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Optical diagnostics for sprays: temperature

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Introduction / outline

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- Faculty since January 2017
- Optical Diagnostics for Thermofluids
  - Non-intrusive temperature measurements

- LIGS technique
- Application in charge cooling
- Examining spray event
- Enhanced resolution LIGS
- Conclusion

What is LIGS?

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- "Laser Induced Grating Scattering"
- "Four wave mixing" laser diagnostic technique
  - Non-intrusive
  - Three input beams cross to define a "point"
  - Two colours (wavelengths)
  - Interaction generates signal beam

- Measures *T* with exceptional precision (~0.1%)
  - Temperature drives chemistry, heat transfer, …
- Straightforward signal analysis

LIGS implementation

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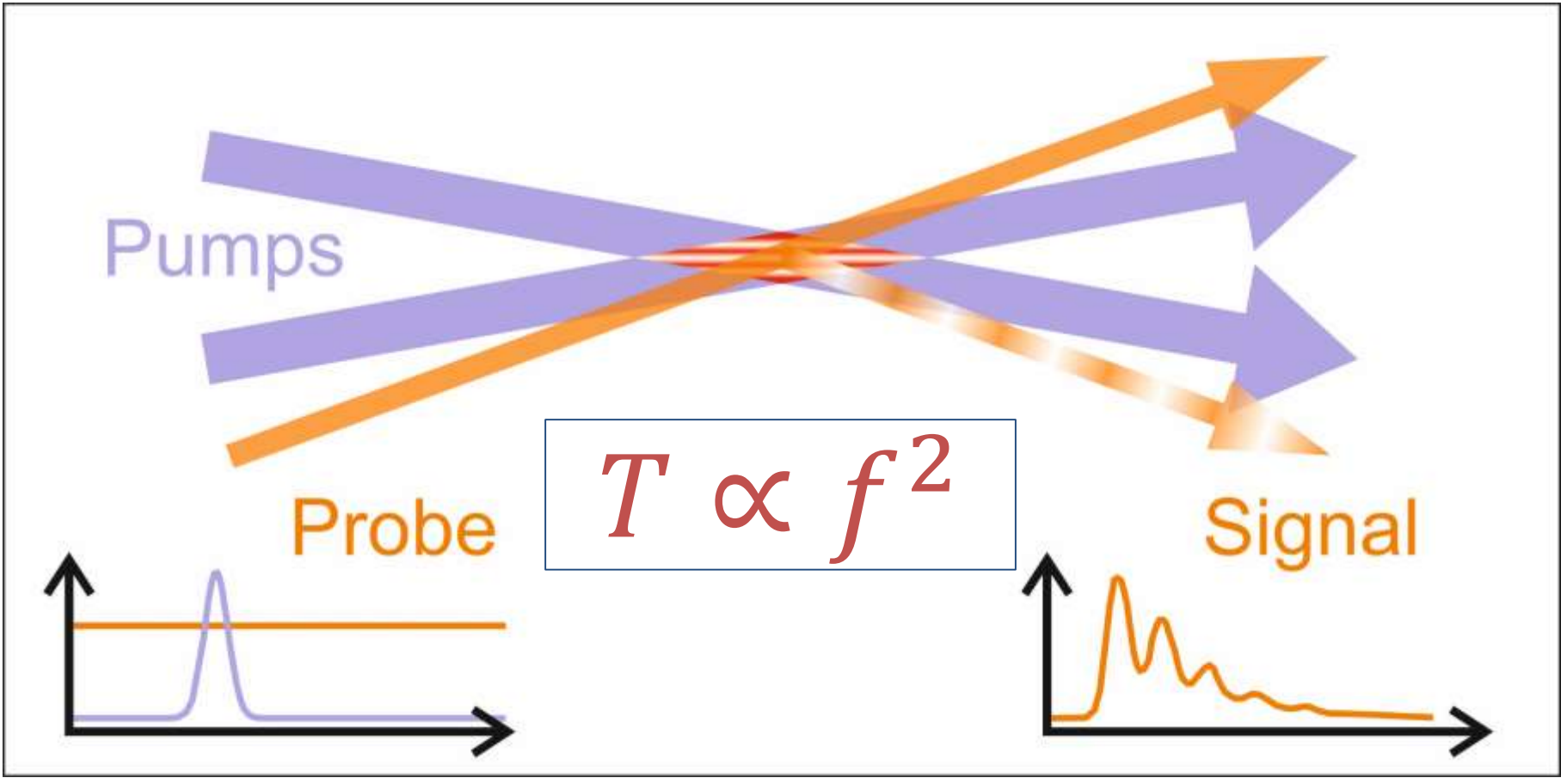

