# OPENING PRESENTATION

## LISST-TECHNOLOGY AND PERFORMANCE – CHALLENGES AND SOLUTIONS

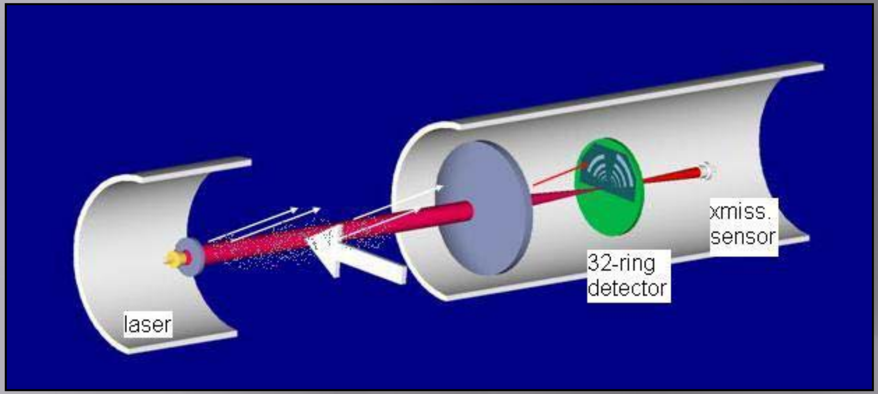
-TEAM SEQUOIA

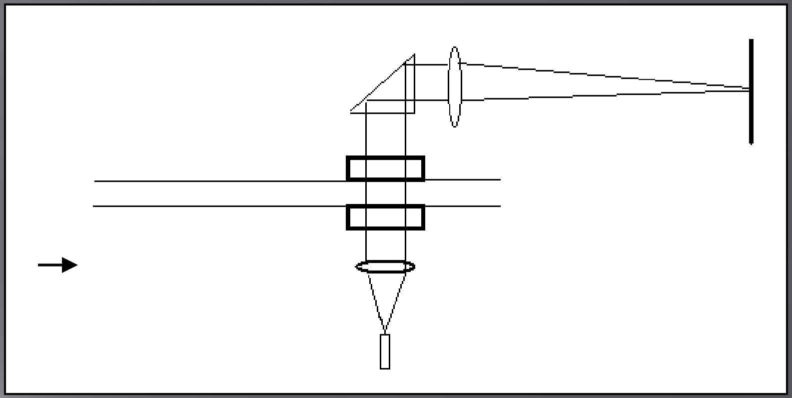
# Scope of Opening Presentation


- Technology basics – review
- Limitations of LD Technology in general
- Limitations of LISST instruments
- What can go wrong in data/operations
- What can go wrong in interpretation
- Analysis of your experiences –
  - Tim Straub; Mark Landers

# Technology Basics

# LD Technology Basics



- All LD technology provides PSD and Concentration of an ensemble of particles
  - 'A view in a flash'
- LISST and all other LD instruments are NOT particle counters, and NOT samplers.

