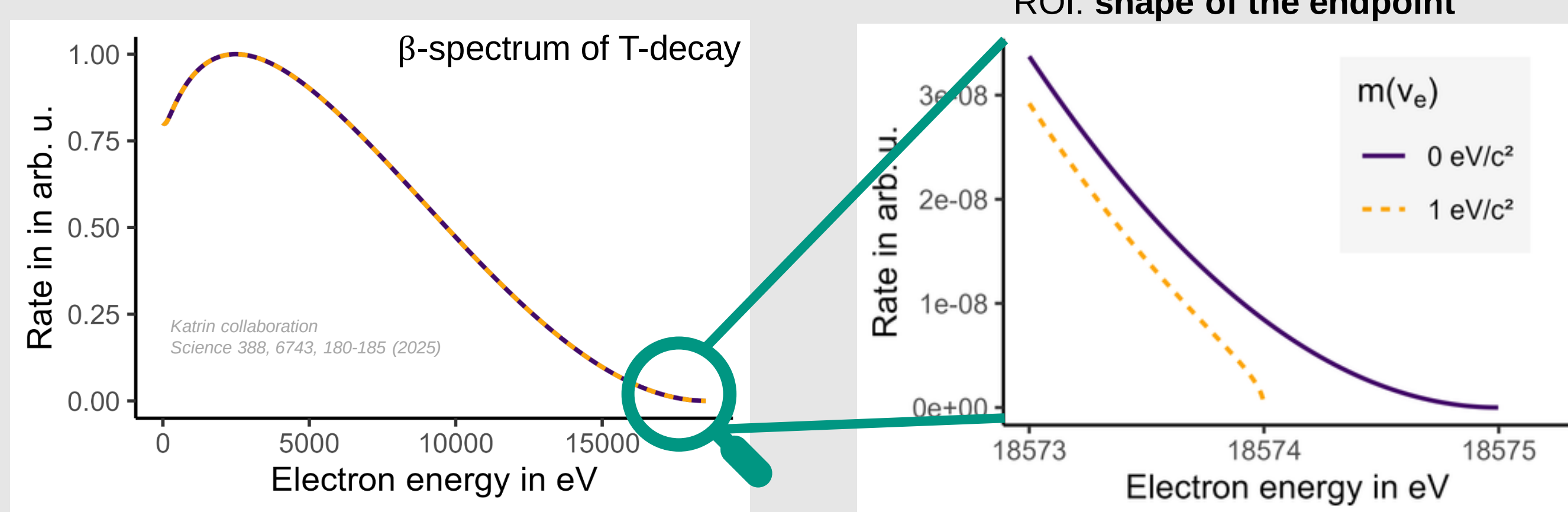


Developing an atomic tritium source for KATRIN++

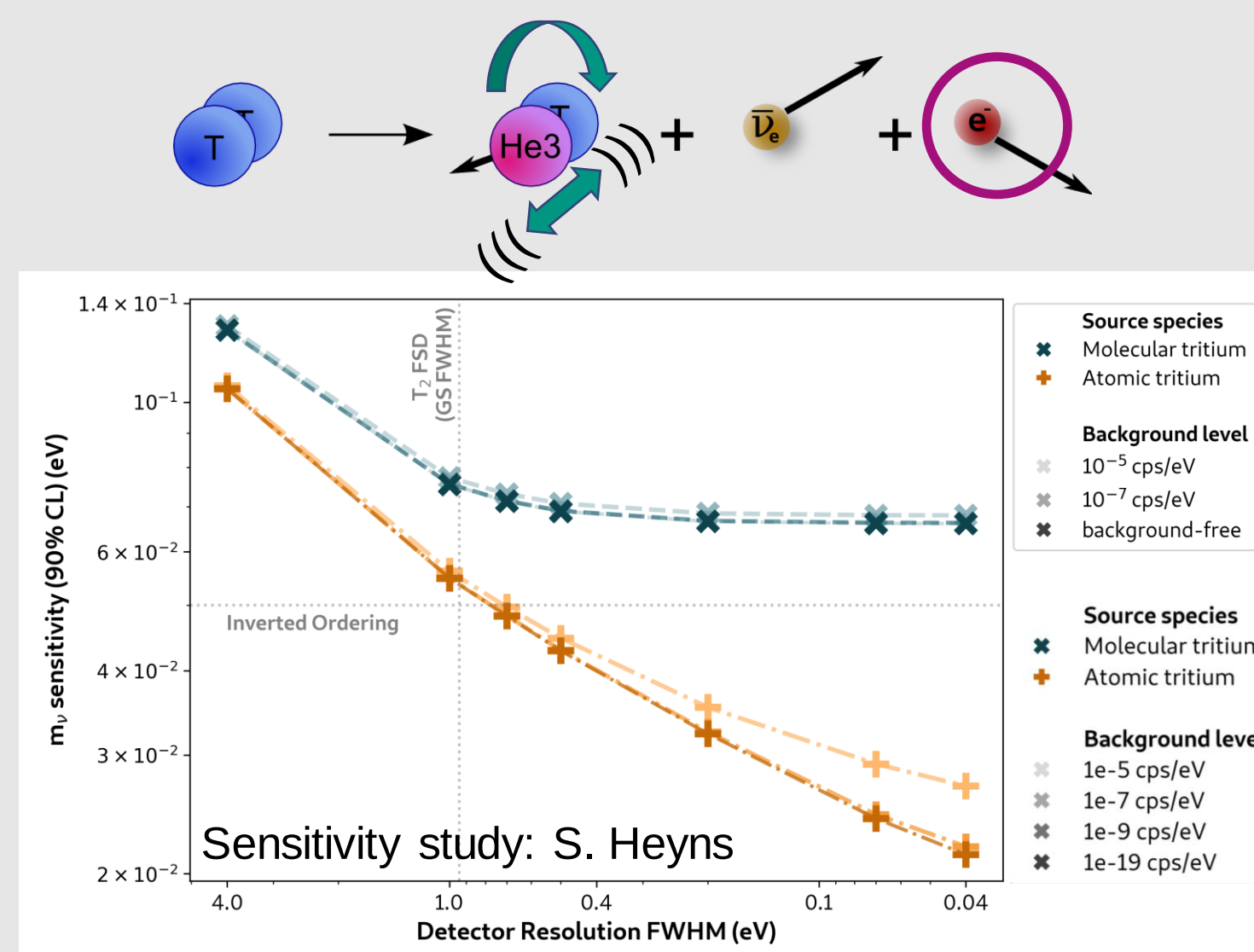
David Frese, Beate Bornschein, Tobias Geier, Robin Gröble, Linus Hartmann, Leonard Hasselmann, David Hillesheimer, Marcus Lai, Alexander Marsteller, Florian Priester, Marco Röllig, Caroline Rodenbeck, Magnus Schlösser, Michael Sturm, Daniel de Vincenz, Gökem Yavuz, Genrich Zeller

Neutrino Mass Experiments with Tritium

- Neutrino oscillations prove that neutrinos have mass
- Karlsruhe Tritium Neutrino (**KATRIN**) Experiment measures the mass of the electron antineutrino
- Current upper limit: **0.45 eV (90% C.L.)**

