The Earliest Stages of Massive Star Formation

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Overview of the UNSW project (Burton et al.): the earliest stages of massive star formation

170 clusters of young massive stars
selection criteria: methanol masers (90), UC HII (80)

Imaging

Radio (ATCA, VLA)

MM (SIMBA)

Submm (SCUBA)

FIR (IRAS)

Mid (TIMMI2, Gemini)

NIR (UKIRT)

Goals:
Census of the YSOs

Masers

CH3OH (EVN, ATCA, VLBA)

H2O (VLBA, ATCA)

Goals:
Kinematics at scales of a few AU

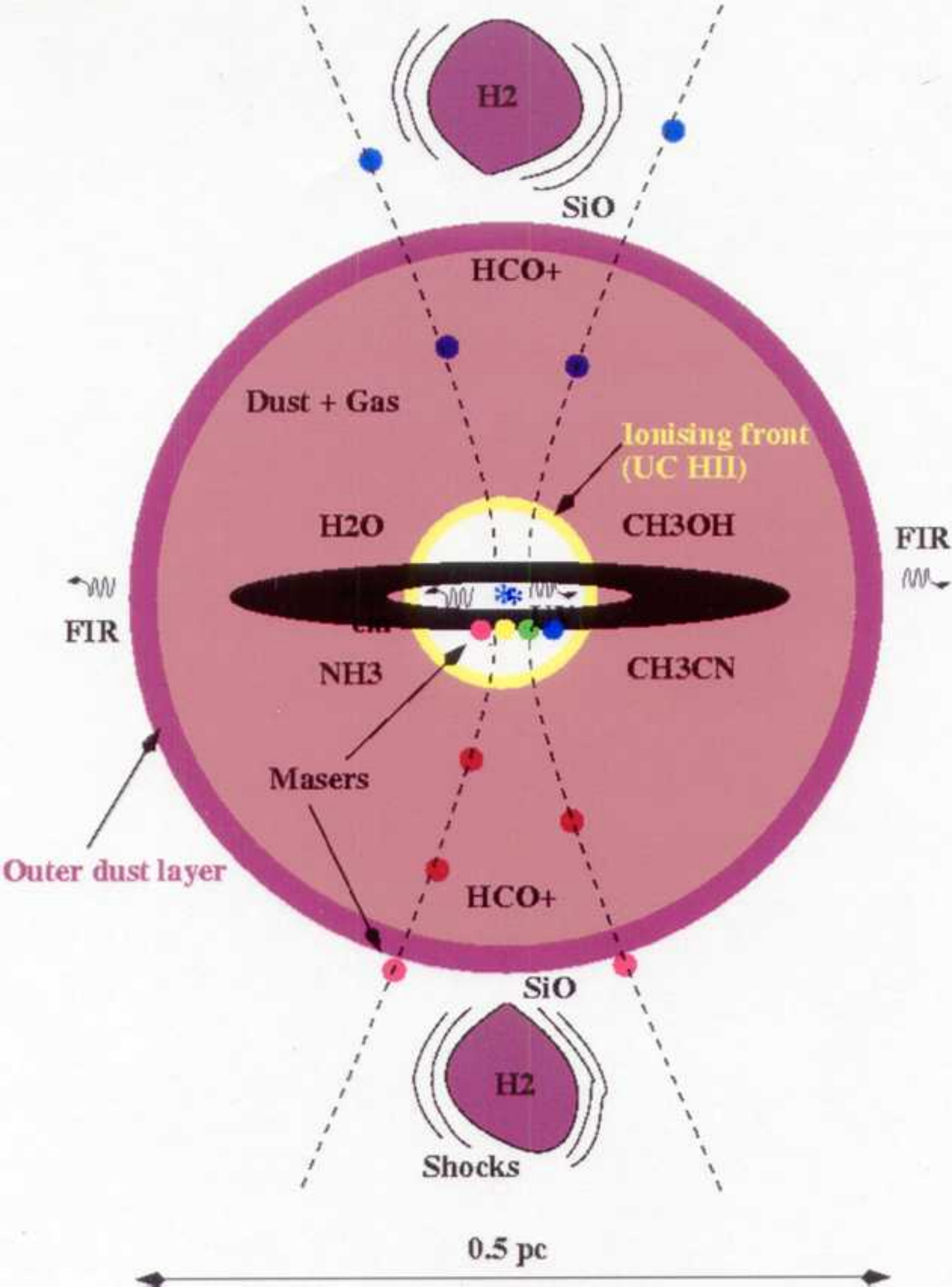
Spectral lines

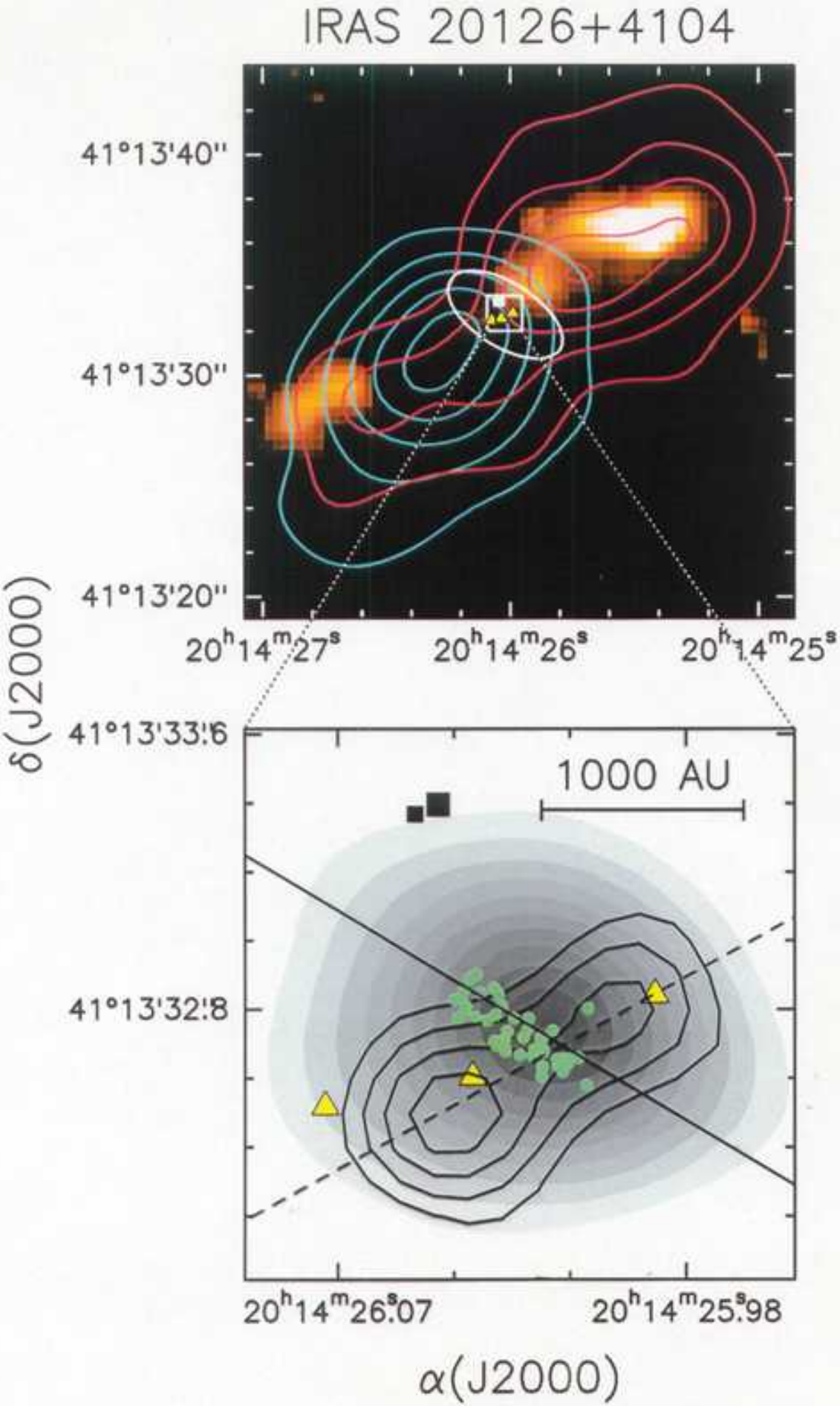
Single dish (Mopra, OSO)

