



Planning Observations and Software Tools



Gail Schaefer

The CHARA Array of
Georgia State University

Mount Wilson, CA

With contributions from:
Fabien Baron, Laurent Bourgès,
Christopher Farrington, and Jeremy Jones



Community Access Time

- Visitor Support Scientist to help with planning observations
- Observations carried out by CHARA staff
- Visitors are encouraged to travel to the Array to participate in the observations
 - Real-time input from PI on decisions that could impact the science objectives and priorities



Data Reduction

- CHARA staff supports data reduction to OIFITS format
 - Data reduction software available for those interested in reducing and calibrating data
- OIFITS Format:
 - Data exchange standard for Optical Interferometry
 - Description of format (target info, UV coord, VIS2, T3)
 - Resources available for reading OIFITS files (C, IDL, OIFITS Explorer)



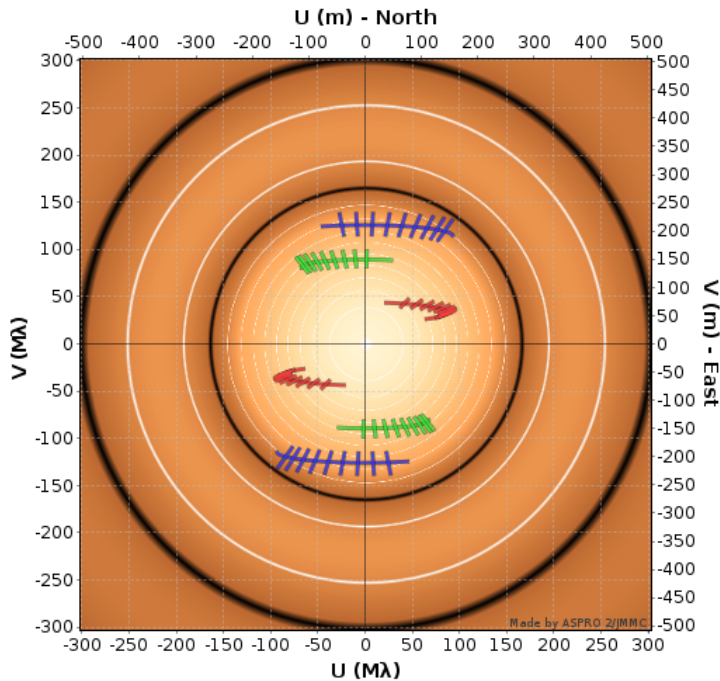
Data Access and Searchable Archive

- Under Development
- Located at GSU Data Center
- 3 Virtual Machines on CHARA server:
 - Database/Archive Machine
 - Data Reduction Machine
 - Remote Observing Machine
 - Active Mode
 - Passive Mode

Data Scientist
Jeremy Jones



Data Analysis



- Interferometers measure the Fourier Transform of the brightness distribution
- Sparse sampling
- Geometric model fitting
- Physical models
- Image reconstruction

<http://www.chara.gsu.edu/observers/data-analysis-software>



Guide for Planning Observations

<http://www.chara.gsu.edu/observers>

- **Applying for Time**
- **Planning Observations**



Beam Combiners

Combiner	Num Tel.	Band	Typical Mag	Best Mag	Spec. Res.	Science
CLASSIC	2T	H or K	7.0	8.5	Broad	Diameters
CLIMB	3T	H or K	6.0	7.0	Broad	Binaries, disks
JouFlu	2T	K	4.5	5.0	Broad	Diam, precision
MIRC	6T	H	5.0	6.0	40	Stellar imaging, binaries, disks
PAVO	2T	630-900 nm	7.0	8.0	30	Diameters
VEGA – HiRes	2-4T	2 bands (7nm) in 480-850 nm	4.0	5.0	30000	Spectral studies
VEGA – MedR	2-4T	2 bands (35 nm) in 480-850 nm	6.5	7.5	6000	Spectral studies, diam.

Limit for acquisition and tip/tilt tracking: $V = 10-12$ mag



Selecting Telescopes and Beam Combiner

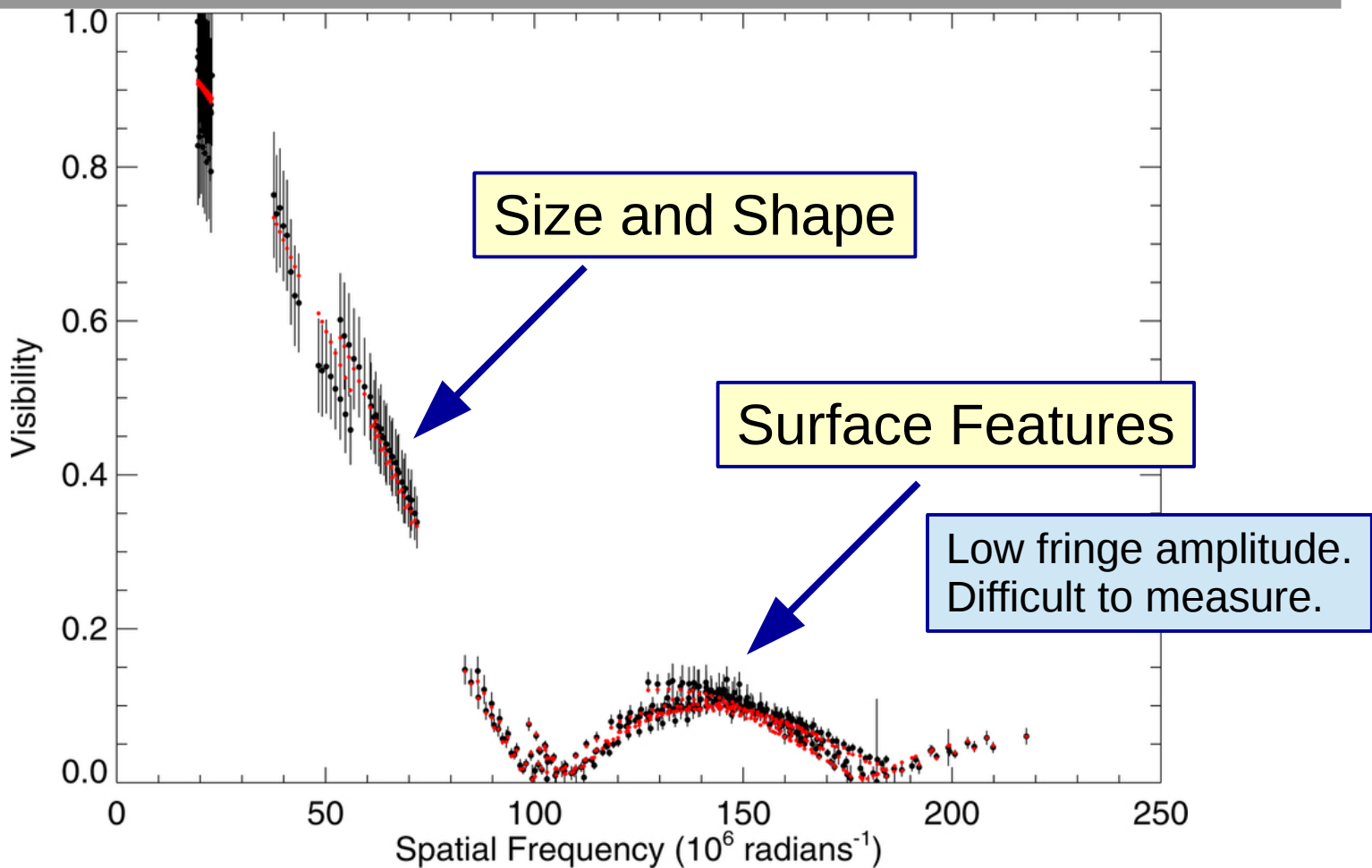
- Angular Resolution on Longest Baseline: $0.5 \lambda / B$
 - 0.66 mas in K-band ($2.13 \mu\text{m}$)
 - 0.52 mas in H-band ($1.67 \mu\text{m}$)
 - 0.20 mas in visible at 650 nm



