Session S-ST2: Simulation Tools and Roadmap
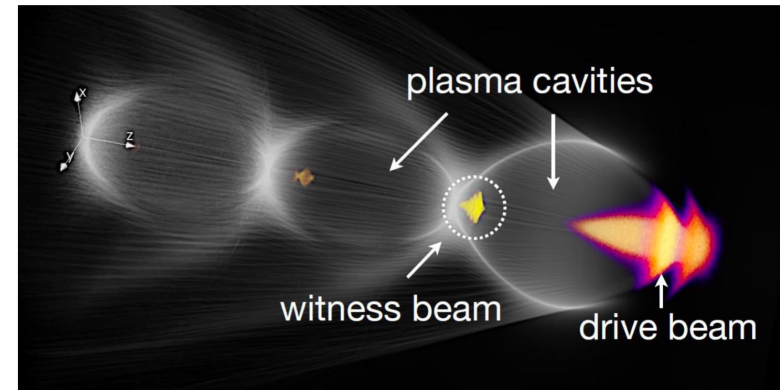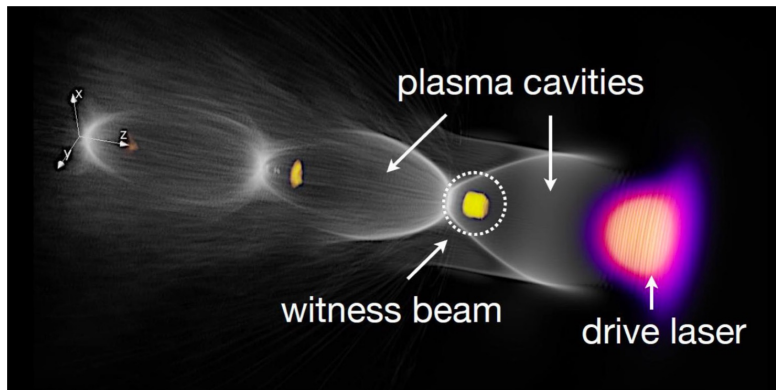

Image credit: LDG Report (2022), EuPRAXIA CDR (2020). Martinez de la Ossa

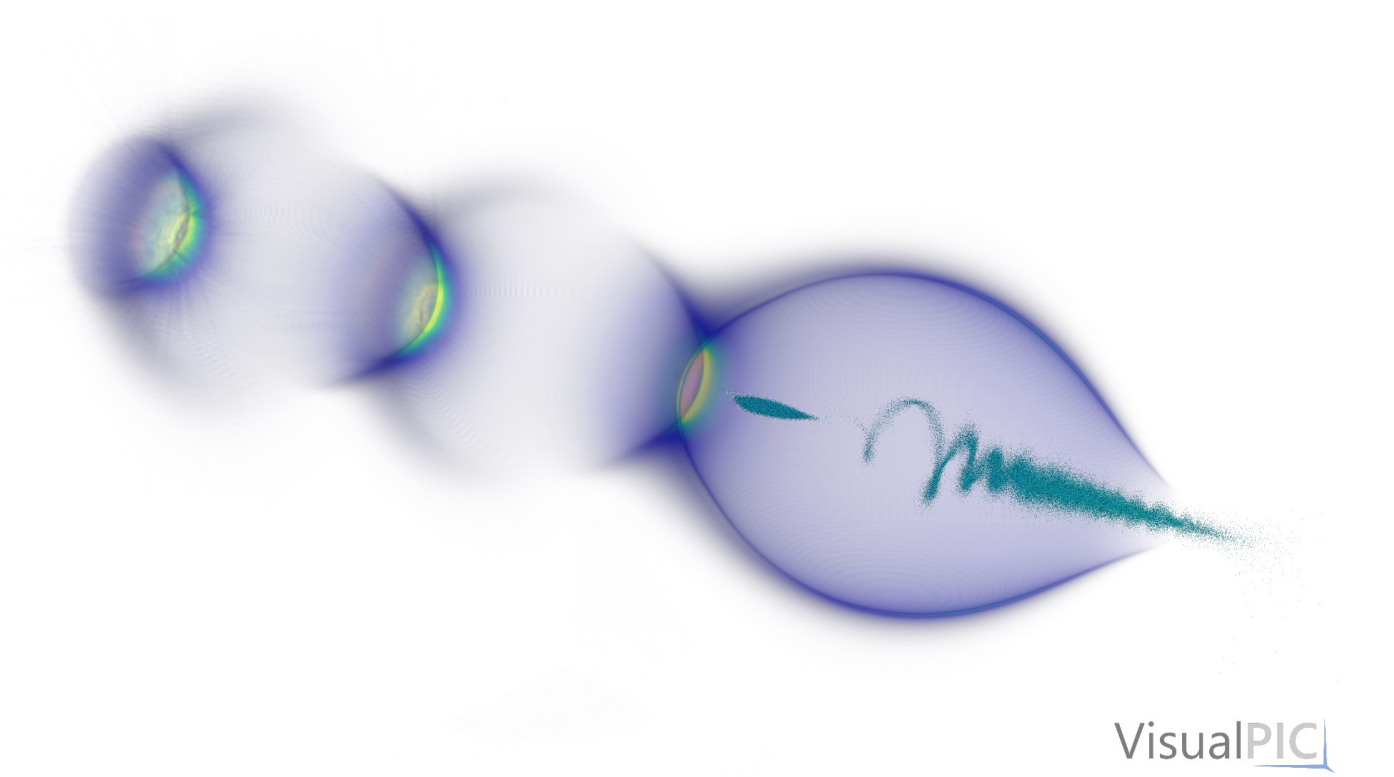Chairs:
   Jorge Vieira – IST
   Maxence Thévenet – DESY

