



Planning Observations at the CHARA Array

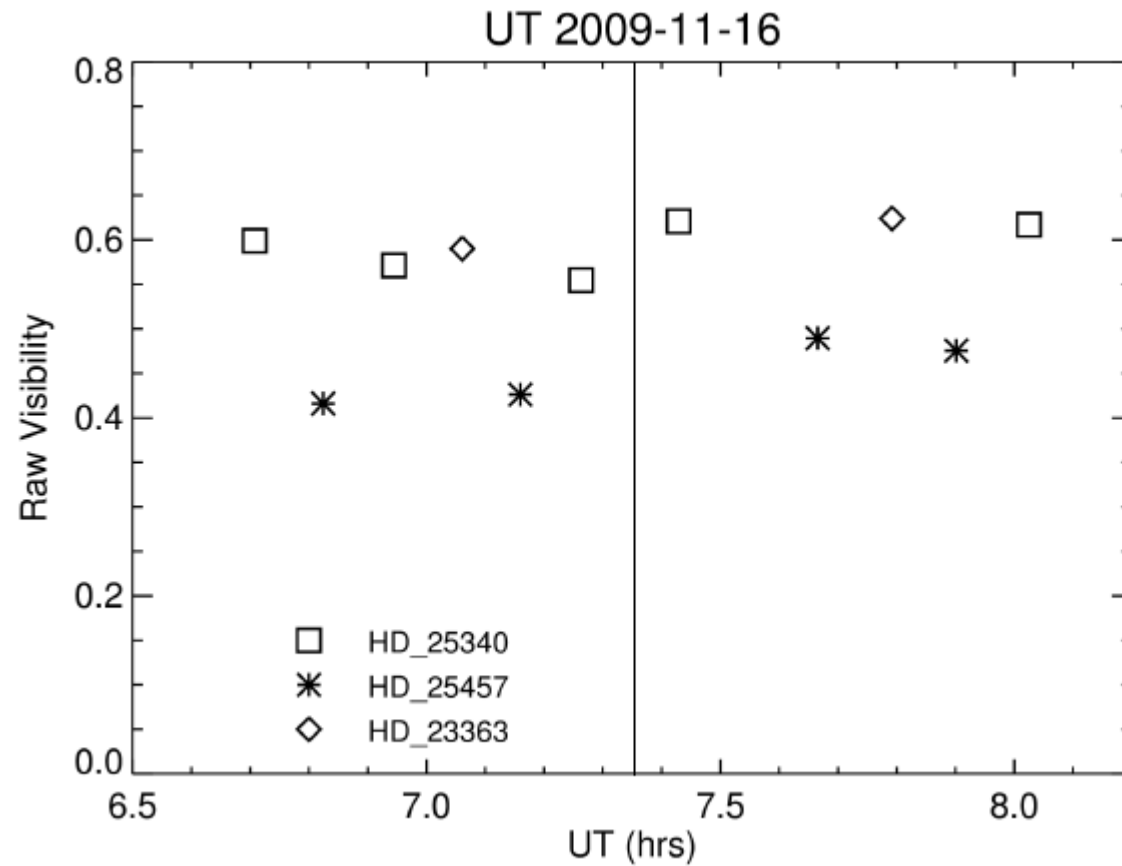


Gail Schaefer

CHARA Array of
Georgia State University

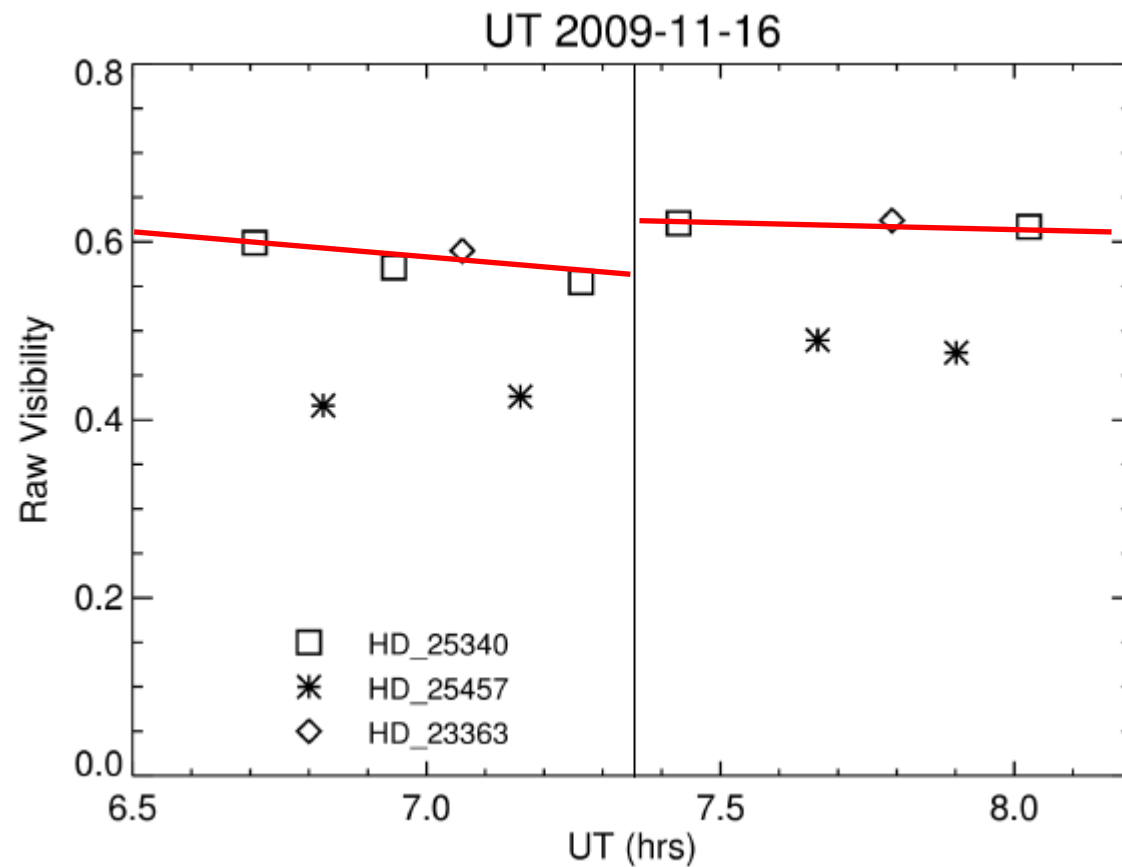


Calibrators Stars





Calibrators Stars





Selecting Calibrators

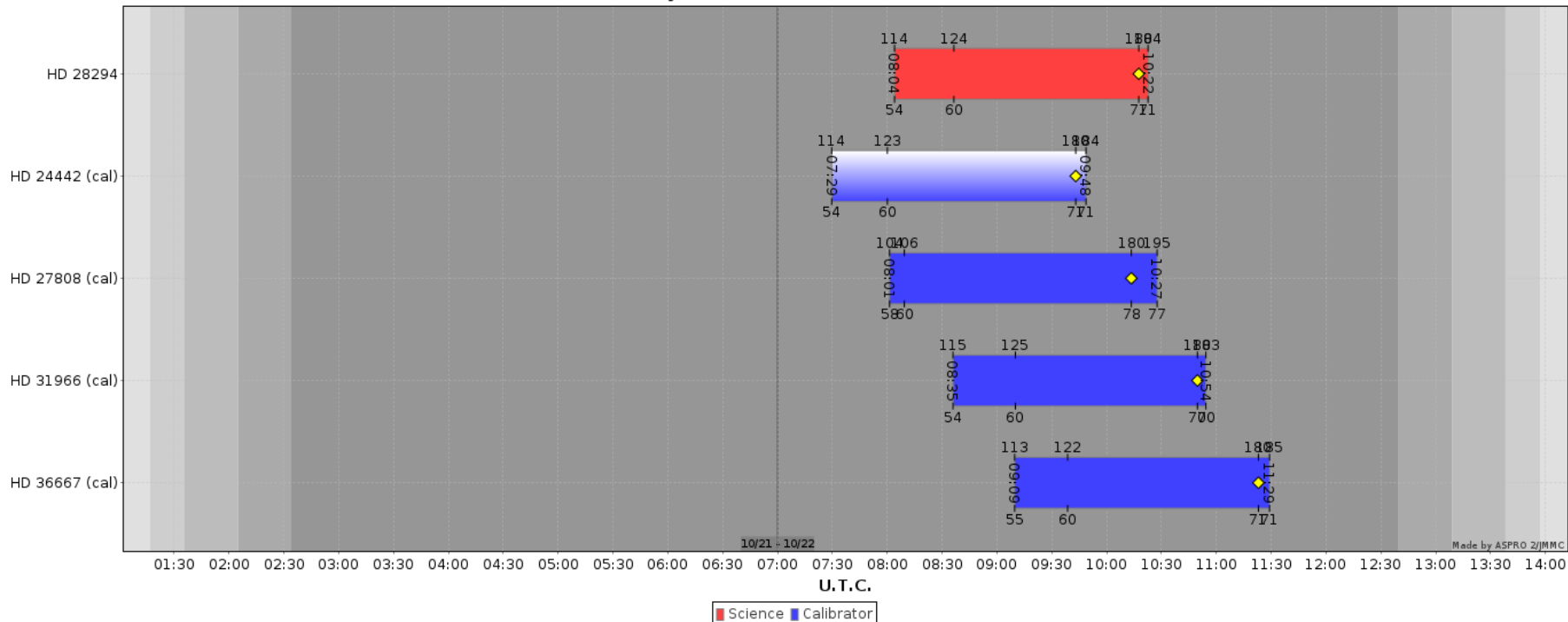
- **Unresolved single stars**
 - $\theta < 0.5$ mas for H-band; $\theta < 0.2$ mas for R-band [for 300 m baseline]
 - If you need to go bigger, look for stars with known diameters (previous interferometric observations)
- **Close in magnitude and color**
 - Use same detector settings (within ~ 1 mag). Similar spectral response.
- **Avoid calibrators too close to sensitivity limits**
 - Challenging to observe + low SNR fringes – poor calibration
- **Literature search**
 - Binarity, rapid rotation ($v \sin i$), photometric standard star, previous calibrator?



How Many Calibrators?

- 2-3 calibrators close on sky (< 5 deg if possible)
- Also select one early and one late calibrator – Flexibility!