- Instantaneous; measurement within 200ns
- Immune to intensity fluctuations

Anatomy of a LIGS signal

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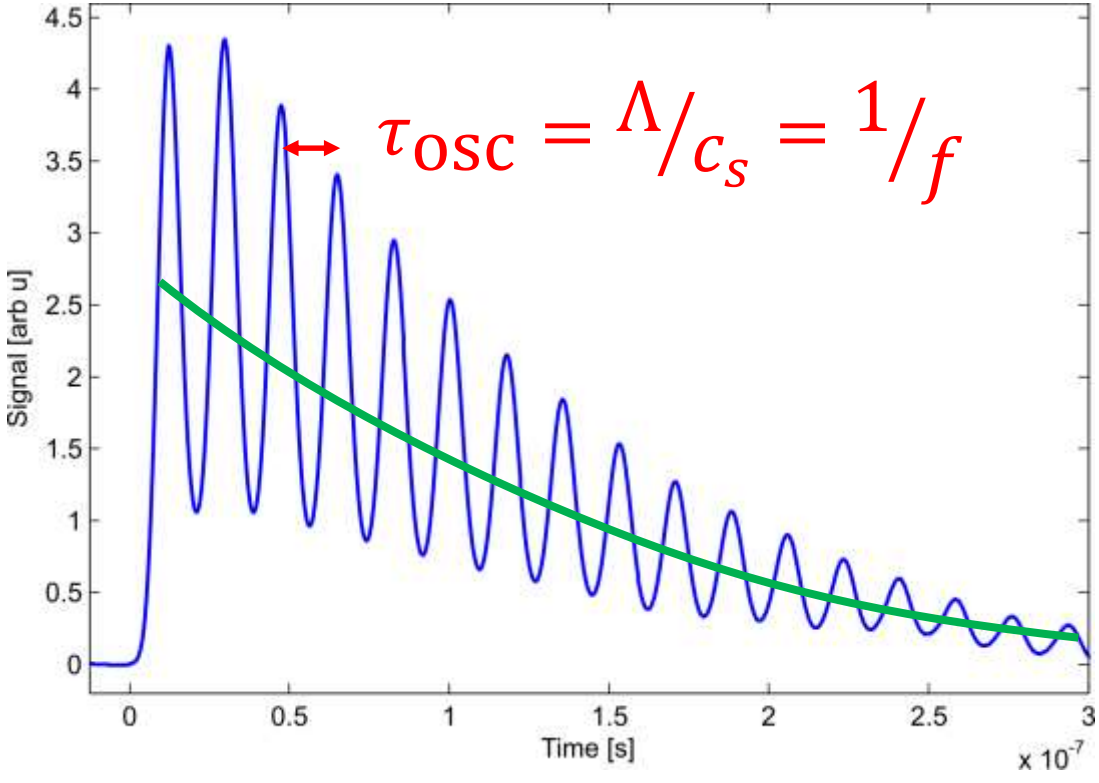
- Signal oscillates as sound wave travels over fringes
- Signal decays as grating diffuses and wave damps



