



2014 Imaging Beauty Contest

J.D. Monnier (U. Michigan) & J.-P. Berger (ESO)

Participants (leads):

Christian Hummel, Karl-Heinz Hofmann, John Young,
Joel Sanchez, Rainer Kohler, Ferreol Soulez, Jacques
Kluska, Gilles Duvert, Stefan Kraus, Brian Kloppenborg

VLTI imaging contest:

- Motivation:
 - OPC is often not “convinced” by the aperture synthesis added value, hard to get “imaging” time;
 - Advertise the imaging capabilities of VLTI *outside of interferometric community*
 - Explore the added value of image reconstruction in a real scientific case
 - Publish the results

VLTI imaging contest:

- Process:
 - Authorisation request to ESO's Director for Science & Paranal Director to use freed technical time for this science.
 - Call for target suggestions to ~20 members of community
 - Criteria 1: well resolved; Selection:
R Car (Mira)
 - Criteria 2: scientific interest; VY CMA (Supergiant)
 - Call for interest in collaboration: 44 answers including non interferometrists (the call percolated outside the community)

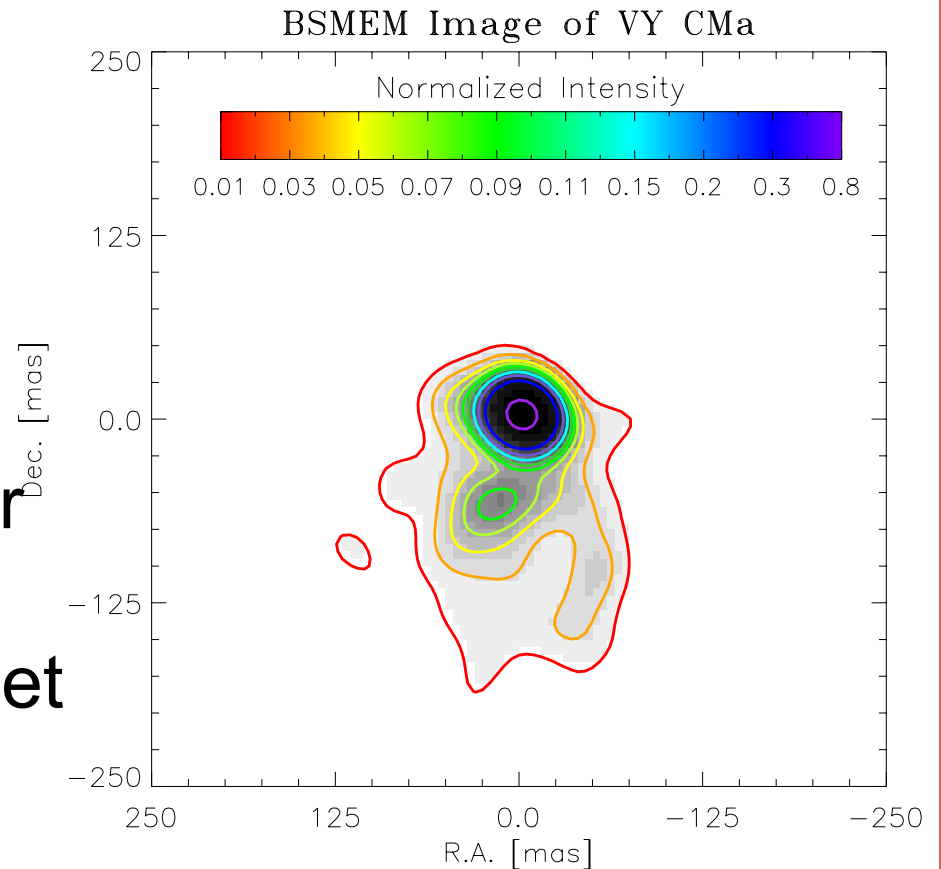
VLTI imaging contest:

Observations

- All 3 ATs configuration
 - Excellent uv coverage
 - Well dimensioned objects (R Car & VY CMA)
 - Good data quality (PIONIER)
- Observers: R. Grellman, A. Mueller, S. Renganswany
- Data reduction: J.B. Lebouquin
- Date: 2014: Jan-22 - Feb 02
 - A1-J3-K0-G1
 - H0-I1-D0-G1
 - A1-C1-D0-B2
- R Car: NV2 ~ 1000
- sigV2 ~ 2% , sig CP ~ 1 deg
- VY CMA: NV2 ~ 300
- Data reduction: pndrs (lebouquin et al. 2011)

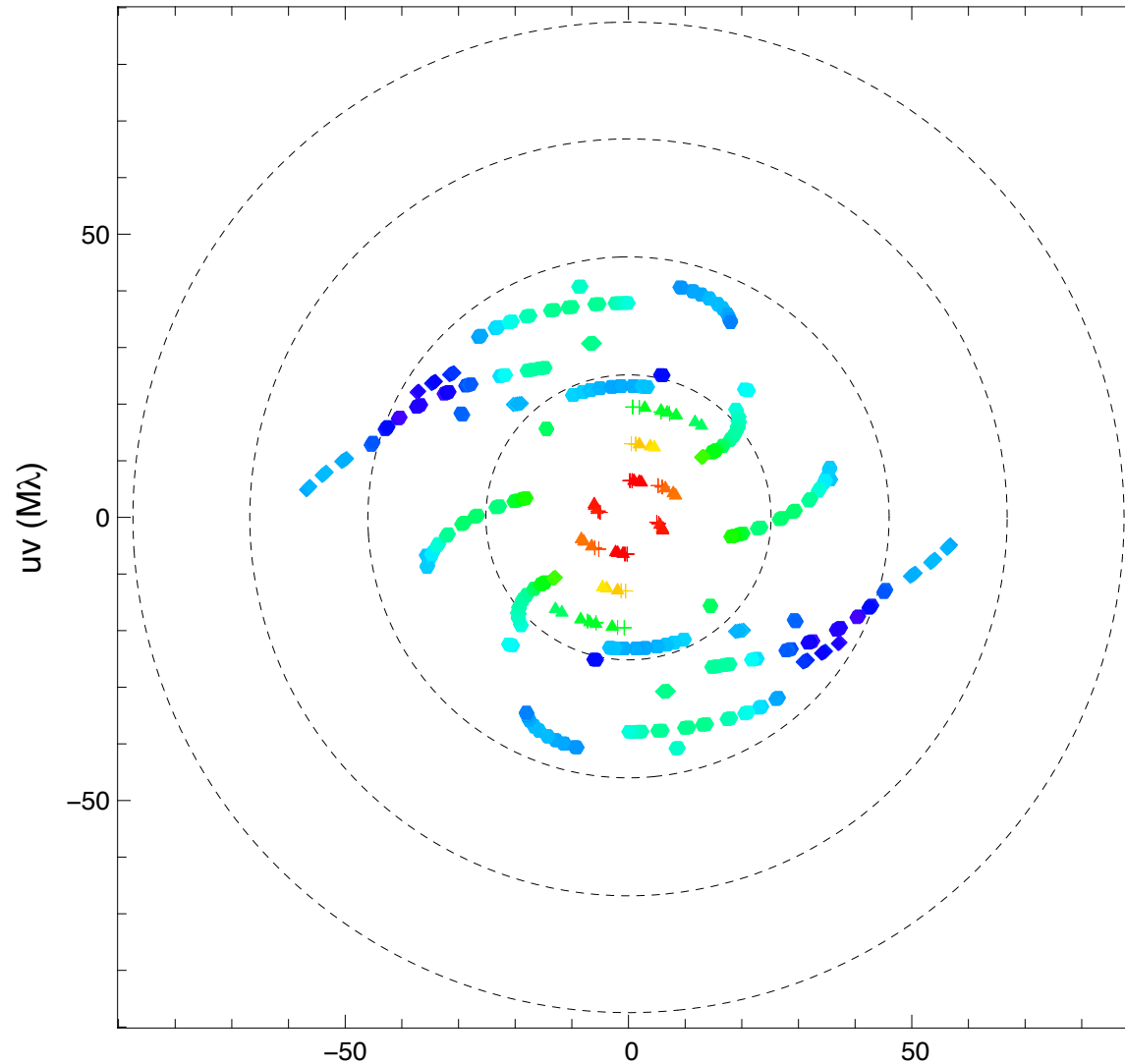
The two objects

- VY CMa
 - Red supergiant M2-5
 - Heavy mass-loss
 - Thick dust shell
 - Recent AMBER paper measured ~ 11.3 mas diameter (Wittkowski et al)

