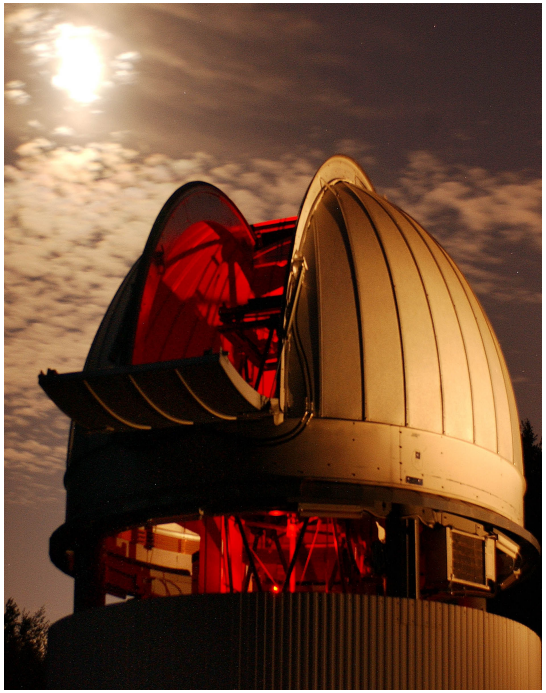
Observing Strategies and Planning Software



Gail Schaefer

The CHARA Array of
Georgia State University

Mount Wilson, CA

With contributions from:
Laurent Bourgès and Christopher Farrington

Outline

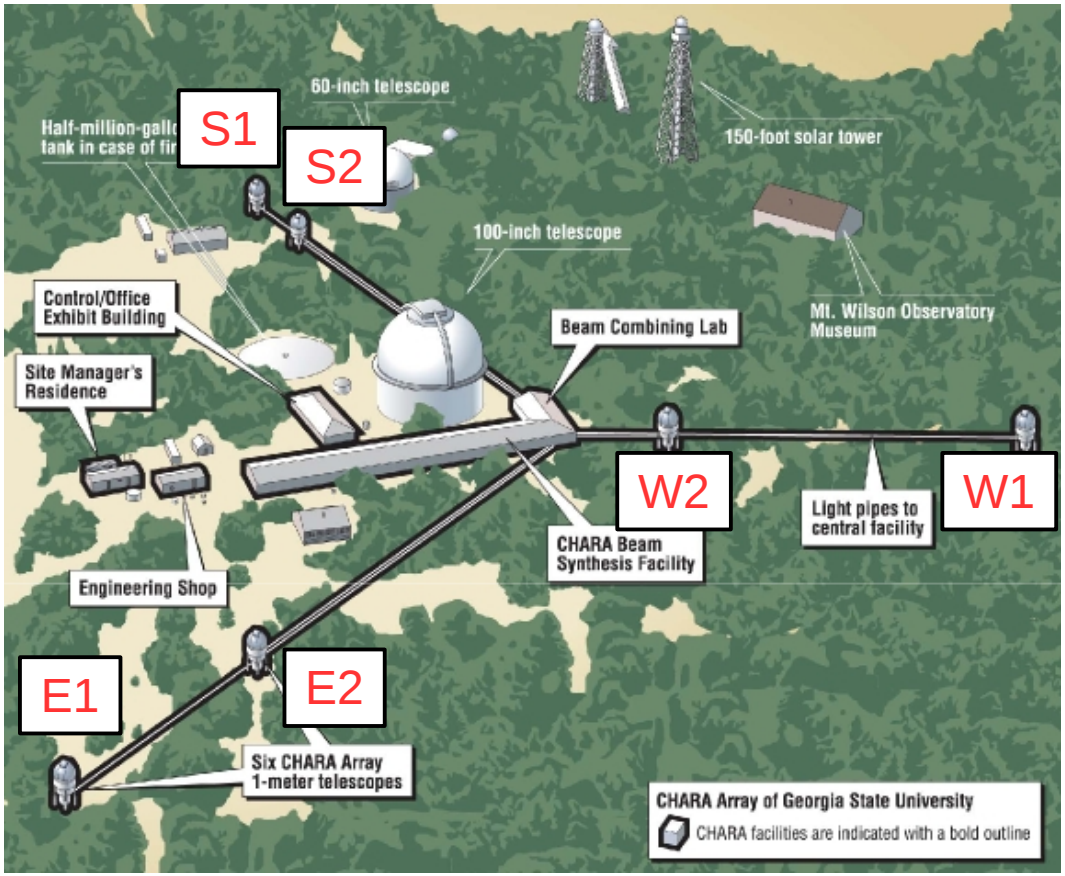
- Selecting a Beam Combiner
- Selecting Telescopes and Baselines
- Selecting Calibrator Stars
- Selecting Delay Settings (POP Configuration)
- Time Needed for Observations

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 tiptilt tracking: V = 10-12 mag

