USA Site Qualification Request

Overview

The following documents and information form the basis of the USA request to be approved for Series Barrel Module Production.
They are provided below following the format given in the "Barrel Module Assembly Site Qualification Procedures and Criteria"
(PDF | MS-Word format).

1. Named Personnel for the USA Barrel Module project

Cluster Responsible:	C. Haber
Cluster Quality Control:	A. Ciocio / V. Fadeyev

Qualified teams exist for module assembly and metrology (LBL), hybrid assembly (LBL and UC Santa Cruz), and electrical testing (LBL and UC Santa Cruz):

LBL:	A. Ciocio, V. Fadeyev, M.Gilchriese, F.Goozen,C.Haber, B.Jayatilaka, T.Johnson, J.Lys, S.McIntyre, F.McCormack, C.Tran, T. Weber, R.Witharm, L.Zimmerman
UC Santa Cruz:	M.Anderson, A.Grillo, F.Rosenbaum, W. Rowe, A.Seiden

Details of this work can be found in this document: PDF | MS-Word format.

An overview of the USA module QA is given here: PDF | MS-Word Format.

2. Steps to have been Completed

Production of 5 electrical modules, satisfying every aspect of the electrical and mechanical specifications listed in SCT-BM-FDR4 and SCT-BM-FDR7. For the summary, including yield, see:

- Summary of USA site qualification modules assembled PDF | MS-Word format
- Summary of Electrical Performance of USA Site Qualification Modules PDF | MS-Word format

3. Documentation

3(a). Manuals for Operator Use

- Hybrid assembly: Operator's Guide PDF | MS-Word format
- Hybrid bonding operation manual PDF | MS-Word format
- ATLAS SCT Barrel Module Main module assembly instructions guide PDF | MS-Word format
- IV probe instructions PDF | MS-Word format
- Adhesive dispensing guide PDF | MS-Word format
- SCT Barrel Module: Hybrid mounting procedure PDF | MS-Word format

- Mechanical Survey Procedures and Data Analysis for ATLAS Barrel Modules at the US Site PDF | MS-Word format
- Barrel Module Bonding Procedure PDF | MS-Word format
- USA Electrical tests operator's guide HTML | PDF | MS-Word format
- Main electrical test specification document

Additional supporting information:

- USA ESD Precautions PDF | MS-Word format

3(b). Batch traveller procedure

- Overview: PDF | MS-Word format
- Hybrid Assembly Check Sheet: The standard EXCEL sheet is used here and an internal paper checklist.
- Module build sheet: Additional use of an internal module build sheet as in RAL PDF | MS-Word format

3(c). Procedure for Component Accountability and Yield Statistics

- Overview Document PDF | MS-Word format

3(d). Visibility of Results to All Barrel Sites

All results for hybrids and modules are visible on the web at:

http://www-atlas.lbl.gov/strips/modules/production.html

- Module construction information, via Nobu-worksheets, is in use
- Metrology summaries (all in Excel format)
- Electrical results in tables and PS format

  Module List:
  - 20220040200004 (Q1)
  - 20220040200003 (Q2)
  - 20220040200006 (Q3)
  - 20220040200007 (Q4)
  - 20220040200005 (Q5)

4. Required Facilities

The appropriate facilities (see Fred Goozen's Pages) are now in place and include:

- inert gas storage for components and completed modules
- appropriate glue storage is implemented as required at LBL
- a clean room for module assembly equipped with all necessary wire bonding, module assembly station, glue dispensing, metrology station is in use at LBL; a clean area is also in use at UC Santa Cruz for hybrid assembly and bonding, and a clean area at LBL for module and hybrid testing..
- a jig set has been commissioned for all processes in module assembly and 6 further sets are in production
- hardware and software for module QA as listed in SCT-BM-FDR7 is in use and for database access.

- barcode reader interfaced to PC

Barrel Module Production

Site Qualification: USA-Barrel

Barrel Module Assembly Site Qualification Procedure and Criteria

1. Named Personnel

   a) A Cluster Responsible Person
   b) A Cluster Quality Control Person
   c) A qualified team of assembly, metrology, and electrical test staff

Site	Cluster Responsible	Cluster QC Responsible
USA Barrel	Carl Haber	Alessandra Ciocio / Vitaliy Fadeyev

2. Steps to have been completed

   a) Production of at least 5 electrical modules, satisfying every aspect of the electrical and mechanical specifications listed in SCT-BM-FDR4 and SCT-BM-FDR7 from a starting date agreed by the module coordinators for each site.
   b) Yield: no more than one failed module to have been part of qualifying series.
   c) At least two modules to have been exchanged between pairs of sites to verify metrology and electrical measurements.

3. Documentation

   a) Sufficient documentation and manuals for operator use in assembly and test.
   b) Agreed batch traveler procedure for module production and test.
   c) Procedure in place for component accountability and yield statistics
   d) All results visible to all sites.

Responsibilities for Barrel Hybrid and Module Assembly in the USA

At LBL work covers hybrid assembly and test, and module assembly and test and rework. At UC Santa Cruz work covers hybrid assembly and test and rework.

Primary LBL Contact People
- Carl Haber, Alessandra Ciocio, and Gil Gilchriese

Primary UCSC Contact People
- Felix Rosenbaum, Alex Grillo, and Abe Seiden

Clean Room Operation Manager
- Qualified persons are: Fred Goozen

Clean Room Maintenance
- Rhonda Witharm

Hybrid Assembly
- LBL: Rhonda Witharm, Fred Goozen. Co Tran is in training.
- At UCSC: Mark Anderson

The Module Construction Team
- Carl Haber, Frank McCormack, Vitaliy Fadeyev, Rhonda Witharm, Tom Johnson, Jeremy Lys.

The Bonding Facility
- LBL Chief Wirebonding Operator is Rhonda Witharm. Co Tran is an operator.
- UCSC Chief Wirebonding Operator is Bill Rowe. Mark Anderson is an operator.

The Electrical and Inspection Facility
- LBL Leader: Alessandra Ciocio, other qualified personnel are Bo Jayatilaka, Leah Zimmerman, Shanna McIntyre, and Vitaliy Fadeyev
- UCSC: Felix Rosenbaum, Mark Anderson

Smart-Scope Operation
- Qualified operators are: Vitally Fadeyev, Frank McCormack, Carl Haber, Tom Johnson, and Fred Goozen. Jeremy Lys is in training.

Glue Dispenser Operation
- Qualified operators are: Frank McCormack and Tom Johnson. Rhonda Witharm is in training.

Alignment stage Operation
- Qualified operators are: Carl Haber, Frank McCormack, and Vitaliy Fadeyev. Rhonda Witharm is in training.

Hybrid Mounting
- Qualified operators are: Frank McCormack, Carl Haber, Vitaliy Fadeyev, Fred Goozen

Analysis of Metrology Data
- Qualified persons are: Vitaliy Fadeyev and Carl Haber. Jeremy Lys is in training.

Rework
- LBL: Rhonda Witharm
- UCSC: Mark Anderson, Bill Rowe

Shipping

- Qualified persons are: Carl Haber, Felix Rosenbaum

Training

There is a continuing program of training between the construction disciplines. What is presented above is the situation at the time of qualification.

C. Haber 11-July-2002

Outline of USA Module QA Activities

9 July 2002

Introduction

This document aims to clarify the locations and institute responsibilities for module QA activities in the USA barrel cluster.

Details of individual QA procedures are given in the Barrel Module FDR QA document SCT-BM-FDR-7. The most recent update is 28-May-2002.

Institute contacts for barrel module QA related matters

LBL: Alessandra Ciocio and Vitaliy Fadeyev (QA responsible) / Carl Haber
UC Santa Cruz: Felix Rosenbaum

QA of components

The QA of barrel module components is not discussed here. USA supplies of components are QA'ed by:

- Passive-stuffed hybrids by KEK (contact Nobu Unno)
- Baseboards at CERN by QMUL/Cambridge (contact Tony Carter)
- Detectors by KEK (contact Nobu Unno)
- ASICs at UCSC (contact Alex Grillo)

All components visually inspected for obvious defects before use.

QA tests during hybrid assembly

Hybrid assembly and QA of the ASIC-stuffed hybrids are the responsibilities of both LBL and UC Santa Cruz. The QA steps are as follows – assembly steps are included also for clarity:

1. Hybrids are received from KEK and unpacked
2. Visual inspection
3. Bond-pull tests
4. Assembly of ASICs onto hybrid, glue curing, wire bonding of chips to hybrid pads (but not yet to pitch adaptor)
5. Electrical characterization sequence
6. Long-term test (initially 100h at 37C on hybrid temp sensors). (For production this step will be modified to include 10 hours at 0C as now required. The cooled fixtures are being fabricated at this time.)
7. Wire-bonding of ASICs to pitch adaptor
8. Final electrical confirmation test

9. Packaging and shipping to LBL if at UC Santa Cruz.

All steps are on a 100% basis. All steps are done for pre-qualification and qualification modules, and all steps will be maintained for full production. The only change anticipated for full production is that the length, and temperature, of the long-term test may be reduced with experience across the SCT.

Hybrids failing steps 2 or 3 are returned to Japan. Hybrids failing tests 5, 6 and 8 are re-worked – chip replacement being the most that can be done. To date all rework has been done at LBL but will be extended to UC Santa Cruz in the near term.

QA tests of baseboard-detector sandwich

This is done at LBL. The steps are:

1. Visual inspection of baseboard
2. Visual inspection of detectors
3. Assembly of detectors onto baseboard
4. Visual check
5. I-V measurement up to 500V
6. Full metrology
7. Cure at 30C for 8 hours.
8. I-V measurement up to 500 V
9. Full metrology.

During qualification step 8-9 showed the same results as step 5-6. For some time in early production we shall continue with both sets of steps but may abandon 5-6 if appropriate at some point.

QA tests during hybrid mounting

These are done at LBL.

1. Electrical confirmation test of hybrid
2. Visual check of hybrid
3. Assembly of hybrid onto module (gluing but not yet wire-bonding)
4. I-V measurement up to 500V as a diagnostic step.
5. Full metrology
6. Detector strip wire-bonding
7. IV test on probe station.

We should aim to reduce/eliminate step 4-5 during production if continued stability of results is observed. A hybrid failing steps 1 or 2 would be returned for re-work where possible.

QA tests on completed module

This is done at LBL.

1. I-V measurement to 500V (ASICs off)
2. Electrical confirmation test
3. Thermal cycling
4. Full metrology
5. Electrical characterization test at room temperature
6. Long-term electrical and I-V stability test (run these two concurrently, at 0C as measured by hybrid temperature sensors, in a controlled dry gas environment). Terminates with a characterization test at 0C.

7. Pack and ship to Oxford
8. Confirmation test at Oxford while still in module box, before mounting onto barrels

Modules failing the I-V tests undergo further tests at, as agreed in the February 2002 SCT week module meeting (documented by Nobu Unno). Modules failing any other tests are evaluated for re-work or storage. This rework if simple will be at LBL or else at UC Santa Cruz.

Sampling QA

Irradiation and test-beam are SCT-wide activities.

Sampling fractions are not yet defined, but will be small.

