

# Southern African Large Telescope

## SALT Position Angle Visibility

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Document Number: SALT-3170AM0009

v 1.1  
4 April, 2011

### **Change History**

Rev	Date	Description
1.0	15 March, 2011	Original
1.1	4 April, 2011	Correcting 180° error

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## 1 Scope

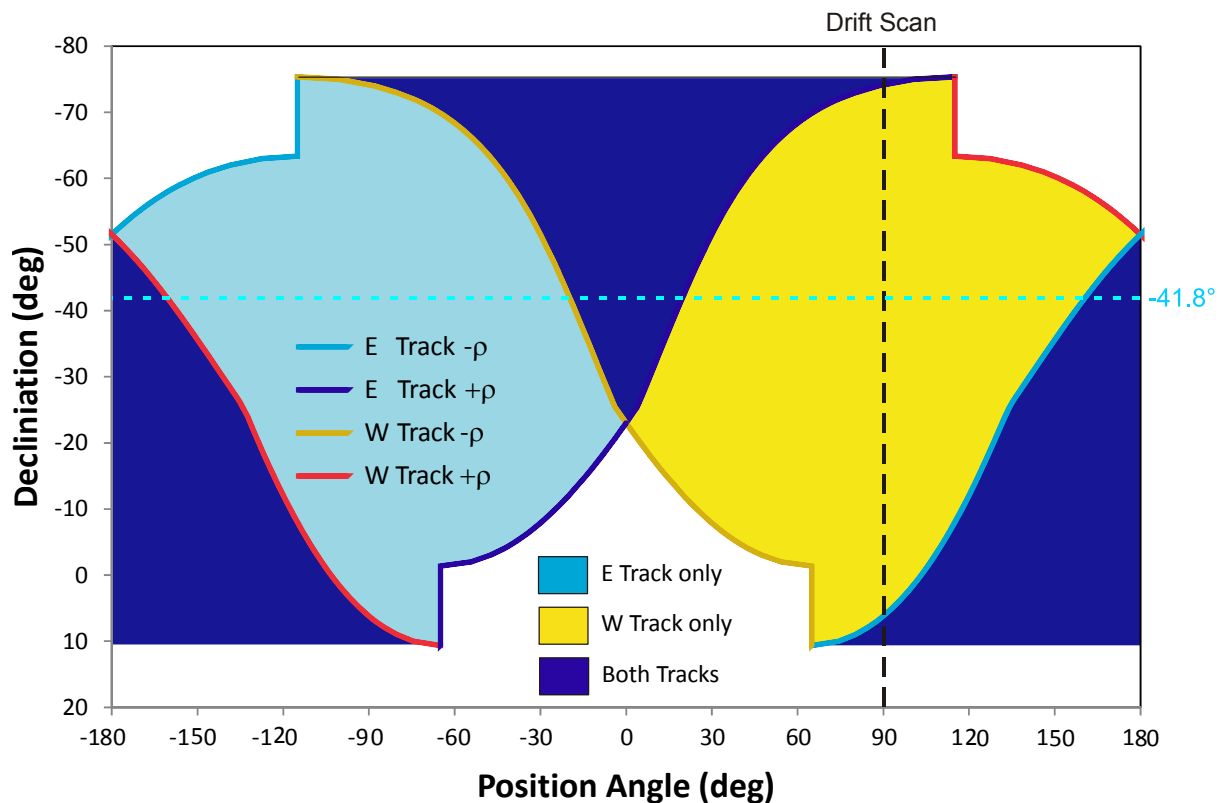
This document describes limitations on SALT visibility imposed by the instrument rotator limits. It is to be used for planning of any SALT observation that imposes Position Angle requirements.

## 2 Affected Modes

Modes affected by these limitations include RSS Multi-Object Spectroscopy, where a PA-dependent mask must be manufactured, RSS longslit spectroscopic observations of diffuse objects where the slit must be placed along a feature in the target, and for drift scans, where the position angle required to line up diurnal motion with the detector readout (East up) is 90 degrees.

