MINIGRAPH

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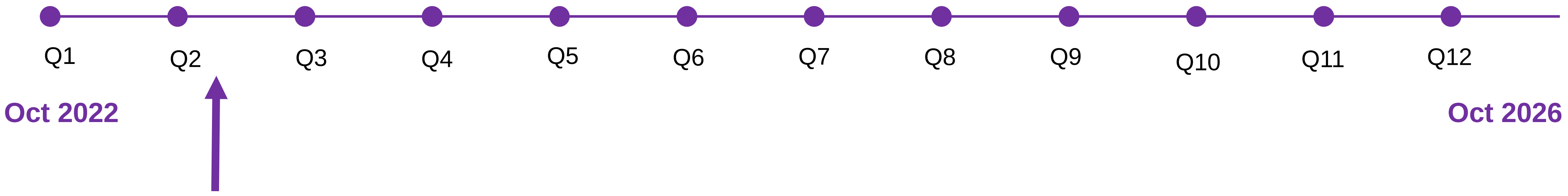
ETH zürich MSRL Multi-Scale Robotics Lab nanoflex robotics

MINIGRAPH:

Minimally Invasive Neuromodulation Implant and implantation procedure based on ground-breaking GRAPHene technology for treating brain disorders



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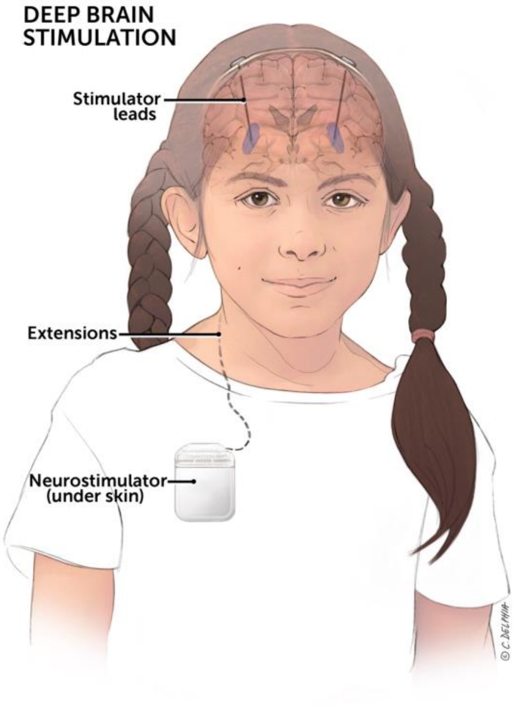
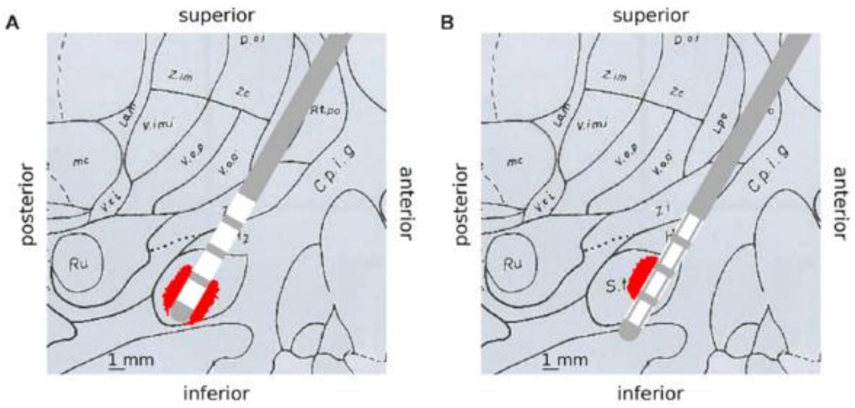
Deep Brain Stimulation (DBS) Background



Boston Children's Hospital



J. Buhlmann *et al.*, "Modeling of a Segmented Electrode for Desynchronizing Deep Brain Stimulation", *Frontiers in neuroengineering*, 4-15, 2011.