- Link speed of sound to T:

$$T = \frac{\Lambda^2}{k_B}\frac{m}{\gamma}f^2$$

- Link decay lifetime to p:

$$p = f(\tau_{decay})$$

Applying LIGS - ICE

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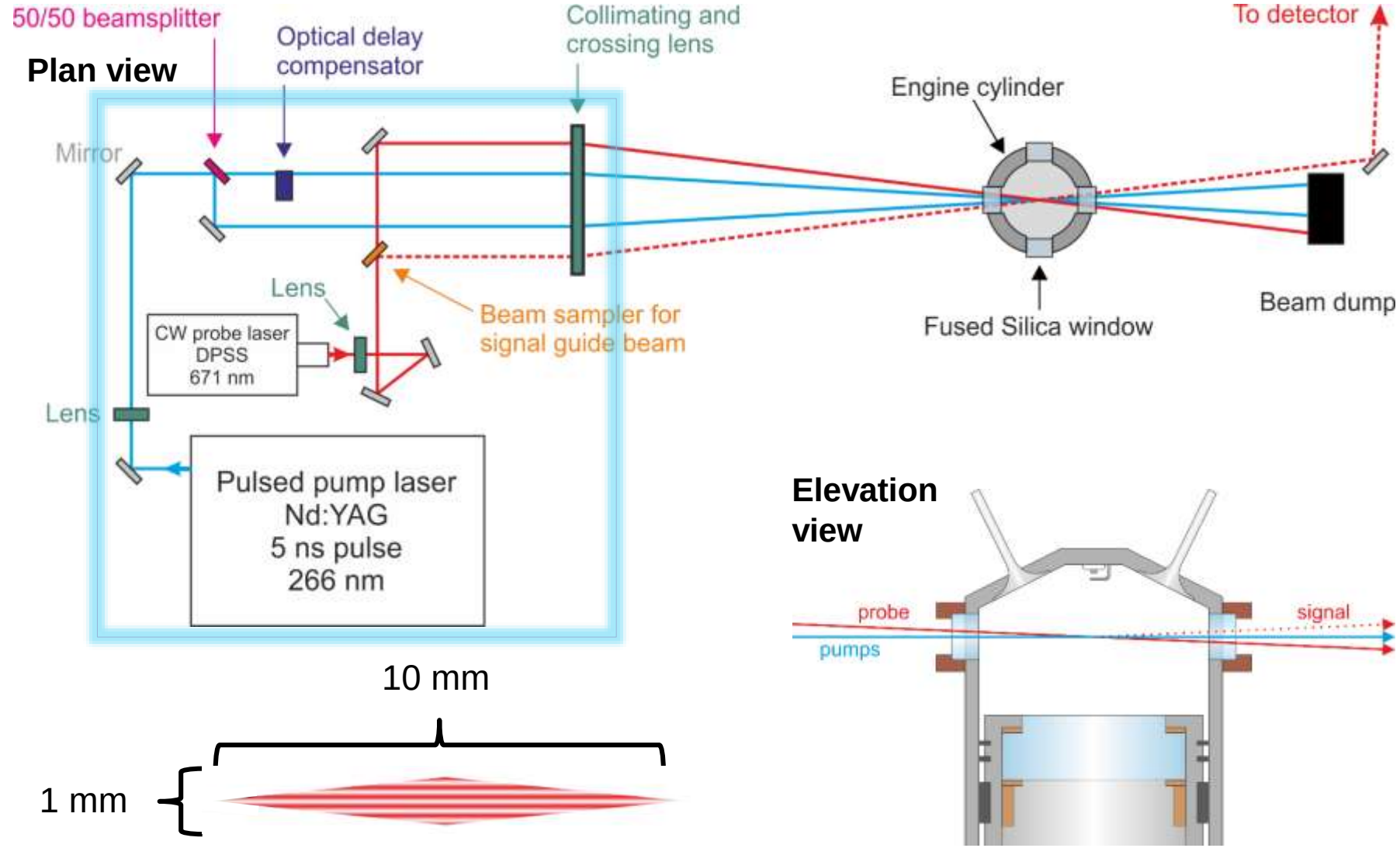

