Master in Neuro-X

Michael Herzog

EPFL
École polytechnique fédérale de Lausanne

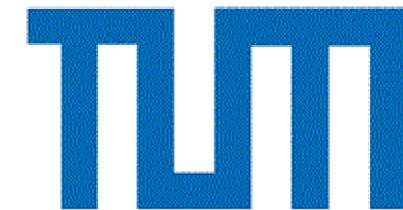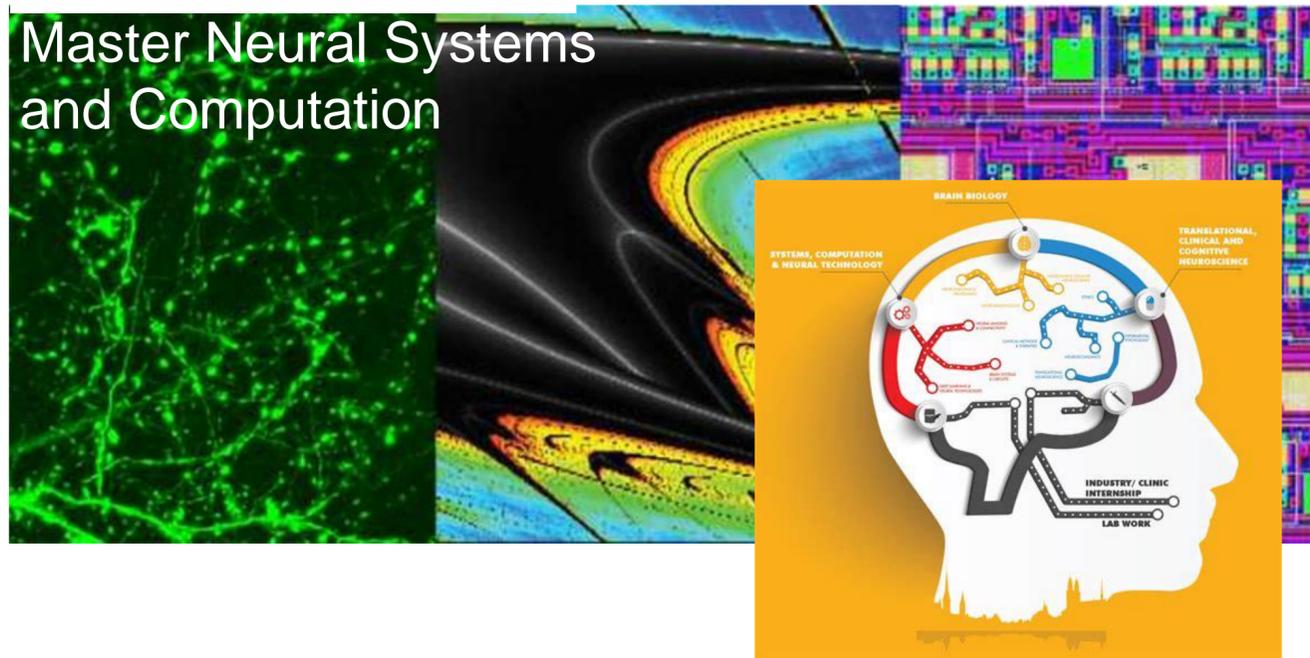February 25, 2026

SV STI IC

Why Master in Neuro-X at EPFL?

- Increasing number of Master programs in neuroengineering at academic institutions

ETH zürich

Master Neural Systems and Computation

TUM

Elite Master of Science in Neuroengineering

Imperial College London

MRes in Neurotechnology

Why Master in Neuro-X at EPFL?

- EPFL has strong reputation in neuro-related research activities
- Educate future professionals in the neuro field
  - From *research* to *applications*
  - In industry, healthcare, and academia
- Neuro-X brings together foundational disciplines that shape brain research
 - Science, Engineering, and Computation

Master in Neuro-X

Science
Engineering
Computation

- X=intersection: being at the crossroads of disciplines
- X=eXpansion: exploiting synergies by combining disciplines
- X=eXploration: explore horizons of what is possible today and tomorrow

Pillars of the Master in Neuro-X

- Discoveries and innovation are driven by the virtuous cycle of
  - Curiosity by questioning current knowledge ~ science
  - Tools to pursue measures to test or explore ~ engineering
  - Analysis of measures to extract information ~ computation
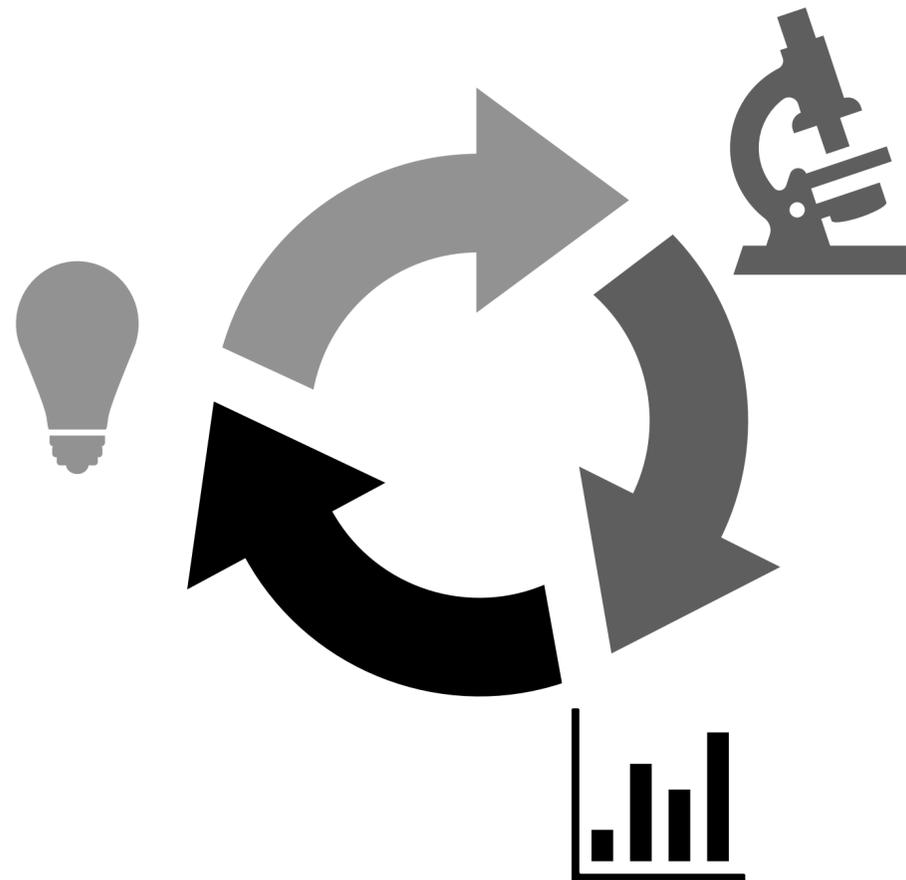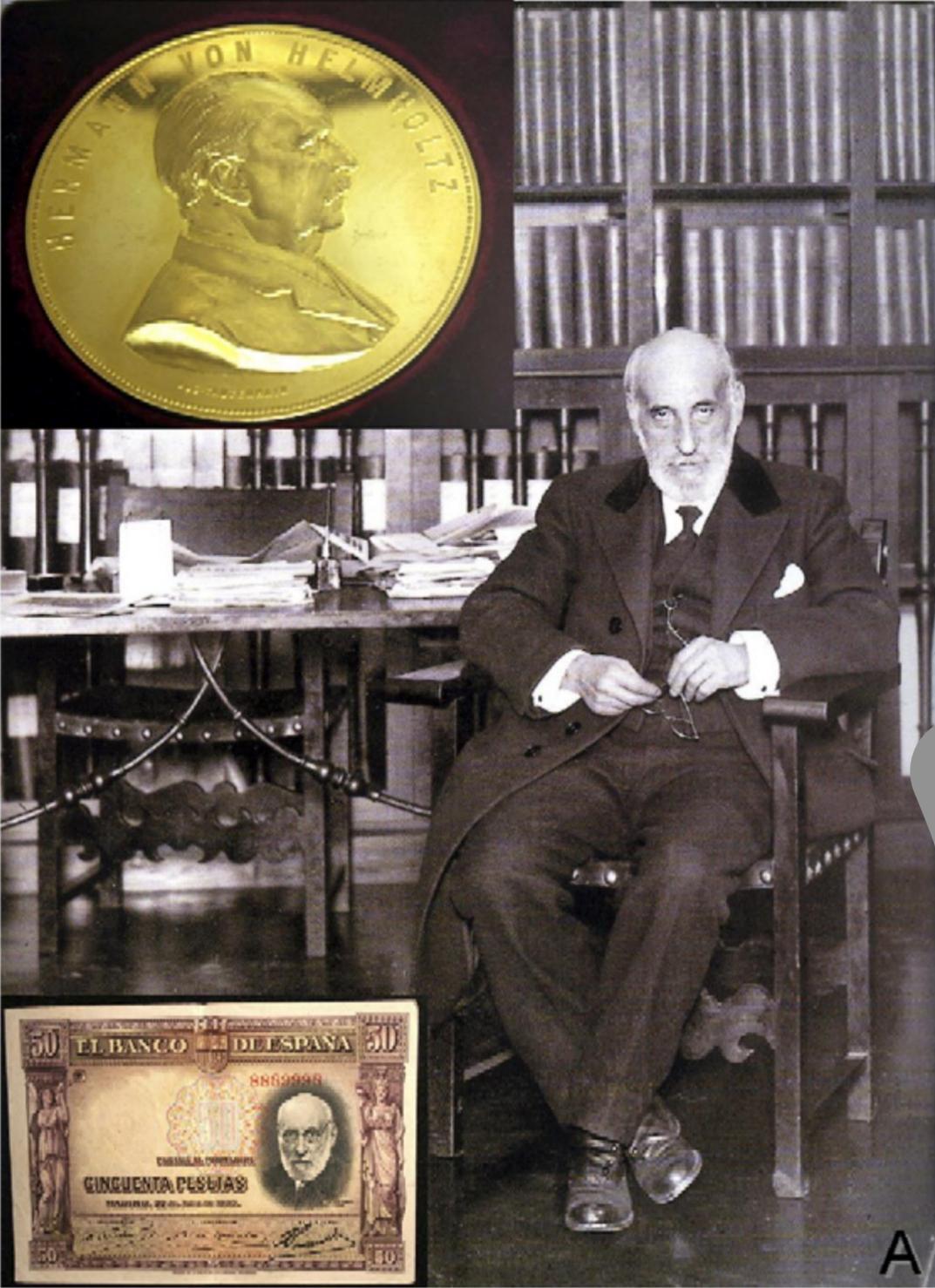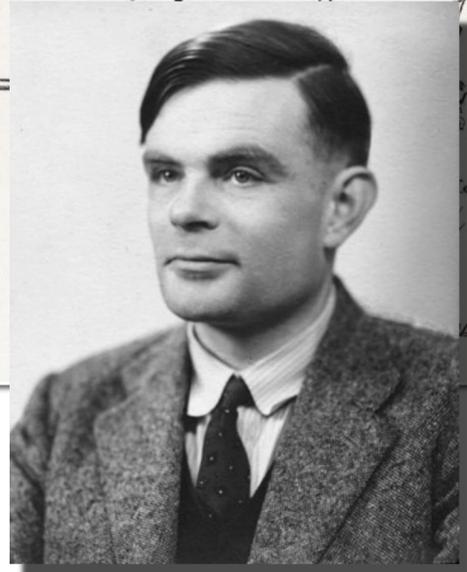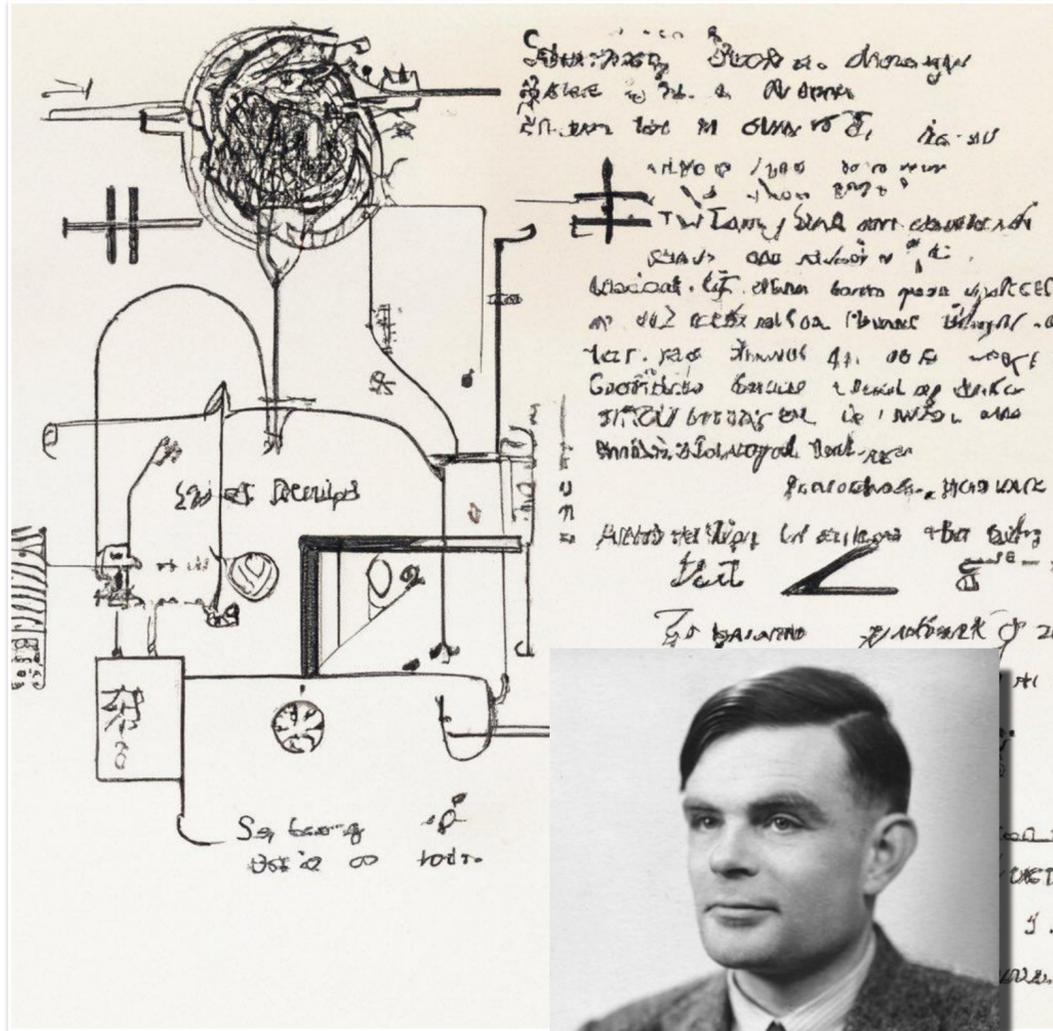
Santiago Ramon y Cajal,
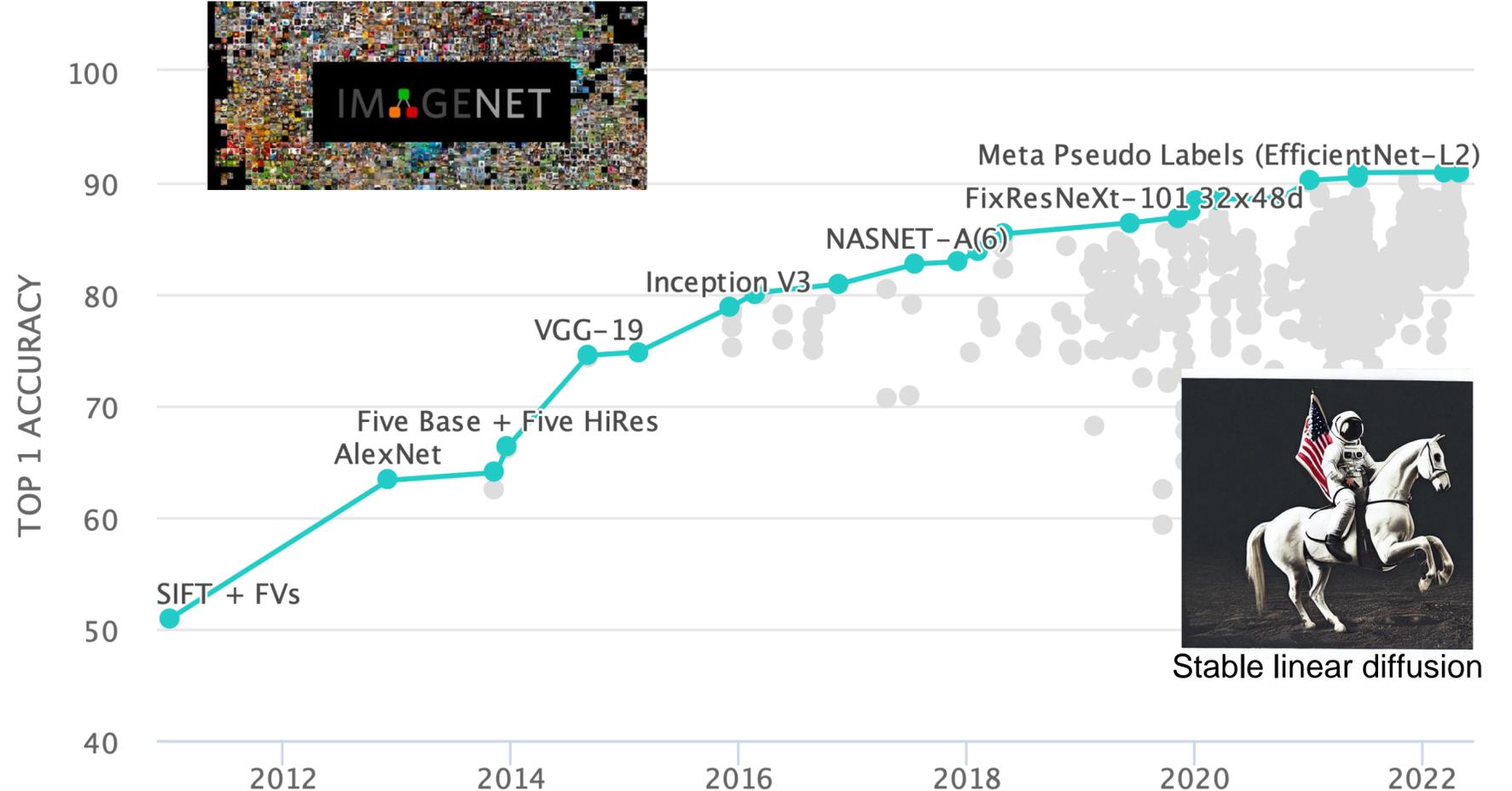1852-1934
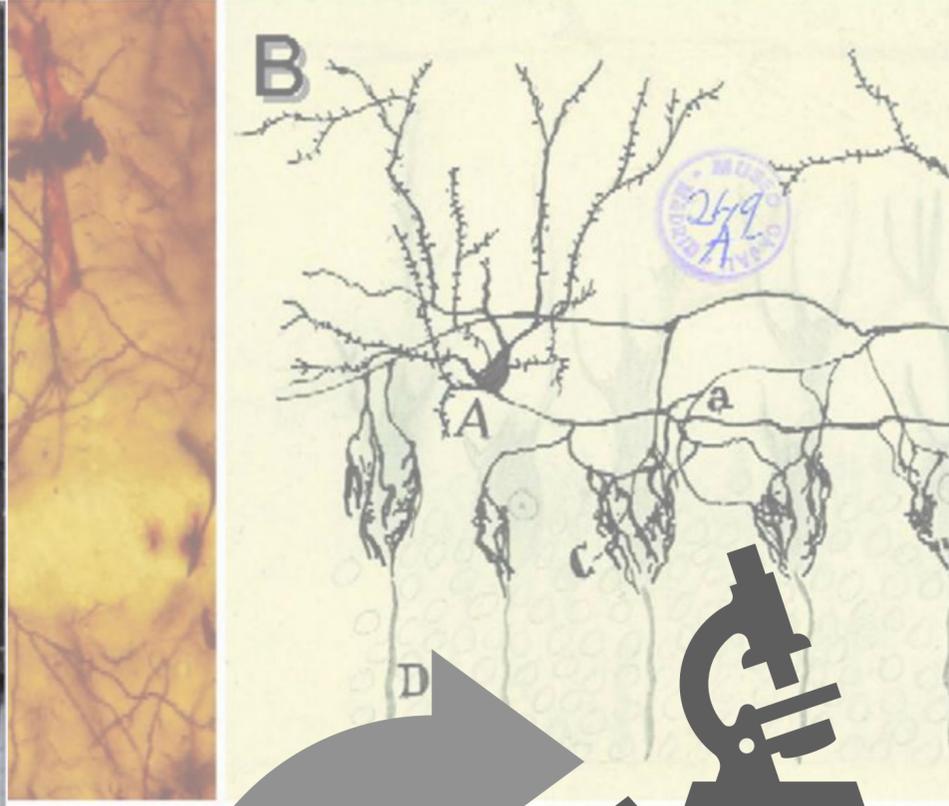
Camillo Golgi, 1843-1926

