Deep Space Exploration Society Science Meeting

December 27, 2021

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DSES.science

Christmas Comet (Leonard)

DSES Information

- James Webb Space Telescope launched 12/25. On it’s way to L2
- SuperSID Status: Collecting & porting data to Stanford Solar Center
  - http://sid.stanford.edu/database-browser/ Search for monitor # 9329
- Haswell Radio Jove – Check it out! TeamViewer ID 615 330 992
- 15 pulsars detected so far at Haswell
  - 13 in 2020 (408 MHz): B0329+54, B0531+21 (Crab), B0740-28, B0833-45 (Vela), B0950+08, B1133+16, B1508+55, B1642-03, B1749-28, B1929+10, B1933+16, B1946+35, B2016+28
  - 2 in 2021 (1420 MHz): B1641-45, B2021+51
  - 1296 MHz:

Citizen Science

- HamSCI Dec. 2021 Antarctic solar eclipse: https://hamsci.org
  - AD0CY recorded WWV Doppler data at 5, 10 MHz Dec. 1-10
- Einstein@Home: Searching for gamma-ray pulsars in Fermi LAT data
  - Contributed 1.6 quintillion floating-point operations since 11/13/2021
- Zooniverse (AI pattern recognition algorithms need human help):
  - Search for variable radio sources from MeerKAT (next chart)
    - https://www.zooniverse.org/projects/alex-andersson/bursts-from-space-meerkat
  - Identify FRB's from CHIME
    - https://www.zooniverse.org/projects/mikewalmsley/bursts-from-space
  - Identify gravity waves from LIGO
    - https://www.zooniverse.org/projects/zooniverse/gravity-spy

MeerKAT: Identify Bursts from Space

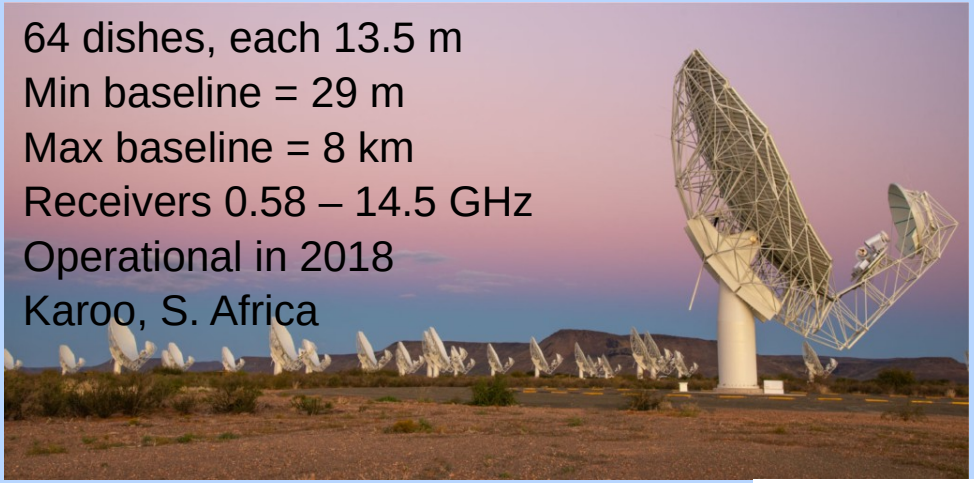
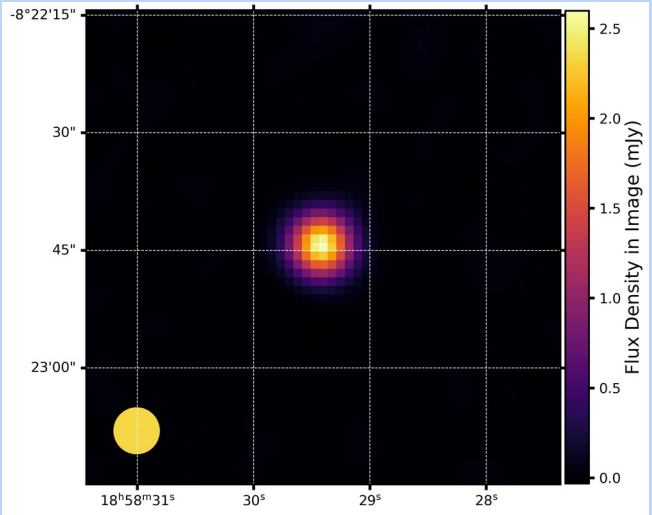
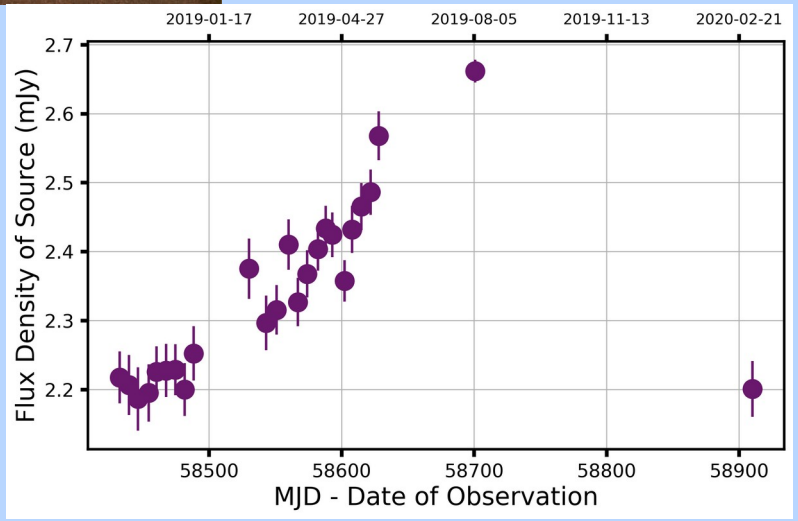


