Binocular Observing 101: A guide to binocular observing at LBT



481s625f 23-March-2014 Presented by: John M. Hill LBT Technical Director

Outline of the presentation

Introduction to Telescope Control
Concepts of Binocular Observing
Passive Scheduling of Dither Positions
Details of Binocular PCS
Details of PSF and Collimation

See the User's Meeting poster by the same title

INTRODUCTION TO THE LBT TELESCOPE CONTROL SYSTEM Telescope Control System (TCS) (really - Observatory Control System)

- High Level Sub-systems on Linux servers in mountain Control Room
- Gigabit+ ethernet communications
- Graphical User Interfaces
- Other distributed computers for hardware interface: PLC or VxWorks
- Real-time digital servos for Mount Control System

Monocular TCS Sub-Systems (just like "regular" telescopes) Mount Control System (MCS) Tracks mount in altitude/azimuth • Pointing Control System (PCS)* Generates tracking polynomials Enclosure Control System (ECS) Telemetry Sub-System (TEL) Instrument Interface (IIF) Command Sequencer

Binocular TCS Sub-Systems (deployed in pairs)

- Guiding Control System (GCS)
 - Off-axis Guiding
- Point Spread Function (PSF)
 - Active Optics and Collimation
- Primary Mirror Cell (PMC)
- Optical Support Structure (OSS)*
- Adaptive Optics System (AOS)
 - Fast Wavefront Correction



Telescope Control System Status

- Basic TCS software sub-systems are complete including monocular PCS.
- Binocular Pointing Control System (PCS) is under development since Summer 2010, and is now being used by several pairs of instruments.
- This presentation describes how binocular observations work in practice from the TCS perspective.

CONCEPTS OF BINOCULAR OBSERVING



Binocular Key Concept #1 Co-Pointing

- The two telescope sides of LBT always point at the same general part of the sky as they are located on the same telescope mount.
- However, the two sides are not required to have precisely the same target, wavelength, position angle, offset, pointing model, etc.
- They are co-pointed within a certain angle on the sky limited primarily by the range of travel of the optics.



Where are the optics? For pure co-pointing the optical axes of the two telescopes are parallel.



Binocular Key Concept #2 Co-Pointing Limit

- The two sides of LBT are always able to deviate from pure co-pointing by a radius of ~20* arcsec on the sky == the Co-Pointing Limit.
 - Neither side should request a target (including offsets) which is farther than this limit from the mid-point between the two (left & right) targets.
 - *The final numerical value of this Co-Pointing Limit has yet to be determined.
 - The physical limits of co-pointing, set by M1/M2 collimation limits and/or image quality, may be larger than the guaranteed Co-Pointing Limit discussed here. (See 481s066 by A. Rakich for technical details.)



Where are the optics? Mode 1 Re-pointing rotates the sided telescope optics as a unit.



M3 doesn't actually move in the present implementation.

Binocular Key Concept #3 No Interruptions

- The instrument on one side of the telescope should not be allowed to interrupt / disrupt observations happening on the other side.
- Asynchronous presets (without any Binocular Control flags) allow small motions of the optics on one side of the telescope without any impact on the other side
 - Asynchronous presets or offsets to a location farther away than the Co-Pointing Limit are not recommended. See the BinocularControl (CLEARPRESET) flag if you must do this.

Binocular Key Concept #4 Synchronized Commands

- Synchronized presets (or offsets) should be used when both sides of the telescope are to be moved a long distance compared to the Co-Pointing Limit.
 - The BinocularControl command tells the TCS that you really want to move both sides, so it should wait until a preset command is received from each side before acting on your preset.
 - Each side should send a BinocularControl (SYNCPRESET) flag in advance of its preset.

Binocular Presets & Offsets

- Normally not using a single side=BOTH preset
 - For reasons of flexibility and recoverability from errors
- Synchronized sided presets to set a new target
 - Side=LEFT BinocularControl (SYNCPRESET)
 - Side=LEFT Preset
 - Side=RIGHT BinocularControl (SYNCPRESET)
 - Side=RIGHT Preset
- Asynchronous sided presets
 - Resend one side of a failed synchronized preset
 - One new sided preset within the same target field
- Offsets work in the same fashion
 - See 481s620 by D. Thompson

Sample Observation: New Target

- Left side sends **BinocularControl** (SyncPreset)
- time IIF starts waiting for the right SyncPreset flag.
 - Left side sends Preset
 - IIF saves target info and continues waiting.
 - Right side sends BinocularControl (SyncPreset)
 - IIF starts waiting for two preset commands.
 - Right side sends Preset
 - PCS checks co-pointing of the new targets.
 - Telescope slews to new location, and optics move.
 - Both of the presets complete.
 - Each instrument may integrate as soon as its sided preset is complete.

