LIGO-G080540-00-Z

University of Glasgow

Update on the Fused Silica Suspension for Advanced LIGO

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L-V Meeting, Amsterdam, 22nd-25th September 2008

IGR LSC SUPA

Overview of the Talk

- Baseline fibre for Advanced LIGO
- Status of the pulling machine at LASTI
- Status of welding at LASTI and Glasgow
- Performance of fibres and welds
- Status of the tooling at LASTI
- Future work and schedule

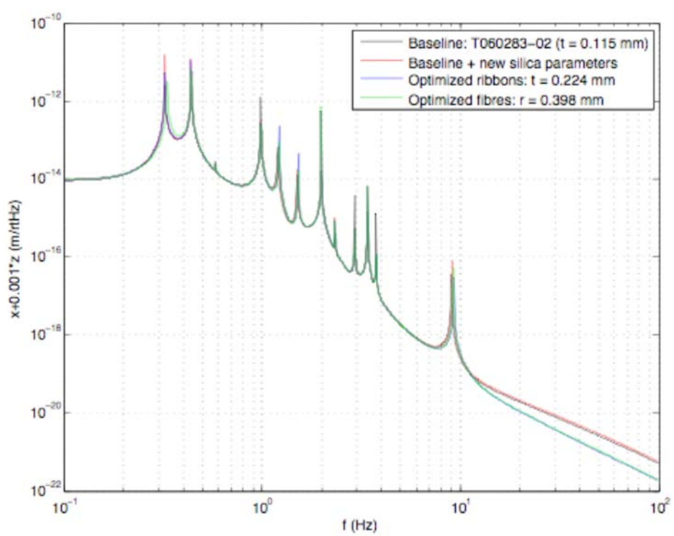
Baseline Fibre for Advanced LIGO

- The baseline design for Advanced LIGO is a circular cross section dumbbell fibre

$$\phi_{total} = \frac{1}{D}\left[\frac{E_{surface}}{E_{bulk}}\phi_{surface} + \left(\frac{YT}{\rho C}\right)\left(\frac{\omega\tau}{1+(\omega\tau)^2}\right)\left(\alpha - \left[\frac{1}{Y}\frac{dY}{dT}\right]\frac{\sigma_0}{Y}\right)^2\right]$$

dilution surface loss thermoelastic loss

- An optimised circular fibre and ribbon have very similar thermal noise performance (T080091-00)



G. Cagnoli and P. Willems, Phys. Rev. B, 2002
P. Willems, T020003-00

A.M. Gretarsson et al., Phys. Rev. A, 2000

M. Barton et al., T080091-00-K

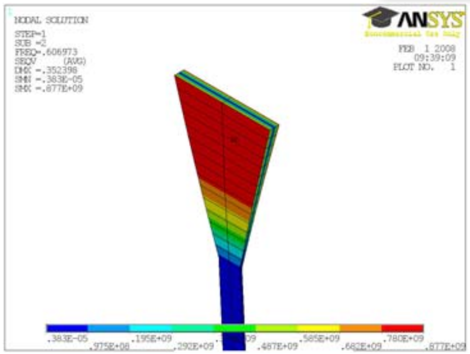
Baseline Fibre for Advanced LIGO

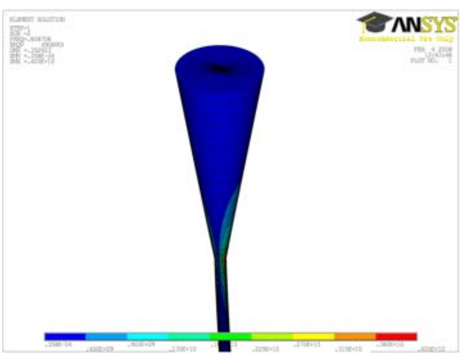
- Furthermore, the dilution factors for “real” and “ideal” suspension elements have been reanalysed using FEA (R. Kumar, MSc. thesis, A. Cumming, Ph.D. thesis)

