Mechanism for LPC Pooling and Release in CMP Slurry Lines

Kelly A. Barry
Product Manager
KBarry@VantageTechCorp.com

Michael A. Fury, Ph.D.
Director of Market Development
MFury@VantageTechCorp.com

Vantage Technology Corporation, 1731 Dell Avenue, Campbell, CA 95008 USA

NCCAVS CMPUG
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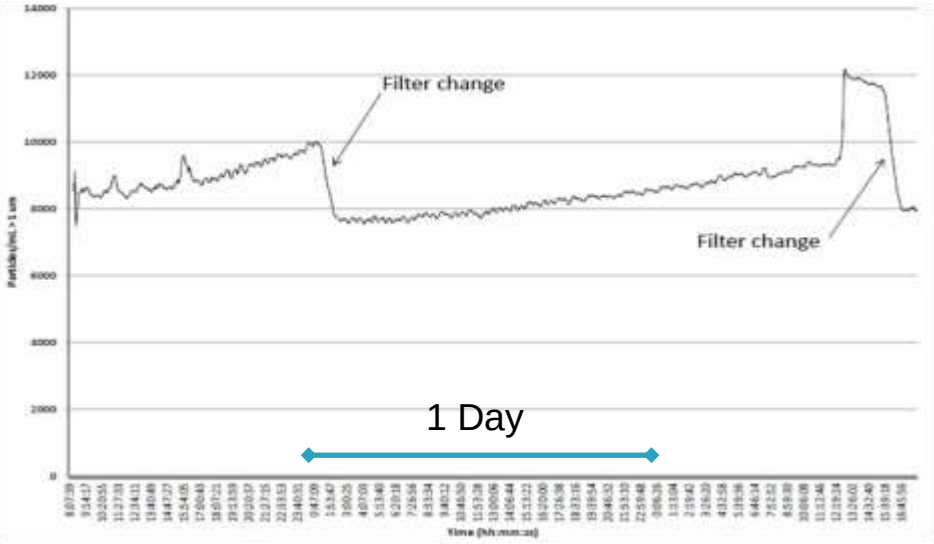
Outline

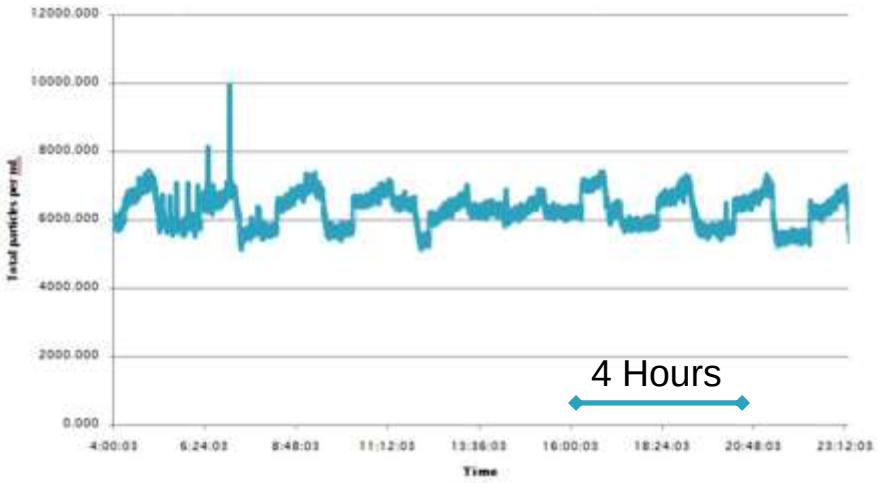
- Experimental setup
- Observations
- Conclusions & Recommendations

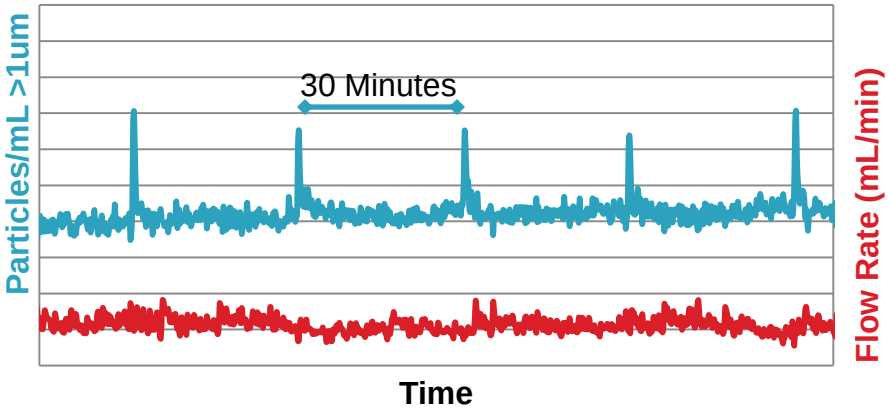
Premise

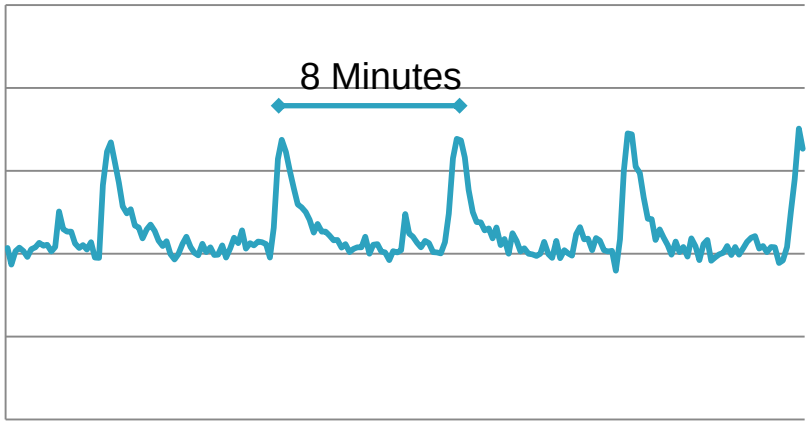
- Vantage performed a simple experiment using fluorescent latex spheres to help visualize particle behavior in slurry lines
- The data yielded some unexpected results
- Our hypothesis has implications for the design of slurry loops, SDS systems, and CMP polishers