CHARA 2023A - MIRCX-MYSTIC - E1(1)-W2(5)-W1(1)-S2(3)-S1(2)-E2(2)
Day: 2021-10-21 - Moon = 97.8%





Going on sky - Be Flexible and Prioritize!

- MIRC-X/MYSTIC observations usually take 30-45 min per star
 - If you only have 10 minutes left of delay, consider skipping to next target
 - ASPRO2 and CHARA delays might be off by a few minutes – Don't be surprised if you end up having 5 minutes less than expected
- Look ahead – make sure you have plenty of time for high priority targets



Delay Lines, Carts, and POPs



Cart

Fixed Delay - POPs



- Fixed delay added using POP mirrors in vacuum tubes
- Continuously variable delay by carts on rails





Optimizing POP Configurations

- Optimize configuration to minimize POP changes during night



Optimizing POP Configurations

- Optimize configuration to minimize POP changes during night
- Imaging programs - change pops to follow target through night
 - After 6T windows end, collect 5T data
 - E1 runs out of delay west of transit
 - S1 runs out of delay in the north (DEC > 60 deg)



Optimizing POP Configurations

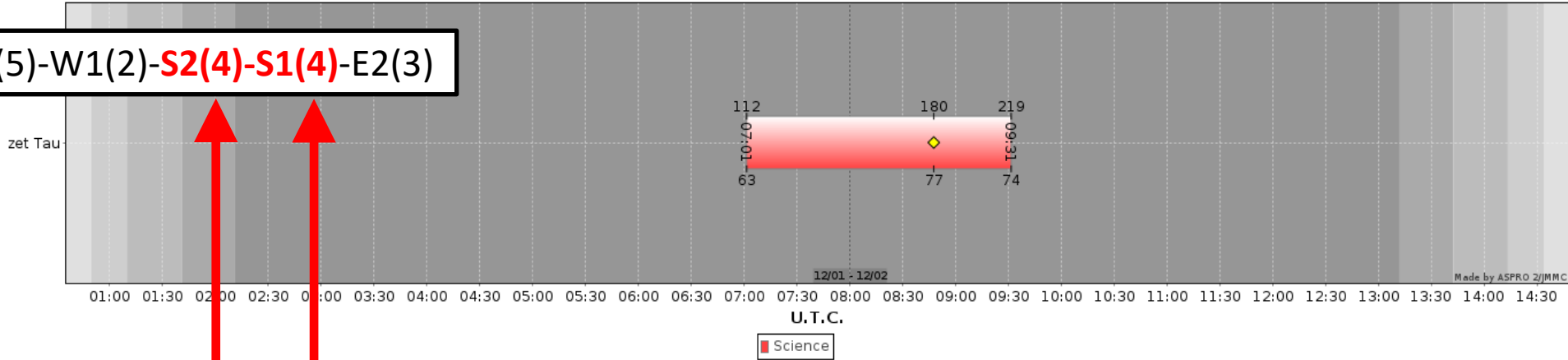
- Optimize configuration to minimize POP changes during night
- Imaging programs - change pops to follow target through night
 - After 6T windows end, collect 5T data
 - E1 runs out of delay west of transit
 - S1 runs out of delay in the north (DEC > 60 deg)
- Multi-target programs - group stars with similar declinations together
 - Similar POPs + share calibrators between targets



Which of these Configurations is Better?

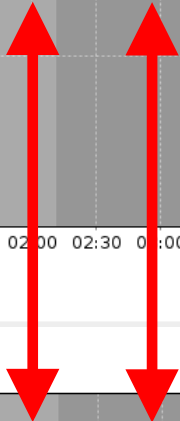
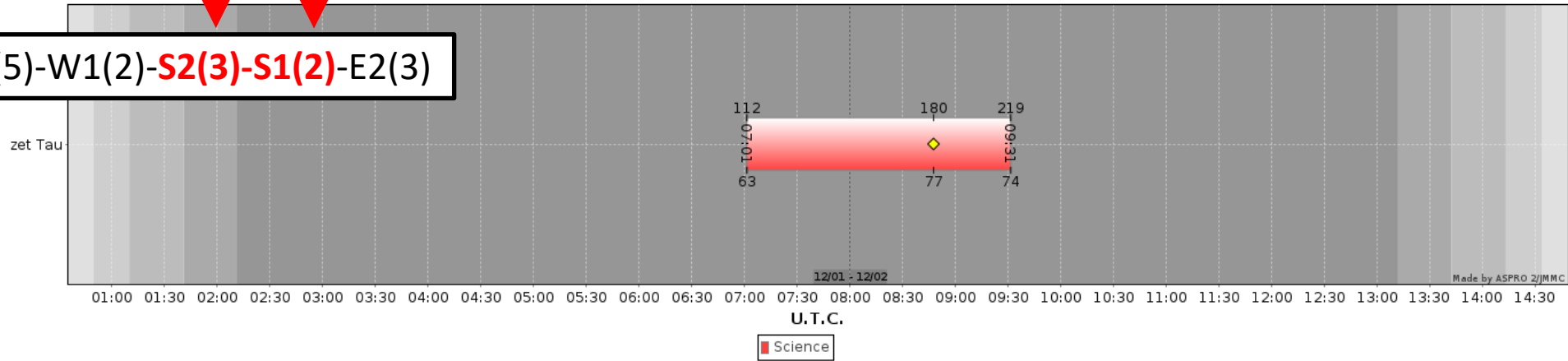
CHARA 2023A - MIRCX-MYSTIC - E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)
Day: 2023-12-01 - Moon = 76.8%

E1(1)-W2(5)-W1(2)-**S2(4)**-**S1(4)**-E2(3)



CHARA 2023A - MIRCX-MYSTIC - E1(1)-W2(5)-W1(2)-S2(3)-S1(2)-E2(3)
Day: 2023-12-01 - Moon = 76.8%

E1(1)-W2(5)-W1(2)-**S2(3)**-**S1(2)**-E2(3)





Use chara_plan2 to fine tune ASPRO configurations: Optimize Delay Settings

- On remote data reduction machine:
 - Type “chara_plan2” in terminal window to start CHARA Plan



NEW CHARA_PLAN

UT Year : 2023 UT Month : 12 UT Day : 1

S1	POP2	BEAM1	<input checked="" type="checkbox"/> S1	SLEW TO	CAL 1	WHEN	FIND IRC	HD_37202					
S2	POP3	BEAM1	<input checked="" type="checkbox"/> S2	NUM	63480	IRC	+20113	HR	1910	HD	37202	SAO	77336
E1	POP1	BEAM1	<input checked="" type="checkbox"/> E1	CLEAR				RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell					
E2	POP2	BEAM1	<input checked="" type="checkbox"/> E2	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET					
W1	POP2	BEAM1	<input checked="" type="checkbox"/> W1	NUM		IRC		HR		HD		SAO	
W2	END	BEAM1	<input checked="" type="checkbox"/> W2	CLEAR				NOT SET					

Reference Cart W2

JOB QUEUE: 0 START JOB QUEUE STOP JOB QUEUE CLEAR JOB QUEUE PI: Prog

Transit or highest elevation at 8:01 at elevation 76.9 degrees.
 Twilight from UT 01 13 00.000 to 14 24 00.000.
 Delay possible 6:28 (Ref = 25.390) to 8:44 (Ref = 44.191)
 Whenstar calculation complete.
 Running job DO NOTHING.
 Do Nothing.
 Data file created.
 Data file plotted.
 HD_37202 Above 20 degrees from 2:19 to 13:43
 Transit or highest elevation at 8:01 at elevation 76.9 degrees.
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BEST POPS QUIT



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S1	POP2	BEAM1	<input checked="" type="checkbox"/> S1	SLEW TO	CAL 1	WHEN	FIND IRC	HD_37202					
				NUM	63480	IRC	+20113	HR	1910	HD	37202	SAO	77336
S2	POP3	BEAM1	<input checked="" type="checkbox"/> S2	CLEAR RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell									
E1	POP1	BEAM1	<input checked="" type="checkbox"/> E1	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET					
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E2	POP2	BEAM1	<input checked="" type="checkbox"/> E2	SLEW TO	CAL 2	WHEN	FIND IRC	NOT SET					
				NUM		IRC		HR		HD		SAO	
W1	POP2	BEAM1	<input checked="" type="checkbox"/> W1	CLEAR									
W2	END	BEAM1	<input checked="" type="checkbox"/> W2	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET					
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Date



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S1	POP2	BEAM1	<input checked="" type="checkbox"/> S1	SLEW TO	CAL 1	WHEN	FIND IRC	HD_37202					
S2	POP3	BEAM1	<input checked="" type="checkbox"/> S2	NUM	63480	IRC	+20113	HR	1910	HD	37202	SAO	77336
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W1	POP2	BEAM1	<input checked="" type="checkbox"/> W1	NUM		IRC		HR		HD		SAO	
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BEST POPS QUIT

Target



Select Telescopes

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S1	POP2	BEAM1	<input checked="" type="checkbox"/>	S1	SLEW TO	CAL 1	WHEN	FIND IRC	HD_37202		
S2	POP3	BEAM1	<input checked="" type="checkbox"/>	S2	NUM	63480	IRC	+20113	HR 1910	HD 37202	SAO 77336
E1	POP1	BEAM1	<input checked="" type="checkbox"/>	E1	CLEAR	RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell					
E2	POP2	BEAM1	<input checked="" type="checkbox"/>	E2	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET		
W1	POP2	BEAM1	<input checked="" type="checkbox"/>	W1	NUM		IRC		HR	HD	SAO
W2	END	BEAM	<input checked="" type="checkbox"/>	W2	CLEAR						
Reference Cart	W2				SLEW TO	CHECK	WHEN	FIND IRC	NOT SET		
					NUM		IRC		HR	HD	SAO
					CLEAR						

JOB QUEUE: 0 START JOB QUEUE STOP JOB QUEUE CLEAR JOB QUEUE PI: Prog

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Select POPs

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S1	POP2	BEAM1	<input checked="" type="checkbox"/> S1	SLEW TO	CAL 1	WHEN	FIND IRC	HD_37202					
				NUM	63480	IRC	+20113	HR	1910	HD	37202	SAO	77336
				CLEAR				RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell					
E1	POP1	BEAM1	<input checked="" type="checkbox"/> E1	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET					
				NUM		IRC		HR		HD		SAO	
				CLEAR									
E2	POP2	BEAM1	<input checked="" type="checkbox"/> E2	SLEW TO	CAL 2	WHEN	FIND IRC	NOT SET					
				NUM		IRC		HR		HD		SAO	
				CLEAR									
W1	POP2	BEAM1	<input checked="" type="checkbox"/> W1	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET					
				NUM		IRC		HR		HD		SAO	
				CLEAR									
W2	END	BEAM1	<input checked="" type="checkbox"/> W2	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET					
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				CLEAR									

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BEST POPs QUIT



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 Do Nothing.

