OXIDE THIN FILMS

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Collaborators and funding

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VMEC The Virginia Microelectronics Consortium

NRI

SRC Semiconductor Research Corporation

NSF

Polaritons

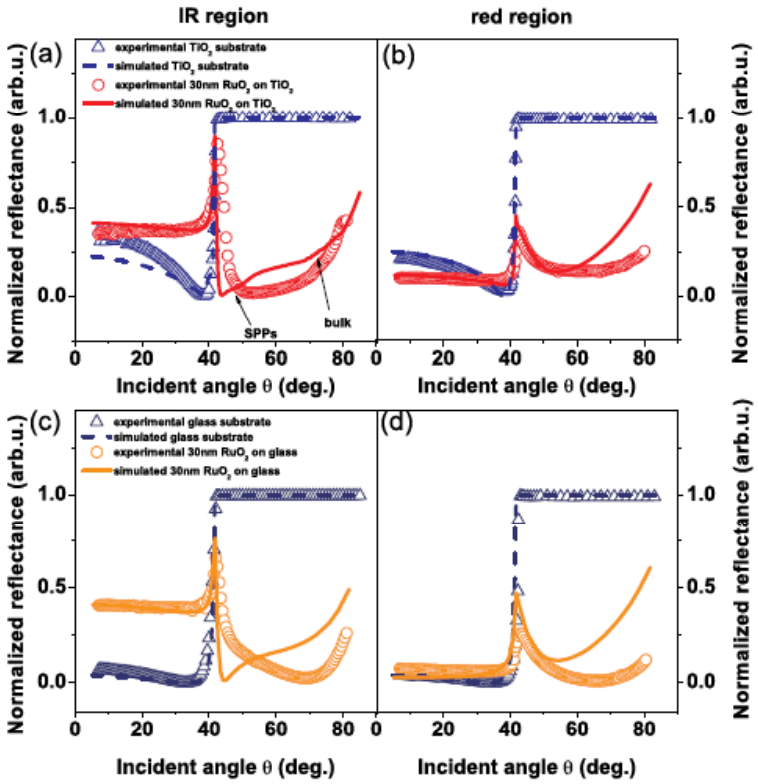
- A **polariton** is the result of the mixing of a photon with an excitation of a material.
- Thus **polaritons** are quasiparticles resulting from strong coupling of electromagnetic waves with an electric or magnetic dipole-carrying excitation.

Oxide thin films

- Studies on simple oxide thin films:
  - surface plasmon polaritons on conducting oxides (e.g. RuO_2)
  - VO_2:
    - ***Metal-Insulator Transition (MIT) in ultra-fast time domain***
    - ***THz radiation studies at the Jlab-FEL***
    - ***Surface plasmon polaritons when in its conducting phase.***

