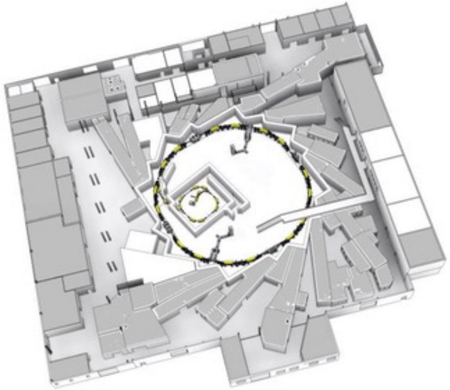
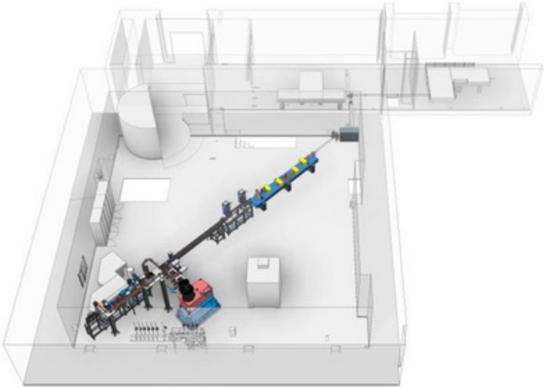
Highlights & News @KIT

Andrea Santamaría García, Niky Bruchon, Michele Caselle, Erik Bründermann, Andreas Kopmann, Chenran Xu, Anke-Susanne Müller

ACCLAIM Innovationspool (25-06-2021)





New publication

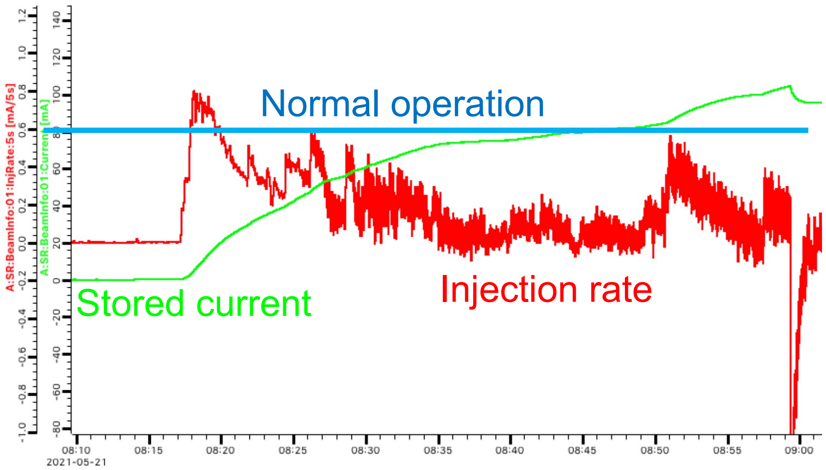
"Accelerated Deep Reinforcement Learning for Fast Feedback of Beam Dynamics at KARA" (W. Wang et al)

IEEE Transactions on Nuclear Science, DOI: 10.1109/TNS.2021.3084515

News MT ARD

WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)

- New **power supplies** for **kicker** and **septa** magnets installed at KARA
- Commissioning needed to find **new magnet settings**



Opportunity to use our previously developed **Bayesian Optimization** algorithm to improve the injection rate