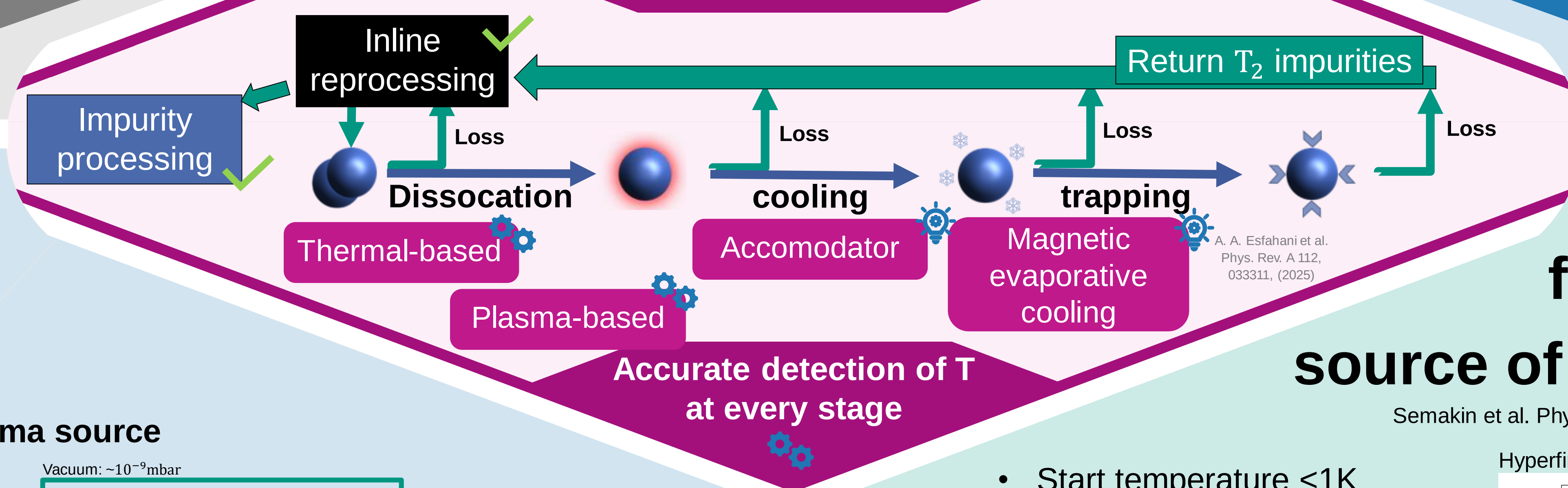


- Next generation experiments aim for $\sim 10 \times$ **improvement** on the neutrino mass sensitivity
- Transitioning to atomic tritium T**
 - No energy broadening of 0.4 eV from ro-vibrational final states
 - Higher statistics
 - Magnetic trapping possible



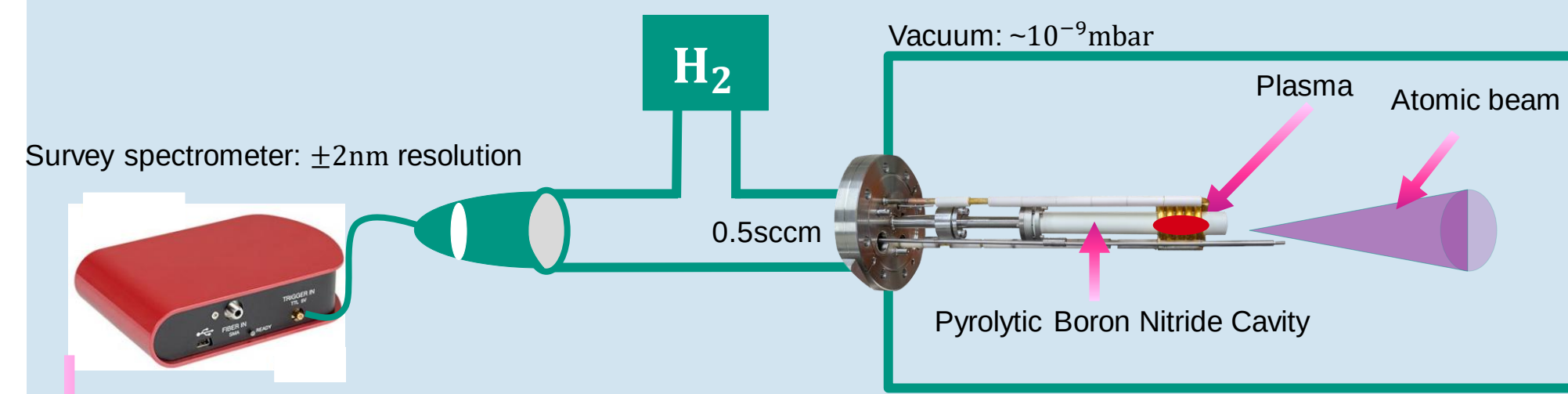
Future neutrino mass experiments need a sub-kelvin atomic tritium source