LIGS in action

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LIGS ICE results - T

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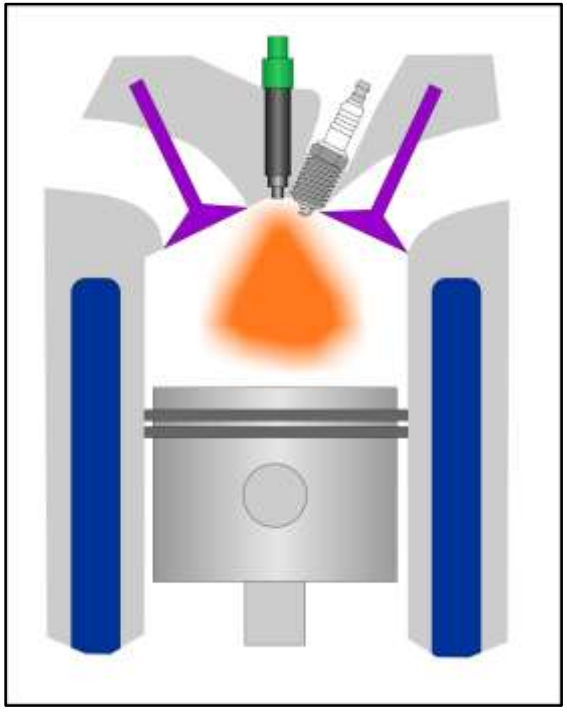
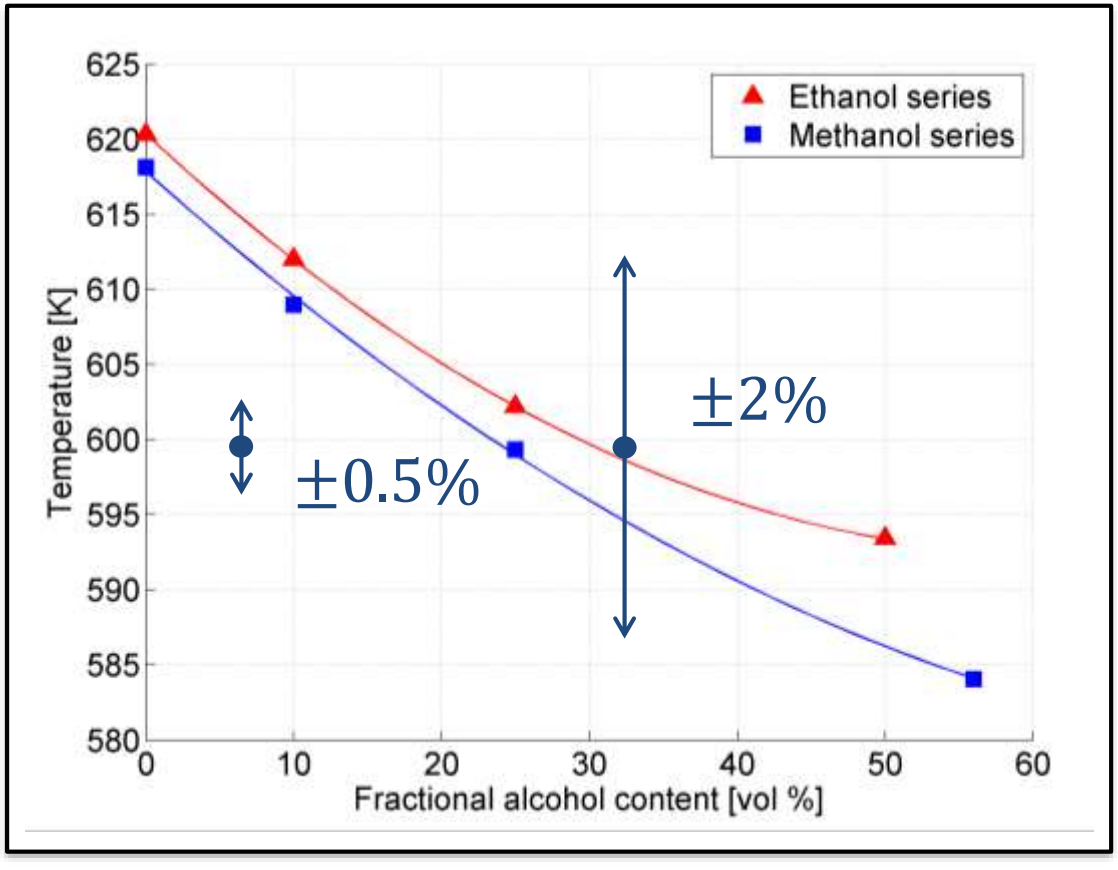
- Charge cooling

