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## ► To cite this version:

Aurélien Favre, Arnaud Bultel, Vincent Morel, Stevica Djurovic, Zoran Mijatovic. Estimate of the departure from excitation equilibrium of a laser-induced plasma obtained in Ar-H mixtures. EMSLIBS 2019, Sep 2019, Brno, Czech Republic. 2019. hal-02314863

**HAL Id: hal-02314863**

**<https://hal.science/hal-02314863>**

Submitted on 14 Oct 2019

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# Estimate of the departure from excitation equilibrium of a laser-induced plasma obtained in Ar-H mixtures

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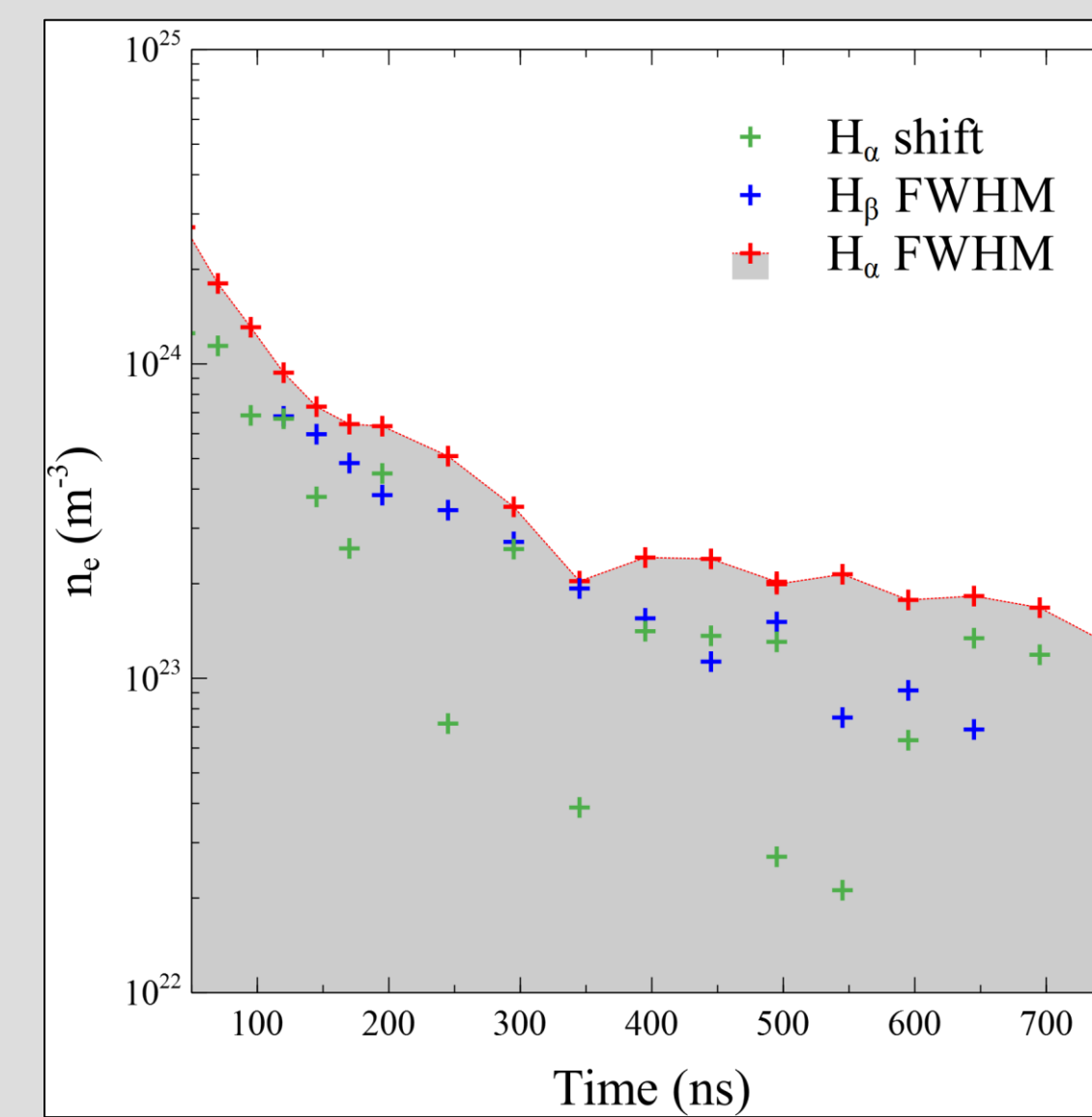
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## CONTEXT & OBJECTIVES

### Diagnostic technique LIBS

There are different ways to characterize (i.e. determination of the electron temperature  $T_e$  and density  $n_e$ ) a plasma (supposed to be at local thermodynamic equilibrium). One efficient procedure is to integrate the Radiative Transfer Equation to build up a theoretical spectrum. The plasma parameters can be estimated once theoretical and experimental spectra match to each other.

