400 kHz repetition rate THz-TDS with 24 mW of average power driven by a compact industrial Yb-laser

C. MILLON[1*], S. HOUVER[2], C.J. SARACENO[1]

[1] Photonics and Ultrafast Laser Science, Ruhr University Bochum, 44801 Bochum, Germany

[2] Université Paris Cité, CNRS, Matériaux et Phénomènes Quantiques, F-75013 Paris, France

*celia.millon@ruhr-uni-bochum.de

puls

FP-RESOMUS

a Fellowship Program of the NCCR MUST and the Cluster of Excellence - RESOLV

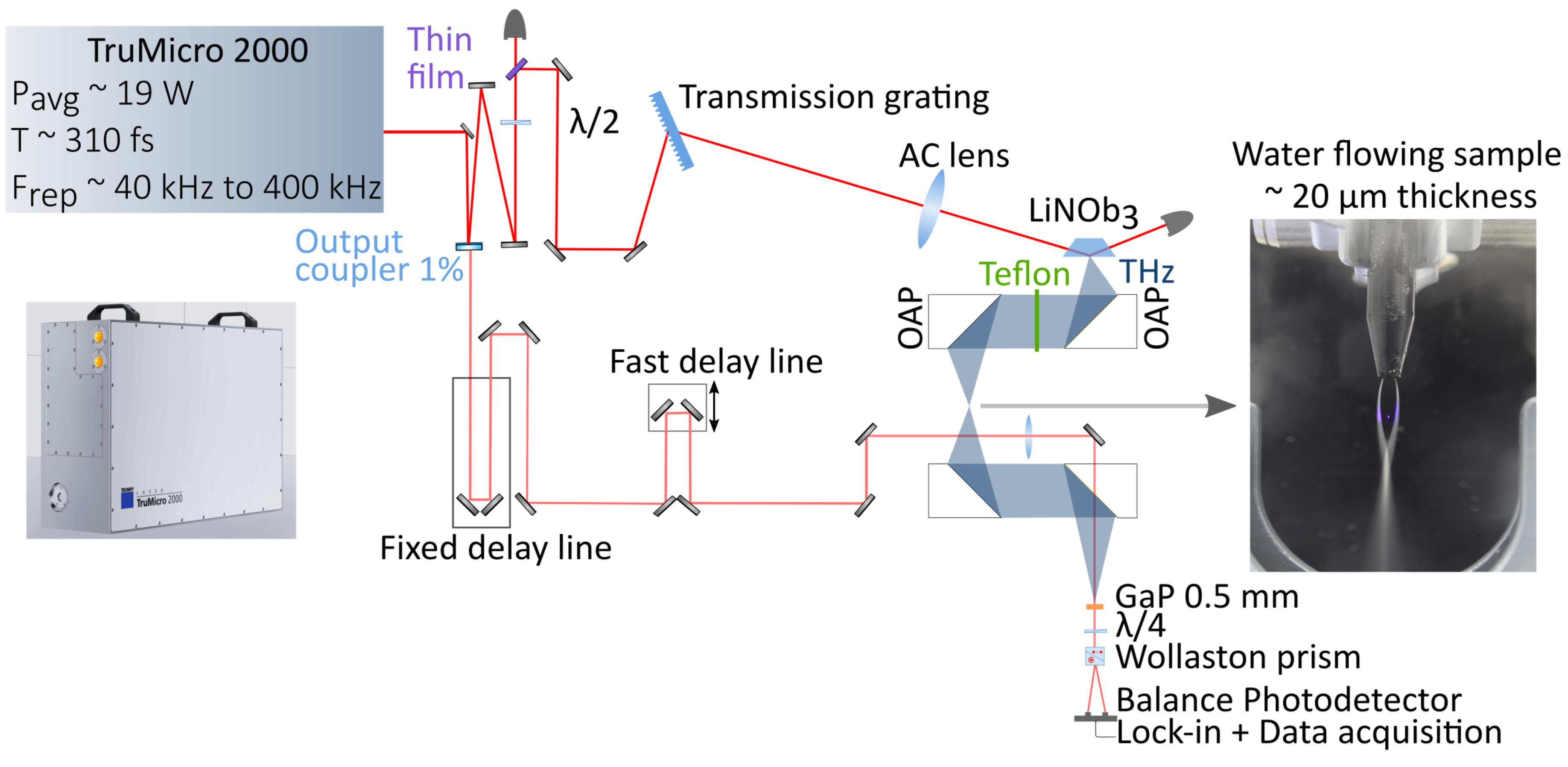
RUB

Marie SFB/TRR 196

Motivation

