Automated Polarimetry with Smaller Aperture Telescopes: The ROVOR Observatory

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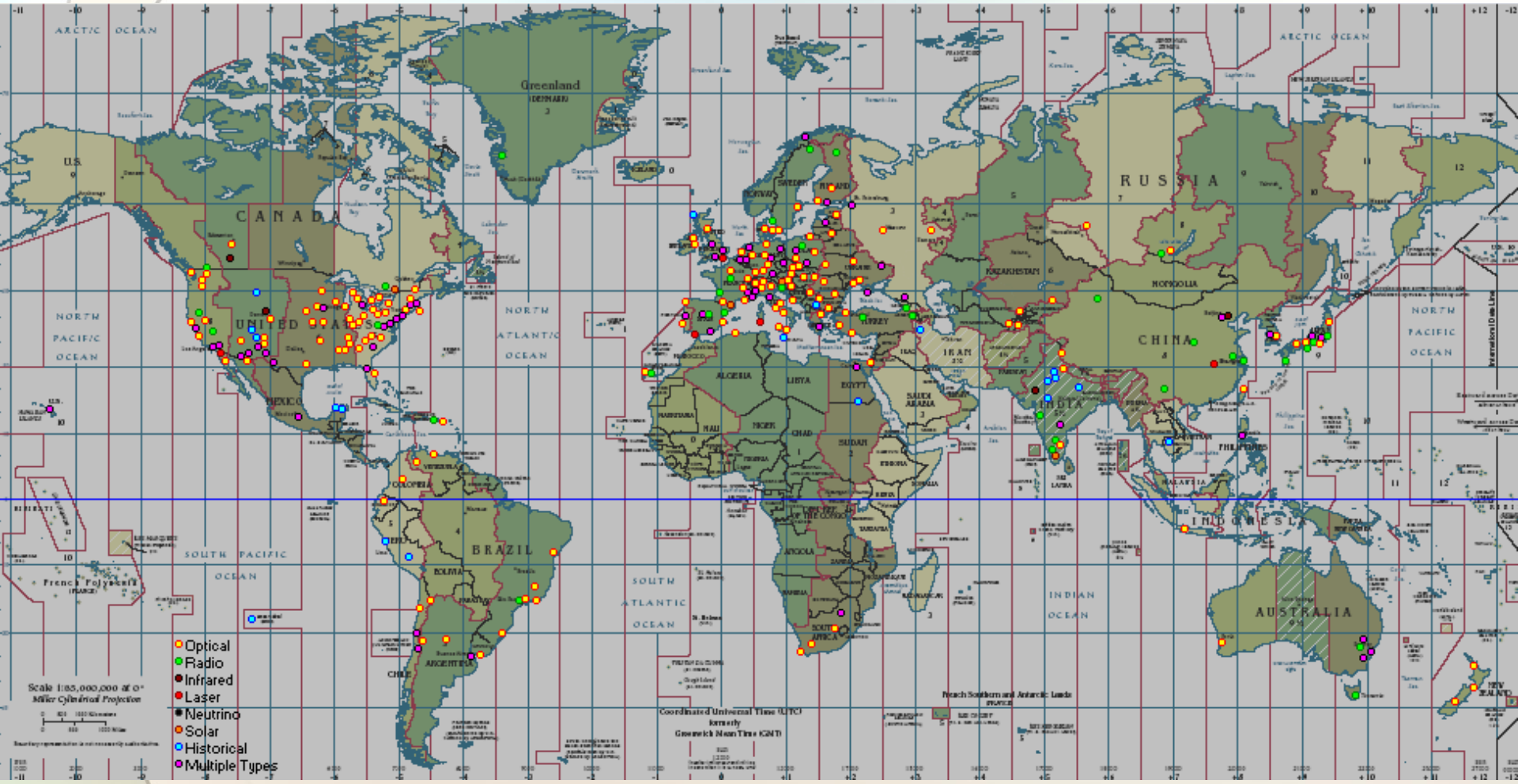
- **Mainly I work on galaxy large-scale structure.**
  - **e.g. Moody et al ApJ 836, 58, 2017 on dwarf emission-line galaxies in nearby voids.**
- **And in publishing**
  - **ASPCS Managing Editor**
  - **AAS publications board**
- **And in remote/robotic telescopes.**
  - **We are always looking for appropriate uses of smaller, remote telescopes. The work of RoboPol, Larionov, Jorstad and collaborators, and others, is impressive and intriguing.**

