# GETTING STARTED GUIDE FOR DATA ARCHIVE FOR 2D AND 3D ELECTRICAL IMPEDANCE TOMOGRAPHY WITH MODERATE CONDUCTIVITY CONTRAST PHANTOMS

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Abstract. Extra information is provided here to help the interested reader get started using the data. This guide accompanies a manuscript describing the experimental methods in full; see the Zenodo record (`https://doi.org/10.5281/zenodo.24120439`) for its citation.

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## 1. Experimental Setups

Data from three experimental tanks are included. Figure 1 shows computer-generated renderings of each experimental tanks, complete with their axial dimensions. Computational meshes are included and discussed in § 2.2

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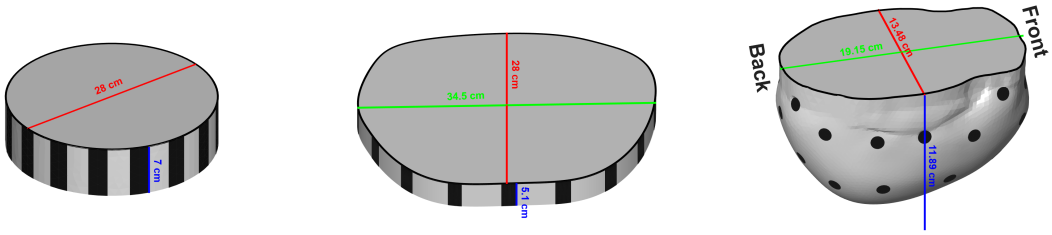



FIGURE 1. Dimensions of the agar cylinder phantom, the agar chest phantom and the head phantom.

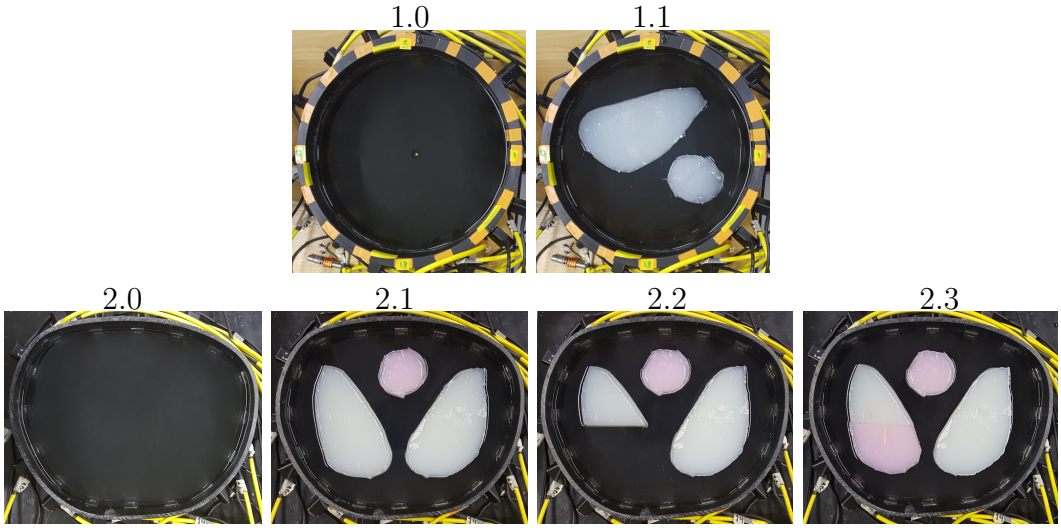



FIGURE 2. Agar phantom measurement setups for the cylinder phantom (top row) and the chest phantom (bottom row).

1.1. **Agar Targets.** The current patterns used for the agar targets were consistent with the previous EIT Open 2D Data [2]: adjacent, skip-1, skip-2, skip-3, and all against one. The experimental setups are shown in Figure 2. Visual depictions of the current patterns are shown in Figure 3 (top) as well as the electrode ordering for the cylindrical and chest-shaped tanks (bottom row).

