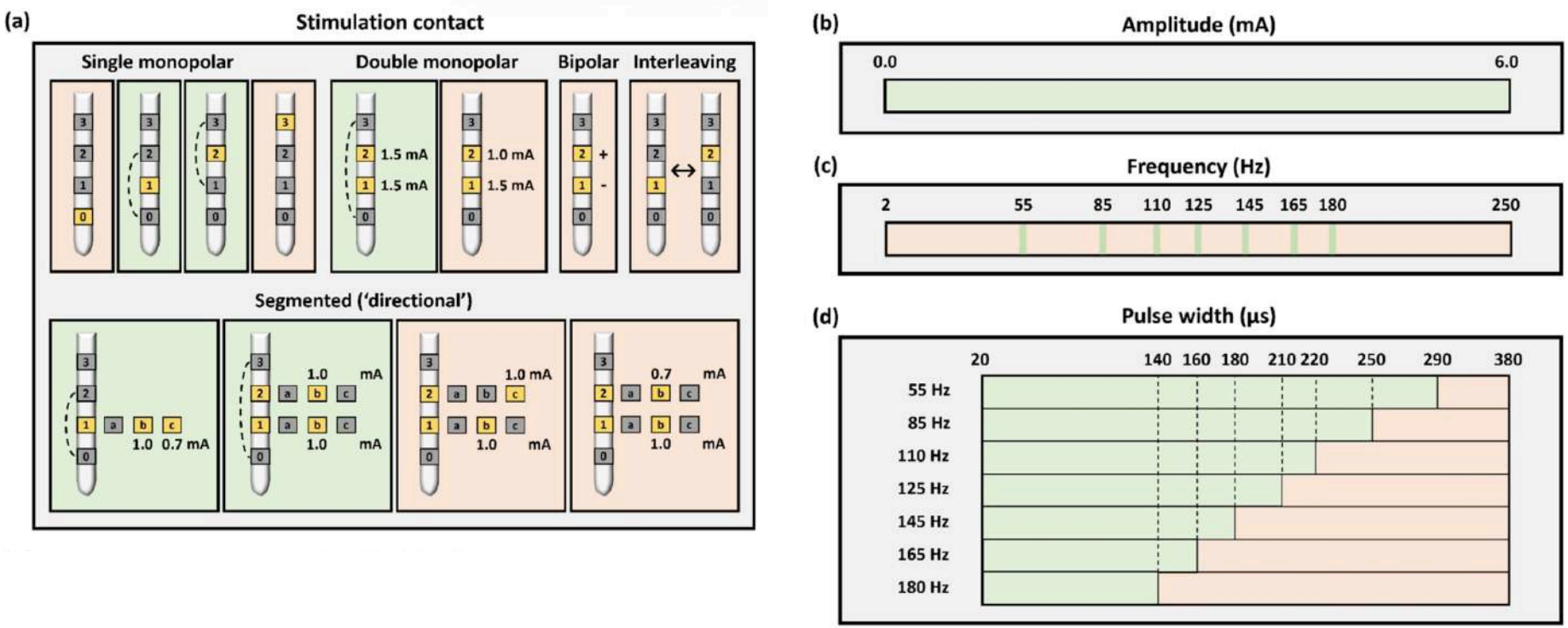
Sensing data modes





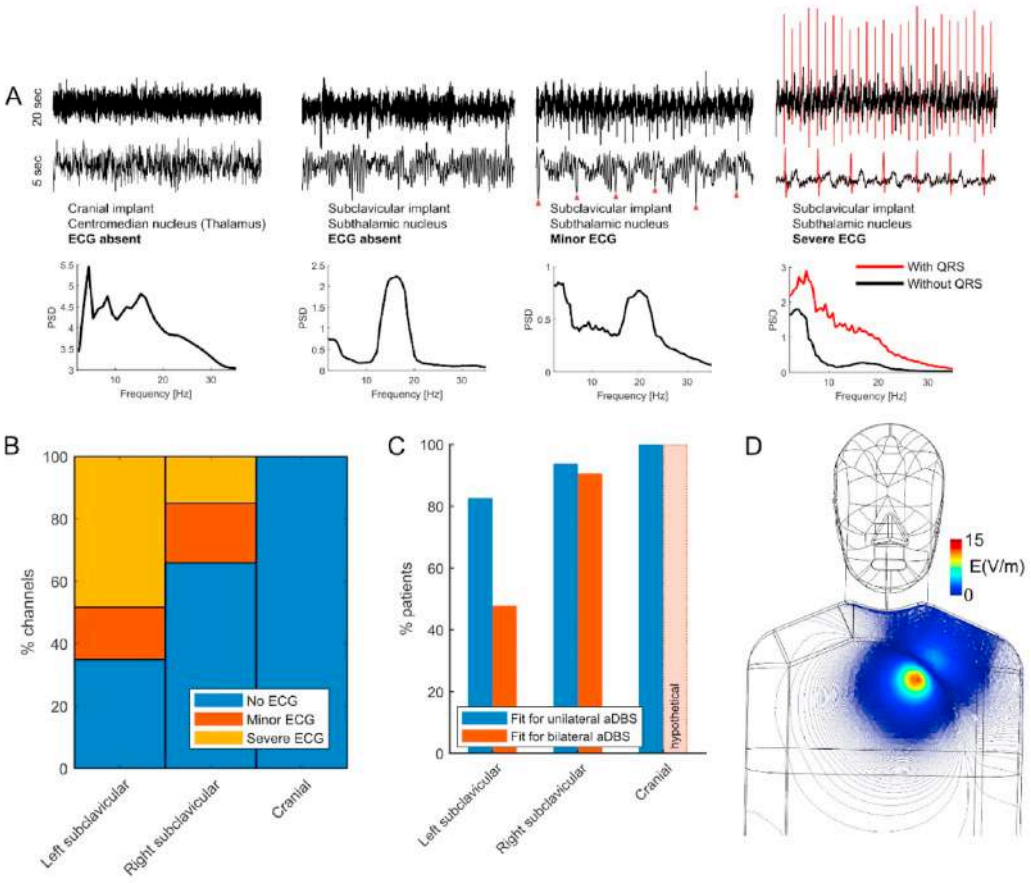
Saengphatrachai W, et al., Neurodegener Dis Manag. 2024

Sensing compatible stimulation parameters



Swinnen B, et al, J Neural Eng 2025

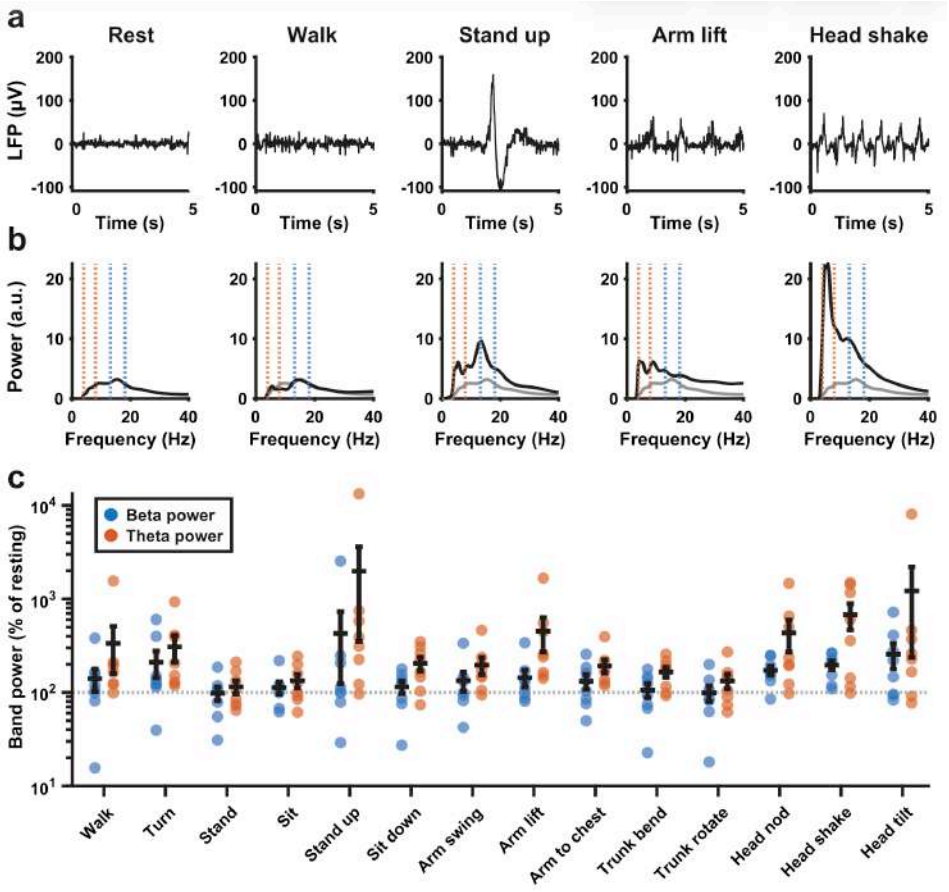
ECG artifact



- ECG artifact is more frequent and larger in amplitude for left vs. right subclavicular IPGs
- ECG artifact can have broad power across the delta-beta (1-30 Hz) frequency range

