Transnational Access experiments at the KIT electron synchrotron test facility KARA

EURO-LABS Annual Meeting at CERN

28th October 2024

Robert Ruprecht, Bastian Härer, Matthias Fuchs, Akira Mochihashi, Michael J. Nasse, Marcel Schuh, Anke-Susanne Müller et al., KIT-IBPT

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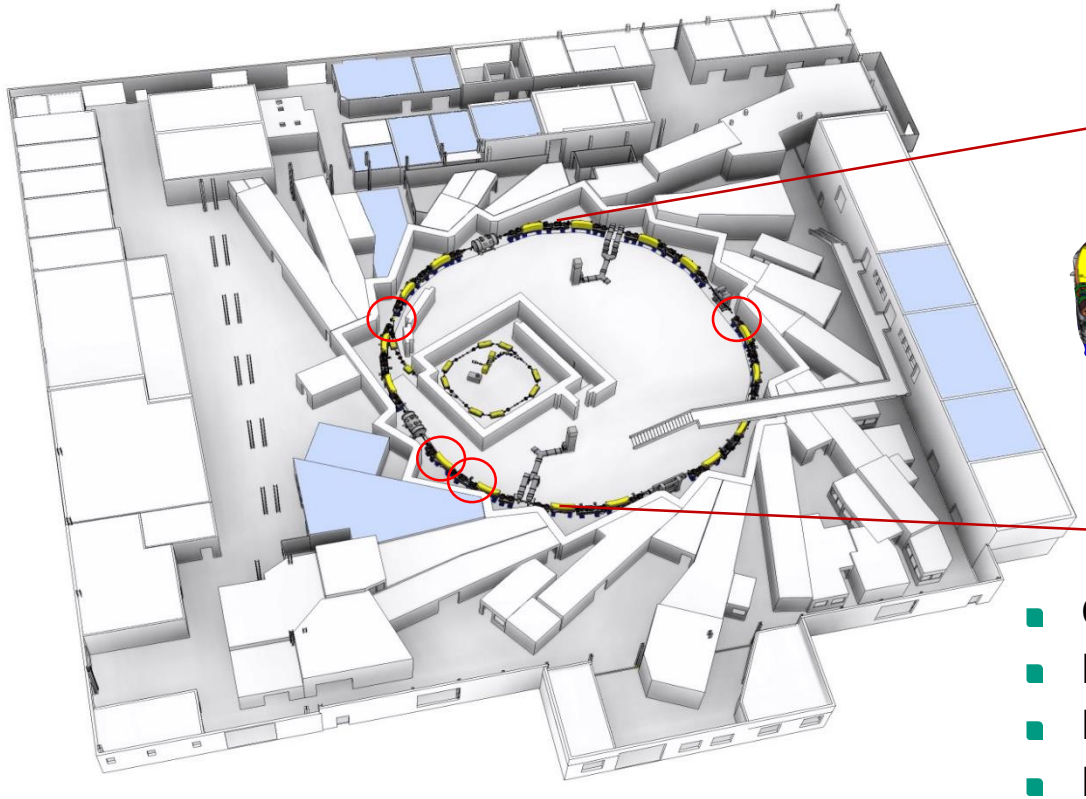
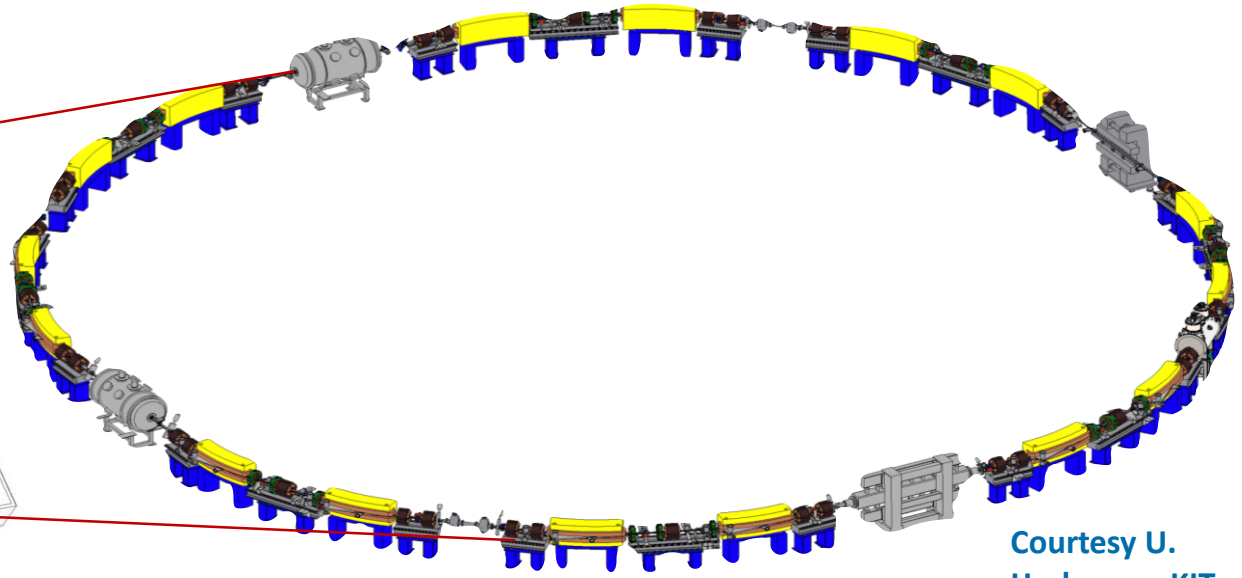
KIT electron synchrotron test facility KARA

KARA (KArlsruhe Research Accelerator)

KARA = electron storage ring of the KIT Light Source & accelerator test facilities at Karlsruhe Institute of Technology





Courtesy U. Herberger, KIT

- Circumference: 110.4 m
- Energy range: 0.5 - 2.5 GeV
- RF frequency: 500 MHz
- Revolution frequency: 2.71 MHz
- Operation Mo: 1pm to Sa: 8am // 23h/d // 30w/y
- Single or multi-bunch mode

www.ibpt.kit.edu/kara

Contact: Marcel.Schuh@kit.edu

*MBI = micro bunching instabilities

KARA (KArlsruhe Research Accelerator)