Image of radio source



You can help identify sources as stable or transient (variable)

Light curve = brightness over time



Possible Feed Schedule

Dates	Observation Plans
Oct – Dec 2021	1296 MHz feed for EME and pulsars
Jan – Feb 2022	1420 MHz feed for pulsar and HI observation
March – May 2022	408 MHz feed for Japanese amateur moon lander & pulsars (dates depend on Artemis 1 SLS launch)
June – Oct 2022	1420 MHz feed for pulsar and HI observation

Observation / Calibration Goals

- Measure actual dish diameter (D), depth (d) and focal length (f)
  - Original design specified D = 60’, f = 25’, d = 9’, f/D = 0.42
- Observation goals
  - Perform HI raster scans and spectral line studies
  - Pulsars: Periodically observe the same pulsar
    - Measure spin-down rate
    - Monitor pulse profiles for shape changes
    - Compare pulse profiles at different frequencies
- Calibration goals: Determine T_{sys} (to report absolute measurements)
  - Try 21 cm absorber and/or noise diode in 1420 feed horn
  - Try S7 calibrator with Radiometer equation (April 2020 SARA Journal)

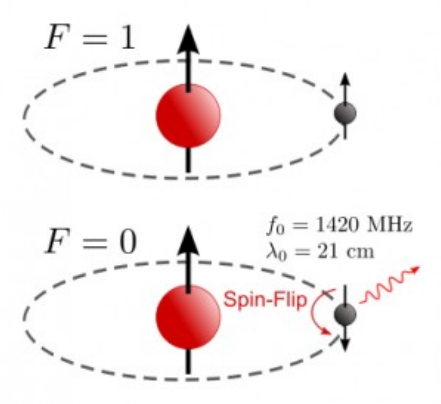
Observing
21 cm Neutral Hydrogen (HI)
High Velocity Clouds (HVC)

References:
“Spectral Observations”, Wolfgang Herrmann, SARA Journal, April 2017
“High-Velocity Clouds” Van Woerden, et al, Kluwer Academic Press, 2004
“Amateur radio astronomy 21 cm hydrogen survey of M31 and M33 galaxies”
Jean-Jacques Maintoux – F1EHN, 2018

