

***Laser-Induced Incandescence:
current applications
&
future prospects***

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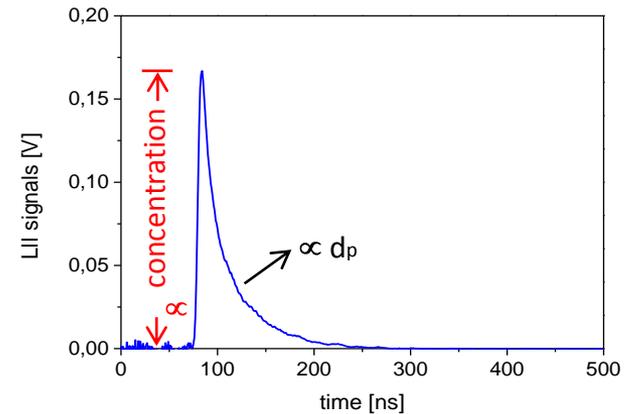
Outline

- Brief introduction to Laser-induced incandescence (LII)
- Sphere-integrated LII Spectroscopy Instrument (SiLIIS)
- Optical properties of laser-heated combustion-generated nanoparticles

Laser-Induced Incandescence (LII)

What is LII ?

LII is a physical process which involves a rapid (ns) heating of refractory nanoparticles with a high-power laser.



What does LII do?

Quantitative measurements of refractory materials:

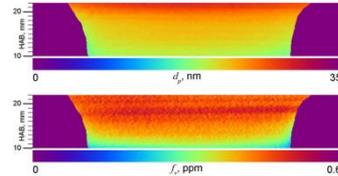
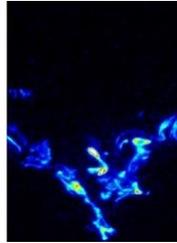
- Concentration
- Primary particle diameter

Measurement features:

- * High selectivity
- * High temporal and spatial resolution
- * High sensitivity and wide dynamic range
 $\text{ng/m}^3 - \text{g/m}^3$

LII application

- * Flames



- * Internal combustion engines

- * Exhaust gases

- * Ambient atmosphere

- * Engineered nanoparticles

- * Suspensions

(black carbon in snow, ice, and rain)

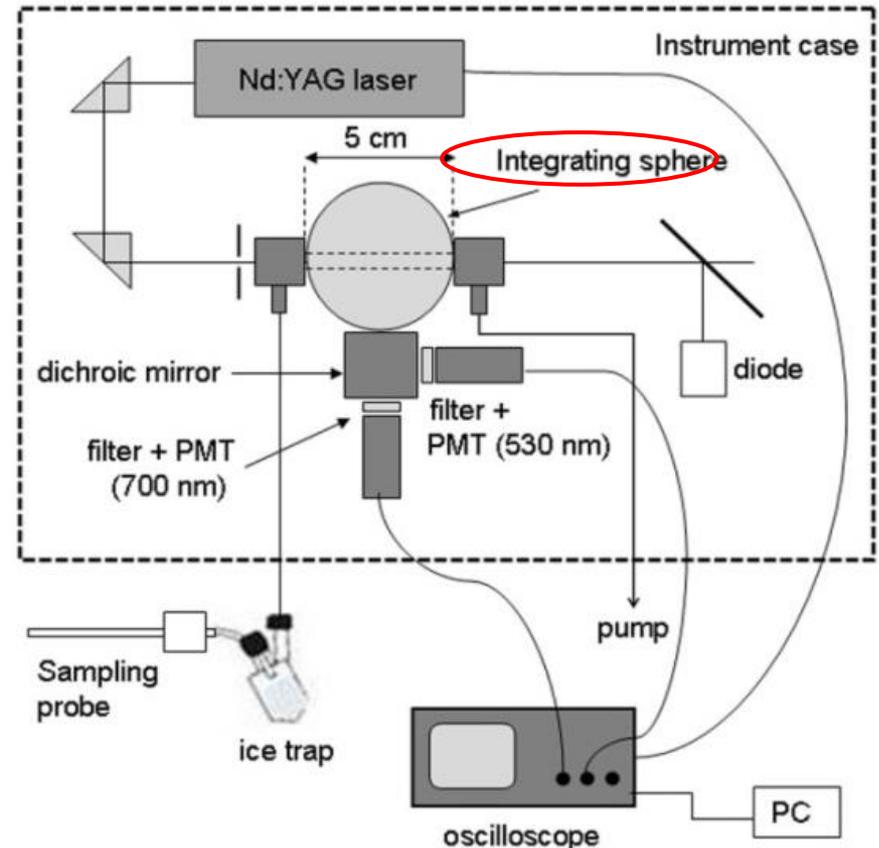


H.A. Michelsen, C. Schulz, G.J. Smallwood, S. Will, Prog Energy and Combust Sci 51, 2015

