Plasma emission monitored via optical emission spectroscopy during the Cs conditioning at SPIDER

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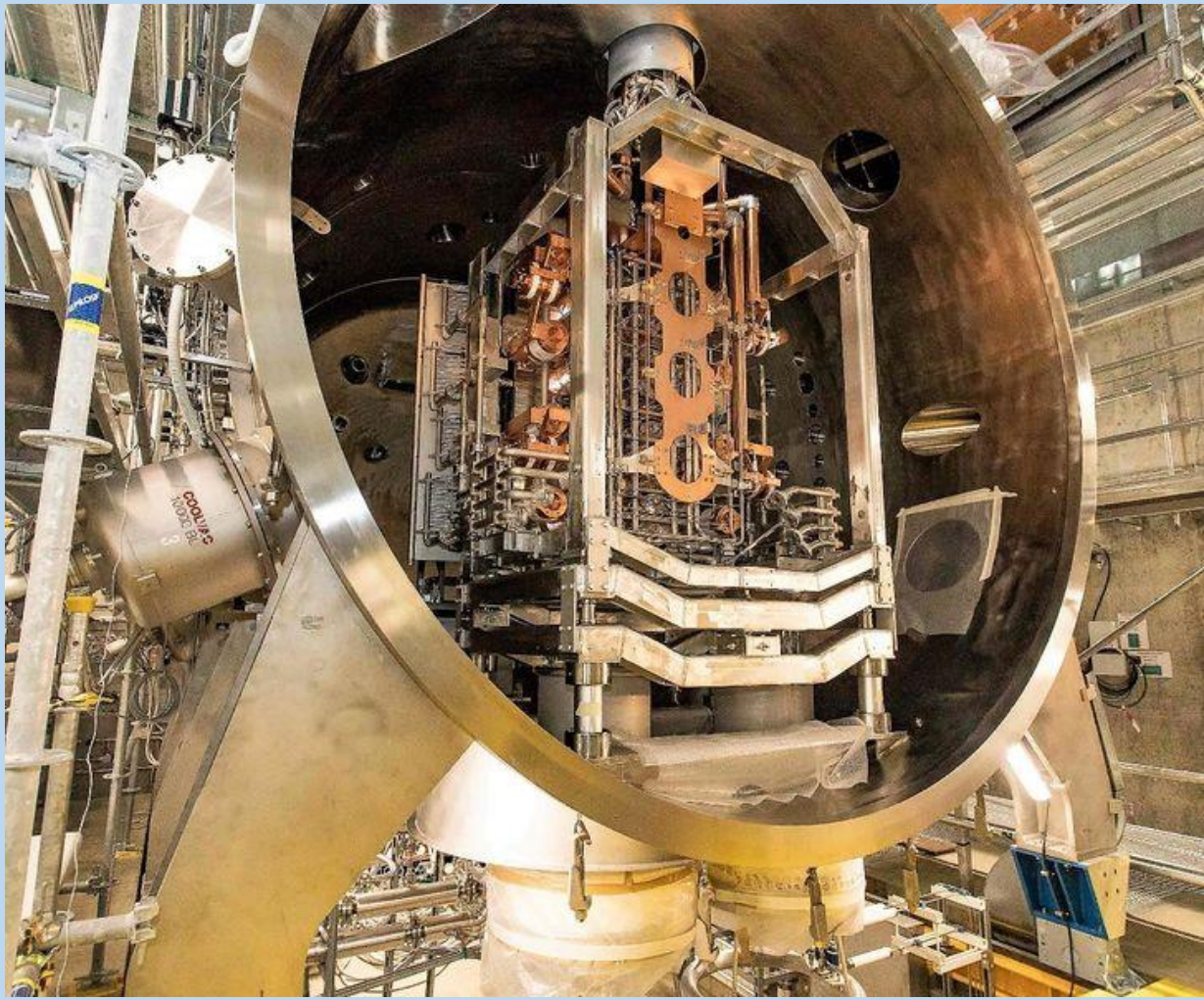
3. ISTP-CNR, Via Amendola 122/D, 70126 Bari, Italy

Corresponding author: isabella.mario@igi.cnr.it

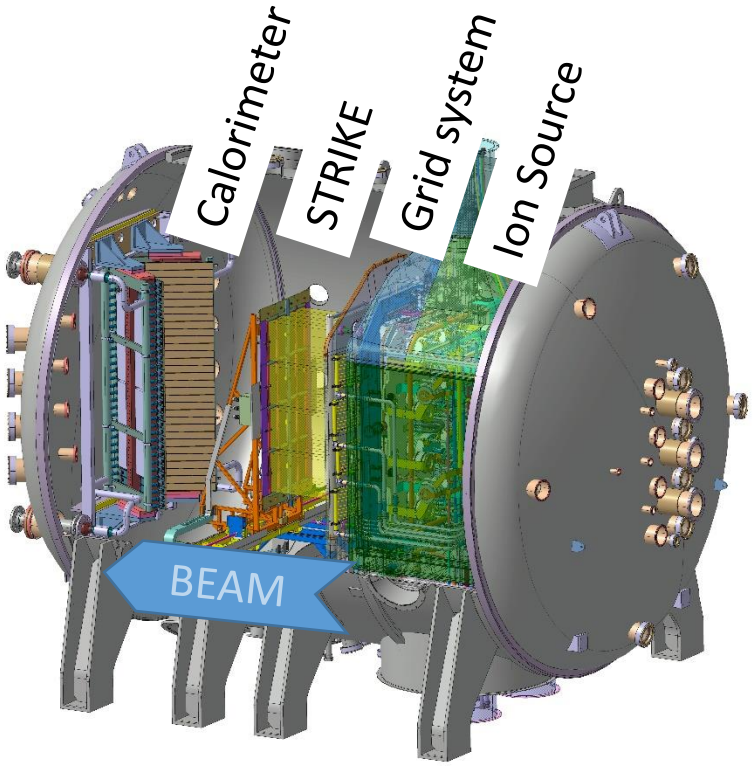


The SPIDER experiment

- Extraction and acceleration of negative ions (H^-/ D^-) produced in a RF-driven plasma
- Operation: macro-pulses in which several plasma and beam phases are performed at different duty cycles
- Magnetic filter field
- Source components biased

} Reduction of the co-extracted electrons

- Vertical plasma drifts
- Negative ions produced by surface production on surfaces covered with Caesium (Cs)
- Several plasma and beam and diagnostics available at SPIDER, capable of spatial resolution



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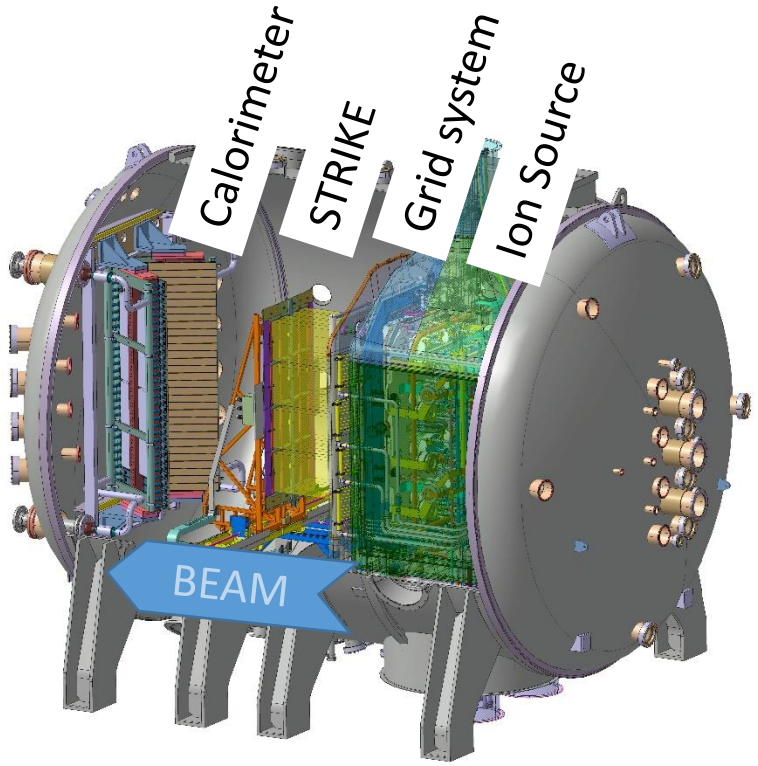
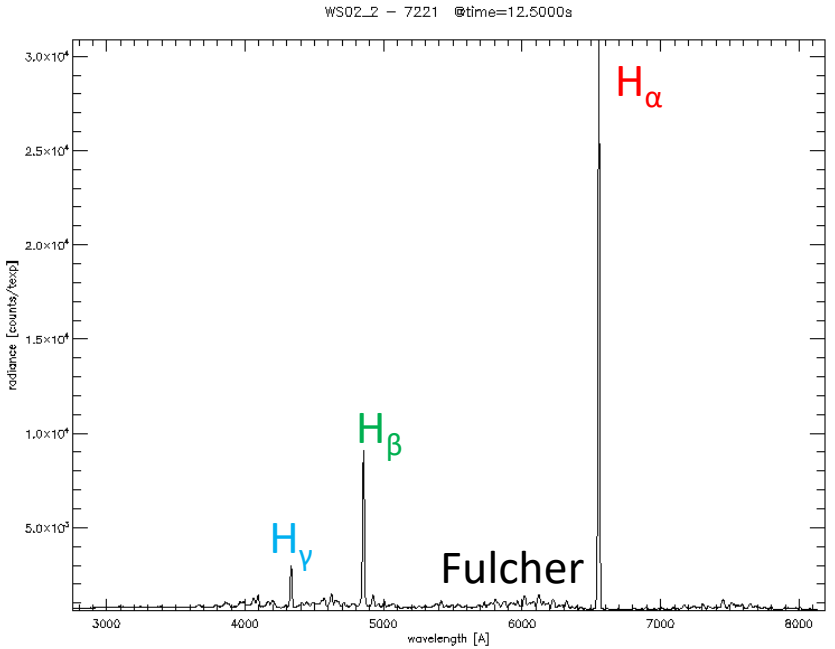


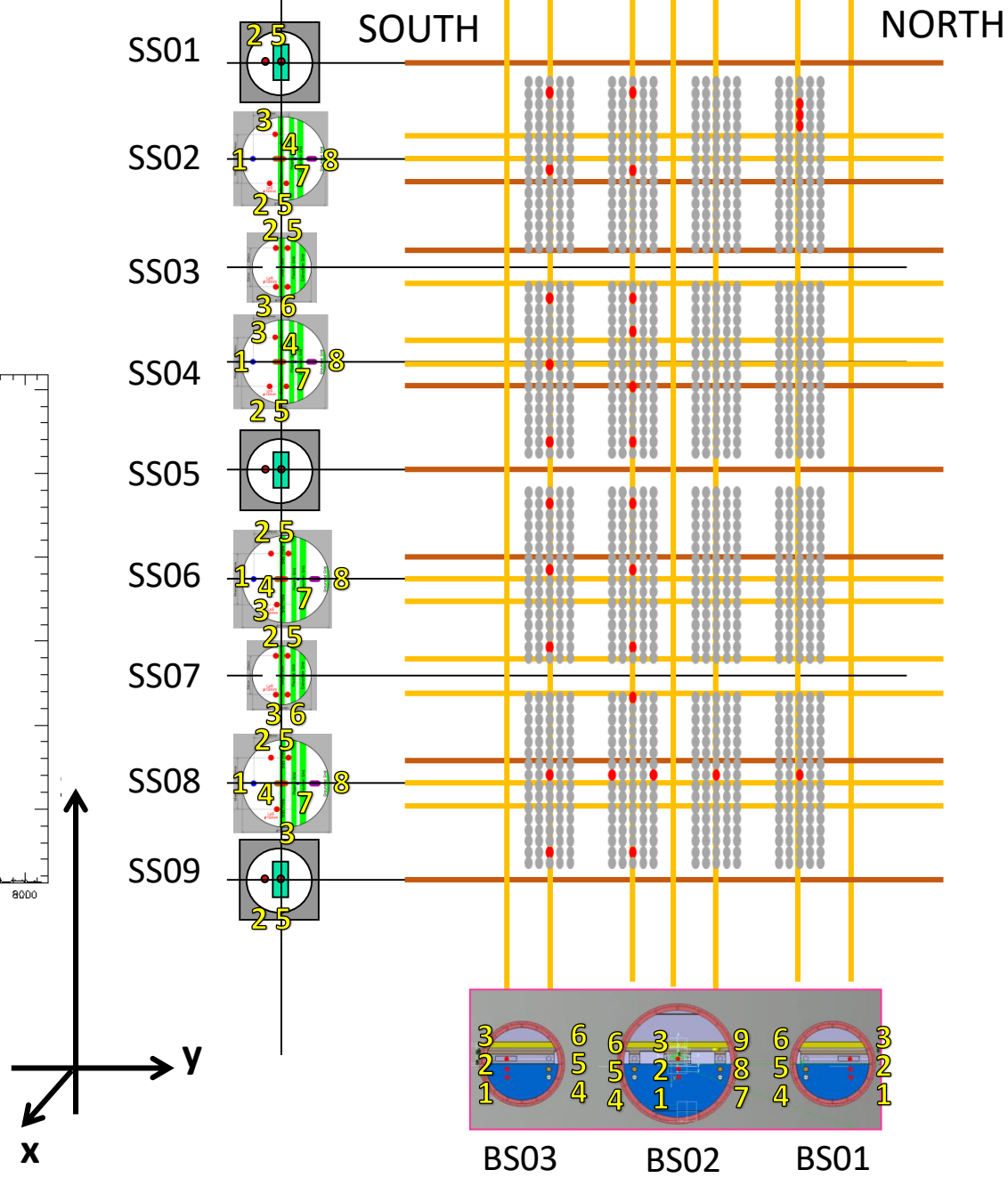
Plasma diagnostics: Optical Emission Spectroscopy

