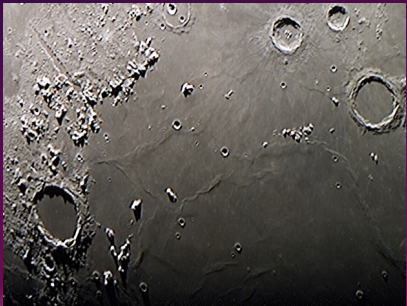


Twenty Years of Lucky Imaging

David Kolb

Astronomy Associates of Lawrence

March 26, 2023



What Do I Mean by Lucky Imaging?

- Record videos of a planet like Mars or Jupiter
- Capture hundreds or thousands of video frames
- Hope for a few frames captured under better seeing conditions, hence the term lucky imaging
- Stack the best frames into a final image

How Did I Get Started?

- Purchased Meade LXD55 in November 2002
- Mars opposition of 2003
- Sky and Telescope article on webcam imaging (June 2003)



Setup in 2003

ToUcam Camera



Barlow Lenses



2003 Mars Images



July 13, 2003



July 26, 2003



August 12, 2003



August 24, 2003



September 3, 2003



September 7, 2003

Cameras in 2003

- Philips Vesta Pro & Philips ToUcam Pro (640x480 CCD sensor, USB 1.1)
 - 5.6 micron pixels
 - CCD superior to CMOS
- Require low frame rate (5 fps) due to compression at higher rates
- Noisy (diagonal bands)
 - Remove with FFT edits

