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Field Validation of Sub-Micron Defect Correlation with ≥1 Micron Particle Behavior in Undiluted POU CMP Slurry

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Outline

- Groundrules
- Production Conditions
- Principles Confirmed

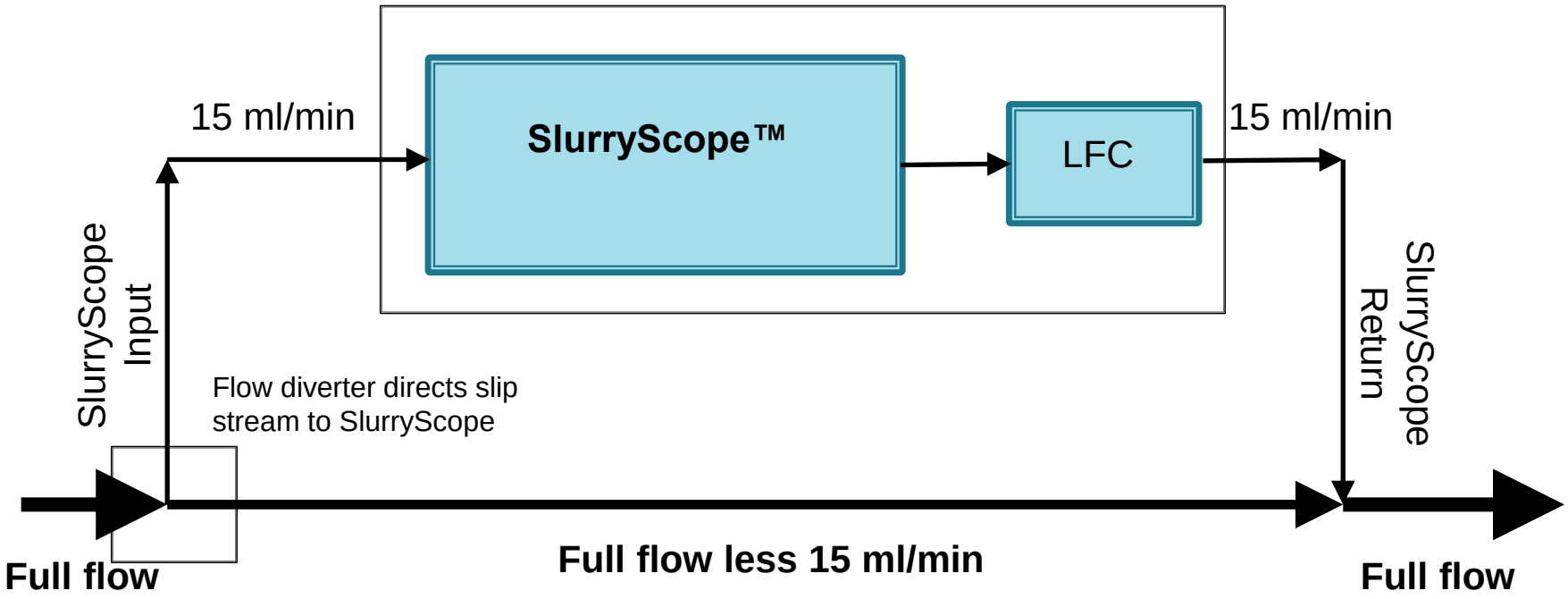
Groundrules

- ICPT 2014 paper accepted
  - Joint publication: IM Flash Technologies & Vantage
  - Fab management has approved release
  - Details of fab correlation data will be presented in November
- Metadata: data about data
  - The lessons learned from this customer fab experience, combined with others, are the subject of this presentation

