Parkes and Tidbinbilla at 12mm

ALMA's missing Band 0

Michael Burton

UNSW


mmm, I think its missing a few things
NANTEN2

Receivers/Front Ends

ALMA Band	Frequency Range	Receiver noise temperature		Mixing scheme	Receiver technology
		T_{Rx} over 80% of the RF band	T_{Rx} at any RF frequency		
1	31.3 – 45 GHz	17 K	28 K	USB	HEMT
2	67 – 90 GHz	30 K	50 K	LSB	HEMT
3	84 – 116 GHz	37 K	62 K	2SB	SIS
4	125 – 169 GHz	51 K	85 K	2SB	SIS
5	163 – 211 GHz	65 K	108 K	2SB	SIS
6	211 – 275 GHz	83 K	139 K	2SB	SIS
7	275 – 373 GHz	147 K	221 K	2SB	SIS
8	385 – 500 GHz	98 K	147 K	DSB	SIS
9	602 – 720 GHz	175 K	265 K	DSB	SIS
10	787 – 950 GHz	230 K	345 K	DSB	SIS

- **Band 0 has been forgotten!**
  - **18-26 GHz or 12mm**
- **Relative sensitivity good at 12mm**
  - **Extended sources: 22 GHz *vs.* 220 GHz**
  - **$S/N_{Parkes/ALMA} \sim (A_{Parkes}\ T_{ALMA} / A_{ALMA}\ T_{Parkes})^{0.5} \sim 1$**

- Dual, linear polarization channels:
  - Increased sensitivity
  - Measurement of 4 Stokes parameters

- 183 GHz water vapour radiometer:
  - Used for atmospheric path length correction

12mm: Band 0

- ***A waveband in transition***
  - **From molecules to ionized gas**
    - **Dense Cores to HCHIIs to UCHIIs to HIIs**
    - **Mighty masers!**
  - **Dust in dense proto-planetary environments**
    - **SKA Cradle of Life**
- ***Characterising the environment of the dense molecular medium of the Galaxy***
  - **Formation of stars, turbulence in the cold ISM, complex organic chemistry**

ATNF Science Priorities
Science in 2010 - 2015

Version 2, 25 November 2008

Parkes

Lewis Ball, Robert Braun, Philip Edwards, Ilana Feain, George Hobbs, Simon Johnston, Naomi McClure-Griffiths

- **Pulsars:**
  - **Searching**
  - **Timing**
- **HI in Galaxies**
- **The Galaxy:**
  - **Galactic ISM**
  - **Star Formation**

Sensitivity and Big Dishes

- **Point Sources:**
  - $F_\nu \propto D^{-2}$; $\theta \propto D^{-1}$ in same int. time
- **Extended Sources:**
  - I_ν Fixed; $\theta \propto D^{-1}$ in same int. time
- **Galactic molecular clouds:**
  - Extended but partially fill the beam

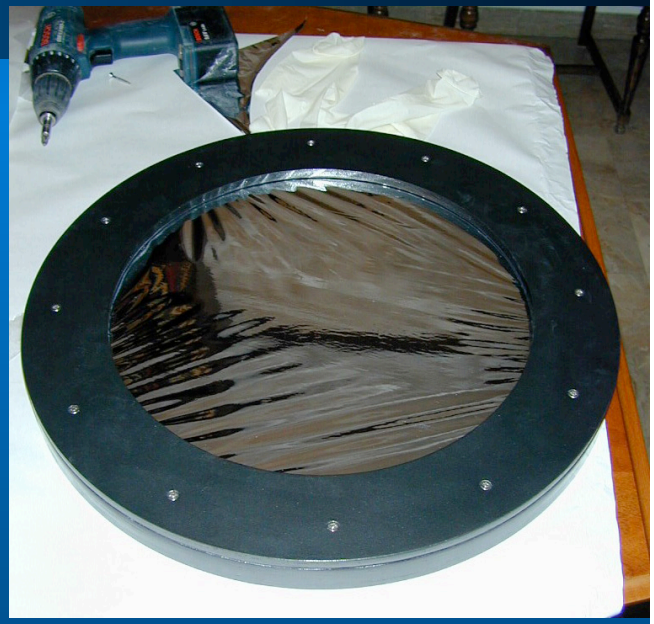
  ⇒*Some where in between*

  i.e. Gains of a factor 3 in resolution,

  upto a factor 10 in sensitivity

Parkes as a gamma-ray telescope?!

