

A Two-Layer Micro-Electrical Impedance Tomography Platform for Three-Dimensional Image Reconstruction using Machine Learning

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Motivation

- Miniaturized cell culture platforms, such as organs-on-chip and microreactors, require non-invasive and continuous characterization techniques.
- Micro Electrical Impedance Tomography (microEIT) offers non-invasive, and label-free characterization of biological samples, even when cell culture platforms are not optically transparent.
- 3D microEIT has been demonstrated for biological samples, but further miniaturization and reliable spatial reconstruction remain challenging.

Research approach

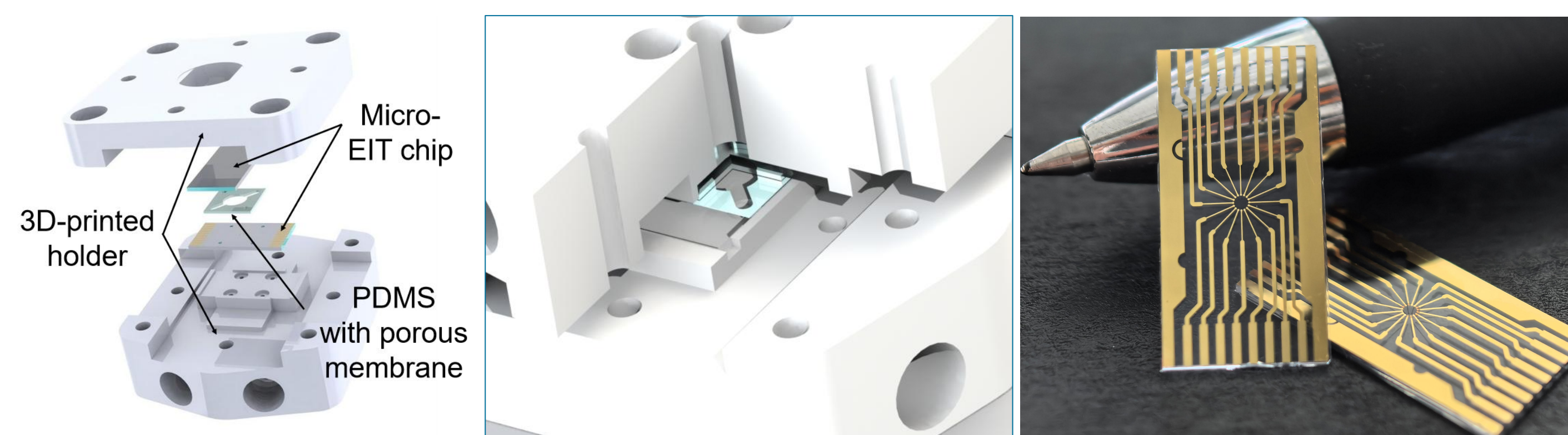
Building on our previous 2D microEIT platform[†], we pursue:

- electrode array miniaturization to 1 mm;
- two-layer 3D array measurement;
- CNN-based image reconstruction.

