

# Overview of monolithic suspension work for Advanced LIGO

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LIGO-G0900507-v2



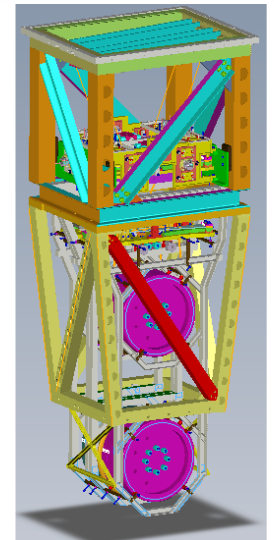
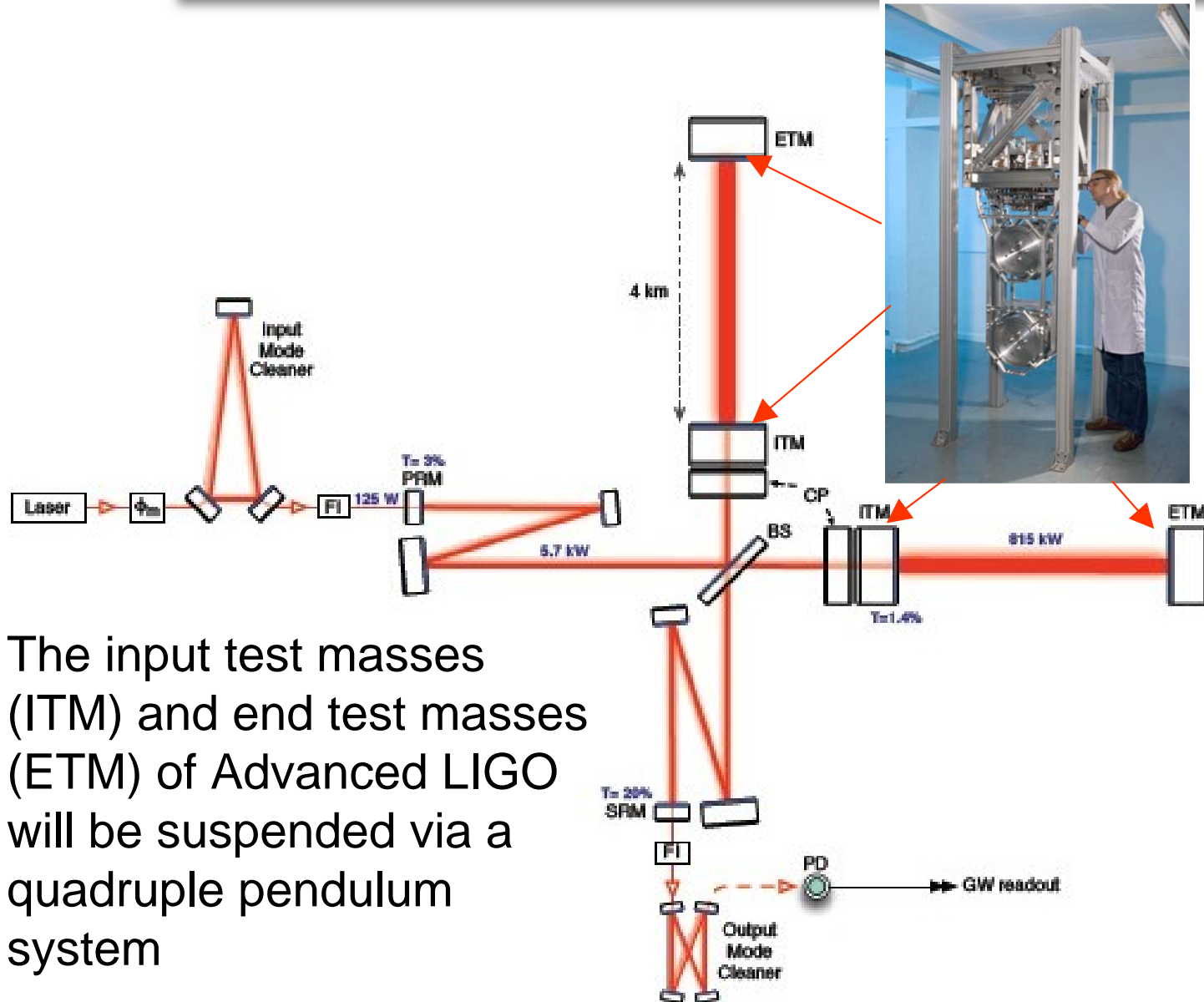
## Overview of the presentation



- Introduction to the Adv LIGO monolithic suspension
- Ear and fibre design and analysis
- Construction of the monolithic suspension
- Current status
  - full 40 kg test hang in Glasgow



