The Galactic ISM in the SKA Era: Focus on the GASKAP Survey

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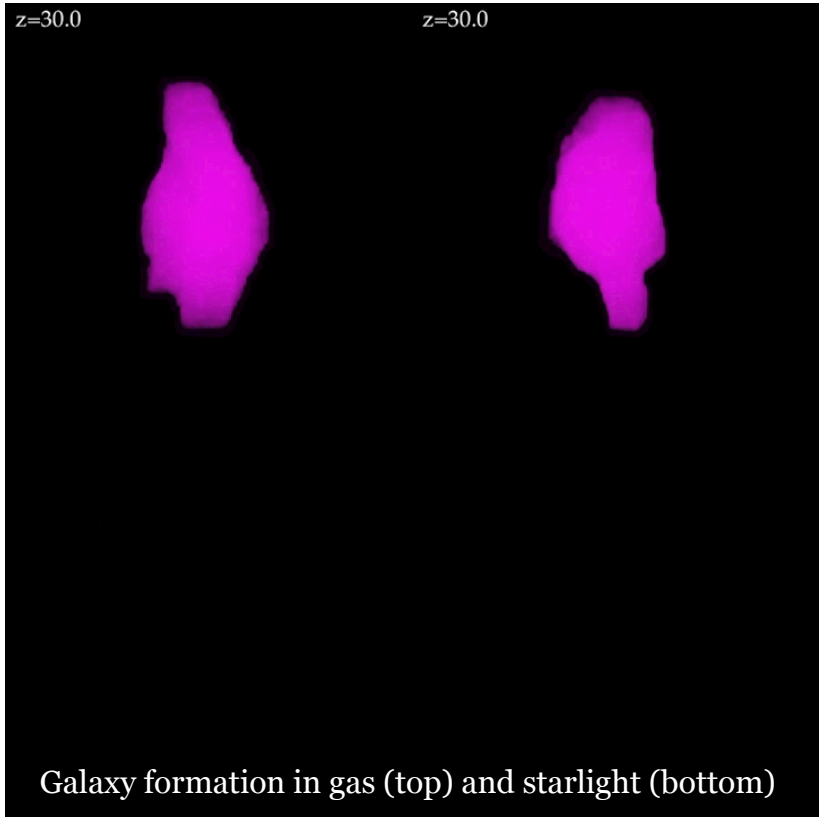
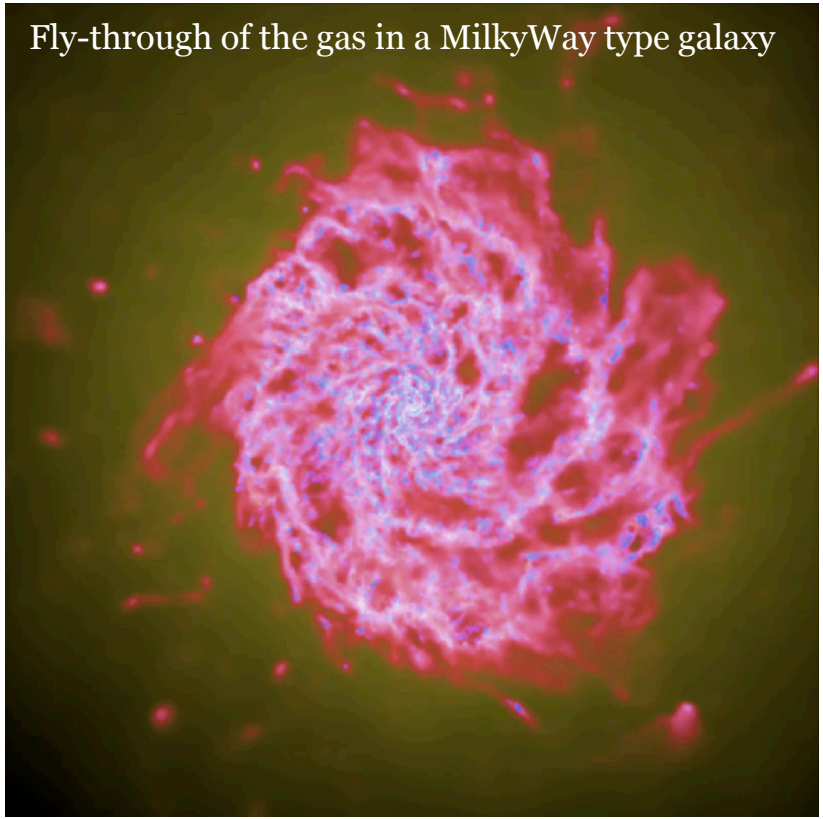
Galaxies are Complicated

