

Peek on recent ML activities at DESY

Raimund Kammering for the IPC team and ...
Shanghai, 15. Oct. 2021 - virtual conference

No news from DESY on ML on ICALEPCS2019, but ...

much has happened since then

- **Bundled DESYs internal forces**
 - **Intelligent Process Control**
 - **ongoing activities**
- **Reaching out - building collaborations**
 - **Helmholtz AI**
 - **HIR^{3X}**
 - **CDCS etc.**
- **A recent example → next talk by Antonin**

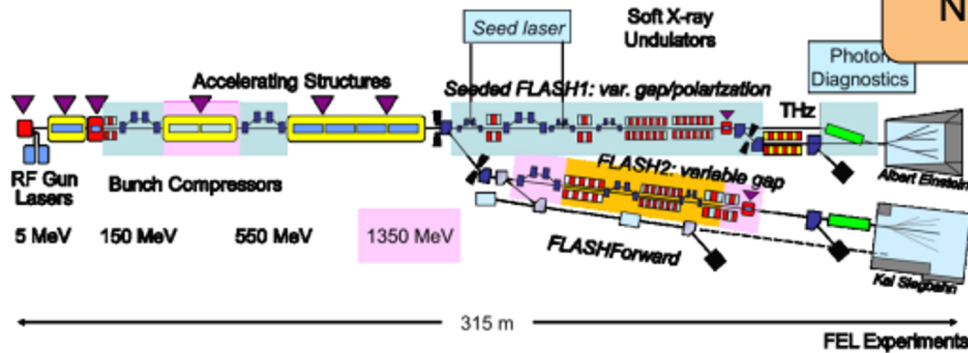
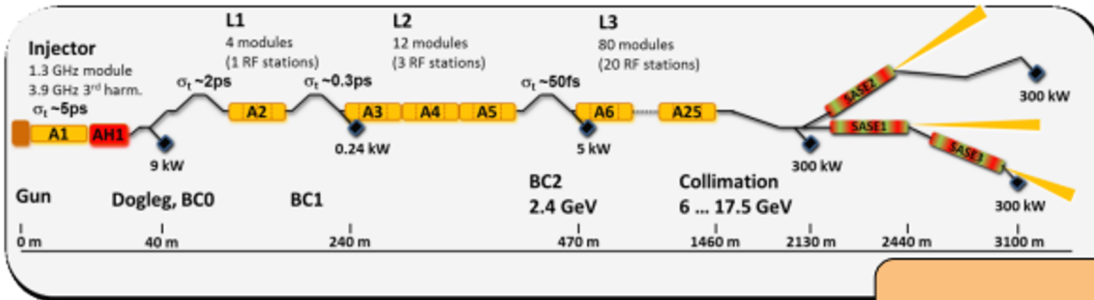
DESY accelerators & test benches



Different machines → different challenges

Accelerators at DESY ...

FELs.... (reproducibility / optimization / flexibility / ...)