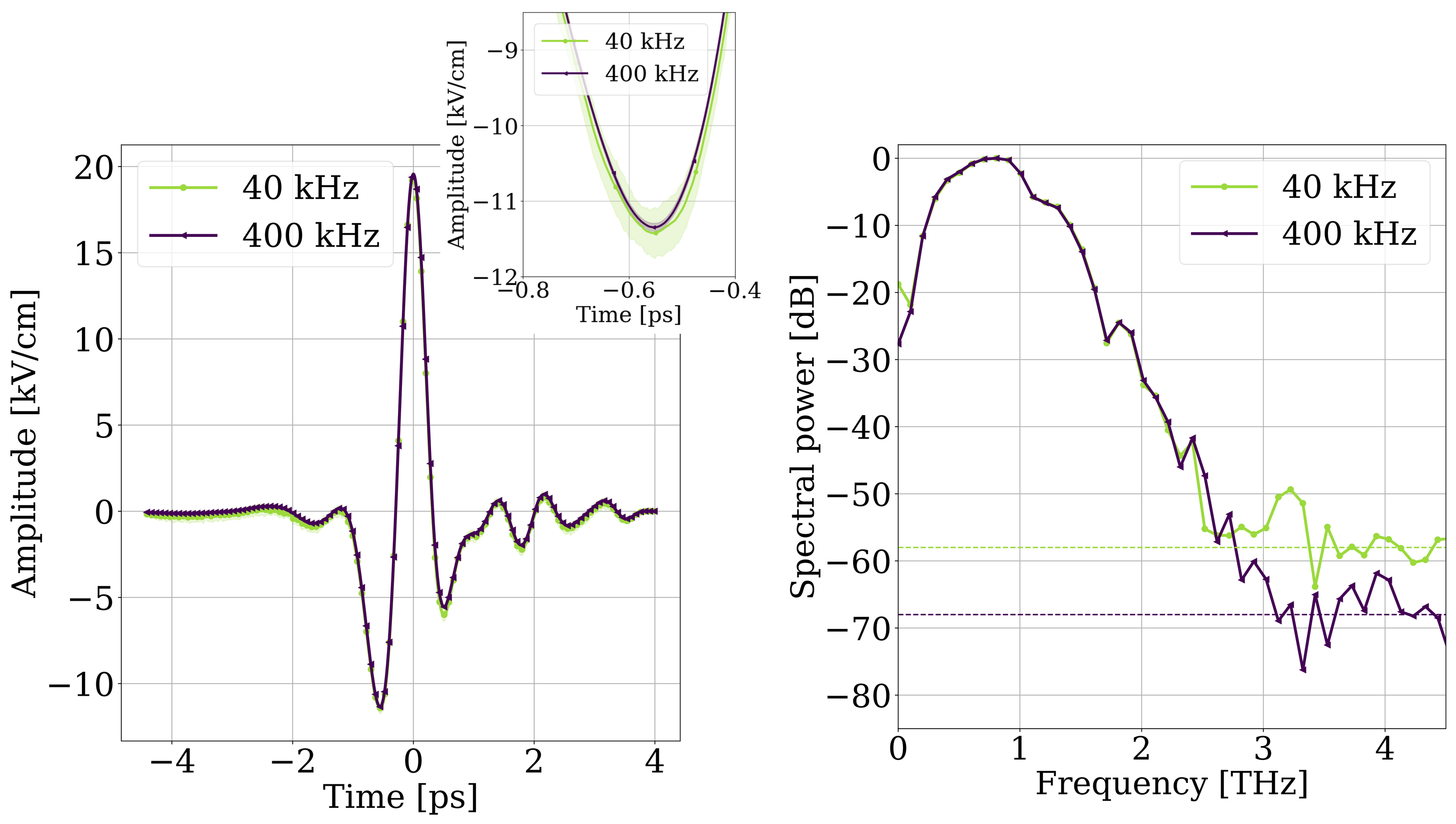
- High THz power for high absorbing sample : H_2O [1]
- Today, to have access to those source : accelerator facilities or some niche lasers with an external compression stage
- **Exploring the >100 kHz – 1 MHz repetition rate range to design a high THz power table-top source**
- Very recently, some THz source were developed @ 25 kHz, 100kHz and 200 kHz [2-4] but with a low conversion efficiency and at the cost of external compression stage
- **Optical rectification** in Lithium Niobate achieved high power THz [5]