Conditioning phase at SPIDER: operational phase, in which the beam performances are enhanced by injecting Cs into the ion source

Experimental setup

- PG mask with 28 apertures
- 8 horizontal LOS available for OES





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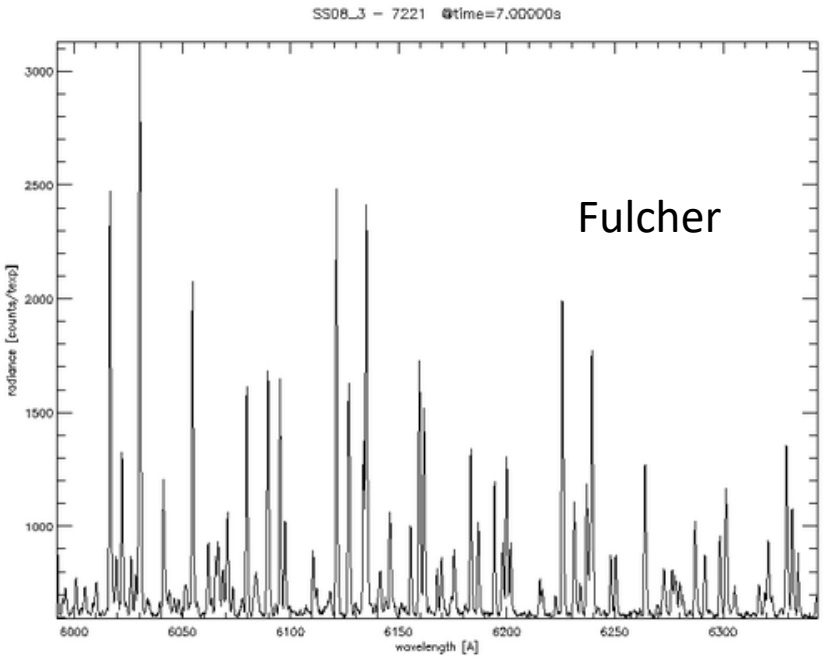

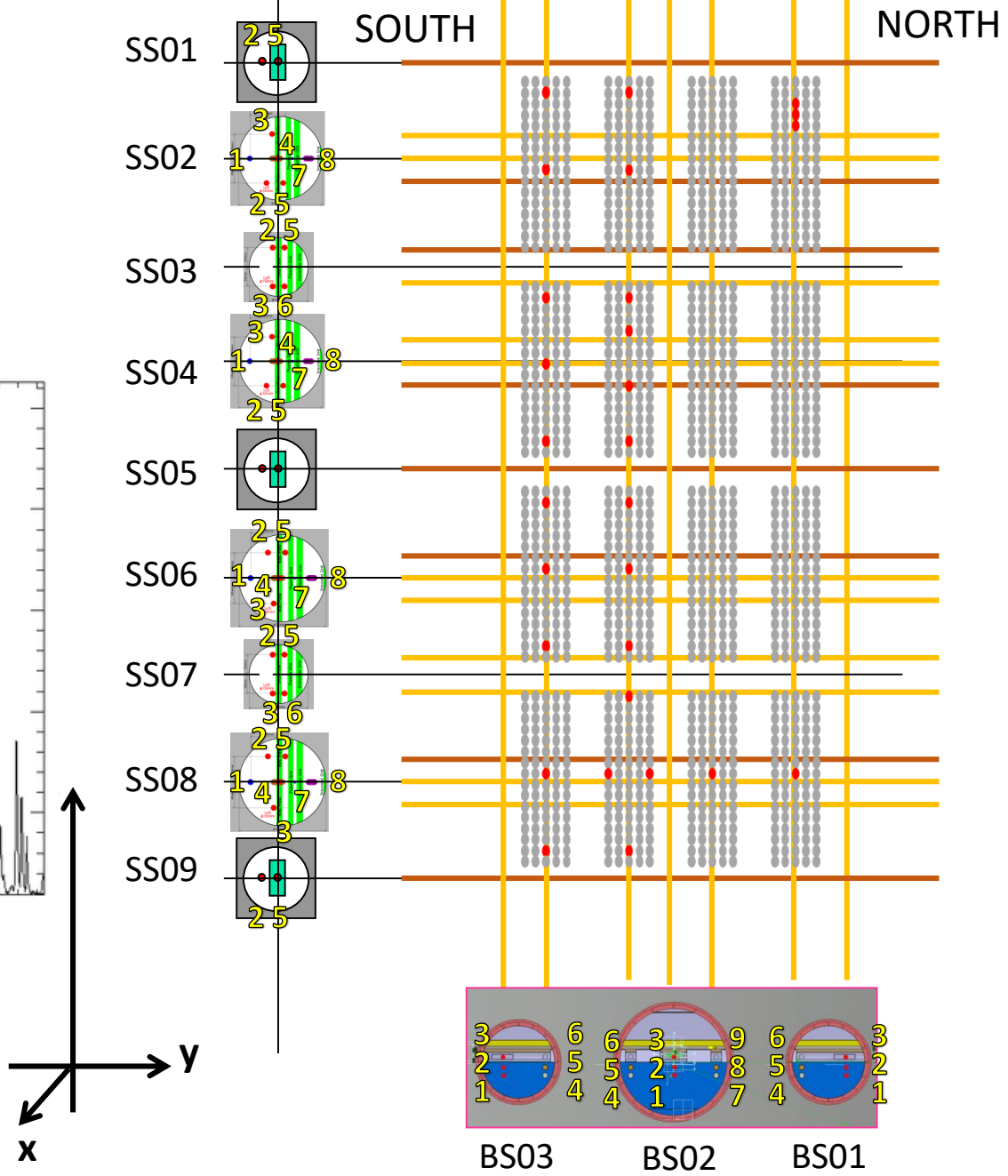

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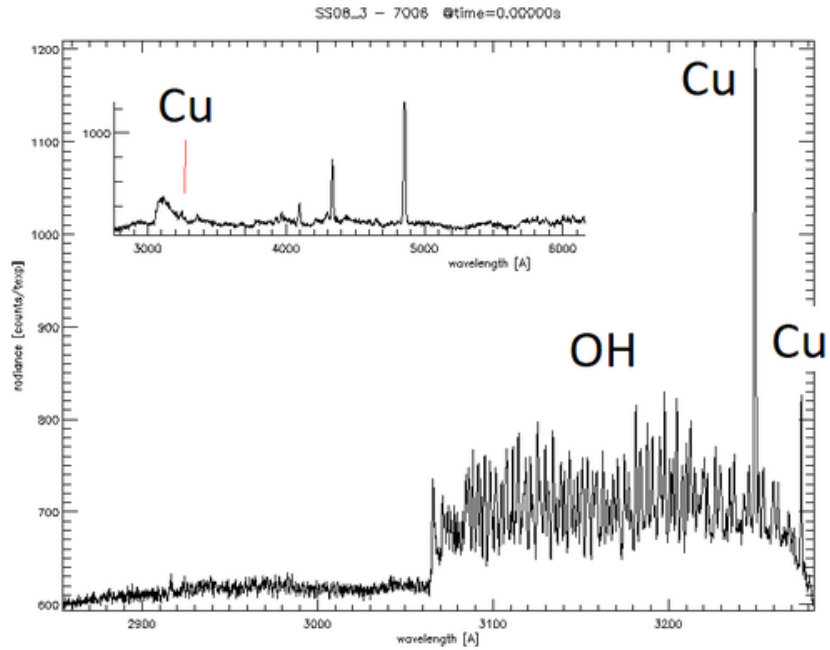