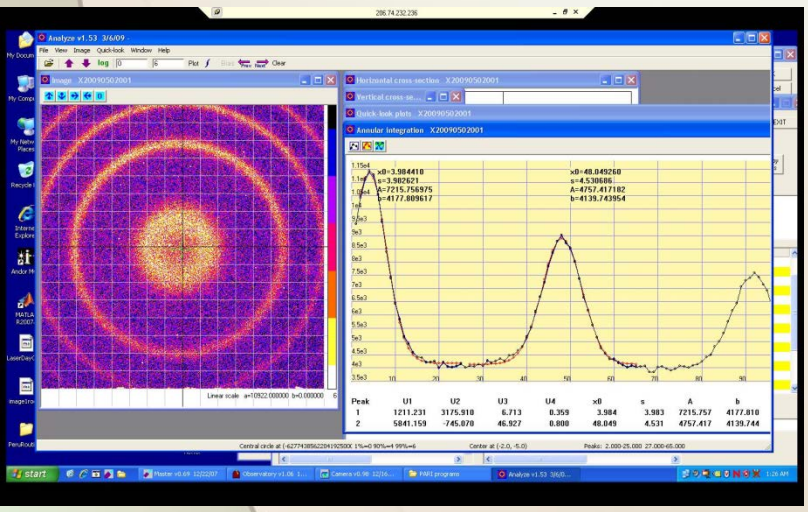
Where are the world's smaller telescopes?



Where people are!

The time and money economics of remote observing have become more affordable. It makes sense to refurbish/relocate some telescopes and dedicate them to monitoring specific objects for long stretches of time.

- **Remote observing started for me in Peru in 1985.**
- **U of Michigan Space Physics Research Laboratory Arequipa airglow station.**
- **We discovered equatorial auroras.**
  - **(Meriwether et al. JGR 1986 on)**



ROVOR

- Remote Observatory for Variable Object Research (Moody *et al*., *PASP* 124, 956, 2012).
- First light in 2008.
- In the Great Basin desert of Utah/Nevada.
- Dark, 70% clear, ~35% photometric.

Lifferth Dome

Roof pulls off in 2m 20s with a 1.5 hp motor

~$10k to build.
Very robust
Camouflage colors ☺

Telescope

- 0.4 m RCO on a Paramount ME
  - Very stable focus
  - Same as the PROMPT telescopes
- FLI Proline 1k x 1k 24 µ pixel SITe CCD with Proline 10 slot dual filter wheel.
- 23' FOV. Pointing accuracy ~ 1’
- S/N ~12 on V~16 object in 60 seconds, unguided.

Why Build ROVOR?

- **Understand and improve remote observing economics**
  - **Learn how to make observing inexpensive yet robust**
    - **~$100K to build, $2 – 3k per year to operate (if student labor is free…)**
    - **Maybe one emergency site visit per year.**
- **Transfer learning & technology to other telescopes**

- **0.6 m, 0.8m and 0.9m systems at BYU WMO and U of Utah Frisco peak observatories.**
- **Large amounts of time on these telescopes are potentially available for polarimetry monitoring**

