INGRID

Commissioning Programme

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Revision: 2.0

1.0 Revision History

Version No.	Date	Comments
1.0	1999/02/01	First draft
2.0	1999/03/03	Updated to Word 6, format changed, tests revised and more tests added, date and examiners listed
3.0	1999/01/27	Second draft issued

2.0 Use of Document

This document is intended to be used as a record sheet of the commissioning program of INGRID. The sections detail the specific tests for INGRID and identify a team leader. It is the team leaders responsibility to feed information (such as pass/fail recommendations and comments) back to the document holder (cp) **in electronic form**. This will then be entered into the document; at the start of each week, cp will print out the most current document and leave it on the 4th floor by the IMPBSOFT documentation. Should any INGRID member require a new copy of the document, they should mail cp directly for the most up to date version of this document.

1.0 Before Commissioning: Integration to the WHT

Code	Objective	Requirements	Description of Test Performed	Date & Examiner	Pass / Fail	Comments
1.1	Mechanical mounting of INGRID to the WHT	?? INGRID ?? INGRID Cass mounting bracket ?? WHT	1. Assemble and attach the Cass mounting bracket to the WHT. Ensure that bracket is secure. 2. Place INGRID in the Cass bracket. 3. Connect CCC, all electronics, etc. 4. Balance the WHT. 5. Move WHT and visually check that INGRID remains stable in the bracket at many orientations (especially when the WHT is at ZD~85° and with 360° rotation of the rotator). 6. Ensure that all connections remain intact during test 5.			
1.2.1	Optical alignment of INGRID to the WHT optical axis using the pupil imager	?? INGRID ?? INGRID Cass mounting bracket ?? WHT ?? Pupil imager optics ?? INGRID folding flat ?? K band filter	1. Attach INGRID to the WHT. 2. Confirm that the tip, tilt and piston of the folding flat focuses the light to the centre of the collimator. 3. Put the K band filter and the long pupil stop into the beam. 4. Put the pupil imager optics in the beam. 5. Move the array to its mid focus position. 6. Take non-saturated images of the pupil image. 7. If INGRID is correctly aligned, the images should show (a) a negative image of the pupil stop and a flat field image of the primary and (b) the vanes of the secondary support structure. If INGRID is incorrectly aligned the most notable feature will be that the secondary will have an arc of emission where the pupil stop is not correctly mapping the Cass hole. Also the primary may show a similar arc of emission. 8. Minimise the tip, tilt and piston of INGRID in her bracket until the pupil stop correctly masks the Cass hole. It may be necessary to move INGRID in x and then y to find the midpoints of the alignment			
1.2.2	INGRID alignment to WHT using pupil imager: repeatability	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? K band filter ?? Dark dome	1. Put the K band filter, the long pupil stop and the pupil imager into the beam. 2. Take a non-saturated image. 3. If INGRID is correctly aligned, the images should show (a) a negative image of the pupil stop and a flat field image of the primary and (b) the vanes of the secondary support structure. If INGRID is incorrectly aligned the most notable feature will be that the secondary will have an arc of emission where the pupil stop is not correctly mapping the Cass hole. Also the primary may show a			

			similar arc of emission. 4. Move INGRID in her bracket until the pupil stop correctly masks the Cass hole. It may be necessary to move INGRID in x and then y to find the midpoints of the alignment. 5. Take the pupil imager out of the beam. Put the pupil imager back into the beam. Take a new non-saturated image. 6. Confirm that no changes are seen in the images. If there are changes the pupil imager mechanism is not returning to the same position.			
1.2.3	INGRID alignment to WHT using pupil imager: flexure	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? K band filter ?? Dark dome	1. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 2. Take a non-saturated image at each of the following Cass rotator positions 90°, 180° and 270°. 3. Confirm that no changes are seen in the images. If there are changes the pupil imager mechanism is moving within its mounting.			

2.0 Before Commissioning: Confirm INGRID Operation on WHT

Code	Objective	Requirements	Description of Test Performed	Date & Examiner	Pass / Fail	Comments
2.0	Confirm operation of moving parts at various orientations	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure	1. Point WHT at zenith. 2. Move pupil stop wheel and filter wheels to ~4 positions. Confirm that mechanisms reach their positions at their nominal time and at their correct positions. Confirm correct position by making similar exposures throughout test 2.1. 3. Next move the pupil imager mechanism into the light beam. Confirm it reaches its position at its nominal time and confirm image quality is independent of tests 2.1. 4. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 5. Repeat 2-3. 6. Move the Cass rotator to 45°, 90°, 135°, 180°, 225°, 270° and 315°. Repeat test 2-3 at all polar positions.			
2.1	Confirm array operation	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure	1. Repeat tests acceptance tests 4.1, 4.2, 4.4, 4.9, 4.11, 4.12, 4.13. 2. Success if achieved if read noise is <10 e^- per read			