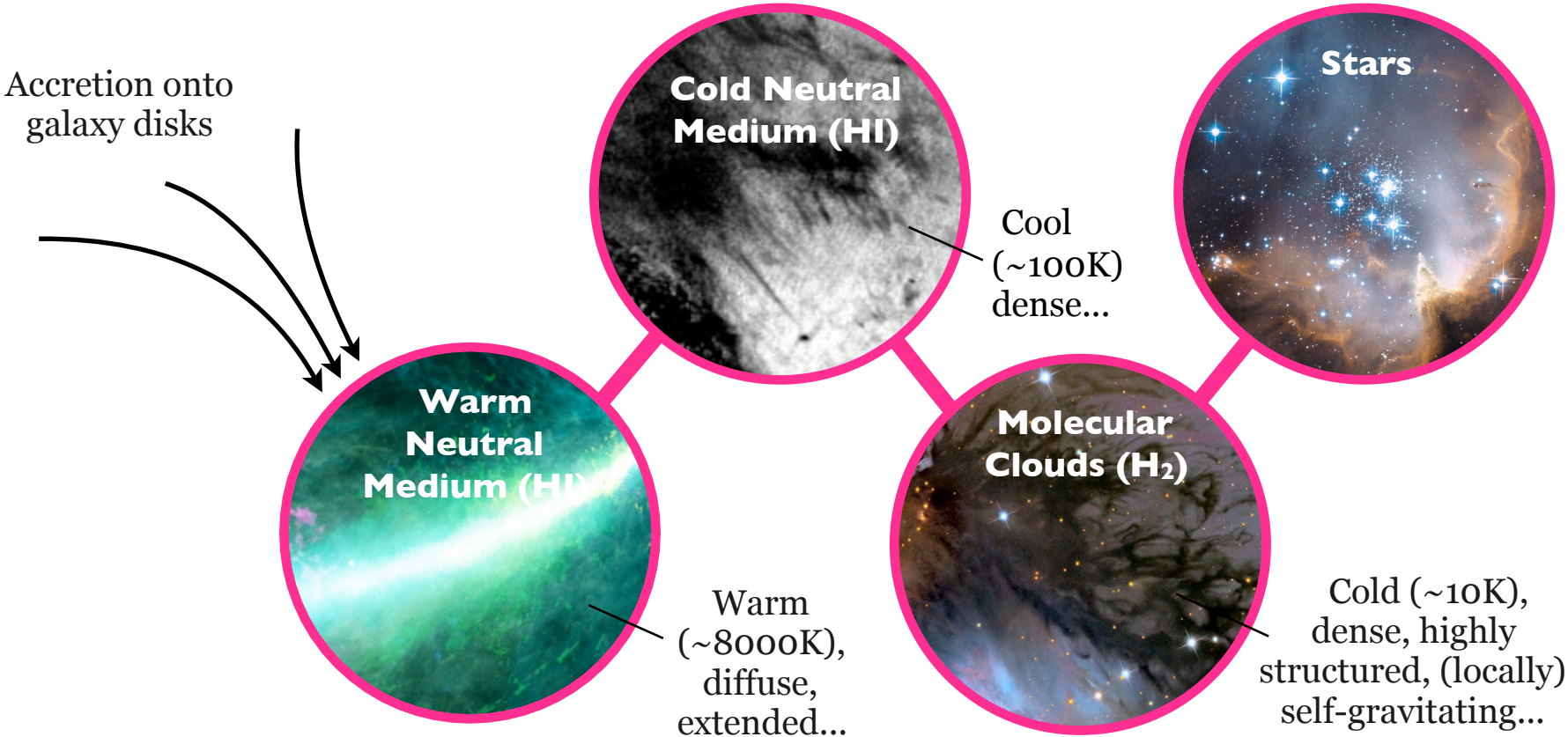


Galaxy formation in gas (top) and starlight (bottom)



Movies from FIRE simulations (https://fire.northwestern.edu/)

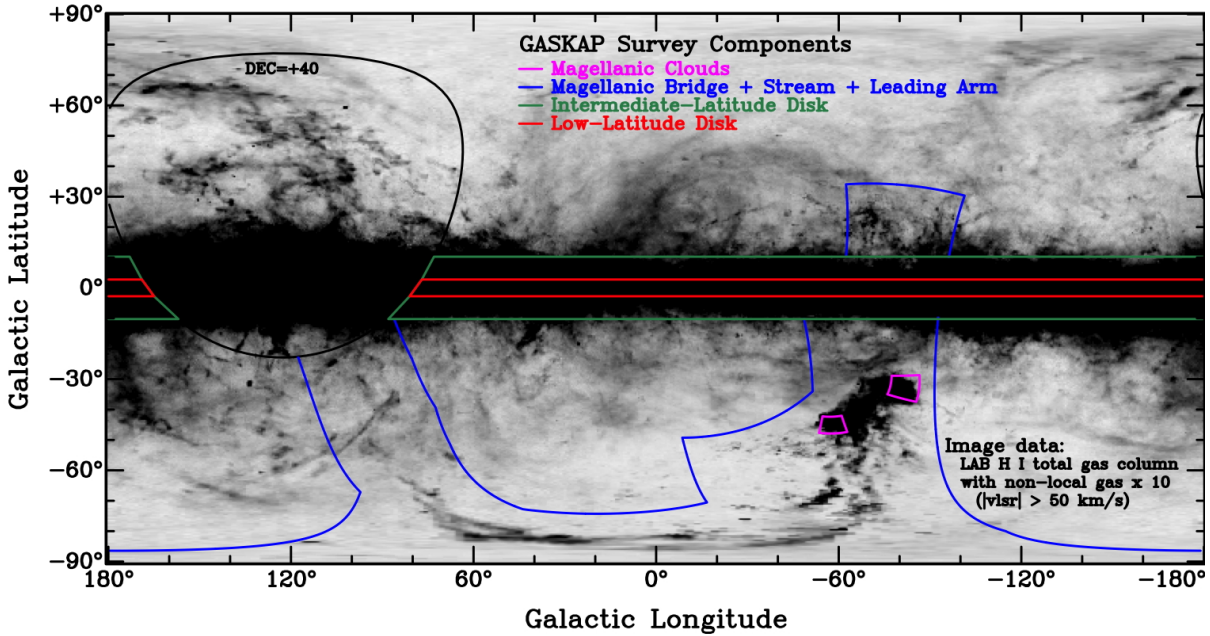
Gas to Stars: Devil is in the Details



Optical image credits: Adam Block, U. Arizona; Space Telescope Science Institute

The Galactic ASKAP Survey

AIM: To study the evolution of the Milky Way and Magellanic Clouds through their interstellar gas and star formation.

