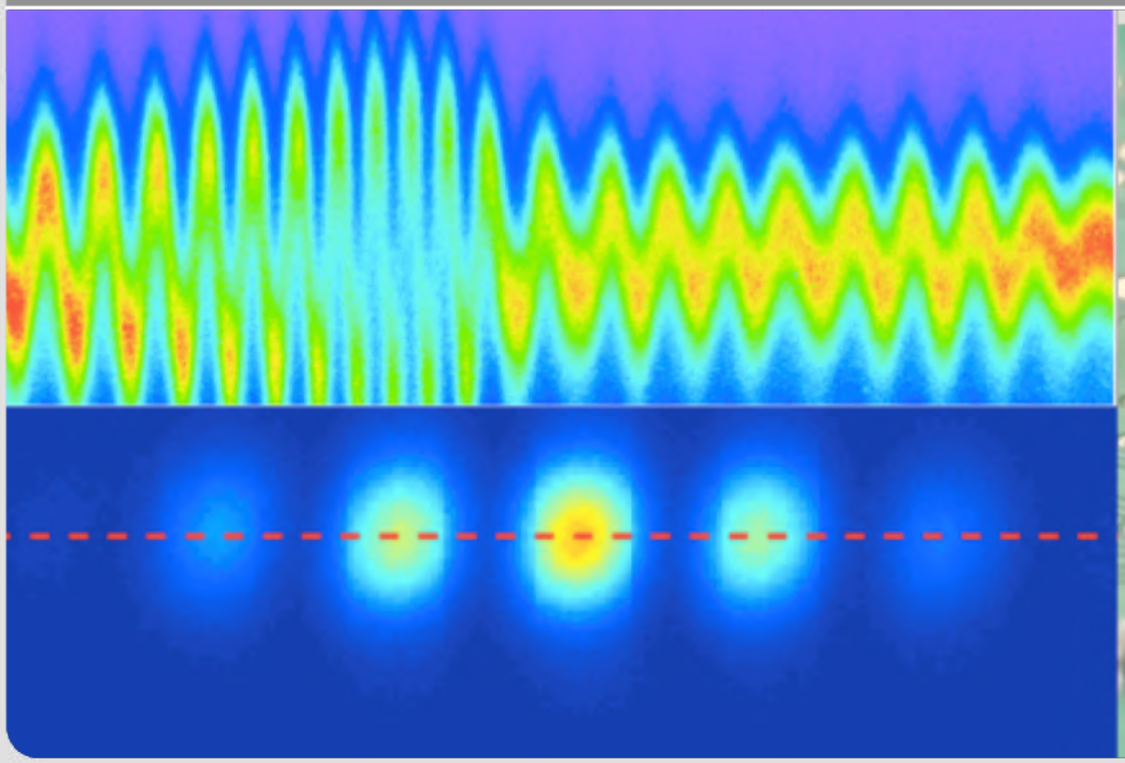
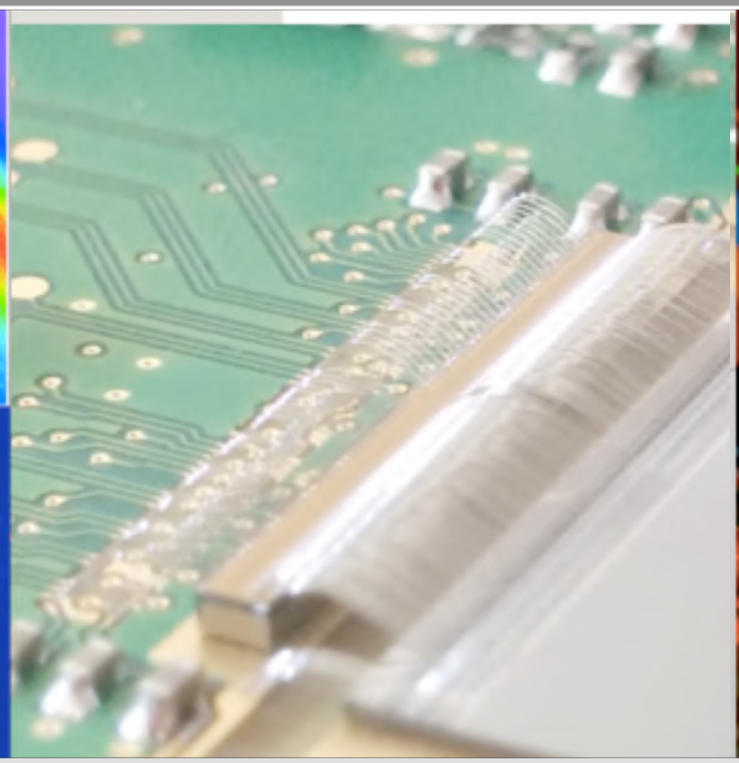
KIT - IBPT accelerator status report

26th ESLS Workshop, Kraków, Poland 26-28.11.2018

M. Schuh for the accelerator team

Institute for Beam Physics and Technology (IBPT)





Outline

- FLUTE
  - First beam
  - Status
- KARA
  - Installation and operation
  - R&D Actives
- Outlook

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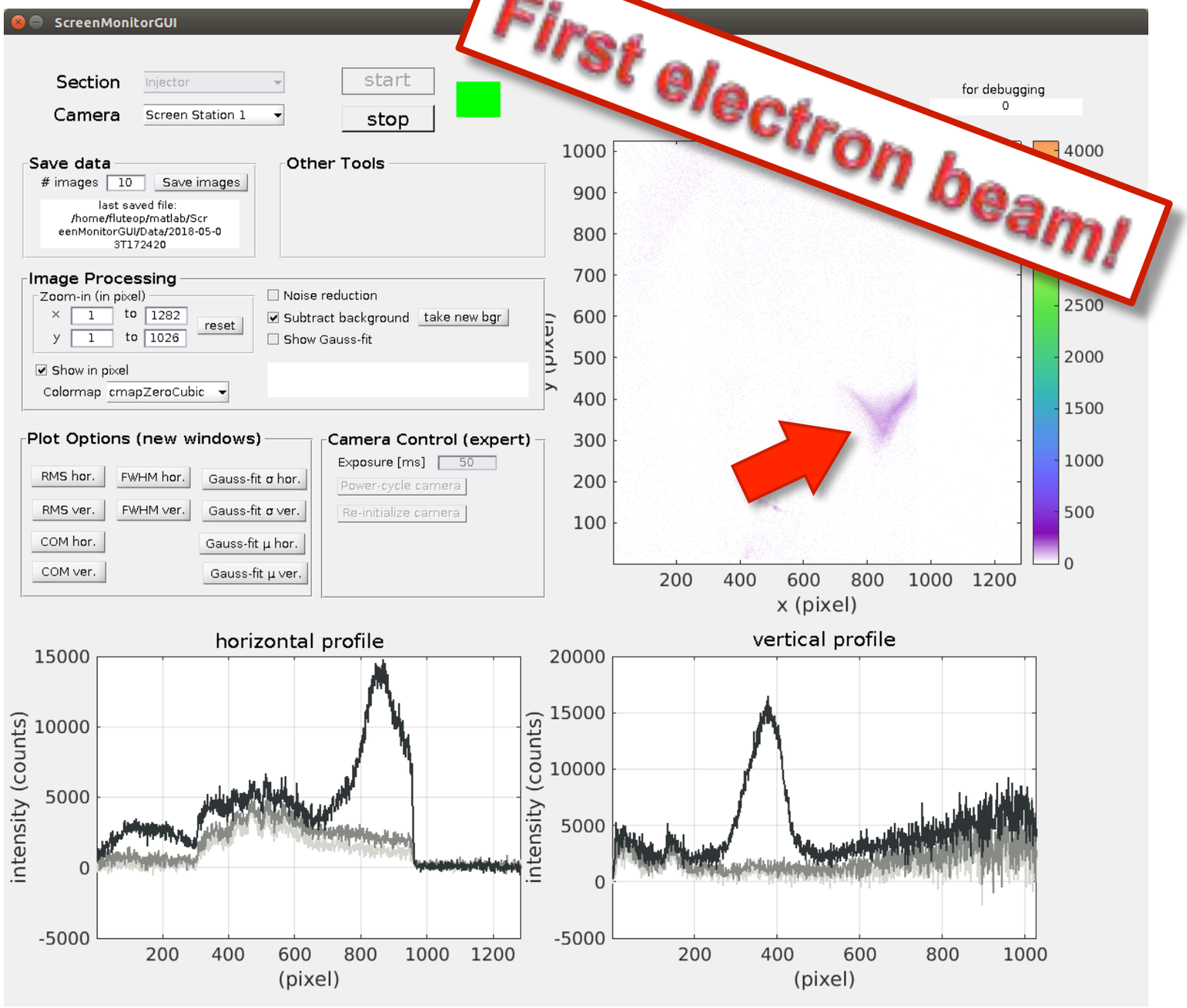
FLUTE - First beam 2018-05-03



YAG screen monitor: First electrons! (2018-05-03)

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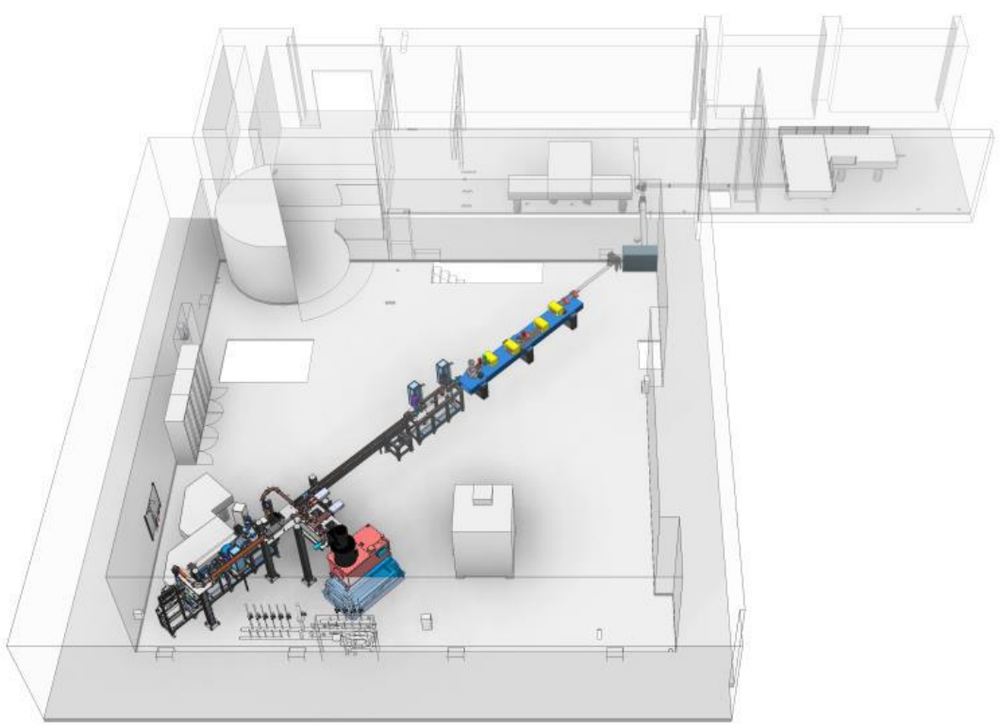
FLUTE: Accelerator test facility at KIT

