Bringing the Invisible Universe
into the Classroom

Designing an Educational Radio Telescope and Developing an Innovative Science Curriculum for Schools



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Background and Current Status of Astronomy Education in Schools

- Observation and experimental activities in the field of astronomy are less frequently practictical activities in schools.
- The curriculum heavily emphasizes "classical" astronomical topics.

How can we make modern astronomy accessible in a school environment?

- Learning the latest cosmological views is more than just knowledge acquisition. It inspires interest in science and fosters the acceptance of diverse perspective. Modern astronomy serves as a crucial foundation for developing the competencies and skills necessary for children to survive in the new era.

Why Astronomy is Hard to Teach in Schools

- Saito (2009): Survey of 323 junior high school teachers in miyagi prefectures – many textbook activities are rarely conducted.

10 items with the lowest practice rates out of 64 textbook activities.

5 of the 10 most difficult items = the field of astronomy

The remaining difficult items were mostly concentrated in the field of geoscience (Earth science).

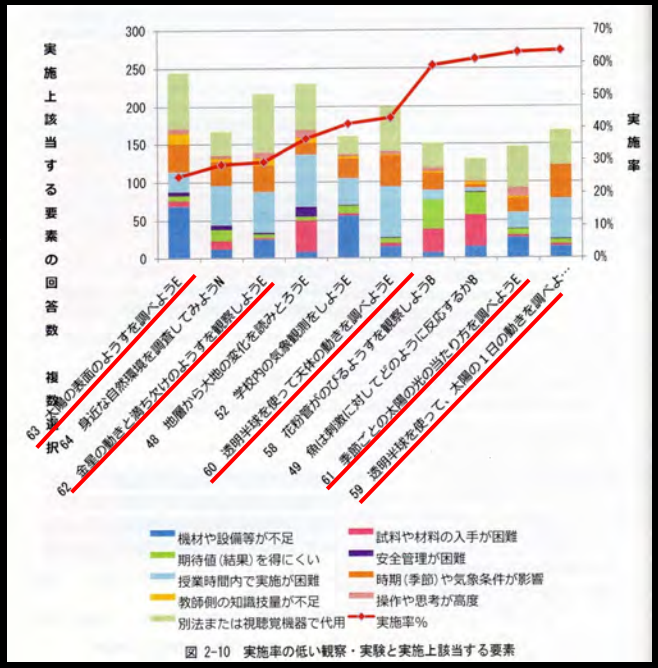


図 2-10 実施率の低い観察・実験と実施上該当する要素

Key Reasons for Instructional Difficult

- Lack of equipment suitable for observations
- Weather dependence and seasonal restrictions
- Limited class time for experiments

Accessible Radio Astronomy with Commercial Parts

Software Defined Radio (SDR)

The amplified signal (analogue signal) is sampled at high speed and converted into a digital signal (Analogue-to-Digital Converter; ADC).

- Various signal processing operations are performed on the digitised signal (Digital Signal Processor; DSP).



Development of a Radio Astronomy Observation System Capable of Observing HI(atomic hydrogen)

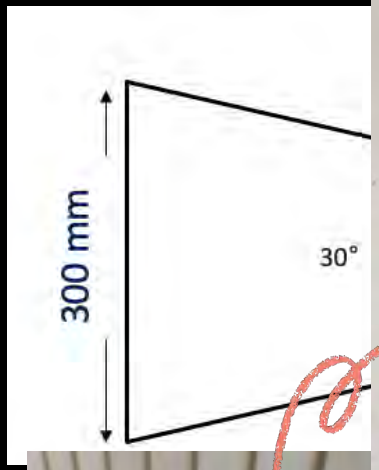
Construction of a Radio Astronomy Learning Programme for Schools, Adapted for Learners at Various Levels

