

# Improving Perovskite Solar Cell Efficiency by Studying the Transport Layers with Ultrafast Lasers

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## Importance

### Why clean electricity?

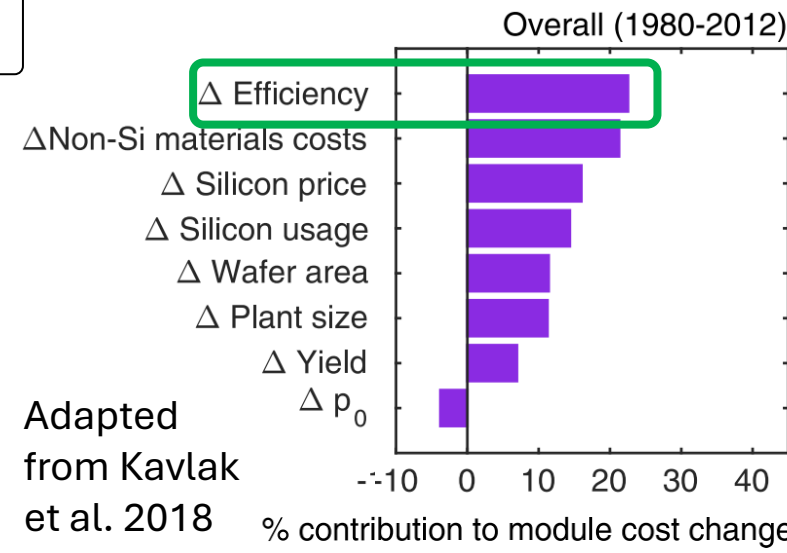
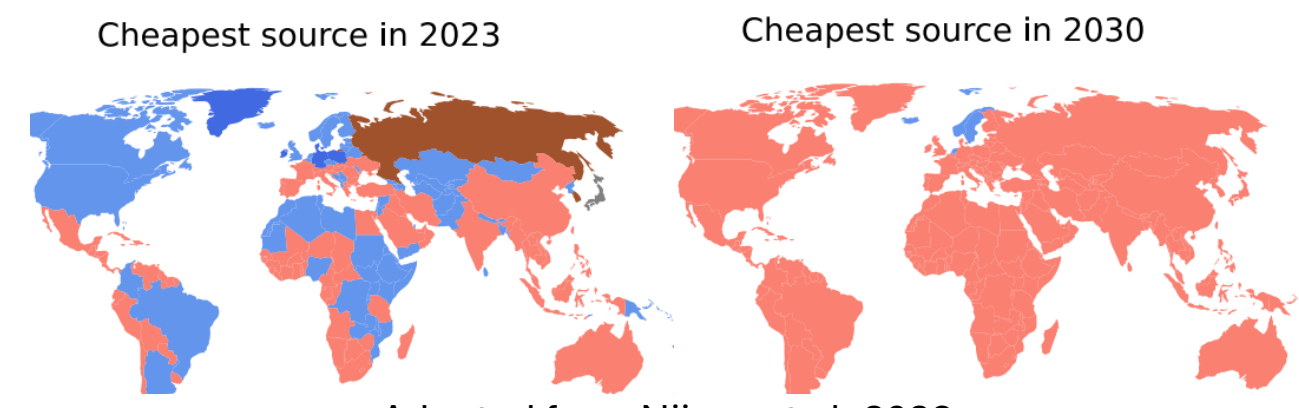
- Energy security
- Climate change
- Air pollution

