Karlsruhe Institute of Technology

Status of KIT-IBPT facilities

The XXV European Synchrotron Light Sources Workshop, Dortmund, Germany, 20-22.11.2017

M. Schuh for the accelerator team

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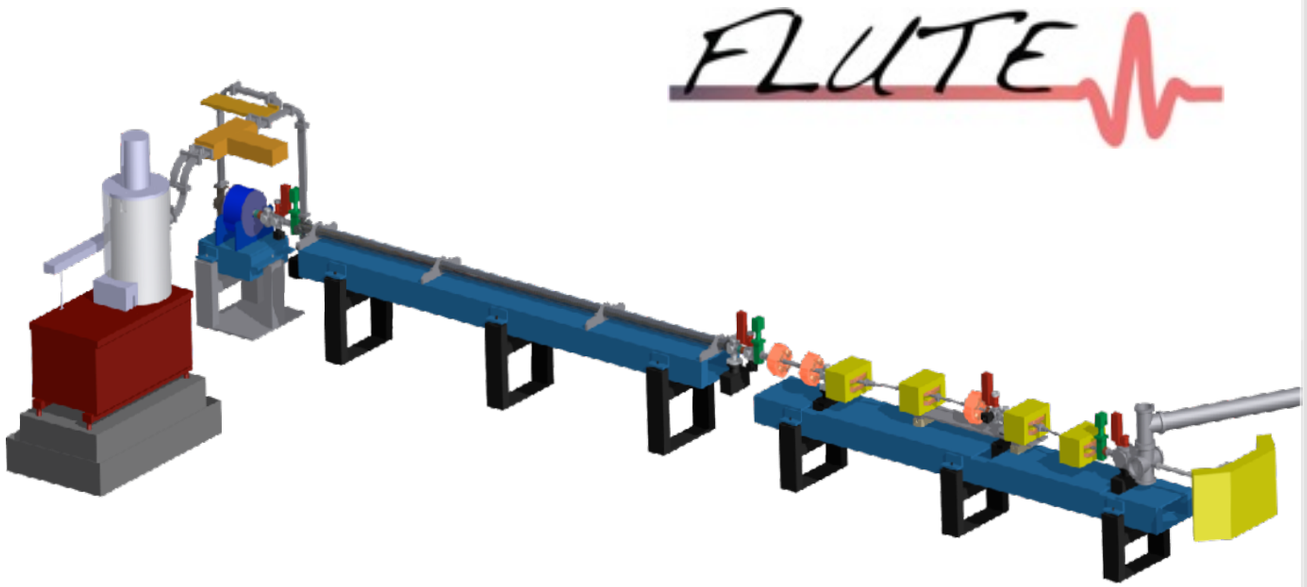

Acknowledgements

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

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Outline

- FLUTE
  - Layout and status
  - Split Ring Resonator Project
- KARA
  - Operation
  - Diagnostic developments
  - SCU20
  - EuroCircol test stand
- Summary and outlook

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Inauguration ceremony of FLUTE: 2017-07-13

http://www.ibpt.kit.edu/news_2017_7_KIT_press_release_FLUTE_inauguration_presidents.php

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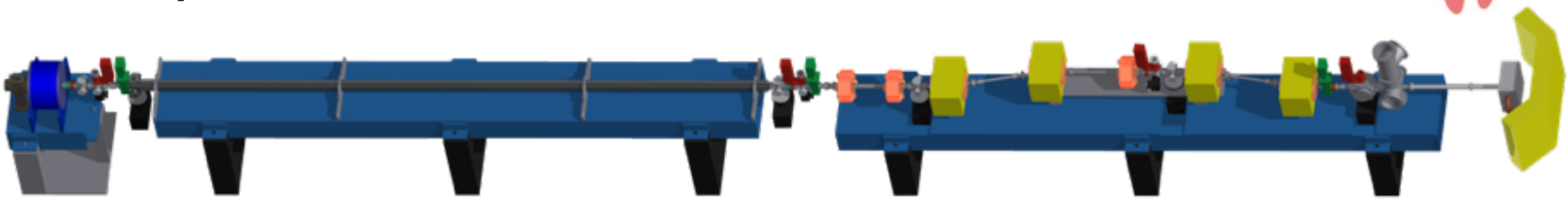
FLUTE: Accelerator test facility at KIT

- FLUTE (Ferninfrarot Linac- Und Test-Experiment)
  - Test facility for **accelerator physics within ARD**
  - **Experiments** with THz radiation



- Serve as a test bench for new beam diagnostic methods and tools
- Develop single shot fs diagnostics
- Synchronization on a femtosecond level
- Systematic bunch compression studies
- Generate intense THz radiation
- Compare different coherent THz radiation generation schemes in simulation and experiment

