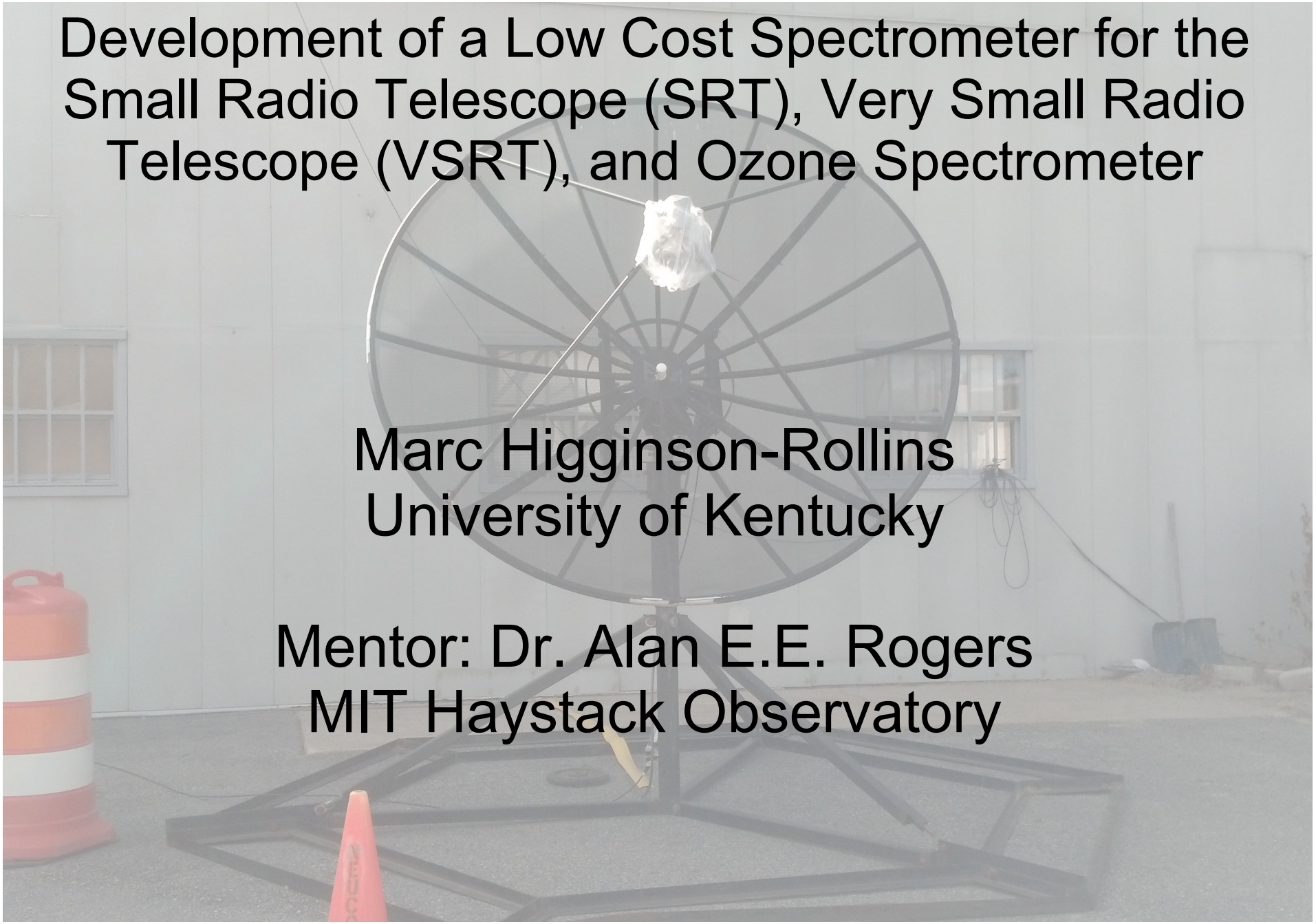
Development of a Low Cost Spectrometer for the Small Radio Telescope (SRT), Very Small Radio Telescope (VSRT), and Ozone Spectrometer



Marc Higginson-Rollins
University of Kentucky

Mentor: Dr. Alan E.E. Rogers
MIT Haystack Observatory

Outline

- Introduction and Motivation
- System Overview
- Challenges
  - Gain and Saturation
  - RFI (Radio Frequency Interference)
  - Frequency Drifting
  - Frequency Offset
- Astronomical Observations
- Conclusion

