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Baptiste Ristagno, Julien Fontchastagner

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Development of numerical dosimetry for low-frequency induced fields in human head models

Baptiste RISTAGNO

Institut National de Recherche et de Sécurité, EVO,
Vandœuvre-lès-Nancy, France

Julien FONTCHASTAGNER

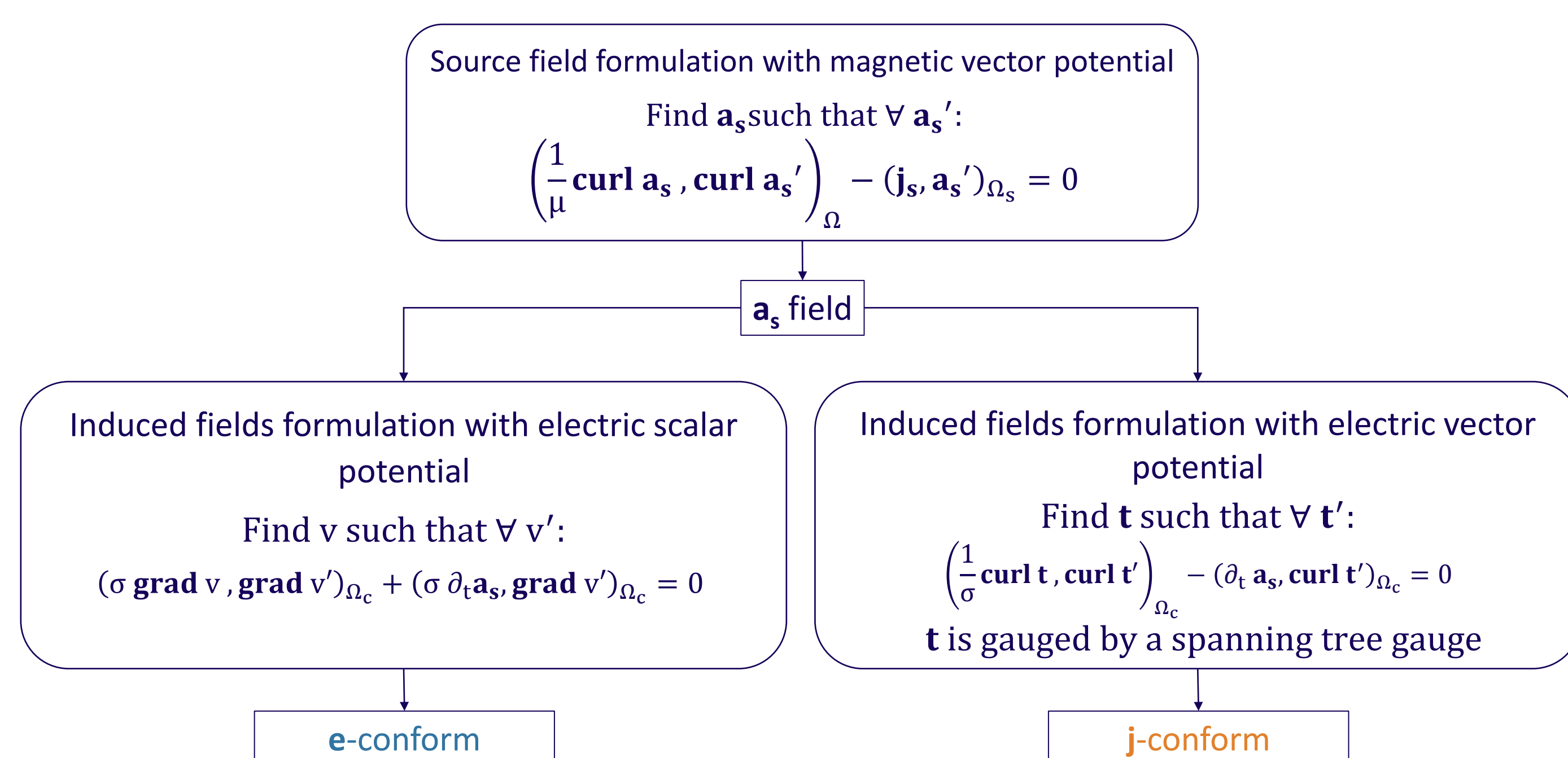
Université de Lorraine, GREEN,
Nancy, France