## 3 Position Angle Visibility

The SALT PA visibility was calculated (Figure and Table below) by determining the Position Angle corresponding to the  $\rho$ -drive limits of  $\pm 115^\circ$  as a function of the declination  $\delta$  and the Zenith distance  $\zeta$  at the inside, center, and outside of the SALT tracker visibility annulus,  $\zeta =$



31, 37, 43°. First, the Hour Angle  $H$  is computed from  $\delta$  and  $\zeta$ :

$$\cos H = (\cos \zeta - \sin \delta \sin \varphi) / \cos \delta \cos \varphi$$

Then the parallactic angle  $P$  is obtained from  $\delta$  and  $H$ ,

$$\cos P = (\sin \varphi \cos \delta - \cos \varphi \sin \delta \cos H) / \sin \zeta$$

$$\sin P = \cos \varphi \sin h / \sin \zeta$$

where  $H < 0$  for the East track and  $H > 0$  for the West track, and  $\varphi = -32.3760^\circ$  is the SALT latitude. Finally

$$PA = P + \rho + 180$$

In addition to every degree, the table below shows results for declinations with useful properties (shaded). For the purposes of this analysis, the SALT tracker visibility annulus is divided into two regions, East and West, joined at the North-South meridian. The East and West tracks are adjacent from  $-63.4^\circ$  to  $-75.4^\circ$  and from  $10.6^\circ$  to  $-1.4^\circ$ . The table lists the PA ranges for which the rotator is between its  $-115^\circ$  and  $+115^\circ$  limits for the entire E or W track. The West track is shown twice, since obtaining the same PA in the West track as the East can sometimes be achieved by either running the rotator counterclockwise (towards minus  $\rho$ ) or clockwise. The single-track visible PA range is maximum ( $229.6^\circ$ ) at the declination ( $-25.3^\circ$ ) where the track passes through the EW line at the center of track, which is where the rotator must reverse direction. Position Angles which can be followed over both E and W tracks are shown at the right side of the table, and shaded dark blue in the figure. These are the most favorable position angles for assuring the maximum visibility of a target. This important region is centered on  $0^\circ$  in the South and  $180^\circ$  in the North, which is the default position angle used by the SALT control system. For the former, the rotator is moved clockwise between the E and W tracks, and for the latter, it is moved counterclockwise. For a range of declinations,  $-23.0$  to  $-51.5$ , either orientation is possible, but a larger range of 2-track position angles is possible if North-up is used South of declination  $-41.8^\circ$ , and South-up is used North of this point. Position angles that are available in one track but not the other are shaded in light blue and yellow in the figure.

For most applications, there is no astronomical preference between position angles differing by  $180^\circ$ . The data presented here is then useful for selecting the one which has the best visibility, or deciding whether both orientations should be allowed (putting in the observation twice, and possibly making two MOS masks). However for one application, drift scanning, East must be up to allow the CCD to read out in unison with diurnal motion. This PA is marked in the diagram; clearly this mode almost always requires the West Track.

Table: Position Angle Limits vs Declination

$\delta /$ $\rho$	E Trk		W Trk CCW		W Trk CW		Range	Both Trks - W CCW		Both Trks - W CW		Range
	-115	115	-115	115	-115	115		-115	115	-115	115	
-75.4	-115.0	115.0			-115.0	115.0	230.0			-115.0	115.0	230.0
-75.0	-115.0	100.6			-100.6	115.0	215.6			-100.6	100.6	201.2
-74.0	-115.0	88.0			-88.0	115.0	203.0			-88.0	88.0	176.1
-73.0	-115.0	80.3			-80.3	115.0	195.3			-80.3	80.3	160.6
-72.0	-115.0	74.4			-74.4	115.0	189.4			-74.4	74.4	148.9
-71.0	-115.0	69.6			-69.6	115.0	184.6			-69.6	69.6	139.3
-70.0	-115.0	65.6			-65.6	115.0	180.6			-65.6	65.6	131.2
-69.4	-115.0	63.3			-63.3	115.0	178.3			-63.3	63.3	126.7
-69.0	-115.0	62.1			-62.1	115.0	177.1			-62.1	62.1	124.1
-68.0	-115.0	58.9			-58.9	115.0	173.9			-58.9	58.9	117.9
-67.0	-115.0	56.1			-56.1	115.0	171.1			-56.1	56.1	112.2
-66.0	-115.0	53.6			-53.6	115.0	168.6			-53.6	53.6	107.1
-65.0	-115.0	51.2			-51.2	115.0	166.2			-51.2	51.2	102.4

