Figure 3 : HPC Idris CNRS

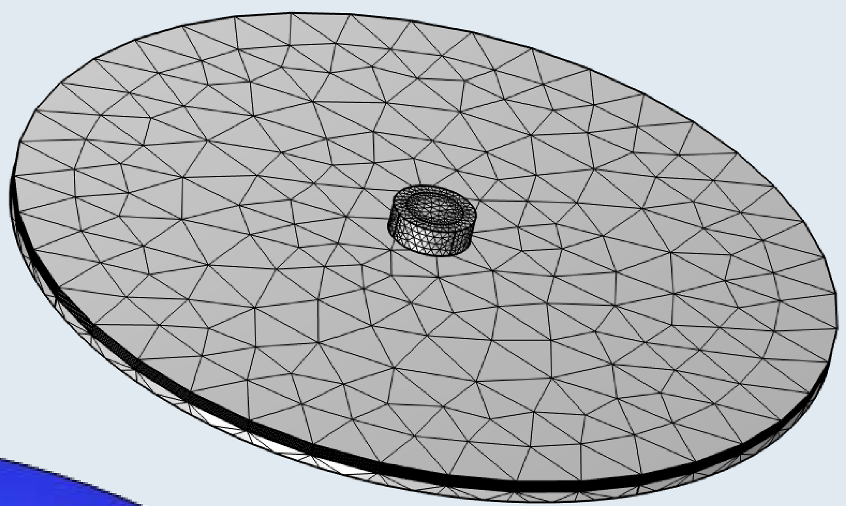

Figure 1 : EC-NDT Problem (Benchmark geomtry)

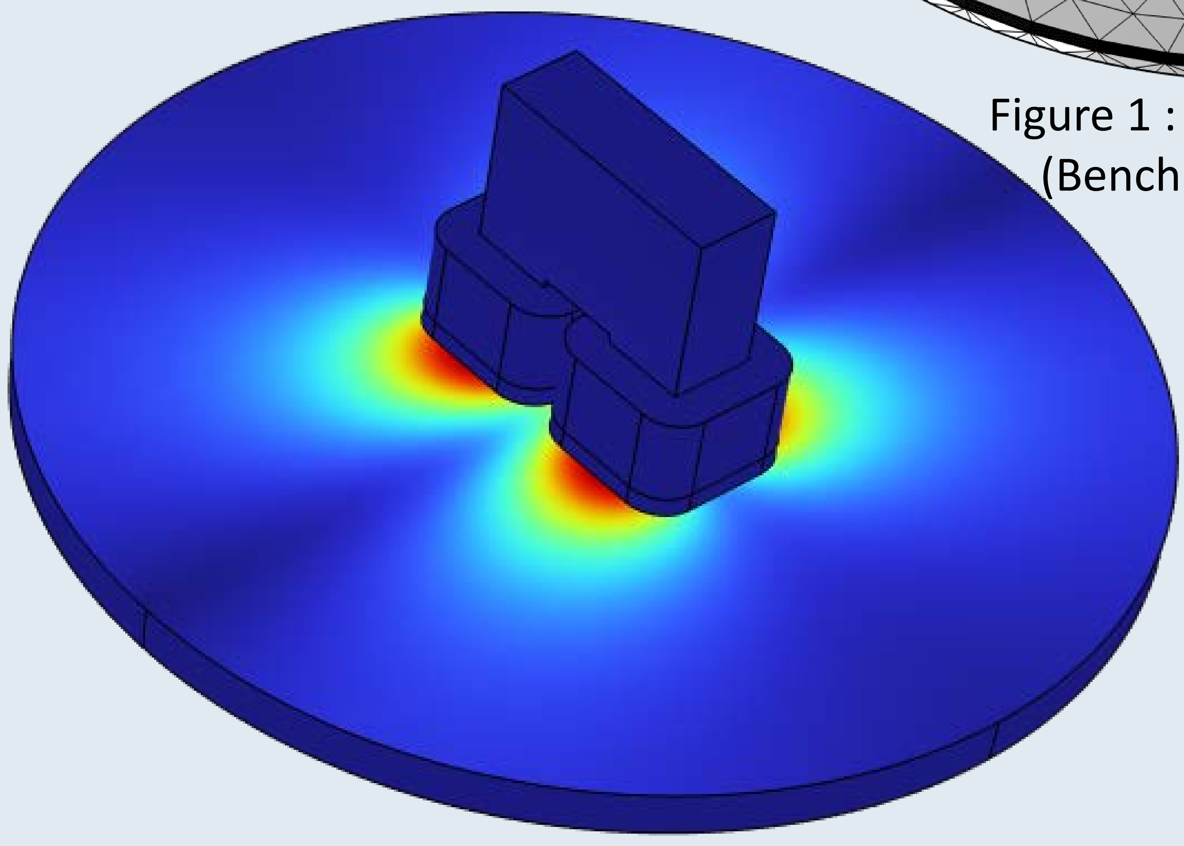

Figure 2 : EC-NDT Problem (Stress Chracterization)

Evaluation of Different Parallelization Strategies on a Cluster for parametric sweep in EC_NDT

This work deals with the scalability on a cluster of a parametric swept for non-destructive eddy current testing problem.

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Abstract

Our study concerns the identification of 2D mechanical stresses in ferromagnetic materials using an eddy current non destructive testing (EC-NDT) method. The inversion problem consists in identifying the results of impedance measurements on maps obtained by numerical simulation. COMSOL Multiphysics® will enable us to generate these impedance maps as a function of the stress state along x and y and the orientation of the sensor in this plane. It has been established that for ferromagnetic materials, the magnetic permeability of the magnetic field also depends on the stress state. To take account of this magneto-elastic behavior, a multi-scale model is used. For each state of mechanical stress in XY, this model returns a permeability tensor for the material, which is then entered into the software. Our numerical model consists in a 3D magnetodynamic frequency (AC/DC Module - MF model). To generate Impedance maps, parameter swept process is used. That means that the same model is running for different samples of permeability tensors. To speedup the computation, parametric swept is running on Ruche Cluster of computing center of Paris-Saclay.

