Report on the STSM Project
Part1: HIM detection of nanoparticles of soot in nucleation flames
(C.Betrancourt)
From 27 June to 1st July 2016 at Bielefeld University

The objective of the STSM was to use the performance of the Helium Ion Microscope (HIM) facilities in Bielefeld to identify very small « soot » particles sampled in selected premixed flames from PC2A-Lille. The objective was to validate/confirm recent results obtained in Lille using another experimental approach relying on the in-situ detection of very small particles by laser-induced incandescence (LII) and applied in flames having the unique particularity to produce small soot particles which do not grow.
HIM is a technique is similar to scanning electron microscopy (SEM) but it can achieve higher contrast and improved surface sensitivity, especially for carbonaceous materials. The HIM microscope yields images which allows for the unambiguous recognition of smaller nascent soot particles than those observed in previous transmission electron microscopy studies. HIM is ideal for probing of the morphology of nascent soot, with surface details visible down to approximately 5 nm, and particles as small as 2 nm are detectable.

PC2A brought its own burner and mass flow controllers to Bielefeld in order to stabilize the same flames as those previously analyzed by LII in Lille. Three premixed n-butane/O_2/N_2 atmospheric flames were investigated at equivalence ratio 1.95, 1.8 and 1.75. This last one so called nucleation flame produces very small particles which do not undergo growth along the flame, a statement resulting from time-resolved LII analyses.
Particles were sampled thermophoretically and deposed on a silicon wafer. The samples were analysed by the experimental physics (EP) group of Prof. Gölzhäuser in Bielefeld. In each flame, particles could be detected by HIM although images in the nucleation flame were very weakly contrasted. The HIM results, still under analysis, show a good agreement with the relative evolution of primary particles size with LII observation. The figures 1-3 below illustrate some of the results, still under analysis.

