GASKAP
the Galactic ASKAP spectral line survey

Paul Jones (UNSW)

John Dickey (U. Tas)
plus many more !

ASKAP

Australian Square Kilometre Array Pathfinder

- 36 x 12 m dishes
- 700 to 1800 MHz
- max 300 MHz bandwidth, max 16384 channels
- up to 6 km baselines (3 km core)
- field of view 30 square degrees, using focal plane arrays
- Murchison Western Australia

Survey Science Projects (> 1500 hours)

75 % of time in first 5 years (the rest shorter Guest Science Projects)

2008 Dec 15 - Expressions of Interest - 38 received

2009 Jun 15 - Survey Science Project proposals

(GASKAP combines Galactic and Magellanic System EoIs)

mid 2009 to late 2011 - Design Study phase - simulations, pipelines, testing

early 2012 - Survey Science Project scheduling

late 2012 - Science Operations start - reduced data comes out of pipelines

GASKAP team

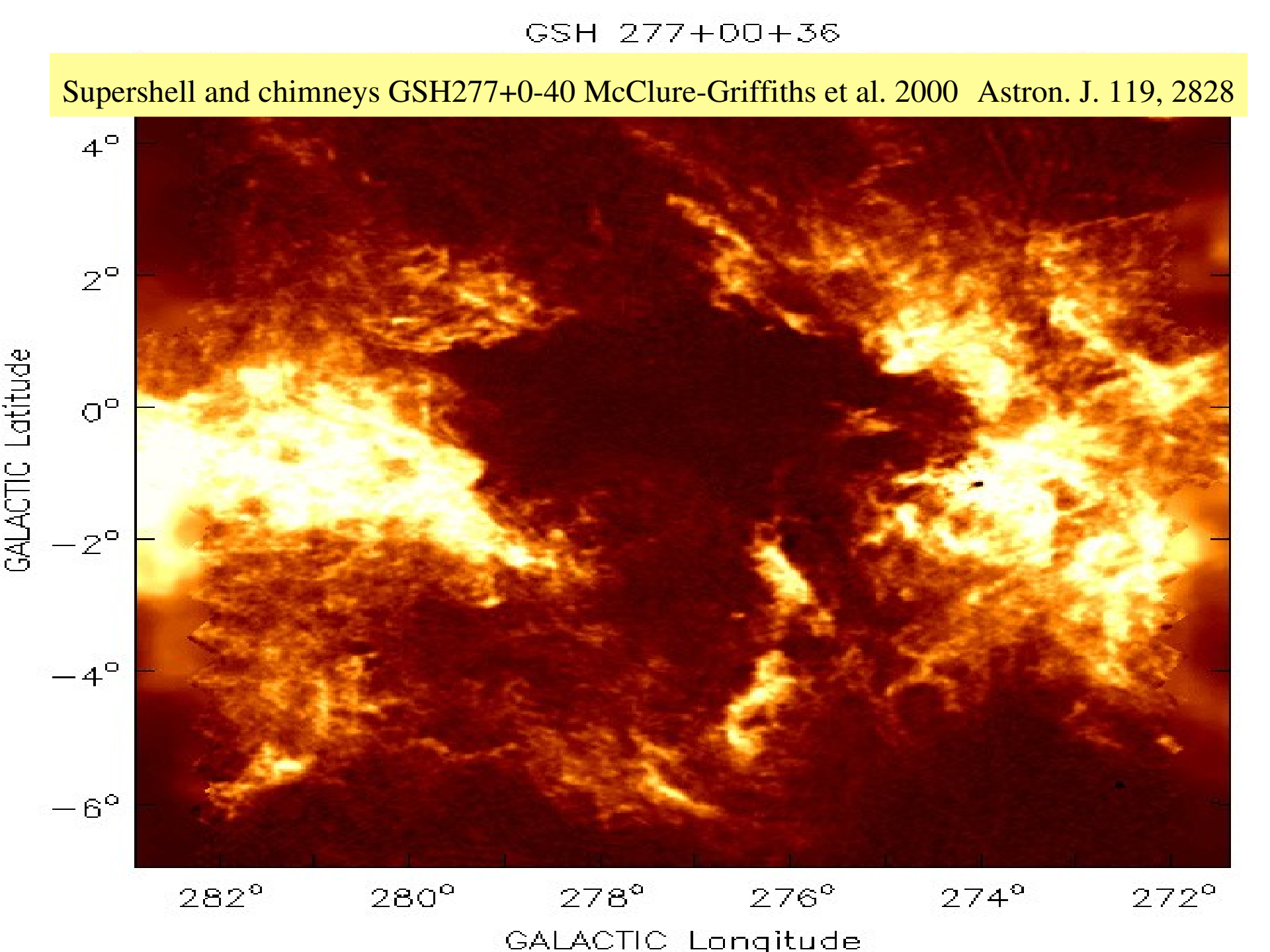
Coordinators - Steering Committee
(Principal Investigators of Expressions of Interest)