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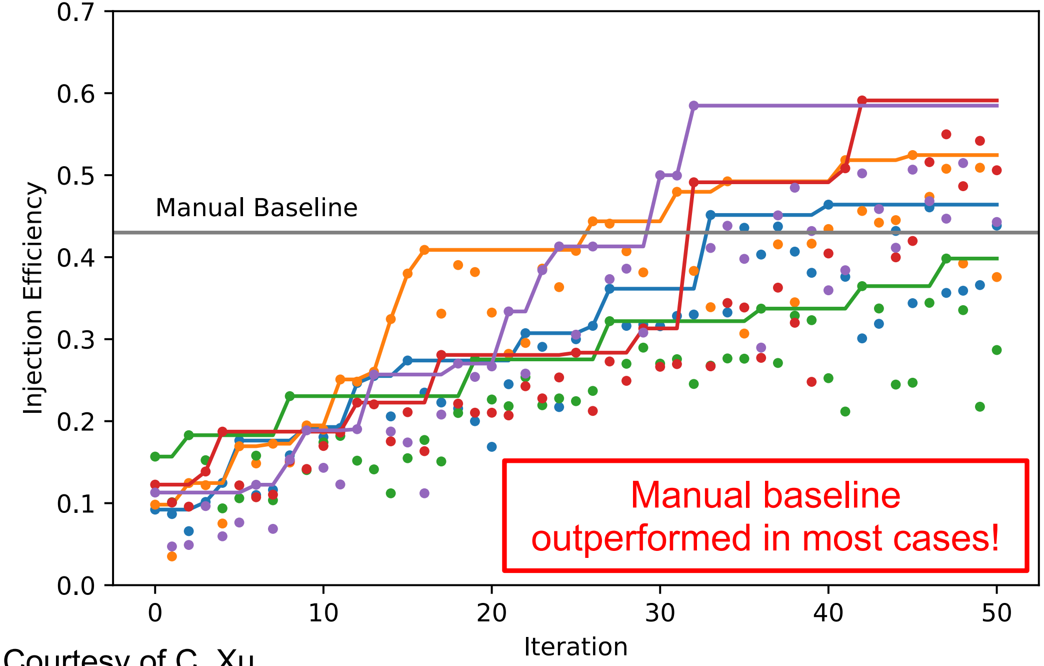
Karlsruhe Institute of Technology

WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)



Courtesy of C. Xu

- 5 different runs
- Upper Confidence Bound as acquisition function
- Using estimated parameter range
- Fluctuations partly come from unstable pre-injectors (booster extraction septum)

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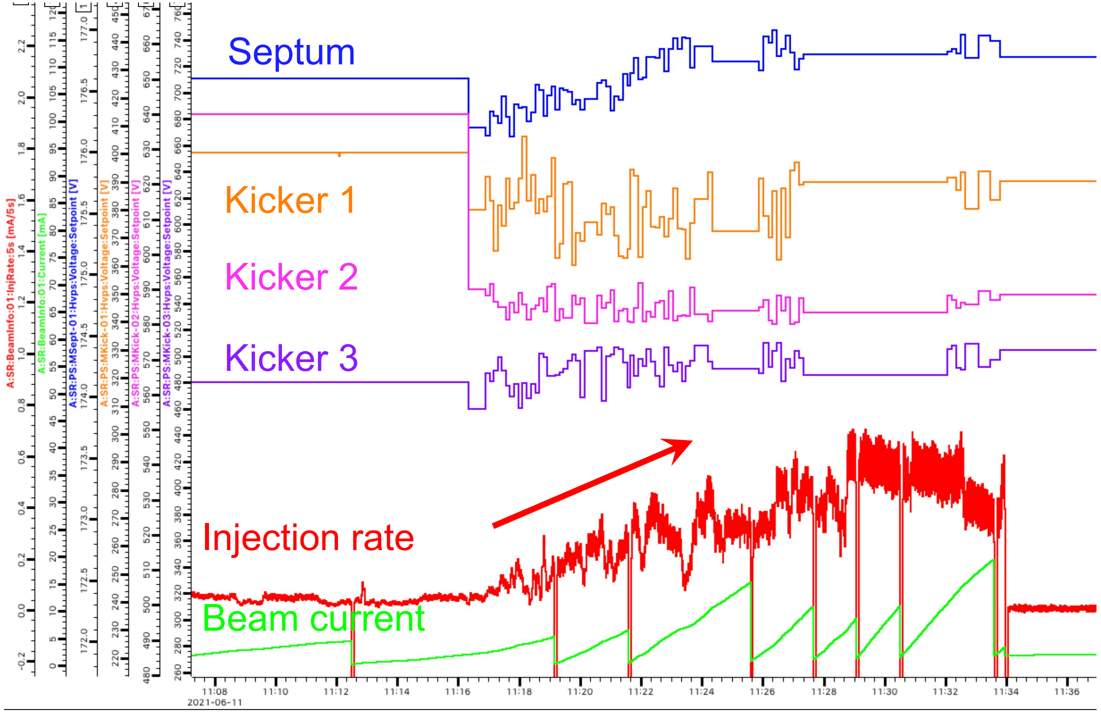
WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)

