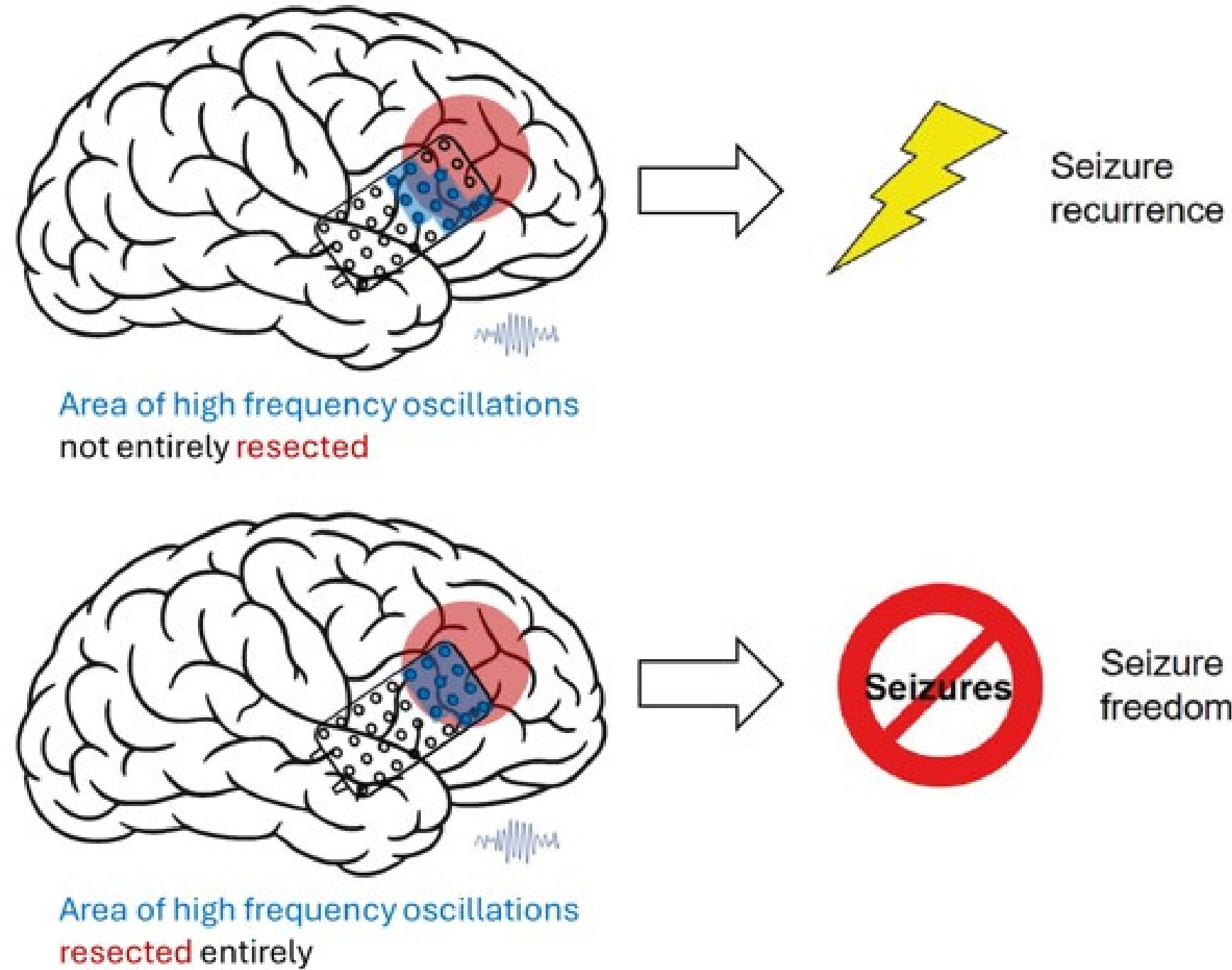