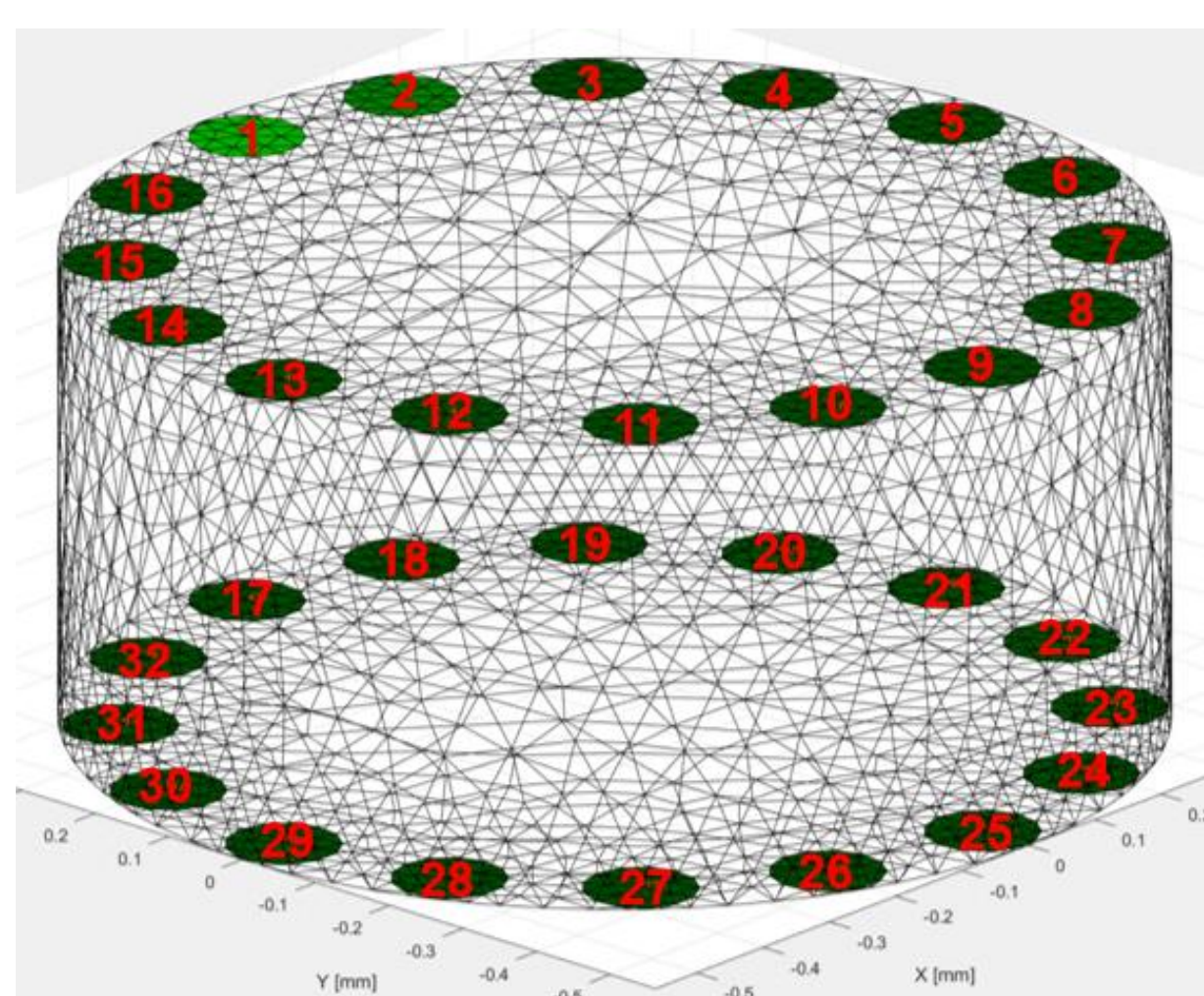
[†] Our previous work: Liu et al., ACS Sensors, 2025, 10, 9093–9102.

