EMG DECOMPOSITION TO DECODE MOTOR UNIT ACTIVITY

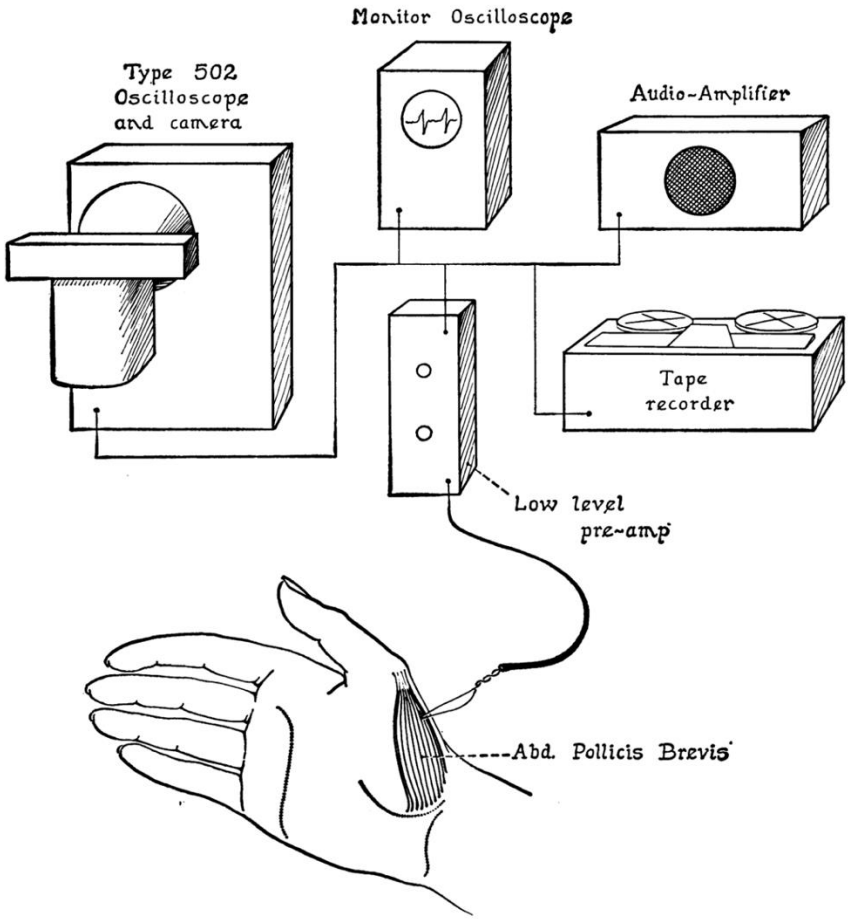
Simon Avrillon
Nantes Université & Imperial College London