2.2.1	Confirm optical configuration	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Pinhole array ?? Tungsten flat field lamp	1. Illuminate the pinhole array by using tungsten flat field light projected at the top of the dome. 2. Put K band filter into light path. 3. Repeat acceptance test 1.5.1.			
2.2.2	Confirm optical stability	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Pinhole array ?? Tungsten flat field lamp	1. Illuminate the pinhole array by using tungsten flat field light projected at the top of the dome. 2. Put K band filter into light path. 3. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Repeat acceptance test 1.5.3 but instead of tipping INGRID to six positions, move the Cass rotator to 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°.			
2.3.1	Confirm baffling configuration	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Pinhole array ?? Filter and pupil stop blanks ?? Dark dome	1. Move all filter and pupil stop blanks into the light beam. 2. Take an exposure of, say 2 seconds. 3. Success is achieved if the number of electrons recorded by the array is $< 1e^-$/sec/pix.			
2.3.2	Preliminary scattered light characterisation	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Pinhole array ?? Tungsten flat field lamp ?? Narrow band filters	1. Illuminate the pinhole array by using tungsten flat field light projected at the top of the dome. 2. Take narrow band images of the dome. 3. Images should show a 'clean' pinhole. If significant ghosting occurs there could be a problem downstream of the pinhole array or light leaks between the foreoptics and the cryostat window (or even the pinhole and the foreoptics).			
2.3.3	Secondary scattered light characterisation	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Pinhole array ?? Broad and narrow band filters ?? Bright (daytime) K band star	1. Ensure that pinhole array is not in the beam. 2. Move K band filter into optical path. 3. Point WHT at a bright daytime star. 4. Take short exposure of the star. 5. Put pinhole mask in front of the foreoptics. Take short exposure of the star. 6. The straight through image will show a large amount of scattered light that will come from anywhere in the INGRID beam. 7. The pinhole image will show scattered light downstream of the pinhole array.			

			8. The difference between the two images will show where scattering is coming from. 9. Put in additional baffling where needed to reduce scattered light.			
2.4.1	Integrated software testing: preliminary tests	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure	1. Confirm operation of the following parts of INGRID to similar speed/reliability/noise as in the lab: rotation of the three wheels, array mount focus, run, dark, flat, MNDR, automatic switch from AUX to INGRID. 2. Success is achieved if similar characteristics on the WHT to the lab. are found.			
2.4.2	Integrated software testing: secondary tests	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure	1. Make changes to INGRID configuration via scripts i.e. filter K should change pupil stop position, one (or two) filter wheel positions, array mount focus. 2. Repeat for all installed filters to ensure that changes are made correctly. 3. Make scripted observations that include exposures, filter changes and WHT dithering. Check for reliable and rapid motions. 4. Check the RTD is displaying incoming data correctly and rapidly. 5. Check FITS headers are being correctly recorded in the file. 6. Operate the quick look data reduction scripts and ensure data is correctly reduced.			
2.5.1	Confirm positional accuracy of filters and pupil stops: flexure	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Tungsten flat field lamp	1. Illuminate the top of the WHT dome using the tungsten flat field lamp. 2. Put the Z band filter and the short pupil stop into the beam. 3. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Take a non-saturated exposure of the dome. 5. Move the Cass rotator to 45°, 90°, 135°, 180°, 225°, 270° and 315° and take a similar non-saturated exposure at each position. 6. Confirm that each image is identical (within the limits of the noise levels of INGRID). 7. Success is achieved if condition 5 is met.			
2.5.2	Confirm positional accuracy of filters	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS)	1. Illuminate the top of the WHT dome using the tungsten flat field lamp.			

	and pupil stops: repeatability	?? Support infrastructure ?? Tungsten flat field lamp ?? All broad band filters and pupil stops	2. Put the Z band filter and the short pupil stop into the beam. 3. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Take a non-saturated exposure of the dome. 5. Move the filter wheel to another position and also move the pupil stop wheel to a different position. 6. Put the Z band filter and the short pupil stop back into the beam. Take a non-saturated exposure of the dome. 7. Confirm that the two images are identical (within the limits of the noise levels of INGRID). 8. Repeat 2-6 for the J, H, K and K_s filters. 9. Success is achieved if condition 6 is met for all 5 broad band filters.			
2.6.1	Confirmation of array focus: flexure	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Tungsten flat field lamp ?? Pinhole array ?? Z band filter	1. Illuminate the top of the WHT dome using the tungsten flat field lamp. 2. Put the Z band filter and the short pupil stop into the beam. 3. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Move the Cass rotator to 45°, 90°, 135°, 180°, 225°, 270° and 315° and take a similar non-saturated exposure at each position. 5. Confirm that each image is identical to within ±0.06mm over a 90° rotation.			
2.6.2	Confirmation of array focus: repeatability	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Tungsten flat field lamp ?? Pinhole array ?? Z band filter	1. Illuminate the top of the WHT dome using the tungsten flat field lamp. 2. Put the Z band filter and the short pupil stop into the beam. 3. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Note the position of the best focus. Take an image and measure the FWHM. 5. Decrease the focus position (without going to the datum) and then increase it back to the best focus position. Take an image, measure the FWHM and confirm no focus shift has occurred. 6. Repeat test 3 for several different focus position offsets. 7. Repeat tests 3 and 4 for a positive focus position offset.			

2.7.1	Interaction with Cass A/G box: flexure	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Tungsten flat field lamp ?? Pinhole array ?? Z band filter	1. Illuminate the top of the WHT dome using the tungsten flat field lamp. 2. Put the Z band filter and the short pupil stop into the beam. 3. Place the pinhole array in front of the foreoptics. 4. Use the script to move the folding flat to the INGRID port. 5. Point the WHT to an elevation of ~10° and move the Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 6. Take a non-saturated image. 7. Move the Cass rotator to 45°, 90°, 135°, 180°, 225°, 270° and 315° and take a similar non-saturated exposure at each position. 8. Confirm that all images are nearly identical (within the limits of the noise levels of INGRID). 9. Success is achieved if condition 7 is met to within: Lateral/axial motion: ±0.06mm over 90° tilt in any direction (in spec.) Angular droop: ±100 micro radians over 90° tilt in any direction (in spec.) Angular twist: ±200 micro radians over 90° tilt in any direction (in spec.)			
2.7.2	Interaction with Cass A/G box: positional repeatability of folding flat mirror	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Tungsten flat field lamp ?? Pinhole mask ?? Z band filter	1. Illuminate the top of the WHT dome using the tungsten flat field lamp. 2. Put the Z band filter and the short pupil stop into the beam. 3. Place the pinhole mask in front of the foreoptics. 4. Use the script to move the folding flat to the AUX port. 5. Use the script to move the folding flat to the INGRID port. 6. Take a non-saturated image. 7. Repeat steps 4 and 5. Take a similar exposure as made in 6. 8. Repeat step 7 several times. 9. Confirm that all images are identical (within the limits of the noise levels of INGRID). 10. Success is achieved if condition 9 is met.			

