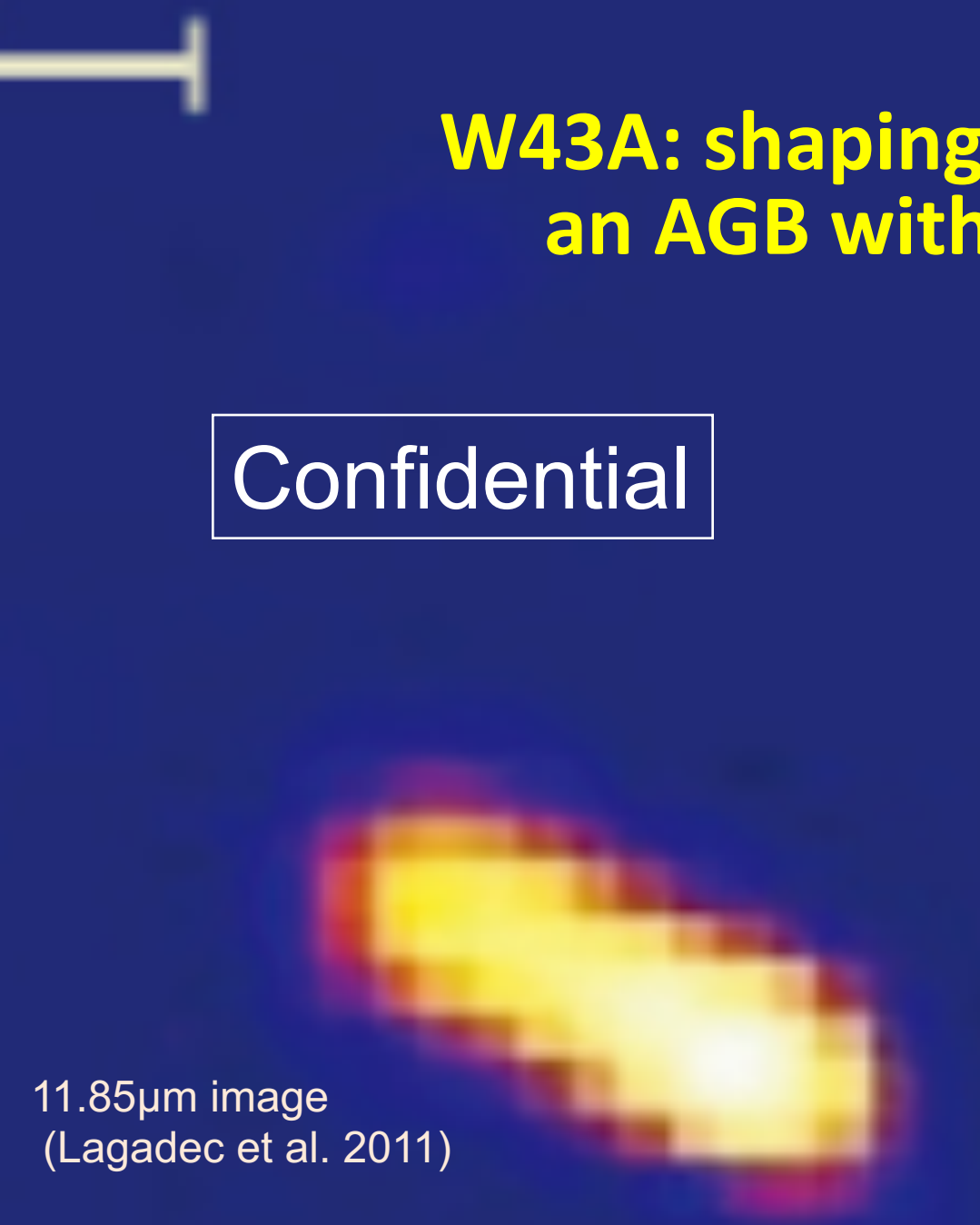
W43A: shaping the envelope of an AGB with a collimated jet

Confidential

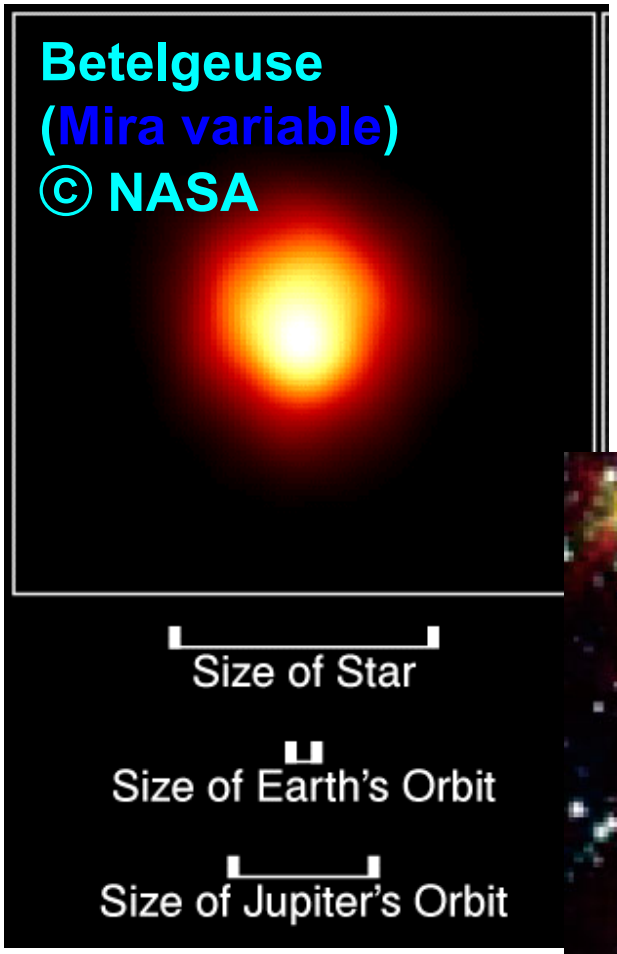
Hiroshi Imai
(Kagoshima University)
Jun-ichi Nakashima
(Ural Federal University)
Gabor Orosz
(University of Tasmania)
Bosco Yung
（Nicolaus Copernicus Astronomical Centre)
José-Francisco Goméz
(CSIC/IAA)
Daniel Tafoya
(NAOJ/EA-ARC)

