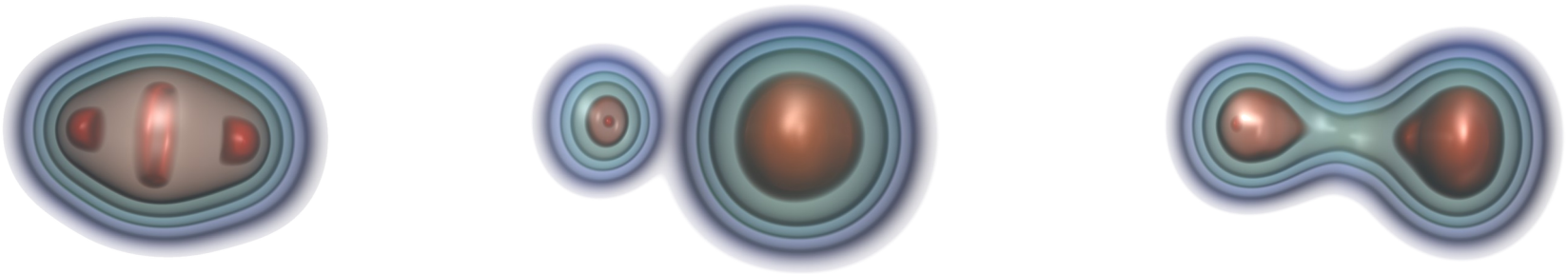
NPAC Computing projects
Nuclear Physics

How nuclear matter organizes itself when the nucleus is vibrating, fissioning, colliding with another nucleus ?



Projects :

1) Machine-learning the deformation energy of an atomic nucleus
2) Simulating the dynamics of a low energy heavy-ion collision

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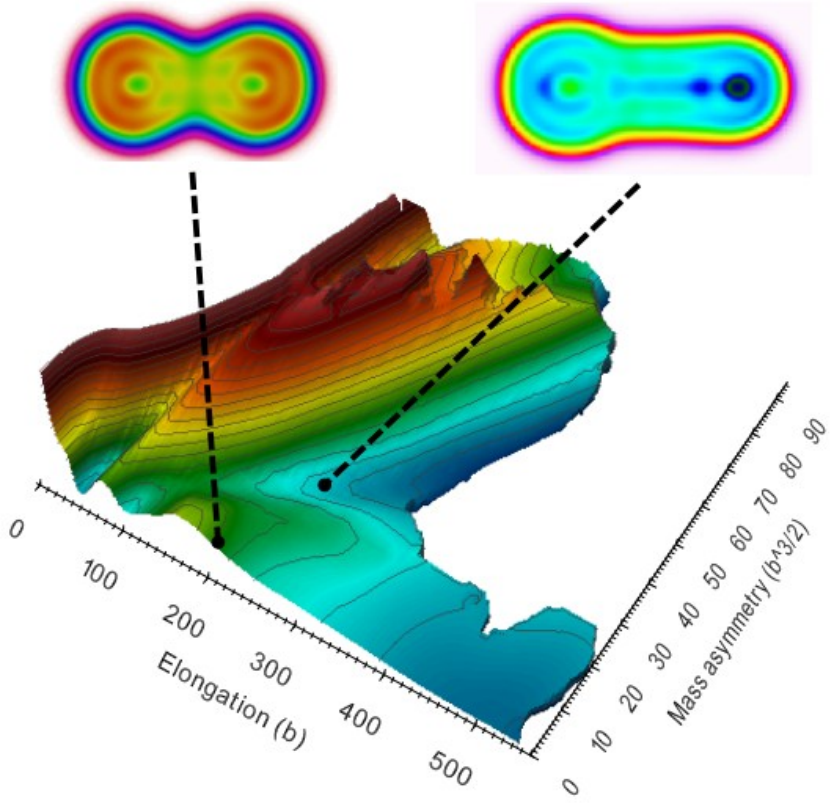
Machine learning generation of potential energy surfaces (PES)