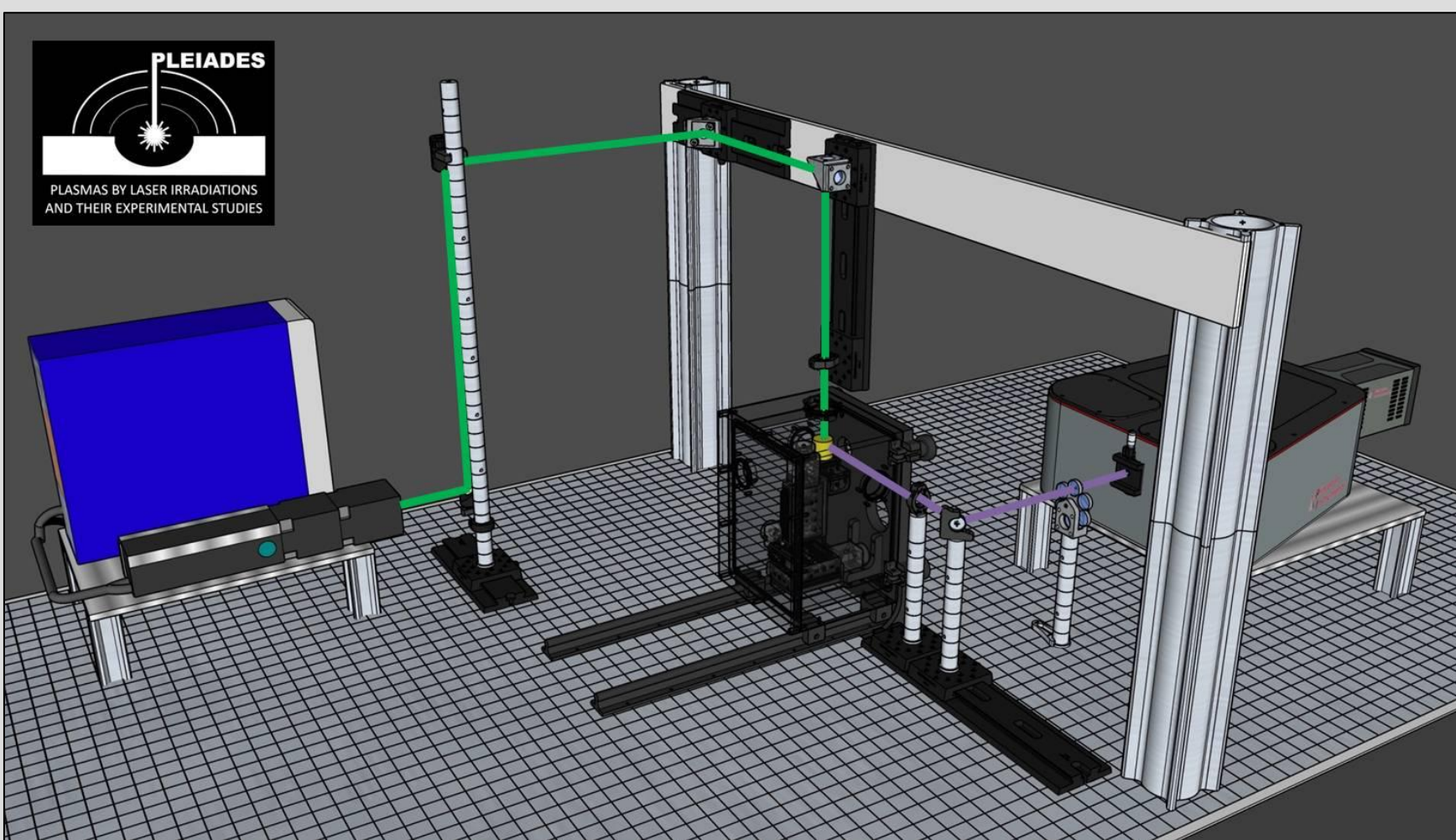
The determination can be more or less accurate depending on the studied spectral region. In the case of an Argon – Hydrogen plasma, it can be done by focusing on Ar lines broadening or shifting. A previous study on Acetone-saturated plasma showed that the determination from  $H_\alpha$  leads to an over-estimation of electron density compared to  $H_\beta$  values which are quite close from Ar determination.