$\delta / \rho$	E Trk		W Trk CCW		W Trk CW		Range	Both Trks - W CCW		Both Trks - W CW		Range	
	-115	115	-115	115	-115	115		-115	115	-115	115		
-64.0	-115.0	49.1			-49.1	115.0	164.1			-49.1	49.1	98.1	
-63.4	-115.0	47.8			-47.8	115.0	162.8			-47.8	47.8	95.6	
-63.0	-127.5	47.0			-47.0	127.5	174.5			-47.0	47.0	94.1	
-62.0	-138.7	45.1			-45.1	138.7	183.9			-45.1	45.1	90.3	
-61.0	-145.9	43.4			-43.4	145.9	189.3			-43.4	43.4	86.7	
-60.0	-151.6	41.7			-41.7	151.6	193.2			-41.7	41.7	83.4	
-59.0	-156.3	40.1			-40.1	156.3	196.4			-40.1	40.1	80.2	
-58.0	-160.5	38.6			-38.6	160.5	199.0			-38.6	38.6	77.1	
-57.0	-164.2	37.1			-37.1	164.2	201.3			-37.1	37.1	74.2	
-56.0	-167.5	35.7			-35.7	167.5	203.3			-35.7	35.7	71.4	
-55.0	-170.7	34.4			-34.4	170.7	205.0			-34.4	34.4	68.7	
-54.0	-173.5	33.1			-33.1	173.5	206.6			-33.1	33.1	66.1	
-53.0	-176.2	31.8			-31.8	176.2	208.1			-31.8	31.8	63.6	
-52.0	-178.8	30.6			-30.6	178.8	209.4			-30.6	30.6	61.2	
-51.5	-180.0	30.0	-390.0	-180.0	-30.0	180.0	210.0	-180.0	-180.0	0.0	-30.0	30.0	60.0
-51.0	-181.2	29.4	-389.4	-178.8	-29.4	181.2	210.6	-181.2	-178.8	2.4	-29.4	29.4	58.8
-50.0	-183.5	28.2	-388.2	-176.5	-28.2	183.5	211.8	-183.5	-176.5	7.1	-28.2	28.2	56.5
-49.0	-185.7	27.1	-387.1	-174.3	-27.1	185.7	212.9	-185.7	-174.3	11.5	-27.1	27.1	54.2
-48.0	-187.9	26.0	-386.0	-172.1	-26.0	187.9	213.9	-187.9	-172.1	15.7	-26.0	26.0	52.0
-47.0	-189.9	24.9	-384.9	-170.1	-24.9	189.9	214.8	-189.9	-170.1	19.8	-24.9	24.9	49.9
-46.0	-191.9	23.9	-383.9	-168.1	-23.9	191.9	215.8	-191.9	-168.1	23.8	-23.9	23.9	47.7
-45.0	-193.8	22.8	-382.8	-166.2	-22.8	193.8	216.6	-193.8	-166.2	27.6	-22.8	22.8	45.6
-44.0	-195.7	21.8	-381.8	-164.3	-21.8	195.7	217.5	-195.7	-164.3	31.4	-21.8	21.8	43.6
-43.0	-197.5	20.8	-380.8	-162.5	-20.8	197.5	218.3	-197.5	-162.5	35.0	-20.8	20.8	41.6
-42.0	-199.3	19.8	-379.8	-160.7	-19.8	199.3	219.1	-199.3	-160.7	38.6	-19.8	19.8	39.6
-41.8	-199.6	19.6	-379.6	-160.4	-19.6	199.6	219.2	-199.6	-160.4	39.2	-19.6	19.6	39.2
-41.0	-201.0	18.8	-378.8	-159.0	-18.8	201.0	219.8	-201.0	-159.0	42.1	-18.8	18.8	37.6
