(Excerpts from) Statistical descriptors and application to vibration criteria

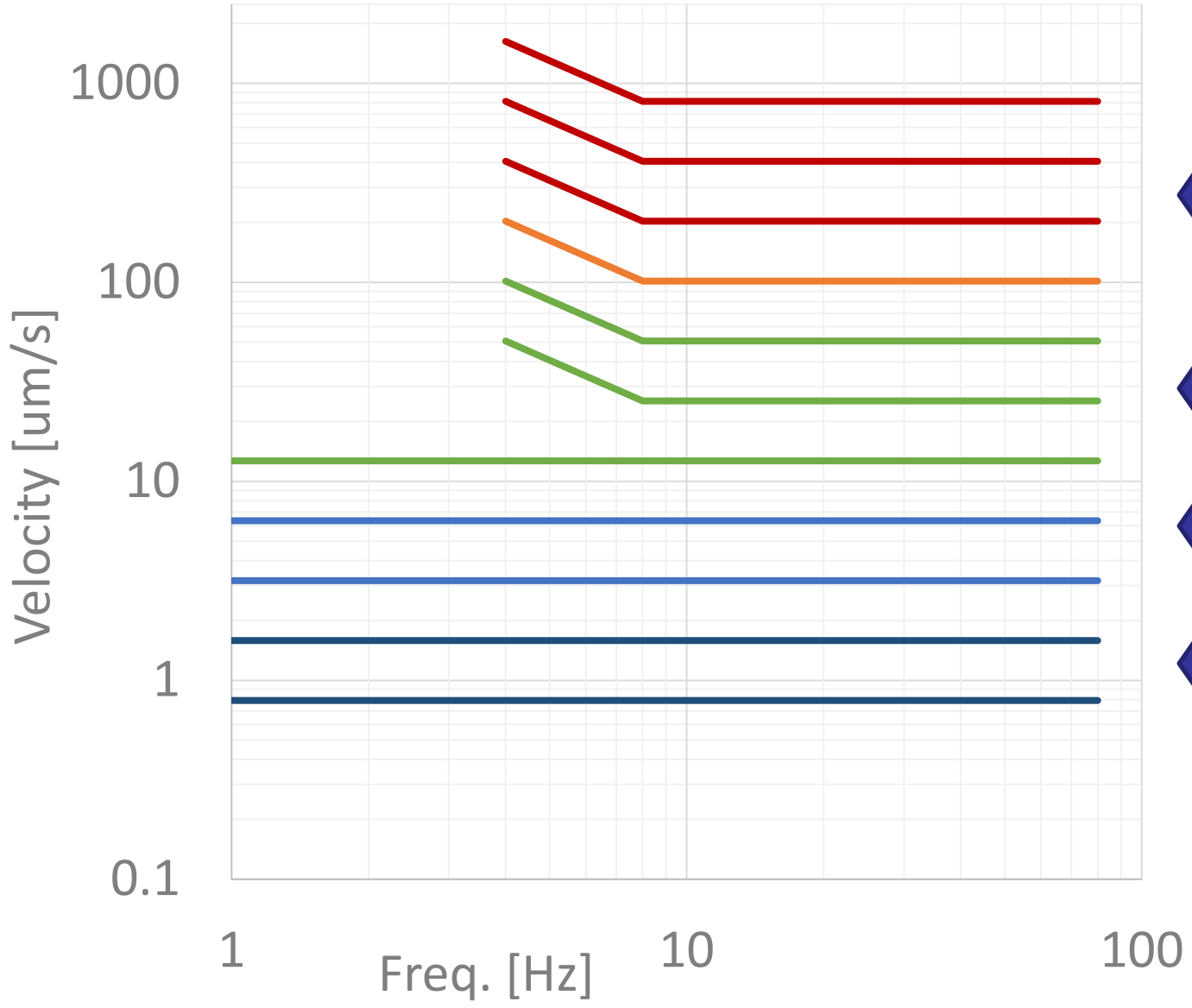
Presented at IEST / ESTECH17, Louisville

Byron Davis

Vibrasure

byron@vibrasure.com

Vibration Criteria (VC), and qualitative scales

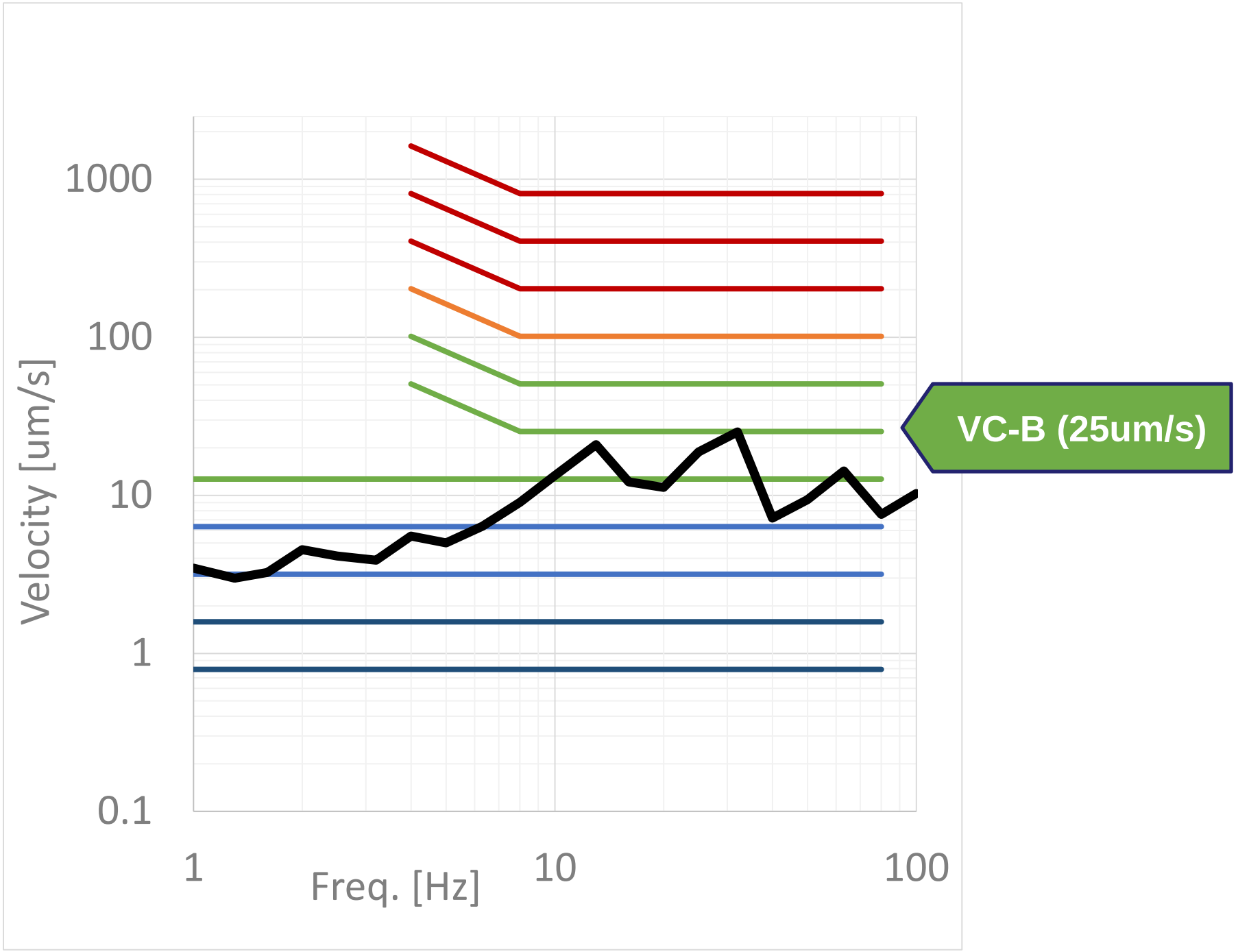


Human-scale (feelable)

Routine Labs (*e.g.*, optical)

