Dense Gas in the LMC and the Circumstellar Shell of R Scl

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Millimetre Workshop

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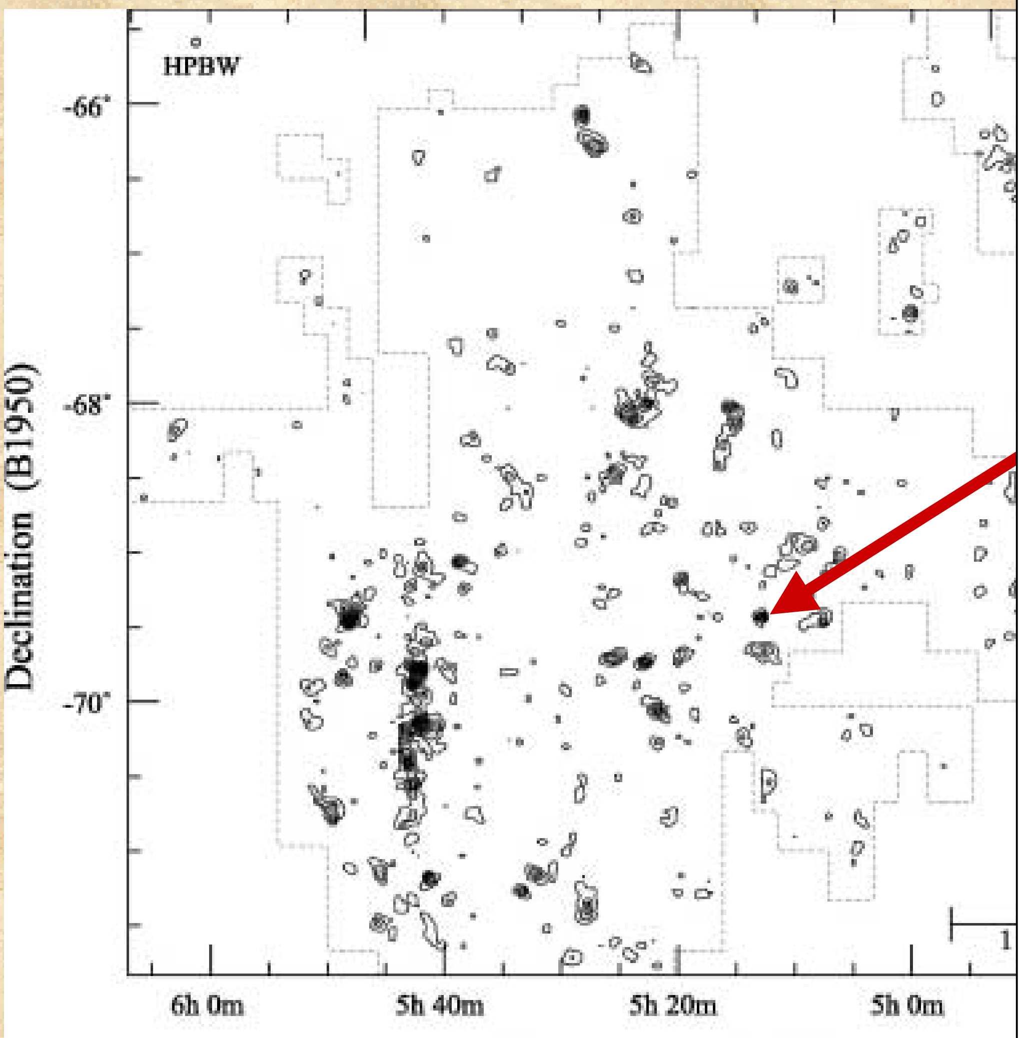
1. Dense Gas in the LMC

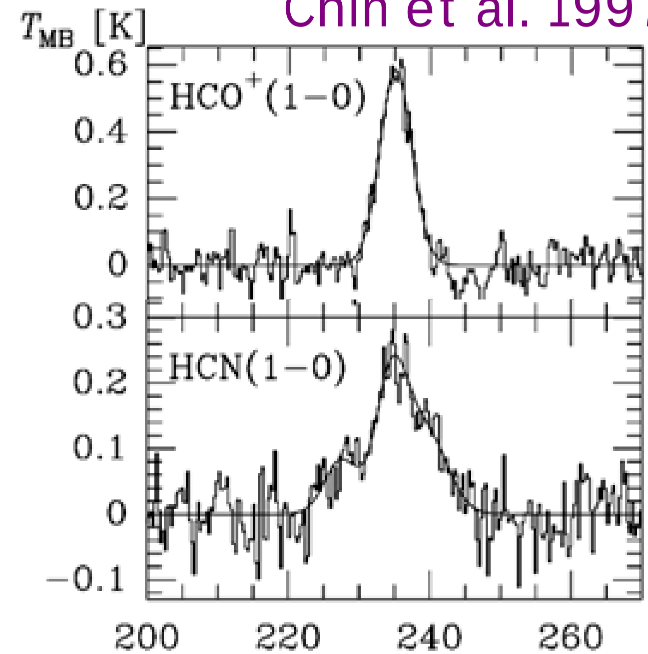
- At a distance of ~50 kpc (1” = 0.25 pc), the LMC is the nearest actively star-forming galaxy.
- Low metallicity (~0.25 $Z_{\odot}$) $\Rightarrow$ less dust $\Rightarrow$ very different interstellar environment!
- Due to strong FUV field, most molecular gas will be in photon-dominated regions (PDRs).
- Initial target: N113 cloud, observed with SEST by Chin et al. (1997).
- The Future: Take advantage of CO survey at 160” resolution conducted with 4m NANTEN telescope (N. Mizuno et al.)
- Follow up with SEST, Mopra, and ATCA.

HCO^+ / HCN in N113



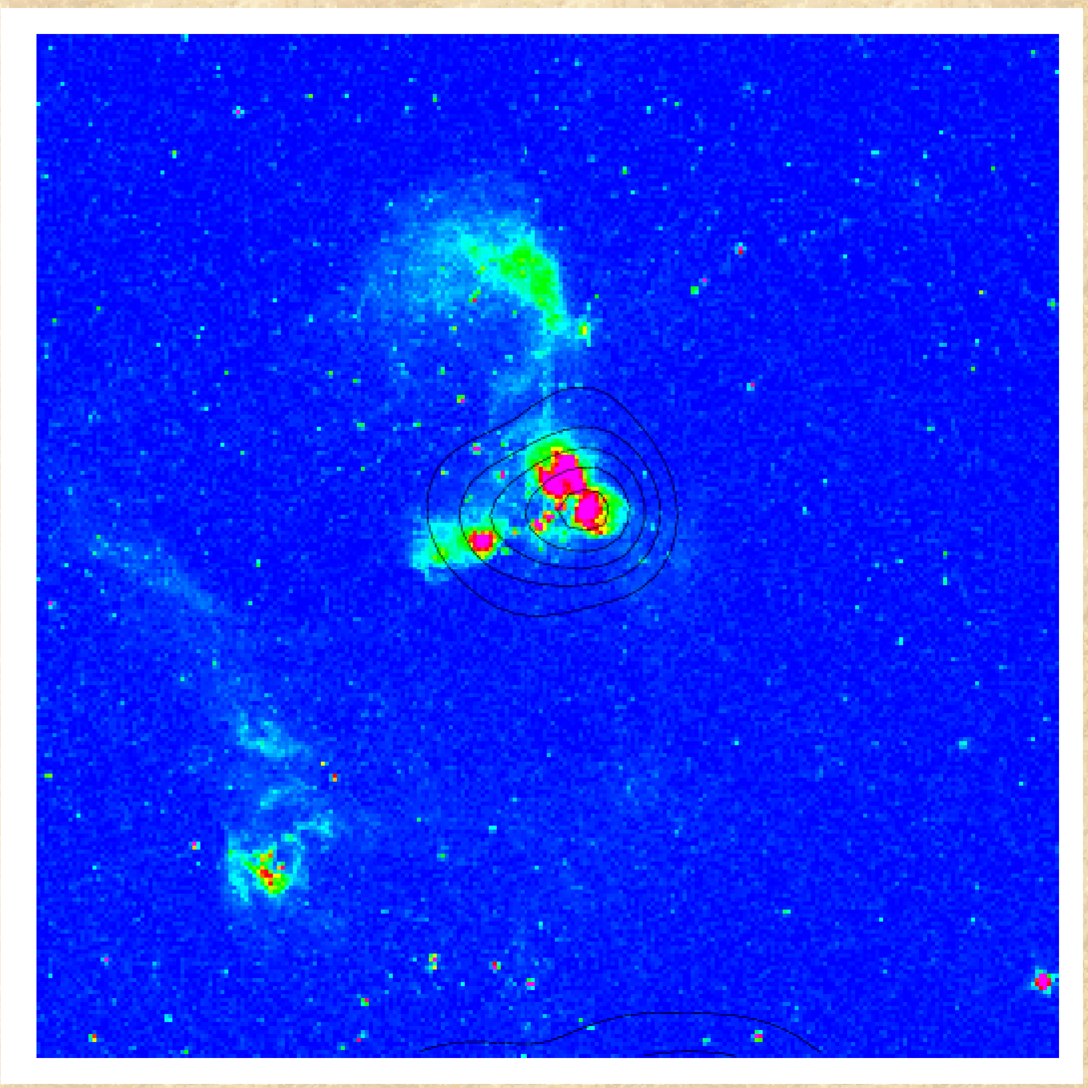
Fukui et al. 2001

Chin et al. 1997



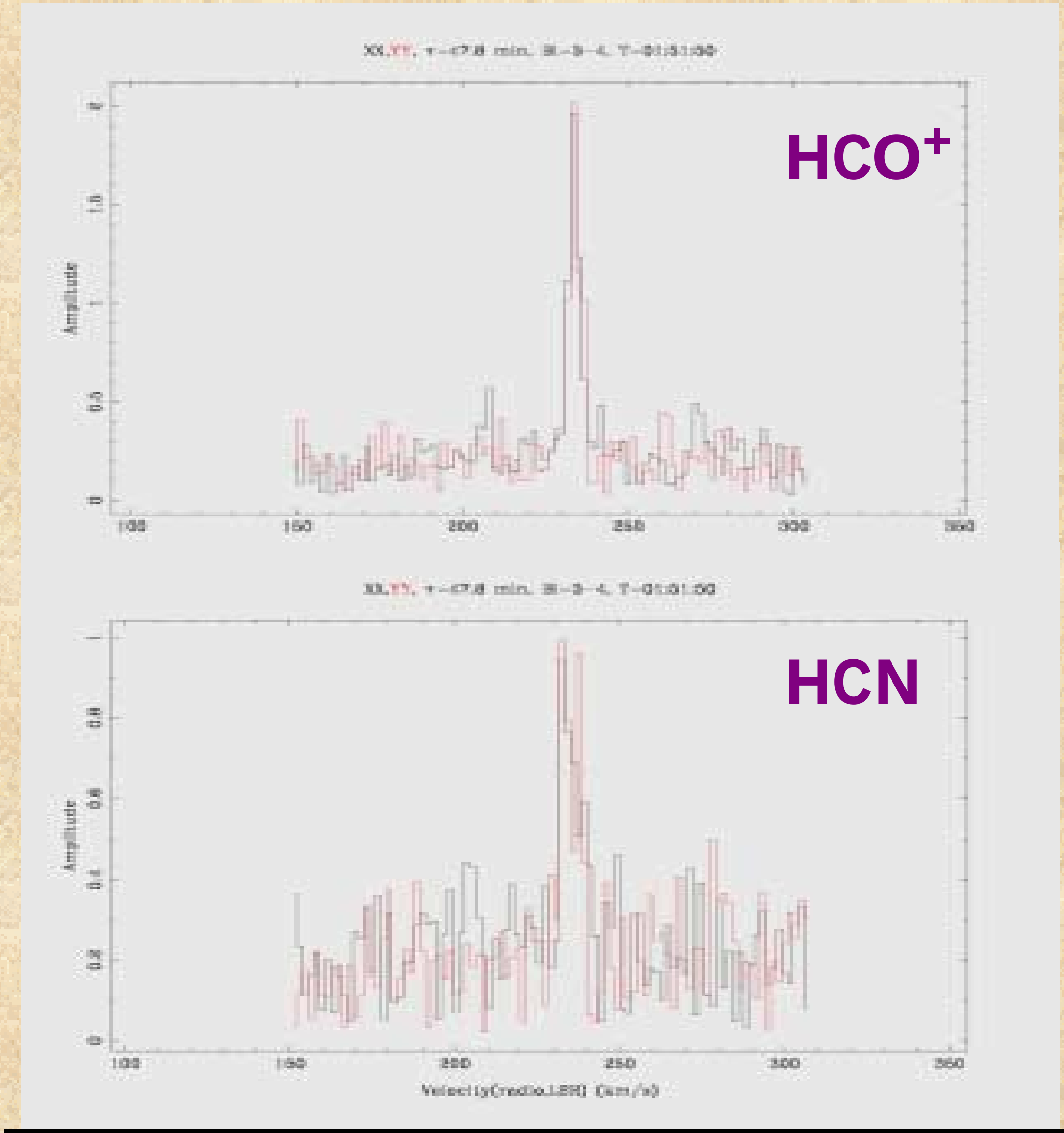
- **SEST 58” beam**
- **T_{mb}(HCO^+) ≈ 0.6 K**
- **Flux ≈ 15 Jy**