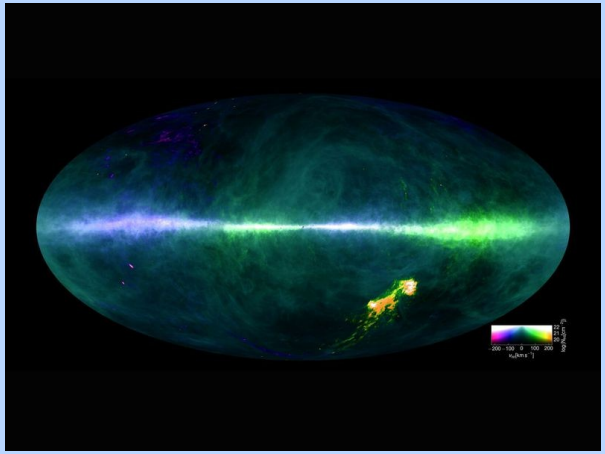
Deep Space Exploration Society

21 cm Neutral Hydrogen (HI)

- Hydrogen is the most abundant element in the universe
- Neutral hydrogen gas is main component of interstellar medium
- Observe 21 cm spectral line to map bright objects and Milky Way



Spin-flip transition produces
a 21-cm photon (1420.4 MHz)



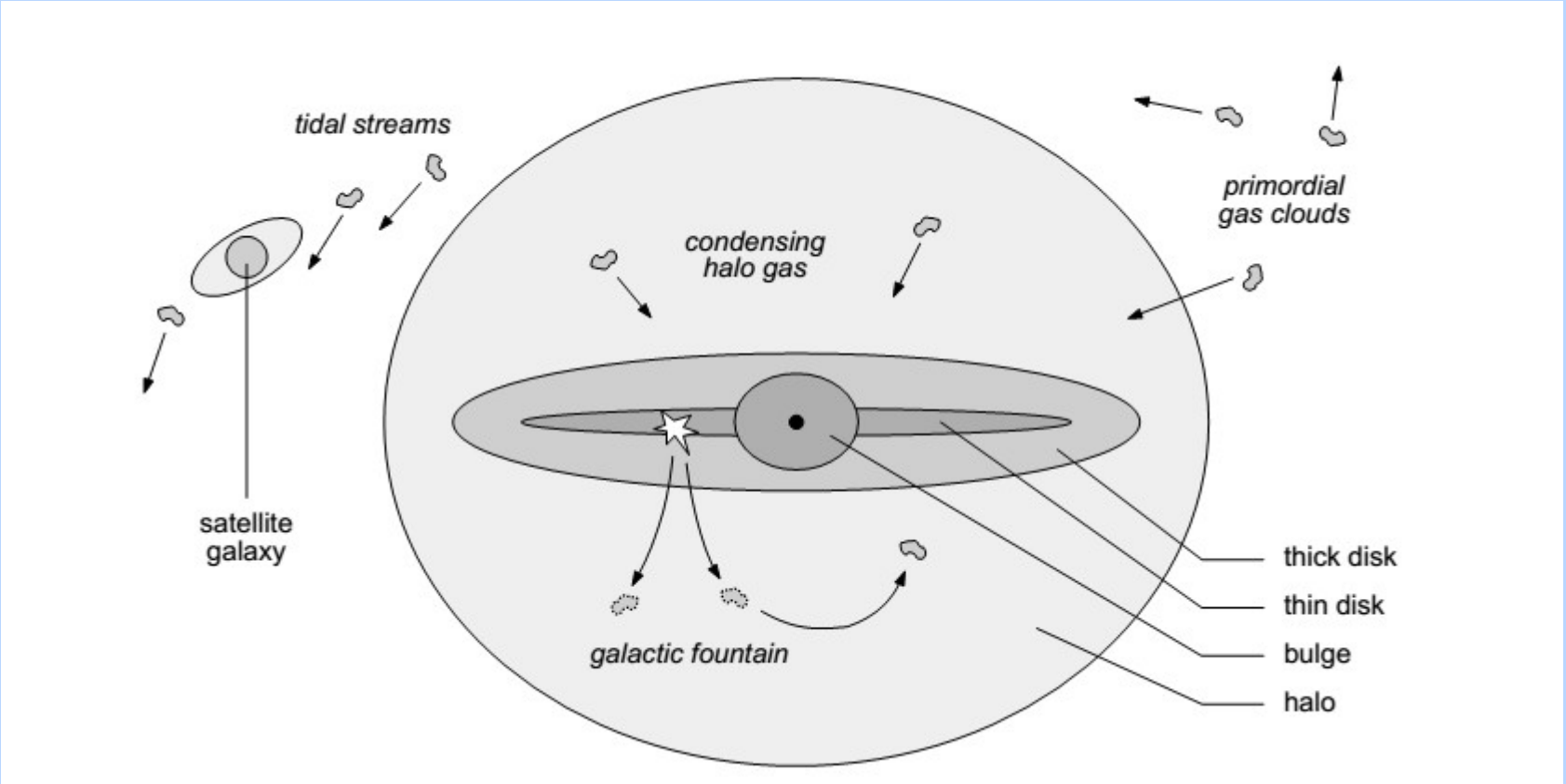
21-cm all sky map of neutral hydrogen.
The Milky Way is the bright band in center