Telescopes and Baselines

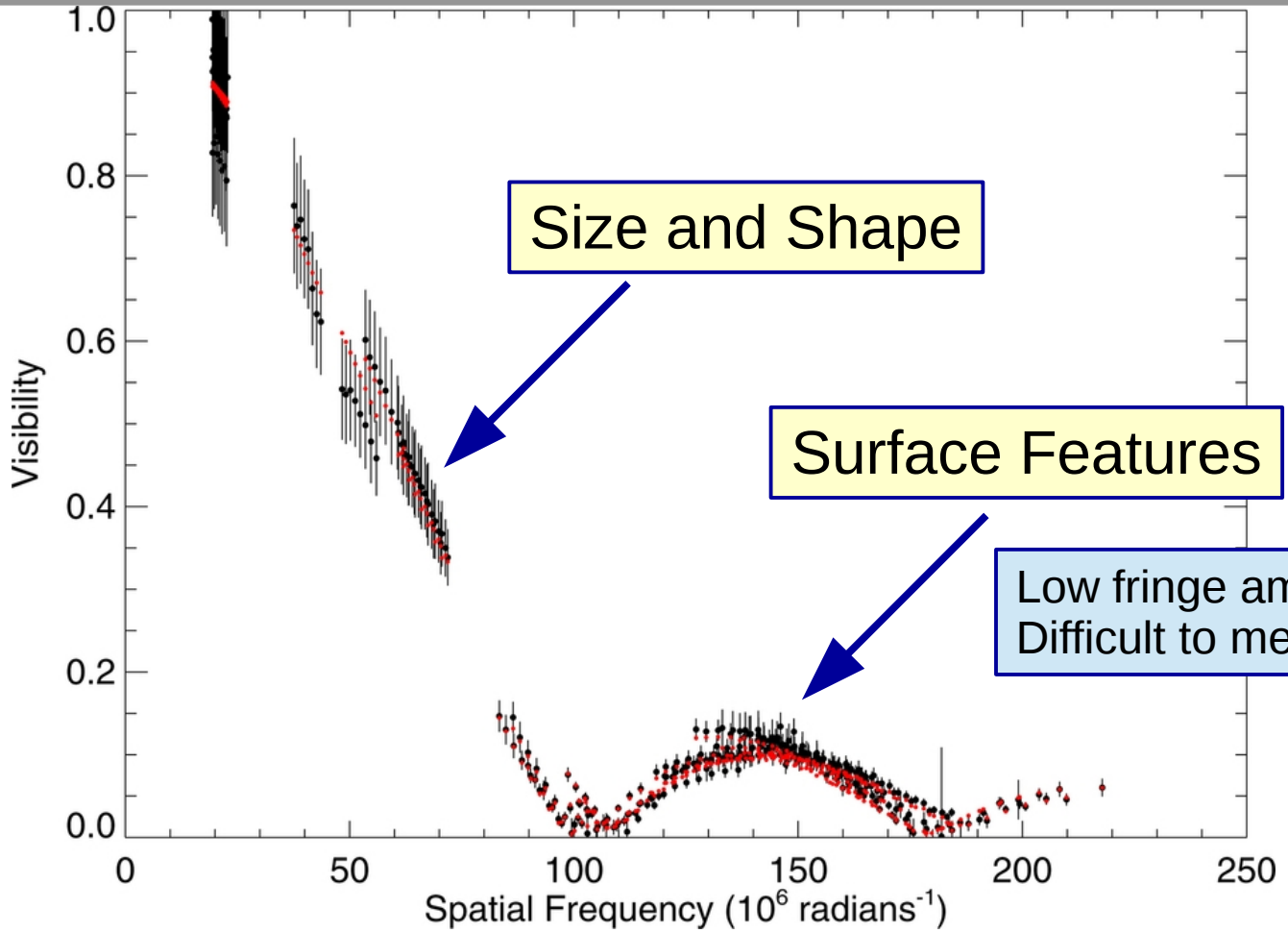


Baseline	Length (m)
E1-S1	331
W1-E1	314
E1-S2	302
E2-S1	279
W1-S1	279
W1-E2	251
W1-S2	249
E2-S2	248
W2-S1	211
W2-E1	222
W2-S2	177
W2-E2	156
W2-W1	108
E2-E1	66
S2-S1	34

Selecting Beam Combiner and Baselines

- Angular Resolution: 0.5 λ /B
  - 0.66 mas in K-band (2.13 μm)
  - 0.52 mas in H-band (1.67 μm)
  - 0.20 mas in visible at 650 nm
- Simple diameter:
  - Single baseline (two telescopes)
- Imaging complex sources: Binaries, rapid rotators, stellar surfaces
  - Multiple baseline projections
  - Imaging - sample beyond the first null (at 1.22 λ/B)

