Motivation

- Localization of dipole in human brain
- Data from EEG/MEG measurement
- Application example:
  - Presurgical epilepsy diagnosis
  - Reconstruction by NeuroFEM

ParExPDE

- C++ library for Finite Element solvers of PDE
- User-friendly and easy to use interface
- Efficient code by Expression Templates
- Regularly refined hexahedral grids
- Capability for high-performance computing
e.g. parallelism with MPI

Task

- Integration of a Full-Multigrid solver into NeuroFEM
  - Initialization procedure:
    - Build a structured volume grid from the original unstructured grid
    - Construct the local stiffness matrix with insulating air layer
    - Initialize all multi-grid levels
  - Solving procedure:
    - Initialize the solution
    - Get the right hand side
    - Solve the equation system
    - Store the result back to NeuroFEM
  - Minimizing the bounding box:
    - e.g. for original grid with 94 cells, use 96 ($=1.5\times2^6$) instead of 128 ($=2^7$) cells

Results & Conclusion

- Comparison with AMG-CG
  - Faster setup time
  - Less memory consumption
  - Solving is slower than AMG-CG
  - Slow convergence with conductivity jumps

Performance of FMG (using Gauss-Seidel smoother) and AMG-CG

<table>
<thead>
<tr>
<th>Memory (MB)</th>
<th>Setup Time (s)</th>
<th>Runtime (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMG-CG</td>
<td>1147</td>
<td>54.59</td>
</tr>
<tr>
<td>FMG</td>
<td>885</td>
<td>23.27</td>
</tr>
</tbody>
</table>

Test case:

- Resolution of 2mm
- Cube discretized into 94 x 94 x 94 cells
- A ball with a dipole at the center
- Four layers with different conductivities

Electric potential (red marks AMG-CG, green marks FMG) in x-y planes at different z-positions.
Differing results for AMG and FMG due to different boundary conditions and insulating layer.