

Acoustic Emission Analysis for Drive Failure Prediction

Bernhard Knigge, Grad. Student, CMRR

Prof. Roberto Oboe, University of Padova & STMicroelectronics

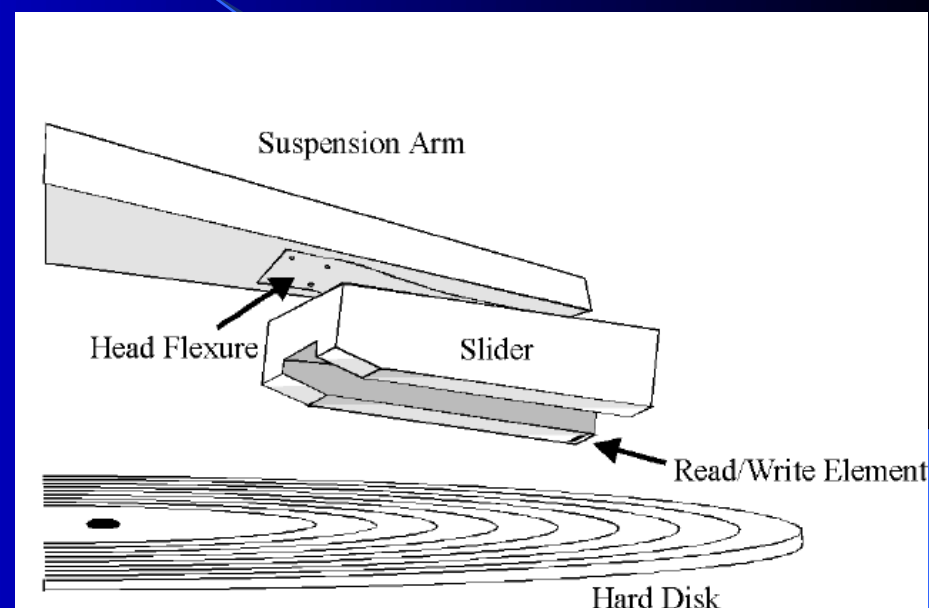
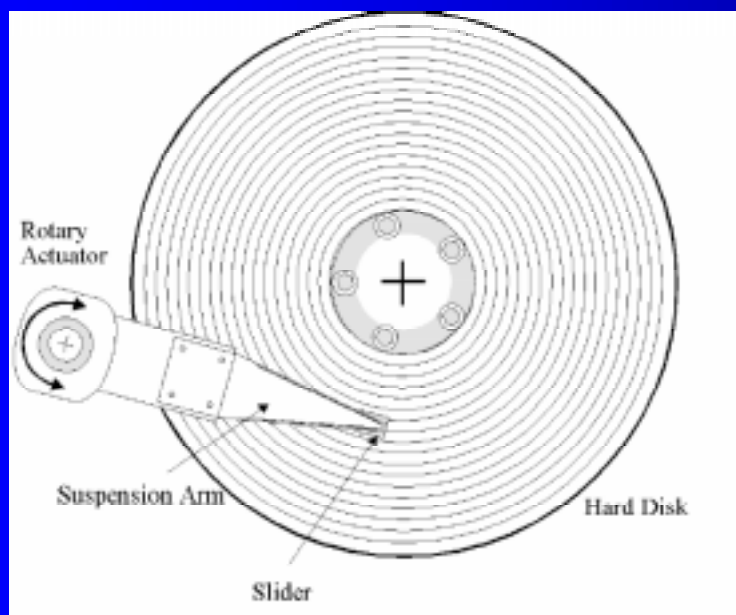
Prof. Frank Talke, CMRR

SMART workshop
August 25, 2000

Overview

- Introduction
- Background
 - what is acoustic emission?
- Experimental Setup
- Results from Spinstand
 - CSS testing
- Results from real hard drive
 - AE signal during seek, startup and track following

Introduction



- head is flying over the disk at operation
- rubbing of slider/disk interface during start and stop and shock
- interfacial wear causes head crash

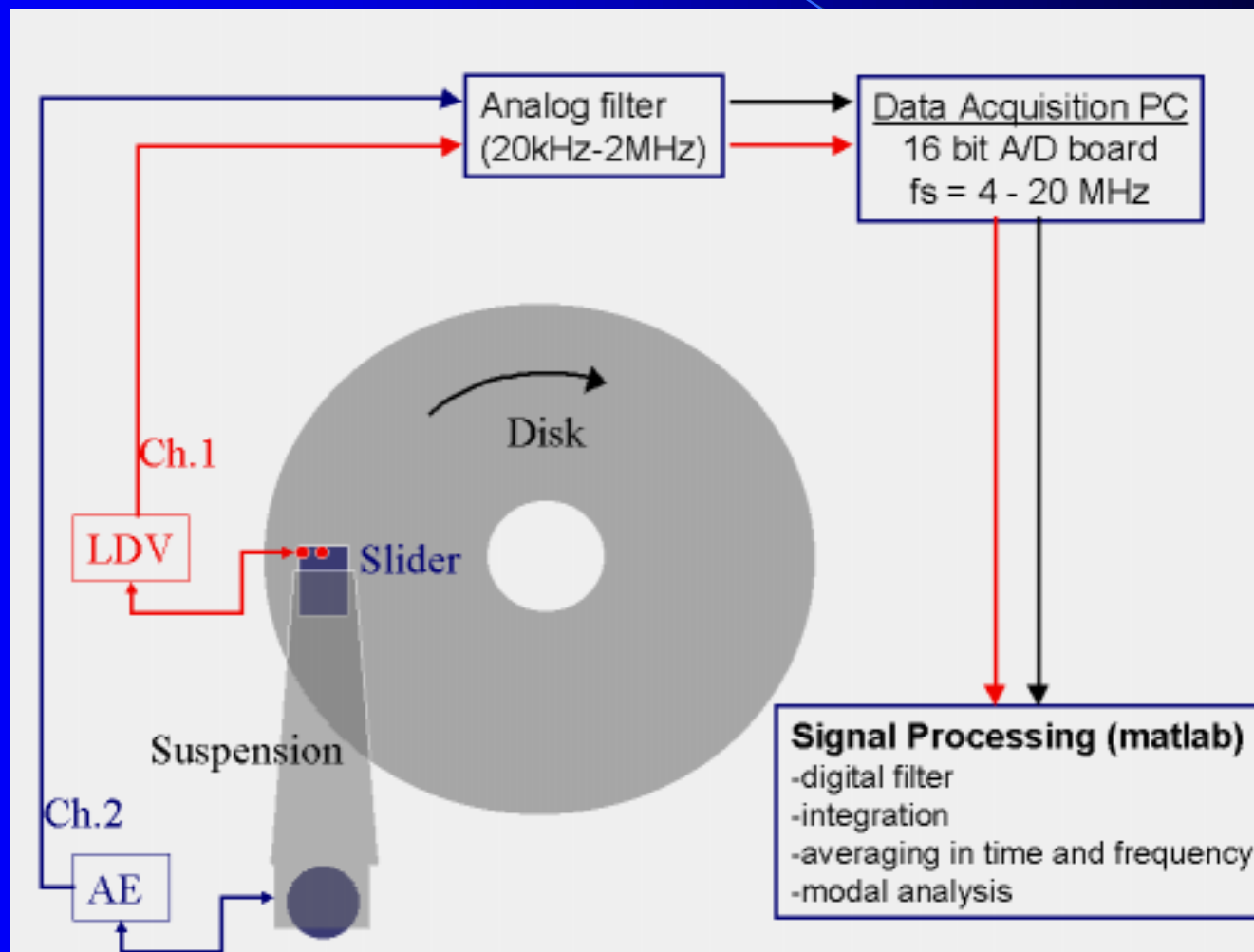
Possible methods to predict failure

- Increase in friction
 - spindle motor startup current measurement
 - implemented by Quantum
- Increase in AE
 - more sensitive than friction
 - not implemented yet
- Read / Write channel
 - flying height modulation