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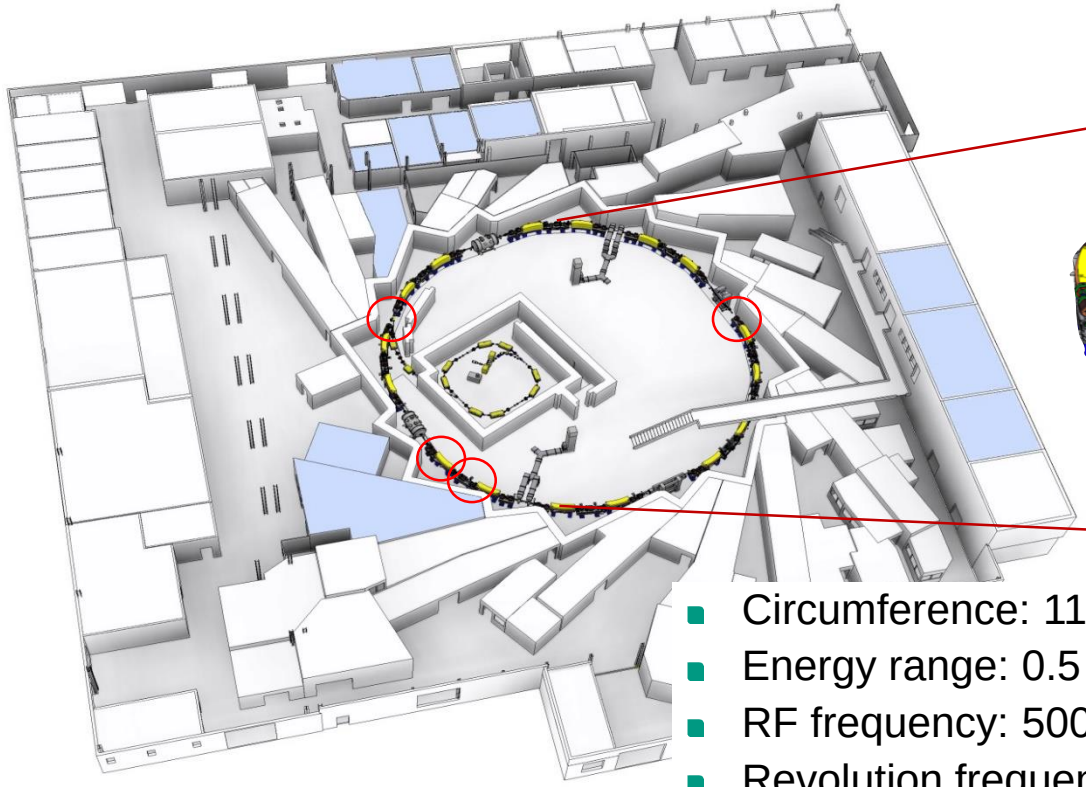
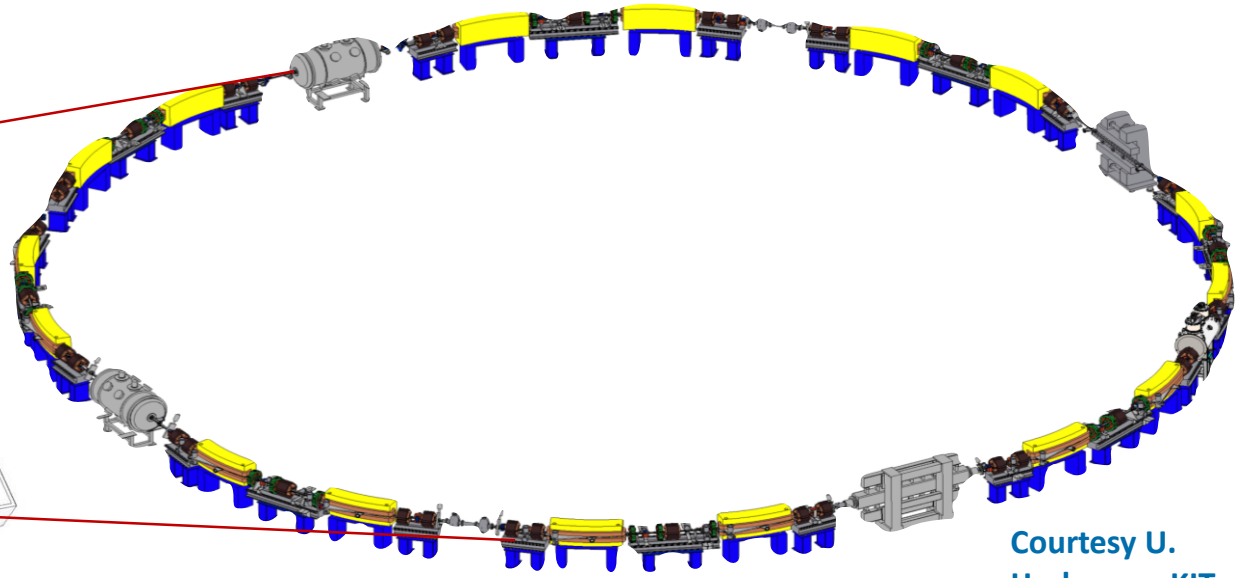
with different operation parameter for user operation or accelerator research /machine physics





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Short bunch mode

- Lower momentum compaction factor → Bunch length: 45 ps ↘ few ps
- Coherent synchrotron radiation (CSR) in THz range
- Negative momentum compaction factor

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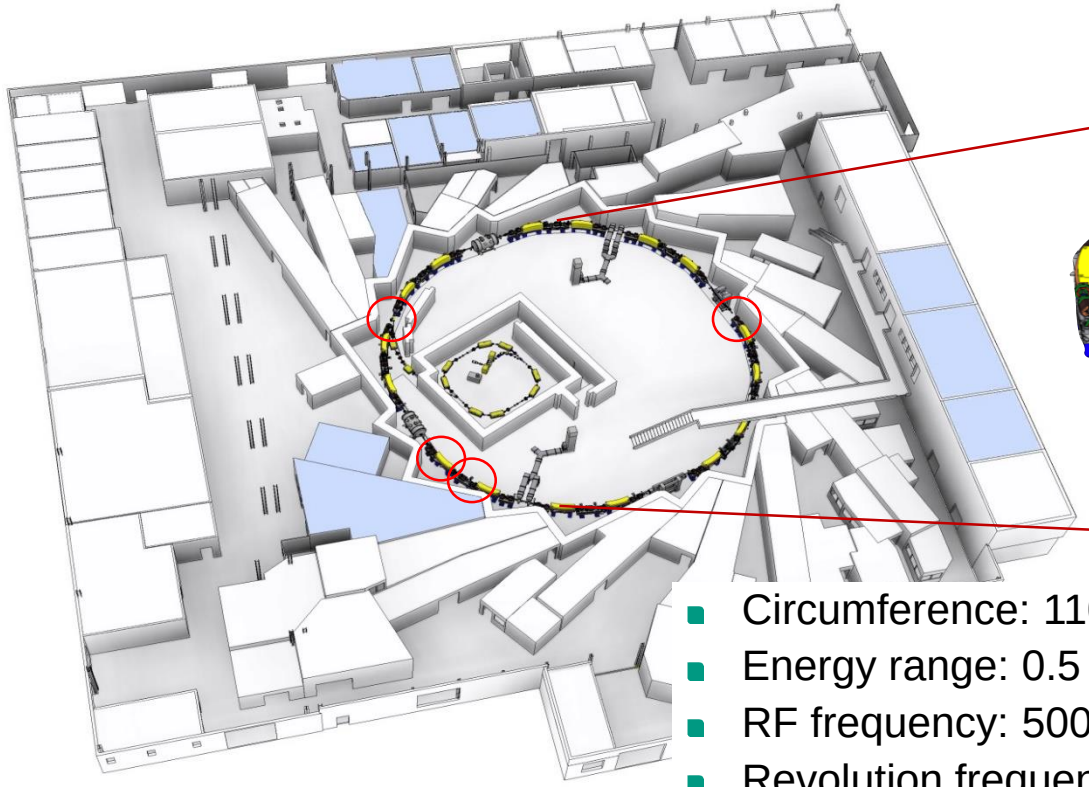
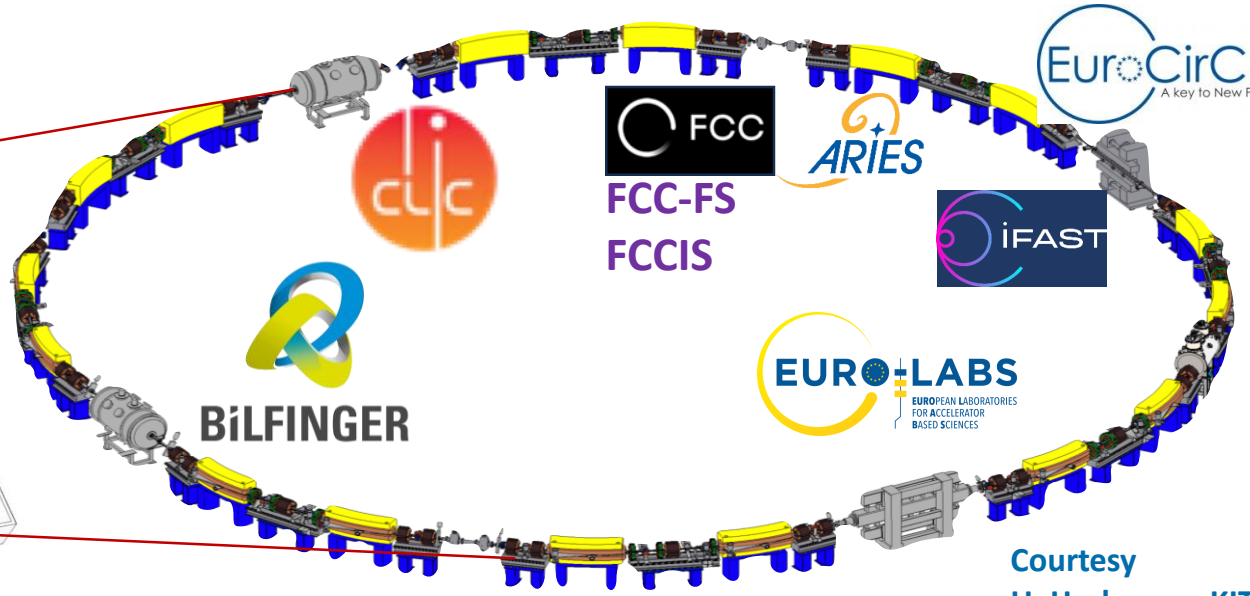
for accelerator technology development in collaboration with industry & international partners





