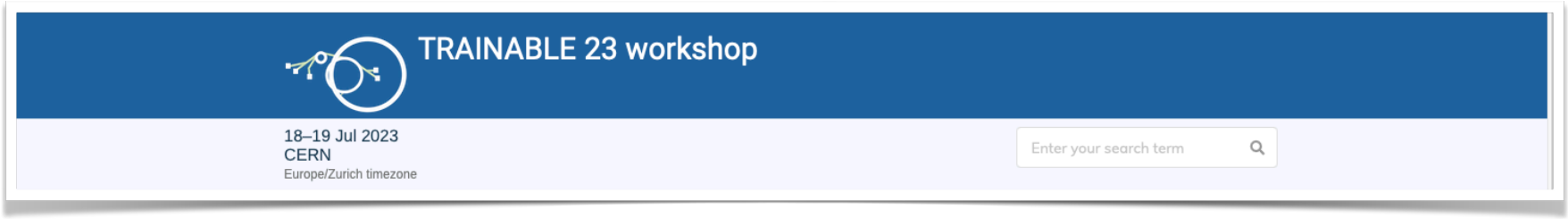

optimisation

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What - 2 main aspects

Control/optimisation solution to overcome lack of accurate, invertible models and/or observables

- ✳ Clear link with data generation WG

→ Advanced algorithms for automatic multi-parameter control, optimisation and stabilisation for running facilities and simulation

- ✳ Adapting or developing new algorithms as well as applying existing ones do accelerator domain

→ Together with infrastructure and hardware/instrumentation design considerations

- ◉ Will need to underline contrast or specificities in comparison with EURO-LABS and other INFRA-TECH project

Why - the story line

Current approach of operating/optimising/designing particle accelerators does not necessarily scale because

- Next generation machines more demanding requirements for various parameters or scale: light sources, FCC,…
- Upcycling existing facilities: more efficiency - more stability - faster commissioning - more flexibility → many more users, more set ups, more physics in less time and for less money.
- Additional constraints: energy efficiency, sustainability
- Additional constraints: reduce operational cost of future machines

Impact - scientific

- Autonomous accelerators for highest performance, reproducibility and flexibility
- Global sample-efficient design optimisation in simulation
- Defines how to operate FCC

Potential publications at

- ICALEPCS
- IPAC
- Potentially: solution for "hard" problem for PRAB
  - E.g. source control

Impact - societal - AI and society

- Training, creating new profiles and expertise in accelerator domain
- Democratising accelerator operation expertise, faster training for new operators

Need to carefully introduce autonomous systems to avoid push back:

- Transition phase: autonomous systems as “assistant”: → half-autonomous approach to start with.
  - Use uncertainties to set threshold for autonomous/half-autonomous.
  - Design user interface such that can integrate human control while have algorithms running. Existing example of RF system at TEX facility EuPraxia

Objectives - optimization WP

- Establish: **status and limitations** of current optimisation approaches for particle accelerators
  - What is common practice, what still needs research?
- **Guideline** for minimum set of facility **controls infrastructure** and equipment communication for AI
- **Common code base** for optimisers and optimisation problem definition → shareable package
- **Autonomous accelerator test** - need to find facility to host it
  - Facility to guarantee: several control aspects, complex enough hardware
    - Drift control
    - Optimisation after mode/set up changes: auto-launch mode
    - Potentially real time control

Task 1

Overall coordination, communication, knowledge sharing

- Organise mini-workshop for "status and limitation of current optimisation approaches”
  - Define what is missing? Set up discussion with AI experts in case
  - Prepare report
- Set up example catalog, collect/organise training
  - Cover: control theory, optimisation, RL, modelling for accelerator control
- Help porting optimisation/control solution to other accelerator for similar problem

