# Speed Poster Session 1

## Monday 12:05 to 12:35

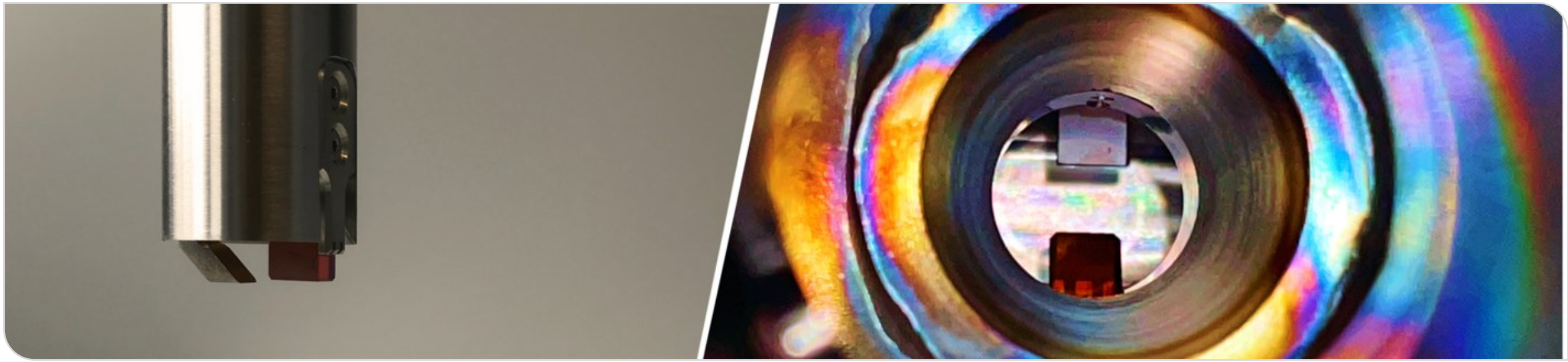
1. S. Funkner,  Phase Space THz Tomography at KARA
2. M. Nabinger,  Characterization and optimization of laser generated THz beam for THz based strea
3. F. Donoso, Time-dependent Phase Space THz-Tomography
4. Q. Demazeux, Tabletop Prototype of Diversity EO at FLASH
5. M. Kellermeier, Passive Streaking towards Current Profile Reconstruction of Low Energy beams
6. J. Roever, Mechanical Engineering for Longitudinal Diagnostics

**Lunch until 14:00**

Karlsruhe Institute of Technology

# Phase Space THz-Tomography at KARA


## S. Funkner for IBPT/DRD group

Phase space densities

# ~~Attention~~ Is All You Need


**Ashish Vaswani*** Google Brain avaswani@google.com

**Noam Shazeer*** Google Brain noam@google.com

**Niki Parmar*** Google Research nikip@google.com

**Jakob Uszkoreit*** Google Research usz@google.com

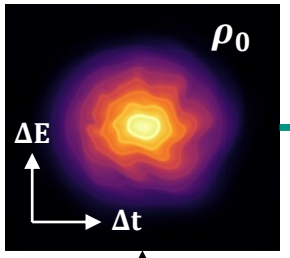
**Llion Jones*** Google Research llion@google.com

**Aidan N. Gomez*** † University of Toronto aidan@cs.toronto.edu

**Łukasz Kaiser*** Google Brain lukaszkaiser@google.com

**Illia Polosukhin*** ‡ illia.polosukhin@gmail.com

# Measurements



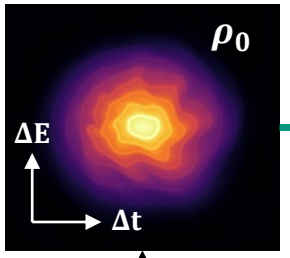

- emission spectrum
- bunch length
- energy spread

Phase space densities

~~Attention~~ Is All You Need

**Ashish Vaswani*** Google Brain avaswani@google.com
**Noam Shazeer*** Google Brain noam@google.com
**Niki Parmar*** Google Research nikip@google.com
**Jakob Uszkoreit*** Google Research usz@google.com
**Llion Jones*** Google Research llion@google.com
**Aidan N. Gomez*** † University of Toronto aidan@cs.toronto.edu
**Łukasz Kaiser*** Google Brain lukaszkaiser@google.com
**Illia Polosukhin*** ‡ illia.polosukhin@gmail.com

## Measurements




- emission spectrum
- bunch length
- energy spread

Phase space density

~~Attention~~ Is All You Need


**Ashish Vaswani*** Google Brain avaswani@google.com

**Noam Shazeer*** Google Brain noam@google.com

**Niki Parmar*** Google Research nikip@google.com

**Jakob Uszkoreit*** Google Research usz@google.com

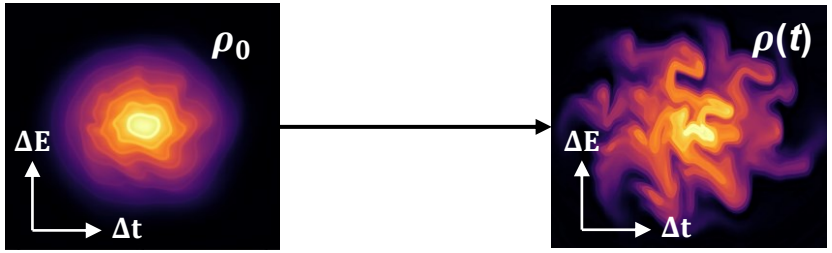
**Llion Jones*** Google Research llion@google.com