### Objectives

- Describe the influence of major parameters on the determination :
  - auto-absorption size
  - hydrogen dilution
- Quantify accurately electron density and temperature from Argon lines

## EXPERIMENTAL SETUP



### PLEIADES characteristics :

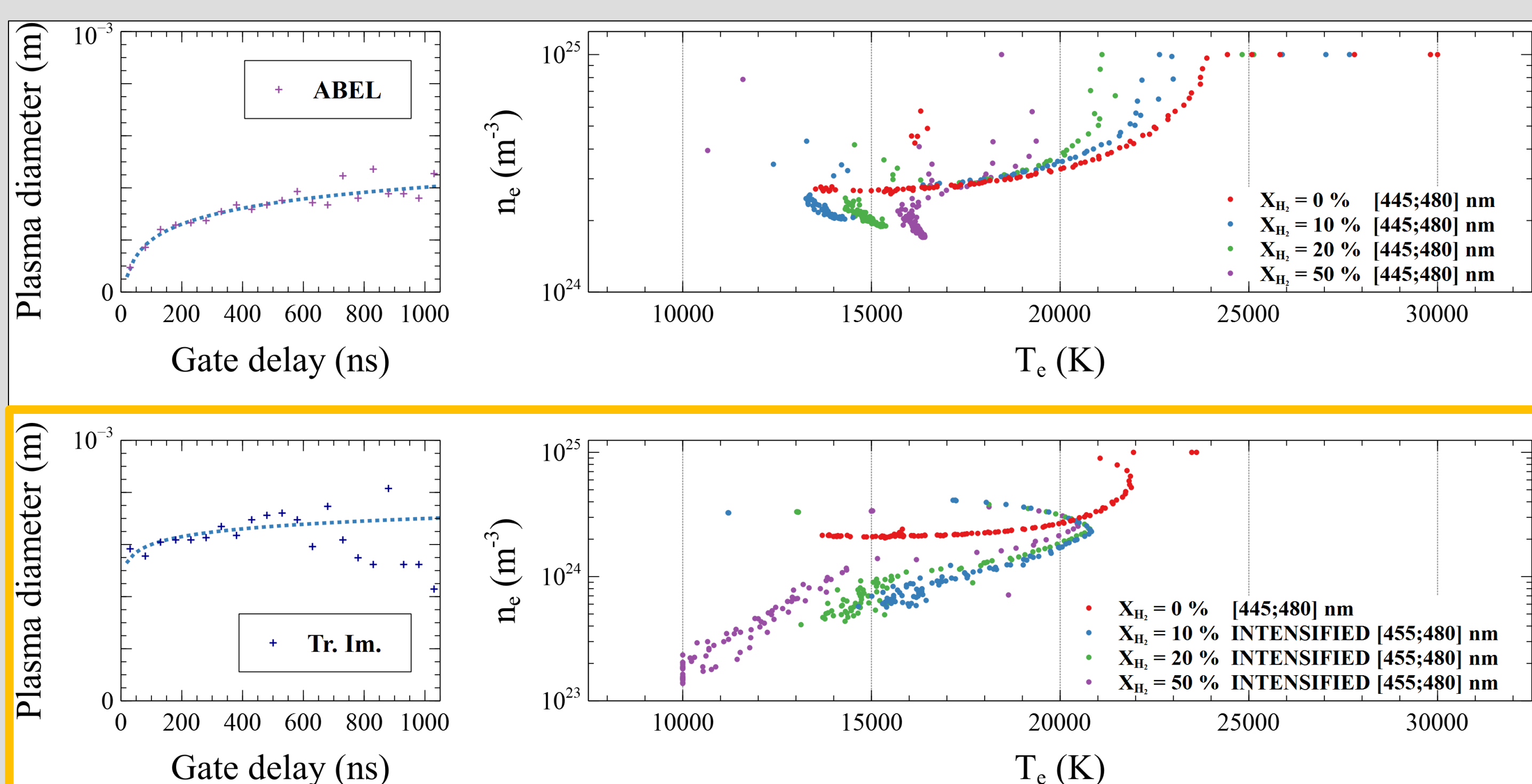
**LASER** : Q-SMART 450 (532 nm, 6 ns, 40 mJ)  
**FOCUSING LENS** :  $f_l = 125$  mm  
**SPECTROMETER** : SCT-320 ( $f = 0.32$ m,  $f/4.6$ )  
**GRATING** : 600 l/mm  
**CAMERAS** : PI-MAX 4 V-UV and PI-MAX 4 V-IR

A **nanosecond laser pulse** is focused to reach target energy threshold. The **plasma** is generated in the chamber. Its radiation is collected on a **second optical axis** to be analysed with the spectrometer.