Atomic Tritium Source

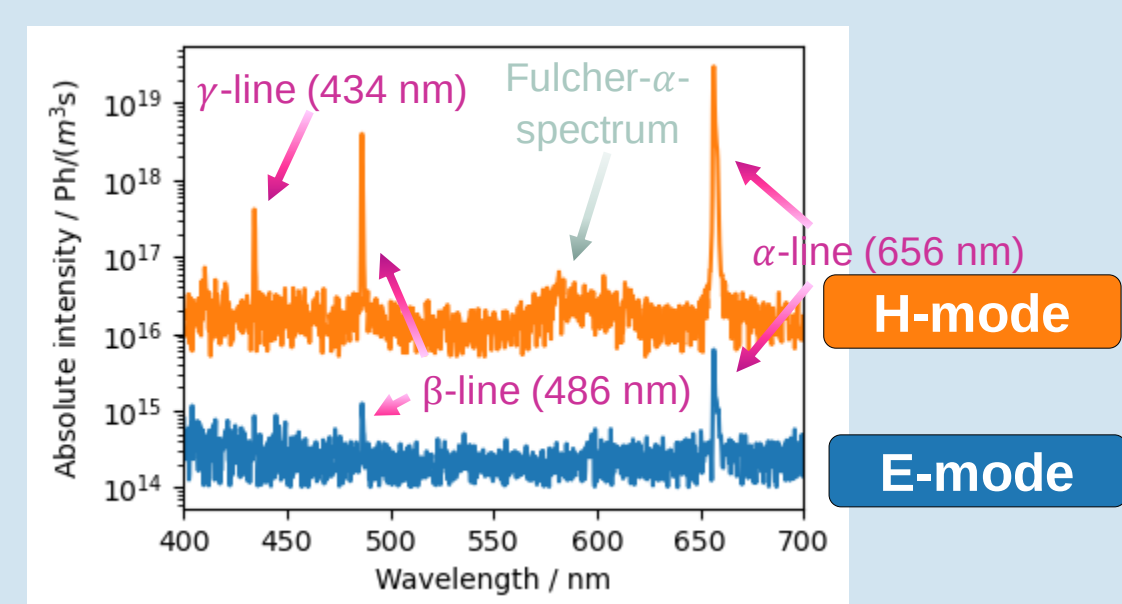


Production of H atoms via plasma

Inductively Coupled Plasma source

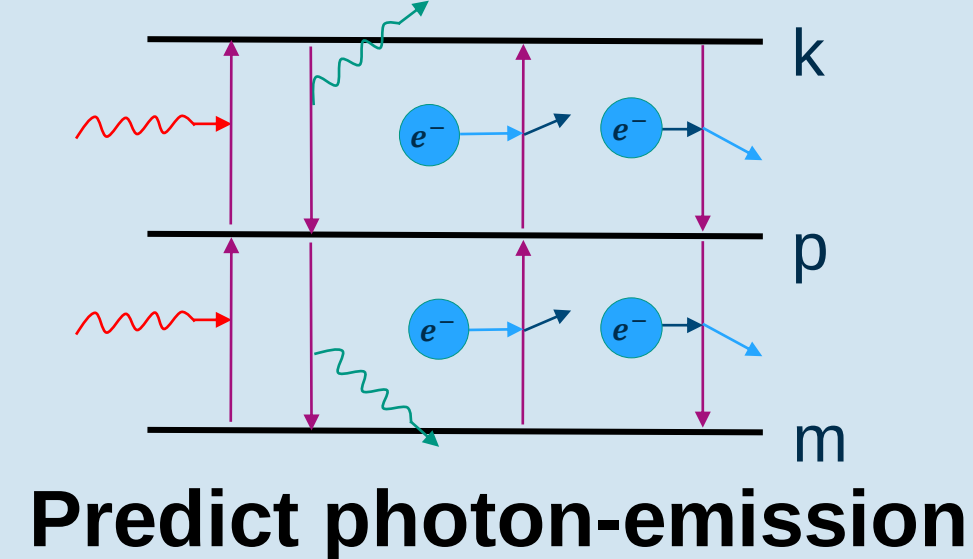


Optical Emission Spectroscopy

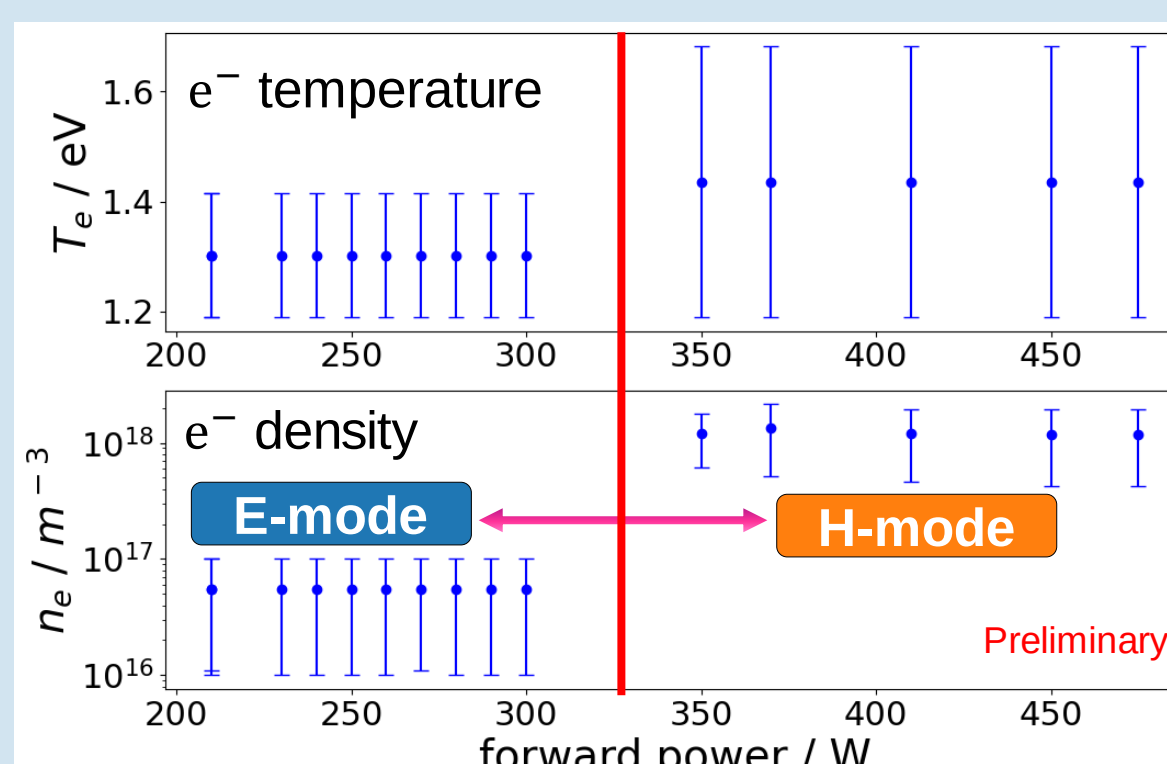


Collisional Radiative (CR) modeling

D. Wunderlich, M. Giacomini, R. Ritz and U. Fantz, J. Quant. Spectrosc. Radiat. Transfer 240, 2020, 106695



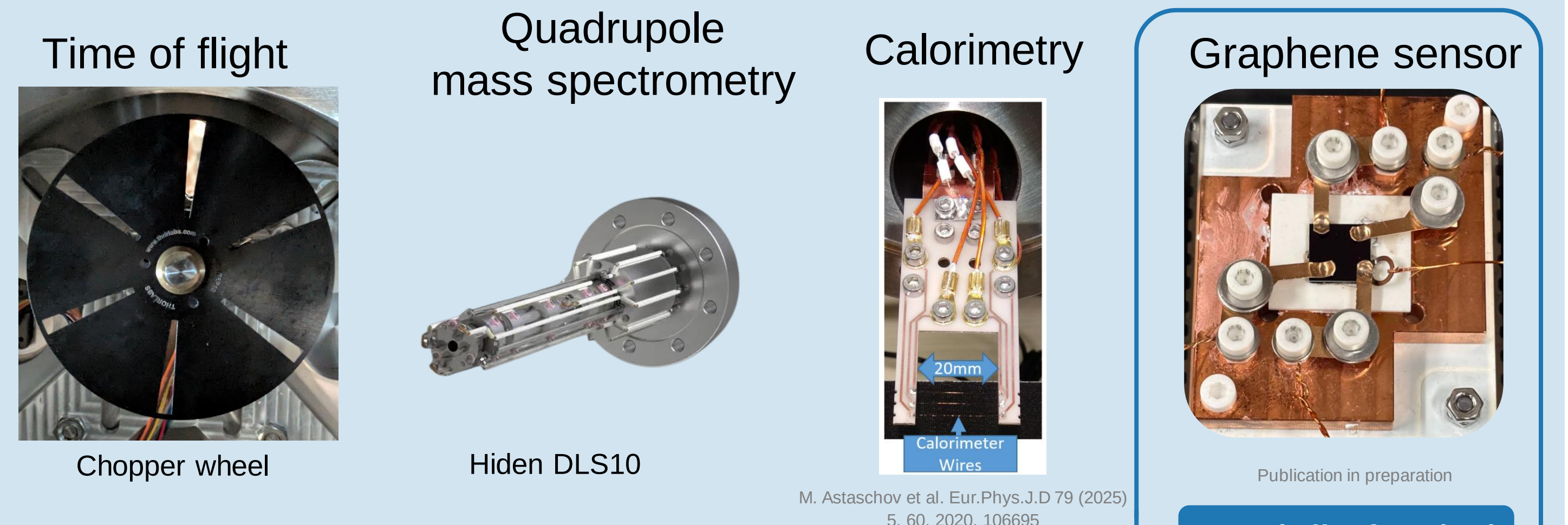
Determination of plasma parameters



