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Two-photon Absorption Laser Induced Fluorescence of Carbon Monoxide in Premixed Opposed Flames

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- 3. Literature review
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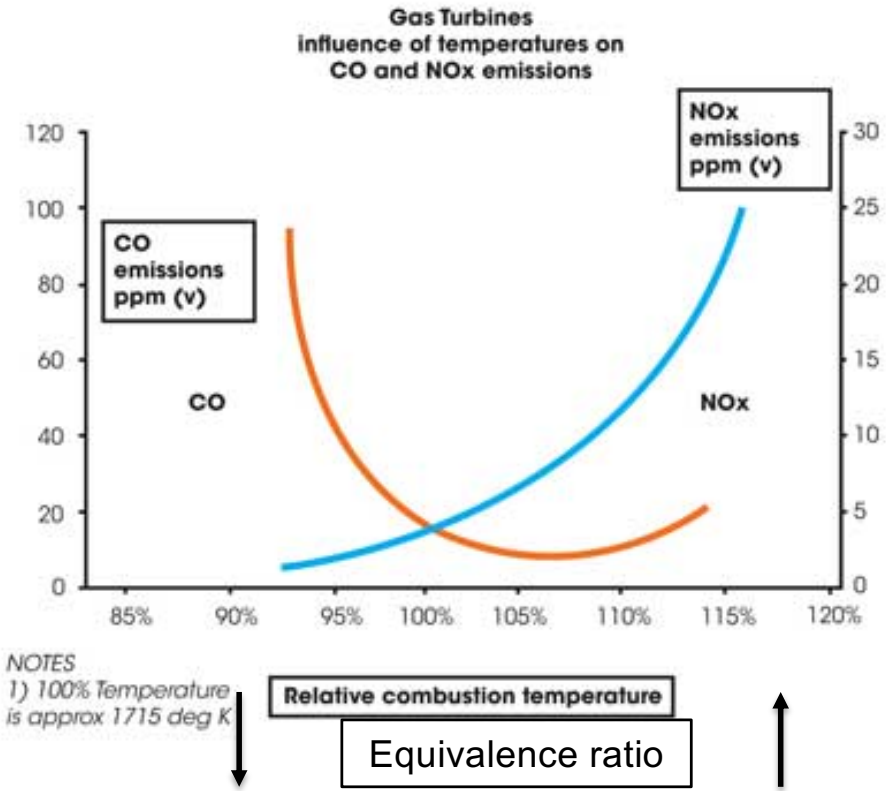
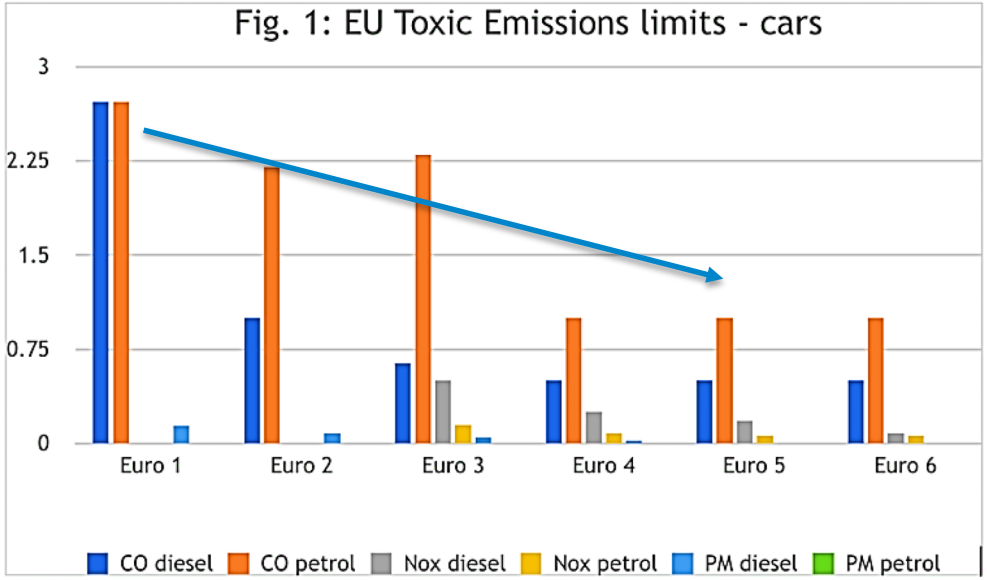
Motivation

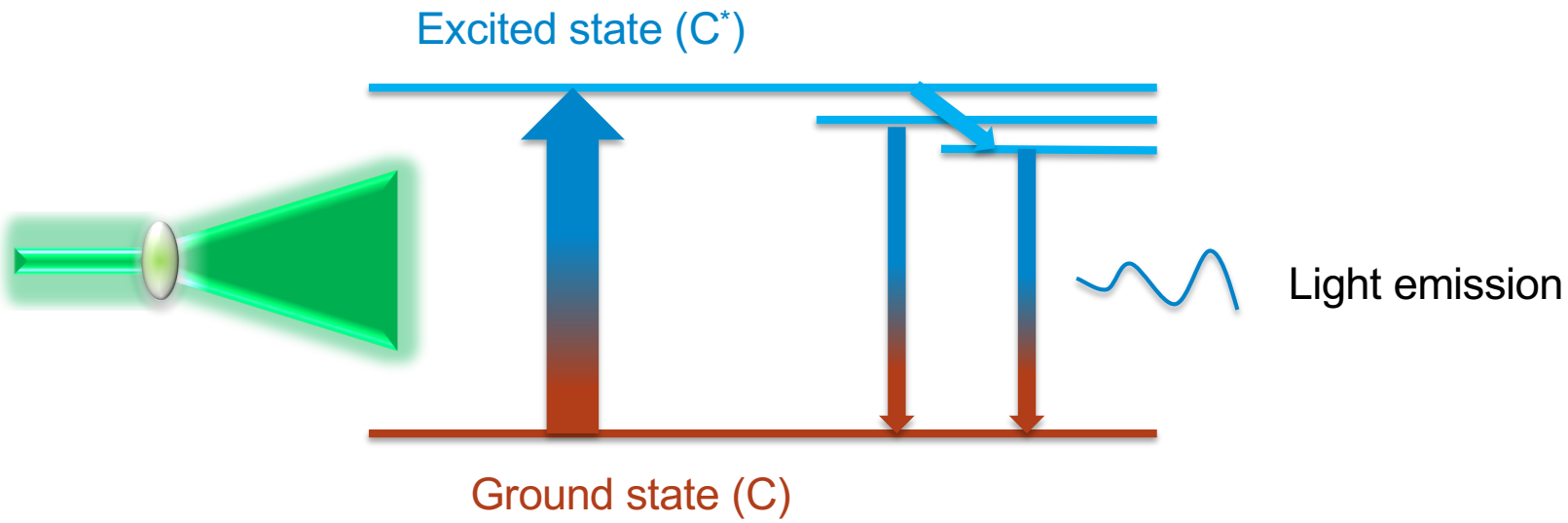


https://www.powerengineeringint.com/articles/print/volume-22/issue-9/features/hitting-the-gas.html



https://www.theengineer.co.uk/fact-check-are-diesel-cars-really-more-polluting-than-petrol-cars/

