Minutes from LBT672 progress meeting

Meeting: LBT672 monthly progress meeting
Date: Aug 2, 2007
Location: Telecon – LBTPO, Arcetri, Microgate

Participants: Brusa, Brynnel, Green, Salinari, Fini, Esposito, Biasi

Highlights of the month

- Joar and Guido witnessed TS#1 closed loop operation at Microgate.
- Test tower initial interferometer tests showing encouraging results.
- TS#4 repair method endorsed.
- Slightly ahead of schedule for Solar Tower pre-test.

Agenda Item 1: Status of Action Items

#7: Daniele and Guido to develop TS#3 flipping procedure
Update: Hardware has been manufactured. Draft procedure exists. Issue is not urgent, but procedure should be reviewed and released.

#11: Daniele to prepare TS#3 shipping plan from ADS to MG.
No update.

#13: Armando to discuss TS#3 silvering handling with Guido.
Update: Piero reports that according to ADS design of equipment is progressing well. Delivery of equipment is scheduled for 17 September.

#16: Roberto to discuss cold test with Armando and Simone
No progress. Preparations for cold test delayed due to higher priority work with TS1. It is not yet clarified whether the refrigerated trailer has humidity control. Issue remains urgent.

#19: Guido to review TS#1 installation procedure.
Guido says draft procedure exists, but needs to be reviewed and released.

#20: Arcetri to establish LBT672 unit handling plan for test tower.
No progress.
#21: Guido to contact Brian Cuerden regarding stress analysis on TS4 damage.

Guido reports that the analysis was done, and results are documented in PowerPoint presentation [Appendix A]. A meeting was held at Steward to discuss the various options and results [Appendix B]. Analysis shows internal stress increase by about 30% after cutting out a “mousehole” which is considered uncritical.

#22: Guido to discuss TS#4 RoC measurement with ML

Measurement not yet done. Guido will open discussion with ML.

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**Agenda Item 2: Official Schedule**

Simone submitted schedule V7, dated 2-Aug-07 [Appendix H].

The following was noted: Milestone “AO system #1 delivered to Mt Graham” moved from 29-July-08 to 12-Aug-08. Reason: Introduced 2 weeks delay for Italian vacation during summer 2007.

2.1 Guido stated that a delivery of TS#4 to ADS as scheduled on 24 September is unrealistic. New date is 24 October. Simone to update schedule line 36.

2.2 Line 35 “BP#3 coating” and line 37 “TS4 magnets gluing” are currently scheduled in parallel. It is not clear that ADS can support those activities in parallel. Simone to clarify.

2.3 Line 43 “W unit 2 AIT” schedule needs update to reflect actual progress. Simone to update. Uncritical for major milestones.

2.4 It is recommended to add milestone “AGw#2 delivery to Arcetri”. See also Action Item #27.

2.5 Line 11 “TS#3 delivered to MG” shall be updated to Aug 27. No immediate schedule impact (buffer time).
**Agenda Item 3: Status update - progress since last meeting**

**Microgate**

The process of gluing the central membrane on TS1 was completed successfully. After membrane was mounted, an increased gap around the center hole with an amplitude of 5 μm was observed. The prevailing theory is that this “volcano” shaped effect is caused by a misalignment between membrane and shell caused by a sub-optimal procedure used for the gluing operation. The estimated increase of glass stress is low, about 0.4 MPa. Guido noted that although uncritical at the moment, the membrane offset could have an impact on TS#1 future science use.

**Action Item:** ADS to establish improved procedure for membrane installation.

An attempt to close the loop with installed membrane revealed serious electrical problems (shorts and non-contacts) at the membrane. Shell was un-installed to analyze this problem, and also to troubleshoot existing problems with actuator noise and “jumping”. A new design using spring-loaded contacts and better wiring/miniature connectors at the membrane was designed. Roberto reports that the new wiring and spring contacts will solve not only the membrane electrical problems, but also the old actuator issues due to the much lower impedance from the improved wiring.

The chiller performance continues to be an issue. It is believed that the chiller is oversized, and can not regulate temperature reliably with the low thermal load. Currently the temperature cycling has been improved from 10C to 5C. Efforts to further improve chiller performance have been postponed until the membrane issues have been sorted out.