Selecting Beam Combiner and Baselines

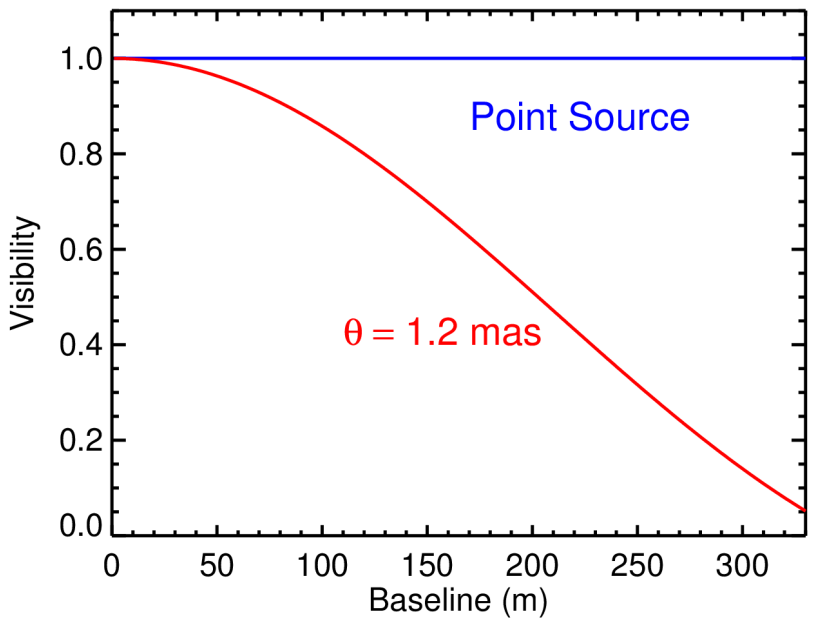


Wavelength Coverage

- Broad-band
  - Higher sensitivity for faint objects
  - Bandwidth smearing
- Spectrally dispersed visibilities
  - Increase u,v sampling by measuring fringes in different wavelength channels
  - Emission/absorption line studies
- Coherence length (width of fringe packet)
  - Sets the interferometric field of view

$$\frac{\lambda^2}{\Delta\lambda}$$

Calibrator Stars



- Unresolved point source:
  - Visibility = 1.0
- However, 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.

Selecting Calibrators

- Unresolved stars or stars with a known angular diameter.
- Within 5-10 degrees on the sky from the science target.
- Within 1-2 mag in brightness from science target and similar in color.
- Avoid binary stars, rapid rotators, emission line stars.
- Minimum of two calibrators per object, three is better.
  - Discovery of unknown binaries

Selecting Calibrators

- SearchCal – developed by JMMC
  - http://www.jmmc.fr/searchcal_page.htm
- getCal – developed by NexSci
  - http://nexsciweb.ipac.caltech.edu/gcWeb/gcWeb.jsp

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] : 300.0

2) Science Object

Name : HD 69897

RA 2000 [hh:mm:ss] : 08 20 03.86158

DEC 2000 [+/-dd:mm:ss] : +27 13 03.7416

Magnitude (H) : 3.942

3) SearchCal Parameters

Min. Magnitude (H) : 3.0

Max. Magnitude (H) : 5.0

Scenario : Bright Faint

RA Range [mn] : 240.0

DEC Range [deg] : 20.0

Progress :

Get Calibrators

Found Calibrators (2041 sources, 1826 filtered)

