

High Contrast Astronomy with Starshades

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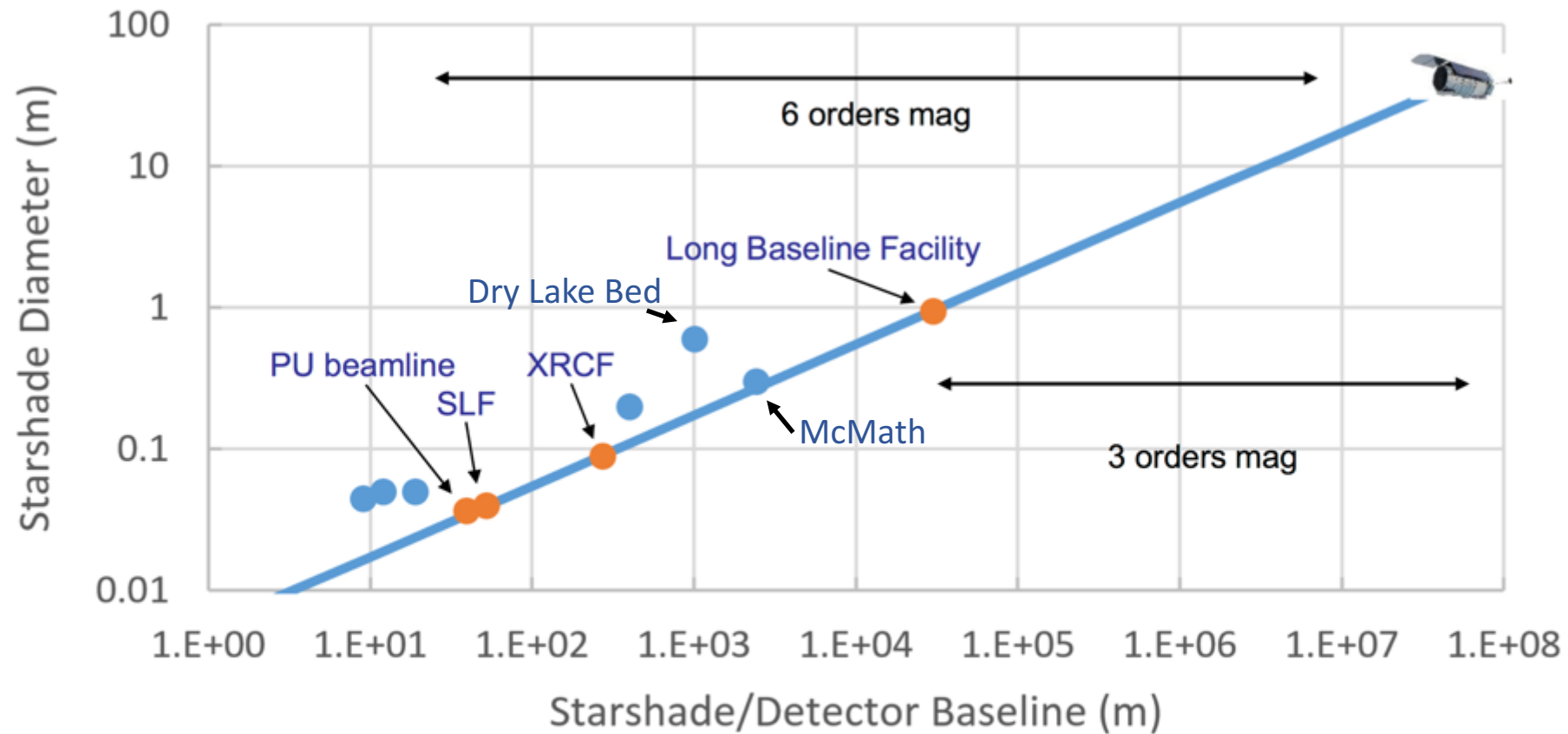
Photo: Robert Brown (NG)

Webster Cash, CU
Steve Warwick, NGAS

Approved for public release; distribution unlimited. NGAS Case 15-0712 dated 4/9/15.

Motivation for long baseline testing

- Extending starshade field tests led by Steve Warwick (NGAS) to a longer baseline
- Need to validate scalar diffraction assumption in optical models
- Testing a more flight-like starshade configuration
 - Proper Fresnel number
 - Proper telescope resolution
 - Macroscopic features on starshades
 - Smaller inner working angle (IWA)
 - Suppression of parallel astronomical wavefronts
 - Broadband wavelength coverage (400 nm – 800 nm)
- Opportunity to do high contrast astronomy at moderate IWA (10" - 40")
 - Typically an inaccessible region of parameter space
- Funded through:
 - Strategic University Research Partnership (SURP) - JPL
 - Technology Development for Exoplanet Missions (TDEM) – NASA Exoplanet Exploration Program



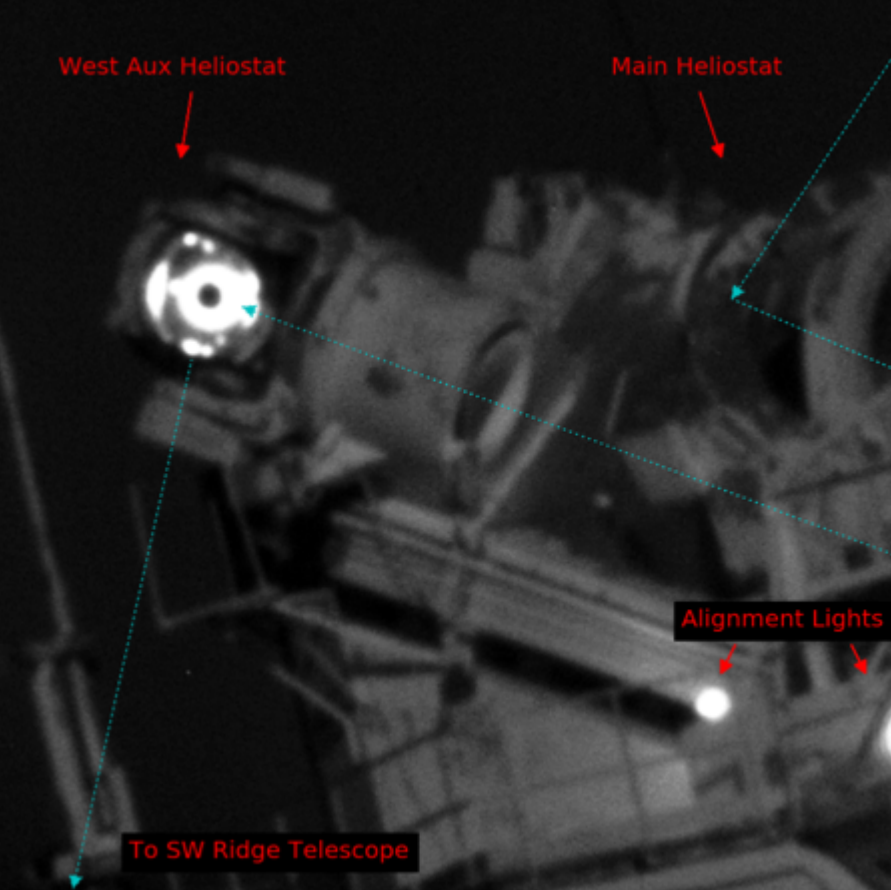
Test	Starshade - Telescope Separation	Starshade Diameter	Telescope Diameter	Fresnel Number*	Inner Working Angle	Resolution Elements*
Short Baseline	570 m	16 cm	2 cm	22	29"	11
Long Baseline	2.4 km	24 cm	2 cm	12	10"	4
Flight	55,000 km	36 m	2.4 m	12	68 mas	3