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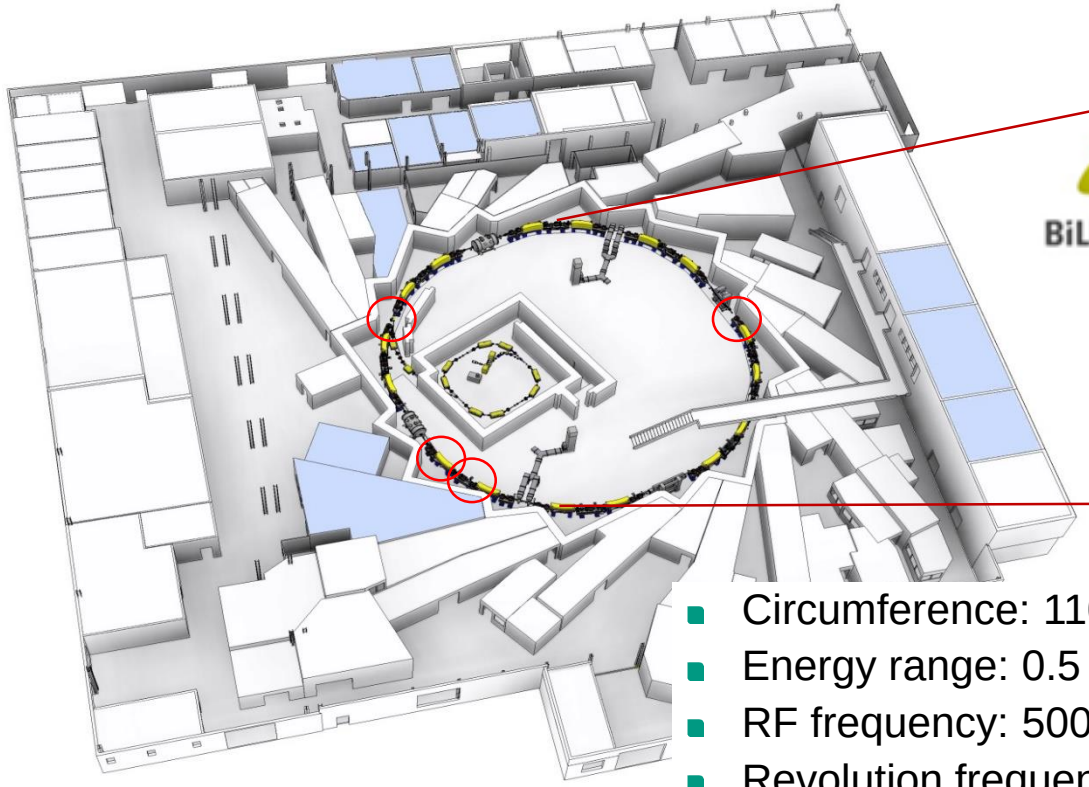
KIT electron synchrotron test facility KARA

KIT Superconducting Undulator (SCU) Development at KIT

Karlsruhe Institute of Technology

Story of a successful industrial collaboration since 2011 from TLR-3 to TRL-9

SCU20 installed in KARA Dec. 2017



BILFINGER NOELL GMBH

SCU 20 reaching soon 7 years of successful operation for a user beamline at KARA

Courtesy
B. Krasch et al. KIT

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www.ibpt.kit.edu/mcf.php
Contact: Bennet.Krasch@kit.edu

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KIT electron synchrotron test facility KARA

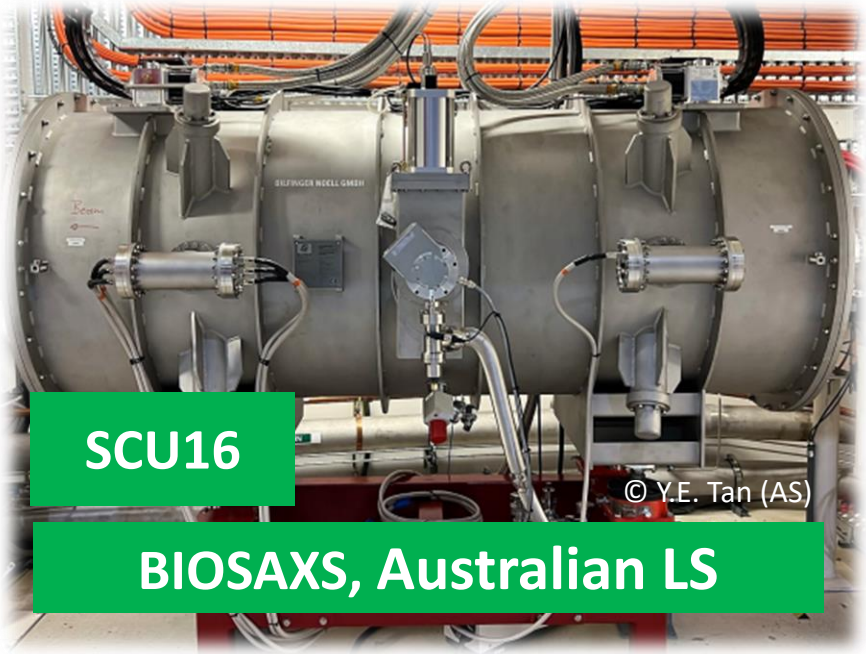
KIT Superconducting Undulator (SCU) Development at