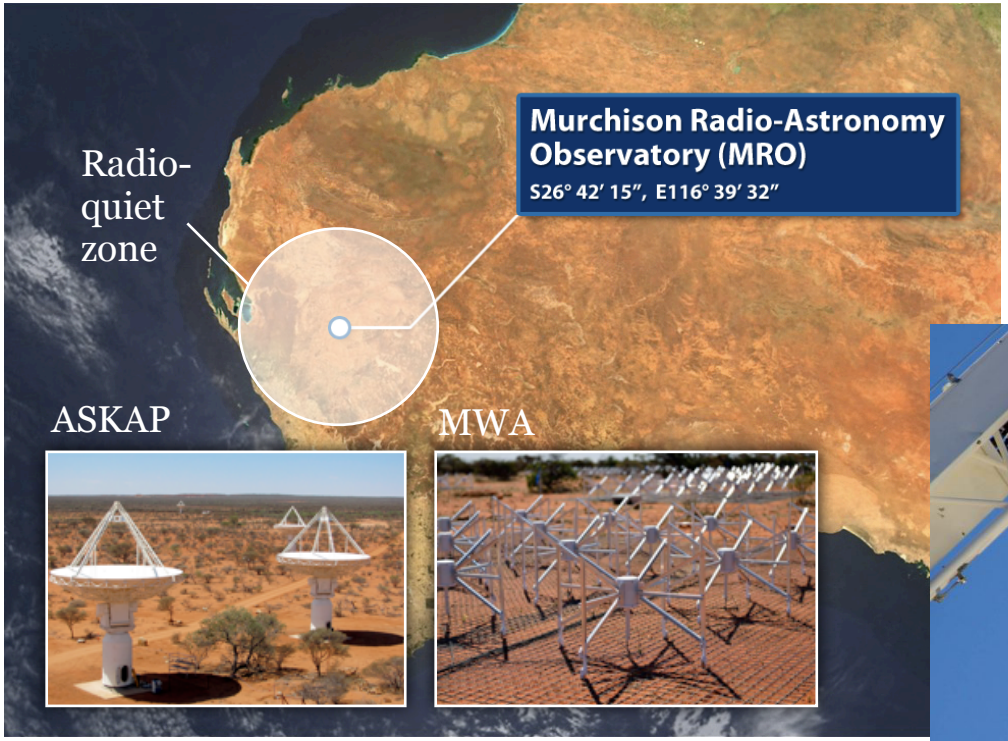


Survey of the Galactic Plane and Magellanic System

- HI 21-cm emission & absorption
- OH 18-cm masers and diffuse absorption

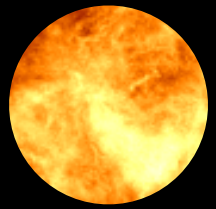
More than an order of magnitude more sensitive than previous surveys

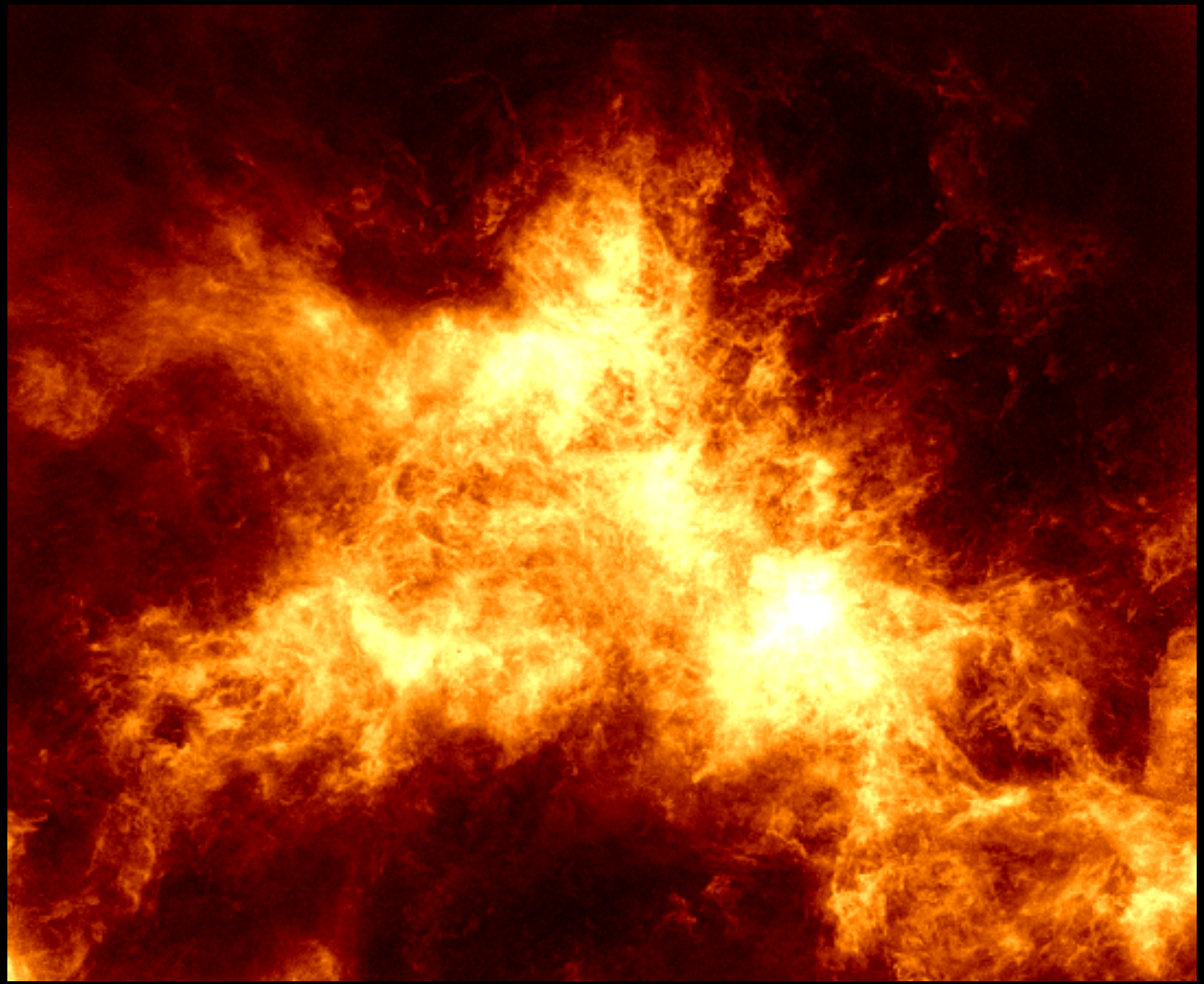
The ASKAP Telescope



- 36 12m antennas; baselines 22m - 6km
- Phased Array Feeds (PAFs)
- ~700-1800 MHz (288 MHz instantaneous bandwidth)
- Resolution up to ~10 arcsec

Conventional interferometer: FoV ~ 1 deg^2





ASKAP Early Science observations of the Small Magellanic Cloud

(+Single dish data from Parkes)