[De Carlos, Borrell,
Brain Research Reviews, 2007]

SNX

Inspiration for brain-like computing

- Computer science learns from neuroscience and vice versa

Alan Turing
1912-1954

IMAGENET

Meta Pseudo Labels (EfficientNet-L2)
FixResNeXt-101 32x48d
NASNET-A(6)
Inception V3
VGG-19
Five Base + Five HiRes
AlexNet
SIFT + FVs

Stable linear diffusion

a hand holding a san francisco 49ers football

a row of cannons with the eiffel tower in the background

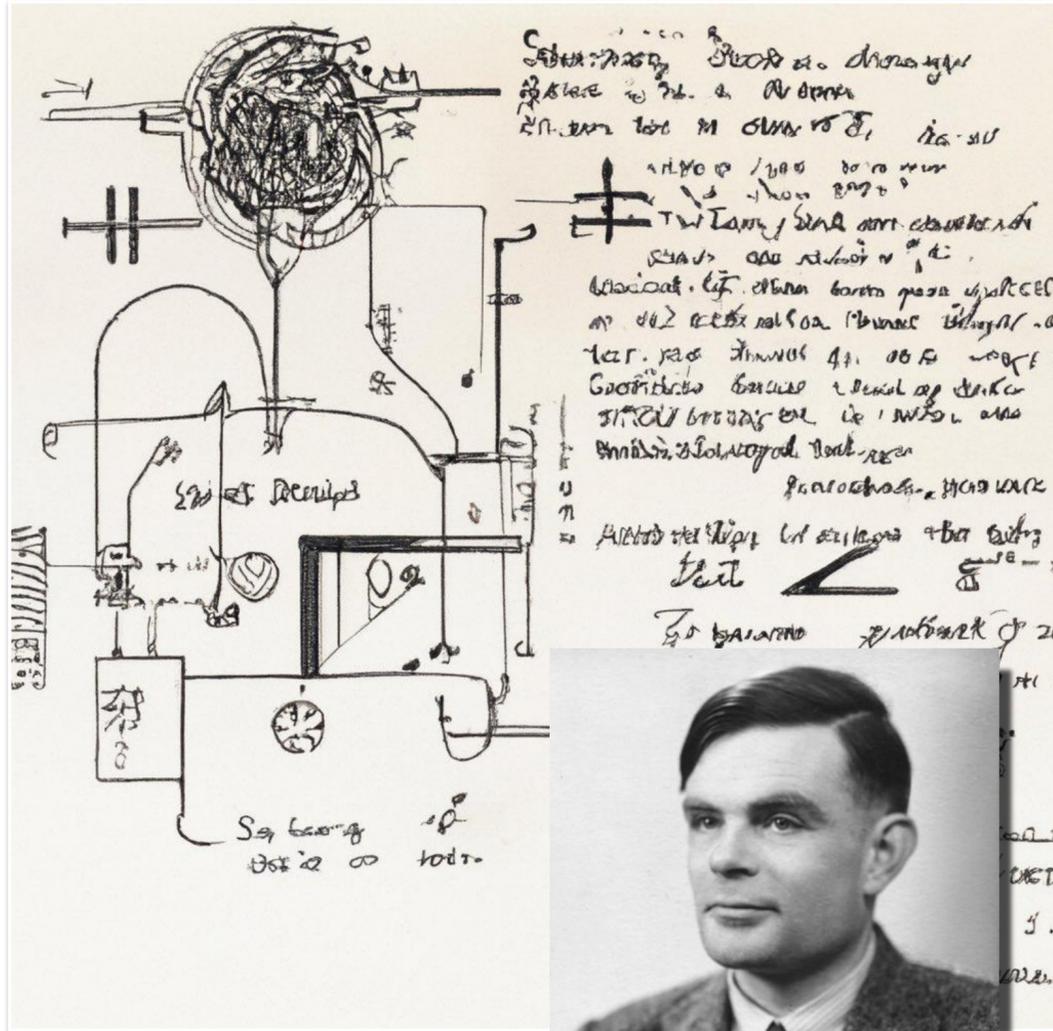a white van with a license plate that says we love flynn

a person sitting on a wooden bridge holding an umbrella

a truck is reflected in the side mirror of a car

[https://paperswithcode.com/sota/image-classification-on-imagenet

Yu et al, arXiv 2205.01917, 2022]

Inspiration for brain-like computing

- Computer science learns from neuroscience and vice versa

Alan Turing
1912-1954

Why would students opt for the Master in Neuro-X program?

