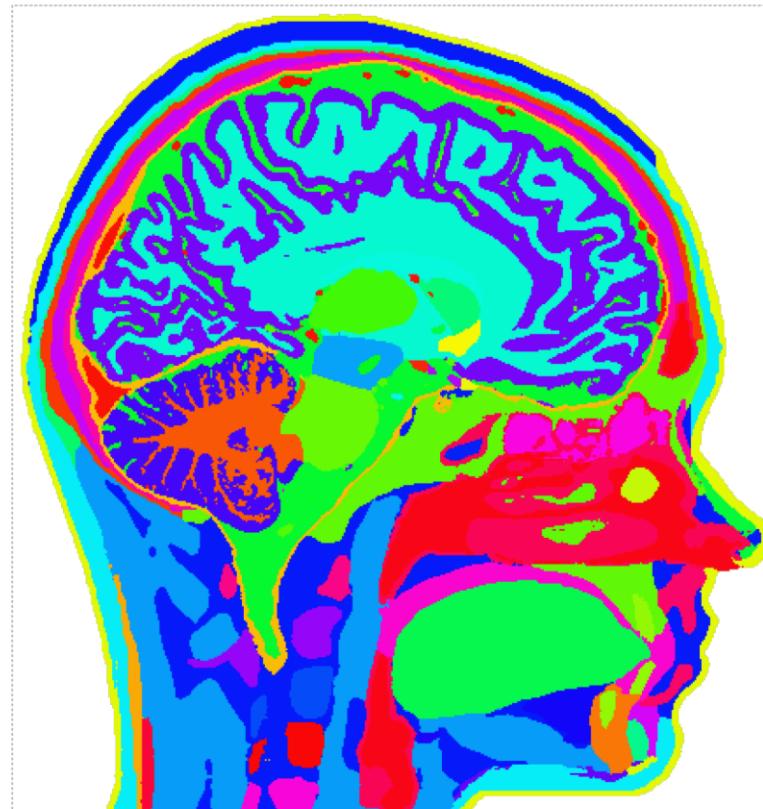
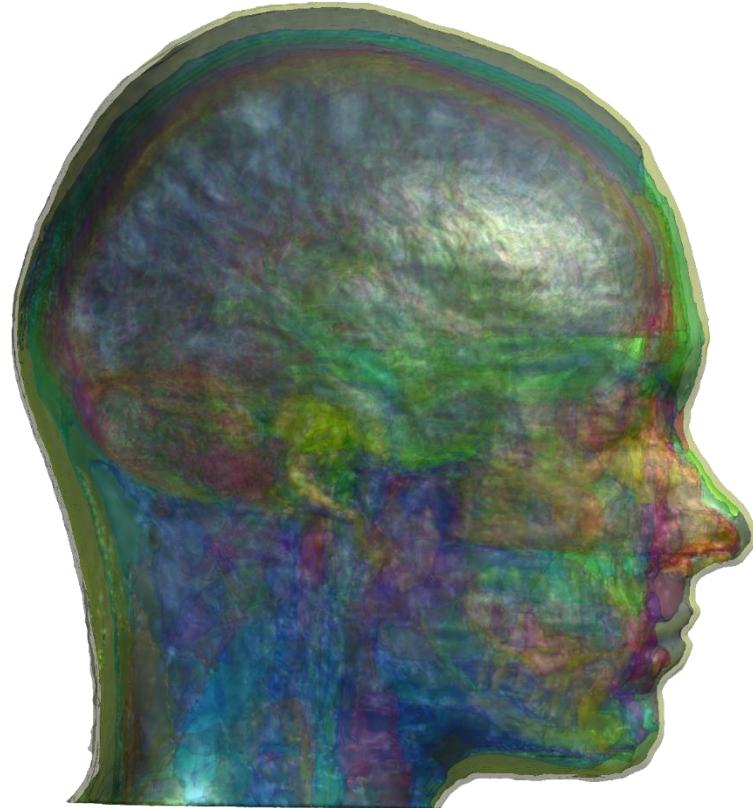


Modulation of visual contrast sensitivity with tRNS across the visual system, evidence from stimulation and simulation.

Modeling part

Weronika Potok^{1,2*}, Alain Post¹, Valeria Beliaeva³, Marc Bächinger^{1,2}, Antonino Mario Cassara⁴, Esra Neufeld⁴, Rafael Polania^{2,3}, Daniel Kiper⁵, Nicole Wenderoth^{1,2,6*}

MIDA model



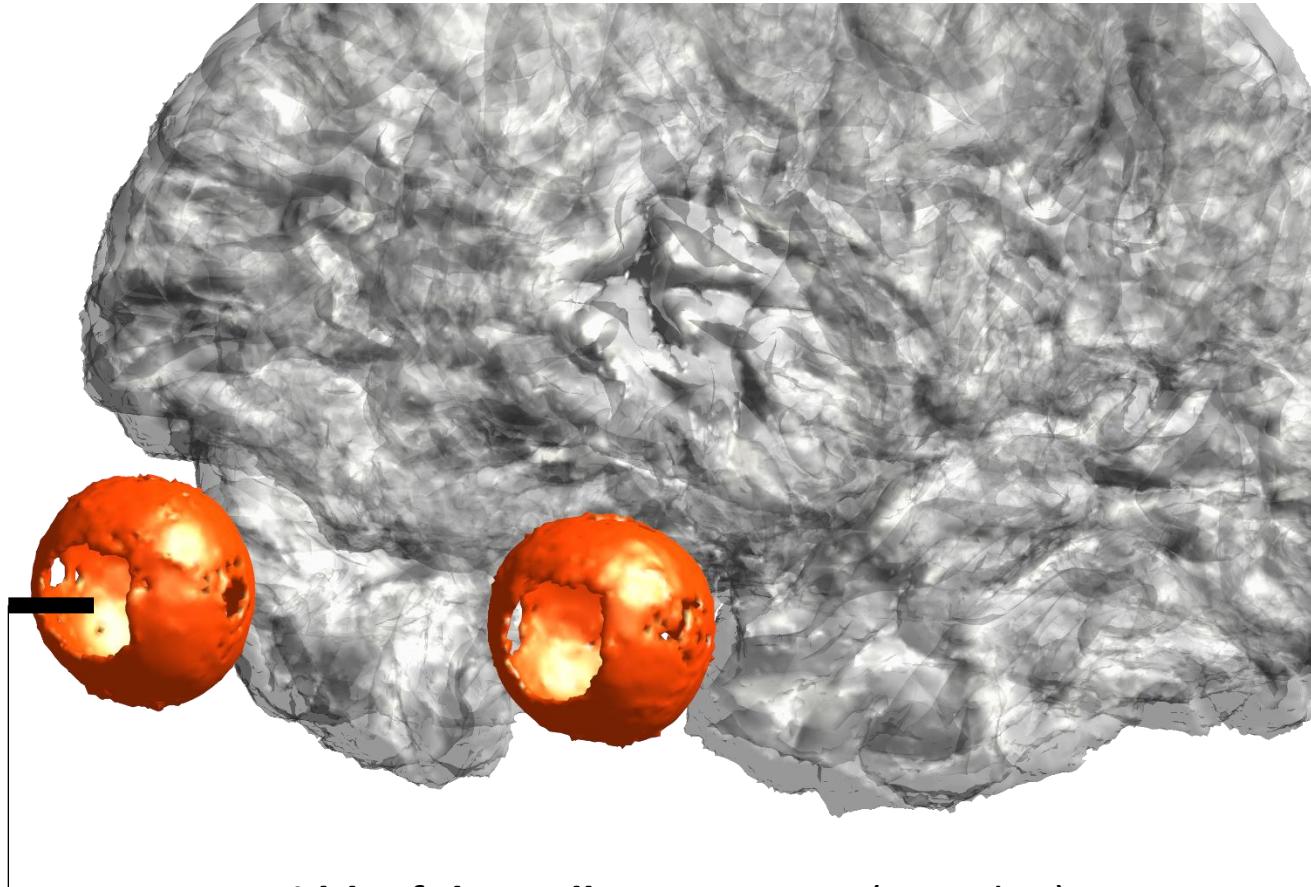
Model description

117 segments

37 materials with different
tissue conductivities

Material database:
ITIS LF 4.1

Target: retina



Width of the walls: 0.8 – 1 mm (very thin)

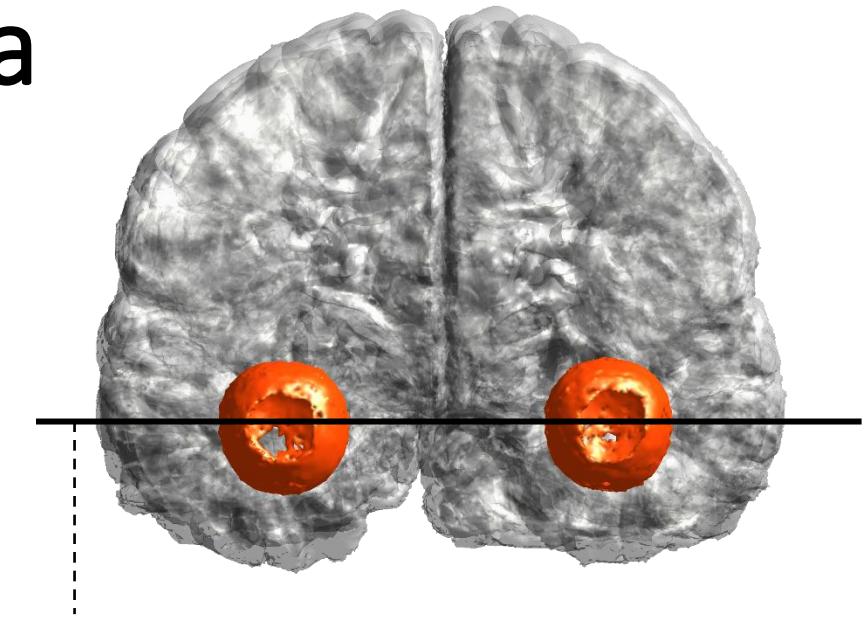
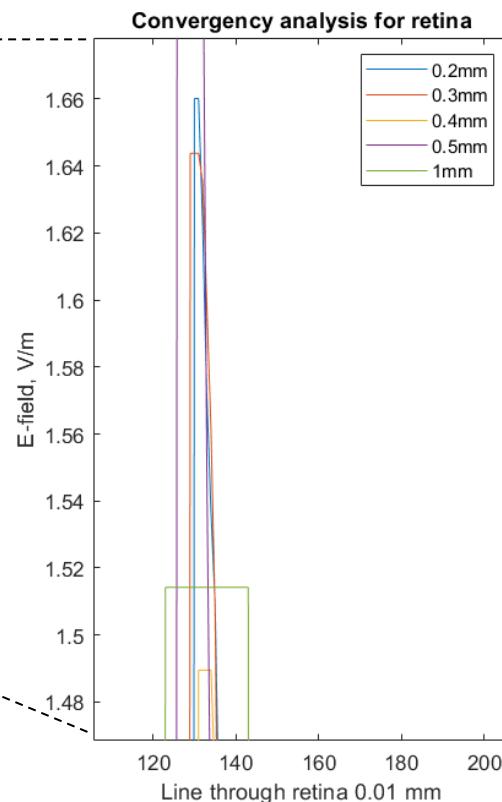
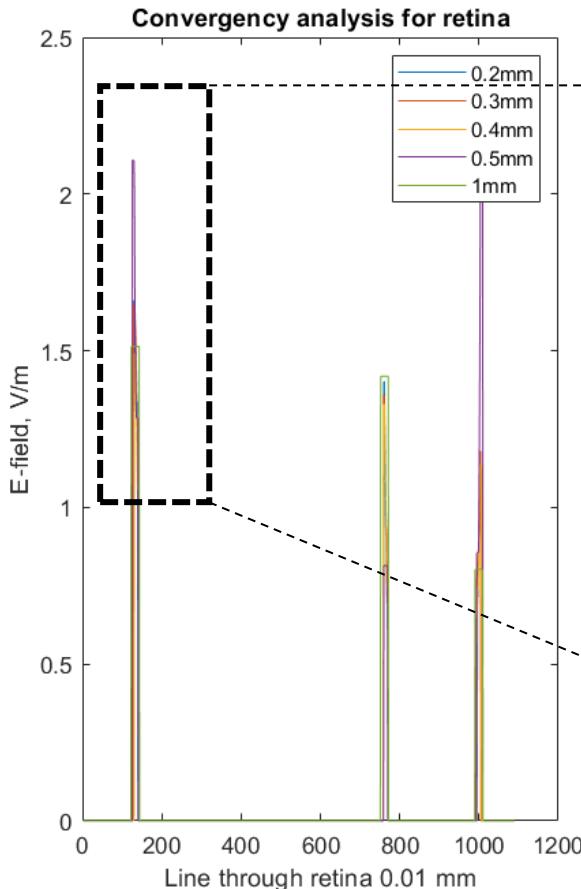
The walls of the retina are very thin and to calculate properly E-field within them, **HD grid is required** (at least 3 voxels in the wall).

