

Implementing a Horn Radio Telescope in HS Physics and Astronomy



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Outline

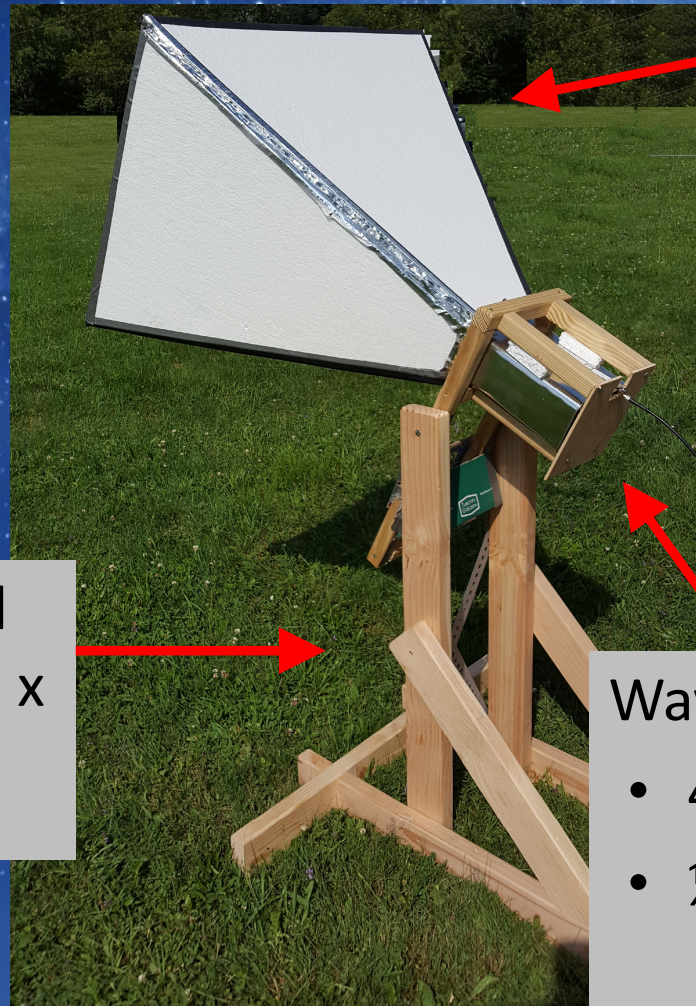
- Introduction
- Design and construction
- Operation and capabilities
- Implementation in the classroom



Introduction – Horn Telescopes

- This talk is the result of 2 summers attending the RET DSPIRA program at WVU and GBO.
- A horn is a metal waveguide that is shaped like a horn at one end and is uniformly shaped at the other end.
- The horn telescopes described here are designed to detect the 21 cm radio waves transmitted by neutral atomic hydrogen (HI) emitted by interstellar hydrogen in the galaxy.

Horn Telescope Design



Horn

- aluminized insulation board
- 60 cm x 75 cm horn opening

Stand - constructed from 2" x 2" and 2" x 4" wood

Waveguide & Antenna

- 4 ½ " x 6 ½ " metal can
- ¼ wave antenna: 5.25 cm

EPS INSULATION

POLYPRO™ BOARD
FOIL FACING with AIR SPACE

1.44	1.93	2.69
2.8	2.8	2.8

SYSTEM R-VALUE

** To obtain the System R-Value there must be
between the foil facing and the exterior cladding
R-Value is equivalent to heat flow.
The higher the R-value the greater the insulating power.

Notice: This insulation sheathing board meets or exceeds the
properties of the American Society of Testing Methods (ASTM)

Installation: Install over exterior studs using a 7/16" cross
plastic cap nail fasteners. Fasteners should be at least
edge and center of sheathing penetrating the stud into
the interior of the sheathing will help keep all from falling
structure. Do not use as a nailing base. Come back.

Warning: Although this product contains a fire retardant,
it is combustible. Keep away from open flames,
heat and electricity. It may burn readily. It should
be adequately protected for a long period of time.
Your local building official for specific rules.

