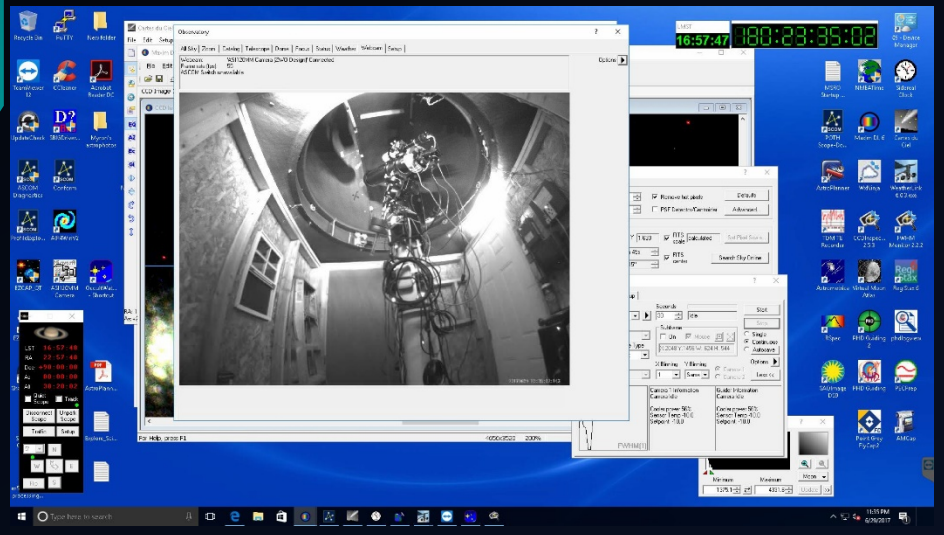
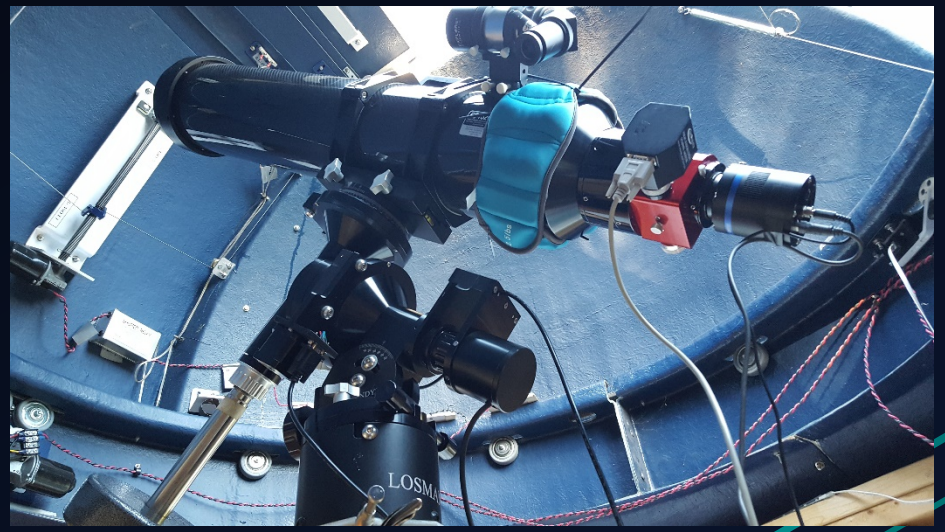
The Mark Slade Remote Observatory (MSRO)

CONSTRUCTING, OPERATING, AND MAINTAINING THE MSRO

Jerry Hubbell
Assistant Director, MSRO
Director Electrical Engineering, Explore Scientific, LLC.

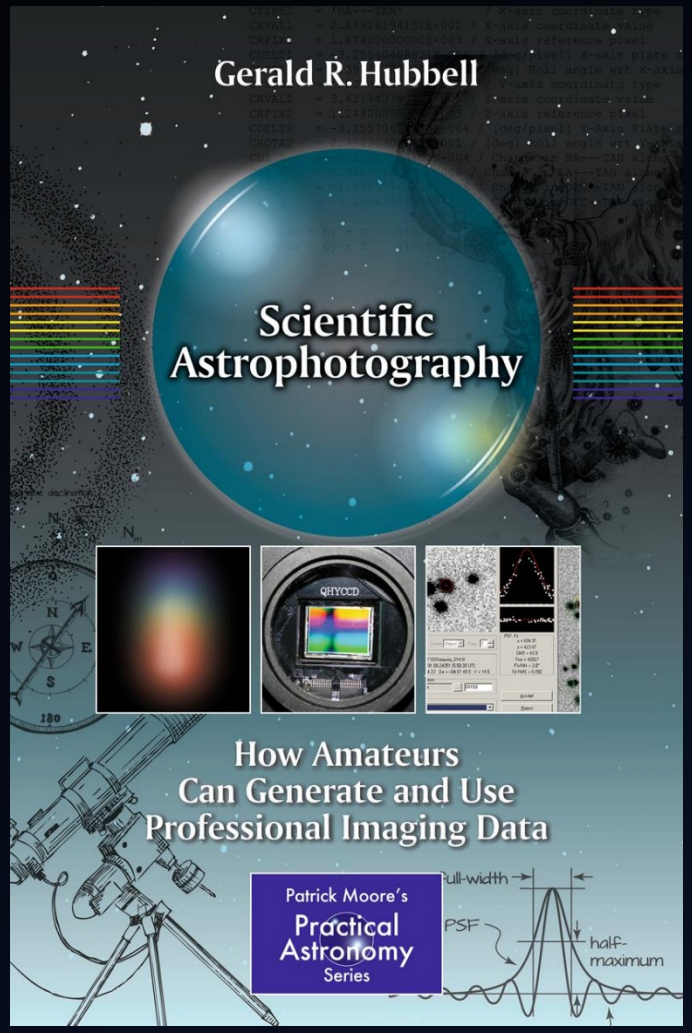


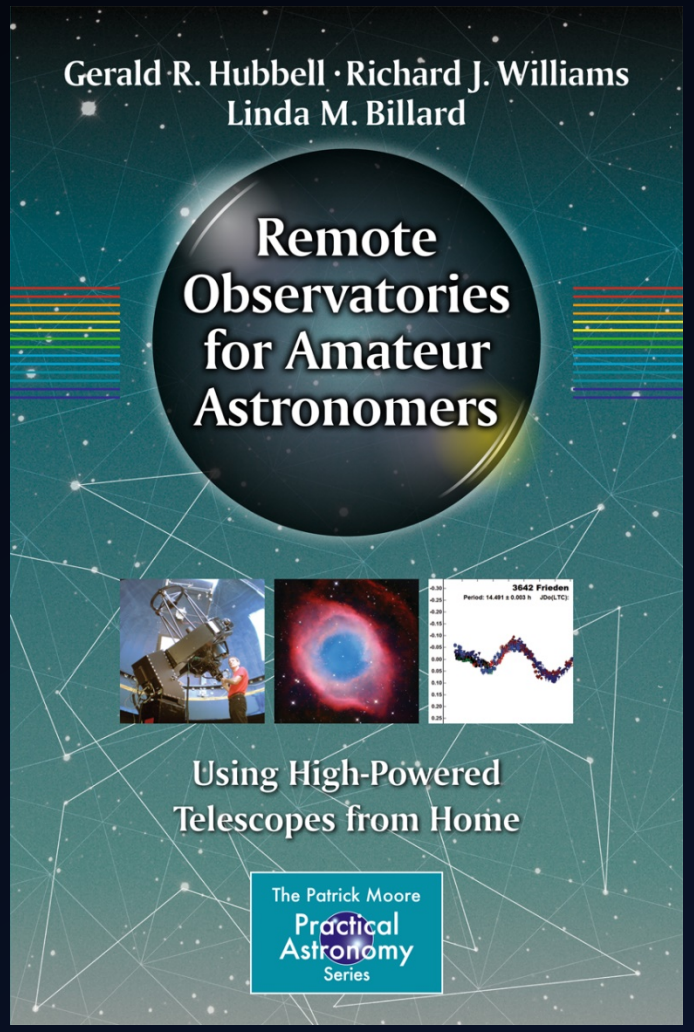


Introduction – Jerry Hubbell

- **Jerry Hubbell** is currently the Director of Electrical Engineering for Explore Scientific, LLC. He is the principle engineer heading the team on the development of the PMC-Eight mount control system.
- He is also a retired Dominion Nuclear Instrumentation and Controls Engineer with over 35 years of experience in the Nuclear and Electric Utility business.
- Jerry is the Assistant Director for the Mark Slade Remote Observatory (MSRO). He is an active Minor Planet observer and obtained the MPC Observatory Code W54 for the MSRO in October 2016.
- He is also the Assistant Coordinator for Topographical Studies, Lunar Section of the Association of Lunar and Planetary Observers (ALPO) and an active high-resolution lunar imager.

Introduction – Jerry Hubbell





- Jerry is the author of 2 books published by Springer Books and available on Amazon.com:
- *Scientific Astrophotography: How Amateurs Can Generate and Use Professional Imaging Data* (2012)
- *Remote Observatories for Amateur Astronomers: Using High-Powered Observatories from Home* (2015)
- Both are from the Patrick Moore Practical Astronomy Series.

The MSRO Facility

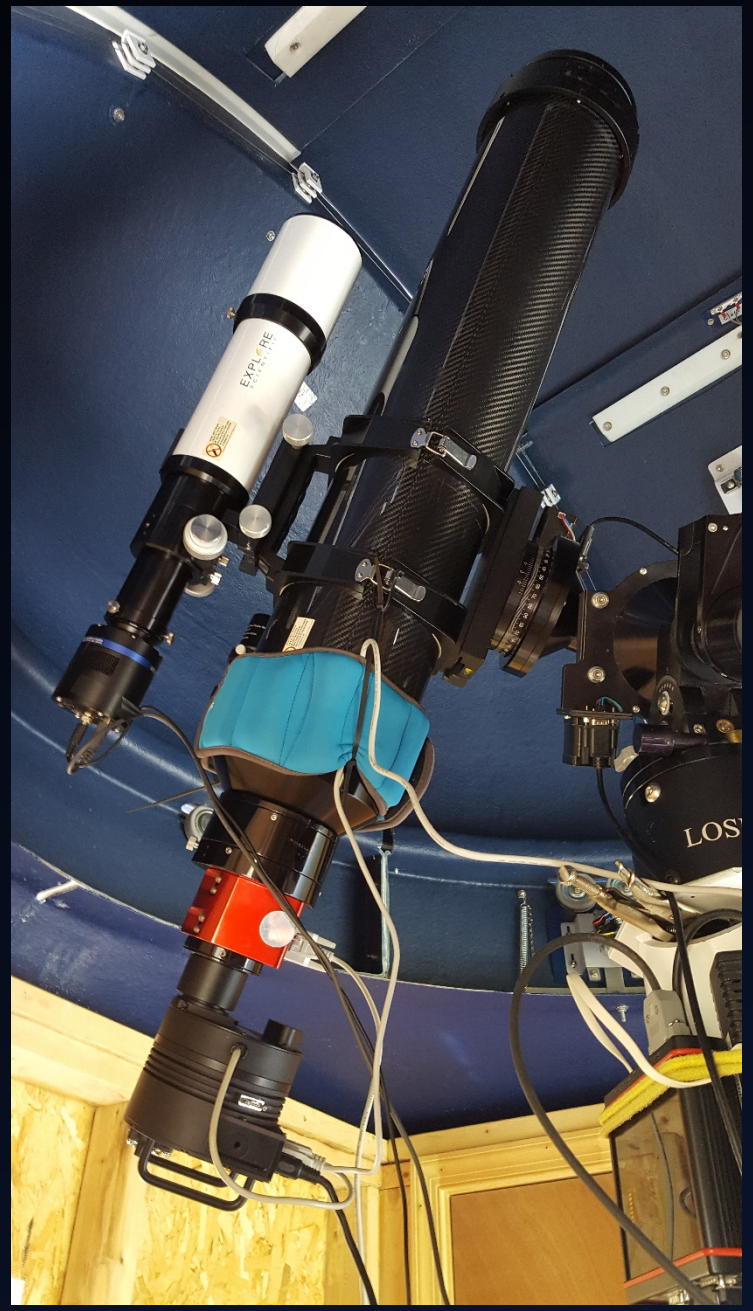
- Located in Wilderness, VA, the MSRO is a modern, state-of-the-art facility using the latest in low-cost, high-value astronomical instrumentation. Its mission is to serve as both a training and research facility for anyone interested in astronomy and astronomical research.
- This facility is designed to be remotely operated over the Internet by multiple users for research and training.
- This facility is named in memory of Astronomer and Astrophotographer Mark Slade. Mark was an active astrophotographer and observer and a long term member of the Rappahannock Astronomy Club (RAClub.org).

