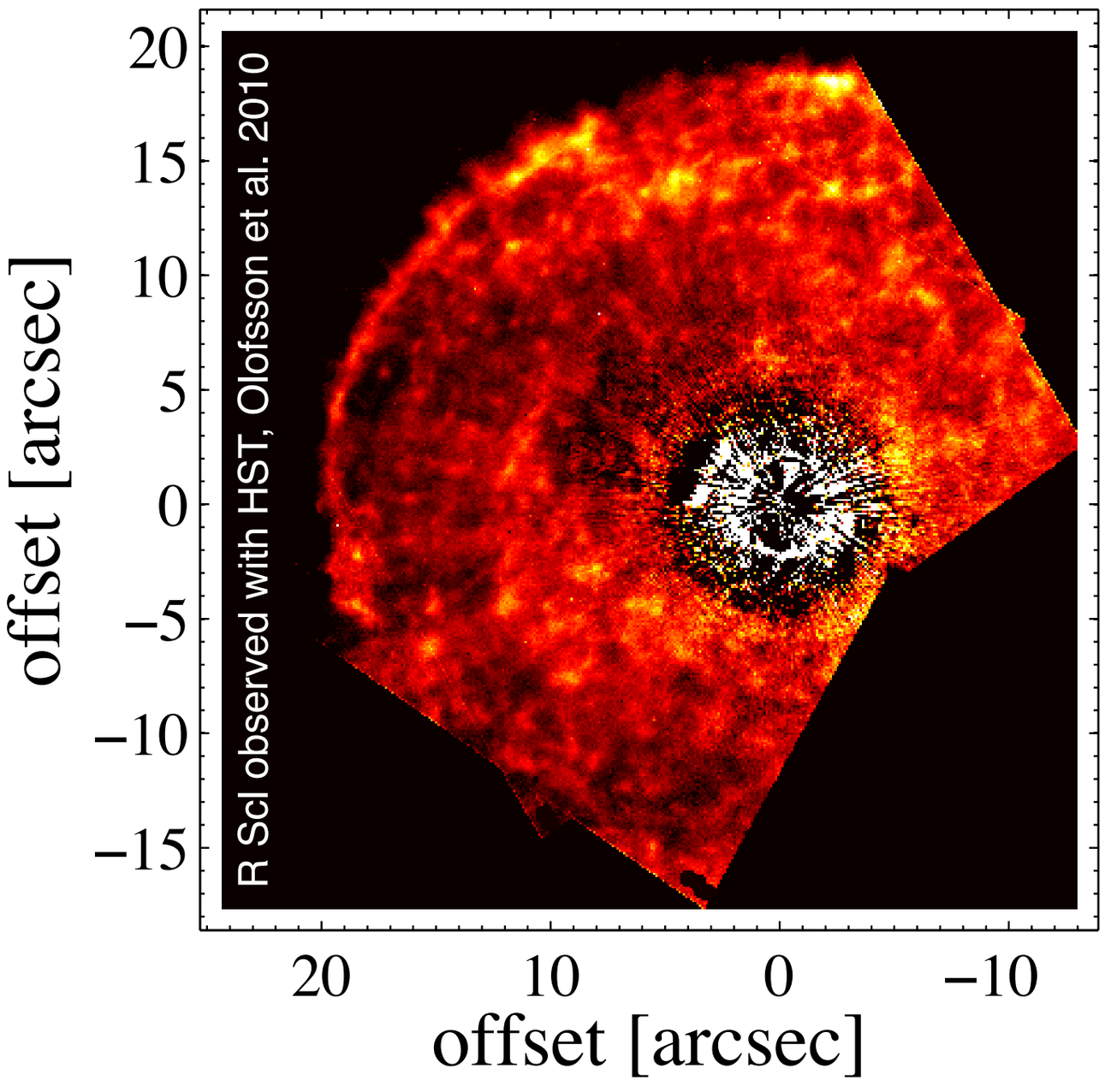
ALMA observations of the carbon AGB star

R Sculptoris

The not-so detached shell and circumstellar environment

Matthias Maercker

Detached shells around carbon AGB stars



Increase in expansion velocity and mass-loss rate during a thermal pulse creates a detached shell

