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# Quantitative Analysis of $\text{NH}_2^*$ in Premixed Ammonia-Air Flames

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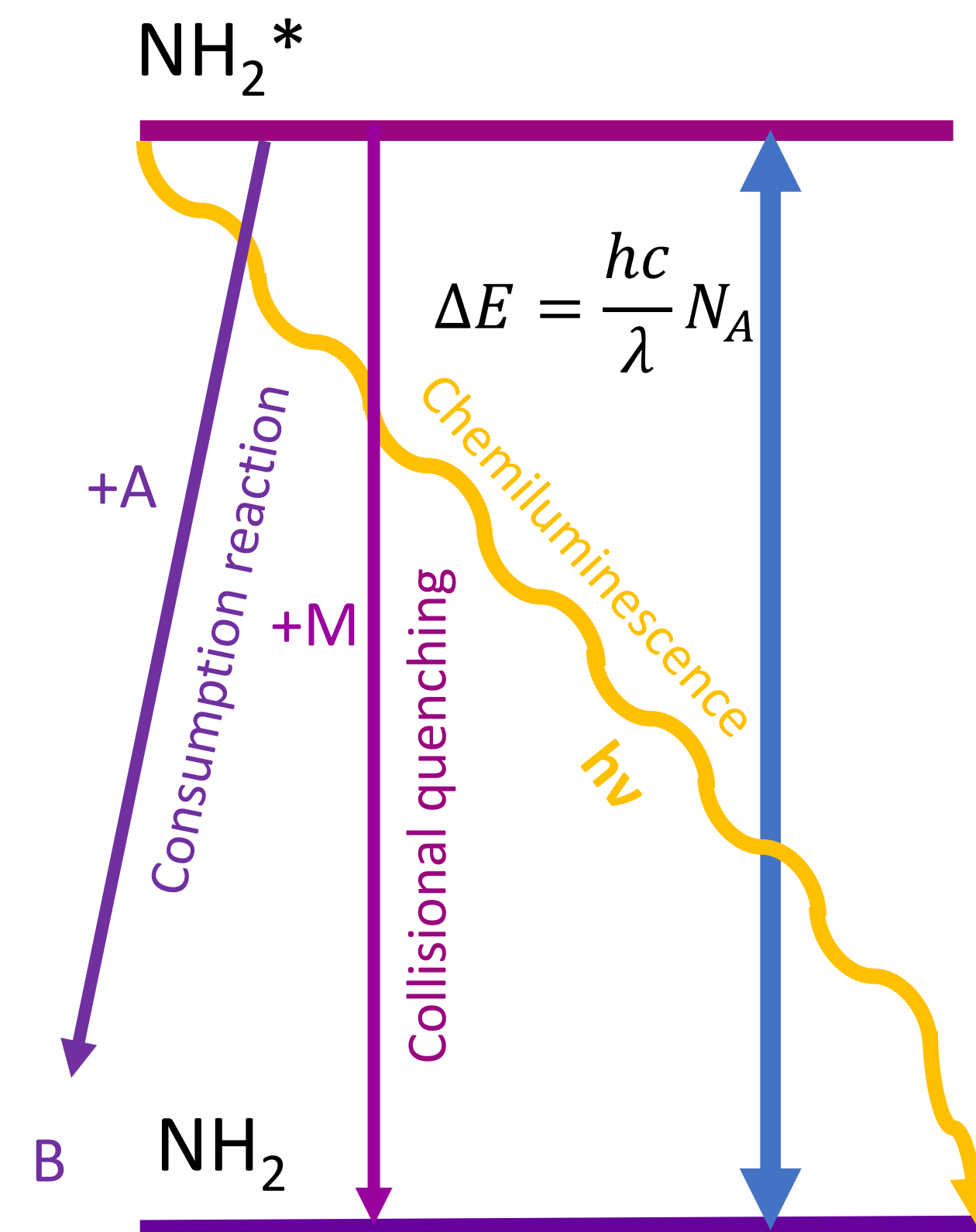
The interest in studying ammonia flames arises from the need to curb carbon emissions and to solve the energy crisis arising from the depletion of fossil reserves.

## Why chemiluminescence?

- A cheap and non-intrusive diagnostic tool
- It provides various information on the combustion process, like assessing flame ratio and understanding flame topology.

