code_aster

Towards massive parallelism

Massive parallelism: the genesis

- **Fundamental changes in the mind and functioning of code_aster**

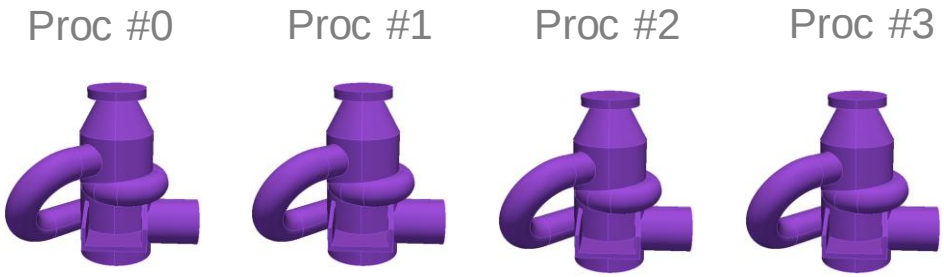
- **From a simple question**
  - Modification of machines and uses
  - Is it possible to transform code_aster into HPC code?

- **Answer**

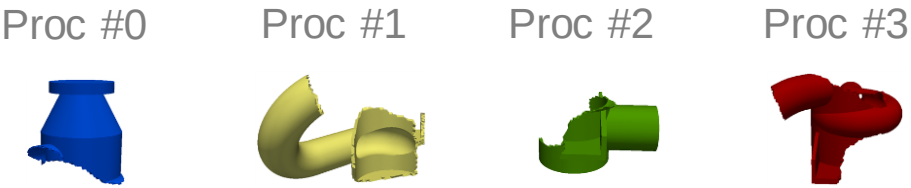
YES!!

Massive parallelism: the solution

- **Initial problem: memory consumption**
- **Domain Cutting**
  - code_aster parallelism today



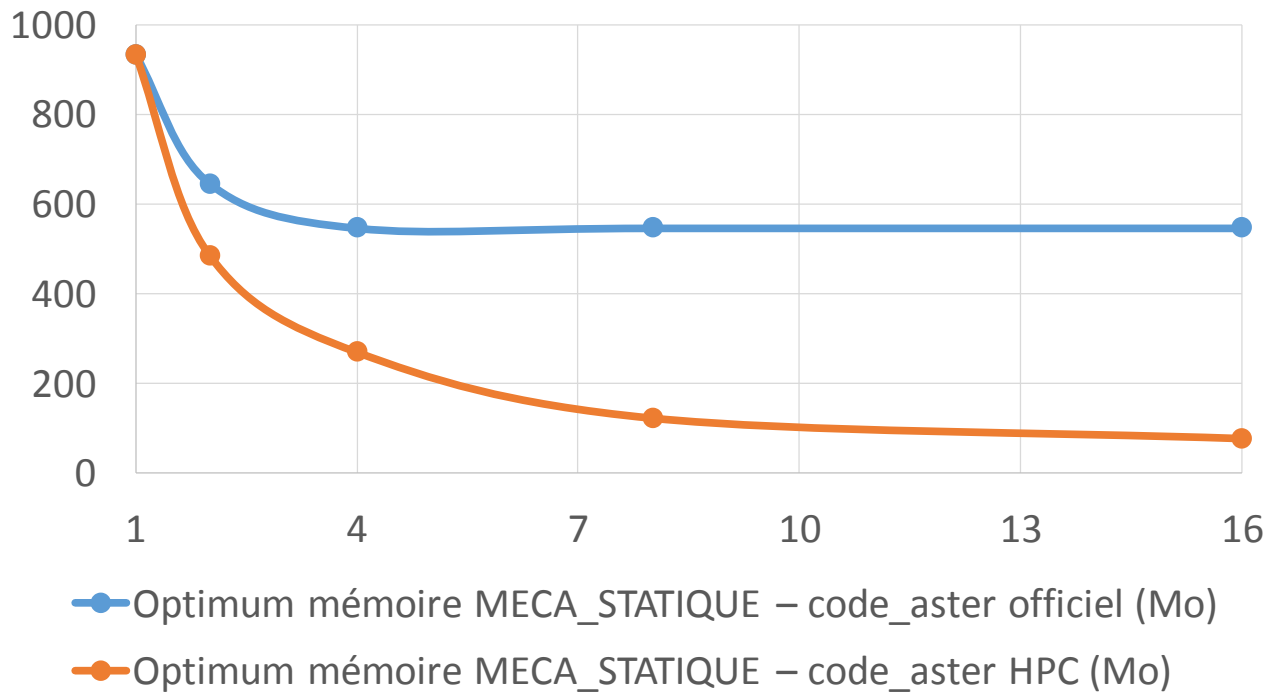
  - code_aster HPC



    - => Reconstruction of a global problem

Massive parallelism: the results (1/3)