Bayesian Optimization package can be used for any type of beam physics!

Measurement with single bunch mode →



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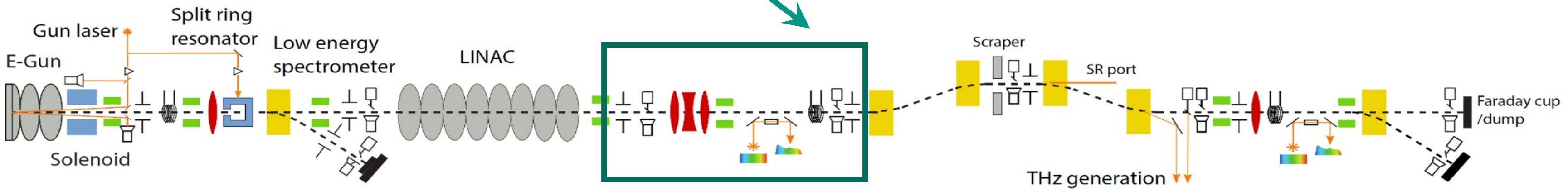
WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)

Autonomous Accelerator Project (KIT+DESY): Reinforcement Learning at FLUTE

Collection of OpenAI gym environments for accelerator tasks:
- ARES experimental area beam focusing
  - Quad triplet + 2 correctors
- FLASH SASE tuning

@Jan Kaiser,Oliver Stein

Start to implement FLUTE tasks & models



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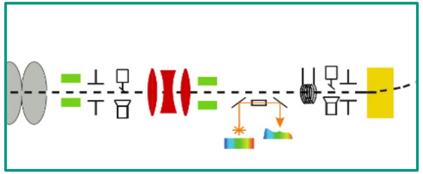
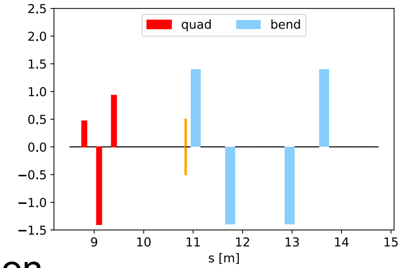
WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)

Toy environment with simplified FLUTE lattice:

- Between the linac and bunch compressor
- Consisting of a quad triplet and a screen
- **Goal: focus the beam**





