Collins Consulting

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THIC Inc.

Measuring *Small*

The technique of measuring very small Lateral Tape Motion (LTM)

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Why measure LTM?

- As cartridge capacities grow to 1 – 10 TB range, track spacing will drop to 1 micron.

- For reliable data, the servo should follow the track movement close enough to yield a position error signal (PES) of no more than 1/10th the track spacing.

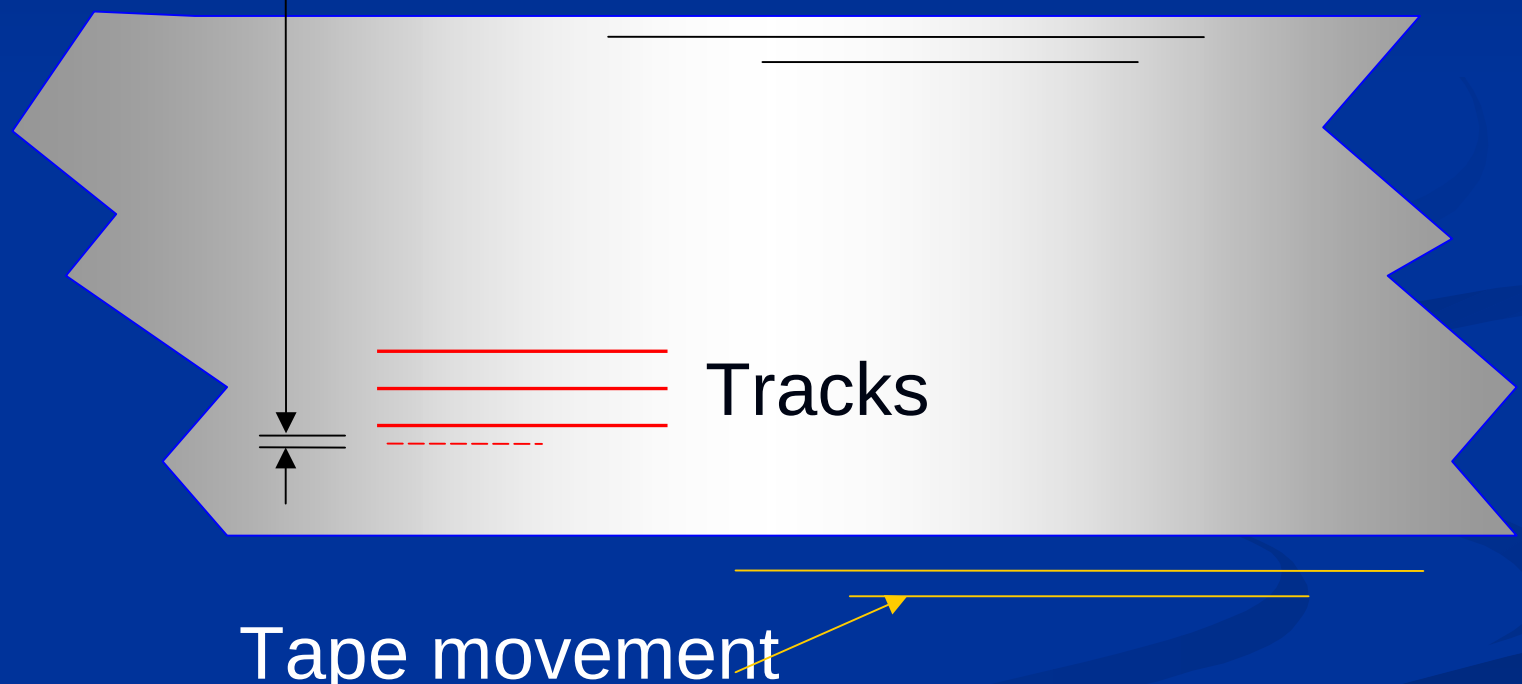
Why measure LTM?