Can be used to treat neurological disorders, including:

- **Parkinson's disease**
- Essential tremor
- Dystonia
- Epilepsy
- Obsessive-compulsive disorder
- Depression
- Alzheimer's disease
- Chronic pain syndrome

MINIGRAPH Objectives

	Implant	Implantation	DBS strategy
State of the art	Metal electrode	Manual surgical procedure	Open-loop algorithms for neuromodulation
Objective	Graphene electrode (probes + ASIC)	Robotic delivery with magnetic carrier, steering guided by X-ray	Closed-loop ML/AI for neuromodulation
Advantages	• Higher resolution recording and stimulation • Lower immune response	• Minimally invasive • Higher location accessibility • Precise electrode position	• Continuous real-time monitoring • Adaptive + personalized therapy

MINIGRAPH Objectives

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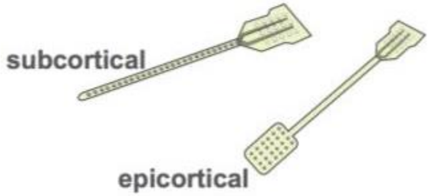
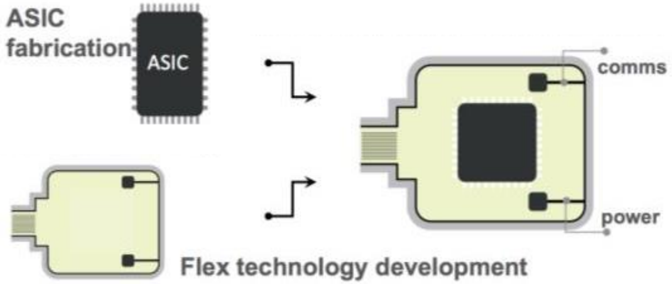
Graphene neural probes



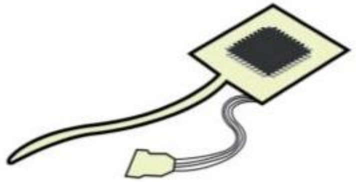
ICN2
Institut Català de Nanociència i Nanotecnologia

Ultrathin implantable electronics



imec INBRAIN NEUROELECTRONICS

Fully integrated neural interface



Fraunhofer IZM

Robotic implantation

Magnetic navigation system

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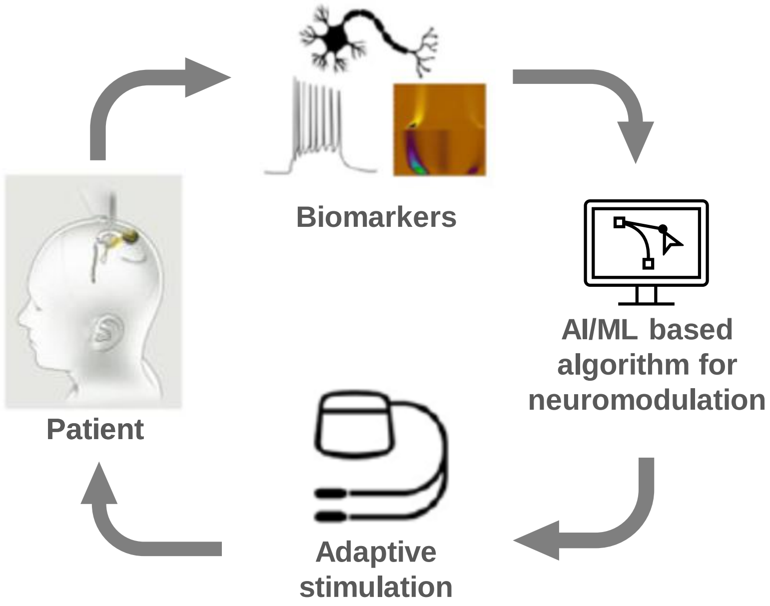
Closed-loop DBS



