LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000016-v1 *ADVANCED LIGO* 29th January 2010

ALIGO NP-type: - Preparations of Ear Bonding at LASTI (February 2010)

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1 Contents

2 Document history

Version v1	*29th January 2010*	*First draft of report for comment (M. Van Veggel, N. Beveridge)*

3 Introduction

In the second half of February 2010 an exercise will be done at LASTI to bond the “new” silica ears to the second penultimate mass and reglue the prisms onto the penultimate mass, remove the current prisms and ears from the test mass and bond the “new” silica ears to the test mass.

In July 2009 the “old” ears and prisms were already removed from the penultimate mass. This has been reported in T0900369-v1.

This document is a preparation document for the work described above. It lists: goals, needed documents, check list of needed materials, list of tasks to be completed before the exercise starts, a schedule and procedure for the work that will be done.

4 Reference documents

Design documentation 'glass' essentials	
D050421-05-K	NP- type ETM Penultimate Mass
D040431-C-D	Quad ETM Silica Test Mass
D080751-v2	NP-type Ear (second prototype)
D090007-v1	NP-type Notched Ear (second prototype)
D060099-03	NP-type Penultimate Mass break-off prism
Design documentation of the alignment jigs	
D0901592	ASSEMBLY DRAWING – NP-type bonding jig
D0901591	Baseplate – NP-type bonding jig
D1000128-v1	Penultimate mass prism holder
D1000129	Assembly of the bonding jig with prism holder on the ETM/ITM penultimate mass
Measurement reports on 'glass' essentials	
GNL-4025-R1	Penultimate mass 1 measurements
GNL-4027-R2	Penultimate mass 2 measurements
C070035-00	Test mass measurements
T0900557-v3	N/P-type monolithic suspension: testing record for test ears
Back ground documents	
E050228-00-D	(Specification) Silicate Bonding Procedure
E070070-00-D	LASTI Test Mass, Handling and Shipping Procedures
T070223-00-K	ALIGO NP-type: - Report on Ear Bonding at LASTI 27th August – 31st August
E970154-D-D	Large optics suspension balancing: component specification
T0900369-v1	Removal of the ears and prisms at LASTI in July 2009
T0900447-v3	Ear fabrication readiness review
T070138-00-K	Ribbon/Fibre Length Budget
T0900374-v1	The new D2 value for the ALIGO Quad suspension
T0900372-v1	Assembly Data for the Quad Noise Prototype
T080041-01	ALIGO NP-type - Report on prism bonding at LASTI on 11th -17th February 2008

5 Goals of visit to LASTI

Goals of the visit are to:

1) Bond ears to 2nd penultimate mass
2) Glue prisms to 2nd penultimate mass
3) Unglue prisms from test mass
4) Remove old ears from test mass
5) Bond ears to test mass

6 List of tasks to be completed before visit to LASTI

1) Practise grinding of ears (Nicola and Marielle)
2) Fit check mask (Nicola)
3) Design and build debonding rack (Marielle)
4) Design and build prism holder (Marielle)

7 Expected time schedule

Table 7.1 Expected time schedule

	Wednesday 17-02-2010		Thursday 18-02-2010		Friday 19-02-2010		Saturday 20-02-2010		Sunday 21-02-2010	
Preparations										
Remove prisms test mass										
Remove ears tests										
Prepare for bonding										
Bond ears to side 1 penultimate mass										
Bond ears to side 2 penultimate mass										
Bond ears to side 1 test mass										

	Monday 22-02-2010		Tuesday 23-02-2010	
Bond ears to side 2 test mass				
Glue prism to side 1 penultimate mass				
Glue prism to side 2 penultimate mass				
Clearing up				

8 Required items list

Essentials

- Ears (2x D080751 for the test mass + 2x D090007 for the penultimate mass, plus spares)
- Masses (penultimate mass 2 and the test mass)
- Penultimate mass prisms two grooves (2x D , plus spares)

Bonding Jig

- 2 full bonding jigs are available for use (D0901592 including templates, prism holders, t-pieces etc)
- Tools for setting up jig (Allen keys)

Ear removal equipment

- Aluminium ear cover sheet
- Dremel tool with grinding discs
- Respiratory masks with P3 dust filters
- Protective goggles
- ULPA vacuum cleaner

Bonding equipment and consumables

- Flowing de-ionised water
- Methanol
- Acetone
- Deionising gun with pure, filtered nitrogen (low pressure)
- Centrifuge tubes (15 ml)
- Small centrifuge tubes (1.5 ml)
- Centrifuge
- Optical wipes
- Cerium oxide powder
- Sodium bicarbonate powder
- Petri dishes
- Sodium silicate solution (14% NaOH, 27 % SiO_2, Sigma-Aldrich)
- 10 µl pipettes
- 10 µl pipette points
- Copper wire
- Permer-Elkin Vac-Seal epoxy
- Vacuum chamber for debubbling
- Heat lamp on stand

Large items

- Ergo arm + vacuum pump and container and ring clamp
- Washing trolley (trolley with ultrasonic bath)
- V-blocks
- 2 tables (one for set-up and one for bonding)

Measuring devices

- Plastic ruler
- Digital callipers
- Metric Slip gauges

Other items

- Lighting: Osram LED work light
- Magnifying glass
- Clothing: Clean room suits, overshoes, gloves, hairnets, face covers
- First Contact™ surface polymer
- Crash mat: used below ergo arm when manipulating the mass in free space
- Photo camera
- UHV aluminium foil
- Kapton tape

9 Procedure

9.1 Preparations

Fill in safety forms with David Schoemaker and Rich Mittleman.