- Today with 20 micron tracks, that means a PES of 2 microns.
- Tomorrow with 1 micron tracks, it means a PES of .1 micron.

How can we insure a PES of .1 micron?

- By limiting the lateral excursions of the tape.
- Today we have LTM of about 20 microns on most tape decks – about the same as a track width
- Tomorrow we must have an LTM of less than 1 micron if we are to reliably write 1 micron tracks.
- Why? The less LTM, the less the servo has to work, and the more reliably it writes the track.

The challenge: Measure track and tape movements as small as .1 micron.



How do we do this?

- There are plenty of ways to measure .1 micron. But they all use expensive lab instruments. Big, Cumbersome.

- To be useful to tape developers, it has to be *fast, reliable, cheap, and portable*.

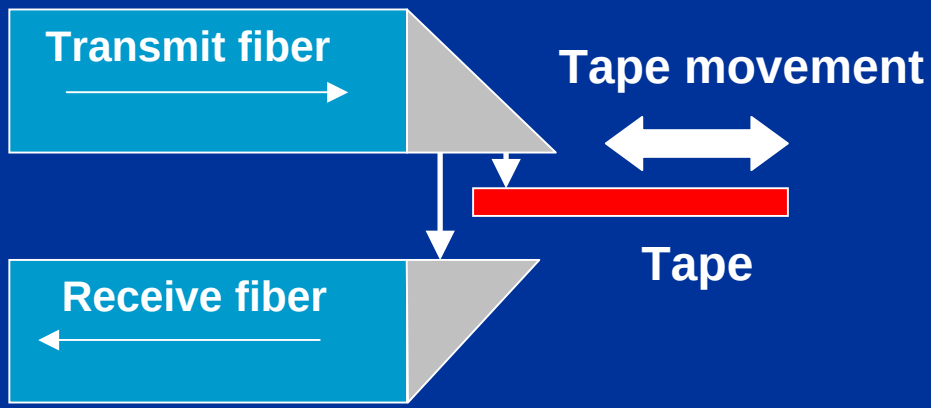
- What fits this requirement?

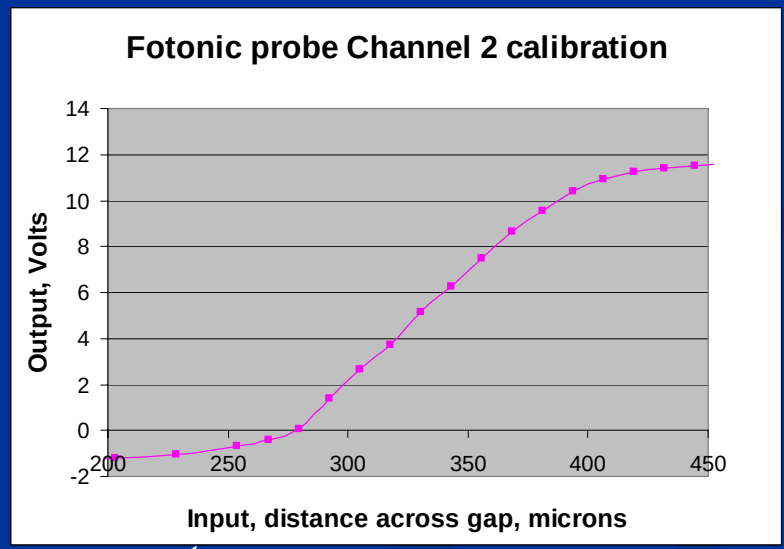
Four methods are candidates

- Fotonic probe edge measurement
- Measuring a pre-written servo track
- Writing and measuring adjacent high freq/low freq tracks
- Measuring tape surface movement with a laser

