

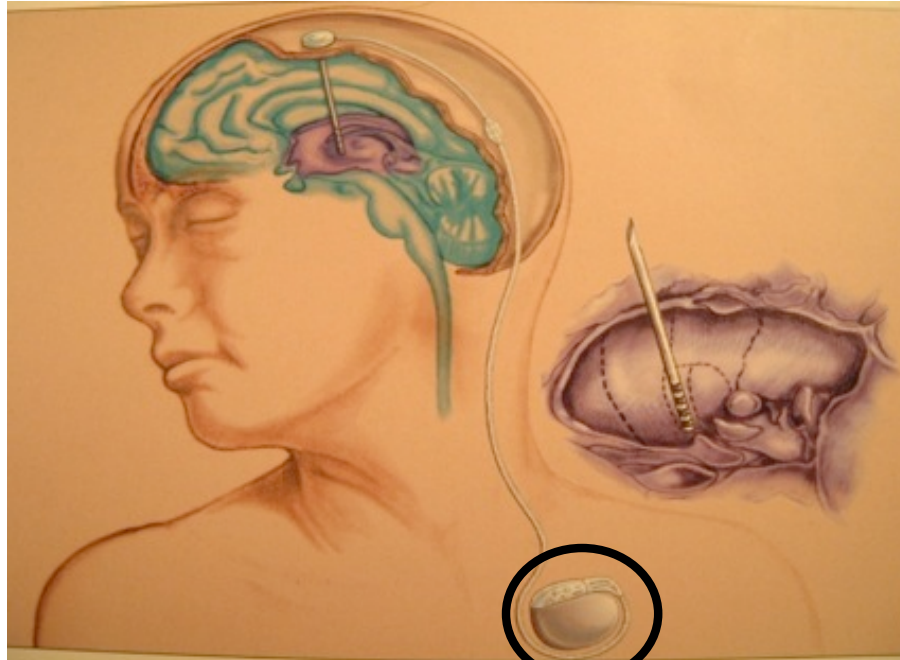
**PROGETTO DIDATTICO:
LE REGISTRAZIONI
INTRAOPERATORIE DURANTE
DBS PER LA MALATTIA DI
PARKINSON**

*Complementi di analisi dei segnali biomedici –
modulo Neurosegnali*

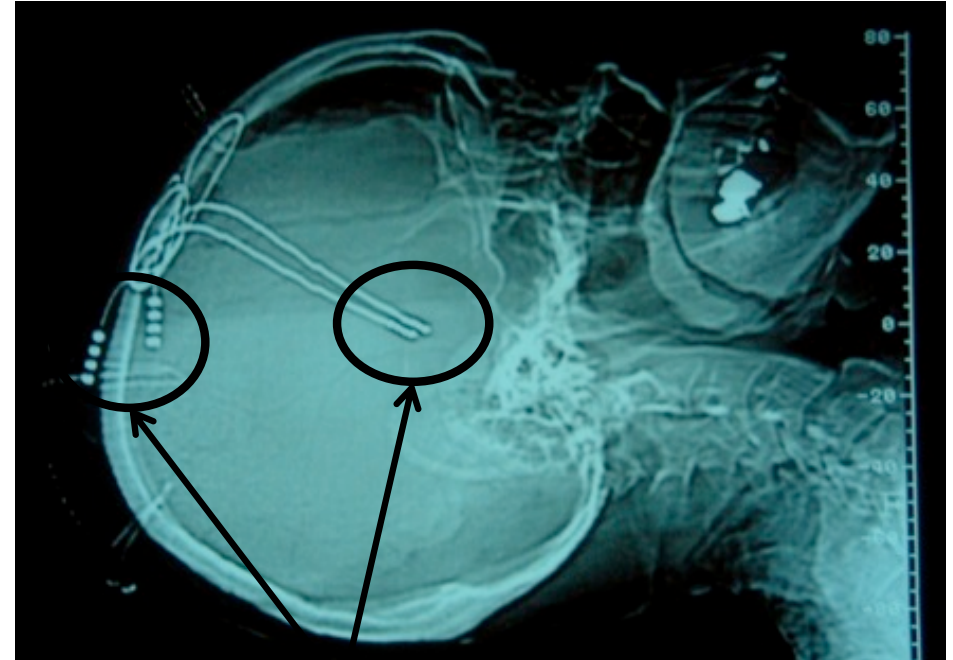
Aa 2019-20

INTRODUCTION: DEEP BRAIN STIMULATION FOR PARKINSON'S DISEASE

- ✓ High frequency stimulation (100-180 Hz) of the subthalamic nucleus
- ✓ Electrocateters implanted during stereotactic neurosurgery
- ✓ Subcutaneous stimulator in the supra clavicular area



Subcutaneous impulse generator



Electrocatheters (4 contacts) implanted in the subthalamic nucleus

INTRODUCTION: LEAD POSITION AND DBS OUTCOMES

ORIGINAL CONTRIBUTION

Improvement in Parkinson Disease by Subthalamic Nucleus Stimulation Based on Electrode Placement

Effects of Reimplantation

Mathieu Anheim, MD; Alina Batir, MD; Valérie Fraix, MD; Madjid Silem, MD; Stéphan Chabardes, MD; Eric Seigneuret, MD; Paul Krack, MD; Alim-Louis Benabid, MD, PhD; Pierre Pollak, MD