Background

- Acoustic emission (AE) is a stress wave
- Stress waves are caused by contact, bending, torsion and crack-formation
- Stress waves are subject to wave propagation phenomena such as dispersion and reflection from boundaries
- AE (or PZT) sensors are used to detect crack-formation (i.e. pressure vessels), leaks in pipes, and in the HDD industry to detect contact of the slider with the disk

Spinstand experimental setup



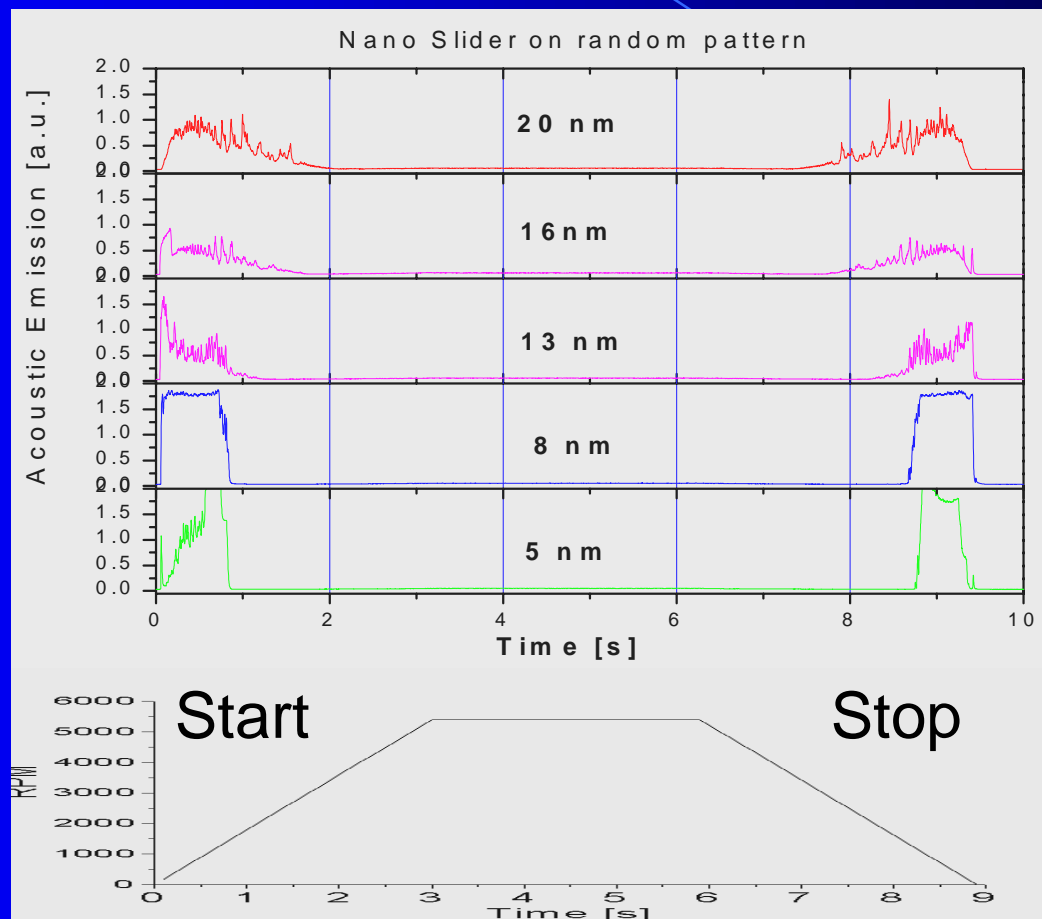
Experimental Specifications

- LDV bandwidth up to 1.5MHz
- AE bandwidth up to 2MHz
- Lotus and CETR Spinstand up to 10,000rpm
- Data Acquisition with 16bit AD/Board sampling rate of up to 10MHz

Start / Stop Experiments (CSS)

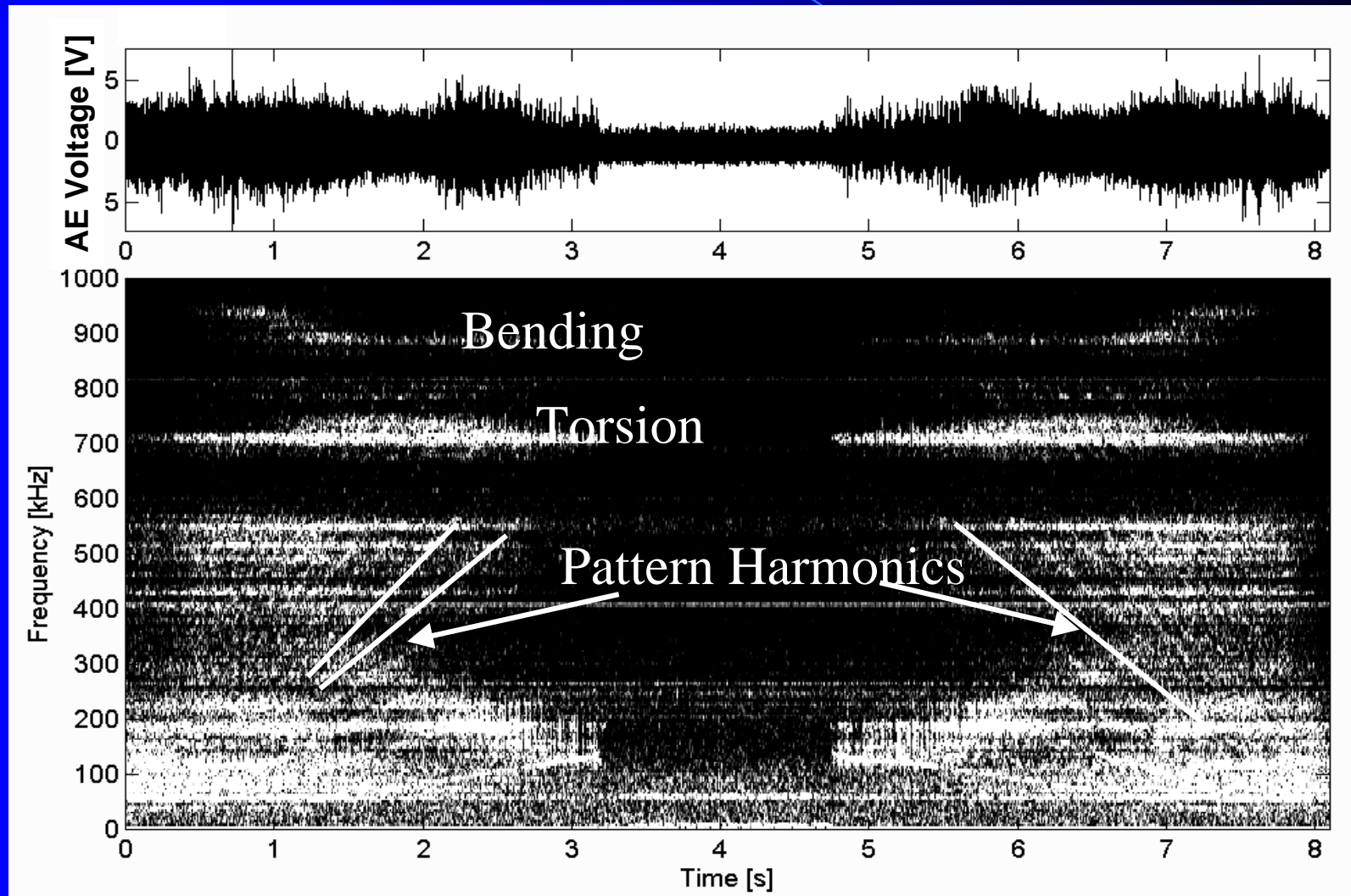
- AE signal increases during start and stop and levels off at flying => head/disk contacts during start/stop
- Spectral analysis shows the occurrence of slider body modes (>700kHz) and of airbearing modes (>50kHz) during contact
- Proposal: use AE to detect slider/disk contacts in real hard drive

Start / Stop Experiments (CSS)



Typical AE signal during startup and landing (RMS values) on various laser textured bumps

CSS cycle in time-frequency domain



AE testing with real HDD

- How close to the interface do we have to place the AE sensor to detect failure?
- Can we place the AE sensor outside the HDD and detect failure?
- Is there a AE signature for each HDD?