There are several reasons why students might opt for a Master's program in Neuro-X, such as:

1. Interdisciplinary approach: Neuro-X is an interdisciplinary field that combines neuroscience, engineering, and other related fields. Students interested in exploring the intersection of different disciplines and applying a diverse skill set to solve complex problems may find this program appealing.

2. Growing demand: There is a growing demand for professionals with expertise in Neuro-X. As technology continues to advance, there is an increasing need for individuals who can develop new tools and techniques to better understand the brain and nervous system and improve human health.

3. Career opportunities: Graduates of a Master's program in Neuro-X may pursue a wide range of career opportunities in academia, industry, and government. These include roles in research and development, product design, clinical applications, and more.

4. Advancing scientific knowledge: Neuro-X is an exciting and rapidly evolving field, with many unanswered questions about the brain and nervous system. Students interested in advancing scientific knowledge and contributing to breakthroughs in neuroscience may find this program rewarding.

5. Personal interest: Finally, many students may opt for a Master's program in Neuro-X simply because they have a personal interest in the field. The study of the brain and nervous system is fascinating to many people, and a Master's program in Neuro-X provides an opportunity to explore this interest in greater depth.

Affiliated to three faculties
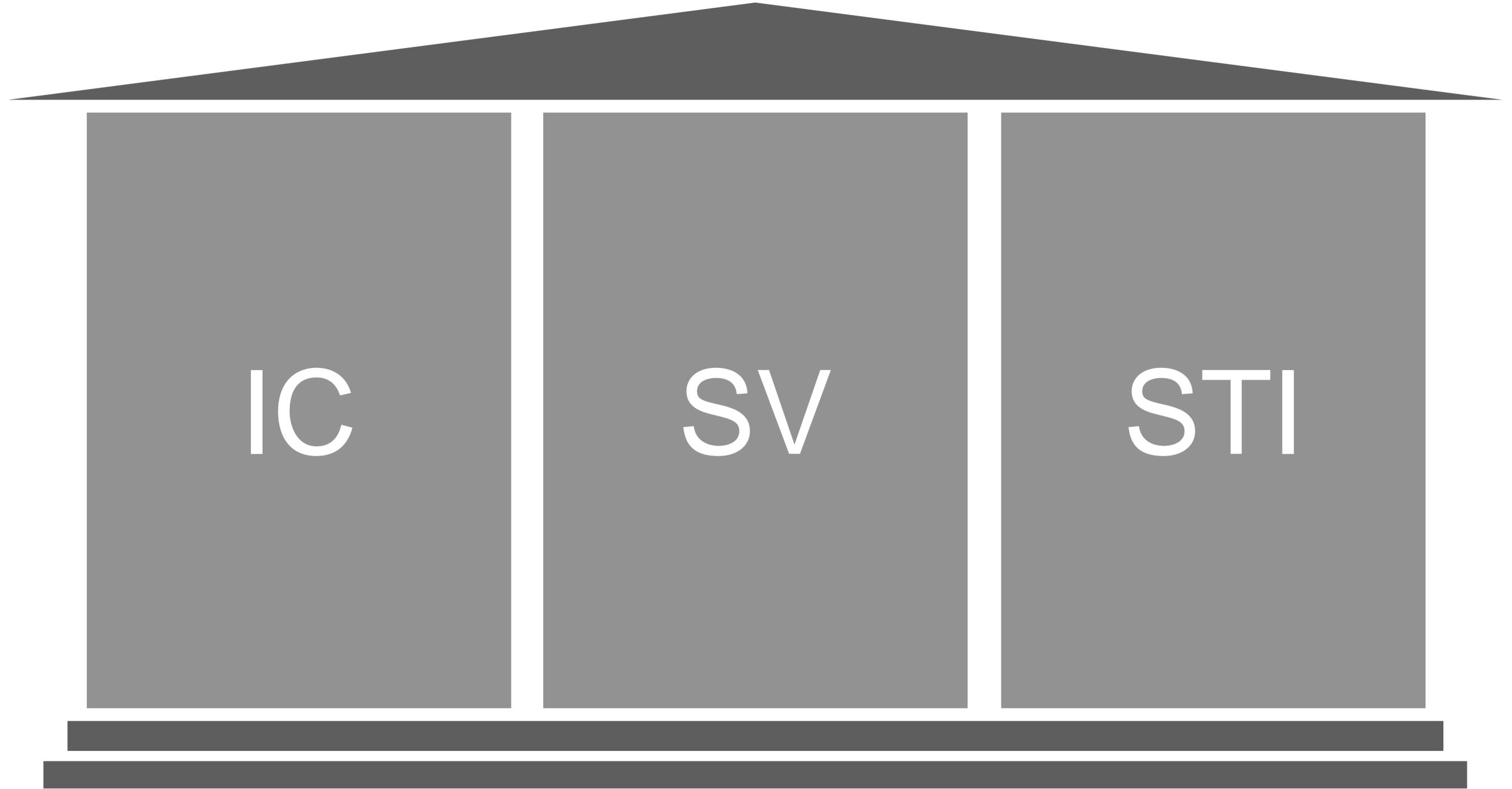
Core disciplines

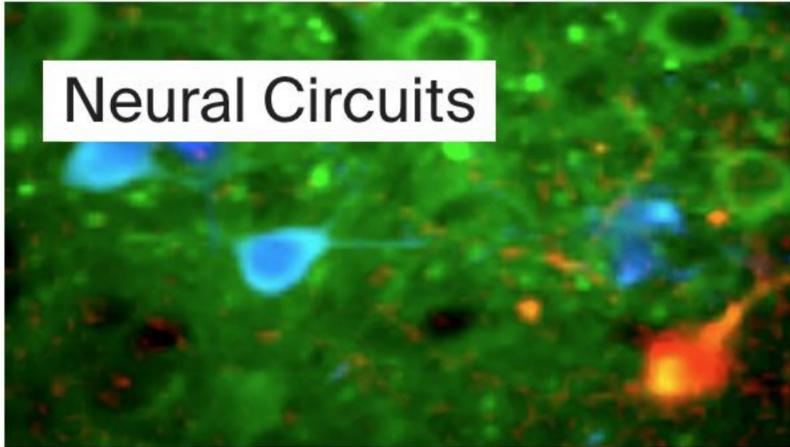computational neurosciences

neurosciences

neuro-engineering

Neurosciences

computational neurosciences

neurosciences

neuro-engineering

Neural Circuits

Neuroscience:
Cellular and Circuit Mechanisms
(**Petersen**/Crochet)
BIO-482

5

Cellular and Molecular Neuroscience
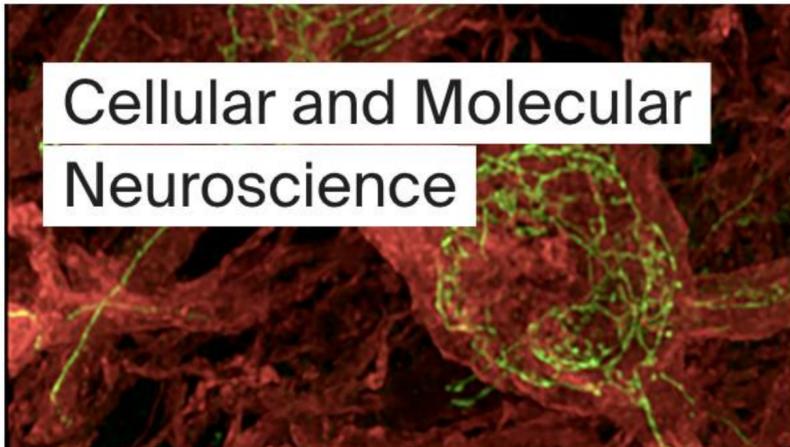
Neuroscience:
From Molecular Mechanisms to Disease
(**Graeff**/Mahul/Schneider)
BIO-480

5

Behaviour and Cognition

Neuroscience:
Behavior and Cognition
(Sandi/Blanke/Herzog)
BIO-483

5

Computational neurosciences

| computational neurosciences | neurosciences | neuro-engineering |

8

Machine Learning
(**Jaggi**/Flammarion)
CS-433

5

Brain-like computation and intelligence
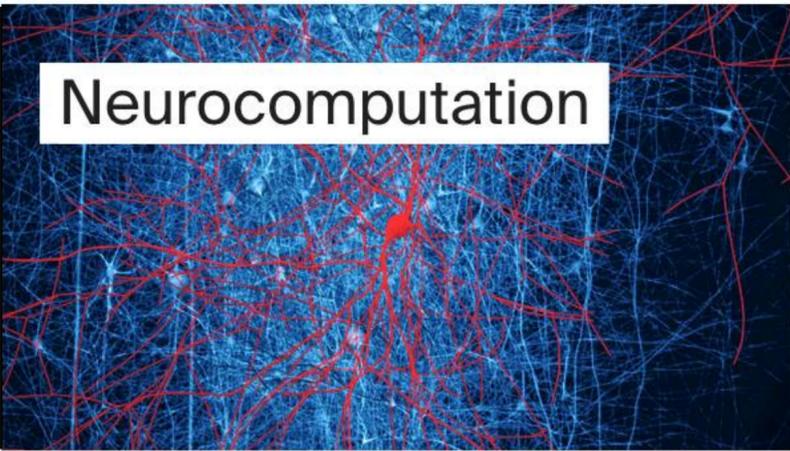(**Matthis A**/Schrimpf)
NX-414

NEW

5

Computational neuroscience:
Neuronal Dynamics
(**Gerstner**)
NX-465

UPDATED

Neurocomputation

Neuroengineering

computational neurosciences

neurosciences

neuro-engineering

Signals

Interfaces

Translation

NEW

Neural Signals and Signal Processing
(**Van De Ville**/Micera)
NX-421
6

NEW

Neural Interfaces
(**Lacour**/Shiavone/Shoaran)
NX-422
6

NEW

Translational Neuroengineering
(**Hummel**/Blanke/
Micera/Courtine)
NX-423
6

Neurotechnology

Master in Neuro-X

Core courses (31 ECTS)

Master in Neuro-X

computational neurosciences

neurosciences

neuro-engineering

Fall
Spring

Machine Learning (**Jaggi**/Flammarion) CS-433 — 8	Neuroscience: Cellular and Circuit Mechanisms (**Petersen**/Crochet) BIO-482 — 5	Neural Signals and Signal Processing (**Van De Ville**/Micera) NX-421 — 6
Brain-like computation and intelligence (**Matthis A**/Schrimpf) NX-414 — 5	Neuroscience: From Molecular Mechanisms to Disease (**Graeff**/Mahul/Schneider) BIO-480 — 5	Neural Interfaces (**Lacour**/Shiavone/Shoaran) NX-422 — 6
Computational neuroscience: Neuronal Dynamics (**Gerstner**) NX-465 — 5	Neuroscience: Behavior and Cognition (Sandi/Blanke/Herzog) BIO-483 — 5	Translational Neuroengineering (**Hummel**/Blanke/ Micera/Courtine) NX-423 — 6

Neuroscience focus
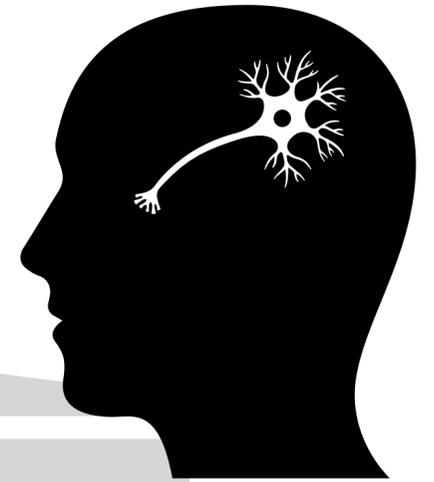
computational neurosciences

neurosciences

neuro-engineering

Machine Learning
(**Jaggi**/Flammarion)
CS-433

Brain-like computation and intelligence
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(**Hummel**/Blanke/Micera/Courtine)
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Computational focus
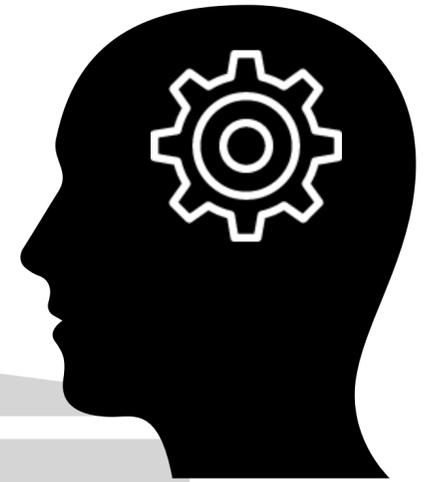
computational neurosciences