Bouton et al (2016) Nature - Battelle

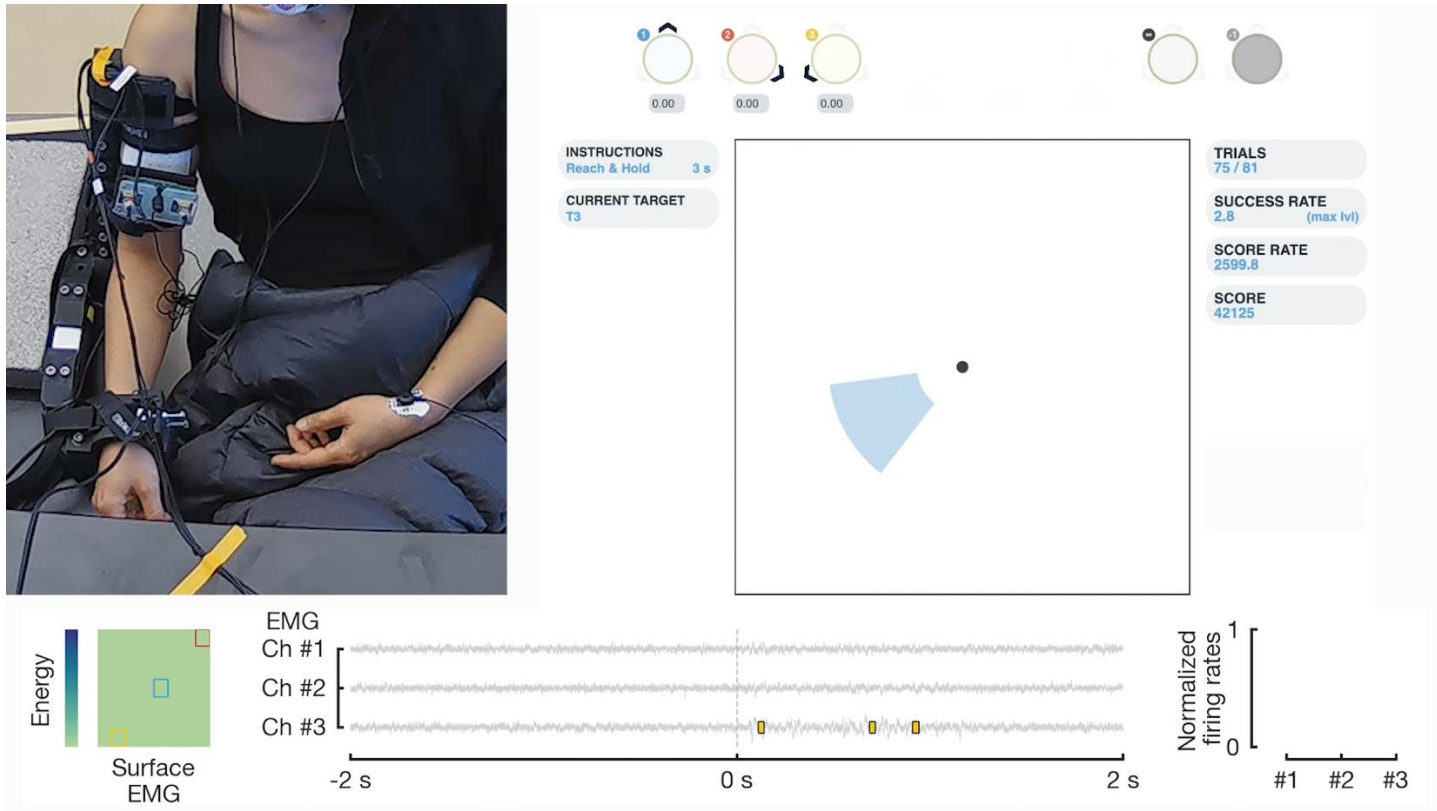
IMPERIAL

Nantes Université

MOTOR UNIT DECODING



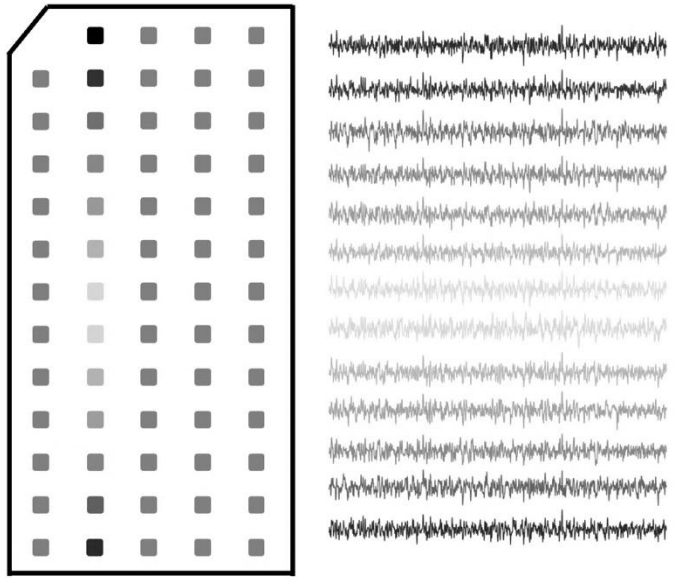
Basmajian (1963) Science



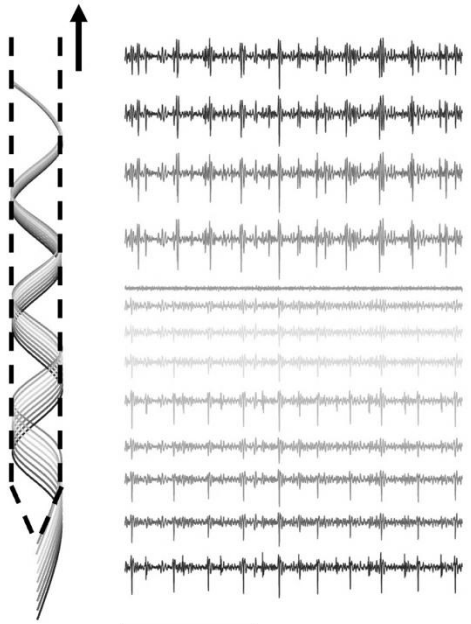
Formento et al. (2021) J Neural Eng

RECORDING TECHNIQUES

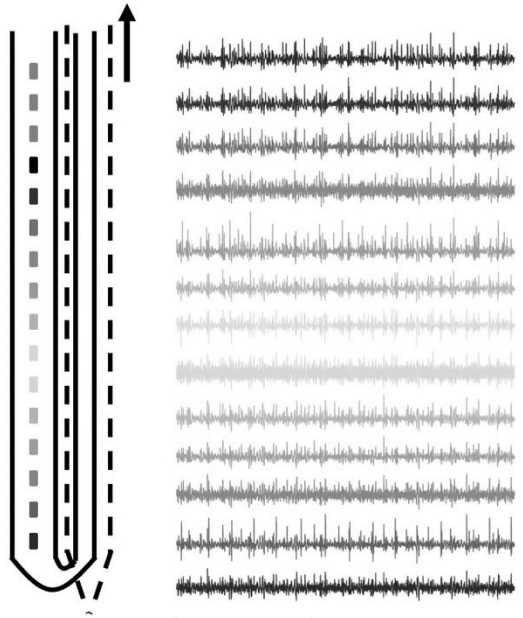
Grids of surface electrodes

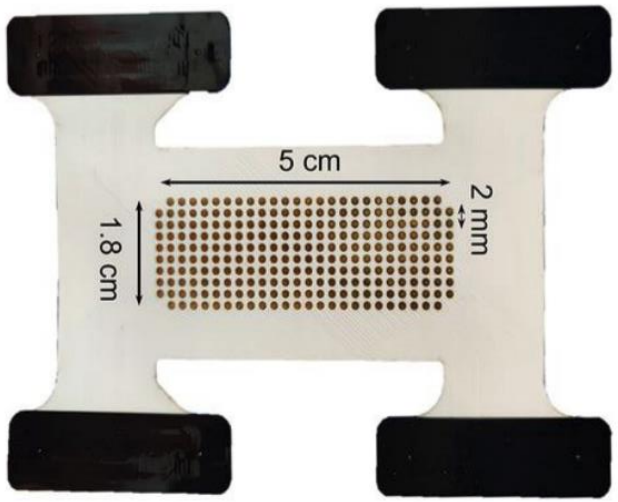


Intramuscular tetrode

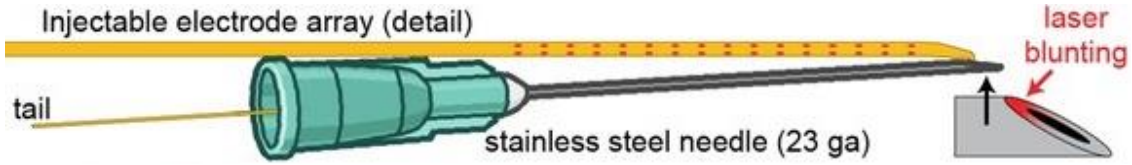


Intramuscular thin films



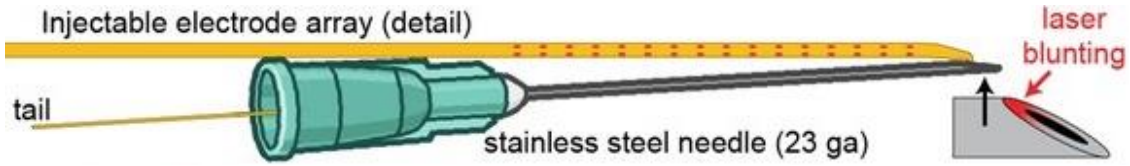


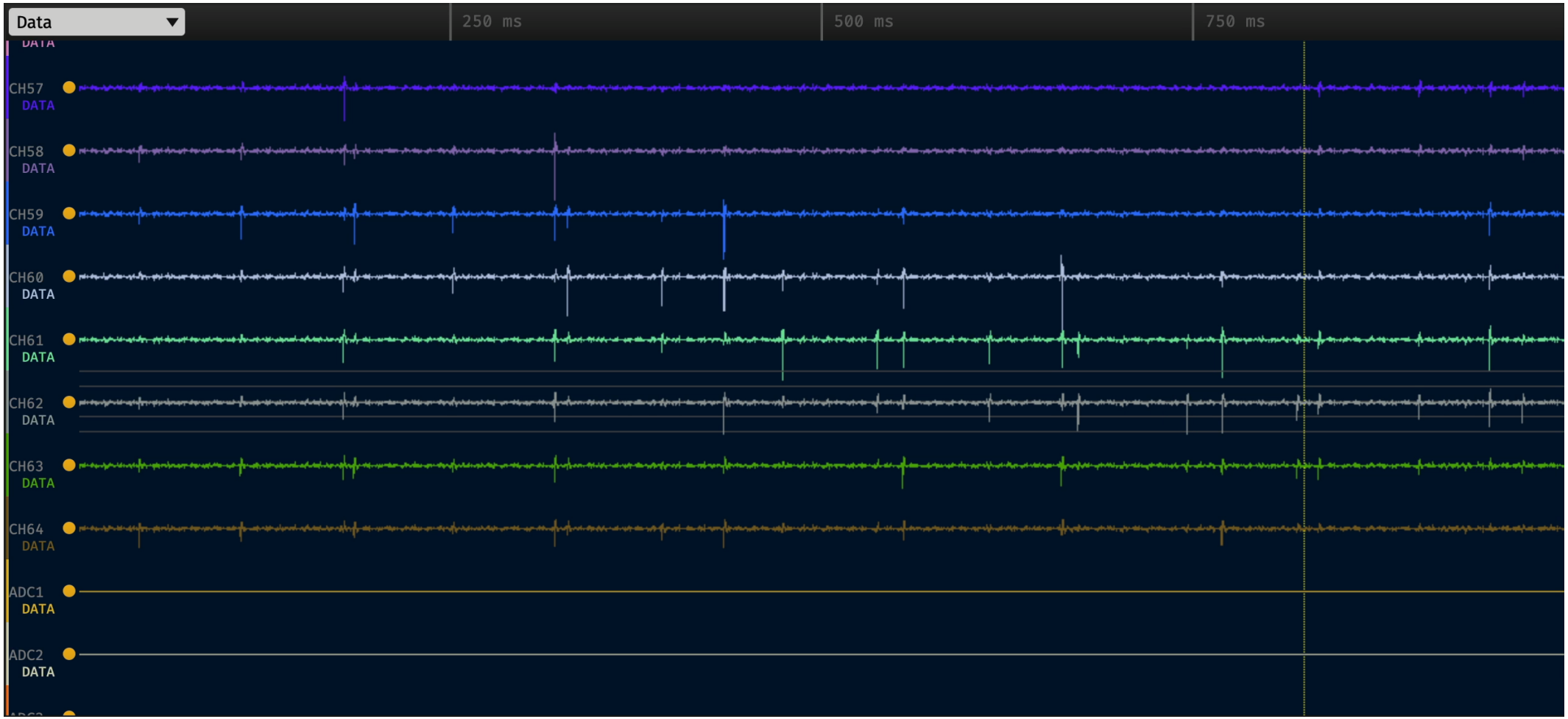
Caillet*, Avrillon* et al. (2023) eNeuro