Story of a successful industrial collaboration: products & future prospects

HEX-SCW

© T. Tanabe (NLSL-II)

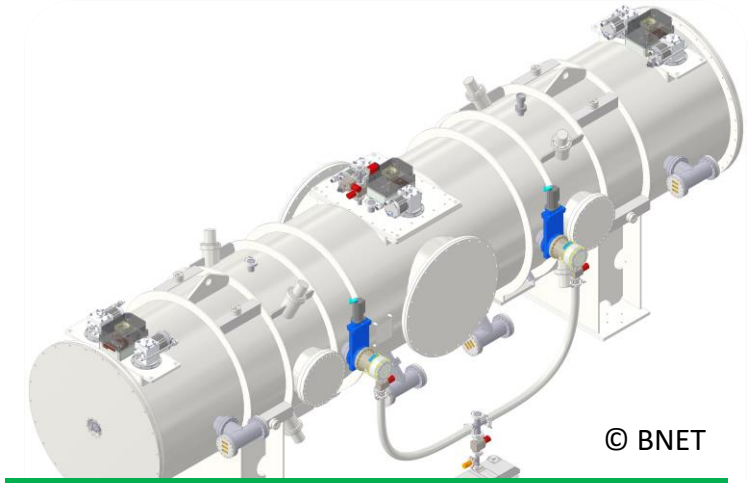
X-ray scattering at NSLS-II, USA



SCU16

© Y.E. Tan (AS)

BIOSAXS, Australian LS



© BNET

5 m undulator for EuXFEL "S-PRESSO"

www.ibpt.kit.edu/mcf.php

Contact: Bennet.Krasch@kit.edu

Courtesy
B. Krasch et al. KIT

KARA for Transnational Access in EURO-LABS

KARA (KArlsruhe Research Accelerator)

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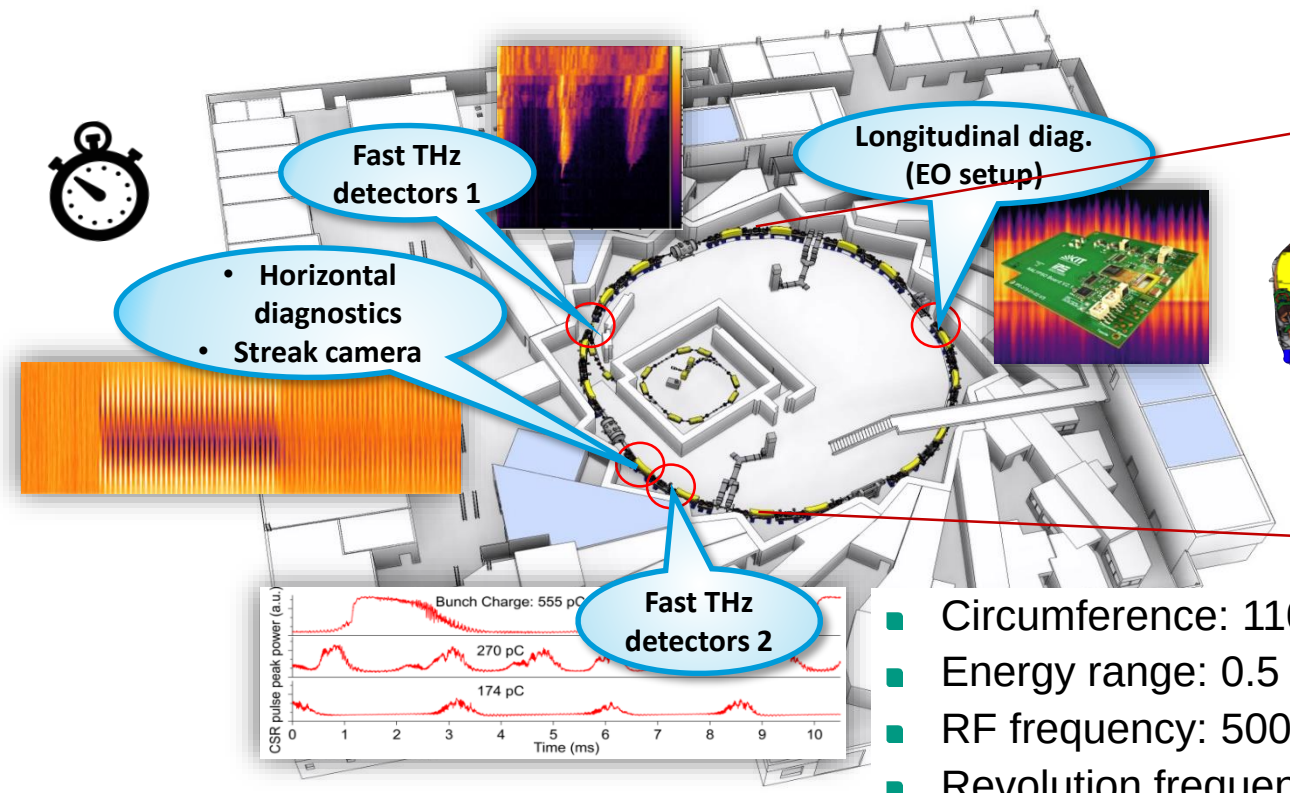
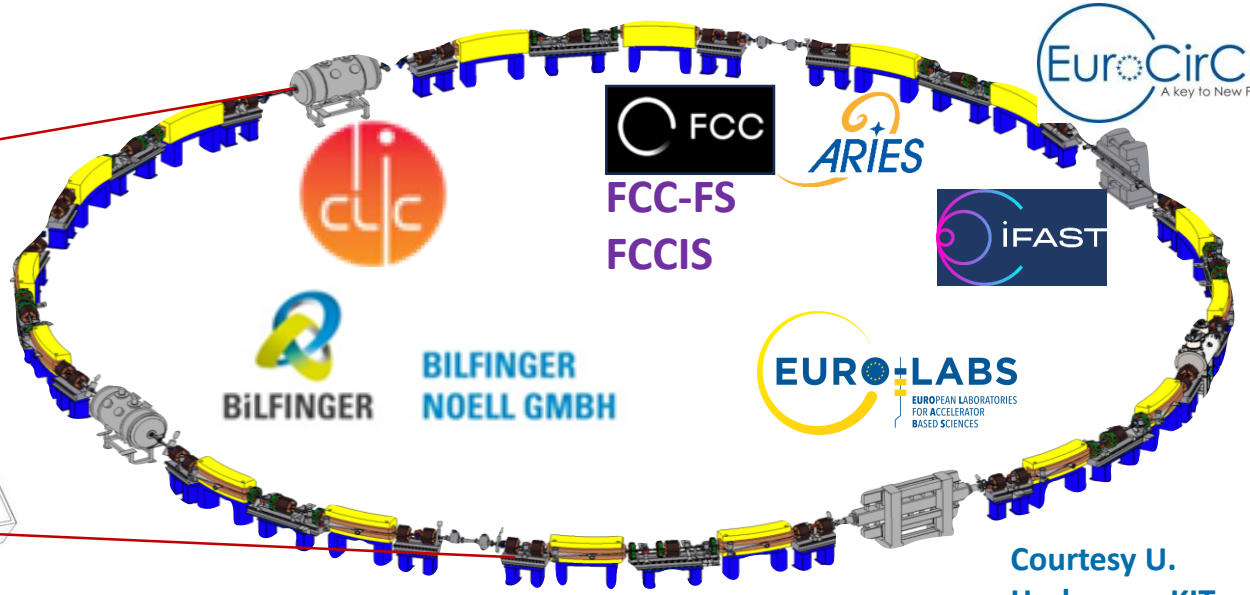
distributed synchronized sensor network: emitted CSR, energy spread, bunch profile, phase space tomography in MBI*