Principle of LIF



$$I_{LIF} = \frac{I_{LASER}}{h\nu} N\sigma \frac{A}{A+Q+P} \eta_{DET} \frac{\Omega}{4\pi}$$

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Principle of two photon LIF

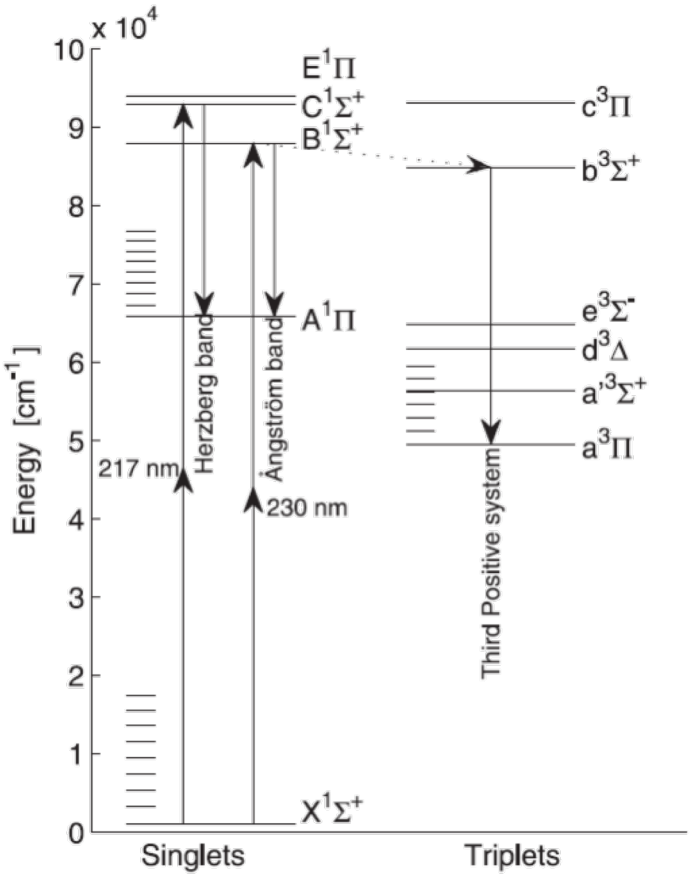

FIG. 1. A schematic energy-level diagram for the electronic levels and transitions cited in this paper. Shorter lines indicate vibrational levels.

M. Alden (2013)

$$I_{LIF} = \left(\frac{I_{LASER}}{h\nu}\right)^2 N_{CO}\sigma \frac{A}{A+Q+P+RI_{LASER}} \eta_{DET} \frac{\Omega}{4\pi}$$

Additional challenges

- 230 nm laser is not very easy to achieve
- Photoionization
- Crosstalk with other luminescence from flame
- Laser energy and sheet profile

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Literature review of CO TALIF

Burner	Authors
Engine	P. C. Miles (2008, 2009, 2009, 2010), M. Alden (2007)
Turbulent jet flame	R. A. A. M. Jacobs (1995)
Bunsen flame	M. Alden (1984), H. B. Levinsky (1991)
Flat flame	A. V. Zobnin (1998), M. Alden (2013)
Impinging-jet flame	A. Dreizler (2012, 2014, 2018)

Counterflow Burner?
Premixed methane flame?
Strain rate?
Equivalence ratio?

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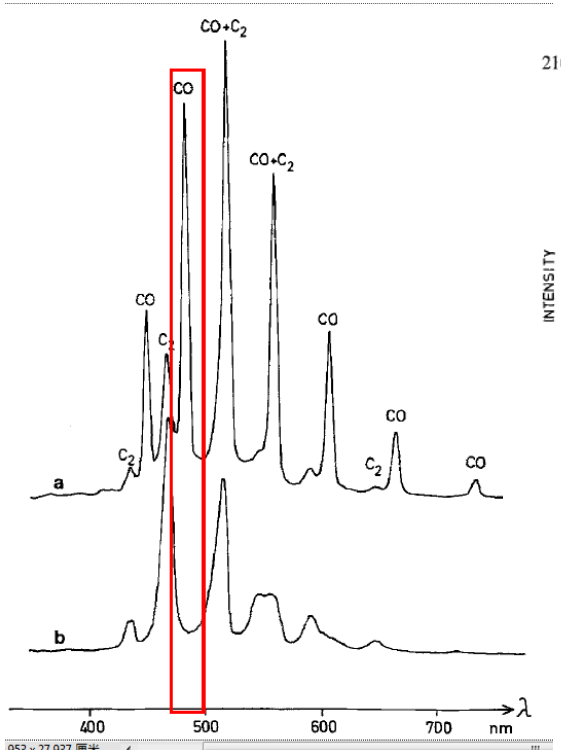
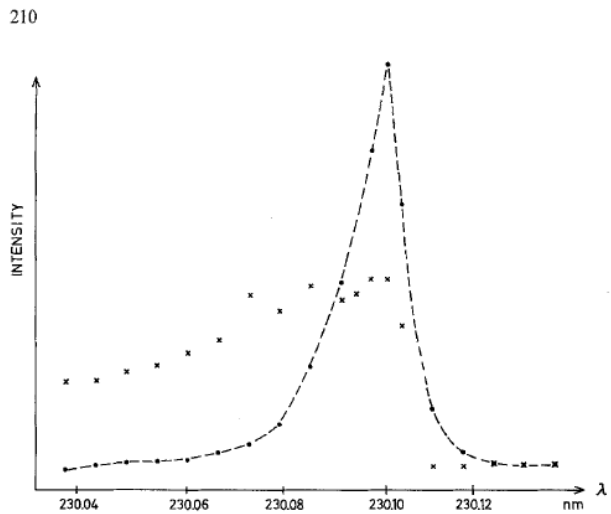
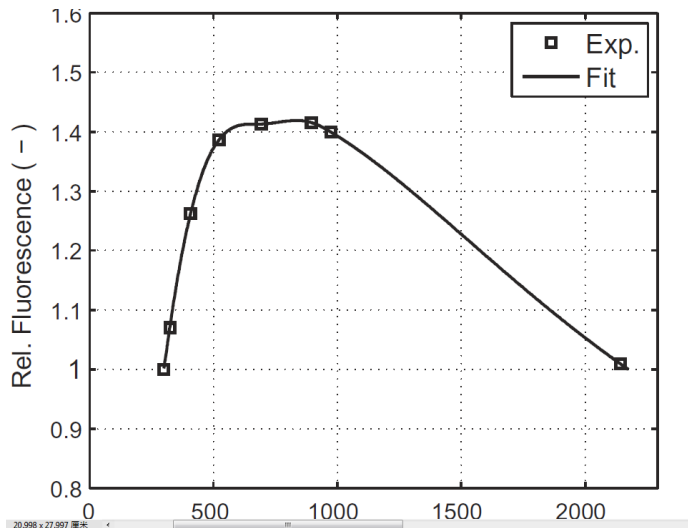
Literature review of CO TALIF

M. Alden (1984)





A. Dreizler (2014)



C_2 Swan band crosstalk, Excitation wavelength, Temperature effect
CO photoionization, CO_2 photoionization and LIF, CH_4 photolytic