Index	dist	HD	RAJ2000	DEJ2000	vis2	LDD	UD_V	UD_H	UD_K	SpType	V	H	K
1	**5.21E-6**	**69897**	**08 20 03.8602**	**+27 13 03.7380**	**0.374**	**0.701**	**0.662**	**0.686**	**0.689**	**F6V**	**5.13**	**3.942**	**3.868**
2	2.975	67542	08 09 35.1816	+29 05 35.0772	0.622	0.503	0.468	0.488	0.49	G0II	6.47	4.699	4.621
3	3.383	67544	08 09 24.8645	+24 49 34.0716	0.619	0.509	0.468	0.49	0.493	G8III	7.29	4.966	4.908
4	3.595	71730	08 29 40.0634	+24 20 40.9452	0.581	0.542	0.496	0.52	0.523	K0III	7.05	4.872	4.81
5	3.977	73080	08 37 22.1112	+28 17 39.8328	0.554	0.555	0.52	0.541	0.543	G5	6.63	4.702	4.591
6	4.945		08 10 54.7320	+22 43 43.1904	0.514	0.588	0.548	0.573	0.575	K0	8.026	4.909	4.698
7	6.121	65471	07 59 42.6055	+23 10 58.4652	0.506	0.594	0.554	0.579	0.581	K0	6.92	4.73	4.562
8	6.902	75216	08 49 45.3118	+29 26 55.9824	0.534	0.581	0.529	0.557	0.561	K2III	7.38	4.868	4.712
9	7.14	63138	07 48 28.8108	+28 45 51.2748	0.519	0.592	0.542	0.568	0.572	K0III	6.86	4.694	4.605
10	7.303	75646	08 52 00.4543	+25 43 07.1004	0.568	0.553	0.504	0.53	0.534	K2III	7.54	4.983	4.834
11	7.524		08 52 09.6634	+29 51 13.3848	0.515	0.588	0.548	0.572	0.575	K0	7.08	4.742	4.631
12	7.677		08 32 54.2333	+34 23 03.2748	0.544	0.565	0.524	0.549	0.552	K2	7.52	4.934	4.798
13	7.731	75783	08 53 00.0972	+29 57 41.5296	0.564	0.549	0.509	0.533	0.536	K2	7.35	4.982	4.813
14	*7.809*	74198	08 43 17.1466	+21 28 06.6000	0.774	0.366	0.351	0.362	0.362	A1IV	4.66	4.788	4.638
15	7.842	64092	07 53 01.0094	+22 20 04.3116	0.557	0.553	0.515	0.538	0.541	K0	7.05	4.85	4.755
16	7.845		08 03 34.1340	+20 20 18.6972	0.599	0.519	0.486	0.506	0.508	G5	7.03	4.836	4.742
17	8.769	67482	08 09 39.7601	+35 42 08.5032	0.58	0.535	0.498	0.52	0.523	K0	7.3	4.952	4.839
18	8.815	64602	07 56 01.9399	+34 22 10.4160	0.572	0.541	0.505	0.527	0.53	K0	7.57	4.972	4.827
19	8.917		07 48 06.8957	+32 51 25.0308	0.557	0.552	0.518	0.539	0.541	G5	7.204	4.952	4.548
20	10.159	60204	07 34 31.5922	+28 41 11.6808	0.519	0.583	0.547	0.569	0.571	G5	6.66	4.605	4.498
21	10.402	77694	09 04 51.4817	+24 36 18.5040	0.561	0.559	0.509	0.536	0.539	K2III	7.8	4.982	4.838

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 Visiblity 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

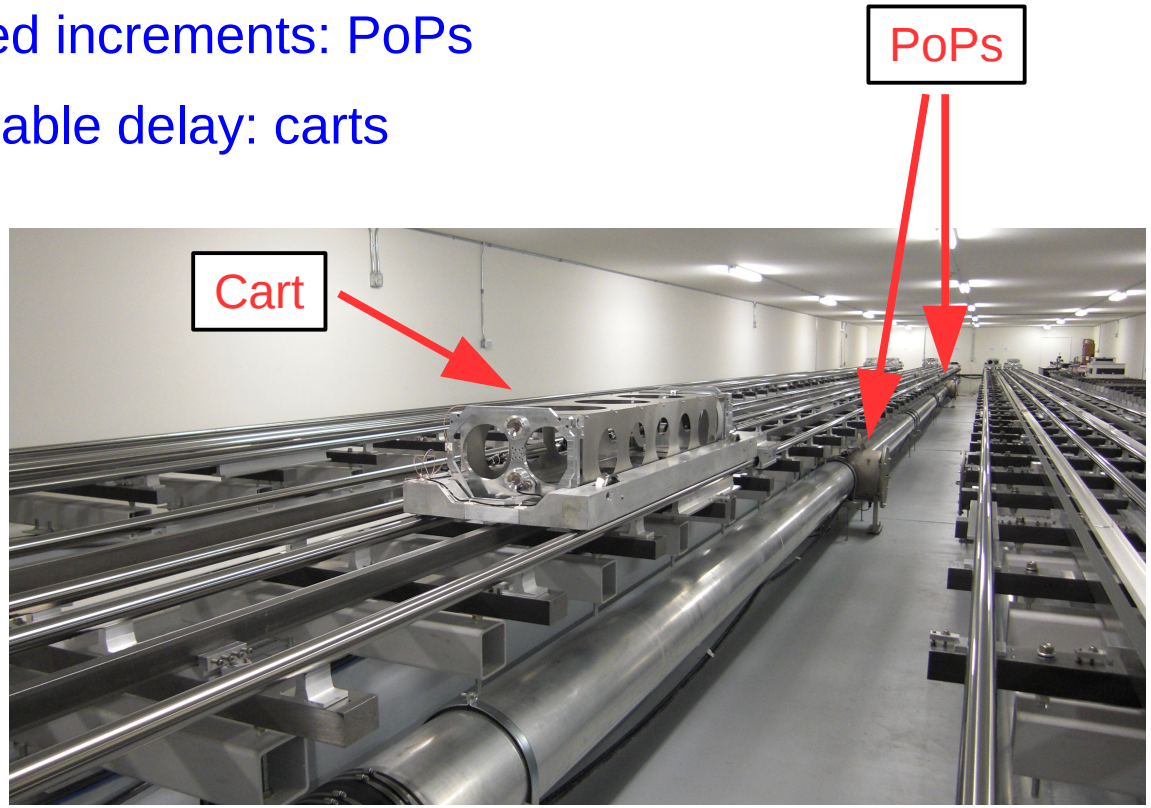
searching calibrators... done.

