



HAL
open science

Experimental characterization of double pulse laser-induced plasmas

Aurélien Favre, Arnaud Bultel, Vincent Morel, Gilles Godard

► **To cite this version:**

Aurélien Favre, Arnaud Bultel, Vincent Morel, Gilles Godard. Experimental characterization of double pulse laser-induced plasmas. HTTP, Jul 2018, Toulouse, France. 2018. hal-03011336

HAL Id: hal-03011336

<https://hal.science/hal-03011336v1>

Submitted on 18 Nov 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Experimental characterization of double pulse laser-induced plasmas

AURÉLIEN FAVRE¹, ARNAUD BULTEL¹ ‡, VINCENT MOREL¹, GILLES GODARD¹

¹ CORIA, UMR CNRS 6614, Normandie Université, 76801 Saint-Étienne du Rouvray, FRANCE

‡arnaud.bultel@coria.fr

CONTEXT & OBJECTIVES

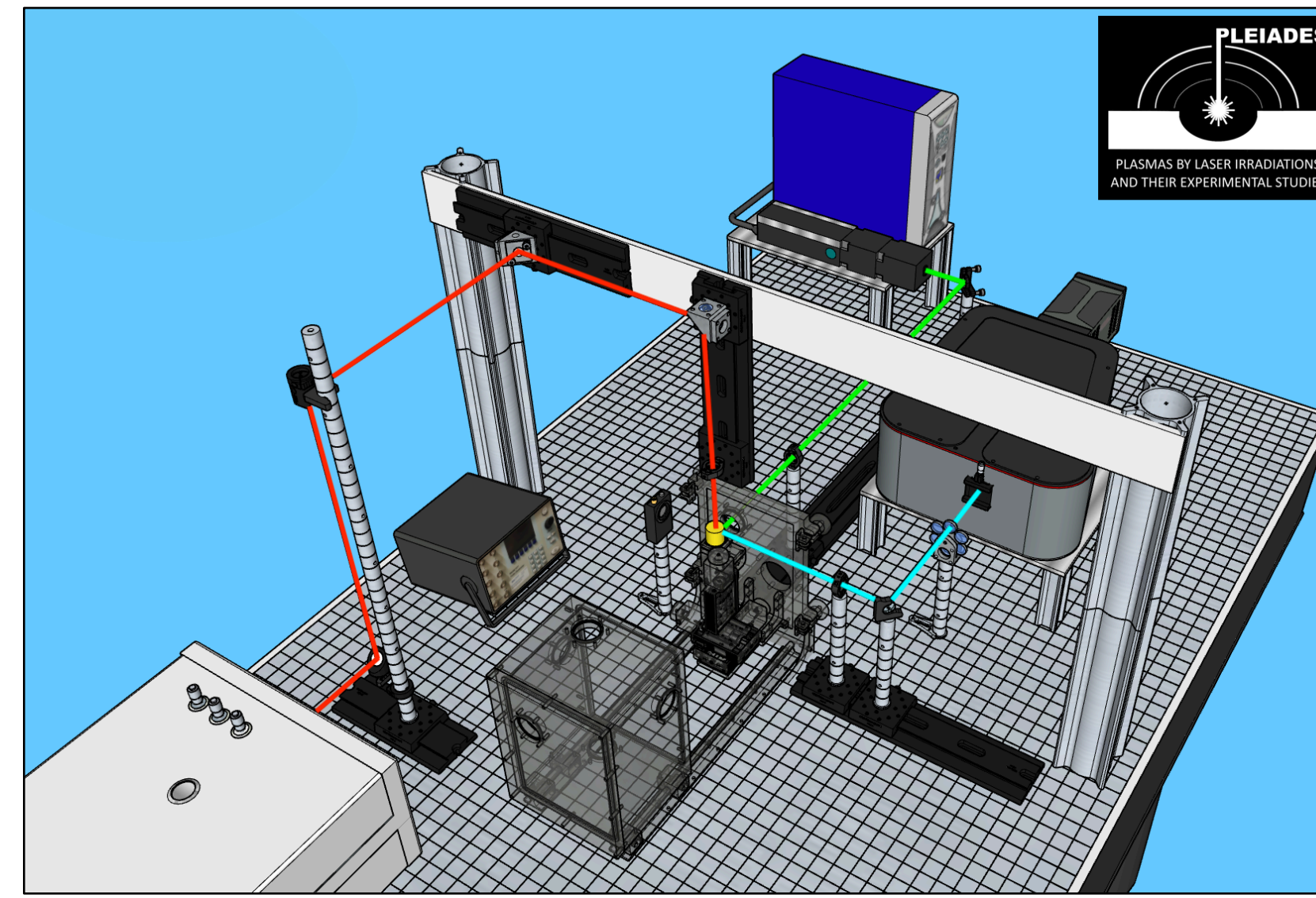
Diagnostic technique LIBS (Laser-Induced Breakdown Spectroscopy)

For a target composed of elements in very low concentration or whose upper levels of common transitions are high (10 eV or more) the maximization of the output signal is mandatory. One efficient technique is to heat up the plasma with a second pulse shifted in time. This experimental process is called double pulse (DP).

Objectives

- Obtaining an experimental setup accurately controlled in time and space.
- Quantifying the improvements in terms of output spectral radiance.
- Observing absorption lines by LIAS.
- Quantifying roughly electron and low level number densities.