- FLUTE (Ferninfrarot Linac- Und Test-Experiment)
  - Test facility for **accelerator physics within ARD**
  - **Experiments** with THz radiation
- R&D topics
  - Serve as a test bench for new beam diagnostic methods and tools
  - Systematic bunch compression and THz generation studies
  - Develop single shot fs diagnostics
  - Synchronization on a femtosecond level

Final electron energy	~ 41	MeV
Electron bunch charge	0.001 - 3	nC
Electron bunch length	1 - 300	fs
Pulse repetition rate	10	Hz
THz E-Field strength	up to 1.2	GV/m



www.ibpt.kit.edu/flute

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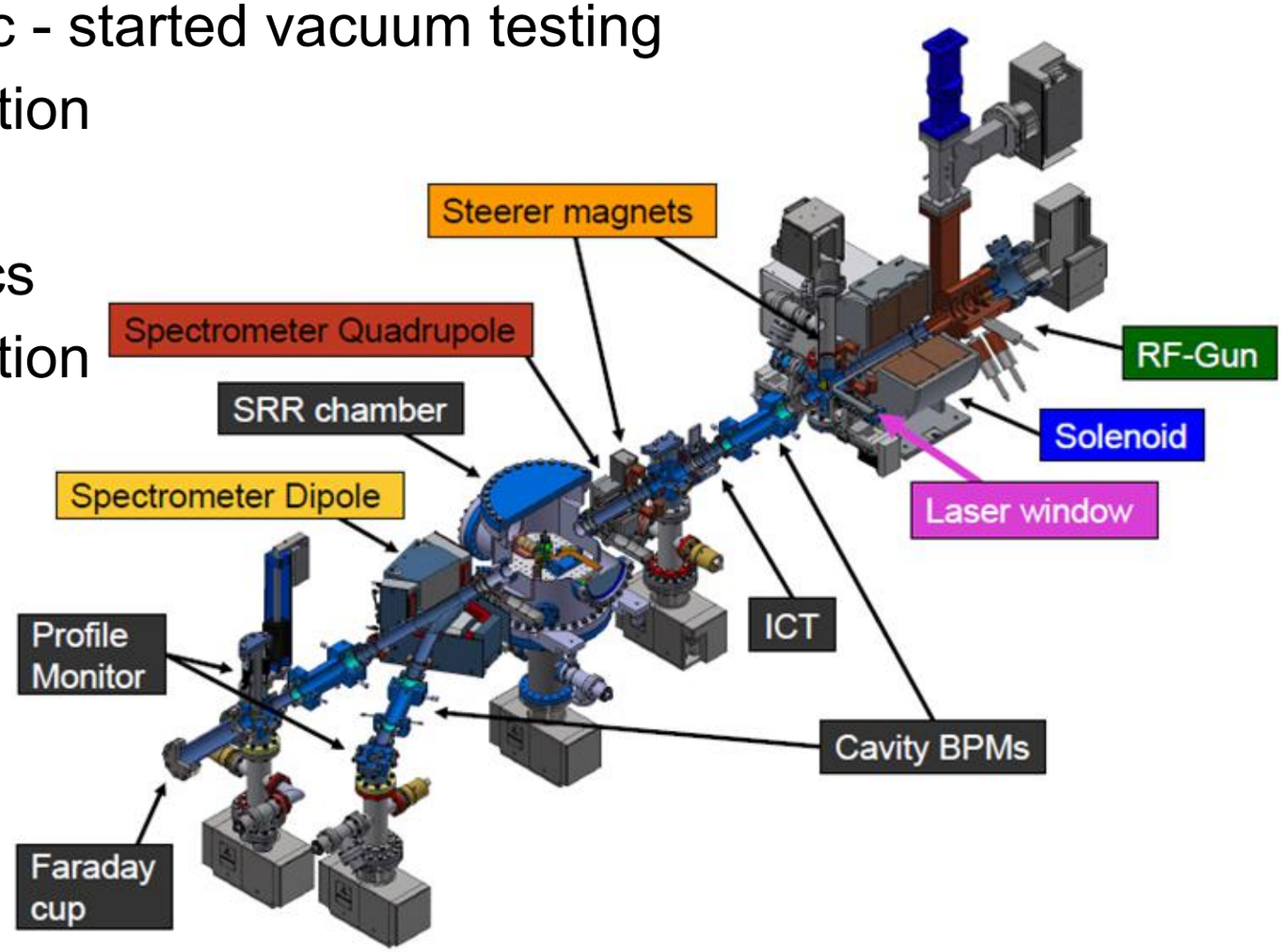
FLUTE Status

- First beam (gun section) ✔
- Chicane dipole magnets have arrived ✔
- RF-Power limited due to broken circulator - new circulator ordered
- Work in progress
  - Assembly diagnostic after linac - started vacuum testing
  - Chicane girder under construction
  - Phase lock RF and laser
  - Laser feedback and diagnostics
  - Systematic beam characterization
- First ARIES user experiment: Split ring resonator



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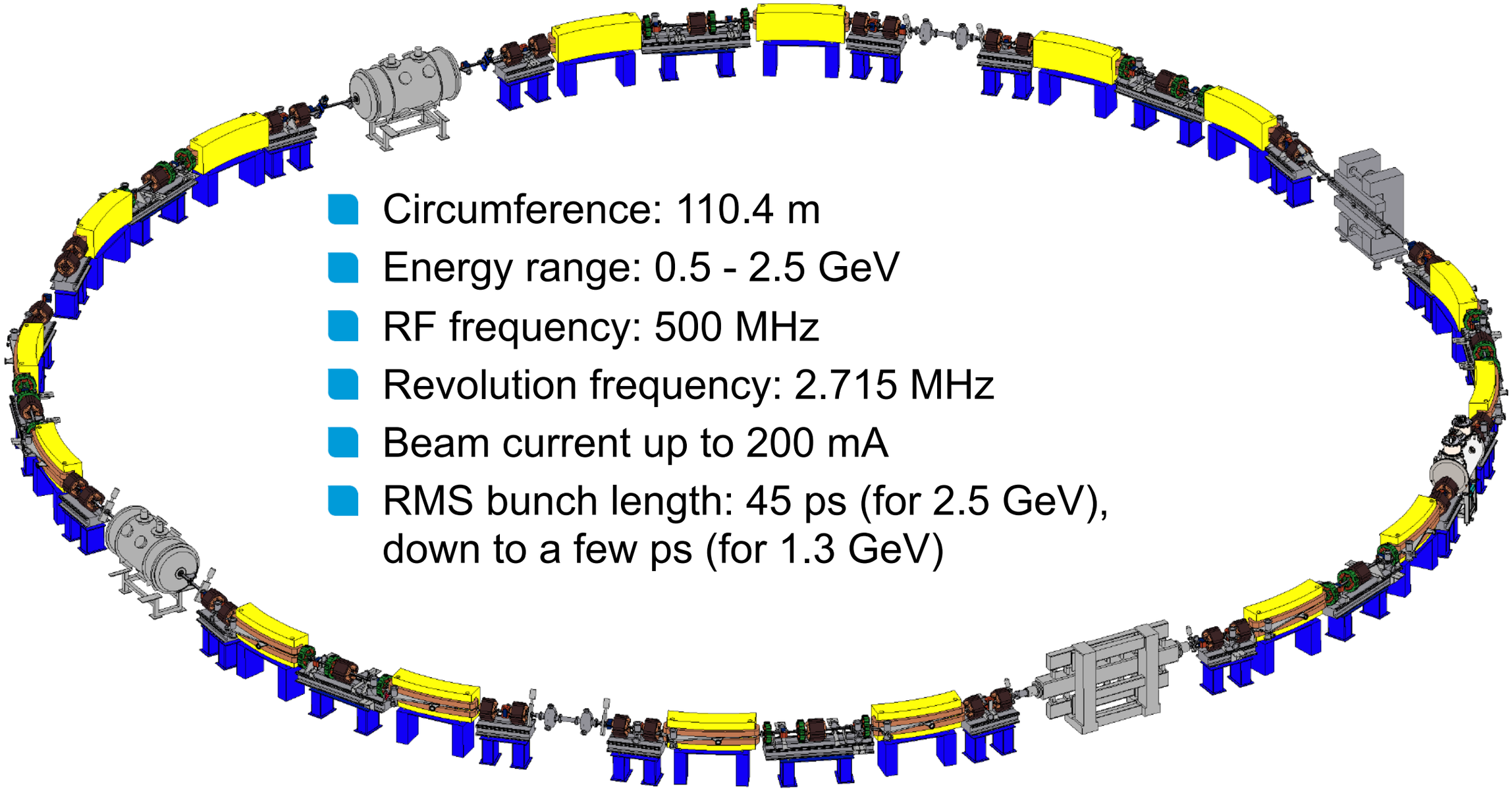
Karlsruhe Research Accelerator (KARA)

- User applications & accelerator test facility



- Circumference: 110.4 m
- Energy range: 0.5 - 2.5 GeV
- RF frequency: 500 MHz
- Revolution frequency: 2.715 MHz
- Beam current up to 200 mA
- RMS bunch length: 45 ps (for 2.5 GeV), down to a few ps (for 1.3 GeV)

www.ibpt.kit.edu/kara

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Installation activities

- Installed and commissioned the SCU20
- Finished replacement of all corrector power supplies in the injector
  - Straight forward for the booster and the Injection and Extraction line
  - Complete recommissioning of the microton needed
- Service at the In-Vacuum Undulator
  - Replaced leaking components
  - Installed additional vacuum pumps to improve the vacuum
- Vacuum control PLC
  - Started renewal of all control cables using distributed IO units
  - Preparing the migration of the control into EPICS
- 500 MHz Distribution
  - New master oscillator
  - Design of a new 500 MHz distribution