29 M

Provided by JMMC

Delay settings (sky coverage)

- Delay settings to equalize optical path length
  - Fixed increments: PoPs
  - Variable delay: carts

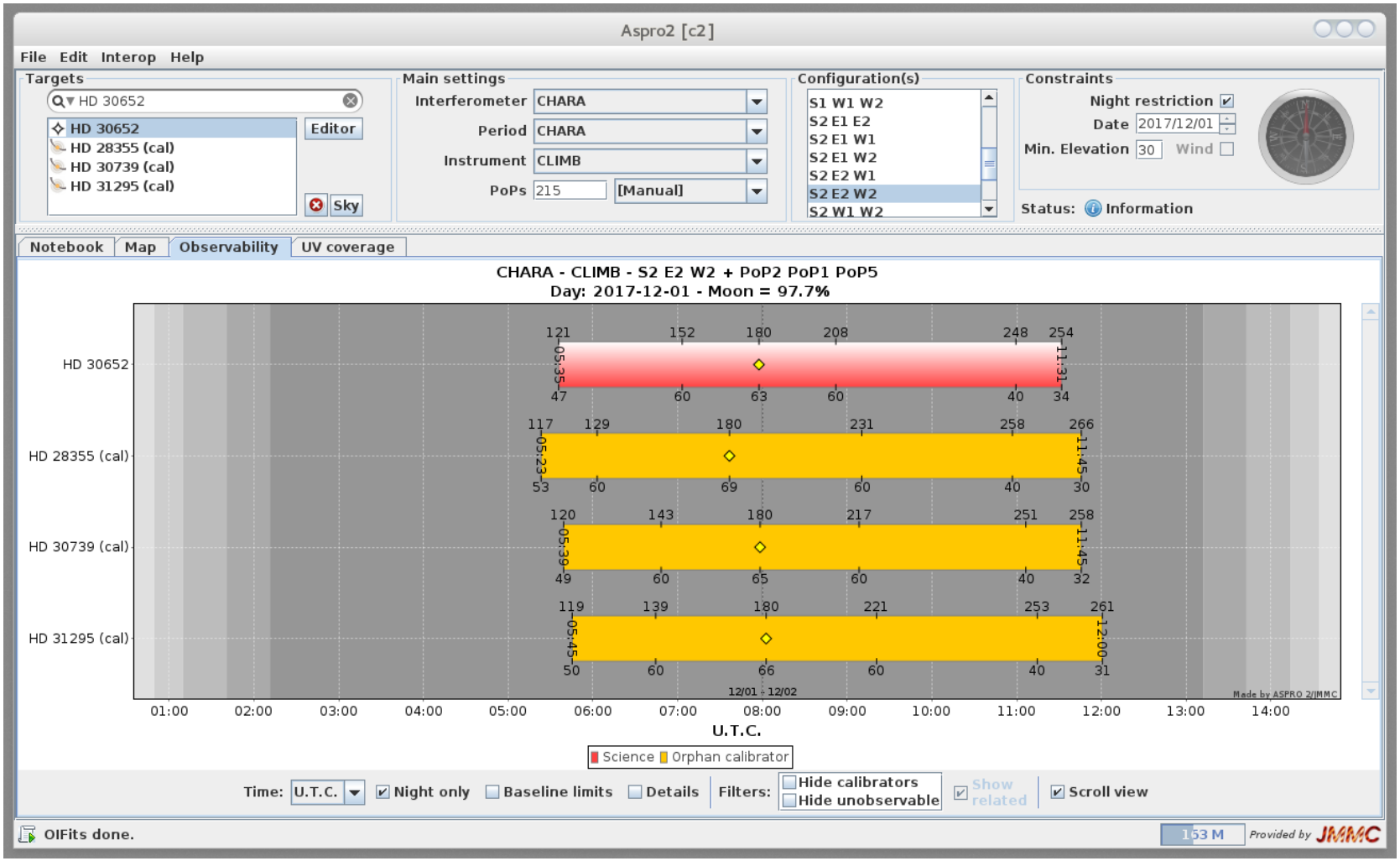


Planning Software

- ASPRO2 – developed by JMMC
  - http://www.jmmc.fr/aspro_page.htm
- CHARA_PLAN2 – developed by CHARA
  - http://www.astro.gsu.edu/~theo/chara_reduction/index.html