**Aidan N. Gomez*** † University of Toronto aidan@cs.toronto.edu

**Łukasz Kaiser*** Google Brain lukaszkaiser@google.com

**Illia Polosukhin*** ‡ illia.polosukhin@gmail.com

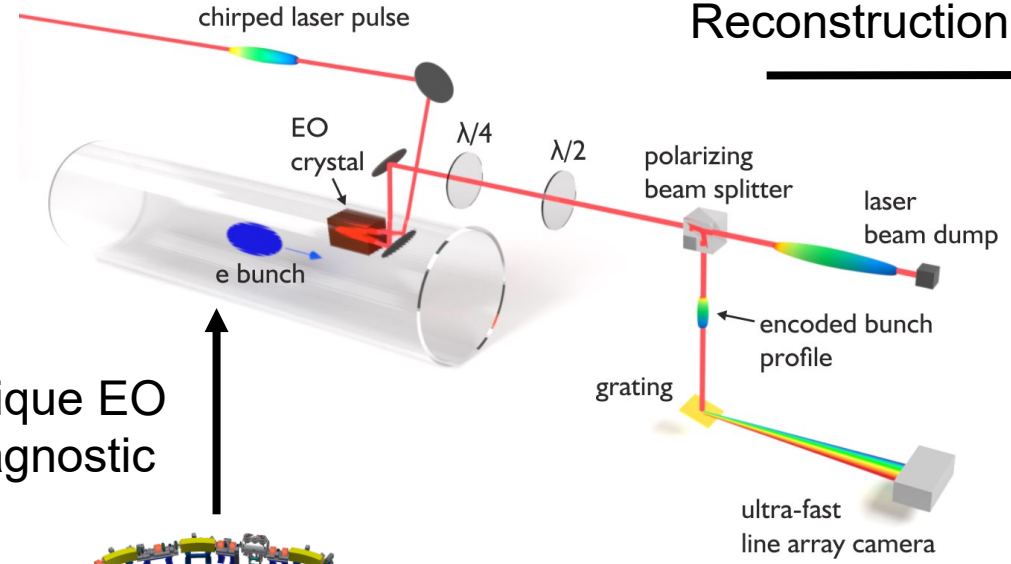

## Determinism – one phase space density is enough



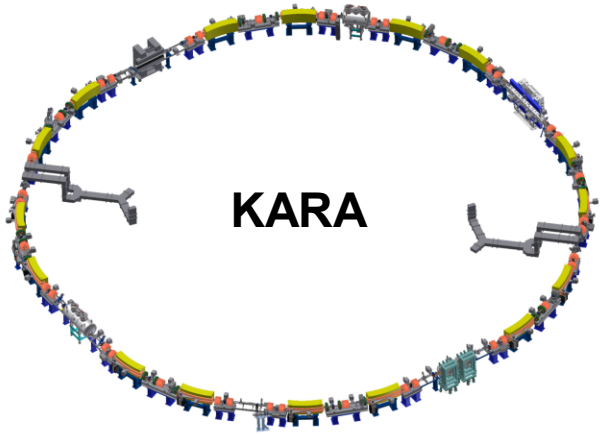

$\rho_0$ ***determines*** $\rho(t)$ via Vlasov-Fokker Planck Equation

- RF
- self-interaction (impedance)
- velocity diffusion

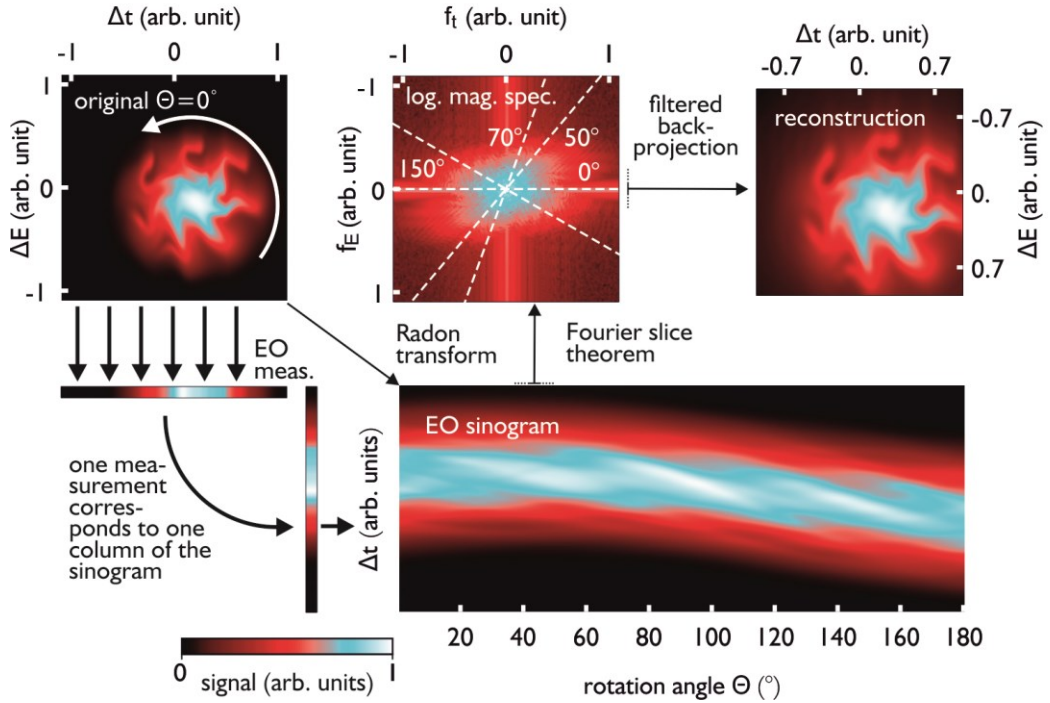
# Phase space tomography



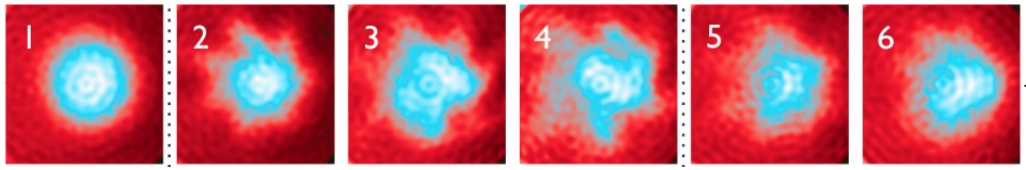

unique EO diagnostic




Reconstruction method




from experimental data

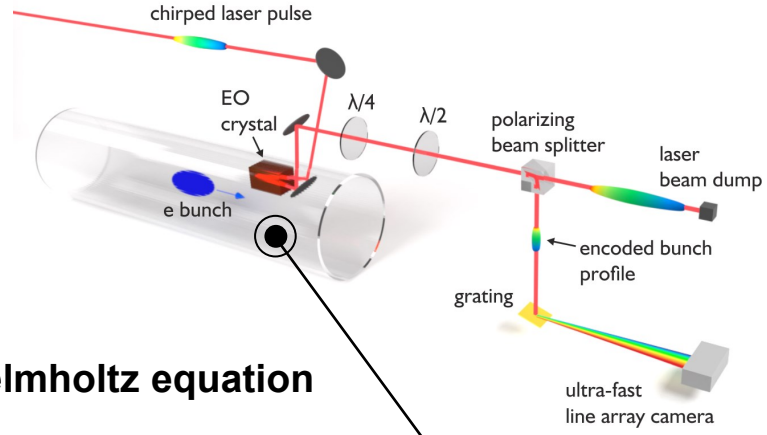



**Revealing the dynamics of ultrarelativistic non-equilibrium many-electron systems with phase space tomography**

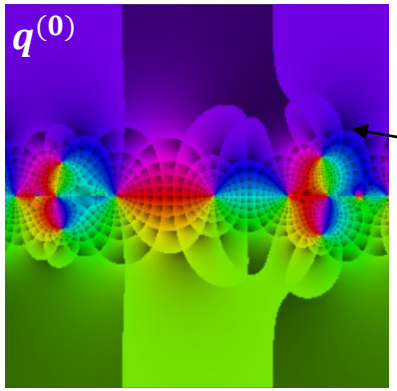
S Funkner, G Niehues, M J Nasse, E Bründermann, M Caselle, B Kehrer, L Rota, P Schönfeldt, M Schuh, B Steffen, J L Steinmann, M Weber, A-S Müller

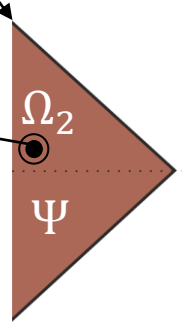
Scientific Reports, 13 (1), 4618

# Diffraction of THz-waves

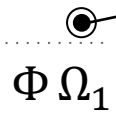


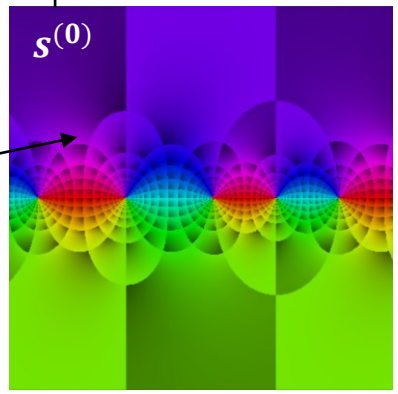

**Helmholtz equation**





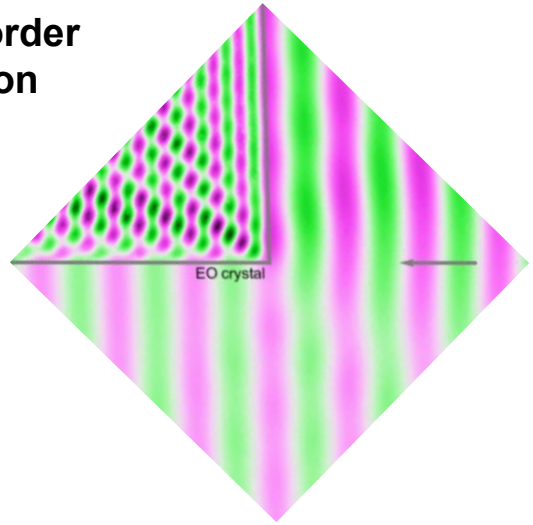



**Solution: Wiener-Hopf + Sommerfeld Malyuzhinets technique**

Nethercote et. al., "IMA Journal of Applied Mathematics 85.3 (2020): 421-466."

**zero-order solution**




**Questions**

- **general properties of the solution**
- **connection to electron-bunch measurements with EO sampling**
- **reconstruction shape of an incoming TD-pulse possible?**
- **solution for: edges? two wedges? cube?**

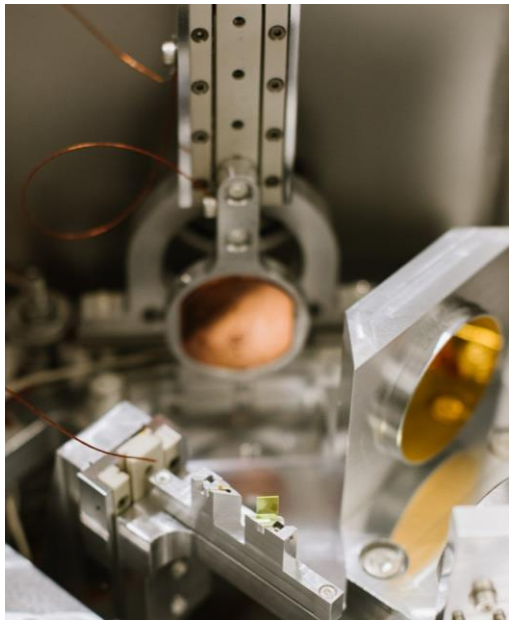
Karlsruhe Institute of Technology

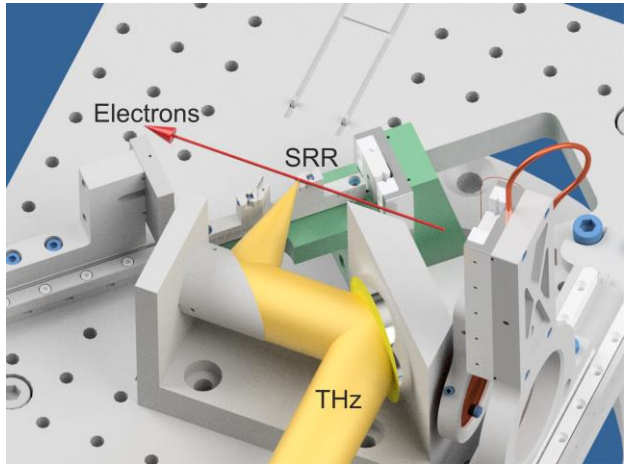
# Characterization and optimization of laser-generated THz beam for THz based streaking

**M. Nabinger, M. J. Nasse, J. Schäfer, A. Schmidt, J. L. Steinmann, C. Widmann, Z. Ollmann and A.-S. Müller**

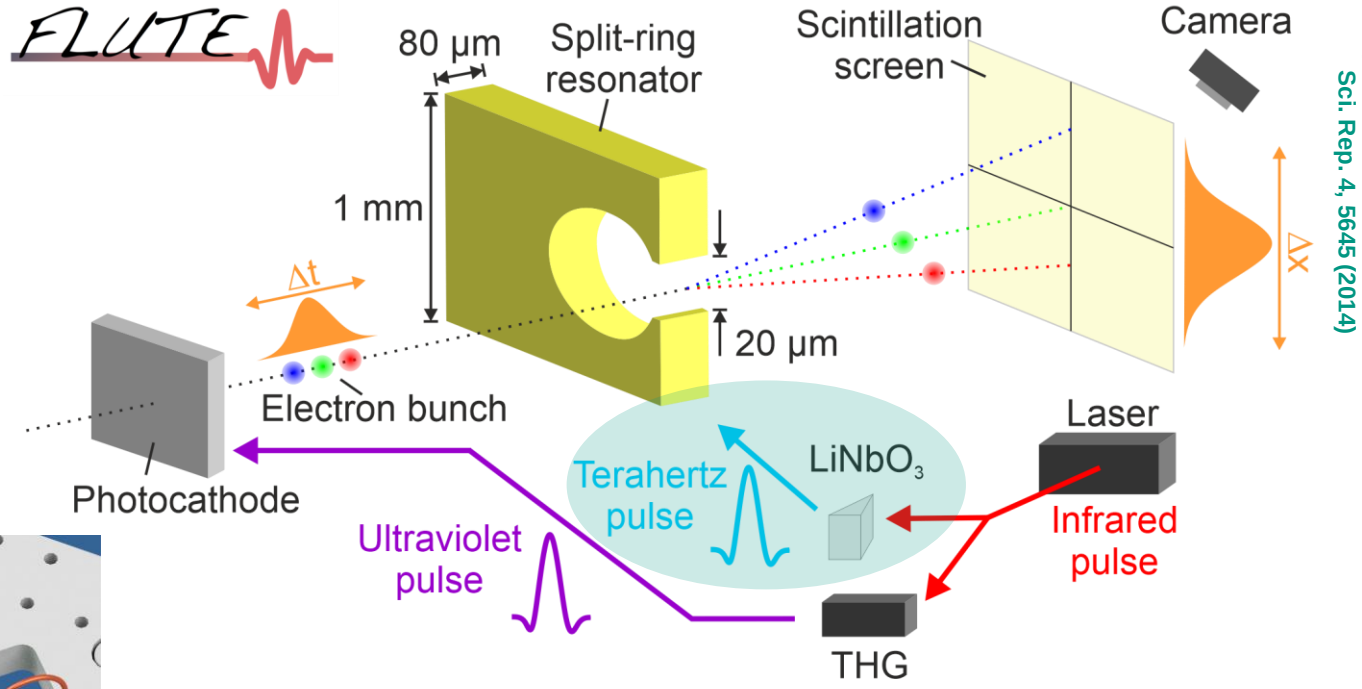
# Split-Ring Resonator Compact Transverse-Deflecting System