- Galactic Plane HI and diffuse OH:
  John Dickey (U. Tas), Steven Gibson (Western Kentucky U.)
- Magellanic Clouds, Bridge, and Stream:
  Snezana Stanimirovic (U. Wisc), Jacco van Loon (U. Keele)
- OH masers from evolved stars and high mass SF regions:
  Jose F. Gomez (Inst. Astron. Andalucia), Hiroshi Imai (U. Kagoshima)
- Recombination Lines from Galactic HII regions:
  Paul Jones (UNSW)
- Molecular Lines from dense molecular clouds regions (and OH 1720):
  Paul Jones (UNSW)

Plus around 70 **Co-Investigators**

GASKAP is a survey of emission and absorption at 21-cm (the HI line) and maser emission, diffuse emission, and absorption in the 18-cm lines of OH. It is an order of magnitude deeper than any survey at comparable resolution (IGPS), and it covers an order of magnitude more area at low latitudes than any survey at comparable sensitivity (GALFA).

The objective is to get **ground truth on the astrophysics of galaxy evolution** by determining in the Milky Way how processes of accretion and outflow of gas are driven by star formation in the disk, and to get the **context of star formation** through mapping structures in the warm neutral interstellar medium, the cool neutral medium, and the molecular clouds, and to study the **old stellar population of the bulge and halo** using OH masers.


GSH 277+00+36
Supershell and chimneys GSH277+0-40 McClure-Griffiths et al. 2000 Astron. J. 119, 2828
4°
2°
0°
−2°
−4°
−6°
GALACTIC Latitude
282°
280°
278°
276°
274°
272°
GALACTIC Longitude

Some specific questions GASKAP will answer:

- What is the structure and dynamics of the gas in the Magellanic Clouds?

GASKAP goes more than an order of magnitude deeper than any cm-wave survey ever done on the LMC and SMC.

- How does the ambient gas in the outer halo influence the Magellanic Stream and other gas accretion flows ?

GASKAP will study the multi-phase medium of the Stream, phase transitions due to thermal instabilities and likely also dynamical instabilities due to shock cascades and halo gas ram pressure.

