HZB Facility Talk

Thorsten Kamps

Helmholtz-Zentrum Berlin and Humboldt-Universität zu Berlin

HGF MT ARD ST3

ST3 Annual Meeting, Dresden, 05. to 07.07.2023

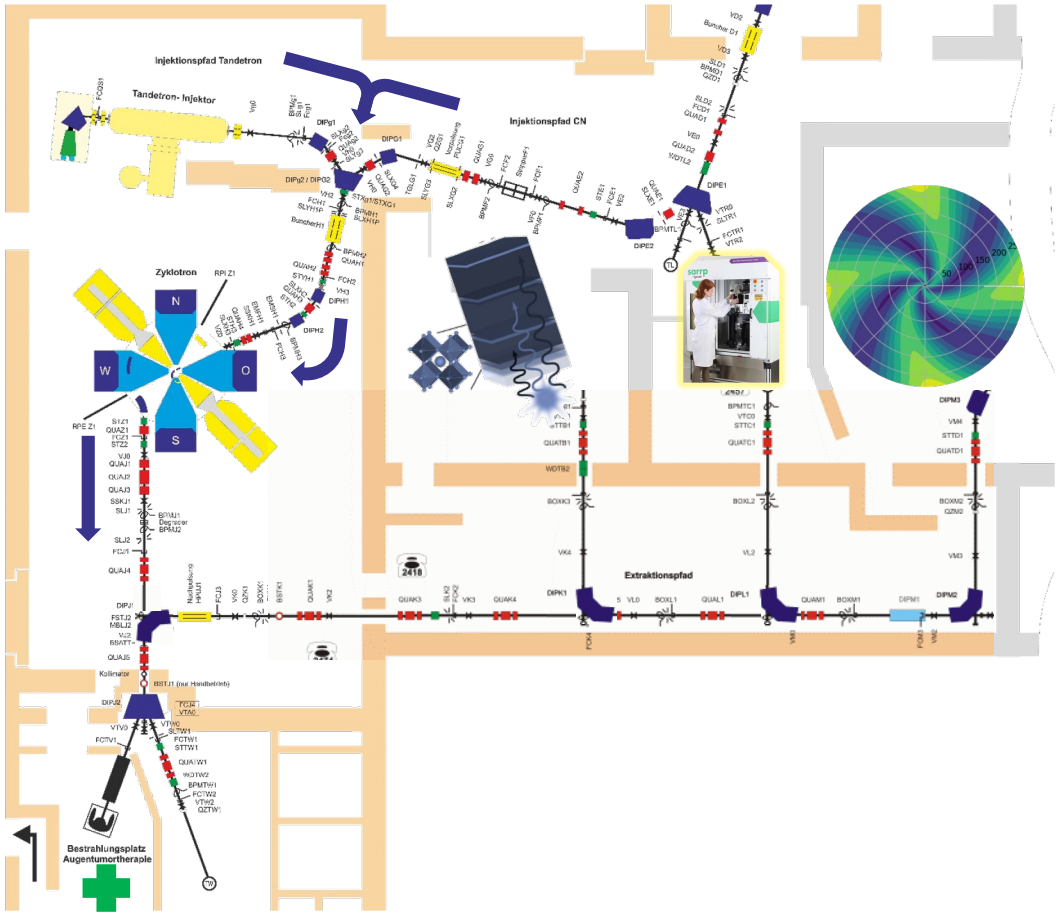
Today

- Our facilites for proton therapy,
- Walk you through Bessy II, its upgrade path and Bessy III,
- Take you to SEALAB: Accelerator R&D for ultrafast scattering applications
- Conclude and open some points for the transition from PoF IV to PoF V

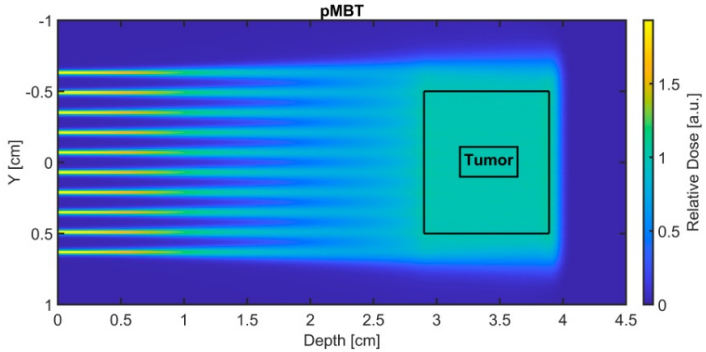
Disclaimer

- Stay tuned for the presentation by Arnold Kruschinski on Steady State Microbunching and related activities at the Metrology Light Source, Thursday afternoon
- Will leave out activities related to Superconducting Radio-Frequency (SRF) developments like VSR Demo, check ARD-ST1
- Would like to thank all my colleagues at HZB and elsewhere to help with material for this presentation.