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

M. Nasse et al. , Rev. Sci. Instrum. 84, 022705 (2013)

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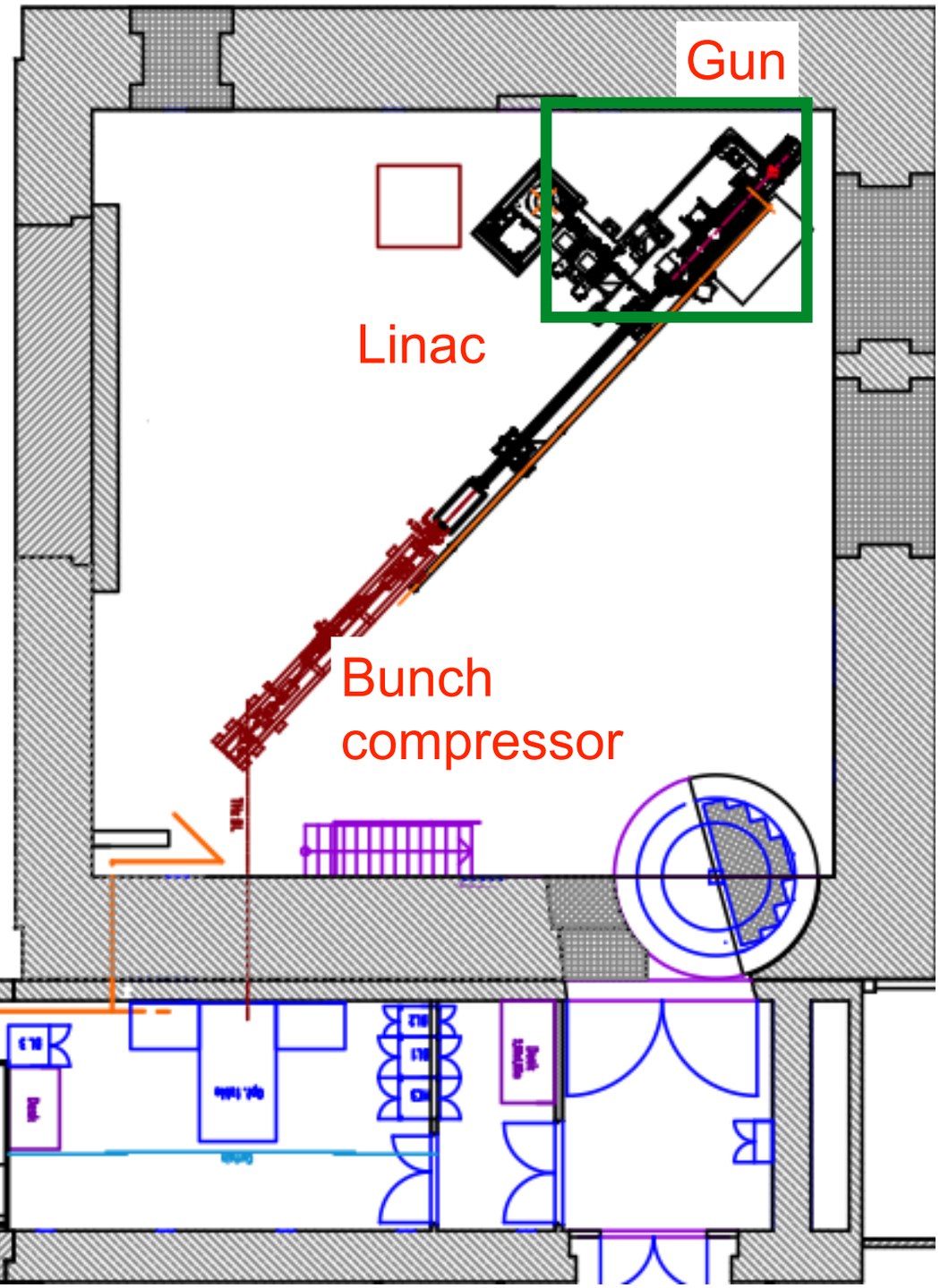
FLUTE layout and status

- TÜV Approval ✔
- Klystron RF tests ✔
- First experiment (SRR) installed ✔
- Optic for laser transport ✔
- Preparing gun commissioning



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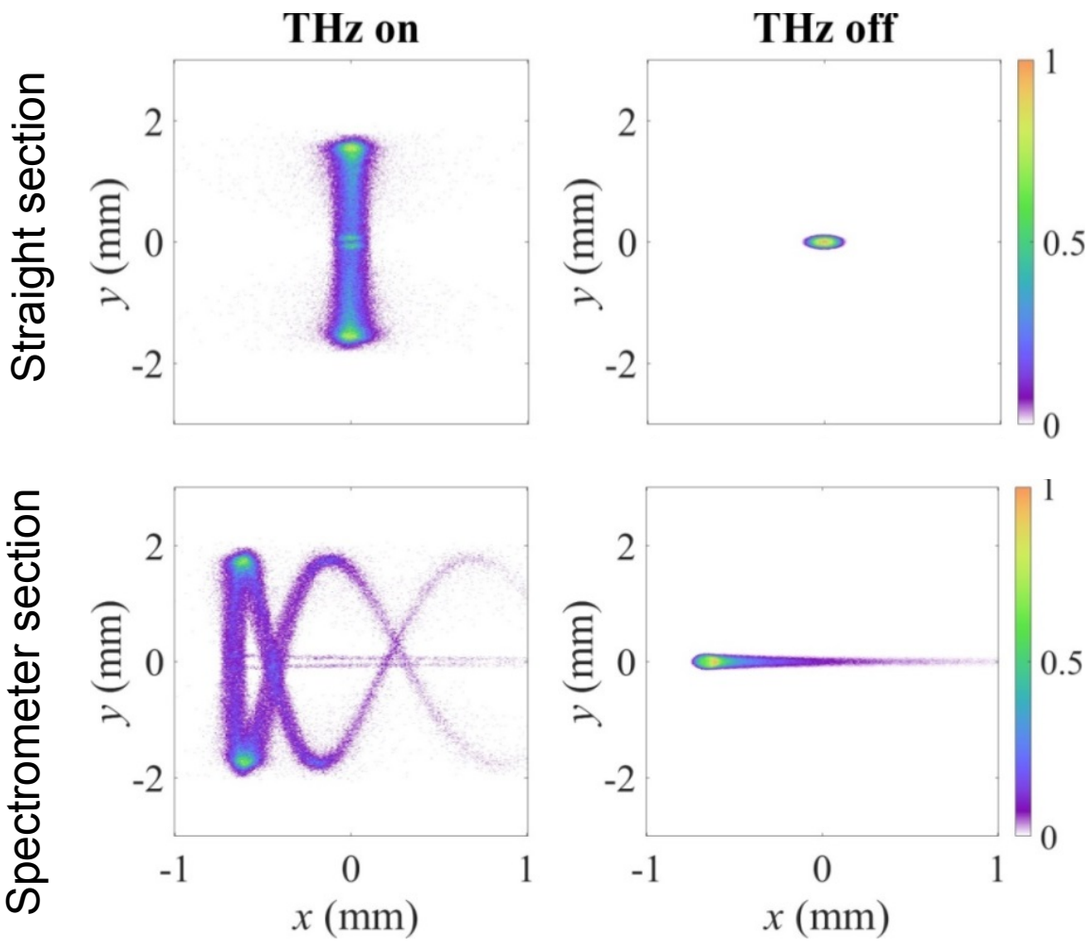
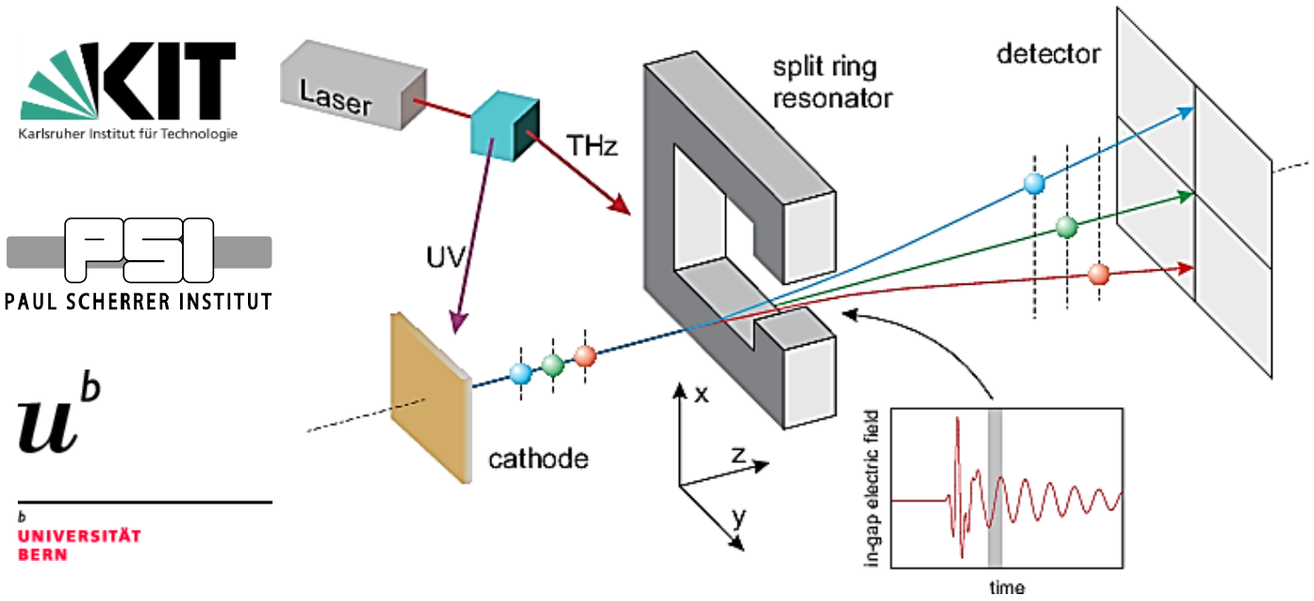
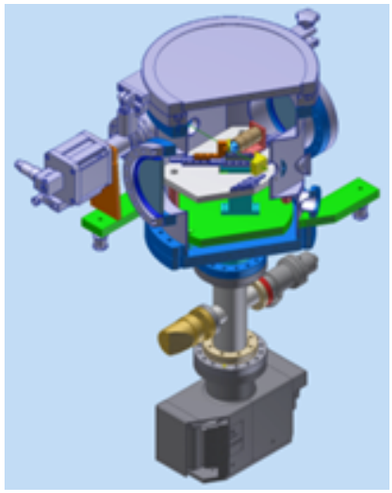
Femtosecond time-resolved electron diagnostics based on split ring resonators (SRR)