*at 0.5 μm

McMath-Pierce Solar Telescope

Kitt Peak National Observatory



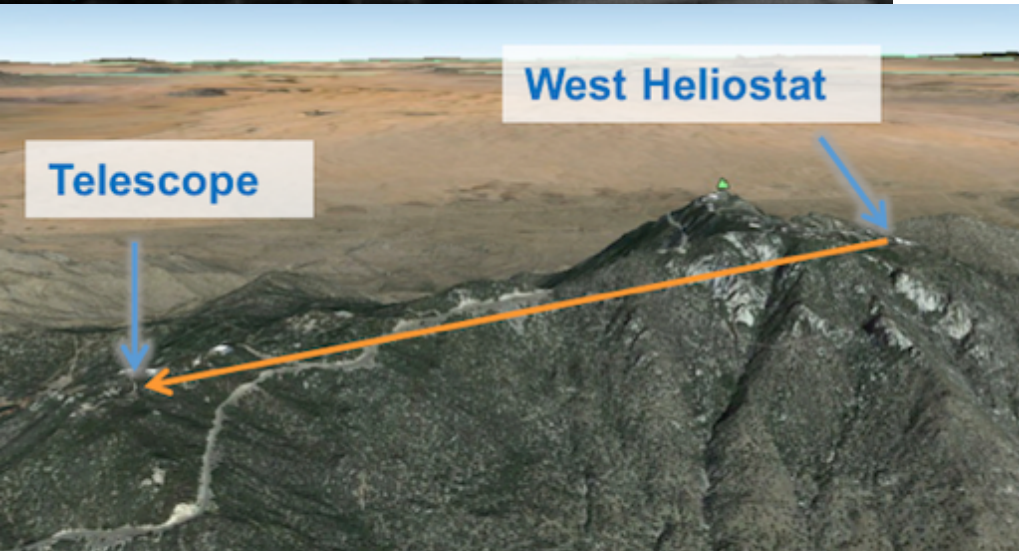
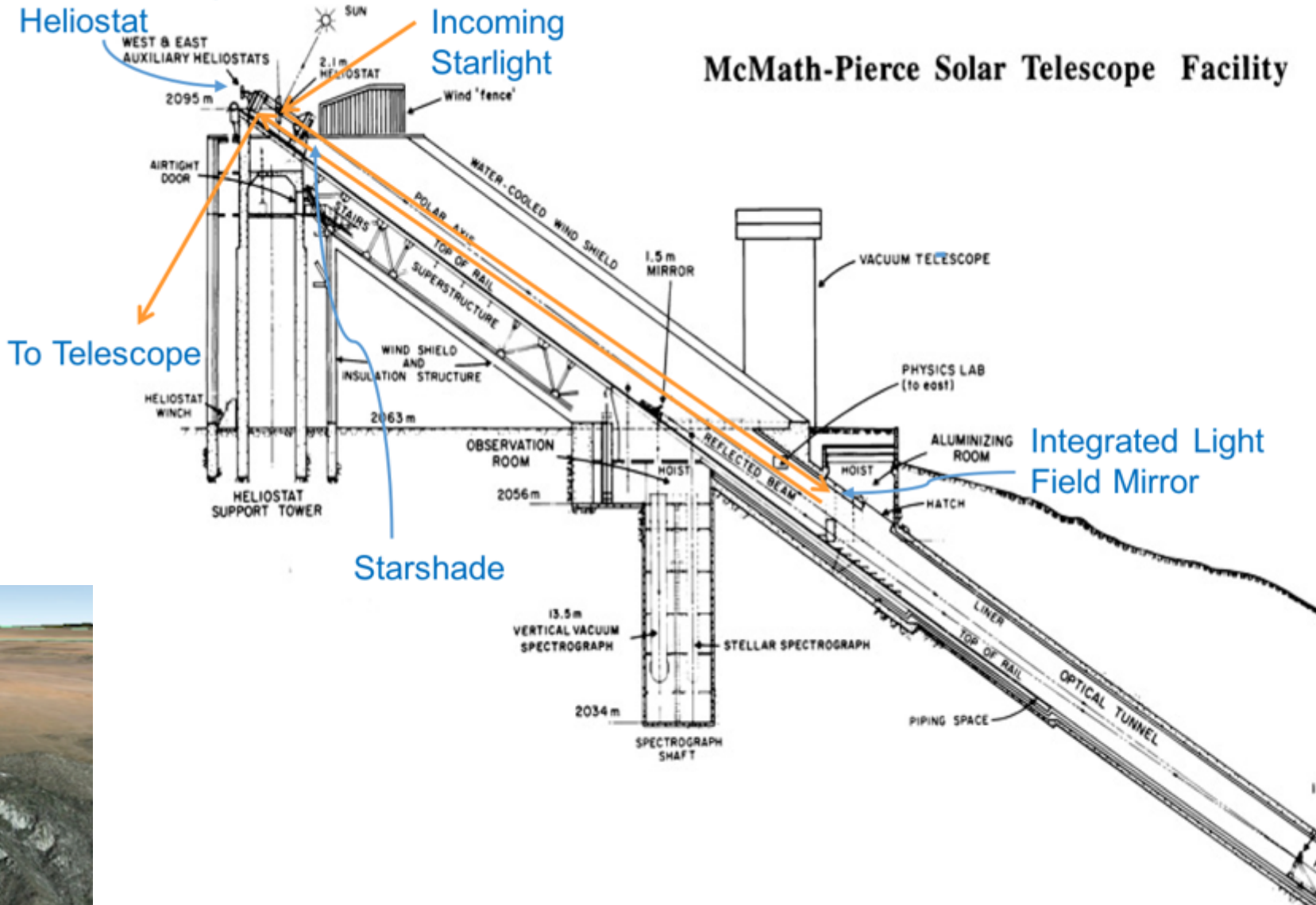