MicroEIT platform

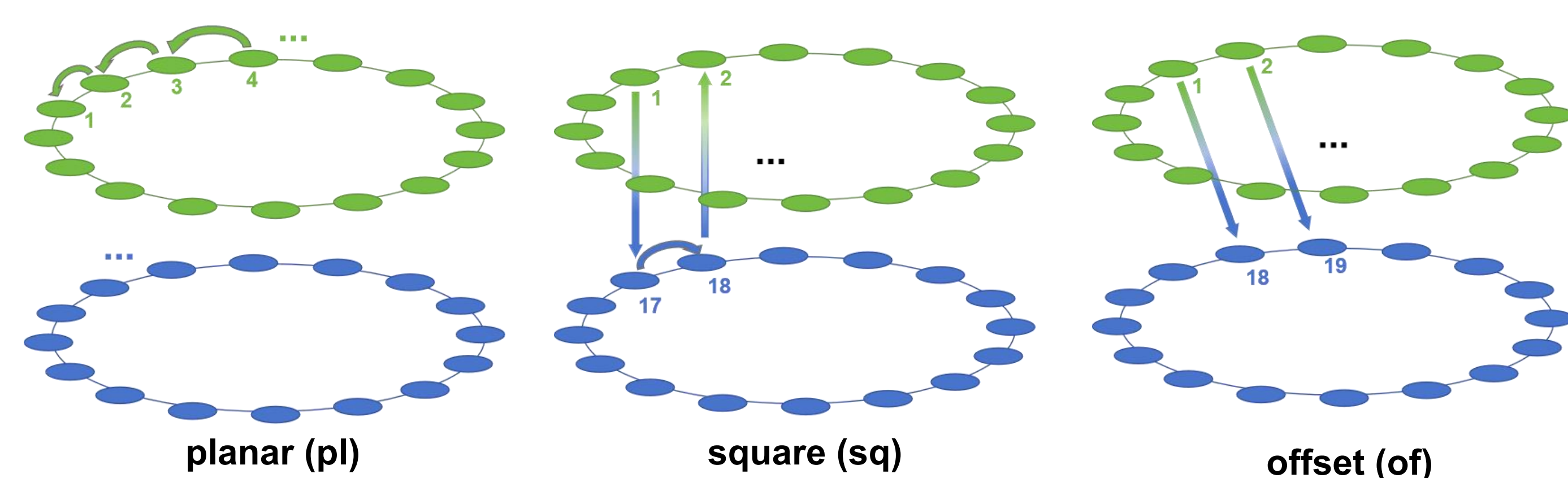
- **Miniaturized chamber:** 1 mm diameter × 0.5 mm height
- **Two-layer configuration:** 32 electrodes, 16 electrodes on each layer
- **Modular assembly:** 3D-printed holders with integrated fluidic channels, two electrode-integrated chips separated by a PDMS layer