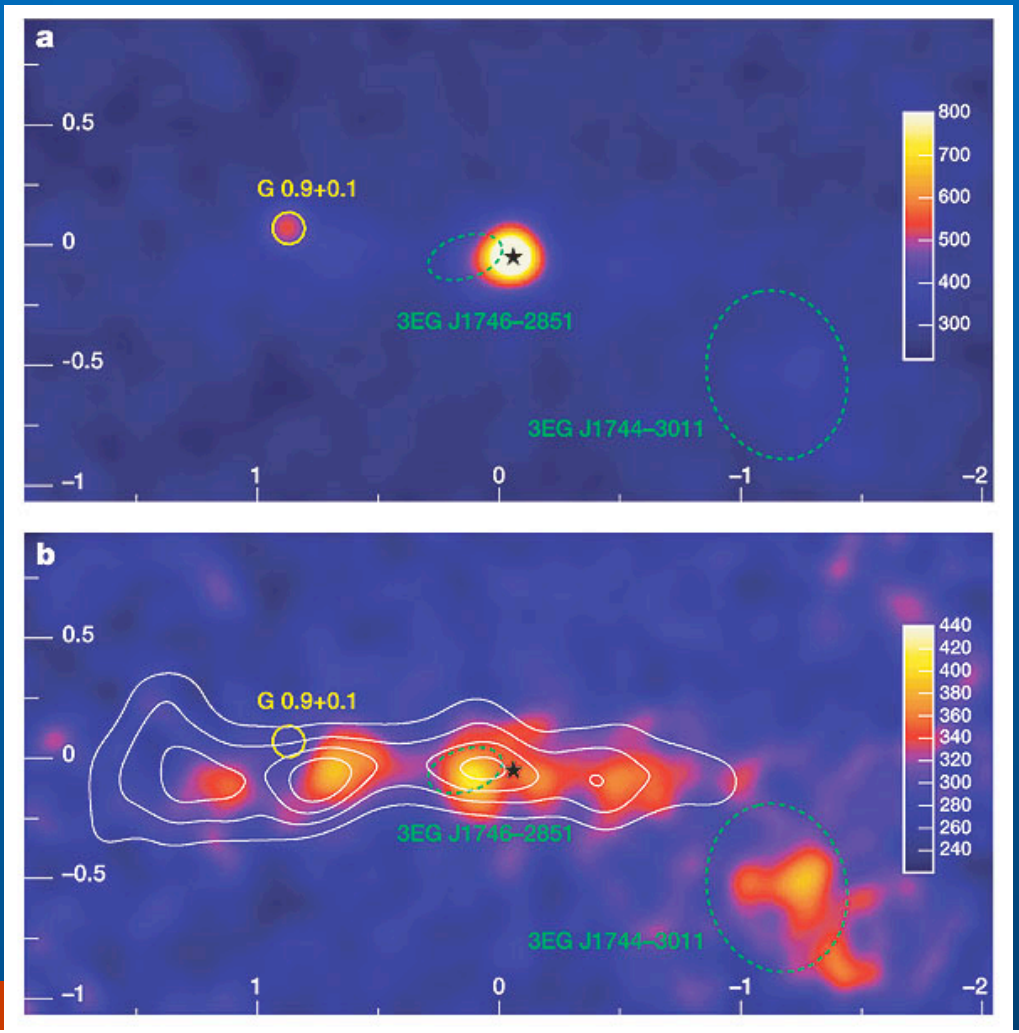
Cover in mylar sheeting!



Gamma Rays and Dense Molecular Gas

CMZ

CS contours
γ-rays image



Discovery of very-high-energy γ-rays from the Galactic Centre ridge

Aharonian et al, Nature, 2006, 439, 695

What about Ammonia at 12mm?!