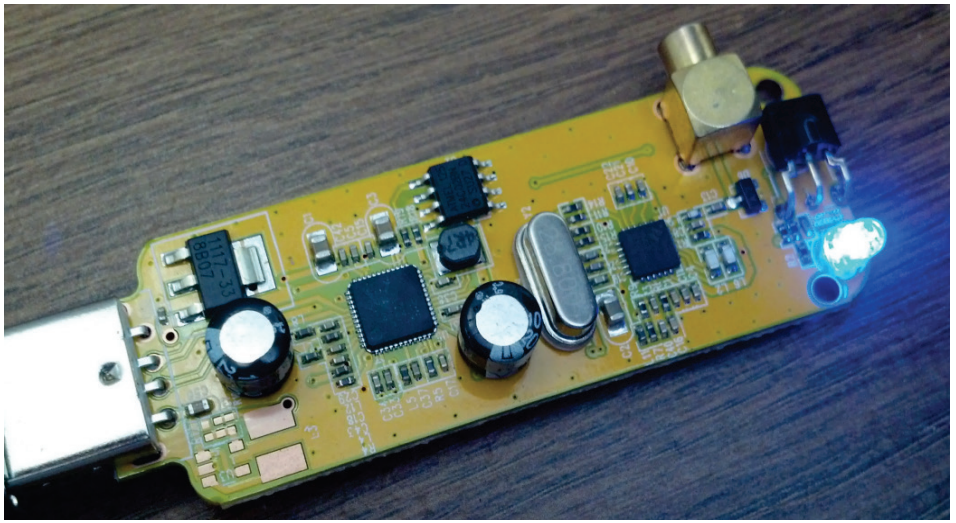
Introduction and Motivation

- The SRT (Small Radio Telescope) was developed by Haystack Observatory as an educational tool for universities and colleges to teach astronomy and radio technology.
- Still in demand and used by academic institutions.
- Development of a low cost alternative to the current SRT system could be widely beneficial.