3.0 First Light; Preliminary Commissioning Tests

Code	Objective	Requirements	Description of Test Performed	Date & Examiner	Pass / Fail	Comments

3.0.1	Focus tests: array focus	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? Z, J, H, K_s and K band filters ?? Focus mask ?? Quick look reduction software	1. Put the Z band filter into the beam 2. Point the WHT at bright near-IR star and **focus the WHT** on the star using movie mode readout. 3. Offset the focus of the WHT and the array by a small amount. 4. Put the focus mask into the beam. 5. Take a non-saturated image of the star. 6. Run the image through the focusfind script. 7. Correlate the suggested focus from focusfind with that determined from movie mode observations. 8. Change the parameters of focusfind if needed. 9. Repeat tests 1-7 until focusfind agrees with the focus determined from movie mode observations. 10. Confirm that all other broad band filters work with the focusfind script.			
3.0.2	Focus tests: determination of focus offsets	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? All available filters ?? Focus mask ?? Quick look reduction software	1. Put the Z band filter in the beam. 2. Point the WHT at a bright near-IR star and **focus the WHT** using the focusfind script and record this focus. 3. Put the next filter into the beam and repeat test 2. 4. Repeat test 3 until all filters have had their focus offsets determined. 5. Compare these values to those estimated from Zemax. If in good agreement these values should be entered into an offset focus database on the INGRID sparc.			
3.0.3	Focus tests: maintaining constant plate scale	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright binary stars (see appendix 1) ?? All available filters ?? Focus mask ?? Quick look reduction software	1. From knowledge of Zemax, the effect of the changing focus of the telescope on the plate scale of INGRID will have been determined and the compensation in the position of the array will have been estimated. 2. Point the WHT at a bright double star (see appendix 1 for examples). 3. Put the Z band filter into the beam. Focus the WHT using focusfind. 4. Put a filter with a substantial focus offset into the beam. 5. Obtain the best focus using focusfind by changing the focus of the WHT and INGRID. 6. Confirm that the plate scale does not change between the filters by measuring the pixel distance between the stars on IRAF. 7. Repeat tests 4 – 6 for all filters. 8. Update the INGRID filter focus offset database.			

3.1.1	Plate scale determination	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? All available filters ?? Bright binary pair (see appendix 1) ?? Quick look reduction software	1. Point the WHT at a bright double star (see appendix 1 for examples). 2. Put the Z band filter into the beam. 3. Focus the WHT using focusfind. 4. Take a non-saturated image of the binary pair. Measure the separation of the pair in pixels (using IRAF) and the work out the conversion factor to equate pixels to arcseconds. Record this value. 5. Put the next filter into the beam. 6. Repeat tests 3-5 until all filters have been characterised. 7. Success is achieved if the plate scale does not change between filters. Maximum allowable change is 10% of plate scale (~0.025").			
3.1.2	Confirmation of plate scale determination and flexure at constant rotator position	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? All available filters ?? Bright binary pair (see appendix 1) ?? Quick look reduction software	1. Point the WHT at a second binary pair (see appendix 1 for examples). 2. Move the WHT Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. Keep rotator at 0° for remainder of test 3.1.2. 3. Obtain the best focus for all filters using focusfind and take non-saturated images of the binary pairs. 4. Measure the separation of the pairs in pixels (using IRAF) and the work out the conversion factors to equate pixels to arcseconds. Record these values. 5. Go to three more binary pairs and repeat 2-3 for the binaries. 6. Compare the plate scales for all binaries. Success is achieved if maximum plate scale change between binaries is 5% of plate scale (~0.013").			
3.1.3	Confirmation of plate scale determination and flexure of various rotator positions	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? All available filters ?? Bright binary pair (see appendix 1) ?? Quick look reduction software	1. Point the WHT at a bright double star (see appendix 1 for examples). 2. Put the H band filter into the beam. 3. Move the WHT Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 4. Focus the WHT using focusfind. 5. Take a non-saturated image of the binary pair. Measure the separation of the pair in pixels (using IRAF) and the work out the conversion factor to equate pixels to arcseconds. Record this value.			

			6. Move the Cass rotator to 45°, 90°, 135°, 180°, 225°, 270° and 315° and take a similar non-saturated exposure at each position. Re-measure the plate scale at each rotator angle. 7. Success is achieved if maximum plate scale change between binaries is 5% of plate scale (~0.013").			
3.2	Orientation of objects at various Cass A/G rotator angles	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? K band filter ?? Quick look reduction software ?? Extended object (see appendix 2)	1. Focus the WHT on any star using the focusfind script. 2. Move the WHT Cass rotator so that INGRID is at a polar position of 0° (pointing straight up) as mapped onto the Cass rotator. 3. Put the K band filter in the beam 4. Point the WHT at one of the objects taken from appendix 2. 5. Take a non-saturated image of the source. Note the orientation of the object wrt N-S E-W. 6. Move the Cass rotator to 90°, 180° and 270°. Take non-saturated images of the object and note the orientation of the object.			
3.3.1	Astrometry: field distortion	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? All available filters ?? Quick look reduction software ?? M67	1. Put the K band filter into the beam. 2. Go to a star to confirm the focus of the WHT using the focusfind script. 3. Go to M67 and take several non-saturated exposures of the source. 4. Put the J band filter into the beam. 5. Repeat tests 2-3. 6. Measure the FWHM and ellipticity across the array and confirm that it is similar at all positions. Also confirm that the centroid of the star does not move between filters. 7. Success is achieved if FWHM and ellipticity does not vary by more than 5%.			
3.3.2	Astrometry: pointing offset from WHT	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? All available filters ?? Quick look reduction software	1. Put the K band filter into the beam. 2. Go to a bright star that has a well-determined position. 3. Confirm the focus of the WHT is optimal by using the focusfind script. 4. Measure the offset of the star from the centre of the array. Record this value. 5. Move the WHT by the amount determined in test 4 and confirm that the star is in the centre of the array. This is the offset from where the WHT is looking to the centre of INGRID's f.o.v.			