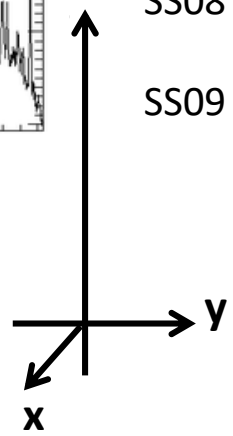

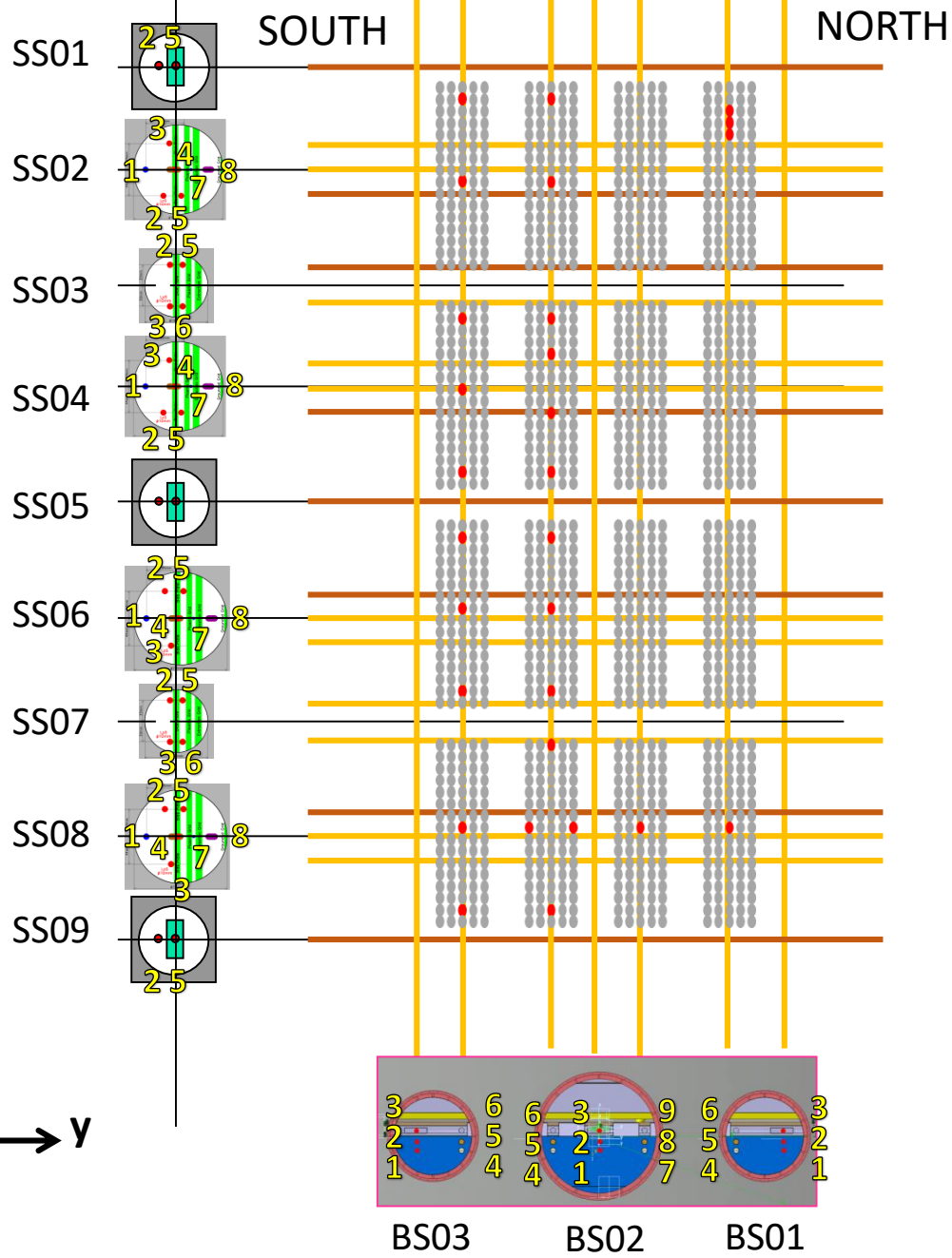

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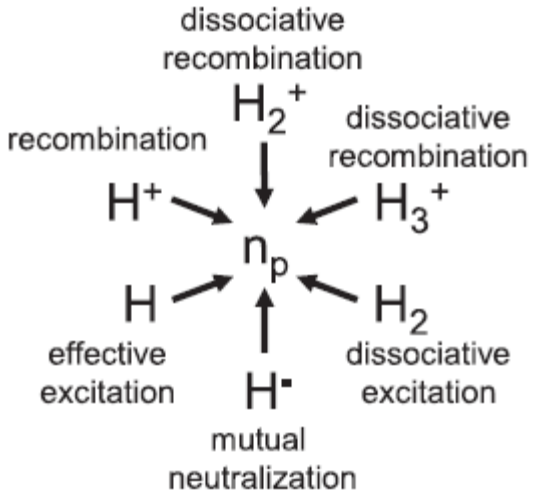
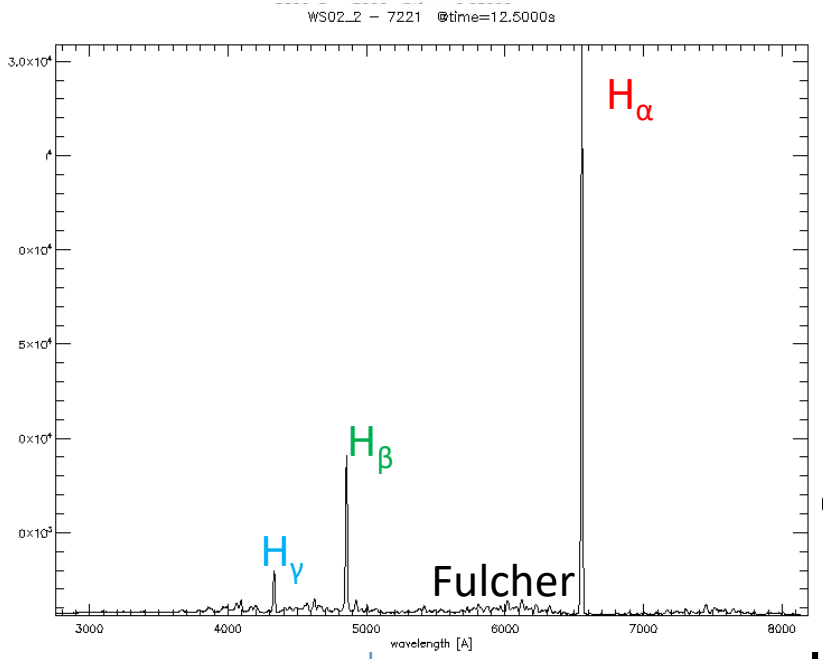
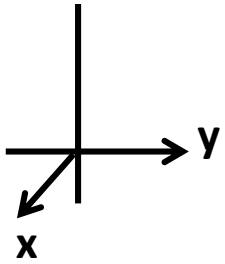
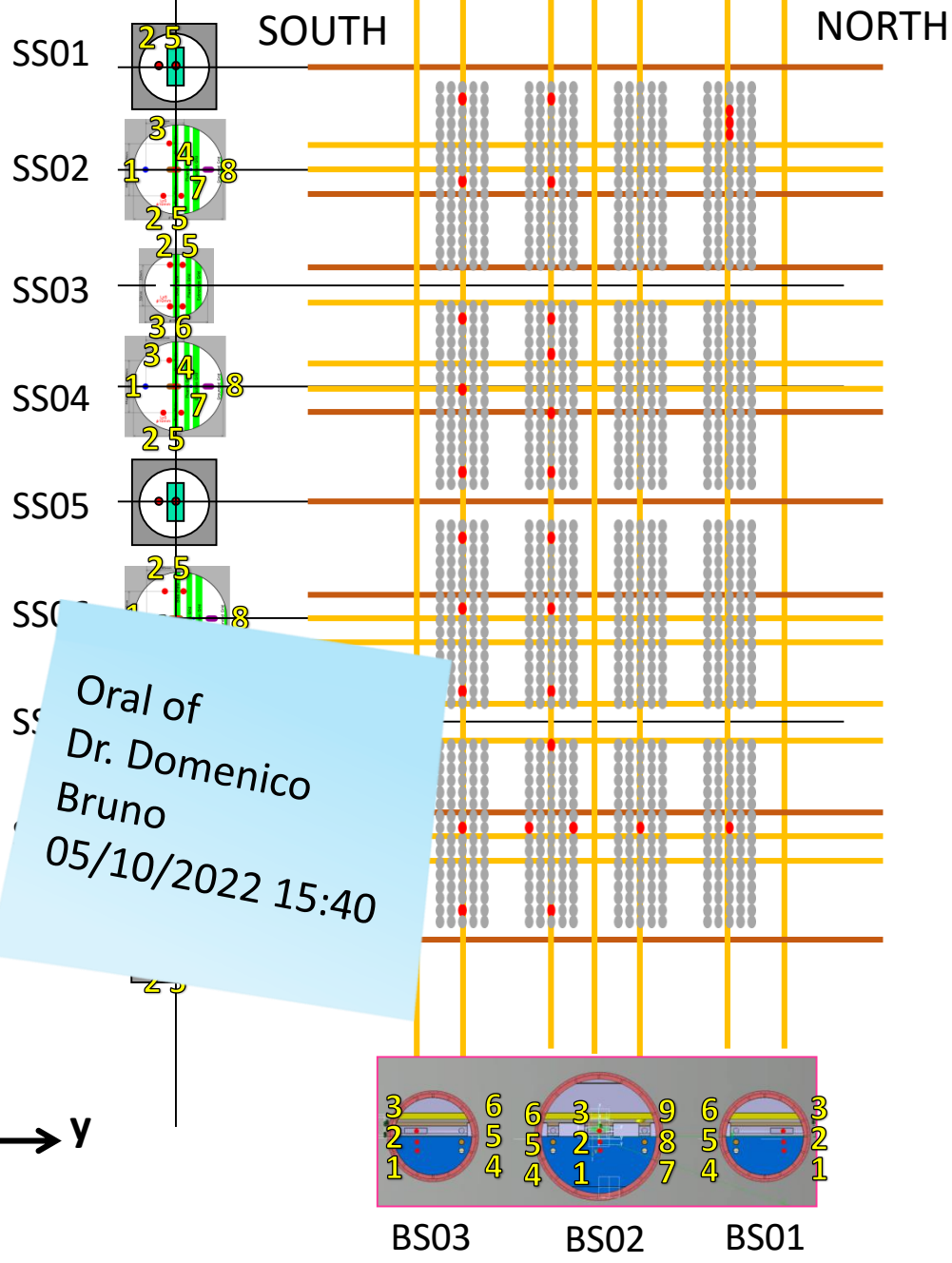
[Journal of Quantitative Spectroscopy & Radiative Transfer 110 (2009) 62–71]





Plasma parameters available through application of CR models

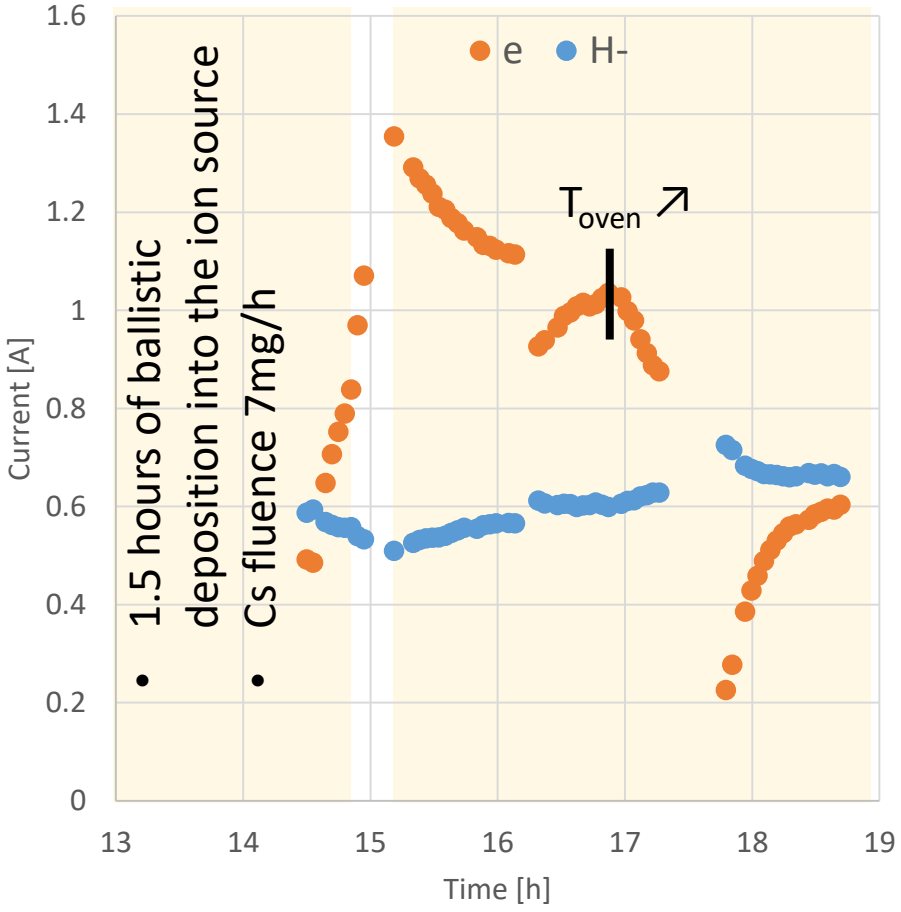




Oral of Dr. Domenico Bruno 05/10/2022 15:40

First day of Cs conditioning

Pulse parameters: 270 kW
1.5 kA (2.4 mT)
80 A biasing current (BP+PG)
5 - 38 kV U_{ext}-U_{acc}



Two power supply (ISEG and AGPS) in use for the extraction and acceleration system at SPIDER can measure the electrical current:

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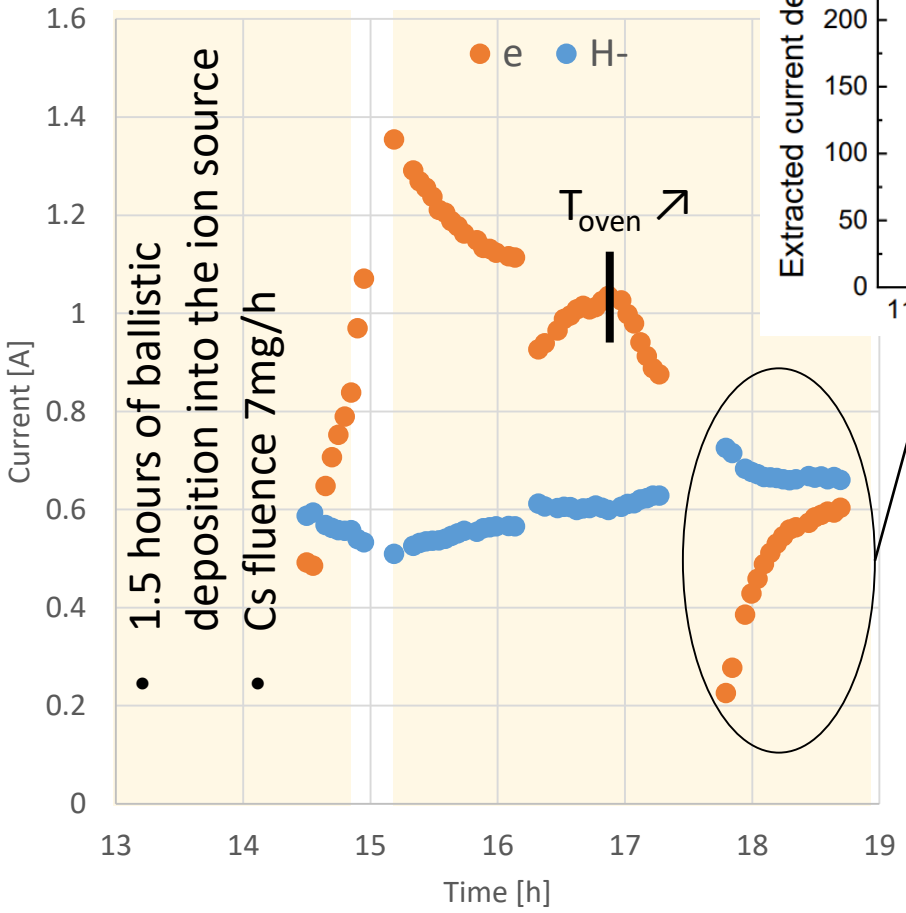

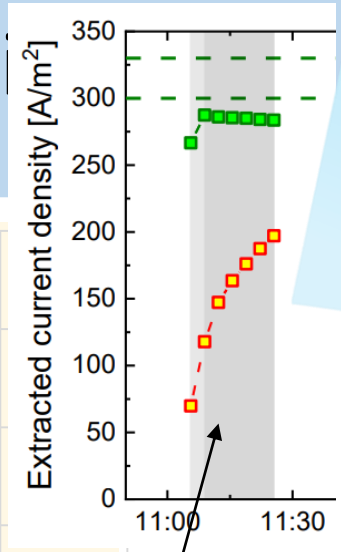

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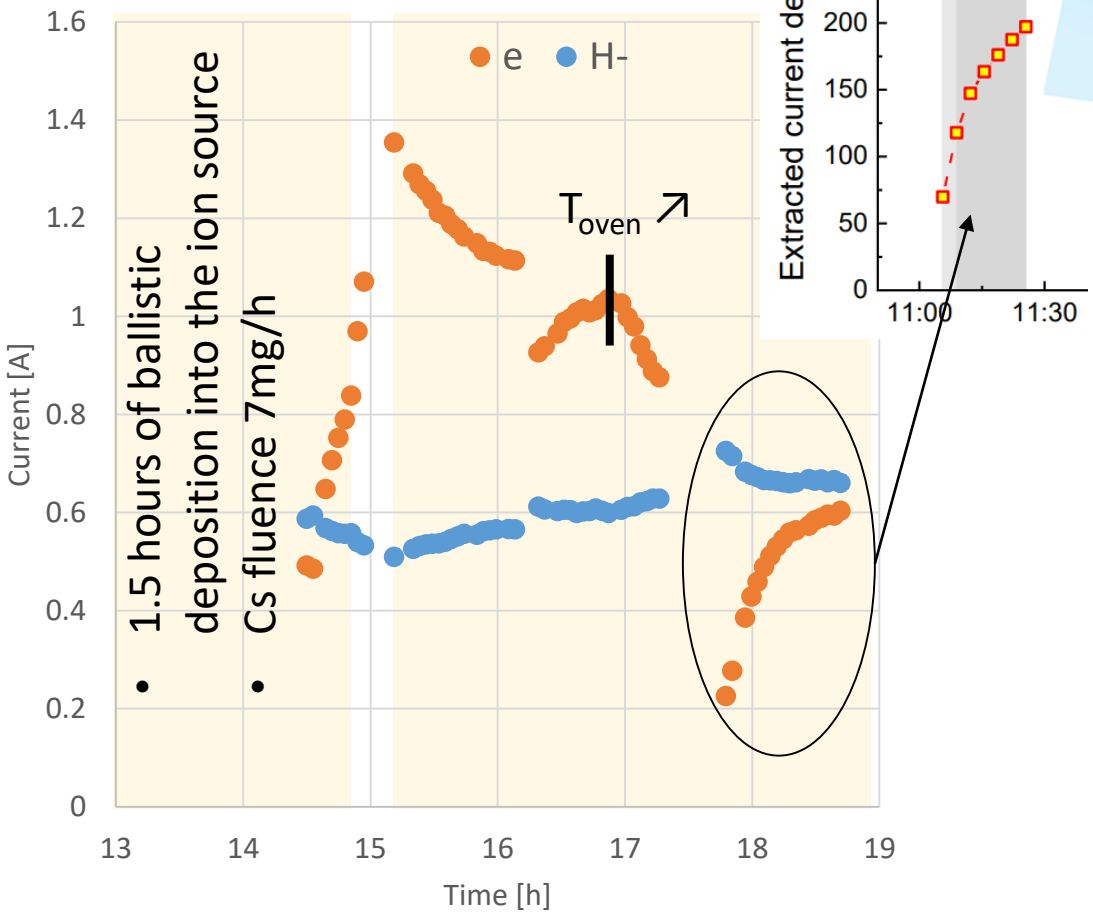