Massive Star Formation in N113



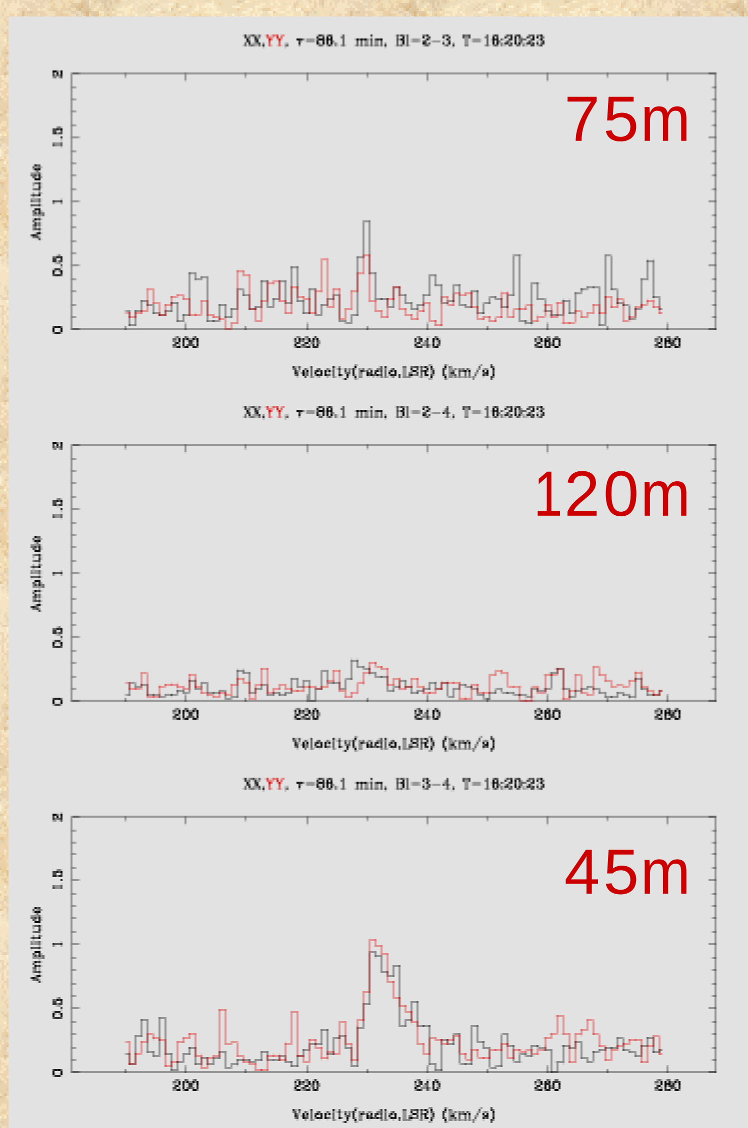
NANTEN CO contours over Hα image from Kennicutt

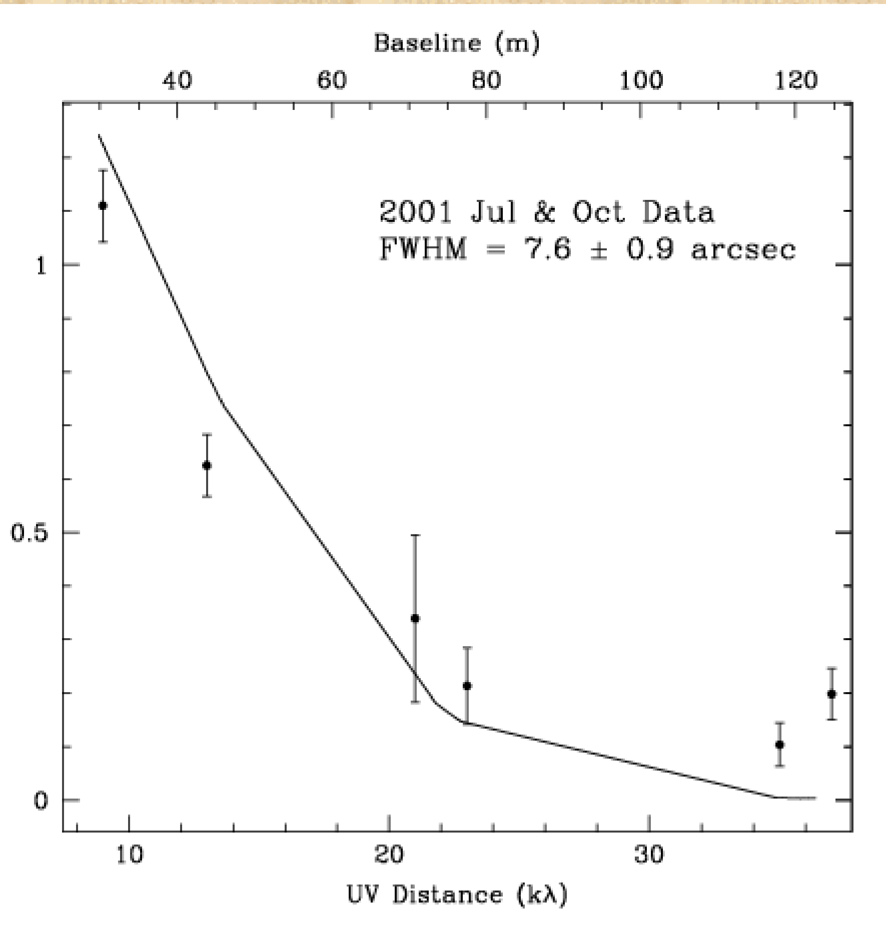
First ATCA Observations

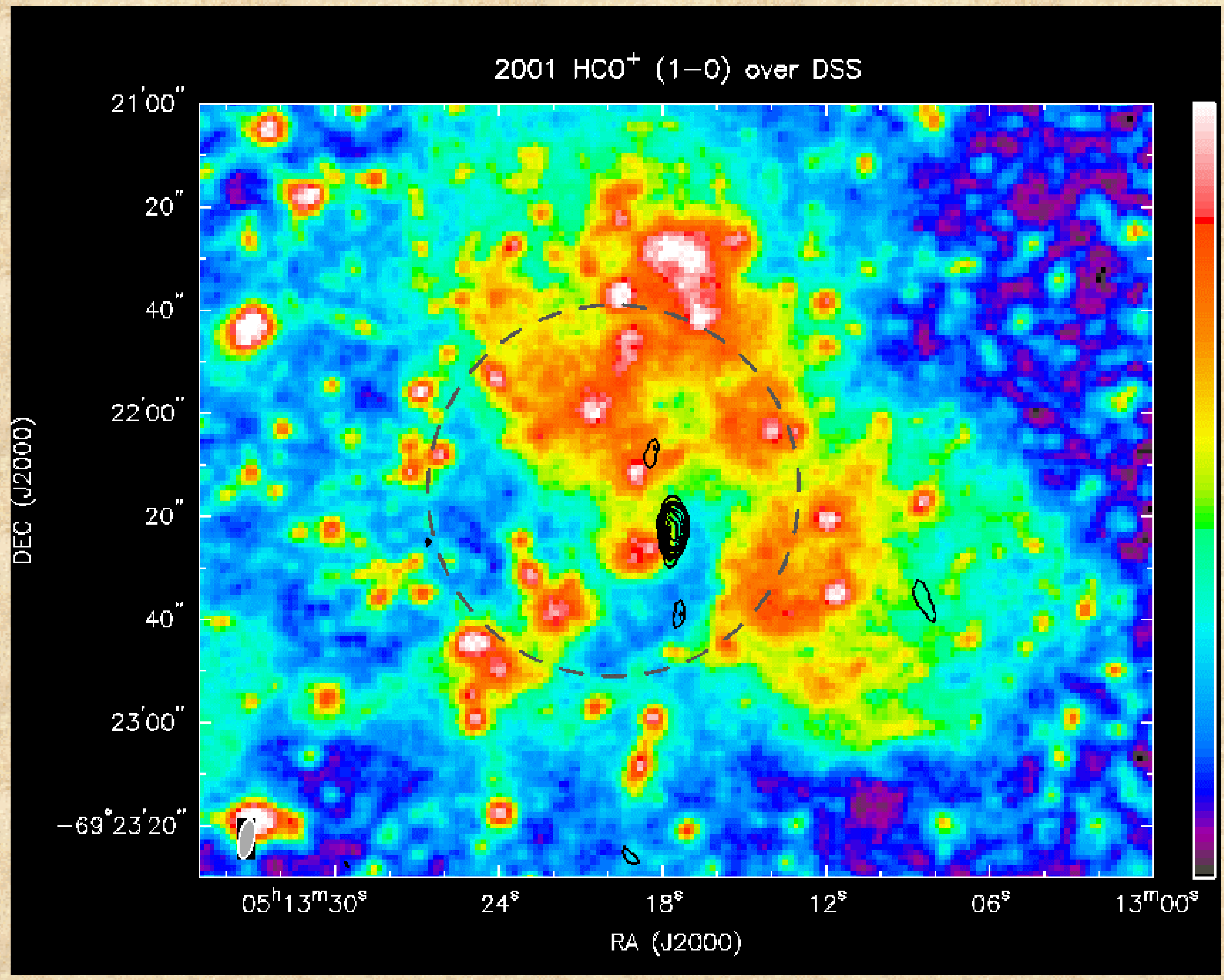


- **9 Jul 2001, single baseline**
- **Additional observations on 10 Jul and with 3-element system on 4 and 8 Oct.**
- **No T_{sys} or flux calibration – assumed fluxes for calibrators.**

