

ARD-ST3

Erik Bründermann, KIT (Spokesperson ST3)

Holger Schlarb, DESY (Spokesperson ST3)

Thorsten Kamps, HZB

Pavel Evtushenko, HZDR

Peter Forck, GSI

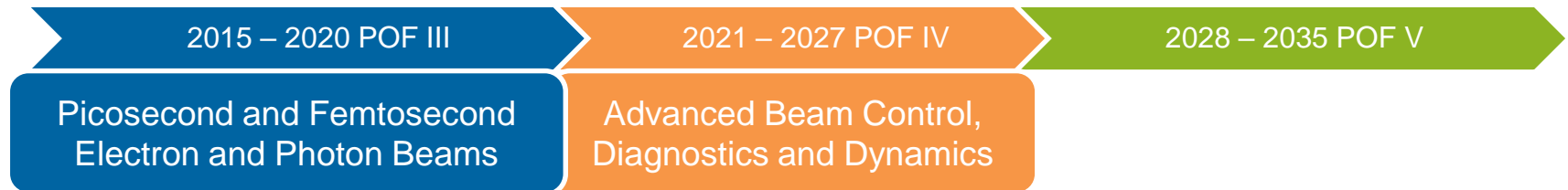
July, 7th, 2023
Annual MT ARD ST3 Meeting
12:15-13:15

Y(OUR) VISION

Where do you see yourself in ...

- 5 years ???
- 12 years ???

program-oriented funding



INFORMATION IN INDICO

INCLUDING TUTORIALS IN PREVIOUS ANNUAL MEETINGS



M T ARD 11th MT ARD ST3 Meeting 2023 in Dresden-Rossendorf

Jul 5 – 7, 2023
Dresden
Europe/Berlin tmezone

Enter your search term

Overview

The 2023 edition of the MT-ARD-ST3 meeting will be held in-person and in Dresden-Rossendorf. Link of this webpage: indico.desy.de/e/2023-st3
See [Venue/Travel](#) and [bus shuttle service](#) from Dresden center to and from the venue to HZDR each day.

Two Pre-workshops precede the meeting (5. July 2023, in the morning until lunch time). "Open Source Firmware & ChimeraTK" ([link](#)) and "UED" ([link](#)).

All posters can be put up on the first day and can stay on the poster stands during the whole meeting. Details for Speedtalks&Poster combi see [link](#).

The Helmholtz Initiative for Accelerator Research & Development (ARD) was established to strengthen development in accelerator physics and technology and to ensure international competitiveness. In this framework, accelerator scientists push the limits of today's technology in a research network of six Helmholtz centers (Deutsches Elektronen-Synchrotron (DESY) in Hamburg and Zeuthen, Forschungszentrum Jülich (FZJ), Helmholtz Zentrum for Heavy Ion Research (GSI) in Darmstadt, Helmholtz Zentrum Berlin for Materials and Energy (HZB), Helmholtz Zentrum Dresden-Rossendorf (HZDR), and Karlsruhe Institute for Technology (KIT)), two Helmholtz institutes, eleven universities, two Max-Planck institutes, and the Max-Born institute.

Advanced beam control, beam diagnostics and beam dynamics is the MT-ARD-ST3 scope in POF-4. ST3 has a [strategy](#) and [vision](#).

The eleventh ARD topical workshop for ST3 will be organized by HZDR in Dresden.
The workshop is held on 3 consecutive days.

This workshop aims to bring scientists from universities and Helmholtz centers together. It shall also serve to further strengthen collaborative projects at and between the different accelerator facilities. The workshop shall also serve to educate young researchers and students participating in projects and experiments within ARD ST3.

A look back: 2022 meeting on [indico](#).