Protons for eye tumor therapy and accelerator R&D

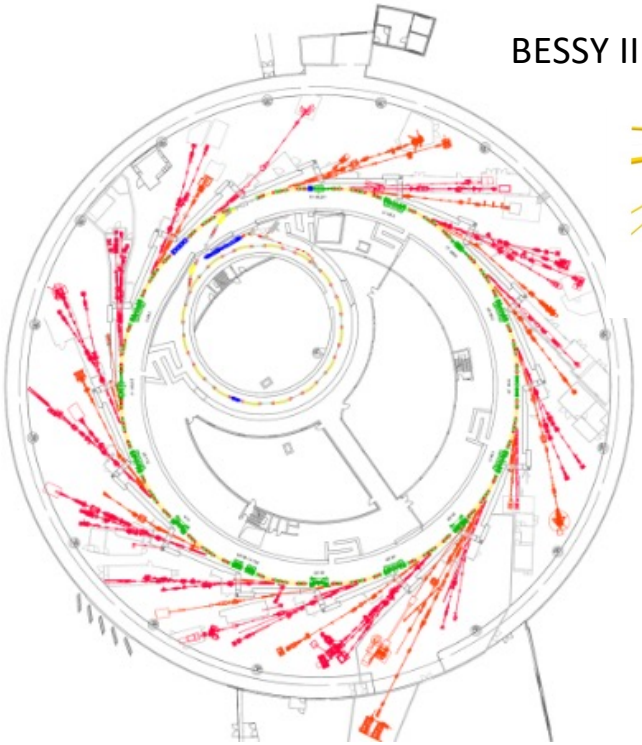


Dose distribution for proton minibeam studies

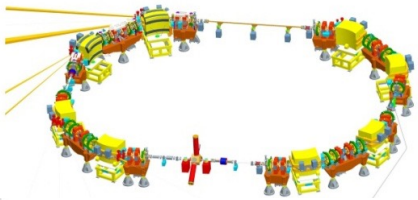


A. Denker, et al. IPAC 2023 – THPM129
G. Kourkafas, et al. IPAC 2023 - THPM065
A. Rousseti, et al., IPAC 2ß23 – THPL043

Two radiation sources – UV and Soft X-Rays for materials discovery



BESSY II



Metrology Light Source

PTB

The goal is to develop more **sustainable methods and technology** to expand the research possibilities and allow for:

Sustainable Science

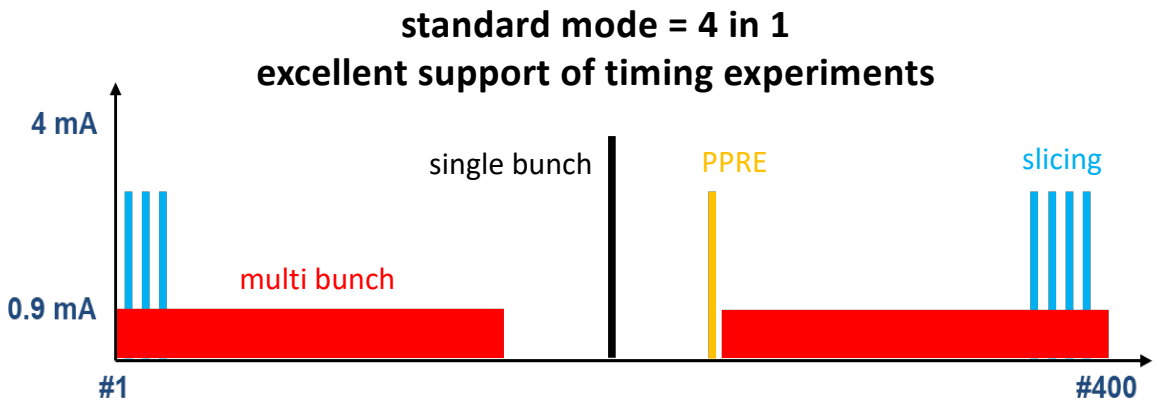
We develop, operate, maintain and modernize our accelerators to provide unique research opportunities

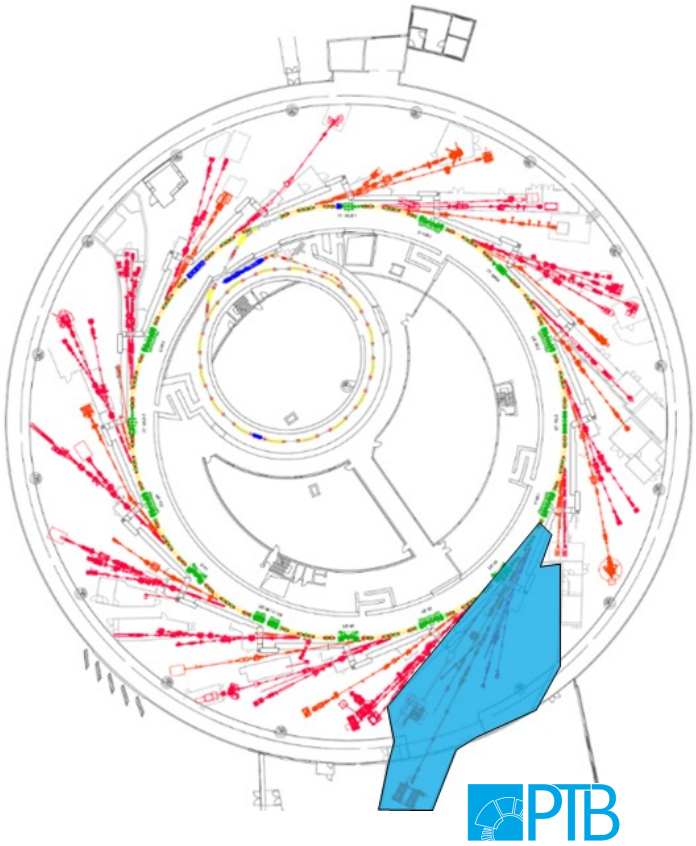
Our synchrotron radiation source Bessy II

HZB BESSY II Light Source

Bessy II, a soft X-ray light source with 36 beamlines (13 undulators, 2 wave length shifters), setup from 1992 to 1998, in user operation since 1999. Constantly evolving.