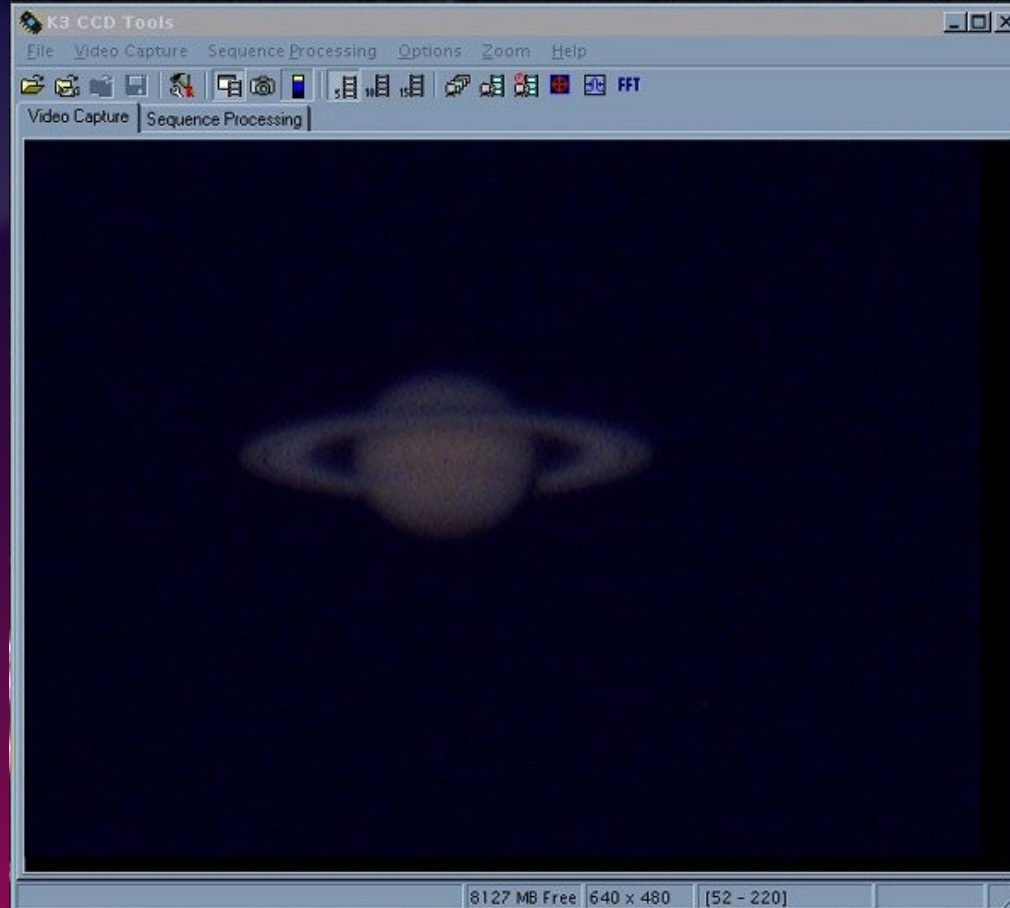


Mars image with diagonal bands

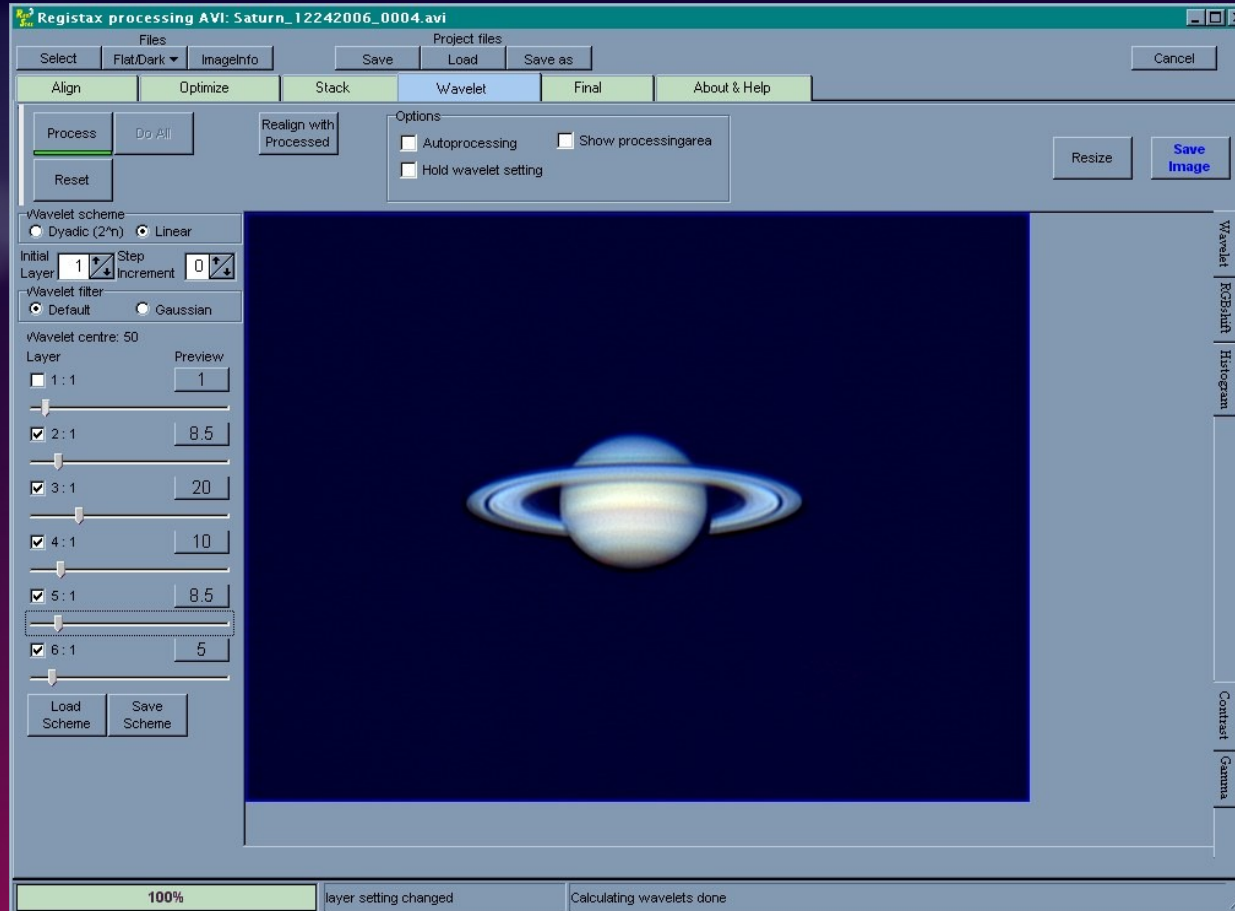
Software in 2003

- Windows 98
- Philips VRecord initially used for video capture
- K3CCDTools (free) for subsequent capturing
- Registax (free) for stacking
- Paint Shop Pro 9 for final processing

Software in 2003



Software in 2003



Video Formats and File Sizes

- 8 bit AVI format (256 color)
- 5 fps for uncompressed video
- 2 to 4 minute capture length ~ 300 Mb to 1 Gb
 - 2 minutes for Jupiter
 - 3 minutes for Saturn
 - 4 minutes for Mars
- Easily store several night's data on a Windows 98 laptop

