Excellence Center in Plasma Simulations and Theory

for Discovery Science and Disruptive Technology in Plasma Accelerators

Jorge Vieira, Luís O. Silva

GoLP / IPFN, Instituto Superior Técnico, Lisbon, Portugal

Numerical Simulations
the third pillar of the scientific method

Experimental discovery strongly assisted by numerical simulations

- Purely theoretical models are not available
- Experiments explore sub-set of all available parameters

Recent technological and computational advances make simulations virtual experiments

- Explore the physics self-consistently, no approximations
- Bridge between theory and experiments

Excellent plasma simulation tools
ready for the exa-scale

Simulations in the exascale computing era

- Simulations are computationally intensive
- Large scale simulations require large supercomputers and advanced models
- Exa-scale computing in Europe through **EuroHPC**

Sequoia @ LLNL

Concept for IST excellence center

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Collaboratorium

- platform for **coordination**, **collaboration**, scientific and technical **exchange**
- **lead coordination efforts** for code development and integration
- **front end for the EU exascale** initiatives in plasma accelerators
- **hub for new and disruptive ideas**, and to explore the future directions for the facility

Why now? Why IST?

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The time is ripe

- Long tradition in plasma theory and simulation in Portugal
- Collaborations with the leading theory and experimental groups
- Code architects and co-developers of **Osiris**
- Developers of **ZPIC**

ZPIC

IST nurtured plasma theory&simulation developments

- Tools developed and used at **IST** and by many leading institutions in Europe, US and Asia
- Model for theory and simulation ***collaboratorium***