ASKAP: FoV ~ 25 deg^2

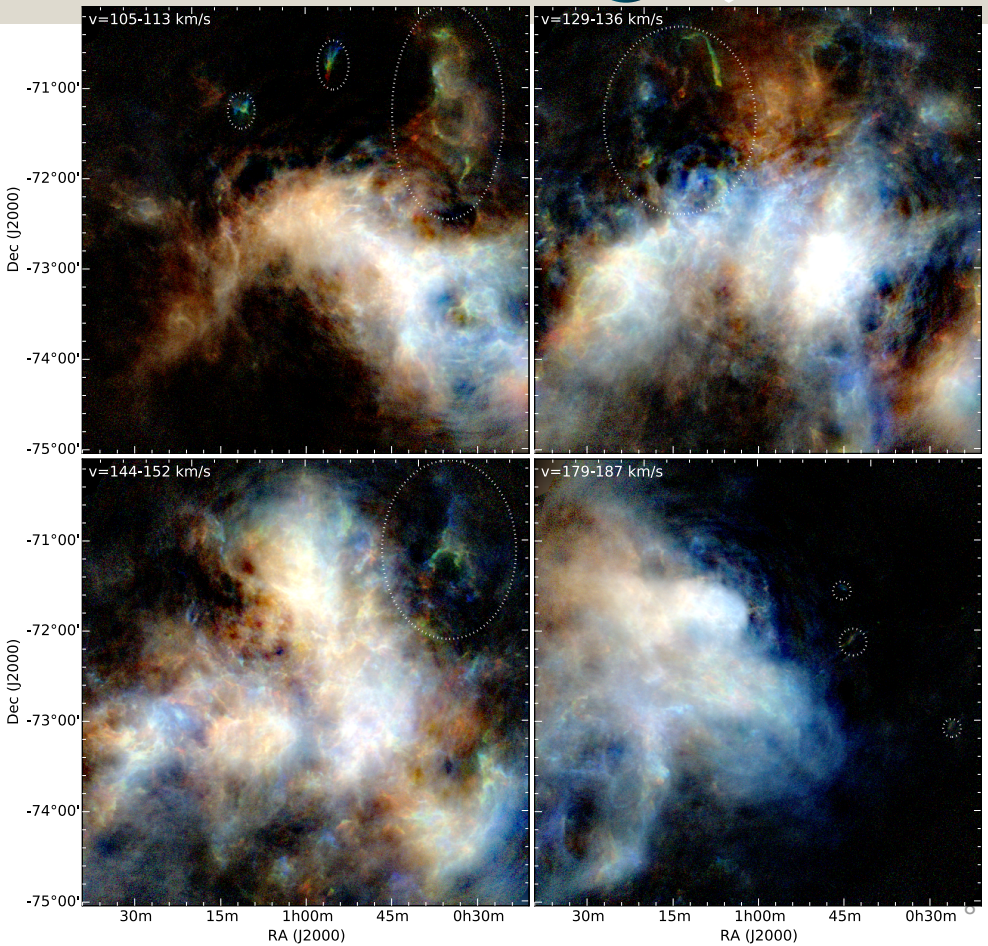
30” resolution

Data taken in only 20 hours!

Cold Outflows from the SMC

Cold (< 400 K) HI extending ~ 2kpc from the disk:

- Filamentary, HVCs and extended diffuse emission
- Likely outflow from peak of star formation ~25-60 Myr ago
- Total mass flux: dM/dt ~0.3-1.8 $M_\odot$ yr^{-1}
  - 3-12 x current SFR!
  - Gas depletion timescale 0.9-3 Gyr
- Most will likely be stripped by interactions with MW & LMC, feeding the Magellanic Stream

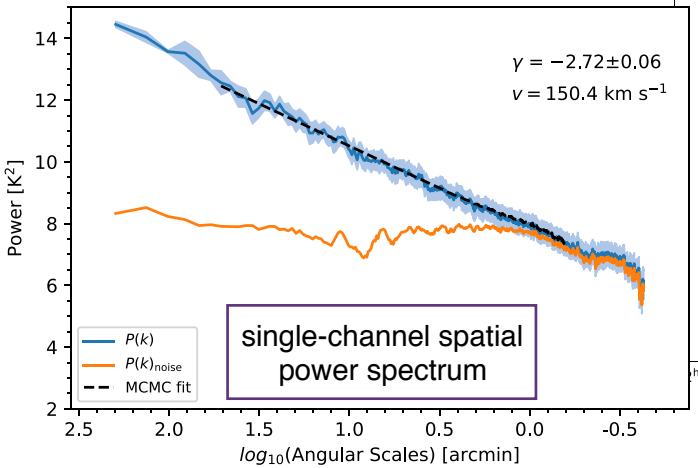


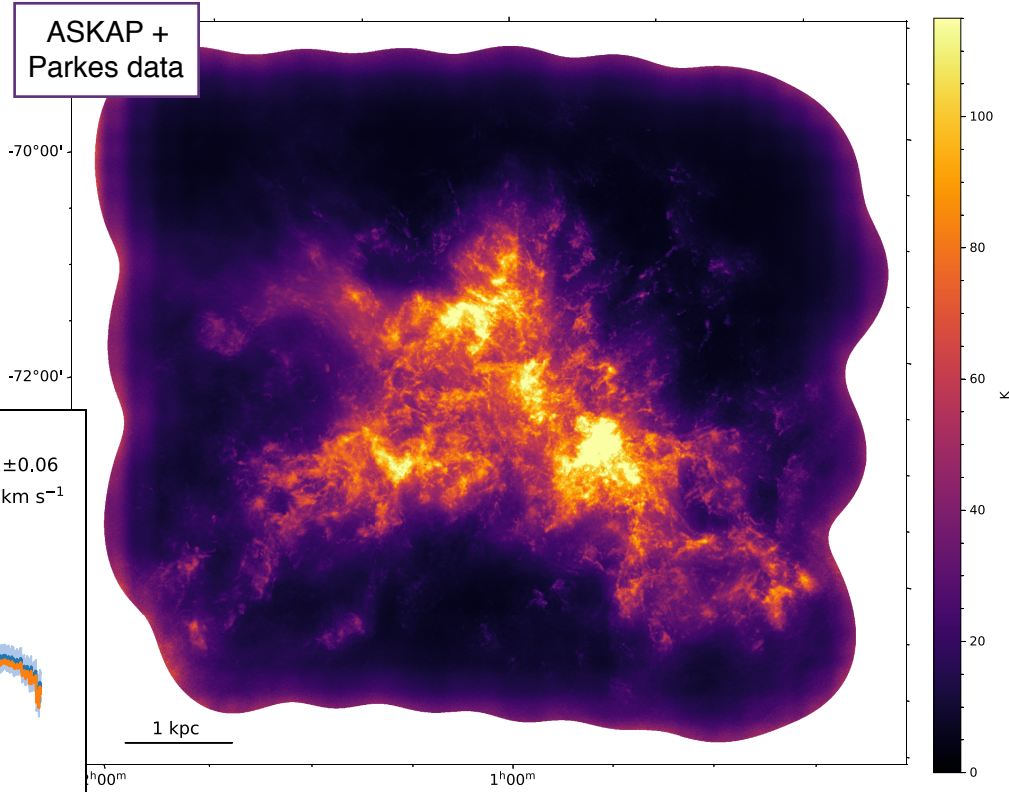
McClure-Griffiths et al. (2018)

