

The Mopra Southern Galactic Plane CO Survey: why the CTA needs it!

PASA (*Publications of the Astronomical Society of Australia*),
2013, 30, e044 (Burton et al.) + 2015, 32, e020 (Braiding et al.)

www.phys.unsw.edu.au/mopraco

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plus many, many collaborators.....

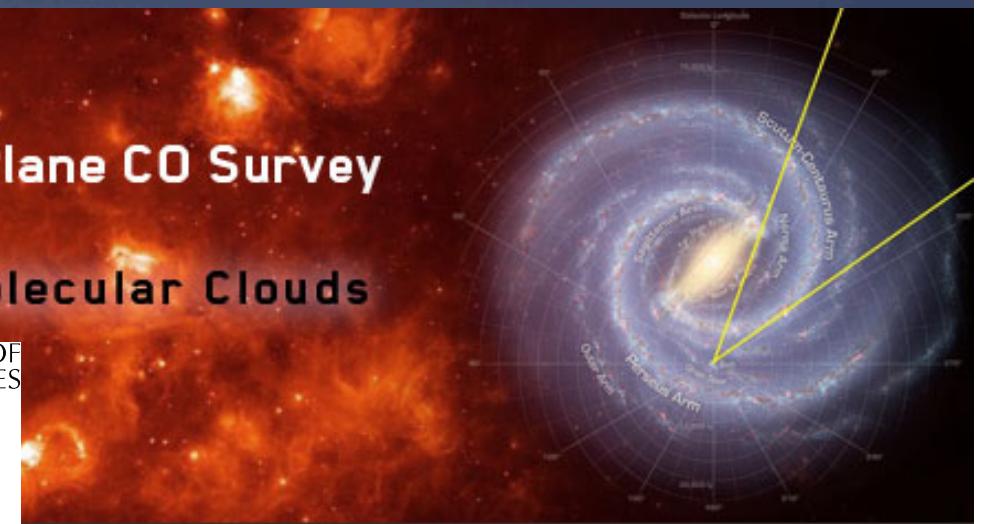


mopra.org

The Mopra Galactic Plane CO Survey

The Formation of Molecular Clouds

THE UNIVERSITY OF
NEW SOUTH WALES



Outline

1. Molecules and TeV Gamma-rays

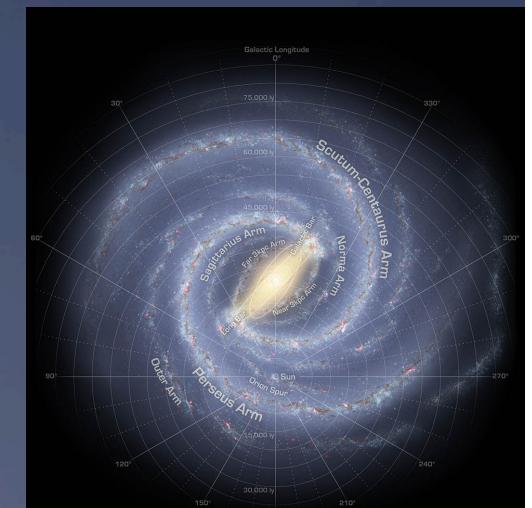
- What's the connection?!
- The greatest column density of nuclei for cosmic-ray interactions

2. Radio telescopes and the interstellar gas

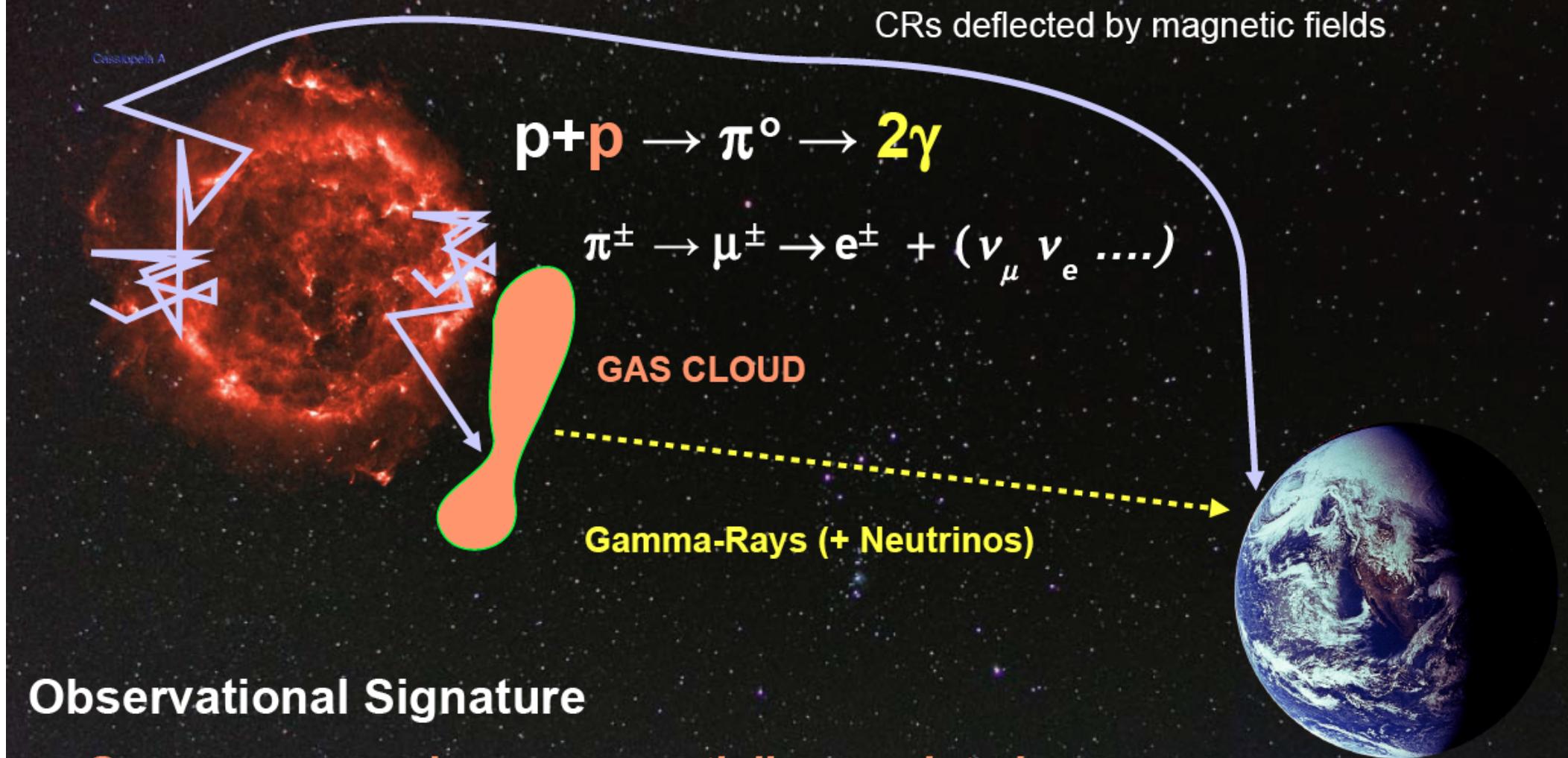
- **Mopra** + Nanten2 + HEAT + Parkes + ATCA + ASKAP + STO2 +