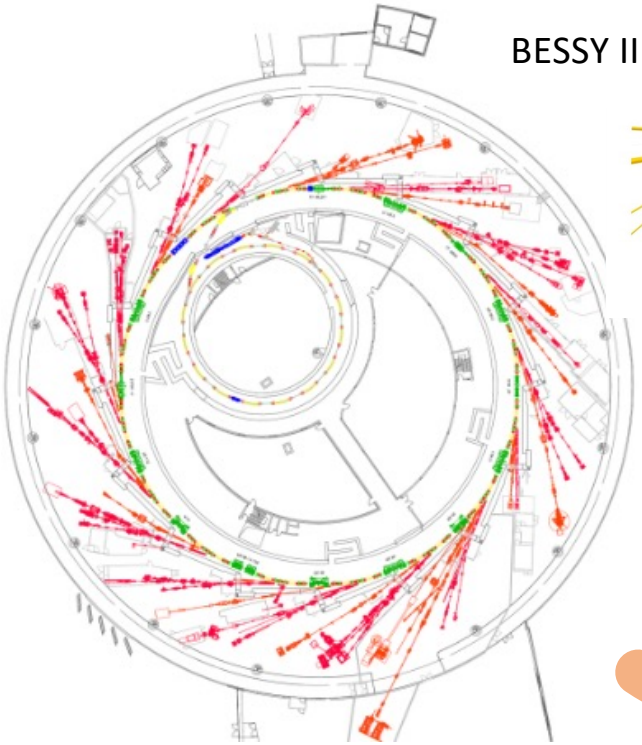
Complex fill pattern supporting imaging, spectroscopy and timing experiments: low-α mode for ps beams serving CSR and THz, femto slicing for 100 fs beams for pump probe applications



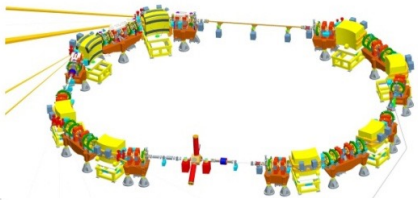


A. Jankowiak, M. Ries, A. Schälicke

One center, two campuses and many accelerators



BESSY II



Metrology Light Source

PTB

BESSY III

& MLS2

PTB

BESSY II+

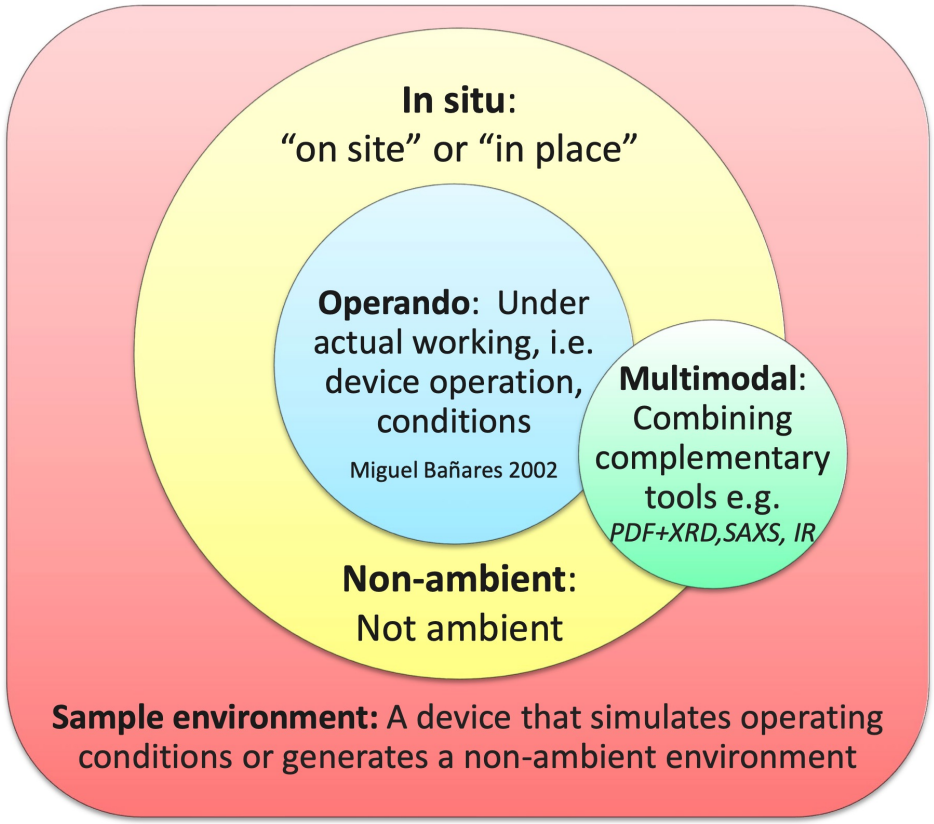
Operando
- *Scientific focus: Energy, catalysis and green IT*
- *New instruments and sample environments*

Modernisation
- *Stable & reliable accelerator performance*
- *Improved digitalisation, automation & remote access*
- *Lower barriers & higher instrument output*

Sustainability
- *Increased self-sufficiency of energy supply*
- *Reduced energy consumption*