Hierarchical Structure in the ISM

SMC HI spatial power spectrum:

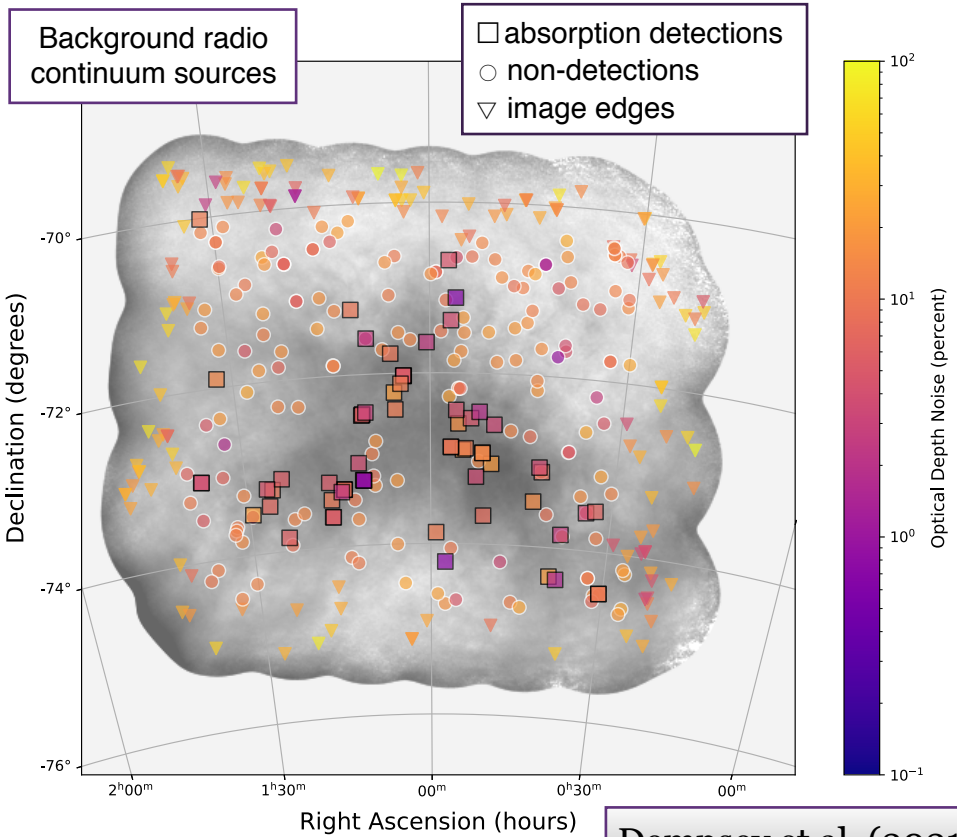
- ASKAP = more complete uv coverage and smaller scales than ever before
- Single power-law down to 10pc → highly uniform turbulent properties
  - No evidence of driving from stellar feedback; dominant energy injection on larger scales?





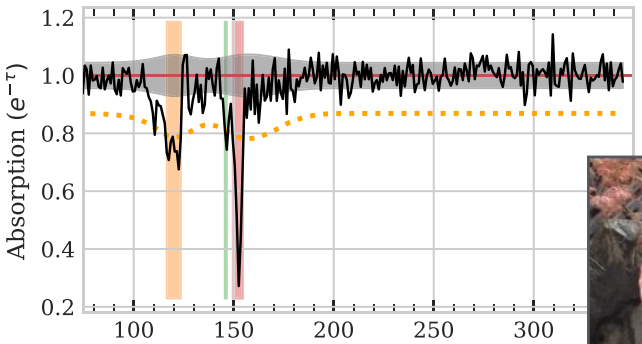
Pingel et al. (2021, submitted)

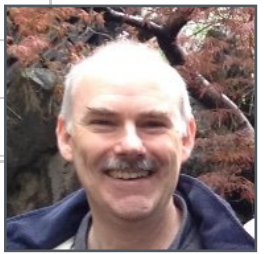
Cold Atomic Gas in the SMC



Measure cold HI with emission/ absorption pairs:

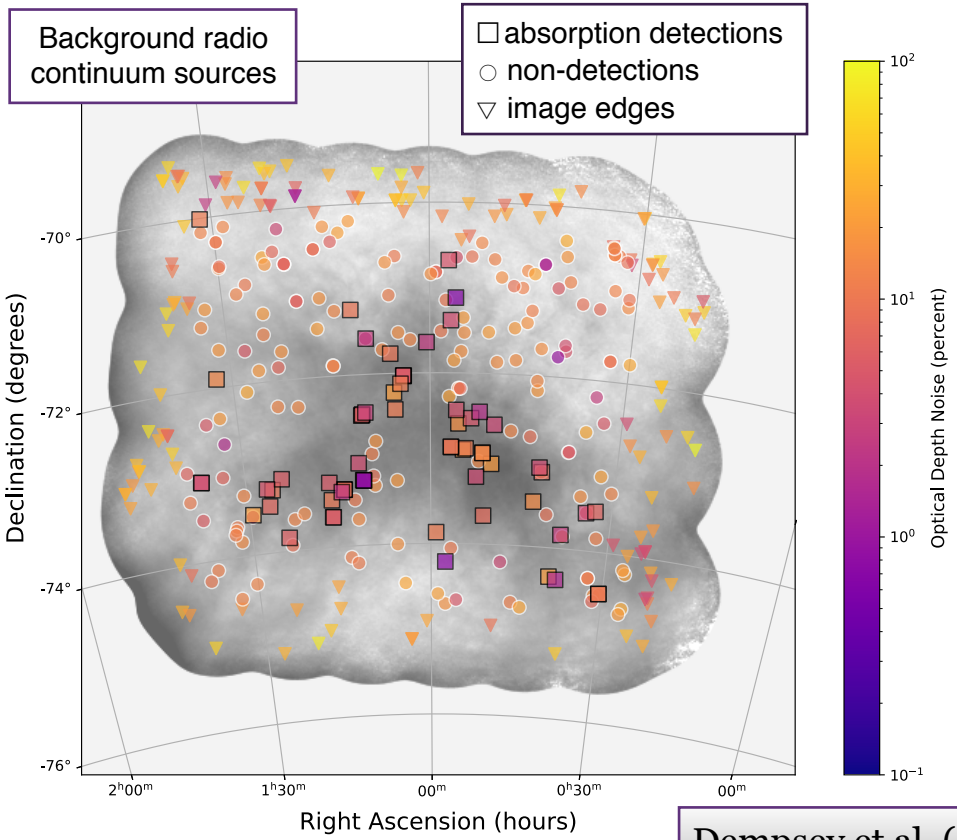
- Used to be slow: ATCA = 12 hours per source, 320 hours → 55 sources, 37 detections (Jameson et al. 2018).
- Now it's fast: ASKAP = 20 hours → 229 sources, 65 detections.