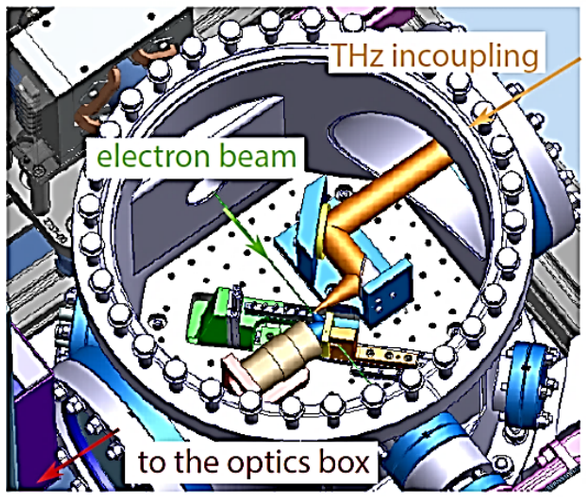
- First experiment planned at FLUTE, KIT
- Resolution down to fs range





J. Fabianska et al., Scientific Reports 4, 5645 (2014)





M. Yan et al, “Design of a time-resolved electron diagnostics using THz fields excited in a split ring resonator at FLUTE”, IBIC2016

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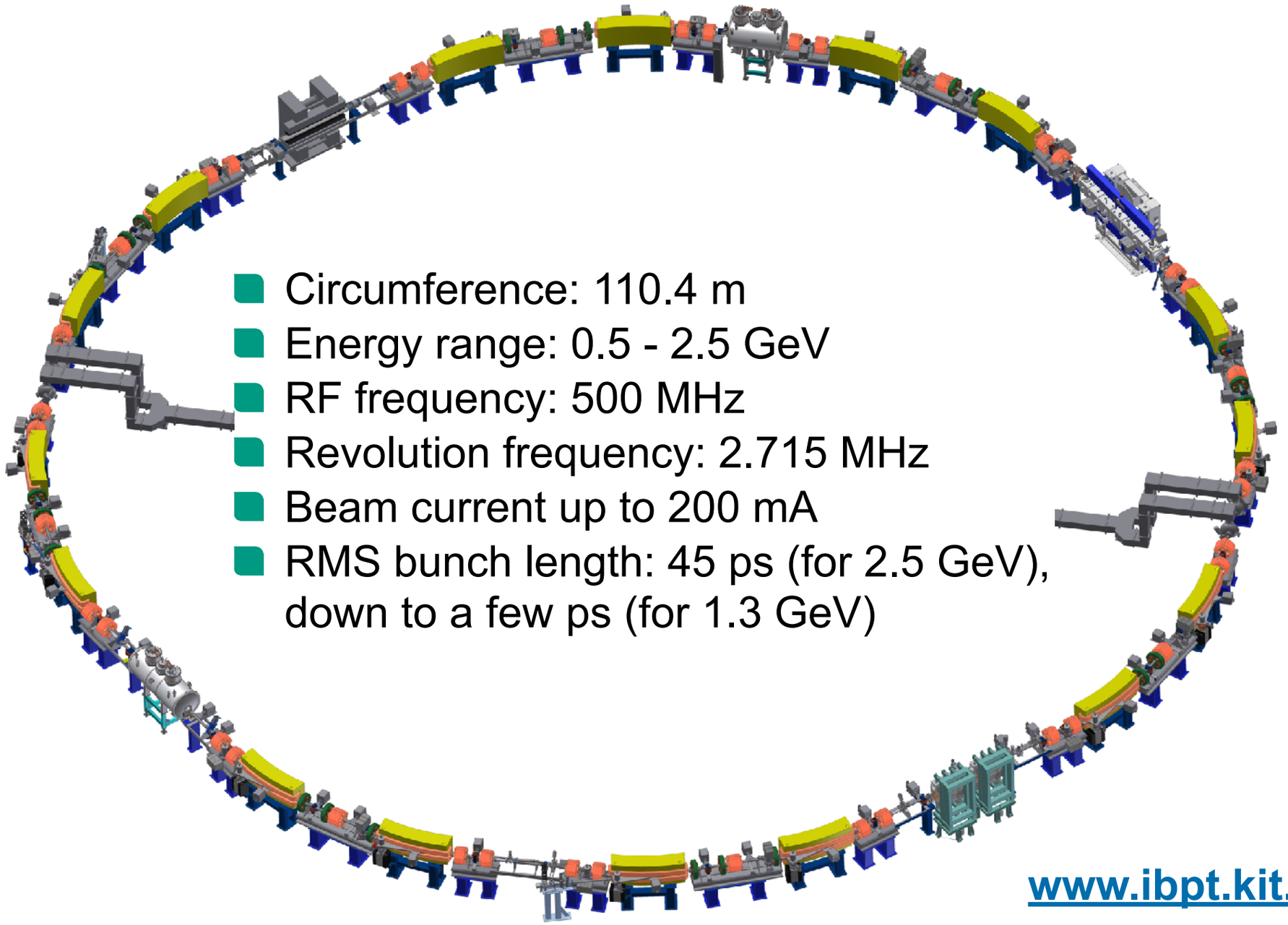
Karlsruhe Research Accelerator (KARA)