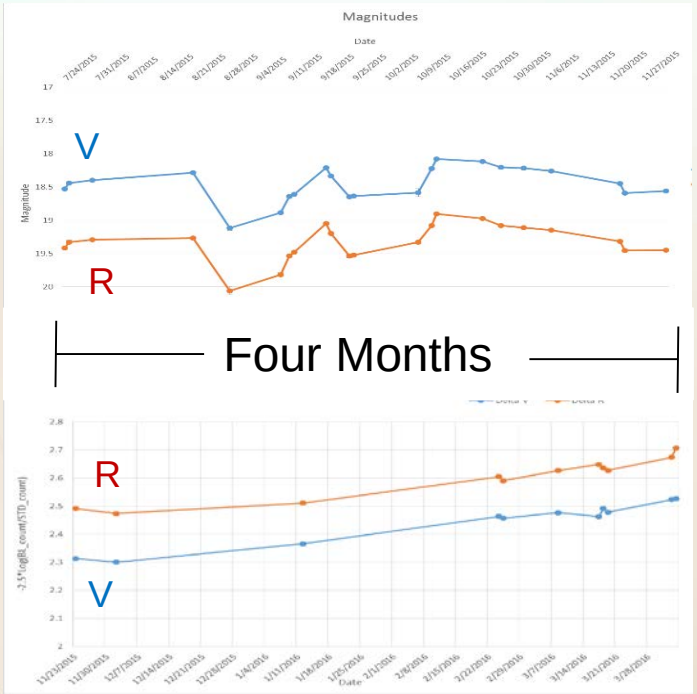
Education

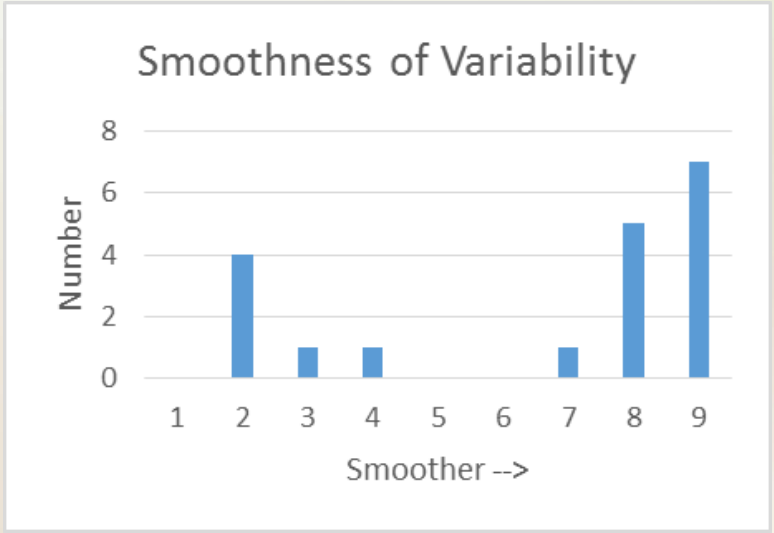
- **Most astronomers are educators.**
  - **The undergraduate component of our profession is growing.**
  - **The BYU UG physics and astronomy program is one of the largest in the world**
  - **We send students everywhere; Max Plank, Yale, Texas, Indiana, Boston U.**
- **Students *cannot* take classes all day and observe all night.**
  - **Neither can faculty…**
  - **So let the computer stay up all night!**

The “Pretty Picture Project”