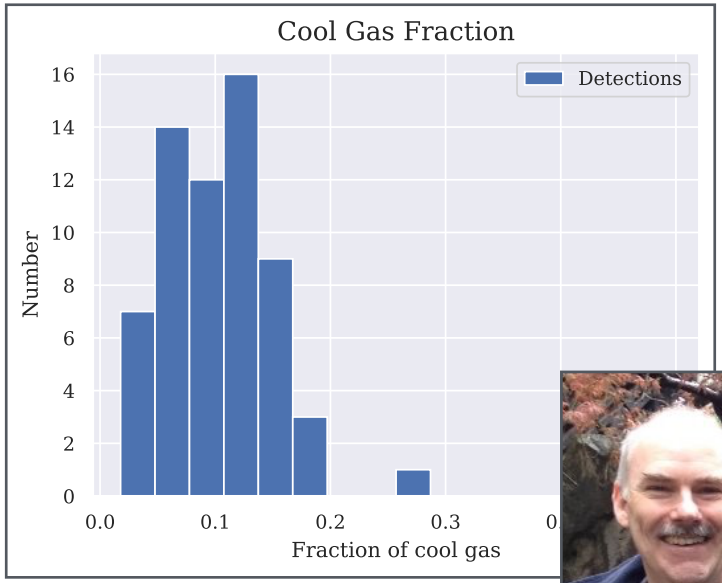


Dempsey et al. (2021, submitted)

Cold Atomic Gas in the SMC



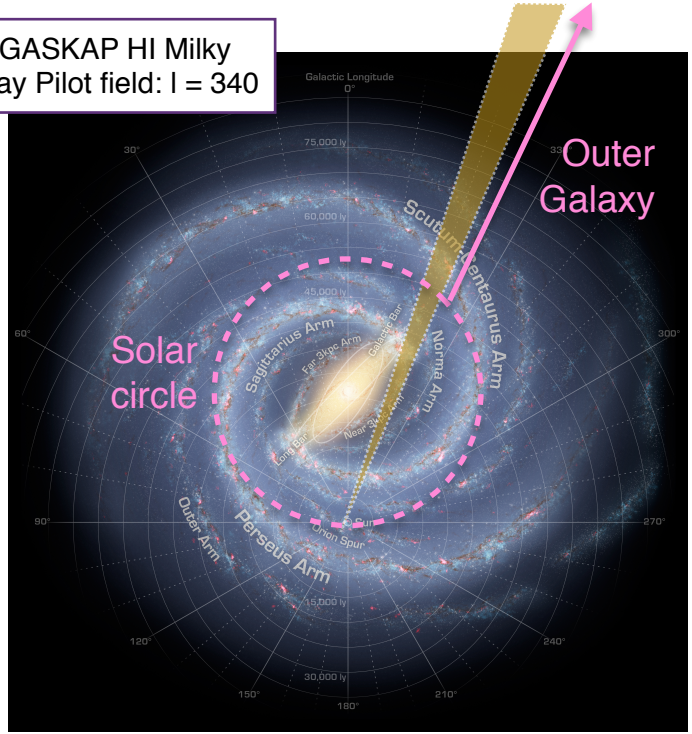
Unbiased view provides best estimate of global SMC cool gas fraction to-date (~11%)



Dempsey et al. (2021, submitted)

Cold HI in the Outer Milky Way

GASKAP HI Milky Way Pilot field: l = 340



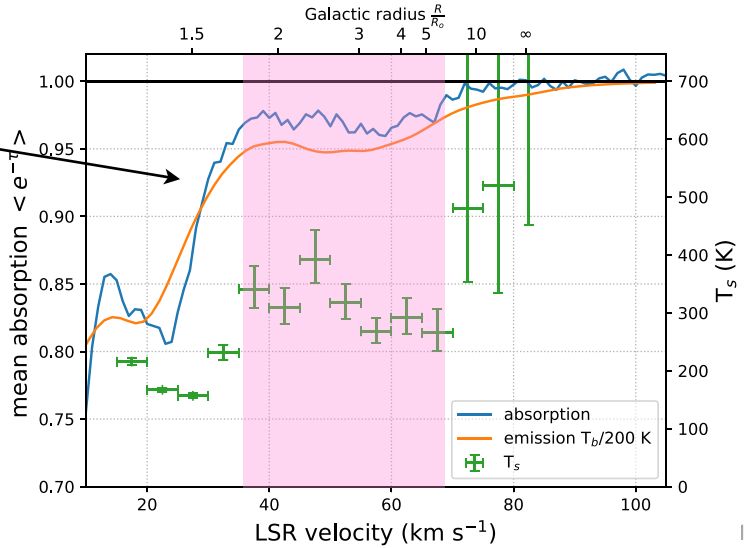
Dickey et al. (2021, submitted)

Comparing integrated HI absorption and emission in the outer Galaxy:

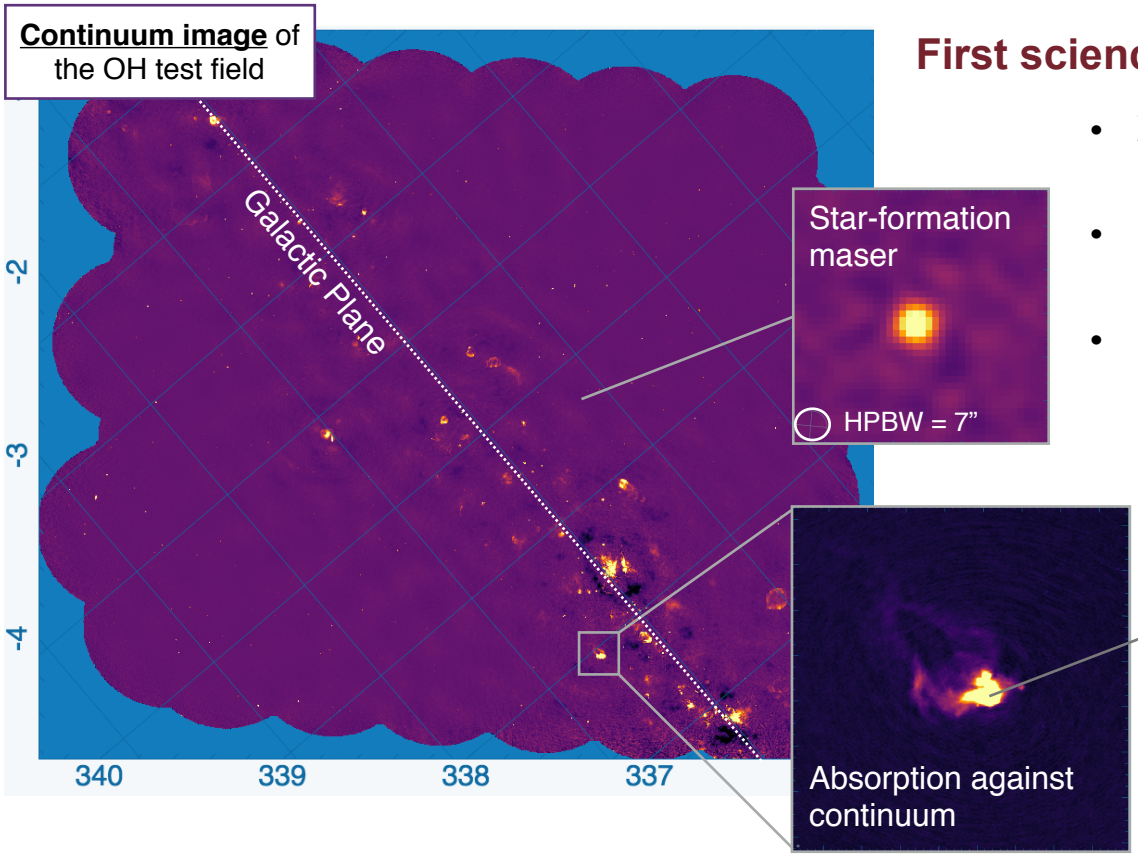
- Cool gas fraction constant with Galactic radius, between R ~ 15-40 kpc.
- Cool clouds (< 50K) present 25 < R < 40 kpc

Averaged emission and absorption spectra across whole field

T_S defined from ratio of emission/ absorption → measure of cool gas fraction

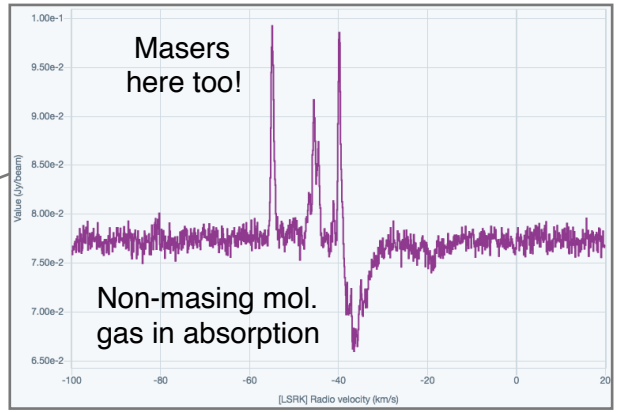


First OH Test Field

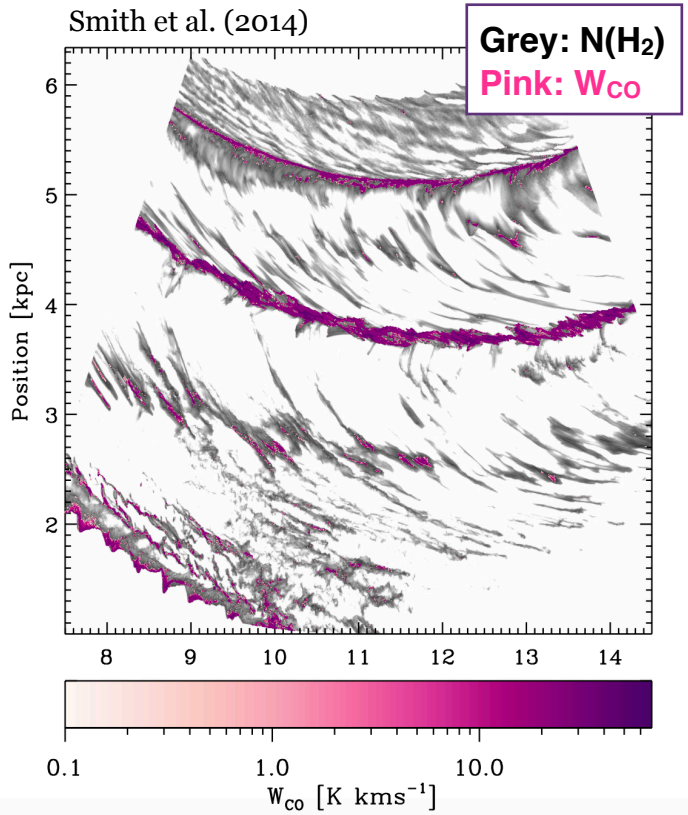


First science-quality OH test data Sep 2021!

- Masers (star formation, evolved stars, SNRs) + OH absorption (mol. clouds)
- Pushing limits of the system: 0.1 kms^{-1} channels, <10” spatial resolution.
- Single footprint = 4 TB datacube 😱
  - Presents some challenges...