Chung et al. (2023) eLife

RECORDING TECHNIQUES





OPEN-SOURCE ALGORITHMS

Spike sorting

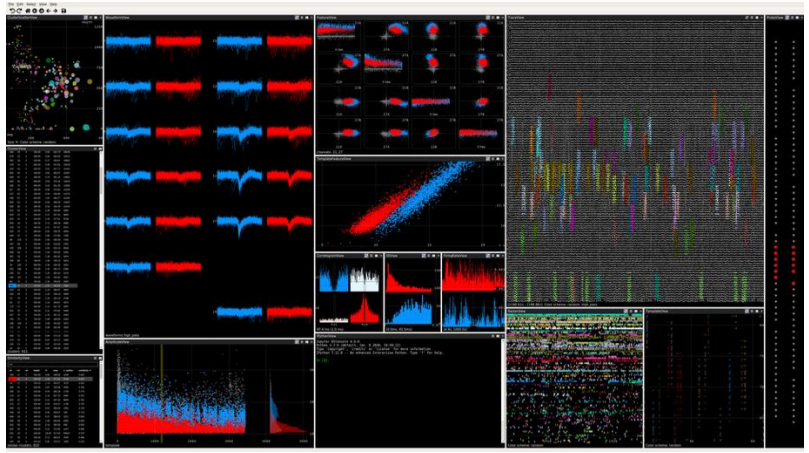
Intramuscular arrays

GitHub

EMUsort

Enhanced **M**otor **U**nit **sort**er

Sean O'Connell - Emory University

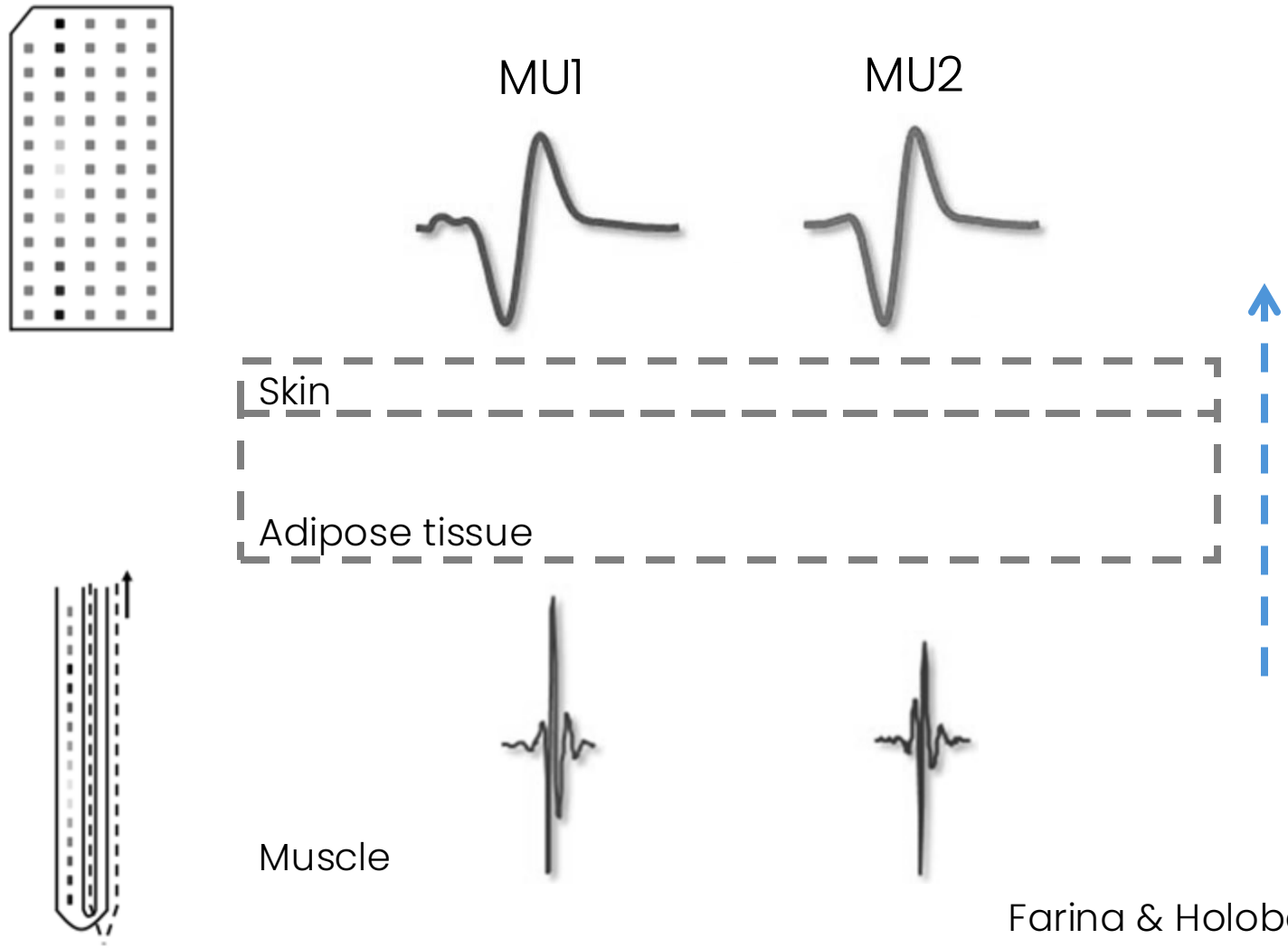


Phy

Interactive visualisation and manual spike sorting

Cyrille Rossant – IBL/UCL

EFFECT OF VOLUME CONDUCTOR



Filtering effect of the volume conductor

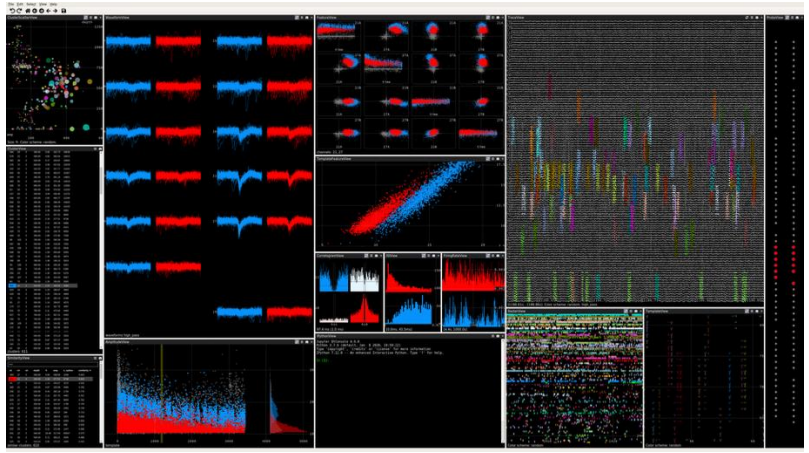
Farina & Holobar (2016) Proceedings of the IEEE

Spike sorting algorithms will fail to discriminate these two motor units with surface EMG

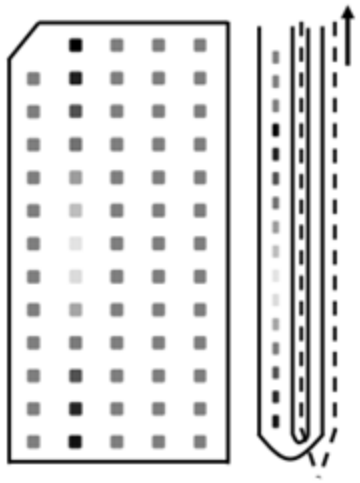
OPEN-SOURCE ALGORITHMS

Spike sorting
Intramuscular arrays

EMUsort
Enhanced **M**otor **U**nit **sort**er
Sean O'Connell - Emory University



Phy
Interactive visualisation and manual spike sorting
Cyrille Rossant – IBL/UCL



Blind source separation
Intramuscular and surface arrays

https://github.com/neuromechanist
https://github.com/The-Motor-Unit
https://github.com/carmenalab
https://github.com/ciaragibbs
and others

IOP Publishing Journal of Neural Engineering
J. Neural Eng. **13** (2016) 026027 (17pp) doi:10.1088/1741-2560/13/2/026027

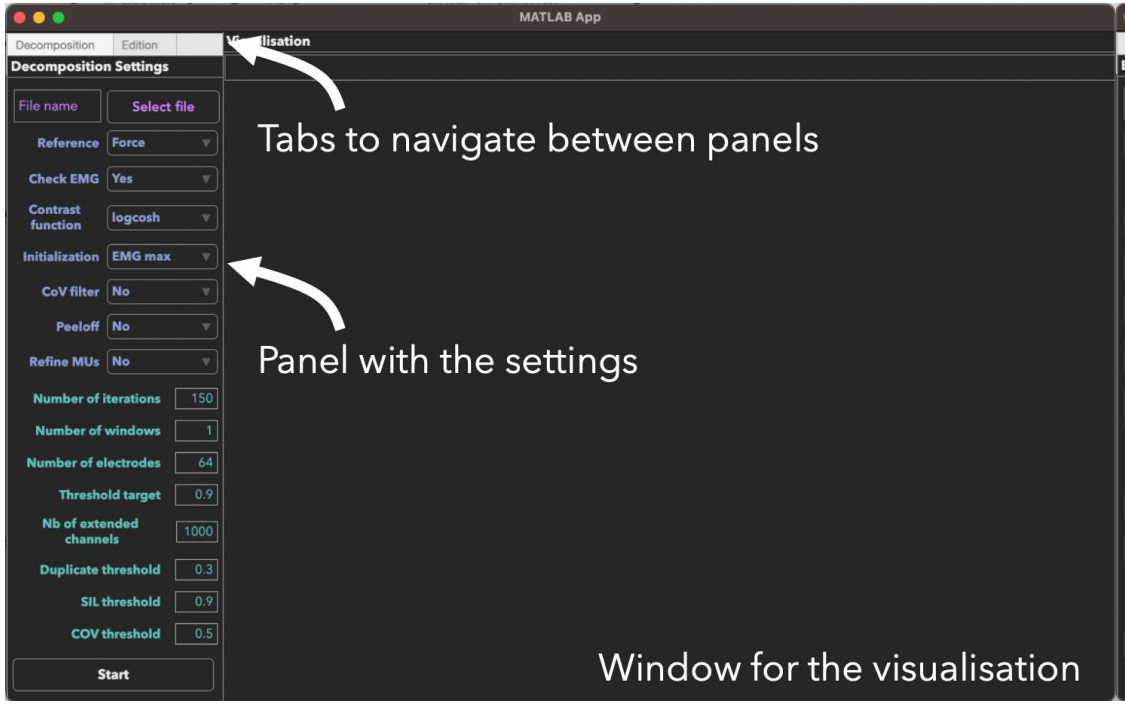
Multi-channel intramuscular and surface EMG decomposition by convolutive blind source separation

Francesco Negro[1], Silvia Muceli[1], Anna Margherita Castronovo[1], Ales Holobar[2] and Dario Farina[1]