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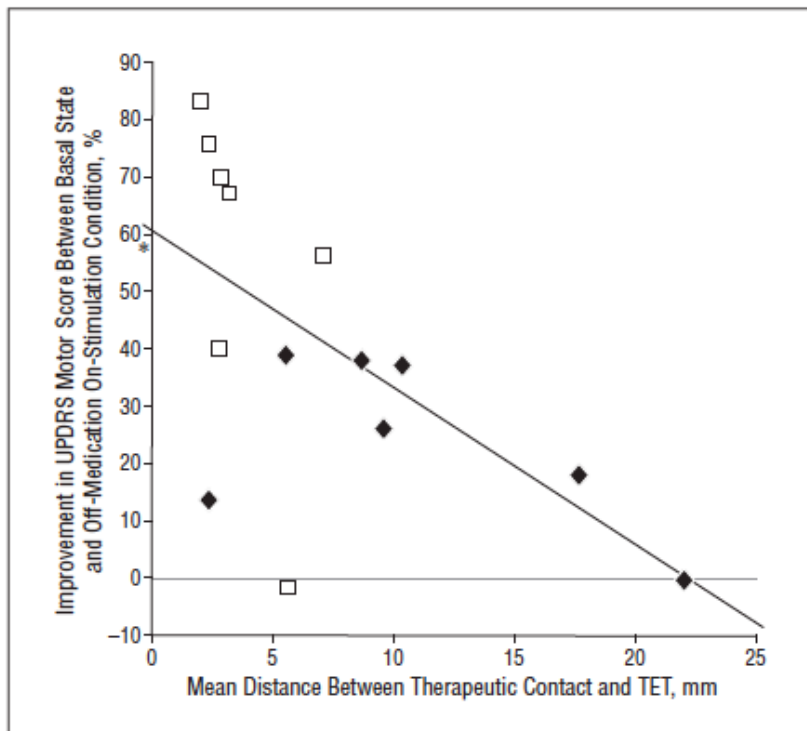


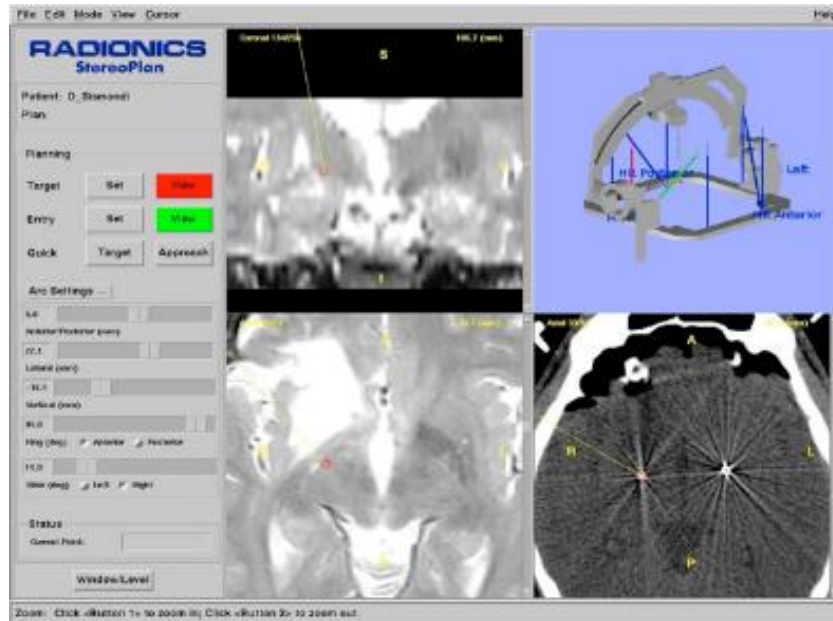
Figure 2. Correlation between the percentage improvement in the Unified Parkinson Disease Rating Scale (UPDRS) motor score under off-medication on-stimulation (ie, the patient is not receiving medication but receiving stimulation) condition compared with basal state (off-medication off-stimulation condition before reimplantation) and the mean distance in millimeters between the center of the electrode contact and the theoretical effective target (TET). Solid diamonds indicate results before reimplantation; open squares, results 1 year after reimplantation. On the x-axis, the distances from the center of the therapeutic contact to the TET are the sum of the left-side and right-side distances (* $P=.02$, Spearman rank correlation [diagonal line]).

The precision of lead positioning correlates with better DBS outcome



the intraoperative assessment of electrode position during stereotactic neurosurgery is crucial

