

**Simultaneous 5-wavelength Interferometry for
Head/Media Spacing Measurement**

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Outline

- **Motivation**
- **Implementation of simultaneous 5-wavelength interferometry**
- **Spacing measurement in a tape drive**
- **Tape asperity compliance measurement**
- **Comparison between 3- and 5-wavelength interferometry**
- **Summary**

Motivation

- **Measurement reliability can be further improved by using more than 3 wavelengths**
- **Simultaneous measurement is required to measure the spacing in a tape drive**

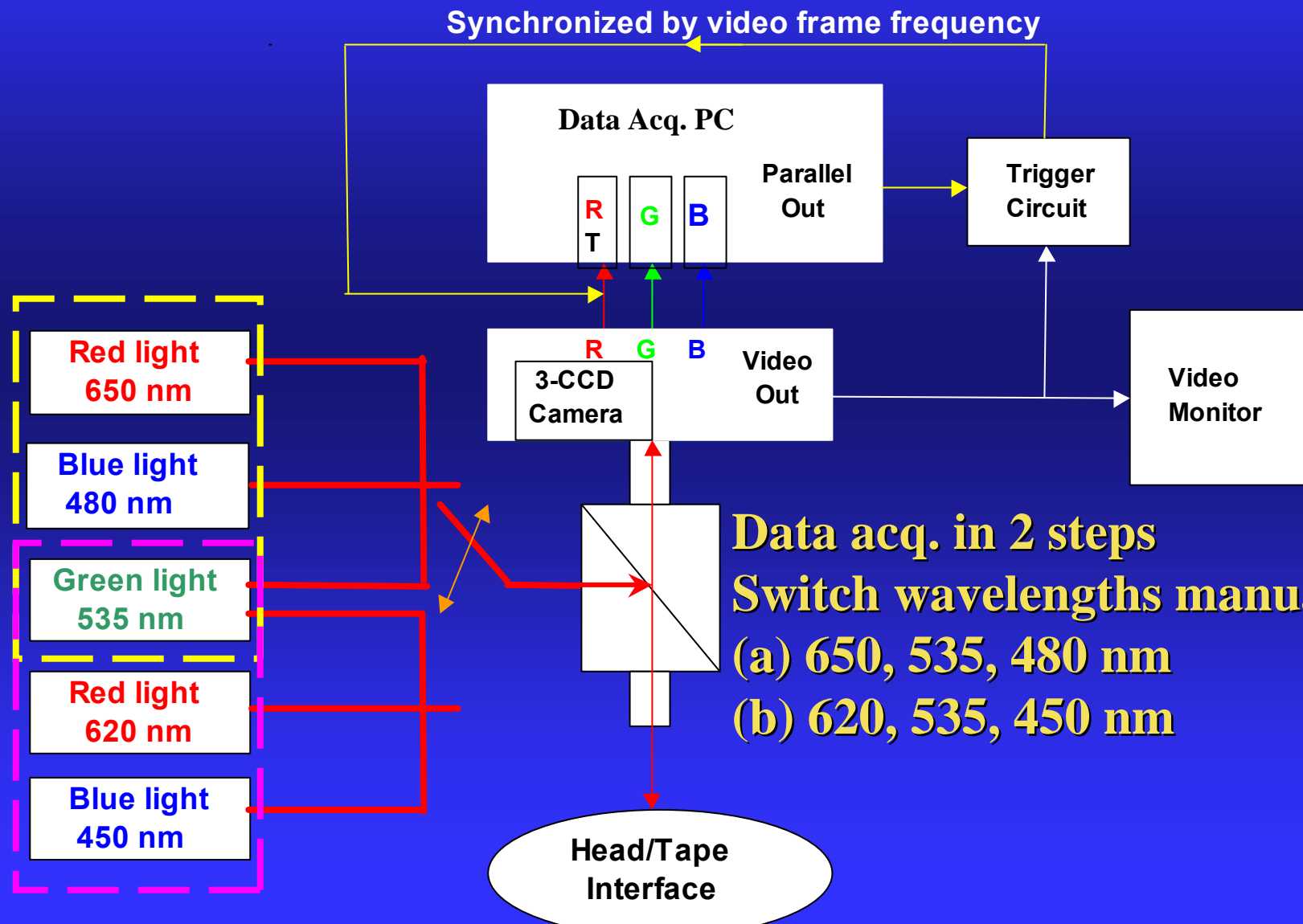
5-wavelength interferometry

Monte Carlo Error Analysis: 5 vs. 3-wavelength

All units in nm.	Spacing: 35 nm		Spacing: 50 nm		Spacing: 80 nm	
Technique	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
3-wavelength	35.0	1.6	50.0	1.5	80.0	2.3
5-wavelength	35.0	1.2	50.0	1.2	80.0	1.9