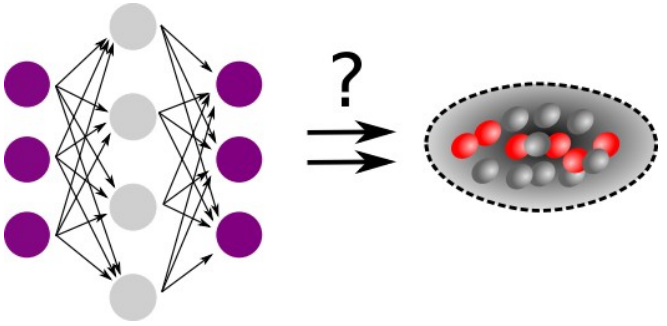


Interest: dynamics of large collective motion of the atomic nucleus (fission).

State of the art method: one constrained Hartree-Fock-Bogoliubov calculation per deformation point.

Problem: high numerical cost (>40000 points for a 2D energy surface).

Goal of the project: build an artificial intelligence capable of quickly generating quality PES.



Project

Resolution steps:

1) Generate a reference 2-dimensional PES (black box structure code)

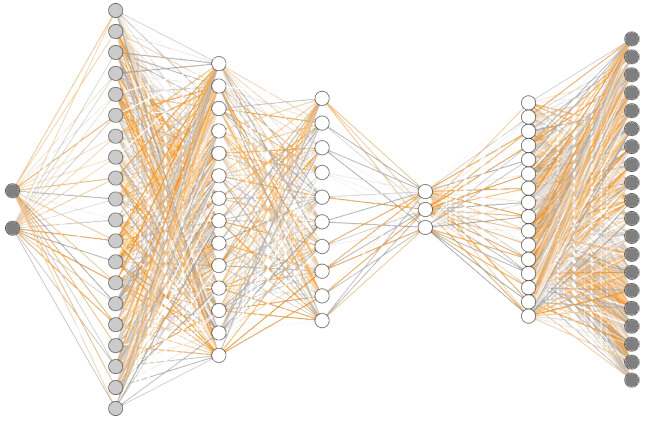
2) Build and train a neural network to emulate the function:

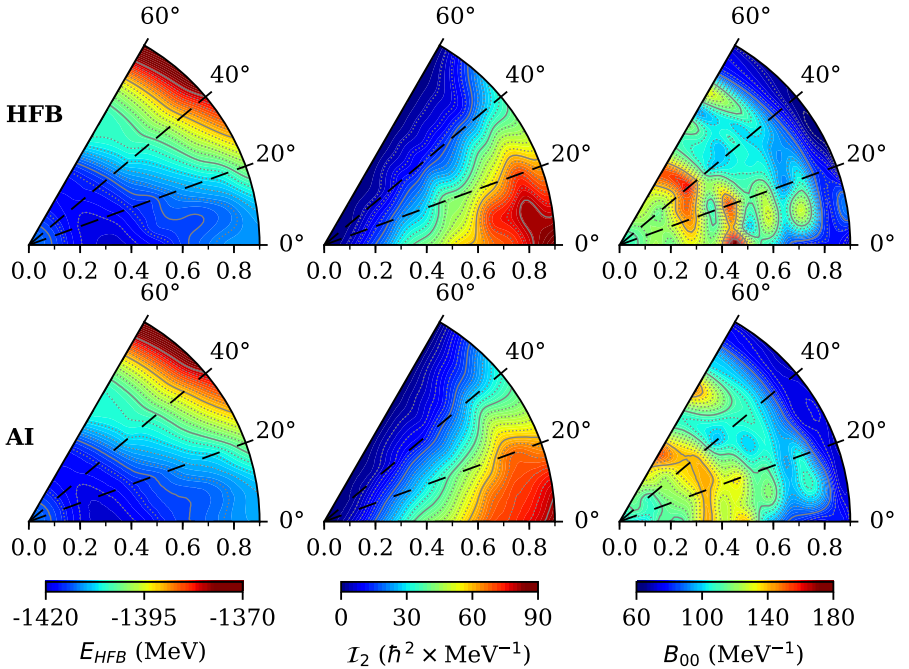
deformations parameters ⟶ total energy of the nucleus

3) Implement an active learning algorithm: the neural network determines by itself which points to calculate for its training.