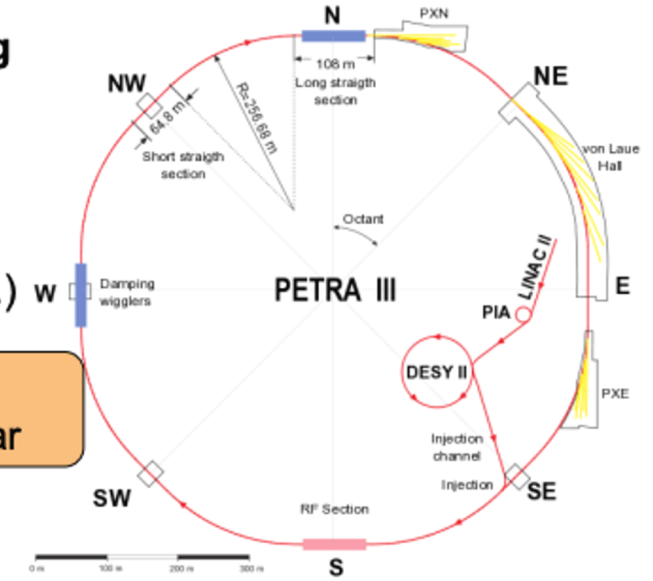


No equilibrium

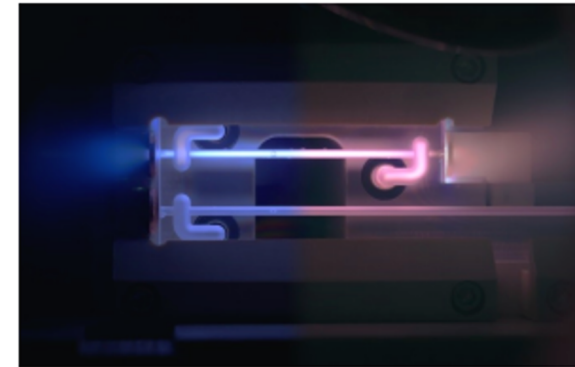
Equilibrium but non-linear

Highly non-linear

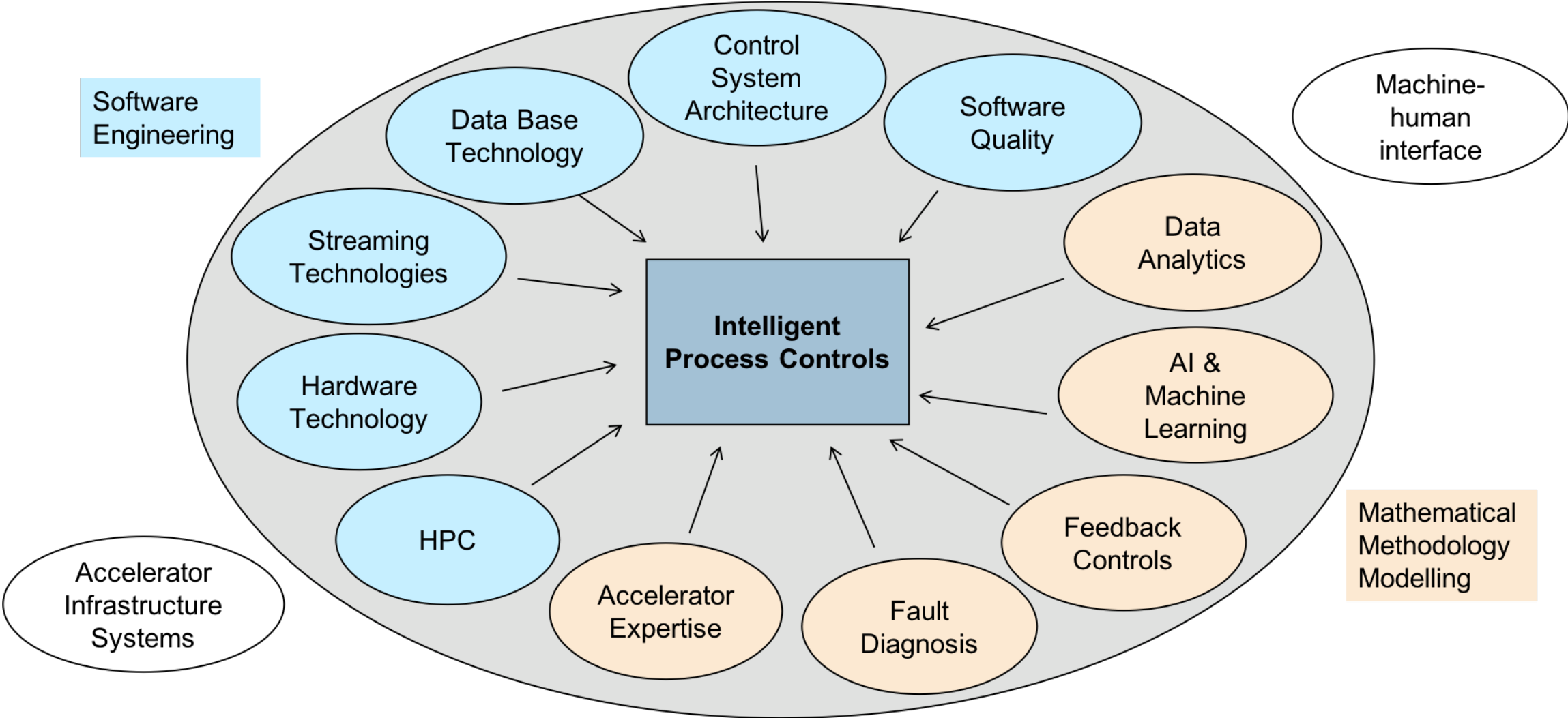
Plasma accelerators (lasers control/ HPC /in-situ FB)



- Challenges and degree of maturity very different, but
- Increased complexity of controls
 - Higher demands on accelerator operations
 - Push on the limits regarding performance & flexibility & availability



Intelligent Process Control (virtual) group founded in 2020



Reaching out - Helmholtz AI

Subheading, optional

- Already in 2019
- Autonomous Accelerator
- collaboration with KIT



HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

A screenshot of the Helmholtz AI website. The header includes the Helmholtz AI logo (HELMHOLTZ AI | ARTIFICIAL INTELLIGENCE COOPERATION UNIT) and navigation links: OUR MODEL, OUR RESEARCH, YOU + HELMHOLTZ AI (highlighted), and LATEST. Social media icons for Twitter and LinkedIn are also present. The main content area shows a news article snippet with a green highlight. The highlighted section is titled 'Autonomous Accelerator: Machine learning for autonomous accelerators (DESY + KIT)' and contains text about modern particle accelerators and their operation. The contact information for Dr. Annika Eichler is provided at the bottom of the highlighted section.

