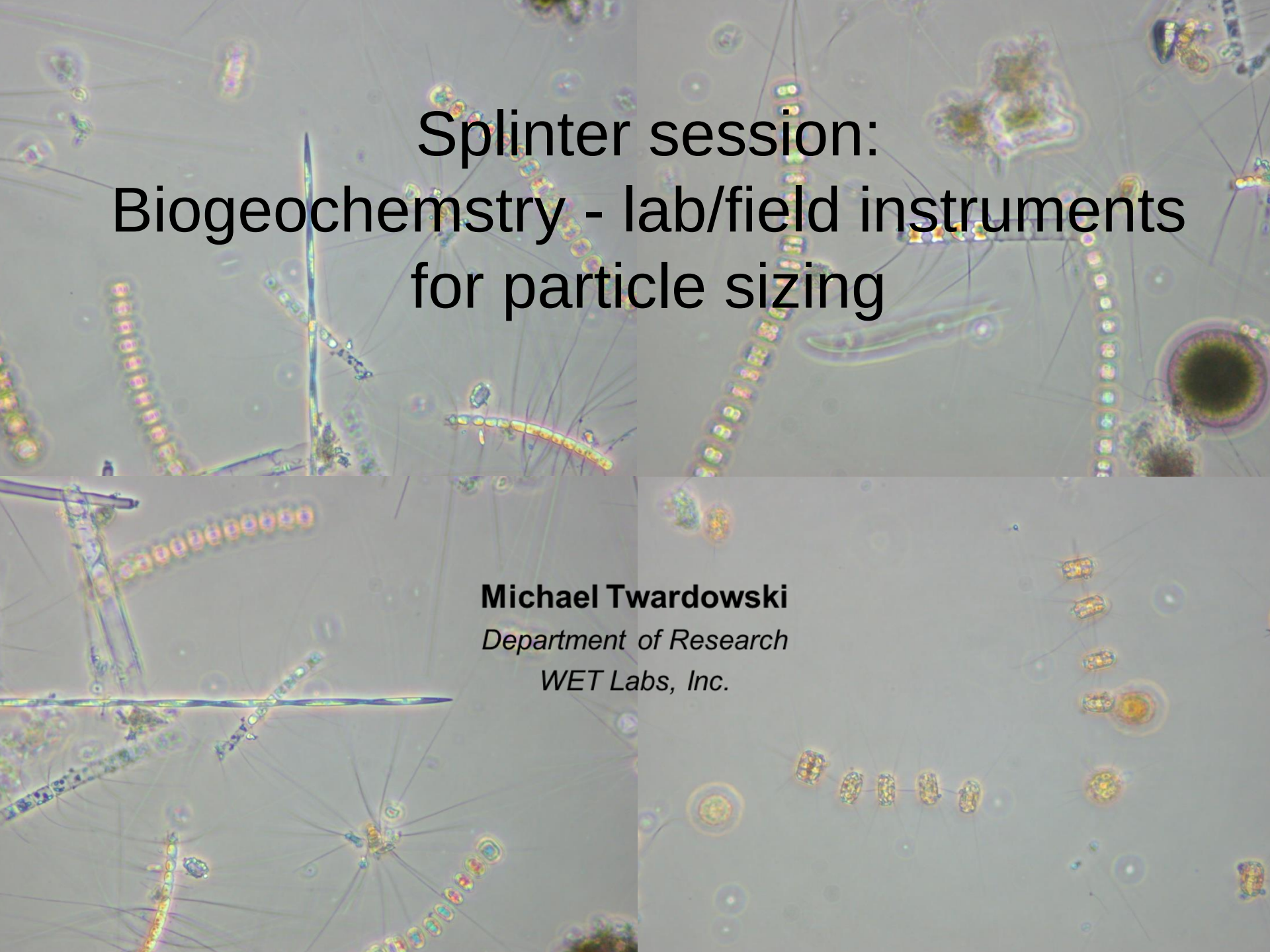


Splinter session: Biogeochemstry - lab/field instruments for particle sizing

Michael Twardowski

Department of Research

WET Labs, Inc.