neurosciences

neuro-engineering

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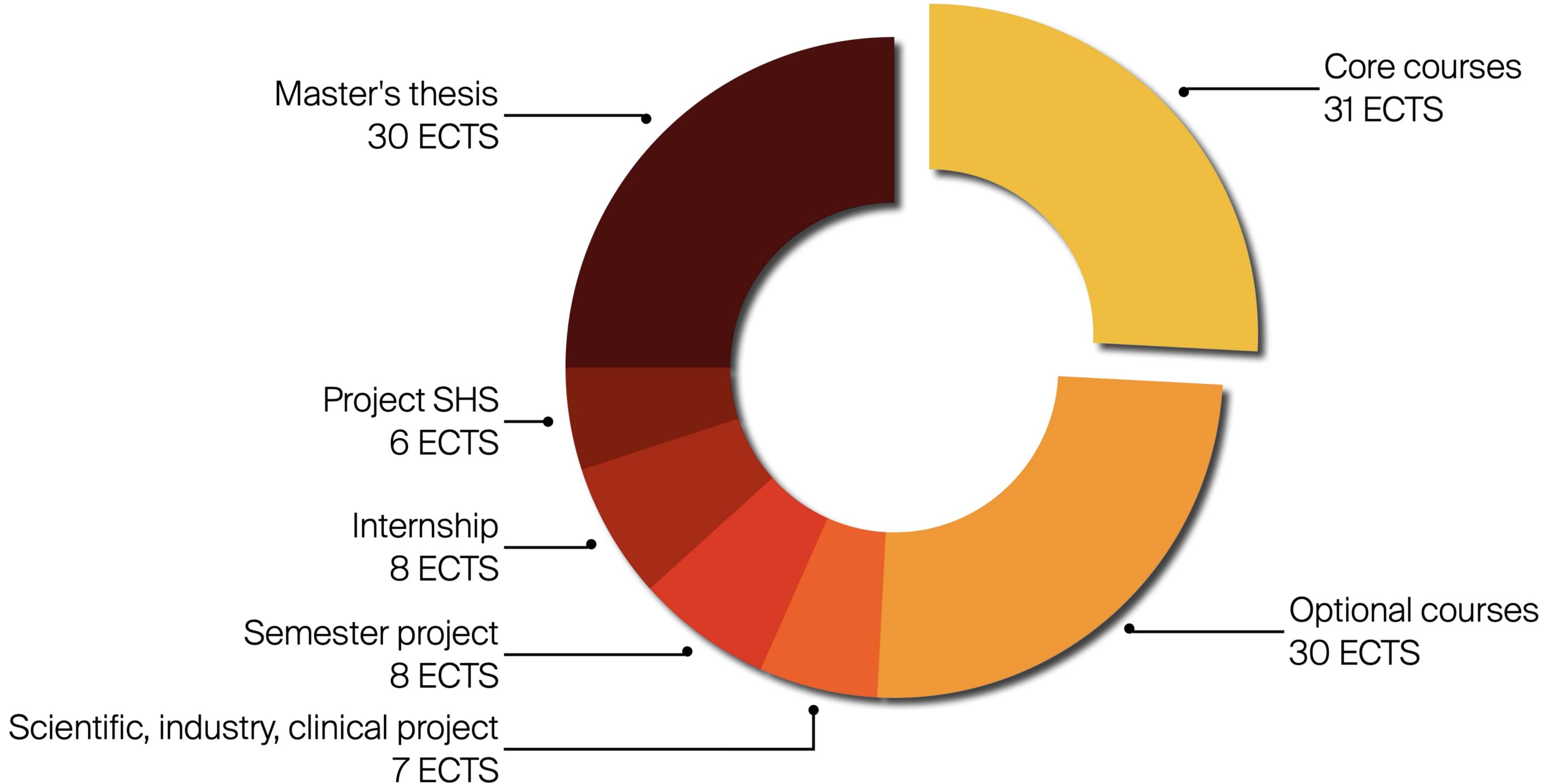| 5 |
|---|
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Neuroscience: Behavior and Cognition (Sandi/Blanke/Herzog) BIO-483

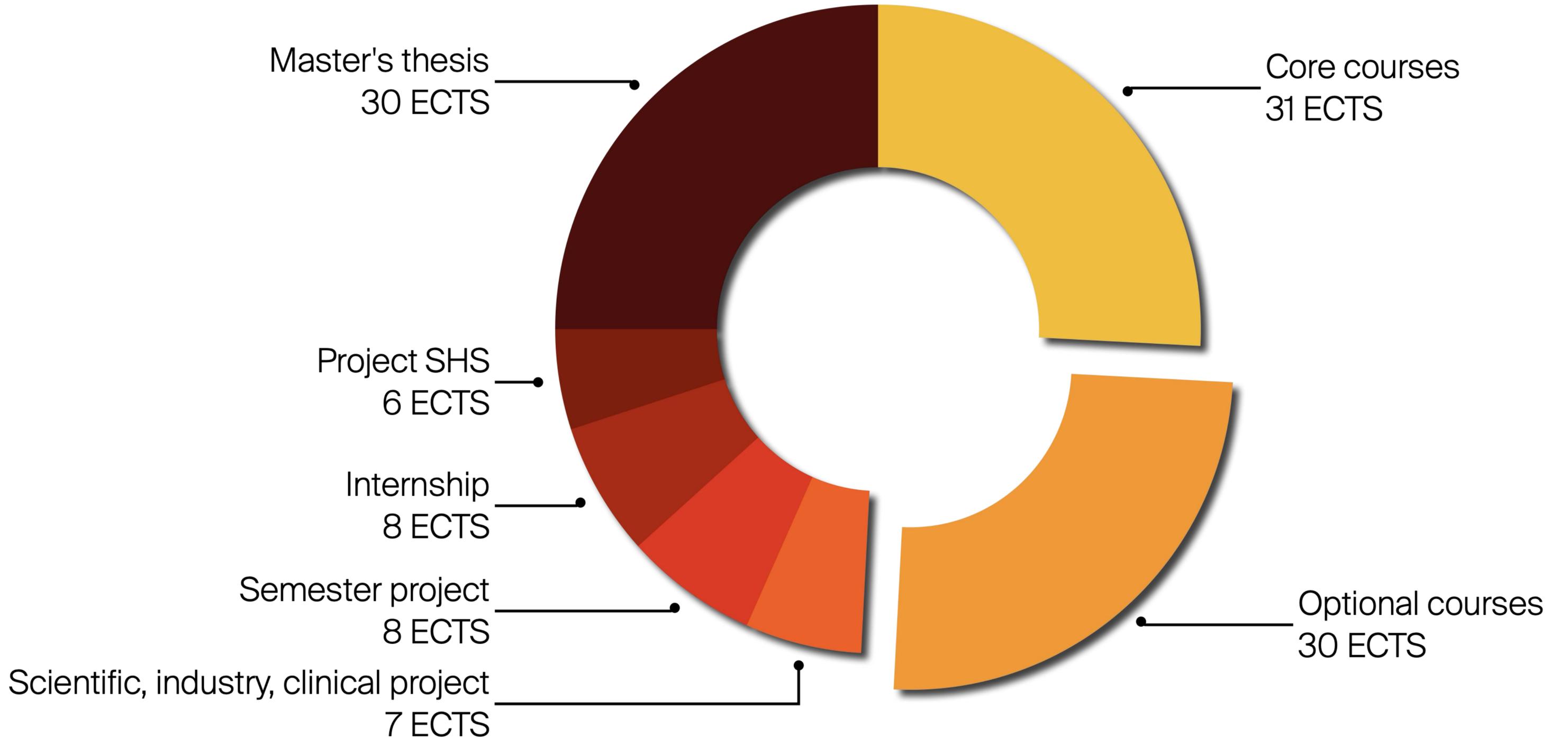| 6 |
|---|
| Neural Signals and Signal Processing (**Van De Ville**/Micera) NX-421 |

Neural Interfaces (**Lacour**/Shiavone/Shoaran) NX-422

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Translational Neuroengineering (**Hummel**/Blanke/ Micera/Courtine) NX-423

Neuroengineering focus

computational neurosciences	neurosciences	neuro-engineering

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Master in Neuro-X (120 ECTS)

Master's thesis
30 ECTS

Core courses
31 ECTS

Project SHS
6 ECTS

Internship
8 ECTS

Semester project
8 ECTS

Optional courses
30 ECTS

Scientific, industry, clinical project
7 ECTS

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Area: Technology
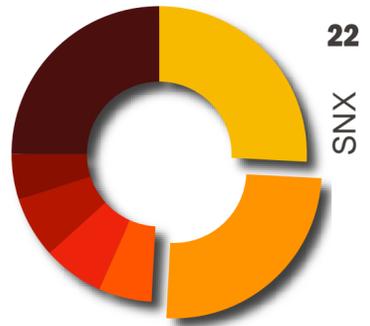
- BIOENG-456   4   Controlling behavior in animals and robots (Ramdya)
- MICRO-432   6   Computational motor control (Ijspeert)
- MICRO-450   3   Basics of robotics for manipulation (Bouri)
- MICRO-505   2   Organic and printed electronics (Briand/Subramanian)
- MICRO-530   3   Nanotechnology (Boero/Brugger)
- MICRO-553   3   Haptic human robot interfaces (Bouri)
- EE-320   3   Analog IC design (Shoaran)
- EE-511   3   Sensors in medical instrumentation (Chételat/Ionescu)
- EE-515   3   Fundamentals of biosensors and electronic chips (Guiducci)
- EE-517   3   Bio-nano-chip design (Carrara)
- EE-519   3   Bioelectronics and biomedical microelectronics (Schmid)
- CS-444   4   Virtual reality (Boulic)
- CS-472   6   Design technologies for integrated systems (De Micheli)
- MSE-341   3   Sustainability and materials (Abitbol)

Master in Neuro-X

Area: Data Science and Machine Learning
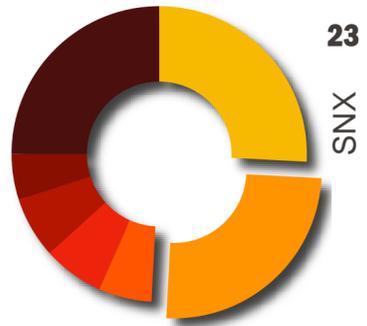
- CS-401   8   Applied data analysis (Brbic)
- CS-421   6   Machine learning for behavioral data (Käser)
- CS-431   6   Introduction to natural language processing (Chappelier/Rajman/Bosselut)
- CS-439   8   Optimization for machine learning (Jaggi/Flammarion)
- CS-456   6   Deep reinforcement learning (Gulcehre)
- CS-479   6   Learning in neural networks (Gerstner)
- CS-502   6   Deep learning in biomedicine (Brbic)
- CS-503   6   Visual intelligence: machines and minds (Zamir)
- COM-502   6   Dynamical system theory for engineers (Thiran)
- EE-556   6   Mathematics of data: from theory to computation (Cevher)
- EE-559   4   Deep learning (Cavallaro)
- BIO-449   4   Understanding statistics and experimental design (Herzog)
- MICRO-455   4   Machine learning I (Billard)
- MATH-352   5   Causal thinking (Stensrud)
- MATH-474   5   Applied biostatistics (Goldstein)
- MGT-484   4   Applied probability and stochastic processes (Cristi)
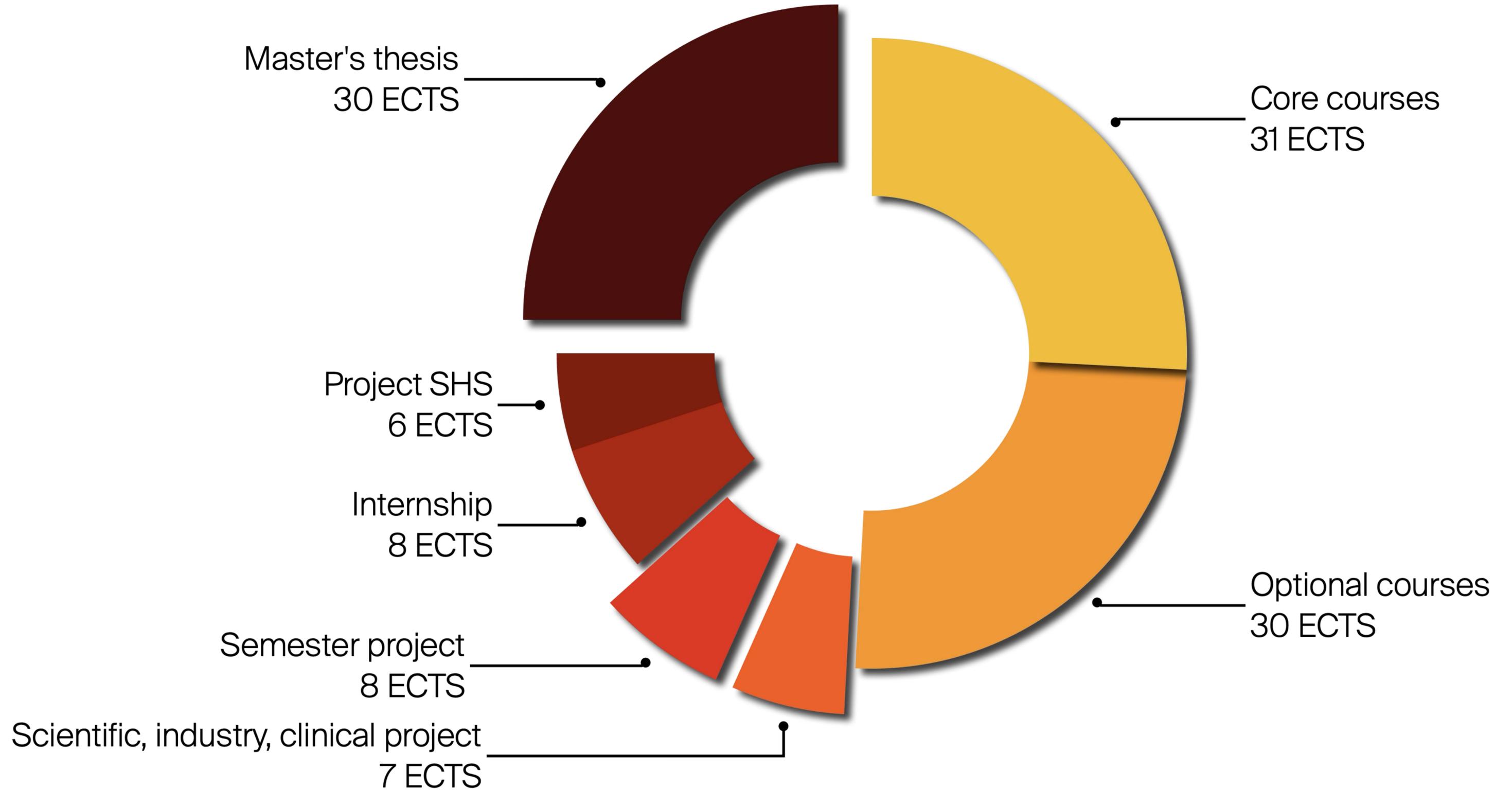
Area: Imaging and image analysis
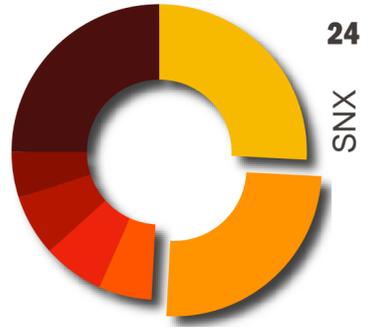
- BIO-443   3   Fundamentals of biophotonics (Radenovic)
- BIOENG-445   3   Biomedical optics (Wagnieres)
- MICRO-511   3   Image Processing I (Unser/Van De Ville)
- MICRO-512   3   Image Processing II (Unser/Van De Ville/Sage)
- MICRO-561   3   Biomicroscopy I (Seitz)
- MICRO-562   4   Biomicroscopy II (Altug + Seitz)
- EE-451   4   Image analysis and pattern recognition (Bozorgtabar/Thiran)
- CS-440   6   Advanced computer graphics (Jakob)
- CS-442   6   Computer vision (Fua)
- PHYS-438   4   Fundamentals of biomedical imaging (Gruetter)
- PHYS-473   3   CIBM Practicals on CIBM preclinical imaging systems (Cudalbu, Lanz)

