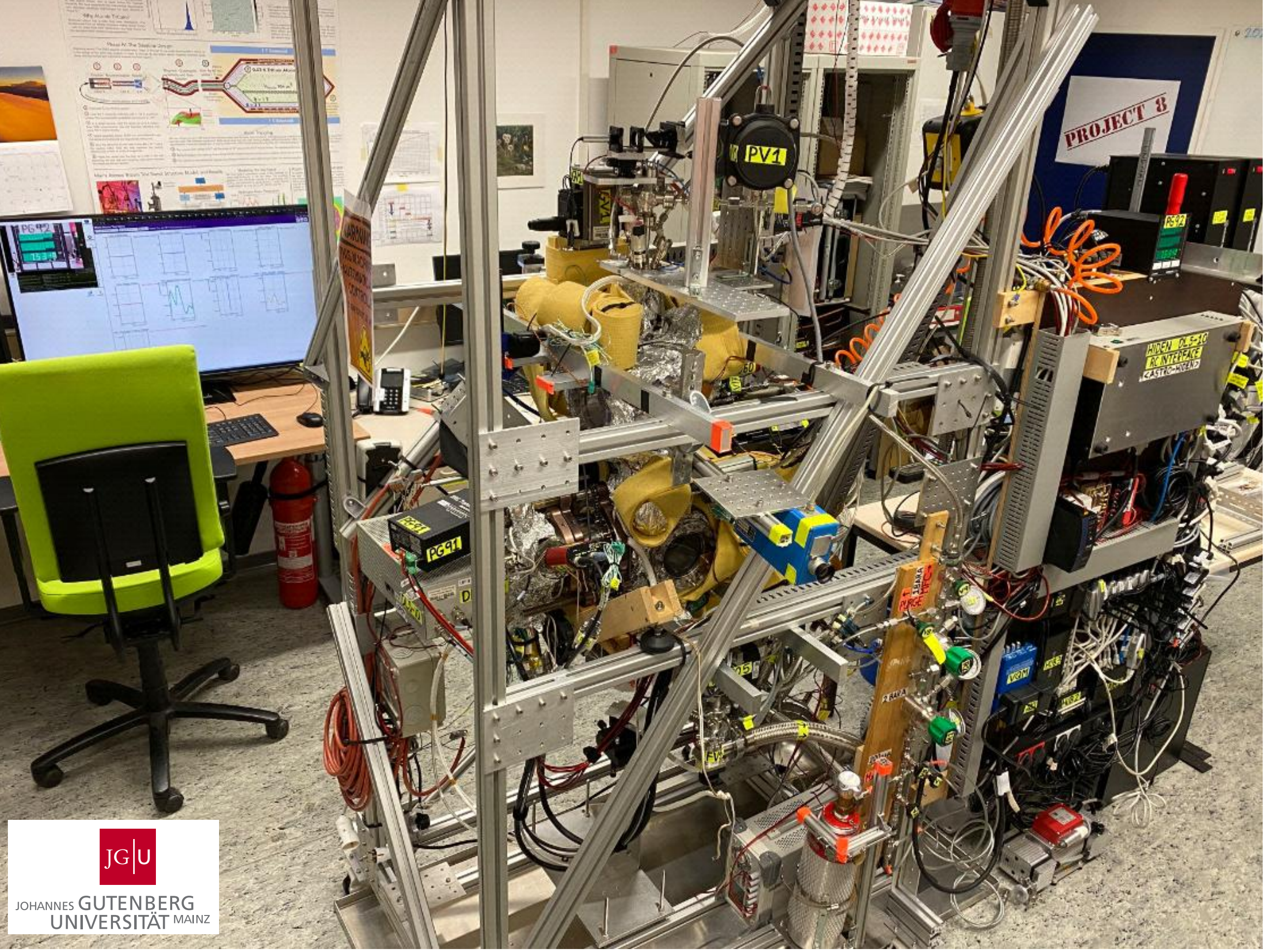
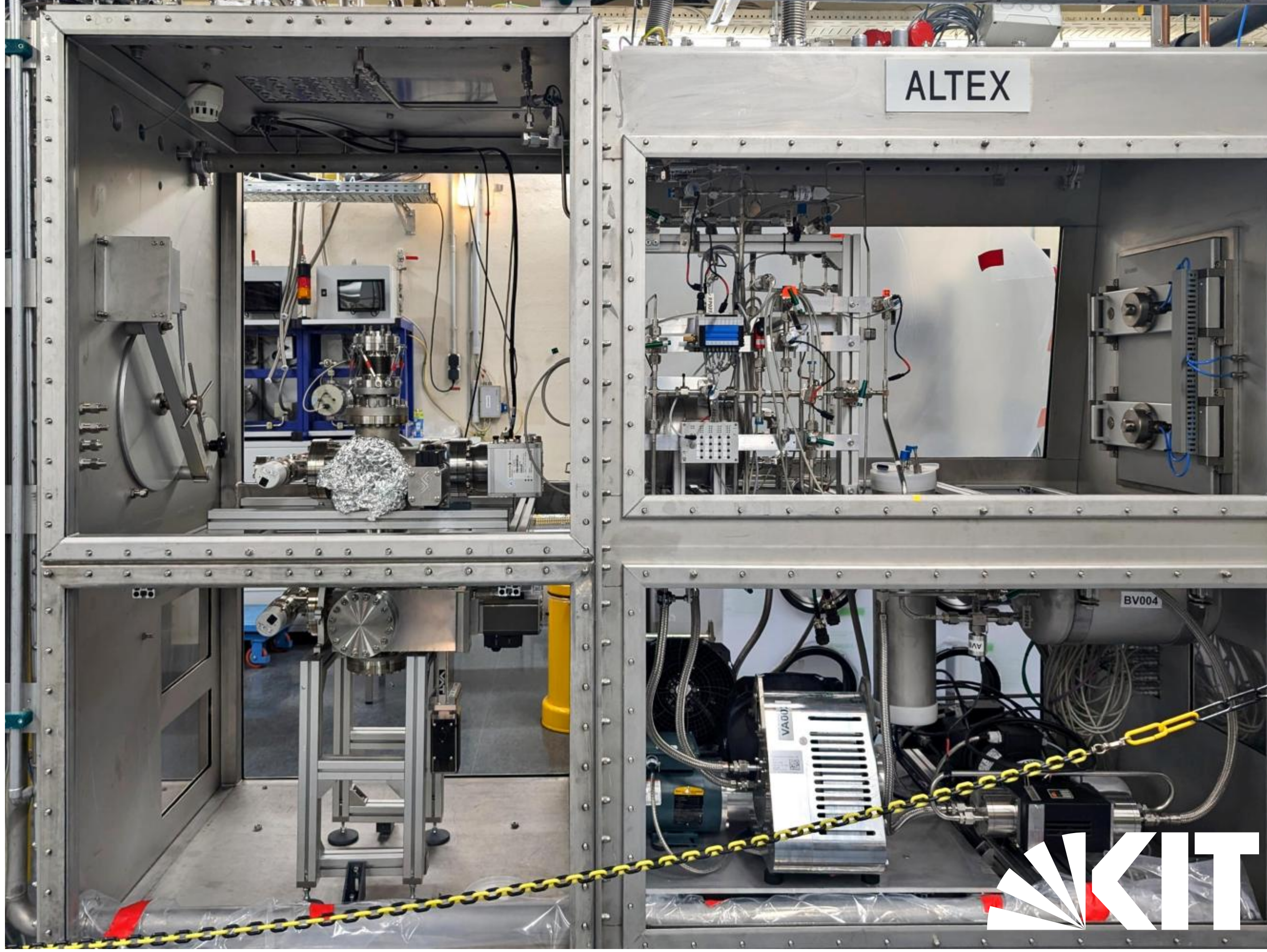




