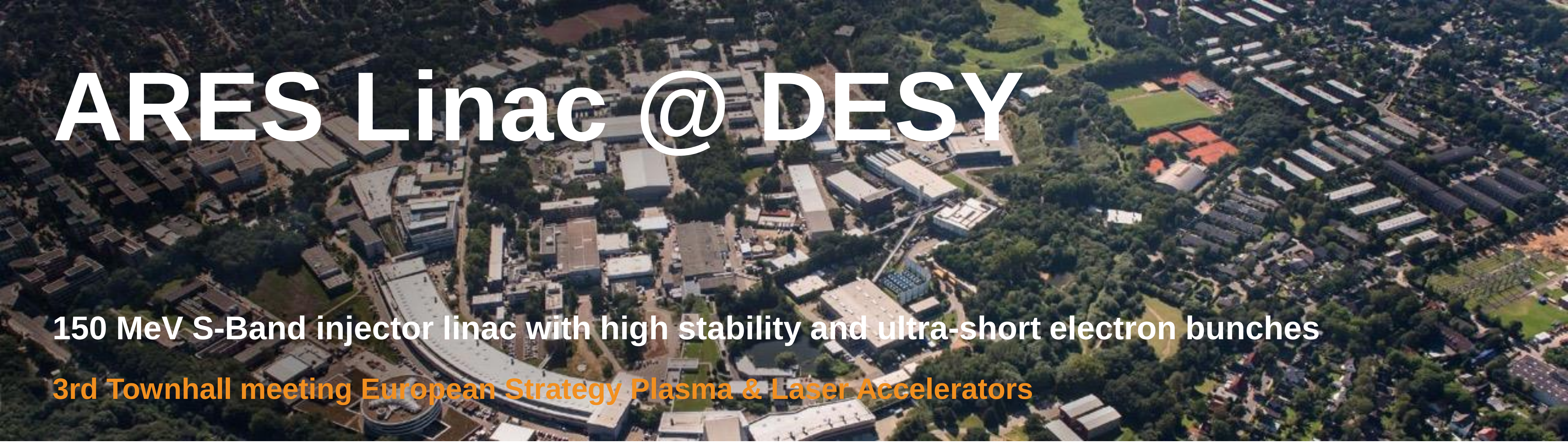


ARES Linac @ DESY

150 MeV S-Band injector linac with high stability and ultra-short electron bunches

3rd Townhall meeting European Strategy Plasma & Laser Accelerators

F. Burkart for the ARES team

with input from R. Assmann, H. Dinter, S. Jaster-Merz, W. Kuropka, F. Mayet, T. Vinatier

Acknowledgements to U. Dorda, B. Marchetti, R. Brinkmann, W. Leemans and the DESY M Technical Groups