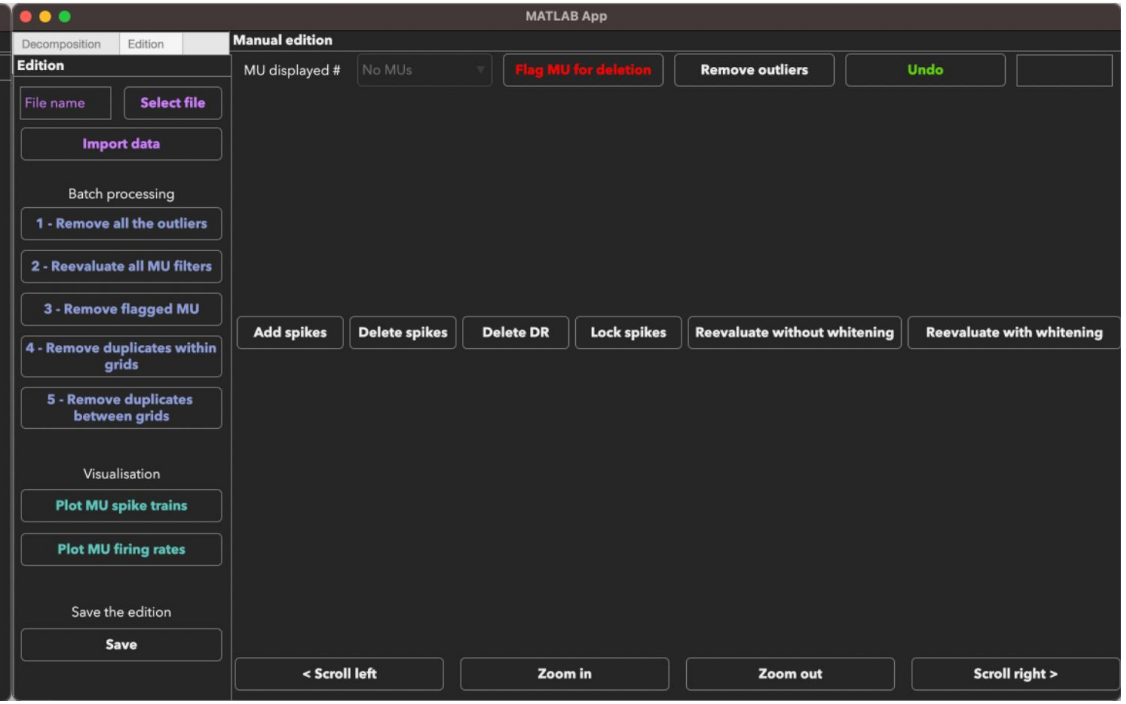
EMG DECOMPOSITION WITH MUedit

Import data → Pre-process EMG → Identification of pulse trains → Post processing

Decomposition panel



Edition panel

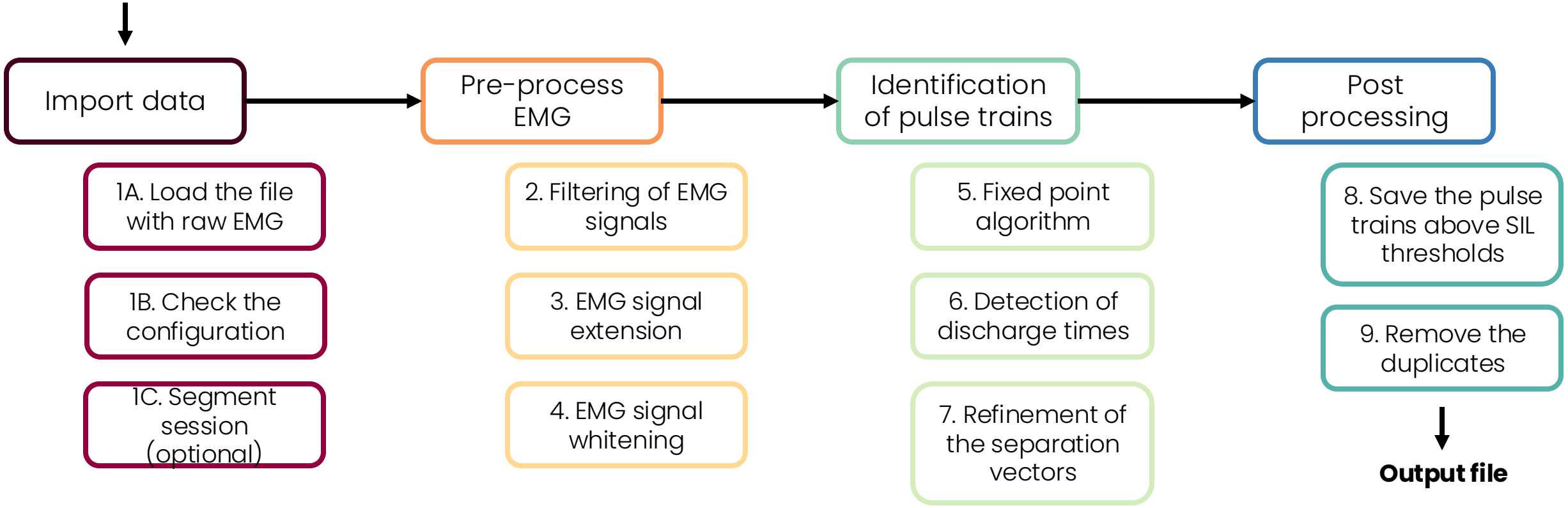


https://github.com/simonavrillon/MUedit

Avrillon et al. (2024) J Electromyogr Kinesiol

PIPELINE

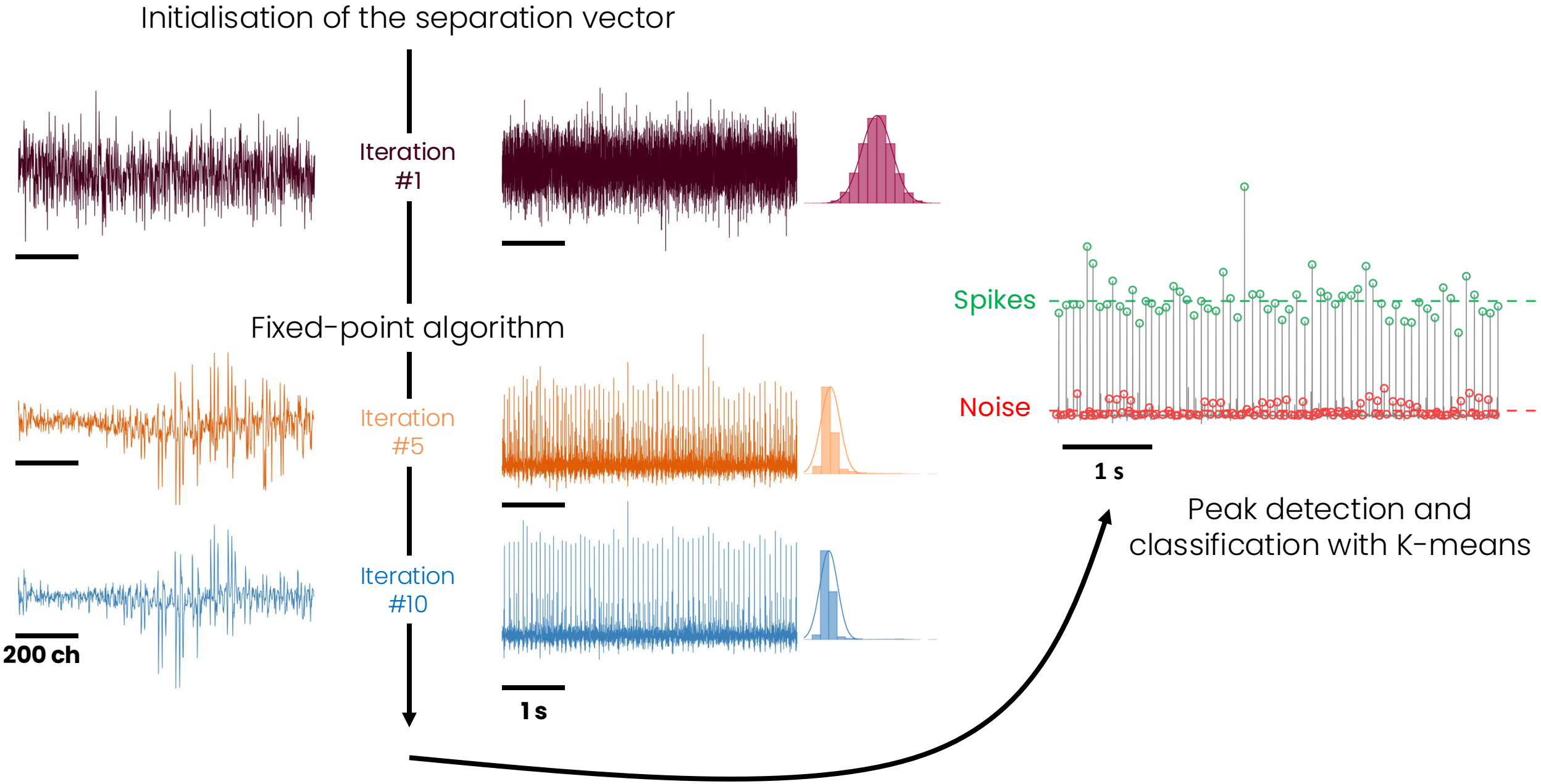
EMG signals from all the arrays



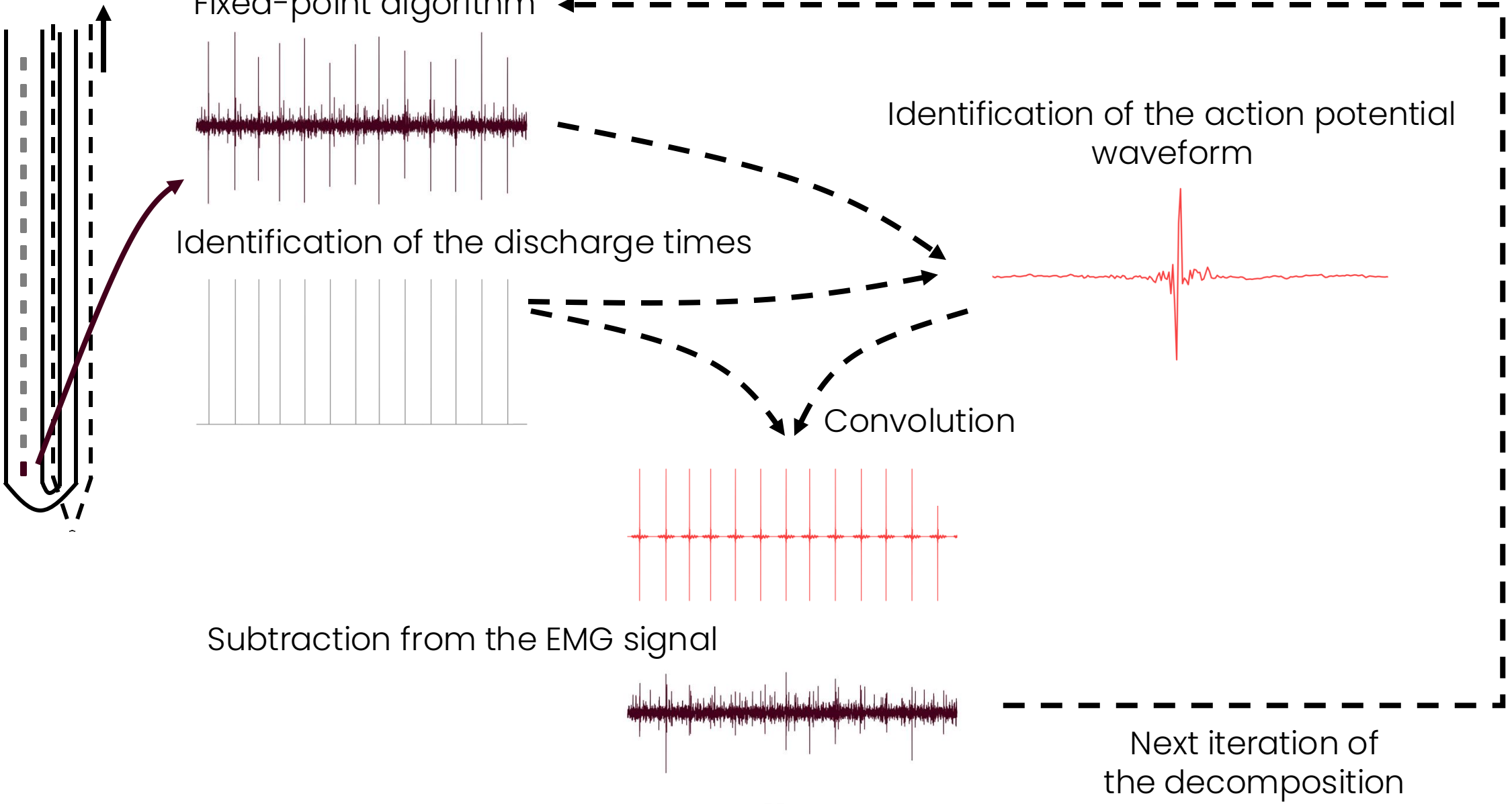
Code
https://github.com/simonavrillon/ISB25-tutorial