P. Gaslowski, et al., IPAC 2023 – WEPL036
O. Schwarzkopf, et a., Eur. Phys. J. Plus (2023) 138:348

In operando?



vs

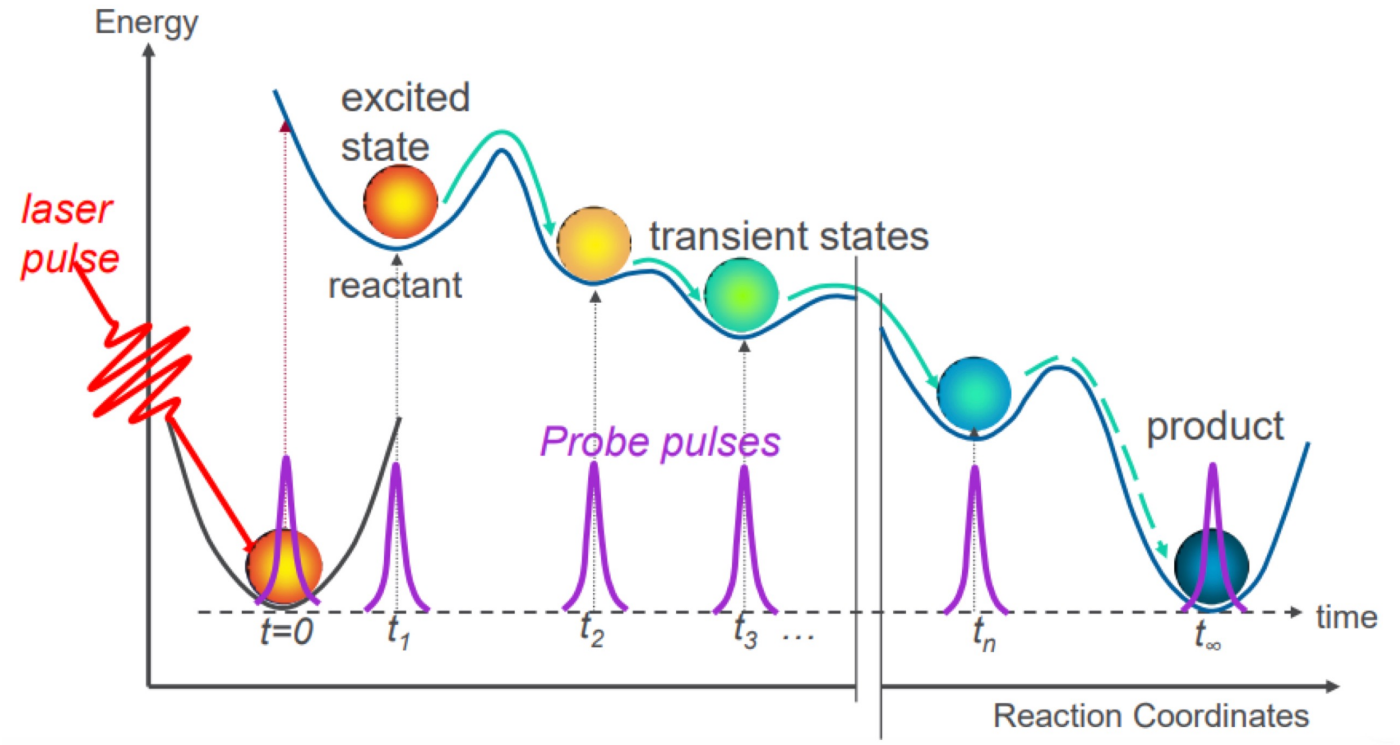
ex situ:
"off site"
or recovered

Courtesy
Karena W. Chapman

IUPAC Project 2021-009-2-500 : to clarify Latin terms used to describe the characterization of materials made under non-ambient conditions, materials within systems, and of materials during change