Interferometry (ATCA, BIMA)

Goals:
Chemistry, Kinematics

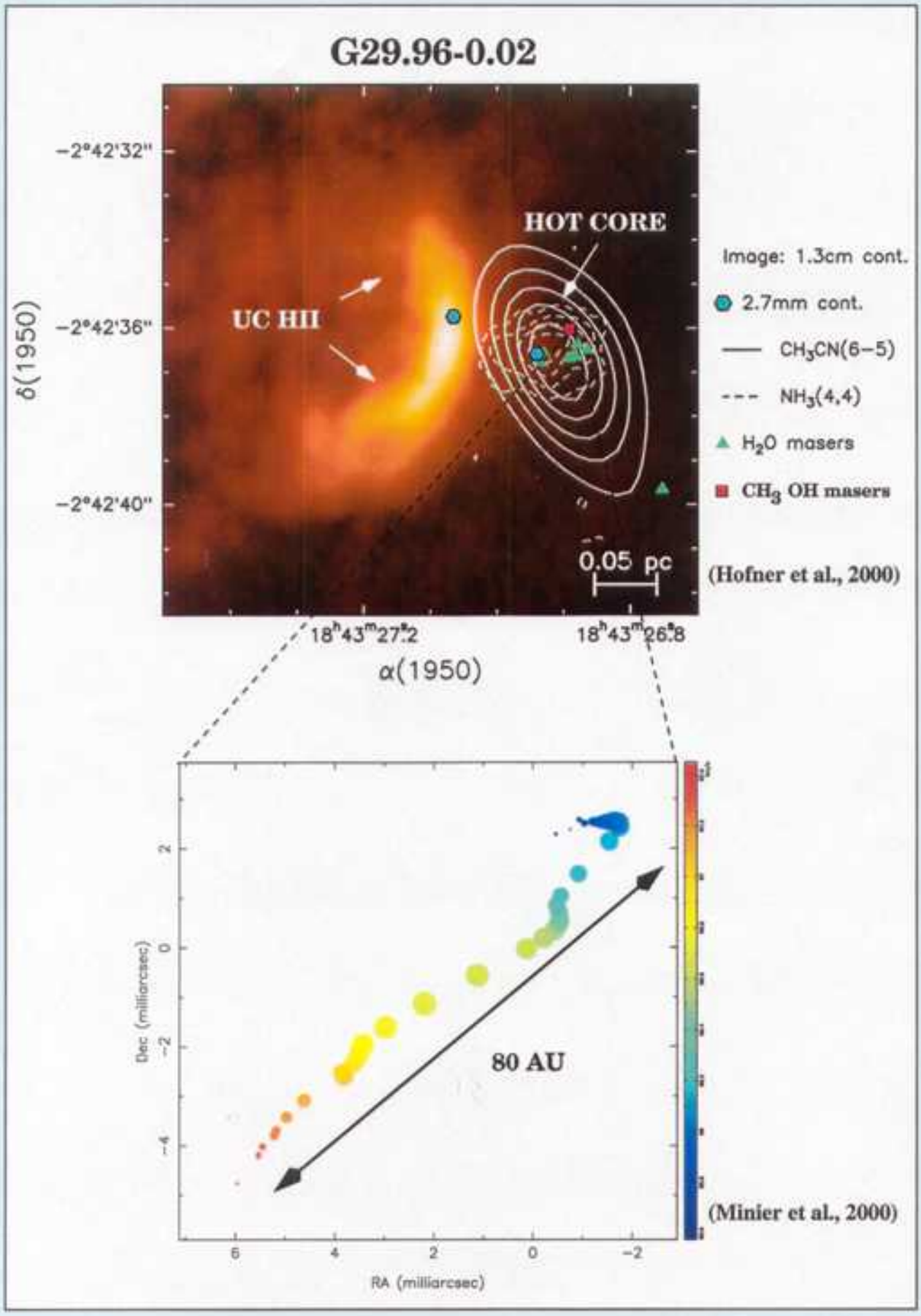
The natal cocoon of massive stars

