TELBE data analysis workflow and the PaN training platform UX

Jan-Christoph Deinert

Helmholtz-Zentrum Dresden – Rossendorf, TELBE terahertz facility

Oct. 26th, 2021

PaNOSC and ExPaNDS projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements 823852 and 857641, respectively.

Who is TELBE?

The High-Field Terahertz-Driven Phenomena Group

Sergey Kovalev
Beamline scientist, team leader

Jan-C. Deinert
Deputy team leader, Young investigator group

PostDocs

Igor Ilyakov
Project TRANSPIRE

Alexey Ponomaryov
Physics of Life

Thales de Oliveira
THz Near-Field Imaging

Data Management Support:

- Thomas Gruber
- Oliver Knodel

PhD students

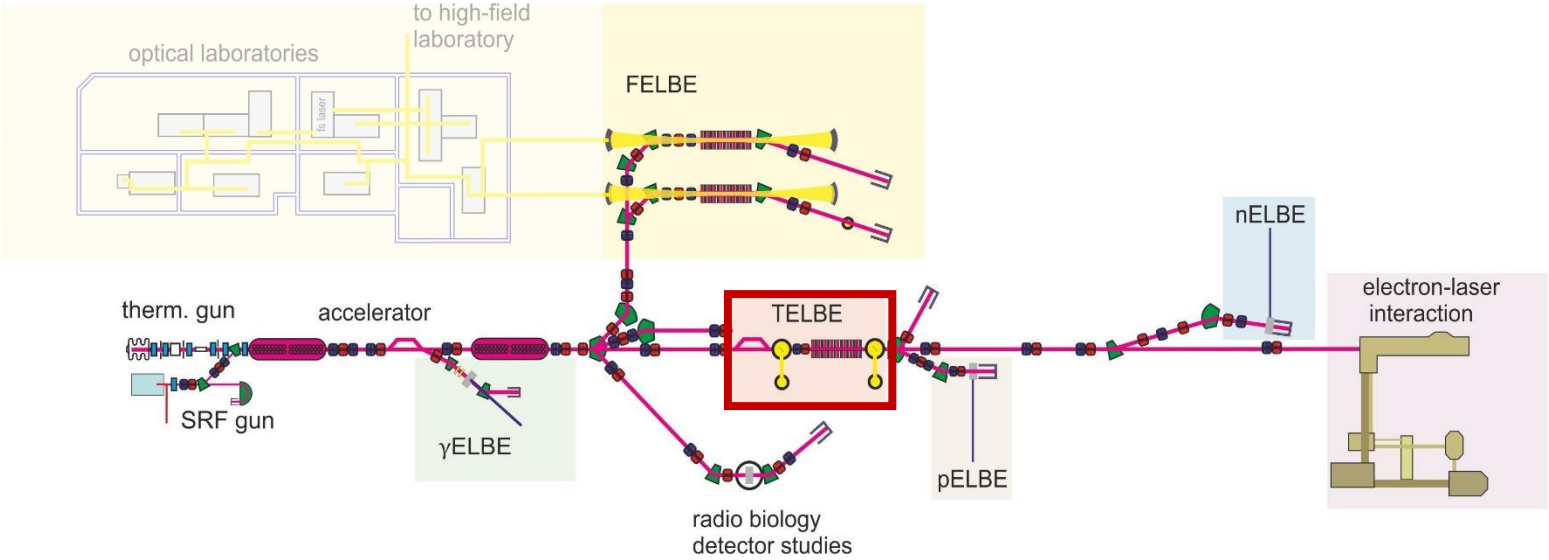
Min Chen
Synchronization

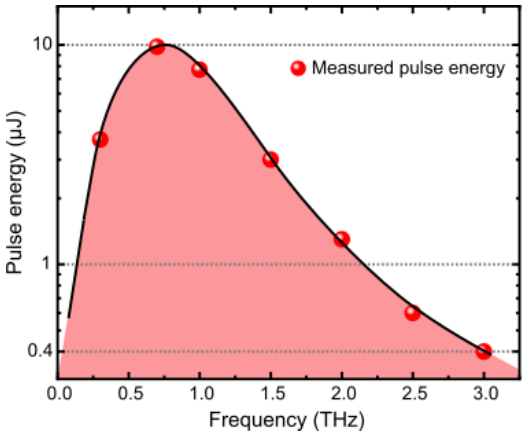
Atiqa Arshad
THz-surface dynamics

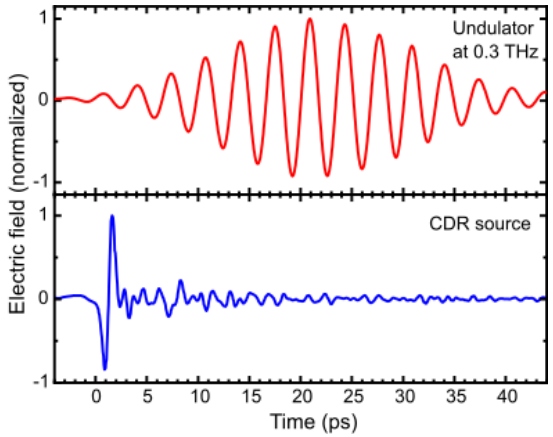
- **In-house research**
  - Accelerator research and development
  - New materials and ultrafast THz-driven dynamics
- **Support for world wide TELBE user community**

What is TELBE?