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

SINBAD

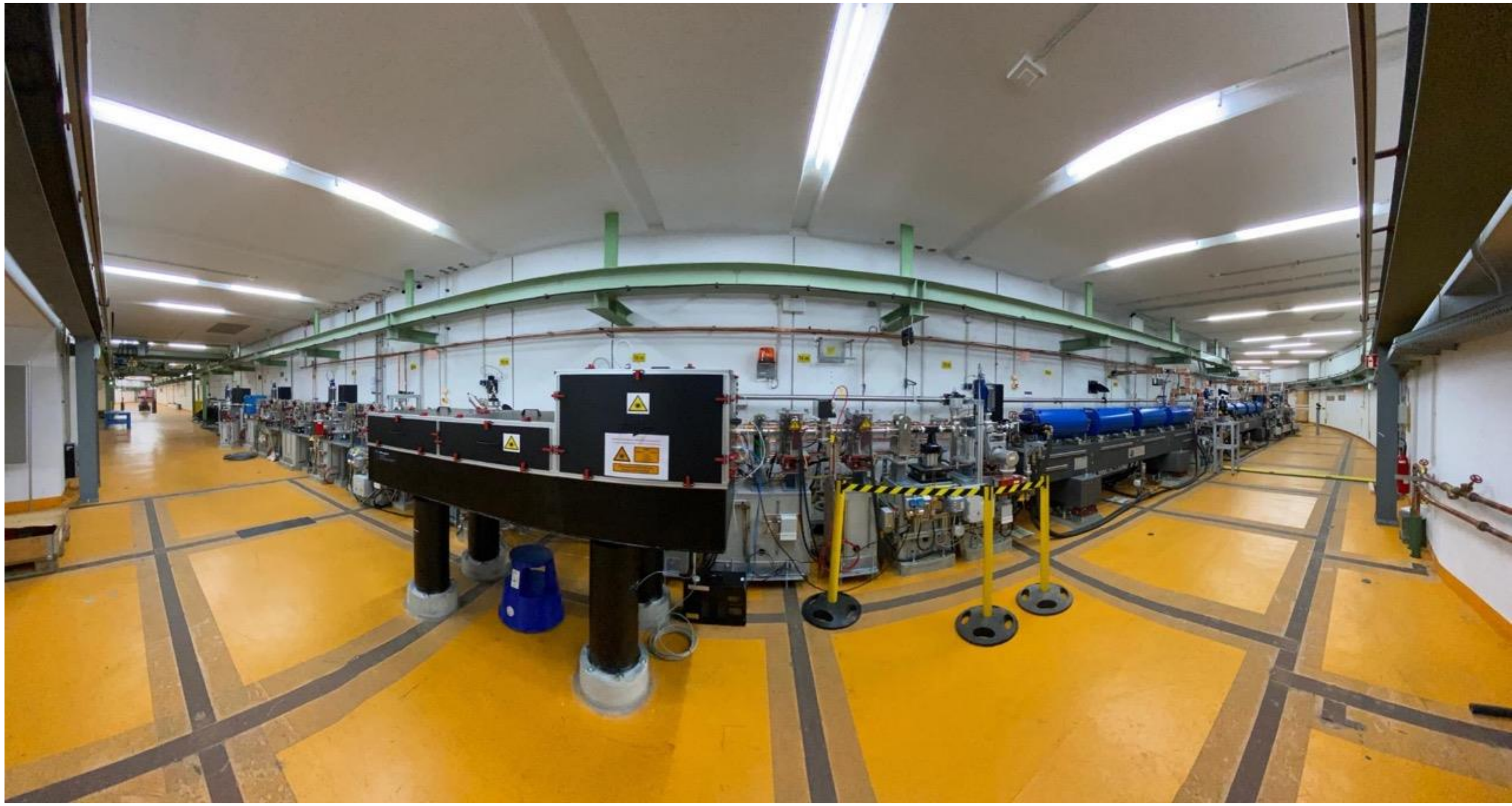
M T ARD

DESY.

SINBAD ARES - Linac

Short reminder

- Normal conducting S-band electron linac for the production of **ultra-short bunches**
- **Novel acceleration techniques / beam manipulation testbed (DLAs, fibers)**
- **Accelerator components R&D**
- **Autonomous accelerator**