Selecting Telescopes and Beam Combiner

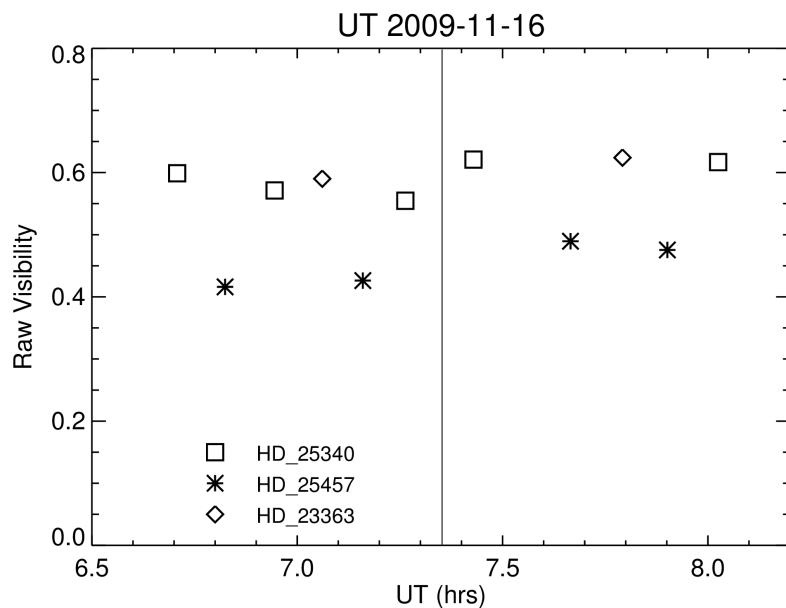
- Angular Resolution on Longest Baseline: $0.5 \lambda / B$
 - 0.66 mas in K-band ($2.13 \mu\text{m}$)
 - 0.52 mas in H-band ($1.67 \mu\text{m}$)
 - 0.20 mas in visible at 650 nm
- Resolving stellar diameters
 - One or two baselines long enough to resolve star
- Binaries
 - Ideally three or more telescopes (2D separation)
- Imaging stellar surface features
 - Multiple baselines (all 6 telescopes)
 - Sample beyond the first null (at $1.22 \lambda / B$)

Selecting Beam Combiner and Baselines





Calibrator Stars



- Instrumental and atmospheric effects will cause a loss in coherence, causing a drop in the measured visibility.
- Observe unresolved calibrator stars to define the true visibility of the target.
 - Within 5-10 degrees on sky
 - Within 1-2 mag in brightness



How much time is needed?

- Calibration Strategy:
 - Cal1 – Obj – Cal2 – Cal1 – Obj – Cal2 ...
- Time to collect Cal-Sci-Cal set:
 - Seeing and brightness dependent
 - CLASSIC, CLIMB, PAVO, JouFlu: 15 – 45 minutes
 - VEGA: 30 – 60 minutes
 - MIRC: 90 minutes for Cal-Sci set
- Collect many repeated calibration sets
 - Improve detection, test systematics
 - Increase u,v coverage on the sky



Interactive Component

Using planning software tools:

www.chara.gsu.edu/workshops/instructions



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Workshop Tutorial - Planning CHARA Observations

1. Pick a target - estimate the angular diameter (or binary separation, disk size, etc).

JMMC Stellar Diameters Catalogue available through VizierR.



Select Target


- Select favorite target
- Or use example target:


HD 30652: F6V, $V=3.2$, $H=1.8$, $K=1.6$

(resolved by Boyajian et al. 2012)

Estimate Target Size

- JMMC Catalog of Stellar Diameters
 - <http://vizier.u-strasbg.fr/viz-bin/VizieR>
 - II/346/jsdc_v2
 - Bourges et al. (2017)

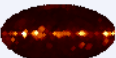

[Portal](#)
[Simbad](#)
[VizieR](#)
[Aladin](#)
[X-Match](#)
[Other](#)
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[Send to VO tools](#)

VizieR


[Show the target form](#)
[Show constraint information](#)

The 3 columns in **color** are computed by VizieR, and are **not part of the original data**.

[II/346/jsdc_v2](#)
[JMMC Stellar Diameters Catalogue - JSDC. Version 2 \(Bourges+, 2017\)](#)
[2014ASPC..485..223B](#)
[ReadMe+ftp](#)


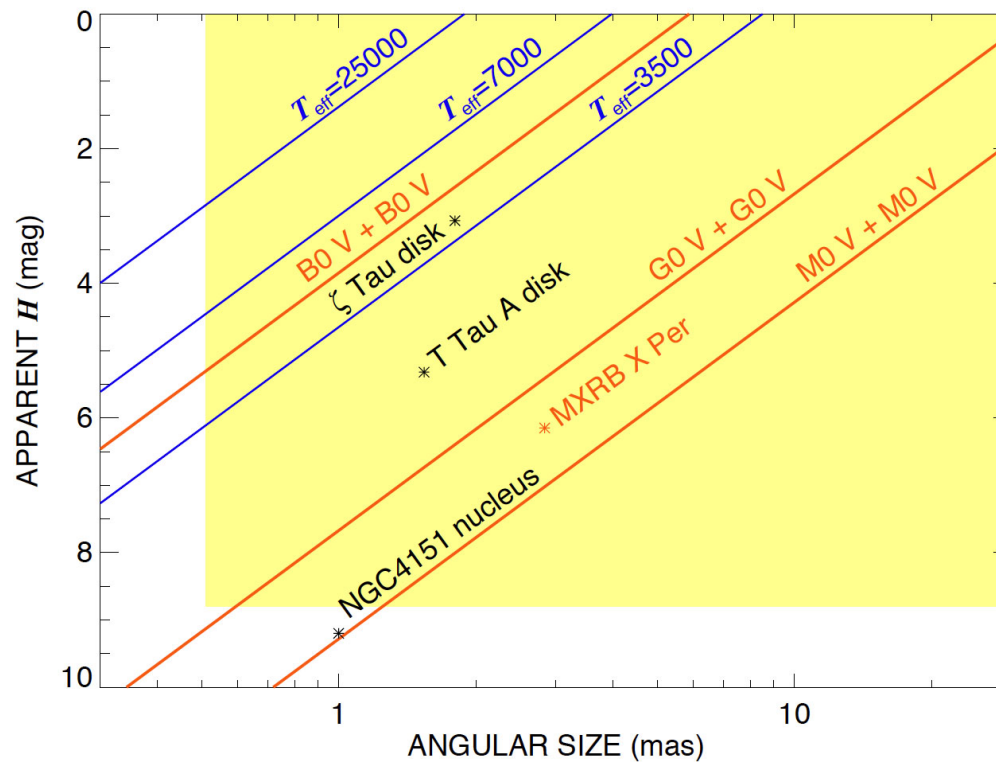
 [start AladinLite](#)
 [plot the output](#)
 [query using TAP/SQL](#)