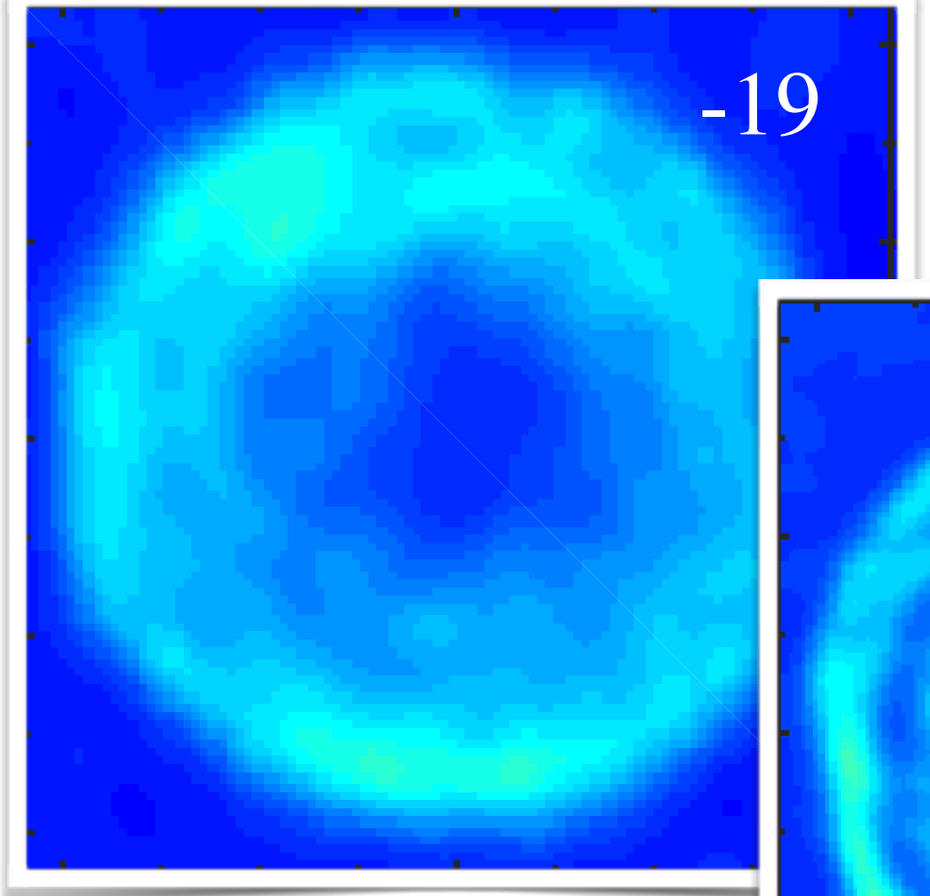
e.g. Steffen & Schönberner 2000, A&A
Mattsson et al. 2007, A&A

observed in dust and gas

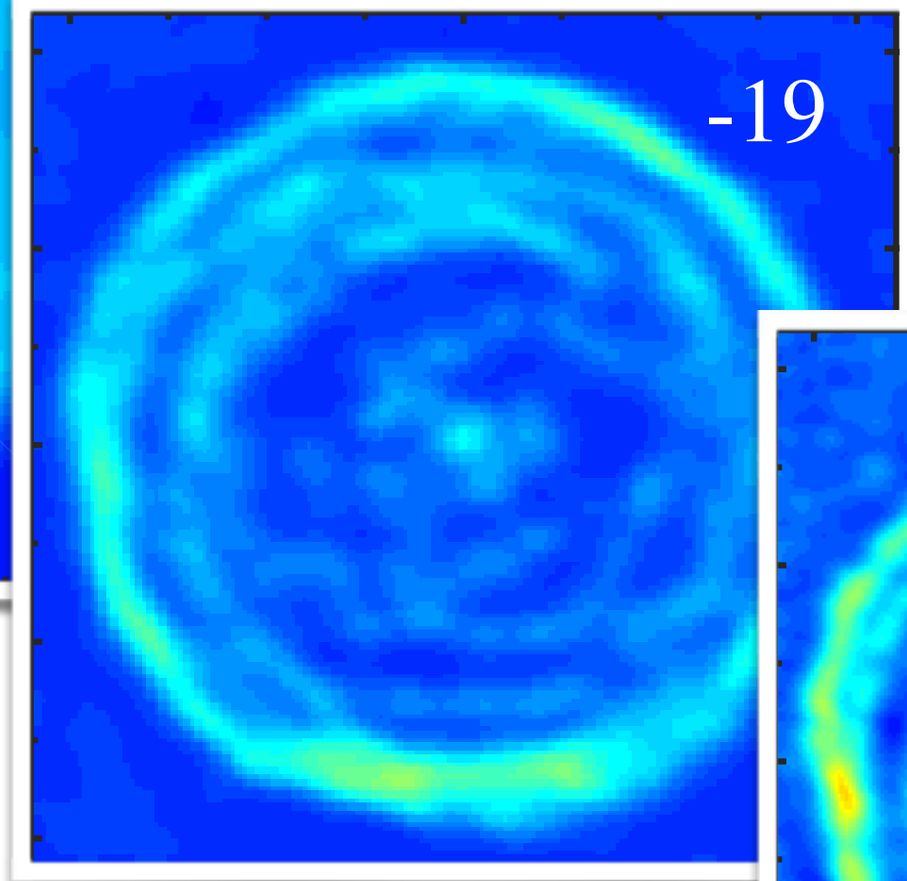
Stellar yields depend on pulse duration and stellar mass-loss rate

