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The Sampling Statistics of Low Particle Counts in CMP Slurry

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

- Slurry monitoring practices today
- Introduction to Vantage SlurryScope™
- Sampling statistics
- Implications for fab operations
- Summary

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Slurry Monitoring – prior methods

- Full particle size distribution (PSD)
  - Offline lab tool (*e.g.* Horiba LA-950)
  - 0.01 µm to 3,000 µm
  - Dilution to single particle passing through detector
  - Sample size 0.25 ml to 1.0 ml typical
- Large particle count (LPC) detectors
  - Offline and inline variations
  - 0.5 µm and above
  - Dilution to single particle passing through detector
  - Sample size 0.25 ml to 1.0 ml typical

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Slurry Monitoring – Hypothesis

- Particles < 0.3 µm
  - Many particles, by design
  - PSD is well-represented by small sample volumes
- Particles > 1.0 µm
  - Few particles, by design
  - PSD is poorly represented by small sample volumes
  - Particle counts are poorly represented by small sample volumes
  - Sampling count error increases as particle size increases (particle count decreases)

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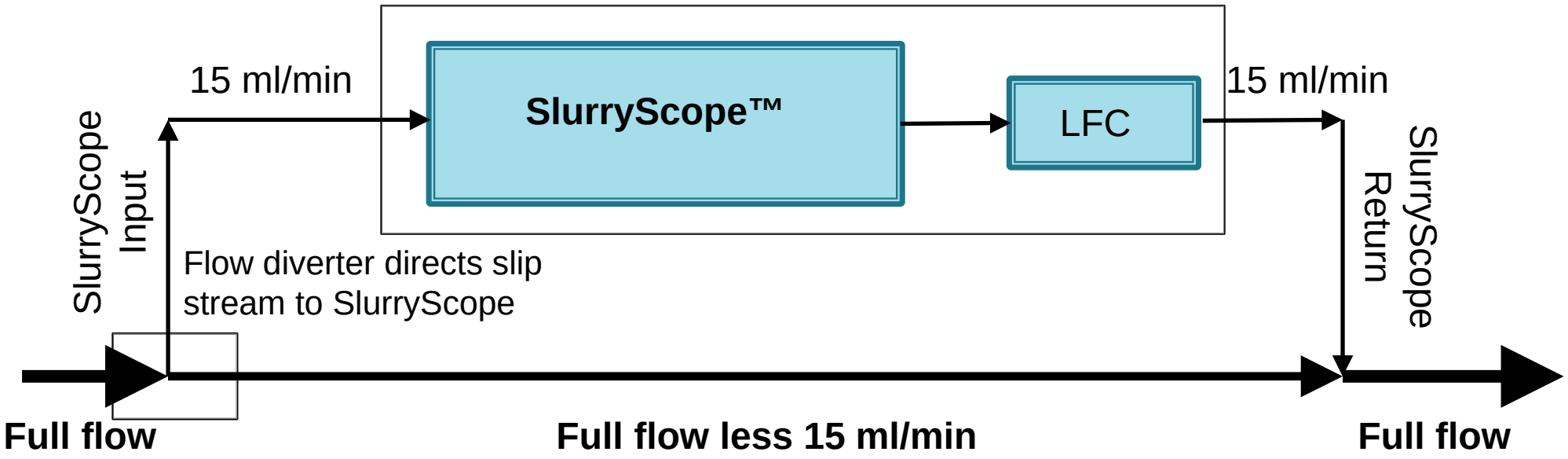
Vantage Technology SlurryScope™



- Continuous, real-time measurement @ 15 ml/min
- Detection range 1-12 µm in 0.2 µm increments
- Undiluted CMP slurry, all types

