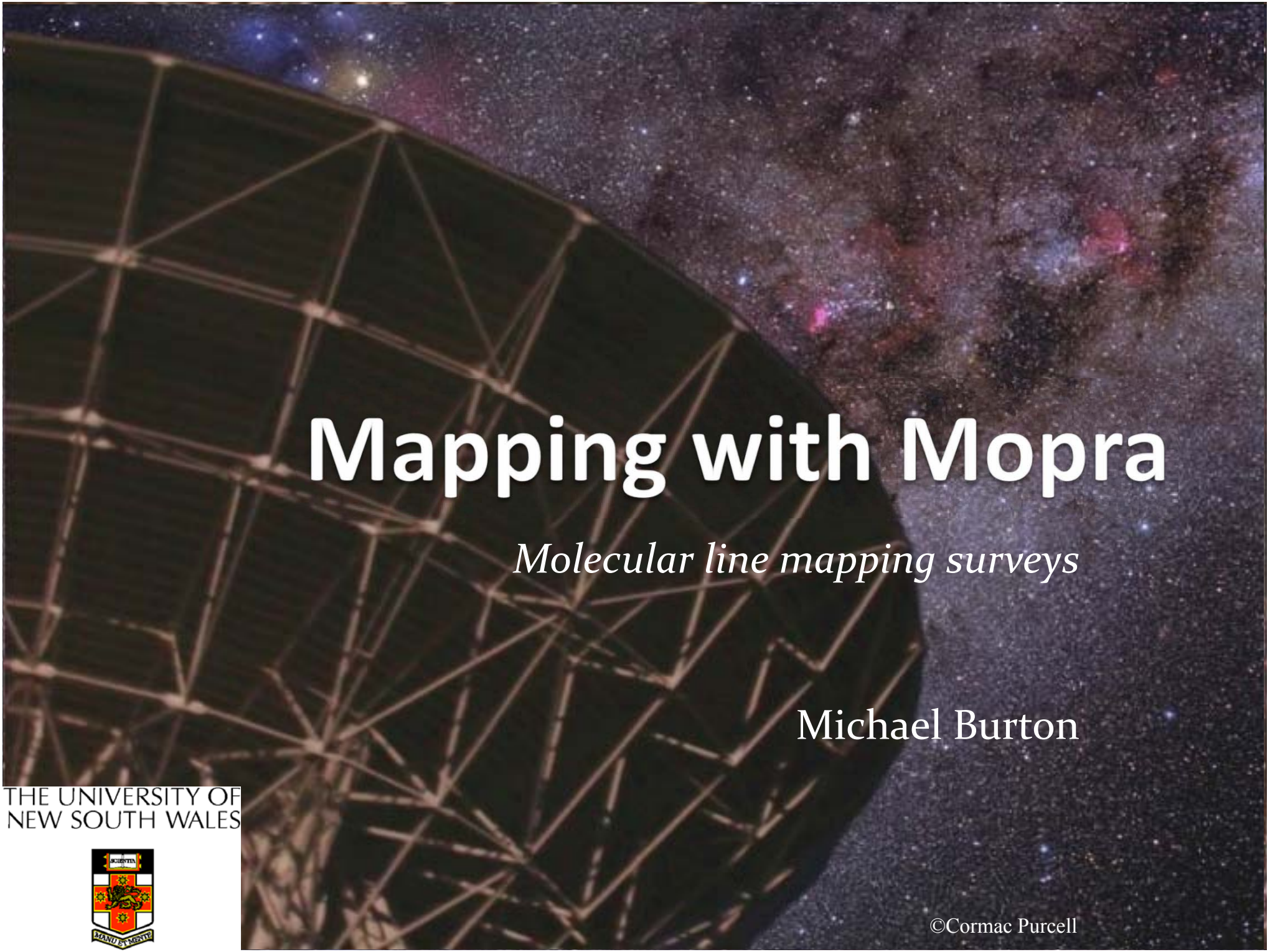


Mapping with Mopra

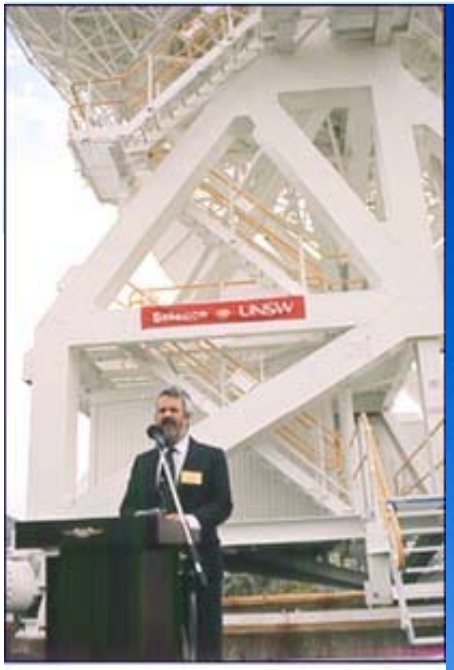
Molecular line mapping surveys

Michael Burton

THE UNIVERSITY OF NEW SOUTH WALES

Mopra Radio Telescope

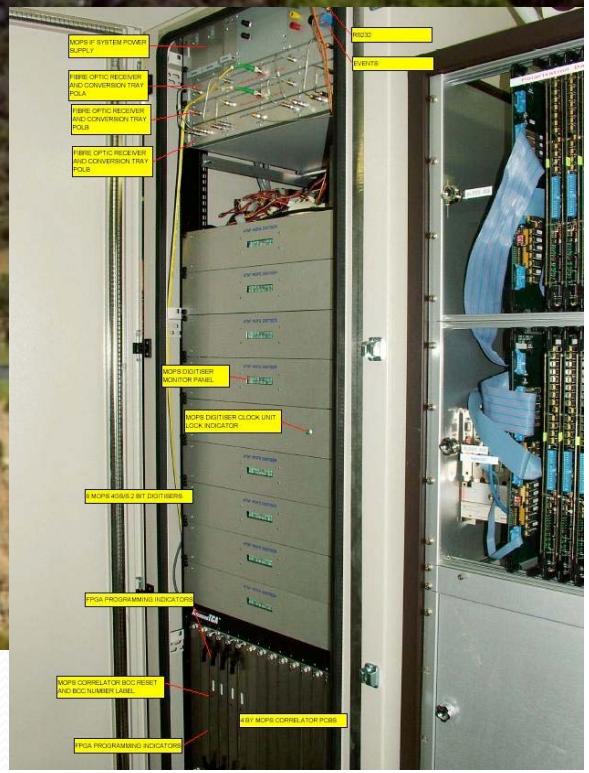
OTF Mapping with 22m dish



SEEKING THE BIRTHPLACE OF THE STARS

MMICs using HEMT devices

UNSW-MOPS 8 GHz DFB

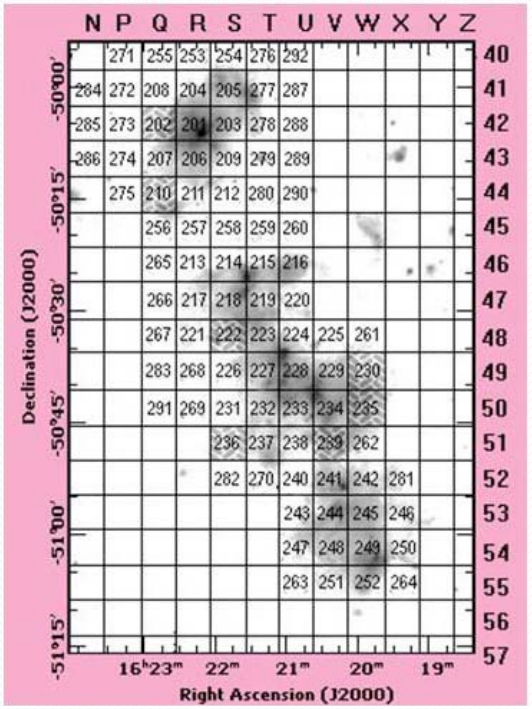


Some Mopra Millimetre History

- 1994 Commissioned with 3mm SIS receiver
  - 85-115 GHz, 64 MHz, 1024 channels, dual-polarization