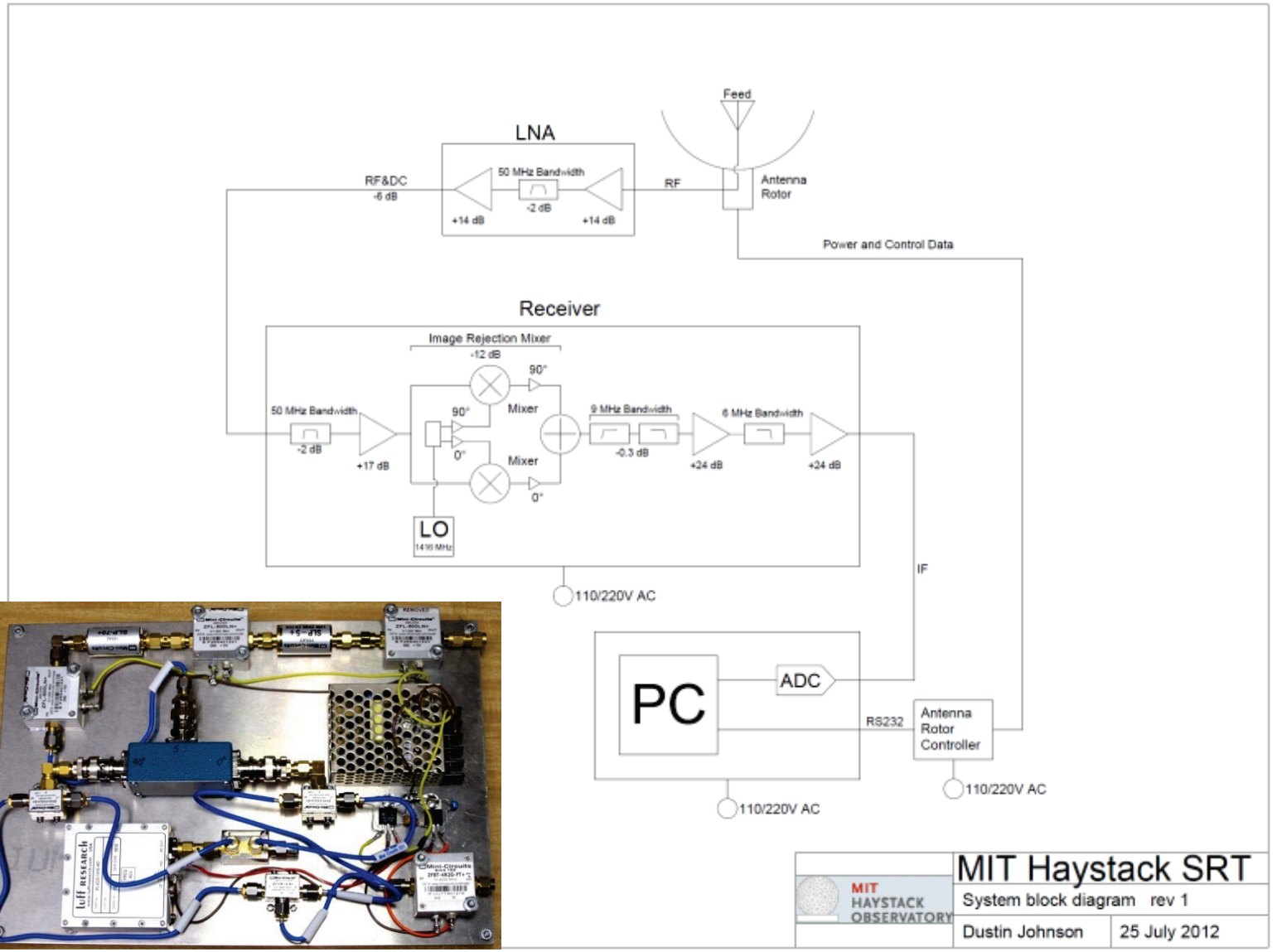
[1] Old SRT

System Overview

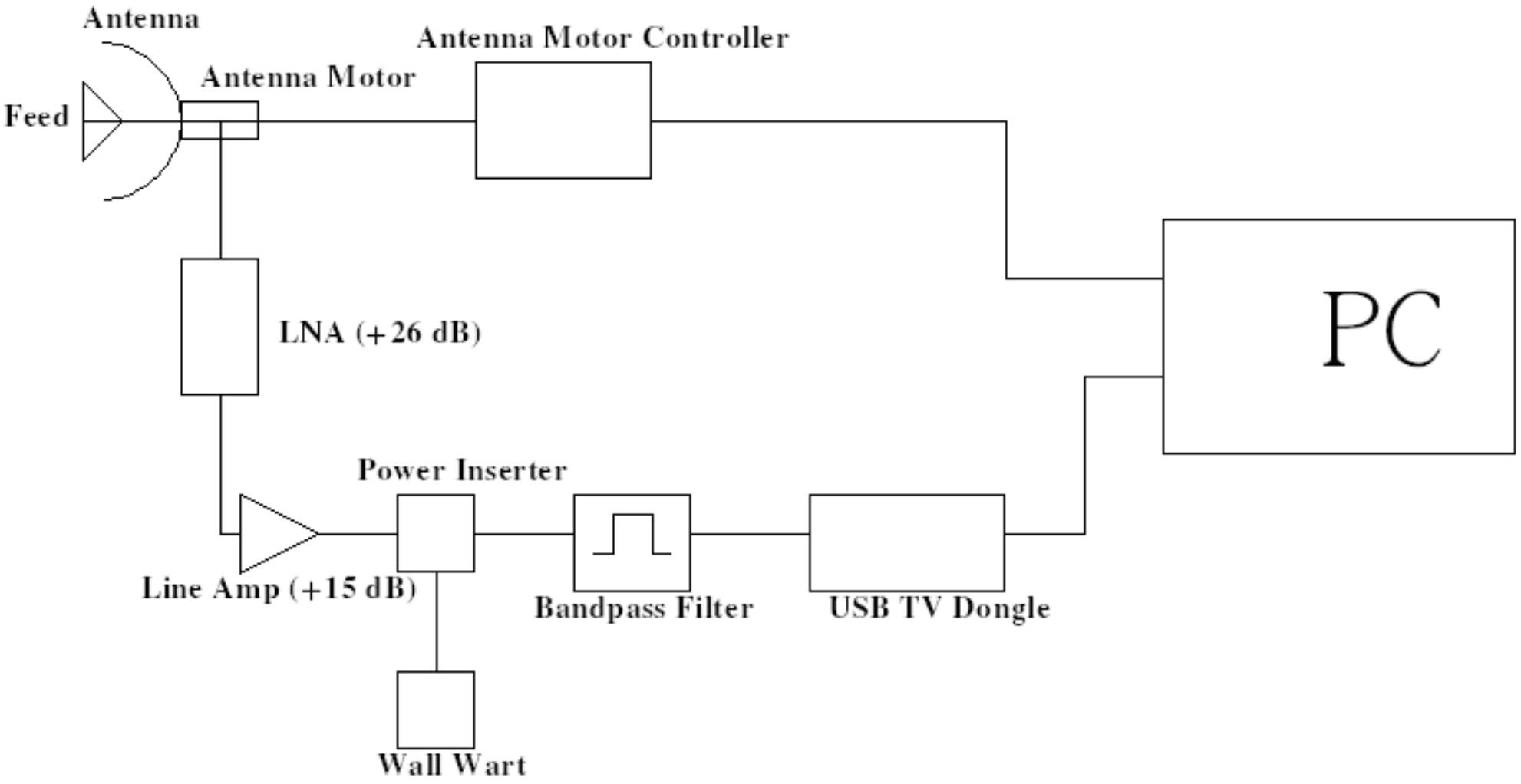
- Tuner: Rafael Microelectronics, Inc. R820T
- ADC/Demodulator Chip: Realtek, Inc. RTL2832U
- Superheterodyne receiver
- I/Q Demodulation
- Frequency Range: 24-1766 MHz
- Max Sample Rate: 2.4 MS/s (3.2 MS/s)
- Cost: ~$12-22