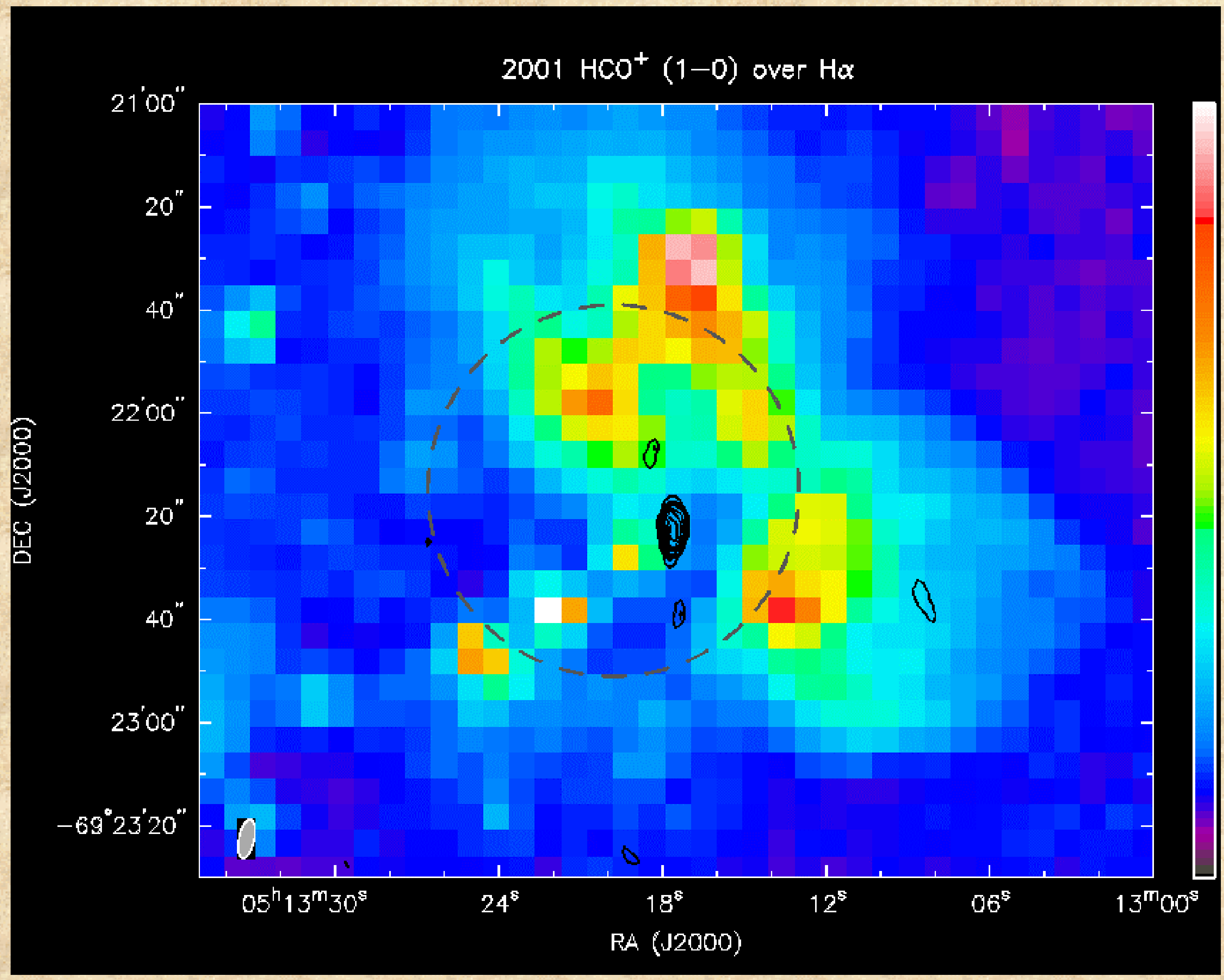
Emission is Heavily Resolved



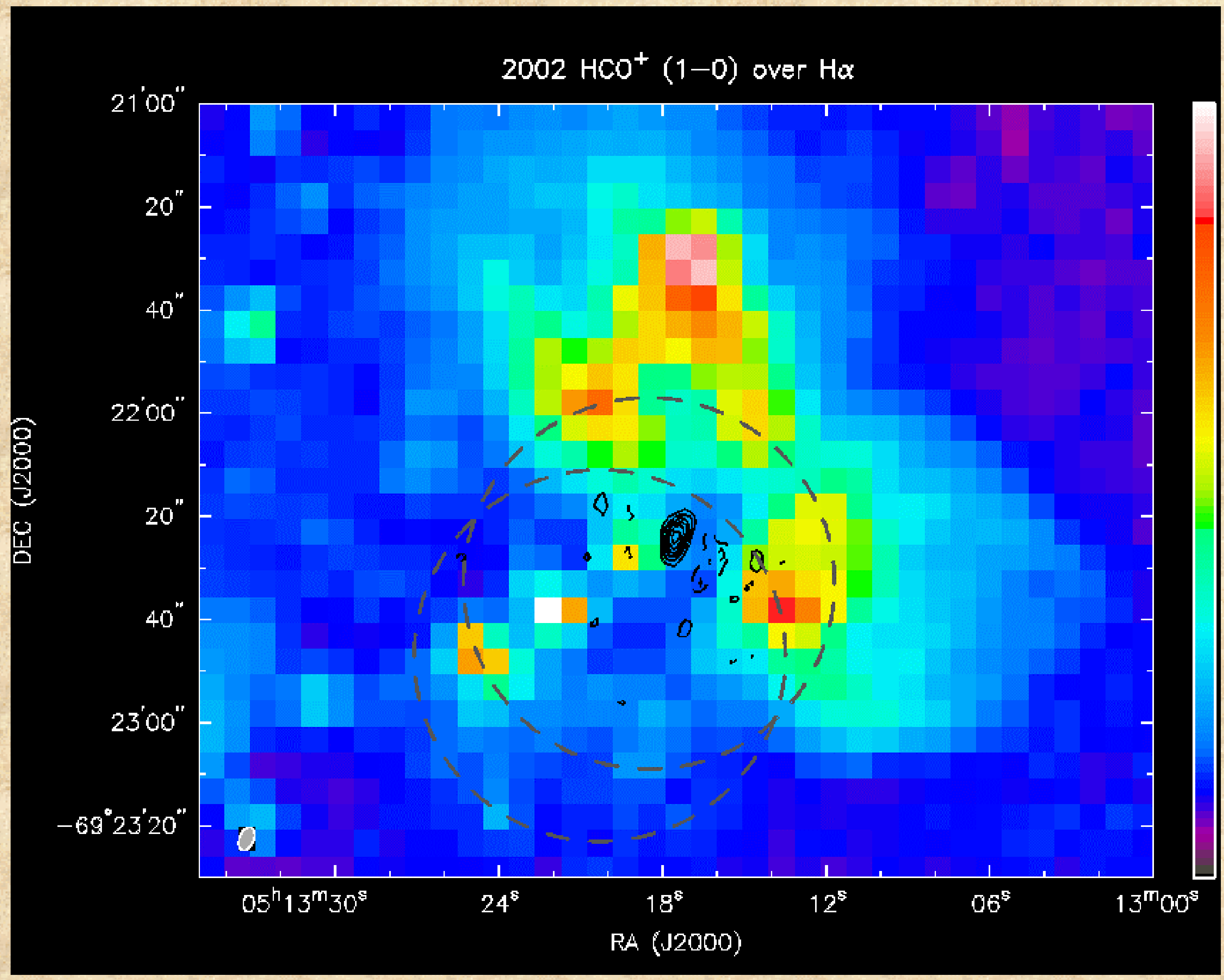




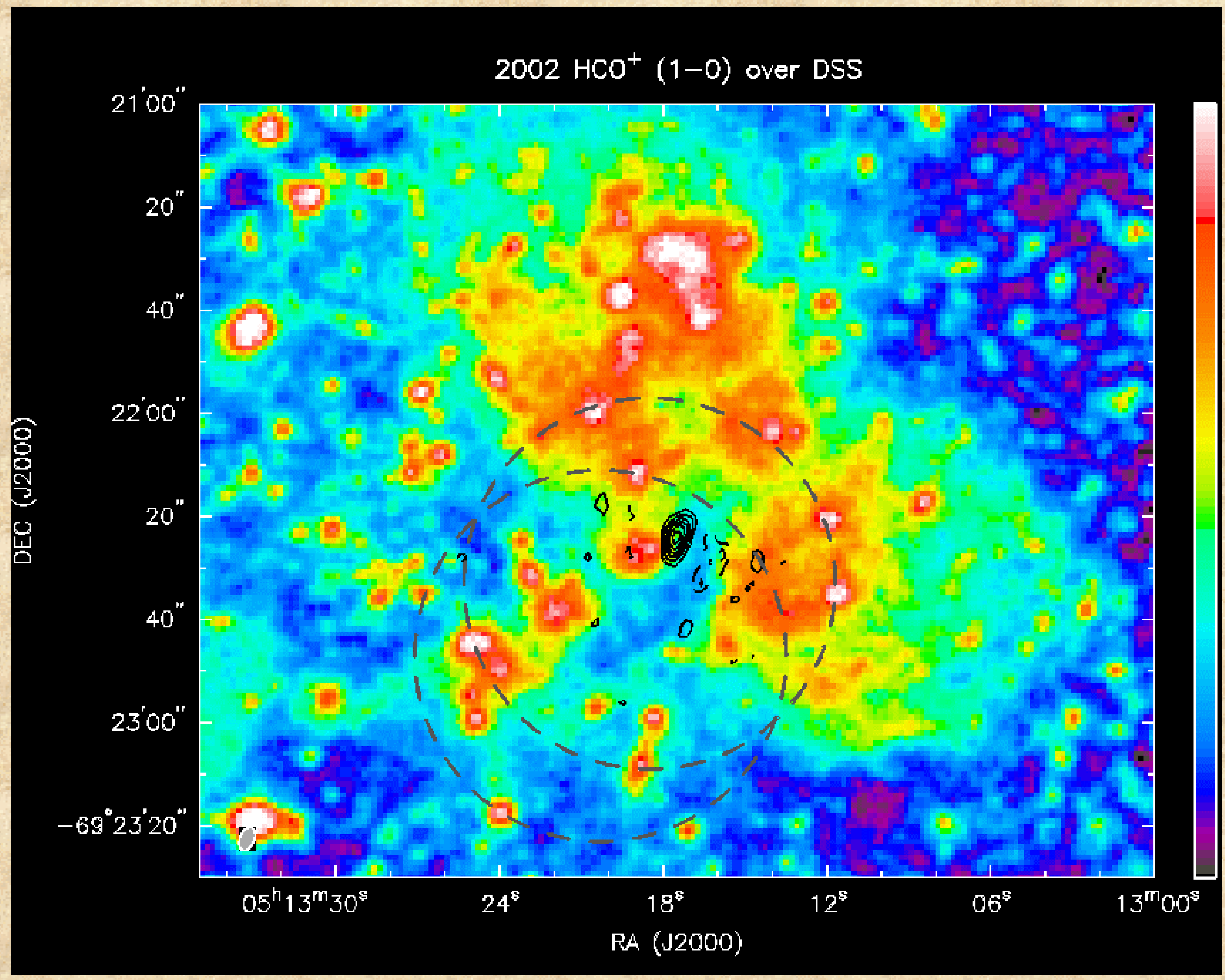
2001 HCO+ (1–0) over DSS
21'00"
20"
40"
22'00"
20"
40"
23'00"
−69°23'20"
DEC (J2000)
05h13m30s
24s
18s
12s
06s
13m00s
RA (J2000)



2001 HCO+ (1–0) over Hα
21′00″
20″
40″
22′00″
20″
40″
23′00″
−69°23′20″
DEC (J2000)
05h13m30s
24s
18s
12s
06s
13m00s
RA (J2000)



2002 HCO+ (1–0) over Hα
DEC (J2000)
21′00″
20″
40″
22′00″
20″
40″
23′00″
−69°23′20″
05h13m30s
24s
18s
12s
06s
13m00s
RA (J2000)