SiLIIS: Sphere-integrated LII Spectroscopy

Home-made LII based instrument for Black Carbon monitoring

- * Quartz tube cell placed into an **integrating sphere**
- * Two-color pulsed LII : 530 and 700 nm
- * Optical calibration
- * High laser fluence $\sim 300 \text{ mJ/cm}^2$
- * Detection limit: 200 ng/m^3



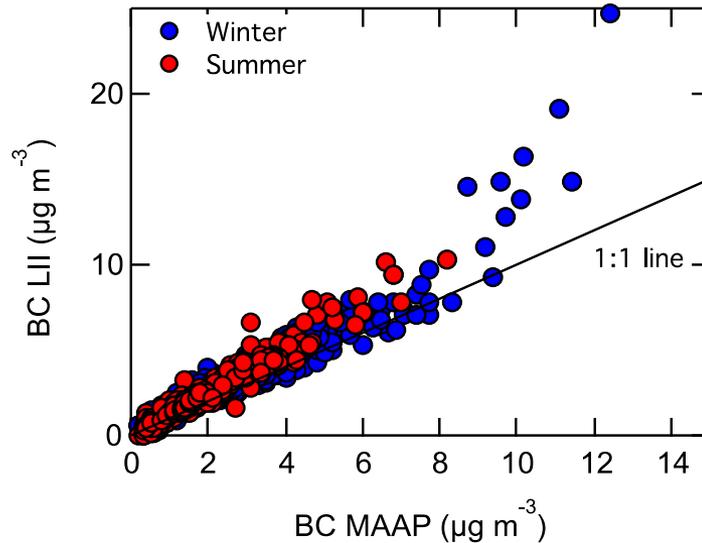
Italian Patent ITRM20090617

LII for BC monitoring in the environment



Black Carbon Tool – BLACK CAT

develop and optimize a methodology and an algorithm for an accurate quantification of BC in urban and rural environment in the surrounding of Milan metropolitan area.



- Good agreement
- MAAP tends to underestimate BC concentration for values larger than 10 mg m⁻³, due to filter overloading effect

Project funding: Fondazione Cariplo

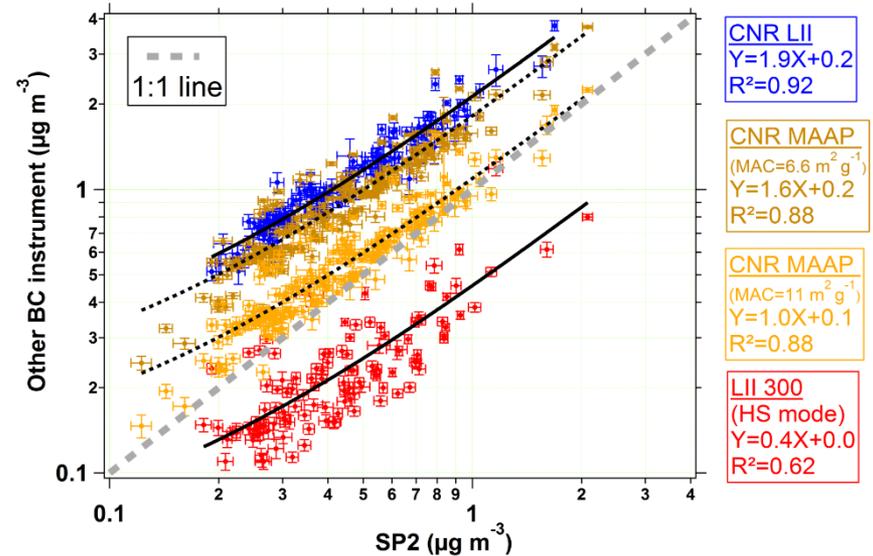
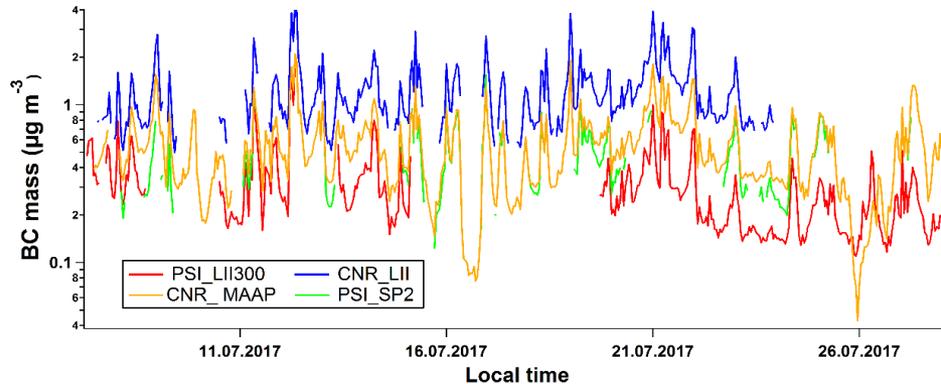
Partners:



21-22 May, 2019 - Conferenza di Istituto, Padova

LII for BC monitoring in the environment

ACTRIS-2 Mt. Cimone and Po Valley field Campaign 2017



Comparison of four BC instruments

! We don't know which instrument is more accurate currently

Partners:



<http://actris-cimone.isac.cnr.it/>

LII for indoor air quality monitoring

Atmospheric particulate matter: a threat to the health of Raffaello

Objectives:

- * Monitor the concentration and chemical composition of the aerosol particulate matter
- * Design a new showcase according to the specific environmental and microclimatic conditions of the room

Take home message:

- * Particles in the range 0.3-0.5 μm interaction with the porosity of the surfaces of works of art
- * high concentration of organic carbon interaction with paper supports

Partners:



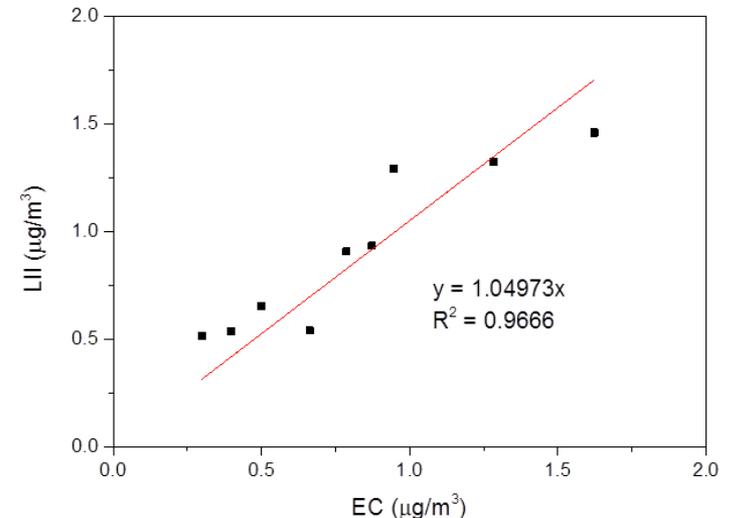
UNIVERSITÀ
DEGLI STUDI
DI MILANO



POLITECNICO
MILANO 1863



Cardboard of the School of Athens (1509-1511)
Ambrosiana Art Gallery in Milan



Good correlation between LII and chemical speciation by thermal/optical transmittance analysis

Black Carbon intercomparison workshop @ PSI

PSI Calibration Center for soot Measurements (CCSM) in Villigen (CH)



Objective

Conduct a common set of BC calibration experiments in order to intercompare a large number of LII instruments.

A variety of BC aerosols (both coated and uncoated) will be generated in a simulation chamber for this purpose.



integrating the most advanced European atmospheric simulation chambers into a world-class infrastructure for research and innovation

- Sphere-integrated LII Spectroscopy Instrument
- Optical properties of laser-heated combustion-generated nanoparticles

Laser-heating for tuning flame-soot optical properties

The concept of circular economy is promoting a renewed interest in combustion-generated nanoparticles (soot) that from polluting and unwanted material can turn into a **resource**

the use of **flame-soot** as an **innovative** and **useful material** requires careful control of its properties.

explore the possibility to tailor their **optical properties**
by in-line irradiation with a high-power laser