What Are HVC's?

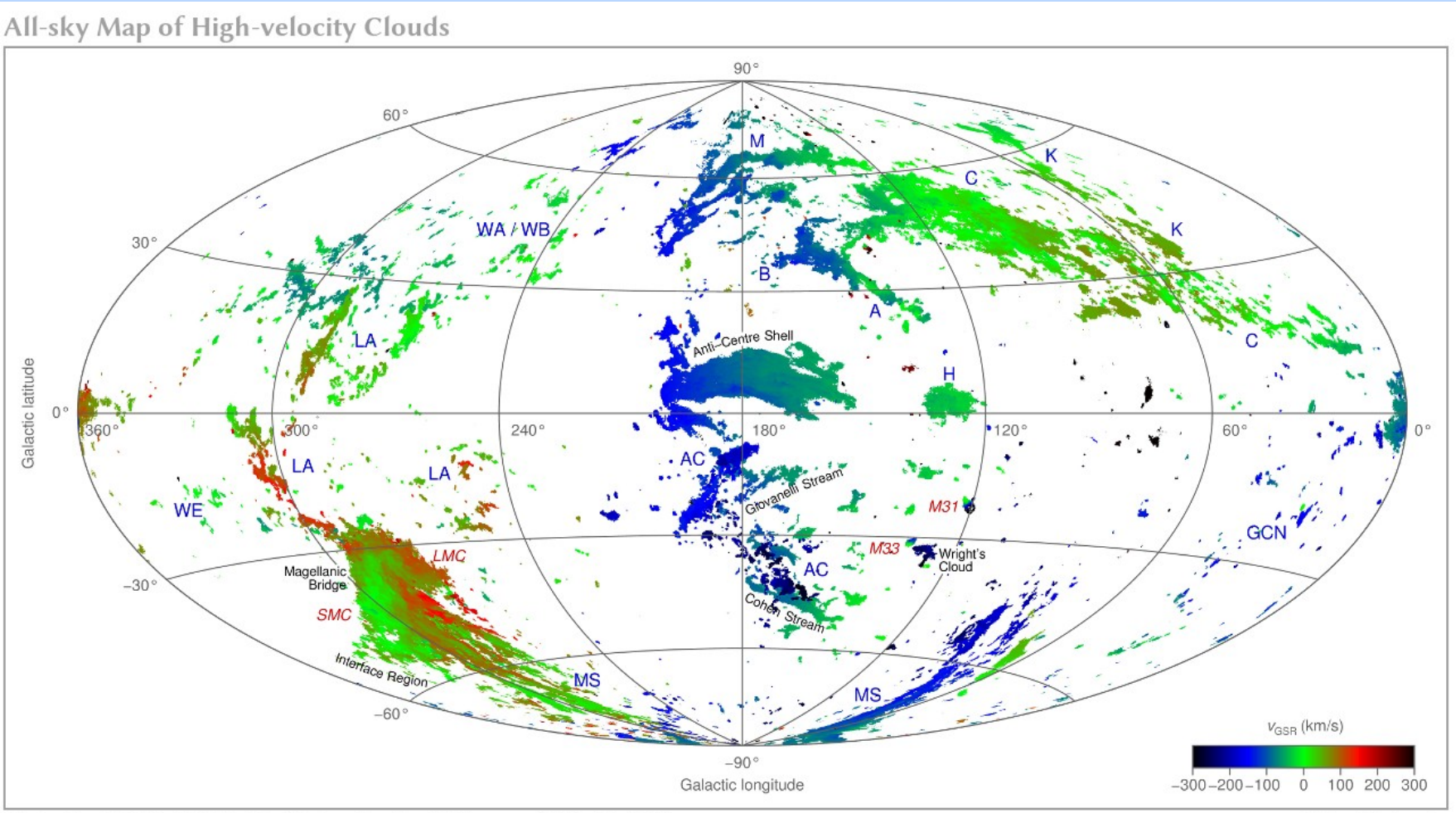
- Cold, dense pockets of gas outside the galactic plane moving at high speeds (> ± 100 km/s) relative to the average motion of local stars in the Milky Way
- Usually blue-shifted. First observed in mid-1950s, and located in 1963
- HVC's appear to "fall" into the Milky Way from different directions
- HVC's are faint; so far only observed in Local Group of galaxies
  - In 2013 the 300' GBT confirmed HVC's between and around M31 and M33
  - Streaming (or tidal) HVC's have been observed between Magellanic dwarf galaxies
- To maintain their observed level of star formation, spiral galaxies must acquire new gas, possibly coming from intergalactic hydrogen