Excitation and measurement modes

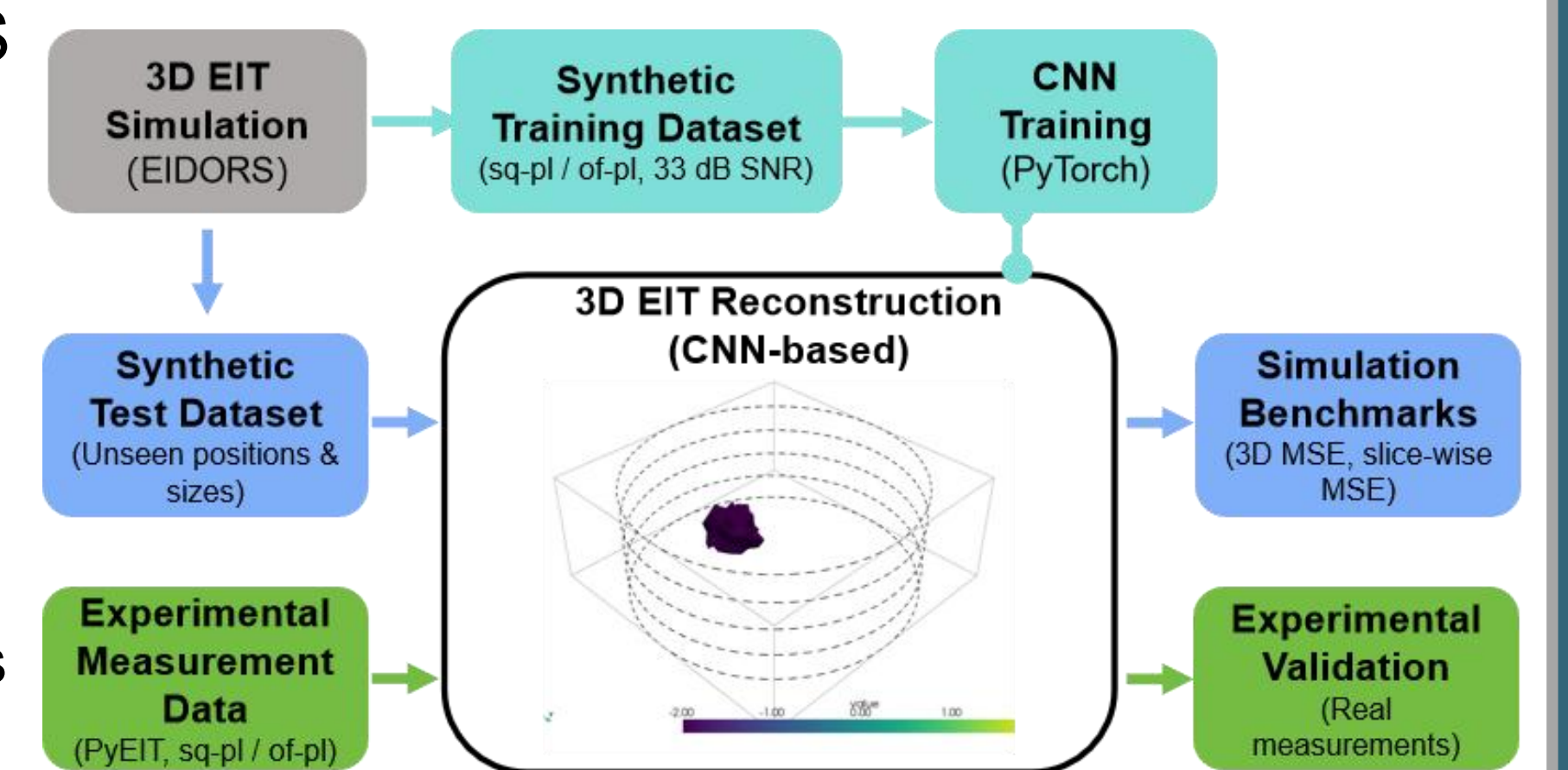


- In EIT current is applied between two electrodes and voltage is measured between other electrode pairs.
- Many possible excitation and measurement patterns: we compare **square (sq)** and **offset (of)** excitations, combined with a **planar (pl)** measurement pattern.
- We measure 1024 voltages (32 × 32)