Previous SRT

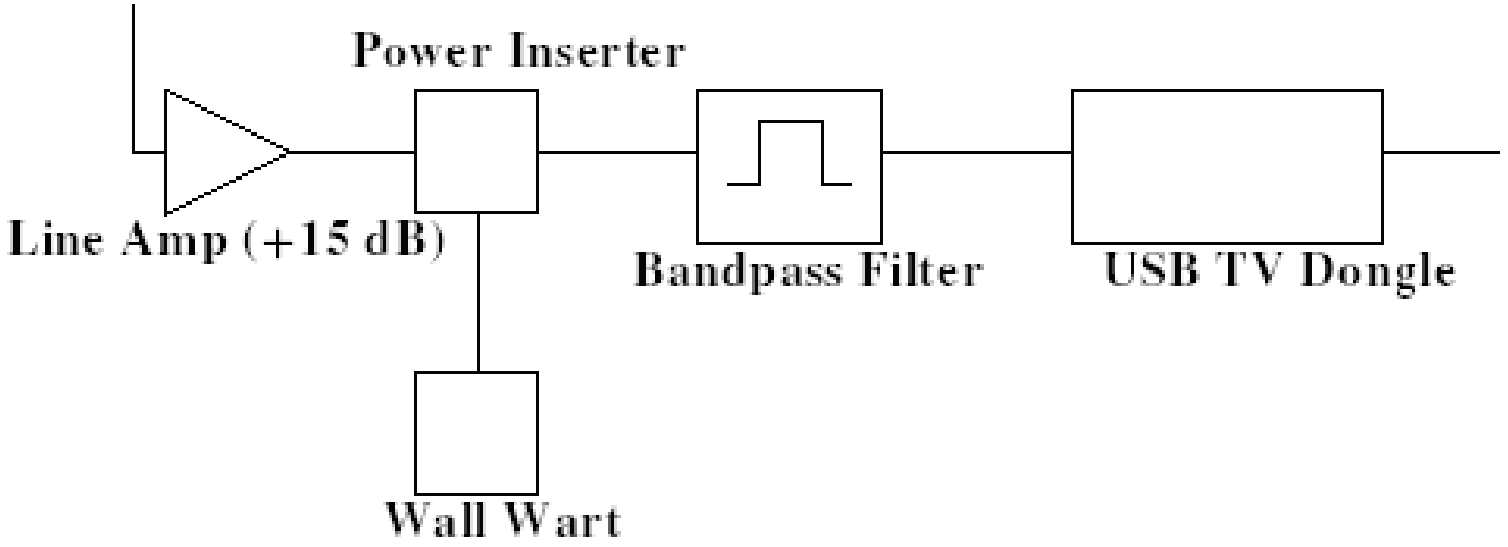


Dongle-Based SRT Schematic



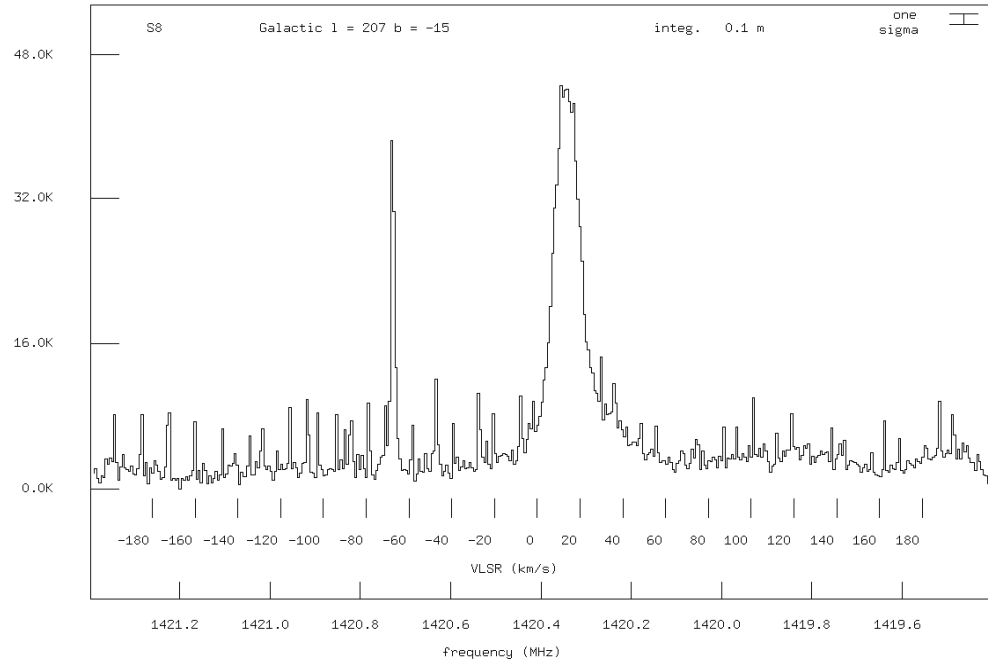
Gain and Saturation

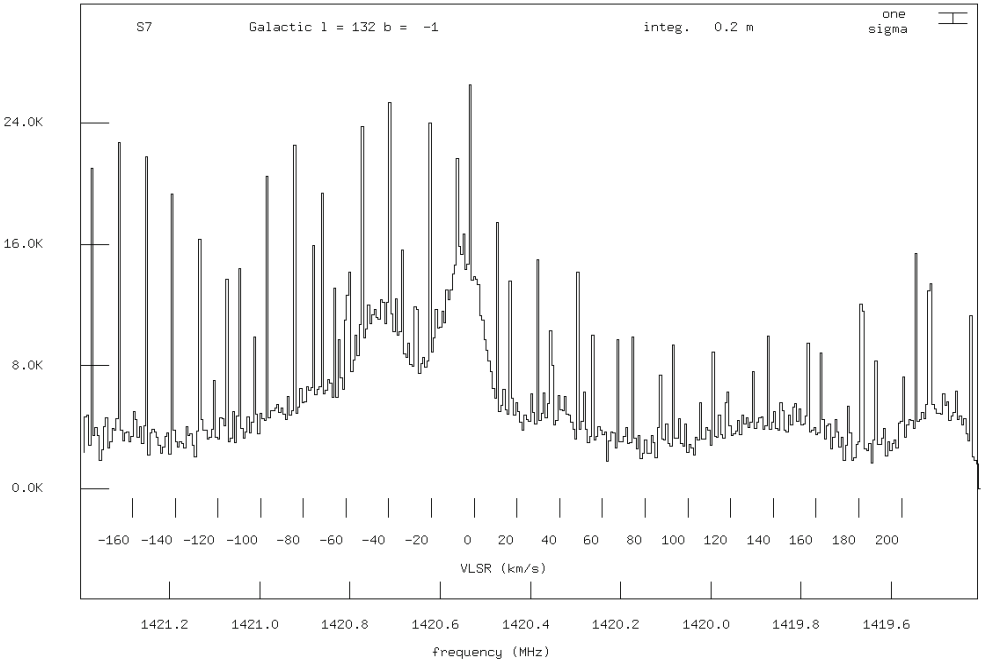
- Expected power level from Hydrogen Line -125 dBm
