Observations of H_2O and OH masers in star-forming regions

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Cosmic masers

- Hydroxyl OH (1965), λ = 18 cm
- Water vapour H_2O (1968), λ = 1.35 cm
- Silicon monoxide SiO, λ = 7, 3.5 … mm
- Methanol CH_3OH
- Formaldehyde H_2CO, λ = 6 cm
- Cyanic acid HCN

RT-22 radio telescope, Pushchino

D = 22 m, 22.235 GHz, HPBW = 2.6′

2048 channels, dVr = 0.082 km/s

F ~ 5-7 Jy

Nançay radio telescope

λ = 18 cm,
HPBW = 3.5'x18'
dVr = 0.068 km/s
(1024 channels)
Stokes:
I
Q **= *F*(0°) – *F*(90°)**
U **= *F*(-45°) – *F*(45°)**
V **= *F*(RC) – *F*(LC)**

Source sample of star-forming regions (~60 *):**
W3, W49, W51, W75, Ori A, Cep A, ON 1, ON 2,...

Meaning of single-dish monitoring:
Sources frequently observed (~once per month)
Available interferometric data invoked

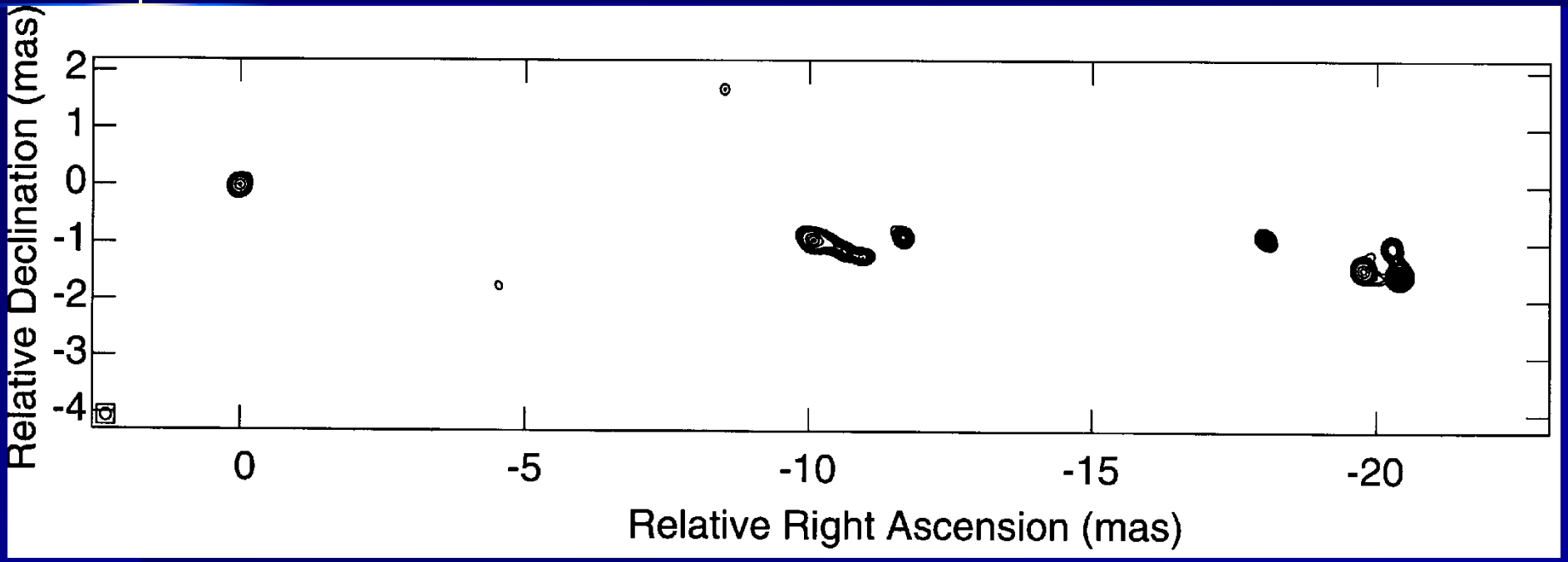
H_2O Maser IC 1396N
(No OH detected)