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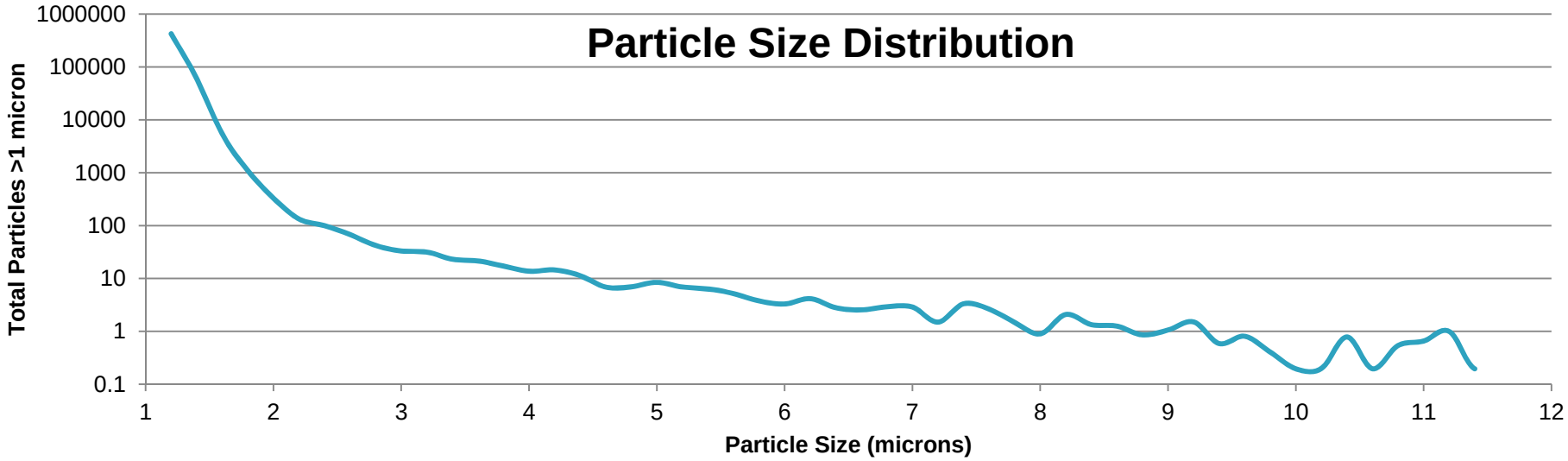
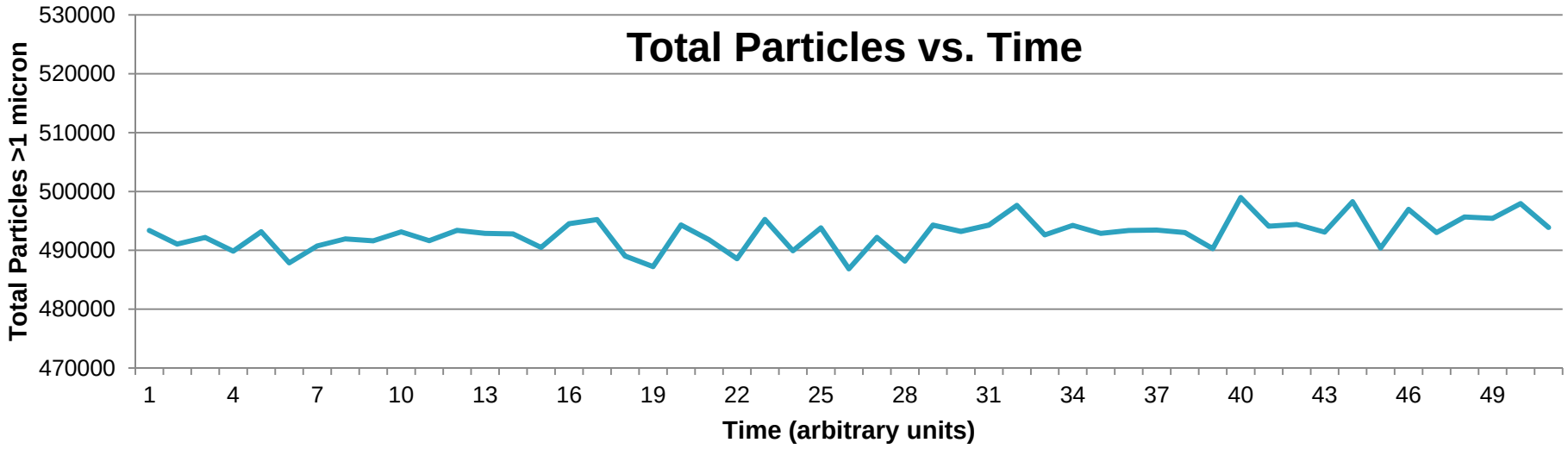
SlurryScope Typical Data





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SlurryScope Monitoring

- Continuous measurement at a regulated flow of 15 ml/min
  - 0.25 ml in a 1 second measurement period
  - This simulates rapid sampling with other methods
  - **Key difference:** undiluted, so no risk of soft optical agglomerates
- Use a series of 1 second measurement intervals from SlurryScope to simulate many, many sample measurements by prior methods
- Ceria slurry used in these experiments

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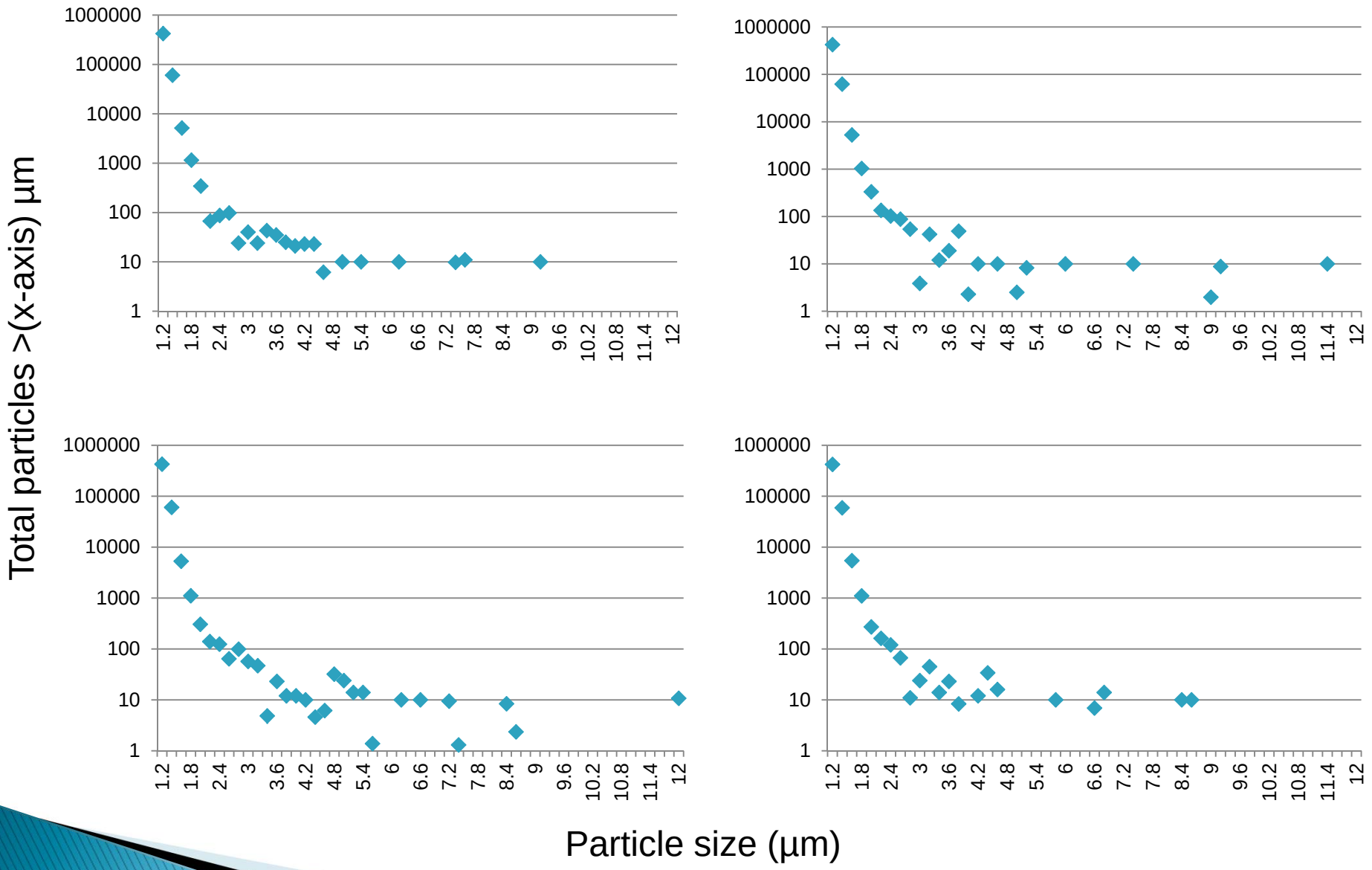
Individual 1 Sec Sample Data