- **First results, demonstration of interest**
  - Academic test comparison with code_aster “legacy”



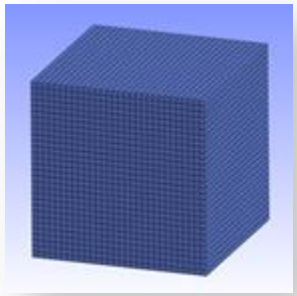
Cube elastic
~ 700 000 dof
On 16 procs

Massive parallelism: the results (2/3)

- **More ambitious**

Number of Dof	Number of procs	Solving time (s)
128 625 000	360	1 477
128 625 000	720	820
128 625 000	1 080	627

87% of parallel efficiency between 720 and 1080 processors



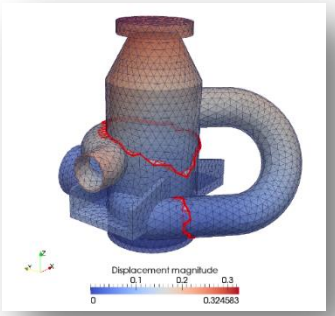
- Huge reduction of memory consumption and simulation times
- Enlarges the range of possibilities in terms of model size

Massive parallelism: the results (3/3)

- **Elasto-plastic computation (static and non-linear)**

Dof	Procs	Solving time (s)
5 547 411	1 080	56
41 051 928	1 080	257

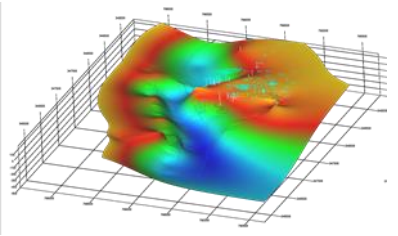
code_aster: **3 h 30 min**
code_aster HPC: **4 min**



- **Sedimentary basin calculation (linear dynamic)**

Dof	Procs	Solving time (s)
25 842 015	270	1.5
185 911 227	1 080	4.8

Extrapolation for 2000 time steps: **3 h**



Massive parallelism: the integration

- **Difficulty: each processor could think it is alone**
  - Data handling risk

- **Solution: add encapsulation**
  - Object oriented programming
  - Data access control

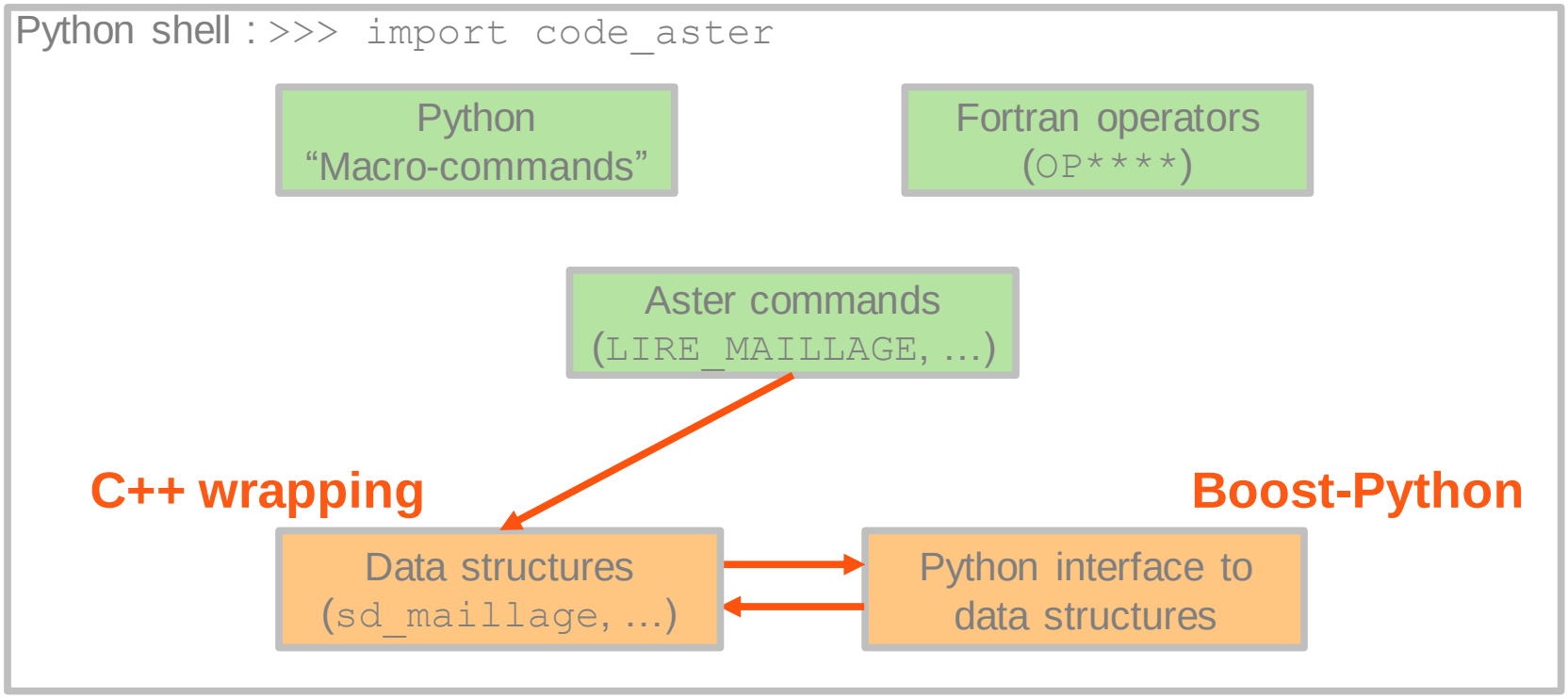
- **Fundamental change in architecture of code_aster**
  - Adding of a new programming language : **C++**
  - Replacement of the “aster supervisor” by Python supervision