Method 1. Fotonic Edge Probe

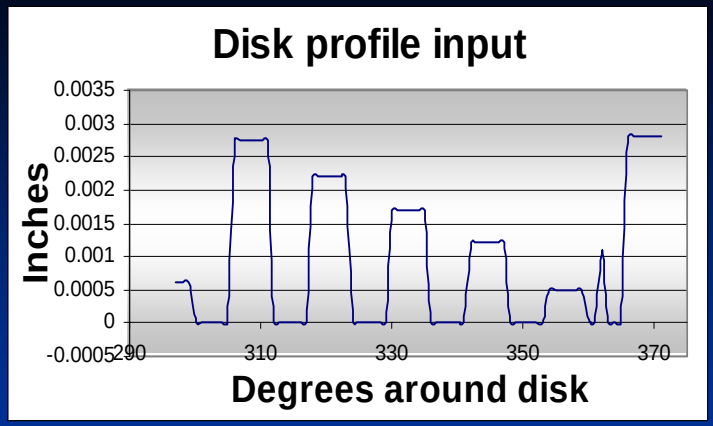
- The amount of light received is proportional to the edge position.

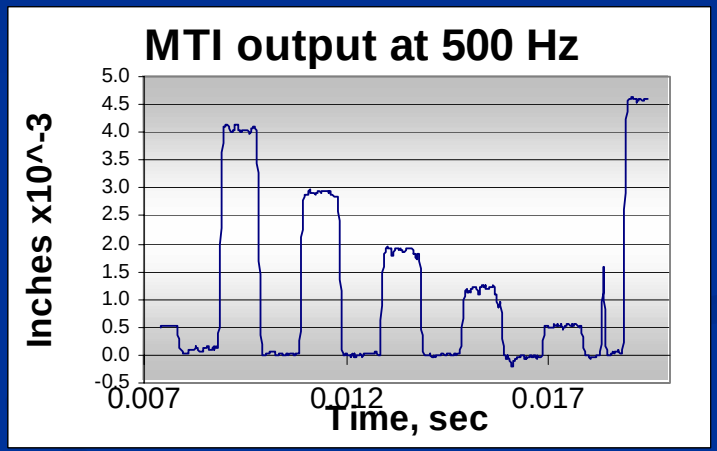


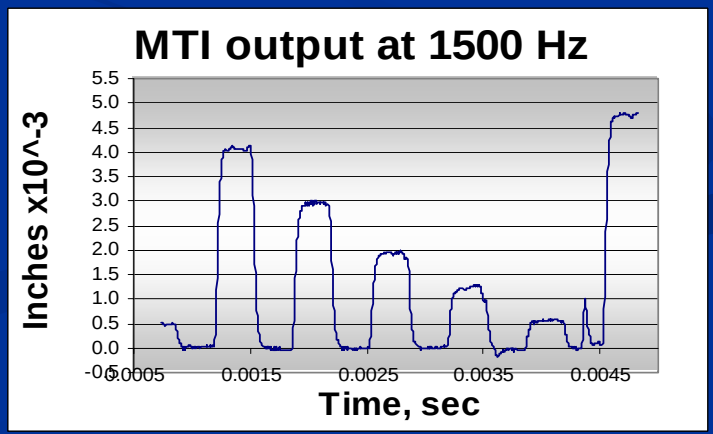


Sensitivity = 10 microns/volt – what's needed for submicron work

- The probe has the sensitivity needed. What about resolution and bandwidth, especially above 800 Hz, which most servos can't follow?
- Resolution characteristics of the Fotonic Probe
- Conclusion: the Probe is adequate up to 1500 Hz