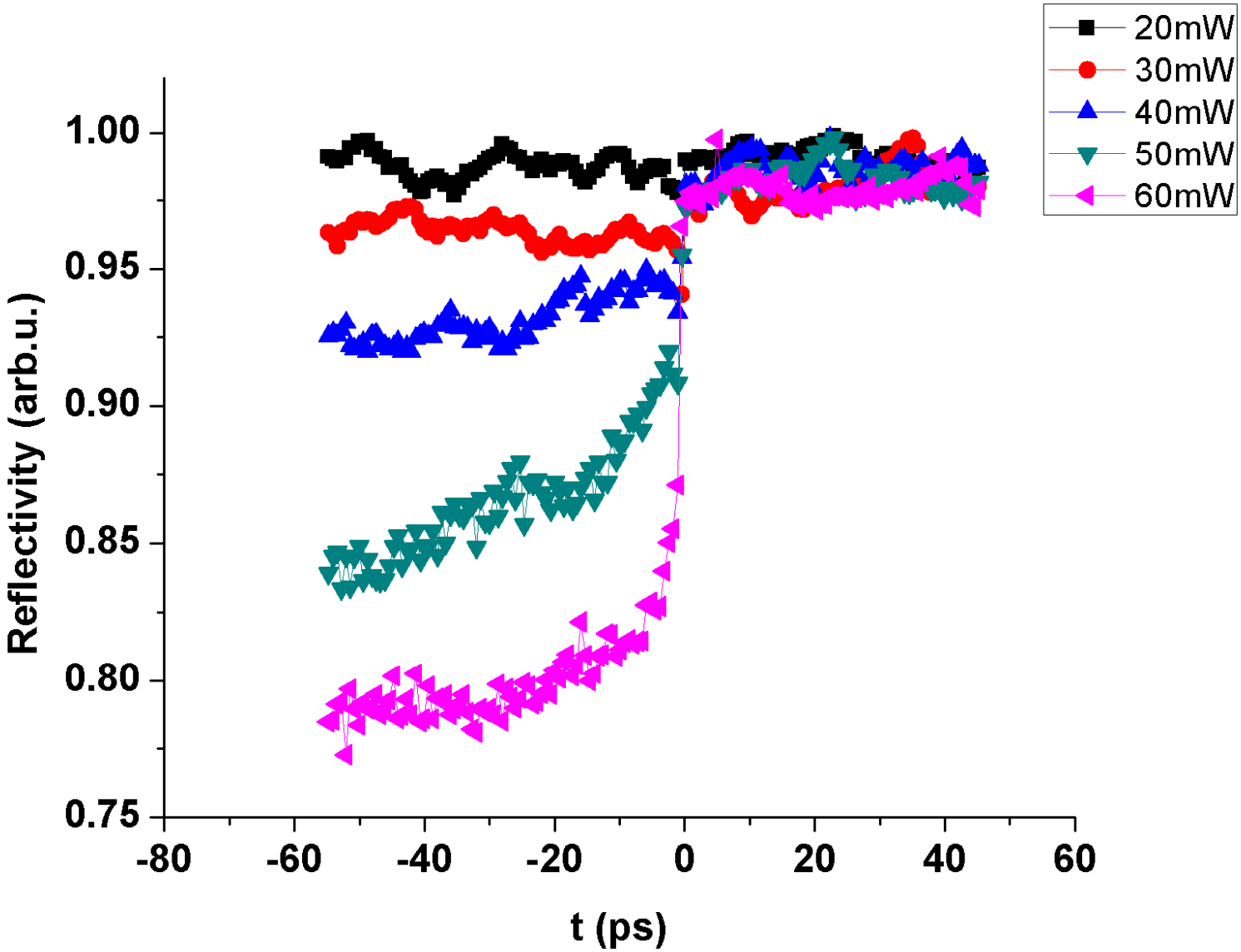
Conducting oxides: RuO_2

- **RuO_2**: alternative to metals for metamaterials and plasmonic applications.
- Bulk and surface plasmon modes can simultaneously exist in the IR region while only the bulk plasmons are supported at higher optical frequencies.
- Radiative polaritons are not observed in conducting oxides.