### Experiments in gases:

**Argon – Hydrogen** mixtures maintained at **atmospheric pressure**.

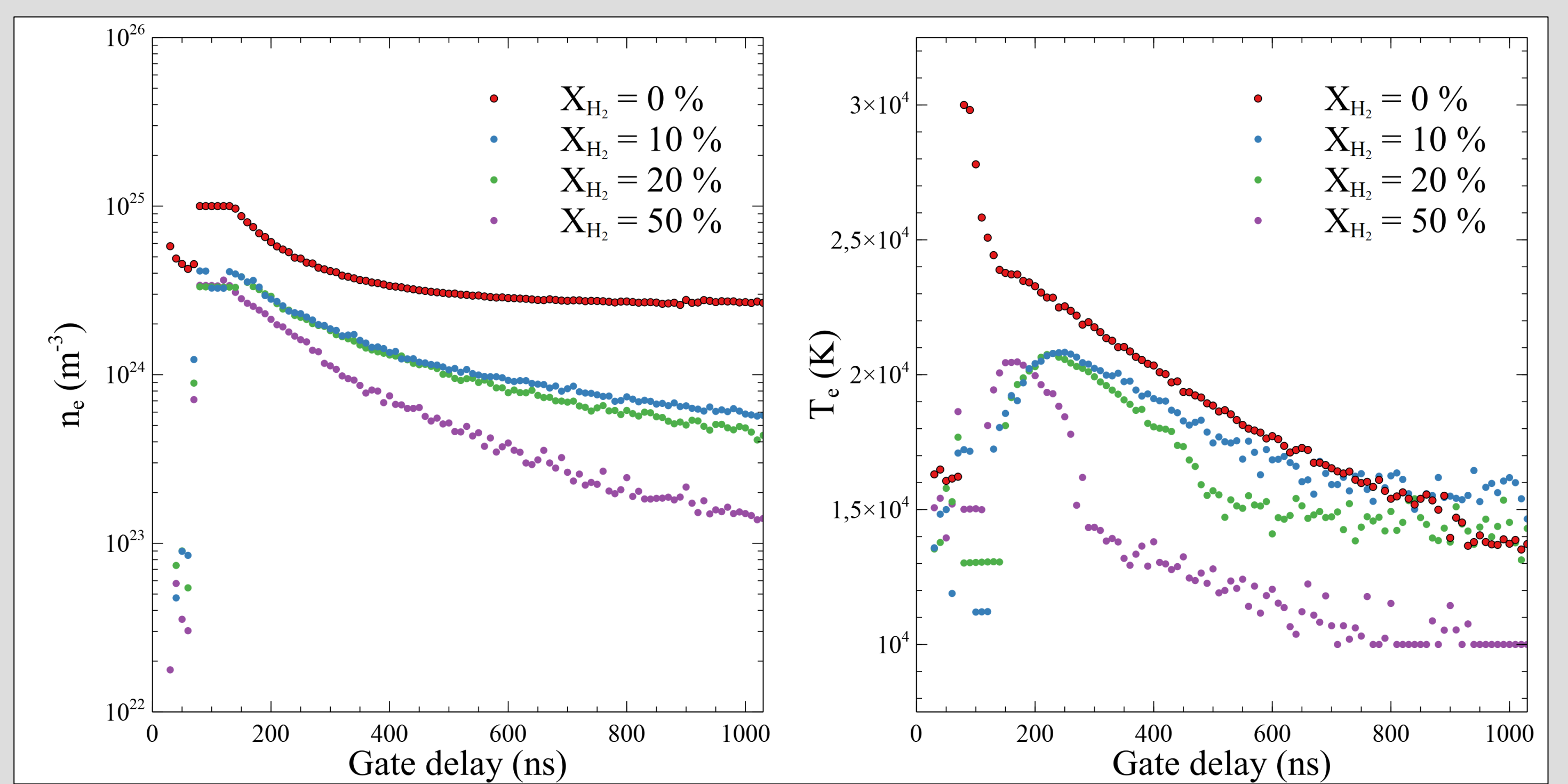
## PLASMA SIZE INFLUENCE



### Comments

- Non linear response of ( $n_e$  ;  $T_e$ ) with plasma diameter
- Intensified signals are needed to clearly observe  $H_\beta$