Two-step sequential 5-wavelength interferometry

Sequential measurement--- asperity compliance



Simultaneous 5-wavelength interferometry

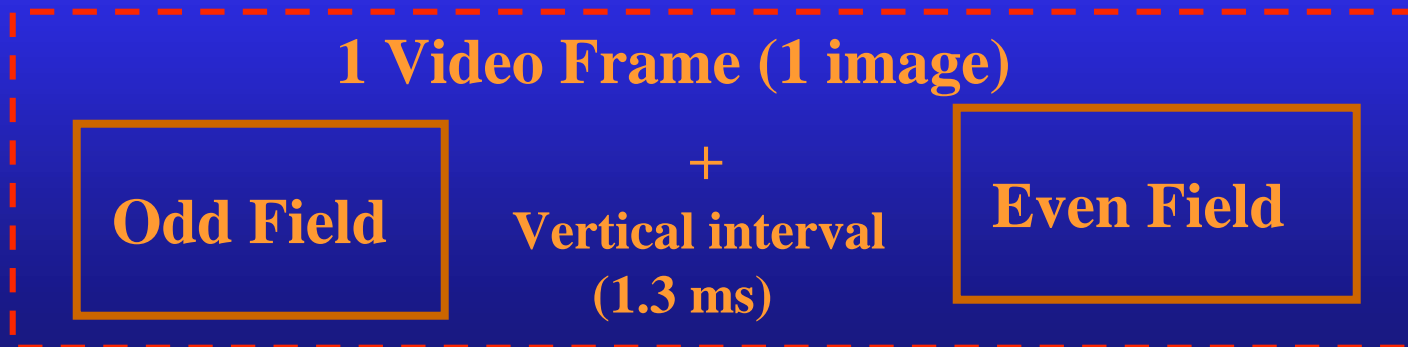
2 possible choices for simultaneous measurement :

One 3-CCD camera \implies data acq. must be done in 2 steps
(With a switching of wavelengths)

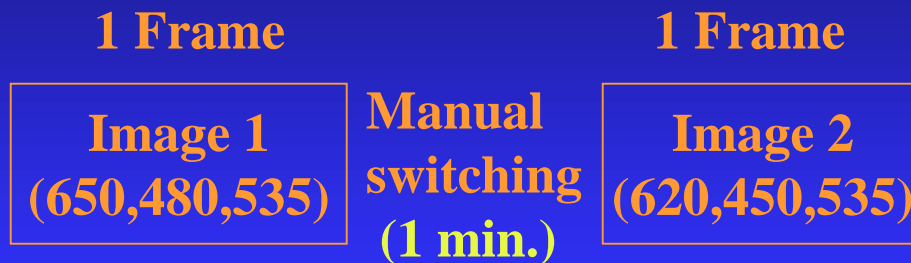
Two 3-CCD cameras \implies difficult to align the two cameras
(No switching of wavelengths)