Solution: *convergency analysis* to identify proper resolution of the grid

Additionally, checked the conductivity of the nearby tissues – it differs a lot from retina (0.62 S/m), e.g., ventricular humor (2.1 S/m).

Convergency analysis for retina

version 2



The **line** which goes through the **center of 2 retinas**. 3 retina walls – 1 is missing as there is a hole for a nerve. On this line (**resolution = 0.1 mm**), I interpolated different grids on the cell center. **Stimulation on plot**: 1 mA ptb.

Conclusion: resolution that should be chosen for retina – 0.2 or 0.3 mm

Convergency analysis for retina

version 2

Changes to **version 2** analysis:

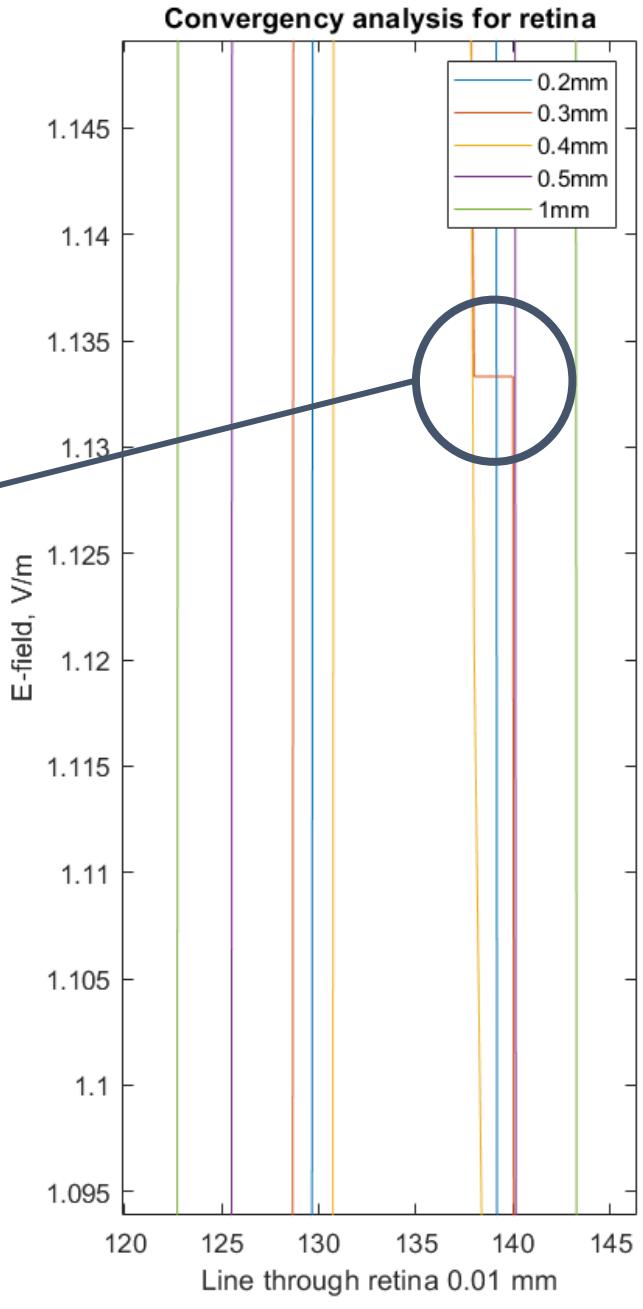
- stimulation 1 mA
- Interpolation to cell center

Main problem is on the edges, not at the peaks

Comparison 0.2 and 0.3mm resolution*:

- Maximum error: 15% (0.2 V/m)
- Average error: 5% (0.04 V/m)

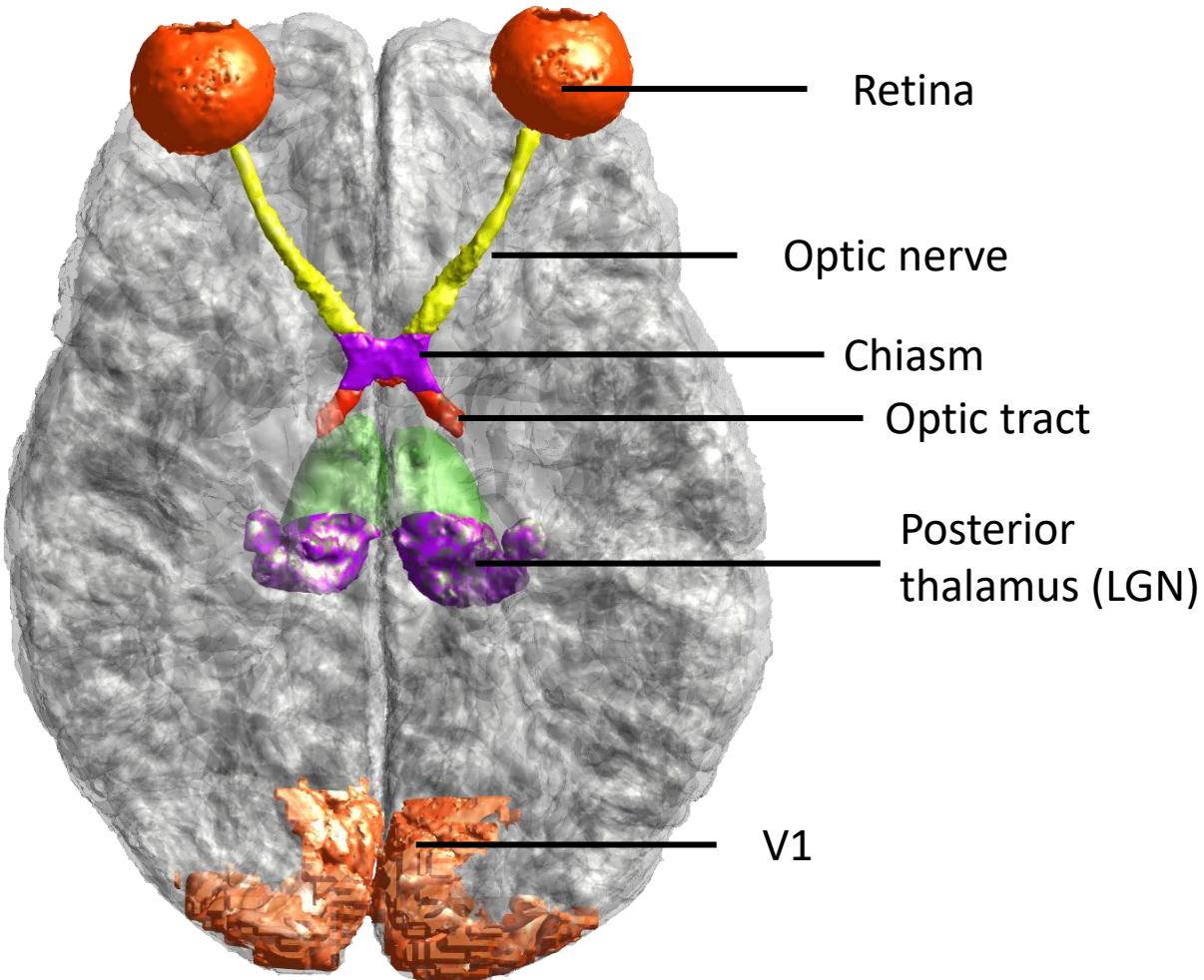
* NaNs and zeros removed from both vectors



Analysis path:

C:\Users\vbeliaev\Documents\TI_fMRI\Modelling\Weronika_paper_v1\Retina_convergency_results\Retina_on_line_v2_cell_center

Visual system



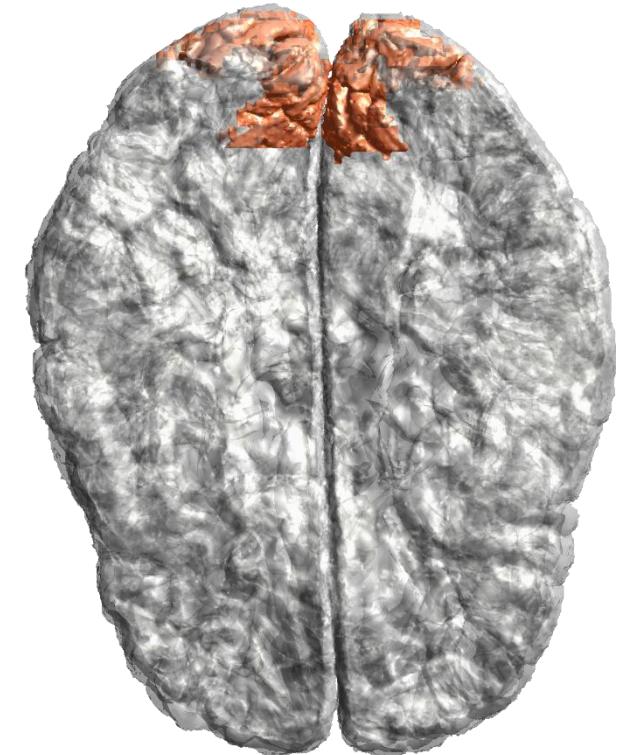
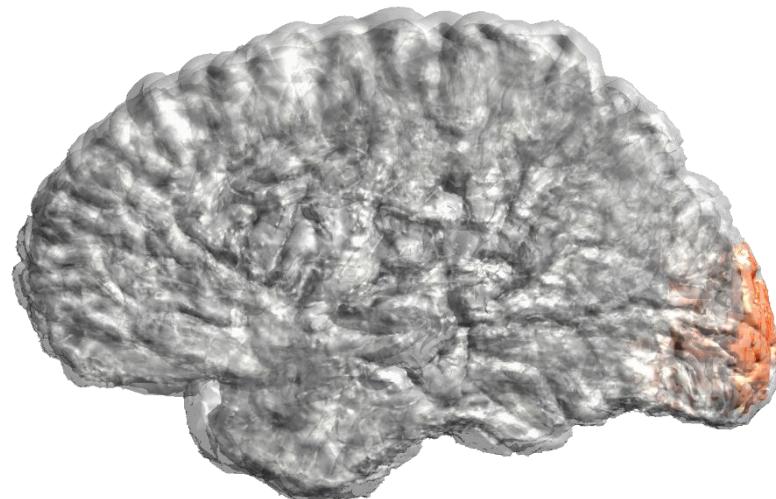
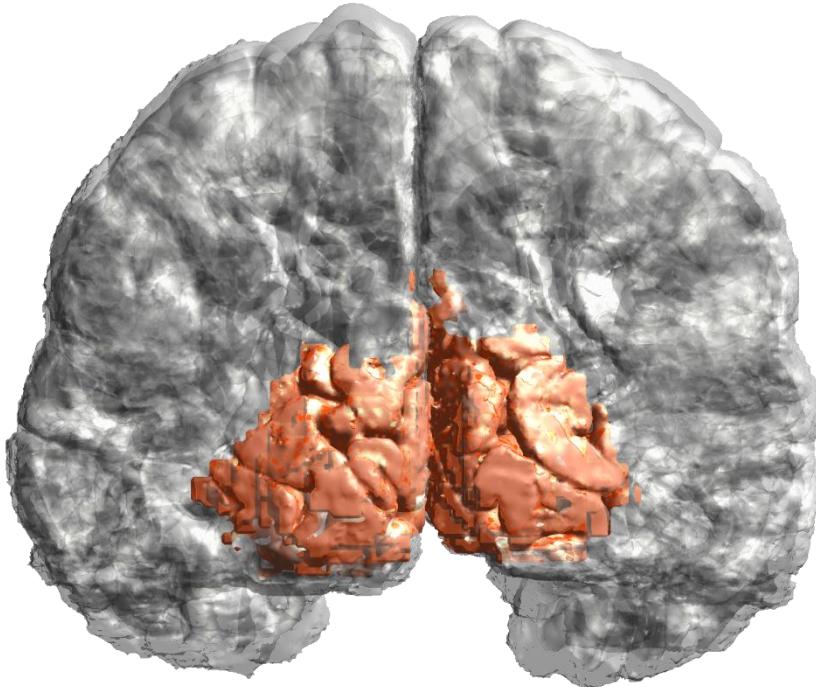
Main targets: retina and V1

Additional targets: optic nerve, tract + optic chiasm, posterior thalamus or lateral geniculate nucleus (LGN)

Additional targets **are thicker than retina** (> 2.5 mm), therefore current grid (0.5 mm) should be sufficient to study the E-field in these regions.

