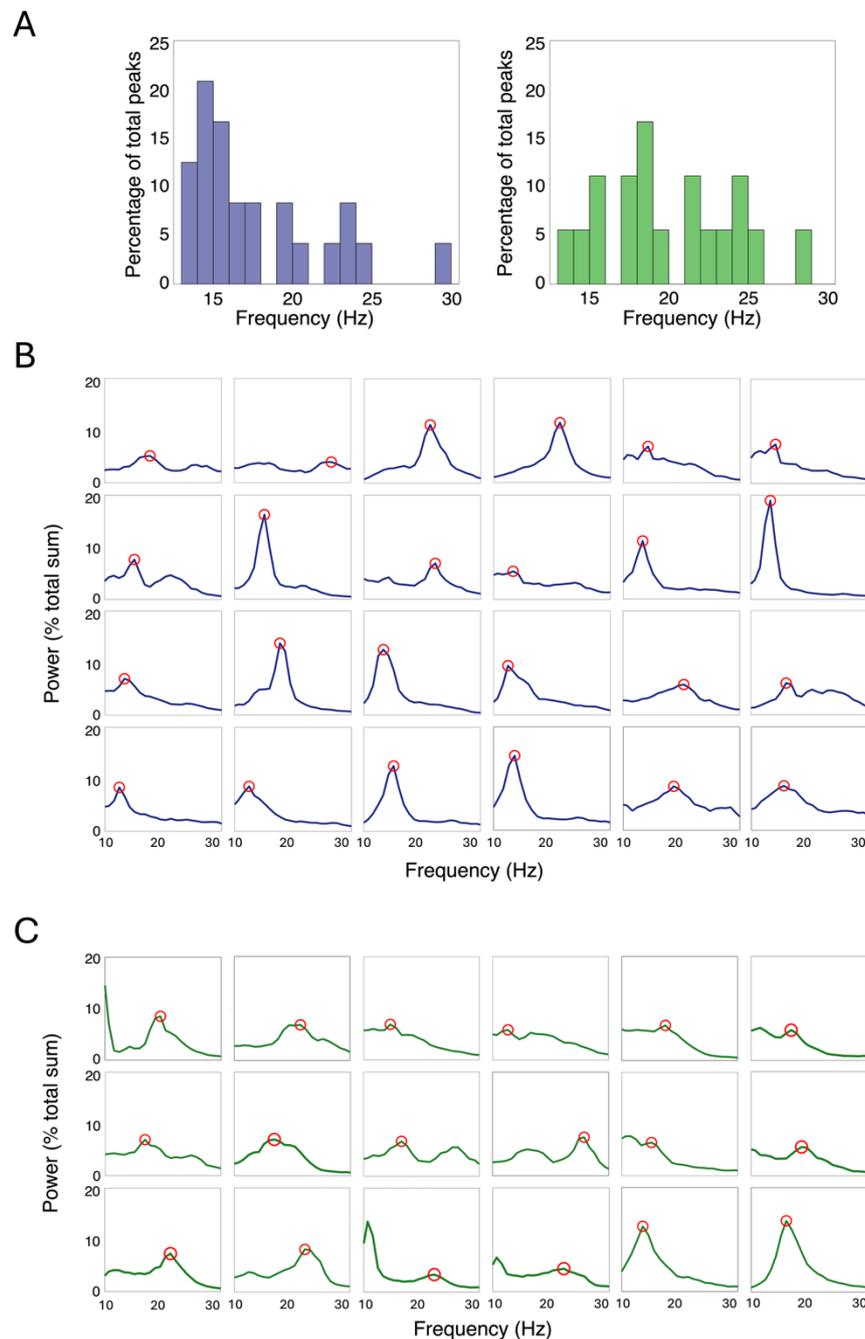


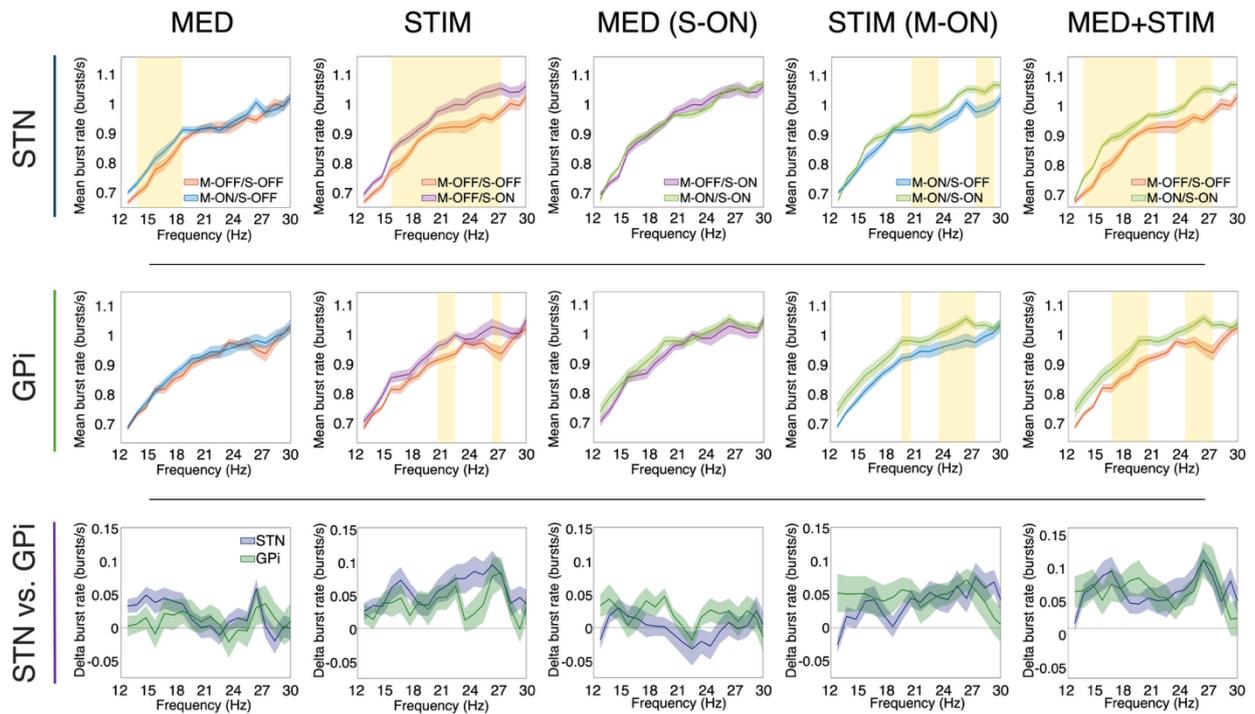
Supplementary Information

“Distinct subthalamic and pallidal beta dynamics in Parkinson’s disease”