- 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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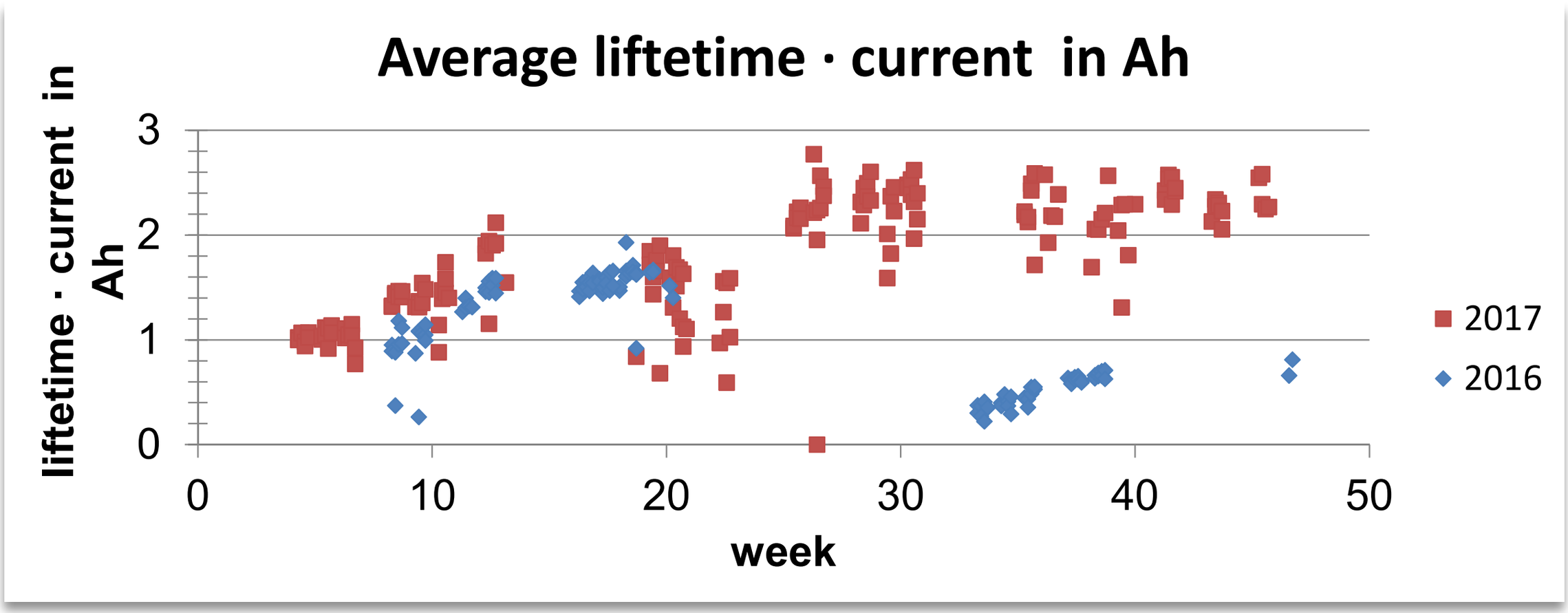
KARA operation

- New working point for all operation conditions — Talk: A. Papash
- Operation issues
  - Vacuum leak in ID
  - Main fuse of storage ring broke
  - Water interlocks



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Refurbishment progress

- Replaced one of the three main cooling stations
- Replacement of all corrector power supplies in the injector
  - First batch (26) delivered and will be installed in winter shutdown 2017/18
  - Second batch (30) ordered and will be installed in summer 2018
- Orbit correction at KARA
  - Decided not to implement a fast orbit correction
  - Replace only the corrector power supplies
  - Planned installation end of 2018
- Installing more diagnostics for infrastructure
  - Water flow meter
  - Power meter

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Electro-optical measurements

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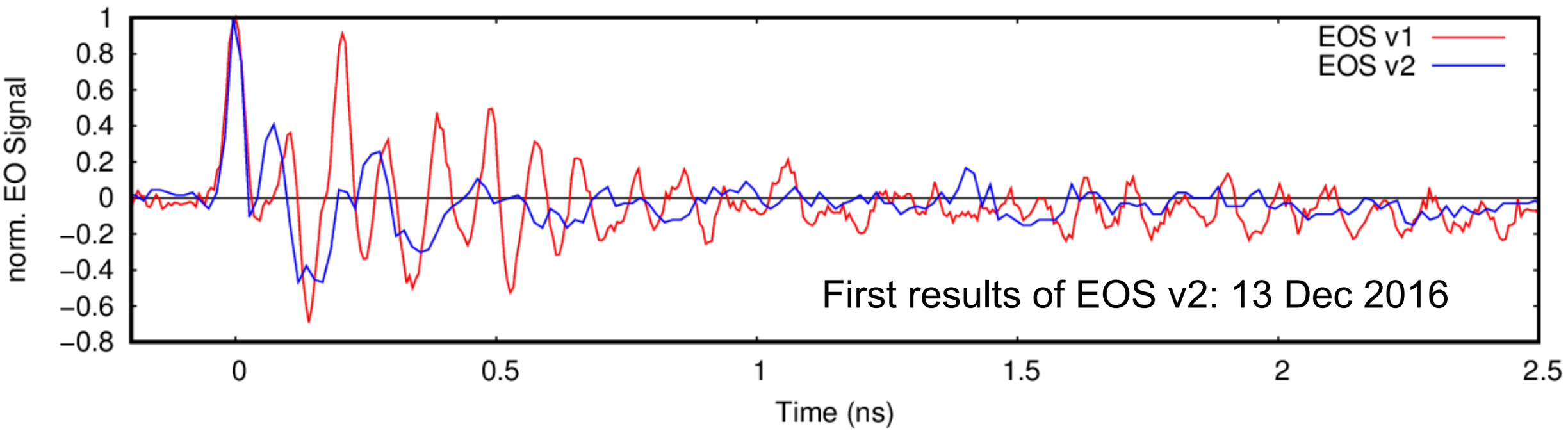
THz_KoDiag 05K13VKA
Karlsruhe Institute of Technology