IC 1396N (IRAS 21391+5802) J2000 RA = 21^h 40^m 42.3^s DEC = $+58^o$ 16′ 10″

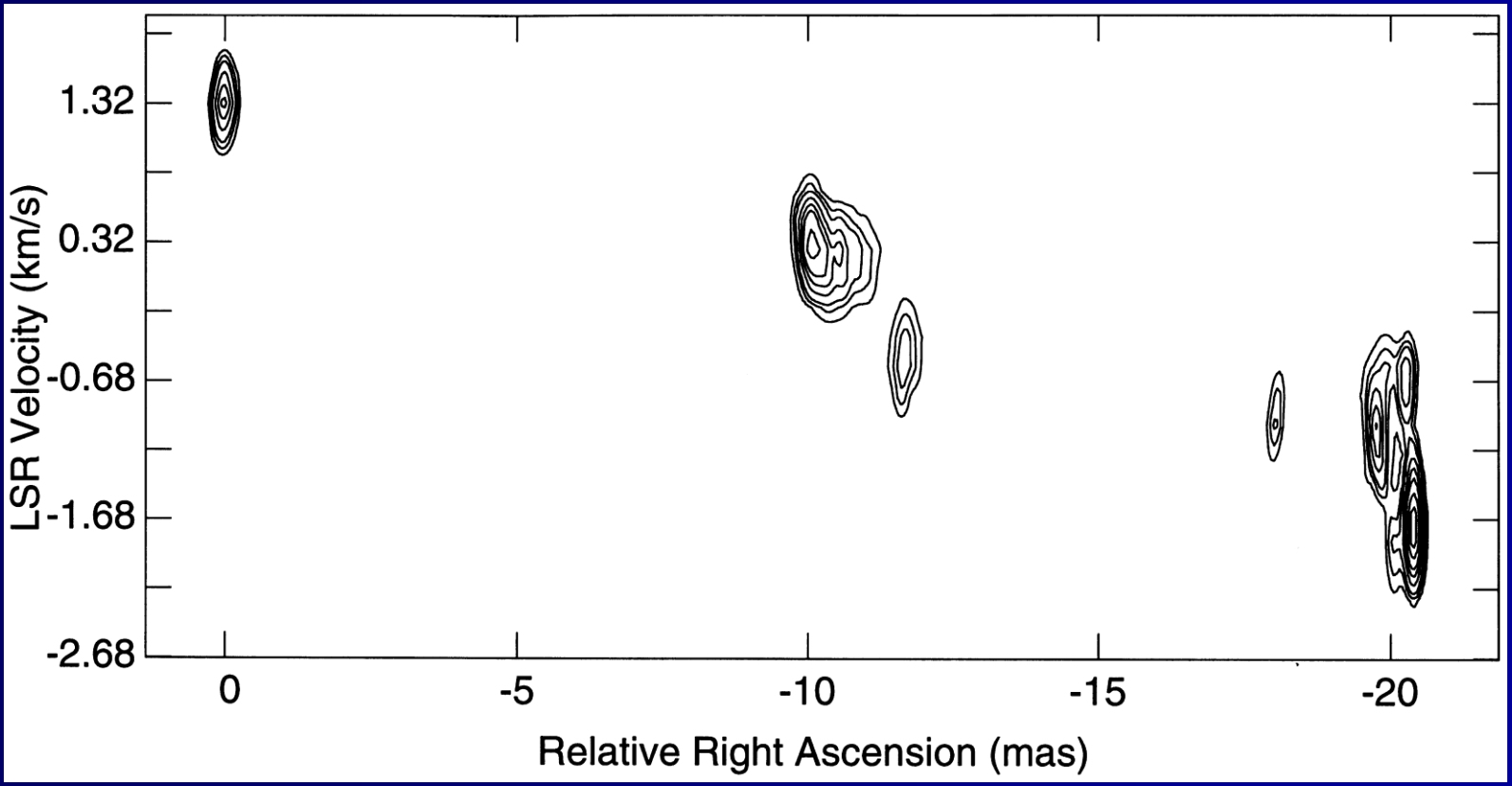
d **= 750 pc**

IC 1396 (Elephant Trunk Nebula), IC 1396N = IRAS 21391+5802

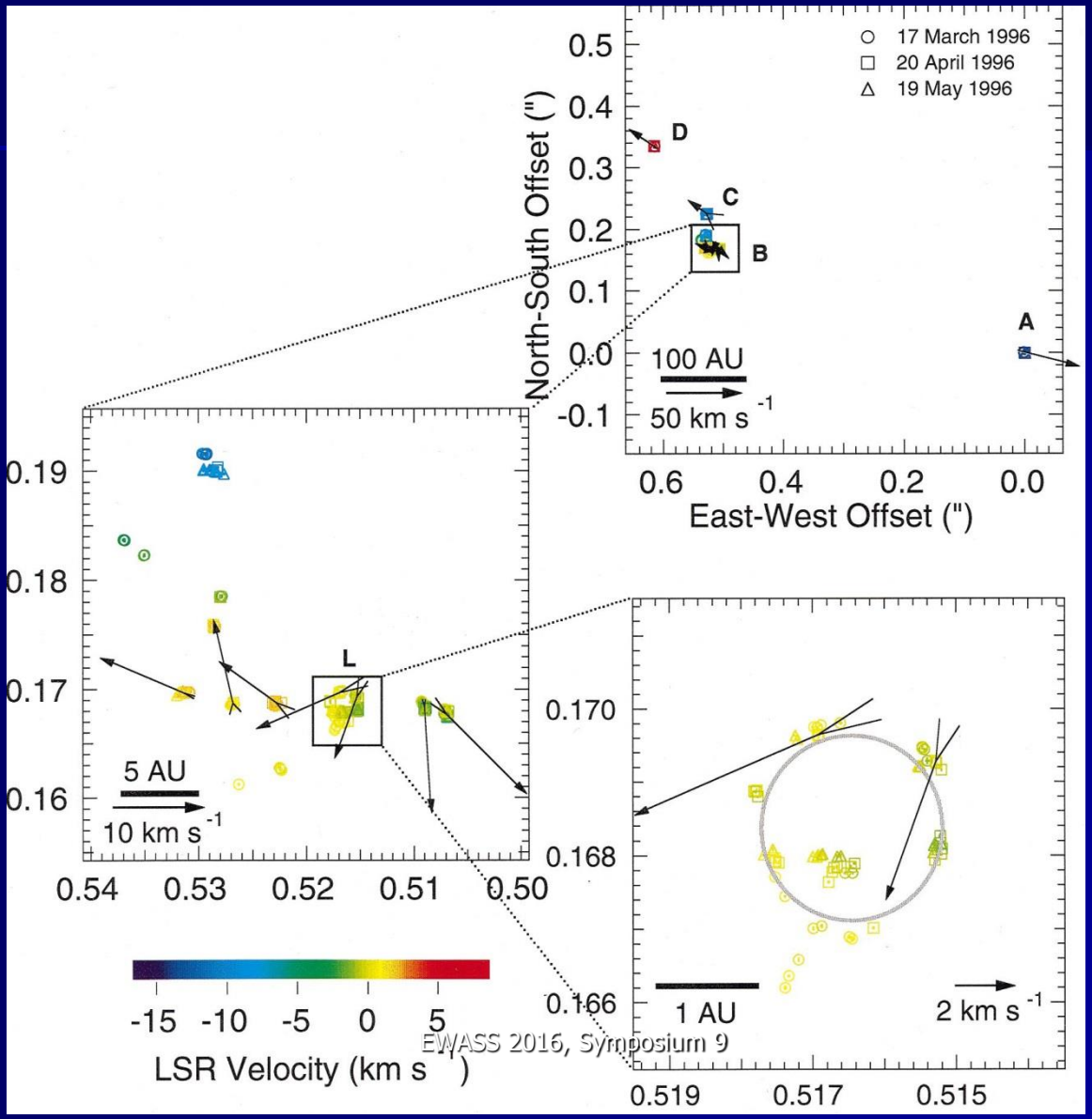
Slysh et al. 1999, ApJ 526, 236
VLBA, June 1996