**ADS**

No update – vacation.

**Arcetri**

Simone reports that initial discussions have been held between Arcetri and Microgate regarding integration and wiring of “W” sensor #2 electrical boxes. It was agreed that this would be attractive from a technical standpoint to optimize quality of wiring, grounding etc. It is not yet fully understood if MG can support the effort without impacting other activities. Activity will be funded by Arcetri directly.

**Action Item:** Simone to make decision and planning for “W” boxes integration at MG

See [Appendix C] for a detailed report on “W” sensor activities and progress, test tower progress, and Arcetri SW progress.
Luca stated that he is confident that software will be available to support all test tower activities. Luca also points out that TCS deliverables from Tucson are still under development which mandates a close collaboration between Arcetri and the LBT SW group. It is very important to work out a good mechanism for obtaining stable versions of TCS components.

Simone submitted an updated schedule for the Solar Tower pre-test activities [Appendix F]. One activity was added: Verification of hexapod crosstalk performance. It was noted that we are actually slightly ahead of schedule for Solar Tower pre-test.

Tucson

During his visit to ADS Guido inspected (and used) the new Aluminum shell shipping frame. Joar and Guido witnessed TS#1 closed loop operation at Microgate (!)

Some residual issues regarding TS#3 transport needs to be worked out as soon as Daniele returns from vacation.

Action Item: Daniele and Guido to finish TS#3 transport procedures

Guido reported on TS#4 damage. The proposed repair (a.k.a. mouse hole) was endorsed and adopted. See [Appendix G] for repair geometry. Roberto pointed out that the cutout must be optimized for contact area in the membrane area. The modification (cut-out) means that a custom membrane is required. Guido said that the procedure for the hole cut-out at the ML has not yet been established.

Action Item: Guido to discuss hole cut-out procedure with ML

The repair operation will take place in two weeks at the earliest. After the cut-out operation the shell will be deblocked. Guido stated that a delivery of TS#4 to ADS as scheduled on 24 September is unrealistic. New date is 24 October.
**Agenda Item 5: Planned activities for the next month**

**Microgate:**

- Membrane contacts and wiring modification
- Verification of actuator noise
- Chiller performance improvement
- System cold test

**ADS:**

**Arcetri:**

- Discuss AGw#2 delivery schedule with Potsdam
- Continued solar tower test
- Seal optical tube in test tower
- SW: Support solar tower test
- Continued AOS development

**Tucson:**

- TS#4 machining
- Preparation for aluminizing
- Work with ADS in preparation for TS#3 shipping/handling

**Action Item List**

#7: Daniele and Guido to develop TS#3 flipping procedure  
#11: Daniele to prepare TS#3 shipping plan from ADS to MG.  
#13: Armando to discuss TS#3 silvering handling with Guido.  
#16: Roberto to discuss cold test with Armando and Simone  
#19: Guido to review TS#1 installation procedure.  
#20: Arcetri to establish LBT672 unit handling plan for test tower.  
#22: Guido to discuss TS#4 RoC measurement with ML  
#23: Simone to make decision and planning for "W" boxes integration at MG  
#24: ADS to establish improved procedure for membrane installation  
#25: Daniele and Guido to finish TS#3 transport procedures  
#26: Guido to discuss hole cut-out procedure with ML  
#27: Simone to establish planning for AGw#2 delivery to Arcetri
Appendices

Appendix A: TS4 Stress Analysis [Brian Cuerden]
Appendix B: Minutes from discussions regarding TS#4
Appendix C: “W” sensor, test tower, SW detailed progress report
Appendix D: Powerpoint presentation: Test Tower and “W” sensor
Appendix E: New membrane contact system
Appendix F: Updated schedule for Solar Tower pretest
Appendix G: TS#4 repair geometry
Appendix H: LBT AO schedule, version 7, dated 2-Aug-07
LBT Shell 4 Center Damage

July 17, 2007

Sketch of Damage

Sketch of Center with Mousehole Repair

Photo of Damage

10 mm radius

15 mm diameter (magnets)
Appendix A - TS#4 Stress Analysis - Brian Cuerden

Repair Options

• 1. Remove the damaged area with a 10 mm radius cut (mousehole repair)
• 2. Bond crack faces together and stop drill all cracks.
• 3. Remove short cracks by grinding on surface (these cracks may not go all the way through the thickness).