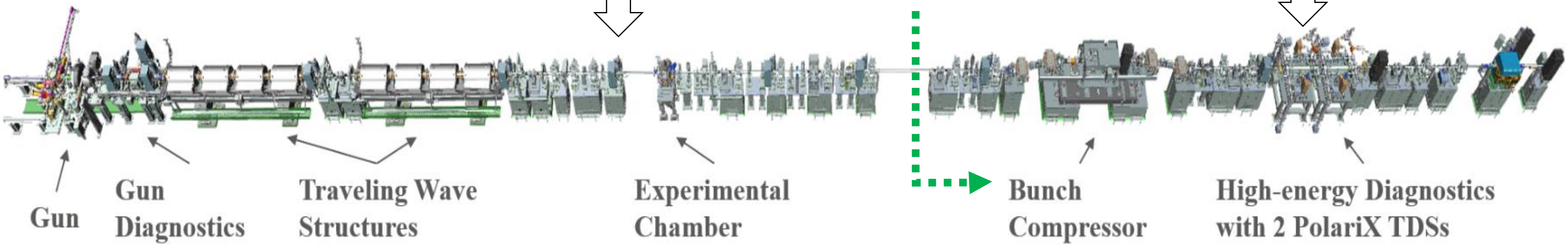


- Target Parameters:
  - 50 - 155 MeV,
  - 0.5-200 pC,
  - single pulse @ 50Hz,
  - few fs / sub-fs pulse length,

ARES Layout

PolariX collaboration with CERN & PSI
Successful commissioning of the PolariX structure in collaboration with FLASH / FF
Needed for:
→ **Full-characterization** of phase space of **few fs-long** electron bunches.

First experimental area
injection into DLA (ACHIP)

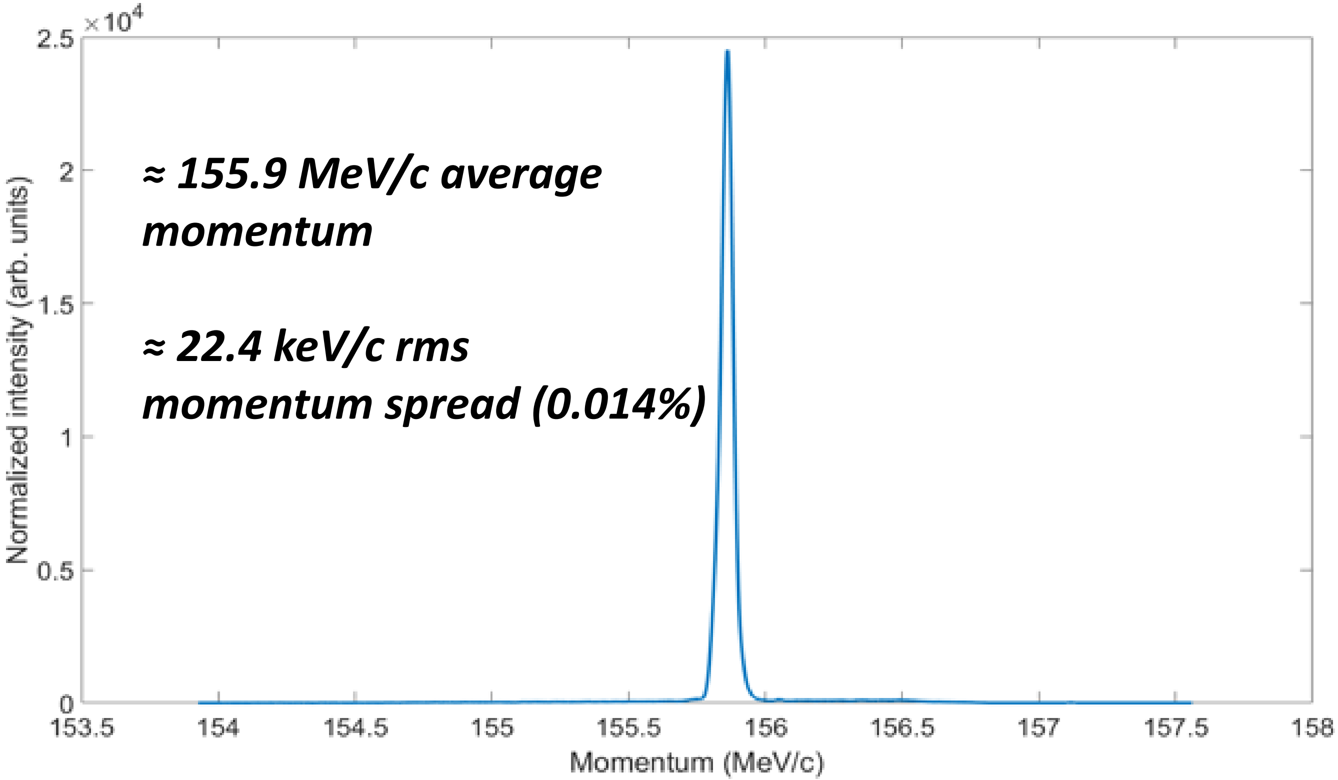


Required for the production of short pulses
Beam Diagnostics, Collimators, movable girder