Binocular Key Concept #5 Graceful Fallback to Monocular Mode

- If one side of the telescope is disabled, observations may continue on the other side by authorizing the disabled side of the telescope as instrument NONE.
 - The same instrument scripts or observing blocks may be used without modification.
 - The IIF knows to ignore all BinocularControl flags when only one side is authorized.

CONCEPTS OF PASSIVE SCHEDULING

Binocular Key Concept #6 Simple Scheduling

- Since the IIF always waits until the second of a pair of synchronized presets or offsets is received, a pair of observation sequences (usually dither positions) can be scheduled (coordinated in time) passively without the need for an intelligent scheduler which is aware of the integration state of both instruments.
 - Each instrument sends its synchronized offset request once it has finished integrating.
 - With suitable planning, LBC imaging can be coscheduled with LUCI spectra, MODS spectra, etc.

time

Sample Observation: Passive Scheduling Left Right

- Integrations at dither position 1 complete
- Send BinocularControl flag (SyncOffset) —
- Send Offset command
 - IIF waits until second offset received.
 - Offset command complete
- Begin integrations at dither position 2

- Integrations at dither position 1 complete
- Send BinocularControl flag (SyncOffset)
 - Send Offset command
 - Offset command complete
 - Begin integrations at dither position 2

See 481s621 by T. Sargent for a detailed example.

Caveats to Scheduling

- This concept of scheduling considers coordinating observations with a time resolution of several seconds to make efficient use of the telescope. There is no consideration of the timing of individual integrations at the millisecond level.
- A planning tool is required to account for the exposure times and instrument overheads to make the dither intervals similar (within seconds) for efficiency on both sides.
- There is no allowance presently for auto-filling of dead time at the end of a dither.

Sample Observation: Recovery

- Left side sends **BinocularControl** (SyncPreset).
- Left side sends Preset.
- Right side sends BinocularControl (SyncPreset).
- Right side sends Preset.
 - Telescope slews to new location.
 - Right preset fails for fixable reason (i.e. M1 not ready).
 - Left instrument may integrate as soon as its sided preset is complete.
- Re-send Right side Preset asynchronously without BinocularControl after fixing problem.
 - Right instrument may integrate as soon as its sided preset is complete.

Binocular Instrument Pairs

- LBC-Blue and LBC-Red (many years)
- LBTI (routine operation with AO)
- LUCI1 and LBC-Red (limited use)
- PEPSIPFU (limited testing)
- LUCI1 and LUCI2 (limited testing)
- MODS1 and MODS2 (testing soon)

• Warning: Not all instrument software is fully binocular-aware.

Special Observing Mode

- Pseudo-monocular mode is a special observing mode where one instrument observes as if monocular, and the second instrument follows along passively.
- For example, LBC-Red could take survey images while MODS1 takes spectra on the other side.

What's Next?

- Binocular-aware instrument software
- Binocular-aware planning tools
- Collimation to expand co-pointing limit
- TCS optimization for interferometry

MORE TECHNICAL DETAILS ABOUT THE BINOCULAR PCS SUB-SYSTEM

Pointing Control System (PCS)

- The PCS sub-system controls telescope pointing and tracking.
- It contains the computing engine (kernel) to generate polynomial tracking trajectories for the mount axes and rotators at a rate of 20 Hz.
- It sends optics pointing information (relative to the mount) to both PSF (left/right) subsystems every few seconds.
 - See De La Peña 481x122

How pointing arbitration works (simplified): Binocular PCS Pointing Flow



After Figure 1 of Terrett 481x120

Flow Diagram of Binocular PCS



Binocular PCS Main GUI



Binocular PCS Pointing GUI



Mount Locking

- In general, the telescope mount will be pointing near the mid-point between the left and right targets.
- One side making an asynchronous offset or guide correction will move only the optics on that side leaving the position of the mount and the other side optics unchanged.