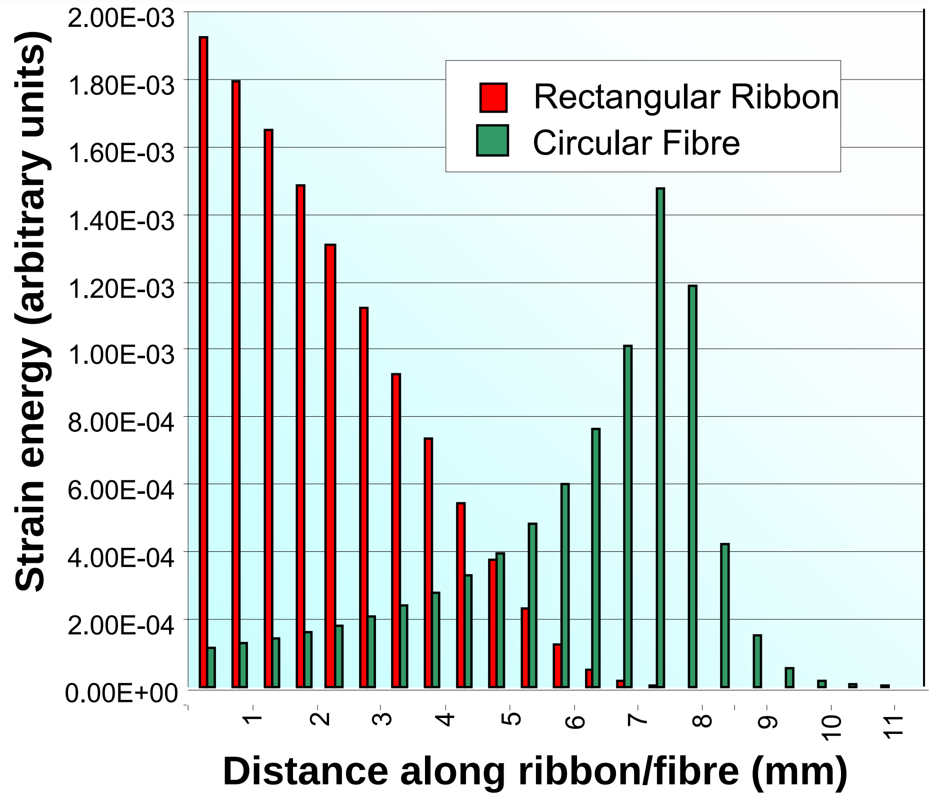
(following work by P. Willems and M. Thattai, Phys. Lett. A, 1998)

- The strain energy distribution in the neck region is an important factor when trying to assess the real performance of a particular geometry