## Why $\text{NH}_2^*$ chemiluminescence?

- $\text{NH}_2^*$  chemiluminescence is used to determine the position of the maximum HRR in premixed ammonia-air flames.
- The relative intensity of  $\text{NH}_2^*$  can give information on NOx formation



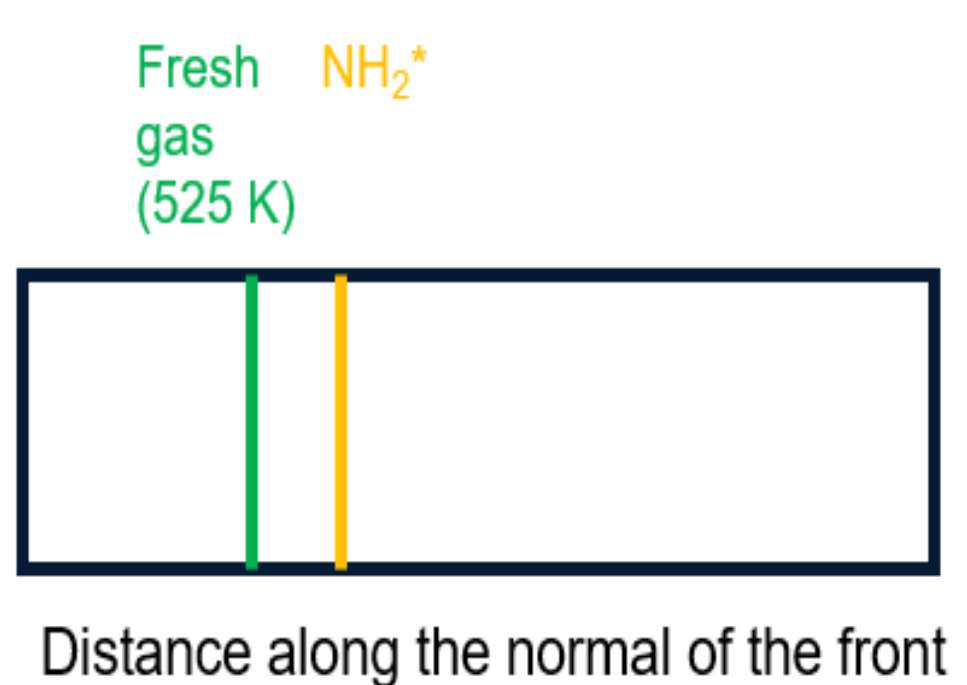
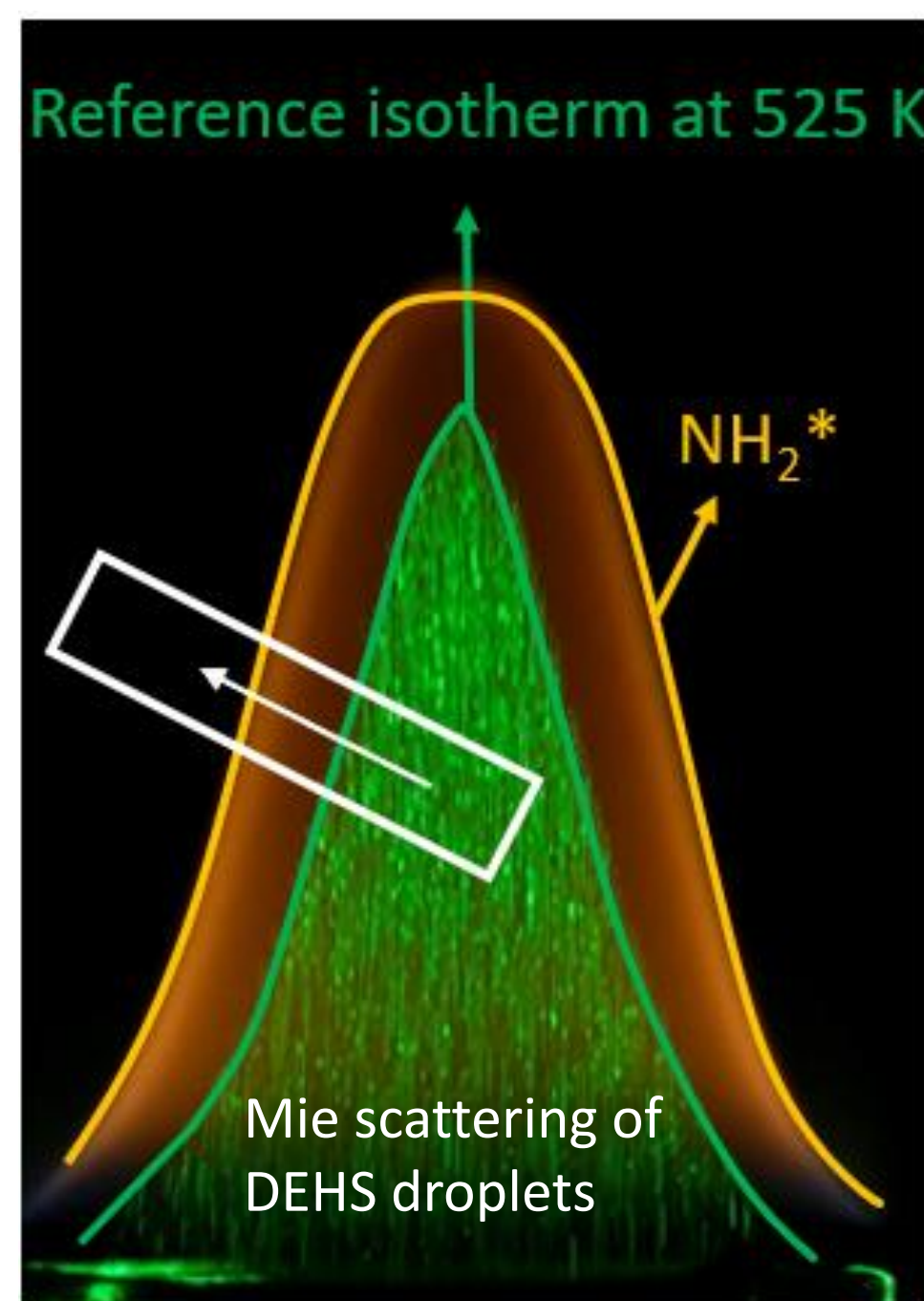
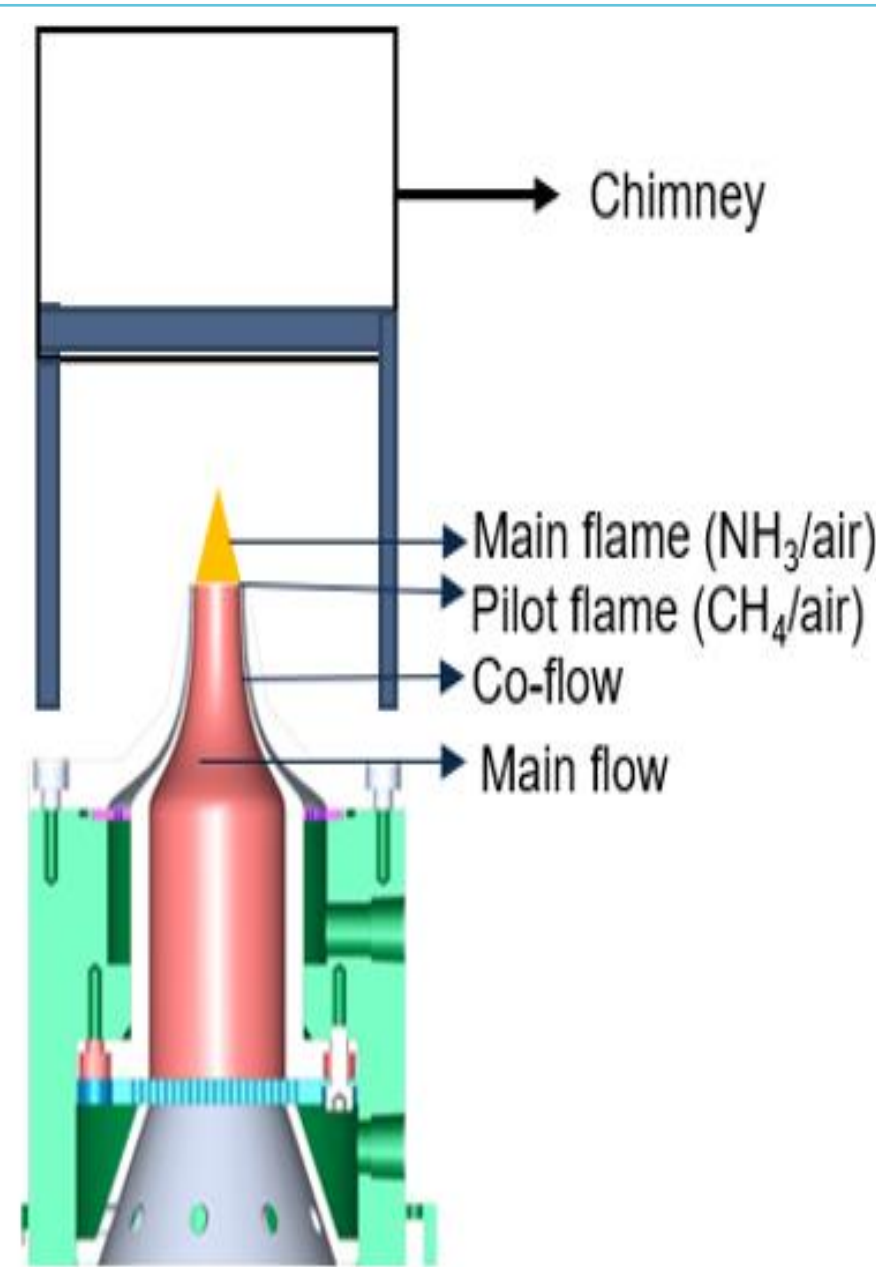
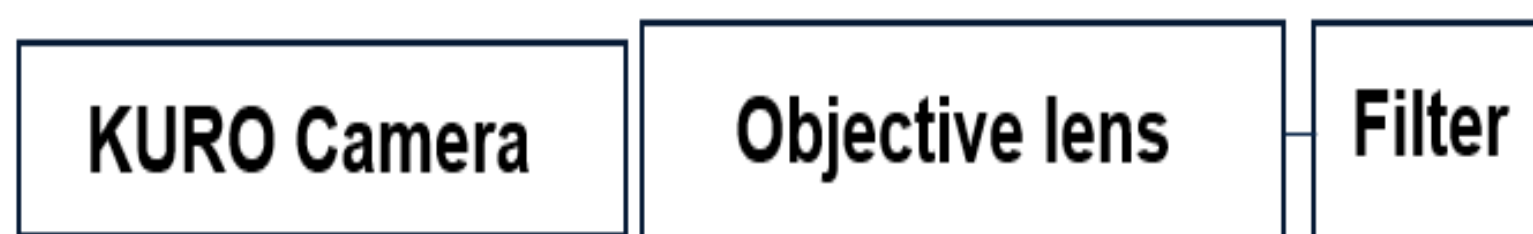
## Why quantitative analysis?