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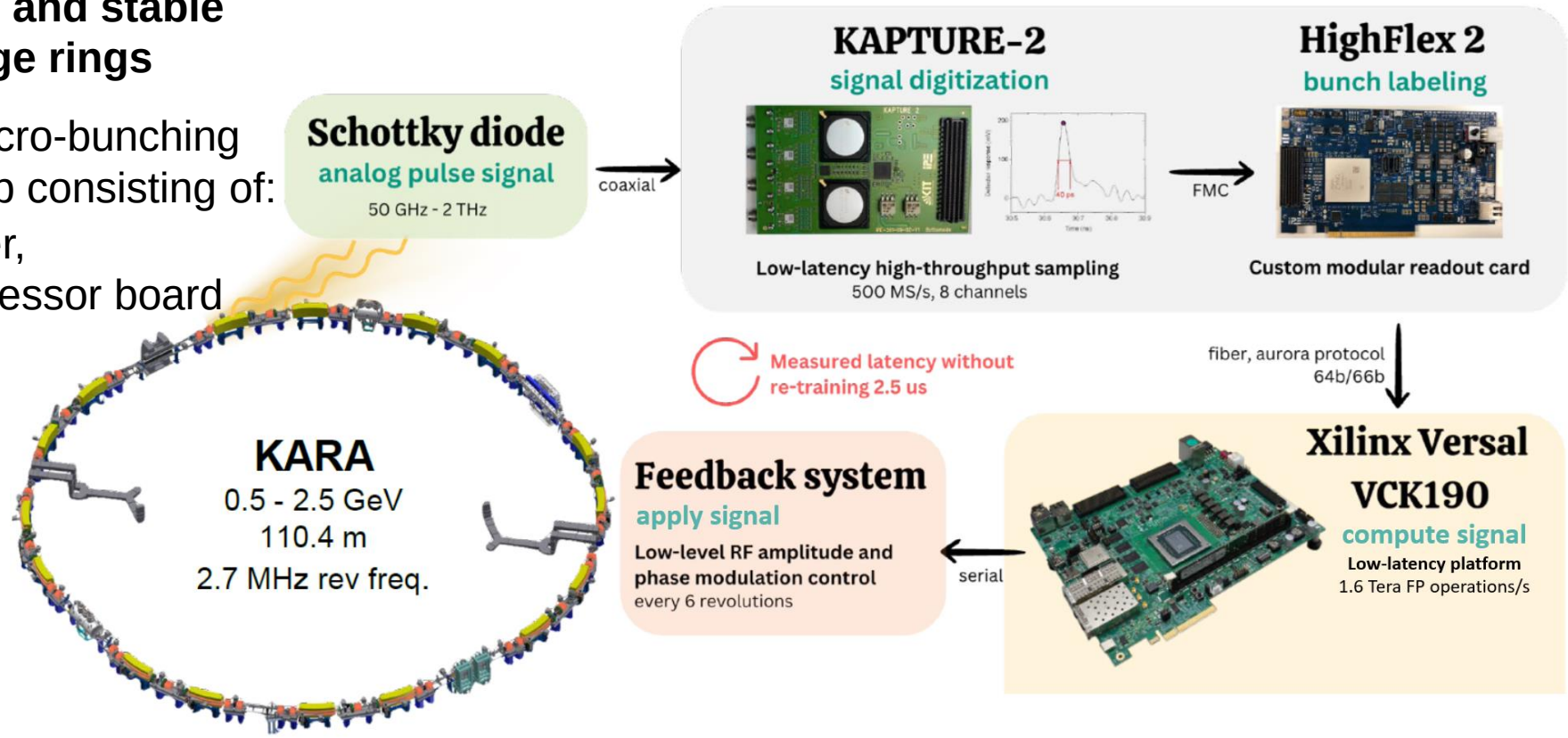
KIT – ALFA - KARA – Status (1)

- **Advanced control of the microbunching instability at KARA: Uni Lille & KIT**

➢ **goal: generate a very intense and stable THz source at electron storage rings**

- Solution: measure & control micro-bunching instability using a feedback loop consisting of:
  - ✓ ultra-fast detector and digitizer,
  - ✓ low-latency digital signal processor board
  - ✓ acting on the RF cavity
  - ✓ via the low-level-RF system.



adapted from https://accelconf.web.cern.ch/fls2023/talks/th3d3_talk.pdf: A. Santamiaria Garcia et al.

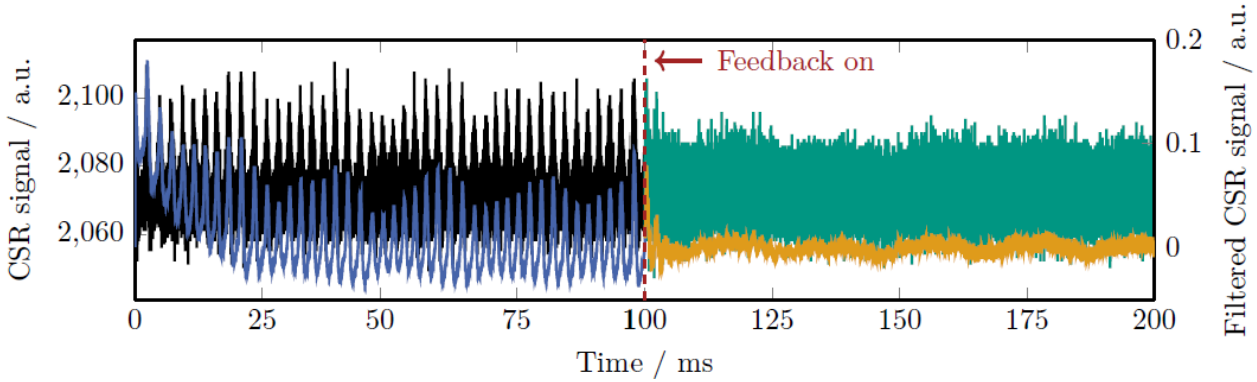
KIT – ALFA - KARA – Status (1)

- **Advanced control of the microbunching instability at KARA** Université de Lille

➢ **goal: generate a very intense and stable THz source at electron storage rings**

TA experiment:

- Suppression of the sawtooth outburst fluctuation variance by a factor of 28 in the CSR emission at the KARA electron storage ring, after switching on the FPGA-based feedback loop developed by the PhLAM team of Université de Lille
- The fast CSR fluctuations are still present after the feedback is switched on, leading to a stabilization of the THz emission.
- Publication in preparation.



The CSR signal was measured with a fast Schottky diode (at a KIT infrared beam line).

After 100 ms the team of the Université de Lille switched on the FPGA-based feedback loop.

For better visibility, the raw signal (black & green) was filtered (blue & orange) to remove the fast sinusoidal fluctuation.