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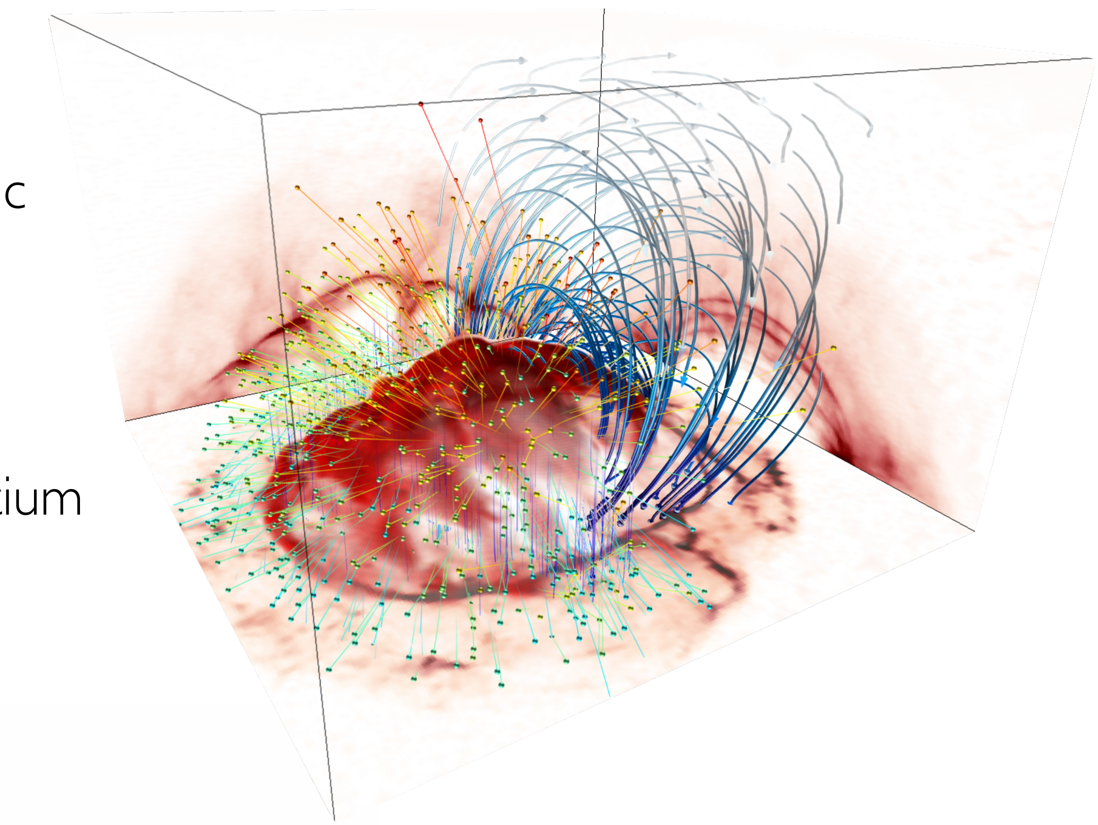
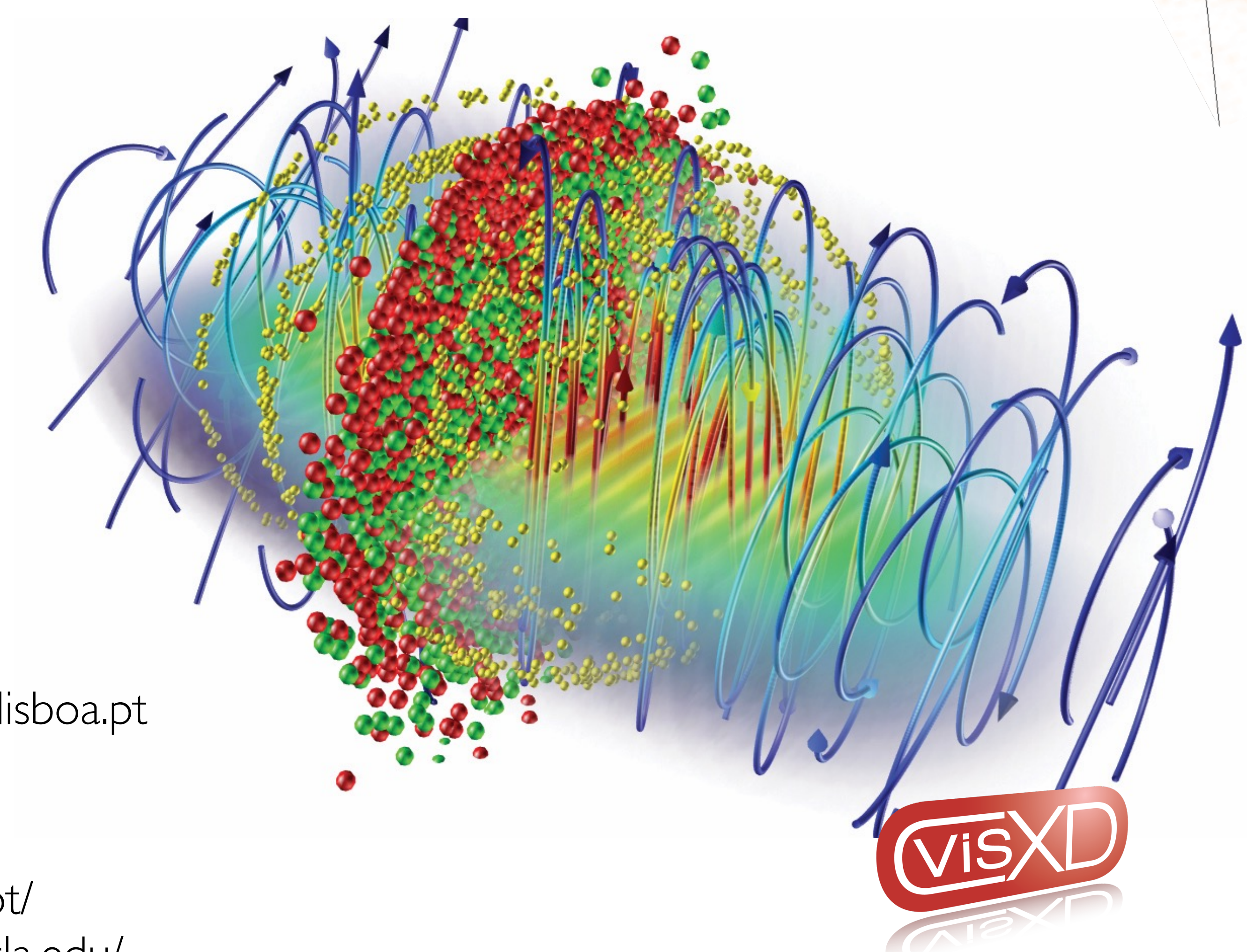
Osiris 4.0



