Can CHARA Image Cool Starspot?

A Case Study of Lambda Andromedae

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Special Thanks

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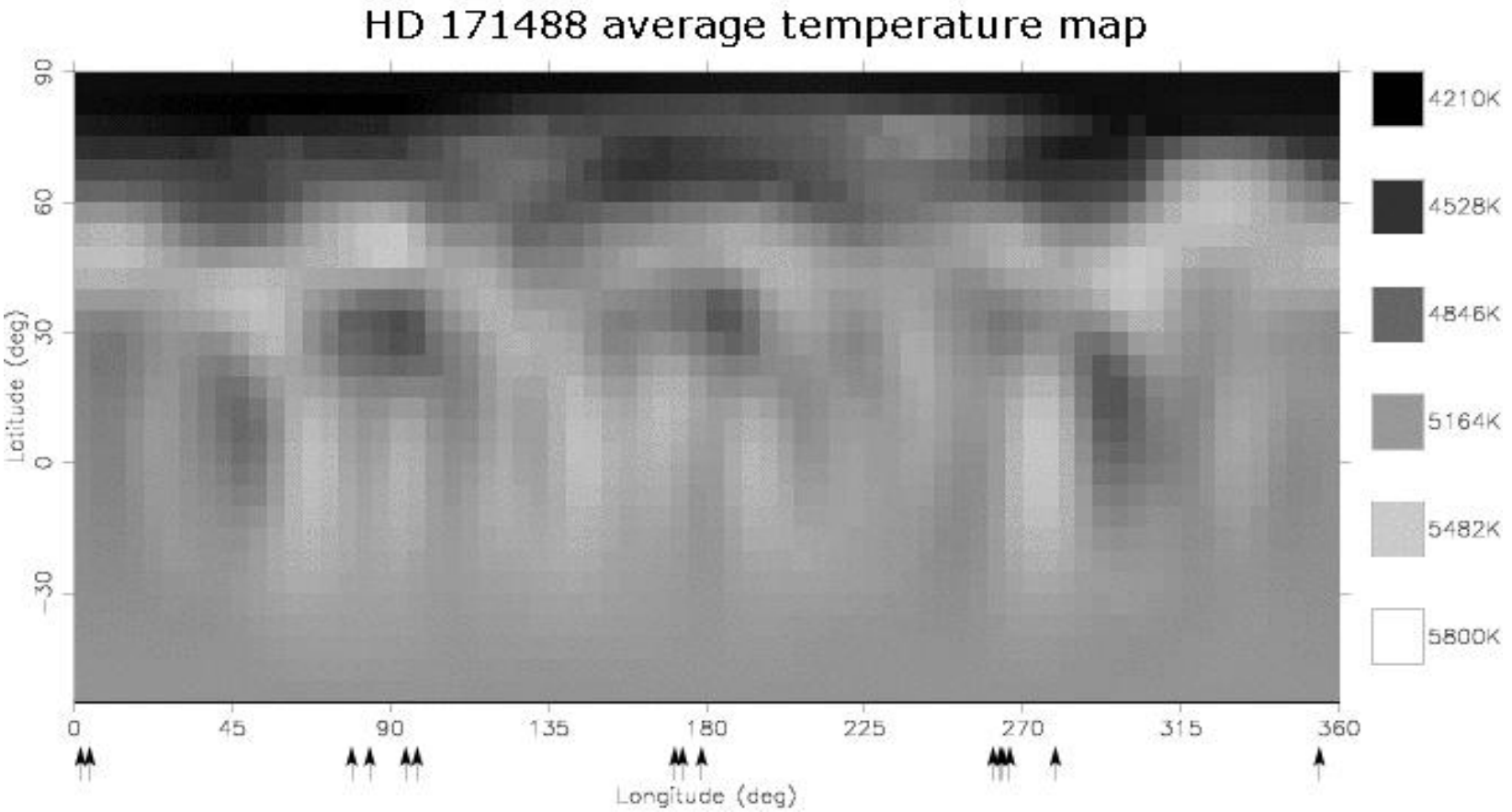
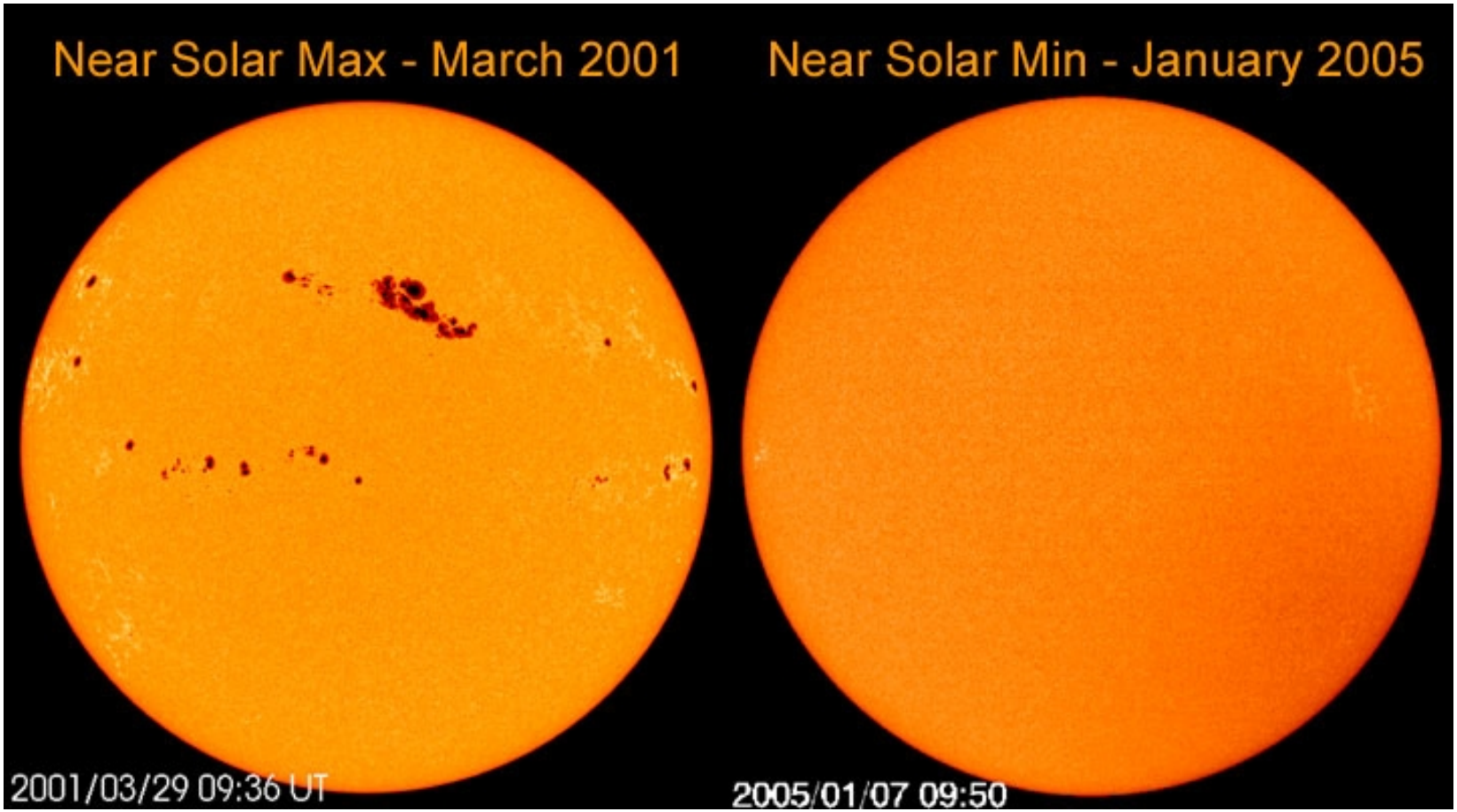
The CHARA team