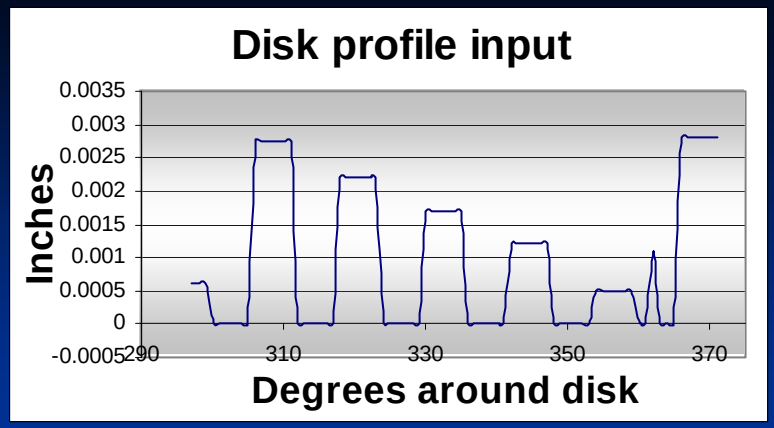
An Alternative to the Fotonic Probe

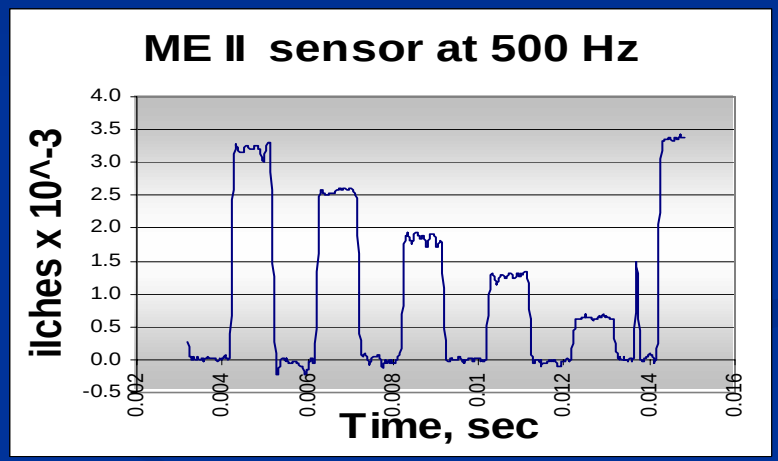
- The Fotonic Probe is expensive. Most labs have only one.
- What if you need several probes to make multiple measurements along the tape path at the same time?
- A cheaper alternative is needed.

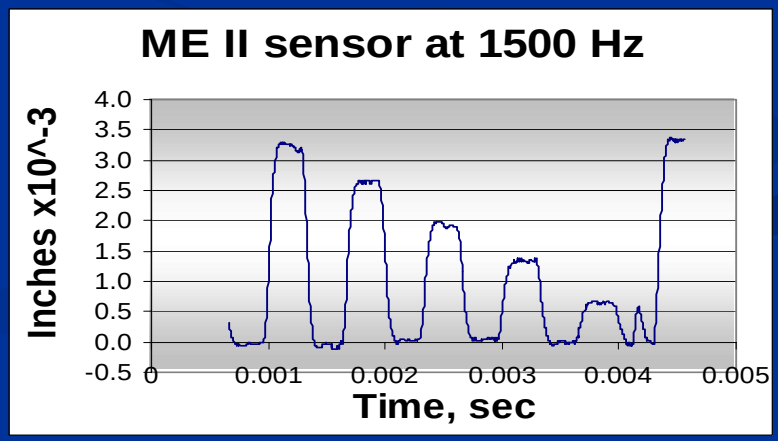
Alternative to the Fotonic Probe

- Try using a common photo switch with noise reducing circuitry.
- Successfully used by Carnegie Mellon University and other tape drive labs.
- Refined by Mountain Engineering II until it matches the Fotonic Probe's performance.

- A photo switch with appropriate circuitry matches the Fotonic Probe for a fraction of the cost.
- Multiple units can be placed along the tape path to get a complete picture of LTM.