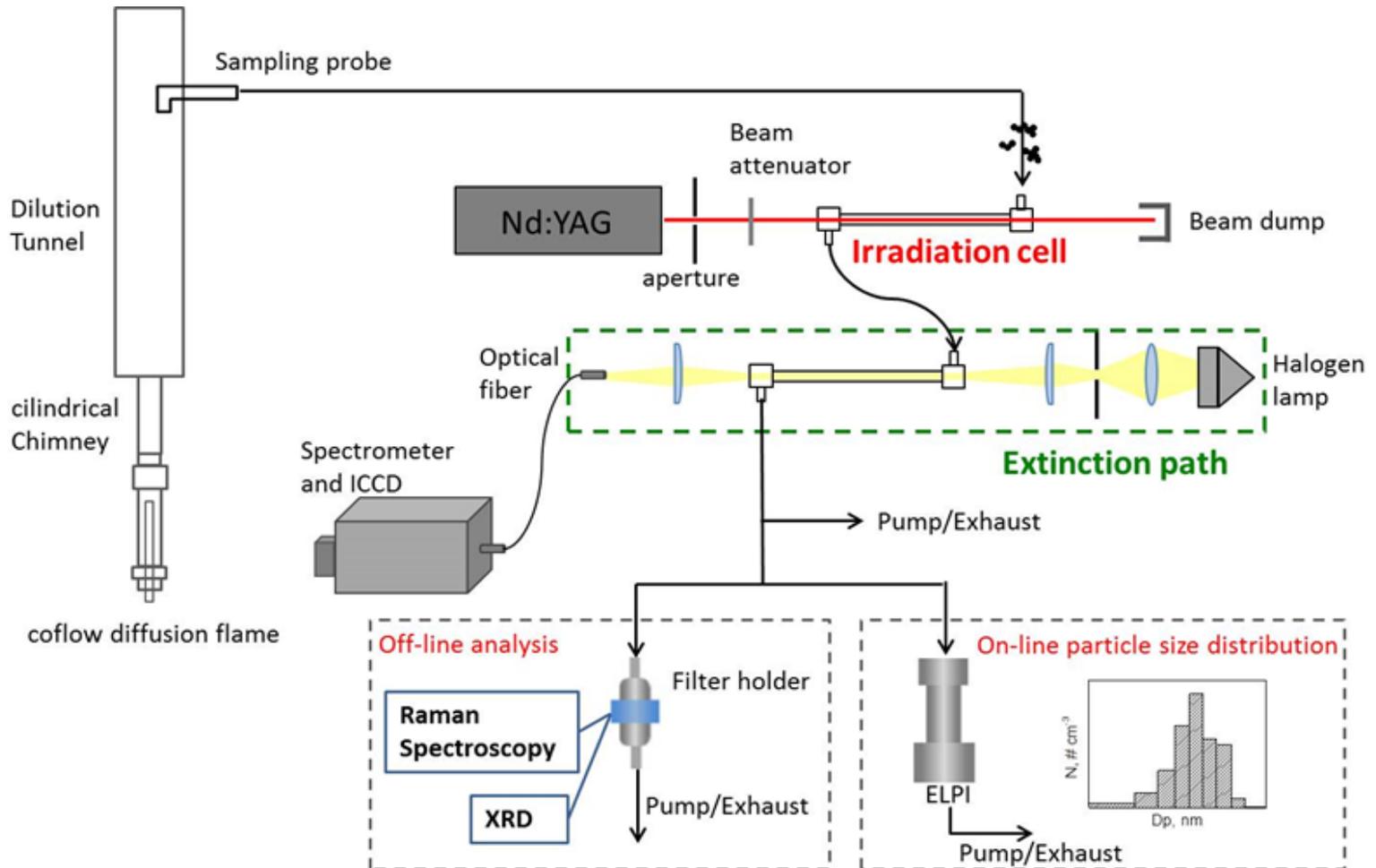


Methodology

Coupling optical and non-optical techniques to clarify the effect of laser- heating

- Extinction measurement → **optical properties**
- Raman Spectroscopy → **particle nanostructure**
- X-Ray diffraction analysis → **particle nanostructure**
- Particle size distribution evaluation → **aggregate size**