Overview of methodologies for sizing optically relevant oceanic particles

- Electrical resistivity
- Size separation
- Light scattering
- Acoustic scattering
- Imaging

Resistivity

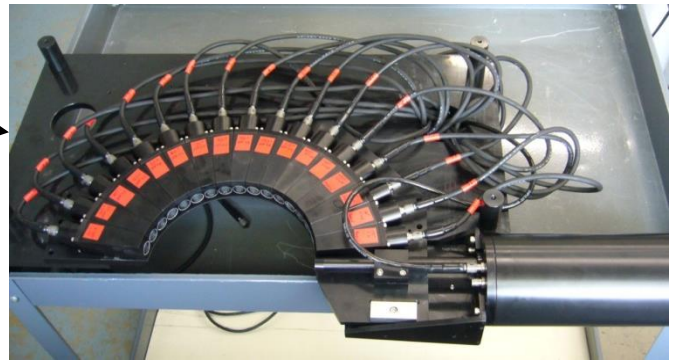
- Coulter counter

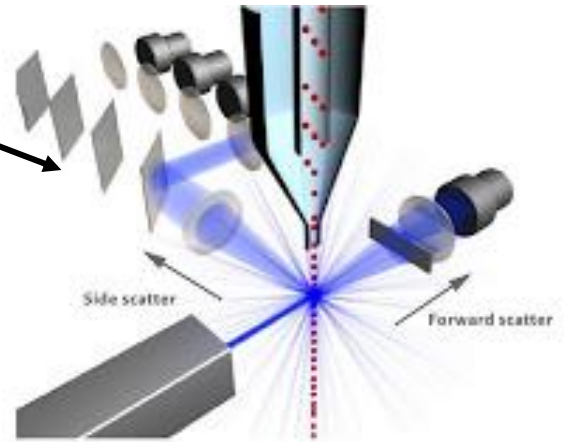
Size-separation

- Ultrafiltration
- Field-flow fractionation
- Settling tube

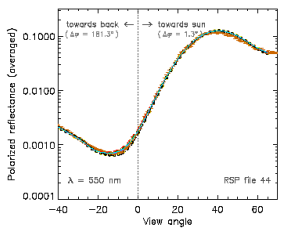
LIGHT SCATTERING

- Diffractometry (Sequoia LISST)
- Light occlusion/obscuration (e.g., Hiac/Royco)
- Time of transit (Galai)
- Dynamic Light Scattering (DLS) (e.g., Wyatt)
- * VSF inversion for particles >> λ
  - Zhang et al. 2011; Twardowski et al. 2012
- VSF inversion for particles <~ λ (Rayleigh)
  - (e.g., Wyatt Dawn)
- * Spectral attenuation inversion
  - Diehl and Haardt 1981; Boss et al. 2001
- Flow cytometric SS-FS (e.g., Sosik-Olson lab)
- Transmission fluctuations
  - Shifrin 1988; Briggs et al. 2011