osiris framework

- Massively Parallel, Fully Relativistic Particle-in-Cell (PIC) Code
- Visualization and Data Analysis Infrastructure
- Developed by the osiris.consortium
  ⇒ UCLA + IST



code features

- **Scalability to ~1.6 M cores**
- SIMD hardware optimized
- Parallel I/O
- Dynamic Load Balancing
- **Ionization**
- **PGC support**
- Quasi-3d support
- QED module
- Particle merging
- Xeon Phi/GPGPU support

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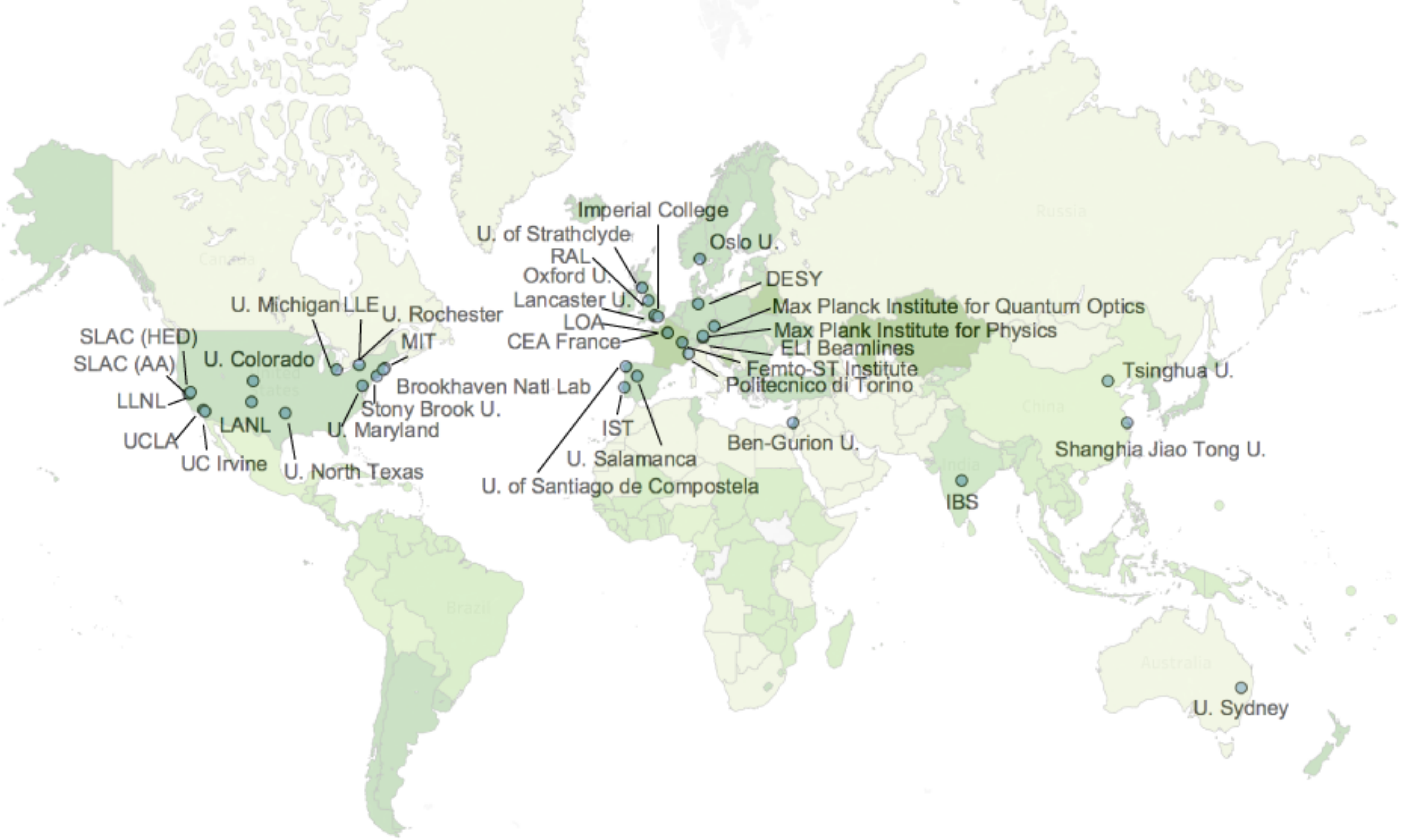
UCLA