SlurryScope Field Observations









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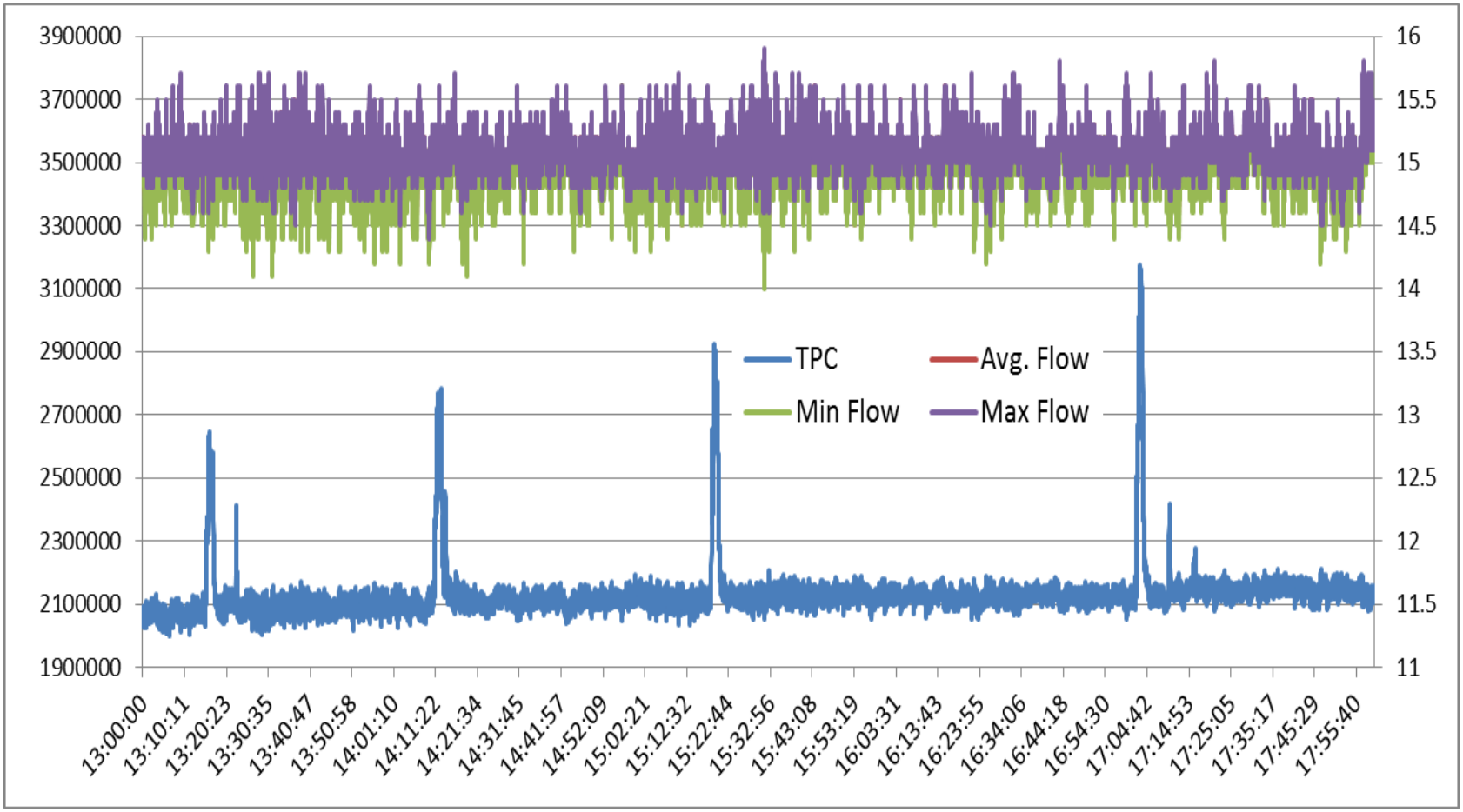
Vantage Lab Observation



Periodic LPC spikes not caused by change in flow rate

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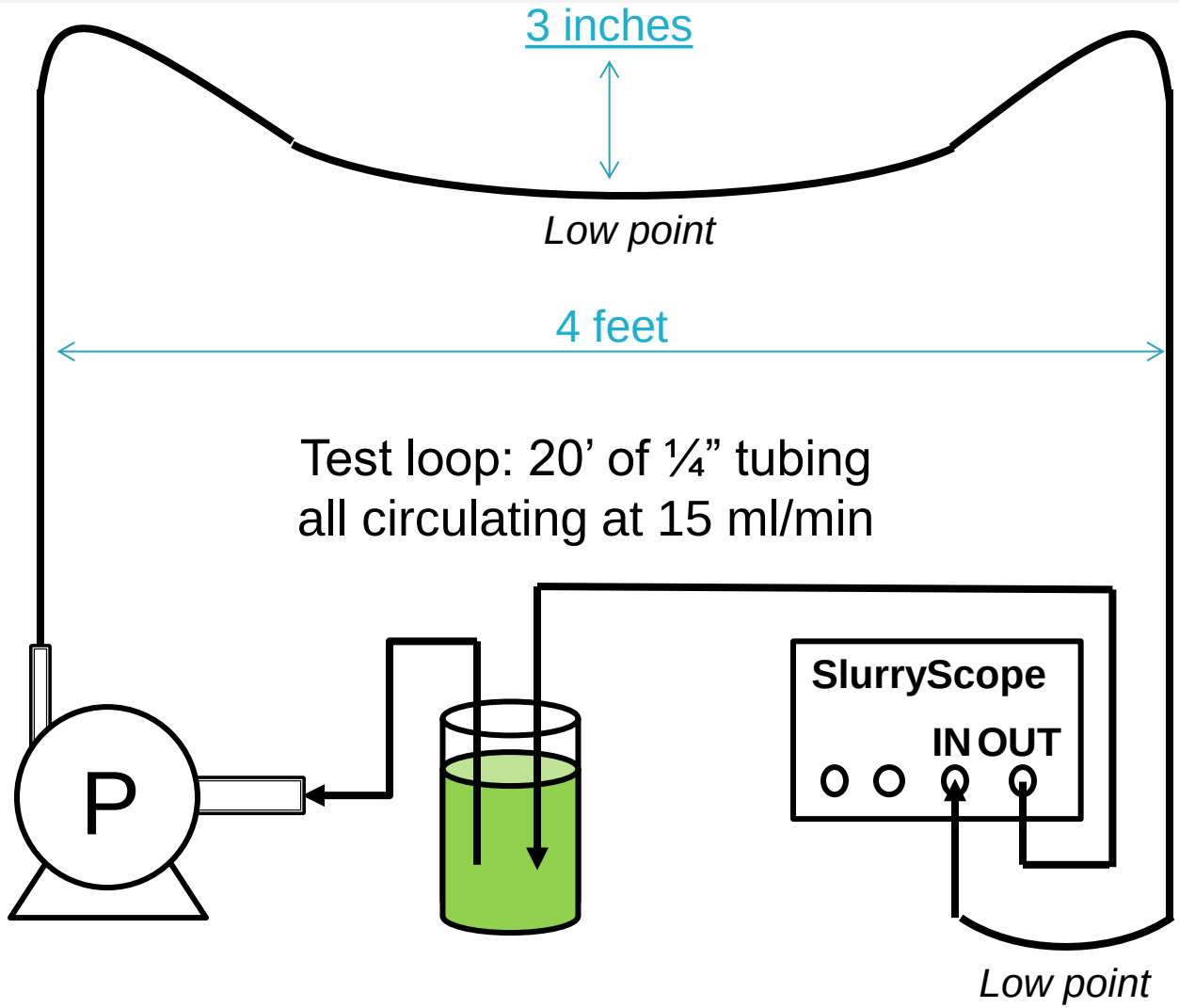
Fluorescent Particle Experiment



UV Fluorescent Latex Particles

- UV fluorescent latex microspheres, 1-5µm
- Glow bright green under UV light
- Sonicated for 6 min
- Recirculated in pump loop for SlurryScope measurement