Full	<u>r</u>	<u>RAJ2000</u>	<u>DEJ2000</u>	Name	SpType	Vmag	Rmag	Hmag	Kmag	LDD	e	UDDV	UDDR	UDDH	UDDK
	arcmin	"h:m:s"	"d:m:s"			mag	mag	mag	mag	mas	mas	mas	mas	mas	mas
1	0.0000	04 49 50.4109100	+06 57 40.588300	* pi.03 Ori	F6V	3.190	2.668014	1.757	1.600	1.986537	0.165749	1.876938	1.896239	1.944618	1.951365

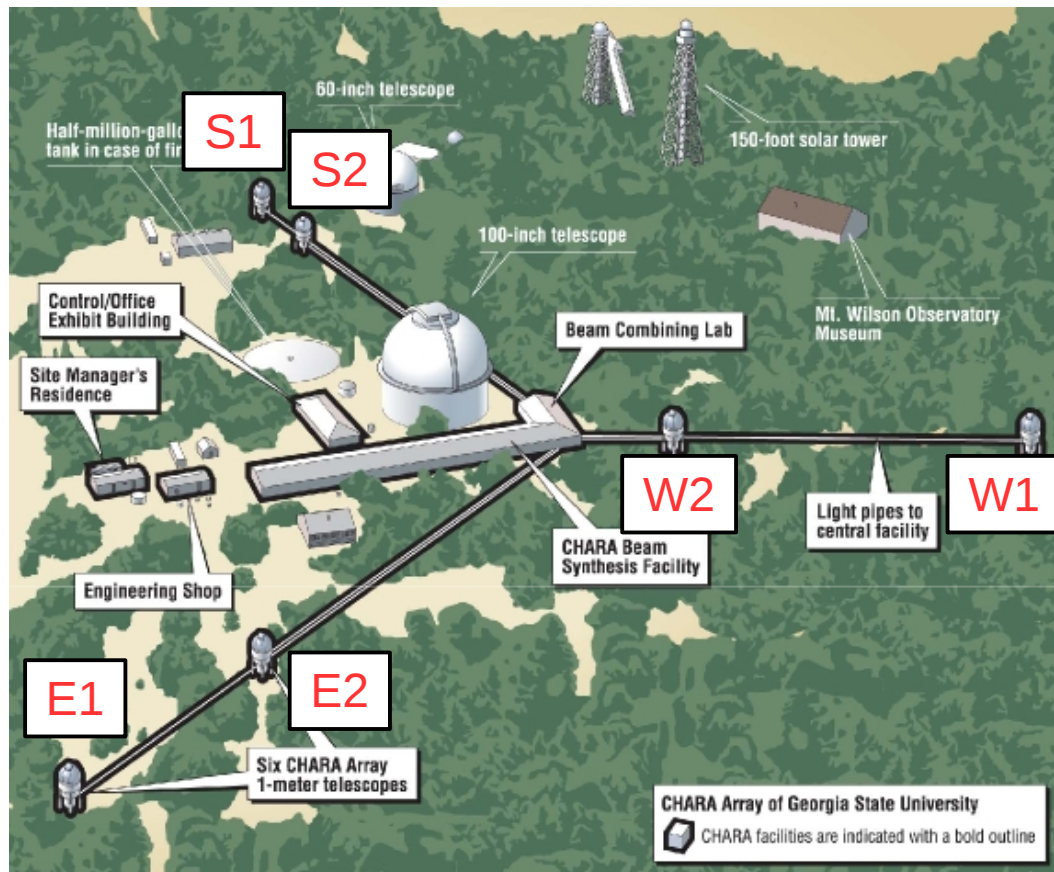
[plot the output](#)
 [query using TAP/SQL](#)

Estimate Target Size

- Color and temperature relations
- Look up tables



Telescopes and Baselines



Resolutions listed for H-band ($1.6 \mu\text{m}$)

Baseline	Length (m)	Res (mas)
E1-S1	331	0.52
W1-E1	314	0.55
E1-S2	302	0.57
E2-S1	279	0.62
W1-S1	279	0.62
W1-E2	251	0.69
W1-S2	249	0.69
E2-S2	248	0.69
W2-E1	222	0.78
W2-S1	211	0.82
W2-S2	177	0.97
W2-E2	156	1.10
W2-W1	108	1.61
E2-E1	66	2.65
S2-S1	34	5.08



Selecting Calibrators: SearchCal

← ⓘ | www.jmmc.fr/searchcal_page.htm

www.jmmc.fr/searchcal_page.htm



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User Support

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SearchCal: the JMMC Evolutive Search Calibrator Tool

[subscribe to SearchCal feed](#)

SearchCal is a tool developed by the JMMC Working Group "catalogue of calibration sources" to assist the astronomers in this calibrator selection process for long baseline interferometric observations.

The science behind **SearchCal** is described in the 2016 paper "[Pseudomagnitudes and differential surface brightness: Application to the apparent diameter of stars.](#)" by Chelli A., Duvert G., Bourguès L. et al., 2016, A&A, 589, 112.

The SearchCal user interface (check download link below) give access to the complete [JSDC catalog](#) for stars having a spectral type estimate and to a less precise estimate for the other 2 million stars of the Tycho list for which the spectral type has not been measured (yet).

Additional help in using SearchCal results can be found on the [SearchCal Wiki Page](#).

Last Minute: expect some problems with the few stars identified by SIMBAD as planet-hosting stars (confusion). This will be corrected ASAP.

Acknowledgement

If this software was helpful in your research, please use this [acknowledgement and reference paper](#).

A previous version of SearchCal was based on the following works:

- Bright calibrator request scenario :
[Bonneau D., Clausse J.-M., Delfosse X., et al., 2006, A&A 456, 789](#)
- Faint calibrator request scenario :
[Bonneau, D., Delfosse, X., Mourard, D., et al., 2011, A&A 535, A53](#)

Click on
"Download
Application"

Download Application

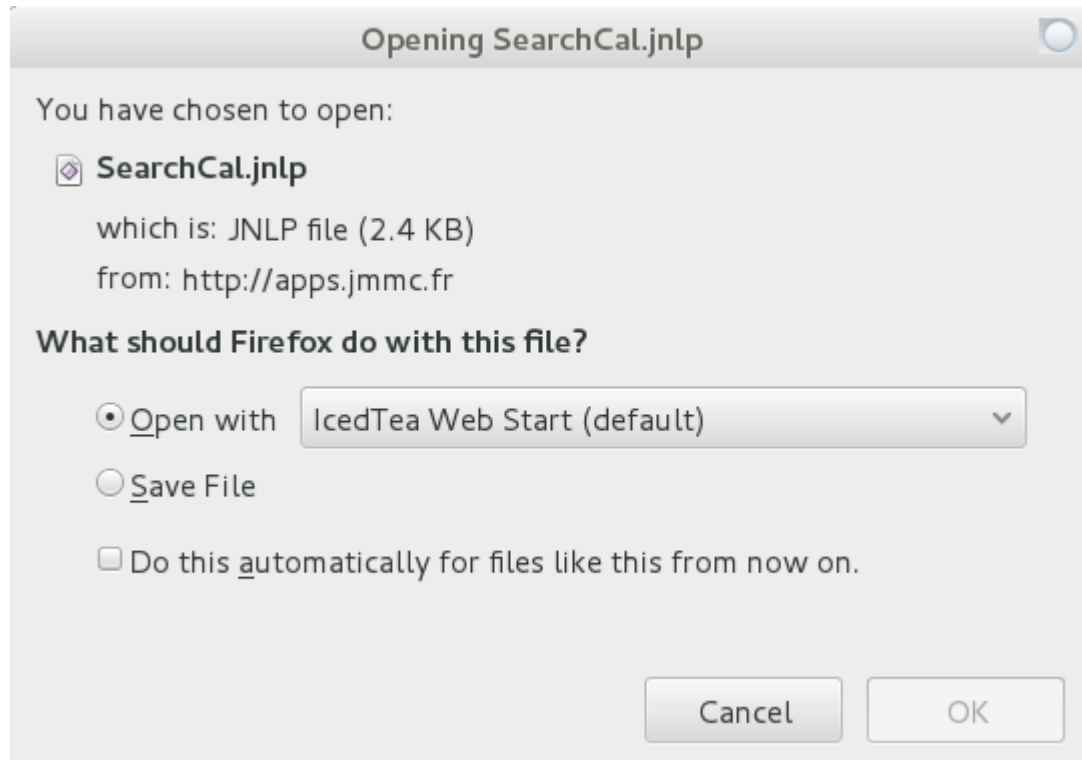


Installation Help



SearchCal

JMMC



Click Proceed... Allow... Create Desktop Shortcut... Wait



SearchCal



SearchCal [c1]