Baseline Fibre for Advanced LIGO



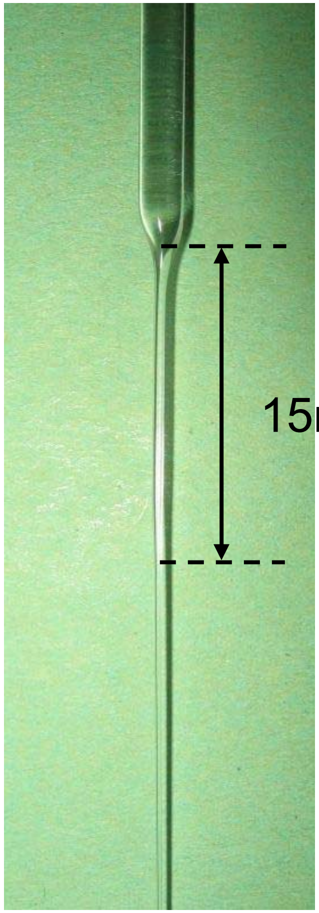


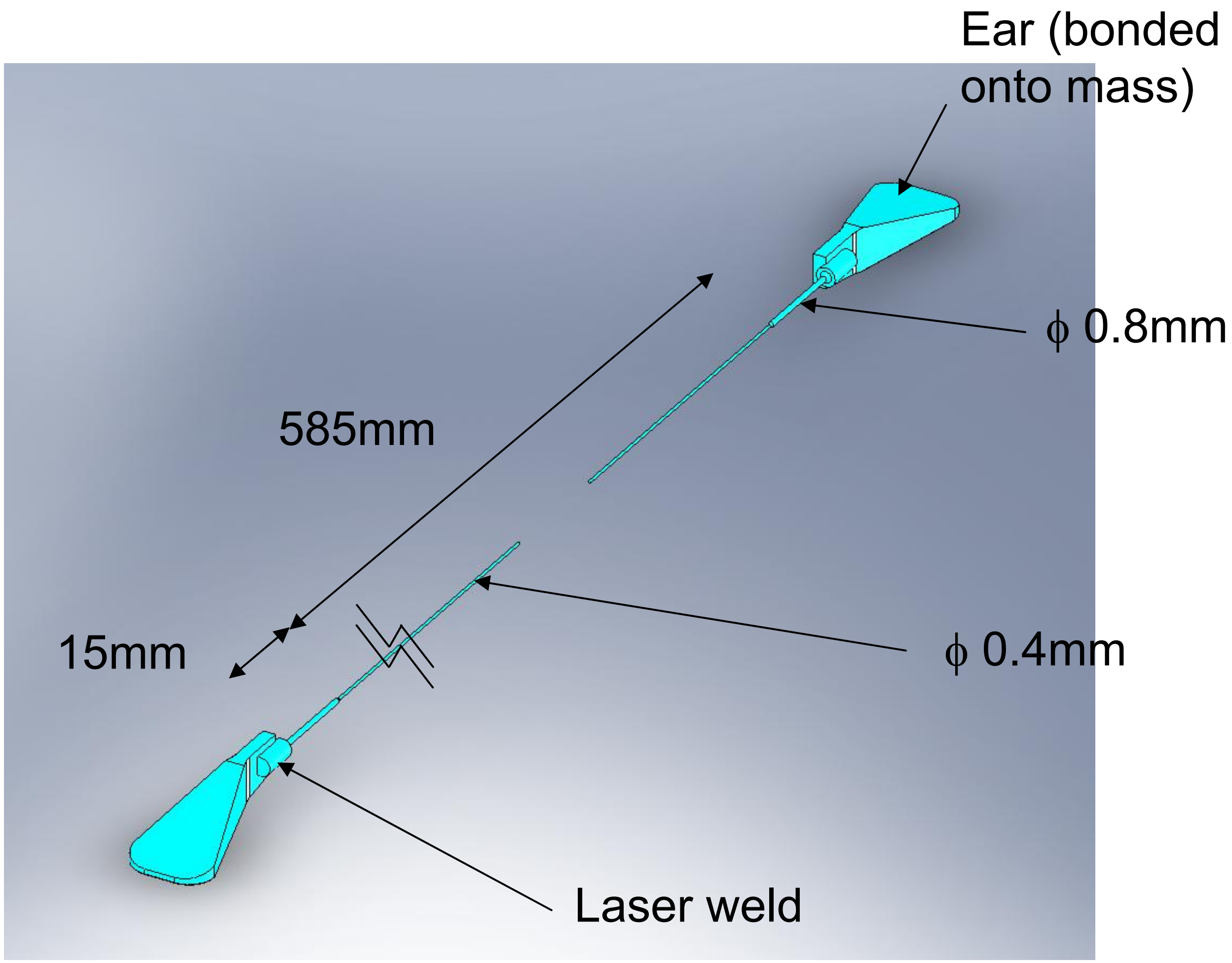


- The FEA can also be used to predict amount of strain energy residing in the neck/weld region

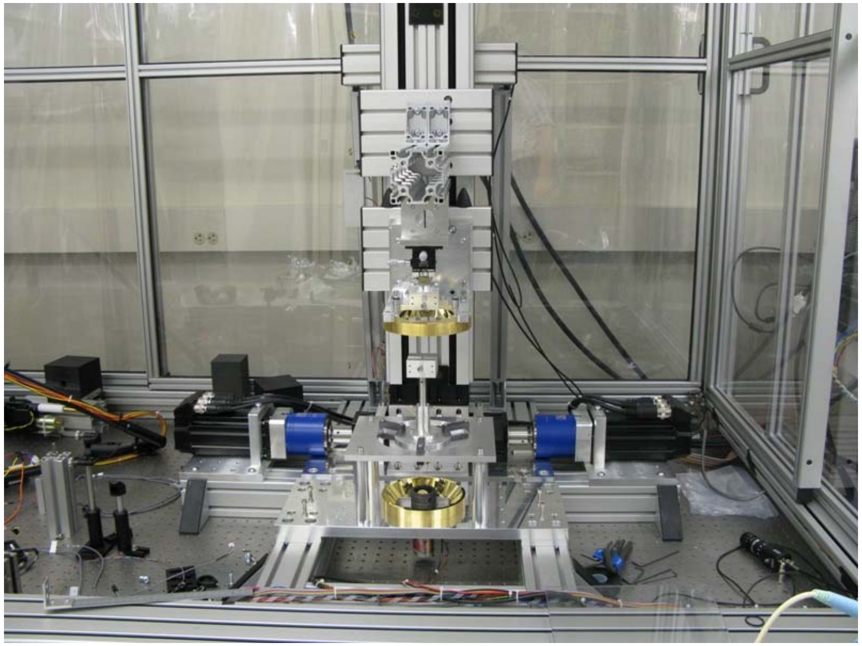
- This allows the prediction of the thermal noise in real fibres