Stress Analysis

• Model the local, undamaged region
• Model the stop drilled region (not considered a viable repair)
• Model the stop drilled and bonded cracks.
• Model the mouse hole repair.

• Compare results to the local undamaged results for:
  – Applied moments in two orthogonal directions.
    • Moment magnitudes are arbitrarily selected
    • Compare $K_{tg}$ of the repair options (best repair has the lowest $K_{tg}$)
  – Temperature change (bonded cracks)

Baseline, Undamaged, Model

Baseline Results

Baseline Results

Mx = 0.067 in-lb/node
Note max stress in corners not at center hole

My = 0.067 in-lb/node
Note max stress in corners not at center hole
Baseline Results, Near Center Hole

Mx = 0.067 in-lb/node  Max stress = 103.6 psi

My = 0.067 in-lb/node  Max stress = 53.2 psi

Stop Drilled and Bonded Model

Cracks are assumed to be 25 microns wide based on measured 25 micron surface removal by acid etching (cracks could be 50 microns wide but are probably less than 25 microns)

Cracks filled with Norland 61 material (purple color)

Bonded and Stop Drilled, Same Loads as Baseline

Mx applied  Max stress = 172.2 psi  (1.66 times the baseline stress)

My applied  Max stress = 86.1 psi  (1.62 times the baseline stress)

Bonded and Stop Drilled, -70°F, Uz, Waves
Mouse-Hole Repair Model

Mouse-Hole Repair Results

Summary of Results

<table>
<thead>
<tr>
<th>Case</th>
<th>Baseline</th>
<th>Stop Drilled</th>
<th>Drilled and Bonded</th>
<th>Drilled</th>
<th>Item</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mx</td>
<td>103.6</td>
<td>288.3</td>
<td>172.2</td>
<td>172.2</td>
<td>150.6</td>
<td>stress psi</td>
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<tr>
<td>My</td>
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<td>140.1</td>
<td>86.1</td>
<td>86.1</td>
<td>69.0</td>
<td>stress psi</td>
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Stress relative to Baseline

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<th>Case</th>
<th>Mx</th>
<th>My</th>
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</thead>
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<tr>
<td>70 deg F</td>
<td>1.45</td>
<td>1.30</td>
</tr>
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</table>

“Stop Drilled” results are for the stop drilled but not bonded shell.

Bonding Concerns

Strength: Clean, bonded, cracked glass samples have tested out at ~1800 psi short term (bending).

Long term strength may be half this.

Expected shell strength (FS=1.0) is 3,000 to 3,500 psi.

Have not tested bonds on pitched glass (oil in pitch may contaminate crack faces).

It has been reported that the adhesive does not wick into cracks in pitch bonded thin shells.

Stress is 2.78 times nominal if adhesive fails (see “stop drilled” results in summary table).
Recommendation

Use mouse-hole repair
  No thermal effect
  Lower stress than alternatives

If we want to stop drill and bond:
  Need to test bonding of shells pitched to substrates.
  Need to determine crack width if thermal
displacements are uncorrectable with 25
micron crack width.

Stop Drill and Bond, Short Radial Fracture

- Ref. Peterson, STRESS CONCENTRATION FACTORS, Fig 137.
- This gives $K_t$ in uni-axial tension for a small hole, radius $r$, on the
  edge of a large hole, radius $R$, as a function of $r/R$.
- The proposed mouse-hole repair has $r=10$ mm and $R=27.2$ mm
  - $r/R = 0.37$ and $K_t = 5.0$
- A mouse-hole repair of the short (4 mm) fracture would give:
  - $r/R = 4/27.2 = 0.15$ and $K_t = 6.5$
- A stop drill repair with no adhesive or ineffective adhesive:
  - $r/R = 2/27.2 = 0.075$ and $K_t = 7.6$
- For reference, the FEA solution for the mouse-hole repair ($r=10$ mm)
gave a stress of $1.45^*\text{Baseline}$. The baseline $K_t$ is ~3.0 so the net $K_t$ is
4.35 this is less than the $K_t=5.0$ above but probably because the $K_t$ for
simple bending when the thickness to diameter ratio exceeds 6 is less
than 1.82 instead of 3.0 (estimated $K_t$ of mouse-hole repair =
$1.45^*1.82 = 2.64$).