3.4	Standard star (photometric) observations	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Z, J, H, K and K_s filters ?? Quick look reduction software ?? UKIRT faint standard star (appendix 3) ?? Photometric skies!	1. Point the WHT at a UKIRT faint standard star (see appendix 3 for examples) which is at a low airmass. 2. Confirm that the focus of the WHT is optimal using the focusfind script. 3. Take non-saturated images at Z, J, H, K and K_s. 4. Compare the near-IR colours from INGRID to those of the UKIRT faint standards. Confirm that colour values are similar. 5. Repeat tests 3-4 for four further UKIRT faint standards. 6. Measure the flux detected by INGRID at each waveband and each standard star. Compare this to calculated flux levels and confirm that they are similar. 7. If INGRID is significantly down from what we expect there is a problem.			

4.0 Observing Characterisation

Code	Objective	Requirements	Description of Test Performed	Date & Examiner	Pass / Fail	Comments
4.0.1	Simple dithering of the WHT: small movements	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Dithering script	1. Point the WHT at a bright star at a ZD~5° and put the H band filter into the beam. 2. Run a dithering script taking non-saturated images of the bright star. The movement in the dither should be 5”. 3. Measure the FWHM, ellipticity and centroid of each of the stellar images – all should be similar. 4. Confirm that exposures do not start until the WHT has reached it dither position from test 3 by confirm ellipticity and FWHM are similar for all observations. If there is a difference it is probable that the WHT is still moving when the exposure begins – this must not happen. 5. Also confirm that correct WHT dither positions are made by measuring difference in centroid of the star from test 3. 6. Repeat tests 2-5 for bright stars at ZD ~10°, 20°, 30°, 50° and 70°. 7. Run quick look reduction software to remove dithering from reduced frame.			
4.0.2	Simple dithering of the WHT: moderate	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS)	1. Point the WHT at a bright star at a ZD~5° and put the H band filter into the beam.			

	movements	?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Dithering script	2. Run a dithering script taking non-saturated images of the bright star. The movement in the dither should be 20”. 3. Measure the FWHM, ellipticity and centroid of each of the stellar images – all should be similar. 4. Confirm that exposures do not start until the WHT has reached it dither position from test 3 by confirm ellipticity and FWHM are similar for all observations. If there is a difference it is probable that the WHT is still moving when the exposure begins – this must not happen. 5. Also confirm that correct WHT dither positions are made by measuring difference in centroid of the star from test 3. 6. Repeat tests 2-5 for bright stars at ZD ~10°, 20°, 30°, 50° and 70°. 7. Run quick look reduction software to remove dithering from reduced frame.			
4.0.3	Simple dithering of the WHT: large movements	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Dithering script	1. Point the WHT at a bright star at a ZD~5° and put the H band filter into the beam. 2. Run a dithering script taking non-saturated images of the bright star. The movement in the dither should be 60”. 3. Measure the FWHM, ellipticity and centroid of each of the stellar images – all should be similar. 4. Confirm that exposures do not start until the WHT has reached it dither position from test 3 by confirm ellipticity and FWHM are similar for all observations. If there is a difference it is probable that the WHT is still moving when the exposure begins – this must not happen. 5. Also confirm that correct WHT dither positions are made by measuring difference in centroid of the star from test 3. 6. Repeat tests 2-5 for bright stars at ZD ~10°, 20°, 30°, 50° and 70°. 7. Run quick look reduction software to remove dithering from reduced frame.			
4.1.1	Dithering of the WHT with the A/G: small movements	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Dithering script ?? Cass A/G	1. Point the WHT at a bright star at a ZD~5° and put the H band filter into the beam. Start autoguiding on an off-axis guide star. 2. Run a dithering script taking non-saturated images of the bright star. The movement in the dither should be 5”. 3. Measure the FWHM, ellipticity and centroid of each of the stellar images – all should be similar. 4. Confirm that exposures do not start until the WHT has			