Main safety risks are:

- the lifting of the masses (have catcher bars in place during moving the masses)
- silica vapour production. Precautionary measures are: having a running ULPA filtered vacuum cleaner near the silica vapour source, wear protective facemasks and goggles.

The bonding solution is not hazardous as we are working with very small quantities and will wear protective clothing (overall and gloves)

The preparations of the laboratory involve:

- Ensuring that the laboratory is clean
- That the HEPA filters are running
- Ask for a particle count
- Sufficient stock of:
    - Cleanroom clothing (overalls, shoes, hairnets, facemasks, gloves: size small)
    - Cleanroom wipes
    - Methanol
- Check required items list all accounted for
- Check ergo-arm (check it is working and also check cleanliness)

9.2 Take the test mass out of the structure

The mass will still be sitting in the inner structure and or task is to take it out of the structure and pack it in its container and transport it to the bonding laboratory. The proposed procedure is the following:

In the high-bay:

- Apply First Contact on both the HR and AR surfaces
- Set-up the metal container ready to lower the mass down into it. The metal container should be clean.
- Move in the ergo-arm, align and apply the vacuum (the First Contact will stay on the surfaces when lifting the mass)
- Very carefully retract the stops (Earthquake and line stops)
- Very carefully move the mass out of the structure (this will require 3 or 4 people, two persons manipulating the arm, two people looking very carefully at specific locations (prisms) to avoid collision.
- Make sure ergo-arm is well clear of the structure
- Move the ergo-arm with test mass to the metal container
- Place the mass in the metal container and release vacuum valve
- Move away ergo-arm
- Close lid of the metal container
- Put metal container with mass on trolley and move through to the bonding lab.
- Move the ergo-arm through to the bonding lab

9.3 Remove prisms from the test mass

Currently temporary wire break-off prisms are glued to the test mass (Figure 1). These prisms have functioned to supply guidance to the steel wires for the interim steel wire suspension. The prisms sit very close to the “old” ears on the test mass and have been glued on by Rich Mittleman and Brett Shapiro using VacSeal. These prisms will need to be removed to make space for the monolithic suspension. A procedure very similar to the procedure used to remove the prisms from the penultimate mass discussed in T0900369-v1 will be used for this mass.

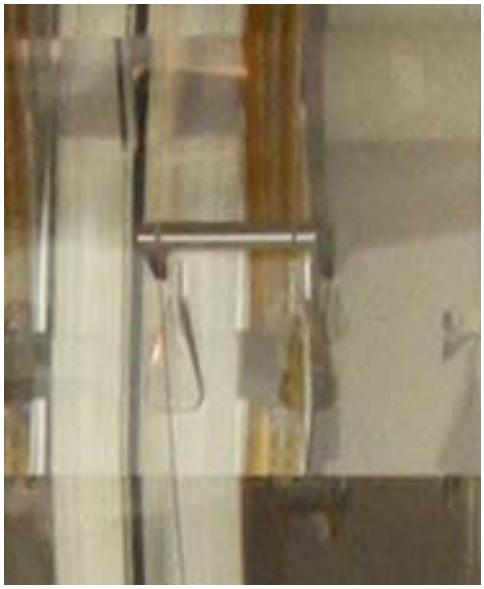


Figure 1 Steel break-off prism sitting just above the ears on the NP-type test mass at LASTI

Procedure

- Take the test mass out of its container using the ergo arm
- The test mass is set-up on it's V-block using the ergo arm, with one of the flat sides with ears up
- A clean room cloth is cut to fit around the prism with one end in a bath of DI water and Micro90
- The cloth soaks up the mixture from the bath and keeps the prism wet (Figure 2)
- This is left for ~8 hours until the prism comes loose
- The surface is then cleaned with methanol and a small piece of leaf steel
- Repeated this procedure for the other side

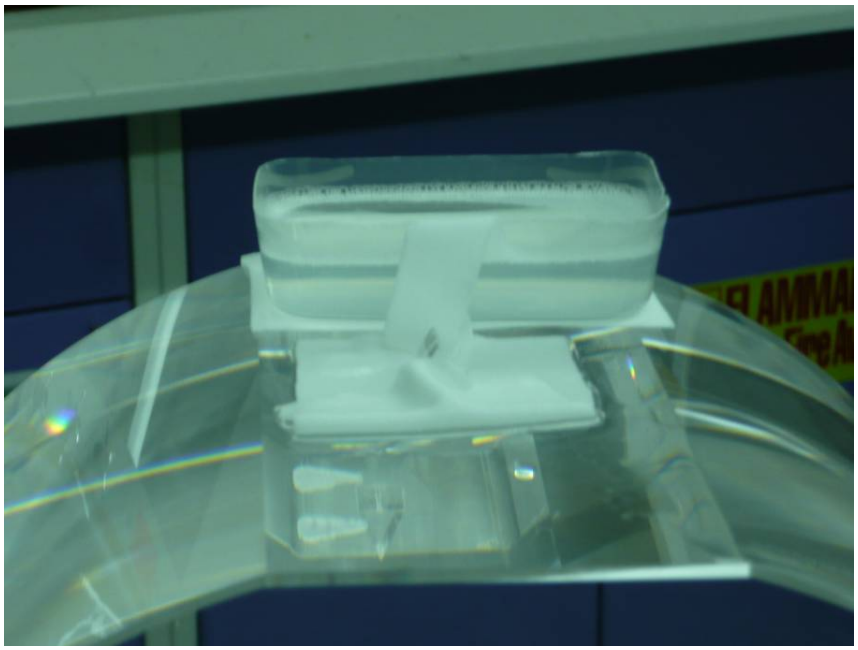


Figure 2 Prism with bath of DI water and micro90

Possibly the glue will be more secure. In that case a step will be added by applying heat to the glue with an air heat gun (Figure 3). This combined with the soaking should be enough to remove the prisms successfully.