# Introduction (monolithic suspension)

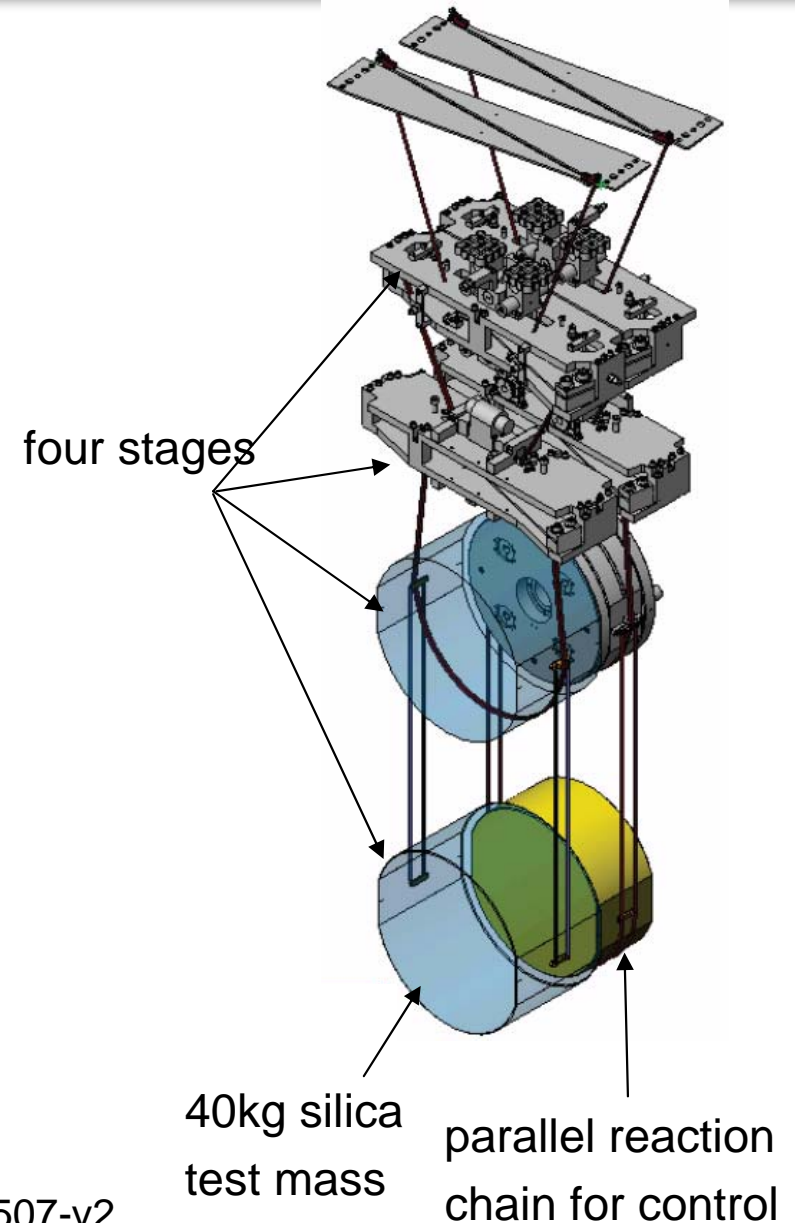


- The input test masses (ITM) and end test masses (ETM) of Advanced LIGO will be suspended via a quadruple pendulum system