ASPRO 2

JMMC



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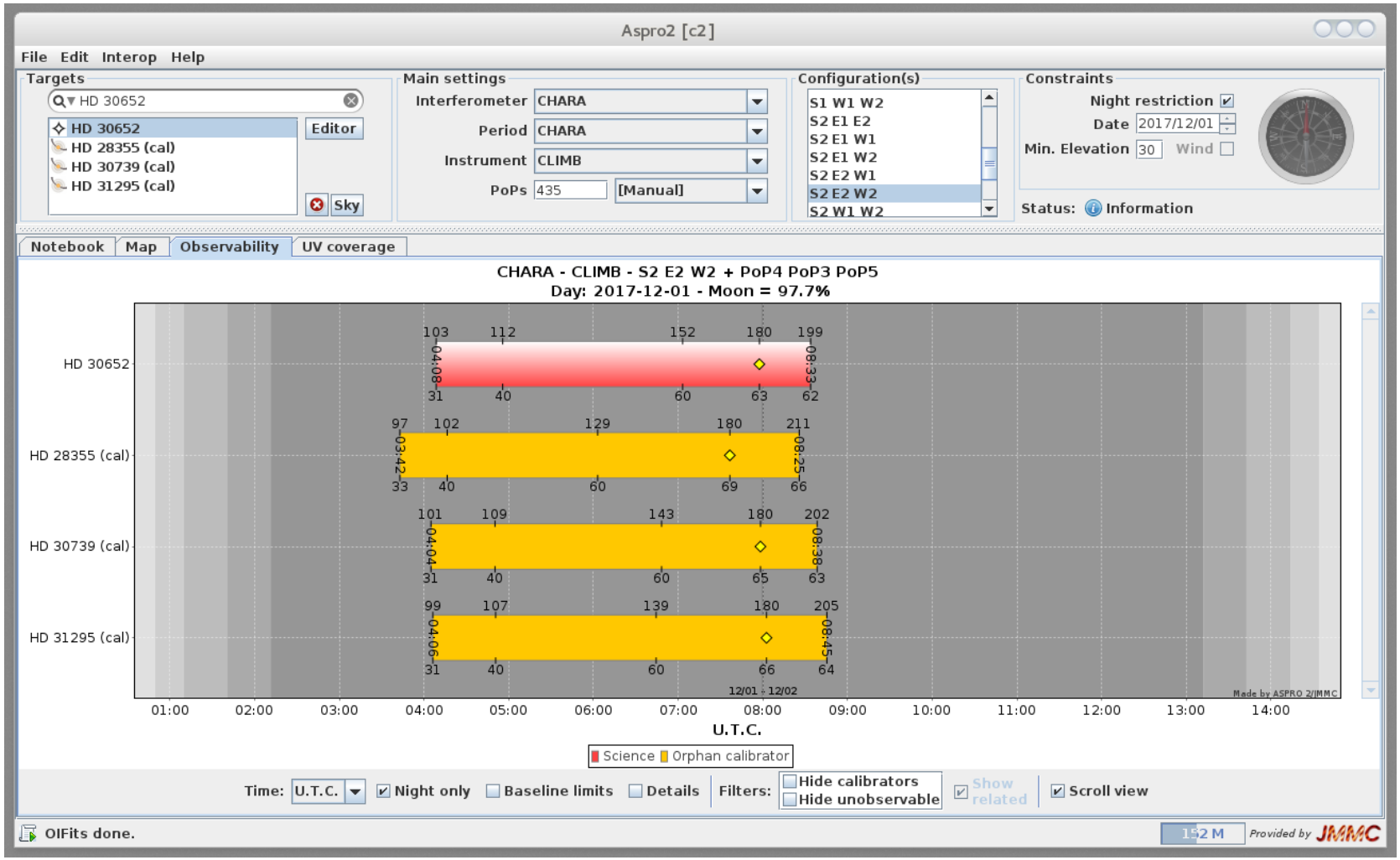
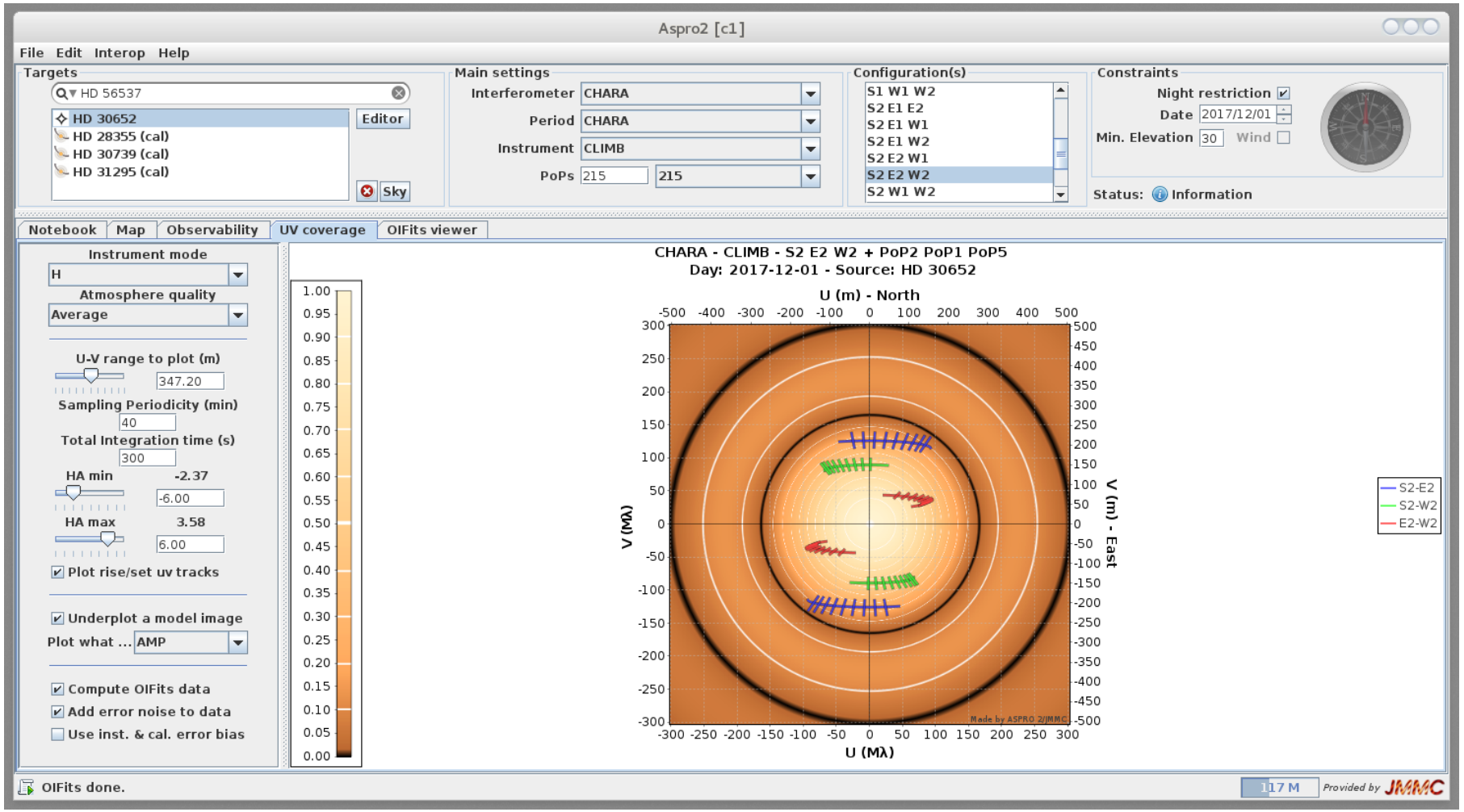
ASPRO 2