### Why Solar?

- Cheapest

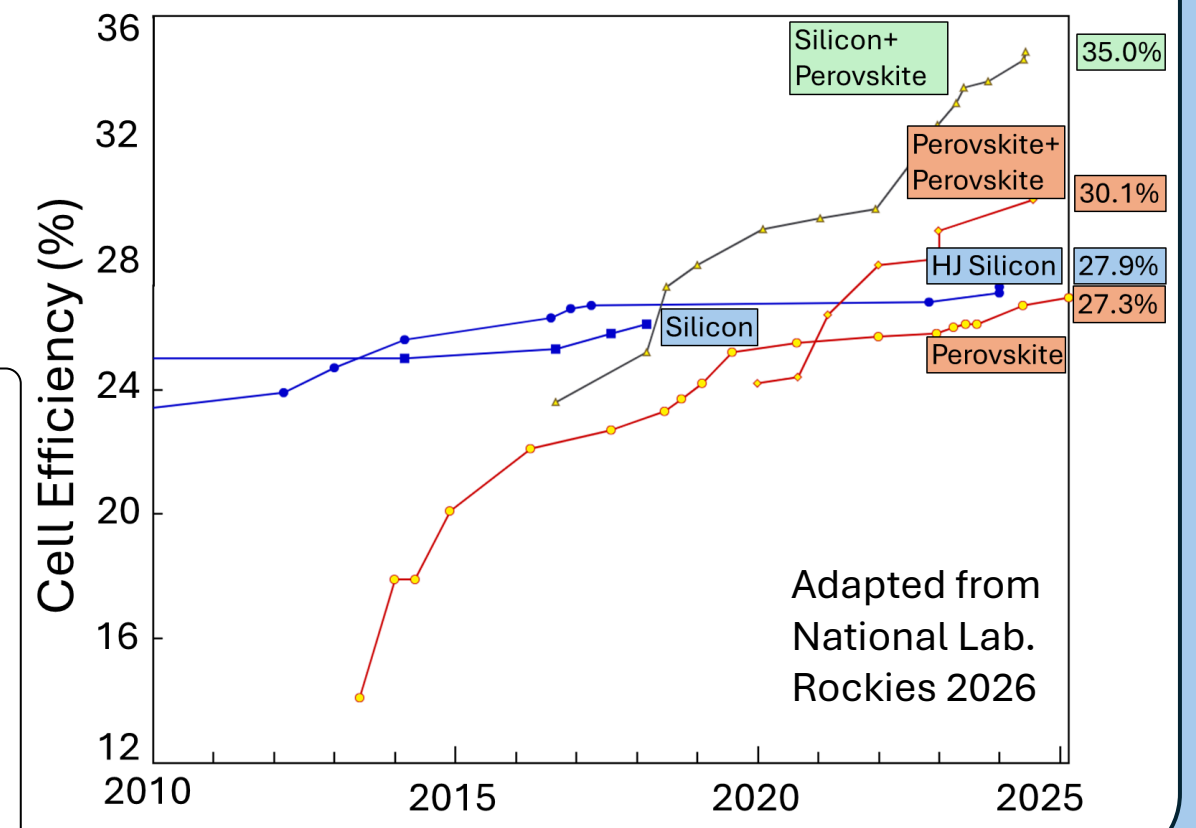
### Why improve efficiency?

- Makes electricity cheaper
- Particularly urban and cloudy



### Why perovskite?

- Silicon efficiency limited
- Silicon + Perov boosts efficiency 50%
- More locations



## Problem:

In "Perovskite" solar cells, the efficiency is limited by the **Transport Layers (TL)**