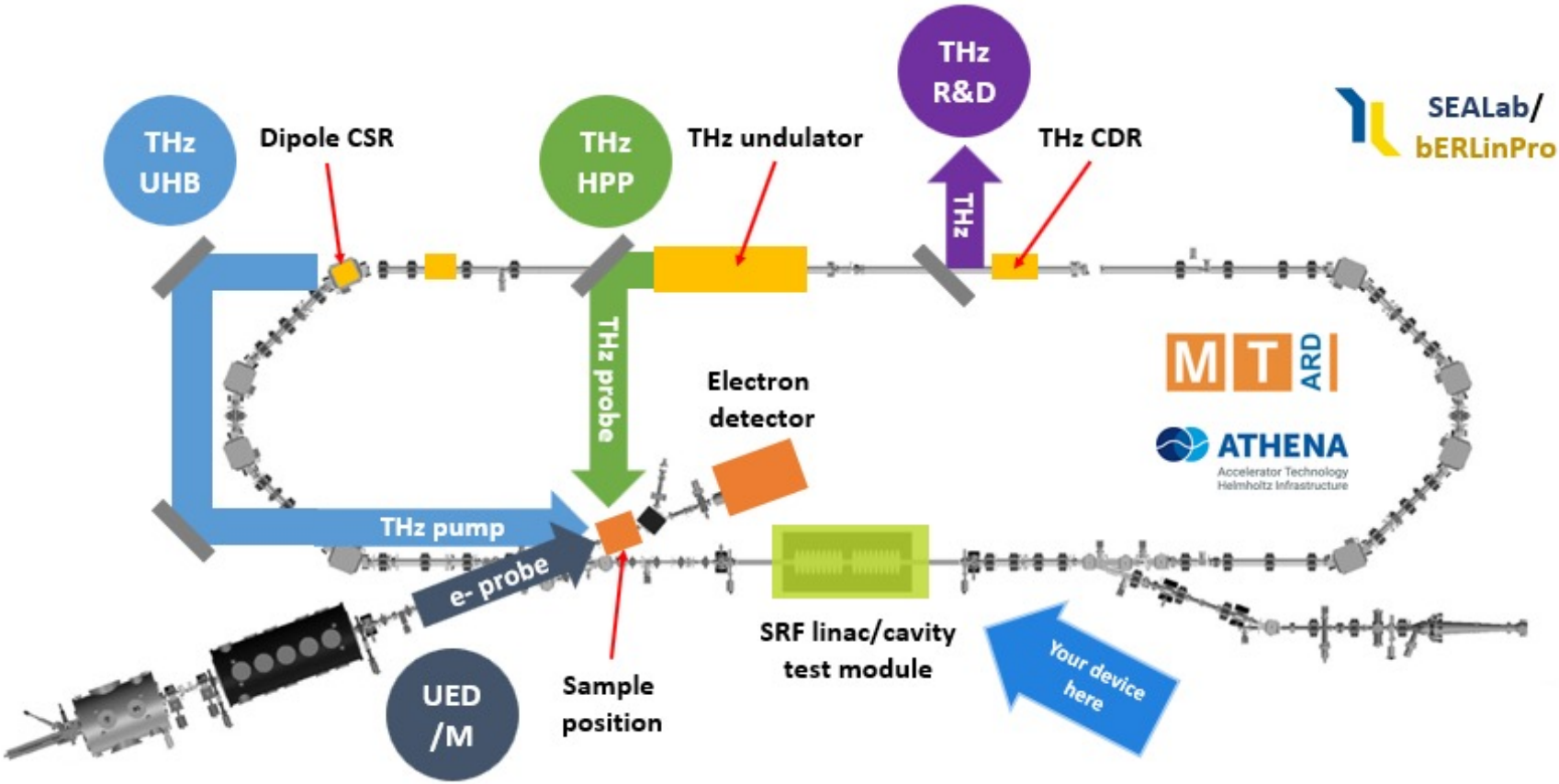
Ultrafast processes need pump/probe strategies

Use a pulsed source (synchrotron with timing modes, UED, XFEL)
to probe a system at defined intervals after a reaction is initiated



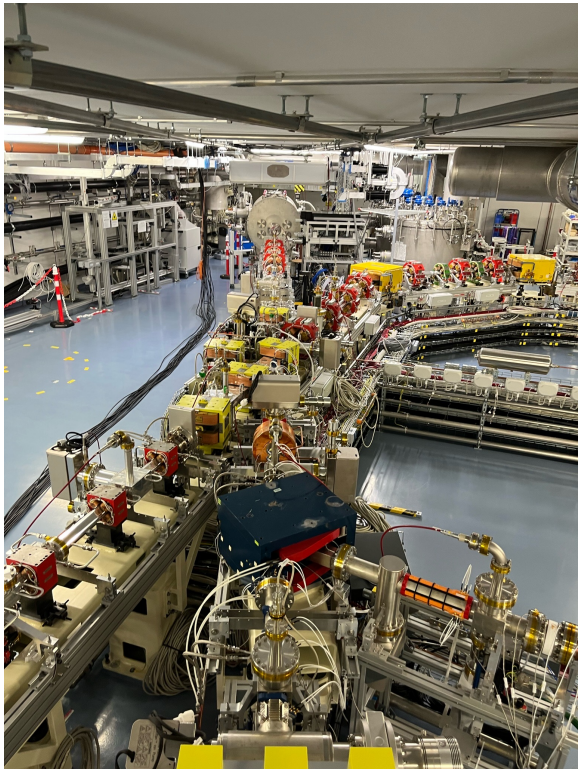
Courtesy
Karena W. Chapman

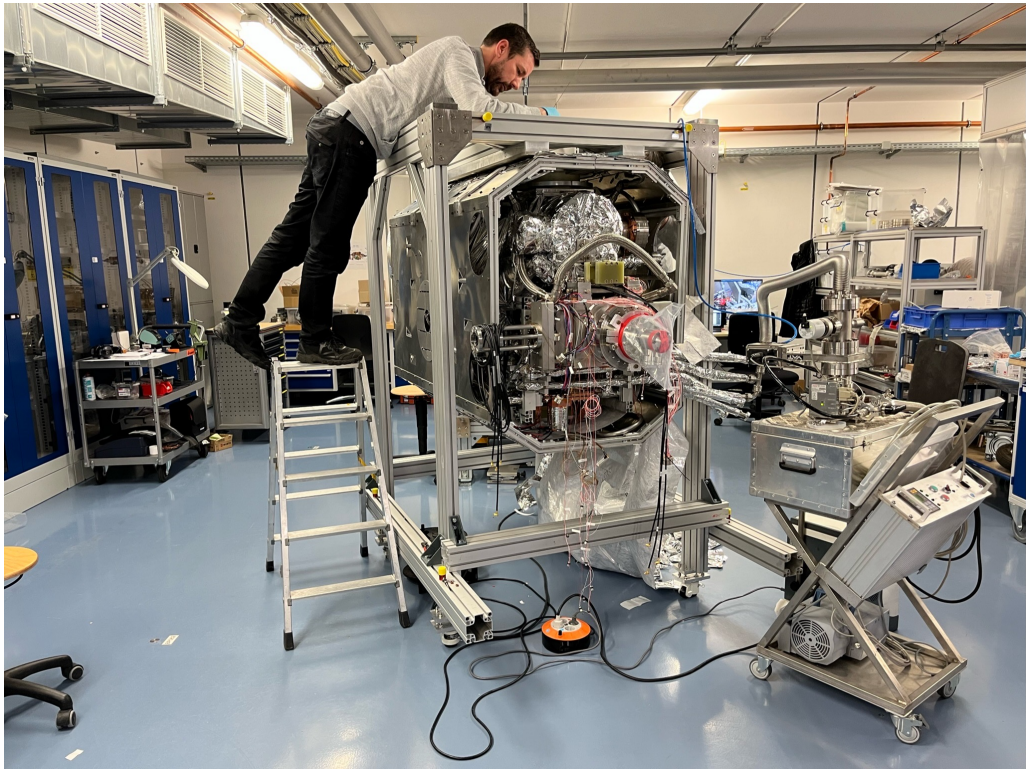
Developing SEALAB towards a multi-science facility