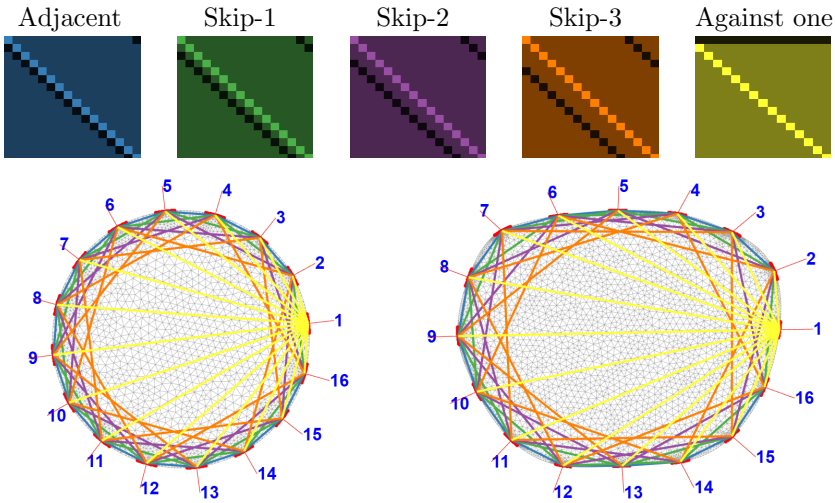



FIGURE 3. Current injections used with the agar cylinder phantom. Adjacent (blue), skip-one (green), skip-two (purple), skip-three (orange), and all-against-one (yellow) current injections are visualized as current injection matrices on the left and as lines connecting the injection pairs on the right. Each column of a current injection matrix defines the source and sink of the current injection with light and black color so that the rows correspond to electrode numbers.

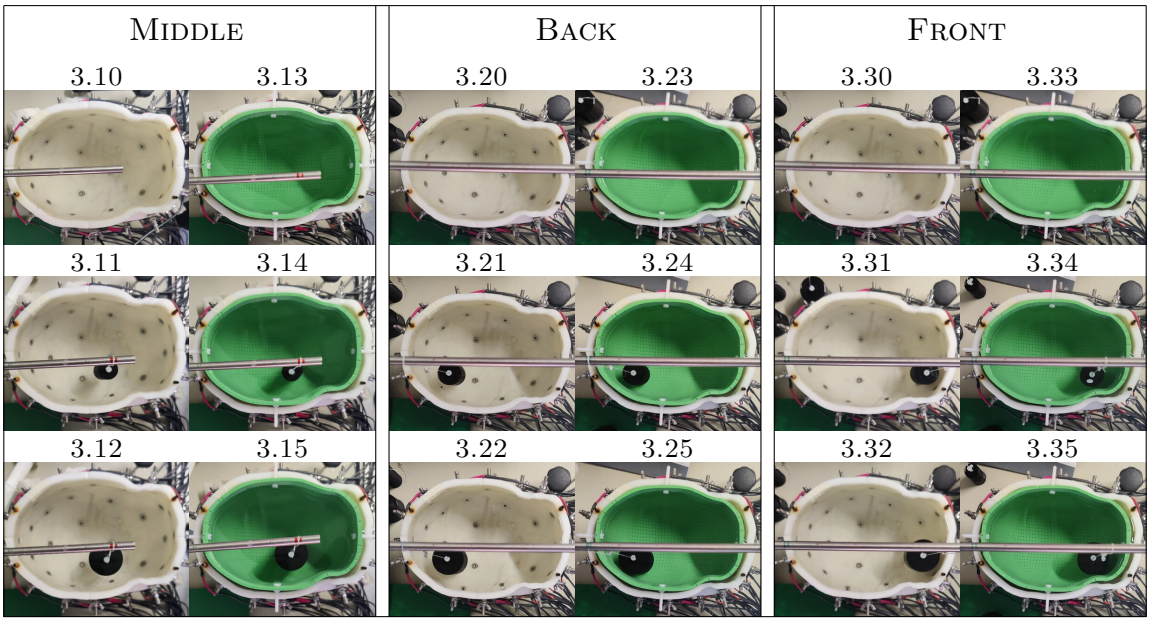



FIGURE 4. Head phantom measurement setups separated based on the location of the conductive cylinder.