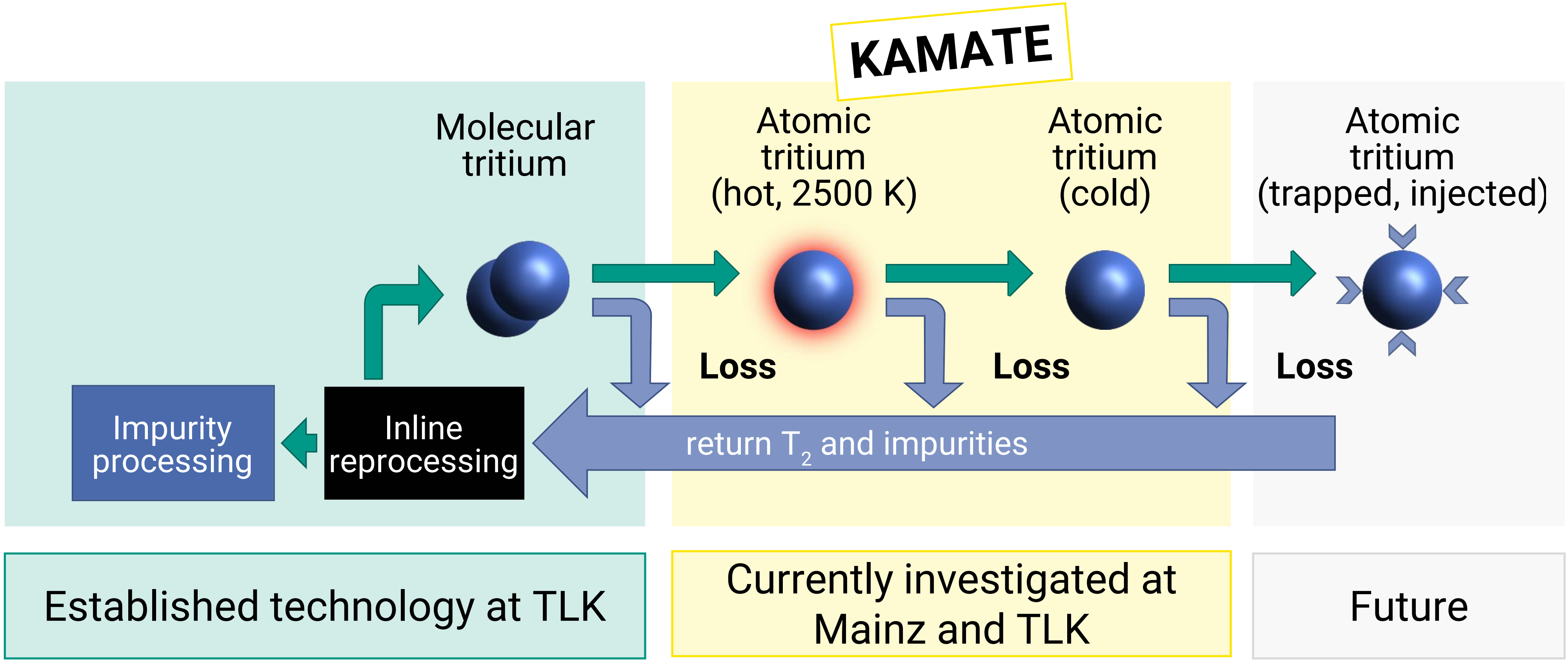
Atomic tritium source activities

Caroline Rodenbeck for the KAMATE collaboration

TLK
Tritium Laboratory Karlsruhe

KATRIN++ call, June 23, 2025

Steps towards an atomic tritium source



Beam for Atomic Tritium Experiment (BeATE)