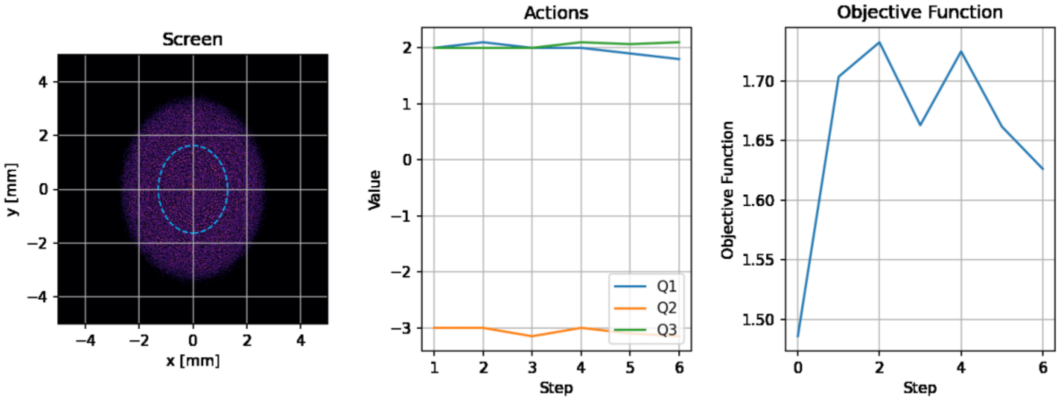
Using beam dist from ASTRA simulation

Allow optimization both by RL agent and traditional optimizers

First tests using scipy Nelder-Mead optimizer →

Objective = $\max(\sigma_x, \sigma_y)$

Actuators = $[Q_1.k_1, Q_2.k_1, Q_3.k_1]$



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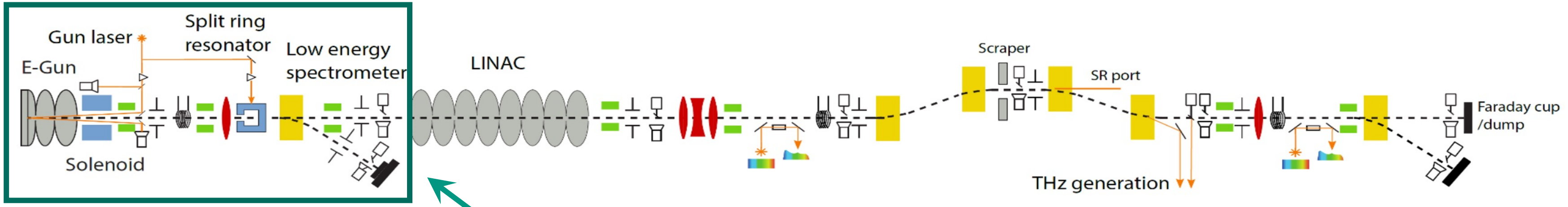
WP2: Applications of AI to accelerator tuning and control (DESY, GSI, HZB, KIT)



Next steps

- Test different RL algorithms
- Implement gym env for low energy section
  - Actuators: Gun phase, amplitude, solenoid, ...
  - Objective: $E, \sigma_E, \sigma_x, \sigma_y$
  - Use ASTRA as simulation backend
  - All devices are installed and working → **measurement possible**

Courtesy of C. Xu

News MT ARD

WP3: Machine detection and prediction of anomalies (DESY, GSI, HZB, KIT)

First efforts on Beam Position Monitor (BPM) anomaly detection

BPM faults are not interlocked, are detected late, difficult to interpret

Recorded faults:

Date	Description
12.04.2021	BPM restart loop
22.10.2020	Sudden variation of BPM charge button
16.10.2019	Sudden variation of BPM charge button
06.09.2019	Faulty fan in BPM cooling system
04.09.2019	BPM RAM usage warning
28.10.2016	No data readout