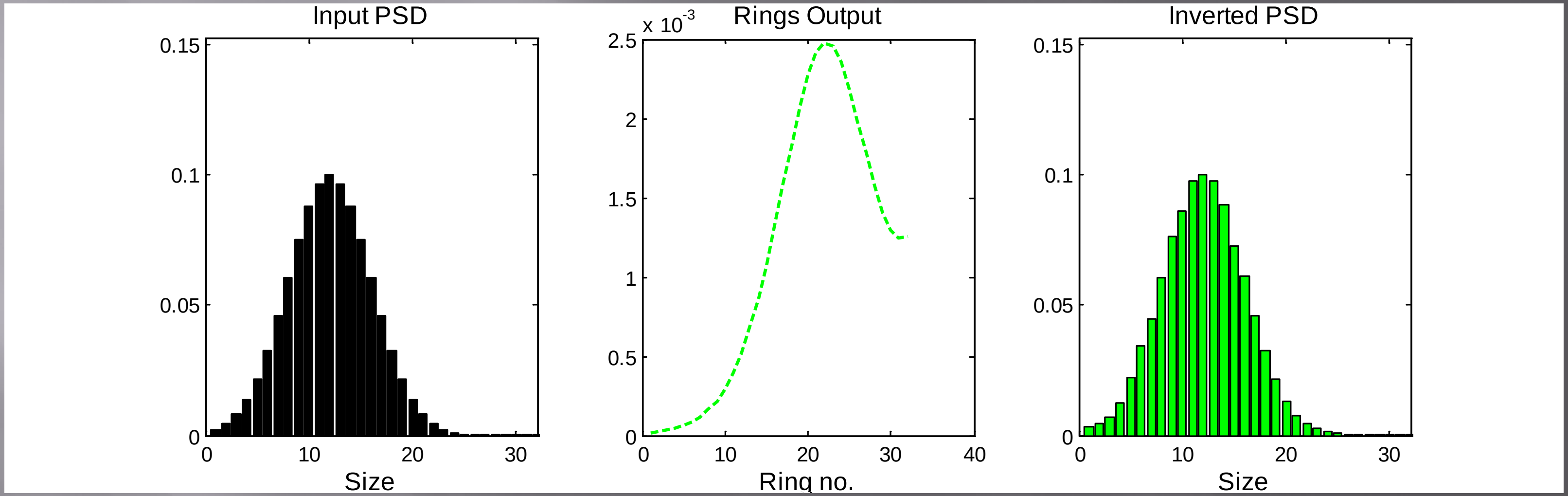
# ISO 13320:2009

- ISO-13320 was written only for PSD
- Summing PSD gives concentration over the size range

## Contents

Page

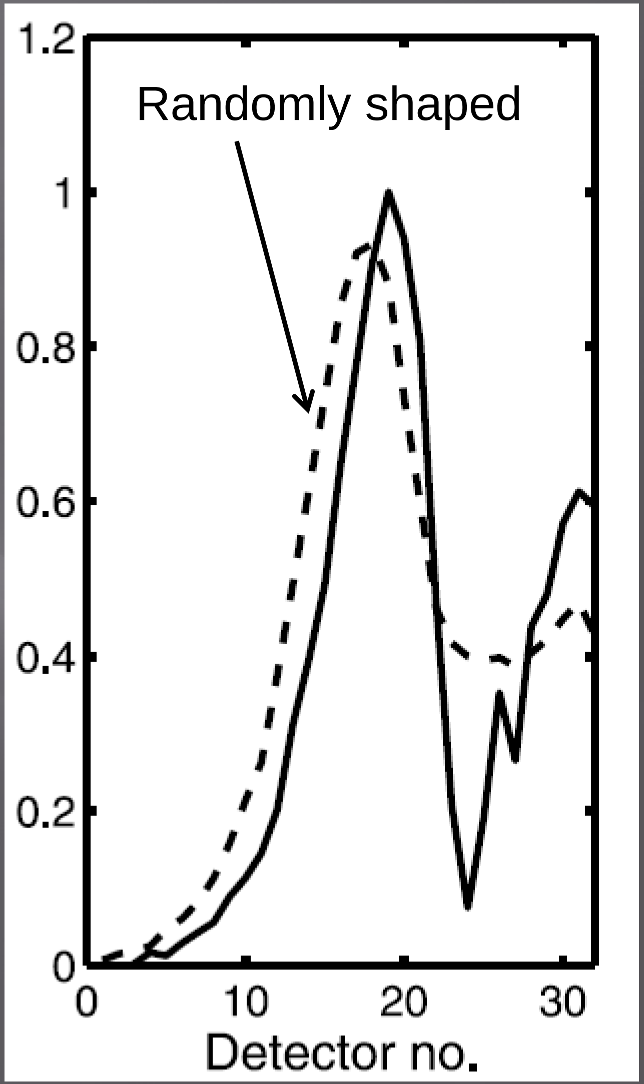
# How Laser Diffraction Works




- Particles of ANY size produce light on ALL rings
  - Light on a particular ring does NOT represent concentration of any particular size particle.
  - Common misunderstanding

# Randomly Shaped Particles

- Scattering from randomly shaped grains differ slightly from same-size spheres; this changes the size scale
- All pre-Sequoia work produced PSD of equivalent spheres
  - Only Sequoia offers inversion to give PSD of ‘sieved sizes’.
- Using the randomly shaped matrices enables comparison with existing, historical SIEVE data sets

