18-cm Thermal OH Emission in the ISM

Some New Prospects

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This story also begins with Miller …

OH ABSORPTION IN THE GALAXY*

W. MILLER GOSS†
Radio Astronomy Laboratory, University of California, Berkeley
Received April 26, 1967

ABSTRACT

A survey of northern hemisphere radio sources for 18-cm OH absorption has been completed using the 85-foot Hat Creek telescope of the University of California. The observations were made with the 100-channel receiver with frequency resolutions of 10 kHz (1.8 km/s) and 2 kHz (0.36 km/s).

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Why might this be interesting?

Some advantages …

- 18-cm thermal OH has some advantages as a tracer for the molecular ISM:
  - Low critical density (≈ 1 cm^{-3}, easily excited);
  - Low optical depth (few radiative transfer issues);
  - 18-cm lines ubiquitous (absorption everywhere);
- … and one big disadvantage:
  - The emission is very faint.

Imagine a map of OH emission …

– A map of the 18-cm OH emission of the Galaxy or a nearby galaxy would resemble …
  A. The CO(1-0) emission
  B. The21-cm HI emission
  C. The radio continuum emission
  D. The Far-IR dust emission
  E. None of the above
  F. Don’t know

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A well-ploughed field …

– A lot of work has been done on OH in the nearly 50 years since the discovery of the 18-cm line emission:
  - Dust clouds in the Galaxy (Heiles, Turner, Crutcher, ...)
  - Absorption surveys (… Goss, Dickey, …)
  - Magnetic fields from Zeeman effect (… Goodman, …)
  - Excitation (… Rieu, Liszt, …)
  - Maser sources in the Galaxy, and nearby galaxies (…)
  - Megamaser emission from AGN (…)

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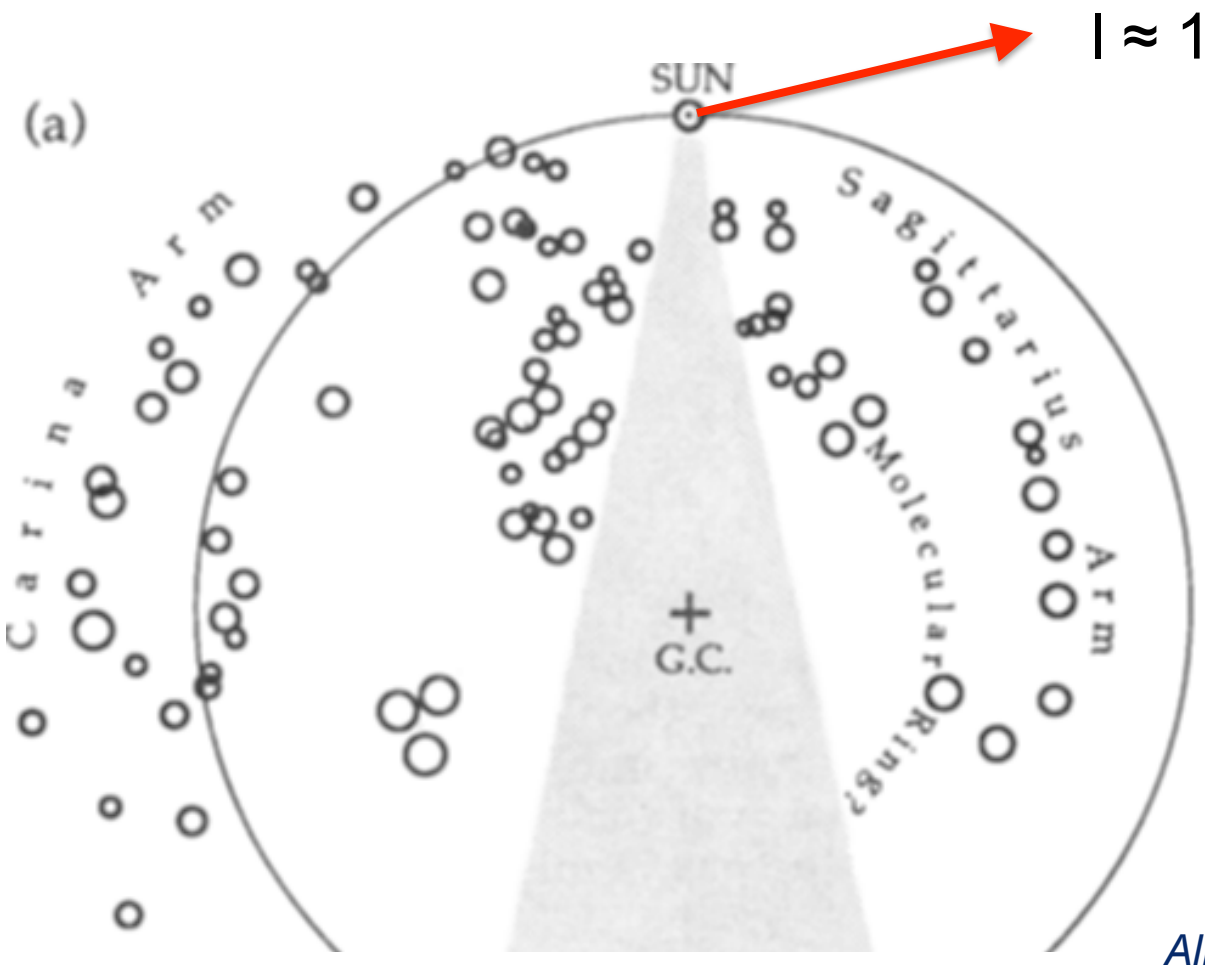
  - ***A pilot survey for OH emission in the Galaxy***