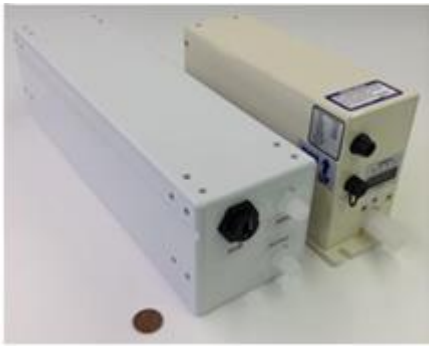
SlurryScope Experimental Setup

- Slurry Information
  - Ceria based slurry
  - 1-5% solids at point of use dilution
  - Median particle size: ~ 150 nm
  - Slurry flow rate target: 15 ± 1 mL/min
- Phase 1
  - SlurryScope placed under the platen
  - Sample taken at slurry input to the polisher before the POU filter
  - Data collection triggered by the pneumatic signal used to open slurry valve supplying the polisher
  - ~1 minute data collection with **1 second accumulation interval**
  - Stop data collection when slurry flow drops below 14 mL/min
- Phase 2
  - Sample taken in the CMP tool chase
  - Continuous data collection with **10 second accumulation interval**

Vantage SlurryScope™ LPC Monitor



- Continuous, real-time measurement @ 15 ml/min
- Detection range 1 - 10+ µm in 0.2 µm increments or 0.8 - 4+ µm in 0.1 µm increments
- Undiluted POU CMP slurry



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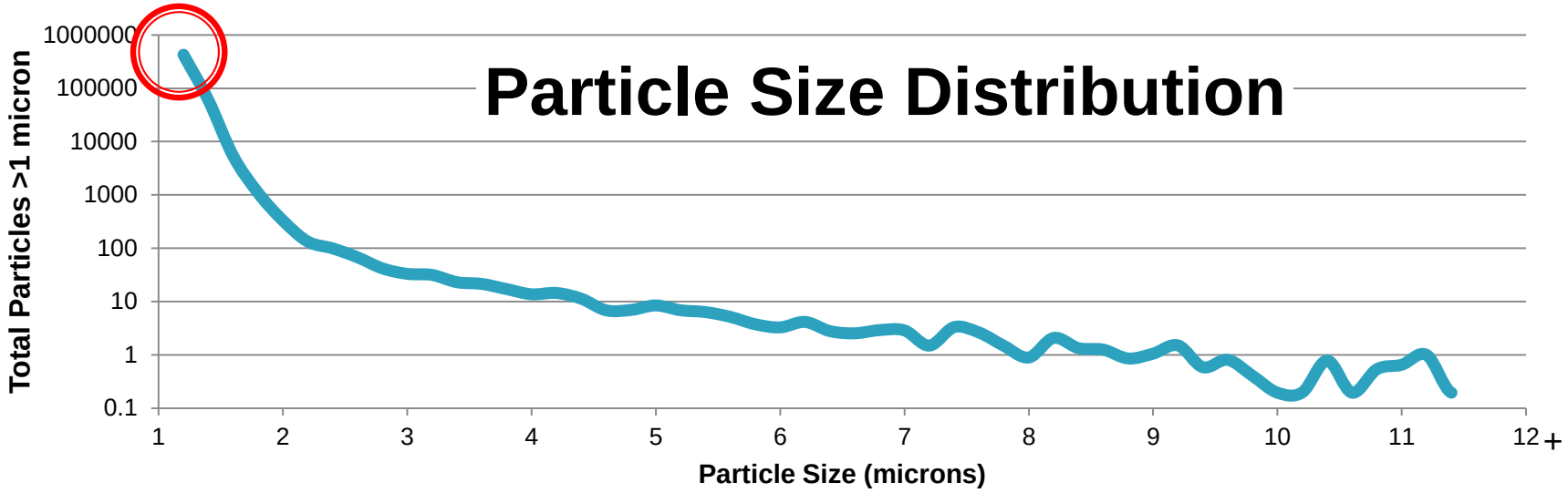
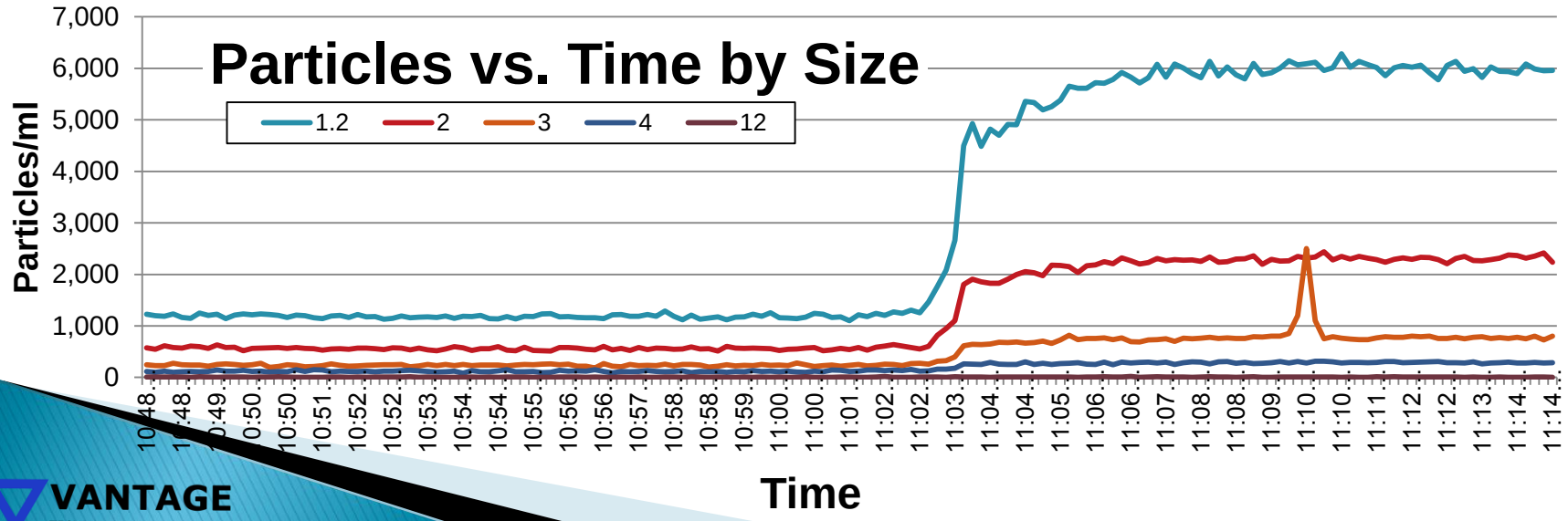
SlurryScope Data Modes