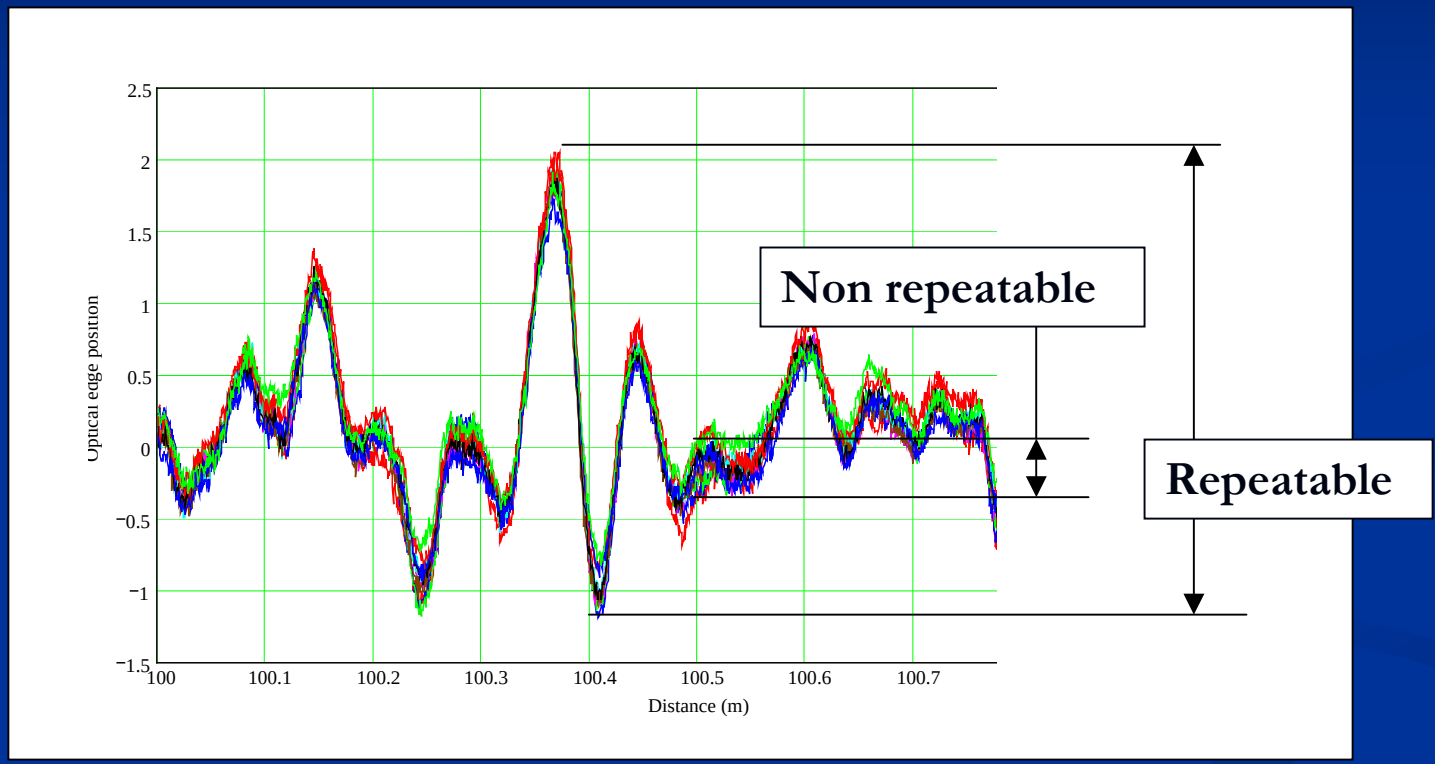






Actual edge-probe trace of tape movement

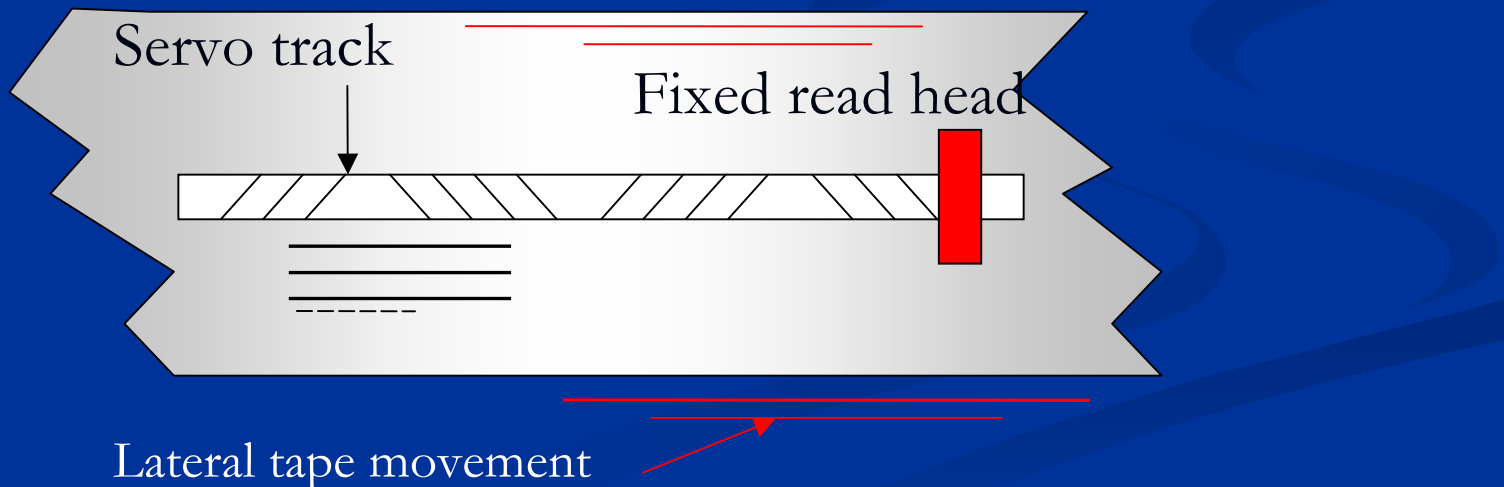
- What is needed is to separate the repeatable from the non repeatable LTM.



- The repeatable is edge wear and once-around. The non repeatable is the true LTM

Method 2. Position decoding of a written servo track

- The servo track is, in a sense, an artificial edge written on the tape.
- Measuring this comes closer to the true LTM because it eliminates edge roughness.



Measuring the Servo Track

Advantages

- Eliminates edge roughness.
- Does not require complex equipment.