BEST POPS QUIT

Select Reference Cart
 W2 for mircx/mystic



NEW CHARA_PLAN

UT Year : 2023 UT M... UT D... 1

S1	POP2	BEAM1	<input checked="" type="checkbox"/>	S1	SLEW TO	CAL 1	WHEN	FIND IRC	NUM	63480	IRC	+20113	HR	1310	HD	37202	SAO	77336	
				CLEAR RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell															
E1	POP1	BEAM1	<input checked="" type="checkbox"/>	E1	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET										
				CLEAR															
E2	POP2	BEAM1	<input checked="" type="checkbox"/>	E2	SLEW TO	CAL 2	WHEN	FIND IRC	NOT SET										
				CLEAR															
W1	POP2	BEAM1	<input checked="" type="checkbox"/>	W1	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET										
				CLEAR															
W2	END	BEAM1	<input checked="" type="checkbox"/>	W2	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET										
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BEST POPS QUIT

Click When Button



NEW CHARA_PLAN

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S1	POP2	BEAM1	<input checked="" type="checkbox"/>	S1	SLEW TO	CAL 1	WHEN	FIND IRC	NOT SET
					NUM	63480	IRC	+20113	SAO
					CLEAR RA: 05 37 38.6854 DEC: +21 08 33.159 V: 3.03 H: 3.07 K: 2.97 Type: B1IVe_shell				
E1	POP1	BEAM1	<input checked="" type="checkbox"/>	E1	SLEW TO	OBJECT	WHEN	FIND IRC	NOT SET
					NUM		IRC		HR
					CLEAR				
E2	POP2	BEAM1	<input checked="" type="checkbox"/>	E2	SLEW TO	CAL 2	WHEN	FIND IRC	NOT SET
					NUM		IRC		HR
					CLEAR				
W1	POP2	BEAM1	<input checked="" type="checkbox"/>	W1	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET
					NUM		IRC		HR
					CLEAR				
W2	END	BEAM1	<input checked="" type="checkbox"/>	W2	SLEW TO	CHECK	WHEN	FIND IRC	NOT SET
					NUM		IRC		HR
					CLEAR				

Reference Cart W2

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BEST POPS QUIT

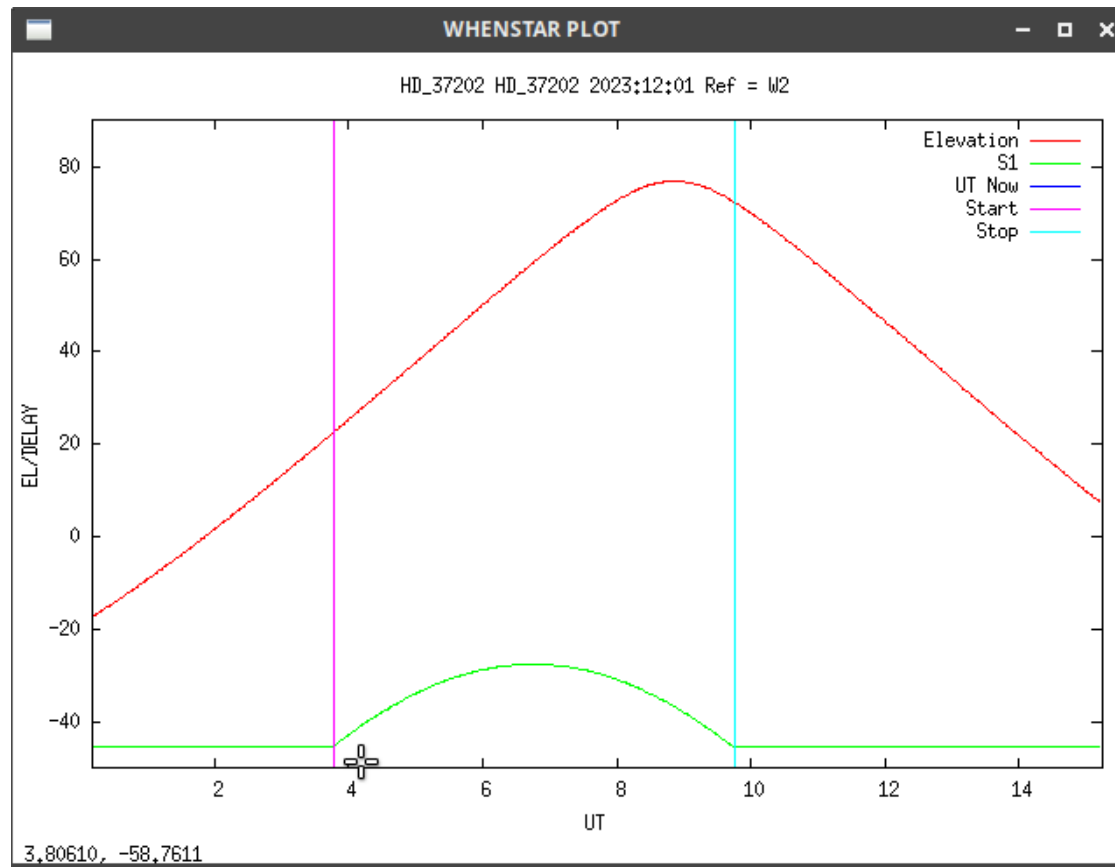
Click When Button

HD_37202 Above 20 degrees from 2:19 to 13:43
 Transit or highest elevation at 8:01 at elevation 76.9 degrees.
 Twilight from UT 01 13 00.000 to 14 24 00.000.
 Delay possible 6:28 (Ref = 25.390) to 9:34 (Ref = 44.191)
 whenstar calculation complete.
 Running job DO NOTHING.
 Do Nothing.



chara_plan2: "WhenStar" Plot

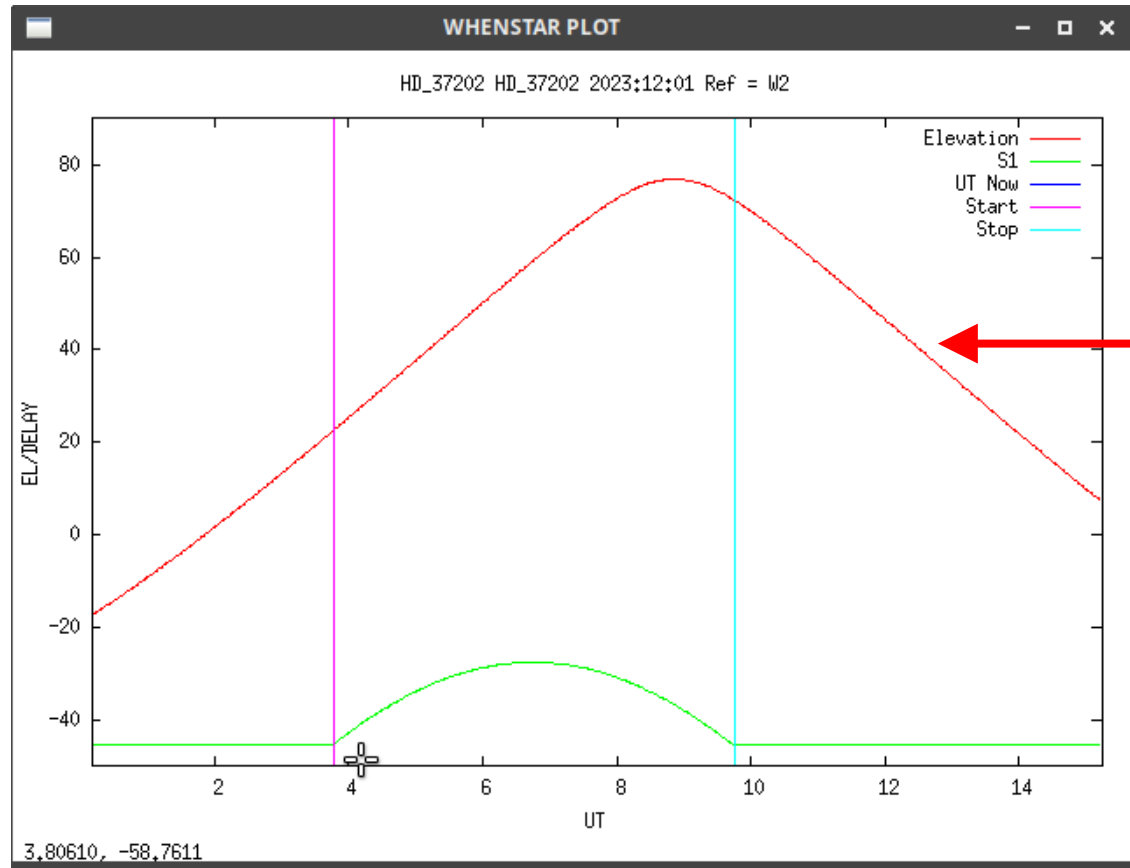
W2(5)-S1(4)





chara_plan2: "WhenStar" Plot

W2(5)-S1(4)