HOPS – The H_2O southern Galactic Plane Survey

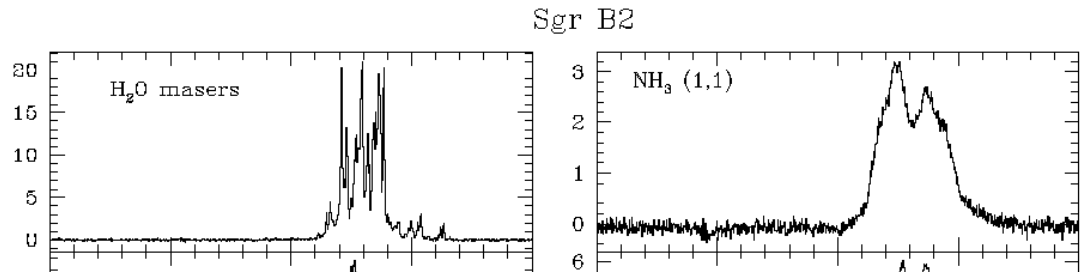
Andrew Walsh, JCU
Michael Burton, UNSW
Graeme White, JCU
Steven Longmore, CfA, USA
Cormac Purcell, Manchester
Nadia Lo, UNSW
Kate Brooks, ATNF
Chris Phillips, ATNF
Shari Breen, Utas
Lyshia Quinn, Manchester

Maxim Voronkov, ATNF
Maria Cunningham, UNSW
Paul Jones, UNSW
James Urquhart, ATNF
Melvin Hoare, U. Leeds
Mark Thompson, U. Hertfordshire
Lisa Harvey-Smith, Sydney Uni
Tui Britton, ATNF
Luke Hindson, U. Hertfordshire

http://www.jcu.edu.au/astronomy/awalsh/HOPS/

Image Courtesy: Cormac Purcell

l=359-010

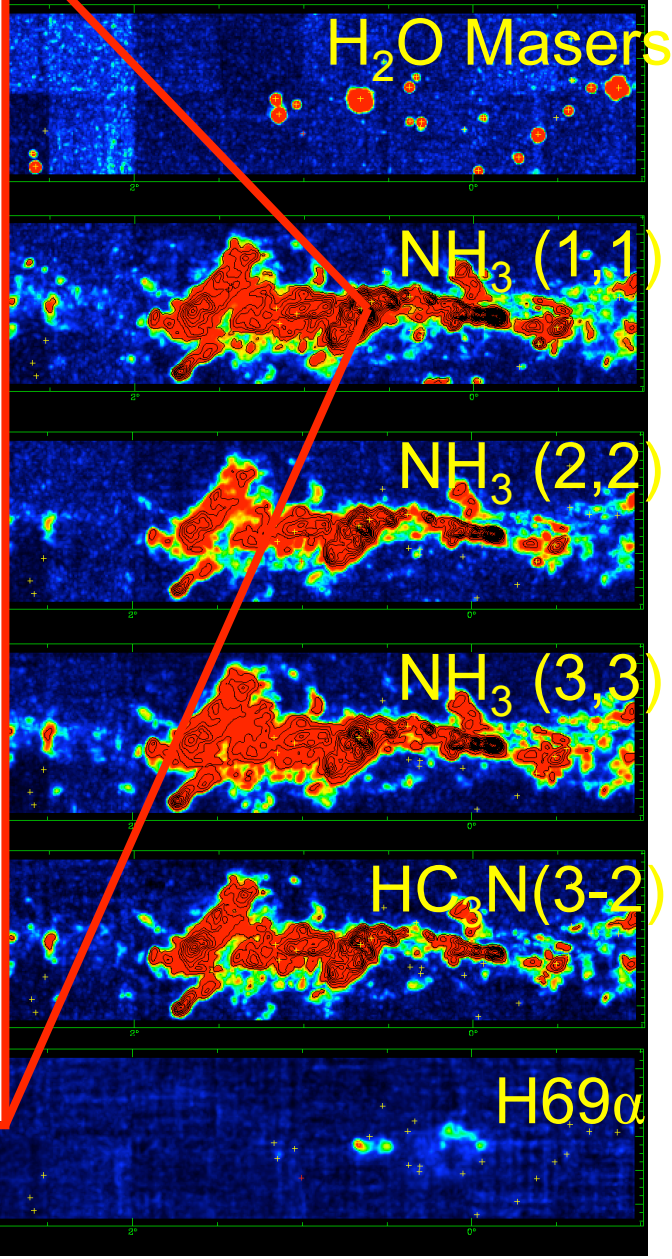


~540 H_2O Masers in 100 sq deg.

- Reaches 1.5 Jy
- 2/3rd new
- MMB achieved 0.4 Jy for CH_3OH
  - How many more??