Simultaneous 5-wavelength interferometry

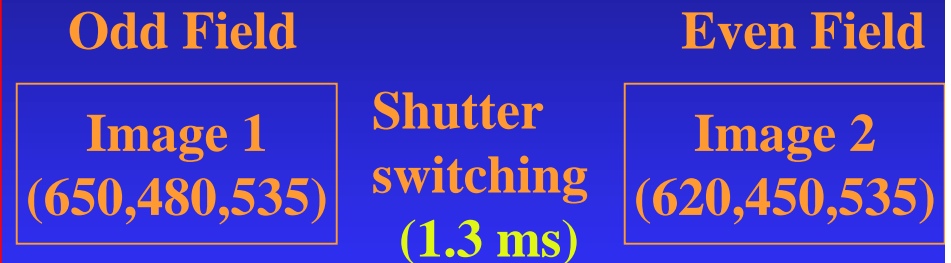
Data acquisition using 3CCD camera



Sequential acquisition

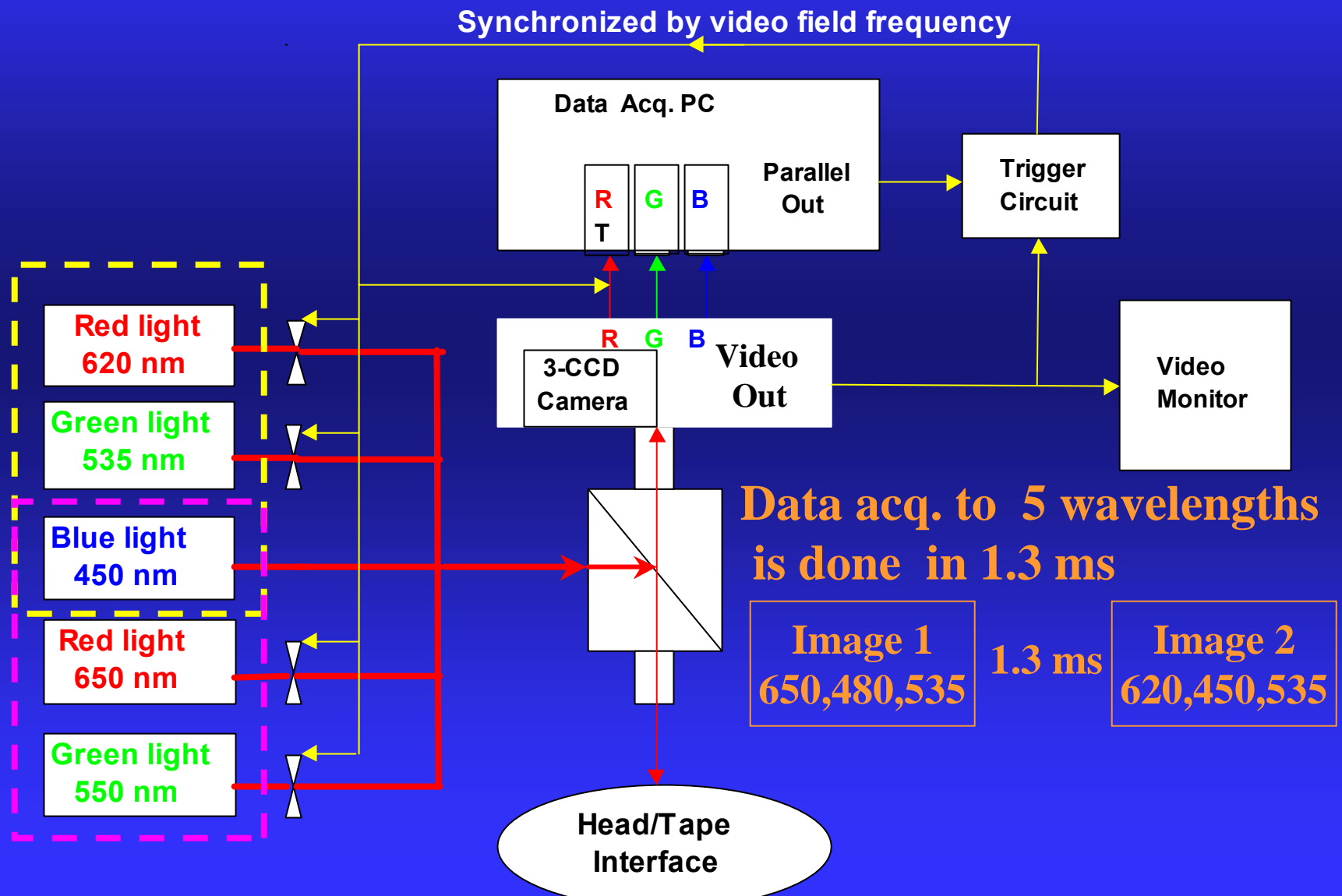


Simultaneous acquisition



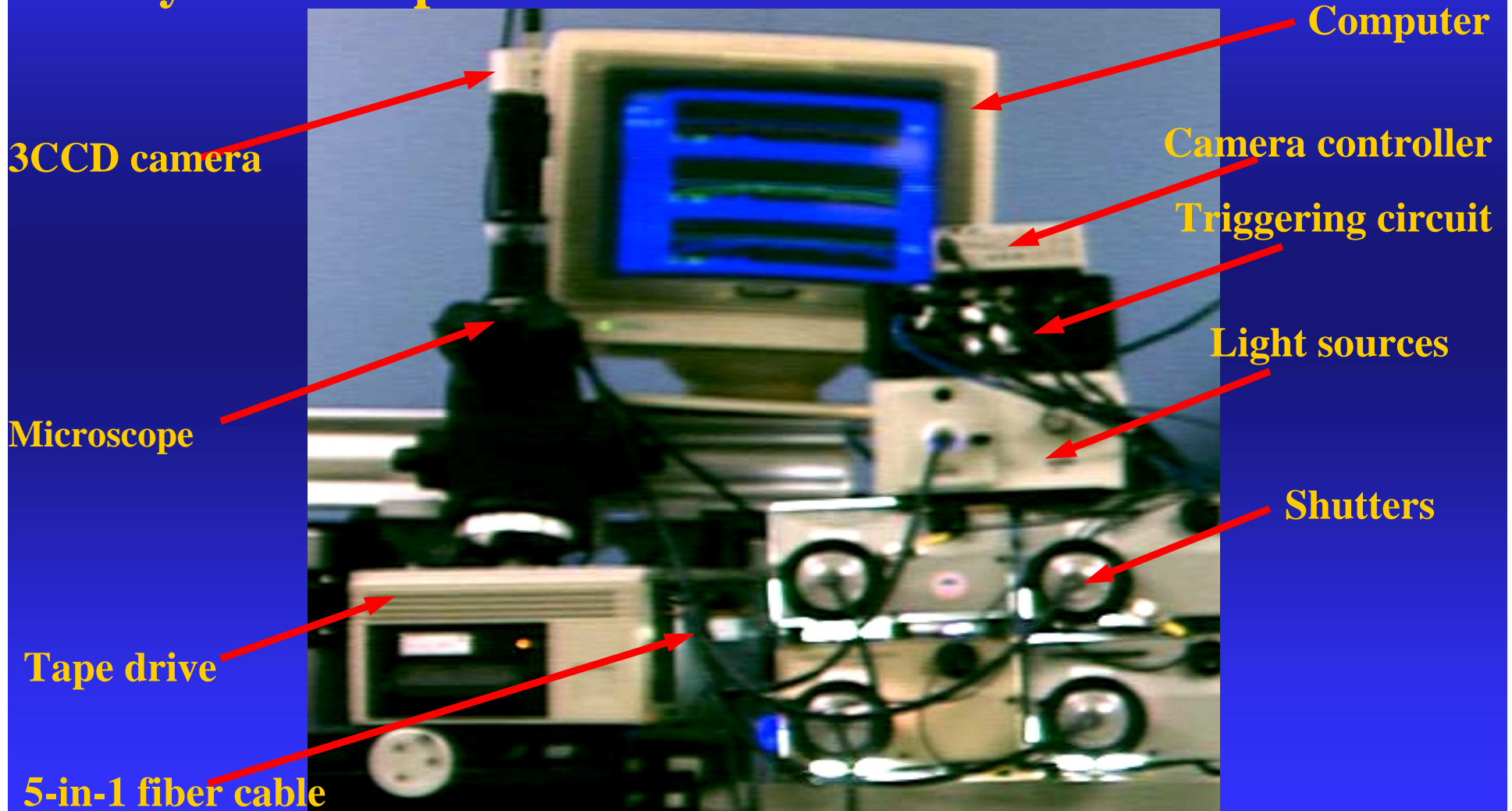
Simultaneous 5-wavelength interferometry