			reached it dither position from test 3 by confirm ellipticity and FWHM are similar for all observations. If there is a difference it is probable that the WHT is still moving when the exposure begins – this must not happen. 5. Also confirm that correct WHT dither positions are made by measuring difference in centroid of the star from test 3. 6. Repeat tests 2-5 for bright stars at ZD ~10°, 20°, 30°, 50° and 70° with autoguiding on. 7. Run quick look reduction software to remove dithering from reduced frame.			
4.1.2	Dithering of the WHT with the A/G: moderate movements	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Dithering script ?? Cass A/G	1. Point the WHT at a bright star at a ZD~5° and put the H band filter into the beam. Start autoguiding on an off-axis guide star. 2. Run a dithering script taking non-saturated images of the bright star. The movement in the dither should be 20". 3. Measure the FWHM, ellipticity and centroid of each of the stellar images – all should be similar. 4. Confirm that exposures do not start until the WHT has reached it dither position from test 3 by confirm ellipticity and FWHM are similar for all observations. If there is a difference it is probable that the WHT is still moving when the exposure begins – this must not happen. 5. Also confirm that correct WHT dither positions are made by measuring difference in centroid of the star from test 3. 6. Repeat tests 2-5 for bright stars at ZD ~10°, 20°, 30°, 50° and 70° with autoguiding on. 7. Run quick look reduction software to remove dithering from reduced frame.			
4.2.1	Dithering of the WHT: script functionality without A/G	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Several dithering scripts	1. Point the WHT at a bright star and put the H band filter into the beam. 2. Run scripts that dither the WHT in various patterns and dither distances. These should include a 2, 3, 5 and 9 point slide; 5 and 9 point boxes and a couple of pseudo-random slides. 3. Confirm that all scripts work well, are user-friendly and that the quick look data reduction can easily and quickly reduce the data. 4. Make backups of these scripts and protect them.			
4.2.2	Dithering of the	?? Cold fully assembled INGRID	1. Point the WHT at a bright star and put the H band filter into			

	WHT: script functionality with A/G	?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Several dithering scripts ?? Cass A/G	the beam. Start autoguiding on an off-axis guide star. 2. Run scripts that dither the WHT in various patterns and dither distances. These should include a 2, 3, 5 and 9 point slide; 5 and 9 point boxes and a couple of pseudo-random slides. 3. Confirm that all scripts work well, are user-friendly and that the quick look data reduction can easily and quickly reduce the data. Also confirm that that autoguiding remains locked onto the star throughout.			
4.3	Chopping of the WHT	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Bright star ?? H band filter ?? Quick look reduction software ?? Several chopping scripts	1. Point the WHT at a bright star and put the H band filter into the beam. 2. Run scripts that chop the WHT to four different locations (at the cardinal points) 5' from the pointing position. Confirm that the WHT comes back to point at a similar position for all chops at different positions. 3. Run scripts that chop the WHT to four different locations (at the cardinal points) 10' from the pointing position. Confirm that the WHT comes back to point at a similar position for all chops at different positions. 4. Success is achieved if the WHT points to the same position when chopping back to the target.			
4.4	Sensitivity, throughput and sky brightness	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? Standard star ?? All broad band filters ?? Quick look reduction software ?? Cass A/G	1. Put the K band filter in the field of view. Go to a one of the FS standards (listed in appendix 3). Start autoguiding. 2. Take exposures so that a good s/n ratio is achieved. 3. Repeat for the Z, J and H band filters. 4. Offline, measure the sky brightness, the sensitivity and hence the ultimate throughput of INGRID.			
4.5	Pupil stop efficiency	?? Cold fully assembled INGRID ?? All software (ISP, TCS and EPICS) ?? Support infrastructure ?? K band filter ?? Quick look reduction software	1.			

Appendix 1: Double Stars

Double stars for plate scale determination. These are taken from an ING technical note that arrived to ING in March 1998. The first table lists stars north of zenith and the second south of zenith. All star pairs have a separation >90".

ING Name	RA (h)	RA (m)	RA (s)	Dec (º)	Dec (')	Dec (")	Sep. (")	Angle (º)	Mag 1 (V)	Mag 2 (V)
P0022+722	0	22	59.1	+72	16	34.0	220.33	24.9	11.1	11.1
P0156+525	1	56	39.5	+52	32	20.5	166.16	26.3	9.7	10.2
P0242+329	2	42	44.2	+32	53	7.8	135.69	148.1	7.6	7.9
P0328+443	3	28	3.1	+44	21	53.6	181.77	178.5	8.3	8.7
P0641+386	6	41	59.5	+38	41	32.9	173.54	97.2	10.0	11.5
P0725+565	7	25	22.2	+56	33	23.8	113.32	142.8	7.6	7.7
P0826+399	8	26	46.9	+39	55	9.1	194.69	178.4	9.8	8.1
P1037+327	10	37	45.7	+32	42	37.9	176.38	161.9	10.2	8.9
P1111+660	11	11	26.1	+66	1	18.6	96.78	52.0	8.1	8.2
P1425+607	14	25	41.6	+60	43	45.9	209.01	41.7	10.4	9.8
P1520+603	15	20	2.4	+60	21	36.2	151.60	15.6	7.5	7.6
P1740+312	17	40	45.6	+31	16	59.4	116.65	105.8	6.3	7.9
P1814+308	18	14	59.1	+30	49	59.7	182.44	96.8	10.5	9.8
P1832+388	18	32	47.9	+38	51	2.3	149.01	146.6	6.9	8.0
P2002+646	20	2	16.7	+64	38	48.0	98.84	153.1	6.3	7.9
P2139+444	21	39	46.4	+44	26	14.6	167.81	103.2	8.4	6.7
P2212+309	22	13	0.1	+30	56	4.5	203.44	32.5	10.6	9.2