Leiden University Medical Center

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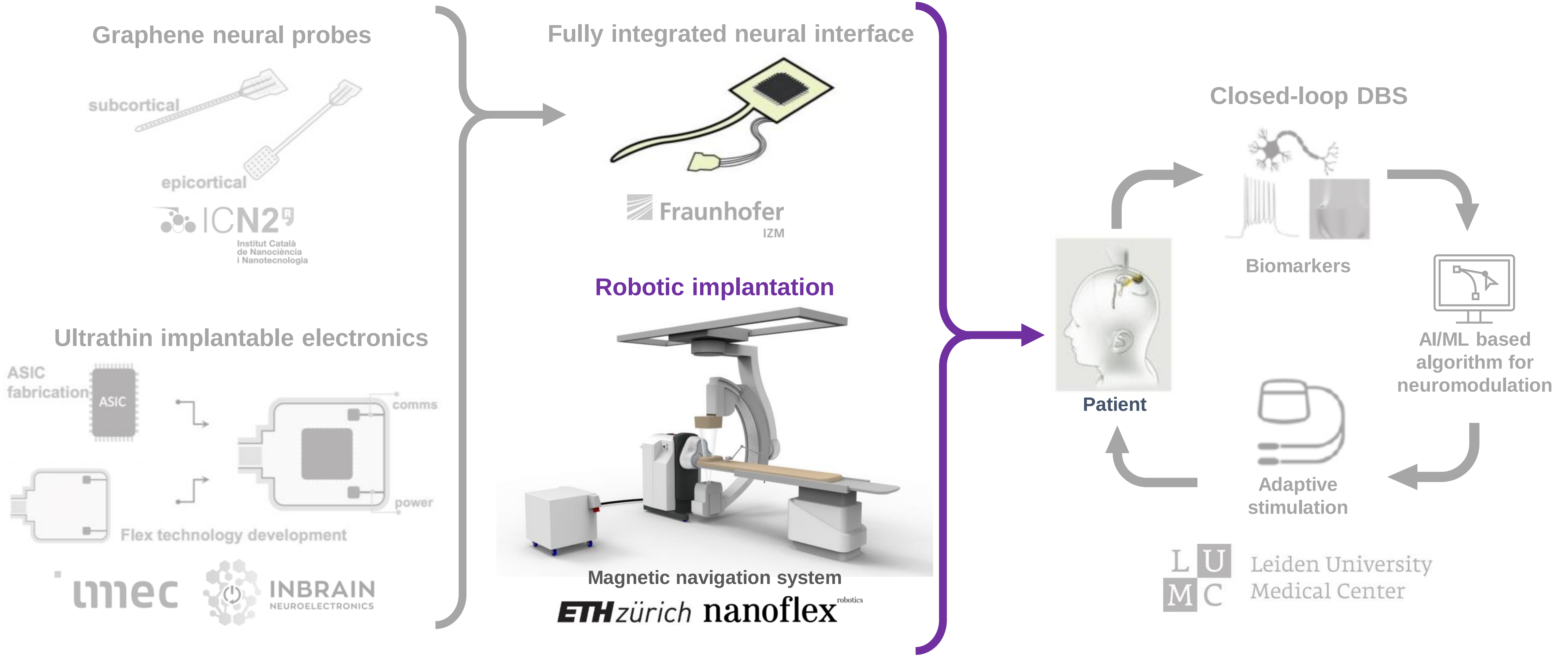
MINIGRAPH Objectives



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Preliminary Data

Remote magnetic navigation system: Navion

- Dexterous and safe navigation of soft surgical instruments for a broad range of minimally invasive surgeries

