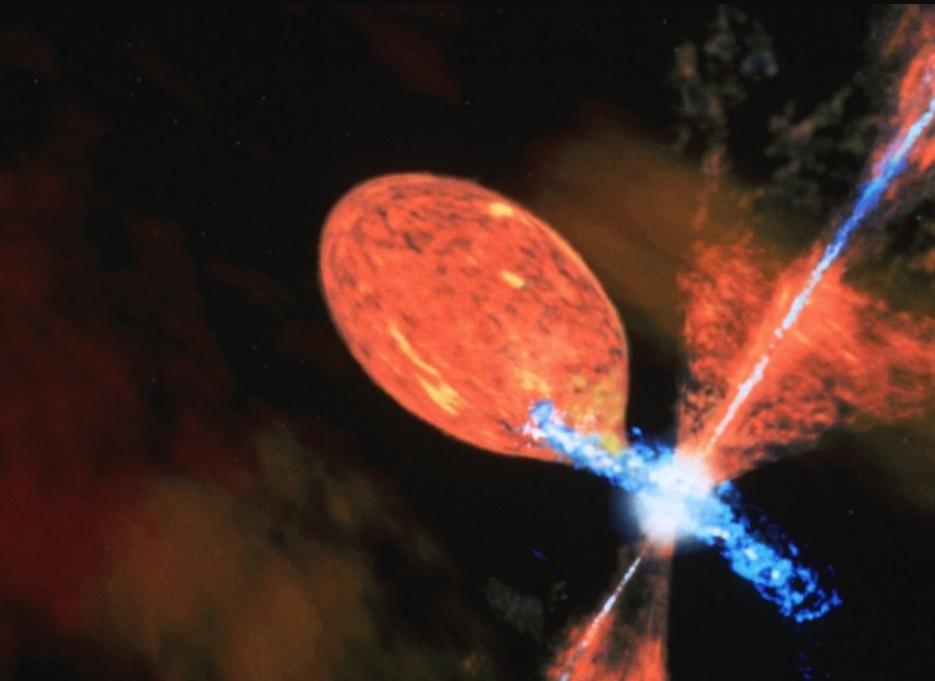


# Investigating Mass Transfer in Symbiotic Stars: A High-Resolution Approach

Thomas Gaudin

PSU Lunch Talk 4/11/23

# What are Symbiotic Stars?



- **3 components:**
  - Cool Giant
  - Hot Compact Object
  - Dense Circumstellar Medium
- **Widest interacting binary systems**
  - Earth-like orbital parameters

# Mass Transfer in Symbiotic Stars: What is the governing mechanism?

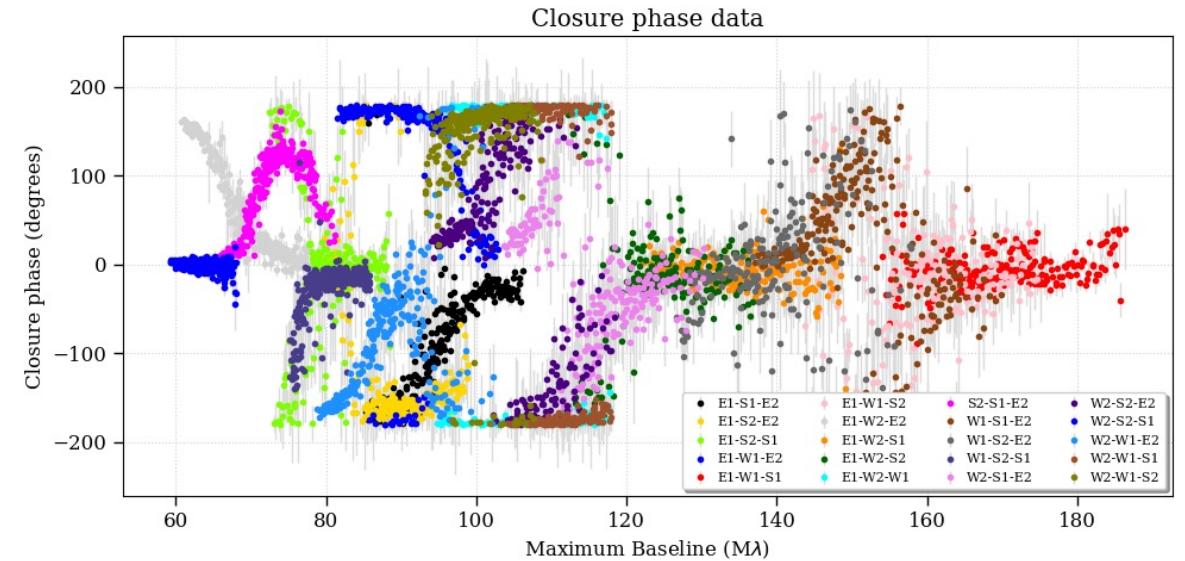
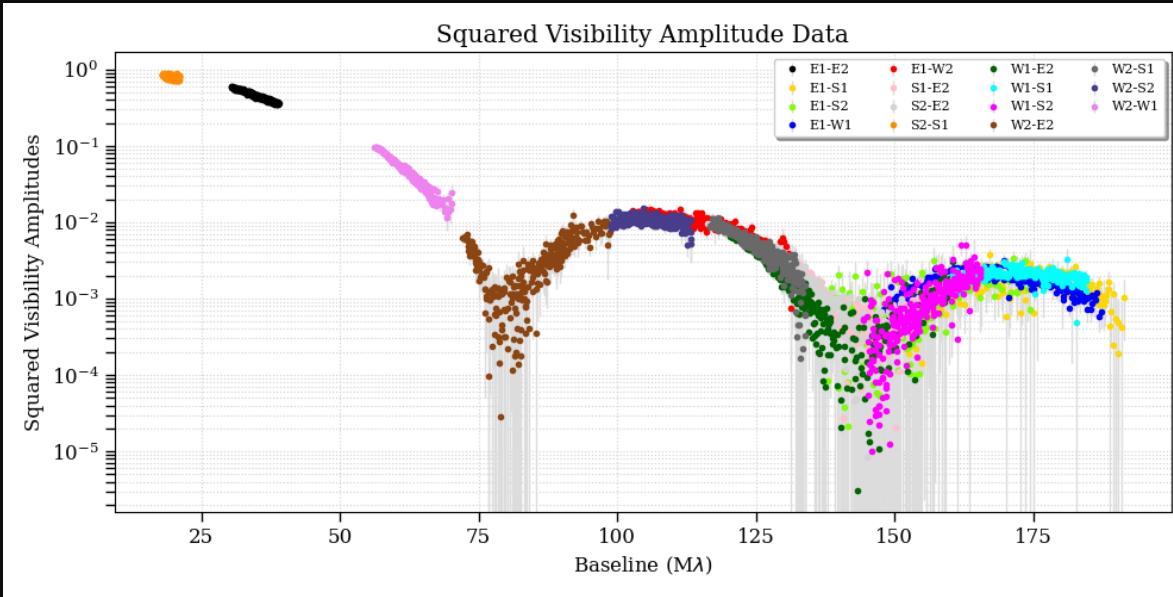
- Evidence for Roche lobe overflow
  - Ellipsoidal variations in observed light curve
- Evidence against Roche lobe overflow
  - Derived radius from light curve is inconsistent with radial velocity measurements
  - Numerical simulations raise questions about stability
- Do symbiotic stars fill their Roche lobe?

# An Interferometric Approach



- **CHARA Array: NIR Interferometry**
  - 6 telescopes
  - 300m baseline maximum
  - $\sim 0.5$  mas imaging resolution
- **Goals:**
  - Directly resolve disk of 4 nearby symbiotic red giants
  - Examine shape for evidence of a filled Roche lobe

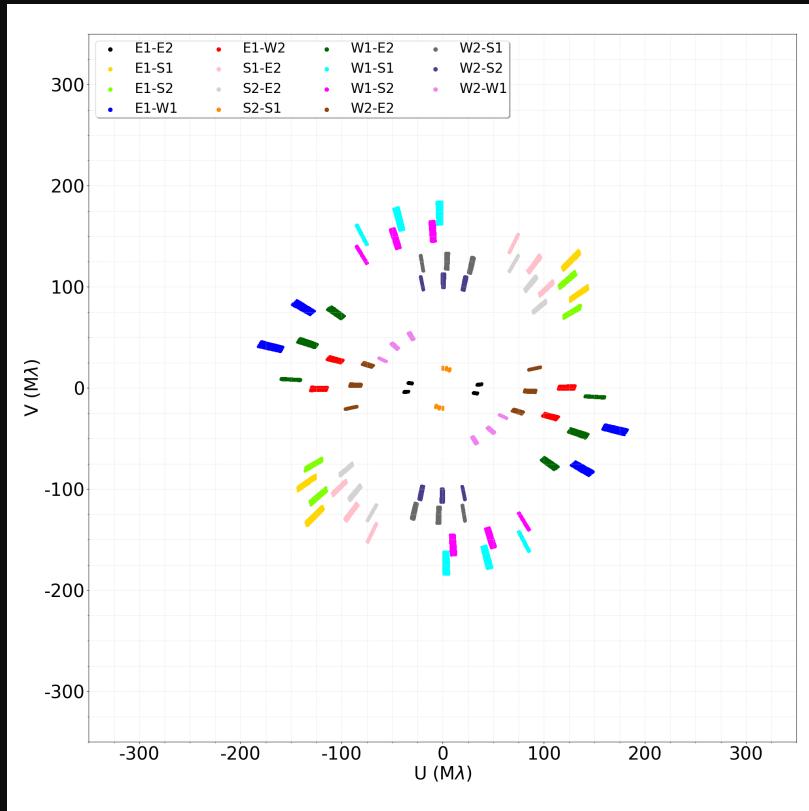
# Basics of Optical Interferometry Observables