1.2. **Head-shaped Tank.** The current patterns used for the head-shaped tank were: skip-1, skip-3, skip-6, and non-uniform. The experimental setups are shown in Figure 4. Visual depictions of the current patterns are shown in Figure 5 (top) as well as the electrode ordering for the head-shaped tank (bottom row).

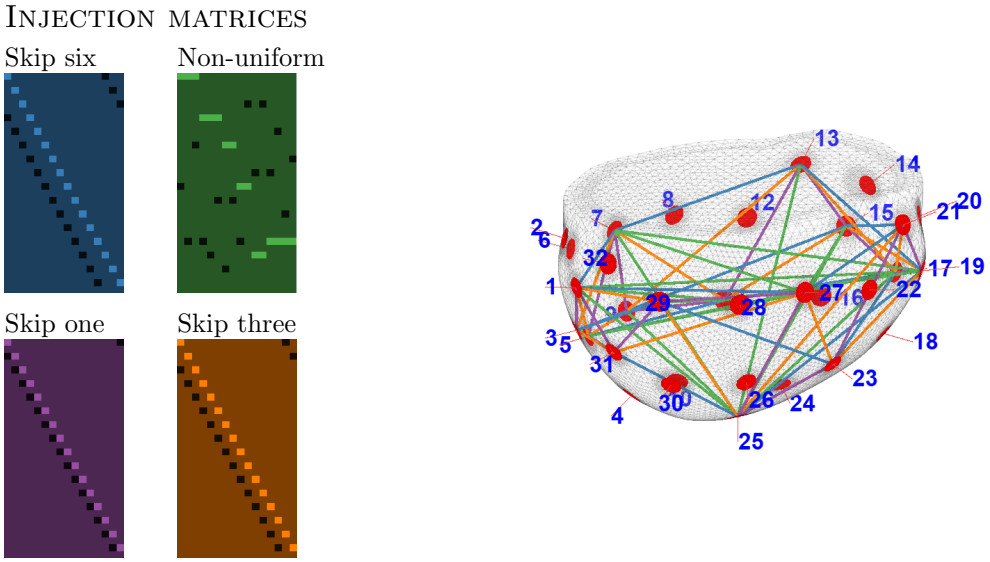



FIGURE 5. Current injections used with the head phantom. Skip-six (blue), non-uniform (green), skip-one (purple) and skip-three (orange) current injections are visualized as current injection matrices on the left and as lines connecting the injection pairs on the right. Each column of a current injection matrix defines the source and sink of the current injection with light and black color so that the rows correspond to electrode numbers.

## 2. What's included?

The data were separated into three zip folders (`AgarCylinderPhantom`, `AgarChestPhantom`, and `HeadPhantom`) in a single zenodo repository [1] each containing `Data`, `ExampleCodes`, and `Photos` folders. The `Photos` folders contain a photograph of each experiment, named to match the data files. A spreadsheet `KIT4Agar_KIT5Head_DataTracking.xlsx` (with PDF and per-phantom versions) is additionally included containing the filenames and experimental details and photos for each experiment for the user's convenience.

Each mat file contains the following variables

```
currents_matrix: [num_electrodes x num_injections]
voltages_matrix: [num_electrodes x num_injections]
units_info:      [string]
```

The matrix `currents_matrix` defines the injected currents. Each column defines one current injection and the nonzero values in a column give the amplitude of the injected current, and the row numbers of those nonzero values define the source and sink electrodes. The matrix `voltages_matrix` contains the measured voltages for each current injection. Column $j$ of the matrix contains measured voltages on all electrodes, in order, for current injection $j$. The string `units_info` identifies the units of the given current and voltage values. The values are in milliamperes and volts for all data files.