INTRODUCTION: STN TARGETING TECHNIQUES



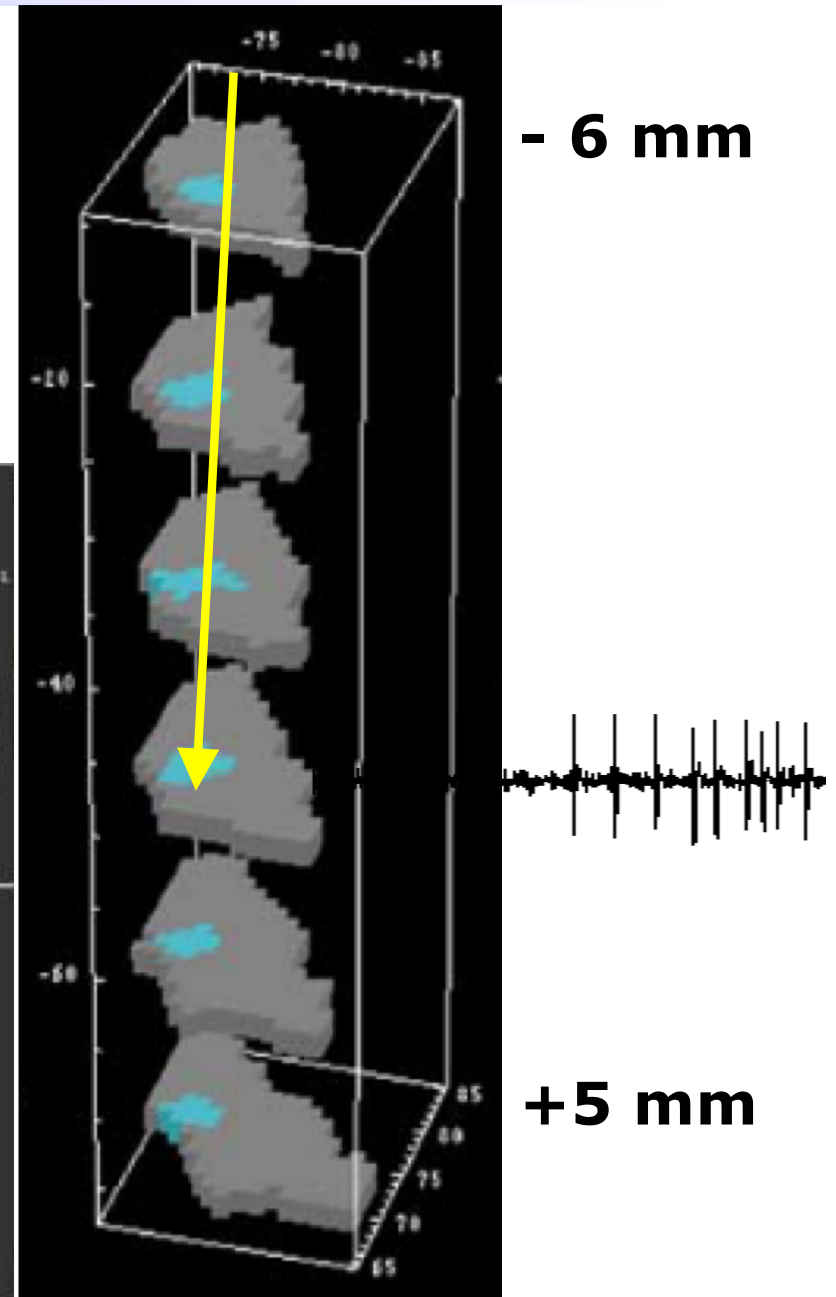
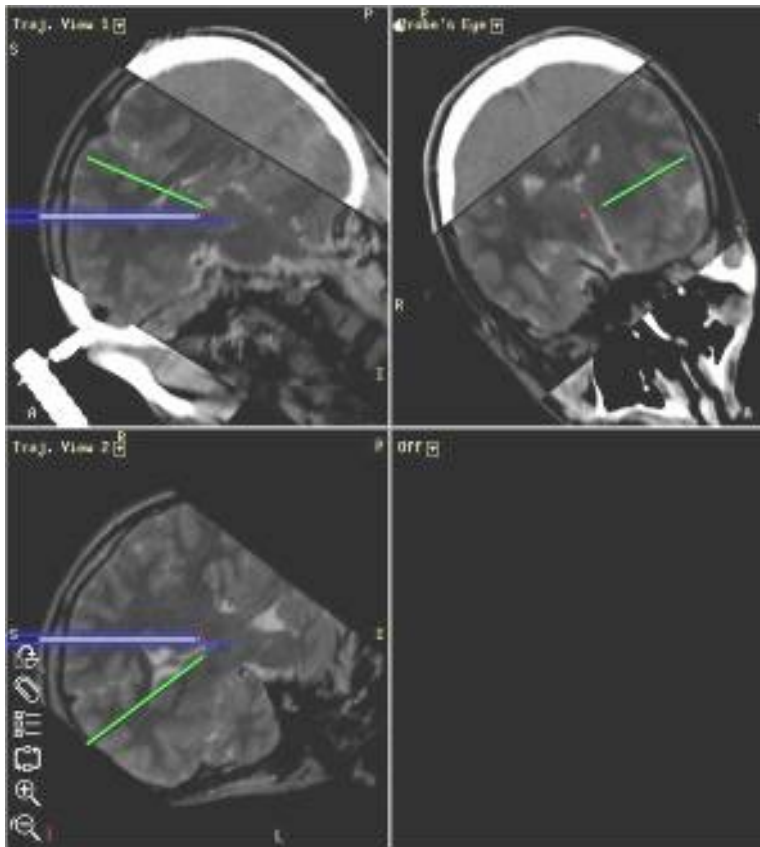
- Preoperative Imaging:
- MRI-CT fusion technique
 - Definition of the anatomical target
 - Definition of the trajectories



- Intraoperative Monitoring:
- Combination of microelectrode recordings and functional stimulation
 - Definition of the optimal functional target