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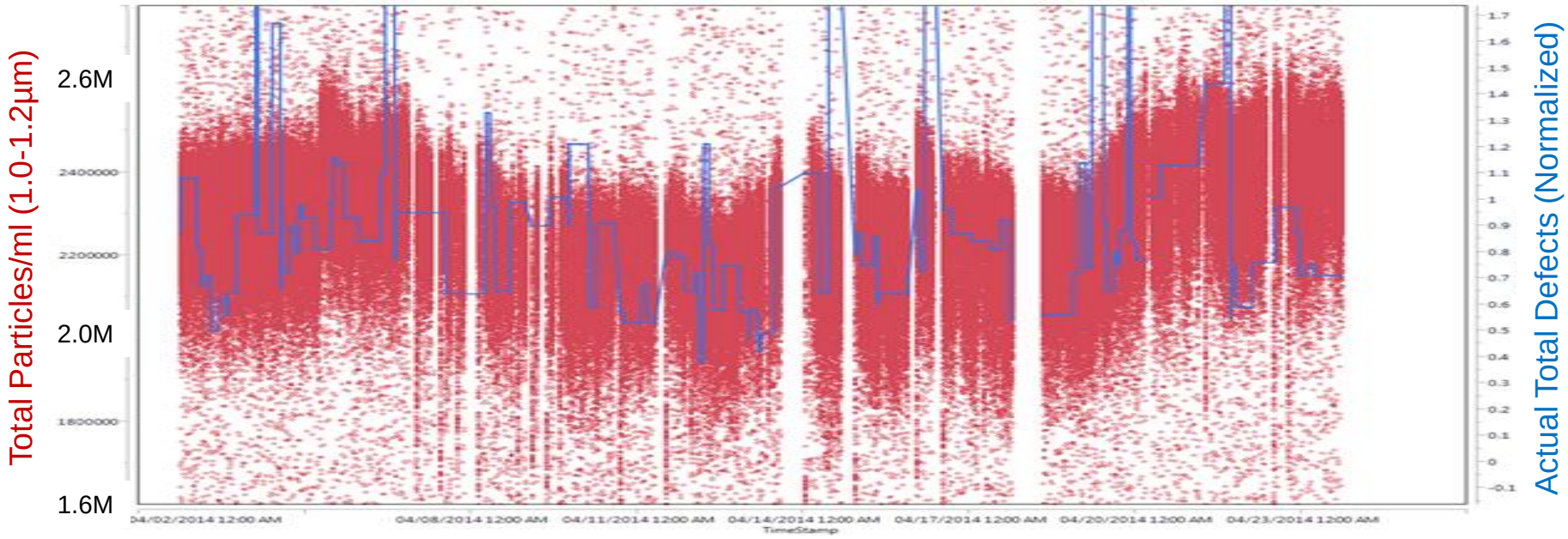
Principle #1 Confirmed