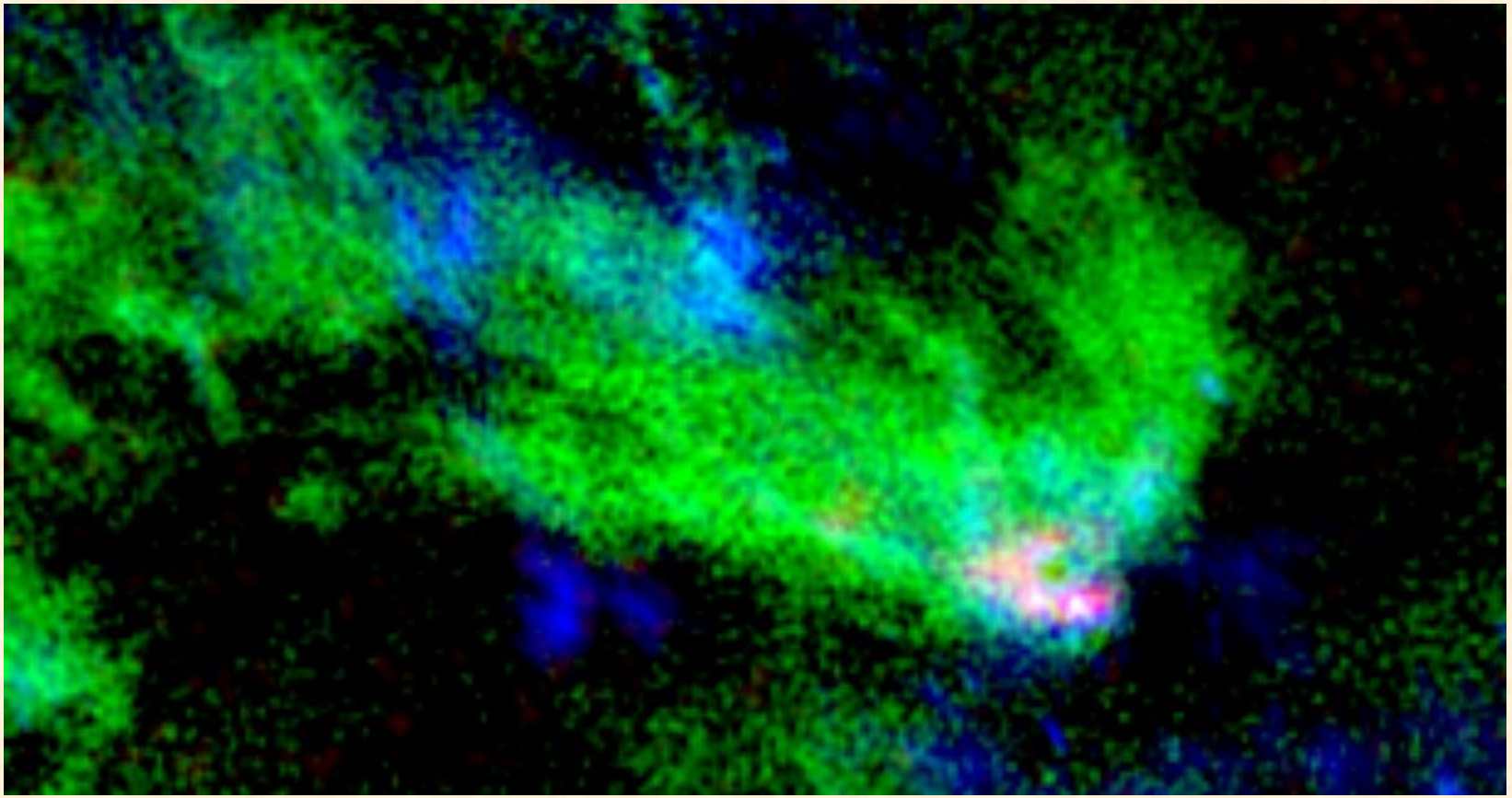
- Where, how, and how much does the Galactic Fountain drive gas from the disk into the halo?

GASKAP will show how the old superbubbles connect the hot gas in the disk with the halo, and how their shells are ablating and evaporating the cool interstellar clouds.

- How does the cool phase of the ISM stay in equilibrium with the warm medium even in low pressure environments?

GASKAP will be the first survey to sample HI and OH absorption on many thousands of lines of sight at low Galactic latitudes.

From the CGPS - an ablating molecular cloud with atomic tails.



“The Dragon’s Breath” Knee et al. 2005 Ap. J. 628, 758.

Other points more relevant to molecular medium

- How do molecular clouds form out of cool and cold atomic clouds ?

GASKAP will show HI self-absorption and diffuse OH emission that are better tracers of cold atomic and molecular gas in low density clouds than CO or other mm-wave lines.

- Where are stars forming now, and where did they form in the distant past ?

GASKAP will discover thousands of OH masers from AGB and post-AGB stars, and hundreds of masers in high mass star formation regions. It will trace the flow of gas in evolved stars. It will also trace HII regions through their recombination lines.

Radio Recombination Lines

GASKAP is largely driven by HI and OH (as are the extragalactic line Survey Science Projects).

My interest in molecular lines and star formation led me to put forward two Expressions of Interest for the other lines in the ASKAP band, the radio recombination lines (RRLs) and the molecular lines.