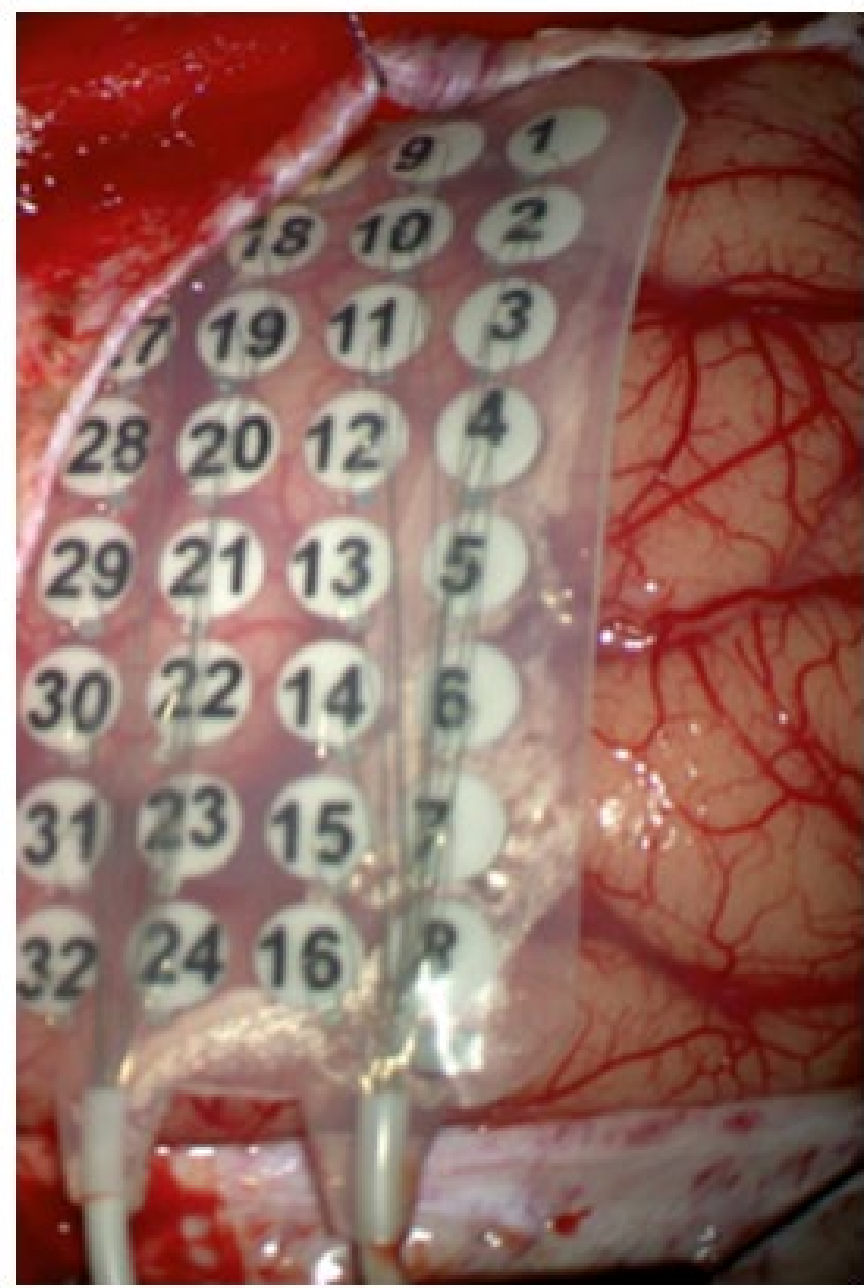