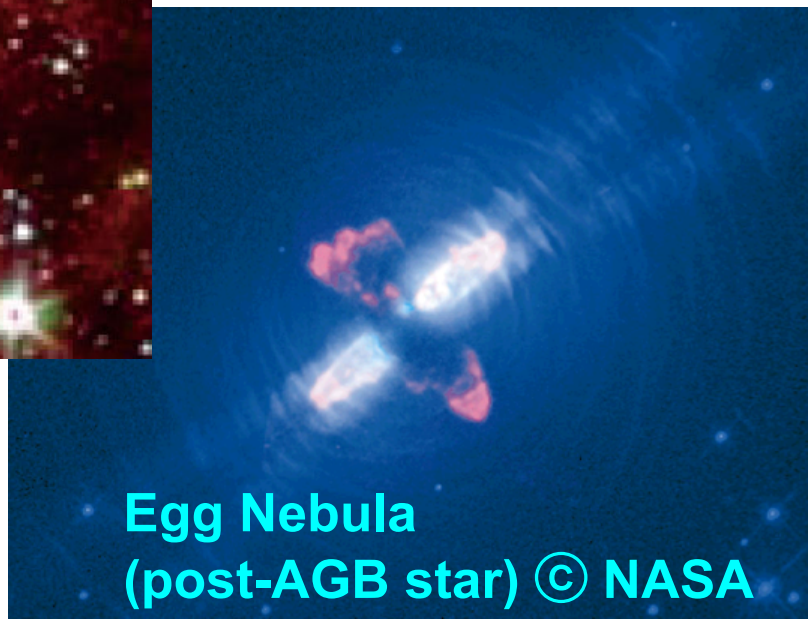


11.85μm image
(Lagadec et al. 2011)

VLBI Consortium Symposium on 2018 December 1, Kumamoto University

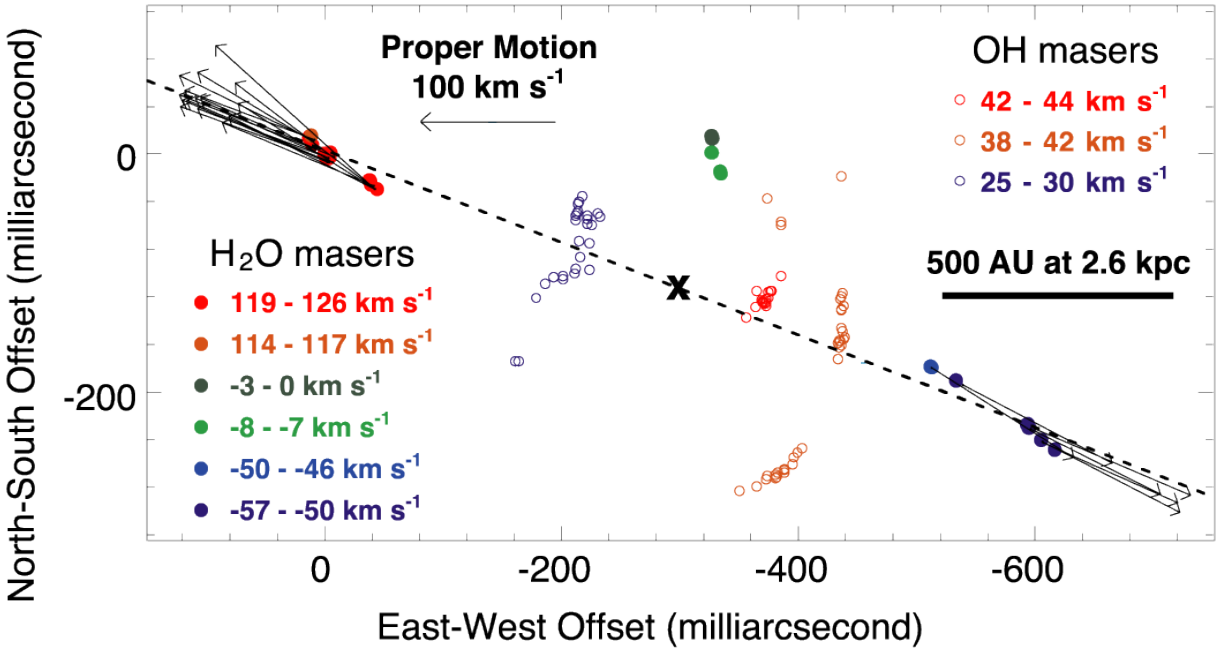
Transition phase from AGB to post-AGB star, from spherical symmetric to asymmetric circumstellar envelope