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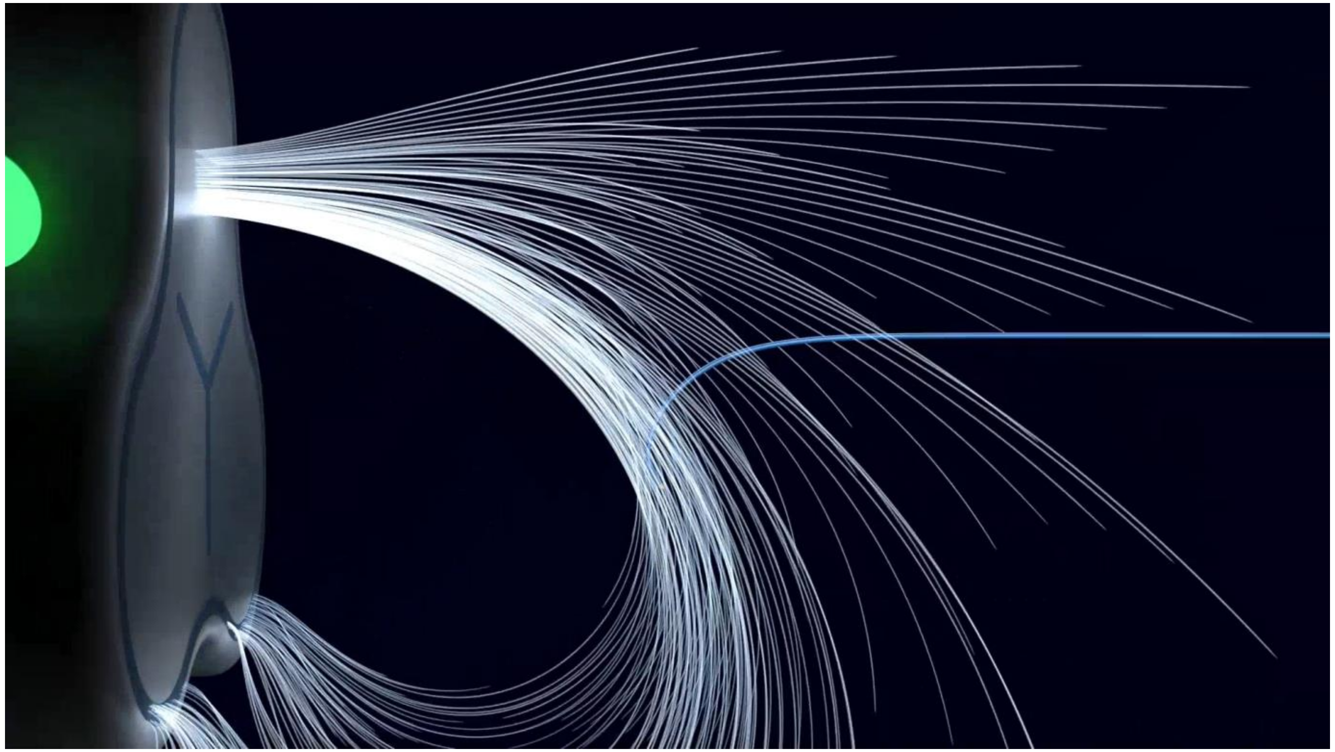
Preliminary Data

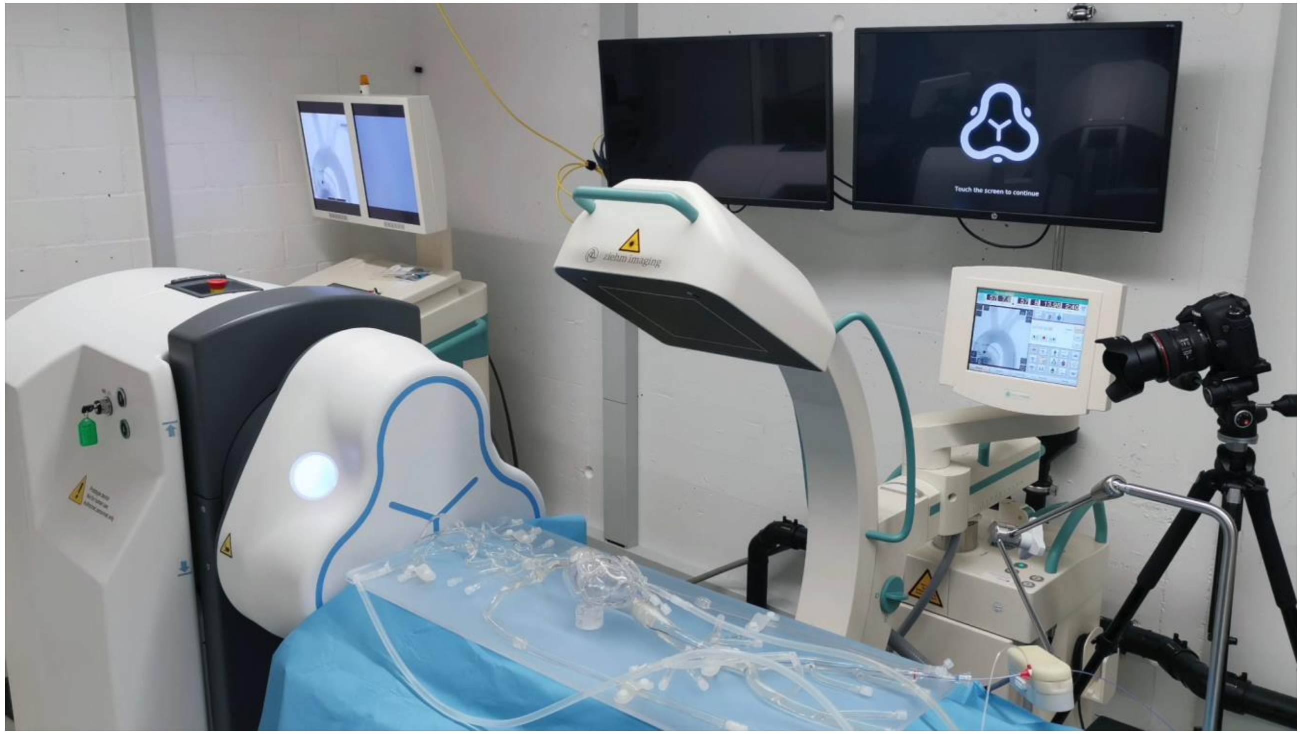
Remote magnetic navigation system: Navion