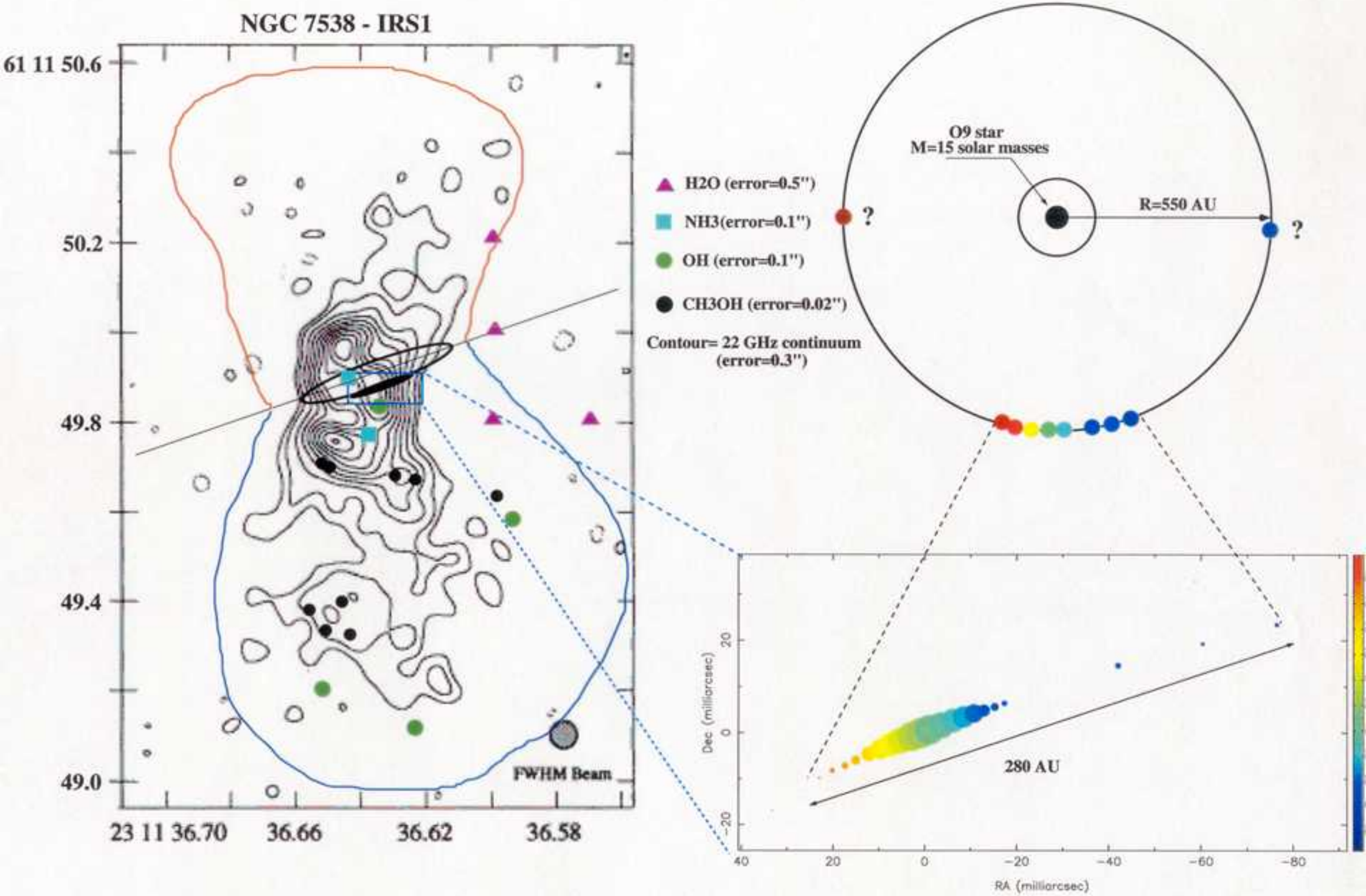




(MINIER et al. 2001) ; Cesaroni et al. 1997 ; Zhang et al. 1998 ; Hofner et al. 1999