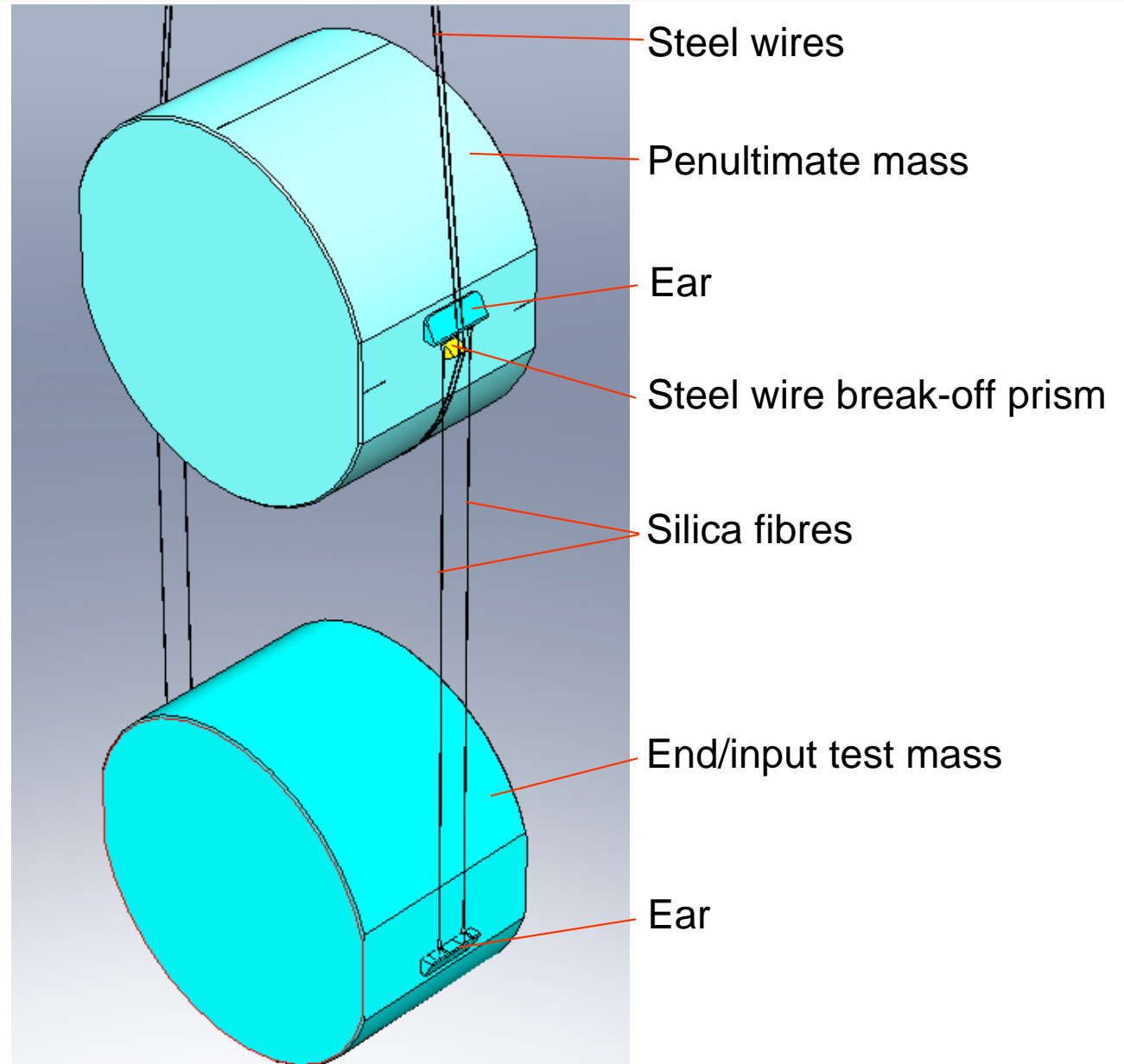


## Introduction (monolithic suspension)

- Thermal noise reduction: monolithic fused silica suspension as final stage - low pendulum thermal noise and preservation of high mirror quality factor
  - *silica fibre loss angle*  $\sim 3 \cdot 10^{-7}$ ,
  - *c.f. steel*  $\sim 2 \cdot 10^{-4}$
- Seismic isolation: use quadruple pendulum with 3 stages of maraging steel blades for enhanced vertical isolation



# Introduction (monolithic suspension)



## 1. Bond area

- Thermal noise of the bond  
**(see poster 69 Liam Cunningham)**
- Location of the ears to meet required suspension dynamics

## 4. Fibre and weld horn

- Flexure point
- Strain energy distribution
- Thermo-elastic loss  
**(see poster 113 Alan Cumming)**