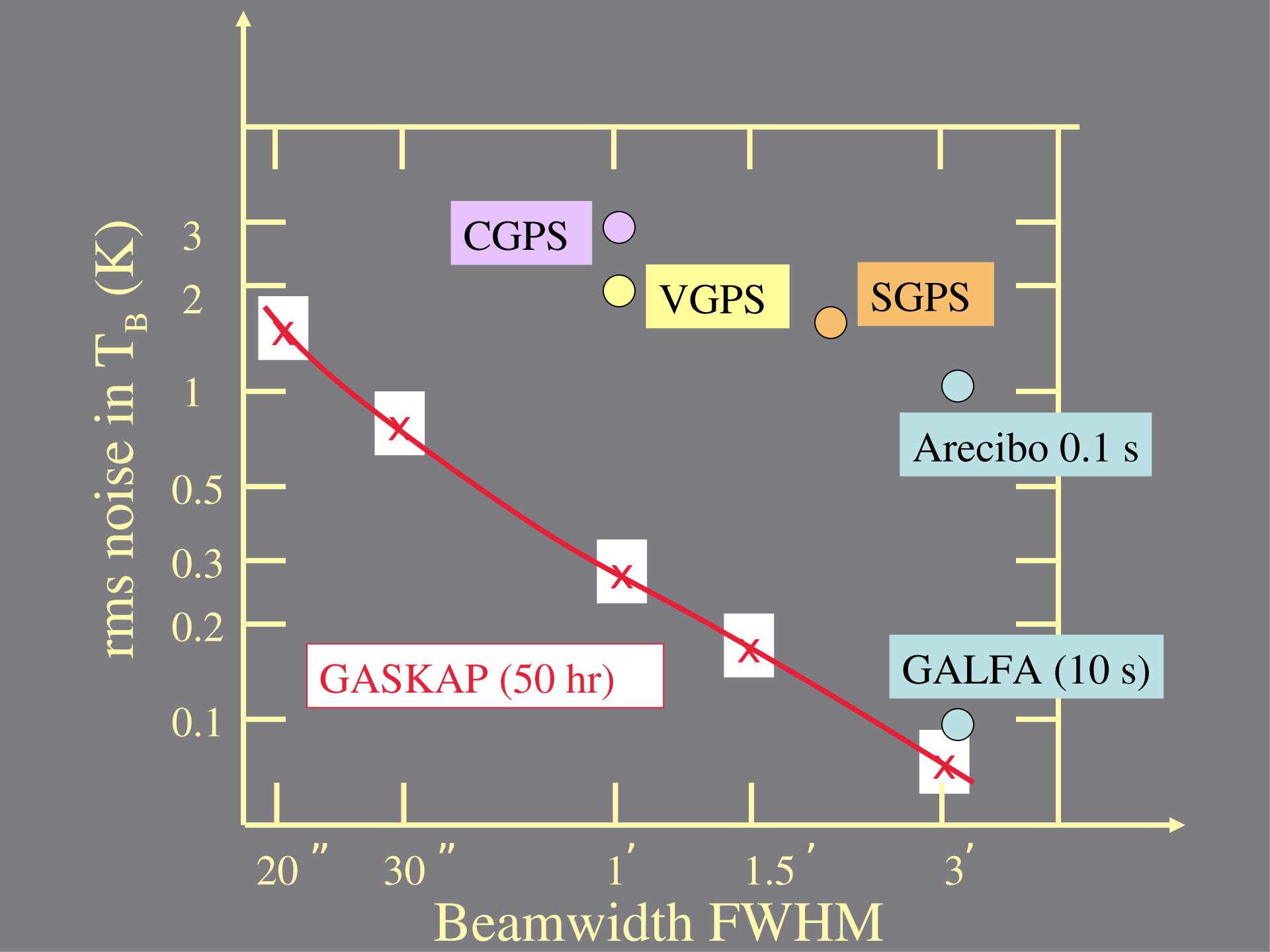
The current GASKAP plan includes (as a small part) covering the area $|l| < 60$ deg., $|b| < 2.25$ deg., with the different tuning 1480 to 1780 MHz, to study the radio recombination lines H α 155 to H α 163 from H II regions in the inner Galaxy (ie most of the active SF area).
This maps out the star formation in 3-D, gives electron temperatures, and He abundance (for the brightest H II regions).