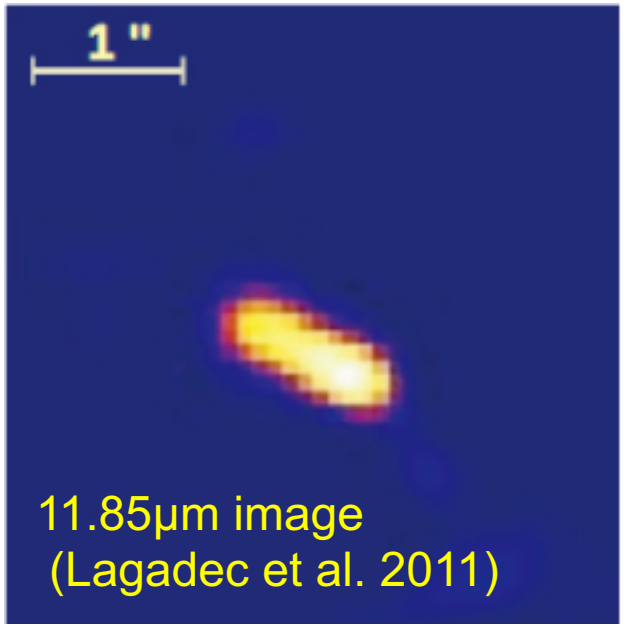


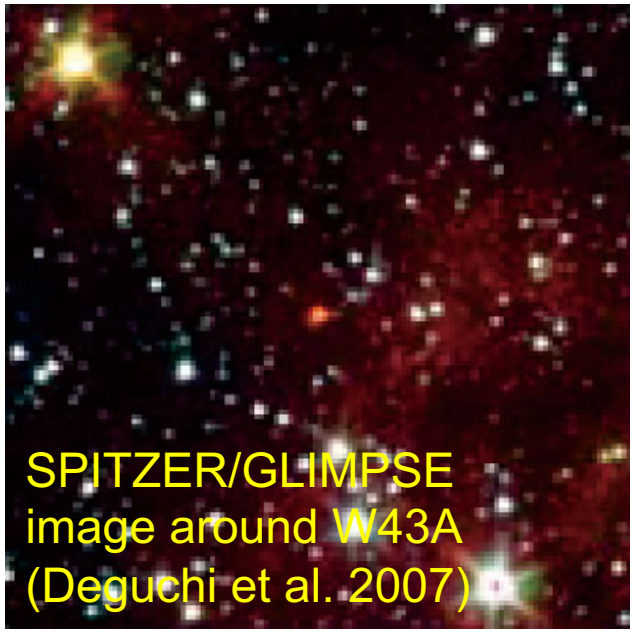
- When / how is a water fountain launched?
- Which kind of star becomes a host of a water fountain?

Water fountain: highly-collimated *stellar* molecular jet traced by H_2O maser emission



H_2O and OH masers in W43A (Imai et al. 2002)



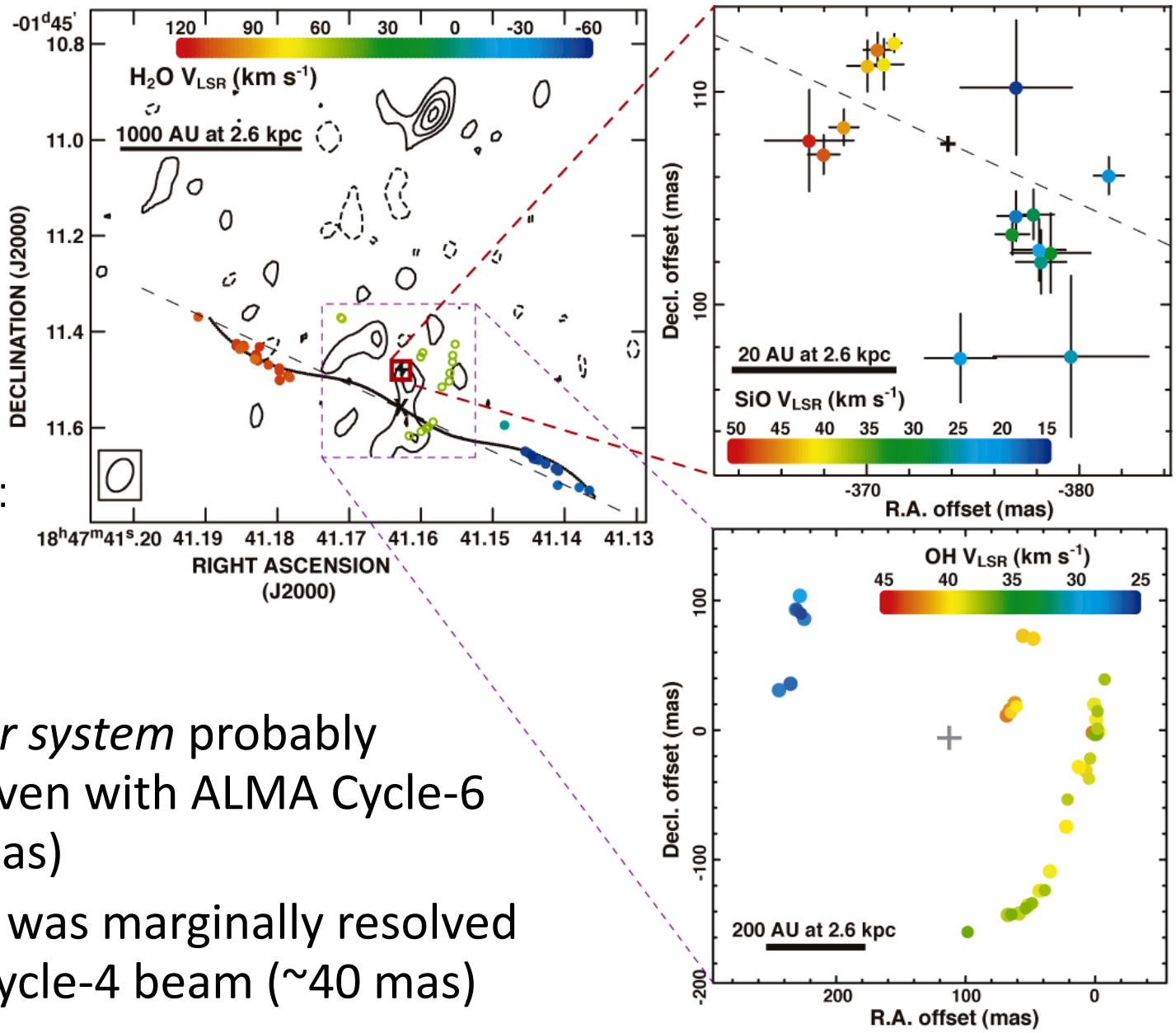


- V_{exp} (H_2O) (>100 km/s) >> V_{exp} (OH) (10—30 km/s)
- **Very short dynamical time scale (?):** <100 years
- **Very high mass loss rate (?):** $dM/dt > 10^{-5} M_{sun} yr^{-1}$

The origins of the jets: double stars or single star?