## 5. Manufacturability

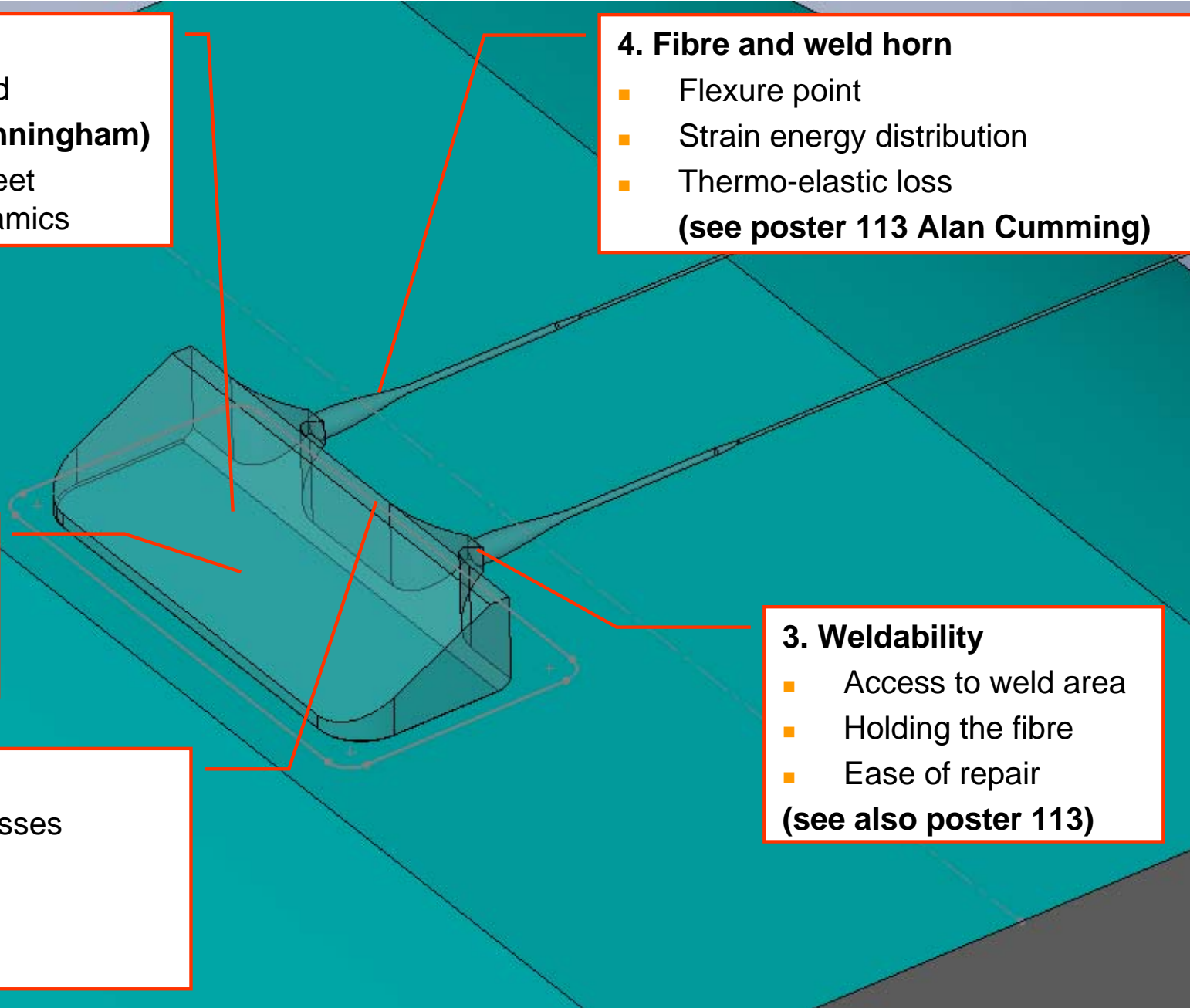
- Overall machining
- Surface finish (flame polishing)

## 2. Stresses

- Maximum principal stresses
- Peeling
- Stress concentrations
- Bending

## 3. Weldability

- Access to weld area
- Holding the fibre
- Ease of repair  
**(see also poster 113)**



## Production of the monolithic suspension



3 main stages

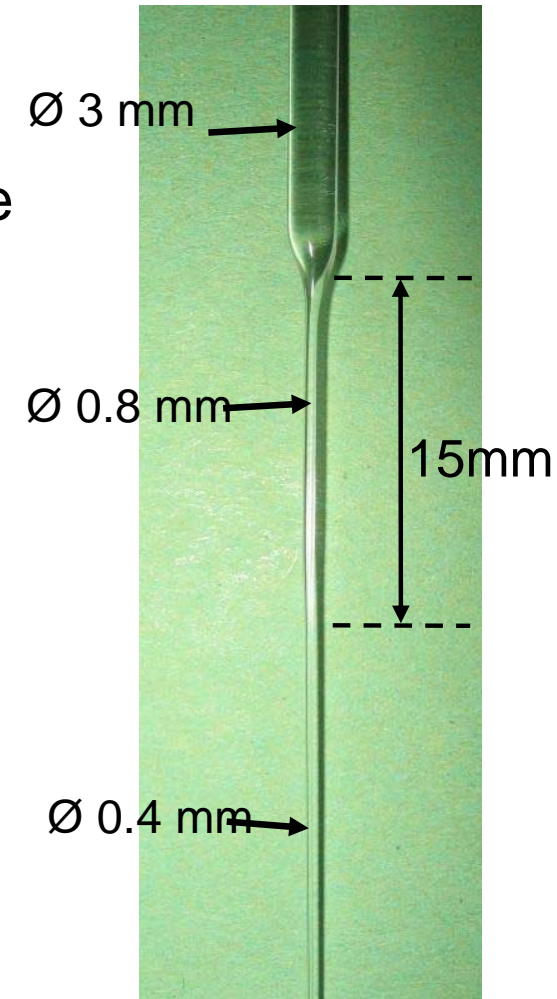
- Preparing masses by hydroxide catalysis bonding of the ears to:
  - the test mass and
  - the penultimate mass
- Manufacturing of the fibres
  - fabricate by laser pulling
  - characterisation
- Installation of fibres using laser welding