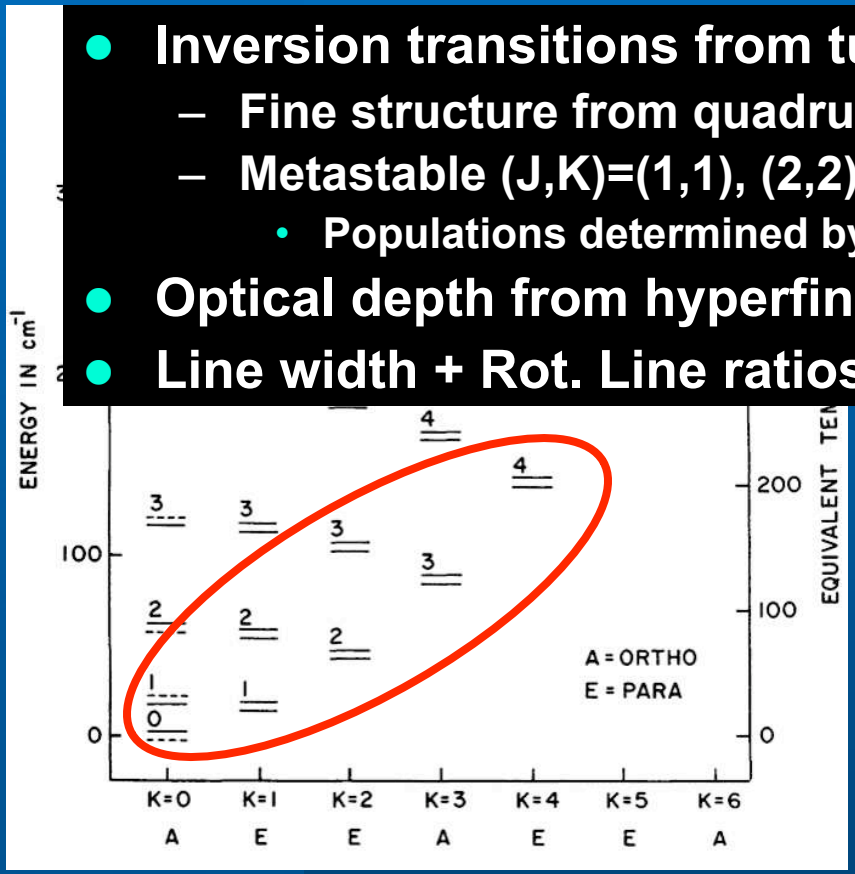
Lots (!) of NH_3 (1,1) detections

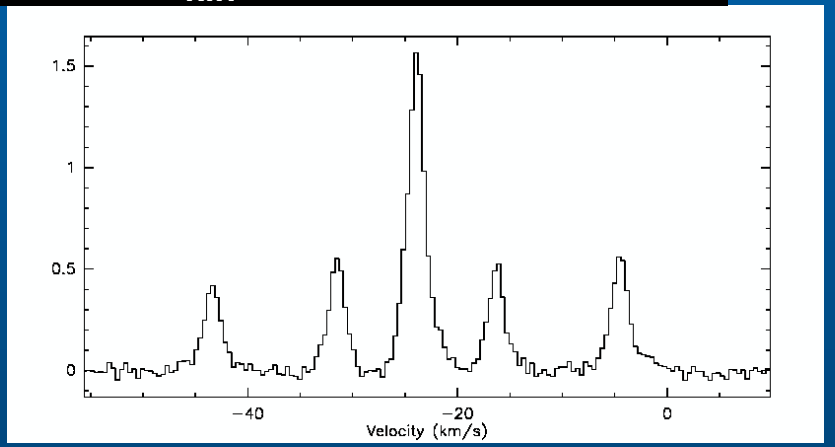
- Only 1/3rd seen in (2,2) line.
  - Needed for T-characterisation
- Extended emission but small overall filling factor