MSRO Users and Training Program

- We currently have 4 active observers plus 2 astronomers in training. We are currently developing documentation and training videos to help train observers.
- There is a request form on the RAClub website (www.raclub.org/msro) to request access to observe using the MSRO as a guest or as a trainee. We have had several guest observers including world class imager, Jack Newton. Jack worked with me on a project to image a couple of deep sky objects (M51, and M13).

MSRO Staff/Commission Members

- In December 2015, a formal observatory commission was formed to manage and maintain the observatory and ensure its continued success.
- Dr. Myron Wasiuta – Director and Founding Member MSRO Commission
- Jerry Hubbell – Assistant Director and Founding Member MSRO Commission
- Lauren Lennon - Staff Astronomer
- Dr. Bart Billard – Founding Member MSRO Commission
- Linda Billard – Founding Member MSRO Commission
- Scott Lansdale – President Rappahannock Astronomy Club (RAClub.org)



MSRO Facility & Instrumentation – The Astronomical Imaging System (AIS) Primary Equipment

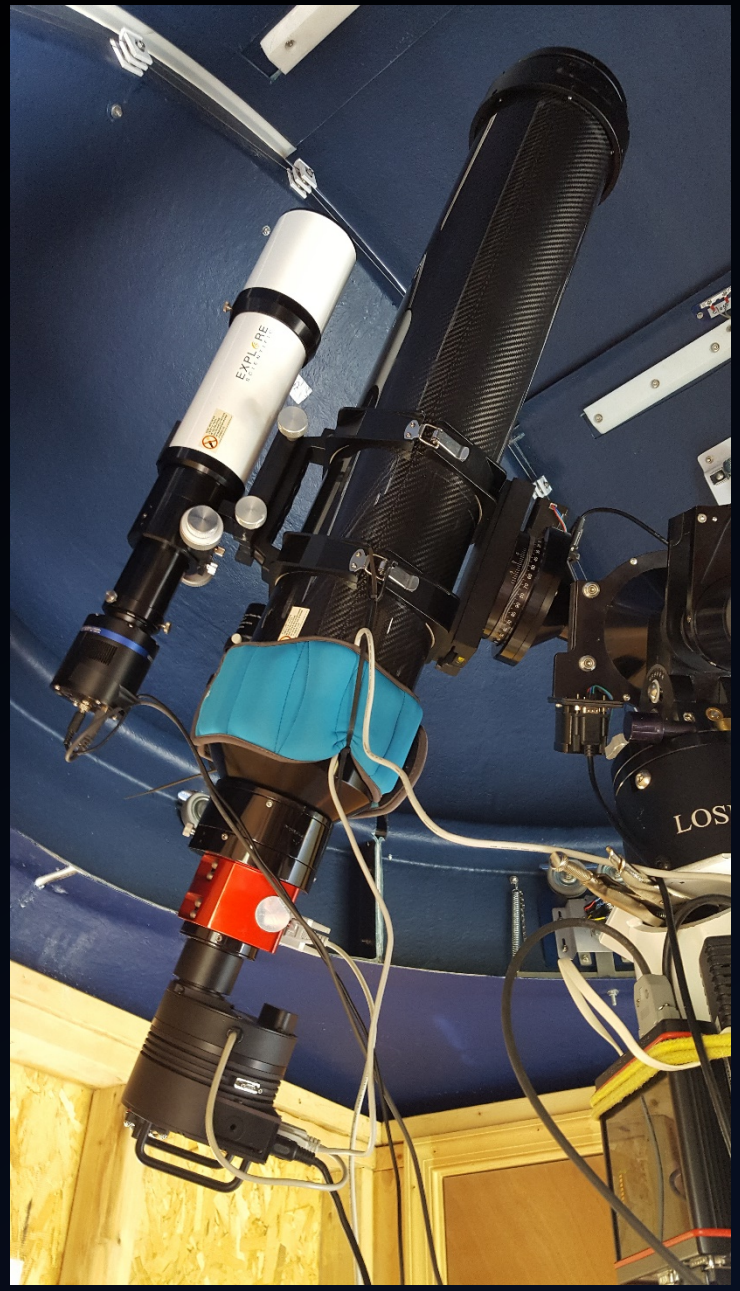
- Technical Innovations 6-foot HomeDome with Digital Domeworks Control System
- Current Primary Instrument – Explore Scientific 6-inch (0.15-m) 152 ED APO CF Refractor with 0.7x FR/FF Effective f/5.6 851.2 mm FL (January 2017- Present)
- Previous Primary Instrument – Meade 12-inch (0.30-m) LX200 Schmidt-Cassegrain (SCT) Optical Tube Assembly (OTA) (January 2016-January 2017)
- Losmandy G-11 German Equatorial Mount
- Explore Scientific PMC-Eight® Mount Control System
- Explore Scientific Telescope Drive Master® (TDM) Drive Correction System
- Primary Sensor – SBIG ST2000XM TEC CCD Camera System w/filter wheel, Red, Green, Blue, and Luminance Filters. Paten Hawksley Star Analyser 200 Spectral Grating.
- Secondary OTA and Sensor – QHYCCD QHY163C TEC CCD Camera System mounted on Explore Scientific 3.1-inch (0.08-m) 80 ED APO Refractor with FF f/6.0 480 mm FL

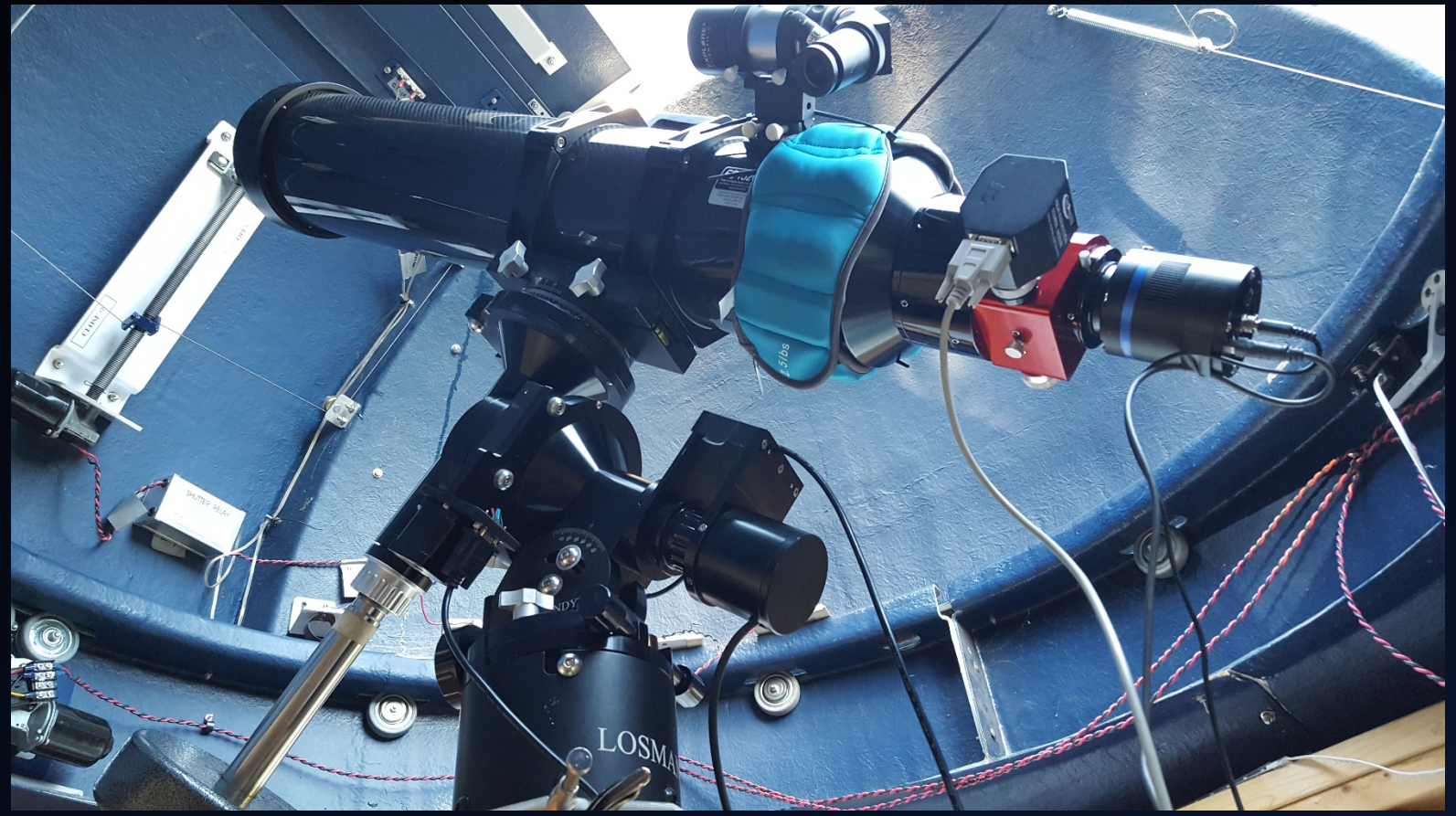
MSRO Facility & Instrumentation – The Astronomical Imaging System (AIS) Secondary Equipment

- Moonlite 2.5-inch Precision Focuser
- Digital Domeworks Dome Control System
- Explore Scientific Telescope Drive Master (TDM) High Resolution Drive Correction System
- Digital Logging, Inc. Web Power Switch Remote Power Management
- Dell Desktop Computer System with 8 GB ram and 2 – 1TB hard drive systems. Windows 10 Operating System.
- High Performance GPS Receiver used for Accurate Time Reference using NMEATime
- Davis Weather System

MSRO Facility & Instrumentation – The Astronomical Imaging System (AIS) Software Applications

- There are several key pieces of software installed on the observatory computer system, including the following:
- Maxim DL Pro 6
- Cartes du Ciel 4.0
- Astrometrica
- Registax 6
- ASCOM – Standards Platform 6.3
- NMEATime GPS Time Reference
- Instrumentation drivers for dome, mount, cameras, TDM, GPS receiver, remote power management controller
- Sidereal Clock Display





Observatory Construction, Equipment, and Instrumentation

The Observing Facility

- Having a permanent observing facility to house your AIS provides a whole host of benefits that make doing science with a small telescope so much better!
- No Spending 1-2 hours setting up and taking down your AIS including polar alignment and acquiring calibration data.
- Quick startup to facilitate observing transient phenomenon.
- Protection from the elements.
- Opportunity to setup your observatory for remote operations to even better utilize the facility.

The Observing Facility

- There are several common themes as it concerns the design and construction of an observatory for small telescopes.
- The purpose of the observatory building is to first protect the AIS from the elements, and provide enough space and support equipment to do required maintenance and operate the AIS in furtherance of the goal of obtaining high quality science data

The Observing Facility

- The observatory building has certain performance requirements including: Isolation from the Telescope Pier, Rapid temperature equalization, effective wind restraint, protection from moisture and rain, and reliable power.
- All this needs to be accomplished in a cost effective manner by using inexpensive materials in its construction.
- Wood construction on a deck provides for very good performance at a cost effective price.

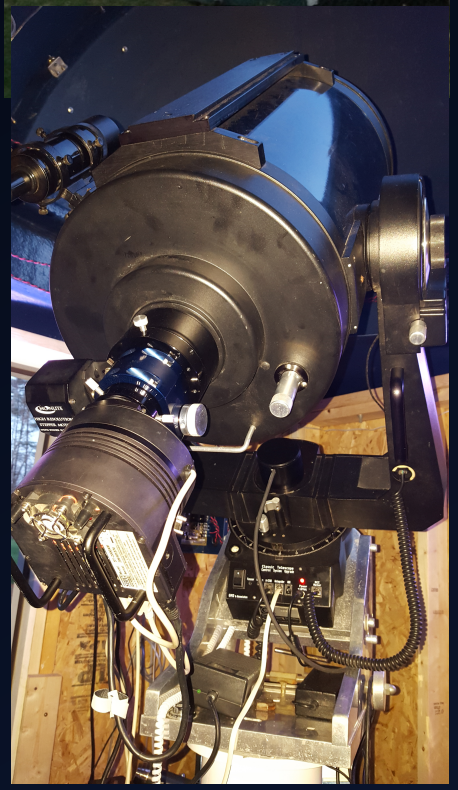
Mark Slade Remote Observatory (MSRO) MPC W54 Construction











Construction of Observatory Framing and Dome transition – 7x7-foot building In Myron’s garage!

