

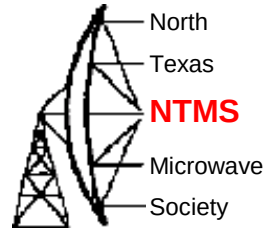
Astro-Imaging or Receiving at 300nm to 750nm Wavelengths

Wes Atchison

WA5TKU

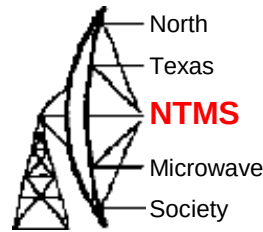
March 8, 2025

Basic Astro Imaging



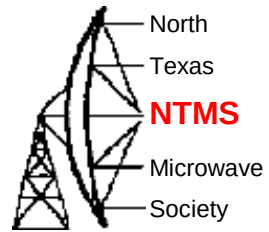
- Telescope
- Mount
- Camera
- Okie-Tex Star Party
- Processing Tools
- Local Groups

Telescope Basics

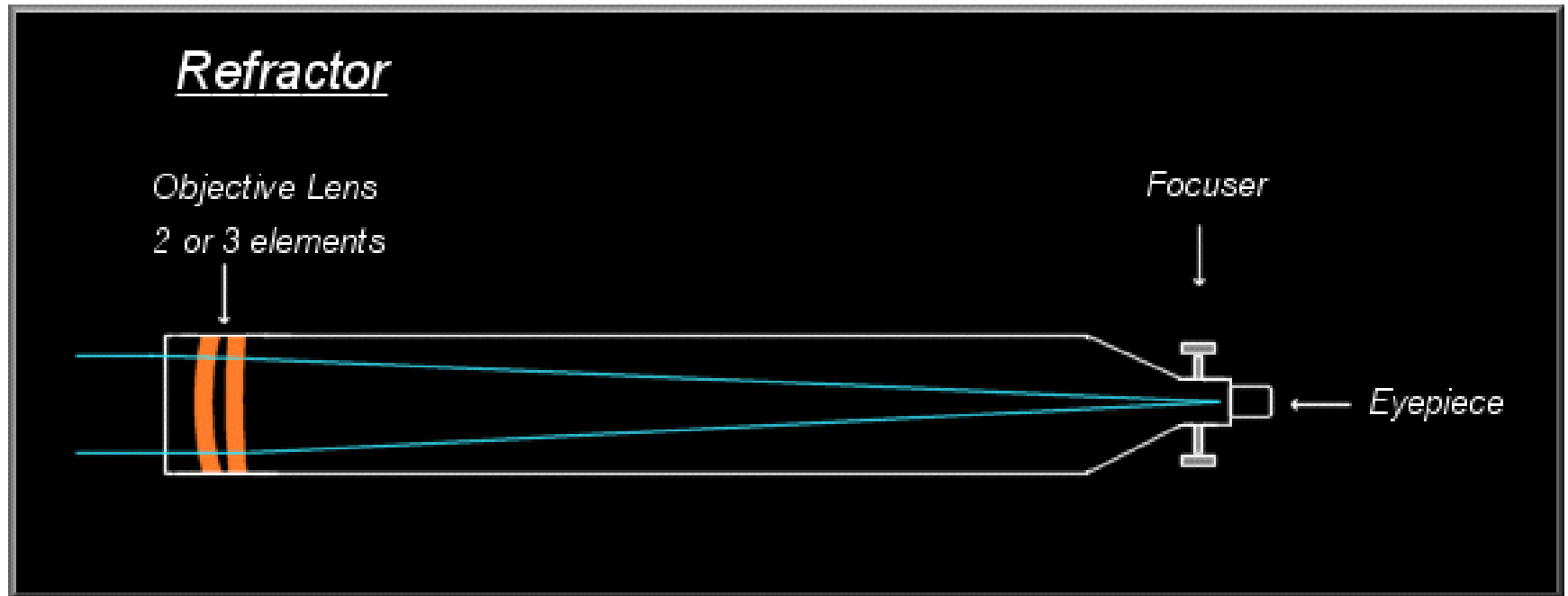


- Refractor
 - Galileo
 - 400 Years Ago, Pointed @ Moon & Jupiter
- Reflector
 - Newton
 - 1669 1st Built
- Catadioptric
 - Cassegrain - 1672
 - Schmidt - 1930
 - Maksutov – 1941
 - Ritchey–Chrétien – 1910