EXPERIMENTAL SETUP

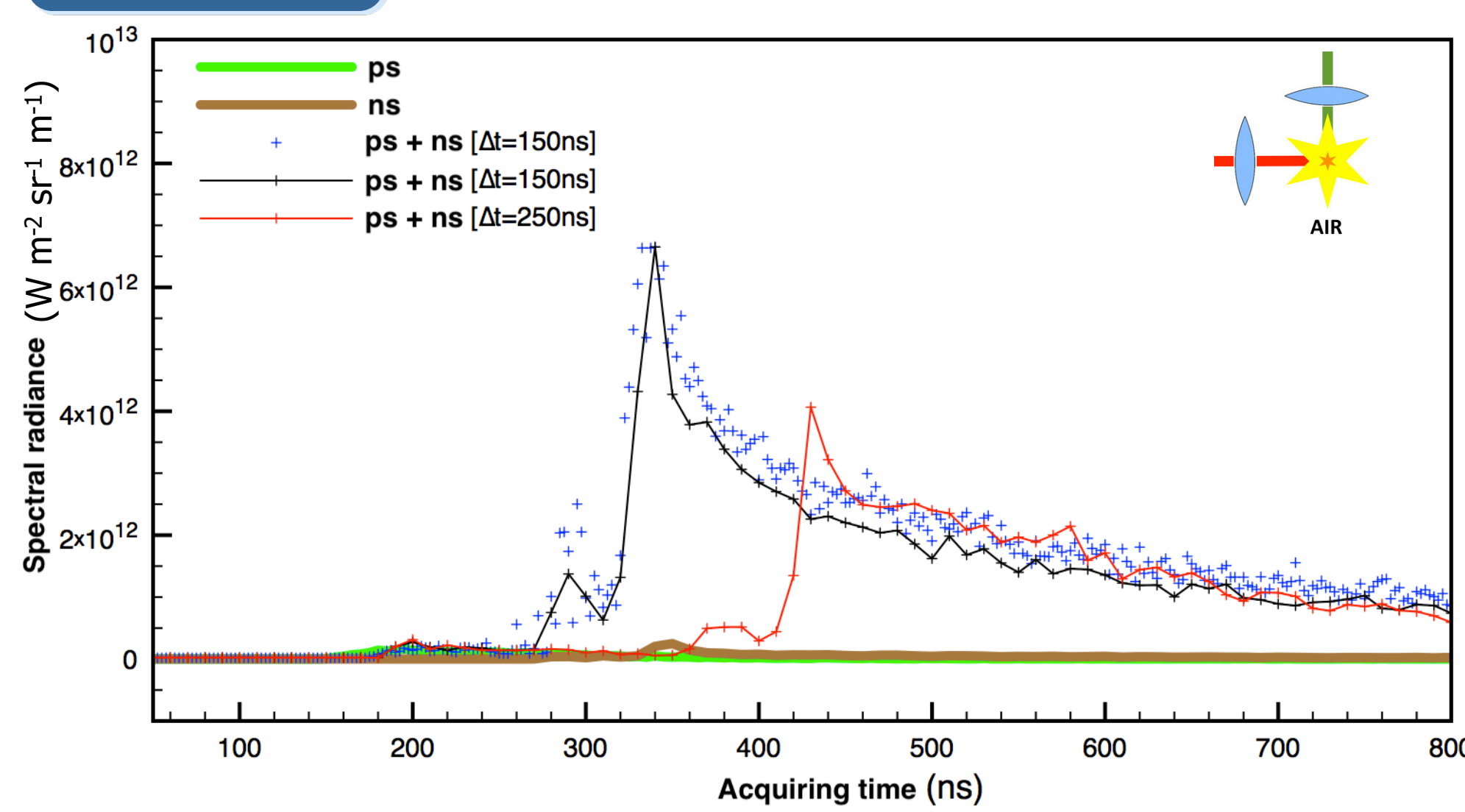


The **first pulse** (1064 nm, 30 ps, 14 mJ) is focused to produce a plasma. The **second pulse** (512 nm, 6 ns, 65 mJ) is focused in this plasma with a temporal shift of Δt . **Heated plasma's** radiation is collected on a **third optical axis** to be analysed by our SCT-320 spectrometer.

LASERS:

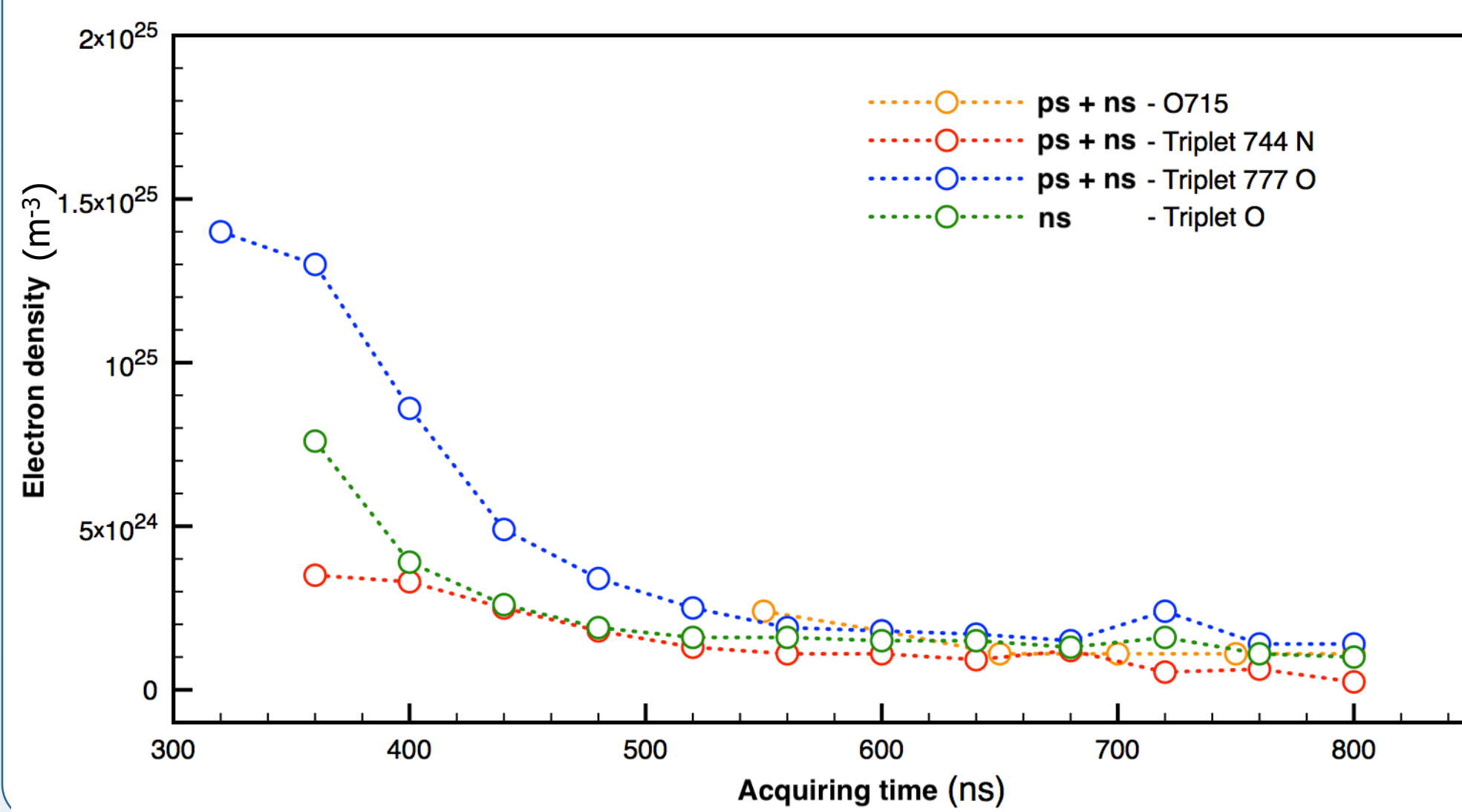
- EKSPLA PL-2251: **ps**
- QUANTEL U100: **ns**

DP in AIR

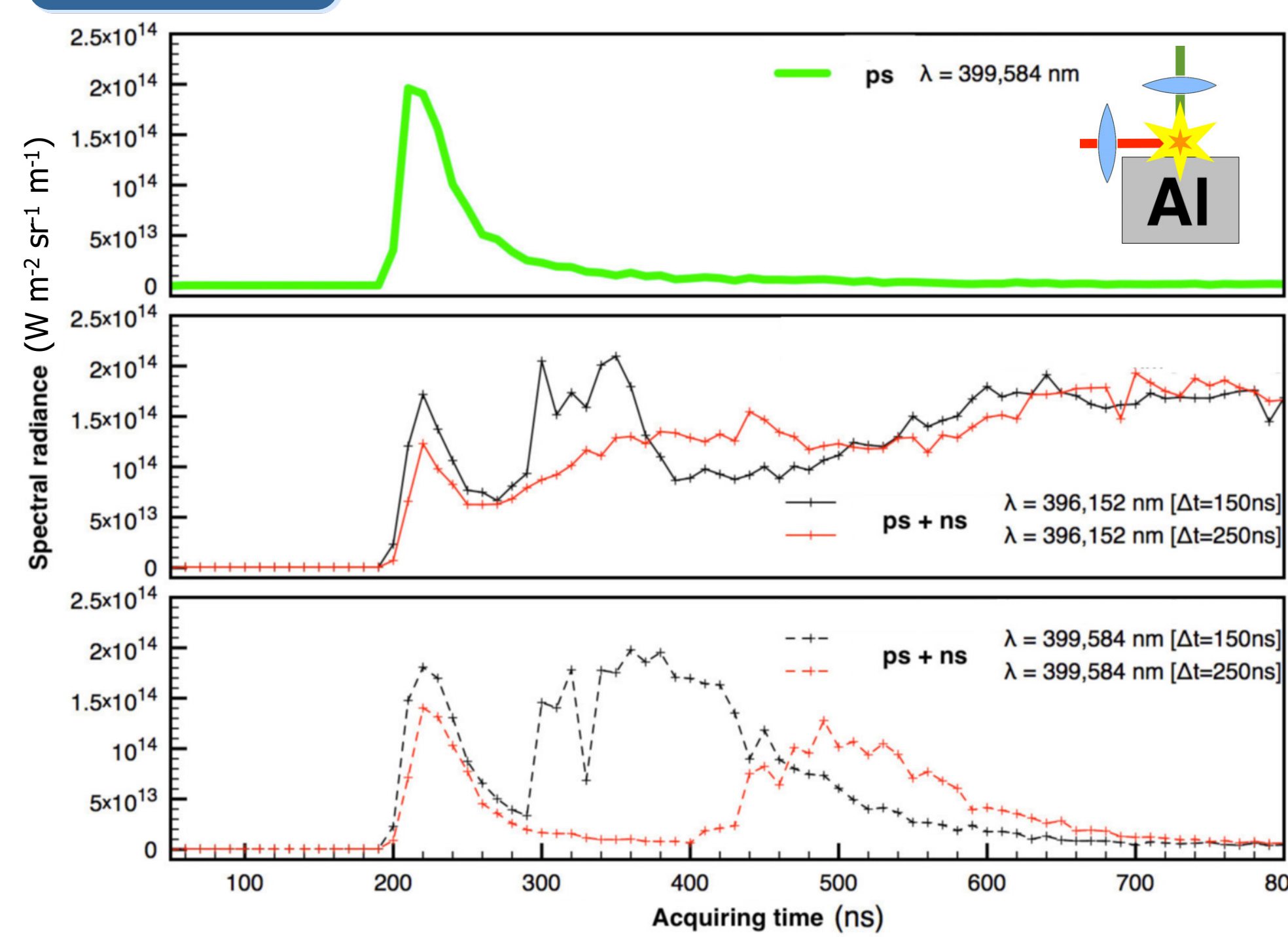


Comments

- Double pulse setup effective.
- Optimal time shifting to improve the output signal: $\Delta t = 150$ ns
- First determination of electron density: $10^{24} \text{ m}^{-3} < n_e < 10^{25} \text{ m}^{-3}$