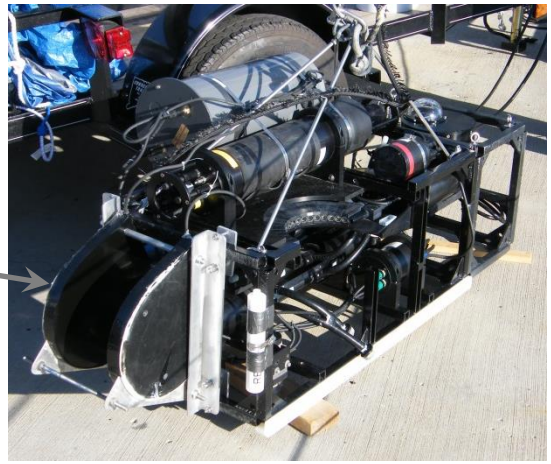




*Directly adaptable to remote sensing



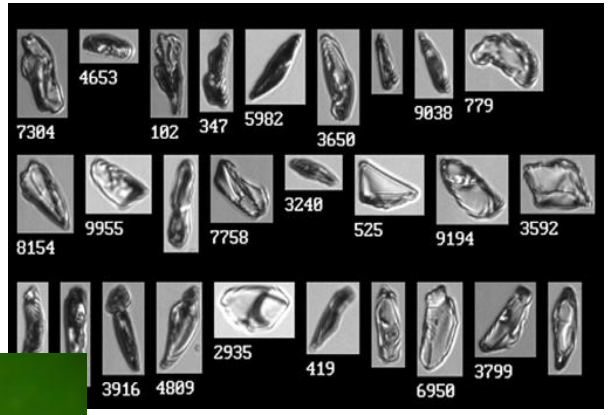
ACOUSTIC SCATTERING



- Acoustic resonators for bubbles (Czerski et al. 2012; Farmer-Vagle group)
- High frequency acoustics – attenuation, angular scattering, thermal (e.g., Dispersion Tech)
- Optoacoustics (Dion et al. 1982)

IMAGING

- Microscopy – light, SEM, TEM, etc
- Flow cytometric imagers
  (FLOWCAM, FlowCytobot, etc)
- Holographic imaging



General Technical Challenges

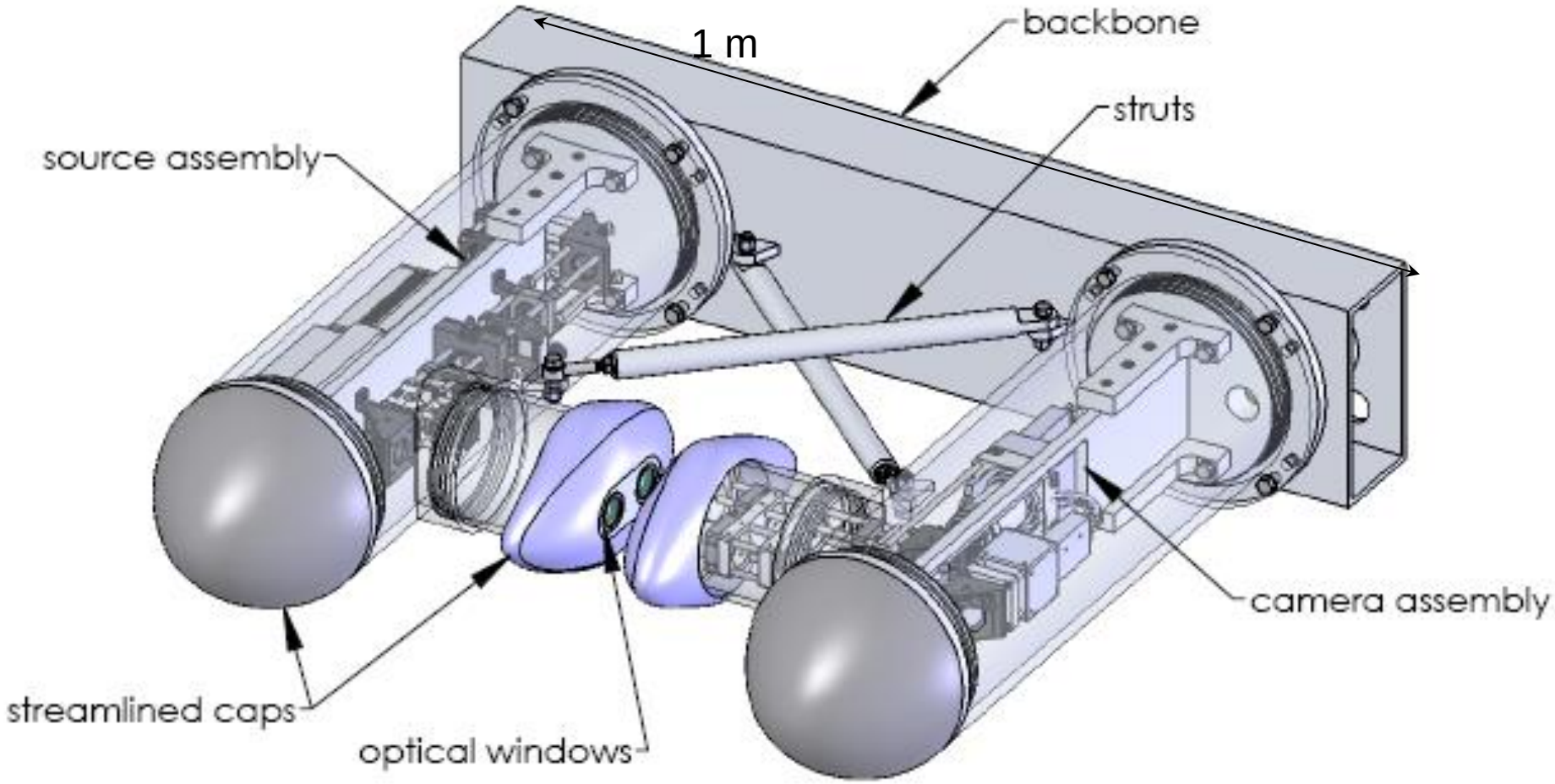
- Need broad range in particle sizes (incl < 1μm), shapes, and densities (refractive index) resolved
- Need delicate and/or ephemeral particles/aggregates resolved
- Need particle type discrimination
- Need to consider particle orientation
- Water sampling introduces forms of bias
- Large particle statistics
- High turbidity
- Spatial and temporal sampling at relevant scales