- Optimized in-vacuum EO arm for storage rings
  - Version 1 arm (EOS v1)
  - LINAC design
  - By DESY & PSI

  - New arm (EOS v2)
  - First design for rings by KIT
  - **Reduced wake fields at 2 ns (500 MHz)**



P. Schönfeldt et al., IPAC17, MOPAB055

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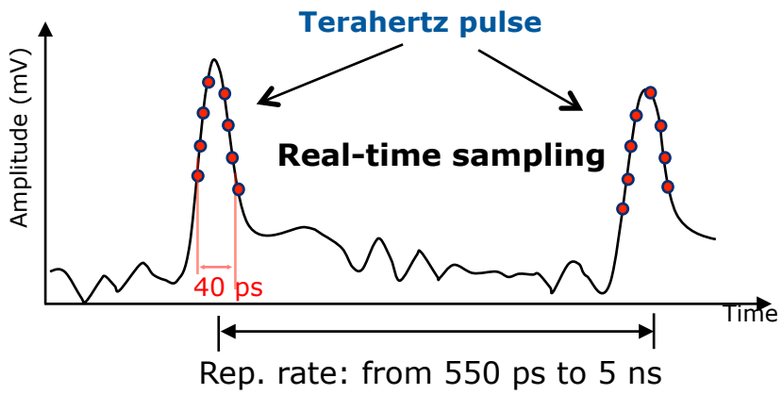
Readout electronics and processing

- KAPTURE II
  - Picosecond sampling system
  - Up to 1 GHz trigger rate
  - Up to 8 sampling points per THz pulse
  - Continuous readout by PCIe, up to 64 Gb/s
  - Real-time data elaboration by GPUs
  - Mechanically and electrically compatible with FMC / µTCA system

KAPTURE working principle



- KALYPSO III
  - 10 Mfps @ 512 pixels
  - ASIC on CMOS 110 nm, prototype being tested
  - Custom Si sensor (opt: low-gain avalanche PD)

KALYPSO III: prototype of new ASIC, 48 channels operating up to more than 10 Mfps

KALYPSO III: layout of custom Si sensor, 25um pitch

M. Caselle et al.

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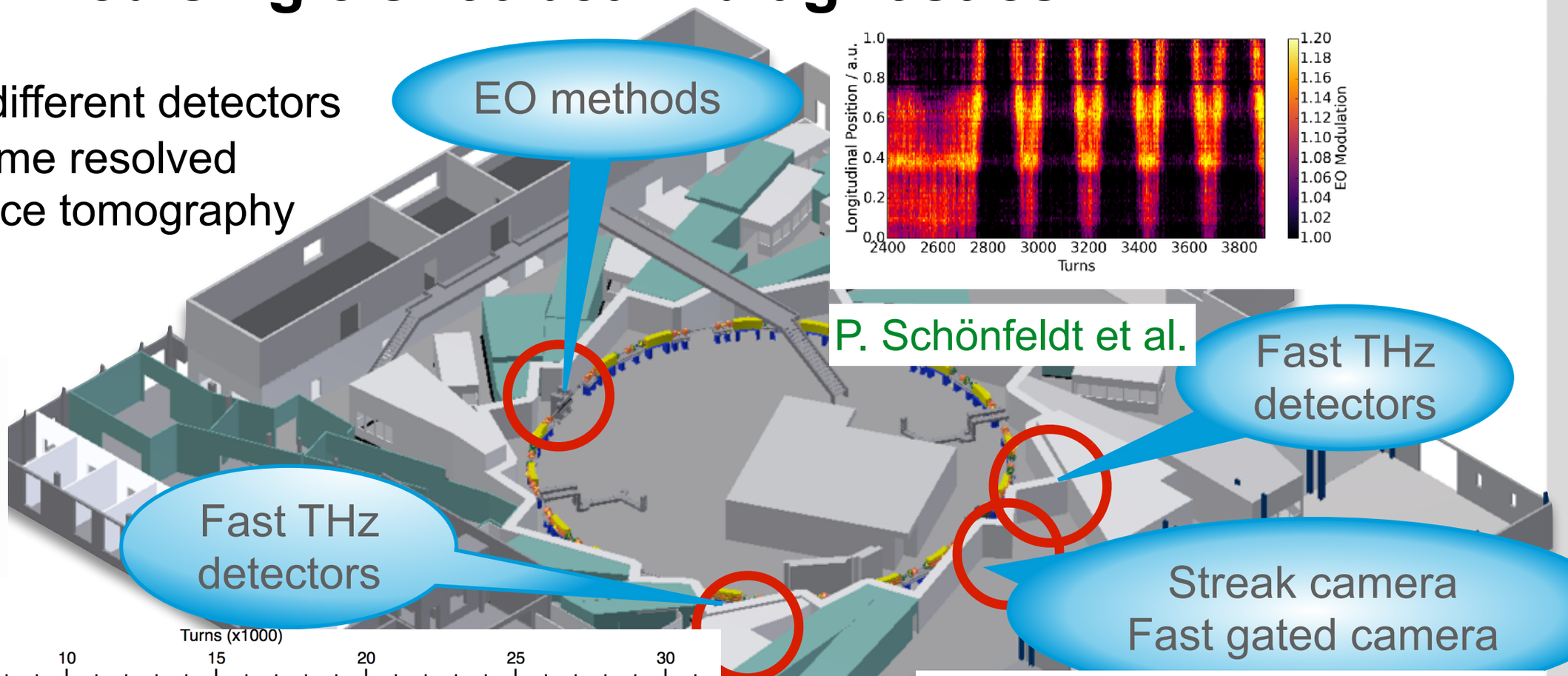
Synchronized single shot beam diagnostics