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Effect of deconditioning/conditioning/redistribution

Long break between pulses has a strong effect on the electron current

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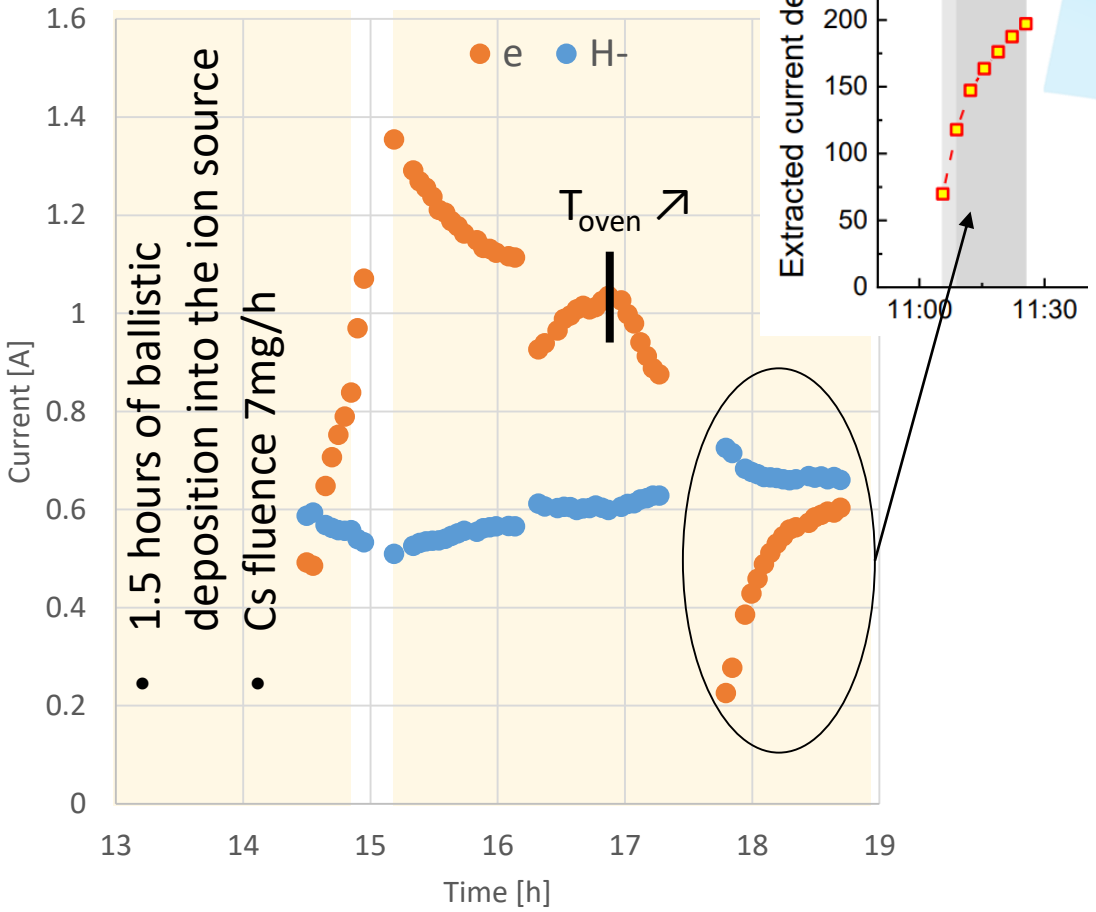

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Fast response of the ion source performances on the Cs dynamics

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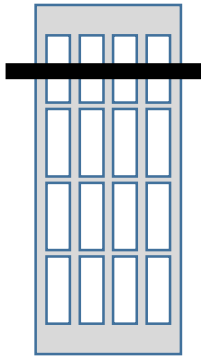

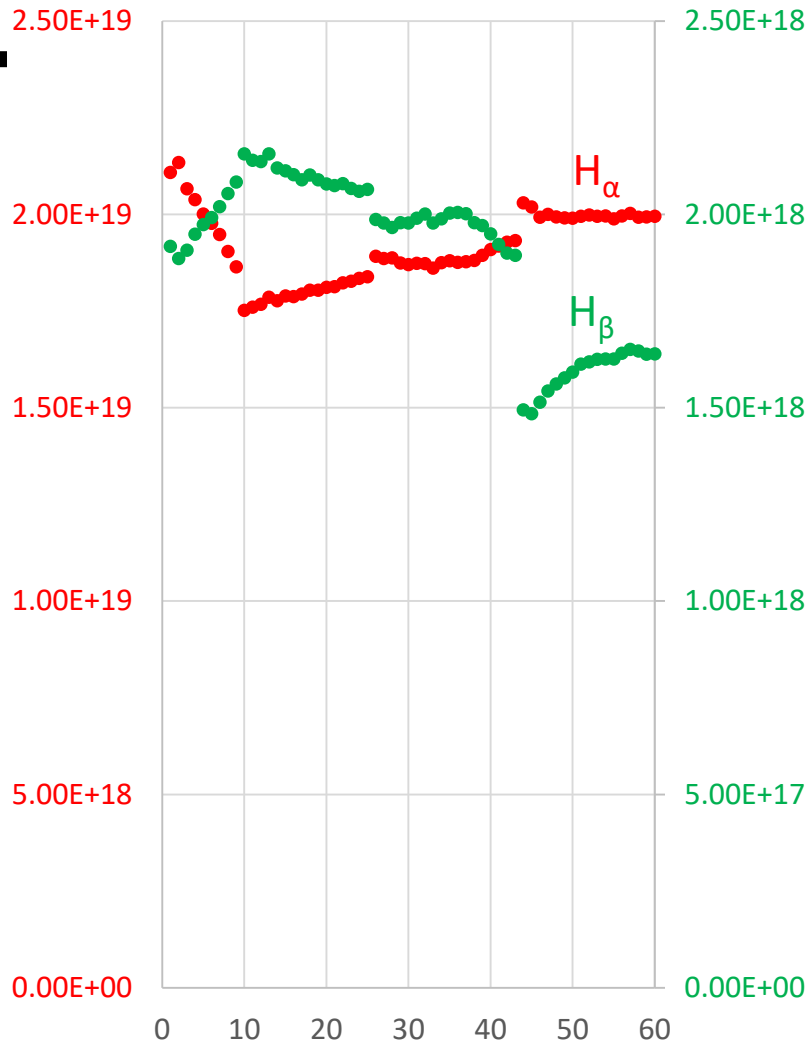

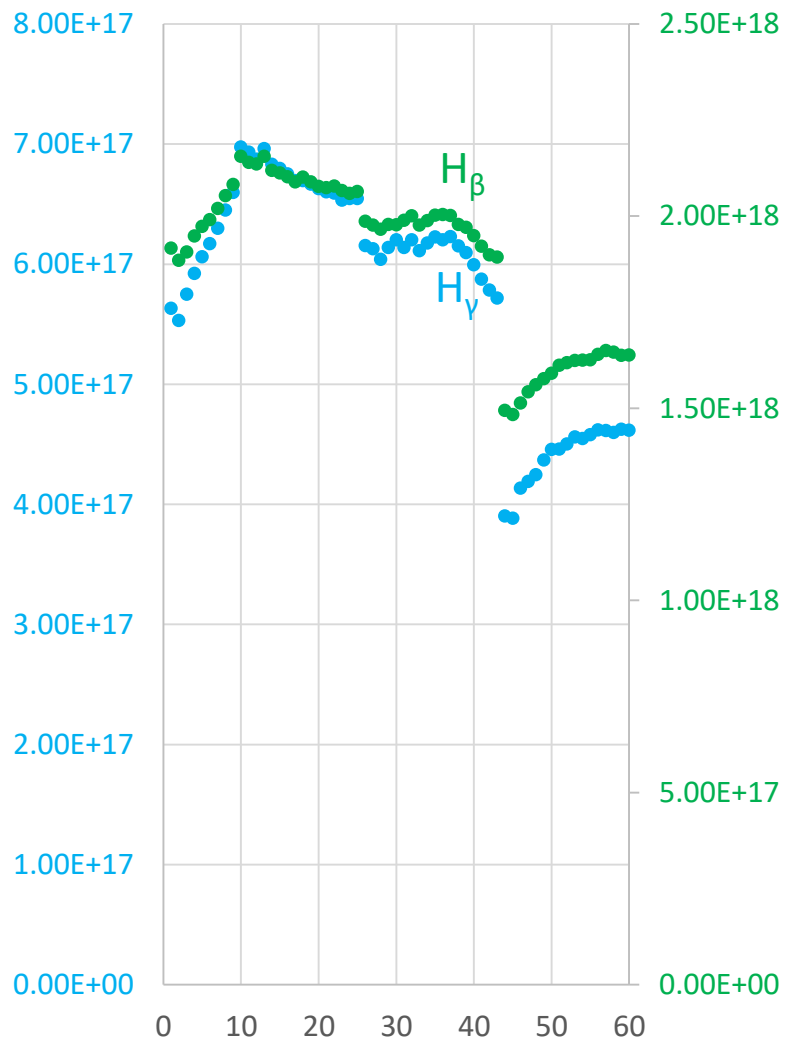

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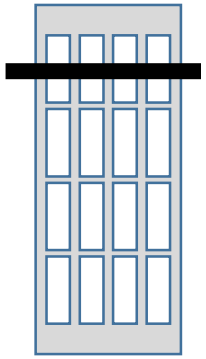
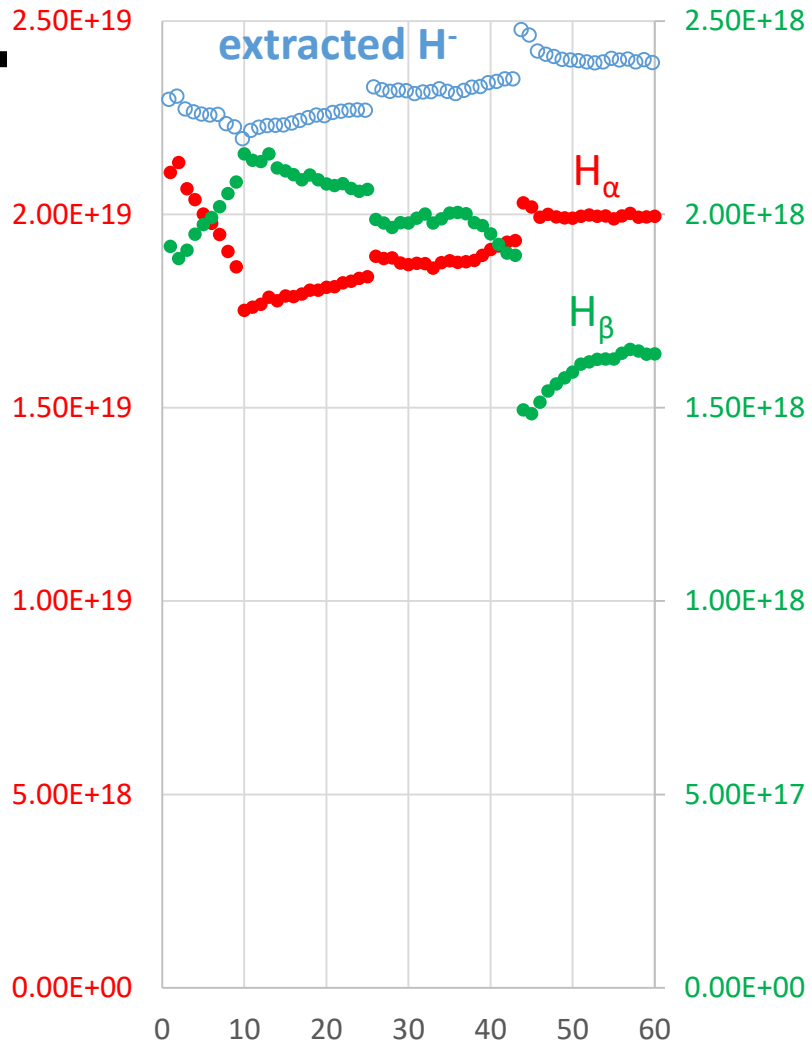
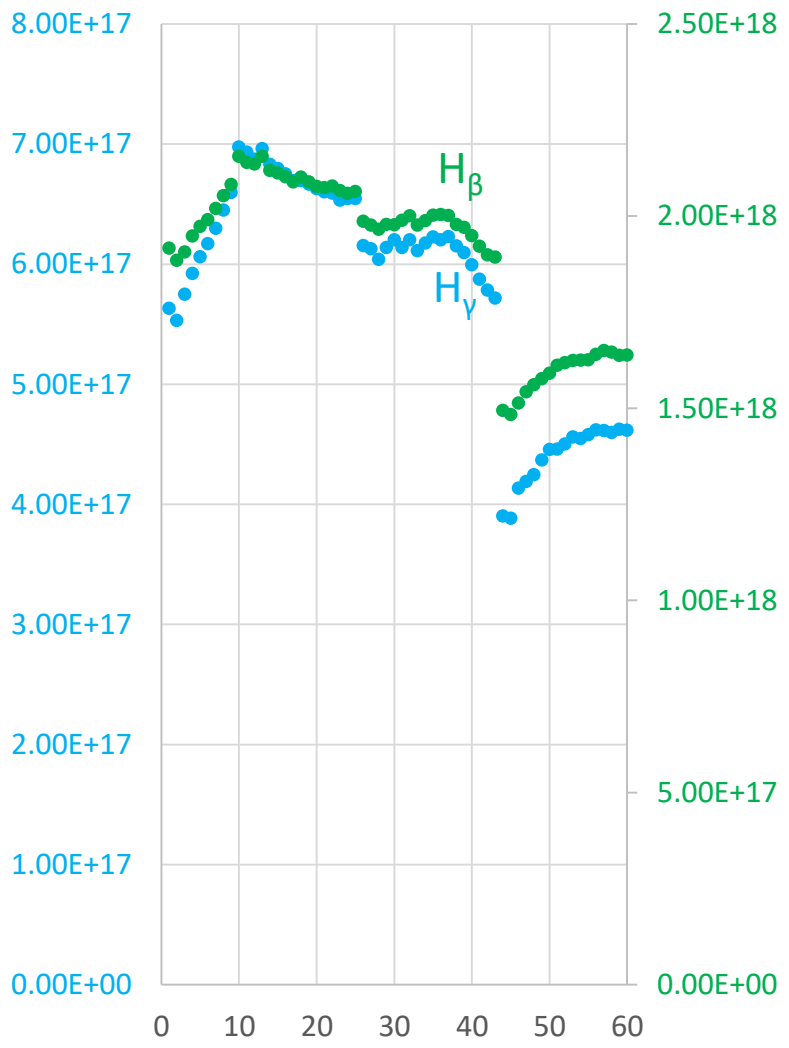