Imaging, semiconductor

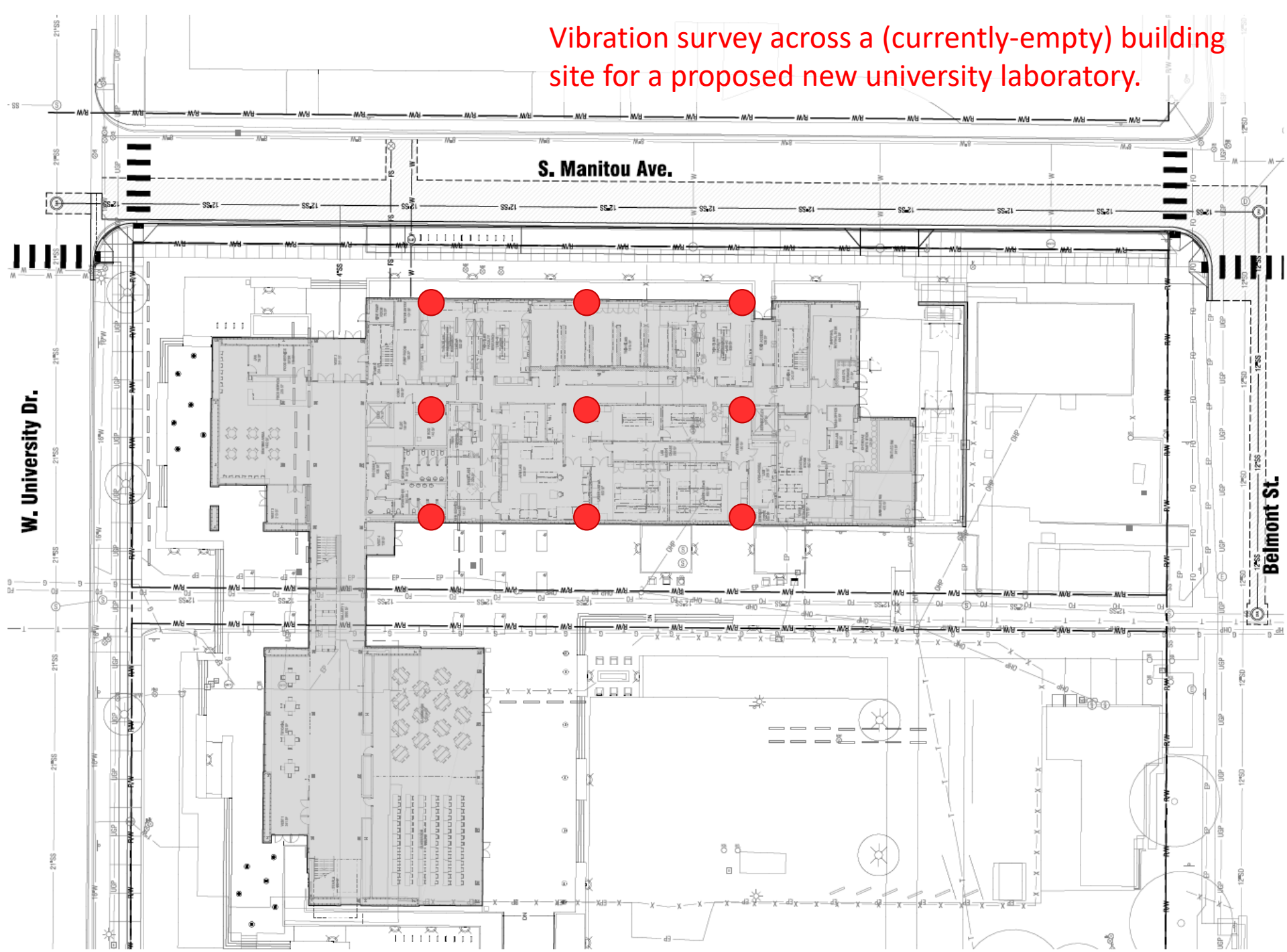
Nanotech, high-end imaging


1000
100
10
1
0.1
Velocity [um/s]
1
10
100
Freq. [Hz]
VC-B (25um/s)

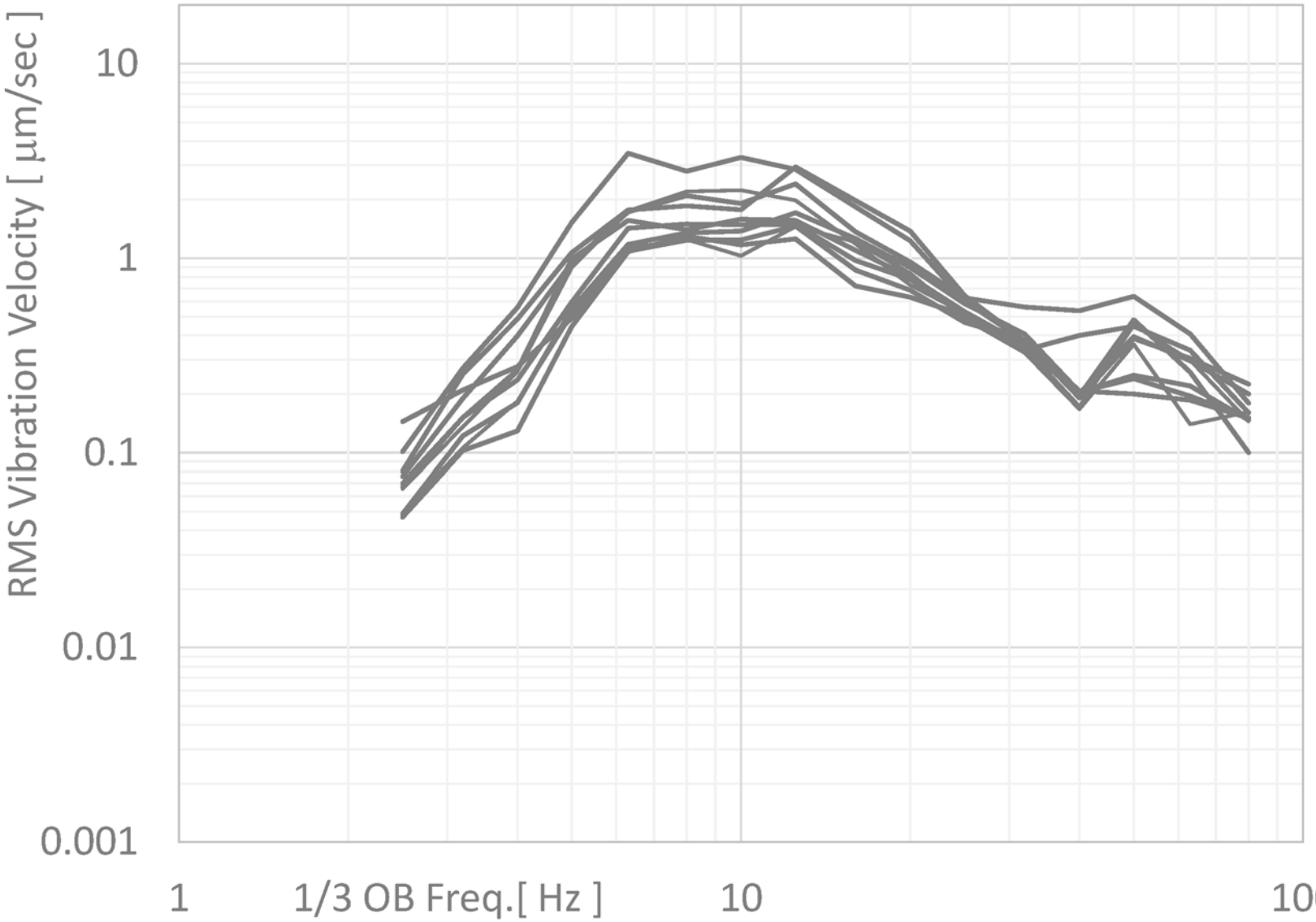
How do sites get qualified for low-vibration uses like laboratories?

Traditional Survey Data

- Select averaging technique / times
- Develop averages across the site
- Construct gross statistics based on these
- Evaluate based on an appropriate statistic


Vibration survey across a (currently-empty) building site for a proposed new university laboratory.
S. Manitou Ave.
W. University Dr.
Belmont St.