A mini-survey for 1667 MHz OH emission from the general ISM in the Outer Galaxy with the 25-m telescope at Onsala

Some preliminary results

Ron Allen, Monica Rodriguez,
John Black, & Roy Booth

A search for OH in the Outer Galaxy …



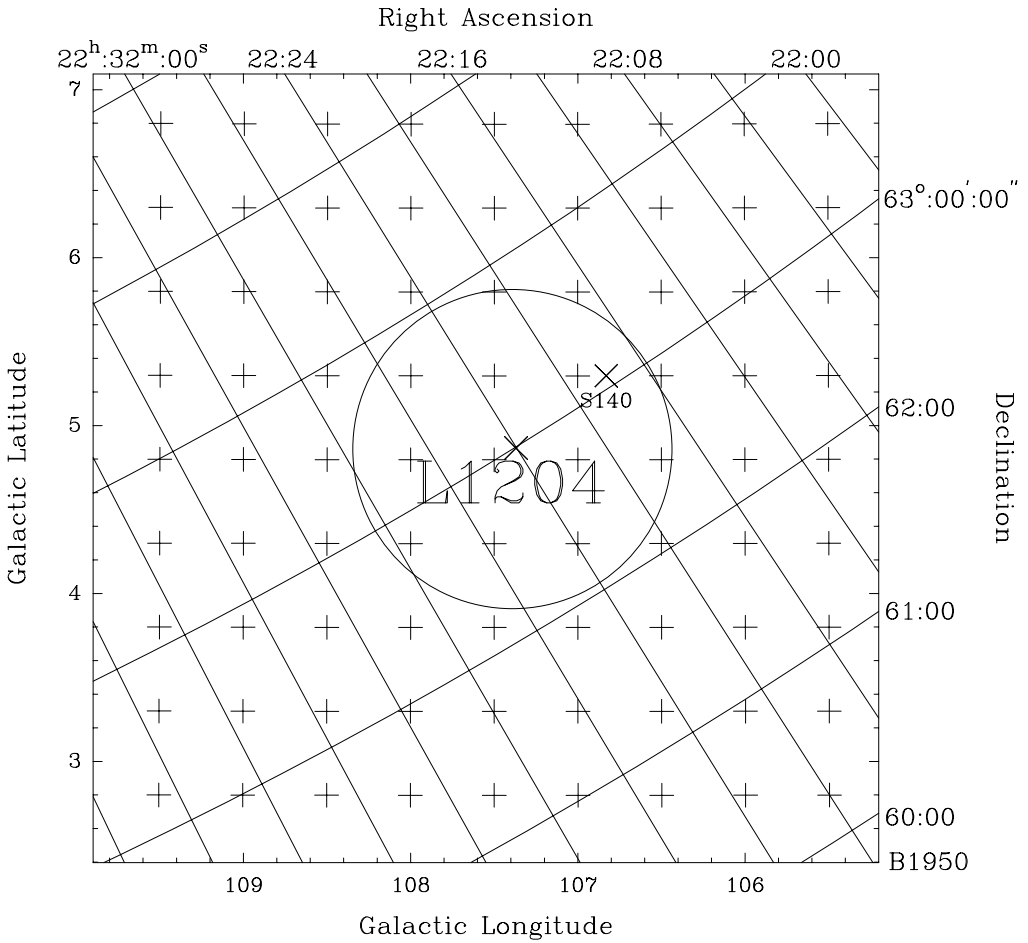
CO(1-0) GMCs:

$5 \times 10^5\ M_\odot$
$1 \times 10^6\ M_\odot$
$5 \times 10^6\ M_\odot$

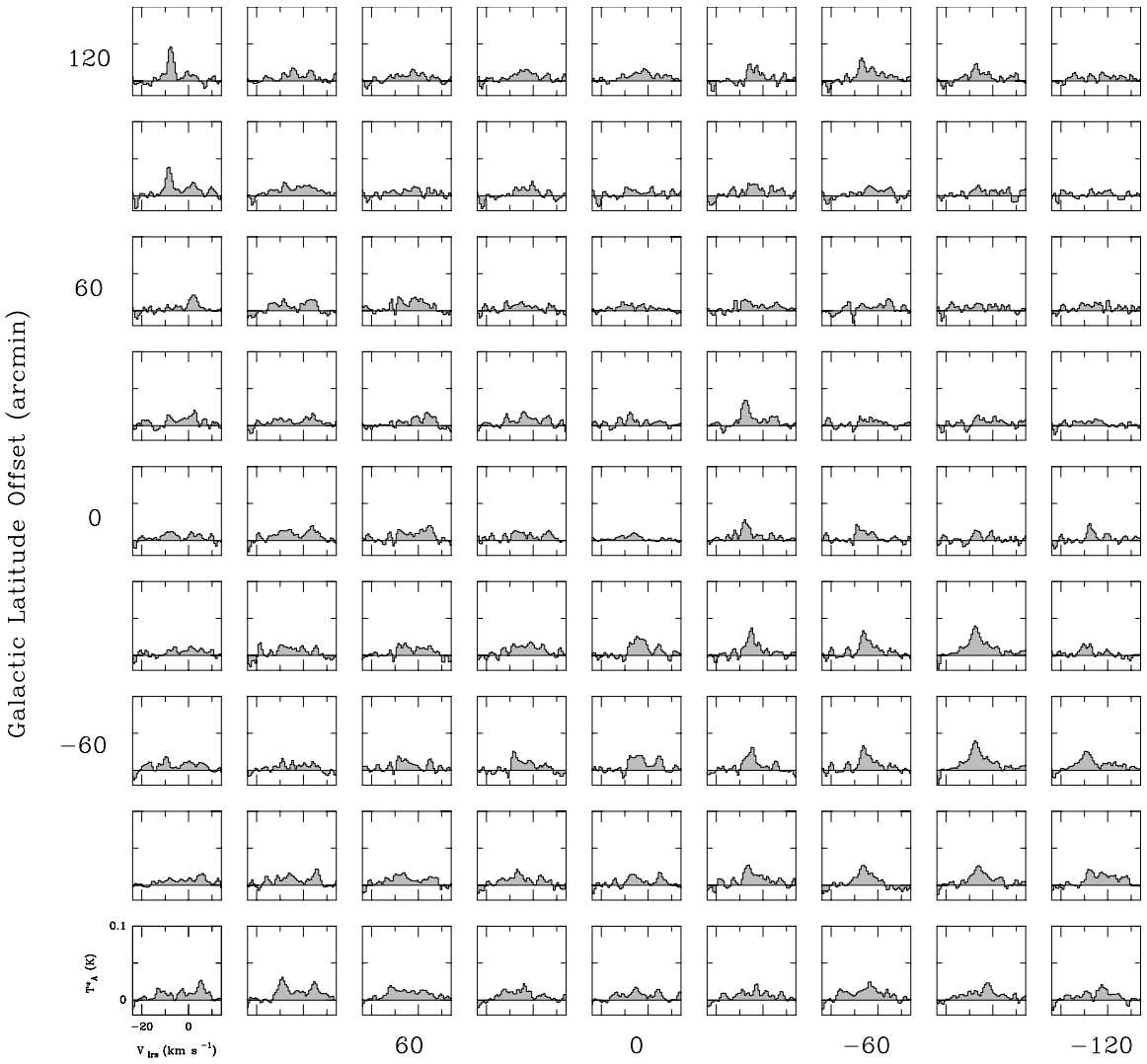
Figures from: Dame 1993

Allen et al 2011, in prep.