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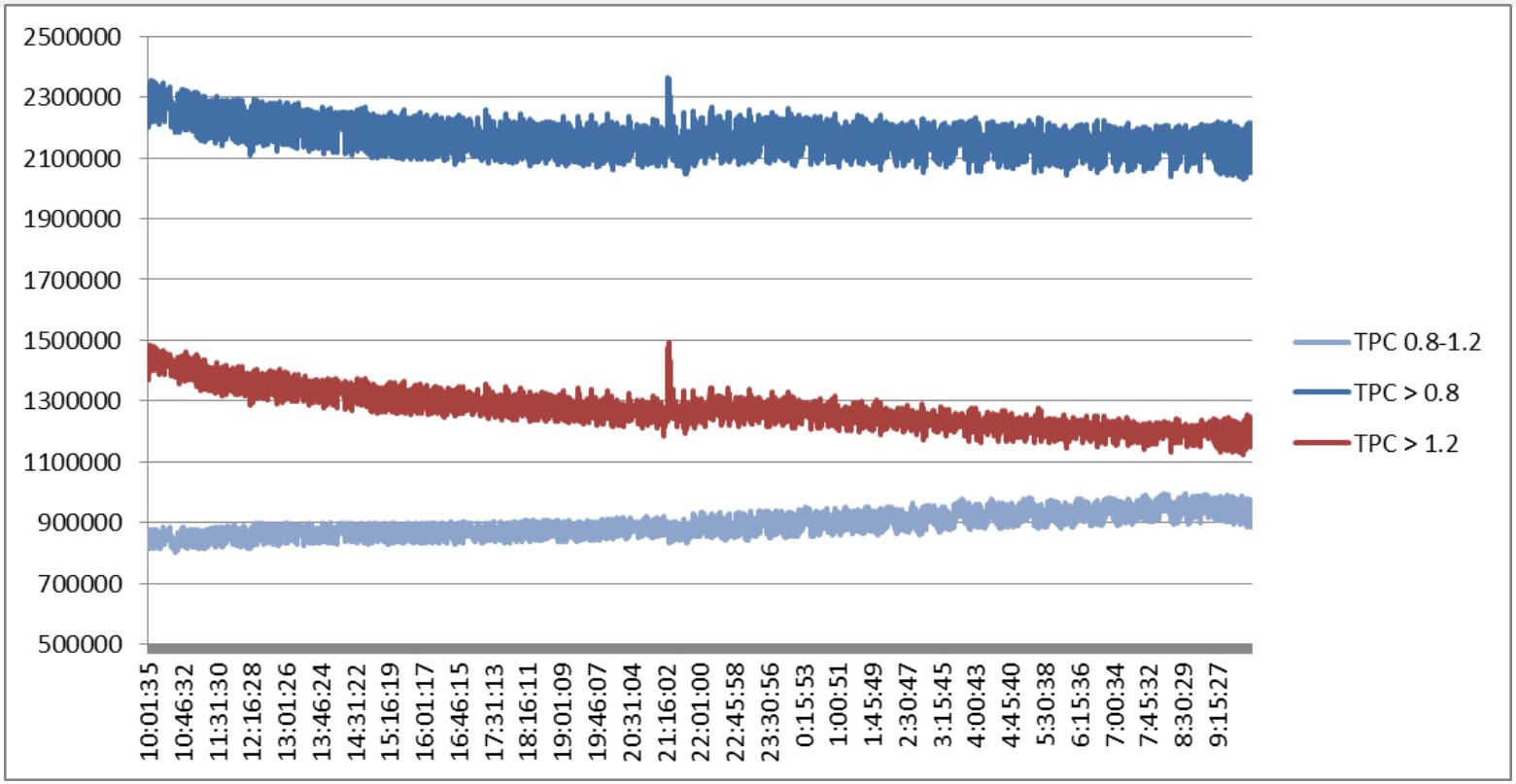
Particle Count and Size: 0h-24h



- TPC > 1.2um gradually decreases, indicating settling of larger particles
- TPC 0.8-1.2um gradually *increases,* possibly indicating latex particles being broken up in the pump

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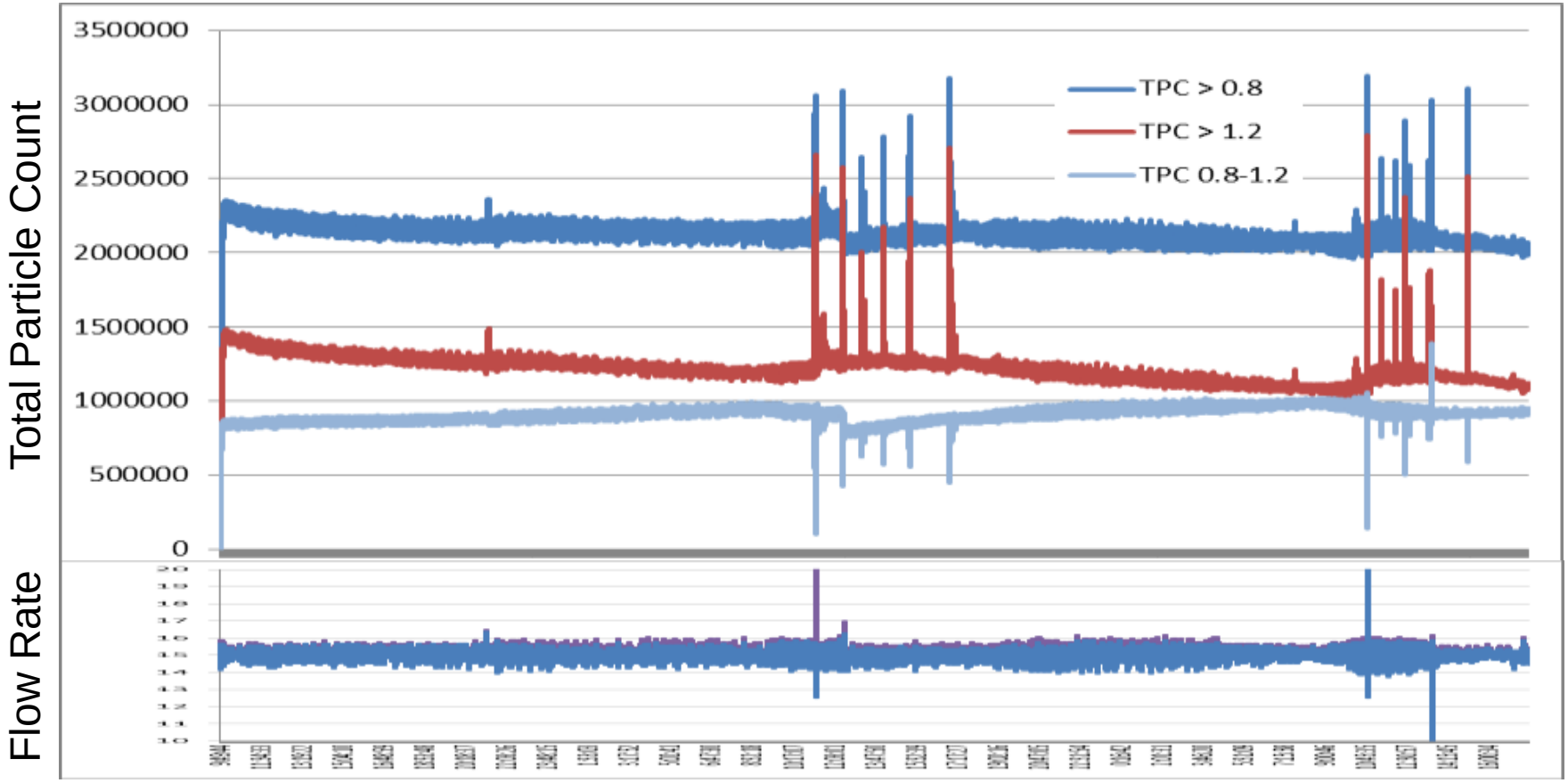
Particle Count and Size: 0h-56h