Here's your vibration data from those locations…



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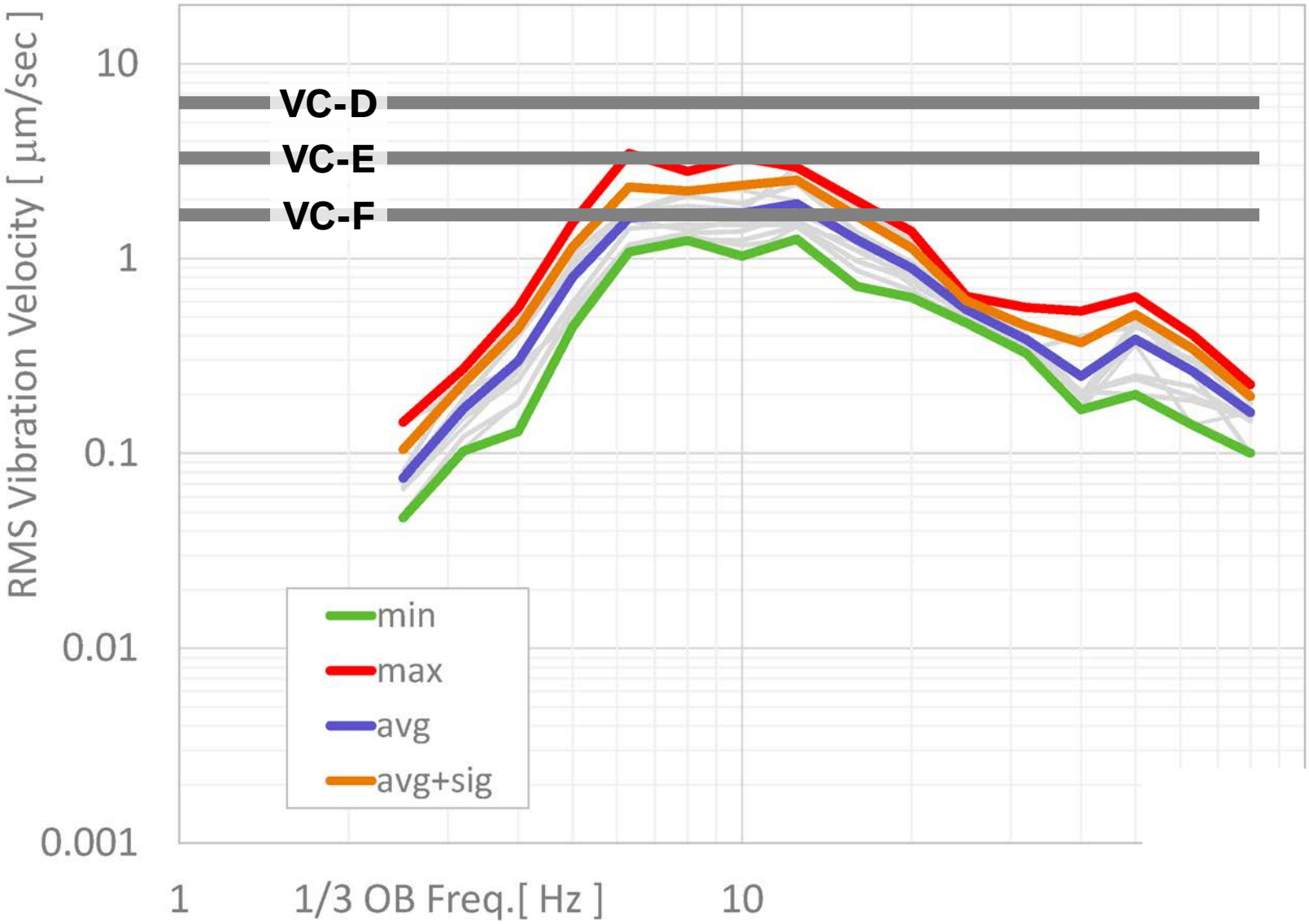
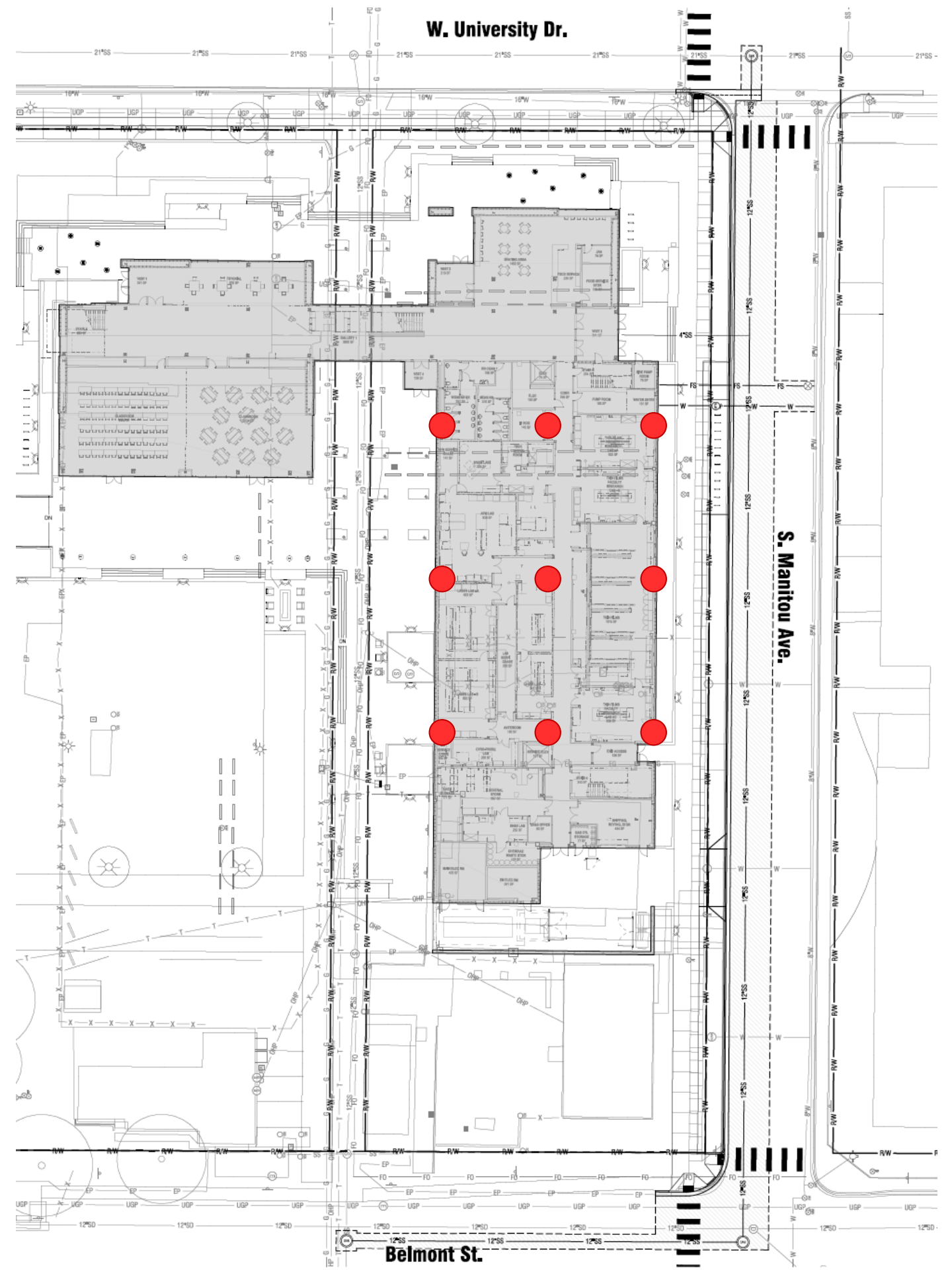
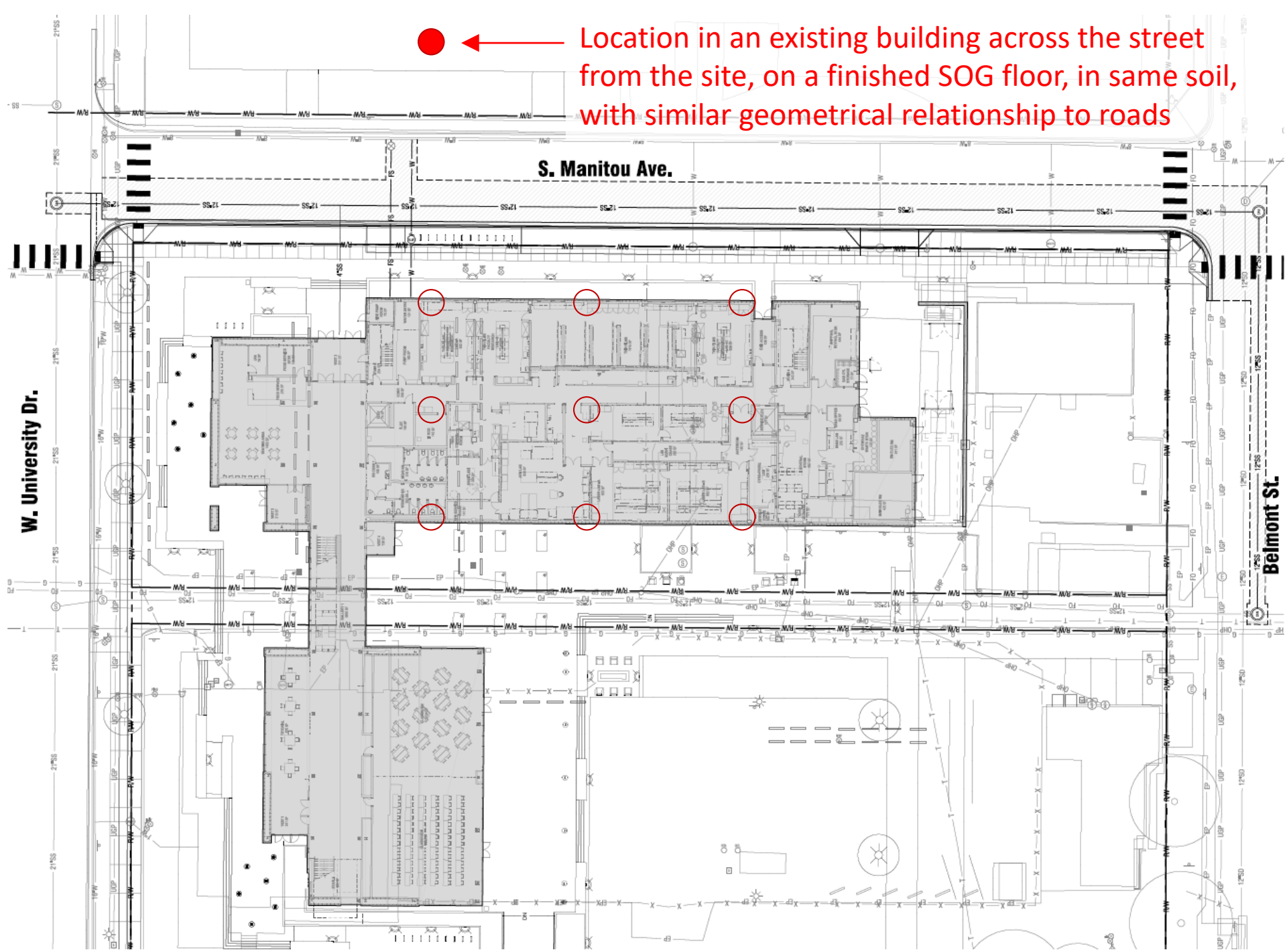
“spatial” statistics… or are they?




W. University Dr.
S. Manitou Ave.
Belmont St.


Location in an existing building across the street from the site, on a finished SOG floor, in same soil, with similar geometrical relationship to roads
S. Manitou Ave.
W. University Dr.
Belmont St.

Proposed alternative technique for developing useful ground/building micro-vibration data.