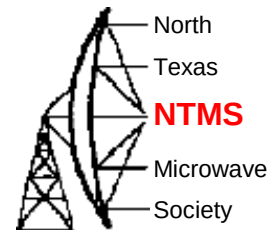
Telescope Basics



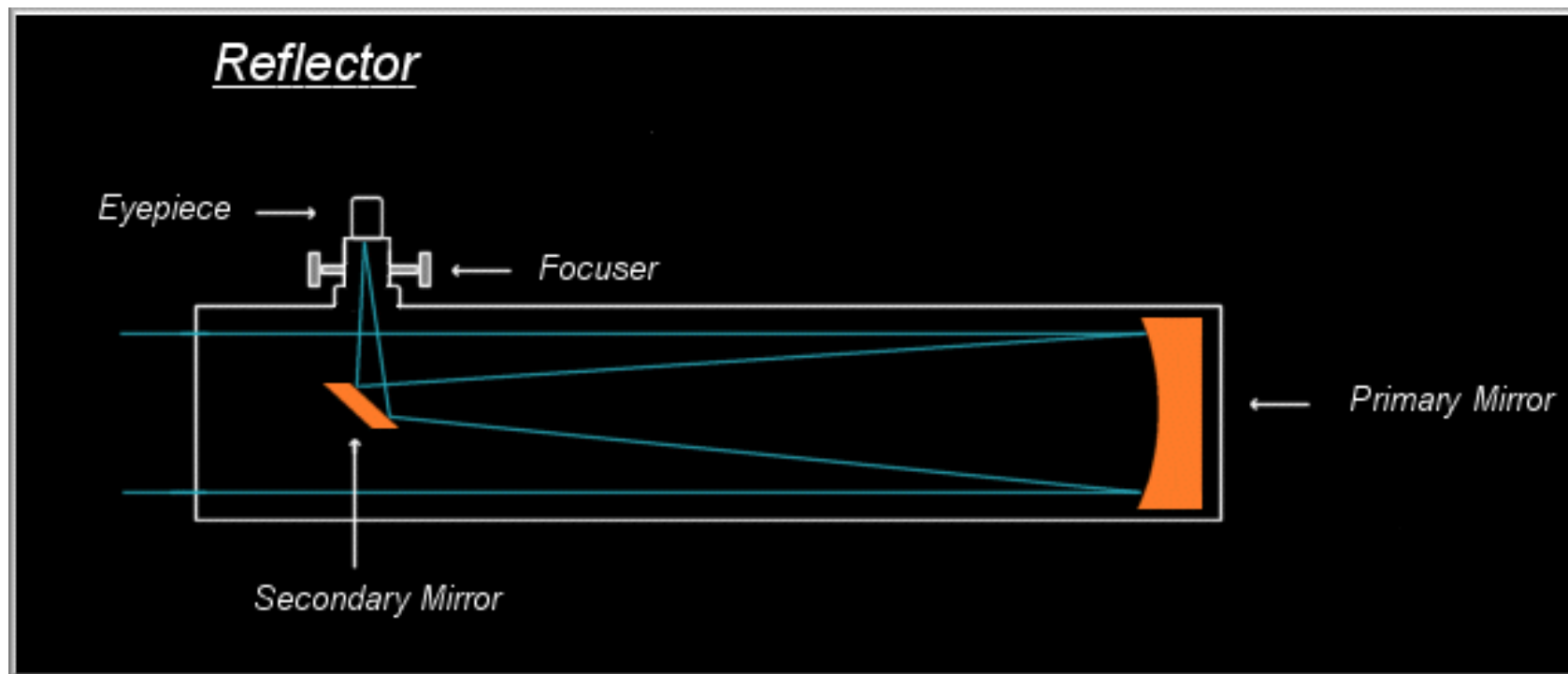
- Refractor



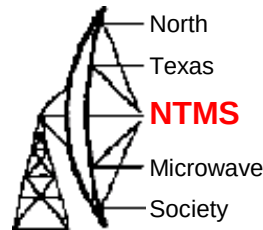
Telescope Basics



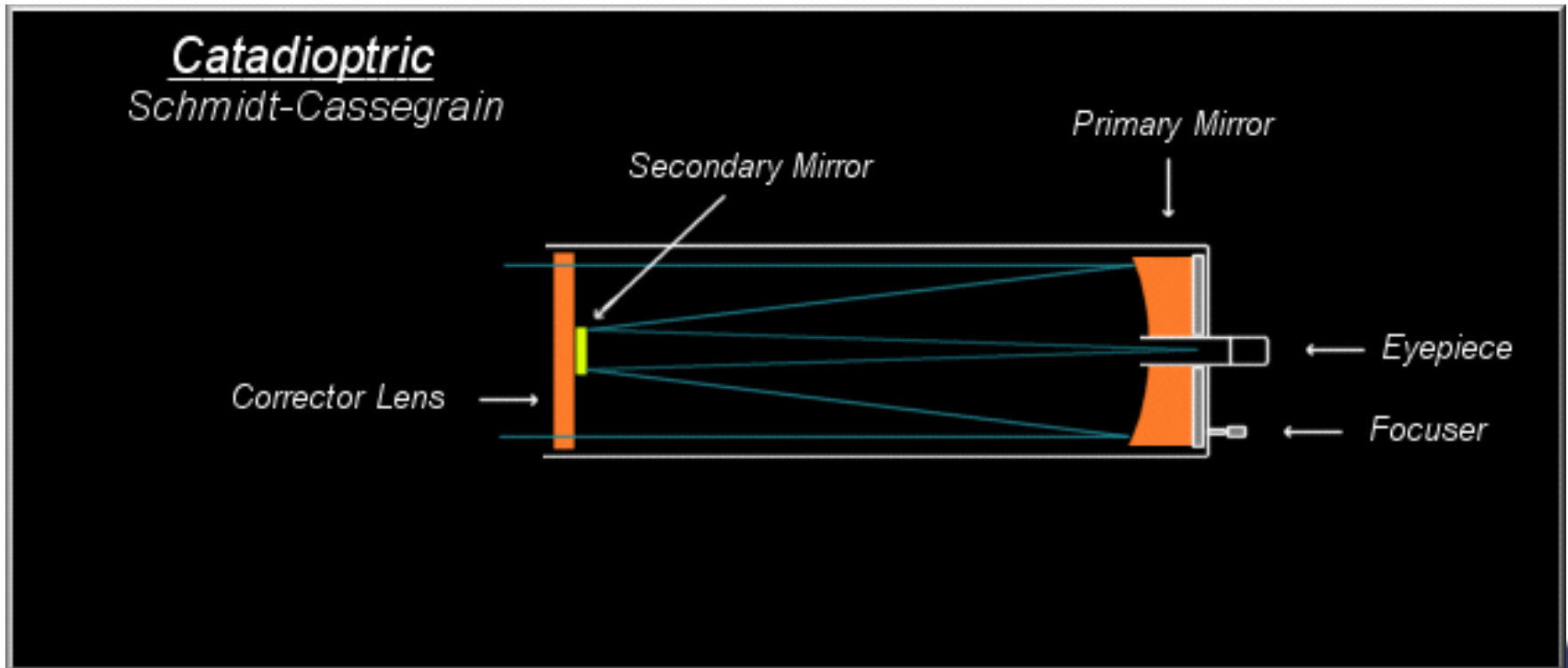
- Reflector



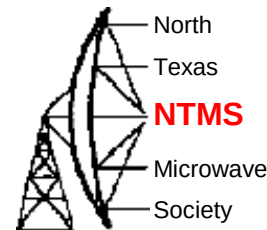
Telescope Basics



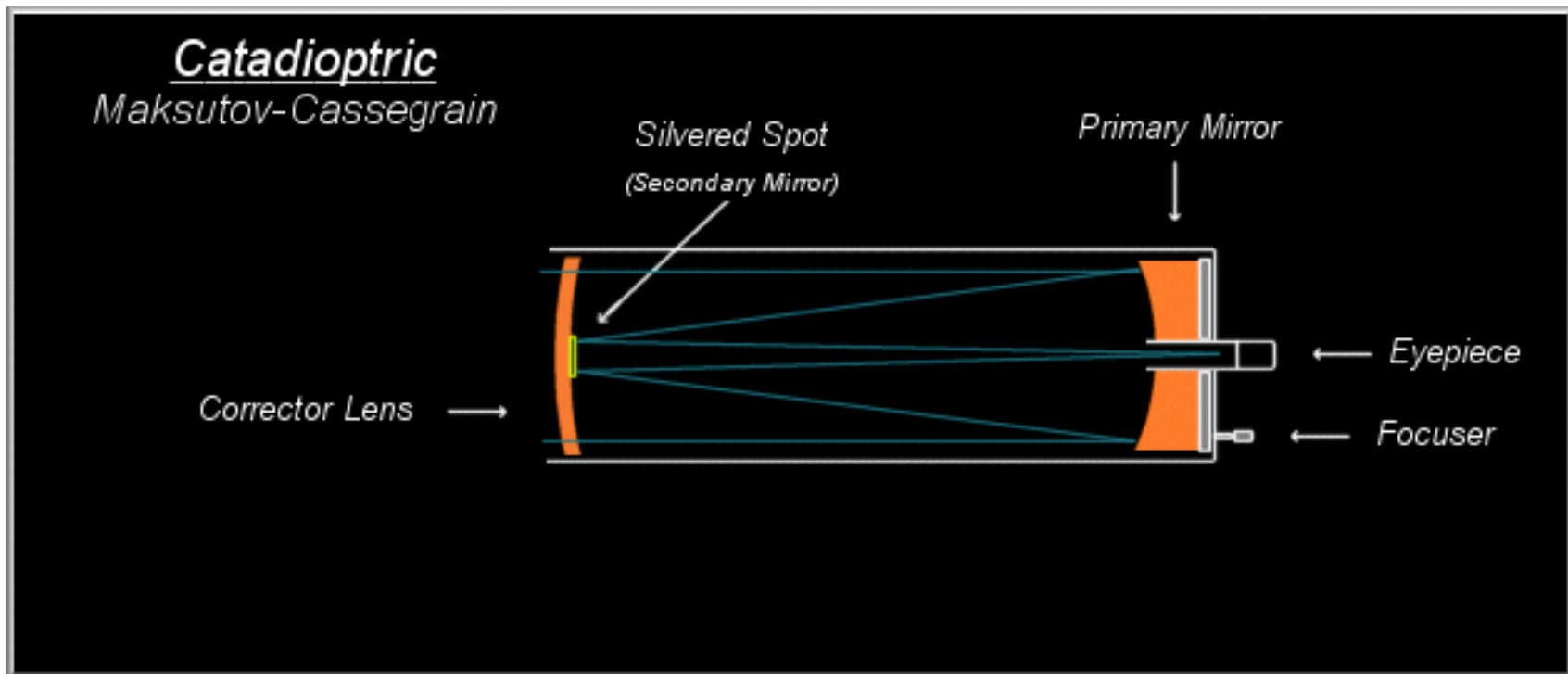
- Catadioptric