File Edit Query Calibrators Interop Help

Query Parameters

1) Instrumental Configuration

Magnitude Band : H

Wavelength (H) [μm] : 1.65

Max. Baseline [m] : 200.0

2) Science Object

Name : Q▼ HD 30652

RA 2000 [hh:mm:ss] : 04 49 50.41091

DEC 2000 [+/-dd:mm:ss] : +06 57 40.5883

Magnitude (H) : 2.15

3) SearchCal Parameters

Min. Magnitude (H) : 0.0

Max. Magnitude (H) : 5.0

Scenario : ☒ Bright ☐ Faint

RA Range [mn] : 240.0

DEC Range [deg] : 20.0

Get Calibrators

Progress :

Found Calibrators (3094 sources, 2036 filtered)

Index	dist	HD	RAJ2000	DEJ2000	vis2	LDD	UD_V	UD_H	UD_K	SIMBAD	SpType	V	H	K
1	6.01E-7	30652	04 49 50.4110	+06 57 40.5900	0.003	1.986	1.877	1.944	1.951	* pi.03 Ori	F6V	3.19	1.757	1.6
2	1.576	04 46 36.2734	+08 19 04.3212	0.639	0.731	0.678	0.711	0.714	0.714	HD 30285	K2	8.01	4.588	4.326
3	1.948	30739	04 50 36.7214	+08 54 00.6192	0.8	0.514	0.492	0.507	0.508	* pi.02 Ori	A1Vn	4.35	4.208	4.166
4	2.786	04 53 39.7939	+09 34 53.9832	0.701	0.656	0.605	0.637	0.64	0.64	HD 287245	K5	8.861	4.957	4.688
5	2.813	29499	04 39 06.1574	+07 52 15.5244	0.889	0.376	0.357	0.37	0.371	HD 29499	A5m	5.38	4.928	4.808
6	2.976	30990	04 52 29.8397	+09 51 50.7312	0.715	0.636	0.593	0.619	0.622	HD 30990	K0	7.68	4.699	4.545
7	3.18	05 02 31.4748	+07 25 26.5008	0.769	0.563	0.527	0.549	0.551	0.551	HD 32304	G5	6.86	4.739	4.586
8	3.426	31295	04 54 53.7278	+10 09 02.9988	0.881	0.389	0.373	0.384	0.385	* pi.01 Ori	A0Va JB	4.64	4.517	4.416
9	3.445	04 48 43.3073	+10 23 42.6012	0.653	0.713	0.671	0.694	0.698	0.698	HD 287163	K7	8.73	4.852	4.573
10	3.59	05 04 03.4222	+07 38 27.7908	0.619	0.757	0.702	0.735	0.739	0.739	HD 32513	K2	8.911	4.653	4.368

Filters

☐ Reject stars farther than : Maximum RA Separation (mn) : 10.0 Maximum DEC Separation (degree) : 10.0

☐ Reject stars with magnitude : below : 0.0 and above : 10.0

☐ Reject Spectral Types (and unknowns) : ☒ O ☒ B ☒ A ☒ F ☒ G ☐ K ☐ M

☐ Reject Luminosity Classes (and unknowns) : ☐ I ☐ II ☐ III ☒ IV ☒ V ☒ VI

☒ Reject Visibility below : vis2 : 0.5

☐ Reject Visibility Accuracy above (or unknown) : vis2Err/vis2 (%) : 2.0

☐ Reject Variability

☒ Reject Multiplicity

☒ Reject Invalid Object Types

☒ Diameter quality : Maximum chi square : 2.0 Maximum relative error (%) : 10.0

searching calibrators... done.
51 M
Provided by **JMMC**



Planning Software: ASPRO 2

http://www.jmmc.fr/aspro_page.htm

← | www.jmmc.fr/aspro_page.htm

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ASPRO:
The Astronomical Software to PRepare Observations


subscribe to ASPRO 2 feed

ASPRO 2 - the new version of **ASPRO** - is a complete observation preparation tool developed and maintained by the JMMC that allows to prepare interferometric observations with the VLTI or other interferometers. It is a Java standalone program providing a dynamic graphical interface to simulate the projected baseline evolution during the observations (supersynthesis), derive the visibilities for your targets (single star, binaries, user defined FITS image,...), and offers many additional useful functions: load and save your observation settings, generate Observing Blocks ...

A description of the JMMC Working Group on the development of ASPRO can be found on [this page](#).

