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Experimental investigation on fiber-laden jet flows


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Rod-like particles





Drag Reduction

- Fibers as a substitute of polymers




Pulp and paper processing

- Controlling rheological behaviour and wood fiber orientation distribution crucial to optimize operations


Furniture Industry


- Pneumatic transport of wood fibers




Environmental Phenomena

- Ice crystals in clouds

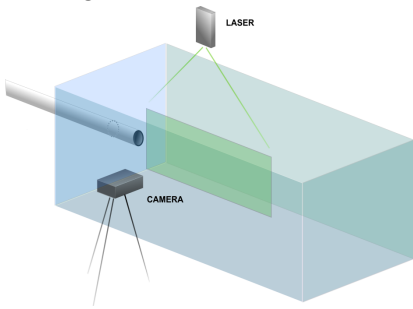






Pipe-jet set-up




- Time resolved Particle Image Velocimetry with Ar-Ion continuous laser source
- Near field region ($x/D=6$)
- High-speed camera (1024X1024 pixel res, 1KHz)
- Reynolds number range 5000-9000



Particles

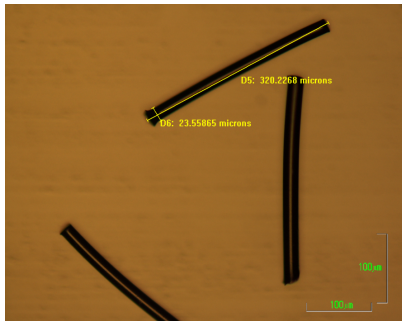



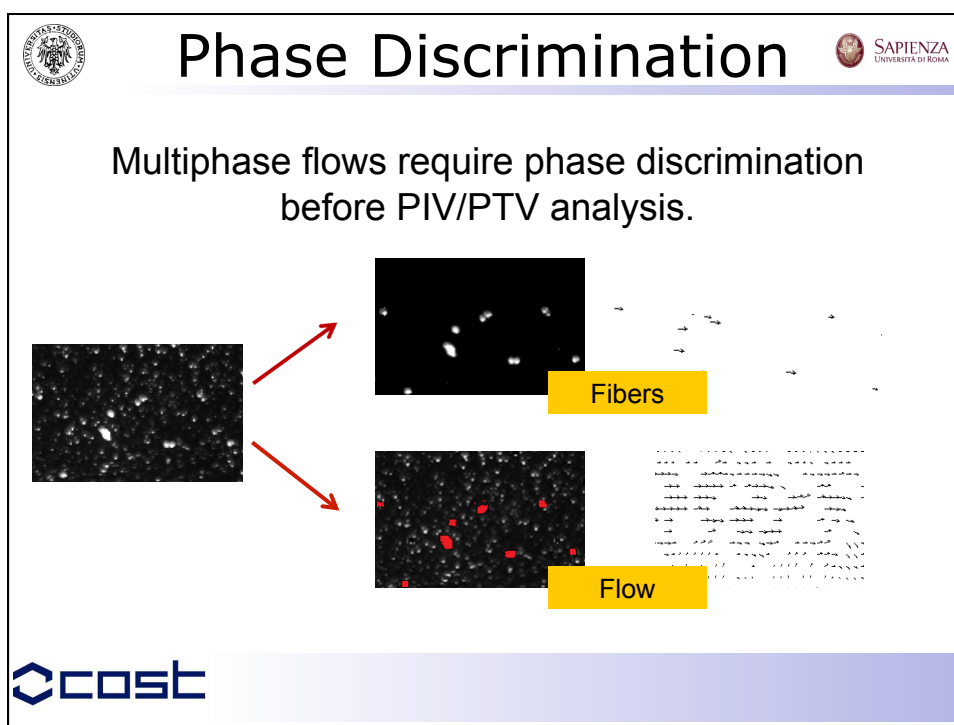
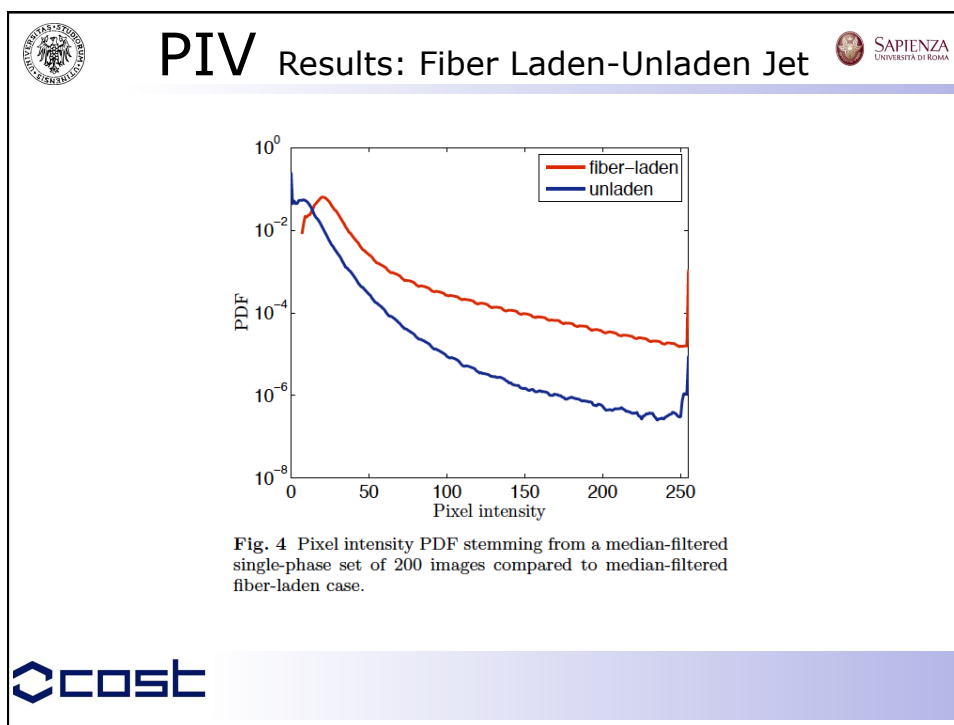
Flow tracers: hollow glass spheres