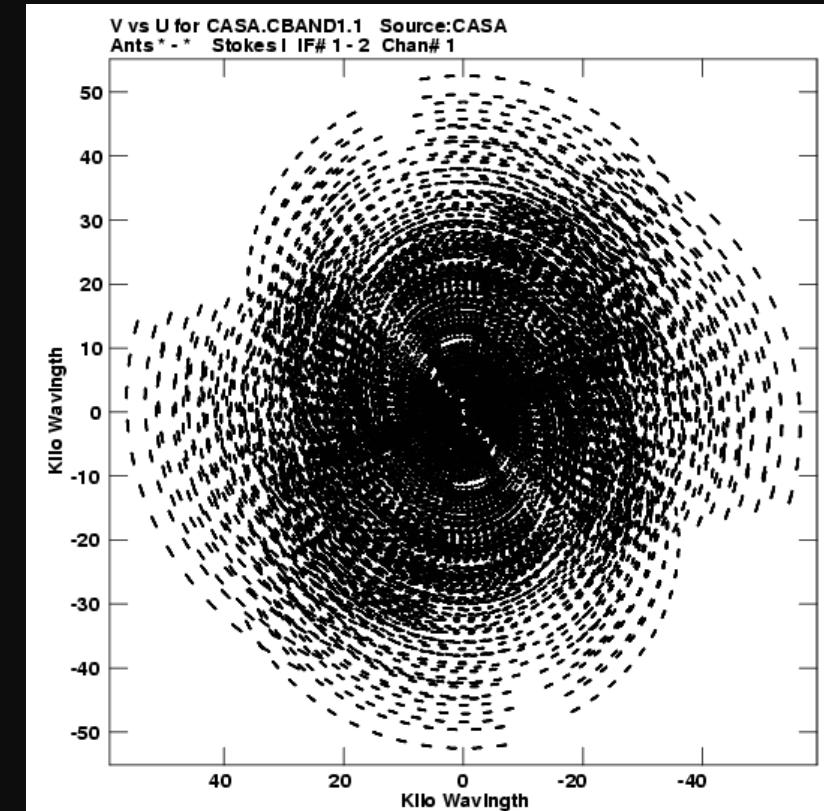
Squared Visibilities

Closure Phases

# Difficulties of Optical Interferometry

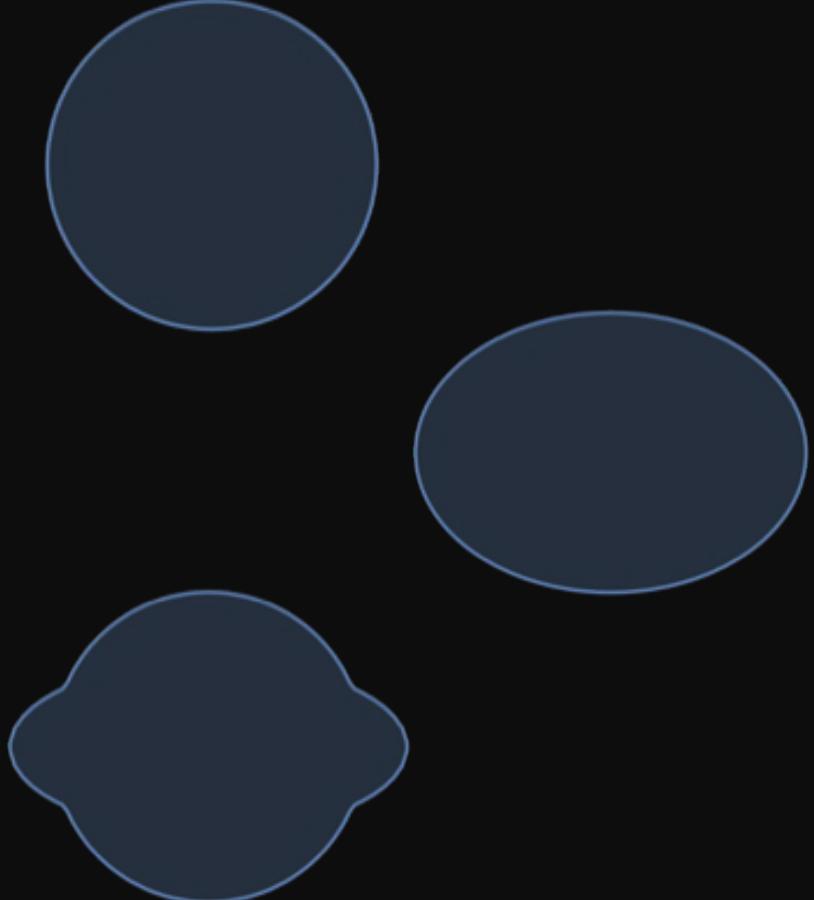


Optical



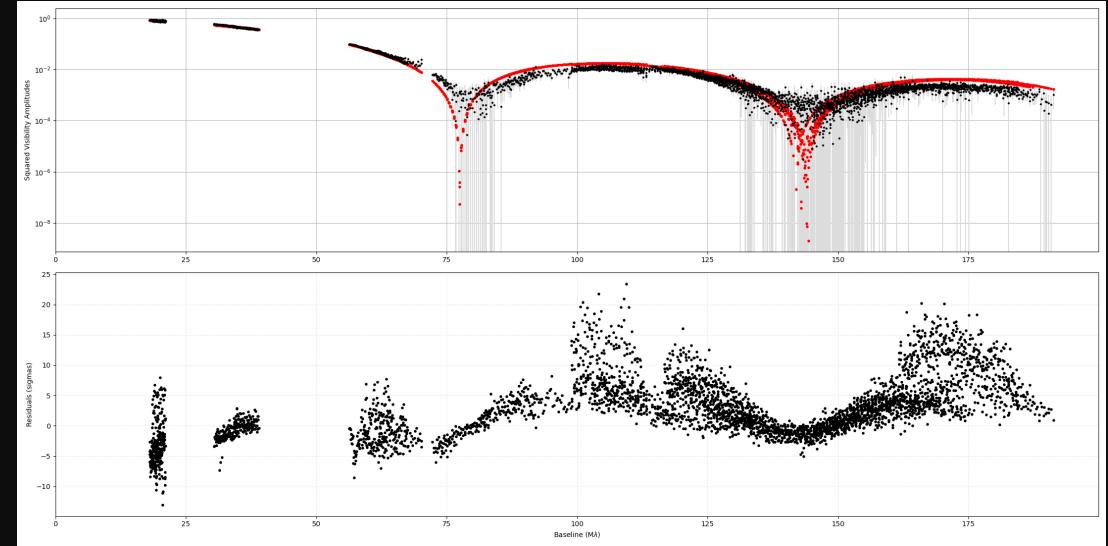
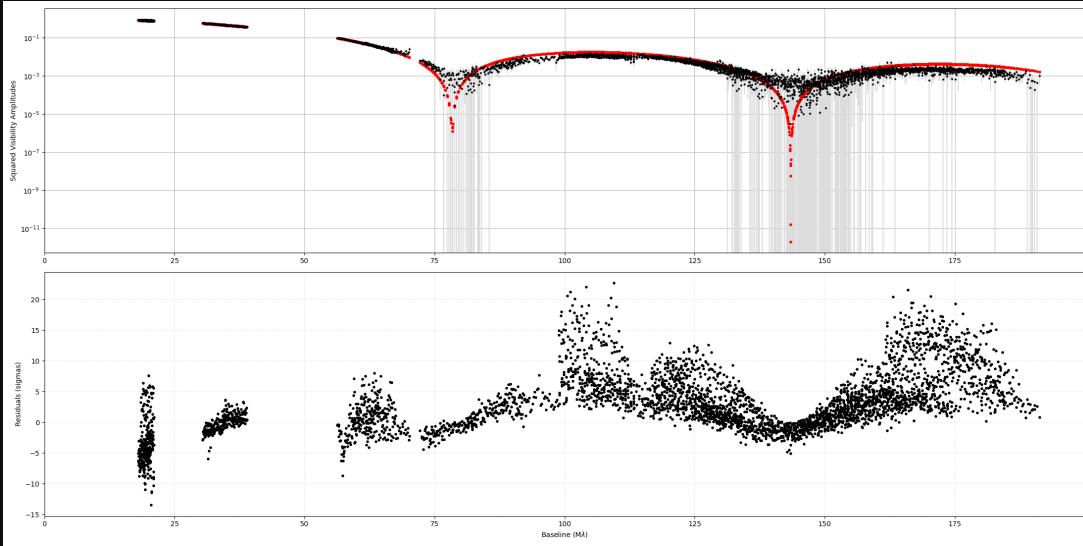
Radio