- Experiment at FLUTE (in low energy section)
- Measurement of longitudinal bunch profile on a fs scale
- Streaking with THz radiation & Amplifying electric field with split-ring resonator






SRR Compact-TDS principle:

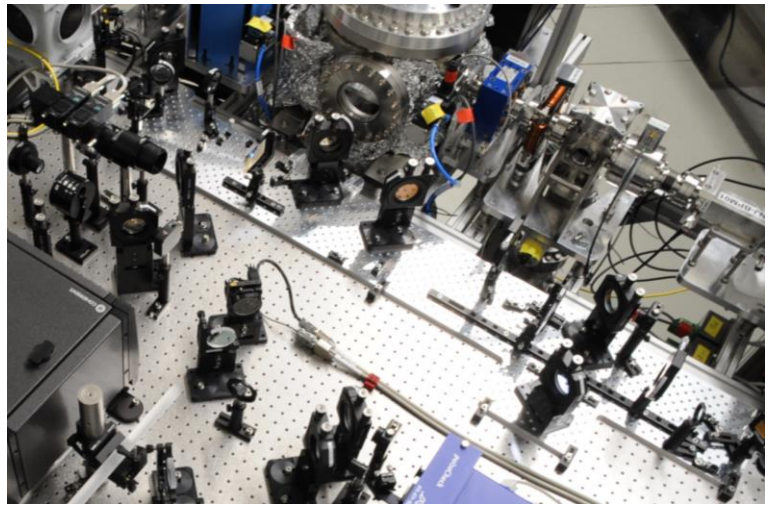


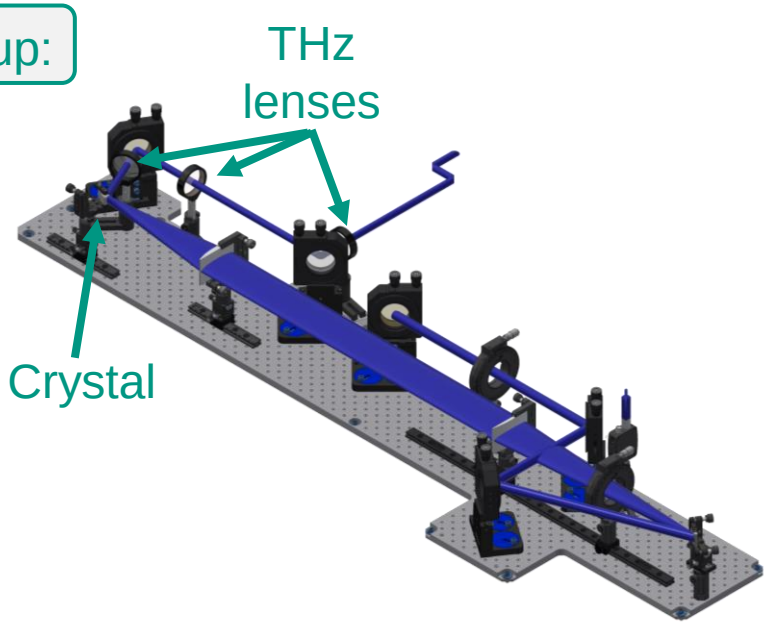

Adapted from J. Fabiańska et. al., Sci. Rep. 4, 5645 (2014)

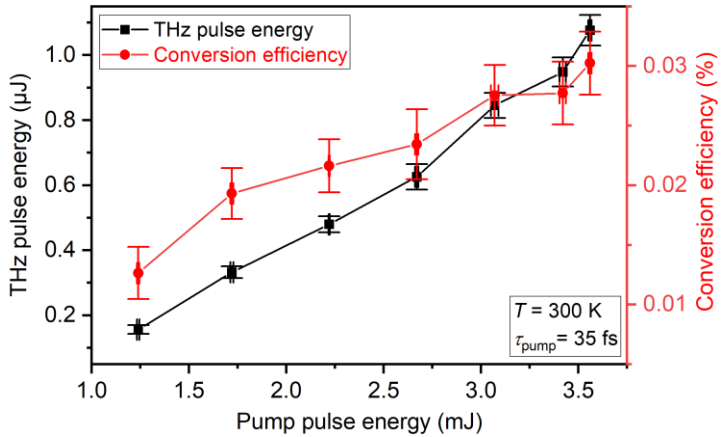
High energy THz pulses needed!

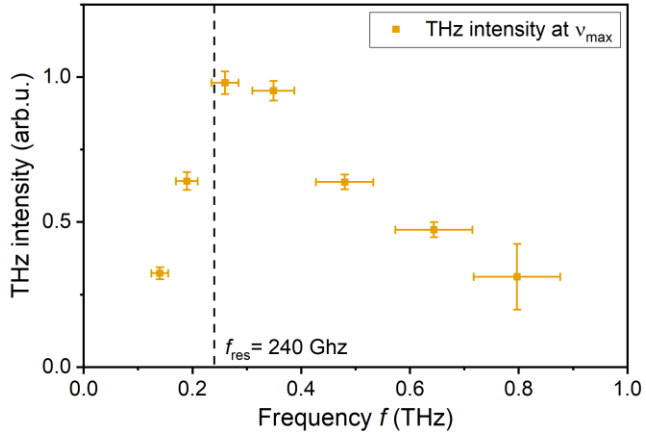
# THz generation setup and transport optics

Tilted-pulse-front pumping THz setup:



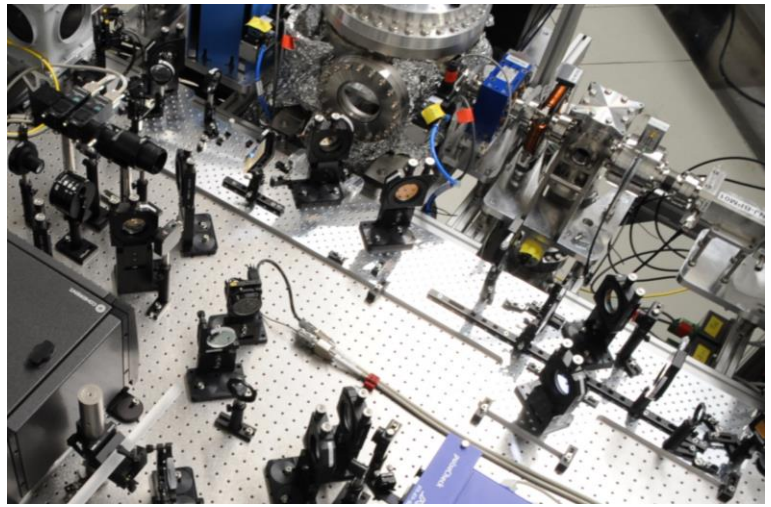


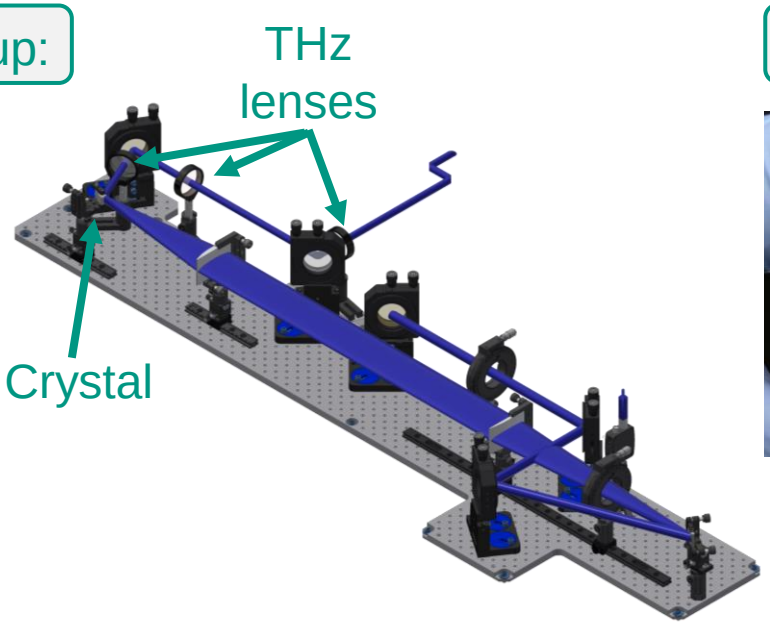



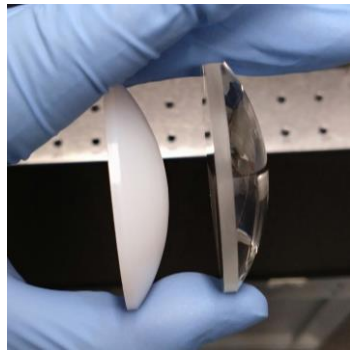
# THz generation setup and transport optics

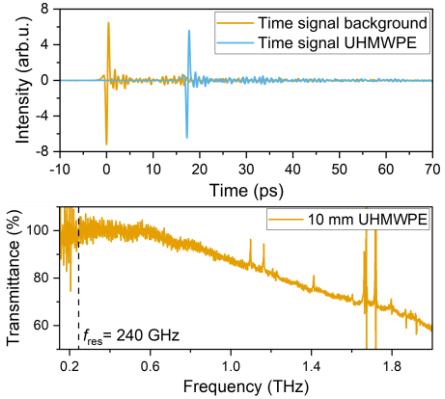
## Tilted-pulse-front pumping THz setup:

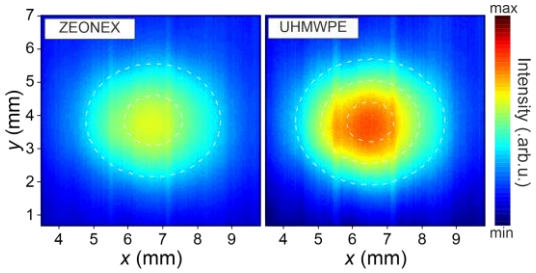


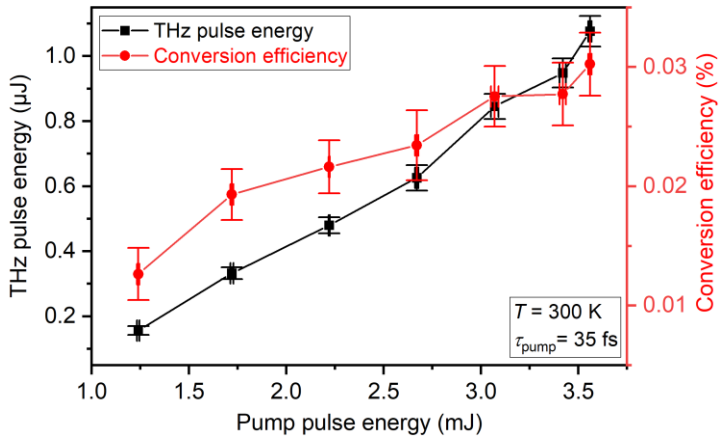


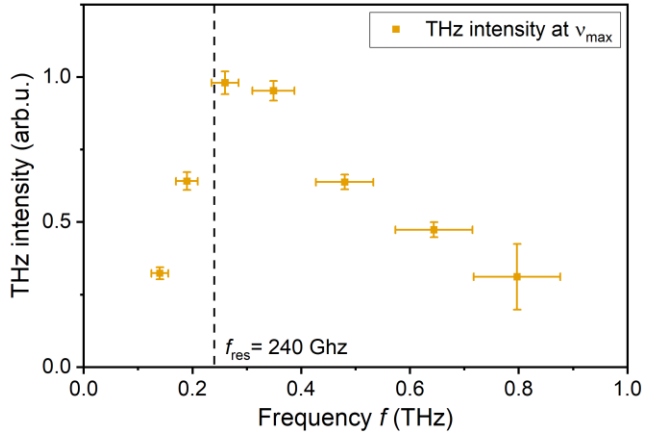

## Optimization:

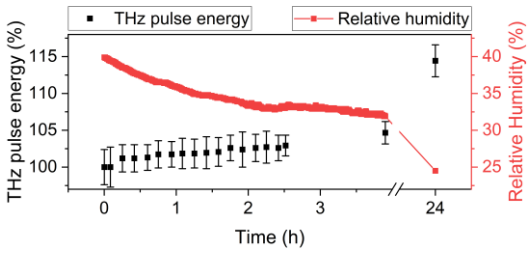




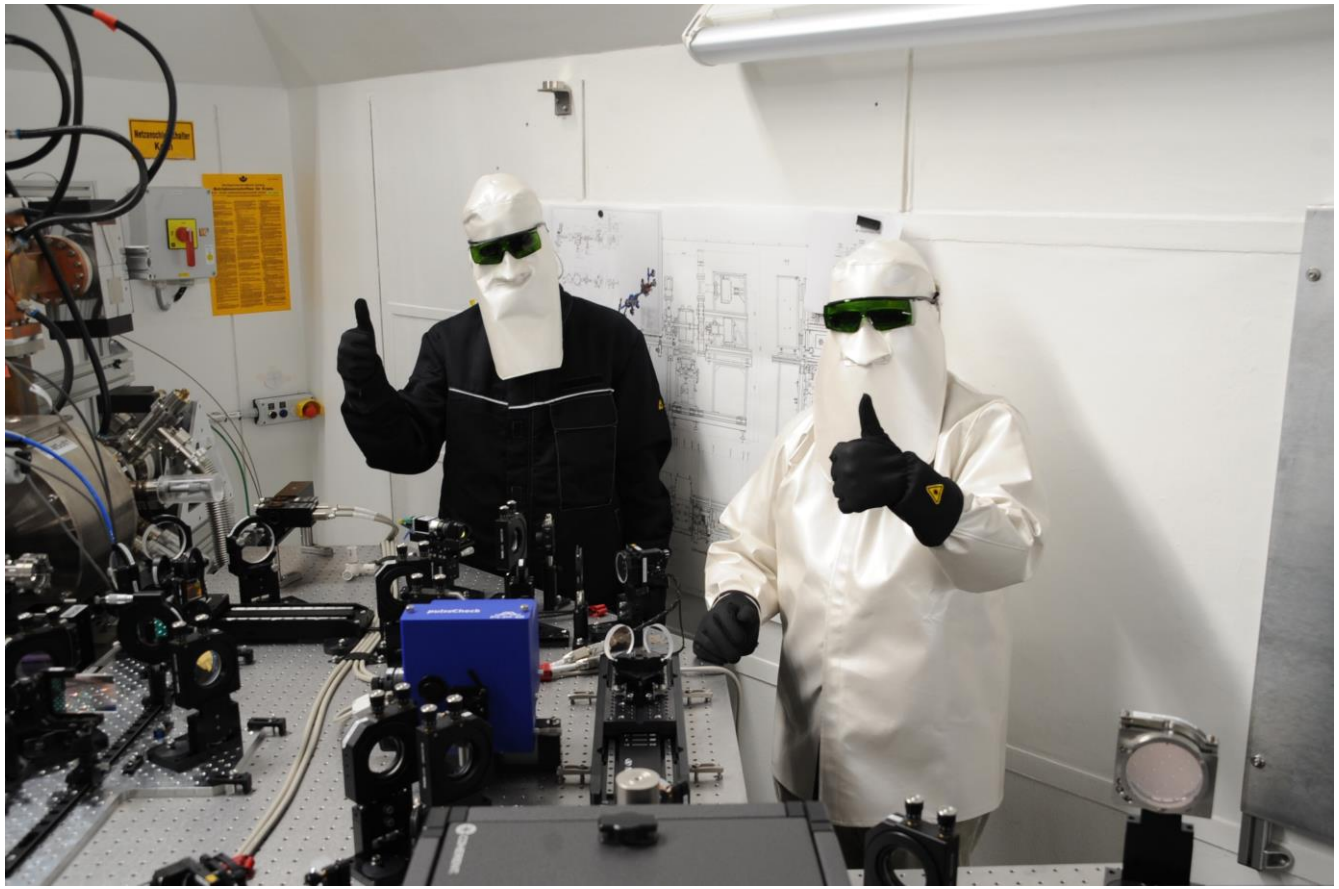



**Matthias Nabinger**
Doctoral researcher

Contact: matthias.nabinger@kit.edu

## Thank you for your attention!

M. Nabinger & J. Schäfer acknowledge the support by the DFG-funded Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology" (KSETA).



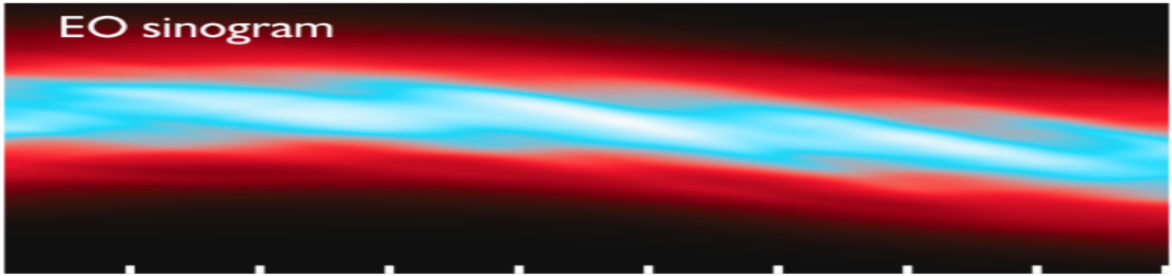
Karlsruhe Institute of Technology

IBPT
Institute for Beam Physics and Technology

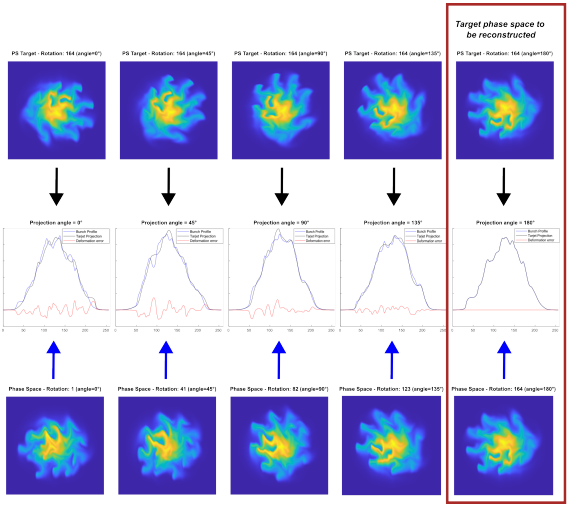
# Time-dependent Phase Space THz-Tomography

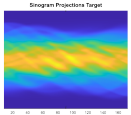
Felipe Donoso | 12 June 2023

INSTITUTE FOR BEAM PHYSICS AND TECHNOLOGY (IBPT)



# Phase Space Tomography Challenge



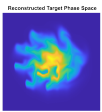

**TOMOGRAPHY METHODS (Inverse Problem)**

$$Wx = p$$

$$\Downarrow$$

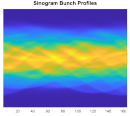
$$x^* = argmin_x \|p - Wx\|$$

**x = Target phase space**
**W = Projection matrix**
**p = Projection target sinogram**




## Phase Space Tomography

- **Based on the bunch profile measurement in every synchrotron turn.**
- **Relies on the rotation of the phase space in every synchrotron turn.**
- **Assume rigid rotation of the phase space.**



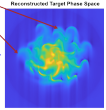

**TOMOGRAPHY METHODS (Dynamic Inverse Problem)**

$$W^\theta x_m = p_m$$
$$\vdots$$
$$W^\theta x_1 = p_1$$
$$W^\theta x_0 = p_0$$

**- What is the target phase space?**

**- Is it possible to find them all?**

**Movement Artifacts**



# Time-Dependent Tomography

- If the time-dependent deformation is modeled, the reconstruction of the phase space can be improved.

**Research Hypothesis**

*There is a system matrix that relates a sequence of bunch profiles to a specific phase in time.*

$$
\begin{aligned}
W^{\theta_m} x_m &= p_m \\
&\vdots \\
W^{\theta_1} x_1 &= p_1 \\
W^{\theta_0} x_0 &= p_0
\end{aligned}
\quad \rightarrow \quad
\begin{aligned}
W(t)x &= p_m \\
&\vdots \\
W(t)x &= p_1 \\
W(t)x &= p_0
\end{aligned}
$$

- W(t) ia the time-dependent system matrix.
- x is the target phase space.
- p is the bunch profile sinogram over half a cycle.