Data
https://doi.org/10.7910/DVN/L9OQY7

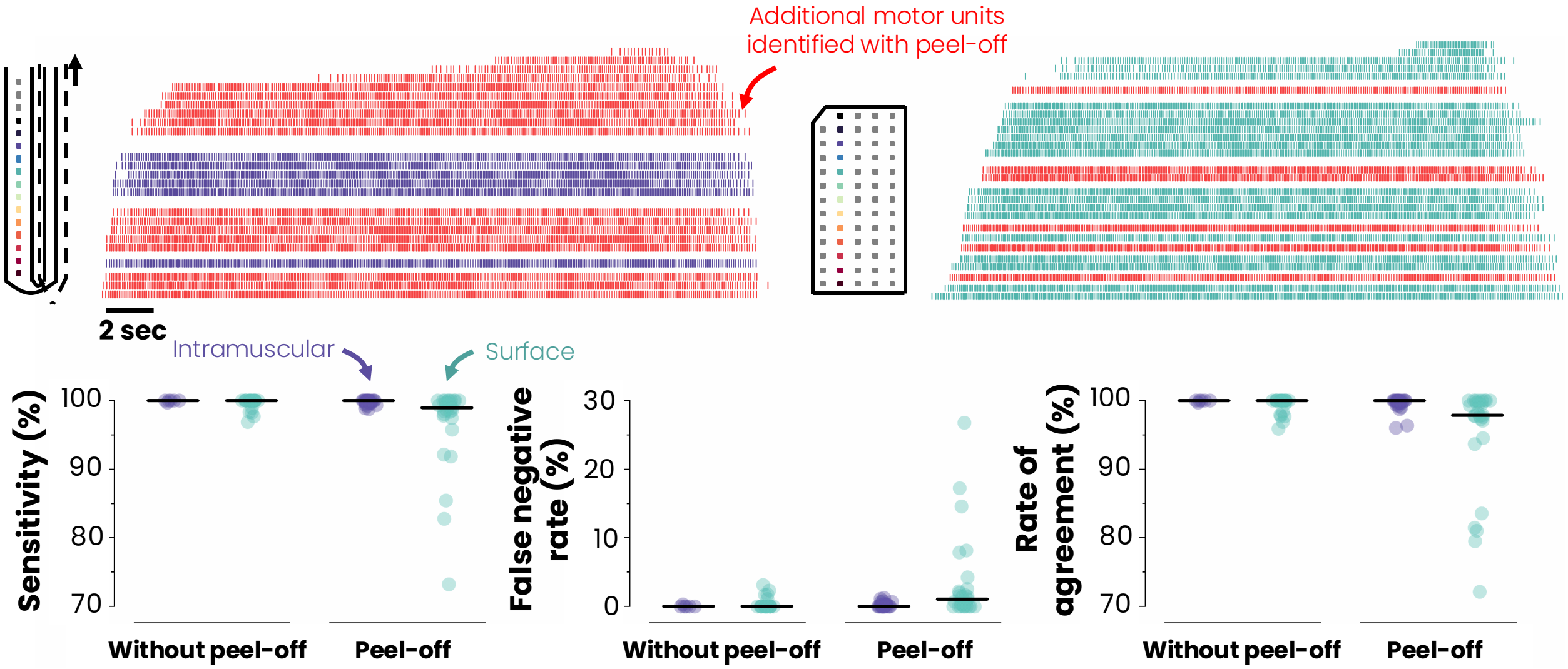
DECOMPOSITION OF EMG SIGNALS



DECOMPOSITION OF EMG SIGNALS – PEEL OFF



DECOMPOSITION OF EMG SIGNALS – PEEL OFF



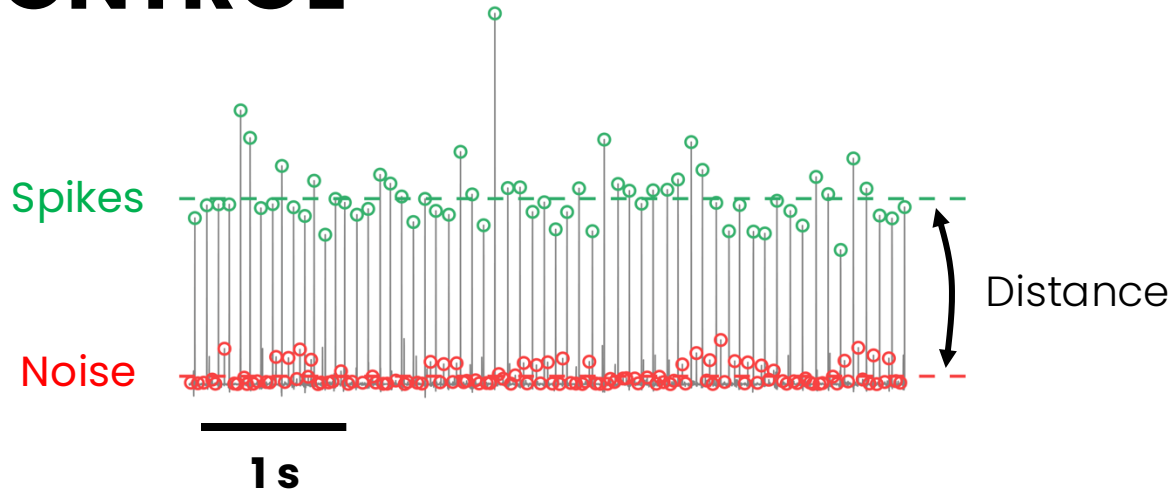
QUALITY CONTROL

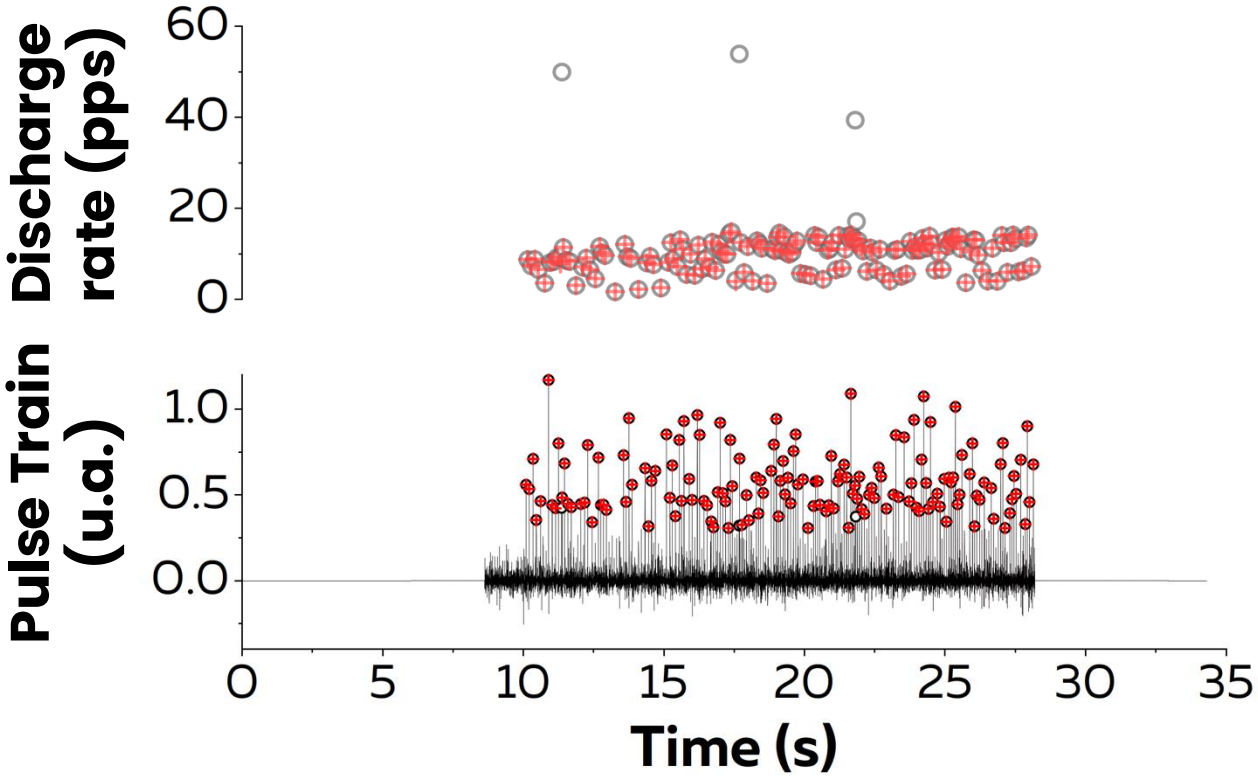