… in the region surrounding Lynds 1204 …



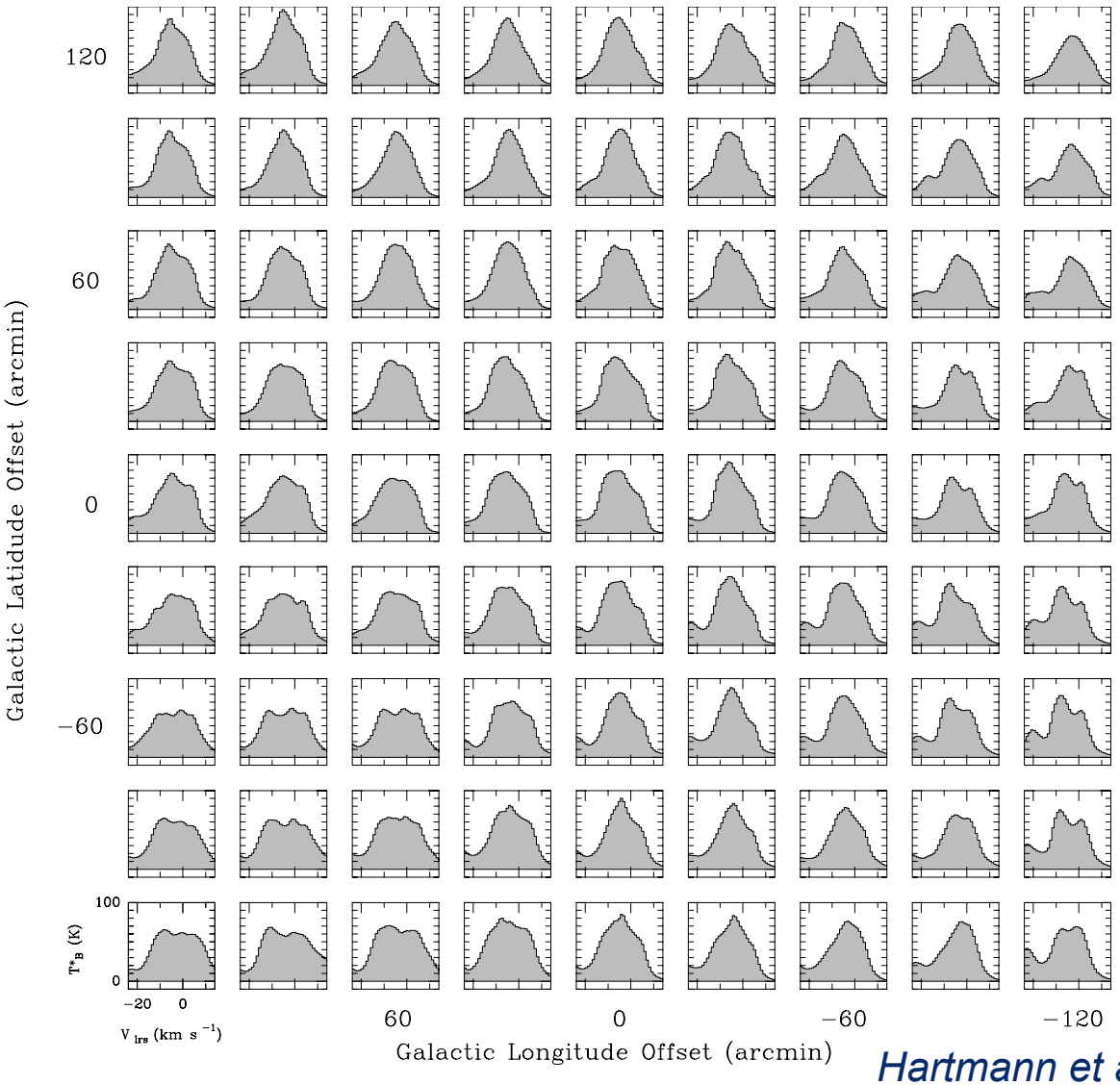
… reveals ubiquitous OH 1667 emission …