2002 HCO+ (1–0) over DSS
21'00"
20"
40"
22'00"
20"
40"
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DEC (J2000)
05h13m30s
24s
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12s
06s
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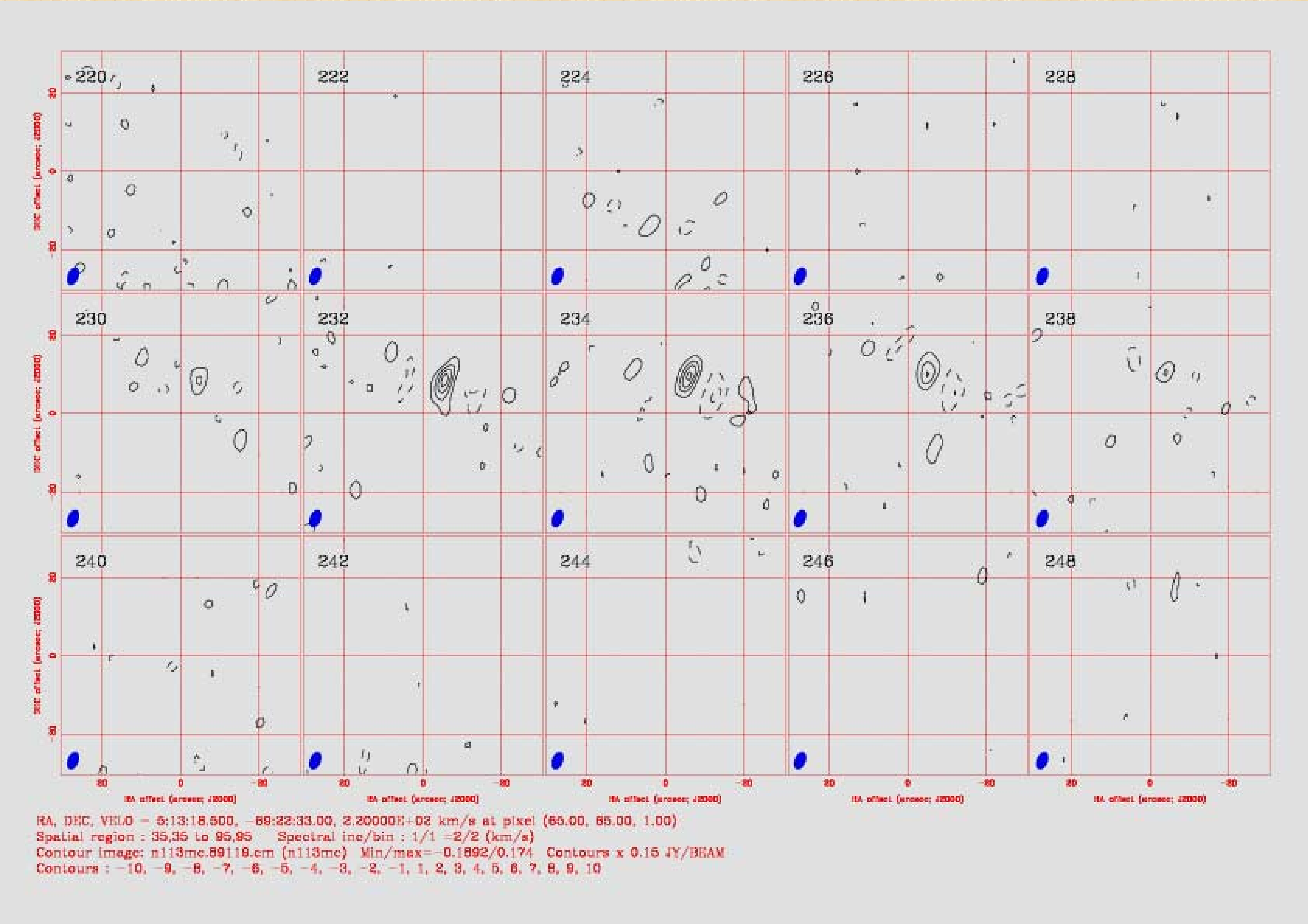
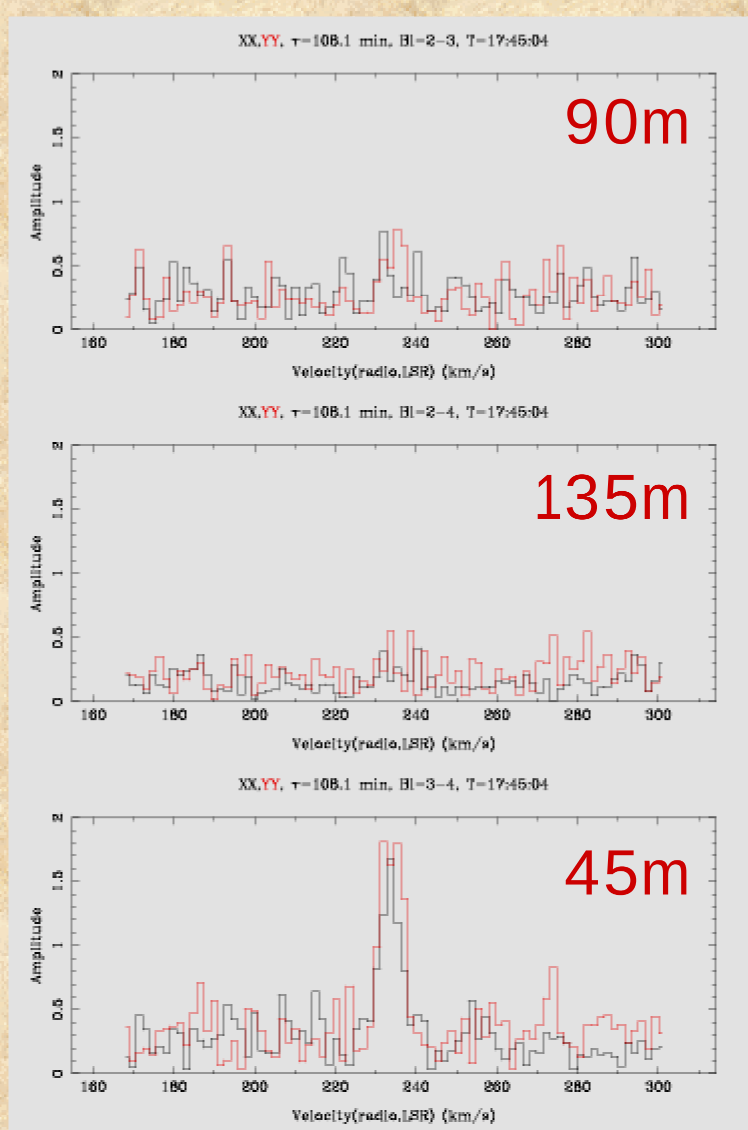
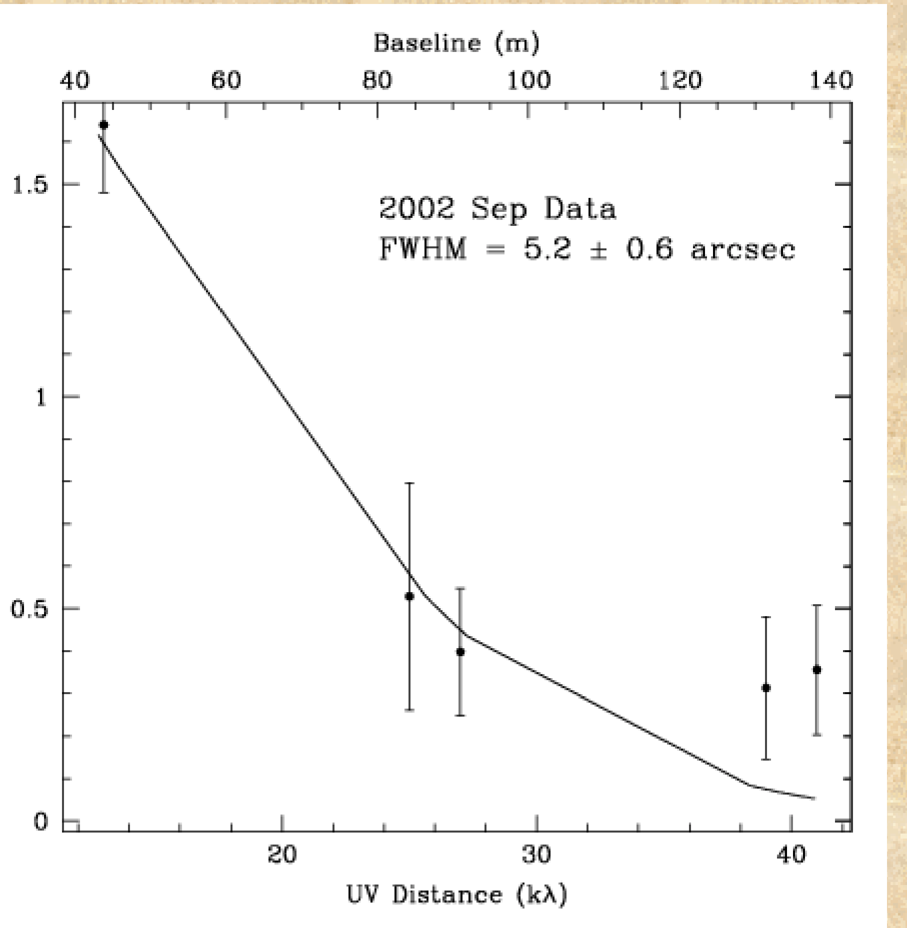
RA (J2000)

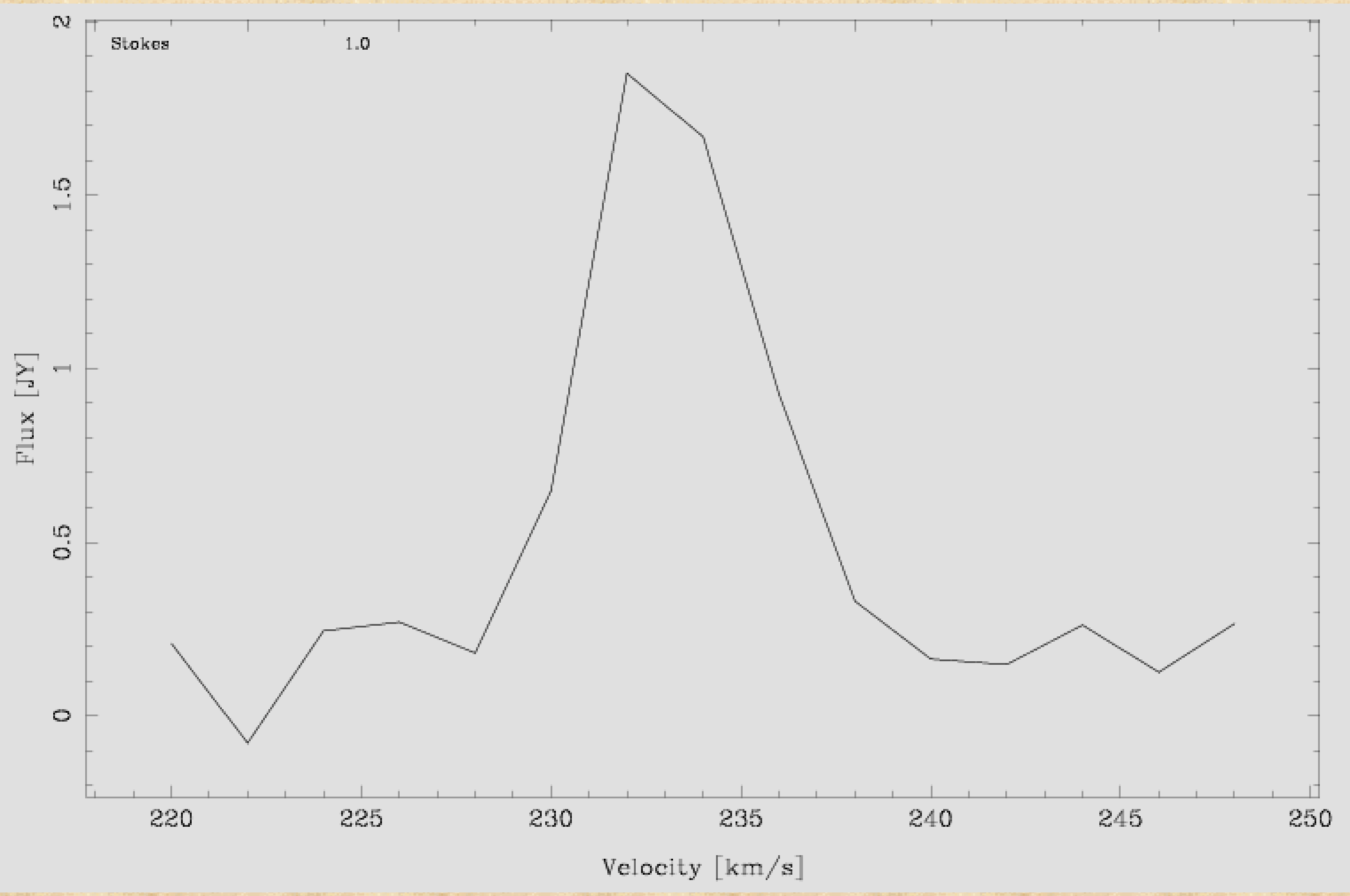

220
222
224
226
228
230
232
234
236
238
240
242
244
246
248
RA offset (arcsec; J2000)
DEC offset (arcsec; J2000)
RA, DEC, VELO = 5:13:18.500, −69:22:33.00, 2.20000E+02 km/s at pixel (65.00, 65.00, 1.00)
Spatial region : 35,35 to 95,95   Spectral inc/bin : 1/1 =2/2 (km/s)
Contour image: n113mc.89119.cm (n113mc) Min/max=−0.1892/0.174 Contours x 0.15 JY/BEAM
Contours : −10, −9, −8, −7, −6, −5, −4, −3, −2, −1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