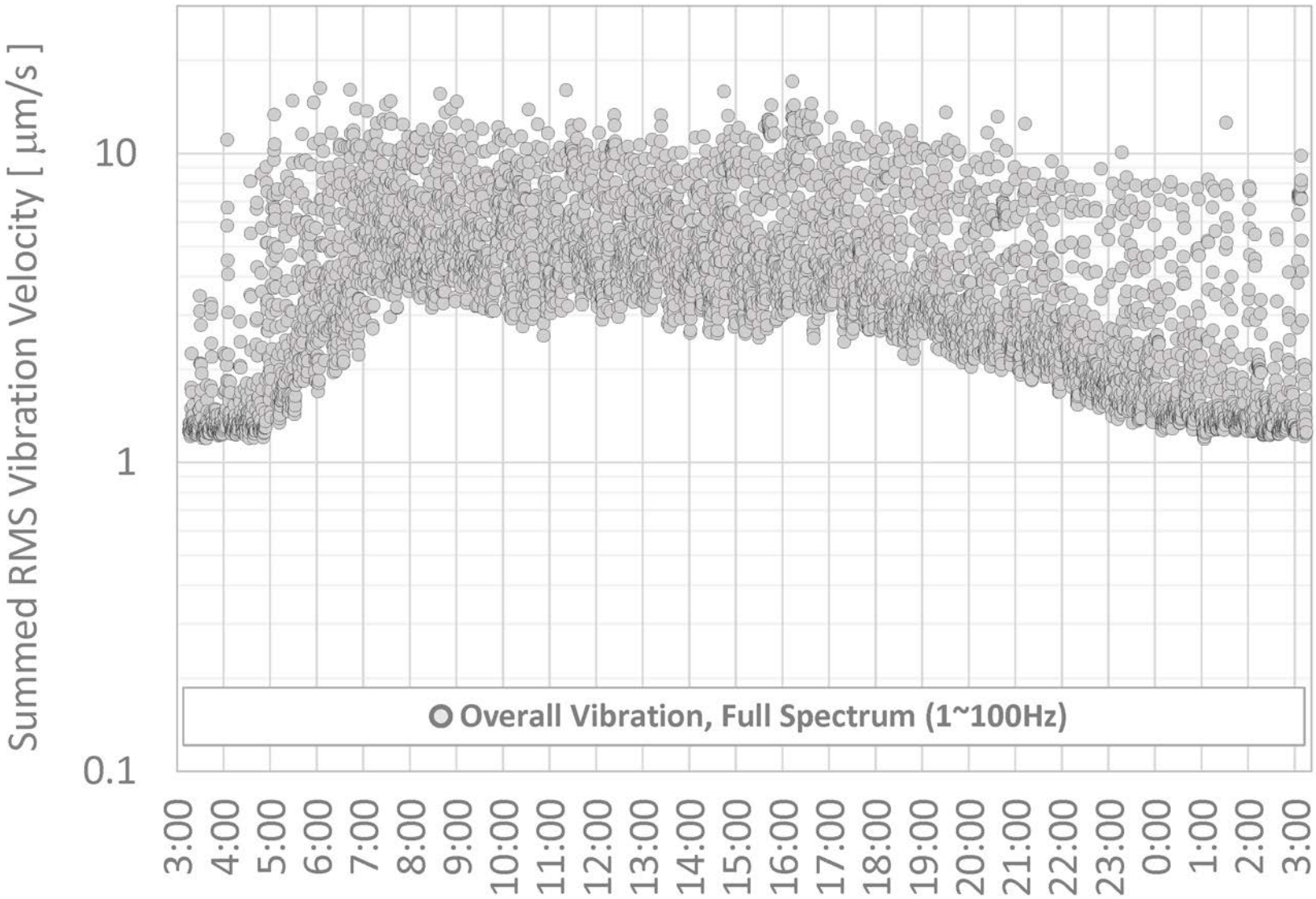
Acquiring Temporal Data

- Select appropriate timescales
- Develop data on those timescales
- Construct statistics based on these
- Evaluate based on an appropriate statistic

Example Dataset

- Select appropriate timescales
- Develop averages on that timescale
- Construct statistics based on these
  - What's the "maximum average"?
  - What's the "average average"?
  - What's the "average maximum"?
  - What are the ***percentiles***?
- Evaluate based on appropriate statistic(s)

15-second linear averages (overall)



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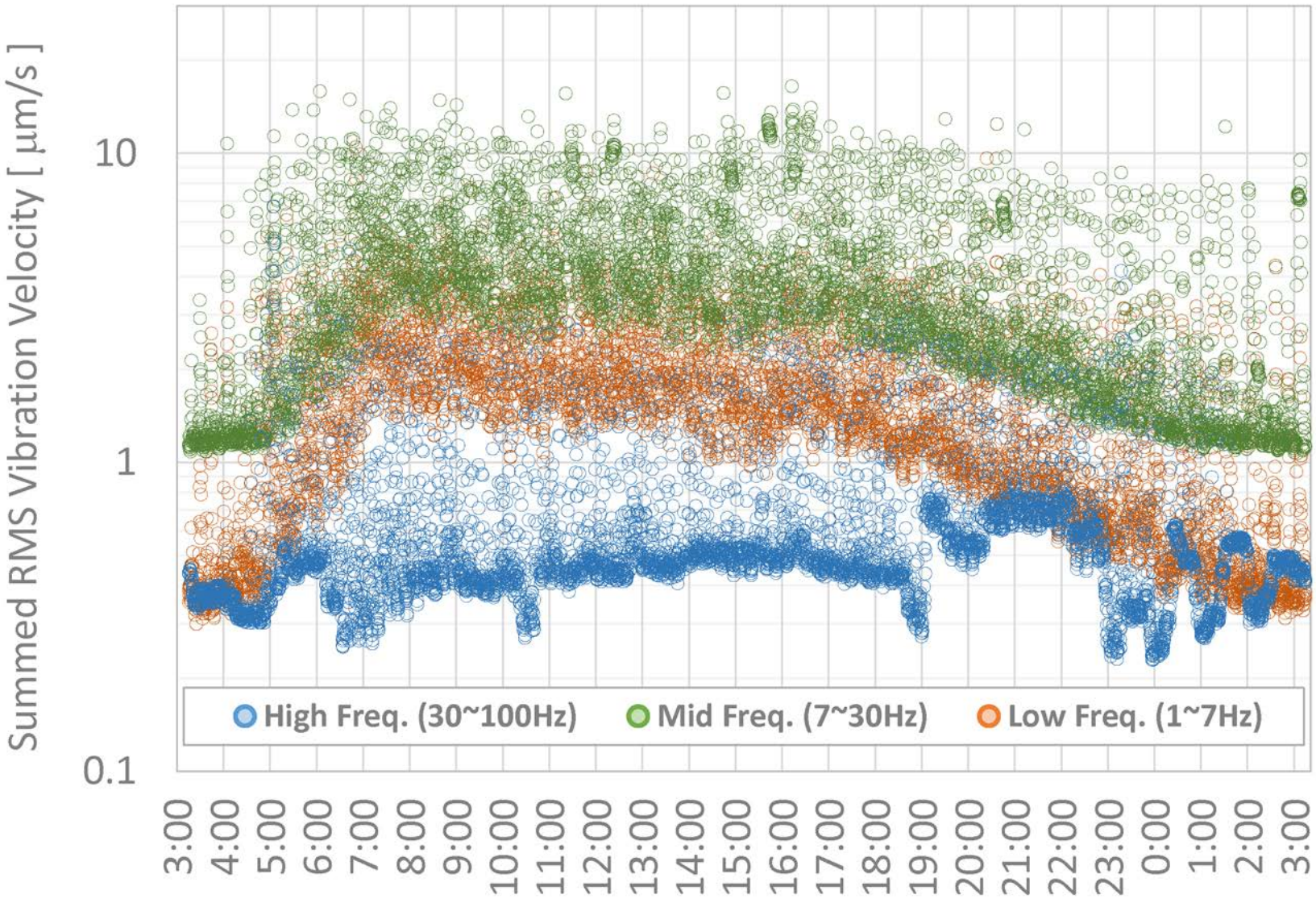
15-second linear averages (low / middle / high frequencies)