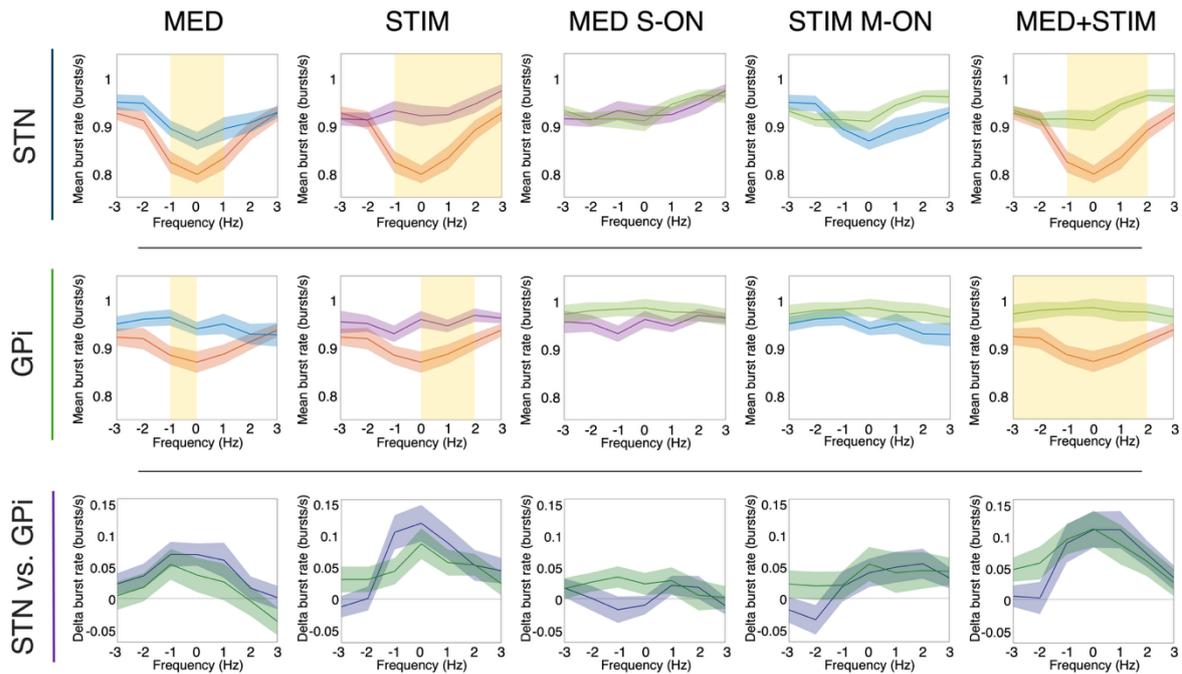
Supplementary Figure 1: Beta peaks at baseline (M-OFF/S-OFF condition). A) frequency distribution of beta peaks detected in the STN (left) and GPi (right), reported as percentage of total peaks detected in each group. B) peaks identified in the STN. C) peaks identified in the GPi. Abbreviations: STN: Subthalamic Nucleus; GPi: Globus Pallidus internus.



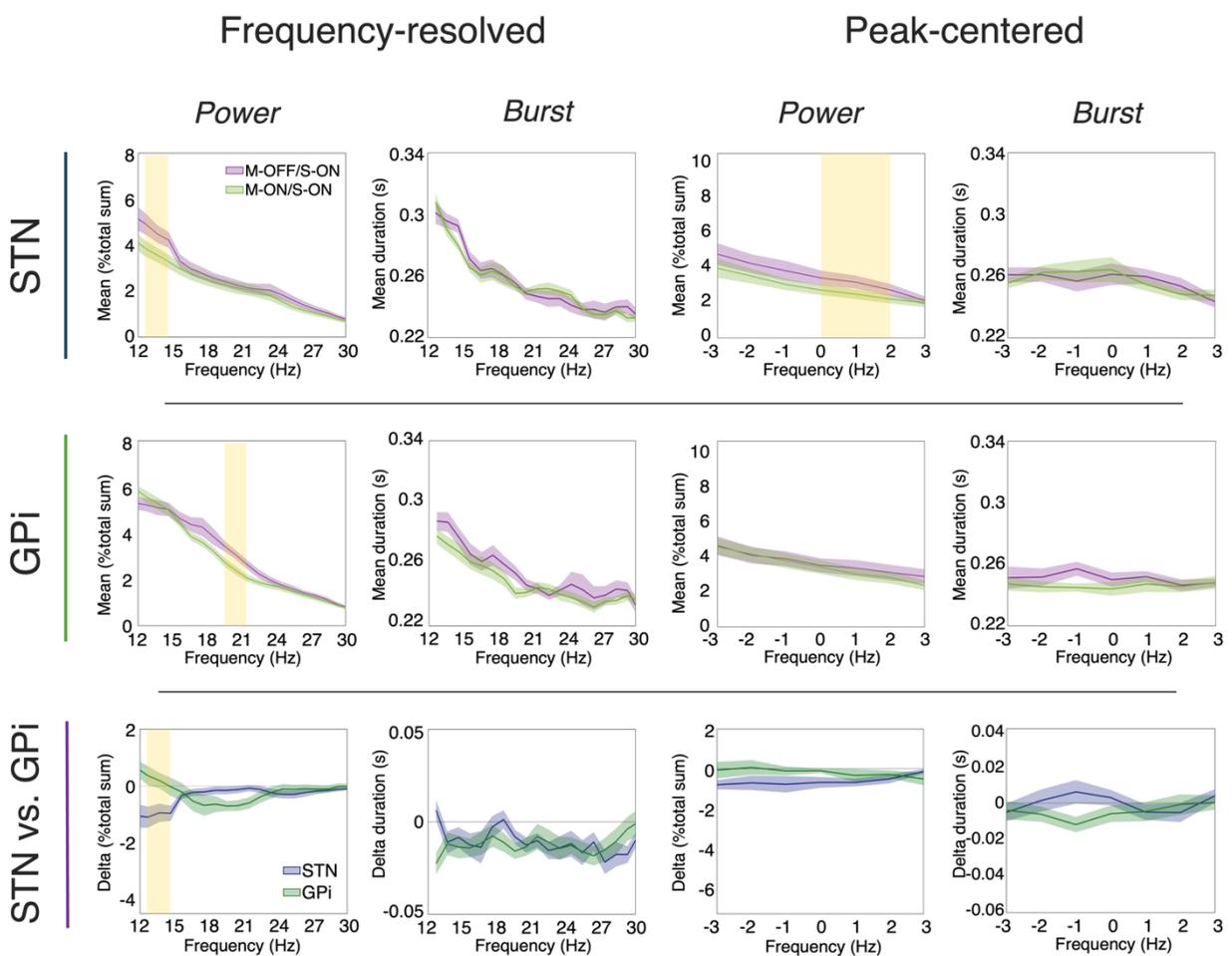
Supplementary Figure 2: Frequency-resolved modulation of burst duration in STN and GPI. Cluster-based, frequency-wise modulation of burst rates in all tested therapeutic conditions in the STN (top row), GPI (middle row) and comparison of changes between targets (bottom row). Power spectra are reported as means across subjects, and shaded lines represent standard error. Yellow shaded bars indicate significant differences ($p < 0.05$).