POLYPRO
INSULATION FOAM

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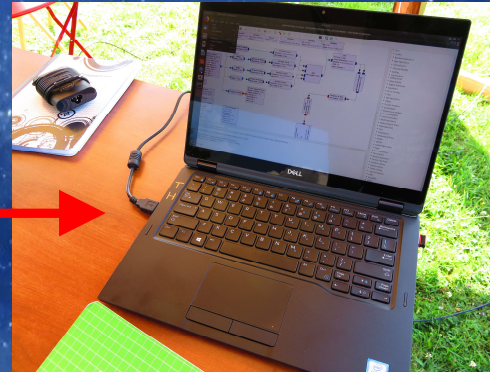
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Low noise amplifier:

- optimized for 21 cm radio waves at 1420.4 MHz
- gain = 50 db
- Stabilized for operation in urban environments



Horn Telescope Operation

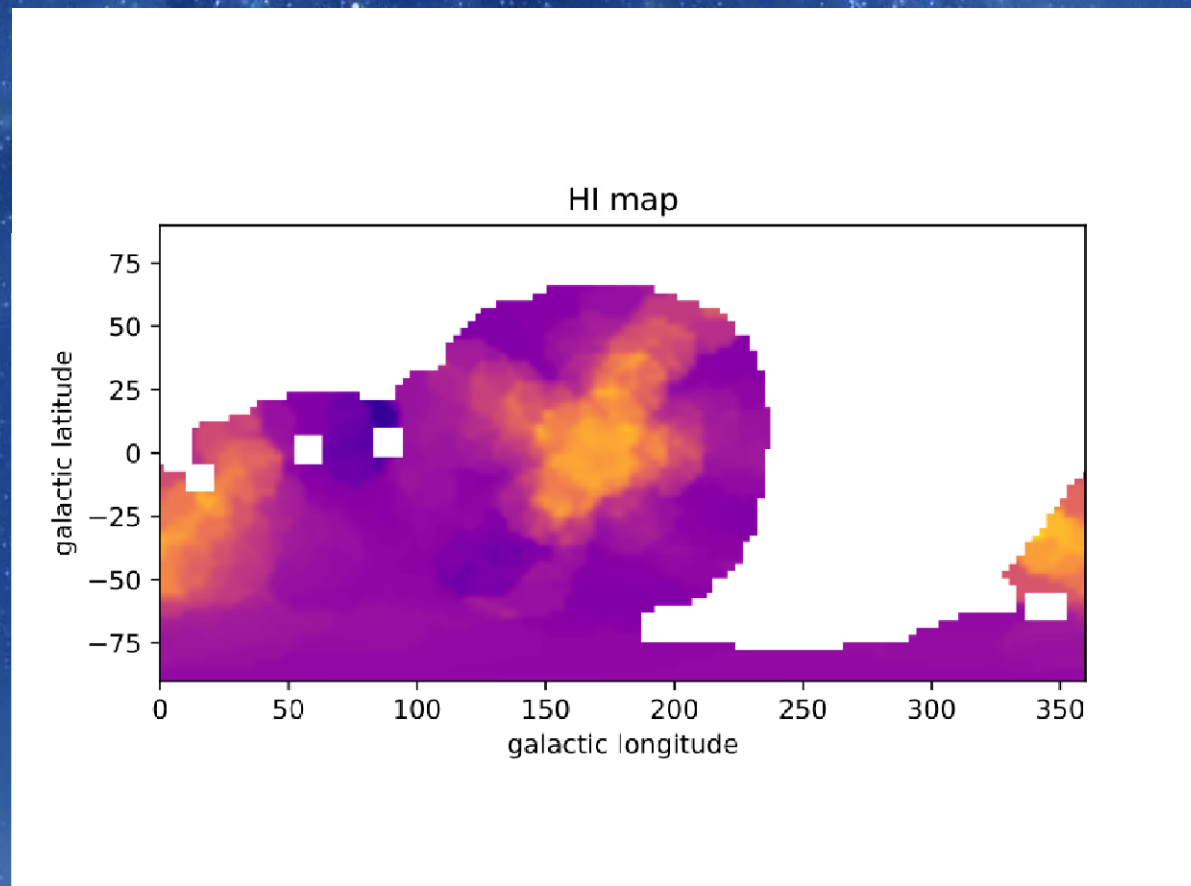


Software Defined Radio (SDR)