- LNA provides +26 dBm
- Internal amplifiers of the USB Dongle aren't enough!



RFI

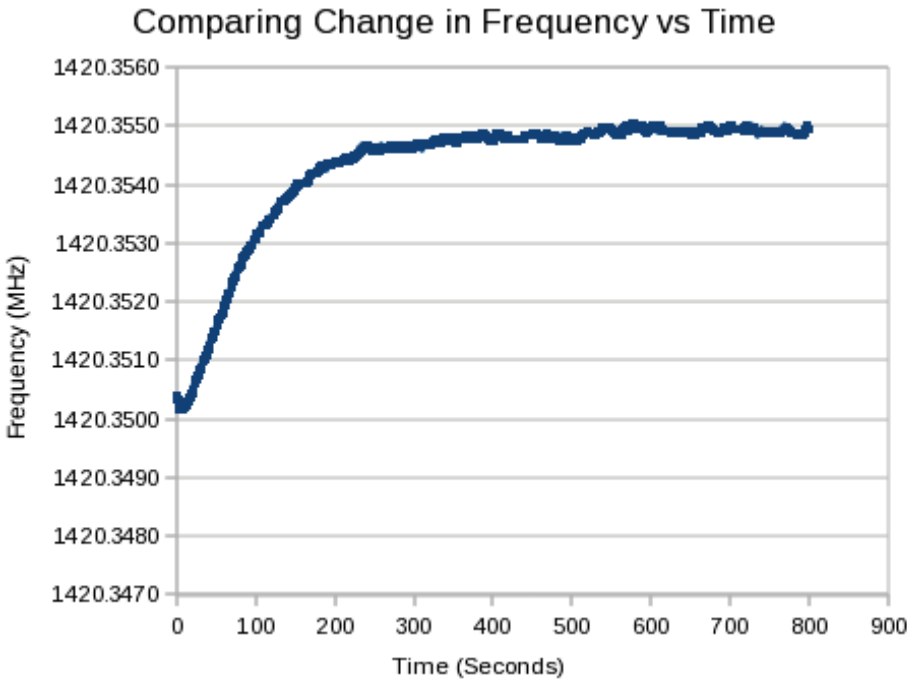
- Replaced high pass filter with a 1420-1470 MHz band pass filter.