West Auxiliary Heliostat

Incoming Starlight

To Telescope

Starshade

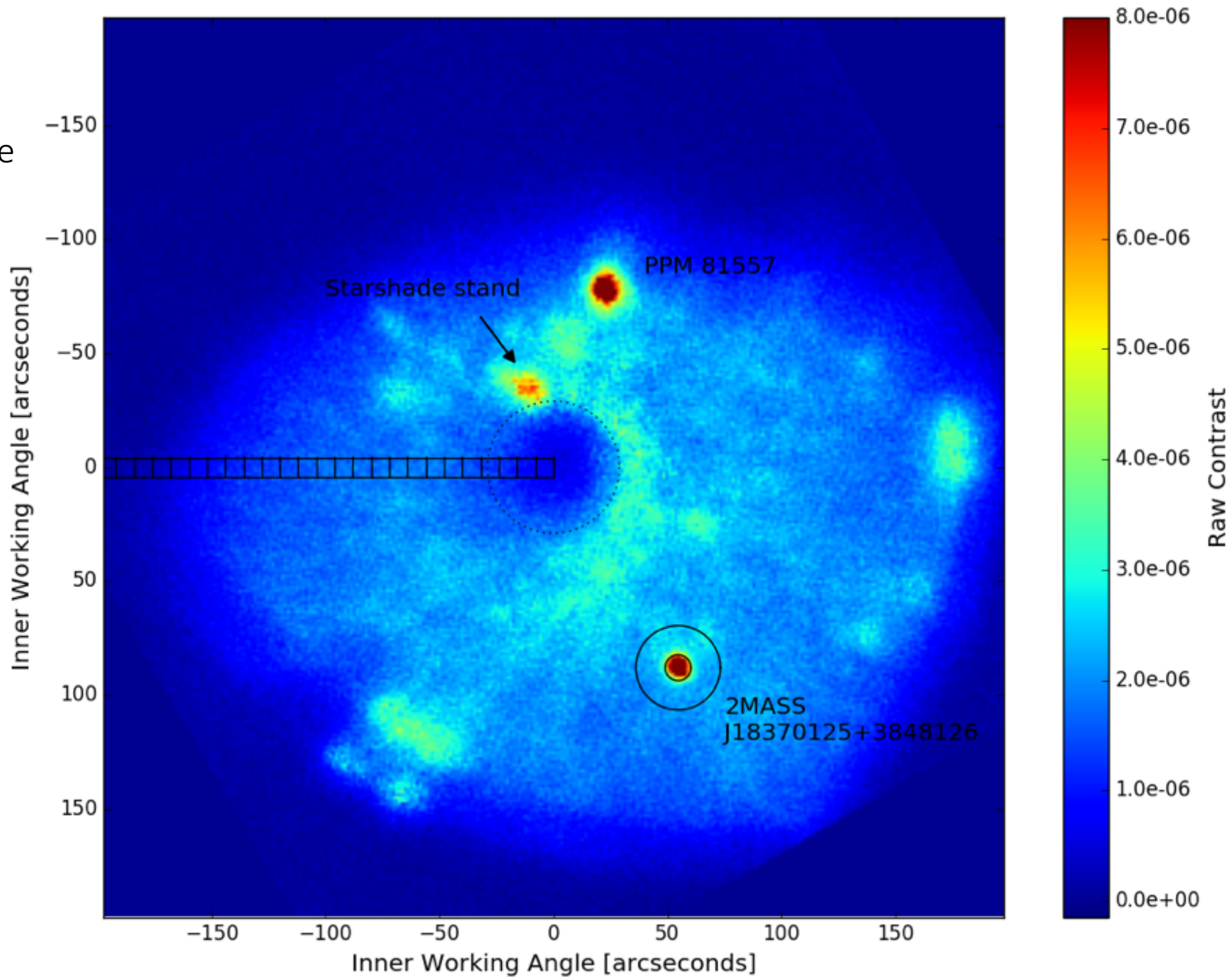






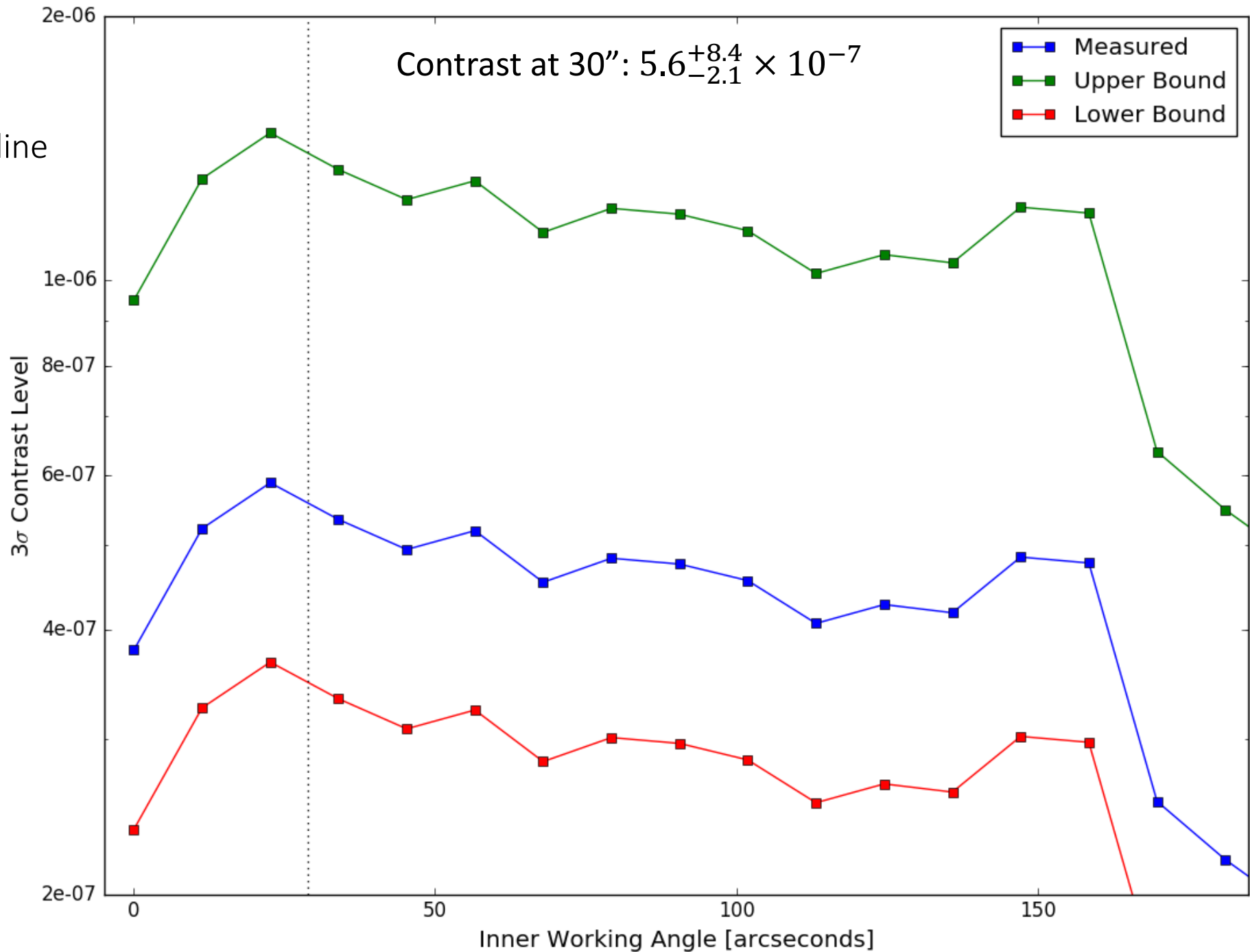
Vega

-Short Baseline



Vega

-Short Baseline



PPM 81557

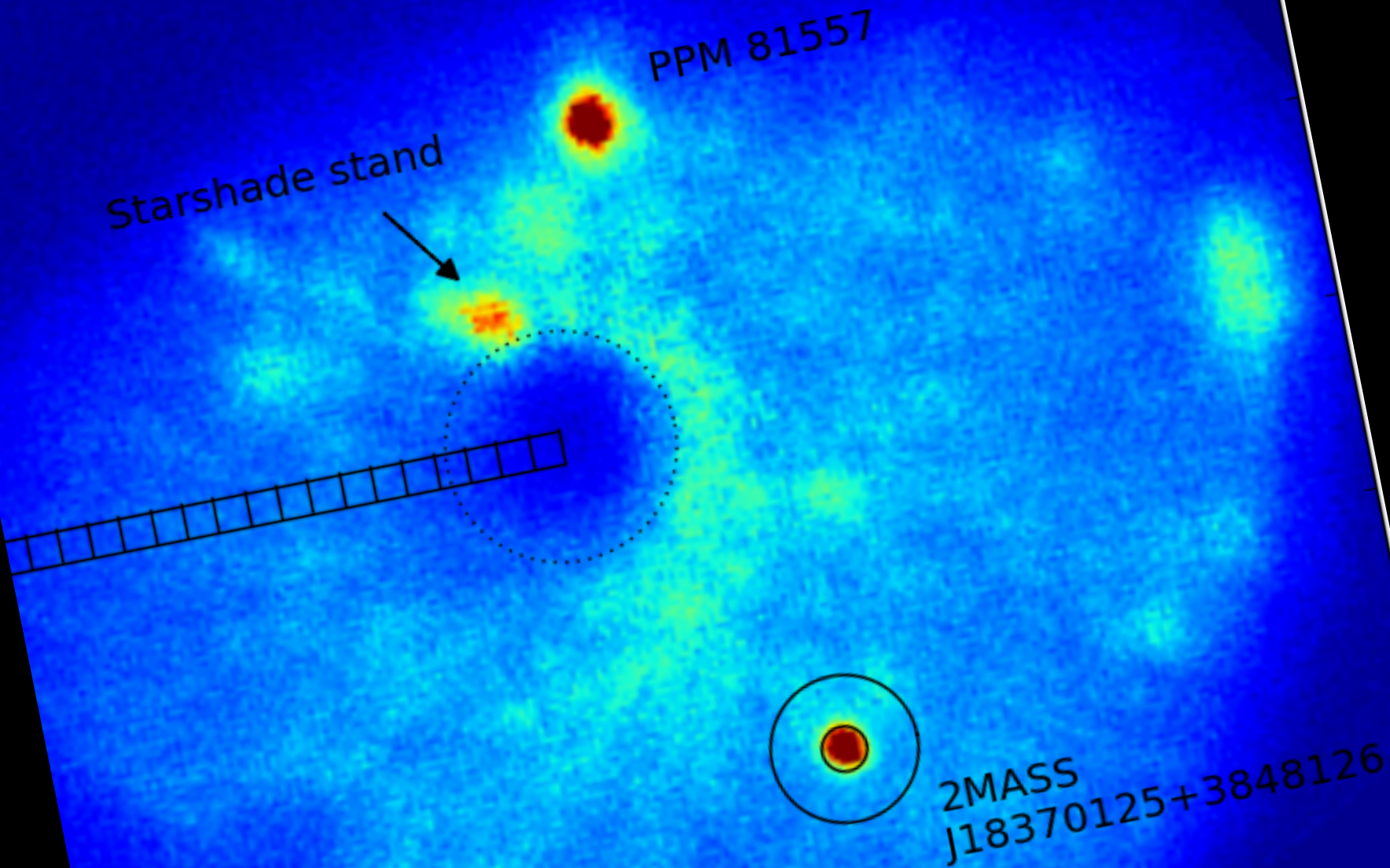


**2MASS
J18370125+3848126**