Numerical Data File

Particle size bin (µm)

Total particles counted in size bin

1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	10.4	10.6	10.8	11	11.2	11.4	11.6	11.8
426003	60079	5319	1039	323	182	89	55	0	0	0	10	0	0	0	0
422701	60814	5606	1027	306	103	86	67	0	0	10	0	0	0	0	0
425011	59475	5518	1204	356	130	132	59	0	0	0	0	0	0	0	0
422218	60429	5137	1149	343	67	87	98	0	0	0	0	0	0	0	0
426133	59394	5458	1217	417	164	110	56	0	10	0	0	0	0	10	0
422450	58341	5297	1040	283	82	87	23	0	0	0	0	0	0	0	0
423492	59527	5423	1293	338	197	133	60	0	0	0	0	21	0	0	0
425466	59205	5351	1146	290	119	118	28	0	0	0	0	0	0	0	0
424718	59669	5213	1141	377	157	58	44	0	0	0	0	0	0	0	0
423875	62059	5273	1031	331	135	102	88	0	0	0	0	0	10	0	0
424822	58876	5725	1341	347	69	78	66	0	0	0	0	0	0	0	0
424921	61402	5124	1016	328	109	90	66	0	0	0	0	0	0	0	0
425888	59954	5060	1105	337	111	61	45	0	0	0	0	0	0	0	0
425563	59688	5656	959	302	160	70	56	0	0	0	0	0	0	0	0
424391	58898	5248	1079	311	93	54	89	0	0	0	0	0	0	0	0
426447	60634	5287	1109	305	140	124	64	0	0	0	0	0	0	0	0
426835	60968	5483	952	340	191	102	67	0	0	0	10	0	0	0	0
421106	60313	5553	1039	368	114	87	77	0	0	7.52	3.24	0	0	0	0
420119	59380	5473	1207	405	175	149	49	0	0	0	0	0	0	0	0
425245	61286	5526	1351	375	117	60	32	0	0	0	0	0	0	0	0
425934	58961	5020	969	314	121	56	68	10	0	0	0	0	0	0	0
421781	59382	5438	1103	271	162	120	67	0	0	0	0	0	0	0	0
428509	59148	5580	1162	339	101	94	58	0	0	0	0	0	0	0	0
423015	59581	5250	1068	351	160	119	132	0	0	0	0	0	0	0	0