First Jupiter and Saturn Images



Jupiter 10/12/2003



Saturn 10/12/2003

2005 Images of Jupiter and Saturn



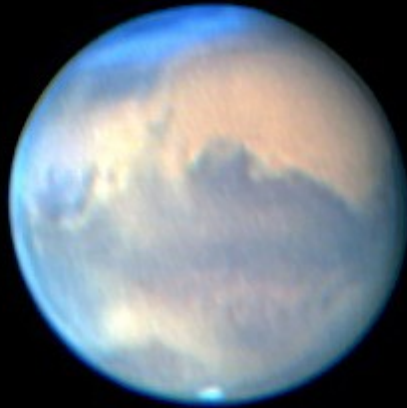
Jupiter
6/19/2005



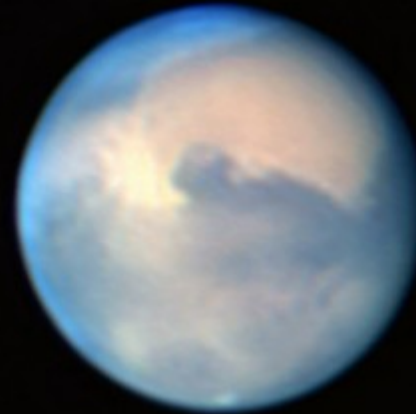
Saturn
2/3/2005

2005 Martian Dust Storm

Changes in the Martian Dust Storms of Oct. 2005



Oct. 26, 2005
7:14 UT
CM 359.8 °



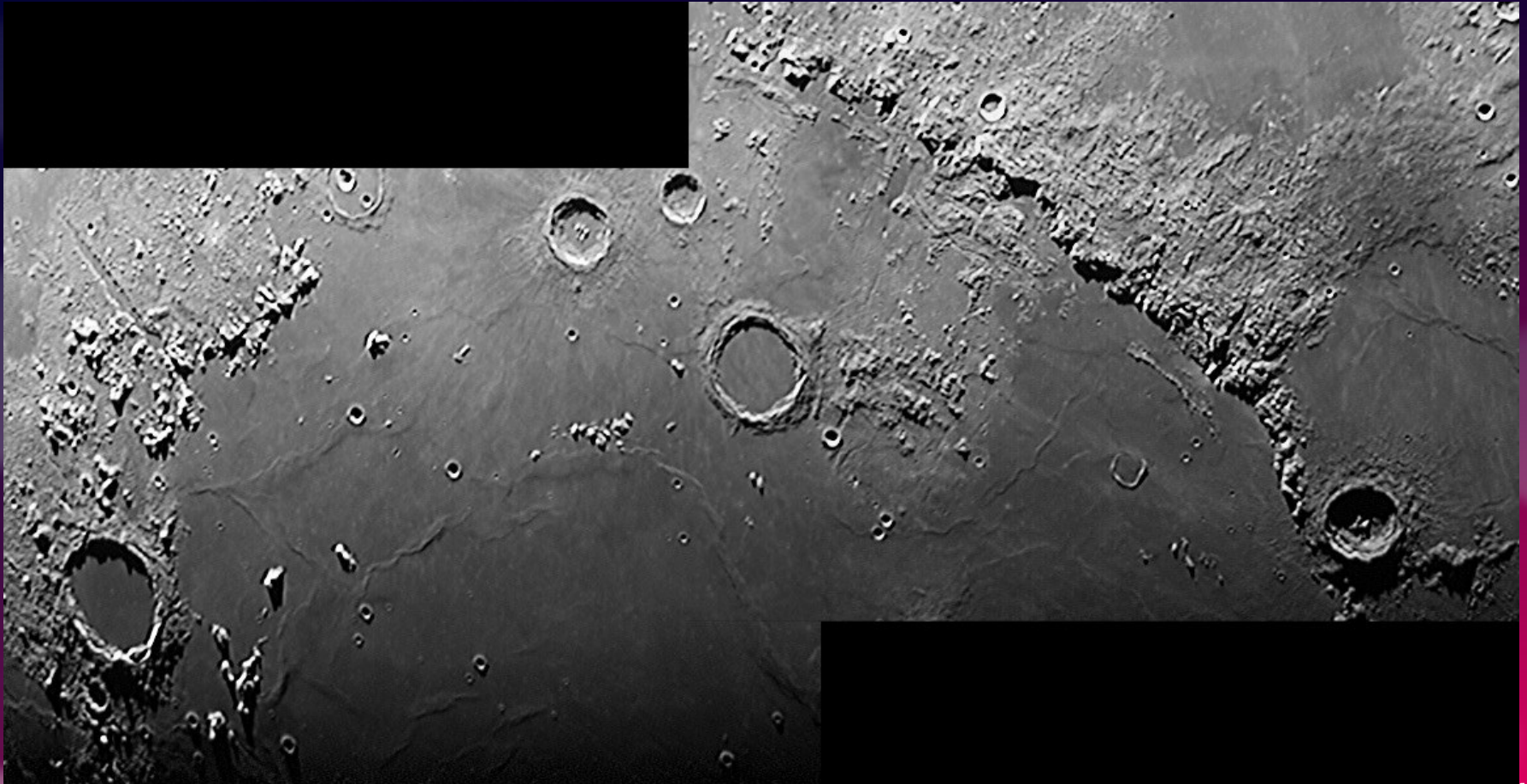
Oct. 28, 2005
7:53 UT
CM 341.9 °

David Kolb, Lawrence, KS USA, Meade LXD55 8 Inch SCT, ToUcam Pro, 5X Powermate

Mercury Transit - Nov. 8, 2006



First Quarter - Mare Imbrium - June 24, 2007



Equipment circa 2008

- Philips SPC900 NC Webcam
 - Basically the same as the ToUcam but supported USB 2.0 transfer speeds
- Windows XP laptop with 320 Gb drive inserted in DVD drive bay



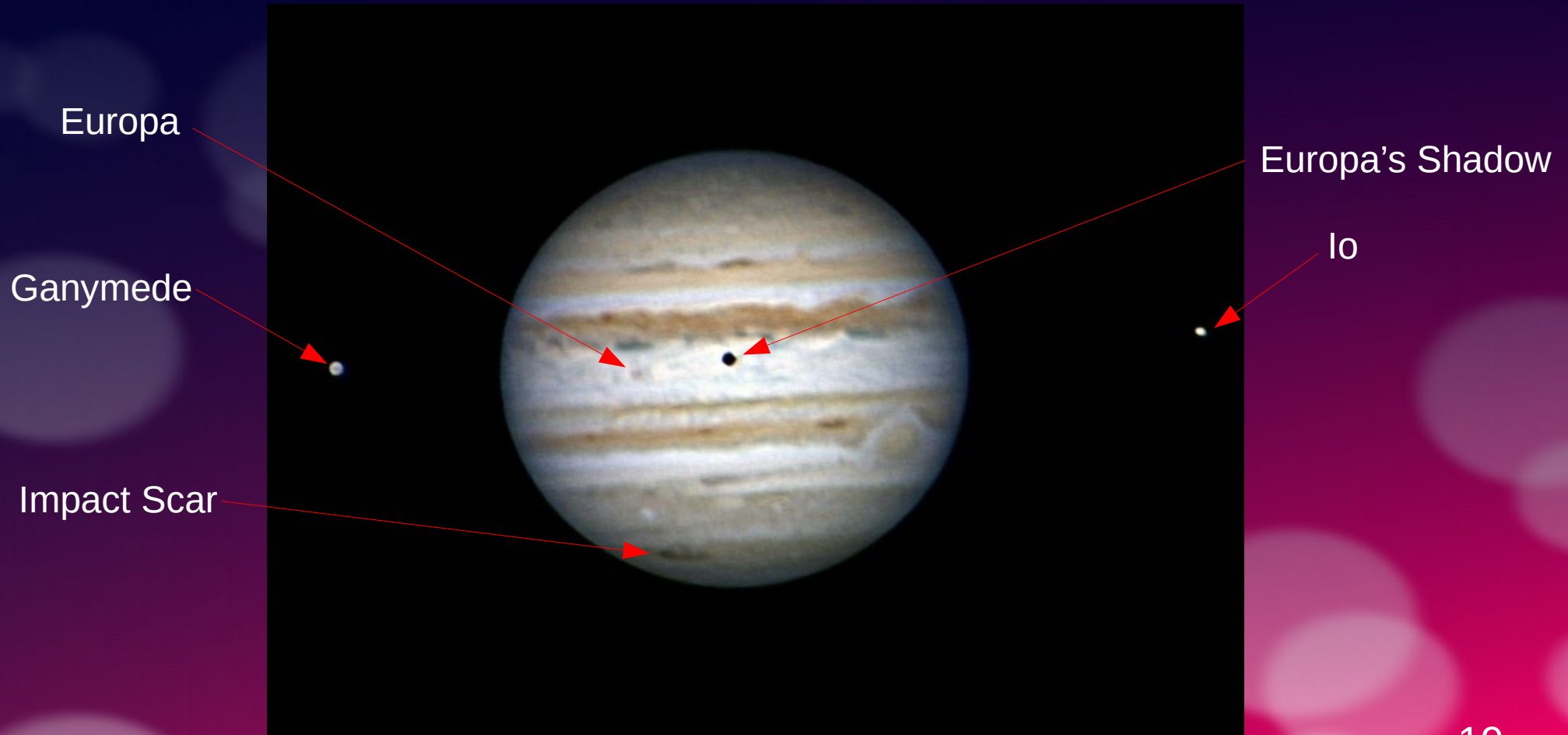
Software Utilized circa 2008

- K3CCDTools (free)
- Registax 4 (free) – stacking
- Astra Image (commercial) – deconvolution
- Neat Image (commercial) - noise removal
- Photoshop CS2 (commercial) - final processing