W43A
(Imai et al. 2008)

- H_2O: jet
- 1612 MHz OH: envelope
- SiO: torus

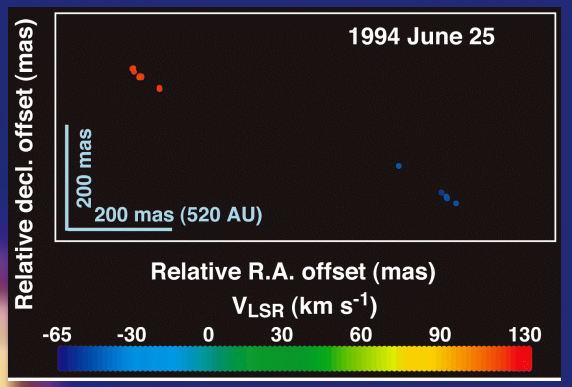


- Central *stellar system* probably unresolved even with ALMA Cycle-6 beam (~20 mas)
- Central *torus* was marginally resolved with ALMA Cycle-4 beam (~40 mas)

What seen in ^{12}CO J=2→1 emission

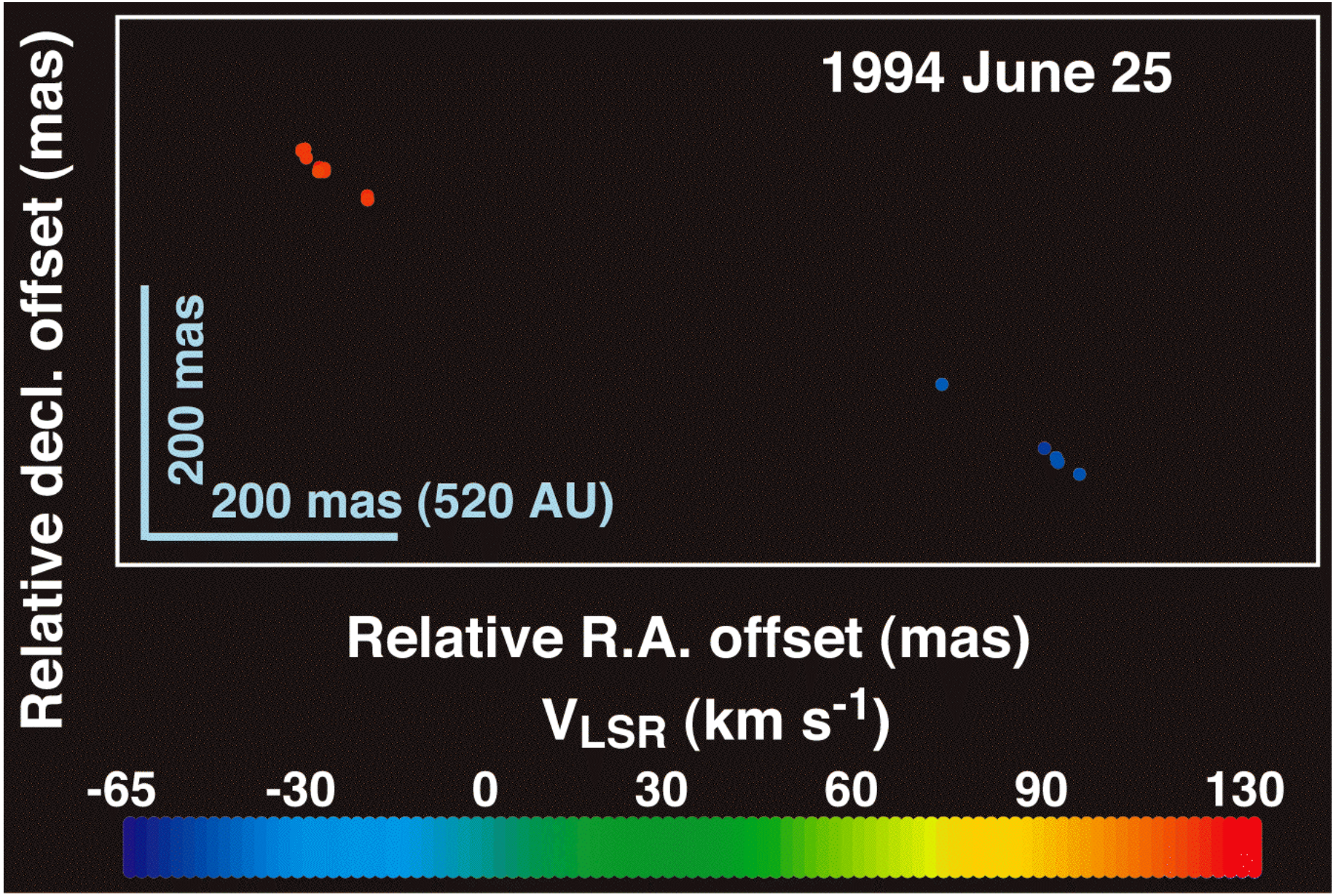
- Intermediate velocity components
  - Along the major axis of a MIR cavity
  - Consistent with low-velocity components of H_2O masers