JMMC


Aspro2 [c2]
File Edit Interop Help
Targets
HD 30652
HD 30652
HD 28355 (cal)
HD 30739 (cal)
HD 31295 (cal)
Editor
Sky
Main settings
Interferometer CHARA
Period CHARA
Instrument CLIMB
PoPs 435 [Manual]
Configuration(s)
S1 W1 W2
S2 E1 E2
S2 E1 W1
S2 E1 W2
S2 E2 W1
S2 E2 W2
S2 W1 W2
Constraints
Night restriction
Date 2017/12/01
Min. Elevation 30
Wind
Status: Information
Notebook
Map
Observability
UV coverage
CHARA - CLIMB - S2 E2 W2 + PoP4 PoP3 PoP5
Day: 2017-12-01 - Moon = 97.7%
HD 30652
HD 28355 (cal)
HD 30739 (cal)
HD 31295 (cal)
12/01 - 12/02
Made by ASPRO 2/JMMC
01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00
U.T.C.
Science
Orphan calibrator
Time: U.T.C.
Night only
Baseline limits
Details
Filters:
Hide calibrators
Hide unobservable
Show related
Scroll view
OIFits done.
152 M
Provided by JMMC

ASPRO 2

JMMC

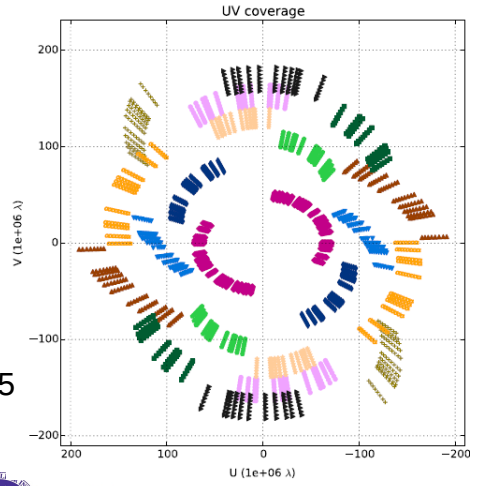


How much time is needed?