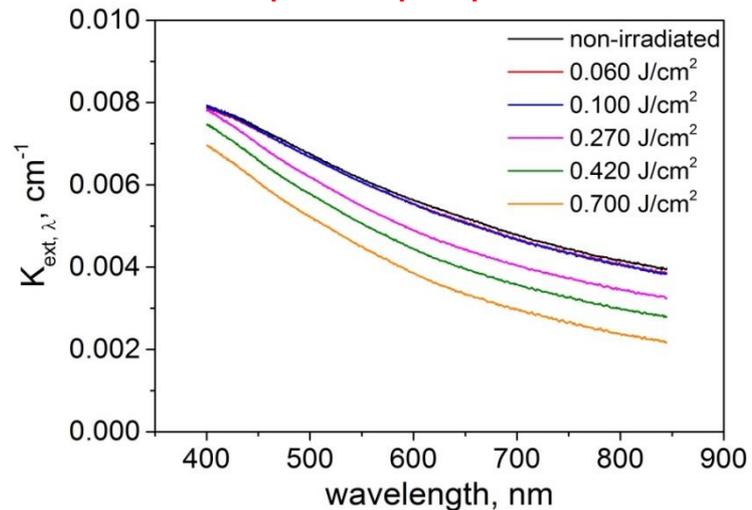
Experimental layout



Results 1

Wavelength-resolved
extinction
measurements

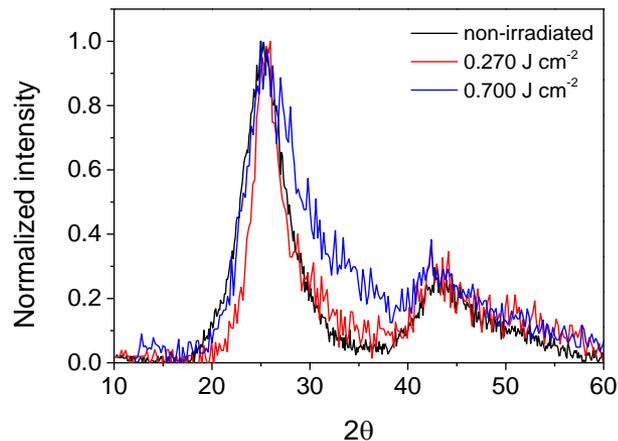
optical properties



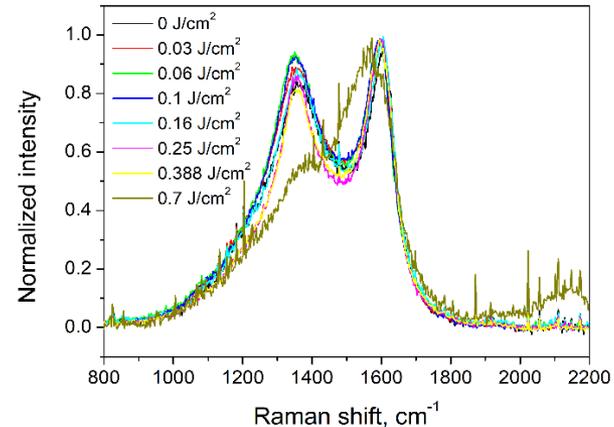
significant variation in the
optical properties of laser-
irradiated particles.