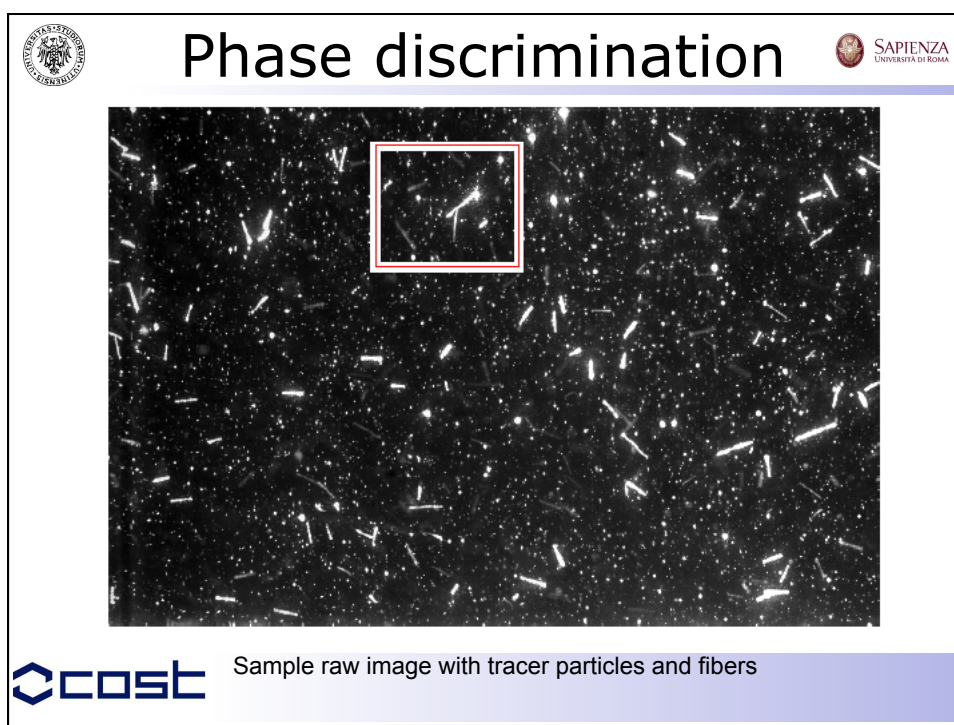
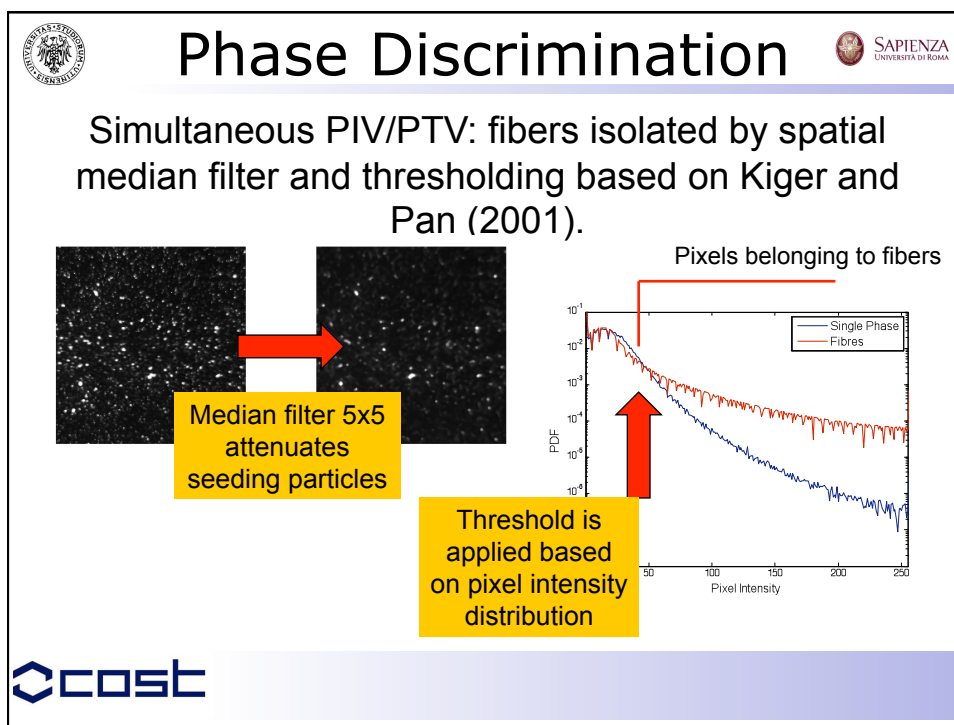
- Mean diameter 12 μ m, neutrally buoyant