- Calibration Strategies:
  - Cal1 – Obj – Cal2 – Obj – Cal1 ...
  - Cal1 – Obj – Cal2 – Cal1 – Obj – Cal2 ...
- Time to collect data on single object (star acq. + data)
  - Seeing and brightness dependent
  - Fast instruments (CLASSIC, CLIMB, PAVO, JouFlu):
    - 5 – 15 minutes
  - VEGA: 10 – 20 minutes
  - MIRC: 45 – 60 minutes
- Cal-Sci-Cal will take between 30 – 120 min

How much data is needed?

- Diameters – Several (5-10) brackets of data per baseline on two separate nights.
- Binaries – Minimum of three brackets or observations on at least three baselines.
- Imaging – Many brackets on multiple baselines during the night to fill in the sky coverage.



Kloppenborg et al. 2015

On the night of observation

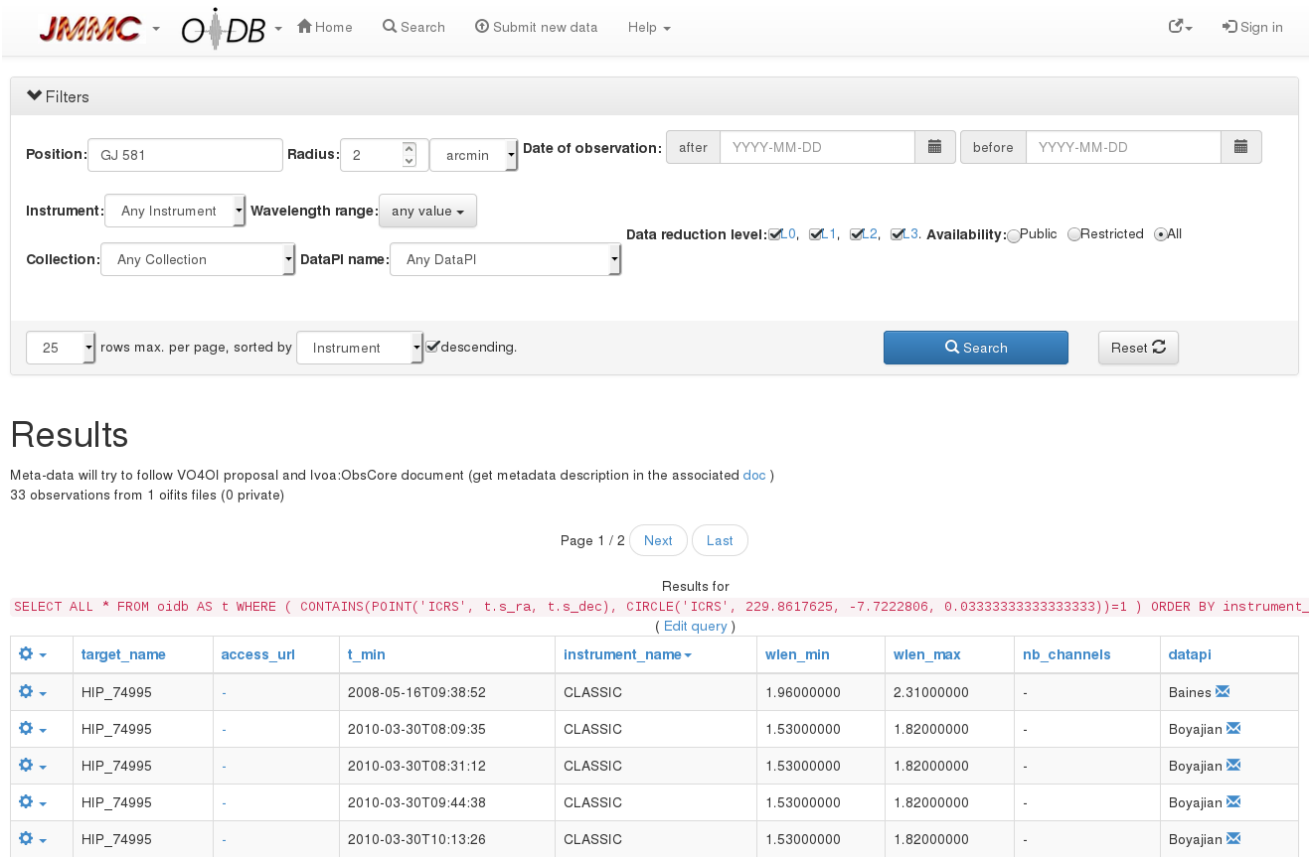
- Observations will be carried out by CHARA staff
- Visitors are encouraged to travel to the Array to participate in the observations
  - Real-time input from PI on decisions that could impact the science objectives and priorities

Guide to planning observations available on the CHARA website:

http://www.chara.gsu.edu/observers/planning-an-observation

Do observations already exist?

- OI Database
- Query and download data (OIFITS)
- CHARA observation logs for Classic, CLIMB, VEGA only



http://oidb.jmmc.fr/index.html