Summary of USA Site Qualification Modules Assembled

1. Overview of Qualification Modules

The USA site qualification modules are:

Module Number	Hybrid Type	ASIC Wafer	Baseboard Type	Hamamatsu Detector Type
20220040200004 (Q1)	K5	UCSC-Z38850-W16-2	Site qualification, new washers	Pre-series 100
20220040200003 (Q2)	K5	UCSC-Z38850-W16-2	Site qualification, new washers	Pre-series 100
20220040200006 (Q3)	K5	UCSC-Z38850-W20	Site qualification, new washers	Pre-series 100
20220040200007 (Q4)	K5	UCSC-Z38850-W20	Site qualification, new washers	Pre-series 100
20220040200005 (Q5)	K5	UCSC-Z38850-W20	Site qualification, new washers	Pre-series 100

In addition, 2 pre-qualification modules were built and studied with production protocols:

Module Number	Hybrid Type	ASIC Wafer	Baseboard Type	Hamamatsu Detector Type
20220040200001 (E3)	K5	UCSC-Z38850-W12-2	Pre-series epoxy mounting holes	Pre-series 111/100?
20220040200002 (E4)	K5	UCSC-Z38850-W12	Pre-series epoxy mounting holes	Pre-series 111/100?

Further component details can be found at
http://www-atlas.lbl.gov/strips/modules/production.html

All tests have been completed on all these modules and the full documentation exists on the web at the above location.

2. Discussion of results on each module:

Q1: This module remains inside specification mechanically in X-Y and Z after full thermal cycle. This module is inside specification electrically. Following construction and test this module had 3 bad channels. The total leakage on the complete module was 2.25 micro-Amps at 500 Volts. This module has been sent to, and received at, KEK for cross checking. <u>Based upon the data presented this module passes qualification</u>.

Q2: This module remains inside specification mechanically in X-Y and Z after full thermal cycle. This module was accidentally scratched on the surface of one of the detectors during an I-V probing step. As a result it has a leakage current exceeding specification. This is discussed further below. Other than the leakage current problem, the module is inside specification electrically. Following construction and test this module had 5 bad channels. Of these 1 is isolated and can't be trimmed. The remaining 4 appear as two noisy pairs. This is certainly due to bond wire or fanout shorts and are probably repairable with some effort.

Discussion of Q2 leakage current: Due to the scratch on the surface of Q2, a large (10's of micro-Amps) current is measured immediately after biasing up to 500 V. If the module is operated in a dry atmosphere, this current is observed to fall steadily over a period of hours or days. Such a conditioning led to the result shown on the web, with a total current of 6.4 micro-Amps at 500 V. This still exceeds spec although additional conditioning or long term operation, might lead to further improvement. **We propose Q2 for the one allowed failed module.**

Q3: This module remains inside specification mechanically in X-Y and Z after full thermal cycle except for the slot position in Y (Msy) and the angle of the cooled facing along the strip direction (loCoolFacing a). These mechanical issues are discussed further below. This module is inside specification electrically. Following construction and test this module had no dead or un-usable channels. The total leakage on the complete module was 1.06 micro-Amps at 500 Volts. This module has been sent to, and received at, RAL for cross checking.

Discussion of Q3 mechanical deviations:

1. Slot Y position deviates from nominal by 32 microns while the specification is 30 microns. We have measured the slot width on the baseboard washer for this module. The measured value is 1826 microns while the specification is for 1800 - 1810 microns. This measurement has been repeated a number of times with consistent results. The deviation we observe on the module results from this additional space in the slot width since the module, as mounted in the metrology frame, can be pushed to either extreme of the slot width along Y. We therefore claim that this deviation is not due to the module build process and should not be considered a problem of module assembly.

2. The measured angle, loCoolFacing "a", is -0.896 mrad and the spec is 0.5 mrad absolute. The spec corresponds to 24 microns over 48 mm (hole to slot spacing). In the Z survey analysis spread sheets, the reference plane is defined by sets of points taken off the loCoolFacing surface and non-cooled tab. The loCoolFacing angles are based upon points from this same set. The loCoolFacing "a" angle is not independent of the reference plane. It can be argued that loCoolFacing "a" as defined ought to be zero. In the RAL metrology frame, the cooled facing is constrained to be in contact with the support shelf. The plane of the metrology fixture is defined by this support shelf as well. In the actual measurements made,

the metrology frame obscures the lower facing surface. Therefore, loCoolFacing is measured off the top of the cooled facing. (It is done the same way at RAL.) In this case, any angle measured for loCoolFacing could be due to the upper and lower facings being out of parallel or any residual bow or aplanarity of the facing/baseboard sandwich. This would be a feature of the baseboard and not due to module assembly. <u>Therefore we do not consider this to be a module assembly problem.</u> Later, in production, new metrology frames will be employed at all sites which give direct measurement access to the lower cooled facing. (A similar loCoolFacing deviation is seen on Q4, see below in the Q4 discussion for additional measurements bearing on this issue.)

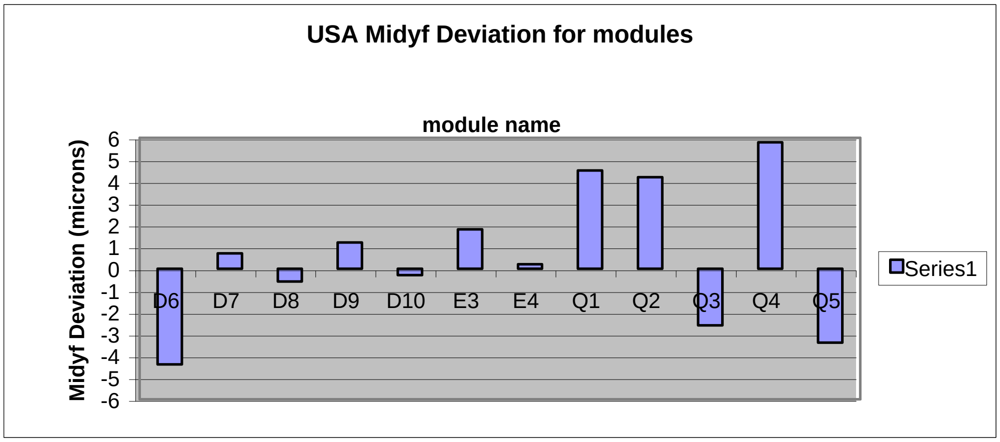
<u>Based upon the performance data presented and the discussion given we consider Q3 to have passed qualification.</u>

Q4: This module remains inside specification mechanically in X-Y and Z after full thermal cycle except for Midyf, loCoolFacing a, and maxZerrorUpper and Lower. These deviations are discussed below. This module is inside specification electrically. Following construction and test this module had 13 bad channels. Of these 8 were lost due to damage on the fanout (discussed below) and 4 occur as 2 pair. The pairs are probably due to wire bond shorts and are therefore repairable with some effort. The total leakage on the complete module was 2.82 micro-Amps at 500 Volts.

During wire-bonding, the bonding machine malfunctioned and the bonding head dropped onto the hybrid. The first slave chip on the top side, and a group of about 8 channels on the fanout, were damaged in this incident. The damaged chip was replaced and re-bonded. Later, during post thermal cycle electrical tests, the top side master chip failed to function in SELECT=1 (bypass) mode. The master was also replaced and re-bonded. The fully repaired module was retested through the long term test and functions electrically within specification. The total number of bad channels, as reported above, remains below the specified cut as well.

Discussion of Q4 mechanical deviations:

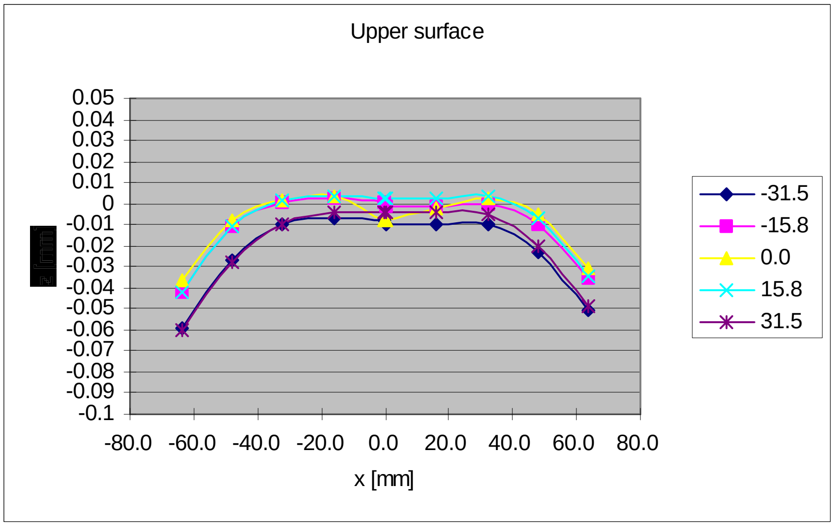
1. Midyf deviates from nominal by 5.8 microns when measured after thermal cycle. The specification is 5 microns. We have re-measured the Midfy deviation a few times over the course of assembly and it ranges between 5.1 and 5.8 microns. The value of Midyf on the other electrical and dummy modules is distributed as shown in the plot below. We don’t consider the measurement process to be accurate at the sub-micron level and therefore propose that Q4 passes qualification in this parameter.



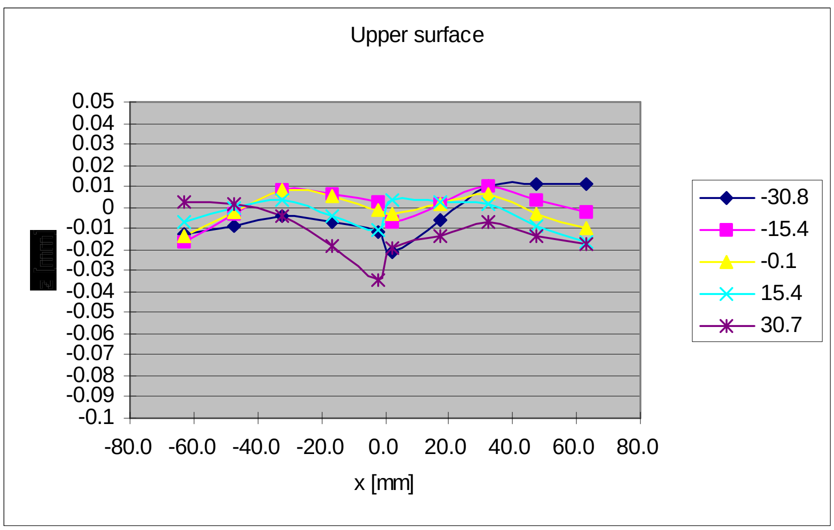
With regard to this plot, we note that modules D6-D10 used baseboards with epoxy hole washers, E3 and E4 used baseboards with old style Aluminum washers and Q1-5 used baseboards with new production style Aluminum washers.

2. loCoolFacing "a" deviates from nominal in a similar way to module Q3. For the same reason we don't consider this to be a failure either. We measured the total thickness across the cooled facings on this module with a micrometer. Near the hole we find 0.91 mm and near the slot we find 0.96 mm. This deviation from parallel in the baseboard/facing sandwich is actually in the opposite direction to the loCoolFacing angle observed but is indicative that the baseboard assembly could contribute to deviations in the survey.