ALMA observations of R Sculptoris - Cycle 0

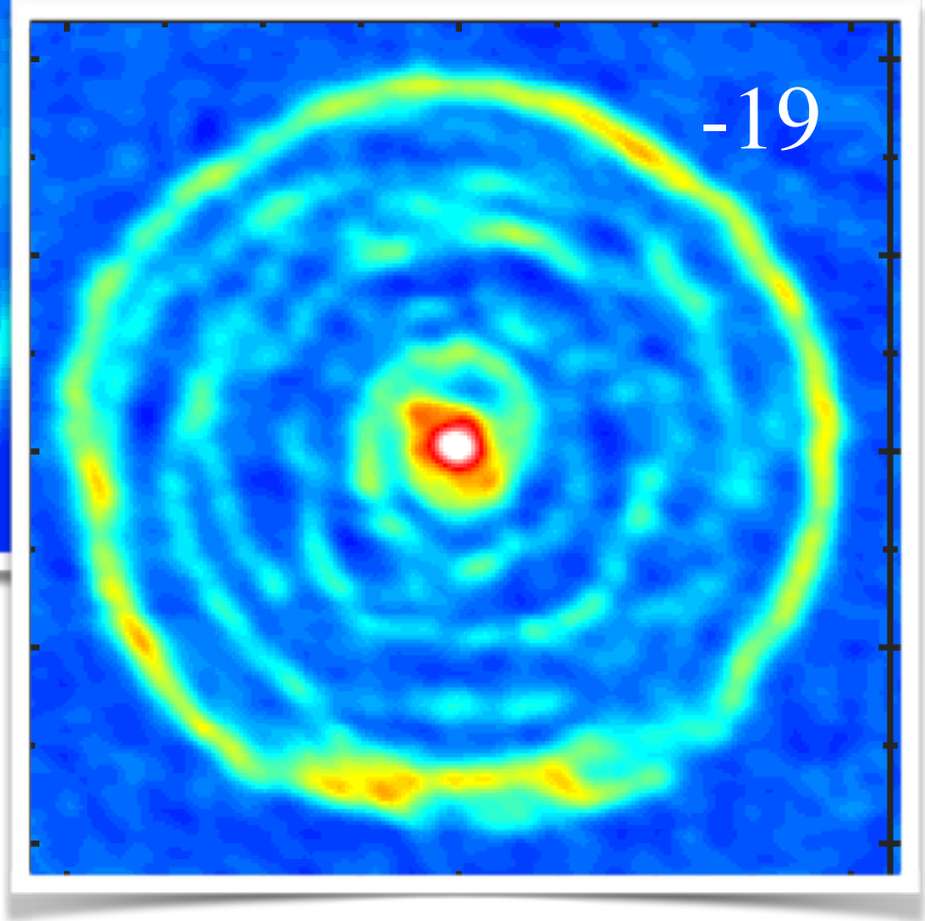
CO(1-0)



CO(2-1)