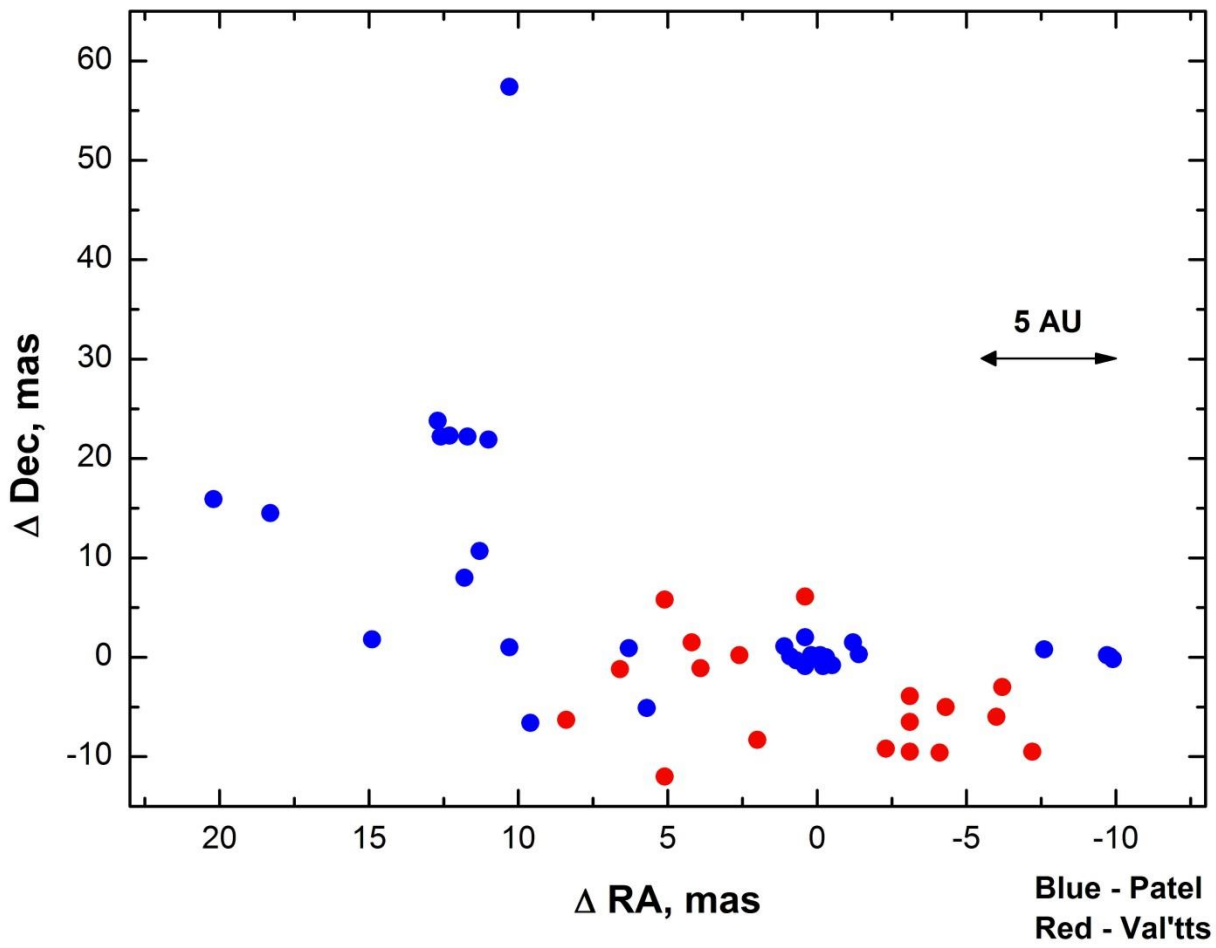


Slysh et al. 1999, RA – VR Diagram



Patel et al. 2000, ApJ 538, 268





H_2O Maser IC 1396N: Patel + Valtts et al. 1998 ASPC 144, 365

Radioastron H_2O experiment

Radioastron

Effelsberg 100 m

Torun 32 m