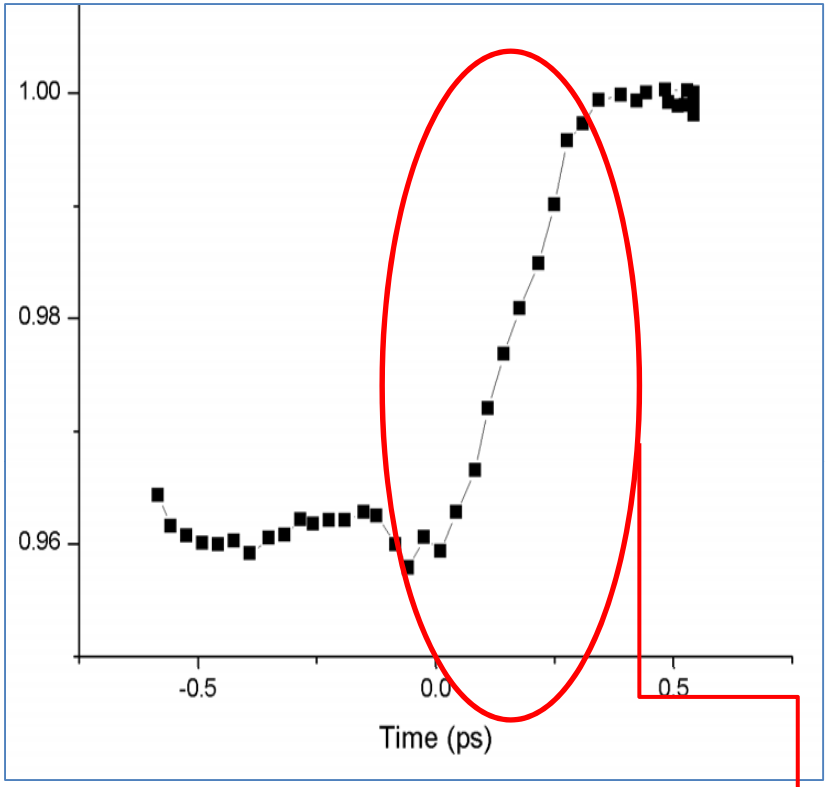


L. Wang, C. Clavero, K. Yang, E. Radue, M. T. Simons, I. Novikova and **R. A. Lukaszew**, "Bulk and surface plasmon polariton excitation in RuO2 for low-loss plasmonic applications in NIR", *Optics Express* **20**, 8618 (2012).