Goals

Strassmeier et al. 2003

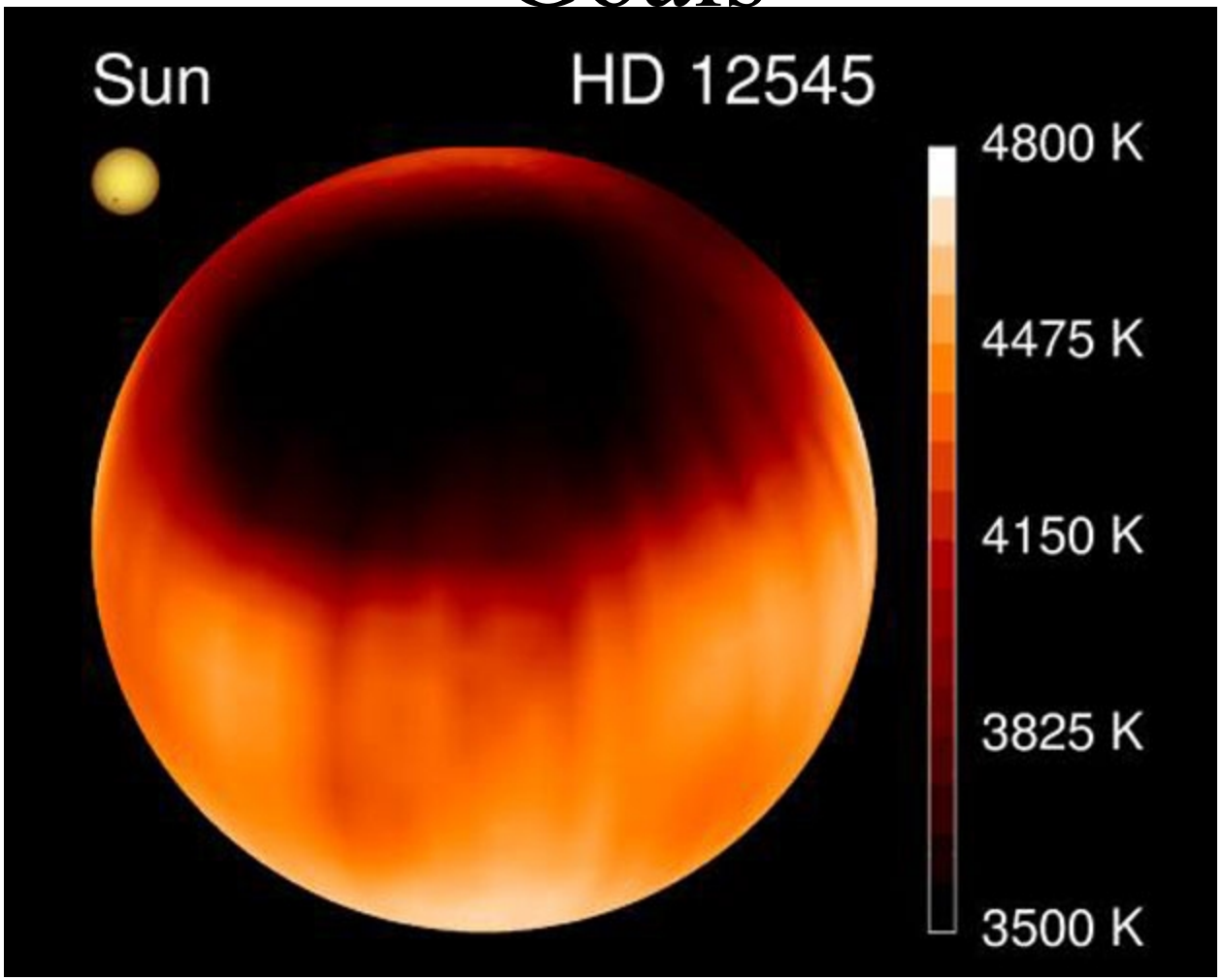


Goals


Near Solar Max - March 2001
Near Solar Min - January 2005
2001/03/29 09:36 UT
2005/01/07 09:50

Goals

Strassmeier 1999



Goals

- Directly image cool starspots
- Precisely measure cool starspot properties
- Observe stellar rotation via cool starspot motion
- Develop techniques for imaging other active stars → compare with Doppler maps

"Lambdy Andy"

G8 III

SB1

$\pi = 38.74 \pm 0.68$ mas

D ~ 25 pc

vsini = 6.5 km/s

$P_{phot} = 54.33$ days

H mag = 1.501

Δ V mag = 0.22

$\theta \sim 2.75$ mas

Henry et al. 1995

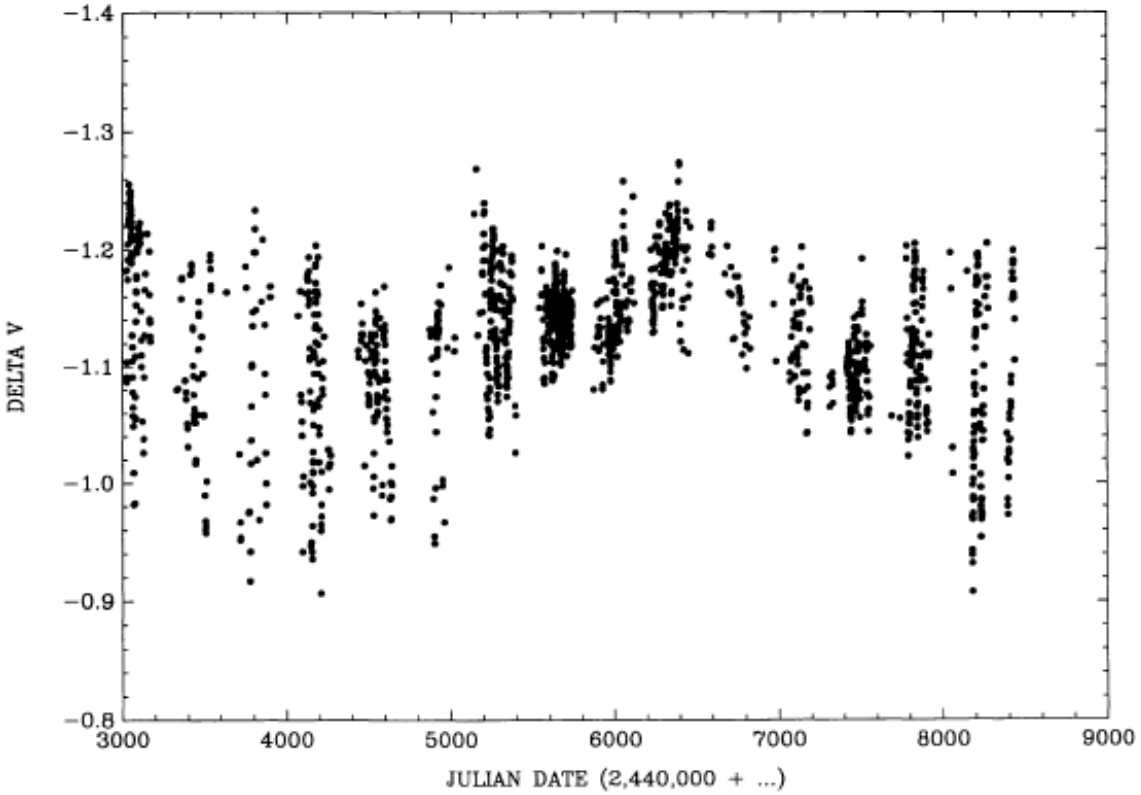
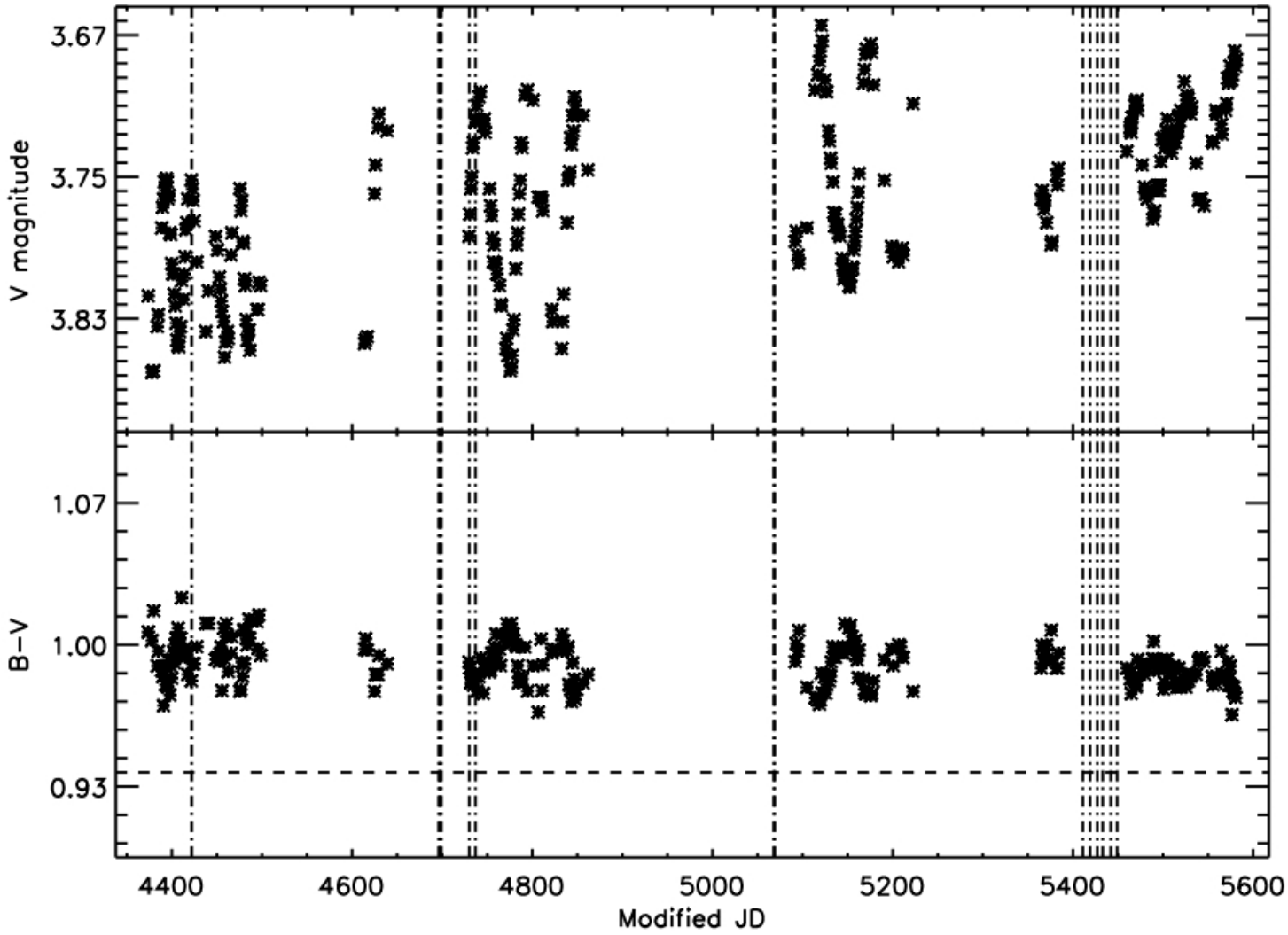


