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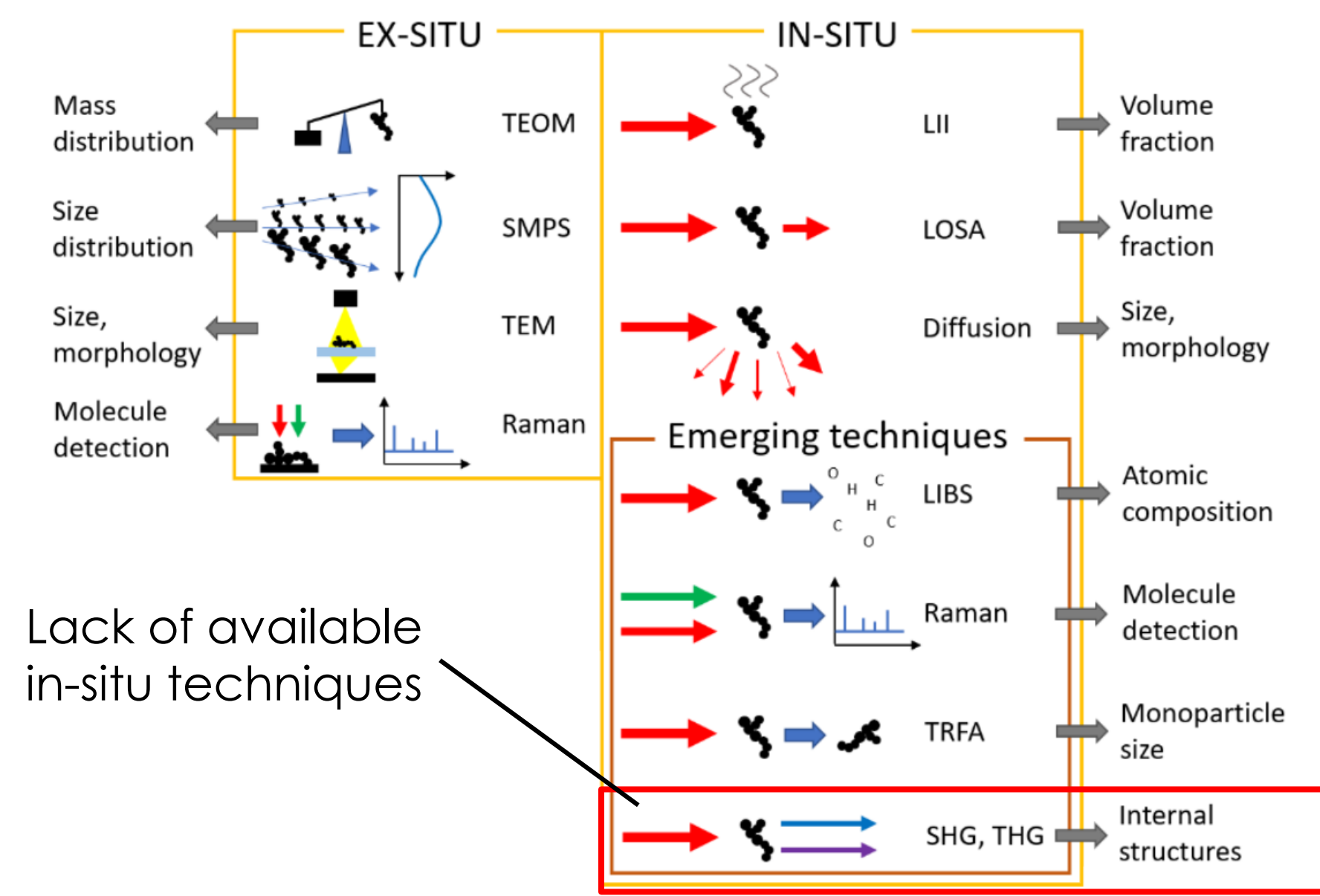
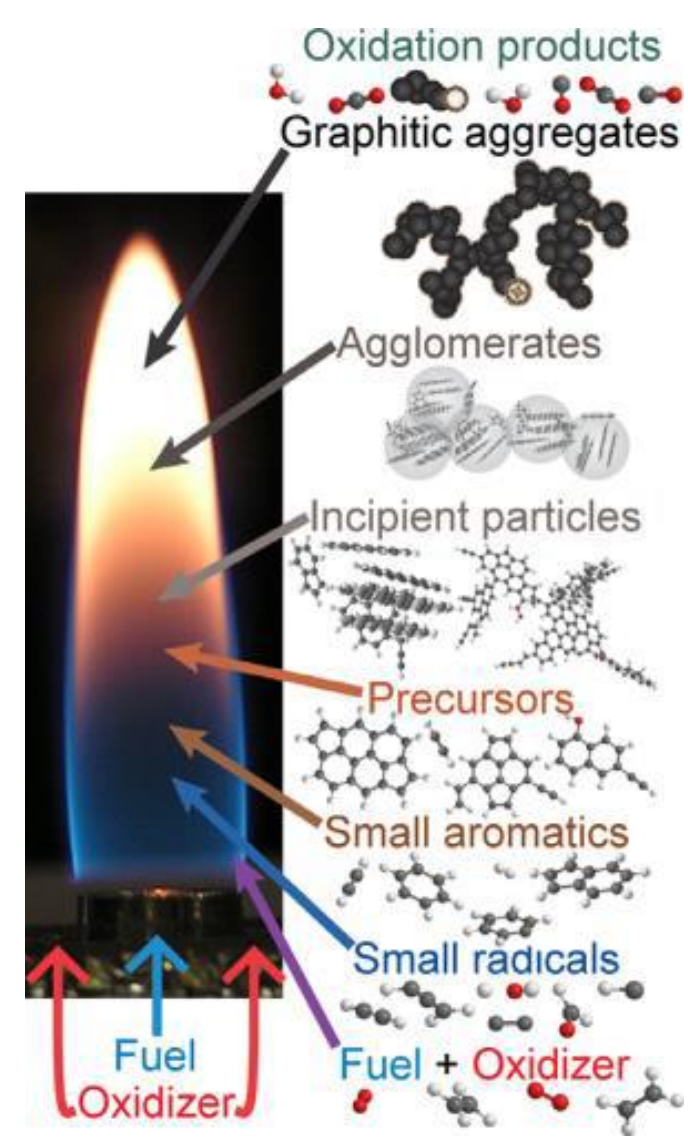