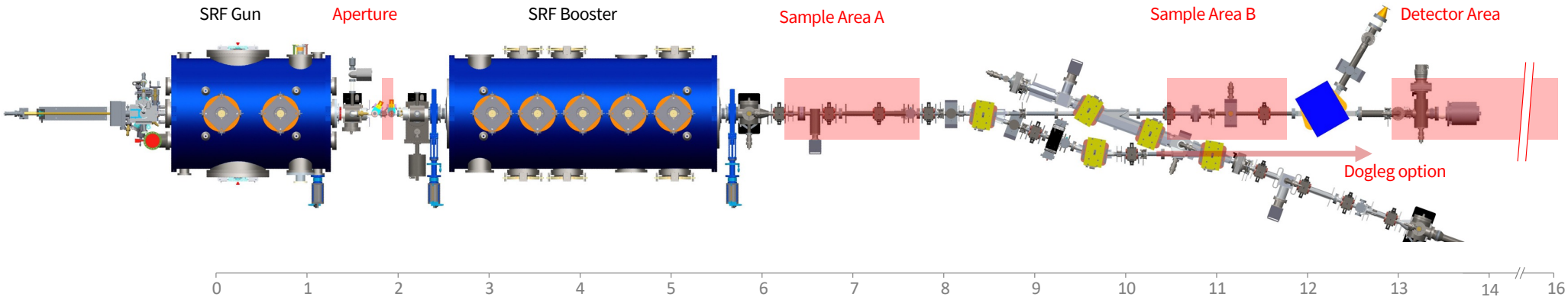
[1] TK et al., arXiv:1910.00881v2 [physics.acc-ph] 8 Jan 2020
[2] J.-G. Hwang et al., J. Korean Phys. Soc. 77, 337–343 (2020).
[3] TK et al., IPAC 2023

Status of the SRF photoinjector of SEALAB





Ultrafast scattering modalities with the SRF photoinjector of SEALAB



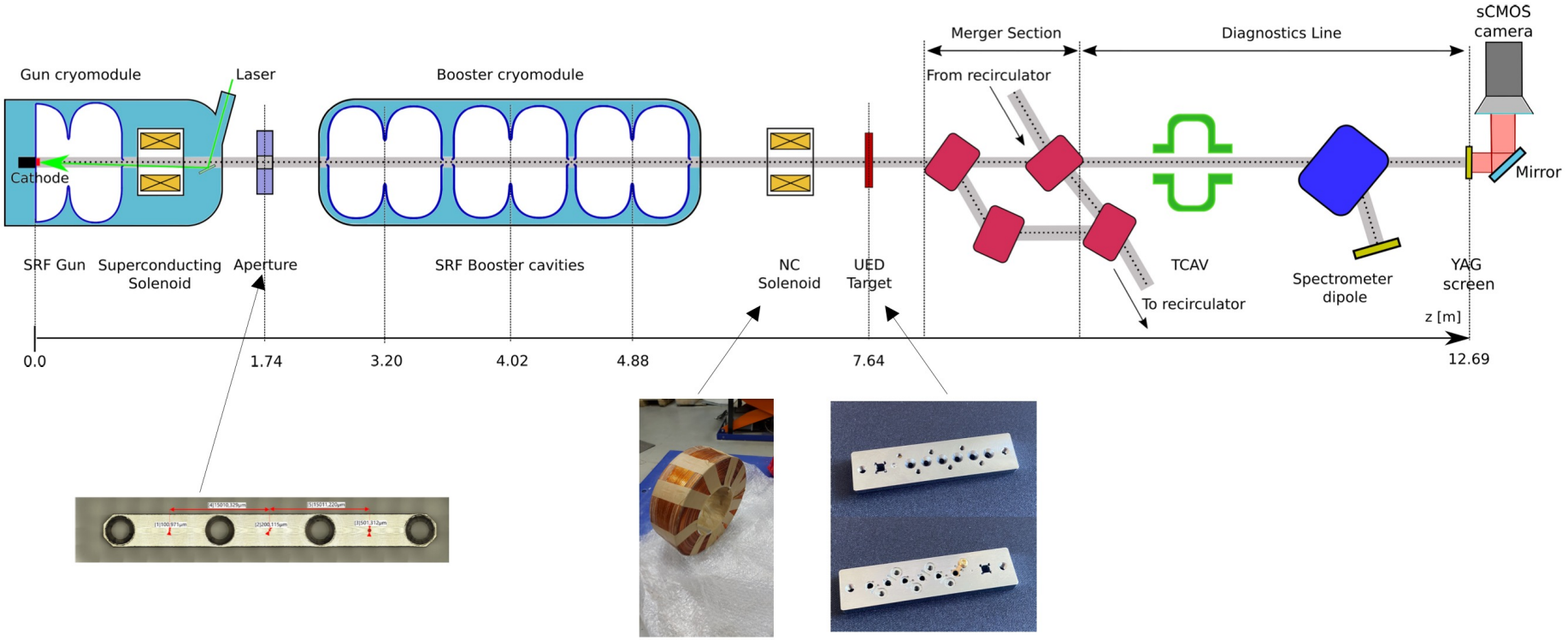
Capabilities of the photoinjector:
1 to 3.5 MeV beam energy with **variable** bunch charge (1 fC to 100 pC), pulse length (10 fs to 6 ps) and spot size (10 to 100s µm), **high stability at MHz repetition rate.**