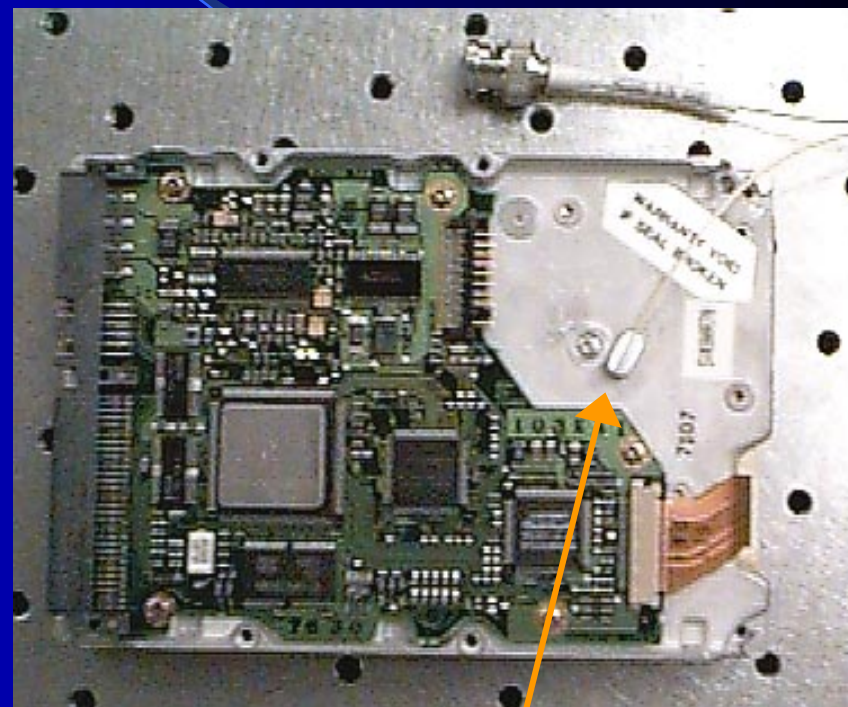
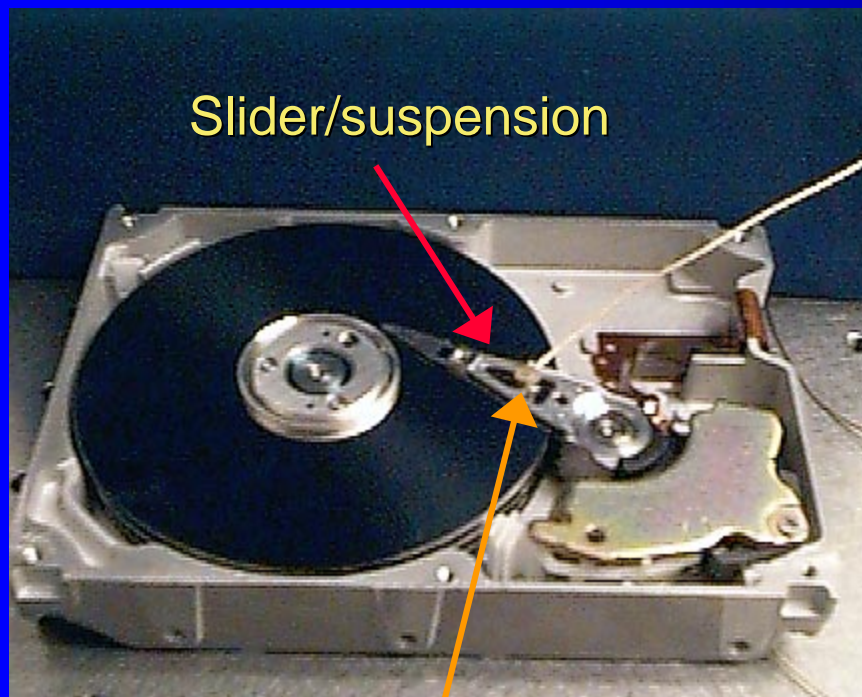
Compare two locations of AE sensor

- A) AE outside HDD near VCM pivot point
- B) AE inside HDD on E-Block

Test conditions:

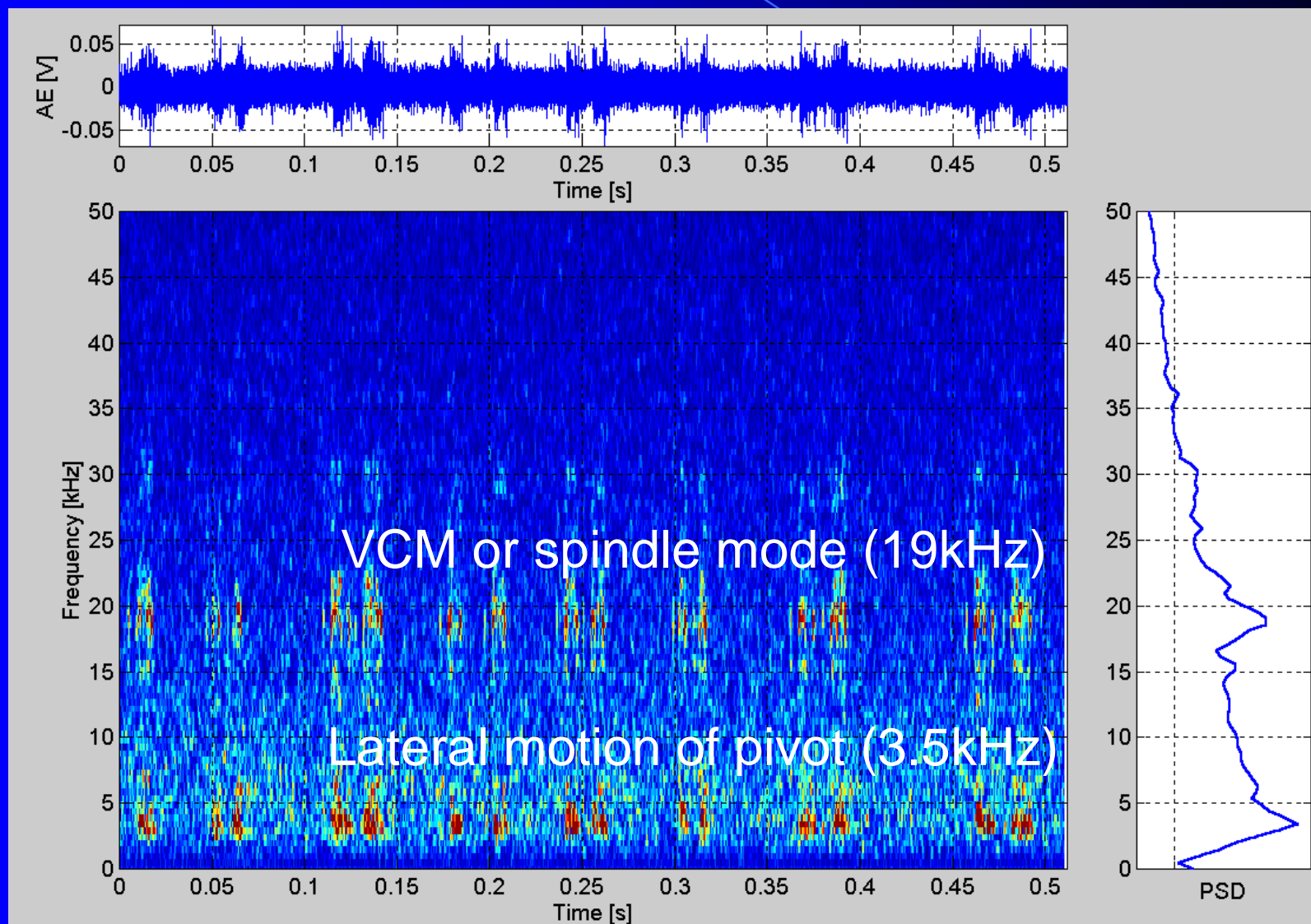
- 1) During Seek
- 2) During Startup
- 3) During Track-following (scratched disk)