# Spectral and angular analysis of non-linear optical response of soot exposed to femtosecond laser light

Maxime JORET, Said IDLAHCEN, Alexandre POUX, Marek MAZUR, Jérôme YON  
UMR6614 CORIA, INSA Rouen Normandie, CNRS, Université de Rouen Normandie



## Context



Lack of available in-situ techniques

Black carbon during formation and oxidation [2]

- Soot nanoparticles are known to be **dangerous for human health and to promote climate change** [1]
- Numerous diagnostics exist for their macroscopic analysis but **not for their inner structure (crystalline/amorph/organic)**

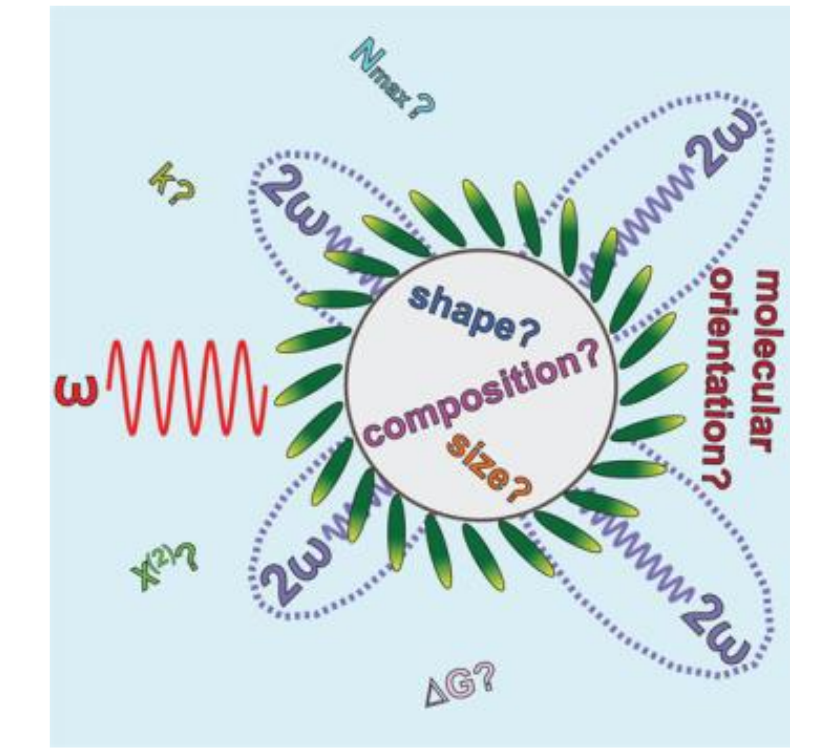
The aim of the present work is to use non-linear optics to assess new information about black carbon nanoparticles

## Theoretical background

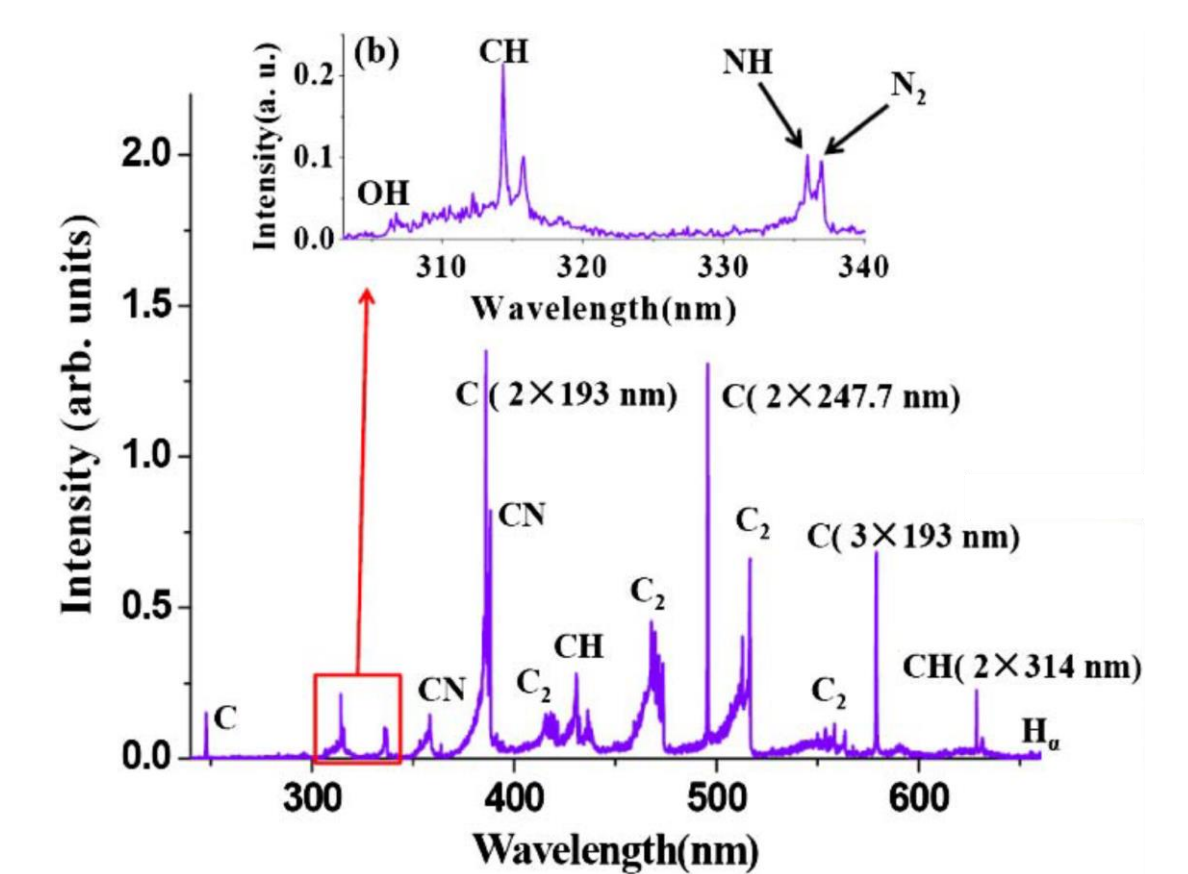
- Non-linear optics (NLO): **Optical response of a medium to light of very high intensity** (femtosecond laser)
- Induces the generation of **light with other wavelengths, polarisations,...**
- Second harmonic generation (SHG): **Generation of light with half wavelength, quadratically related intensity:**