Venus - January 25, 2009



Jupiter with Moons & Impact Scar – Aug. 2, 2009



Uranus - September 4, 2010

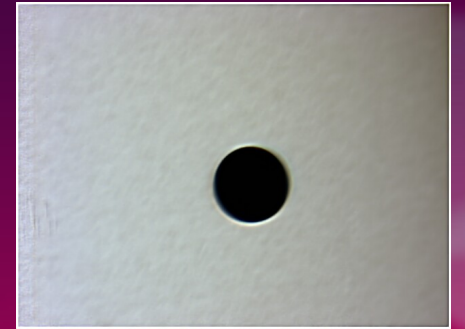
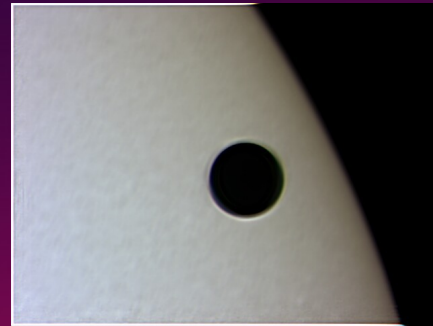
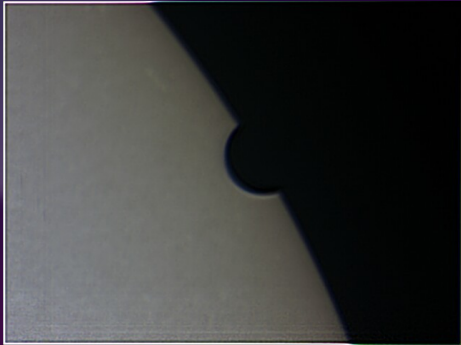