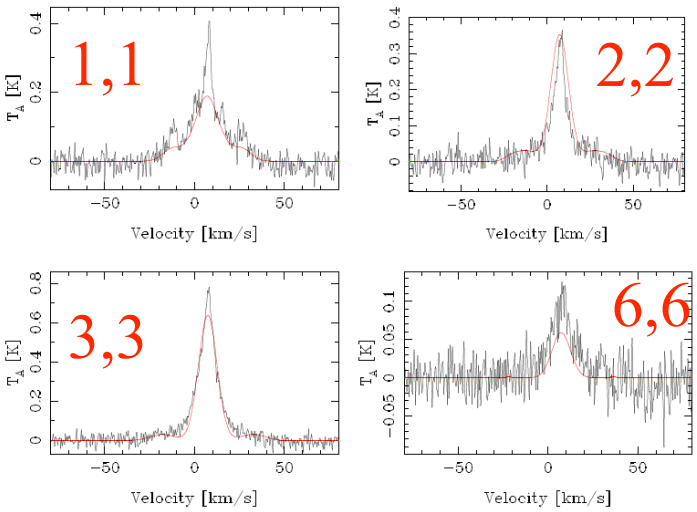


Some Ammonia Physics

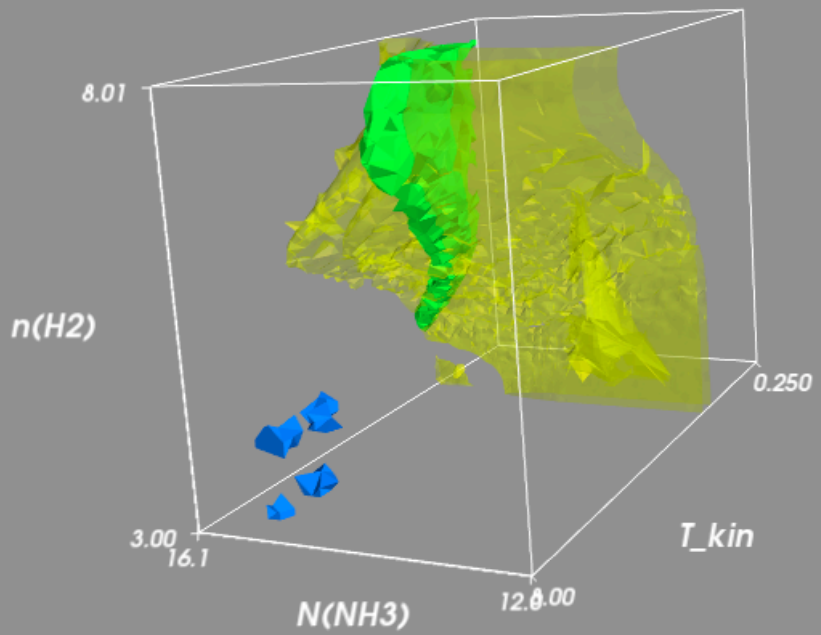
- Inversion transitions from tunnelling
  - Fine structure from quadrupole splitting
  - Metastable (J,K)=(1,1), (2,2)… transitions
    - Populations determined by collisions
- Optical depth from hyperfine line ratios
- Line width + Rot. Line ratios + LVG → T_{kin} and Density