Faint OH(1667) at Onsala

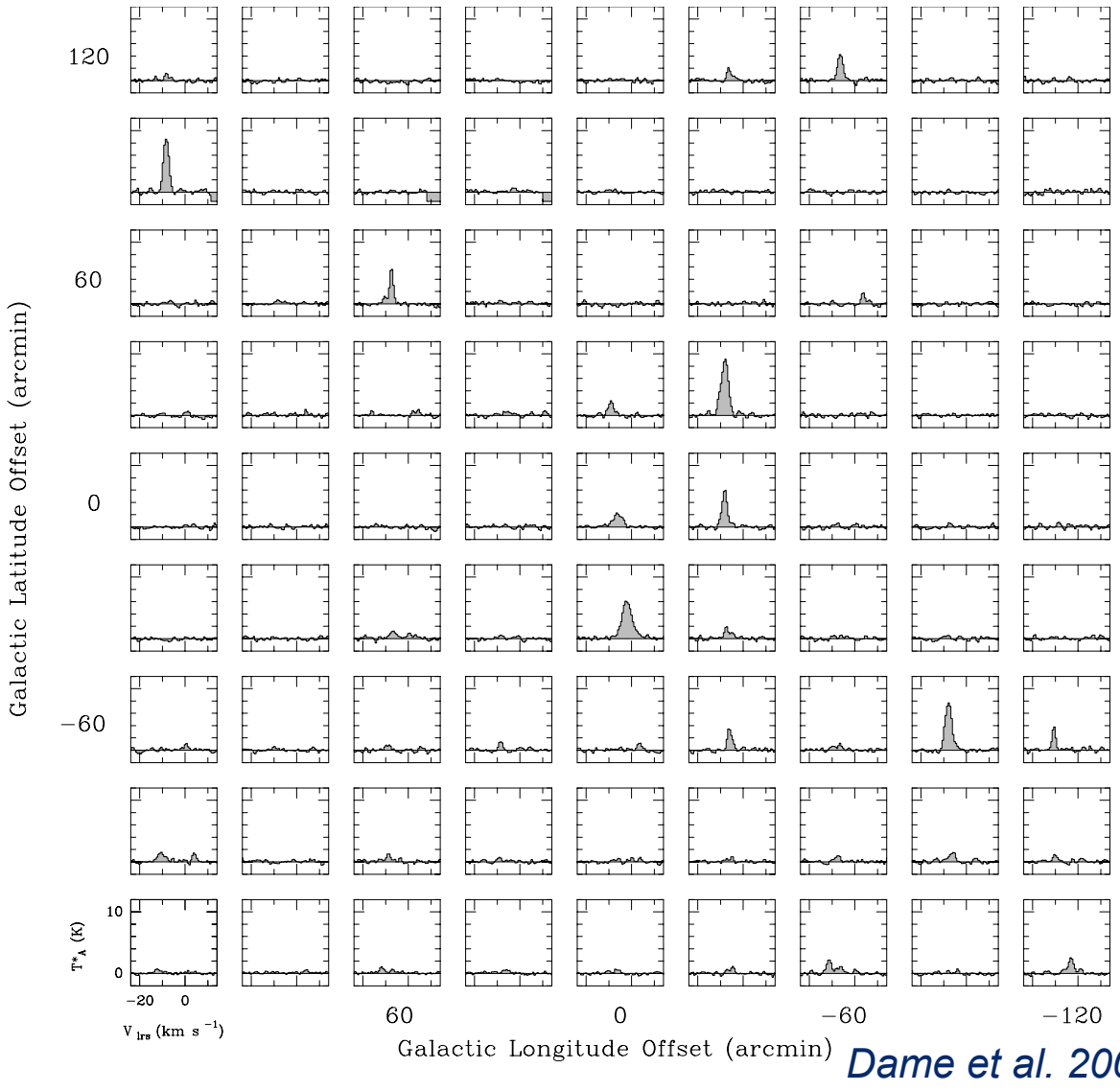
Allen et al 2011, in prep.