Very **flexible accelerator/lens system**: one gun cavity and three booster cavities, many quadrupoles, done optimization for bunching/diffraction/imaging schemes,

Ultrafast science drivers:
fs thermometer for the lattice – study of functional materials, solar cells, …
Later protein imaging

Complementary to SR and FEL light sources. Enabling **multi-modal capabilities** for the integrated research facility Bessy II/III.

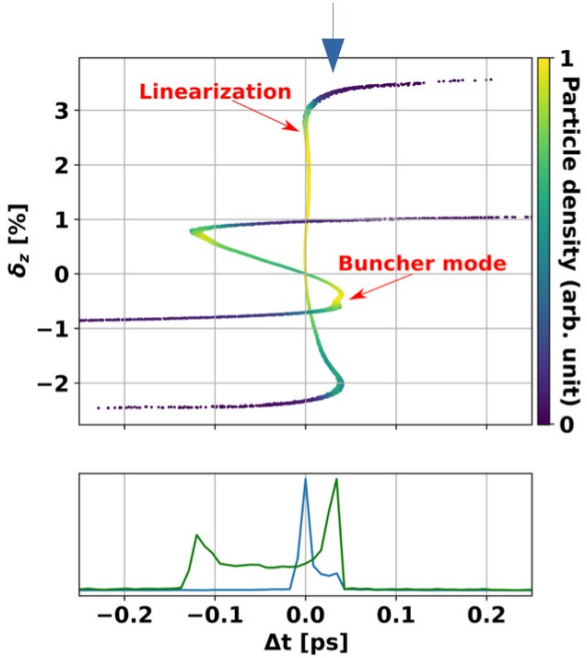
Ultrafast scattering modalities with the SRF photoinjector of SEALAB



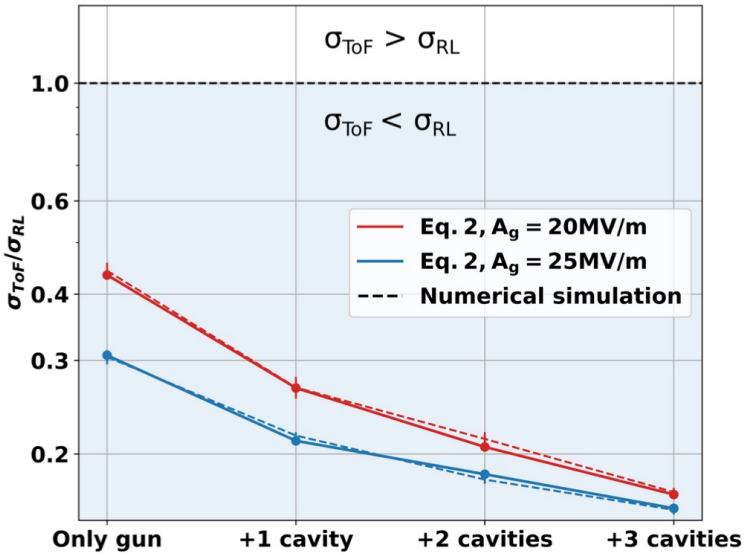
B. Alberdi-Esuain, J.G. Hwang, et al., Sci. Rep. (2022) 12:13365
B. Alberdi-Eusain, IPAC 2023 – TUPL124 and PAHBB 2023