- Particle counts in the 1.0-1.2µm size bin are a good proxy for what is happening in the majority sub-micron particle size distribution
  - For systemic slurry issues, large particles track the behavior of sub-micron particles
  - Continuous, real-time measurement of particles >0.8µm in undiluted slurry is well demonstrated by SlurryScope
  - Continuous, real-time measurement <0.8µm by any method remains an unsolved technical challenge

Current Customer Data - Preview



- Expanded LPC vertical scale (particles / mL)
- Normalized total defect data
- 3 weeks of data
- Blank spaces in data when not polishing

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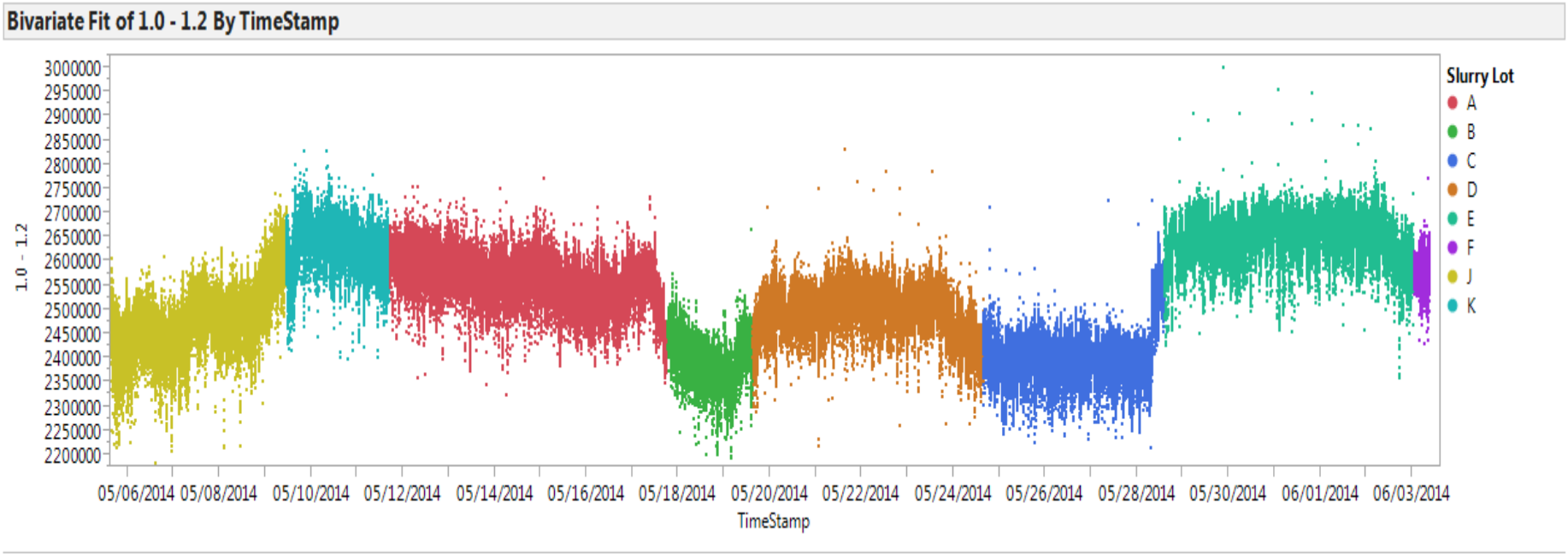
Principle #2 Confirmed