$$P_{(2\omega)} \propto \chi E_{(\omega)}^2$$

- SHG related to the **centrosymmetry of molecules**
- Already applied in **biology** (NLO microscopy), **BC particles in liquid suspension, dyes in aerosol phase or electric fields** [3-6].
- Combustion intermediates sensing** by femtosecond filament excitation [8]
- Not yet applied and analyzed for BC aerosols**

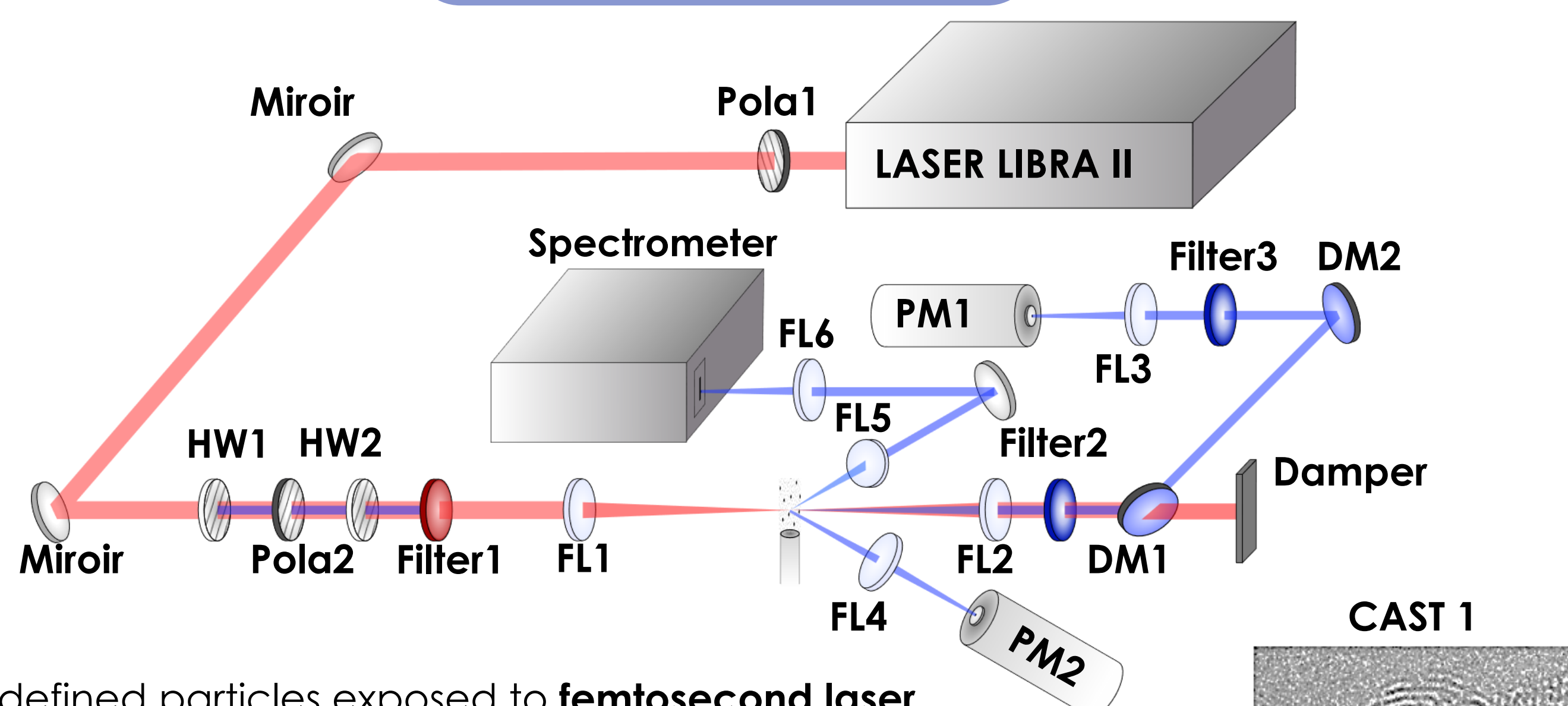


Possible NLO effects on aerosols [7]