G 29.96-0.02: UC HII and hot core



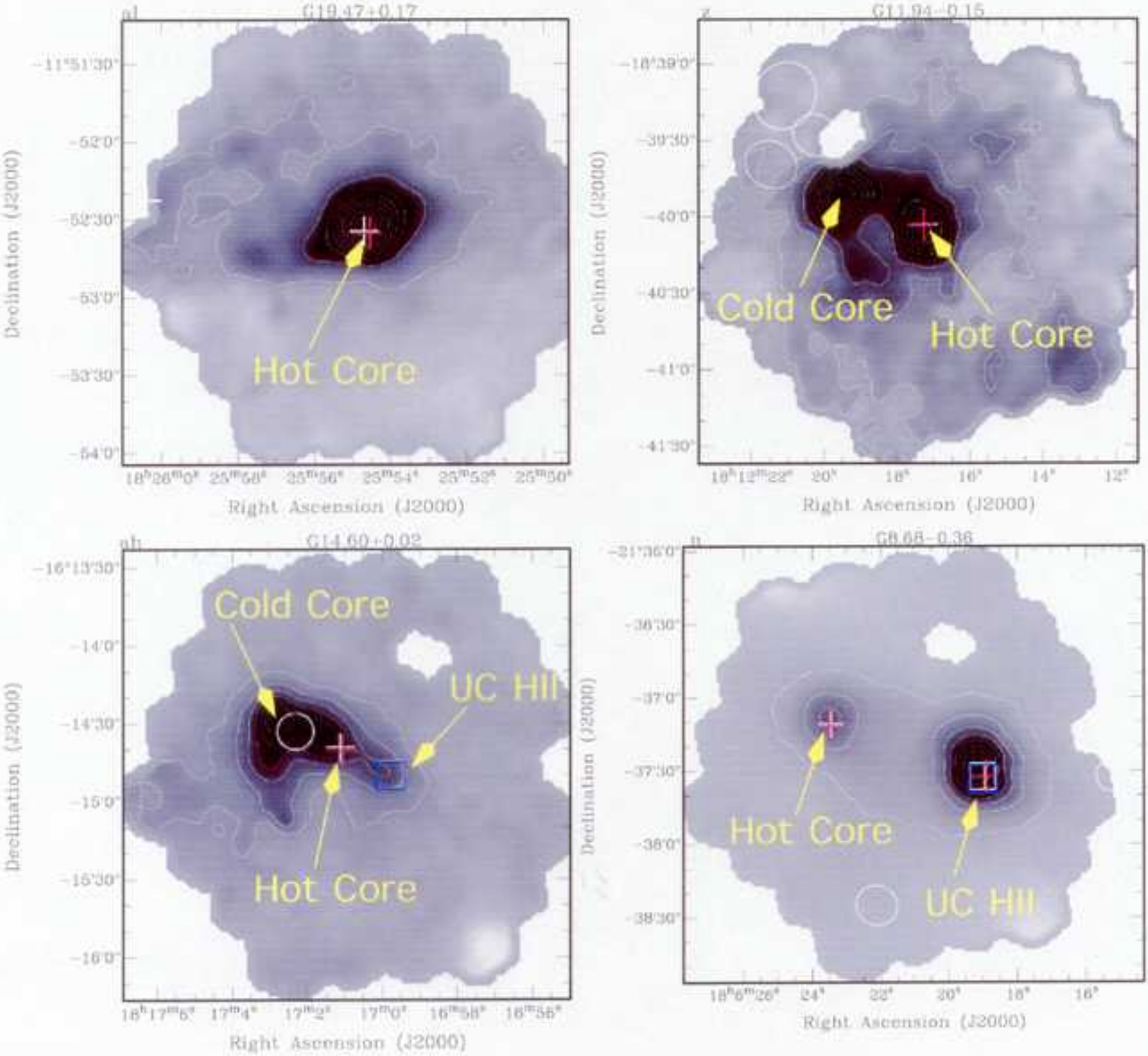


GAURE et al. 1995 + MINIER & al. 2000, 2001

Scuba observations of methanol maser sites (Walsh et al. 2002)