Introduction

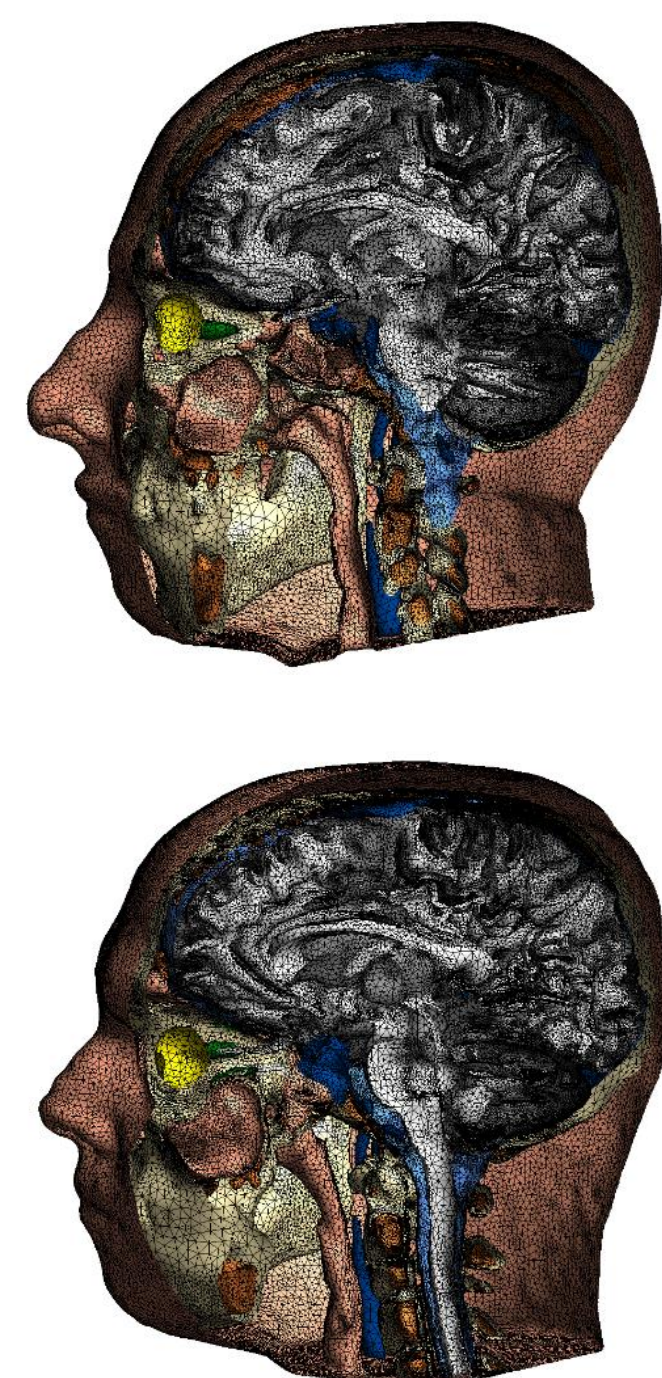
- Low-frequency (LF) magnetic fields as found in industrial sources can **induce electric fields in the human body**, raising health and safety concerns.
- Direct measurement is obviously not feasible, so numerical dosimetry using **computational models** is employed.
- The finite element method (FEM) is especially suitable for modeling **complex human anatomy** and electromagnetic interactions.
- The aim is to compute the electric field induced in a human head when it is exposed to a low-frequency magnetic field, considering **the head as a low conductive medium**.

Methods

- Finite element simulations are conducted using the free and open-source **ONELAB software**, which incorporates the mesh generator **Gmsh** and the finite element solver **GetDP**.
- The simulations use the **magnetic vector potential as source field**, which is easily computed from current density and source geometry. Any geometry can therefore be taken into account.