    - Graeme Carrad, John Whiteoak, Robina Otrupcek
  - 15m solid surface + 7m mesh surface
    - *Single frequency, manual tuning*
- 1997 MNRF-I: funded the mm-upgrade
- 1999-2004 UNSW: 22m extension + "Friend of the Telescope"
  - Series of small but important upgrades
    - Software, ACC, Telescope characterisation, OTF-mapping, Livedata + Gridzilla
    - MM-wave workshops
    - Tony Wong + Ned Ladd + Ramesh Balasubramanyam + Cormac Purcell + Mark Calabreta
- 2006 MMIC receiver, 77-117 GHz
- 2006 UNSW–MOPS 8 GHz DFB, with 16 x 137 MHz x 4096 channel zoom modes
    - ARC-funded with UNSW, Sydney, Monash, CSIRO
    - Dick Ferris, Warrick Wilson
- 2007 MMIC receiver 18-28 GHz
  - Narrabri operation
- 2008 MMIC receiver 30-50 GHz
  - Remote operation

Four illustrative mapping projects

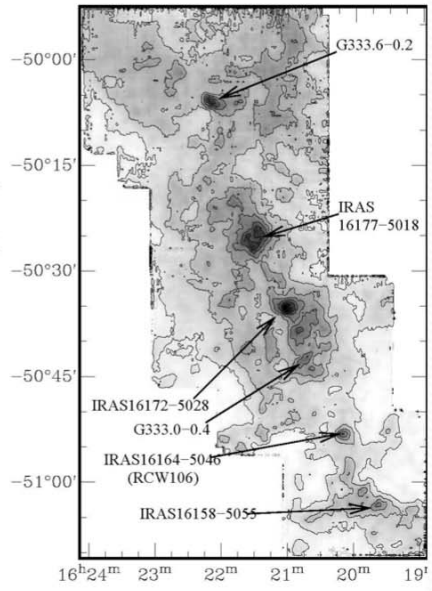
- DQS
  - Multiple-molecular line mapping at 3mm
  - Zoom-mode, 35”, 1°
- CMZ
  - Multiple-molecular line mapping at 3mm
  - Broad-band, 35”, 3°x1°
- HOPS
  - Multiple-molecular line mapping at 12mm
  - Zoom-mode, 2.5’, 90°x1°
- MAGMA
  - Single-line molecular mapping at 3mm
  - Sampler over ~6°x6°