Final construction of Technical Innovations
Dome on top of 7x7-foot observatory building

Original pier with heavy-duty wedge and pier extension placed in service

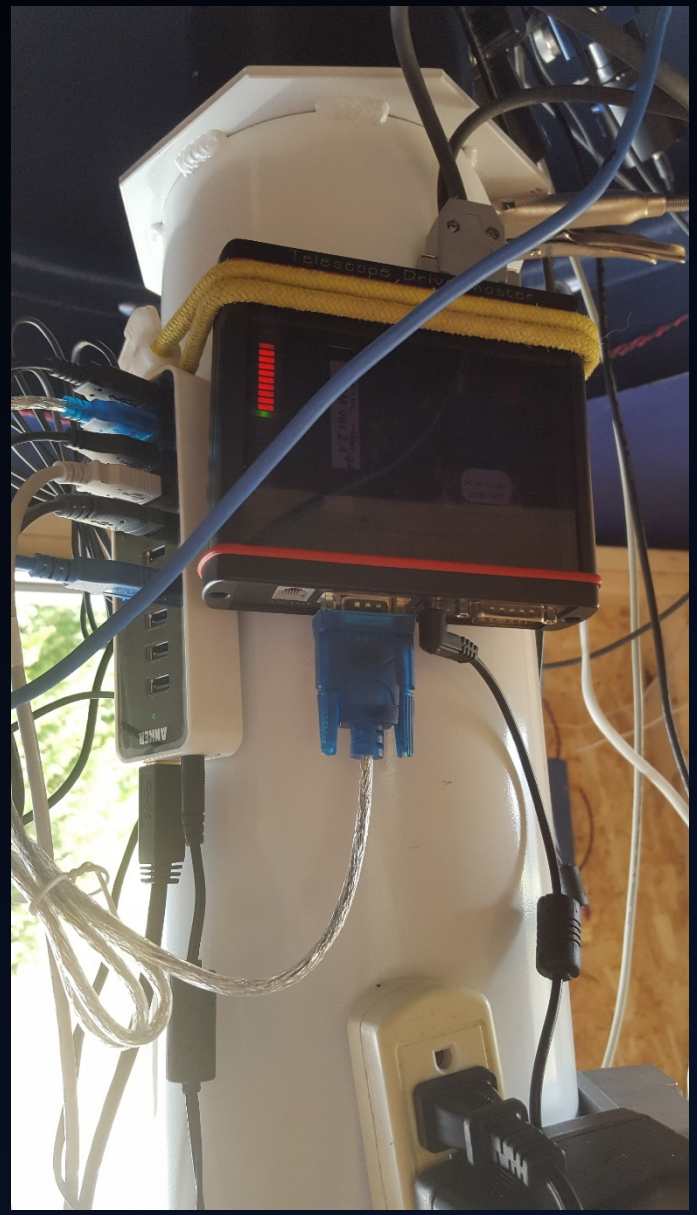
Corner of observatory with Digital Domeworks controller, Davis weather station, and observatory computer system


MEADE LX200 EMC

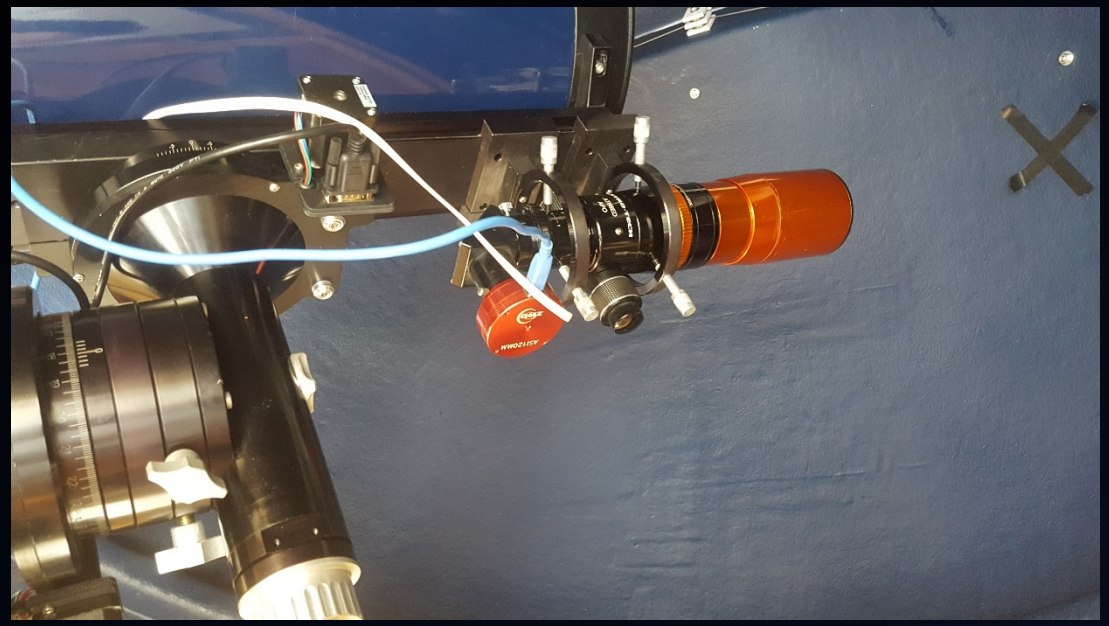

LOSMAND

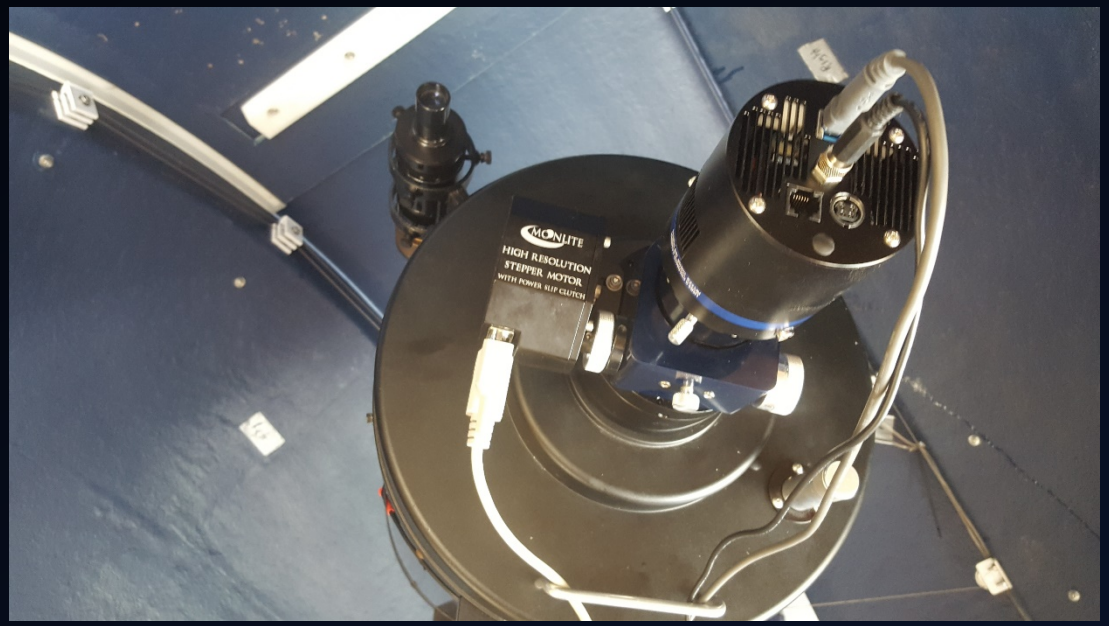

POWER
SHUTTER
POWER SUPPLY
PS 1
DIGITAL DOME WORKS
Observatory Control System
Model 4
CAUTION
ALL STOP
DAVIS