Each line of data = 1 second sampling interval = 0.25 ml slurry

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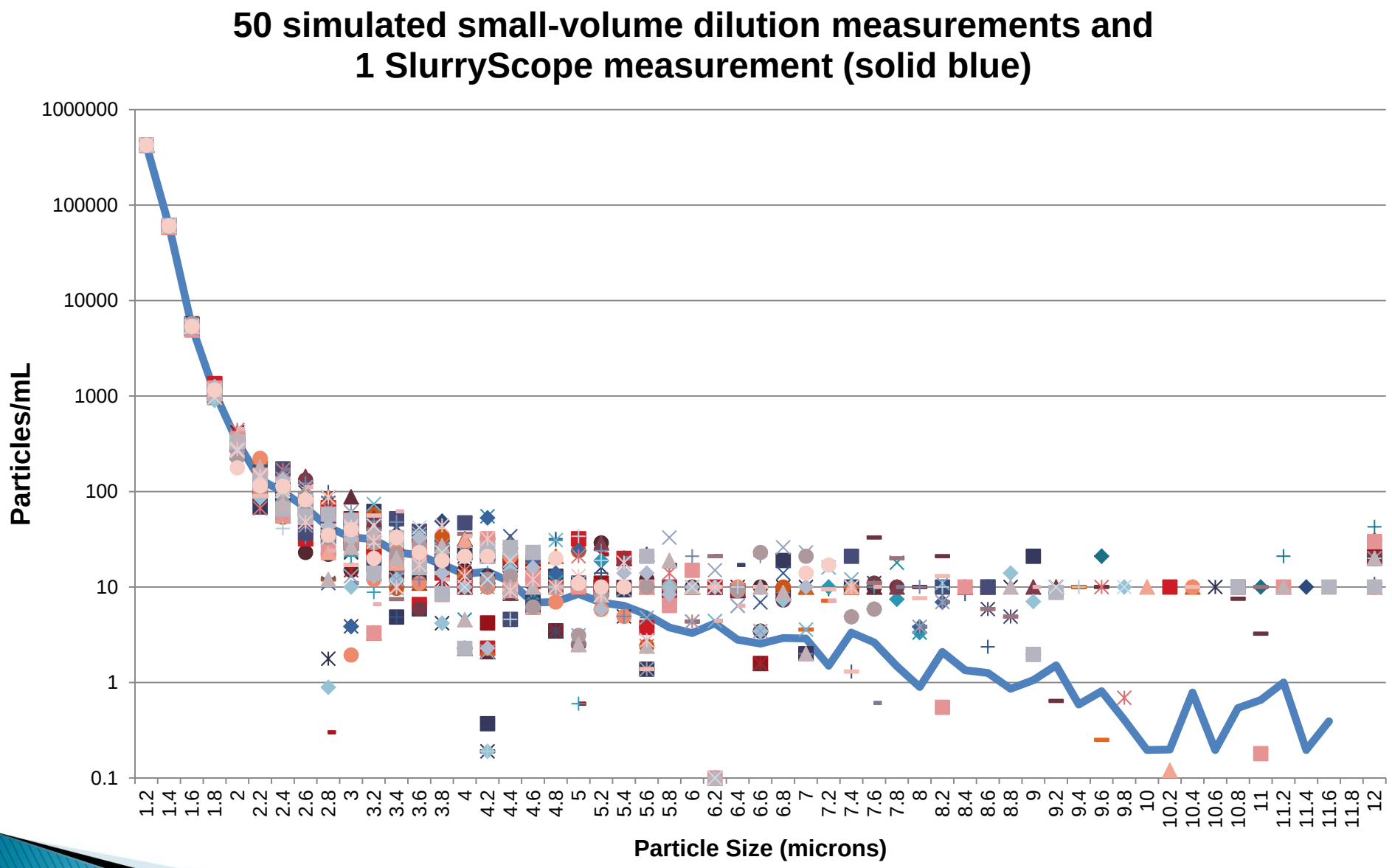
Overlay of Fifty 1 Sec Data Sets



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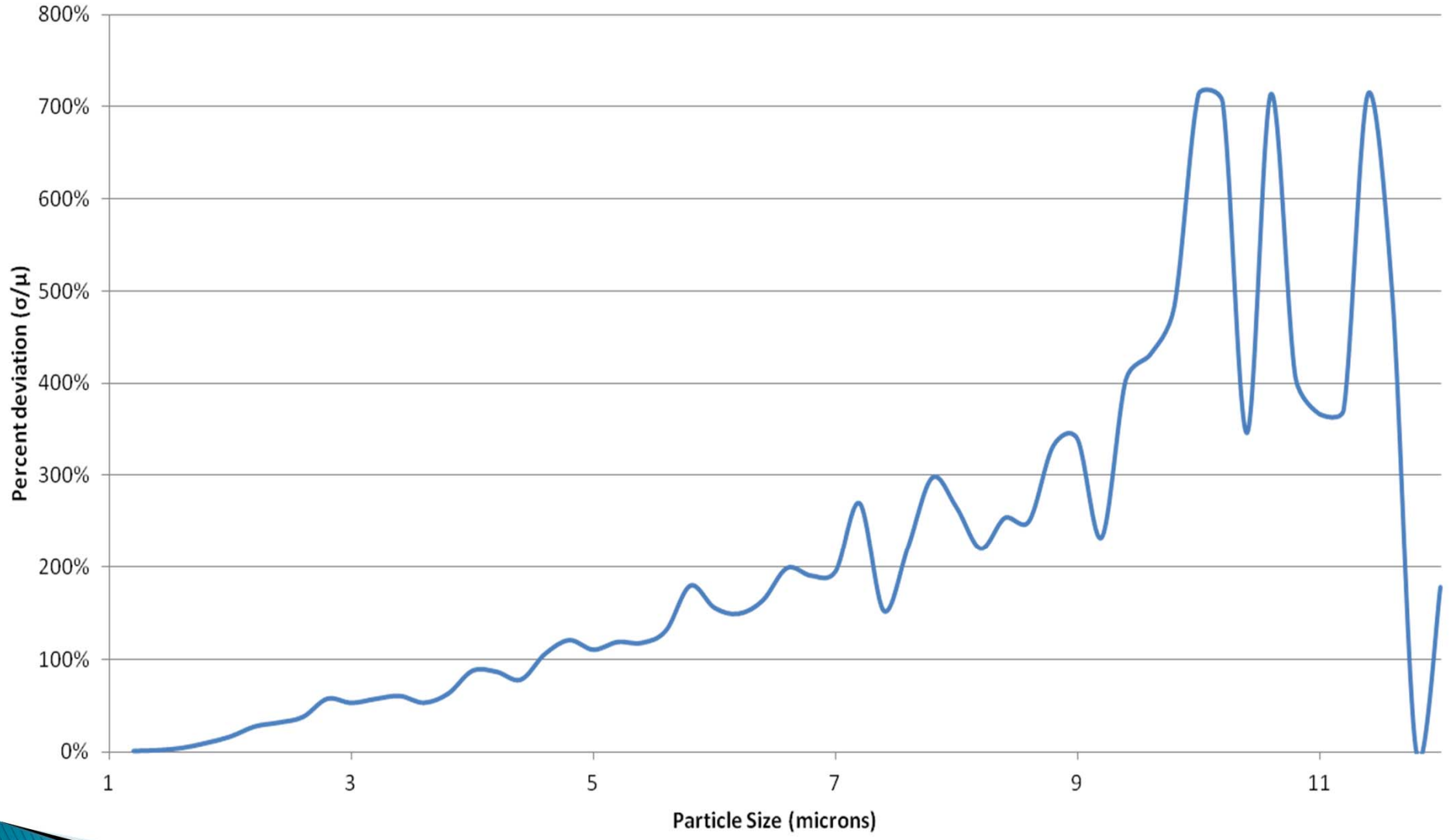
Percent Deviation vs. Particle Size