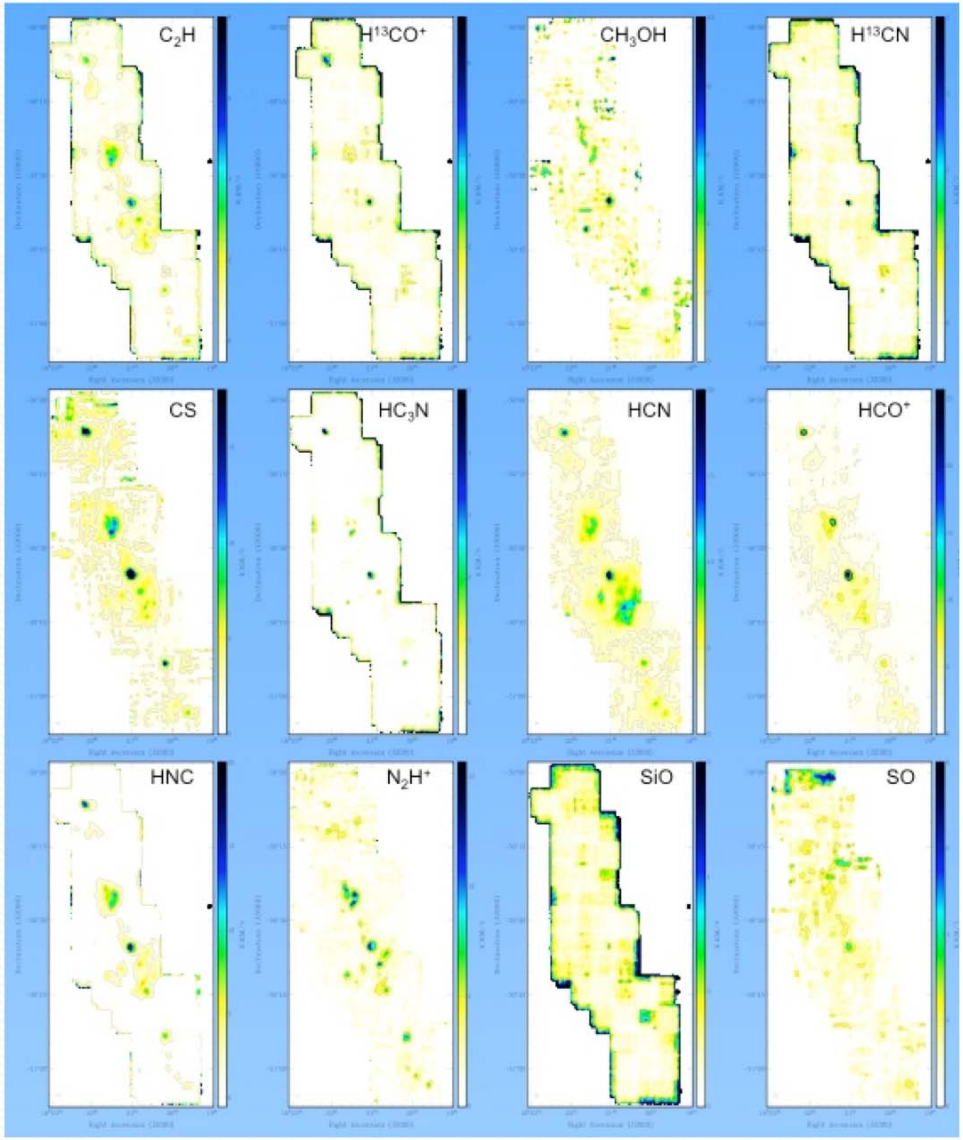


Mapping Projects I: The DQS

Maria Cunningham, Indra Bains, Tony Wong, Nadia Lo

- 1□° multi-molecular line mapping at 3mm
- 35” + 0.1 km/s
  - Zoom-mode
- GMC-complex