Terahertz facility at the ELBE center for High-Power Radiation Sources







- Tunable sources for intense THz radiation driven by compact electron accelerator
- Superradiant emission from two radiators
  1. Undulator (multicycle)
  2. Metal foil (single cycle)

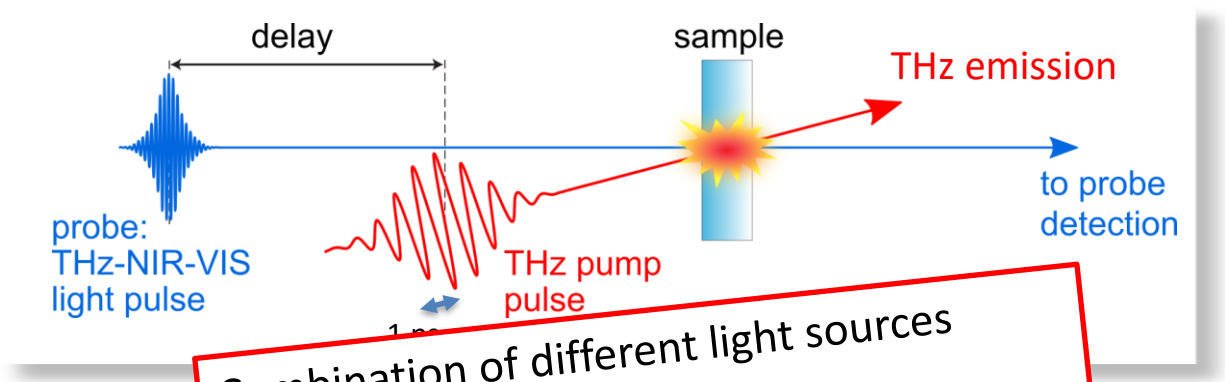
panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services

Introduction: Ultrafast experiments at TELBE

Mission:
Measure THz-driven dynamics on *sub-cycle* timescales
→ temporal resolution $\ll 100$ fs

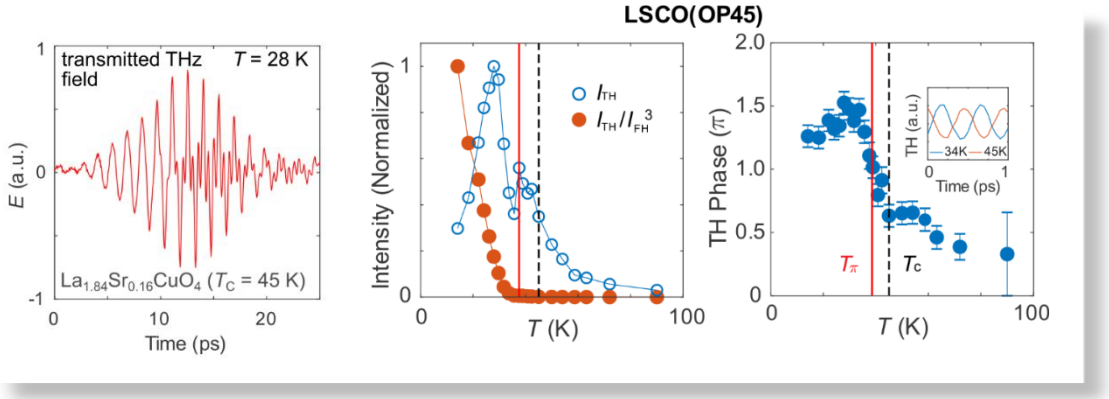
Pump-probe experiments combine accelerator-based THz source with table top laser systems.



Combination of different light sources causes **jitter** in
- **Time** (delay) and
- **Intensity.**
- How do we reach fs time resolution?

Example:
Higgs modes in *d*-wave superconductors

- Third harmonic response directly visible in *E*-field
- Phase-resolved detection gives insight into coupling of modes



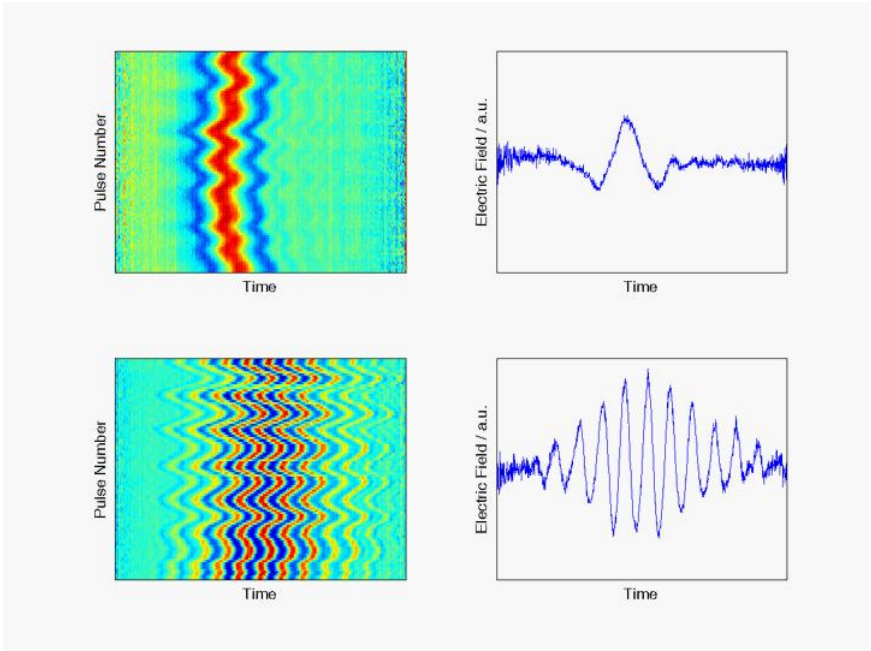
H Chu, MJ Kim, K Katsumi *et al.*, *Nat Commun* **11,** 1793 (2020).