Rods: synthetic plastic fibers (nylon)

- Density 1.13-1.15 g/cm³
- Mean length 320 μ m
- Mean diameter 24 μ m
- Aspect ratio 13.3
- Tested fiber concentrations: 0.002% and 0.006% mass fraction





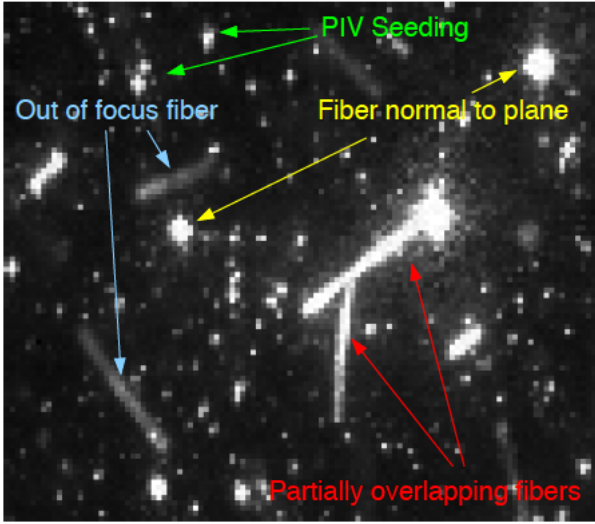








Phase discrimination






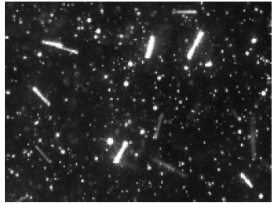



Shadows of out of focus fibers (blue arrows), partially