HELMHOLTZ AI | ARTIFICIAL INTELLIGENCE COOPERATION UNIT

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tissue using high-resolution 3-D microscopy. AI supports the evaluation of the images and the analysis of radiation damage.

Contact: Dr. Stefan Bartzsch, stefan.bartzsch@helmholtz-muenchen.de (HMGU)

▪ **Autonomous Accelerator: Machine learning for autonomous accelerators (DESY + KIT)**

Modern particle accelerators offer extraordinary beams for new discoveries in science. Increasing beam requirements make their operation more demanding, and a fully autonomous accelerator seems a long way off. However, this project is taking its first steps towards implementation. It brings reinforcement learning to the linear accelerator operation at DESY and KIT.

Contact: Dr. Annika Eichler, annika.eichler@desy.de (DESY)

Reaching out - HIR3X

Subheading, optional

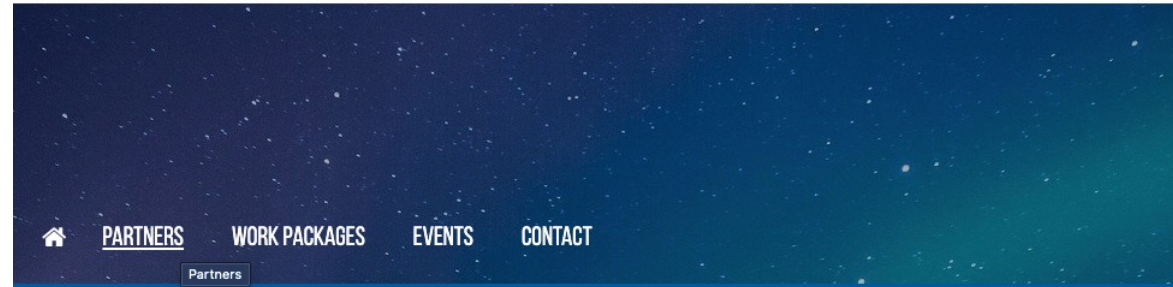
- Helmholtz International Laboratory

VIRTUAL PROJECT KICK OFF

8 September 2020



HIR³X Helmholtz International Laboratory
on Reliability, Repetition, Results
at the Most Advanced X-Ray Sources



Home > Partners

PARTNERS



The "Stiftung Deutsches Elektronen-Synchrotron", DESY, is one of the world's leading accelerator centres for the investigation of the structure of matter with approximately 2,300 employees and the most advanced scientific, technical and administrative infrastructures. DESY develops, operates, and uses complex accelerators, detectors and observatories for photon science, particle and astroparticle physics.

→ DESY website



The European XFEL is the world's largest X-ray laser. With its ultrashort X-ray flashes—27 000 times per second—and a peak brilliance a billion times higher than that of the best synchrotron X-ray radiation sources, the European XFEL will enable researchers from all over the world the investigation of still open scientific problems in a variety of disciplines (physics, structural biology, chemistry, planetary science, study of matter under extreme conditions and many others).

→ XFEL website



The SLAC National Accelerator Laboratory is one of 17 Department of Energy national labs. SLAC pushes the frontiers of human knowledge and drives discoveries that benefit humankind. They invent the tools that make those discoveries possible and share them with scientists all over the world.