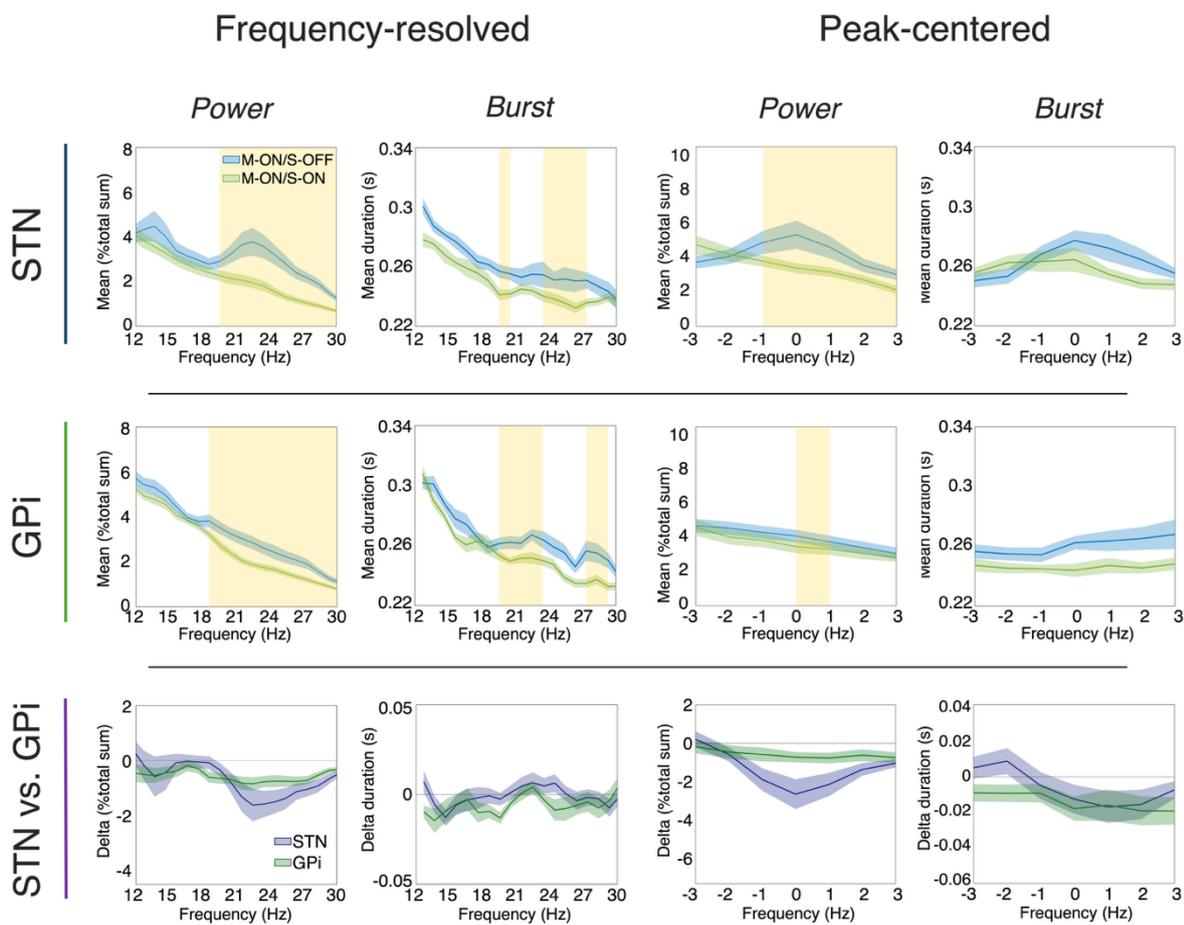
Supplementary Figure 3: Changes in burst rate around the beta peak. Results of cluster-based permutation tests on the rate of bursts computed in individual bins (± 3 Hz) around the beta peak frequency. Top panels display averaged burst rates in different conditions for the Subthalamic Nucleus (STN), middle panels for the Globus Pallidus internus (GPI), and bottom panels depict between-target differences. Burst rates (bursts/second) are reported as means across hemispheres, and shaded lines represent the standard error of the mean. Yellow shaded bars indicate significant differences ($p < 0.05$). Abbreviations: STN: Subthalamic Nucleus; GPI: Globus Pallidus internus.