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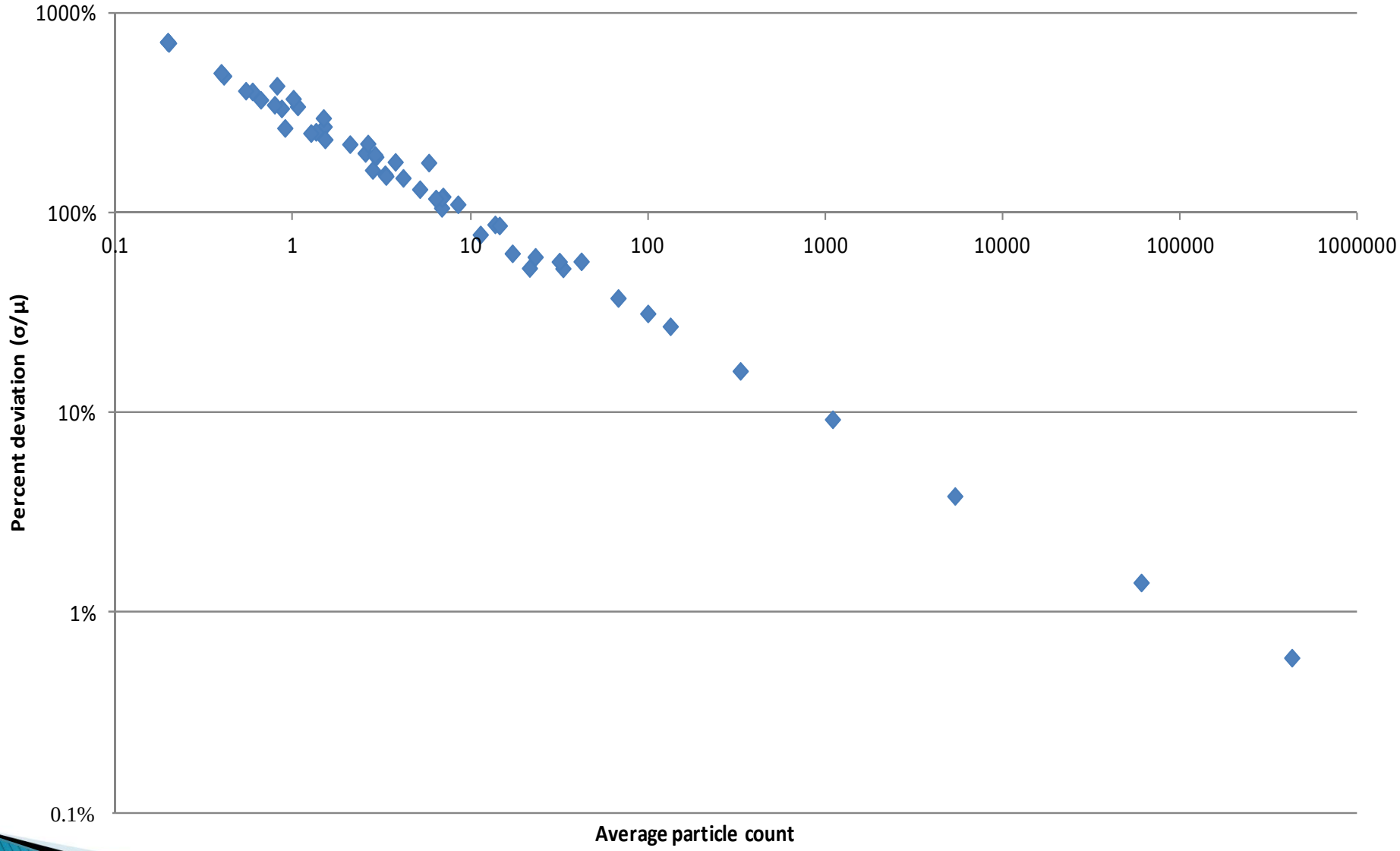
Percent Deviation vs. Particle Count