Possibility to have reference data for the chemiluminescent part of the species to model the total excited species.

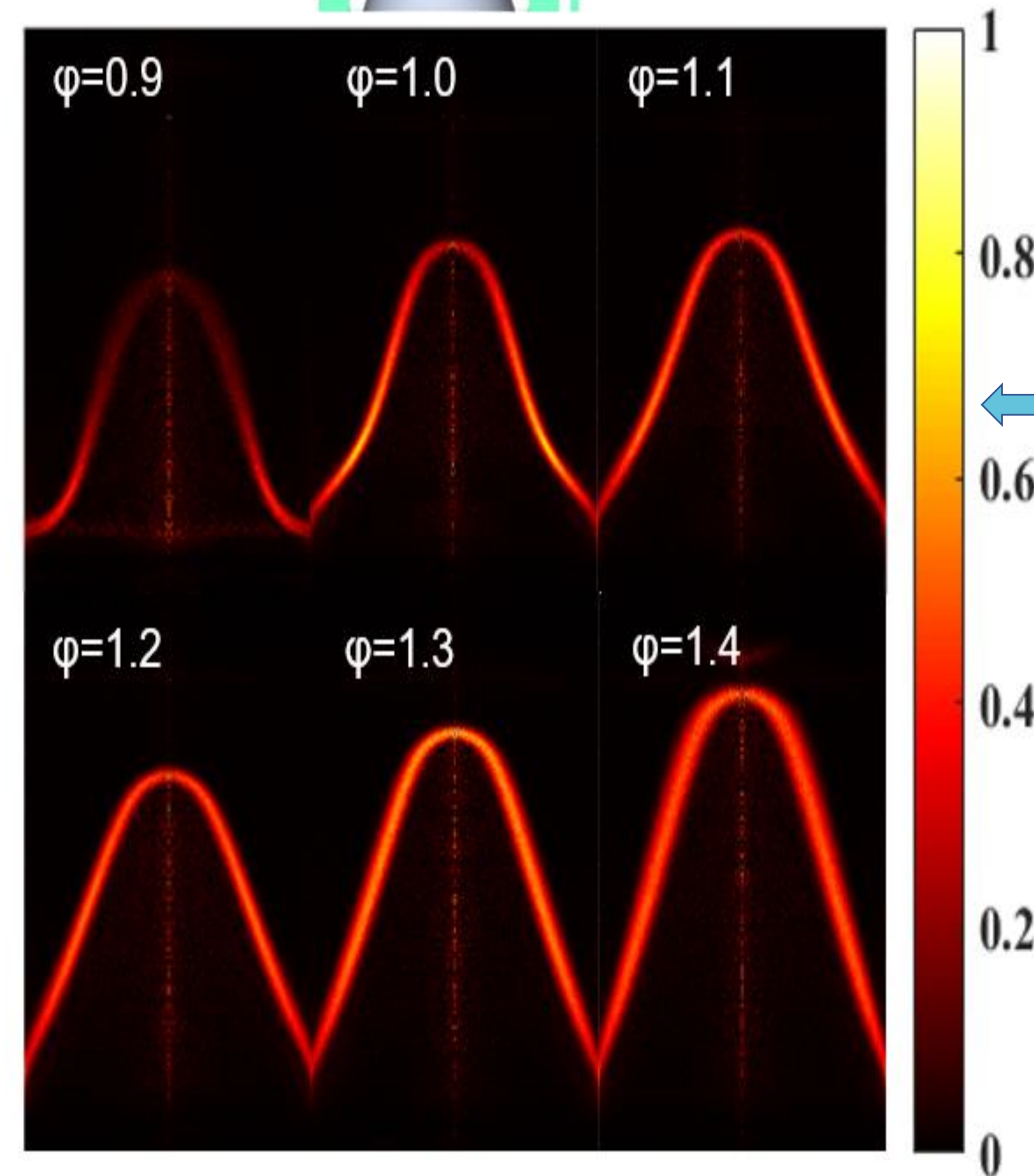
## Procedure

- $\text{NH}_2^*$  chemiluminescence data at 632 nm for ambient conditions.
- Calibration to quantify the data.