- Can be installed in a standard operating room and provides appropriate accessibility to the patient

Preliminary Data

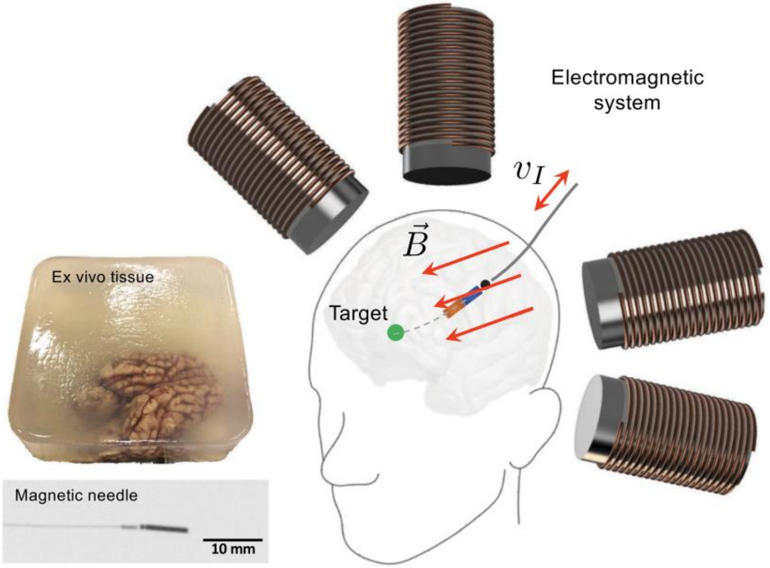
Remote magnetic navigation system: Navion