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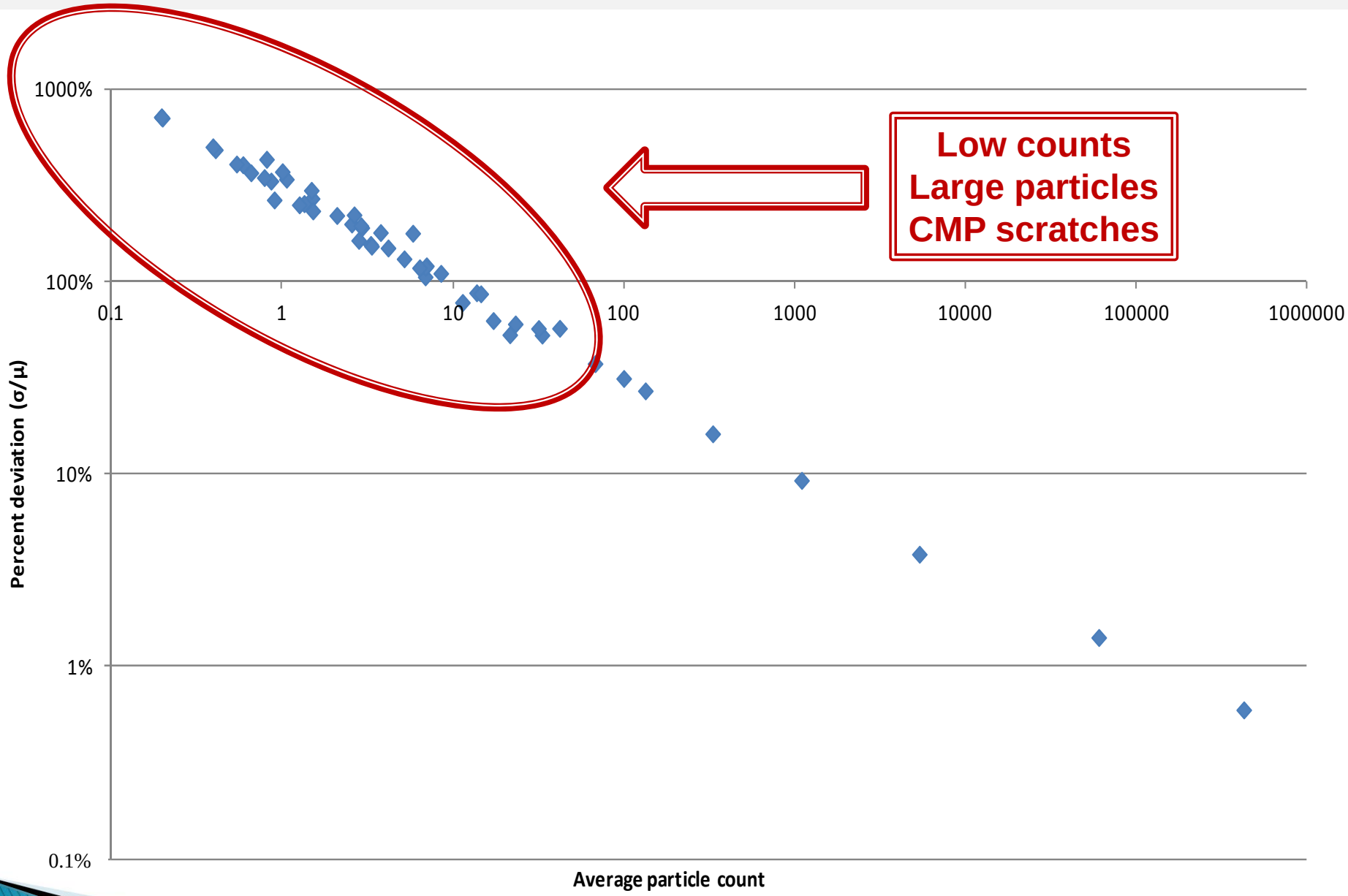
Percent Deviation vs. Particle Count



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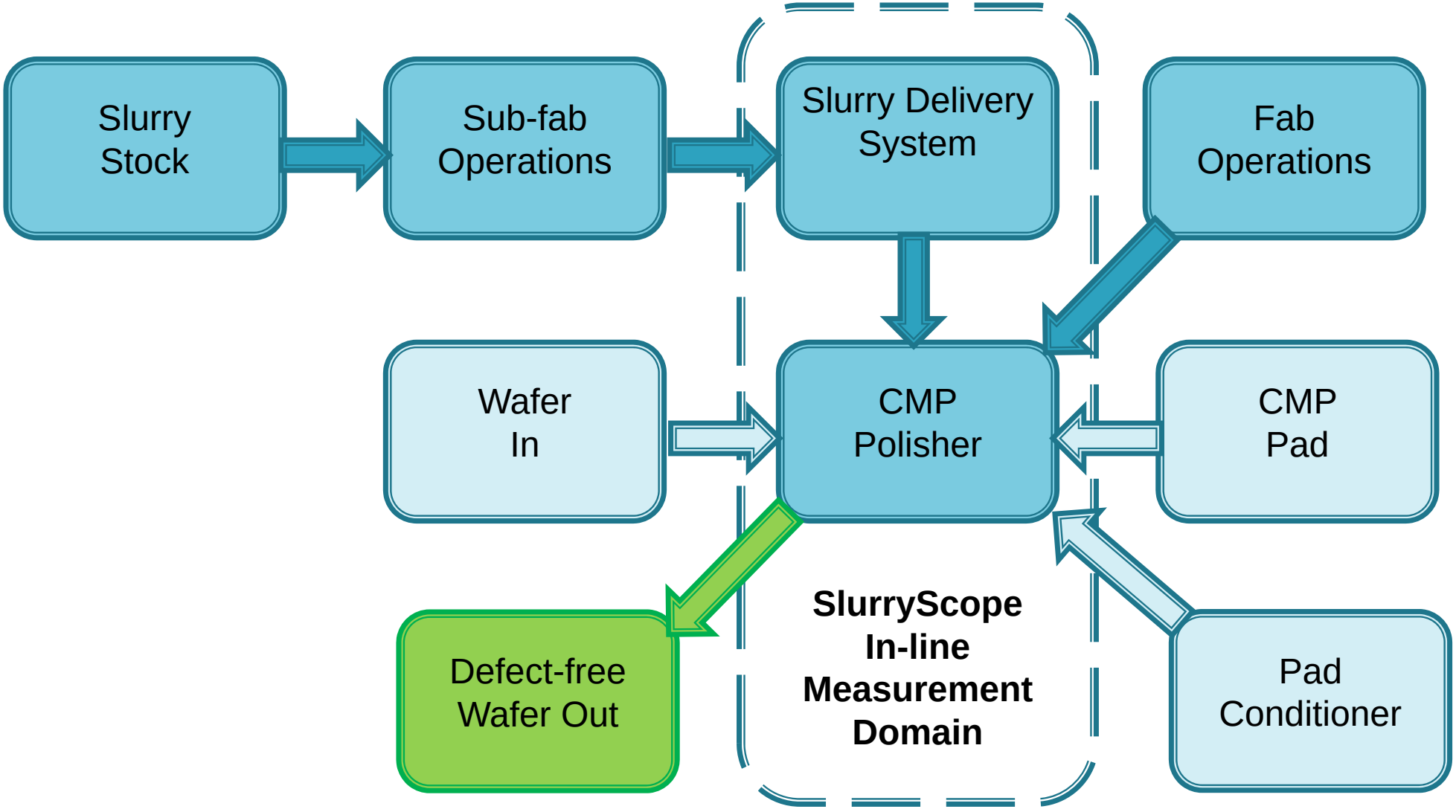
CMP Fab Environment