Additional targets should be studied to estimate the influence of each electrode configuration.

Primary visual cortex (V1)



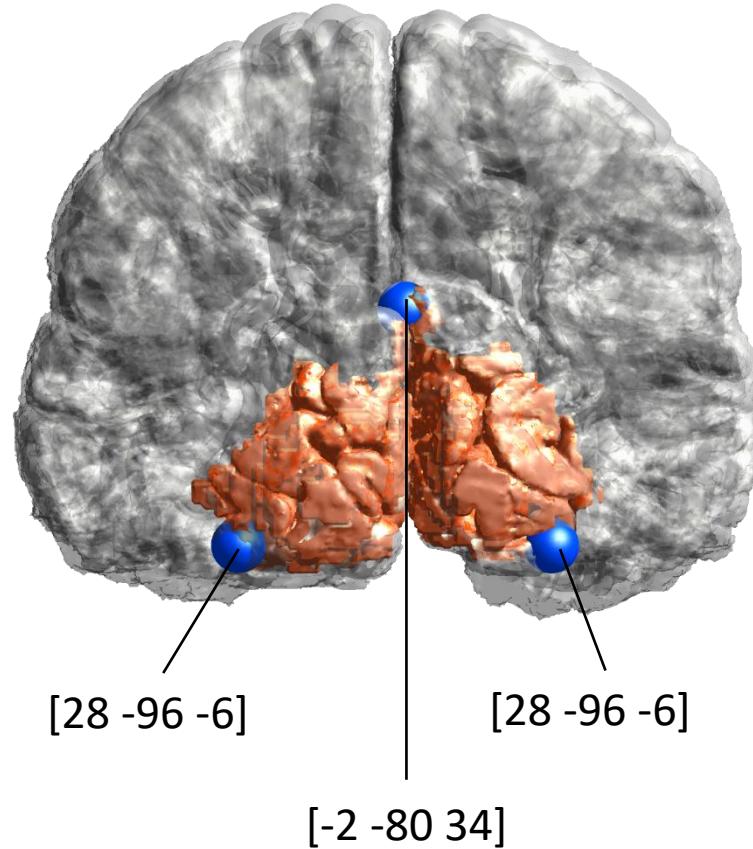
BNA subregions

189/190 – caudal lingual gyrus
193/194 – caudal cuneus gyrus
203/204 – occipital polar cortex

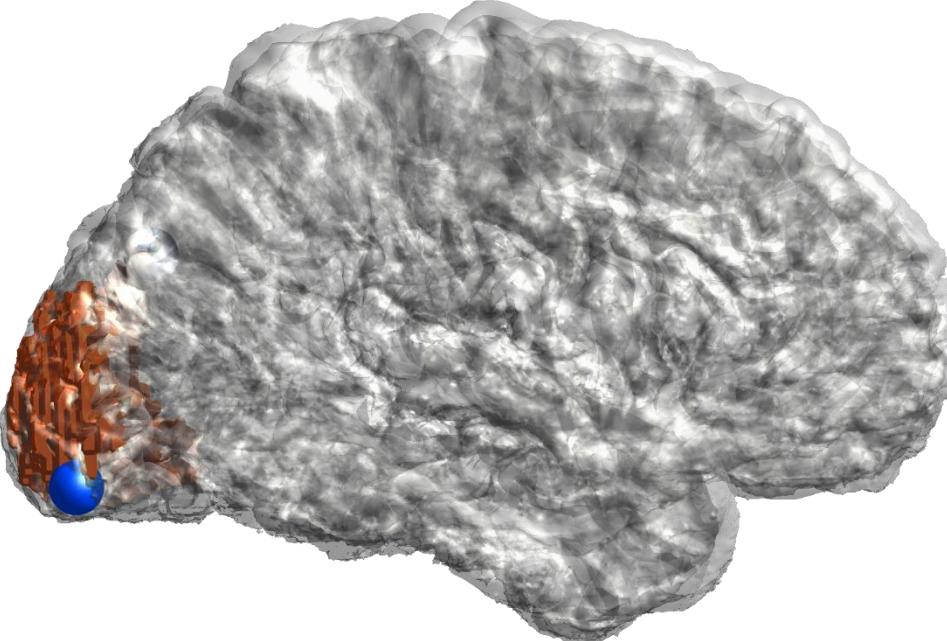
Procedure

This co-registered BNA (Brainnetome) mask was then cut by grey matter of the MIDA model

Primary visual cortex (V1)



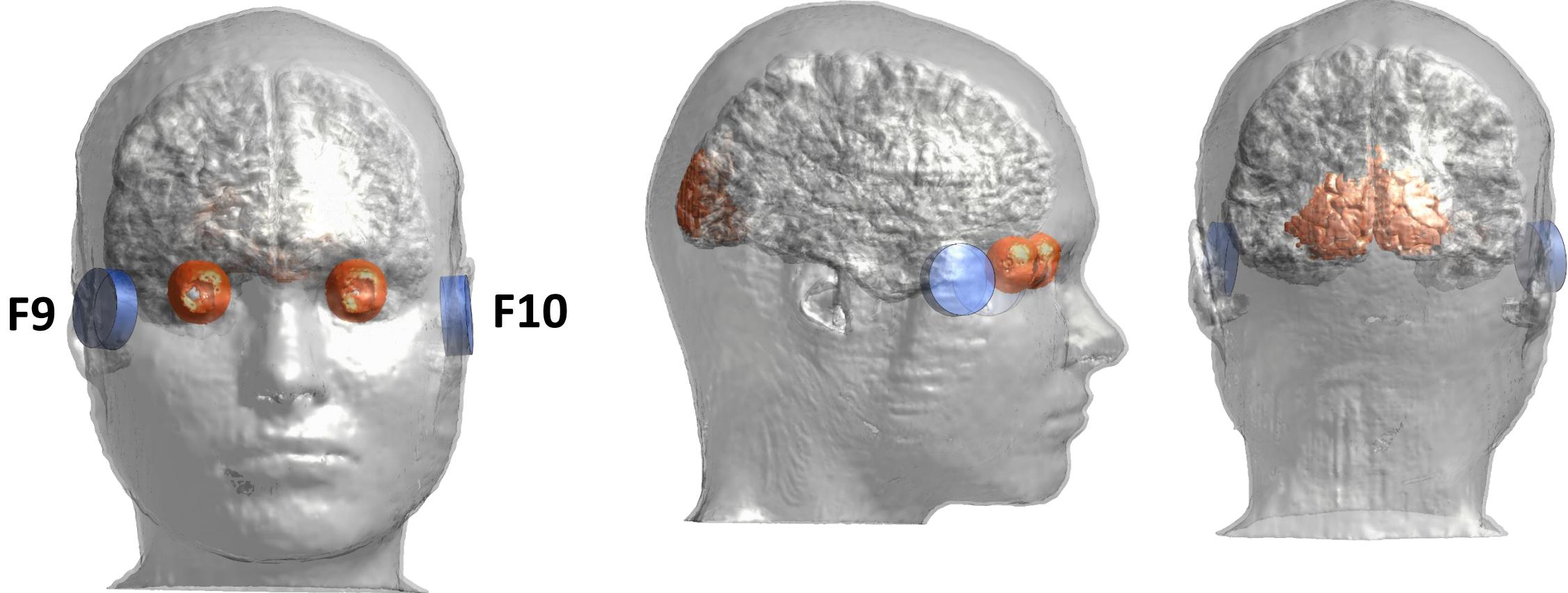
MNI coordinates of V1 BA17



Conclusion

Chosen BNA subregions fit well in MNI coordinates taken from another atlas (also co-registered with MIDA)

Retina configuration

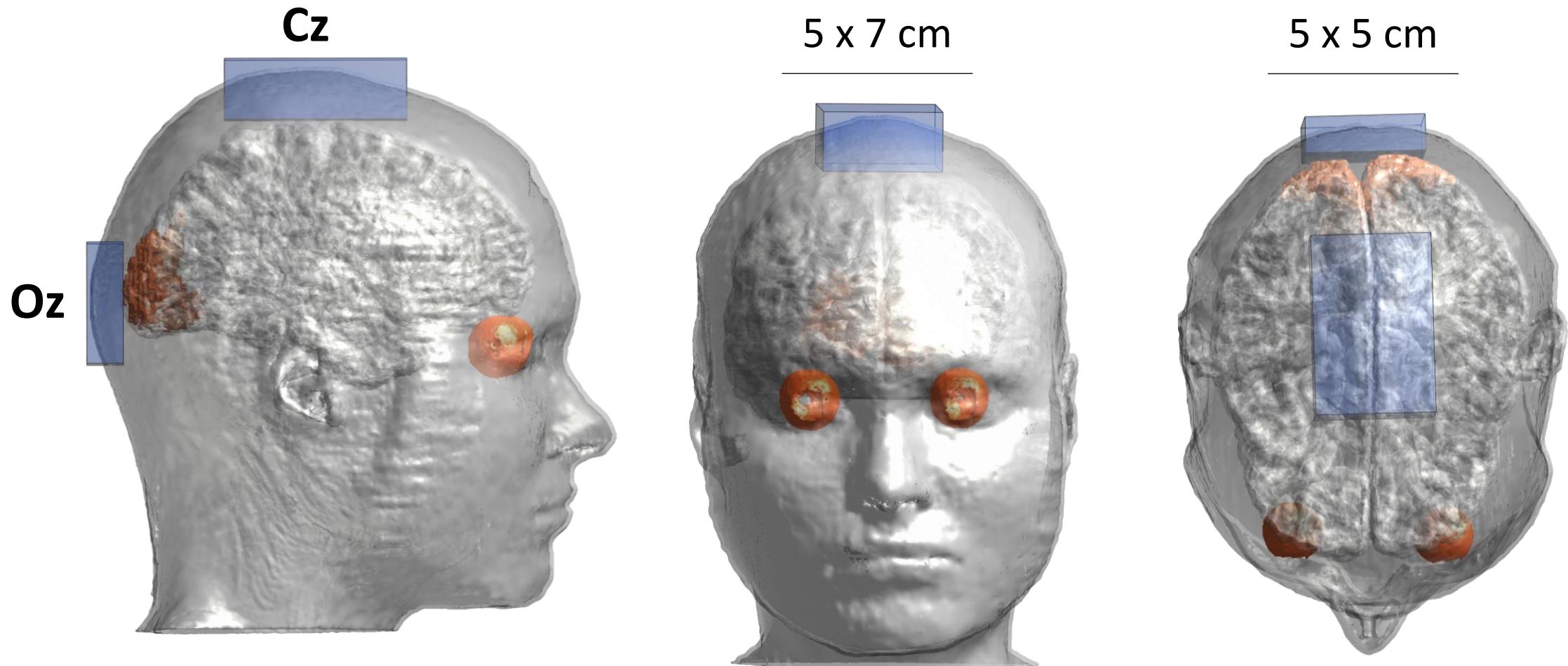


Electrodes

Locations are F9 and F10 (EEG 10-10 System)