Supplementary Figure 4 Beta power and burst modulation with medication add-on to stimulation in STN and GPi. Frequency-resolved (12–30 Hz, left) and peak-centred (± 3 Hz around the individual beta peak, right) modulation of beta power (left panels) and burst duration (right panels) between M-OFF/S-ON (purple) and M-ON/S-ON (green) conditions for the Subthalamic Nucleus (STN; top row), Globus Pallidus internus (GPi; middle row), and between-target differences (STN vs. GPi; bottom row). Power spectra and burst durations are reported as means across hemispheres, while shaded lines represent the standard error of the mean. Yellow shaded regions indicate frequency ranges with significant modulation (cluster-based permutation test, $p < 0.05$). Abbreviations: STN: Subthalamic Nucleus; GPi: Globus Pallidus internus.



Supplementary Figure 5 Beta power and burst modulation with stimulation add-on to medication in STN and GPi. Frequency-resolved (12–30 Hz, left) and peak-centred (± 3 Hz around the individual beta peak, right) modulation of beta power (left panels) and burst duration (right panels) between M-ON/S-OFF (blue) and M-ON/S-ON (green) conditions for the Subthalamic Nucleus (STN; top row), Globus Pallidus internus (GPi; middle row), and between-target differences (STN vs. GPi; bottom row). Power spectra and burst durations are reported as means across hemispheres, while shaded lines represent the standard error of the mean. Yellow shaded regions indicate frequency ranges with significant modulation (cluster-based permutation test, $p < 0.05$). Abbreviations: STN: Subthalamic Nucleus; GPi: Globus Pallidus internus.