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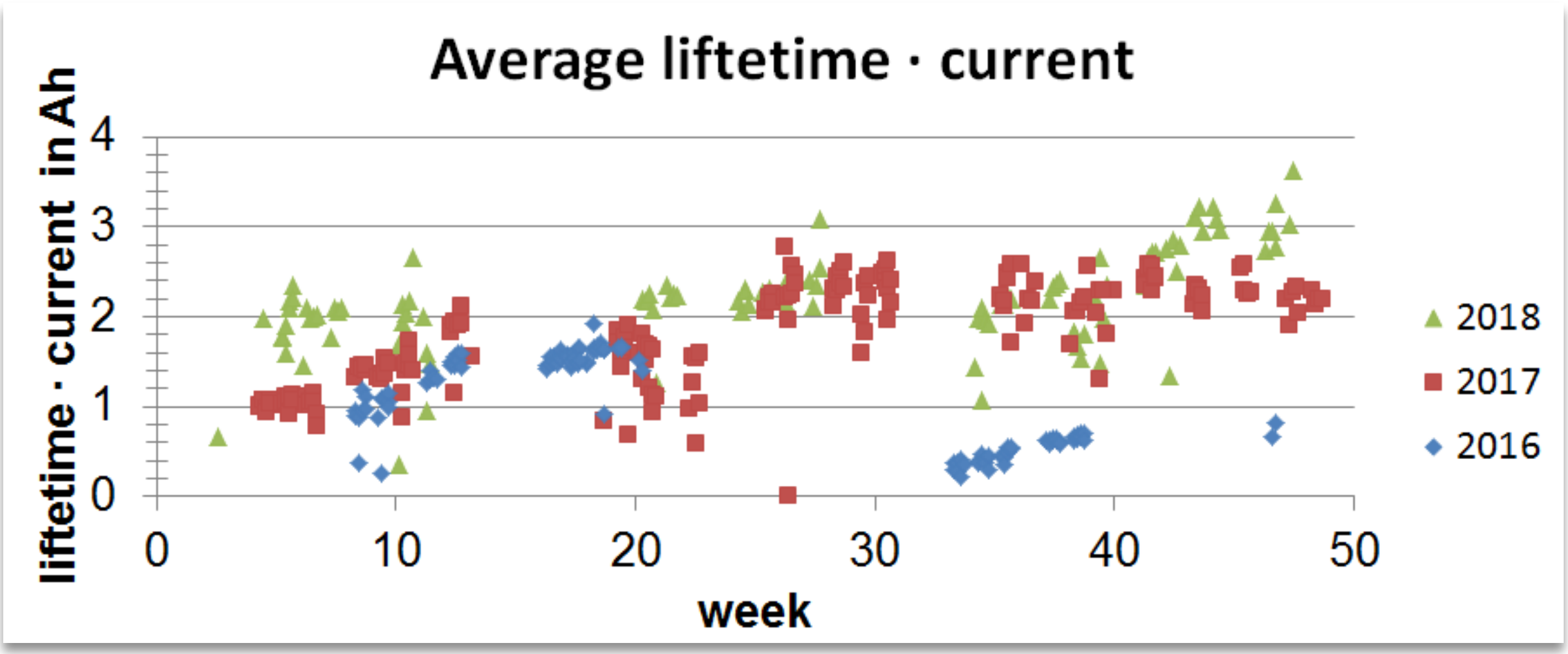
Operation

- Moved to a one injection per day scheme
- Vacuum and lifetimes improved continuously
- Study further methods to improve the lifetime
  ➜ see Talk A. Mochihashi.



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Operation Issues

- Issues with the personnel safety system
  - Errors are not easy to debug due to missing diagnostic features
  - Found faulty relay ➜ started discussion on new system for the storage ring
- Vertical corrector power supply (50V, 2A) failures
  - No spare left - broken ones beyond repair
  - Installed temporary ITEST BE2811 units with modified firmware
  - Replacement of all corrector power supplies with ITEST BE2850 next spring
- Water interlocks
  - Cooling circuit operates at limit
  - Flow limitier are not working as intended:
    Flow drops over time due to pollution of the springs
- Cooling issue at CLIC damping ring wiggler
  - HTS feed through was getting too warm
  - After service of the CryoCooler temperature is fine again
- Summer thunder storms with heavy rain (60 l/m² in 30 min)

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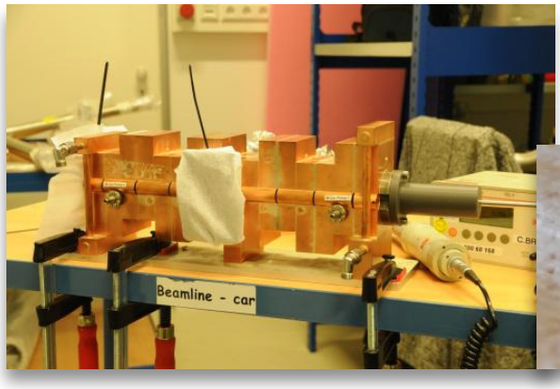
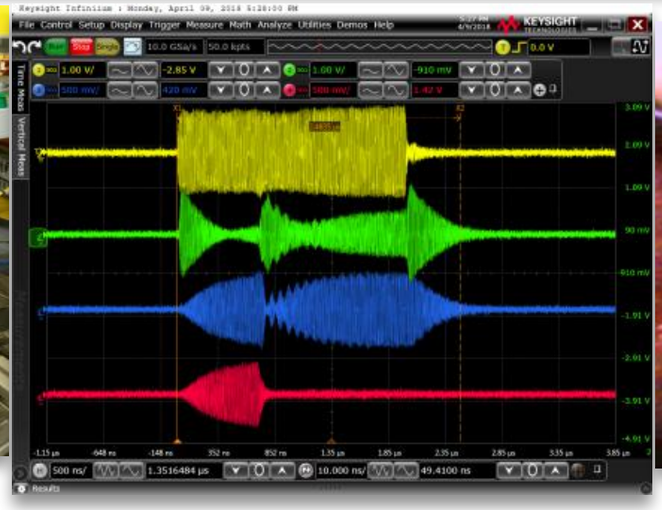
Microtron linac breakdown



15.03.18

24.04.18

RF break down



Beam back

Images: S. Schott, M. Süpfle, A. Völker, M. Schuh, P. Wesolowski

- Vented the microtron several time including taking out and in the linac
- Cleaning of the RF window and the linac with pressurized air
- Discussed several cleaning methods, which all could not be used
- Improved diagnostic
- Over one week of RF conditioning brought the power back to nominal
- **Thank you for your support!**

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KARA distributed sensor network

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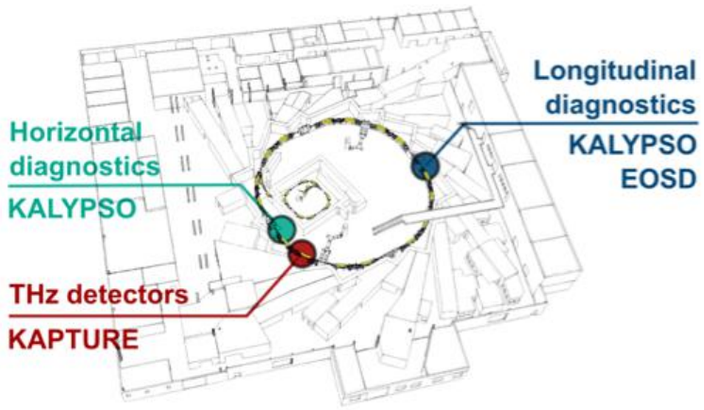
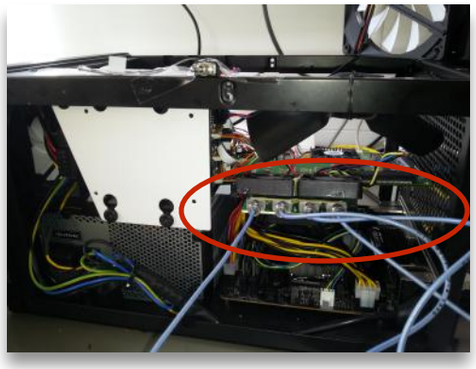


Analyze Longitudinal Phase Space

Emitted CSR
- **THz Detector**
  - **KAPTURE**

Energy Spread
- **Horizontal bunch profile in dispersive section**
  - **FGC: fast gated camera**

Bunch Profile
- **Electro-optical spectral decoding**
  - **KALYPSO**



KAPTURE-2 inside PC

B. Kehrer et al, 10.1103/PhysRevAccelBeams.21.102803

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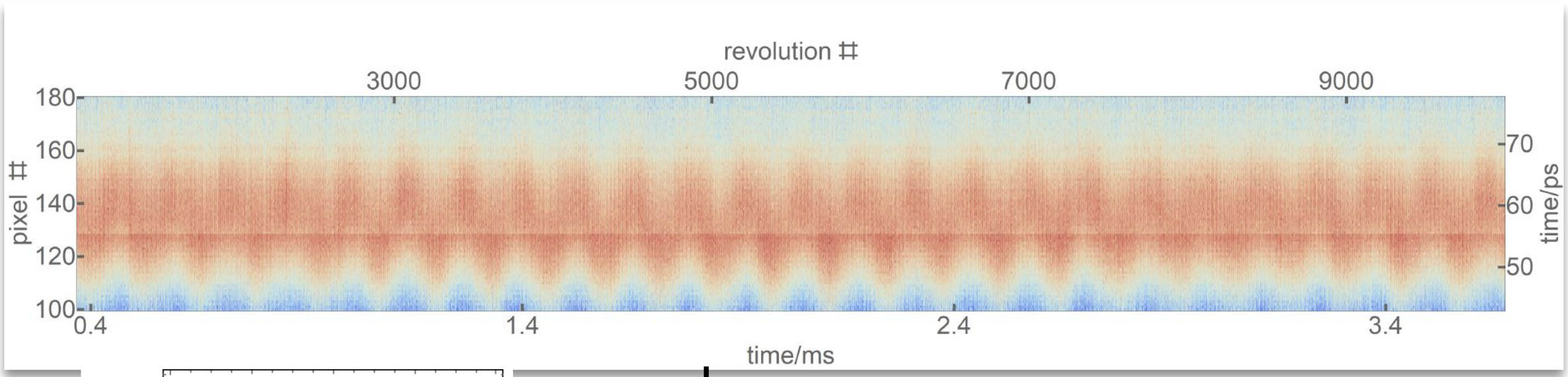
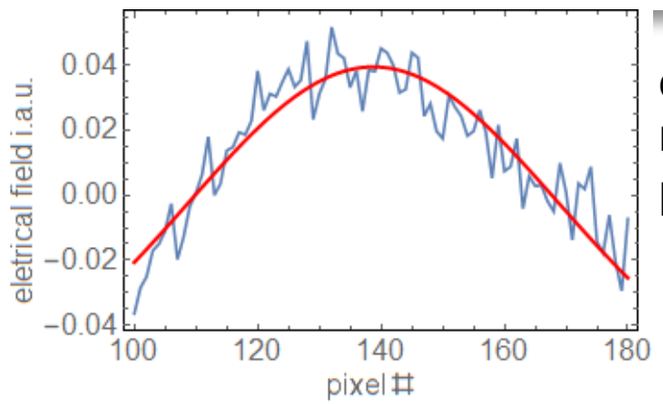
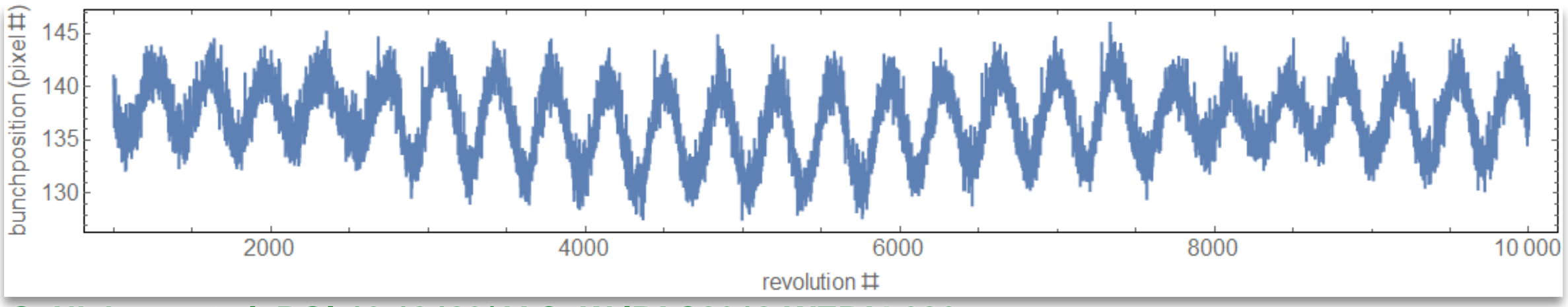
KALYPSO: EO measurement
Monitoring effects at long time scales (3.6 s)