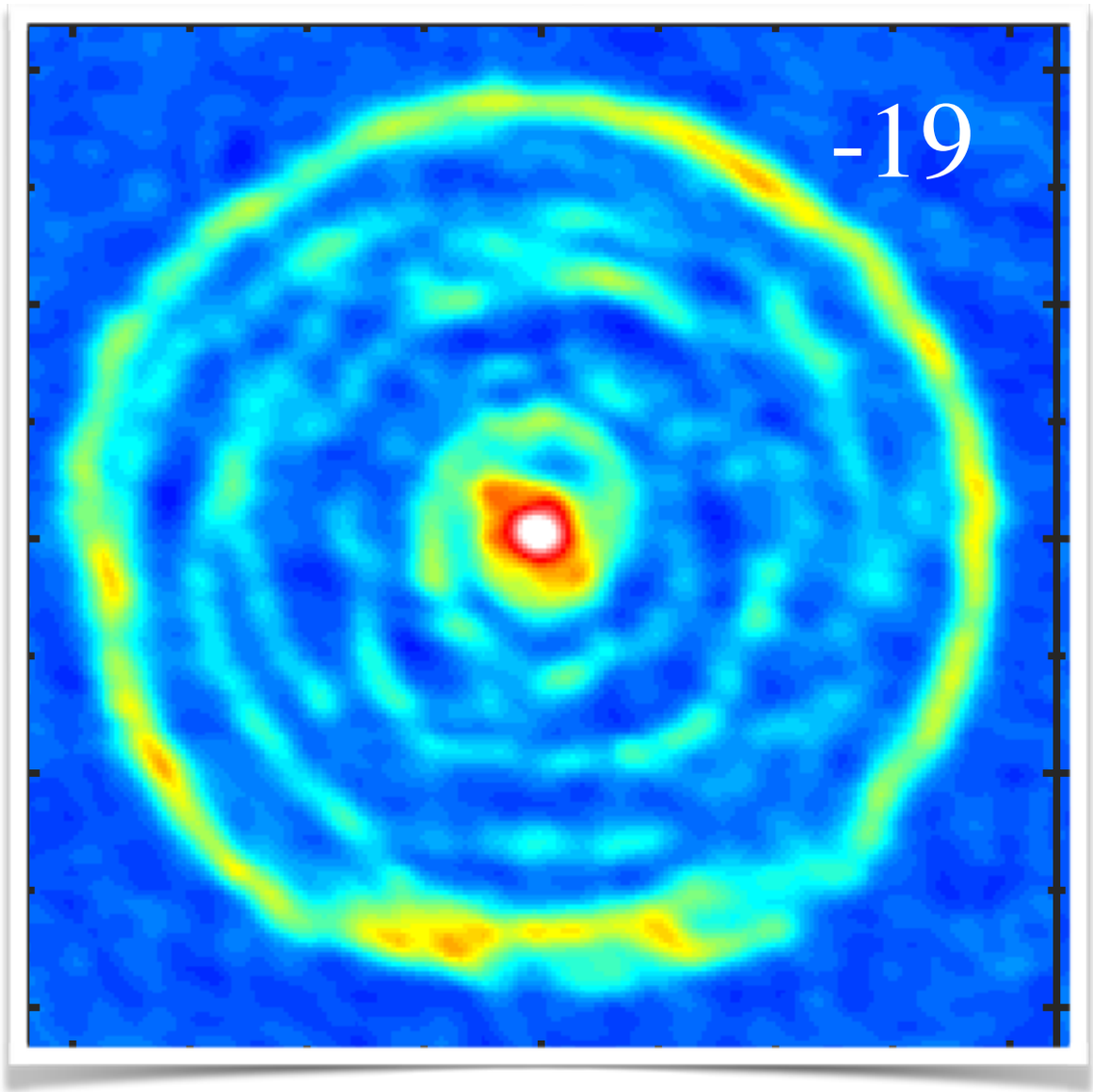


CO(3-2)