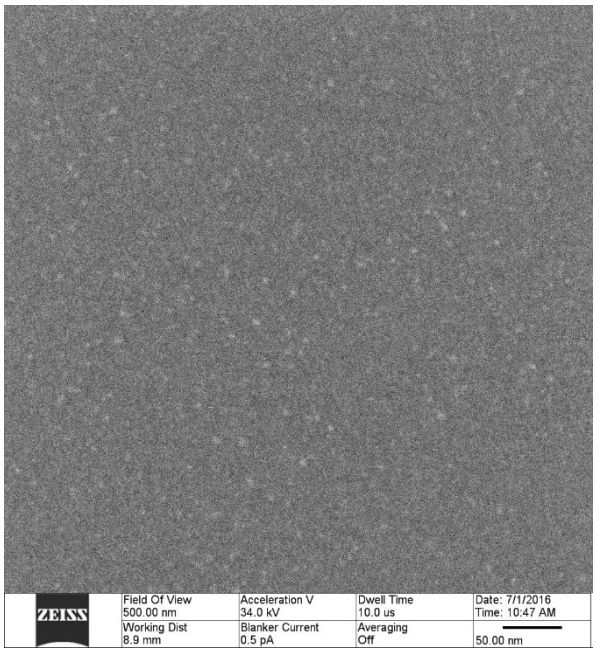

Fig 1a: HIM image taken in Flame1.75 at 12 mm above the burner surface

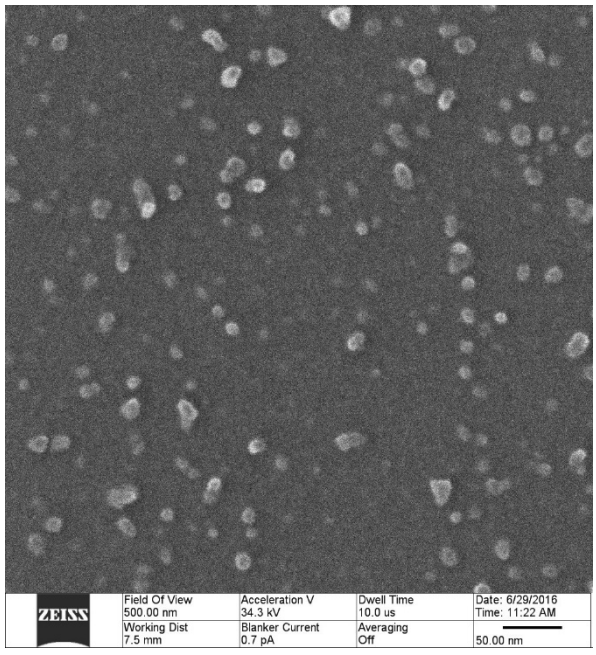

Fig 1b: HIM image taken in Flame1.95 at 6 mm above the burner surface

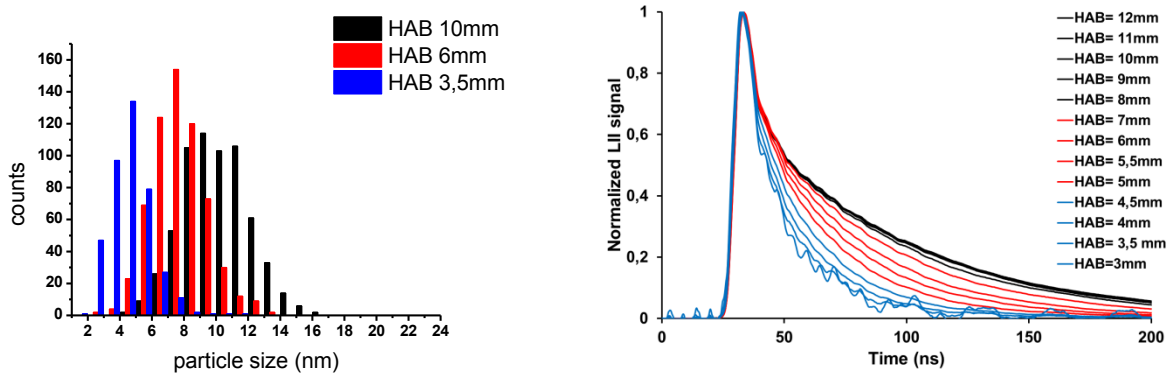

Fig 2: Particles size distributions (left) and time-resolved LII measurements taken at location of the standard richesse flame ϕ=1.95 where the particles grow along the flame.

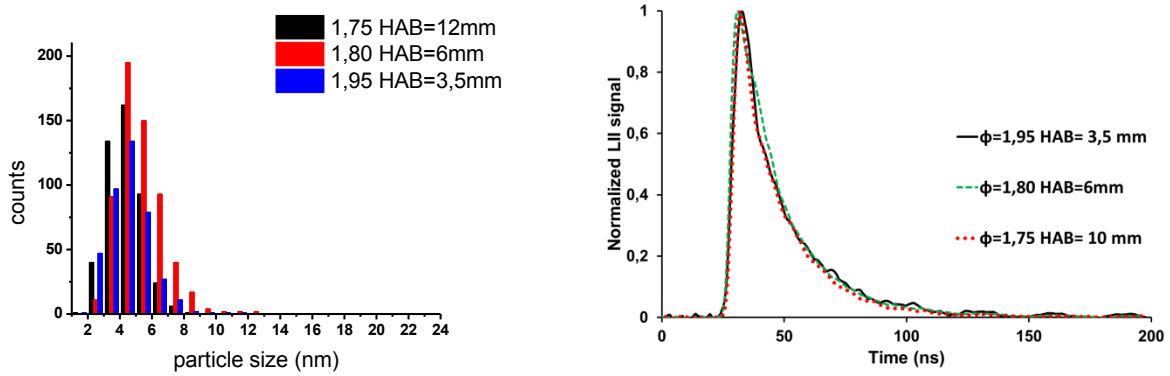

Fig 3: Particles size distributions (left) and time-resolved LII measurements taken at location of the three flames where the particles are the smallest.

Input of the collaboration within COST STSM

- A publication is under preparation with National Research Council laboratory in Ottawa "Numerical and Experimental Investigation of the size of the Smallest Incandescent Soot Particles in Premixed Butane Flames Using Laser-Induced Incandescence and HIM"
- A continuation of the collaboration is expected before the end 2016 with the visit of Dr. Maurin Salamanca at Lille.

People involved

PC2A – University of Lille

- Christopher Betrancourt (PhD Student)
- Pascale Desgroux (Researcher)

PC1 – University of Bielefeld

- Dr. Maurin Salamanca Guzmán (AvH Fellow)
- Lena Ruwe (PhD Student)
- Prof. Katharina Kohse-Höinghaus

EP – University of Bielefeld

- Daniel Emmrich (PhD student)
- PD Dr. André Beyer (Senior Researcher)
- Pro. Armin Gölzhäuser