Pulse to noise ratio

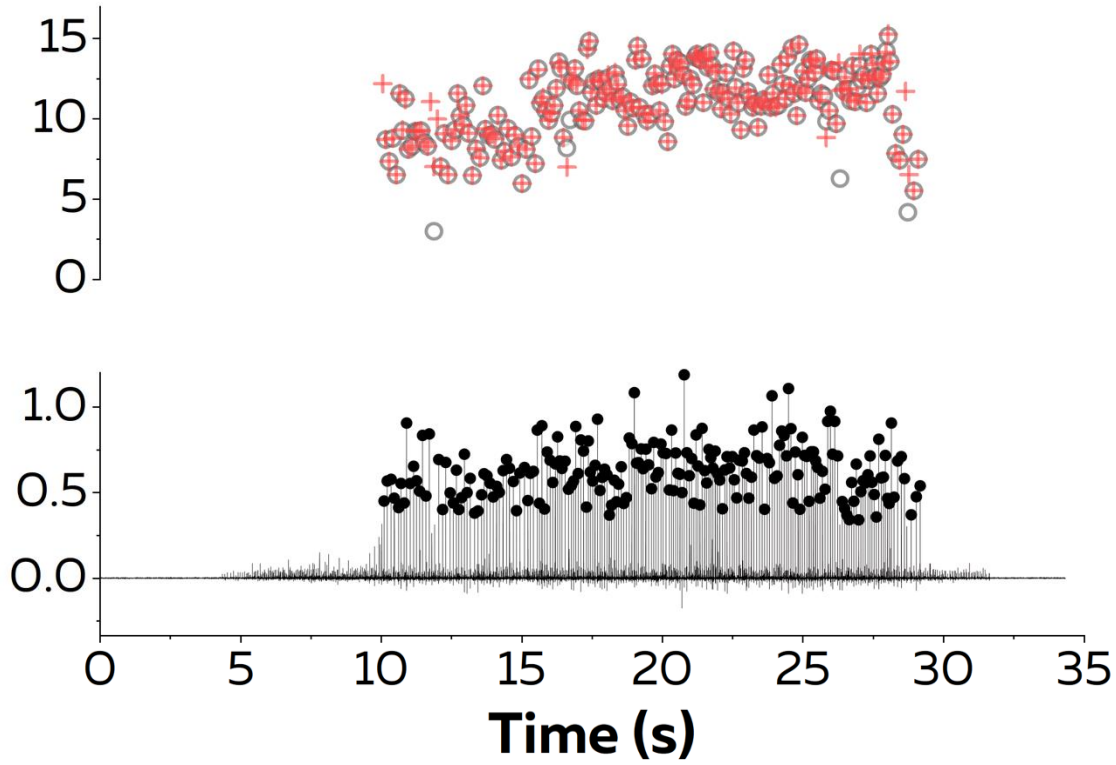
Holobar et al., 2014

Silhouette value

Negro et al., 2016

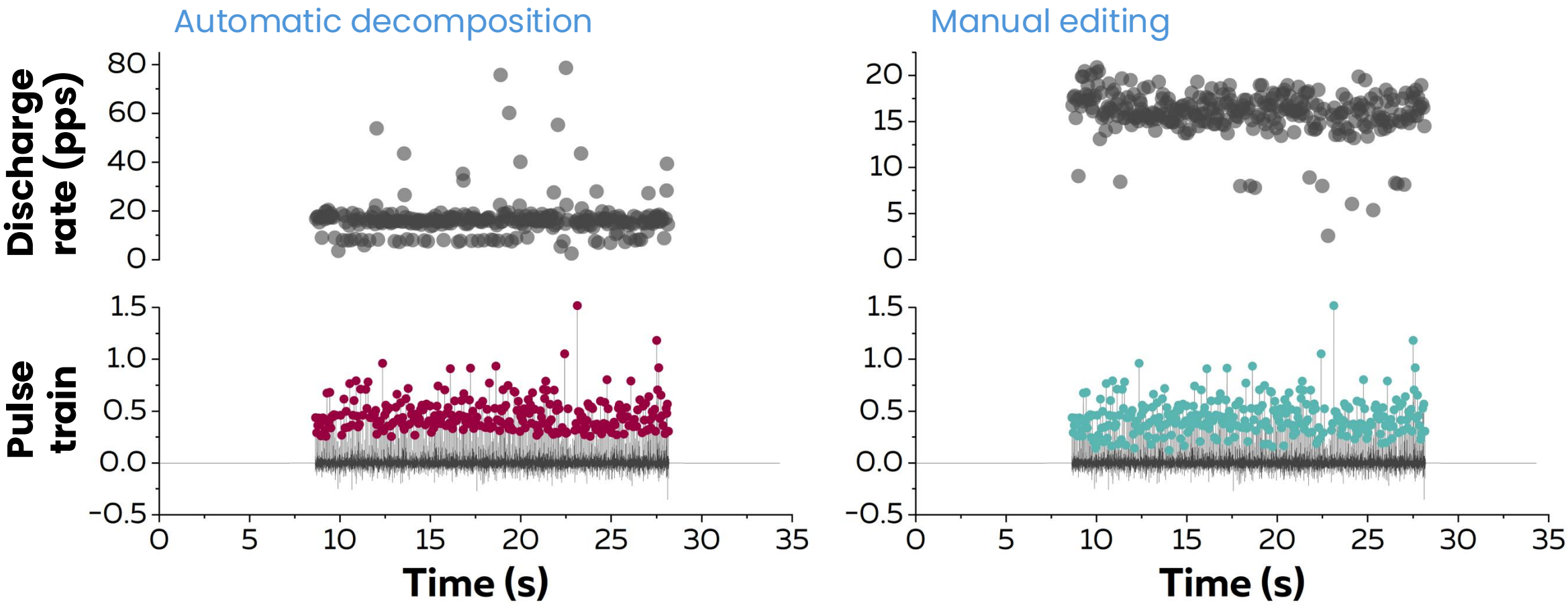






POST PROCESSING – MANUAL EDITING

Automatic decomposition → Remove/add spikes → Update separation vector → Estimate editing quality