Maercker et al. 2015, A&A

Binary induced spiral shape - CO(3-2) observations



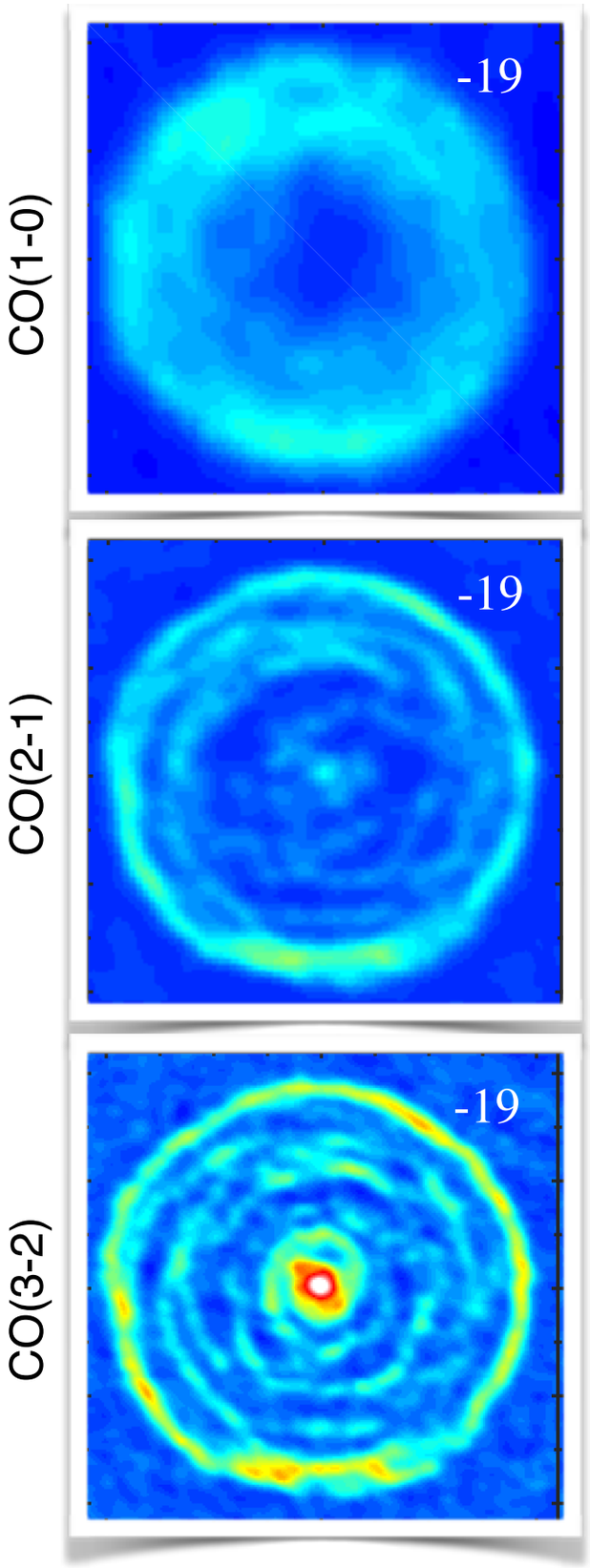
Maercker et al. 2012, Nature

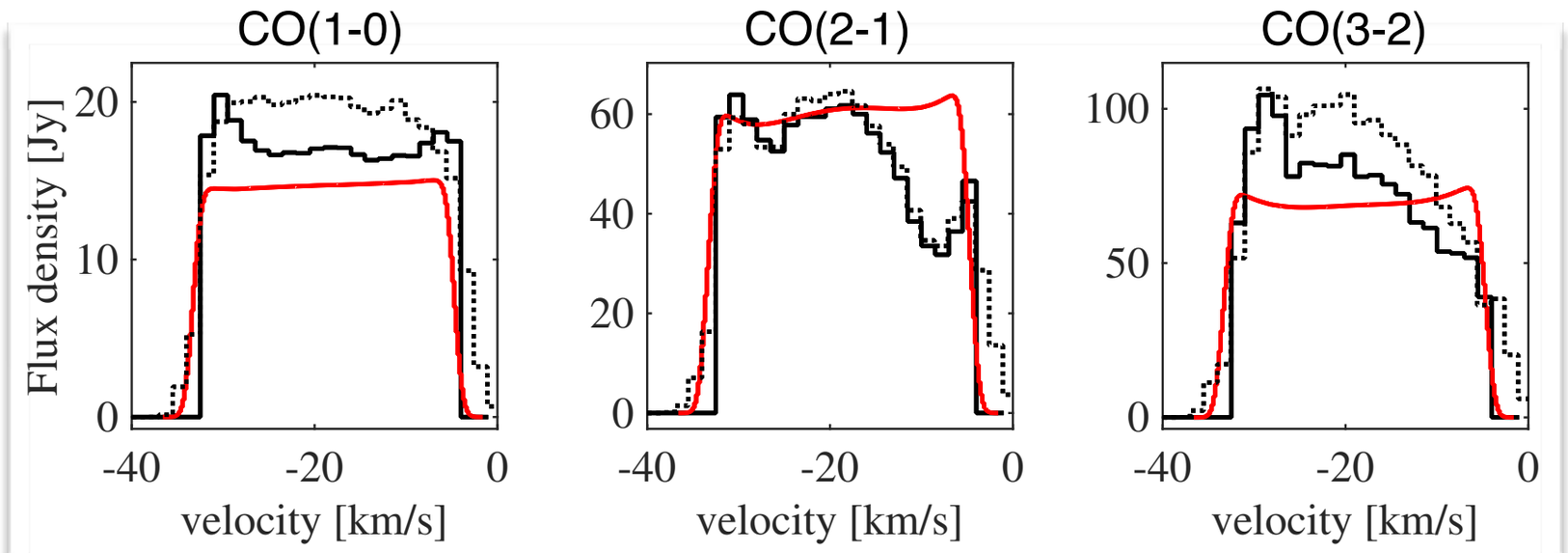
Binary companion shapes post-pulse wind into a spiral