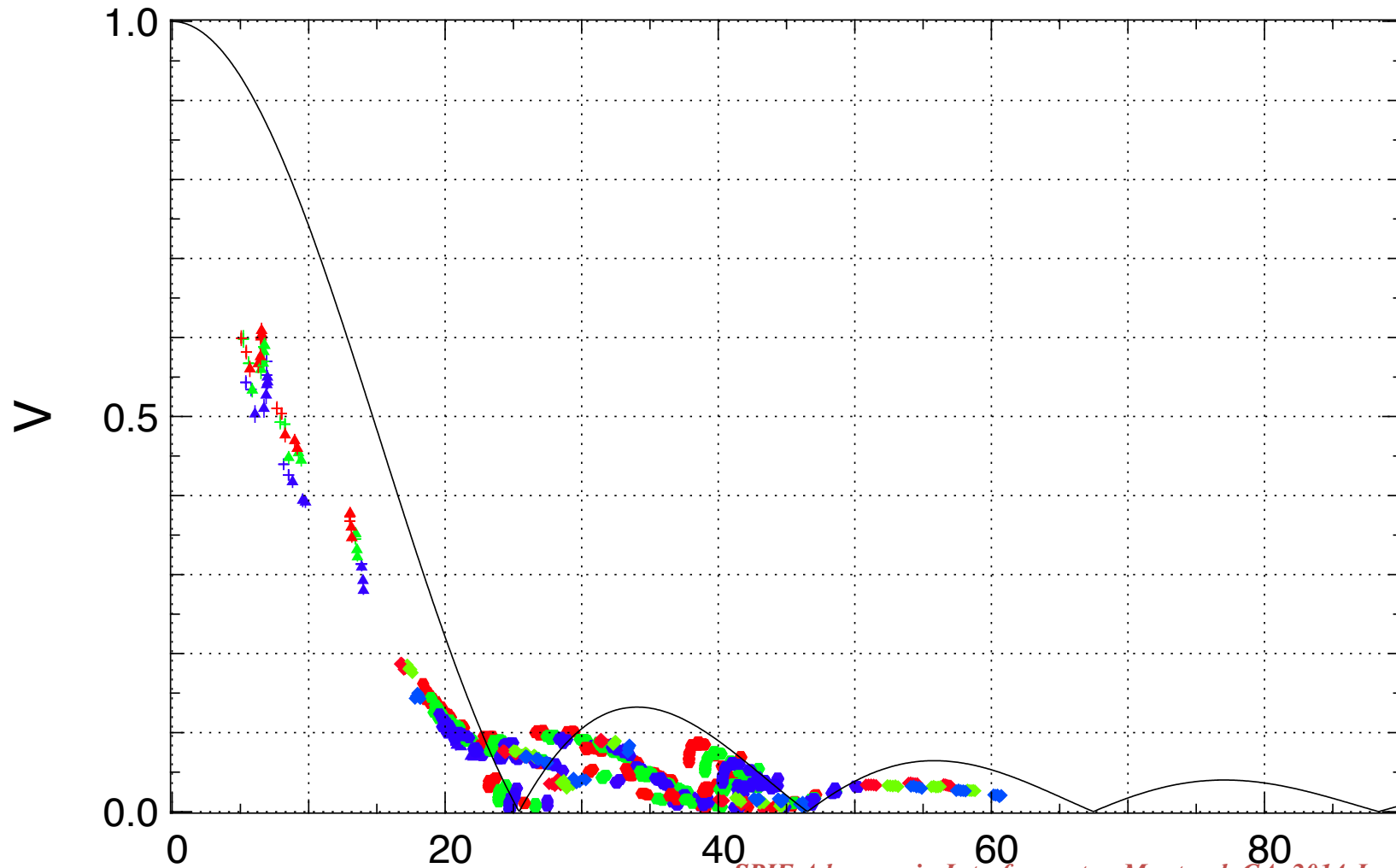


Tuthill aperture masking

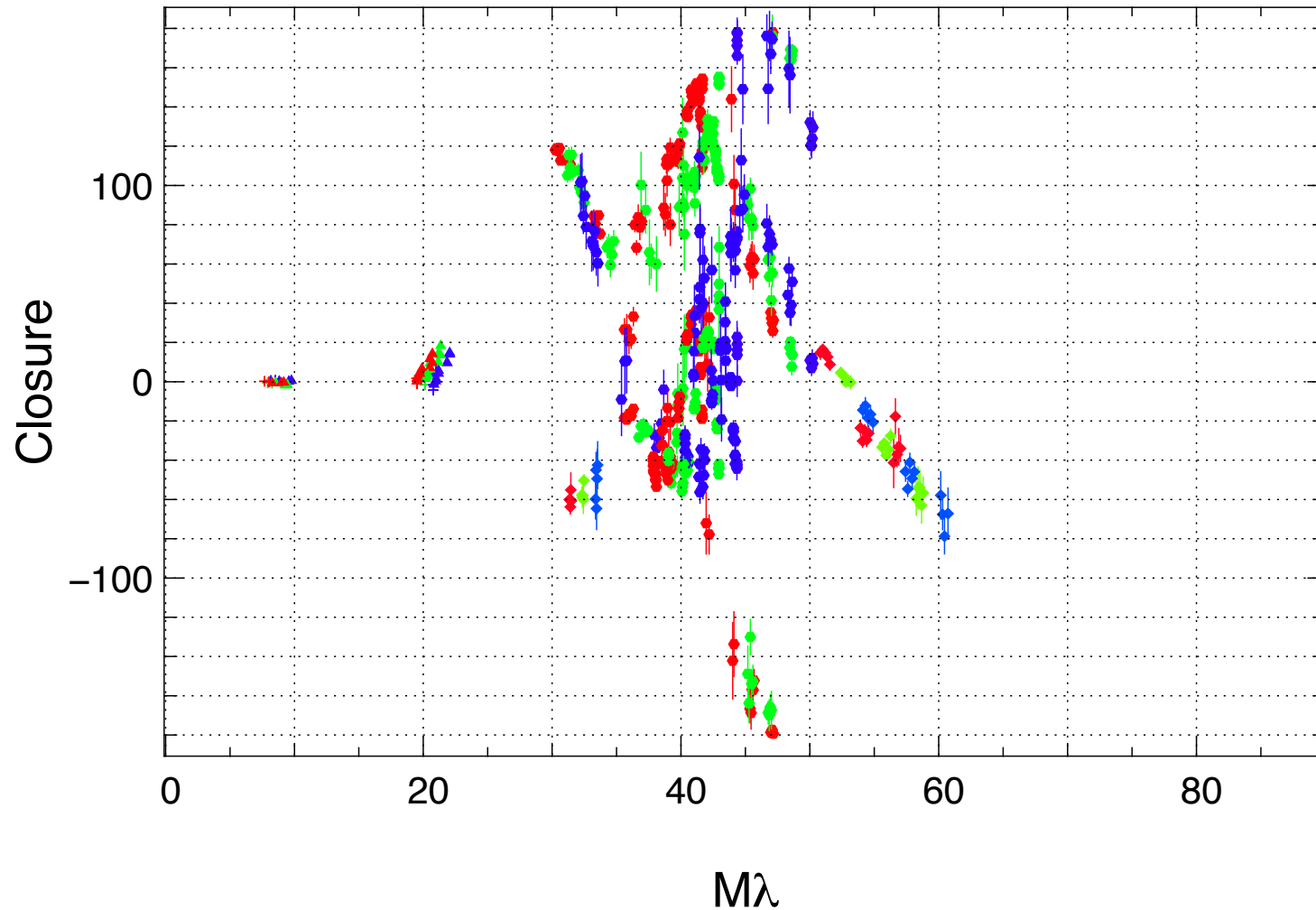
VY CMa Fourier Coverage



VY CMa Visibilities

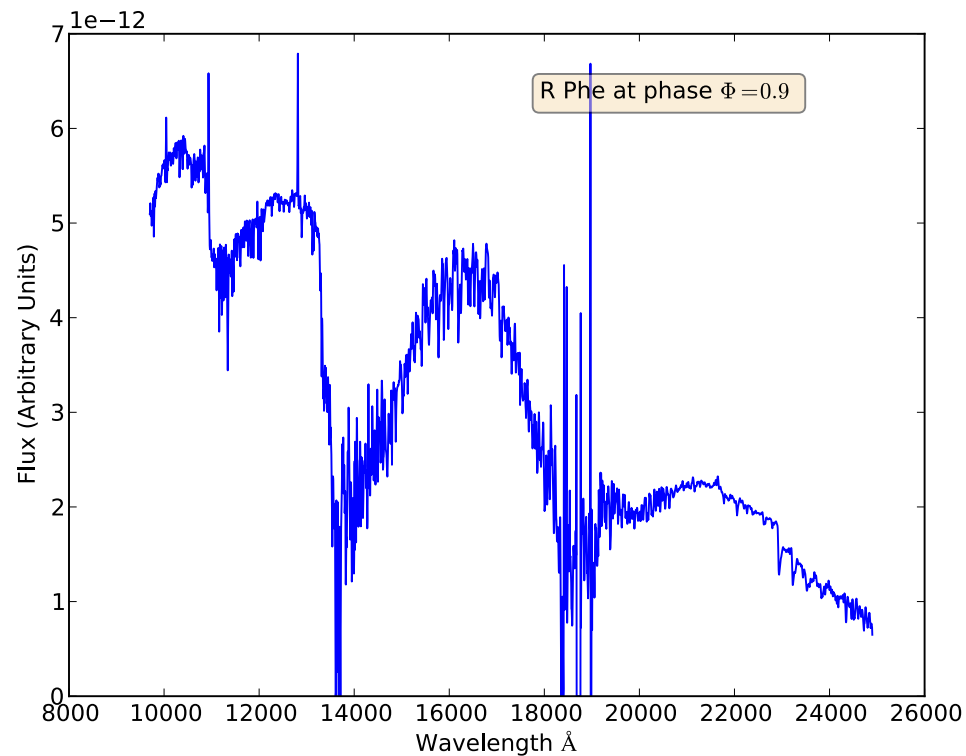