- Few events recorded (data asymmetry)
- Heterogeneity of fault types

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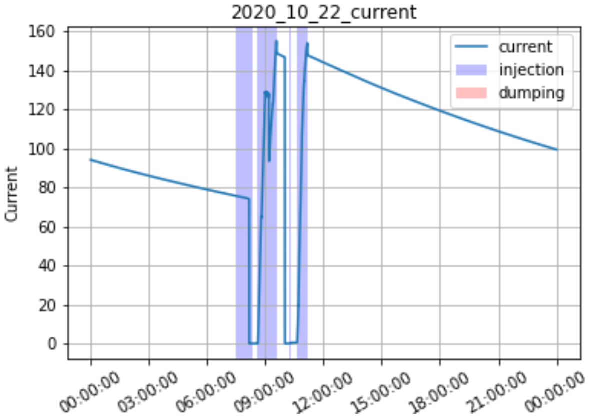
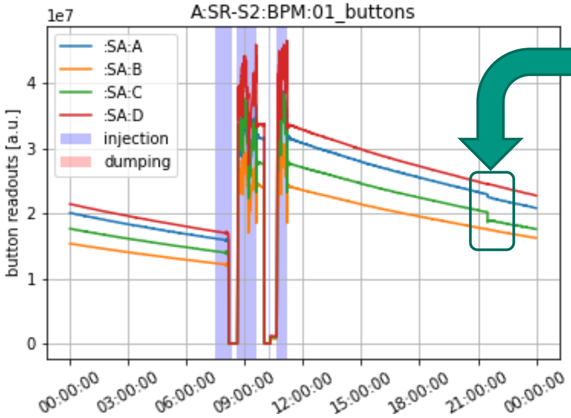
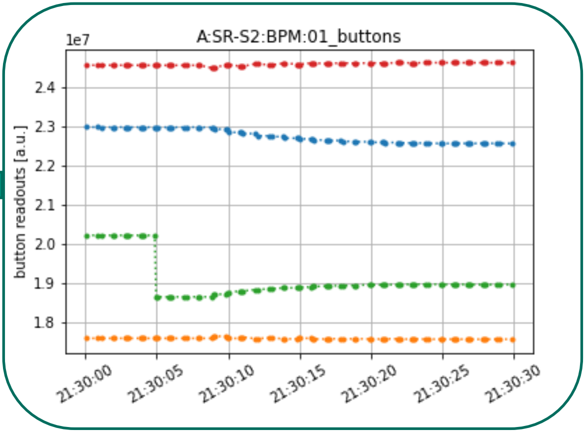
22.10.2020: sudden variation of charge in button



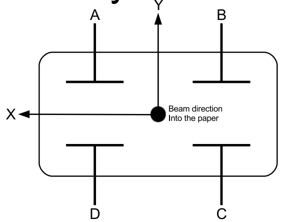
Current along all day



Faulty BPM buttons charge



Anomaly on button C



Courtesy of N. Bruchon

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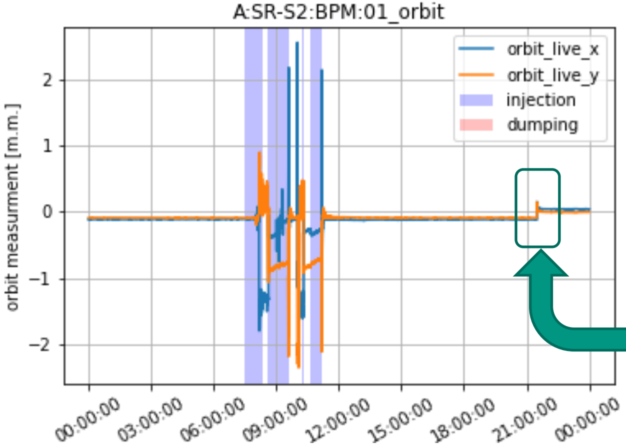
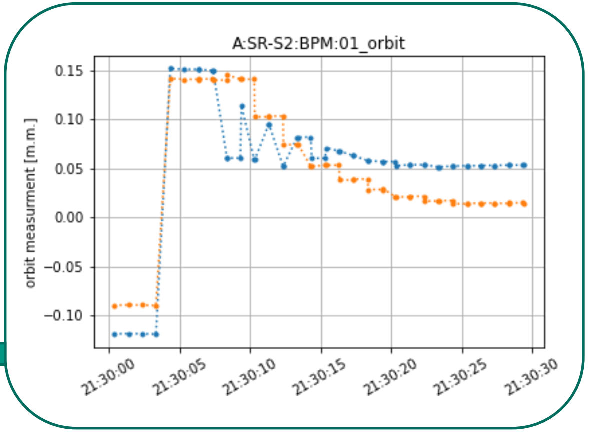