Area: Neuro-exploration
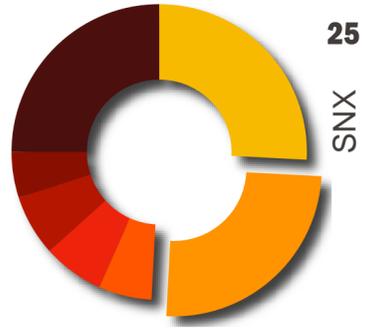
- NX-434   4   Computational psychiatry (Graeff)
- NX-435   4   Systems neuroscience (Mathis M)
- NX-436   4   Advanced methods for human neuromodulation (Hummel F)

- BIO-451   4   Scientific literature analysis in neuroscience (Sandi/McCabe)
- BIO-493   4   Scientific project design in integrative neurosciences (Petersen)
- BIO-487   4   Scientific project design in translational neurosciences (LeCoutre/Graeff)
- BIO-499   4   Neural circuits of motivated behaviors (Kochubey/Schneggenburger)

- DH-415   4   Ethics and law of AI (Rochel)

- MGT-406   4   Design in innovation: creation for adoption (Henchoz/Laperrouza)
- NX-451   3   Regulatory, quality and clinical affairs (Rochat)

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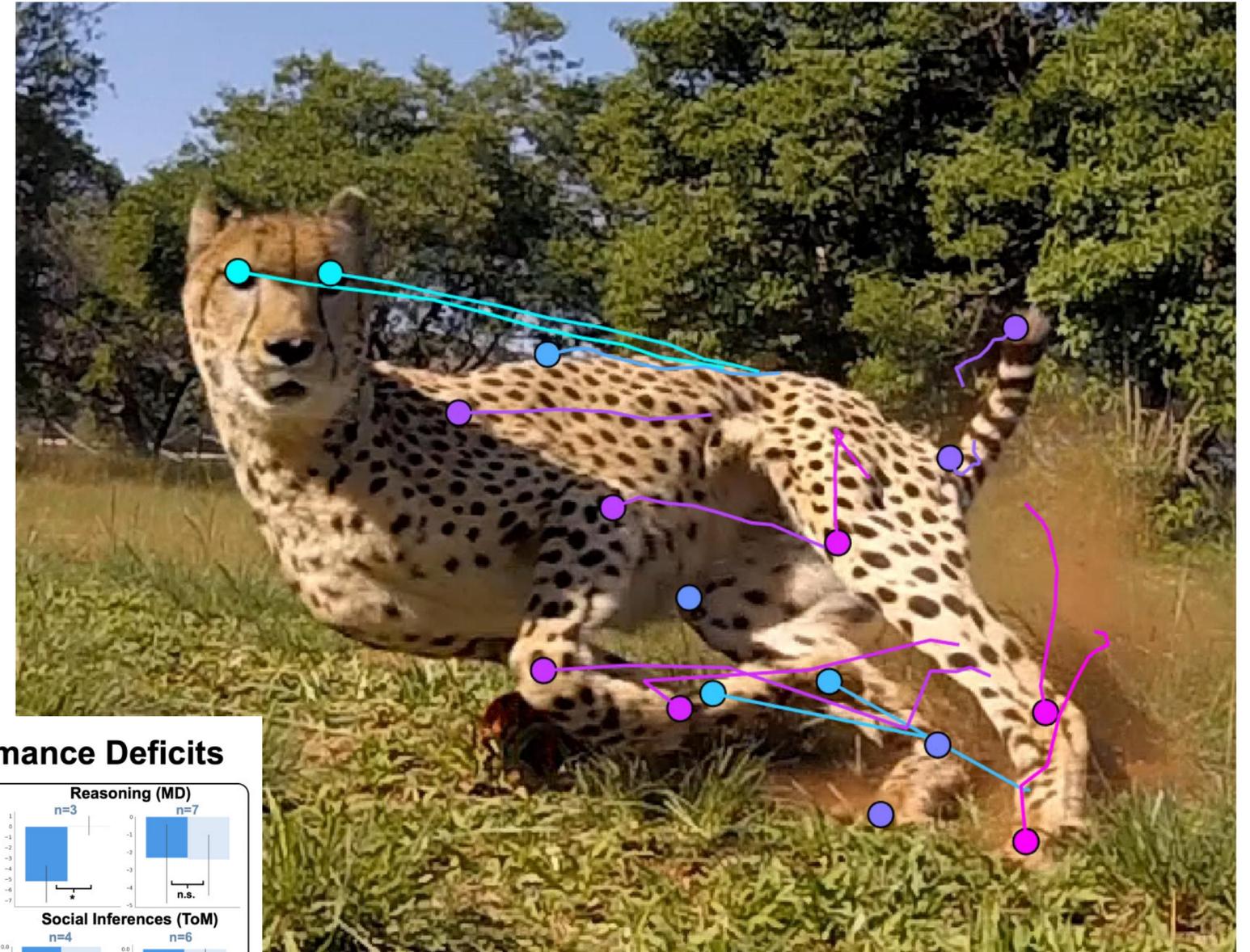
Investigating fundamental mechanisms

- **Traumatic memory formation**
  - Identify preclinical molecular and cellular mechanisms with translational potential
  - From RNA sequencing to optogenetics to control neuronal function with light
- **Brain organoids**
  - Epigenomic atlas