Desirable Sensor Characteristics…

- In situ, undisturbed (remote) measurements
- Resolve particles < 1 μm
- Characterize particle shape, composition also
- Large sample volumes
- Small path lengths
- Autonomous, with relatively high sampling rates
- Timely results
- More than one technical solution likely needed…

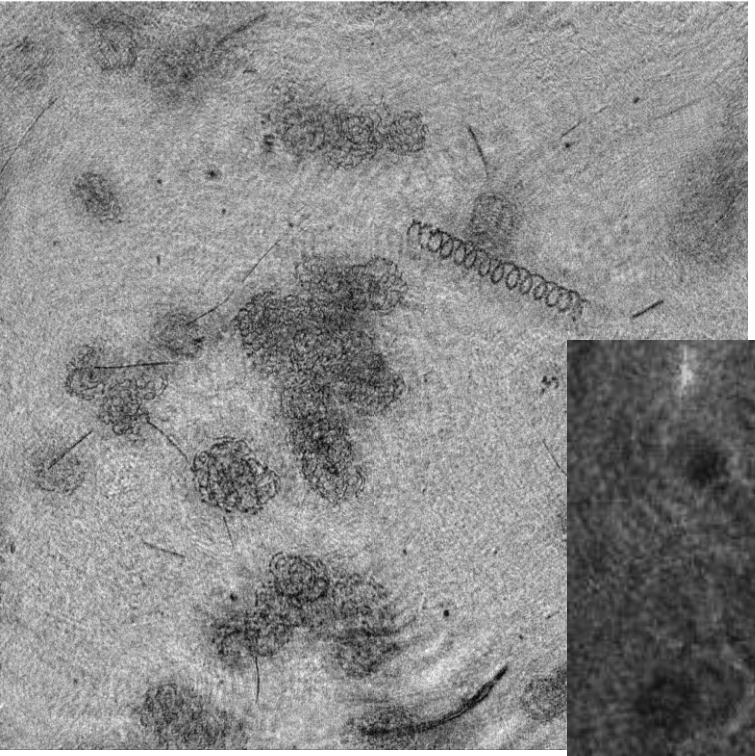
Note no Ocean Optics Protocols currently exist…..