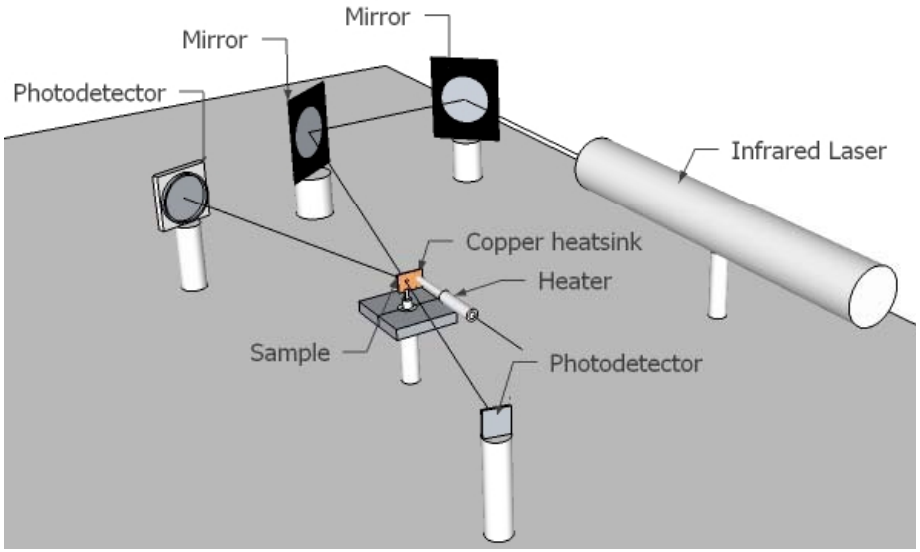
VO_2: Really fast MIT transition…



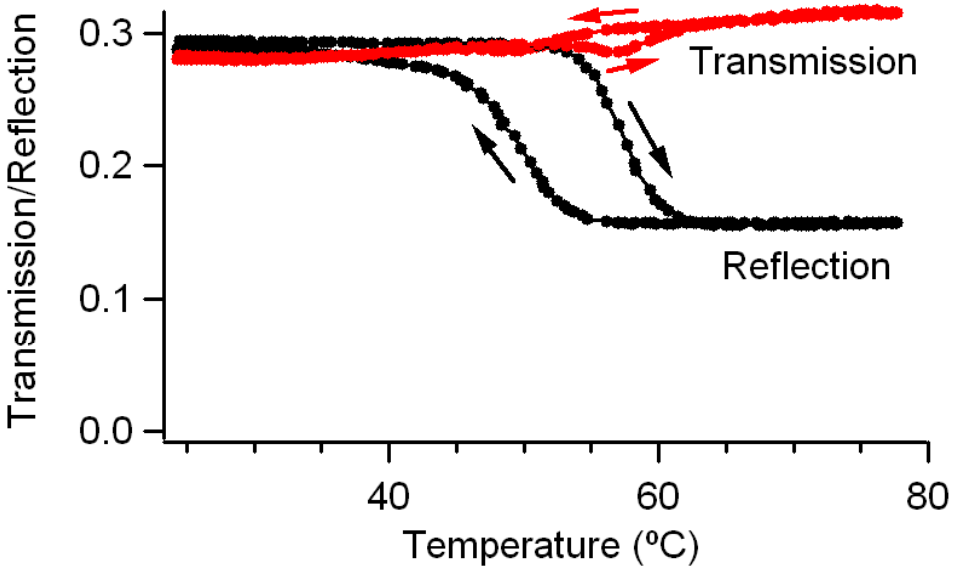
- MIT combines pure Mott Hubbard (very fast) electronic transition with Peierls structural transition.
- We observed SPPs in its conducting phase and have observed radiative polaritons when in the insulating state.