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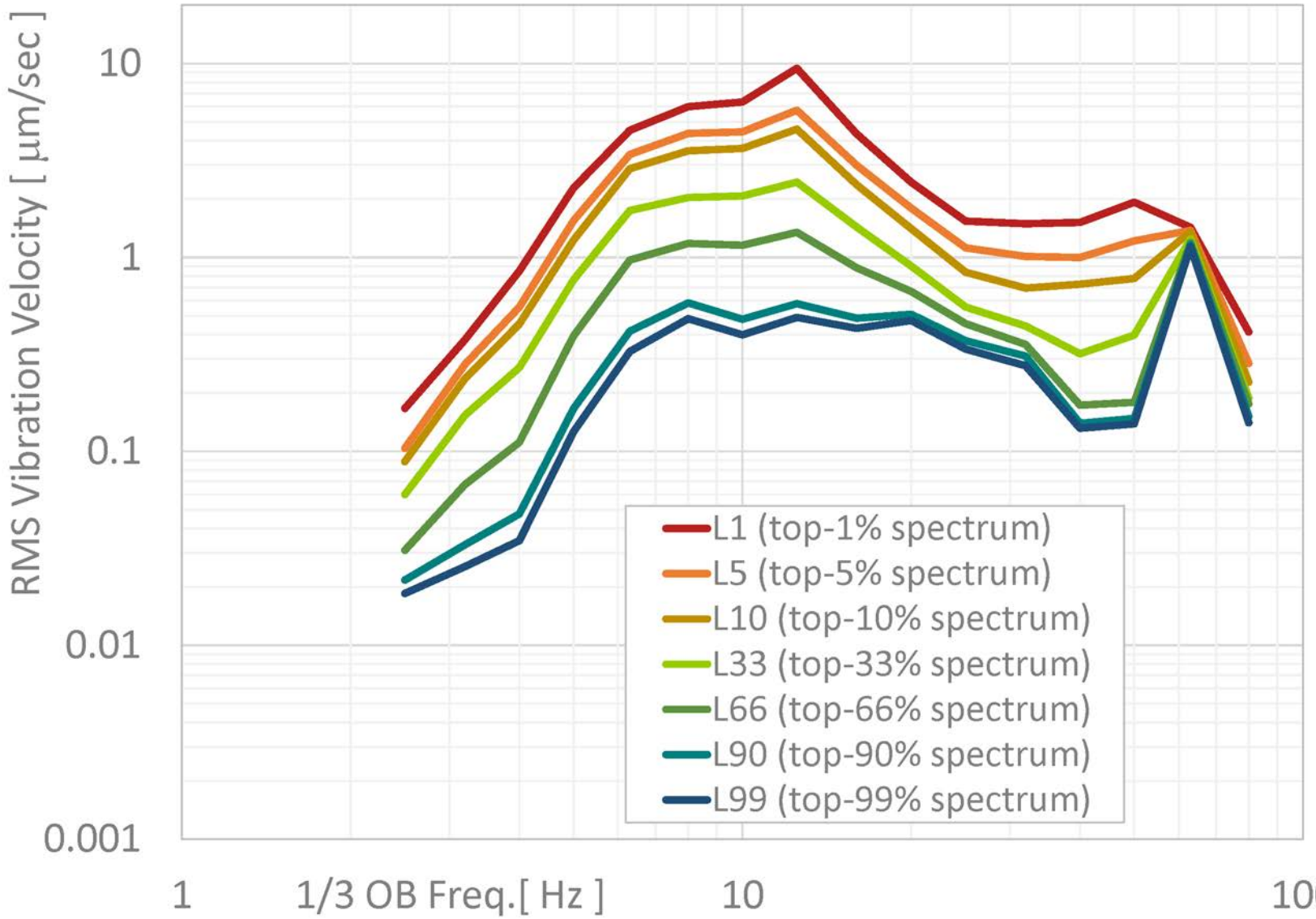
15-second linear averages: 24 hours (3AM—3AM) == 5,760 data points



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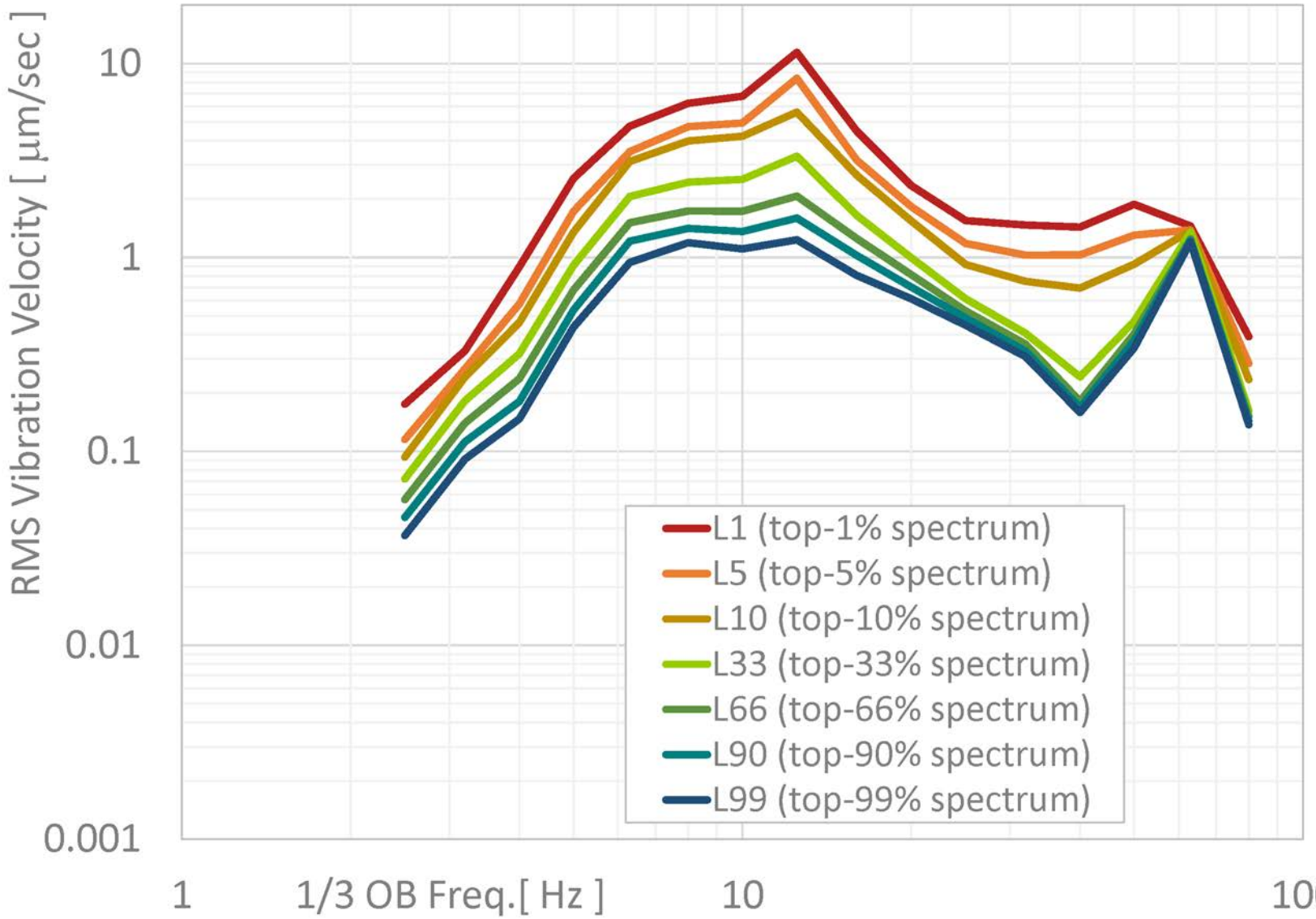
15-second linear averages: daytime (8AM—6PM) == 2,400 data points



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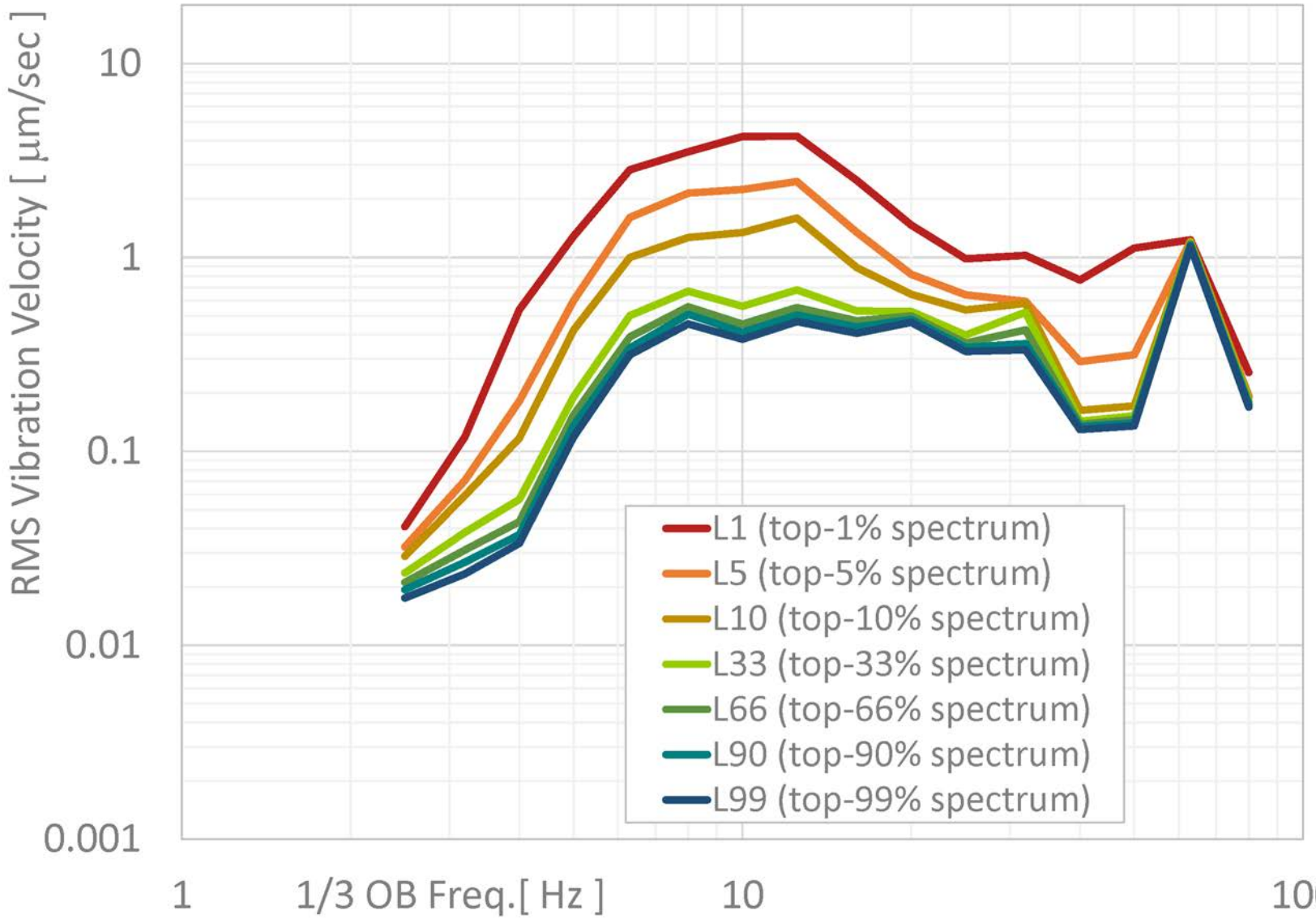
15-second linear averages: overnight (1AM—4AM) == 720 data points