Produce Serious Science

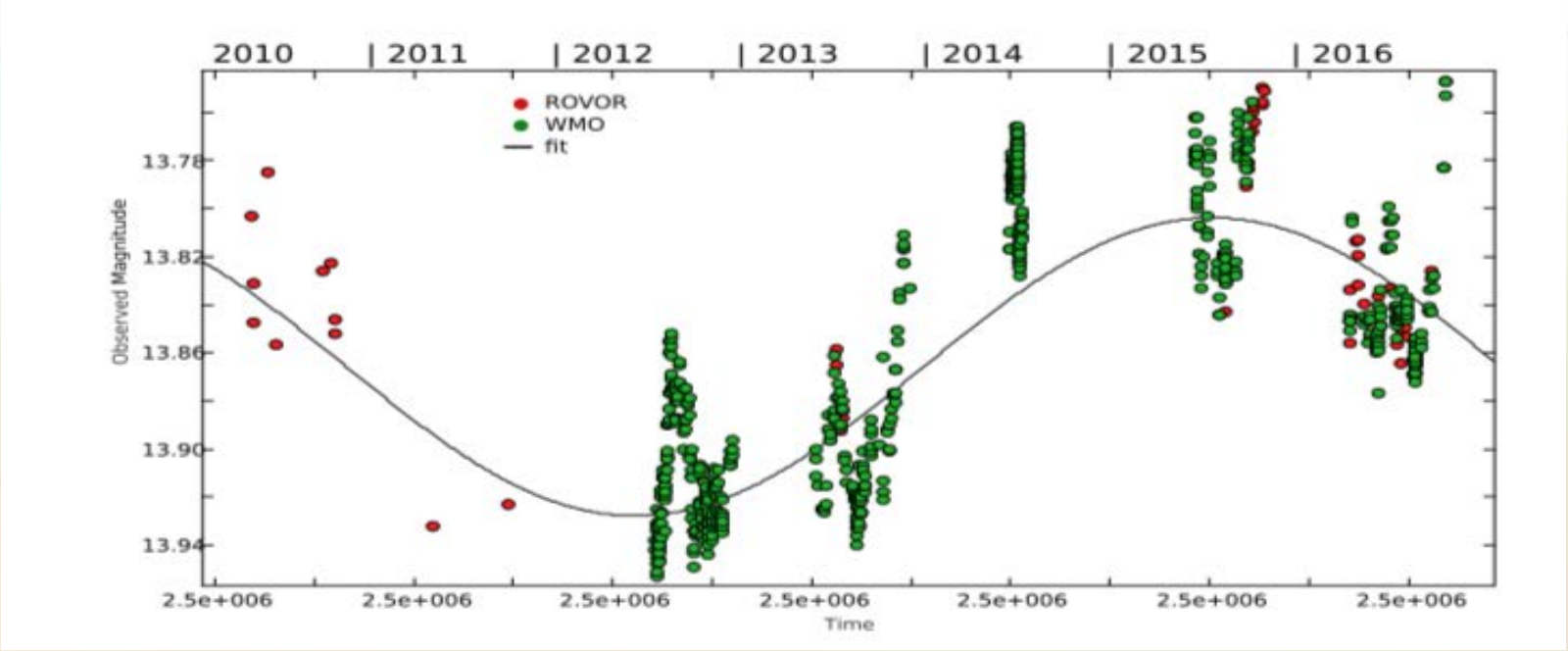
- **Still room to explore the bright-sky time domain, particularly with specialized filters.**
- **Finishing a year-long monitoring of 190 bright northern blazars. 27,000 images from 2,500 pointings.**
  - **~10% varied > 0.2 mag in two modalities.**





Mrk 501

- **Finishing a 6 year V & R monitoring campaign of several blazars, particularly a quiescent Mrk 501. Also used WMO 0.9m telescope.**
- **Two telescopes, same detectors, same place on the detectors, same aperture radius, same standards, even the same side of the pier! Accuracy is better than 0.01 mags.**