Supplementary Table 1: Individual stimulation and recording settings and acute L-Dopa doses in STN- and GPi-DBS patients

ID	Subject	Contacts		DBS parameters A/PW/Fs [mA]/[μs]/[Hz]	TEED (μJ/s)	Acute LEDD (mg)
		Recording	Stimulating			
1	STN	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1b-1c	Le: 3.4/50/125 Ri: 3.1/50/125	Le: 234.5 Ri: 217.9	100
2	STN	Le:1-3 Ri:1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le: 2/60/125 Ri: 2.4/60/125	Le: 80.3 Ri: 84.5	150
3	STN	Le:1-3 Ri:1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le: 3.0/60/125 Ri: 3.1/60/125	Le: 214.7 Ri: 227.2	100
4	STN	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b-1c	Le: 2.9/60/180 Ri: 3.1/60/180	Le: 558.3 Ri: 497.1	100
5	STN	Le: 1-3 Ri: 0-2	Le: C+/2a-2b-2c Ri: C+/1a-1b-1c	Le: 3.5/60/125 Ri: 3.2/60/125	Le: 228.8 Ri: 192.4	100
6	STN	Le: 1-3 Ri: 0-2	Le: C+/2a-2b Ri: C+/1a-1b-1c	Le: 2.9/60/125 Ri: 2.2/60/125	Le: 193.1 Ri: 110.5	100
7	STN	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b-1c	Le: 3 /60/125 Ri: 2.2/60/125	Le: 215.9 Ri: 116.5	100
8	STN	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b	Le: 3.5/60/125 Ri: 3.7/60/125	Le: 300.6 Ri: 388.3	50
9	STN	Le: 1-3 Ri: 1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le: 2.0/60/125 Ri: 2.7/60/125	Le: 90.0 Ri: 165.7	50
10	STN	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b-1c	Le: 2.1/60/125 Ri: 2.6/60/125	Le: 96.4 Ri: 237.6	100
11	STN	Le:1-3 Ri: 0-2	Le: C+/2a-2b-2c Ri: C+/1a-1b-1c	Le:1.7/60/125 Ri:2.4/60/125	Le: 77.2 Ri: 116.3	100
12	STN	Le: 1-3 Ri: 1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le: 1.9/60/125 Ri: 1.8/60/125	Le: 90.0 Ri: 79.7	100
13	GPi	Le: 1-3 Ri: 1-3	Le: C+/2a-2b-2c Ei: C+/2a-2b-2c	Le: 4.0/60/180 Ri: 3.0/60/180	Le: 574.8 Ri: 579.3	100
14	GPi	Le: 1-3 Ri: 1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le:4.8/60/125 Ri: 5.4/60/125	Le: 448.9 Ri: 546.5	100
15	GPi	Le: 1-3 Ri: 1-3	Le: C+/2a-2c Ri: C+/2a-2b-2c	Le:5.3/60/125 Ri: 4.8/60/125	Le: 517.8 Ri: 848.3	150
16	GPi	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b	Le:4.2/60/125 Ri: 4.1/60/125	Le: 515.7 Ri: 382.1	100
17	GPi	Le: 0-2 Ri: 0-2	Le: C+/2a-2b-2c Ri: C+/2a-2c	Le: 4.3/50/125 Ri: 4.1/50/125	Le: 649.9 Ri: 406.8	100
18	GPi	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b-1c	Le: 5.6/60/180 Ri: 4.5/60/180	Le: 465.0 Ri: 421.8	100
19	GPi	Le: 0-2 Ri: 0-2	Le: C+/1a-1b-1c Ri: C+/1a-1b-1c	Le: 3.7/70/100 Ri: 3.9/70/100	Le: 215.9 Ri: 195.3	133
20	GPi	Le: 1-3 Ri: 1-3	Le: C+/2a-2b-2c Ri: C+/2a-2b-2c	Le: 3.6/60/125 Ri: 3.2/60/125	Le: 271.6 Ri: 175.7	100
21	GPi	Le: 1-3 Ri: 0-2	Le: C+/2a-2b-2c Ri: C+/1a-1b-1c	Le: 3.0/60/125 Ri: 3.6/60/125	Le: 224.4 Ri: 402.9	100
<i>Median (IQR) STN</i>		-	-	-	192.8 (138.5)	100 (0)
<i>Median (IQR) GPi</i>		-	-	-	435.4 (274.9)	100 (16.5)
<i>p value</i>					<0.0001	0.12