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L "Open Source Firmware & ChimeraTK"
L "UED"
ARD ST3 Strategy
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L ARD - Topic Homepage
KfB / Forum

- The **vision** for MT ARD ST3 (PoF 4, 2021-2027):
<https://indico.desy.de/event/36133/page/4250-vision>
- Description of ST3 for PoF 4:
https://www.helmholtz-ard.de/e42986/e43194/index_eng.html

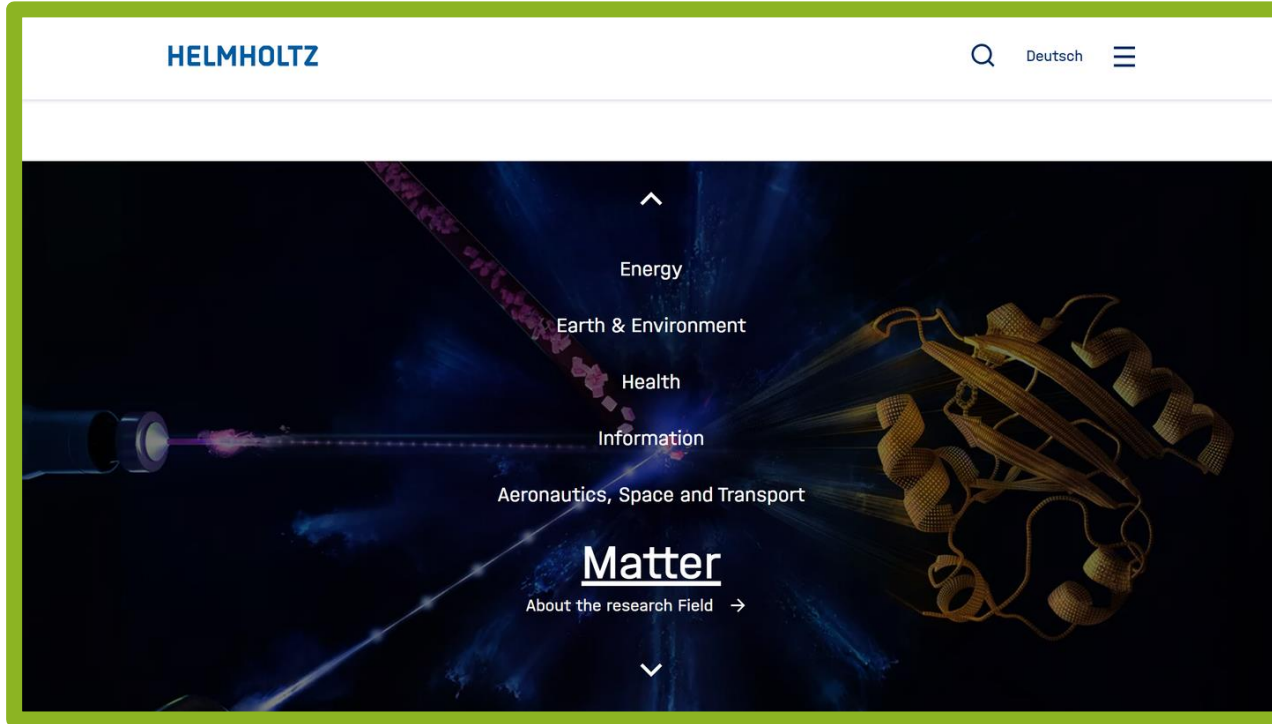


ARD ST3 Strategy

- └ Vision
- └ Annual Meetings (archive)
- └ ARD - Topic Homepage

OUR RESEARCH

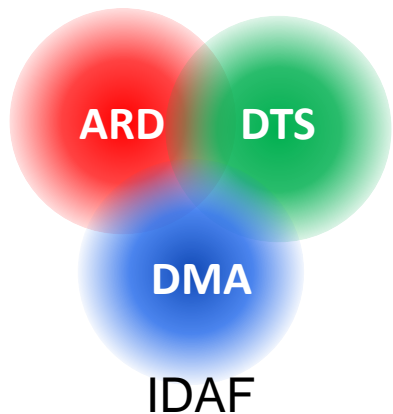
IN OUR 6 RESEARCH FIELDS, WE WORK
ON THE PRESSING ISSUES FACING OUR SOCIETY.