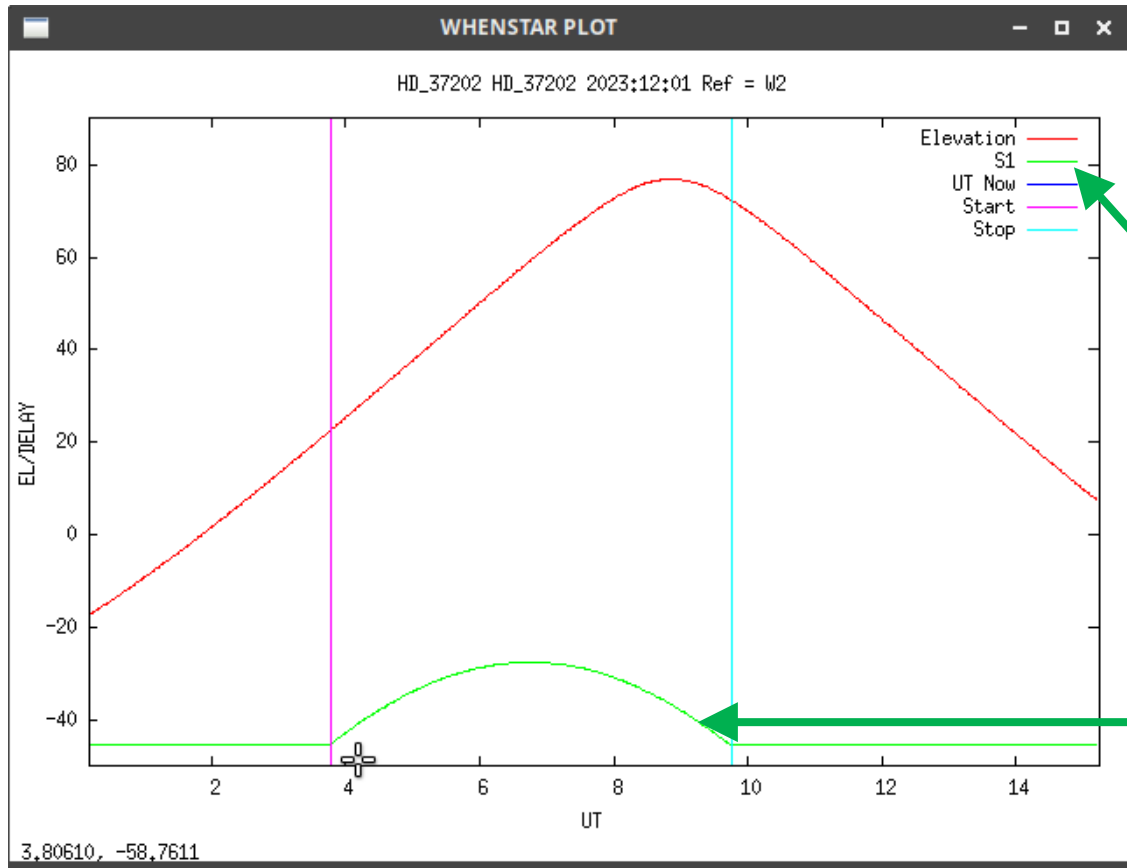


Star Elevation



chara_plan2: "WhenStar" Plot

W2(5)-S1(4)



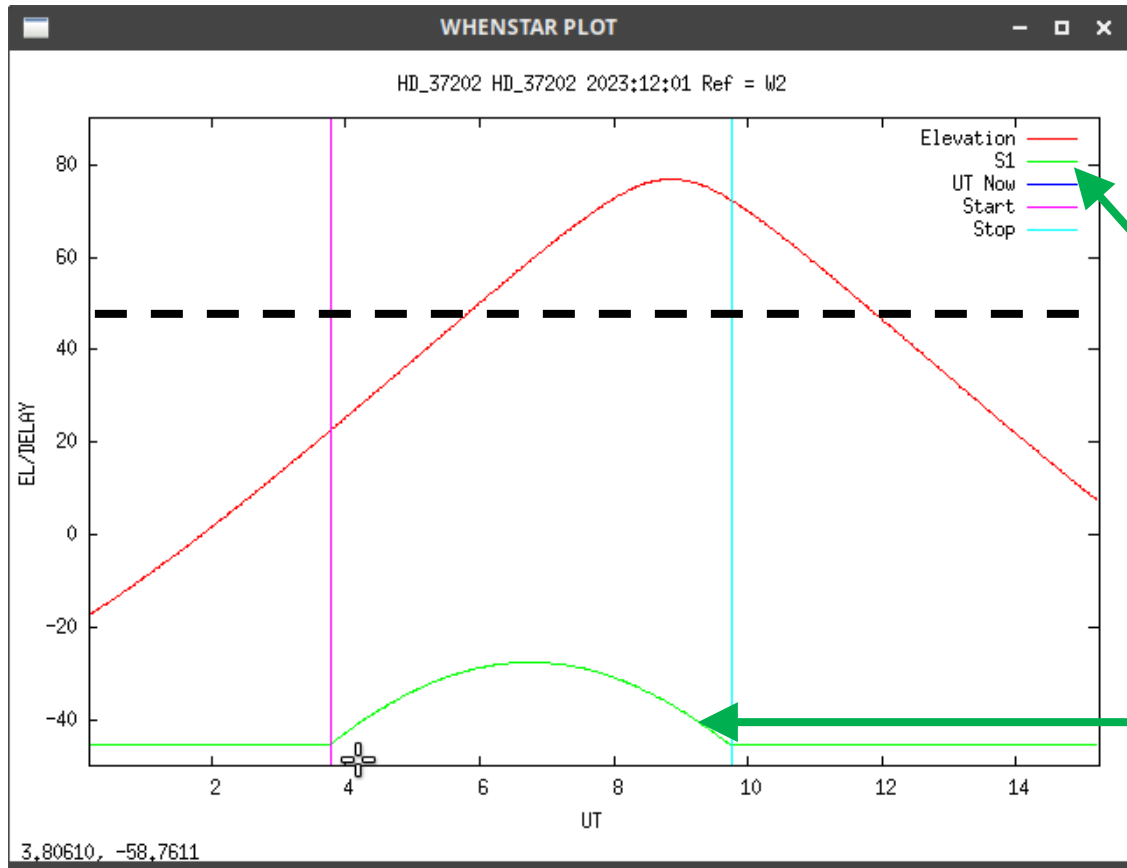
S1 cart position relative to reference cart W2



chara_plan2: "WhenStar" Plot

W2(5)-S1(4)

Delay Range:
± 45 m



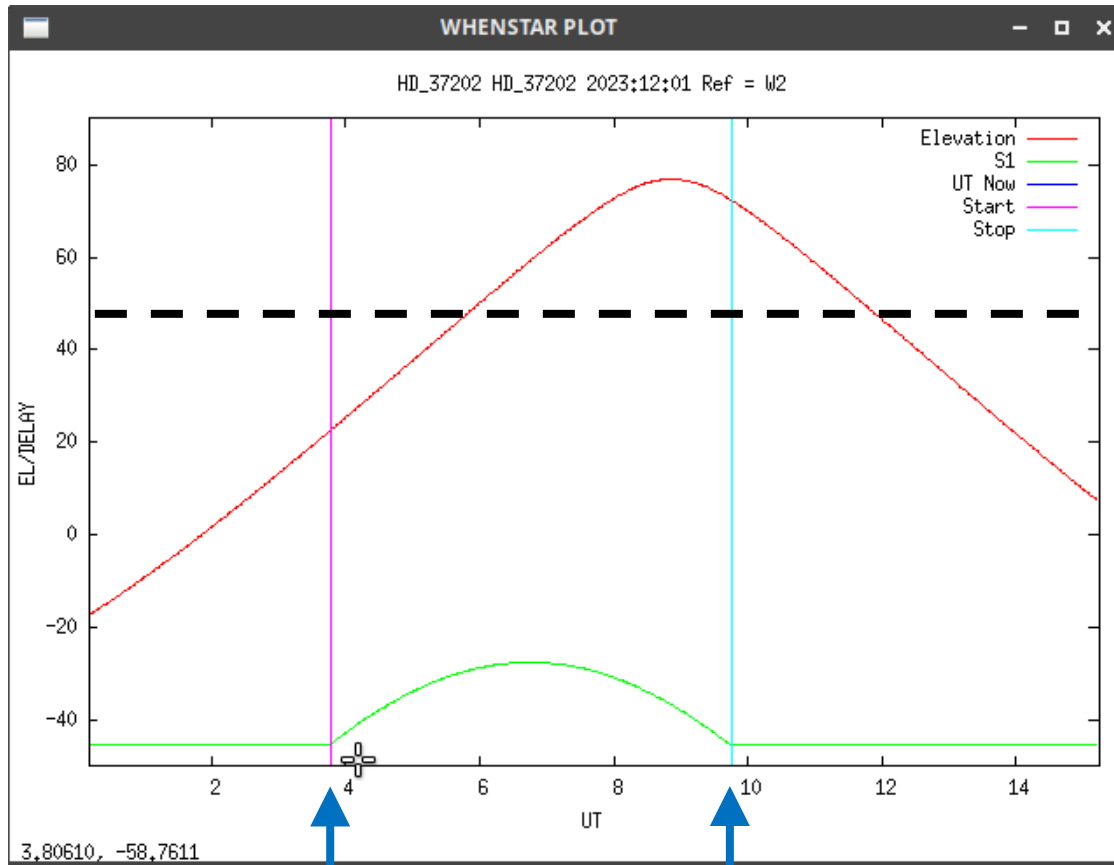
S1 cart position relative to reference cart W2



chara_plan2: "WhenStar" Plot

W2(5)-S1(4)