EuroNNAc-2022, Isola d'Elba, Italy, 19/09/2022

Simulations play a central role in advanced accelerators R&D

➢ Educate

➢ Interpret experiments

➢ Propose and investigate concepts

VisualPIC

- **Particle-in-cell** is the method of choice for plasma acceleration
- multi-physics
- <u>Complex simulations</u> (radiation, low emittance, many stages) <u>remain challenging/expensive</u>

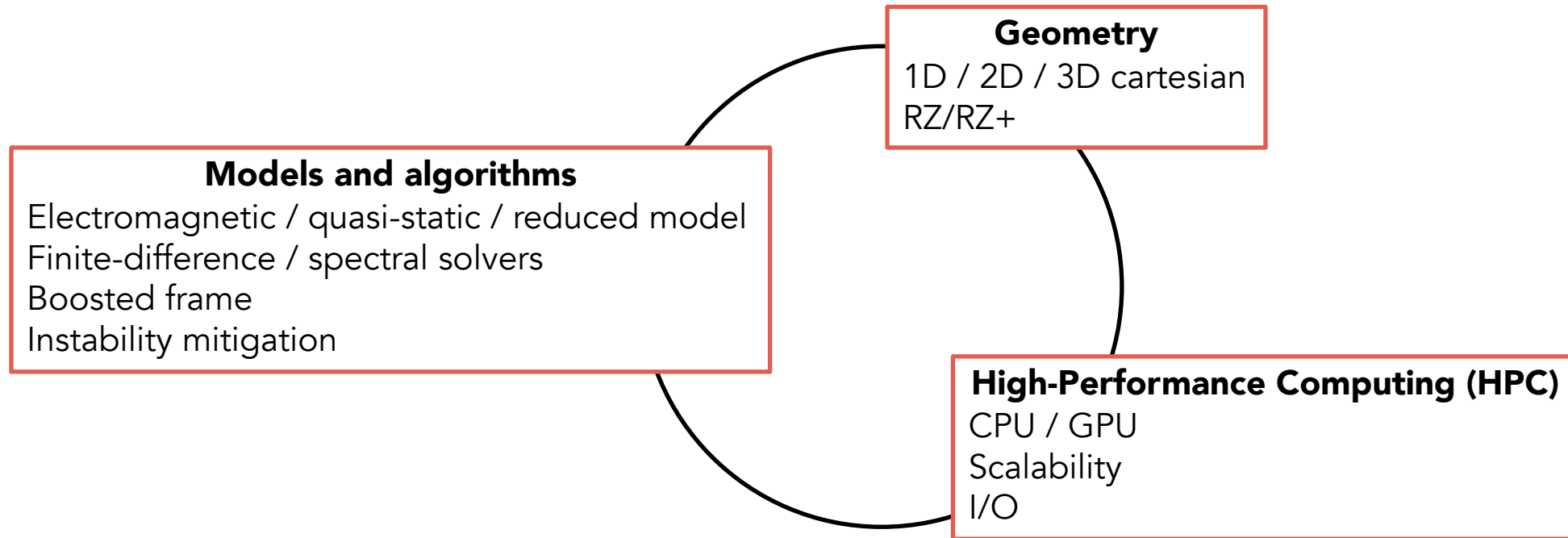# Simulations capabilities must improve to satisfy the needs