## Chemiluminescence set-up



Determining the position of  $\text{NH}_2^*$  within the flame

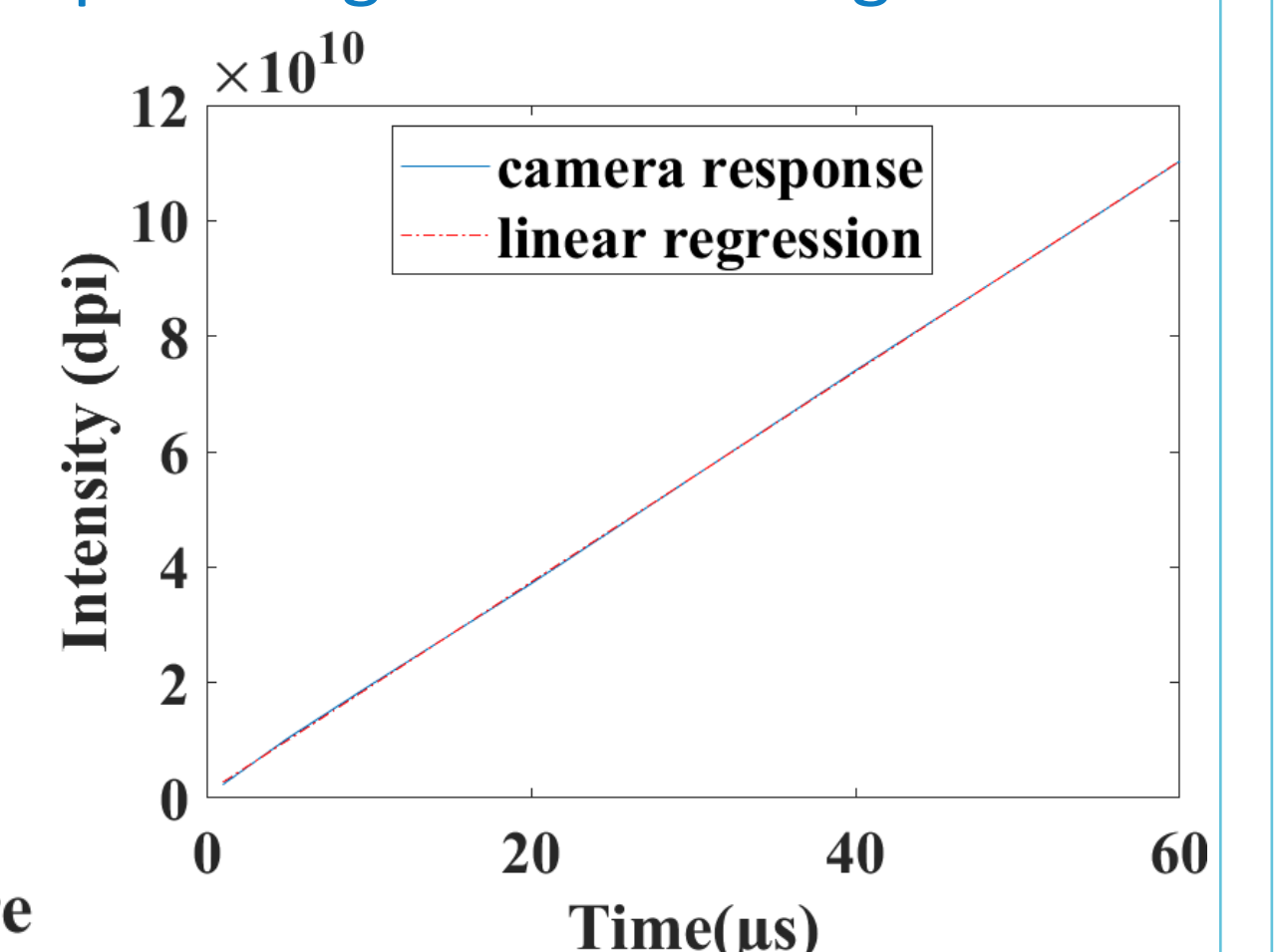
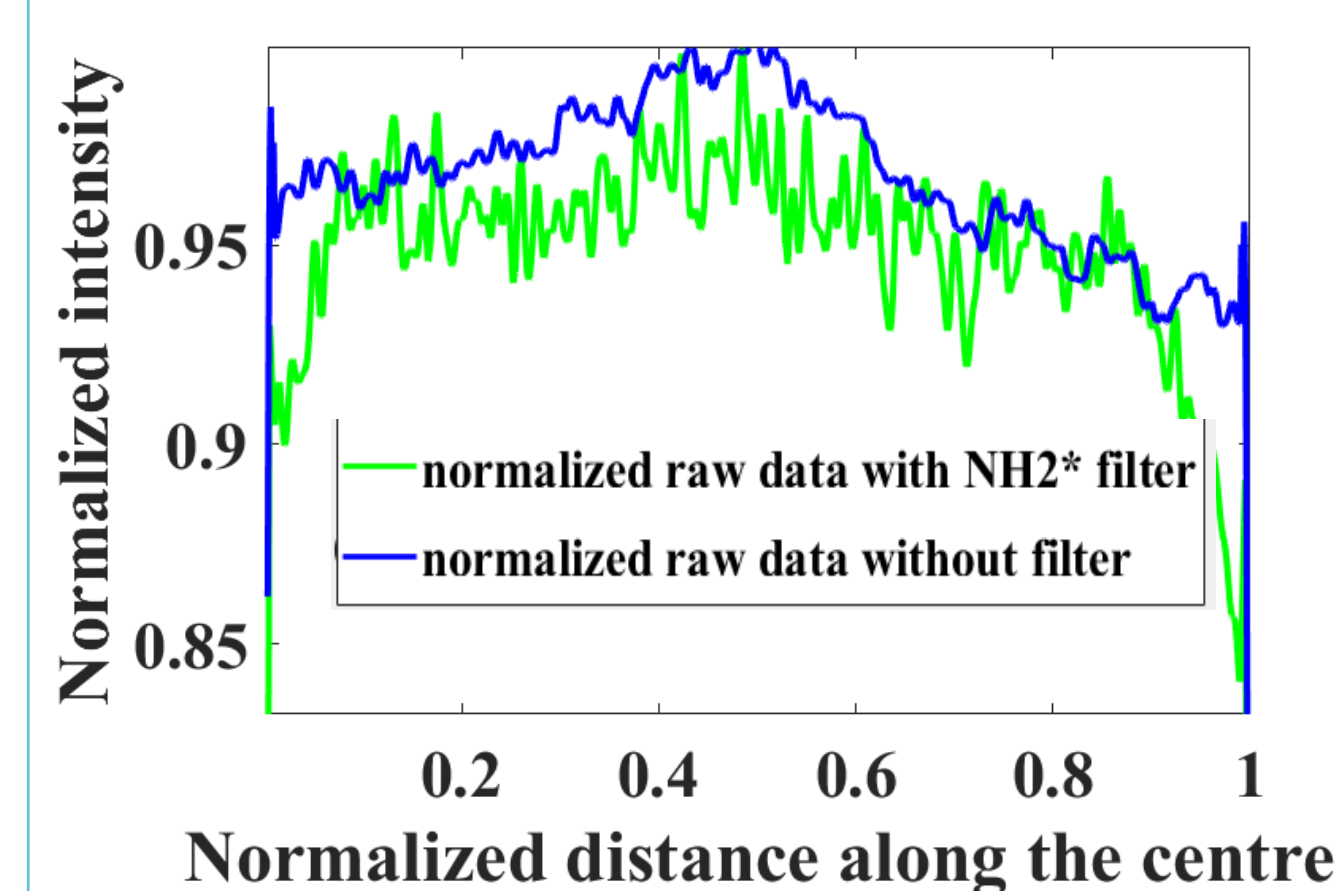