VY CMa Closure Phases

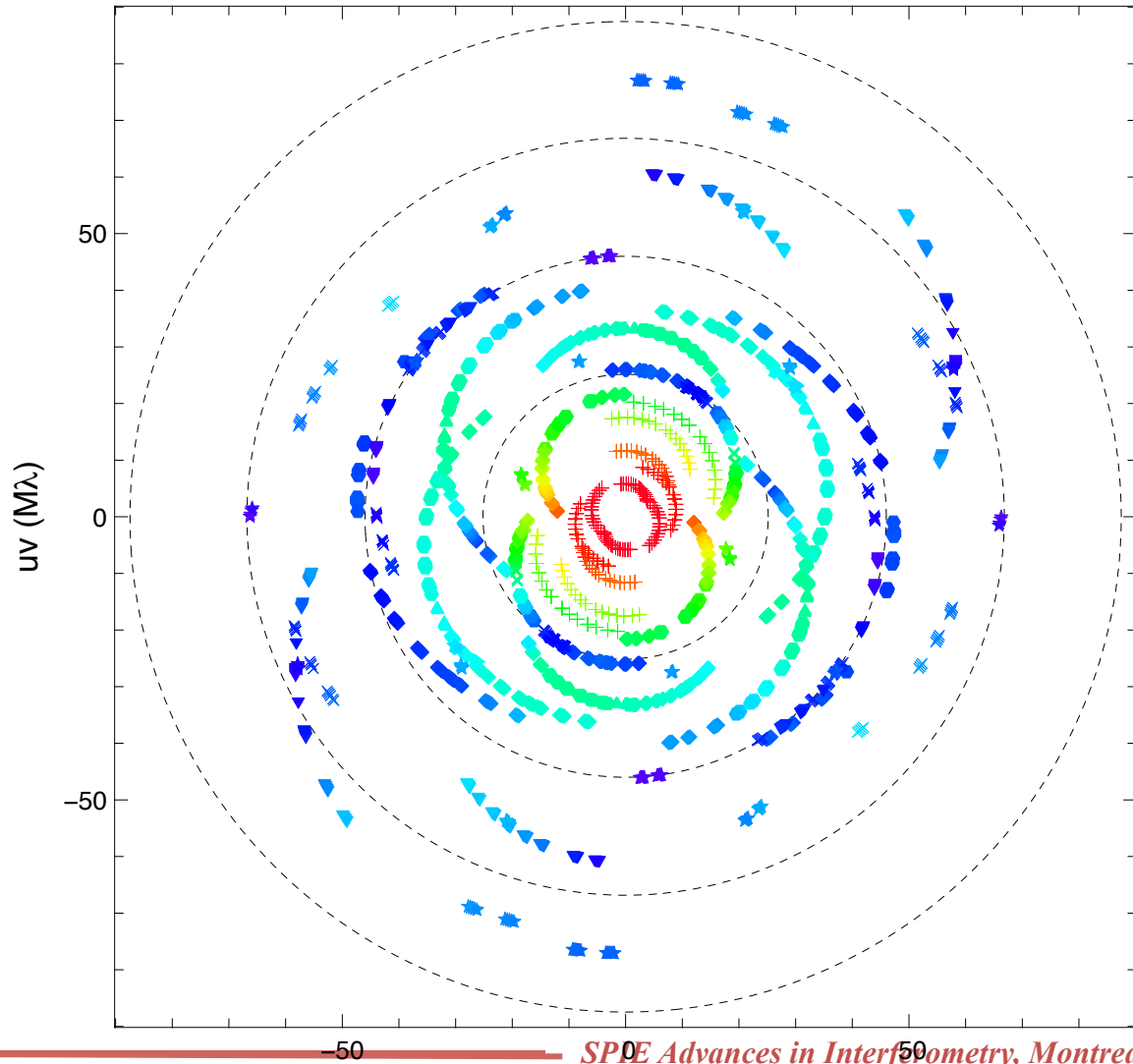


The two objects

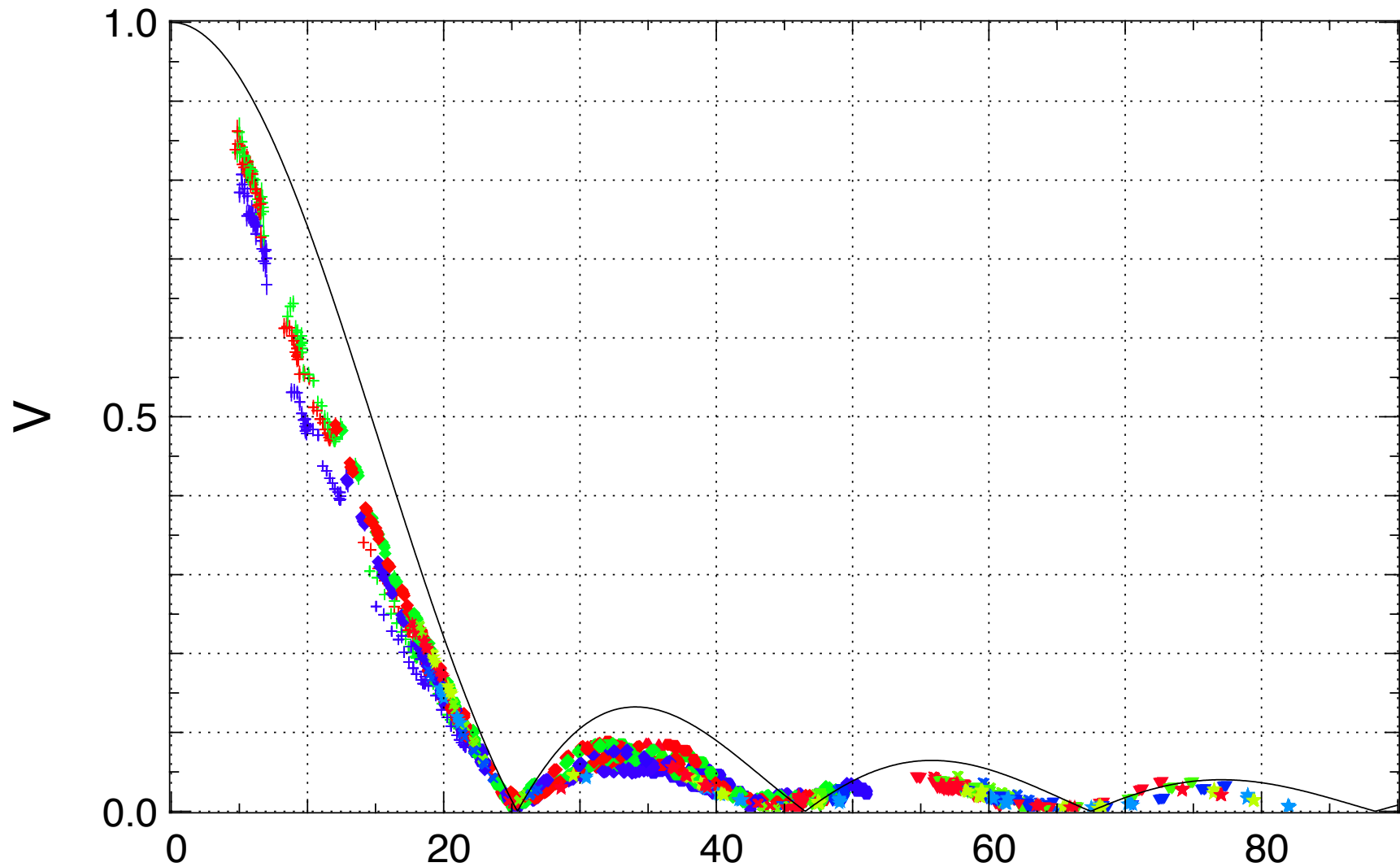
- R Car
 - Mira Variable M5-8
 - Strong water bands in near infrared