Goal: Demonstrate tritium operation in *simple setup*

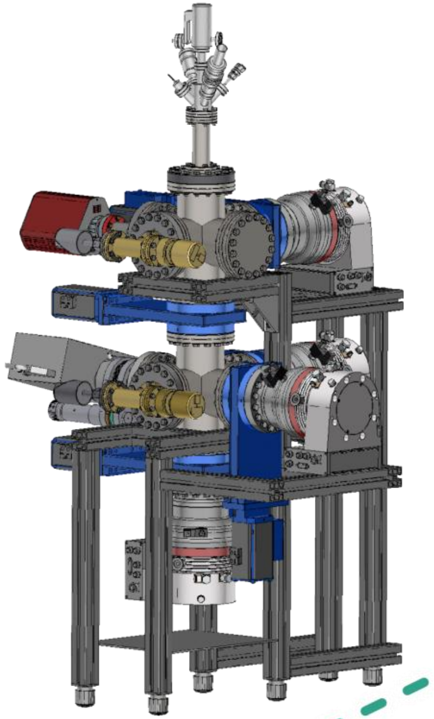
Use standard vacuum parts to investigate:

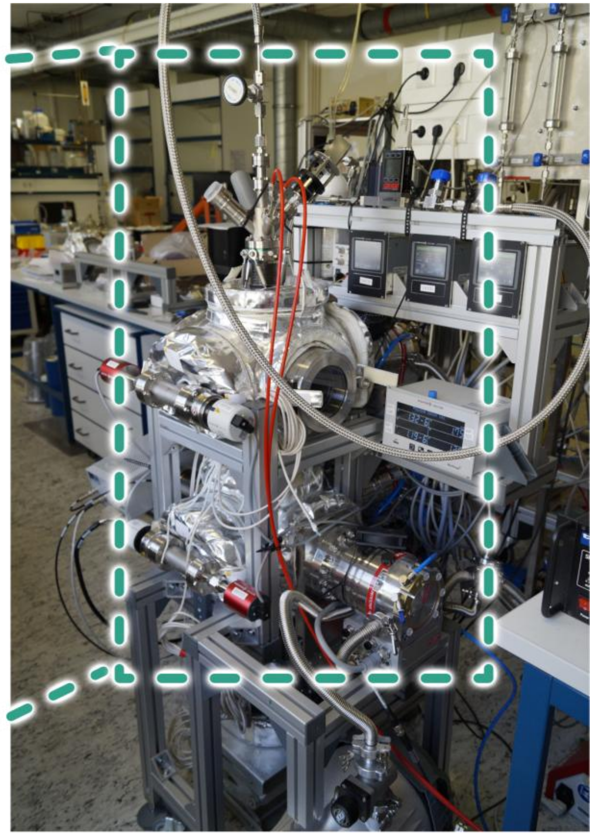
- Tritium compatibility
- Tritium recovery
- Isotopic effects

Pre-KAMATE

Measure atomic fraction with differentially pumped mass spectrometer (shroud around mass spec.)


Tectra h-flux





Input for KAMATE

Commissioning of tectra h-flux
→ Source comparison in KAMATE 0.5

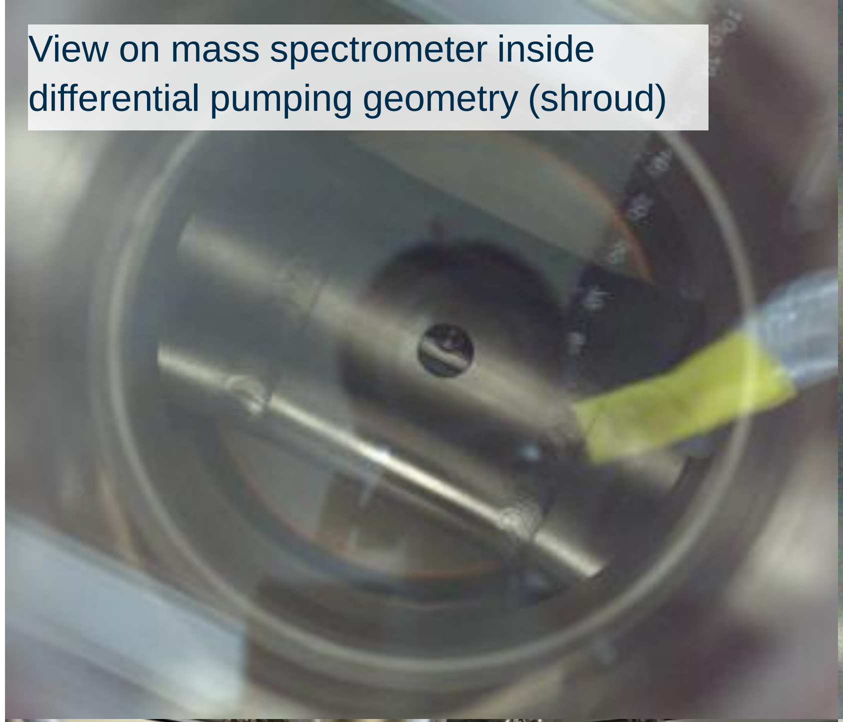
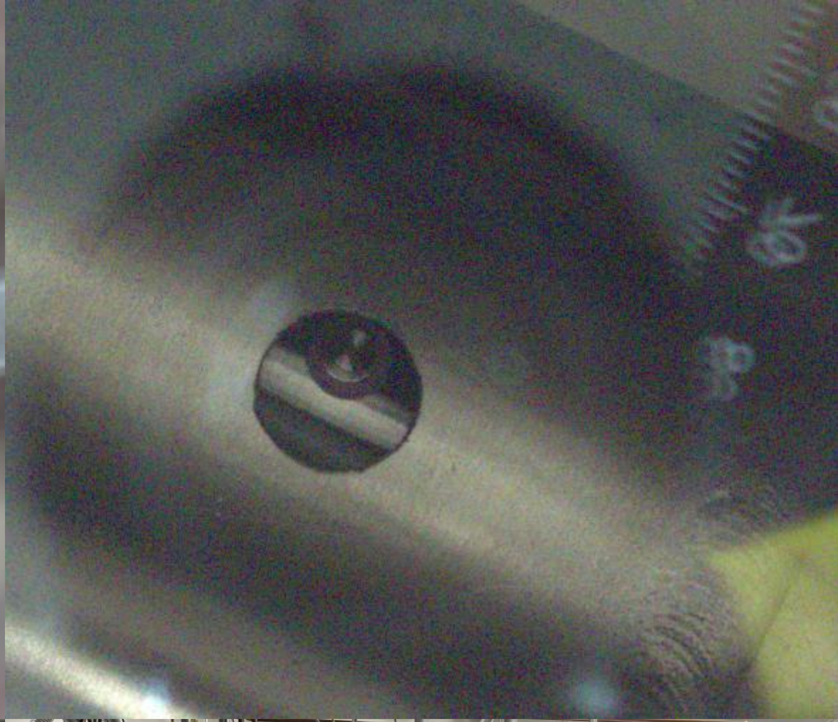
First tritium operation experience → KAMATE 1.0