3. The Mopra Southern Galactic Plane CO Survey

- $100^\circ \times 2^\circ$ across the 4th Quadrant of the Galaxy
- 0.6 arcmin, 0.1 km/s, 3 isotopologues
- Resolution commensurate with CTA's needs



Gamma Rays from multi-TeV Cosmic-Rays (p, He ...etc)

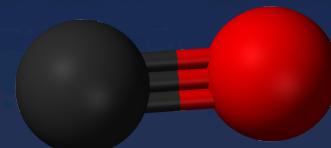
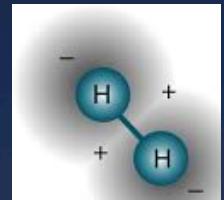


Observational Signature

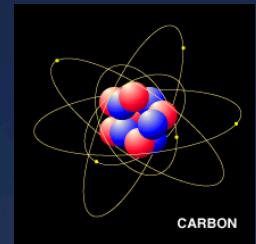
- Gamma-rays and gas are *spatially correlated*
- Intimate connection with mm- radio astronomy (tracing gas)

.....we expect gamma-ray flux $F_\gamma \sim k_{\text{CR}} M_{\text{gas}}$

H



Dark Gas \rightarrow C



1.2m Columbia
New York + Chile
Dame et al 2001.
CO J=1-0 2.6mm



60cm HEAT
Ridge A, Antarctica
[CI] : THz

Parkes + ATCA
SGPS – **HI 21cm**
McClure-Griffiths et al. 2005



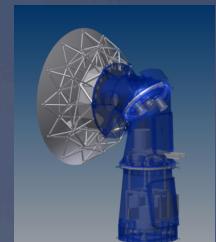
GASKAP
Dickey et al. 2013



4m Nanten2 (Nagoya)