Snowmass 2021 white paper "Linear colliders based on laser-plasma accelerators"
- "*Development of enhanced modeling capabilities is required in order to guide the R&D effort towards a TeV collider*".
- "*Addressing these challenges requires developing an array of novel, high-fidelity and fast numerical tools, and exploiting high-performance computing on the upcoming exascale-capable supercomputers*"
- "*The development of simulation tools needed for the design of a multi-TeV collider will require robust and sustained team efforts based on collaborations in the accelerator modeling community, as well as coordination between national laboratories and university groups*".

<div align="right">C. Benedetti, et al. arXiv:2203.08366 (2022).</div>

Similar points in the **European Strategy for Particle Physics: Accelerator R&D Roadmap – LDG (2022)**

There is a large variety of flavors for PIC codes

Geometry
1D / 2D / 3D cartesian
RZ/RZ+

Models and algorithms
Electromagnetic / quasi-static / reduced model
Finite-difference / spectral solvers
Boosted frame
Instability mitigation

High-Performance Computing (HPC)
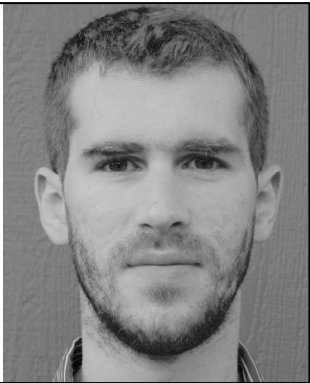CPU / GPU
Scalability
I/O

In addition:
- More and more challenging problems
- Additional physics can be added
- Combine with machine learning

Program of the S-ST2 simulation session (Tuesday 10:50-12:30)

Rémi Lehe (LBNL)

Ph.D. in 2014 at LOA (France)
2014-*2017: Postdoc* at LBNL (USA)
2018-present: research scientist at LBNL

Plasma acceleration, particle-in-cell, advanced solvers, HPC

10:50-11:10	**Rémi Lehe (LBNL)**	Applications of machine learning to plasma-based acceleration
11:10-11:30	Xavier Davoine (CEA)	Examples of PIC code limits and potential for the simulation of wakefield acceleration and accelerator applications
11:30-11:40	Franz Pöschel (CASUS)	openPMD – F.A.I.R and open scientific I/O at the Exascale
11:40-12:00	Bertrand Martinez (IST)	Direct laser acceleration of positrons with intense pulses
12:00-12:20	Severin Diederichs (DESY)	Recent advances in quasi-static Particle-in-Cell simulations for modeling plasma accelerators
12:20-12:30		*Discussion*

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Xavier Davoine (CEA)

Ph.D. in 2009 at CEA (France)
2009-2011: Postdoc at IST (Portugal)
2011-present: Scientist at CEA (France)
Plasma acceleration, ion channel laser,
plasma-based photon sources, SF-QED,
numerical schemes

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Franz Poeschel (CASUS)

M. Sc. Computer science at TU Dresden (Germany)
Scientist at the CASUS center

Particle-in-cell, FAIR principles, I/O at Exascale, I/O streaming, openPMD

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Bertrand Martinez (IST)

Ph.D. in 2018 in IST (Portugal)
2018: postdoc in Ecole Polytechnique
2019-present Postdoc in IST

Gamma-ray sources, APOLLON, lab astrophysics, positron acceleration

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Severin Diederichs (DESY)

M. Sc. From UHH
<u>2020-present Ph.D. at DESY (Germany)</u>

Positron acceleration, quasi-static particle-in-cell, HPC

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> 1) What are the future developments needed and planned?
>
> 2) Do the planned activities address the requirements from funded projects (AWAKE, EuPRAXIA, …) and from various roadmaps for plasma accelerators? Are there urgent holes?
>
> 3) Does simulations and theory require its own roadmap or is work adequately driven/supported through funded projects and through overall plasma accelerator roadmaps?

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Thank you

Chairs:
   Jorge Vieira – IST
   Maxence Thévenet – DESY

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