e.g., Kim & Taam 2012, ApJ
Mohamed & Podsiadlowski 2012

can measure the evolution of the expansion velocity and mass-loss rate

The shell around R Scl - ALMA Cycle 0 observations

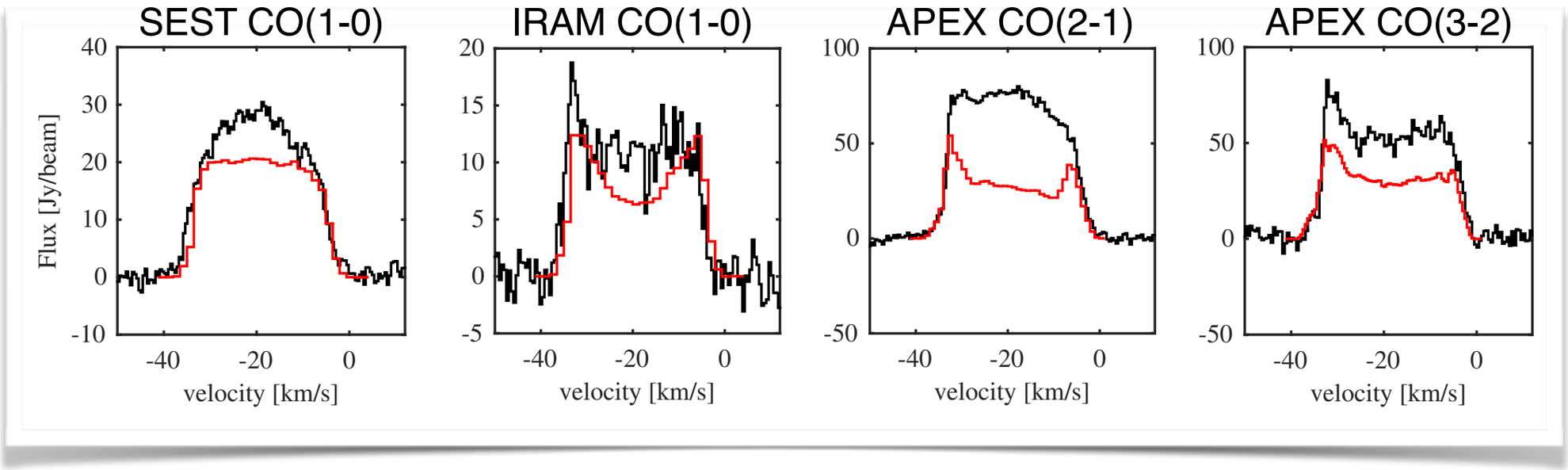




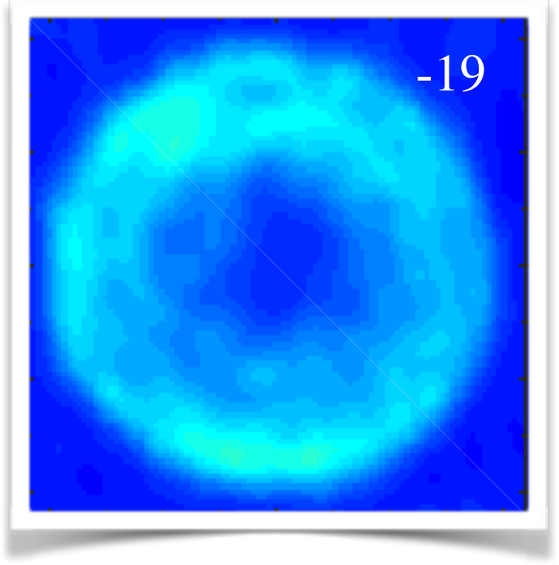
spatially resolved observations allow separate analysis of the shell

Modelling gives M_{shell}: 4.5x10^{-3} $M_{\odot}$ and T_{shell}: 50K