Neumann J, et al. Brain Stimulation 2021

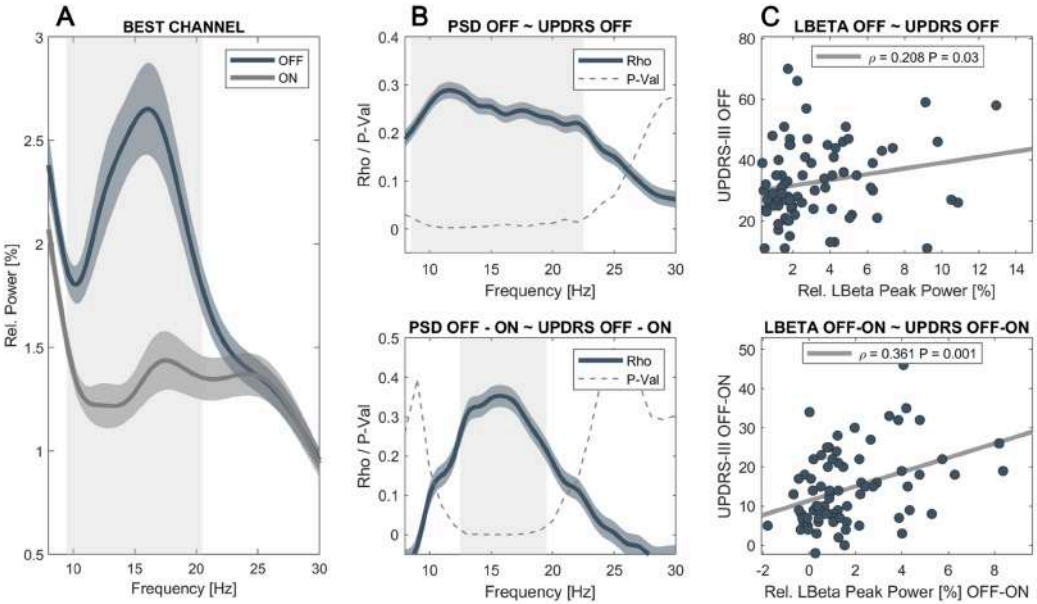
Motion artifacts

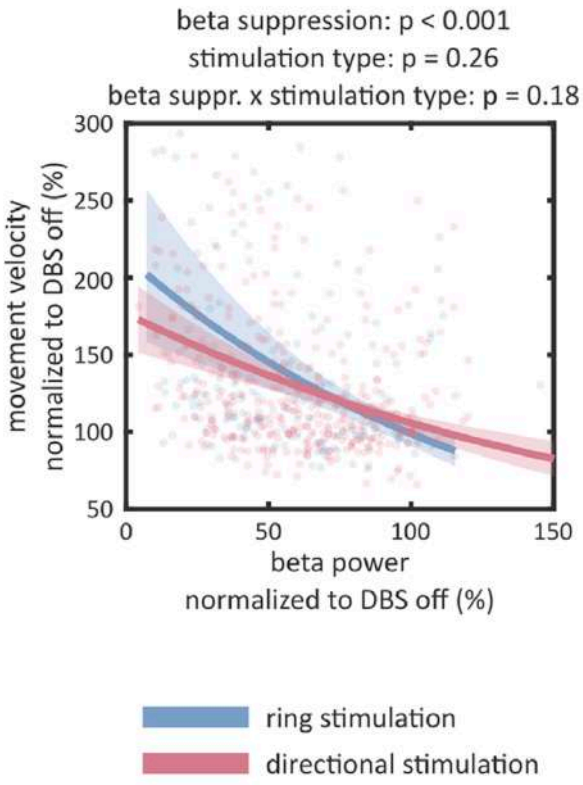


van Rheede JJ, et al. npj Parkinson's disease 2022

- Movements that move the IPG or strain the extenson lead can result in artifacts with significan theta, alpha and beta power

Beta power suppression correlates with clinical response to levodopa or DBS

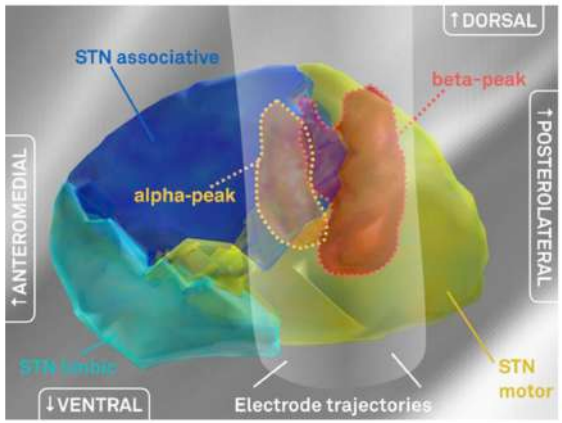


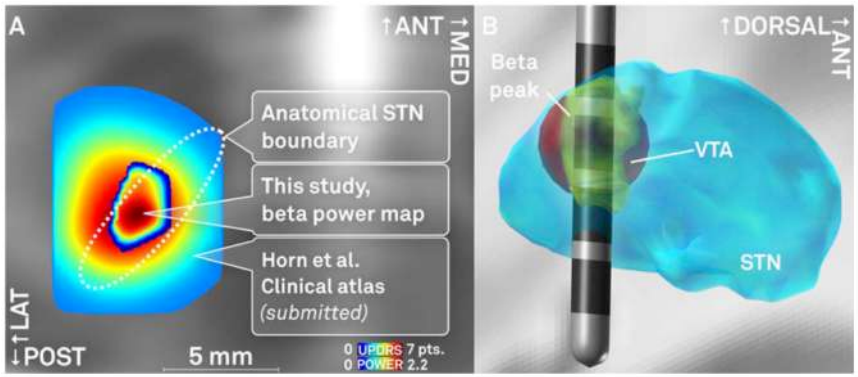


Lofredi R, et al. NPJ Park's Dis 2023

Busch JL, et al. Mov Disord 2023

Region of highest STN beta power aligns [on average] with best stimulation location