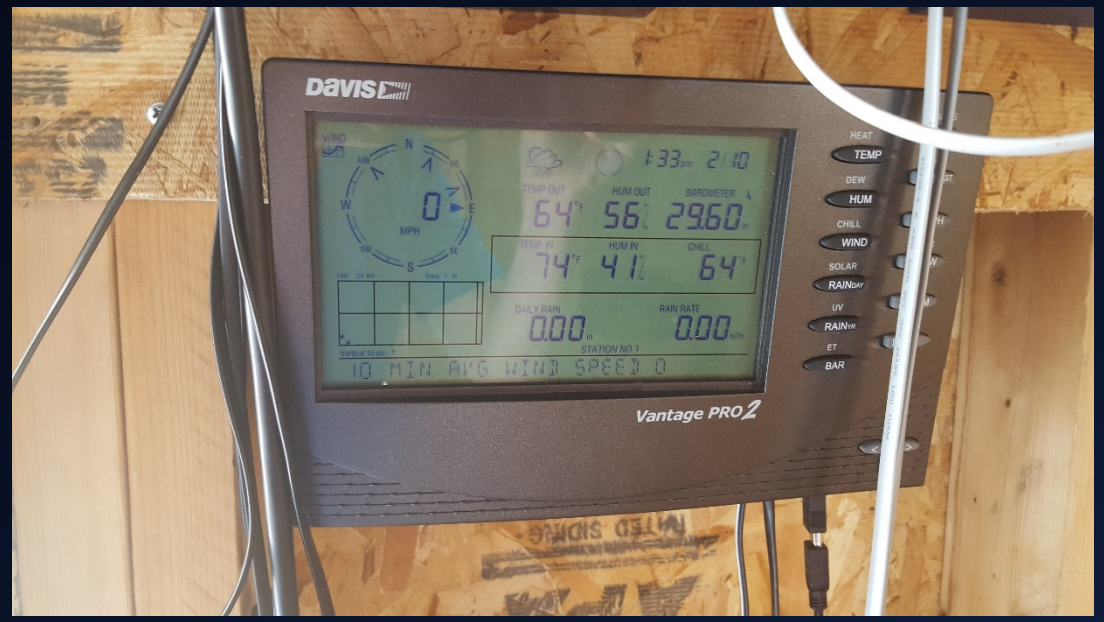

MONLITE
Mini Controller
v2




DIGITAL DOME WORKS
POWER SUPPLY
CALIBOR



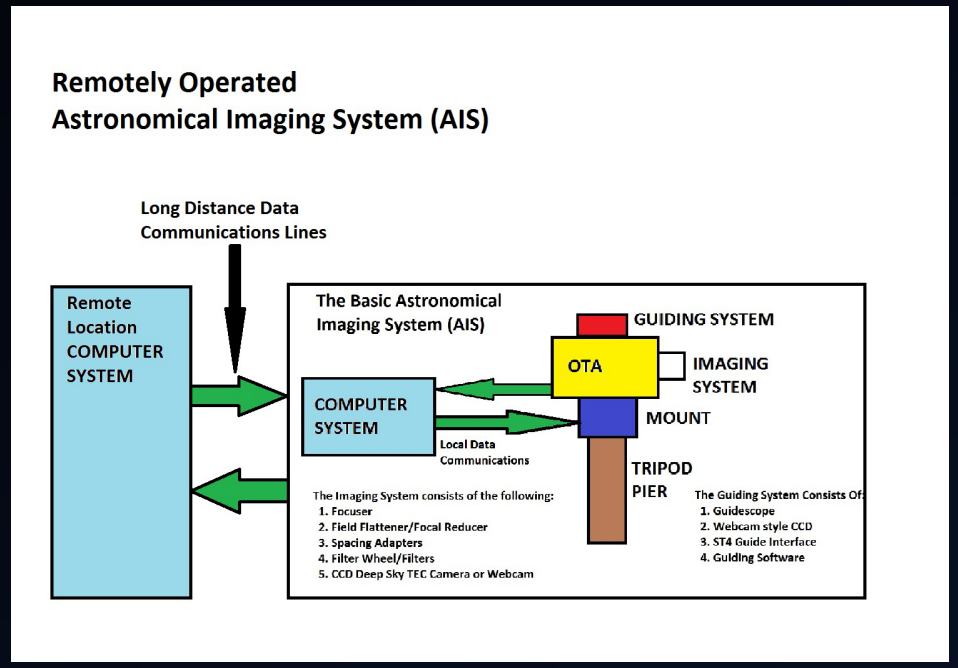

MONLITE
HIGH RESOLUTION
STEPPER MOTOR
WITH POWER SLIP CLUTCH

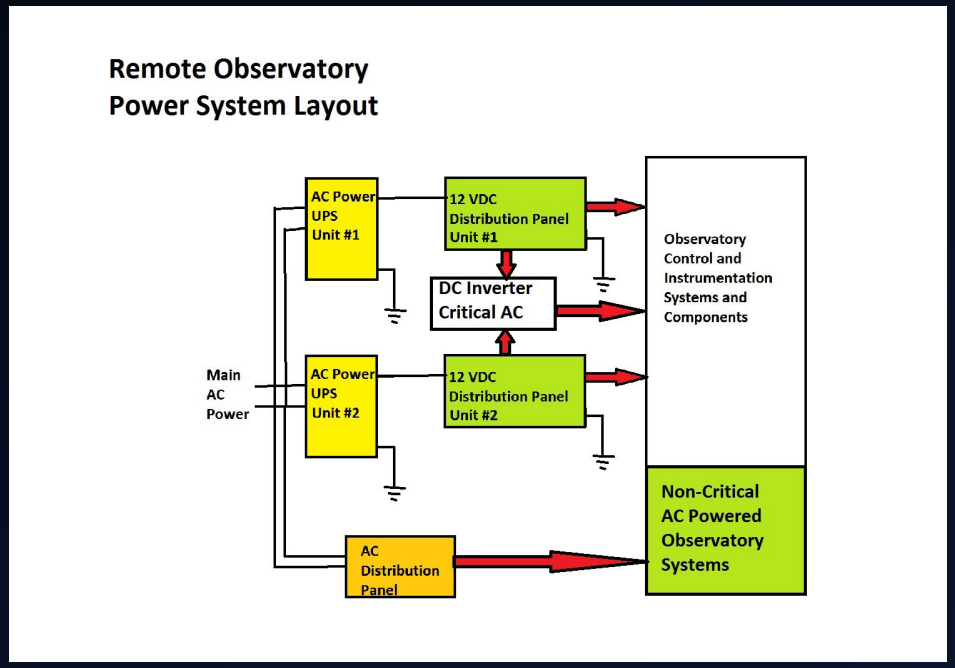

DAVIS
Vantage PRO2

Remote Access To Your Observatory

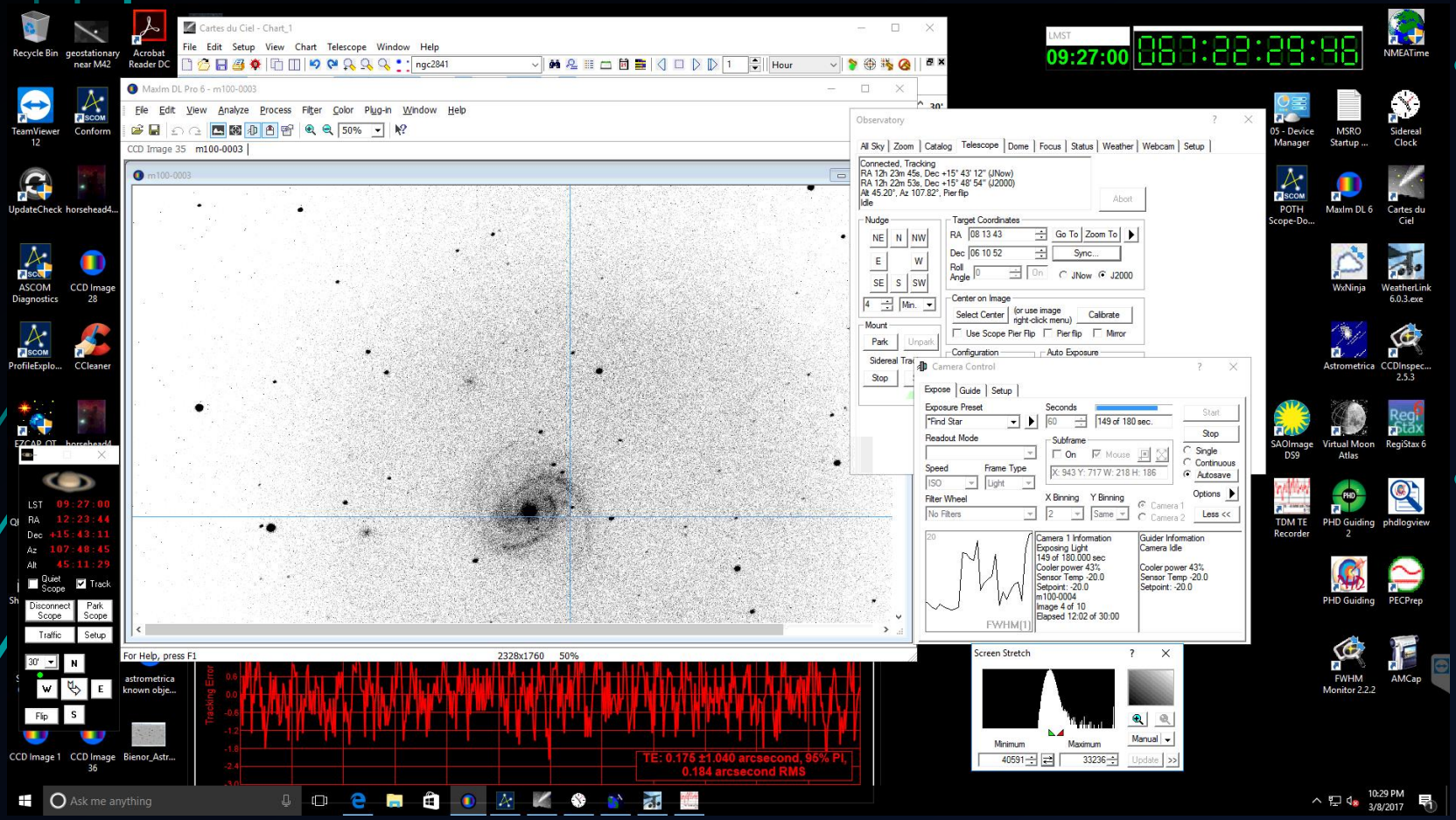
- Once there is a working observatory building housing the AIS, then you can consider what it would take to upgrade it for remote controlled operations
- Prime focus areas are: Power System Reliability, Communications Systems, Facility Protection, and Downtime Mitigation/Spare Parts.
- Today we have many choices in the way to successfully accomplish this goal.
- The key to success in this endeavor is to keep the systems as simple as possible, provide redundancy when warranted, and take it a subsystem at a time. Work on the physical building first, then the power system, then the communications, and then finally, integrate the AIS into the observing facility.
- Building components: Floor/Deck, Pier/Concrete foundation, Isolation measures, Roll-off roof, Dome
- Power components: Batteries, UPSs, Lightning protection, AC mains power, Web Power remote connection manager.
- Communications: Ethernet cabling, Routers, Wireless, USB Hubs, Cable Modem, DSL Modem, Cell communications

Remote Access To Your Observatory





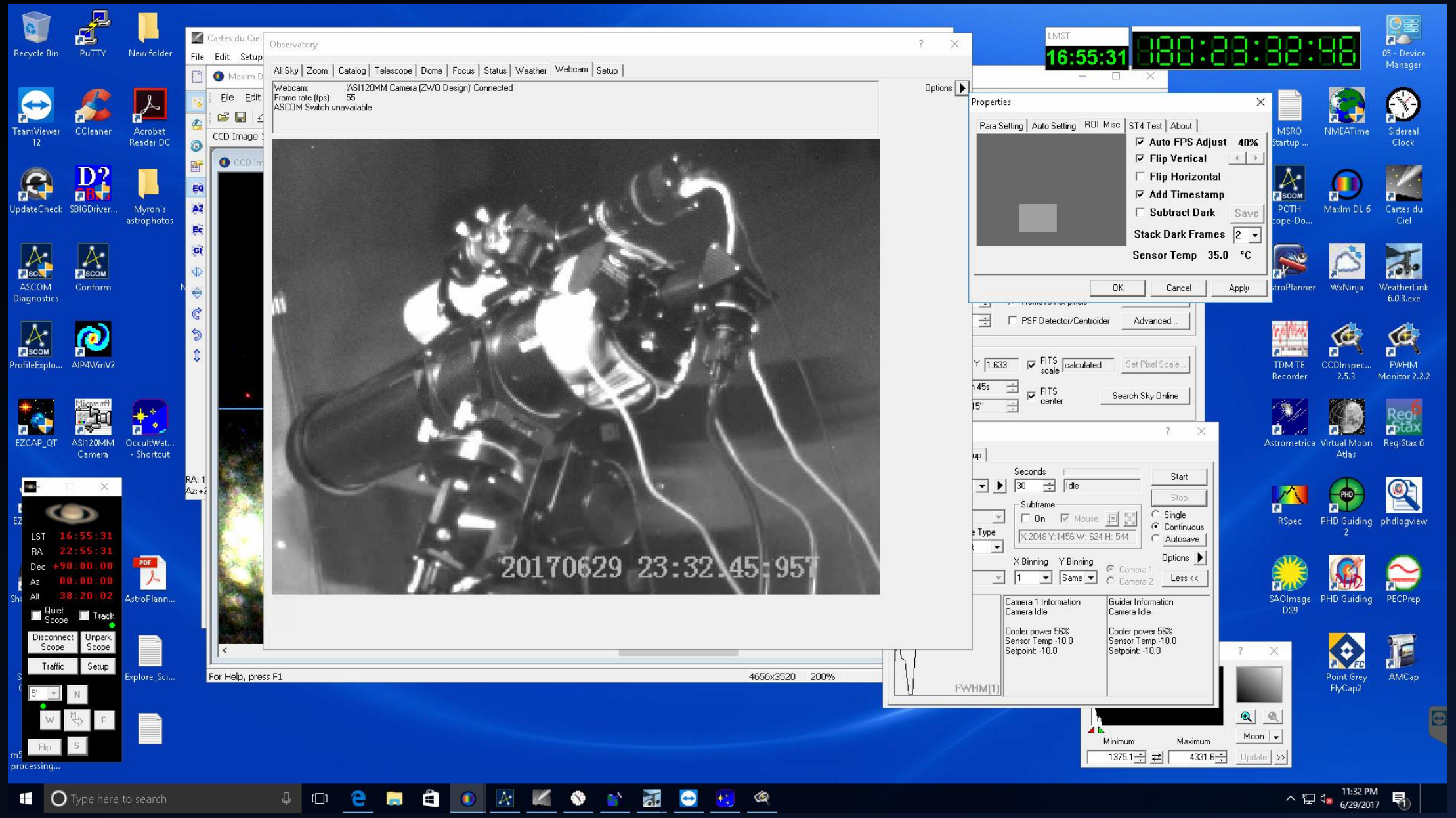
Remote Access To Your Observatory - TeamViewer