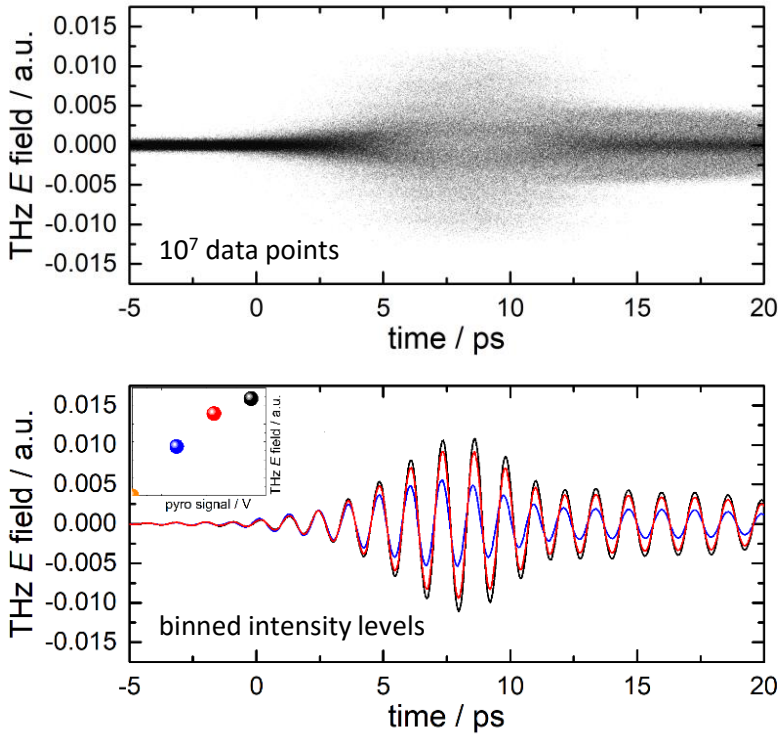
panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services

Post mortem data correction

Timing and intensity fluctuations at TELBE: *Big data challenge*: pulse-resolved acquisition at 100 kHz





Problem solved:
- 12 fs RMS timing accuracy
- dynamic range of 10^6

Enables
1. Ultrafast experiments at SRF linac-driven photon sources
2. Detailed bunch diagnostics

S. Kovalev et al., *Struct. Dyn.* **4**, 024301 (2017)

panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services

Pulse-resolved detection and data sorting

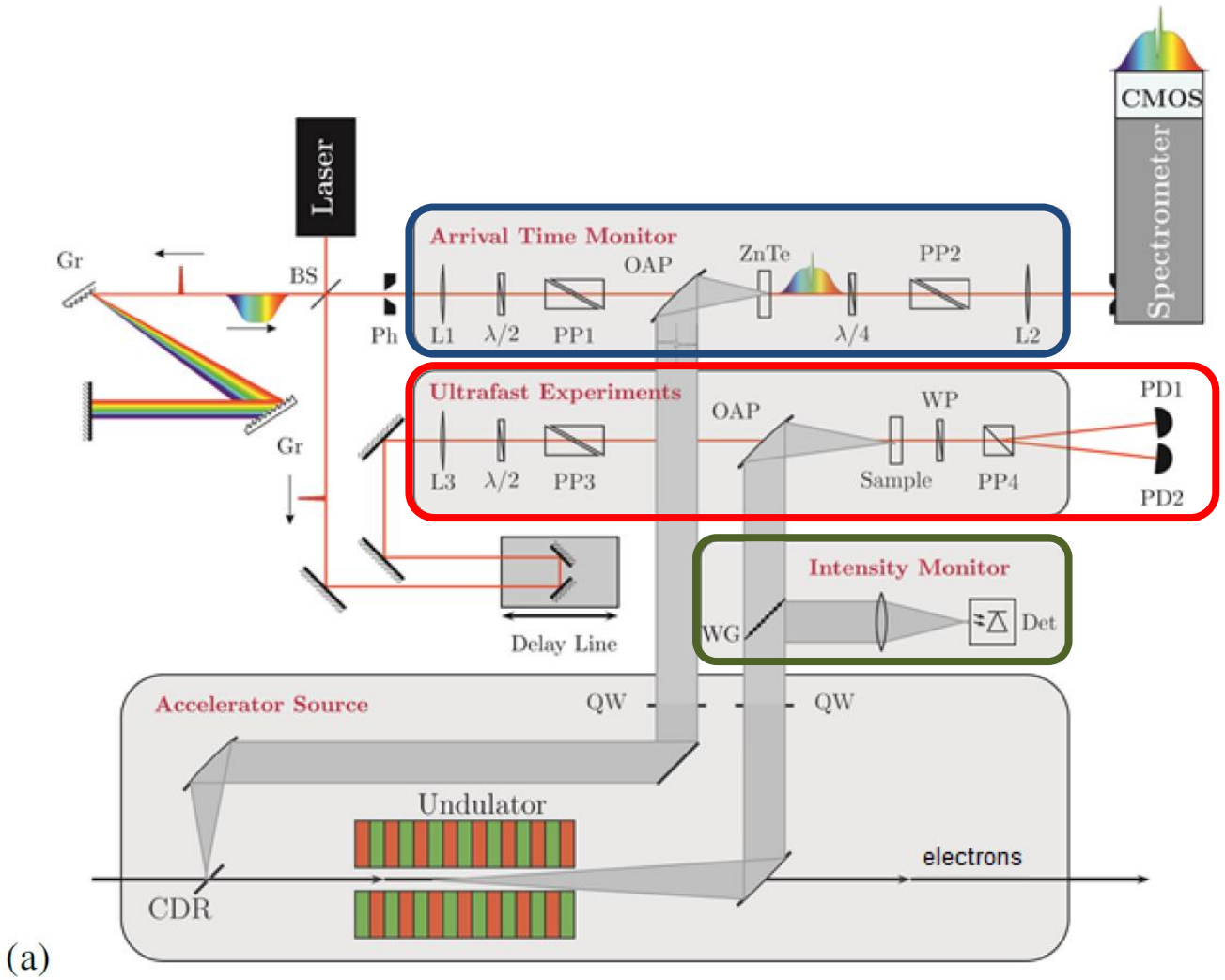
We record:

- **Timing**: Arrival time monitor system:
  → Spectral decoding technique with CDR-THz
- **Intensity**: Monitored by fast pyro detectors
- Experimental data (several channels possible)