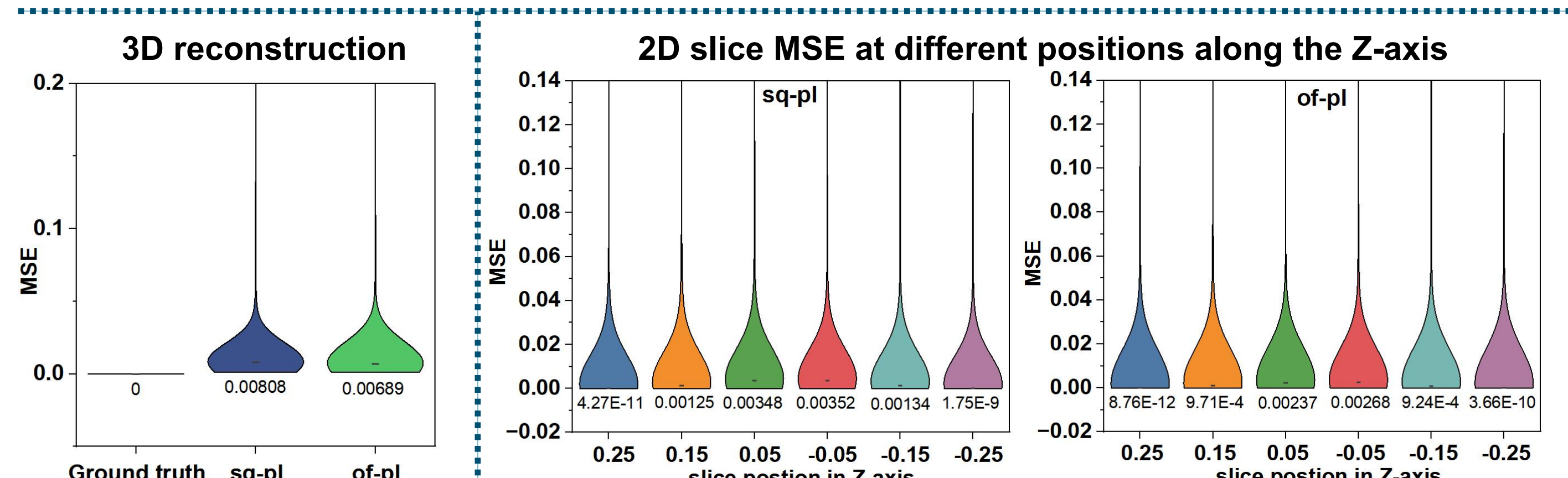
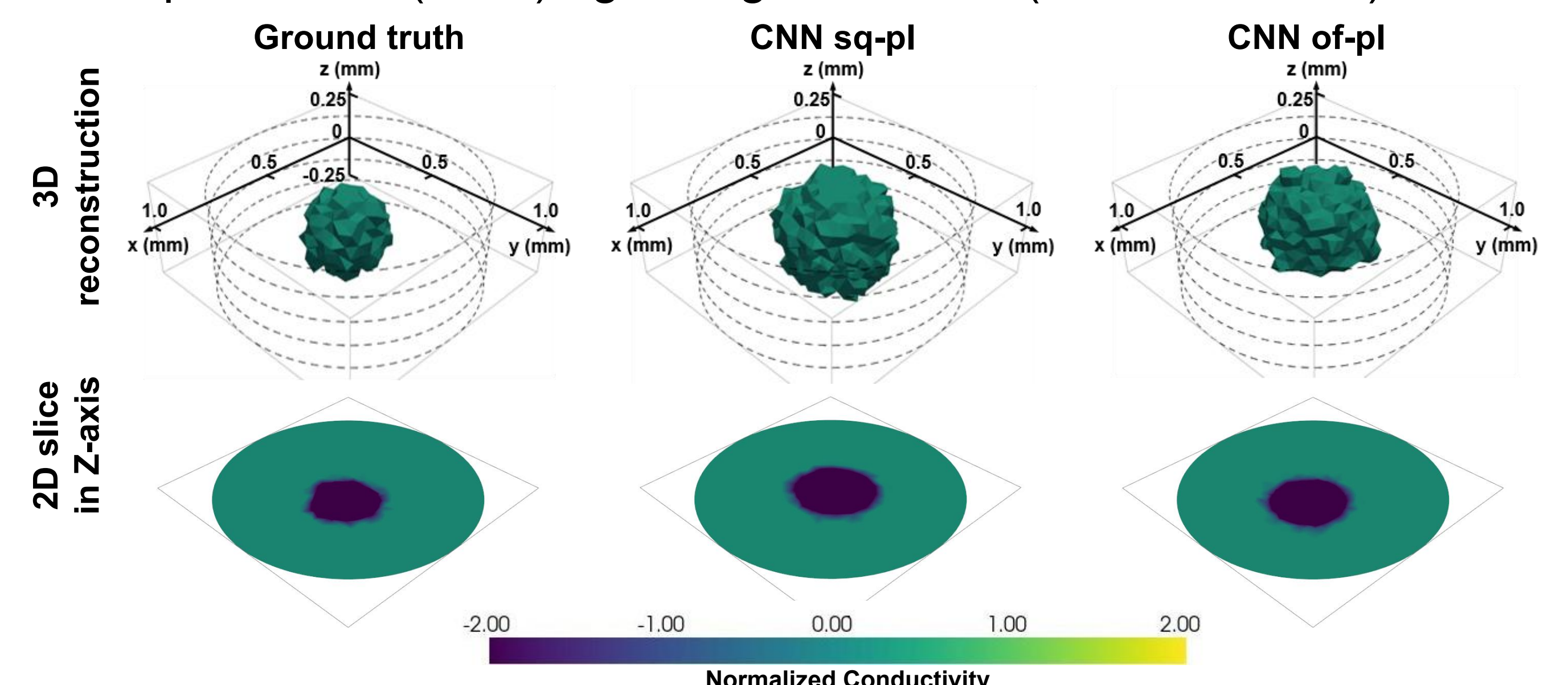
Framework for EIT reconstruction

