The Completely Hackable Amateur Radio Telescope (CHART)
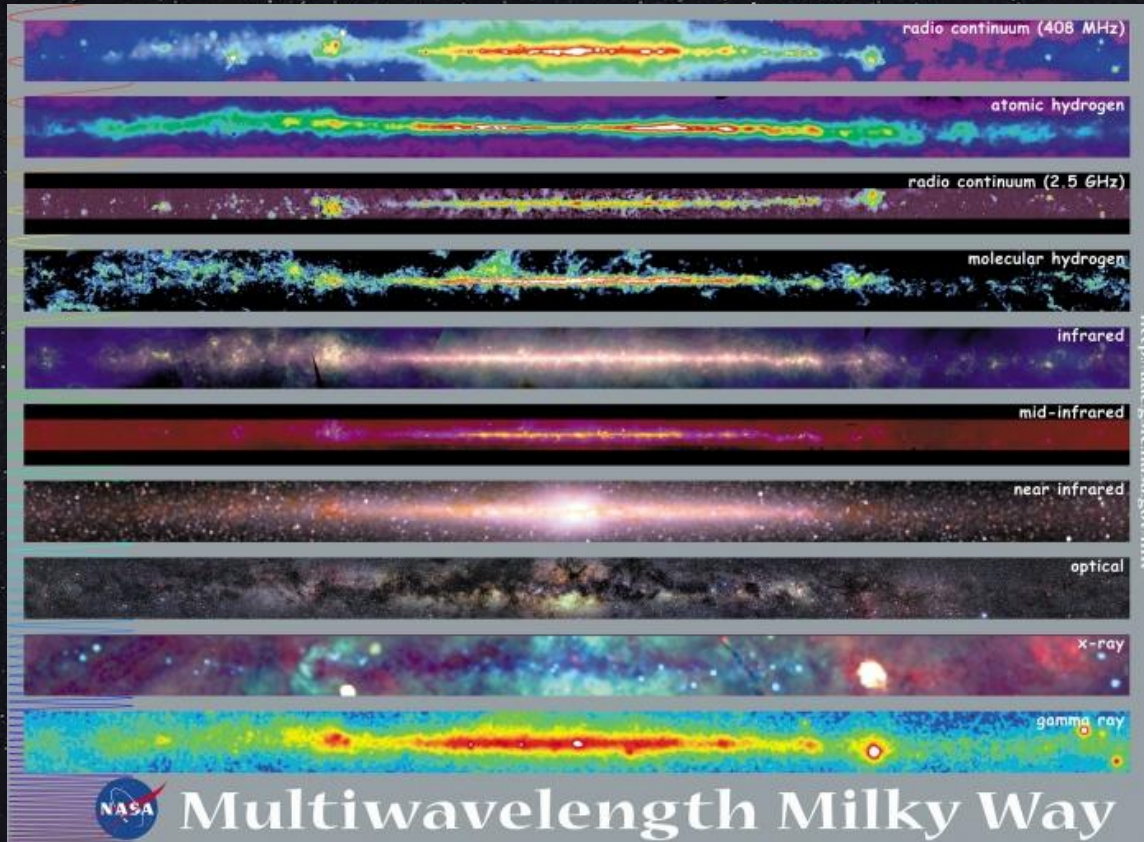
Libby Berkhout, GRCON 2023