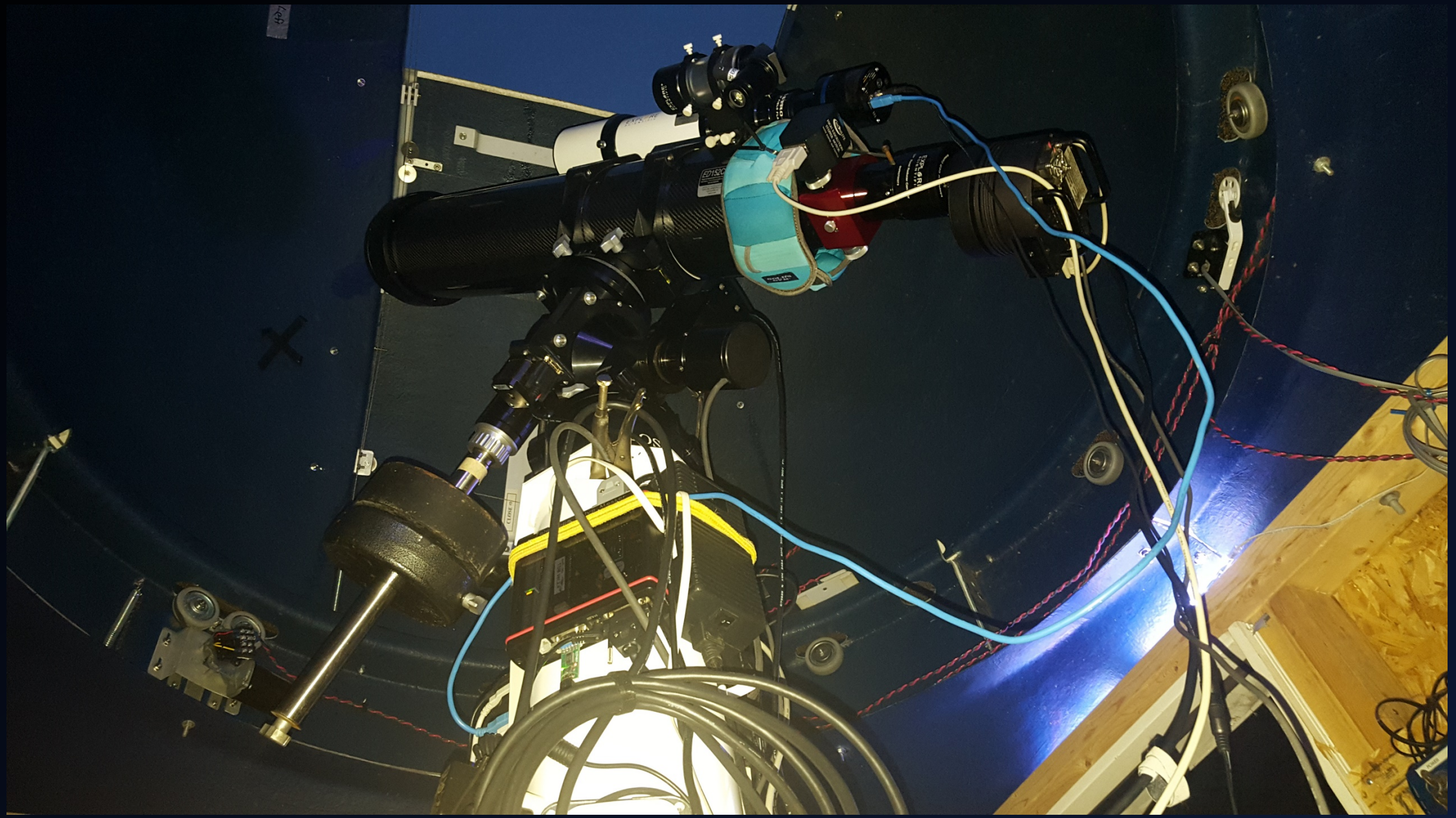


- The MSRO is accessed remotely using the program TeamViewer version 12. This is a very nice remote access application that includes file transfers and remote desktop sharing for multiple users.
- This is used by the MSRO staff to train users in remote operations, obtaining calibration and science data, and maintaining the software, drivers, databases, and catalogs installed on the system

Remote Access To Your Observatory

- When building your remote observatory, keep meticulous notes on its configuration and design. Incorporate this data into your operations and maintenance procedures.
- Keep your facility information up to date for when the time comes to upgrade it, or if you run into an issue that you may be able to solve remotely to get yourself back up and running.
- Use a remote control application such as TeamViewer to remotely access the observatory computer for performing maintenance updates and other necessary operations.


Observatory
All Sky | Zoom | Catalog | Telescope | Dome | Focus | Status | Weather | Webcam | Setup
Webcam: 'ASI120MM Camera (ZWO Design)' Connected
Frame rate (fps): 55
ASCOM Switch unavailable
Options
20170629 23:32:45:957
Properties
Para Setting | Auto Setting | ROI Misc | ST4 Test | About
Auto FPS Adjust 40%
Flip Vertical
Flip Horizontal
Add Timestamp
Subtract Dark
Save
Stack Dark Frames 2
Sensor Temp 35.0 °C
OK
Cancel
Apply
LMST
16:55:31
180:23:32:46
LST 16:55:31
RA 22:55:31
Dec +90:00:00
Az 00:00:00
Alt 38:20:02
Quiet Scope
Track
Disconnect Scope
Unpark Scope
Traffic
Setup
Flip
Seconds
Start
Stop
Subframe
Single
Continuous
Autosave
X Binning
Y Binning
Camera 1 Information
Camera Idle
Cooler power 56%
Sensor Temp -10.0
Setpoint: -10.0
Guider Information
Camera Idle
Cooler power 56%
Sensor Temp -10.0
Setpoint: -10.0
FWHM(1)
Minimum
Maximum
1375.1
4331.6
Moon
Update
For Help, press F1
4656x3520
200%
Type here to search
11:32 PM
6/29/2017



MSRO Observing Programs / Projects

- There are many observing projects that are possible with the MSRO as it has some basic instruments that can image and take data from a variety of objects. Among the projects possible are:

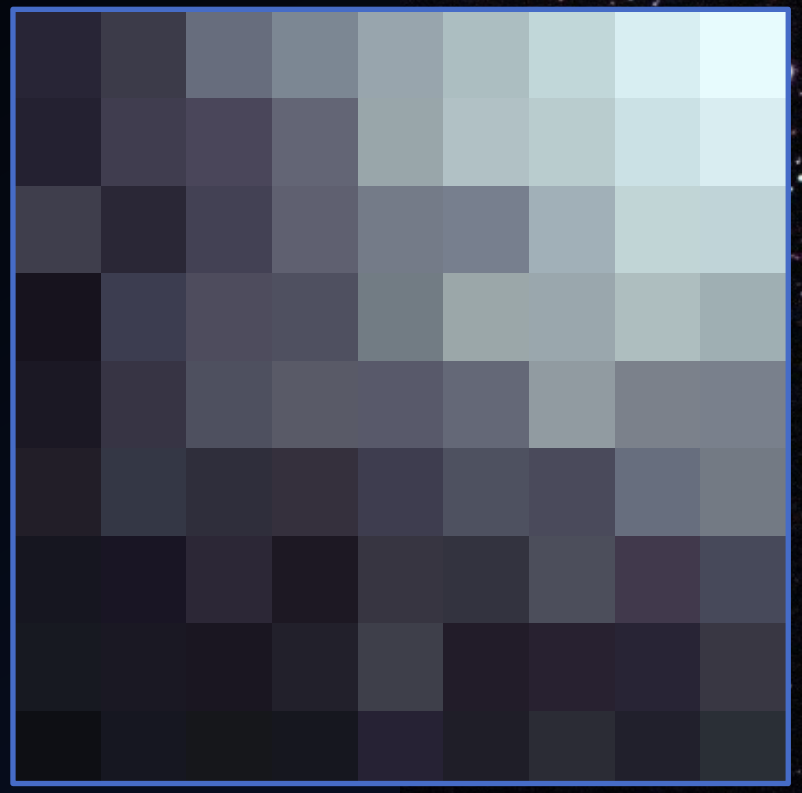
- Astrometry
  - Minor Planet Position Measurement
  - Binary Star Orbit Measurements
- Photometry
  - Minor Planet Photometric Magnitude
  - Variable Star Light Curve Measurements
  - Exo-Planet Transit Measurements
  - Minor Planet Rotation Rate Measurements
- Spectroscopy
  - Stellar Type Classification
  - Stellar Temperature Measurements
- Deep Sky/Lunar/Planetary Imaging
  - Full Color Nebula Imaging
  - High Resolution Lunar Topographical Studies
  - Planetary Imaging

Minor Planet Observations Performed Remotely at the MSRO on March 20th Astrometric Measurements and Magnitude Estimates (V-Band Photometric) for 16 different Minor Planets 12.3 mag to 18.2 mag

```
COD W54
OBS G. R. Hubbell
MEA G. R. Hubbell
TEL 0.15-m f/8.0 refractor + CCD
ACK MPCReport file updated 2017.03.20 21:21:41
AC2 jerry.hubbell@comcast.net
NET URAT-1
NUM 32
00150         C2017 03 20.19990 11 58 27.42 -01 20 04.8          12.9 V      W54
00150         C2017 03 20.28750 11 58 23.41 -01 19 37.0          12.9 V      W54
00356         C2017 03 20.16382 11 56 16.49 -00 44 16.6          12.3 V      W54
00356         C2017 03 20.25289 11 56 11.32 -00 43 59.5          12.3 V      W54
01564         C2017 03 20.18911 11 55 35.08 +00 51 28.4          15.6 V      W54
01564         C2017 03 20.27605 11 55 31.42 +00 52 04.0          15.6 V      W54
03373         C2017 03 20.18911 11 55 56.21 +00 38 14.2          16.1 V      W54
03373         C2017 03 20.27605 11 55 51.06 +00 38 55.6          16.3 V      W54
04651         C2017 03 20.18096 11 58 45.41 +00 02 02.7          16.7 V      W54
04651         C2017 03 20.26826 11 58 41.16 +00 02 32.8          16.8 V      W54
08428         C2017 03 20.16382 11 55 25.62 -00 40 30.8          16.8 V      W54
08428         C2017 03 20.25289 11 55 20.41 -00 39 53.9          16.7 V      W54
08946         C2017 03 20.19392 12 02 43.15 +00 01 44.6          17.6 V      W54
08946         C2017 03 20.28103 12 02 39.08 +00 02 13.2          17.9 V      W54
10401         C2017 03 20.27954 12 03 17.43 +00 06 54.2          17.1 V      W54
10401         C2017 03 20.28251 12 03 17.41 +00 06 57.1          17.3 V      W54
11751         C2017 03 20.17096 11 51 27.58 -00 28 45.2          16.0 V      W54
11751         C2017 03 20.26234 11 51 22.21 -00 28 19.4          15.8 V      W54
22001         C2017 03 20.18096 11 59 13.20 -00 04 56.8          17.6 V      W54
22001         C2017 03 20.18245 11 59 13.22 -00 04 56.5          17.8 V      W54
24562         C2017 03 20.26529 11 57 08.86 -00 28 51.7          18.2 V      W54
24562         C2017 03 20.26826 11 57 08.71 -00 28 50.2          17.7 V      W54
25294         C2017 03 20.17096 11 52 36.09 -00 12 20.6          17.3 V      W54
25294         C2017 03 20.17394 11 52 35.98 -00 12 19.9          18.0 V      W54
53595         C2017 03 20.16531 11 56 25.27 -00 34 36.0          16.6 V      W54
53595         C2017 03 20.25289 11 56 20.40 -00 33 45.6          17.1 V      W54
70027         C2017 03 20.19392 12 01 11.96 -00 08 27.4          17.2 V      W54
70027         C2017 03 20.19690 12 01 11.79 -00 08 27.5          16.9 V      W54
D4886         C2017 03 20.25937 11 49 53.03 -00 40 18.6          17.5 V      W54
D4886         C2017 03 20.26234 11 49 52.93 -00 40 18.9          17.9 V      W54
E3404         C2017 03 20.18096 11 58 19.04 -00 15 48.3          14.9 V      W54
E3404         C2017 03 20.26826 11 58 10.84 -00 14 12.1          14.8 V      W54
```