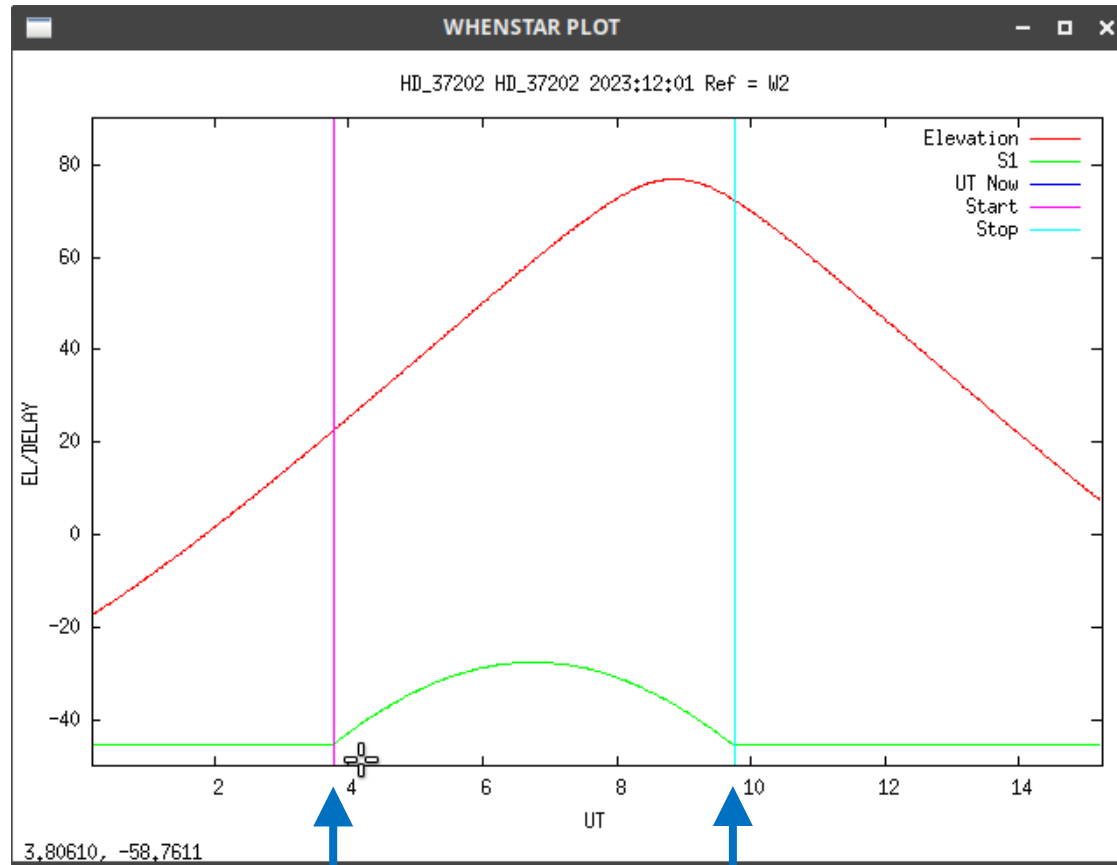
Delay Range:
± 45 m





chara_plan2: "WhenStar" Plot

W2(5)-S1(4)

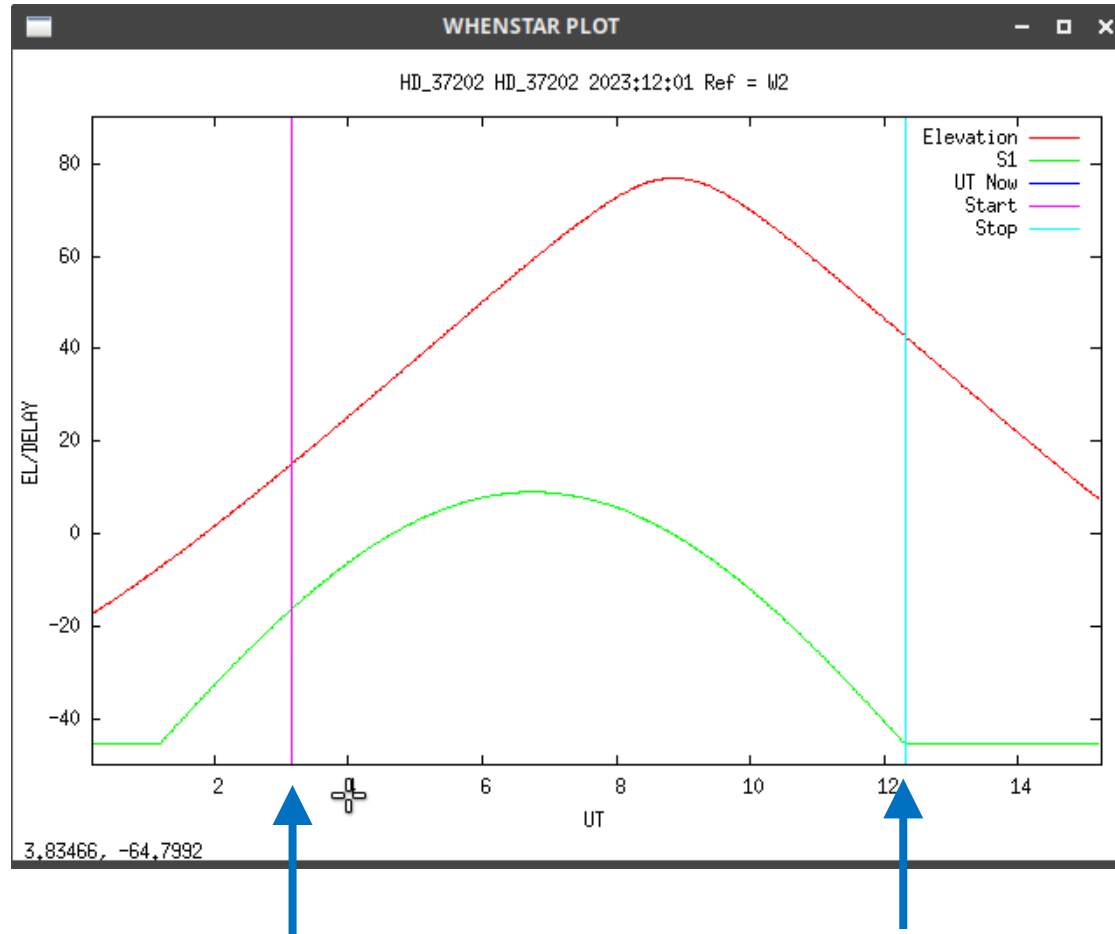




chara_plan2: "WhenStar" Plot

W2(5)-S1(X)

W2(5)-S1(2)

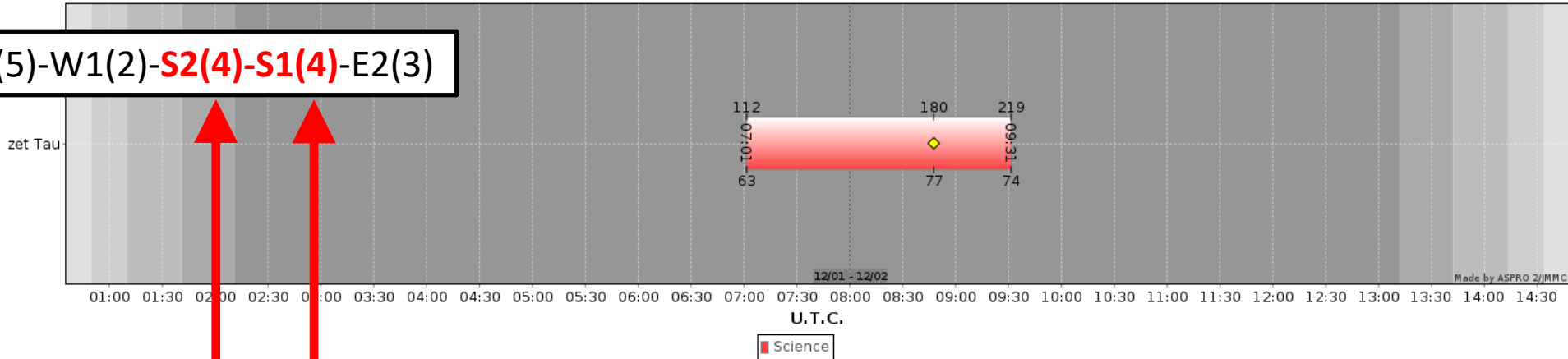




Which of these Configurations is Better?

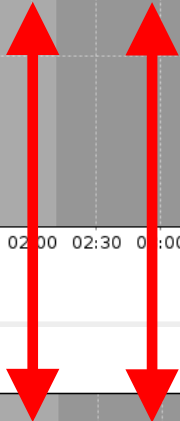
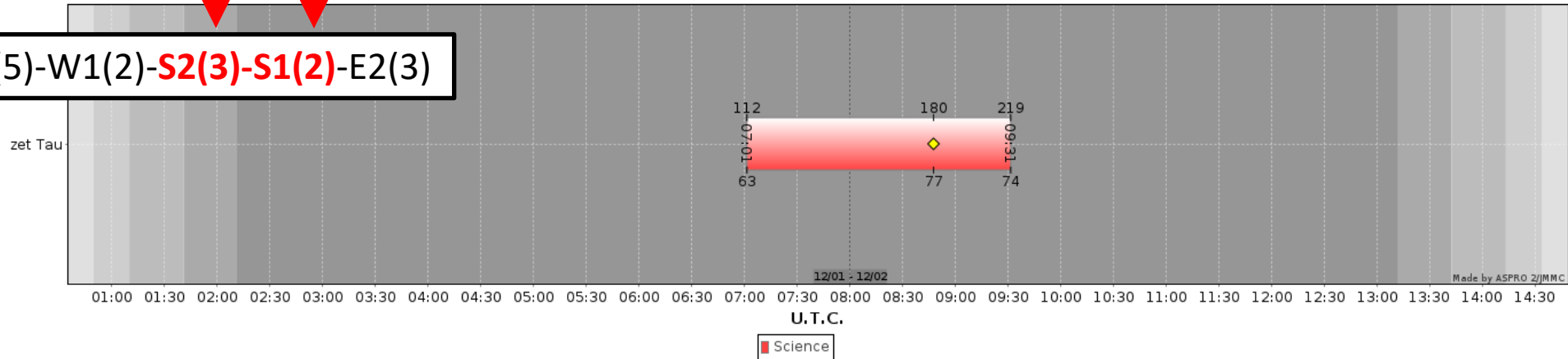
CHARA 2023A - MIRCX-MYSTIC - E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)
Day: 2023-12-01 - Moon = 76.8%

E1(1)-W2(5)-W1(2)-**S2(4)**-**S1(4)**-E2(3)