Spectrum of flame by laser induced filamentation excitation [8]

## Experimental setup



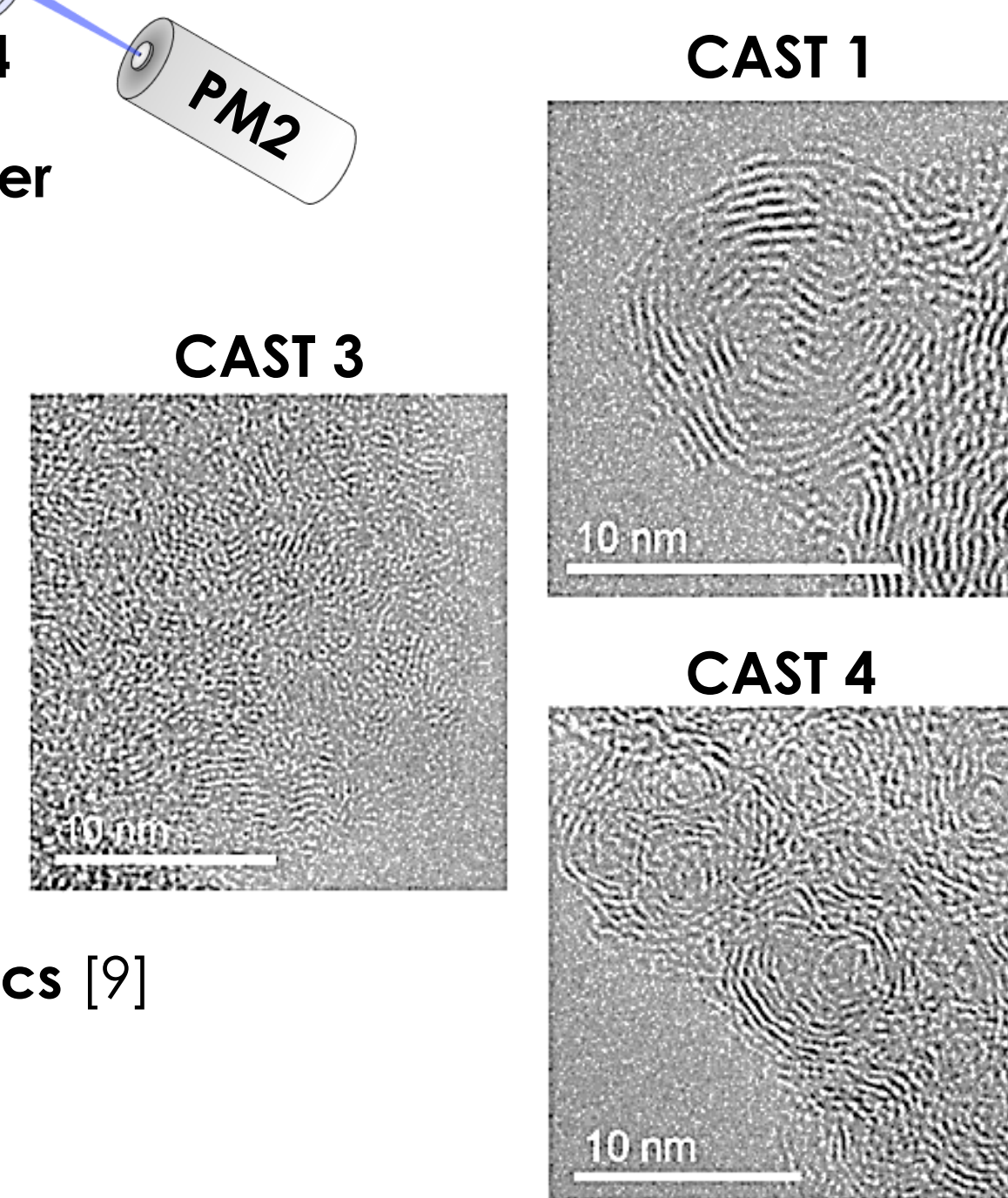
- Well-defined particles exposed to **femtosecond laser pulses (100fs/800nm)**
- 3 detection lines:

**Temporal analysis at 0 degrees**  
filtered for 400nm (Photomultiplier tube)

**Temporal analysis at 30 degrees**  
filtered for 400nm (Photomultiplier tube)

**Spectral analysis at 30 degrees**  
(Spectrometer + ICCD Camera)

- Great care for **not generating SHG through the optics** [9]
- Particles generated with MiniCAST** with mainly graphitic (CAST1), organic (CAST3) and amorph (CAST4) compounds as well as organic spherical particles (DEHS) [10,11]