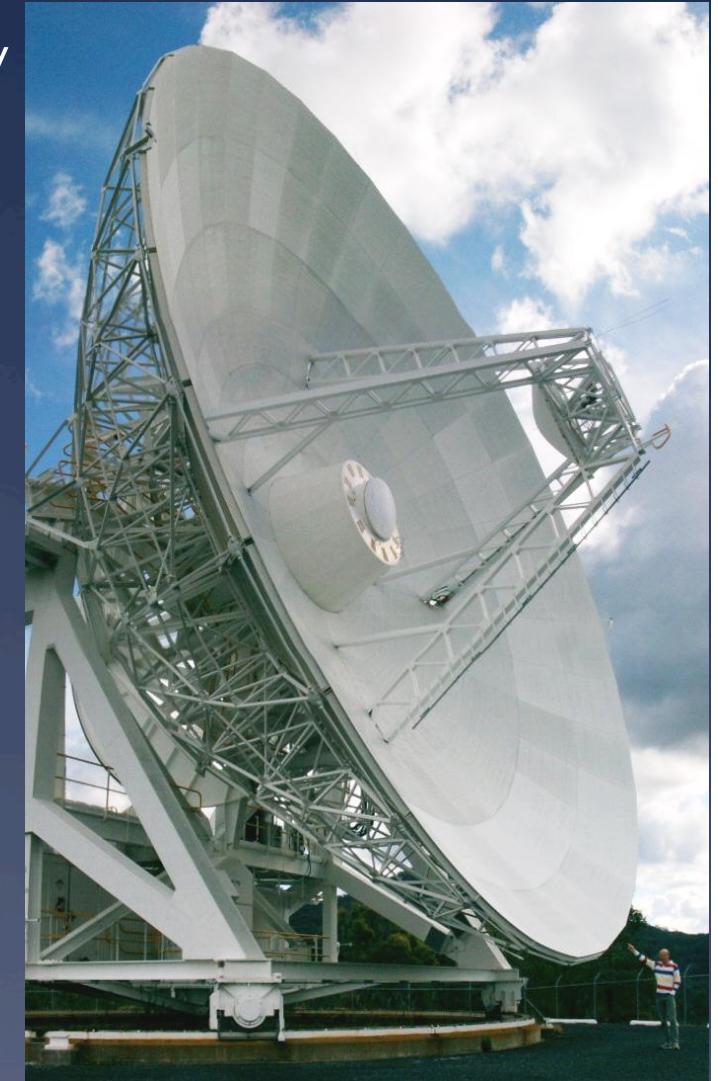
60cm STO-2

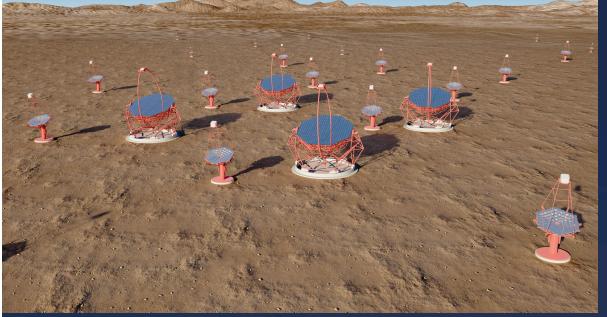


5m DATE5

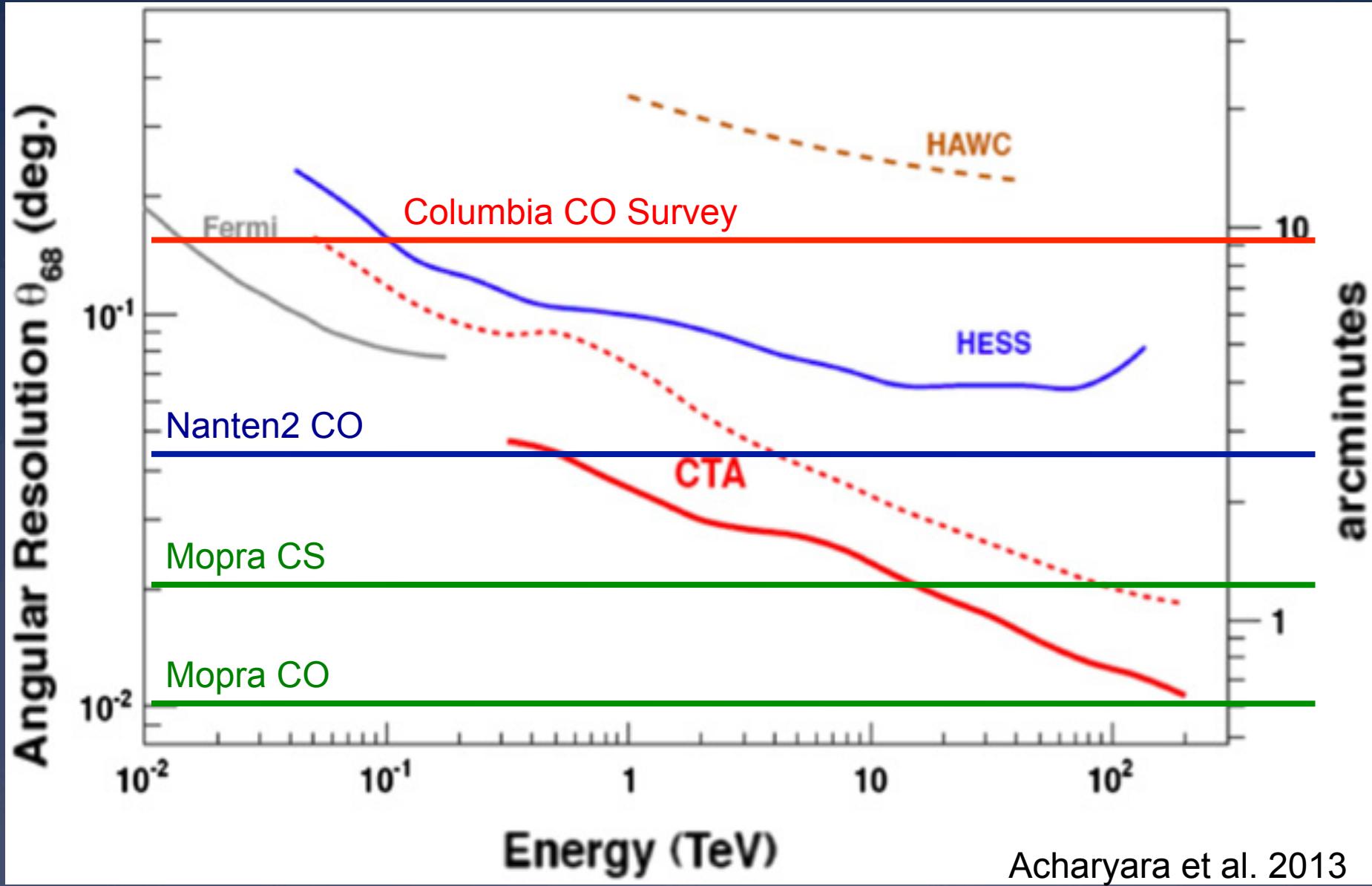
Mopra Telescope: Millimetre-Wave Capabilities

- * 22-m Telescope for long-wave mm astronomy
 - Receiver 3mm + 7mm + 12mm
- * Bandwidth 8 GHz: UNSW-MOPS correlator
 - Broad Band 32,000 channels, 0.8 km/s resn.
 - 16 Zooms modes over 137 MHz
4096 channels/zoom, 0.1 km/s@3mm
- * “Fast-On-the-Fly” (FOTF) Mapping
- * User-pays operation:
 - UNSW/Adelaide + NAOJ 3-year contract
 - 2013-2015 (Just finished)
 - What now???
 - Crowdfunding campaign





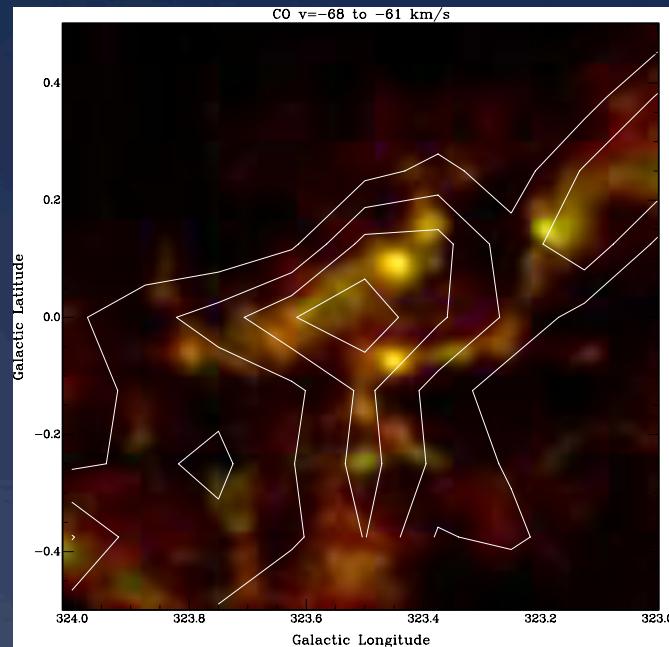
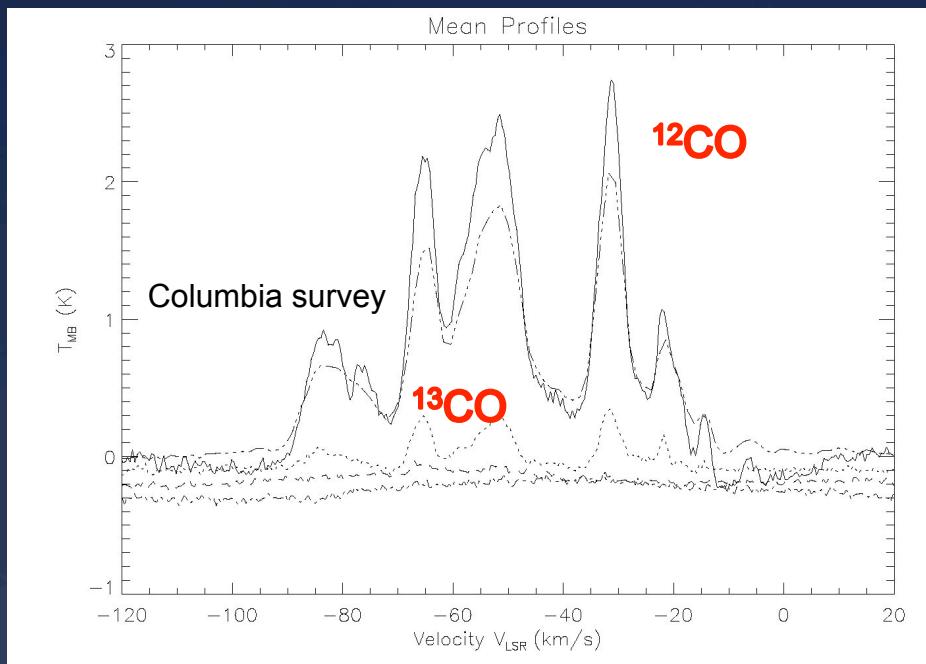
CTA's need for better angular resolution in the ISM