2002 Observations





Integrated Spectrum

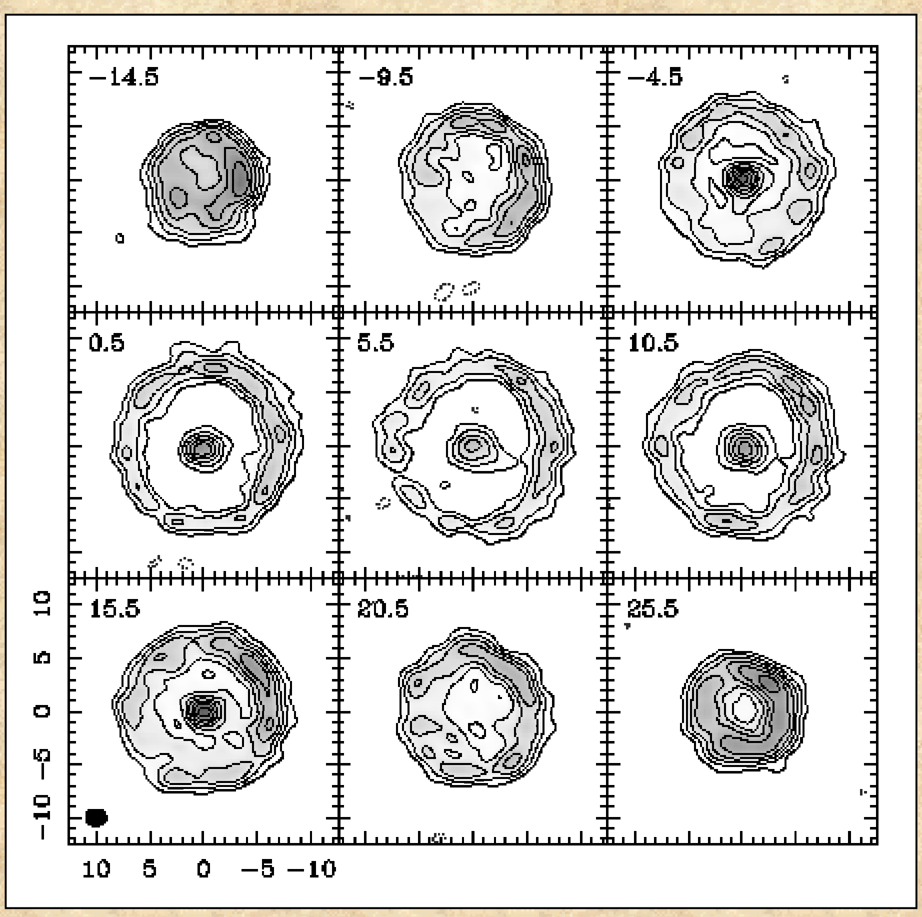


Conclusions for N113 core

- Deconvolved FWHM ≈ 1.5 pc ⇒ R ~ 1 pc.
- Line width $\Delta v \sim 5$ km s^{-1}.
- For a virialized cloud, ignoring optical depth effects, $M \approx 200(R_{pc})(\Delta v_{km/s})^2 \approx 5000\ M_{\odot}$.
- For constant density, $n_H \sim 5 \times 10^4$ cm^{-3}.
- Peak flux ~ 2 Jy, only ~13% of SEST flux.
- Most of the HCO^+ is probably in relatively diffuse gas associated with the PDR.
- HCO^+ enhanced due to high C^+ abundance (Graedel et al. 1982).

2. Circumstellar Envelopes

- In late AGB evolution, a slow wind produces a circumstellar envelope (CSE) of gas & dust.
- Strong variations in mass-loss rate (He shell flashes?) can lead to a detached shell of molecular gas (Olofsson et al. 1990).

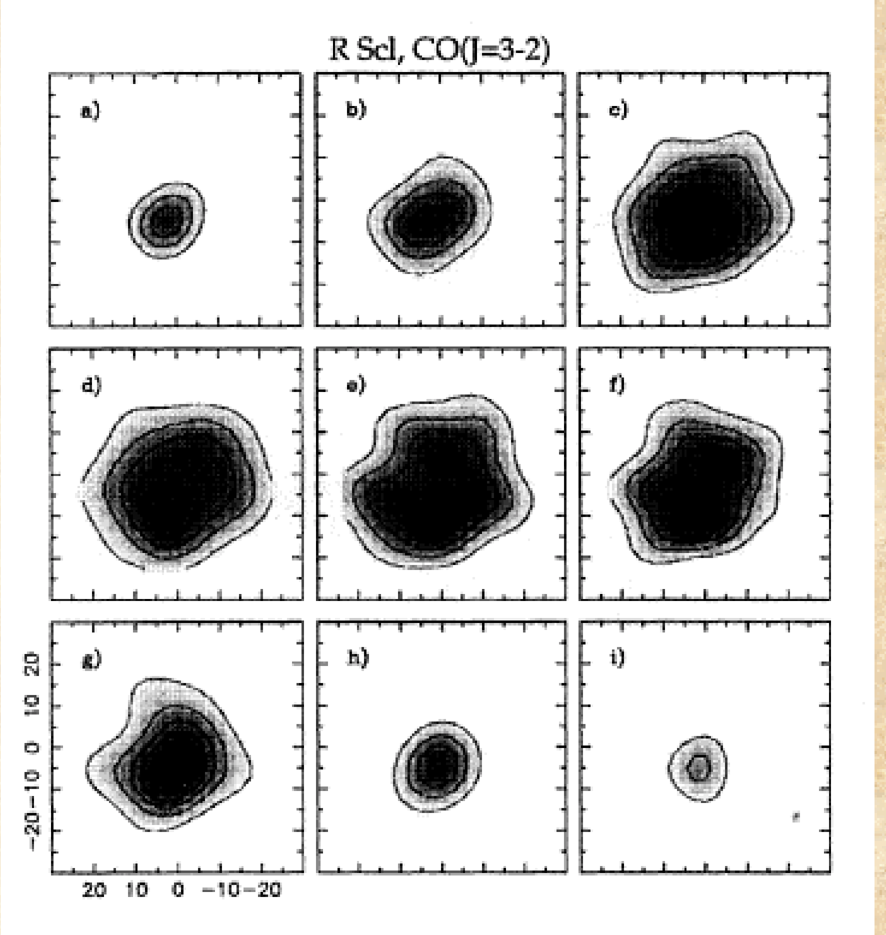


U Cam (CO)

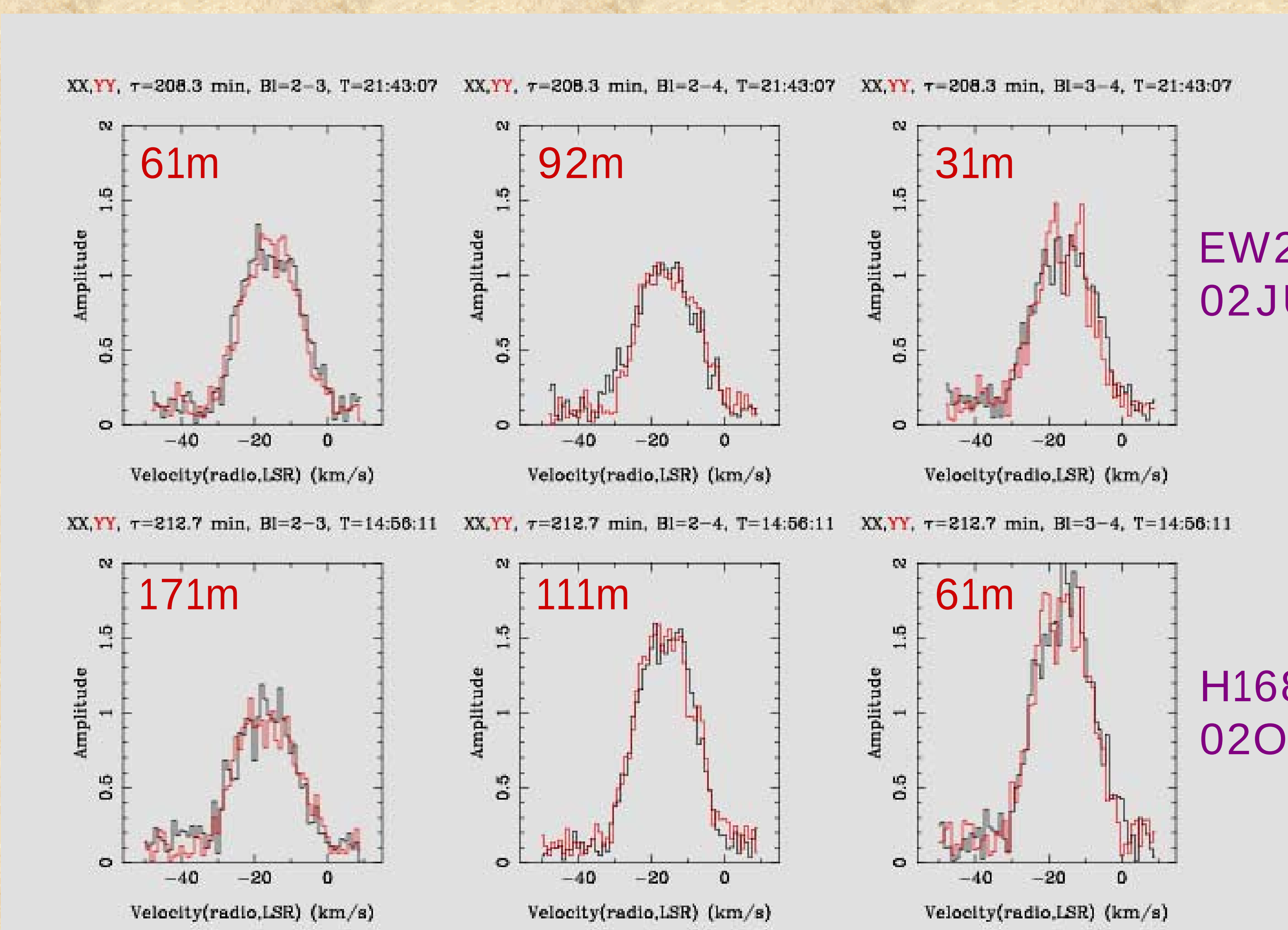
Lindqvist et al. (1999)

Circumstellar Shell Around R Scl

- R Sculptoris has been inferred from SEST CO (3-2) observations to have a detached shell (Olofsson et al. 1996).
- However, the data had insufficient resolution (16”) to determine the mass loss rate or shell thickness.