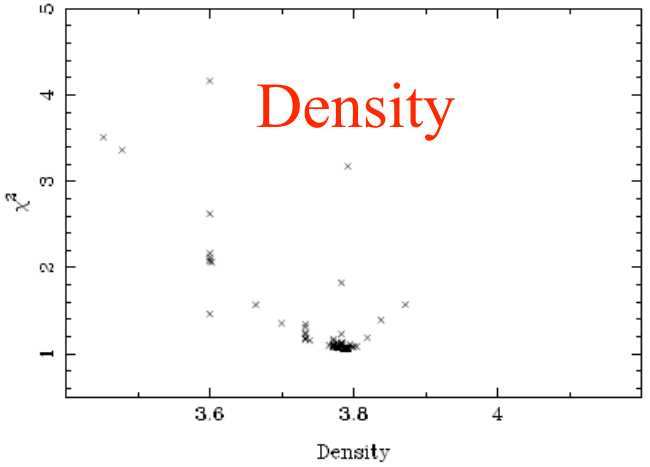


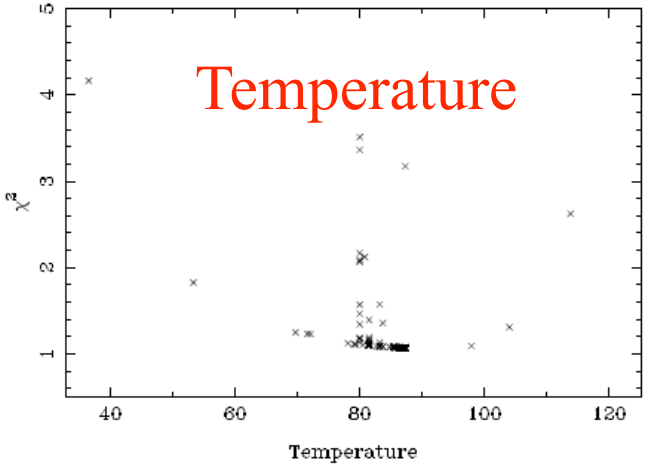


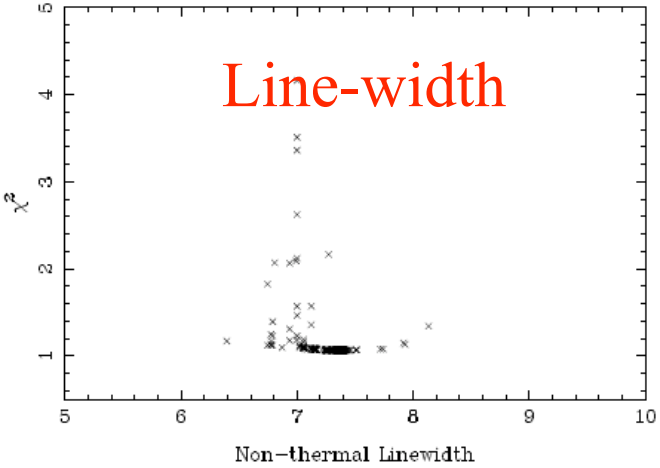


Obtaining Gas Parameters from NH_3





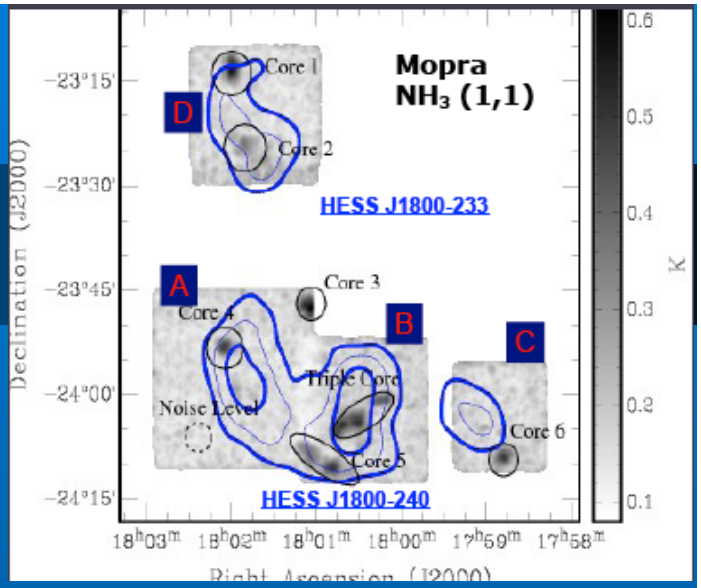


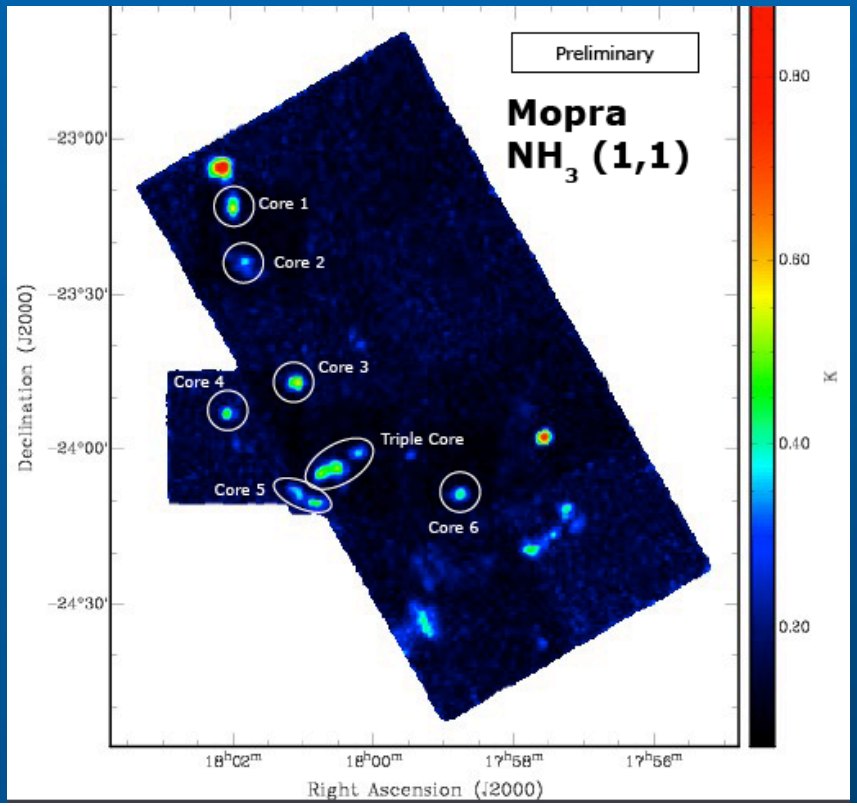


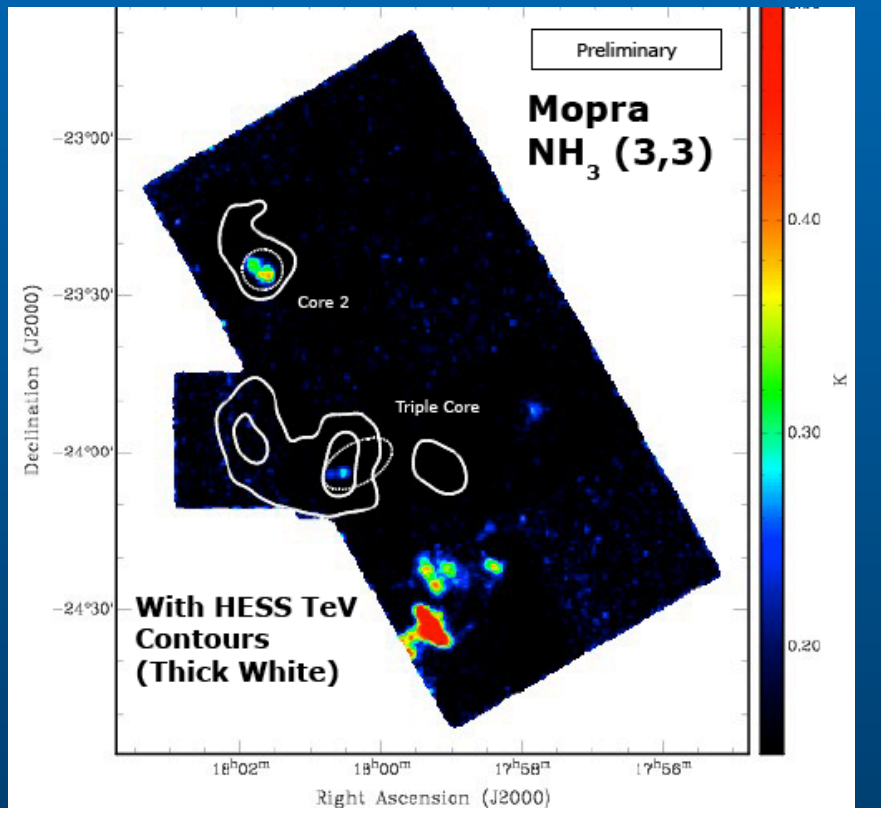
Nicholas, Rowell et al: W28 Mopra Program

γ-rays, SNRs & MSF

Big Dish wins for the high-J lines







Comparing the Dishes

Telescope	D	FWHM @ 12.7mm	Tsys	Ap. Eff	Gain	Bandwidth	Point Source Line	Extended Source Line
	m	arcmin	K		K/Jy	MHz		
Mopra	22	2.4	**70**	0.6	0.08	8,000	1.00	1.00
Parkes	55	1.0	60	0.5	0.43	**1,000**	0.16	0.86
Tidbinbilla	70	0.7	40	0.5	0.70	**280**	0.07	0.57

Primary Lines

Species	Transition	Frequency
NH_3	(1,1)	23.694
	(2,2)	23.722
	(3,3)	23.870
	(4,4)	24.139
	(5,5)	24.533
	(6,6)	25.056
	(9,9)	27.477