METHODOLOGY

```
#!/bin/bash
# slurmsubmit.sh

#SBATCH --nodes=1
#SBATCH --ntasks-per-node=10
#SBATCH --cpus-per-task=2

#SBATCH --mem=90G
#SBATCH --time=1:35:00

#SBATCH --job-name=comsol_bench_aircoil_finemesh
#SBATCH --partition=mem

module load comsol/6.1/intel-20.0.4.304

comsol batch -nn 10 -np 2  -inputfile  mymodel_Ruche.mph
 -outputfile mymresults_Ruche.mph
 -batchlog refnn10np2finemesh.log
 -tmpdir /gpfs/workdir/mylocaldir/tmpcomsol
```

Figure 4 : Slurm job shell

Two ways

1- Open process

Number of cores use for one sample finite element resolution

Cpu-per task (slurm)
np COMSOL Multiphysics

2- MPI process

Number of samples running simultaneously

ntasks-per-node (slurm)
nn COMSOL Multiphysics

- Evaluation of the scalability on a typical problem with a analytical solution
  - Air-coil on a ferroplate (figure 1)
  - Parameter swept with 20 identical parameters
  - Two meshes :
    - Normal mesh : about 190 000 degrees of freedom (1 parameter) 54s
    - Fine mesh : about 1 000 000 degrees of freedom
- Evaluation on the real case : our EC- NDT Characterization (about 400 000 dofs, 20 parameters) (figure 2)

The **speedup** is defined as the ratio between the execution time using several cores and the execution time using one core

Air coil case

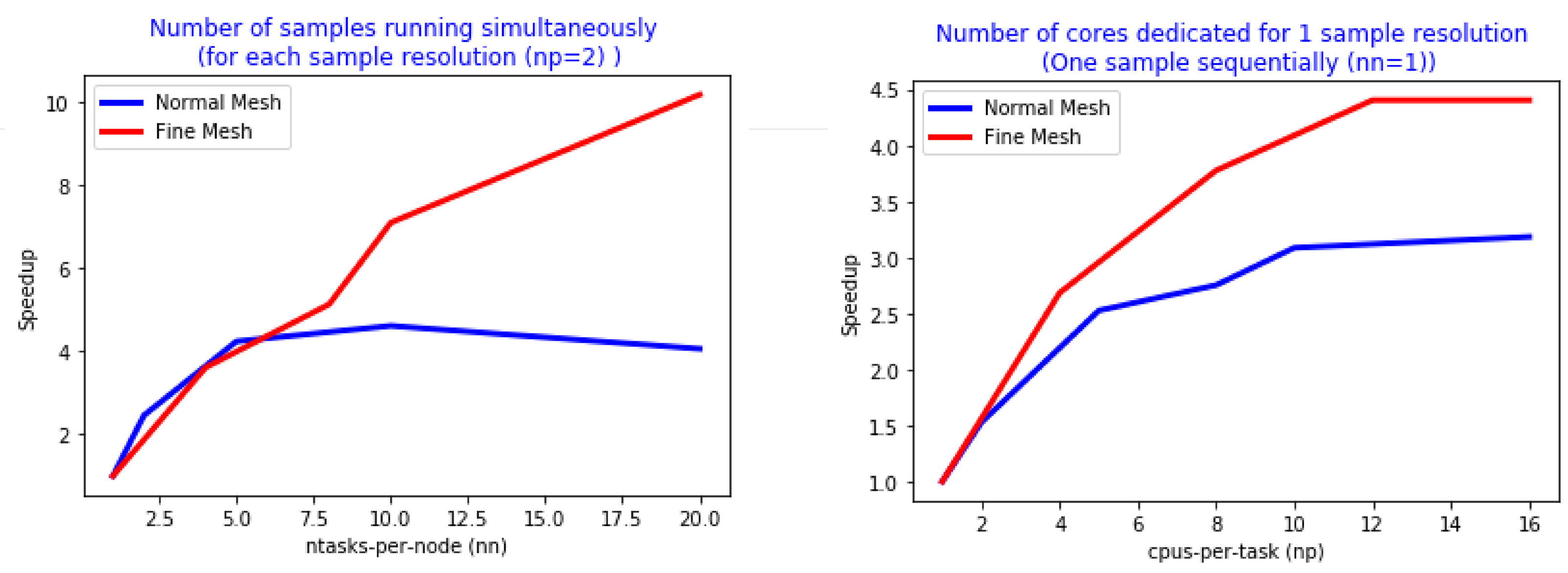

Figure 5 : Speedup evolution

Left : MPI process varying - - Right : OPENPMP process varying

EC- NDT Characterization case

nn	1	8	8	1	10
np	1	4	1	4	4
Speedup	1	7.75	4.1	3	7.75

Tab 1: gain for the real case

Results

- Figure 5 left shows that the gain is important at the beginning and next a threshold is observed for the small problem.
- Figure 5 right shows that for each FEM resolution a optimal number of cores is reached which depends also of the problem size
  - ➢ This confirms that parallelization is most effective for large-scale problems. This is partly explained by the processing time for the fork and join process.
- A gain of the same order of magnitude is observed for the real case (Tab 1), but in this case this gain may also be affected by the convergence of the linear system, which may vary from one set of parameters to another.

REFERENCES

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