determine mean bunch position



G. Niehues et al, DOI:10.18429/JACoW-IPAC2018-WEPAL026

S. Funkner et al, IRMMW-THz 2018

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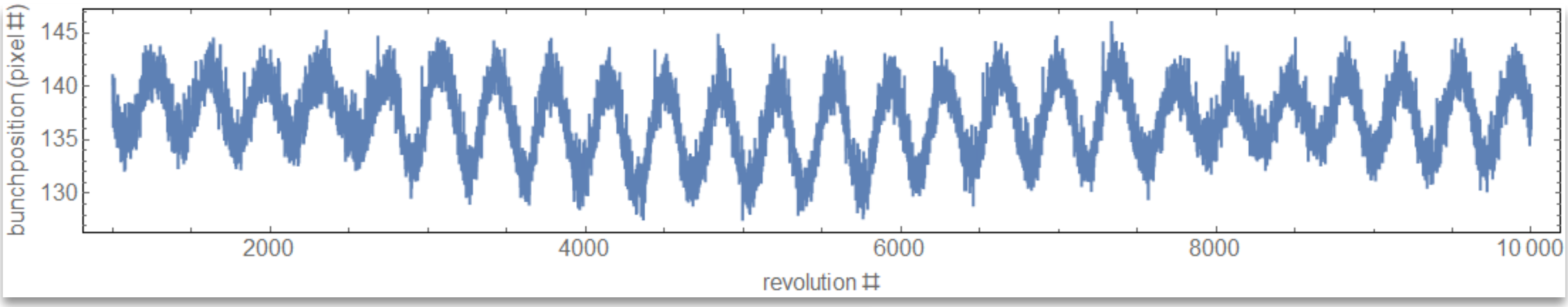
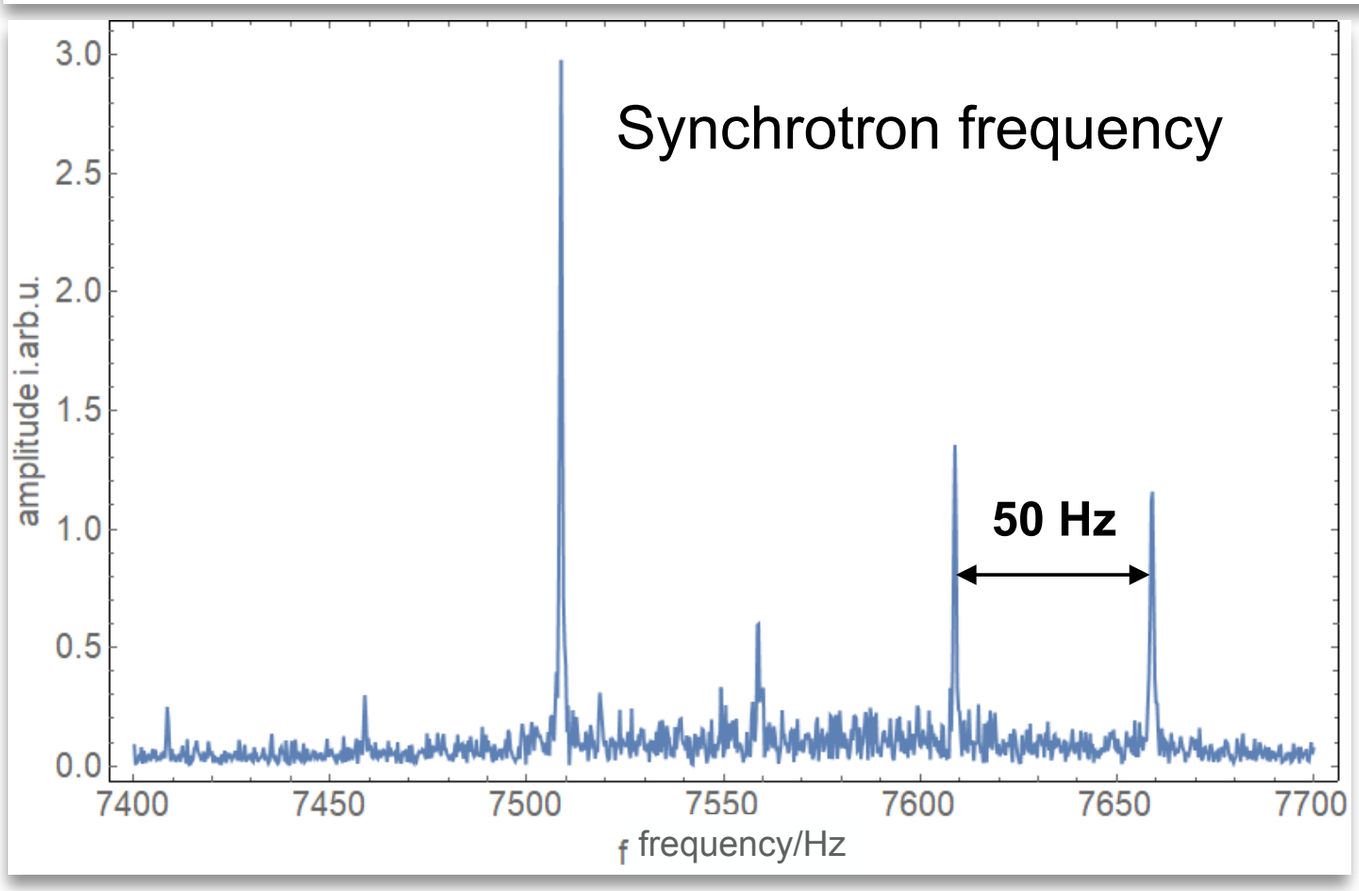
KALYPSO: EO measurement
Monitoring effects at long time scales (3.6 s)





FFT from $9*10^6$ data points

G. Niehues et al,
DOI:10.18429/JACoW-IPAC2018-WEPAL026
S. Funkner et al, IRMMW-THz 2018
S. Funkner et al, submitted to Peer-Review https://arxiv.org/abs/1809.07530.

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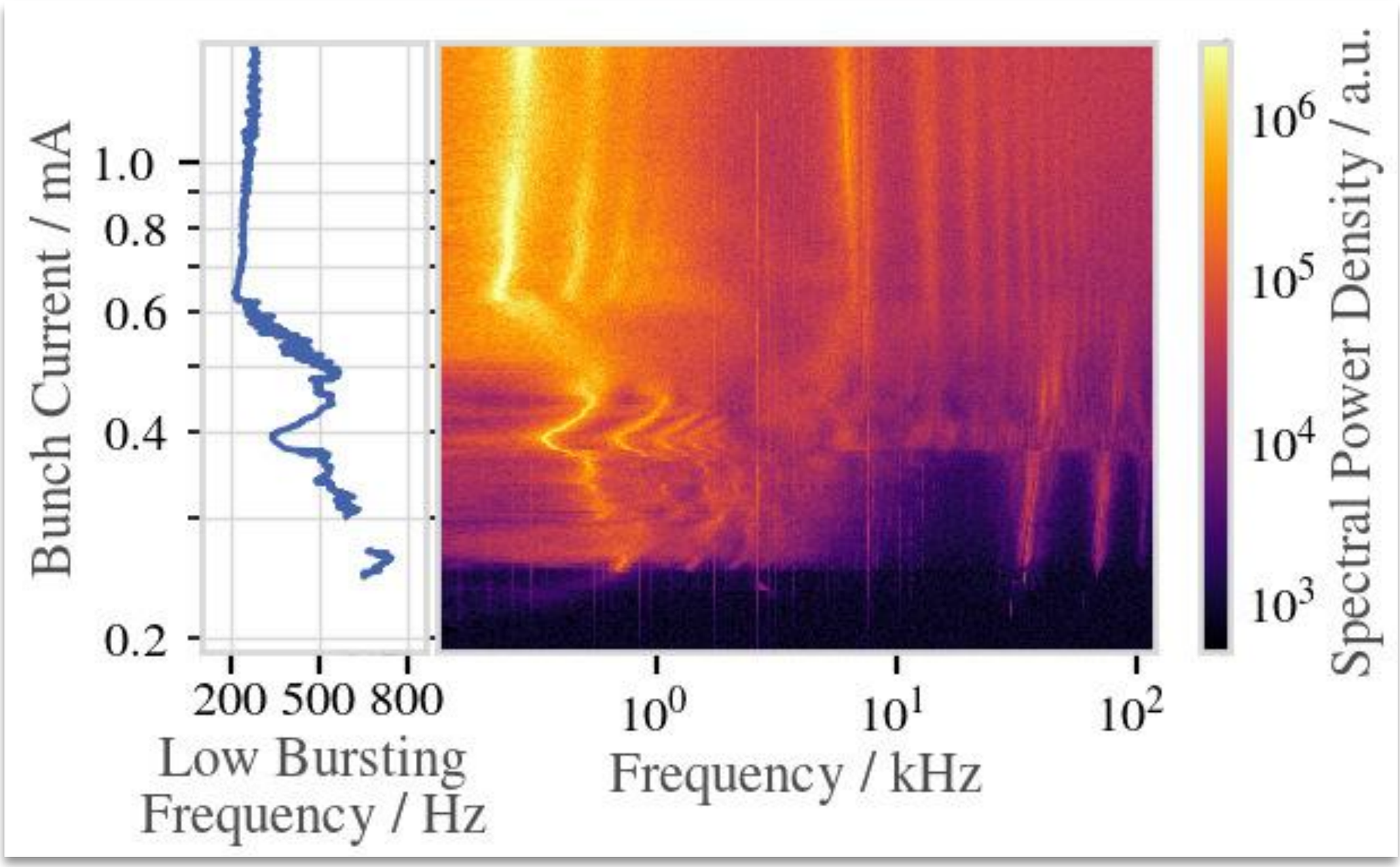
Influence of a damping wiggler on the micro-bunching instability