3. maxZerrorUpper and Lower: Throughout the qualification process we have been comparing to a common profile as stored in the Z metrology spreadsheets provided on the web. While the labeling of the common profile is ambiguous, as best we can determine, it corresponds to modules made with 100 type silicon. The silicon we used in the qualification series is also 100. However, it is clear that many of the modules we built are considerably flatter than those used to form the common profile. We also compared to the explicitly labeled 100 profile on the web and we remain flatter than that as well. See the figures below for an example. <u>At worst we claim to be comparing to the wrong profile but as our modules are quite flat they should not fail qualification in this deviation.</u> We suggest the maxZerrorUpper and Lower cuts should not be based simply upon the deviation from the common profile. They should instead be based on the requirement that the module bows by no more than 50 microns **beyond** the common profile.



Above: The official 100 profile for the upper surface from the barrel module web page.



Above: Measured upper surface for USA module Q4

<u>Based upon the performance data presented and the discussion given we consider Q4 to have passed qualification.</u>

Q5: This module remains inside specification mechanically in X-Y and Z after full thermal cycle. This module is inside spec electrically. Following construction and test this module had 13 bad channels. Of these 7 were already bad on the wafer (chips with 1 bad channel were used on the hybrid for this module). Of the remaining 6, 3 were a contiguous triplet and thus due to a wire bond short, and probably repairable with some effort. The total leakage on the complete module was 0.49 micro-Amps at 500 Volts. <u>Based upon the data presented, Q5 passes the qualification</u>.

In addition we discuss the results on the pre-qualification module E3 and E4:

E3: This module remains inside specification mechanically in X-Y and Z after full thermal cycle. This module is inside spec electrically. Following construction and test this module had 14 bad channels but of these 12 were present already at ABCD wafer level (chips with 1 bad channel were used in pre-qualification). The total leakage on the complete module was 0.5 micro-Amps at 500 Volts. While not a qualification module, E3 none-the-less meets the specifications to pass qualification.

E4: This module remains inside specification mechanically in X-Y and Z after full thermal cycle. This module is inside spec electrically. Following construction and test this module had 17 bad channels, of these 9 were present already at the ABCD wafer level. Of the remaining 8, 6 are found in 3 pairs, indicating shorted wirebonds or fanout traces. In one of these pairs we found a hairline short in the fanout lithography. The other shorts are repairable with some amount of effort. The total leakage on the complete module was 0.338 micro-Amps at 500 Volts. While not a qualification module, E4 none-the-less meets the specifications to pass qualification.

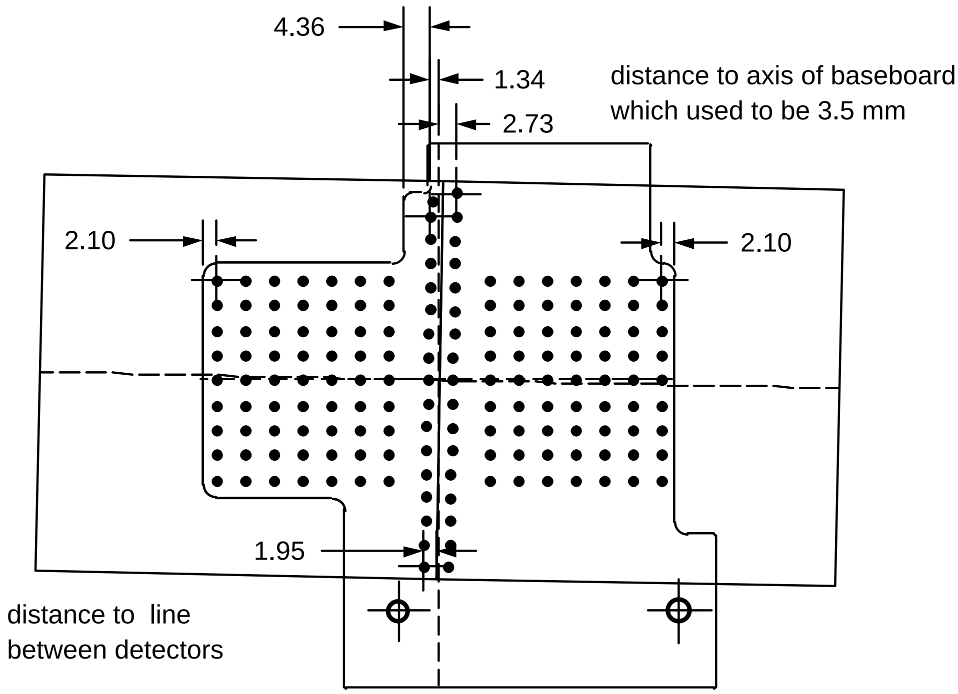
3. General Discussion

1. Dust: During the qualification series RAL reported the appearance of micron scale dust or debris on the detector surfaces after the assembly alignment step. This was attributed to the vacuum pickup system and the use of clean room paper which did not completely cover the silicon surface. RAL associated this dust with some increased leakage current. We saw this dust as well but not any associated leakage increase. Part way through qualification RAL recommended, and we adopted, a larger clean room paper cover sheet. With the larger paper the dust was no longer present.
2. Hybrid Alignment: Hybrid alignment was incorporated into the build specification with the May 28, 2002 release of Barrel Module FDR-7. During qualification we used a temporary hybrid mounting fixture in lieu of our production model which was delayed in fabrication. The temporary fixture did not place the hybrids within the 100 micron tolerance stated in FDR-7 along the strip (Y) direction. They were placed well enough to align fanout and detector pads for straight wirebonding and to fit into the module test boxes. Since the completion of the qualification run our production hybrid placement fixture has been commissioned and we have mounted mechanical grade hybrids on dummy modules with a deviation of 25-40 microns from nominal along the strip direction and about 25 microns across the strips. We do not foresee any difficulty to meet the hybrid mounting specification in production.\
3. Wirebonding: As demonstrated by the good channel yields seen on all the qualification and pre-qualification modules our wire bonding has been reliable. This result however masks a number of difficulties experienced in the process and reported on during the Valencia SCT week. We had difficulty to bond from detector to detector particularly in the regions close to channels 1,2,3…. Because of this we had to repeat bond to some pads and this was time consuming and frustrating for the

operators. After considerable study and consultation with the bonding machine technical support staff and other experts we concluded that there may be two sources for these difficulties.

- In the difficult region, the bond pads are quite far from the nearest Araldite/BN glue dots. The silicon is therefore cantilevered and is seen to deflect significantly under the bonding tool. No simple variation of bonding parameters improves the bonding.
- The bonding machine force, set by a mechanical adjustment and force gauge measurement, is at the manufacturer’s default value. By lowering this, and making other adjustments on controllable bonding parameters, the difficulties in this region might be reduced.

In parallel with our qualification work we made extensive studies of effect of glue dot position also using dummy parts. We plan to also study the effect of reduced bond force. With a modified glue pattern shown below, we observed a significant and dramatic improvement in bonding reliability in the difficult region. Following our study of reduced bond force we will consider requesting of the barrel module community permission to modify the glue pattern as shown. We can foresee no effect on thermal or mechanical performance from such a modified pattern.



2-July-2002
revised glue pattern to improve wirebonding performance
7x9 dot regions are not changed.
2x15 dots along centerline are changed as follows:

1) group becomes 2x17
2) group is rotated by stereo angle
3) group is shifted closer to detector to detector gap in order to be located beneath bond pads. Distance to gap becomes 1.95 mm.

Summary of Electrical Performance of USA Site Qualification Modules

Alessandra Ciocio, Bo Jayatilaka, Shanna McIntyre, Leah Zimmerman

July 19, 2002

1. Detailed Results

The full electrical test data of the completed modules can be found at

http://www-atlas.lbl.gov/strips/modules/production.html

All measurements satisfy the module electrical specifications.

An overview summary of the results is given in the Table below.

Module Number	Uncorrected Noise ENC (from NO)	Noise-Occupancy at 1fC	Poor Quality Channels (Inclusive Masked Channels)	Leakage Current (warm) at 500V bias
20220040200004 (Q1)	1247 - 1386	2.6e-007 – 5.5e-006	7(2)	2.255 µA
20220040200003 (Q2)	1193 - 1333	1.9e-007 – 1.0e-006	15(5)	6.426µA
20220040200006 (Q3)	1190 - 1302	1.8e-007 – 1.2e-006	4(0)	1.056 µA
20220040200007 (Q4)	1138 - 1214	1.6e-008 – 2.2e-007	13(4)	2.819 µA
20220040200005 (Q5)	1200 - 1406	2.6e-007 – 2.4e-006	13(10)	0.492 µA

Table 1. Overview summary of the electrical results

2. General comments

2.1 Noise and Noise-Occupancy

The results presented here have not been corrected for differing values of ASIC calibration capacitor. One effect of this is to flag a number of otherwise good channels as "partbonded" due to measured (uncorrected) noise falling slightly below the software cut during the low temperature (0 C) long term test of Q3, Q4, and Q5.

Given the normal uncertainties, the noise and noise occupancy results seem satisfactory.

2.2 S-Curves

These can be found with the electrical results. They show a standard level and shape.

2.3 Bad Channels

The numbers of bad channels is given in Table 1. The number of channels masked by the TrimRange test, which is a subset of the total number, is given in parentheses. The remaining “bad” channels fall in one of the following categories: noisy (often due to wirebond shorts), unbonded, and low gain. Of the bad channels in Q5, seven were present at the wafer level (chips with 1 bad channel were used on the hybrid for this module). In addition, two channels were masked manually since they had high offset and the TrimRange test was not masking them automatically.

2.4 Leakage Currents

Module Q2 shows a high leakage current due to a scratch on the surface of one of the detectors. Operating the module at 350V bias for several hours or days in a dry atmosphere results in the current dropping to the level shown in the above table (see assembled module summary).

The remaining qualification modules all have leakage current within specifications.

2.5 Long-Term Cold Electrical Tests

The long-term (24 hour) cold tests at ~ 0?C (thermistors reading) and a bias voltage of 200V have been completed for all modules. The results show good long-term stability. In the case of Q1, Q4 and Q5, the characterization test at the end of the long-term run had to be re-run due to software crashes. In the case of Q2, the characterization test had to be re-run due to a SCTHV current trip at the end.

3 Comparison of Results at Different Institutes

Module Q1 and Q3 have been sent to KEK and RAL, respectively, for mechanical and electrical measurement by clusters outside the USA.

Hybrid Assembly: Operator's Guide

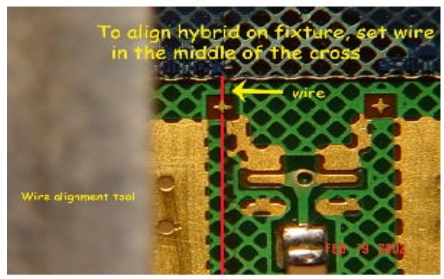
Lawrence Berkeley National Laboratory
Rhonda Witharm Version 1.0, July 16 2002

Revision History
V1.0 Original Version 16-July-2002

In-coming bare hybrids are logged as received in the clean room hybrid logbook, then stored in the dry air cabinet behind the bonder.

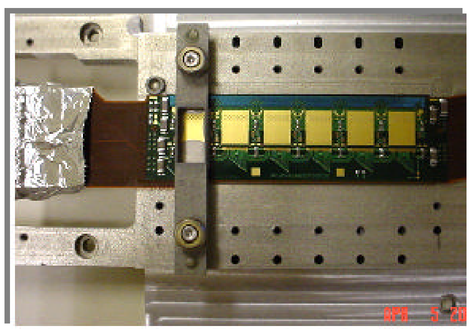
1. Visually inspect hybrid and chips under microscope. List any irregularities.