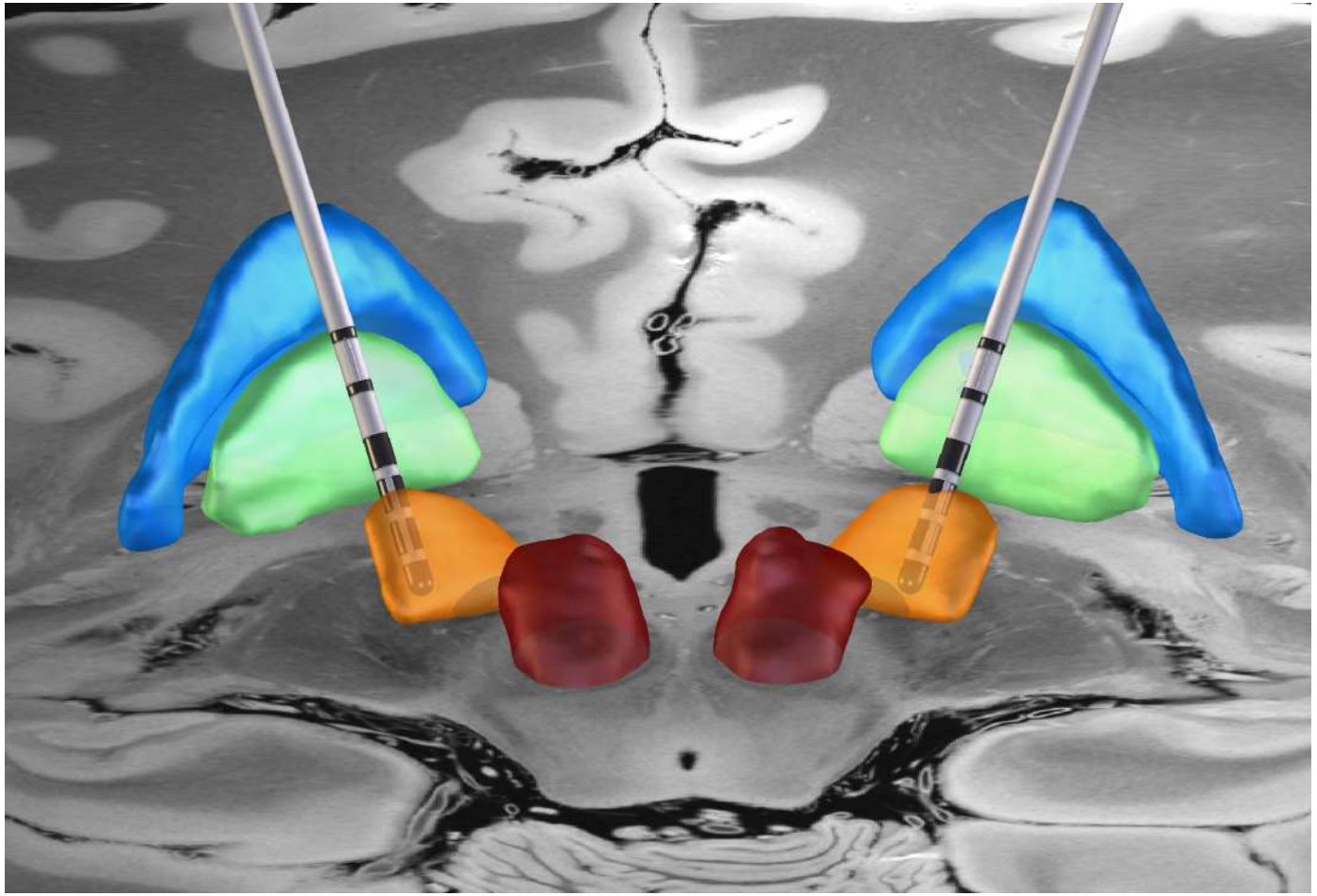




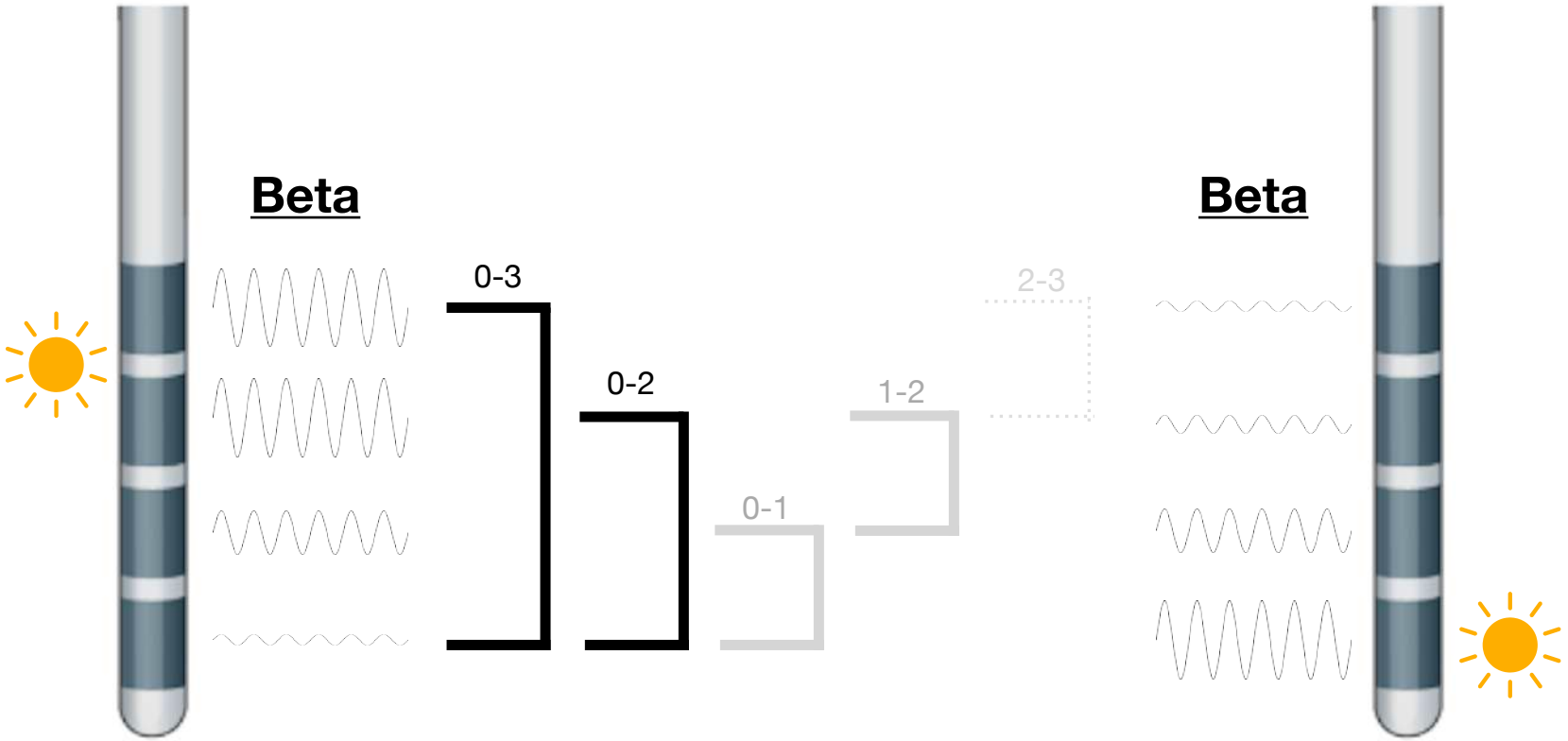
- STN beta power and the stimulation location associated with greatest UPDRS improvement both map to the posterior-dorsal-lateral (sensorimotor) STN

Horn A, et al. Human Brain Mapping 2017

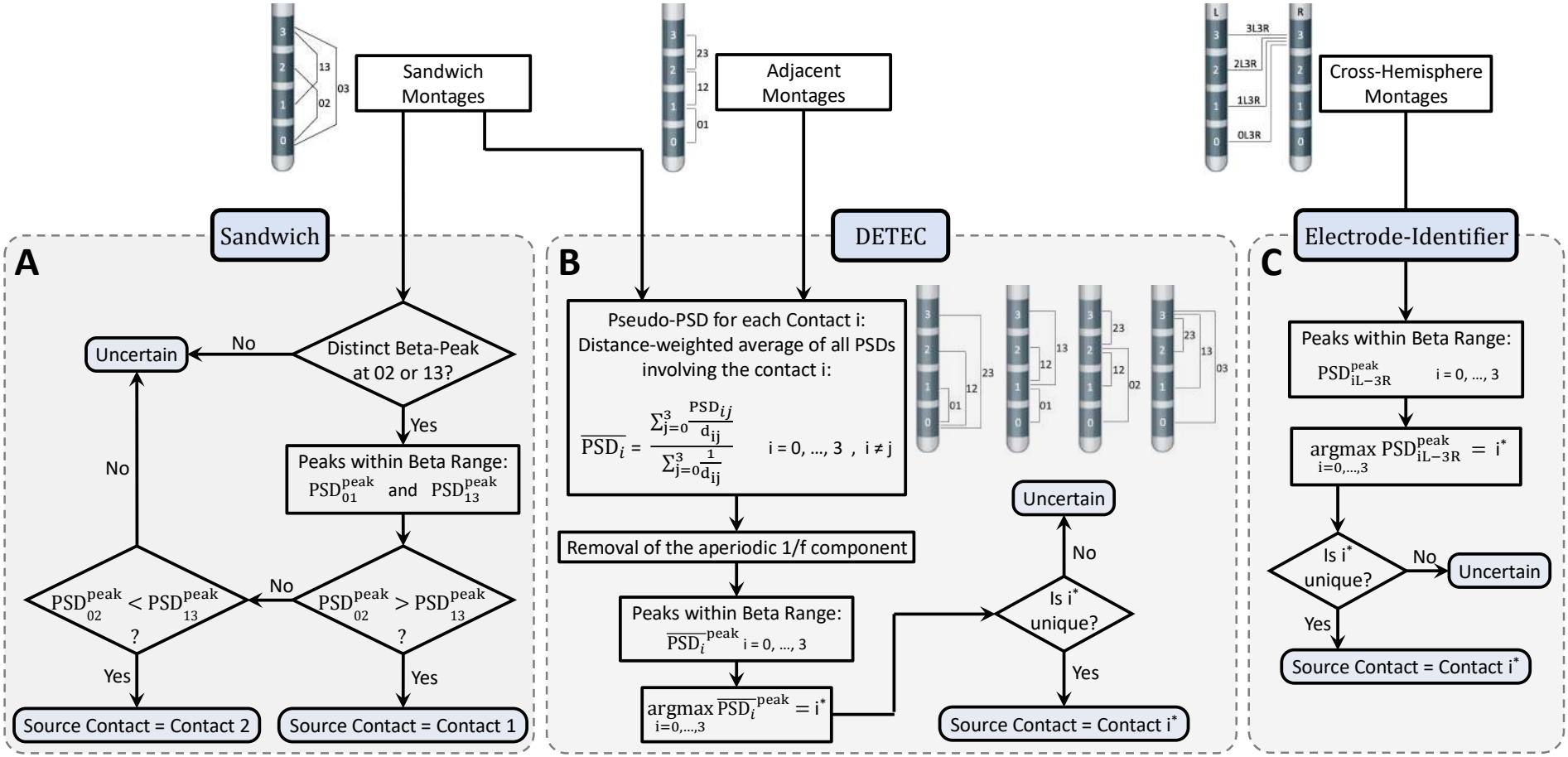
Can we localize the beta power along our DBS electrode?