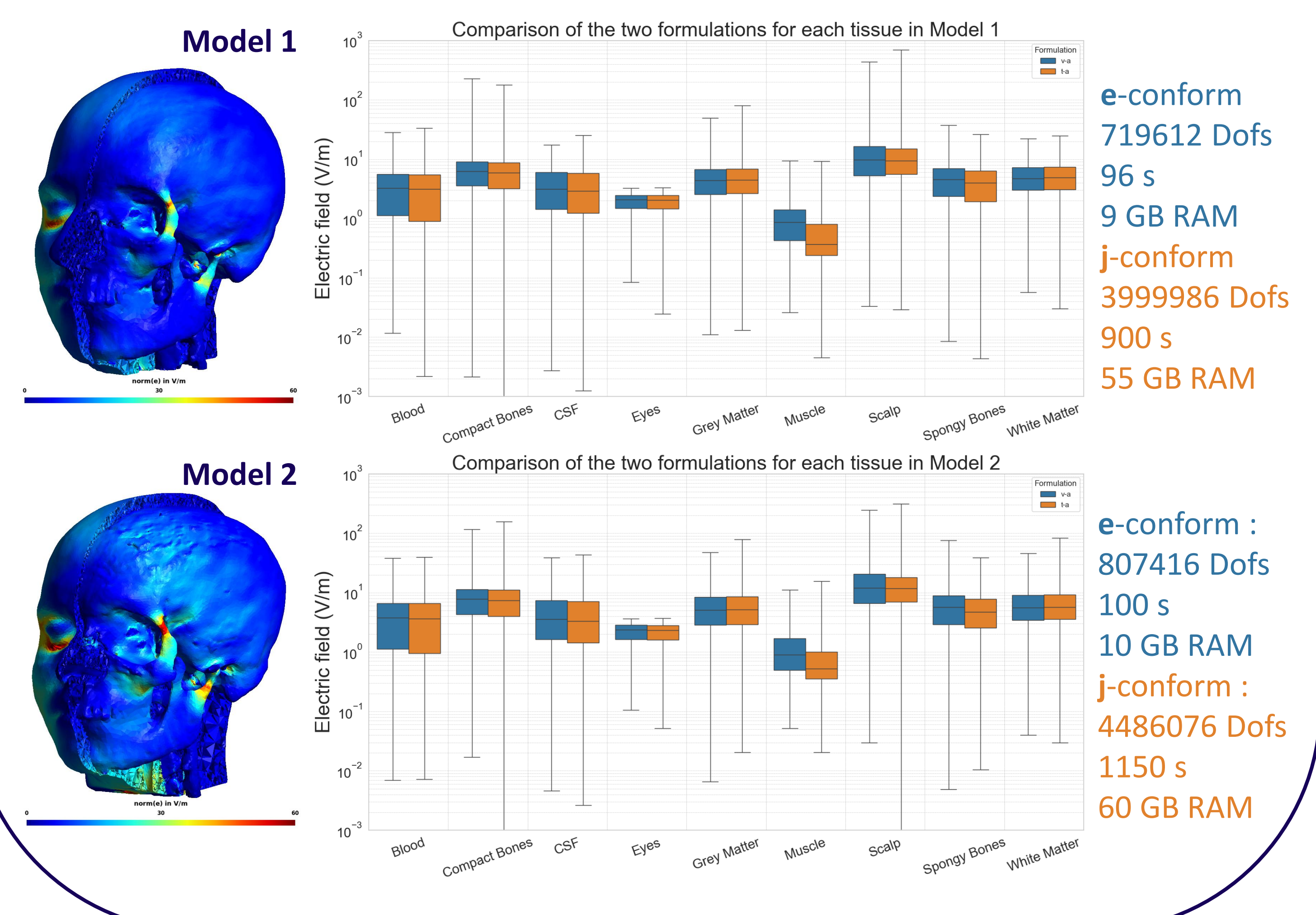
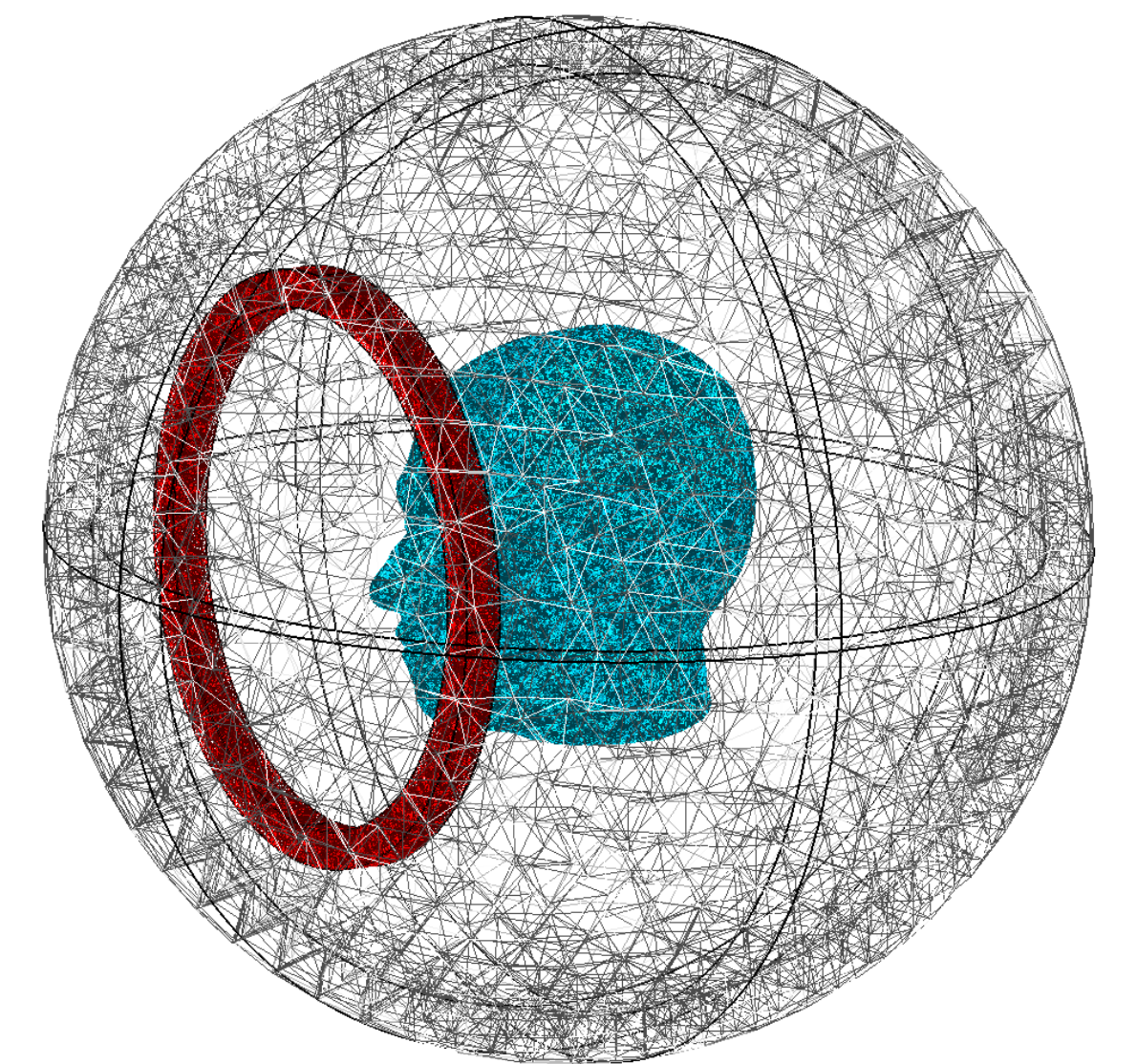