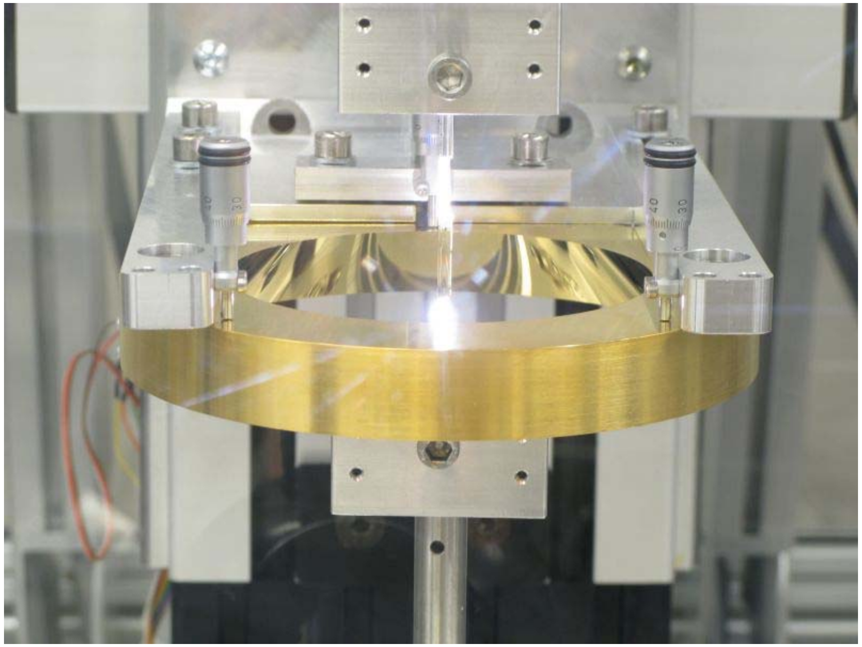
Baseline Fibre for Advanced LIGO





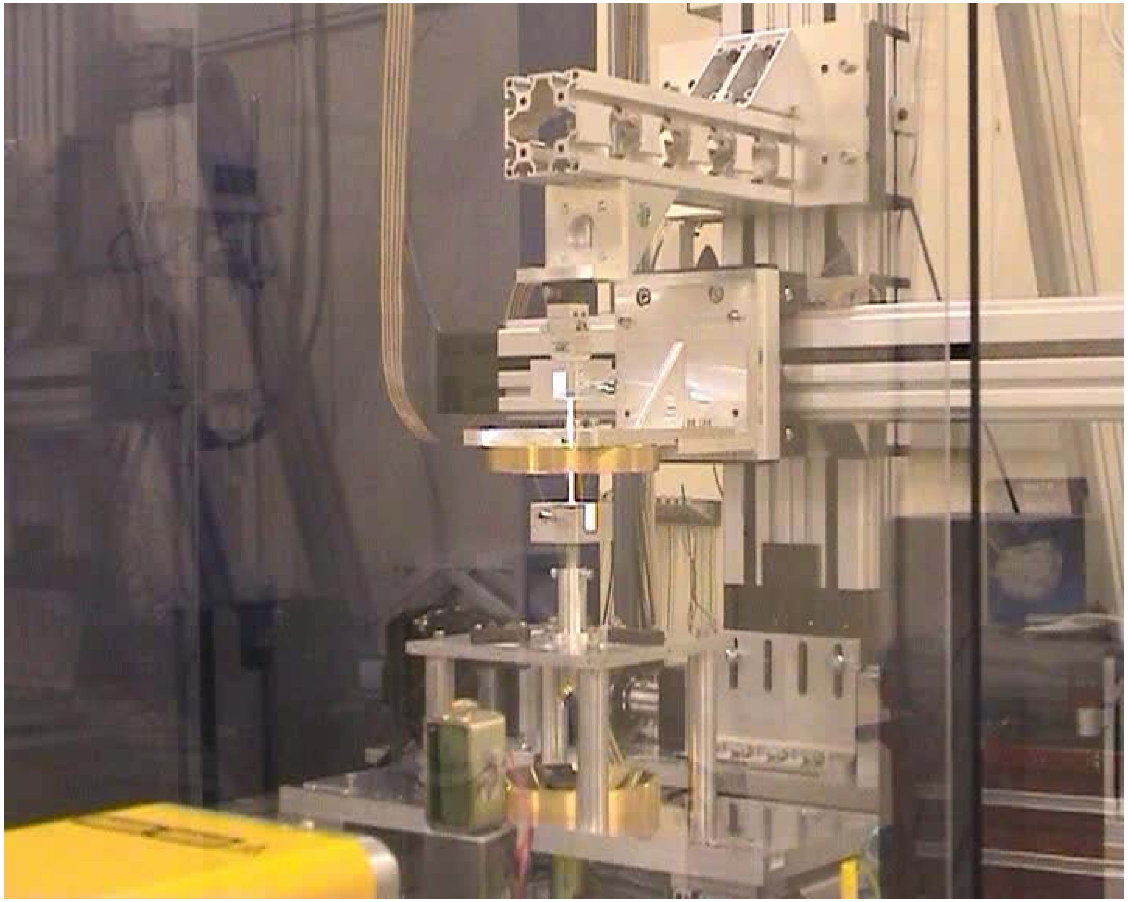
Pulling Machine at LASTI





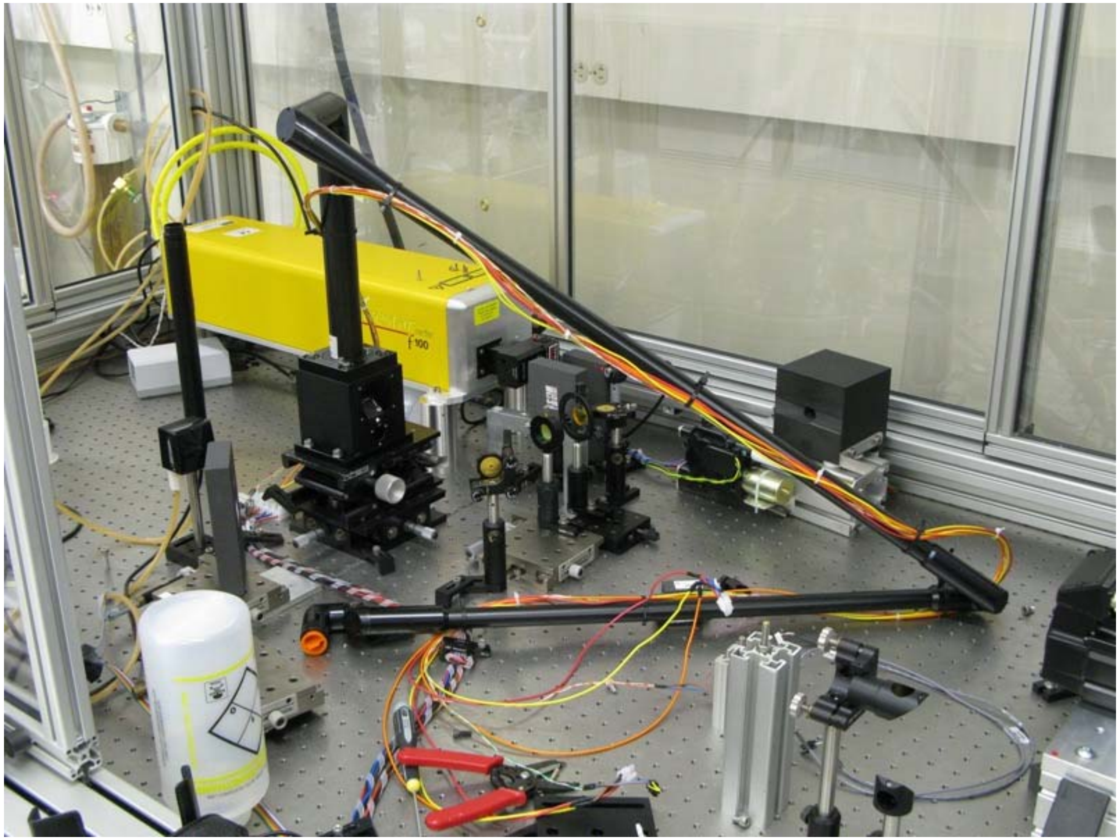
- Pulling machine is well aligned and capable of good reproducibility
- Length tolerance ≈0.1mm
- Recipe for fibres developed in collaboration with Glasgow/LASTI
- Fibres are stored in racks within a low humidity enclosure
- Strong fibres (>5GPa) are possible with high power + laser polishing