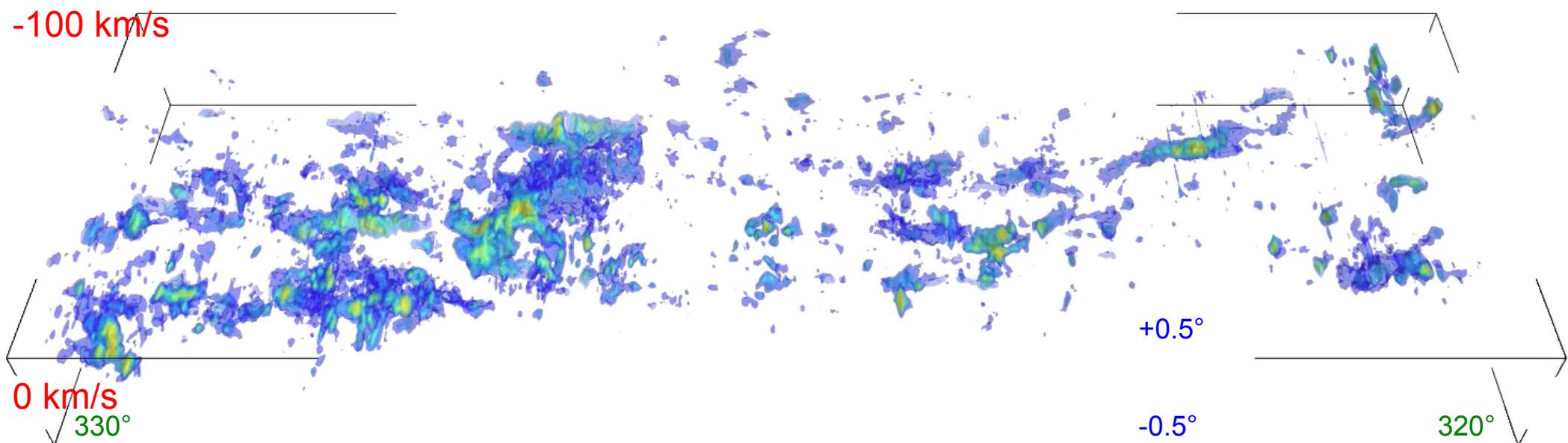
Sample Results

Mean ^{12}CO & ^{13}CO line profiles in G323

^{12}CO & ^{13}CO images + Columbia survey contours



G320-330 ^{12}CO Rendering: *longitude-latitude-velocity*

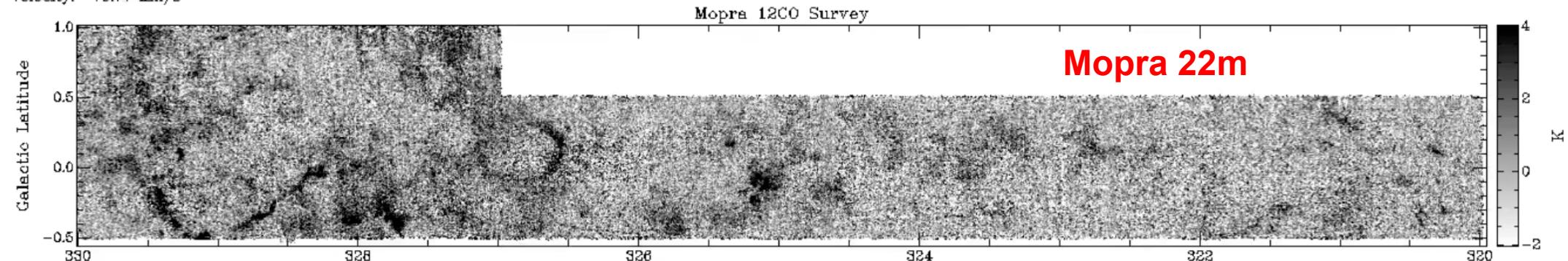


^{12}CO : Mopra vs. Columbia

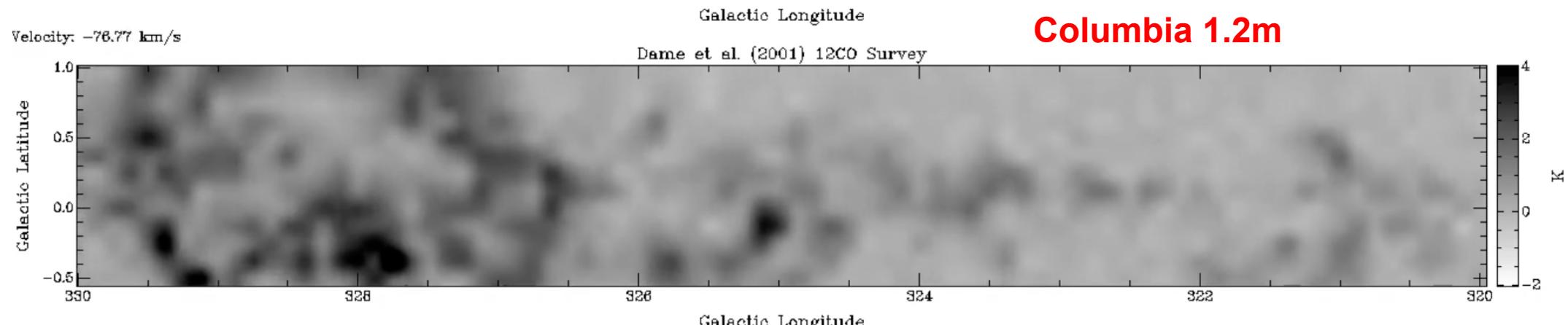
Resolution Gain:

0.6 vs. 9 arcmin and 0.1 vs. 1 km/s

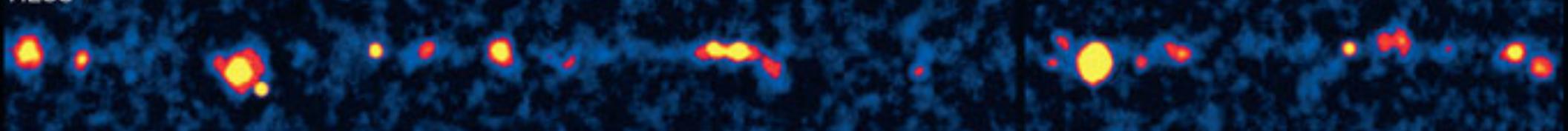
Velocity: -76.77 km/s



Velocity: -76.77 km/s



HESS

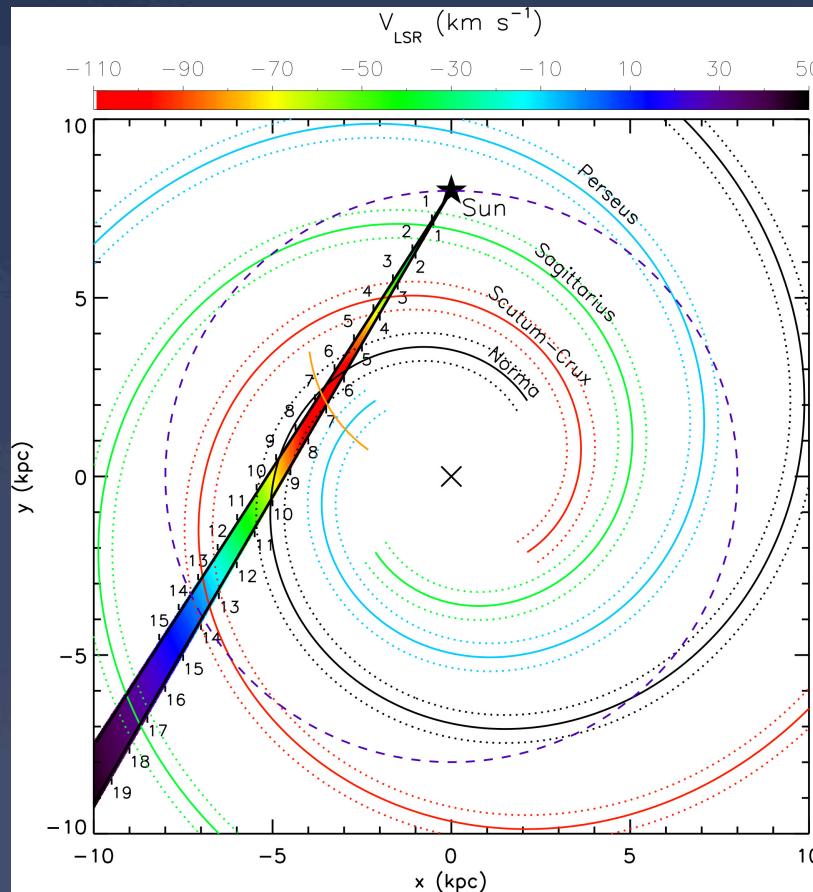
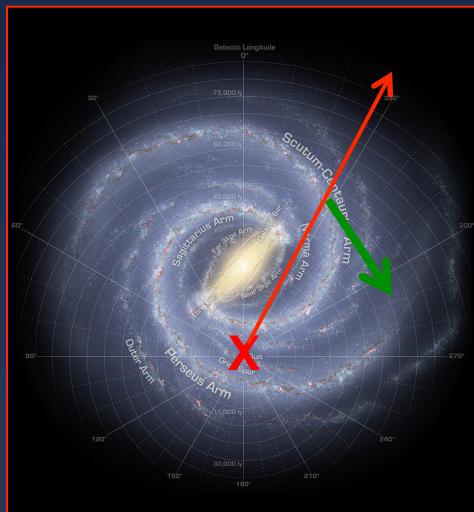


CTA



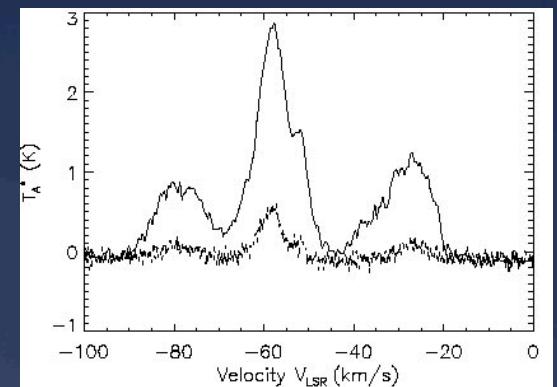
CO Lines yield: Source Distance + Column Density