$$\Delta T = Q/(m \times C_p)$$



Williams et al, https://dx.doi.org/10.1016/j.combustflame.2013.07.018



- 2014 Sugden Award for first direct measurements

LIGS ICE results - p

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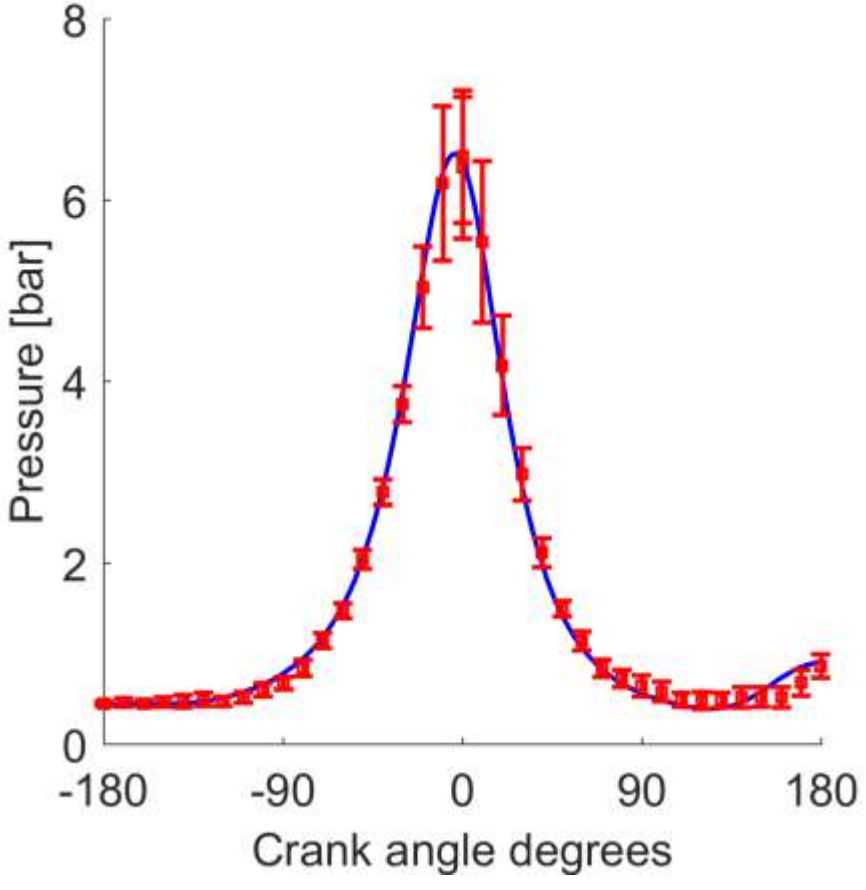
- Rapid pressure recovery by examining signal shape
- Compared against in-cylinder wall mounted fast response transducer
- Typically within 10% with improvements in the pipeline
- To be published…



Commercialisation

DANTEC DYNAMICS Turn Measurements into Knowledge

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LGS Temperature

Laser-induced Grating Spectroscopy (LGS) is a novel optical technique for non-intrusive measurements of gas temperatures. Based on this technique, Dantec Dynamics offers a complete and compact solution to measure the temperature of gas. Compared with other optical temperature measurement techniques, it is relatively simple, but still able to accurately measure temperature in a wide range.

Transmitter probe of the LGS Temperature

Features

Non-intrusive, in-situ measurements	Real-time temperature measurement
No calibration needed	Proven accuracy and high resolution
Compact and integrated solution, easy to use	Synchronization with engine supported

Products & Services

- General Literature
- Fluid Mechanics
- Spray and Particle Characterization
- Inkjet printhead quality control
- Combustion and Temperature Diagnostics
  - LGS Temperature
  - Measurement Principles LGS Temperature
- Rayleigh Thermometry
- Microfluidics
- Shearography - NDT
- Services & Consulting
- Thermal Comfort

Upcoming Events

- Commercial version of our portable LIGS prototypes
- Visiting Oxford next week
- On sale shortly afterwards!