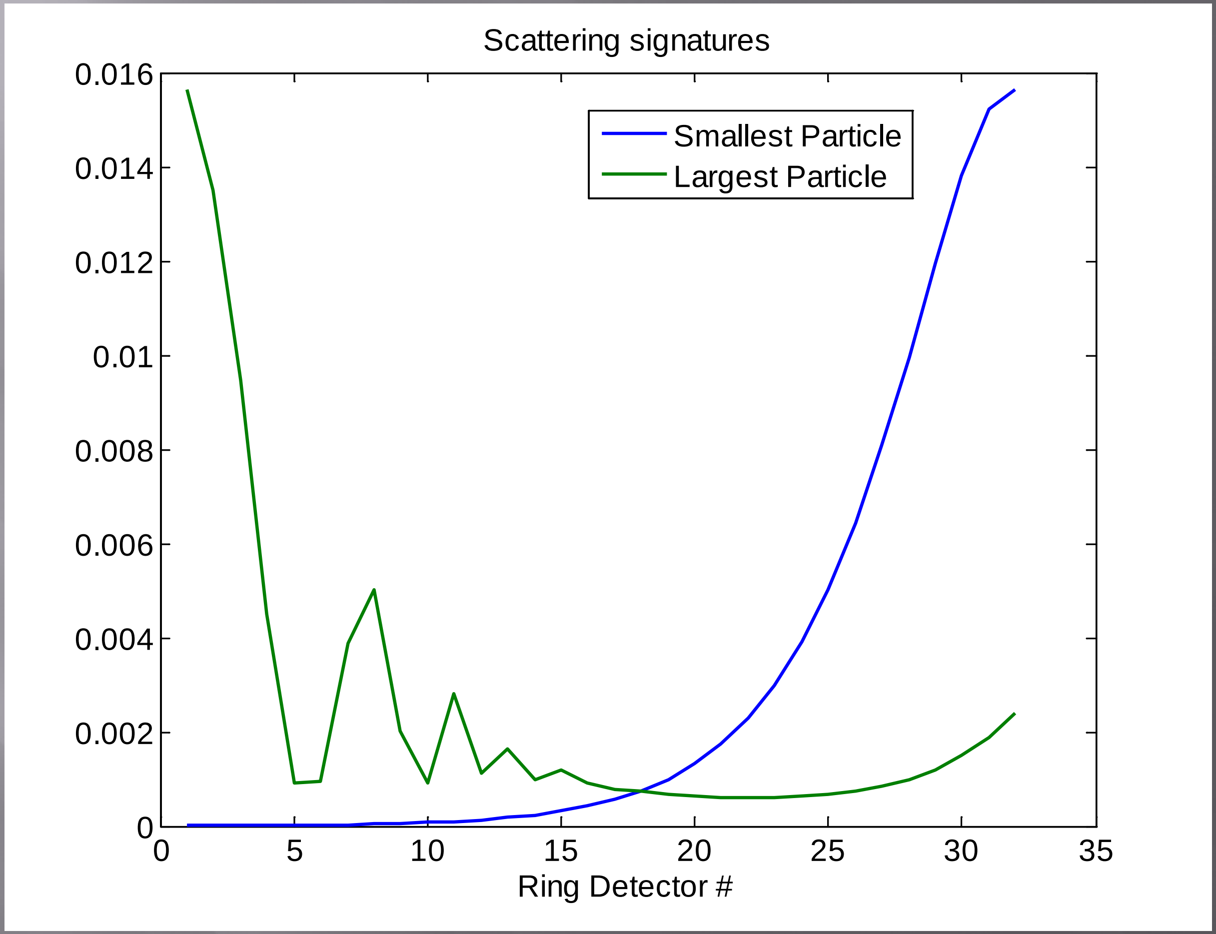



Agrawal et al. 2008 (JGR)

# LIMITATIONS OF LD TECHNOLOGY IN GENERAL

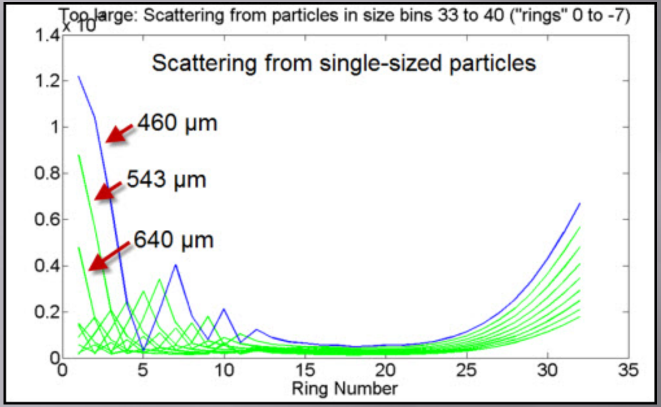
- Upper and lower size limits
- Cannot discriminate types of particles