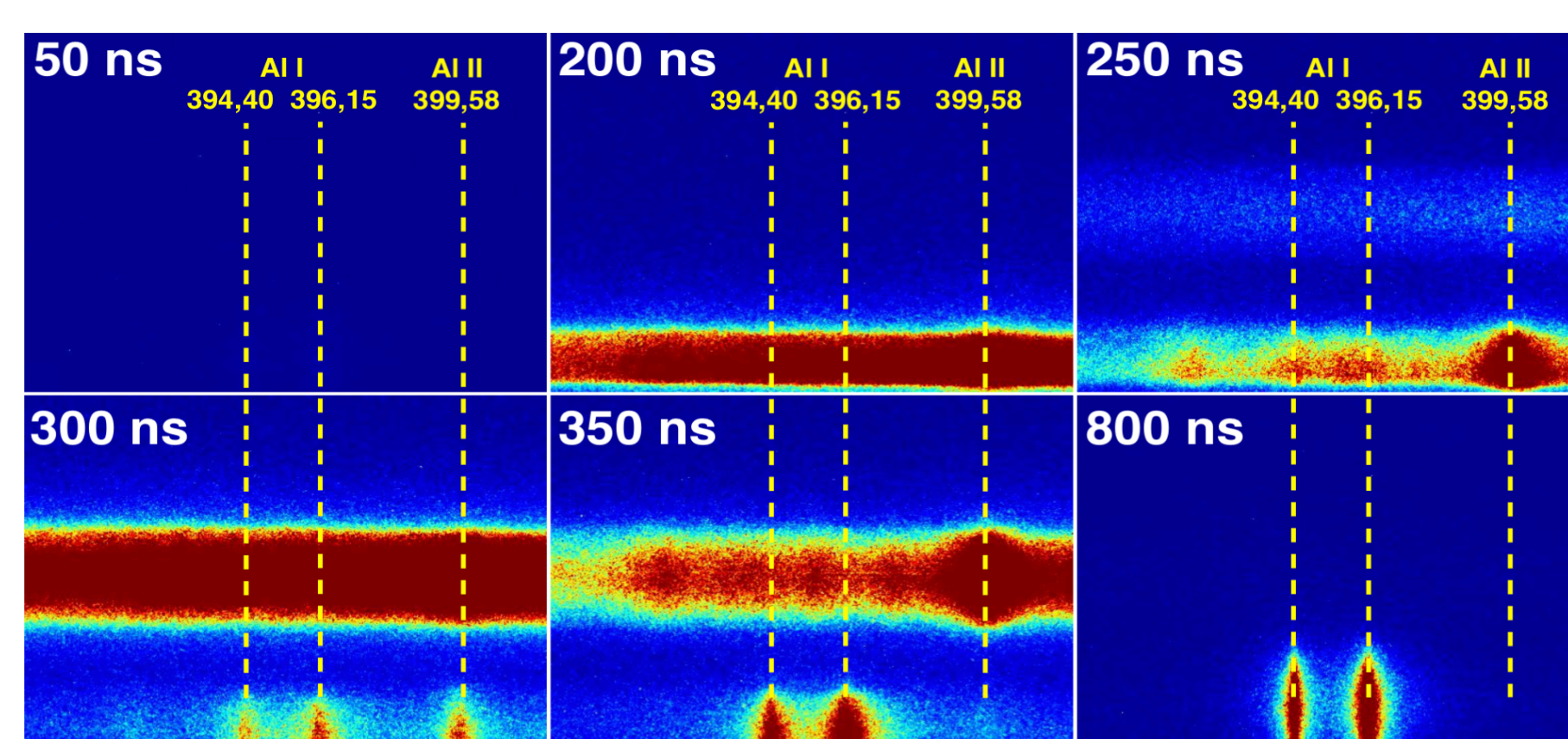


DP on AL

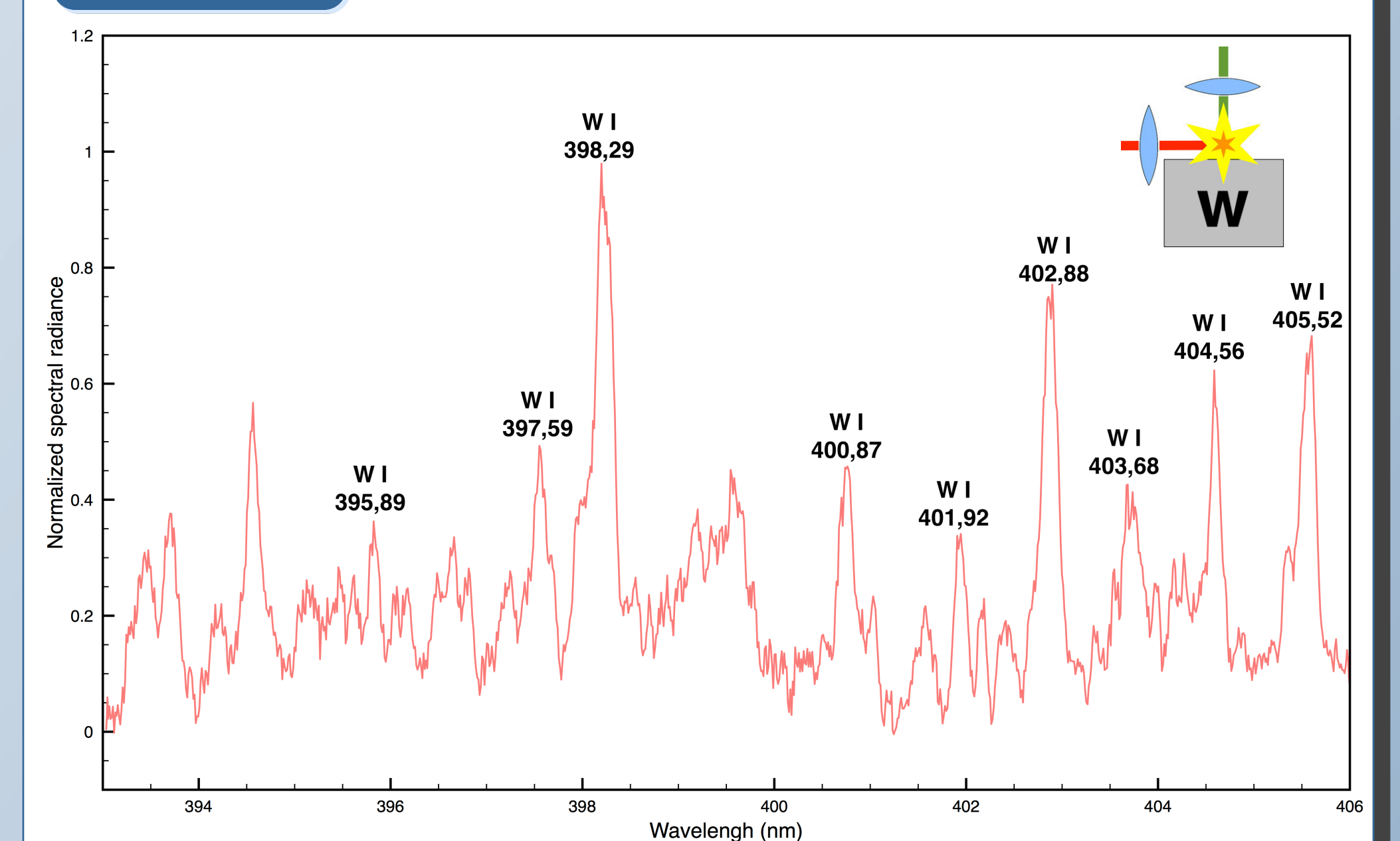


Comments

- Al II lines only observed in double pulse.
- Recombination significant (ionic emission decreasing for the benefit of atomic one's).

