Roundtable: Project Sustainability & Legacy Initiatives

Moderator: Ingmar

→ Questionaire sent out

- 1) What tools / methods were developed during the Project in your workpackages / field of resarch or will be still developed ?
- 2) Which of those tools / methods in your opinion will be valuable for future follow-up research?
- 3) Which of those tools / methods might be useful to future XFEL operations / productive laser & accelerator environments?
- 4) What still needs to be done in your opinion in terms of archiving, documentation, publishing test code and test data sets etc. to allow either an researcher which will be working on a follow-up project or a staff scientist who would like to implement this to productive systems to build upon the OPAL FEL results.

Datengetriebene Photoinjektoroptimierung

- **1) What tools / methods were developed during the Project in your workpackages / field of resarch or will be still developed ?**
- Within WP. C, an interface for efficient sampling of training data using existing beam dynamics simulation has been developed. The application of inverse models has been studied on the problem of inferring machine parameters from slice emittance measurements. Ongoing development is going into the direction of implementing a surrogate forward model to the electron gun dynamics, allowing for gradient based optimization and control of the resulting beam emittance. The results will be compared with the ones from the inverse modeling.
- The paradigm of generative modeling has been applied to temporal laser pulse shapes, providing low dimensional representations as well as sufficiently accurate reconstructions.

2) Which of those tools / methods in your opinion will be valuable for future follow-up research?

Developed electron gun surrogate models can be used within other studies around photoinjectors, targeting more efficient yet comparably accurate differentiable simulations and including collaborations with software developed by other research groups.

Learning lower dimensional representations of data such as for pulses have the potential both to denoise data as well preprocessing it for further use, leading to a better data management.

3) Which of those tools / methods might be useful to future XFEL operations / productive laser & accelerator environments?

The differentiable forward surrogate model can be used to set up a fully differentiable simulation pipeline, including the pulse propagation in the fiber, the translation of the intensity profile into an electron bunch distribution and the connection with other tools such as Cheetah.

Using a sufficiently good initial guess of an optimal set of machine parameters provided the inverse model, an efficient feedback/gradient based control can be implemented.

4) What still needs to be done in your opinion in terms of archiving, documentation, publishing test code and test data sets etc. to allow either an researcher which will be working on a follow-up project or a staff scientist who would like to implement this to productive systems to build upon the OPAL FEL results.

The training data for the gun surrogate needs to be resampled, meeting the current requirements regarding the facility (PITZ setup) as well as regarding the models (learning of time sequences). The resulting data has to be published.

All developed components have to be integrated to provide an easy to use start to end simulation of the whole system including the laser frontend as well as the photoinjector.

Photoinjektoroptimierung

- **1) What tools / methods were developed during the Project in your workpackages / field of resarch or will be still developed ?**
- A 3D beam dynamics code for modeling the photoinjector being implemented in python;
- Data-driven models being built for simulating the photoinjector in both future HDC/CW and the present pulsed operation modes of the European XFEL

2) Which of those tools / methods in your opinion will be valuable for future follow-up research?

* 3D beam dynamics code allowing more accurate follow-up studies of realistic electron bunches with non-uniform / asymmetric spatial distributions
* data-driven models of the EuXFEL injector allow for fast generation of required large amount of data sets for training ML models based on different methodologies; providing a basis for modeling downstream accelerator components using ML techniques

3) Which of those tools / methods might be useful to future XFEL operations / productive laser & accelerator environments?

* all of these tools/methods enable detailed and more accurate studies of the photoinjector performance in the present pulsed and future HDC/CW operation modes of the EuXFEL

4) What still needs to be done in your opinion in terms of archiving, documentation, publishing test code and test data sets etc. to allow either an researcher which will be working on a follow-up project or a staff scientist who would like to implement this to productive systems to build upon the OPAL FEL results.

already produced training data sets covered a very wide range of operational parameters of the laser system as well as the accelerator components, which need to be properly organized and published with clear description

Photoinjektoroptimierung

- **1) What tools / methods were developed during the Project in your workpackages / field of resarch or will be still developed ?**

- **Operational Software**
  - **XFROG Control Software:** Used for primary system control and diagnostics.
  - **Pulse Shaping Script:** The current script (used by Denis) for setting custom laser pulse shapes.
- **Simulation & Research Tools**
  - **Frontend Simulator:** Code for modeling the initial laser pulse generation.
  - **SHG Simulator:** Code for modeling the second-harmonic generation process.
  - **Optimization Loops:** Algorithms for system optimization and parameter exploration within the simulations.

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Todo

- Get overview of tools

- Archive tools such that they can be used