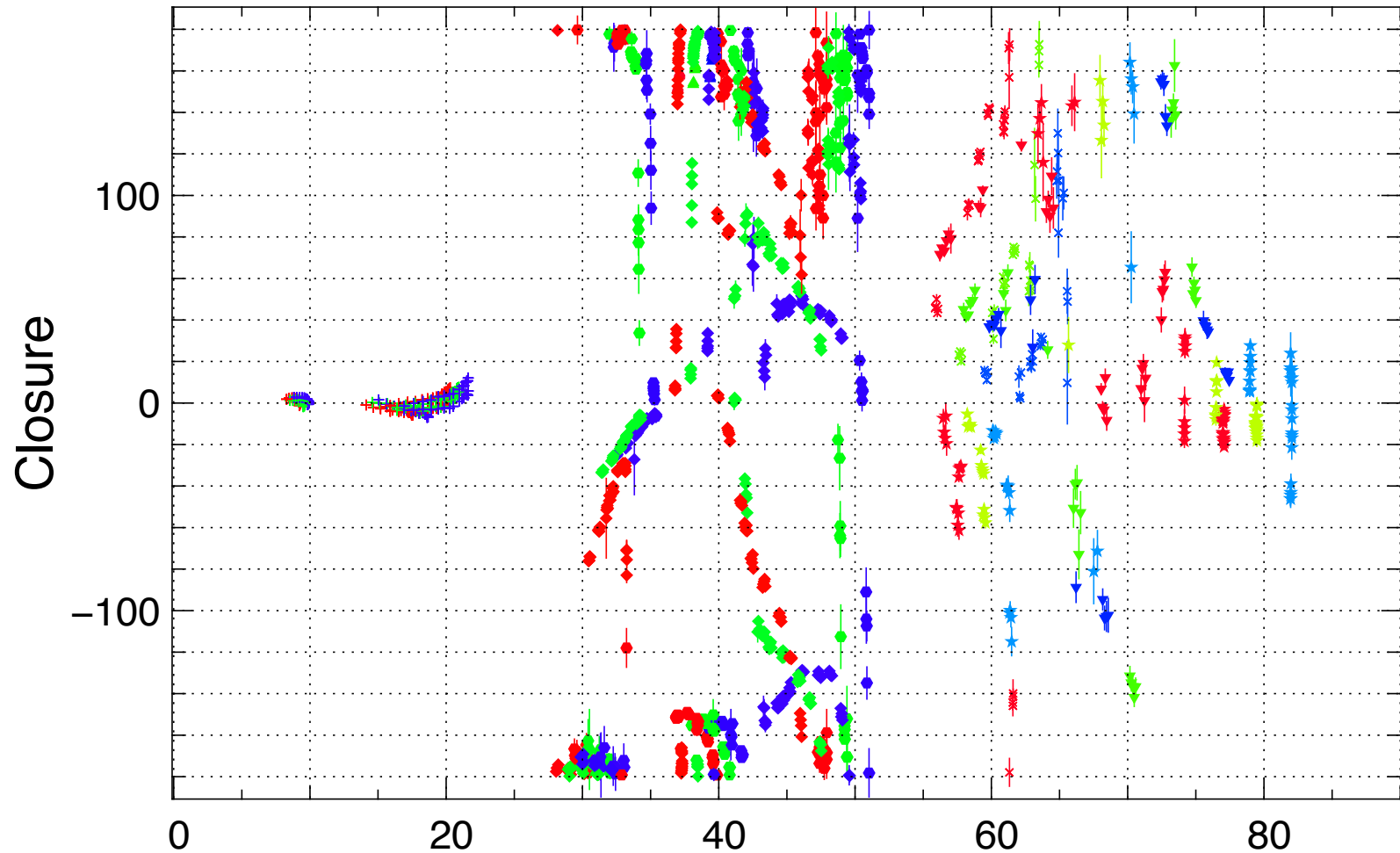
R Car Fourier Coverage



R Car Visibilities

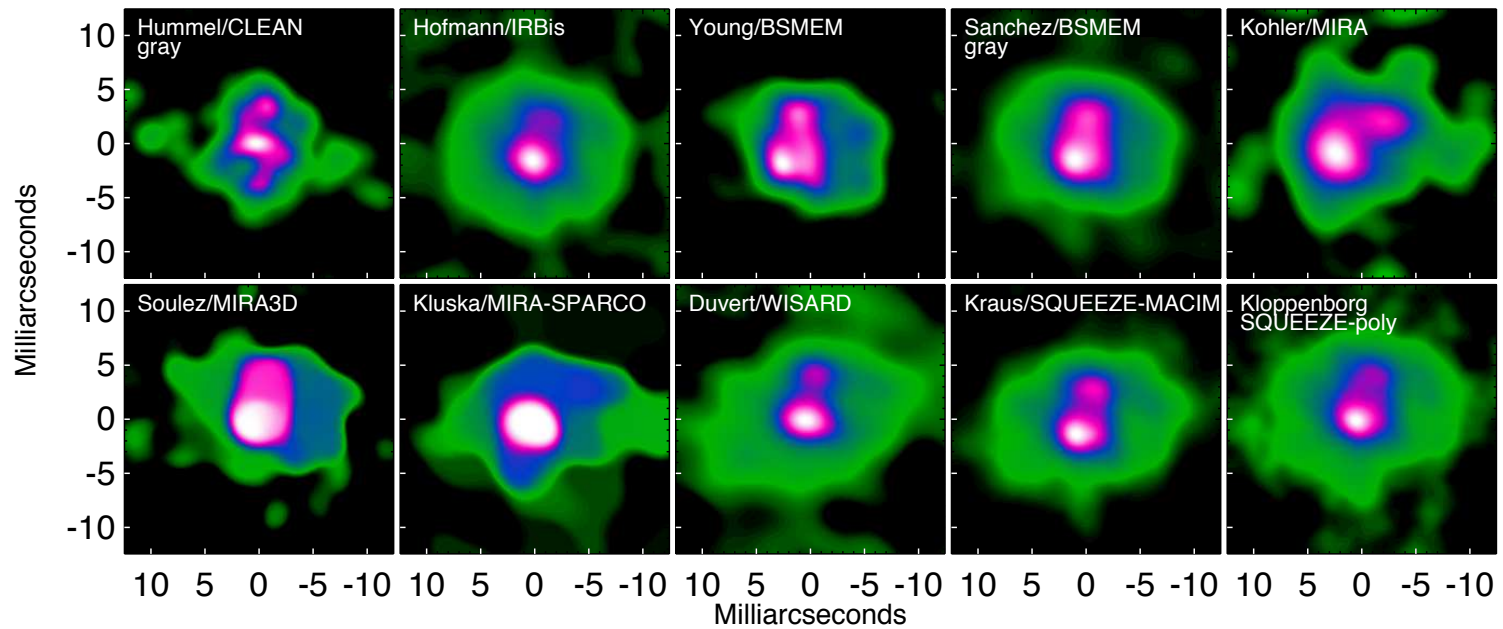
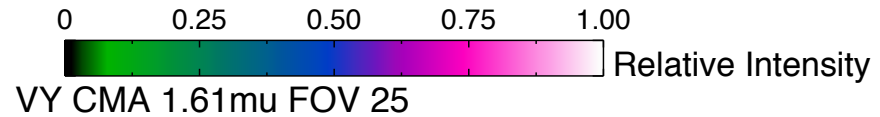
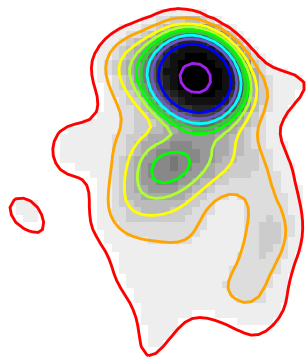


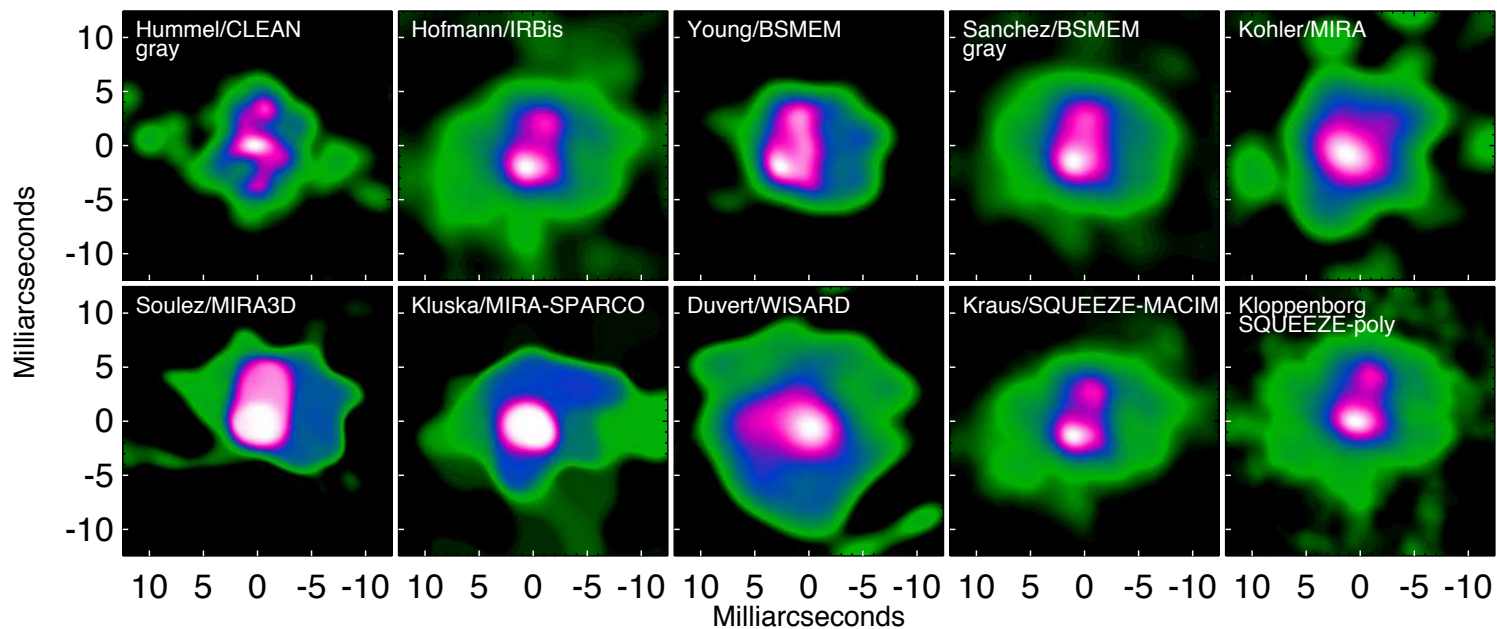
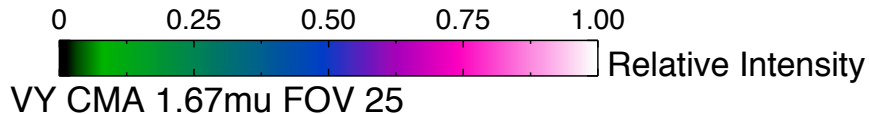
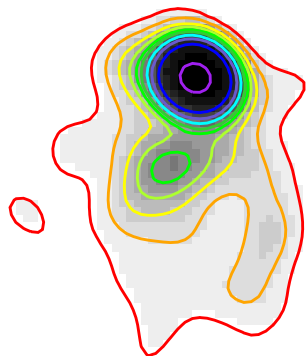
R Car Closure phases