CHARA 2023A - MIRCX-MYSTIC - E1(1)-W2(5)-W1(2)-S2(3)-S1(2)-E2(3)
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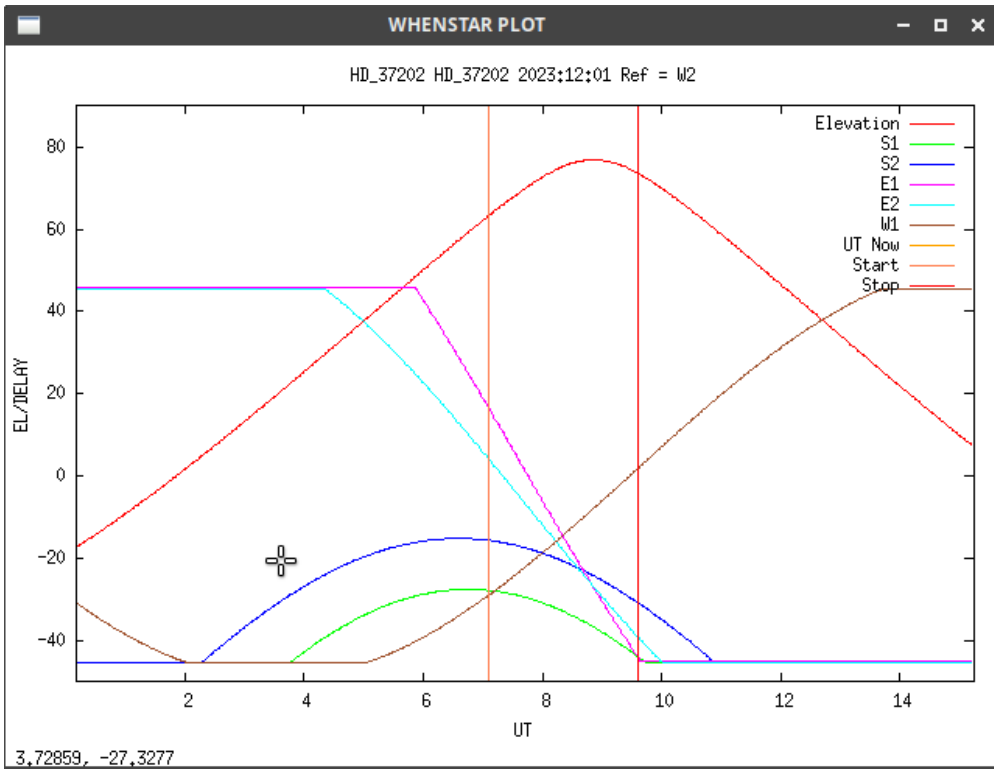
E1(1)-W2(5)-W1(2)-**S2(3)**-**S1(2)**-E2(3)





chara_plan2: "WhenStar" Plot

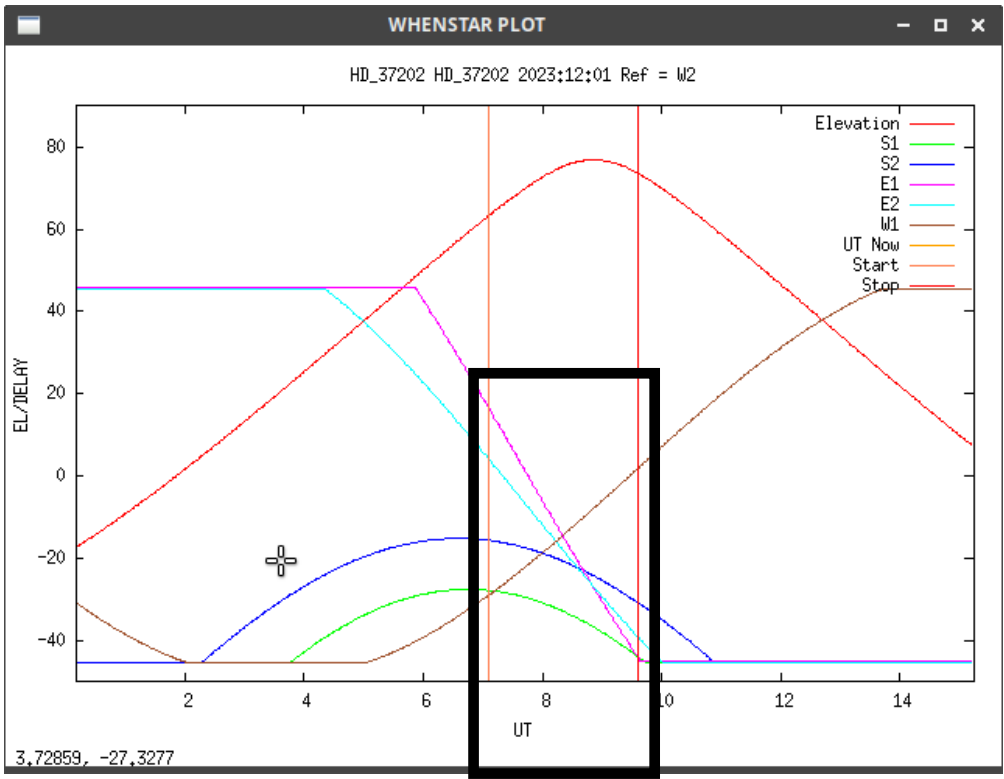
E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)





chara_plan2: "WhenStar" Plot

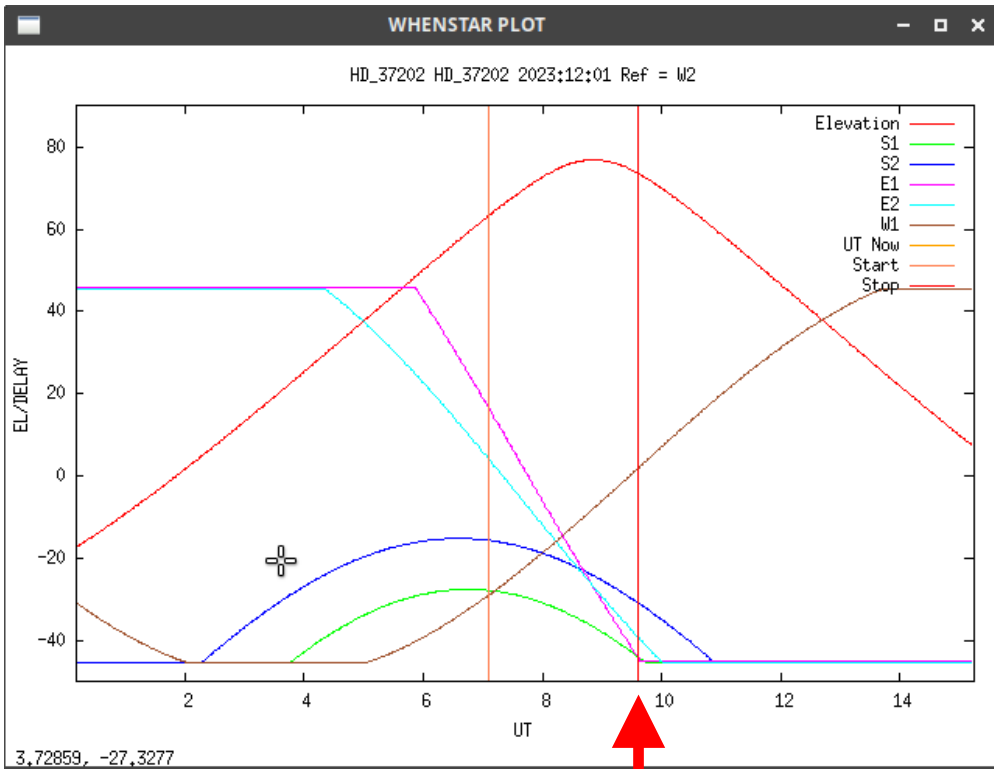
E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)





chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)

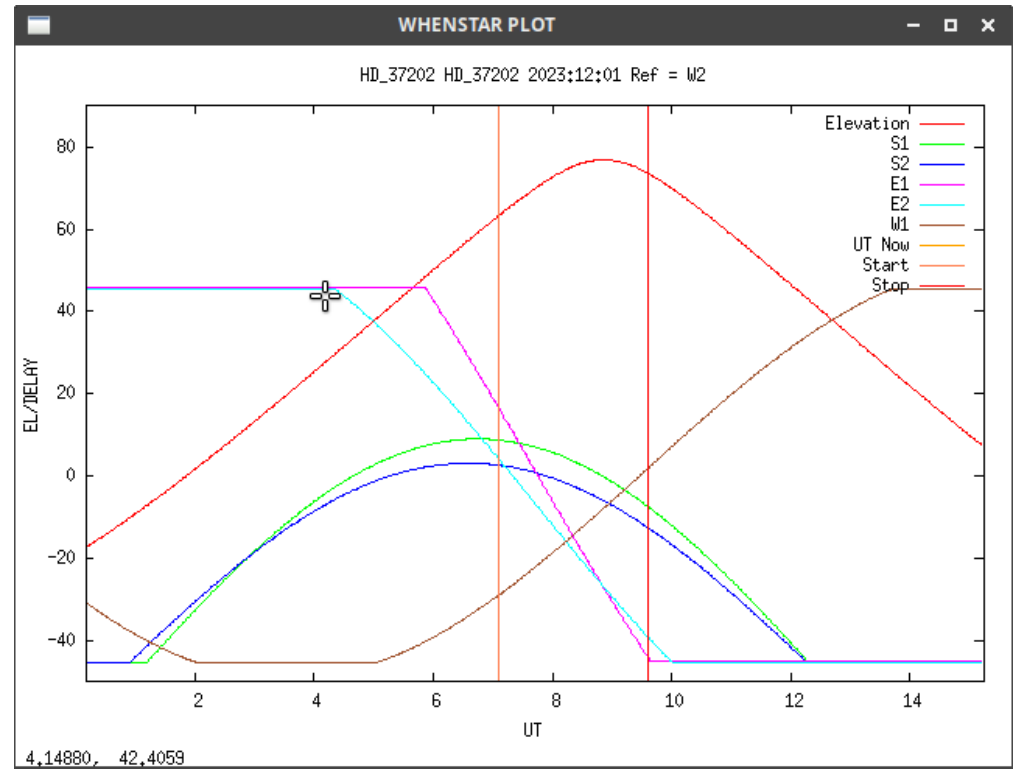
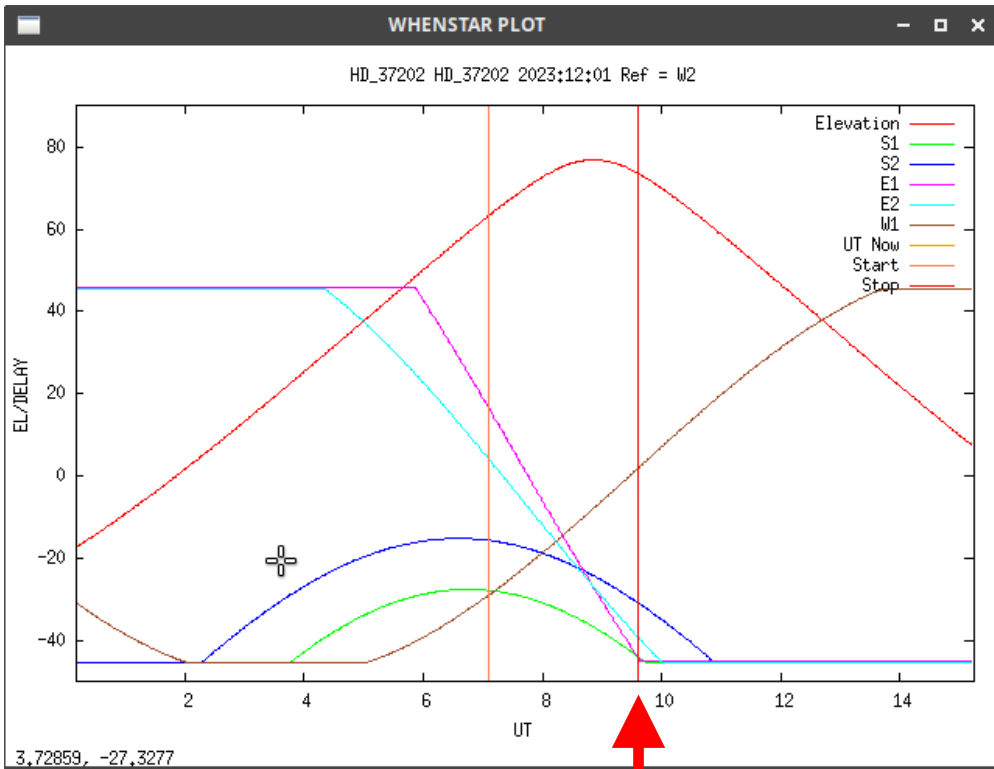




chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)

E1(1)-W2(5)-W1(2)-S2(3)-S1(2)-E2(3)

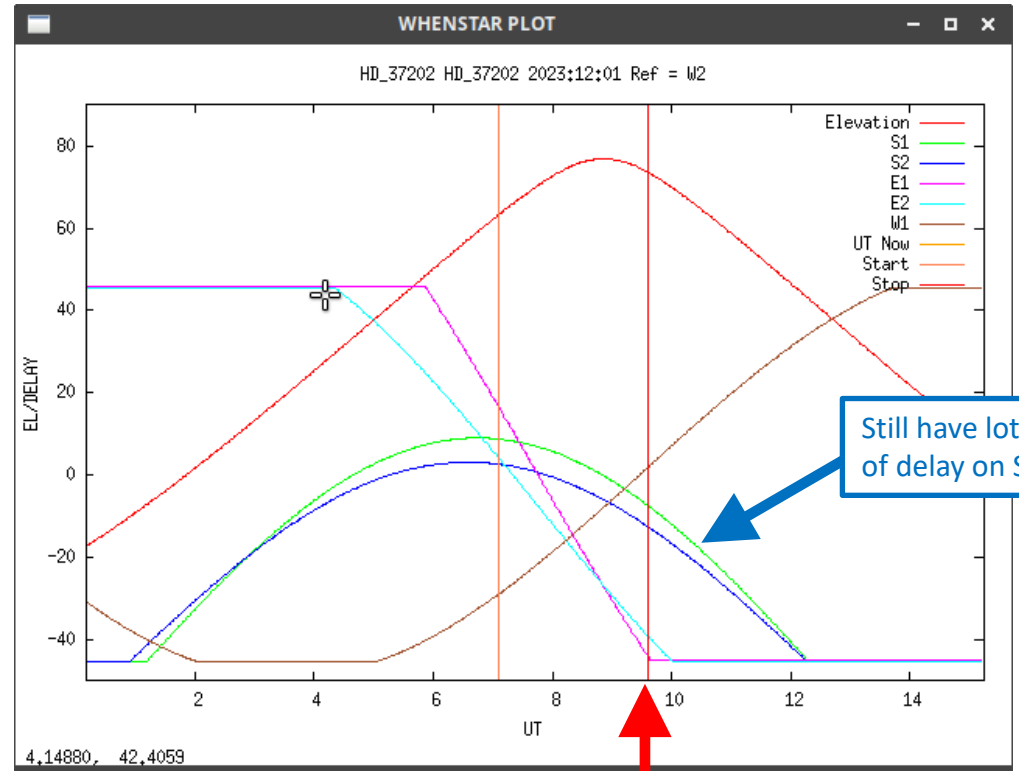
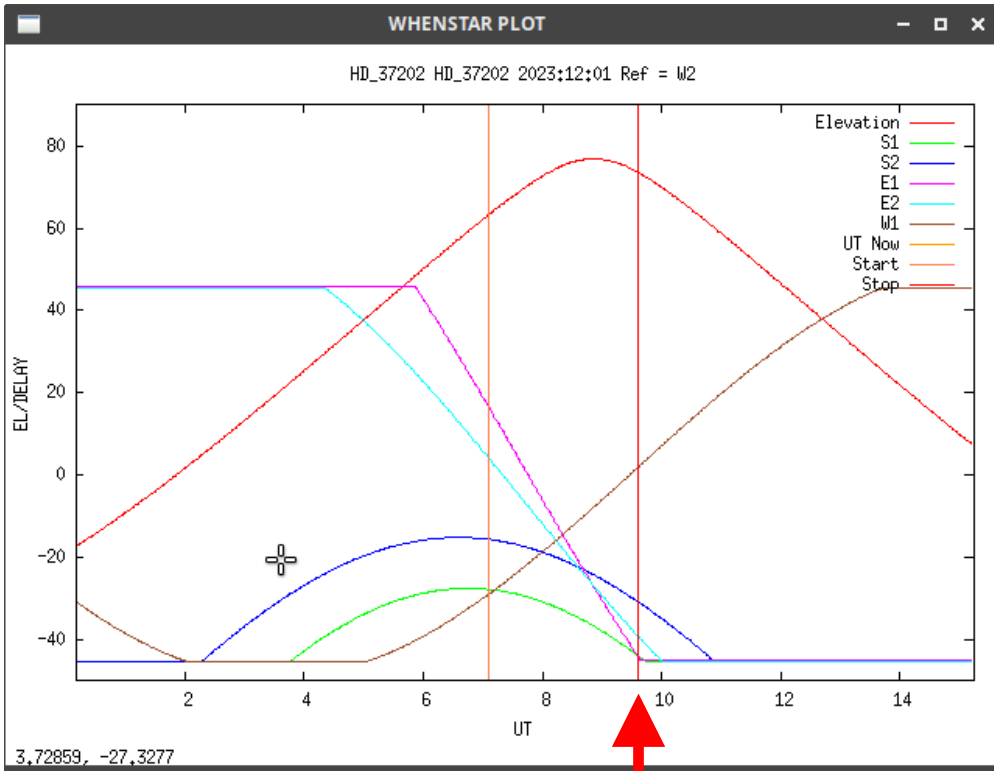




chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-W1(2)-S2(4)-S1(4)-E2(3)

E1(1)-W2(5)-W1(2)-S2(3)-S1(2)-E2(3)

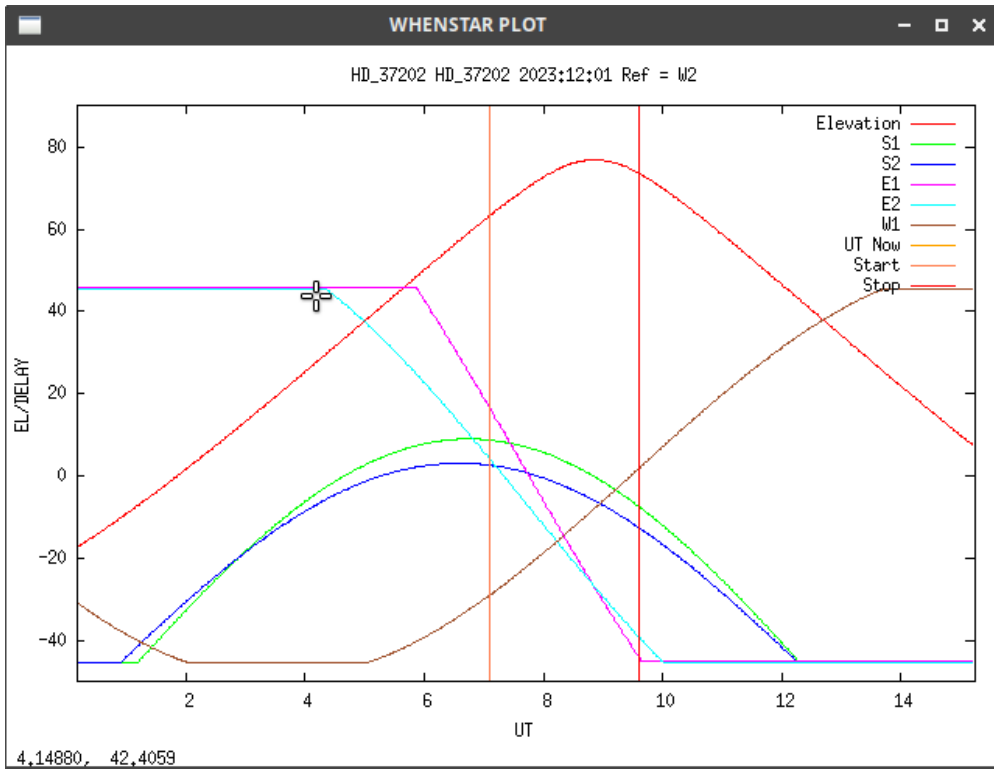


Still have lots of delay on S1+S2



chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-W1(2)-S2(3)-S1(2)-E2(3)