Prototype Submersible Holocamera

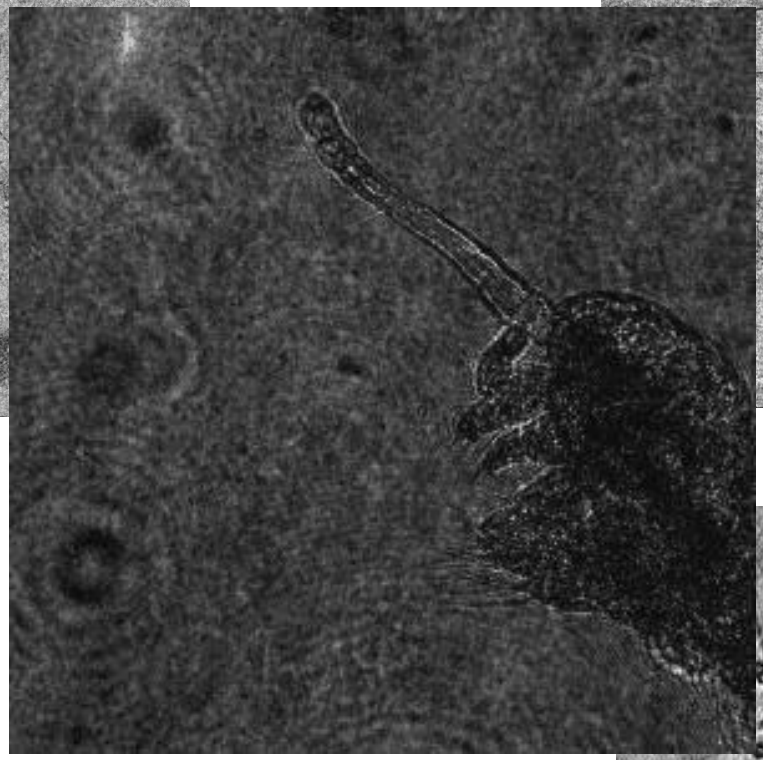


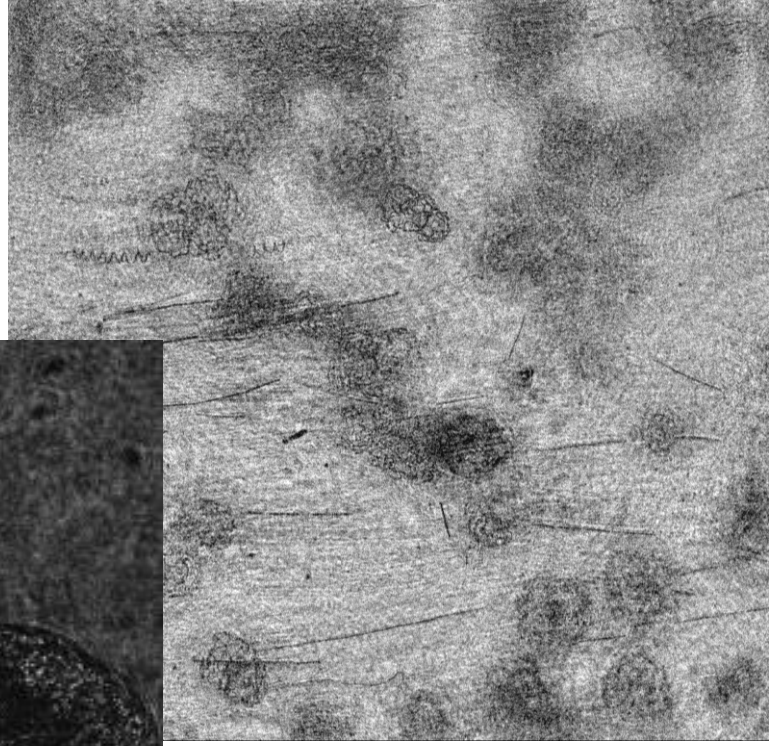
ONR NOPP

sample volumes:
10 μL high mag (sizes 4 μm to 1 mm)
2.25 mL low mag (sizes 0.4 μm to 40 μm)