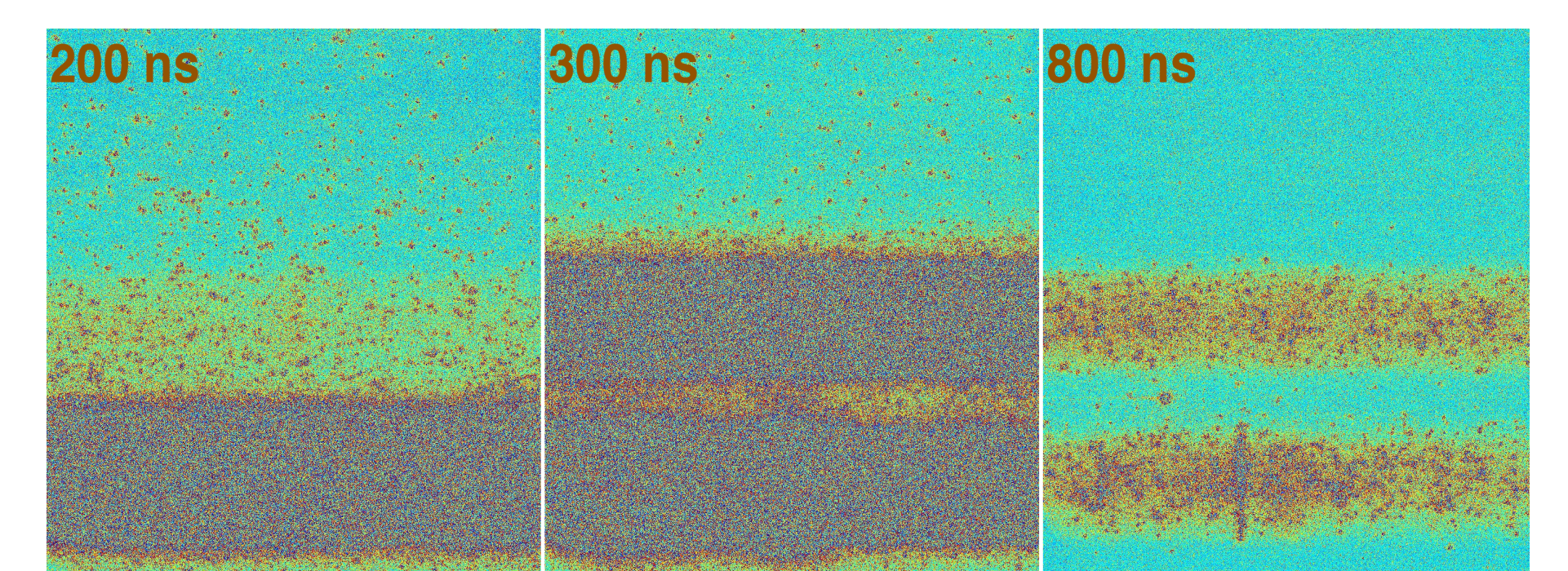


DP on W

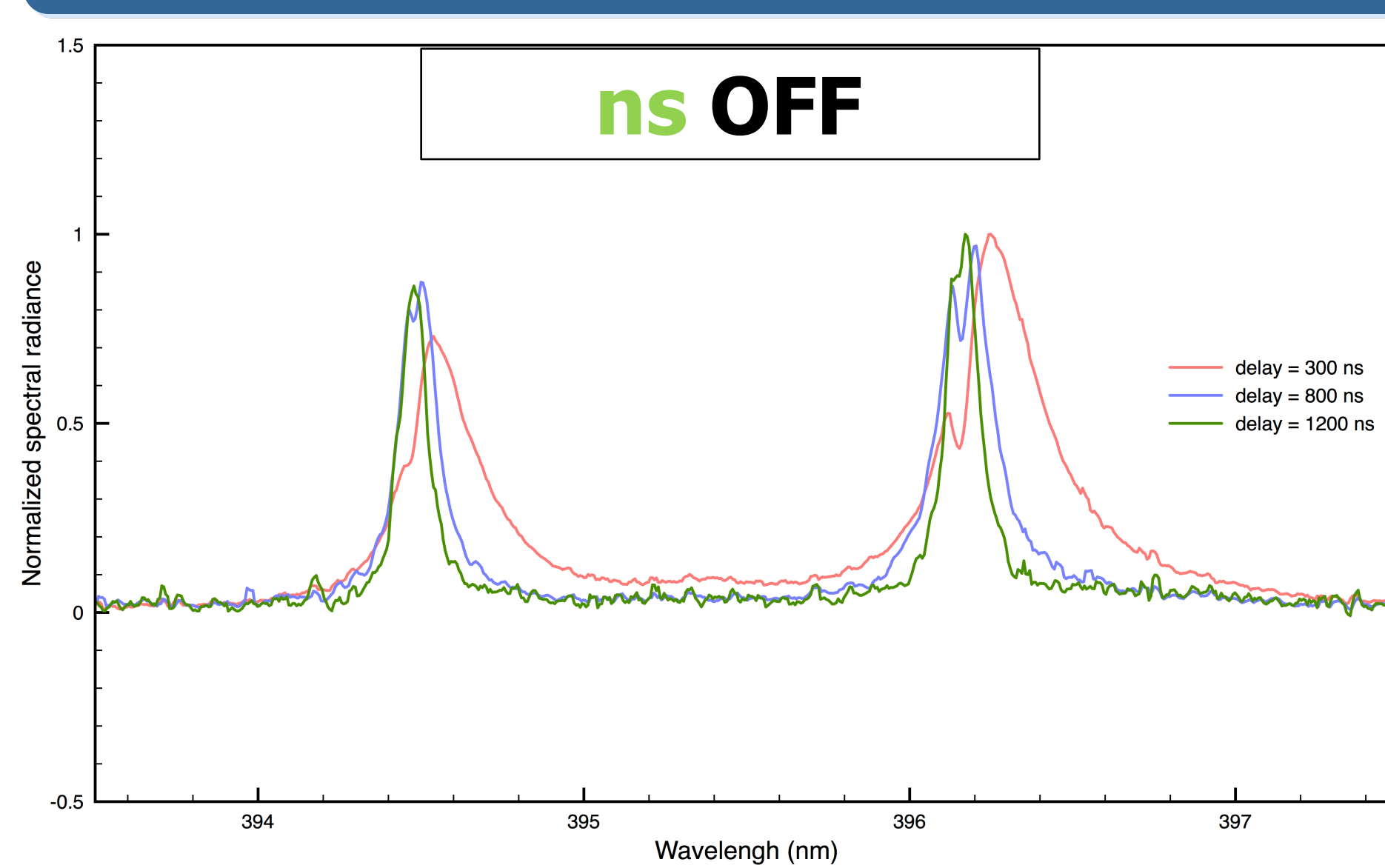


Comments

- Tungsten significantly radiates, transitions identification is tricky.
- Emission spectra obtained from spectroscopic imagery.
- Computed spectra will be performed to accurately identify the emission lines observed.



Laser-Induced Ablation Spectroscopy (LIAS)