ING Name	RA (h)	RA (m)	RA (s)	Dec (º)	Dec (‘)	Dec (“)	Sep. (“)	Angle (º)	Mag 1 (V)	Mag 2 (V)
P0002+160	0	2	45.0	+16	4	14.8	174.81	15.4	9.4	9.3
P0107+020	1	7	29.4	+2	3	9.2	223.47	81.8	10.4	10.4
P0109+200	1	9	49.6	+20	1	28.2	197.84	65.3	10.4	10.1
P0157+177	1	57	15.2	+17	48	26.1	179.63	66.2	9.7	5.9
P0206+146	2	6	55.2	+14	38	21.2	130.97	176.7	10.4	9.4
P0209+140	2	9	57.3	+14	0	28.5	110.81	162.2	9.7	10.6
P0301+050	3	1	11.75	+5	0	12.3	160.58	97.9	9.5	11.7
P0302+200	3	2	34.1	+20	4	24.7	182.85	49.2	11.3	10.5
P0323+165	3	23	12.5	+16	34	13.3	188.49	100.1	9.1	8.7
P0338+151	3	38	21.5	+15	9	37.6	162.36	118.8	8.7	8.4
P0344+278	3	44	41.0	+27	54	33.3	133.41	50.2	6.7	6.8
P0405+154	4	5	30.4	+15	28	51.7	203.58	37.1	9.5	10.7
P0502+034	5	2	37.5	+3	27	4.0	215.26	77.4	9.1	7.2
P0506+281	5	6	50.6	+28	9	19.7	207.42	90.2	10.0	10.8
P0602+180	6	2	20.3	+18	3	6.8	202.68	179.1	9.4	8.2
P0653+239	6	53	54.9	+23	53	57.9	189.56	178.9	9.5	10.3
P0658+142	6	58	12.6	+14	14	5.1	106.86	13.1	7.3	8.4
P0700+000	7	0	7.7	0	4	15.0	204.02	63.66	9.4	8.5
P0800+126	8	0	42.8	+12	39	36.0	227.43	54.4	7.8	6.8
P0801+126	8	0	42.8	+12	39	36.0	227.43	54.4	7.8	6.8
P0901+045	9	1	24.4	+4	32	17.5	164.11	75.6	10.7	11.7
P0902+032	9	2	7.2	+3	18	16.8	193.28	22.2	8.4	10.3
P0902+258	9	2	27.7	+25	52	15.7	178.09	129.1	10.9	8.2
P1000+129	10	0	16.4	+12	59	32.6	227.57	99.9	10.9	11.0
P1103+018	11	4	2.2	+1	48	39.6	171.04	156.4	9.6	11.0
P1108+210	11	8	24.5	+21	3	37.5	159.60	19.4	8.0	8.5
P1221+140	12	11	57.8	+14	2	39.0	198.15	11.6	10.1	10.4
P1304+086	13	4	33.6	+8	40	34.5	186.56	26.5	8.3	10.2
P1358+131	13	58	37.3	+13	6	39.5	161.45	117.3	10.3	10.7
P1500+086	15	0	40.9	+8	35	34.5	181.76	107.09	7.9	9.9
P1559+131	15	59	3.5	+13	7	13.4	160.94	177.6	8.9	11.3
P1701+041	17	1	42.1	+4	8	55.5	179.53	97.2	9.7	10.2
P1706+266	17	6	12.7	+26	40	54.4	156.51	128.2	10.2	10.0
P1802+110	18	2	7.3	+11	3	36.4	200.19	34.3	9.5	9.8
P1854+018	18	54	33.5	+1	53	32.9	94.64	112.6	7.4	7.4
P1900+085	19	0	28.9	+8	33	32.8	218.37	69.1	9.6	9.5
P1901+240	19	1	31.2	+23	59	18.6	168.15	154.1	10.0	11.0
P2045+127	20	45	1.64	+12	42	52.4	97.08	155.2	8.0	8.3
P2101+010	21	1	15.2	+1	3	42.3	218.39	74.8	9.3	8.9
P2102+267	21	2	40.29	+26	43	43.7	179.29	60.9	11.7	10.0
P2203+107	22	4	4.1	+10	44	38.3	164.03	51.6	9.9	10.5
P2300+213	23	0	56.0	+21	21	57.4	218.92	120.4	8.1	10.4

Appendix 2: Extended Objects

Below are four objects that are useful for determination of the orientation of INGRID and PR purposes. The data is valid for the night of Jan. 16th.

*** Hourly airmass for M42 *** (Orion Nebula)

Epoch 1950.00: RA 5 25 17.4, dec -5 23 28
Epoch 2000.04: RA 5 27 45.0, dec -5 21 02

At midnight: UT date 2000 Jan 16, Moon 0.65 illum, 43 degr from obj

Local	UT	LMST	HA	secz	par.angl.	SunAlt	MoonAlt
19 00	19 00	1 27	-4 01	2.577	-55.7	-5.7	64.2
20 00	20 00	2 27	-3 01	1.755	-49.2	...	70.8
21 00	21 00	3 27	-2 01	1.409	-38.7	...	68.8
22 00	22 00	4 27	-1 01	1.254	-22.3	...	59.9
23 00	23 00	5 27	-0 00	1.208	-0.2	...	48.3
0 00	0 00	6 28	1 00	1.252	22.0	...	35.9
1 00	1 00	7 28	2 00	1.406	38.5	...	23.2
2 00	2 00	8 28	3 00	1.748	49.1	...	10.6
3 00	3 00	9 28	4 00	2.559	55.6	...	-1.8
4 00	4 00	10 28	5 00	5.570	59.4	...	...
5 00	5 00	11 28	6 01	(down)	61.4	...	...
6 00	6 00	12 28	7 01	(down)	61.6	...	...
7 00	7 00	13 29	8 01	(down)	60.0	-14.3	...
8 00	8 00	14 29	9 01	(down)	55.7	-2.0	...