orbital motion

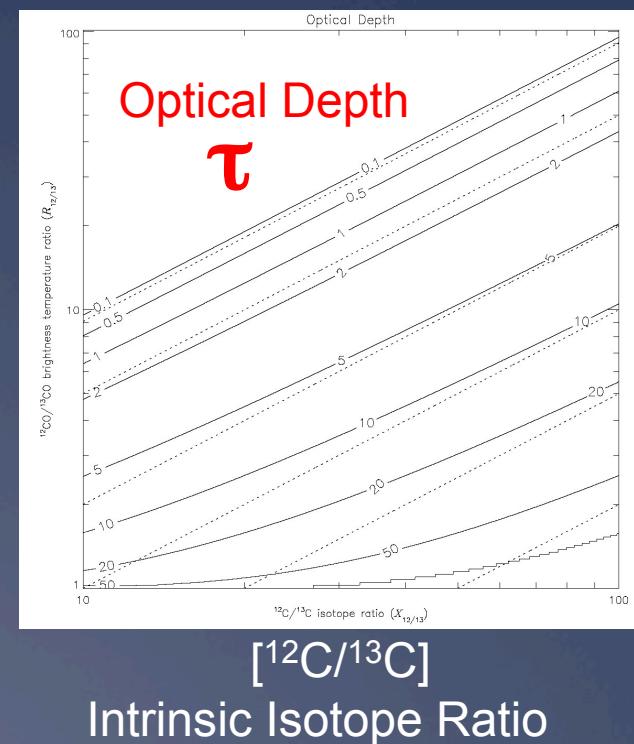


$$N \propto \text{Flux} \times \frac{\tau}{1 - e^{-\tau}}$$

$^{12}\text{CO} + ^{13}\text{CO}$
Line Profiles



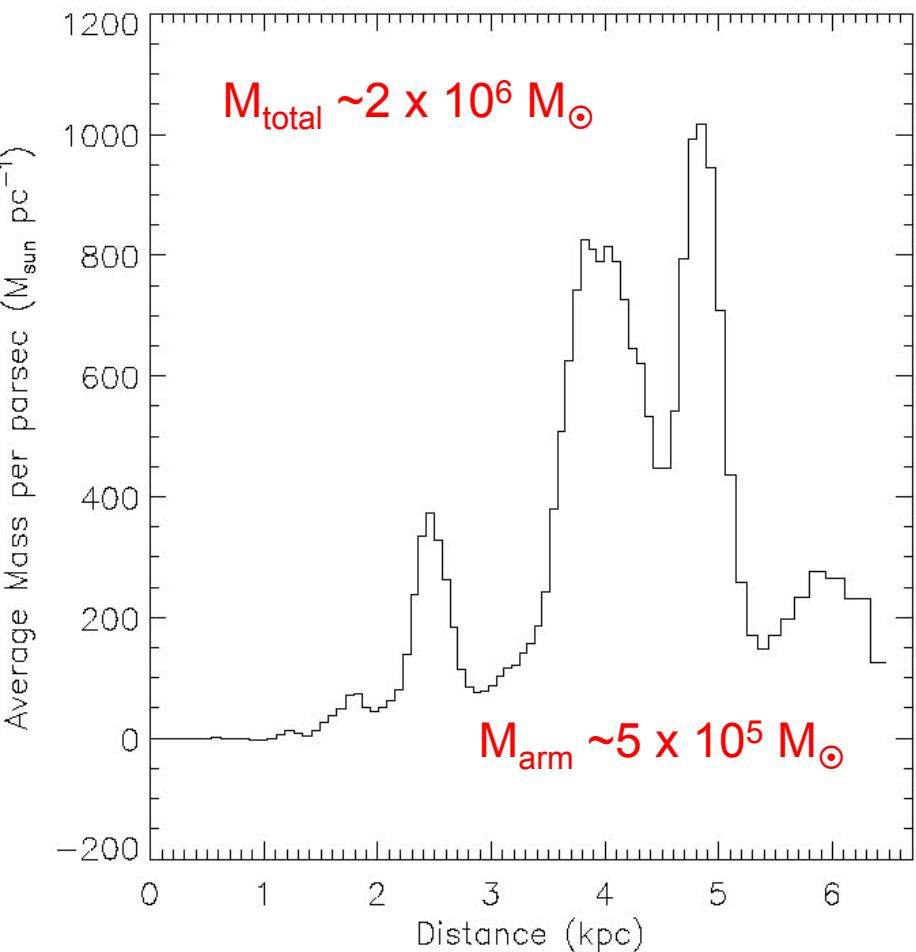
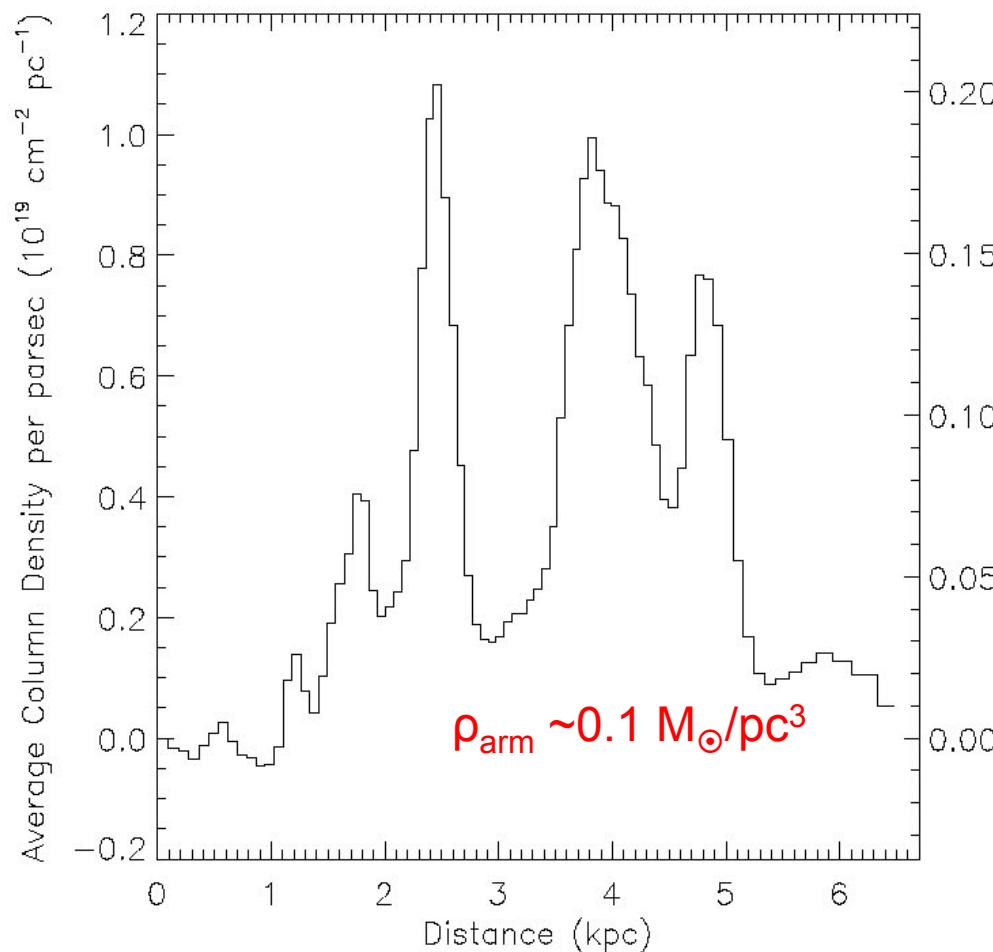
$^{12}\text{CO}/^{13}\text{CO}$
Observed Line Ratio