# Model Fitting Analysis



- Performed using nested sampling Monte Carlo methods
- No analytical visibility function exists for the Roche potential
- 3 Model shapes used:
  - Uniform Disk
  - Elongated Disk
  - Multi-component model

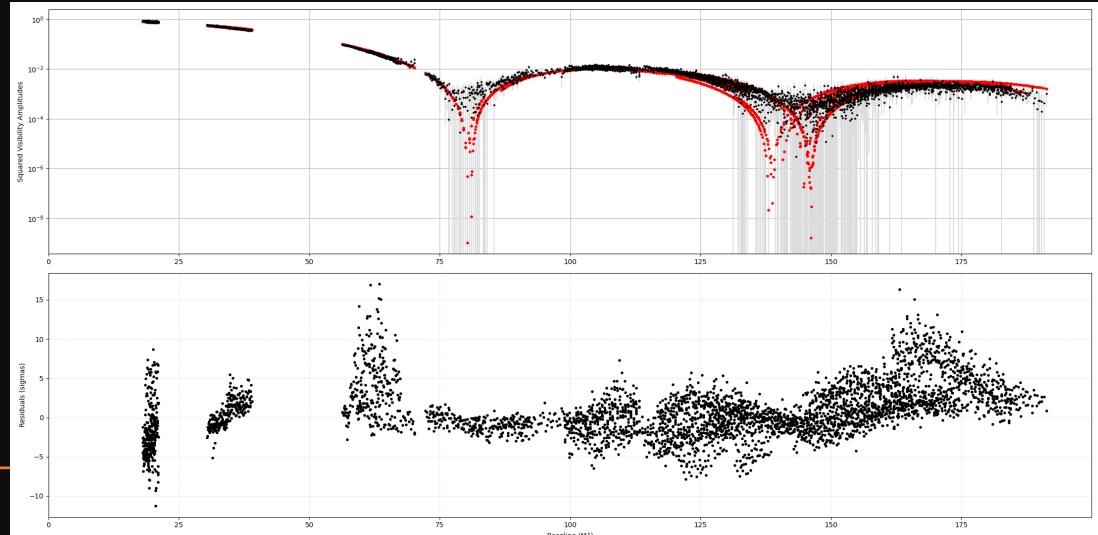
# Model Fitting Analysis



Uniform Disk  $\chi^2$  - 30.1

Elliptical Disk  $\chi^2$  - 29.5

Hybrid Disk  $\chi^2$  - 14.6

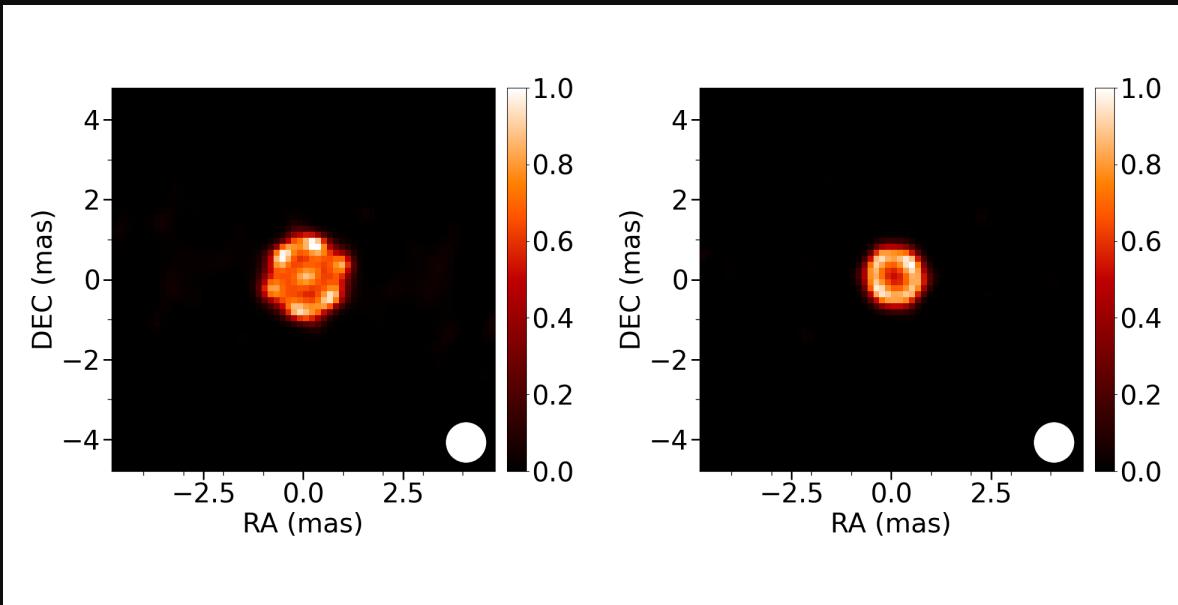


TARGET: SU Lyn

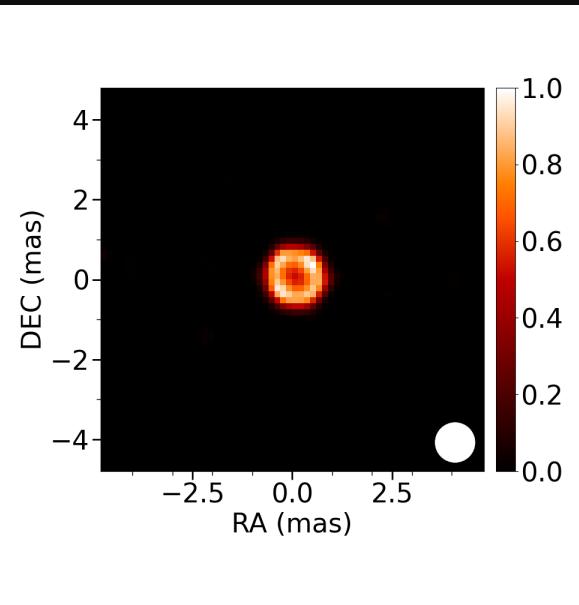
# Model Fitting Analysis

Target	$\chi^2$ UD	$\chi^2$ ED	$\chi^2$ Multi	$\frac{R_*}{R_L}$
V1724 Aql	11.7	10.7	5.53	0.3-0.5
EG And	2.67	2.57	2.37	$\sim 0.3$
BD Cam	33.96	24.1	14.0	< 0.4
SU Lyn	30.1	29.5	14.6	-----

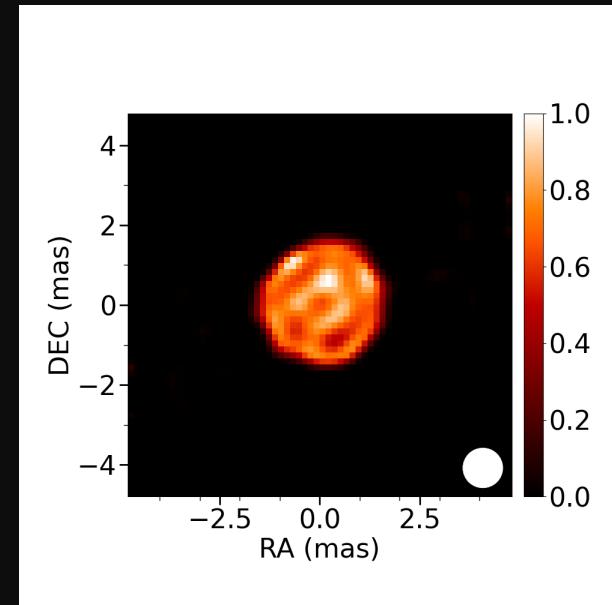
# Imaging Analysis: Initial SQUEEZE Images