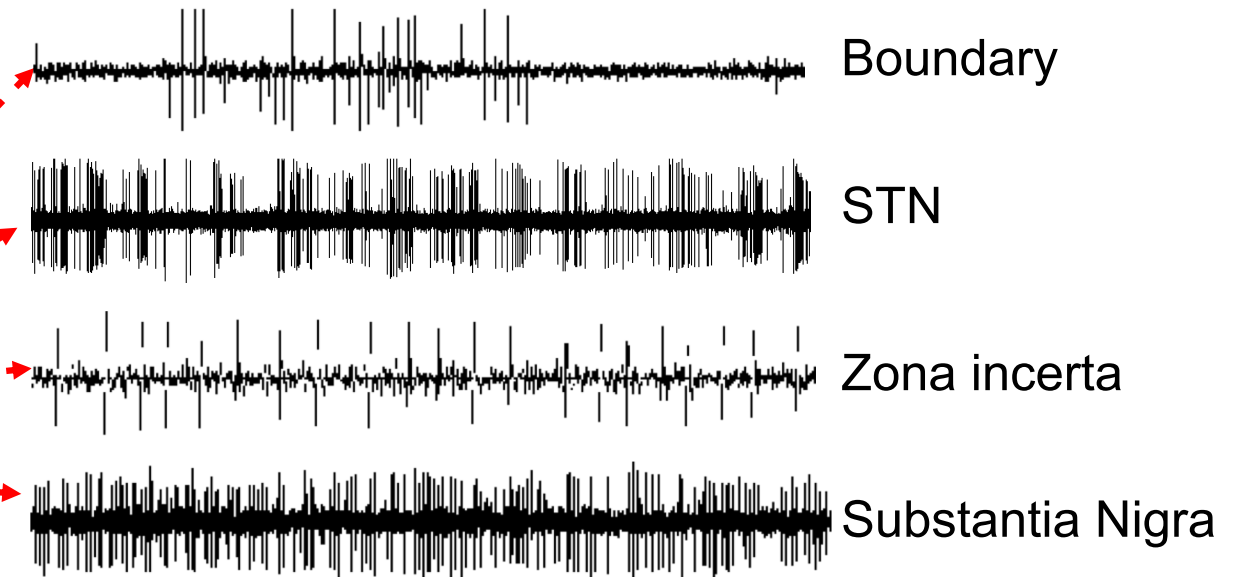
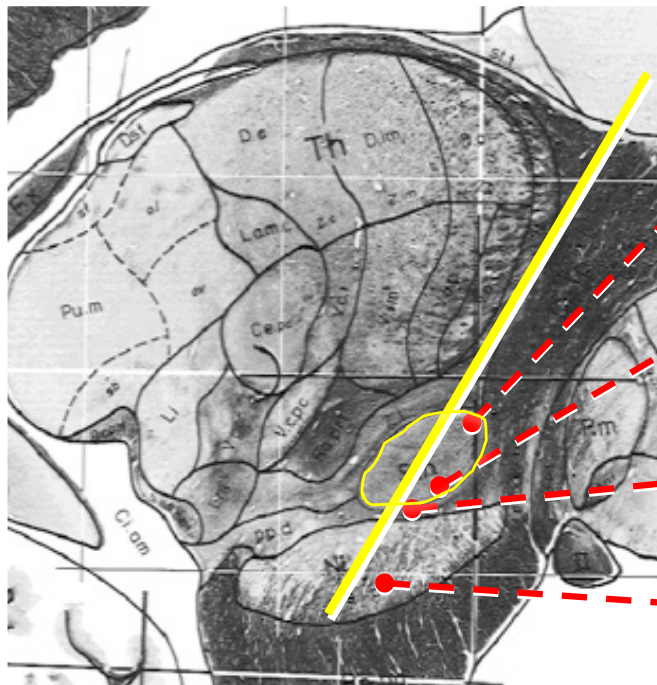
MICRORECORDINGS DURING DBS STEREOTACTIC NEUROSURGERY (1)

- 2/3 explorative microelectrodes record the extracellular action potentials of few (2-3) neurons during descent towards DBS anatomical target
- impedance 1 M Ω at 1 kHz
- sampling frequency 10 kHz
- band pass 250Hz-5 kHz

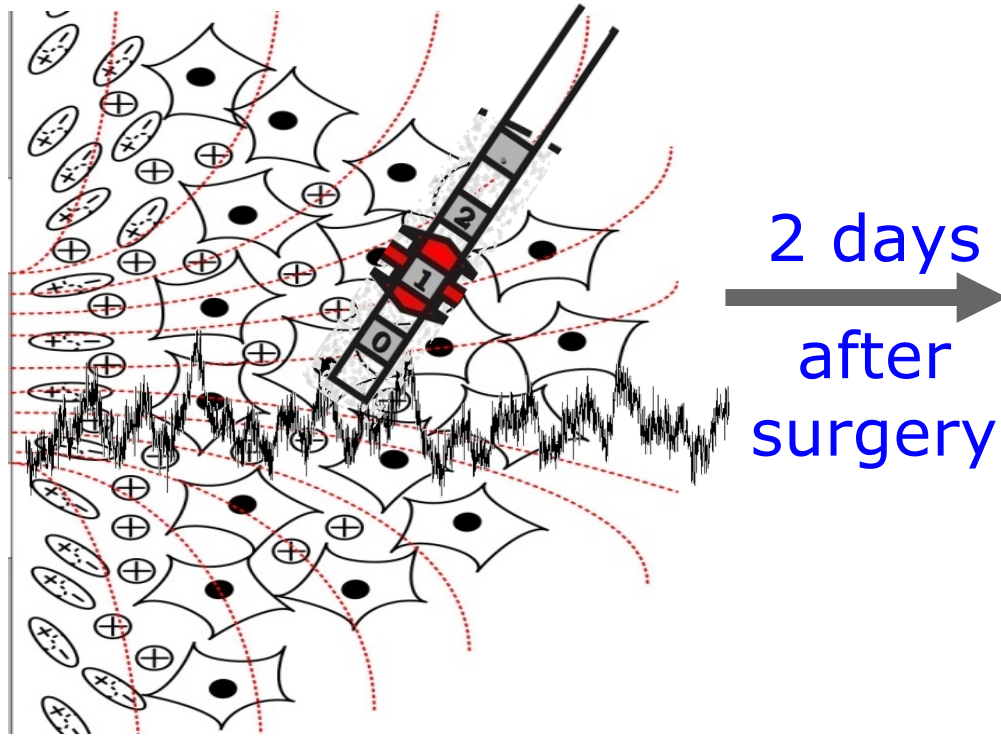


MICRORECORDINGS DURING DBS STEREOTACTIC NEUROSURGERY (2)