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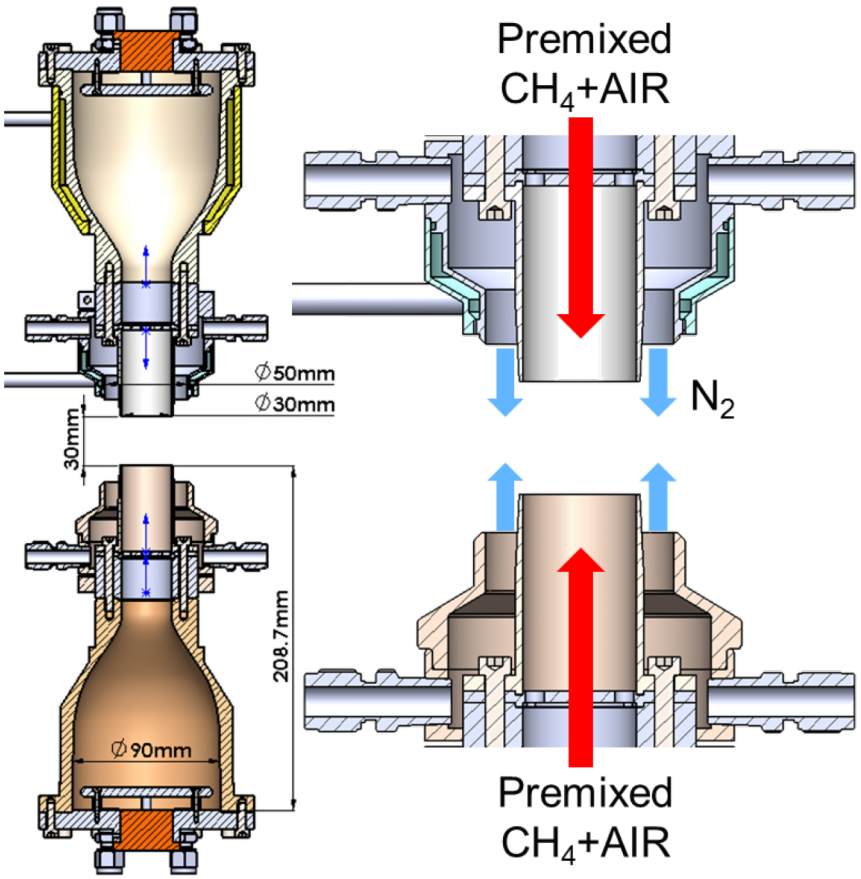
Experiment arrangement: Counterflow burner



Strain rate(a)	80, 120, 160, 240, 320, 400 s^{-1}
Fuel / Oxidant	CH_4 / Air
Equivalence ratio	0.6 - 1.3
H	30 mm
D	30 mm

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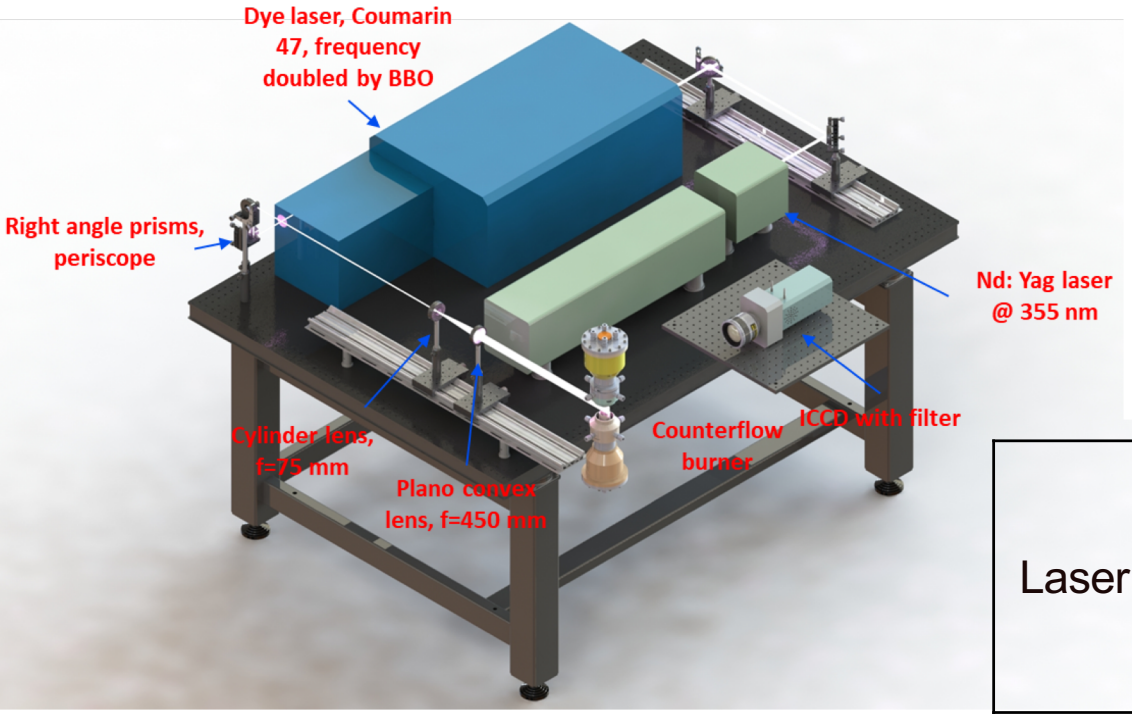
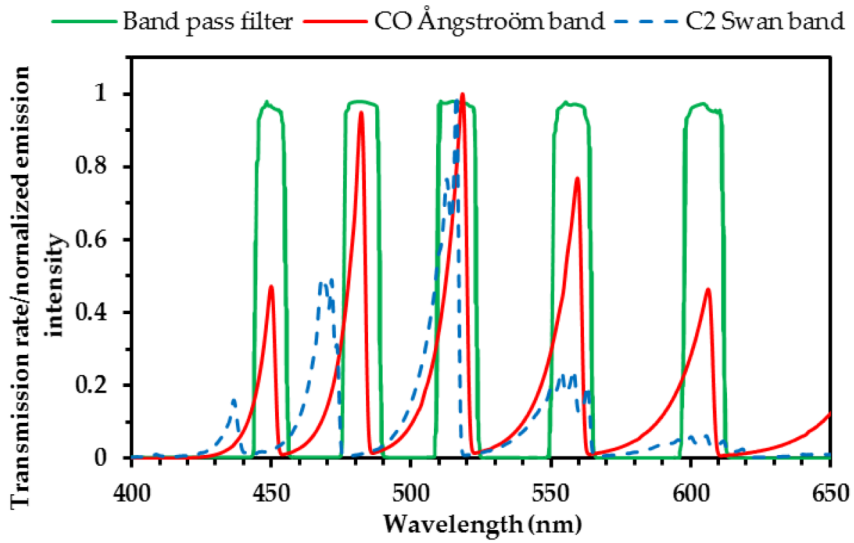
Experiment arrangement: CO TALIF





Laser	Pump	Nd: Yag @ 355 nm, 10HZ
	Dye	Coumarin 47 @ 460 nm BBO SHG > 2mJ @ 230.1 nm
	Sheet	Near 30 mm, 200 μm
ICCD	Andor DH 534	100 averaged, 50ns expose, 0.3HZ