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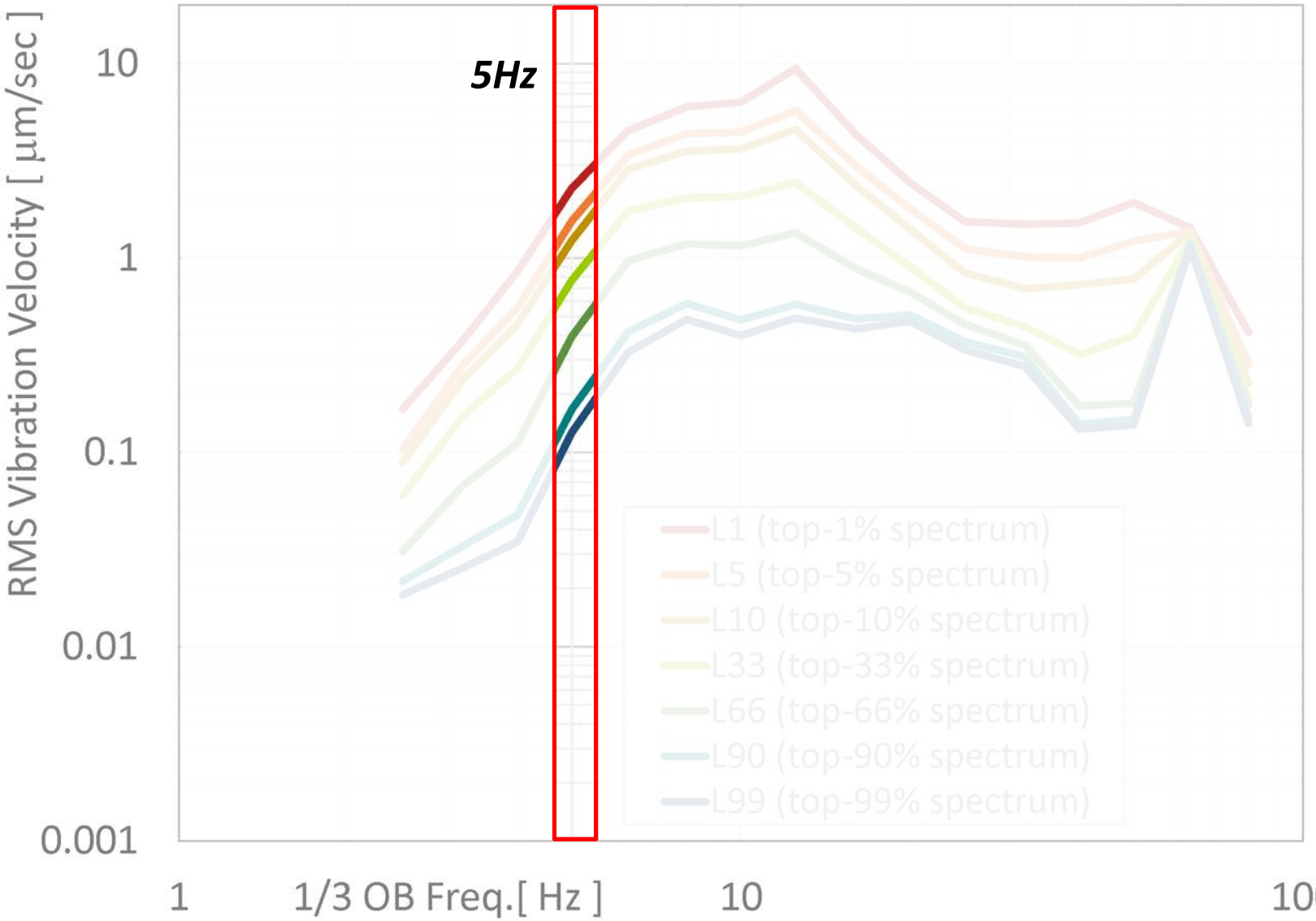
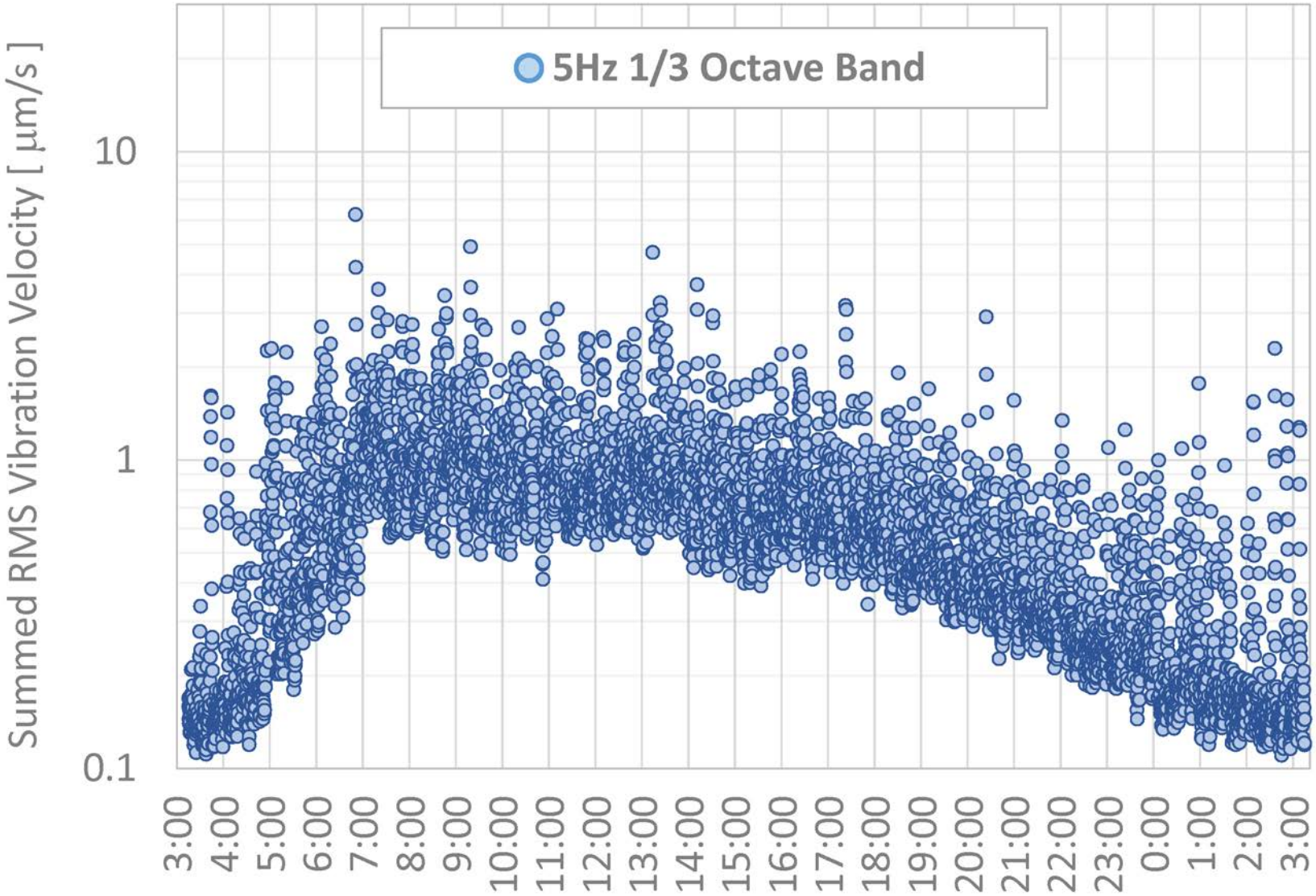
15-second linear averages: 24 hours (3AM—3AM) == 5,760 data points