Haffner 18
5-min Exposure
QHY163C CCD
camera

M13-Great Hercules Cluster



M20-Trifid Nebula

M8-Lagoon Nebula

M81-Bode’s Galaxy

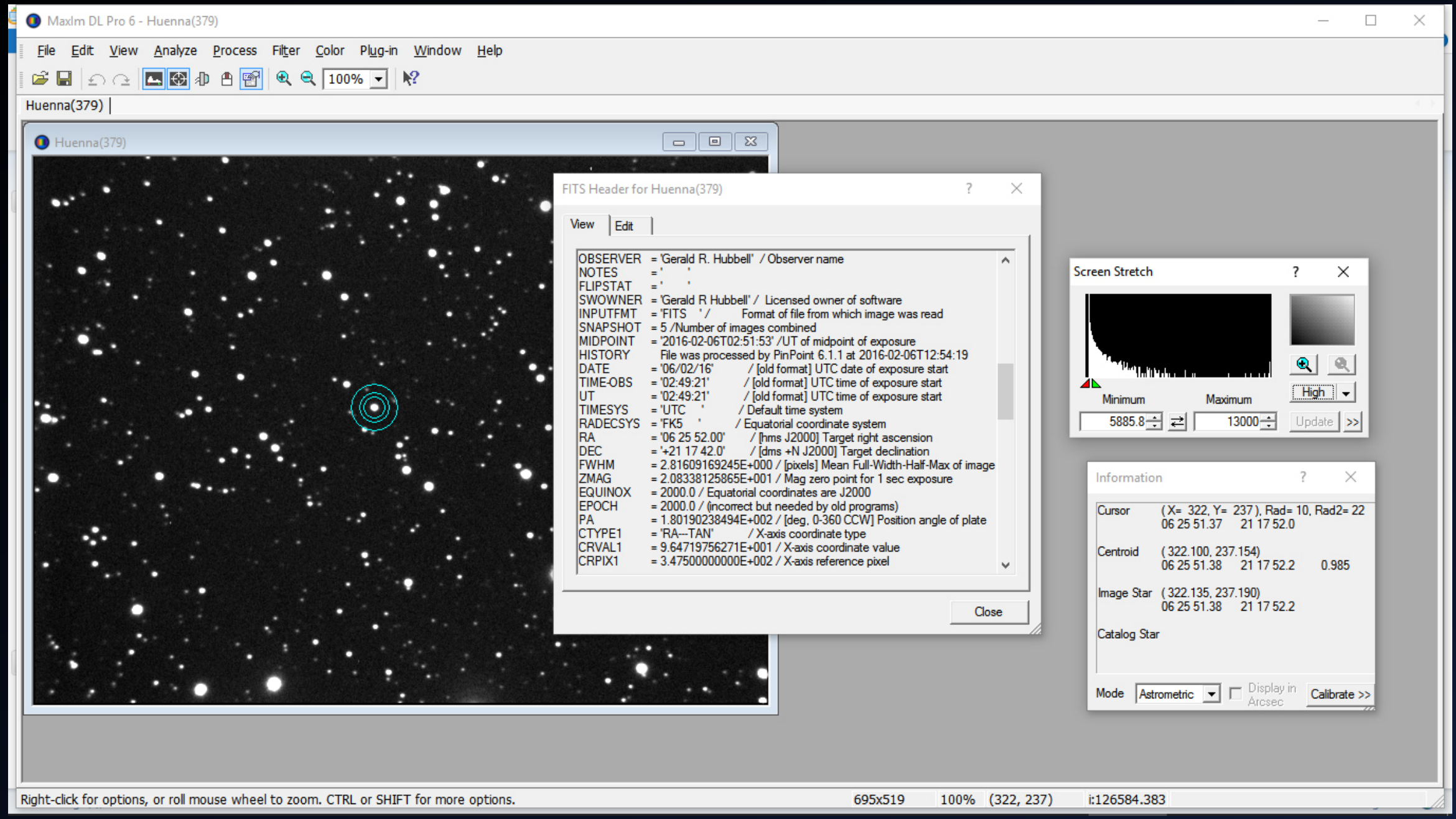
M51-Whirlpool Galaxy

M1-Crab Nebula

30-min Unguided Exposure
(30 x 60-sec subframes stacked)
IC434 Horsehead Nebula with 12-inch Meade LX200 and QHY163C CCD Camera on Losmandy G11 mount

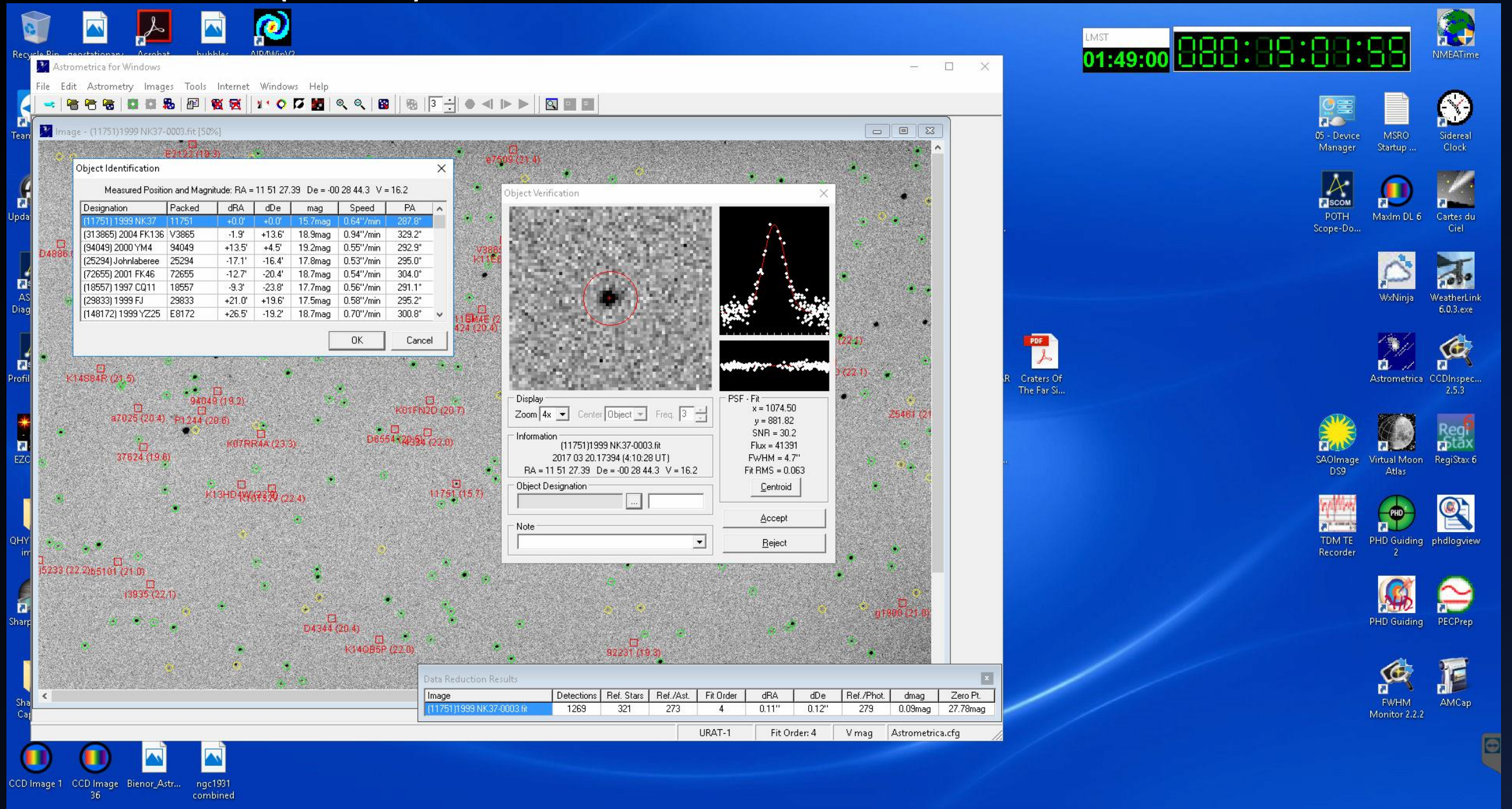
20-min Exposure
IC434 Horsehead Nebula
with 12-inch Meade
LX200 and SBIG
ST2000XM Camera

M104-Sombrero Galaxy

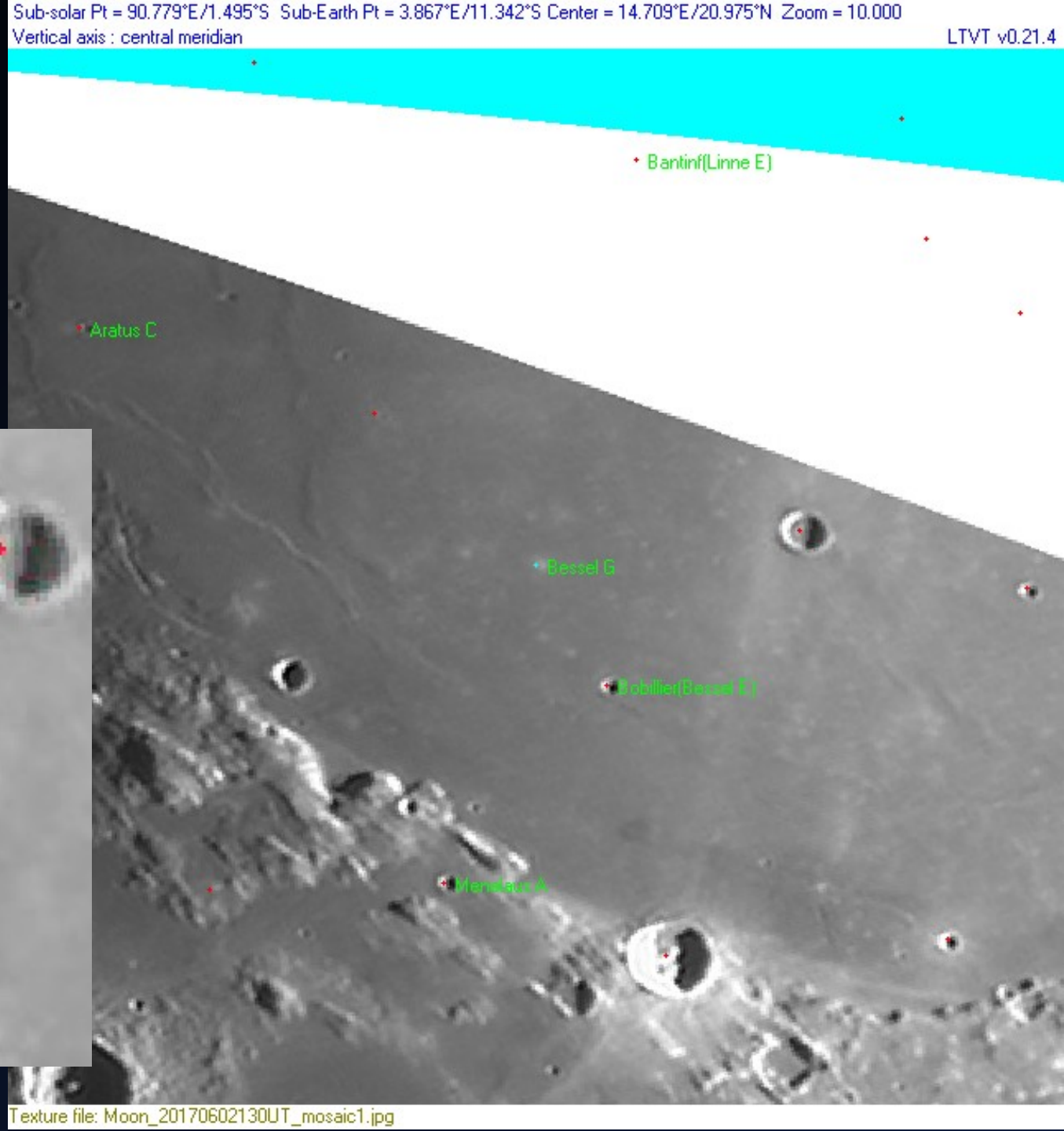

MaxIm DL Pro 6 - Huenna(379)
File Edit View Analyze Process Filter Color Plug-in Window Help
100%
Huenna(379)
Huenna(379)
FITS Header for Huenna(379)
View Edit
OBSERVER = 'Gerald R. Hubbell' / Observer name
NOTES = ' '
FLIPSTAT = ' '
SWOWNER = 'Gerald R Hubbell' / Licensed owner of software
INPUTFMT = 'FITS ' / Format of file from which image was read
SNAPSHOT = 5 /Number of images combined
MIDPOINT = '2016-02-06T02:51:53' /UT of midpoint of exposure
HISTORY File was processed by PinPoint 6.1.1 at 2016-02-06T12:54:19
DATE = '06/02/16' / [old format] UTC date of exposure start
TIME-OBS = '02:49:21' / [old format] UTC time of exposure start
UT = '02:49:21' / [old format] UTC time of exposure start
TIMESYS = 'UTC ' / Default time system
RADECSYS = 'FK5 ' / Equatorial coordinate system
RA = '06 25 52.00' / [hms J2000] Target right ascension
DEC = '+21 17 42.0' / [dms +N J2000] Target declination
FWHM = 2.81609169245E+000 / [pixels] Mean Full-Width-Half-Max of image
ZMAG = 2.08338125865E+001 / Mag zero point for 1 sec exposure
EQUINOX = 2000.0 / Equatorial coordinates are J2000
EPOCH = 2000.0 / (incorrect but needed by old programs)
PA = 1.80190238494E+002 / [deg, 0-360 CCW] Position angle of plate
CTYPE1 = 'RA---TAN' / X-axis coordinate type
CRVAL1 = 9.64719756271E+001 / X-axis coordinate value
CRPIX1 = 3.47500000000E+002 / X-axis reference pixel
Close
Screen Stretch
Minimum
Maximum
5885.8
13000
High
Update
>>
Information
Cursor (X= 322, Y= 237), Rad= 10, Rad2= 22
06 25 51.37 21 17 52.0
Centroid (322.100, 237.154)
06 25 51.38 21 17 52.2 0.985
Image Star (322.135, 237.190)
06 25 51.38 21 17 52.2
Catalog Star
Mode Astrometric
Display in Arcsec
Calibrate >>
Right-click for options, or roll mouse wheel to zoom. CTRL or SHIFT for more options.
695x519
100%
(322, 237)
i:126584.383