Conclusion: Need to perform FEA on the actual repair of the short radial fracture.

Kt Calculation and Model Checks

- Obtained nominal stresses for the same loads applied to the
  same size plate without the center hole
- Refined the models
  - $M_x$ case, No hole stress = 67.24 psi (63.68 refined)
  - $M_y$ case, No hole stress = 32.96 psi (31.61 refined)
- Refined model results for the cases discussed above are
summarized on the following slide:

Refined Model
Table 2: Confinement Result

<table>
<thead>
<tr>
<th>Model</th>
<th>Case</th>
<th>Baseline</th>
<th>Stop Drilled</th>
<th>Drilled and Bonded</th>
<th>Mouse-Holed Item</th>
<th>Units</th>
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<td>17.8</td>
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<td>P-V Displ. waves</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions:

Baseline $K_{rc}$ per Peterson Fig. 160 should be 1.82

It is concluded that since results do not change much when the mesh is refined, the relative performance predicted for the various repairs is correct.
Gentlemen,

Here is a short summary of the discussion had today at the meeting on TS4 decision. Present at the meeting were: Brian Cuerden, John Hill, Steve Miller and myself. Piero Salinari talked briefly on the phone with John and gave some results of a FEA done by Ciro reported in the following.

FEA Results

Ciro's FEA analysis with soft glue included shows that the maximum stress in the shell when supported in the 'horizon pointing' (mousehole down) condition (by the central ring and thru the glue layer) is 0.5MPa for a 'perfect' hole and 1MPa with the addition of the mousehole. Although the stress is double it is still well below the 5-6MPa allowed (~30Mpa ultimate with a safety factor of 5). Thus, both Ciro's and Brian's FEA results confirm that while the mousehole increases the stress concentration, the resulting stresses are still at acceptable levels.

Glue versus Mousehole

It was decided that the 'glue' solution (repairing the existing damage by wicking in UV-curing epoxy) has too many uncertainties related to the execution (wicking, loose chips) and results (the actual and future strength of the bonds).

We therefore opted for the 'mousehole' solution (removing all of the damaged glass by cutting it away) which has a more certain endpoint. This unfortunately requires more machining. Most of the meeting was spent discussing how this machining could be carried out.

It was recognized that a likely cause of the small crack discovered during the inspection process of the inner hole edge was the high stress applied during the machining required to enlarge the center hole, possible combined with fluttering caused by delamination from the pitch. This means that we should carefully investigate this operation, an alternative solution would be to use the jig-borer for this task.
'Patch' for the mousehole (short version)

The presence of the mousehole complicates some of the operations done on the shell to coat both sides, it also requires some long term solution to avoid gap contamination when the shell is installed on the adaptive secondary unit. The idea is to design and test a 'patch' that will fit in the mousehole and be semi-permanently glued to the mousehole edge.

The Plan

It was decided that we should:
1) test the drilling of the mousehole on blocked glass samples with the jig-borer;
2) plan the operation of gluing the cracks anyway as a mean of strengthening the glass before drilling the mousehole. After the tests on the jig-borer are completed, if successful, a procedure will have to be written before proceeding on the actual shell.
3) start designing a 'patch' for the mousehole.

Let us know your comments,

Ciao,
Guido and John

P.S. Here are some more details:

Glue vs. Mousehole (more details)

The drawbacks of the 'glue' solution can be summarized as follows:
1) the width of the crack is unknown and hard to determine. This means that the temperature effect (distorsion of the shell surface with temperature) is hard to predict.
2) the presence of pitch residues could cause the glue not to stick to the glass.
3) the long term variation of the strength of the glue bond is unknown.
4) the compatibility of the glue to the various chemical used to clean the shell for the aluminization are unknown.
5) the hygroscopicity of the glue material could be significant, causing an effect even larger than the one computed for the temperature variation.