Localizing beta using sensing-enabled DBS



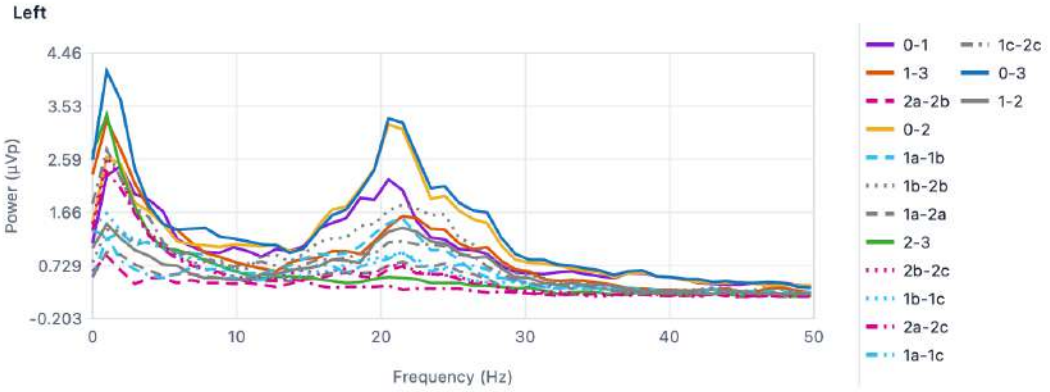
Methods to localize beta field potentials



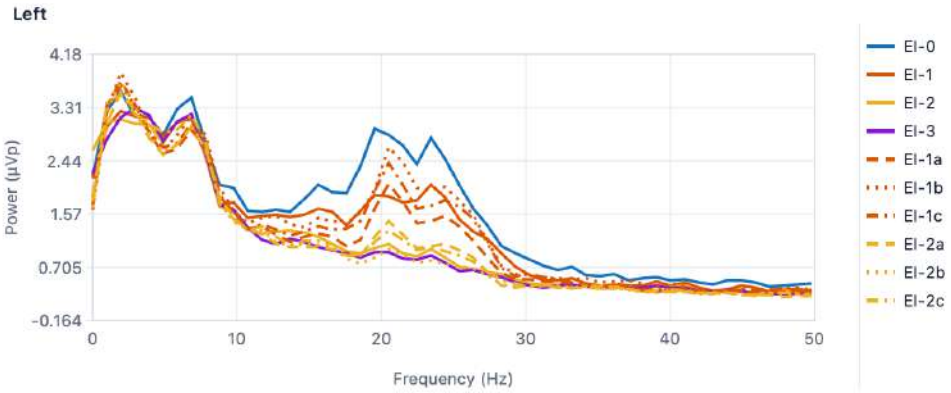
Mapar and Herrington, *in preparation*

Electrode identifier

BrainSense Survey



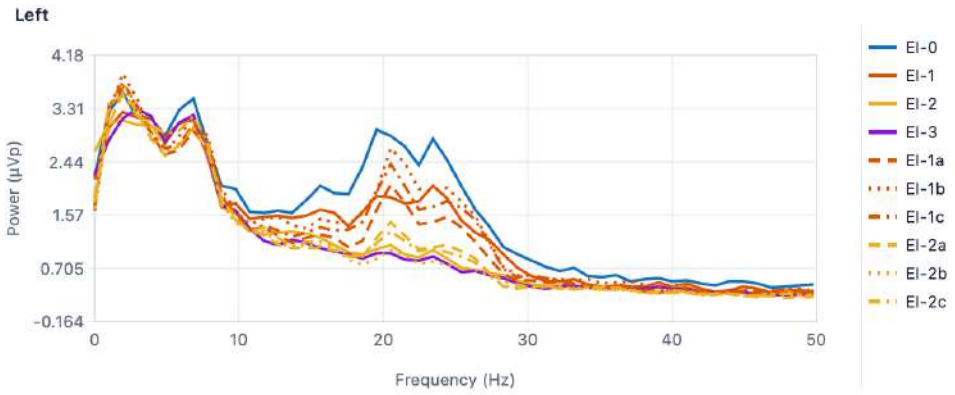
Electrode Identifier



- BrainSense Survey (bipolar recordings) is ambiguous as to the contact with largest beta amplitude
- Electrode identifier confirms largest beta amplitude at contact 0 > 2 (b>c>a)

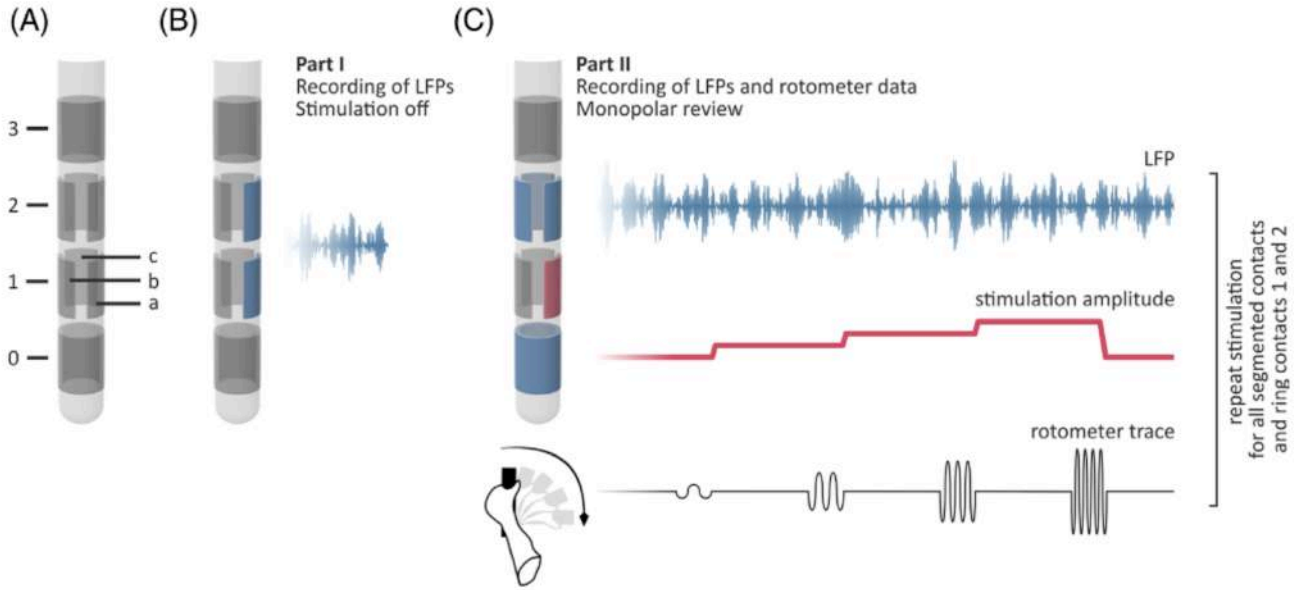
Beta features to predict most effective contact

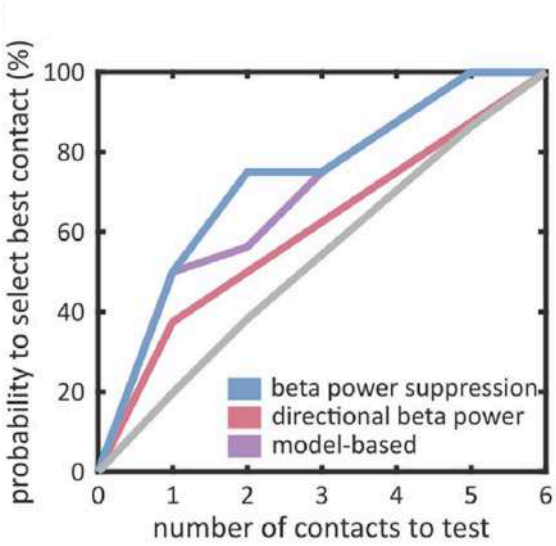
Max beta power location (Electrode Identifier)



Max beta suppression (BrainSense streaming)

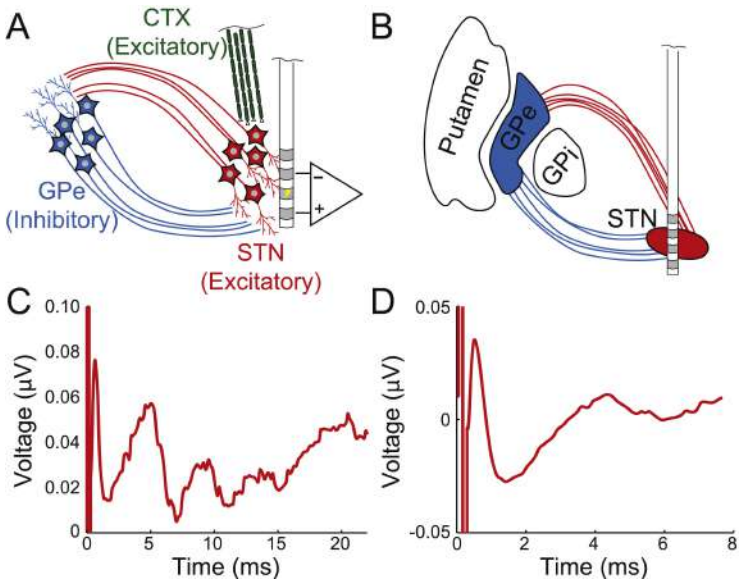
Beta features to predict most effective contact