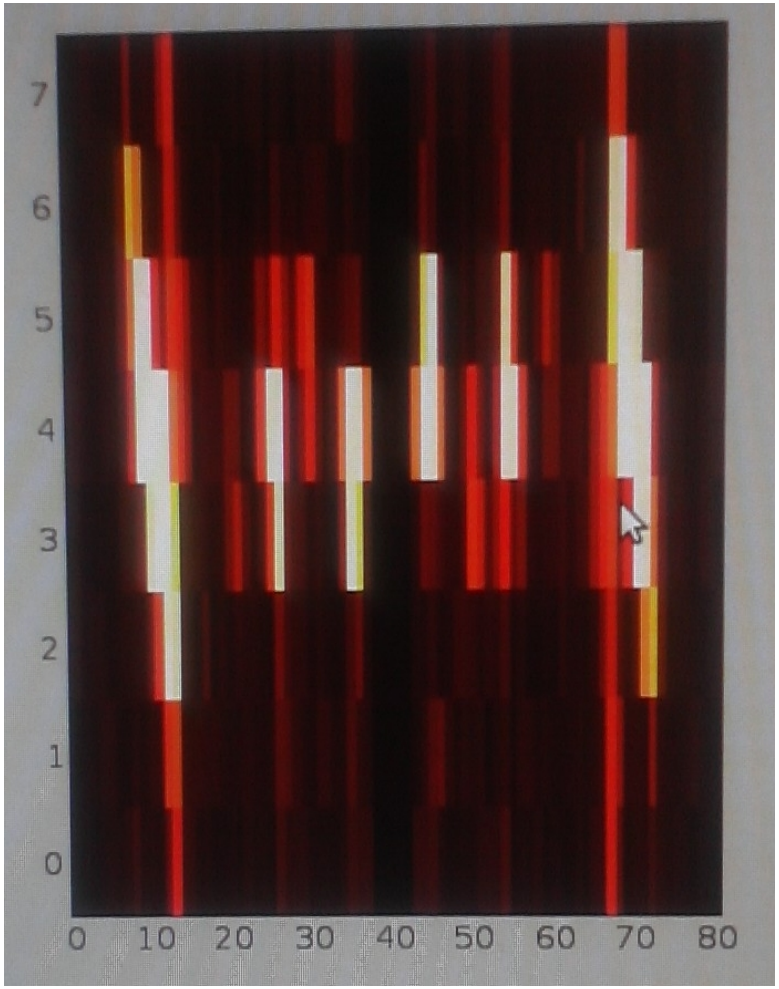
FIG. 2.—1976–1991 *V* light curve of λ And from the data sources listed in Table 1. Each point is the mean of (usually) three differential observations in the sense of λ And minus Ψ And. While the 54 day rotation period is difficult to see at this scale, the changing amplitude of the spot wave and the long-term variations in mean magnitude are readily apparent.

Lam And Light Curve 2007-2011

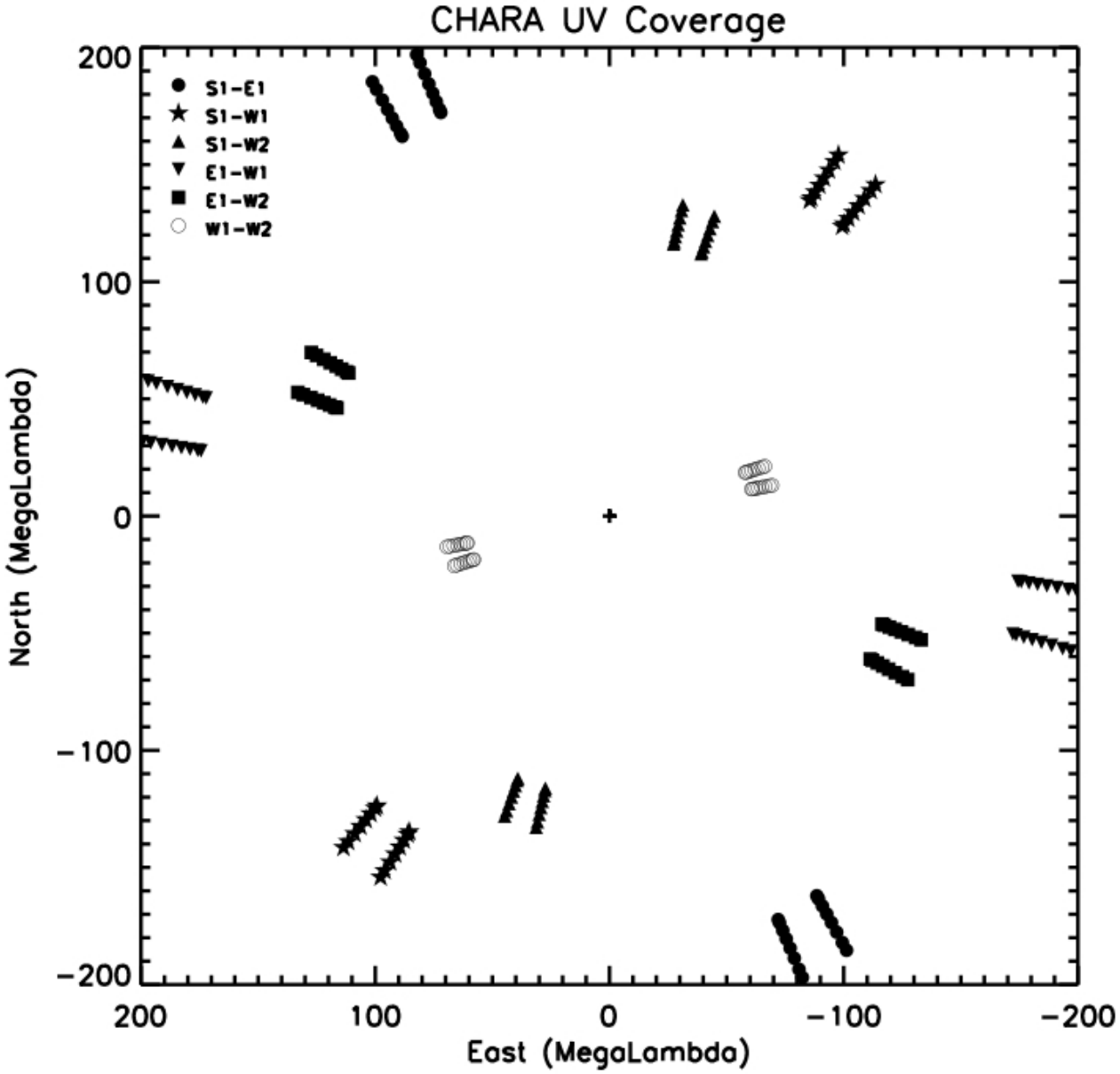


CHARA Observations

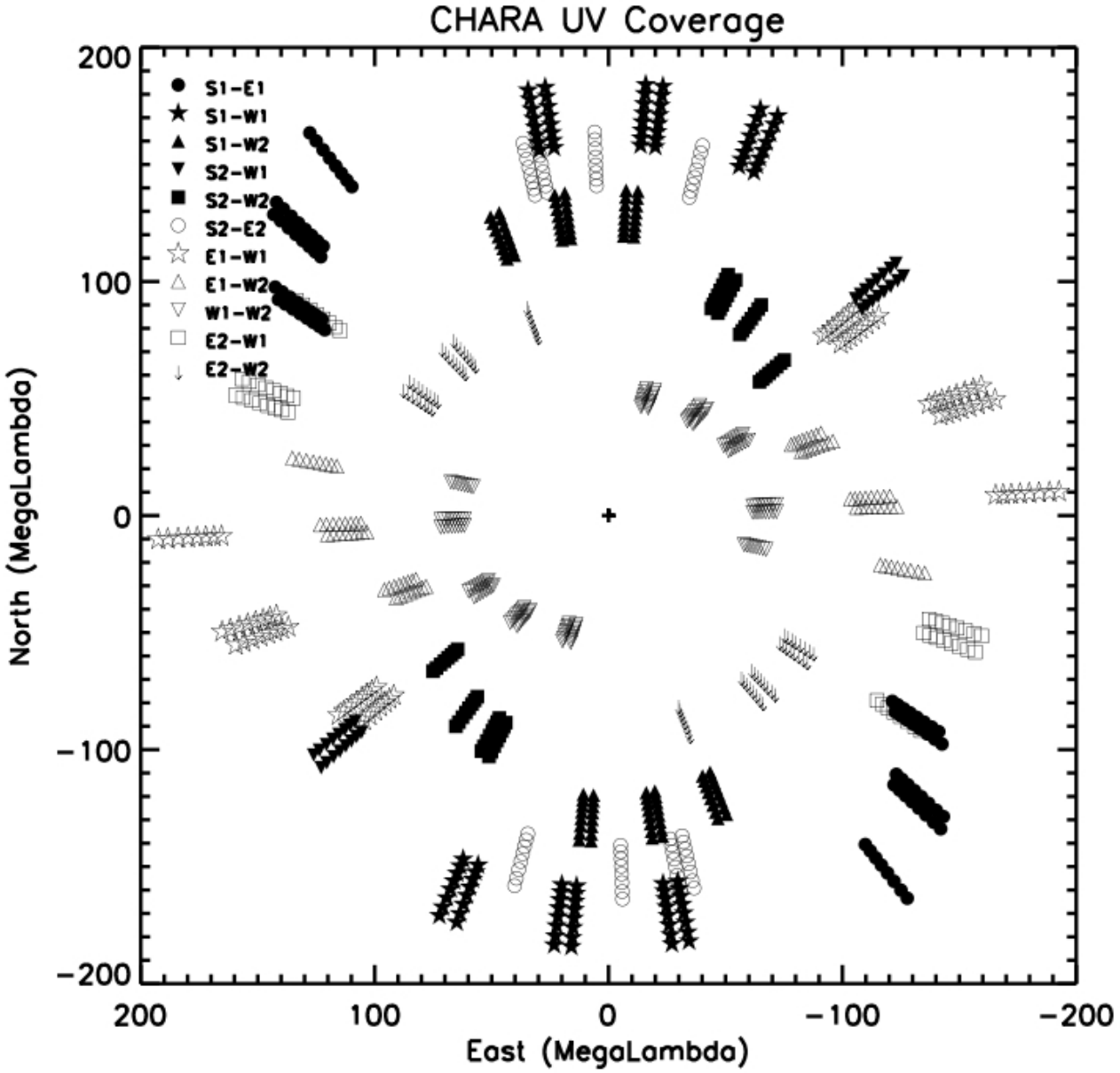
- MIRC – H band
- 21 epochs
  - 11/17/07 to 09/10/11
- Various UV coverage
- Mainly use "Schaefer" configuration