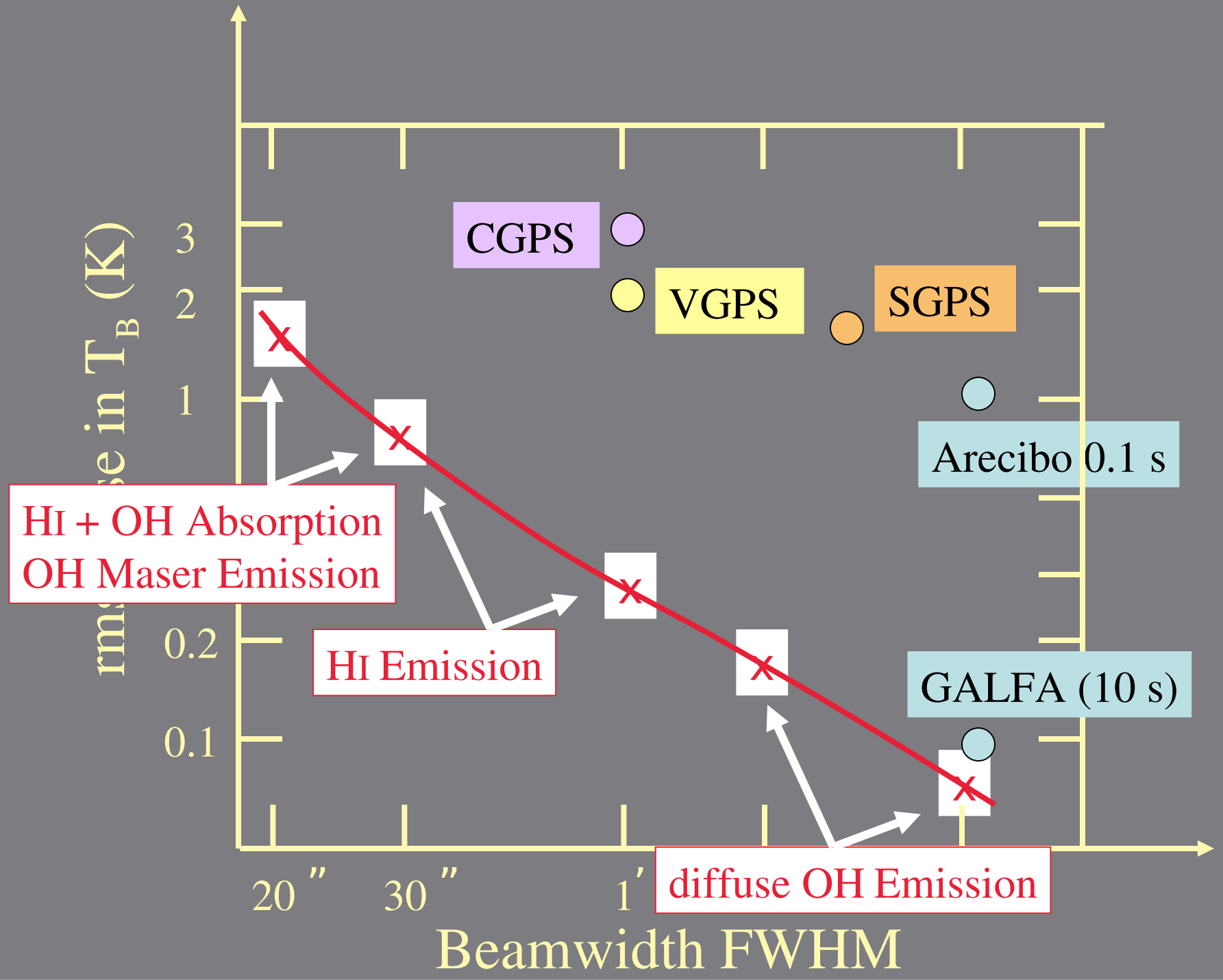
This tuning also allows the 1720 MHz OH line to be included, for e.g. masers associated with supernova remnants.

Molecular Lines

Low energy transitions of a number of complex molecules are known in the ASKAP band, including methanol (CH_3OH, 834 MHz), acetaldehyde (CH_3CHO, 1065 MHz), formamide (NH_2CHO, 1539 MHz), methyl formate (CH_3OCHO, 1610 MHz) and formic acid (HCOOH, 1638 MHz). These transitions have non-thermal excitation, associated with strong continuum eg in Sgr B2.