Project Overview
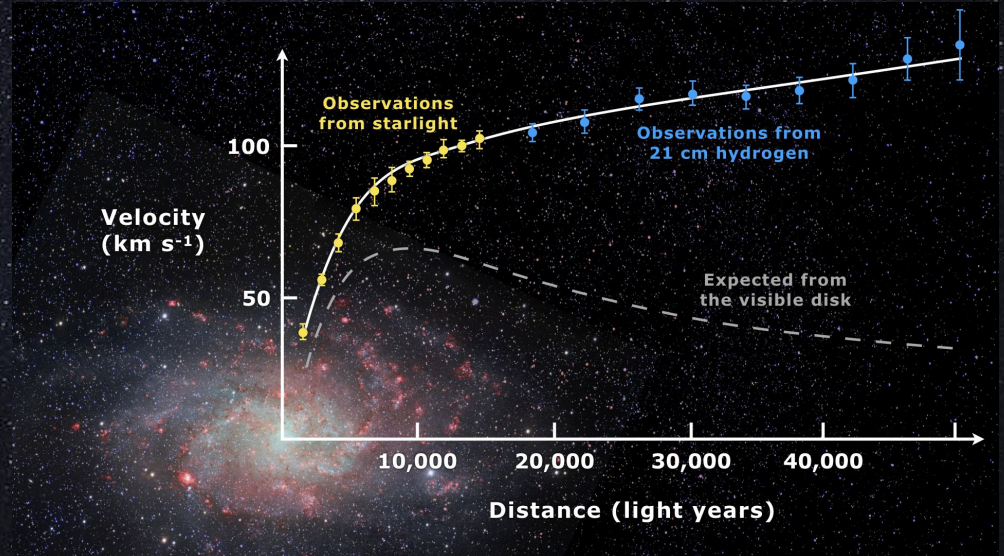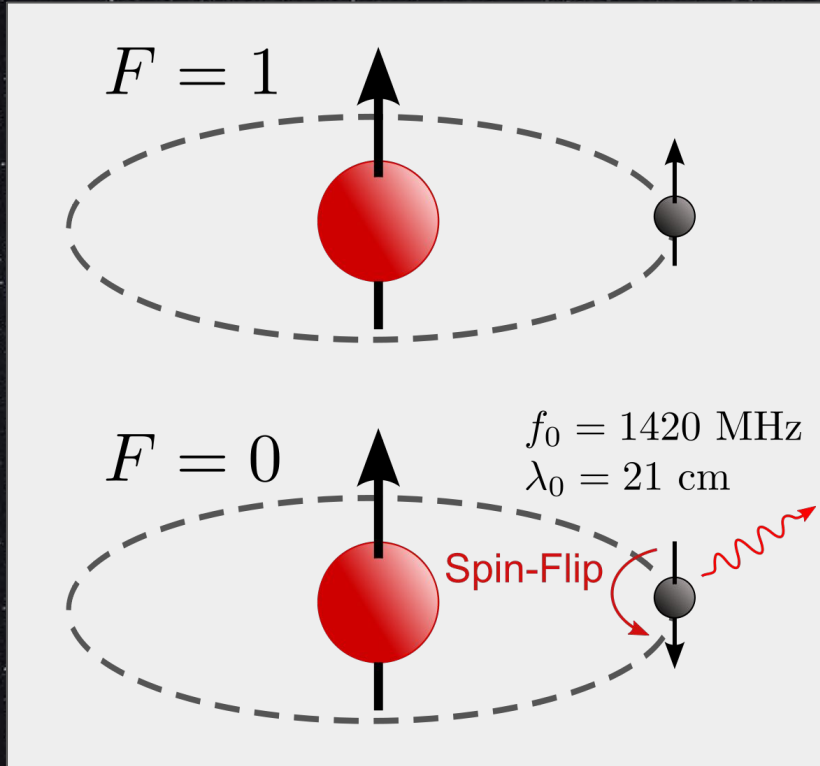
- A low cost, open source platform for radio astronomy
  - "Platform" includes the full pipeline from learning about the astronomy, to setting up the system, to analyzing the data!
- Targeted at secondary school and undergraduate educators
- Undergraduate students take ownership of the development and testing
- See next talk for GNURadio involvement!

Why do Radio Astronomy in Secondary School?

Multiwavelength Milky Way

- radio continuum (408 MHz)
- atomic hydrogen
- radio continuum (2.5 GHz)
- molecular hydrogen
- infrared
- mid-infrared
- near infrared
- optical
- x-ray
- gamma ray

http://adc.gsfc.nasa.gov/mw

NASA

https://www.e-education.psu.edu/astro801/content/l8_p6.html

- Optical astronomy is more traditional
- Different wavelengths = different information
- Backyard Optical Telescopes are limited, both in scientific information and visibility
- Radio telescopes still have limitations, but clear scientific measurements can be made in cities, during school hours!