The circumstellar envelope around R Sculptoris



Maercker et al. 2015, A&A



comparison to single-dish spectra indicate missing extended emission in the ALMA observations

shell entirely filled with gas, i.e. not detached

The mass-loss rate evolution

thermal pulse mass-loss rate
$2.3 \times 10^{-5}\ M_{\odot} yr^{-1}$

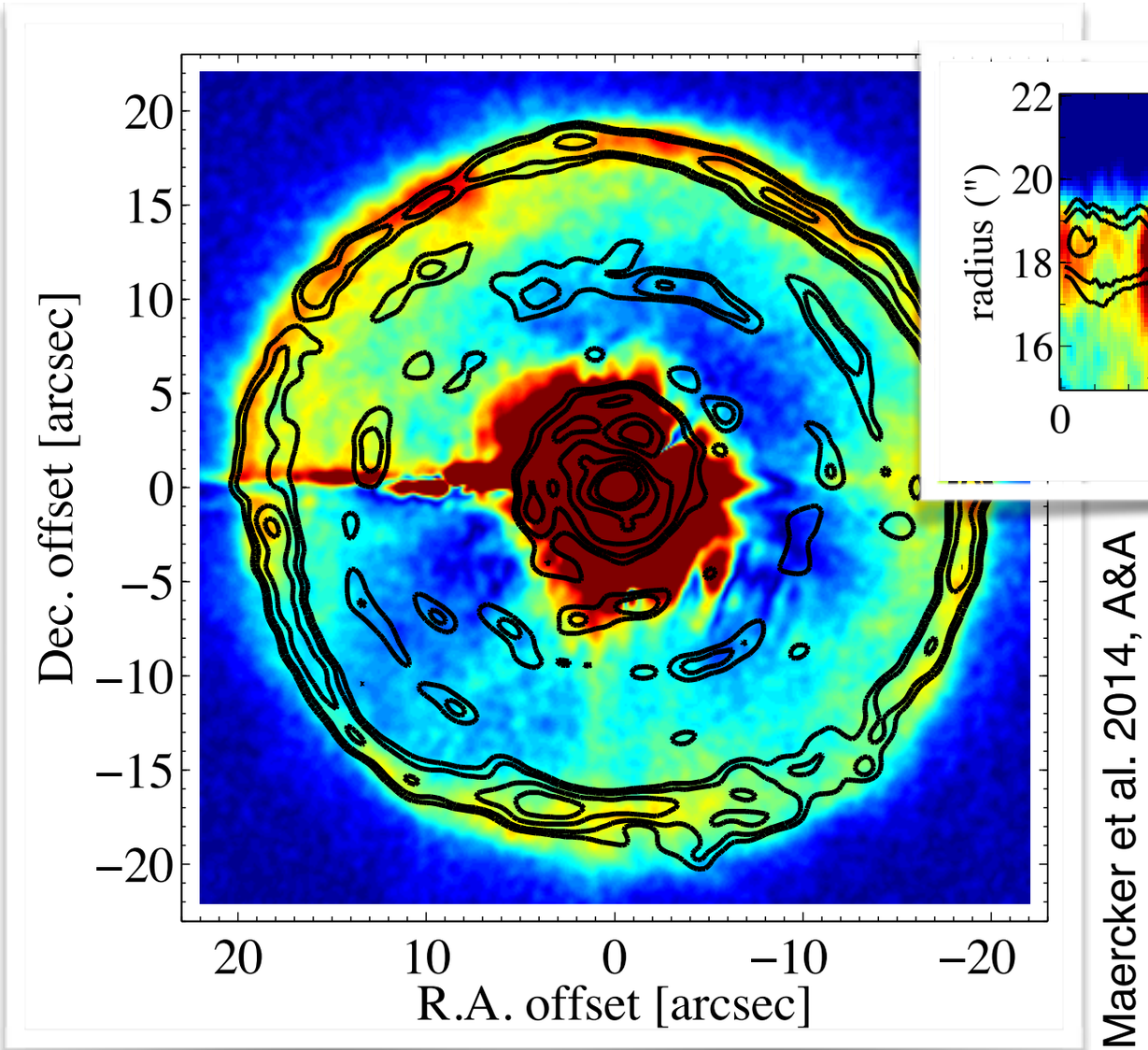
slower decline in mass-loss rate after a thermal pulse than predicted by models