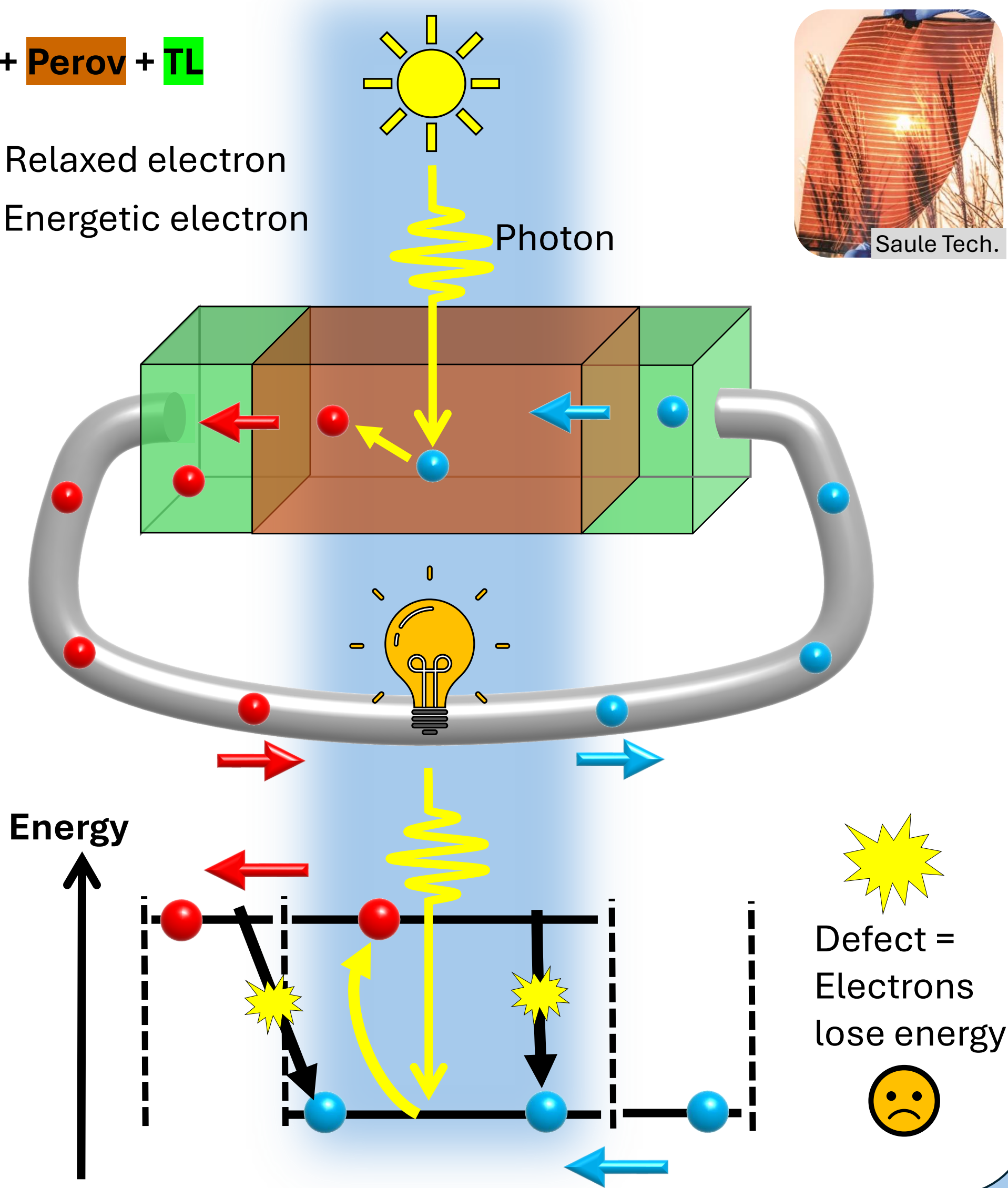
## Solution:

- 1<sup>st</sup> → Understand why by using ultrafast laser spectroscopy
- 2<sup>nd</sup> → Improve the **TLs**