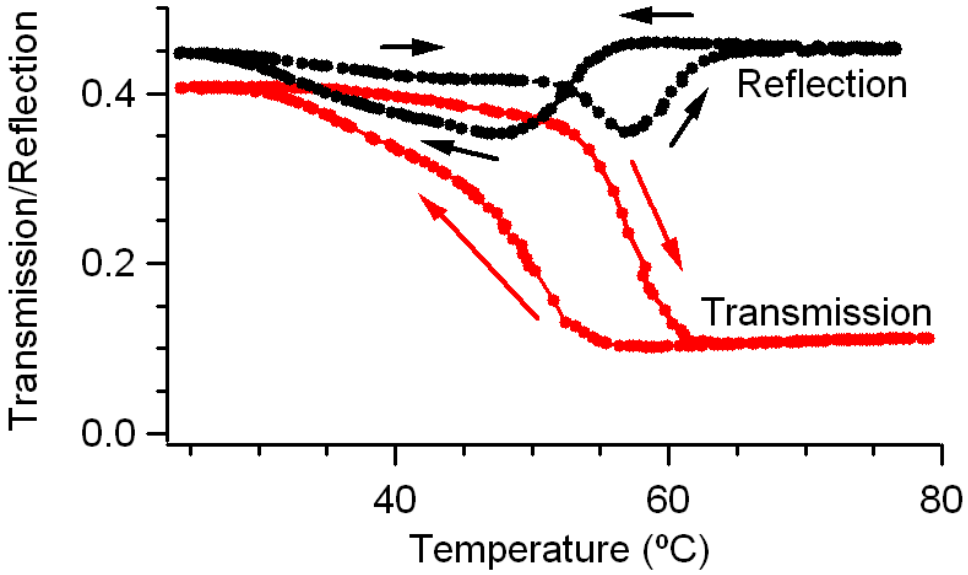
…exhibits hysteresis



800 nm

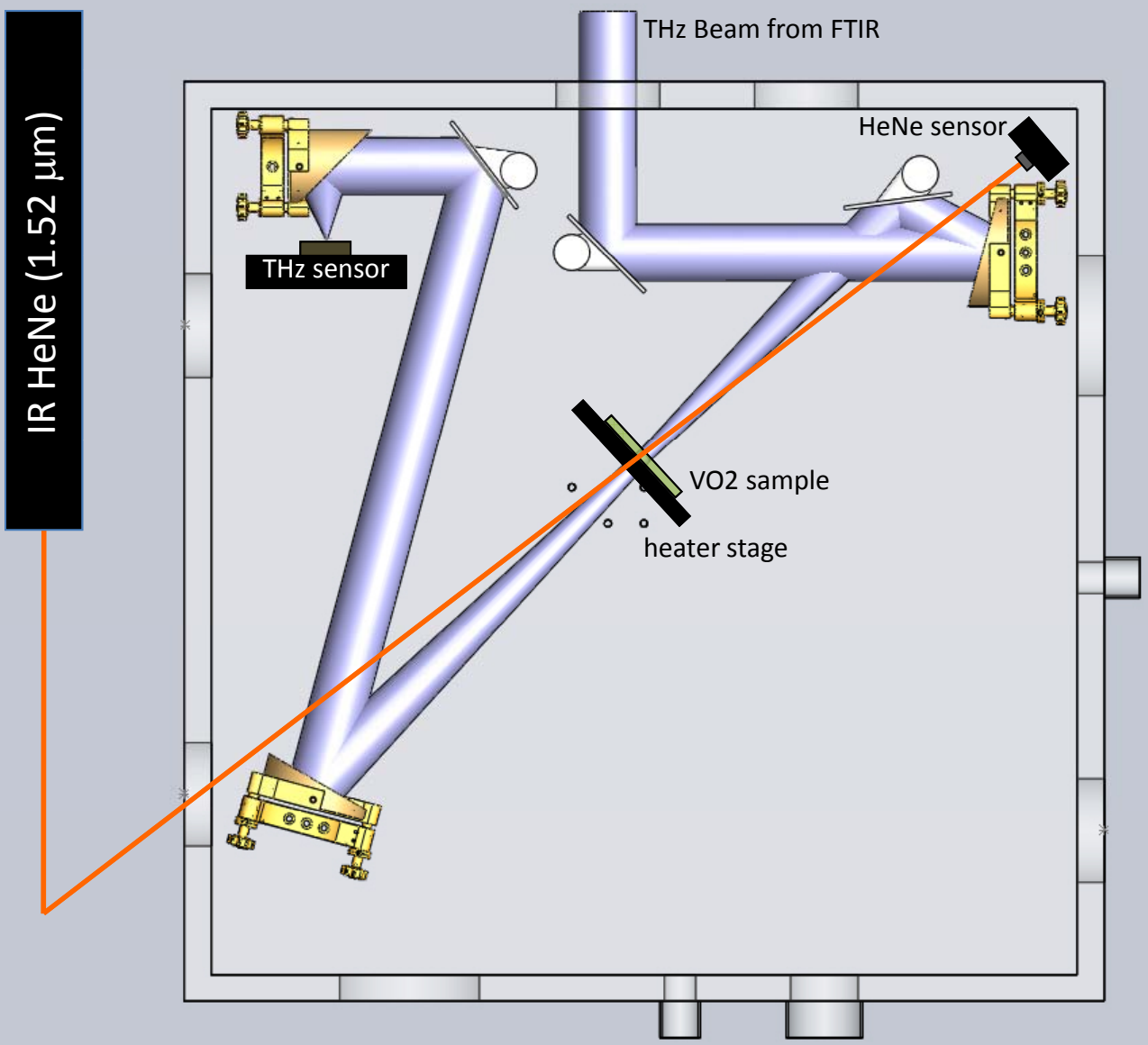


1500 nm

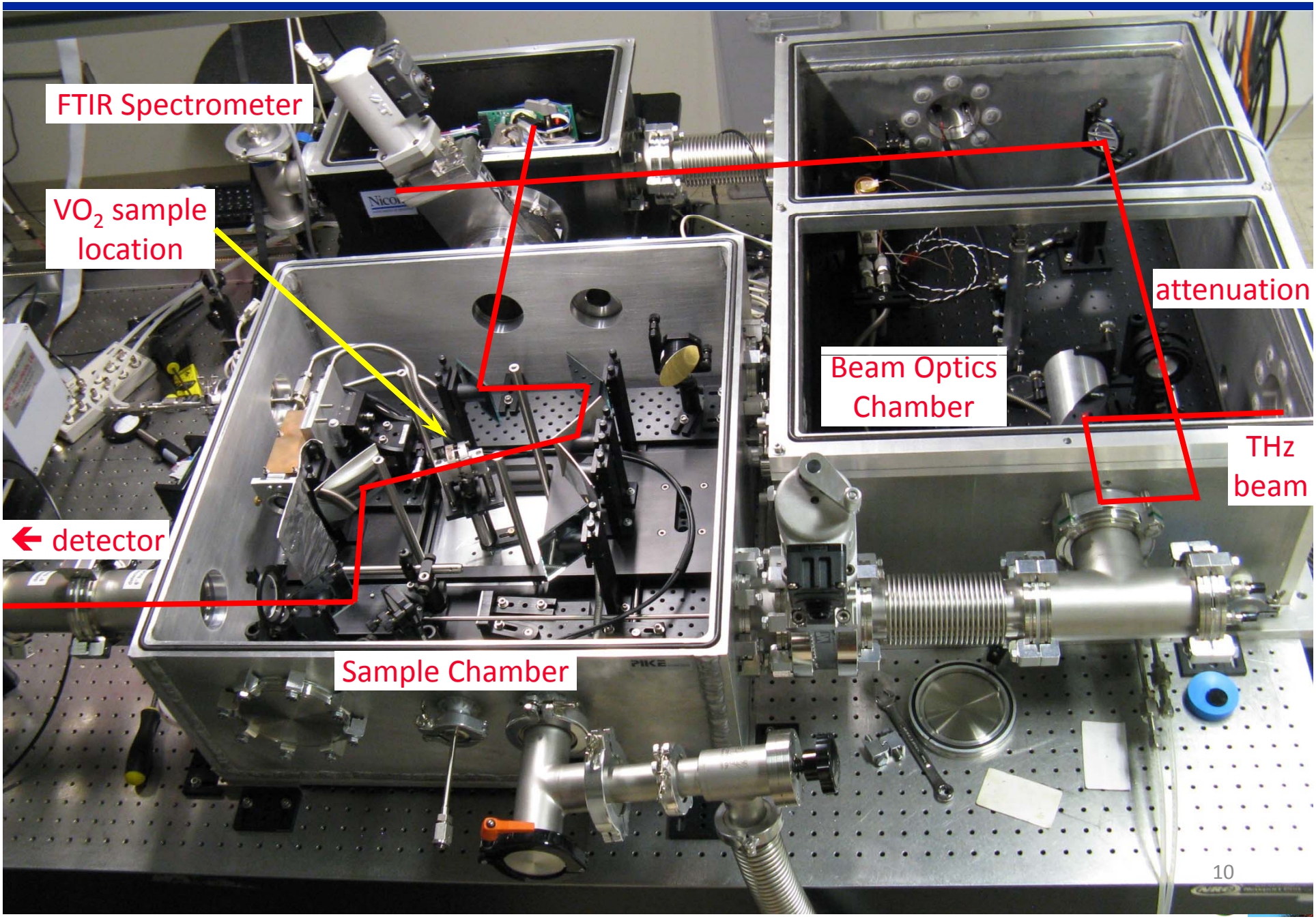


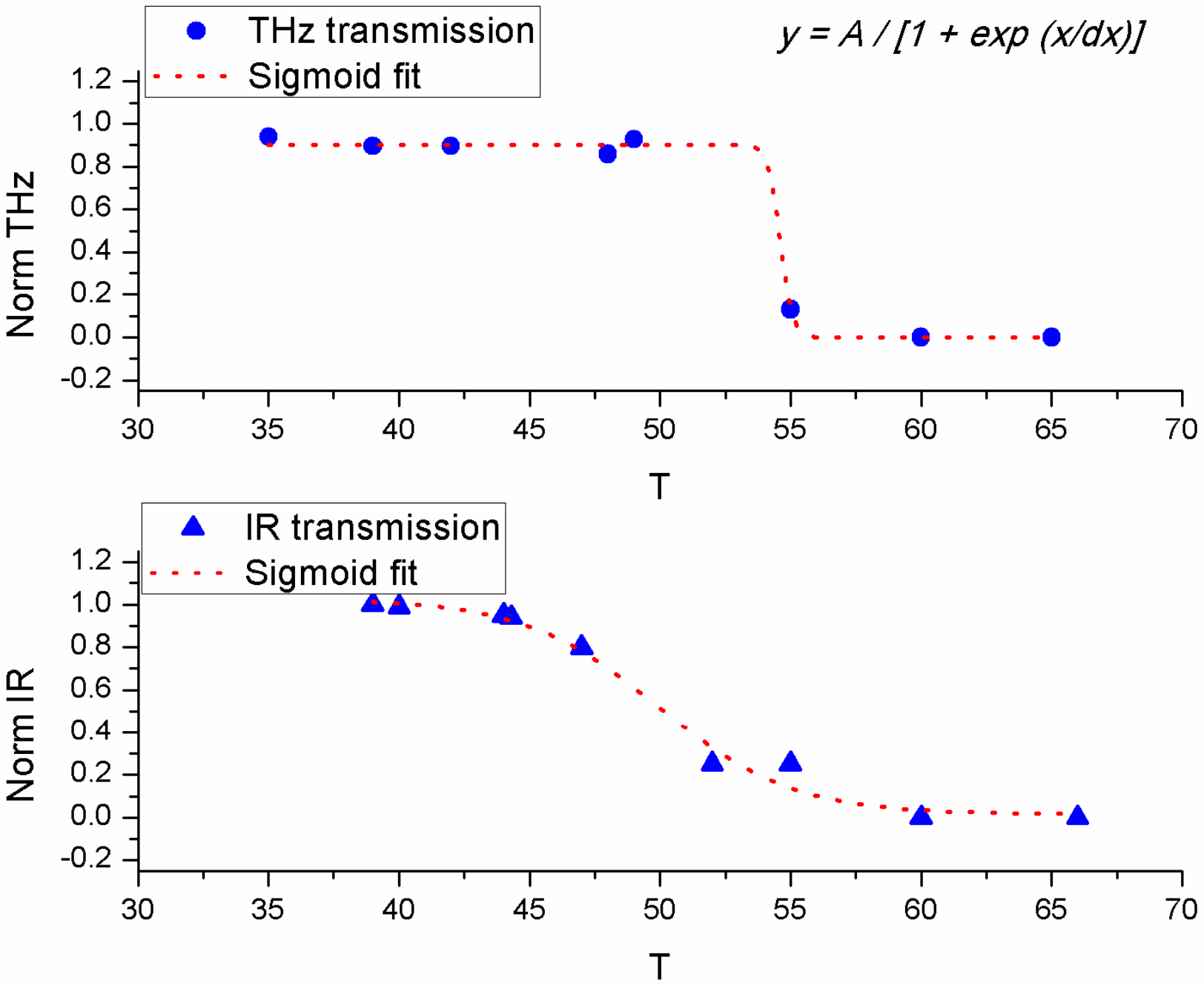
Normalized transmission and reflection from the sample as a function of its temperature for 800nm and 1500nm radiation correspondingly.

Jlab-THz Spectroscopy Vacuum System



Jlab: THz Spectroscopy Vacuum System




THz transmission
Sigmoid fit
y = A / [1 + exp (x/dx)]
Norm THz
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
30
35
40
45
50
55
60
65
70
T
IR transmission
Sigmoid fit
Norm IR
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
30
35
40
45
50
55
60
65
70
T

Results and future plans

- We have observed that the IR probe spans a broader T-range across the transition than the THz probe.
- We have also observed pump-power MIT dependence. We will continue in-house pump-probe experiments at low T to clarify this.
- We propose to continue VO_2 investigations by looking at time-resolved IR pump-THz probe FEL based experiments.
- We will look at the time-evolution of radiative polariton across the MIT.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