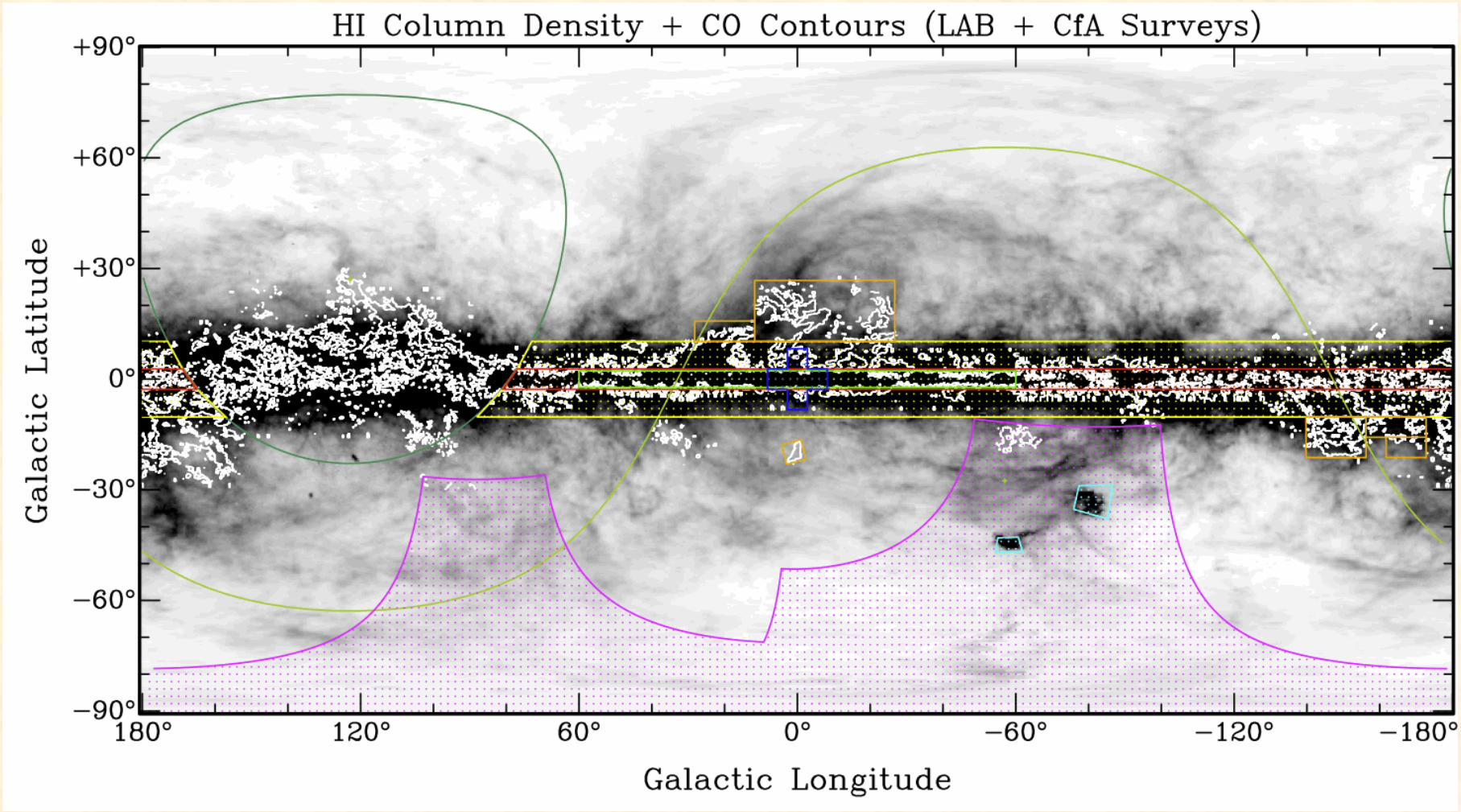
I am proposing with ASKAP
a) a line survey of the Central Molecular Zone over the full ASKAP band (sensitive array, in a radio quiet site) and
b) mapping the molecular lines (such as the 1539 MHz formamide lines) in the area and tuning used for the RRLs


rms noise in T_B (K)
3
2
1
0.5
0.3
0.2
0.1
CGPS
VGPS
SGPS
Arecibo 0.1 s
GASKAP (50 hr)
GALFA (10 s)
20″
30″
1′
1.5′
3′
Beamwidth FWHM


rms Noise in T_B (K)
3
2
1
0.2
0.1
CGPS
VGPS
SGPS
Arecibo 0.1 s
GALFA (10 s)
HI + OH Absorption
OH Maser Emission
HI Emission
diffuse OH Emission
20 ″
30 ″
1 ′
Beamwidth FWHM

GASKAP straw-man survey parameters

Frequency Coverage 1416.4-1424.4 MHz (HI line |v| < 840 km/s), 1610-1614 MHz, 1662-1670 MHz (OH lines) all with resolution 1.16 kHz = 0.25 km/s observed simultaneously



Conclusions:

- GASKAP will go an order of magnitude or more in sensitivity and/or resolution beyond any existing survey of the HI and OH emission and absorption in the Milky Way and Magellanic Clouds and Stream.

- GASKAP and Mopra surveys complement each other in the links between the different phases of the ISM and star formation.

- Possible lessons for future of ATNF survey modes, operations and project management.