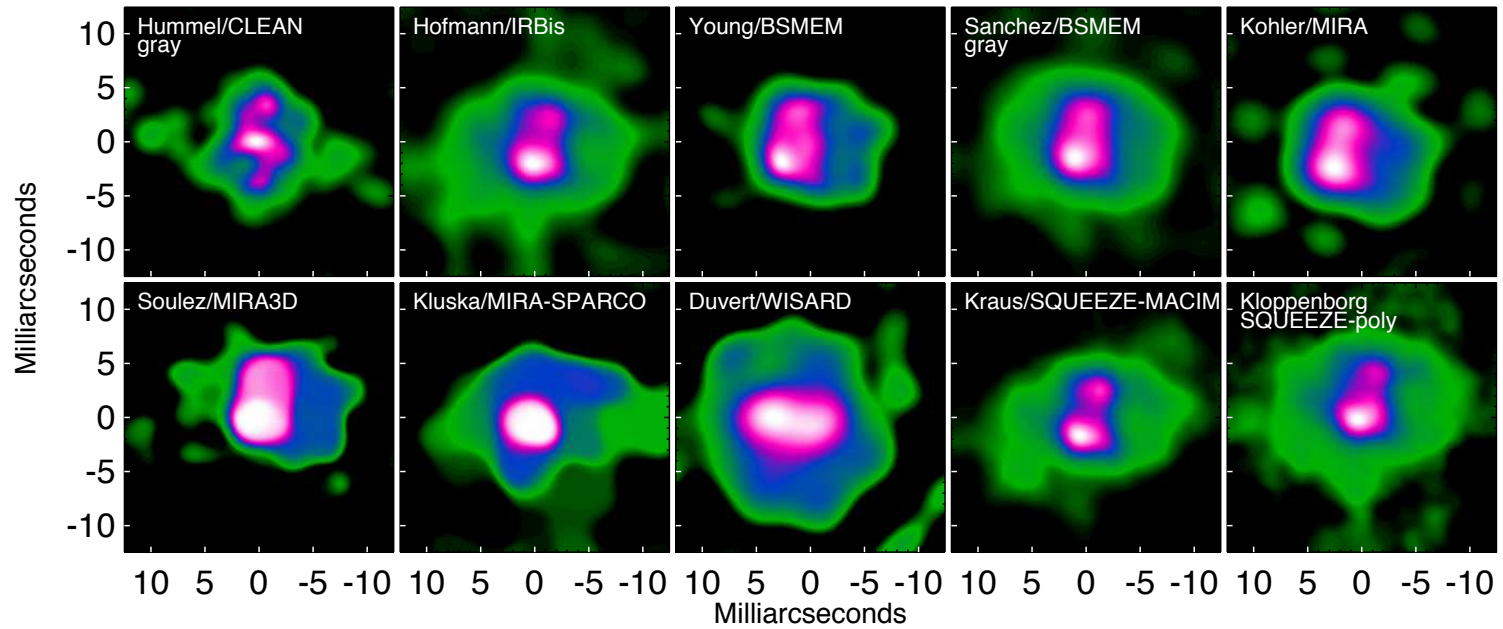
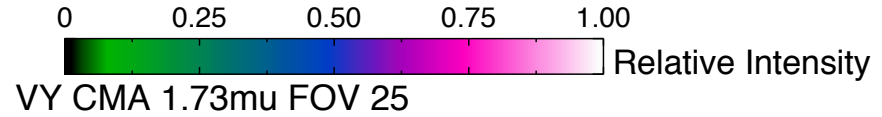
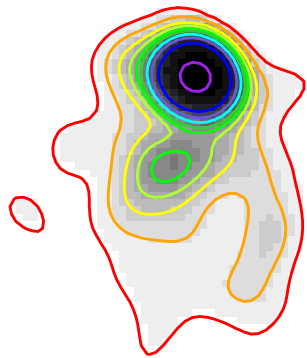


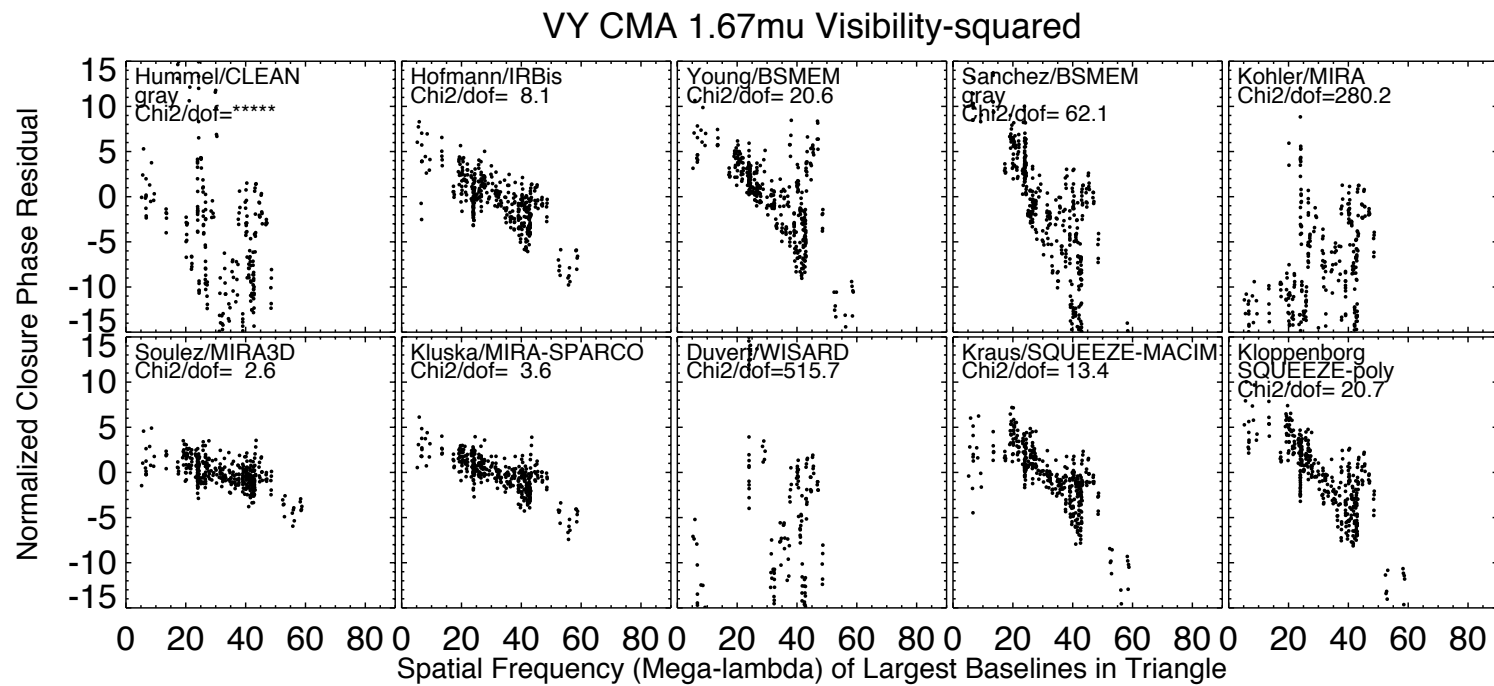


| Submitter | Algorithm | Prior? | | Wavelength Regularization | |
|-------------|---------------|-------------------------|-------------------------|---------------------------|-----------|
| | | VY CMa | R Car | VY CMa | R Car |
| Hummel | PEARL/CLEAN | No | No | Gray | Gray |
| Hofmann | IRBis | No | No | Separate | separate |
| Young | BSMEM | gaussian +gaussian | LDD +gaussian | Separate | Separate |
| Sanchez | BSMEM | Compact+ 2 gaussians | Compact+ 2 gaussians | Gray | Gray |
| Kohler | MIRA | No | No | Separate | Separate |
| Soulez | MIRA3D | No | No | Yes | Yes |
| Kluska | MIRA-SPARCO | Gray image | Gray image | Via prior | Via prior |
| Duvert | Wisard | No | No | No | No |
| Kraus | SQUEEZE/MACIM | No | No | No | No |
| Kloppenborg | SQUEEZE-poly | No | No | Yes | Yes |