Leaking and Locking

- After an asynchronous offset occurs, we would like the mount to be pointing at the mid-point between the targets, but locking prevents that in the short term.
- The PCS algorithm for pointing the optics includes a slow leak (configurable in PCSInstrument.conf) that allows the mount point to very slowly move back toward the midpoint.

Co-Pointing Limits

- Only a warning is issued when the co-pointing limit is exceeded relative to the mid-point of the two targets. This limit is deterministic for observation planning purposes.
- An error will be issued when a larger (x2) limit is exceeded relative to the mount point. This limit is not deterministic as it depends on recent history, flexure, leaking, temperature gradients, etc.

MORE TECHNICAL DETAILS ABOUT HOW THE PSF SUB-SYSTEM WORKS

Point Spread Function (PSF)

- Each of the left and right PSF sub-systems receives input from a variety of sources.
- The Collimation Arbitrator(s) in PSF sums all of these inputs to calculate the present commanded position of each mirror.
- These inputs include the optics tip-tilts which are calculated by PCS.
- PSF also reports back to PCS the desired tip-tilt for each side to center the optics in their range of travel (range balancing).

LBT Active Optics - PSF

Point spread function control (left/right)



Original slide courtesy of C. Biddick

PSF GUI For M1

Displays Inputs to the Collimation Arbitrator in X,Y,Z,rx,ry,rz space



Left PSF Primary	Mirror Active Optics	and Collimation Control (Build BP9)
Actuator Forces Actuator Forces Actuator Correction 101 Clear C00 Prev Next Plot Control Cleast Control Clear C00 Plot Control Clear C00 Clear Clear	Mirror Active Optics or Platform Position n X 0.4544 se Y 1.0427 e Z -0.4349 ile RX 26.7975 RY -72.6954 hase RZ -0.0072 ISZ H 1.600	Total Collimation Control (Build BP9) X (mm) Y (mm) Z (mm) RX (") RY (") RZ (") 0.246 1.266 -1.064 29.563 -73.016 0.000 Lookup Table 0.247 1.268 -1.955 29.467 -73.002 0.000 Initialize Angle 90.0 Feb 12 00:19:04 Enabled Disable Temperature Correction -0.000 -0.002 -0.009 0.096 -0.014 0.000
O Total	ear Active Optics	Table Temp. 0.00 Temp. -0.11 Enabled Disable
Zernike Coefficients Idle Number Value Modes FCin Gain 4 0 3 0 1 Prev Next Clear values Restore Defaults Send 0 3 0 1.000		0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
		Instrument Offsets 0,000 0,000 0,000 0,000 0,000 Remove Corrections Image: Content of the second secon
Count O Adjust Mirror Load File PMZernikes.txt Save File PMZernikes.txt	Plot Surface Error	Pointing Offsets O.000
Global Offsets X (mm) Y (mm) Z (mm) RX (") R 0 0 0.9 0	Y (") RZ (") 0 0	Group Rotation 0.000
0.000 0.000 0.900 0.000 0 Clear Inputs Reset Inputs U	.000 0.000 pdate	Secondary Offload 0.000 0.000 0.000 0.000 Sec offload No Remove Corrections
0.000 0.000 0.000 0.000 0 Remove Corrections	.000 0.000 Details	Collimate Close