- The **charm** process from **SimNIBS** software is used to **segment T1w and T2w MRI images to generate head mesh**.
- **IXI dataset** provides public MRI datasets : around 600 T1w and T2w images from healthy subjects.
- Mesh generation takes over an hour on a system with 32GB RAM and 16 threads.
- Electrical conductivity values come from the **IT'IS foundation** database.



Results

- The test case involves a **human head exposed to the magnetic field generated by a coil**. The source field is first computed in free space without the head using a **coarse mesh**. This field is then interpolated and **projected onto the fine mesh** of the head model.
- The **electric field is computed using both formulations**. The resulting distributions are presented below for each physical region.
- Simulations were carried out on AMD Ryzen Threadripper PRO 7975WX 32-cores (64 threads) 4 GHz and 256 GB RAM.



Discussion & future work

- Box plot analysis suggests **similar results between both formulations**, which is encouraging.
- More robust **statistical methods** are needed for rigorous dataset comparison, as finite element meshes tend to overweight problematic regions, complicating statistical interpretation.
- Suitable **smoothing algorithms** or alternative data representations should be considered.
- Then **additional formulations** will be investigated, specifically direct field-based formulations.
- Finally, **new meshes obtained from MRI segmentation** will enable **inter-subject comparisons** and statistical analyses.