- Combine different detectors
- Towards time resolved phase space tomography



P. Schönfeldt et al.

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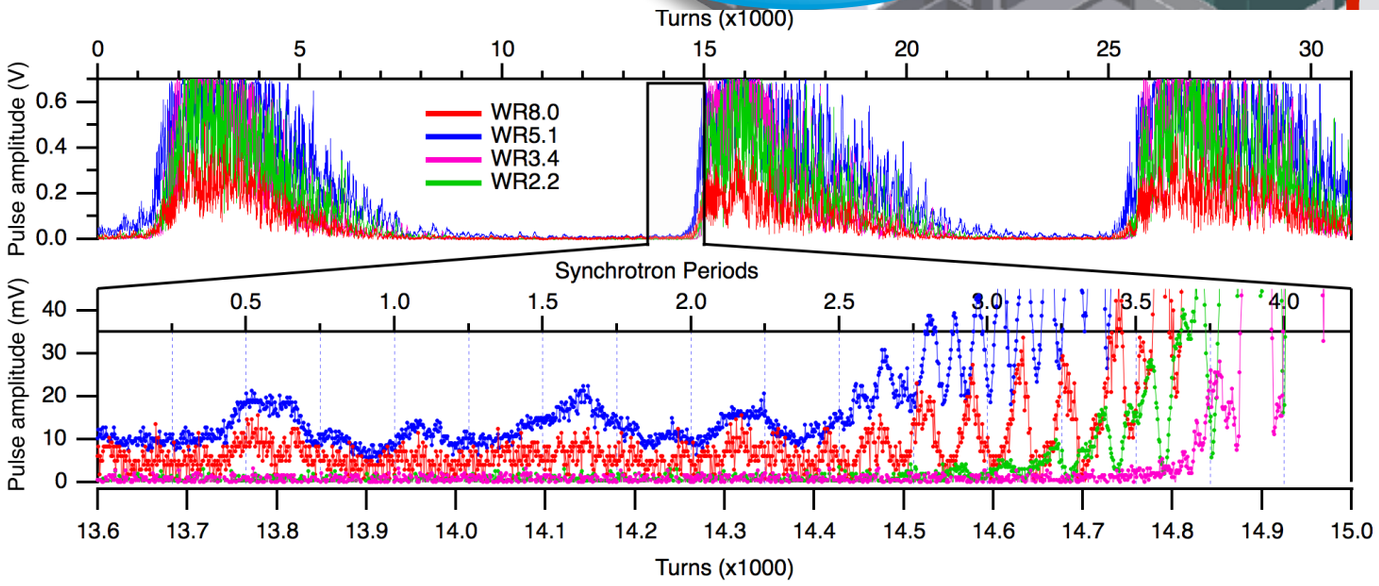
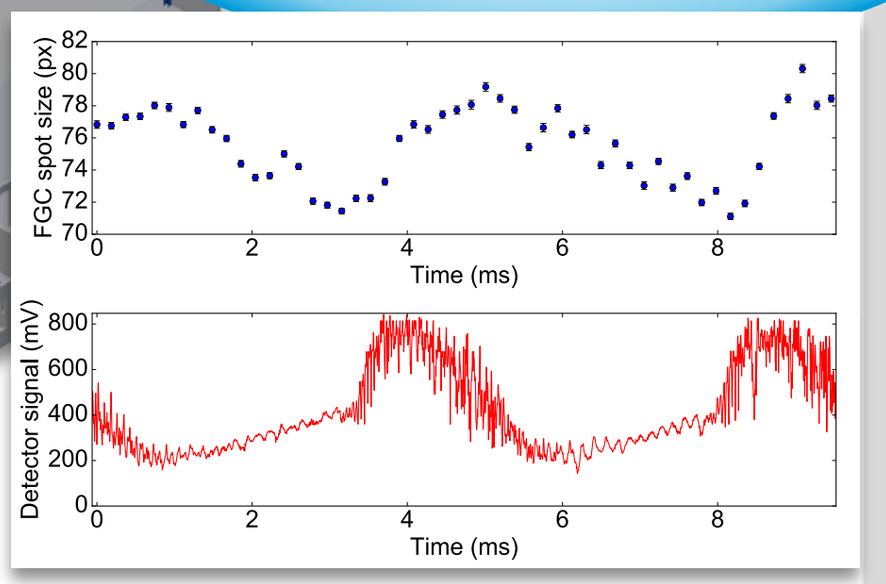