Normalized  $\text{NH}_2^*$  distribution along the flame for different  $\phi$

## Calibration process

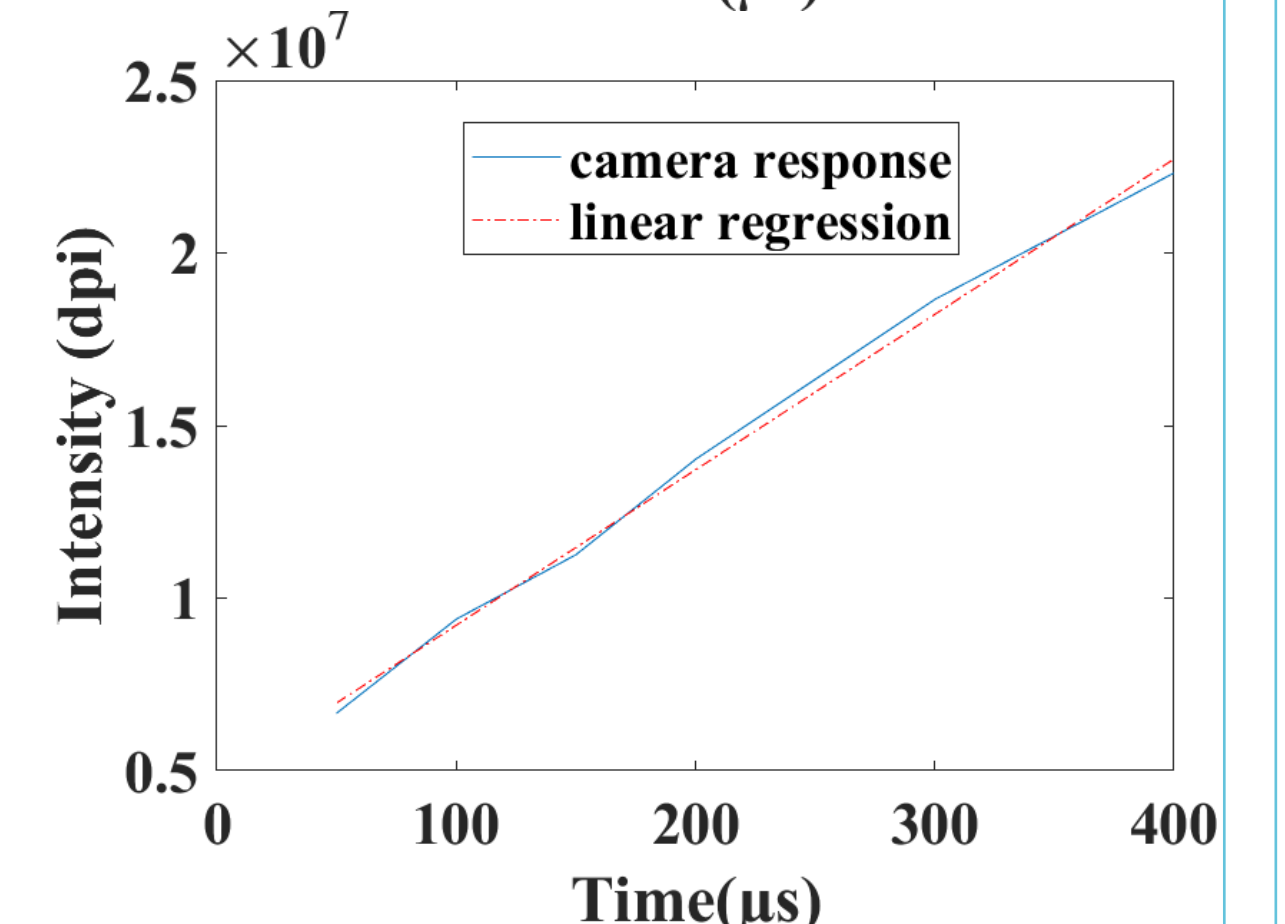
### Step 1: Optics Calibration

$\text{NH}_2^*$  filter response and camera response against a fixed light source



### Step 2: Tungsten lamp calibration

- Irradiation data as a function of wavelength
- Filter and camera response against the tungsten lamp