Jeroen.Teurlings@usz.ch
hfzuri.ch

1. Klinik für Neurochirurgie, Universitätsspital Zürich (USZ), 2. Institute of Neuroinformatics, UZH and ETH Zürich
3. University Medical Center Utrecht, 4. Stichting Epilepsie Instellingen Nederland (SEIN),
5. Neuroscience Center Zürich (ZNZ), University of Zürich and ETH Zürich, 6. Schweizerisches Epilepsie Zentrum.

Key points

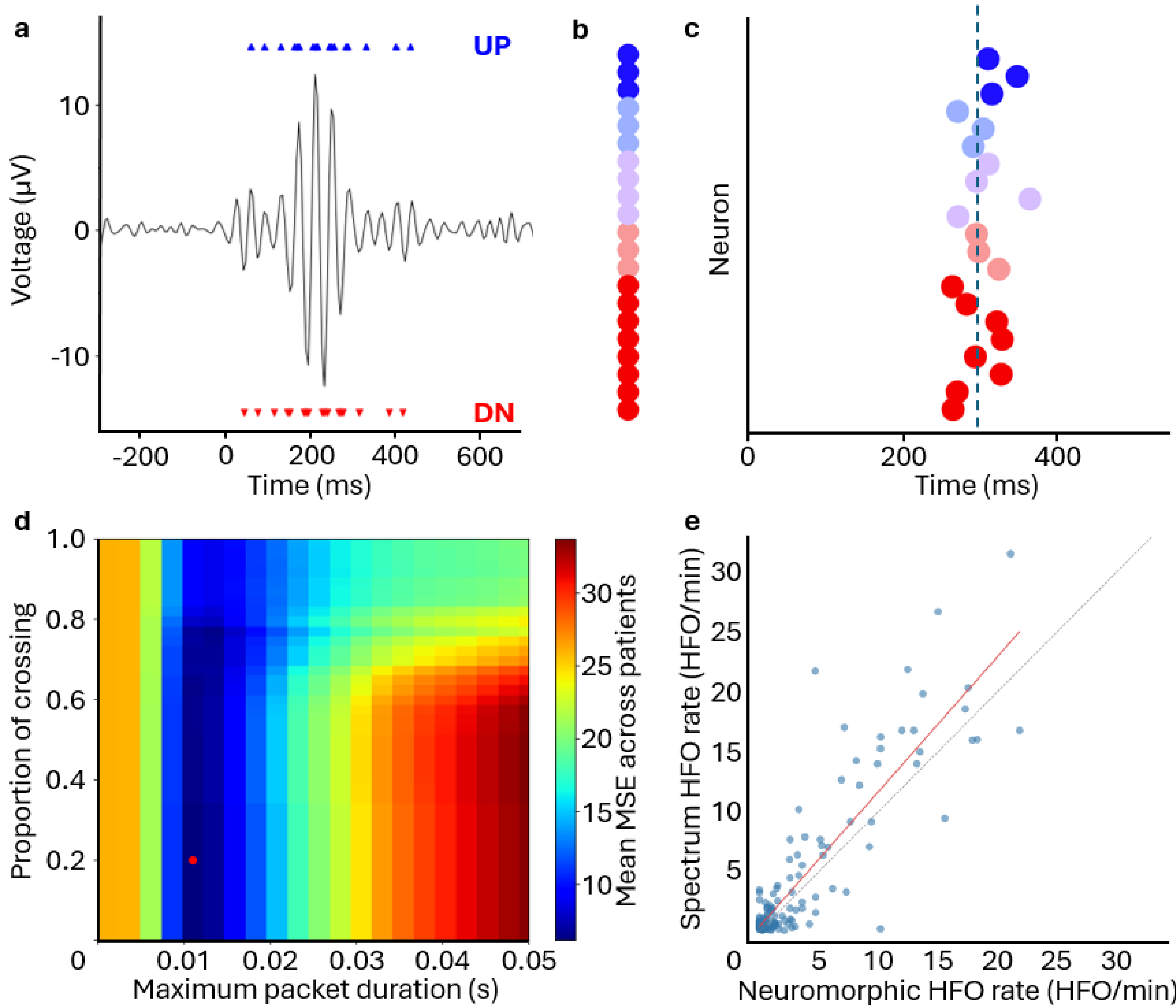
- We implemented a spiking neural network to detect HFOs in real-time in intraoperative ECoG.
- Residual HFOs in the test set ECoG predicted poor postoperative seizure outcome (DOR = 17, 95% CI [2.0 150]).
- The external validation across centers, amplifiers, and anesthesia protocols demonstrates robustness and generalizability.
- We detected HFOs in real-time and feedback for the epileptologist and surgeon was available directly after the recording period.



Introduction

During neurosurgery for epilepsy, electrocorticography (ECoG) may be used. High-frequency oscillations (HFOs) in the ECoG are discussed as biomarkers of the epileptogenic zone. (1) We train an automated HFO detector and (2) validate against a dataset with visual HFO annotation. (3) We apply the algorithm during surgery for real-time HFO detection.