Minor Planets (14) Irene and (4358)Lynn

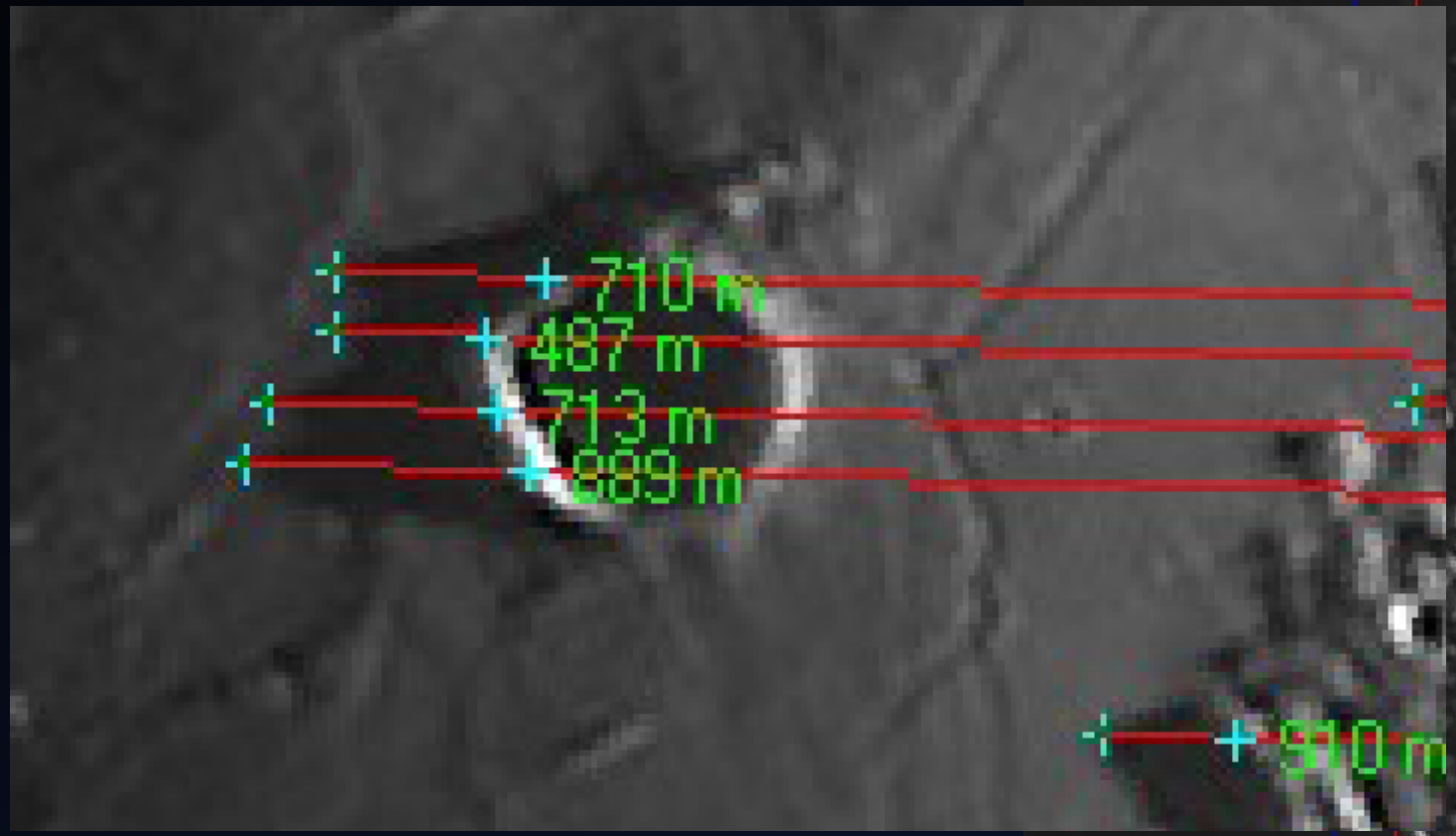
Minor Planet (11751)1999 NK37 Measurement