## 2.1. **Current and Voltage Data.**

2.1.1. *AgarCylinderPhantom.* The repository contains the following mat files for the agar cylinder phantom measurements.

```
AgarCylinderPhantom
  1o0_AgarCylinderPhantom_NoInc
  1o1_AgarCylinderPhantom_2Incs
```

The numbering matches that of the experimental data figures 2. In addition to the prefix number identifiers and the phantom identifier, the suffix `NoInc` is used for the no-inclusion, water only measurement setup, and the suffix `2Incs` is used for the two-inclusion measurement setup.

2.1.2. *AgarChestPhantom.* The repository contains the following mat files for the agar chest phantom measurements.

```
AgarChestPhantom
  2o0_AgarChestPhantom_NoInc_1
  2o0_AgarChestPhantom_NoInc_2
  2o1_AgarChestPhantom_Inc_all_1
  2o1_AgarChestPhantom_Inc_all_2
  2o2_AgarChestPhantom_Inc_missingPiece_1
  2o2_AgarChestPhantom_Inc_missingPiece_2
  2o3_AgarChestPhantom_Inc_highCondPiece_1
  2o3_AgarChestPhantom_Inc_highCondPiece_2
```

The suffixes `_1` and `_2` are used to separate repeat measurement of the same setup. The suffix `NoInc` is used for no-inclusion, water-only measurement setups. The suffix `Inc_all`, `Inc_missingPiece` and `Inc_highCondPiece` correspond to measurement setups simulating intact lungs, right (DICOM) lung missing a piece, and right (DICOM) lung with higher conductivity piece (e.g. to simulate a pleural effusion)

2.1.3. *HeadPhantom.* The repository contains the following mat files for the head phantom measurements.

```
HeadPhantom
  3o10_HeadPhantom_Middle_NoInc_1
  3o10_HeadPhantom_Middle_NoInc_2
  3o11_HeadPhantom_Middle_SmallInc_1
  3o11_HeadPhantom_Middle_SmallInc_2
  3o12_HeadPhantom_Middle_LargeInc_1
  3o12_HeadPhantom_Middle_LargeInc_2
  3o13_HeadPhantom_Middle_Skull_NoInc_1
  3o13_HeadPhantom_Middle_Skull_NoInc_2
  3o14_HeadPhantom_Middle_Skull_SmallInc_1
  3o14_HeadPhantom_Middle_Skull_SmallInc_2
  3o15_HeadPhantom_Middle_Skull_LargeInc_1
  3o15_HeadPhantom_Middle_Skull_LargeInc_2
  3o20_HeadPhantom_Back_NoInc
  3o21_HeadPhantom_Back_SmallInc
  3o22_HeadPhantom_Back_LargeInc
```

```
  3o23_HeadPhantom_Back_Skull_NoInc
  3o24_HeadPhantom_Back_Skull_SmallInc
  3o25_HeadPhantom_Back_Skull_LargeInc
  3o30_HeadPhantom_Front_NoInc
  3o31_HeadPhantom_Front_SmallInc
  3o32_HeadPhantom_Front_LargeInc
  3o33_HeadPhantom_Front_Skull_NoInc_1
  3o33_HeadPhantom_Front_Skull_NoInc_2
  3o34_HeadPhantom_Front_Skull_SmallInc_1
  3o34_HeadPhantom_Front_Skull_SmallInc_2
  3o35_HeadPhantom_Front_Skull_LargeInc_1
  3o35_HeadPhantom_Front_Skull_LargeInc_2
```

In addition to the prefix number identifiers and the phantom identifier, the following additional suffixes are included in the filenames to enhance clarity. The suffixes `Middle`, `Back` and `Front` identify the position of the inclusion. The suffix `Skull` is used if the skull is in the measurement setup. If this suffix is not used, the skull was not used in the measurement setup. The suffixes `_1` and `_2` are used to separate repeat measurement of the same setup. The suffix `NoInc`, `SmallInc` and `LargeInc` indicate the size of the inclusion in the measurement setup.