Leit i Sr	Finnary Minor Active Optics	
Actuator Forces Actuator Forces Last Correction 0.0 0.0 C00 Prev Next 11.8 Total Correction Clear C00 18.5 Plot Control © Last 0 c00 Plot 0 Total 0 Z force	Mirror Mirror Run X 0.4544 Chase Y 1.0427 Idle Z -0.4349 Angle RX 26.7975 90.0 RX 26.7975 RY -72.6954 Stop Chase RZ -0.0072 R 1.137 H 1.600 Clear Active Optics	Total Collimation X (mm) Y (mm) Z (mm) RX (") RY (") RZ (") 0.246 1.266 -1.064 29.563 -73.016 0.000 0.246 1.266 -1.064 29.563 -73.016 0.000 0.247 1.268 1.353 29.467 -73.002 0.000 Initialize Angle 90.0 Feb 12 00:19:04 Enabled Disable Temperature Correction -0.009 0.096 -0.014 0.000 Table Temp. 0.00 Temp. -0.11 Enabled Disable
Zernike Coefficients Number Value Modes 4 0 3 Prev Next Clear values Rest	FCin Gain 0 1 ore Defaults Send 0 1.000	0.000 0.000 0.000 0.000 0.000 Remove Corrections Instrument Offsets 0.000 0.000 0.000 0.000 0.000 Remove Corrections Remove Corrections 0.000 0.000 0.000 0.000
Count O Adjust Mirror Load File PMZernikes.txt Save File PMZernikes.txt	Plot Surface Error	Pointing Offsets O.000 O
Global Offsets X (mm) Y (mm) Z (mm) RX 0 0 0.900 0.000 0.900 0.000 Clear Inputs Reset Inputs Manual Pointing Offsets 0.000 0.000 0.000 0.000	(") RY (") RZ (") 0 0 00 0.000 0.000 5 Update	0.000 0.000 0.000 0.000 0.000 Remove Corrections Remove Corrections 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.000 0.000 0.000 Sec offload No Remove Corrections Image: Correction S Image: Correction S
Remove Correc	tions Details	Collimate Close

DX M1 Collimation vs Elevation for RFBG



Left PSF Primary Mirror Active Optics	and Collimation Control (Build BP9)			
- Actuator Forces	Total Collimation			
Last Correction Mirror Platform	X (mm) Y (mm) Z (mm) RX (") RY (") RZ (")			
Actuator 0.0 Puis	0.246 1.266 1.064 29.563 73.016 0.000			
101 C00 X 0.4544	0.246 1.266 -1.064 23.363 -73.016 0.000			
Prov. Next 11.8 Chase V 10427	Ellowation Table			
Total Correction				
Clear C00 Angle Z -0.4349	0.247 1.208 -1.955 29.407 -75.002 0.000			
18.5 90.0 RX 26.7975	Initialize Angle 90.0 Eab 12.00:19:04 Enabled Disable			
Plot Control	Initialize Angle 50.0 reb 12 00.15.04 Enabled Disable			
Last Stop Chase	Temporto contra Forber			
RZ -0.0072				
Plot R 1.137 H 1.600				
O Total	Table Temp, 0.00 Temp, -0.11 Enabled Disable			
O Z force Clear Active Ontics				
Status Idle	0.000 0.000 0.000 0.000 0.000 0.000			
Zernike Coefficients				
Number Value Modes FCin Gain	Remove Corrections			
4 0 3 0 1				
Pure Next Character Party Party Party	Instrument Offsets			
Prev Next Clear values Restore Defaults Send	0.000 0.000 0.000 0.000 0.000			
0 3 0 1.000				
	Remove Corrections			
Count 0 Adjust Mirror Plot Surface Error	- Pointing Offsets			
DMZ miles ht				
Load File PMZernikes.txt	Remove Corrections Details			
Save File PMZernikes.txt				
	Group Rotation			
-Global Offsets	0.000 0.000 0.000 0.000 0.000 0.000			
X (mm) Y (mm) Z (mm) RX (") RY (") RZ (")				
0 0 0.9 0 0 0	Remove Corrections			
0.000 0.900 0.000 0.000 0.000	Secondary Offload			
	0.000 0.000 0.000 0.000 0.000 0.000			
Clear Inputs Reset Inputs Update				
- Manual Pointing Offsets	Sec offload No Remove Corrections			
Remove Corrections Details				
	Collimate Close			