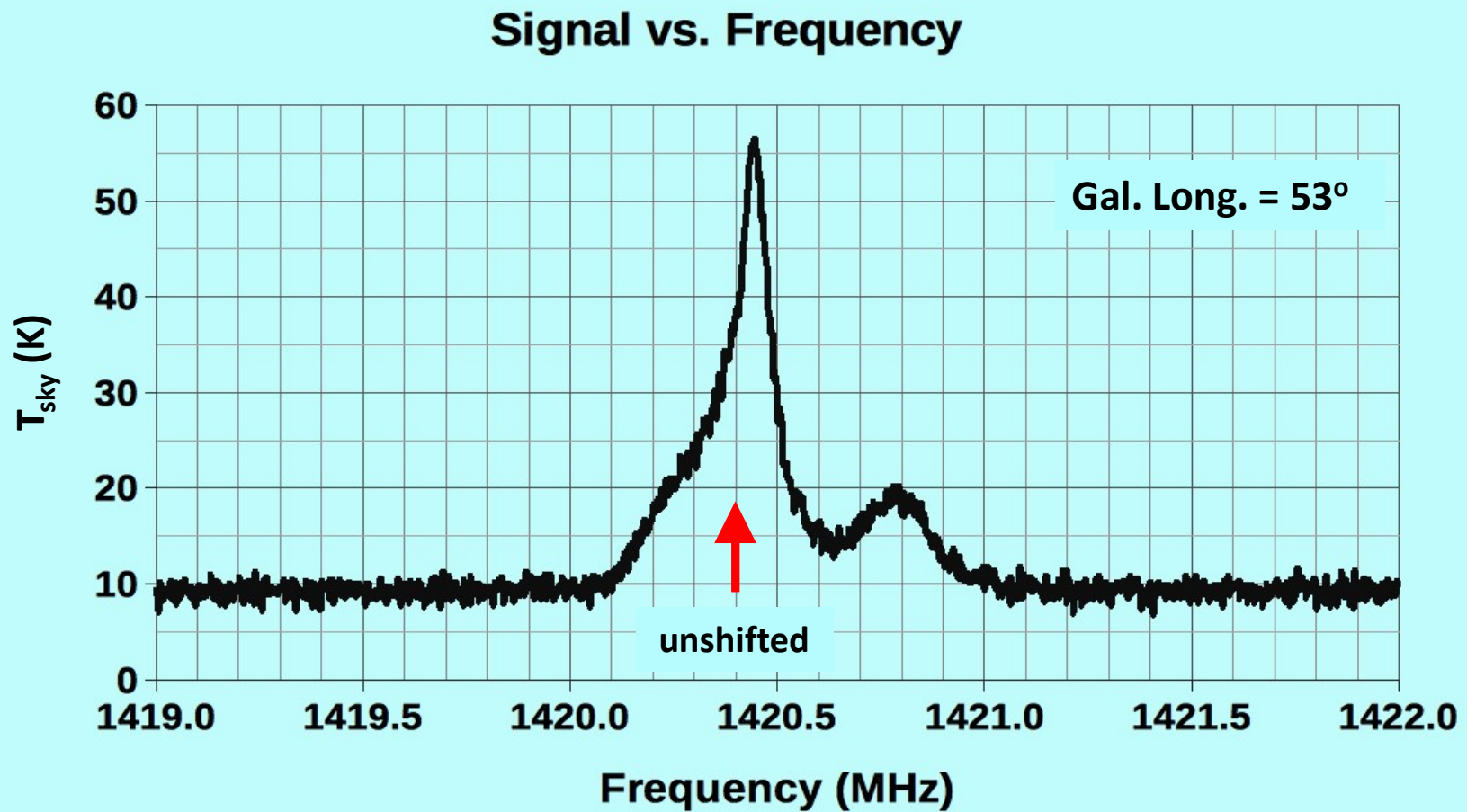
- Airspy radio
 - 24 MHz – 1800 MHz range
 - 10 MHz bandwidth
- Gnuradio program:
 - used to perform the signal processing
 - free & open source

Horn Telescope Performance

- Can detect neutral hydrogen (HI) from the Milky Way Galaxy.