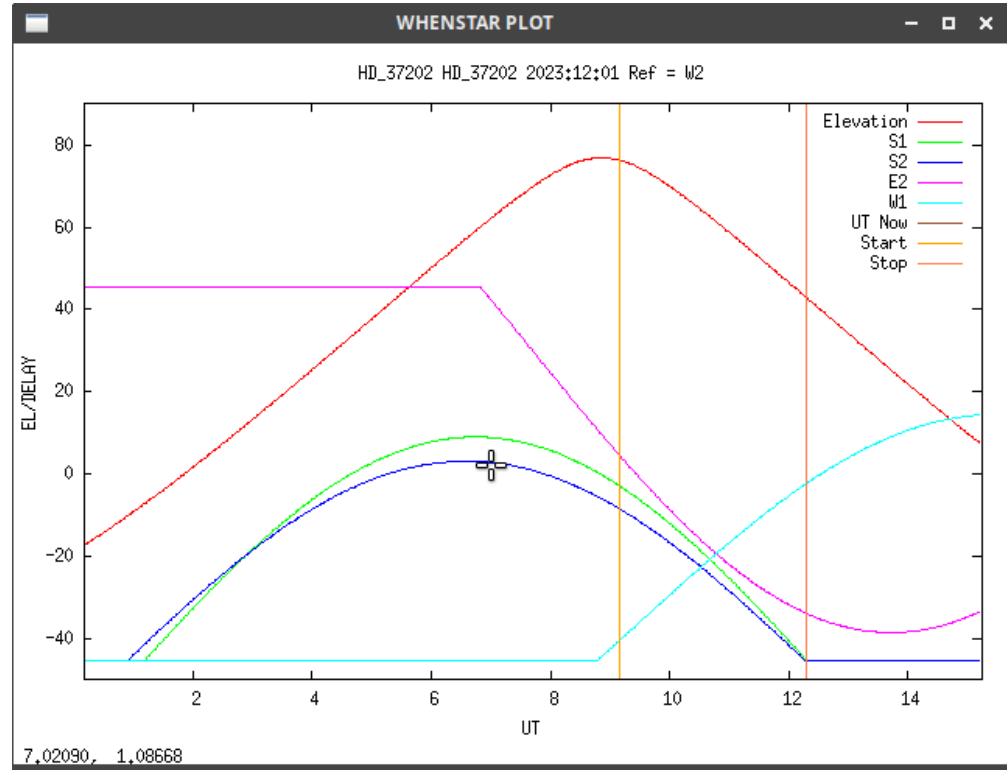
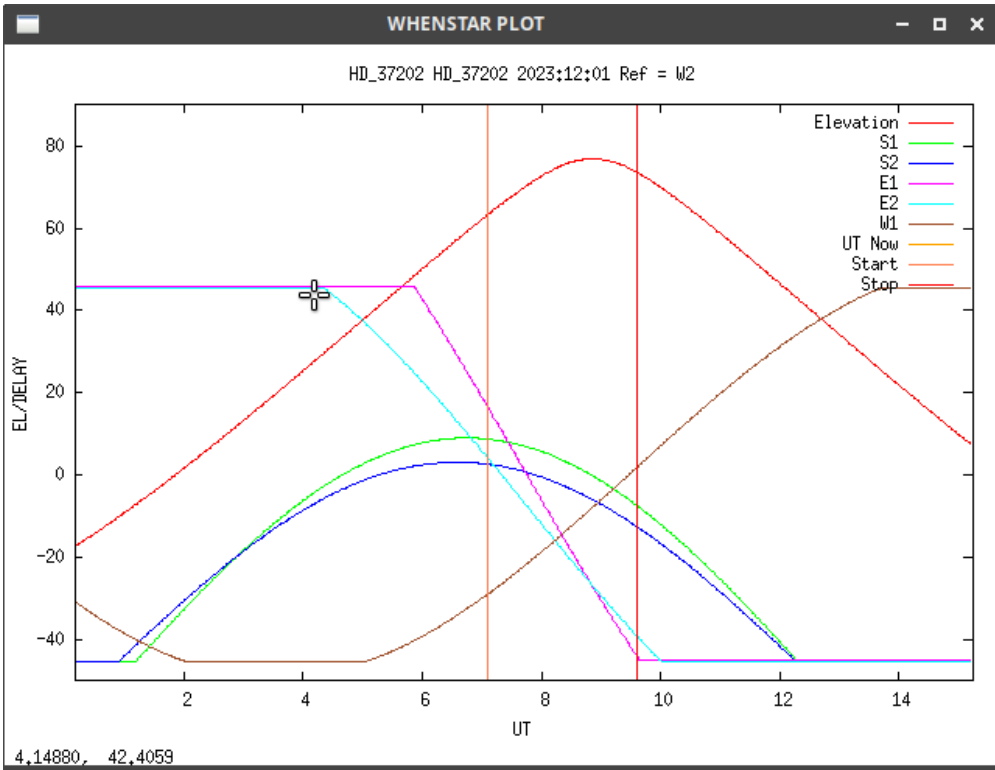




chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-**W1(2)**-S2(3)-S1(2)-**E2(3)**

W2(5)-**W1(4)**-S2(3)-S1(2)-**E2(1)**

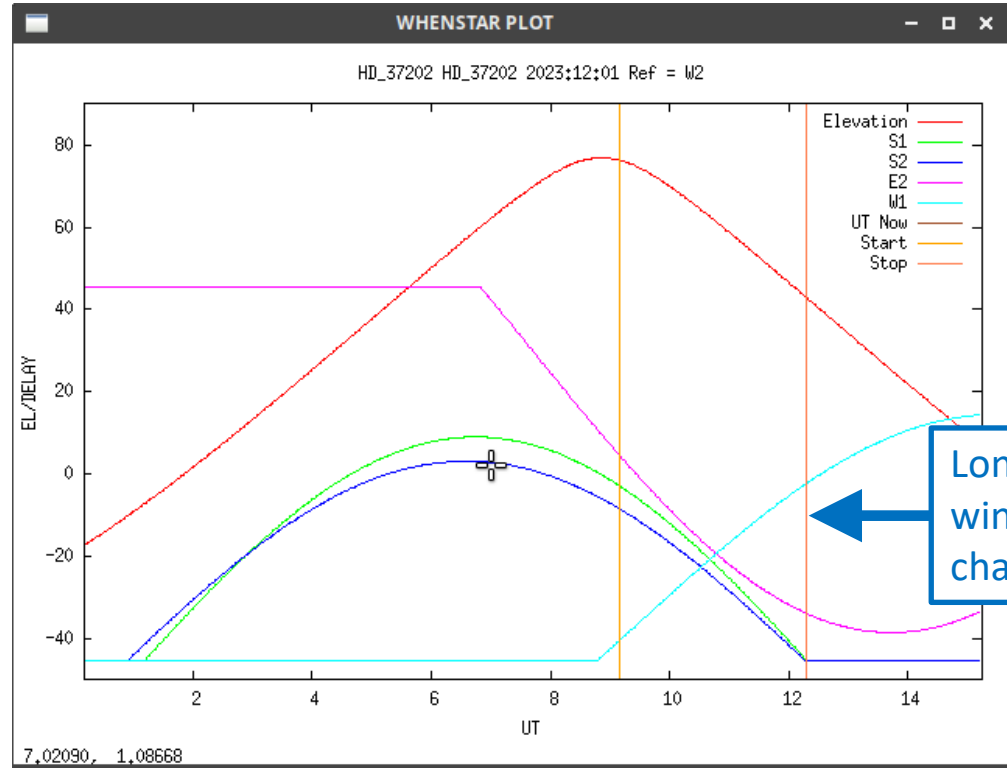
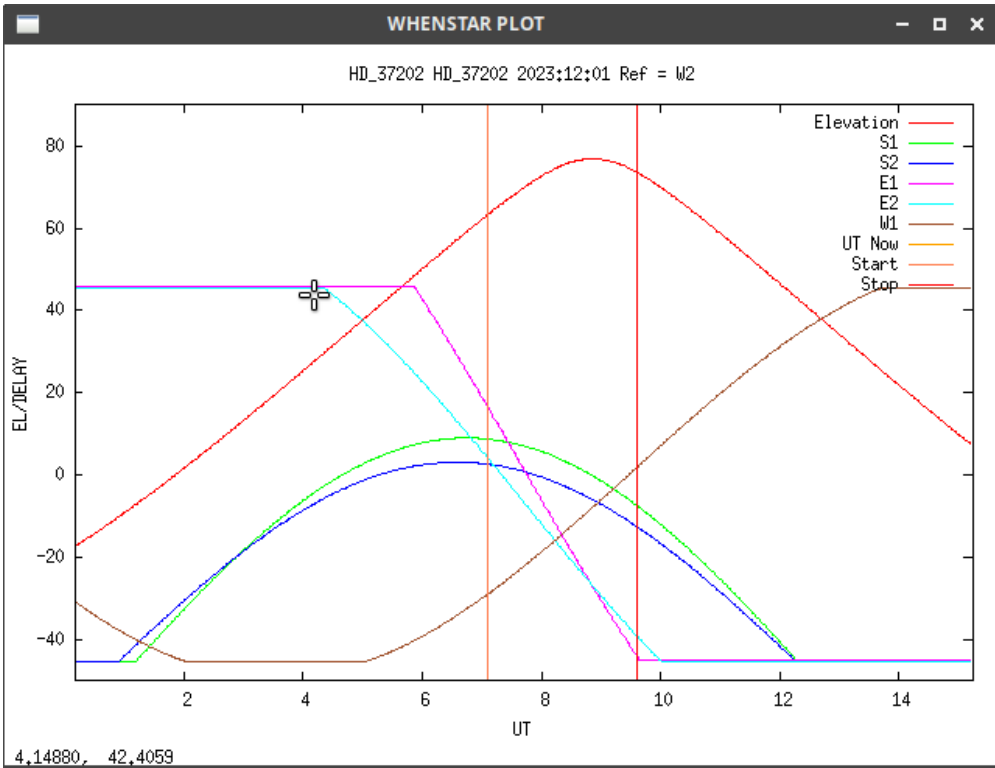




chara_plan2: "WhenStar" Plot

E1(1)-W2(5)-**W1(2)**-S2(3)-S1(2)-**E2(3)**

W2(5)-**W1(4)**-S2(3)-S1(2)-**E2(1)**



Long 5T delay window by only changing 2 POPs



Optimizing POPs

- Use ASPRO2 as a first pass to select POPs
 - Maximize delay and optimize timing during night
- Use chara_plan2 to fine-tune delay settings
 - Figure out which configuration is best
 - Minimize the number of POP changes during night – more time for observing
- Use ASPRO2 while observing
 - Easy to add many science targets + calibrators
 - Good for planning full night of observations