## Production of the monolithic suspension

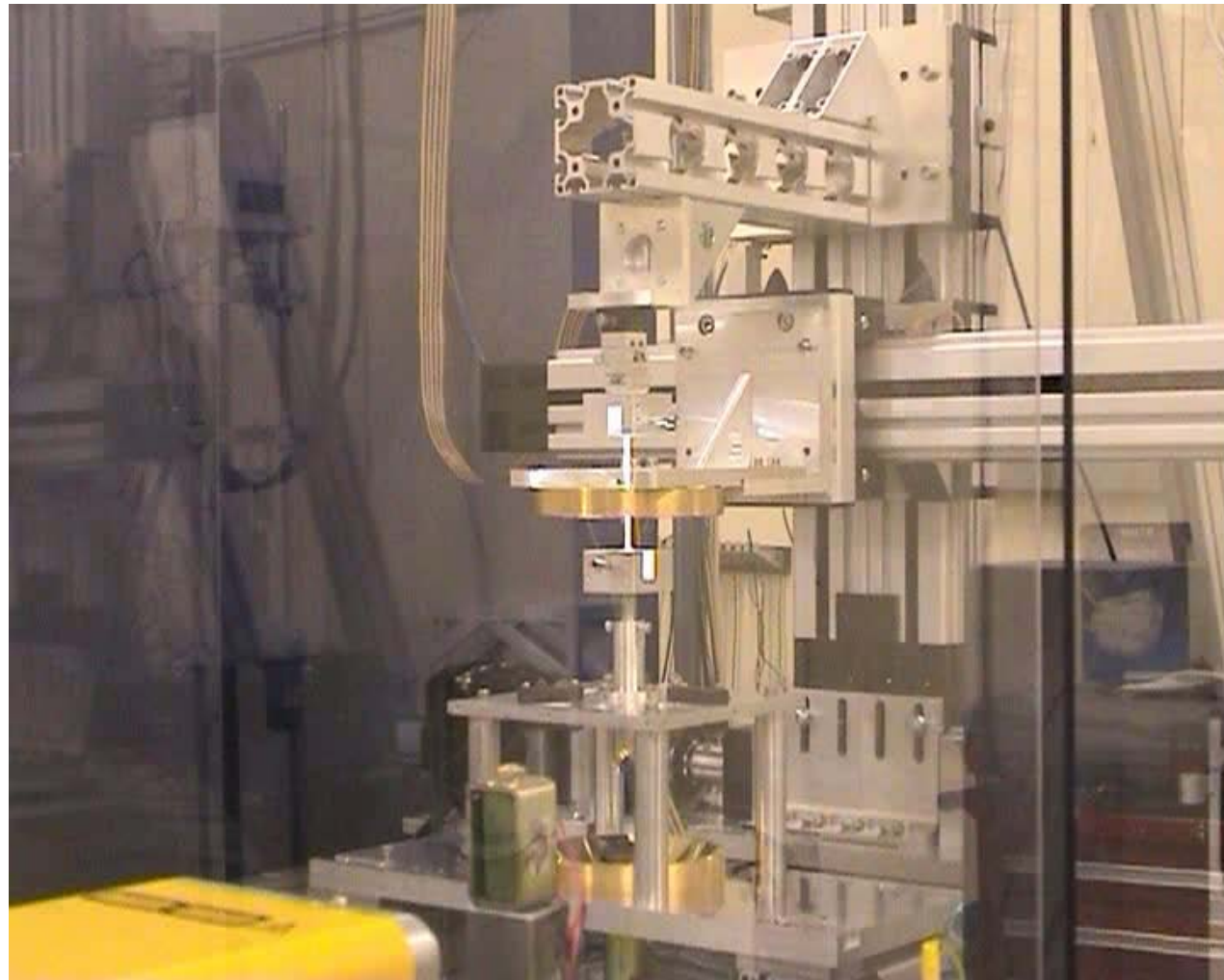
Manufacturing and characterising the fibres

- Pull fibres with a laser pulling machine
  - Dumbbell shape for thermo-elastic noise optimisation and frequency