V1472 Aql

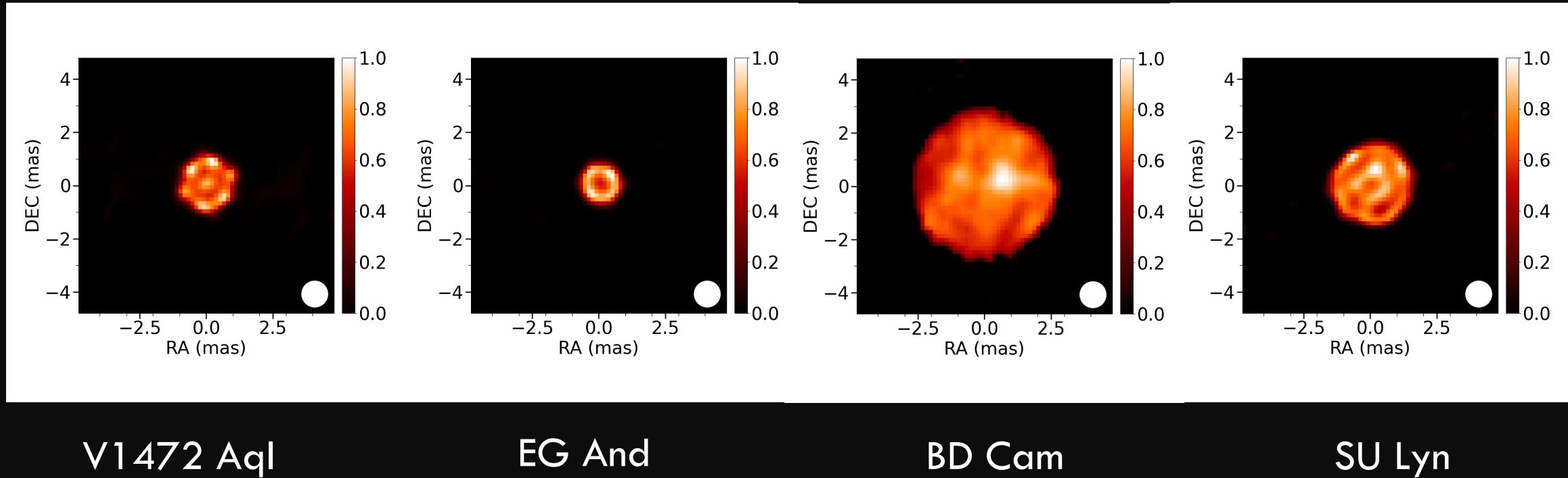


EG And

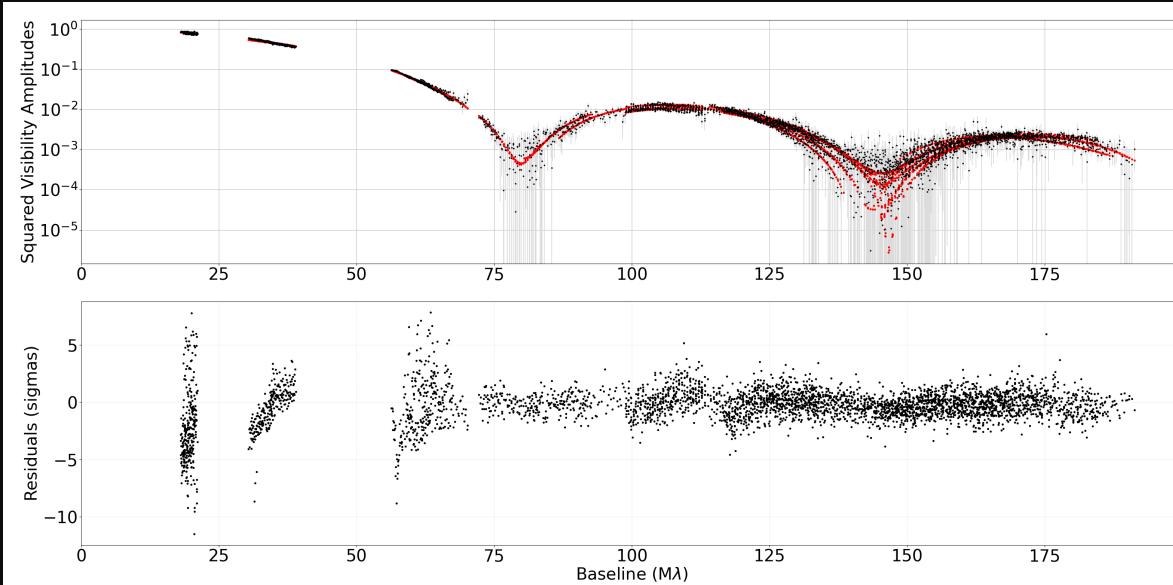


SU Lyn

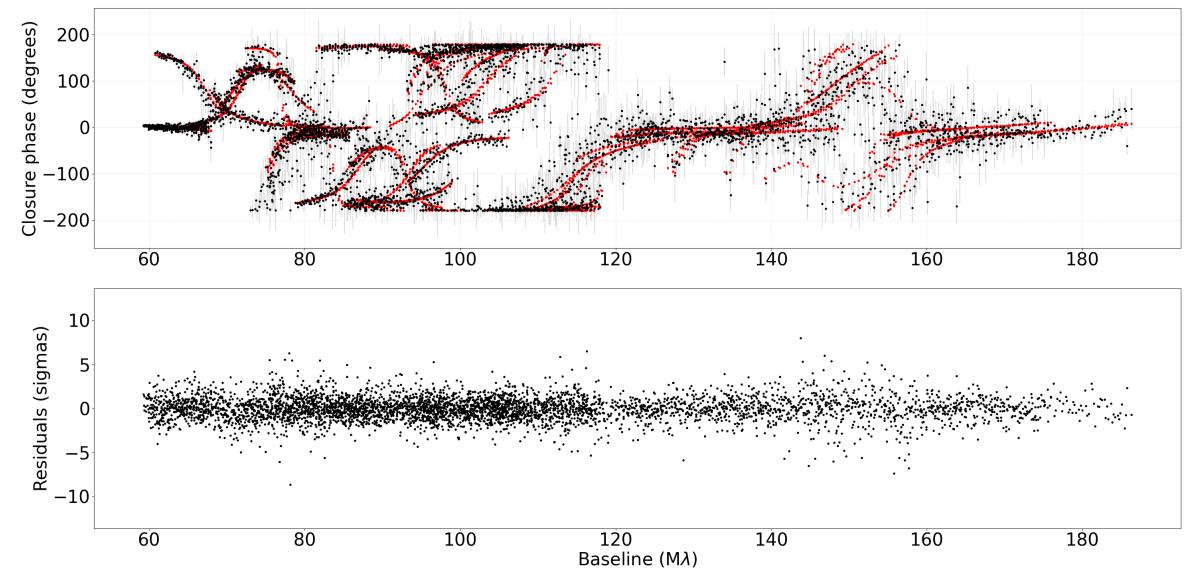
# Imaging Analysis: Prior-Influenced SQUEEZE Images