Concept: Accessible Radio Astronomy for Schools

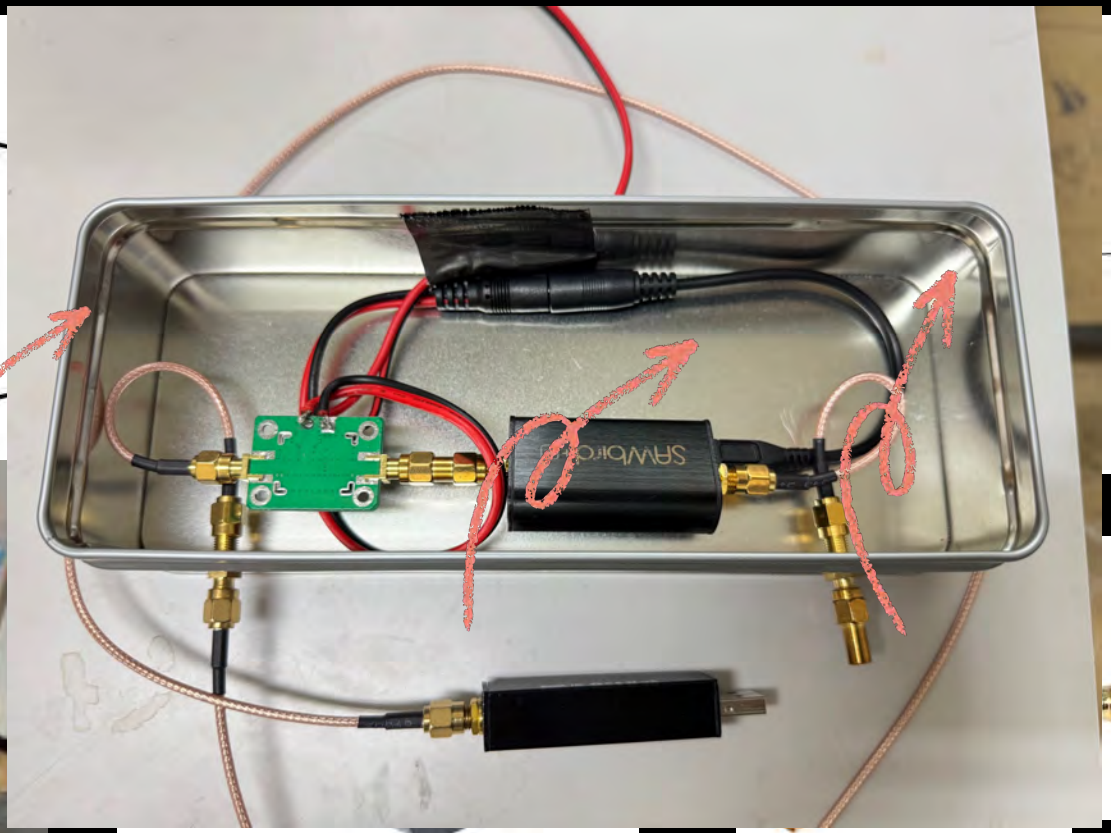
- Affordable components allow students to observe the 21-cm HI line (neutral atomic hydrogen)
- System designed for hands-on use by junior high school students
- Aims to provide authentic research experiences using real data

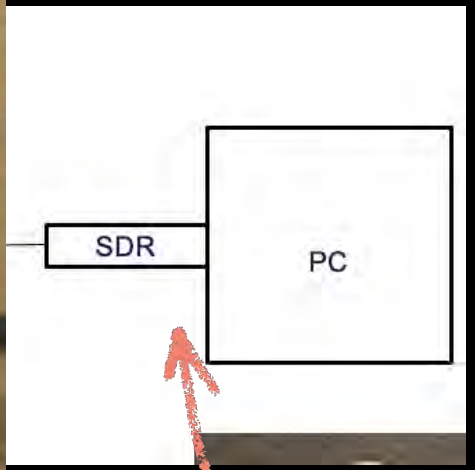
System Overview

- Antenna → LNA → SDR → PC (Python interface)
- All components available commercially (Amazon, etc.)