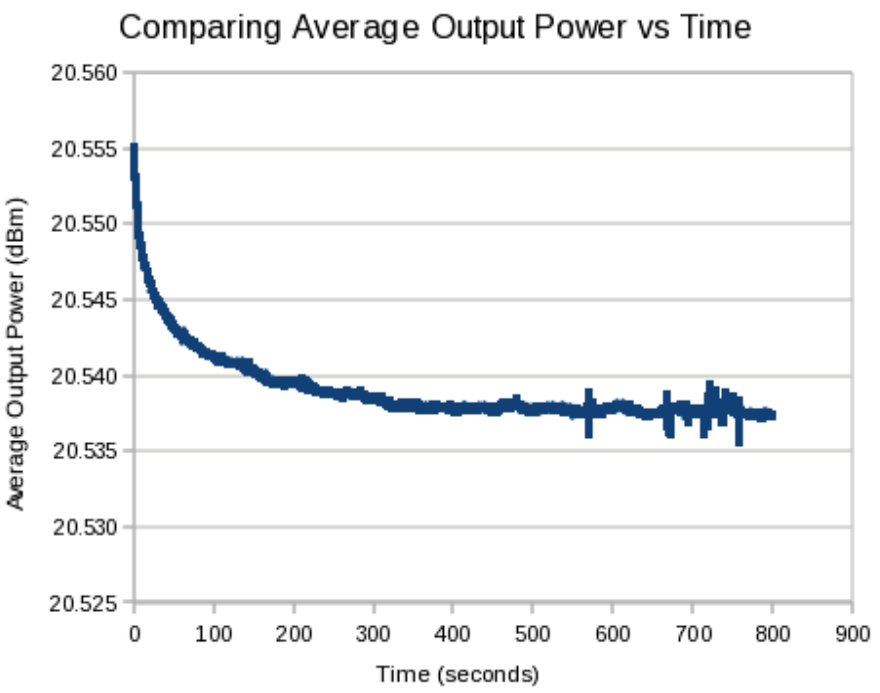




Frequency Drifting

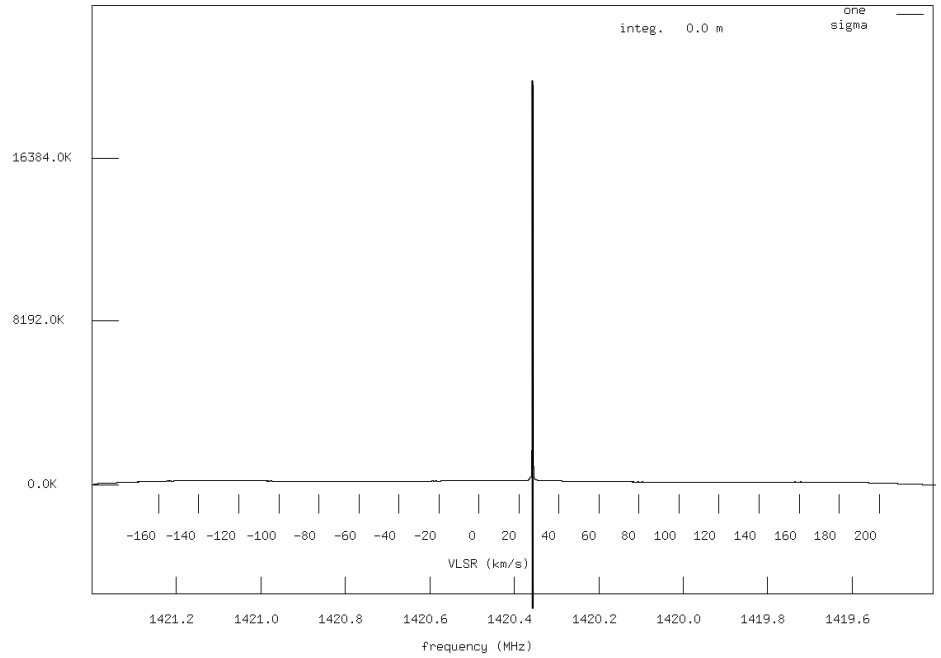
- Vast temperature changes (≥20°C)