21 cm Milky Way

$F = 1$

$F = 0$

$f_0 = 1420$ MHz
$\lambda_0 = 21$ cm

Spin-Flip

Observations from starlight

Observations from 21 cm hydrogen

Velocity (km s^{-1})

100

50

Expected from the visible disk

10,000   20,000   30,000   40,000
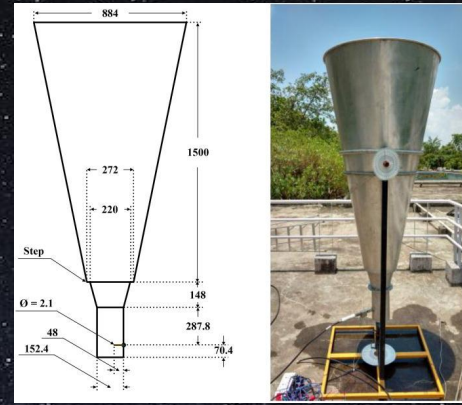
Distance (light years)

M33 Rotation Curve

Similar Projects

DSPIRA

Physics Open Lab
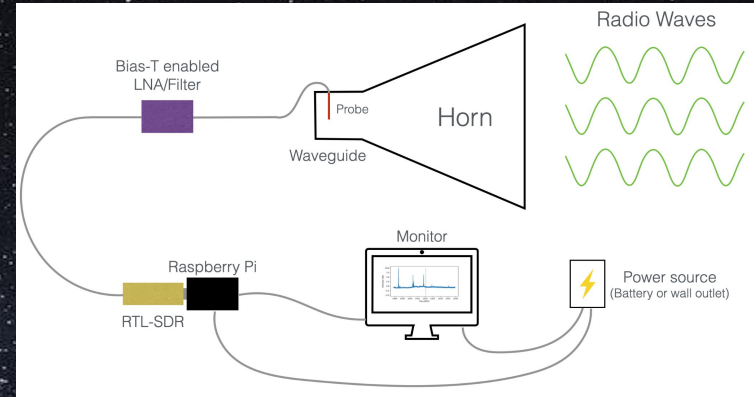

BHARAT (Mhaske 2022)

PICTOR

- Many projects, many focuses
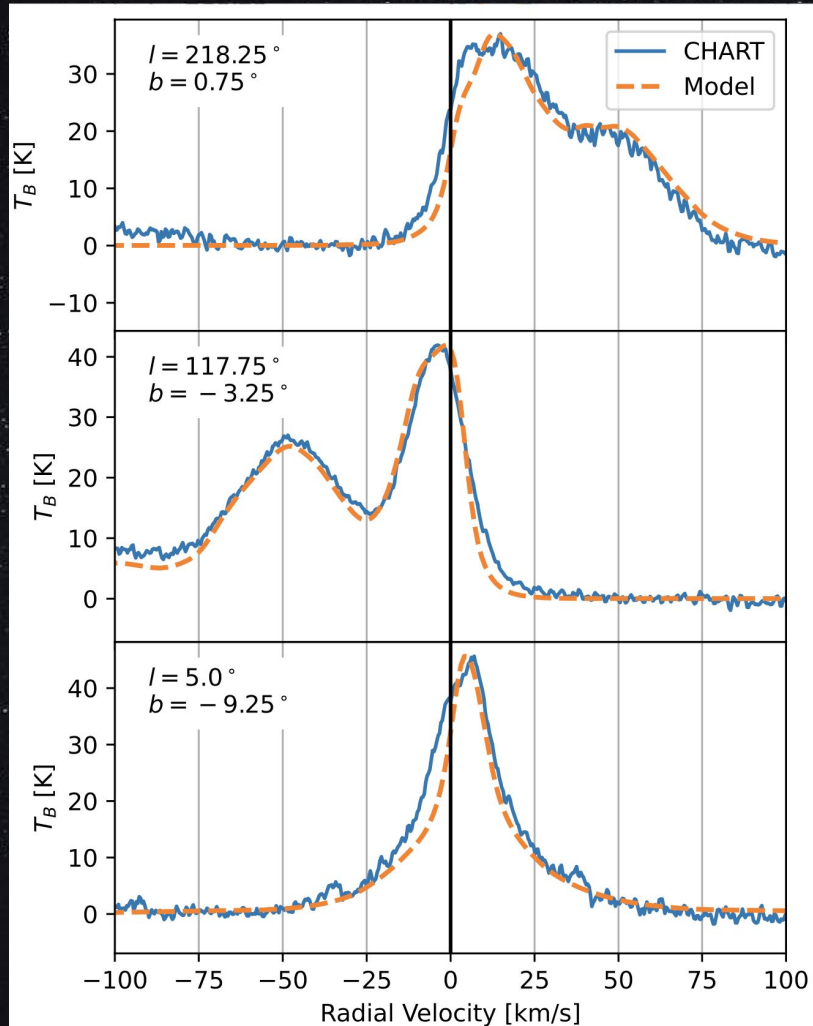- We focus on complete system and low entry barrier