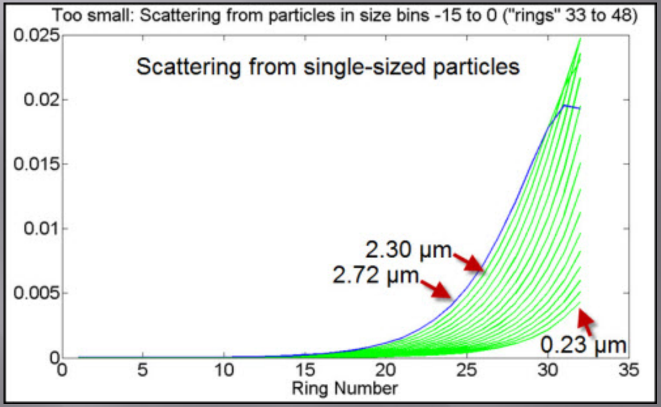
# Upper and Lower Size Limits

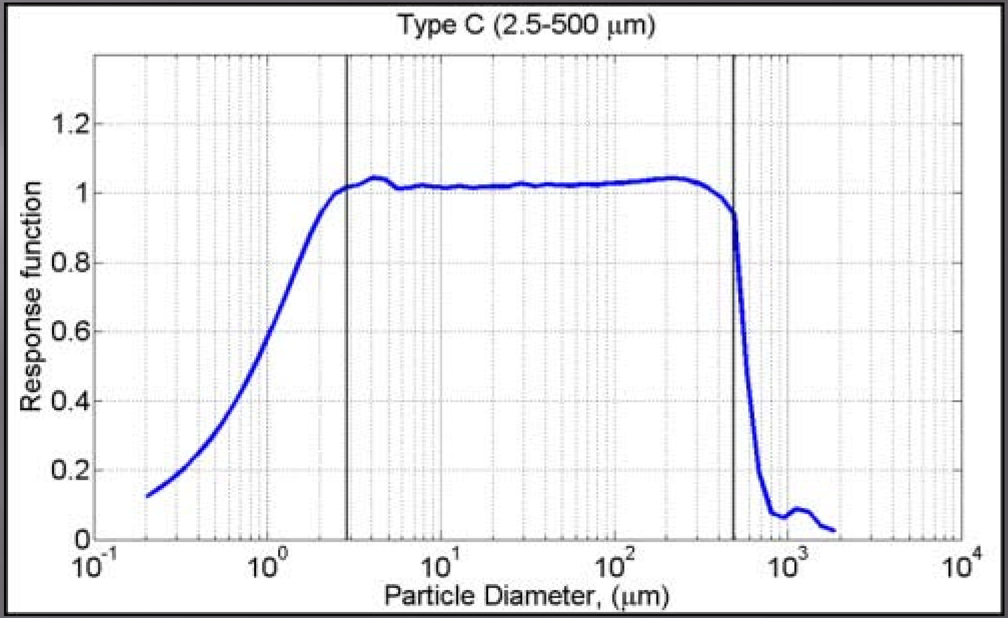



- Upper size limit derives from smallest ring
- Lower size limit derives from largest ring

# How LD sees particles outside this range

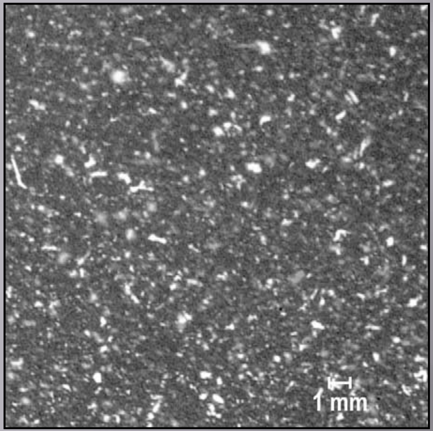



- Particles Leak into the nearest size bins
- This often produces rising tails in PSD
  - More so for particles smaller than the smallest size bin of the LISST