## Manufacturing and proof testing fibres

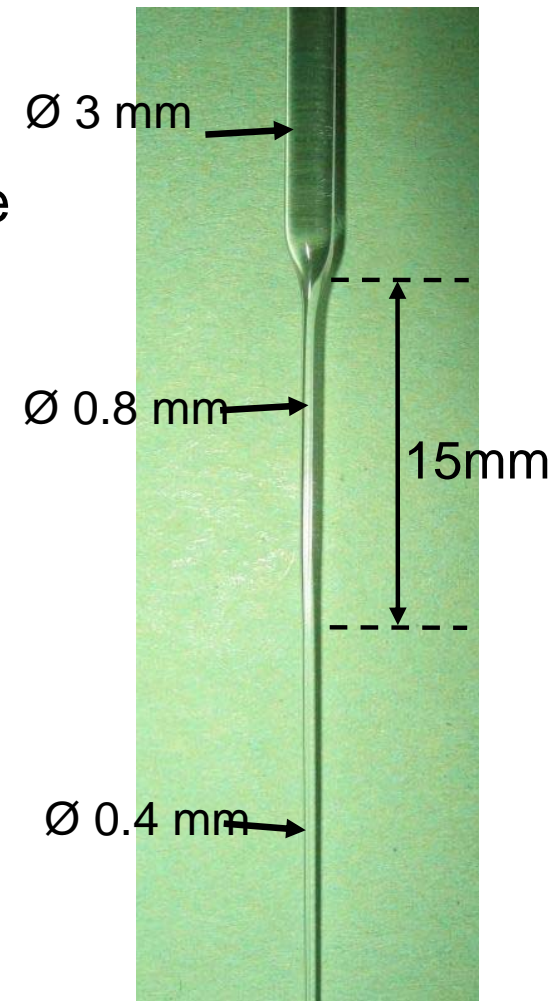


## Production of the monolithic suspension

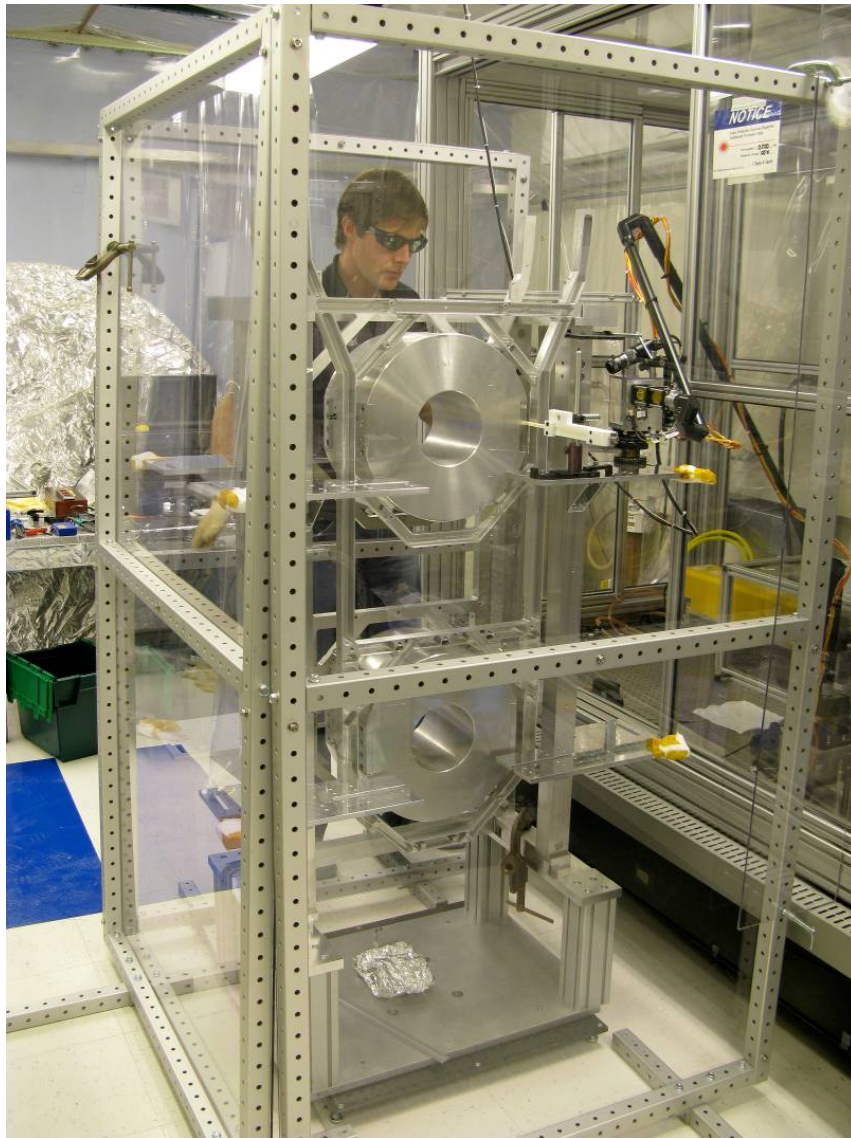


### Manufacturing and characterising the fibres

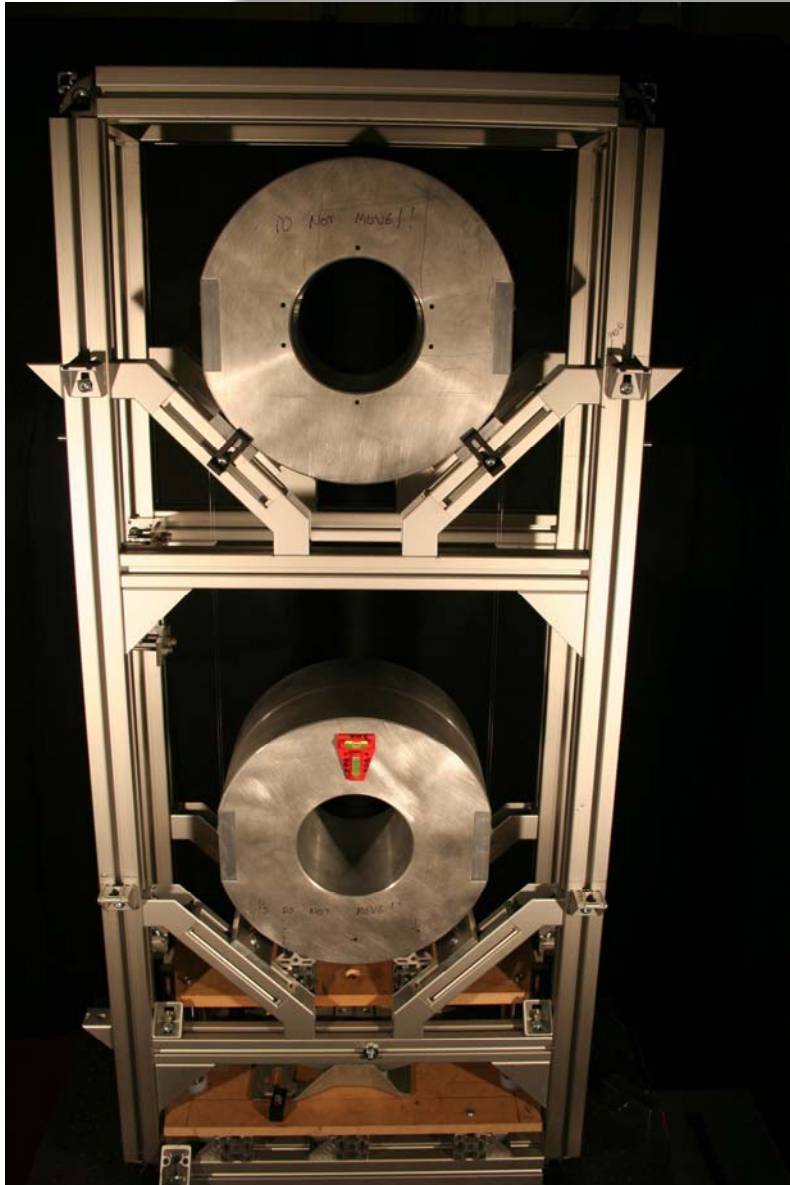
- Pull fibres with a laser pulling machine
  - Dumbbell shape for thermo-elastic noise optimisation and frequency
- Proof test fibres
  - Load fibres with 12.5 kg
- Measure the fibre profile
- Bounce test fibres
  - To determine the bounce frequency and therefore the stiffness of the fibres



## Installation of fibres



## Current status (40 kg test hang in Glasgow)



25th June 2009



LIGO-G0900507-v2

## Current status (40 kg test hang in Glasgow)



## Current status

- First 40 kg test mock ‘monolithic’ suspension has been successfully accomplished in Glasgow
- Experiments have been conducted to measure the resonances of the suspension