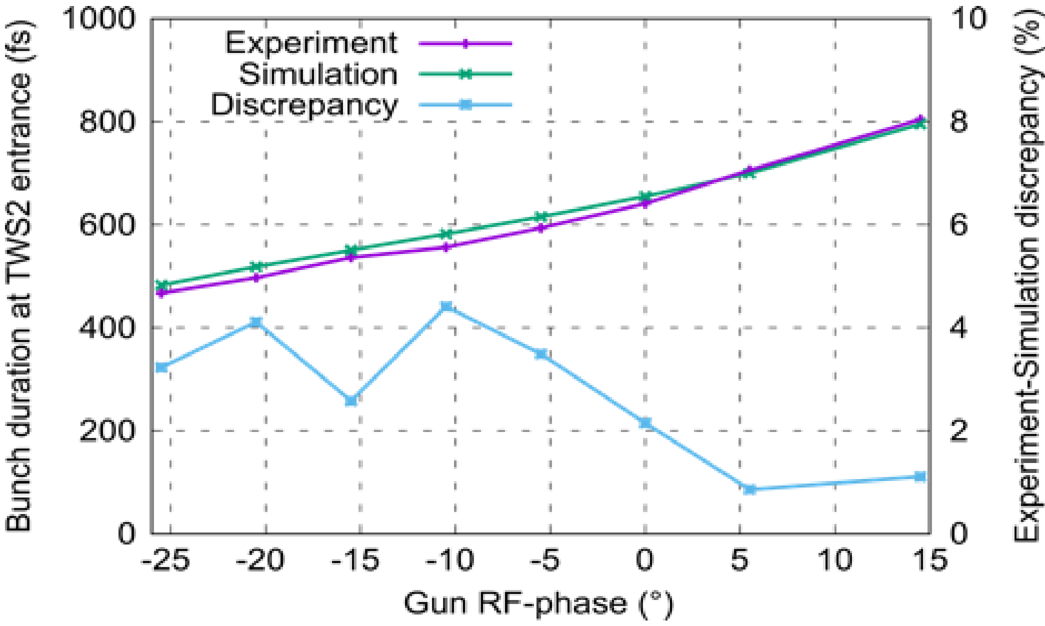
Beam at the end of the beamline!

With good momentum spread and stability

- Nominal beam momentum of 156 MeV/c reached.
- First studies for velocity bunching.
- **Reached the first milestone.**



