Activities at UNIOXF

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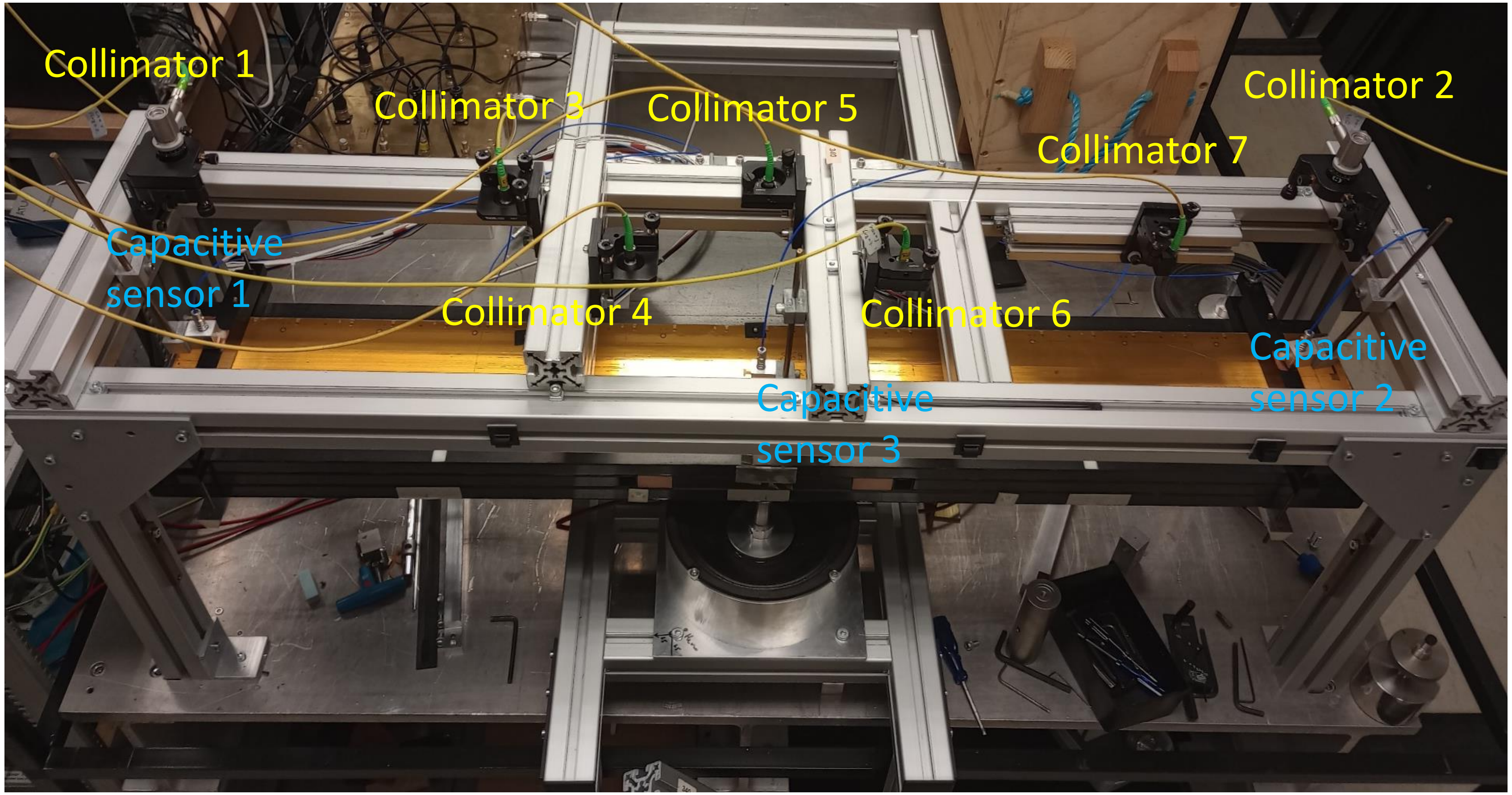
Introduction

- Goals
  - AIDAinnova: Deliverable D10.4 “Upgraded FSI” in M45
    - Development of mirrorless FSI
  - In addition (our goals):
    - Improve our vibration and air flow systems
    - Measure devices, also from external users
    - Develop theory of how structures respond to loads
- Past developments
  - For the work on improved FSI we have upgraded our FSI system
    - More channels (4 → 14) to allow for capture of more complex mode shapes
    - Higher power (10 μW → ~900 μW per line) to allow for mirrorless operation (using EDFAs: 2-stage Erbium Doped Fibre Amplifiers)
  - For the upgrade system was sent back to Etalon (~1.5 years ago)
  - Unfortunately, when the system came back there were a number of issues
    - It took a long, miserable time to identify these issues, find the cause, and then get a fix
    - In the end, most of these got only resolved when a member of Etalon came to Oxford a month ago, and fixed them in situ (only remaining issue appears to be a slightly lower power in high power mode than claimed)