“New” Mount 2012

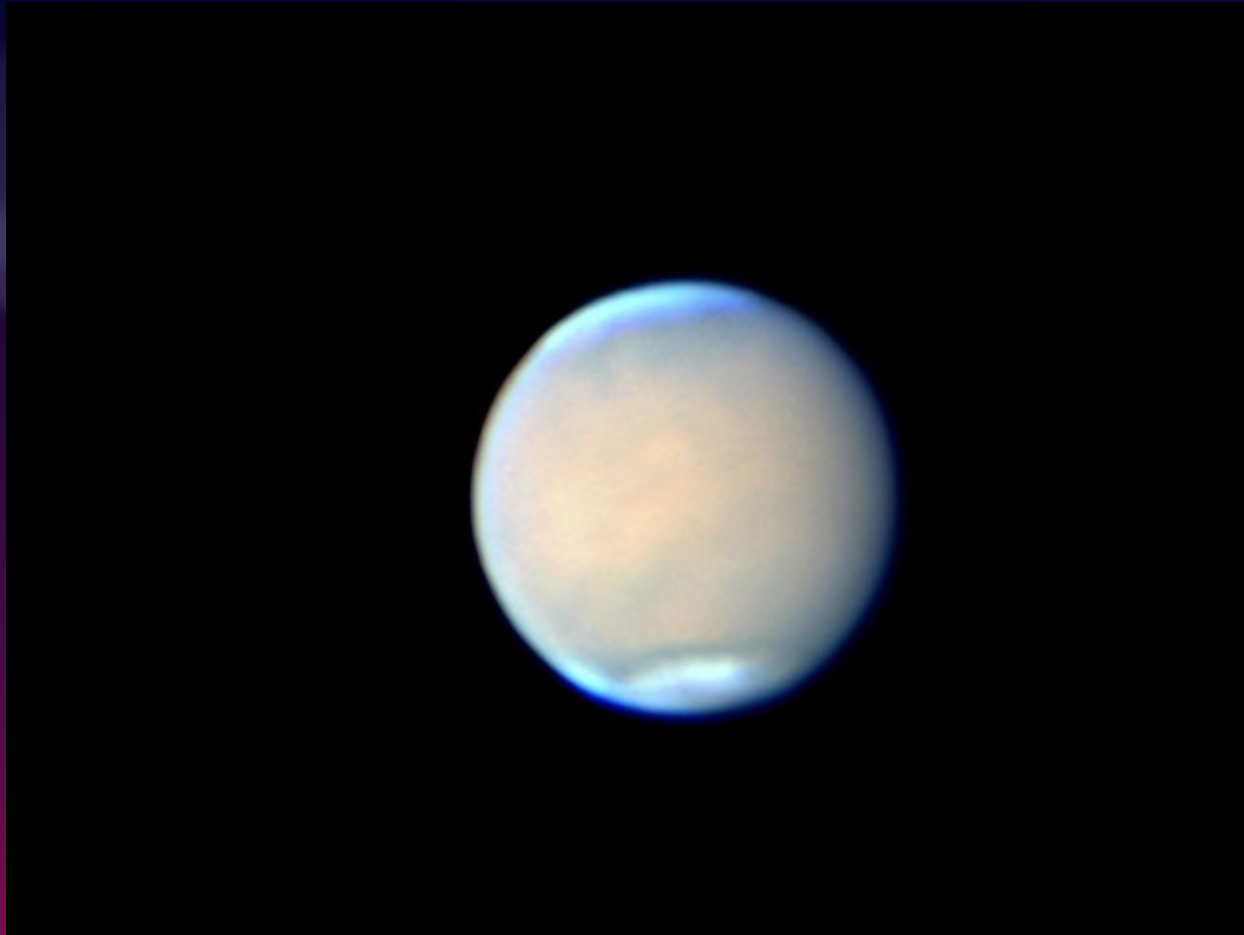
- Meade LXD650



Venus Transit - June 5, 2012



Mars - Planet Wide Dust Storm - July 5, 2018

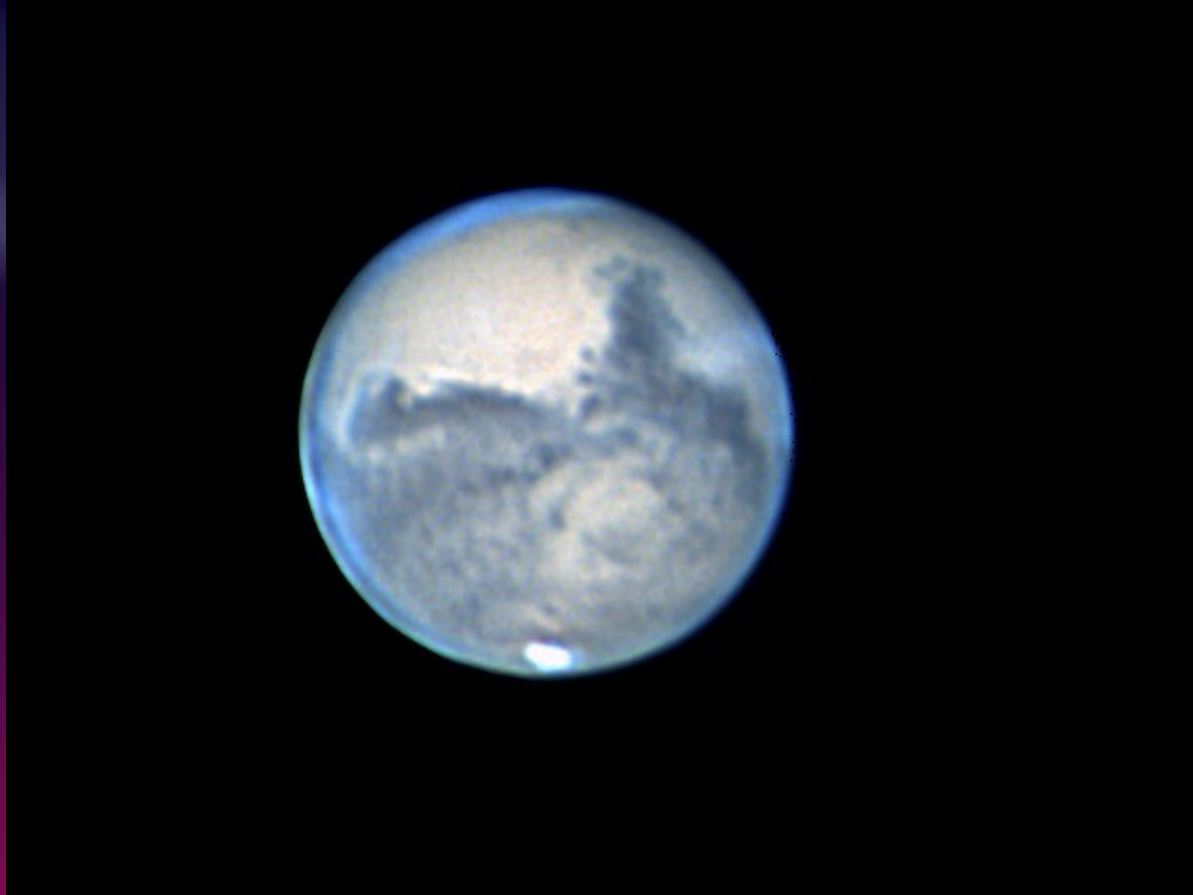


Equipment in 2020

- ZWO ASI178MC CMOS Camera
 - USB 3 - high frame rates possible (60 fps) -> huge videos (> 10 Gb)
 - Large sensor (3096x2080 pixels)
 - Small pixels (2.4 micron)
 - 16 bit data
 - CMOS finally as good or better than CCDs
 - Low noise
 - No compression
- LINUX Laptop
 - Ubuntu LINUX
 - Very stable
 - SSD drives
 - 4 Tb data drive - inserted in place of DVD drive



Mars - October 8, 2020

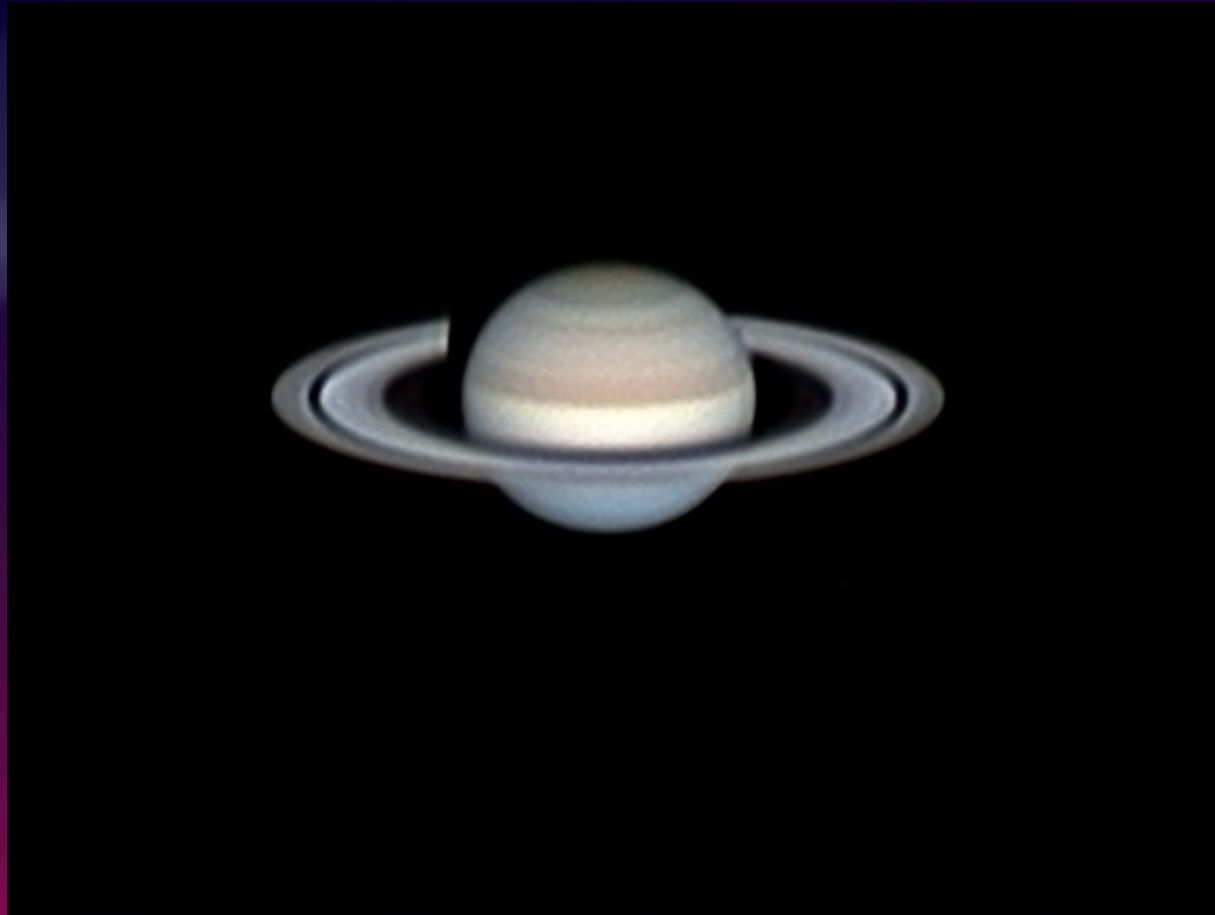


Jupiter - November 01, 2022



Perhaps one of my best images of Jupiter

Saturn - November 01, 2022



Current Software


- ASI Studio (vendor provided) - capture
- Autostakkert (free) - stacking
 - Faster than Registax
- Astra Image (commercial) - deconvolution
- Neat Image (commercial) - noise removal
- PixInsight (commercial) - very powerful, lots of functions
 - Very CPU intensive
 - Will utilize a GPU
- AstroSurface (free) - <http://astrosurface.com/pageuk.html>
 - Currently testing its capabilities
 - Stacking, wavelets, deconvolution, noise filtering, and other post processing
 - Swiss Army Knife of astronomical image processing
 - Runs on LINUX under Wine
 - YouTube video: https://www.youtube.com/watch?v=2oLnJv2V_Pk&ab_channel=TheDigitalAstronomer