-40.0	-202.7	17.8	-377.8	-157.3	-17.8	202.7	220.6	-202.7	-157.3	45.5	-17.8	17.8	35.6
-39.0	-204.4	16.8	-376.8	-155.6	-16.8	204.4	221.3	-204.4	-155.6	48.9	-16.8	16.8	33.7
-38.0	-206.1	15.9	-375.9	-153.9	-15.9	206.1	222.0	-206.1	-153.9	52.2	-15.9	15.9	31.8
-37.0	-207.7	14.9	-374.9	-152.3	-14.9	207.7	222.7	-207.7	-152.3	55.5	-14.9	14.9	29.8
-36.0	-209.4	14.0	-374.0	-150.6	-14.0	209.4	223.3	-209.4	-150.6	58.7	-14.0	14.0	27.9
-35.0	-211.0	13.0	-373.0	-149.0	-13.0	211.0	224.0	-211.0	-149.0	61.9	-13.0	13.0	26.0
-34.0	-212.6	12.1	-372.1	-147.4	-12.1	212.6	224.6	-212.6	-147.4	65.1	-12.1	12.1	24.1
-33.0	-214.1	11.1	-371.1	-145.9	-11.1	214.1	225.3	-214.1	-145.9	68.3	-11.1	11.1	22.3
-32.0	-215.7	10.2	-370.2	-144.3	-10.2	215.7	225.9	-215.7	-144.3	71.4	-10.2	10.2	20.4
-31.0	-217.3	9.2	-369.2	-142.7	-9.2	217.3	226.5	-217.3	-142.7	74.6	-9.2	9.2	18.5
-30.0	-218.9	8.3	-368.3	-141.1	-8.3	218.9	227.2	-218.9	-141.1	77.7	-8.3	8.3	16.6
-29.0	-220.4	7.3	-367.3	-139.6	-7.3	220.4	227.8	-220.4	-139.6	80.9	-7.3	7.3	14.7
-28.0	-222.0	6.4	-366.4	-138.0	-6.4	222.0	228.4	-222.0	-138.0	84.0	-6.4	6.4	12.8
-27.0	-223.6	5.4	-365.4	-136.4	-5.4	223.6	229.0	-223.6	-136.4	87.2	-5.4	5.4	10.9
-26.0	-225.0	4.5	-364.5	-135.0	-4.5	225.0	229.5	-225.0	-135.0	90.1	-4.5	4.5	9.0
-25.3	-225.9	3.7	-363.7	-134.1	-3.7	225.9	229.6	-225.9	-134.1	91.8	-3.7	3.7	7.5
-25.0	-226.3	3.2	-363.2	-133.7	-3.2	226.3	229.5	-226.3	-133.7	92.6	-3.2	3.2	6.4
-24.0	-227.5	1.6	-361.6	-132.5	-1.6	227.5	229.1	-227.5	-132.5	94.9	-1.6	1.6	3.2
-23.0	-228.4	0.0	-360.0	-131.6	0.0	228.4	228.4	-228.4	-131.6	96.8	0.0	0.0	0.0
-23.0	-228.4	0.0	-360.0	-131.6	0.0	228.4	228.4	-228.4	-131.6	96.9	0.0	0.0	-0.1
-22.0	-229.4	-1.7	-358.3	-130.6	1.7	229.4	227.8	-229.4	-130.6	98.9			
-21.0	-230.4	-3.3	-356.7	-129.6	3.3	230.4	227.1	-230.4	-129.6	100.9			
-20.0	-231.4	-5.0	-355.0	-128.6	5.0	231.4	226.4	-231.4	-128.6	102.9			
-19.0	-232.5	-6.8	-353.2	-127.5	6.8	232.5	225.7	-232.5	-127.5	104.9			
-18.0	-233.5	-8.5	-351.5	-126.5	8.5	233.5	225.0	-233.5	-126.5	107.0			