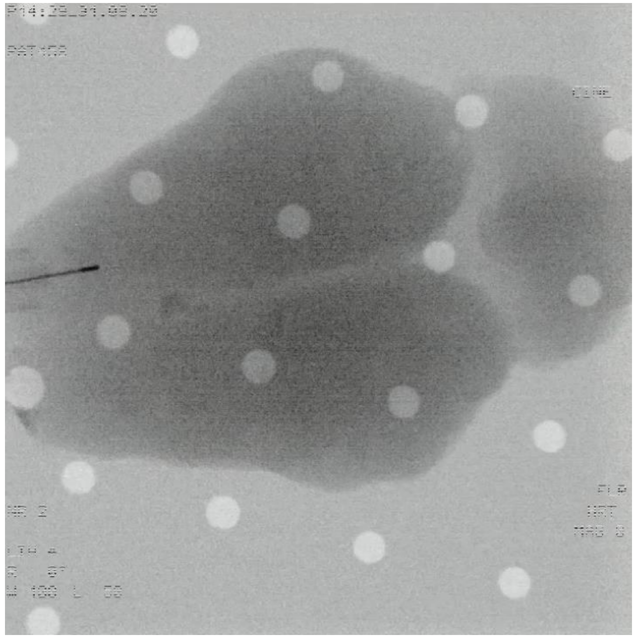


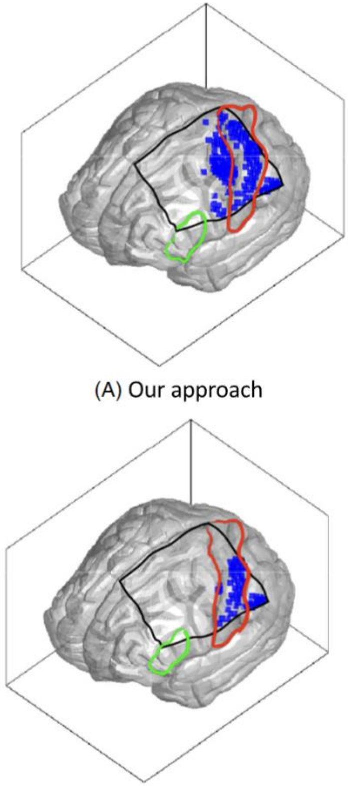
- Successfully demonstrated:
  - *in vitro*: endoscopes for gastroscopy
  - *ex vivo*: fetoscopes for fetal surgeries
  - *in vivo:* neurovascular navigation in a porcine model

Preliminary Data

Initial magnetic carrier design







(A) Our approach

(B) Straight path

A. Hong, A. J. Petruska, A. Zemmar, and B. J. Nelson, "Magnetic Control of a Flexible Needle in Neurosurgery," *IEEE Transactions on Biomedical Engineering*, vol. 68, no. 2, pp. 616–627, Feb. 2021

A. Hong, Q. Boehler, R. Moser, A. Zemmar, L. Stieglitz, and B. J. Nelson, "3D path planning for flexible needle steering in neurosurgery," Int J Med Robotics Comput Assist Surg, vol. 15, no. 4, Aug. 2019

ETH/NFX Objectives

Develop a new robotic minimally-invasive implantation procedure

1. Optimize and adapt a magnetic carrier to deploy the ultrathin cortical and subcortical neural probes

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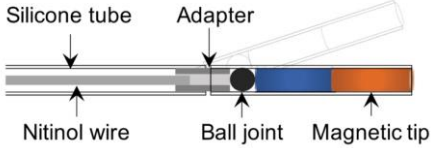

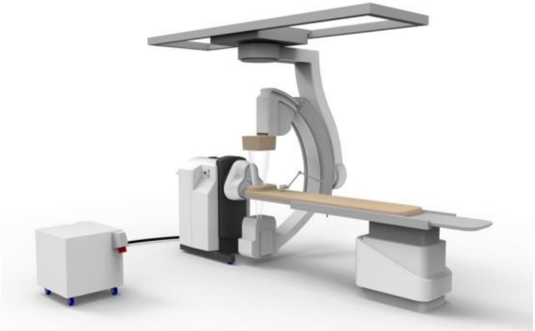

2. Develop the robotic system to precisely insert the electrode guided by X-ray imaging

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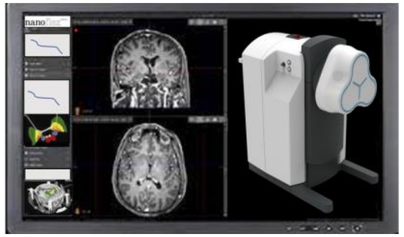

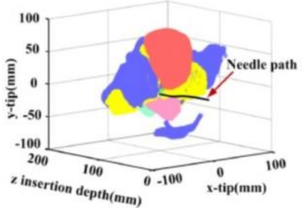

3. Validate the robotic implantation procedure *in vitro* and *in vivo*

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Contributors

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Professor of Robotics and Intelligent System at ETH and Director of MSRL

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Robotics Engineer at Nanoflex

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Contributors

ICN2 Institut Català de Nanociència i Nanotecnologia

INBRAIN NEUROELECTRONICS

LUMC Leiden University Medical Center

imec

Fraunhofer IZM

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Thank you!

European Innovation Council

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Confédération suisse
Confederazione Svizzera
Confederaziun svizra

State Secretariat for Education,
Research and Innovation SERI