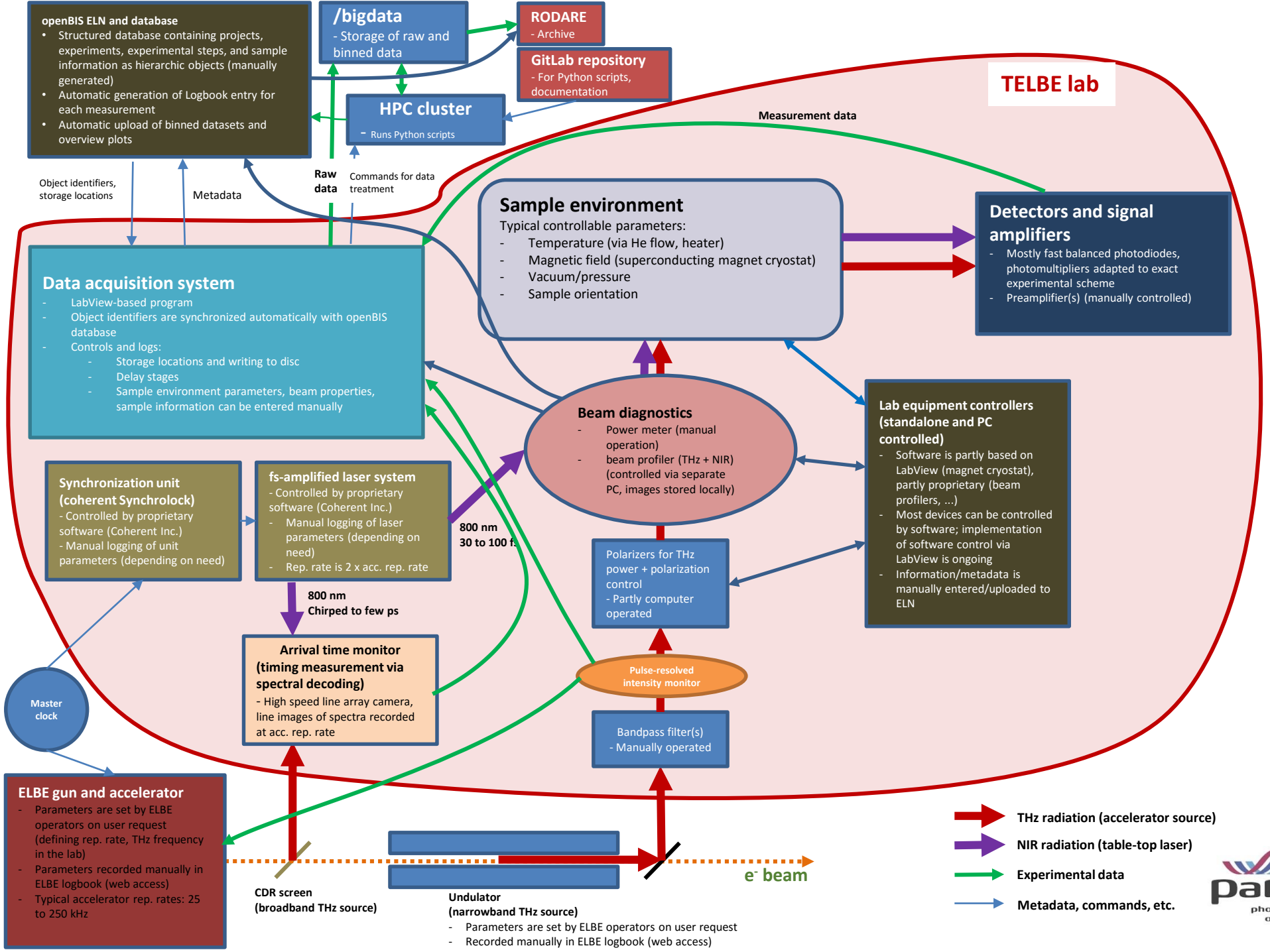
- → **Typically few TB of raw data per campaign**

Post-mortem data analysis (sorting) and reduction (binning)

→ **In routine operation since 2016**
→ **Initial workflow highly labor intensive, slow**



S. Kovalev et al., *Struct. Dyn.* **4**, 024301 (2017)



Integration
of all essential components

Minimal information necessary to *understand* and *reproduce* the data

panosc
photon and neutron open science cloud

ExPaNDS
European Open Science Cloud Photon and Neutron Data Services

The big data challenge

Goals:

- Automatic recording and assignment of metadata
- **Fast and automatic** data sorting, binning and displaying
- Easy data **sharing** and export
- Easy data **archiving**

- Facilitating **remote access**
- Towards fulfilling the **FAIR principle**

How to document (and publish) workflow?
How to inform/train users?

- Not straightforward in case of typical TELBE data rates.

Strategy: Use HZDR computational expertise and ressources

Thomas Gruber, Oliver Knodel (FWCC) *et al*.