$\delta / \rho$	E Trk		W Trk CCW		W Trk CW		Range	Both Trks - W CCW		Both Trks - W CW		Range
	-115	115	-115	115	-115	115		-115	115	-115	115	
-17.0	-234.5	-10.3	-349.7	-125.5	10.3	234.5	224.2	-234.5	-125.5	109.1		
-16.0	-235.6	-12.2	-347.8	-124.4	12.2	235.6	223.4	-235.6	-124.4	111.2		
-15.0	-236.7	-14.1	-345.9	-123.3	14.1	236.7	222.6	-236.7	-123.3	113.4		
-14.0	-237.8	-16.0	-344.0	-122.2	16.0	237.8	221.8	-237.8	-122.2	115.6		
-13.0	-238.9	-18.1	-341.9	-121.1	18.1	238.9	220.9	-238.9	-121.1	117.9		
-12.0	-240.1	-20.2	-339.8	-119.9	20.2	240.1	219.9	-240.1	-119.9	120.2		
-11.0	-241.3	-22.4	-337.6	-118.7	22.4	241.3	218.9	-241.3	-118.7	122.5		
-10.0	-242.5	-24.7	-335.3	-117.5	24.7	242.5	217.8	-242.5	-117.5	124.9		
-9.0	-243.7	-27.1	-332.9	-116.3	27.1	243.7	216.6	-243.7	-116.3	127.4		
-8.0	-245.0	-29.7	-330.3	-115.0	29.7	245.0	215.3	-245.0	-115.0	129.9		
-7.0	-246.3	-32.5	-327.5	-113.7	32.5	246.3	213.8	-246.3	-113.7	132.5		
-6.0	-247.6	-35.5	-324.5	-112.4	35.5	247.6	212.1	-247.6	-112.4	135.2		
-5.0	-249.0	-38.9	-321.1	-111.0	38.9	249.0	210.1	-249.0	-111.0	137.9		
-4.0	-250.4	-42.8	-317.2	-109.6	42.8	250.4	207.6	-250.4	-109.6	140.8		
-3.0	-251.9	-47.5	-312.5	-108.1	47.5	251.9	204.4	-251.9	-108.1	143.8		
-2.0	-253.4	-54.2	-305.8	-106.6	54.2	253.4	199.3	-253.4	-106.6	146.9		
-1.4	-254.4	-65.0	-295.0	-105.6	65.0	254.4	189.4	-254.4	-105.6	148.9		
-1.0	-255.0	-65.0	-295.0	-105.0	65.0	255.0	190.0	-255.0	-105.0	150.1		
0.0	-256.7	-65.0	-295.0	-103.3	65.0	256.7	191.7	-256.7	-103.3	153.5		
1.0	-258.5	-65.0	-295.0	-101.5	65.0	258.5	193.5	-258.5	-101.5	157.0		
2.0	-260.4	-65.0	-295.0	-99.6	65.0	260.4	195.4	-260.4	-99.6	160.8		
3.0	-262.4	-65.0	-295.0	-97.6	65.0	262.4	197.4	-262.4	-97.6	164.8		
4.0	-264.5	-65.0	-295.0	-95.5	65.0	264.5	199.5	-264.5	-95.5	169.1		
4.6	-266.0	-65.0	-295.0	-94.0	65.0	266.0	201.0	-266.0	-94.0	172.0		
5.0	-266.9	-65.0	-295.0	-93.1	65.0	266.9	201.9	-266.9	-93.1	173.8		
6.0	-269.4	-65.0	-295.0	-90.6	65.0	269.4	204.4	-269.4	-90.6	178.9		
7.0	-272.3	-65.0	-295.0	-87.7	65.0	272.3	207.3	-272.3	-87.7	184.7		
8.0	-275.7	-65.0	-295.0	-84.3	65.0	275.7	210.7	-275.7	-84.3	191.3		
9.0	-279.7	-65.0	-295.0	-80.3	65.0	279.7	214.7	-279.7	-80.3	199.5		
10.0	-285.5	-65.0	-295.0	-74.5	65.0	285.5	220.5	-285.5	-74.5	211.0		
10.6	-295.0	-65.0	-295.0	-65.0	65.0	295.0	230.0	-295.0	-65.0	230.0		