Diameter 32 mm

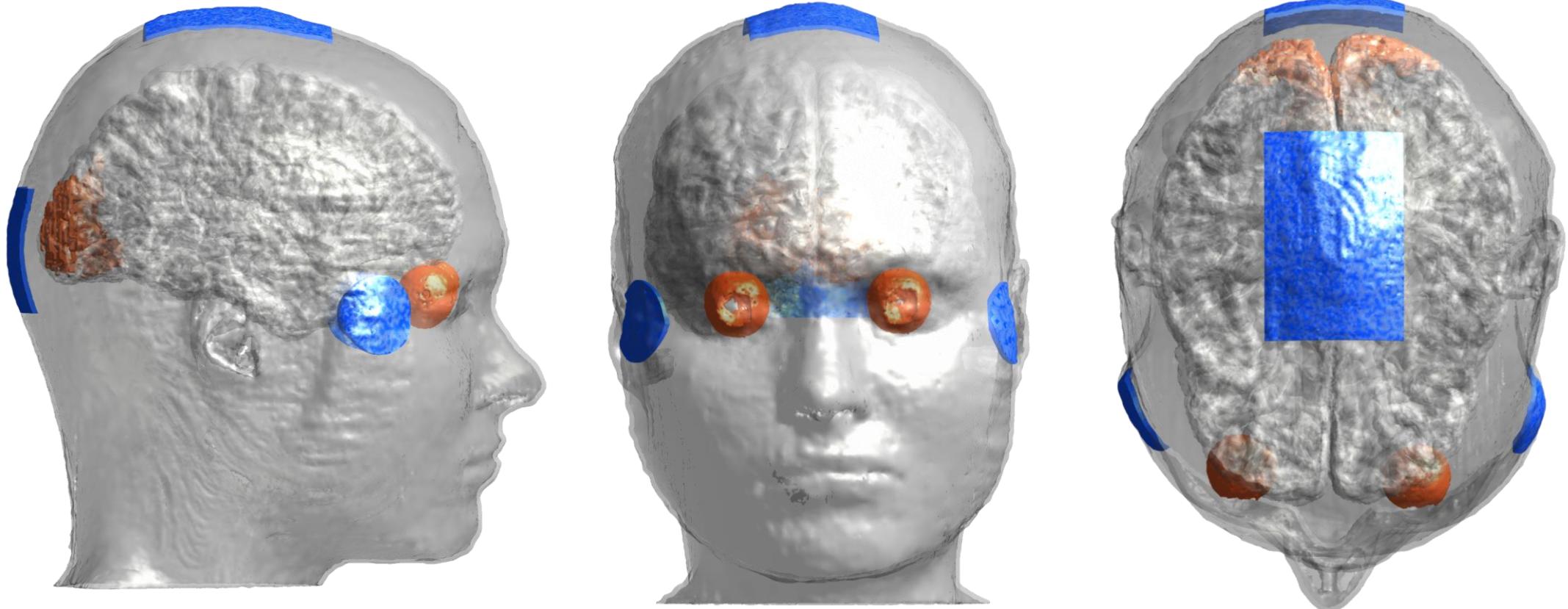
V1 configuration



Electrodes

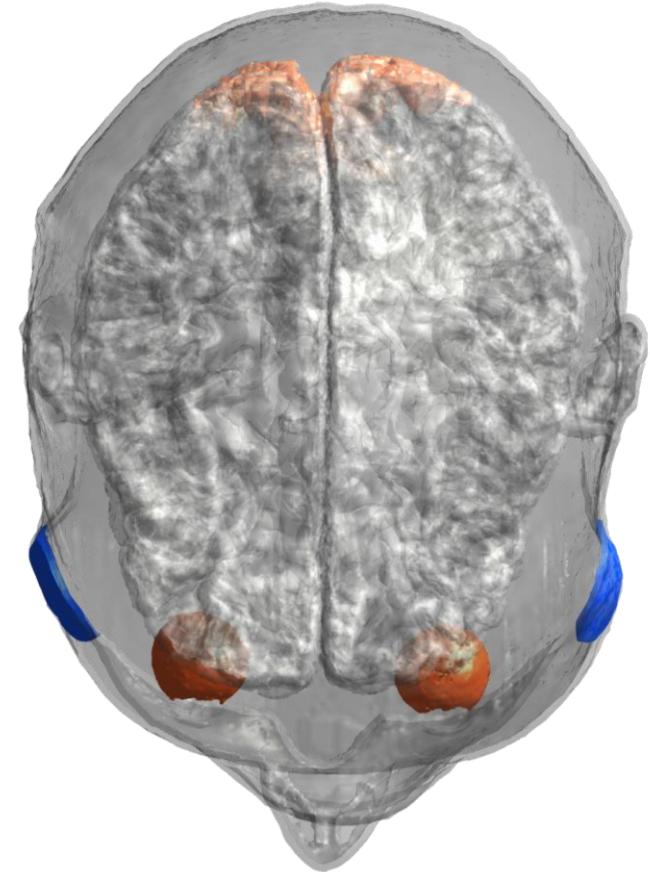
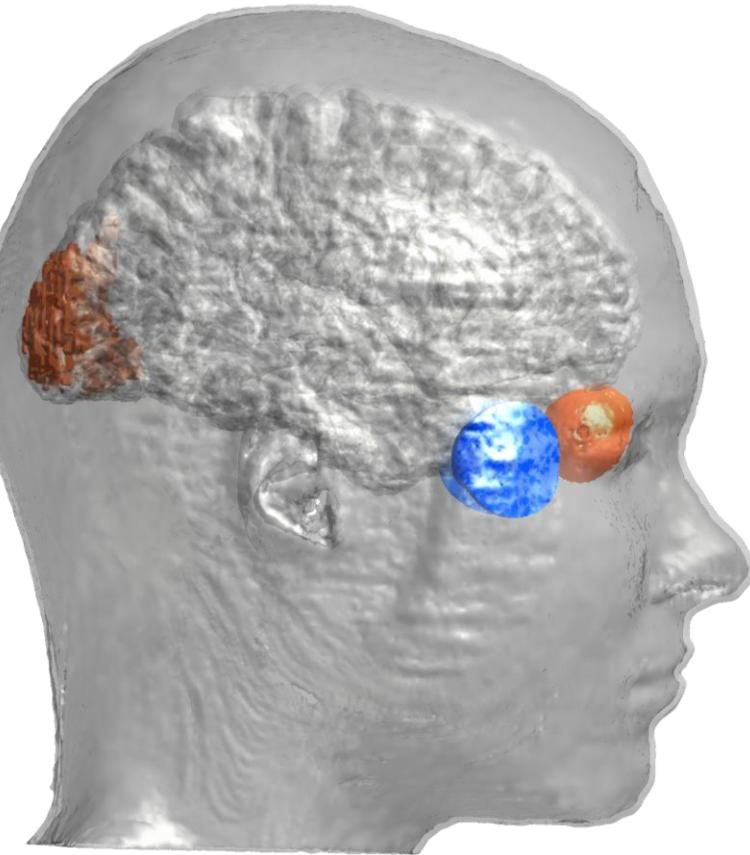
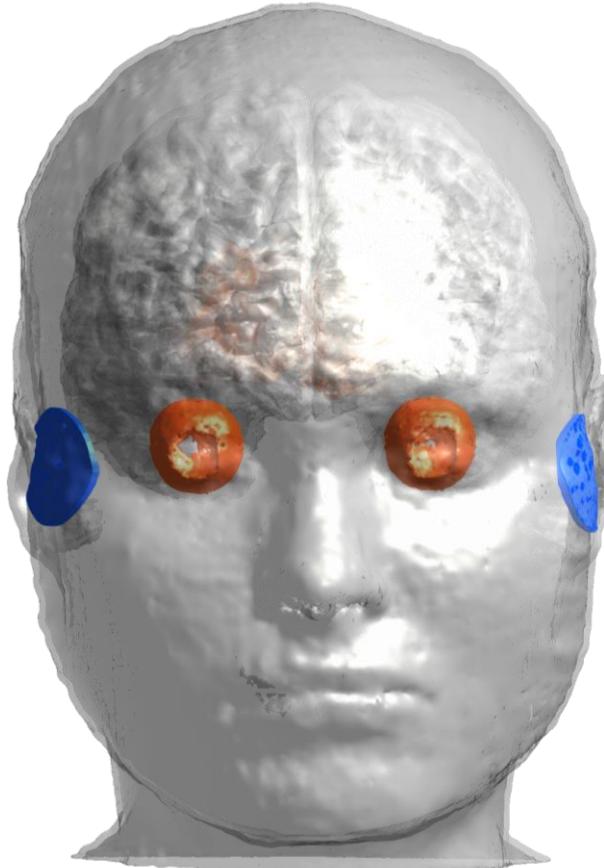
Locations are Cz and Oz (EEG 10-10 System)

General overview

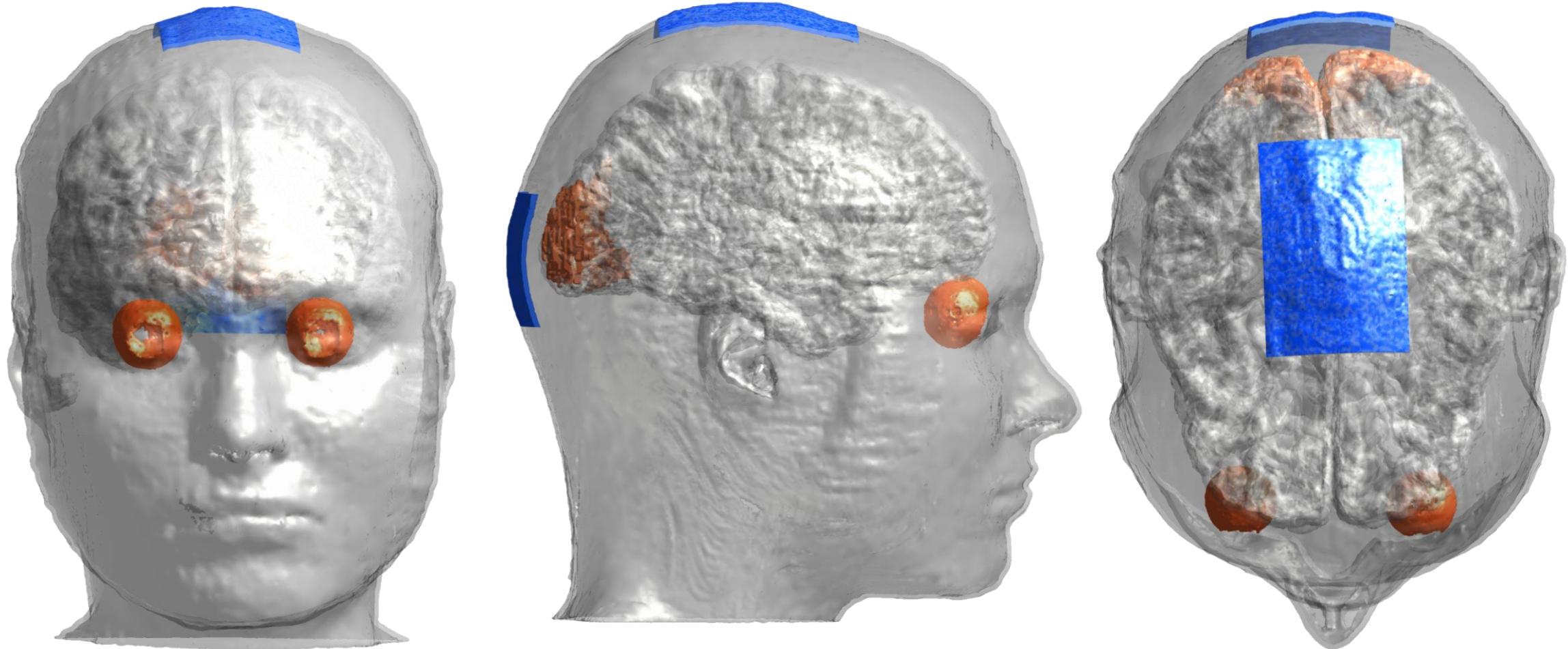


2 configurations and 2 targets

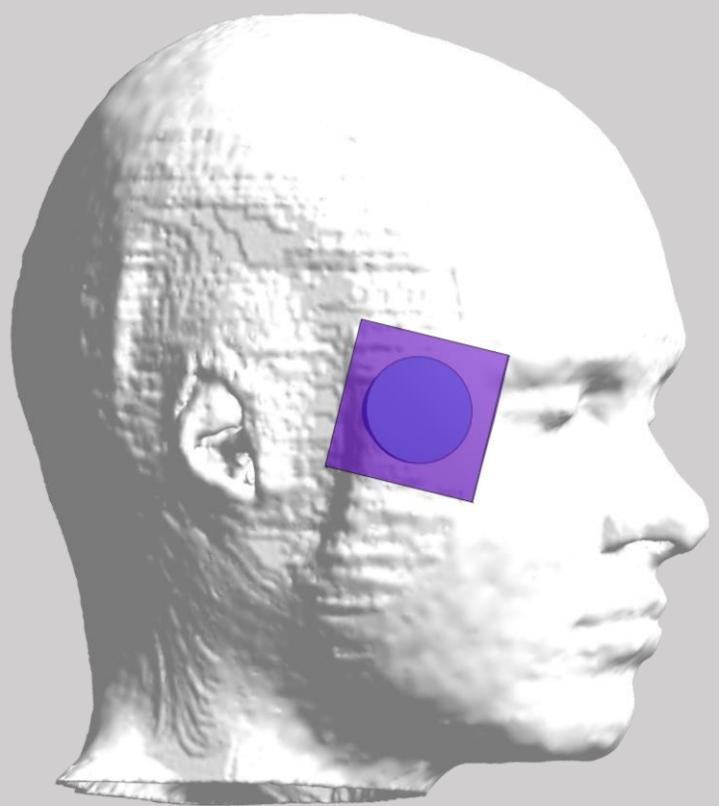
Retina configuration (another view)