MATTER AND TECHNOLOGIES

WHAT WE ARE

From MT Annual Meeting 2022
T. Behnke, A.-S. Müller



Accelerator science
Detector science
Data analytics

- Research in *Matter* is bold and broad
- It relies on people and on advanced technologies

MT is a program for the future of *Matter*
closely intertwined with MML and MU

Matter and Technologies

Other areas
Tech Transfer

R&D

- Fundamental R&D
- Research in technologies

Growth

- Prototyping
- Designing systems
- Scalability

Maturity

- Developing facilities
- Building infrastructures
- Applications

Finalization

- Decommissioning

User communities

THE CHALLENGES

CHANGING THE WAY WE DO SCIENCE

From MT Annual Meeting 2022
T. Behnke, A.-S. Müller

Accelerators

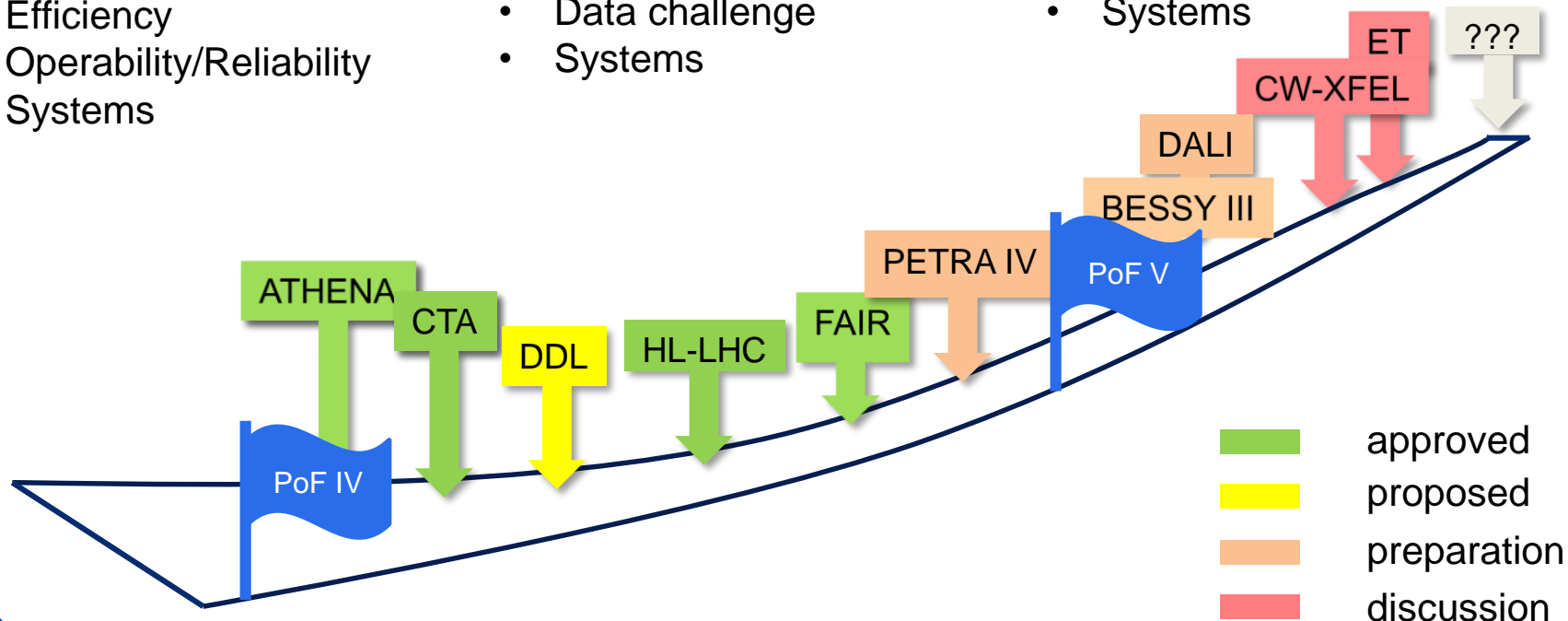
- Performance
- Compactness
- Efficiency
- Operability/Reliability
- Systems