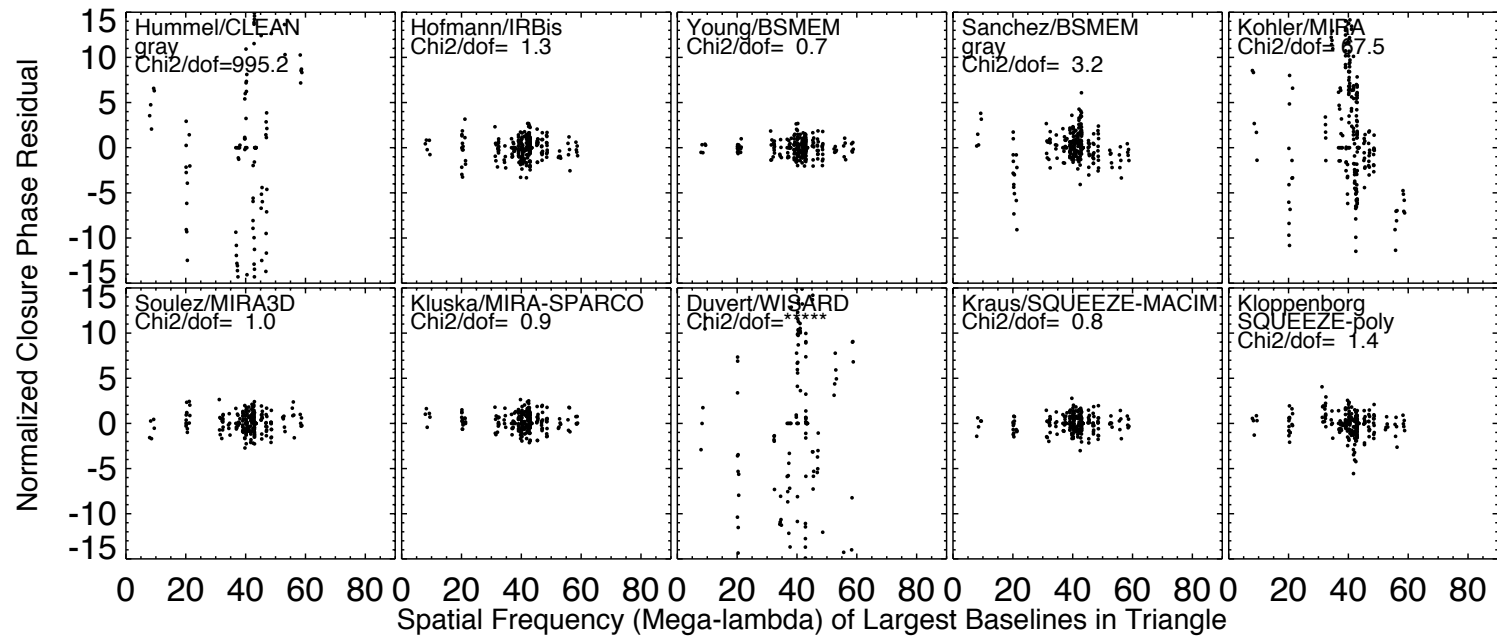






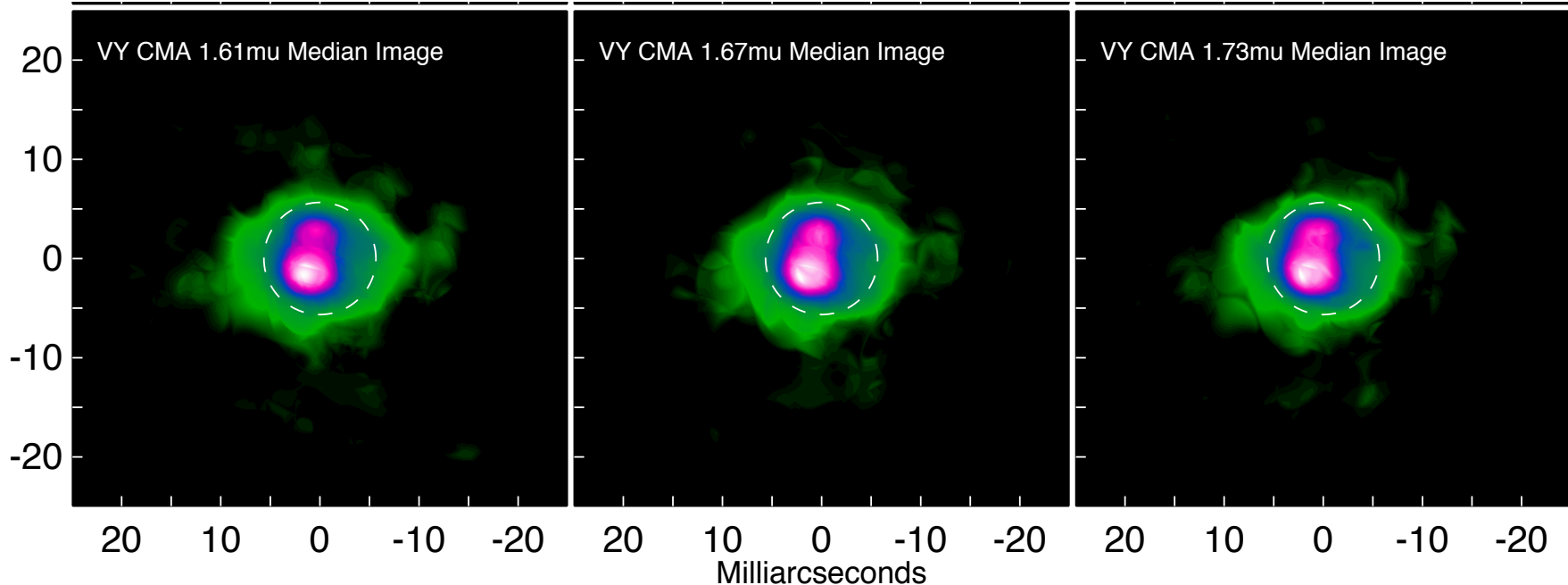


VY CMA 1.67 μ m Closure Phase

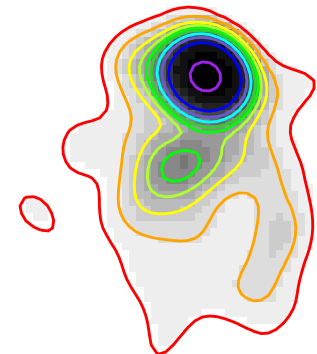


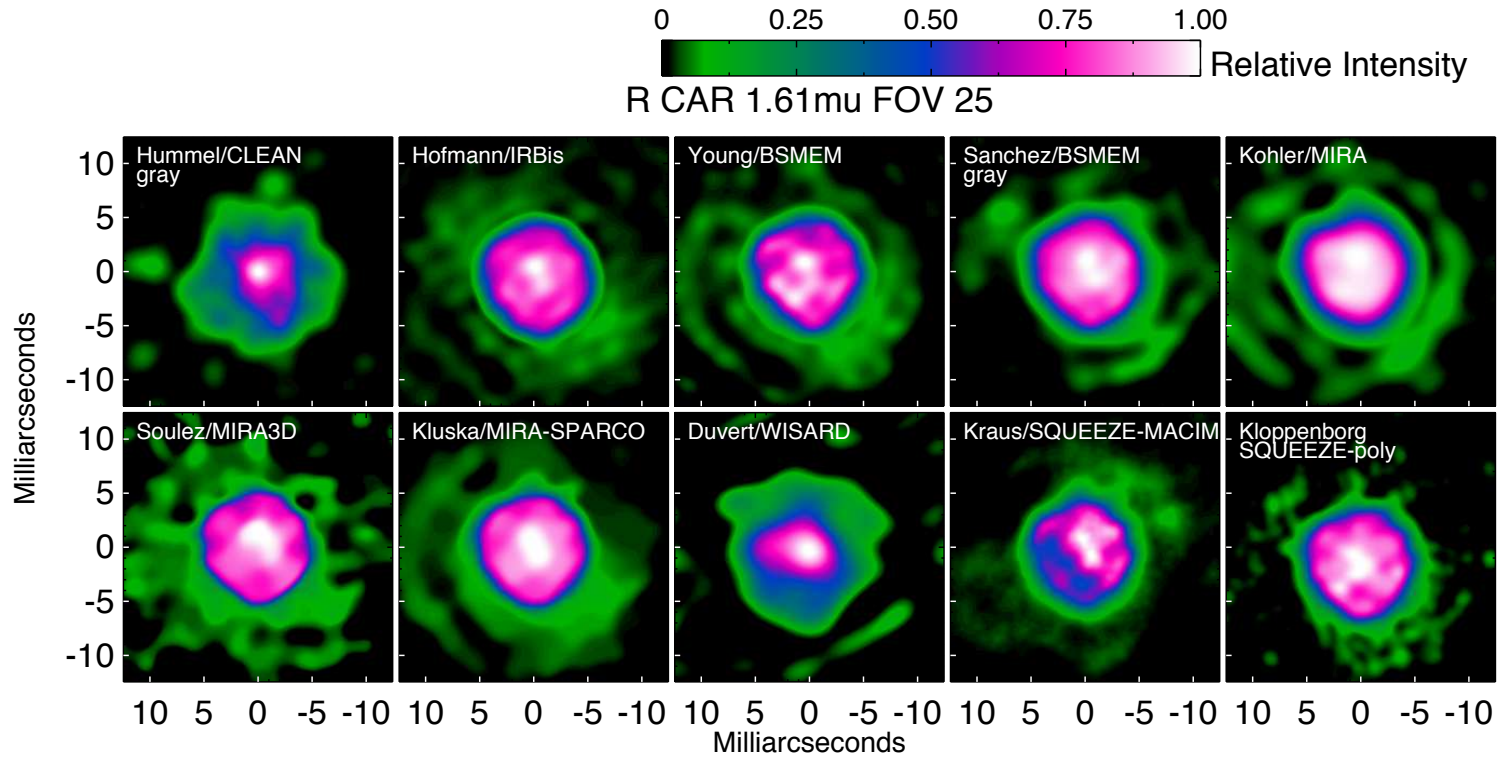
VY CMa

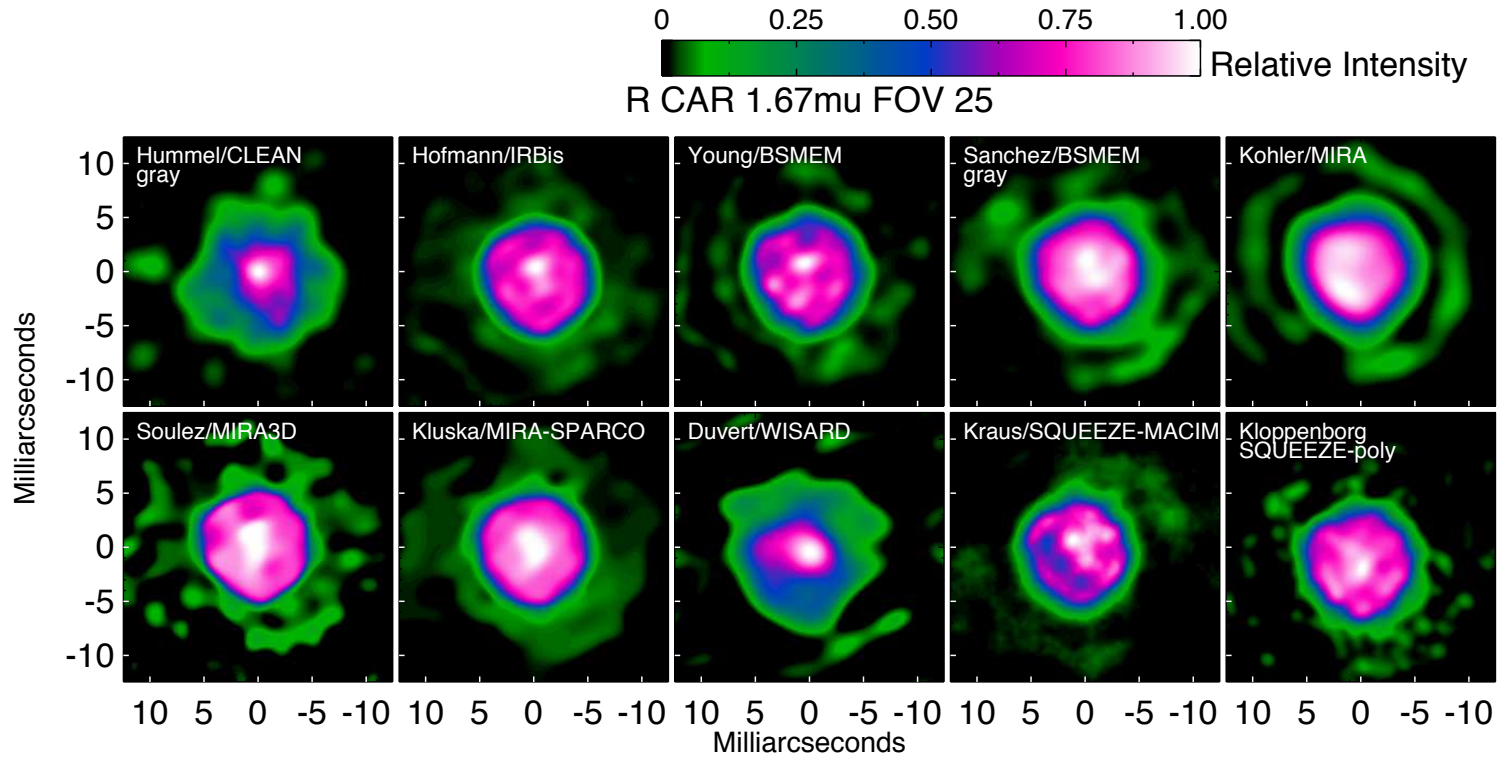
Median Images