M. Brosi, J. Gethmann et al.: DOI:10.18429/JACoW-IPAC2018-THPAK029

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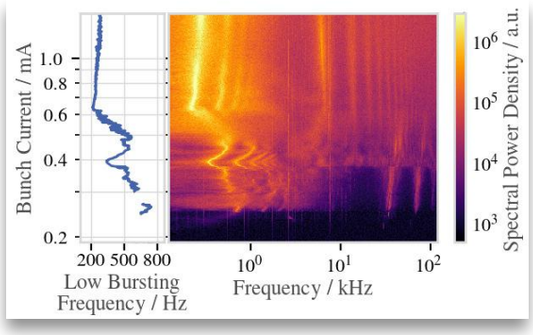
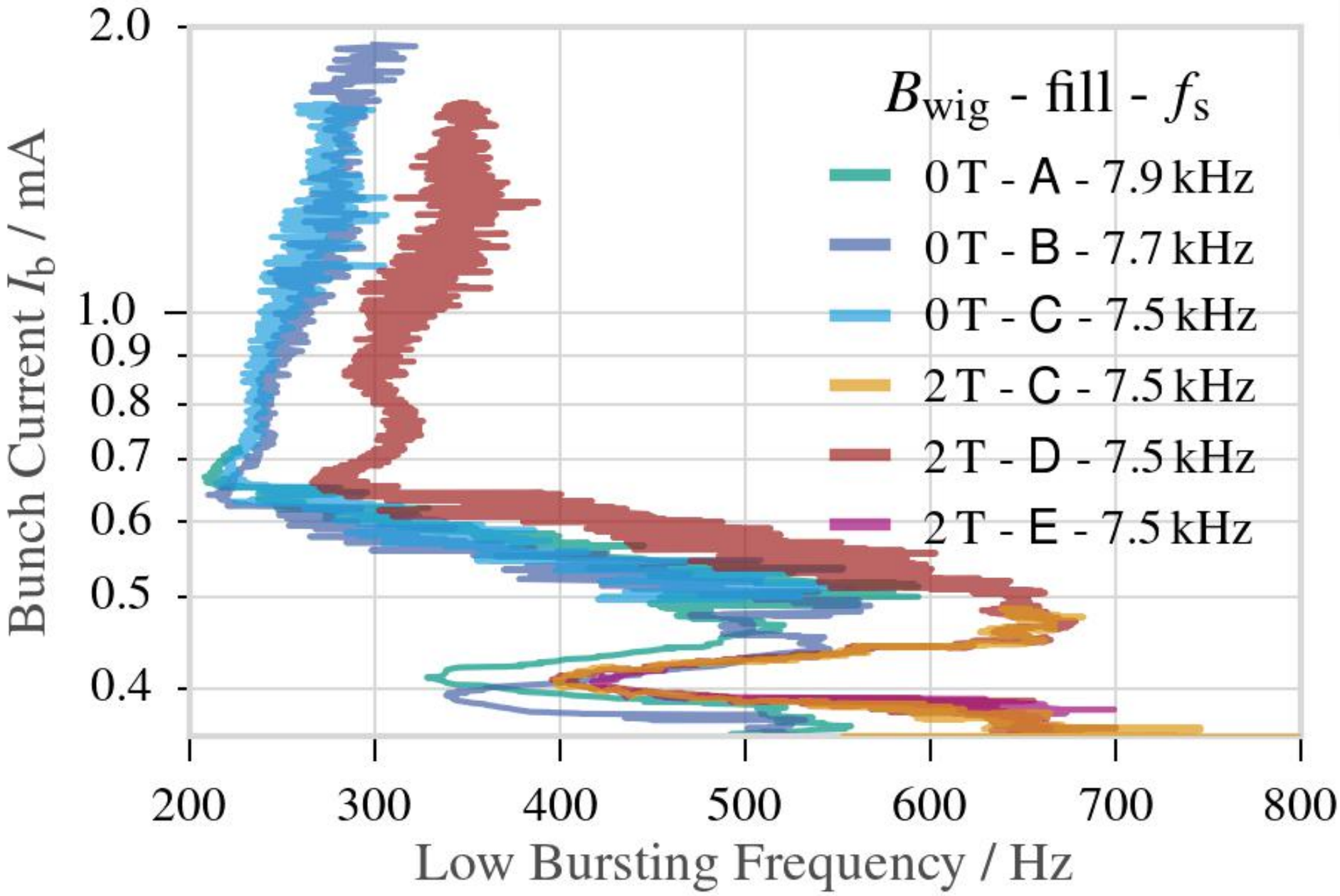
Influence of a damping wiggler on the micro-bunching instability

- Low bursting frequency is shifted





B. Brosi, J. Gethmann: DOI:10.18429/JACoW-IPAC2018-THPAK029

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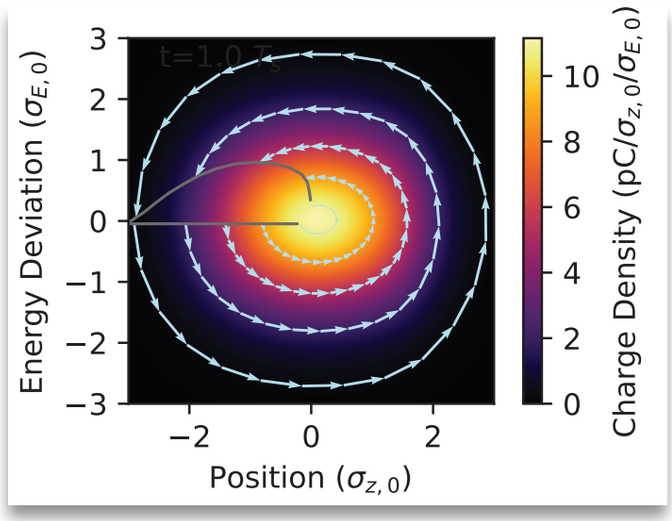
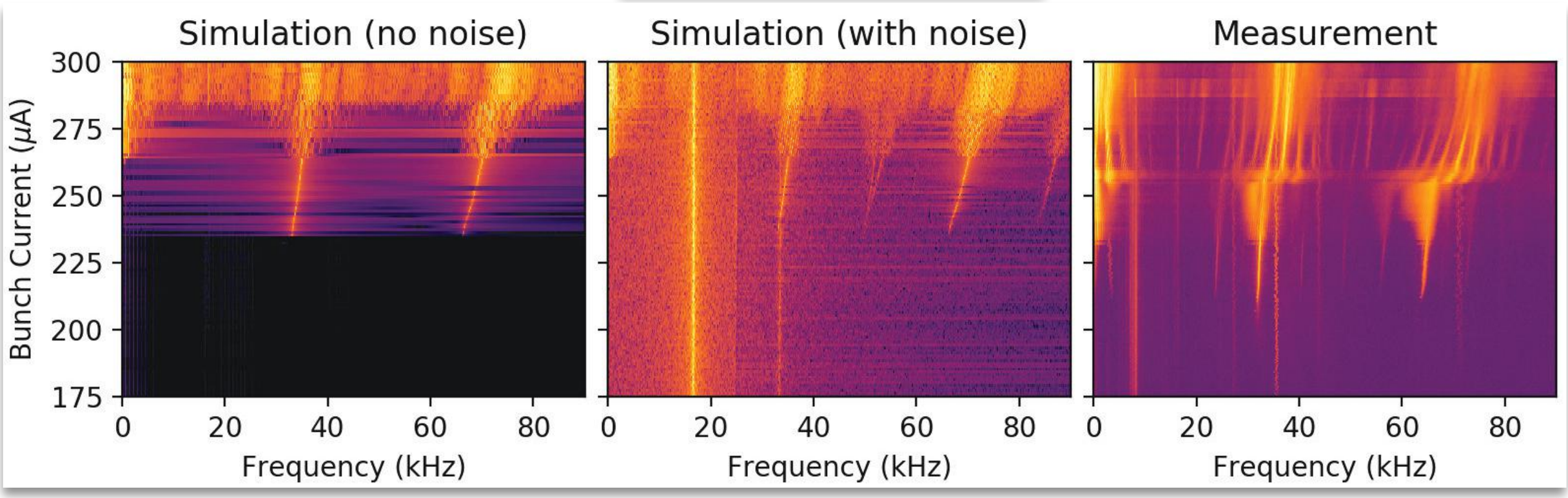
Longitudinal beam dynamics simulations

- New INOVESA features
  - Pseudo particle tracking: Track single electrons within charge distribution