# Imaging Analysis: Simulated Observations



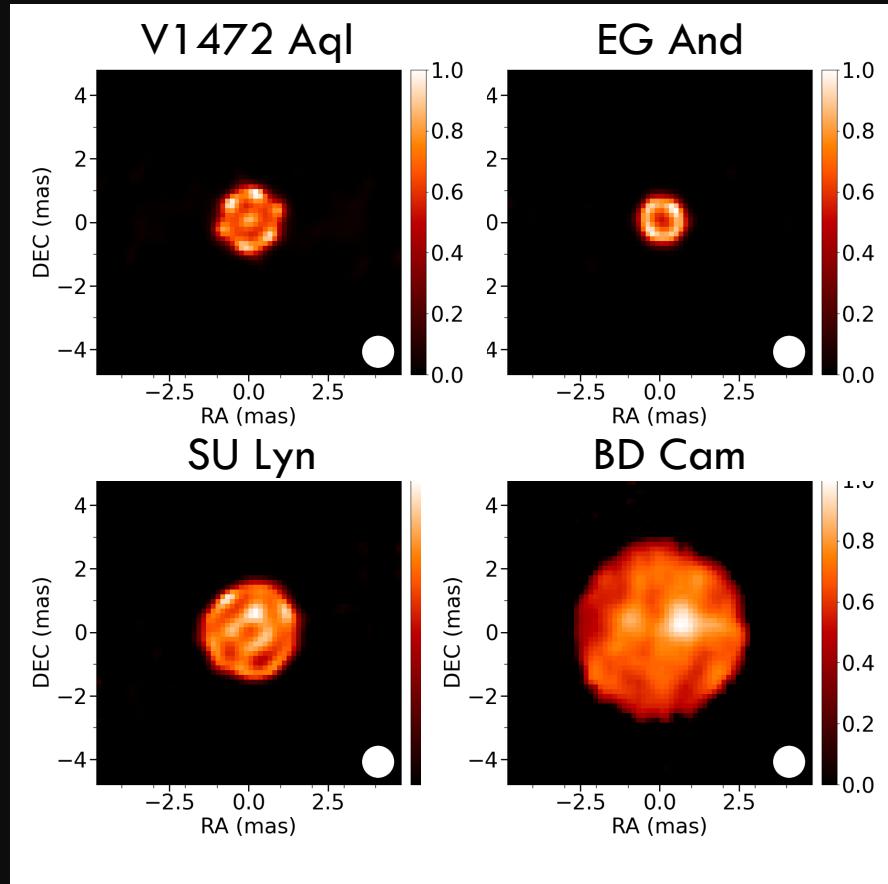
Simulated Fit to  
Squared Visibilities



Simulated Fit to  
Closure Phases

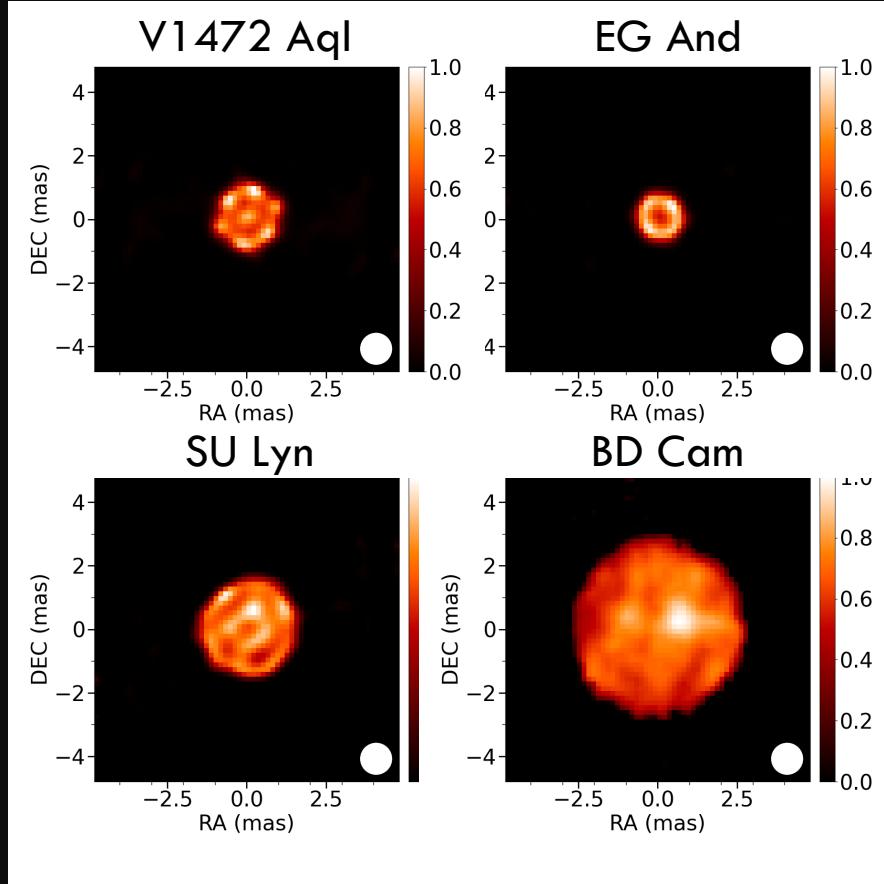
TARGET: SU Lyn

# Results



- Highest-resolution images ever taken of symbiotic stars
- All targets are underfilling their Roche lobe in first epoch
  - 3 targets show evidence of radial asymmetry
  - Strongest evidence against Roche lobe overflow in symbiotics to date

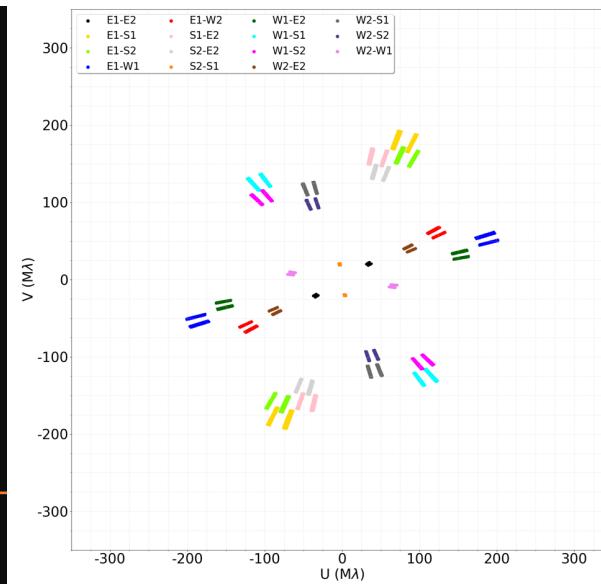
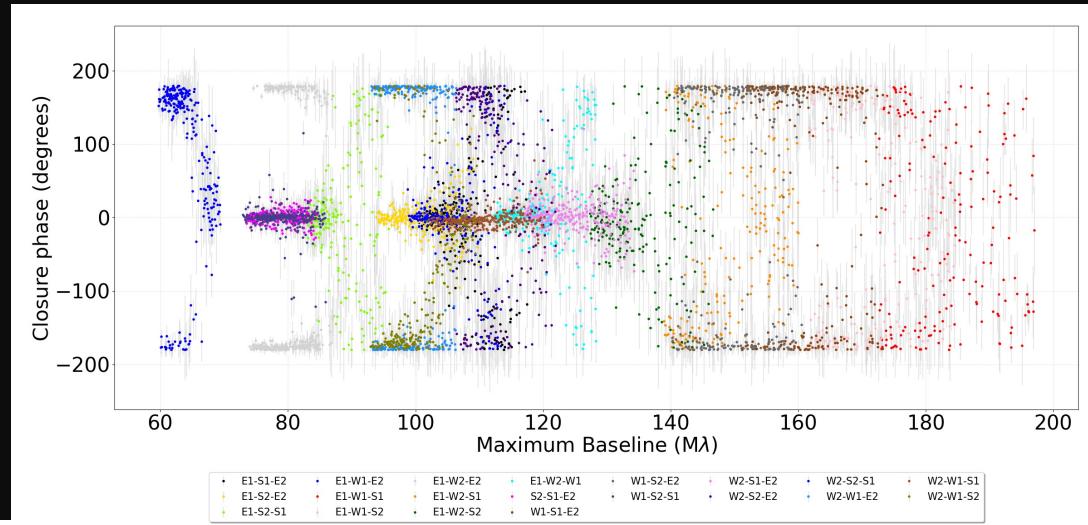
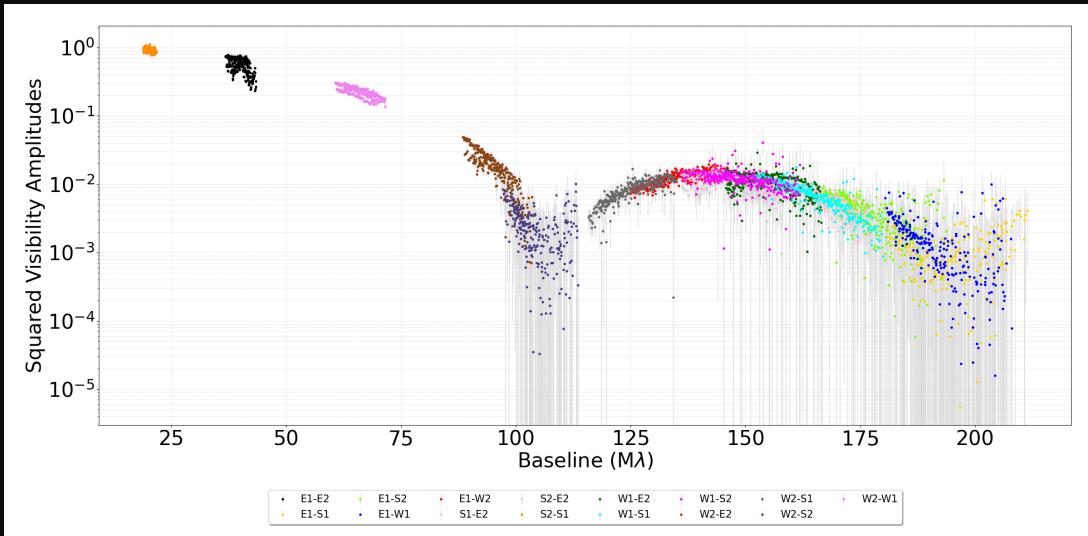
# Future Work