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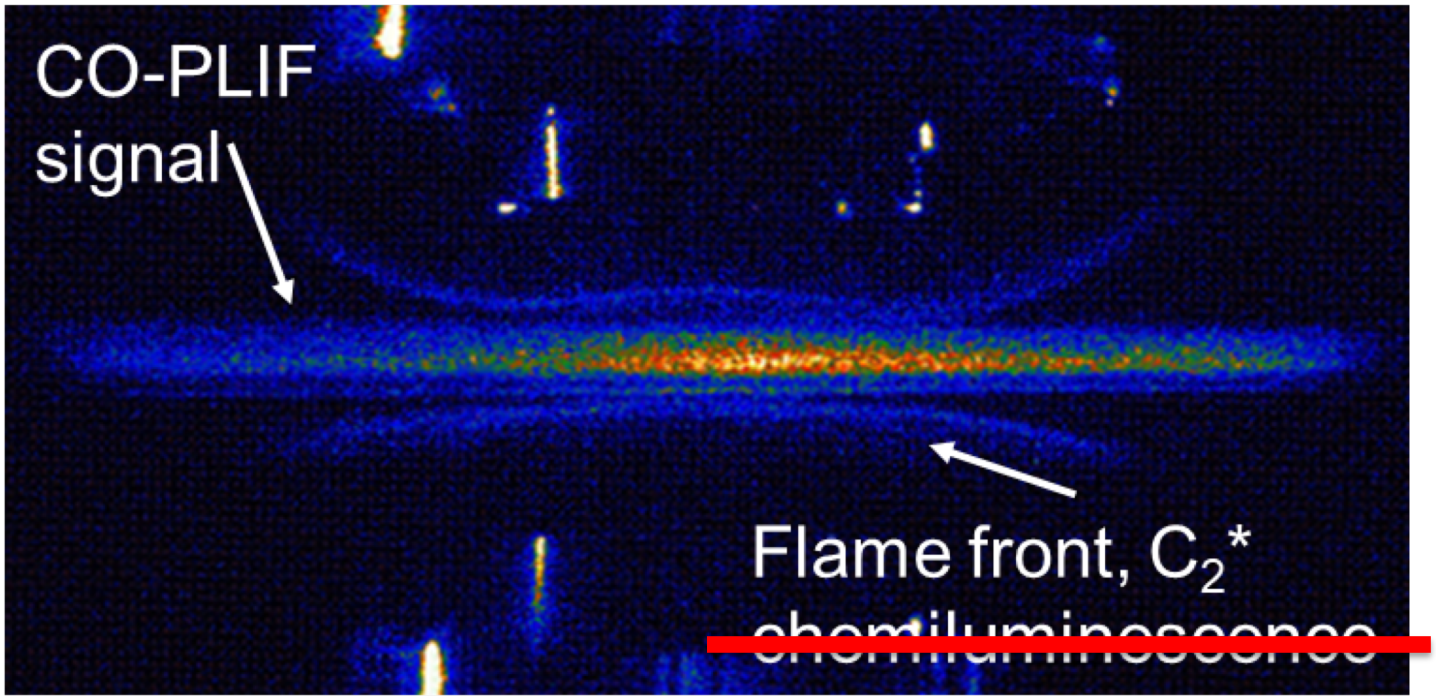
Experiment arrangement: CO TALIF



LIF + Chemiluminescence

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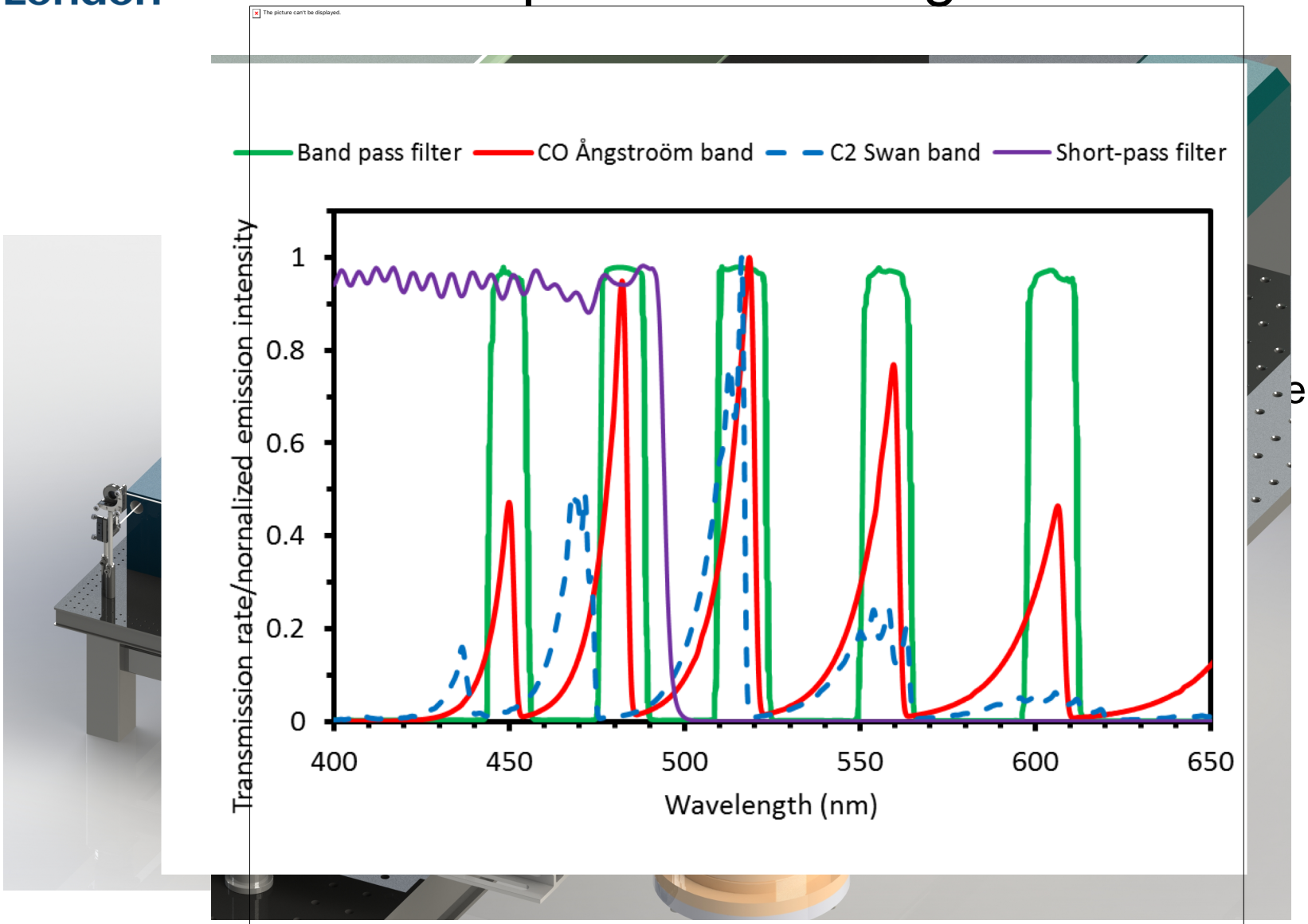
Experiment arrangement: CO TALIF