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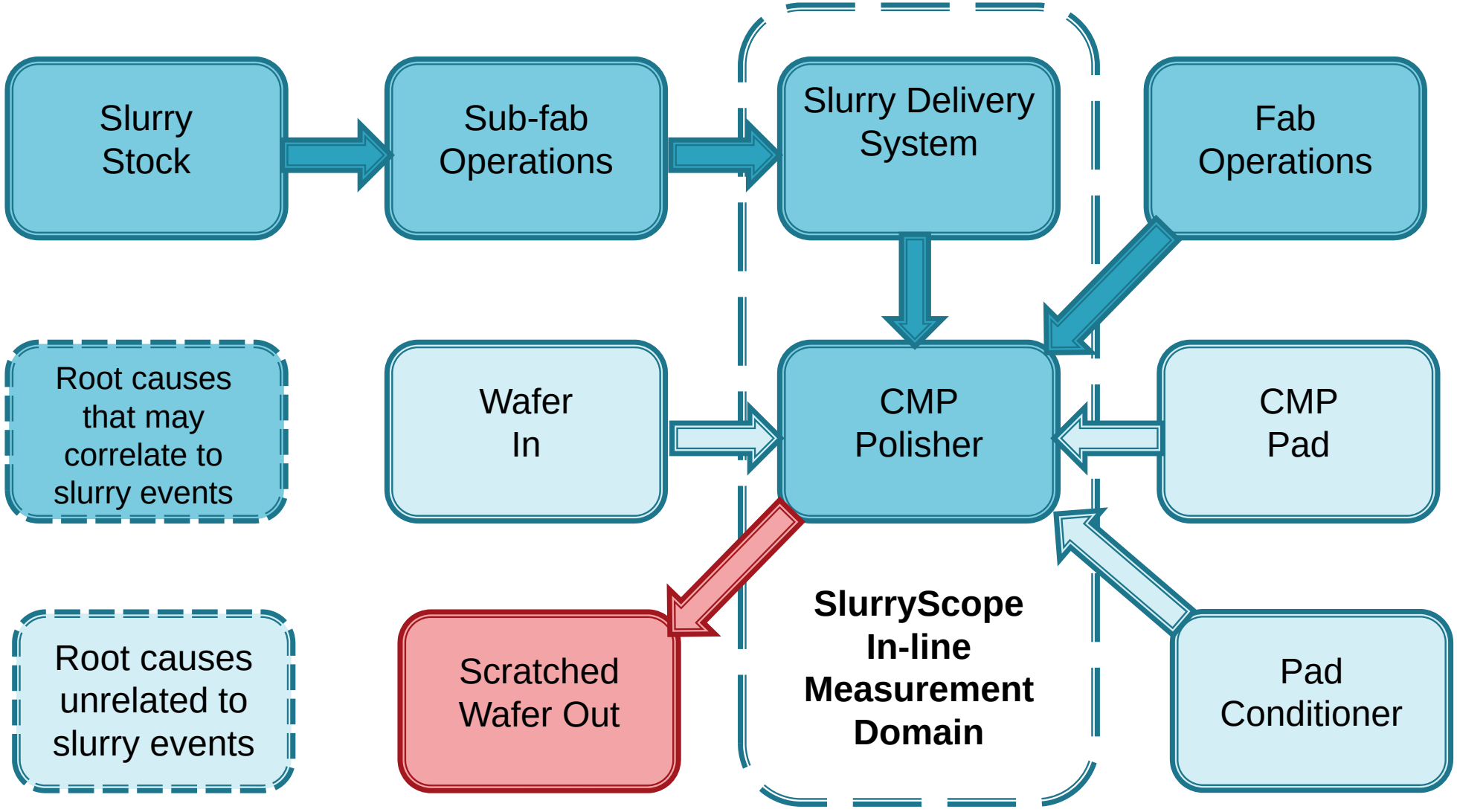
CMP Fab Environment