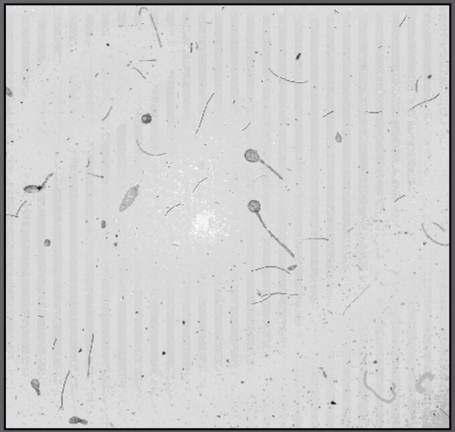
# Almost everything scatters




**Sediment flocs in the Po River, Italy**

**Schlieren / Scintillation**

**Bubbles**



**Phyto- and zoo-plankton**

- Particles, bubbles, algae, etc. but also density fluctuations caused by temperature variance
- Density-related scattering ('scintillation') invents large particles.
  - Scintillation is avoided by letting water and LISST reach identical temperature. This is common to all LD systems.

# Converting volume to mass

- All LD systems measure volume distribution
- Converting to mass requires the user to ASSUME an effective mass density and then apply that
- Easier in the lab, where all particles can be dispersed (ISO 13320:2009).
- Not easy with field data where aggregates, bubbles, low-density biological particles can be present

# LIMITATIONS OF LISST INSTRUMENTS

- Concentration limits
  - Limits exists in the field
  - Optimum accuracy at optical transmission between 0.3 and 0.98
  - For –SL: upper limit (mg/l) = 300*d[μm]
  - For –SS: 200*d[μm]
  - Lower limit limited by signal-to-noise ratio
- Size range may not cover all particles in suspension
- Clogging of intakes for pumped instruments
  - LISST-StreamSide
  - LISST-SL
- Velocity limits for isokinetic sampling and general operation (-SL only)

# WHAT CAN GO WRONG WHEN COLLECTING DATA

- Misalignment of optics
  - Low zscat laser power, increased zscat scattering on inner rings constant in time
- Dirty windows
  - Increased zscat scattering on middle rings
- Poor temperature equilibrium - scintillation
  - Increased scattering on inner rings, decreasing in time
- Clogging of intake by debris
- Clogging of pitot tube by debris (-SL only)

- LISST-SL pump not locked in, still adjusting during sampling
  - Lock-in ~ 2 minutes after immersion when powered
  - After lock-in isokinetic control is better than 10% as set at factory
  - Minimum river velocity for isokinetic operation is 0.5 m/s [1.65 ft/s]
- Purging of bleed port not adequate
  - Erratic velocity readings on TCB

# Is swimming a problem?

- Eddies change instantaneous flow direction
- The component of drag normal to river flow produces side-ways drift of -SL
- Because USGS samplers weight >> drag, they are pushed less in sideways direction
- A look at video of –SL always shows wake of 'sail' aligned with flow.
- Even so, for operation in higher velocity rivers, extra weight will be needed.
  - Sequoia to design.