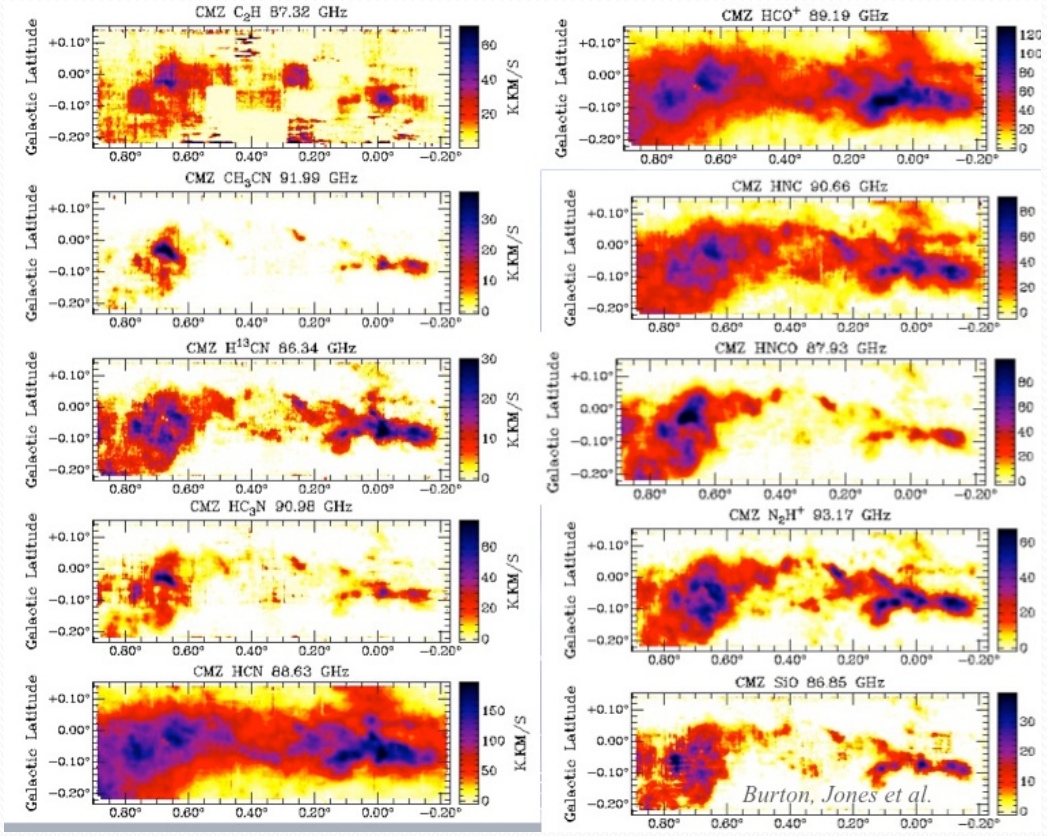




Mapping Projects II: The CMZ

Michael Burton, Paul Jones

- 17 lines over 8 GHz band (85-93 GHz)
- 35" resn + 1 km/s
  - Broad-band
- Inner 3° of the Galaxy
- 3 seasons (@3 wks)

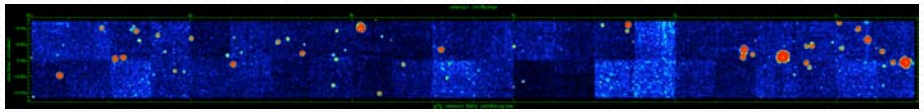


Mapping Projects III: HOPS

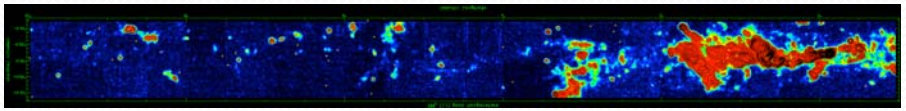
Andrew Walsh

- ~12 lines at 12 mm
- Zoom mode
- 2.5' beam, 0.5 km/s
- 90°x1°
- 3 seasons (@ 6 wks)
- Summer observing!
- Galactic Plane

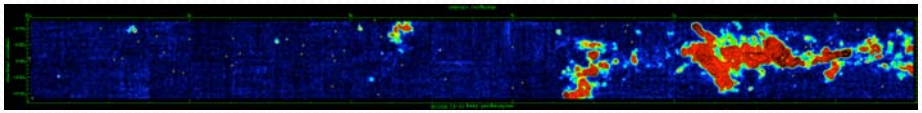
H_2O Masers



NH_3 (1,1)