Starshade stand

PPM 81557

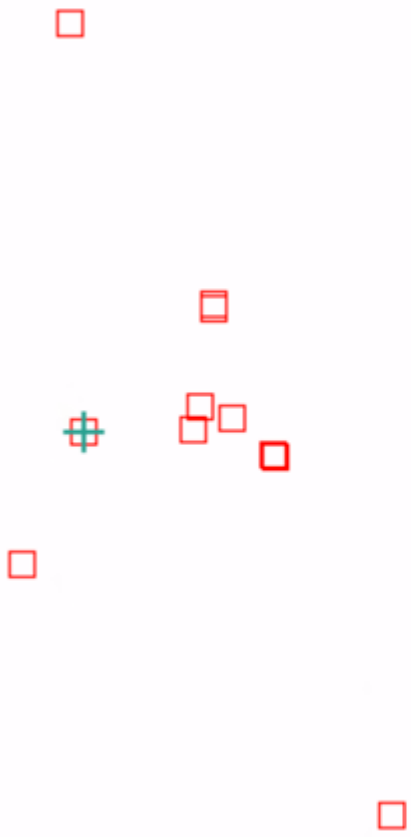
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J18370125+3848126



PPM 81557



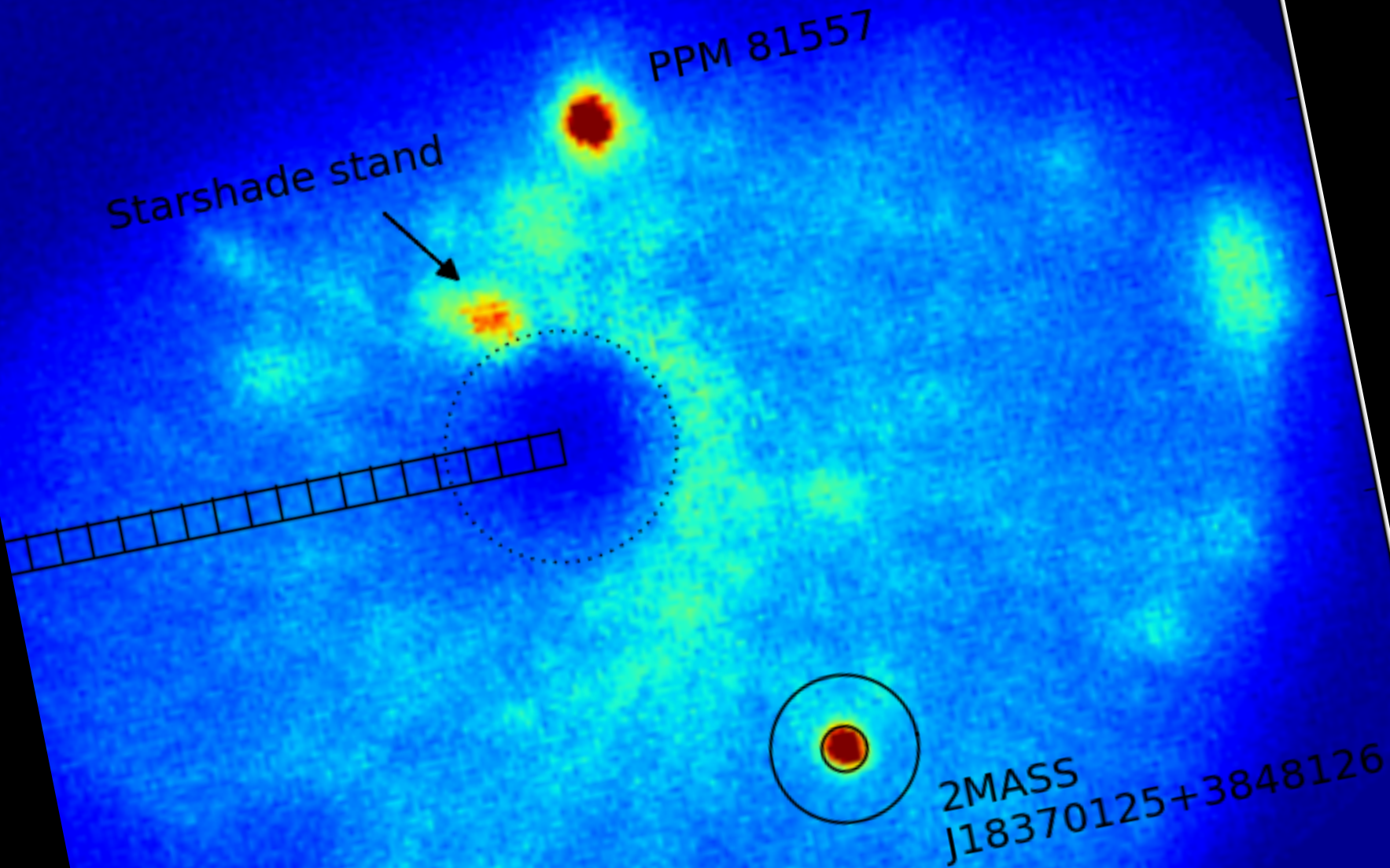
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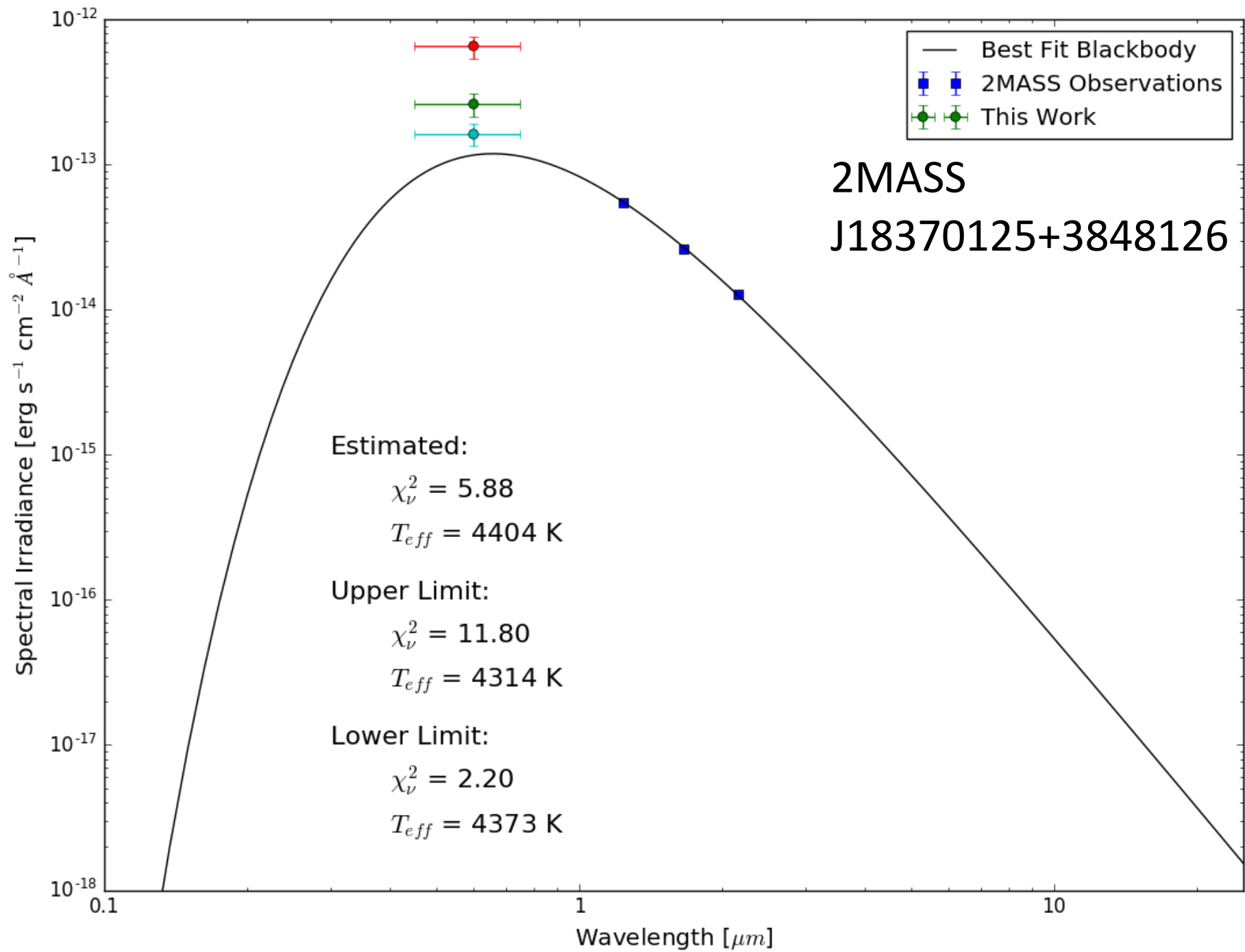