We could find two 'minor' drawbacks of the 'mousehole' solution:
1) an increase in the maximum stress in various conditions but still well within acceptable limits;
2) the need for calibration of the two actuators around the mousehole that will loose a significant area.

The only significant drawback of this solution is that we will have to go back and machine the area around the inner hole again. This will require a relatively modest amount of experimentation with respect to the 'glue'solution.

'Patch' for the mousehole (more details)
We briefly discussed various options for dealing with the extra hole, the most promising being to glue a semi-permanent 'patch' in the mousehole. This patch could be a piece of silicon sheeting cut to shape with a reinforcing rib in correspondence of the glass inner hole bevel. The patch would be glued to the glass all along the mousehole perimeter using silicon glue. The advantage of this solution is that it is 'permanent' and should work during the entire phase of cleaning and coating as well as during operation, protecting the gap between shell and reference body. Obviously we will have to prove that it meets all the requirements in terms of chemical and vacuum compatibility as well as the mechanical requirements. Our plan in this case is to proceed with a design and then use some of the samples produced during the testing of the hole drilling to test our design. In case we find that this solution is not viable we still have the option of having temporary fixes to be used for the various processes and then apply a patch after the integration of the shell is completed.
W report jul07draft1.txt

W unit #1
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W unit electronics
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1) The power supply of the BCU39 was changed after unit failure. The failure was assumed to be linked to the following problem. Because of small diameter of the cable connecting the power supply and the BCU there is a voltage drop on the connection of approx 0.5 V. The dimension of fixed connection on BCU39 rack do not allow to use larger wires. This force the power supply to work at 3.8 V to provide the correct voltage at the BCU terminations. Because the power supply was rated for 3.3-3.5 this overload could have generated the damage. The power supply has been substituted with a power supply having a probe for voltage sensing at the load. This power supply is rated for a large max voltage so that it can accomodate the 0.5 volt of voltage drop. The new power supply is now installed and working. The data sheet of the new power supply is attached in the ppt presentation for convenience.

2) Copies of the control boards of the auxiliary unit and the safety board of the tip tilt unit have been realized by an external company. These boards will be substituted during some downtime of the W unit to improve robustness of the control electronic. This batch of boards include board for W #2 and LBTI.

3) A safety feature has been added for the tip tilt unit to avoid negative voltages going from the BCU47 to the tip tilt control amplifiers. This consist in some diodes that limits the negative current to -0.5V. The safety limit given by the PI company for the tip tilt unit is 2 Volts.

Solar tower activity
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week 2-6, 9-13
- assembly of supporting structure for the spherical mirror
- assembly of hexapod and mirror supporting structure.
- Installation of hexapod in the solar tower.
- focus adjustment moving on optical axis the spherical mirror.

Week 16-21/7
AGW unit moved from laboratory to solar tower
AGW unit bolted on optical tube using test CCDs.
4D interferometer mounted on supporting structure
focus adjustment moving on spherical mirror to 4D interferometer, same procedure as above.
4D interferometer aligned with spherical mirror (no dummy LUCIFER window)

Week 23-28/7
- Fixed chiller problem in the recirculation pipe.
- Chilling circuit of AGW attached to the chiller. test OK.
- W unit functionality test.
- SW for 4D frame acquisition developed and tested.
- Fast acquisition was found 14.2 frames per second, interferometer exposure time was set to 2ms. Maximum number of contiguous frames acquired is about 200. Some work to improve this is ongoing.
- Daytime and night time measurement of optical pipe using 4D interferometer started

30/07 Alignment of optical set-up including reference source of W rotating cube and W WFS board.
31/07 Hexapod connected and tested. Installation of dummy LUCIFER windo on AGW structure. Alignment of the following optical components started
1) reference source of W unit,  
2) rotating cube,  
3) LUCIFER dummy window  
4) Spherical mirror

see optical path schematics in the ppt presentation

01/08 Optical alignment completed using hexapod and LUCIFER dummy window micrometers. The W unit reference source is acquired in the technical viewer beam and the pupil is acquired in the WFS beam using the two test CCDs.