- The system matrix coefficients are determined using the VFP equation.

**Vlasov – Fokker – Planck Equation**

$$\frac{\partial \psi}{\partial \theta} + \frac{\partial H}{\partial p}\frac{\partial \psi}{\partial q} - \frac{\partial H}{\partial q}\frac{\partial \psi}{\partial p} = \beta \frac{\partial}{\partial p}\left(p\psi + \frac{\partial \psi}{\partial p}\right)$$

Measurament noise

$$W(t)x = p + \hat{n}$$

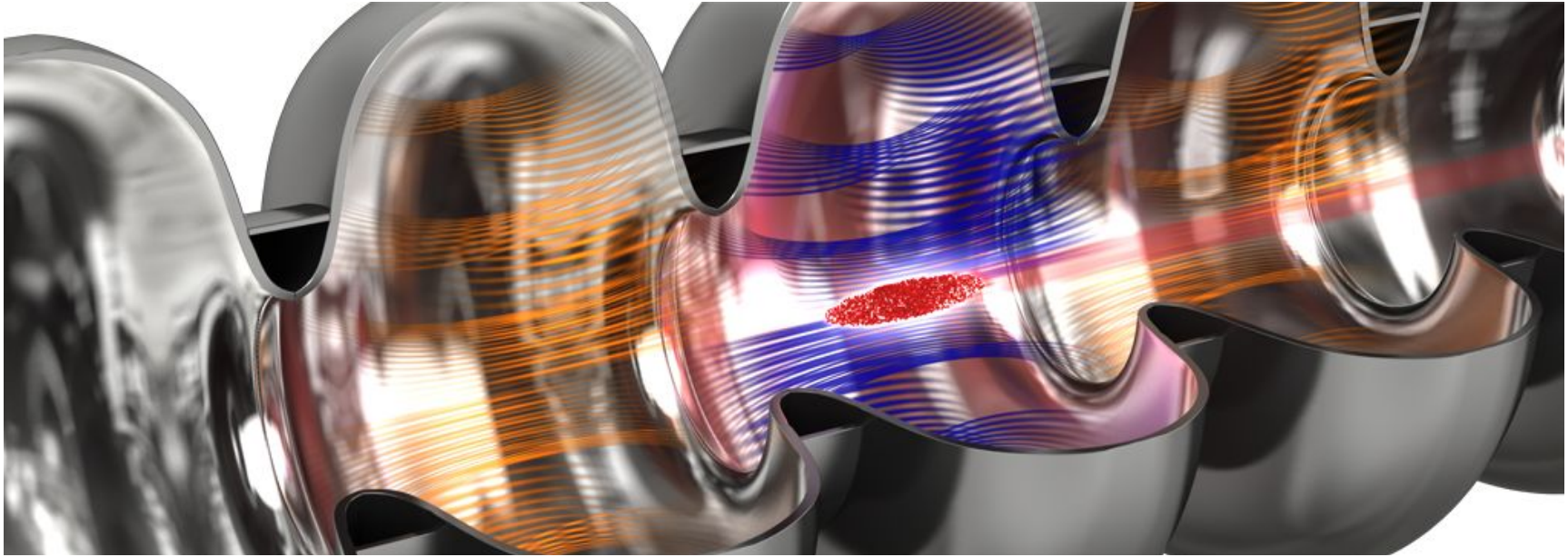
Regularization terms

$$x^* = argmin_x \| p - W(t)x \| + \lambda R(x)$$

# *Status Update : Tabletop Prototype of Diversity EO at FLASH*

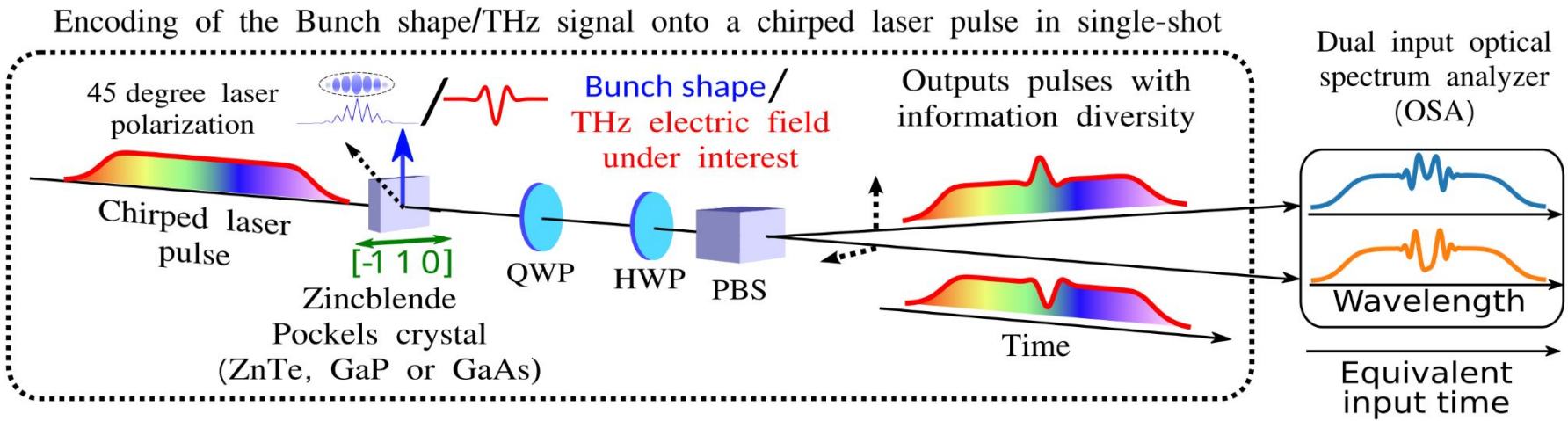
***12 th Workshop on Longitudinal Electron Bunch Diagnostics, KIT 2023***

Demazeux Quentin, Szwaj Christophe, Roussel Eléonore, Bielawski Serge (PhLAM, France), Steffen Bernd (DESY, Germany)



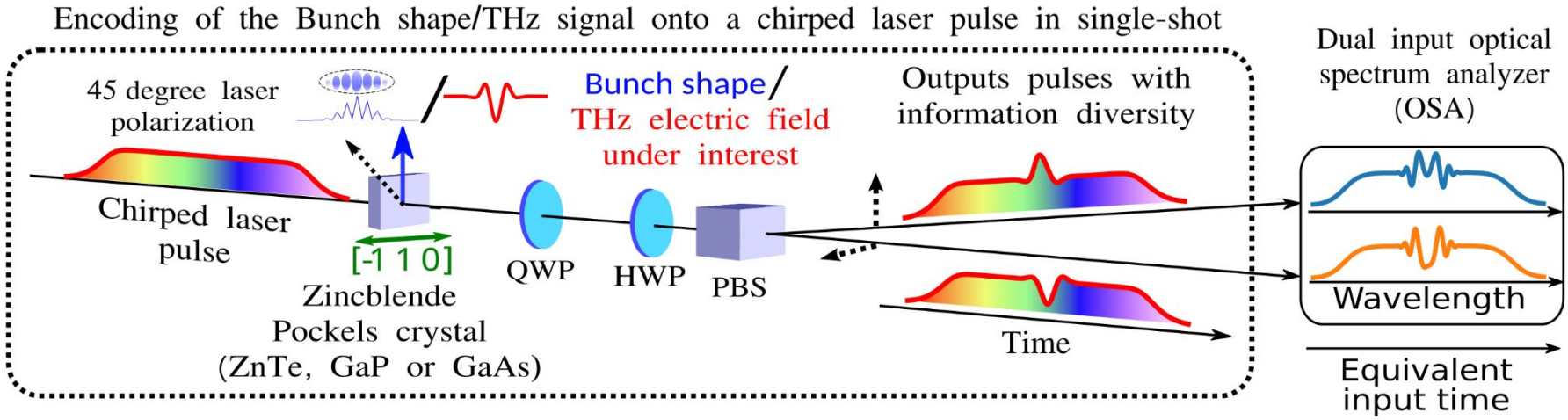
**Motivations:** The main purpose is to **develop systems** that are able to record in **single shot** the shapes of pico or femtosecond relativistic electron bunches.

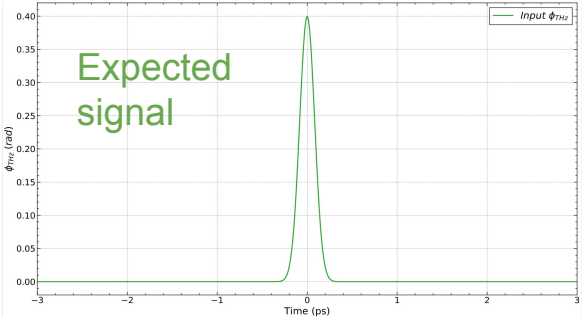
## Phase diversity :



**Motivations:** The main purpose is to **develop systems** that are able to record in **single shot** the shapes of pico or femtosecond relativistic electron bunches.