Confidential



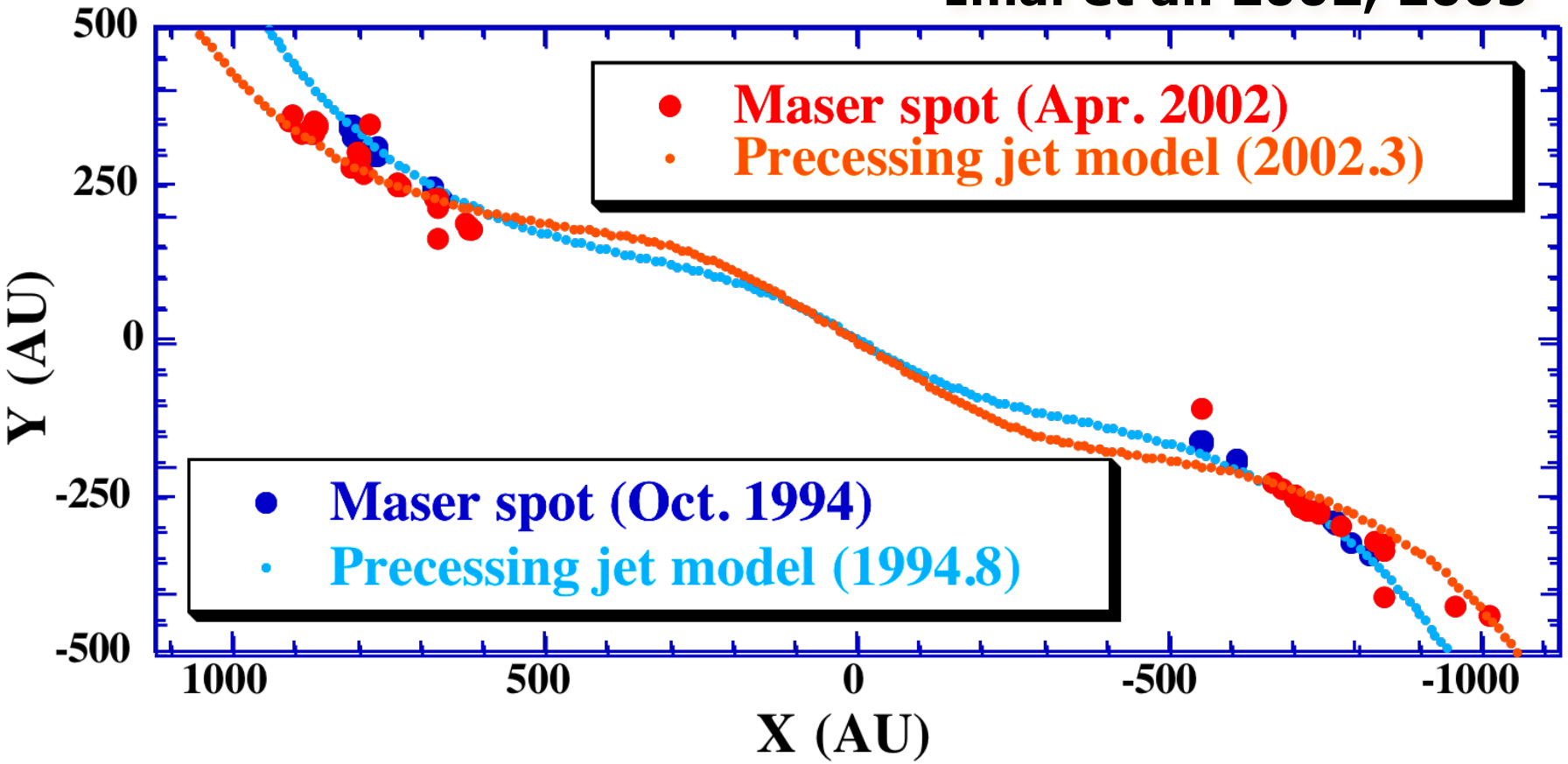
11.85μm image
(Lagadec et al. 2011)

Evolution of the W43A jet



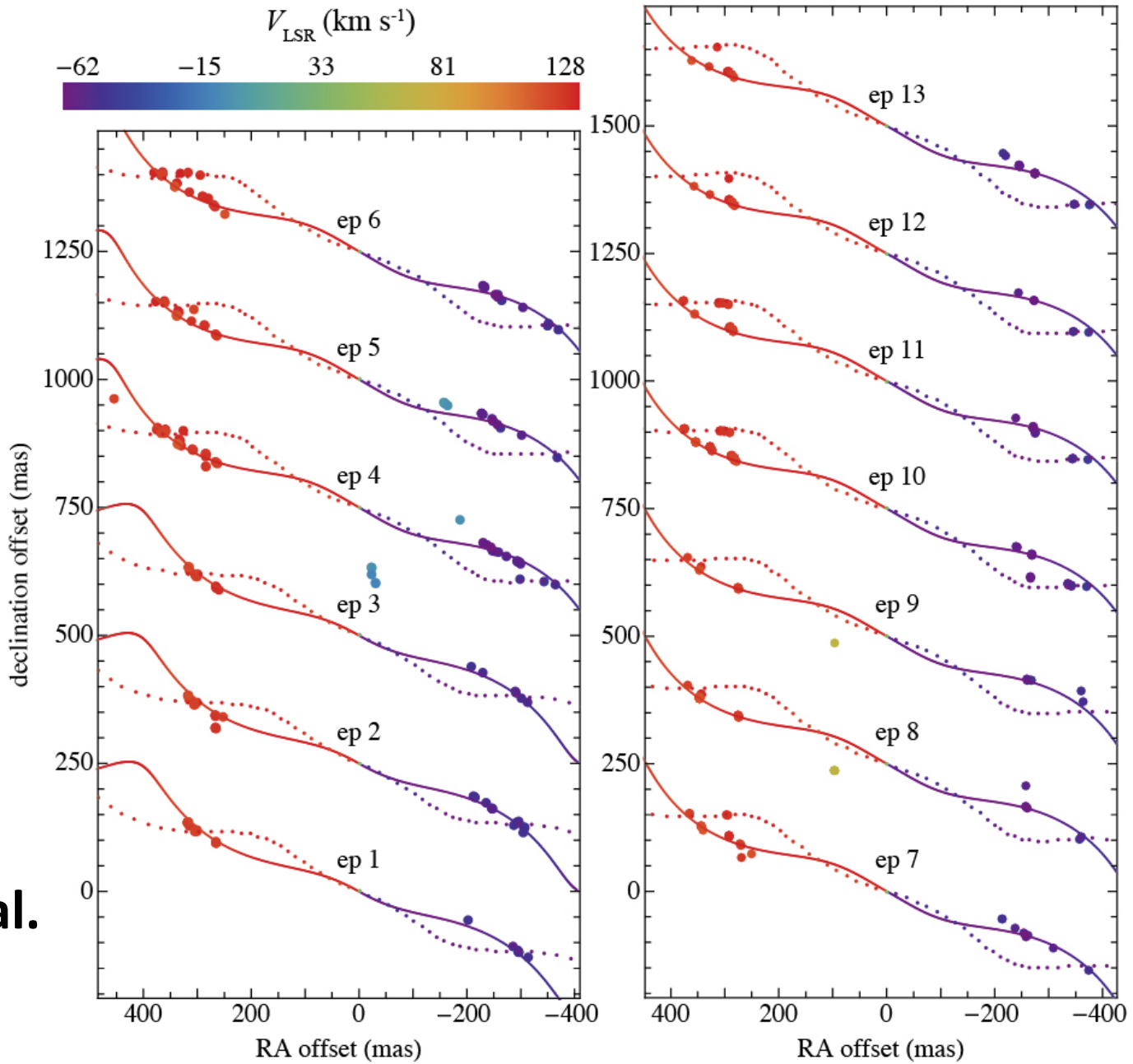
Previous precessing jet model

Imai et al. 2002, 2005



- Precession period ~55 years
- Precession angle amplitude ~5°
- Gas bullets with ballistic motions from the central star and interactions with ambient envelope