 **Download Application**

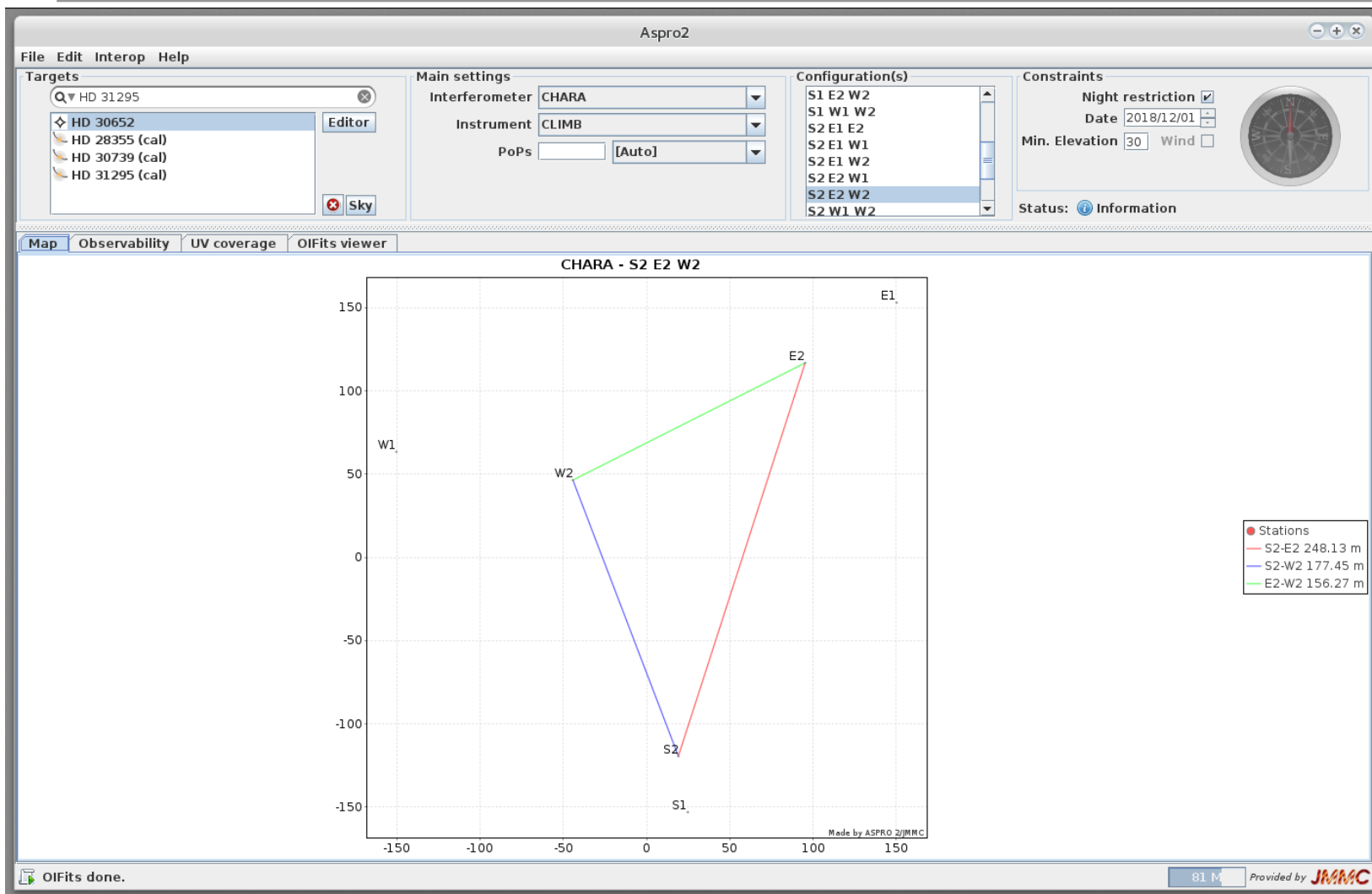


 **Installation Help**

Click on
“Download
Application”



ASPRO 2





ASPRO 2



Target Editor

Targets Models

Q Simbad

Targets

- HD 30652

Target

Name HD 30652 Simbad SED

RA [HMS] 04:49:50.41091 DEC [DMS] +06:57:40.5883

PMRA 464.06 PMDEC 11.21

Magnitudes:

B	3.63	V	3.19
R	2.77	I	2.51
J	2.36	H	2.15
K	2.05	L	
M		N	

Parallax 123.94 Radial Velocity 22.411 Error 0.17

Spectral type F6V

Object types **,*,PM*,V*,IR,UV,X

Identifiers

WEB 4331, NAME Tabit, ** STT 560A, 2MASS J04495040+0657409, PLX 1077, LSPM J0449+0657, TYC 96-1462-1, ASCC 1010229, USNO-B1.0 0969-00046662, * 1 Ori, * pi.03 Ori, 2RE J044951+065736, 2RE J0449+065, BD+06 762, CCDM J04499+0657A, CSI+06 762 1, CSV 100411, Ci 20 306, FK5 1134, GC 5875, GCRV 2837, GEN# +1.00030652, GJ 178, HD 30652, HIC 22449, HIP 22449, HR 1543, IDS 04444+0647 A, IRAS

Target notes [i]

Calibrators

- HD 30739 (cal)

Cancel OK

Flag
Calibrator



ASPRO 2



Drag and
drop to
associate
cal with
target

Target Editor

Targets Models

Q Simbad

Targets

- HD 30652
- HD 30739 (cal)

Calibrators

- HD 30739 (cal)

Target

Name HD 30739 Simbad SED

RA [HMS] 04:50:36.72298 DEC [DMS] +08:54:00.6493

PMRA 1.41 PMDEC -29.91

Magnitudes:

B	4.36	V	4.35
R	4.29	I	4.29
J	4.26	H	4.208
K	4.166	L	
M		N	

Radial Velocity 24.4

Parallax 14.53 Error 0.38

Spectral type A1Vn

Object types *,IR,UV

Identifiers

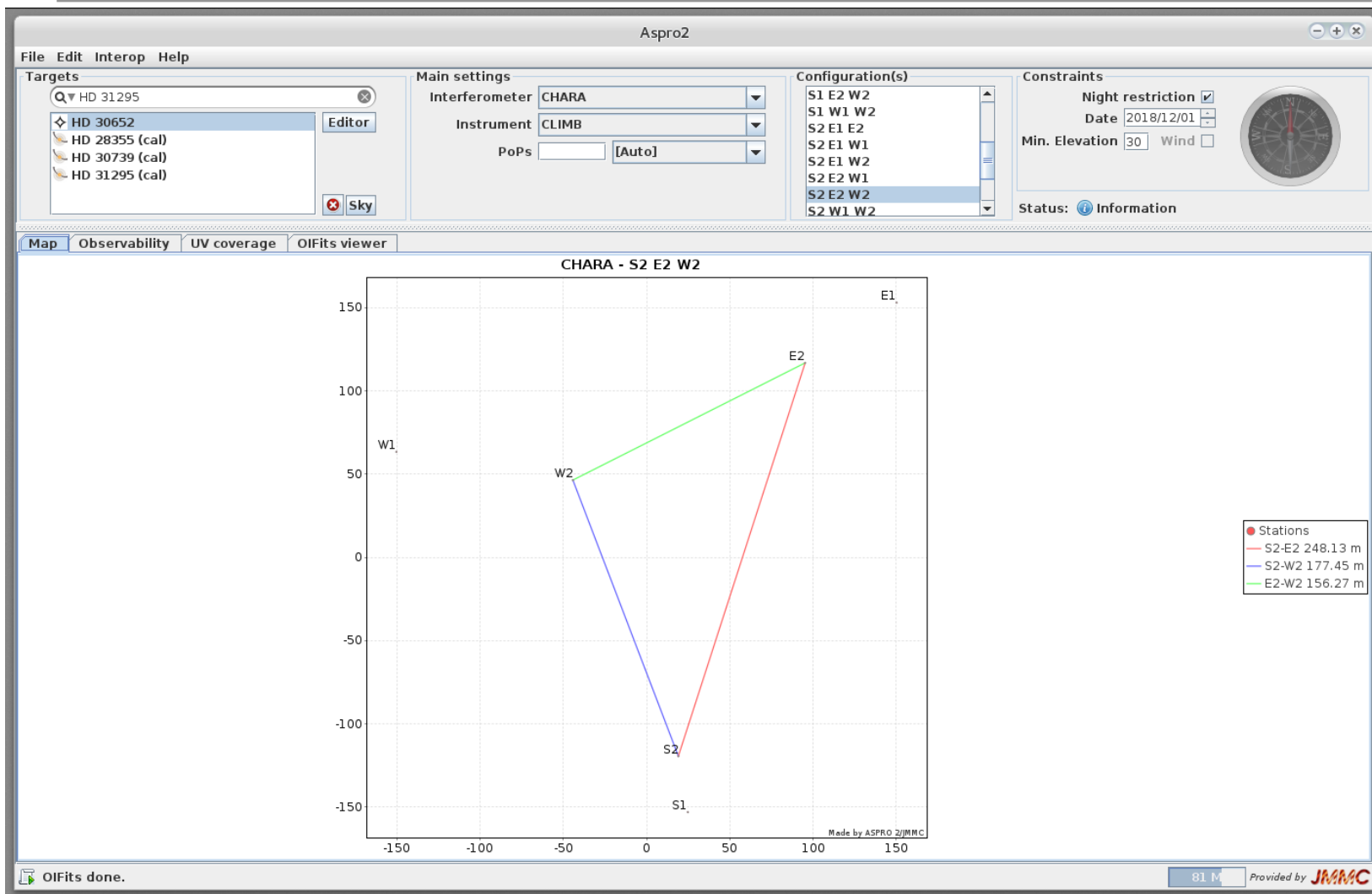
WEB 4343,WISE J045036.73+085400.5,2MASS J04503674+0854004,PLX 1082,* 2 Ori,* pi.02 Ori,AG+08 506,BD+08 777,CEL 472,GC 5892,GCRV 2846,GEN# +1.00030739,GSC 00683-01217,HD 30739,HGAM 346,HIC 22509,HIP 22509,HR 1544,IRAS 04478+0848,JP11 935,PPM 148045,ROT 684,SAO 112124,SKY# 7533,TD1 3609,TYC 683-1217-1,UBV 4648,UBV M 10369,YZ 8 1821,[SC93b] 6,uvby98 100030739,PLX 1082.00