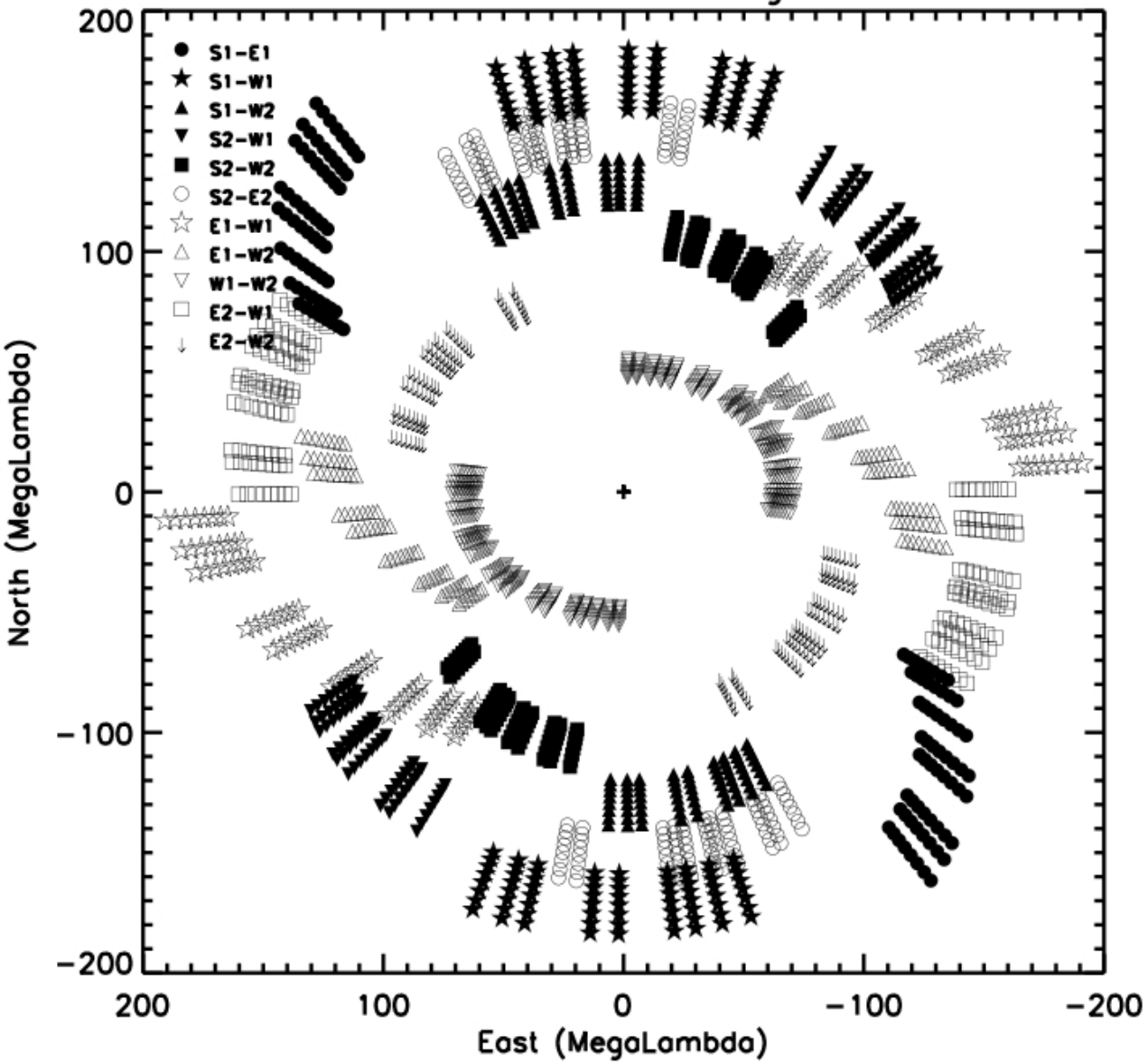
Aug 17, 2008


CHARA UV Coverage
S1-E1
S1-W1
S1-W2
E1-W1
E1-W2
W1-W2
North (MegaLambda)
East (MegaLambda)
200
100
0
−100
−200

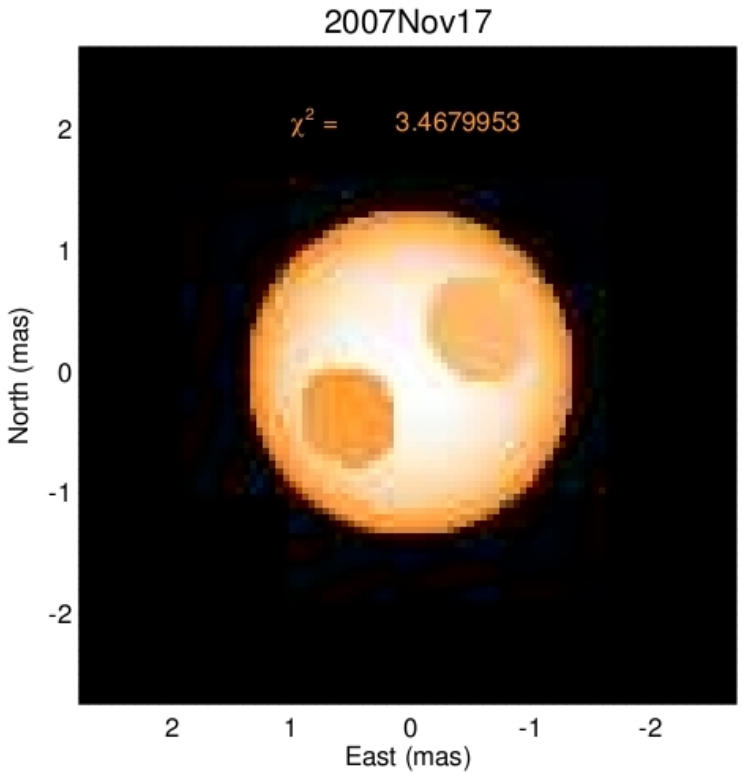
Aug 25, 2009


CHARA UV Coverage
S1-E1
S1-W1
S1-W2
S2-W1
S2-W2
S2-E2
E1-W1
E1-W2
W1-W2
E2-W1
E2-W2
North (MegaLambda)
East (MegaLambda)
200
100
0
−100
−200