ASI Studio



ASICap

ASICAP_V2.7 (ZWO ASI178MC: 22.2 C)



Control

Exposure 5 (ms) 1~100ms

Gain 48

Capture

Path /home/david

Limit 180s RAW Data

Auto Run

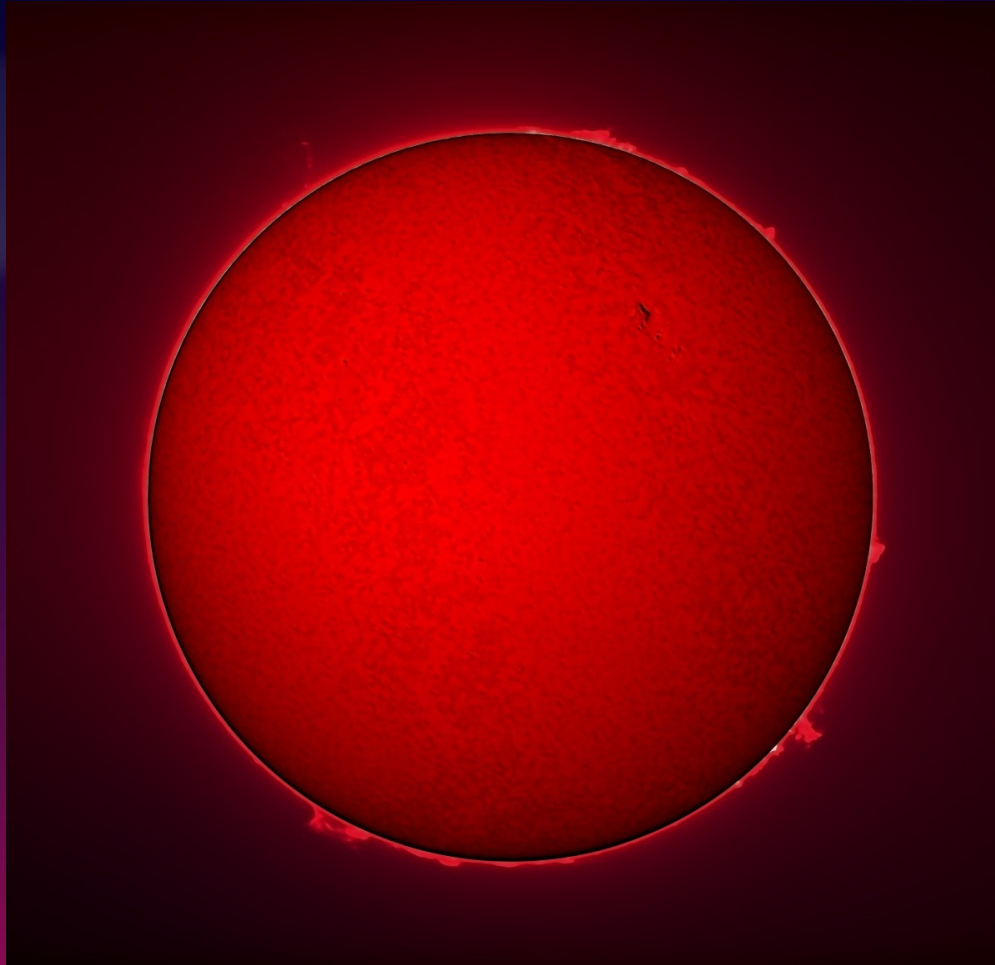
Display Control

Display Gamma 1.0

Record Format [Image: FIT(Raw) Video: SER(Raw)]

preview fps:14.4, total frames:25133, dropped frames:234

Sun in H-Alpha Captured with ASICap



Feb. 27, 2023

Sun Captured with ASI-Cap



March 25, 2023

AutoStakkert

AutoStakkert! 3.1.4 (x64) - Free for non-commercial use

File Memory Usage Colour Advanced Image Calibration Help

1) Open Expand Limit

Threads 4 / 4 SSE2

Status Mem. usage 69.1 % (used 4.1 GB, available 1.8 GB) adaptive buffering Done!

Image Stabilization Surface Planet (COG) Dynamic Background

Quality Estimator Laplace Δ Noise Robust 5 Normal range (bayer override -> 6) Local (AP) Global (Frame)

2) Analyse

Reference Frame Double Stack Reference Auto size Manual size

Pause Cancel...

100% 100%

#F 3494 16 bpp Done! Click for new reference 1/1

Stack Options TIF PNC FIT

Number of frames to stack: 0 0 0 0 #

Frame percentage to stack: 50 0 0 0 %

Normalize Stack 70% Sharpened

RGB Align Save in Folders

Stack(name) Options

Free field

Advanced Settings Drizzle Off 1.5 X 3.0 X Resample 2.0 X

3) Stack

2022-11-22-0130_6-Jupiter.SER Done

Frames 118

Image Size Width 1280 Height 1024 offset 0, 0 remember

Display Options Draw AP's Brightness 1 x

Scaling (FIT / SER) Auto Range 16 bit(A)