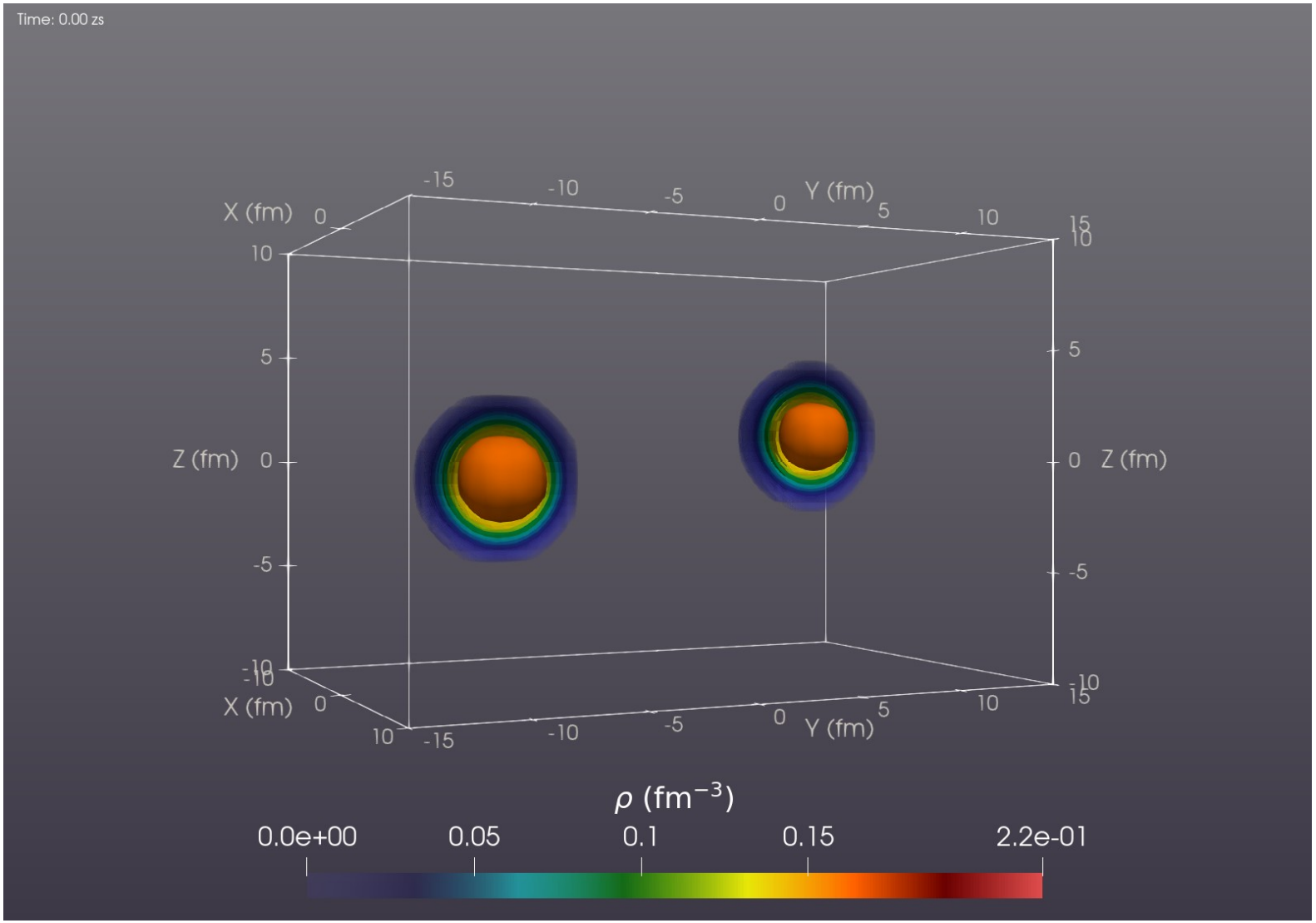
4) Possible extensions: Gaussian process, collective inertia, detection of saddle points, …