 - Schmidt - Cassegrain



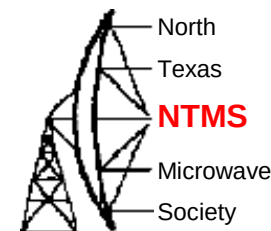
Telescope Basics



- Catadioptric
 - Maksutov - Cassegrain



Ritchey - Chretien



Hyperbolic mirror optical design

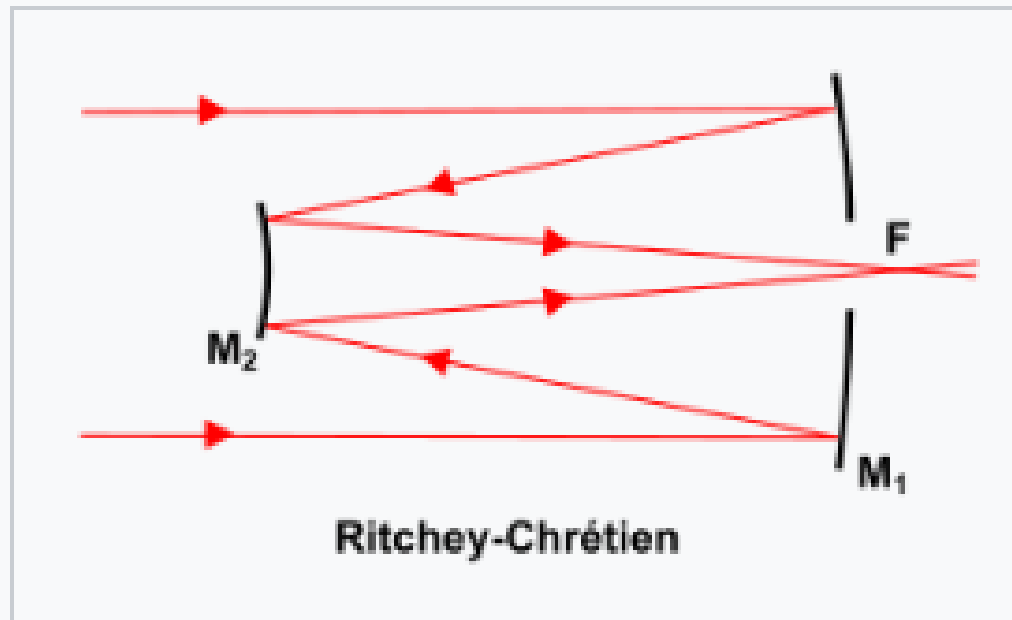
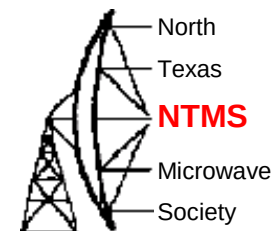


Diagram of a Ritchey–Chrétien reflector telescope 

Mounts



- German Equatorial
 - More Complex Construction