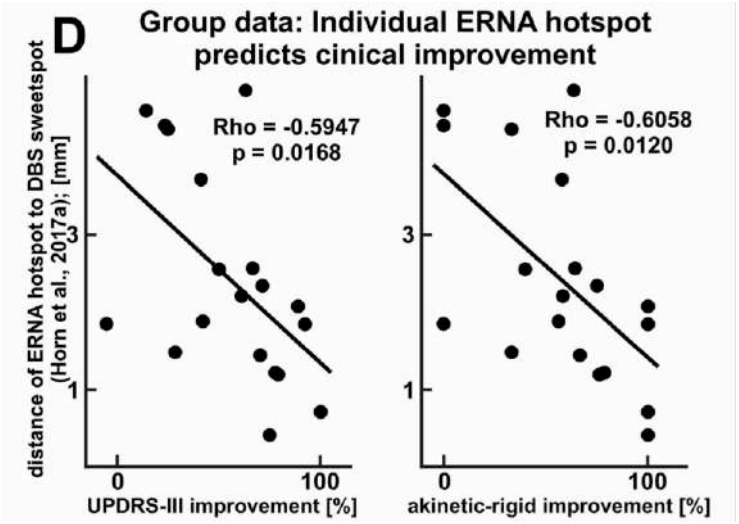


Busch JL, et al. Mov Disord 2023

DBS evoked resonant neural activity (ERNA)



High-frequency DBS induces a 200-500 Hz oscillation that decays gradually after DBS cessation. Most likely an STN-GPe oscillator.

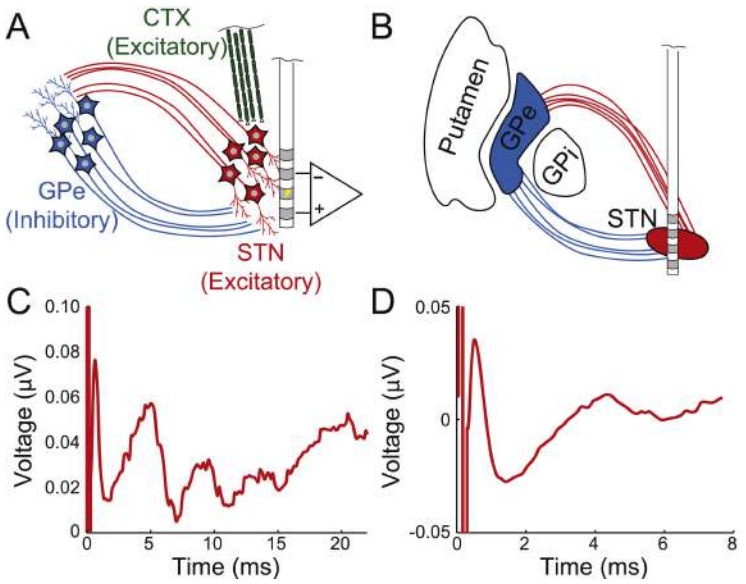


DBS contacts that more effectively engage this ERNA oscillations are associated with better clinical response

Schmidt et al., Brain Stimulation 2020

Steiner et al., Nat Communications 2024

DBS evoked resonant neural activity (ERNA)



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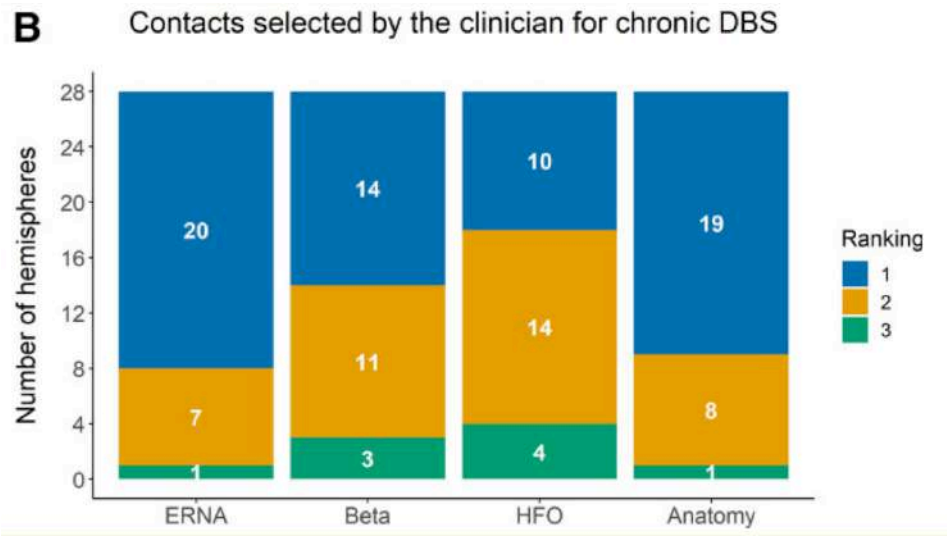


ERNA outperformed beta amplitude in selecting the best stimulation contact, alignign in 20/28 hemispheres.

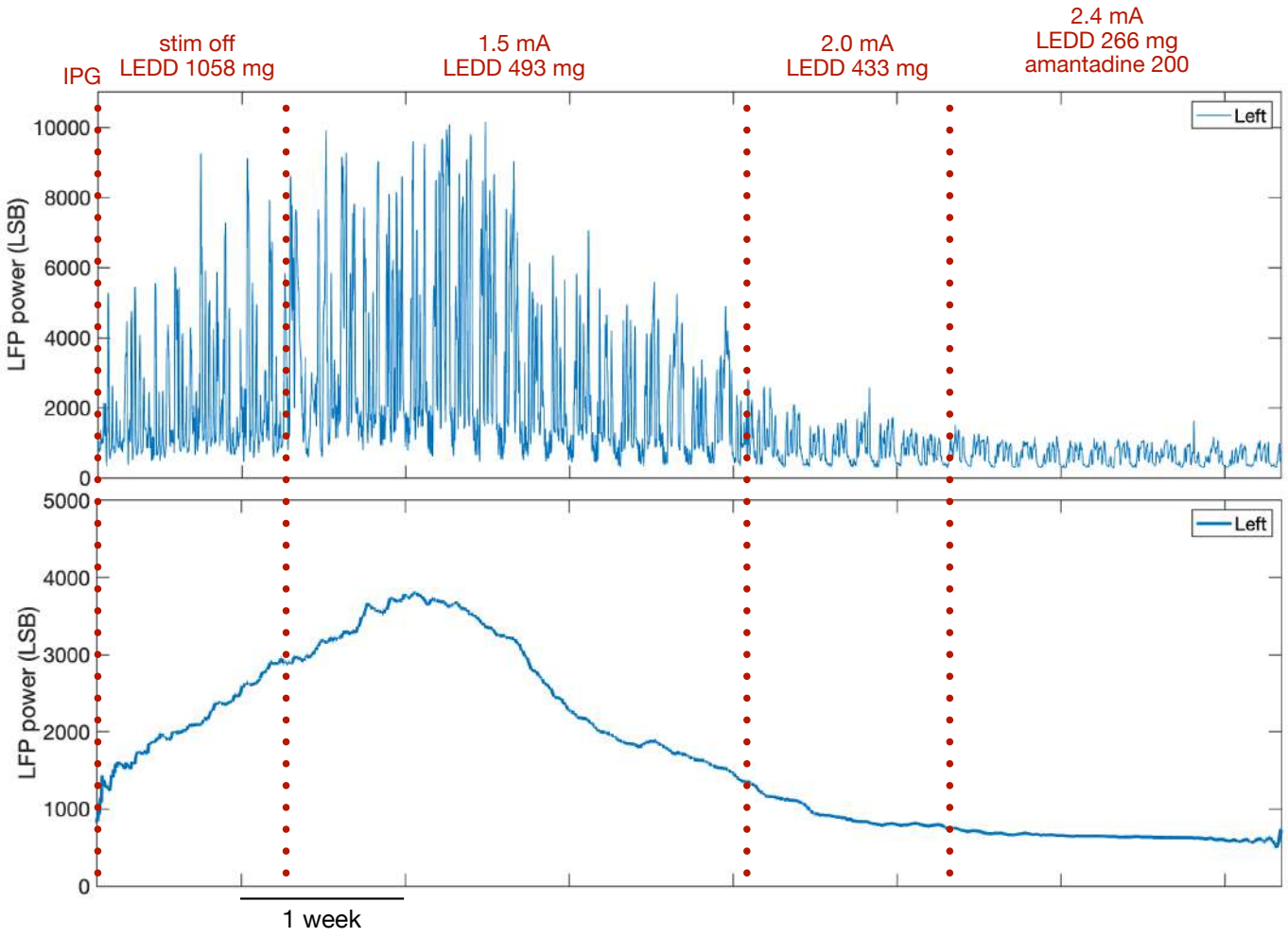
Schmidt et al., Brain Stimulation 2020

Xu et al., Brain Communications 2022

Summary

- Beta power, beta power suppression and ERNA are all better than chance at predicting the DBS contact with best clinical response
- No definitive head-to-head comparison of all methods has been published
  - technical limitations may not allow all methods to be applied to every electrode
  - there are different approaches to quantify each biomarker and these differences may influence results
- No physiology biomarker predicts the best contact with 100% accuracy. Clinical assessment remains primary.