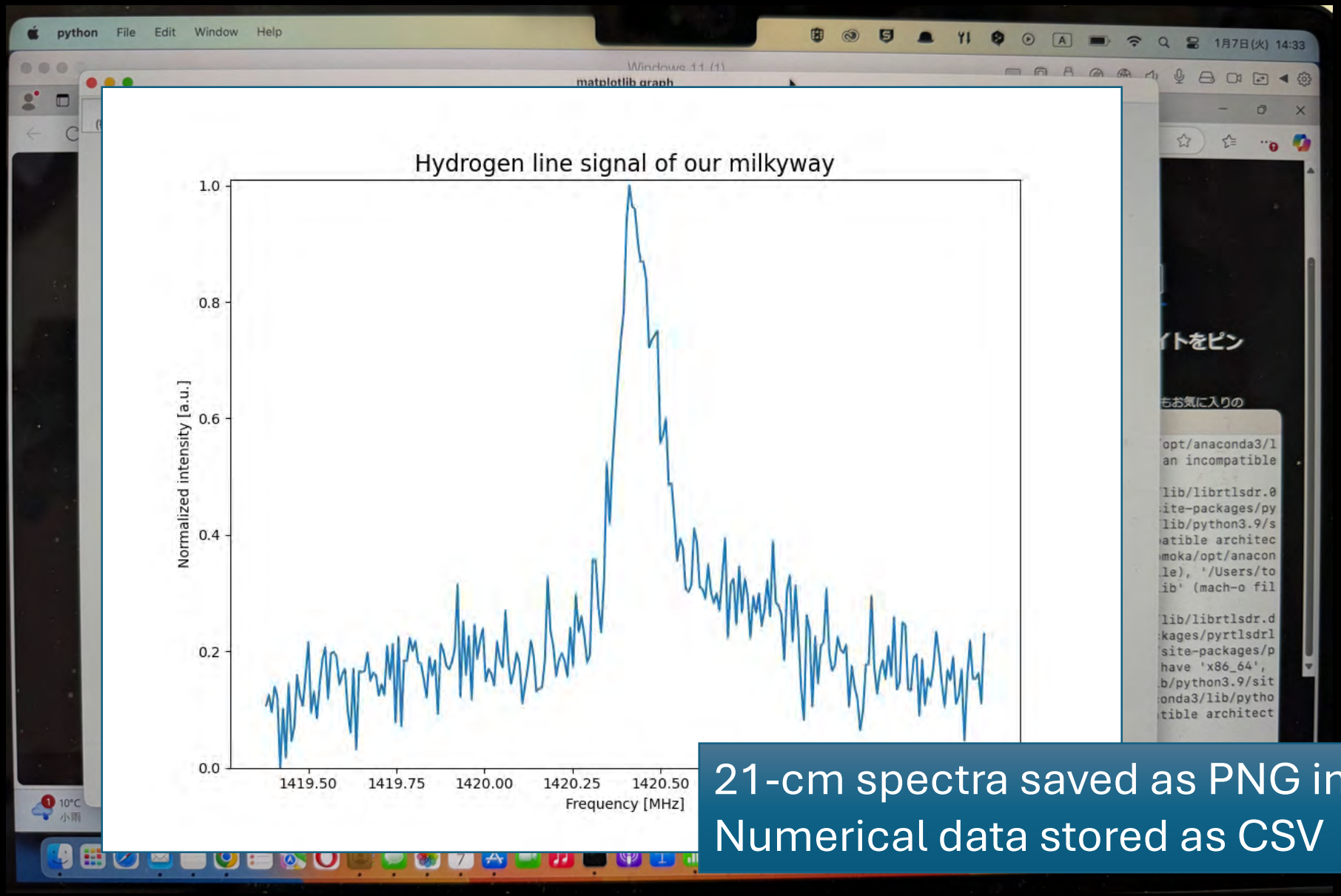








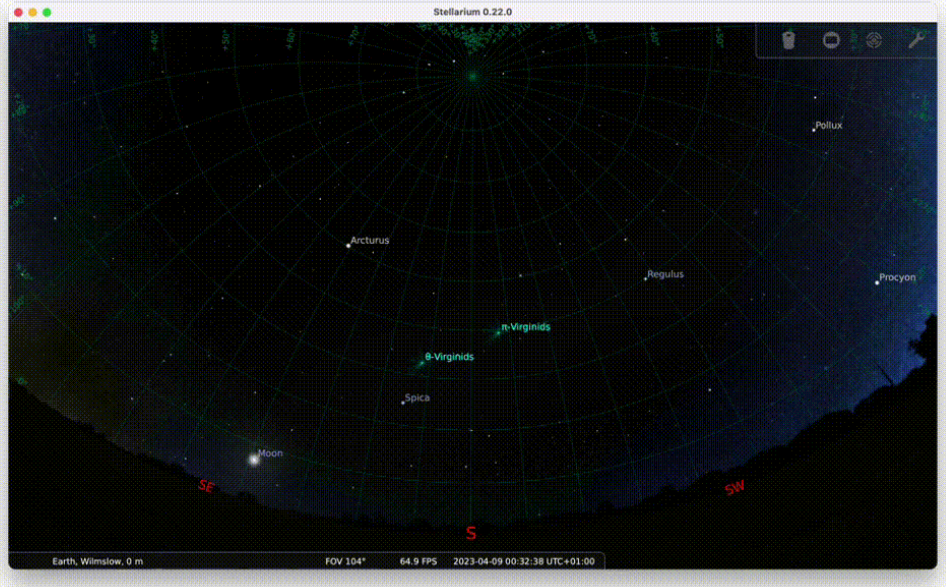
Compatible with Mac/Windows for classroom use