Potential Origins of HVC's

- Material ejected by supernova falling back
- Clouds of intergalactic material attracted by gravity
- Condensing gas in galactic halo



Where Are HVC's?



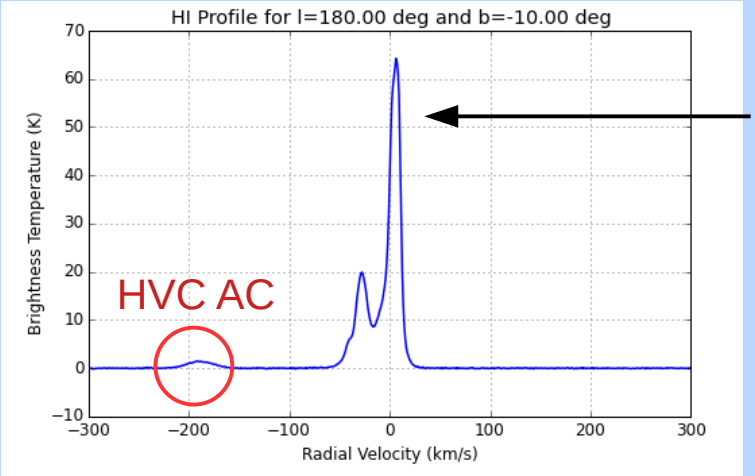
HVC Observation Plans

- 60’ dish (smaller dishes work also) with 1420 MHz feed
- B210 SDR at 5 MHz bandwidth (Airspy only has 2.5, 10)
- Astro-virgo 3.8 Radio Spectrometer (GnuRadio, python)
- Use Local Standard of Rest (LSR) to correct observed Doppler shift of 21 cm HI
  - LSR is defined as the velocity of a circular orbit at the Solar radius from the Galactic center (= average motion of local group of stars)
  - Using kinematic LSR correction from AstroPy 4.2