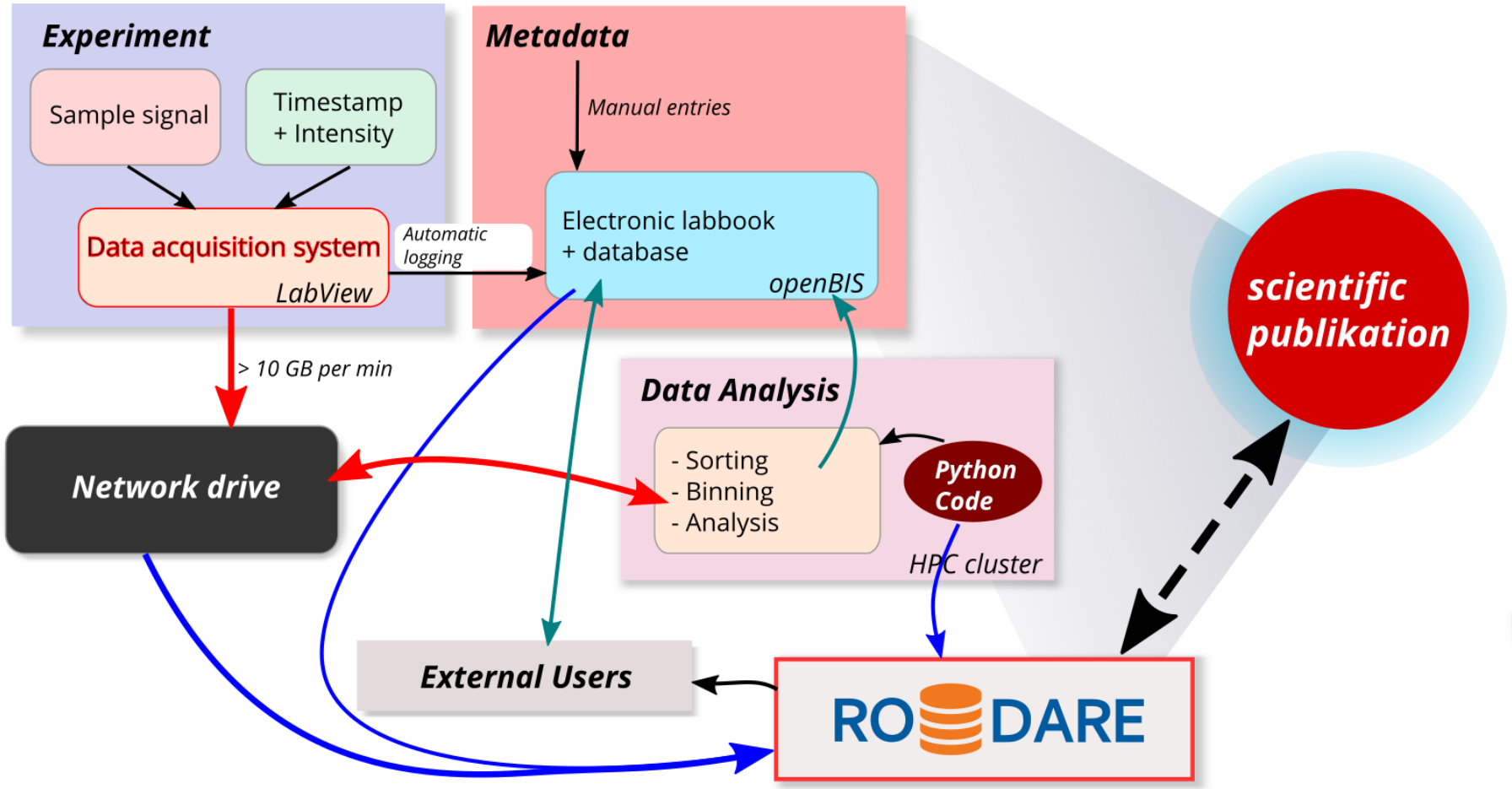
- overall workflow development and integration
  - openBIS labbook and database
  - HPC cluster for data sorting
  - interface for data recording and user
  - ython code development
  - RODARE repository for long-term storage and raw data exchange

openBIS RODARE

panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services

Schematic TELBE data workflow



- "Chunking" of functional units.
- Combination of established tools/platforms and custom solutions

GitLab python™ openBIS RODARE

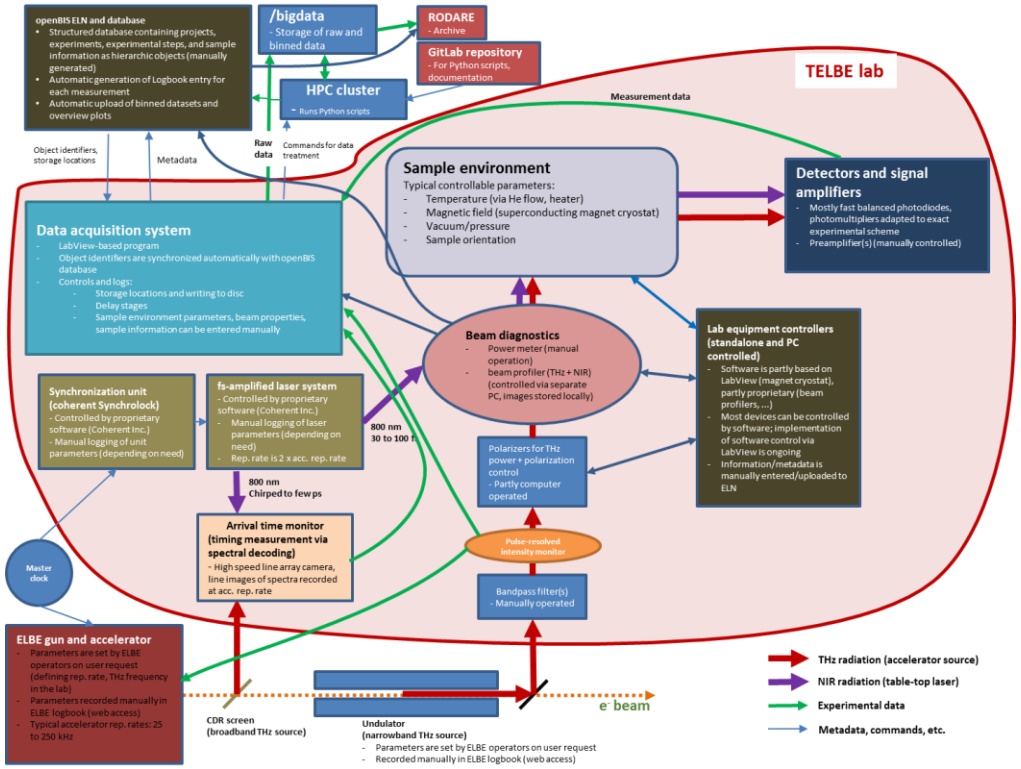
- Requires strong IT support and integration (sensors, data acquisition, software, web services, etc.)