Sardinia 65 m

Svetloe 32 m

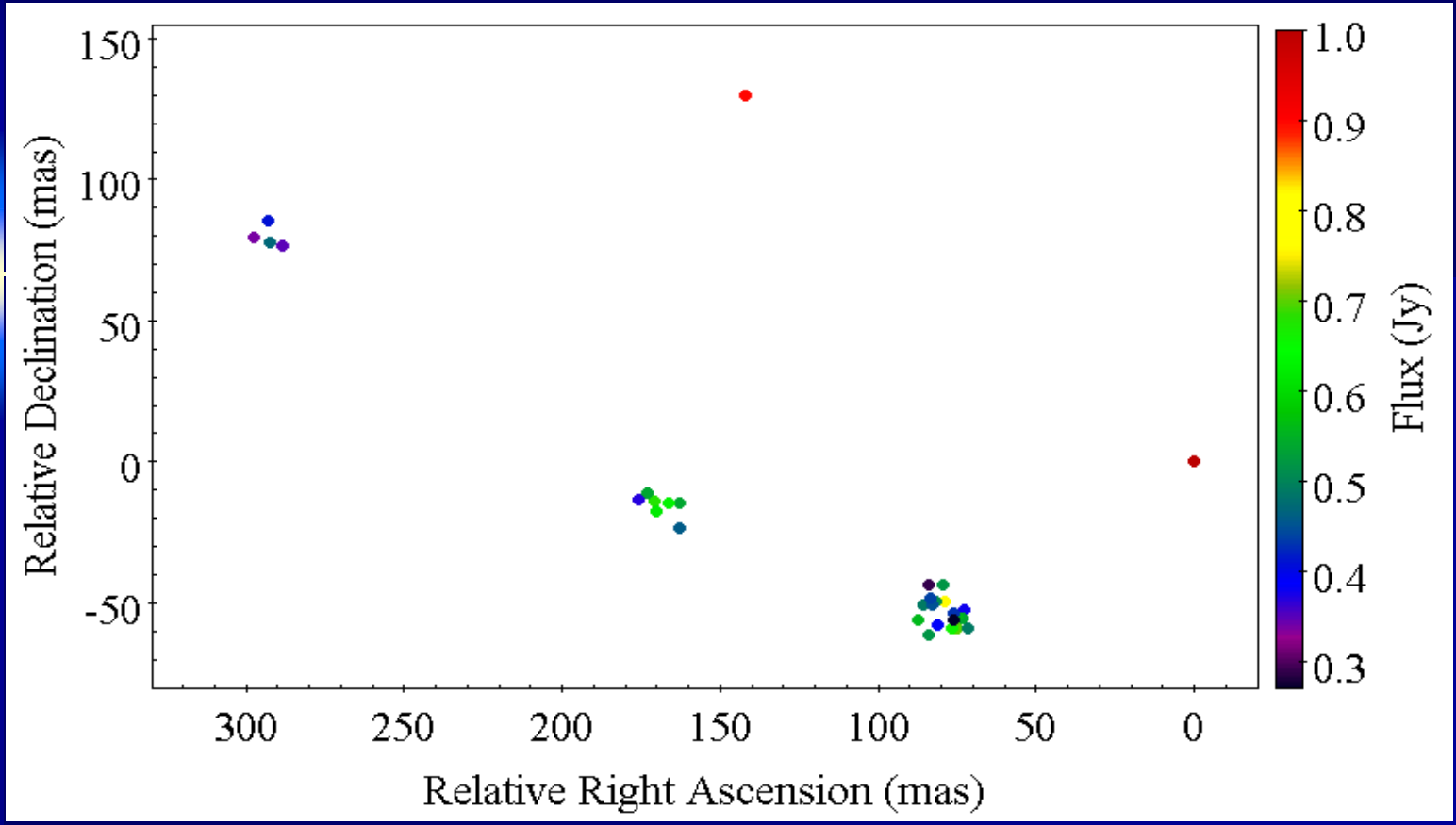
Noto 32 m

Yebes 40 m

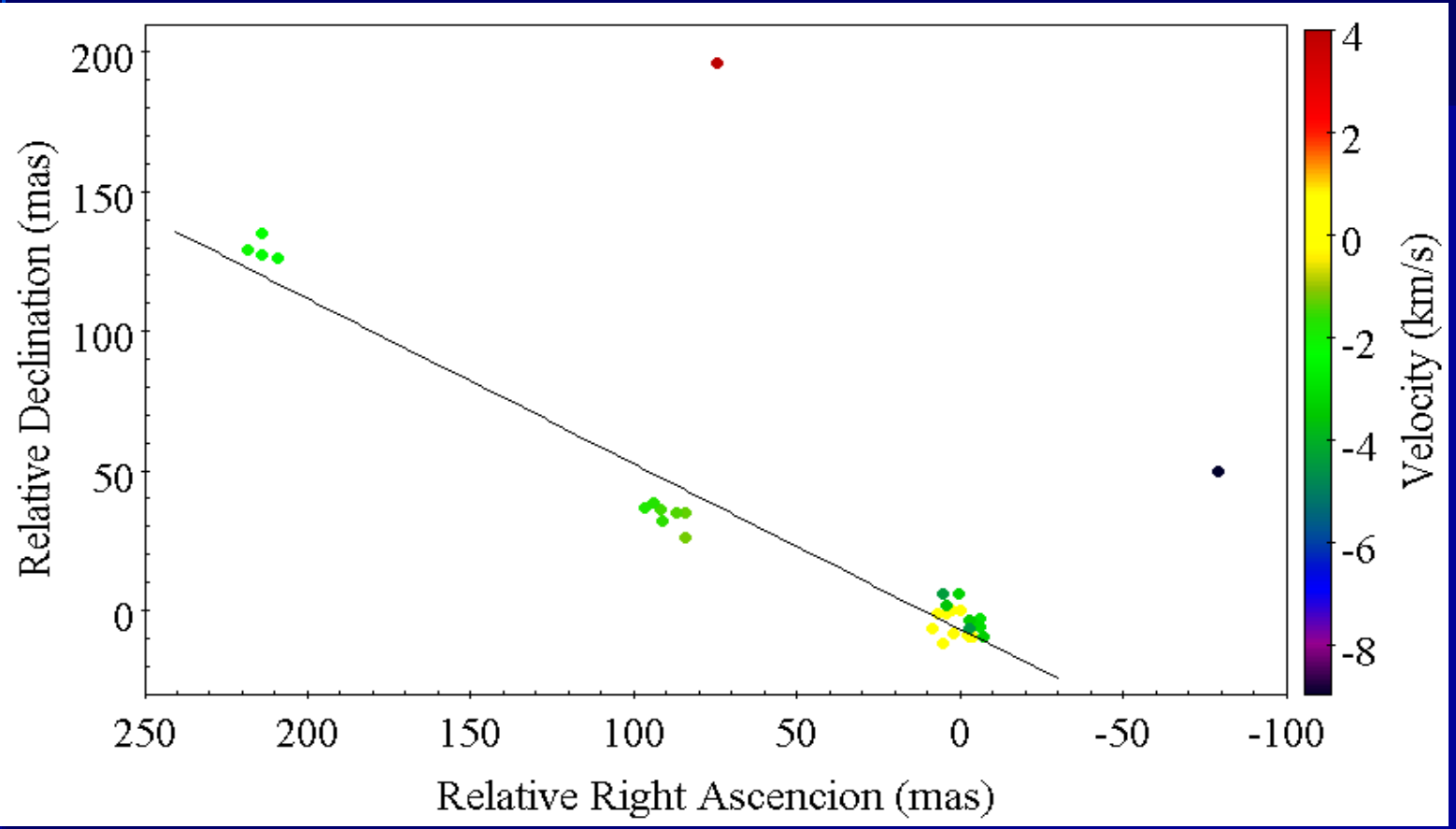
$B > 2.3\ D_E$

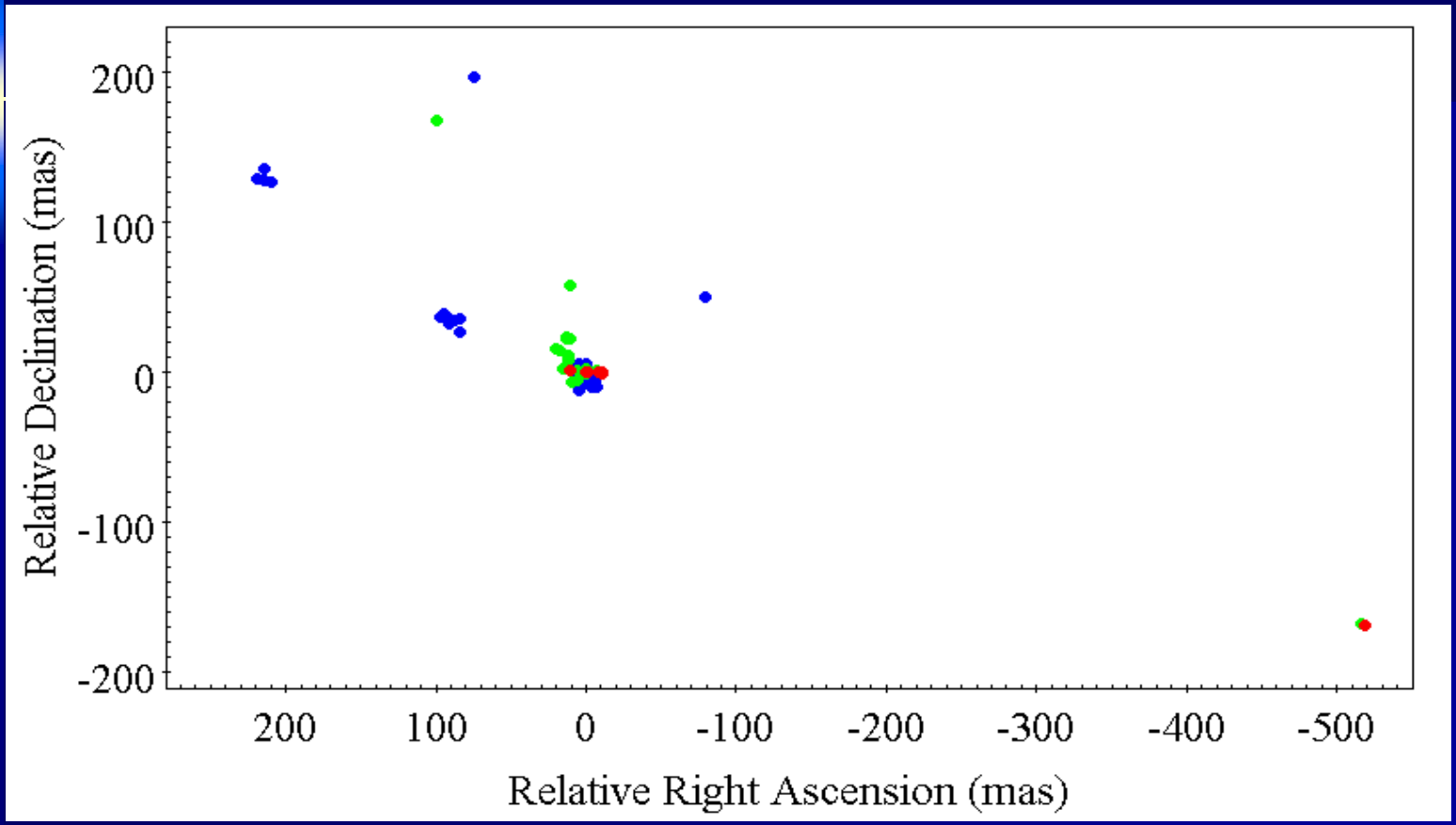
$L > 0.3$ AU

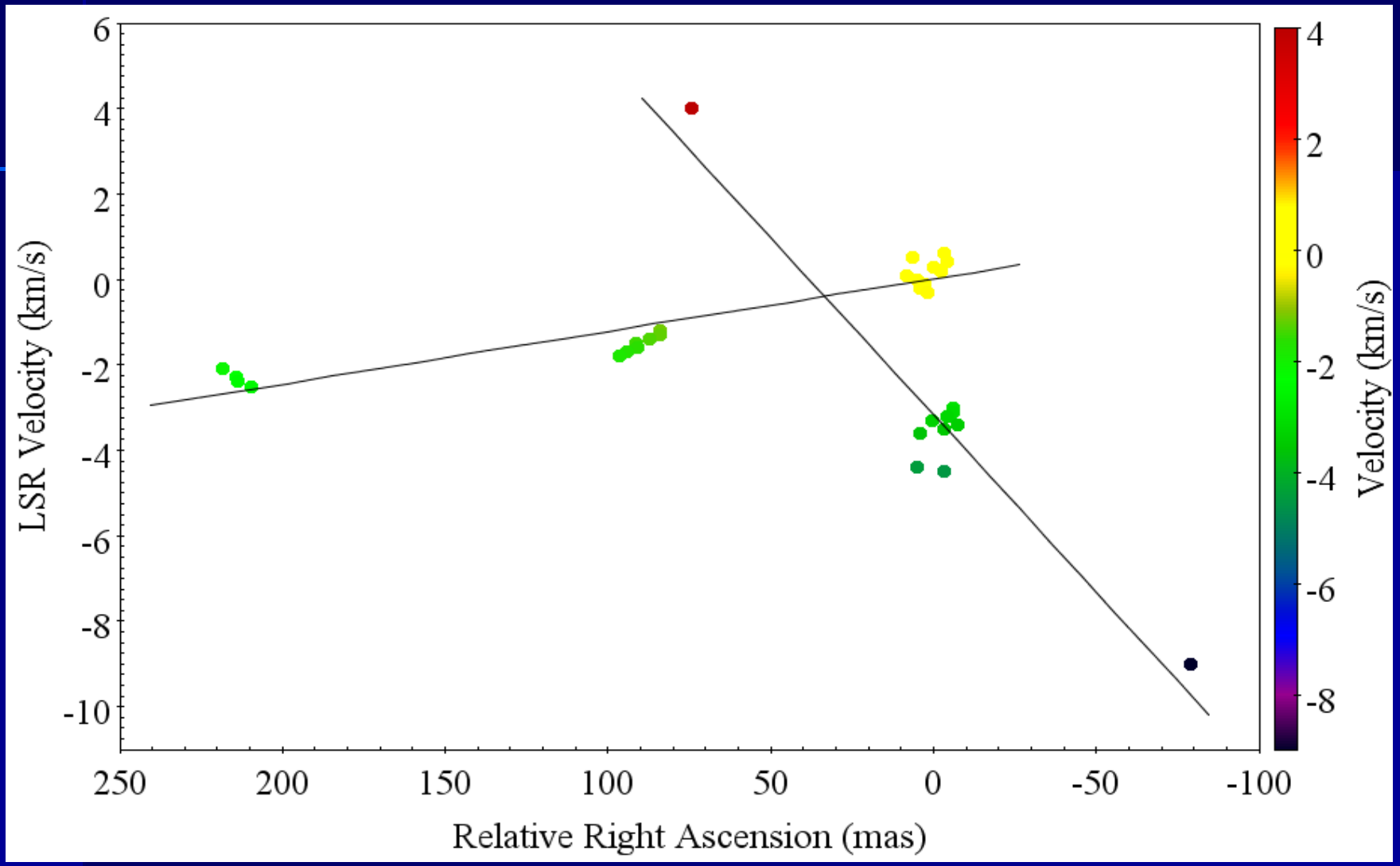