… with wide velocity extent like the HI …



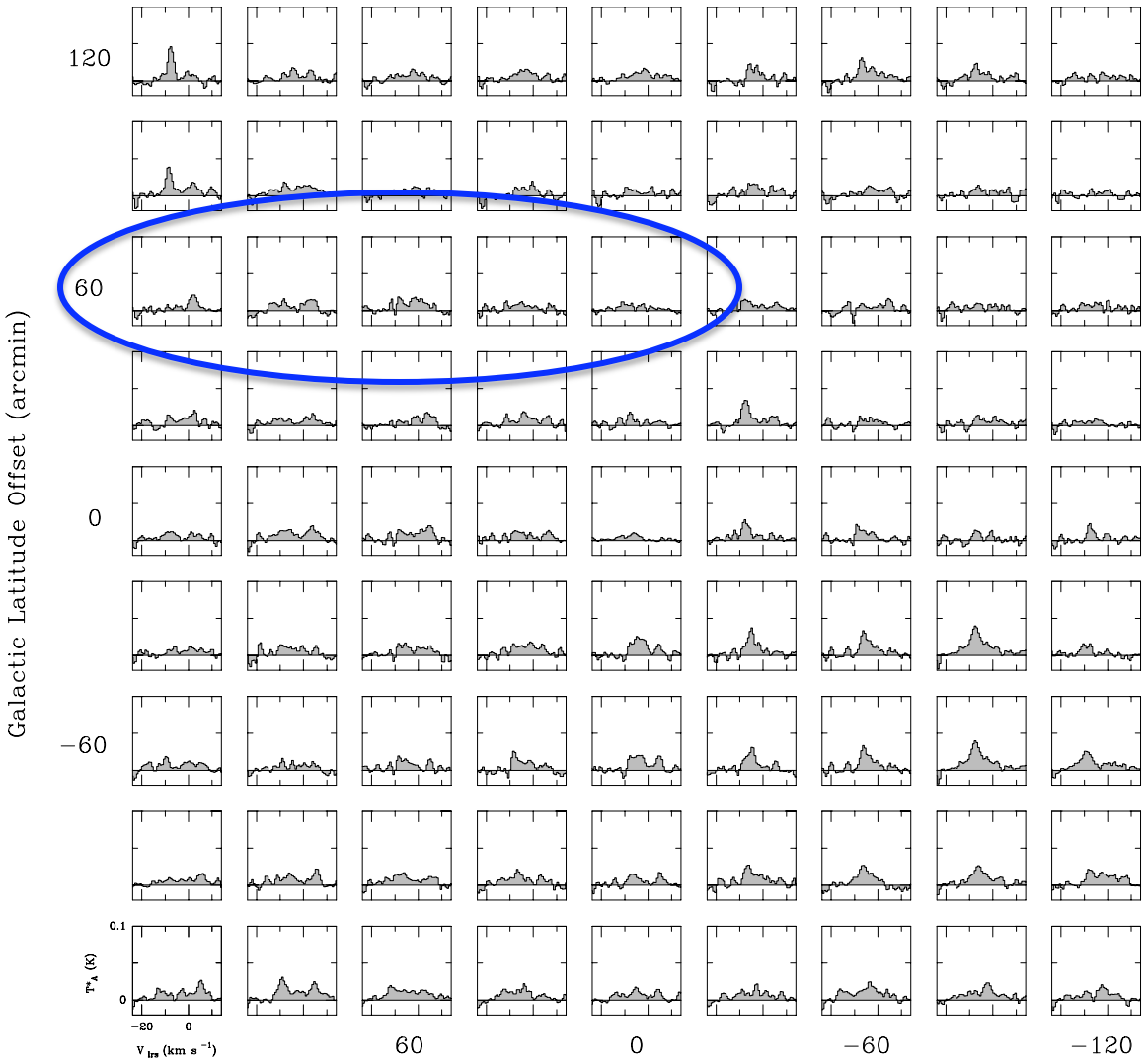
Hartmann et al. 1997

… and little resemblance to the CO(1-0).