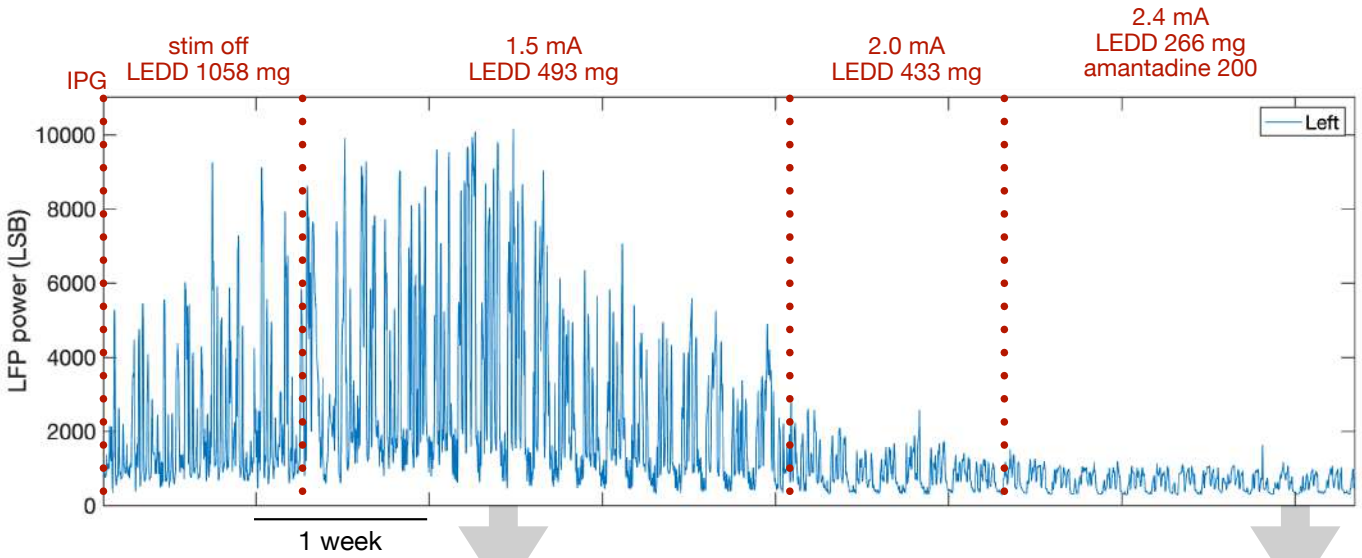
Beta power correlates with levodopa-induced fluctuations