Export Frame(s) Current All As displayed here

F# 3315 [118/3494] top 3.3 % Q 0.3% 48.5 bayer rggg

Zoom 50%

Alignment Points 142 APs Clear

Manual Draw

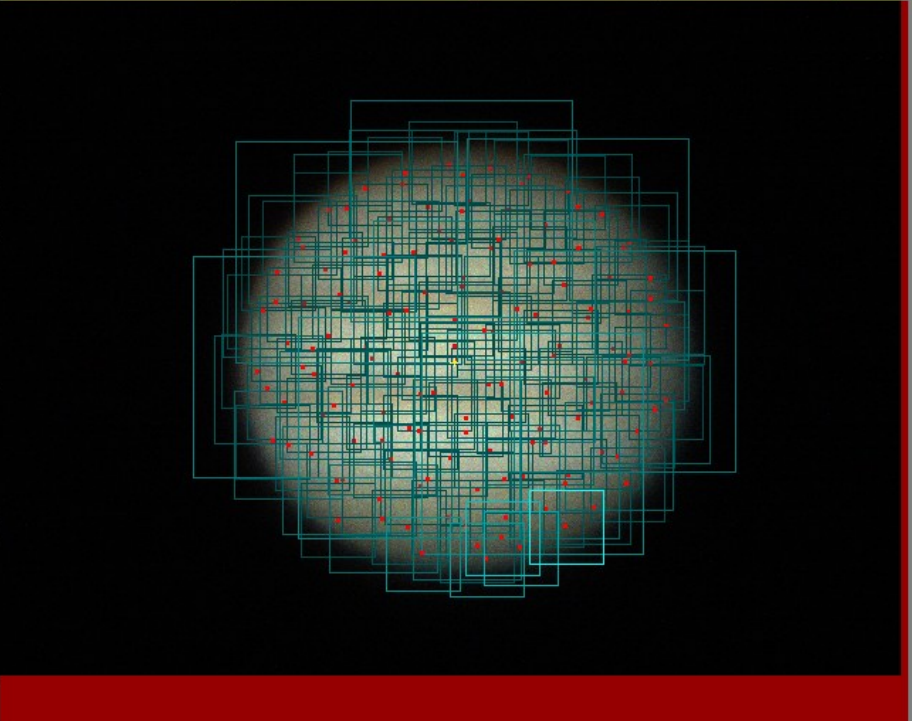
Click in image to add an alignment point

AP Size 104 24 48 104 200 Auto AP

Min Bright 30

Place AP grid

Close to Edge Replace Multi-Scale



AstroSurface

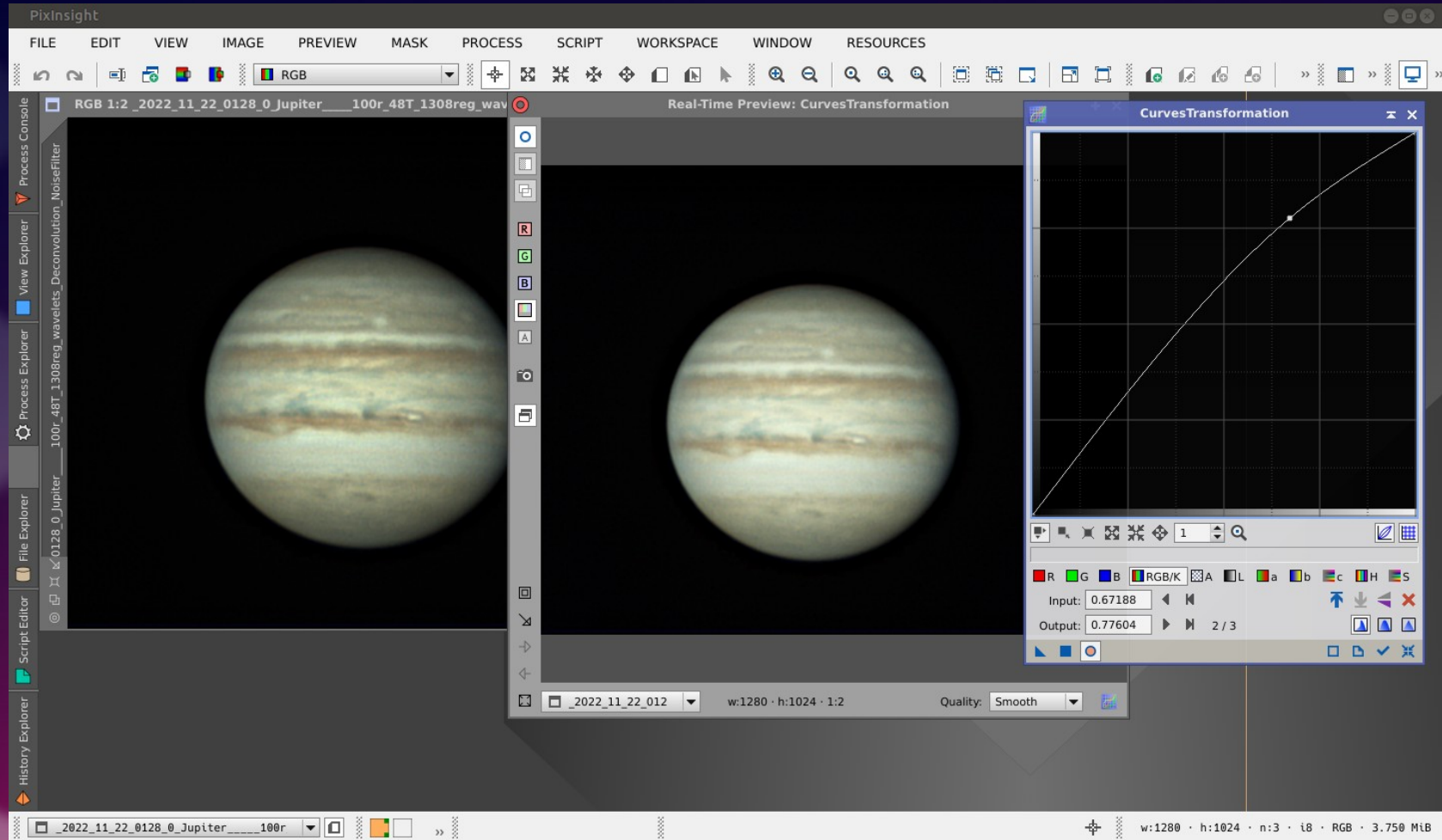
The screenshot displays the AstroSurface software interface. At the top, the window title is "2022-11-22-0128_0-Jupiter_100r_48T_1308reg.png". The menu bar includes "Files", "1_Configure-Decode", "2_Offset-Dark-Flat", "3_Analyze-Register", "Edit", "IMAGE TOOLS", "Filters", "Geometry", "Channels", "Convert/Export/Batch", "Mix/Merge", "MathPix", and "About".