Experimental Setup (Quantum Drive)



- Seagate and Quantum drives

AE outside of HDD near VCM pivot during seek - zoom 0=>50kHz

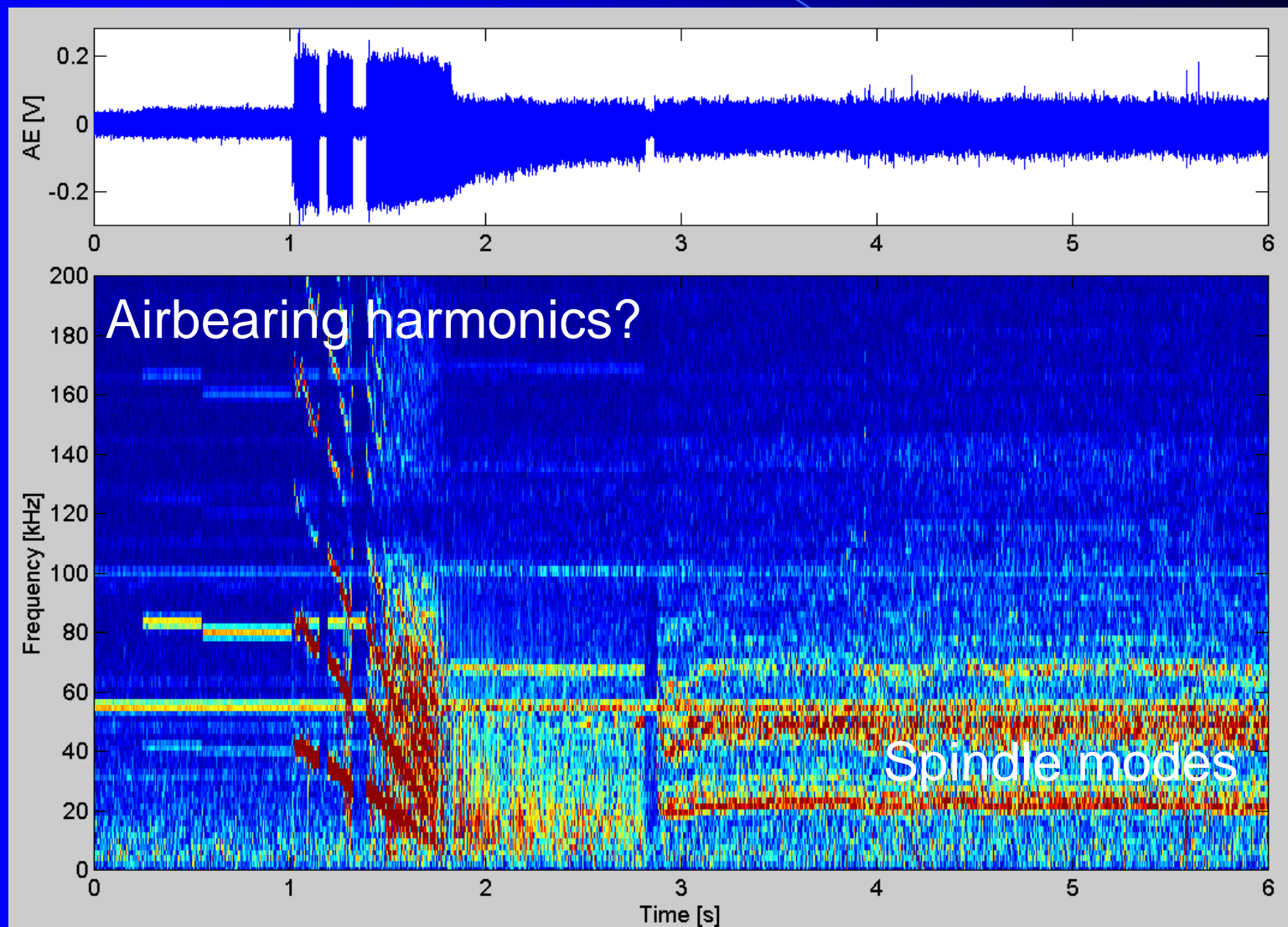


Compare two locations of AE sensor

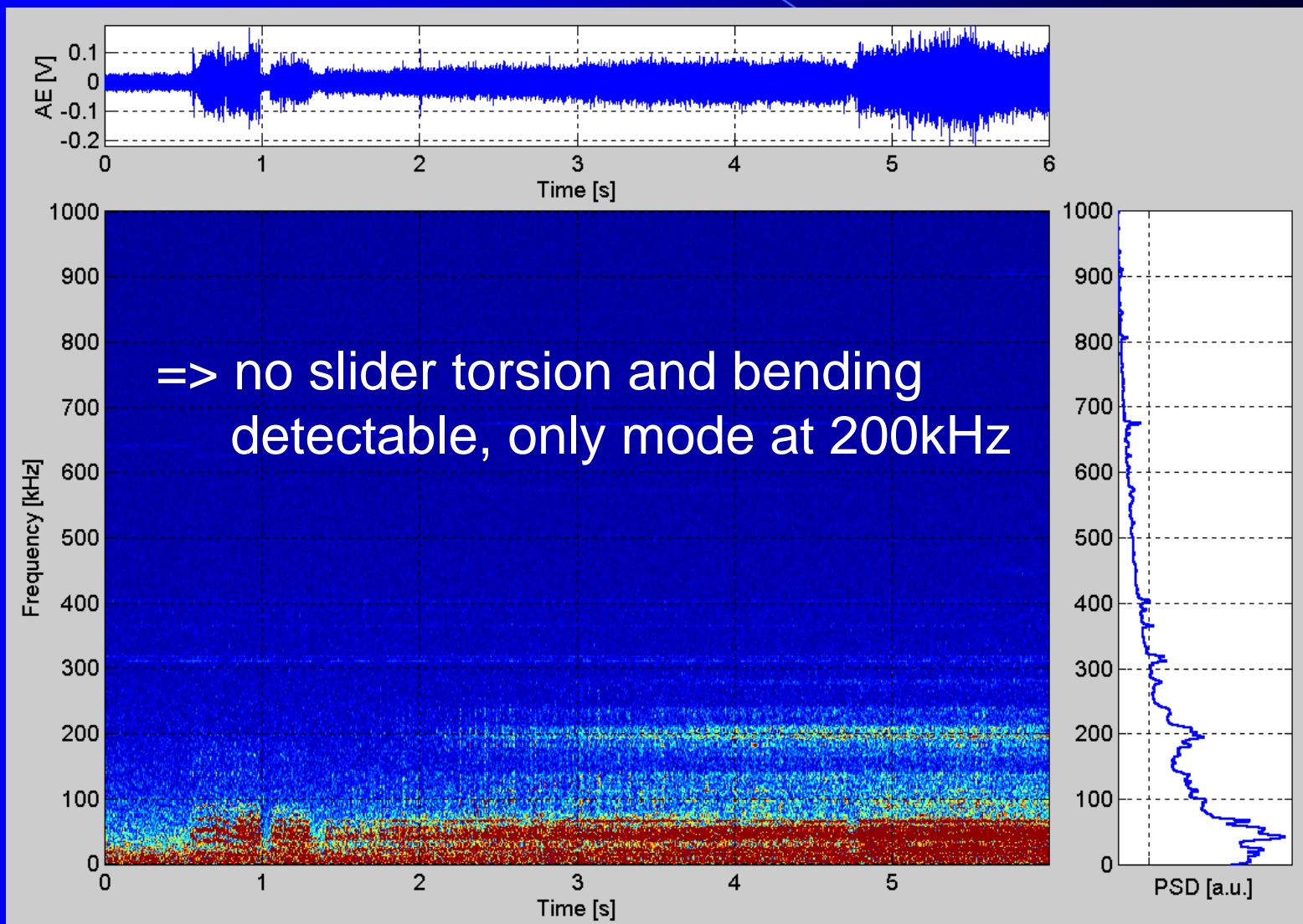
- A) AE outside HDD near VCM pivot point
- B) AE inside HDD on E-Block