Trend of H_α close to **extracted H^- current**



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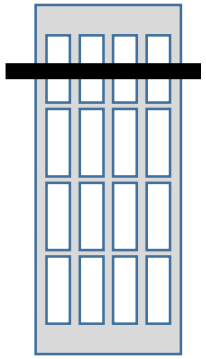
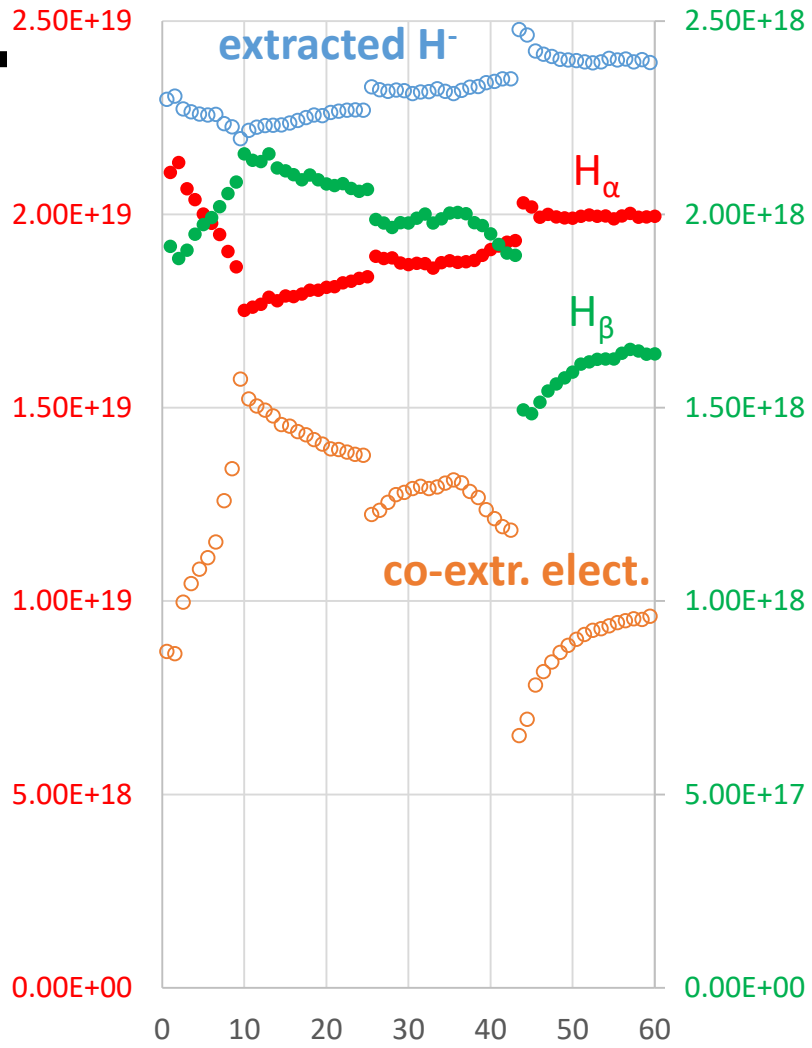
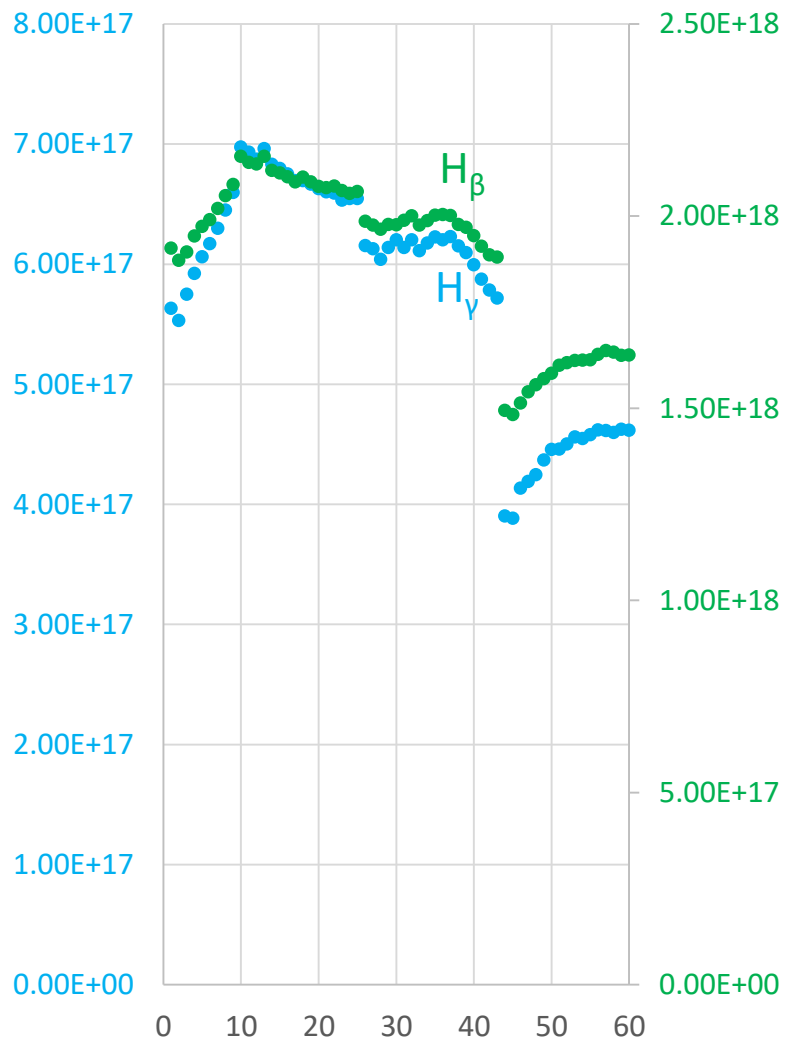




Trend of H_α close to **extracted H^- current**

H_β and H_γ similar to **co-extr. elect.**



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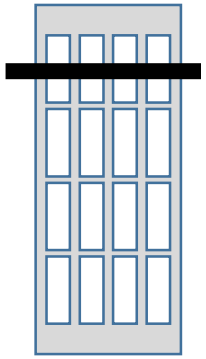
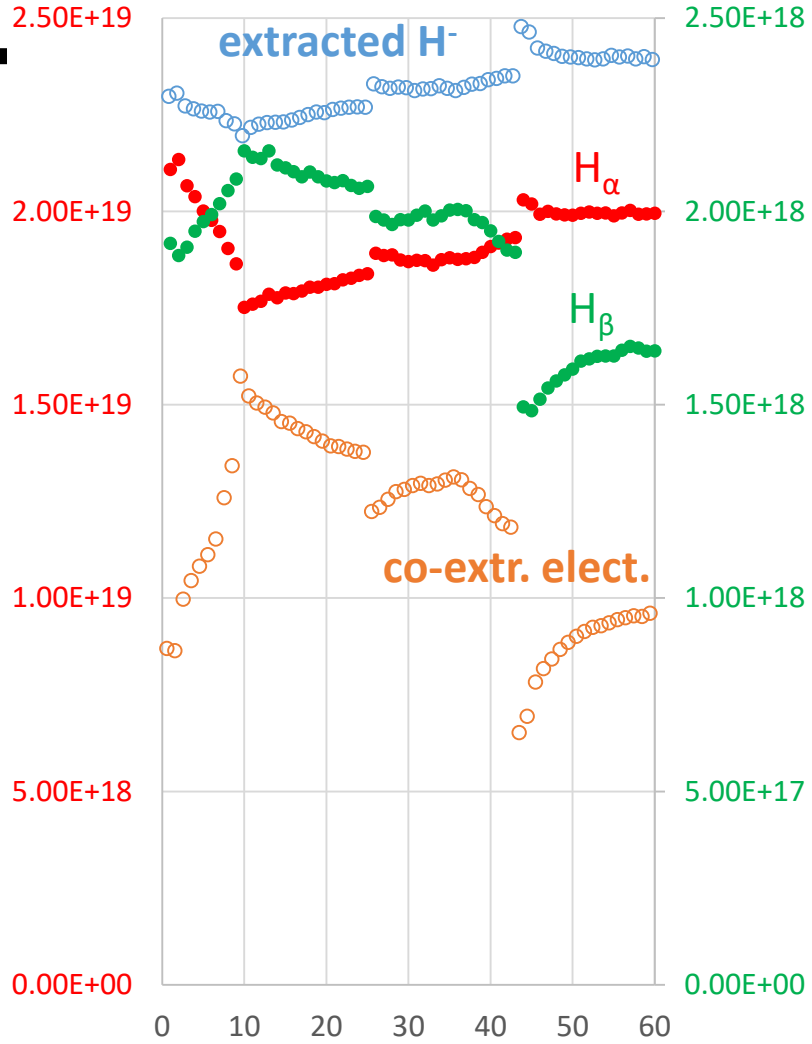


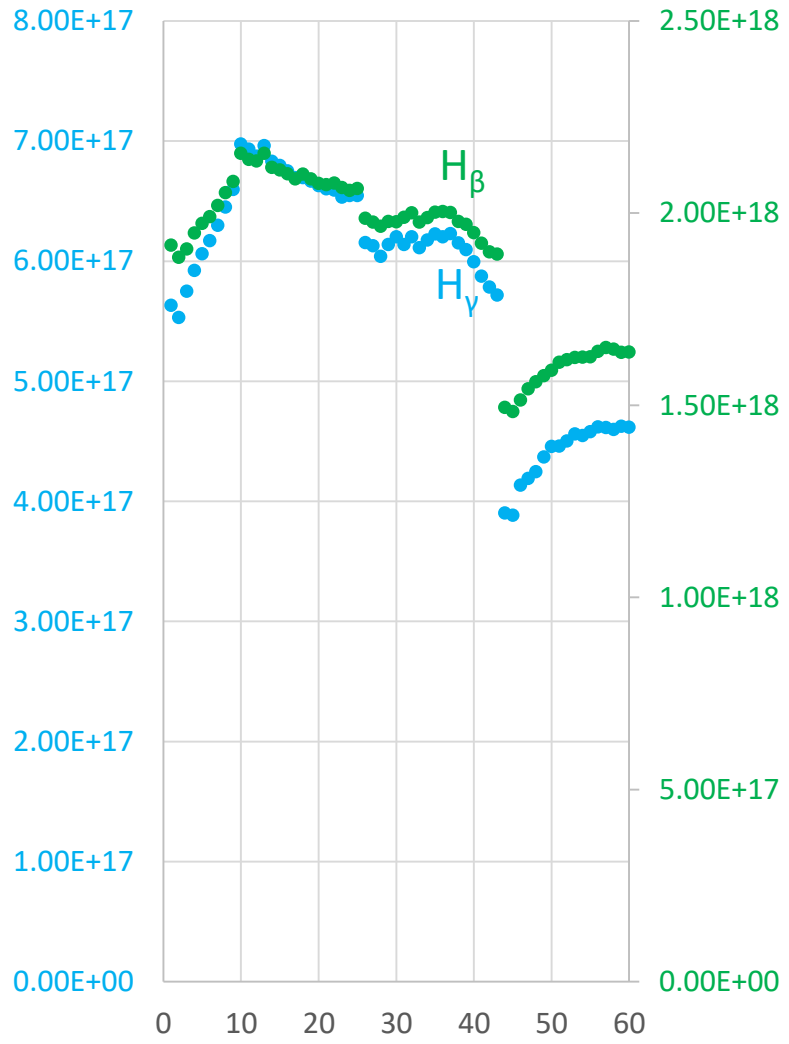


Trend of H_α close to **extracted H^- current**

H_β and H_γ similar to **co-extr. elect.**

H_α/H_β > 10 strong influence of the negative ion on the emission

H_β/H_γ is increasing with time



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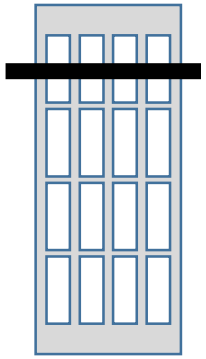