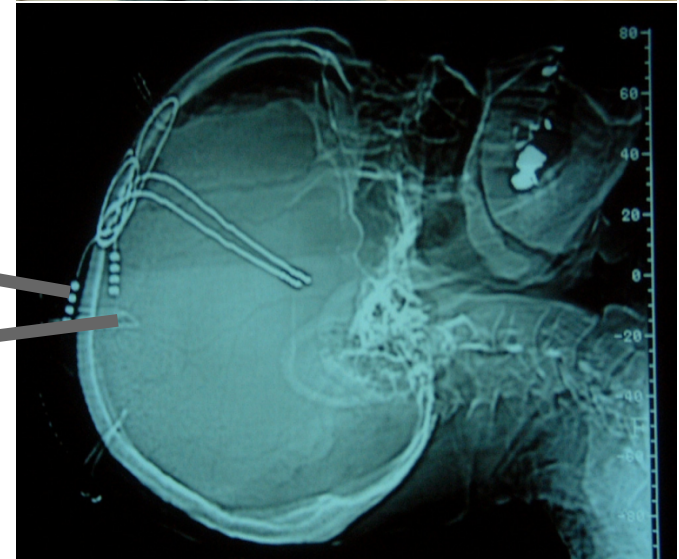
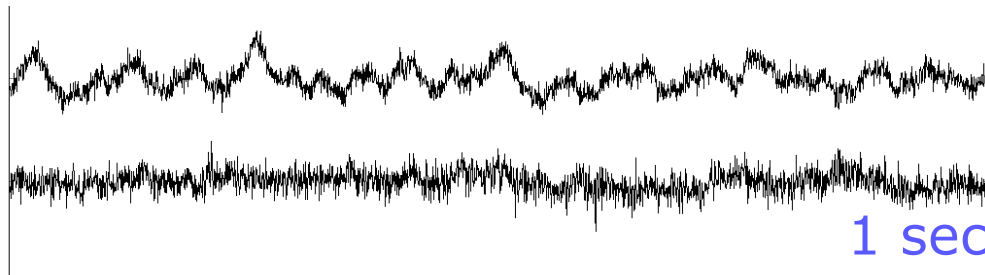
- Specific firing patterns characterize the different structures crossed by the electrode while descending towards the target
- An expert neurophysiologist recognizes the STN firing pattern