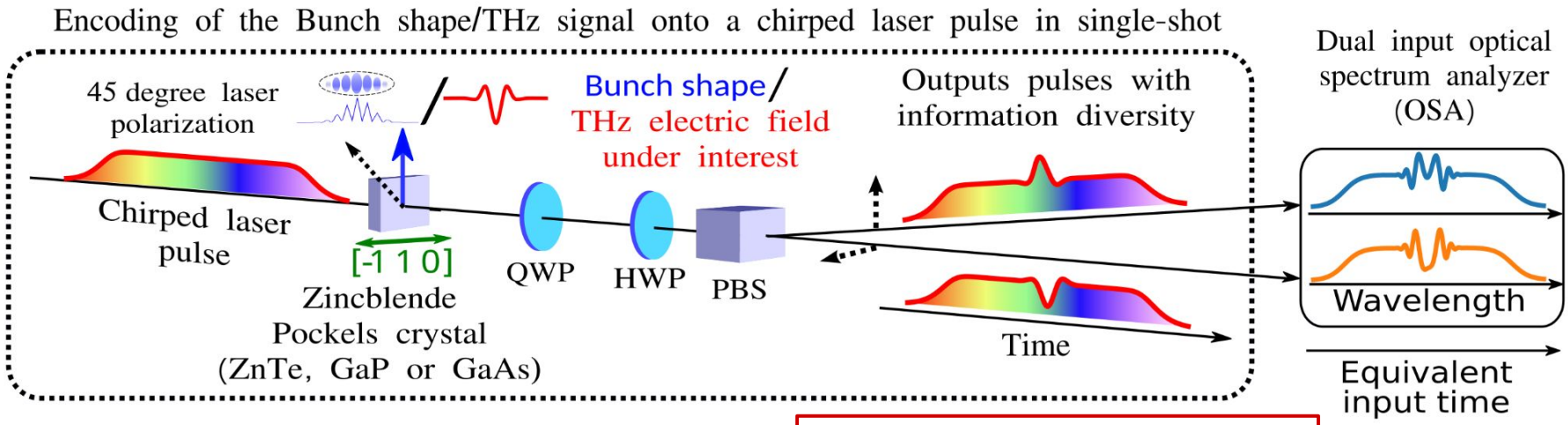
## Phase diversity :



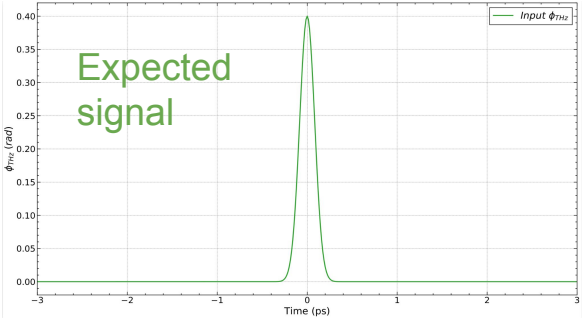



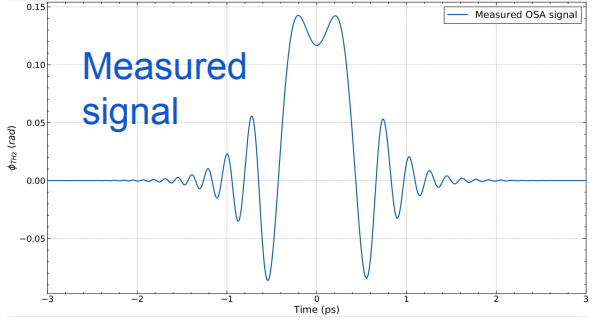
**Motivations:** The main purpose is to **develop systems** that are able to record in **single shot** the shapes of pico or femtosecond relativistic electron bunches.

## Phase diversity :



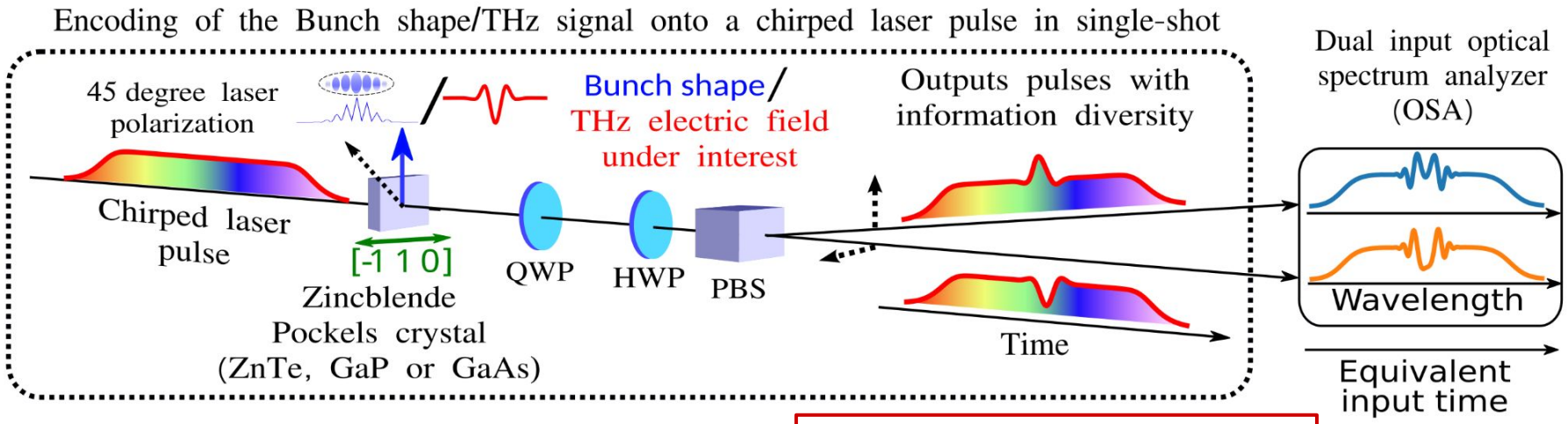

**Reconstruction algorithm is needed !**



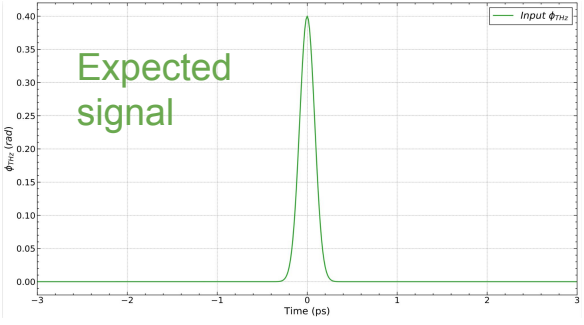



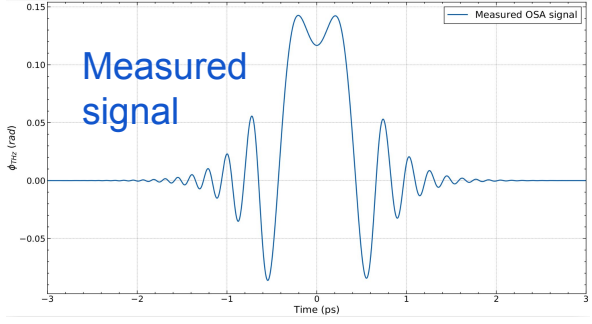
**Motivations:** The main purpose is to **develop systems** that are able to record in **single shot** the shapes of pico or femtosecond relativistic electron bunches.

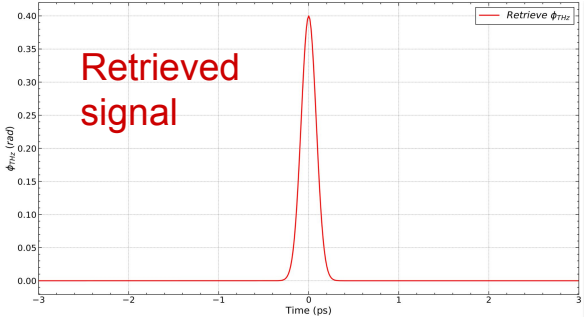
## Phase diversity :