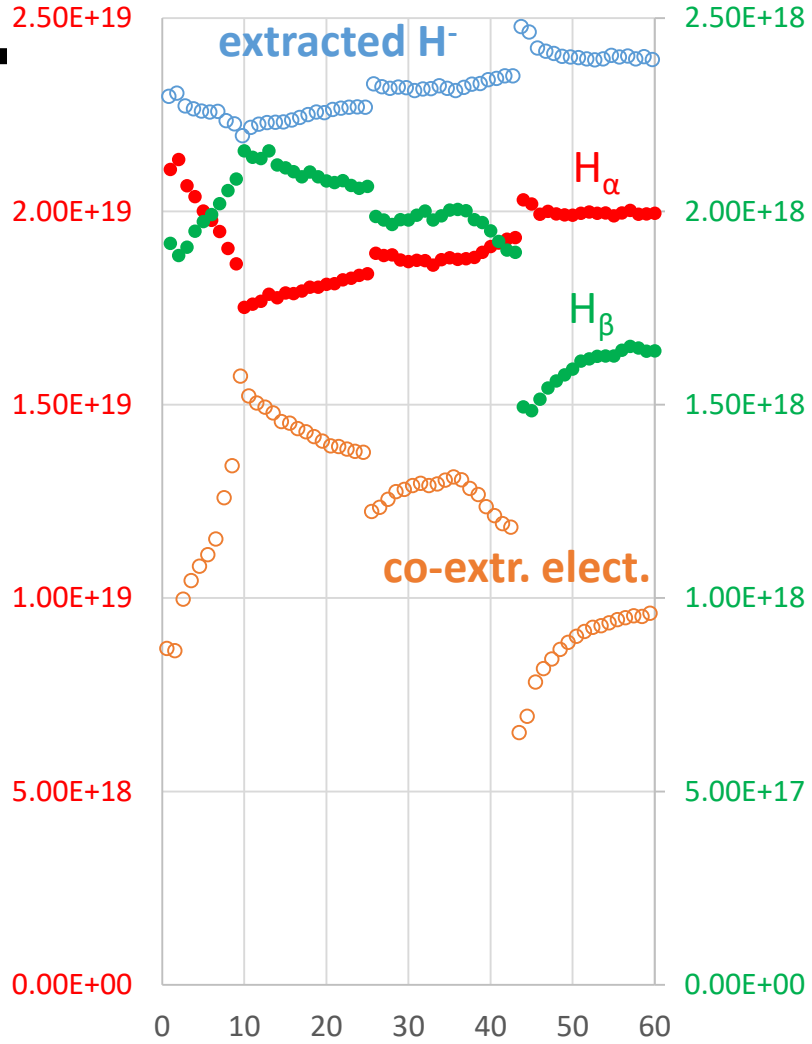

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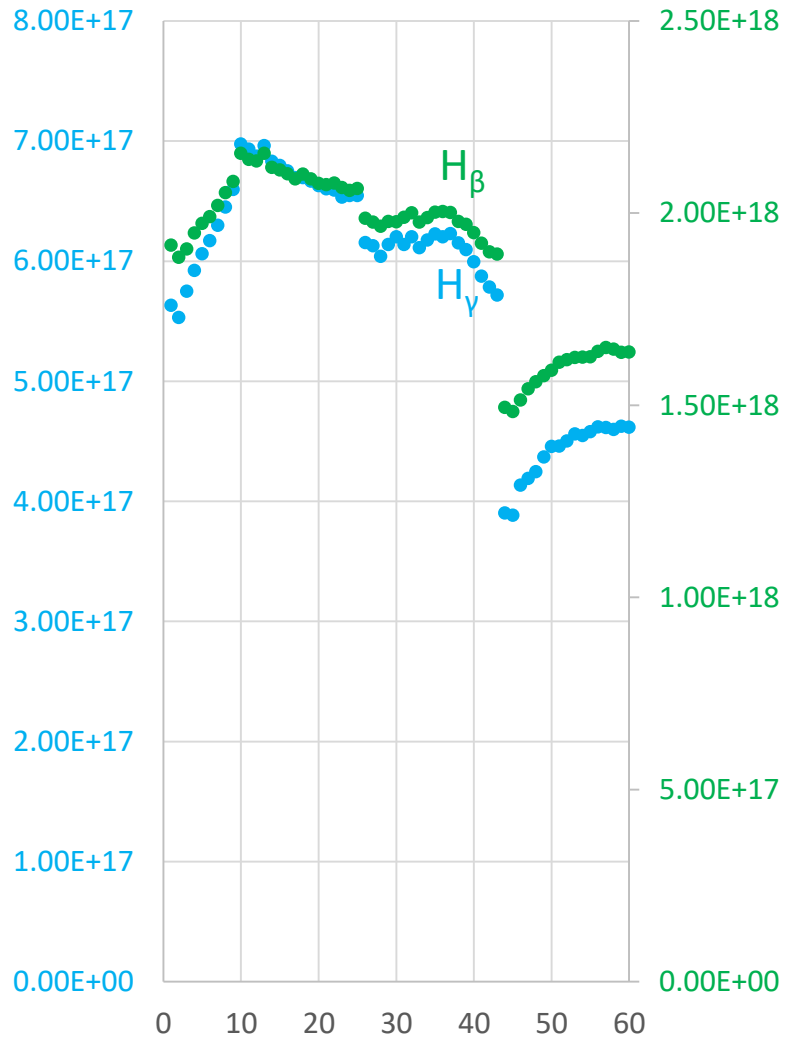
Plasma emission dominated by recombining processes



Vertical comparison on H_β

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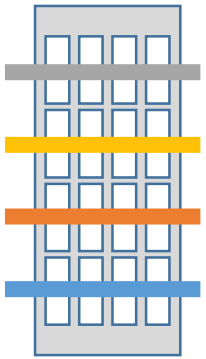

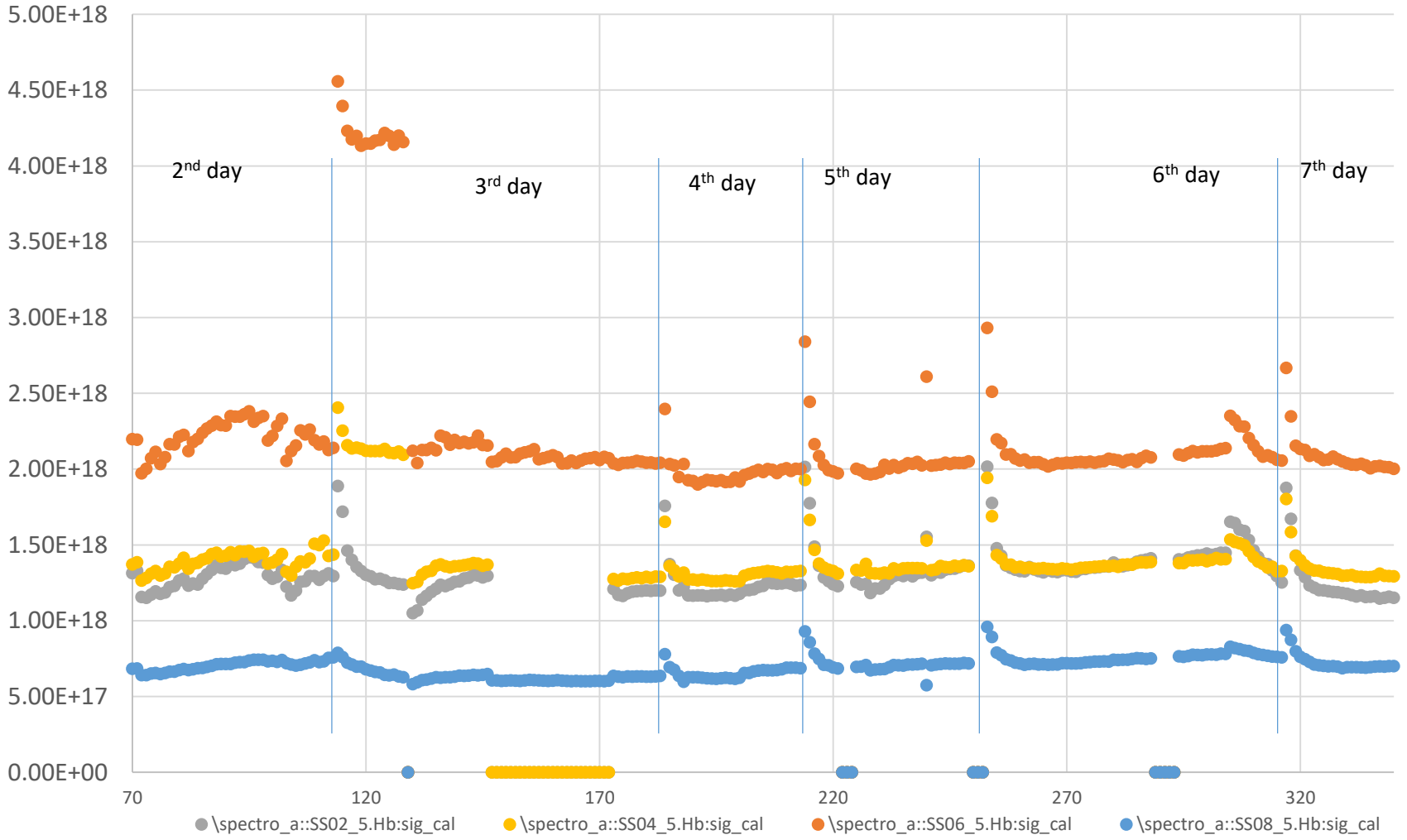

Strong reduction of the plasma emission at the bottom of the ion source

$H_\alpha/H_\beta \approx 5$ $H_\beta/H_\gamma \approx 3$

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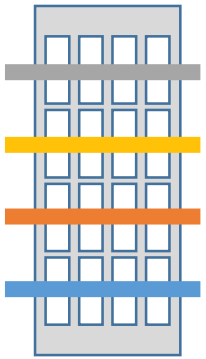

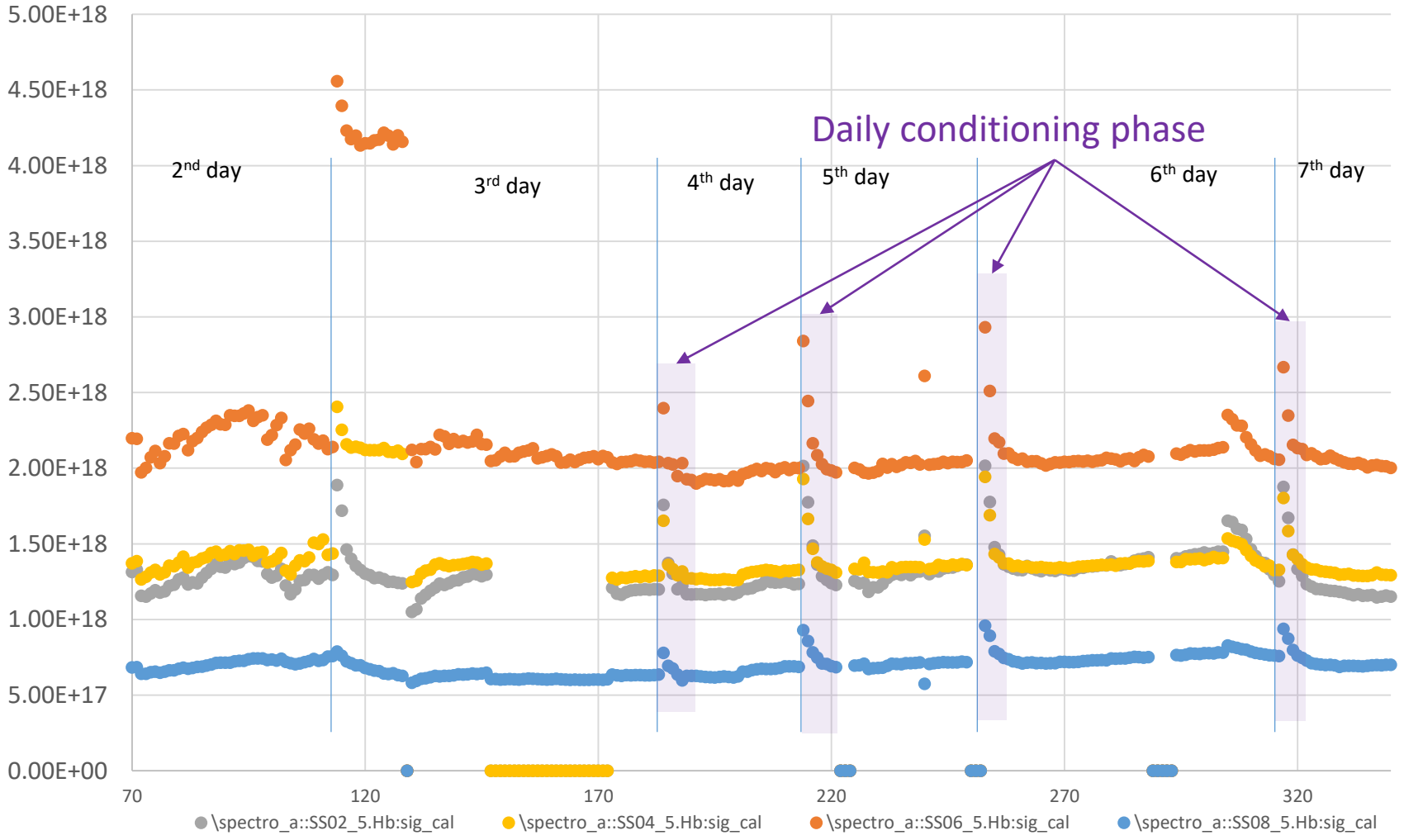

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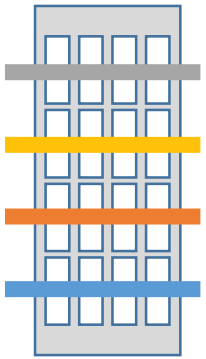