Actuator Forces Last Correction Miror Pladform Actuator 00 00 000 0000 Prev Next Total Correction 0000 0000 0000 Chase Y 0.05333 Angle Y. 0000 0000 0000 Clear C00 BS 0000 RX 607933	Left PSF Primary Mirror Active Optics	and Collimation Control (Build BP9)		
Actuator Last Correction Mirror Pladorm 00 00 Coordination Control Coordination 01 Coordination Control Coordination Control Coordination 01 Coordination Control Control<	- Actuator Forces	-Total Collimation		
100 00 100 000 1000 0000 0000 Prev Next 118 0 05545 0000	Actuator Last Correction Mirror Platform	X (mm) Y (mm) Z (mm) RX (") RY (") RZ (")		
Cool Cool <th< th=""><th>0.0 Run Position</th><th>0.246 1.266 -1.064 29.563 -73.016 0.000</th></th<>	0.0 Run Position	0.246 1.266 -1.064 29.563 -73.016 0.000		
Prev Next Tables Y 0.0327 0.000 None Colorection 0.000 None None </th <th>C00 Chase X 0.4544</th> <th></th>	C00 Chase X 0.4544			
Ideal Correction ISS 2 40333 Ideal Correction Ideal Correction Plot Control ISS Stop Chass RX 26/293 Initialize Angle 200 Eb12001903 Inabled Disable Initialize Angle 200 Plot Control RX 26/293 RX 26/293 Initialize Angle 200 Eb12001903 Inabled Disable Iss Stop Chass RZ 0.0007 Initialize Angle 200 Teb Temp. 000 Temp. 001 Inabled Disable Zernike Coefficients Status Idle Initialize Angle 200 Ioo00 Ioo000 Ioo000 Ioo00 Ioo0	Prev Next 11.8 Idle Y 1.0427			
103 900 RX 6679273 PROCONTOL RY 7269531 Stop Chase RZ 0.0007 Total Clear Active Optics Status Idle Zernike Coefficients Clear Active Optics Number Value Modes Value Modes FCin Gain A Clear Active Optics Status Idle Value Modes FCin O 3 0 1000 Count Adjust Mirror Plot Surface Error Colobal Offsets Status Good 0.000 0.000 0.000 0.000 Colobal Offsets Status Update Secondary Offload 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.000 0.000	Clear C00	0.247 1.268 -1.955 29.467 -75.002 0.000		
Image: Stop Chase RY 22.0335 C 000 Plot Total R 1137 I 2 force Clear Active Optics Status Idle Clear Active Optics Status Status Idle Prev Value Modes Prev Next Clear Active Optics Satus Idle O 3 0 I Prev Next Clear Active Optics Satus Idle O 3 0 I O 3 0 I O A cost Fue Conflictes Instrument Offsets Instrument Offsets 0.000 0.000 0.000 I Dada File PMZernikes.bdt Save File PMZernikes.bdt Save File PMZernikes.bdt I Clear Inputs Reet Inputs U Dada 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Secondary Offload 0.000	18.5 90.0 RX 26.7975	Initialize Angle 90.0 Feb 12 00:19:04 Enabled Disable		
Stop Chase RZ 00002 R 1137 H 1600 Clear Active Optics Status Status Idle Zernike Coefficients Status Number Value Modes 4 0 3 0 Prev Next Clear values Restore Defaults Send 0 3 0 Prev Next Clear values Restore Defaults Count Adjust Mirror Plot Surface Error Cload File PMZernikes.btt Save File MAnual Pointing Offsets O Manual Pointing Offsets O Manual Pointing Offsets O 0.000 0.000 0.000 Remove Corrections Details Sec offload No Remove Corrections Sec offload 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Clear tiputs Reset Inputs Update Secondary Offload 0.000 0.000 0.000 0.000 0.000 0.000 <t< th=""><th>RY -72.6954</th><th></th></t<>	RY -72.6954			
0 c00 Plot 0 total 2 force 2 force Clear Active Optics Status Idle Very Next Clear values 0 3 0 1 Prev Prev Next 0 3 0 1 Instrument Offsets 0 3 0 1 Prev 0 3 0 1 Prev 0 3 0 1 Instrument Offsets 0 0 3 0 1000 0.000 0.000 0.000 0 0 3 0 1000 0.000 0.000 0.000 0 0 3 0 1000 Plot Surface Error Coload Offsets Details Save File PMZemikes.txt Save File PMZemikes.txt Save File PMZemikes.txt Save File PMZemikes.txt 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Stop Chase RZ -0.0072			
O Total Clear Active Optics Status Idle Zernike Coefficients Status Number Value Modes FC in Gain O 4 O 0 3 Prev Next Clear values Restore Defaults Send O 0 3 0 Instrument Offsets 0.000 Count Adjust Mirror Plot Surface Error Cload File PMZernikes.txt Save File PMZernikes.txt Save File PMZernikes.txt Global Offsets Colono X (mm) X (T) Nanual Pointing Offsets O Manual Pointing Offsets O O 000 0.000 0.000 Remove Corrections Details Sec offload No Remove Corrections Details	O c00 Plot R 1.137 H 1.600			
Z force Clear Active Optics Status Idle Value Modes FCin Gain 4 0 3 0 Prev Next Clear values Restore Defaults Send 0 0 3 0 1 Prev Next Clear values Restore Defaults Send 0 3 0 3 0 Load File PMZernikes.txt Save File PMZernikes.txt Secondary Offload 0.000 0.000 0.000 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.00	O Total	Table Temp. 0.00 Temp0.11 Enabled Disable		
Status Idle Status Idle Vertice Coefficients 0.000 0.000 0.000 0.000 0.000 A 0 1 0 3 0 1 Instrument Offsets 0.000 <td< td=""><td>O Z force Clear Active Optics</td><td></td></td<>	O Z force Clear Active Optics			
Zernike Coefficients Number Value Modes FCin Gain 4 0 3 0 1 Prev Next Clear values Restore Defaults Send 0 3 0 1 0000 0.000	Status Idlo	ACTIVE UDITCS		