overlapping fibers (red arrows), PIV seeding particles (green arrows) and fiber normal to image plane (yellow arrows).




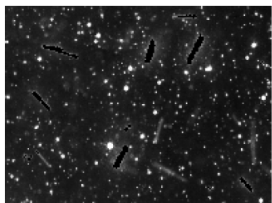
Phase discrimination

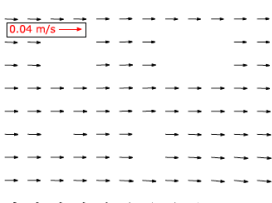


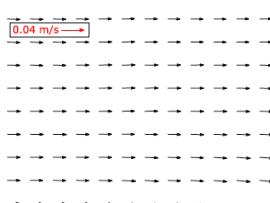
(a)



(b)


(c)


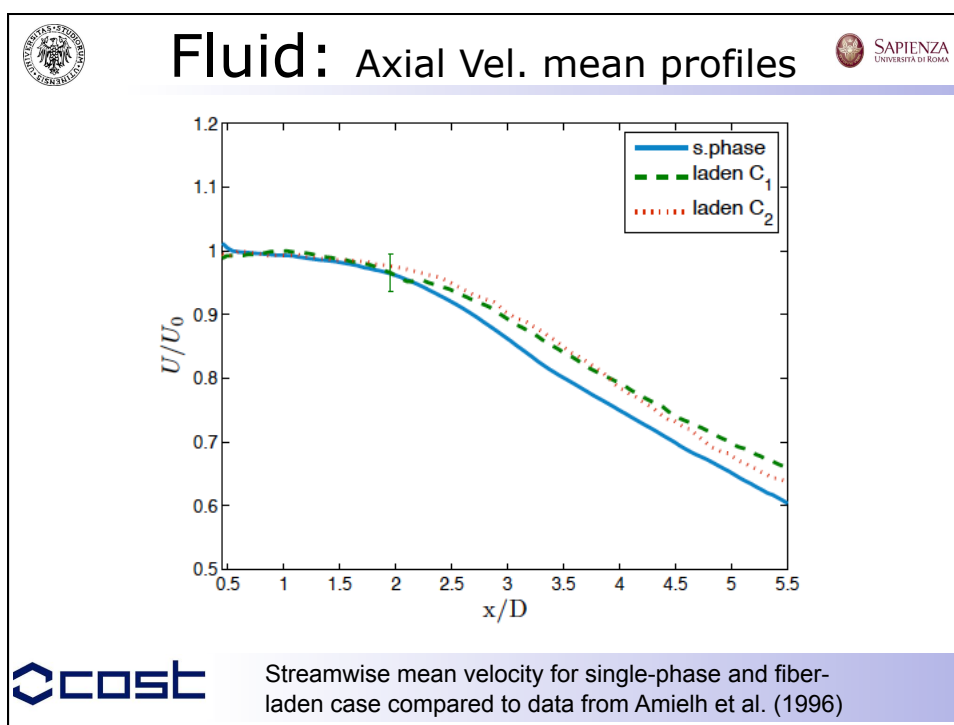
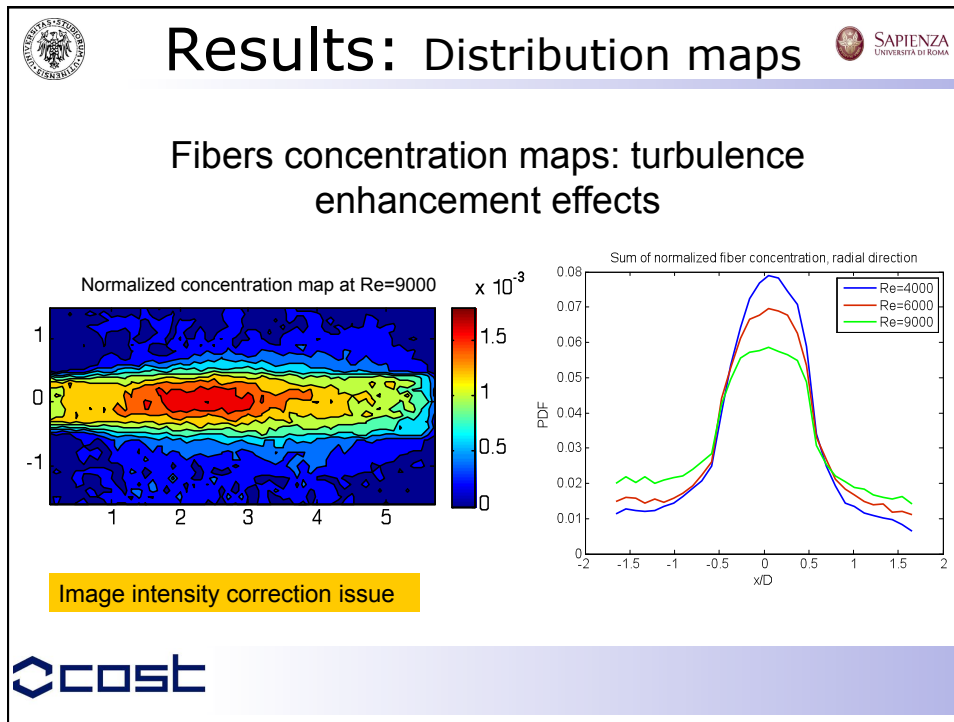
(d)