5-wavelength measurement \subset 3-wavelength measurement



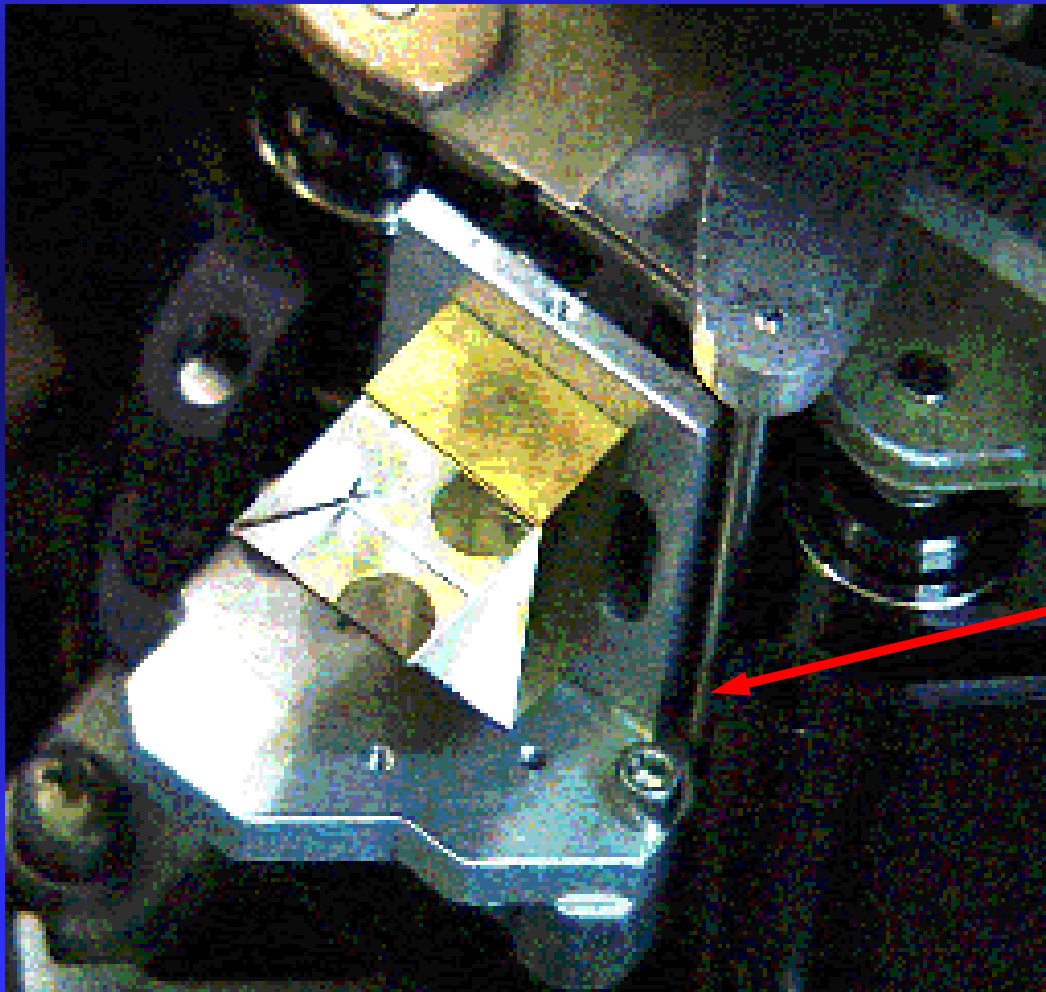
Simultaneous 5-wavelength interferometry