2) AE during startup

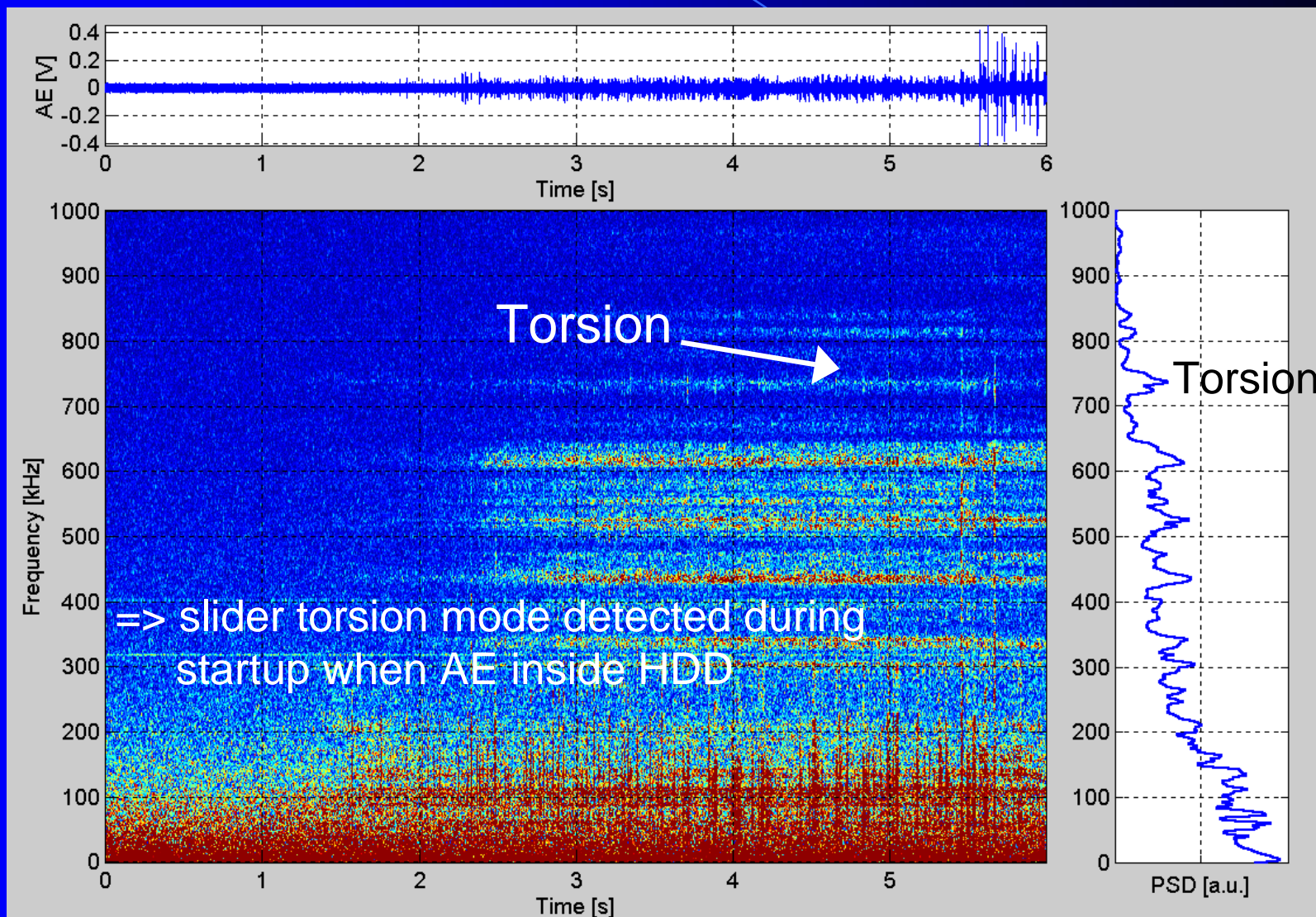
AE outside of HDD near VCM pivot (Quantum SCSI HDD#1 (2.2gig) during startup)



AE outside HDD during startup (Quantum SCSI 4.5gig)



AE sensor on E-block during startup (Quantum SCSI 4.5gig)