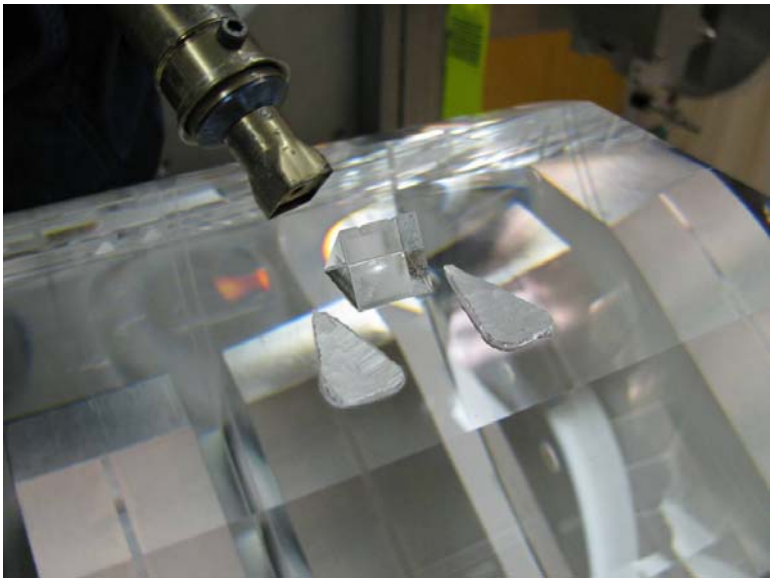


Figure 3 Air heat gun being used on prism glue

9.4 Remove ears from the test mass

The procedure used for removing the “old” ears from the test mass will be practically the same as the procedure used for removing the “old” ears from the penultimate masses as discussed in T0900369-v1:

- Both AR and HR face are protected by applying a First Contact protective layer
- The test mass is set-up on its V-block using the ergo arm, with one of the flat sides with ears up.
- Use a diamond scribe to scratch both sides of the weld horns at the shoulder (Figure 4). The horn is then snapped off by bending the horn inward towards the centre of mass.

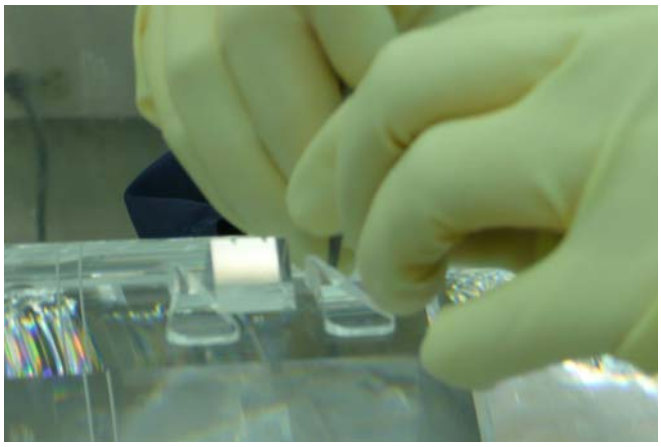


Figure 4 Diamond scribe being used to remove weld horn

- The flat is covered with a protective aluminium sheet (covered with Teflon at the bottom)
- The rest of the mass is covered with a layer of optical cloths and a house of aluminium foil, sealed with Kapton tape (Figure 5)

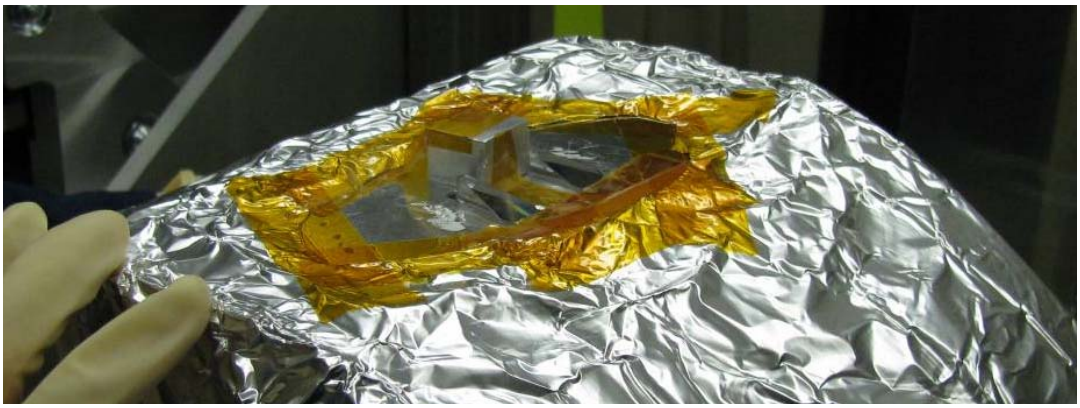


Figure 5 Ears with prism and mass protected by metal plate

- Personnel put on respiratory masks with P3 dust filters and protective goggles (Figure 6)

Figure 6 Wearing protective goggles and respiratory mask with P3 dust filters

- Turn on vacuum cleaner and hold close (Figure 6)
- Use the Dremel tool with diamond cutting disc to remove one ear and then the other ear (Figure 7)