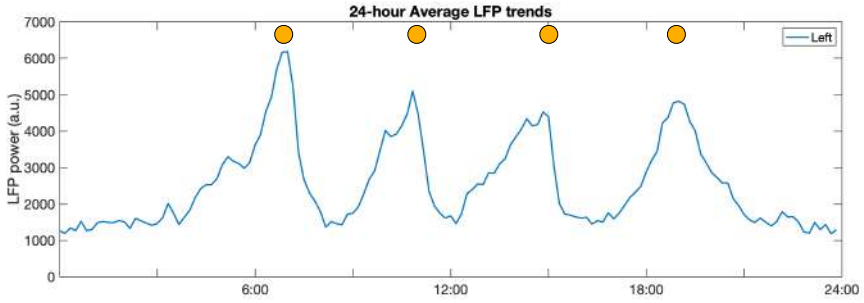
1 hour smoothing

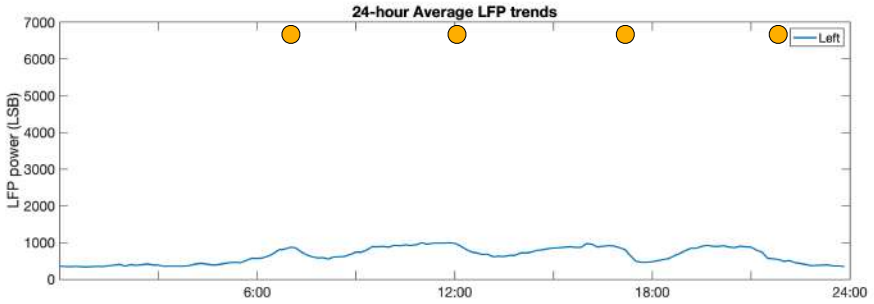
1 week smoothing

Beta power correlates with levodopa-induced fluctuations



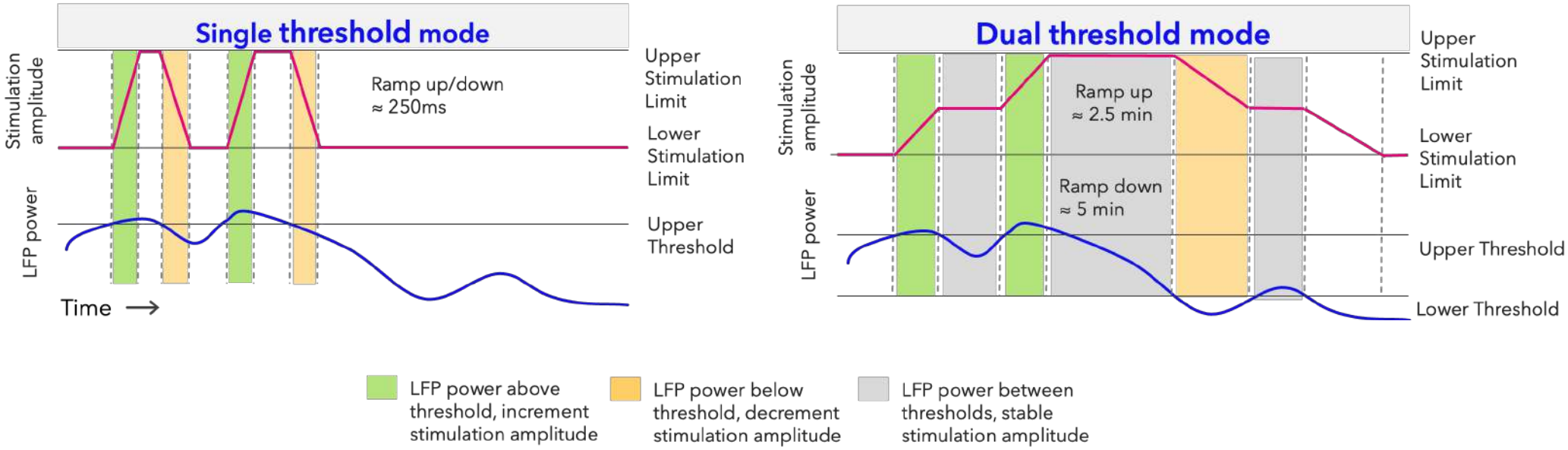
1 hour smoothing





Levodopa dose

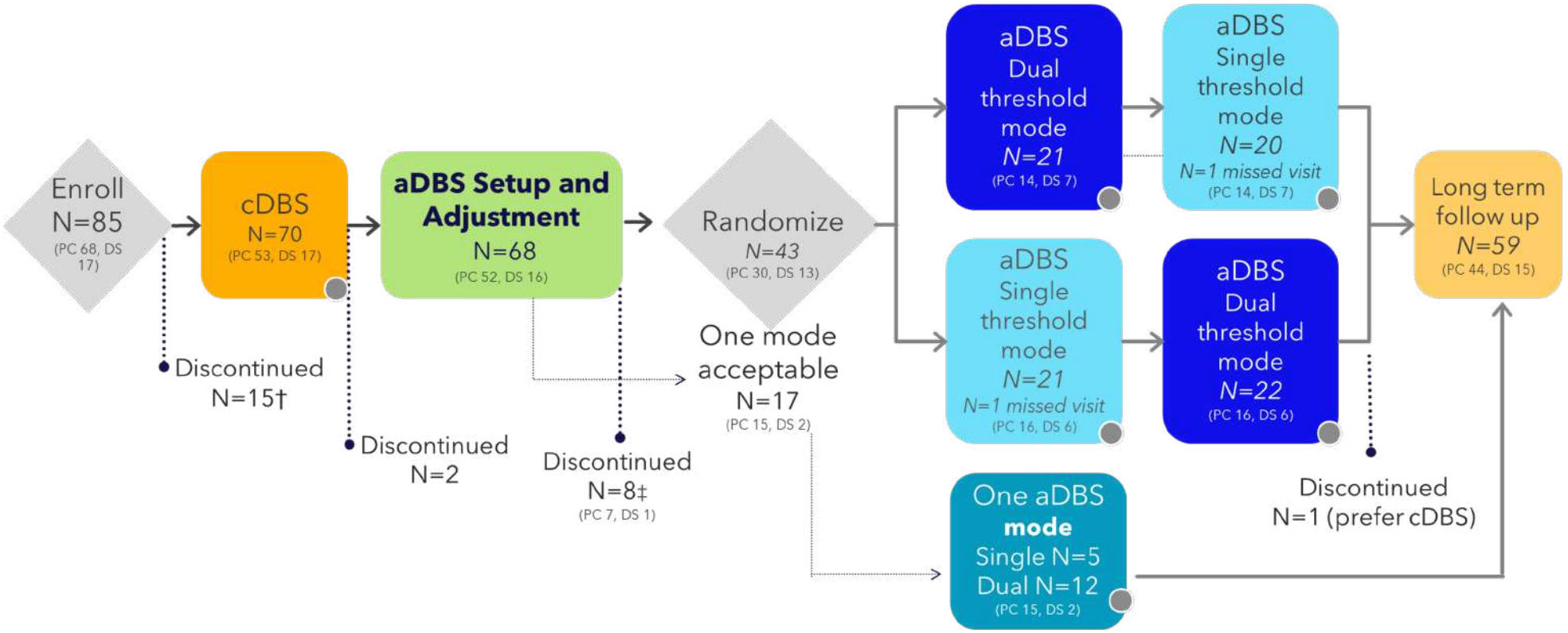
Fast and slow-adapting DBS



adapted from: Stanslaski S, et al. npj Park's Dis. 2024

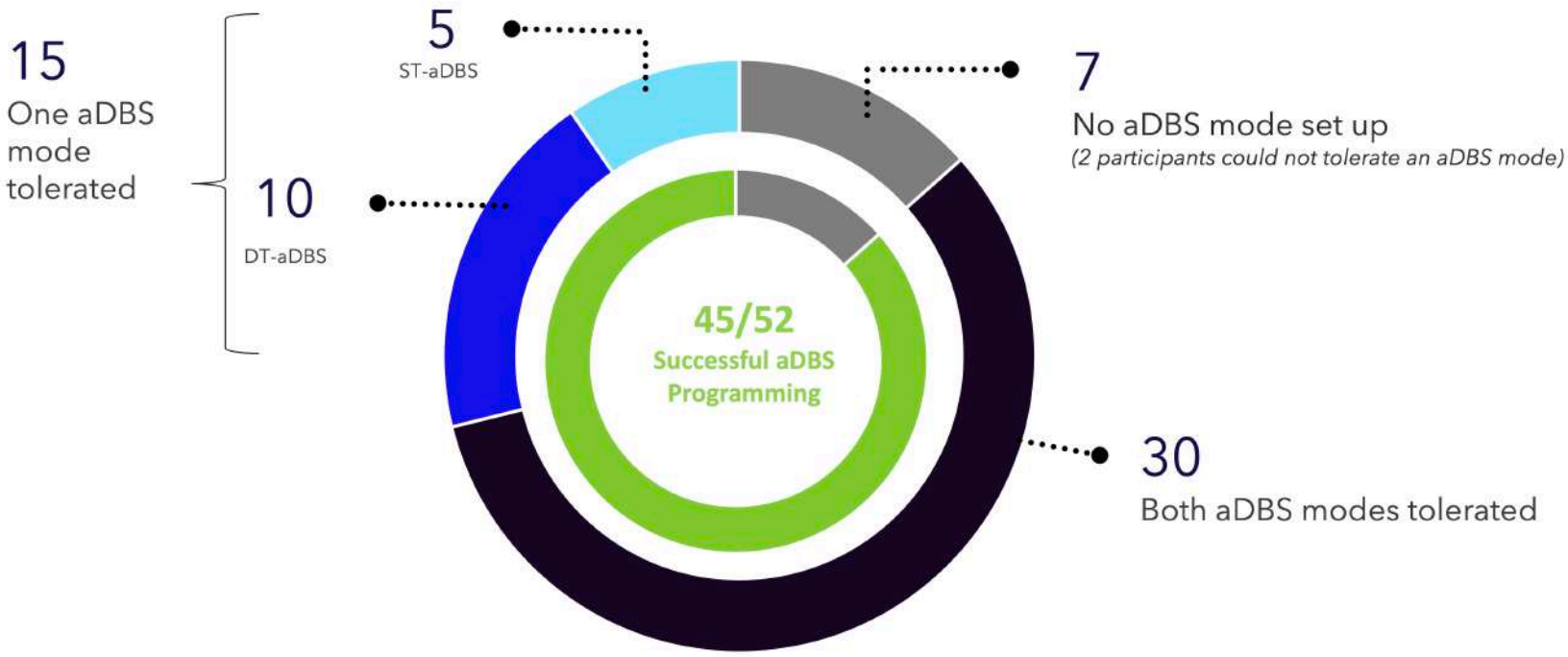
ADAPT-PD trial

Adaptive DBS Algorithm for Personalized Therapy in Parkinson's Disease



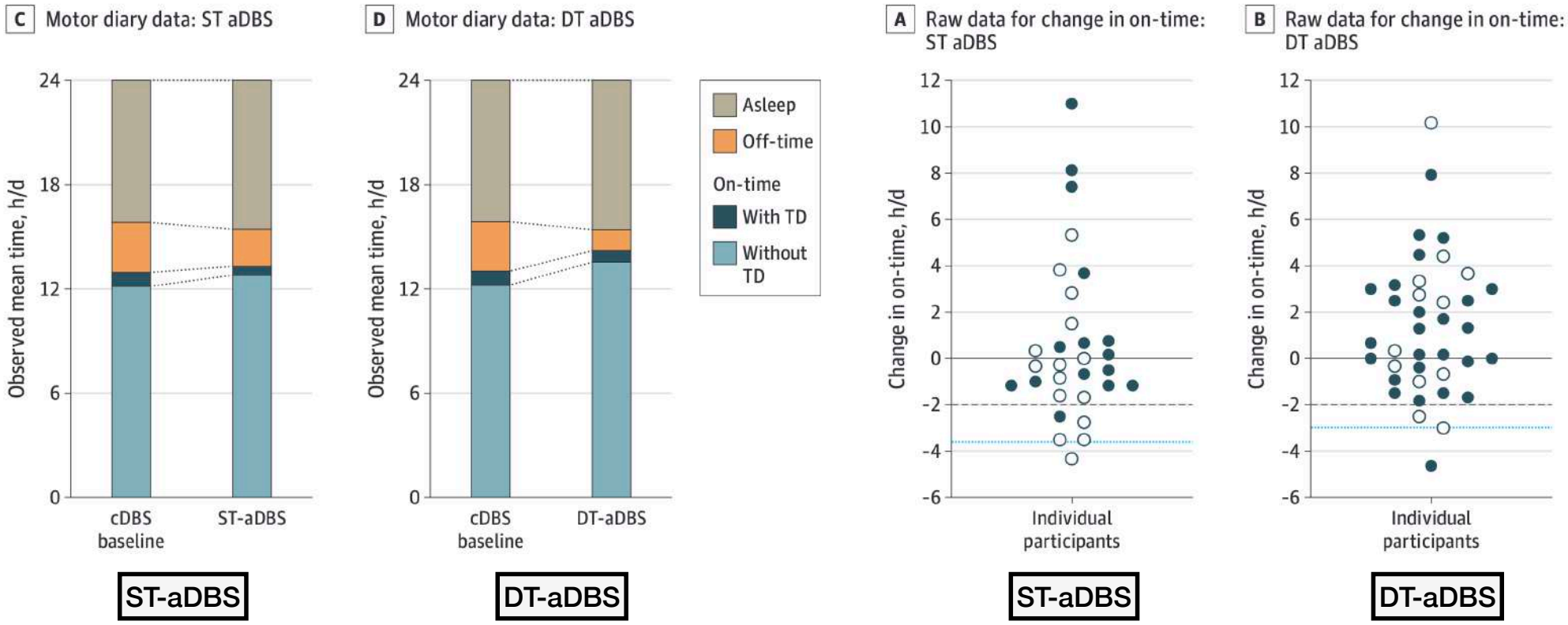
Bronte-Stewart HM, et al. JAMA Neurol 2025

aDBS could be programmed in a majority of screened patients



Bronte-Stewart HM, et al. JAMA Neurol 2025

ADAPT-PD outcomes: aDBS increased “on” time in unblinded comparison against baseline cDBS