- Two events of periodic large LPC spikes not (all) due to flow rate
- Flow disruptions are thought to be air bubbles moving through the LFC

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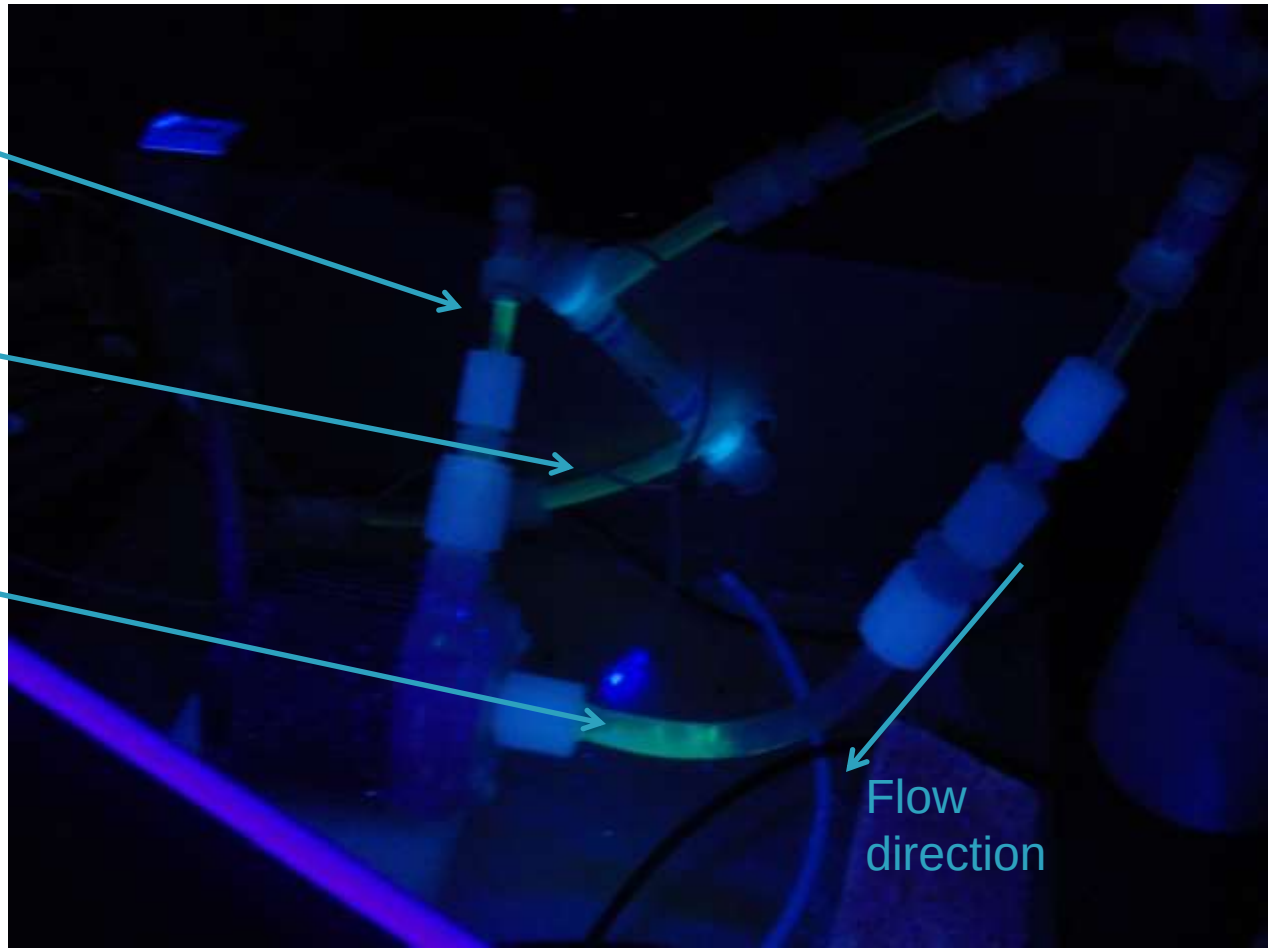
Latex Settling in Tubes