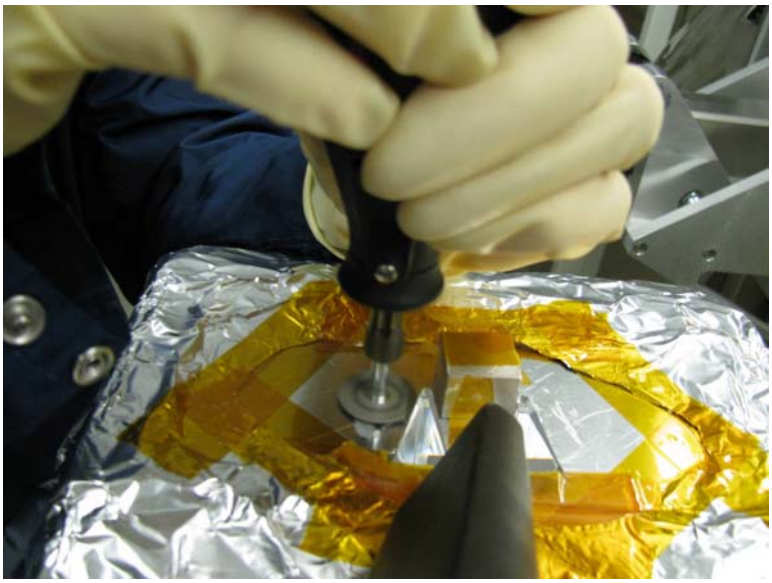


Figure 7 Dremeling ear with diamond cutter

- Vacuum away excess dust

Figure 8 Ears have been removed

- Remove protective sheets
- Vacuum away excess dust again
- Wipe with an optical wipe soaked in methanol and go around the edges of the ears with optical buds.
- Repeat this procedure for the other side

9.5 Bond ears to the test mass and the 2nd penultimate mass

9.5.1 Ear allocation

There are 2 ears needed (4 ears available) for bonding to the NP-type Test Mass. The allocation and details of the ears are shown in Table 2.

Table 2 Ears to go on to the Test Mass

Glasgow ear no.	**PV-Flatness measured in Glasgow [nm]**	**Allocation**	x_{h1} **[mm]**	x_{h2} **[mm]**	y_h **[mm]**	$x_{h1} + \frac{x_{h2} - x_{h1}}{2} + 1.5$ **[mm]**
39	40.8	Spare	13.9	44.3	27.6	30.6
40	29.9	Spare	13.9	43.7	27.6	30.3
41	68.4	Bonding flat 1	13.4	43.4	27.6	29.9
42	72.2	Bonding flat 2	13.5	43.5	27.5	30.0

There are 2 ears needed (4 ears available) for bonding to the NP-type 2nd Penultimate Mass. The allocation and details of the ears are shown in Table 3.

Further details on these ears and the other ears from the test batch can be found in T0900557.

Table 3 Ears to go on to the 2nd penultimate mass

Glasgow ear no.	PV-Flatness measured in Glasgow [nm]	Allocation	x_{h1} [mm]	x_{h2} [mm]	y_h [mm]	$x_{h1}+\frac{x_{h2}-x_{h1}}{2}+1.5$ [mm]
45	79.1	Spare	13.5	43.6	27.5	30.1
46	82.9	Bonding flat 1	13.7	43.9	27.6	30.3
50	87.0	Spare	13.4	43.5	27.6	30.0
51	60.0	Bonding flat 2	13.6	43.9	27.6	30.3

9.5.2 Template settings

The templates for both masses are of the same design. Therefore the same procedure is used for both, except with updated numbers from measurements.

The critical reference dimensions for the bonding jig set-up are shown in Figure 9. D_{screw1}, D_{screw2}, $D_{slider1}$ and $D_{slider2}$ are the dimensions that need set.

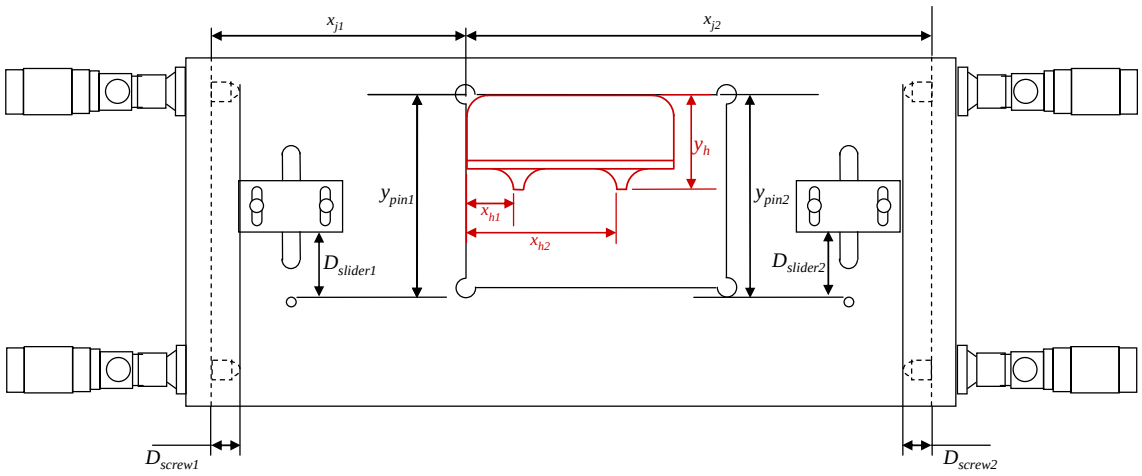


Figure 9 Schematic of ear with bonding jig with critical reference dimensions

Test mass

- Bonding jig no. 1 will be used for the test mass.
- The test mass is wedged; it is thickest at the top and thinnest at the bottom, though this will change now the mass is turned upside down with the new ears Measurement results of the thickness show a maximum thickness of 200.431 mm and a minimum thickness of 199.466 (see C070035). The average thickness of the test mass is therefore w_{TM} = 199.95 mm.