OTHER NEUROPHYSIOLOGICAL RECORDINGS IN DBS: LOCAL FIELD POTENTIALS

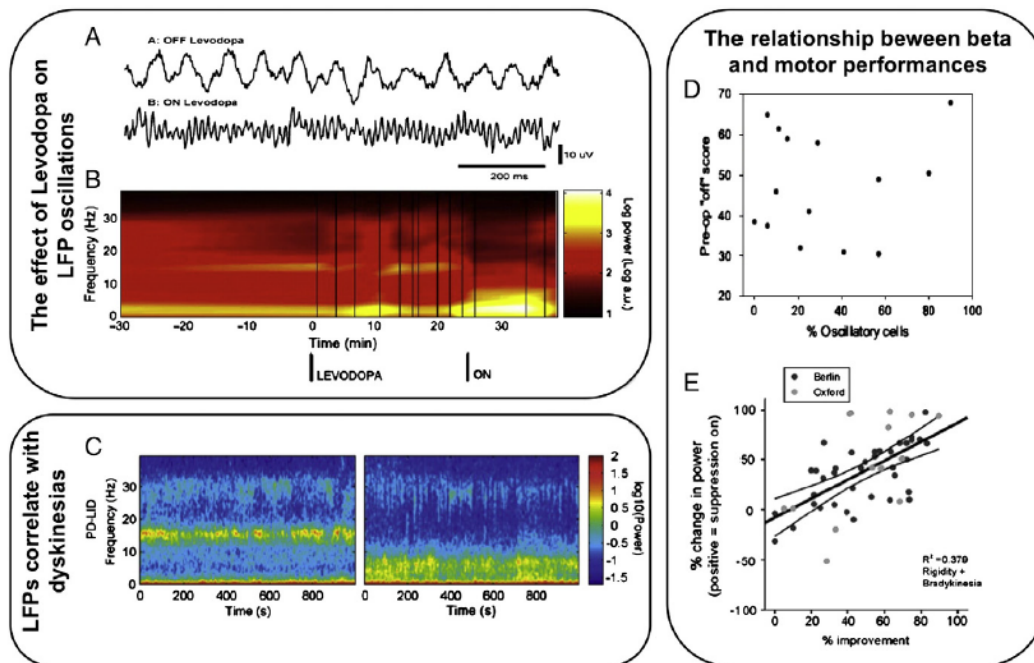


2 days
after
surgery

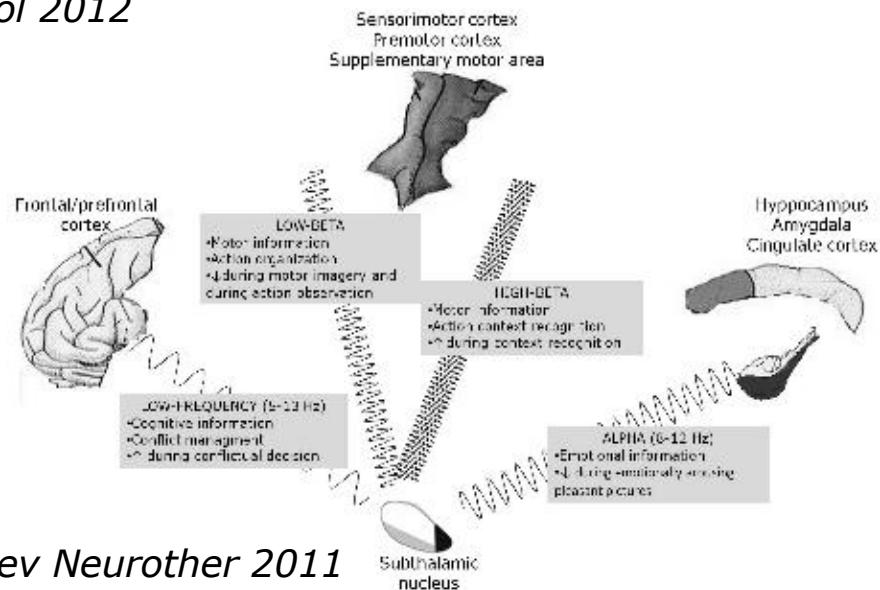


“local field potentials” →
deep EEG activity

LFPs CORRELATE WITH THE PATIENT'S CLINICAL STATE



Priori et al, Exp Neurol 2012

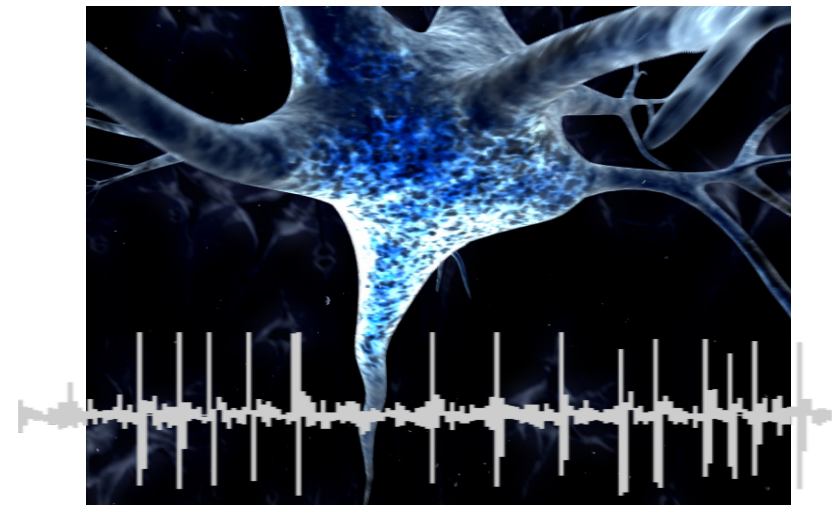
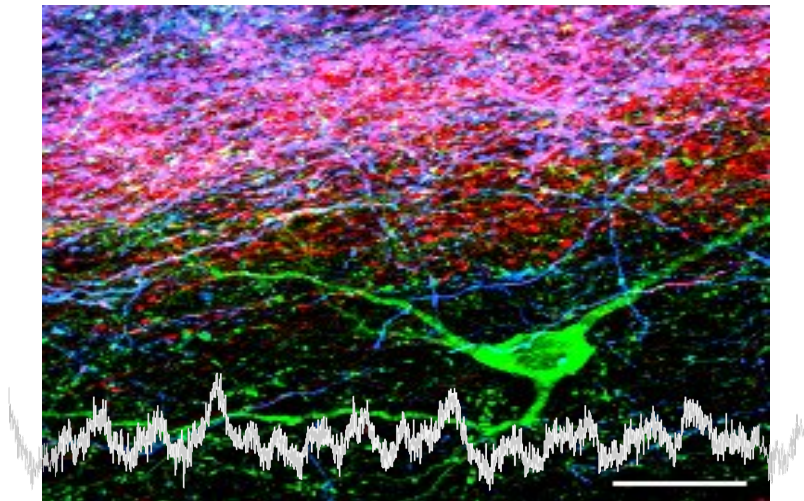
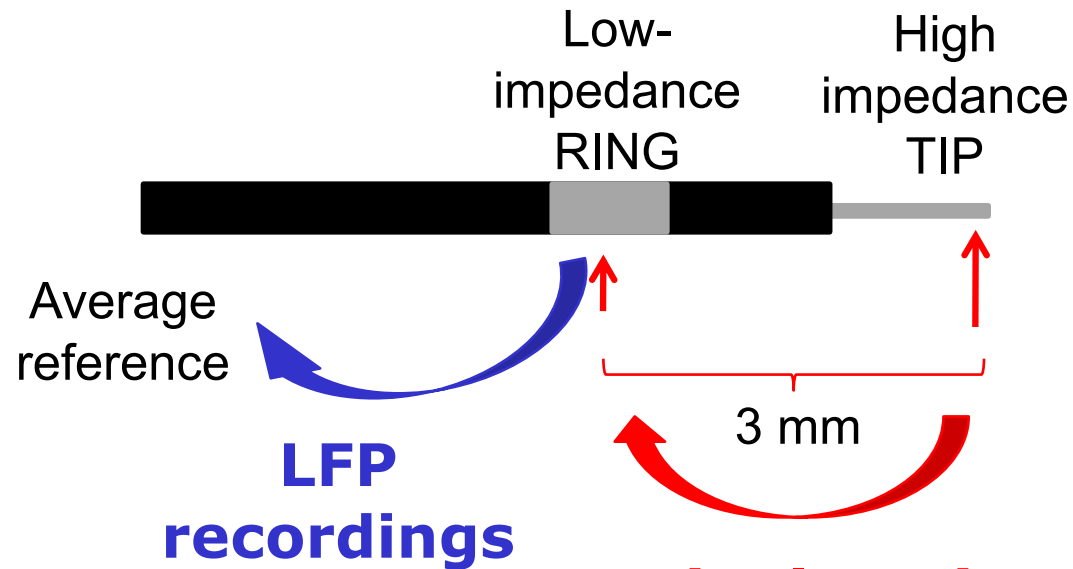