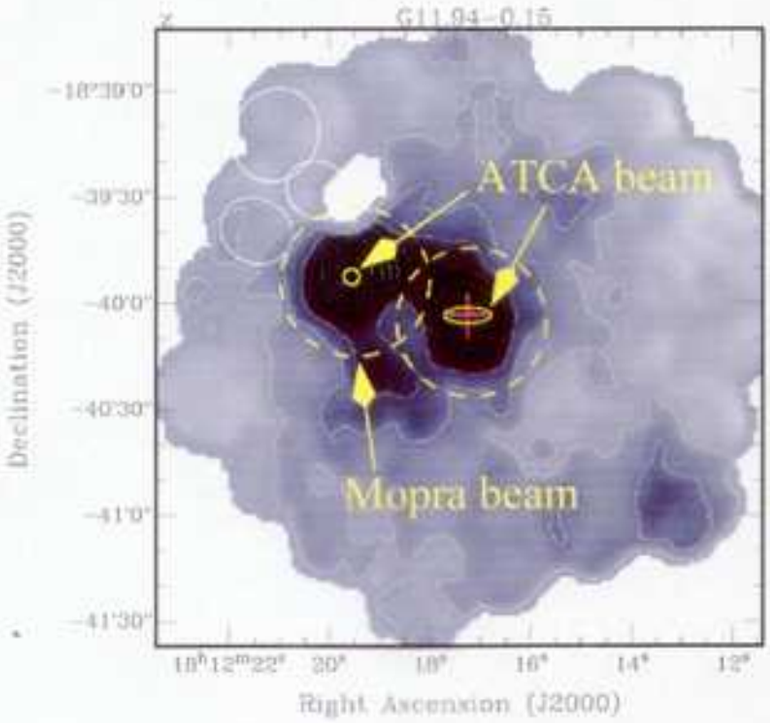
Evolutionary sequence:

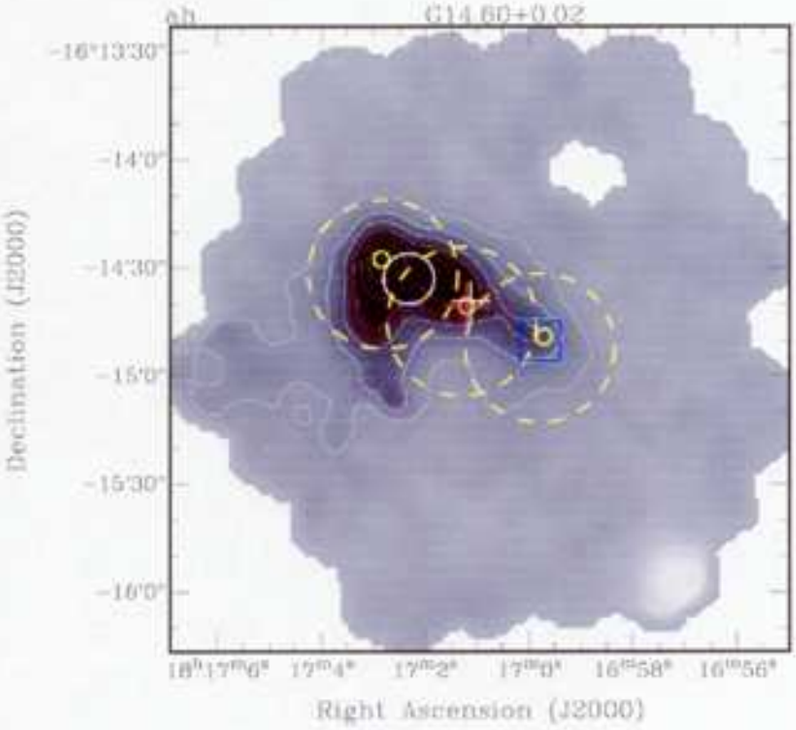
Cold core (maserless core) → Hot Core → UC HII