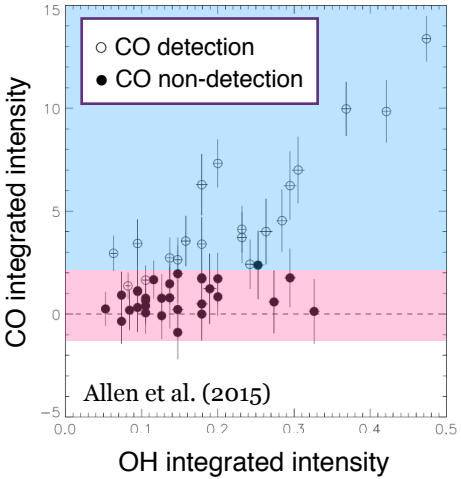


OH: Tracing Diffuse (CO-dark) H_2

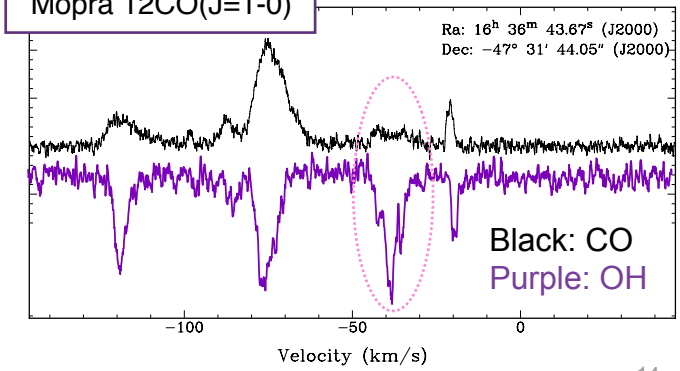


OH is detectable in diffuse molecular regions where CO is dissociated.

- How much of the Milky Way's H_2 is invisible in CO? 10-50%? More? (Grenier et al. 2005, Langer et al. 2013, Busch et al. 2021).
- Can we characterise this ISM phase throughout the MW?



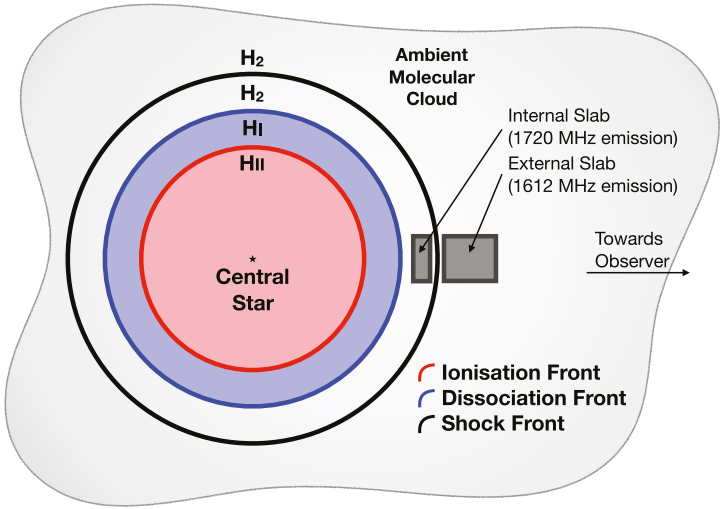
Very preliminary!
GASKAP OH vs
Mopra 12CO(J=1-0)

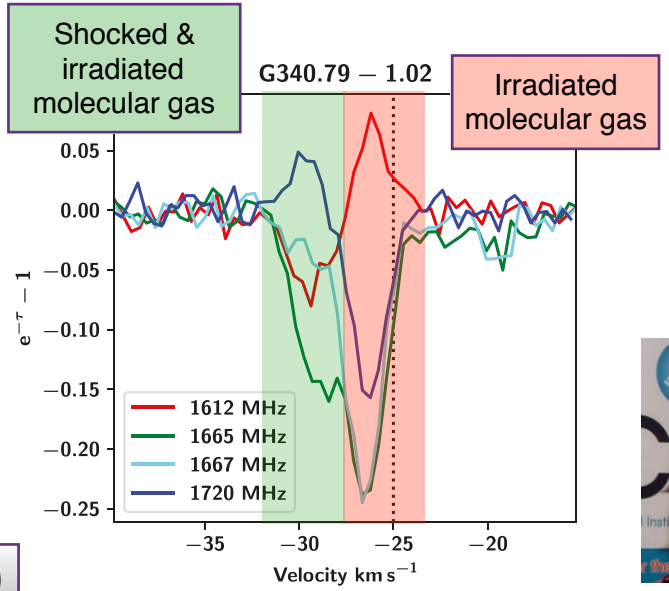


OH: Modelling for Gas Physics

OH lines encode information about physics and environment of molecular ISM

- Non-LTE modelling of OH line ratios gives: kinetic temperature, density, local IR radiation field…
- Can peculiar OH line profiles probe HII region feedback? We think so!

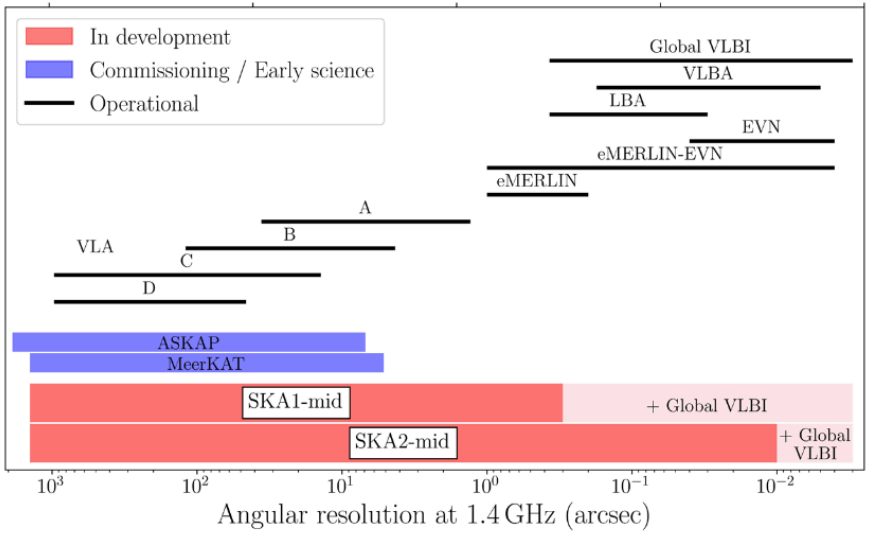




Petzler et al. (2020)

Looking Forward to SKA1-Mid

- 10 x the collecting area of ASKAP.
- Up to ~0.4 arcsec resolution.
- SKA-Mid will be a Milky Way gas survey machine!
- Match to resolutions of ALMA, Spitzer, etc



Summary

(G)ASKAP is producing great images of HI & OH in the Milky Way and Magellanic System & improving our understanding of their evolution through their ISM:

- Pilot HI data from the SMC:
  - Feedback-driven outflows and gas depletion.
  - Hierarchical, self-similar gas structure down to 10pc.
  - Refined measurements of the cold gas fraction.
- Pilot HI data from the Milky Way:
  - Cold gas extending up to R~40 kpc
- First OH data is looking excellent!
  - Watch this space for first discoveries