Detectors

- Resolution
- Speed
- Data challenge
- Systems

Data analytics

- Data challenge
- Algorithms
- Systems



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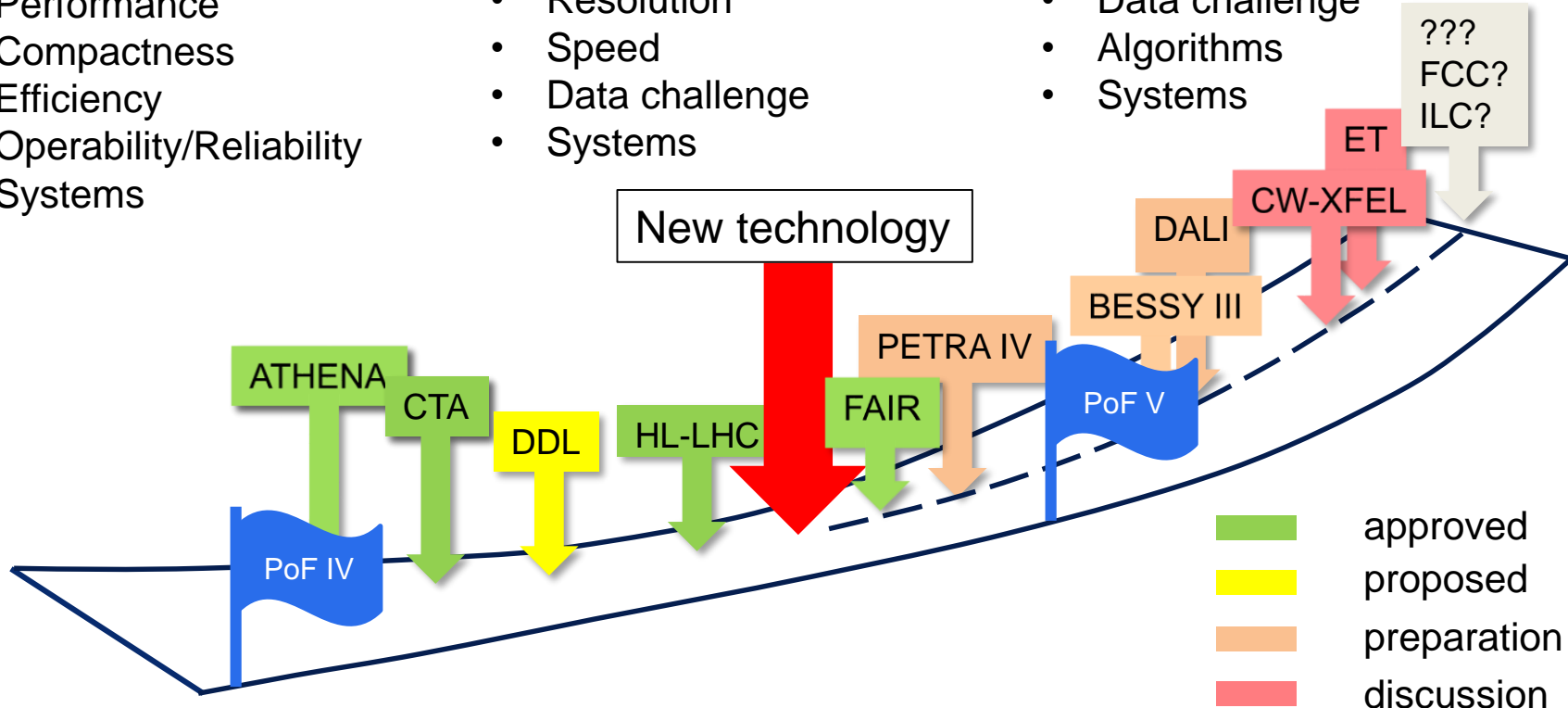
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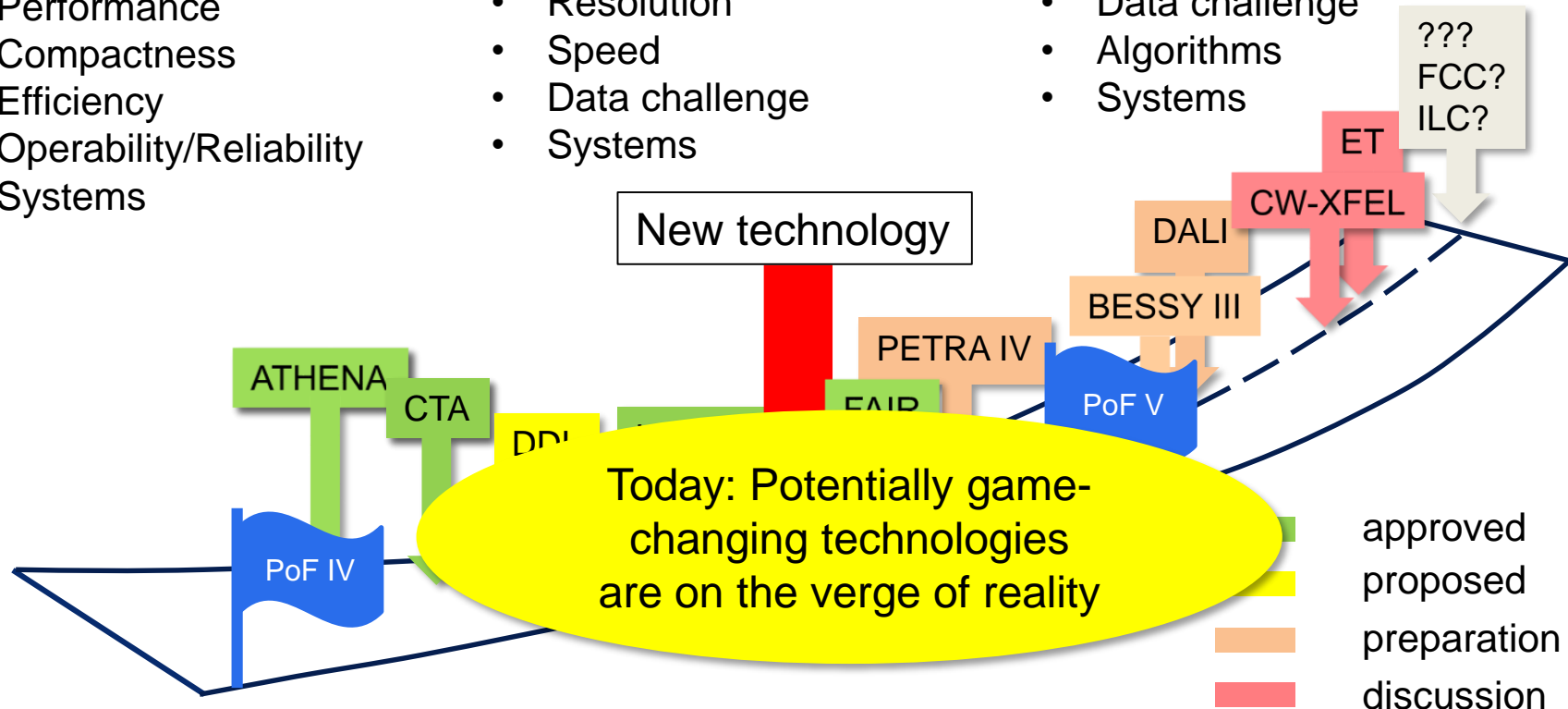
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ST3 – THE BASE & THE PILLARS