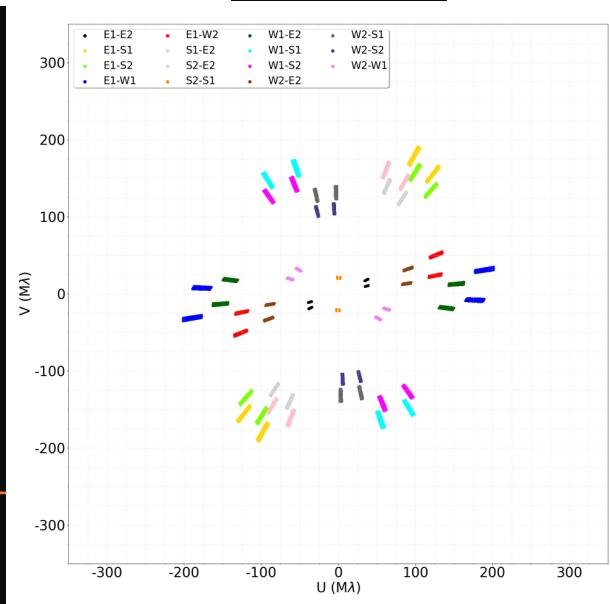
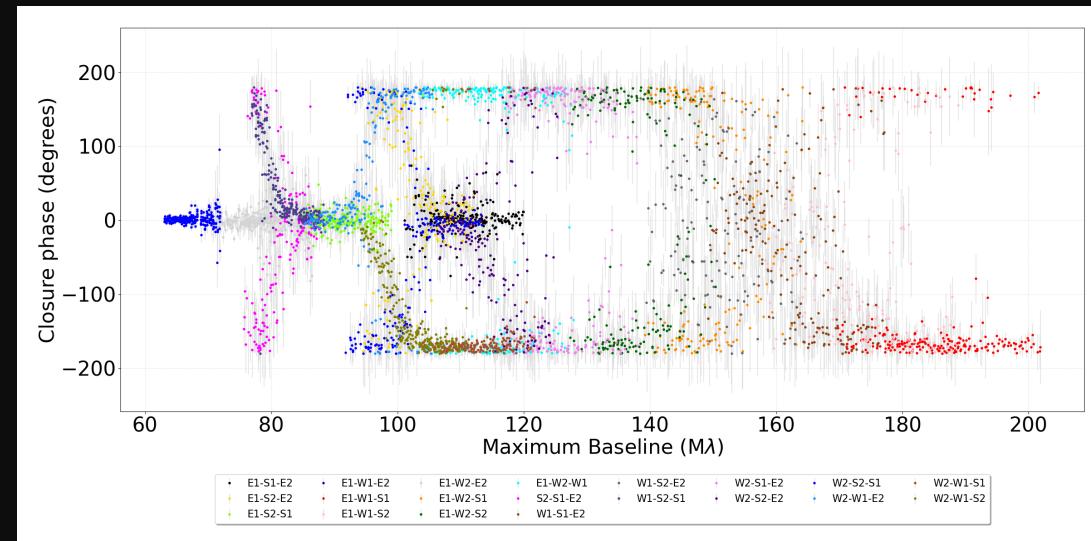
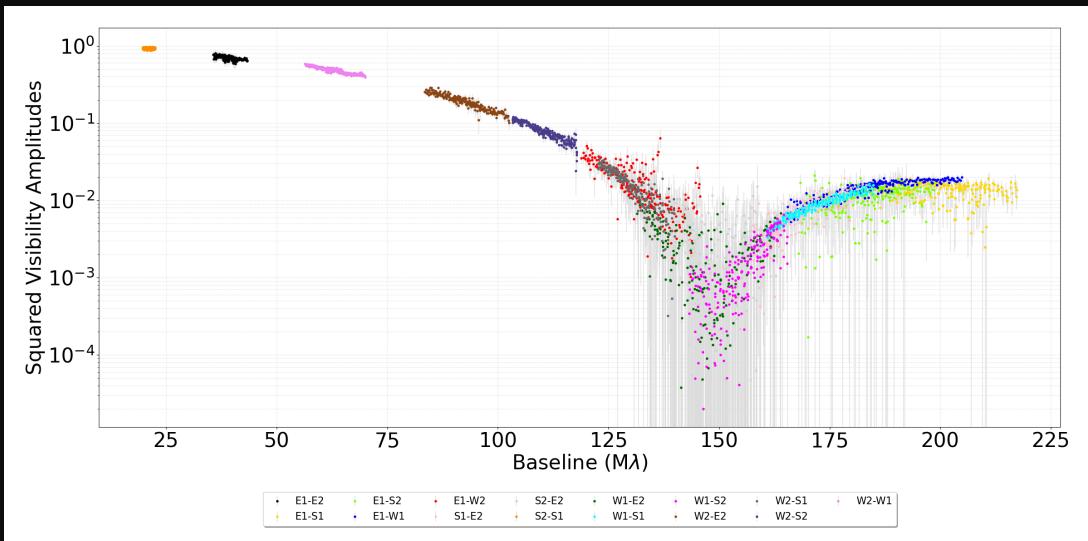
- Need more epochs at different orbital configurations
- Need more targets
- Need orbital ephemeris
- Need more wavelength bands
- Connect to recurrent symbiotic novae (T CrB)

QUESTIONS?