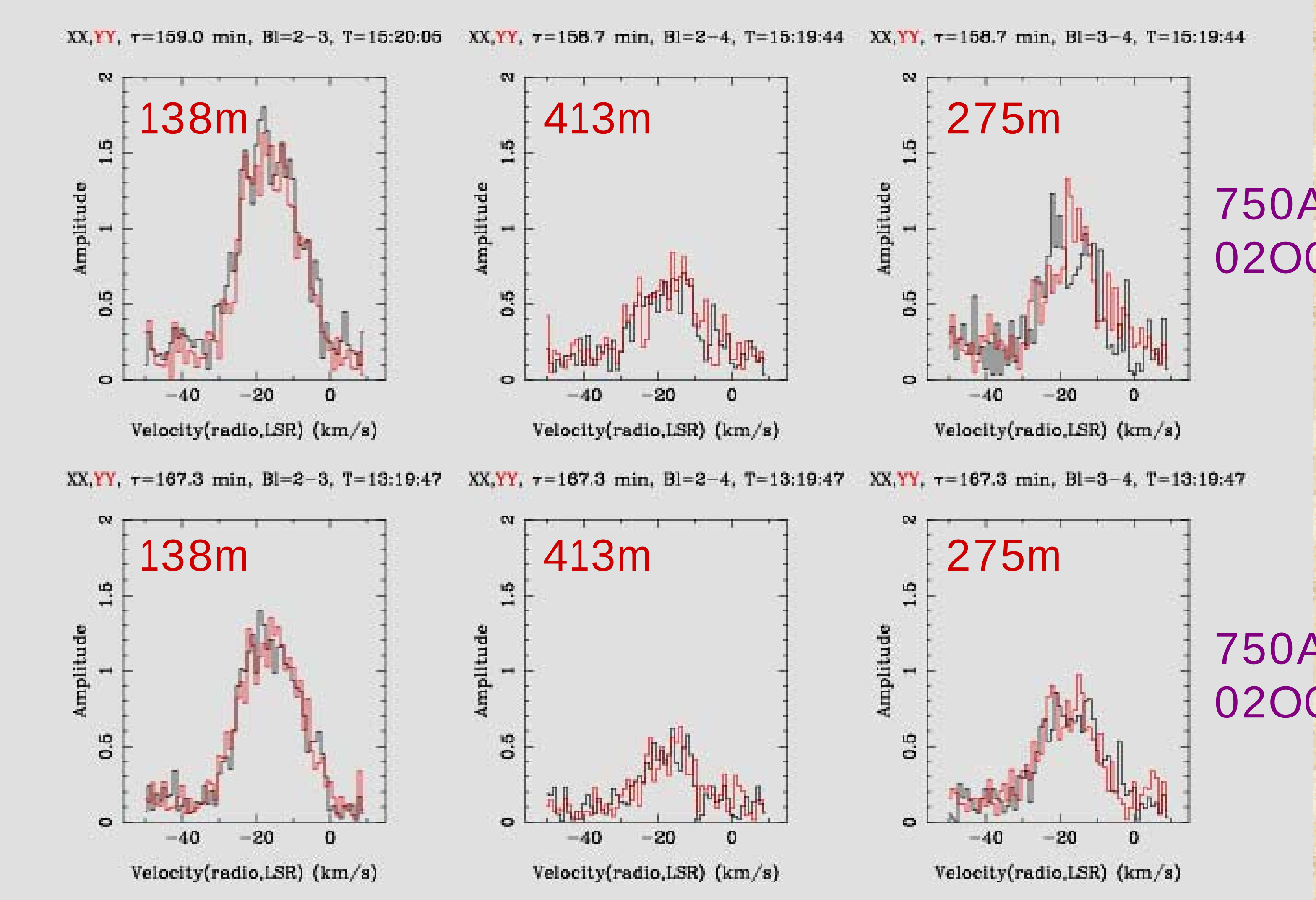
ATCA Observations



EW214
02JUN21

H168
02OCT13

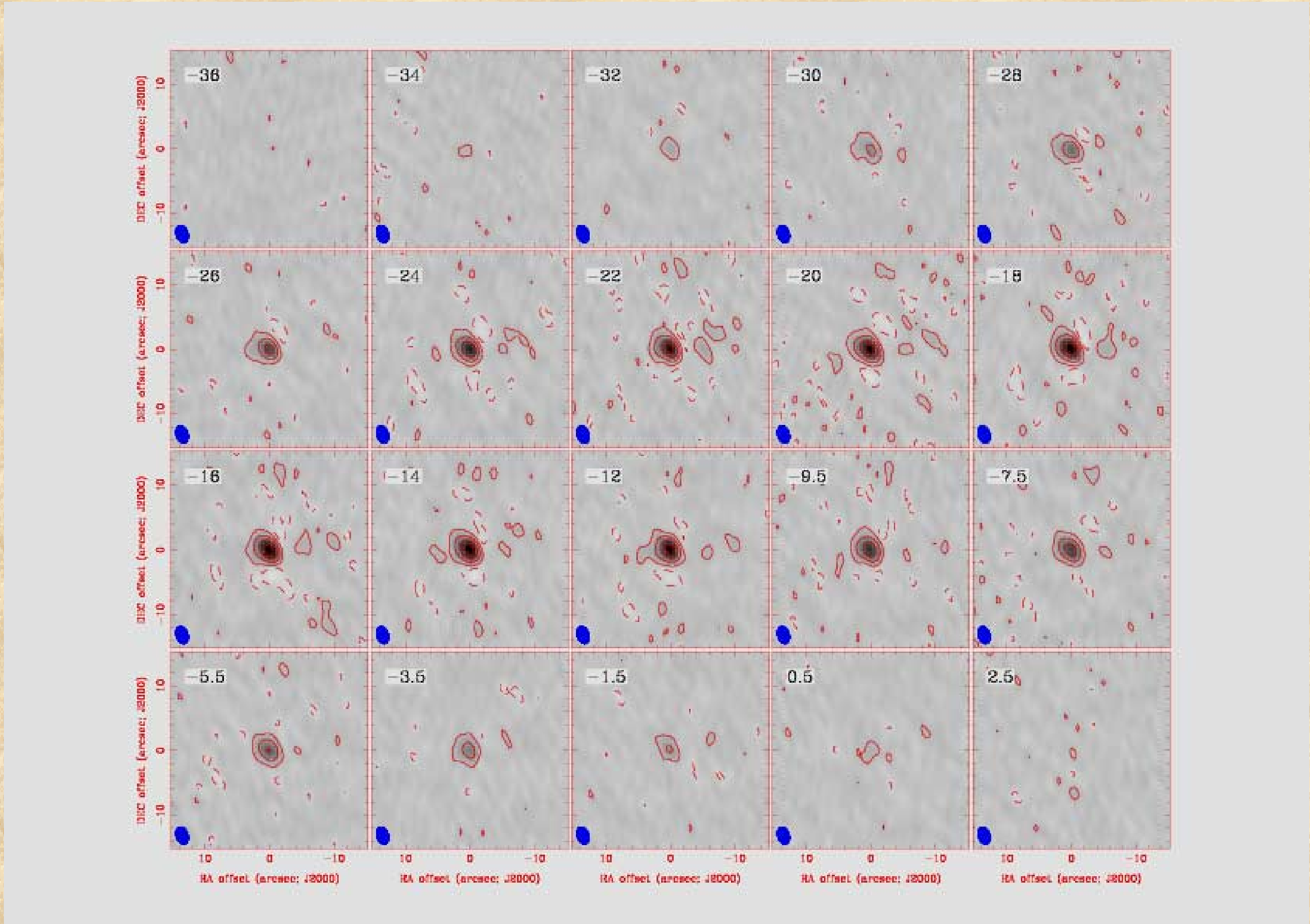
ATCA Observations



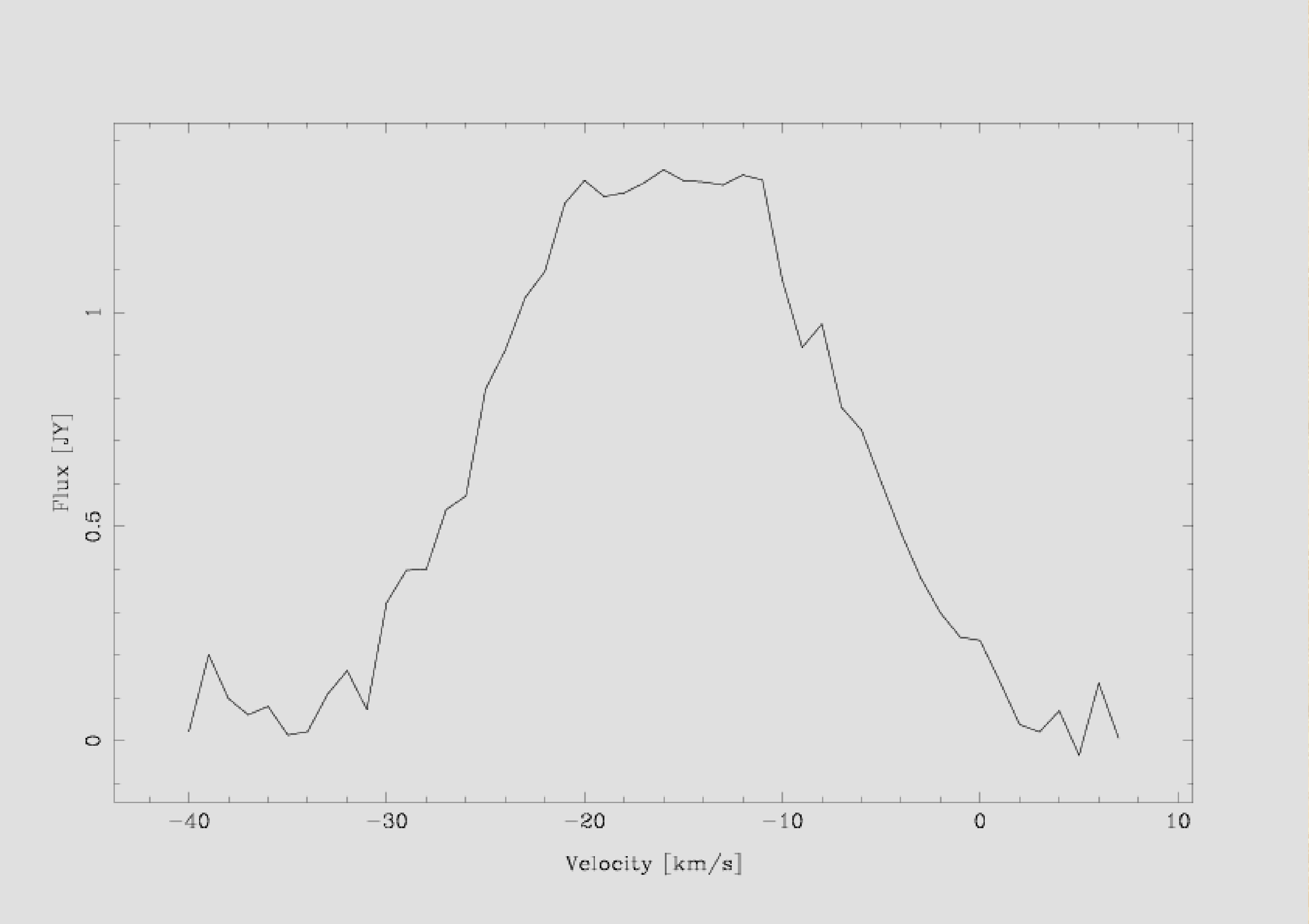
750A
02OCT15

750A
02OCT18

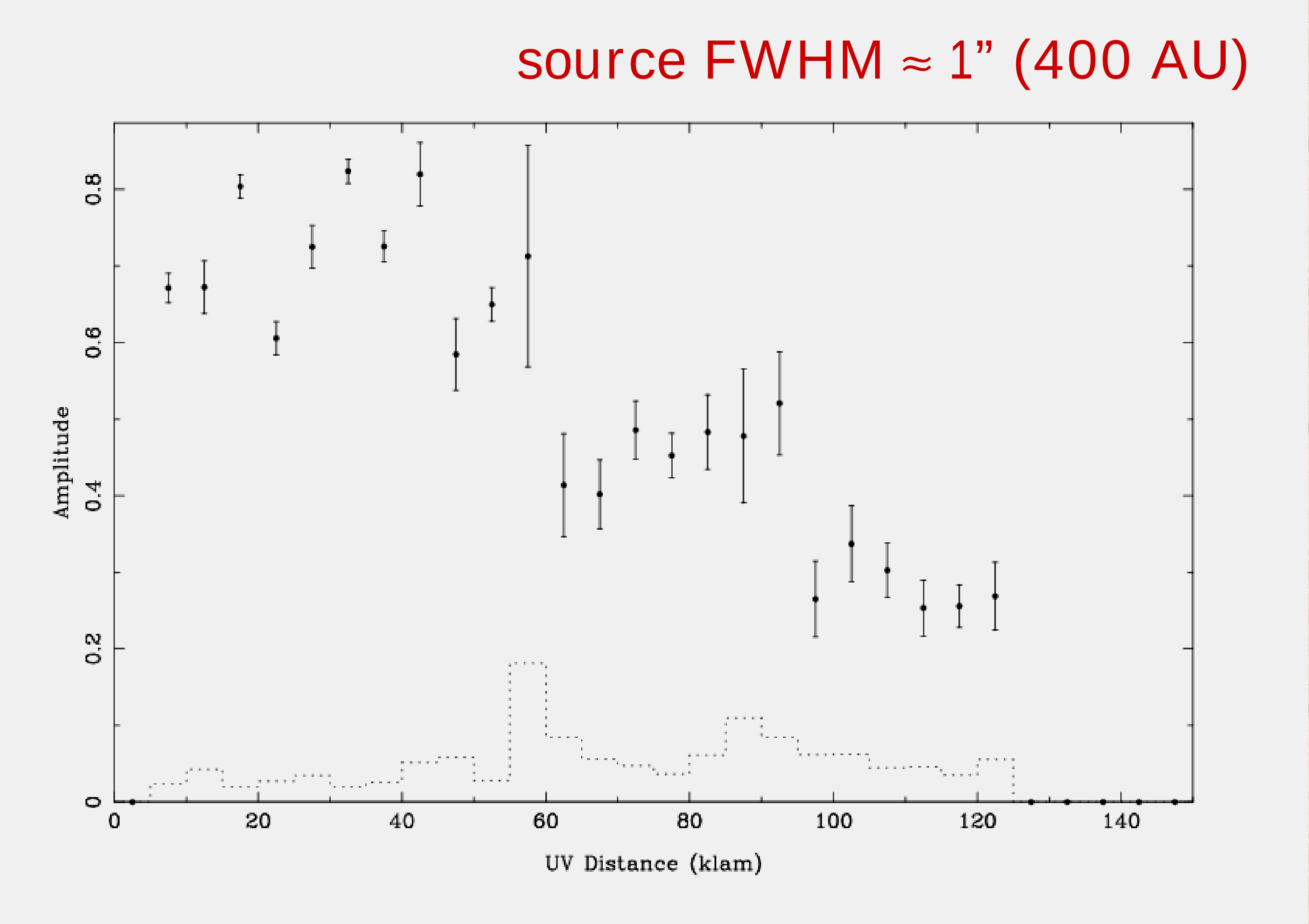
No shell emission (3σ = 75 mJy)