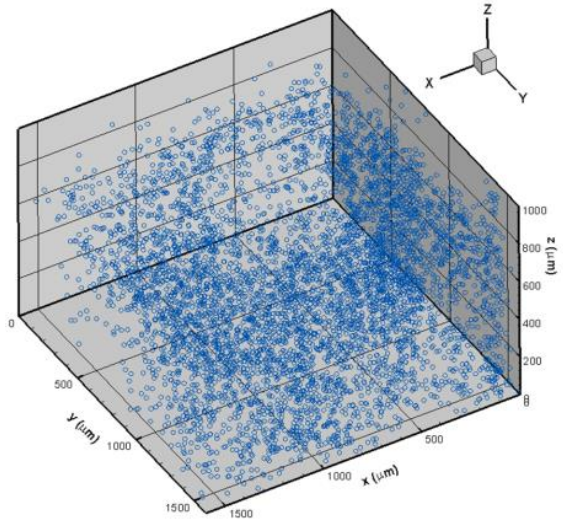


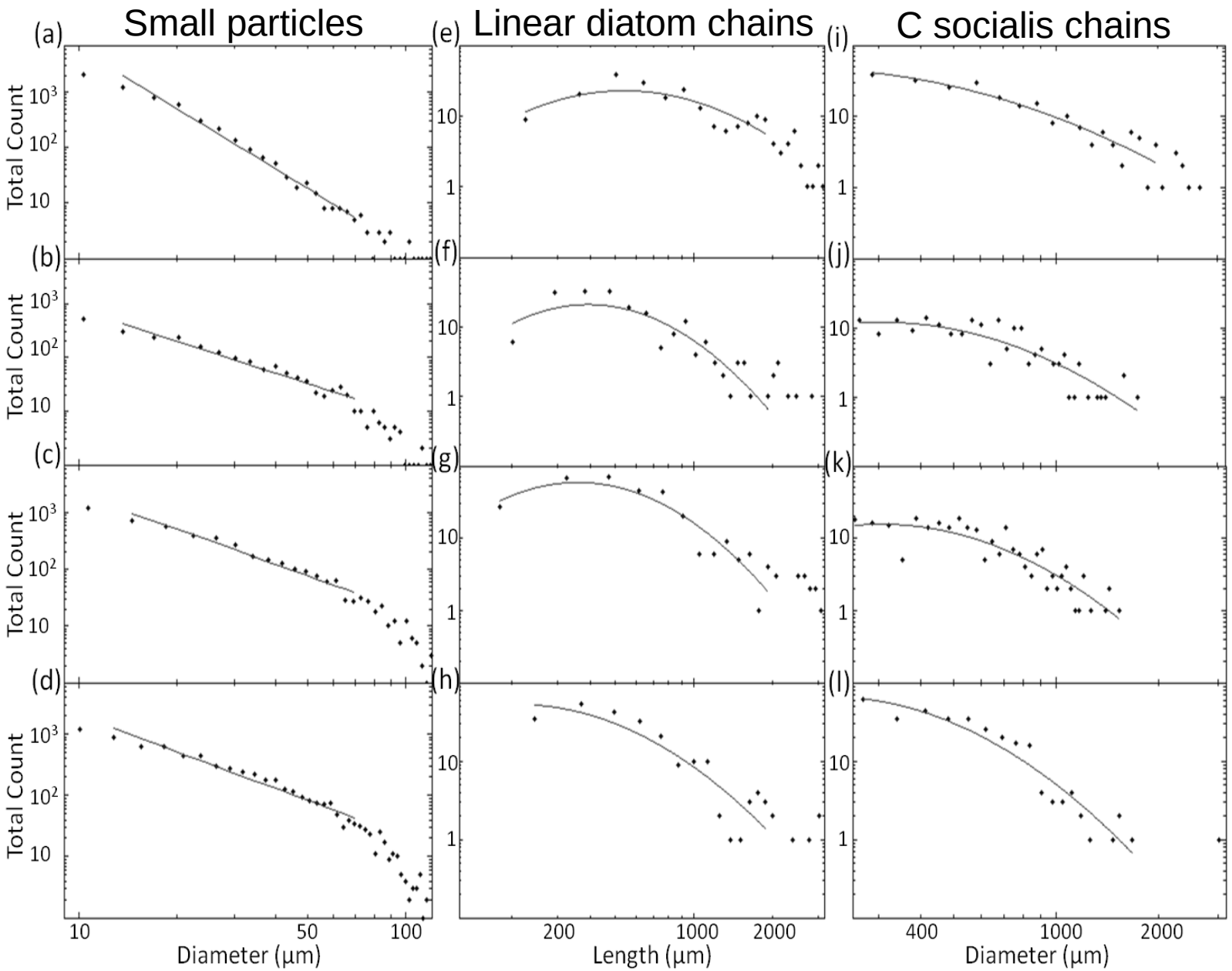
2D “splat” image





2D “splat” image





Talapatra et al. (2012)