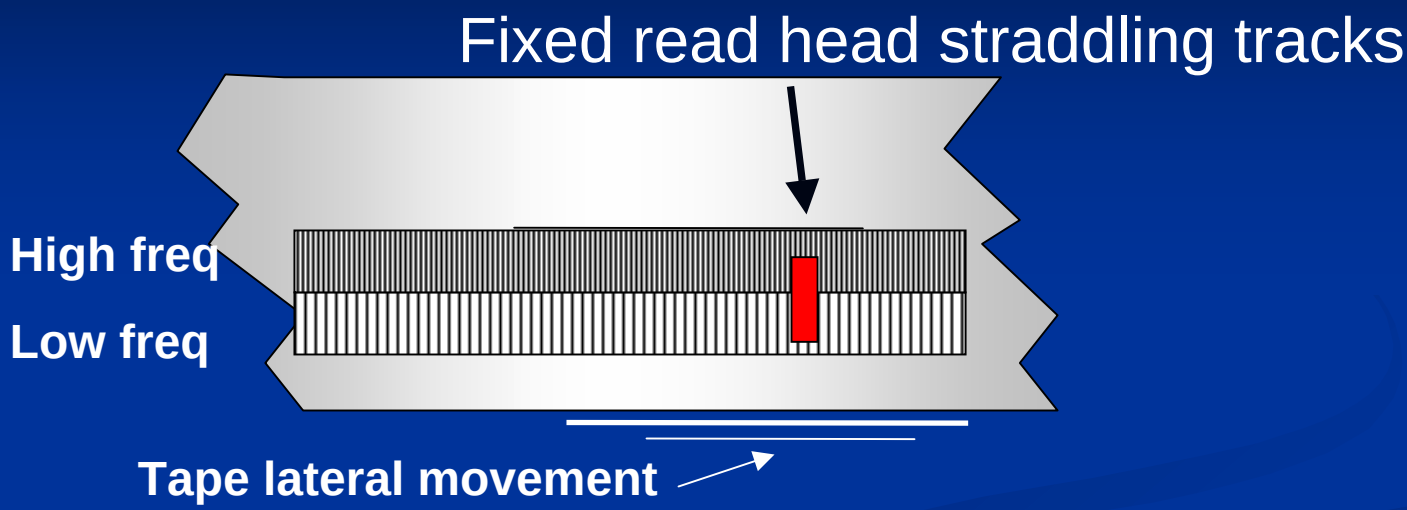
Disadvantages

- Measures full LTM, (repeatable and non repeatable).
- Needs multiple passes to separate the two.
- Includes the written-in servo track error.

Method 3: writing one's own "servo" track

- The problem with a *pre-written* track is interchange.
- If the servo track could be written and read on the same machine, the repeatable LTM would be eliminated.
- Do this by using any tape deck and writing a high freq and adjacent low freq track.