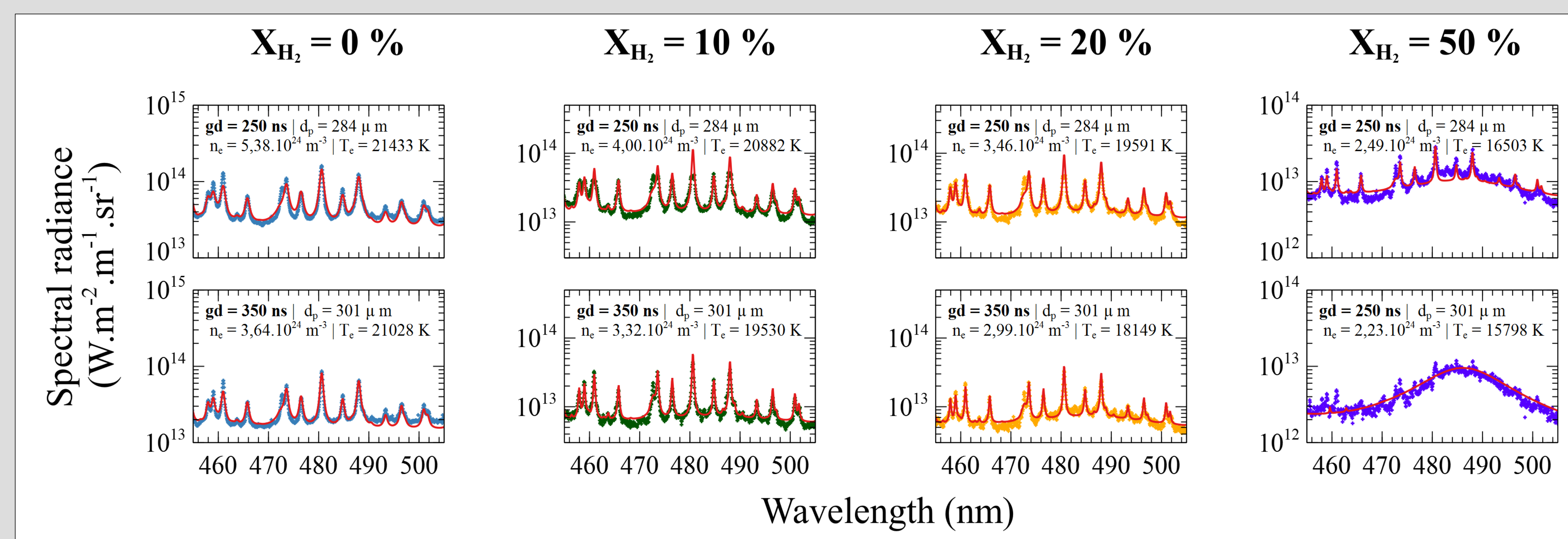
## HYDROGEN DILUTION INFLUENCE



### Comments

- Correlation with experiment: **Image treatment diameters**
- Dilution involves a global decrease in  $n_e$  while  $T_e$  remains high with time

## DETERMINATION MONITORING



### Comments

- The more we dilute the less we are accurate (lower densities)
- Correlation looks promising in global...
- ...but we notice that some ionic lines are under-estimated
- Hydrogen broadening involves determination uncertainties (around 500 nm)

## CONCLUSIONS & PERSPECTIVES

- Temporally resolved determination of ( $n_e$  ;  $T_e$ ) from [455;480] nm Ar lines
- Parameters sensitive to plasma diameter with non-linear response
- Hydrogen dilution involves electron density decreasing: dissociation of  $H_2$
- Adding hydrogen impacts the level of excitation temperature at long time

- Working on  $H_\alpha$  and  $H_\beta$  shifts could be a way to validate the present parameters obtained
- Accuracy can be improved by working only on lines (non continuum considered: radiative recombination is strongly density dependent)
- Additional experiments are planned to work more closely on  $H_\alpha$  and  $H_\beta$  profiles (to validate acetone behavior with Ar-H mixtures)