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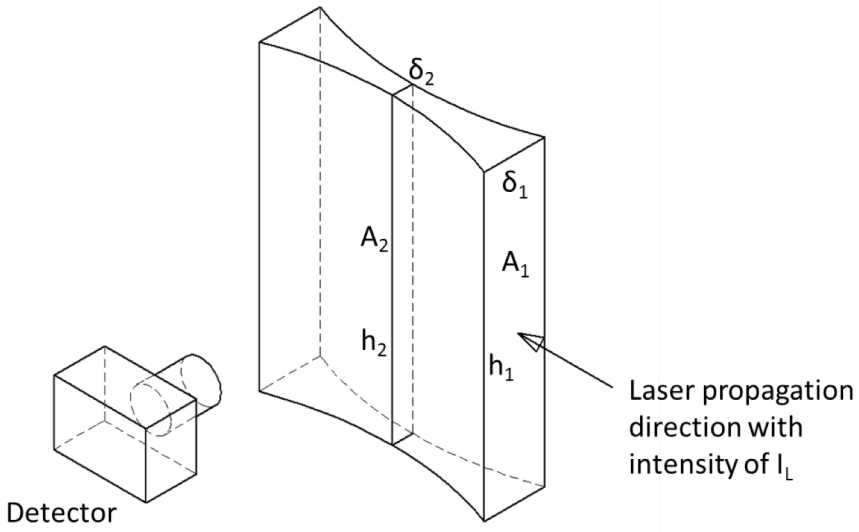
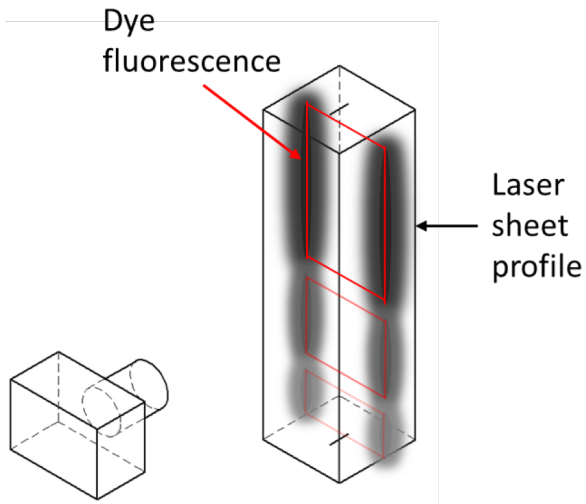
Experiment arrangement: CO TALIF





$$\frac{SI_1}{SI_2} = \frac{\rho_1}{\rho_2}\frac{h_2\delta_2}{h_1\delta_1}\frac{I_{L1}(\delta,h)}{I_{L2}(\delta,h)}$$

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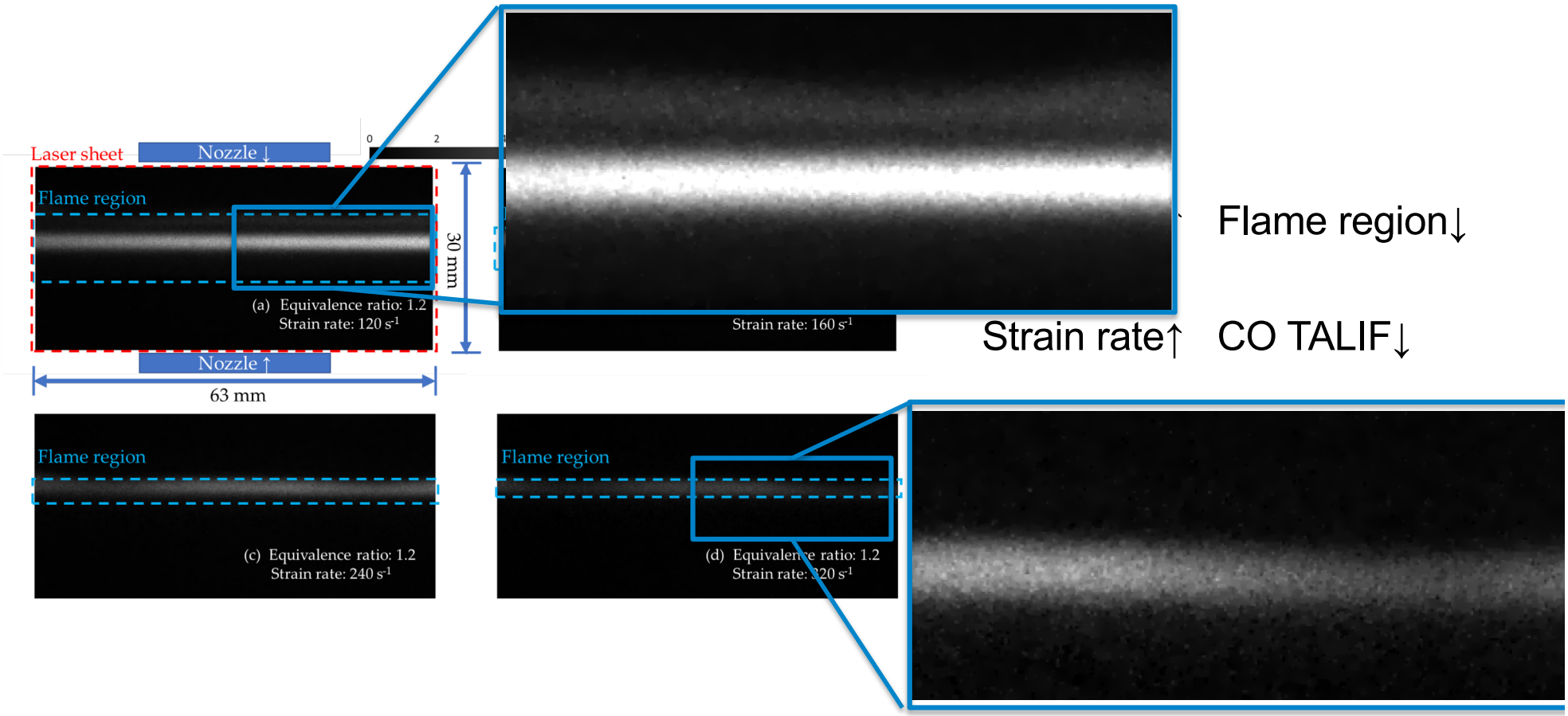
Results and Discussion: flame region and CO TALIF inensity