Dame et al. 2001

Let's take a closer look …



Faint OH(1667) at Onsala

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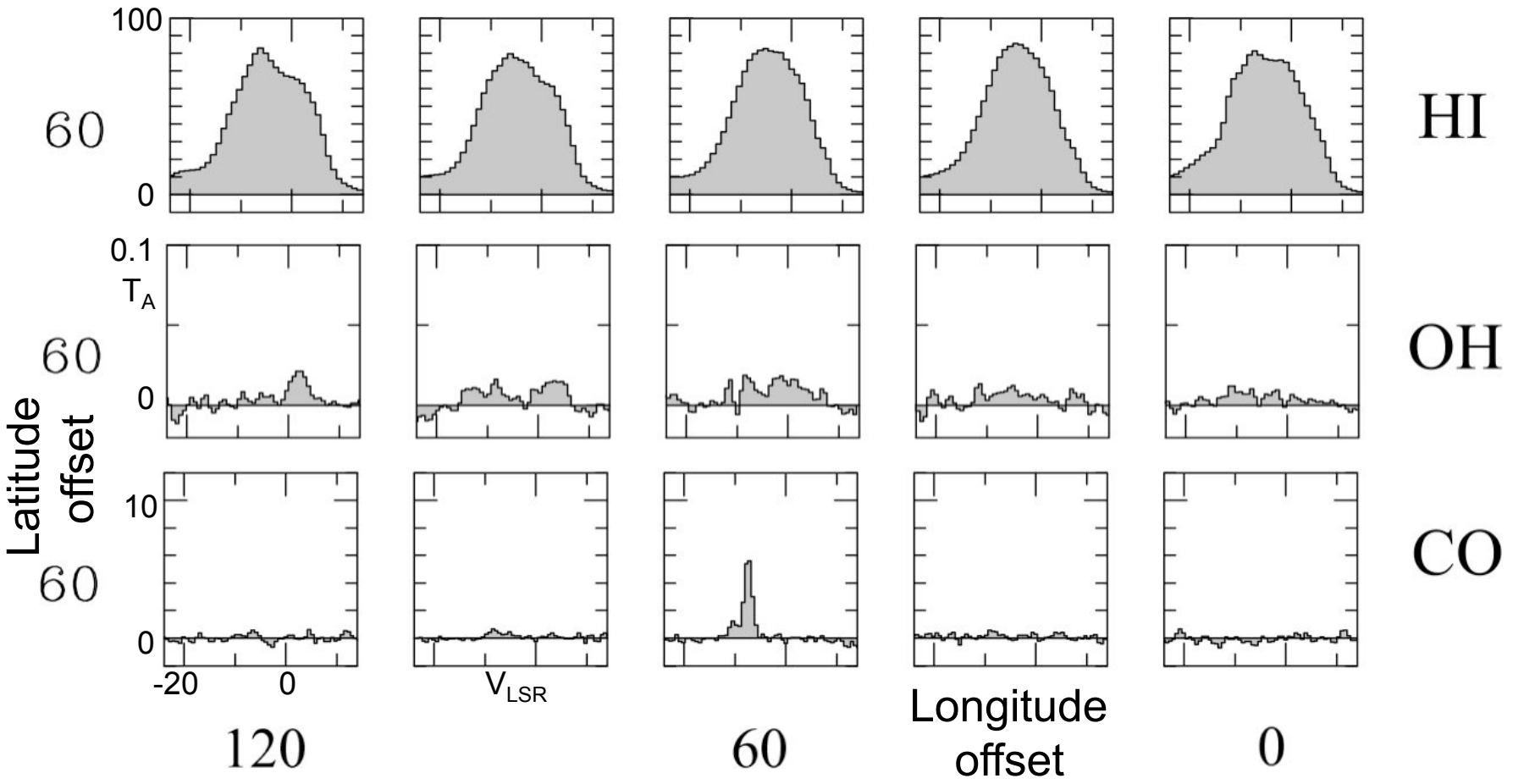
… at the profile details:



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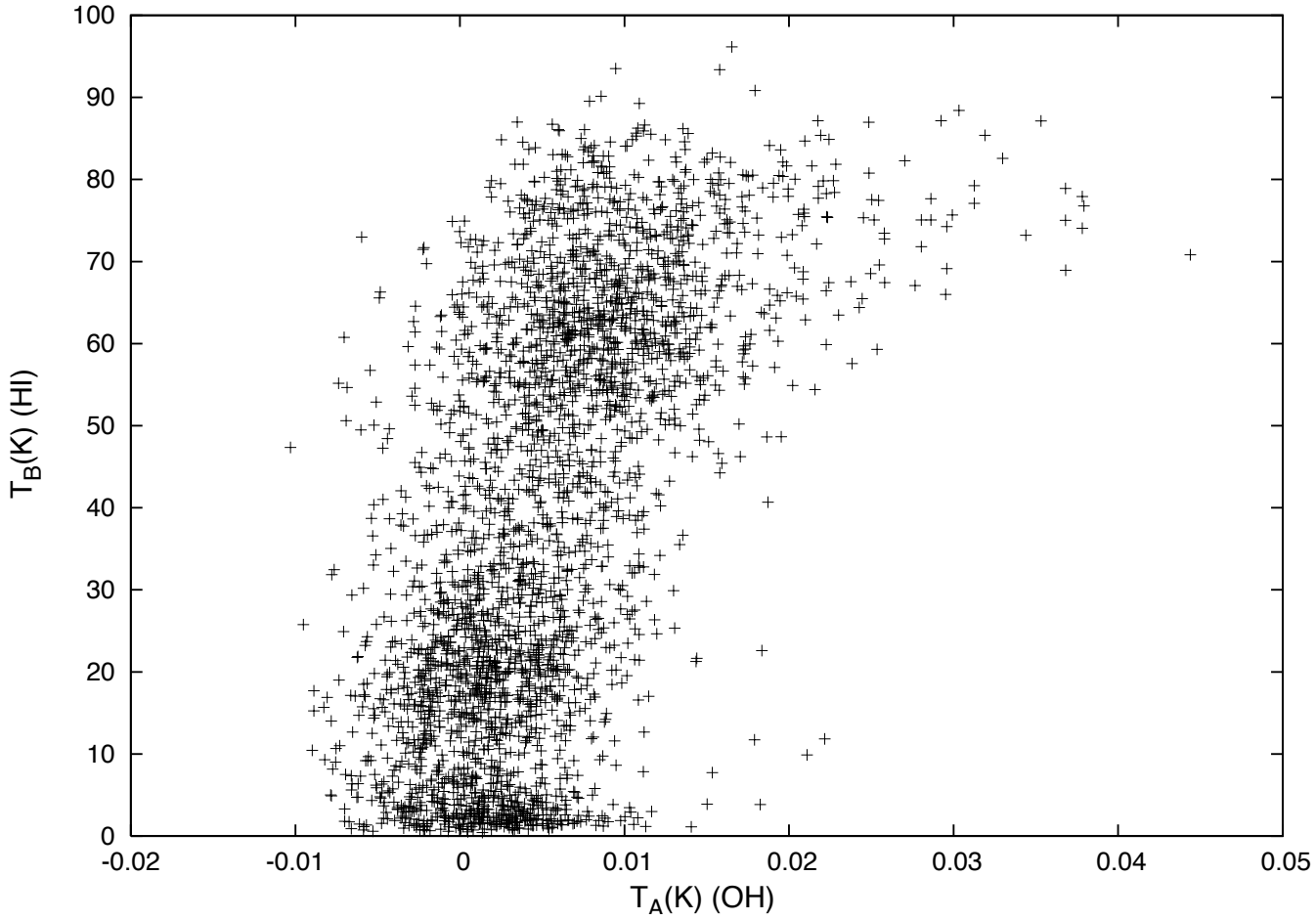
Allen et al 2011, in prep.