Physical setup

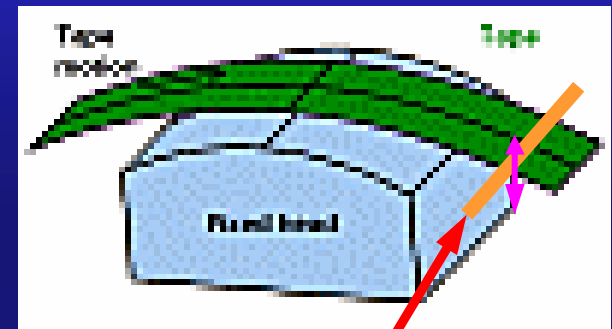


Spacing measurement on DLT4000 tape drive

Unloading Device



$$I = A + B \cos\left(\frac{4\pi h}{\lambda} - \phi\right)$$



Loading/Unloading rod

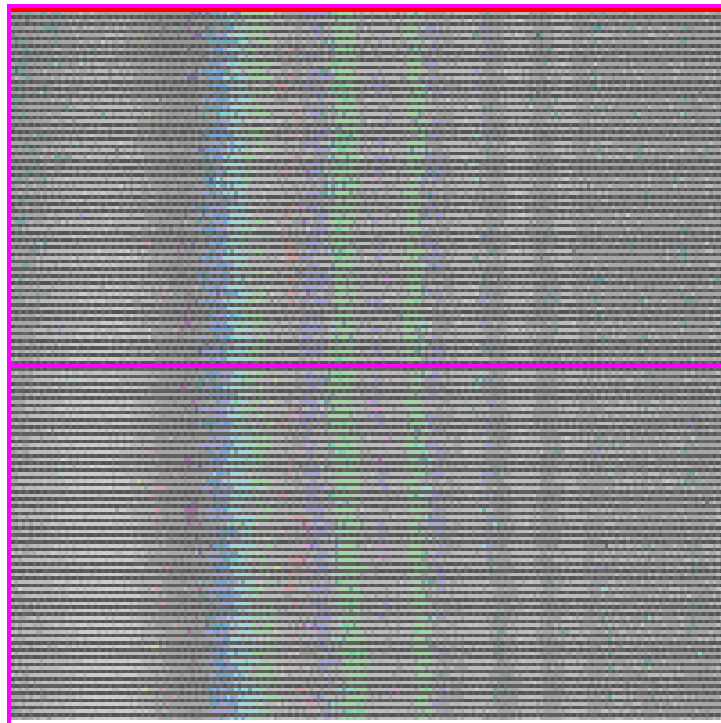
Spacing measurement on DLT4000 tape drive

Envelope calibration

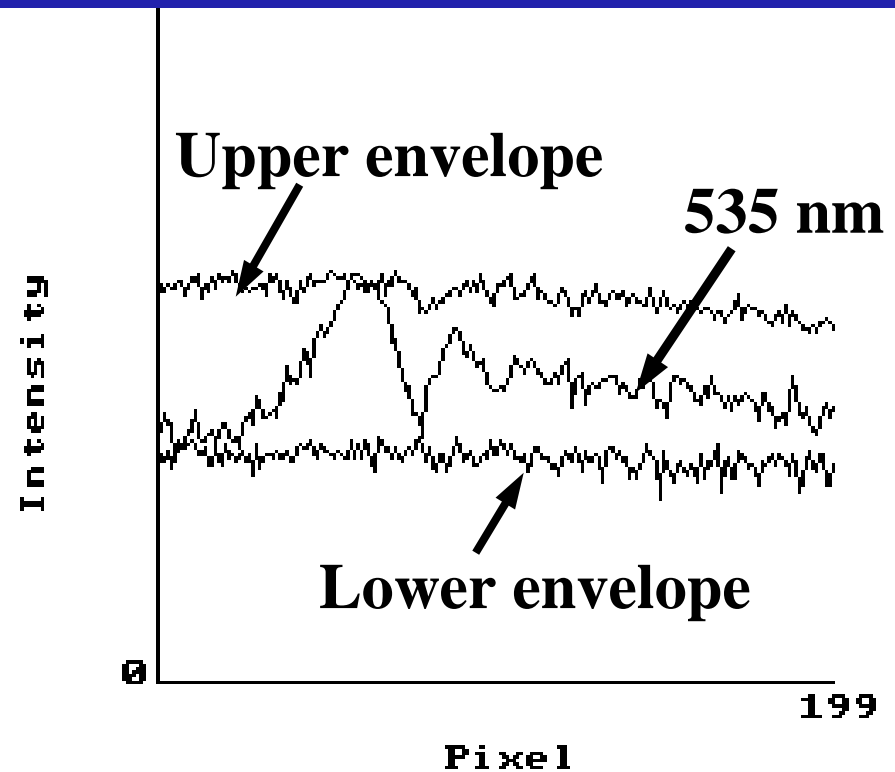
$$I = A + B \cos\left(\frac{4\pi h}{\lambda} - \phi\right)$$