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*** Hourly airmass for M87 *** (Elliptical galaxy with jet)

Epoch 1950.00: RA 12 30 49.5, dec 12 23 28
Epoch 2000.04: RA 12 33 21.3, dec 12 06 55

At midnight: UT date 2000 Jan 16, Moon 0.65 illum, 139 degr from obj

Local	UT	LMST	HA	secz	par.angl.	SunAlt	MoonAlt
19 00	19 00	1 27	-11 07	(down)	-17.3	-5.7	64.2
20 00	20 00	2 27	-10 07	(down)	-33.4	...	70.8
21 00	21 00	3 27	-9 06	(down)	-44.9	...	68.8
22 00	22 00	4 27	-8 06	(down)	-52.8	...	59.9
23 00	23 00	5 27	-7 06	(down)	-58.1	...	48.3
0 00	0 00	6 28	-6 06	12.643	-61.5	...	35.9
1 00	1 00	7 28	-5 06	3.309	-63.4	...	23.2
2 00	2 00	8 28	-4 06	1.955	-63.6	...	10.6
3 00	3 00	9 28	-3 05	1.444	-61.6	...	-1.8
4 00	4 00	10 28	-2 05	1.200	-55.5	...	...
5 00	5 00	11 28	-1 05	1.082	-39.9	...	...
6 00	6 00	12 28	-0 05	1.044	-3.7	...	...
7 00	7 00	13 29	0 55	1.071	35.7	-14.3	...
8 00	8 00	14 29	1 55	1.174	53.8	-2.0	...
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*** Hourly airmass for M100 *** (Pretty face on spiral)

Epoch 1950.00: RA   12 22 56.7, dec   15 49 06
Epoch 2000.04: RA   12 25 28.6, dec   15 32 29

At midnight: UT date 2000 Jan 16, Moon 0.65 illum, 136 degr from obj

Local	UT	LMST	HA	secz	par.angl.	SunAlt	MoonAlt
19 00	19 00	1 27	-10 59	(down)	-18.5	-5.7	64.2
20 00	20 00	2 27	-9 59	(down)	-33.6	...	70.8
21 00	21 00	3 27	-8 58	(down)	-44.8	...	68.8
22 00	22 00	4 27	-7 58	(down)	-52.8	...	59.9
23 00	23 00	5 27	-6 58	(down)	-58.4	...	48.3
0 00	0 00	6 28	-5 58	7.332	-62.2	...	35.9
1 00	1 00	7 28	-4 58	2.815	-64.6	...	23.2
2 00	2 00	8 28	-3 58	1.790	-65.5	...	10.6
3 00	3 00	9 28	-2 57	1.365	-64.3	...	-1.8
4 00	4 00	10 28	-1 57	1.156	-58.9	...	...
5 00	5 00	11 28	-0 57	1.056	-42.5	...	...
6 00	6 00	12 28	0 03	1.027	2.9	...	...
7 00	7 00	13 29	1 03	1.062	45.1	-14.3	...
8 00	8 00	14 29	2 03	1.171	59.8	-2.0	...

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*** Hourly airmass for M104 *** (Sombrero galaxy)

Epoch 1950.00: RA   12 39 59.8, dec -11 37 28
Epoch 2000.04: RA   12 42 36.1, dec -11 53 55

At midnight: UT date 2000 Jan 16, Moon 0.65 illum, 149 degr from obj

Local	UT	LMST	HA	secz	par.angl.	SunAlt	MoonAlt
19 00	19 00	1 27	-11 16	(down)	-29.7	-5.7	64.2
20 00	20 00	2 27	-10 16	(down)	-51.3	...	70.8
21 00	21 00	3 27	-9 16	(down)	-59.9	...	68.8
22 00	22 00	4 27	-8 15	(down)	-63.1	...	59.9
23 00	23 00	5 27	-7 15	(down)	-63.6	...	48.3
0 00	0 00	6 28	-6 15	(down)	-62.3	...	35.9
1 00	1 00	7 28	-5 15	14.620	-59.5	...	23.2
2 00	2 00	8 28	-4 15	3.559	-55.0	...	10.6
3 00	3 00	9 28	-3 15	2.139	-48.1	...	-1.8
4 00	4 00	10 28	-2 14	1.625	-38.0	...	...
5 00	5 00	11 28	-1 14	1.401	-23.5	...	...
6 00	6 00	12 28	-0 14	1.321	-4.7	...	...
7 00	7 00	13 29	0 46	1.349	15.1	-14.3	...
8 00	8 00	14 29	1 46	1.497	31.8	-2.0	...
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*** Hourly airmass for M67 *** (Globular cluster, ideal for distortion mapping)

Epoch 1950.00: RA   8 47 40.0, dec 12 01 00
Epoch 1999.04: RA   8 50 21.0, dec 11 49 59

At midnight: UT date 1999 Jan 17, Moon 0.01 illum, 157 degr from obj

Local	UT	LMST	HA	secz	par.angl.	SunAlt	MoonAlt
19 00	19 00	1 32	-7 19	(down)	-57.2	-5.5	...
20 00	20 00	2 32	-6 19	34.391	-60.9	...	...
21 00	21 00	3 32	-5 18	3.946	-63.0	...	...
22 00	22 00	4 32	-4 18	2.141	-63.6	...	...
23 00	23 00	5 32	-3 18	1.525	-62.0	...	...
0 00	0 00	6 32	-2 18	1.241	-57.0	...	...
1 00	1 00	7 33	-1 18	1.102	-44.1	...	...
2 00	2 00	8 33	-0 18	1.048	-13.0	...	...
3 00	3 00	9 33	0 43	1.062	28.8	...	...
4 00	4 00	10 33	1 43	1.147	50.9	...	...
5 00	5 00	11 33	2 43	1.335	59.7	...	...
6 00	6 00	12 33	3 43	1.720	63.0	...	...
7 00	7 00	13 34	4 43	2.626	63.6	-14.3	...
8 00	8 00	14 34	5 43	6.216	62.4	-1.9	1.8

Appendix 3: UKIRT FAINT STANDARDS: 1. FUNDAMENTAL LIST

These stars are a subset of the UKIRT Faint Standards (M.M. Casali and T.G.Hawarden, JCMT-UKIRT Newsletter, NO.3, August 1992, p33) which have subsequently been re-observed on numerous nights using the now-rebuilt facility imager IRCAM3, either during routine photometric observing or the UKIRT standard-star programme. Data has been included in the compilation for a given star only from those (photometric) nights on which at least 5 other UKIRT Faint Standards were also observed.