2.2. **Computational Meshes and Jacobians.** The repositories contain the following computational meshes

```
AgarCylinderPhantom
  mesh_AgarCylinderPhantom_2D_inverse_1197
  mesh_AgarCylinderPhantom_2D_forward_2815
AgarChestPhantom
  mesh_AgarChestPhantom_2D_inverse_2291
  mesh_AgarChestPhantom_2D_forward_4559
HeadPhantom
  mesh_HeadPhantom_3D_inverse_8848
  mesh_HeadPhantom_3D_forward_41626
```

that were used to compute the reference estimates shown in Figures 7 and 8. The meshes are shown in Figure 6. These meshes can be used in their current forms, or as starting points to create new computational meshes.

The computational mesh files tagged with `forward` contain the following

```
       nodes: [NN×2 double] or [NN×3 double]
    elements: [NE×3 double] or [NE×4 double]
 surfaceNodes: [NS×1 double]
   electrodes: {L×1 cell}
allElectrodes: [LA×1 double]
```

and the computational mesh files tagged with `inverse` are for computational meshes that do not have electrodes, and contain the following

```
       nodes: [NN×2 double] or [NN×3 double]
    elements: [NE×3 double] or [NE×4 double]
 surfaceNodes: [NS×1 double]
```

In the computational mesh files `nodes` is a number-of-nodes times dimension ($NN \times 2$ or $NN \times 3$) matrix with rows giving the coordinates of the nodes. The rows of `nodes` define the indexing of nodes used by the rest of the variables so that row $i$ of `nodes` gives the coordinates of node $i$. `elements` is a number-of-elements times number-of-nodes-in-element ($NE \times 3$ or $NE \times 4$) matrix indexing nodes of elements on its rows, `surfaceNodes` is a number-of-surface-nodes times one ($NS \times 1$) vector indexing the nodes on the domain surface, `electrodes` is a number-of-electrodes times one ($L \times 1$) cell array where cell $e$ indexes nodes under electrode $e$, `allElectrodes` is a number-of-nodes-in-all-electrodes times one ($LA \times 1$) vector indexing all nodes that belong to any electrode.