 - Tracking
 - Manual
 - Motor Driven
 - More Expensive Machining
 - Astronomical Use
 - Visual
 - Imaging



German Equatorial Mount

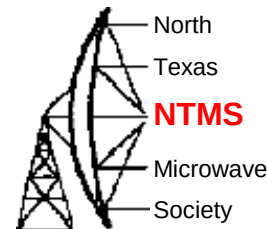
Mounts

- Dobsonian – DOB
 - Simple Construction
 - Accommodate Large Mirror
 - Tracking
 - Manual Simple – Just Push
 - Automatic Expensive
 - Astronomical Use
 - Visual



Dobsonian Mount

Mounts

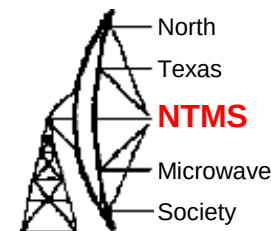


- Alt-Az Mount
 - Relative Simple Construction
 - Light Weight
 - No Tracking
 - Terrestrial Use
 - Inexpensive Mechanics



Altazimuth Mount

Mounts

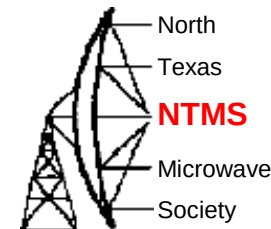


- Fork
 - Altitude Azimuth
 - Expensive
 - Tracking – Motor Driven
 - Astronomical Use
 - Visual
 - Imaging