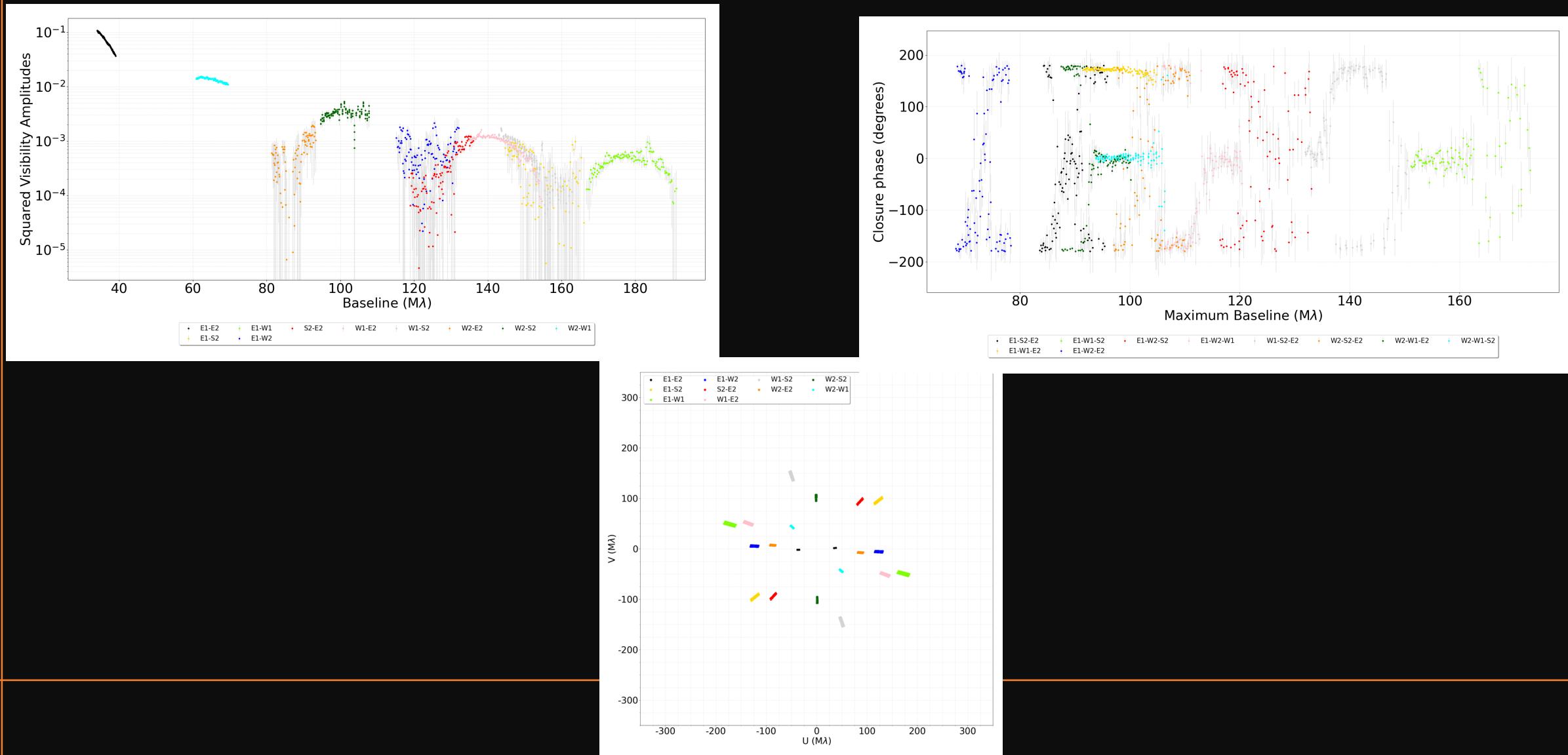
# V1472 Aql - Observables



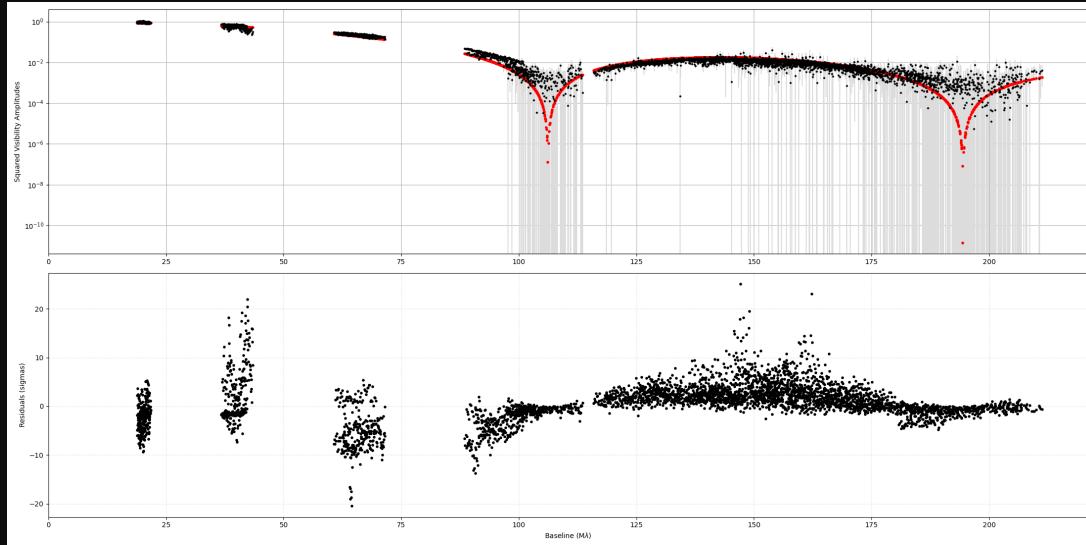
# EG And - Observables



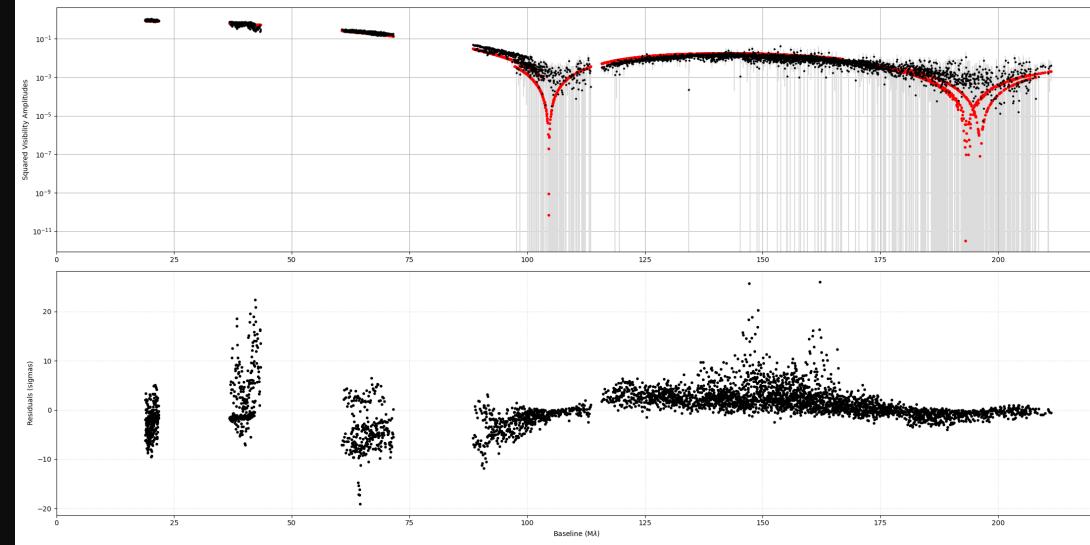
# BD Cam - Observables



# Model Fitting Analysis

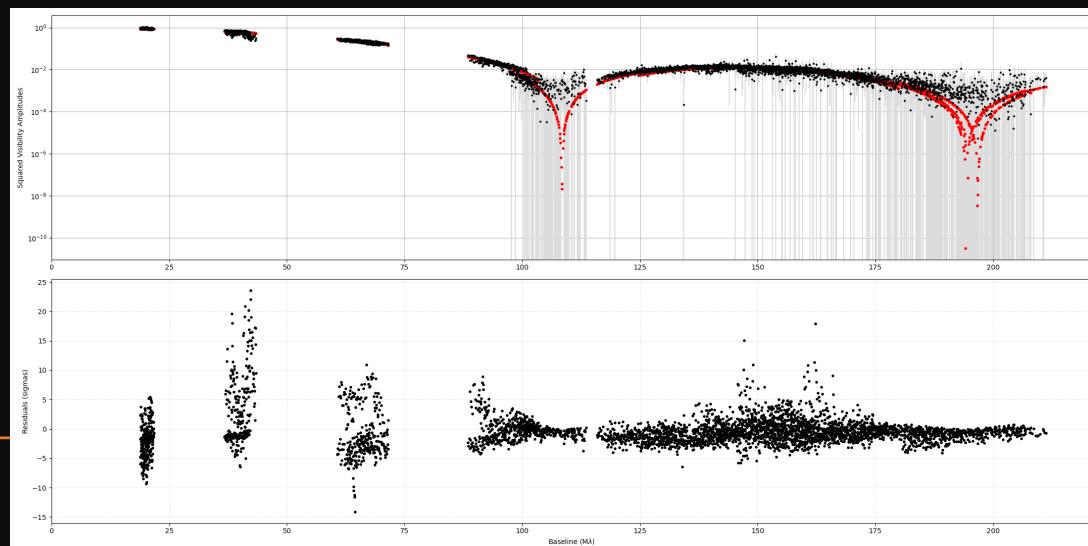


Uniform Disk  $\chi^2$  - 11.7



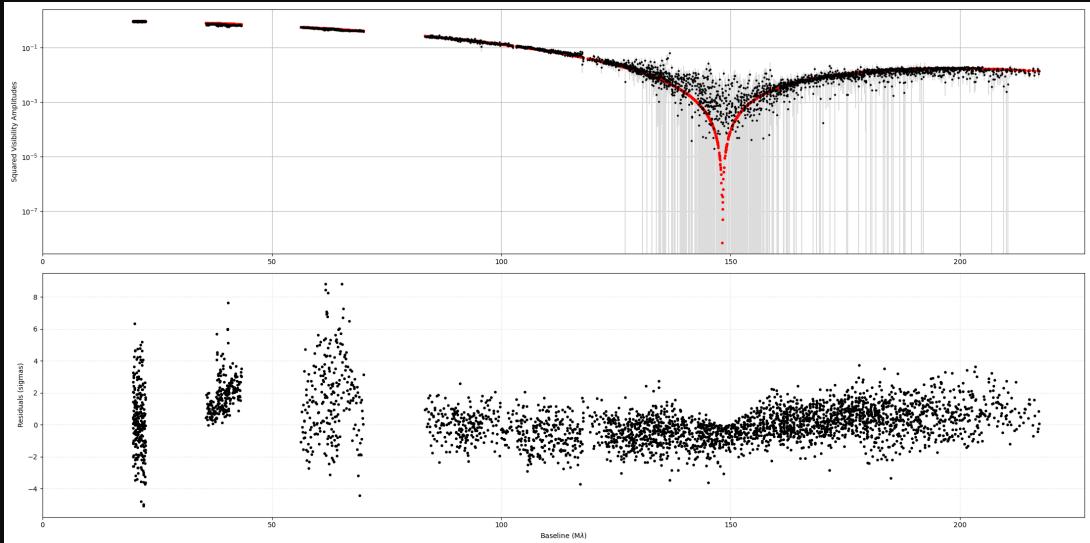
Elliptical Disk  $\chi^2$  - 10.7

Hybrid Disk  $\chi^2$  - 5.53

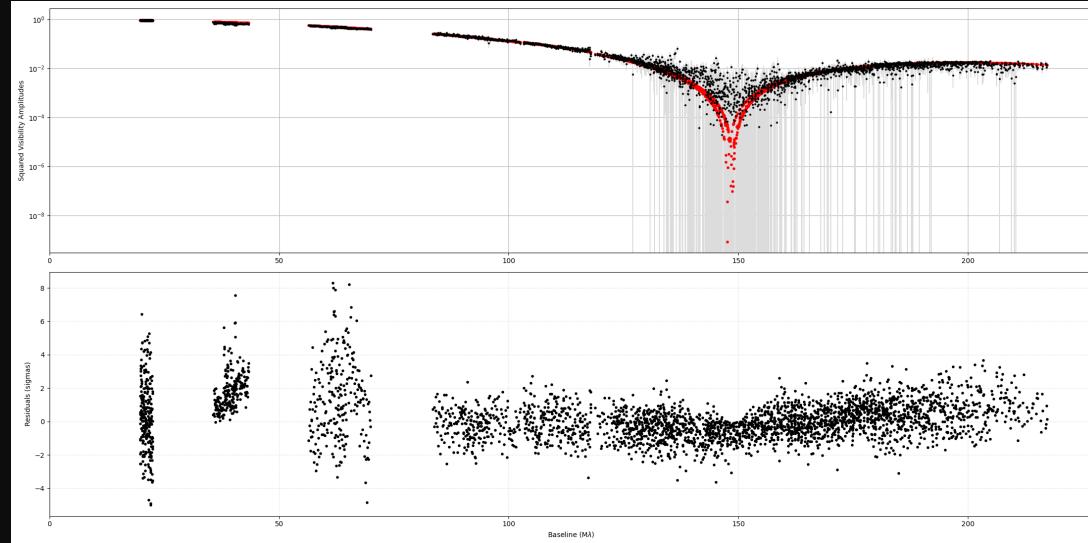


TARGET:  