Ricardo Fonseca
ricardo.fonseca@tecnico.ulisboa.pt
Frank Tsung
tsung@physics.ucla.edu

http://epp.tecnico.ulisboa.pt/
http://plasmasim.physics.ucla.edu/

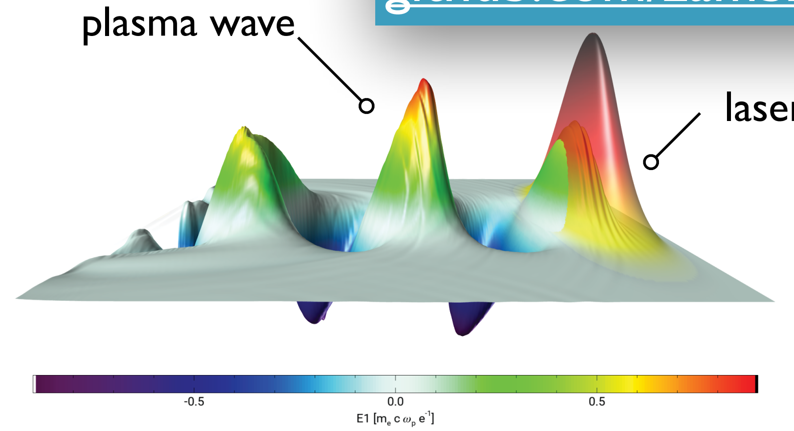
Osiris in the world



ZPIC

- **ZPIC** is a very simple PIC code (R. Fonseca et al) ideally suited for plasma physics and plasma acceleration education.
- **Employed** with success in the previous CERN accelerator school held in Sesimbra, Portugal (2019).
- **User friendly interface** written in c++ and controlled through Jupiyer notebooks.

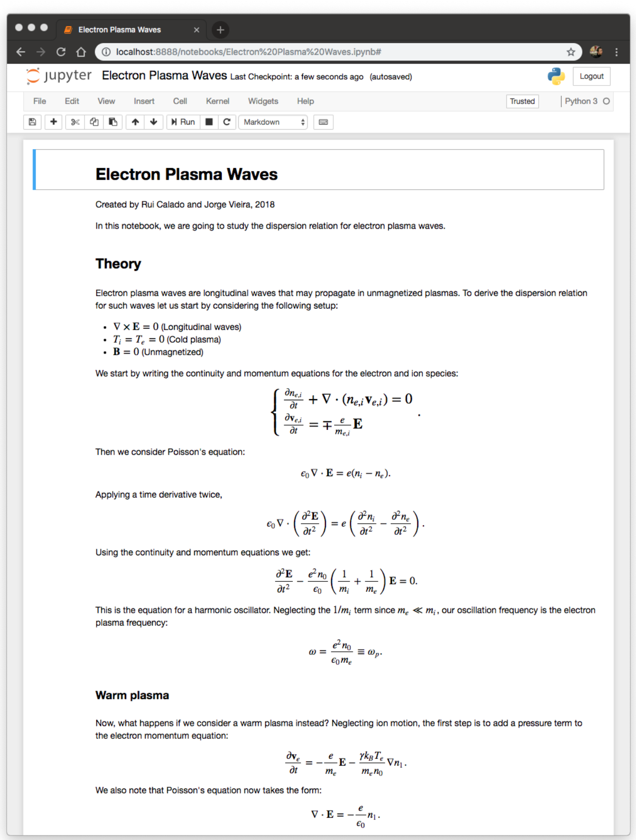
Come find us on GitHub
github.com/zambzamb/zpic