Flame region↓

Strain rate↑ CO TALIF↓

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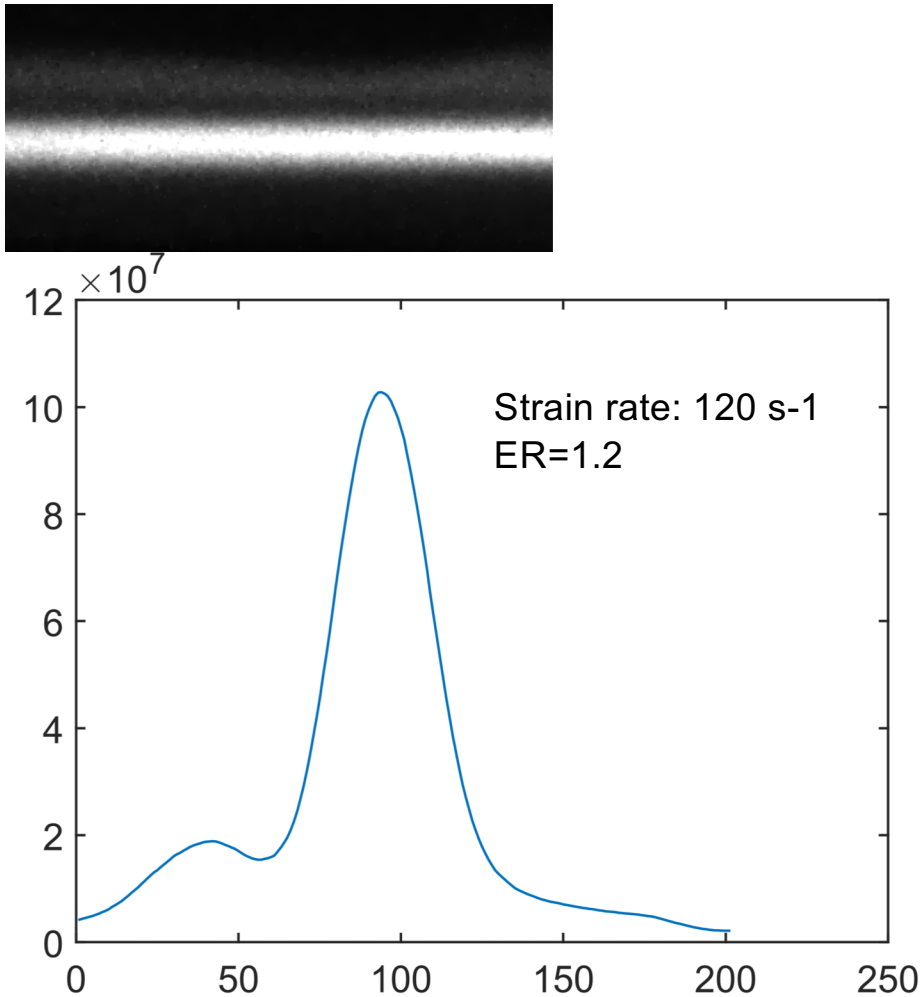
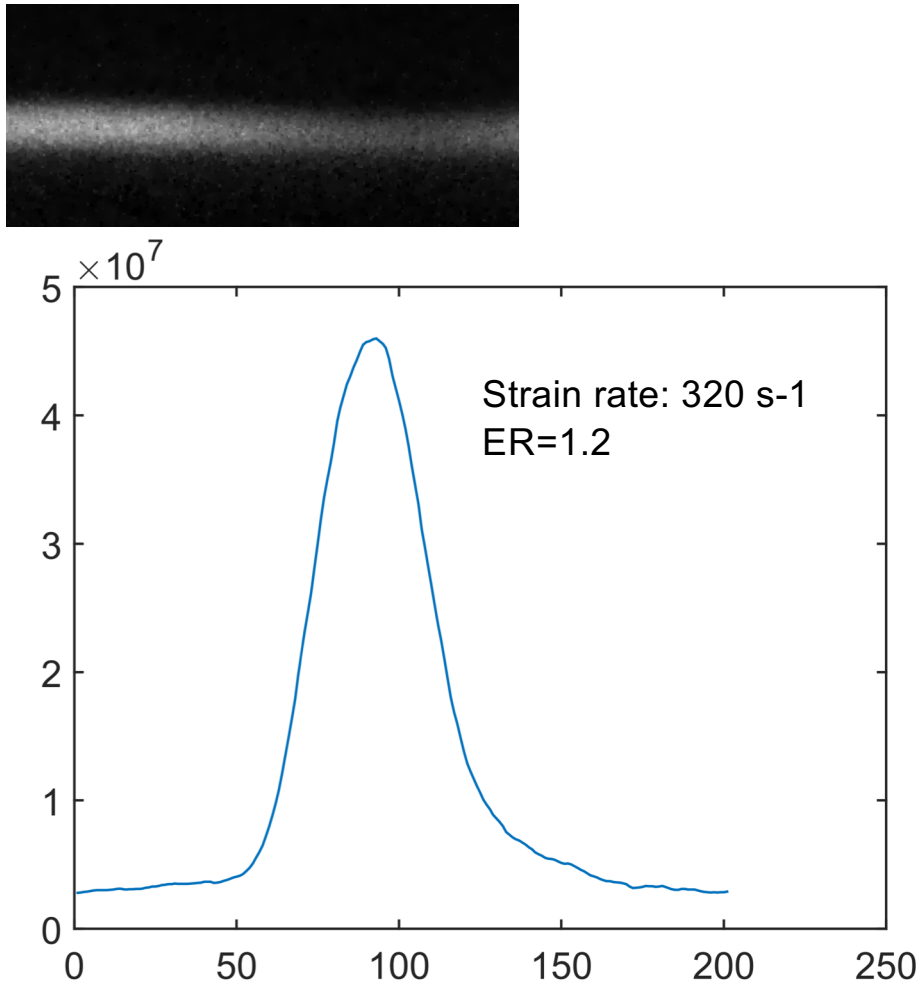
Results and Discussion: CO TALIF





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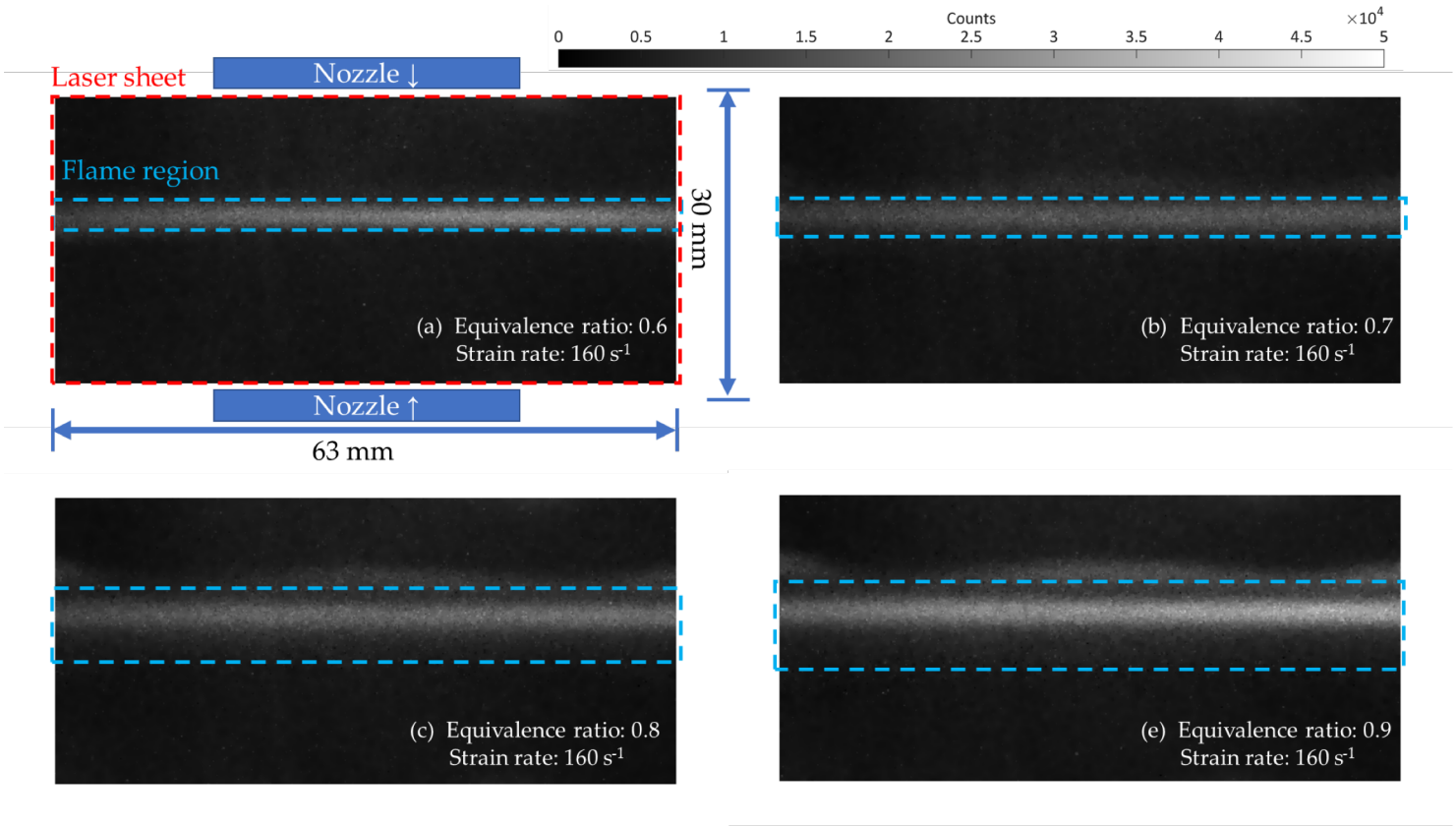
Results and Discussion: CO TALIF