1 Training



Analysis pipeline

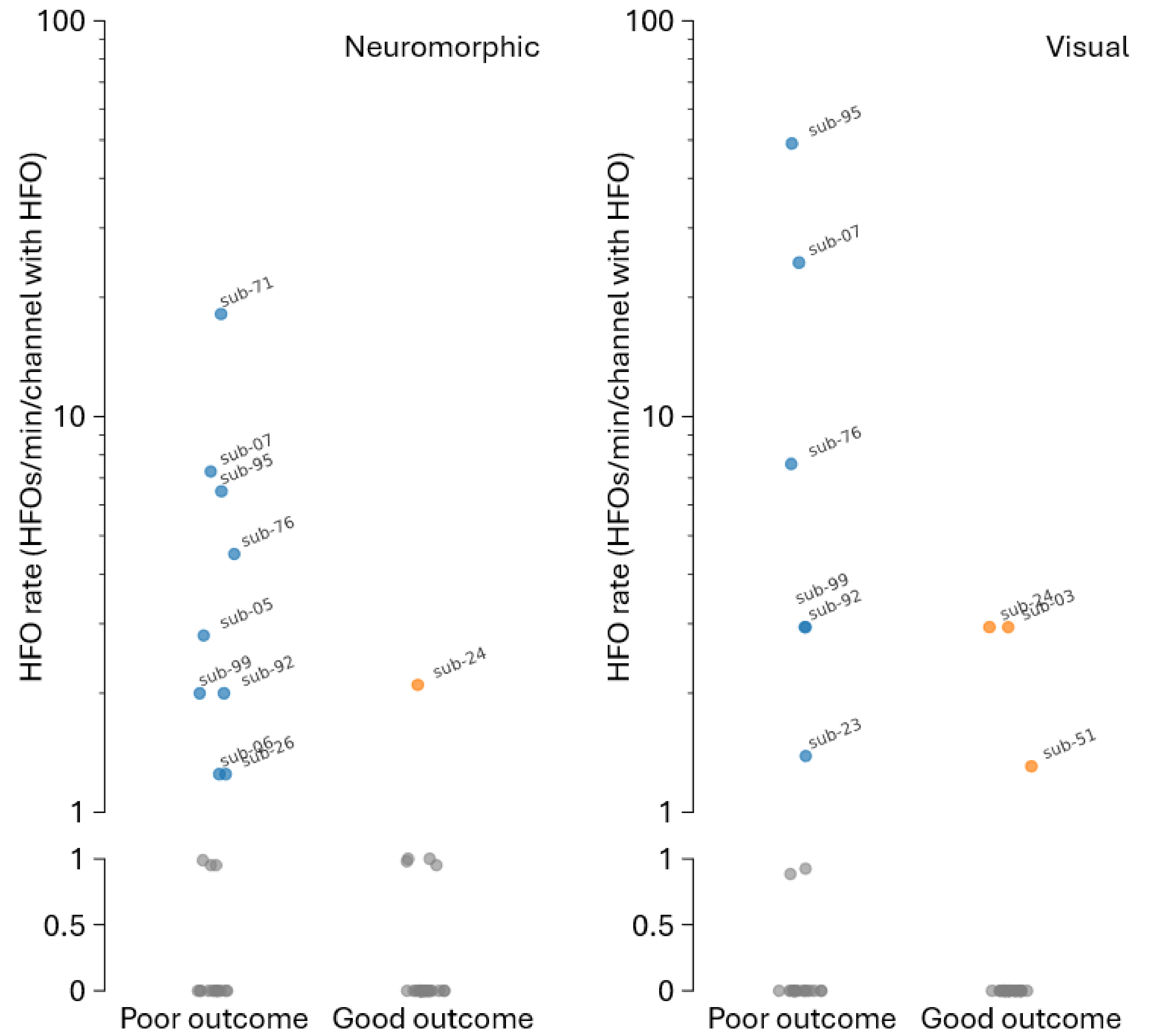
- Asynchronous Delta Modulator encoding (ADM) converts continuous data (250-500Hz) into a discrete string of digital pulses (UP/DN)
- UP/DN pulses enter the spiking neural network (neuromorphic SNN), output is grouped into 'packets'.
- SNN is optimized with only 2 parameters: maximum packet duration and proportion of crossings between UP and DN
- Packets are filtered based on length and proportion of UP/DN crossings

Training data

- USZ (Boran et al, Clin Neurophys 2019)
- 22 patients, Nicolet recording
- Anesthesia sustained with Sevoflurane
- Spectrum detector, automated HFO markings



2 External validation



2. Patients with residual HFOs have poor seizure outcome

We determine the post-resection HFO rate (residual HFOs) in each patient.