$T_B < 6.25 \times 10^{12}$ K

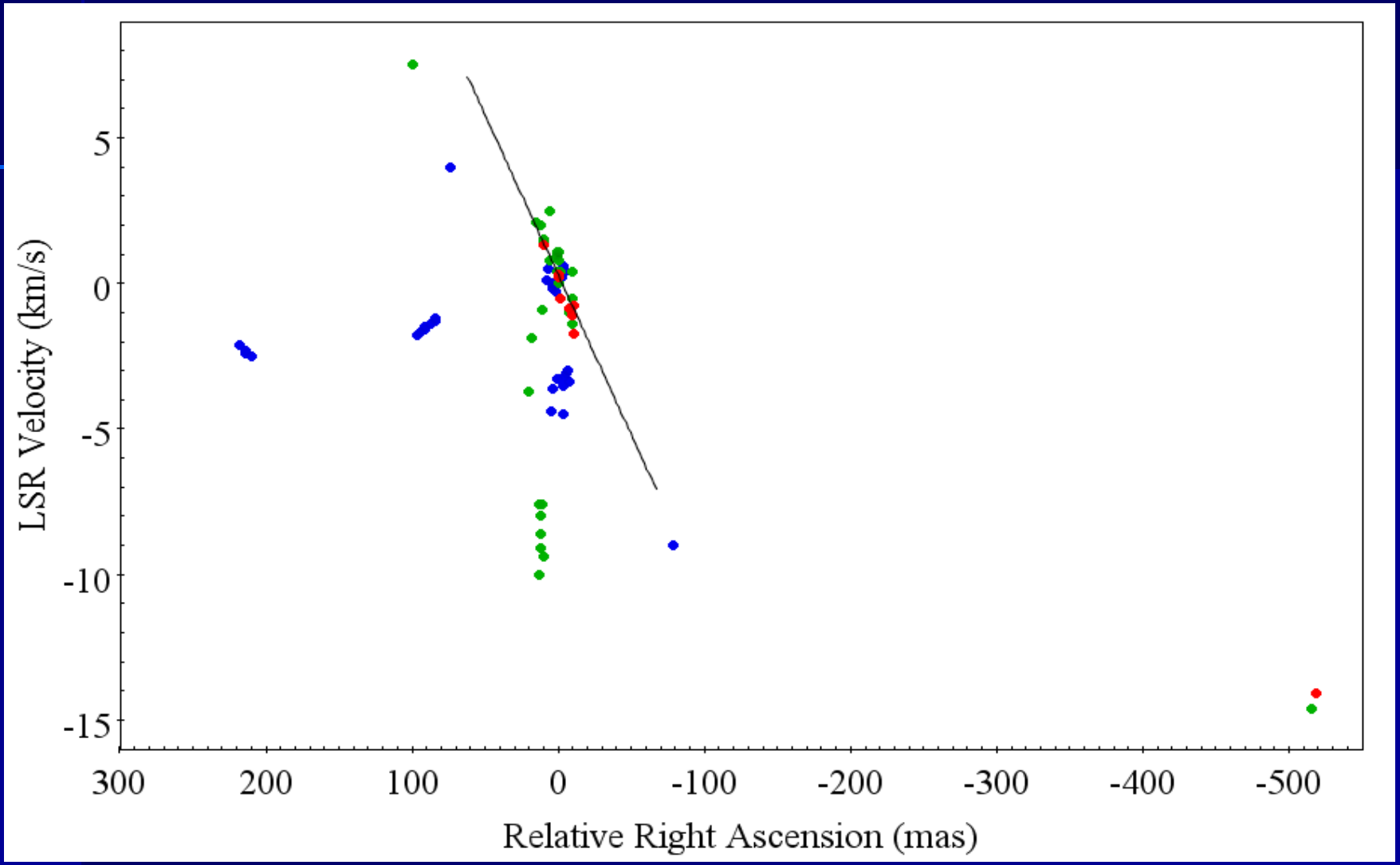


October 2014

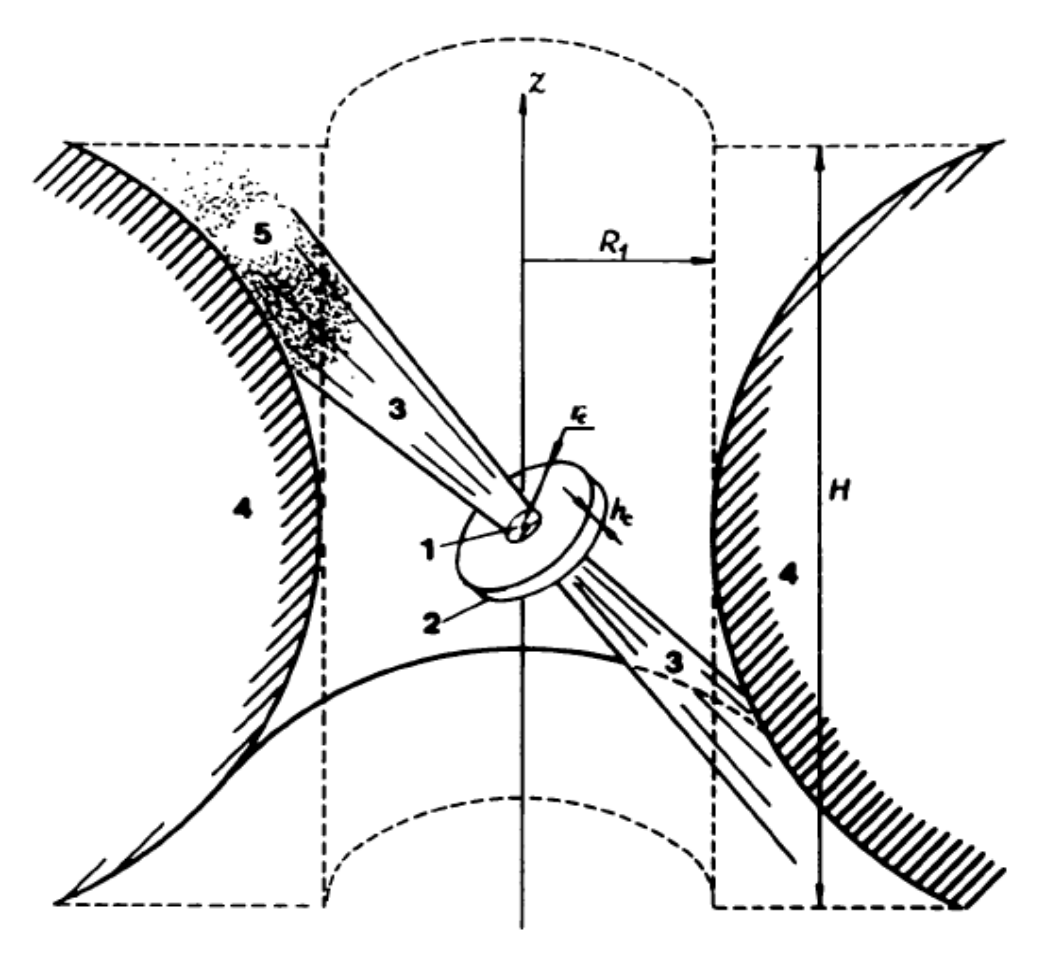

Relative Declination (mas)
200
150
100
50
0
250
200
150
100
50
0
-50
-100
Relative Right Ascencion (mas)
4
2
0
-2
-4
-6
-8
Velocity (km/s)