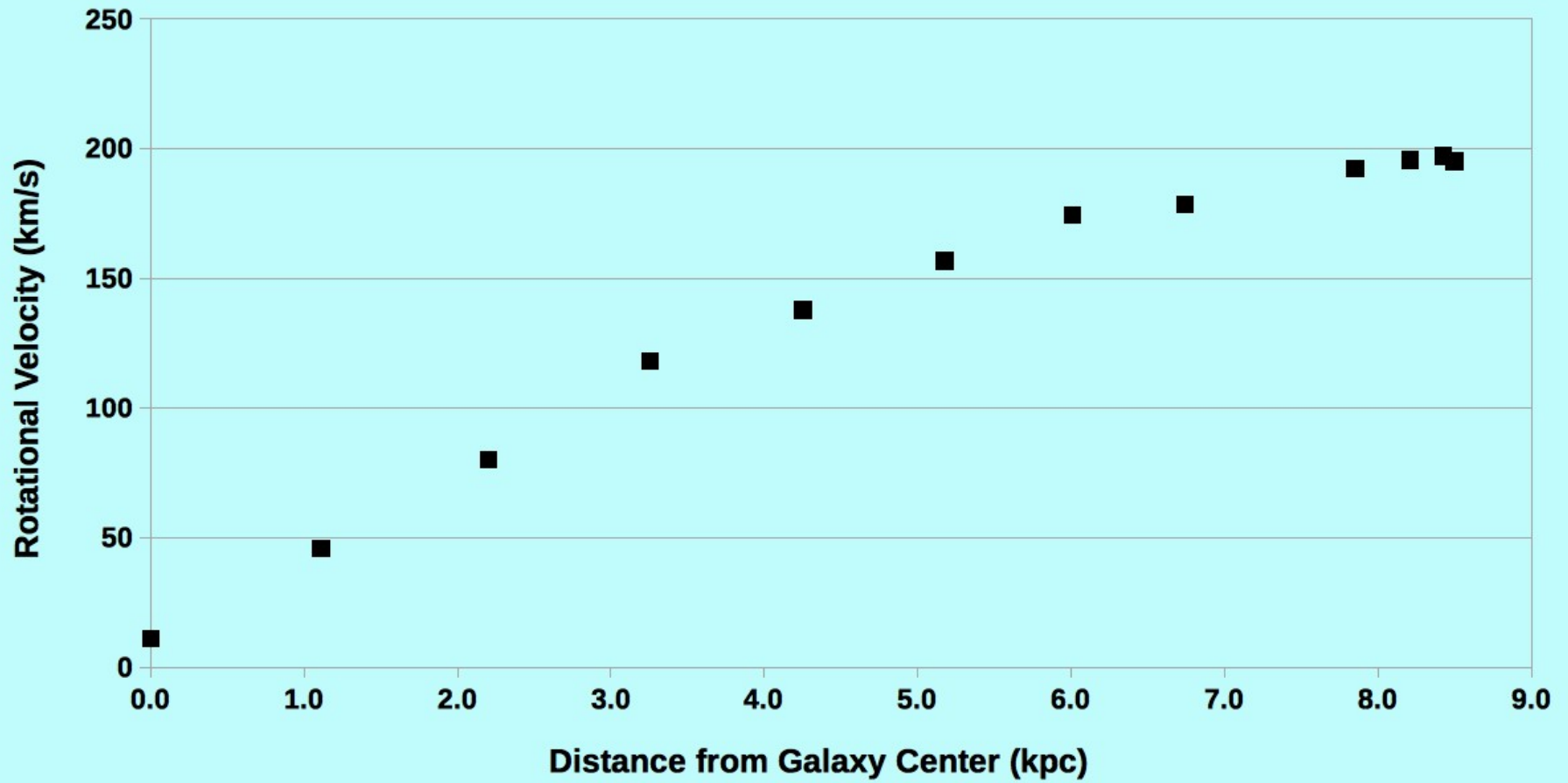


Students can measure the Doppler shift of the hydrogen signal from the expected 1420.4 MHz
→ the MW galaxy is rotating!



MWG Rotation Curve

from horn data 7/26/18



Implementation in the classroom

Utilizing a horn telescope covers many STEM standards:

- Math – in all phases of use
- Engineering & Technology – build/design horns, test/modify cycle
- Computer programming – gnuradio, python
- Astronomy
 - radio waves, EM spectrum, signals, energy
 - telescopes: purpose & design, astronomical measurements
 - structure and motion of galaxies
- Physics
 - Kepler's laws, motions of galaxies, dark matter

Rich in Science Standards

NGSS HS.Space Systems

Horn Telescope Activity	Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Measuring H1 spectrum; determining rotation curve	Developing and using models	ESS1.B – Kepler’s laws, orbits, etc.	Scale, Proportion, and Quantity
	Using mathematical and computational thinking	PS4.B – EM Radiation	Interdependence of Science, Engineering, and Technology
	Constructing Explanations and Designing Solutions		Scientific Knowledge Assumes an Order and Consistency in Natural Systems
	Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena		

SUMMARY

Horn telescopes offer:

- Rich STEM experience for students
- Hands-on science – learn by doing
- Ability for students to develop and/or test models of nature
- Ability for students to experience a part of the world of digital signals

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RET DSPIRA PROGRAM

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