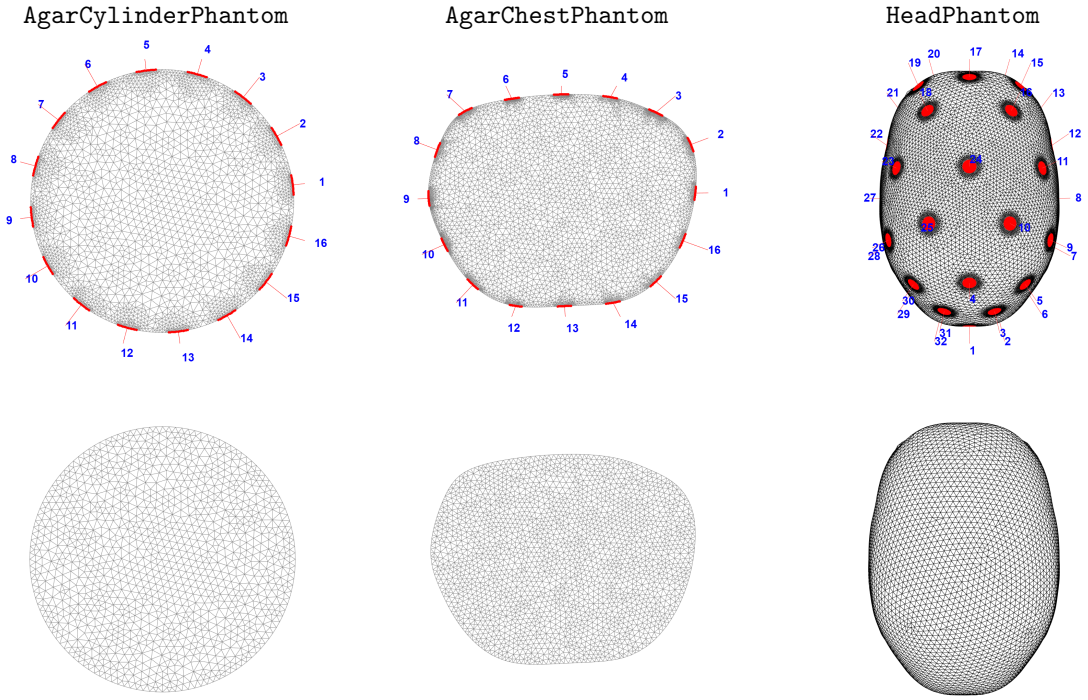



FIGURE 6. Computational meshes with electrodes (top row) and computational meshes without electrodes (bottom row) for the three different phantoms (columns).

## 3. Sample Code for Linearized Reconstructions

To provide an easier start with the repository, each of the three zipped datasets includes an `ExampleCodes` folder containing `PlotMesh.m`, a function for visualizing the computational meshes. Additionally, the two agar tanks each contain sample linear difference reconstruction code in their respective `ExampleCodes` folders:

`Example_CylinderPhantom_LinearDifferenceImaging.m`
`Example_ChestPhantom_LinearDifferenceImaging.m`

These files are examples of linear difference imaging code that use either cylinder or chest phantom data and a precomputed Jacobian matrix to compute and visualize an estimate of conductivity change between two measurements. The precomputed Jacobian matrices

corresponding to the `inverse` tagged meshes of the different phantoms can be found in the same folders as the measurement data files, and they are

`J_AgarCylinderPhantom`
`J_AgarChestPhantom`
`J_HeadPhantom`

Figures 7 and 8 show sample linear difference imaging reconstructions. Figure 7 additionally includes sample total variation regularized absolute images (code for these is not included). No example reconstruction code is provided for the head phantom, but `J_HeadPhantom` can be used as a starting point for a linear difference method of the user's choosing.