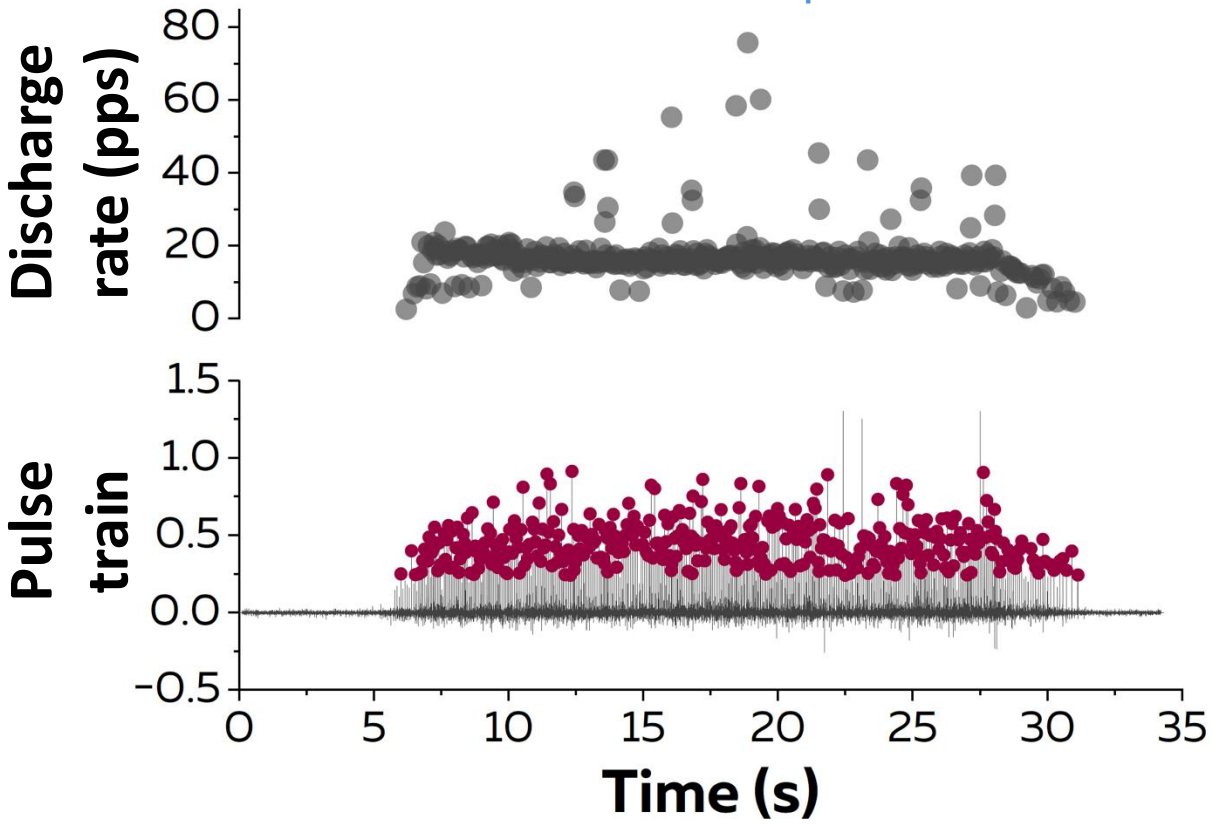


POST PROCESSING – MANUAL EDITING

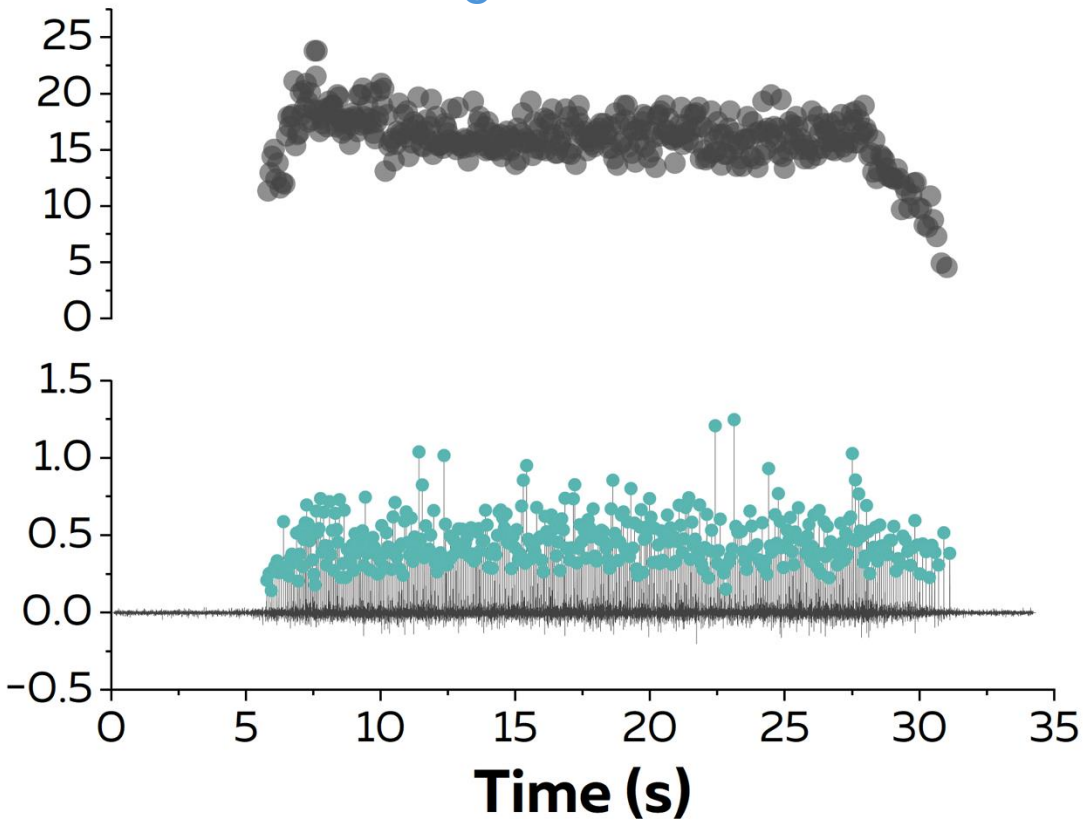
Automatic decomposition → Remove/add spikes → Update separation vector → Estimate editing quality

Update separation vector → Remove/add spikes

Recalculation of the separation vector



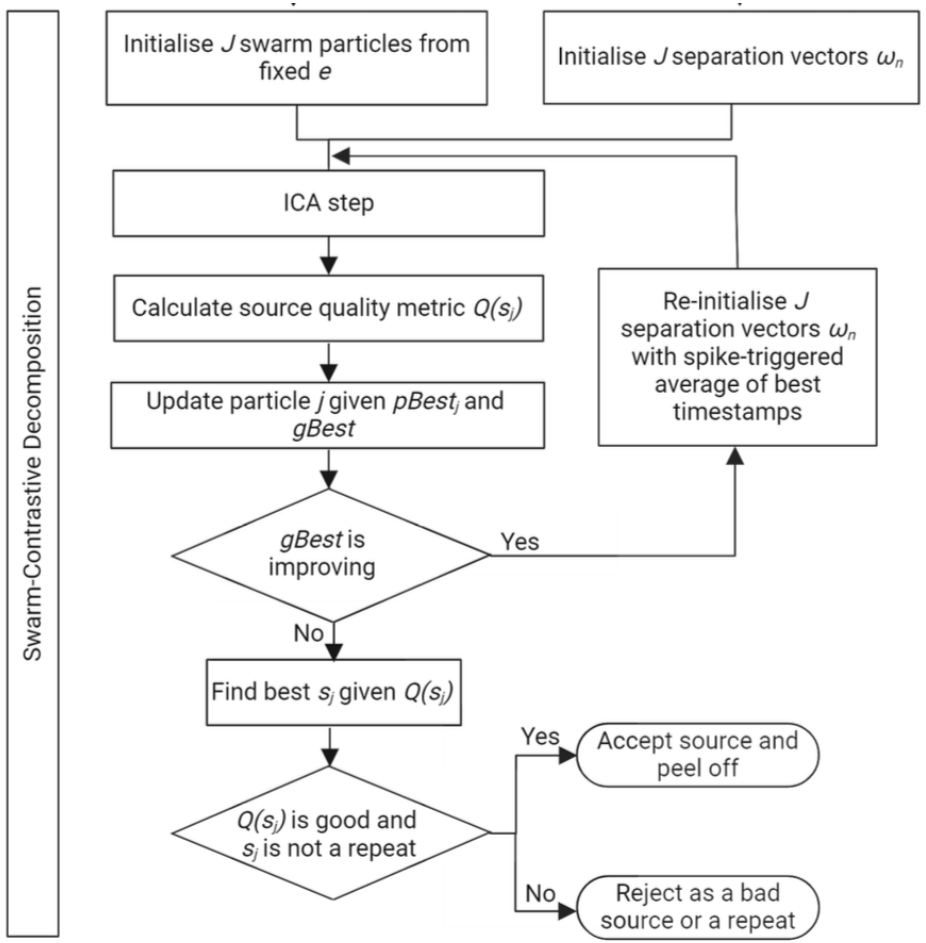
Manual editing



RECENT DEVELOPMENTS – SWARM CONTRASTIVE DECOMP

Import data → Pre-process EMG → **Identification of pulse trains** → Post processing

Simultaneously optimise multiple separation vectors for the same MU



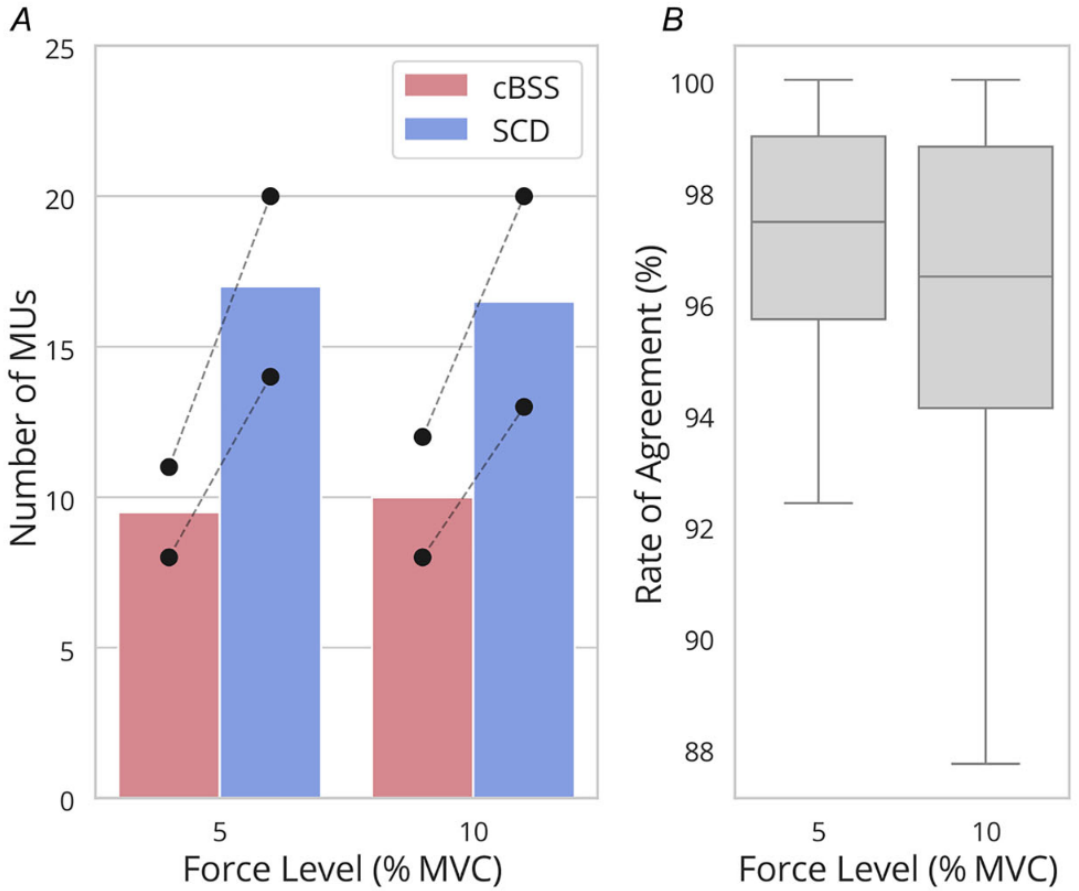
IMPERIAL

https://github.com/AgneGris

Grison et al. (2024) IEEE Trans Biomed Eng
Grison et al. (2025) J Physiol

RECENT DEVELOPMENTS – SWARM CONTRASTIVE DECOMP

Import data → Pre-process EMG → **Identification of pulse trains** → Post processing