Bunch compression and arrival time jitter studies

Phase space linearization provides shortest bunch at target

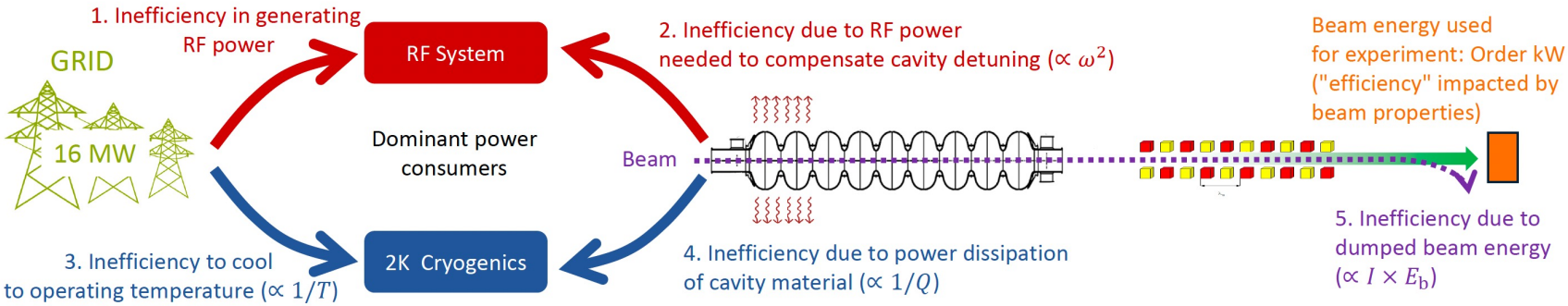


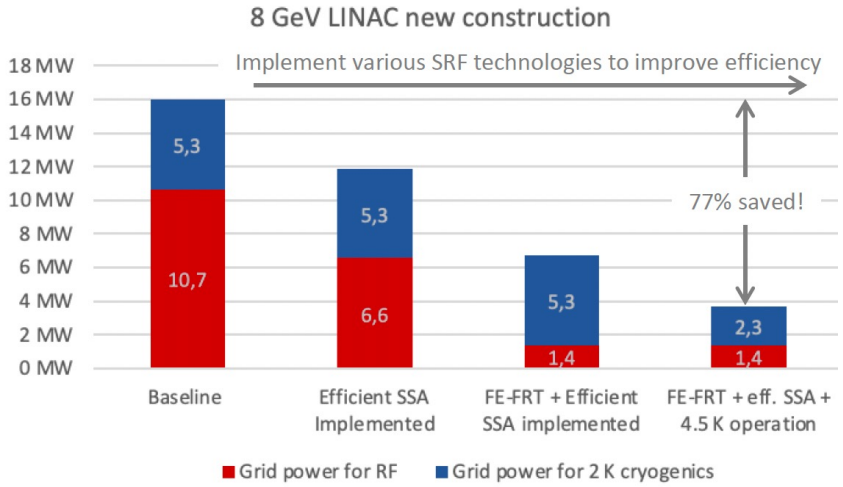
Trade-off between bunch length and jitter i mproves with number of cavities



B. Alberdi-Esuain, J.G. Hwang, et al., Sci. Rep. (2022) 12:13365
B. Alberdi-Eusain, IPAC 2023 – TUPL124 and PAHBB 2023

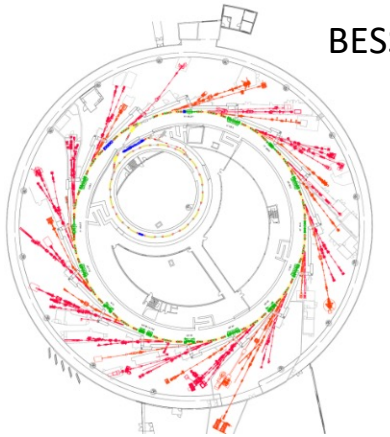
Tackle the main inefficiencies from grid to dump for SRF accelerators



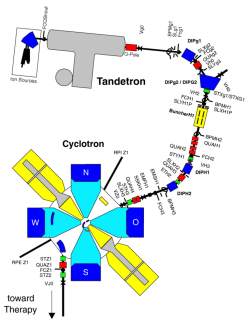


J. d'Hondt, J. Knobloch, A. Neumann

One center, two campuses and many accelerators



BESSY II



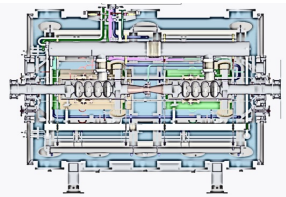
Cyclotron and proton therapy complex

BESSY III & MLS2

PTB

SupraLab@HZB

VSR DEMO



Metrology Light Source

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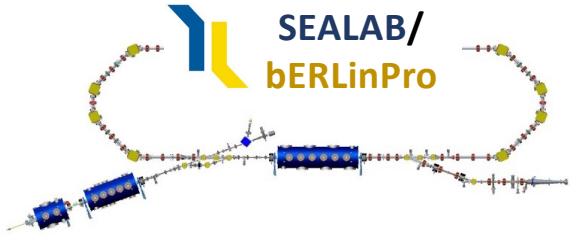
LEAPS League of European Accelerator-based Photon Sources

Digital LEAPS – ML, AI, Data
PerMaLic – permanent magnets

MT ARD

ATHENA Accelerator Technology Helmholtz Infrastructure

SEALAB/ bERLinPro



We develop, operate, maintain and modernize our accelerators to provide unique research opportunities

Summary

HZB operates and develops large scale user **facilities - synchrotron radiation sources, proton therapy -** and accelerator **R&D Infrastructures like SEALAB**

We advance **fundamental and applied accelerator science and forefront technologies** for the continuous improvement of these facilities and to develop state-of the-art accelerator concepts and novel disruptive methods and paradigms to provide perfect experimental opportunities for HZB´s present and future users/partners.

Our strategy is to **maintain Bessy II at the forefront by an ambitious R&D program** (Bessy II+), which is strongly **linked to our new facility Bessy III**.

ARD is crucial to our success, especially here in ST3 where we look at ultra-short pulse generation and diagnostics with SRF photoinjectors, innovative schemes for storage ring based FELs (SSMB) and proton therapy modalities → control of the complete 6D phase space for every bunch to enable innovative modalities for FEL, SR and ultrafast applications. Energy-efficiency stability and reliability during all phases of the accelerator lifecycle.