Faulty BPM orbit



Anomaly on button C

Courtesy of N. Bruchon

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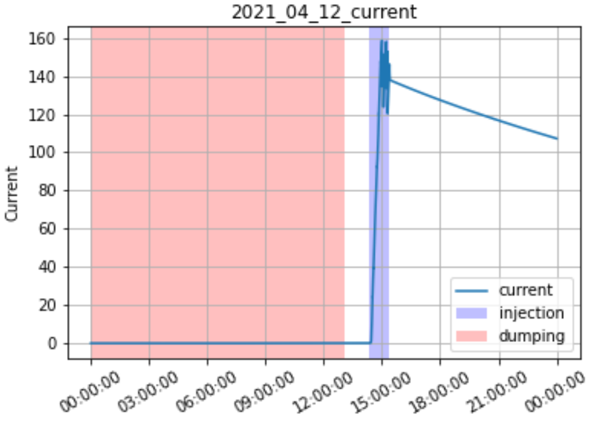
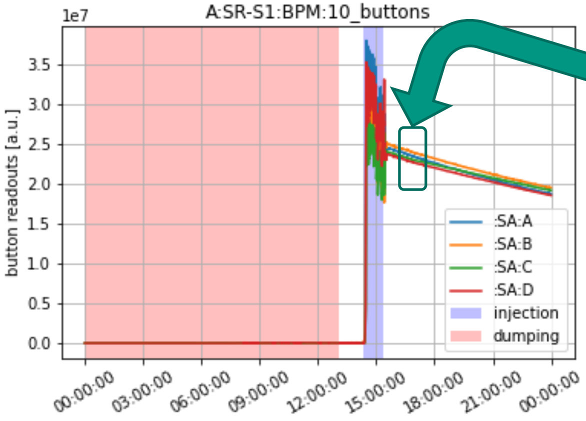
WP3: Machine detection and prediction of anomalies (DESY, GSI, HZB, KIT)

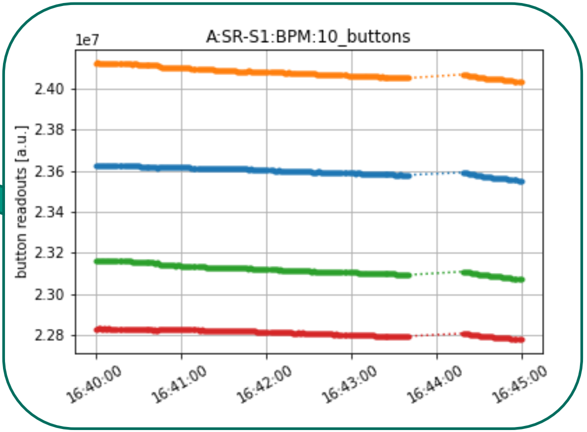
12.04.2021: restart of firmware



Current along all day



Faulty BPM buttons charge



Missing data

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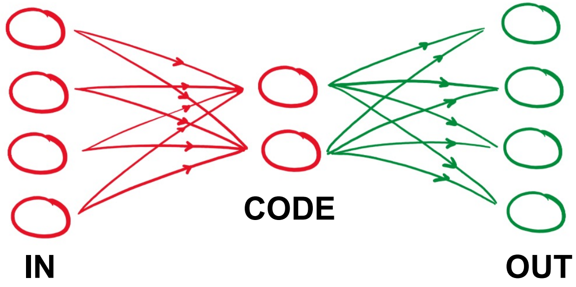
WP3: Machine detection and prediction of anomalies (DESY, GSI, HZB, KIT)

Next steps

AUTOENCODER:



- Bottleneck architecture → condensed representation
- Training without faulty data → high fidelity reproduction
- Anomaly sufficiently distinct → higher recostruction loss
- Loss threshold → anomalies will be above the threshold