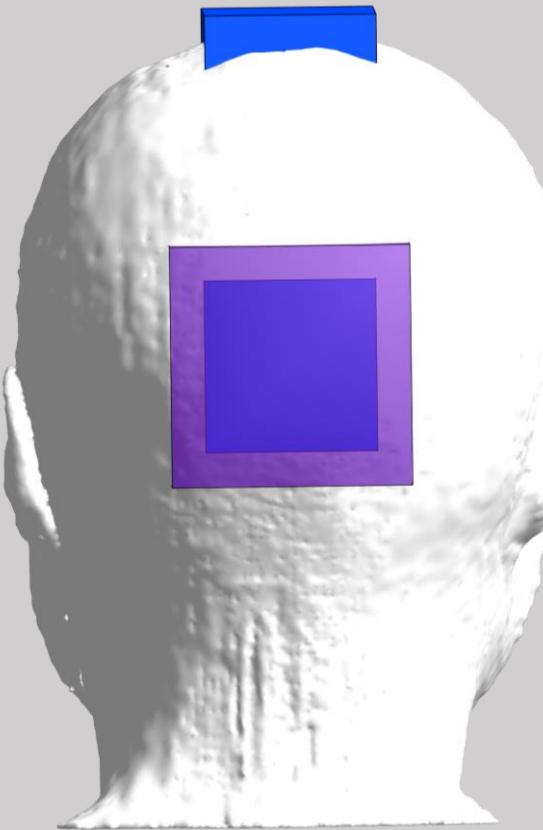
V1 configuration (another view)



Sensors around electrodes



Configuration
For retina – F9 and F10



Configuration
For V1 – Oz and Cz

Sensor flux resolution:
1 mm - 0.00354
0.75 mm - 0.00354
0.5 mm - 0.00354

Conclusion: 1mm resolution is enough

Simulations

Grid 0.4 mm for retina:

Head – 0.5 mm
Retina – 0.4 mm
Electrodes – 0.5 mm
Sensors – 0.75 mm

Overall: 82 MCells (50 minutes)
Check convergence

See additional slides for results



Grid 0.3 mm for retina:

Head – 0.5 mm
Retina – 0.3 mm
Electrodes – 0.5 mm
Sensors – 0.75 mm

Overall: 109 MCells (Already takes more than 25% of RAM – because of 6 masks, and they are important)

**THIS RESOLUTION
WAS CHOSEN FOR
PAPER**

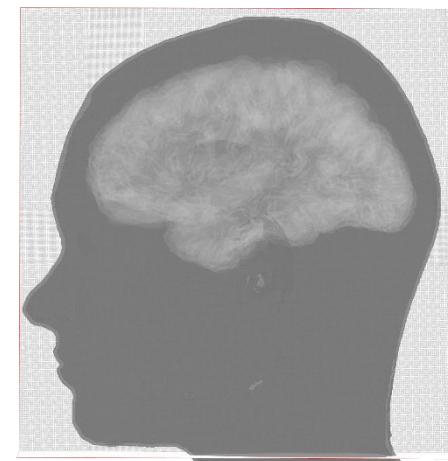


Grid 0.2 mm for retina:

Head – 0.5 mm
Retina – 0.2 mm
Electrodes – 0.5 mm
Sensors – 0.75 mm

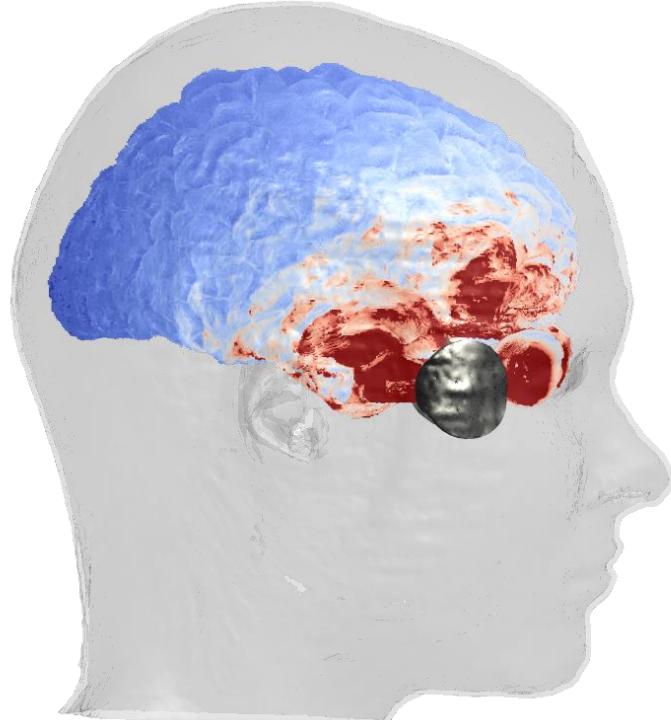
Overall: 174 MCells (? Minute, too much RAM)

Grid figure



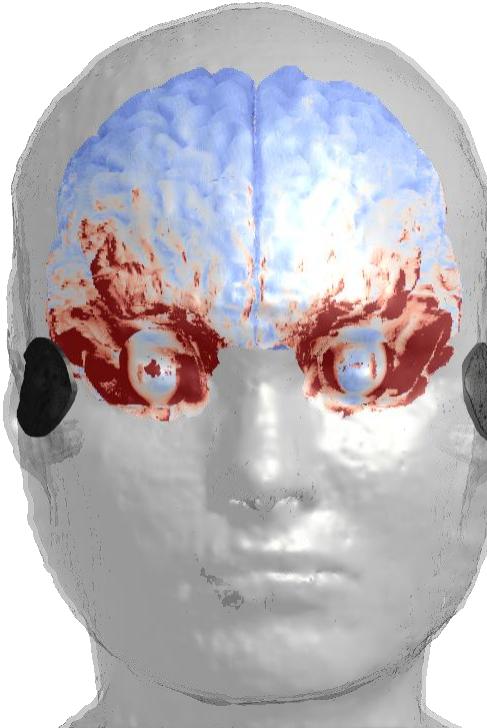
Stimulation: 0.2 mA peak-to-baseline

F9 and F10 (retina 0.3mm)

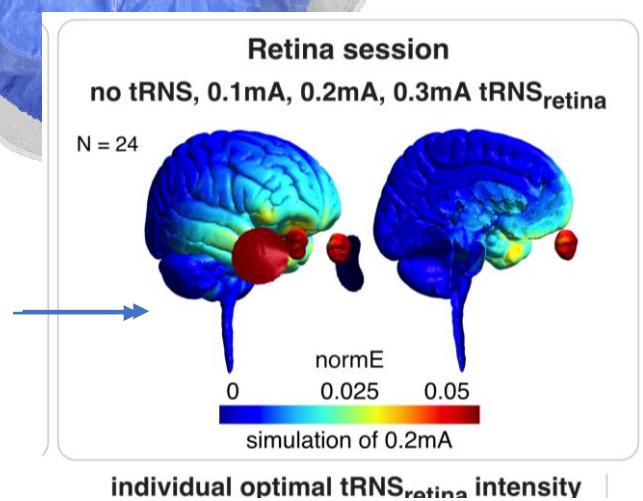
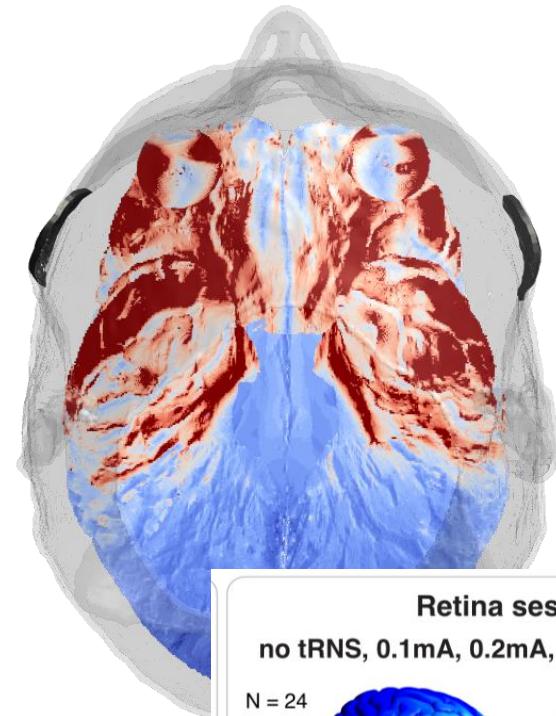


0 0.05 V/m

Absolute magnitude, **same resolution** as in SimNibs

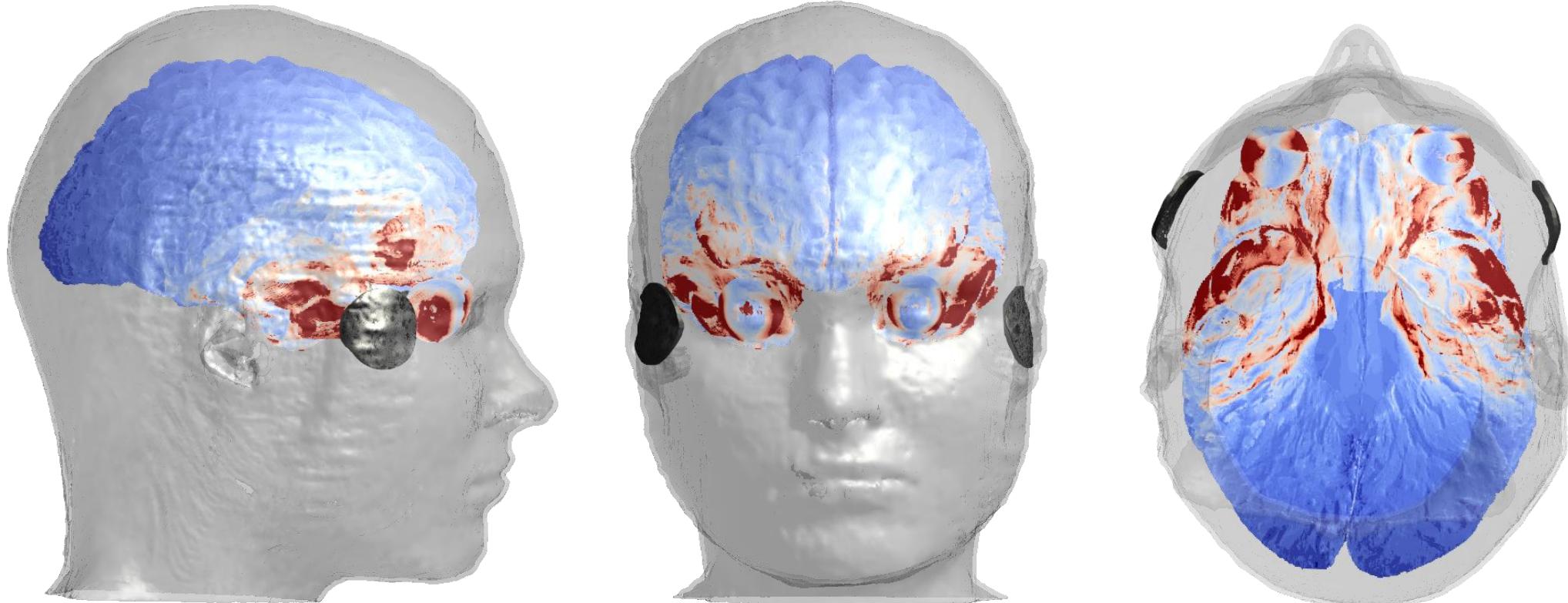


SimNibs simulation



Stimulation: 0.2 mA peak-to-baseline

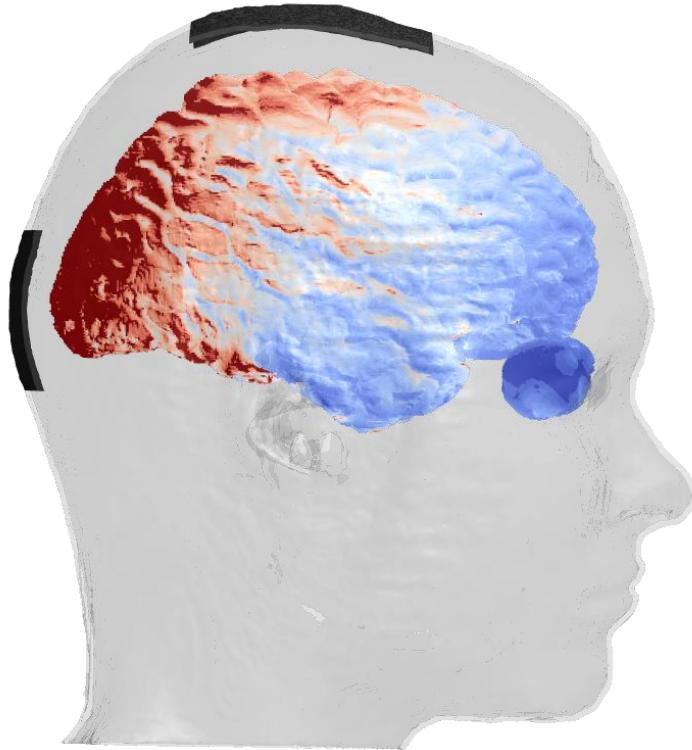
F9 and F10 (retina 0.3mm)