Aug 24-25, 2010

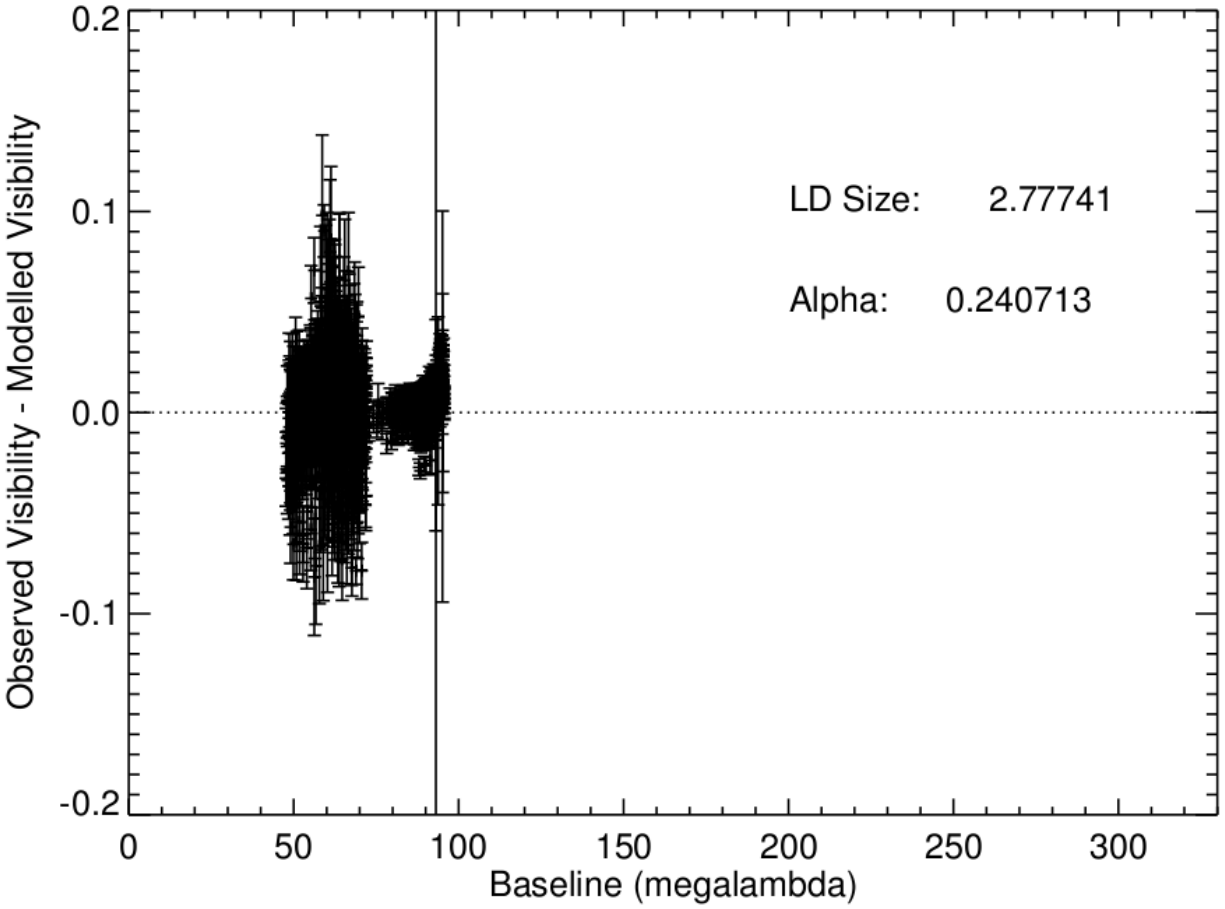


Parametric Model & Reconstructions

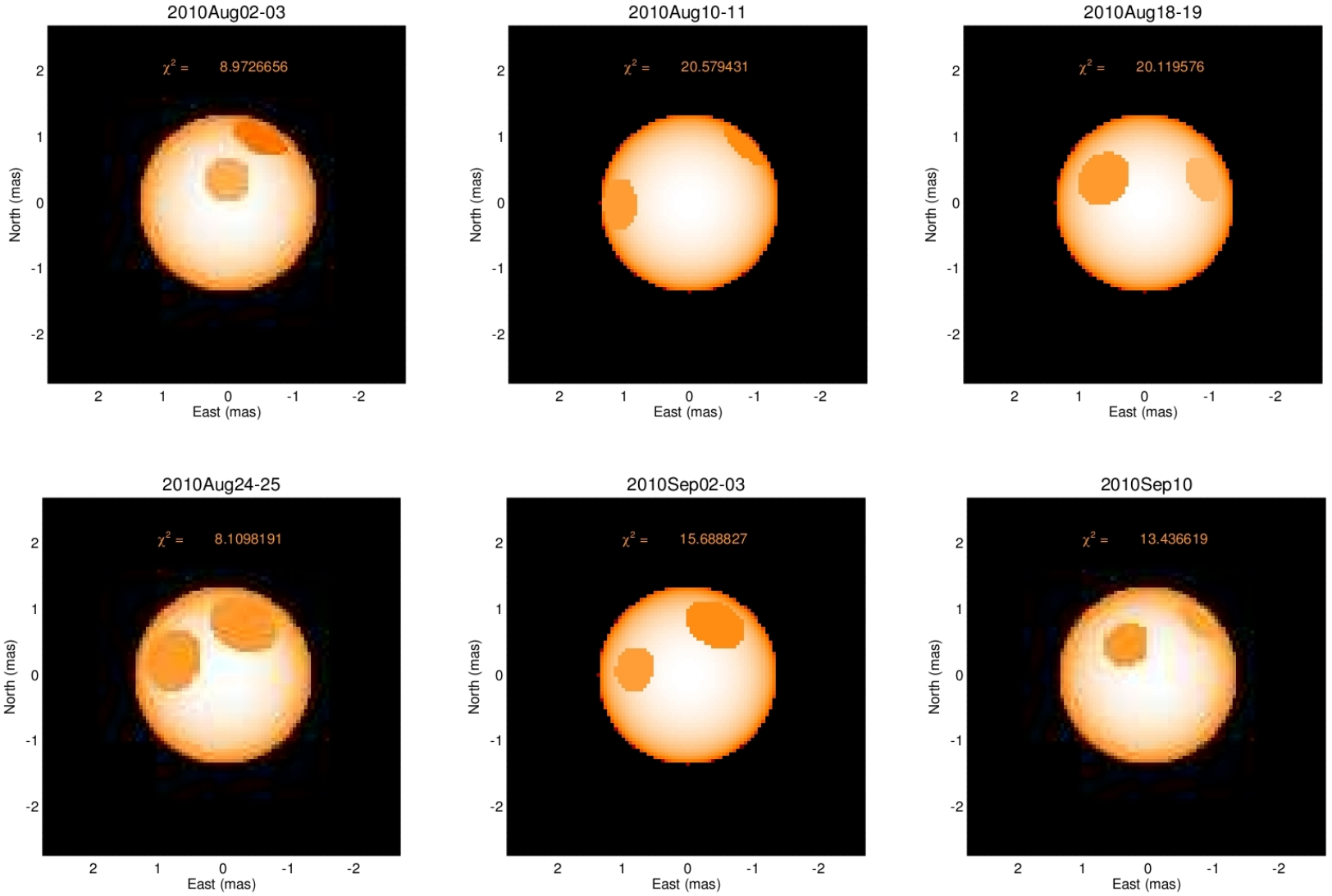


- Model
  - Power-law limb darkening
  - 2 stellar parameters
    - θ, α
  - N spot parameters
    - (φ, b, l, f) per spot
  - Downhill symplex
- MACIM & BSMEM

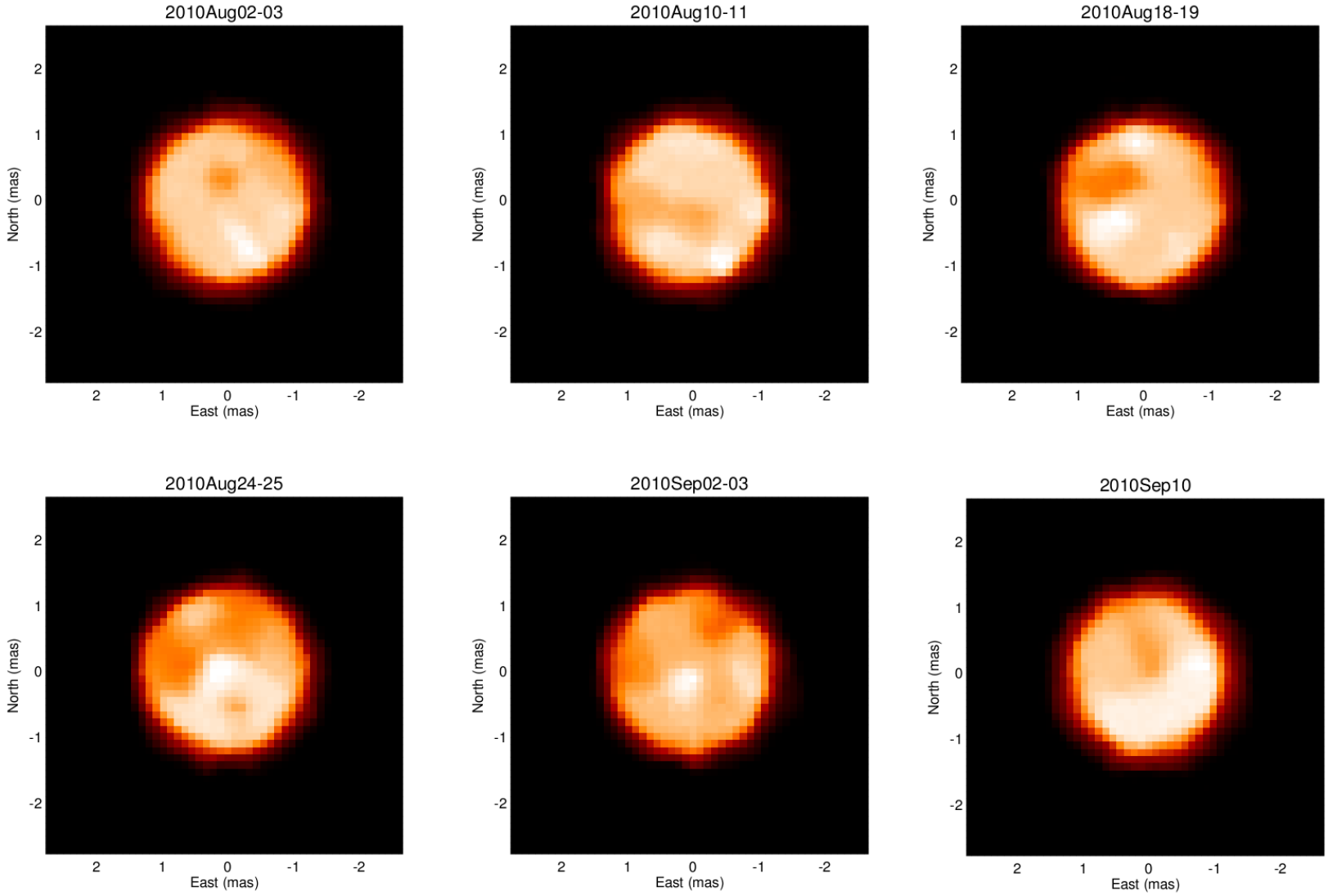
First Step....