Pulling Machine at LASTI

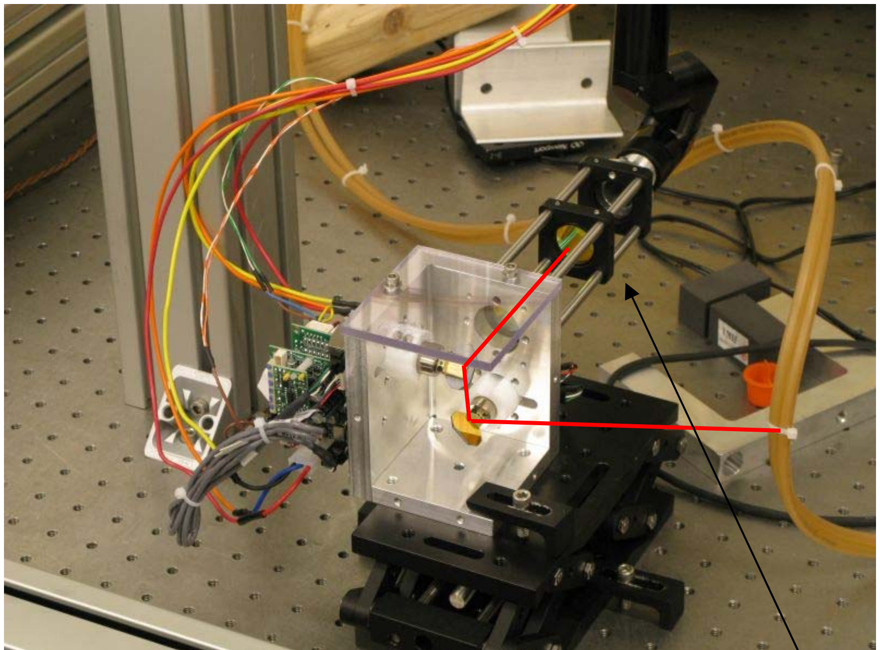


Welding at LASTI and Glasgow

- There has been significant effort on the production and testing of laser welds
- Weld using articulated arm and focussing optics to optimise beam size



Welding at LASTI and Glasgow

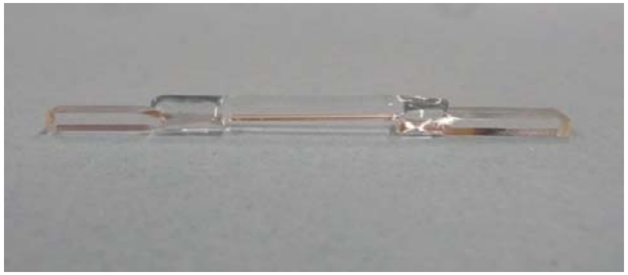


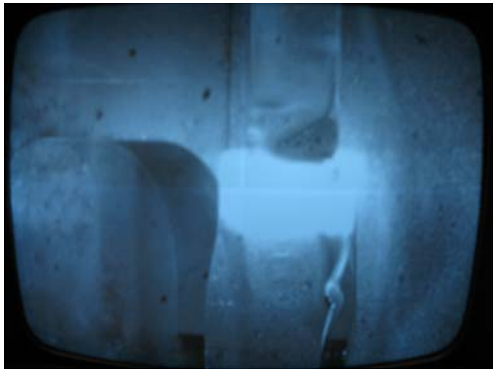
articulated arm

optics

camera

Welding at LASTI and Glasgow





The user can manipulate the beam and observe welding on a TV monitor

Performance of Fibres and Welds

ϕ 0.35mm fibre

Performance of Fibres and Welds

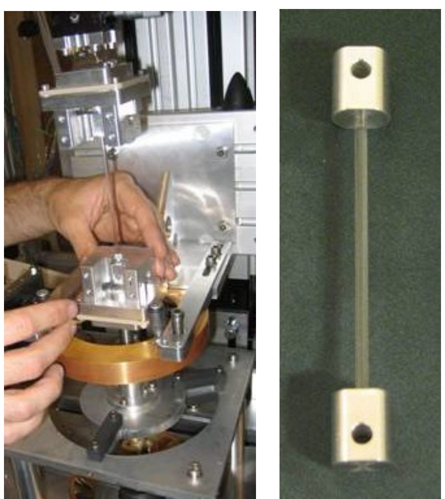
- Strong welds (>25kg) have been produced and are currently limited by misalignment in the strength tester