- There is signal in the noise
  - Small variations in stable LPC are the data that correlates with defects
  - Correlations that can be established over extended periods (several days, weeks) may be *undetectable* over shorter periods (hours, few days)

- Offline dilution particle data are noisy
  - Small sample size, infrequent measurements
  - Correlation to SlurryScope can be established over extended periods

Phase 2 SlurryScope Data



Raw Data

- Reduced noise in measurements
  - Longer accumulation interval (10 sec vs 1 sec)
  - Continuous flow of slurry rather than start/stop with slurry dispense on wafer
- Data shows variation as each new slurry lot begins to mix into slurry loop

Principle #3 Confirmed

- Batch-to-batch and tote-to-tote LPC differences comprise a significant driver for defect trends
  - Customers are asking slurry vendors to adapt methods and report SlurryScope data for QC

- LPC excursion events are *not* the defect driver in a stable SDS operation
  - Excursions are operational, largely self-inflicted
  - Identify the root cause and *STOP DOING THAT*
  - Defects *may be* caused by LPC excursions, but these are a ***separate population*** from the defects caused by systemic slurry changes

Principle #4 Confirmed

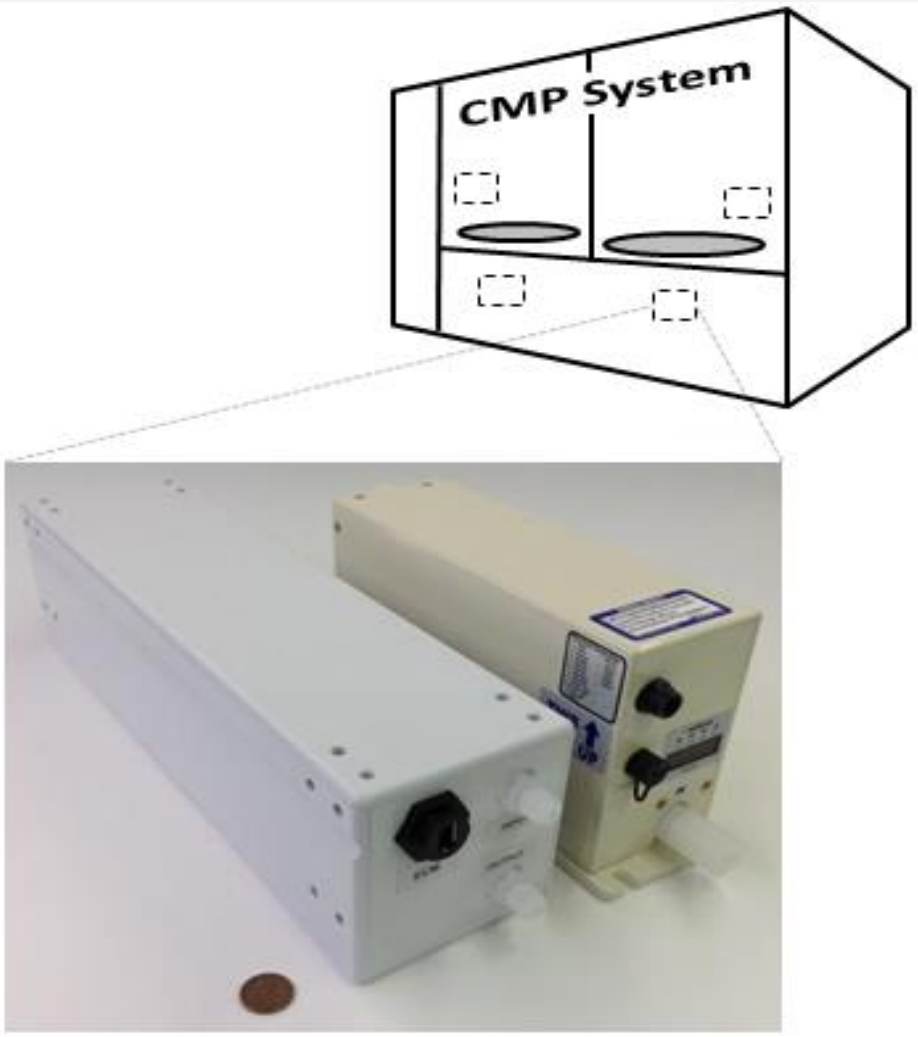
- The particles removed by filtration are not necessarily those that cause defects
  - SlurryScope measured ≥1.0µm
  - SlurryScope sampling was *before* the POU filter
  - *After measurement*, slurry passed through POU filter onto the polishing platen
  - *This is the SlurryScope data that correlates with defects*
- **Say it again:** LPC data for particles ≥1.0µm is a good proxy for monitoring behavior of the sub-micron majority