Observed Visibility - Modelled Visibility
0.2
0.1
0.0
-0.1
-0.2
0
50
100
150
200
250
300
Baseline (megalambda)
LD Size: 2.77741
Alpha: 0.240713

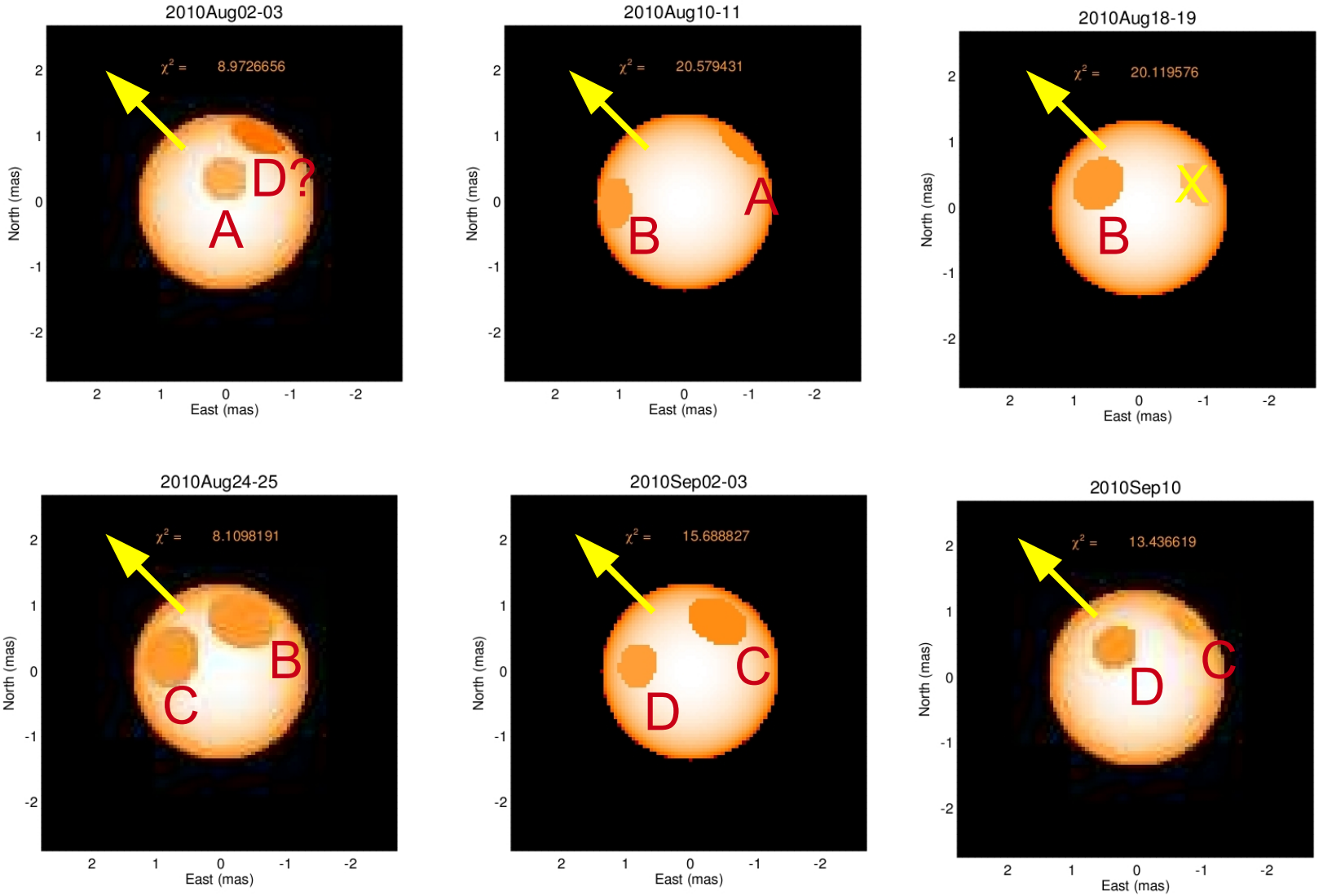
Consistency!

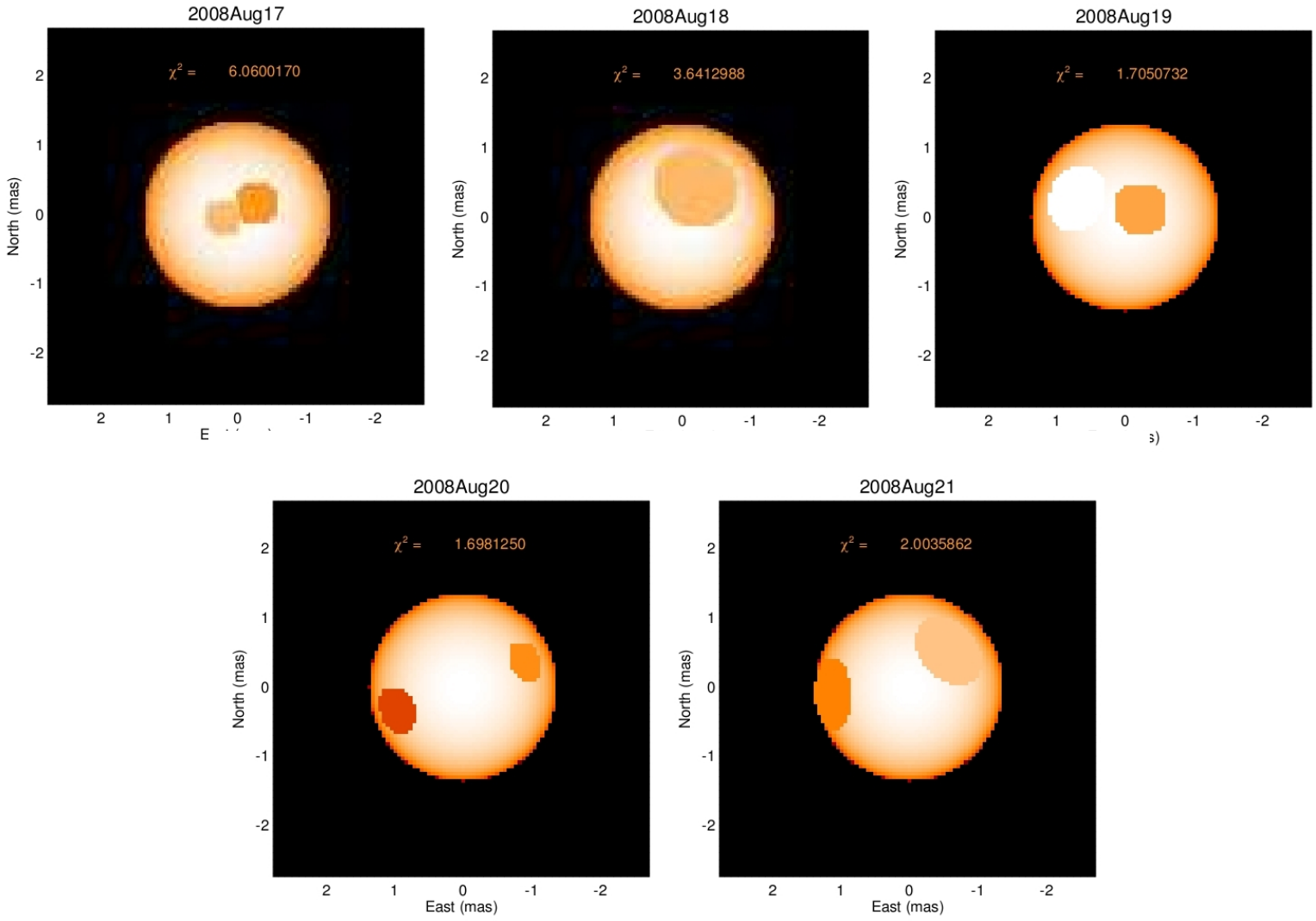


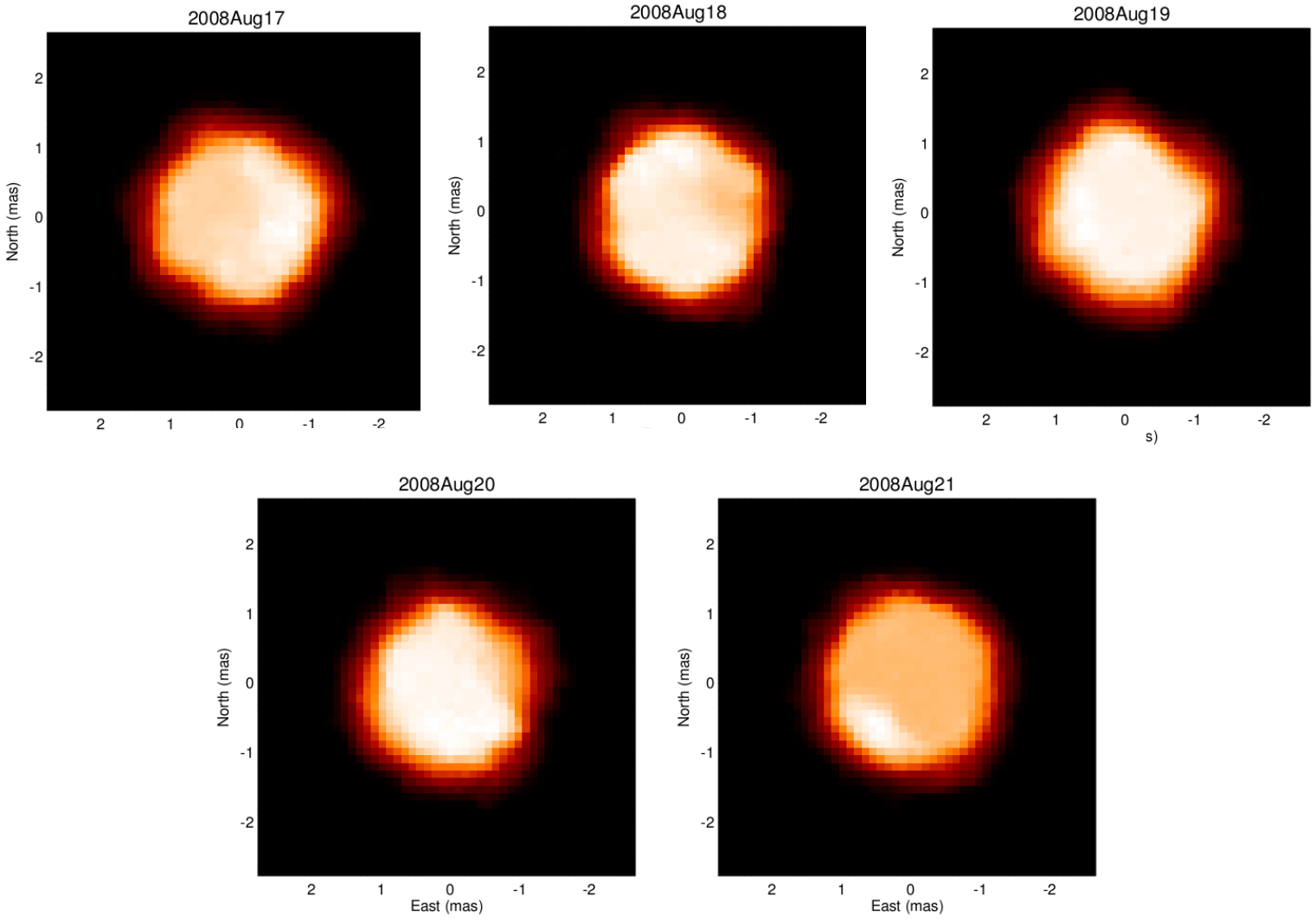
Consistency!