2. Place hybrid on hybrid vacuum fixture. Use wire alignment tool to line up hybrid on fixture.

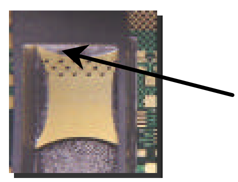


3. Mix glue (Adhesives Procedure document)

4. Place glue mask tool on fixture and lay glue on all 12 chip positions.



Place glue here

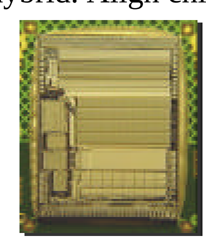


With syringe

5. Place chip gel-pak on vacuum to free chips.

6. Remove chip with plastic tweezers or vacuum pen. Make sure that cup on pen is clean and clear of debris. Place chip on chip chuck with the fan out pads facing away from the stops. Set vacuum.

7. Using chip placement tool, place tool over the chip on vacuum chuck, set vacuum for tool, release vacuum on chip chuck, pick up chip and place on hybrid. Align chip, release vacuum and set chip using pressure so that glue spreads only enough as in picture.



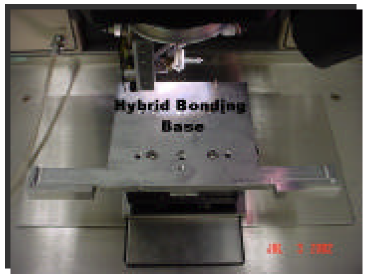
8. Heat in oven at 50C for 2 hours.

<u>Hybrid Bonding operation Manual</u>

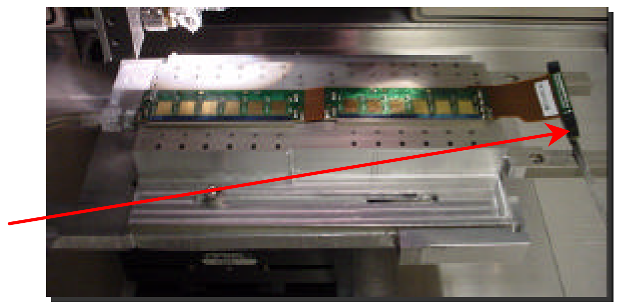
Lawrence Berkeley National Laboratory
Rhonda Witharm Version 1.0, July 16 2002

Revision History
V1.0 Original Version 16-July-2002

1. Bonder set up: Place hybrid bonding base on bonder jack and check for level.



2. Align hybrid on vacuum fixture with the fan out near operator, set vacuum. Position vacuum fixture to the extreme left or right until it stops. Tighten screw. This will place six chips in the center of the bonder travel.

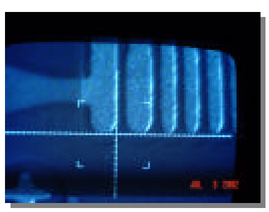


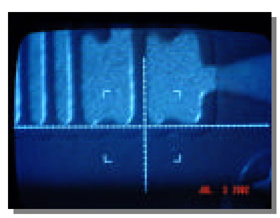
3. Connect grounding strap to hybrid connector.

4. Set power according to bonder log book. Place four test bonds on gold pad at bottom of hybrid. Pull test bonds before bonding chips. Breaking should exceed 9 grams.

5. Load program #00000031.This is a two-chip program. Line up the reference points for both chips. Before running program check Z height, it should be 2400. Run Program.

   a. <u>ref pt 2</u>
   b. <u>left side chip 2</u>



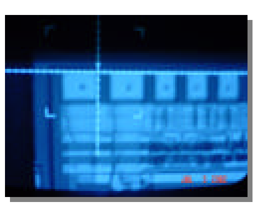


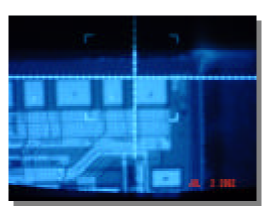
   a. <u>xyo, ref pt</u> 1
   b. <u>right side chip 2</u>

Front row is bonded from chip to hybrid with the first bond power at 2.1 and the second bond at 2.3. The loop height is 300.

The sides of the chip are bonded in reverse in order for the clamp to clear the components.

   a. <u>ref pt 4</u>
   b. <u>left side chip2</u>





   a.<u>ref pt 3</u>

6. Visually inspect bonds. Replace any that were missed.

ATLAS SCT Barrel Module Assembly Process
USA Cluster

Lead Author: Frank McCormack
Contributors: Carl Haber
Vitaliy Fadeyev
Tom Johnson

Date: 17-Jul-02
Version 4.0

Revision History:
11-Feb-02 V1.0: original version
28-Feb-02 V2.0: revised, added metrology, glue dispense
12-Jul-02 V3.0: revised, subtracted glue dispense (now separate doc.)
17-Jul-02 V4.0: General editing, moved metrology and I-V scan to separate documents.

1.0 Detector selection and inspection
1.1 Select wafers from database or provided list
1.2 Inspect visually under the microscope for scratches and other defects.
1.3 Confirm that corner fiducials are not defective
1.4 Check wafers for correct size - that the saw cut street isn't excessively wide. This will cause detectors to collide during alignment. (Note: this step applied to dummy and glass wafers).

2.0 Setting of proper dimensions file (DIMS file)
2.1 The proper dimensions for this module should be in the file:

ATLAS SCT: LabVIEW 5.1:V5_LV51:Assembly-RAL:Data:BarrelFront.dim or
ATLAS SCT: LabVIEW 5.1:V5_LV51:Assembly-RAL:Data:BarrelBack.dim

as appropriate. After the addition 6 assembly kits are commissioned we will have additional dim files for them. Use the appropriate file for the fixture kit in use.

3.0 Setting of lights and video
3.1 The power supply for the assembly optics illuminator should be ON and set to 8.5 V. <u>This supply should never be switched OFF.</u>
3.2 The SONY video monitor should be BRIGHT full scale.
3.4 The JVC camera power supply should be on.

4.0 Load and execute Build.vi
4.1 Run LabVIEW 5.1
4.2 Close the blank windows, which appear at initialization.

4.3 Open Build.vi either from File->Recently Opened Files or from

ATLAS SCT: LabVIEW 5.1:V5_LV51:Assembly-RAL:Progs:Assemble.llb - Build.vi

4.4 Click the RUN arrow
4.5 Select Module type: **Barrel**
4.6 Select Module type: **Front** or **Back** as appropriate.
4.7 Click **Go** on **Start** button.
4.8 The following frames will open automatically:
    Steps.vi
    Log-display.vi
    Image
4.9 User input will be via the Steps.vi frame from now on.

5.0 Loading of wafers

5.1 Move the wafer stages to the load position by using the Steps.vi window.
5.2 Set the wafer alignment stops on the stages by turning the knurled machine screws clockwise till seated finger tight (approx. 2 turns)
5.3 Move wafer to assembly stage via carrying tray.
5.4 Pick up wafer with vacuum pen and place on stage with edges near the alignment stops. Ensure correct orientation.
5.5 Seat wafer against stops with light force at approximately a 45-degree vector between stops. Wafer should be contacting all 3 stops.
5.6 Apply vacuum to wafer while maintaining seating force.

6.0 Running build Steps.vi

If FRONT go to step 7.0
If BACK go to step 12.0

7.0 Baseboard preparation and loading baseboard into assembly window frame

7.1 Inspect washers and holes in b/b for damage or debris. If dirty clean holes with air spray or small pick tool.
7.2 Inspect baseboard for cracks or defects in TPG and for glue deposits on ceramic surfaces.
7.3 Measure TPG thickness with digital calipers. Determine to nearest 10 microns (0.45 mm, 0.46 mm etc). Measure in a few spots and take rough average.
7.4 Run the Baseboard Shim Calculator spreadsheet and determine required shim thickness.

7.5 Record baseboard number, thickness, and shim choice in traveler.
7.6 Clean off b/b support plate with air spray and mount b/b on plate, secure with vacuum.
7.7 Place shims on B side of window frame, insert b/b support plate and secure with three screws using torque wrenches in the 1,2,3… order.

8.0 Glue preparation and dispensing. See document C:\Documents and Settings\Administrator\Desktop\SCT Documentation\ATLAS SCT Barrel Module Adhesive Procedure.doc

Use Program #2

9.0 Pickup wafers

9.1 Pick up wafers from assembly machine using vacuum transfer plate as follows.
9.2 For front, use plate "A". For back, use plate "B".
9.3 Raise plate stop on linear bearing tower to highest position by turning brass thumbwheel clockwise.
9.4 Back off detector alignment stops to full travel by turning black thumbscrews.
9.5 Clean off top of detectors with clean air source.
9.6 Place new sheet of wafer paper on detector pair. **We are now using larger BLUE wafer paper.**
9.7 Carefully slide transfer plate guide posts into linear bearings, lower plate until contact with plate stop.
9.8 Lower plate stop till transfer plate contacts detector pair under paper.
9.9 Gently place weight on top of transfer plate.
9.10 Remove vacuum from stages by closing valves.
9.11 Apply vacuum to transfer plate by opening appropriate valve.

10.0 Loading wafers into window frame fixture

10.1 Select shims of appropriate thickness to set the clearance between detector and baseboard. This controls glue line thickness. For the FRONT or A side we do not use any shims. For the B or backside, determine shim using Baseboard Shim Calculator spreadsheet.
10.2 Center shims on machined surface of compression posts. Make sure threaded holes are visible.
10.3 Lower transfer plate on to window frame fixture, engaging linear bearings and guideposts.
10.4 Seat transfer plate gently against shims, inset and torque screws to specification following 1,2,3…pattern.
10.5 Allow ass'y to cure for 24 hours at 20C, 50%RH before movement.

11.0 Remove baseboard support plate from window frame fixture

11.1 Close vacuum valve to baseboard support plate.
11.2 Remove Allen head retaining screws (3)
11.3 Slide baseboard support plate up until disengaged from linear bearings.

12.0 Glue dispense on back – see step 8.0

Run program #1.

13.0 Pickup wafers

13.1 Pick up wafers from assembly machine using vacuum transfer plate as follows.
13.2 For back, use plate “B”.
13.3 Raise plate stop on linear bearing tower to highest position by turning brass thumbwheel clockwise.
13.4 Clean off top of detectors with clean air source.
13.5 Place new sheet of wafer paper on detector pair.
13.6 Carefully slide transfer plate guide posts into linear bearings, lower plate until contact with plate stop.
13.7 Lower plate stop till transfer plate contacts detector pair under paper.
13.8 Gently place weight on top of transfer plate.
13.9 Remove vacuum from stages by closing valves.
13.10 Apply vacuum to transfer plate by opening appropriate valve.

14.0 Loading wafers into window frame fixture

14.1 Select shims of appropriate thickness to set the clearance between detector and baseboard. See results of Shim Calculator. This controls glue line thickness.
14.2 Center shims on machined surface of compression posts. Make sure threaded holes are visible.
14.3 Lower transfer plate on to window frame fixture, engaging linear bearings and guideposts.
14.4 Seat transfer plate gently against shims, inset and torque screws to specification following pattern.
14.5 Allow ass’y to cure for 24 hours at 20C, 50%RH before movement.

15. Release from window frame fixture

It is important to remove the module while it is still held by vacuum to the B plate.