The stars retained from the earlier list are fainter than K = 10.00 and are either single or, if double, of small enough separation to be easily reduced using standard aperture photometry. The results are in the natural system of the IRCAM3 imager (which uses an InSb array). The Table lists the means of the measurements retained and their formal internal standard errors ("sem", in parentheses), and the number of nights from which results were retained ("nights", in square brackets). Since these stars were being used as primary reference standards for a larger programme, the number of observations on each night was often 2 or more. The formal errors are greatly improved from the values listed by Casali & Hawarden. The zero-points are derived from the Casali & Hawarden results for the same list of stars and are therefore self-referential.

NO	RA (J2000)	Dec	K	sem	nights	J-K	sem	nights	H-K	sem	nights
FS1	00 33 54.48	-12 07 58.1	12.964	(0.004)	[9]	0.387	(0.003)	[10]	0.057	(0.004)	[9]
FS2	00 55 09.93	+00 43 13.1	10.472	(0.004)	[12]	0.206	(0.003)	[11]	0.035	(0.002)	[12]
FS3	01 04 21.63	+04 13 36.0	12.823	(0.003)	[7]	-0.111	(0.003)	[7]	-0.089	(0.005)	[8]
FS4	01 54 37.70	+00 43 00.5	10.284	(0.002)	[11]	0.239	(0.004)	[11]	0.032	(0.002)	[11]
FS5	01 54 34.65	-06 46 00.4	12.339	(0.005)	[8]	0.004	(0.002)	[7]	-0.005	(0.002)	[8]
FS6	02 30 16.64	+05 15 51.1	13.382	(0.005)	[8]	-0.059	(0.005)	[8]	-0.069	(0.005)	[8]
FS7	02 57 21.21	+00 18 38.2	10.945	(0.002)	[14]	0.126	(0.002)	[14]	0.032	(0.001)	[14]
FS10	03 48 50.20	-00 58 31.2	14.983	(0.011)	[9]	-0.104	(0.006)	[9]	-0.118	(0.010)	[9]
FS11	04 52 58.92	-00 14 41.6	11.254	(0.002)	[18]	0.065	(0.001)	[18]	0.022	(0.001)	[18]
FS12	05 52 27.66	+15 53 14.3	13.916	(0.006)	[13]	-0.115	(0.003)	[13]	-0.094	(0.005)	[13]
FS13	05 57 07.59	+00 01 11.4	10.140	(0.002)	[12]	0.313	(0.002)	[13]	0.048	(0.001)	[12]
FS14	07 24 14.40	-00 33 04.1	14.198	(0.008)	[8]	-0.065	(0.007)	[8]	-0.031	(0.010)	[8]
FS15	08 51 05.81	+11 43 46.9	12.348	(0.003)	[13]	0.337	(0.003)	[13]	0.054	(0.002)	[13]
FS16	08 51 15.01	+11 49 21.2	12.628	(0.004)	[11]	0.290	(0.003)	[11]	0.041	(0.002)	[11]
FS17	08 51 19.31	+11 52 10.4	12.274	(0.002)	[10]	0.327	(0.003)	[10]	0.056	(0.002)	[10]
FS18	08 53 35.51	-00 36 41.7	10.527	(0.002)	[11]	0.252	(0.003)	[11]	0.041	(0.002)	[11]
FS19	10 33 42.75	-11 41 38.3	13.782	(0.006)	[9]	-0.085	(0.005)	[9]	-0.115	(0.007)	[9]
FS20	11 07 59.93	-05 09 26.1	13.501	(0.010)	[6]	-0.038	(0.006)	[6]	-0.065	(0.008)	[6]
FS21	11 37 05.15	+29 47 58.4	13.147	(0.002)	[9]	-0.069	(0.004)	[9]	-0.090	(0.004)	[9]
FS33	12 57 02.30	+22 01 52.8	14.254	(0.005)	[6]	-0.112	(0.002)	[5]	-0.103	(0.008)	[5]
FS23	13 41 43.57	+28 29 49.5	12.375	(0.003)	[11]	0.527	(0.003)	[11]	0.066	(0.003)	[11]
FS27	16 40 41.56	+36 21 12.4	13.128	(0.005)	[10]	0.306	(0.005)	[10]	0.048	(0.004)	[10]
FS35	18 27 13.52	+04 03 09.4	11.748	(0.005)	[14]	0.369	(0.003)	[15]	0.084	(0.002)	[15]
FS34	20 42 34.73	-20 04 34.8	13.000	(0.004)	[9]	-0.077	(0.003)	[9]	-0.074	(0.005)	[9]
FS29	21 52 25.36	+02 23 20.7	13.311	(0.003)	[11]	-0.068	(0.002)	[11]	-0.070	(0.003)	[11]
FS30	22 41 44.72	+01 12 36.5	12.022	(0.003)	[15]	-0.042	(0.002)	[13]	-0.031	(0.002)	[14]
FS31	23 12 21.60	+10 47 04.1	14.037	(0.007)	[10]	-0.130	(0.005)	[10]	-0.099	(0.005)	[10]
FS32	23 16 12.37	-01 50 34.6	13.676	(0.007)	[8]	-0.107	(0.003)	[8]	-0.086	(0.005)	[8]

NB: FS18 is a double; separation = 1."36, p.a. 96 degrees, Delta(K) = 2.2