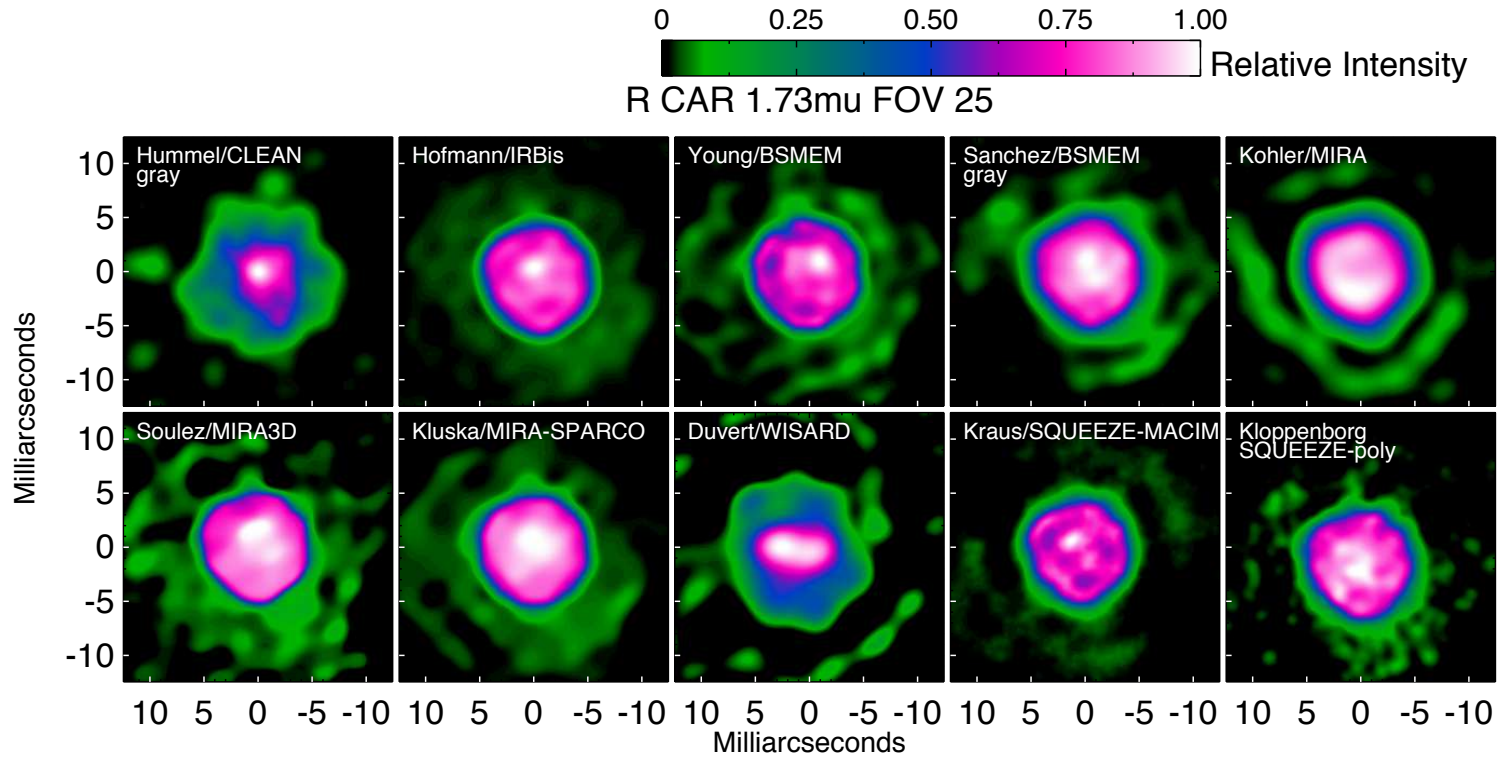


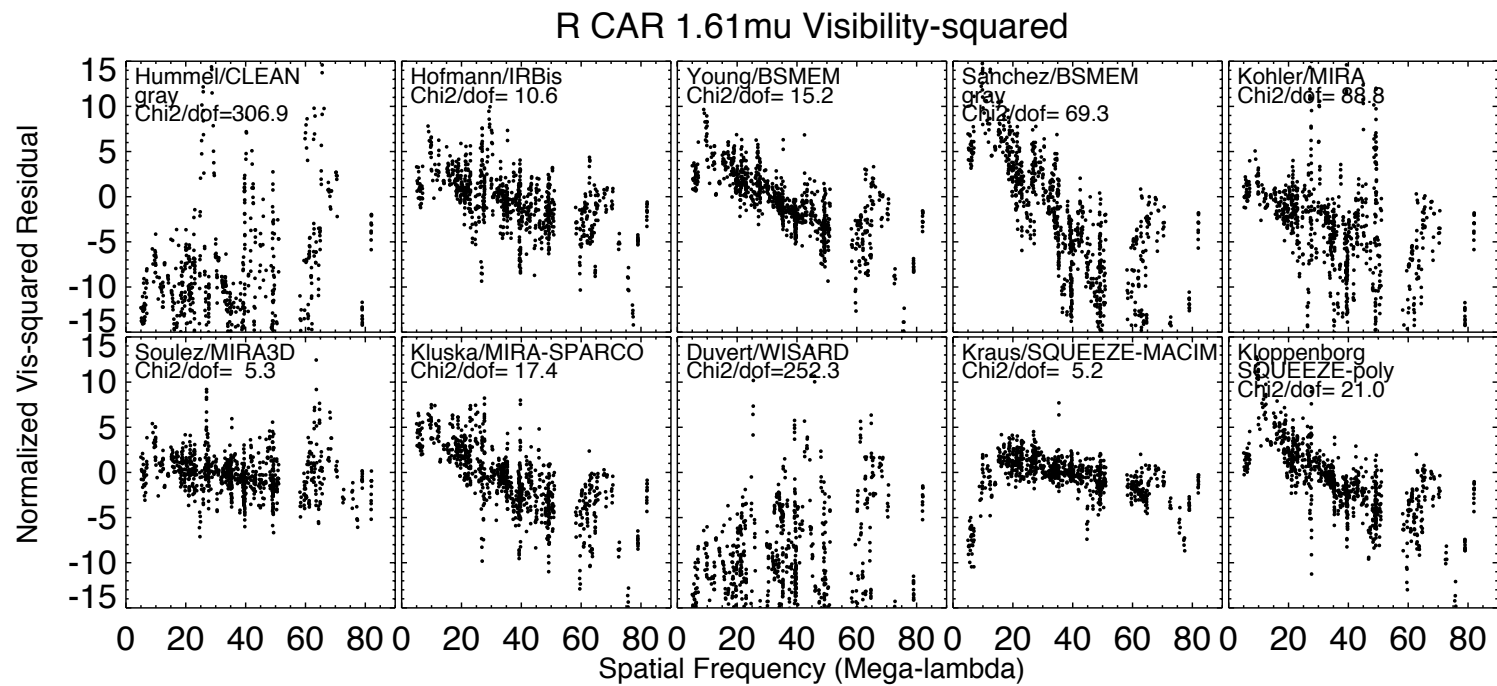
- Dust shell is over-resolved
- Elongated photosphere
- Two bright spots on the eastern limb
- Not much chromaticity
- Approximately the same size as K band (Wittkowski et al.)