## "Perovskite" Solar Cell

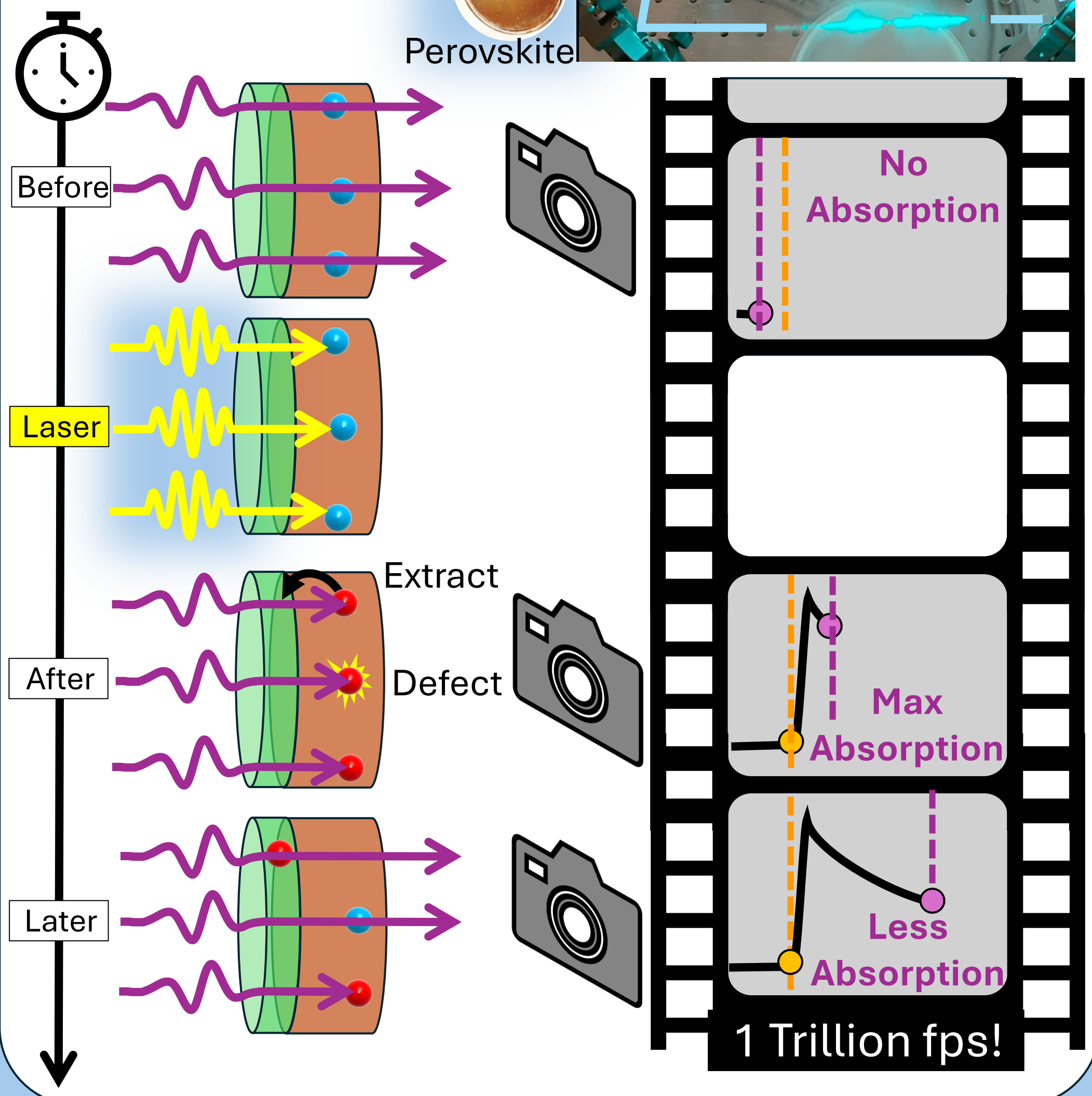
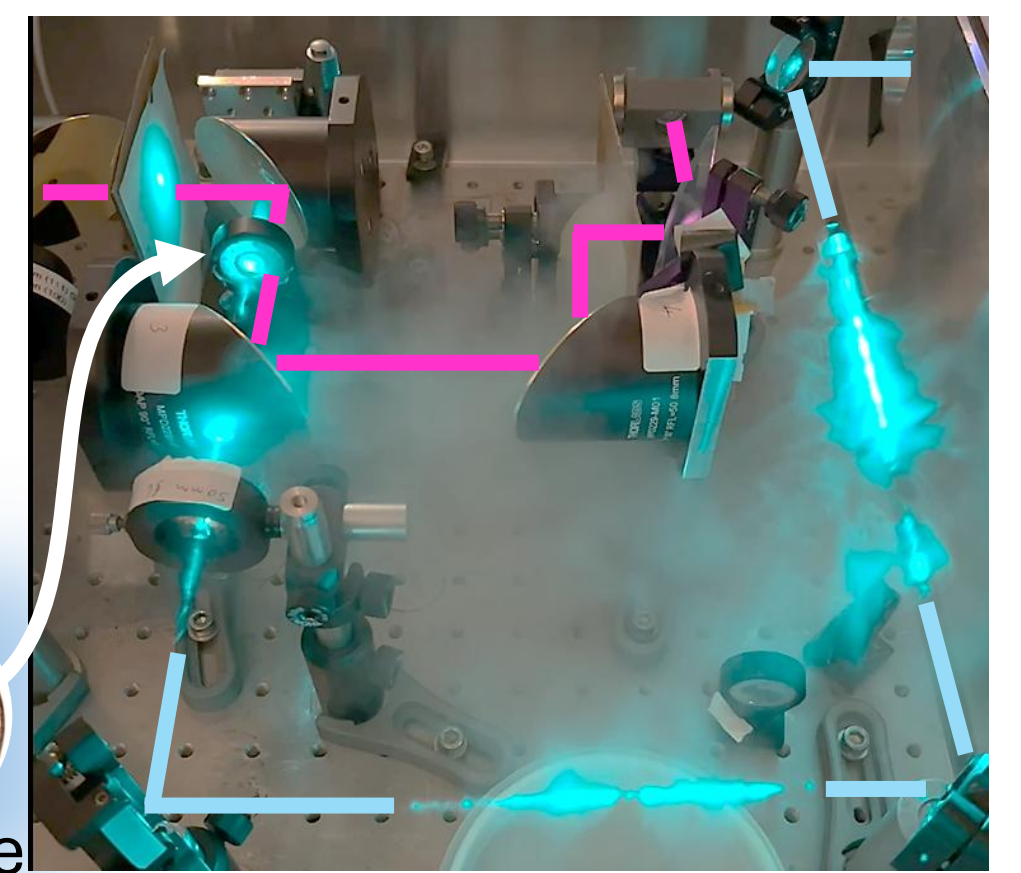
**TL + Perov + TL**