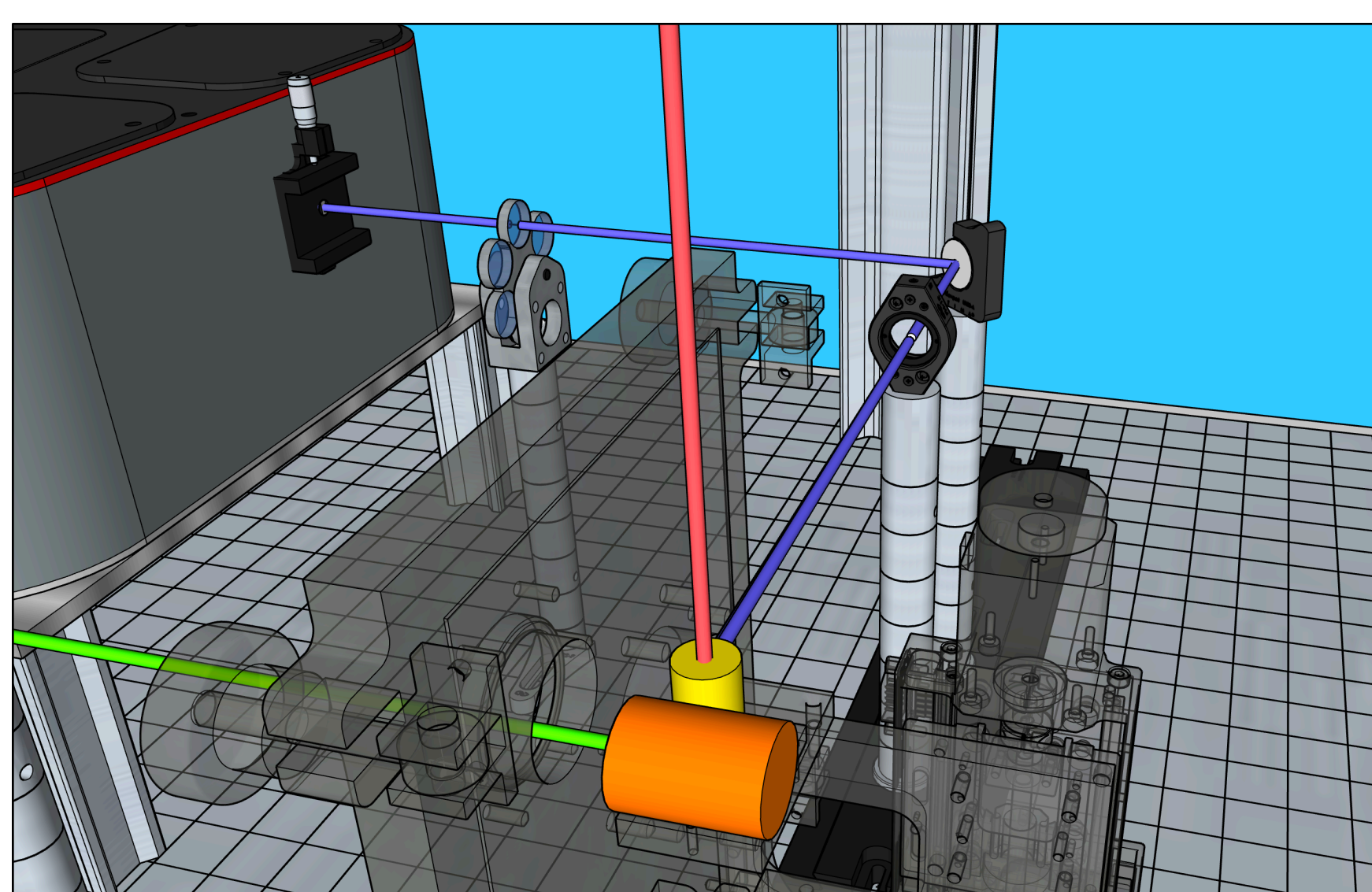


Comments

• In [ns OFF] configuration, we observe *emission spectra*. As Al I 394.40 nm and Al I 396.15 nm are the resonance doublet, auto-absorption is noticed.