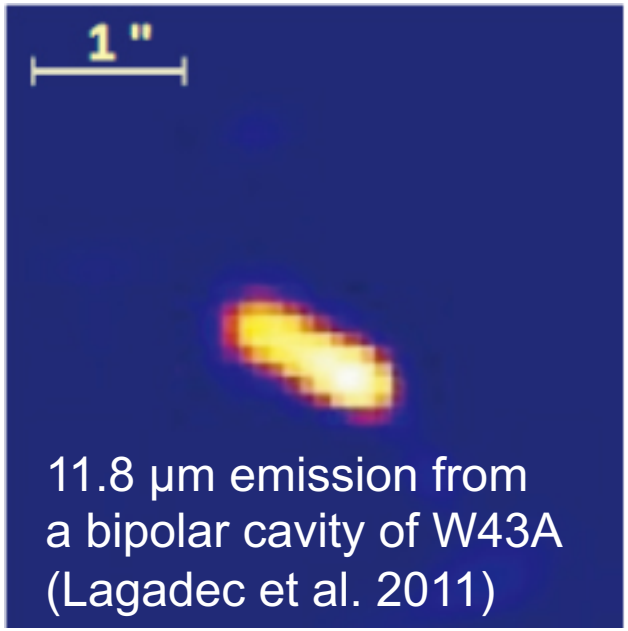
Wrong precessing jet model by Imai et al. (2002)



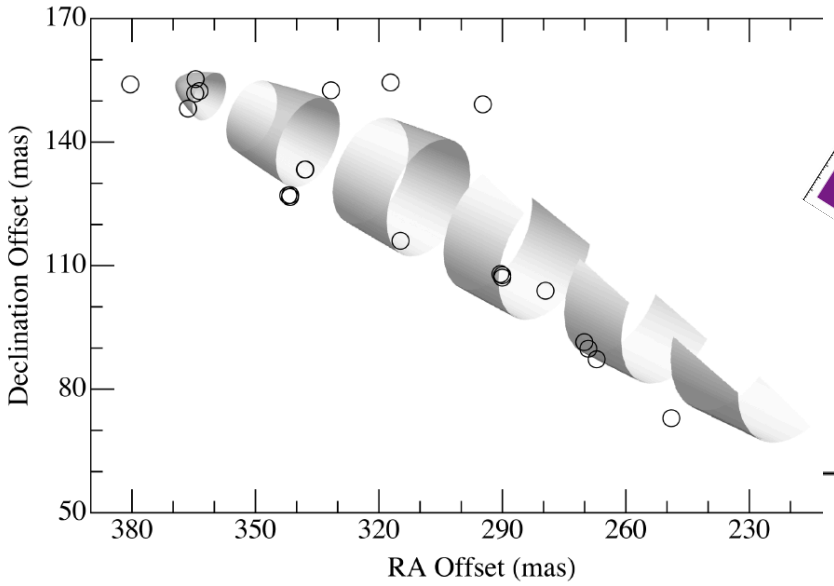
Chong et al. (2015)

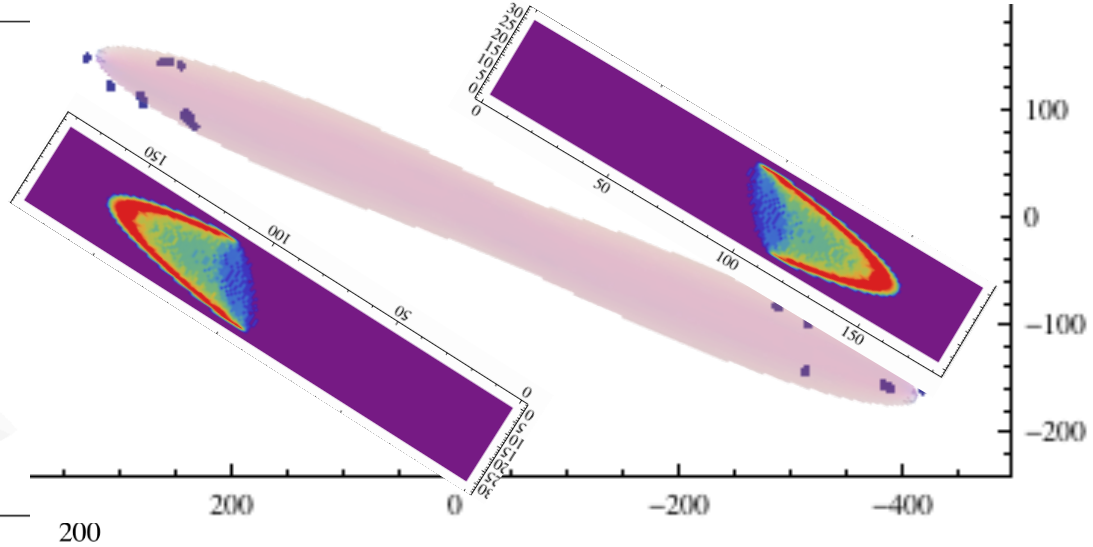
A new model of H_2O maser excitation region

(Chong et al. 2015)

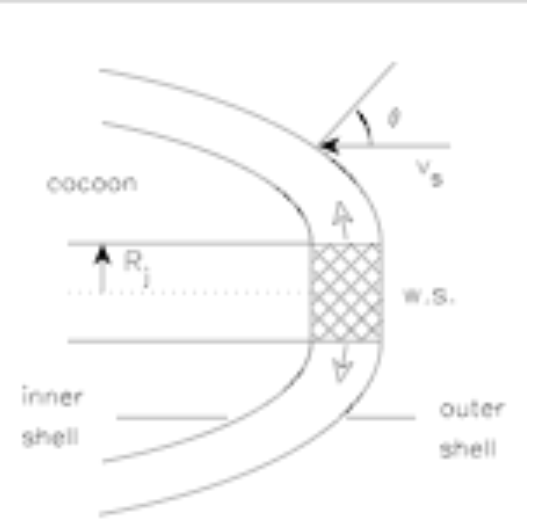


- Bipolar cavity formed by past jet ejection
- New interaction of newly ejected jet at the cavity wall
- Periodic pattern of maser region produced by discontinuous ejection of jet or envelope





