Karlsruher Institut für Technologie

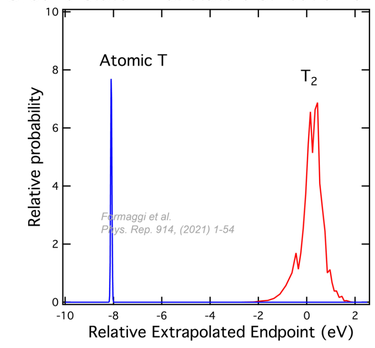
Tritium Laboratory Karlsruhe

Characterization of an inductively coupled plasma source for atomic hydrogen with optical emission spectroscopy

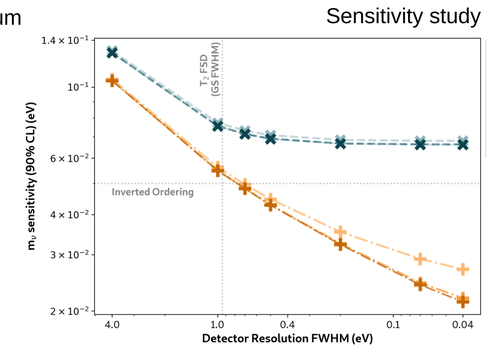
David Frese, Görkem Yavuz, Caroline Rodenbeck for the ATS-Team at TLK

Atomic tritium

Ground state Final state distribution of tritium



Sensitivity study



→ Poster by C. Goupy et al.

- Intrinsic broadening of ground state (std. dev. of about 0.4 eV)
- Reaching beyond inverted ordering requires detector improvements and atomic tritium

Future neutrino mass experiments need an atomic tritium source

Developing an atomic tritium source

KAMATE

- Karlsruhe Mainz Atomic Tritium Experiment: Comparison of **dissociation technologies**
- Development of experimental diagnostics to characterize dissociators:
  - Quadropole mass spectrometer
  - Wire detector
  - Graphene sensor
  - Optical emission spectroscopy (OES) (only plasma-based dissociation):
- First experiments with nonradioactive hydrogen

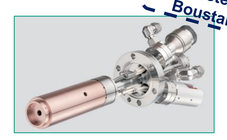
→ Poster by D. de Vincenz et al.

Thermal Dissociation

→ Poster by A. el Boustani et al.

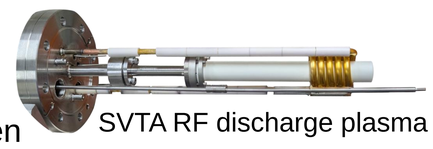


Tectra h-flux



MBE Komponenten HABS

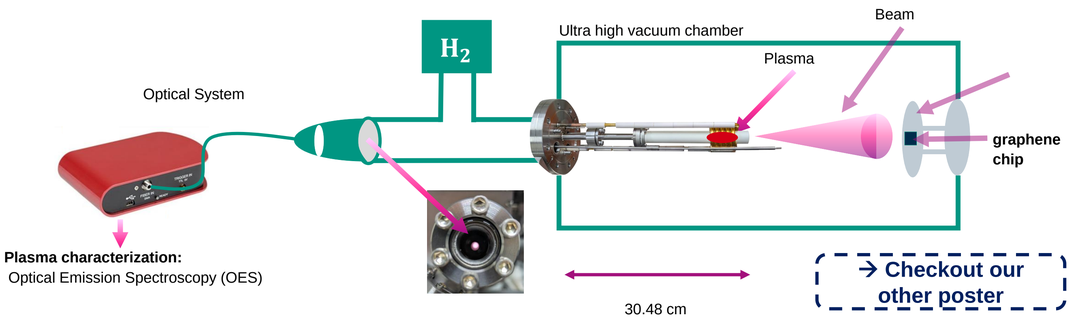
Inelastic collisions with electrons



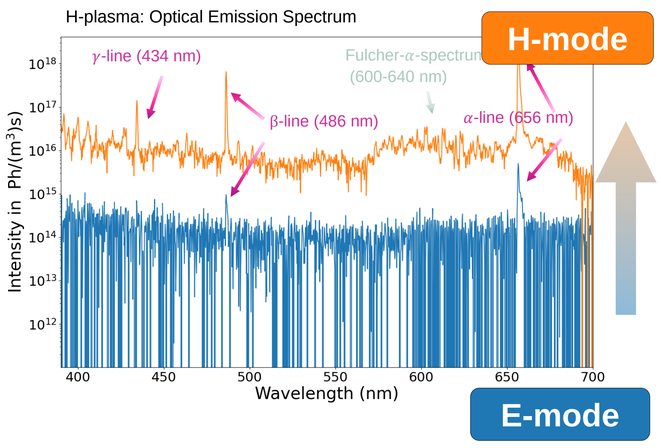
SVTA RF discharge plasma source

Investigate a commercial plasma-based dissociator for atomic tritium production

RF plasma discharge device



→ Checkout our other poster



- Inductive coupling
- Eddie currents accelerate the electrons
  → Swirling-like motion

From E- to H-mode increase in:
- Power transfer efficiency
- Electron density
- SNR

- Capacitive coupling
- Coupling between coil and plasma sheath
  → Breathing-like motion