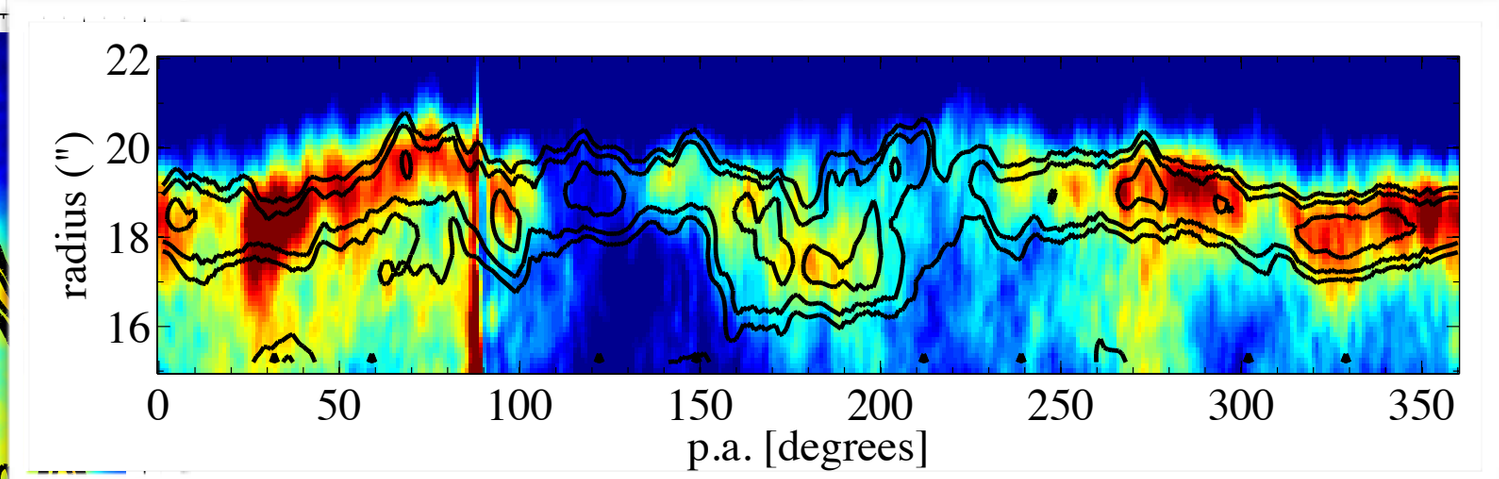
post-pulse mass-loss rate
$1.6 \times 10^{-5}\ M_{\odot} yr^{-1}$

more mass than expected lost during the thermal pulse cycle:
$0.03\ M_{\odot}$ vs. $0.007\ M_{\odot}$

most recent mass-loss rate
$< 3.5 \times 10^{-6}\ M_{\odot} yr^{-1}$

Optical observations - comparing dust and gas





Maercker et al. 2014, A&A

nearly identical distribution of dust and gas in the shell

common evolution of the dust and gas constrains wind interaction and mass-loss mechanism

Conclusions

first **observational** constraints on the behaviour of the star during and after a thermal pulse

shell around R Scl not “detached”

affects stellar evolution models

slow decline of mass-loss rate after a thermal pulse

our understanding of the chemical evolution of the ISM and galaxies