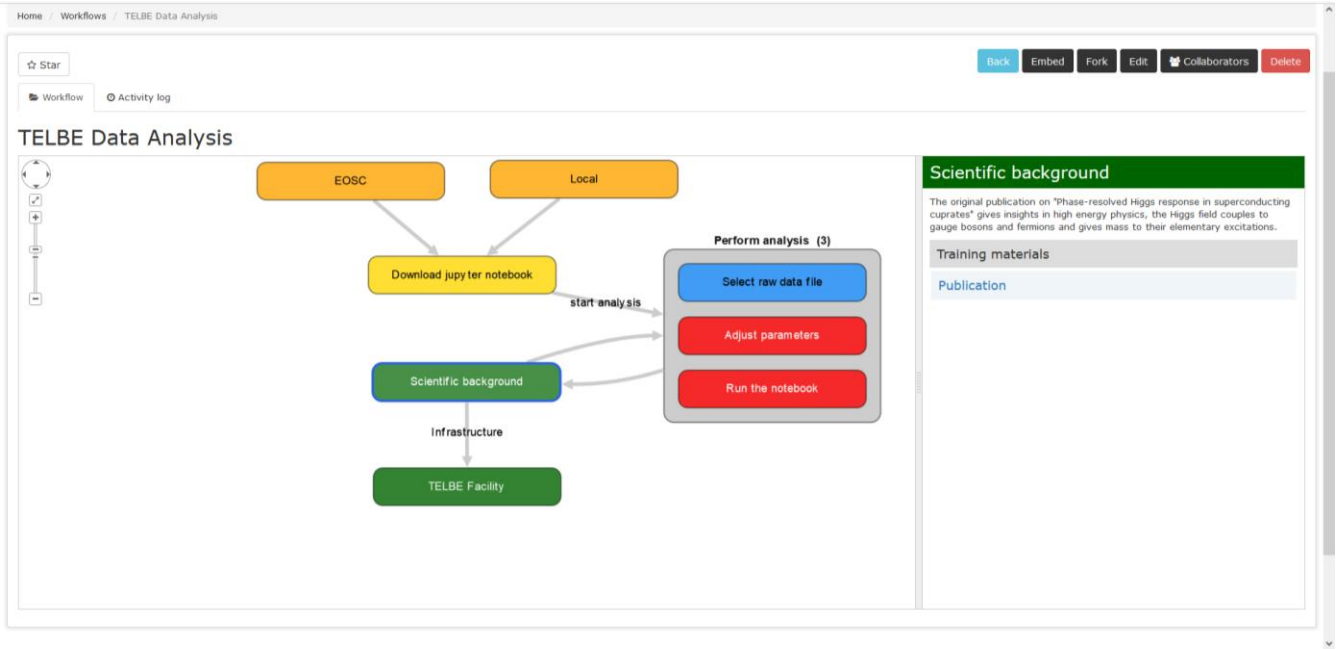
panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services

How to document the TELBE data workflow as a whole?

The PaN training platform UX





HZDR PaN training platform

- Goal: Integration of raw-data repositories, metadata, software
- Easy editing directly in the browser
- Intuitive workflow scheme

panosc photon and neutron open science cloud

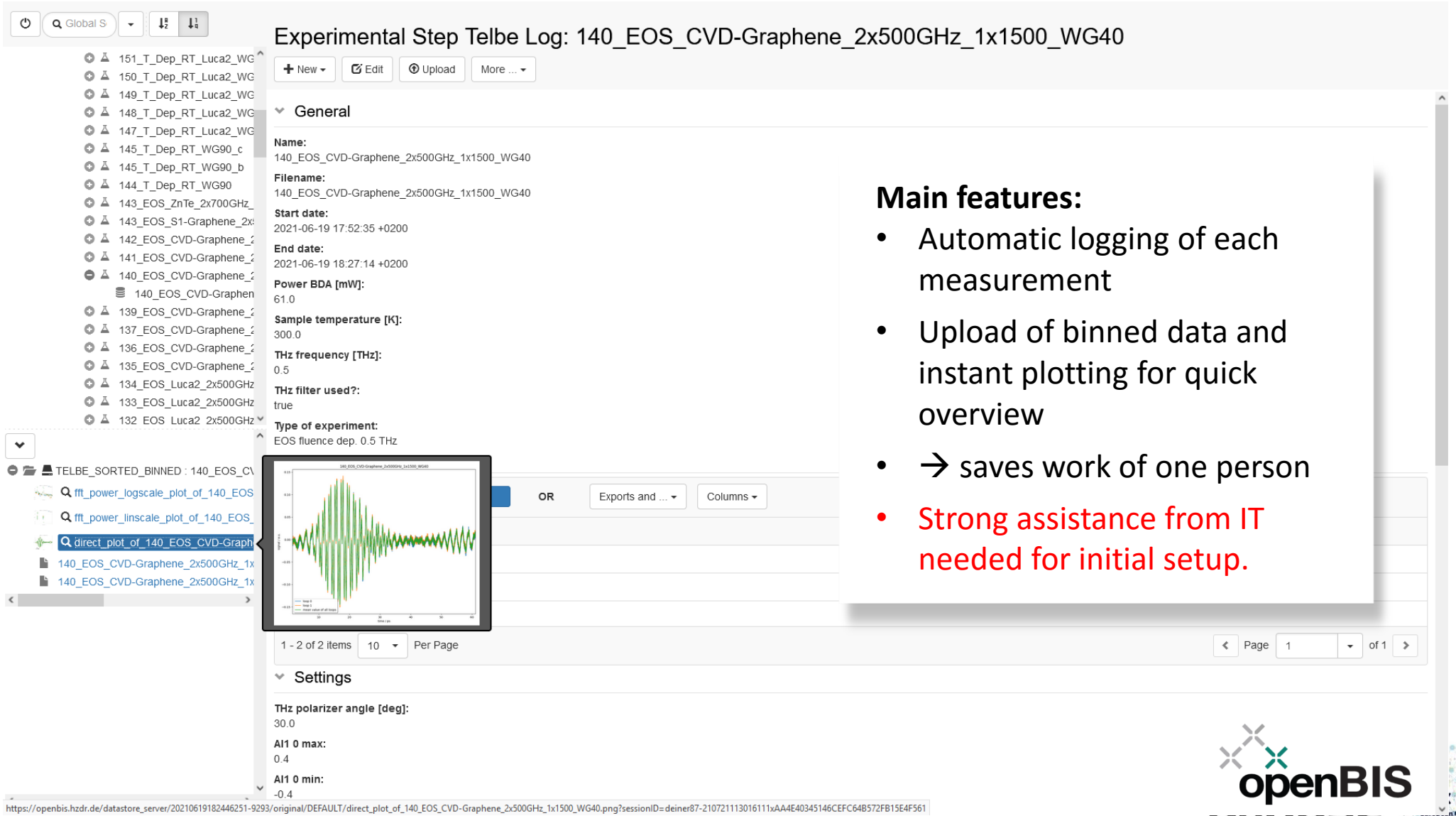
ExPaNDS European Open Science Cloud Photon and Neutron Data Services