ARD-01	2023	Review usage and impact of ML
ARD-02	2024	Update evaluation of the user needs for guidance

Mst	Year	Milestone (centers)
ARD-10	2024	First stage demonstration of experimental and theoretical methods for tailored longitudinal phase space generation (all)
ARD-11	2025	Establish routine femtosecond precision operation at short-pulse accelerator facilities (DESY, HZDR, KIT)
ARD-12	2027	Demonstration of experimental and theoretical methods for tailored 6D phase space generation (all)

2021 – 2027 PoF IV

- ST1** Advanced CW SRF-Systems
- ST2** New Concepts and Prototypes for Maximizing the Performance of Hadron & Electron Accelerators
- ST3** Advanced Beam Control, Diagnostics and Dynamics
- ST4** Ultra Compact, Novel Accelerators and their Applications

Advanced Beam Control, Diagnostics and Dynamics

Dynamics of extreme beams	Extreme range beam diagnostics	Stability, Controls & Synchronization
fs & as pulses	Time domain	Advanced Feedback controls
Coherent radiation & high fields	Frequency domain	RF controls
Custom beam: bunch shape manipulation	Particle beams	Laser controls of particle beams
Transient phenomena & large dynamic range	Photon beams	Controlling Synchronization

Technology Transfer & Networking* & Test Facilities

* & Education (Tutorials, ...)

A LOOK BACK - KEYWORDS

A start

- Attosecond metrology
- Extreme dynamic range
- Compact technology & technology for compact accelerators
- Ultra-high throughput
- Massive standardisation to maximise synergies
- Low-cost / low-maintenance systems (-> max. societal impact)
- ...
- Exploit ST3 strong points: networking, technology transfer, ...
- ST3 as “hub” within MT-ARD but also linking MT topics (DTS, DMA)
- ...