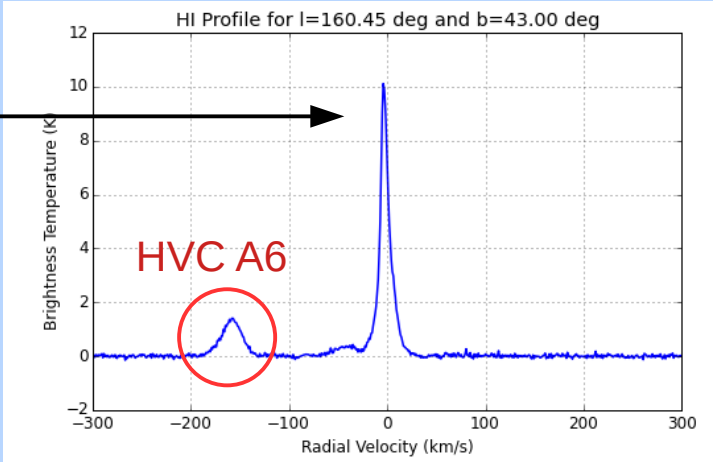
Confirming Spectral Observations

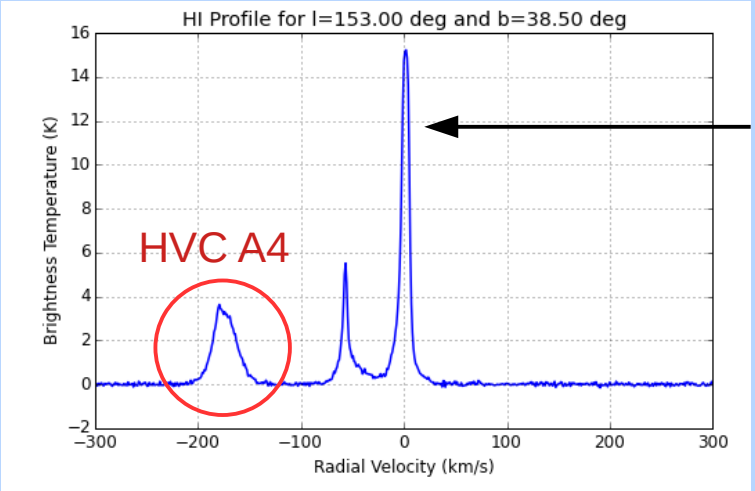
- Calibrate the data:
  - Subtract cold background sky and apply LSR correction (astro-virgo)
  - Convert relative power to brightness temperature and apply T_{sys} (goals chart)
- Compare observed profiles with published results:
  - HI Leiden/Argentine/Bonn (LAB) Survey of Milky Way (MW) ($\pm$ 400 km/s)
  - https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile/index.php
  - Shows expected MW column of interstellar hydrogen in specified direction, including any bright MW source such as supernova remnants (Crab, Cas A)
  - But, extra-galactic sources with high Doppler shift will not be visible. Cyg A (radio galaxy) HI is red-shifted 17000 km/s = 80 MHz (HI line off the chart!)