Latex particles stuck at top of pump output tube

Some latex particles settled at low point in this tube

Many latex particles settled at low point of tube at input to pump

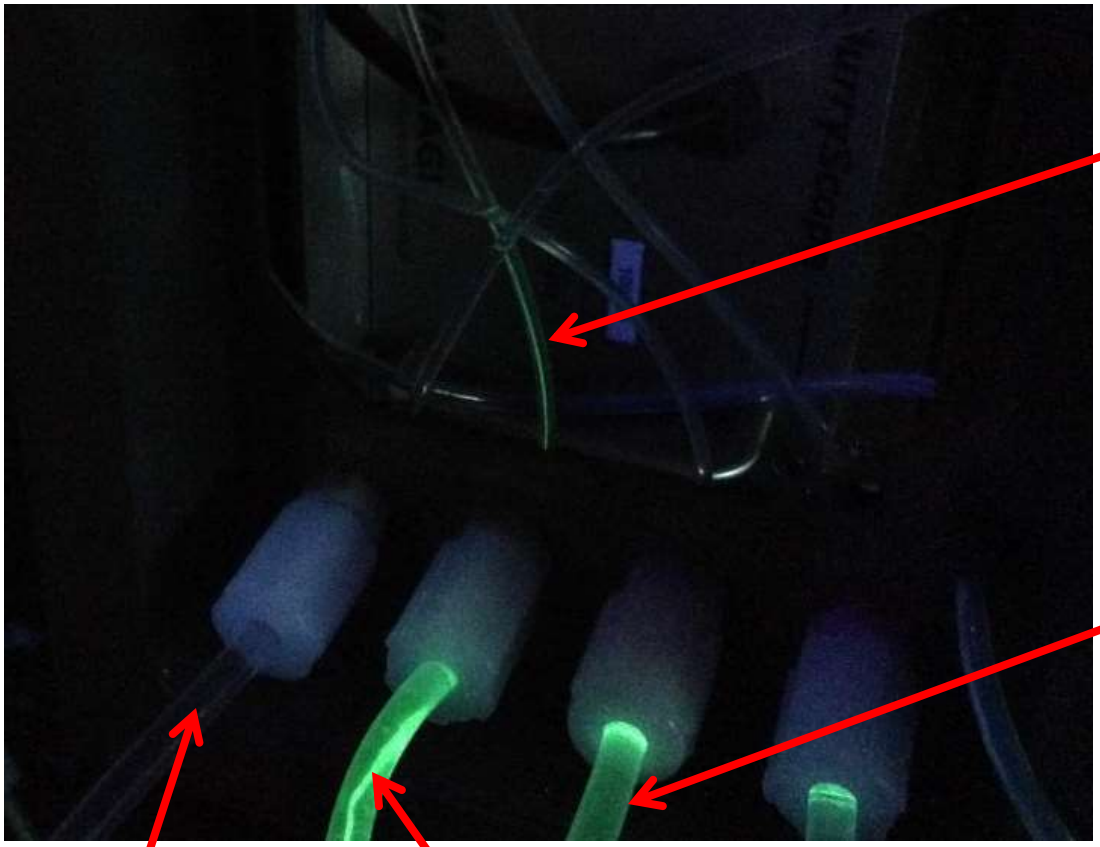


Slurry particles are much more dense than latex

Pump Input – 3/8” Tubing

Settling occurs at input point (horizontal)

Dead Leg Settling: 1/8” and 1/4”



Stagnant 1/8” leg (latex) shows settling as line becomes horizontal

Active uphill ¼” legs (latex) do not show settling

Stagnant ¼” leg (latex) shows settling

Stagnant ¼” leg (DIW only)

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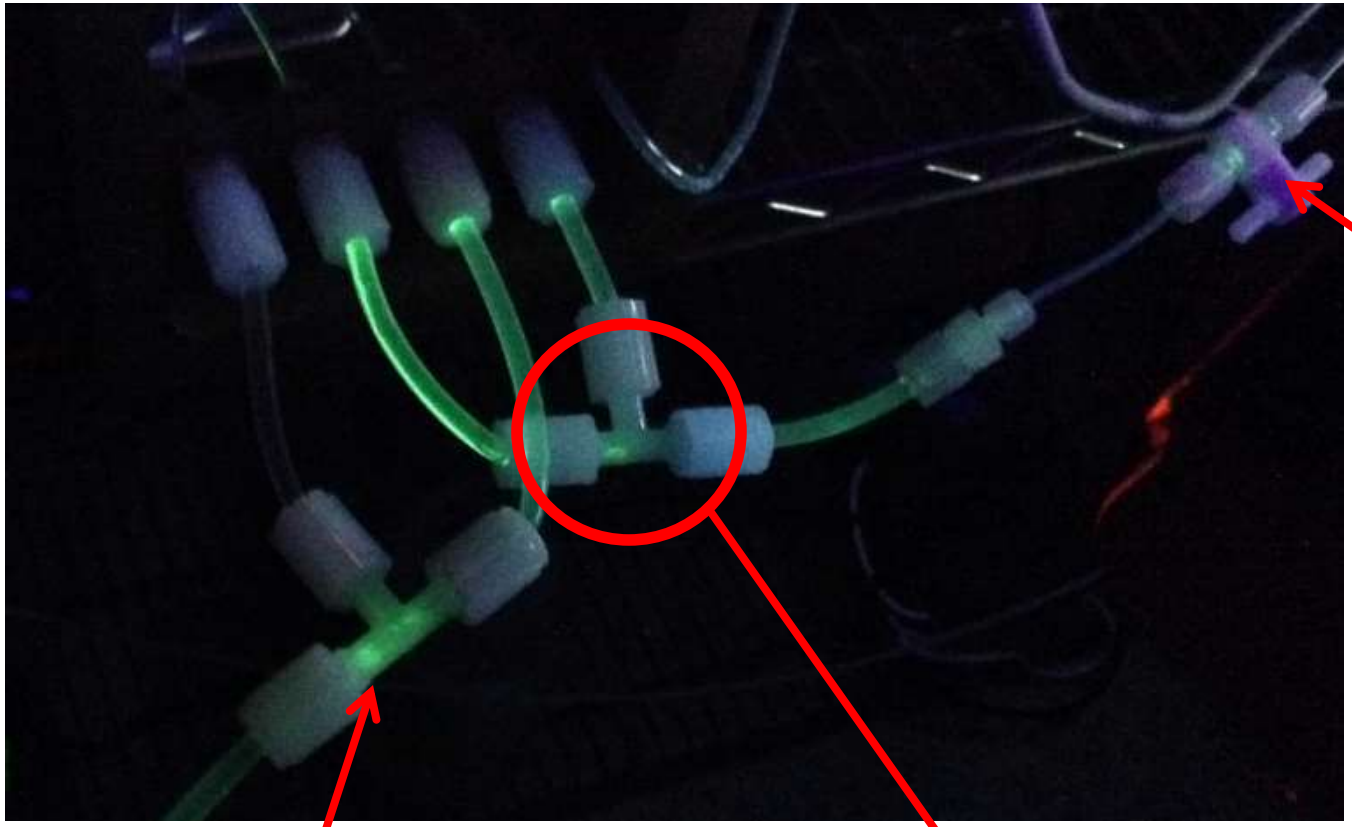
Connector Settling