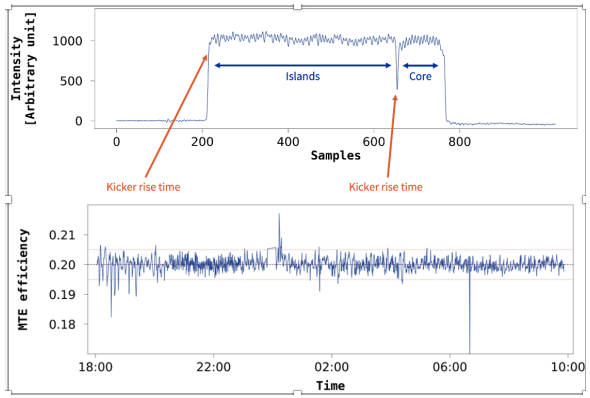
Task 2

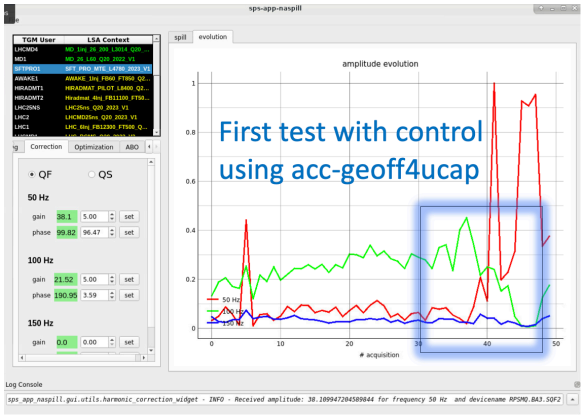
Methods for autonomous accelerators: packages and interfaces for accelerator use cases

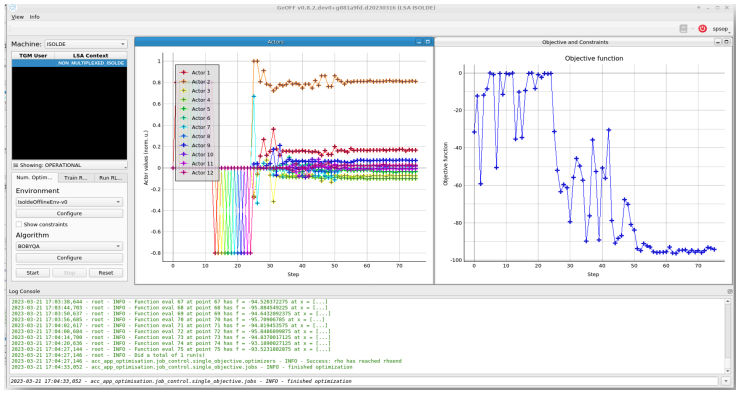
Keywords:

- Sample-efficient, low latency, time varying, safe, noise robust, end-to-end control problem (images as input, non-destructive virtual diagnostics, virtual 6D-phase-space reconstruction,…), interpretable
- Scalability, portability

Overlap with Eurolabs projects: define demarcation







Task 3

Control infrastructure for AI

Keywords:

- Python for control room/control system aka remote device access (a la CERN pyjapc, pyda)/everything abstraction layers
- Data archiving and data retrieval
- Infrastructure for auto-pilots
- Lifecycle management for models
- GPUs on TNs
- Settings management
- Infrastructure for continuous training
- …

Task 4

Integration for pilot project: autonomous accelerator test

- "Who wants to have the first autonomous accelerator?
- Potentially build on advanced use of automation at TEX facility EuPraxia → new small LINAC to be built end of next year
- Potential alternative: CLARA at at Daresbury Laboratory (subject to discussion with STFC/ASTeC)
- Organise collaboration, system design for autonomous operation and integration of control algorithms/auto-pilots
  - **Overlap with anomaly detection for fault prediction/prevention**
- Organise representative test series

Deliverables in order of time

- Status and limitations of current optimisation approaches
  - Through mini-workshop
  - Report of mini-workshop
- Publish optimizer and problem definition package
- Demonstration of methods in real conditions
  - Include simulation: e.g. DA, emittance optimisation for FCC
- Survey of control infrastructure status in European labs
- Guidelines for controls infrastructure for AI
- Demonstrator: autonomous accelerator

Collaboration with Industry

Ideas at this stage. Will need follow-up.

- Cosylab, controls manufactures
- photo cathode laser for TEX: AI compatibility of controls? Manufacturing data for digital twins in control algorithms?
- MedAustron/CNAO, European XFEL, Elettra?

Comment

- Target slide: not representative enough for WP optimisation