(a) Moving fringe pattern

(b) Envelope extract



Fringe moving direction

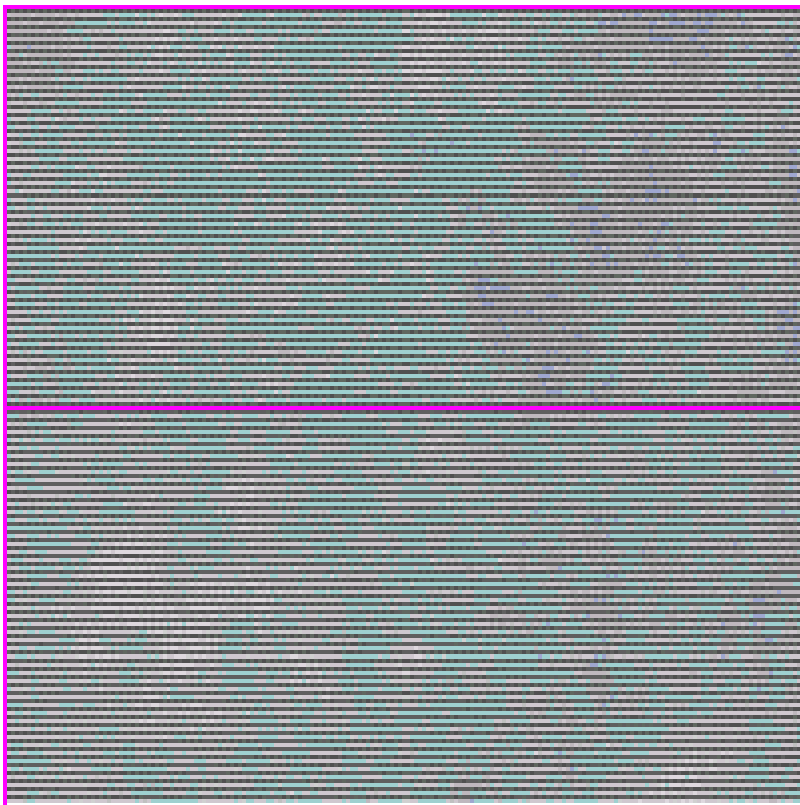


Spacing measurement on DLT4000 tape drive

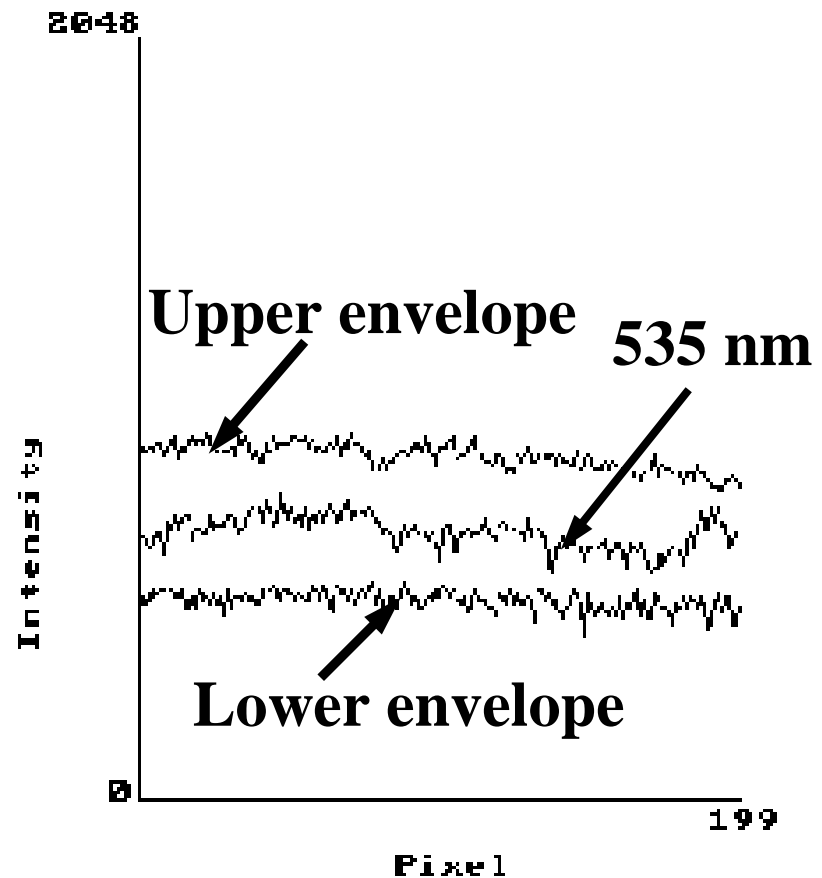
Envelope check $I = A + B \cos\left(\frac{4\pi h}{\lambda} - \phi\right)$