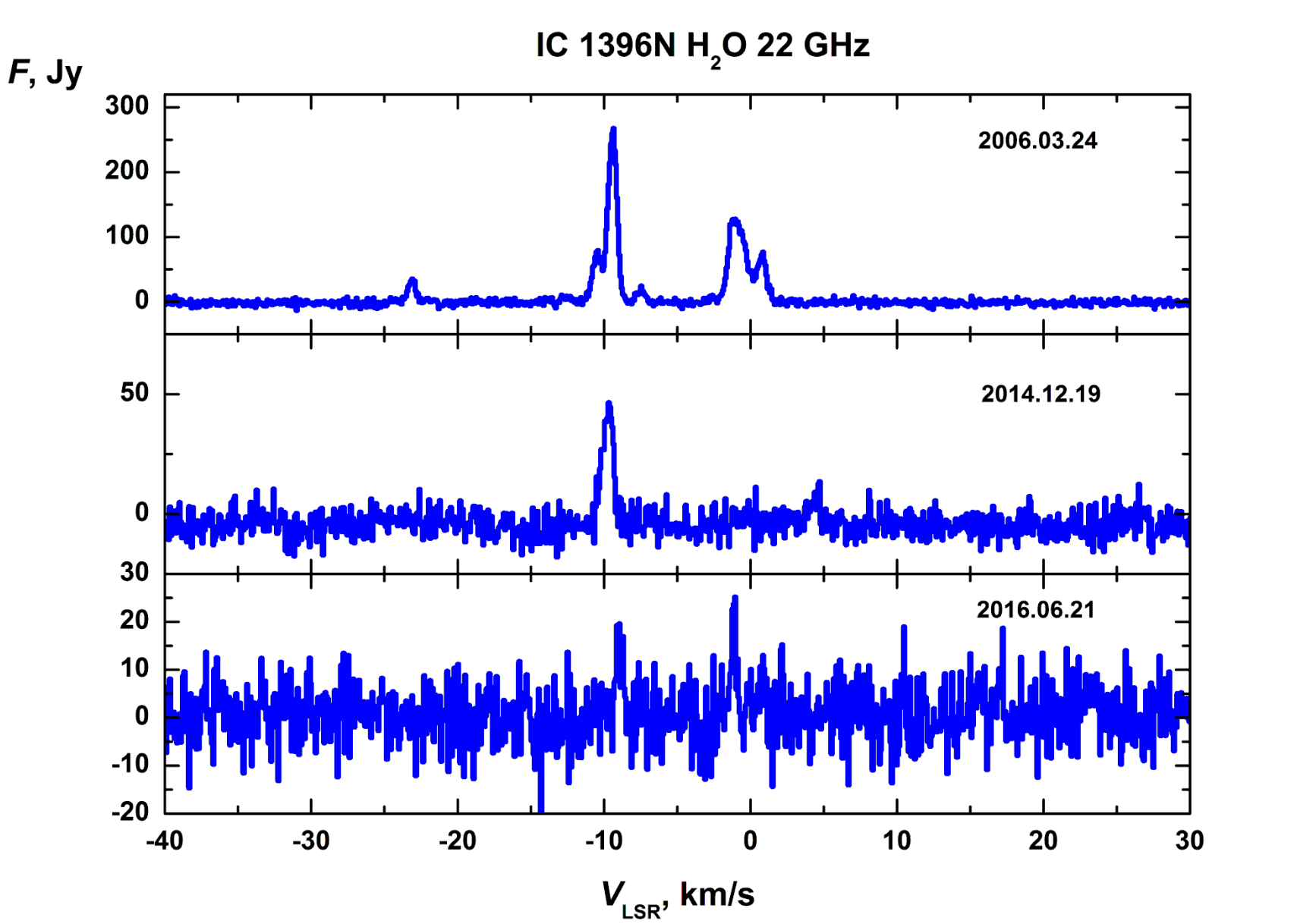

Relative Declination (mas)
200
100
0
-100
-200
200
100
0
-100
-200
-300
-400
-500
Relative Right Ascension (mas)


LSR Velocity (km/s)
6
4
2
0
-2
-4
-6
-8
-10
250
200
150
100
50
0
-50
-100
Relative Right Ascension (mas)
Velocity (km/s)
4
2
0
-2
-4
-6
-8


LSR Velocity (km/s)
5
0
-5
-10
-15
300
200
100
0
-100
-200
-300
-400
-500
Relative Right Ascension (mas)

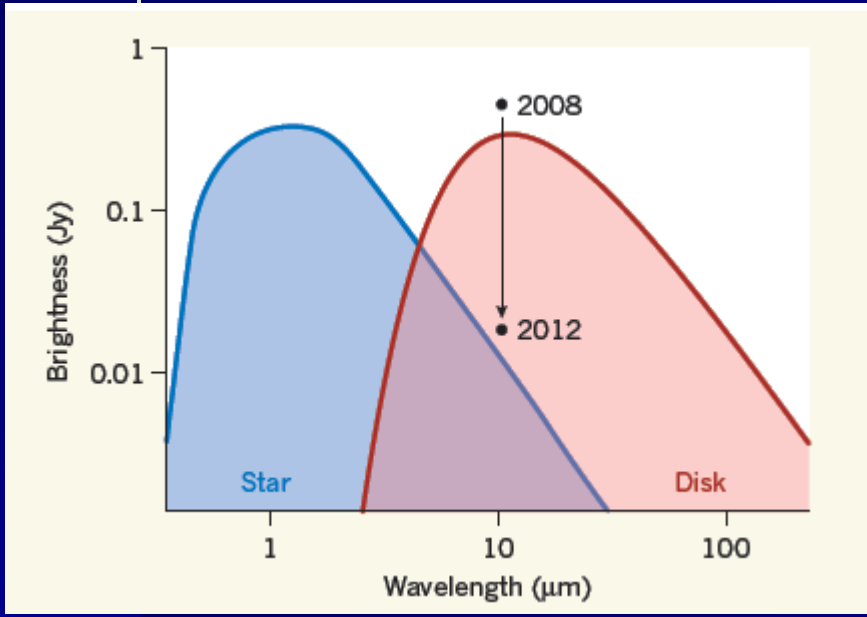
Precessing circumstellar disk (Rudnitskij 1987 IAUS 115, 398)

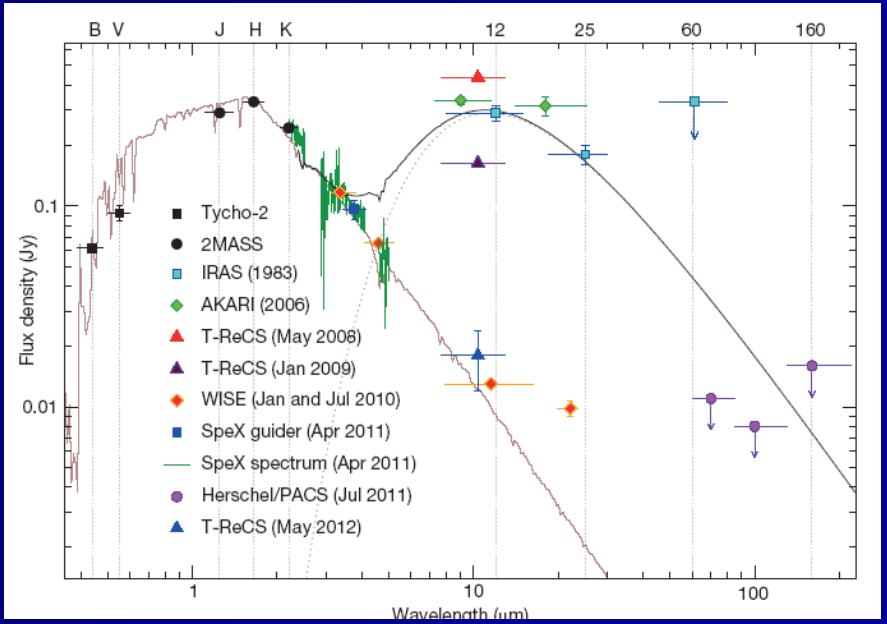



IC 1396N H2O 22 GHz
F, Jy
2006.03.24
2014.12.19
2016.06.21
300
200
100
0
50
0
30
20
10
0
-10
-20
-40
-30
-20
-10
0
10
20
30
VLSR, km/s

Is IC 1396N losing its protoplanetary disk?

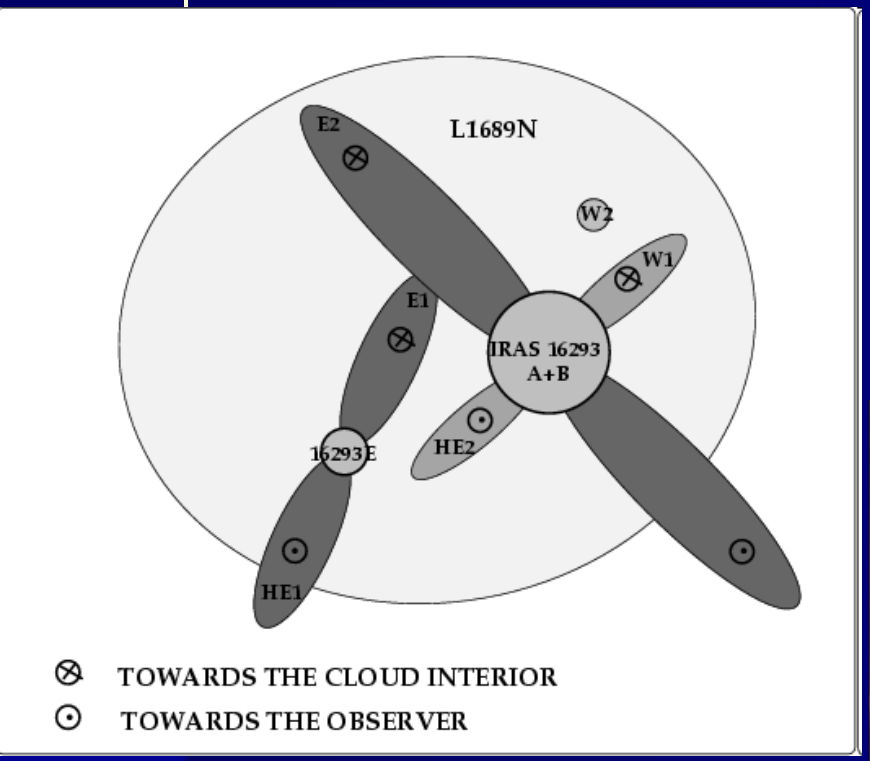
TYC 8241 2652 1 = 2MASS J12090225-5120410
Has its protoplanetary disk disappeared?