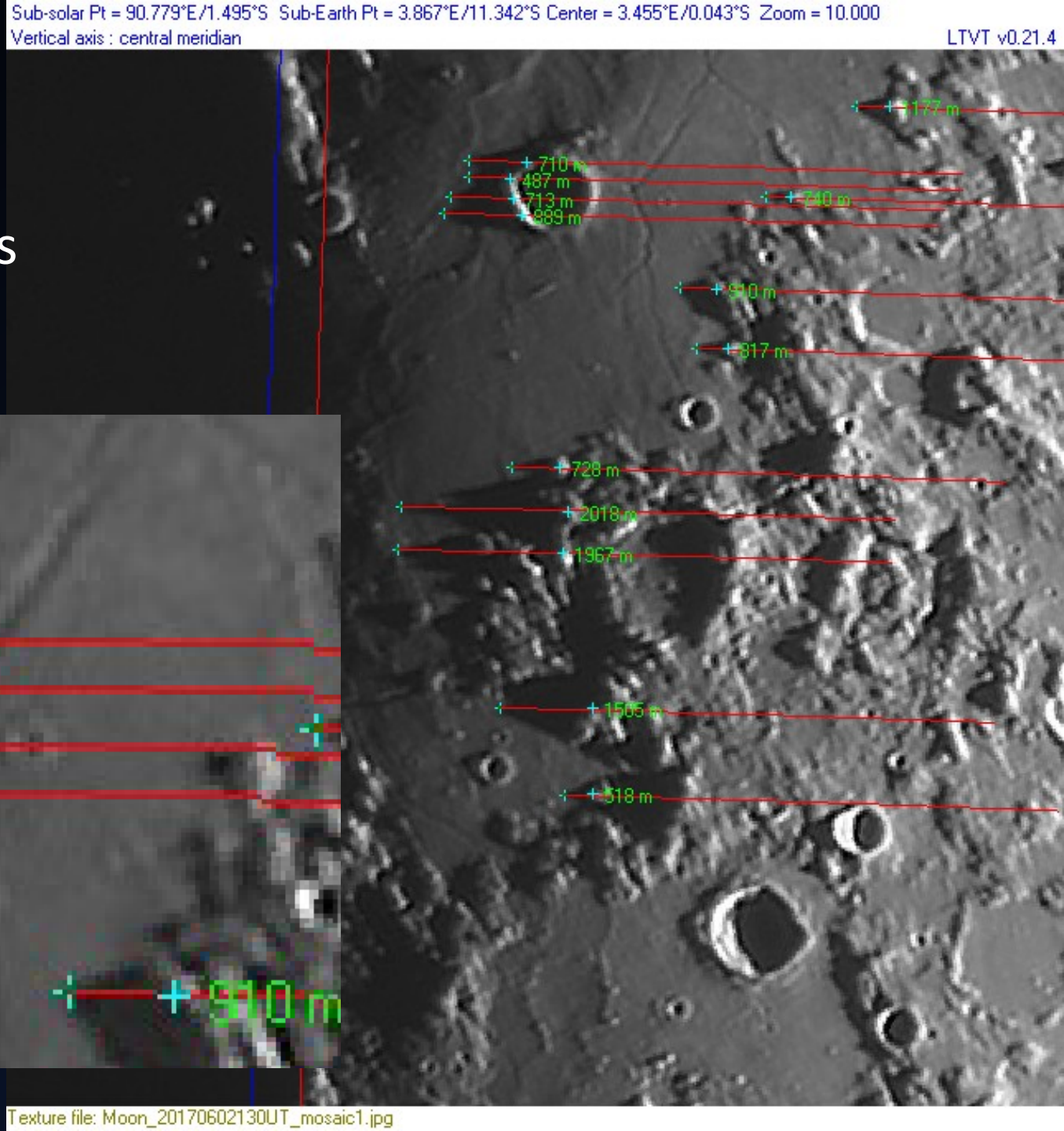


LTVT Crater Locations: 1-mile Crater Bessel G detection

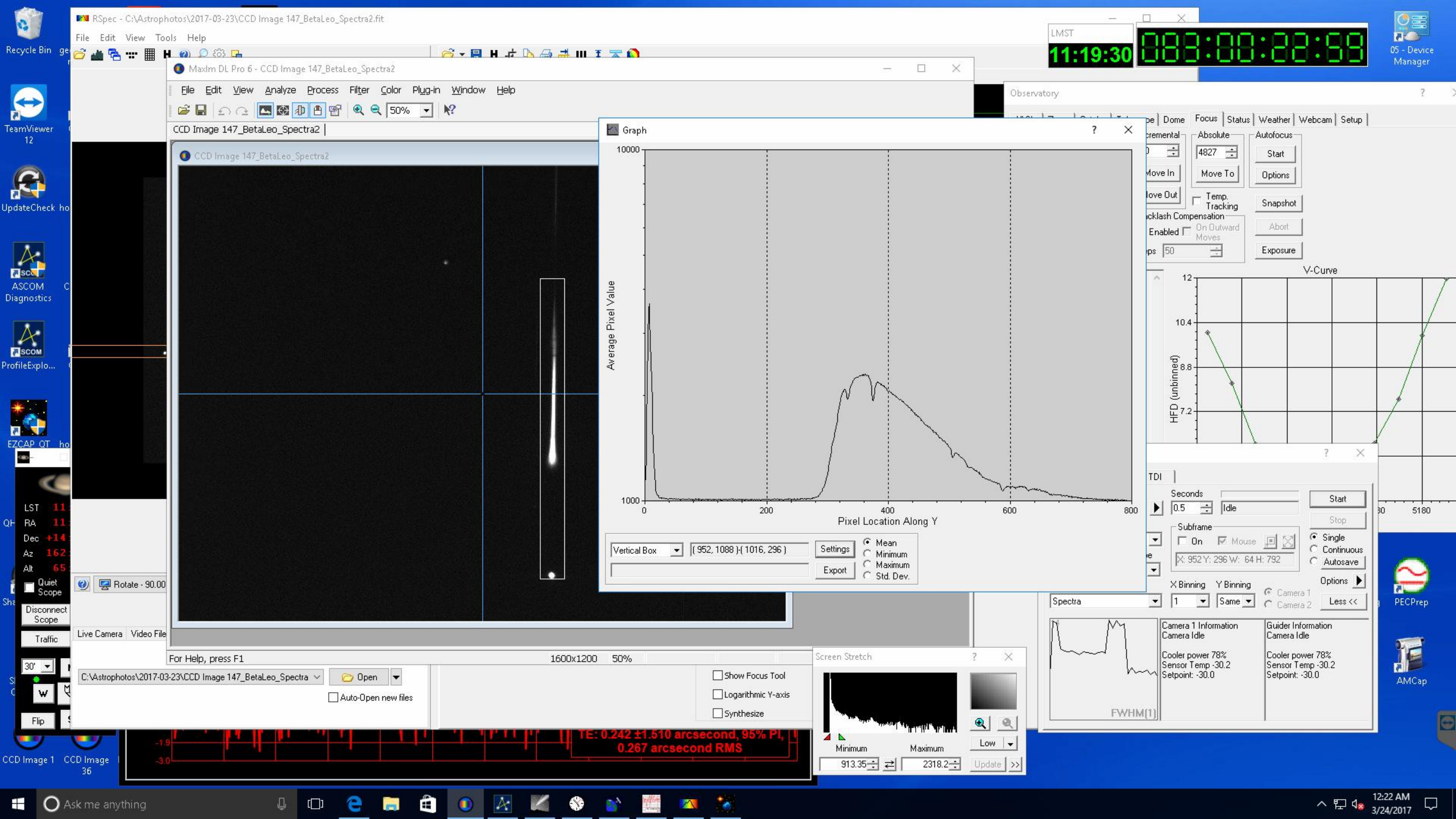


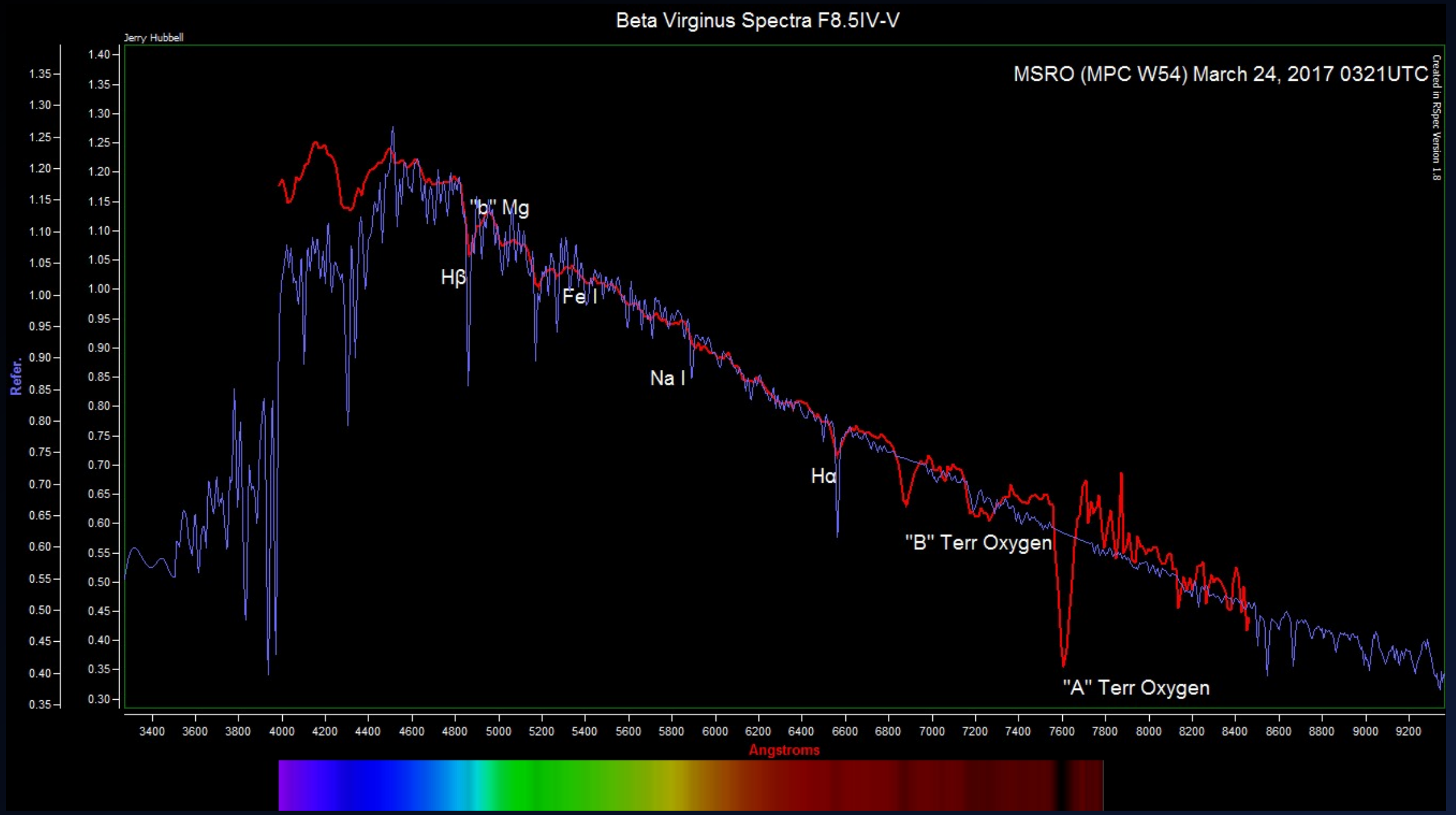
LTVT Shadow Measurements Craters Triesnecker and Rhaeticus

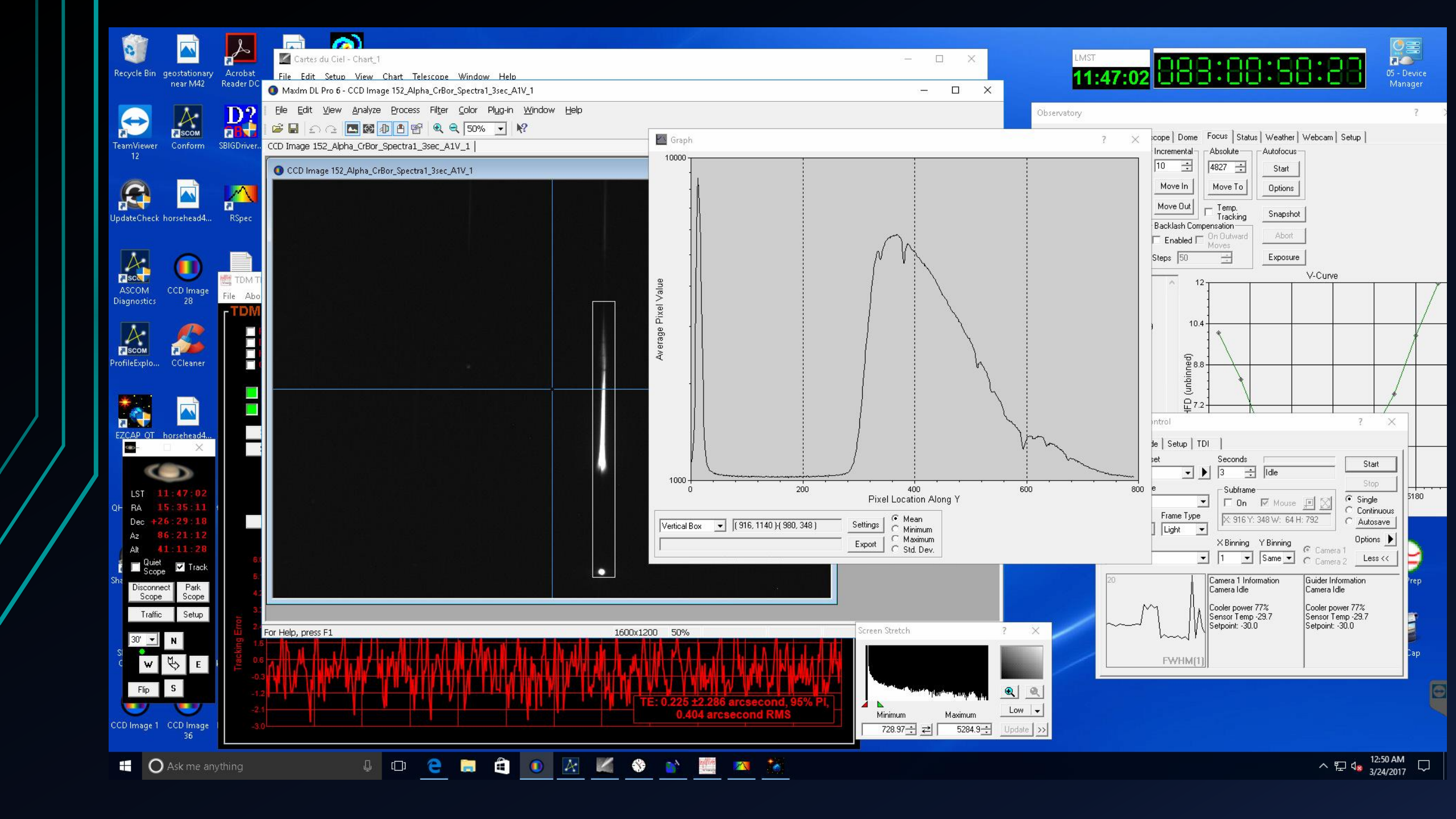




Beta Leo Spectra using Paten Hawksley Star Analyzer 200 – 200 lpmm Spectral Grating mounted SBIG ST2000MX Filter Wheel


RSpec - C:\Astrophotos\2017-03-23\CCD Image 147_BetaLeo_Spectra2.fit
File Edit View Tools Help
LMST
11:19:30
088:00:22:59
MaxIm DL Pro 6 - CCD Image 147_BetaLeo_Spectra2
File Edit View Analyze Process Filter Color Plug-in Window Help
CCD Image 147_BetaLeo_Spectra2
Graph
Average Pixel Value
Pixel Location Along Y
Vertical Box
(952, 1088)-(1016, 296)
Settings
Export
Mean
Minimum
Maximum
Std. Dev.
Observatory
Dome Focus Status Weather Webcam Setup
Absolute
4827
Move To
Autofocus
Start
Options
Snapshot
Abort
Exposure
Temp. Tracking
Backlash Compensation
Enabled
On Outward Moves
V-Curve
HFD (unbinned)
TDI
Seconds
0.5
Idle
Start
Stop
Subframe
On
Mouse
X: 952 Y: 296 W: 64 H: 792
Single
Continuous
Autosave
Options
X Binning
Y Binning
Camera 1
Camera 2
Less <<
Spectra
Camera 1 Information
Camera Idle
Cooler power 78%
Sensor Temp -30.2
Setpoint: -30.0
Guider Information
Camera Idle
Cooler power 78%
Sensor Temp -30.2
Setpoint: -30.0
FWHM(1)
Screen Stretch
Minimum
Maximum
913.35
2318.2
Low
Update
Rotate - 90.00
Live Camera
Video File
For Help, press F1
1600x1200
50%
C:\Astrophotos\2017-03-23\CCD Image 147_BetaLeo_Spectra
Open
Auto-Open new files
Show Focus Tool
Logarithmic Y-axis
Synthesize
TE: 0.242 ±1.510 arcsecond, 95% PI, 0.267 arcsecond RMS
LST
RA
Dec
Az
Alt
Quiet Scope
Disconnect Scope
Traffic
Flip
Recycle Bin
TeamViewer 12
UpdateCheck
ASCOM Diagnostics
ProfileExplo...
EZCAP QT
CCD Image 1
CCD Image 36
05 - Device Manager
PECPrep
AMCap
Ask me anything
12:22 AM
3/24/2017


Beta Virginus Spectra F8.5IV-V
Jerry Hubbell
MSRO (MPC W54) March 24, 2017 0321UTC
Created in RSpec Version 1.8
Refer.
"b" Mg
Hβ
Fe I
Na I
Hα
"B" Terr Oxygen
"A" Terr Oxygen
Angstroms


Cartes du Ciel - Chart_1
MaxIm DL Pro 6 - CCD Image 152_Alpha_CrBor_Spectra1_3sec_A1V_1
CCD Image 152_Alpha_CrBor_Spectra1_3sec_A1V_1
Graph
Average Pixel Value
Pixel Location Along Y
Observatory
V-Curve
HFD (unbinned)
Tracking Error
TE: 0.225 ±2.286 arcsecond, 95% PI,
0.404 arcsecond RMS
Screen Stretch
LST 11:47:02
RA 15:35:11
Dec +26:29:18
Az 86:21:12
Alt 41:11:28
Disconnect Scope
Park Scope
Traffic
Setup
Flip
Start
Stop
Snapshot
Abort
Exposure
Move In
Move Out
Move To
Options
Recycle Bin
geostationary near M42
Acrobat Reader DC
TeamViewer 12
Conform
SBIGDriver...
UpdateCheck
horsehead4...
RSpec
ASCOM Diagnostics
CCD Image 28
ProfileExplo...
CCleaner
EZCAP_QT...
CCD Image 1
CCD Image 36
05 - Device Manager

DEMO

- Live MSRO Teamviewer Session

QUESTIONS?