J.L. Steinmann et al., IPAC17, MOPAB056



B. Kehrer et al., IPAC17, MOOCB1

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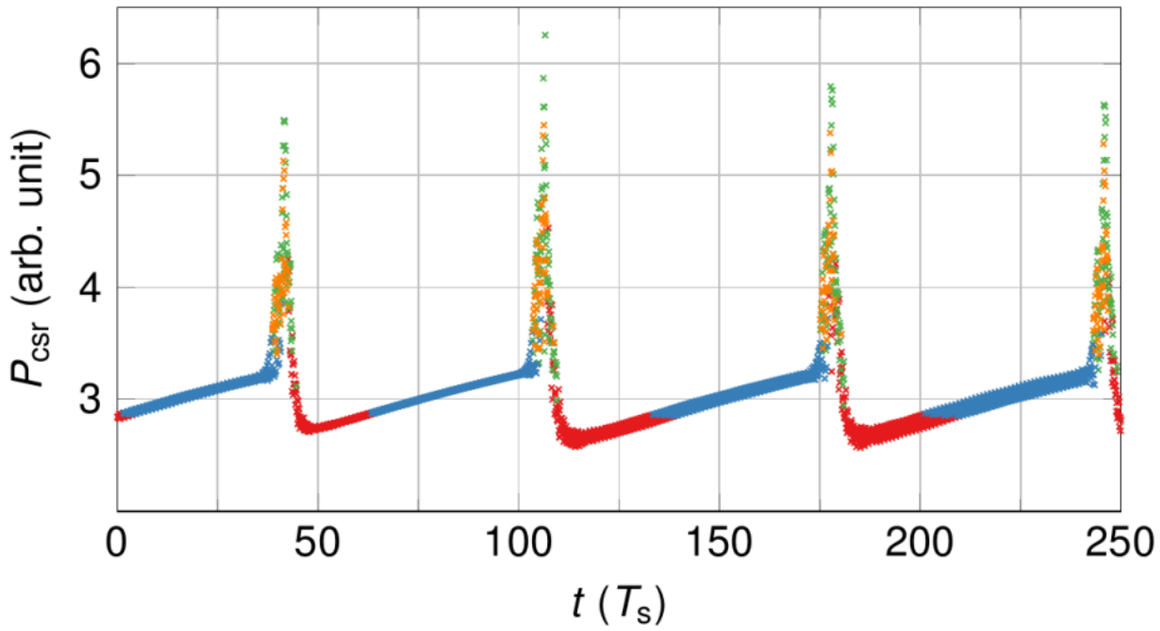
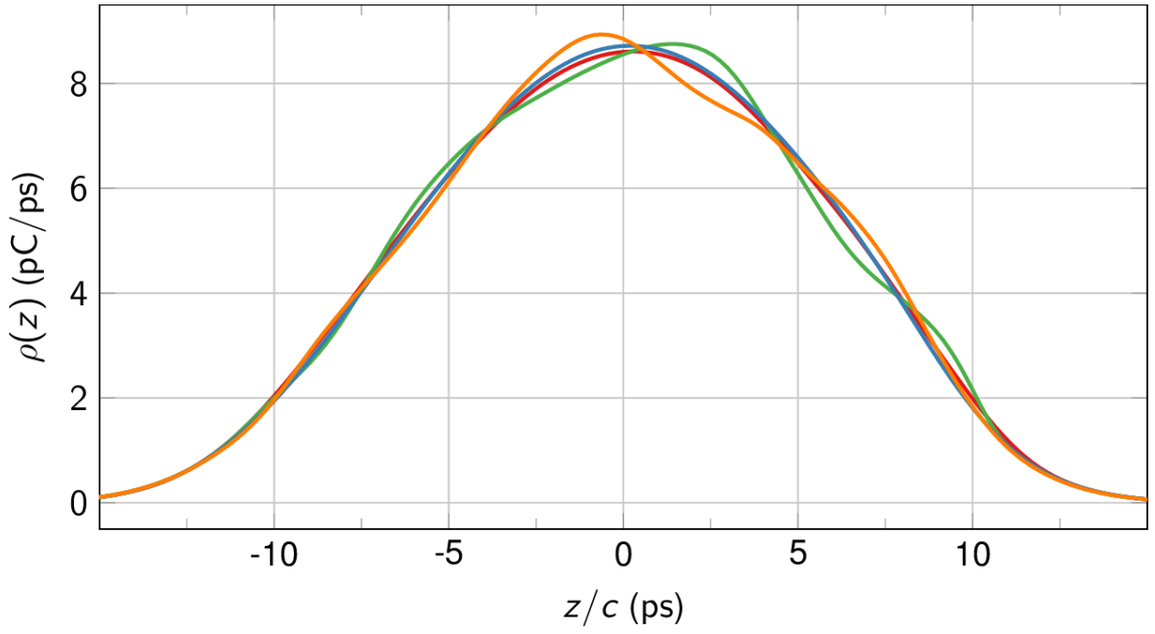
Machine learning based data analysis

- Several detector systems with high data rate (KAPURE, KALYPSO)
- Simulation tool for longitudinal phase space dynamics available (Inovesa)
- Automation of data analysis necessary
- Use machine learning methods to identify features which can be linked to physics





T. Boltz, Comprehensive analysis of micro-structure dynamics in longitudinal electron bunch profiles, Master thesis 2017
DOI: 10.5445/IR/1000068253

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Superconducting undulator

- Towards an industrial product

- SCU20 is
  - more compact
  - reduction in weight leads to faster cool down and reduced thermal gradients
  - manufacturing processes are more reliable and reproducible

SCU20 **SCU15**

- SCU20 site acceptance test ongoing

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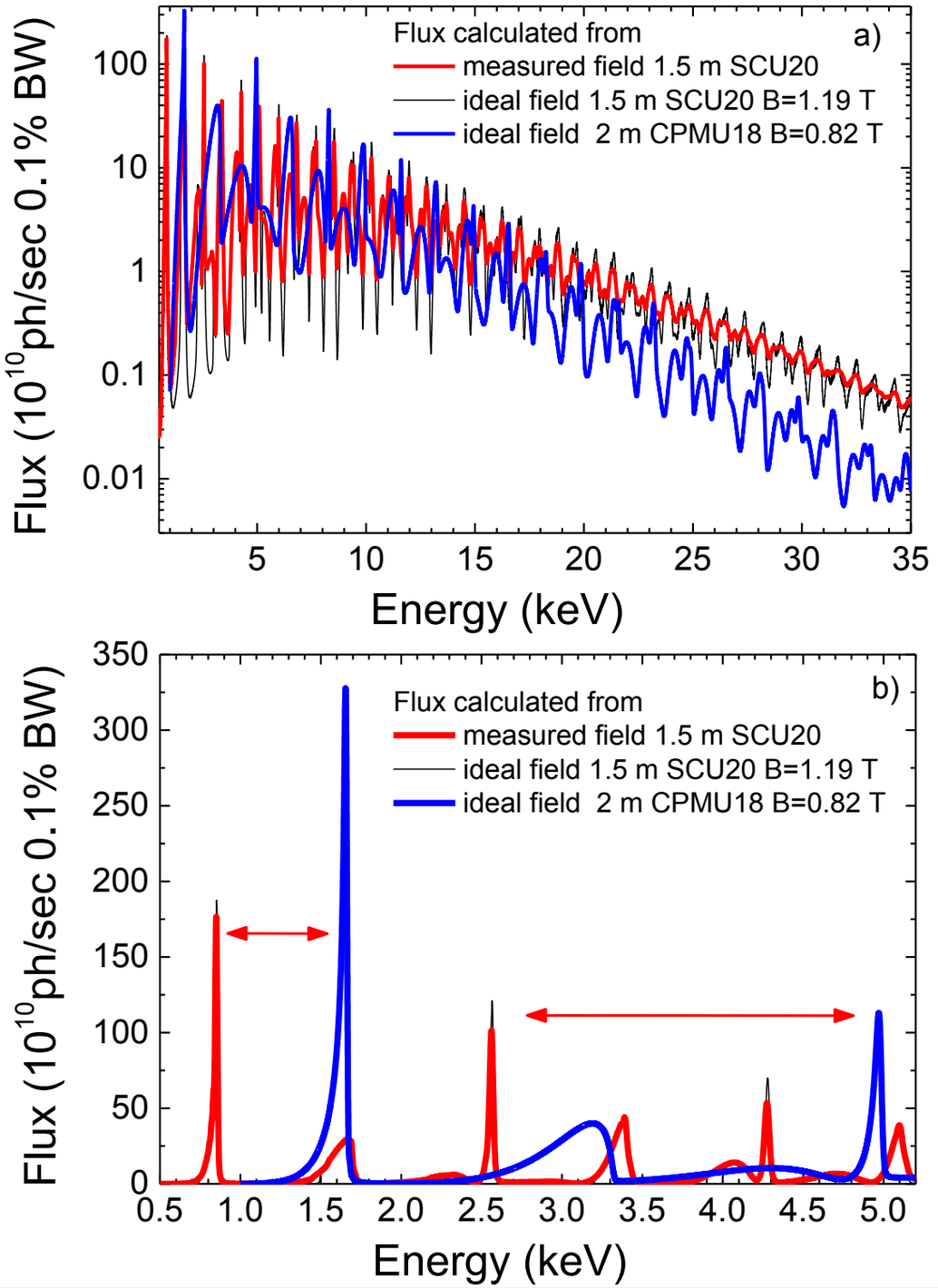
SCU20 calculated spectrum from B measured at CASPER II