**Reconstruction algorithm is needed !**

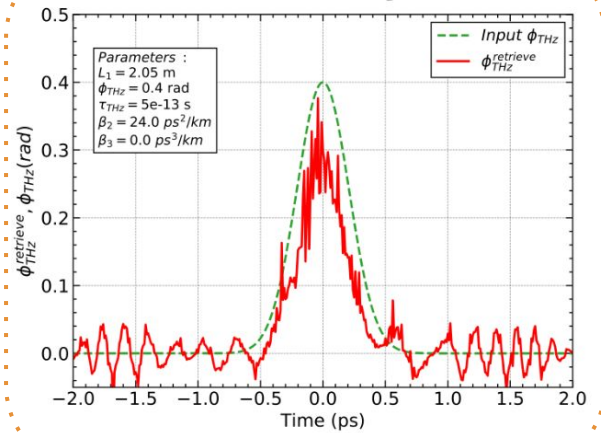


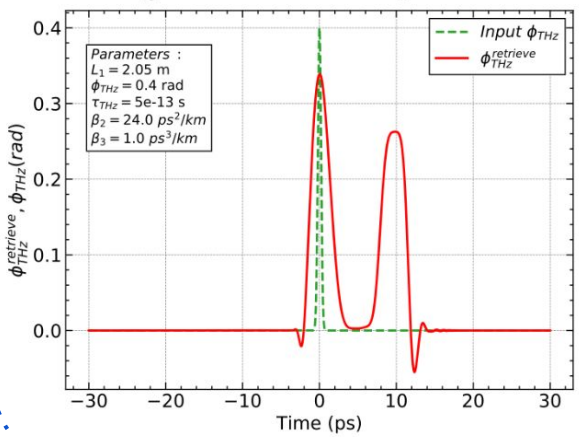



# *Various factors that lead to signal distortions*

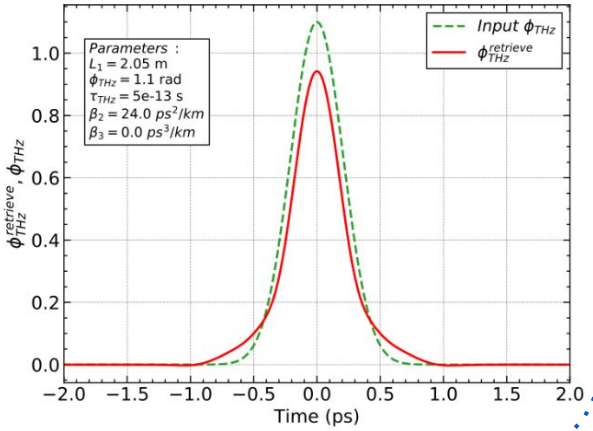
## Sensitivity




## Higher order dispersion

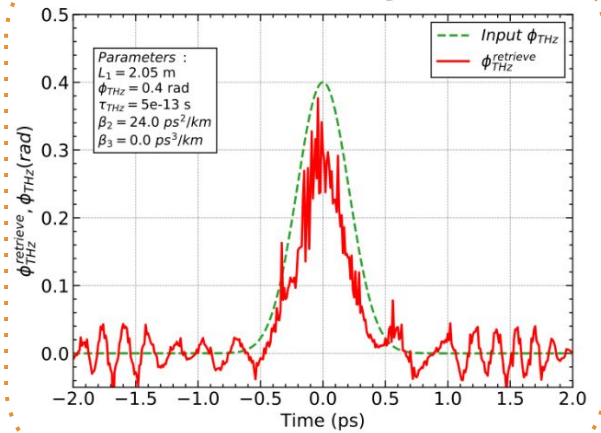



## High THz amplitude

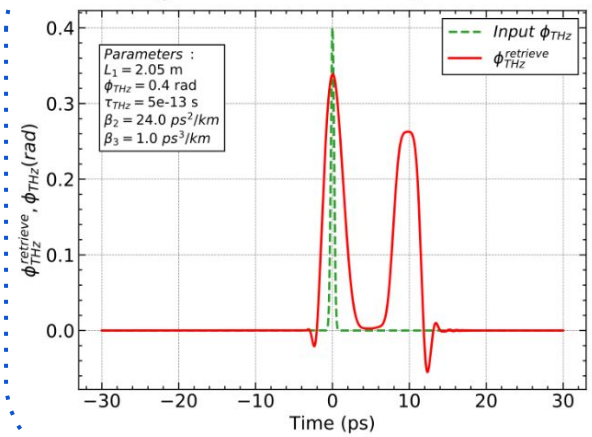


# *Various factors that lead to signal distortions*

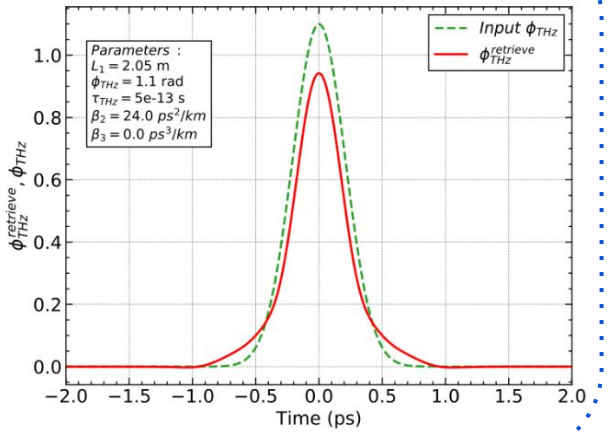
**Sensitivity**




**Higher order dispersion**

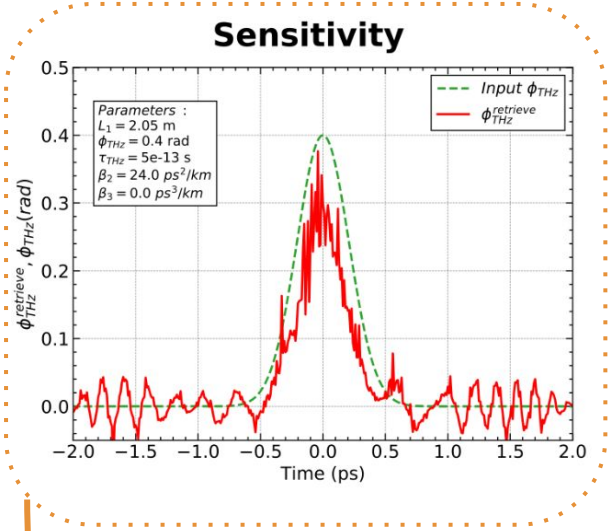


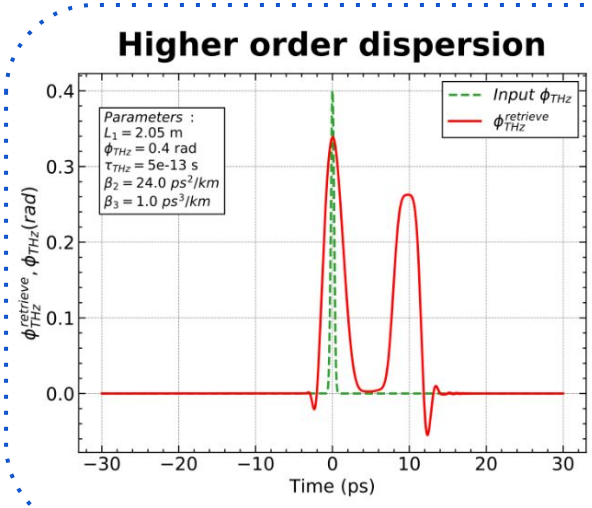

**High THz amplitude**

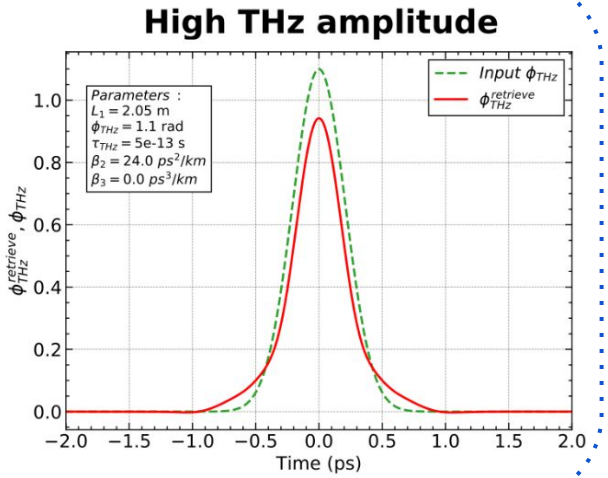



**How to improve the sensitivity and cures the distorsions ?**

# *Various factors that lead to signal distortions*



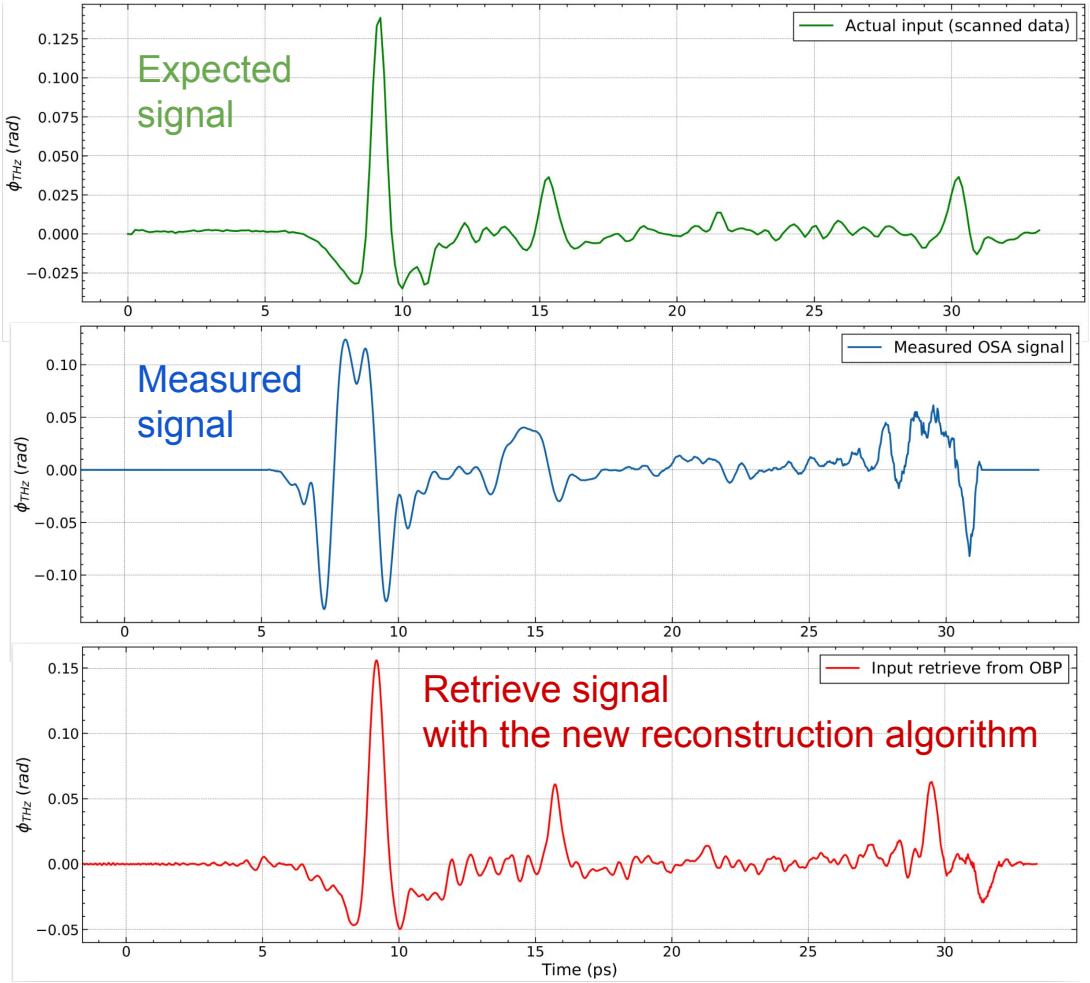

## How to improve the sensitivity and cures the distorsions ?

Sensitivity enhancement using Brewster plates

New reconstruction algorithm
for distorsions compensation

For more details see the poster : “ Status update : Tabletop prototype of diversity EO at FLASH ”

# Experimental results

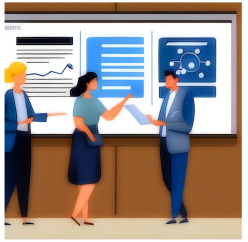



**Thank you for your attention !**

For more details see the poster :

" Status update : Tabletop prototype of diversity EO at FLASH "

**See you there !**



# Passive Streaking towards Current Profile Reconstruction of Low Energy beams

Max Kellermeier, T. Vinatier, R. Assmann, F. Burkart, H. Dinter, S. Jaster-Merz, W. Kuropka, F. Mayet, B. Stacey
Presented at the 12th Workshop on Longitudinal Electron Bunch Diagnostics
Karlsruhe, 11 June 2023
max.kellermeier@desy.de

*The TWAC project is funded by the European Union's Horizon Europe research and innovation programme (EIC Pathfinder scheme) under grant agreement n. 101046504. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.*