Number Value Modes FCin Gain 4 0 3 0 1 Prev Next Clear values Restore Defaults Send 0 3 0 1.000 Remove Corrections Count 0 Adjust Mirror Plot Surface Error Load File PMZernikes.bxt Pointing Offsets Save File PMZernikes.bxt Remove Corrections Ciobal Offsets 0 0 0 X (mm) Y (mm) Remove Corrections Details Global Offsets 0 0 0 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 0.000 0.0000 0.0000 0.0000 0.0000 <td>-Zernike Coefficients</td> <td></td>	-Zernike Coefficients			
A 0 3 0 1 Prev Next Clear values Restore Defaults Send 0 3 0 1.000 Count 0 Adjust Mirror Plot Surface Error Load File PMZernikes.bt Pointing Offsets Save File PMZernikes.bt Details Global Offsets Count 0 0.900 0.000 0.000 0.000 (dotal offsets Coup Rotation 0.000 0.000 0.000 0.000 0.000 0.000 (dotal offsets Coup Rotation 0.000 0.000 0.000 0.000 0.000 0.000 0.000 (dotal offsets Secondary Offload 0.000 0.00	Number Value Modes ECin Gain	To out of the Barrayo Spitec On Francis		
Prev Next Clear values Restore Defaults Send 0 3 0 1.000 0.000 0.000 0.000 0.000 Count 0 Adjust Mirror Plot Surface Error Pointing Offsets 0.000		huzitnuusut Auzsiz		
Image: Serie Processing Serie Serie Processing Serie Serie Processing Serie Ser	Prov. Next Clear values Restore Defaults Send	Instrument Offsets		
Count O JOO LOUD Count Adjust Mirror Plot Surface Error Load File PMZernikes.txt Pointing Offsets Save File PMZernikes.txt Details Global Offsets X(mm) X(mm) RX (") X(mm) Y(mm) Z(mm) RX (") RZ (") 0 0.9 0 0 0 0.000 0.0000 0.0000 0.000 0.000 0.0000 0				
Count Adjust Mirror Plot Surface Error Load File PMZernikes.txt Pointing Offsets Save File PMZernikes.txt Details Global Offsets X (mm) Y (mm) Z (mm) RX (") RZ (") 0 0.39 0 0 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Manual Pointing Offsets Update Sec offload No Remove Corrections 0.000 <td< td=""><td></td><td>Remove Corrections</td></td<>		Remove Corrections		
Count Count Adjust Mirror Pointing Offsets Load File PMZernikes.txt Remove Corrections Details Global Offsets X (mm) X (mm) RX (") RY (") RZ (") 0 0.000 0.000 0.000 0.000 0.000 0.000 Global Offsets X (mm) X (mm) RX (") RY (") RZ (") 0 0.000				
Load File PMZernikes.txt Save File PMZernikes.txt Global Offsets Manual Pointing Offsets X (mm) Y (mm) Z(mm) Reset Inputs Update Secondary Offload 0.000 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.000 Secondary Offload 0.000 0.000 0.000 Sec offload No Remove Corrections 0.000 Sec offload No Remove Corrections Colemate	Count Adjust Mirror Plot Surface Error	Pointing Offsets		
Load File PMZernikes.txt Remove Corrections Details Save File PMZernikes.txt Group Rotation 0.000		0.000 0.000 0.000 0.000 0.000		
Save File PMZernikes.txt Global Offsets Group Rotation X (mm) Y (mm) Z (mm) RX (") RZ (") 0 0 0.9 0 0 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update Secondary Offload 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Sec offload No Remove Corrections Sec offload No Remove Corrections Collimate Close	Load File PMZernikes.txt	Remove Corrections Details		
Global Offsets X (mm) Y (mm) Z (mm) RX (") RY (") RZ (") 0 0 0.9 0 0 0 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update Secondary Offload 0.000 0.000 0.000 Manual Pointing Offsets	Save File PMZernikes.txt			
Global Onsets X (mm) Y (mm) Z (mm) RX (") RZ (") 0 0 0.9 0 0 Remove Corrections 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update Secondary Offload 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.0000 0.000 <	Cickel Office	Group Rotation		
0 0.9 0 0 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update Manual Pointing Offsets 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close	X (mm) X (mm) Z (mm) RX (") RY (") RZ (")	0.000 0.000 0.000 0.000 0.000 0.000		
0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update 0.000 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.000 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close		Remove Corrections		
0.000 0.000 0.000 0.000 0.000 Clear Inputs Reset Inputs Update 0.000 0.000 0.000 0.000 Manual Pointing Offsets 0.000 0.000 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close				
Clear Inputs Reset Inputs Update Manual Pointing Offsets Sec offload No 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close	0.000 0.900 0.000 0.000 0.000	Secondary Offload		
Manual Pointing Offsets Sec offload No Remove Corrections 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close	Clear Innuts Reset Innuts Lindate	0.000 0.000 0.000 0.000 0.000		
Manual Pointing Offsets 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close		Sec offload No Remove Corrections		
0.000 0.000 0.000 0.000 0.000 Remove Corrections Details Collimate Close	Manual Pointing Offsets			
Remove Corrections Details Collimate Close	0.000 0.000 0.000 0.000 0.000			
Collimate Close	Remove Corrections Details			
Collimate Close				
		Collimate Close		