Set-up

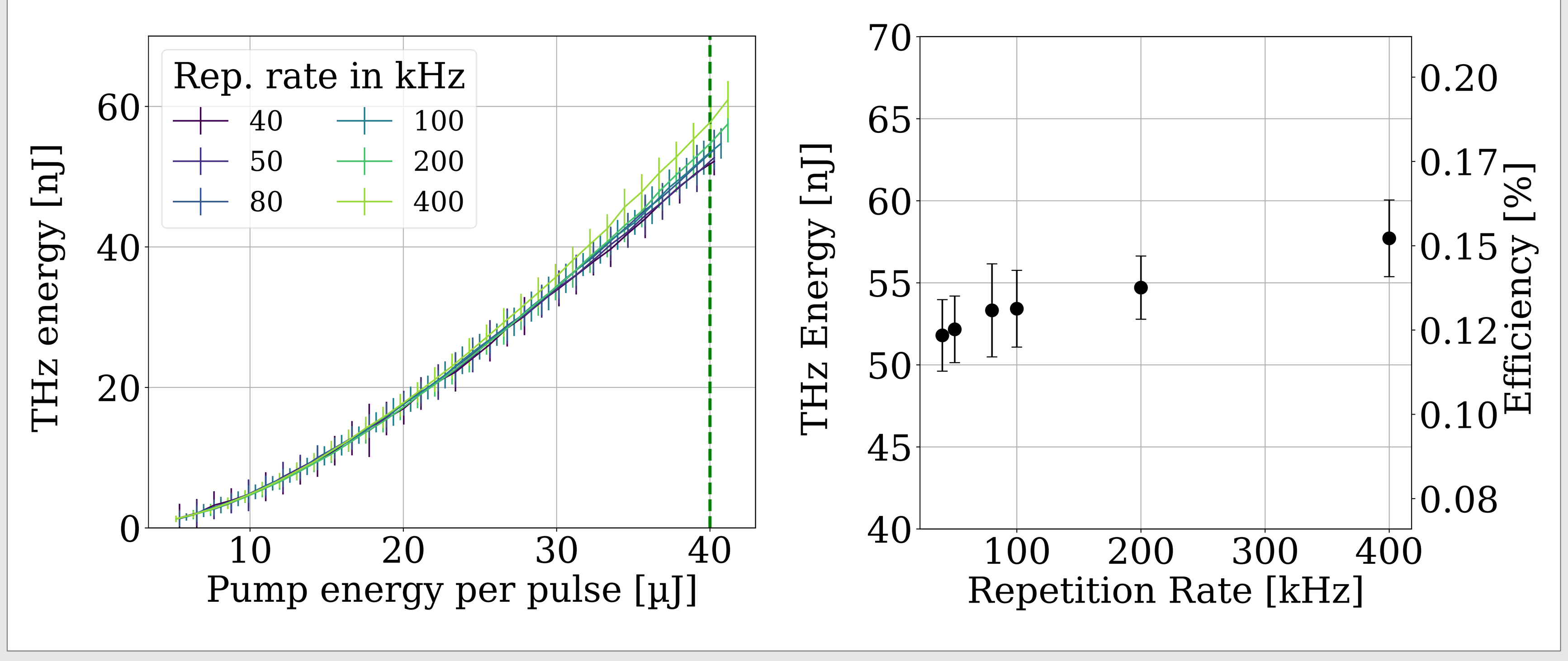


- Commercial laser based set-up without compression stage

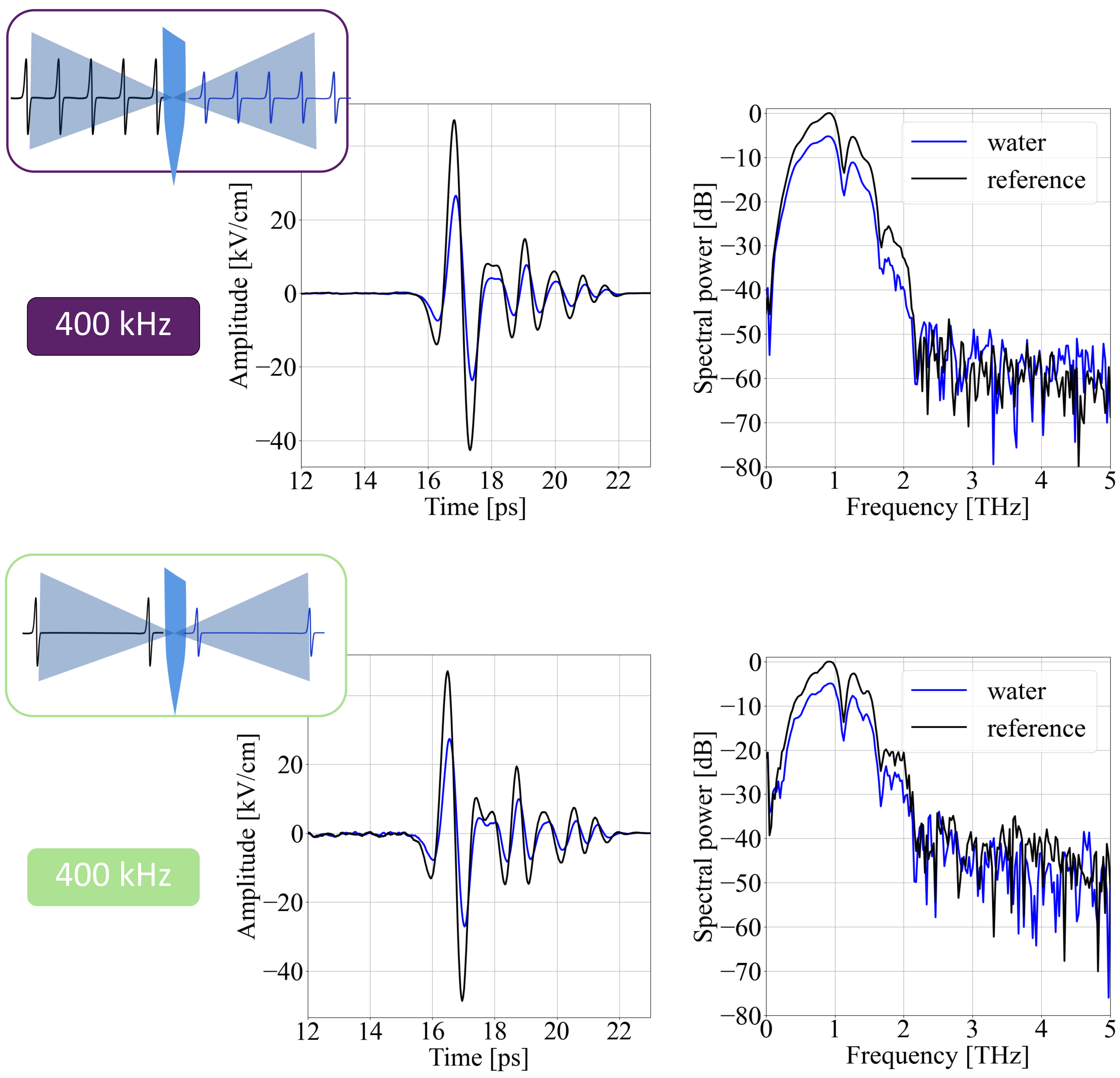
Repetition Rate Dependance

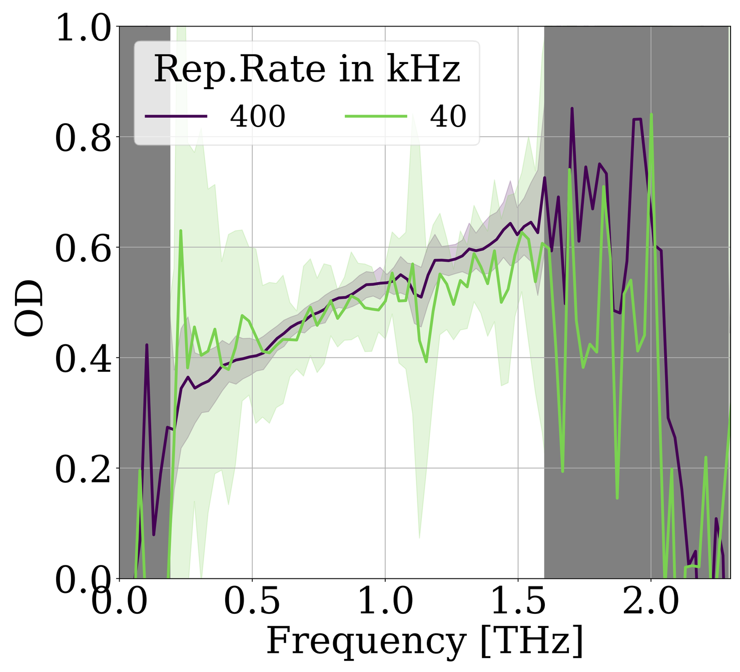


- EOS measurements
  - Transient THz remain u with repetition rate in the time domain
  - Dynamic range ↗ by 10 dB when repetition rate ↗ by a factor of 10.
  - Bandwidth of 2.5 THz centered at 0.8 THz
- Pyroelectric measurements
  - At maximum pump power (40 µJ, 400 kHz), P_{THz} **= 24 mW** which corresponds to an **efficiency of 0.15%.**
  - **THz energy** remains **constant with the repetition rate** (40 kHz to 400 kHz) for a given pump energy of 40 µJ within the measurement accuracy



Water transmission





- Transmission through 20 µm water
- 13 traces averaged within 17 s
- Dynamic range ~ 50 dB
- Optical density (OD) is proportional to the absorption

$$OD = -\log\left[\frac{FFT^2_{water}}{FFT^2_{ref}}\right]$$

Conclusion and outlook

- Enabling high resolution spectroscopy for challenging samples
- High dynamic range
- Cumulative effects negligeable
- E_{THz} = 20 KV/cm - 80 kV/cm
- Non-linear spectroscopy for semiconductors ?

Millon, Opt. Exp., 2023

[1] Novelli, Appl. Sc, 2020 [2] Guiramand, Photon. Res., 2022 [3] Kramer,Opt. Exp., 2020 [4] Nilforoushan,Opt.Exp., 2022 [5] Meyer, Opt. Exp., 2020