BeATE–Status

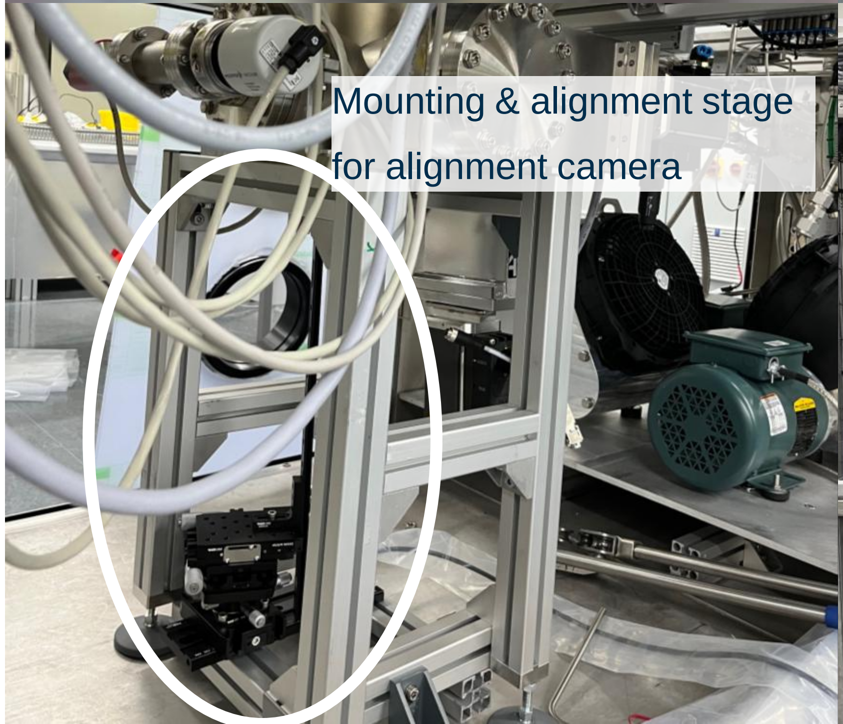
- System moved from cold lab to warm lab
- Added camera for alignment observations

Next steps:

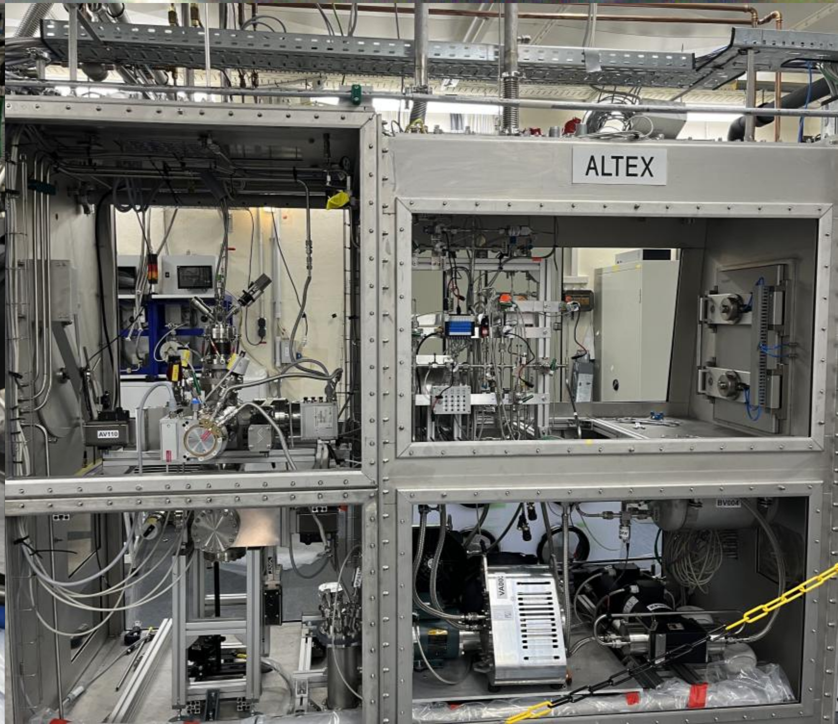
1. “FaroArm” measurements of shroud and mass spectrometer
2. Align mass spectrometer and shroud inside shroud and cross, afterwards mount cross
3. Leakage test of vacuum system
4. Electrical check of Loops system
5. Leakage test of glove box
6. Commissioning of gas inlet
7. Measurements: Check for atoms with H2, D2 before inserting T2

View on mass spectrometer inside differential pumping geometry (shroud)