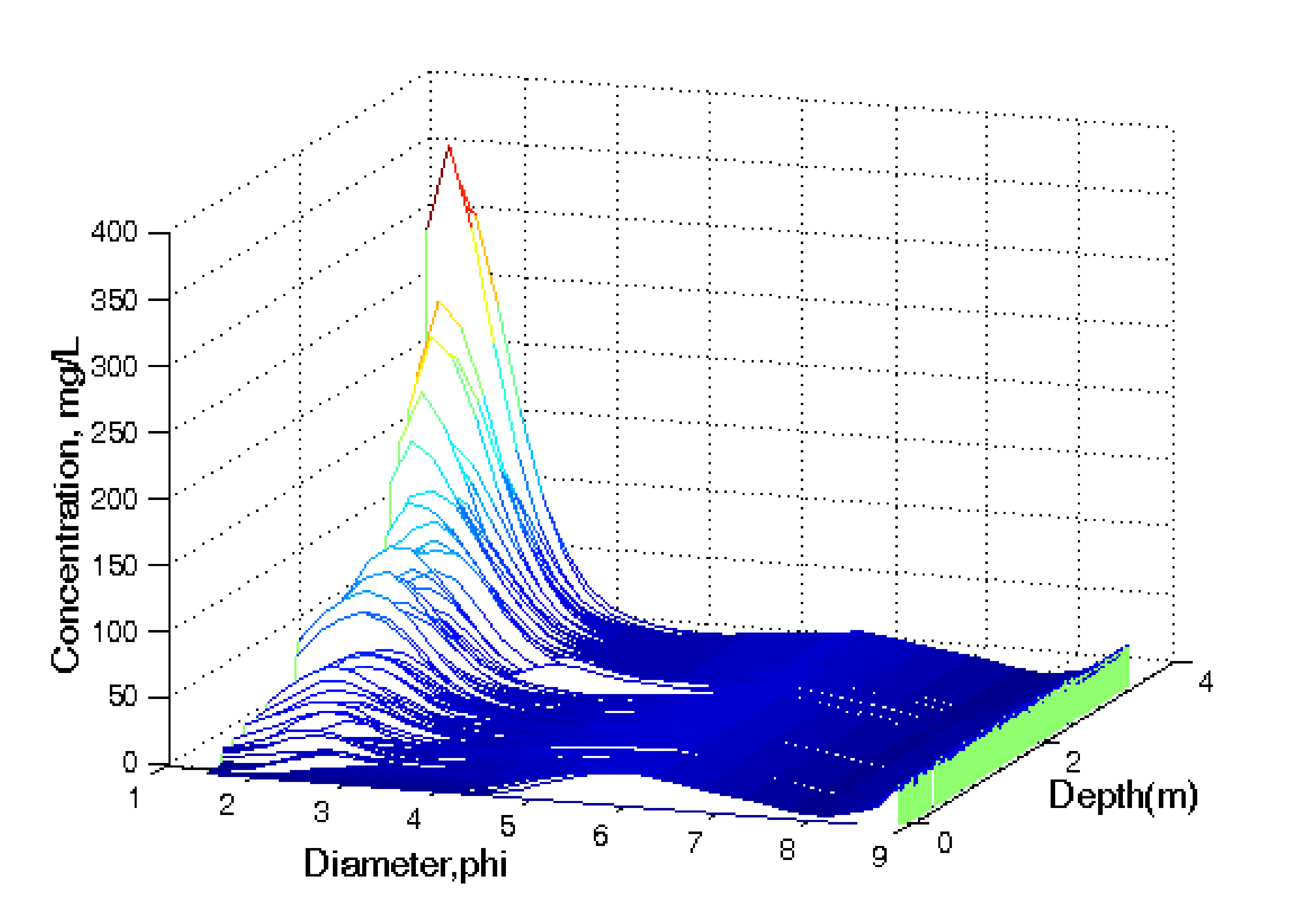
# WHAT CAN GO WRONG WHEN INTERPRETING DATA

- Short LISST-SL time series is an issue
  - Makes interpretation and troubleshooting more difficult
  - Measurement duration should be >> time-scale of local eddies
- Presence of loosely aggregated particles
  - Density << 2.65
  - Affects conversion from volume to mass!
- Particles outside the size range
  - Will influence computation of size parameters (mean, median etc.)
  - Will overestimate total concentration

# A common source of error – Mixing

- Concentration gradients exist everywhere, in the field and lab
  - [Rouse (1937) showed C ~ z $-ku^*/w_f$ ]
- To avoid, turbulent velocity fluctuations >> settling velocity
- Location of intake pump in a gauging station will affect measured PSD [see Cowlitz/Puyallup river data]
- Even in the lab, concentration gradients make calibrations and comparisons very difficult.