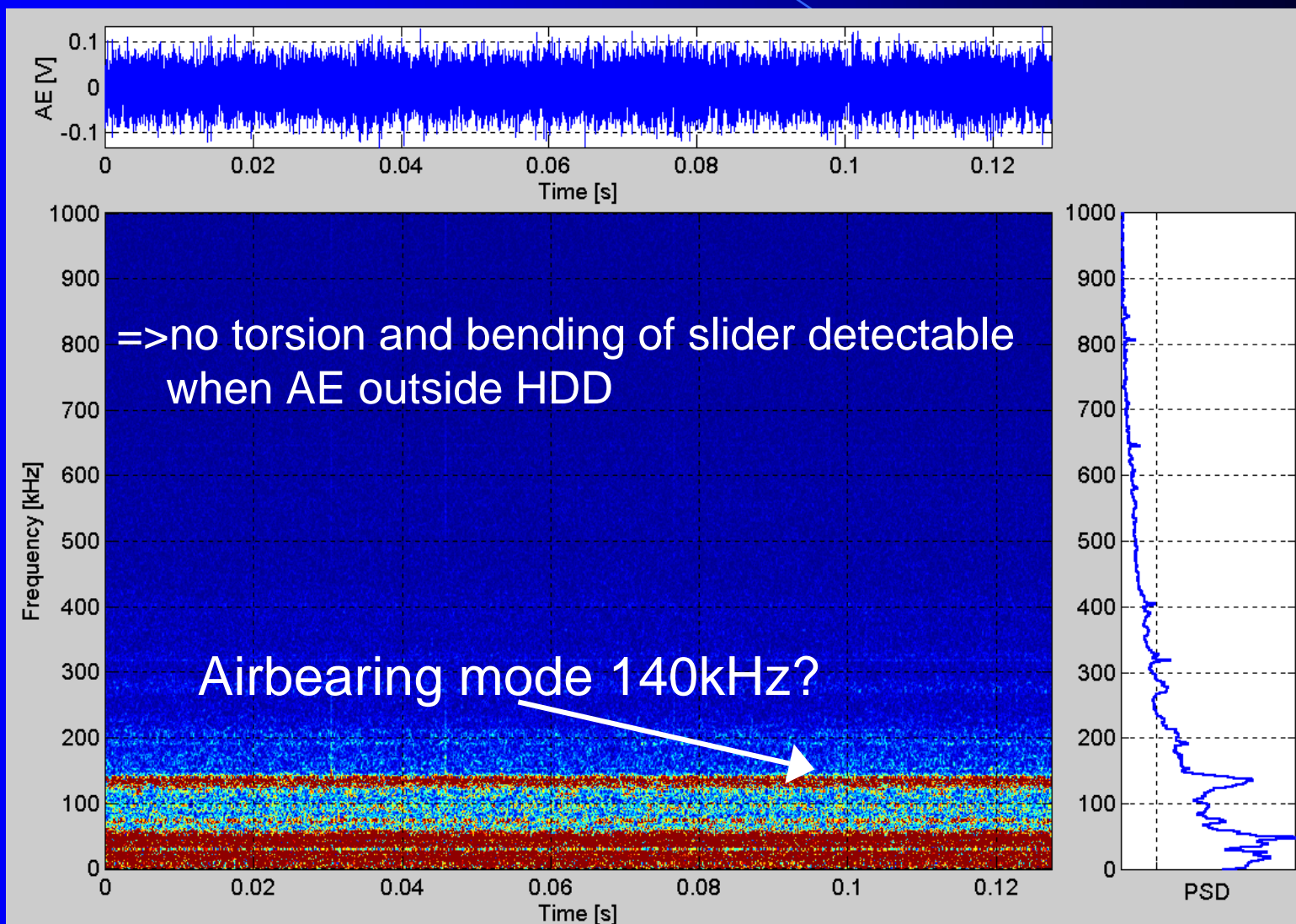
Compare two locations of AE sensor

A) AE outside HDD near VCM pivot point

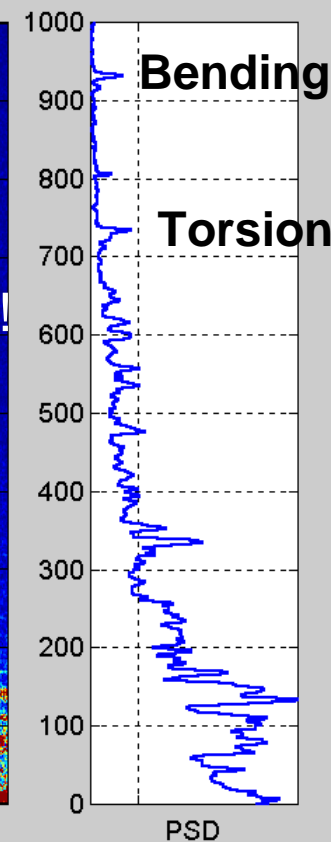
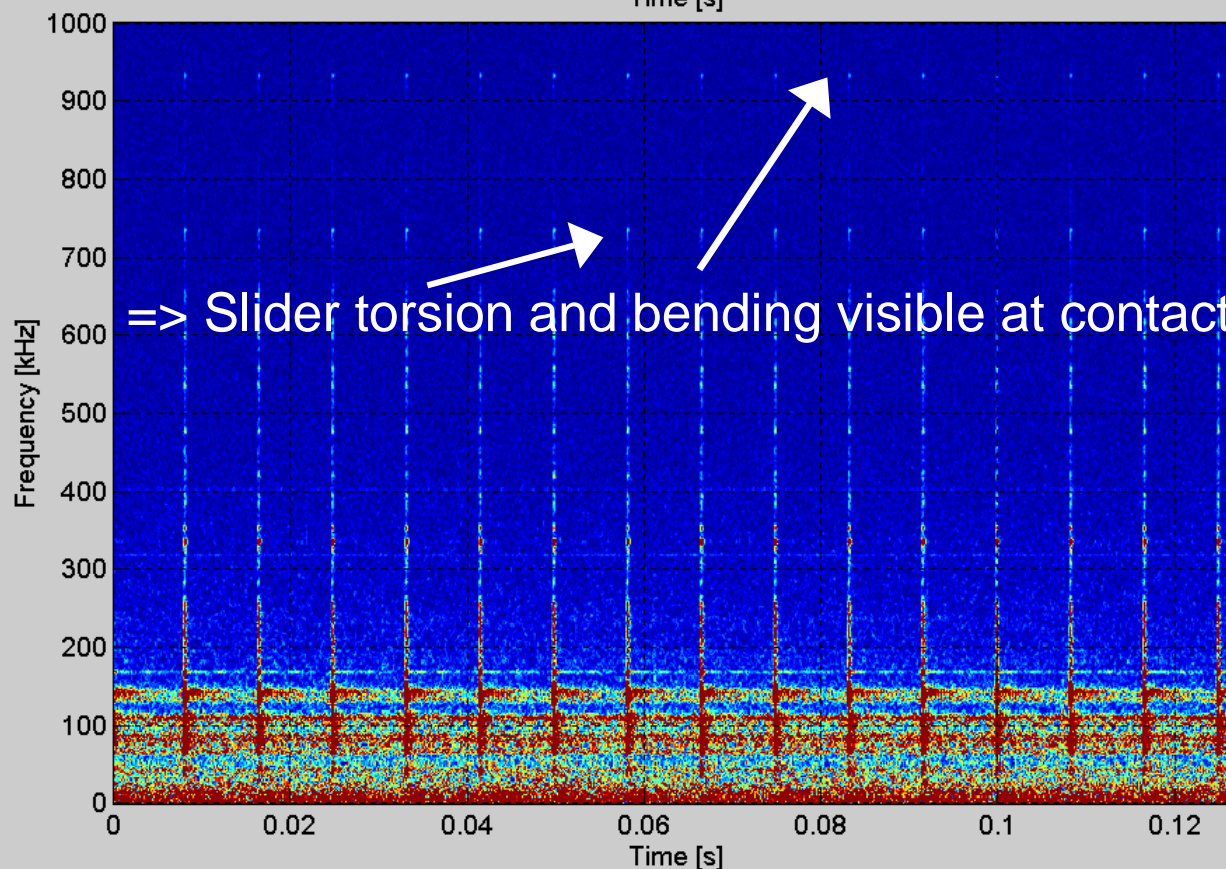
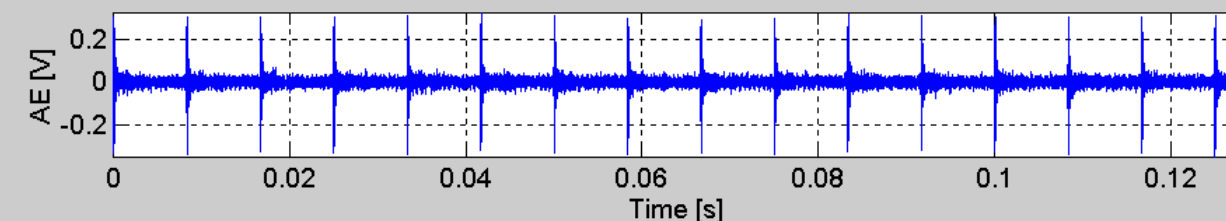
B) AE inside HDD on E-Block

3) AE during track following at outer diameter
(scratched disk)