Marceglia et al, Exp Rev Neurother 2011

MOTOR STATE

NON-MOTOR STATE

LFPs CAN BE RECORDED INTRAOPERATIVELY



AIM OF THE WORK

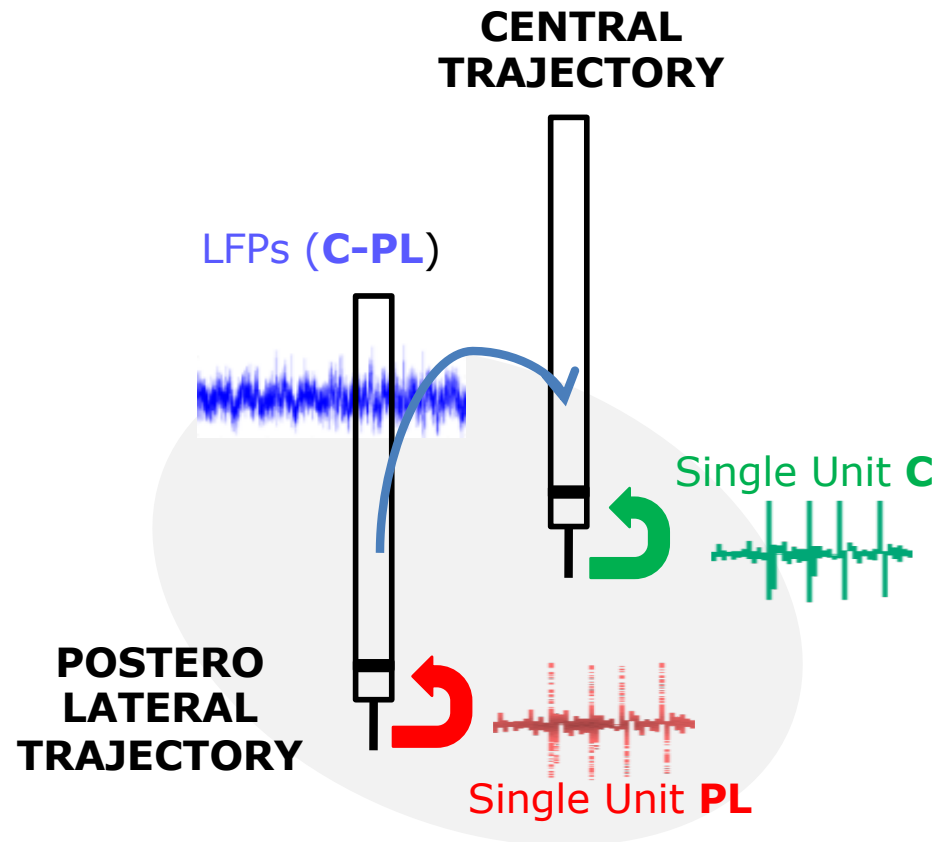
Analyse the **spatial distribution of LFP** oscillatory patterns during DBS electrode positioning procedure

RECORDINGS (1)



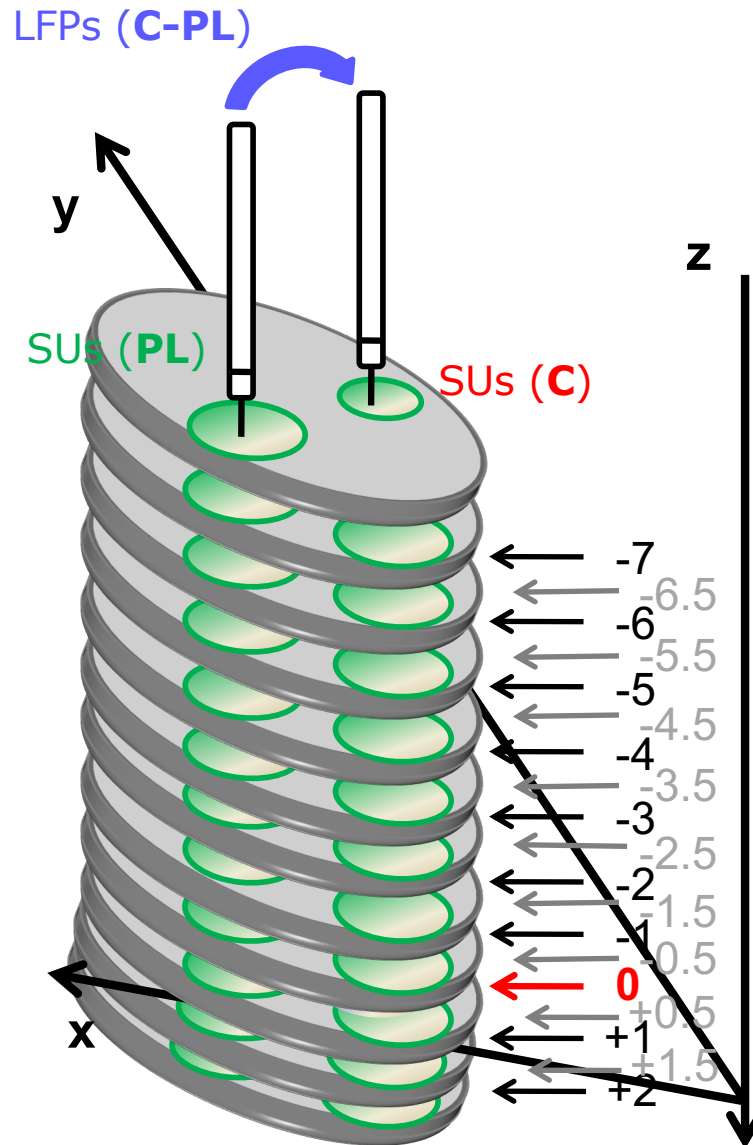
- 2 explorative microelectrodes:
 - central
 - postero-lateral
- Symmetric geometry