Absolute magnitude, **different scale** from SimNIBs

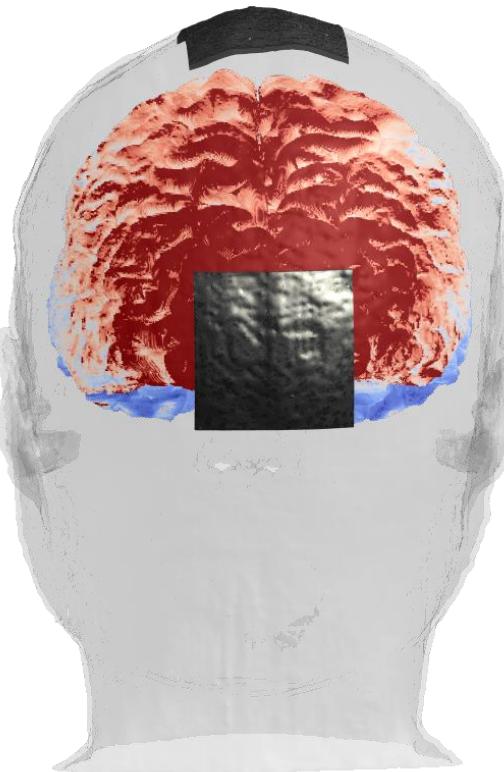
Stimulation: 1 mA peak-to-baseline

Oz and Cz (retina 0.3mm)

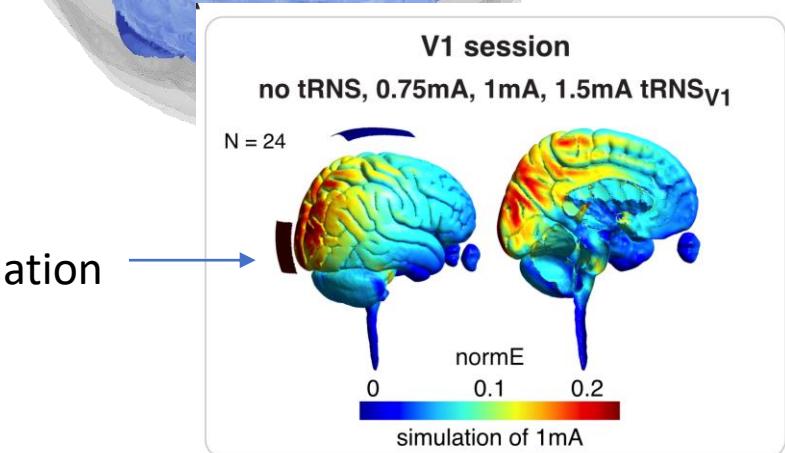


0 0.2 V/m

Absolute magnitude, **same scale** as in SimNibs

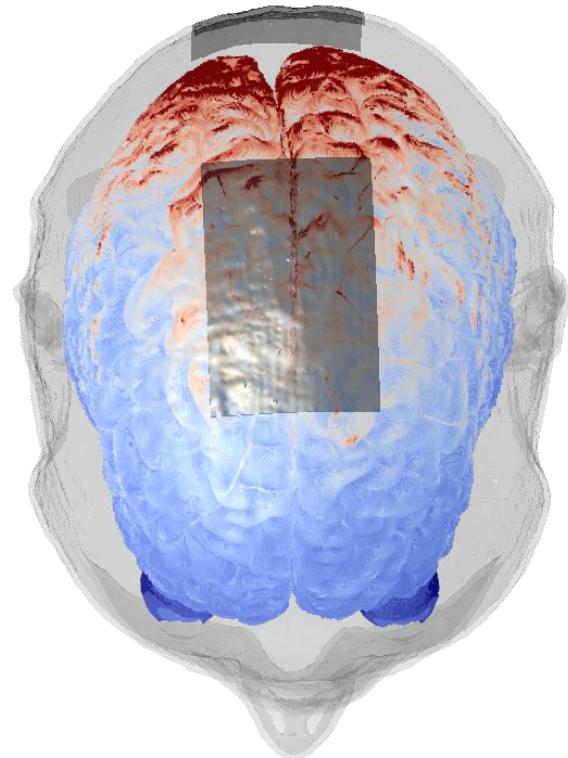
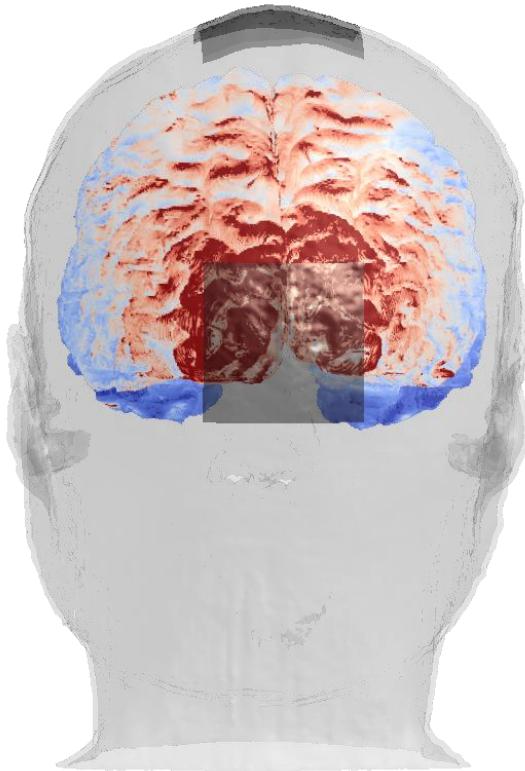
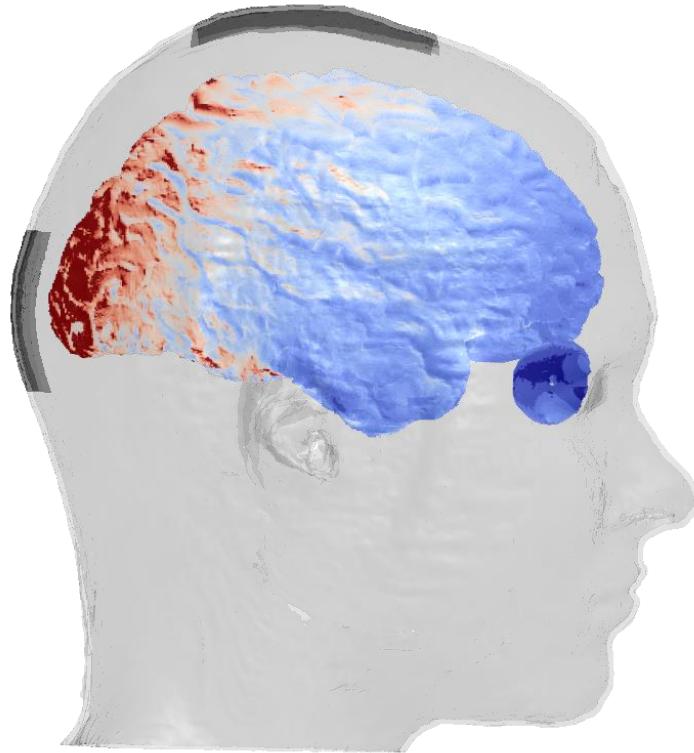


SimNibs simulation



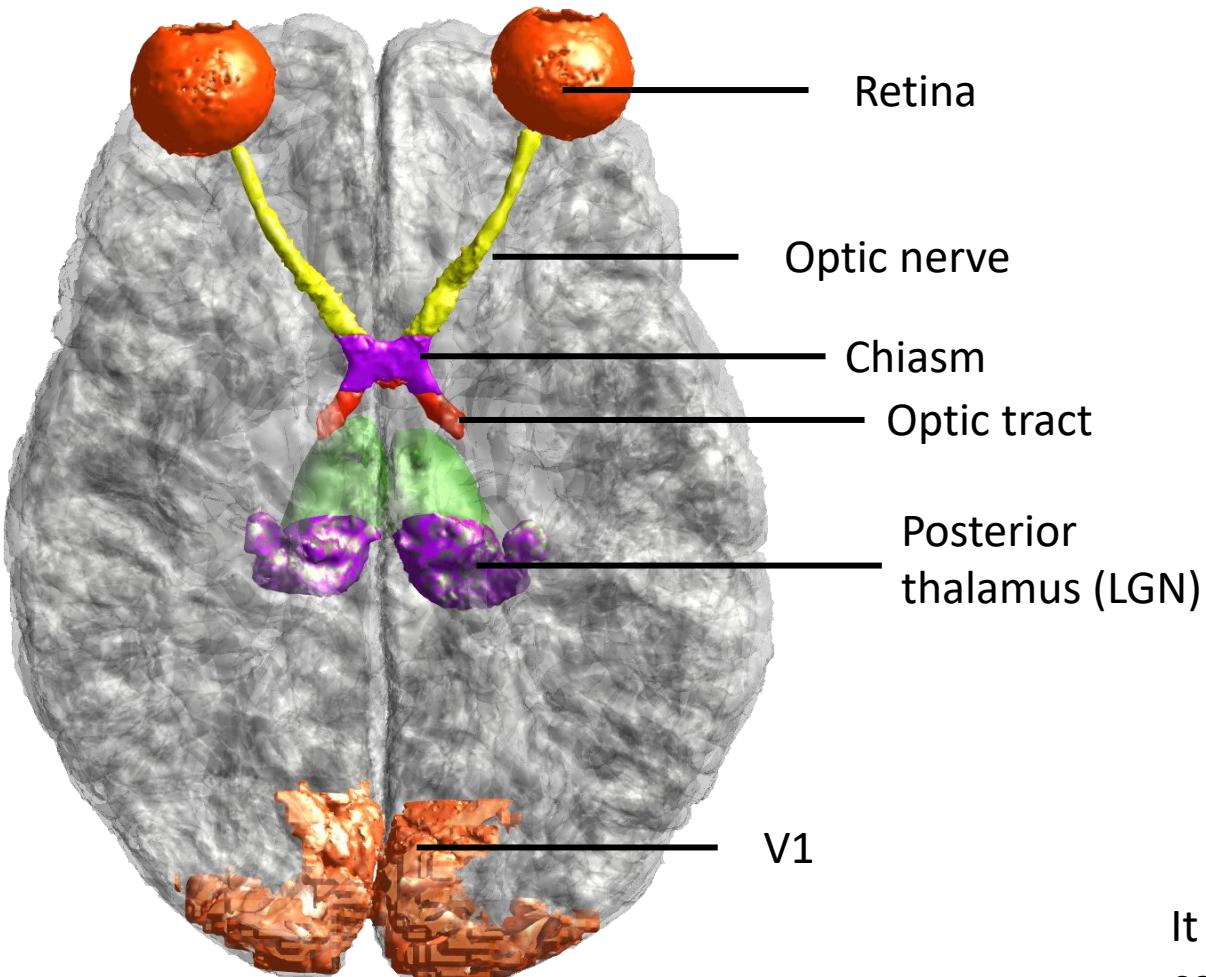
Stimulation: 1 mA peak-to-baseline

Oz and Cz (retina 0.3mm)