Thank you

Dr. Jan Christoph Deinert
High-Field THz-Driven Phenomena Group
j.deinert@hzdr.de

PaNOSC and ExPaNDS projects have received funding from the European Union's Horizon 2020 research and innovation programme under grant agreements 823852 and 857641, respectively.

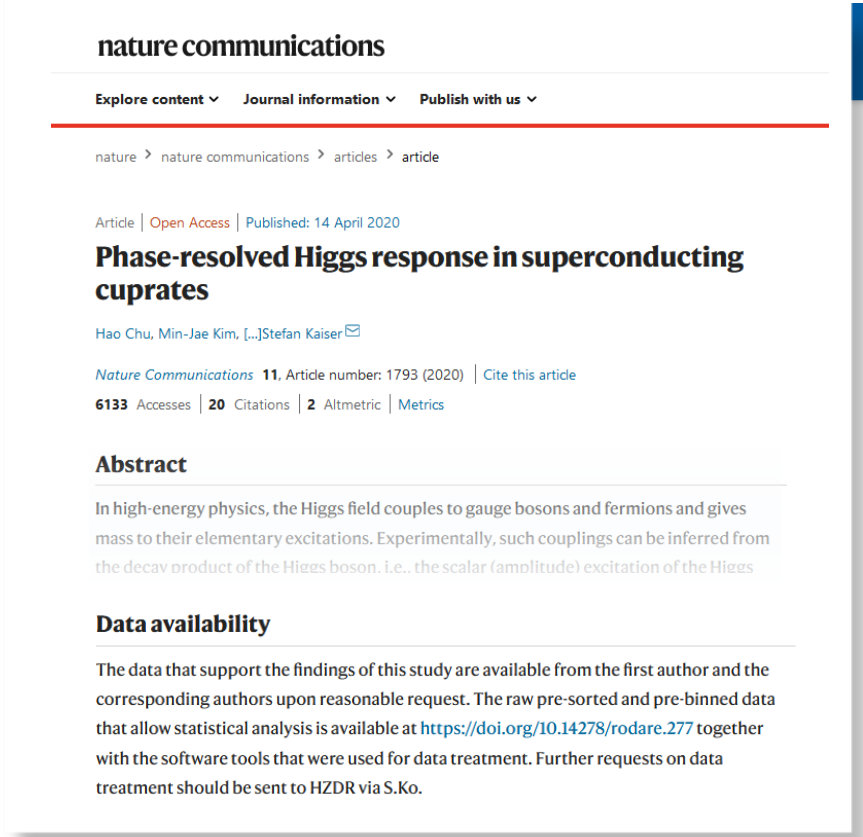
Metadata management – the openBIS interface



Main features:

- Automatic logging of each measurement
- Upload of binned data and instant plotting for quick overview
- → saves work of one person
- Strong assistance from IT needed for initial setup.