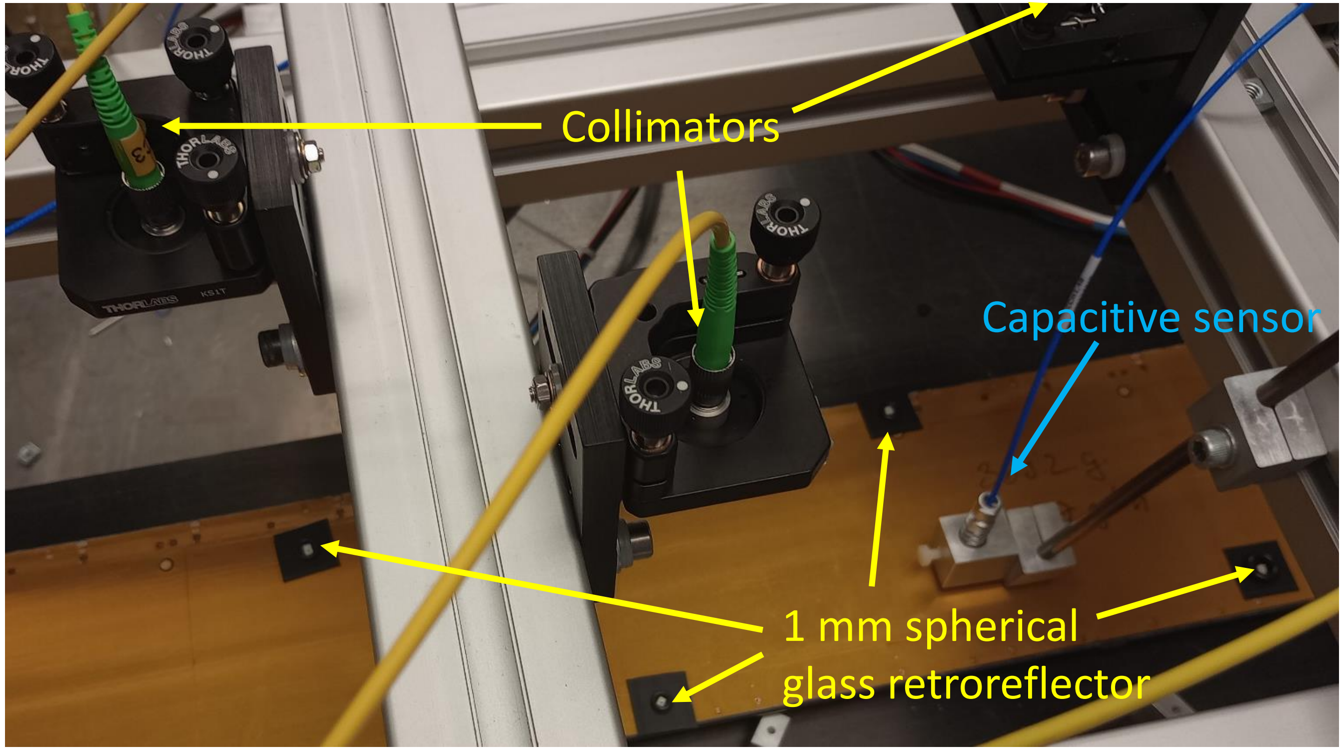
Status

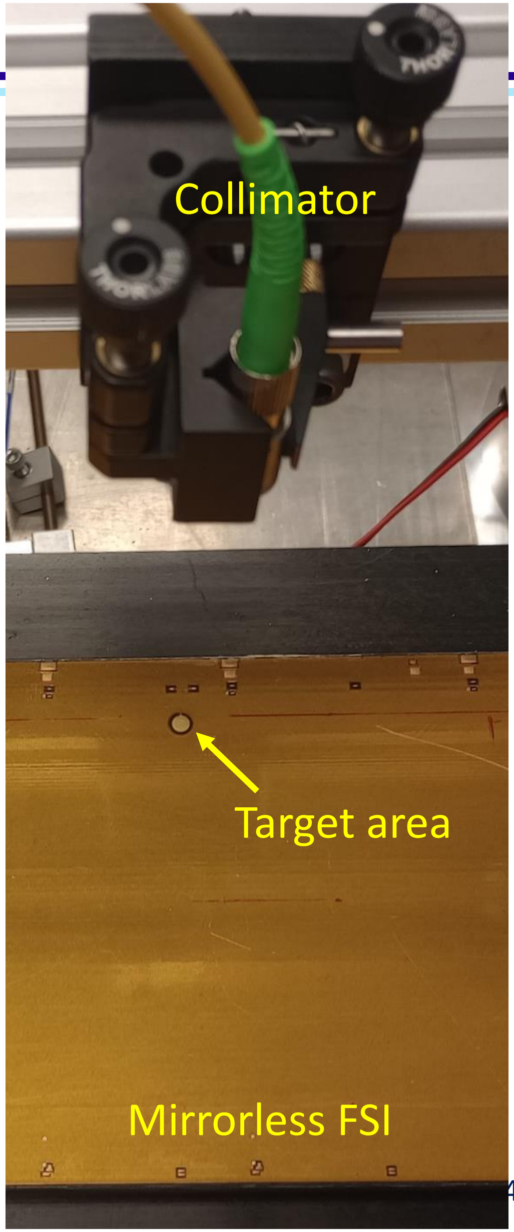
- FSI system is now operational
  - Set up on vibration table (with an ATLAS upgrade stave core – 1.4 m + most simple beam geometry)
  - 7 FSI lines + 3 capacitive sensors



Reflector details

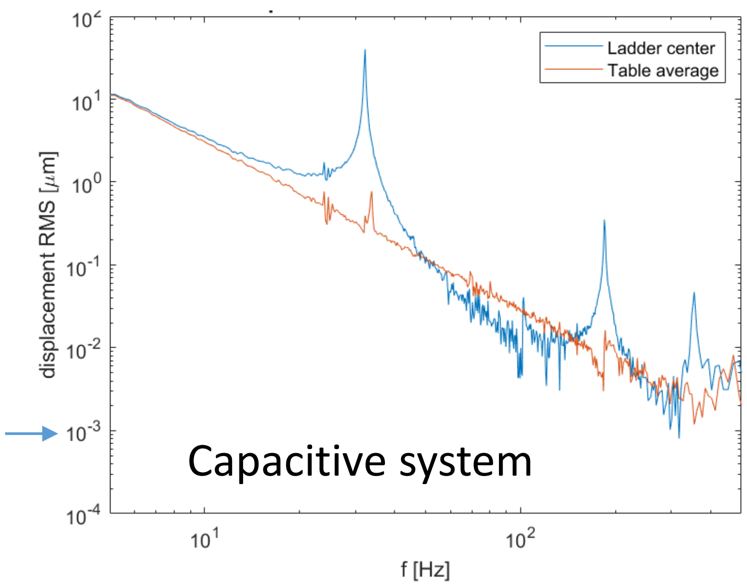
- 7 lines set up
  - 2× Reflective collimators with 5 mm diameter spherical glass retroreflectors (for table)
  - 4× Fixed focus collimators with with 1 mm diameter spherical glass retroreflectors
  - 1× Fixed focus collimator mirrorless: pointing at gold coated copper pad
- Glass retros are n = 2 with back-hemisphere coated with 350 nm gold
- Started data-taking in this configuration