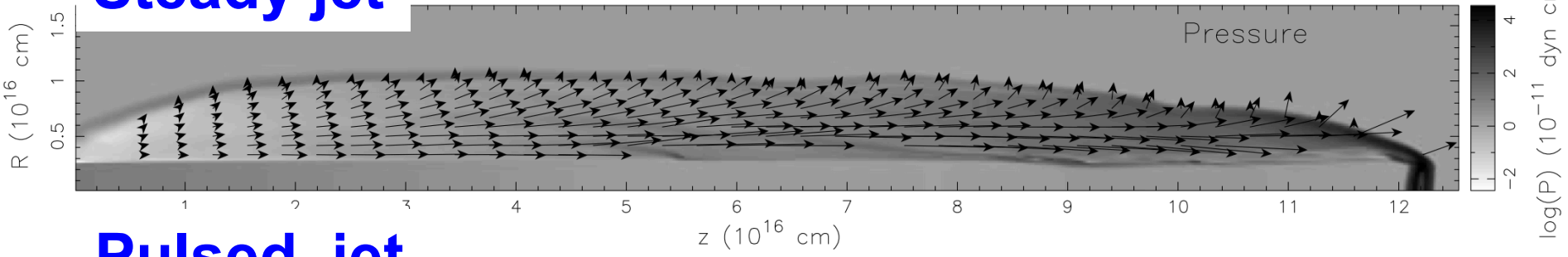
Jet with a large opening angle



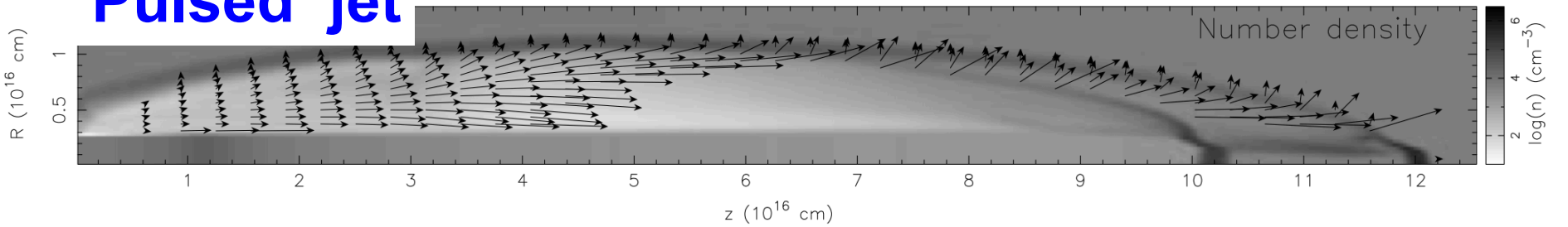
- Formalization (Ostriker 2001)
- Simulations (Lee et al. 2001)
  steady v.s pulsed jets
- Application to water fountain jet to explain directions of maser motions and thickness of maser distribution

(Orosz et al. 2017 in prep.)