[$^{12}\text{C}/^{13}\text{C}$]
Intrinsic Isotope Ratio

Molecular Mass Distribution at $|l|=323^\circ$

Aim to produce a 3D galactic molecular mass distribution

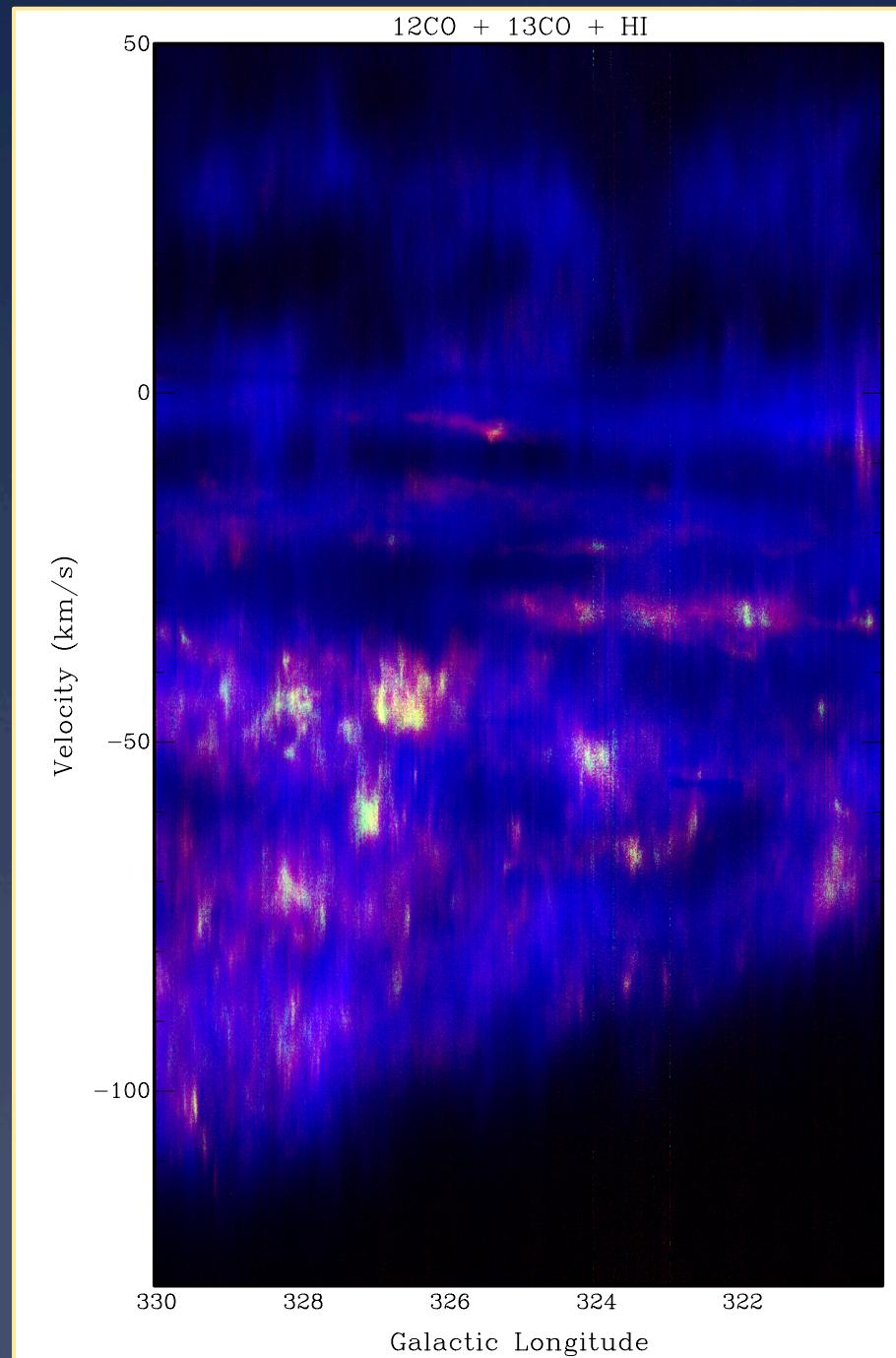


The ISM for G320° – 330°

Sag -
Carina

Scutum -
Crux

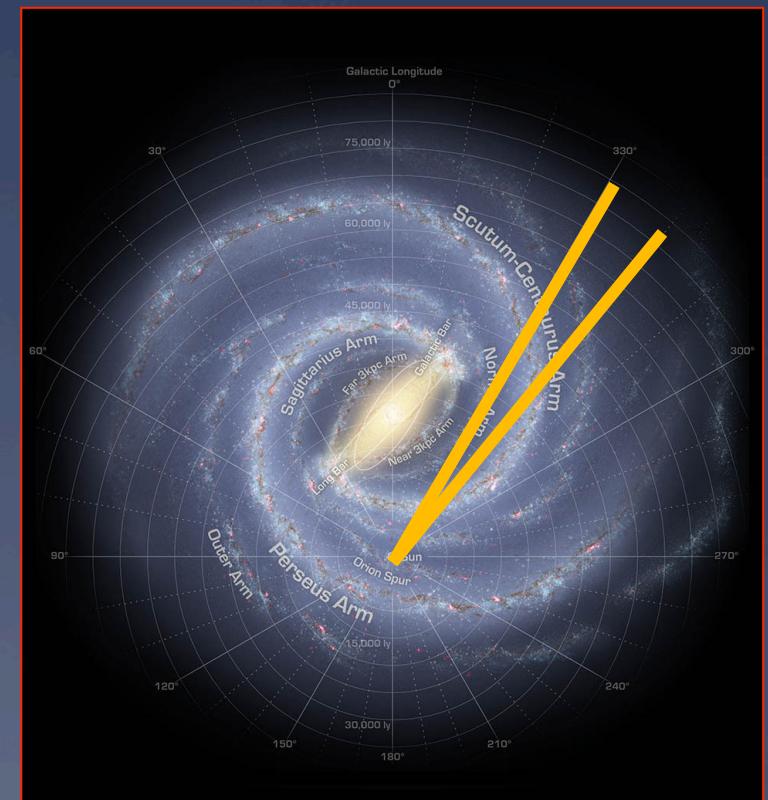
Norma -
Cygnus



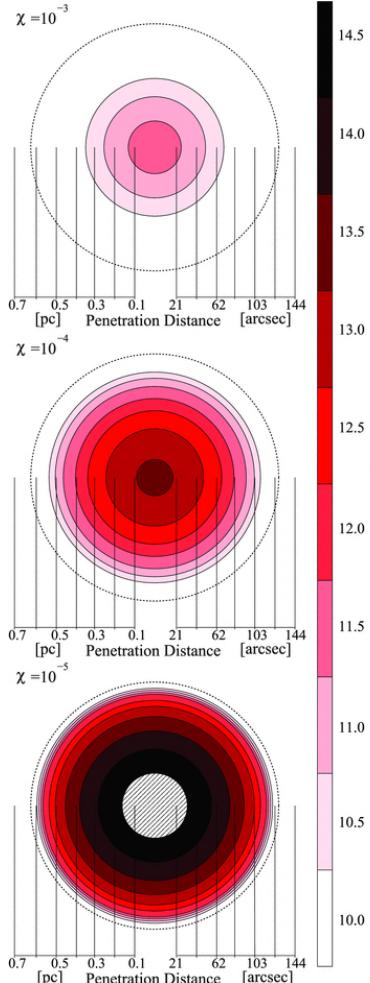
12CO, 13CO, HI

Spiral arms clearly evident

[Scutum - Crux]