1 GHz

2 GHz

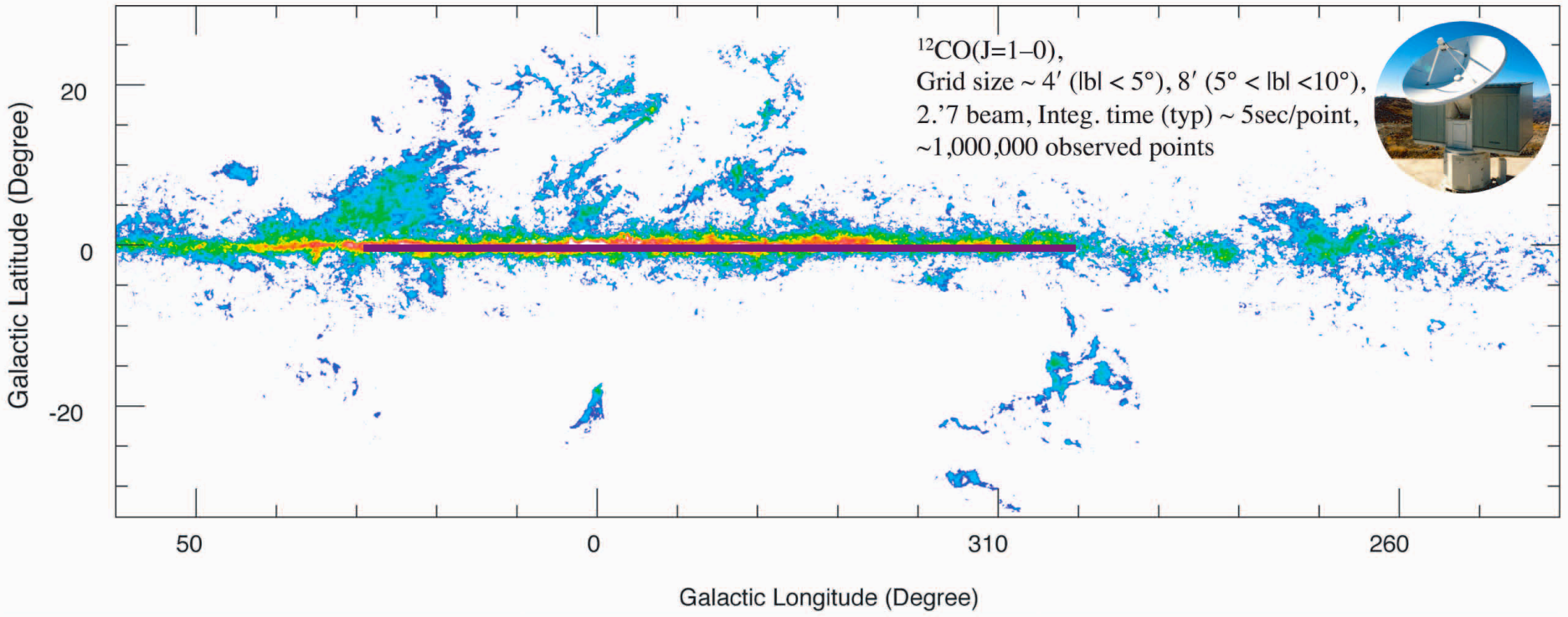
Secondary Lines

Species	Transition	Frequency
H_2O	Maser	22.235
HC_3N	3-2	27.294
H	69α	19.591
	68α	20.462
	67α	21.385
	66α	22.364
	65α	23.404
	64α	24.509
	63α	25.686
	62α	25.686

8 GHz

Wide Bandpass + Zoom Modes required

Focal Plane Arrays for Southern Sky Surveys



HOPS took ~20 weeks to map 100°x1° with 2.5 arcmin beam

An even bigger project with a smaller beam!

A Science Program

- **The Dense, Cold Molecular Medium of the Galaxy: characterising the environment where star formation occurs**
  - **(*n, T, V, N*) through Ammonia Lines**
  - **Big Dishes bring the sensitivity needed for higher-J lines plus the spatial resolution**
- **Ancillary investigations for free:**
  - **Water Masers, Organic Cores (HC_3N)**
  - **HII regions across the galaxy**

The Needs

- **Wide-band pass spectrometer with Zoom Modes**
  - **1 or 2 GHz: NH_3 Only**
  - **8 GHz: the lot!**
  - **Be sure we're getting the best T_{sys} the sites offer**
- **Large Area of Sky:**
  - **No multibeam: zoom into HOPS-peaks**
  - **With a 12m multibeam: "Super-HOPS"**
- **The Telescope**
  - **Parkes good, Tid better if can be equipped**
  - **Australian-led survey with our National Facilities**
    - ***Our contribution to ALMA science participation***
  - **Consider 10% dedicated usage of Tid?**
    - **Single observing mode**

The End