High SNR of H mode allows determination of atomic density

Determination of plasma parameters

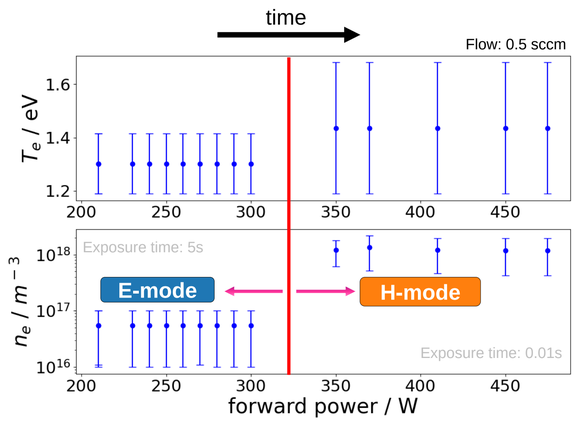
$$I_{exp} = I_{theo}$$

- OES measurements
- Absolute intensity calibration performed with Ulbricht sphere at IPP MPG in Garching
- Normalization of spectra to 1s

- Collisional Radiative (CR) model calculations
- CR-model solver ‘Yacora on the web‘ population rate coefficients
- Uses plasma parameters as input

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

New grid search algorithm for online plasma parameter determination



E-mode

Consider only α- and β-line

H-mode

Consider α-, β-, γ-line and ratios

Expected increase in electron density n_e observed

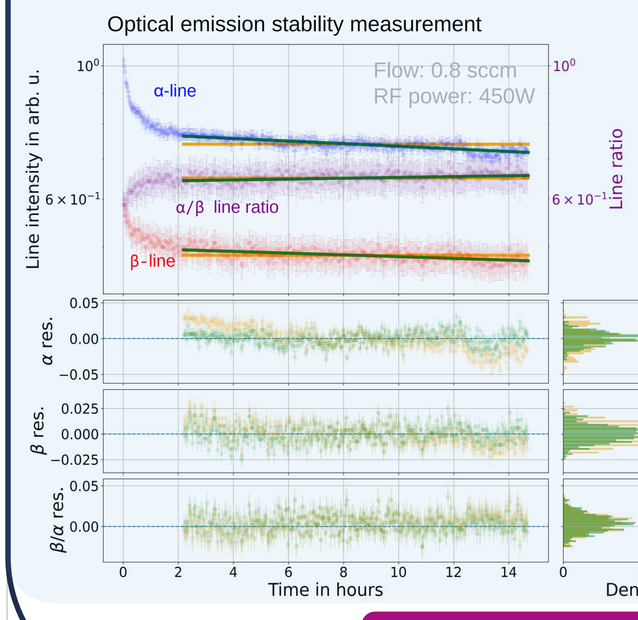
New algorithm for near-time determination of n_e and T_e

Ongoing efforts:
- Include dissociative excitation
- Include Fulcher-α-band
  → **Online determination of atomic density in H-mode**

Plasma stability measurements and inlet pressure correlations

E-mode

Optical emission stability measurement



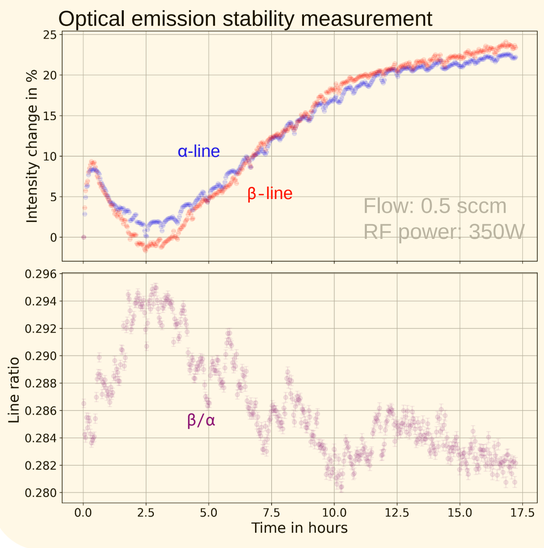
Line	Slope in %/h	σ in %/h
α	-0.478	0.029
β	-0.348	0.072
$\frac{\beta}{\alpha}$	**0.177**	**0.033**

Linear fit

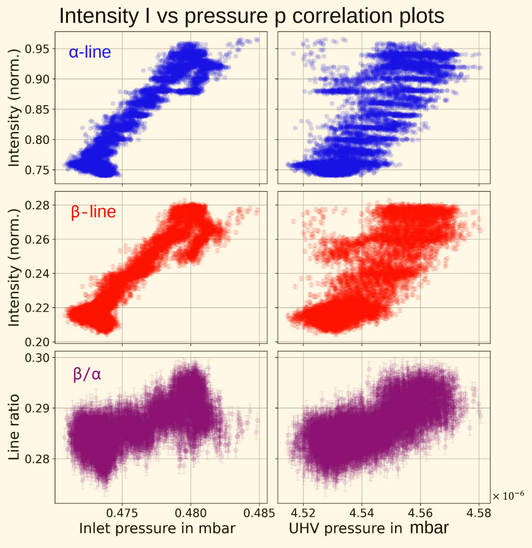
Constant fit

H-mode

Optical emission stability measurement



Intensity I vs pressure p correlation plots



- Inlet pressure unstable during H-mode measurement
- Line intensities follow pressure oscillations

Ongoing efforts:
- Quantify I vs. p correlation
- Correct intensity for pressure fluctuations
- Study E-H mode transition

α/β line ratio is suitable for online plasma and pressure stability monitoring

[1]Tritium Laboratory Karlsruhe (TLK), Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany

iap.kit.edu/tlk

linkedin.com/company/tritiumlab