Brain organoid 90 days — DAPI

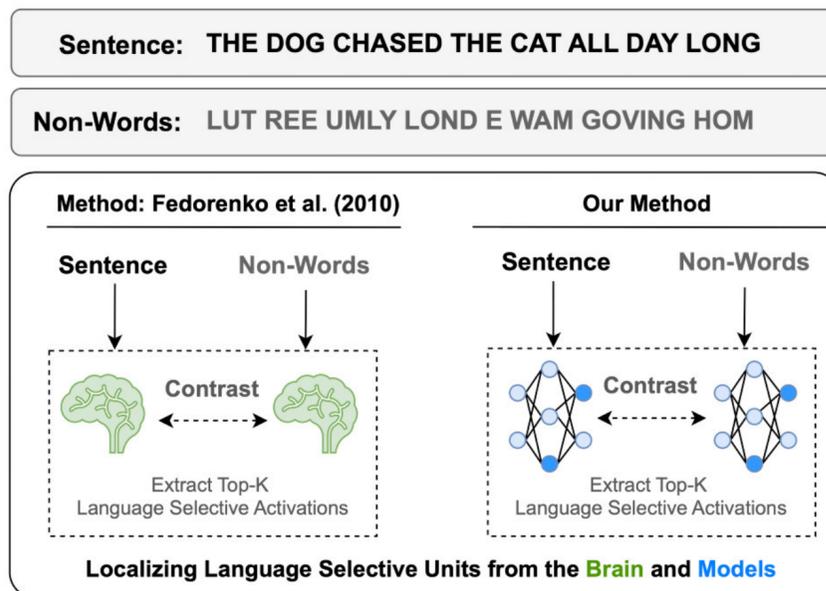Individual region — H3K27ac / H3K27me3 / H3K4me3
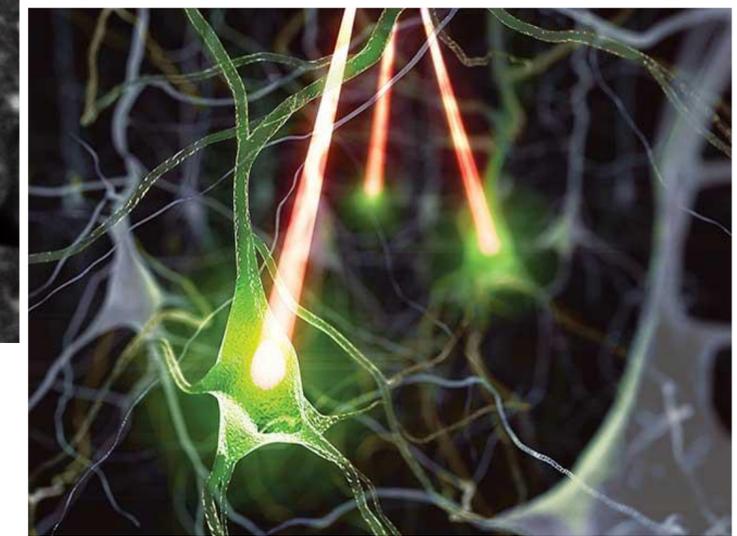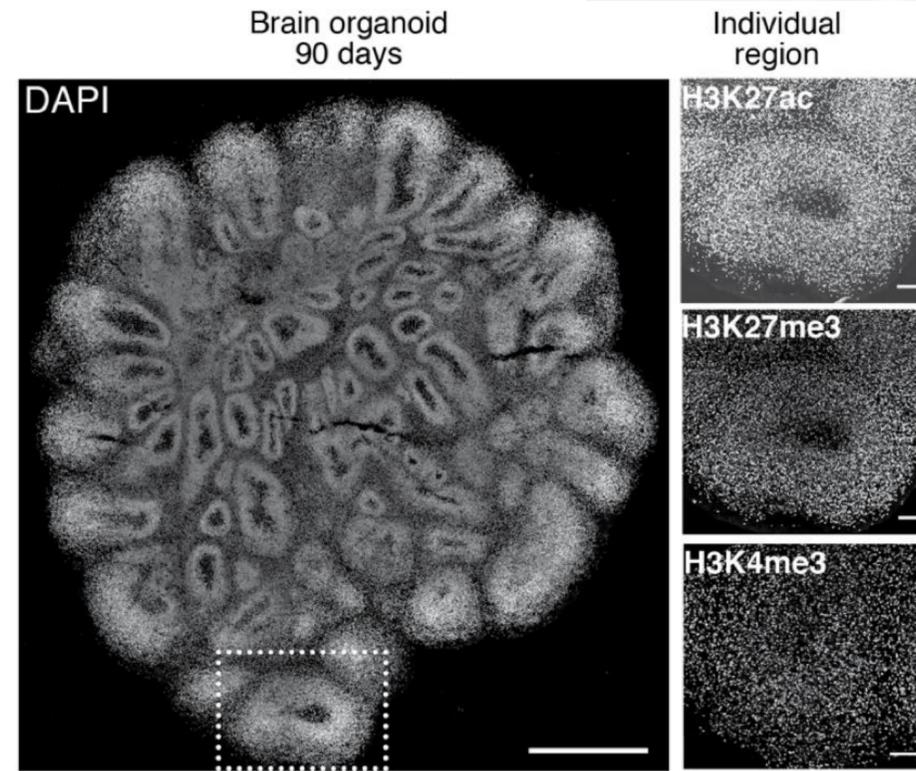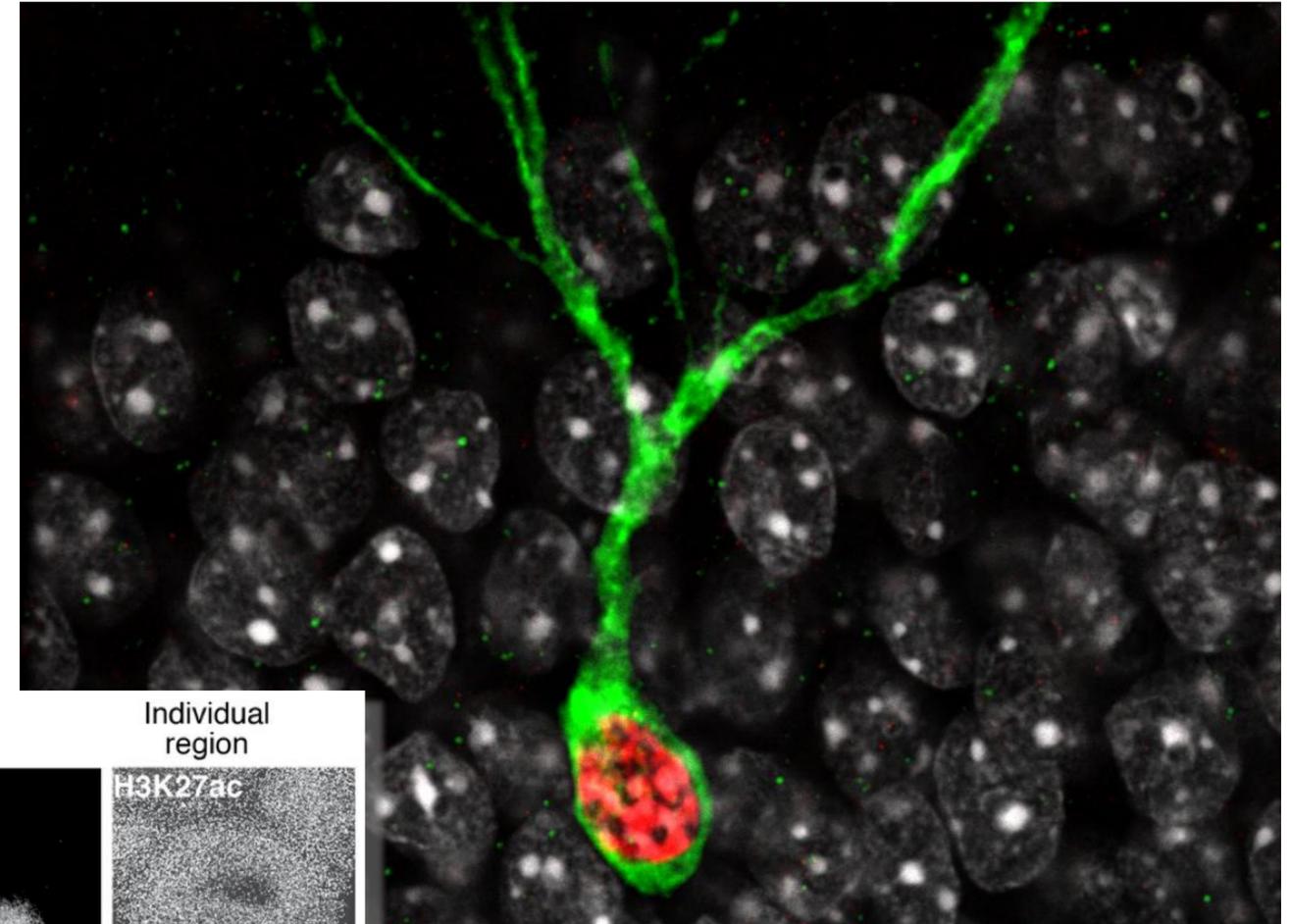
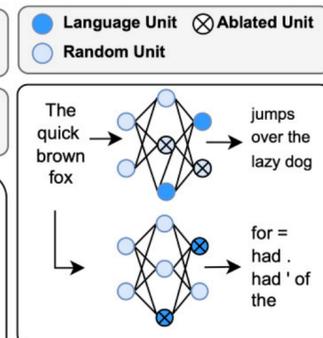Examples from the labs of J. Gräff, F. Zenk

- Brain control of behavior and motor actions
  - Inverse dynamics
    - 2D and 3D pose estimation
    - Infer biomechanical torques from video material
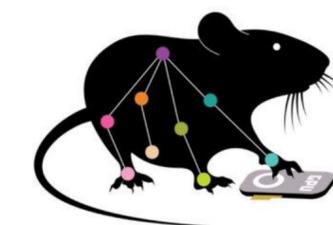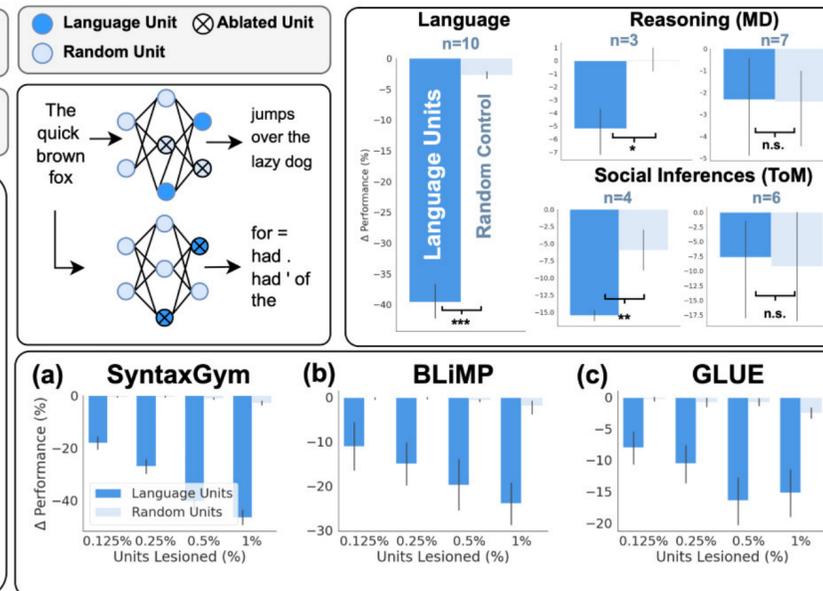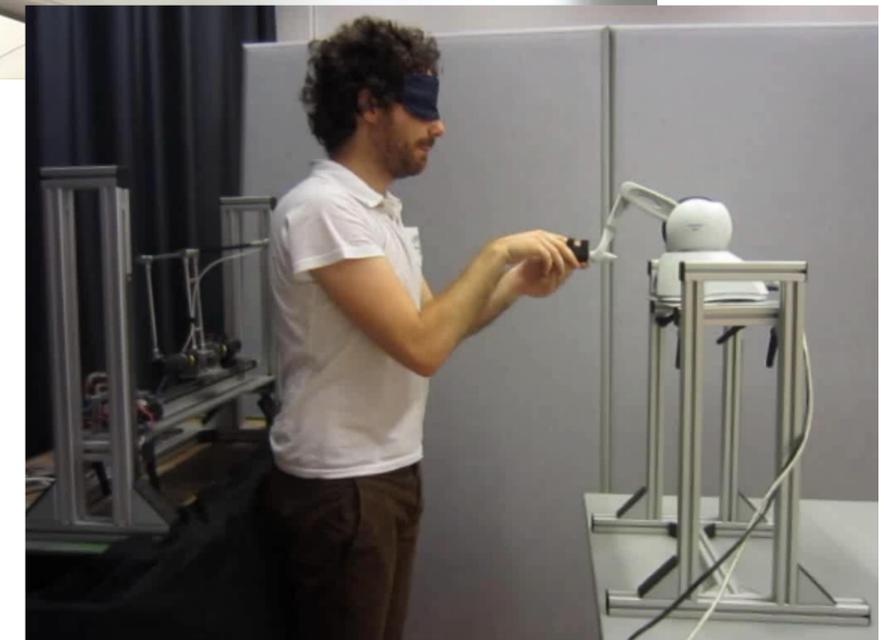- Brain-like specializations in LLMs

① **Localizing Language Units**

Sentence: THE DOG CHASED THE CAT ALL DAY LONG

Non-Words: LUT REE UMLY LOND E WAM GOVING HOM

Method: Fedorenko et al. (2010)

Sentence   Non-Words

Contrast

Extract Top-K
Language Selective Activations

Our Method

Sentence   Non-Words

Contrast

Extract Top-K
Language Selective Activations

Localizing Language Selective Units from the Brain and Models

② **Lesion Units**

● Language Unit ⊗ Ablated Unit
○ Random Unit

The quick brown fox → jumps over the lazy dog

for = had . had ' of the

③ **Performance Deficits**

Language
n=10

Reasoning (MD)
n=3   n=7
n.s.

Social Inferences (ToM)
n=4   n=6

***   **   n.s.

(a) SyntaxGym (b) BLiMP (c) GLUE

Language Units
Random Units

0.125% 0.25% 0.5% 1%
Units Lesioned (%)
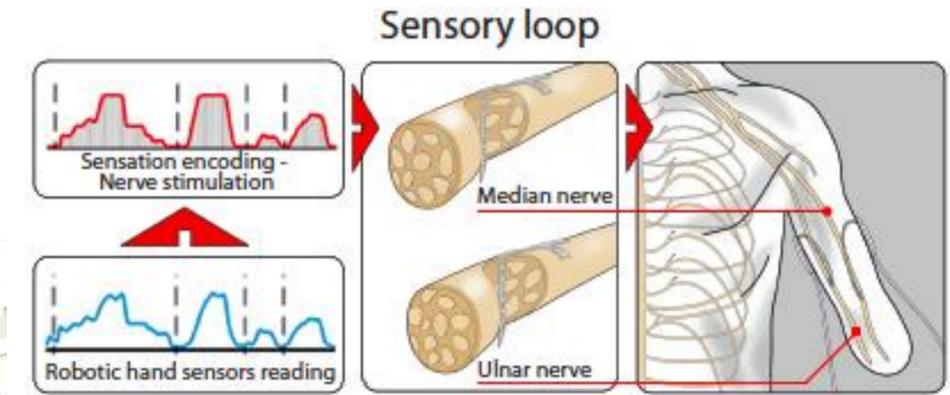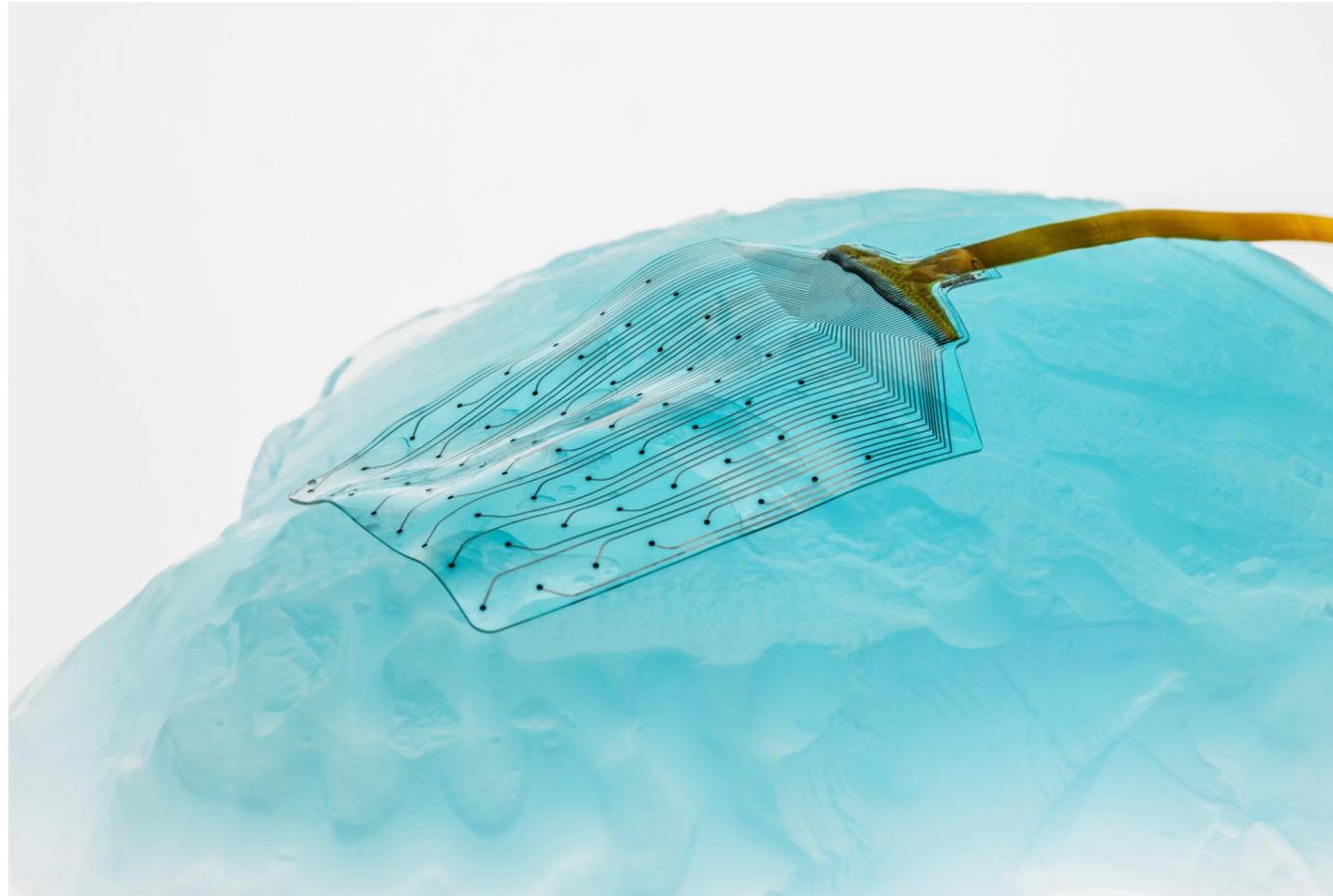
DeepLabCut™:
a software package for animal pose estimation