Results:

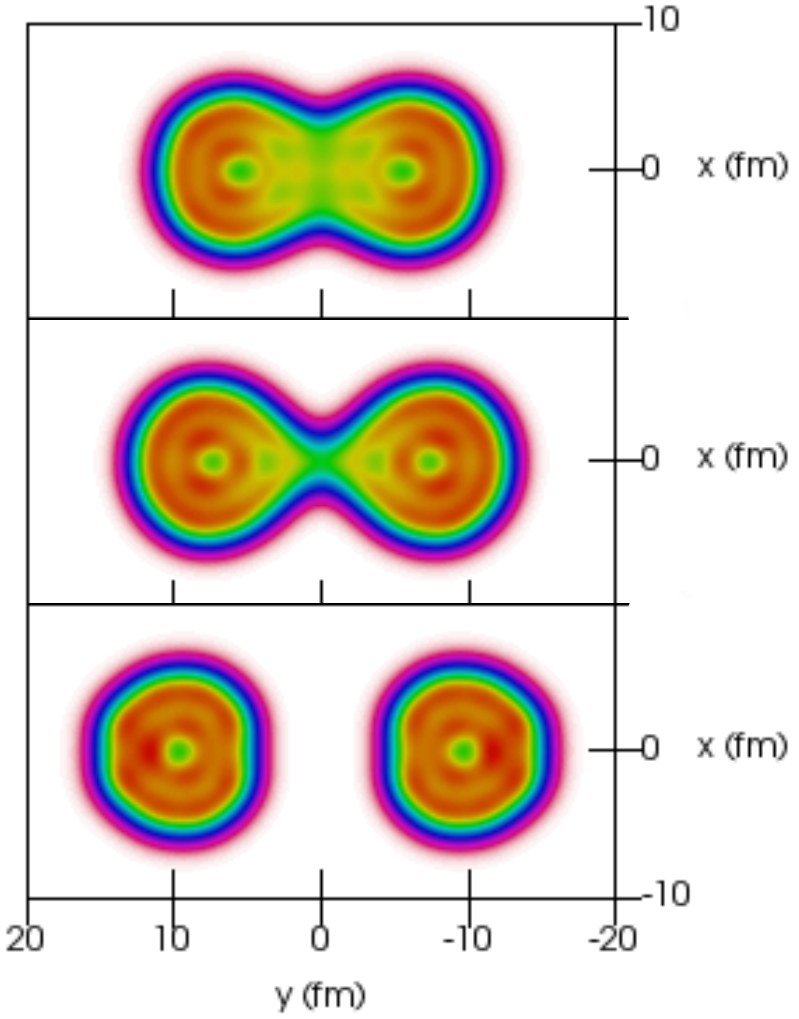




Simulating the dynamics of a low energy heavy-ion collision



Project



Interest: fusion, quasi-fission, giant resonance

Goal of the project: Simulate the dynamics in a semi-classical approximation (Vlasov)

$$\frac{\partial f}{\partial t} + \vec{u} \cdot \vec{\nabla}_r f + \frac{\vec{F}}{m} \cdot \vec{\nabla}_u f = 0$$

Method : test particles

Challenges :

- Fast solver, optimization
- Beautiful visualization

Technicalities

Languages :

- C++
- Python-3
- Fortran

Documentation :

We expect a Doxygen (or similar) documentation of your project

Versioning :

Your project should be managed with git

Grade :

Quality of the results + Cleanliness of your code + 10' Oral presentation