HC_3N

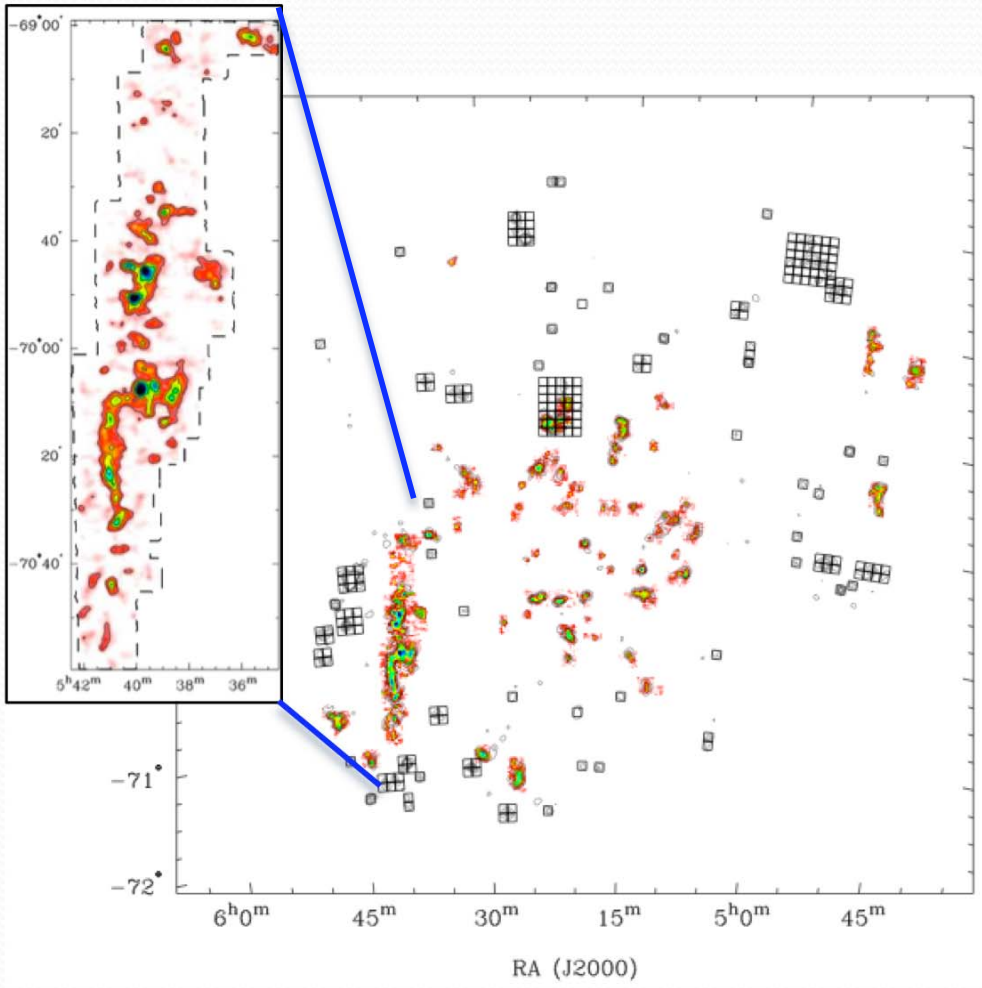


10° x 1°

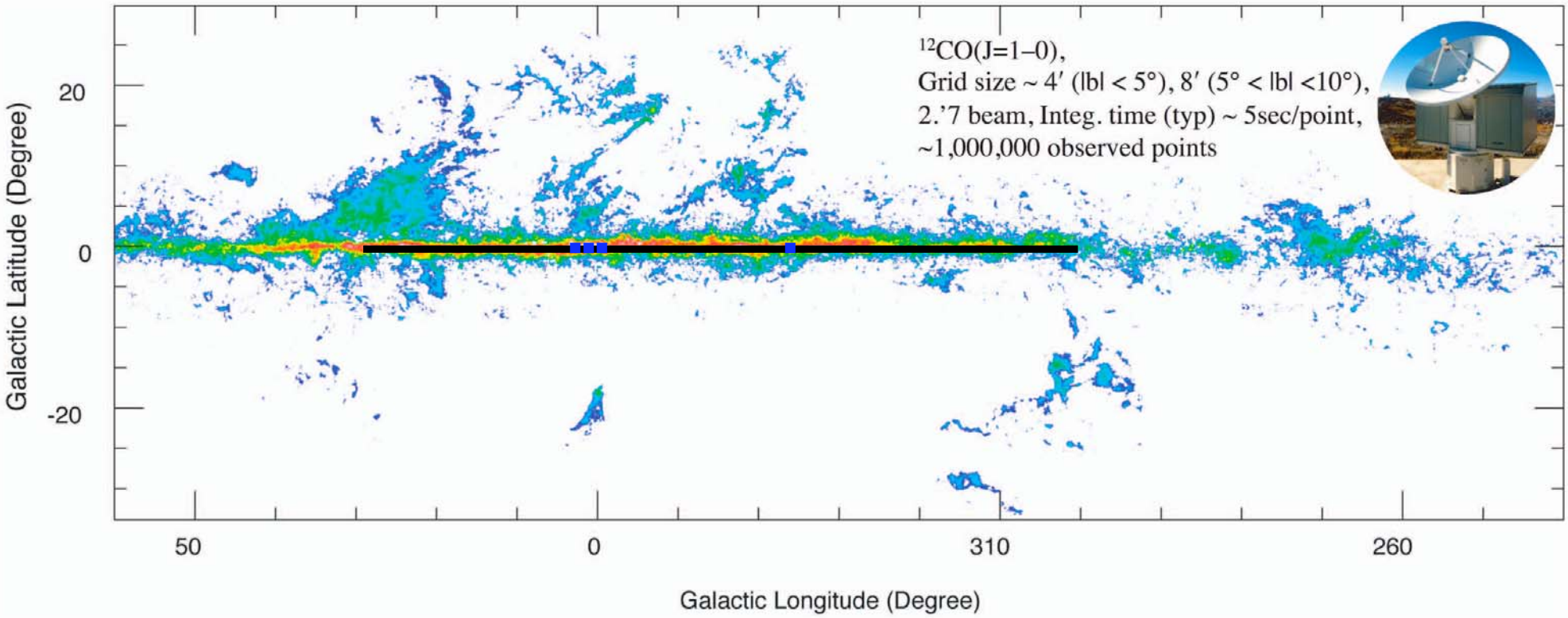
Mapping Projects IV: MAGMA

Tony Wong, Erik Muller, Annie Hughes

- Single-line mapping
- Zoomed-resolution, sampled over ~6°x6°
  - 2.6' ➔ 45"
- 0.1 km/s
- 3 seasons (@6 wks)
  - Opposite the Galaxy



Placing Mopra Sky Surveys in Context



What could Mopra do?

1. *Multiple molecular line mapping at 3 mm*
   - ~0.9□° in ~10 lines in ~1 month with 35" beam
     - esp. 85-93 GHz, at 0.1 – 1 km/s resolution
   - Individual GMC-complex investigations (c.f. DQS)
   - Zoomed-spatial resolution investigations
     - Milky Way sampler, CHAMP
2. *Multiple molecular line mapping at 12 mm*
   - ~20□° in ~5 lines in ~1 month with 2.5' beam
     - 0.5 – 5 km/s resolution
   - Summer time!
   - HOPS, TeV