Examples from the labs of A. Mathis, M. Mathis, M. Schrimpf

Prostheses and embodiment

- Improving hand prosthesis with fine force control using sensory-nerve stimulation

- Use of new technologies to study embodiment

  - Virtual reality

  - Robotic stimulation, including inside MRI

- Study presence hallucinations in Parkinson's disease

Sensory loop

Sensation encoding - Nerve stimulation

Robotic hand sensors reading

Median nerve

Ulnar nerve

VR

stim.

Examples from the labs of S. Micera, O. Blanke

# Neurotechnology for brain communication

- Open communication channels with the CNS (read+write)

- Develop and validate soft bioelectronic interfaces

- Restore motor function in chronic spinal cord injury

- Targeted epidural spinal stimulation with implantable pulse generator controlled by AI software

NeuroRestore

Examples from the labs of S. Lacour, G. Courtine, M. Shoaran, S. Micera

Imaging and modeling of the central nervous system

- State-of-the-art anatomical and functional neuroimaging

- Imaging-based biomarkers for diagnosis

- Connectomics and brain graphs

Examples from the labs of D. Van De Ville, F. Hummel, J.-Ph. Thiran, O. Blanke
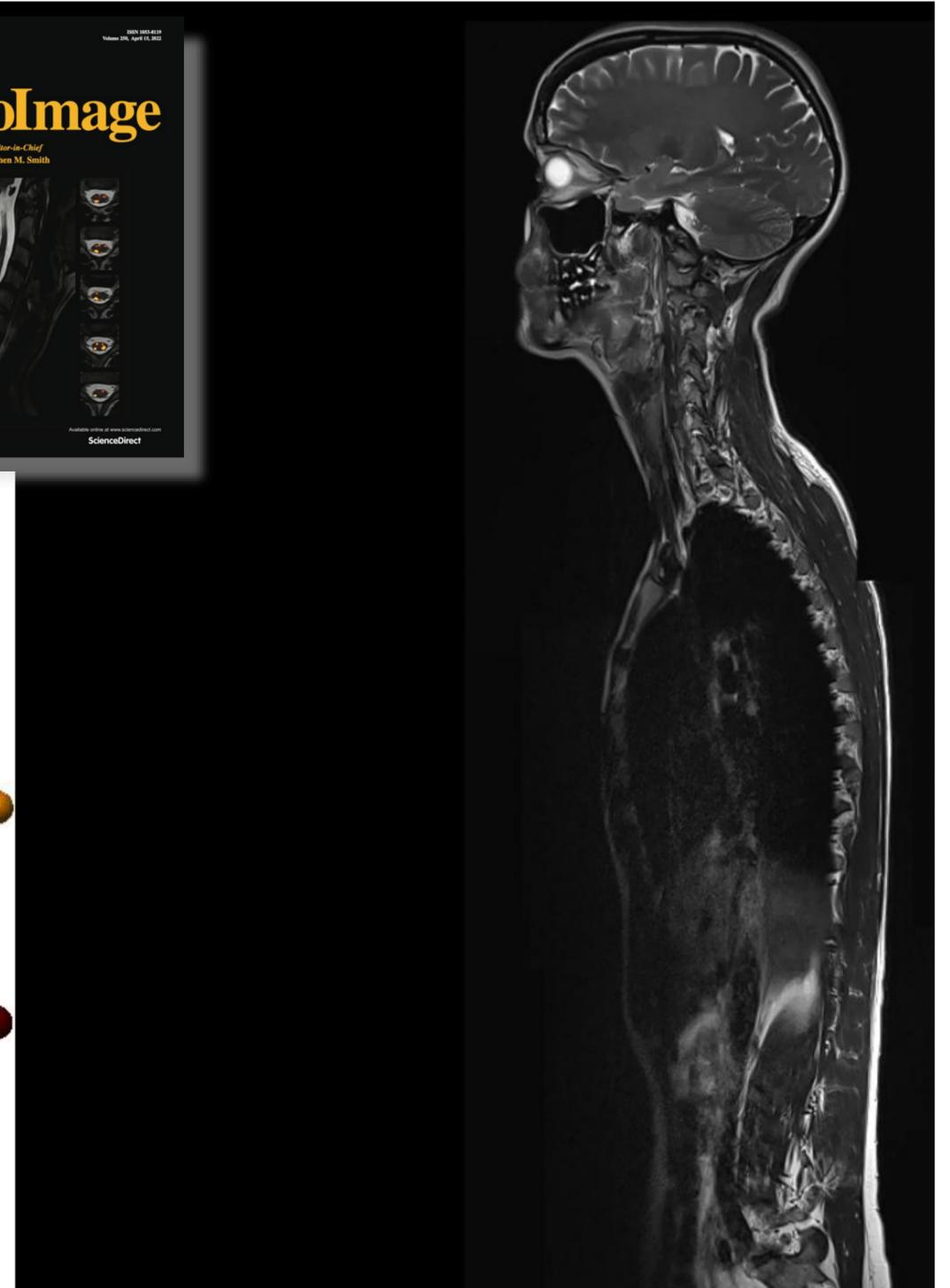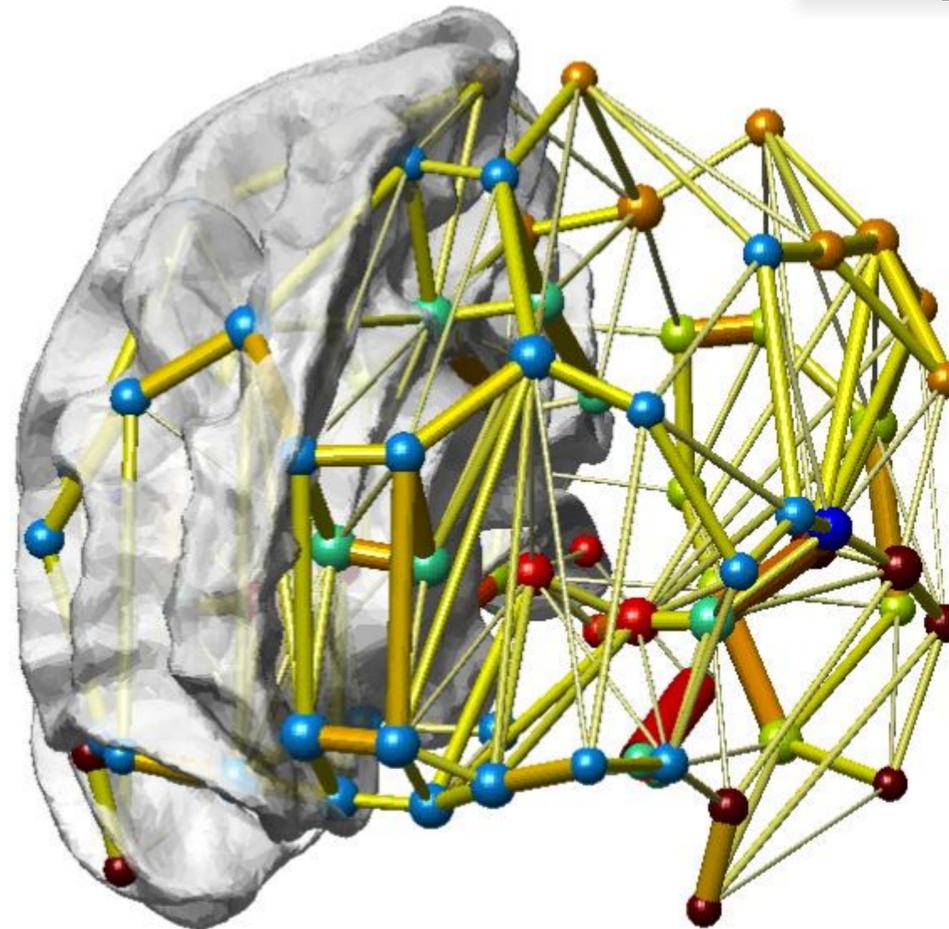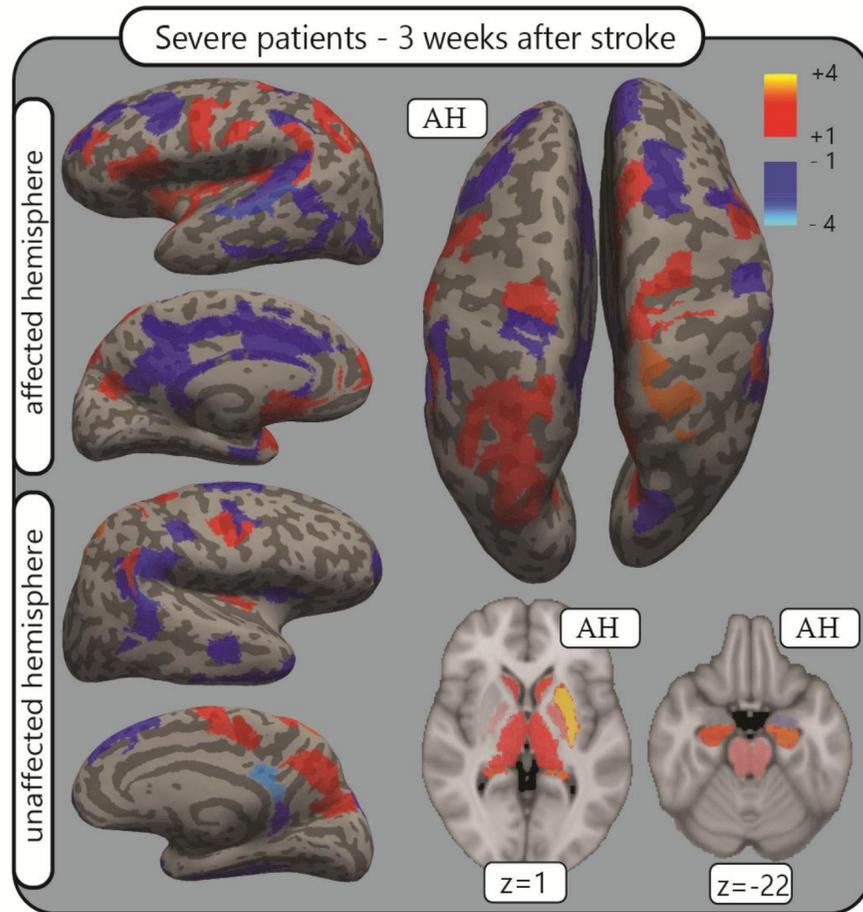
Translation to industry

- Active network of industry partners
- Many start-ups in the Lausanne-Geneva area
- Community-driven events