Equivalence ratio ↑
CO LIF signal ↑
Except ER=0.6 and 0.7

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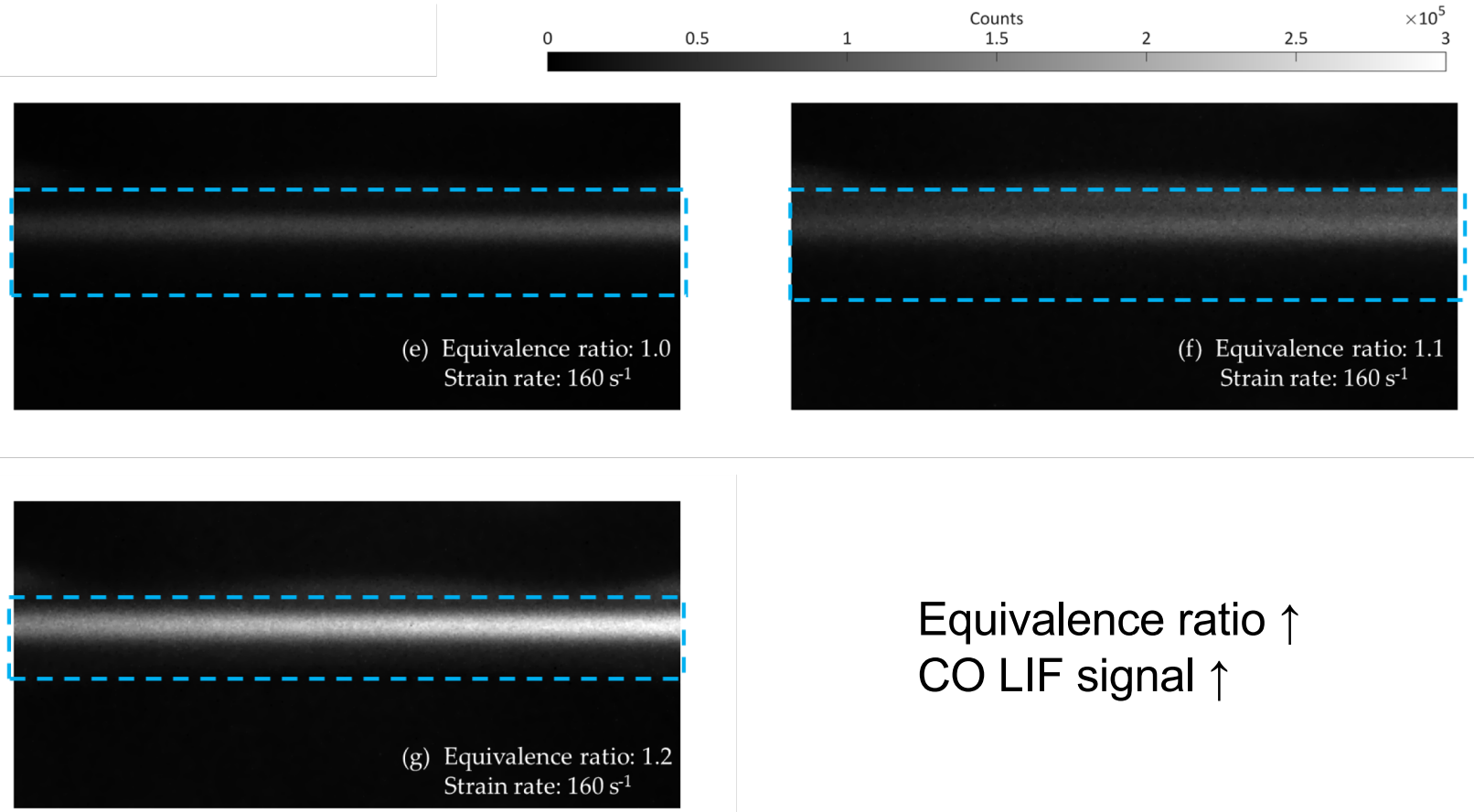
Results and Discussion: CO TALIF