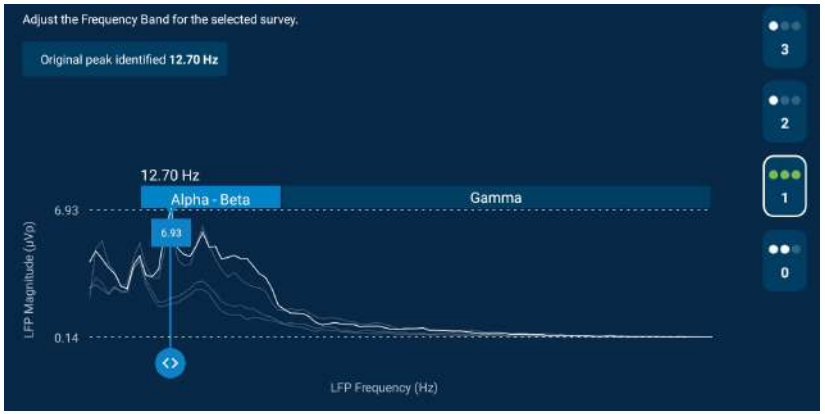


Bronte-Stewart HM, et al. JAMA Neurol 2025

aDBS case

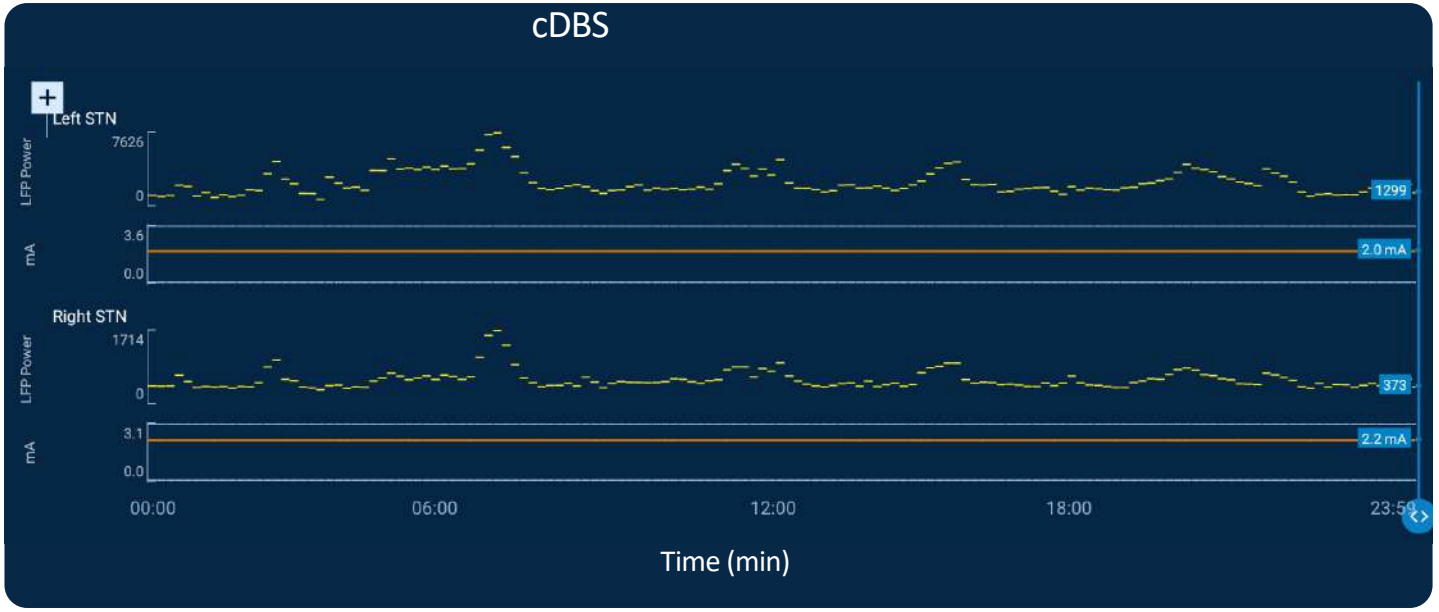
Programming

- pre-DBS levodopa
  LEDD 1150 + prn levodopa
  amantadine 300 mg/day
- cDBS settings
  Left: C+ 2-, 2.0 mA, 60 µs, 125 Hz
  Right: C+ 9-, 2.2 mA, 60 µs, 125 Hz
- post-DBS levodopa
  LEDD 650 + minimal prn levodopa
  amantadine 100 mg/day



Patient Response to cDBS

- Improvement in gait, off time, dyskinesia
- Still experiencing intermittent off time but increase standing levodopa or cDBS current worsened dyskinesia



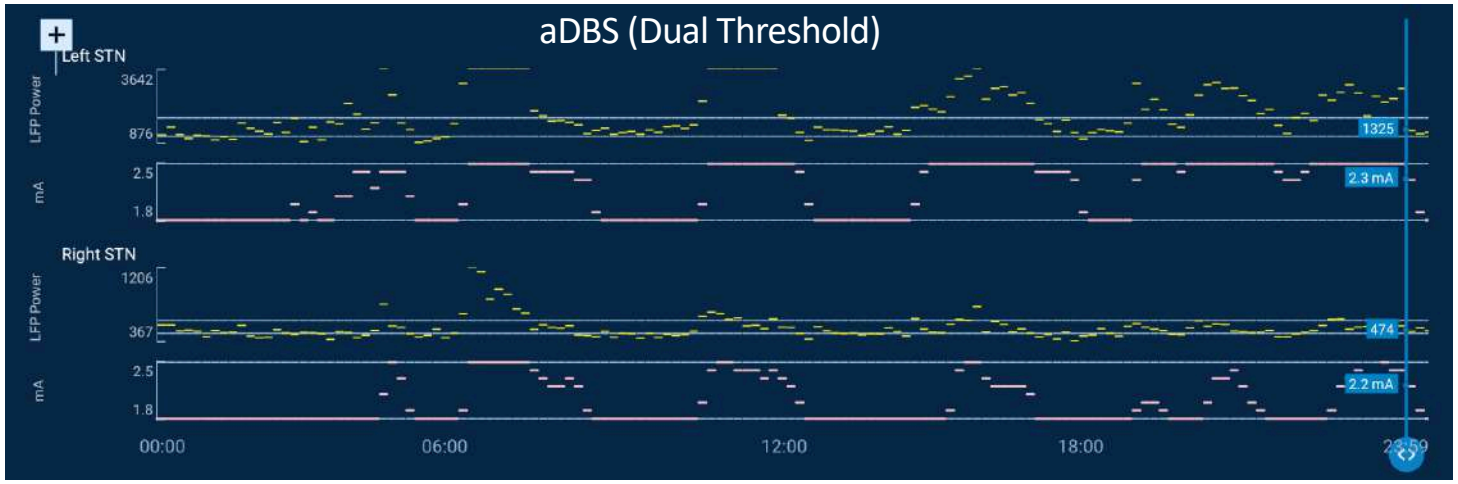
aDBS case

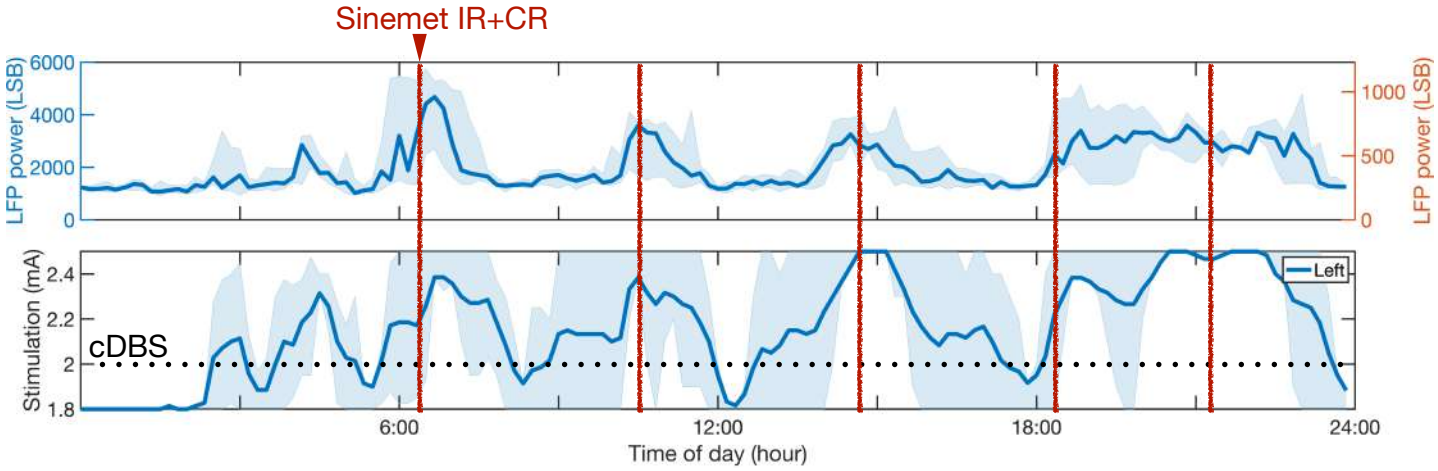
Programming

- cDBS settings
  - Left: C+ 2-, 2.0 mA
  - Right: C+ 9-, 2.2 mA
- aDBS settings (dual threshold)
  - Left: range 1.8 - 2.5 mA
  - Right: range 1.8 - 2.5 mA

Patient Response to aDBS

- Minimal dyskinesia (non troublesome)
- "No off time" — improved mobility throughout the day. No longer taking prn levodopa.






Thank you