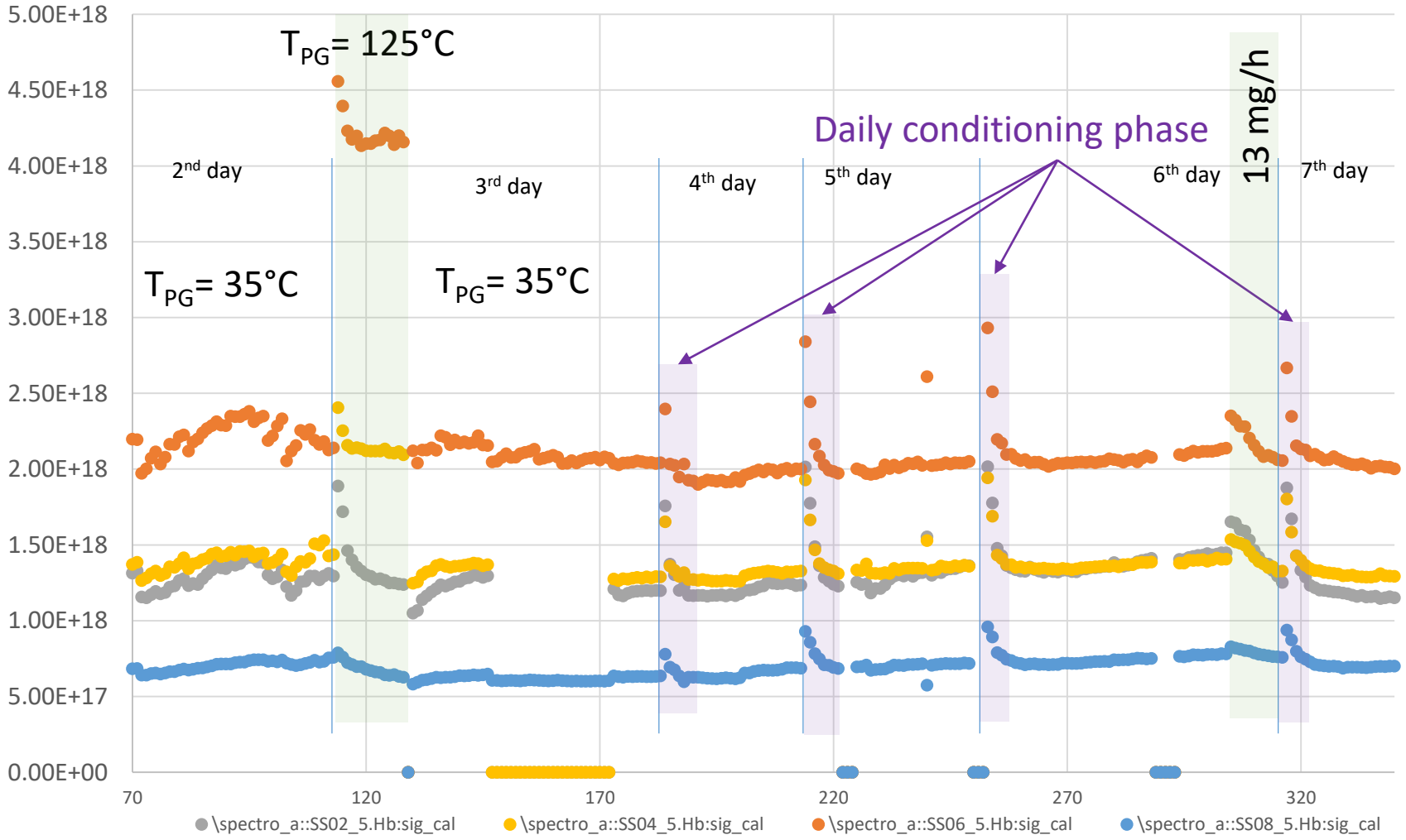

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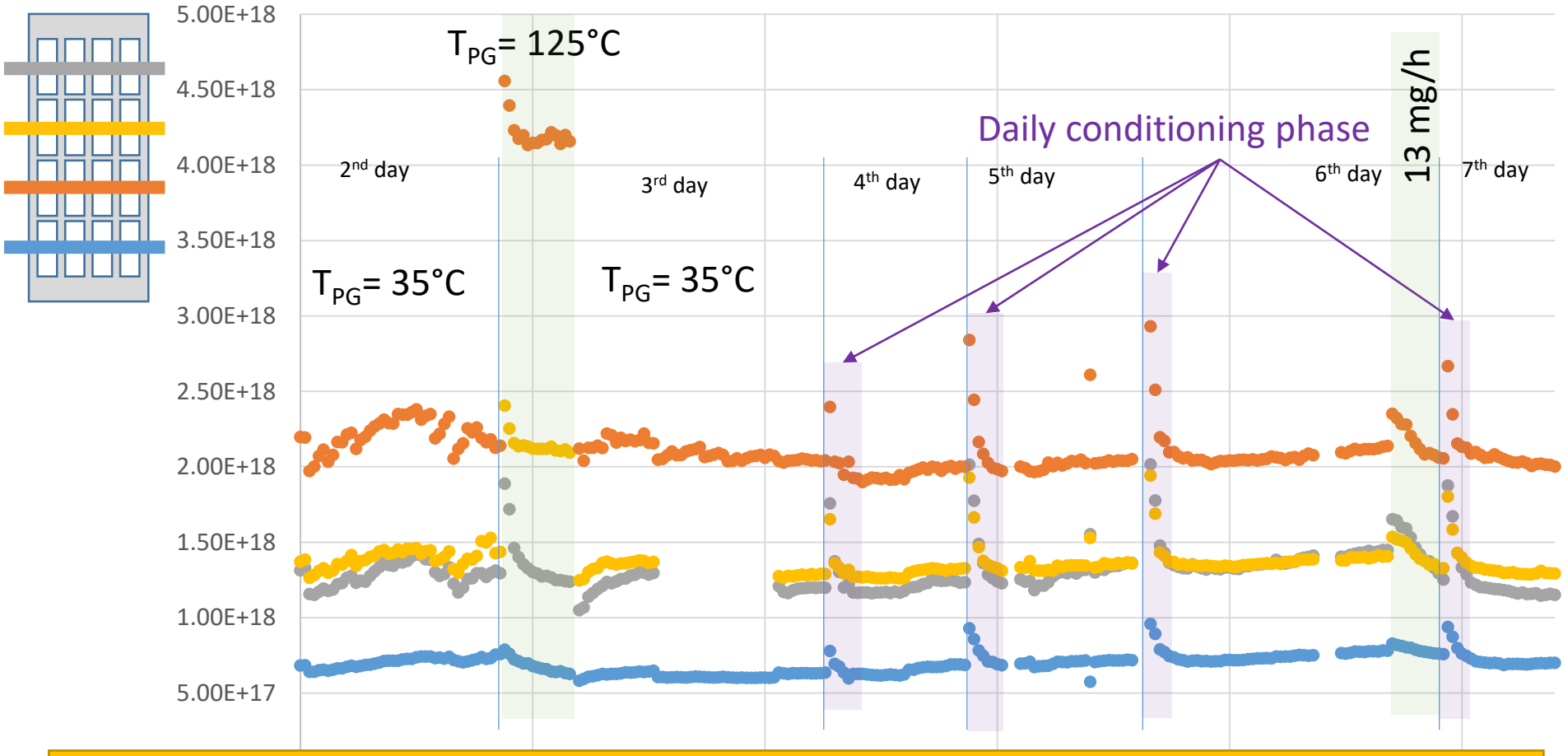

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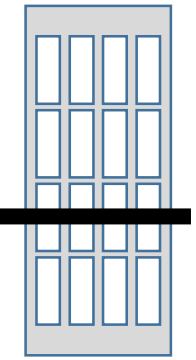
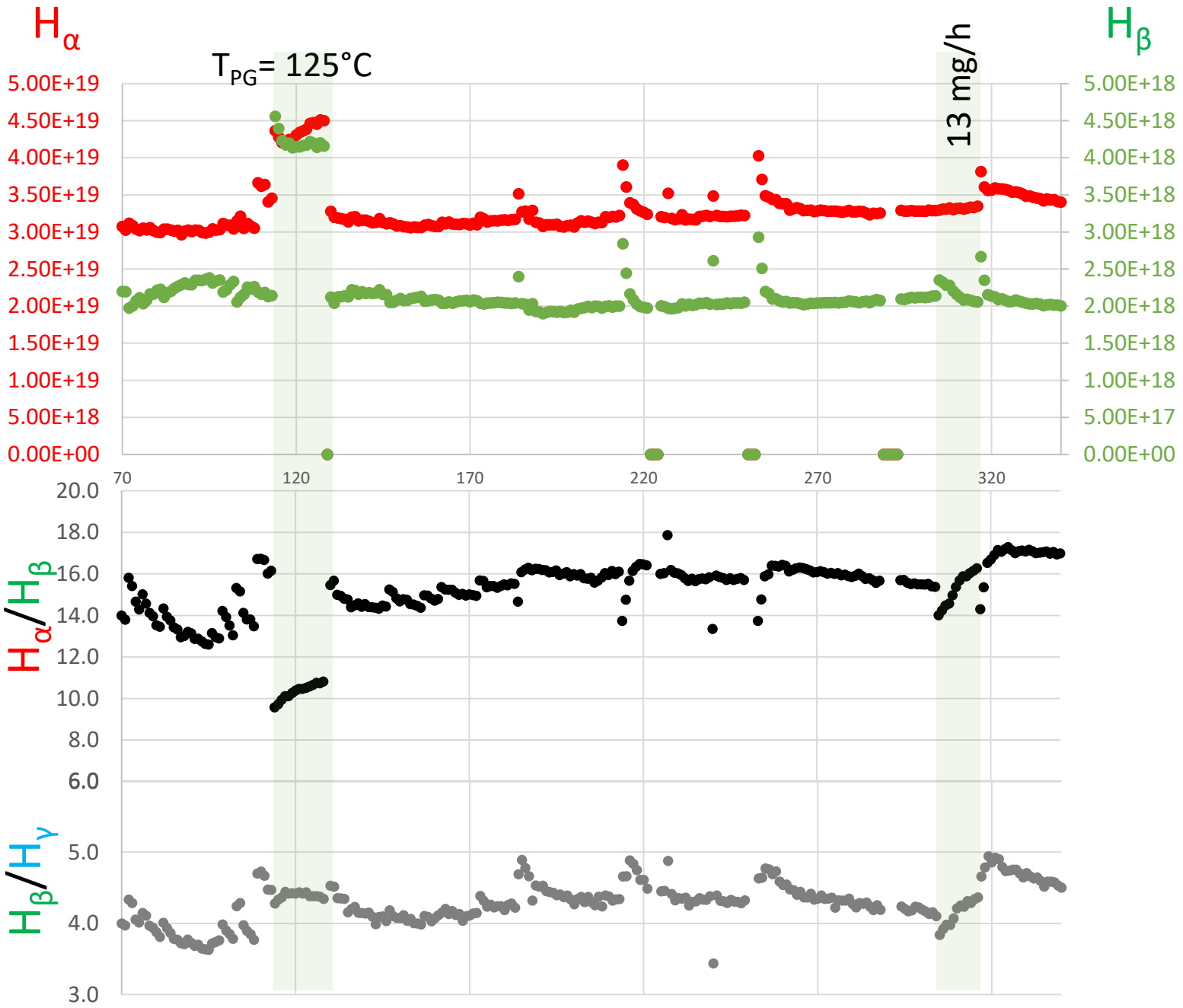
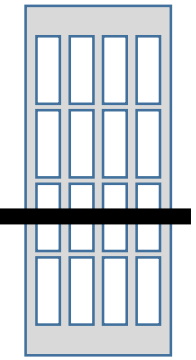
General comment: plasma emission quickly reacts on Cs-related phenomena