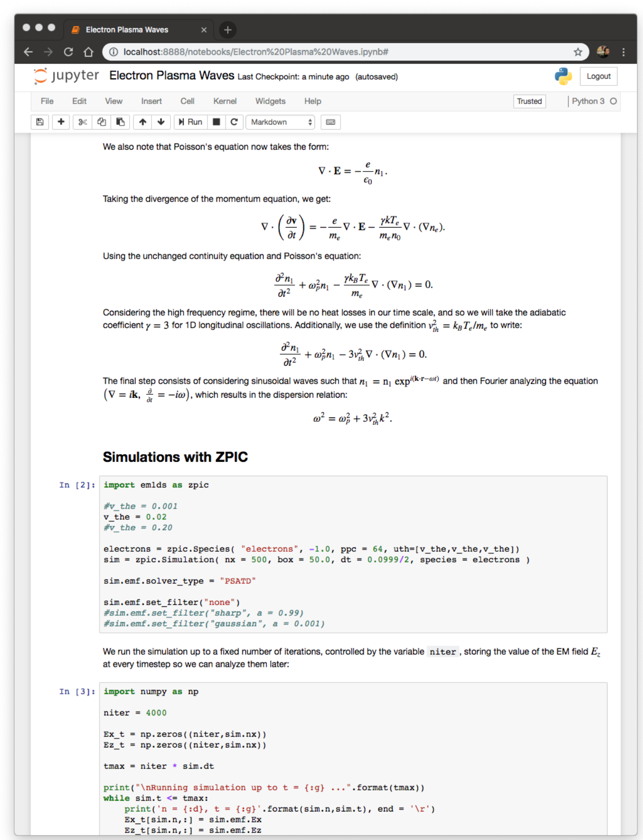
compact plasma accelerator in ZPIC

Example

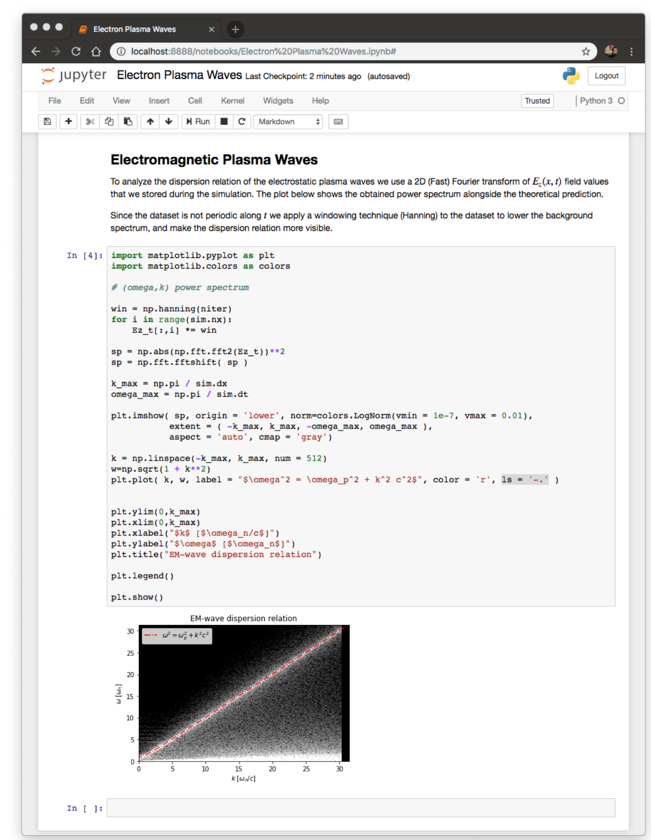
Theoretical introduction



simulation initialisation



analysis and questions for discussion



Instituto Superior Técnico (IST)