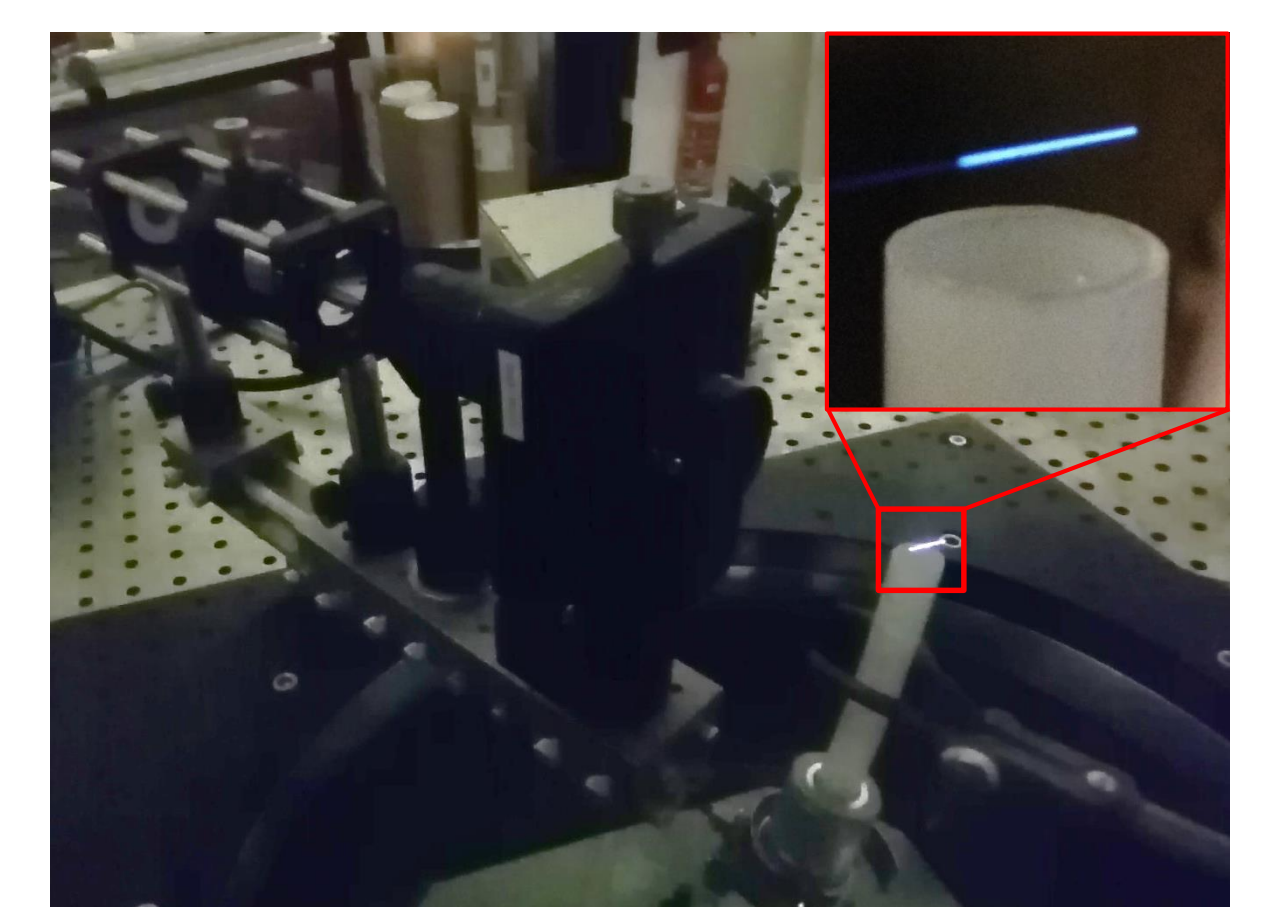
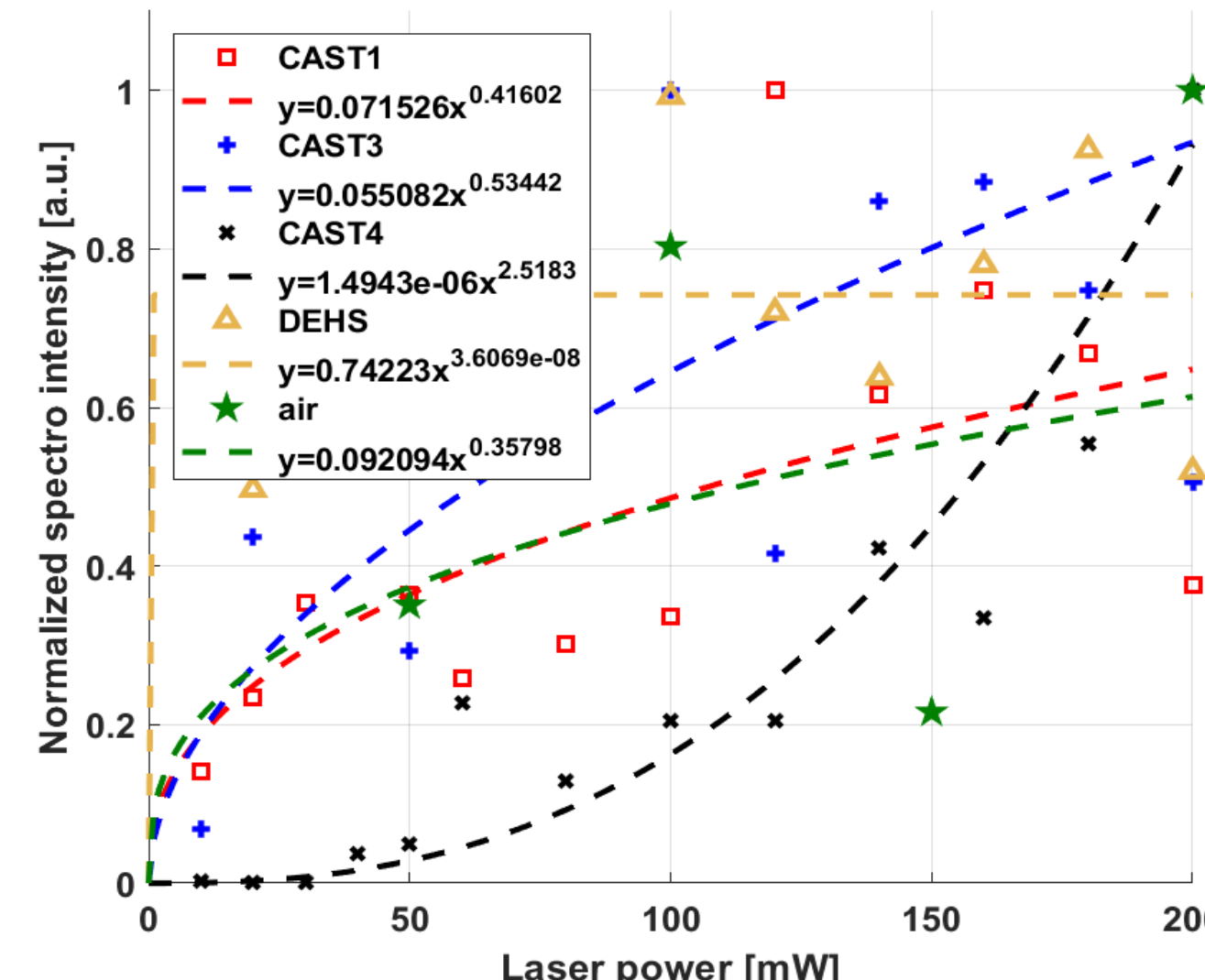