15.1 Unscrew 3 retaining bolts from fixture on the A transfer plate only.
15.2 Remove vacuum from transfer plate A, slide transfer plate up and off.
15.3 Turn Window Frame over. Remove 3 retaining bolts from the B fixture.
15.4 Lift B fixture up and out with module still attached.

15.5 Place B fixture with module facing up on the table. When ready, release B vacuum and lift module with module handling tool.

16. Mount module on metrology frame

For metrology steps refer to the document C:\Documents and Settings\Administrator\Desktop\SCT Documentation\US_Mechanical_Survey_V2.doc

Basic Smart Scope setup is as follows:

16.1 Clear the Smart Scope glasswork area of all parts and tooling unrelated to this measurement.
16.2 Switch on power to the table drive controller - look for green light on the IN/MM switch to ensure power is on.
16.3 Switch on power to the computer and monitor.
16.4 Open the software programs called MeasureMind.
16.5 Retract lens to highest position by rotating joystick knob clockwise.
16.6 Press START/STOP button on right side of table drive controller.
16.7 Click OK on "stage seek home" dialog box.

US ATLAS SCT Barrel Module Assembly: I-V Probing Procedure V2.0
15-July-2002

Authors: F.McCormack
C.Haber
W.D.Wise

Revision History:
V1.0 April 10, 2002 Original Version
V2.0 July 17, 2002 Reformat, changes for post qualification period.

1. Overview

These tests consist of measuring the leakage current vs. increasing voltage. Testing is done in a light-tight enclosure. A voltage source/pico-ammeter (Keithley 487) imposes a voltage across the detector in the box. The resulting current is then read by the ammeter and recorded. The v/ammeter is controlled by a computer running a LabVIEW program, which sweeps through predefined bias voltage points. This generates a data file, which is stored for further comparison. In some cases the measurements may be on a single detector but in general the measurements are done on 4 detector/baseboard assemblies.

2. Initial setup

Turn on the camera power supply. Nominal readings are 0.2A @12VDC
Turn on the camera lighting to about halfway between low and high.

The camera can be moved independently from the chuck, and this allows sighting on the bias access port without moving the detector.

Set the camera magnification to1x by rotating the black lens housing fully CCW.

Focus on the chuck surface by using the coarse and fine camera Z-stage movement controls on the tower.

Center the camera on the right side of the stage, using the camera tower X-stage controls.

3. Placing the detector on the vacuum chuck in the dark box.

Because of the large size of the detector relative to the chuck, the detector must be substantially offset to the right or left of chuck center. This results in an overhanging detector, without full vacuum engagement, and extreme care is called for.

Move the chuck to the full right position using the chuck X-stage controls.

Carefully place the detector face-up on the chuck surface. Focus the camera on the detector surface.

Position the wafer so the bias ring access port is centered in the camera field-of-view.

Very carefully move it sideways until the bias ring access port can be seen in the camera field-of-view.

Turn on the chuck vacuum while supporting the detector.

Now move the probe needle to a position above the detector. A fuzzy shadow should be visible on the target area of the detector.

Turn the Z-axis control of the probe CCW to lower the probe needle (warning! this is reversed from the intuitive feeling with normal RH thread systems).

The shadow will coalesce into a sharper image as the needle lowers to the detector surface.

Stop turning the Z-axis control momentarily when the needle touches the surface.

If the alignment of the needle with in the access port looks good, slowly turn the Z-axis control about ½ to 1 turn more. The needle should skid slightly and then furrow into the pad surface.

Turn the camera light off, and close the dark box by pulling down on the center of the door. The door will go over-center, and attempt to close itself within about 1 foot of bottom edge contact. Don't let it slam. Latch the top first, bottom second.

4. Running an V/I scan

Select the LabVIEW program C:\Documents and Settings\Administrator\Desktop\487 control**487controller.vi.**

The Users Guide is in:
C:\Documents and Settings\Administrator\Desktop\487 control\487 Labview documentation.doc

Enter the detector serial number.

Check the electrical test parameters.

Enter the dark box temperature from the SDT46 digital thermometer.

Press the Plot I (V) button to begin the scan. Cycle time is approx. 15 seconds.

After scan is complete, press the Print I (V) button to generate a data line hardcopy. Save the data also in the SCT database format.

5. Post detector-to-baseboard gluing leakage test

Each detector is tested after gluing the 4 crystals to the baseboard assembly. This is the same test electrically as a single detector measurement, but has a different mechanical setup to accommodate the assembly form factor. Principally, the detector ass'y needs to support and measured in a holding fixture. There are two holding fixture styles, front or back (facing up). Only two detectors can be tested in each fixture, so both must be used sequentially to test a full assembly. Two needle probes must be used, one to contact the detector test pad, and an extra one to contact the detector backplane. Two different contact schemes must be used to make the backplane connection. The backplane of front detectors are accessible via a gold metal pad on the baseboard ass'y. The gold pad is not accessible when the detector ass'y is inverted to measure the back detectors. The contact must be made on the backplane of the front detectors, which is visible when the detector ass'y is inverted. This is visible as a long, narrow triangular region below the back detector.

6. Post hybrid-to-module gluing leakage test

This step may not be used in all cases. Each detector is tested after the hybrid is bonded to the baseboard assembly. This is the same type of test electrically, but has a slightly different mechanical setup to accommodate the assembly form factor.

USA ATLAS SCT Barrel Module Adhesive Procedure

7/15/2002 V2.0

Frank McCormack
Tom Johnson

Revision History
V1.0 Original version
V2.0 Major revision after qualification, added electrically conductive procedure

1.0 Adhesive dispense - Thermally conductive adhesive

1.1 Turn on machine Fisnar 750LN & press the HOME key.

1.2 Clean room PSI should be 60 PSI min, machine regulator set at 50 PSI.
If the pressure is too low - turn off all unnecessary vacuum pumps and seal off any air leaks. A stable pressure is needed to dispense consistent adhesive dots.

1.3 Have the part located and securely fastened to its fixture.
Make sure the stage and the surface of the fixture are clean and free of debris.

1.4 Press MODE to cycle thru the options to 'POINT REGISTER' and press ENTER.
Select the program you want (use the EDIT keys to select) and press ENTER.
Make sure there is no syringe in the collet at this time.
The display will show the first point. Press GO to go to first point.
Now install a syringe with a tip into the collet and position the tip onto the surface of the fixture with a .012 shim between the tip and the fixture. DO NOT TIGHTEN the collet (collet is kept loose so if anything is wrong the tip will not crash into the part). The Z height is set off the top surface of the fixture.

Press GO to move to return position, then press GO to move tip to first position.
Check first point (bottom left) for correct Z-height and X & Y positioning
If first point is good then move onto the far top right point (# 137)
Use EDIT keys to cycle thru the program, or SHIFT & EDIT+ simultaneously to go directly to end of program, then EDIT key back to point # 137
Check Z height and X & Y positioning.
If everything looks OK, return stage and syringe to home position (press HOME key) and go to step 6.

1.5 **Changing the tip location**

If the tip position is bad, check that the fixture is snug against the locating pins, check that the part is secure, and the syringe and tip is not bent.
If the tip is still not in the desired position, you need to change the program location.

Return stage to HOME. Press the MODE to return to “POINT REGISTER”.
Select desired program with edit keys and press ENTER.
Press PROGRAM, press EDIT until you see option 5 and 6 (or X and Y)
Choose axis you want to reposition (**Caution** - X and Y axis are physically reversed from a normal machine).
Enter the amount to move the program (enter 0 before the number for a negative amount)
* Whenever any part of the program is changed and before you exit “POINT REGISTER” mode you must go to the end of the program (SHIFT + EDIT). The last step will have an “E” on it. Press END button, then ENTER, and this will register any changes made to the program.

2.0 ADHESIVE MIXING and LOADING

Only mix the glue when ready to apply it. Practical useful working time is 20-30 minutes.

2.1 MIX WEIGHTS

2.5g Epoxy
2.0g Hardener
2.0g Boron nitride powder

DO NOT breathe BN powder. Mixing is done at glue mixing station. Operator should wear rubber gloves and a breathing mask.

2.2 INSTRUCTIONS FOR GLUE MIXER

Mix using Keyence mixing machine.

2.3 Syringe fill and purge

Attempt to fill the syringe without air bubbles. Bubbles can result in poor/no dispensing of epoxy.
Connect syringe to air line.
Press MODE until you get to PLAYBACK MODE, then set the MANUAL selector switch on the machine (lower right corner of machine) to “E”. Turn on the orange switch on the pneumatic dispenser.
Press the START button to start dispensing epoxy. Let the epoxy flow until you are sure you have a smooth bubble free flow from the tip.
Be sure to turn off the orange switch on the pneumatic dispenser when finished purging the syringe. (this is the timer switch)

3.0 ADHESIVE RUN

Reinstall the syringe into the collet, but do not tighten.

Press MODE until you return to the “PLAYBACK MODE.”
On the MANUAL selector on the machine select the program you wish to run (preferably the one you just set up to run).
Press START.
The tip will move to the Z height set spot on the fixture and come to a stop.
Slide the syringe down till it rests on your shim placed on the fixture. (Z zero on the fixture is Z zero on the part. The shim will determine the height the tip is above the part (.012).
Snug up the syringe in the collet.
Press START to continue the program run.
Watch the program as it runs (approx.13 min) and keep a small stick or scalpel on hand to clean up any strings or mishaps that may occur.

4.0 Electrically conductive glue

If glue is already prepared (less than 100 hours) and has been in freezer, thaw it out and go directly to step 8.12, otherwise,

4.1 Weigh hardener droplet on precision digital scale. For 1 gram of silver, require 0.02 grams of hardener.
4.2 Add appropriate quantity of resin/silver component
4.3 Mix thoroughly by HAND.
4.4 Load syringe or cup.
4.5 Deposit small sample on another aluminum cup and cure for 2hr at 50C if a test run is specified.

US Atlas SCT Barrel Module Hybrid Attach Process.

Carl Haber V1.0 12-June-2002

This document will be replaced with a new version referring to the production fixtures.

Parts list:

Large plate - backside gluing
Small plate – front side gluing
2 rods for alignment
2 Al strips for clamping
2 short cap head screws for back side clamping
2 long cap head screws for front side clamping
3 wire segments for securing the kapton

1) Confirm that hybrid fits properly into recesses. If not you may need to trim excess kapton with a new scalpel blade – carefully.
2) Fill four small holes with 5-minute epoxy. After cure, remove any excess which beads out onto top surface.
3) Place hybrid into backside fixture and front side fixture. Secure on Large plate only with one wire clamp.
4) Mix glue.
5) Deposit glue on backside hybrid "feet", avoid edges so that there will not be excess flow onto metal causing hybrid to stick!
6) Place detector sandwich in place and locate with drill rod pins.
7) Clamp in place with Al strips and small cap head screws. Tighten until Al starts to flex. Note that on LEFT side Al will partly cover washers and may tilt a bit. This is OK.
8) Remove drill rod pins.
9) Lift front side hybrid out of fixture and flip assembly over. Inspect under microscope and confirm that hybrid is centered on detector. At this point hybrid position can be shift left/right to maintain pad alignment.
10) Place front side back in fixture and secure with additional 2 wire segments.
11) Cure for 24 hours in cabinet.
12) Remove Al strip clamps. Confirm that hybrid detector assembly can lift out of fixture. Leave in place.
13) Mix glue.
14) Deposit glue on front side hybrid "feet", avoid edges so that there will not be excess flow onto metal causing hybrid to stick!
15) Fold front side hybrid over, position and slip drill rod pins in place to locate accurately.
16) Secure with Al strips and long cap head screws. Tighten until Al starts to flex.
17) Inspect and confirm that sandwich is "flat".
18) Check alignment under the microscope and adjust to correct any small shifts if needed.
19) Cure for 24 hours in cabinet.
20) Remove three wire pieces. Remove drill rod pins.
21) Remove Al strips and open fixture, lift module out.