Massive parallelism: the architecture

- **Imperative: preserve the existing**
  - 29 years of Fortran
  - 29 years of user habits (Aster syntax)

What doesn't change

What's new



Massive parallelism: the collaborative project (1/2)

- **Subsidized collaborative project**
  - EDF R&D
  - Public research institution : IFPEN
  - Academic partner : LMT Cachan, CERFACS
  - SME:
    - V&V: NECS
    - Interoperability and deployment: PhiMeca

- **Shared target:**

Develop and make available a more powerful and interoperable HPC version of code_aster

Massive parallelism: the collaborative project (2/2)

- **PAMSIM (PA**rallélisme **M**assif en **SI**mulation numérique pour la **M**écanique)
- **A 3-year project ending in late 2018**
- **Late 2018**
  - HPC version of code_aster
  - With same V&V as code_aster “legacy”
  - Deployed on external supercomputers

Massive parallelism: the consequences (1/2)

- **What changes for users?**
  - In practice

my_file.comm :

```
DEBUT();

# (…)

FIN();
```

my_file.py :

```
import code_aster

code_aster.init()

# (…)
```

- **No other changes to the command file**
  - The most transparent solution possible for the user

- **“Old-fashion” parallelism continues to exist**
  - The two modes co-exist

Massive parallelism: the consequences (2/2)

- **What changes for developers?**

- **New architecture designed to preserve habits**
  - Ease of change management

- **In the short term: nothing changes abruptly**

- **Progressively:**
  - The core team will develop in C++
  - Occasional developers will work in Python

Massive parallelism: the new things

- **The HPC, of course**
  - Linear and non-linear mechanical calculations
  - Always with the same license cost

- **New access to data structures (python shell)**
  - To be enriched according to needs

```
# (…)
mesh = LIRE_MAILLAGE()

# get coordinates of the mesh
coord = mesh.getCoordinates()

# print coordinates
print "coord[3]", coord[3]
```

Access to value without copy

Massive parallelism: the outlooks

- **Developing and using AsterHPC's capabilities**
  - Valorisation through use on critical studies for EDF
    - Site effect for the seismic justification of our nuclear power plants
      - 200 M of physical ddl in linear dynamics over 4 000 time steps
      - Contribution to the robustness of our seismic safety demonstrations
    - Sizing of PWR nuclear waste repository galleries
      - 50 M of ddl in very non-linear quasi-static modelling
      - Costs avoided in billions €
- **Continue to enrich the interfaces of the objects**
  - Facilitate data access and interfacing
- **Replacement of "official" code_aster by the new version**
  - Replacement in **2019**

Merci de votre attention !