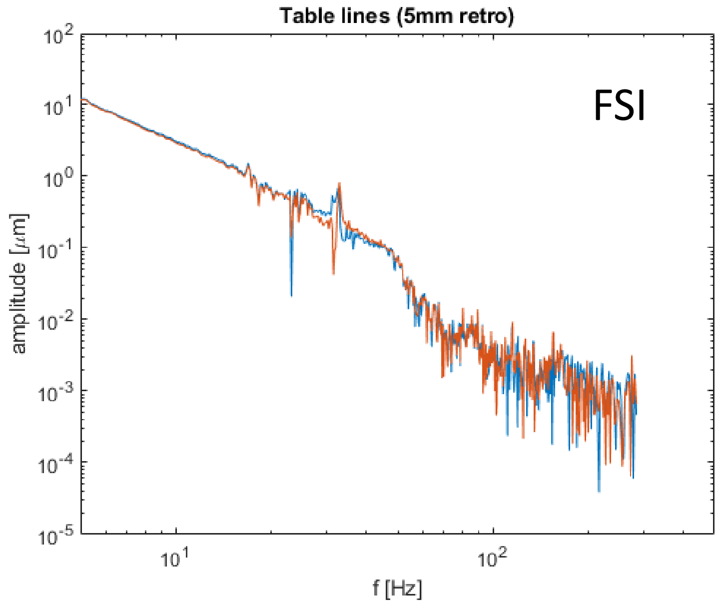


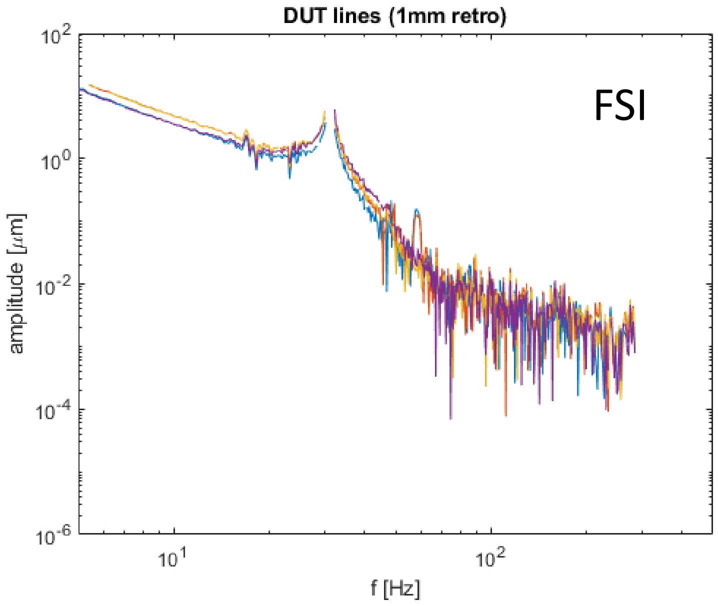


Results (very preliminary)