Settling in open 1/8” valve

Settling in active ¼” connector

Settling in stagnant leg of active ¼” connector

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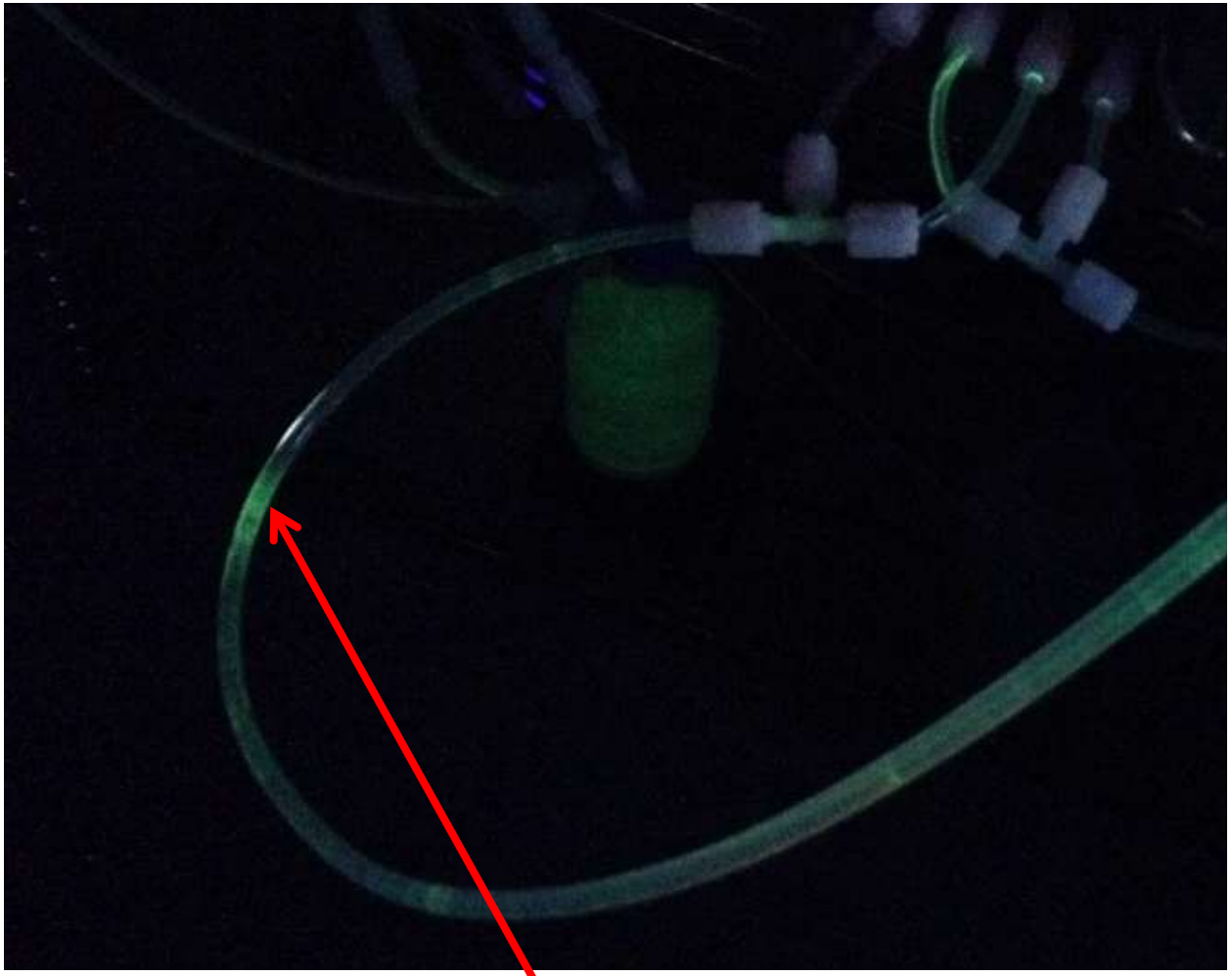
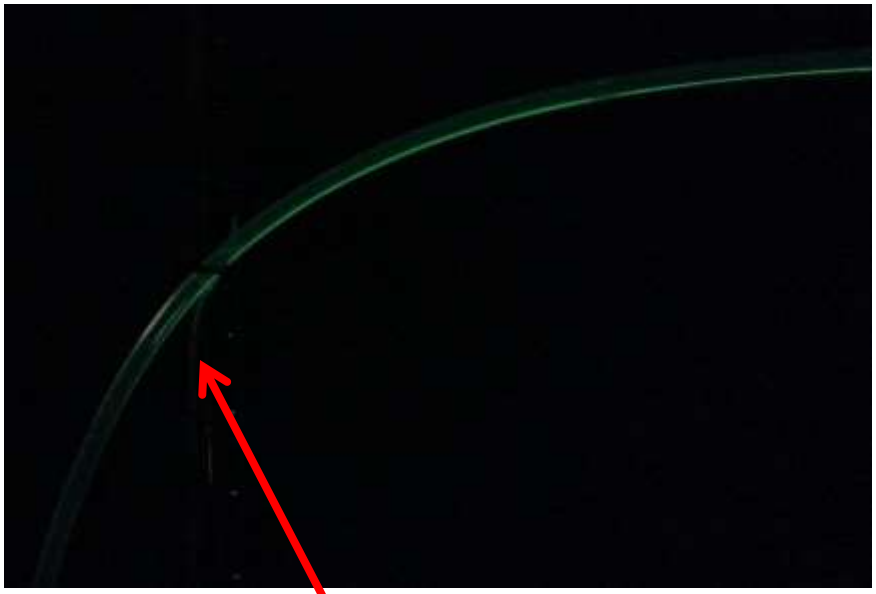
Low Point Settling