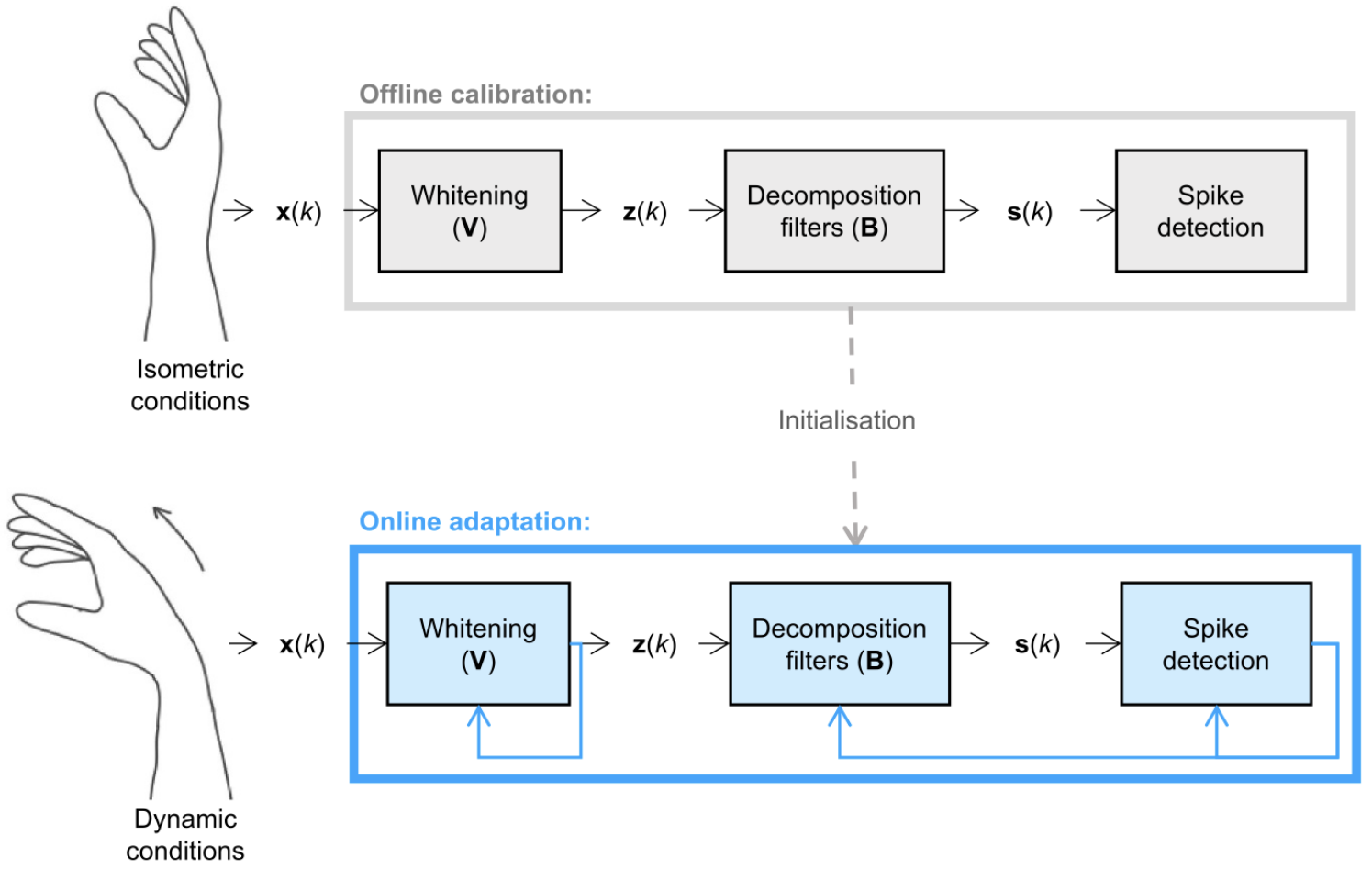
IMPERIAL

https://github.com/AgneGris

Grison et al. (2024) IEEE Trans Biomed Eng
Grison et al. (2025) J Physiol

RECENT DEVELOPMENTS – ADAPTIVE DECOMPOSITION

Import data → Pre-process EMG → Identification of pulse trains → Post processing



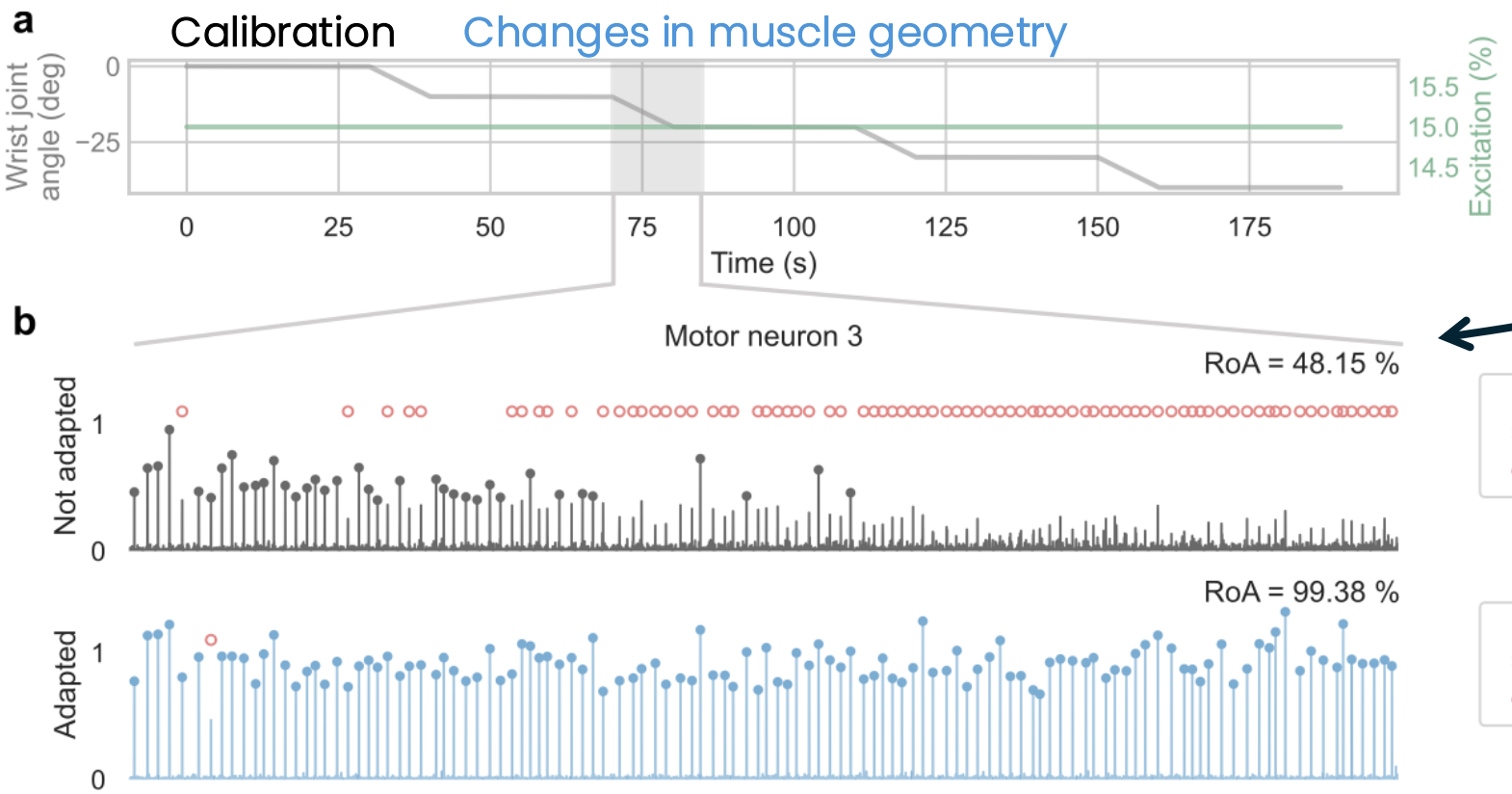
IMPERIAL

https://github.com/imendezguerra

Mendez Guerra et al. (2024) J Neural Eng

RECENT DEVELOPMENTS – ADAPTIVE DECOMPOSITION

Import data → Pre-process EMG → Identification of pulse trains → Post processing



Simulated data, but works with experimental data

IMPERIAL

https://github.com/imendezguerra

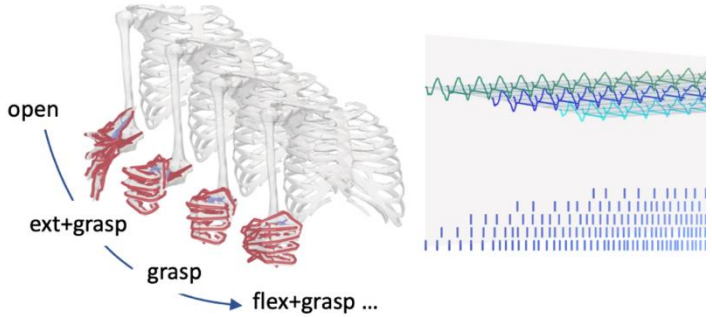
Mendez Guerra et al. (2024) J Neural Eng

RECENT DEVELOPMENTS - STANDARDS

Import data → Pre-process EMG → Identification of pulse trains → Post processing

File formats → Simulator for validation → Benchmarks

BIDS
BRAIN IMAGING DATA STRUCTURE



Ma et al. (2024) Plos Comp Biol
https://github.com/shihan-ma

IMPERIAL

https://github.com/pranavm19

THANK YOU

Simon Avrillon
Nantes Université & Imperial College London
https://github.com/simonavrillon

IMPERIAL

Dario Farina

Ciara Gibbs

Agnese Grison, Irene Mendez Guerra,
Pranav Mamidanna

UNIVERSITÉ CÔTE D'AZUR

François Hug

Nantes Université IMPERIAL