Minimum momentum spread measured after the 2 TWS



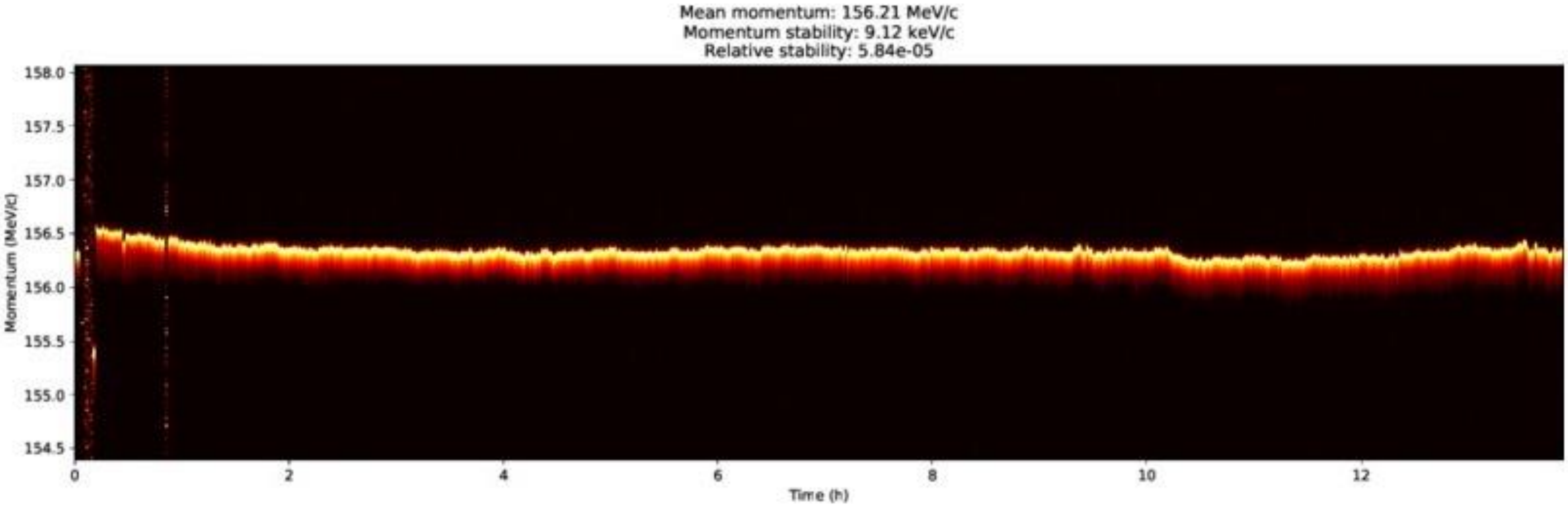
Bunch length measurements

- ≈ 1 pC; Gun at 70 MV/m; laser at 100 fs rms Gaussian and 320 µm Ø flat-top).
- Measurement performed close to 3-phase method and tomography resolution limit (few tens of fs rms).
- ***Best measured so far: 85 fs***
- ***Optimization and data analysis ongoing.***

Unprecedented stability at ARES

High precision temperature and modulator stabilization has resulted in excellent stability and reproducibility:

- 17 μm rms position jitter (5-10% of $\sigma_{x/y}$)
- **5.8e-5 rms relative energy stability** over 14 hours (63 hours with 2.4e-4) – still w.o. LLRF feedback fully operational.



Commissioning beam parameters

Parameter	Design parameters	Actual commissioning parameters
Energy	50 – 155 MeV	50 – 156 MeV
Charge	0.5 – 200 pC	0.1 – 100 pC
Rep. rate	Single pulse @ 50 Hz	50 / 10 Hz
Bunch length	few fs / sub-fs pulse length	85 fs (w/o magnetic bunch compression)
Norm. Emittance	norm. emittance: < 0.8 mm*mrad	< 0.5 mm*mrad

Nominal working points	Description
Working point R1	High-charge bunch: 100 MeV, 100 pC, sub-ps duration, ≤ 2 π.mm.mrad
Working point R2	Ultrashort bunch: 100 MeV, ≤ 1 pC, sub-fs duration, ≤ 1 π.mm.mrad
Working point R3	High-current (still ultrashort) bunch: 100 MeV, 20 pC, few fs duration, ≤ 1 π.mm.mrad

Summary

- **ARES is operational** at its first working point
  - Reached design energy
  - Beam characterization and optimization ongoing
  - Excellent stability results.
- First beam tests with **ACHIP collaboration – more users to come**.
- Installation of bunch compressor and Xband TDS currently ongoing.
- Next commissioning **step towards short pulses** in the second half of 2021.
- ARES design can be used as **prototype injector** with
  - short pulses
  - excellent stability and beam quality
  - well known/measured bunch properties.