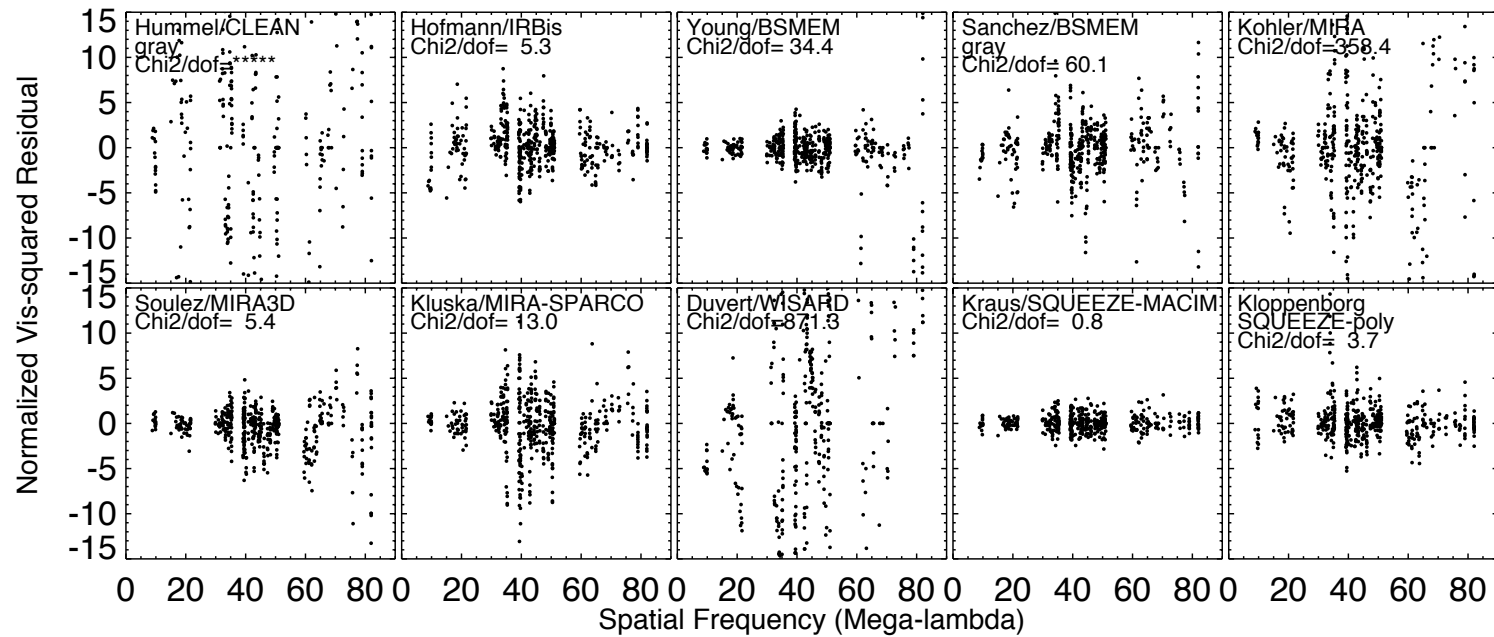






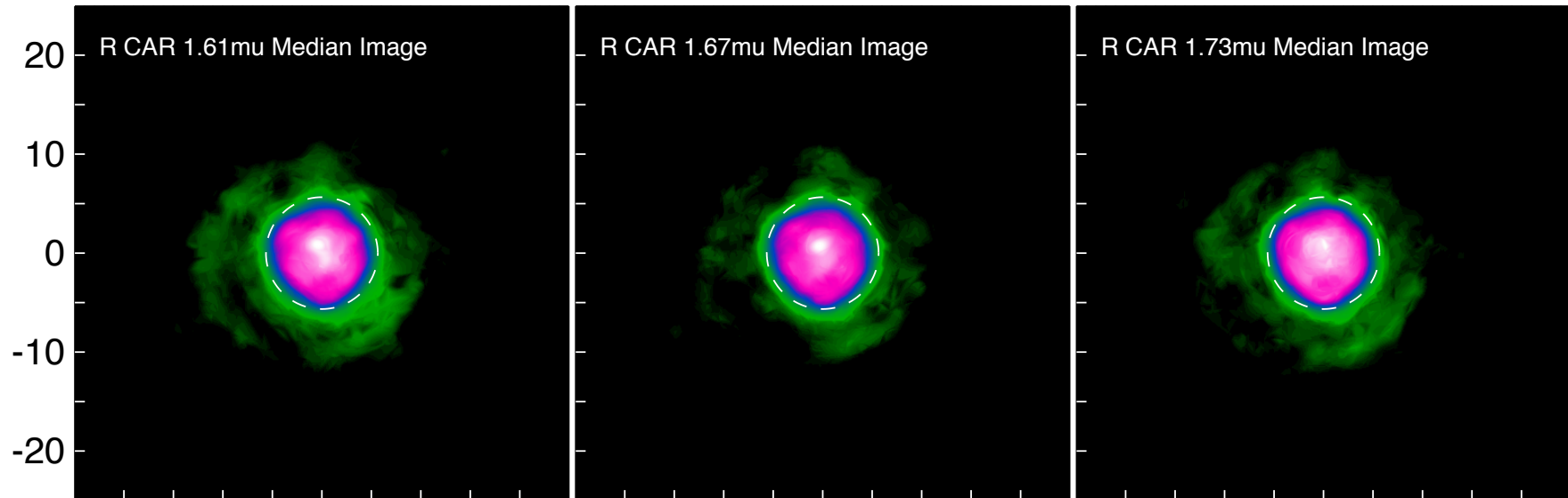


R CAR 1.61μ Closure Phase



R Car

Median Images



- Prominent circumstellar emission shells seen mainly in edge channels
- Two spots (or one elongated spot) near center

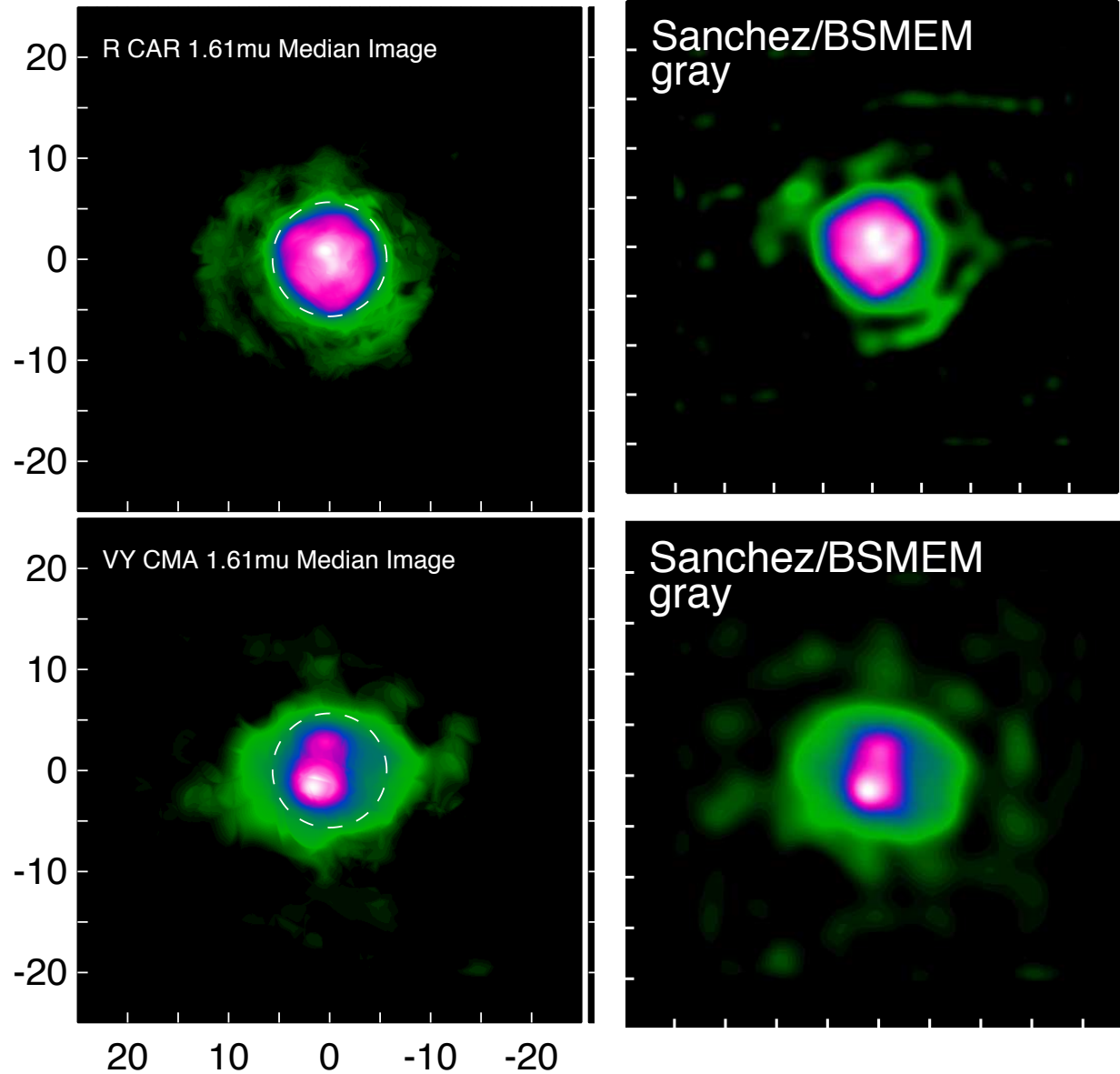


| Submitter | VY CMa | | R Car | | Score |
|-------------|---------|-----------|--------------|---------|-------|
| | 2 spots | Placement | Water Shells | 2 spots | |
| Hummel | | | | | |
| Hofmann | | | | | |
| Young | | | | | |
| Sanchez | | | | | |
| Kohler | | | | | |
| Soulez | | | | | |
| Kluska | | | | | |
| Duvert | | | | | |
| Kraus | | | | | |
| Kloppenborg | | | | | |



| Submitter | VY CMa | | R Car | | Score |
|-------------|---------|-----------|--------------|---------|-------|
| | 2 spots | Placement | Water Shells | 2 spots | |
| Hummel | ☹️ | ☹️ | ☹️ | ☹️ | -2 |
| Hofmann | 😊 | ☹️ | ☹️ | 😊 | +2 |
| Young | 😊 | 😊 | 😊 | ☹️ | +3 |
| Sanchez | 😊 | 😊 | 😊 | 😊 | +4 |
| Kohler | ☹️ | 😊 | 😊 | ☹️ | +1 |
| Soulez | 😊 | 😊 | 😊 | ☹️ | +3 |
| Kluska | ☹️ | 😊 | ☹️ | ☹️ | -1 |
| Duvert | 😊 | ☹️ | ☹️ | ☹️ | 0 |
| Kraus | 😊 | ☹️ | ☹️ | 😊 | +1 |
| Kloppenborg | 😊 | ☹️ | ☹️ | ☹️ | +1 |

Comparison



Possible next steps

- VY CMa
 - Scale visibility in the channels to account wavelength dependence of dust emission
 - Perhaps suppress short baselines
 - Make gray image
- R Car
 - Hybrid model – star+spots are gray but envelope has wavelength dependence

Conclusions

- Key features were tentatively identified via consensus
- All methods recovered key features
 - Variety of assumptions make comparisons difficult
 - More differences between images than in the past when using simulated data
- Congratulations to Joel Sanchez from IAA-CSIC/Spain using BSMEM for recovering all the key image features!

Thanks to all the Contest Participants!