Charge cooling and heat transfer

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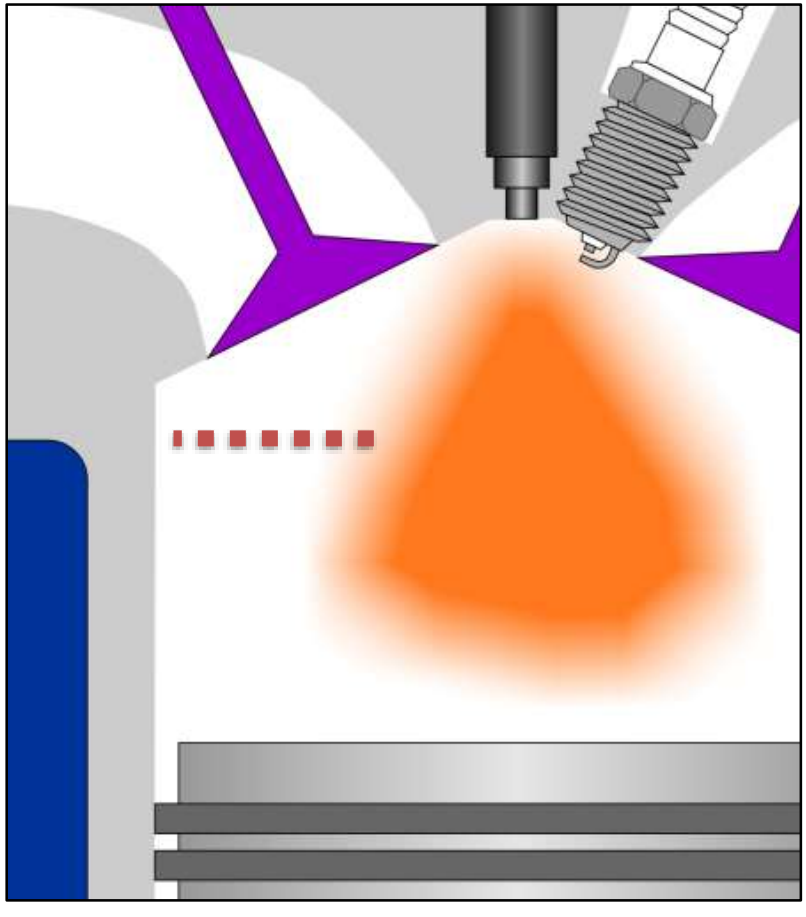
- Where does the energy come from to vaporise?
  - Heat transfer, $\dot{q} = -k\frac{dT}{dr}$
- Measure temperature as a function of radius near the spray
  - LIF or Rayleigh, but suffer from interferences
- Raster-scanning LIGS?
  - …there is a better way!