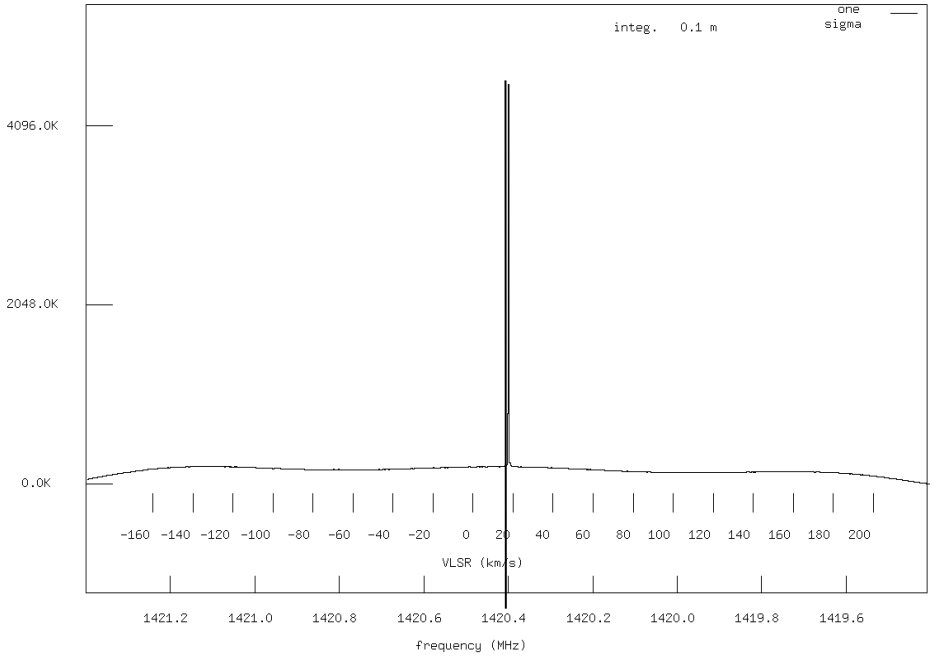




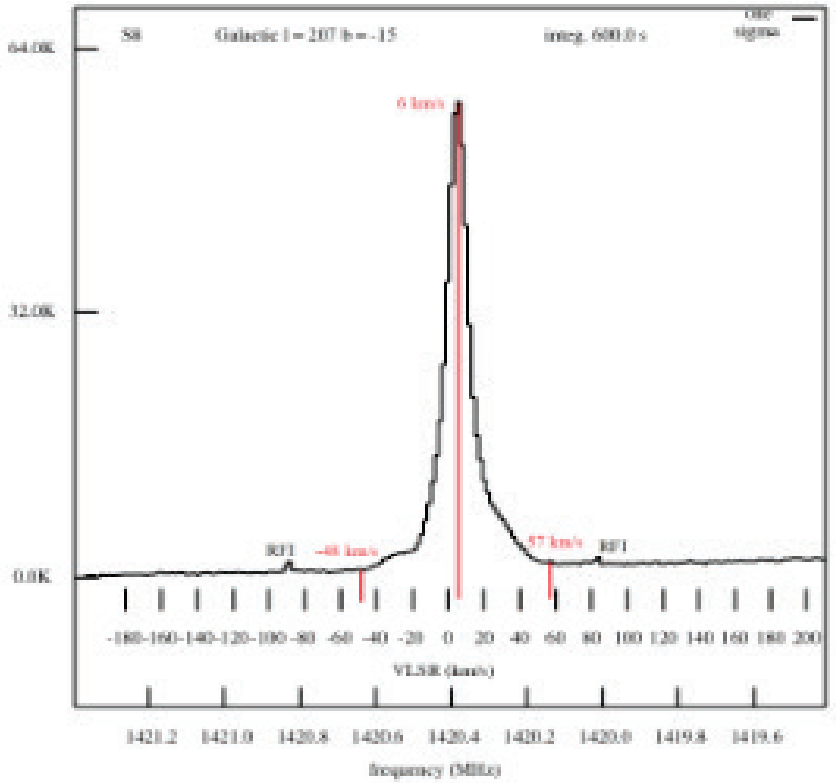
Frequency Offset

- Offset at 1420.4 MHz = ~44.4 kHz
- 31.3 ppm frequency error (Expected is 30-50 ppm)
- Offset can be easily corrected!