Point-by-point profile correlation



Other work

- After our initial discovery at Onsala in 2005 a literature search turned up some scattered detections of such profiles in the last decade:
  - Goodman et al. (1989) saw it in baselines on OH maser profiles.
  - Liszt & Lucas (1996, 2000) have studied this OH as part of their extensive absorption/emission work.
  - A recent paper by Barriault et al (2010) on Galactic cirrus clouds shows individual OH features similar to what we observe.

Status …

- Thermal OH emission is detectable in the general ISM of the Galaxy.
  - The OH emission is ubiquitous.
  - OH generally resembles the HI at this resolution.
  - The OH profiles often appear to be in distinct features.
  - CO(1-0) appears only sporadically with the OH.
- Analysis of the Onsala OH results is ongoing
  - Allen, Rodriguez, Black, & Booth 2011 (in prep.)

Finally …

- Thanks to Miller for more than 30 years of:
  - willing collaboration on the science of HI in galaxies; for help and advice with both scientific and historical matters; and for counsel on many administrative issues in two different countries.
- Thanks to both Miller and Libby for more than 30 years of friendship:
  - sharing our experiences as “foreign guests” at Groningen University,
  - watching our kids grow up in Bunne and Yde, and,
  - going on to new challenges in Socorro and in Baltimore.


Congratulations Miller
on a fantastic career!
Now please slow down so I can catch my breath …

OH from absorption – ca. 1967

- Miller's main conclusions from absorption spectra on 26 Galactic and 2 extragalactic sources.
  1. Several Galactic HII region sources also showed emission (later identified as maser emission).
  2. Most of the absorption sources showed normal intensity ratios in the main lines.
  3. The OH and HI absorption spectra are generally similar, suggesting that OH may have a distribution similar to that of HI.
  4. The excitation temperature $T_{ex} < 10$ K.
  5. $N(OH)/N(HI) \approx 10^{-7} – 10^{-8}$.

OH in the Galaxy, ca. 2011

1. The ratios of the main lines (1665 & 1667 MHz) show no significant departures from LTE.
2. Emission and absorption spectra towards many extragalactic sources show that:
   - OH absorbing gas has low $T_{ex} \approx T_{BG} + 0.5\ K \approx 4\ K$.
     - Emission from this component is weak and narrow in velocity; it adds little to the total emission on any sight line. Note that $T_{BG} = T_{GAL} + T_{CMB} \approx 0.8 + 2.7 = 3.5\ K$
   - OH emitting gas has higher $T_{ex} \approx T_{BG} + (4 – 10)\ K \approx 10.5 \pm 3\ K$.
3. $N(OH)/N(HI) \approx (2.5 – 5) \times 10^{-8}$ in diffuse Galactic clouds.
   - Our Onsala data gives 4.7×10^{-8}.
4. $N(H_2)/N(OH) \approx 9 \times 10^{6}$ from direct UV absorption data.
   - This is the equivalent of an X factor for 18-cm OH emission.