Starshade stand

PPM 81557

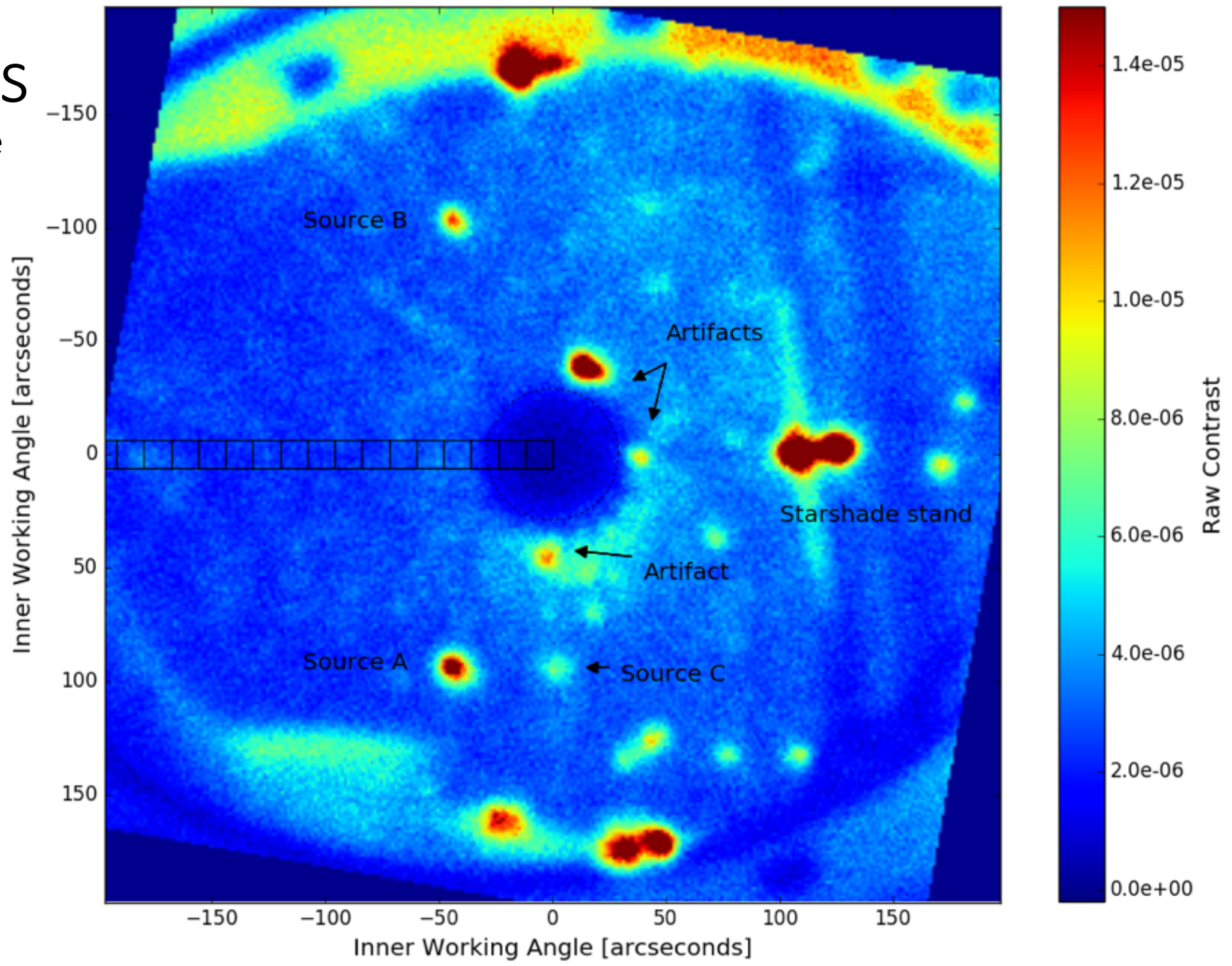
2MASS
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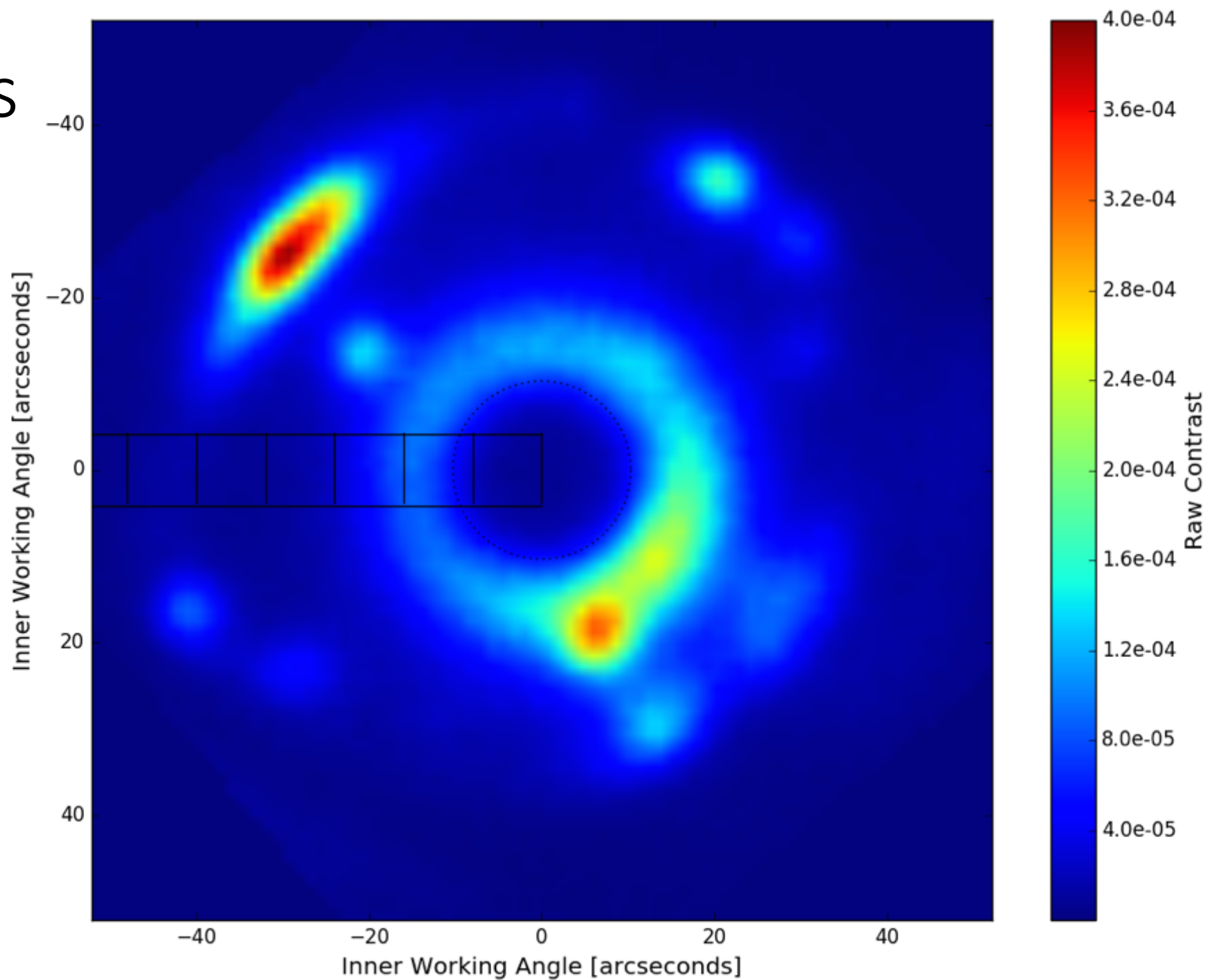
Antares