Data archiving – the RODARE repository



nature communications

Explore content | Journal information | Publish with us

nature › nature communications › articles › article

Article | Open Access | Published: 14 April 2020

Phase-resolved Higgs response in superconducting cuprates

Hao Chu, Min-Jae Kim, [...]Stefan Kaiser

Nature Communications **11**, Article number: 1793 (2020) | Cite this article

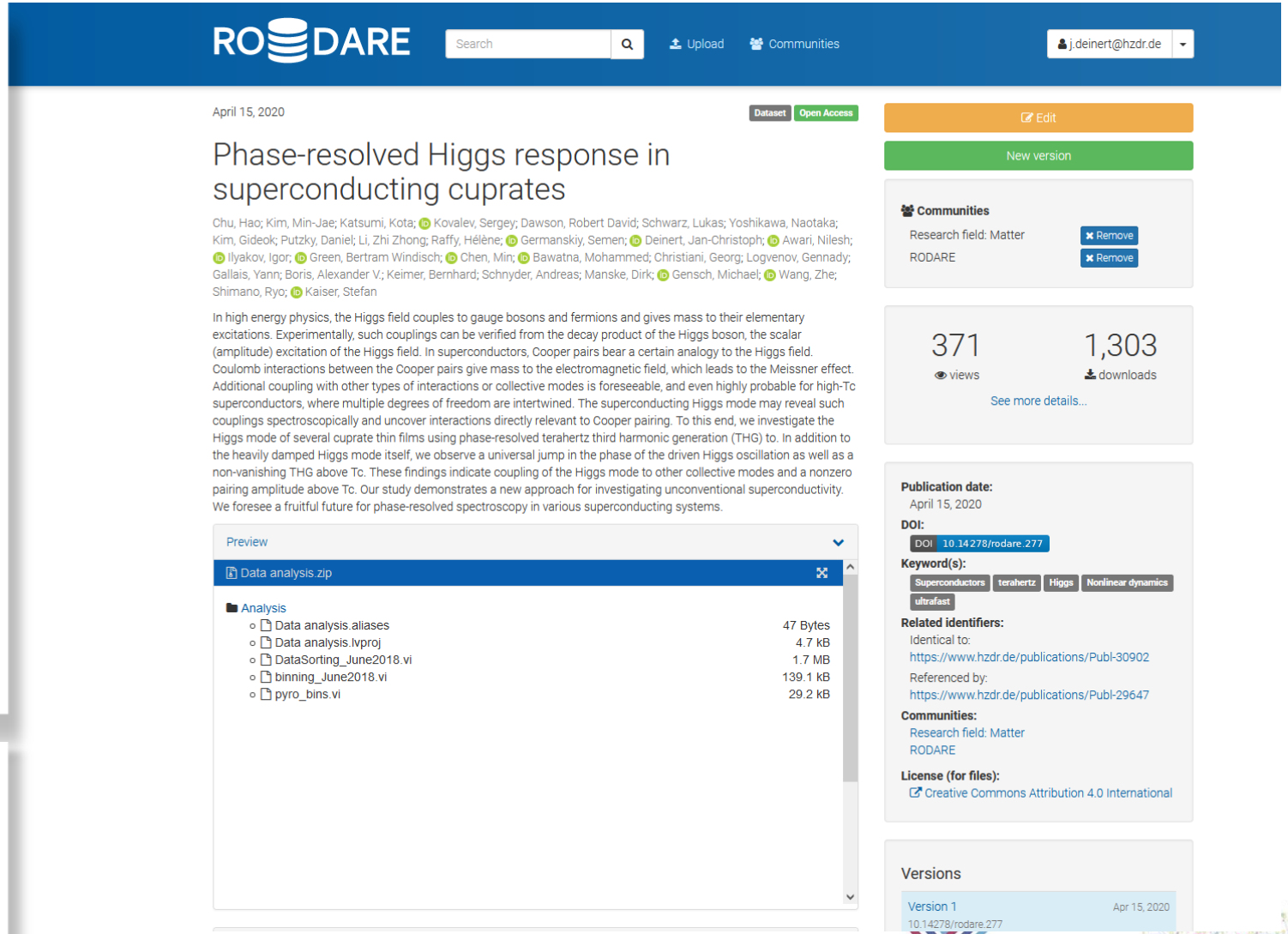
6133 Accesses | **20** Citations | **2** Altmetric | Metrics

Abstract

In high-energy physics, the Higgs field couples to gauge bosons and fermions and gives mass to their elementary excitations. Experimentally, such couplings can be inferred from the decay product of the Higgs boson, i.e., the scalar (amplitude) excitation of the Higgs

Data availability

The data that support the findings of this study are available from the first author and the corresponding authors upon reasonable request. The raw pre-sorted and pre-binned data that allow statistical analysis is available at https://doi.org/10.14278/rodare.277 together with the software tools that were used for data treatment. Further requests on data treatment should be sent to HZDR via S.Ko.



RODARE Search | Upload | Communities | j.deinert@hzdr.de

April 15, 2020 Dataset Open Access

Edit

New version

Phase-resolved Higgs response in superconducting cuprates

Chu, Hao; Kim, Min-Jae; Katsumi, Kota; Kovalev, Sergey; Dawson, Robert David; Schwarz, Lukas; Yoshikawa, Naotaka; Kim, Gideok; Putzky, Daniel; Li, Zhi Zhong; Raffy, Hélène; Germanskiy, Semen; Deinert, Jan-Christoph; Awari, Nilesh; Ilyakov, Igor; Green, Bertram Windisch; Chen, Min; Bawatna, Mohammed; Christiani, Georg; Logvenov, Gennady; Gallais, Yann; Boris, Alexander V.; Keimer, Bernhard; Schnyder, Andreas; Manske, Dirk; Gensch, Michael; Wang, Zhe; Shimano, Ryo; Kaiser, Stefan

In high energy physics, the Higgs field couples to gauge bosons and fermions and gives mass to their elementary excitations. Experimentally, such couplings can be verified from the decay product of the Higgs boson, the scalar (amplitude) excitation of the Higgs field. In superconductors, Cooper pairs bear a certain analogy to the Higgs field. Coulomb interactions between the Cooper pairs give mass to the electromagnetic field, which leads to the Meissner effect. Additional coupling with other types of interactions or collective modes is foreseeable, and even highly probable for high-Tc superconductors, where multiple degrees of freedom are intertwined. The superconducting Higgs mode may reveal such couplings spectroscopically and uncover interactions directly relevant to Cooper pairing. To this end, we investigate the Higgs mode of several cuprate thin films using phase-resolved terahertz third harmonic generation (THG) to. In addition to the heavily damped Higgs mode itself, we observe a universal jump in the phase of the driven Higgs oscillation as well as a non-vanishing THG above Tc. These findings indicate coupling of the Higgs mode to other collective modes and a nonzero pairing amplitude above Tc. Our study demonstrates a new approach for investigating unconventional superconductivity. We foresee a fruitful future for phase-resolved spectroscopy in various superconducting systems.

Preview

Data analysis.zip

Analysis
- Data analysis.aliases 47 Bytes
- Data analysis.lvproj 4.7 kB
- DataSorting_June2018.vi 1.7 MB
- binning_June2018.vi 139.1 kB
- pyro_bins.vi 29.2 kB

Communities
Research field: Matter Remove
RODARE Remove

371 views | 1,303 downloads

See more details...

Publication date: April 15, 2020

DOI: DOI 10.14278/rodare.277

Keyword(s): Superconductors | terahertz | Higgs | Nonlinear dynamics | ultrafast

Related identifiers:
Identical to: https://www.hzdr.de/publications/Publ-30902
Referenced by: https://www.hzdr.de/publications/Publ-29647

Communities: Research field: Matter, RODARE

License (for files): Creative Commons Attribution 4.0 International

Versions

Version 1 Apr 15, 2020
10.14278/rodare.277

- HZDR internal repository
- Supports open publishing (DOI) and restricted sharing of raw data.
- Process still largely manual

panosc photon and neutron open science cloud

ExPaNDS European Open Science Cloud Photon and Neutron Data Services