P. Schönfeldt et al, DOI:10.18429/JACoW-IPAC2018-THPAK032

  - RF Noise



- INOVESA based studies

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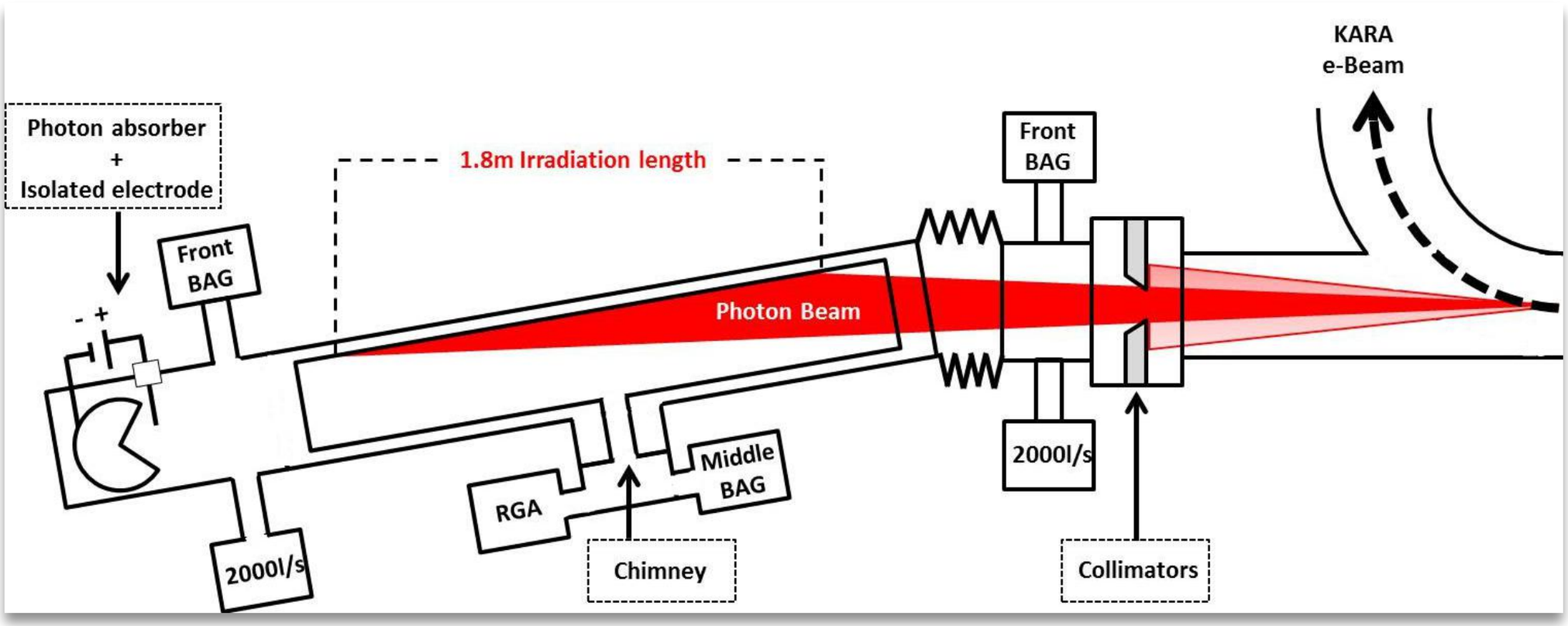
EuroCirCol - FCC H2020 Project: BESTEX setup

- Two FCC-hh Beam Screen prototypes have been tested so far at BESTEX
- Third prototype (Baseline design is currently under study)



L. A. González et al,
DOI:10.18429/JACoW-IPAC2018-MOZGBE5

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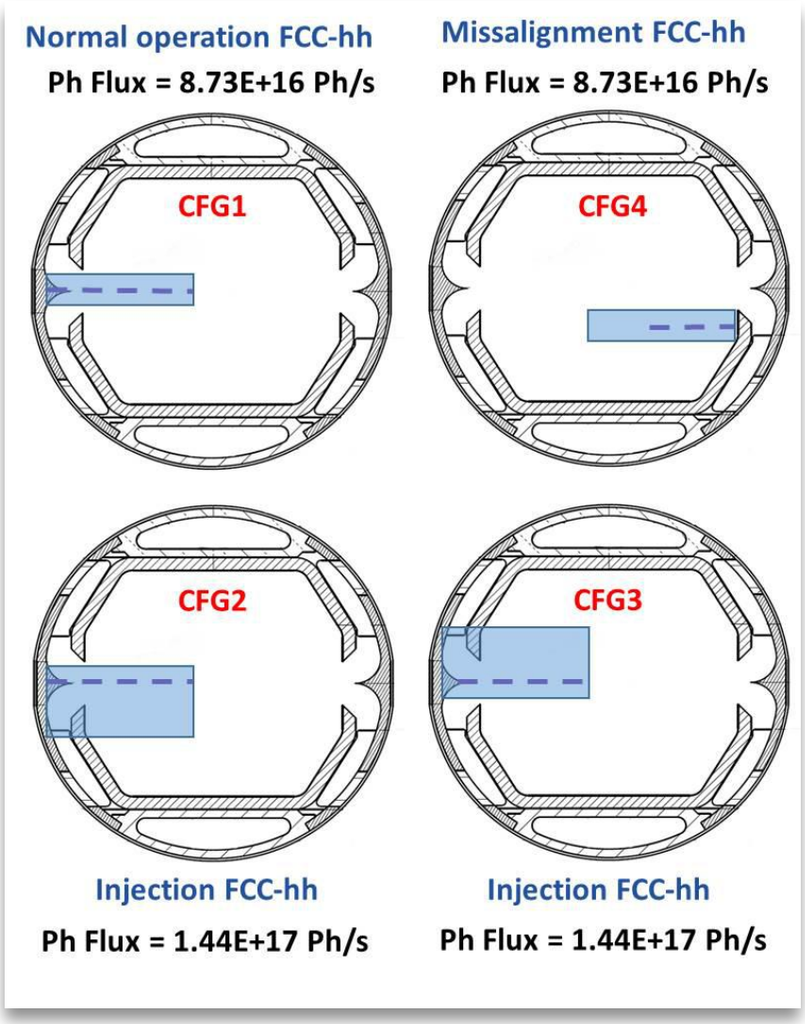
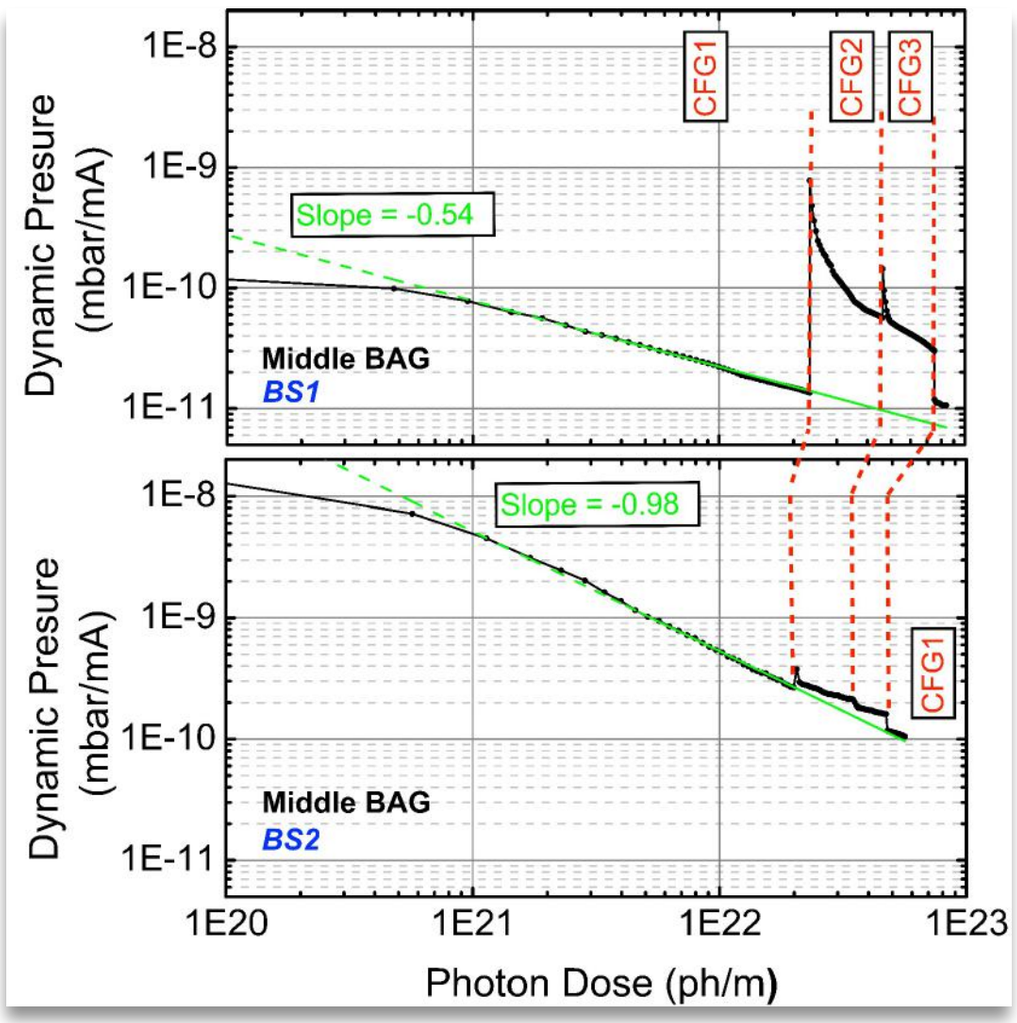
EuroCirCol - FCC H2020 Project: BESTEX results

- Each Beam Screen Prototype was irradiated in different configurations in order to mimic all the scenarios of FCC-hh operation.
- The results showed a large amount of photons reflected towards the inner walls of the Beam Screen





Electro deposited Cu at inner walls

Clearing Electrode (high photo stimulated desorption) at inner walls

L. A. González et al, DOI:10.18429/JACoW-IPAC2018-MOZGBE5

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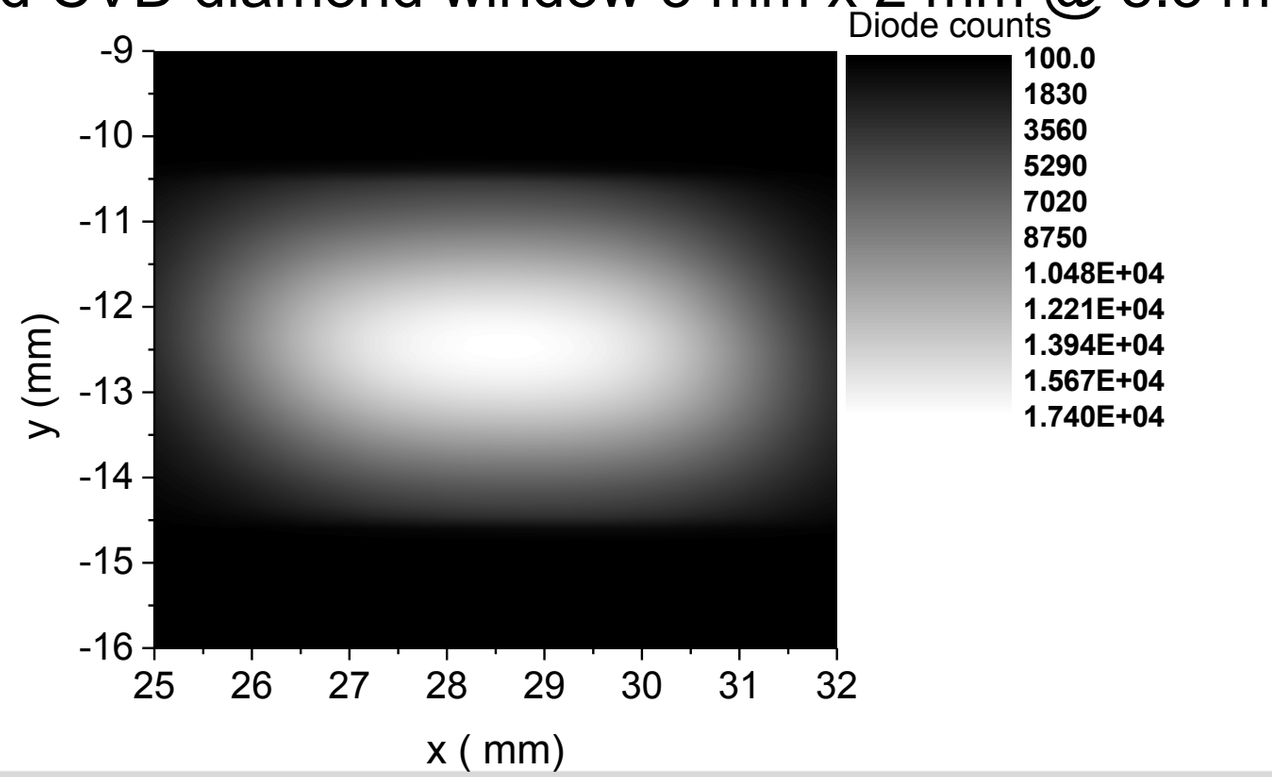
SCU20: tests with beam