Mechanical Survey Procedures and Data Analysis for ATLAS SCT Barrel Modules at the US Site

Version 2.0
July 17, 2002

Vitaliy Fadeyev
Carl Haber
Frank McCormack

Revision History

V1.0 21-June-2002 Original Version
V2.0 17-July-2002 General post-qualification edit

Purpose

The goal of this manual is to document the existing mechanical surveying procedures of the modules, so that a new person could be easily brought up to speed.

Location and Equipment

All equipment is located in LBNL Room 50B-4004 (aka "4th floor clean room"). The surveying is done with "Avant 400 ZIP" SmartScope manufactured by the OGP. The data analysis is done at "50B-cleanroom" PC located about 70 ft North from the SmartScope. During a survey, a module is held by a custom-built fixture (Fig. 1).

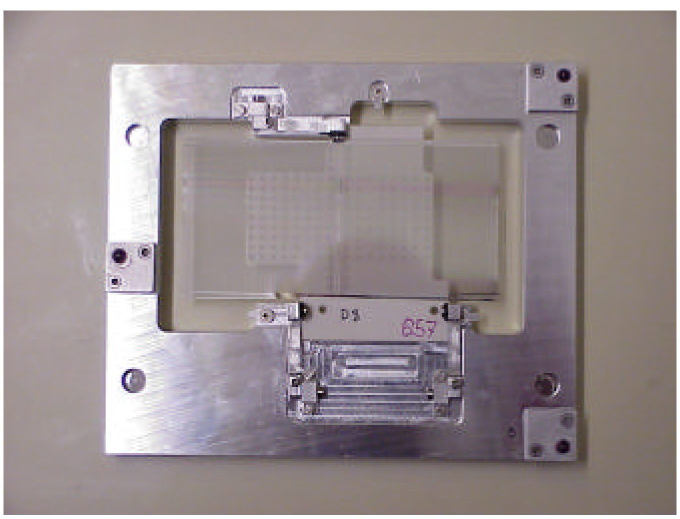


Figure 1. Mechanical survey fixture (with a dummy module).

Surveying Sequence

The following steps are taken to fully survey a module:

1) Secure the module in the fixture and place the fixture on the SmartScope table
2) Run two XY survey programs (one for each of “top” and “bottom” sides)
3) Run two Z survey programs (one for each of “top” and “bottom” sides)
4) Move the data to the analysis PC and process the Excel spreadsheets

We describe the individual steps in more details below.

(1) Module Attachment

A module is attached to the fixture with three clamps. Two of them are parallel, they go over the “hole” and “slot” washers on the cooling facing, and the third one pins down the opposite facing. The arrangement was designed to mimic the module attachment in the real experiment. To fixate the module in place, one has to:

- Unscrew leverage screws and open the clamps
- Position the module on the plate
- Fix the XY location of the module with precision shoulder pins going thru the destination holes in the plate, with tips going thru the hole and slot washers of the module baseboard
- While holding the barrels, close the clamps and screw down the leverage screws. **<u>Attention</u>: make sure that the clamps are still holding the rubber O-rings, and that they are not blocking parts of hole and slot apertures from the top-down view.**
- Remove the shoulder pins

On the SmartScope table there should be a large Al plate for securing the metrology fixture in the absolute coordinates. If absent, it should be located and installed (screwed down with two large screws) in the top left corner. The fixture is positioned on the plate with the use of three ruby balls glued on to its surface.
The one in the low right corner goes over a machined hole in the plate, the ball in the top right corner goes over a machined slot in the plate, and the third (left) ball is placed over a pedestal area for the 3D fixation. No mechanical action is required to secure the fixture over the plate, due to the three-ball design. The metrology fixture is flipped over for the other side surveys.

(2) XY Surveys

All the programs are located in *C:\Partrtn* folder of the SmartScope PC. The following programs do the XY (“in-plane”) surveys: *Survey-XY-top-W2.rtn* and *Survey-XY-bot-W2.rtn.* They are for the top and bottom surfaces of the module correspondingly.

The SmartScope control program is called *MeasureMind*. All other user-written programs are scripts executed by *MeasureMind* one step at a time. To start the user program (script), one a) pulls down *File->Open* menu to load it in the memory, b) pulls down *File->Run* menu option to start the execution, c) click "OK" button over the yellow field on the right of the screen.

All our survey programs start by the manual targeting steps over two fixture pinholes. This procedure is designed to alleviate the otherwise strict mechanical requirements of the Al plate absolute position. After tuning the position with a joystick, the user hits the left button of the device to go ahead to the next step.

Soon after the beginning there are another two manual steps, for positioning over the crosses in the black boxes of the leftmost module sensor on the surface being surveyed. This procedure takes off possible variation in the module mechanics.

There are no other manual steps, and the program normally runs smoothly until the end. In the cases of poorly machined hole and slot washers it is possible for the program to stop, due to either inability to focus on the surface, or absence of a measurable edge in the view. In such cases, the user is prompted for an action (such as manual focusing). After acknowledging the failure (hit "OK" button), tuning, and hitting the left joystick button the user is given an option to continue the program execution.

At the end of the survey we save the data with the "Print" option. One pulls the *File->Print* menu item, chooses *C:\Printrtn\Data* directory, and saves a file with the following name convention:
XY-{Module Number**}-{**top/bot**}-**Date**-**Time**.txt**

<u>Attention</u>: It is important that the data are saved immediately after the program execution, without any other measuring steps in-between.

It takes about 7 minutes for each program to execute.

(3) Z Surveys
The Z surveys are done with programs *Survey-Z-top-W2_clear.rtn* and *Survey-Z-bot-W2_clear.rtn* for the bare modules. The modules with hybrids attached are surveyed with programs with *Survey-Z-top-W2_hybrid.rtn* and *Survey-Z-bot-W2_hybrid.rtn.*

Most of the XY surveys ideology is applied to the Z surveys as well. The convention for the data file names is similar:
Z-{Module Number**}-{**top/bot**}-**Date**-**Time**.txt**

It takes about 15 minutes for each program to execute.

(4) Data Processing

Once the surveys are done, the data files are copied to the *DataExchange* folder on the *Desktop*. This is a shared folder on the “50B-cleanroom” PC. There, it is known as *C:\DataExchange* folder.

The data processing is done in Excel spreadsheets, located in *C:\Electrical Modules\{Module Number}* folder. The user creates the folder, if the module has not been surveyed before. Other modules spreadsheets can be used as a starting point. (For X-Y this will be replaced by the equivalent Perl scripts).

The XY spreadsheets have the naming convention of
CU-FF-Survey-{module number**}-{**Date**}-{**Assembly Step**}.xls**
The data input goes in the two tables on “Sheet 1”. One can “click-and-paste” the data by opening a data file from Excel clicking thru the options to interpret the ASCII file in a tabular format. Only bottom 14 rows of the data file are used. Those are the measurement summary. Once both top and bottom survey results are pasted on “Sheet 1”, “Sheet 7” will display the analysis summary with table of the physics quantities measurement, nominal values, and deviations. The rightmost column shows either “OK” or “NOT-OK” value, based on weather the quantity is in specs or not.

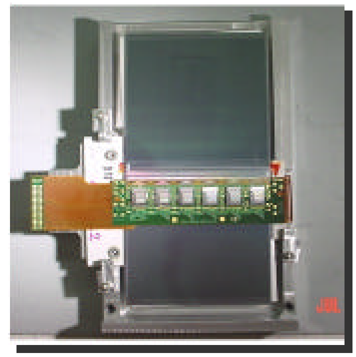
The Z spreadsheets have the naming convention of
survey_Z_{**module number**}_{**Date**}_{**Assembly Step**}.xls
The data input goes in two rightmost tables on “RawDataInput” sheet. Similar “click-and-paste” procedure would work, as the one for the XY surveys. Care has to be taken to extract the proper number of rows from the bottom of the data file.
Once the tables are filled in, the “Tolerances” sheet displays the measurement summary. Sheets “OptimalFrameView” and “CommonDeviationsView” show the individual module Z shape and its deviation from the ideal.

Module Bonding Operation Manual

Lawrence Berkeley National Laboratory
Rhonda Witharm   Version 1.0, July 16, 2002

Revision History
V1.0 Original Version 16-July-2002

1. Place module in module bonding fixture, attach to base plate with two screws.



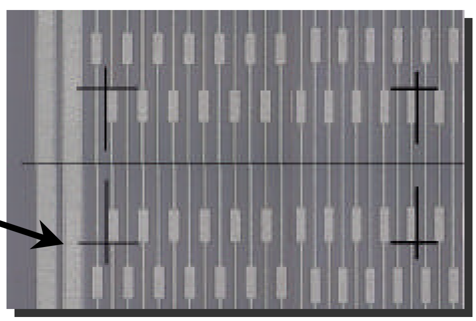
2. Set Z height on detector at 2400.

3. Start with the **detector-to-detector** bonding program, inner row **#00000029**. This program bonds half the detector. After first half is done, restart program at mid detector to finish row.

   Load floppy disk, press "floppy" button on front panel then press play. The program number will appear, press the accept button. The program will load. When it flashes, "program loaded", press semi-auto button and start lining up the reference points.

3.1 Reference points for detector-to-detector program are as follows.

xyo



It is divided into three devices and uses three sets of reference points, which correspond with three chips.

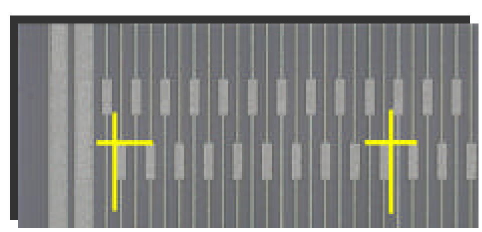
Enter these reference points three times which will take you to the middle of the detector and the first half of the detector will be bonded.

Power 1st bond is 2.2, 2nd bond is 1.9 loop height is 300

3.2 Repeat this program starting from where it ended to finish the row. There will be one bond at the end of the row which will be bonded in manual.

4. Next do the outside row, **detector-to-detector** program, **#00000030**.The set up is the same as the inner row but the reference points are on the outer row. Loop height is 500.