Strength testing welds

Test hang with 12.5kg

Tooling at LASTI

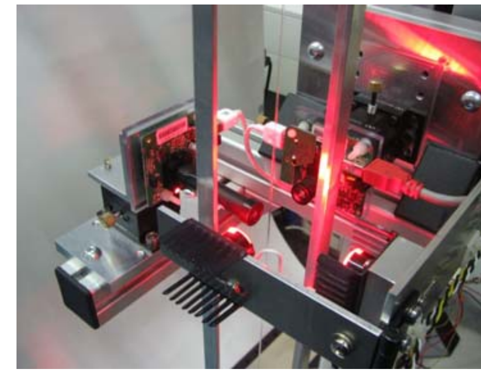
Fibre storage



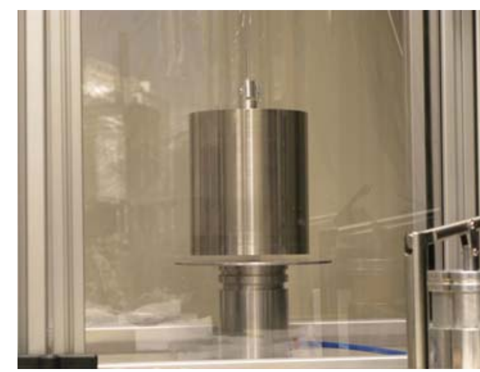
Fibre handling

Cut fibre on “bow”

Profiler Cutter Bounce tester



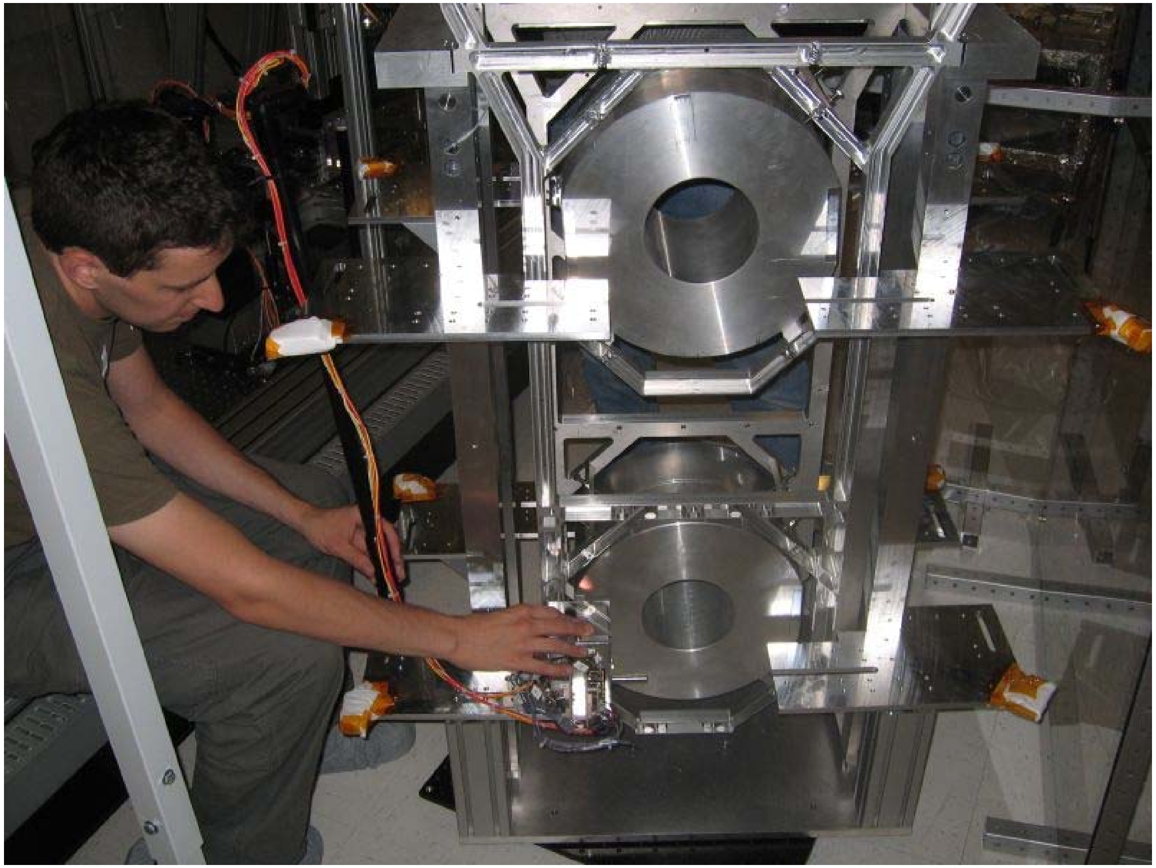
Profiler



Proof test (12.5kg)