KIT – ALFA - KARA – Status (2a)

- **Resonant Depolarisation (RDP) measurement campaign: CERN -> J. Keintzel***

- resonant spin depolarization (RDP) is known for its high accuracy to measure the beam energy
- **Goal: RDP studies are of particular interest for future colliders like FCC-ee**

- At KARA energy measurements with resonant spin depolarization are implemented as a standard routine and
- used regularly to measure both the beam energy and the momentum compaction factor for different energies and optics regimes.

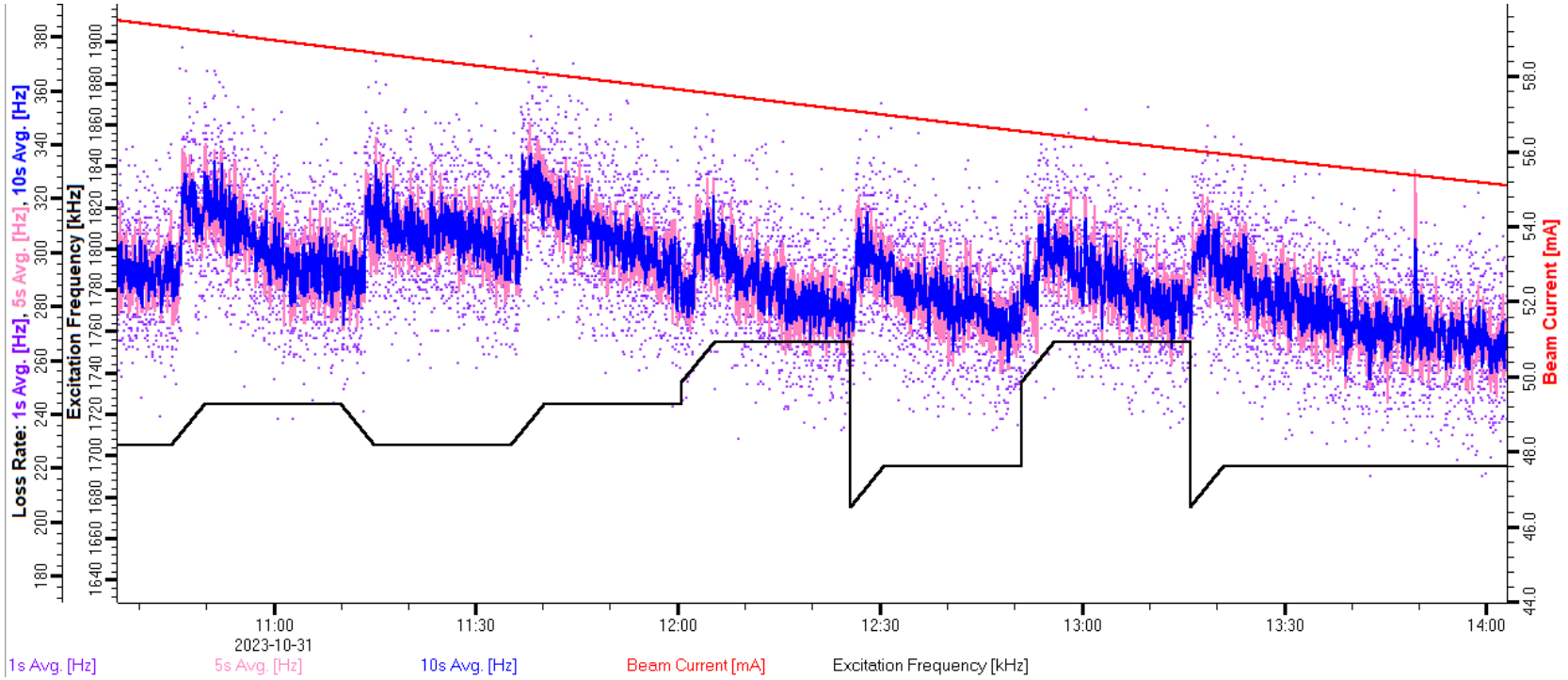
- The strip-line kickers of the bunch-by-bunch feedback system stimulate depolarisation.
- The resonant frequency is measured via change in Touschek lifetime.

Team of CERN and KIT in the KARA control room

Sources: FCCIS_WP2-workshop, 2023-11-15, B. Härer et al.: Polarisation studies at KARA; and following IPAC papers:
https://doi.org/10.18429/JACoW-IPAC2024-TUPG33
https://doi.org/10.18429/JACoW-IPAC2024-WEPG51
https://doi.org/10.18429/JACoW-IPAC2024-WEPR20
*** see J. Keintzel et al. this Meeting, Monday Morning**

KIT – ALFA - KARA – Status (2b)

- **Resonant Depolarisation (RDP) measurement campaign: CERN -> J. Keintzel***
  - > 40 successful RDP scans
  - scan direction: up/down
  - scanning time: 100 s – 600 s
  - ✓ detailed optics measurement after transverse strip-line kicks using turn-by-turn data as input for simulations



Team of CERN and KIT in the KARA control room

  - under preparation: simualtions for spin matching with vertical orbit bumps

Sources: FCCIS_WP2-workshop, 2023-11-15, B. Härer et al.: Polarisation studies at KARA; and following IPAC papers:
https://doi.org/10.18429/JACoW-IPAC2024-TUPG33
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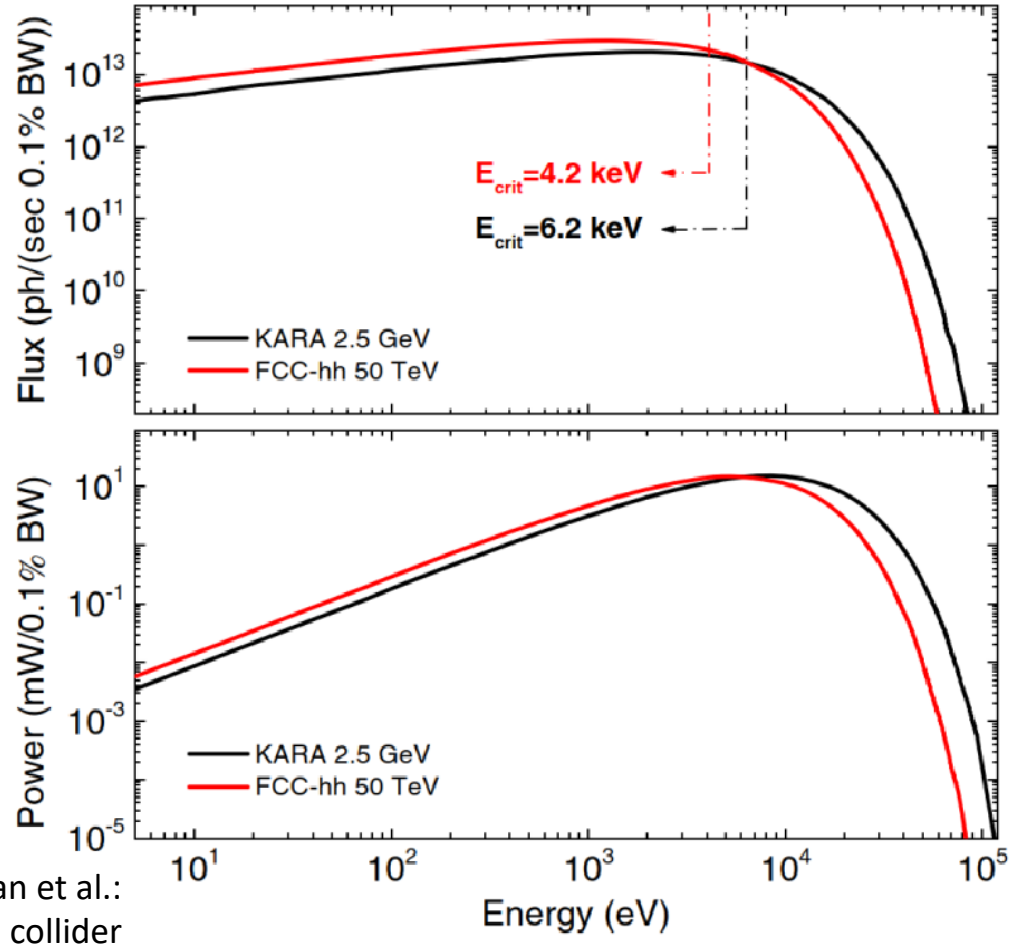
https://doi.org/10.18429/JACoW-IPAC2024-WEPR20
*** see J. Keintzel et al. this Meeting, Monday Morning**