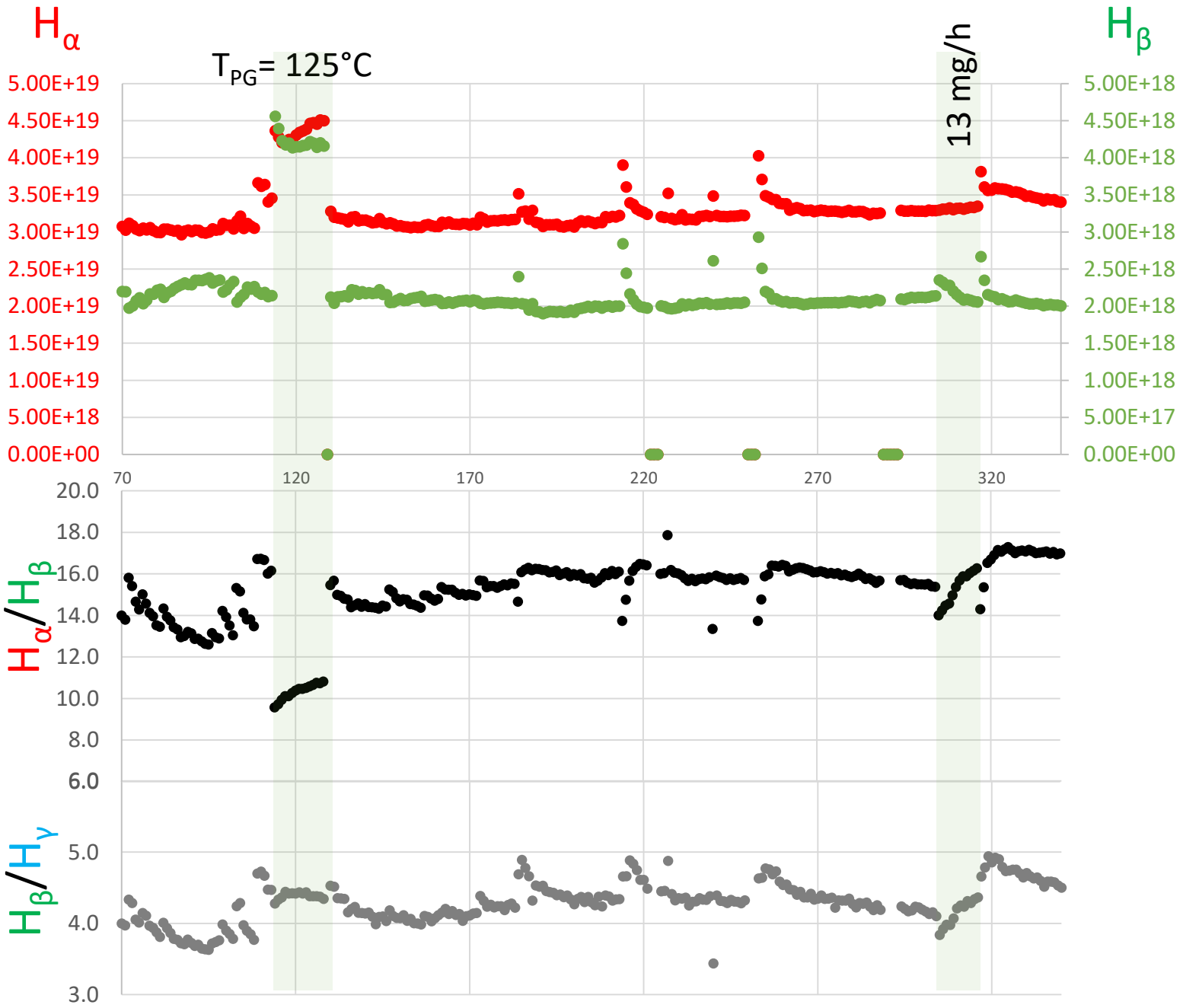




Increase of the plasma emission

Variation of the line ratio in the two cases





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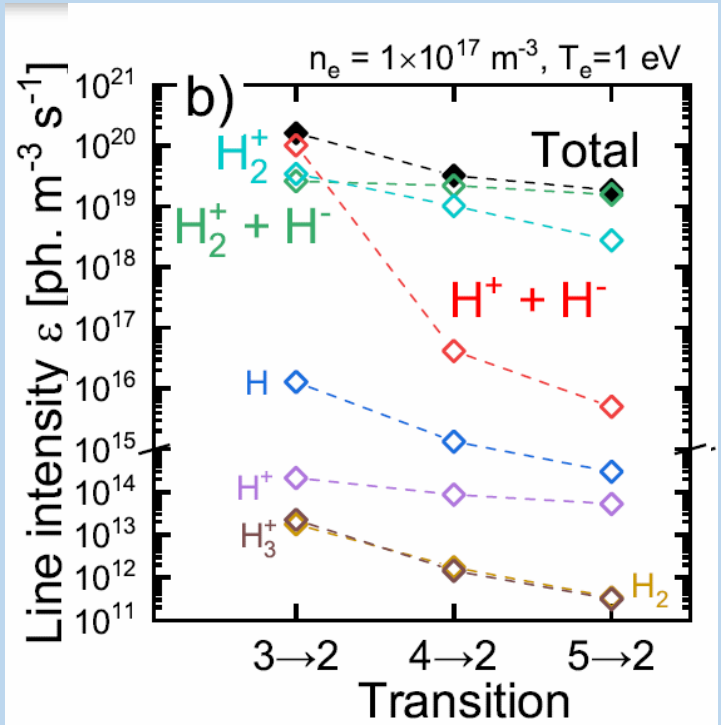
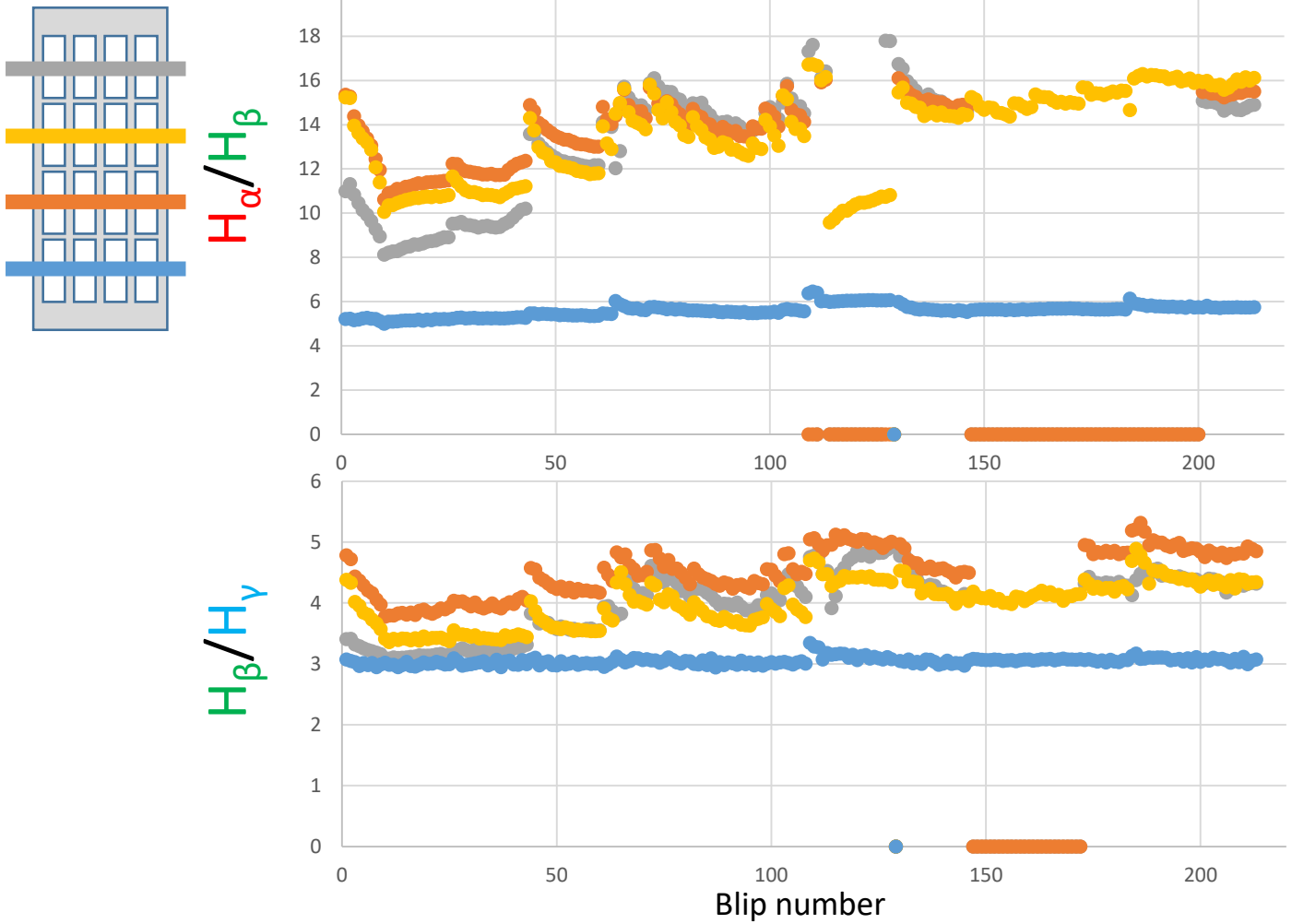


*D. Wünderlich, M. Giacomin, R. Ritz and U. Fantz, J. Quant. Spectrosc. Radiat. Transfer 240, **2020**, 106695, doi:10.1016/j.jqsrt.2019.106695"*

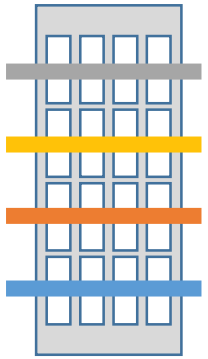
Vertical uniformity with time

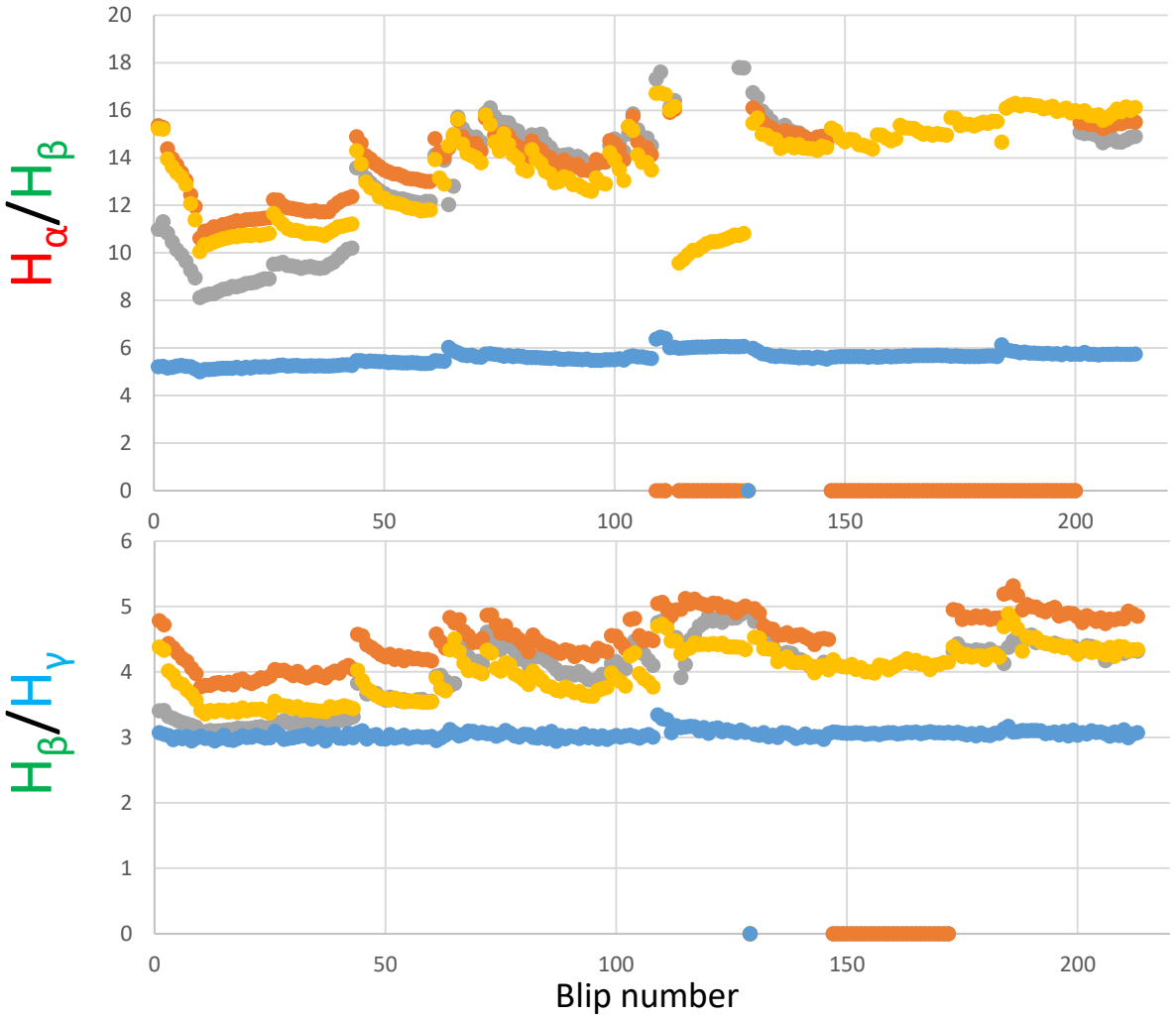


The line ratio at the centre of the each segment increases with time (except the lowermost case)

The values for the 1st, 2nd and 3rd segment get closer one to the other

Vertical uniformity with time





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Improvement of the vertical symmetry (between beam segments – measured at the centre of each segment) with Cs conditioning

Conclusions & Outlook

Fast response of the ion source performances on the Cs dynamics

Plasma emission dominated by recombining processes close to PG

Plasma emission quickly reacts on Cs-related phenomena

Improvement of the vertical symmetry of the line ratio H_α/H_β and H_β/H_γ with Cs conditioning
(between beam segments – measured at the centre of each segment)

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Future work:

- Extensive study of the OES database
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- Application of the data analysis to deuterium campaign

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Thank you for your attention!

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