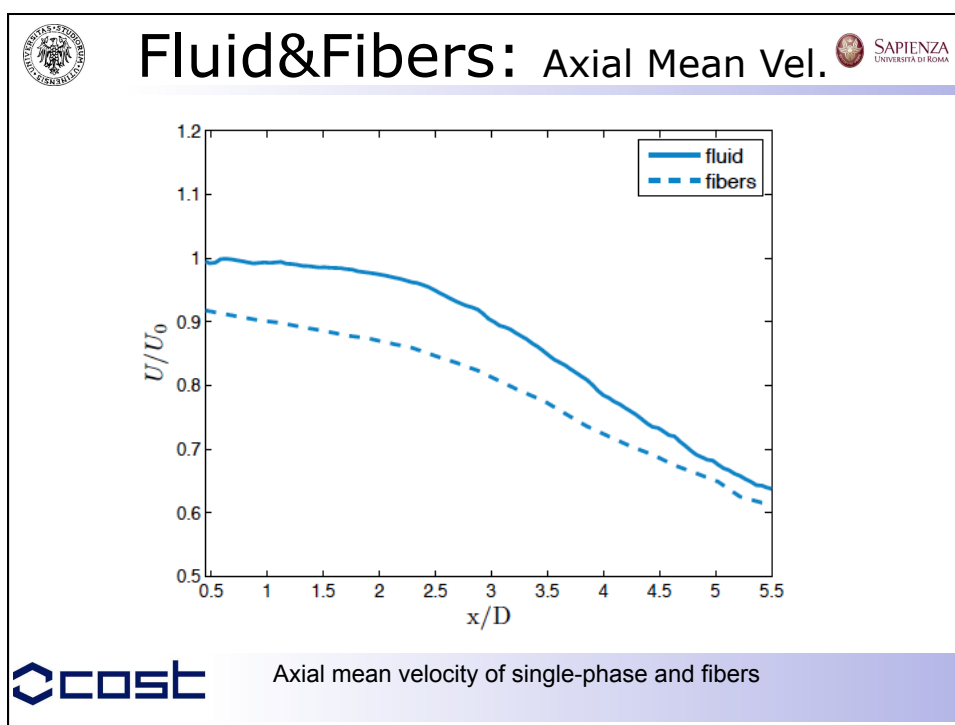
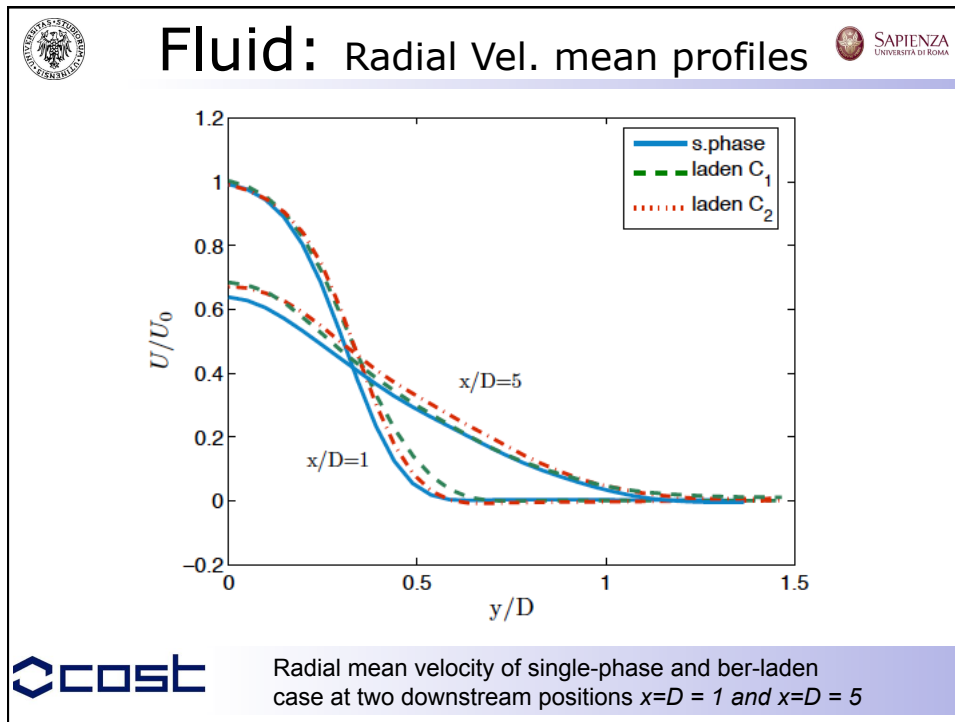
(e)