-Short Baseline



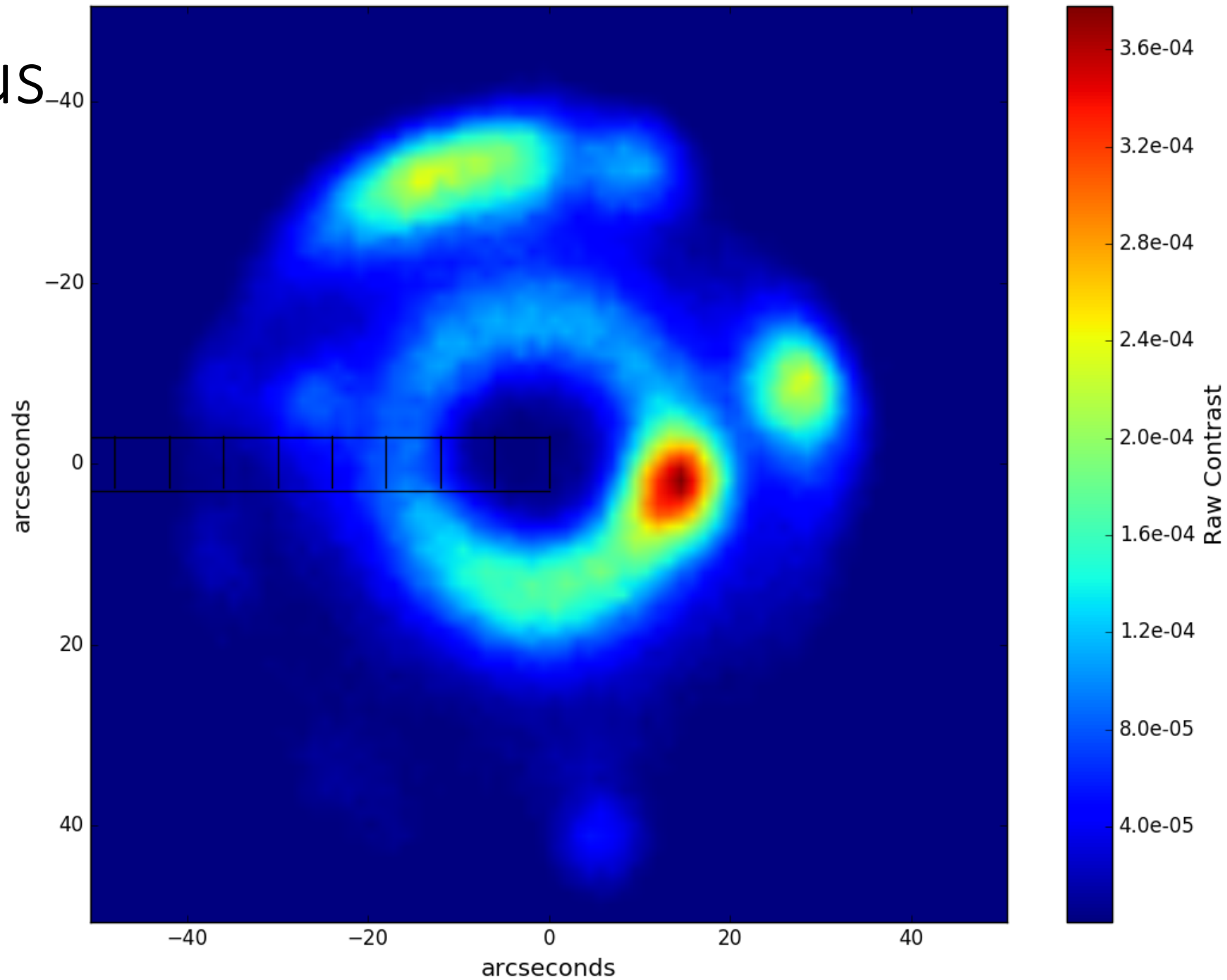
Antares

-Long Baseline



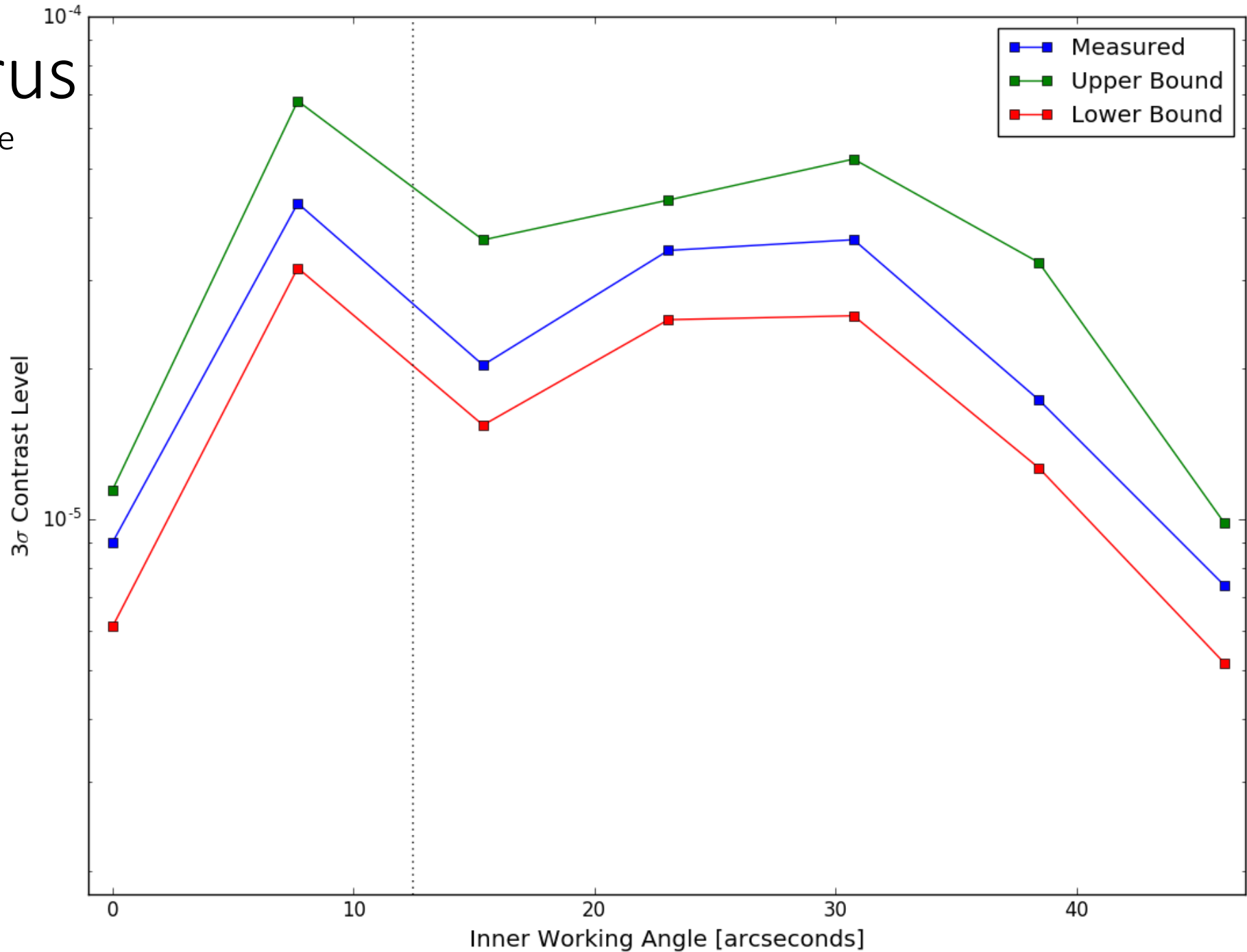
Arcturus

-Long Baseline



Arcturus

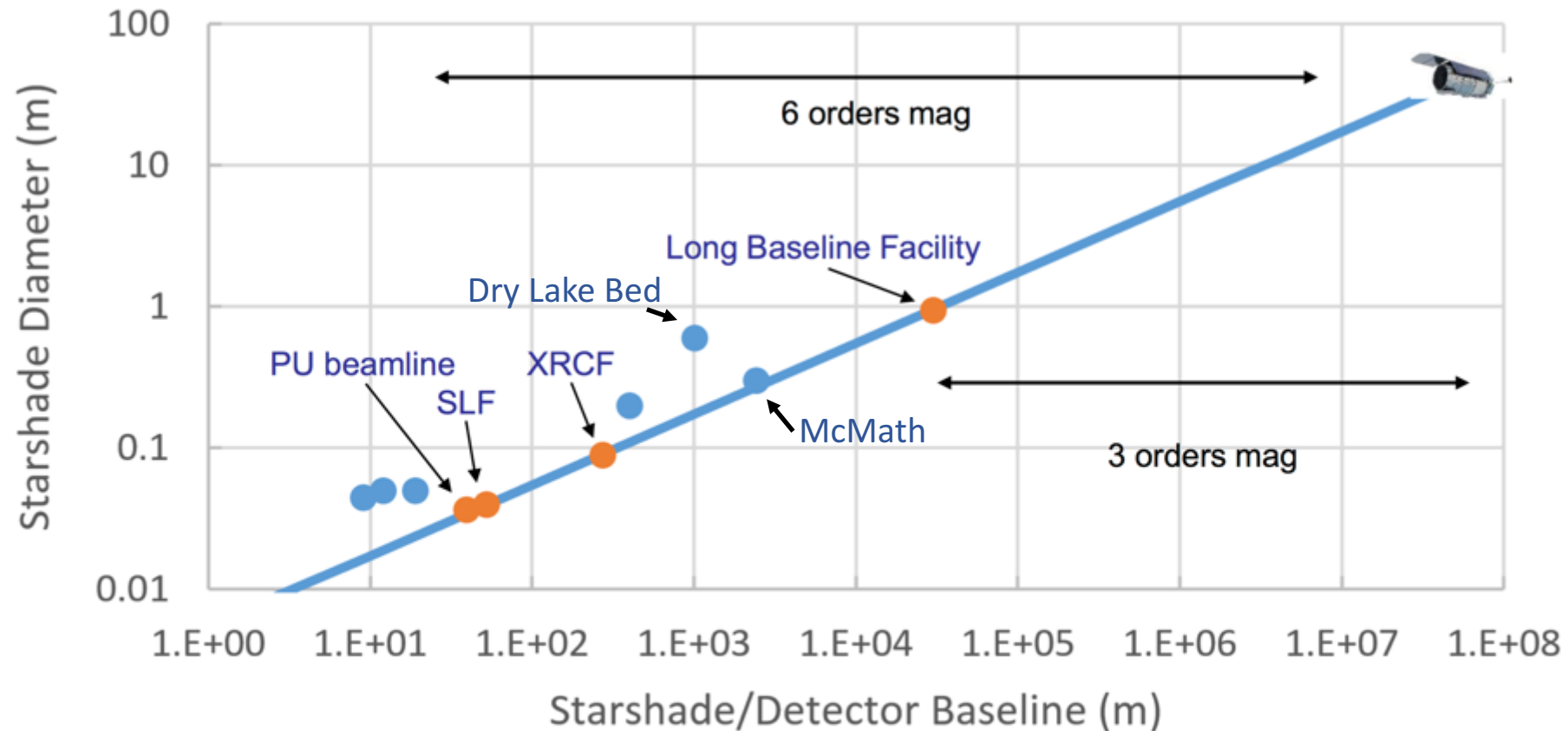
-Long Baseline



Limitations of McMath

- Turbulent Atmosphere
 - Atmosphere at McMath is very turbulent (9" seeing)
 - Difficult to maintain alignment with starshade
 - Large error on contrast due to variation in unblocked source brightness
 - Lower resolution degrades contrast
- Stray light
 - Test relies on 3 (not great quality) mirrors
 - Dust on mirrors generates high background
 - Scratches on mirrors generate artifacts that are difficult to distinguish from astronomical objects

Long Baseline Facility



Test	Starshade – Telescope Separation	Starshade Diameter	Telescope Diameter	Fresnel # *	IWA	Resolution Elements*
LBF (a)	10 km	0.48 m	0.1 m	12	5"	10
LBF (b)	30 km	0.84 m	0.2 m	12	3"	11

*at 0.5 μm

Long Baseline Facility

- Dedicated siderostat facility to overcome limitations of McMath
 - Built at 'high and dry' site with less atmosphere
 - Minimize number of reflections before collection telescope
 - Adaptive optics on collection telescope
 - Closed loop tracking
- Baselines extend up to 30 km
- Opportunity for high contrast science down to 3"
- Requires high quality flat mirror ~3-4 m diameter
- Possible risk of atmosphere limiting interpretation of results

A large, white, ribbed structure, possibly a telescope or antenna, is shown against a dark blue night sky filled with stars. The structure is composed of two main vertical sections that meet at a top point, with a horizontal section extending from the top of the right section. A blue metal railing is visible in the foreground. In the background, a smaller white structure with a yellow top is visible.

Thank You

We are looking for financial support to keep McMath-Pierce operational. Please contact me if you are interested in using McMath-Pierce and able to commit operational funds.