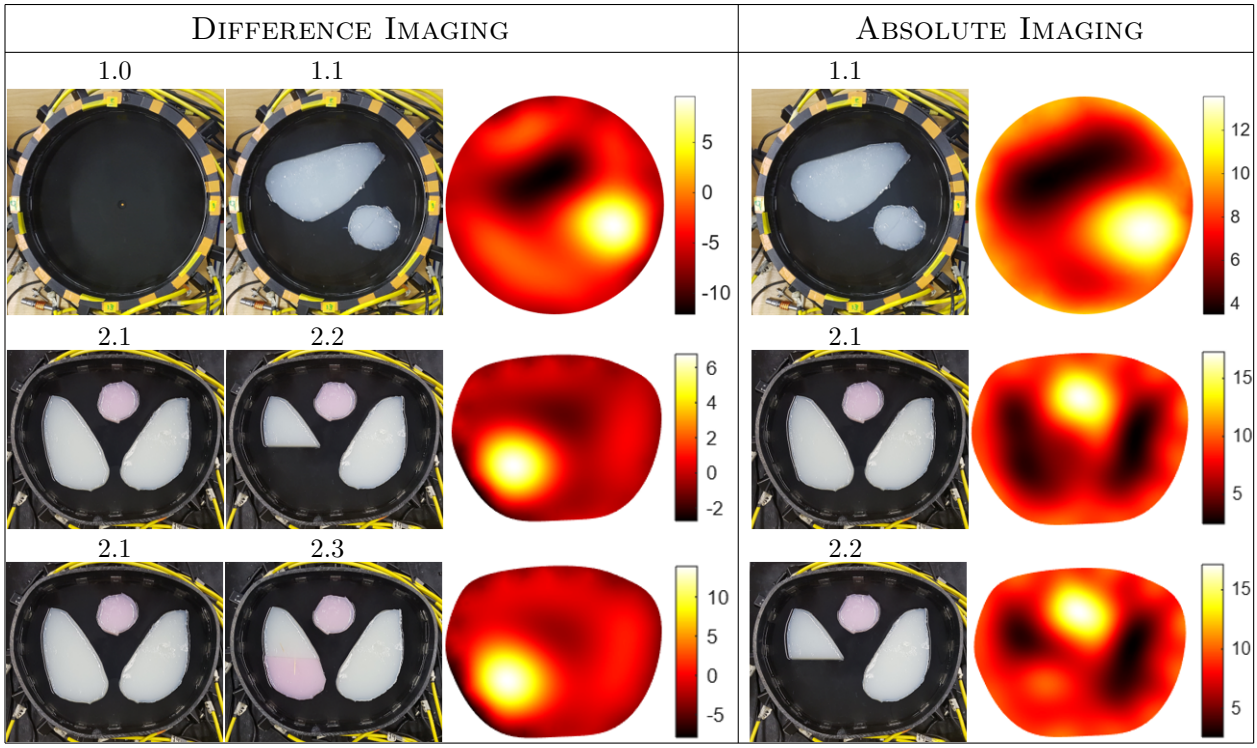



Figure 7. Example linear difference imaging reconstructions (left) and smoothness regularized absolute reconstructions (right) using the agar cylinder phantom data and the agar chest phantom data. The conductivity changes are nominally in mS/cm, however, using 2D computations for 3D setups makes the values inexact.

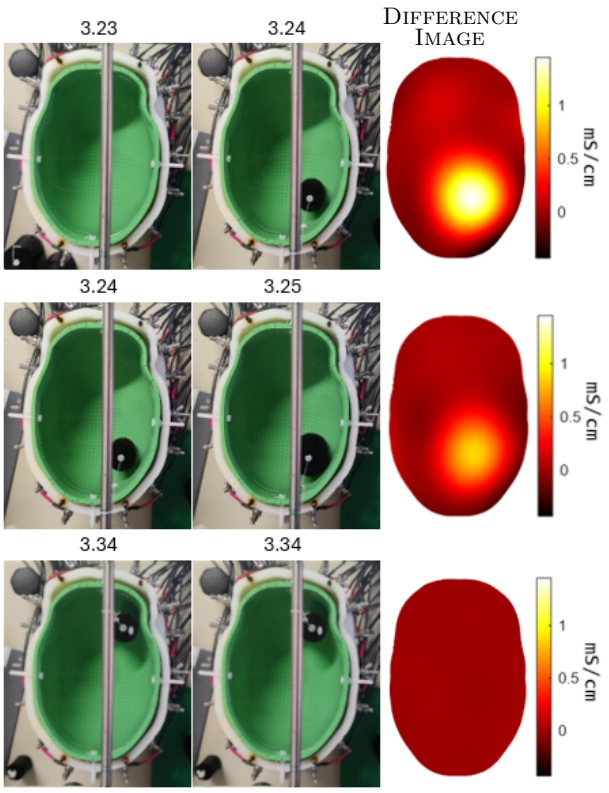



FIGURE 8. Example linear difference imaging reconstructions using the head phantom data.

## REFERENCES

[1] S. J. Hamilton, A. Hauptmann, A. Hänninen, V. Kolehmainen, J. Niskanen, T. Savolainen, and J. Toivanen. Open Electrical Impedance Tomography data from phantoms with moderate conductivity contrast for 2D and 3D reconstruction (KIT4 and KIT5). Zenodo, Version 1.0, 2026. `https://doi.org/10.5281/zenodo.24120439`.

[2] A. Hauptmann, V. Kolehmainen, N. M. Mach, T. Savolainen, A. Seppänen, and S. Siltanen. Open 2d electrical impedance tomography data archive. *arXiv preprint arXiv:1704.01178*, 2017.