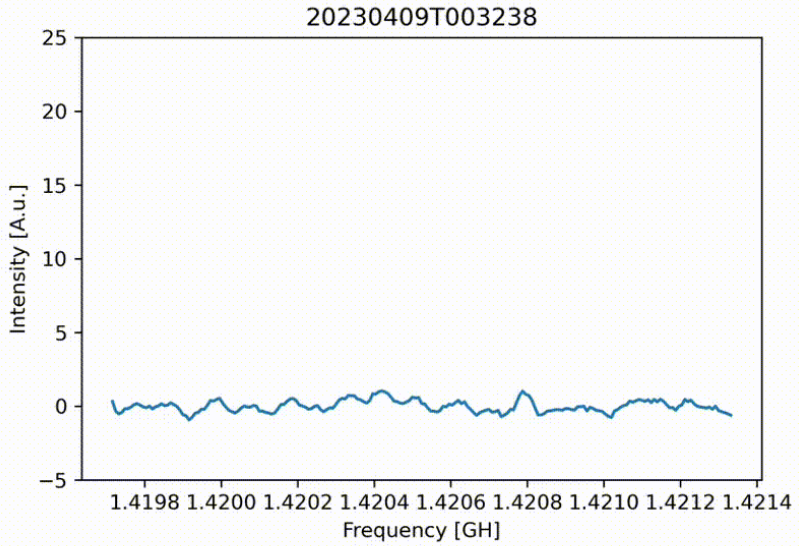


21-cm spectra saved as PNG images
Numerical data stored as CSV

An example of the observations
HI distribution shown in time-lapse movies

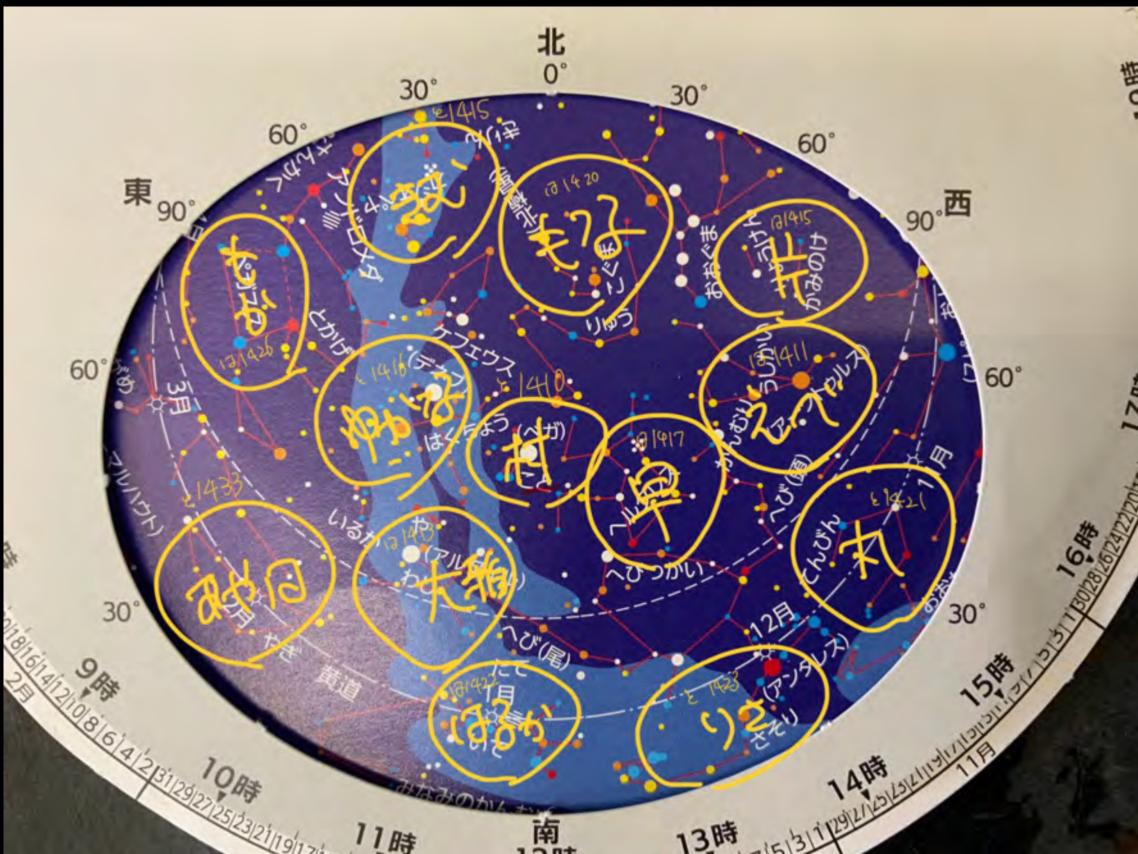






Classroom Implementation: Hojo Junior High school

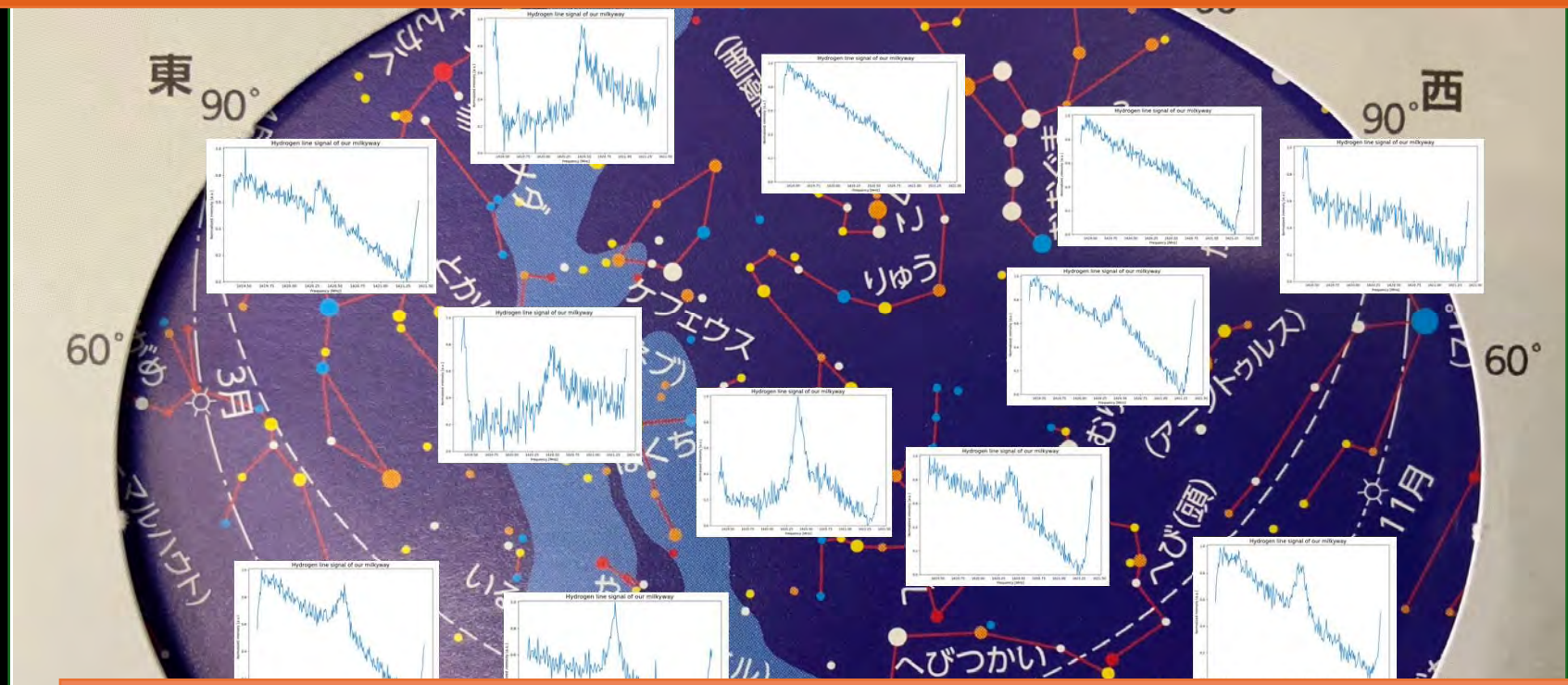
- 3rd-year students (N = 13), November 2024
  the curriculum for 3-rdYear includes the topic
  “The Expansiveness of the Universe(宇宙の広がり）
- Students selected telescope directions with star charts
- Observed variation of 21-cm emission toward all sky


北
0°
東
西
南
30°
60°
90°
ケフェウス
はくちょう
りゅう
とかげ
へびつかい
てんびん
さそり
いて
やぎ
黄道
9時
10時
11時
12時
13時
14時
15時
16時
17時
19時





strong emission toward the Galactic plane



In the post-class questionnaire positive answer to the question of whether they would like to study astronomy in future

Classroom Implementation: Mizuho Junior High school

- 3rd-year students (N = 80), September 2025
- Tablet-based prototype enabled group observations
- Pre/post surveys under analysis

Preliminary





collaboration with NSI, company in Joetsu








N
E
W
S
Horizon
Horizon
10h
11h
13h
14h
15h
おおぐま
こぐま
かんむり
へびつかい
へび
てんびん
スピカ
コップ
うみへび
かみのけ
ケンタウルス
じょうぎ

The Benefits and Educational Impact

- Observations can be conducted even during the day or in cloudy (probably rain) conditions
- Observation equipment can be constructed easily and inexpensively
- The use of star charts can also be learnt (during the day)

- Successful detection of 21-cm HI emission by all groups
- Increased student interest in astronomy
- High feasibility reported by teachers



Conclusion and Future Work

- Developed an accessible radio astronomy system for schools
- Successful implementation in two junior high schools
- Promising results for student engagement and STEM motivation

- Refine system robustness for classroom environments
- Develop expanded learning materials
- Analyze large-scale survey data