- The bonding template has to be referenced to surface 1 “S1”, with HR coating, which is the front face. The front face is not wedged. The arrow on the barrel indicates the thinnest side and points towards surface “S1”.
- The setting of the micrometer screws determines the horizontal alignment of the ears. As surface S1 is referenced on both sides, the ear on bonding flat 1 will use the reference screws on side 1 of the bonding jig and the ear on bonding flat 2 will use the reference screws on side 2 of the bonding jig. The setting for the reference screws is calculated as follows:
  - Bonding flat 1 $$D_{screw1} = \left(x_{j1} + x_{h1} + \frac{x_{h2} - x_{h1}}{2} + 1.5 \right) - \frac{w_{TM}}{2}$$

    Based on the measurements: D_{screw1} = 3.00 mm for ear 41 and bonding jig no. 1
  - Bonding flat 2 $$D_{screw2} = \left(x_{j2} - x_{h1} - \frac{x_{h2} - x_{h1}}{2} - 1.5 \right) - \frac{w_{TM}}{2}$$

    Based on the measurements: D_{screw2} = 3.00 mm for ear 42 and bonding jig no. 1
- The setting of the sliders on the bonding jig determines the vertical alignment of the ears. The settings are the same for both flats. The distance needed between the end of the stock and the flexure point for welding is estimated to be 20 mm. As the flexure points should effectively be at 7.2 mm above the COM for the test mass, the bottom of the horns of the ear needs to be at a distance of h_{horns} = 20 – 7.2 mm = 12.8 mm below the centre of mass (COM) of the test mass. The setting of the sliders is calculated as follows:
  - Slider 1 $$D_{slider1} = y_{pin1} - y_h - h_{horns}$$

    Based on the measurements: $D_{slider1}$ = 58.2 – 27.5 – 12.8 = 17.9 mm
  - Slider 2 $$D_{slider2} = y_{pin2} - y_h - h_{horns}$$

    Based on the measurements: $D_{slider1}$ = 58.2 – 27.5 – 12.8 = 17.9 mm

2nd Penultimate mass

- Bonding jig no. 2 will be used for the 2nd penultimate mass.
- The bonding template has to be referenced to the front face, surface “S3” in D050421-05-D, which is the smooth surface without magnet flag insert counter bored holes.
- The average width of the 2nd penultimate mass $w_{2nd\ PM}$ = 200.415 mm (see GNL-4027-R2)
- The bonding template has to be referenced to surface 1 “S1”, with HR coating, which is the front face. The front face is not wedged. The arrow on the barrel indicates the thinnest side and points towards surface “S1”.
- The setting of the micrometer screws determines the horizontal alignment of the ears. As surface S1 is referenced on both sides, the ear on bonding flat 1 will use the reference screws on side 1 of the bonding jig and the ear on bonding flat 2 will use the reference screws on side 2 of the bonding jig. The setting for the reference screws is calculated as follows:

- Bonding flat 1 $D_{screw1} = \left(x_{j1} + x_{h1} + \frac{x_{h2} - x_{h1}}{2} + 1.5 \right) - \frac{w_{2ndPM}}{2}$

  Based on the measurements: D_{screw1} = 2.9 mm for ear 46 and bonding jig no. 2

- Bonding flat 2 $D_{screw2} = \left(x_{j2} - x_{h1} - \frac{x_{h2} - x_{h1}}{2} - 1.5 \right) - \frac{w_{2ndPM}}{2}$

  Based on the measurements: D_{screw2} = 2.9 mm for ear 51 and bonding jig no. 2

Check with Brett and Mark: do we need to counteract the weight of the magnet flags in the horizontal alignment of the ears on the penultimate mass?

- The setting of the sliders on the bonding jig determines the vertical alignment of the ears. The settings are the same for both flats. The distance needed between the end of the stock and the flexure point for welding is estimated to be 20 mm. As the flexure points should effectively be at 7.2 mm above the COM for the test mass, the bottom of the horns of the ear needs to be at a distance of h_{horns} = 20 – 7.2 mm = 12.8 mm below the centre of mass (COM) of the test mass. The setting of the sliders is calculated as follows:

  - Slider 1 $D_{slider1} = y_{pin1} - y_h - h_{horns}$

    Based on the measurements: $D_{slider1}$ = 58.2 – 27.5 – 12.8 = 17.9 mm

  - Slider 2 $D_{slider2} = y_{pin2} - y_h - h_{horns}$

    Based on the measurements: $D_{slider2}$ = 58.2 – 27.5 – 12.8 = 17.9 mm

Table 4 Summary of bonding jig settings (TBC)

	Test Mass		2nd Penultimate Mass	
	Bond flat 1	**Bonding flat 2**	**Bonding flat 1**	**Bonding flat 2**
D-slider1	17.9 mm	17.9 mm	17.9 mm	17.9 mm
D-slider 2	17.9 mm	17.9 mm	17.9 mm	17.9 mm
D-screw1	3.00 mm (±0.1)	(sprung bolt contact)	3.00 mm (±0.1)	(sprung bolt contact)
D-screw2	(sprung bolt contact)	3.00 mm (±0.1)	(sprung bolt contact)	3.00 mm (±0.1)

9.5.3 Ear bonding procedure

- Prepare the washing bath and washing facilities
  - The washing bath consists of an ultrasonic bath sitting on a height-adjustable trolley. The V-block supporting the mass sits on top of the bath. The drainpipe is led to the drain in the floor such that the dirty water can drain away directly.
  - There is a long hose connected to the DI water tap
  - There is a dry nitrogen gun
  - The pipette and pipette tips are ready for use.
  - Cerium oxide, bicarbonate of soda, methanol, and plenty of optical wipes are ready for use
- Prepare the bonding jig according to the dimensions as discussed in section 9.5.2.