# Incomplete mixing in a river

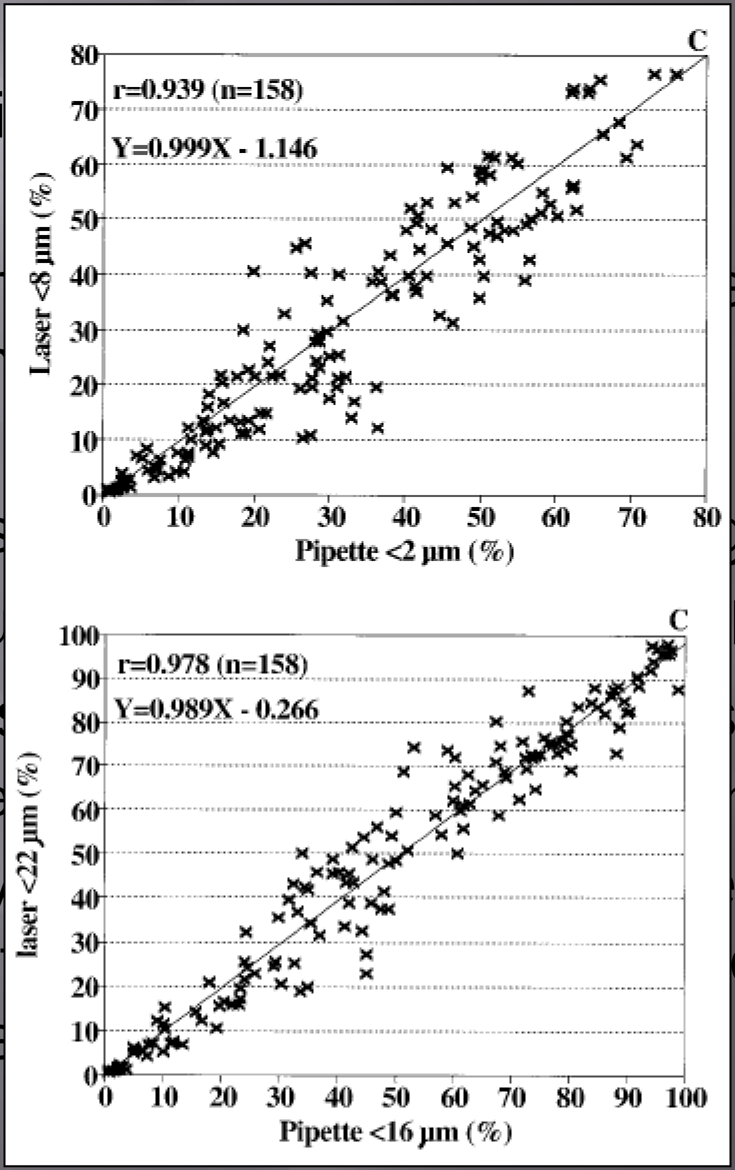



Vertical variation of size distribution seen in Cowlitz (also Puyallup) river

# YOUR EXPERIENCES

# Comparing size distributions

- Size distributi… s CANNOT be compared.
- The pipette m… e smaller diameters than LD for th… Vandenberghe 1997
- Same applies … g
- LD PSD shou… D only
- Discrepancies … spheres)
  - Use literature … nces > expected
- Sample analy… e size distribution compared to … onification, in-situ aggregation e…



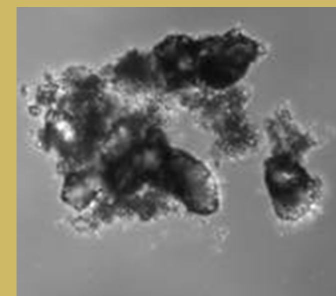
# Converting to mass

- Mass density of in-situ particles is not the same as the density of the same particles in the lab when disaggregated
- Calculating an effective in-situ density using water samples is an effective method for converting in-situ volume to mass