For each subject, recording and stimulating contacts are reported separately for the left and right hemispheres, together with stimulation parameters expressed as amplitude/pulse width/frequency. The corresponding Total Electrical Energy Delivered (TEED) and acute Levodopa Equivalent Daily Dose (LEDD) administered during the experimental session are shown. Median values and interquartile ranges (IQR) are reported separately for STN and GPi groups, and *p* values indicate between-group comparisons. Abbreviations: STN: Subthalamic Nucleus; GPi: Globus Pallidus internus; Le: Left; Ri: Right; C: Case; A: Amplitude; PW: Pulse Width; Fr: Frequency; TEED: Total Electrical Energy Delivered; LEDD: Levodopa Equivalent Daily Dose.

Supplementary Table 2: Clinical-neurophysiological correlations for frequency-wise beta power analysis

	STN				GPi			
	Bradyk+rigidity		Tremor		Bradyk+rigidity		Tremor	
	<i>R value</i>	<i>p value</i>						
Baseline	0.64 (15 Hz)	0.01	0.15 (18 Hz)	0.36	0.52 (19 Hz)	0.01	0.07 (20 Hz)	0.75
Medication	0.51 (15 Hz)	0.03	0.18 (22 Hz)	0.49	0.54 (20 Hz)	0.02	0.09 (17 Hz)	0.74
Stimulation	0.57 (20 Hz)	0.01	0.05 (21 Hz)	0.86	0.63 (21 Hz)	0.01	0.14 (26 Hz)	0.60
Medication+Stimulation	0.61 (14 Hz)	0.01	0.12 (13 Hz)	0.57	0.52 (21 Hz)	0.03	0.28 (28 Hz)	0.47

Spearman’s rank correlation coefficients (*R*) and corresponding *p* values describing the relationship between clinical MDS-UPDRS III subscores (bradykinesia+rigidity and tremor) and spectral power measured in the Subthalamic Nucleus (STN) and Globus Pallidus internus (GPi) at baseline and across therapeutic conditions (medication, stimulation, and combined medication+stimulation). At baseline (M-OFF/S-OFF), correlations reflect associations between absolute motor subscores and absolute power spectra. In contrast, for therapeutic conditions, correlations were computed between the percentage changes in motor subscores and the percentage changes in spectral power relative to baseline. Correlations were computed frequency-wise across the beta spectrum. For each condition, target, and motor subscore, the beta frequency showing the strongest correlation is reported in parentheses (Hz).

Abbreviations: STN: Subthalamic Nucleus, GPi: Globus Pallidus internus; Brady+rigidity: summed MDS-UPDRS III items assessing bradykinesia and rigidity.

Supplementary Table 3: Clinical-neurophysiological correlations for beta peak power

	STN				GPi			
	Bradyk+rigidity		Tremor		Bradyk+rigidity		Tremor	
	<i>R value</i>	<i>p value</i>	<i>R value</i>	<i>p value</i>	<i>R value</i>	<i>p value</i>	<i>R value</i>	<i>p value</i>
Baseline	0.37	0.08	0.18	0.42	0.43	0.07	0.12	0.65
Medication	0.33	0.11	0.13	0.37	0.45	0.06	0.10	0.7
Stimulation	0.24	0.25	0.16	0.60	0.26	0.2	0.22	0.42
Medication+Stimulation	0.39	0.08	0.08	0.76	0.47	0.06	0.17	0.45

Spearman's rank correlation coefficients (*R*) and corresponding *p* values describing the association between clinical motor MDS-UPDRS III subscores (bradykinesia+rigidity and tremor) and beta peak power recorded from the Subthalamic Nucleus (STN) and Globus Pallidus internus (GPi) at baseline and across therapeutic conditions (medication, stimulation, and combined medication+stimulation). At baseline (M-OFF/S-OFF), correlations were computed between absolute motor subscores and absolute beta peak power. In contrast, for therapeutic conditions, correlations were computed between the percentage changes in motor subscores and the percentage changes in beta peak power relative to baseline.

Abbreviations: STN: Subthalamic Nucleus, GPi: Globus Pallidus internus; Brady+rigidity: summed MDS-UPDRS III items assessing bradykinesia and rigidity.