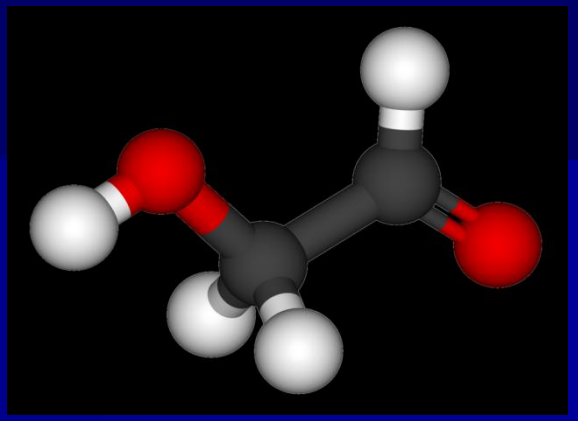


C. Melis et al., 2012, Nature 487, 74

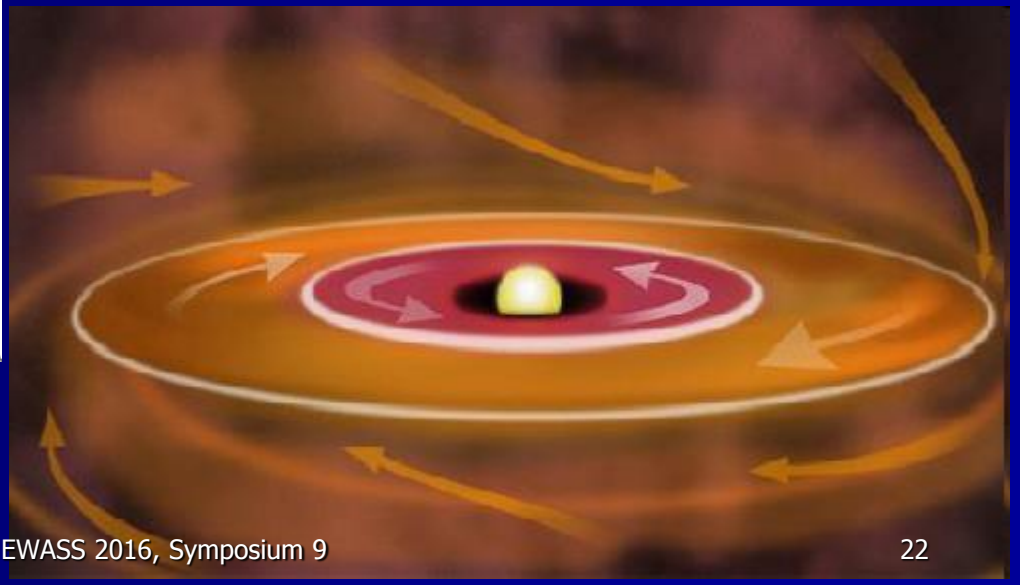
IRAS 16293-2422



d = 160 pc

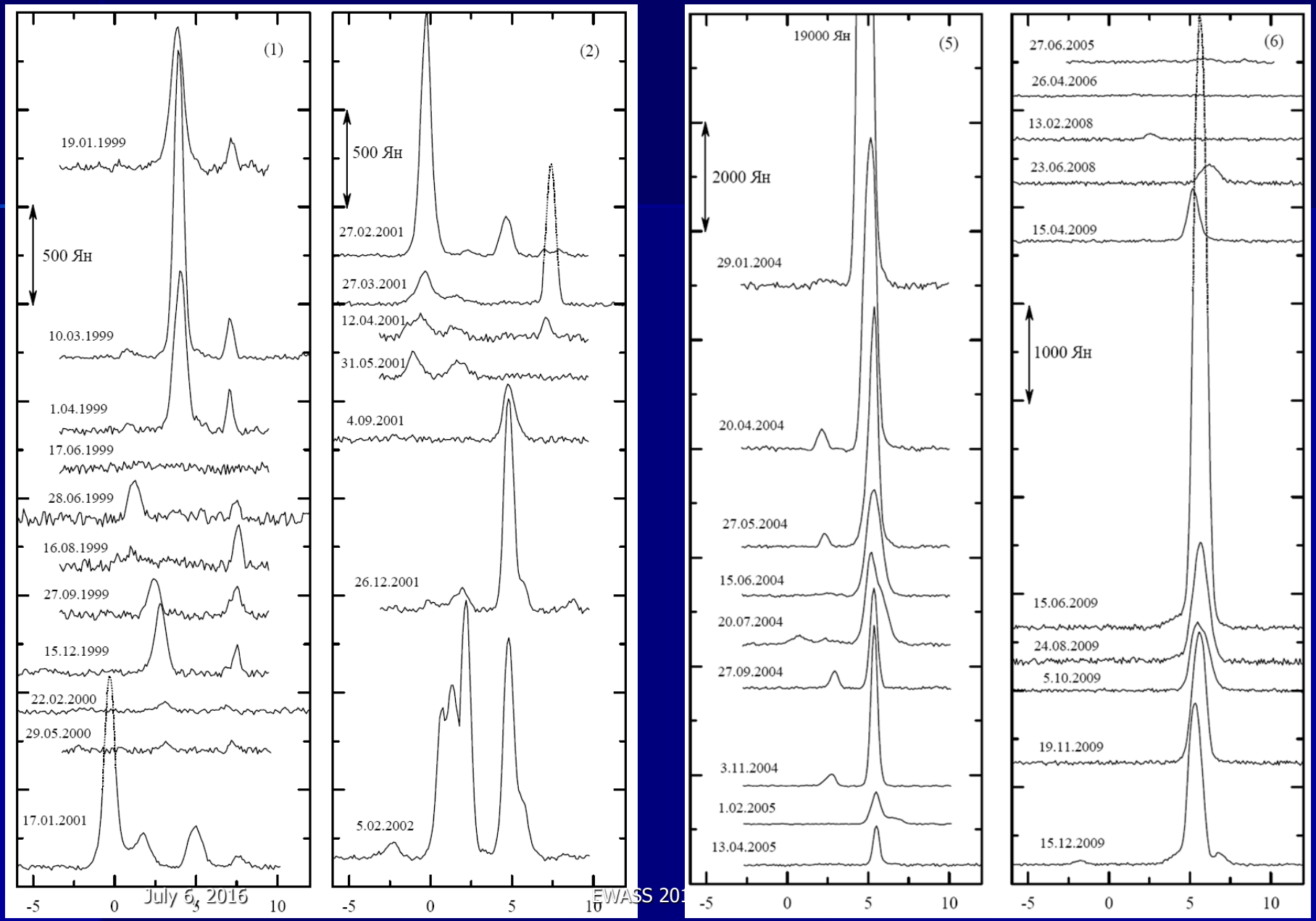


glycolaldehyde $C_2H_4O_2$

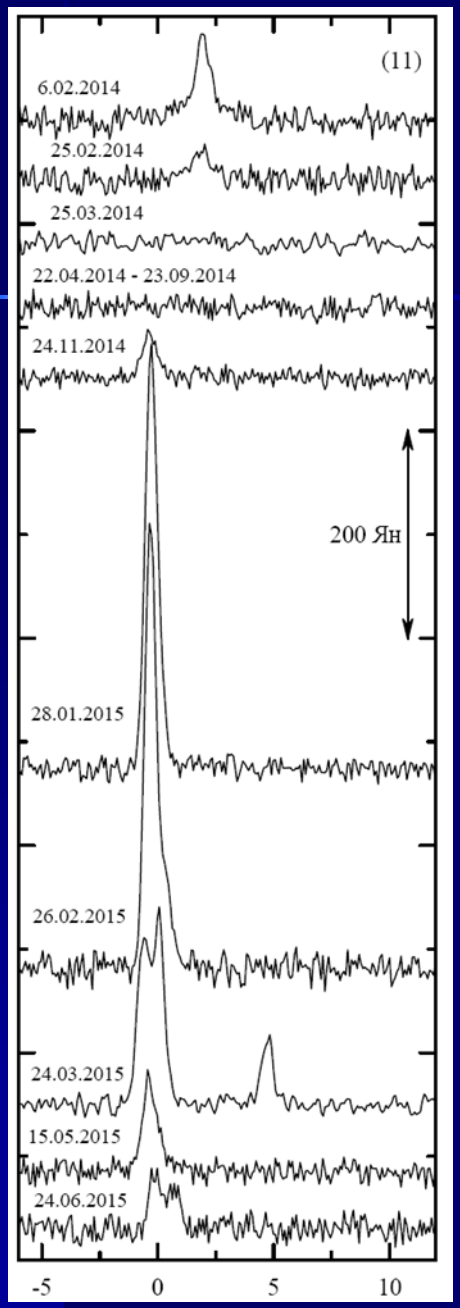


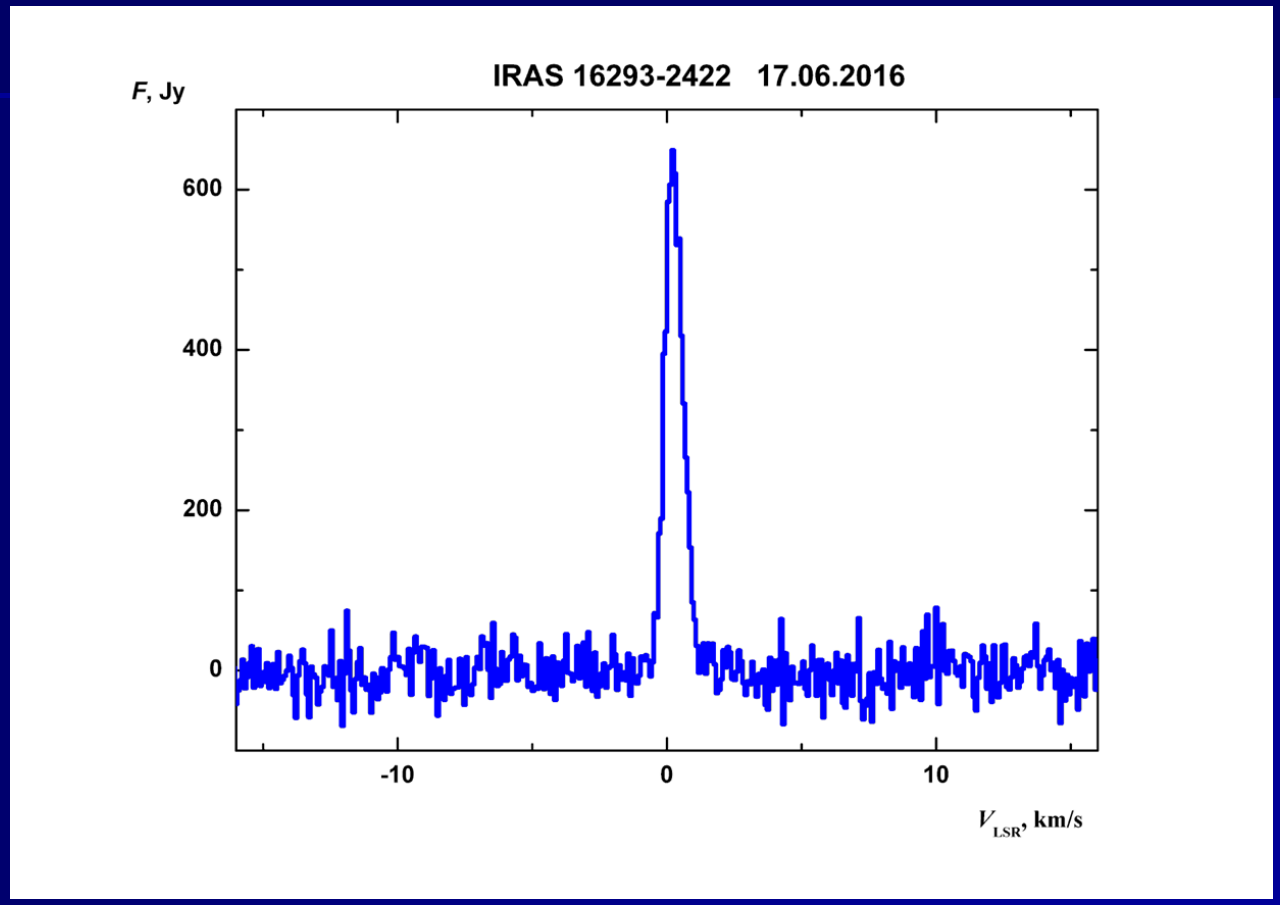
A. Castets et al. 2001, A&A 375, 40