Email: anthony.harness@colorado.edu

BACKUP SLIDES

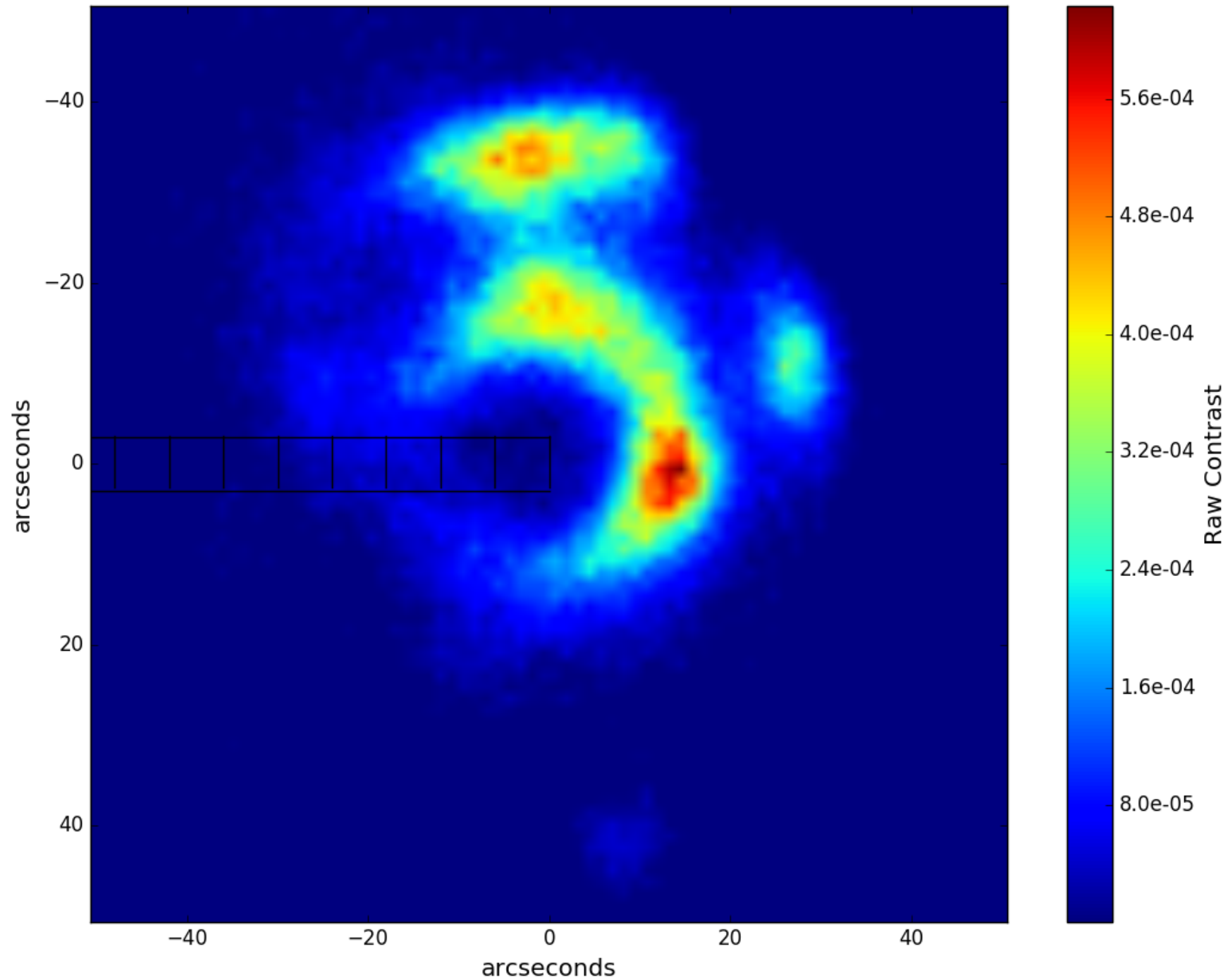
Outdoor Starshade Tests

Test	Starshade - Telescope Separation	Starshade Diameter	Telescope Diameter	Fresnel Number*	Inner Working Angle	Resolution Elements*
NG Dry Lake Bed	1 km	48 cm	4 cm	173	50"	38
NG McMath 2b	400 m	16 cm	8 cm	32	41"	64
NG McMath 2c	400 m	8 cm	4 cm	8	21"	16
Short Baseline	570 m	16 cm	2 cm	22	29"	11
Long Baseline	2.4 km	24 cm	2 cm	12	10"	4
Flight	55,000 km	36 m	2.4 m	12	68 mas	3

*at 0.5 μ m

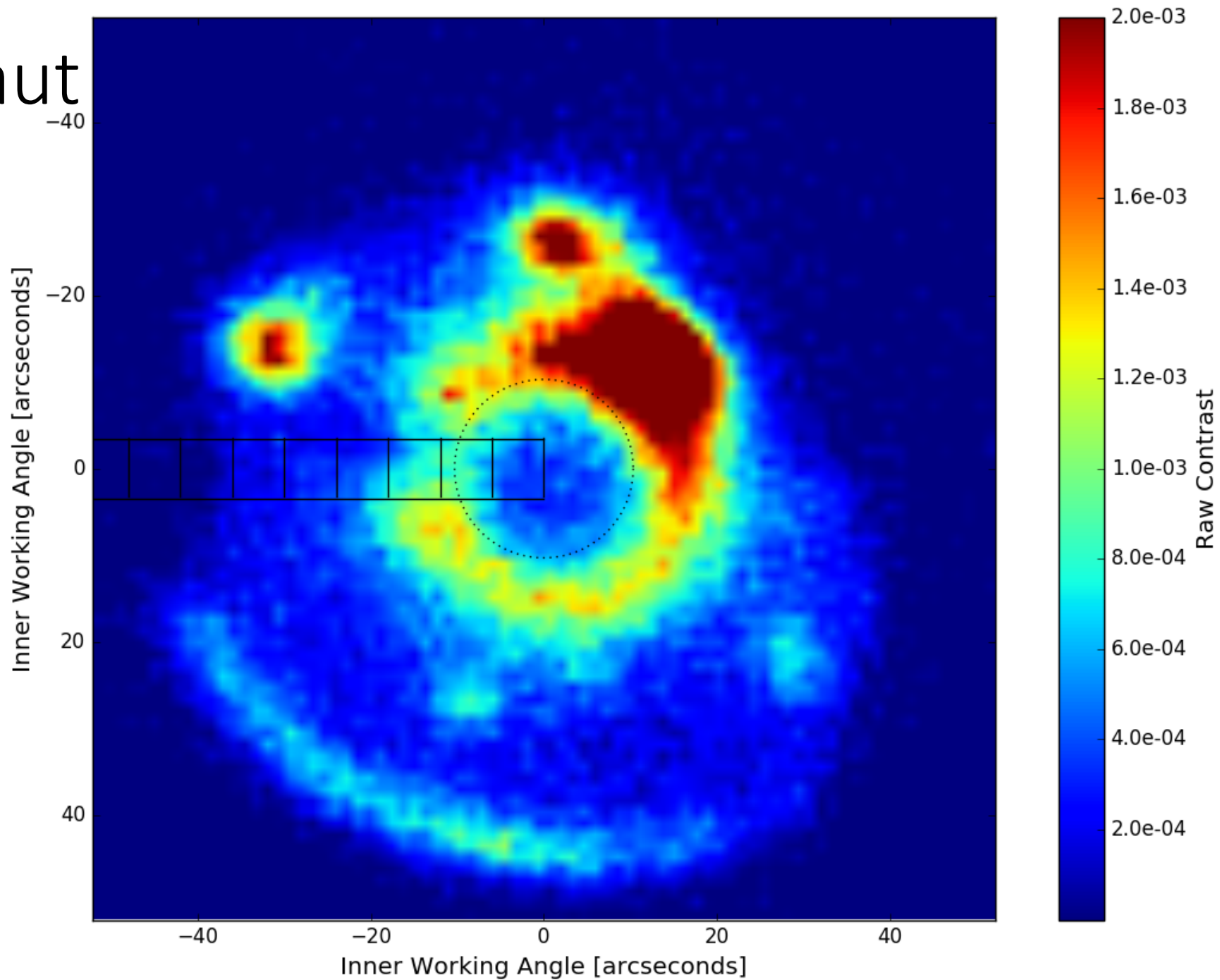
Altair

-Long Baseline



Fomalhaut

-Long Baseline



Vega

-Long Baseline