~	Left PSF Primary Mirror Active Optics	and Collimation Control (Build BP9)
1	Actuator Forces Last Correction Mirror Platform	Total Collimation X (mm) Y (mm) Z (mm) RX (") RY (") RZ (")
	0.0 Run X 0.4544	0.246 1.266 -1.064 29.563 -73.016 0.000
	Prev Next 11.8 Chase Y 1.0427 Total Correction To	
	Clear C00 18.5 Angle 2 011013 -Plot Control 90.0 RX 26.7975	Initialize Angle 90.0 Feb 12 00:19:04 Enabled Disable
	Last RY -72.6954 Stop Chase R7 -70	Temperature Table
	O c00 Plot R 1.137 H 1.600	
	O Z force Clear Active Optics	Table Temp. 0.00 Temp. 0.11 Enabled Disable
	Status Idle	0.000 0.000 0.000 0.000 0.000
	Number Value Modes FCin Gain 4 0 3 0 1	Instrument offsets
Prev Next Clear values Restore Defaults Send 0 3 0 1.000		0.000 0.000 0.000 0.000 0.000
	Count O Adjust Mirror Plot Surface Error	Pointing Offsets
	Load File PMZernikes.txt	
	Save File PMZernikes.txt	
	-Global Offsets X (mm) Y (mm) Z (mm) RX (") RY (") RZ (")	0.000 0.000 0.000 0.000 0.000
	0 0 0.9 0 0 0	Remove Corrections
	0.000 0.000 0.900 0.000 0.000 0.000	Secondary Offload 0.000 0.000 0.000 0.000 0.000 0.000
	Clear Inputs Reset Inputs Update	Sec offload No Remove Corrections
Manual Pointing Offsets		
	Remove Corrections Details	
-		Collimate Close







Control of the Optics (under PSF)

- Each of the left and right Primary Mirror Cell (PMC) sub-systems controls the position and support forces on the primary mirrors.
- The Optical Support System (OSS) sub-system controls the positions of the secondary and tertiary mirrors as well as swing arm configuration.
- The left and right Adaptive Optics System (AOS) sub-systems control the shape of the adaptive secondary mirrors.

LBT Active Optics - PMC

Primary mirror cell control (left/right)



Slide courtesy of C. Biddick