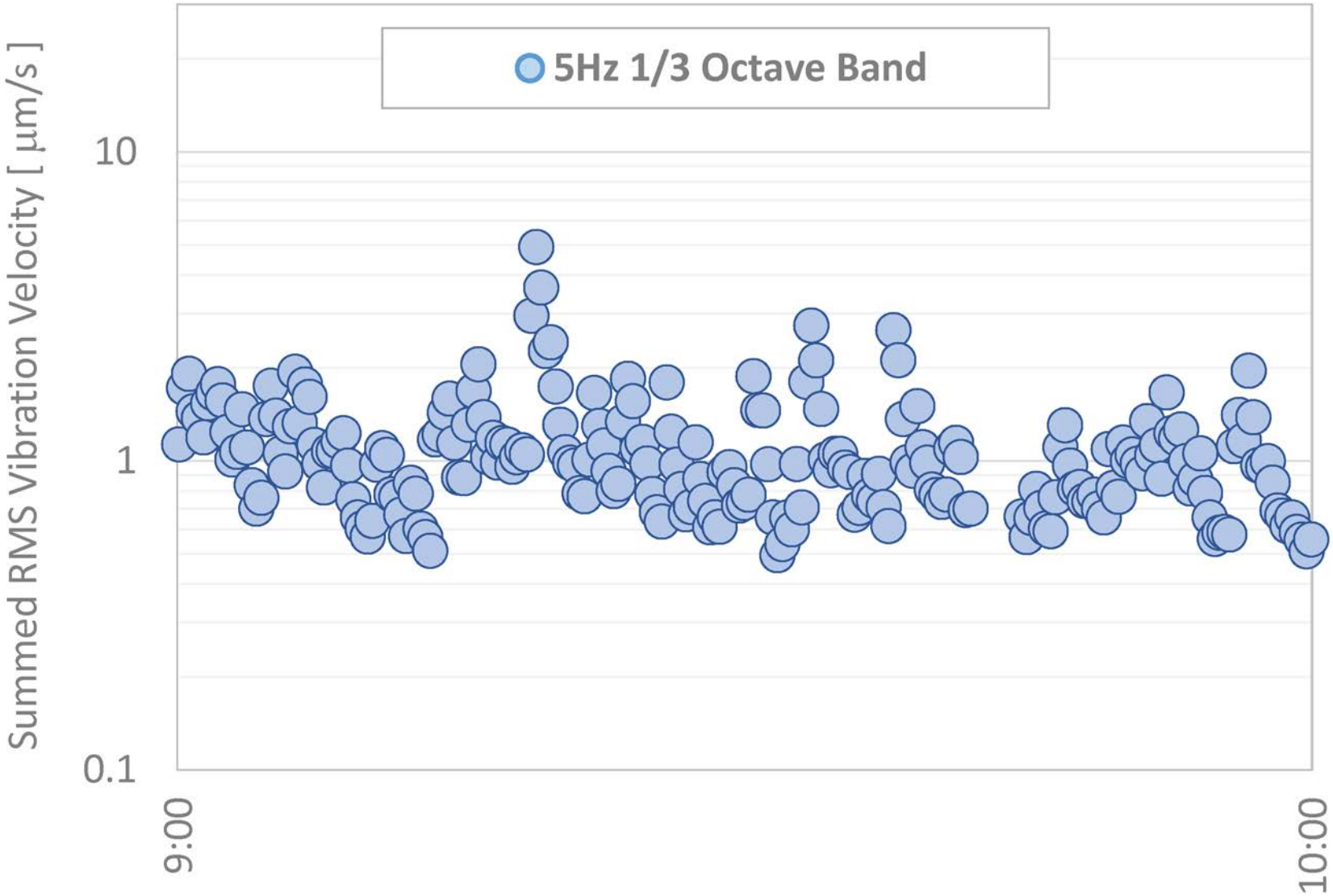


ESTECH 2017

15-second linear averages: 24 hours (3AM—3AM) == 5,760 data points



9AM—10AM: 240 data points; $L_{eq,15s,max}$ = 4.9μm/s & $L_{eq,15s,avg}$ = 1.1μm/s



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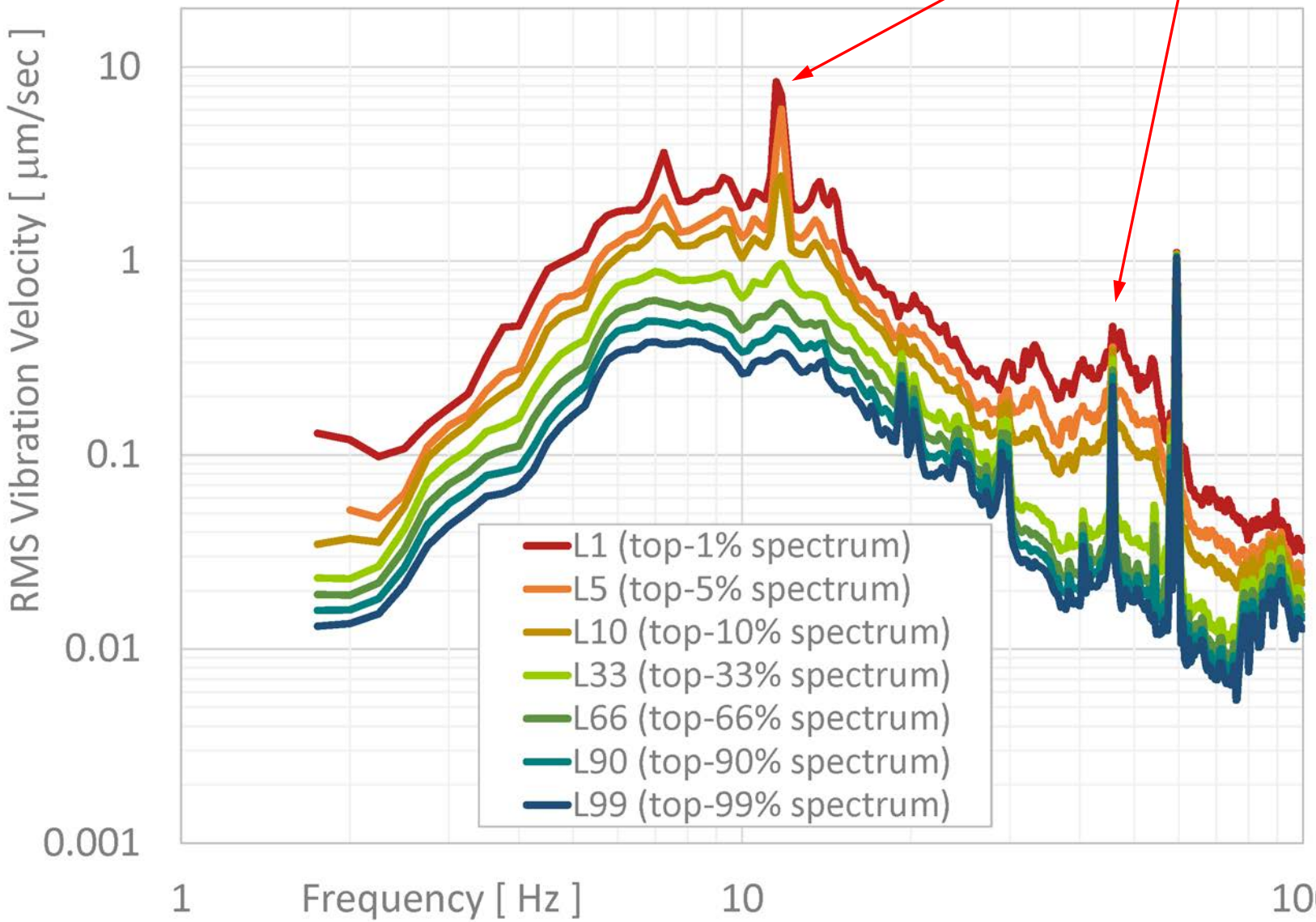
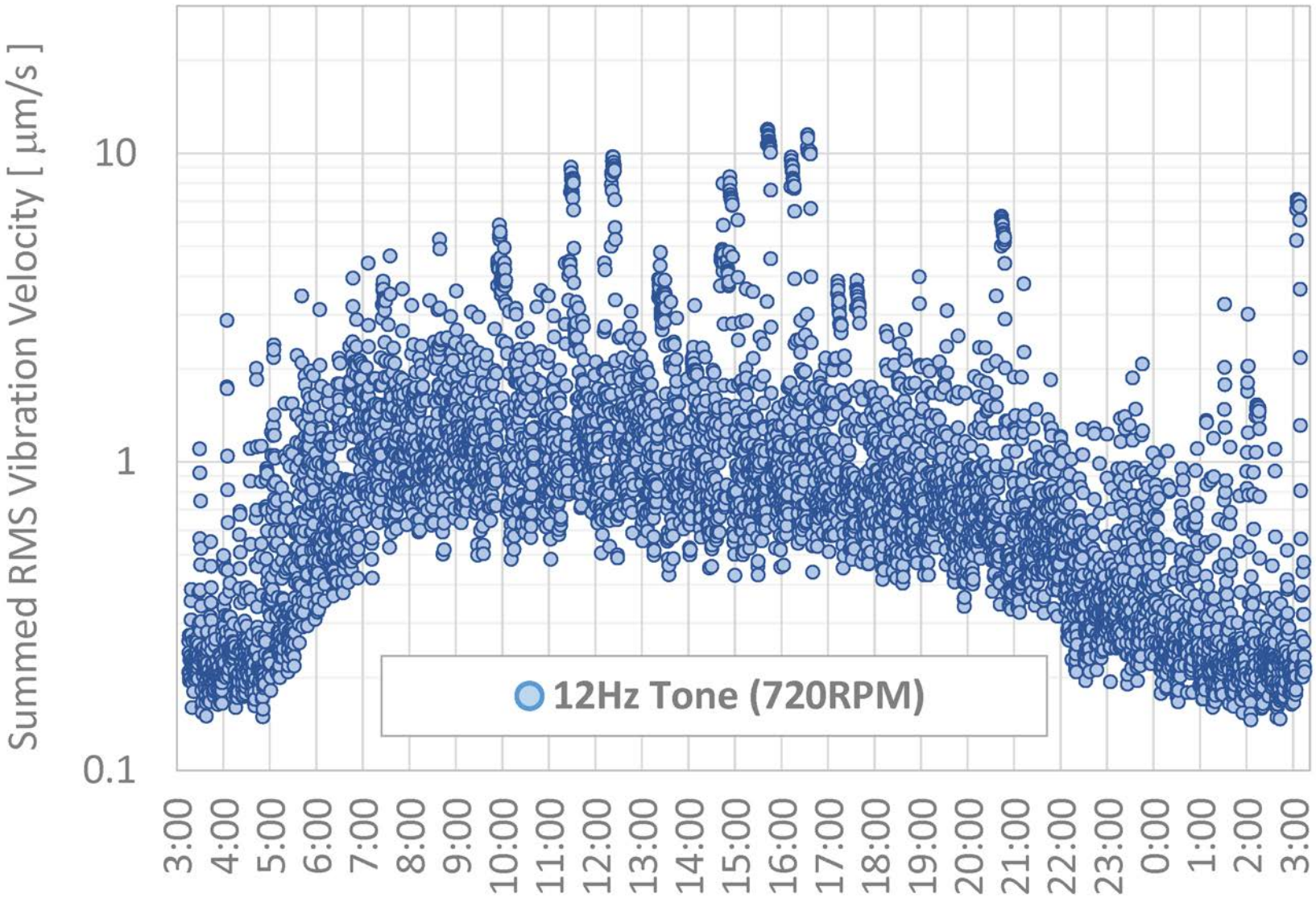
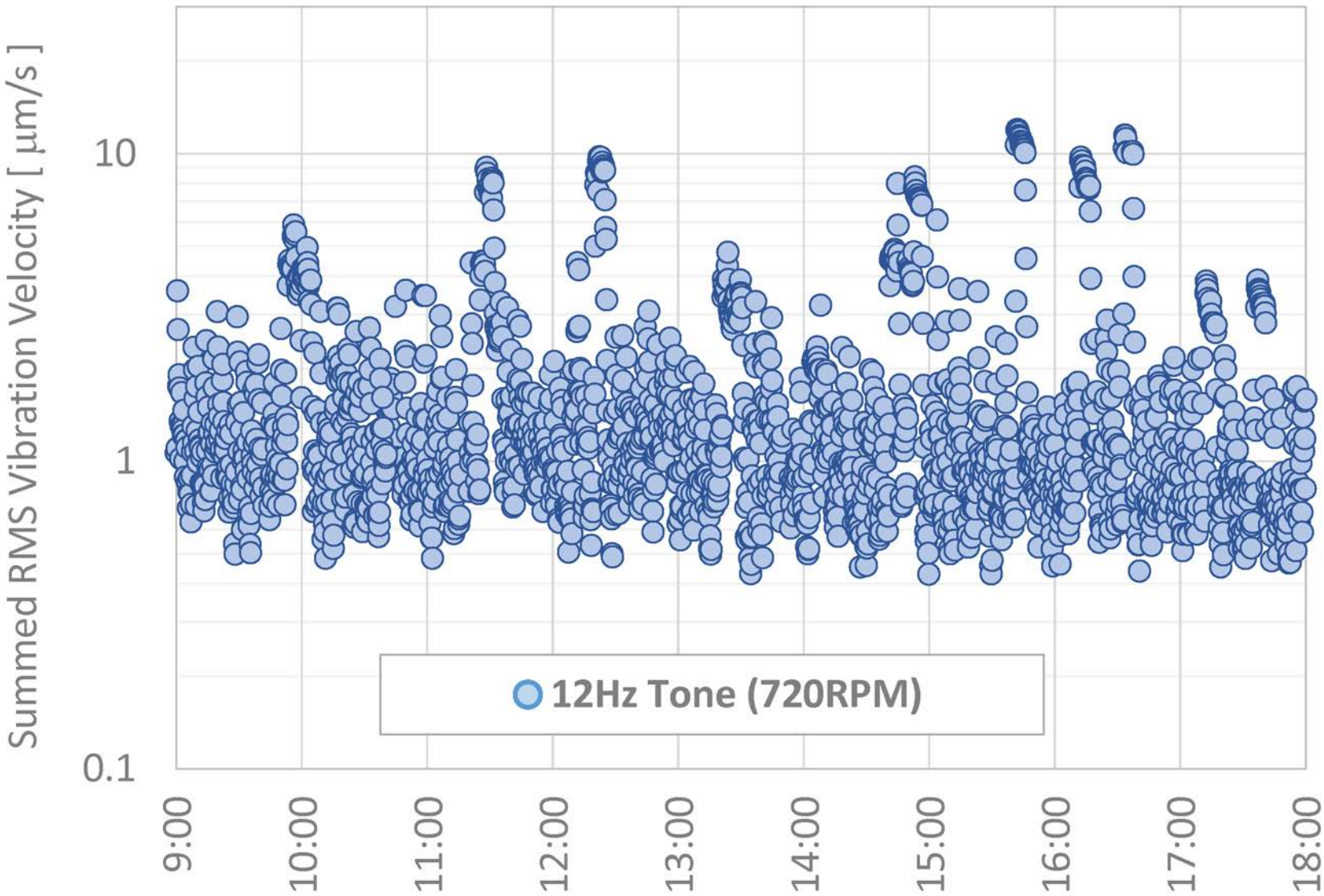
We can look at the spectrum in finer detail…
What's going on at 12Hz and at 45Hz?