Some pictures of W installation and alignment are reported in the ppt presentation attached.

W unit #2 part procurements  
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XYZ stages  
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test of the new control electronic for the stages will be done after italian main holyday end of August beginning of September.

Mechanics  
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ADC: the final design of the second unit of the ADC is completed. Some modifications has been introduced to make the realization of the unit easier. The drawings of the new units are attached in annex1. Some of the drawings are attached in the ppt presentation.

Pupil rerotator  
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The drawings for the second unit of the rerotator are starting now and should be completed in 3/4 weeks.

SW activity (L. Fini)  
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Here follows the software related activities for last mont (july 2007)

1. a number of installation tests has been performed with TCS software. After some interaction with Tucson SW guys we are now able to install and run TCS in a repeatable way. This was aimed mainly to be able to use OSS to control the hexapod at the solar tower.

2. We also discovered the need to make some modifications to the OSS software. We will notify Tucson people (i.e.: Paul) about all this in the next few days.

3. Some software development was devoted to develop a few procedures to control the interferometer which has been installed at the solar tower in order to allow to set up automatic procedures for optics alignments and the like.
4. The software controlling the Adaptive Secondary Shell has been debugged and upgraded during tests with the real thing.

5. Some procedure for the control of the Swing Arm Rack ADAM have been developed.

6. Generic debugging activity

7. AOS related development: a number of improvements have been made to the AOS in order to increase the robustness of communication with the AO Supervisor against all the possible real world conditions (network breakdown, processes disappearing and the like).

8. The coding of the AO Arbitrator (i.e. the AO Supervisor processes which communicate with the AOS) has been started.
Appendix D

MOUNTING AGW TO THE OPTICAL PIPE
16-21 of July

ALIGNMENT OF THE 4D INTERFEROMETER
16-21 of July

Optical configuration in solar tower

Light from W unit reference source placed in the auxiliary unit bench

Light reflected from the BS in the auxiliary unit bench on the LUCIFER dummy window

Light reflected from the LUCIFER dummy to the spherical mirror

Light reflected from the spherical mirror back to the LUCIFER dummy

Light transmitted in the BS reaching the WFS board

New ADC unit: unit mount
New ADC unit: view from tip tilt mirror

- F45 beam on W WFS board refocused from LBT F15
- To pyramid WFS CCD
- To TV CCD

New ADC unit: side view (Pyramid side)

- F45 beam on W WFS board refocused from LBT F15
- To TV CCD
- To pyramid WFS CCD

BCU39 power supply: LPS41 3.3V

BCU39 power supply: LPS41 3.3V
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<th>ID</th>
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<td>Wed 18/07/07</td>
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<td>5 days</td>
<td>Mon 23/07/07</td>
<td>Fri 27/07/07</td>
</tr>
<tr>
<td>13</td>
<td>alignment of W unit with spherical mirror</td>
<td>5 days</td>
<td>Mon 30/07/07</td>
<td>Fri 03/08/07</td>
</tr>
<tr>
<td>14</td>
<td>optical test of W sensor</td>
<td>3 days</td>
<td>Mon 06/08/07</td>
<td>Wed 08/08/07</td>
</tr>
<tr>
<td>15</td>
<td>measure of spherical mirror with 4D / hexapod cross talk</td>
<td>16 days</td>
<td>Thu 09/08/07</td>
<td>Thu 30/08/07</td>
</tr>
<tr>
<td>16</td>
<td>Environment optical quality measurement (WFS &amp; 4D)</td>
<td>16 days</td>
<td>Thu 09/08/07</td>
<td>Thu 30/08/07</td>
</tr>
</tbody>
</table>
Current ID = 54.4mm
Inner Clear Aperture Diameter = 80mm
Maximum allowable ID = 55.5mm
27.9°
Capacitive sensors armatures division lines
Etched area on rear
First ring of actuators
R10.5
Gravity
Maximum Etched area likely on front