The main interface is divided into several sections:

- VIEWER:** Contains zoom controls (0.624), view channel buttons (LM, L1, L2, L3, IV, RST, L, R, G, B), and image coordinates (XY = 729 : 245, RGB = 684_481_820).
- ADJUST:** A grid of processing options including Rotate, Alge-Ops, 8 < > 16, RGB-Mono, Split-RGB, Sharpen, B, Undo-Redo, Crop, Levels, Curves, W-Balance, Gain RGB, Dec Wiener, ResWH, BW-Point, NoiseSharp, CleanColor, Saturation, Dec RLucy, % F, 0, Resize, GammaGain, HDR, LocalContr, Align RGB, Wavelets, B, CH, C >.
- File saved:** E:/CapObj/Jupiter/2022-11-22Z/Aligned/2022-11-22-0128_0-Jupiter_100r_48T_1308reg_wavelets_Deconvolution_NoiseFilter.png
- POST-IT:** A small dialog box with the text "Right-click to open POST-IT. Copy-Paste is available."
- Wavelets-Deconvolution + other adjustments (use ROI):** A large panel with multiple sub-sections:
 - Main:** Includes "Apply RGB adjustments" (checked), "force ROI - Do All optional !", "Noise prefilter: 1", "Sharpen: 3 or 3-(4) or 2-(4) or 2-3-(4)", "Offset ADU: 0", "Gain: 1", "Gamma: 1", "Parameter Files" (Load P, Save P, SaveAs, Reset, Cancel, Do All), and "Preview" (checked).
 - Noise Prefilter: 1:** Includes a slider from 0 to 3.0.
 - Deconvolution Richardson-Lucy: 2:** Includes "PSF: pixels" (0-6) and "Iterations" (0-2.30).
 - Wavelets HF: 3:** Includes "Size" (32) and "Strength" (18) sliders.
 - Wavelets LF: 4:** Includes "Size" (15) and "Strength" (26) sliders.
 - Reduce Noise: prefer Noise Prefilter! 5:** Includes radio buttons for N1, N2, X1, X2 and "Adaptive smoothing" (4).

The central image shows a color image of Jupiter with a dashed white box indicating the region of interest (ROI).

PixInsight



The Future of Imaging



ASlair Plus



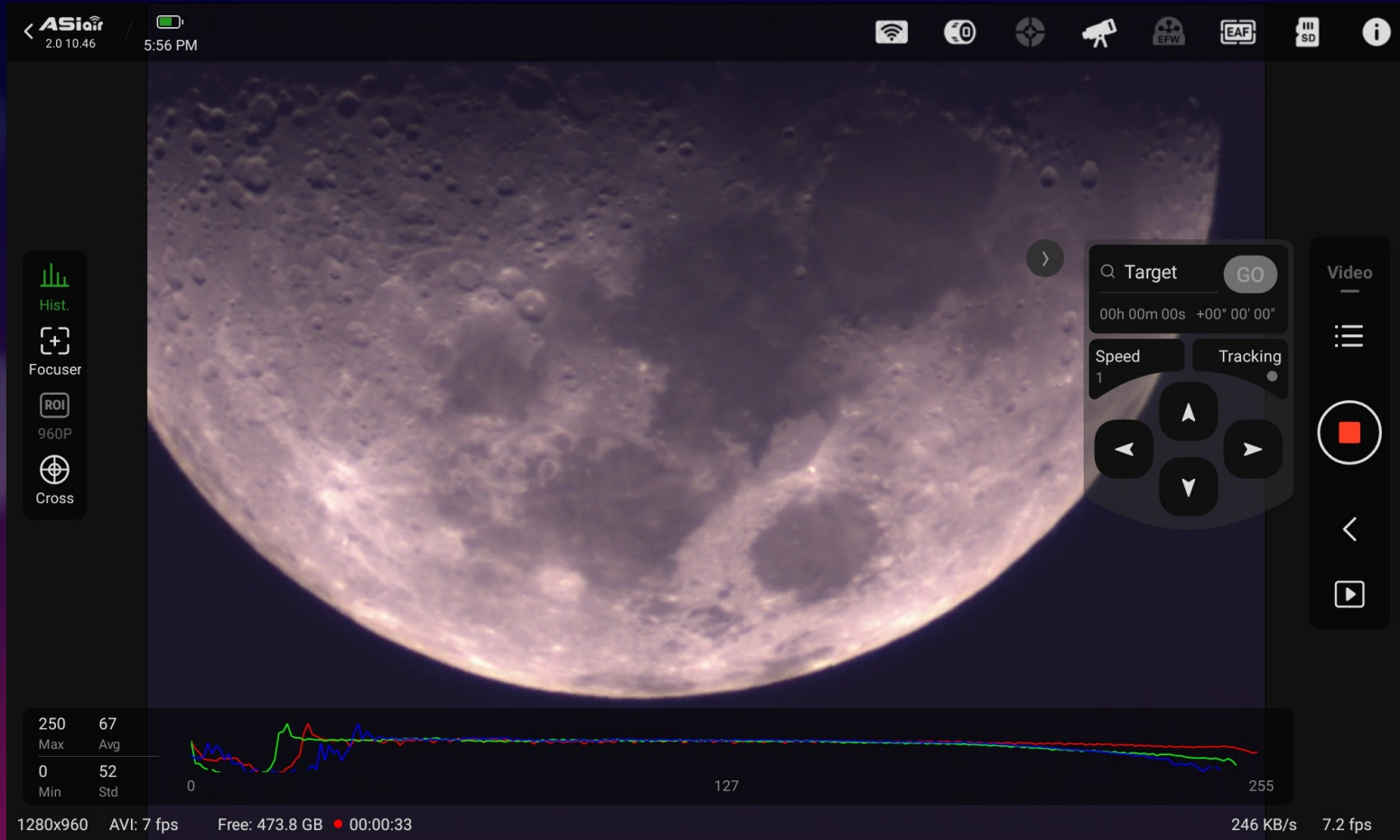
ASlair Controlling Mount,
Focuser & Camera

ASI Focuser

- Custom bracket fabricated
 - ZWO does not support GSO focusers
- Integrates with the ASlair
- Temperature compensating



ASlair App



Runs on smart phones and tablets

Moon Captured Using ASlair



YouTube Resources

- [Christopher Go: Planetary Imaging Essentials Part 1](#)
- [Christopher Go: Planetary Imaging Essentials Part 2](#)
- [Christopher Go: Planetary Imaging Essentials Part 3](#)
- [How To Do High Resolution Planetary Astrophotography by Damian Peach](#)

Questions?