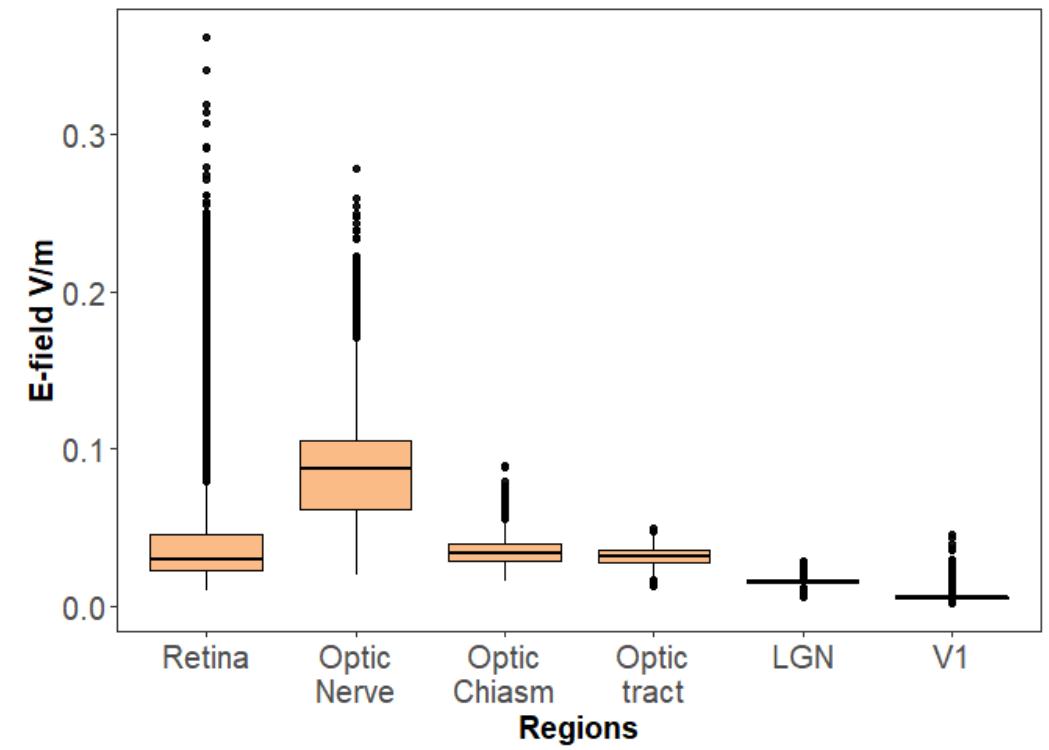


Absolute magnitude, **different scale** from SimNIBs

Visual system

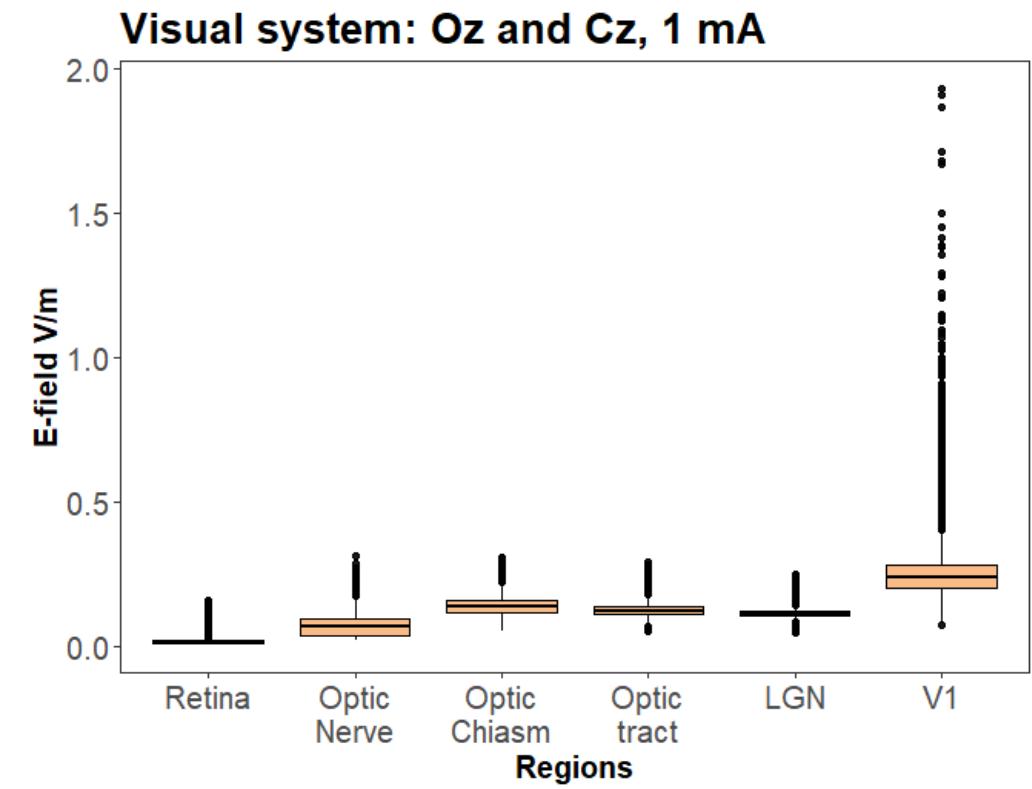
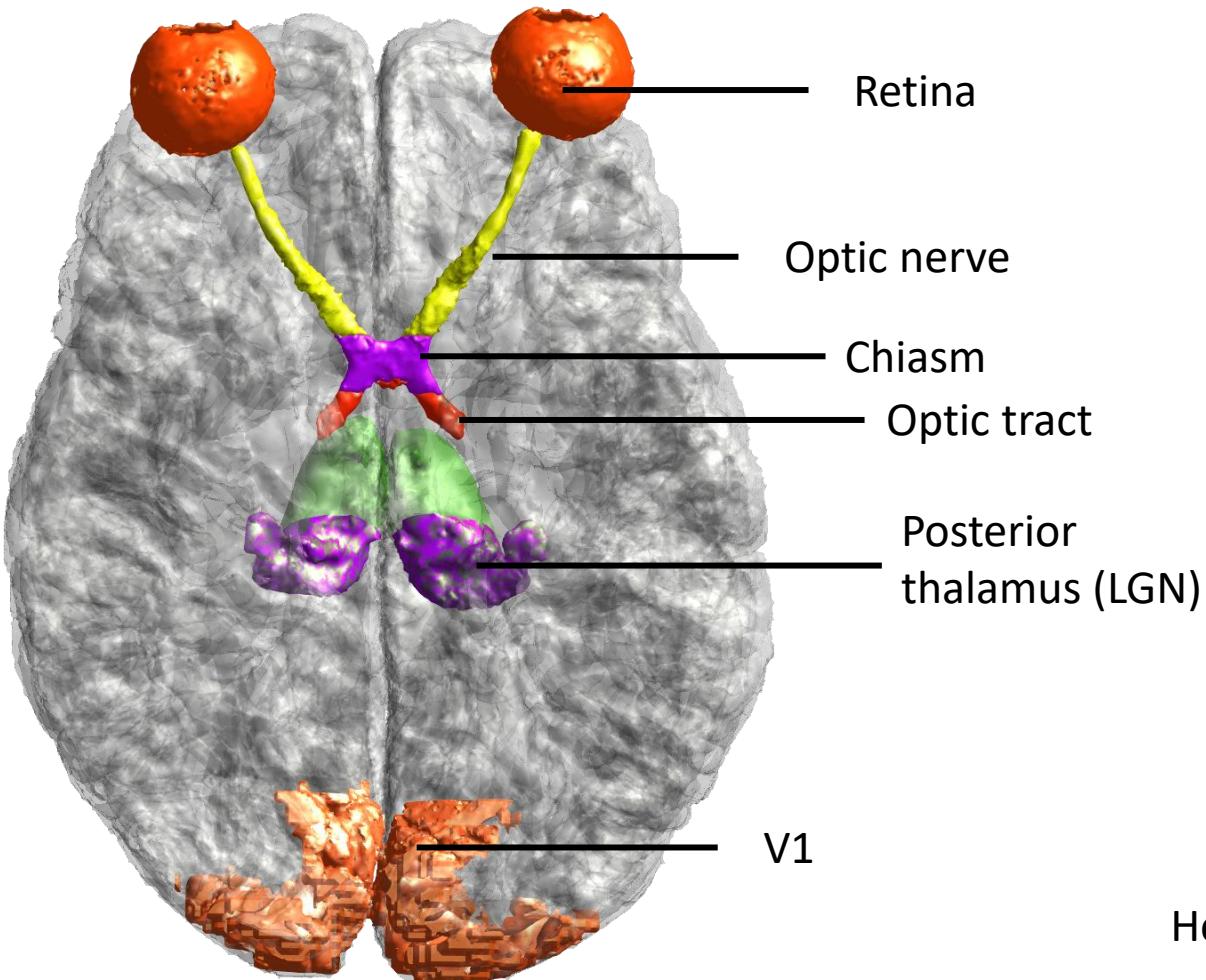


Visual system: F9 and F10, 0.2 mA



It seems that stimulation side-effects (e.g., phosphene) could be present due to **optic nerve** stimulation

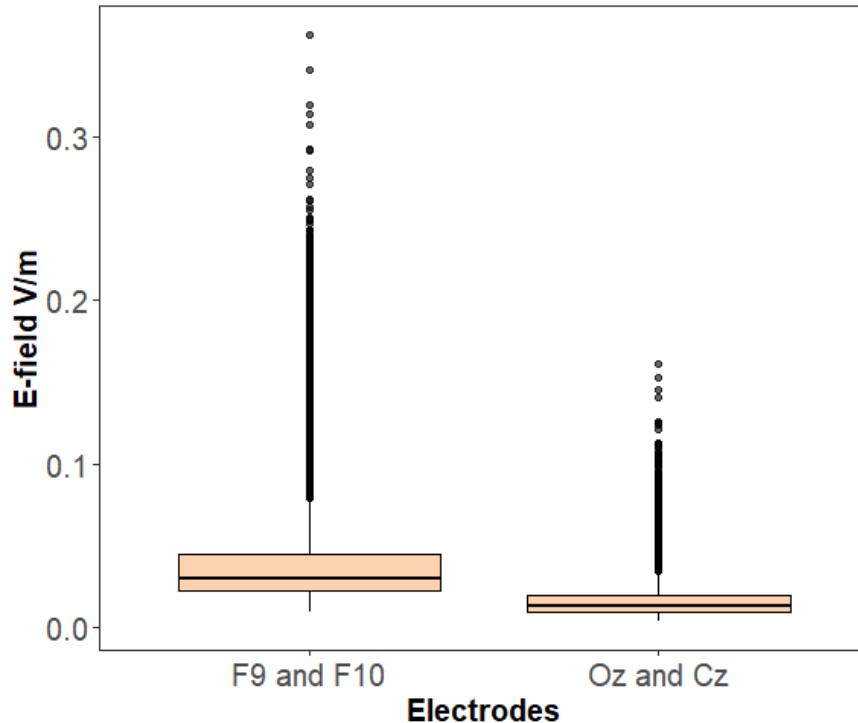
Visual system



Here, main stimulation is present in V1

Retina stimulation

Retina: F9 and F10 0.2 mA, Oz and Cz 1 mA

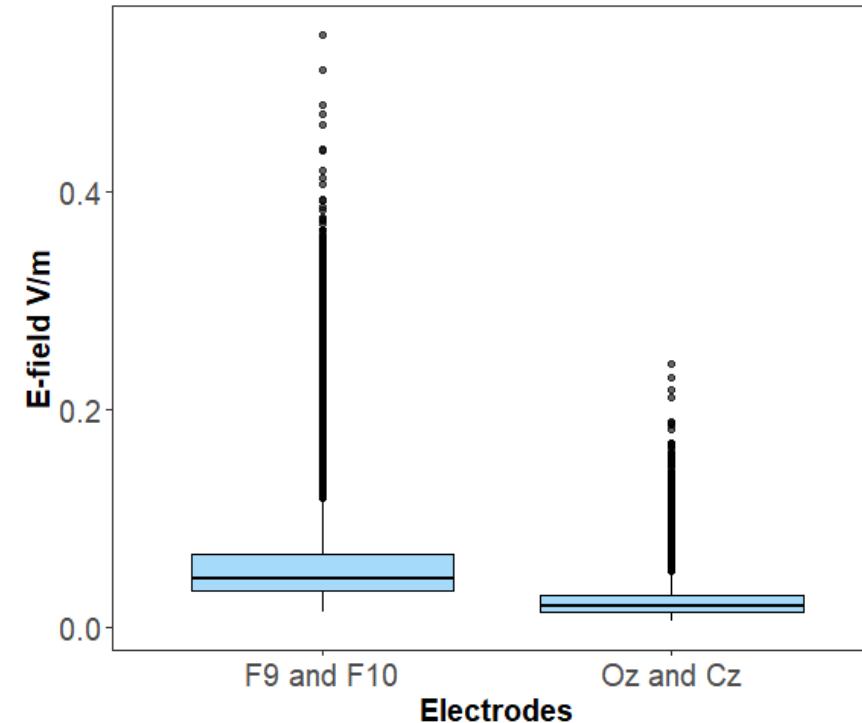


Medium stimulation (mean \pm sd):