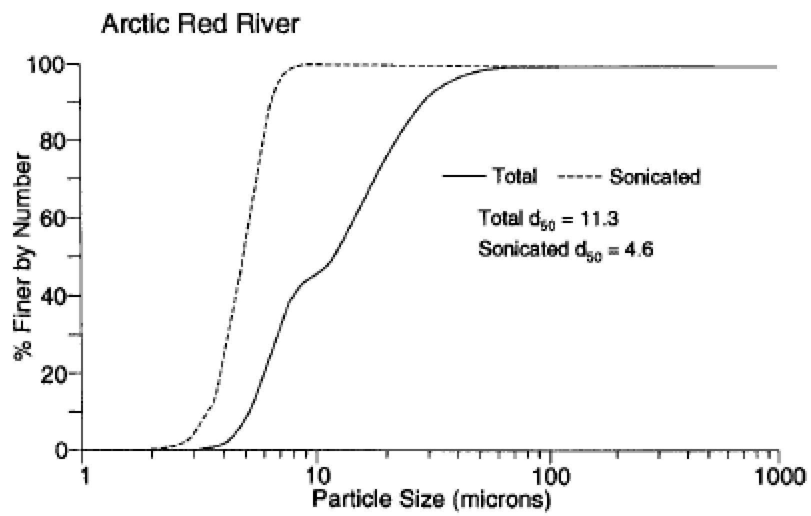
# Effective Density: Definition

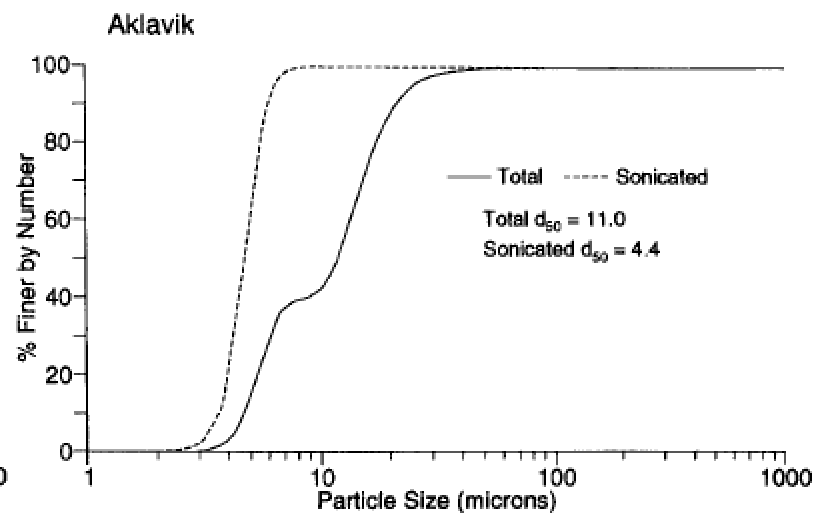
- Effective Density = $\frac{Actual\ Mass\ Concentration}{(LISST)\ Volume\ Concentration}$
- It is NOT the density of the individual particles
- It changes in time and space depending upon conditions

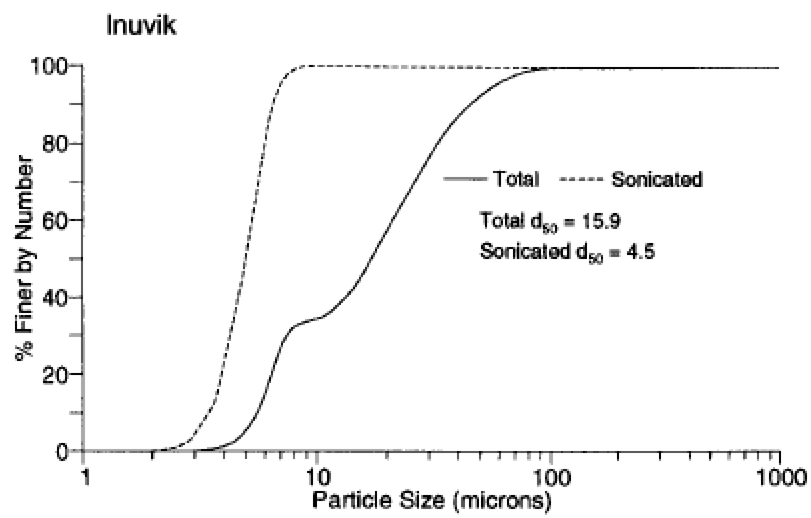
# Effective Density: Example

| |  Sediment Grains |  Flocculated particles |  Bubbles |
|---|---|---|---|
| Particle Size (µm) | 30 | 30 | 30 |
| Volume Conc (µl/l) | 100 | 100 | 100 |
| Filtered and Weighed Mass Conc (mg/l) | 260 | 40 | 0 |
| **Effective Density** | **2.6** | **0.4** | **0** |
| | | | |
| | | | |

# Flocculation effect on size distribution




Arctic Rivers (Droppo et al., 1998)

No single grains > ~10 µm

All in situ particles > 10 µm were flocs

# Conclusions

LD has strengths and limitations.

Data suggest the possibility of flocs in-situ.

Remains to examine data to be presented.