KIT – ALFA - KARA – Status (3a)

- **Photo-stimulated desorption measurements for future accelerators, FCC**

➢ Comparison of the photon flux (top) and power (below) of the FCC-hh at 50 TeV proton beam energy in comparison with KARA's at its nominal 2.5 GeV electron energy for user operation. Calculations were performed with SYNRAD+.

L. A. González et al. DOI: 10.1103/Phys.Rev.Accel.Beams 22, 083201
L. A. González et al. (2021) Phys.Rev.Accel.Beams 24, 113201

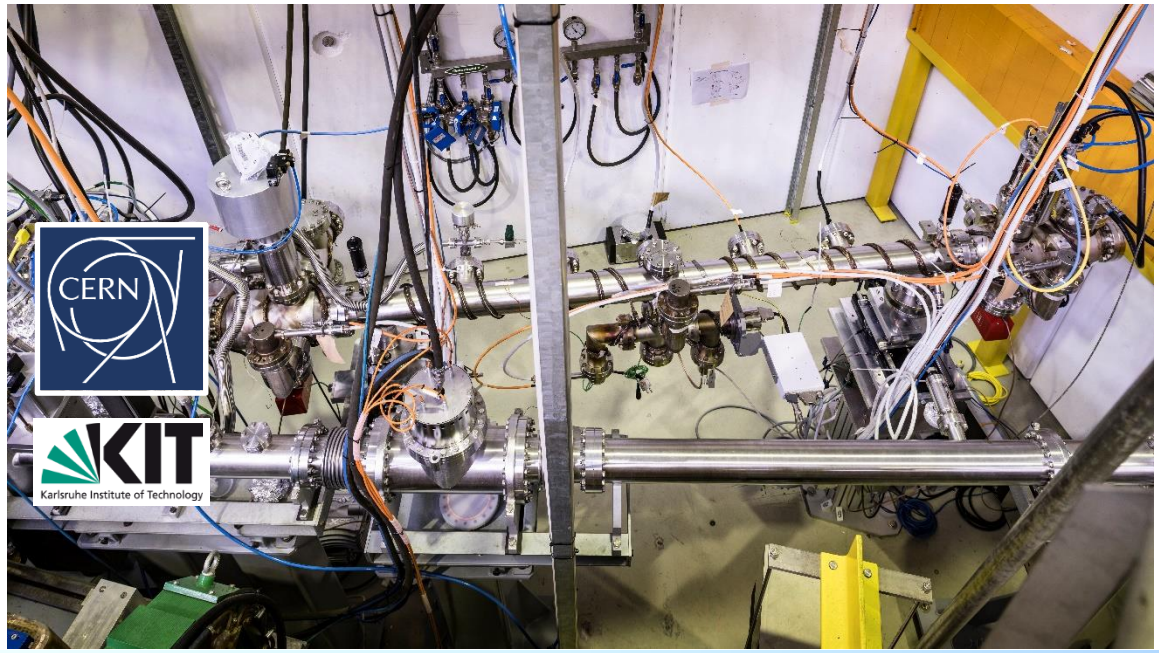


➢ GOAL: explore the vacuum performance of the FCC-hh BS to protect the cold superconducting magnets from the direct irradiation high-power SR photon beams.

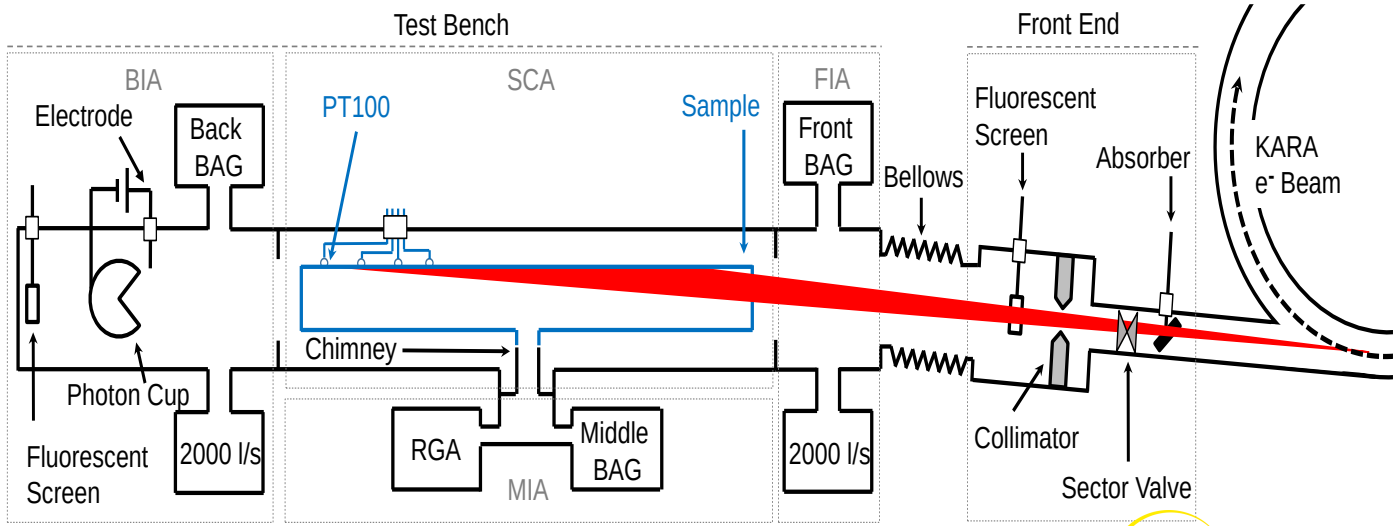
Source: FCCIS_WP2-workshop, 2023-11-15, R. Kersevan et al.: Vacuum system and photoelectron distributions in the collider

CERN's BESTEX beamline at KARA (3b)

- CERN installed the BESTEX beamline at KARA since 2019.
- photo-desorption studies on ➤2x FCC-hh beam screens & ➤(planned) FCC-ee vacuum chamber prototypes
- tests possible under cryogenic conditions (liquid Nitrogen cooling)
- Within EURO-LABS –TA:



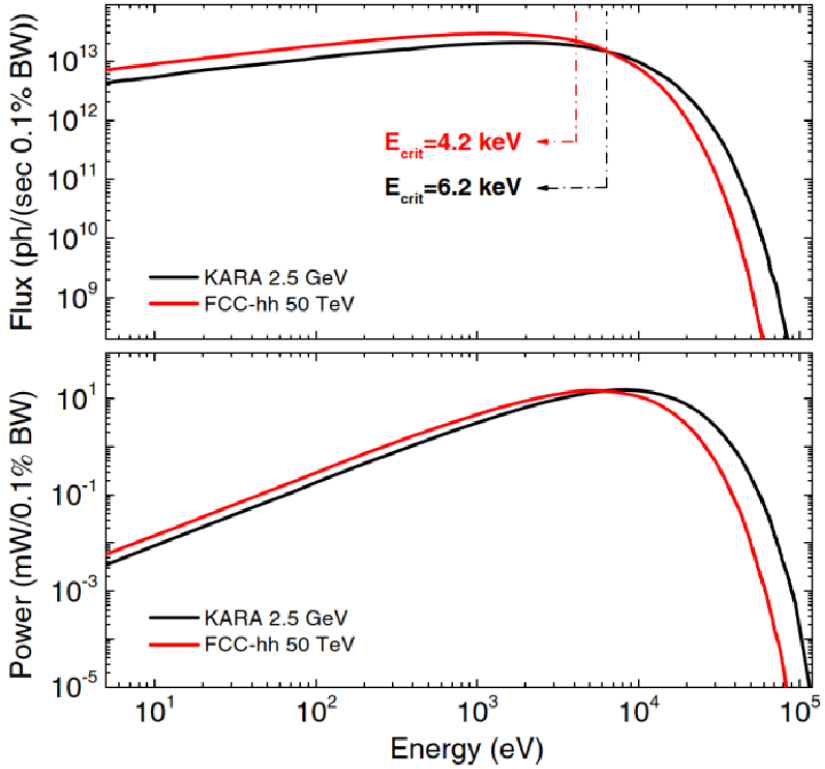
Courtesy:
R. Kersevan et al.



KIT – ALFA - KARA – Status (3c)

- **Photo-stimulated desorption measurements for future accelerators, FCC**

➢ **goal: tests of "the first 2 meters FCC" components**:
FCC-hh beam screen & FCC-ee vacuum chamber prototypes tested in CERN's BESTEX beam-line at KARA: **2x EURO-LABS—TA done**



Source: FCCIS_WP2-workshop, 2023-11-15, R. Kersevan et al.: Vacuum system and photoelectron distributions in the collider

KIT – ALFA - KARA – Status (4)

- **Beam stabilization & handling with bunch-by-bunch (BBB) feedback system**
- Joint experimental campaign 5th – 6th March 2024 with 29 onsite users at KIT following the I.FAST workshop on BBB feedback systems

➢ **3 experiments were defined and carried out**

- vertical emittance / beam size control with BBB feedback system
- search for a common way to commission BBB feedback systems
- test for modulation the longitudinal motion of the KARA booster synchrotron beam with a strip-line kicker

➢ **TA within EURO-LABS, WP 3.3 & Networking within I.FAST, WP 7.2**

Acknowledgements

- The KIT-IBPT accelerator team:
  Axel Bernhard, Edmund Blomley, Erik Bründermann, Samira Fatehi, Matthias Fuchs, Stefan Funkner, Julian Gethmann, Andreas Grau, Bastian Haerer, Dima El Khechen, Sebastian Maier, Anton Malygin, Sebastian Marsching, Yves-Laurent Mathis, Wolfgang Mexner, Akira Mochihashi, Matthias Nabinger, Michael J. Nasse, Marvin Noll, Gudrun Niehues, Meghana Patil, Alexander Papash, Mischa Reissig, Robert Ruprecht, David Saez de Jauregui, Andrea Santamaria Garcia, Jens Schäfer, Thiemo Schmelzer, Marcel Schuh, Markus Schwarz, Nigel J. Smale, Johannes L. Steinmann, Pawel Wesolowski, Christina Widmann, Chenran Xu, and Anke-Susanne Müller
- KIT Institutes as partners of the KIT- Accelerator Technology Platform ATP
  ETIT, ETP, IHE, IHM, IMS, IPE, IPS, ITEP, LAS
- Collaboration partners (examples):

Karlsruhe Institute of Technology

Thank you for your interest, … any questions?

Transnational Access experiments at the KIT electron synchrotron test facility KARA

Robert Ruprecht, Bastian Härer, Matthias Fuchs, Akira Mochihashi, Michael J. Nasse, Marcel Schuh, Anke-Susanne Müller et al., KIT-IBPT

KIT – ALFA - KARA – TA Projects (1)

TA projects status presented last EURO-LABS annual meeting in Krakow

ID	Description	Key participants	Access Units	Status(*)
EURO-LABS-KIT-KARA-2023-01	**Photo-stimulated desorption measurements for future accelerators: FCC-hh beam-screen prototype no.5 with sawtooth profile**	CERN + KIT (8 users)	220 h	completed
EURO-LABS-KIT-KARA-2023-02	Photo-stimulated desorption measurements for future accelerators: FCC-ee Vacuum Chamber Extrusion	CERN (4 users)		postponed
EURO-LABS-KIT-KARA-2023-03	**Photo-stimulated desorption measurements for future accelerators: beam-screen prototype no. 6**	**CERN (8 users)**	617 h	still installed
EURO-LABS-KIT-KARA-2023-04	**Advanced control of the microbunching instability**	Uni Lille + KIT (13 users)	24 h	completed

KIT – ALFA - KARA – TA Projects (2)

New projects since last EURO-LABS annual meeting

ID	Description	Key participants	Access Units	Status(*)
EURO-LABS-KIT-KARA-2023-05	**Resonant Depolarisation studies at KARA for FCC-ee**	CERN + KIT (8 users)	42 h	completed
EURO-LABS-KIT-KARA-2024-06	**Beam stabilization- and handling experiments with KARA bunch-by-bunch feedback system: collaboration with I.FAST, WP7.2**	SOLEIL, PSI,… et al (29 users)	12 h	completed
EURO-LABS-KIT-KARA-2024-07 Not yet submitted	Prototype on BESTEX like 2023-01, …-03	CERN	200 ?	in CERN workshop
EURO-LABS-KIT-KARA-2024-08 Not yet submitted	**experiments in collaboration with I.FAST, WP7.2**	SOLEIL	12 ?	planned in March 2025
SUM KARA	**SUM KARA**	**SUM**	**915 h**	**completed**

KIT - ALFA – Service Improvements

- *Goal: develop & establish meta-database for KARA, FLUTE, & other test facilities of KIT-ATP*
  - Identify relevant metadata ✓
  - Implement structure in eudat/b2share or RADAR: which system will KIT use**?**
  - Next ToDo: Implementation of the automated data handling
  - Next ToDo: data registration in RADAR or EUDAT together with meta data
  - Measurement Framework: ideas ✓ (rather similar to bluesky), first measurements implemented ✓ started handles data file creation, grouping naming, bundling, elog creation, abortion, clean up: (https://ankagit.anka.kit.edu/python-tools/packages/measurement) installed from our own Python package index server
  - Framework for Simulations online simulation model for KARA using the multi-physics simulation toolkit OCELOT is availbale: https://github.com/ocelot-collab/ocelot ✓
- *Our expert moved to another institute. KIT has hired a new person as of 1st Oct 2024.*
  - *> development starts again, task ongoing <*