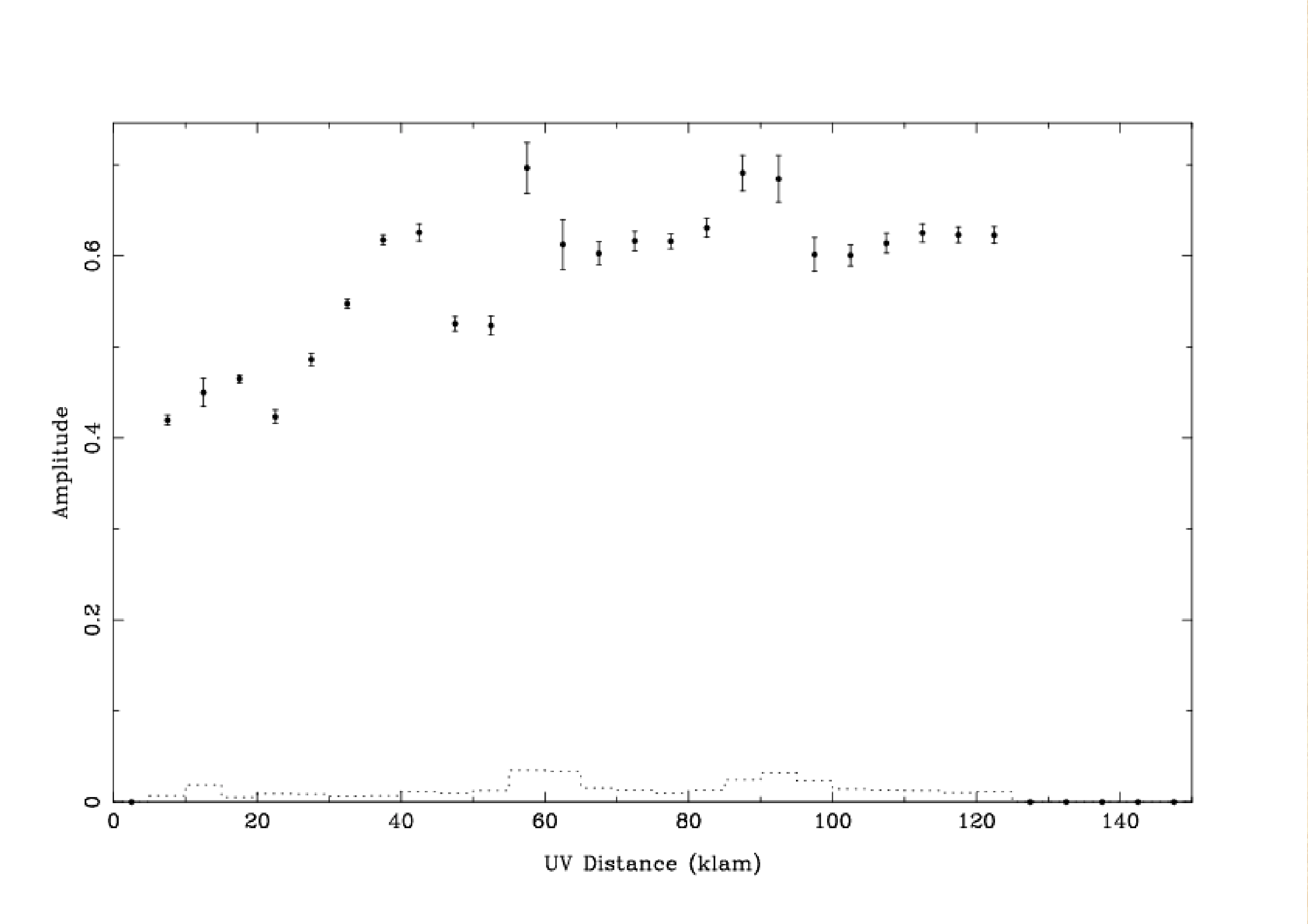
Peak flux ~1.3 Jy



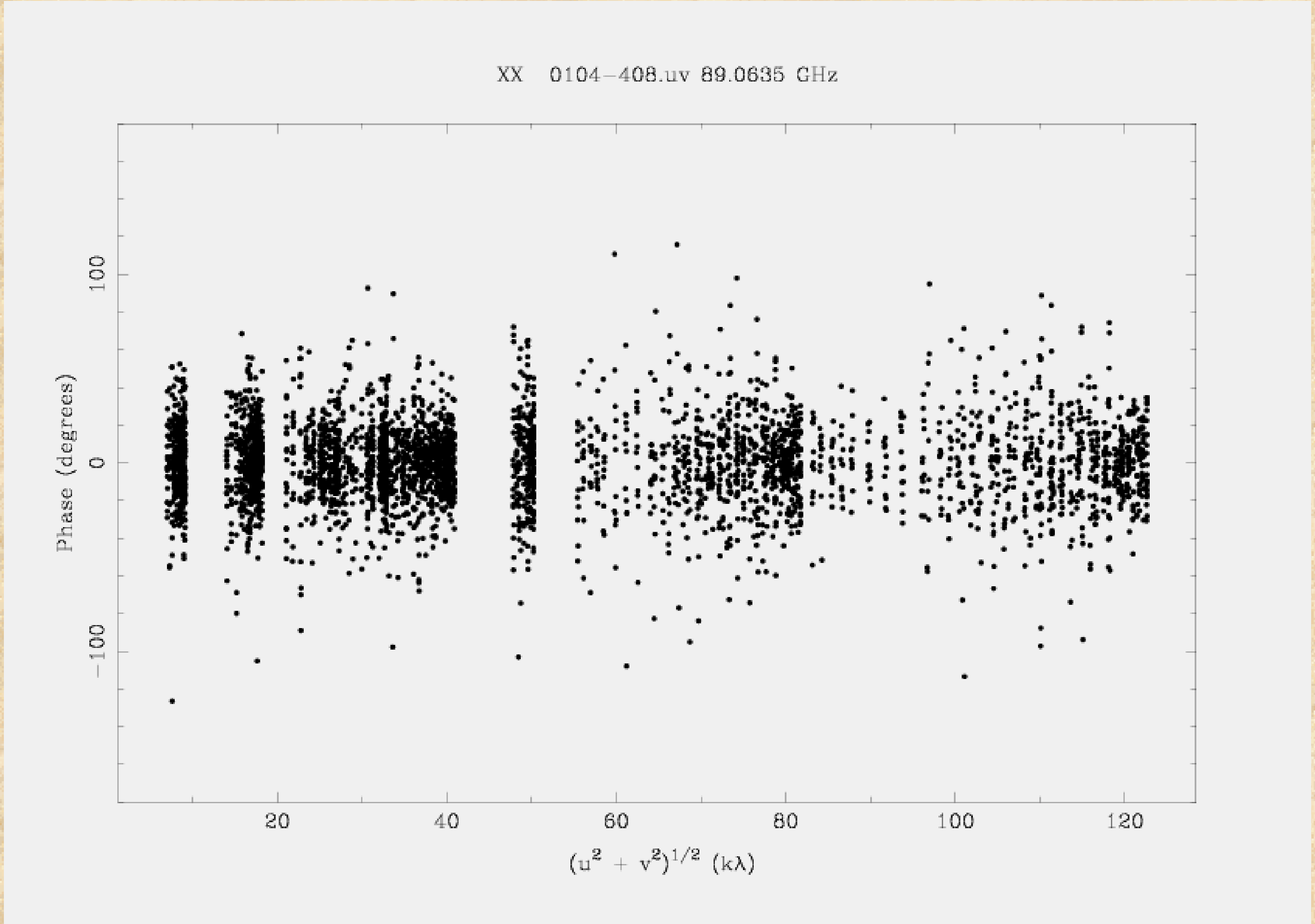
Central source is resolved



Not decorrelation!



Not decorrelation!



Conclusions for R Scl

- HCN (1-0) emission has been resolved with a deconvolved FWHM ≈ 1” (400 AU).
- Peak flux ~ 1.3 Jy, virtually all of SEST flux (0.05 K x 25 Jy/K). S/N ratio of ~40.
- No evidence for emission from the R ≈ 10” shell inferred from CO data, or R ≈ 20” shell seen in scattered light (Gonzalez Delgado et al. 2001).
- HCN is probably emitted from present mass-loss envelope. Dissociation of HCN ⇒ CN probably leads to low HCN abundance in the CO shell.
- Would be interesting to image the CN line at 113.3 GHz, as well as CO and/or ^{13}CO.

An Overview of the 3mm System in 2003

Tony Wong, ATNF

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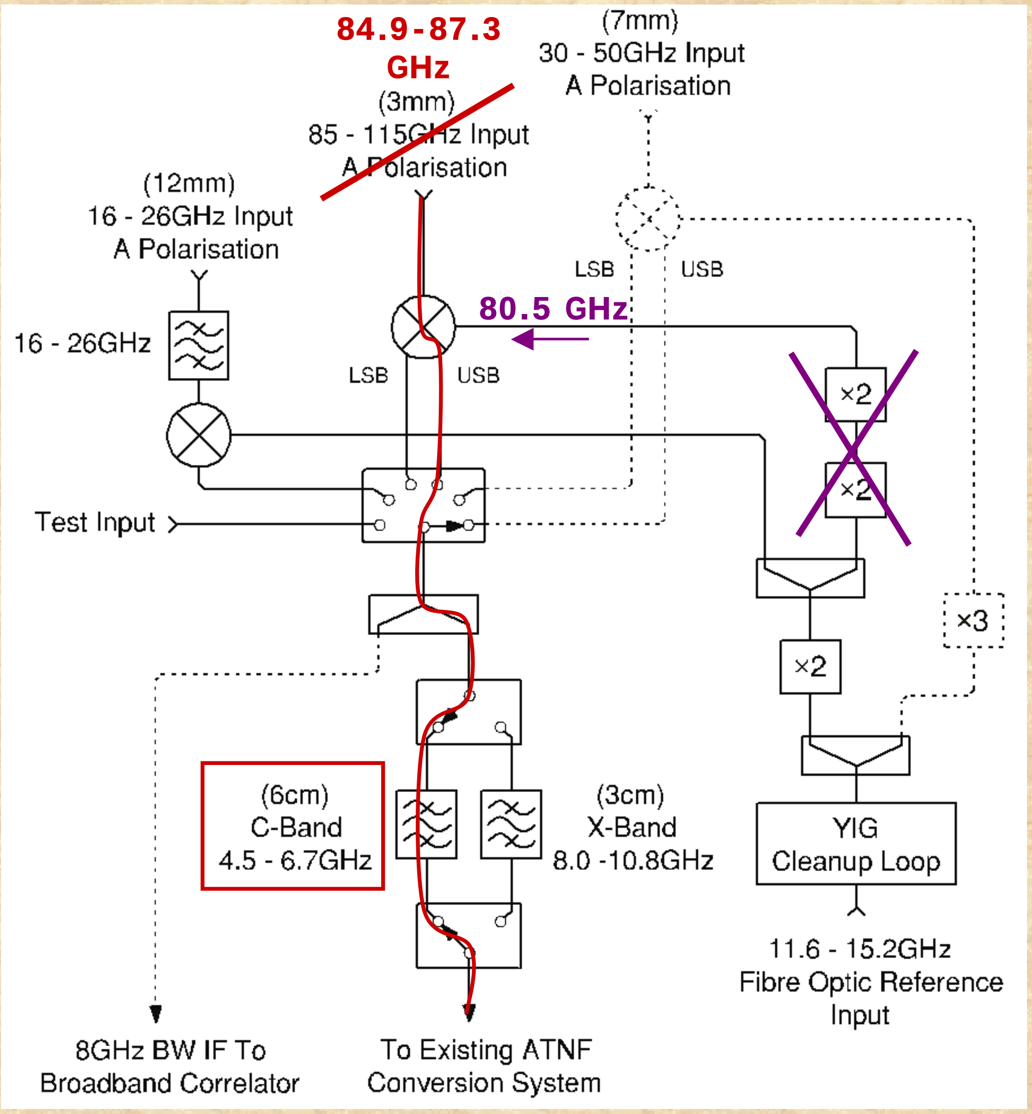
Current System (2001 Sep)