- Installation in December 2017
- Successfully operating in the KIT synchrotron since January 2018 without quenches
- First X-rays 10.01.2018

Image of white beam scanning diode after 15 µm pinhole @ 17.1 m from the source and CVD diamond window 3 mm x 2 mm @ 8.3 m



S. Casalbuoni et al,
Synchrotron Radiation News, 31:3, 24-28 (2018)
DOI:10.1080/08940886.2018.1460171

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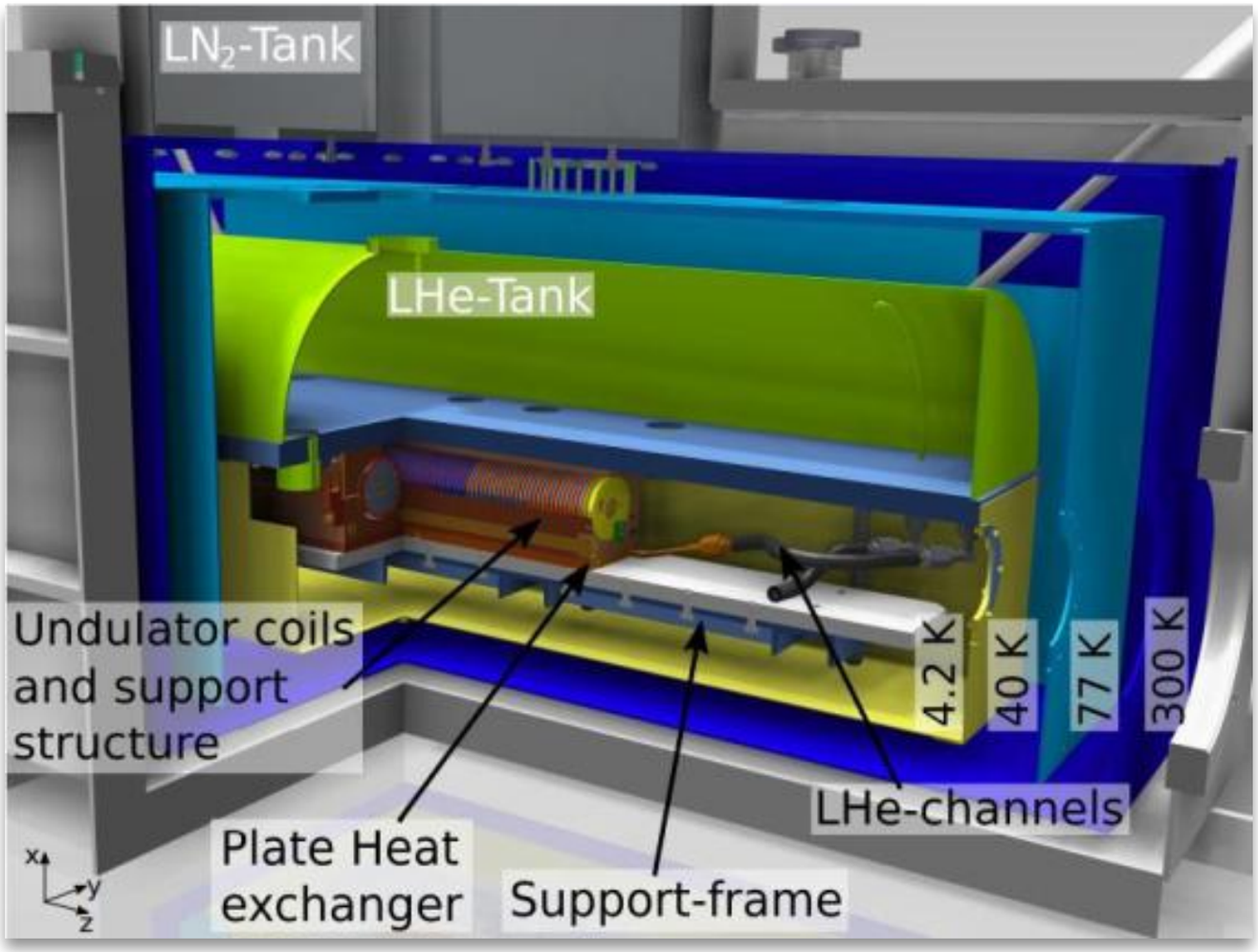
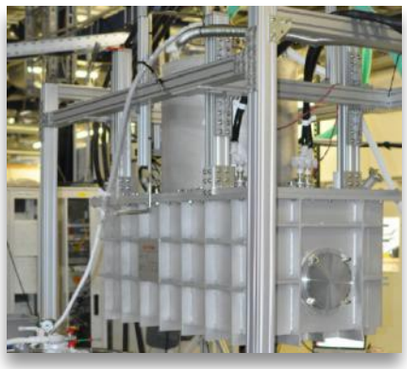
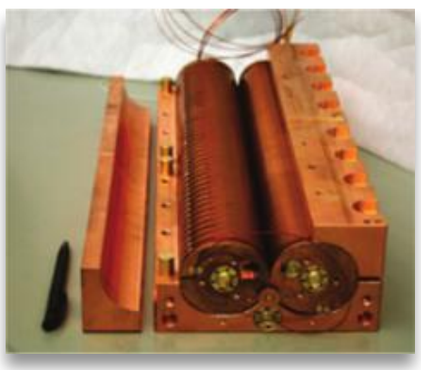
Status of TGU @ KIT

- TGU cool-down
- TGU powering test
- PhD student at work
- Next steps
  - Install B-field measurement system
  - Measure transverse field distribution along longitudinal axis
  - Experiments at HI Jena and SINBAD







A. Bernhard et al.,
DOI: 10.1016/j.nima.2017.12.052

4.2 K / 77 K indirect cooling, Low-T_C superconducting coils, high-T_C current leads

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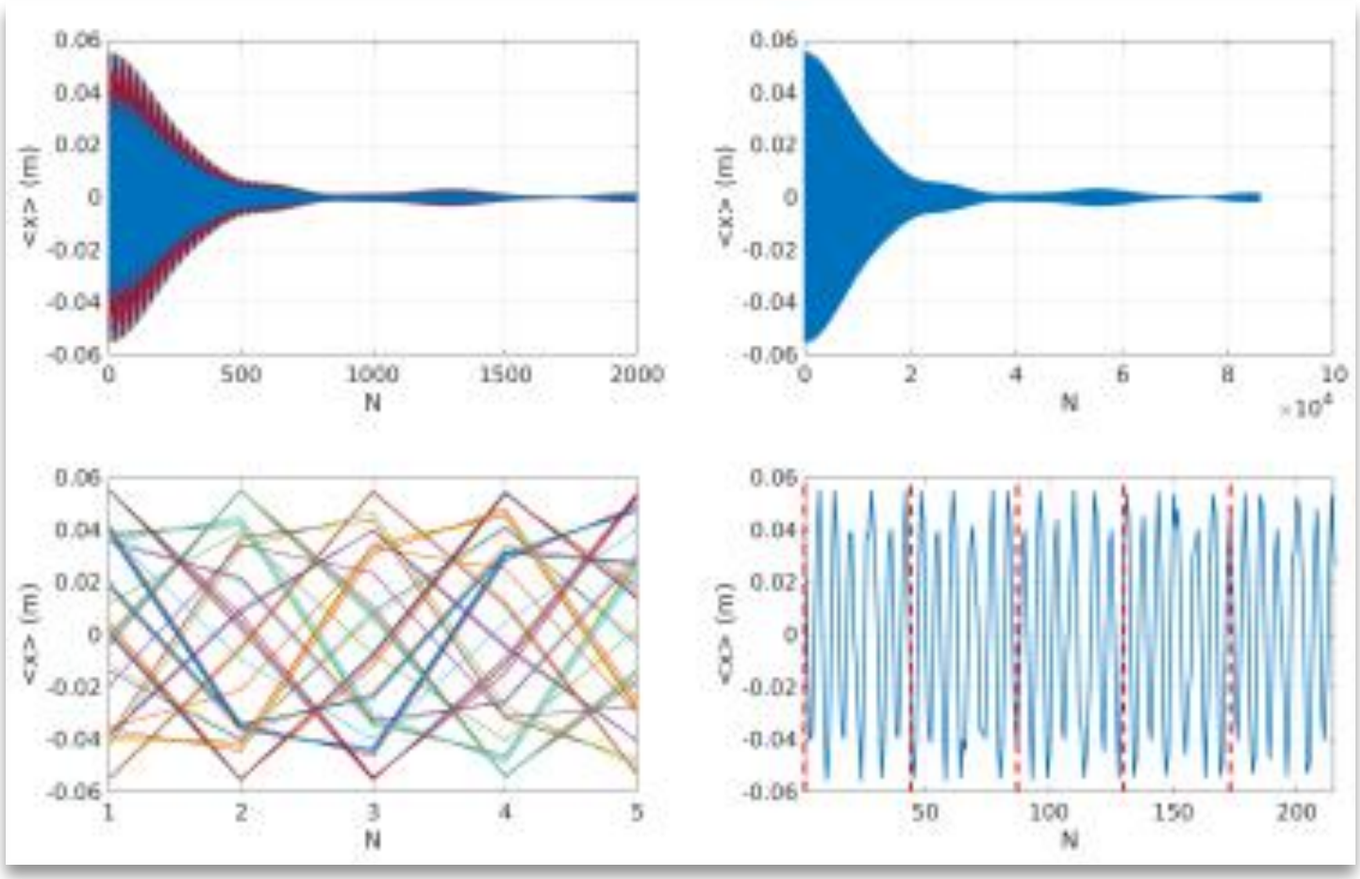
ARIES Activities