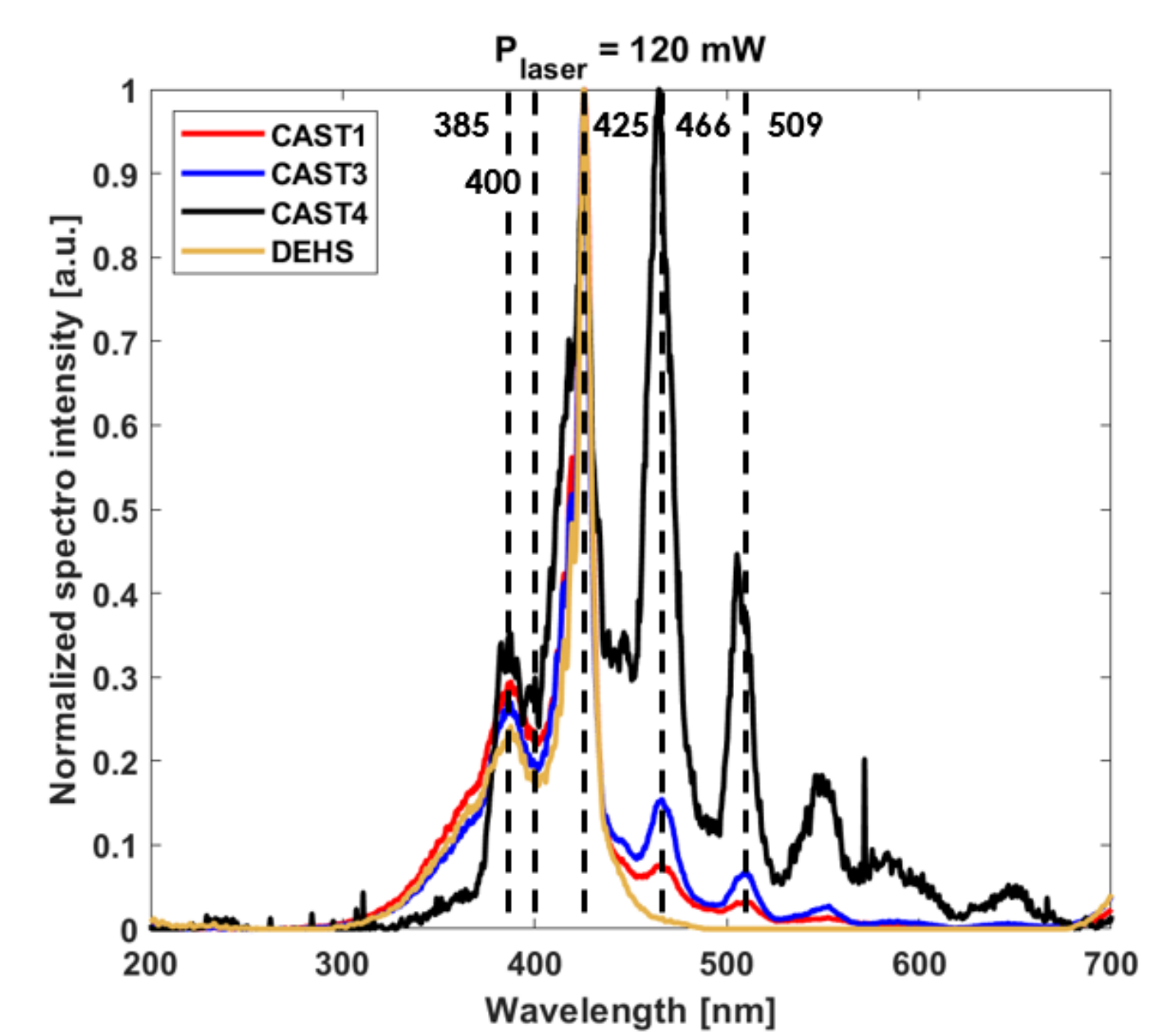
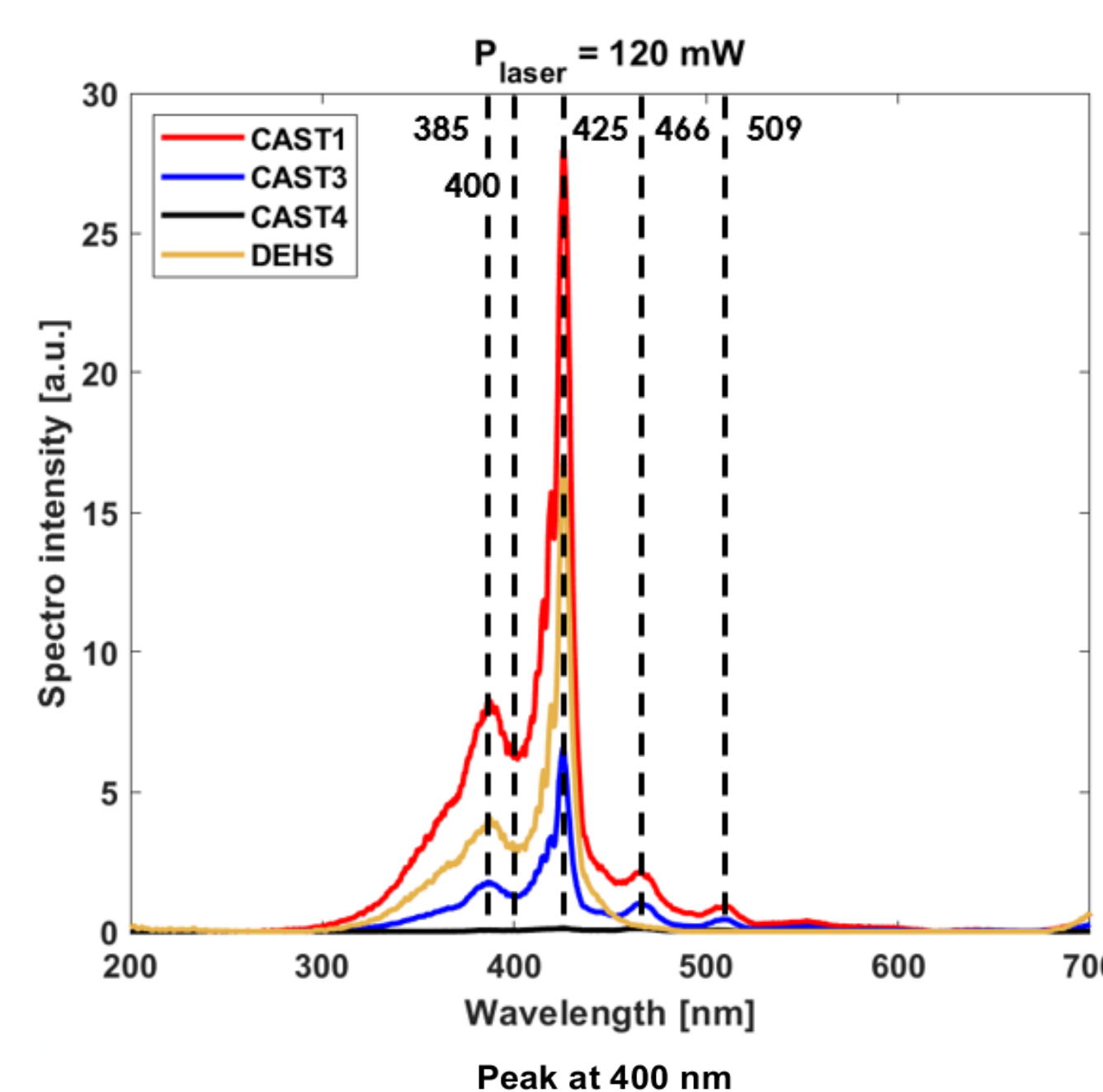