A.-S. Müller,
28.09.2018

A LOOK BACK - KEYWORDS CONTINUED

- Photon pulse diagnostics; photon synthesis
- Undulators
- Beam dynamics & beam control; coherence;
- Emittance control
- Advanced feedback controls
- Modelling (control modelling)
- Phase space synthesis
- Machine learning / AI
- Advanced injection schemes
- Laser system transport & stability
- Bunch profile control; close the loop from diagnostics to control
- High-resolution parasitic diagnostics
- System integration! (modelling, alignment, diagnostics, control, to photons... “the whole chain”)
- Stabilisation of components (e.g. RF sources)



A.-S. Müller,
28.09.2018

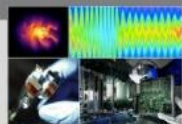
https://indico.desy.de/event/20689/contributions/40054/attachments/25682/32513/MT_ST3_POF4.pdf

ST3 – ADVANCED BEAM CONTROL, DIAGNOSTICS & DYNAMICS

Heart beat of Matter – Faster, more throughput, at highest precision

ARD subtopic 3, MT programme, POF-4: 2021-2027

Control of extreme beams at the forefront of technology



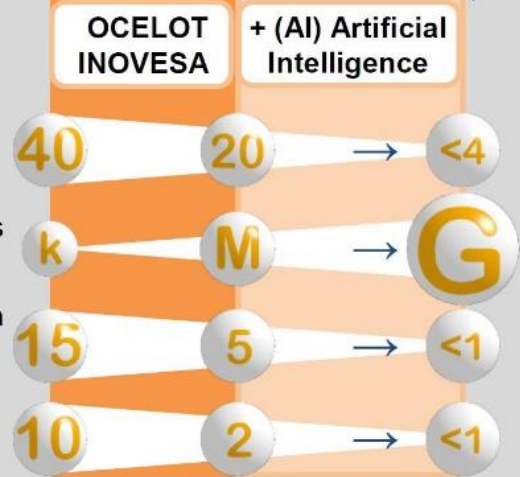
Dynamics code
micro-bunching
instabilities

XUV seeding
nm

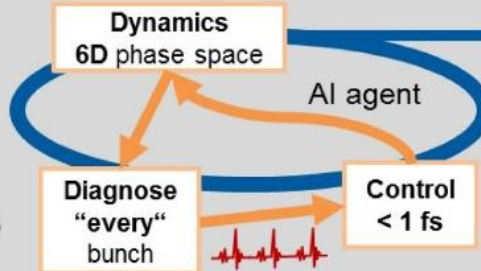
Diagnostic rates
Frames/second

Synchronization
in accelerators
fs

Time-resolved
fs



Custom & Extreme Beams Extreme dynamic range



Advanced beam control Attosecond metrology

Connecting Sub-Topics and being a hub to DTS and DMA



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ARD-ST3 KEYWORDS 2023++

Picked up from discussions during the MT-ARD-ST3 meeting

- Diagnostics
 - fC (UED, ...)
 - ST4 (optical, lasers...)
 - ...
- Dynamics
 - Non-equilibrium (cSTART, ...)
 - SSMB = Steady State Microbunch (MLS, ...)
 - ...
- Control
 - Faster (ST3)
 - Slow (ST2)
 - AI
 - ...

ARD-ST3 KEYWORDS - POST-DISCUSSION

- General
 - Structured beams, microstructured beams, for FEL and storage rings/synchrotrons
 - Could be an important cross-center topic (MBI, seeding, SSMB, ...)
 - Non-equilibrium physics (cSTART, ...)
 - UED (fC bunches at high repetition rates, extension of the limits on dynamic range, source development, challenges for non-invasive diagnostics in general).
 - FEL source development and high brightness beams (e.g. RF/SRF guns)
- Beam Diagnostics
 - Non-invasive diagnostics (e.g. photon detection: transition radiation, dynamic range, ST4 topics, etc.)
- Beam Dynamics
 - Non-equilibrium beam dynamics
 - Models in general, also for ion beams (spilling).
- Beam Control
 - AI at the most difficult level with reinforcement learning and on hardware for real-time.
 - Define interface, boundaries with ST2.