- The distances $D_{slider1}$ and $D_{slider2}$ are set using a set of calipers and an Allen key.

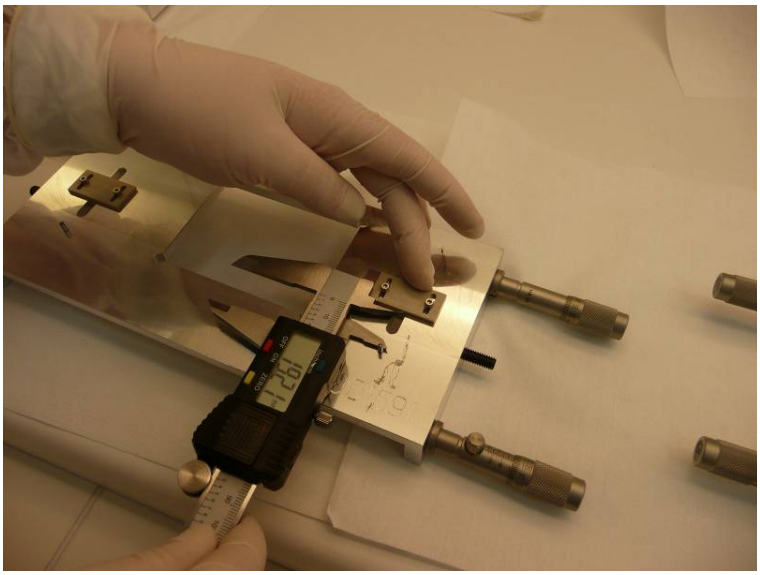
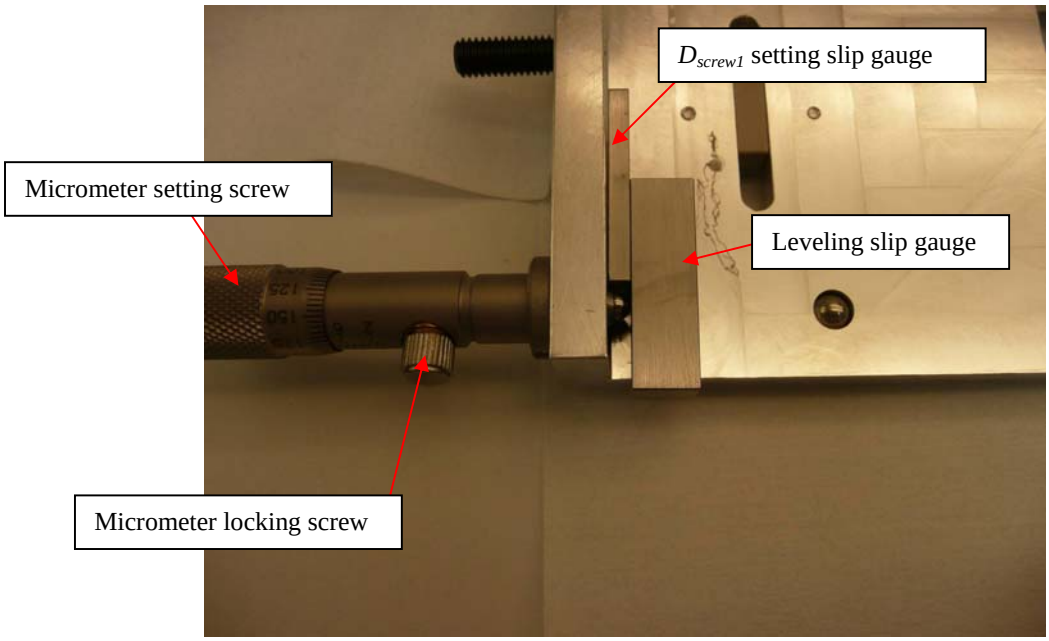


Figure 10 Setting $D_{slider2}$ using a set of calipers

- The distances D_{screw1} for bonding flat 1, and D_{screw2} for bonding flat 2 are set using a combination of slip gauges. The micrometer screw can be set be unlocking it by turning the locking screw and then turning the micrometer setting screw.



- Prepare ear by unwrapping it from its package and inspecting for damage that might have occurred during travel.
- Move mass onto washing bath using the ergo arm. The bonding flats are oriented vertically

Figure 11 Moving the mass onto the washing bath in August 2007 (T070223)

The procedure discussed below follows bonding procedure E050228-00-D and is adapted for handling the large masses.