Transmission electron microscope (TEM) images of CAST1, CAST3 and CAST4 nanoparticle structure [11]

## Conclusion

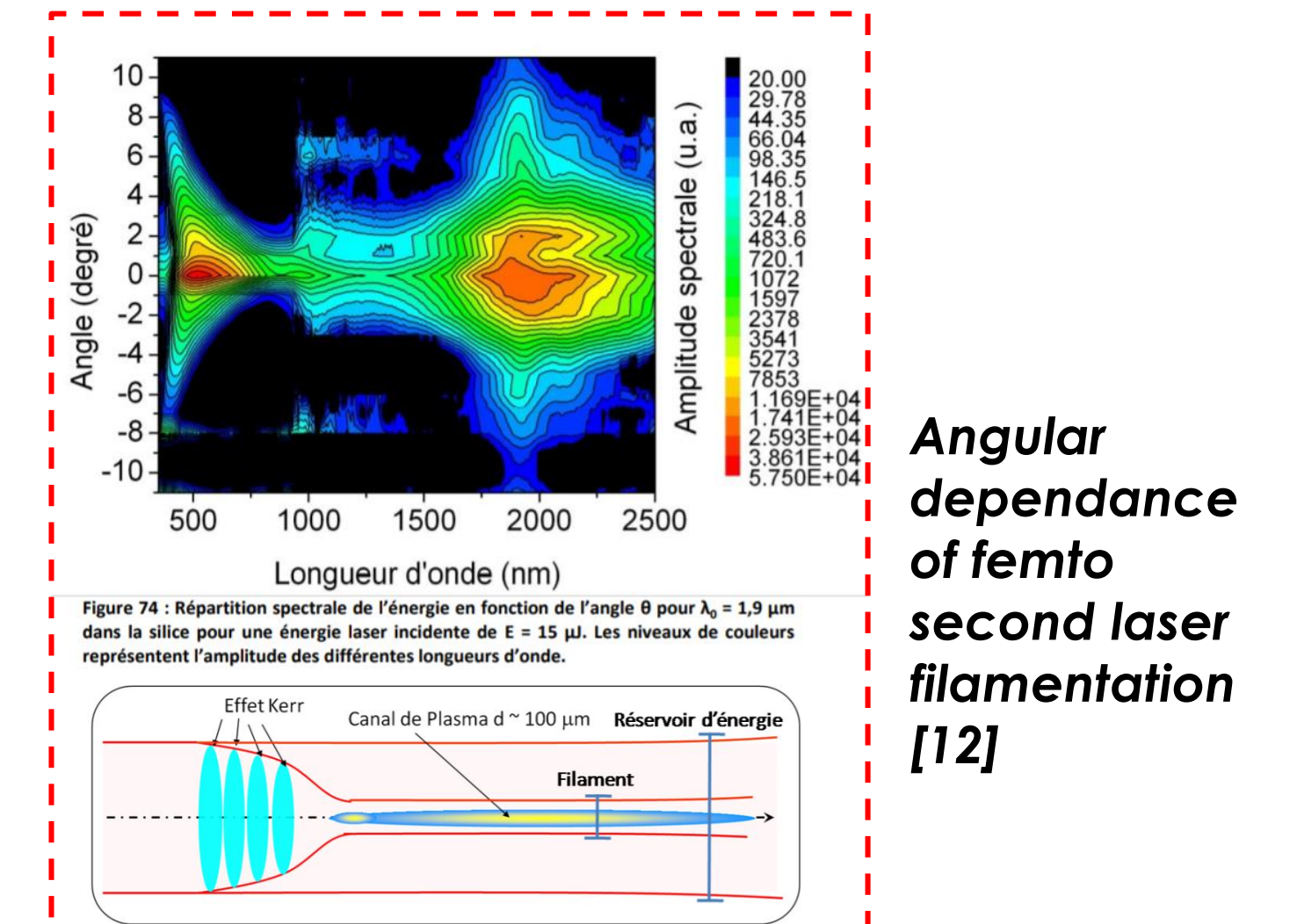
- Results show peaks that probably correspond to **filamentation induced fluorescence**.
- The presence of **aerosol** seems to **influence** the properties of the induced filaments.
- Certain peaks seem to be favored in the presence of **amorphous materials**.
- A soot type dependence is visible**, but it is still too early to quantitatively associate these signatures with structural properties of the particles.