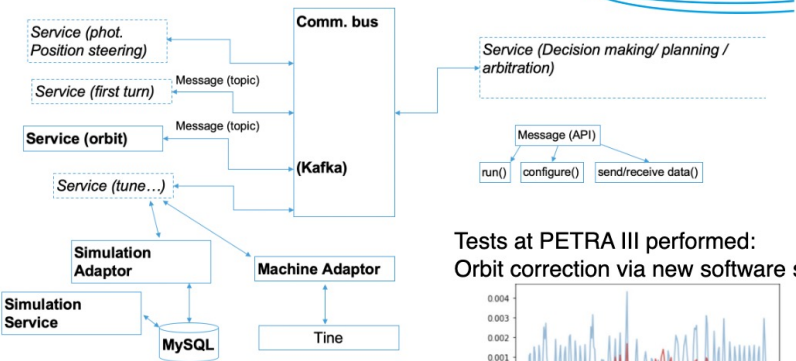
→ SLAC website

Reaching out - HIR3X

Prototyping PETRA IV autonomous stack and digital twin

c/o M. Boese

Implementing automation for storage ring start-up

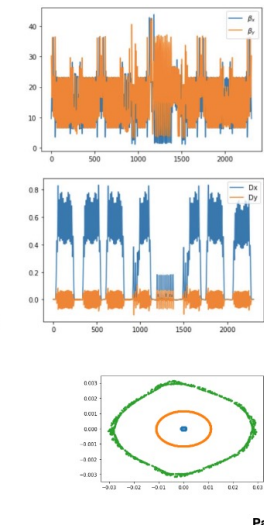


Development and testing underway
Plan beta software release in 2022

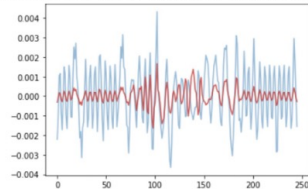
DESY, HIR3X-WP1, Anika Eichler, September 28th 2021



Digital twin based on pyAT

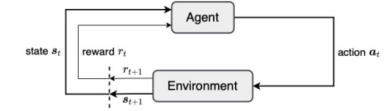


Tests at PETRA III performed:
Orbit correction via new software stack



Reinforcement Learning for Accelerator Optimisation

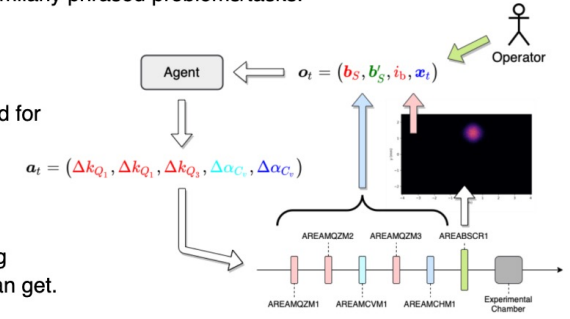
Studies on Feasibility and Best Practices



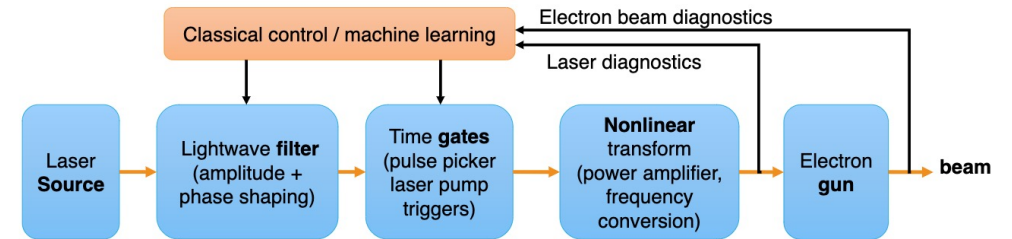
- Train RL controller to autonomously optimise accelerator's state.
- Can be extremum seeking of certain measures or setup of the accelerator such that specific values desired by the operator are achieved.
- Gain experience on simple but also interesting example (ARES Experimental Area) in order to establish best practices to routinely build RL agents for similarly phrased problems/tasks.

Results

- RL controller can come close to the optimum / achieve beam very close to what operator asked for (possibly at physical limit).
- Speed is superior to conventional black-box optimisation.
- Upcoming tests on the real accelerator including investigation of how close to the optimum we can get.



First Results of Task 1.3



- Burst flattening deployed at European XFEL
- Automated pulse shaping using autograd and machine learning
 - Differentiable (classic) laser amplifier modelling. ML based electron gun planned
 - Optimize amplitude and phase for desired output
 - Current status: optimize for arbitrary pulse shapes

Task 1.3: Machine learning

Exchange programs, mobility schemes, workshops &

Courtesy H. Chapman, B. Dunham

Reaching out - CDACS

Collaboration with universities via

Cross Disciplinary Labs

One such project in the next talk by Antonin

Thank you for your attention!



Computational Controls of Accelerators (CDL4)

ist eine neue gemeinsame Einrichtung der Universität Hamburg, des Deutschen Elektronen-Synchrotron DESY und der Technischen Universität Hamburg. In der neu entstehenden Science City Bahrenfeld verbindet es naturwissenschaftliche Forschung mit modernster Informationstechnologie.