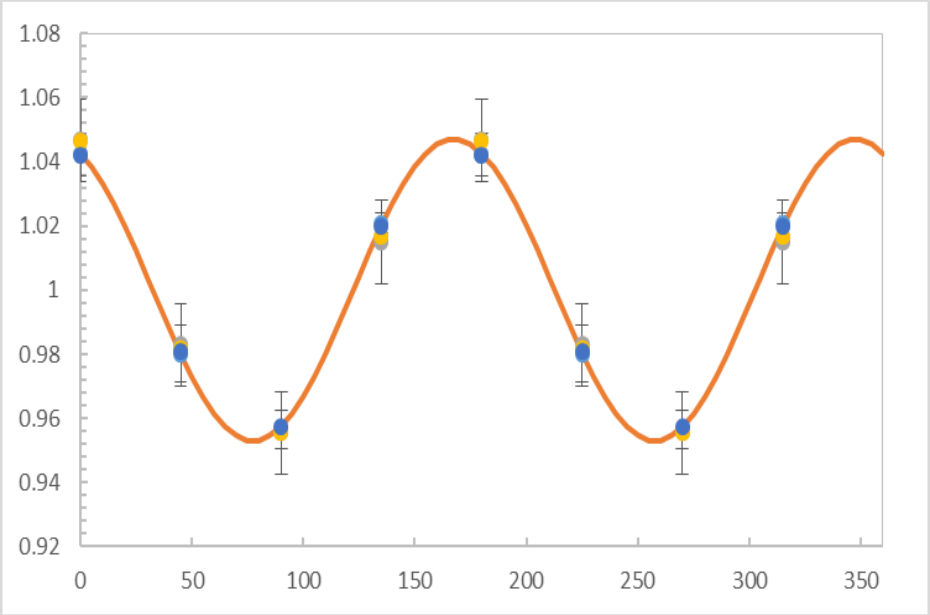
Rivest et al. 2017 AJ

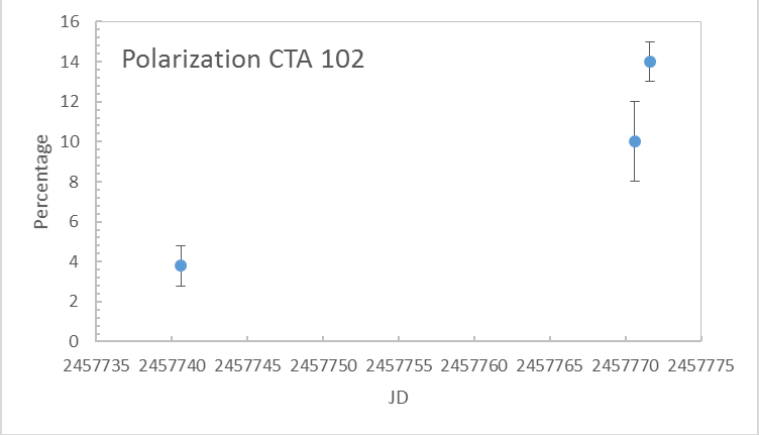
Periods of 6.5 years (0.07 mag), and 113 days (0.03 mags). Even shorter periods are possible…

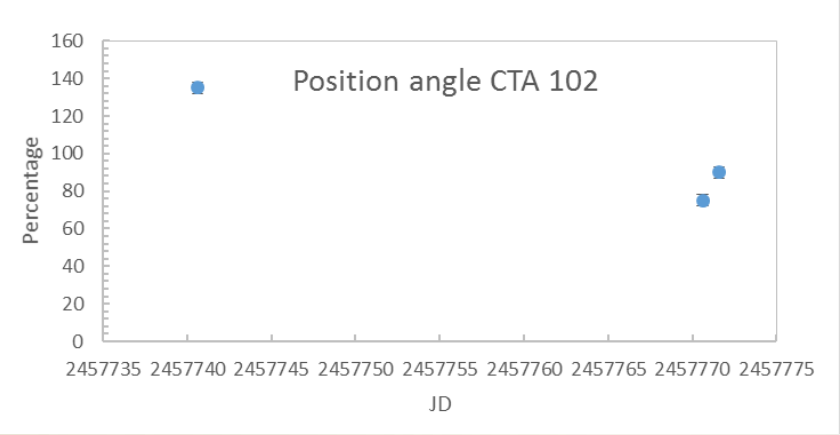
Polarimetry Accuracy

- **Plane polarized filters with Johnson V**
  - **We detect polarization at about the 0.5 percentage point level on 10th mag standards.**
  - **PA accuracy about 3 degrees.**
  - **We don't have much data but you have to start somewhere ☺**

Four nights on standard BD+64d106 (V = 10.3) over three weeks.







Summary

- **Hundreds of little-used or unused < 1 m telescopes are potentially available for repurposing.**
- **Monitoring brighter sources with unique filtering – especially polarimetry – is an excellent purpose.**
- **Existing systems can be made remote for as little as $10K. New systems can be set up for ~ $100K.**
- **An excellent way to produce serious work while training young students.**

Thank you!