## Results



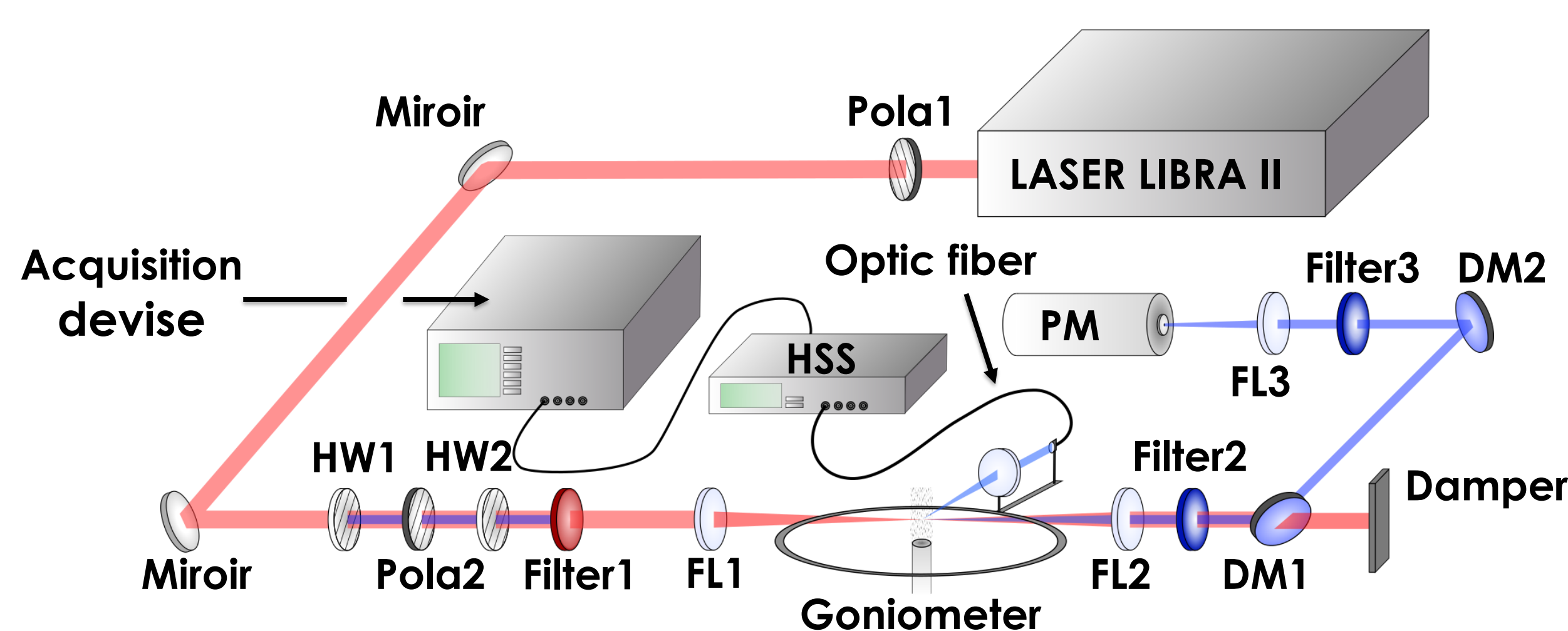
Filamentation in DEHS aerosol

- Several distinct peaks** (385 nm, 425 nm, 466 nm, 509 nm) that correspond to **filamentation induced fluorescence**
- Very weak peak at 400 nm** which could correspond to **SHG**
- Signal at 400 nm has a **near quadratic trend** for CAST4
- Signal is **not quadratic for other aerosols**



Angular dependence of femto second laser filamentation [12]

## Perspectives



New experimental setup proposed to investigate the nature and behaviour of these signals in terms of **temporal, spectral and angular response**.

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