F9 and F10: 0.04 ± 0.03

Oz and Cz: 0.016 ± 0.01

Retina: F9 and F10 0.3 mA, Oz and Cz 1.5 mA

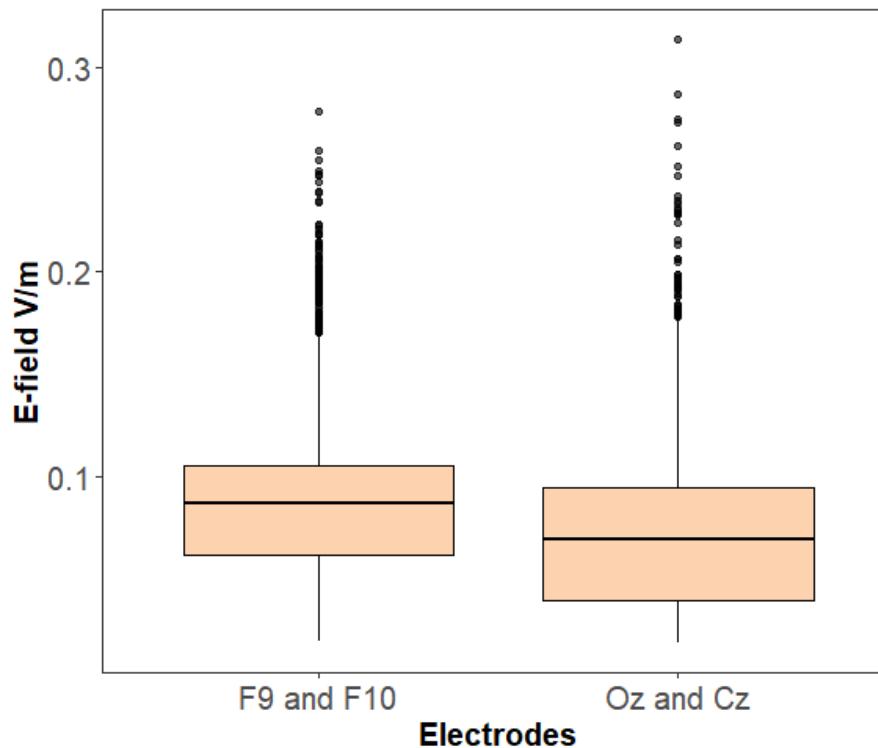


Conclusion:

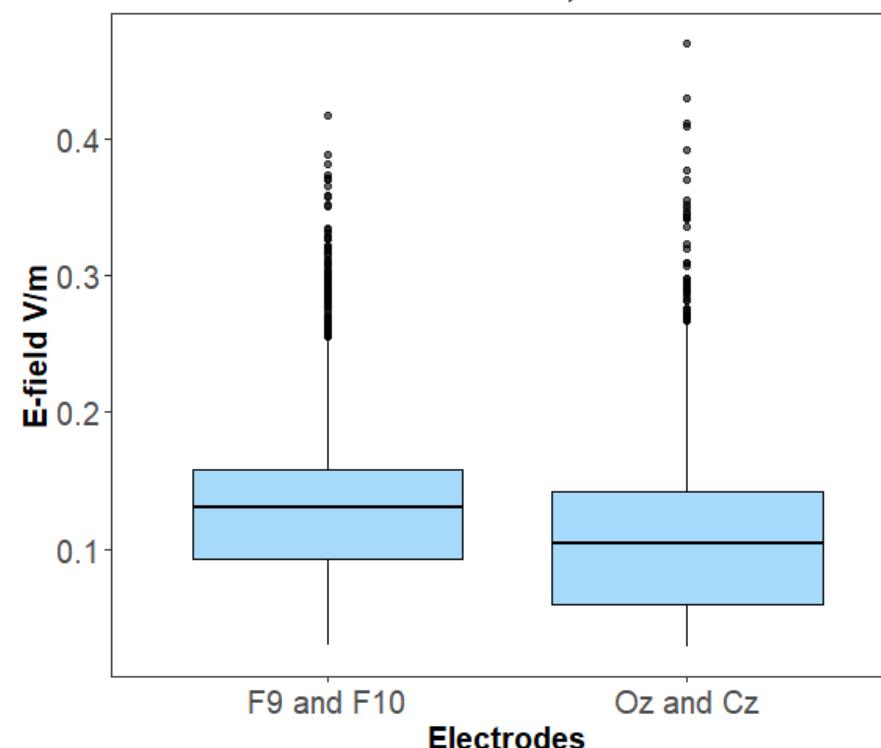
Retina stimulation is higher under F9 and F10 configuration

Optic nerve stimulation*

Nerve: F9 and F10 0.2 mA, Oz and Cz 1 mA



Nerve: F9 and F10 0.3 mA, Oz and Cz 1.5 mA



Conclusion:
There is a larger difference in retina stimulation than in optic nerve between 2 configurations

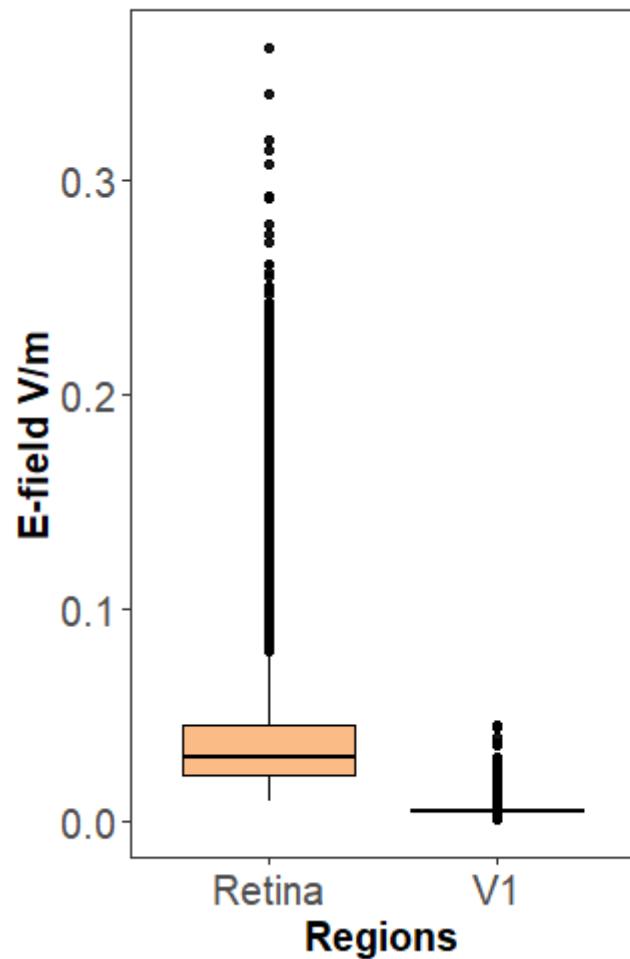
Medium stimulation (mean \pm sd):
F9 and F10: 0.09 ± 0.03
Oz and Cz: 0.07 ± 0.03

Maximum stimulation:
F9 and F10: 0.13 ± 0.05
Oz and Cz: 0.11 ± 0.05

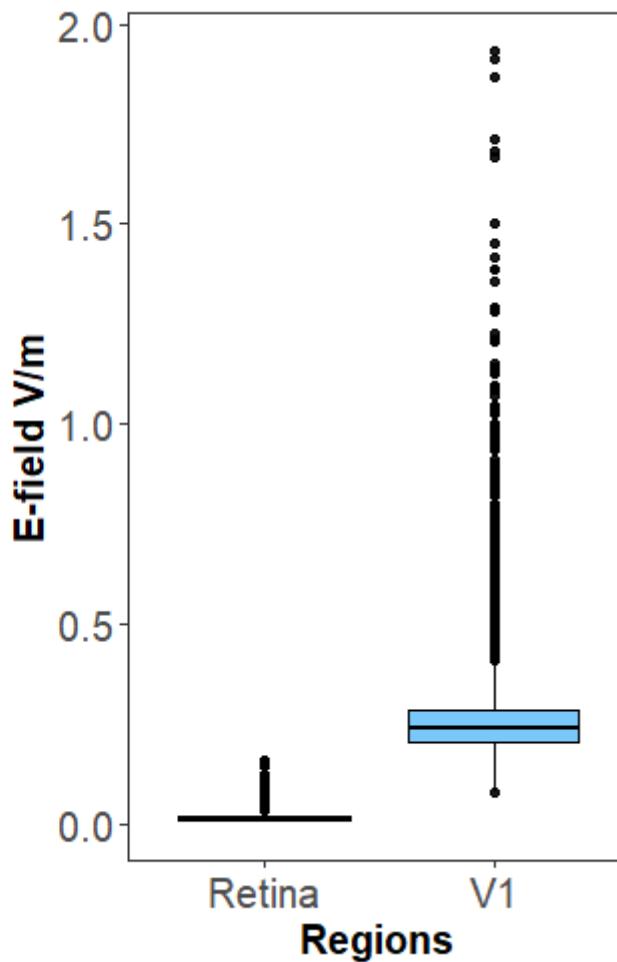
* It seems that optic nerve stimulation was higher than retina

Main targets

F9 and F10 0.2 mA



Oz and Cz 1 mA



Conclusion:

Stimulation is concentrated on its targets as intended.

F9 and F10:

Retina: 0.04 ± 0.03
V1: 0.005 ± 0.001

Oz and Cz:

Retina: 0.02 ± 0.01
V1: 0.25 ± 0.06

To stimulate retina with the same intensity as V1 – current should be 1.25 mA
($0.25 * 0.2 / 0.04$) on F9 and F10 or 6.25 times higher than 0.2 mA

Table comparison

Configuration: **Oz and Cz** (*mean* \pm *sd*)

Mask	E-field 0.75 mA	E-field 1 mA	E-field 1.5 mA
Optic Chiasm	0.1+-0.02	0.14+-0.03	0.21+-0.05
LGN	0.09+-0.01	0.11+-0.01	0.17+-0.02
Optic Nerve	0.05+-0.02	0.07+-0.03	0.11+-0.05
Optic tract	0.1+-0.02	0.13+-0.03	0.19+-0.04
Retina	0.01+-0.01	0.02+-0.01	0.02+-0.01
V1	0.19+-0.05	0.25+-0.06	0.37+-0.09

Configuration: **F9 and F10** (*mean* \pm *sd*)

Mask	E-field 0.1 mA	E-field 0.2 mA	E-field 0.3 mA
Optic Chiasm	0.02+-0	0.03+-0.01	0.05+-0.01
LGN	0.01+-0	0.02+-0	0.02+-0
Optic Nerve	0.04+-0.02	0.09+-0.03	0.13+-0.05
Optic tract	0.02+-0	0.03+-0.01	0.05+-0.01
Retina	0.02+-0.01	0.04+-0.03	0.06+-0.04
V1	0+-0	0.01+-0	0.01+-0

Analysis path:

C:\Users\vbeliaev\Documents\TI_fMRI\Modelling\Weronika_paper_v1\fields_ret0.3mm_nonan