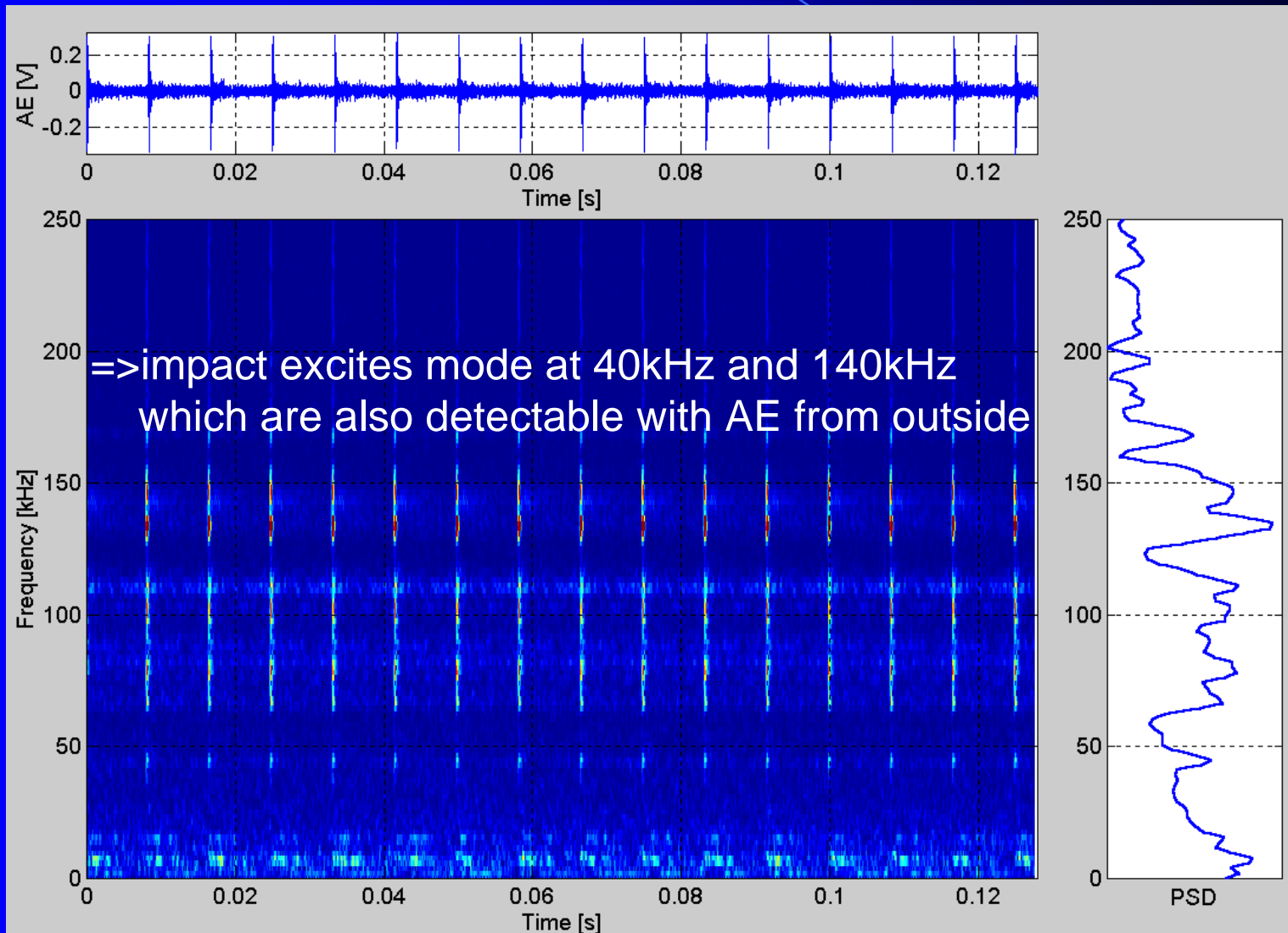
AE on outside of HDD near VCM pivot (Quantum SCSI HDD#3 (2.2gig) track following at OD



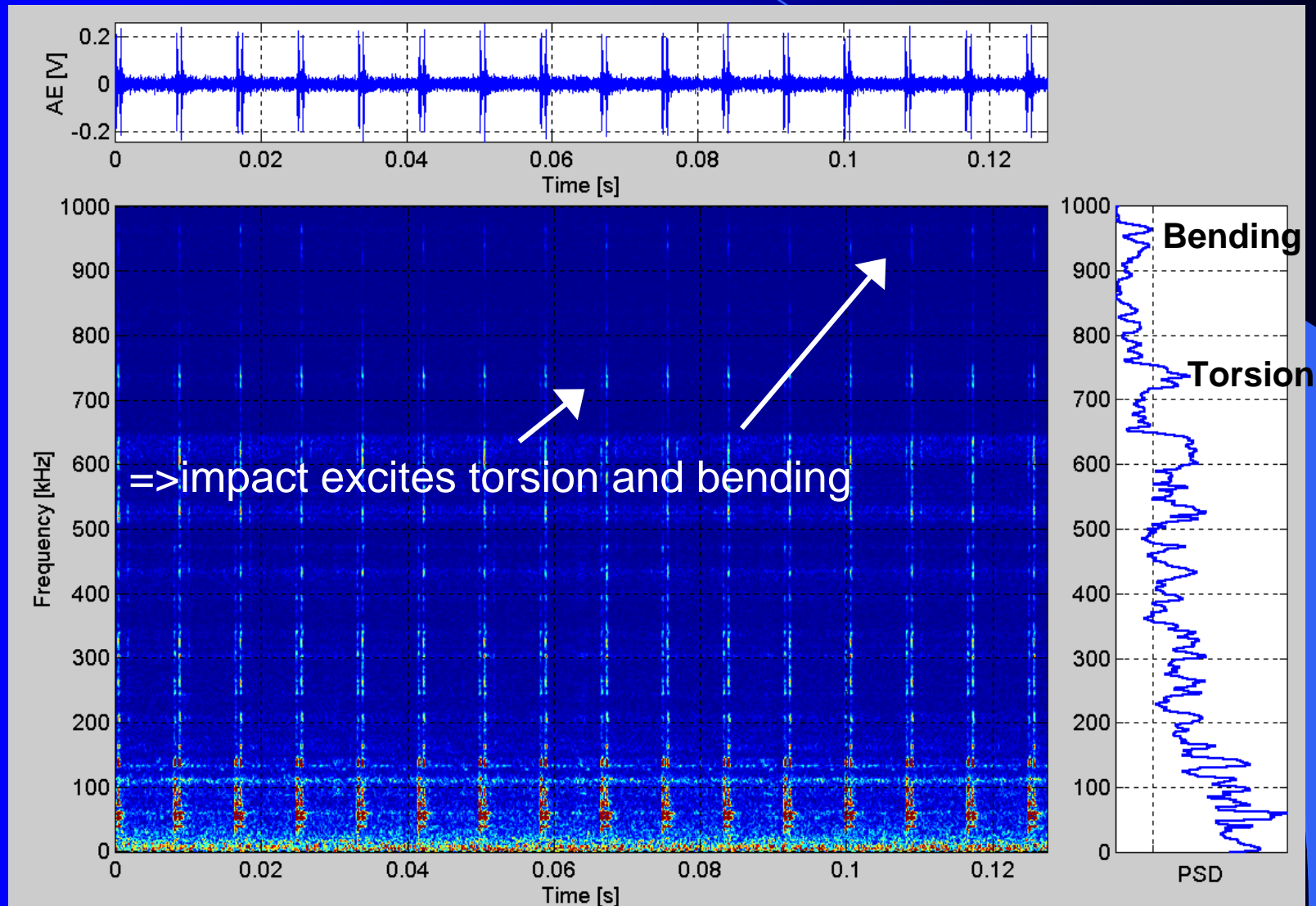
AE inside HDD on E-block, Quantum SCSI HDD#3, scratch on upper disk



AE inside HDD on E-block, Quantum SCSI HDD#3, scratch on upper disk, zoom 0=>250kHz