Rotation?


2010Aug02-03
χ² = 8.9726656
D?
A
2010Aug10-11
χ² = 20.579431
B
A
2010Aug18-19
χ² = 20.119576
X
B
2010Aug24-25
χ² = 8.1098191
B
C
2010Sep02-03
χ² = 15.688827
C
D
2010Sep10
χ² = 13.436619
D
C
North (mas)
East (mas)

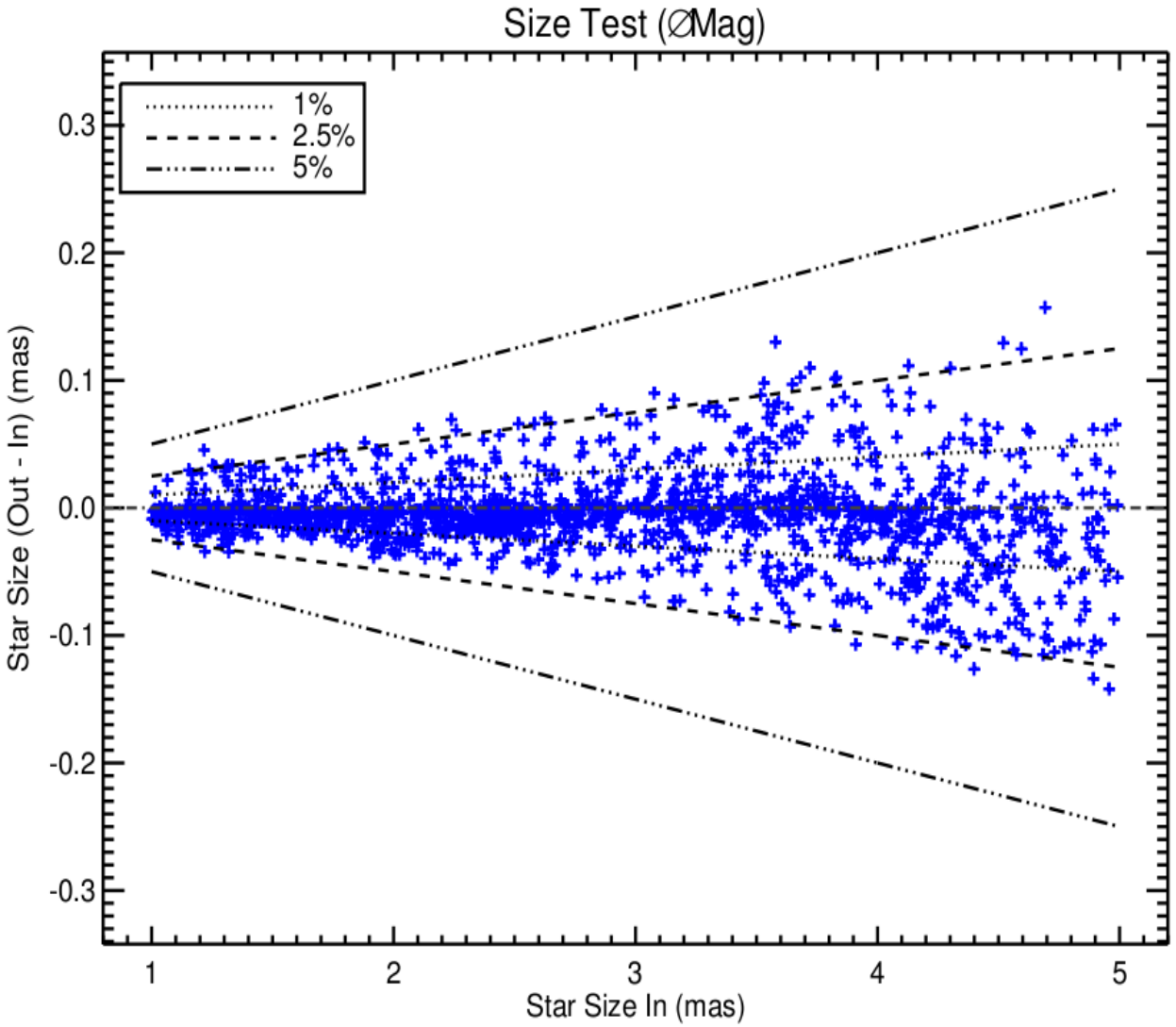

2008Aug17
χ^2 = 6.0600170
2008Aug18
χ^2 = 3.6412988
2008Aug19
χ^2 = 1.7050732
2008Aug20
χ^2 = 1.6981250
2008Aug21
χ^2 = 2.0035862
North (mas)
East (mas)
2
1
0
-1
-2

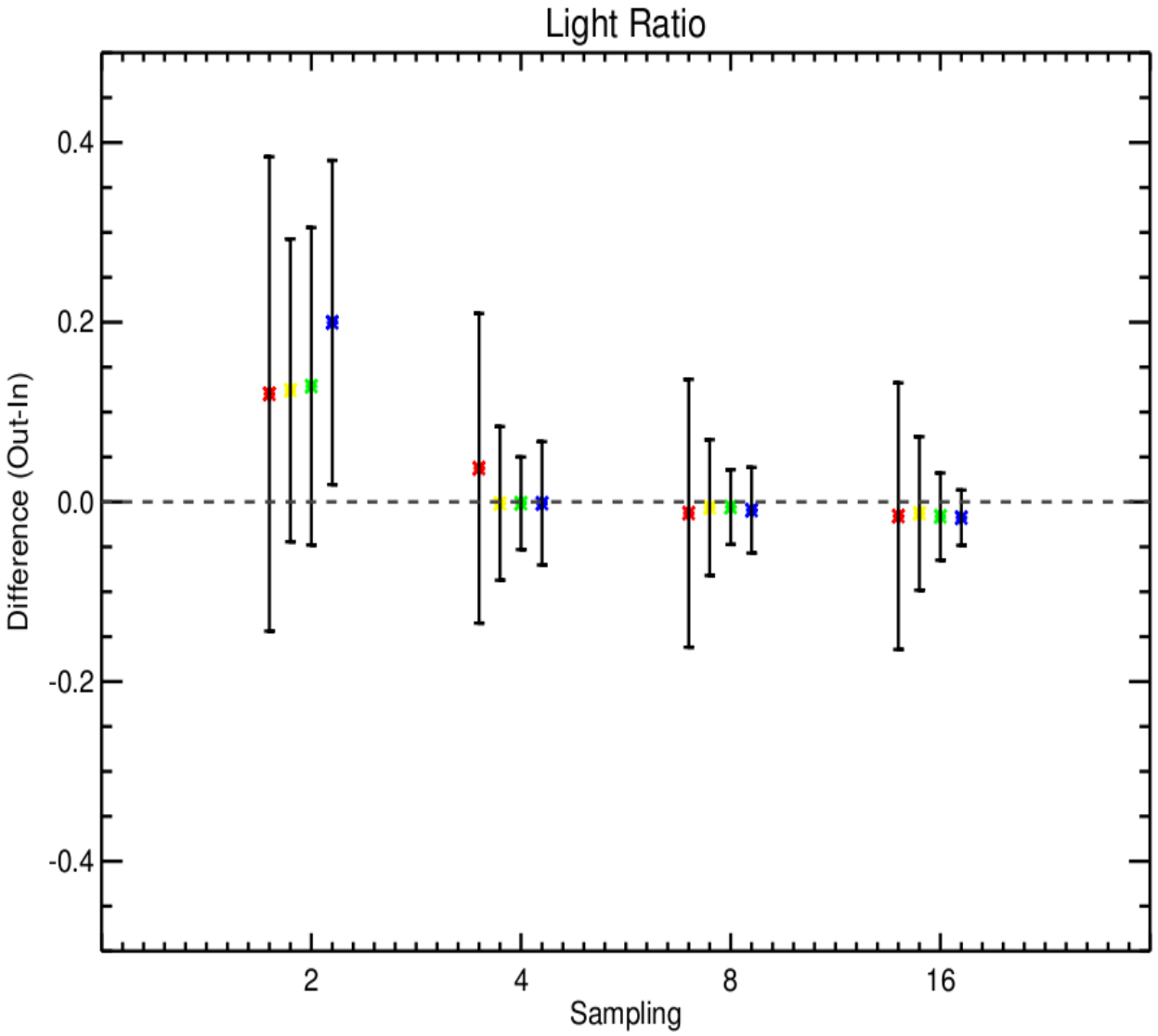

2008Aug17
2008Aug18
2008Aug19
2008Aug20
2008Aug21
North (mas)
East (mas)
2
1
0
-1
-2

Can We Believe These Results?