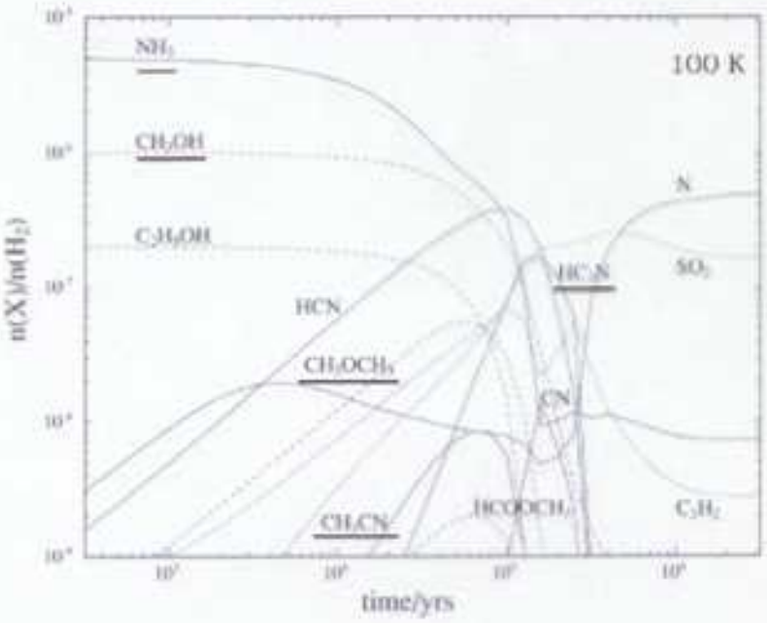
The chemistry of star−forming regions

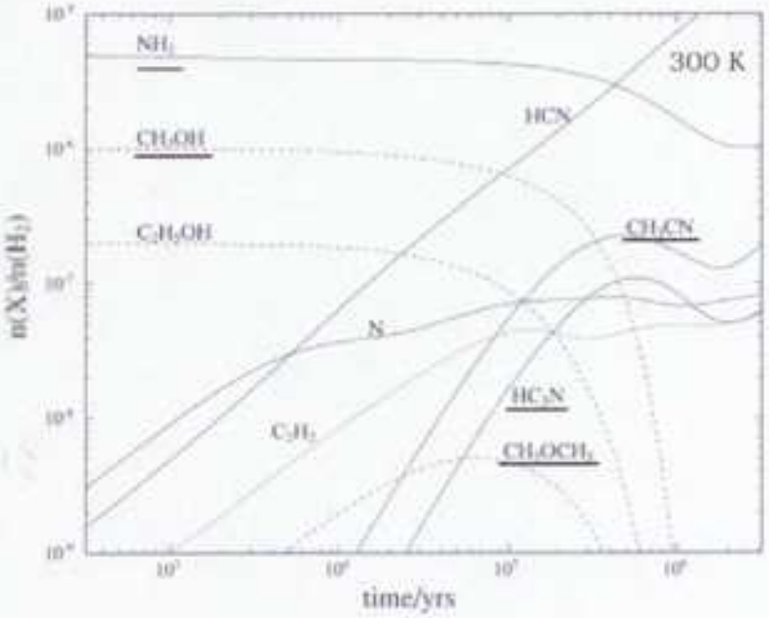
Angular diameter of 5 arc sec => 15000 AU @ 3 kpc





Chemical model for massive star−forming regions





(Rodgers & Charnley 2001)