### Step 3: Converting intensity to concentration<sup>1</sup>

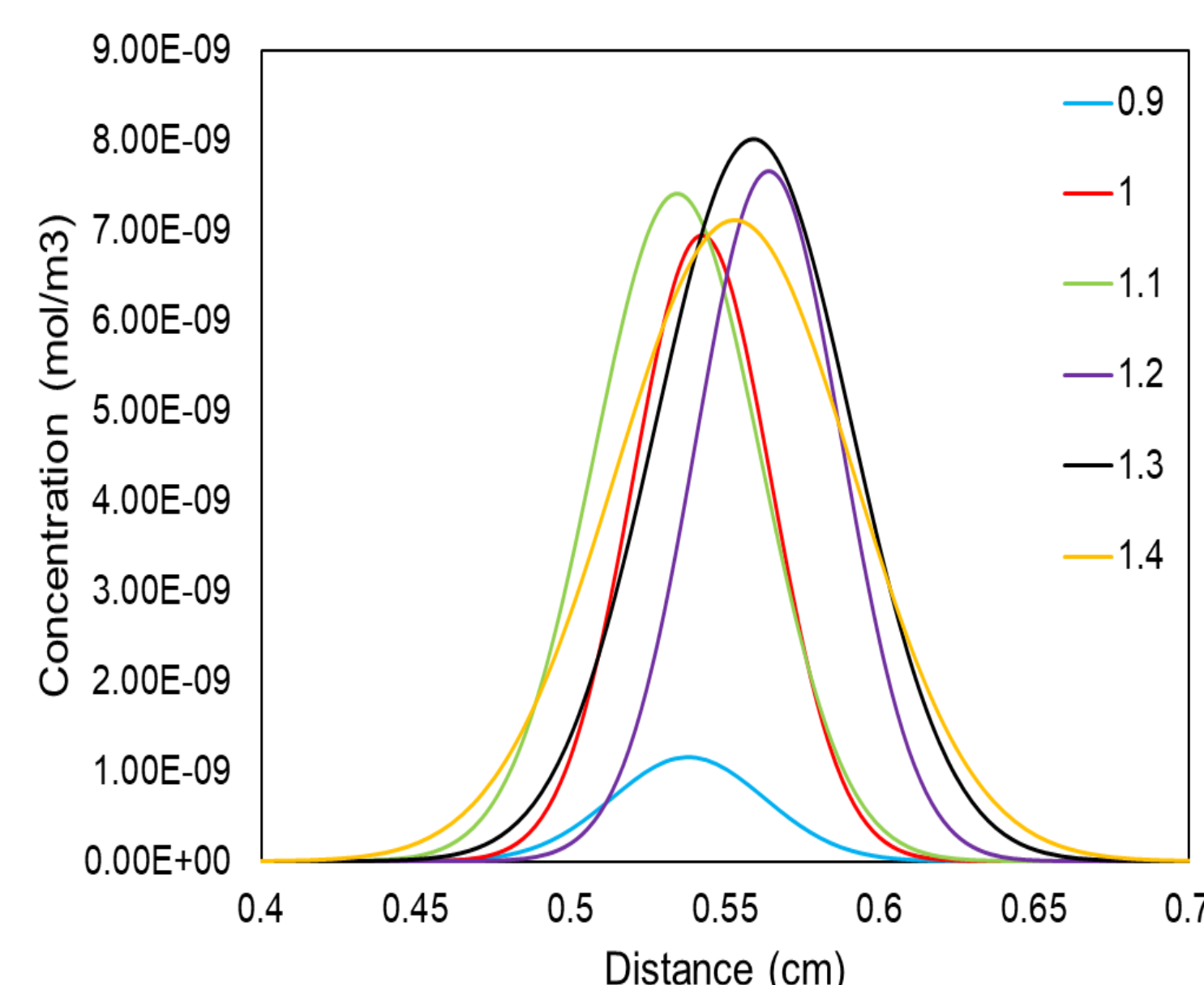
$$\frac{I_{\text{species, Abel}}}{I_c} = \frac{1}{4\pi} \frac{[\text{species}] N_A \eta_\lambda \tau_1 \Delta t_1}{\int_{\lambda_1}^{\lambda_2} \frac{S_c(\lambda)}{h\nu} \eta_\lambda d\lambda \tau_2 \Delta t_2}$$

### Step 4: Adapting to the configuration

- Irradiation values were provided at a distance of 50 cm
- Values adapted to fit the experimental set-up distance

## Results

- On moving from fresh gases towards burnt gases,  $\text{NH}_2^*$  profiles for a low stretch can be plotted.
- It is seen that the thickness of  $\text{NH}_2^*$  increases with the equivalence ratio.
- Preferential diffusion of lighter species towards the base of the flame is noted for leaner flames.
- Future work includes accommodating these species in any existing chemical kinetic schemes.



$\text{NH}_2^*$  concentrations for different  $\phi$  plotted for minimum stretch values

## Acknowledgement

Support from the CAPRYSES project (ANR-11-LABX-006-01) funded by the PIA (Programme d'Investissement d'Avenir) is gratefully acknowledged.

ICARE-CNRS and Université d'Orléans are acknowledged as well.

## Reference

<sup>1</sup>Y. Liu, J. Tan, M. Wan, L. Zhang, X. Yao, Quantitative measurement of  $\text{OH}^*$  and  $\text{CH}^*$  chemiluminescence in jet diffusion flames, ACS Omega, (2020), 15922–30



11<sup>th</sup> EUROPEAN COMBUSTION MEETING 2023