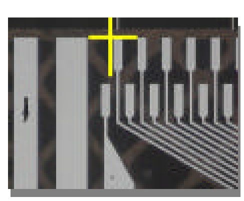
5. **Fan out–to-detector** program**, #00000027**
   This program is similar to the detector-to-detector program in that it bonds half of a fan out then needs to be restarted to finish the second half.
   It also uses three sets of reference points.
   Loop height is 700

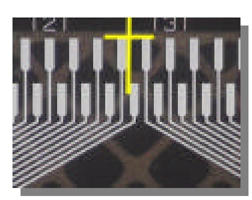


Power for 1st bond on fan out is 2.2

2nd bond on detector is 1.9

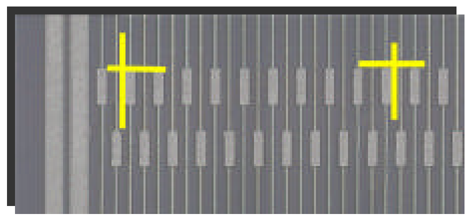
xyo and ref #1





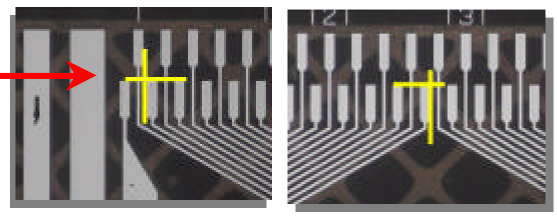
6. **Fan out –to- detector,** outer row program, **#00000028**
The same as #00000027. Pay attention to the reference points. The first pad on the left is not used as a reference point. When the program is restarted to finish the row, one left over bond at the end will need to be bonded in manual as well as this first one. Bond from fan out to detector.

Power 1st bond is 2.2
2nd is 1.9



Loop height is 900

xyo and ref #1



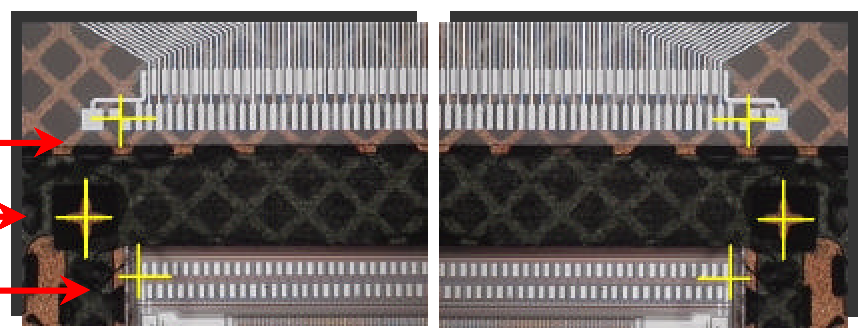
7. **Chip- to- fan out,** inner row program, **#00000020**
This bonds the inner row of one chip. It references three devices, the fan out, the chip and the gold crosses on the hybrid near the corner of the chip. After the row of bonds has been completed, the bonder jumps down to the gold pad and bonds up to the fan out for two bonds on either side of the chip.

Loop height is 300

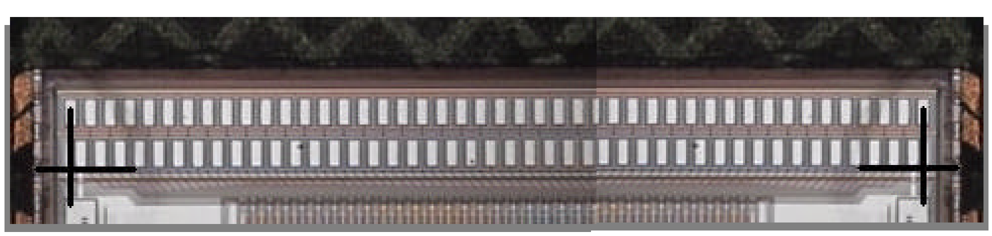
xyo, ref #1

3rd device

2nd device



8. **Chip-to-fan out**, outer row program, **#00000026**, has the same xyo, ref #1 and 3rd device, but the 2nd device references are on the outer row.



Loop height is 400

Operating Manual for LBNL ATLAS SCT Electrical Tests 2002

Leah Zimmerman
Version 3.14
18 July 2002

Hybrid and Module Tests

The VME crate should be on at all times. However, if power cycling needs to occur, disconnect the hybrid/module before commencing with power cycling. Reconnect the hybrid/module after turning on the VME crate.

Hybrid Setup

For both the longterm burn-in and short room-temperature electrical tests, hybrids are tested on a cooling fixture. The patch and support cards are screwed into the fixture to ensure proper grounding. Dry air is circulated into the box at all times.

Module Setup

Once modules are put in their box, they should not be removed; with the exception of a shortage of boxes or rework. The boxes are cooled when tests are running to keep a thermistor measurment of approximately room temperature. Dry air is circulated through at all times. For the longterm electrical test and the thermal cycling test, the module box is placed inside a programmable environmental chamber. During the short electrical tests, module boxes are covered in black cloth to minimize light-induced leakage current.

Running the tests on hybrids or modules

1. Make sure that the VME crate is powered on.
2. Install devices as described above.
3. Make sure that the dry air is flowing.
4. Turn on chiller. More information on specific chillers.
   - For the hybrid room temperature tests, the chiller should be set at approximately 17^{o}C to obtain a thermistor temperature of about 22^{o}C.
   - For the hybrid longterm burn-in, the chiller dial should be set to about 37^{o}C to obtain the same temperature on the hybrid thermistors. (Need to add 10 hours of cold [0^{o}C] test).
   - For the module room temperature tests, the chiller should be set at approximately 9^{o}C to obtain a thermistor temperature of about 27^{o}C.
   - For the module longterm test, the module box should be placed in the environmental chamber set to -19^{o}C to obtain a thermistor measurement of 0^{o}C.
5. In the folder `D:\sctvar\config`, check that the `st_system_config.dat` file defines the correct modules/hybrids. General configuration instructions.
6. In the same directory, check that the .det files exist for the hybrids/modules in question. Make sure that the .trim and .mask files do not exist unless they are specifically required. (Note: the .trim and .mask files will not be needed under normal testing circumstances) Specific configuration instructions.

7. Run the testing software (ST.bat icon on the top-left corner of the desktop). Your username for DB (database) upload is: LBL. No=0, Yes=1.
8. Check that the hybrid power has come on with the "DCS->log" button. If it has not, try "LV recovery" from the main menu. Also check that all appropriate power lights are on.
9. Check the hybrid temperature and currents with the "DCS->log" button.
10. For a module test, switch off the LV power to the hybrid and allow the temperature to stabilize around room temperature. Then run an I-V Curve. Choose 4, ramp up to 500V quickly and return to 200V when completed. Then turn the LV on.
11. Start the appropriate testing sequence. General testing procedure. For the Characterisation Test, use a scope to answer the Hard Reset test questions. (Note: due to windows bugs, you must enter space 1 to answer "yes" to the Hard Reset test questions).
12. All other tests continue without intervention. The Characterisation Test takes a total of about one hour per hybrid or module to complete. For 6 hybrids/modules the test can take all day. The longterm tests currently take 100h(hybrids)/24h(modules), although these times will be reduced with experience among the SCT community. Description of the electrical tests.
13. Monitor the tests while they are running to catch any program crashes as soon as possible. General information about the testing software
14. When the testing sequence has completed, shut down the software with the "Exit" button. Confirm in the Rint window by typing y (often gives you an error the first time, just repeat the process) and the program will power down and shut off. Do **not** stop root using ".q" as this does **not** turn off the LV or the HV power.
15. When sctdaq has exited, check that the LV and HV power lights are off. If they are not, restart the software and immediately "Exit" again. This should turn off the power correctly.
16. Switch off the cooling. For the module longterm test, take care to keep the module in a dry air environment until it reaches room temperature to avoid any danger of condensation.
17. Disconnect devices under test. And put the hybrid or module in the dry air cabinet for safe keeping.
18. Check that the hybrid/module passed each test in the results text file (`serialnumber_date.txt`) and that the ps files look appropriate. How to analyze results
19. Test sequence results may be analyzed using perl scripts. The test sequence name is needed for these. Test results and root files should be archived and backed up, respectively. How to make the web page.

Precautions taken at US Sites against damage to ATLAS barrel modules by electrostatic discharge.

Adapted from document by M. Gibson for particular set ups in the USA.
Carl Haber 10-July-2002

General overview.

In this document we describe the electrostatic discharge (ESD) precautions that are undertaken in the USA as part of the production of ATLAS Barrel modules.

Basic principals for the protection against possible damage to ATLAS barrel modules by electrostatic discharge.

The aim is to produce a safe workable environment that effectively removes the possibility of damage to the electrical components of the ATLAS barrel module by ESD. We have taken great care to ensure that items that are not themselves static-sensitive but which may be used in the construction process have suitable intimate and proximity packaging and so can be allowed into the USA construction areas.

Temperature and relative humidity are controlled and monitored to ensure suitable environmental conditions.

General technical information about the LBL clean-room.

1) The room is equipped with a static dissipitive floor.
   The external clothing worn by the operators when they are working with static sensitive components is anti-static. An approved supplier cleans lab coats once a week.
2) The operators either wears a wrist strap connected to ground or he/she is connected to the floor via their clean room anti-static shoes.
3) All the appropriate work stations are equipped with earth bonding points.
4) All chairs are upholstered with static dissipative fabric.
5) All the free use plastic bags are ether static dissipative or anti-static. All custom containers have ESD intimate and proximity packaging.
6) All the table surfaces are ether manufactured in static dissipative materials or are covered with static dissipative mats. Both are connected to earth via high resistance paths. All surfaces being regularly cleaned with an appropriate ESD cleaner.
7) The module storage boxes are constructed from aluminum. Commercially available plastic containers fabricated from anti-static materials or commercially available custom anti-static boxes.
8) The hybrid boxes that are used for transport and storage provide both intimate and proximity packaging are fabricated from anti-static materials.
9) At the time of writing we have no information about either the baseboard transport boxes and internal packaging or the module test boxes.

Hardware

10) *The alignment system. (We note that the detector/baseboard assemblies are not static sensitive.)*
    A) The small vacuum chucks are connected directly to ground.
    B) The assembly jigs are all aluminum and are handled by operators who are grounded through the static safe floor coating.

11) *The Adhesive Dispensing System*.
    A) The adhesive applicator being of metal construction is all connected to ground.

12) *The sub-assembly probe station*.
    A) The test station is connected to ground.
    B) When testing a 4-detector sub-assembly the module and its surrounding frame which is 100% metallic are both at negative potential defined by the source measure unit, which is not a floating supply.

13) *Hybrid mounting equipment.*
    A) The hybrid mounting station is placed on a table surface, which is static dissipative and grounded.

14) *The metrology hardware*.
    A) The metrology frame is placed on a 3 point carrier which is electrically connected to the SmartScope.
    B) The metal outer frame of the SmartScope is at ground potential.

15) *Wire bonding*.

A) Both the operator and all the relevant frames are connected to ground via high impedance paths.

16) *Electrical testing of the module*.
   A) All table tops are static dissipative and grounded
   B) All operators wear static safe overcoats, booties, and wrist-straps. The straps are grounded.
   C) All test fixtures are metal and grounded.
   D) All pigtails unconnected are covered with aluminum foil.

17) Storage.
   A) Storage cabinets house aluminum shelves which are\ all grounded.
   B) Storage cabinets are continuously flushed with dry air.
   C) Standard metal cabinets (which are floor mounted) are used for the storage of non-critical items, such as gloves, adhesive mixing pots, syringes for adhesive dispensing etc.

USA Module Production: “Batch Traveler” Procedure

12 July 2002

Hybrid ASIC-stuffing, testing and shipping

The hybrid/module Excel ASIC_HYBRID worksheet is completed and made available on the web. Additional electrical test information is made available also on the web

Detectors

Detectors are supplied and tracked by KEK. They are logged at LBL using a bar code reader. Any probe measurement is stored in an ATLAS SCT database format.