- Relaxed electron
- Energetic electron

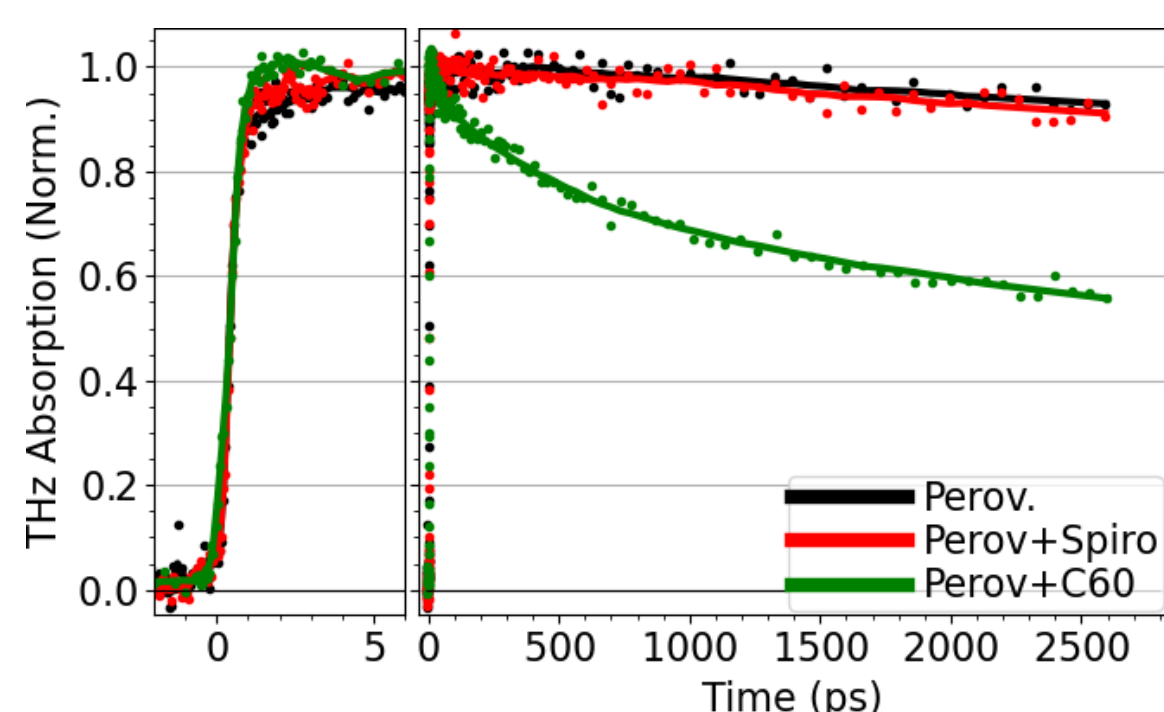


## OPTP = Optical Pump, Terahertz Probe

- **Laser pulse** absorbed by ONLY the **relaxed** electrons, gives them energy
- **Terahertz pulse** absorbed by ONLY the **energetic** electrons
- Count **energetic** electrons @ 1 Trillion fps!