(a) A selected contact zone

(b) Envelope check for 535 nm

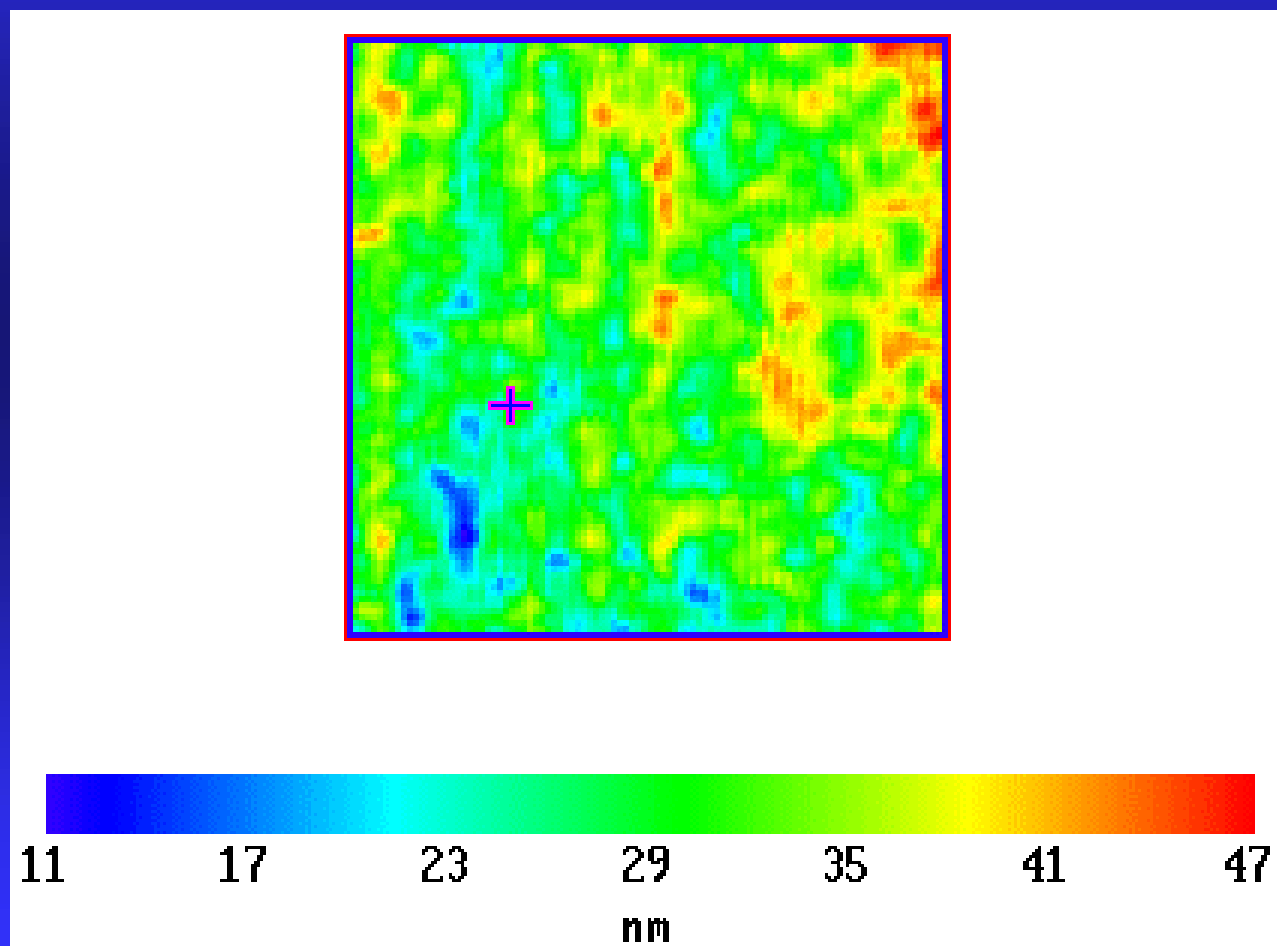


Odd field(620,535,450 nm)