- MATLAB-based EIDORS
→ Synthetic EIT datasets generation
- Python-based PyTorch
→ CNN training on synthetic
- Python-based PyEIT
→ Data acquisition and results visualization



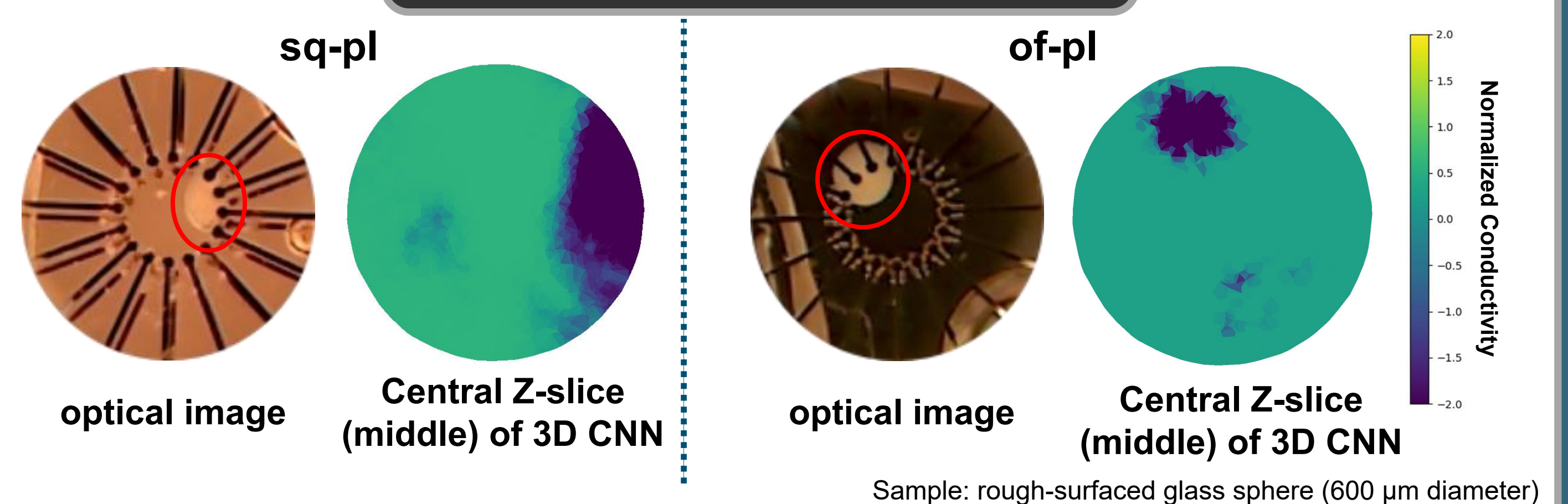
Simulation results

Synthetic datasets used for CNN training displayed various sample positions and sizes at 33 dB SNR. Reconstruction was evaluated by mean square error (MSE) against ground truth (simulated data).



- Reconstruction performance: **sq-pl** ≈ **of-pl**
- Reconstruction accuracy: **distance from electrode layer** ↑, **accuracy** ↓
- Spatial dependence along the Z-axis: **of-pl** < **sq-pl**

Experiment results



Conclusion & Outlook

- Two-layer microEIT platform enables CNN-based 3D image reconstruction with 2D slice visualization at different Z-positions.
- Future work will focus on further reconstruction optimization and validation using biological samples.