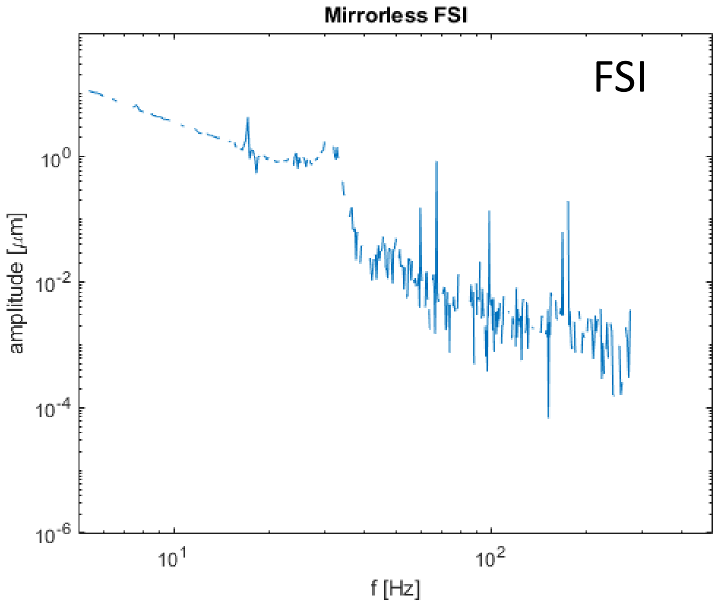
1 nm





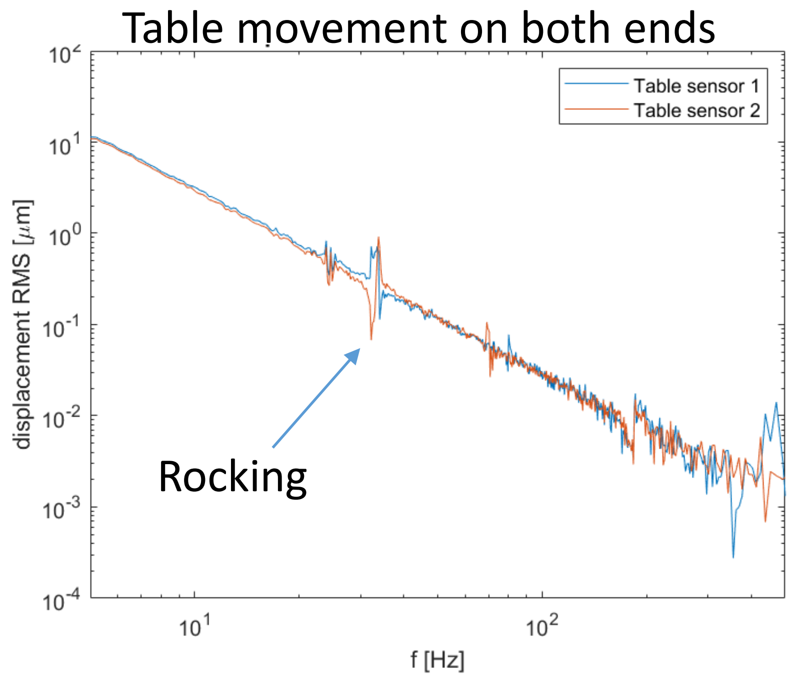


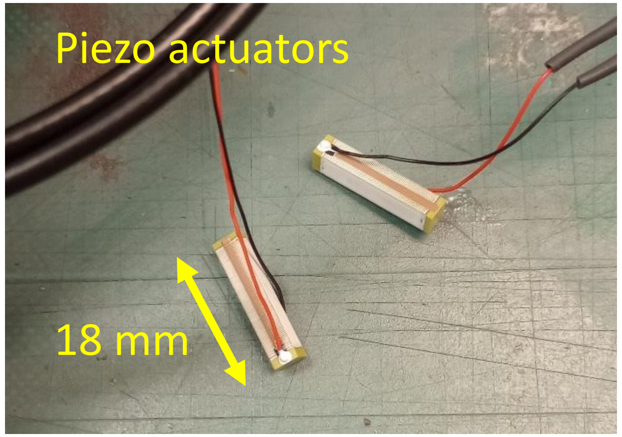
- FSI data has several issues
  - Higher noise than what we have seen in the past
  - The FSI data at the first mode resonance is missing (software currently can't cope with large (>> 10 μm) amplitudes)
  - The amplitude for the table drops at some frequency
  - 3rd and 5th mode are not visible
    - Note that the FSI retros are not in the centre of DUT, need to understand mode shape better…
- We are only at the beginning of understanding all this
  - Many of the issues are believed to be due to mounting of retros
- But: first data from mirrorless FSI is promising (taking into account that no optimisation whatever has been performed)



Vibration table improvement

- Ongoing issue with rocking motion of table (left-right)
- This was already visible for single motor (speaker operation)
- Then tried two motors
    - Still didn't solve the issue – At some frequencies, even if one motor is not excited, this end will move more than the other side
    - The issue is that the motors (speakers) excite vibration, but don't control displacement
- Investigating active control of displacement
    - Move to piezo-actuators
    - Have now procured piezos (± 9 μm) and made control electronics (0-150 V amplifier)
    - Next steps
        - In-house design & manufacture PZT casing for sinusoidal excitation underway, needs to couple to base & vibration table without transmitting moments
        - Commission in *open* and **if** required in *closed-loop* mode
        - Linearity of system not yet clear





Air flow setup

- In the past we have used reflective laser sensor in air flow setup
  - Capacitive system not suitable, as bulky and has to be close (< 1 mm)
  - This seemed to work ok, but resolution known to be poor (a few µm)
  - Access for laser by slot in air flow channel
    - This probably affects laminarity of flow
- We have tried FSI to monitor deformations
  - Stuck 1 mm sphere glass retro to capacitor on pixel ladder
  - Use the same slot for laser beam
  - FSI system fails to measure for a large fraction of events
    - Not clear yet whether this is due to reflections on the slot wall, or too close distance to DUT, or other software issues
  - It's clear that the air flow channel and its interface to the FSI system needs optimisation
    - Will come back to that once the vibration table is sorted

Future plans

- Continue with studying the FSI response with small glass retros as well as mirrorless
  - For mirrorless study
    - Optimise parameters of geometry and FSI reconstruction software
    - Improve performance with axicon lens (conical lens) for increased focal length
    - Different surfaces will be studied
  - For glass retros
    - Investigate higher noise levels and loss of data at 1st mode
    - Improve mounting (alignment is not trivial and we think is made more difficult by rotation of retro)
  - For both optimise software
- Improve control of vibration of table to prevent rocking
- Return to air-flow setup and use FSI
- Take data, write papers

Further material

FSI system data

- 1mm retros suffer from occasional signal loss → focal length shift
- Signal loss is more frequent for channel without retro

5mm Retro + Reflective collimator

5mm Retro + Reflective collimator

1mm Retro + Fixed focus collimator

1mm Retro + Fixed focus collimator

1mm Retro + Fixed focus collimator

1mm Retro + Fixed focus collimator

Mirrorless FSI channel

NOTE: The gain on each of the 7x channels is 1 with the exception of the channel without a retro where the gain is set to 8.

Vibration data (1 event) Mean distance of all events (spike indicates reconstruction failure)