EUROfusion Engineering Grant (EEG)

INTERIM REPORT[1]

For calendar year	2018
Name of Engineer	Laura Mendoza
Beneficiary	CEA
TA ref.	AWP18-EEG-CEA/MENDOZA
Name of Coordinating Project Leader/Task Force Leader	Gloria Falchetto Michele Romanelli
Date	**11/12/18**

1. **Abstract** – please summarise the main achievements in the respective reporting year

The ToFu (*To*mography for *Fu*sion) library is a machine-independent open-source python library for synthetic tomography diagnostics and inversions. Its geometry module is the cornerstone necessary for both direct and inverse problems.

As expected, I spent some weeks in the beginning of the project to get familiarized with the library and the low-level language Cython.

A workshop on python packaging techniques (CondaDay, 2018) was followed, and I was able to implement new strategies for better portability of the code.

I also verified, corrected and optimized some of the unit tests of the library.

During the following months of the project were dedicated to the optimization of the geometry module, with special attention to the ray-tracing method. At the beginning of the mission, ray-tracing one million lines of sight on a geometry similar to the WEST device with 1202 structural elements took almost 9 hours of computation. After the optimization of the code the same simulation on the same machine, took around 20 seconds. Memory-wise, the original simulation used almost 1 Gigabyte of memory (0.85 Gb) whereas the optimized version of it used half the amount (0.42 Gb).

Thus, the optimization yield a speed-up of x14000 for the bigger simulations with 50% less memory usage.

Multiple new functions were necessary for the optimized version, all this functions as well as the old ones that were modified, were documented.

During the months of November and December, a 6-weeks long visit was done in the CEA of Cadarache. I met some of the library's users (and potential users). I visited ITER and participated in the Diagnostic Division Weekly Meeting with a presentation of ToFu, its compatibility with IMAS and the latest results.

2. Objectives

The main objectives for the first six months:
- Optimize ray-tracing tool
- Parallelize ray-tracing tool
- Write and optimize tests (unit tests, non-regression…)
- Add the proper handling of grids
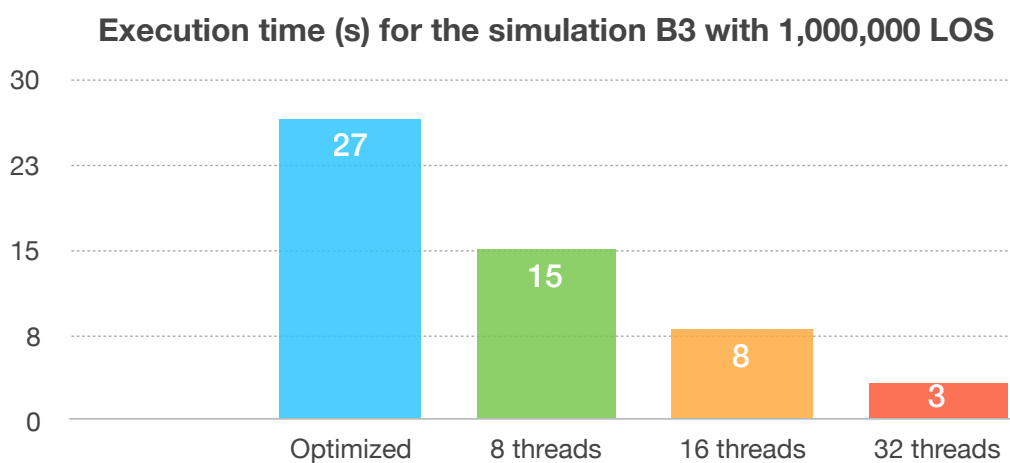- Update the documentation and release a stable version

3. Principal achievements during the reporting period (deliverables, milestones)

The principal achievements of 2018:

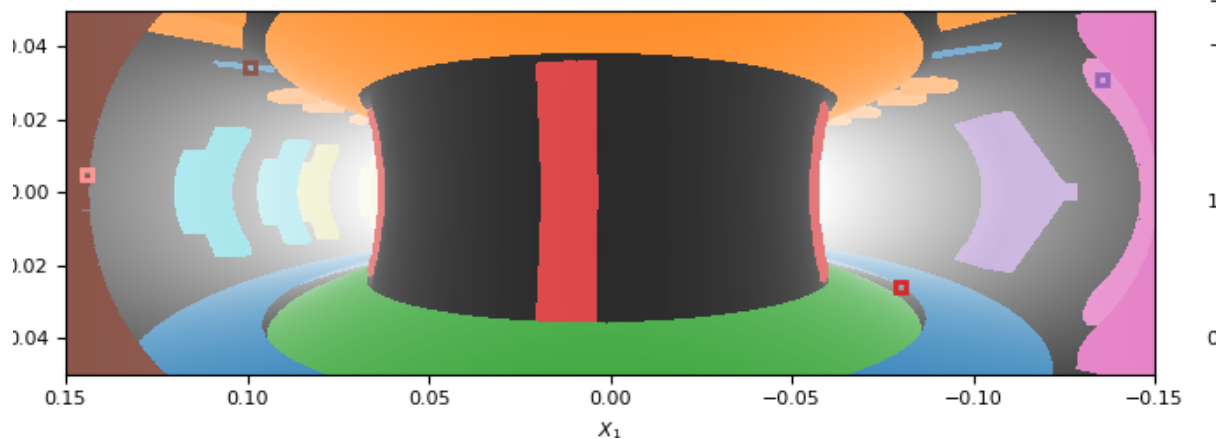- Computing time optimization: up to 1400 of speed up for the ray-tracing tool

Number of LOS	10^3	10^4	10^5	10^6	
original	3.26×10^1	3.10×10^2	3.20×10^3	3.17×10^4	(8h48)
optimized	2.58×10^{-2}	2.72×10^{-1}	2.74	2.66×10^1	(< 30s)

- Memory allocation optimization: up to 50% less memory usage for the ray-tracing tool
- Parallelization: up to 11300 of speed up for the ray-tracing tool using OpenMP

Execution time (s) for the simulation B3 with 1,000,000 LOS

Bar	Value
Optimized	27
8 threads	15
16 threads	8
32 threads	3

- Generalization of the methods to allow complex aperture and configuration definitions
- Better portability of the packaged version of Tofu (updated with last version of Conda)
- Next stable release of Tofu (end of January):
- https://tofuproject.github.io/tofu/index.html

Example of a dummy visible camera in WEST with a million LOS:

4. Description of deviations, if any, from the original work programme

5. Scientific publications

Conference contributions

1. NUMKIN 2018: Conference on numerical methods for plasma physics, IPP
   « *Application of the approximated BGK method on a Semi-Lagrangian parallel python solver on non-conforming patches* »

6. Participation in conferences, patents, teaching and knowledge transfer

Participation for training:

1. CondaDay: Packaging of Python libraries using Conda

Participation in workshop, internal meetings:

2. IPPL: INRIA's plasma team internal meating

3. Iter: Diagnostic Division Weekly Meeting