particle nanostructure

XRD



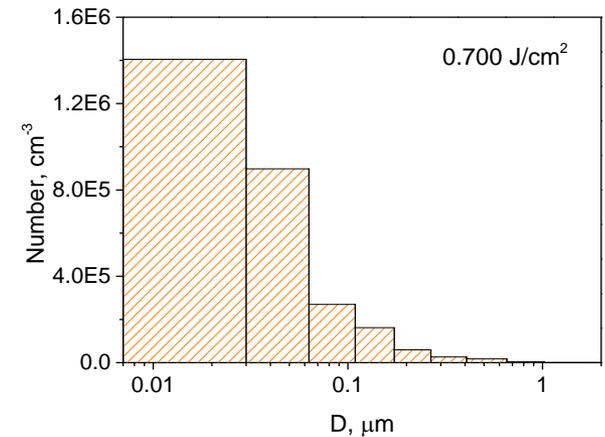
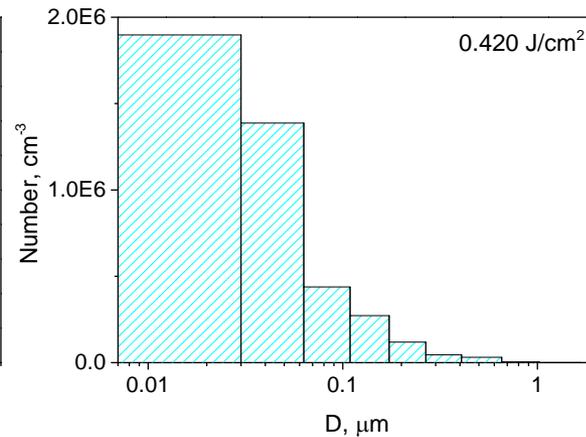
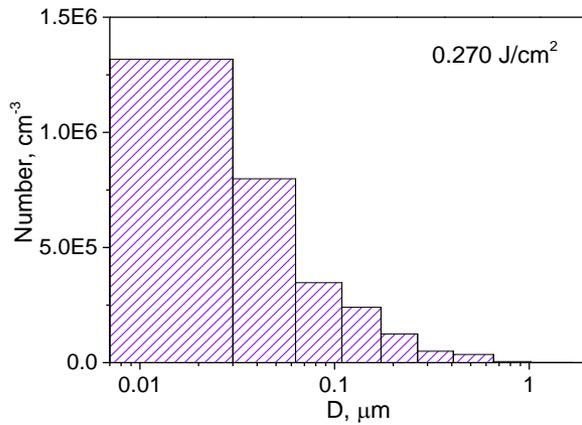
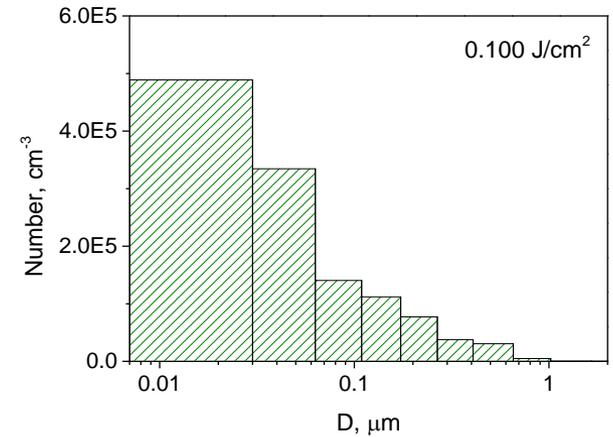
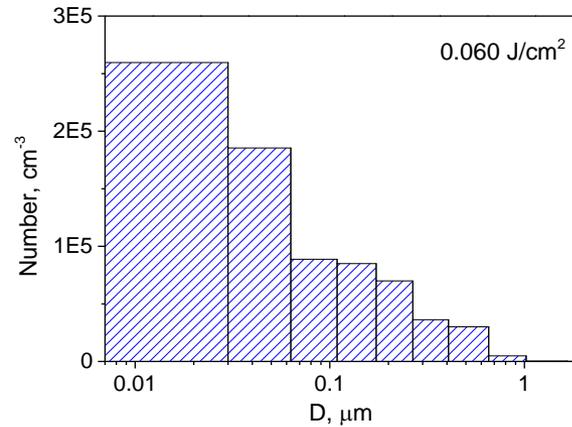
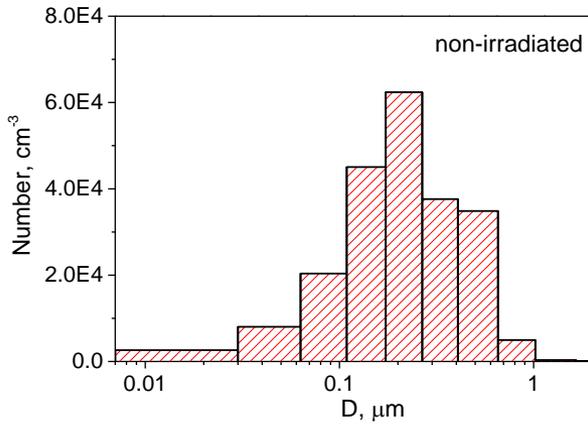
Raman



XRD and Raman spectroscopy analysis emphasize differences in soot nanostructure

Results 2

aggregate size



Significant aggregate fragmentation!

ELPI (Electrical Low Pressure Impactor, Dekati)

Conclusions & Future Prospects

- Applicability of SiLIIS instrument for **outdoor** and **indoor air quality monitoring**
- Effect of laser irradiation on soot **physicochemical properties**
- **Tailor** soot **optical properties** with a tunable laser-irradiation process

- Further study the effect of intense laser irradiation on soot particles
→ **fluorescence properties**
- Explore **new LII applications**

**Thank you all for your attention
&
Cheers from Paul Scherrer Institute**