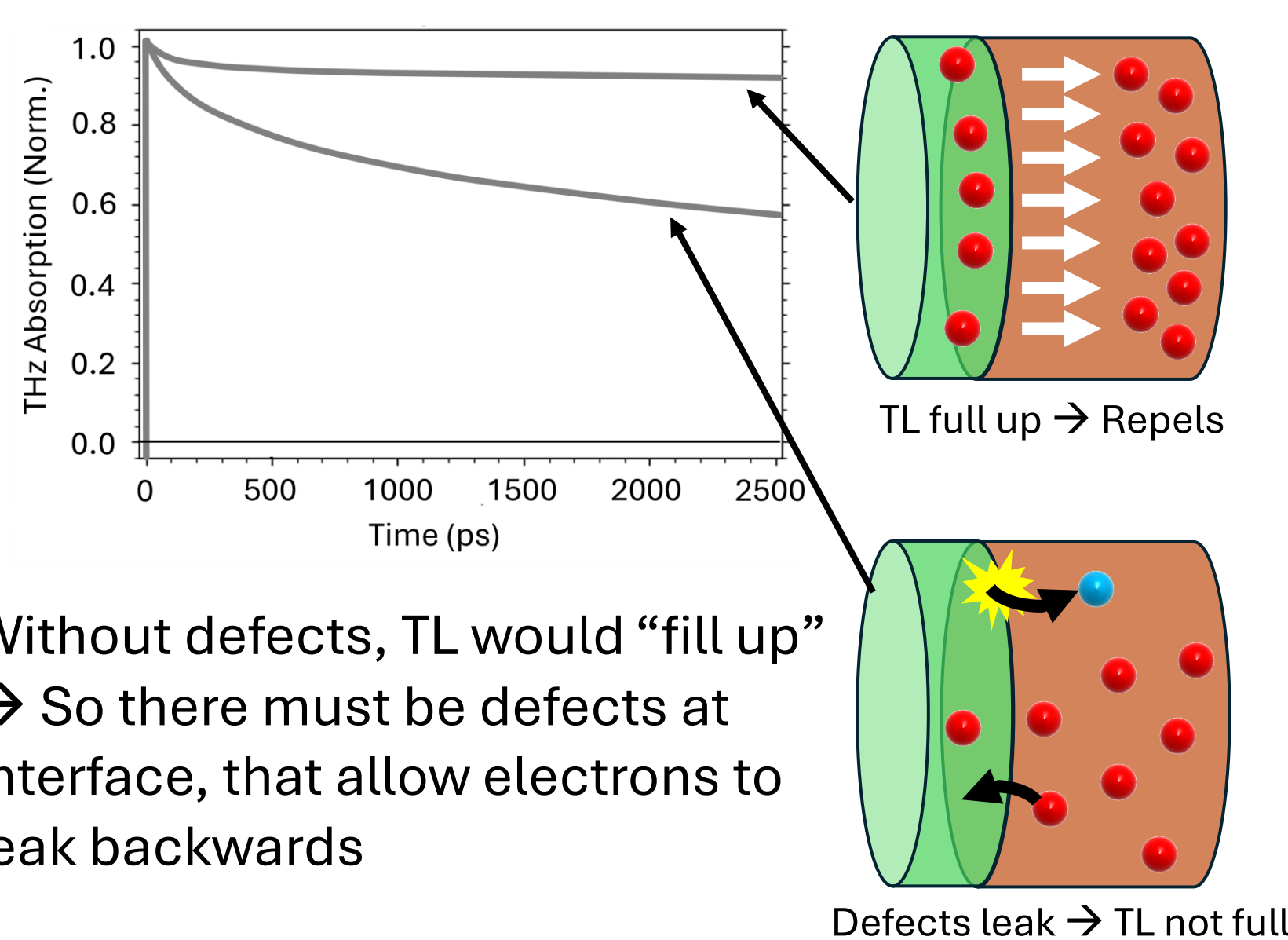
## Results



- **Spiro** has slow extraction
- **C60** has fast extraction

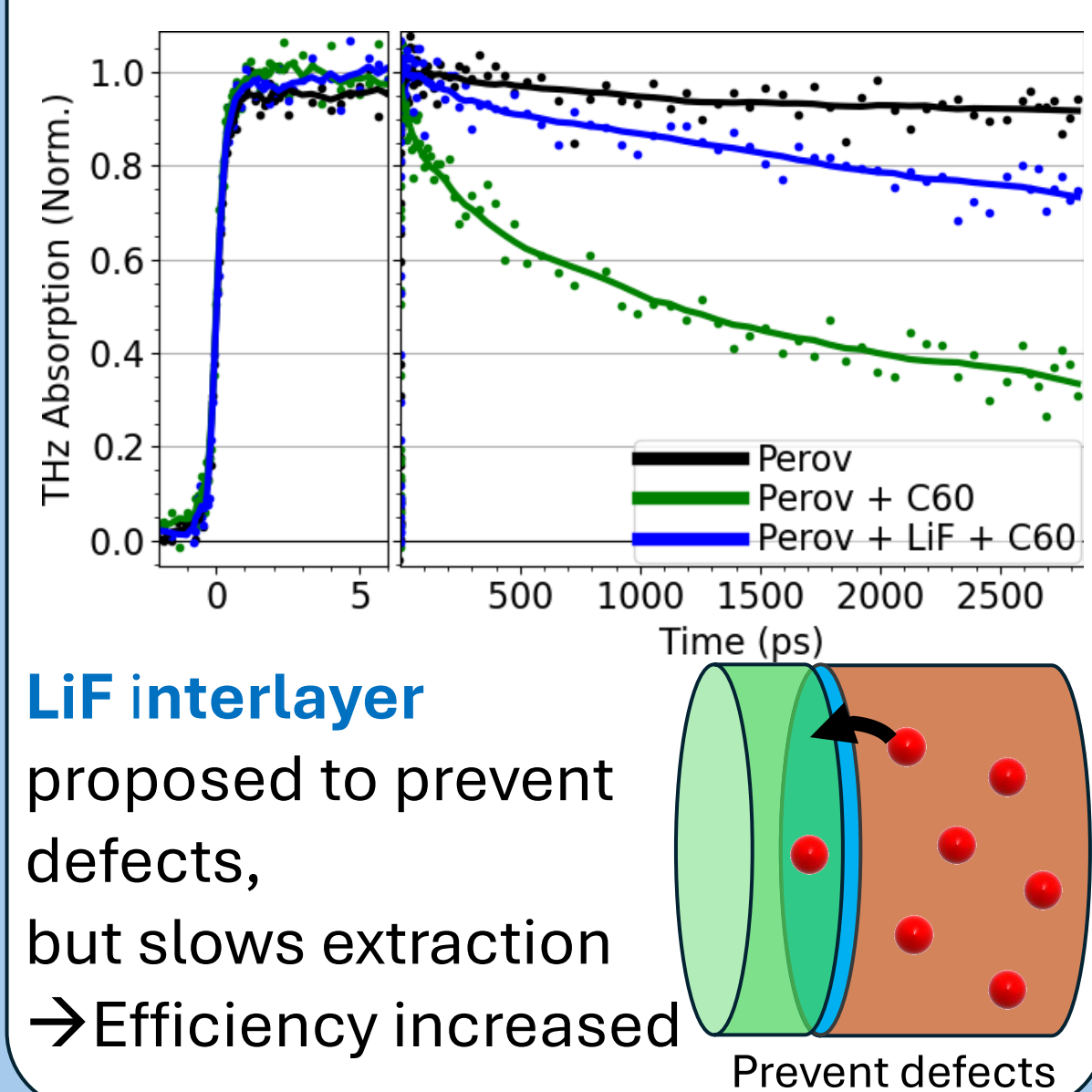
Butler-Caddle et al. 2024 Phys. Rev. App.

## Simulation → Understanding



Without defects, TL would "fill up"  
→ So there must be defects at interface, that allow electrons to leak backwards

## Improvements



### LiF interlayer

proposed to prevent defects, but slows extraction  
→ Efficiency increased