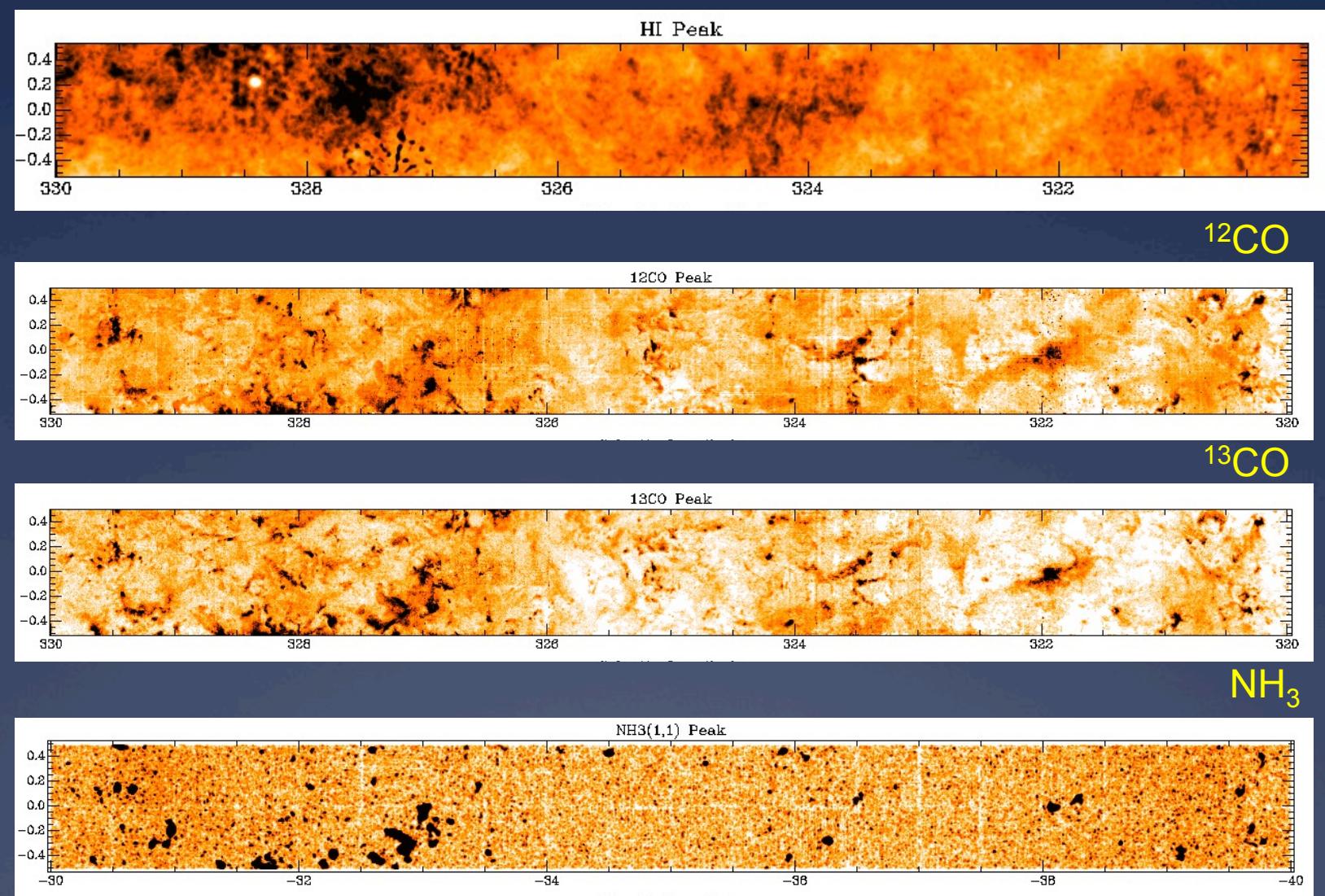


The Galaxy at Different Density: cosmic ray diffusion



Minimum Energy CR penetration with different diffusion suppression coeffs.

Cosmic Ray diffusion depends on both the density and the column density distribution



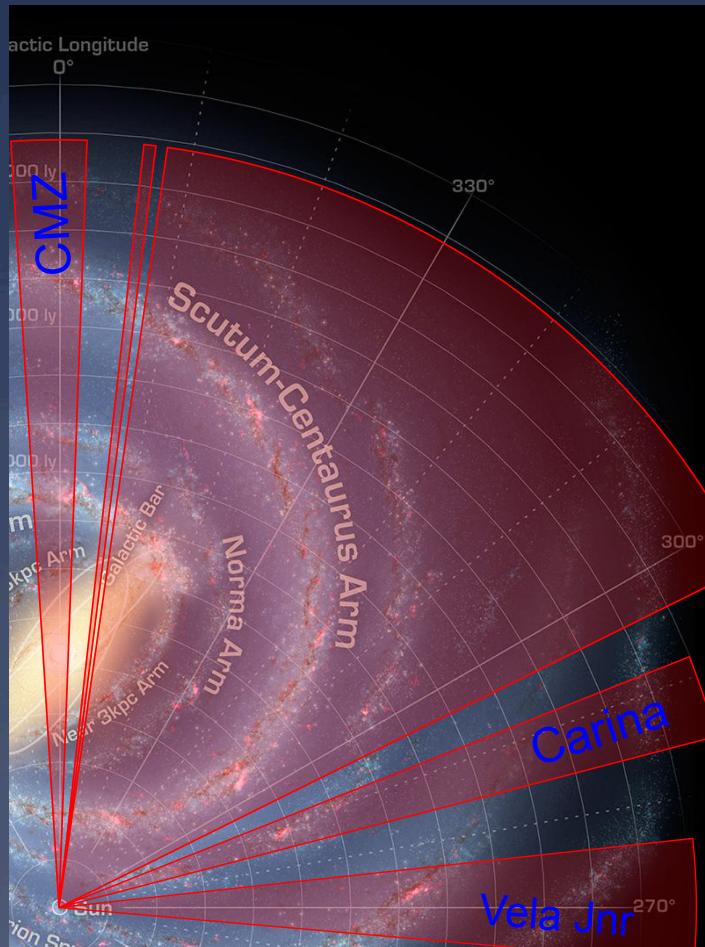
Density Increasing

Survey Status

The 4th Quadrant of the Galaxy

~85 sq. deg covered so far.

Please contact us if interested in early access to the data for particular research projects.



Data will be made available at
www.mopra.org

$|l| \sim 265^\circ - +5^\circ$
Generally $b = \pm 0.5^\circ$

We aim to cover
 $b = \pm 1.0^\circ$



The Future of Mopra and the Galactic Plane Survey?