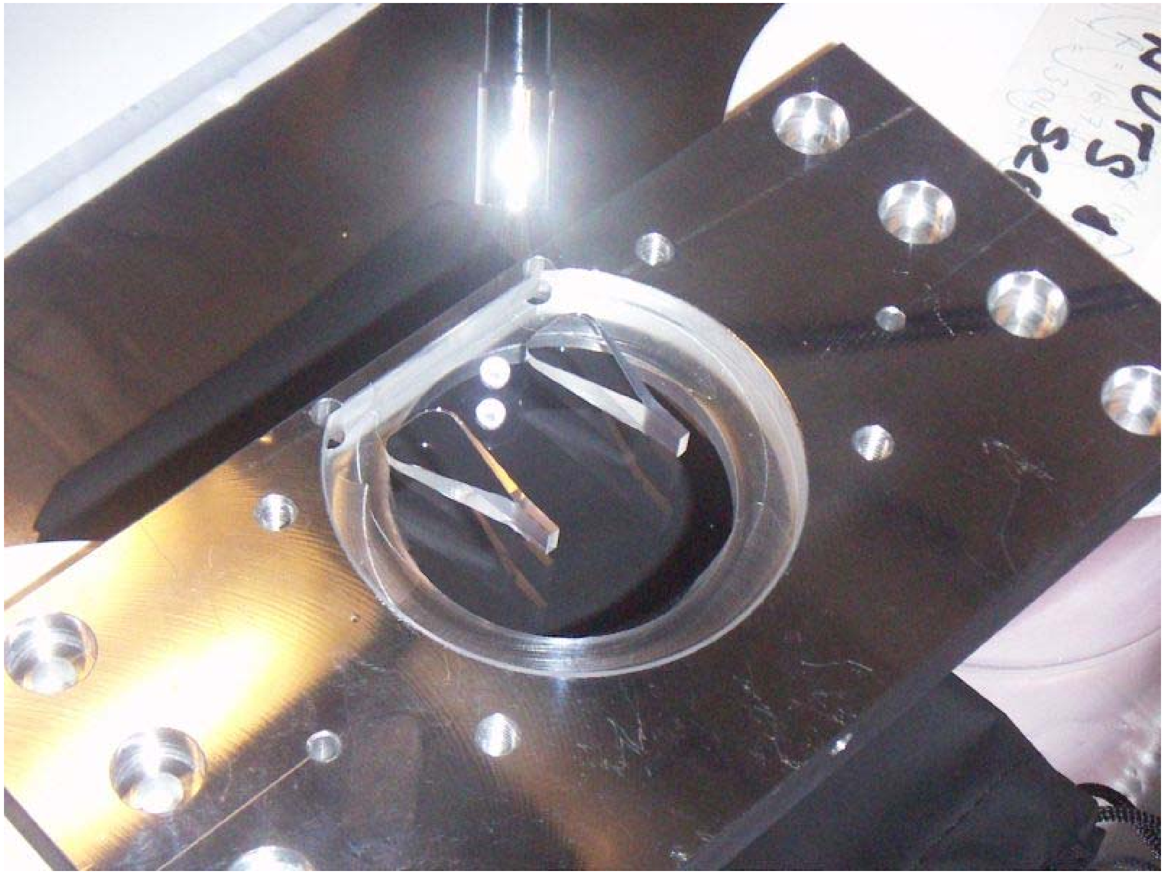
Tooling at LASTI

- Preparation for the Noise Prototype (2 pseudo monolithic hangs and 1 monolithic hang)



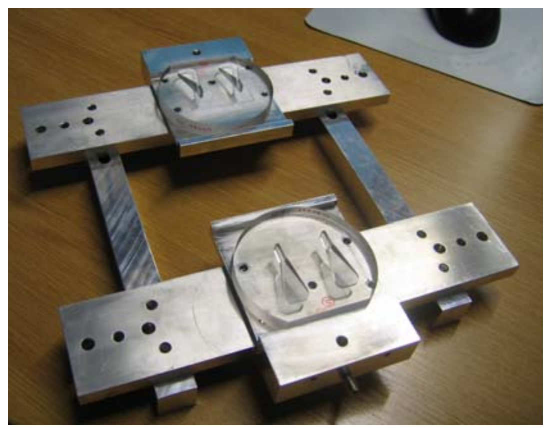
Tooling at LASTI

- Preparation for the pseudo-monolithic hang



Future Work and Schedule

- Circular dumbelled fibres are strong and a well developed recipe exists
- Welds have been seen to be strong under unfavourable test conditions
- A new strength tester at Glasgow is being used to test the strength of two laser welded fibres side-by-side (half a suspension)



- 2 pseudo-monolithic hangs are scheduled for mid October
- If all goes well, a final monolithic hang will take place in late October-early November.