Q&A Part I

1. Where do you see HEP applications of advanced accelerators in 30 years?

2. What intermediate physics applications/steps do you see until a HEP linear collider?

   - Beam quality improvement
   - Stability improvement
   - Reproducibility
   - Higher rep. rate

3. What is the synergy with related fields

   - Test bed for autonomous accelerator development, applicable to state-of-the-art light sources

4. What is the role of your work here?

- R&D to improve beam quality, stability and reproducibility
- R&D on advanced beam diagnostics
- R&D on accelerator components

Q&A Part II

1. What are the important milestones for the next 10 years to get there from today?
    - Stable, high quality beam for injection into novel acceleration schemes.
    - Tools to characterize the phase space of short electron pulses (fully operational XBand TDS).

2. What additional support is needed to achieve these?

3. What should be proposed as deliverables until 2026? Please list in order of priority.
    - Stable operation of RF-based accelerators with high stability and reproducibility and ultra-short pulses as injectors.

4. Is the R&D work for each of those deliverables already funded and, if not, what additional resources / support would be needed?
    - Yes.

Q&A Part III

1. What key R&D needs can be achieved in existing R&D facilities?
    - Demonstration of proof-of-principle experiments
    - Training of personnel and students, which will operate future machines
2. What is the role of the already planned future facilities in Europe and world-wide?
3. What can be done with the existing and planned funding base?
4. Is a completely new facility needed?
    - No. (In the case of developing an excellent beam quality from an RF injector.)
5. Are additional structures needed beyond existing networks and projects, e.g. a design study for a collider or an advanced accelerator stage?
    - Yes

THANK YOU!