Equivalence ratio ↑
CO LIF signal ↑

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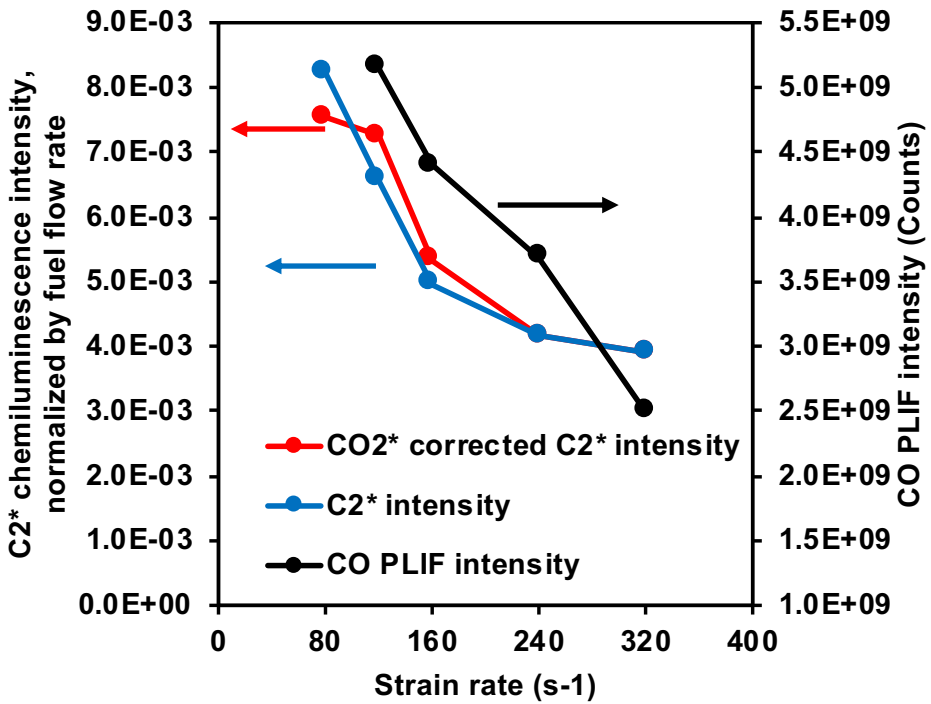
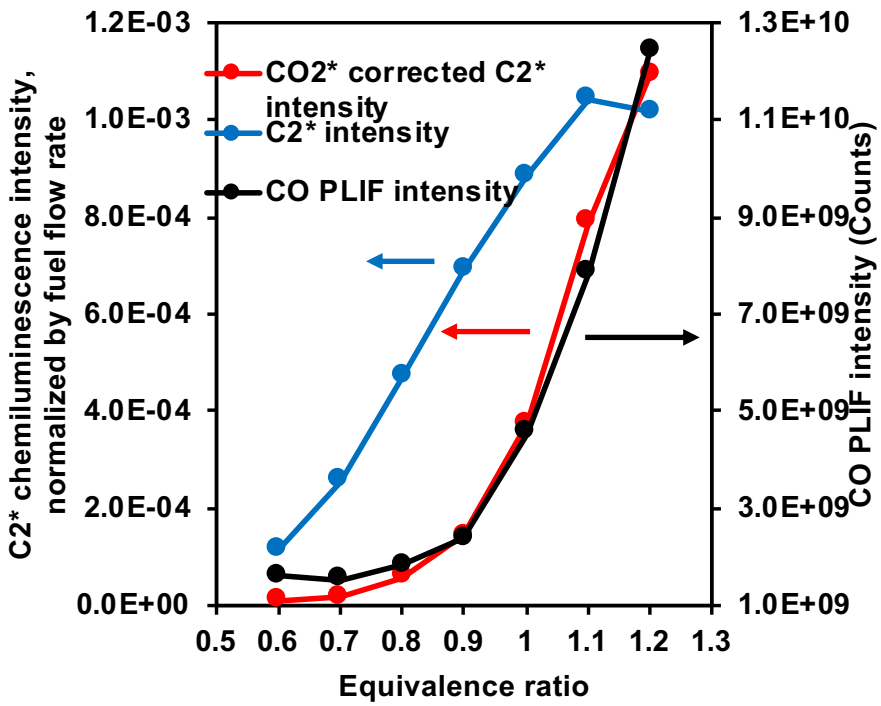
Results and Discussion: Correlation between CL and CO TALIF





Conclusions

1. Although the CO concentration in lean premixed methane-air flames is low, CO TALIF measurements were conducted for the first time under these conditions to detect the CO spatial distribution in the flames with a modest SNR.

2. Both strain rate and equivalence ratio modified the spatial distribution of the CO concentration in the examined flames.

3. The C_2^* chemiluminescent intensity, normalized by fuel mass flow rate, generally correlated well with CO concentration.

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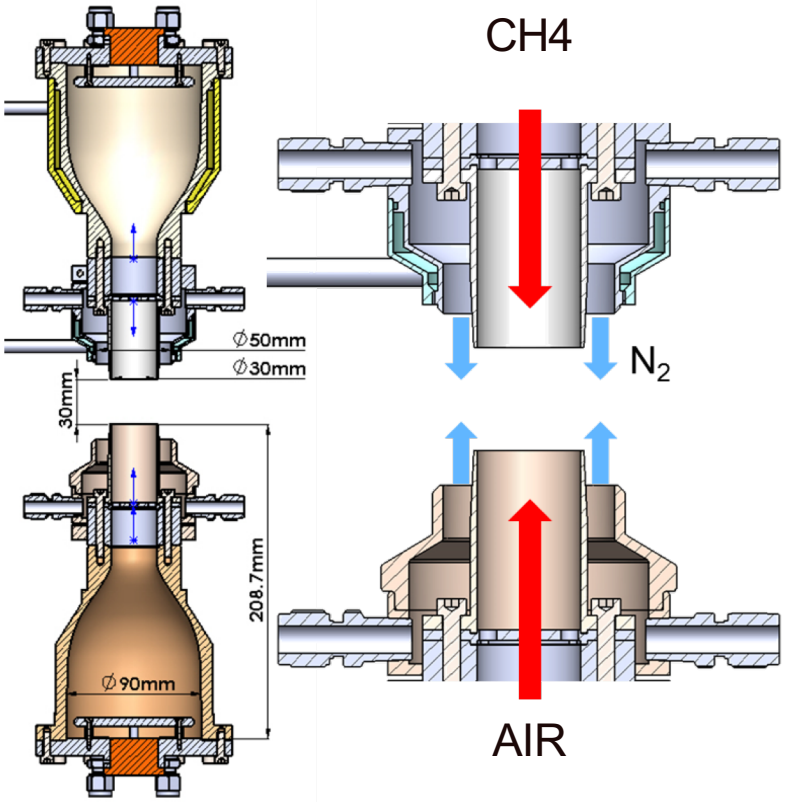
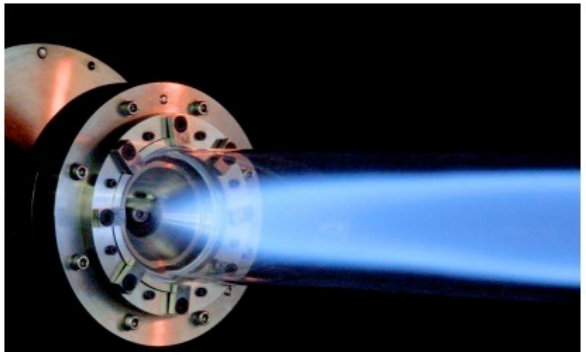
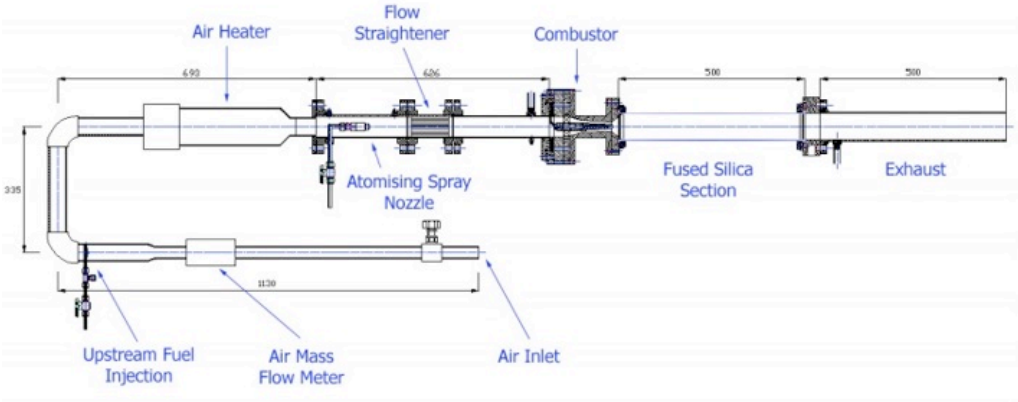
Future works

Counterflow diffusion flame



Model GT combustor, steady and unsteady conditions
PIV+OH PLIF+CO TALIF