IRAS 16293-2422 H_2O Pushchino monitoring

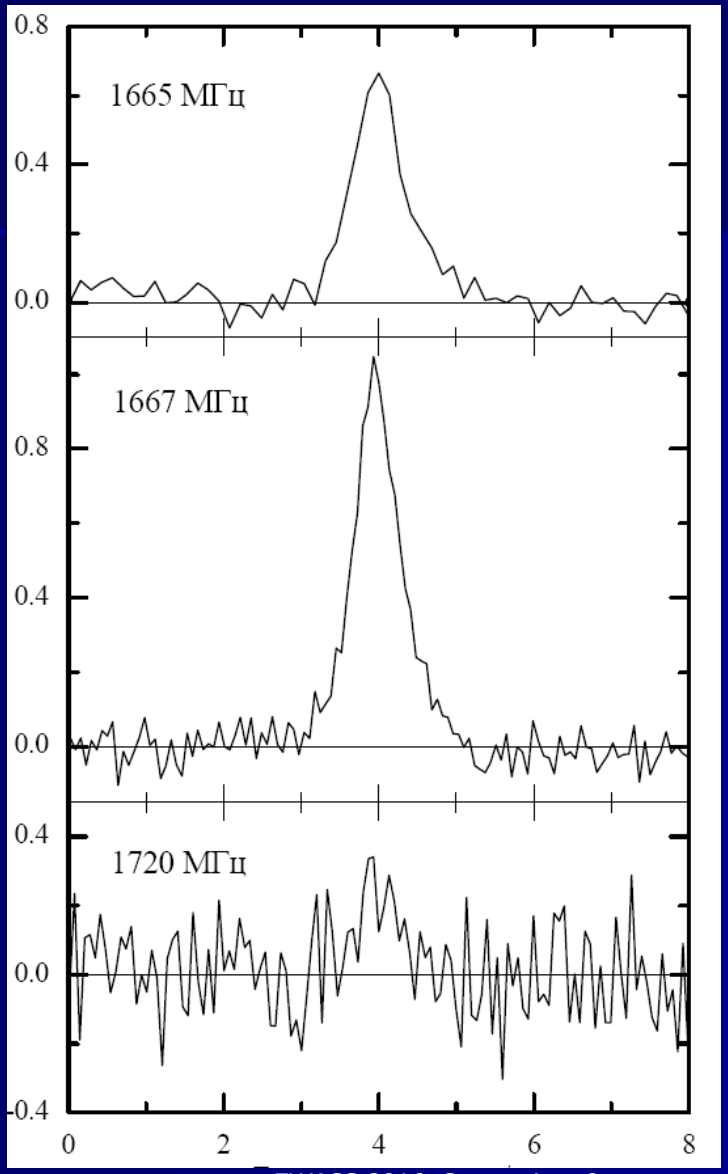


IRAS 16293-2422 OH H_2O Pushchino monitoring





IRAS 16293-2422 OH Nançay



Probable evolutionary sequence:

Class I methanol masers (44GHz) -> H_2O masers ->

-> OH masers + Class II methanol masers + UC HII regions

Rudnitskij et al., 2016, Astron. Reports 60, 129

Thank you!