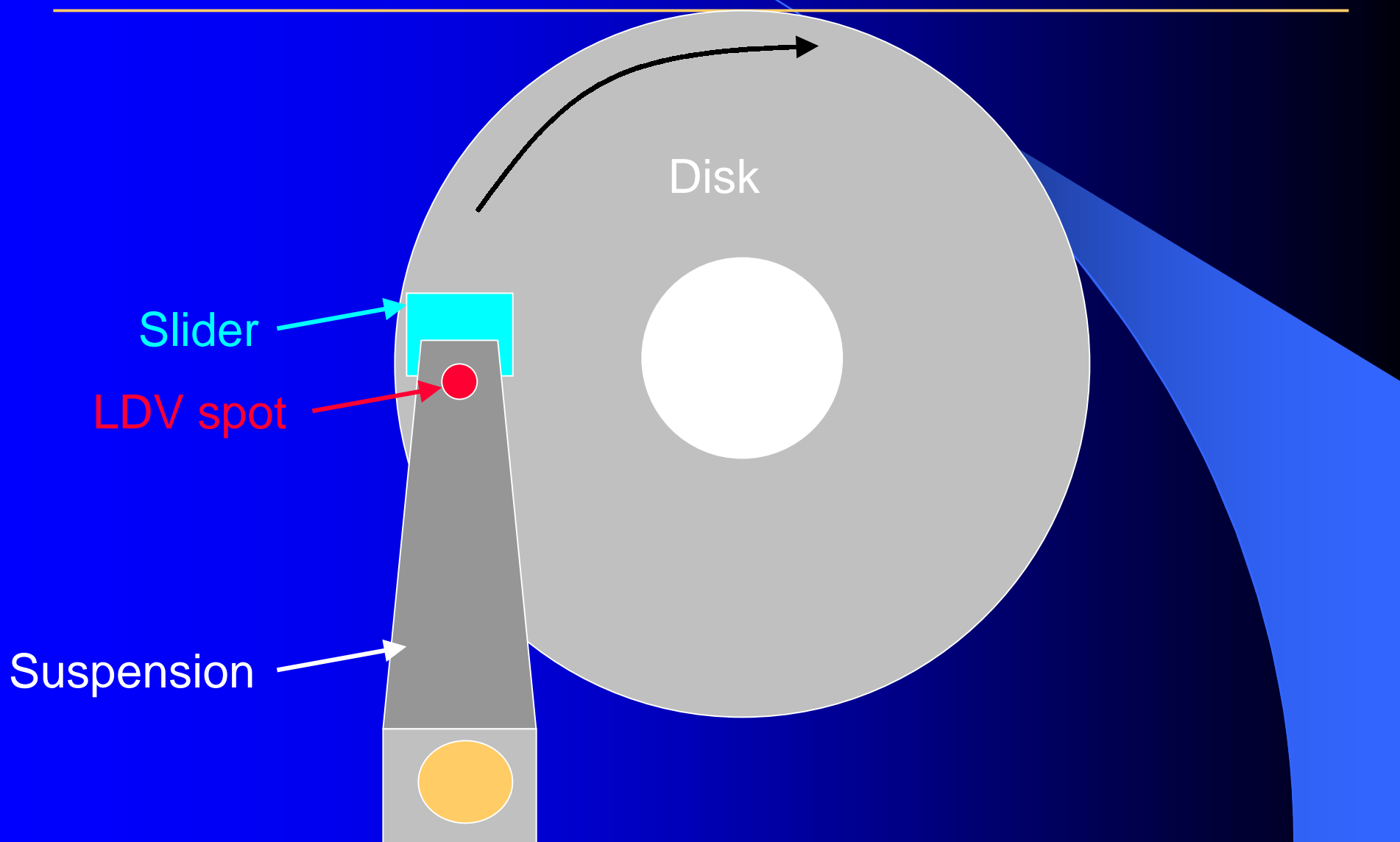
AE on E-Block, Quantum SCSI HD#4 (4.5gig), track following at OD, (scratched upper disk)



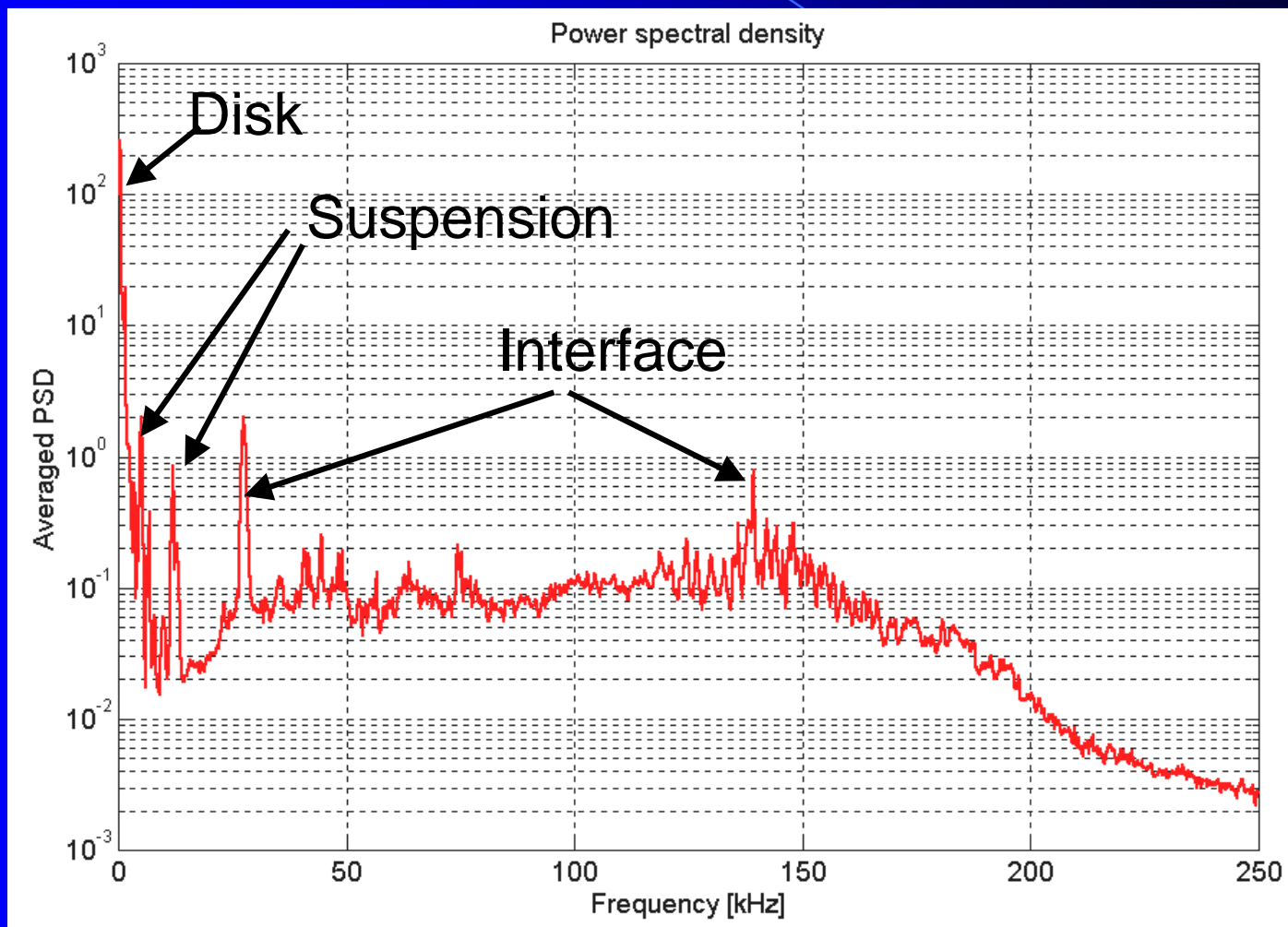
LDV validation of AE data

- Perform laser Doppler vibrometer (LDV) measurements to identify source of each mode
- Validation of AE measurements

LDV measurements



Result from LDV measurement



Summary and Conclusion

- AE is a powerful tool to investigate the head disk interface and other vibrations of the HDD
 - take-off time
 - slider body modes
 - mechanical vibrations
- AE outside HDD detects a mode at 140kHz that only appears at full rotation and possibly originates from the head/disk interface
- AE inside HDD on E-Block is more sensitive and detects each slider disk impact accurately

Future Work

- Evaluate further locations for AE probes
- Investigate more on different types of hard drives / sliders
- Correlate AE readings with VCM modes and bearings failures
- Perform LDV measurements to detect lateral motions of spindle HGA and HSA