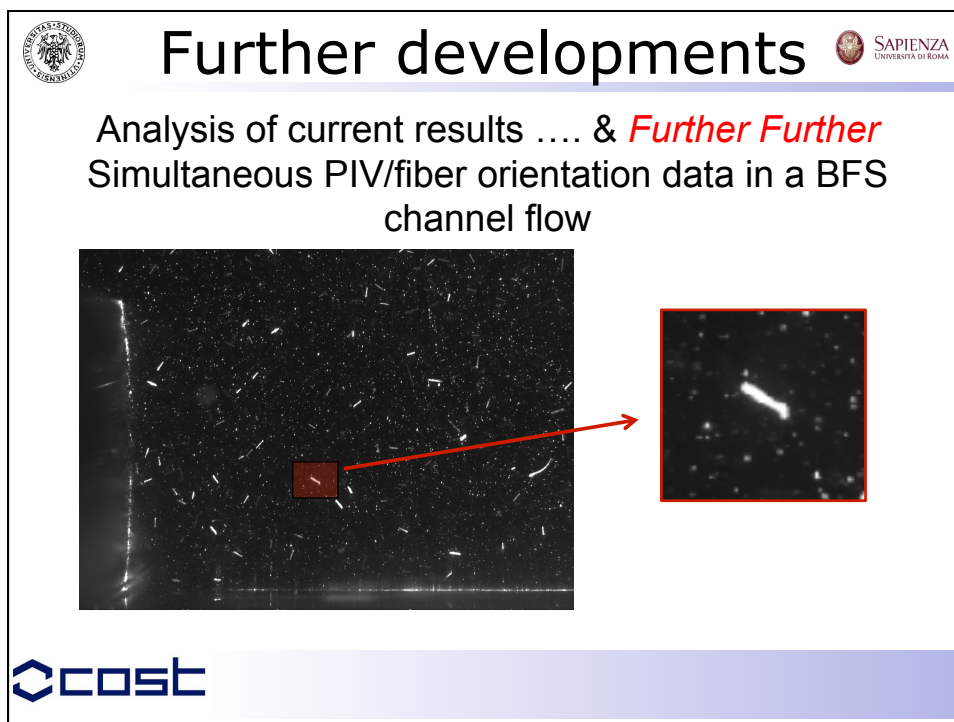
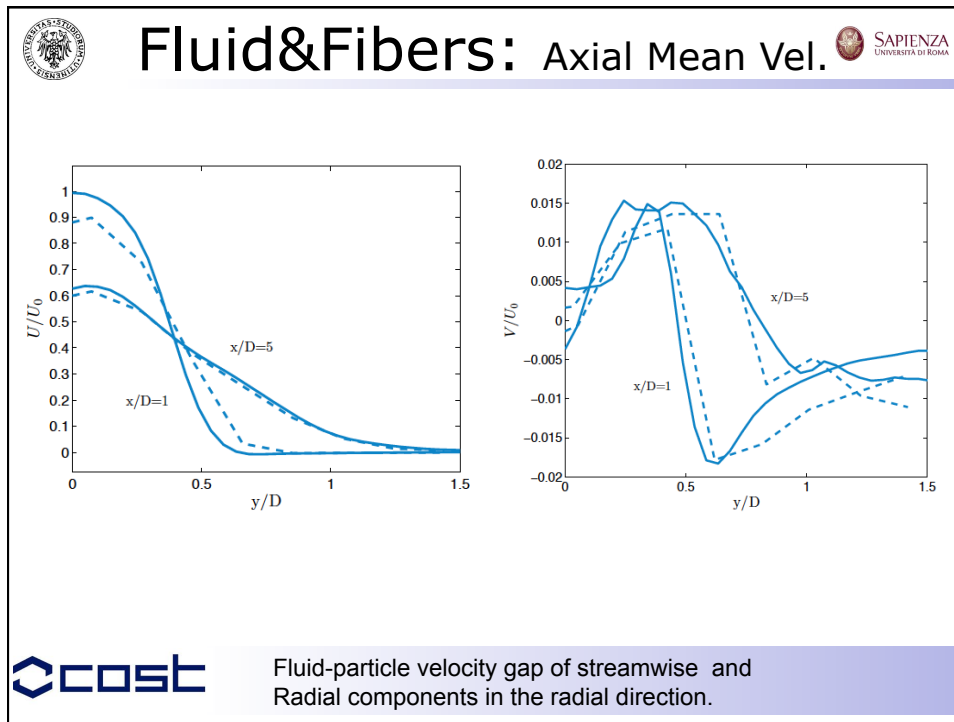
(f)




raw image, pre-processing and phase discriminated fibers (top); seeding only image and PIV analysis (Bottom).









Conclusions



- Phase discrimination (extended from Kiger and Pan (2001)) applied on a jet loaded with rigid fibers. Limitations set by particles/seeding image size and intensity.
- Fiber suspensions feature a complex behaviour difficult to capture with single-parameter criteria.
- Flow turbulence enhancement independent of tested fiber concentrations and Re range, mostly in core region (rods alignment? Lin et al (2011)).



Thank you for your
attention!