- Wash side 1 of mass
    1. Rinse with DI water and rub gently but thoroughly with cerium oxide using an optical cloth and rinse with DI water again
    2. Rub gently with bicarbonate of soda using a fresh optical cloth and rinse with DI water
    3. Rub more thoroughly with bicarbonate of soda using a fresh optical cloth and rinse with DI water
    4. Rinse with methanol
    5. Blow dry with dry nitrogen

Figure 12 Cleaning the side of the penultimate mass with cerium oxide 12/12/07

- Move mass back to bonding table and rotate the mass such that the cleaned surface is horizontal and pointing up. The flat is covered with an optical cloth to limit contamination as much as possible.
- Prepare bonding solution and pipette
    - The bonding solution is made by mixing the Sigma-Aldrich sodium silicate solution (14% NaOH, 27%SiO_2) with DI water in a ratio of 1:6 in a 15 ml centrifuge tube

and shaking it. The solution was then put into 1.5 ml centrifuge tubes and centrifuged. The solution was then filtered using a 0.2 µm medical filter to remove any larger particles.
    - Fresh bonding solution will be made for each side of the masses.
    - The pipette is set to 9.6 µl (this corresponds to approximately 0.8 µl/cm^2). This amount was also successfully used in the bonding tests (see T0900447-v3).
- Clean the ear using the procedure described for the side of the mass and the chemical flow cabinet and wrap in an optical cloth next to the mass.
- Inspect the flat of the mass carefully for dust using a high intensity inspection light. Look from different directions at both grazing and more normal incidence. Wipe any dust specks off with a cloth soaked in methanol and blow dry with dry nitrogen.
- Place the template onto the mass and align with respect to the relevant surface and the fiducial lines that indicate the COM.
- Inspect the ear carefully under the light and wipe off any remaining dust and blow dry with dry nitrogen away from the mass.
- Draw bonding solution using the pipette and check that the amount is right by eye. After one final look at the bonding surface ensuring there is no dust, place the bonding solution on the surface. Then proceed with placing the ear on the flat and aligning it against the reference faces of the bonding template.
- Perform an inspection of the bond and take photographs.

9.5.4 Back-up facilities

Debonding bath (TO DO Marielle)

9.6 Glue prisms

9.6.1 Prism allocation

The prisms that were removed from both penultimate masses have been stored with the penultimate masses in their boxes, such they can be re-used for glueing.

(TO DO Mariëlle: take spares from Glasgow)

9.6.2 Template settings

Figure 13 shows the relevant dimensions for setting the bonding jig for glueing on the prism.

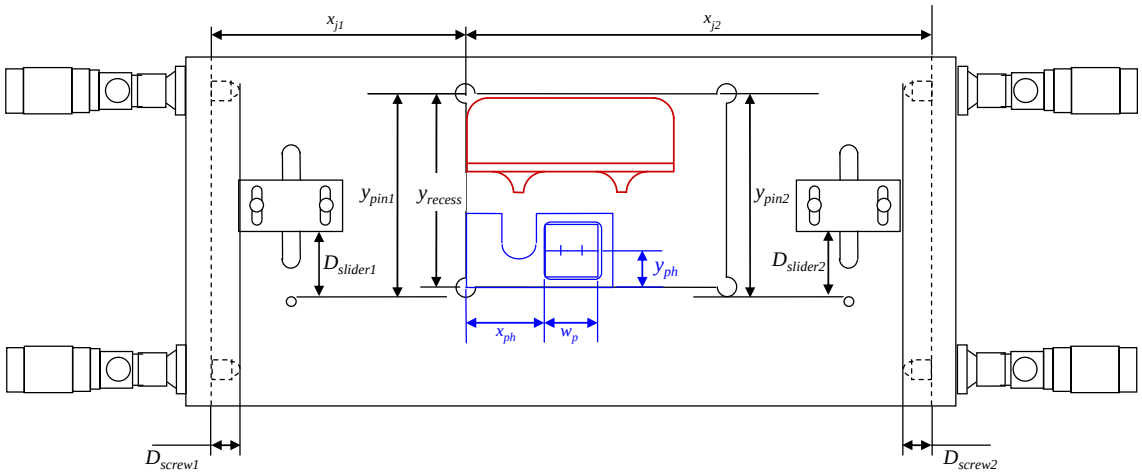


Figure 13 Relevant dimensions for the prism bonding jig settings

- Bonding flat 1 $$D_{screw1} = \left(x_{j1} + x_{ph} + \frac{w_p}{2} \right) - \frac{w_{2ndPM}}{2}$$

  Based on the measurements: D_{screw1} = 2.9 mm for prism holder plus prism 1 and bonding jig no. 1

- Bonding flat 2 $$D_{screw2} = \left(x_{j2} - x_{ph} - \frac{w_p}{2} \right) - \frac{w_{2ndPM}}{2}$$

  Based on the measurements: D_{screw2} = 2.9 mm for prism holder plus prism 2 and bonding jig no. 2

  Check with Brett and Mark: do we need to counteract the weight of the magnet flags in the horizontal alignment of the ears on the penultimate mass?