High Freq and Low Freq track



- The ratio of Hf/Lf is measured, 50% being on dead center

High freq and Low freq track

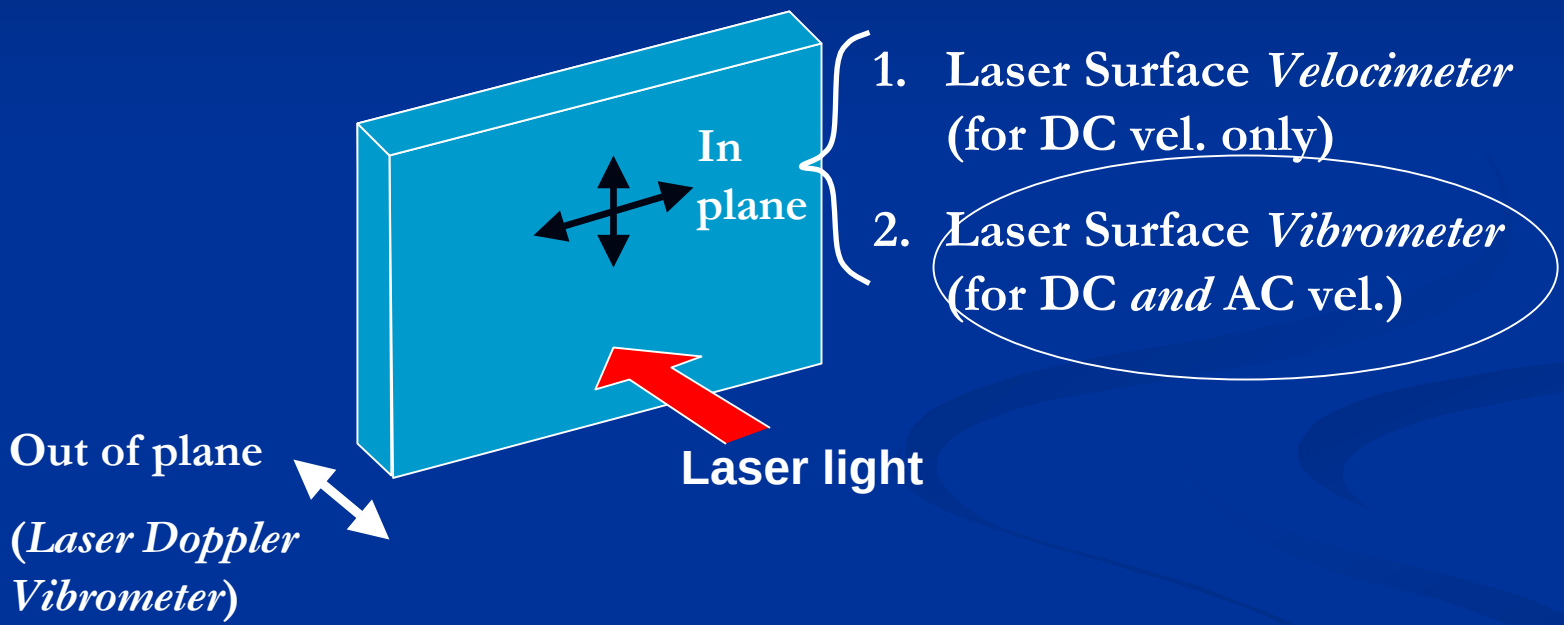
Advantages

- Gives direct measurement of non-repeatable LTM; the repeatable is canceled out.
- Can be used on any tape drive in the lab.

Disadvantages

- Calibration very sensitive.
- Head must be positioned with a micrometer stage.

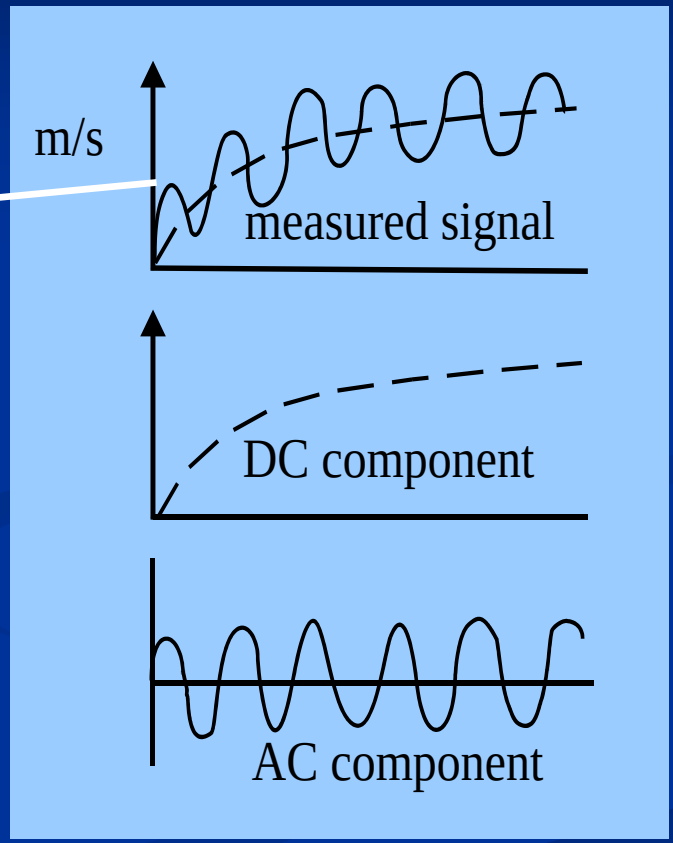
Method 4: Measuring surface movement with a laser



- This method is evaluated because many labs have one of these

Measuring surface movement with a laser

- The Laser Surface Vibrometer is the only instrument with the potential of measuring small instantaneous in-plane movements.
- It has the possibility of measuring Instantaneous Speed Variation, and if turned 90 deg, measuring LTM.



Laser Surface Vibrometer

- Movement must be calibrated with a known frequency and amplitude. One needs a target on a shaker table.
- However, with magnetic tape as a target, the surface is too dark and the returned velocity signal is too noisy to be accurate.
- The noisy velocity signal must be integrated to give movement.
- Averaging the signal *30 times* gives very accurate results. But moving tape cannot be averaged 30 times for LTM !
- CONCLUSION: Laser methods are not acceptable for tape movement.

Conclusion

- A combination of methods is best
- I recommend method 1 in combination with 2 or 3.
- In the lab, the first three methods give results less then .3 microns apart – good enough for measuring LTM of 1 micron.
- Method 4 is not recommended.