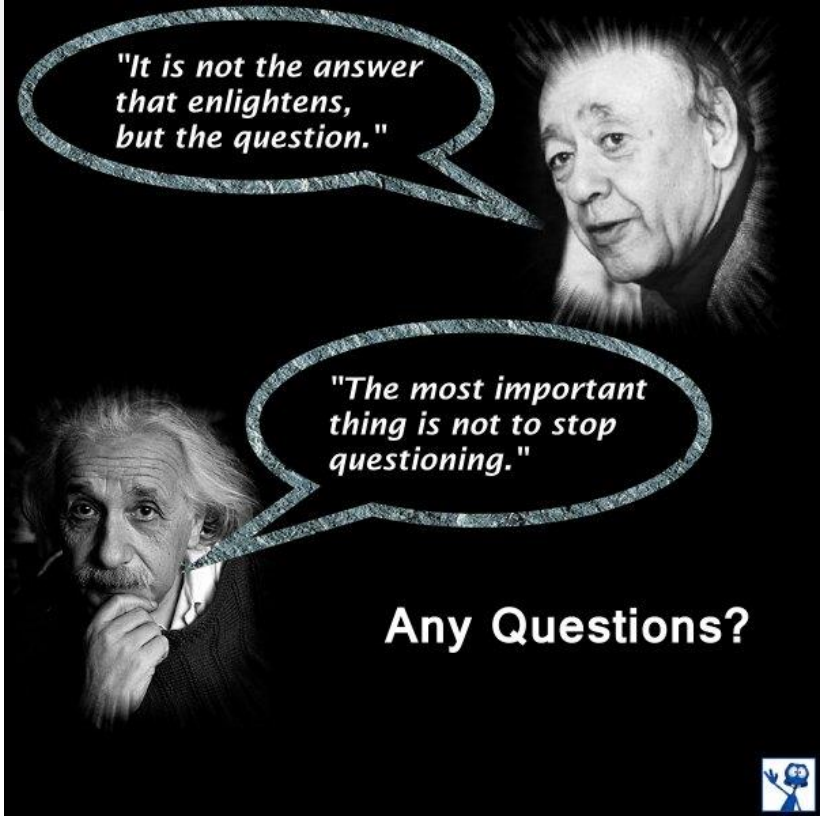
Principle #5 Confirmed

- The smallest particle size bin carries systemic slurry information
  - Correlates with defects
  - Slurry tote and lot changes
  - Slurry pot aging
- Larger particle size bin data can be used to concurrently monitor operational events
  - Day tank changes
  - Filter changes
  - Pump changes

Final Thoughts

- One engineer was responsible for fab process operations and sub-fab slurry management
  - No “Upstairs Downstairs” contention
- The statistical data analysis methods used must be as sophisticated as the data itself
  - Simplistic number crunching can be easily overwhelmed by normal noise levels in the data
- Once SlurryScope data behavior is characterized in retrospect, methods can be developed for better managing fab operations and reducing defects





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