Contact

DESY. Deutsches Elektronen-Synchrotron

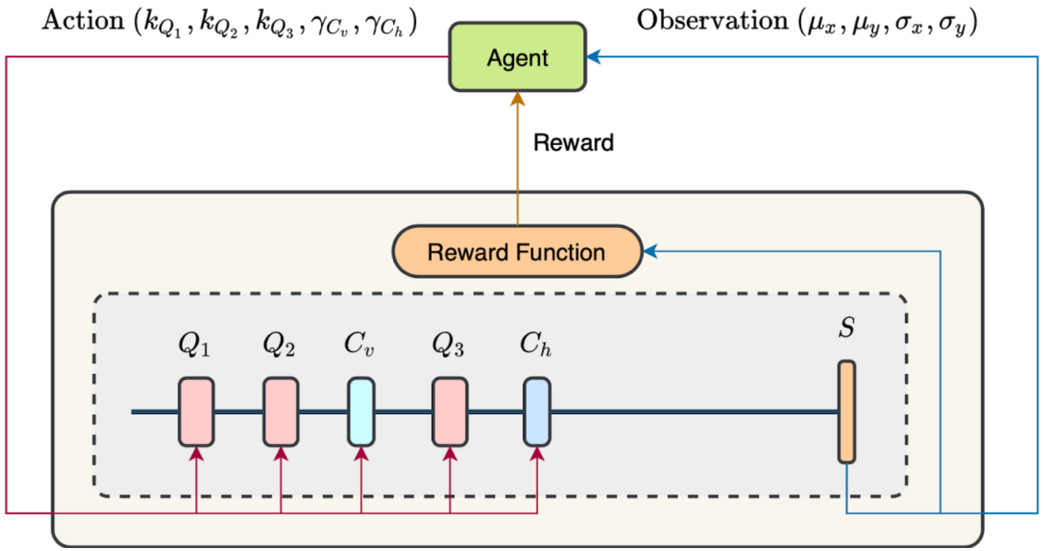
www.desy.de

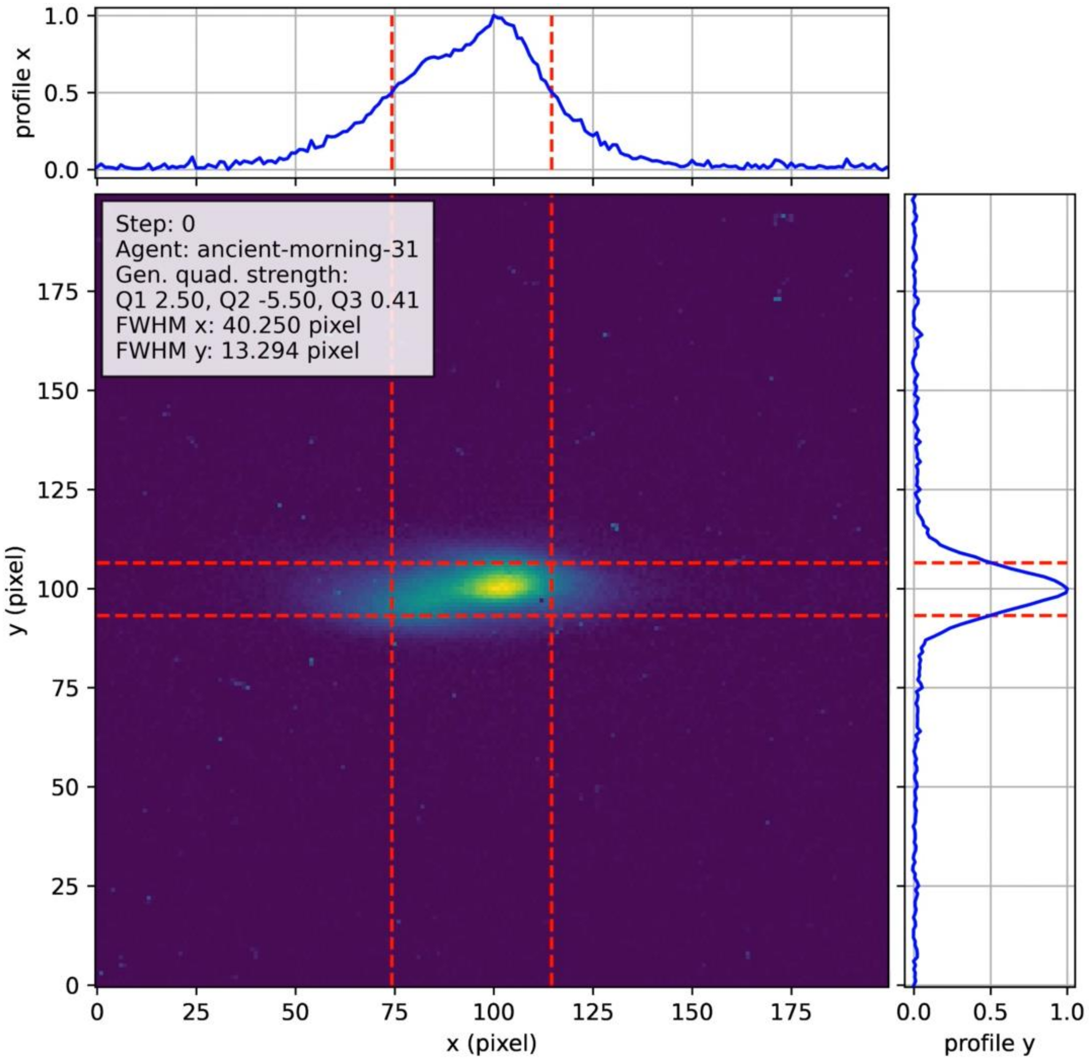
Florian Burkart
MPY1
florian.burkart@desy.de
+49-40-8998-3039

Reinforcement Learning at ARES – regular beam times

Automation and Optimisation of Accelerator Operation using Artificial Intelligence

- 2-year project funded by Helmholtz AI, collaboration of DESY and KIT
- **Proof-of-concept**
  Autonomously focus and centre beam in the ARES experimental area in a matter of minutes using quadrupole triplet and corrector magnets





Results from beam time at ARES on 14 April