Flux at 10 m from the source through a slit 50 μm × 50 μm at ANKA

1.5 m SCU20 versus an ideal (without mechanical errors and perfect end fields) 2 m PrFeB CPMU18 with the same parameters as the one built at SOLEIL. The vacuum gap is for both 7 mm.**

**** C. Benabderrahmane et al., Phys. Rev. Accel. Beams 20, 033201 (2017)**

- Larger flux of the SCU20 with respect to the CPMU18 at high energies up to a factor of 5.
- At low photon energies the energy regions allowed with the SCU20, are not reachable with the CPMU18, due to its lower peak field on axis.

S. Casalbuoni et al, IOP Conf. Series: Journal of Physics 874, 012015 2017

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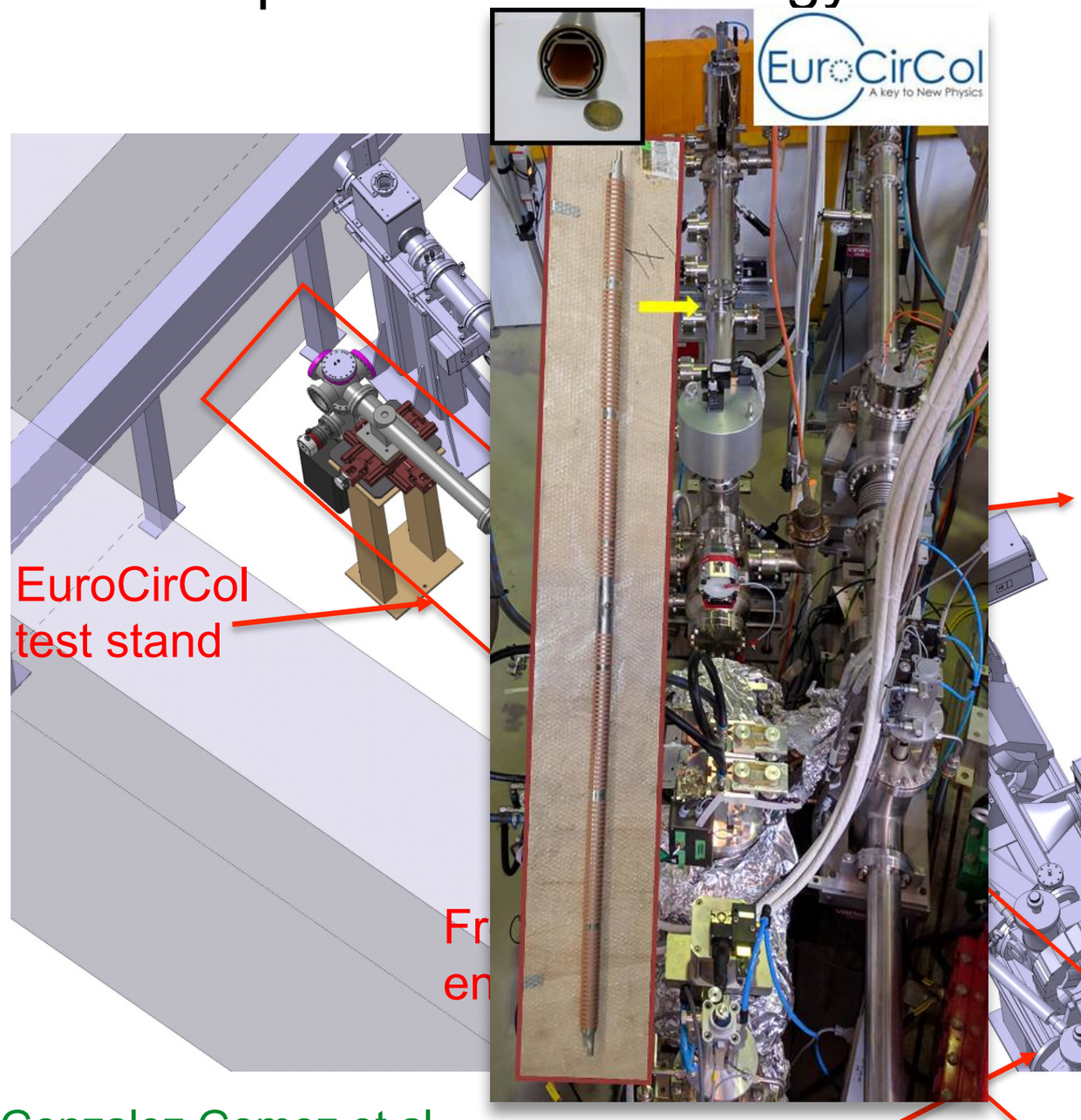
EuroCirCol - FCC H2020 Project

The European Circular Energy-Frontier Collider Study



FCC-hh beam screen prototype

L. Gonzalez Gomez et al.
FCC Week 2017

Video: https://indico.cern.ch/event/556692/contributions/2487658/

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Summary and Outlook

- FLUTE
  - Inauguration in July
  - Construction and commissioning of FLUTE in progress
- Karlsruhe Research Accelerator (KARA)
  - New working point improved operation stability of KARA
  - EuroCirCol installation in operation
- Diagnostic R&D
  - Split ring resonator
  - New EO-Arm and readout electronics
- Outlook
  - Installation of SCU20 in winter shutdown
  - Continue the refurbishment program
  - Continue beam dynamic studies with synchronized diagnostics
  - Develop new data analysis techniques

Thank you for your attention!

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