Baseboards

Baseboards are delivered as simple components with an ATLAS serial number and are logged with a bar code reader.

Module Assembly

Metrology and electrical test information are computerized for internal processing.

Information about every assembled module is made available via the hybrid/module Excel worksheets from Nobu Unno. These can be viewed at the module QA sites and at Oxford, where the modules will be consumed.

Database

Stored data can be loaded onto SCT database from the files stored in the US.

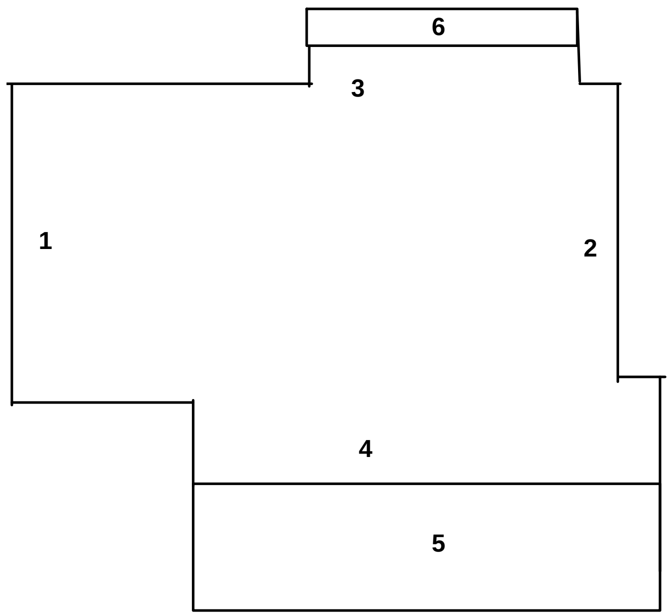
USA Module build sheet check list v1

(derived from RAL sheet V3)

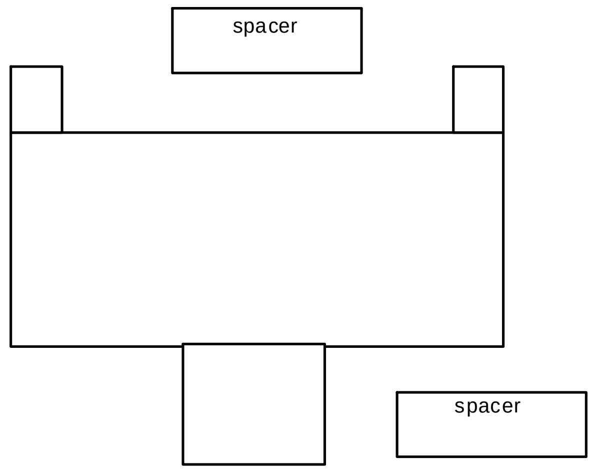
Baseboard serial number					
Hybrid serial number					
Baseboard visual check? ………..		date		inits	
Baseboard thickness measured ?….		date		inits	
4 detectors chosen, collected and baseboard allocated………………		date		inits	
Top side spacers calculated…………		date		inits	
Top side aligned and checks ok…….		date		inits	
Glue dispenser z set up done……….		date		inits	
Conducting glue applied……….		date		inits	
Top side stuck………………………		date		inits	
Bottom side spacers calculated……..		date		inits	
Bottom side aligned and checks ok…		date		inits	
Glue dispenser z set up done……….		date		inits	
Conducting adhesive applied		date		inits	
Bottom side stuck……………… …		date		inits	
Metrology done……………………		date		inits	
Metrology analyzed……………		date		inits .	
Post Cure………………………….		date		inits	
I-V curves ………………………..		date		inits	
Data logged…………………..		date		inits	
Hybrid side 1 stuck.?……………..		date		inits	
Hybrid side 2 stuck?……………		date		inits	
Wire Bonding done ………………		date		inits	

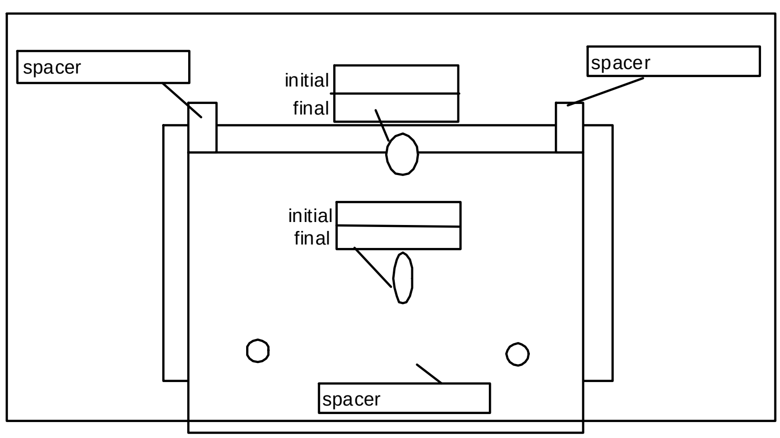
Metrology done?………………….	☐	date	☐	inits	☐
Pictures taken?……………………	☐	date	☐	inits	☐

Baseboard thickness



Spacer calculation





TOP

initial

1) plate	
2) detector	
3) paper	
initial-1-2-3 = gap	
spacer	

final

1) plate	
2) detector	
3) paper	
initial-1-2-3 = gap	
spacer	

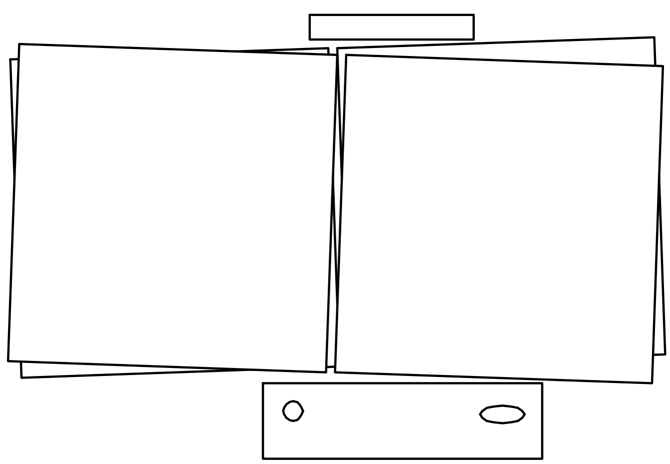
Detector Positions

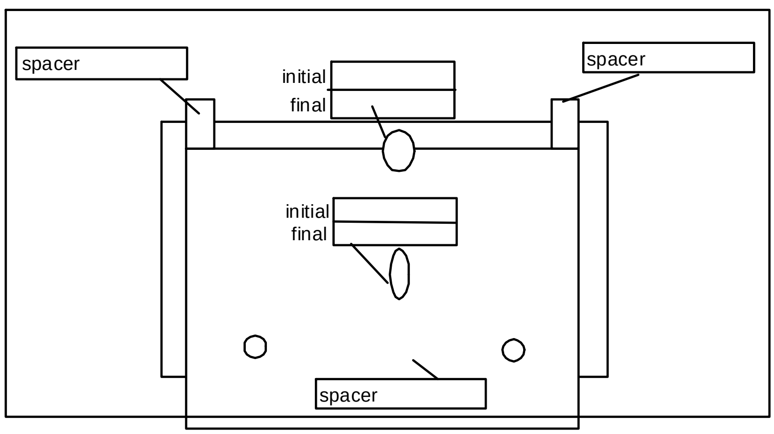
Top side
<u>Stages</u>
C
D
E
F
G
H

Checks.vi:
Position 1
Position 2
Position 3
Position 4

Back side
<u>Stages</u>
C
D
E
F
G
H

Checks.vi:
Position 1
Position 2
Position 3
Position 4





BOTTOM

initial

1) plate	
2) detector	
3) paper	
initial-1-2-3 = gap	
spacer	

final

1) plate	
2) detector	
3) paper	
initial-1-2-3 = gap	
spacer	

IV test summery

I @ 150V…

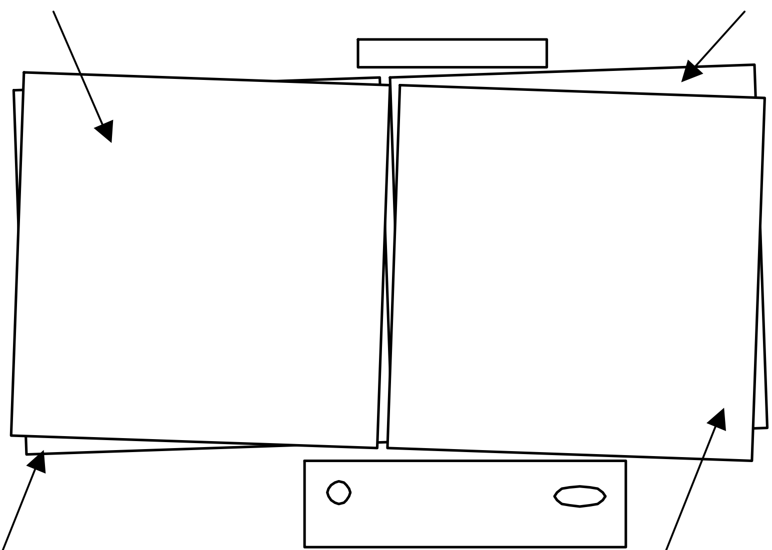
I @ 350V..

I @ 500V…

I @ 150V….

I @ 350V..

I @ 500V……



I @ 150V…

I @ 350V..

I @ 500V…

I @ 150V….

I @ 350V..

I @ 500V……

Comments

Procedure for Component Accountability and Yield Statistics: USA Module Assembly

Version 1.0

18-July-2002

Revision History
V0.5 RAL version
V1.0 edited for USA

All USA module assembly data are recorded electronically either immediately on construction or soon afterwards. Construction and QA data will be uploaded to a central storage repository at LBL. All components are traceable via ATLAS serial numbers or ASIC-numbers (site-lot-wafer-position format). Further consideration is given below to the procedure for detectors, ASICs and passive-stuffed hybrids.

Detectors

Detectors for the USA modules originate in Japan. Tracking of detectors is managed entirely by the SCT database. After fabrication and quality checks, the manufacturer registers the detectors in the database, together with all test data, interfaces directly to KEK. Quality control test data of the detectors in Japan are uploaded directly to the SCT database. Comprehensive reports of detector shipments, and all detector test data from the manufacturer and from ATLAS institutes, are available via a java graphical user interface to the database.

A local database at LBL tracks detectors during module assembly.

ASICs

ASICs used for US modules are probed at UCSC and the data is logged into a database there. Records are kept of chips sent to LBL. Chip numbers used on US modules are stored in the hybrid/module traveler spreadsheets which can be view from our production web site. Data sheet accompany chip shipments to from UCSC. For hybrids assembled or reworked at USCS data is already local.

Baseboards

Baseboards received at LBL are logged on a local database spreadsheet. As they are consumed the b/b number is logged in the hybrid/module traveler.

Hybrids

Hybrids received at LBL or UCSC are logged in a local database spreadsheet. As they are consumed the hybrids numbers are recorded on the web accessible hybrid/module travelers. Hybrid numbers are also loaded into the ATLAS database as part of module assembly logging.

Glue and BN

Consumables are logged locally and inventory tracked through a local spreadsheet. Batch numbers are included in hybrid/module travelers.