- Based on the distance between the top of the prism and the wire flexure point is 2.9 mm (This is from Joe O'Dell document T0900374, for a wire of 0.3175 mm diameter (wire reference T090372 TBC). The effective flexure point position of the wires should be d_2 = 0.3 mm above the centre of mass. This means physical wire break-off point on break-off prism should sit 2.9 – 0.3 = 2.6 mm below the COM. The setting of the sliders is calculated as follows:

  - Slider 1 $$D_{slider1} = y_{pin1} - y_{recess} + y_{ph} + 2.6$$

    Based on the measurements: $D_{slider1}$ = 58.2 – 55.7 + 10.6 + 2.6 = 15.7 mm

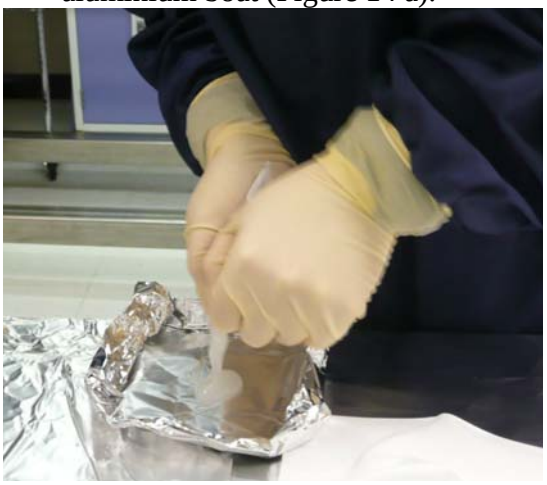
  - Slider 2 $$D_{slider2} = y_{pin2} - y_{recess} + y_{ph} + 2.6$$

    Based on the measurements: $D_{slider2}$ = 58.2 – 55.7 + 10.6 + 2.6 = 15.7 mm

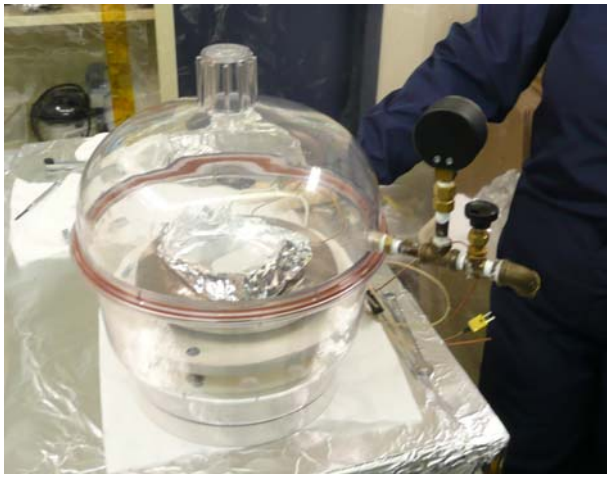
9.6.3 Procedure

The procedure for glueing the prisms using Perkin-Elmer Vac Seal adhesive is based on the procedure stated in E970154-D-D "Component specification".

- Prepare prisms by cleaning them in a bath of hot acetone followed by a bath of methanol.
- Clean flat by wiping with methanol
- Setting prism glueing template on mass
- Clean prism by wiping with methanol.
- Put prism(s) into prism holder(s)
- Wipe prism with methanol
- Clean copper wire with acetone and methanol
- Make a boat of UHV aluminium foil and wipe it with methanol.
- Prepare Vac Seal adhesive: mix the two epoxy components of a Vac Seal "bipax" together thoroughly, approximately 2 minutes. Dispense from the middle of the container into the aluminium boat (Figure 14 a).



a) Dispensing the VacSeal in an aluminium boat



b) Adhesive in vacuum container to get rid of the bubbles

Figure 14 Preparing VacSeal

- Put prepared Vac Seal in a vacuum container and connect a backing pump to evacuate air bubbles. The largest air bubbles did disappear but the vacuum of -25 mercury inches was not quite enough to evacuate all bubbles. It was therefore decided to dip in the wire at a spot with no visible bubbles (Figure 14 b).
  The first 3 prisms were glued with 'older' adhesive that Helena had brought from Caltech, were as all other prisms were glued with 'fresh' adhesive. It seemed that the fresher adhesive had more bubbles after mixing.
- Glue prism(s) to side 1: dip the applicator wire in epoxy and withdraw it, leaving a drop of epoxy on the wire. Apply epoxy on the wire as a drop to the bonding side of the prism. Spread the adhesive as a cross towards the corners of the prism over the surface. Lower the prism onto the flat of the mass (Figure 15 shows how this was done before as reported in T080041-01).

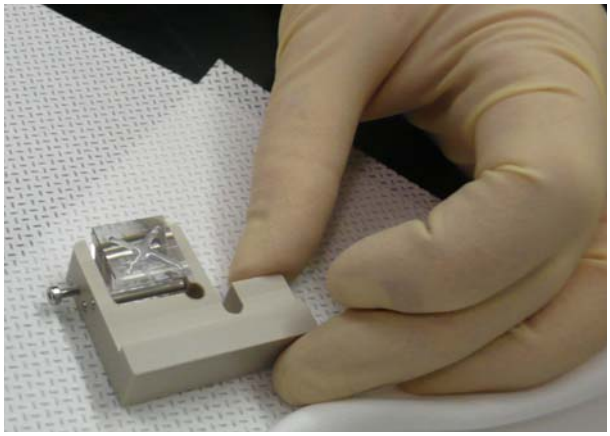


Figure 15 Applying adhesive to penultimate mass prism

- Cure the glued prism for at least 4 hours: using a 250 W heat lamp on a post lighting the prisms at a distance of about 20 cm (Figure 16). Use an infrared thermometer we measured the temperature to be around 60 °C.
- The aluminum boat with remaining adhesive was kept next to the bonds and checked after 24 hours by breaking is, to make sure the adhesive had cured properly.

Figure 16 Heat lamps on the two penultimate masses (13/02/2008)

- Remove holders and template 24 hours after glueing the prisms onto the mass, since VacSeal needs 24 hours curing time at room temperature.

10 Inspection sheet bonds

Bond quality monitoring sheet

Ear no.		Bonding solution	
Mass		Vol. concentration	
Bonding flat		Time prepared	
Date and time bonded		Amount used for bonding