Target notes [1]

Cancel OK

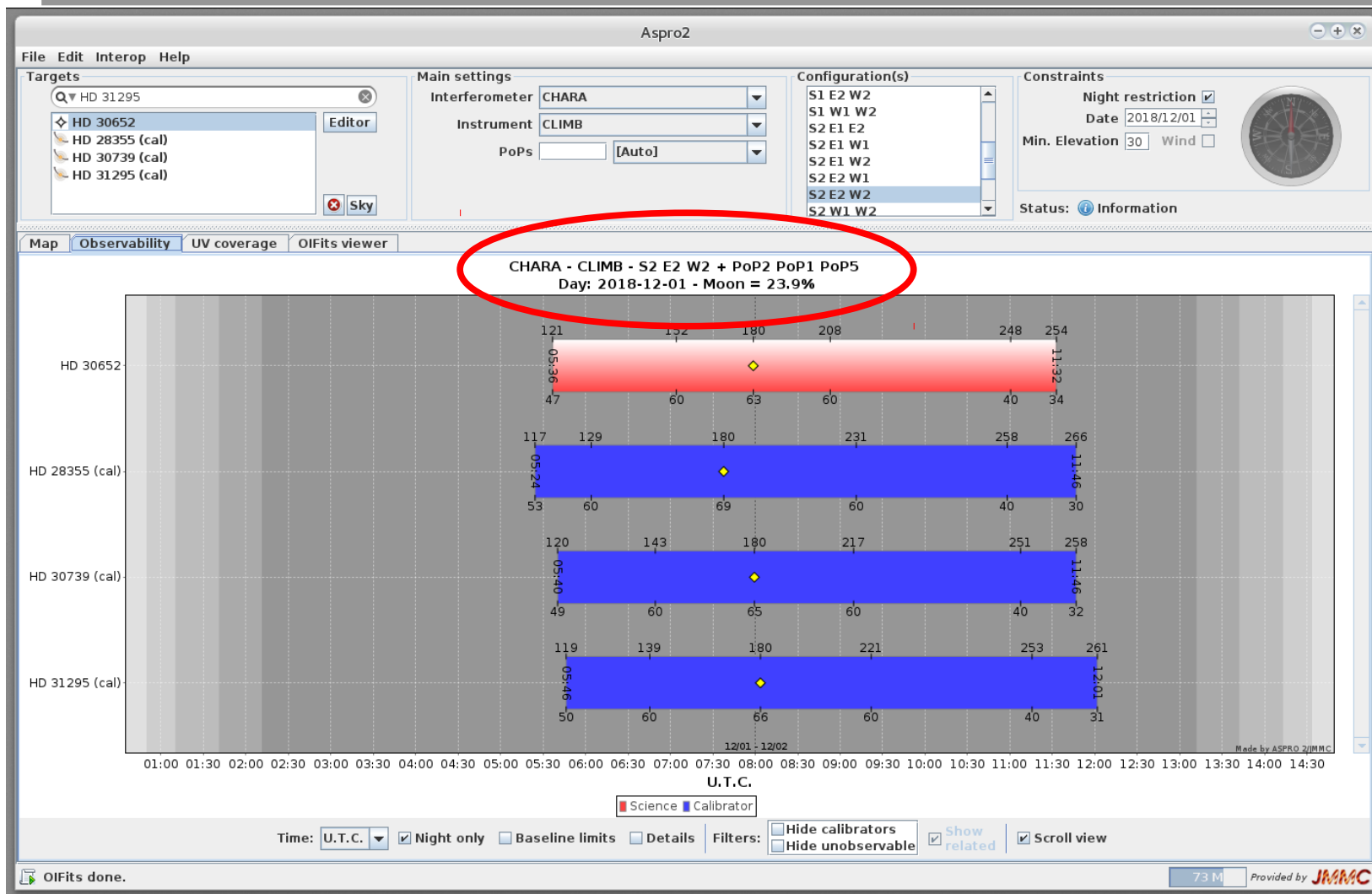


ASPRO 2



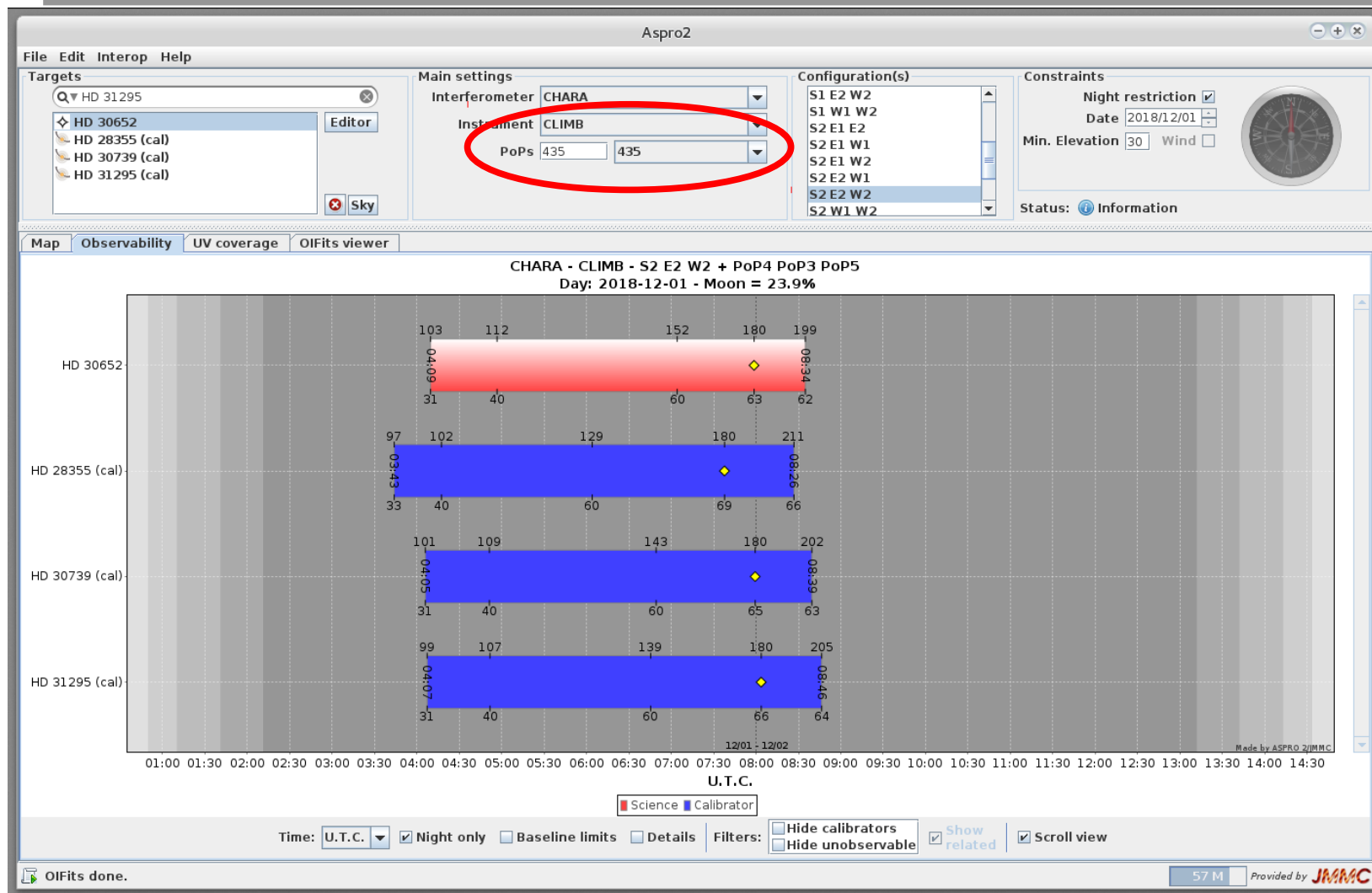


ASPRO 2





ASPRO 2





ASPRO 2



Target Editor

TargetsModels

Models

HD 30652

disk1

HD 28355 (cal)

HD 30739 (cal)

HD 31295 (cal)

Model

Mode

☒ Analytical☐ User Model

Name

disk1

Add

Remove

model type

disk

Update

Model description

Returns the Fourier transform of a normalized uniform disk of diameter DIAMETER (milliarcsecond) and centered at coordinates (X,Y) (milliarcsecond).

FLUX_WEIGHT is the intensity coefficient. FLUX_WEIGHT=1 means total energy is 1.

The function returns an error if DIAMETER is negative.

Model Parameters

Model	Name	Units	Value
disk1	flux weight1		1
	x1	mas	0
	y1	mas	0
	diameter1	mas	1.53

edit positions: ☐ x / y (mas)☒ sep. (mas) / pos. angle [-180°; 180°]