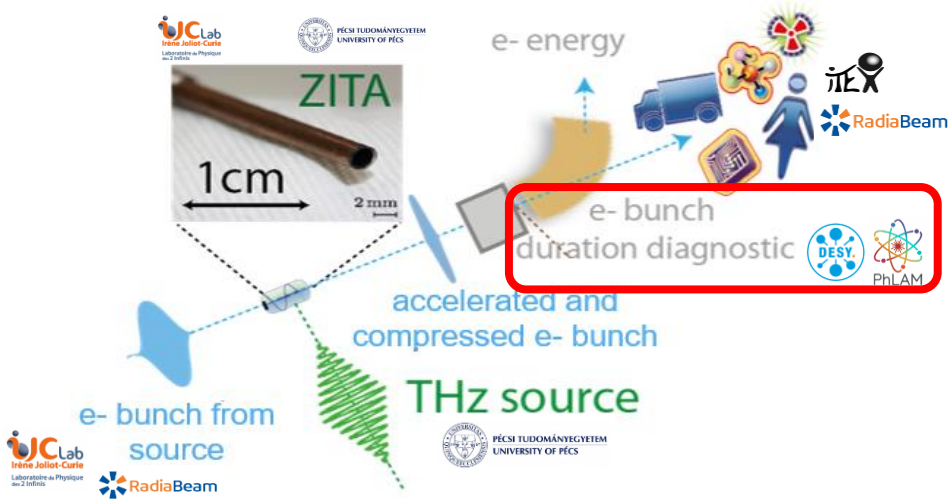
HELMHOLTZ SINBAD

Funded by the European Union

TERAHERTZ WAVE ACCELERATING CAVITY

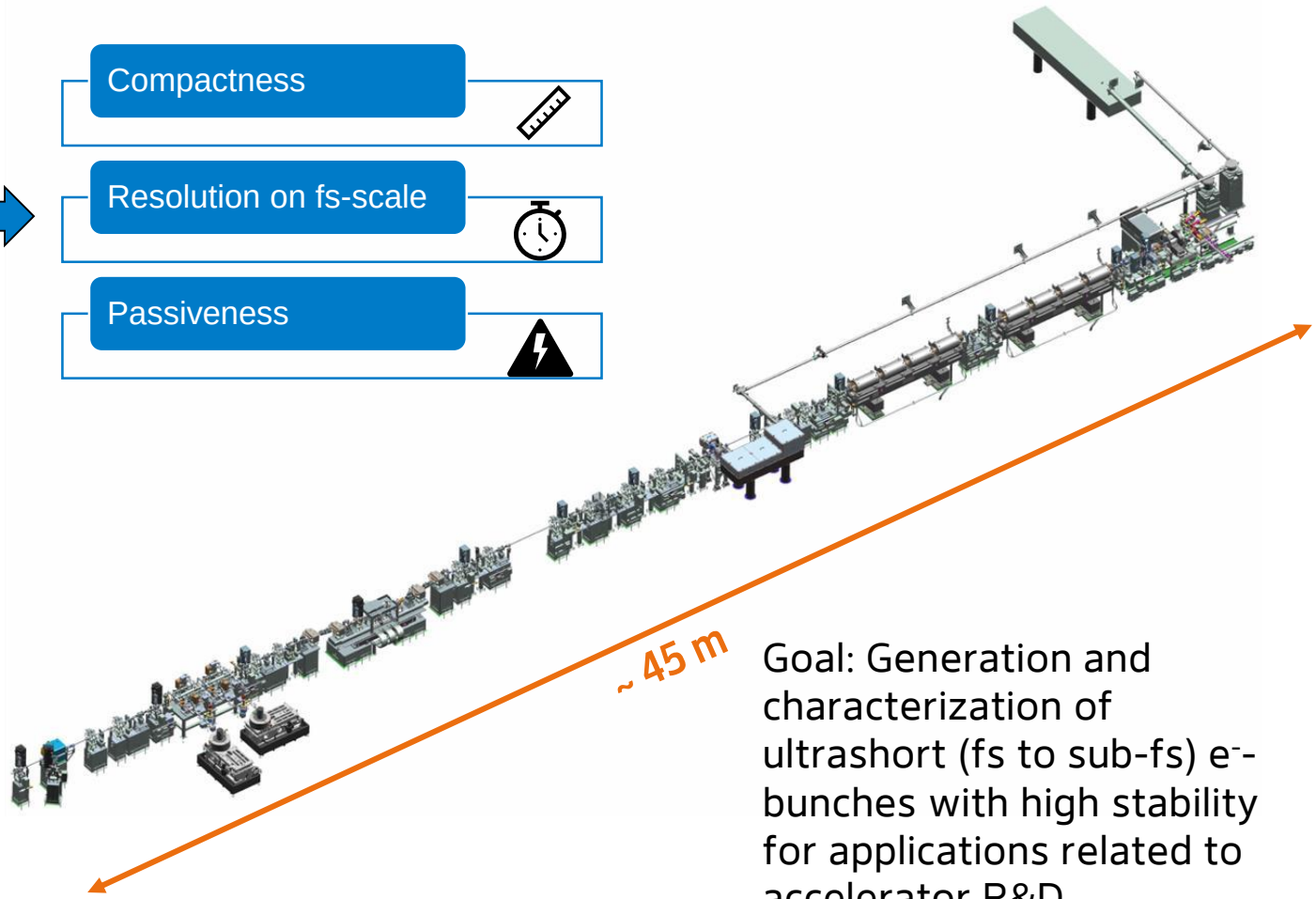
DESY.

# Diagnostics for TWAC and ARES as benchmark platform



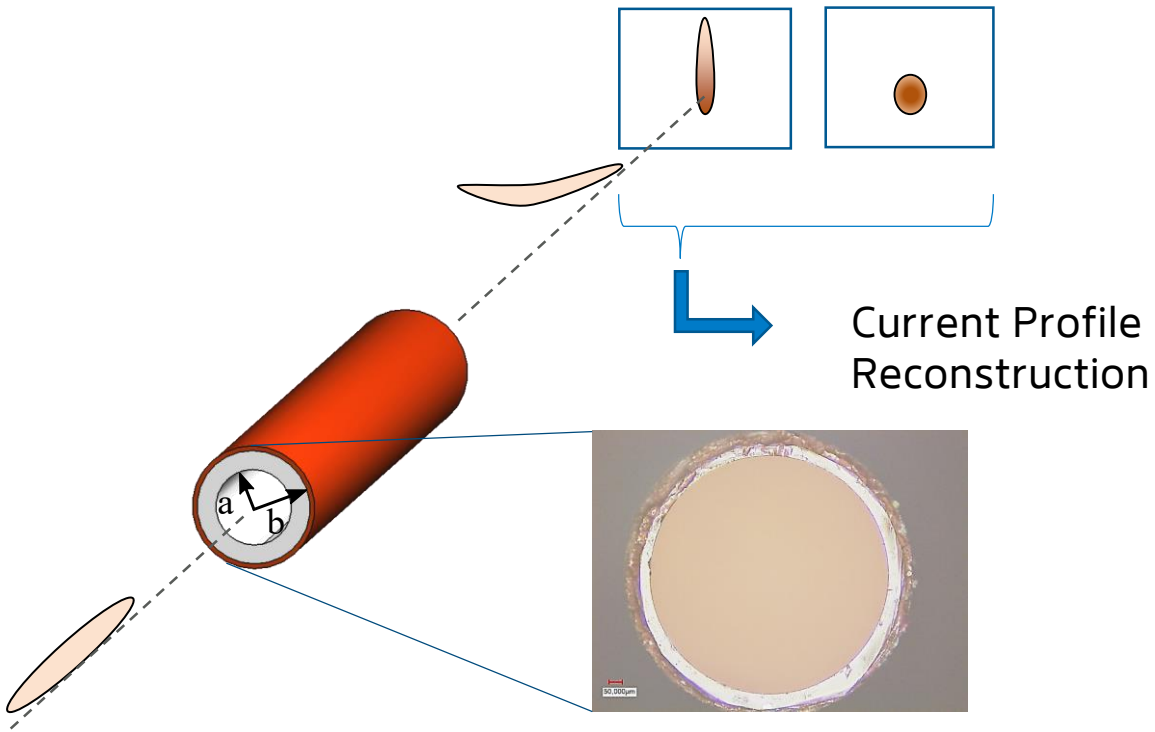

Goal: low-energy, high peak current compact accelerators leveraged by THz-driven acceleration & compression

- Compactness
- Resolution on fs-scale
- Passiveness

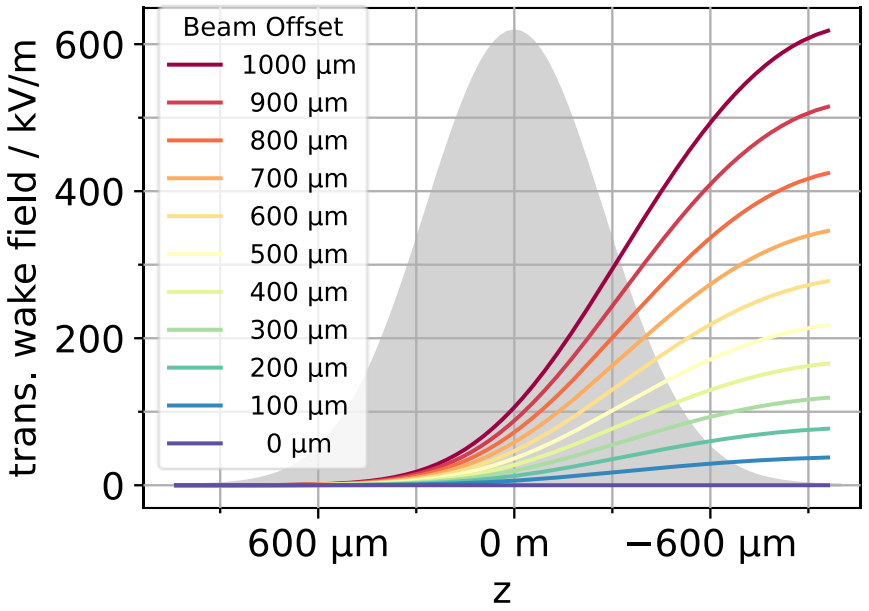



Goal: Generation and characterization of ultrashort (fs to sub-fs) e⁻-bunches with high stability for applications related to accelerator R&D

# Streaking the Beam by its Transverse Wakefield




Current Profile Reconstruction




For more information on the reconstruction feel free to pass by my poster!

# Jan Roever

## mechanical engineer

### me and I

- In my first life I worked as a carpenter.
- Study - Mechanical engineering – mechatronics
  - HAW Bonn-Rhein-Sieg - Dipl. Ing. (FH)
  - HAW Hamburg – Vordiplom
- DESY since 2010
  - 4 years experiments support at PETRA III
  - 2 years XFEL vacuum warm beamline, design and installation
  - and since 2016 at MSK mechanical engineer for longitudinal beam diagnostics

### current work

- Next iteration for the packaging of the Electro-Optical (EO) Unit and Internal Electronics Unit for the BAM
- integration of the longitudinal beam diagnostics for the next flash expansion stage
- the adaptation of a beamline for the decoupling of THz radiation from the FLASH

### future work

- Mechanic design for the 100GHz BAM