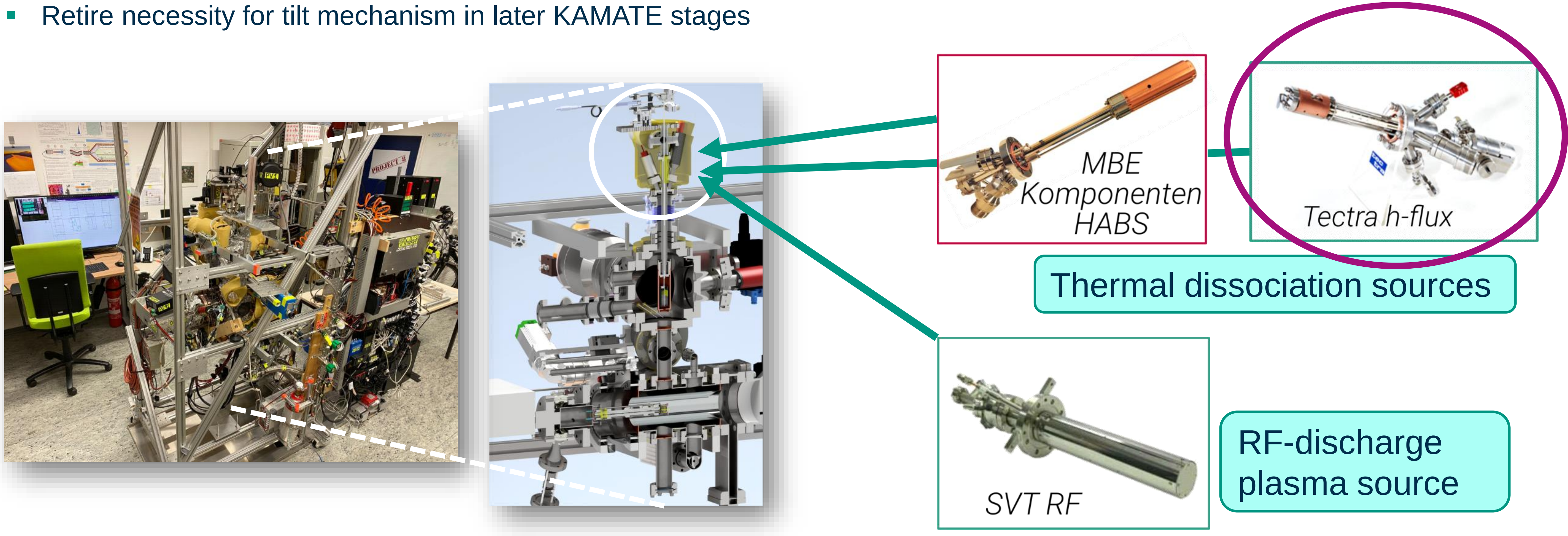
Mounting & alignment stage for alignment camera



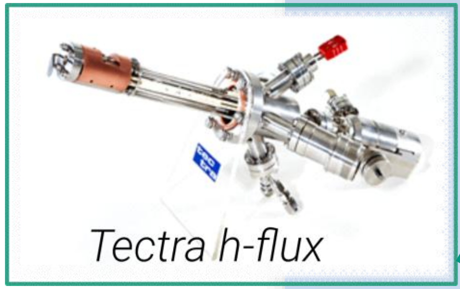
KAMATE 0.5

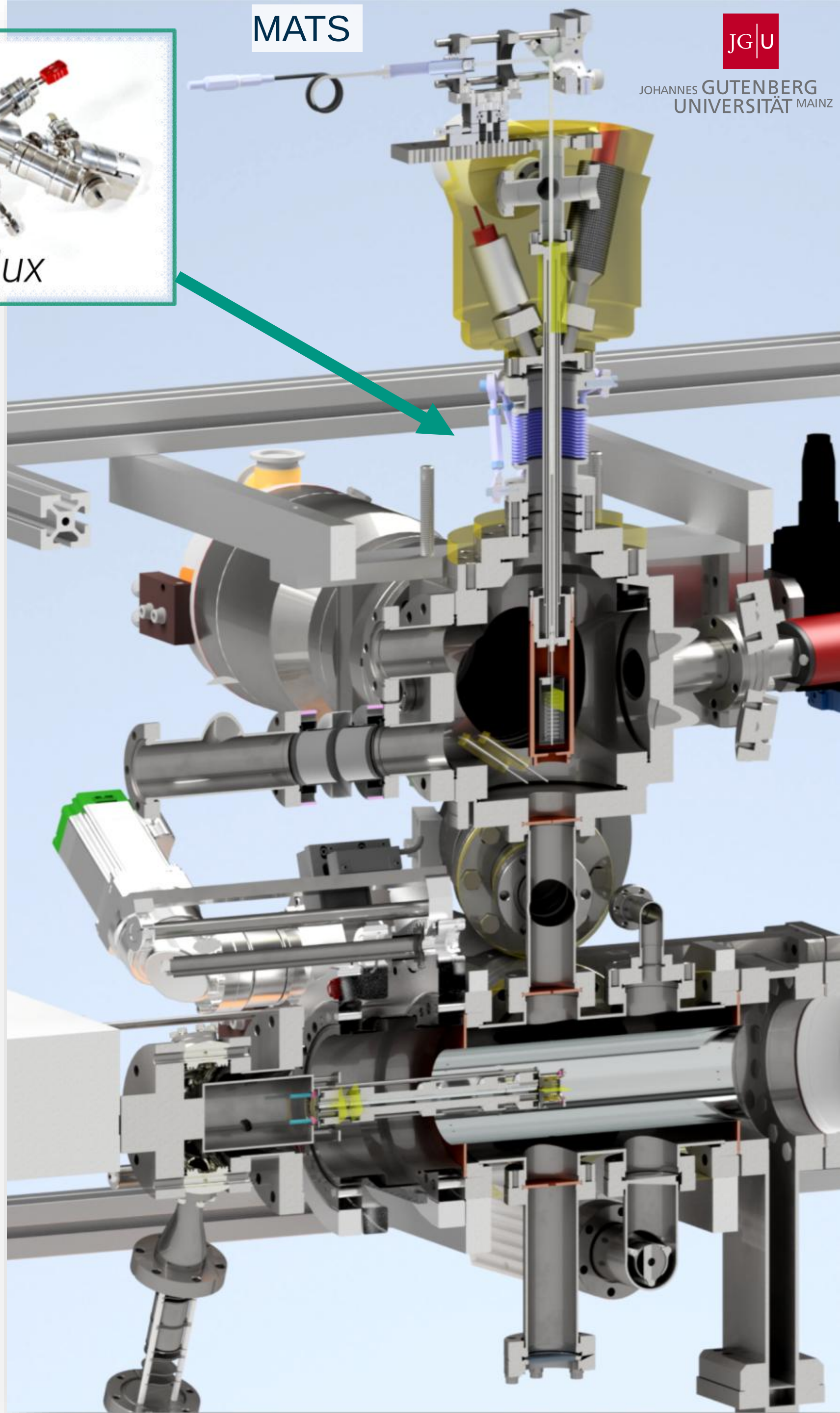
Primary goals:

- Identify best source for later KAMATE stages: thermal dissociation vs. RF-discharge
- Retire necessity for tilt mechanism in later KAMATE stages



KAMATE 0.5 – Tectra@MATS





- **Goal**: Use tools available at the MATS to measure the beam composition and shape of the three different sources.
- **Challenges**:
  - Diagnostic tools still in R&D phase
    → Use source comparison for further development of tools.
  - No significant atom flux with measured Tectra so far (@BeATE-setup)
- **Physics questions for measurements:**
  - Does the tectra emit atoms?
  - Can we reach the dissociation maximum for high temperatures?
  - What is the relative atom intensity inside beam? (Wire detector)
  - What is the dissociation efficiency of the tectra?
  - What is the beam spread at the mass spectrometer position?
  - What is the capillary temperature?
- **Current status**
  - Measurements delayed due to major electrical reworks of MATS (at least 4 weeks)

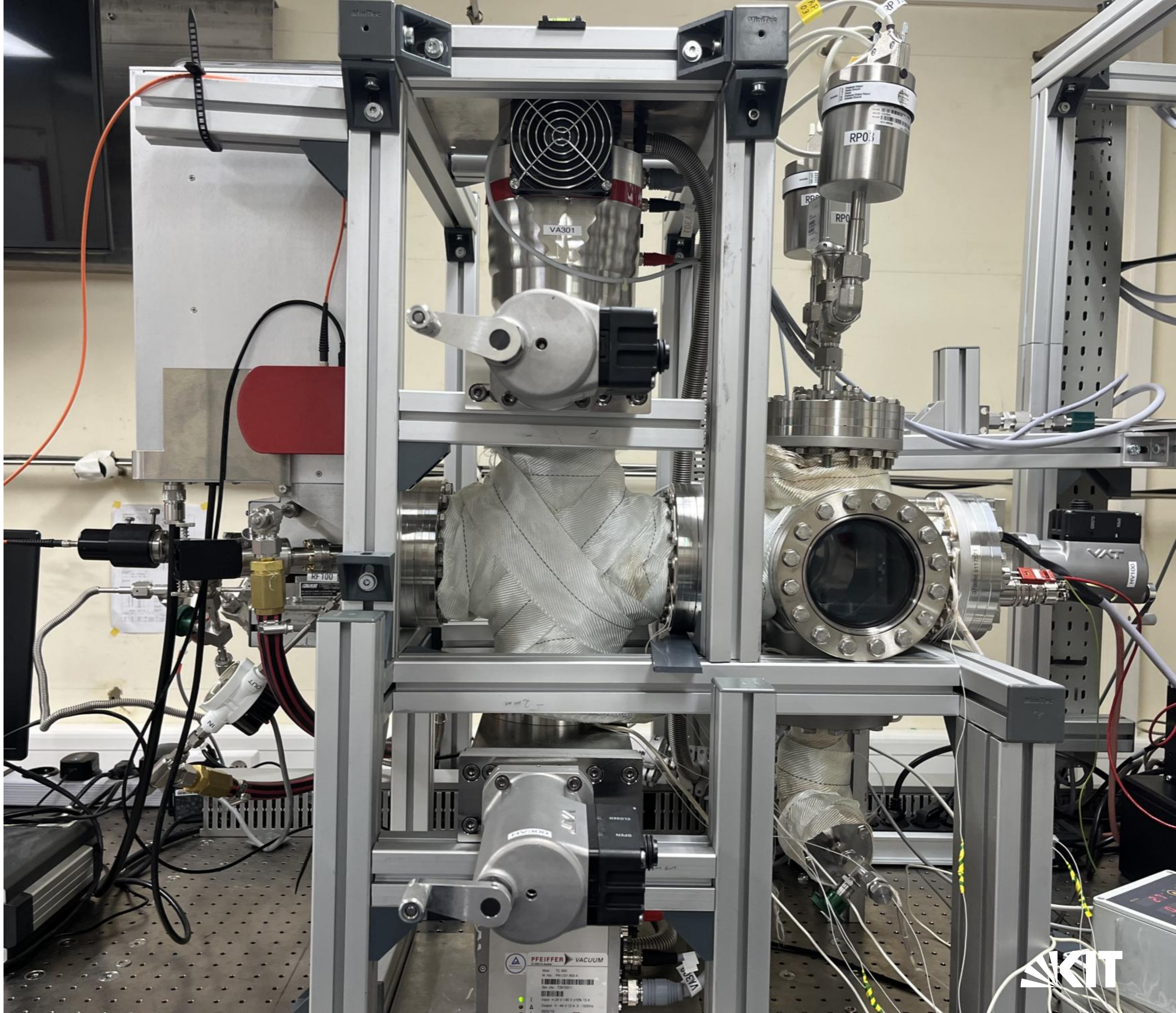
Plasma source

Commissioning of RF-discharge plasma source *SVTA RF 4.5*

- RF coil produces inductively coupled hydrogen plasma $(\mathrm{H^+, H_2^+, H_3^+, e^-})$
- Dissociation by inelastic collisions with electrons inside the plasma
  - Frequency: 13.56 MHz
  - RF Power: 250 – 450 W
- Throughputs: 0.2 – 1 sccm

Quantify atomic fraction with:

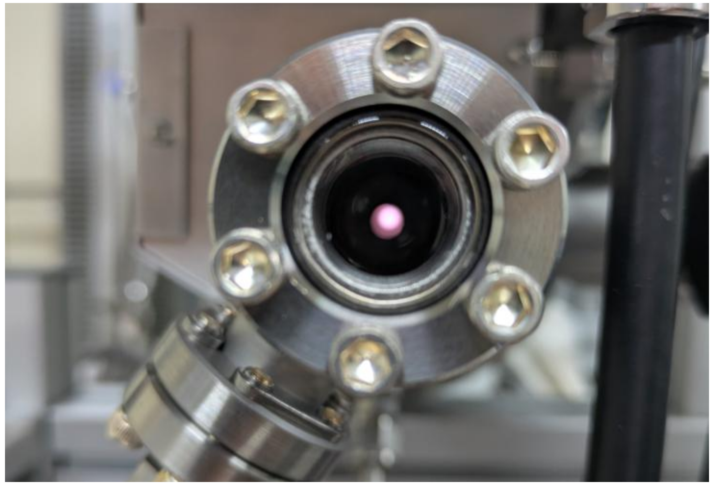
1. Spectral measurement
2. Graphene loading

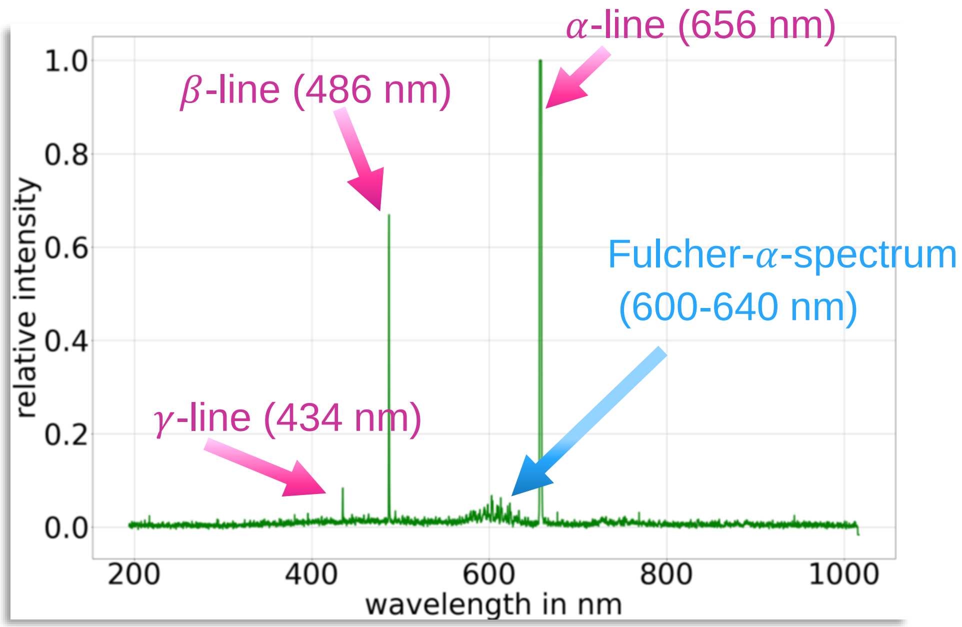


Atomic density inside the plasma

- **Idea**
  - Measure spectra with different drive powers and gas flows
  - **Intensity ratios** of atomic and molecular lines can be compared to theoretical calculations (Collisional Radiative model)
  - Final output: atomic density, electron temperature, electron density
- **Ongoing**
  - Verify calibration of spectrometer
  - Measurement campaign 1 ongoing
    - Flow: 0.5 sccm
    - Drive Powers: 250W, 350W, 450W, 550W
- **Impending**
  - Try to interpret the data and produce first **intensity ratios**

Help from Prof.Fantz-group





Hydrogen plasma spectrum

Content copied from status slides of David Frese

Hydrogenation of graphene

Graphene is selective to atomic hydrogen:

In-situ:

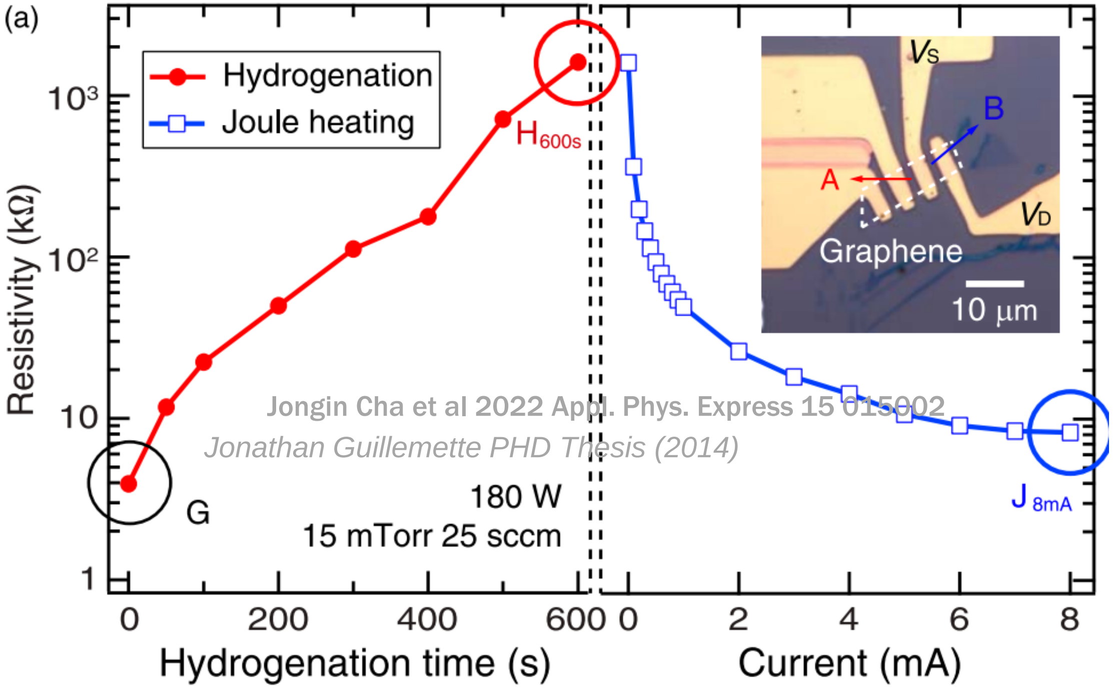
- resistivity measurement of graphene sample
- heating of graphene sample