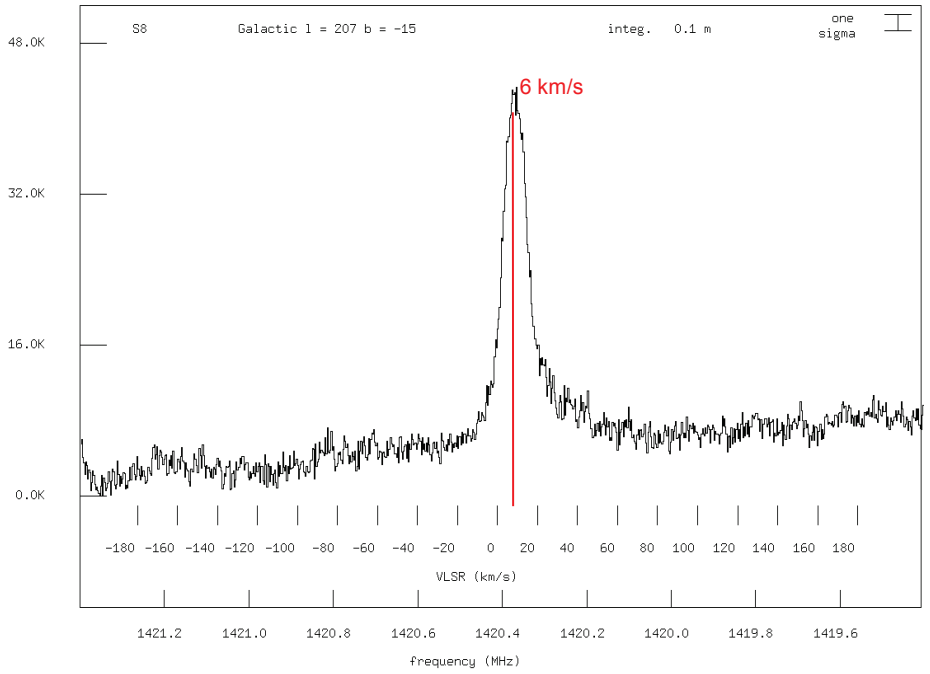




Astronomical Observations: Source S8

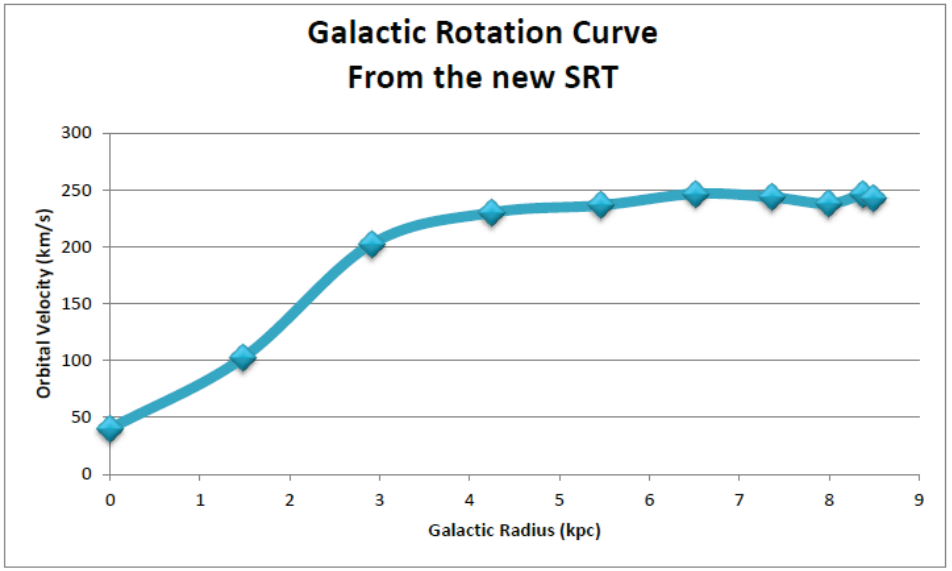


Previous SRT

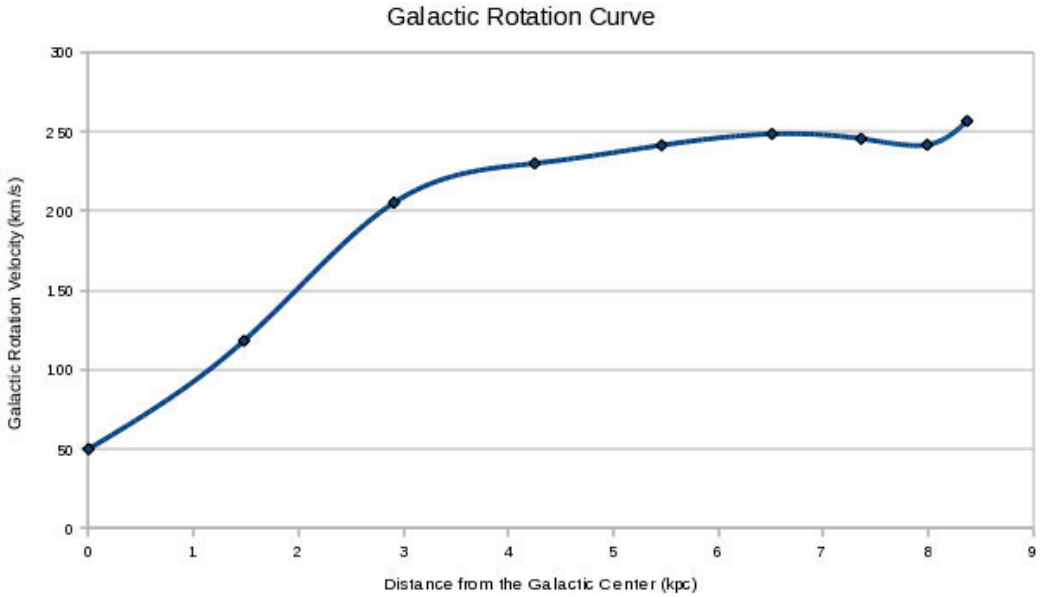


Dongle Based SRT

Astronomical Observations: Galactic Rotation Curve



Previous SRT



Dongle Based SRT

Conclusion

- Using the TV USB Dongles as a replacement is feasible:
  - Huge savings
  - Off the shelf device
  - Easier integration, over-head is all in software
  - Able to make astronomical observations

	Previous SRT	Dongle Based SRT
Y-Factor	2.71	2.82
System Temp.	170.9 K	160.2 K
Sample Rate	20 MS/s	2.4 MS/s (3.2 MS/s)
Resolution	12 bit	8 bit
Cost (No Dish/Motor Controller/Pier)	$3845	$691

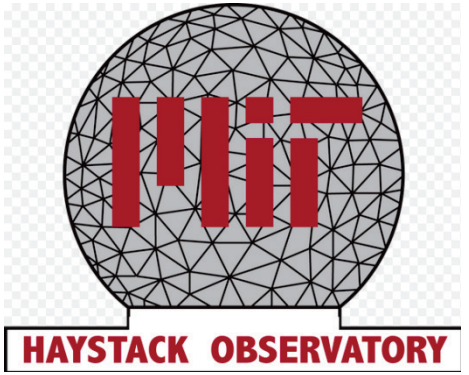
Questions?

Acknowledgements:

•MIT Haystack Observatory:

- •Dr. Alan Rogers
- •Timothy Morin
- •Dr. Juha Vierinen
- •Mark Derome
- •Dr. Vincent Fish, Dr. Phil Erickson, K.T. Paul, Heidi Johnson
- •Everyone else at Haystack!

•NSF



References

- [1] Dr. A. E.E. Rogers, “SRT,” Haystack Observatory, Massachusetts Institute of Technology, Massachusetts, 2012. <http://www.haystack.mit.edu/edu/undergrad/srt/oldsrt.html>
- [2] D. Johnson and Dr. A. E.E. Rogers, “New SRT,” Haystack Observatory, Massachusetts Institute of Technology, Massachusetts, 2012. <http://www.haystack.mit.edu/edu/undergrad/srt/>