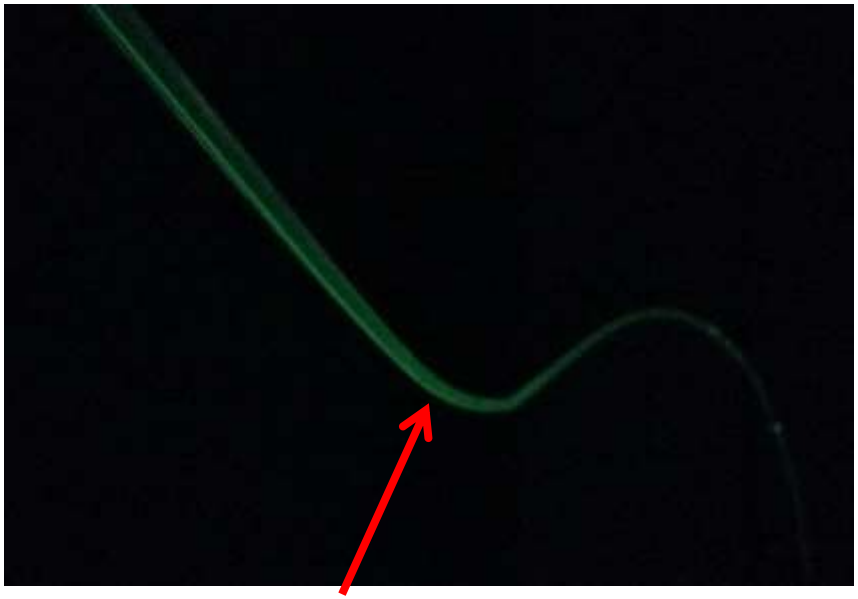


Settling at low point of active ¼” line

Horizontal Line Settling

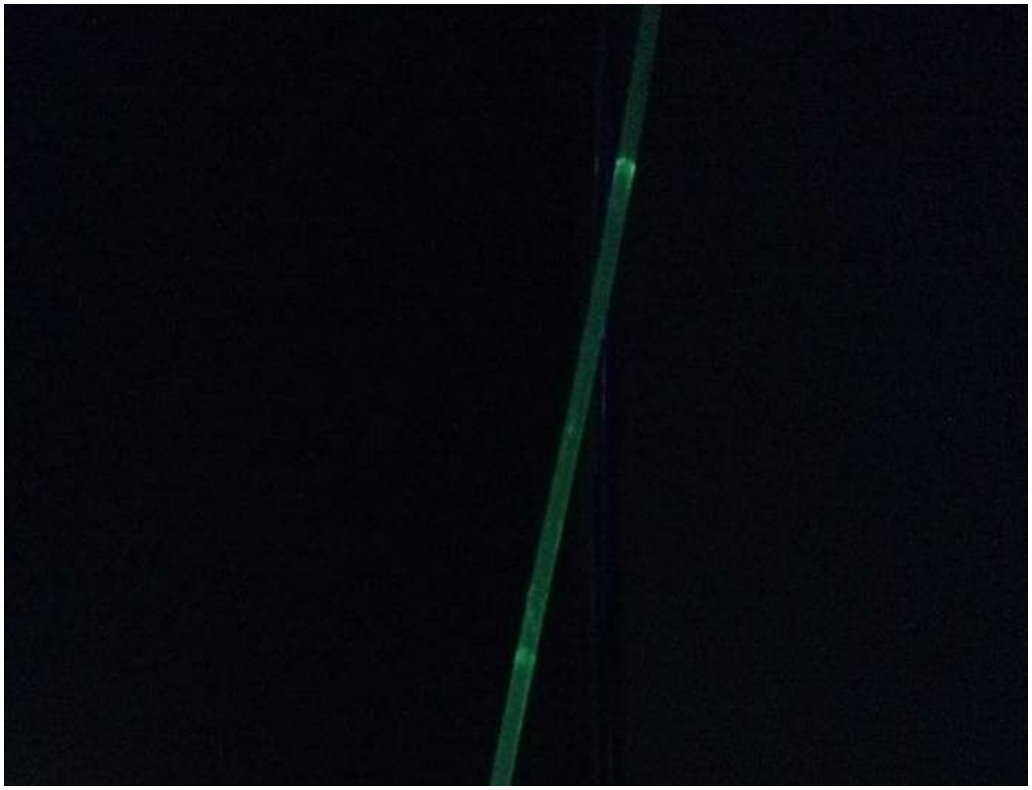


Settling in active ¼” line occurs as the orientation changes from vertical to horizontal



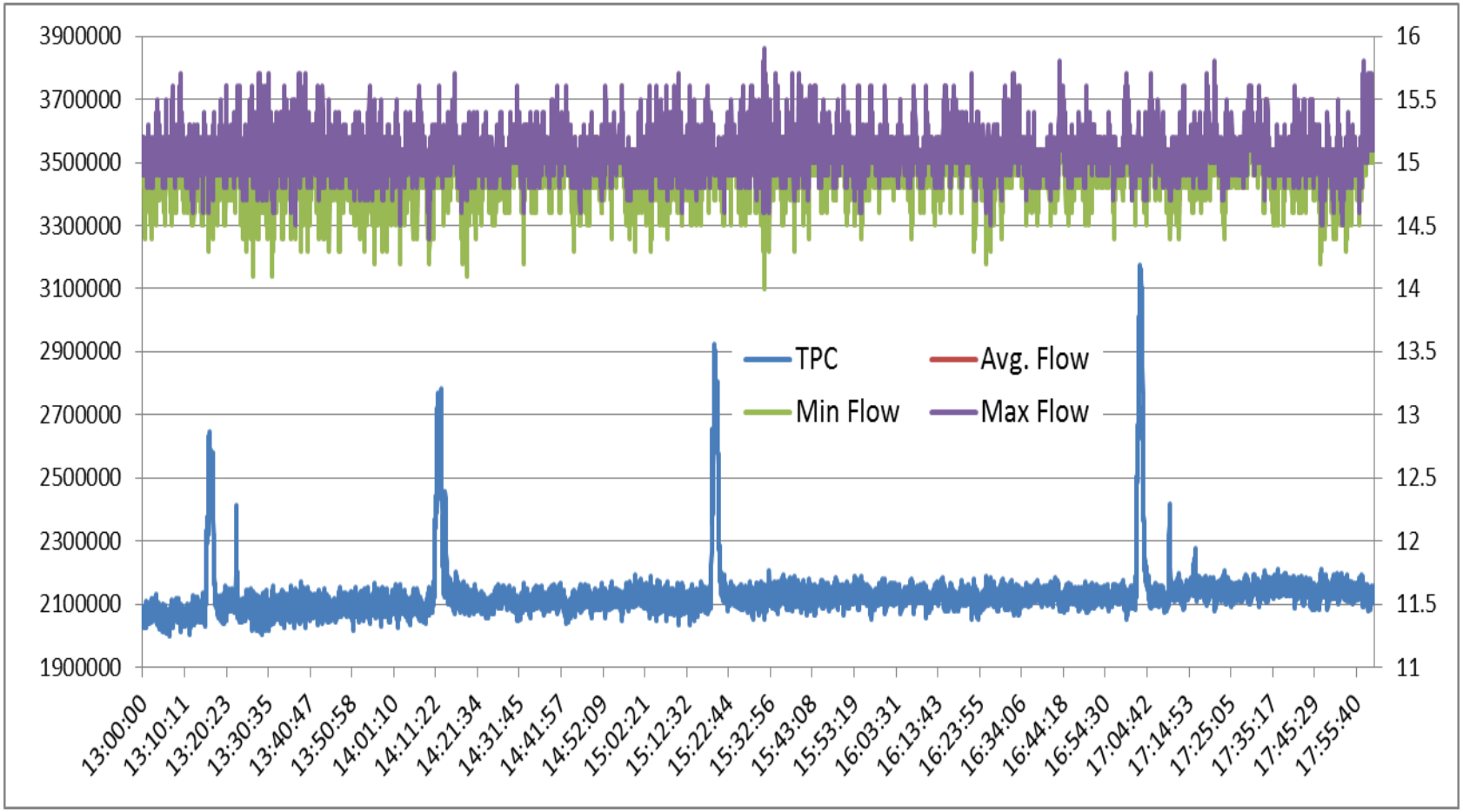
Settling in active ¼” line is more spread out at the low point of the line

Vertical Line Accumulation



Latex clustering was also observed along vertical orientations – may indicate occlusions or surface abnormalities inside the line

Vantage Lab Observation



Periodic LPC spikes with no change in flow rate

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Proposed Mechanism

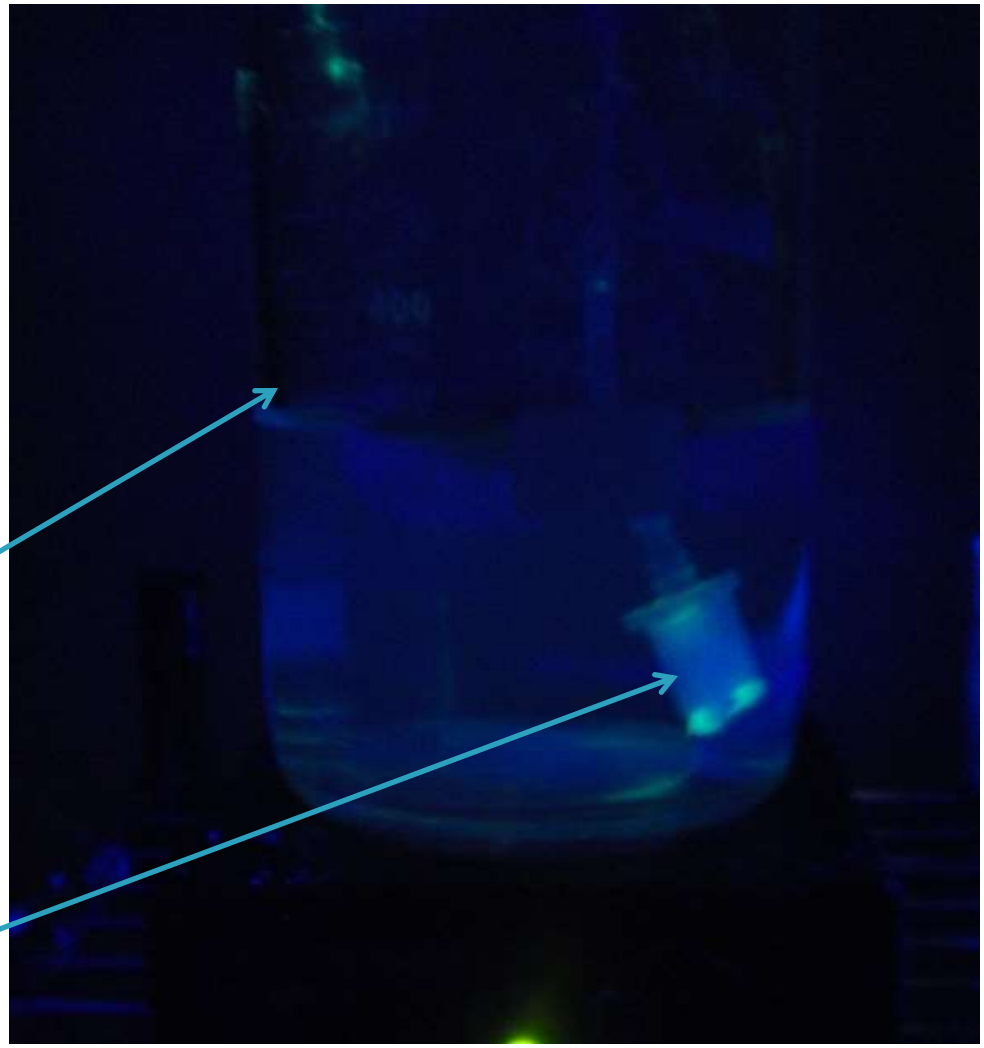
- Particles accumulate in a zone with impaired flow until that zone reaches full capacity
- A portion of the accumulated particles are swept back into the slurry flow
- Accumulation cycle begins again