4 Predicted HVC LAB HI Profiles

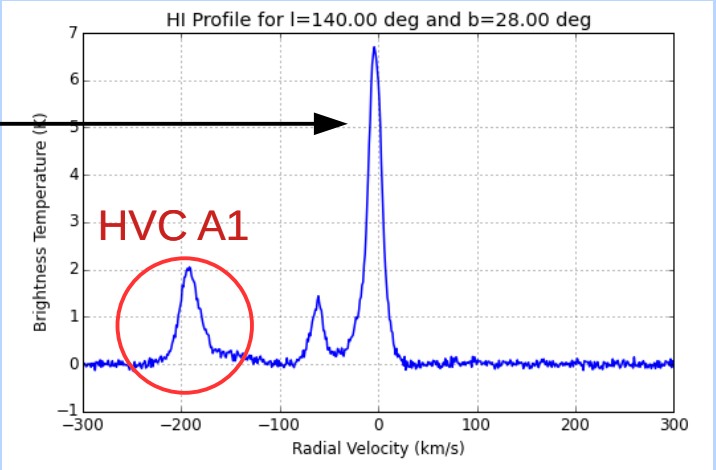


MW HI Column





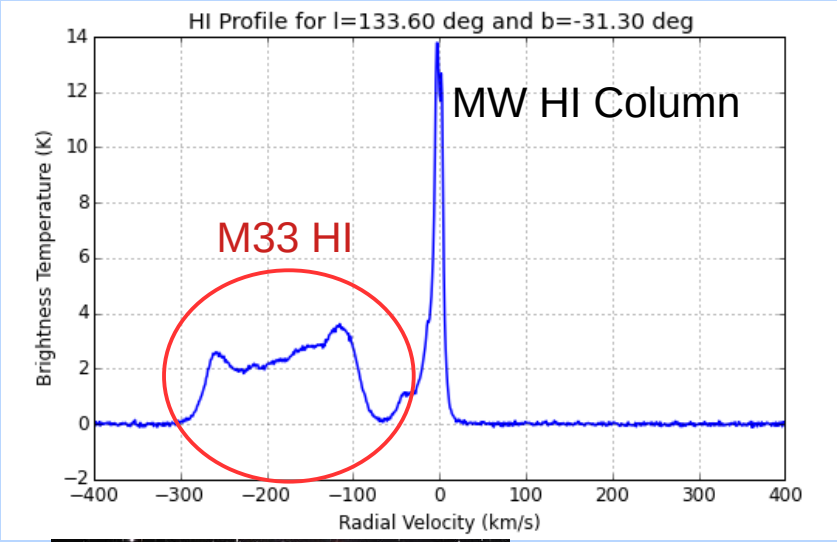
MW HI Column

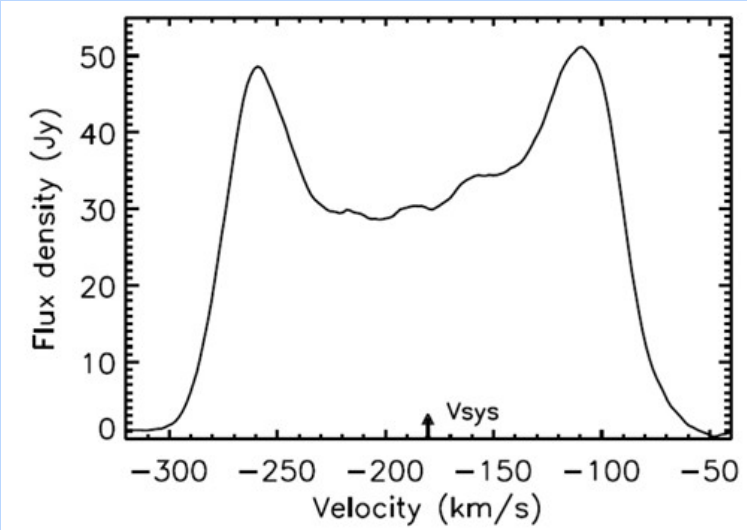


HI Line in M33 Triangulum Galaxy

M33 apparent diameter = 70” x 40” (60’ FWHM FOV = 0.8 deg = 48”)
HI line in spiral galaxies tends to be two-horned