TOP 100 STARTUP AWARD

#5 MindMaze
#29 Onward Medical
#59 Intento
#94 Sensars

mindmaze

ONWARD

intento

SENSARS
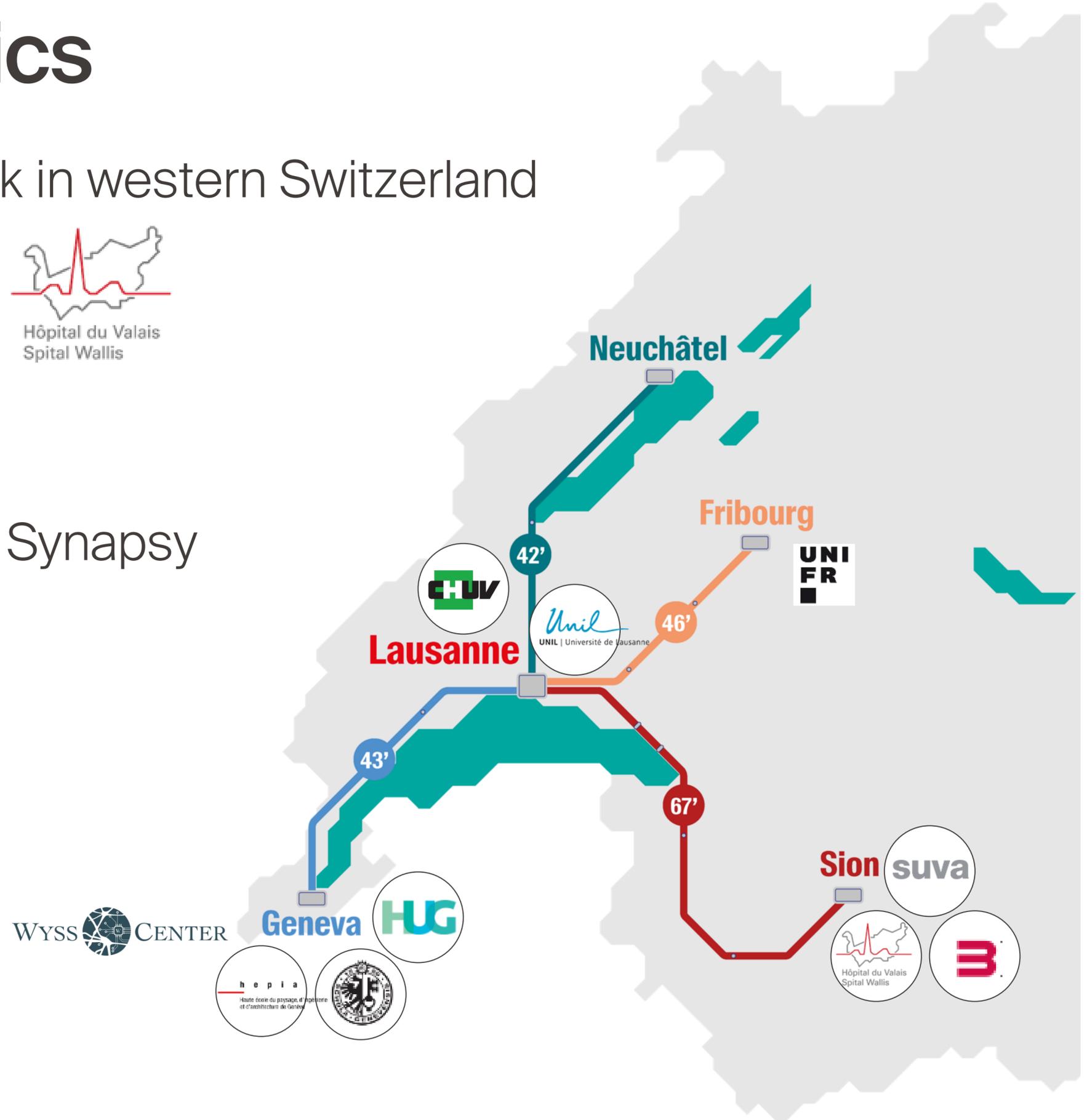
NEUROPROSTHETICS

Translation to clinics

- Outstanding clinical network in western Switzerland

- Strong contributors to
  NCCR Robotics and NCCR Synapsy

- International partnership
  Bertarelli fellowships
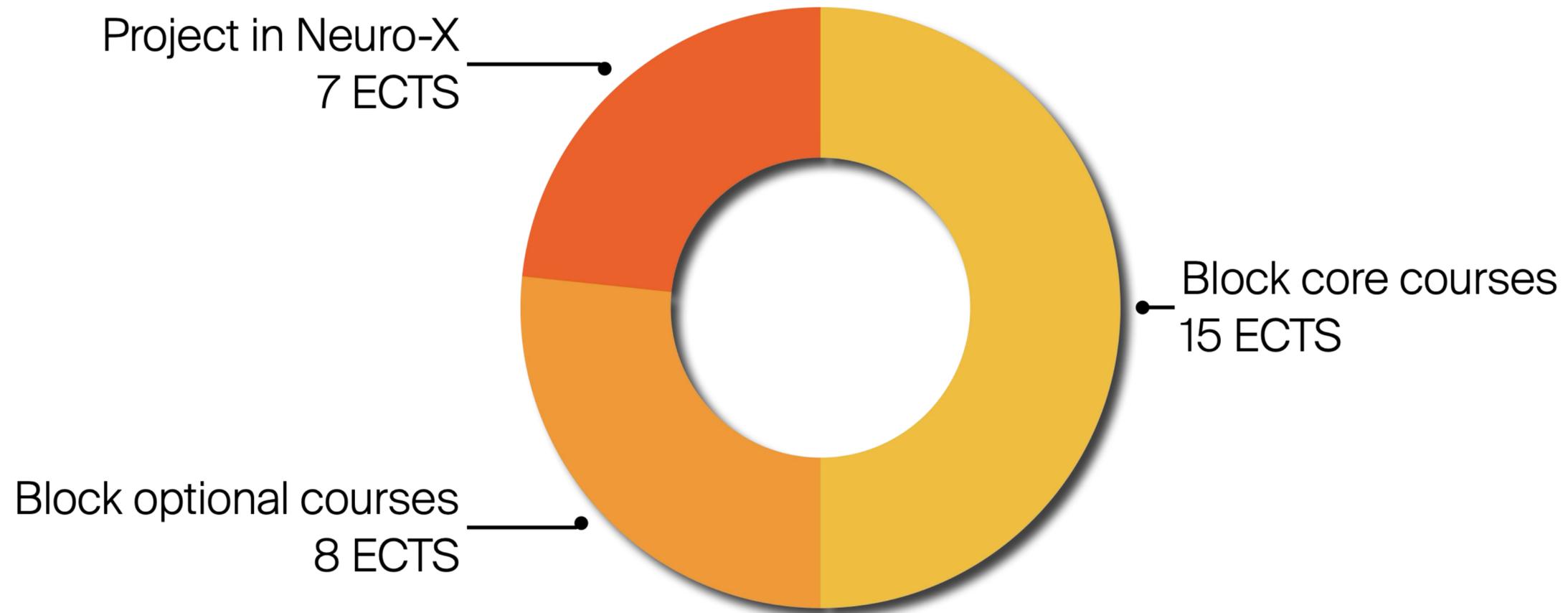
Recommended courses to prepare

- **Upgrade your neuroscience knowledge**
  - BIOENG-310, Neuroscience foundations for engineers (Schrimpf, Zenk), Spring, 6 ECTS
  - BIO-311, Neuroscience (Ramdya), Fall, 4 ECTS
- **Upgrade your engineering skills**
  - EE-295, Electrical systems and electronics I (Guiducci/Koukab/Meinen), Fall, 4 ECTS
  - EE-296, Electrical systems and electronics II (Koukab/Meinen), Spring, 4 ECTS
  - EE-320, Analog IC design (Shoaran), Fall, 3 ECTS
  - MSE-341, Sustainability and materials (Abitbol), Spring, 3 ECTS

Titles and admission conditions

- Official titles
  - `Master of Science (MSc) in Neuro-X`
  - `Ingénieur en Neuro-X (neuro-X-ing. dipl. EPF)`
- Consecutive Master:
  - STI: Microengineering (MT) + Electrical Engineering (EE)
  - IC: Systems and Communications (SC)
  - SV: Life Science Engineering
  - *** Deadline is 2 weeks after start of semester ***
- Admission by application for other sections and external students
  - Two deadlines: December 15 and March 31

Minor in Neuro-X (30 ECTS)

- Coordinators:
  - Silvestro Micera (STI)
  - Friedhelm Hummel (SV)
- Structure

Project in Neuro-X
7 ECTS

Block core courses
15 ECTS

Block optional courses
8 ECTS

Master in Neuro-X

NeuroStudents' Network: NetworX (NSNX)

- Committee
  - Louise Montlahuc (president)
  - Leonardi Silvagni (vice-president)
  - Adrian Bohnenblust (treasurer)

https://go.epfl.ch/nsnx

Advisory Committee

- Giovanni Cherubini (IBM Zürich)

- Claude Clement* (Consultant)

- Jonathan Dan (Logitech)

- Vincent Delattre* (Onward Medical)

- Naveed Ejaz (MindMaze)

- Tom Hilbert** (Siemens Healthineers)

- Nathalie Virag* (Medtronic)

Master in Neuro-X

*=EPFL alumni, **=EPFL PhD

Meet the *Section in Neuro-X* team

Ms. Hind Klinke
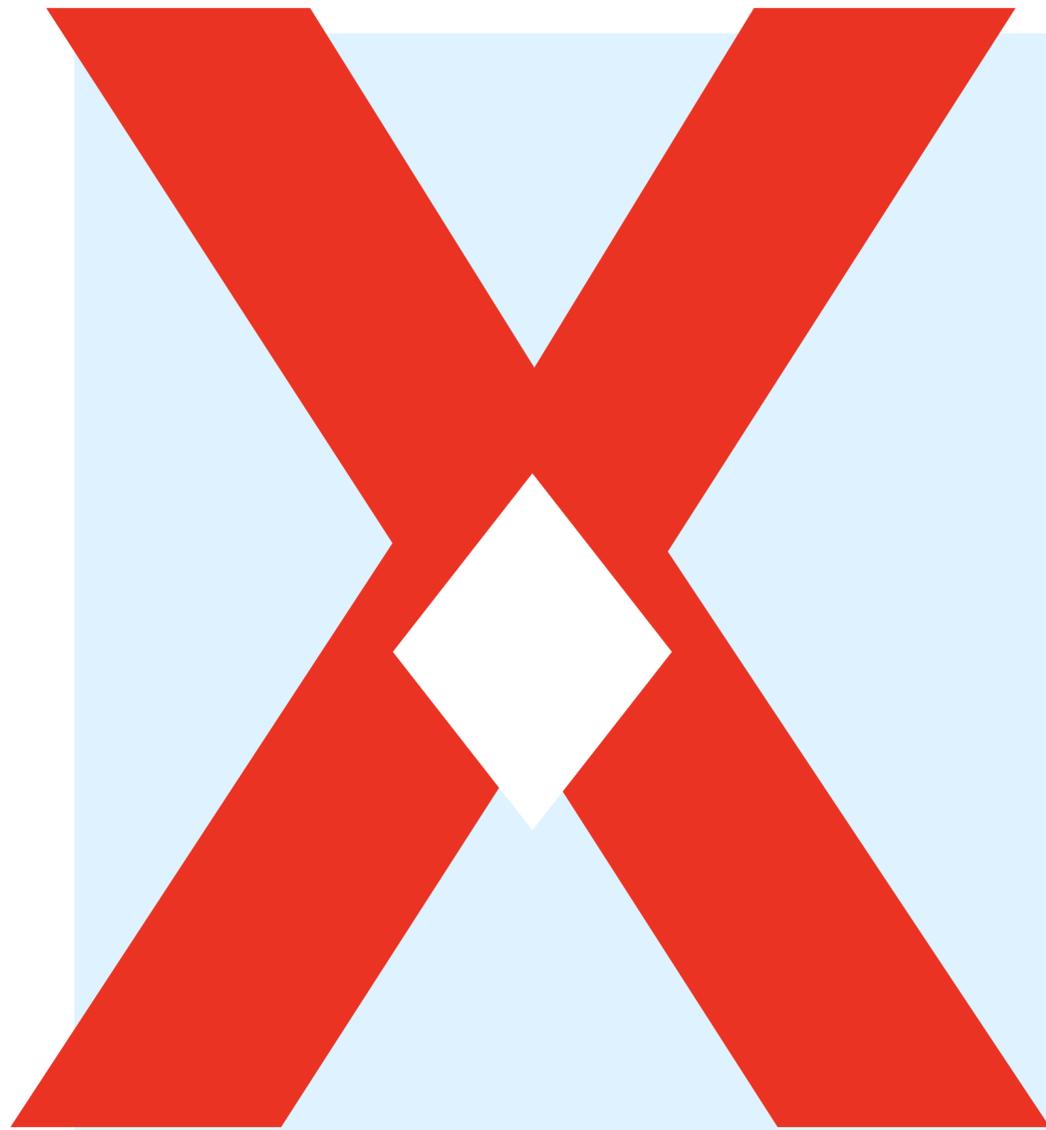**Section
deputy head**

Ms. Emilie Thévoz
**Section
administrative assistant**

Prof. Dimitri Van De Ville
**Section
director**

- Website: http://go.epfl.ch/snx
- Email: snx@epfl.ch

Master in Neuro-X

Master in Neuro-X

Thanks!

École polytechnique fédérale de Lausanne