- Event that triggers the start of a cycle *may be* physical, such as an air bubble or a line bump
- End of a cycle *may be* a return to more uniform flow, or a sustainable metastable condition

Bottle With Fluorescent Latex

After 24 hours loop recirculation at 15 ml/min, there is **no latex** left in the bottle except for a small amount trapped in the filter.

This bottle was bright green when experiment started.



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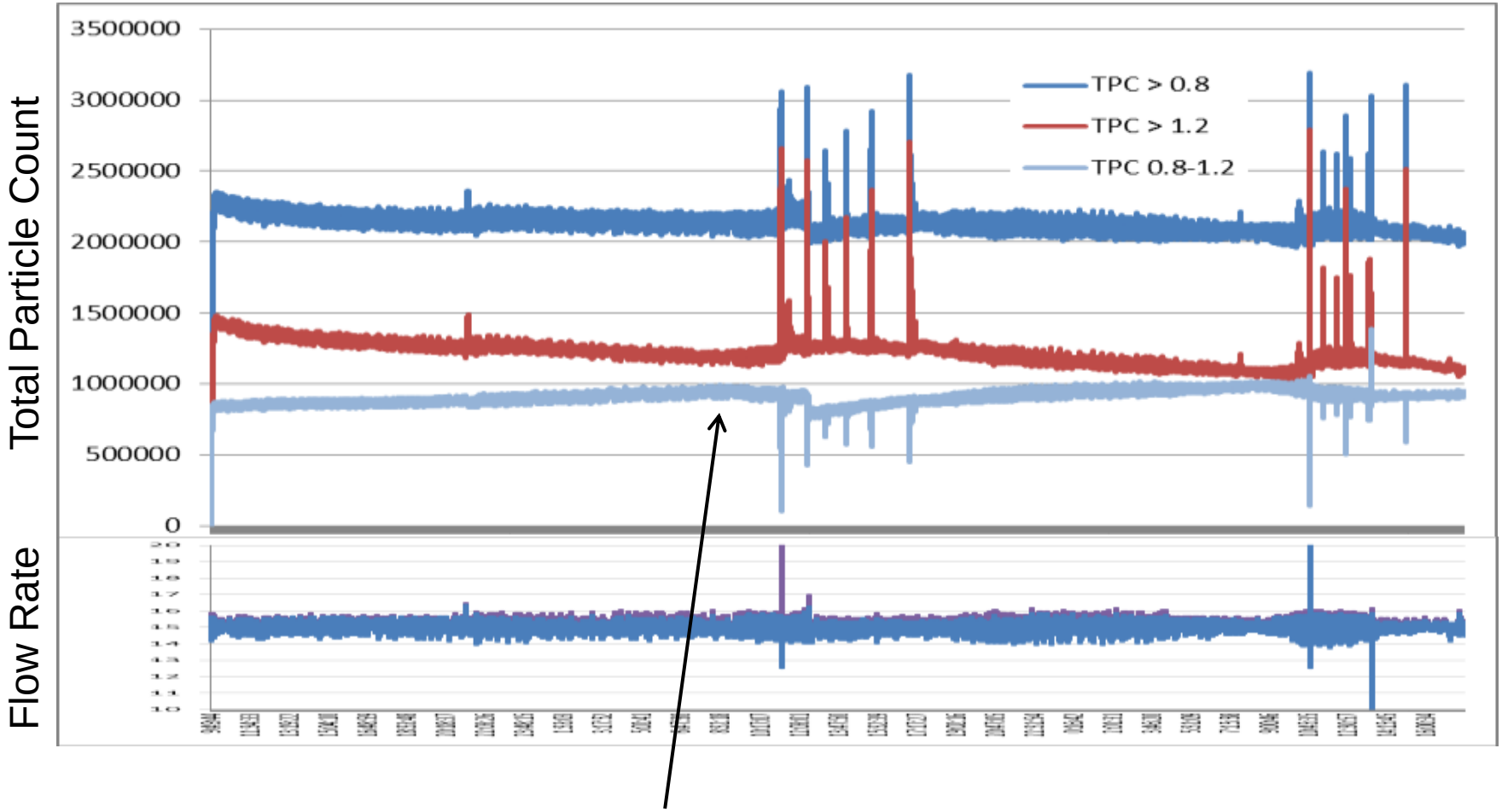

- **No more particles in source bottle after 24 hours**

Implications for Plumbing Design

- Regions of *imperfect slurry flow* collect particles and become a source for random or periodic LPC release
- Low linear velocity allows particles to accumulate even in horizontal runs
- Surface imperfections in tubing promote particle accumulation even in vertical runs
- Flow diameter changes create particle accumulation zones

Implications for SlurryScope

- Tubing diameter, length & orientation are significant LPC issues at 15 ml/min
  - Large particles don't go uphill readily at 15 ml/min
  - Large particles settle readily in low spots at 15 ml/min
  - Lost LPC = missed slurry particle events & inaccurate data

- Tap-off line to SlurryScope must be kept short (<1m), horizontal or downhill and 1/8" to best capture LPC events accurately

Conclusions & Recommendations

- Periodic LPC spikes may be the result of regions of imperfect slurry flow somewhere in the system
  - Continuous slurry monitoring facilitates detection and elimination of the root causes

- Linear slurry flow velocity below the recommended minimum has LPC consequences in the SDS, in the polisher, and in the metrology
  - Locating the SlurryScope as close as possible to the main slurry line tap-off point is critical for accurate LPC monitoring