HI LAB prediction

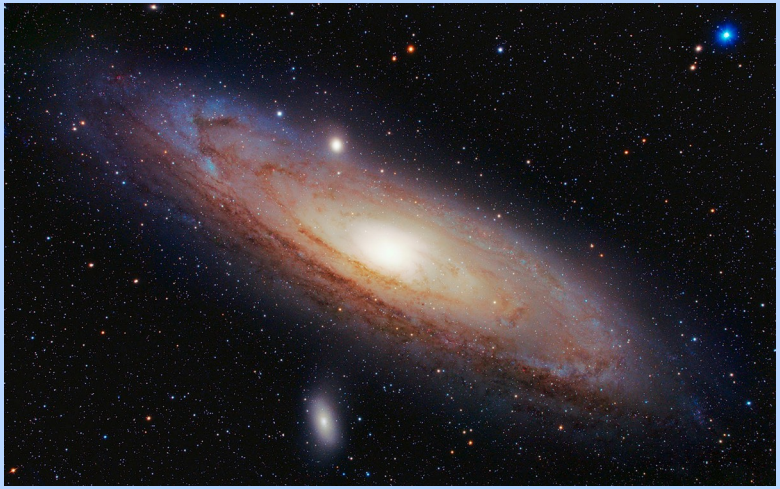




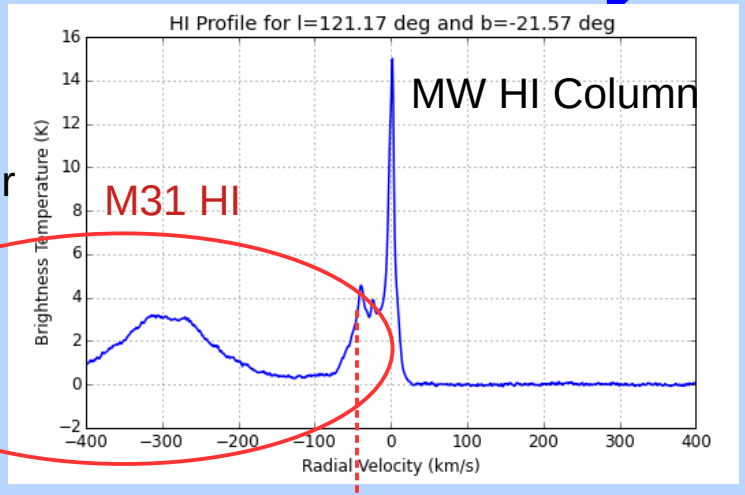
S. Z. Kam, C. Carignan, L. Chemin, T. Foster, E. Elson, T. H. Jarrett, “H I kinematics and mass distribution of Messier 33” https://arxiv.org/pdf/1503.02538

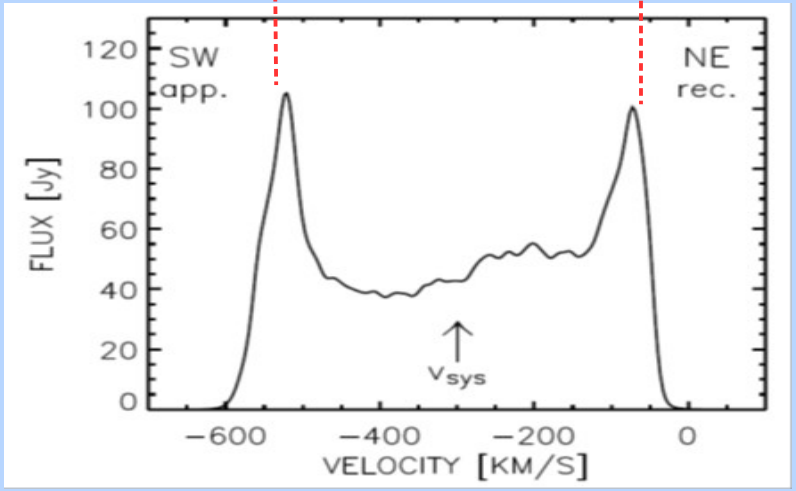
HI Line in M31 Andromeda Galaxy

M31 apparent diameter = 190” x 60”
Too large for single scan. Use grid



HI LAB prediction at M31 center





M31 HI profile. Vsys = -300 km/s, Velocity at M31 center

Laurent Chemin, Claude Carignan and Tyler Foster
“H I kinematics and dynamics of Messier 31”
https://arxiv.org/pdf/0909.3846v1

Questions?

Next Meeting: Interferometry