- Monte Carlo simulations
- Size Recovery – 2000
  - Only fit to 1st visibility lobe
- Spot Recovery – 500
  - Fixed θ & α
- One-spot model

Stellar Size	1 – 5 mas 2.75 mas
α	0.24
Covering Factor	10% - 60%
Latitude	-90° - +90°
Longitude	-90° - +90°
Light Ratio	0.2 - 0.8
Δ Mag Range	~0.0 - 0.25


Size Test (ØMag)
1%
2.5%
5%
Star Size (Out - In) (mas)
Star Size In (mas)
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
1
2
3
4
5

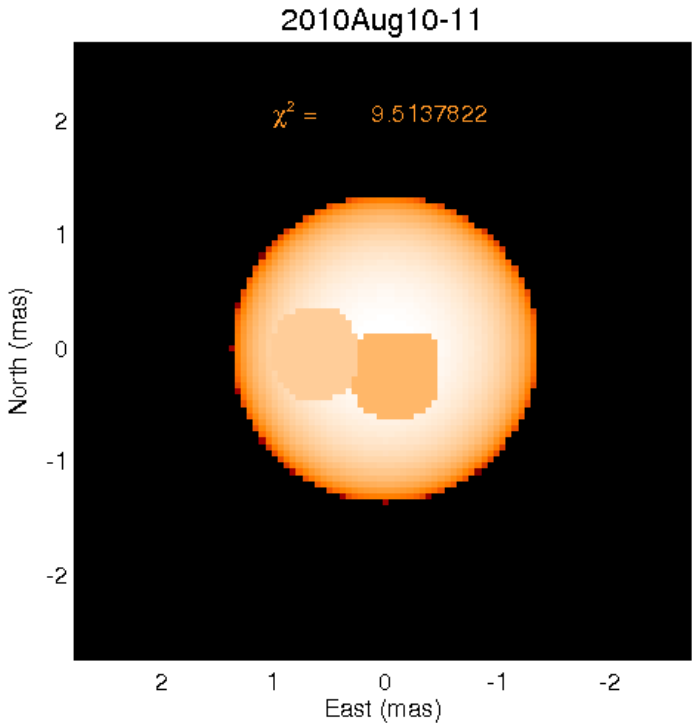

Light Ratio
Difference (Out-In)
0.4
0.2
0.0
-0.2
-0.4
2
4
8
16
Sampling

χ^2 Question

- Four averaging methods

$$\chi_r^2 = \frac{\left(\chi_v^2 + \chi_c^2 + \chi_t^2\right)}{3}$$

Straight Average

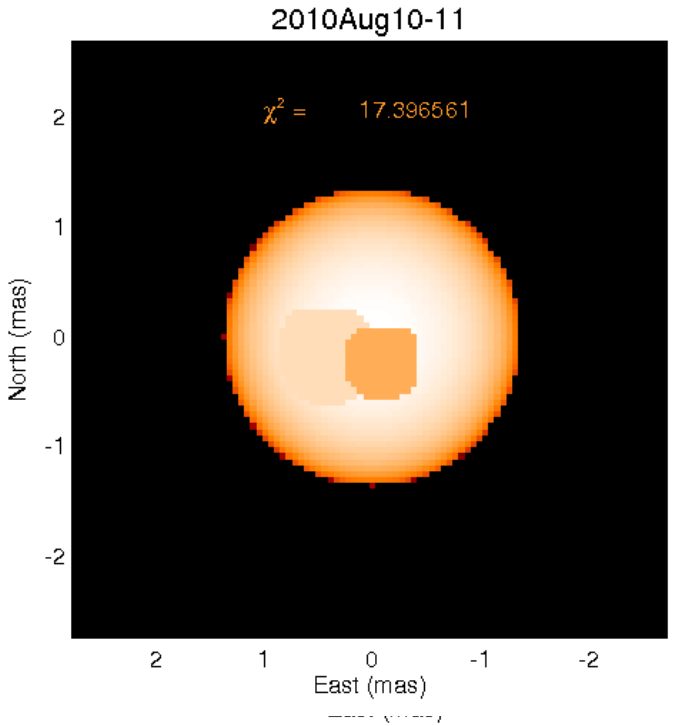


χ^2 Question

- Four averaging methods

$$\chi^2_r = \frac{\left((\chi^2_v)^2 + (\chi^2_c)^2 + (\chi^2_t)^2\right)}{(\chi^2_v + \chi^2_c + \chi^2_t)}$$

"Squared" Average

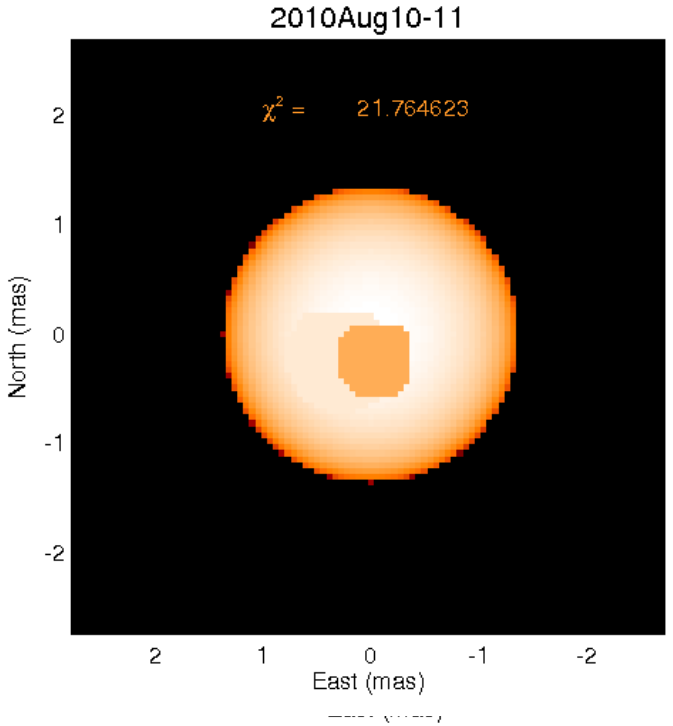


χ^2 Question

- Four averaging methods

$$\chi^2_r = \frac{\left((\chi^2_v)^2 + (2\chi^2_c)^2 + (\chi^2_t)^2\right)}{(\chi^2_v + 4\chi^2_c + \chi^2_t)}$$

"Twice-cp" average

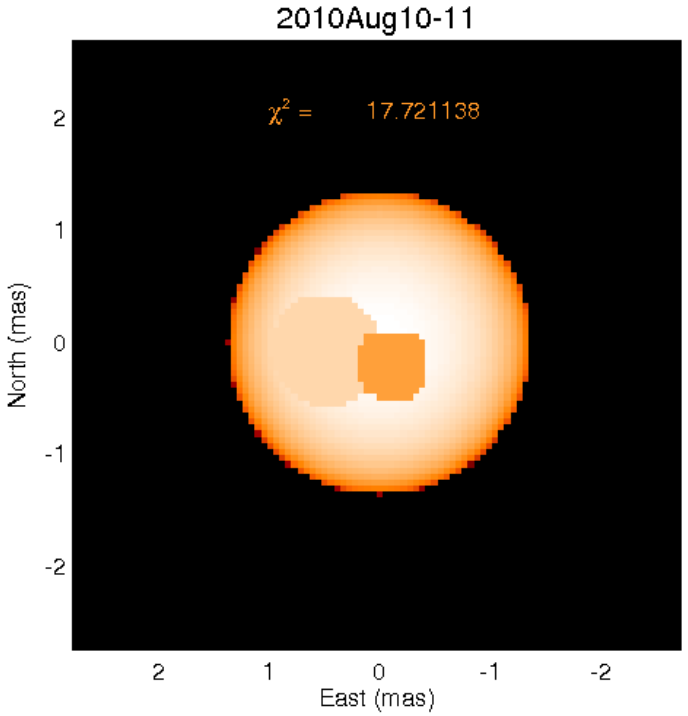


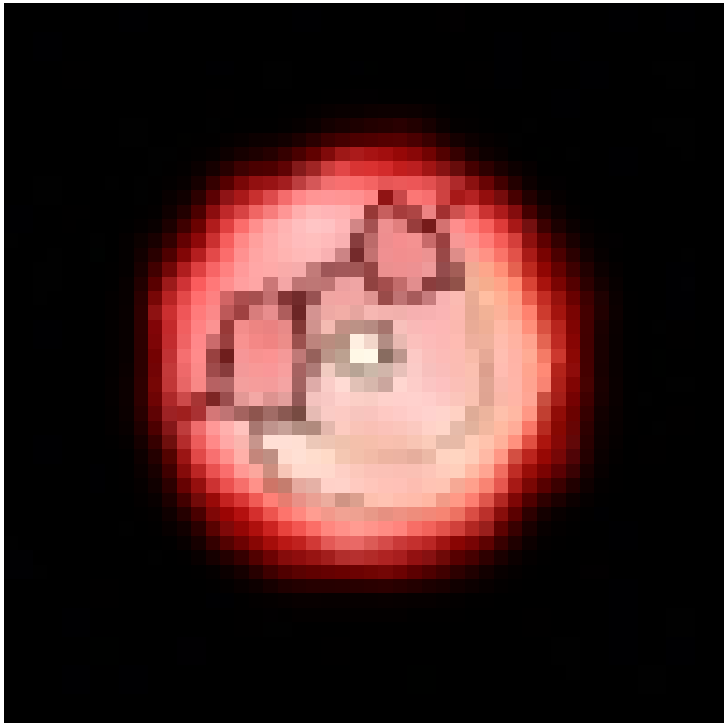
χ^2 Question

- Four averaging methods

$$\chi^2_r = \frac{\left((\chi^2_v)^2 + (\chi^2_c)^2 + (\frac{2}{3}\chi^2_t)^2\right)}{(\chi^2_v + \chi^2_c + (\frac{4}{9})\chi^2_t)}$$

"2/3 T3" Average



Answer:

Yes...Probably