Spatially-resolved LIGS

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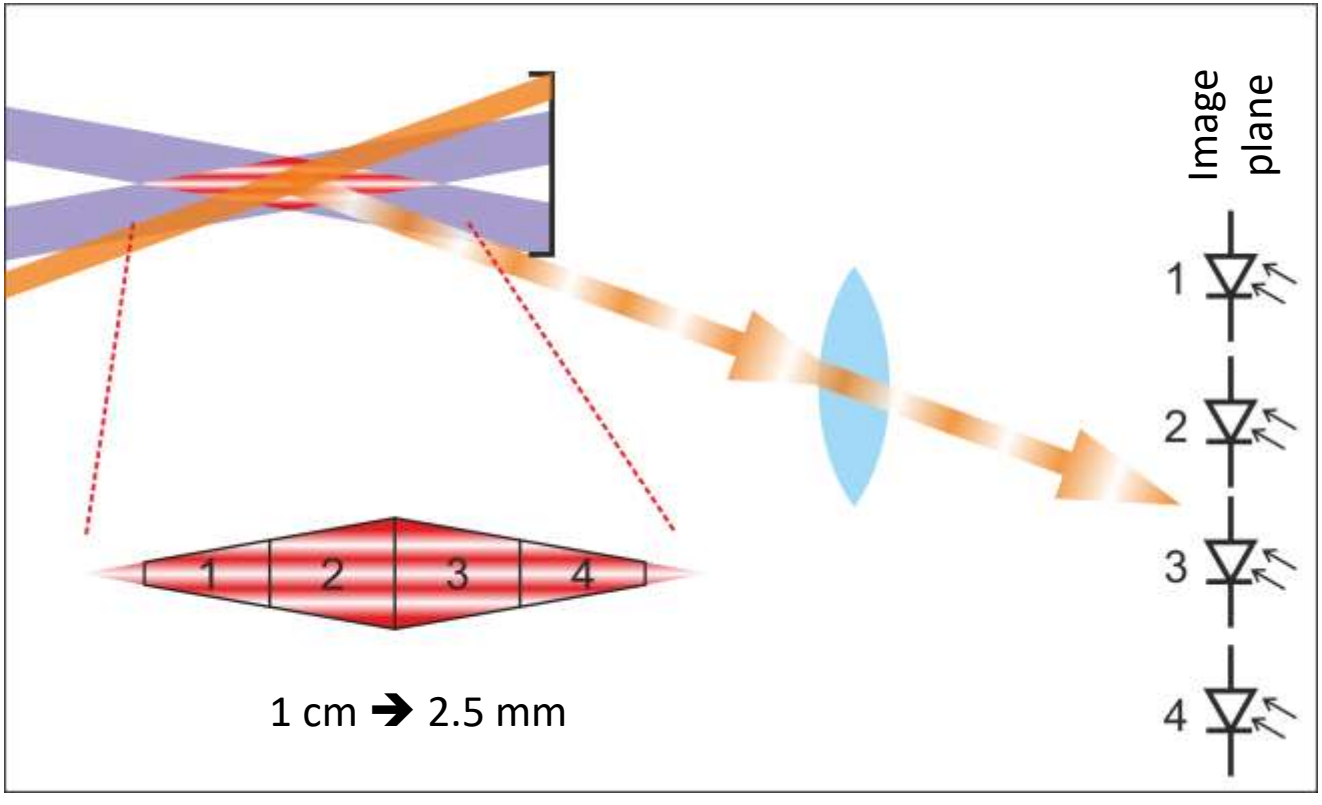

- Sub-divide grating length!
  - Quasi-Scheimpflug imaging
  - High bandwidth multi-element detector

Work in progress!