- E-mode: α - and β -line
- H-mode: α -, β - and γ -line
- Considering direct excitation only
- Step in n_e in the mode transition
- Preliminary atomic fraction of $>90\%$ in H mode

Goal: development of CR models for T and T₂

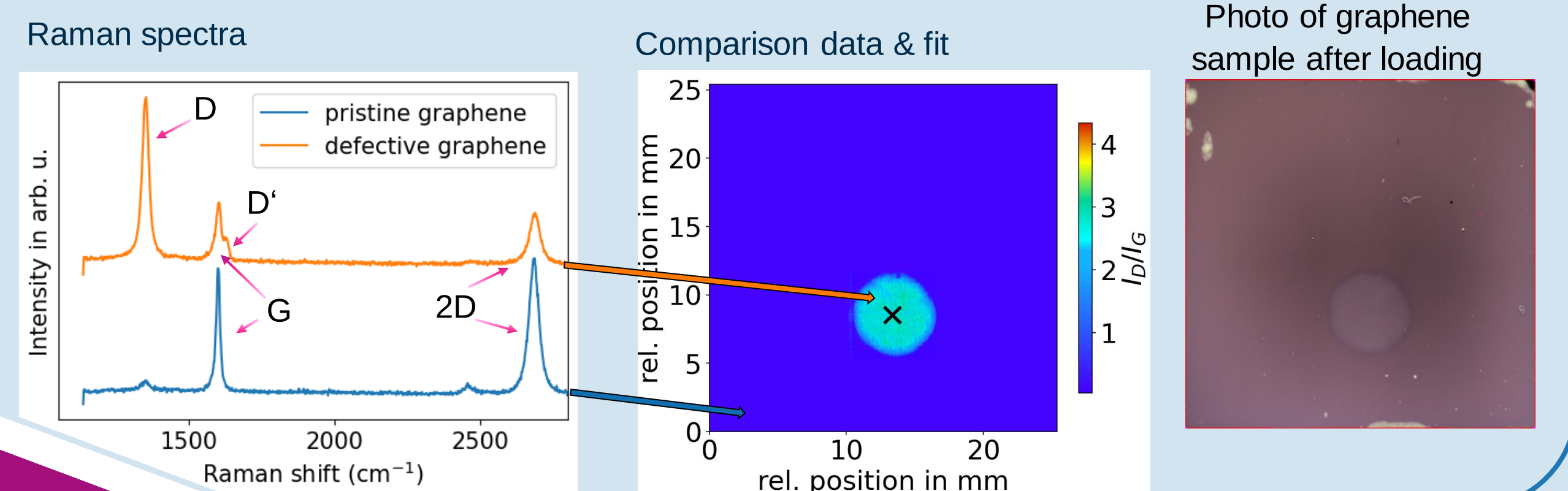
Detection of hot H/D/T



- Selective to H $\rightarrow$ sp³-hybridisation
- In-situ: Sheet resistance measurement
- Ex-situ: Raman spectroscopy

Beam profile determination with Raman spectroscopy

- I_D/I_G intensity ratio indicates defect density L_D
- Exposure for 67 h
- Fit generalized normal beam profile:



Hydrogenation of graphene as a novel atomic beam sensor

Proposal for a cryogenic source of atomic tritium

Semakin et al. Physical Review Research, 8, 033096 (2026)

- Start temperature <1 K
- Freeze T₂ on the walls
- Dissociation:**
 - Self-radiolysis
 - Helium plasma
- Magnetic guiding:**
 - Low field seekers (lfs)
 - Ioffe-Pritchard type magnets
- Cooling:**
 - He-buffer gas