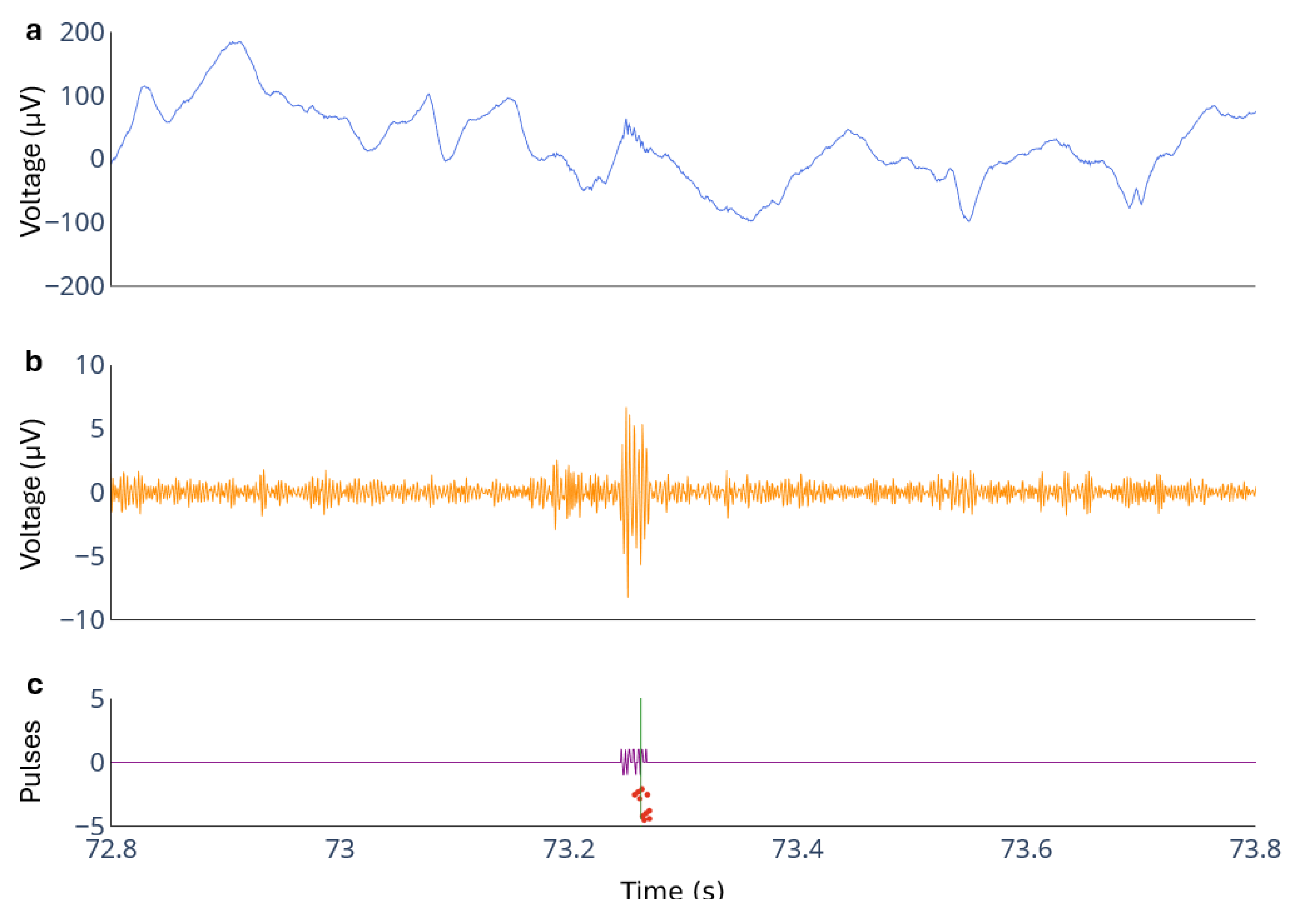
Neuromorphic Detection: residual HFOs appeared in 9 patients with poor outcome (recurrent seizures) and in 1 patient with postsurgical seizure freedom.

Visual marking (van 't Klooster, Neurology 2015): residual HFOs in 6 patients with poor outcome (recurrent seizures) and in 2 patients with postsurgical seizure freedom.

Validation data

- UMCU (van 't Klooster et al. Neurology 2015)
- 54 patients, Micromed recording
- Recorded during pausing Propofol
- HFOs visually annotated, post-surgical seizure outcome

3 Real-time HFO detection



3. HFO are successfully captured in real-time during epilepsy surgery

- (a) Broadband ECoG signal.
- (b) Filtered ECoG signal between 250-500Hz.
- (c) ADM encoding results in UP/DN pulses (violet trace) that enter the SNN. The SNN emits pulses (red dots), which indicate HFO detection (green line).