A compressor, perhaps? It seems to run for a few minutes, once or twice per hour.




Summed RMS Vibration Velocity [µm/s]
10
1
0.1
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
12Hz Tone (720RPM)

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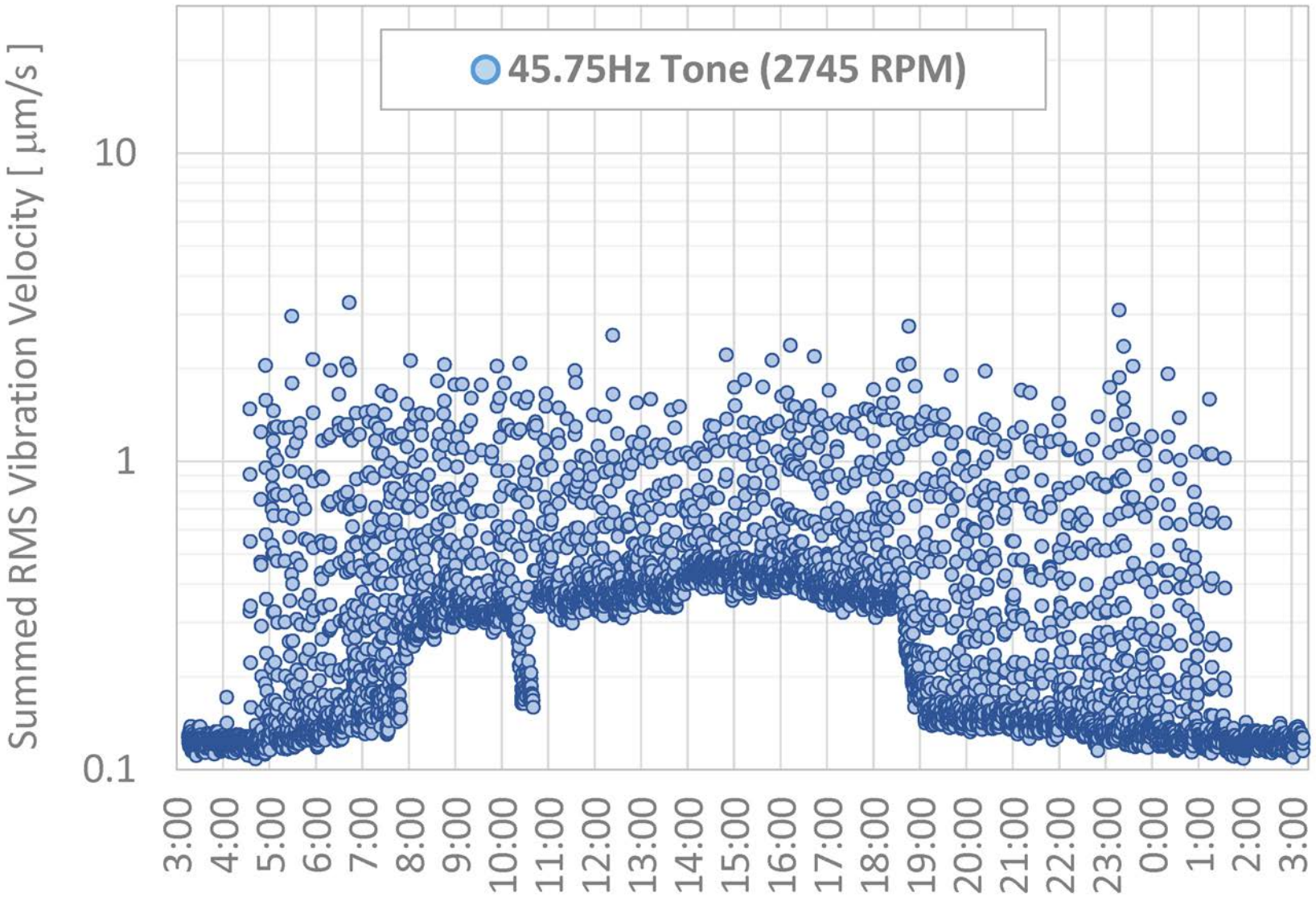
A fan or pump supporting a particular lab?
Whatever it is, it runs from 8AM-6:30PM



So, what else can we do with this technique?

A spectacular example

- Transmission electron microscopy suite
- Otherwise quiet military site, **except cargo**
- Heavy cargo planes visit, ~ 1 per month
- Planes roll past building site, ~ 6 sec each

If a plane causes a vibration problem, can't you just re-start your scan?

If we take enough data, we can talk meaningfully about outlier events, when relevant.

A spectacular example

- Math says interfering events might occur only once every year or two…
- …but the client says that samples cost $1.5MM to generate and that *they are consumed during the scan*

Sometimes, even rare events are relevant