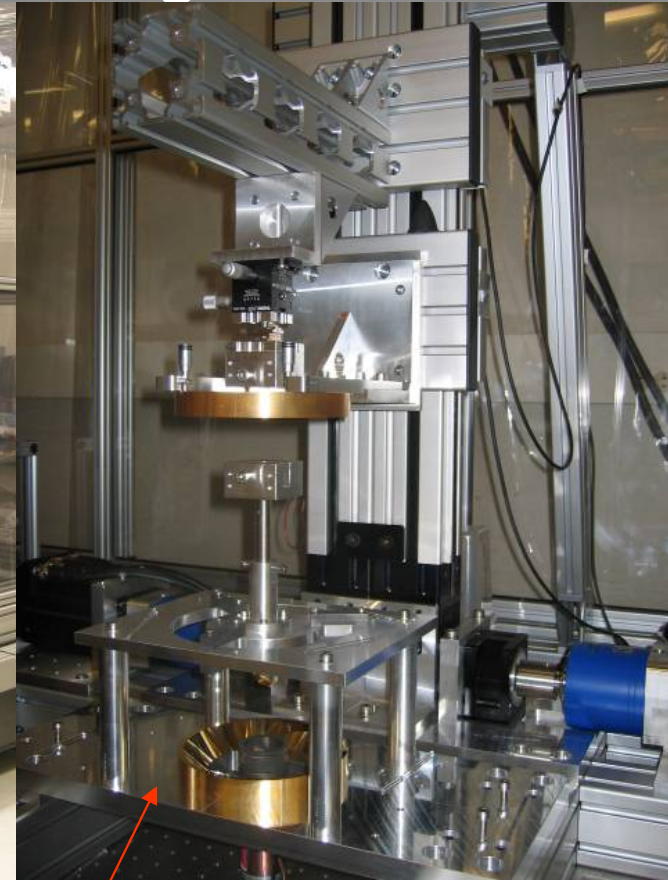
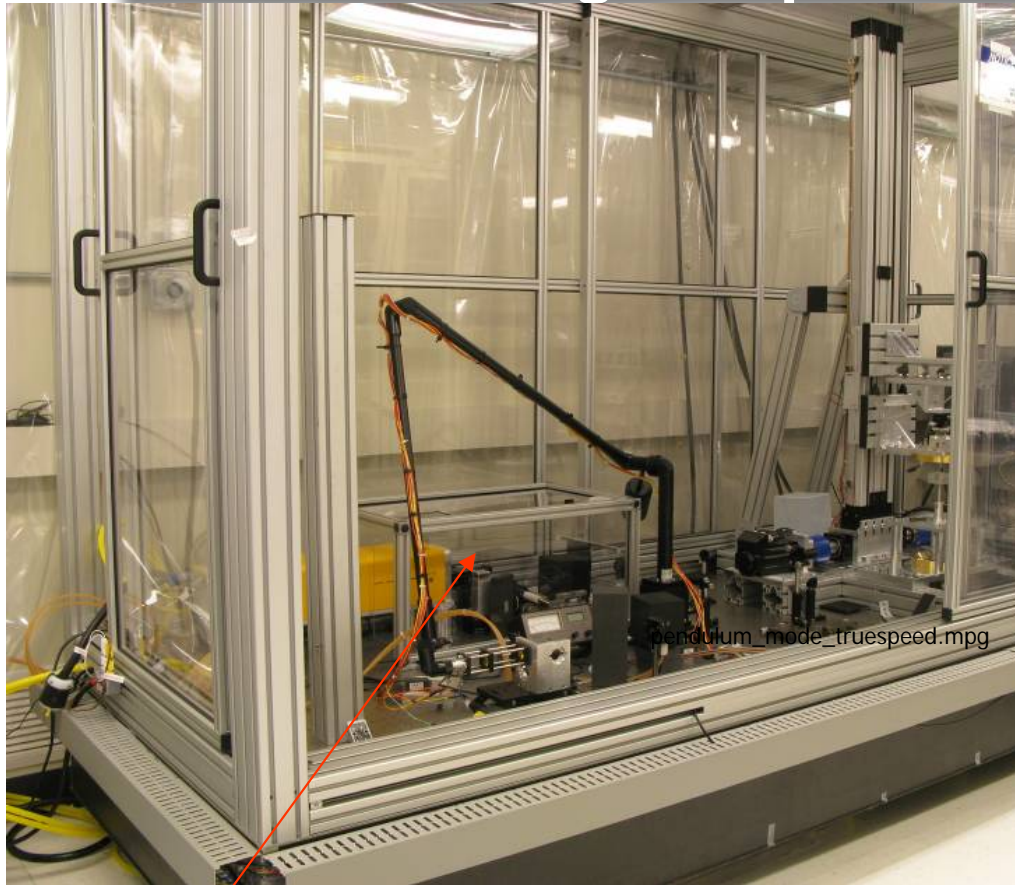
Mode	Modelled frequency (ANSYS) [Hz]	Measured frequency [Hz]
Pendulum	0.65	0.64
Pitch	1.09	1.03
Yaw	1.09	1.08
Bounce	7.00	6.42
Violin	452.2	452.6, 450.9, 453.4, 450.5

- Currently we are preparing for two similar mock suspensions in LASTI followed by the true ‘monolithic’ suspension
- Progress is excellent





# Manufacturing and proof testing fibres



Fibre pulling machine and articulated arm

Close-up of the conical mirrors for fibre pulling