Massive star formation: 3 mm science with the upgraded ATCA

The Mopra millimetre survey

- 80 methanol maser sources
- −60<Dec<−01 deg
- beam=40 arcsec

Followup observations with ATCA

- Higher resolution
- Chemistry
- Chemical diffentiation

84906 – 87305 MHz

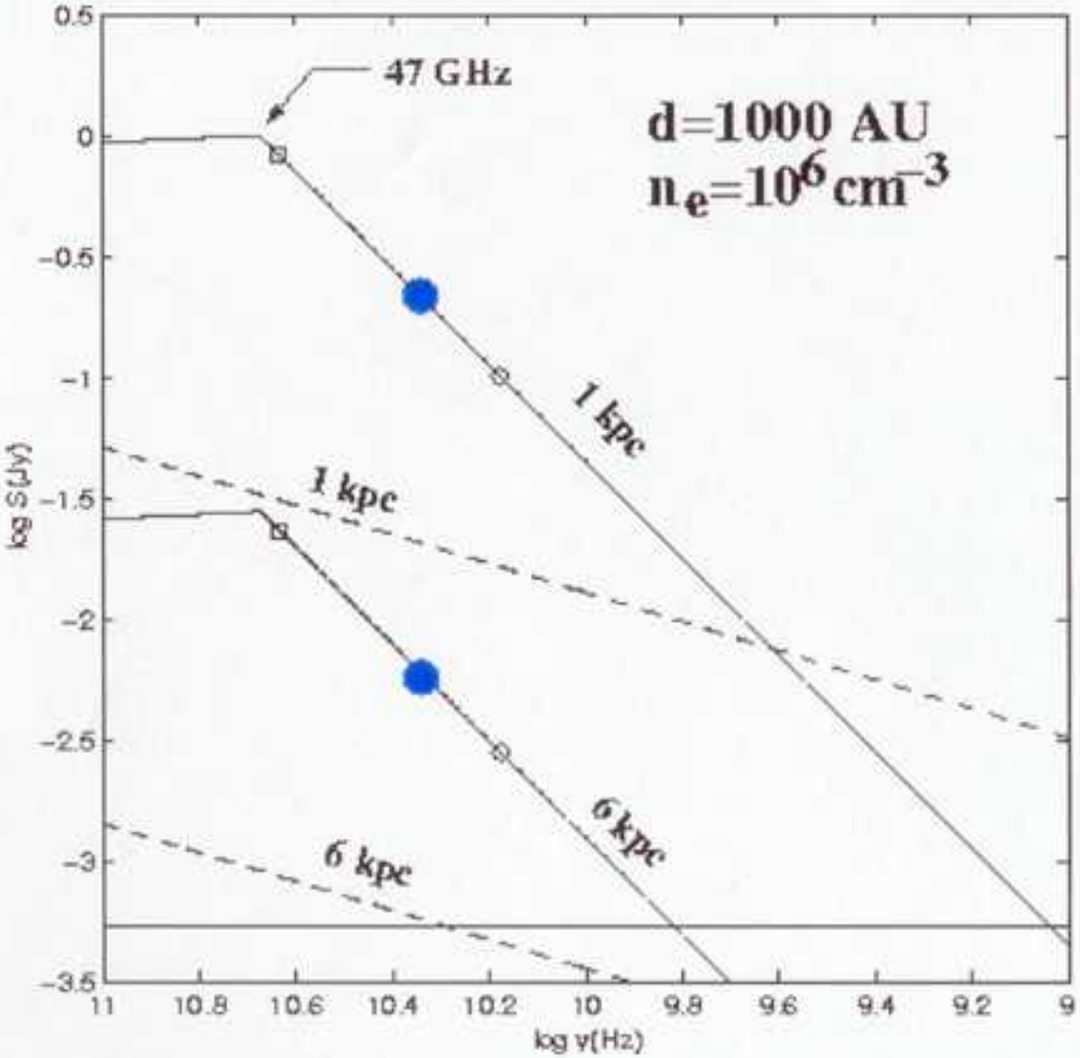
85338.905	C_3H_2 2(1,2)−1(0,1)	Cyclopropenylidene
86243.442	SiO 2−1 v=1	Silicon monoxide
86340.184	$H^{13}CN$ 1−0	Hydrogen cyanide
86754.294	$H^{13}CO^+$ 1−0	Formylium
86846.998	SiO 2−1 v=0	Silicon monoxide

88506 – 91305 MHz

88630.4157	HCN 1−0 F=1−1	Hydrogen cyanide
88631.8473	HCN 1−0 F=2−1	Hydrogen cyanide
88633.9360	HCN 1−0 F=0−1	Hydrogen cyanide
88940.09	CH_3OH 15(3)−14(4) A−	Methanol
89188.518	HCO^+ 1−0	Formylium
90663.543	HNC 1−0	Hydrogen isocyanide
90978.993	HC_3N	Cyanoacetylene
91987.094	CH3CN	Methyl cyanide

Massive star formation: 12 mm science with the upgraded ATCA

Hyper compact HII region @ 22 GHz



NH3 lines @ 23 GHz

Frequency (MHz)	Unc.	Formula	Quantum numbers
22653.022	(5)	NH_3	5(4)–5(4)
22688.312	(5)	NH_3	4(3)–4(3)
22732.429	(5)	NH_3	6(5)–6(5)
22834.1851	(1)	NH_3	3(2)–3(2)
22924.940	(5)	NH_3	7(6)–7(6)
23098.8190	(1)	NH_3	2(1)–2(1)
23232.238	(5)	NH_3	8(7)–8(7)
23657.471	(5)	NH_3	9(8)–9(8)
23692.9265	(2)	NH_3	1(1)–1(1) F,F_1=1/2,1–1/2,0