RECORDINGS (2)

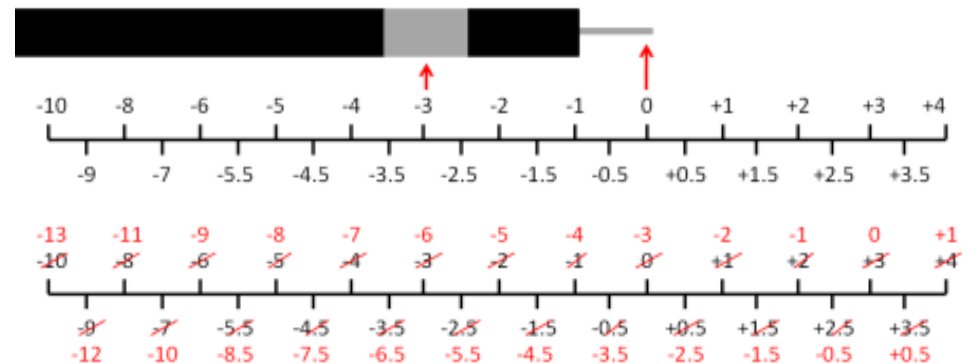


- **LFPs**: Signals were bipolarly captured using the explorative microelectrode rings
- **SUs**: Signals were bipolarly captured using the explorative microelectrode tip vs ring

RECORDINGS (3)



- Resolution:
 z axis \rightarrow 0.5 mm
 xy plane \rightarrow 2 mm
- about 30 seconds recording at each depth from -7 mm to +4mm considering the ring (3mm shift if considering the tip)
- Sampling frequency: 12019
- Band pass: 10Hz-5kHz



PATIENTS

- DBS surgery was performed at the Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico (Milan)
- 2 patients → 4 STN nuclei

		Anatomical target	Functional target (implanted)	Recordings
Patient 1 (Mor)	Right	0C	0PL	From -7 to +4
	Left	0C	2C	From -7 to +4
Patient 2 (Per)	Right	0C	1C	From -7 to +1
	Left	0C	1C	From -7.5 to +1.5

SIGNALS

- PATIENT 1 (Mor):
 - LFPs: matlab matrices Mor_ring_DX and Mor_ring_SX
 - SUs: matlab matrices Mor_SU_DX and Mor_SU_SX

- PATIENT 2 (Per):
 - LFPs: matlab matrices Per_ring_DX and Per_ring_SX
 - SUs: matlab matrices Per_SU_DX and Per_SU_SX

DATA ANALYSIS

1. PRE-PROCESSING:

- Band pass (below 1 kHz) and Resampling (2500 Hz)
- Band pass in the Region of Interest (below 45 Hz)

2. SPACE-FREQUENCY ANALYSIS (SINGLE NUCLEUS)

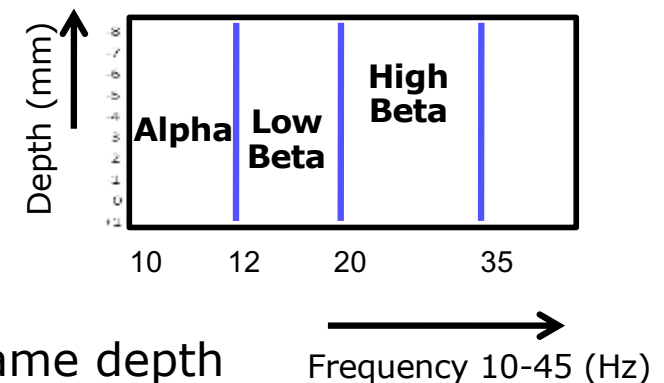
→ Non parametric power spectrum at each depth for each electrode (LFP and SU)

→ Frequency bands to be analyzed:

- Alpha (10 – 12 Hz)
- Low Beta (12 – 20 Hz)
- Alpha – Low Beta (10 – 20 Hz)
- High Beta (21 – 35 Hz)

→ Coherence analysis:

- between LFP and SU signals at the same depth
- between LFPs at two consecutive steps



3. SPACE-FREQUENCY ANALYSIS AVERAGE, ALL NUCLEI

PROJECT DELIVERY

DELIVERABLES

- Functioning routines for data analysis
- PPT presentation of the project development and results

DATE

Upon request (via email)