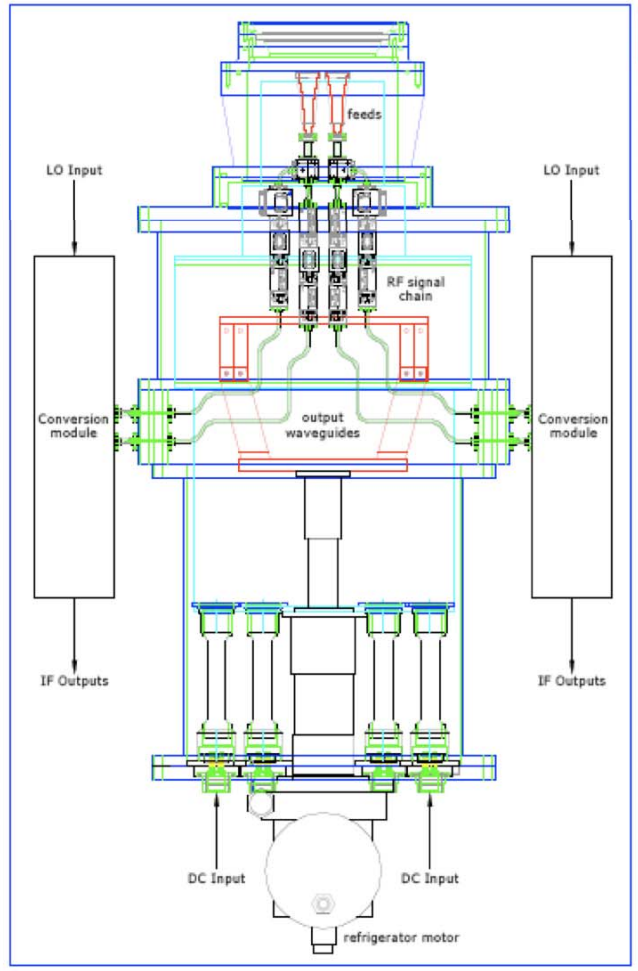
12 hrs/night, Observing efficiency 0.7, 2 scan directions, 1hr per grid

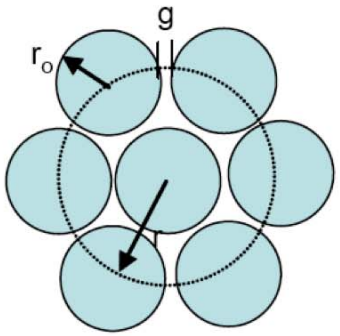
More of what Mopra could do

3. *Multiple molecular line mapping at 7 mm*
   - ~4□° in ~5 lines in ~1 month with 75" beam
   - 0.2 – 2 km/s resolution for SiO, CH_3OH-I, CS, HC_3N, HC_5N…
   - Summer time?
     - CMZ
     - Complete methanol maser studies (early MSF)
4. *"Fast-Mapping" for CO*
   - Cycle time from 2s to 0.2s
   - ~8□° in 3(?) Zoom bands (^{12}CO, ^{13}CO, $C^{18}O$) in ~1 month with 35" beam, 0.1 km/s resolution
   - STO, GRS-south
   - <u>Needs to be evaluated!</u>
5. *"Fast-scanning"*
   - Cycle time unchanged but scan larger area within it
   - Effectively mapping with a larger beam
     - e.g. 2.5' beam as per HOPS, ~20□° in ~1 month
     - Any line within the band with same sensitivity but over the larger beam
   - HOPS-CO, STO

A Mopra Multibeam?

- 4-element, 2-poln, 2-GHz system quite feasible
- But cost beyond ARC LIEF and not really sufficient for the science needs
- A 7-element, 8-GHz system will be expensive!
- International collaborators.....





A 6-element multibeam?!

- Use the 6 ATCA dishes independently!
  - Extend Antenna 6 surface to 22m
  - Extend 3mm receivers to 117 GHz (new LO?)
    - ARC LIEF-scale project
  - Need cycle time lowered to 2s
    - Could map 1°x1° at 3 mm in ~1 week with 35" resn.
  - If cycle time could be decreased to 0.2s ("fast-mapping")
    - Could map 1°x1° at 3 mm in ~1 day with 35" resn.
      - *CO in southern galactic plane in ~6 months*

The Way Forward

- Need driving science cases!
- Examine feasibility of “fast-mapping”
- Pilot needed for 3 mm “fast-mapping” & 7 mm summer
- Concurrent surveys:
  - Winter: 3 mm “fast” CO + Sampler + 1-GMC + LMC
  - Summer: 7 mm + 12 mm Galactic Plane
- Resources
  - Mopra science & operations support
  - Data pipelining
  - Science analysis
- *A full-galactic plane at 3 mm requires a 7-element multibeam or its equivalent*