V1472 Aql

# Model Fitting Analysis

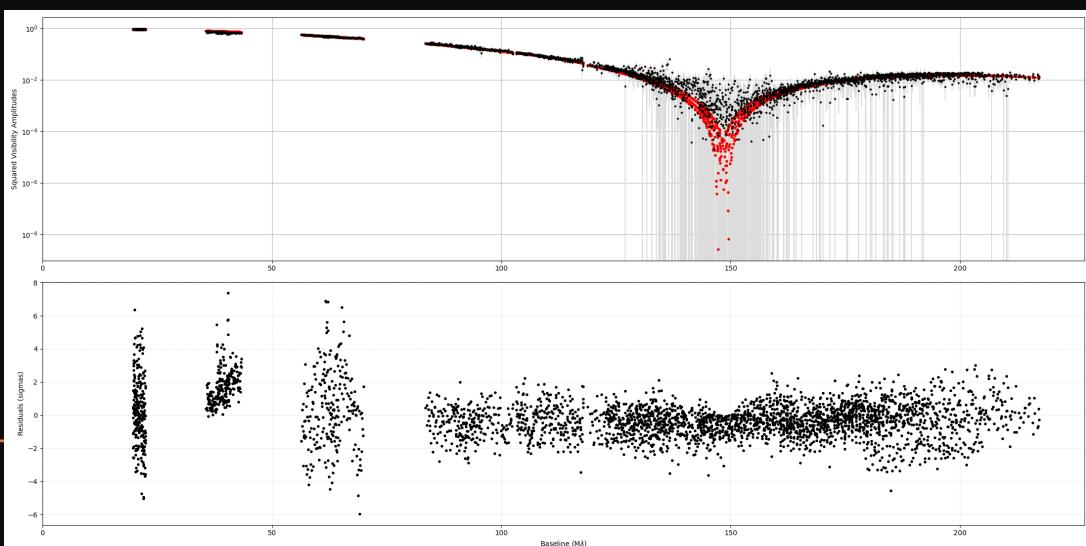


Uniform Disk  $\chi^2$  - 2.67



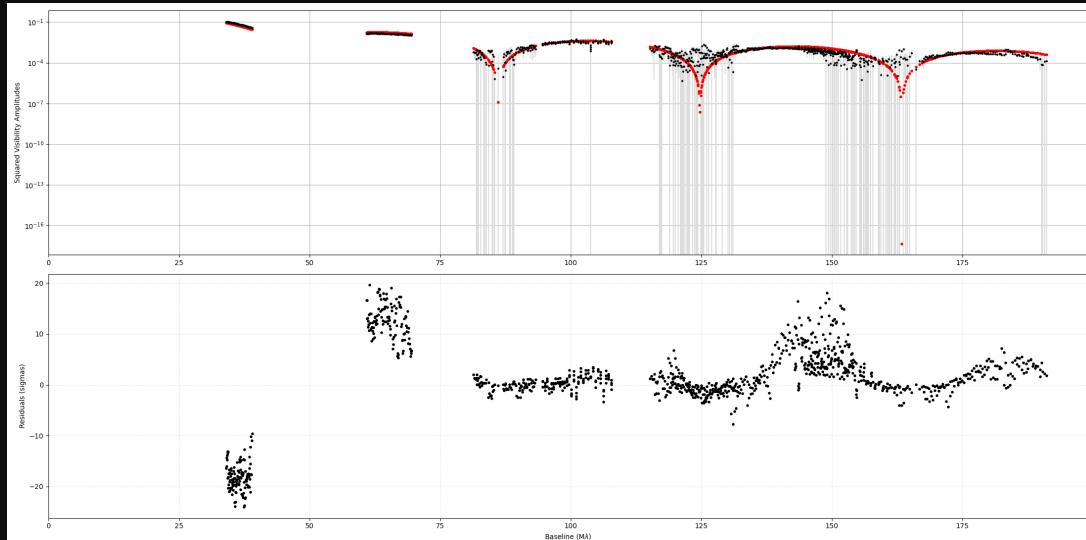
Elliptical Disk  $\chi^2$  - 2.57

Hybrid Disk  $\chi^2$  - 2.37

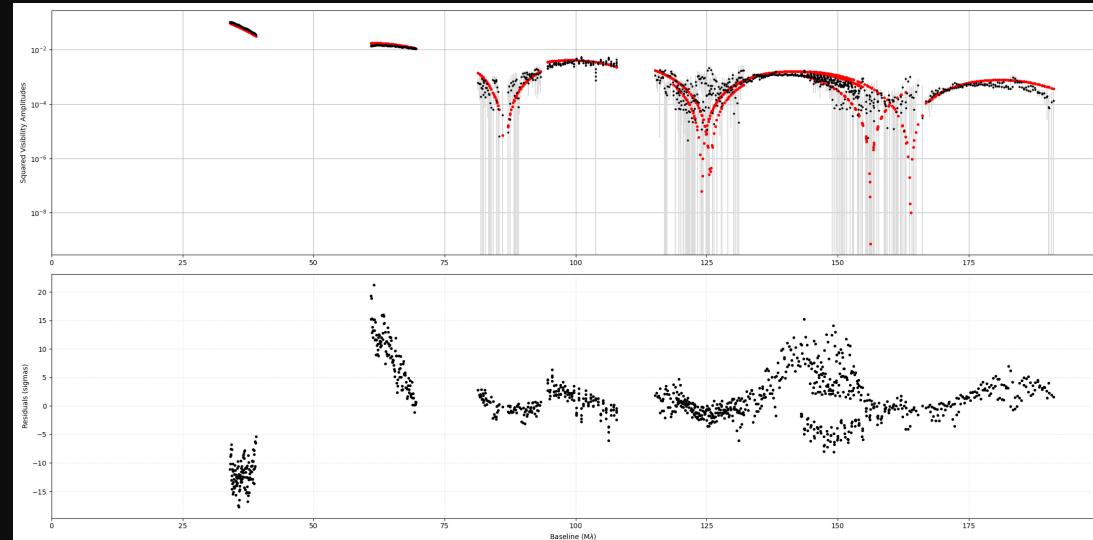


TARGET: EG And

# Model Fitting Analysis

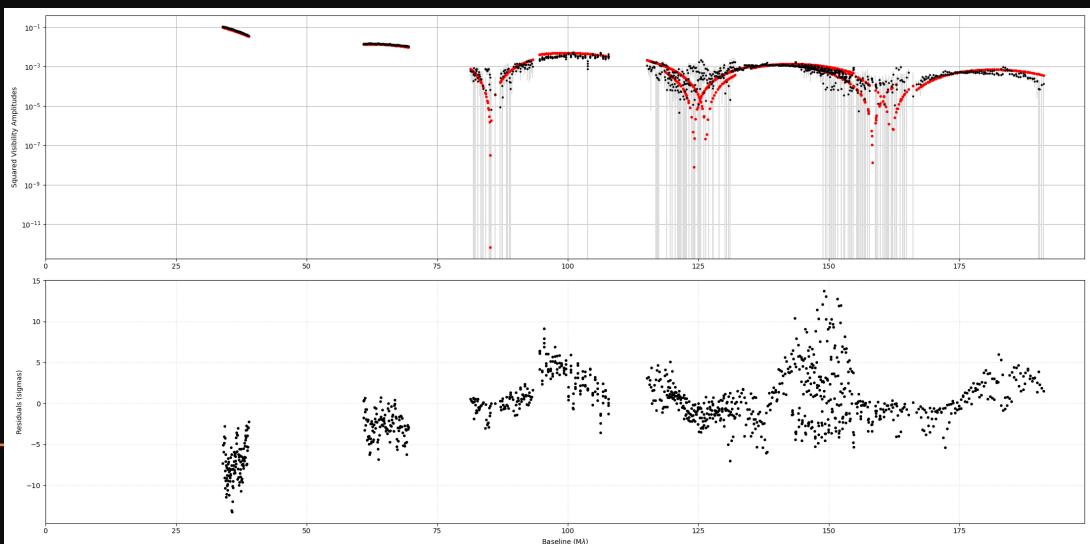


Uniform Disk  $\chi^2$  - 34.0



Elliptical Disk  $\chi^2$  - 24.1

Hybrid Disk  $\chi^2$  - 14.0



TARGET: BD Cam