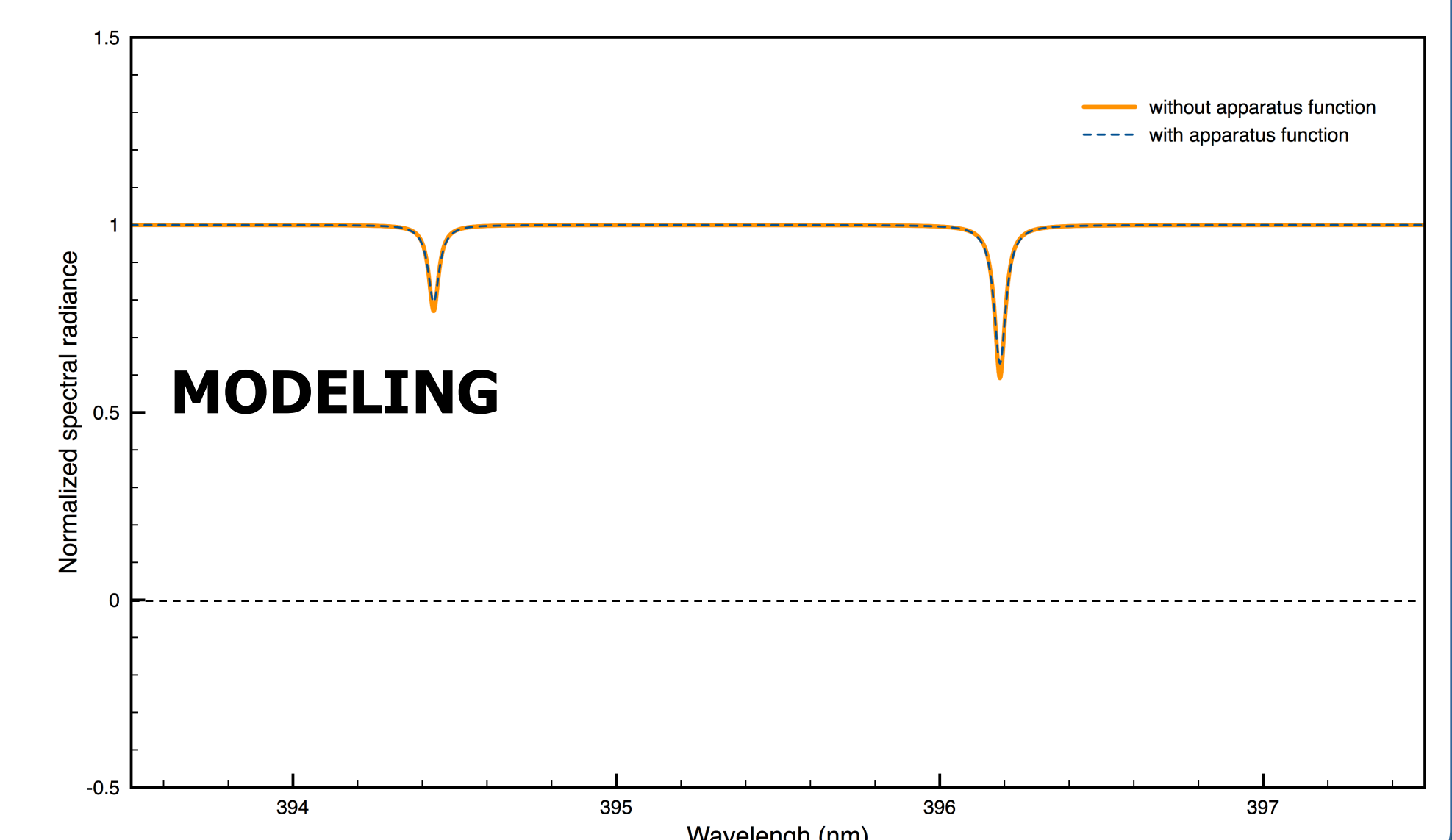
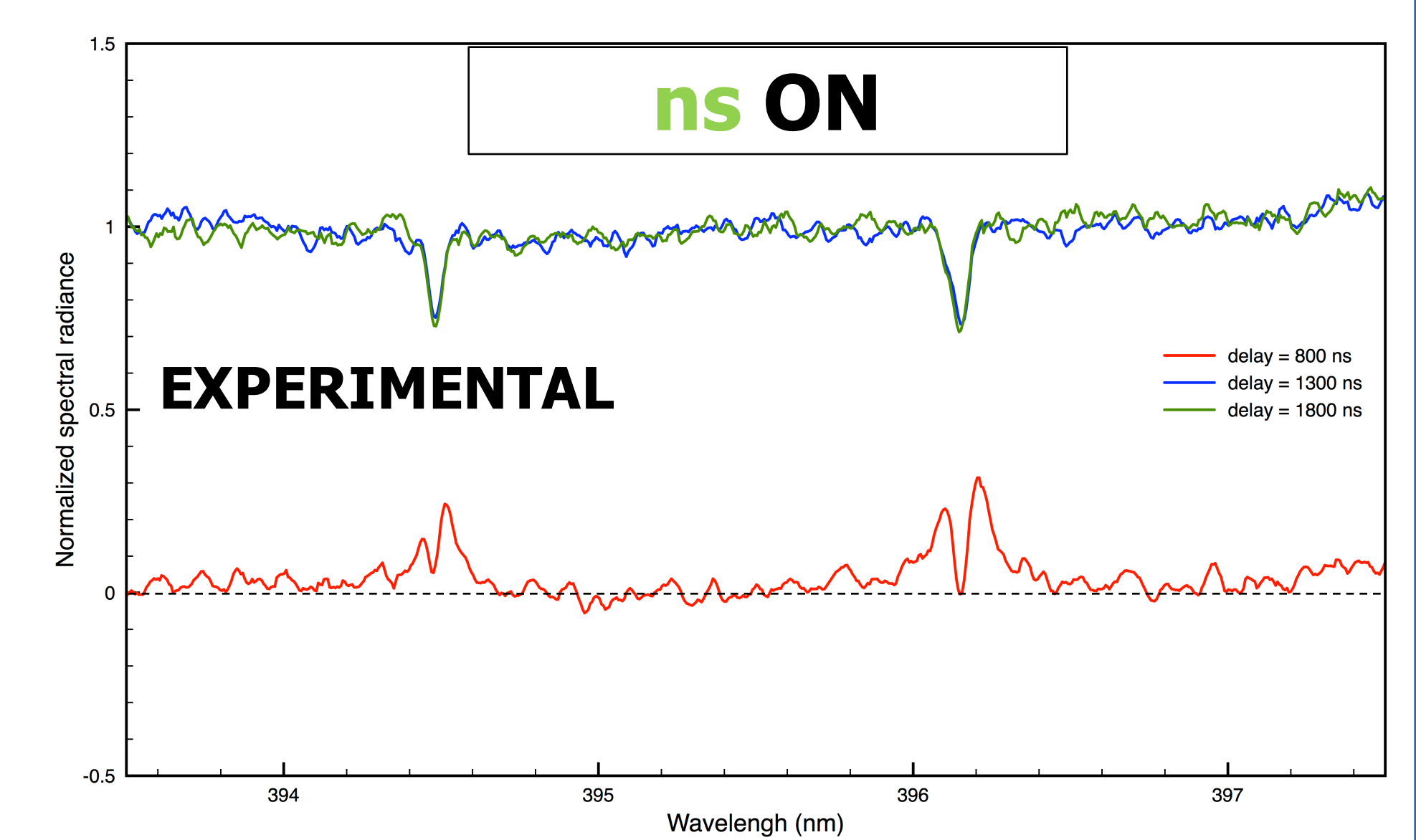
• In [ns ON] configuration, we can observe *absorption spectra*. Absorption is only significant for delay $\geq 1.2 \mu\text{s}$.

- Those absorption lines can be fitted with:
 Electron density $n_e = 2 \times 10^{23} \text{ m}^{-3}$
 Electron temperature $T_e = 10\,000 \text{ K}$
 Ground state number density $[N_i] = 3.5 \times 10^{20} \text{ m}^{-3}$
 External spectral radiance $L_{\text{ext},\lambda} = 10^{13} \text{ W m}^{-2} \text{ sr}^{-1} \text{ m}^{-1}$



The experimental setup used for LIAS is rigorously the same as described above except that the second pulse is spatially translated.

We obtain two plasmas temporally shifted by a delay: **ps plasma** and **ns plasma**.



CONCLUSIONS & PERSPECTIVES

- Effective temporally and spatially controlled double pulse setup.
- Detection limits are sorely enhanced, output signal is at least 5x multiplied.
- Possible determination of electron density and electron temperature.
- Possible characterization of lower states by absorption spectra.
- Accuracy can be strongly improved by working with a higher spectral resolution and signals with accumulations.
- Detection of light elements such as H isotopes in heavy matrices like W remains our long-term objective.