- KARA and FLUTE are available via transnational access for machine physics experiments
- Experiments
  - Test experiments for the split ring resonator at FLUTE
  - Optics characterization at KARA including the high wiggler field
  - Tests for a negative α_c working point at 500 MeV
- Open for your ideas: http://aries.web.cern.ch/ta



P. Zisopouloset al.:

https://indico.cern.ch/event/699219/contributions/2929063/

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

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Outlook

- FLUTE
  - Continue commissioning
  - Prepare and carry out first accelerator user experiment with beam
- KARA Refurbishment
  - Upgrade controller of main power supplies
  - Install new corrector power supplies
  - Renew kicker and septa power supplies
  - Install new 500 MHz and reference distribution
  - Improve diagnostics in the injector
- Work on further lifetime improvements like phase modulation
- Establish low α_c and negative α_c optics at 500 MeV
- Provide beam at 1.8 GeV for beam line applications in the frame of CALIPSOplus
- ARIES Workshop 2019 at KIT: 18.-20.02.2019 https://indico.cern.ch/event/772326/

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Acknowledgements

- The accelerator team:
  Axel Bernhard, Edmund Blomley, Tobias Boltz, Miriam Brosi, Erik Bründermann, Sara Casalbuoni, Kantaphon Damminsek, Stefan Funkner, Julian Gethmann, Andreas Grau, Daniel Hoffmann, Erhard Huttel, Benjamin Kehrer, Anton Malygin, Sebastian Marsching, Yves-Laurent Mathis, Wolfgang Mexner, Akira Mochihashi, Michael J. Nasse, Gudrun Niehues, Meghana Patil, Alexander Papash, Robert Ruprecht, David Saez de Jauregui, Thiemo Schmelzer, Patrik Schönfeldt, Patrick Schreiber, Nigel J. Smale, Johannes L. Steinmann, Pawel Wesolowski, Minjie Yan, and Anke-Susanne Müller
- KIT Institutes (ETP, IHM, IMS, IPE, IPS, LAS)
- Collaboration partners

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Backup slides

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Accelerator Technology Platform

Karlsruhe Institute of Technology

Research

Infrastructure

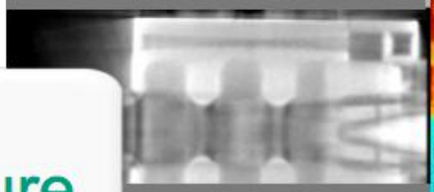
Technologies

Compact magnets

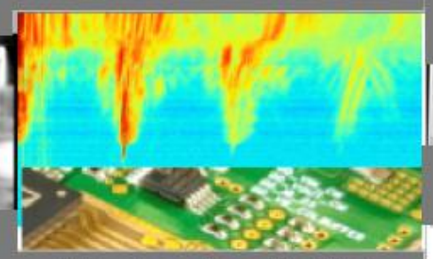
Terahertz sensors

Cryogenics & superconductivity

Vacuum



Imaging



Electronics & high performance computing

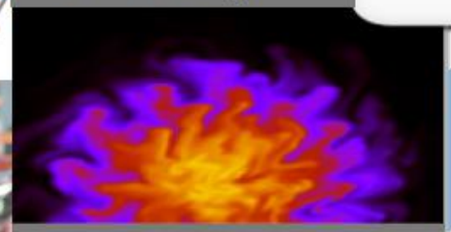
Nano- & micro-technology

KNMF Karlsruhe NANO MICRO Facility

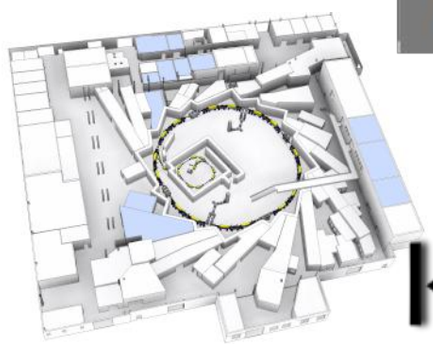
Microwave technologies

Lasers & materials

Accelerators & infrastructures



Mathematics, numerics, physics, modelling



KARA

FLUTE

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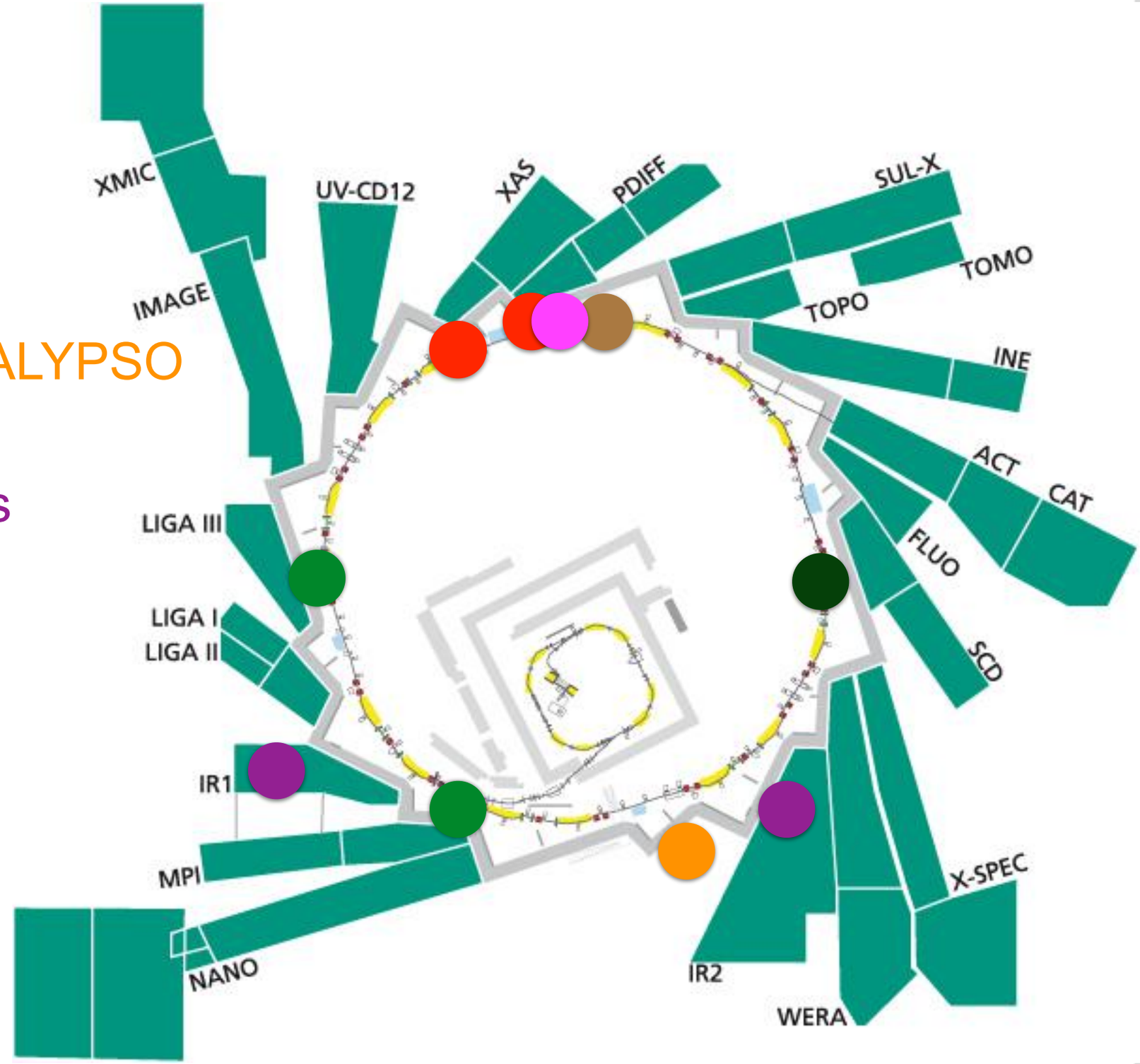
Diagnostics at KARA

- SR light monitor
- In-Air X-ray detector
- EO-Nearfield setup
- Streak camera
- Fast-gated camera / KALYPSO
- BBB feedback system
- Ultra fast THz detectors
- Lead glass detector
- BPMs
- BLMs
- …



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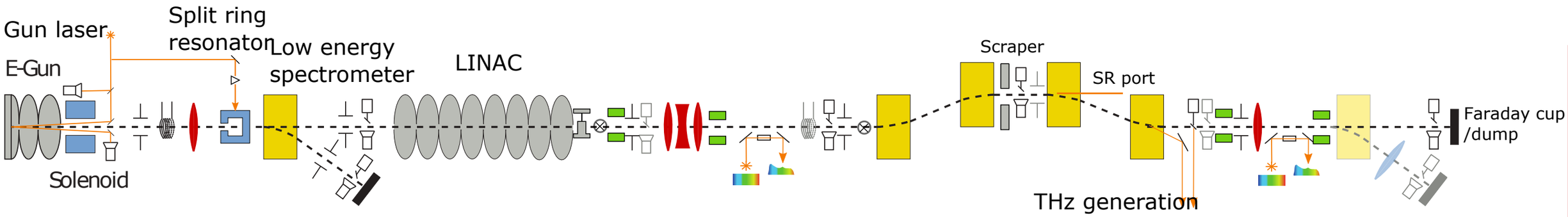
FLUTE diagnostics



- **Large dynamic range:**
  - **Charge: 1 pC - 3 nC**
  - **Energy: 7 - 42 MeV**
  - **Bunch length: 2-3 ps (after gun), few fs (after chicane)**
  - **Transverse bunch size: 20 µm - 4 mm**
- Charge, position, size:
  - Integrating current transformer
  - Faraday cup
  - 7-8 cavity BPMs (XFEL, SwissFEL)
  - 5-8 movable screens (PSI)
- Energy:
  - 2 spectrometers (7 & 42 MeV)
- Bunch length:
  - 2 electro-optical monitors (PSI / DESY)
  - Split ring resonator
- Laser-Diagnostic:
  - Virtual cathode
  - Cathode imaging
  - Auto-Correlator / Grennouille
- THz-Diagnostic:
  - Fast THz-detectors (e.g. HEB, Schottky Diodes)
  - Interferometer: Martin-Puplett, Michelson
  - Electro-optical methods (far-field)

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