Grazing-incidence LIGS

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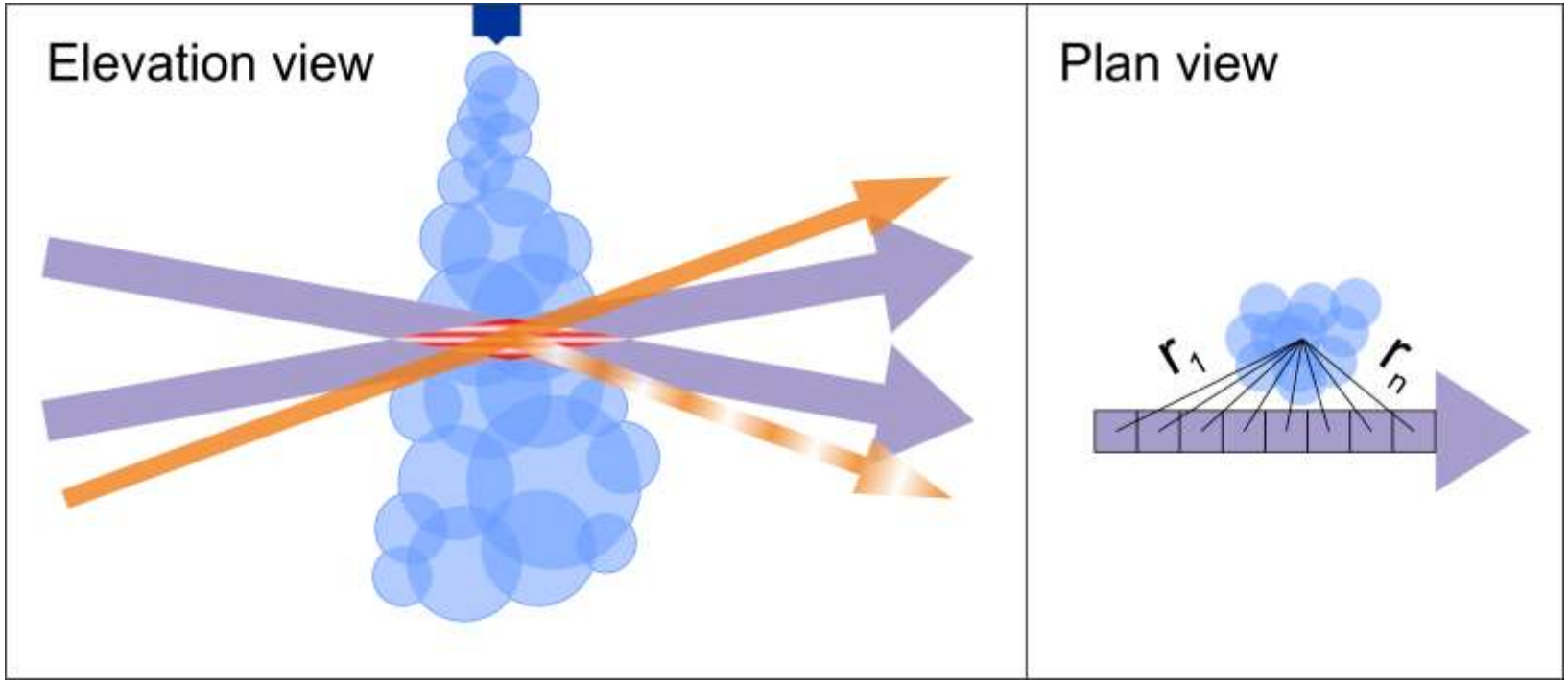

- Skim spray surface
  - What droplet density could be tolerated?
- Irregular sampling of radius

Conclusions

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- LIGS is a flexible multiparameter diagnostic
  - Temperature, pressure, (composition, velocity…)
  - It also complements other diagnostics like PLIF
- Current/future developments include
  - Enhanced spatial resolution
  - 1-D (2-D?) LIGS for heat transfer
  - kHz LIGS for transients, including unsteady/dynamic temperature and pressure measurements
  - (Further) developing “tracer-free” capability
- Watch this space!

Questions?

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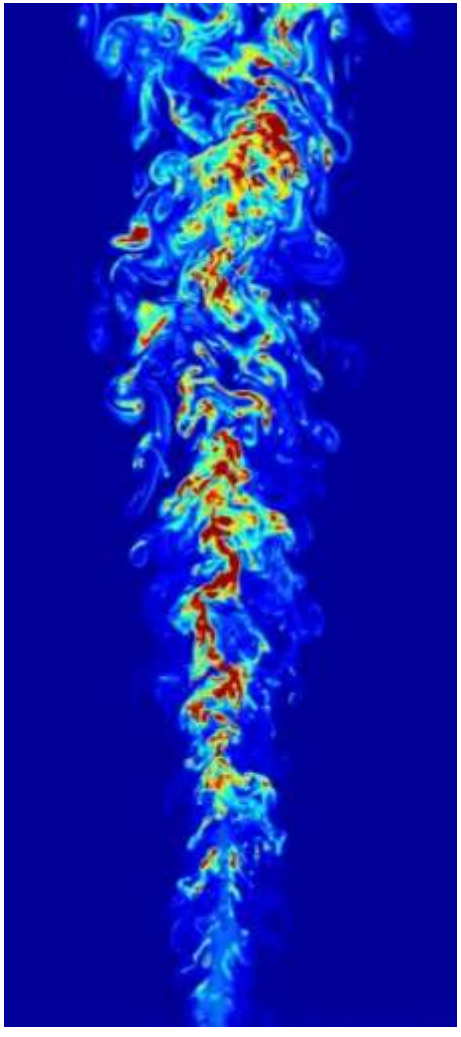

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  - DPhil: Priyav Shah

EPSRC
Pioneering research and skills

bp

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