Base System

PART	COST
Horn	~$30
LNA/Filter	$40
RTL-SDR	$34
R-PI	$70
Monitor	$42
Cables and Connectors	$30
Total	$246

- Modularized and easy to swap out components
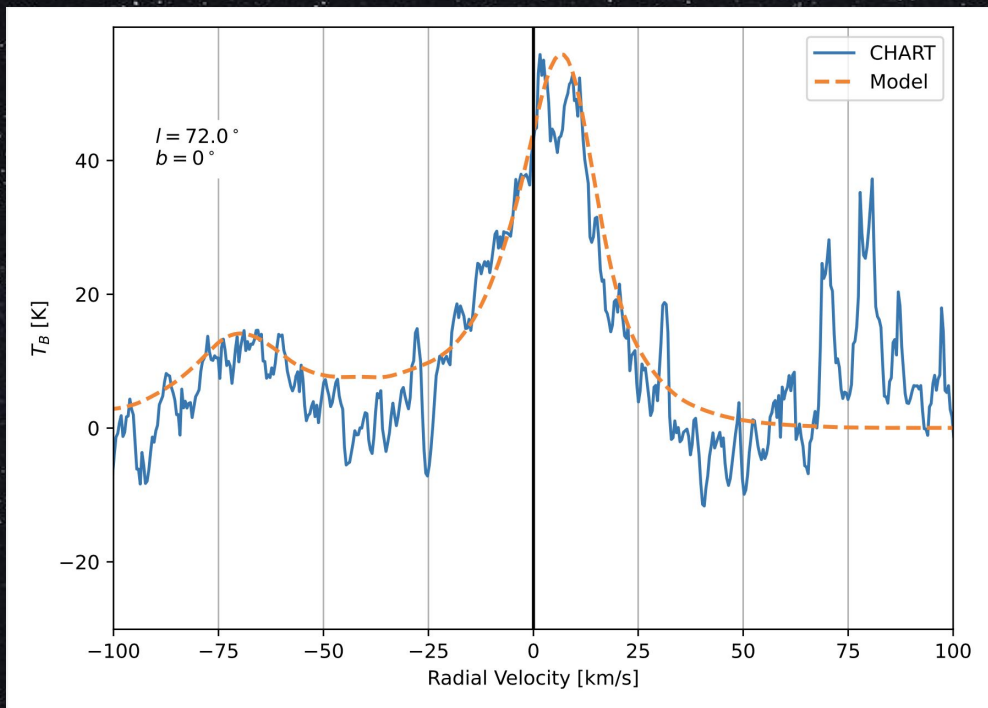
Results from Winona, Minnesota

- Data is bandpass corrected, transformed to VLSR reference frame, and calibrated to a model spectrum from the Leiden/Argentine/Bonn (LAB) survey (Kalberla et al. (2005))
- Likely sources of error: Pointing inaccuracies, beam errors

Web Simulator:
https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile/index.php
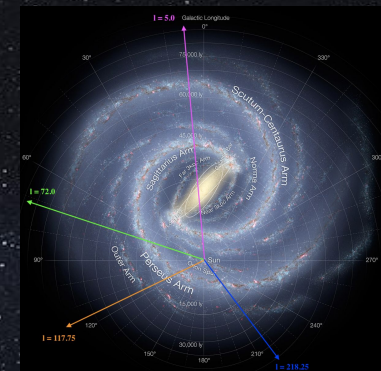
Phoenix, AZ

- RFI heavy test environment, still detects signal!

CHART in the wild!

- Used at undergraduate and high school educator level

Undergrad Bootcamp 2023

ASU Summer 2022 Interns

WSU Teacher Workshop

Spring 2021 RA Course

Contacts

Libby Berkhout (ASU) lmberkhout@asu.edu

Prof. Danny Jacobs (ASU) daniel.c.jacobs@asu.edu

Prof. Adam Beardsley (WSU) adam.beardsley@winona.edu

Website: astrochart.github.io

Github: github.com/astrochart

Paper: Currently on the arXiv, in journal review https://arxiv.org/abs/2307.11173