Steady jet



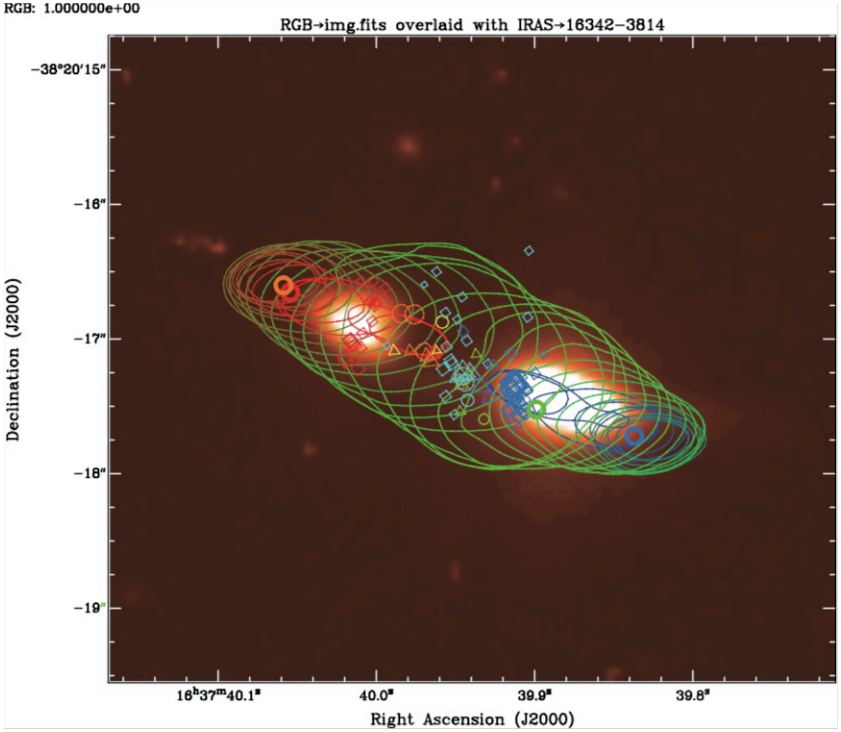
Pulsed jet

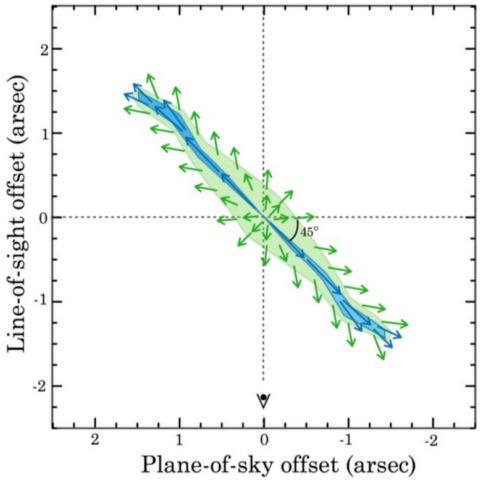


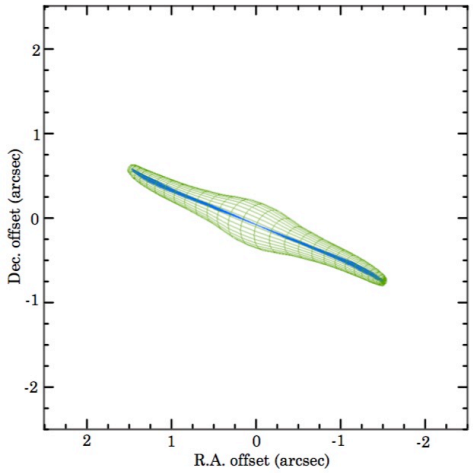
Fast, decelerating, small-precessing jet model

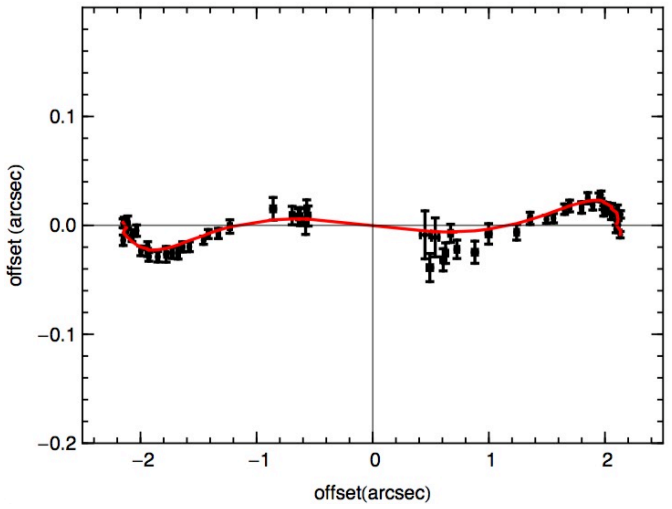
Tafoya et al. (in preparation)

IRAS 16342-3814









Fastest components close to the central system

Anticorrelation between CO and dust continuum emission regions

Confidential

Periodic outbursts of the jet

Confidential

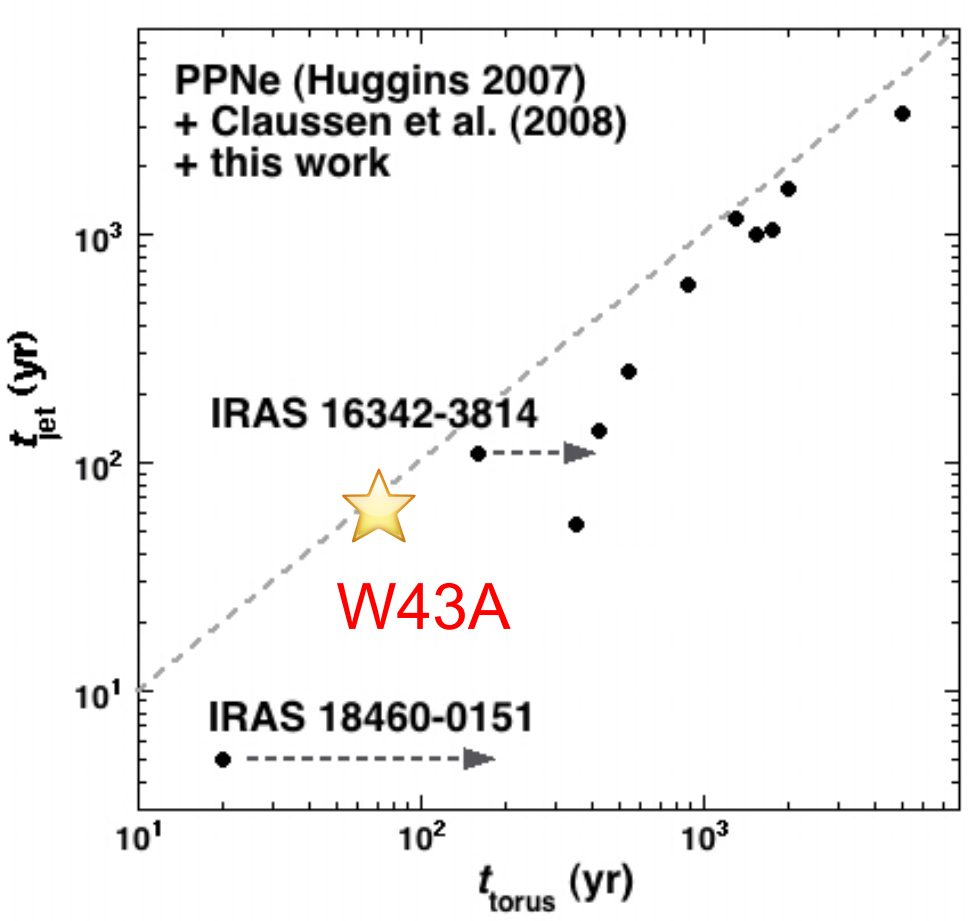
Ejection period: *P*=5—7 years

Tracing the co-evolution of a collimated stellar jet and equatorial torus/flow

- First outburst in W43A
  ~60 years ago
- Interaction event between a compact stellar object and a torus followed by a jet on a short time scale
- **Binary system scenario** may produce the interaction event and explain (multiple) discrete mass ejection.
- The **interaction event** may occur in AGB phase.

Statistical study is necessary.

Mapping the whole envelope/ torus is crucial.



Data point of W43A has been just determined.

Future perspectives

FLASHING

Finest Legacy Acquisitions of SiO and H_2O masers Ignitions by Nobeyama Generation

First observations on 2018 December 1

Simultaneous observations of SiO and H_2O masers with new quasi-optics derived by HINOTORI

(Hybrid Installation Project in Nobeyama, Triple-band Oriented)