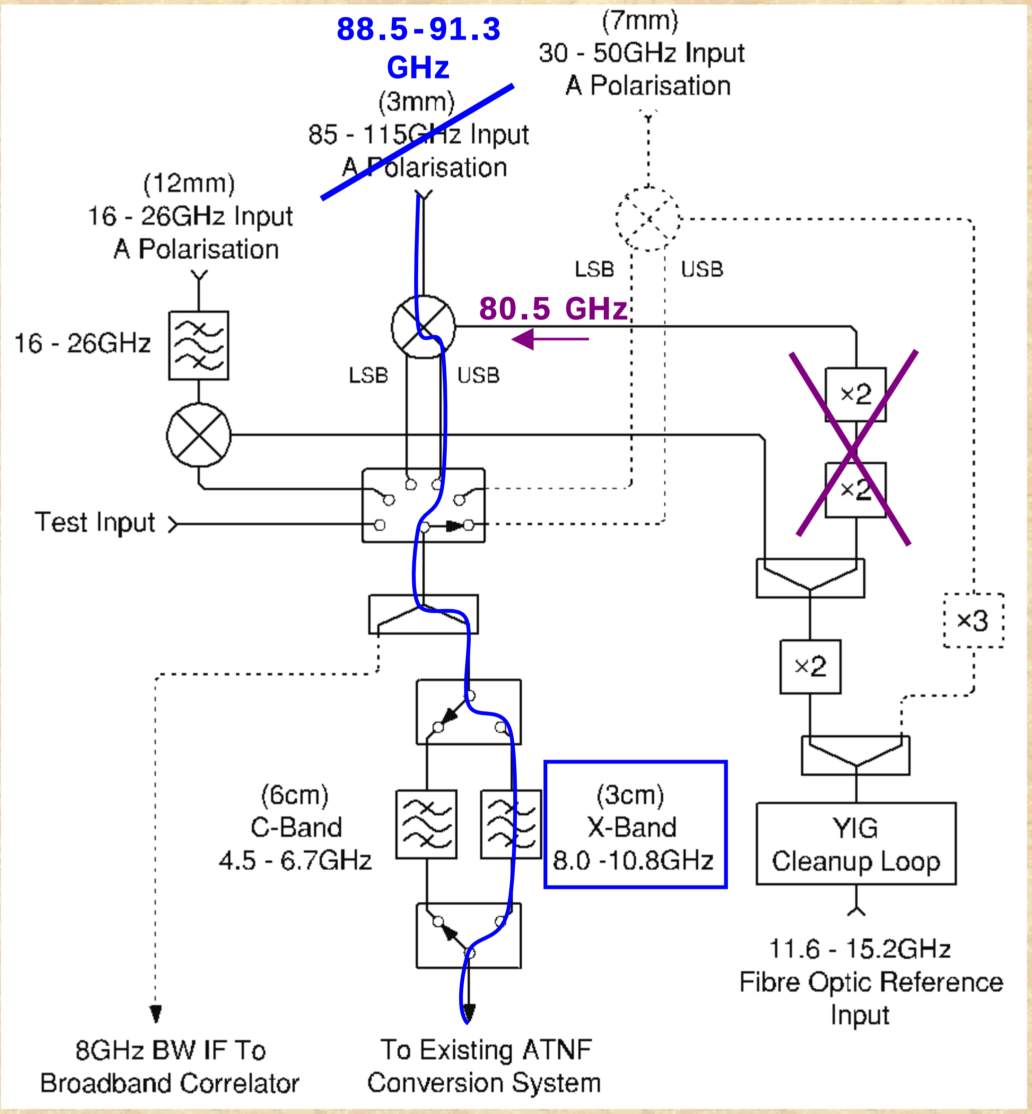
- 3 antennas (CA02, CA03, CA04) with dual polarisation receivers.
- 2 observing bands: 84.9-87.3 and 88.5-91.3 GHz. Module swap at antenna required to change bands.
- Up to 128 MHz bandwidth in each of 2 frequencies.
- Minimum baseline 30m.
- Both N-S and E-W configurations possible (since 2002 Aug).

3mm Receiver System



- **At present, the tuning range is limited since we are using a fixed frequency LO at 80.5055 GHz.**
- **The sky frequency range is 84.9-87.3 GHz using the C-band filter module or 88.5-91.3 GHz using the X-band module.**

3mm Receiver System



- At present, the tuning range is limited since we are using a fixed frequency LO at 80.5055 GHz.
- The sky frequency range is 84.9-87.3 GHz using the C-band filter module or 88.5-91.3 GHz using the X-band module.

Improvements in 2003

- **Currently, C and X modules must be swapped manually to switch from one band to the other.**
- **May: 3 antennas with prototype systems (CA02, CA03, CA04) get new down-conversion systems, eliminating need to swap modules.**
- **Allows one to quickly switch to 86 GHz SiO masers for pointing, even when observing at 89-91 GHz.**
- **Will NOT permit simultaneous observations at 86 and 90 GHz.**
- **September: 4th antenna (CA01) may be equipped with “production” 3mm receiver, but frequency range not compatible with CA02/3/4.**

Priorities for Testing

- **Pointing errors:** there appears to be a systematic offset in antenna pointing between 9, 20, and 86 GHz (M. Kesteven).
- Working on freq-dependent pointing model.
- **Phase errors:** phase jumps when changing sources, seems to be mostly (or to mimic) a baseline error.
- May need a freq-dependent baseline model – but errors appear to also vary in time!
- Still more to be done…

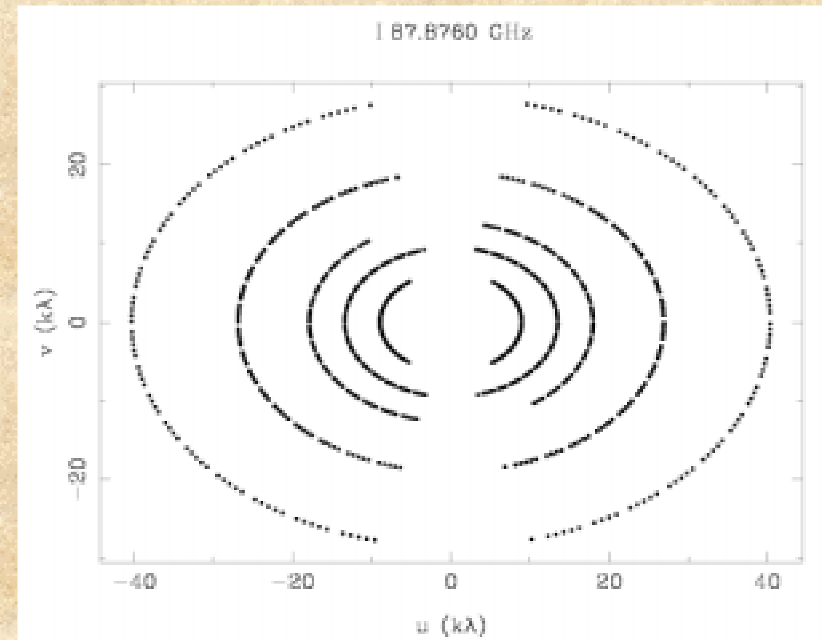
Baseline errors 2002

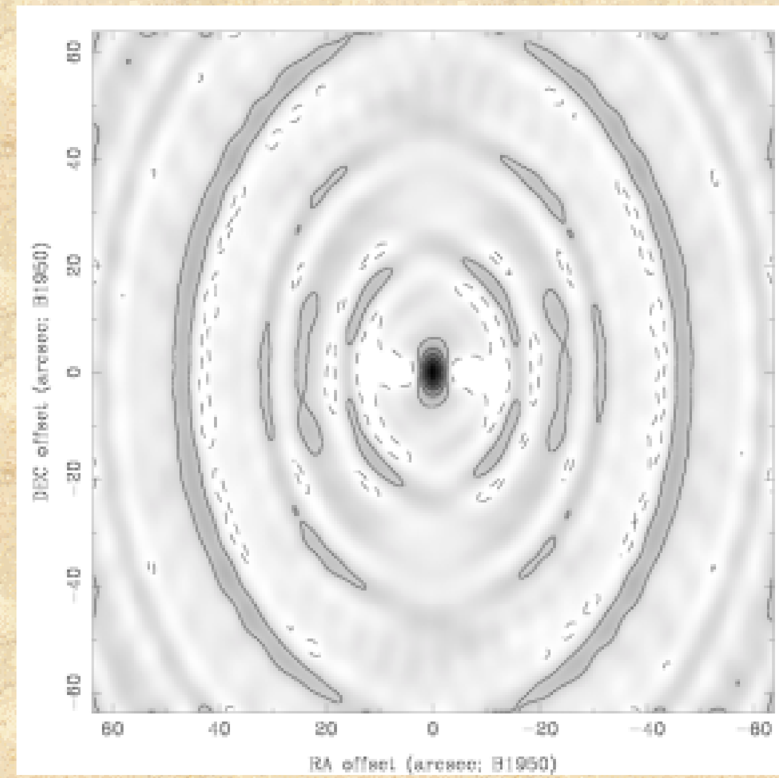
in mm, CA03 as reference

	ΔX_2	ΔY_2	ΔZ_2	ΔX_4	ΔY_4	ΔZ_4
EW214	**1.14**	**0.03**	**-1.68**	**-0.75**	**2.01**	**-2.37**
750B	**0.81**	**0.18**	**0.93**	**-1.8**	**2.67**	**0.78**
H75	**-1.83**	**-3.96**	**2.73**	**-8.58**	**-10.38**	**6.33**
EW367	**-0.39**	**1.11**	**0.63**	**12.06**	**2.46**	**-11.13**
H168	**2.01**	**0.60**	**-1.11**	**-2.82**	**1.83**	**0.06**
750A	**0.96**	**0.36**	**0.03**	**-0.99**	**-0.60**	**1.14**

Planned configurations

- **2002 May term: EW214, EW367, 750C, 1.5C**
- **Proposal deadline: 15 February!**





$EW214_{123}$ + $EW367_{123}$
7.1” x 3.6” at $\delta = -45°$

Suggested Projects

- **Quasar absorption lines: can calibrate out most phase errors, u-v coverage unimportant.**
- **Compact emission sources unresolved with SEST: can expect good S/N.**
- **Ratios of 2 lines that can be observed simultaneously: less reliant on matched uv coverage.**
- **Low dec (<–45°) sources: less shadowing in compact arrays**
- **Anything that looked good today!**

Questions to Consider

1. **Does the Australian user community accept the new timeline for the 3mm upgrade?**
2. **Does it have a choice?**
3. **Are there mechanisms in place to ensure that goals and deadlines are meaningful?**
4. **Does ATNF have its priorities straight?**
5. **Are we sufficiently involving the engineers in the scientific program?**
6. **Should the ATNF Steering Committee be asked to take action?**