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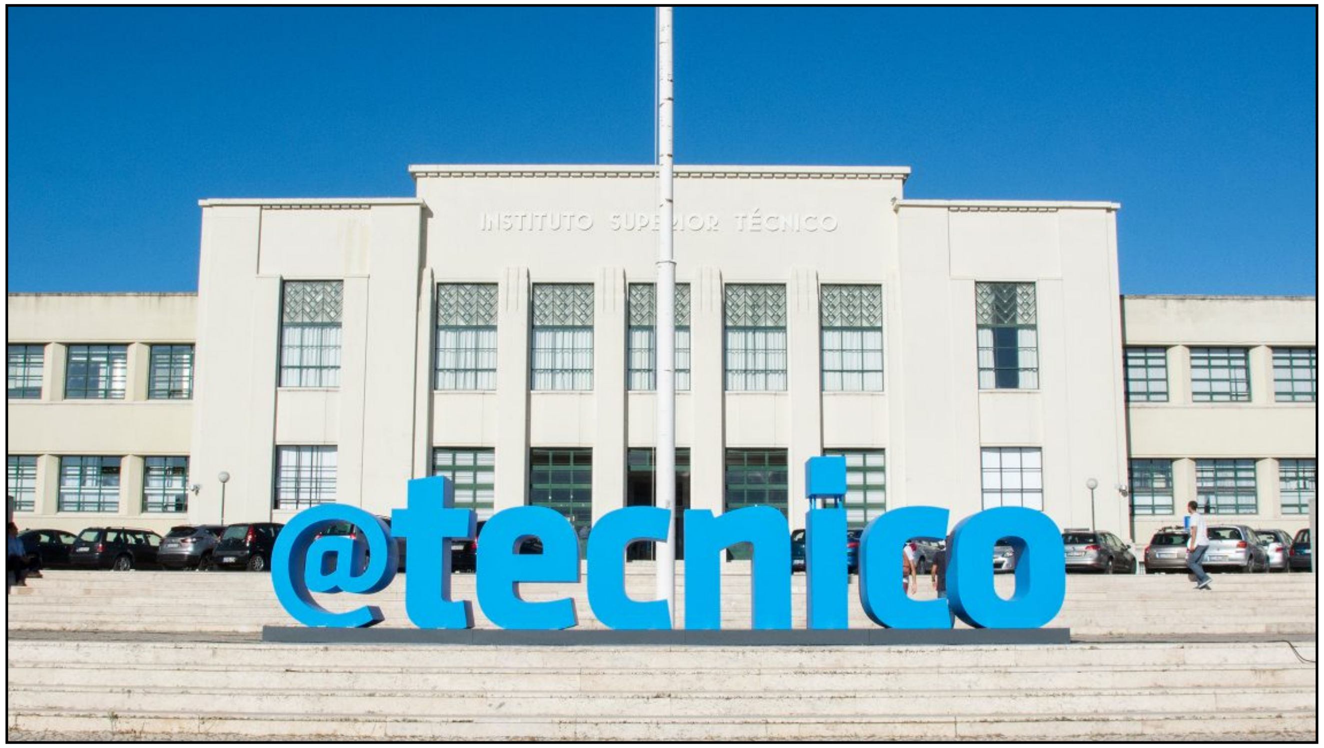
About IST

- **Largest** science&engineering school in Portugal
  - 11500 students
  - 870 research and teaching staff
  - 3 campii (alameda, taguspark, tecnológifo e nuclear)
- **Attracts top** students in science&engineering

Vibrant academic and scientific ecosystem on computational sciences and engineering



Excellence Center
structure and goals

Light structure

- scientific **director**, 1-2 **admin**, 3-5 **computational scientists**, including **visualisation experts**, 1 **outreach/communication officer**
- **strong** connection with national and Iberian supercomputing infrastructures

Main goals

- simulation and theoretical **support for EuPRAXIA** teams involved in computing
- **coordinate** virtual interactions in distributed Eupraxia configuration involved in theory and simulations
- **visiting/workshop program** on plasma accelerators (advanced training, convene PhD students, post docs and senior researchers)

Conclusion

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- Take the form of a ***Collaboratorium***
- **Unique location** of Lisbon (easy access from anywhere in Europe)
- **Institutional support** from the University of Lisbon
- Strongly **benefiting** from
  - integration of Portugal in the **EuroHPC** initiative,
  - **leading role** of plasma acceleration scientists in the Portuguese HPC community

EuPRAXIA