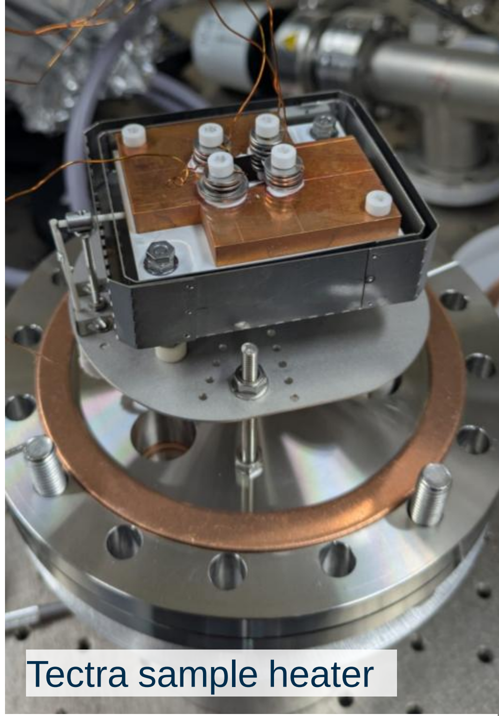
Ex-situ:

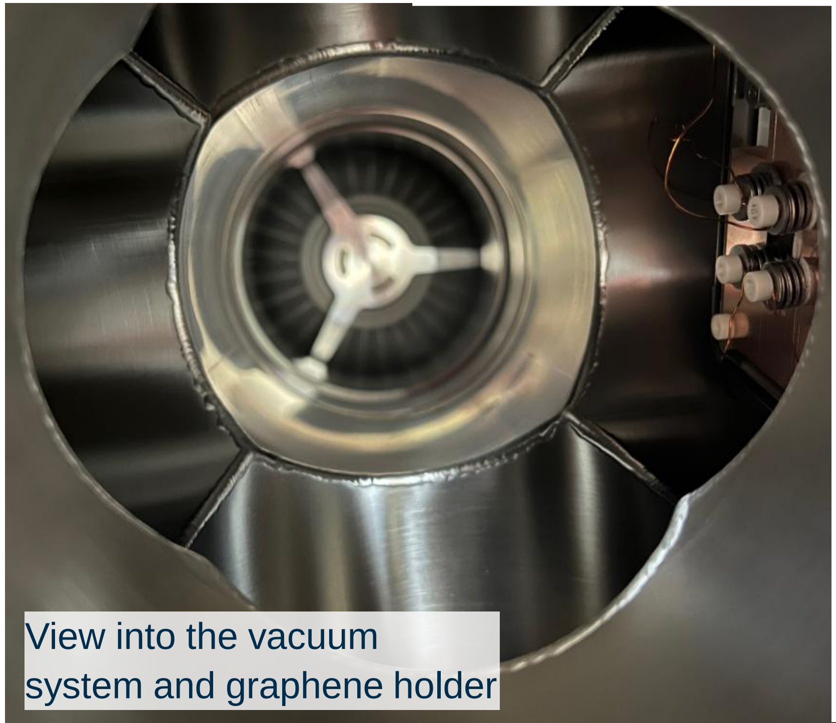
- SEM
- Raman Spectroscopy

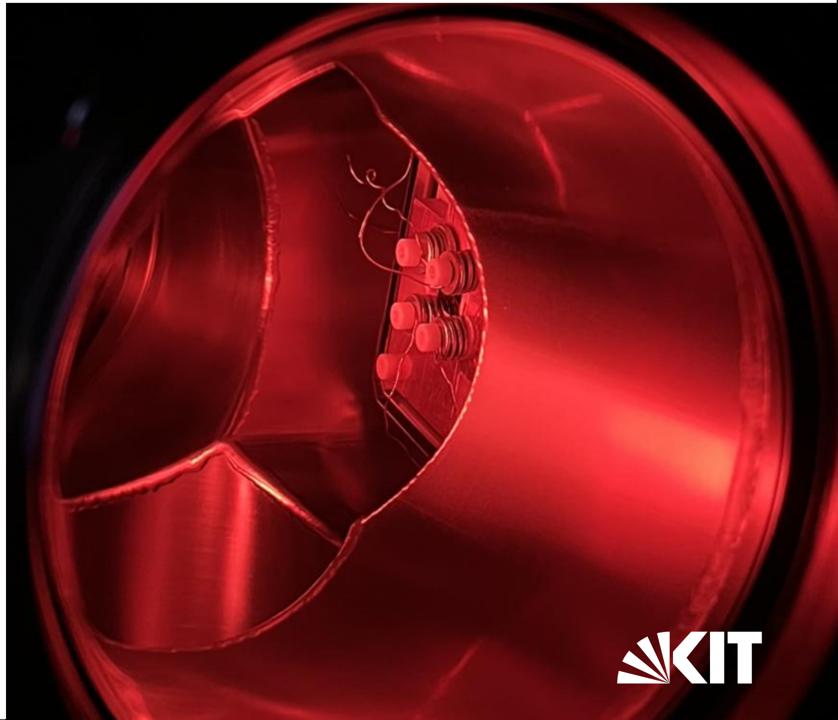
Loading of graphene samples **ongoing!**

Content copied from status slides of David Frese




Tectra sample heater


View into the vacuum system and graphene holder



Summary and outlook

Three different sources under investigation

- Two thermal sources: HABS (Mainz), Tectra (TLK)
- RF-discharge plasma source (TLK)

Four different ways to characterize atom density under development:

1. Mass spectrometer measurements (BeATE, MATS)
2. Wire detector measurements (MATS)
3. Graphene hydrogenation
   - Raman spectroscopy (ex-situ)
   - Resistivity measurement (in-situ)
4. Balmer & Fulcher line spectrum (← only for plasma source)

Coming up next:

1. Commissioning measurements BeATE in hot lab
2. Tectra@MATS measurements (KAMATE 0.5)
   (delayed by at least 4 weeks)
3. Raman spectroscopy of graphene samples