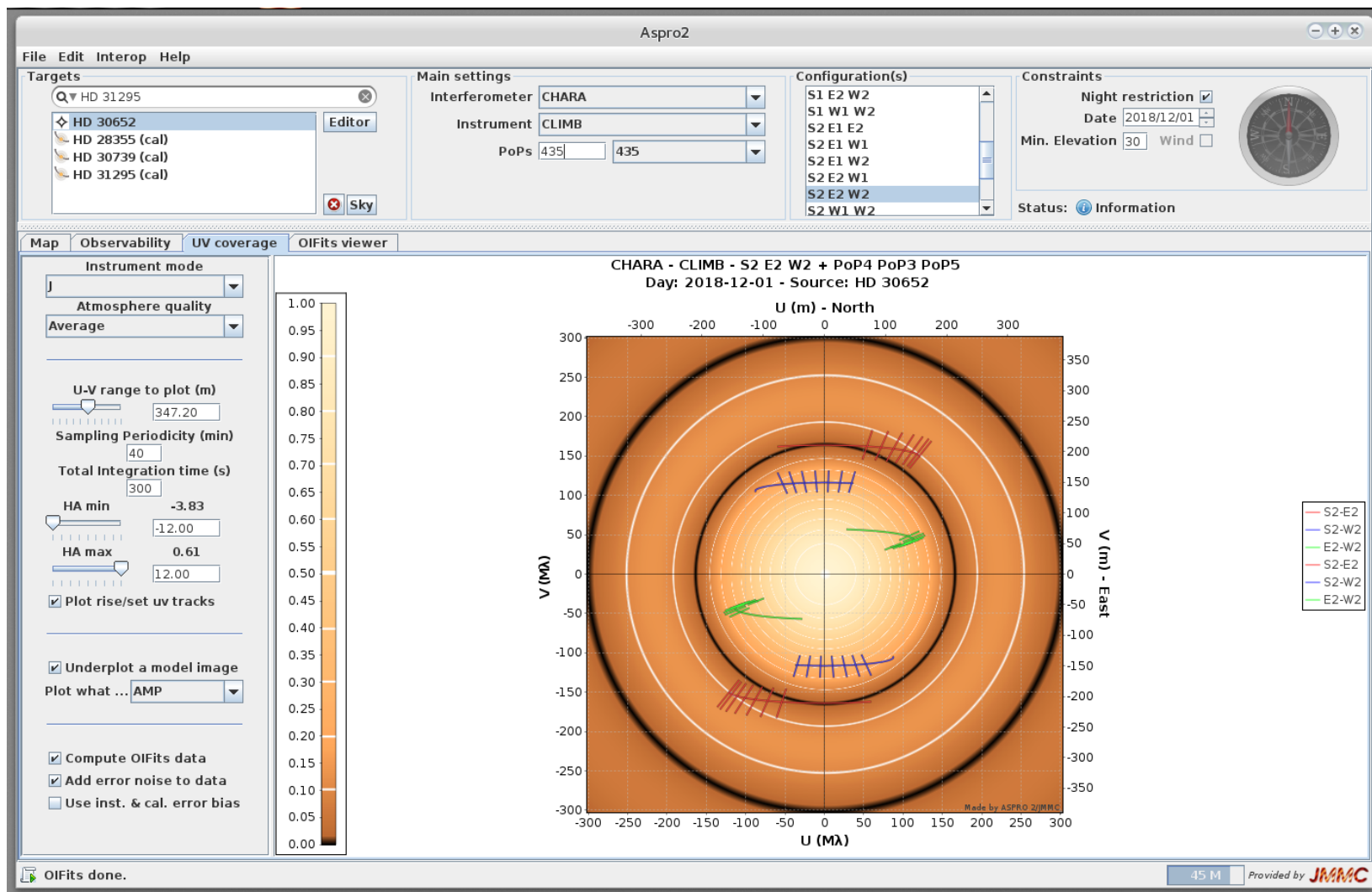
Normalize fluxes

Cancel

OK

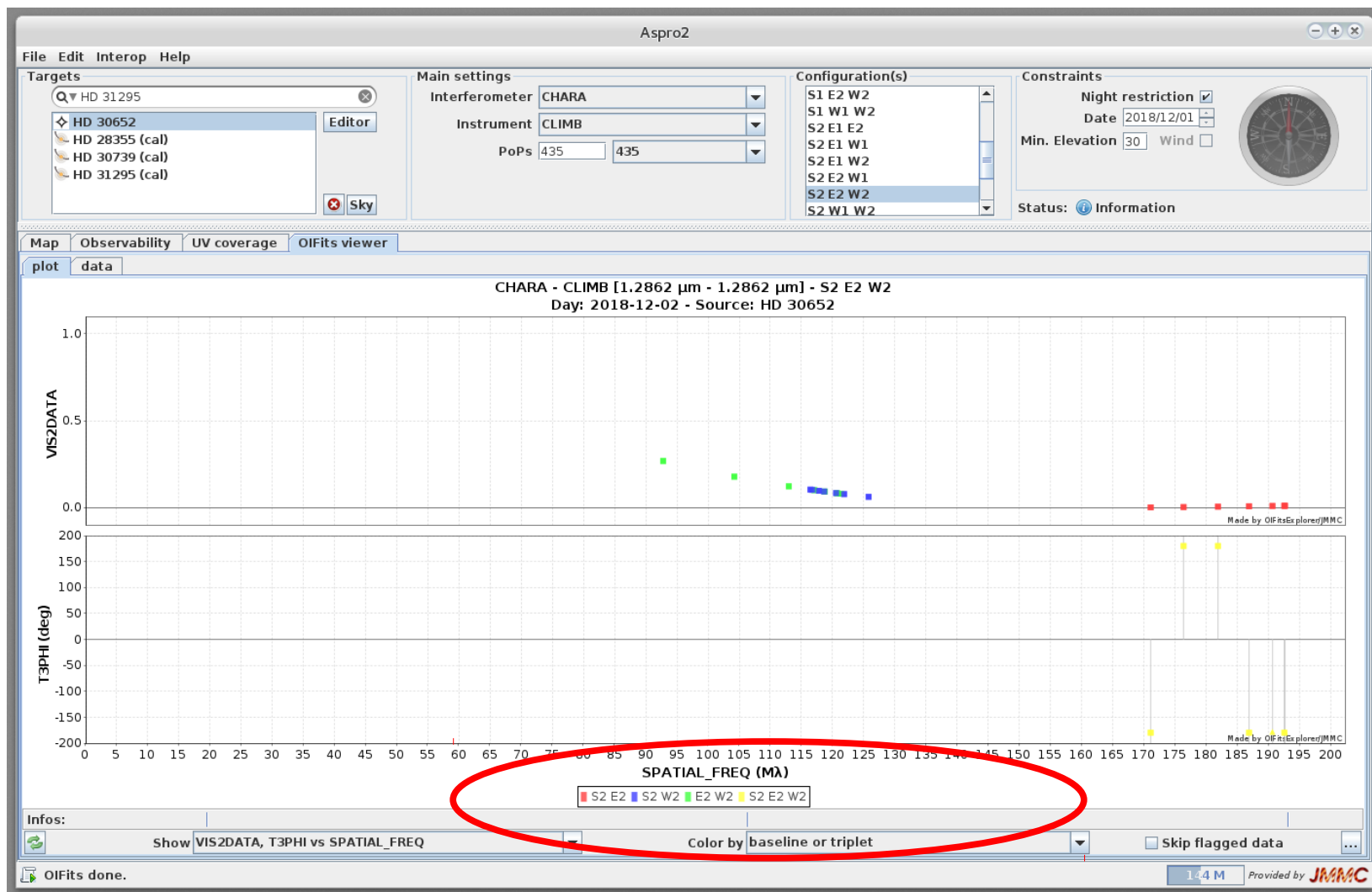


ASPRO 2



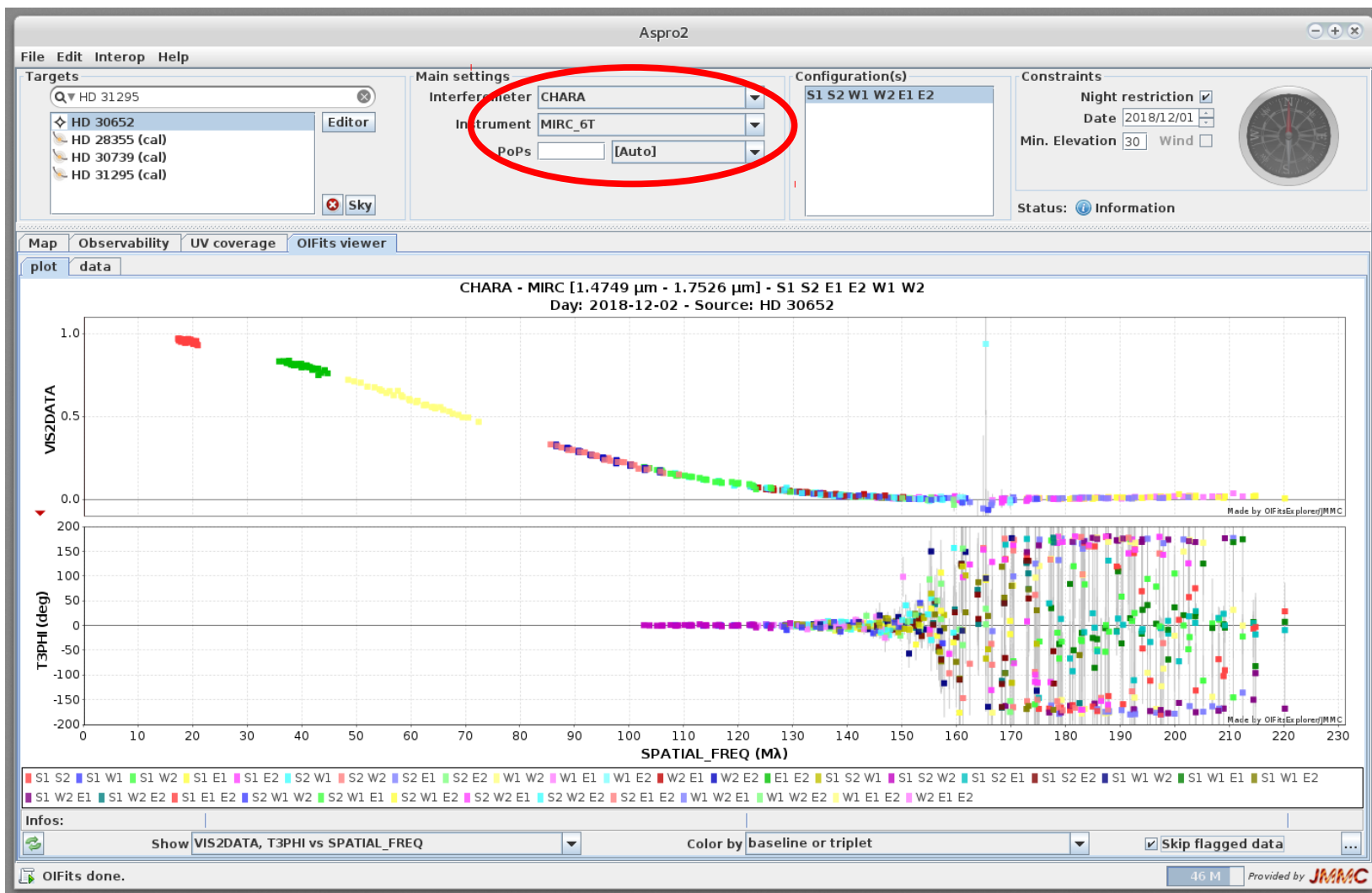


ASPRO 2





ASPRO 2





ASPRO 2



Target Editor

Targets Models

Models

- HD 30652
 - disk1
- HD 28355 (cal)
- HD 30739 (cal)
- HD 31295 (cal)

Model

Mode ☒ Analytical ☐ User Model

Name disk1 Add Remove

model type disk Update

Model description

Returns the Fourier transform of a normalized uniform disk of diameter DIAMETER (milliarcsecond) and centered at coordinates (X,Y) (milliarcsecond).

FLUX_WEIGHT is the intensity coefficient. FLUX_WEIGHT=1 means total energy is 1.

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Model Parameters

Model	Name	Units	Value
disk1	flux weight1		1
	x1	mas	0
	y1	mas	0
	diameter1	mas	1.53

edit positions: ☐ x / y (mas) ☒ sep. (mas) / pos. angle [-180°; 180°] Normalize fluxes

Cancel OK

Try adding
another
model
component.



For more information on observing opportunities at the CHARA Array, visit on the web:

<http://www.chara.gsu.edu>