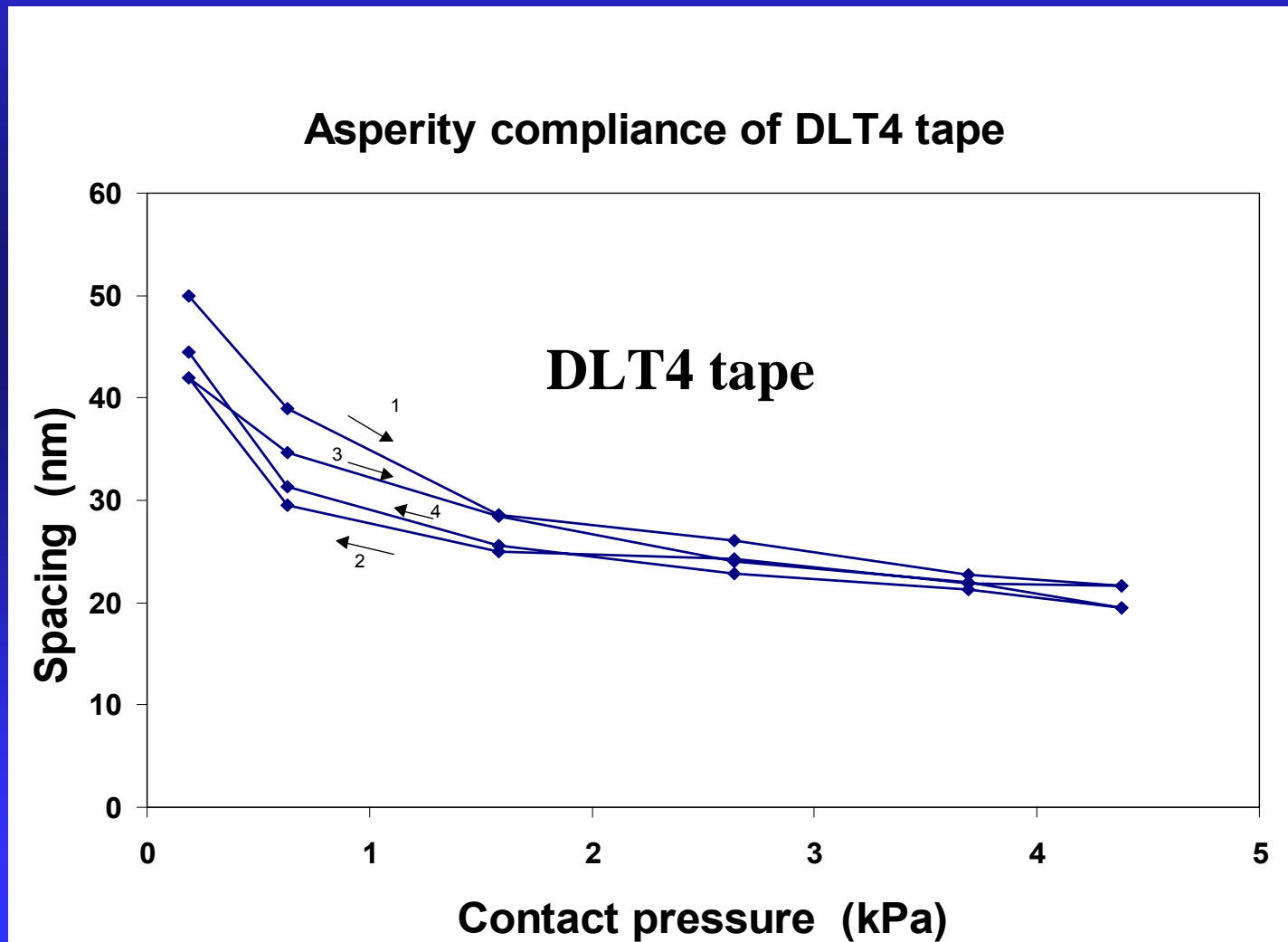
Spacing measurement on DLT4000 tape drive

Spacing map of a contact zone



Tape asperity measurement

Application in asperity compliance measurement



Precision comparison

Spacing measurement on DLT4000 drive

Standard deviation in 10 measurements
(spacing is averaged over 200x200 pixels)

	Mean spacing (nm)	Std. Deviation(nm)
3-wavelength	25.9 ± 0.8	0.3
5-wavelength	29.9 ± 0.6	0.2

Robustness: 5-wavelength > 3-wavelength

Precision comparison

Asperity compliance measurement

Standard deviation of spacing in 10 measurements

(spacing is averaged over 200x200 pixels)

Pressure: 9 psi

	Mean spacing (nm)	Std. Deviation(nm)
3-wavelength	36.9 ± 3.7	1.0
5-wavelength	37.7 ± 2.3	0.6

Robustness: 5-wavelength > 3-wavelength

Summary

- **Implemented simultaneous 5 wavelength interferometry**
- **Measurement accuracy is better with 5 wavelengths than with 3 wavelengths**