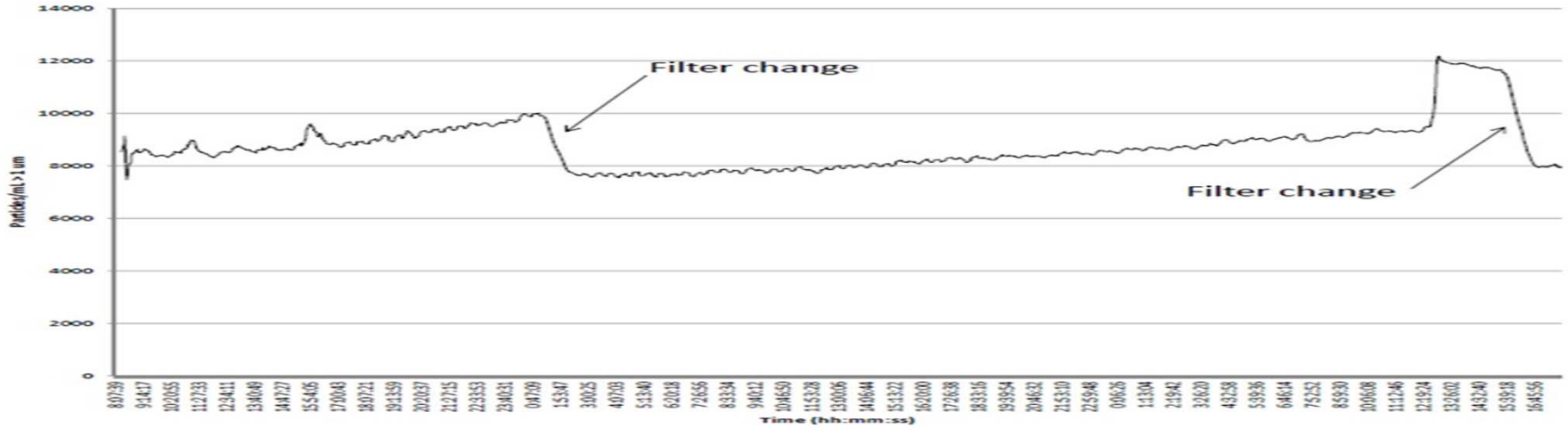


Implications for Fab Operations

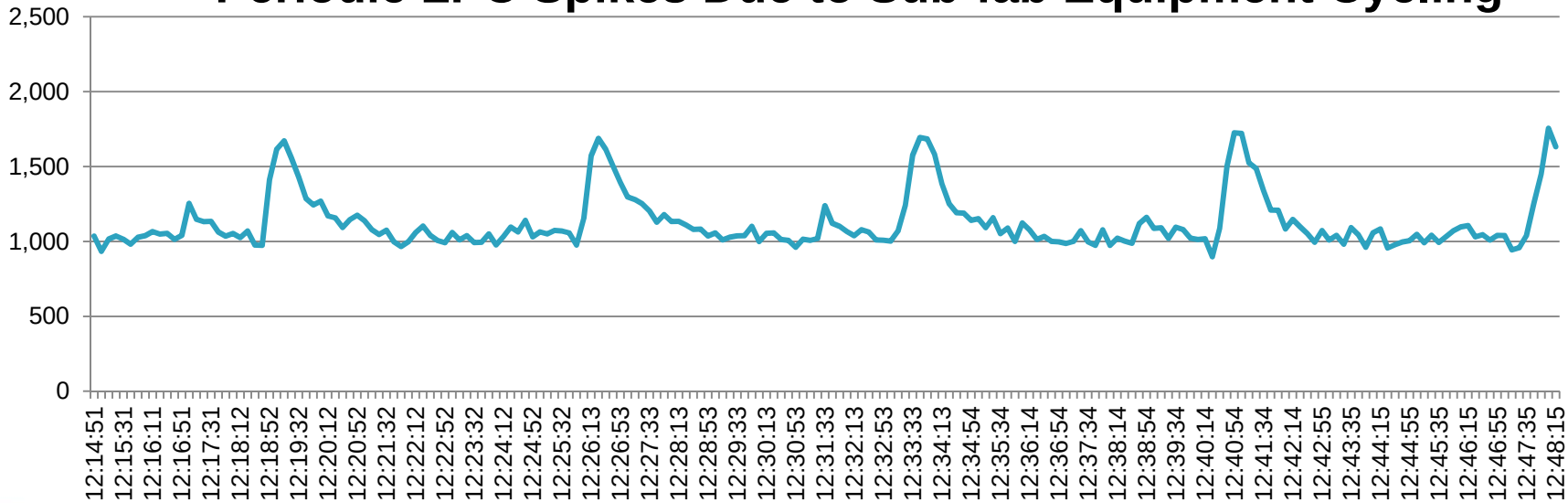
- Periodic online slurry monitoring can assist post-mortem diagnosis of wafer scratching
  - Cannot prevent wafer scratching from occurring
- Continuous online slurry monitoring can identify patterns and practices that contribute to LPC excursions
  - Identify and eliminate the root causes of LPC spikes
  - Reduce the incidence of slurry-induced wafer scratching
  - Apply six-sigma principles to prevent wafer scratching

Continuous LPC Monitoring

LPC Shifts Due to Filter Changes *



Periodic LPC Spikes Due to Sub-fab Equipment Cycling



*ASMC May, 2012; A. Kim, Mega Fluid Systems & M. Parkin, Vantage Technology Corp.

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Conclusions

- Small volume slurry sampling delivers the largest sampling error at low particle counts, typically the largest particles which are most critical for wafer scratching
- Continuous LPC monitoring with SlurryScope provides a more statistically meaningful representation of the largest particle counts
- Continuous monitoring of undiluted slurry provides ***new information*** allowing LPC origins to be traced and eliminated, bringing CMP closer to six-sigma process defect control

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Additional Information

- ASMC May, 2012; A. Kim, Mega Fluid Systems & M. Parkin, Vantage Technology Corp.
- Feb 22 2012 webcast: http://techcet.com/presentations/
- ICPT 2011
- Solid State Technology, July 2011
- http://www.vantagetechcorp.com/

- Upcoming:
  - Semicon West 2012: Malema booth, Levitronix booth
  - Semicon West 2012 CMPUG
  - Clarkson CAMP CMP August 2012
  - ICPT October 2012

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