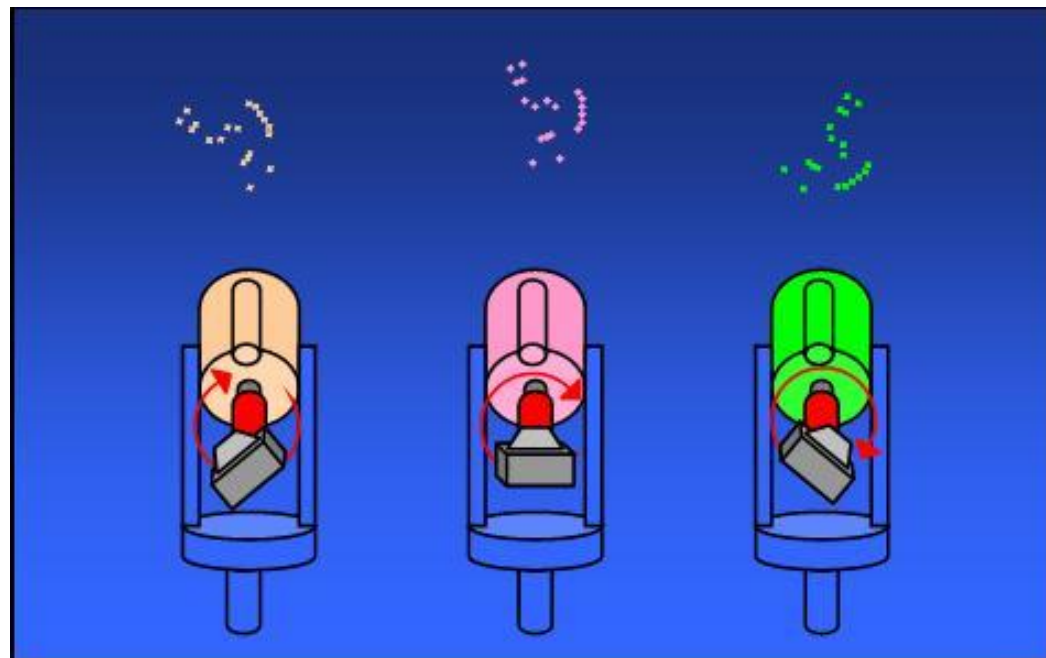


Fork Mount

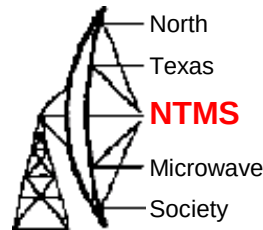
Tracking



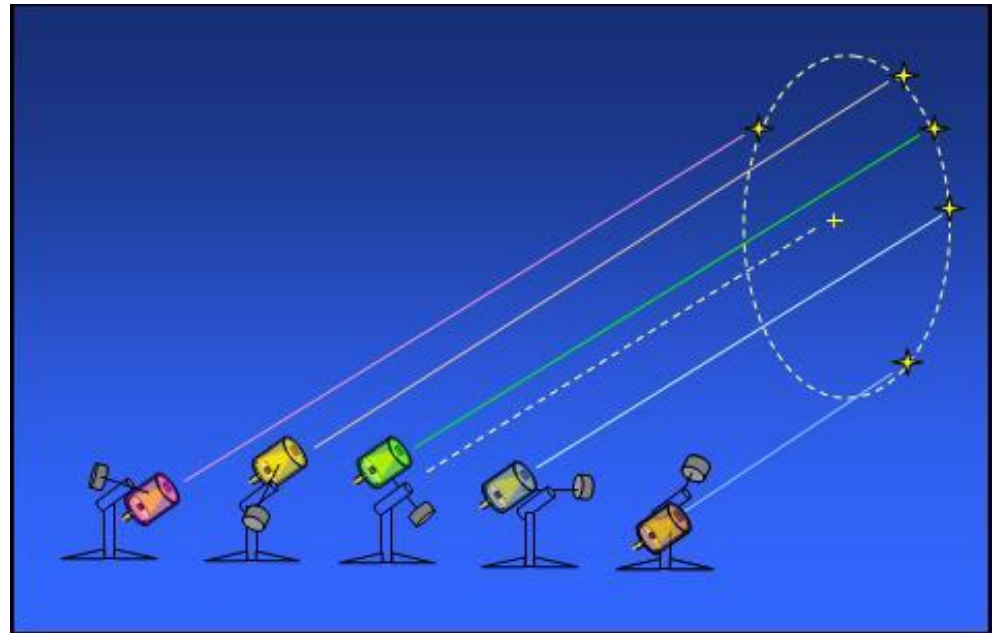
- ALT-AZ Mount
 - Field Rotation
 - Movement in 2 Axis Required



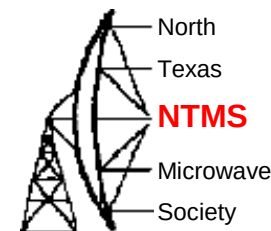
Tracking



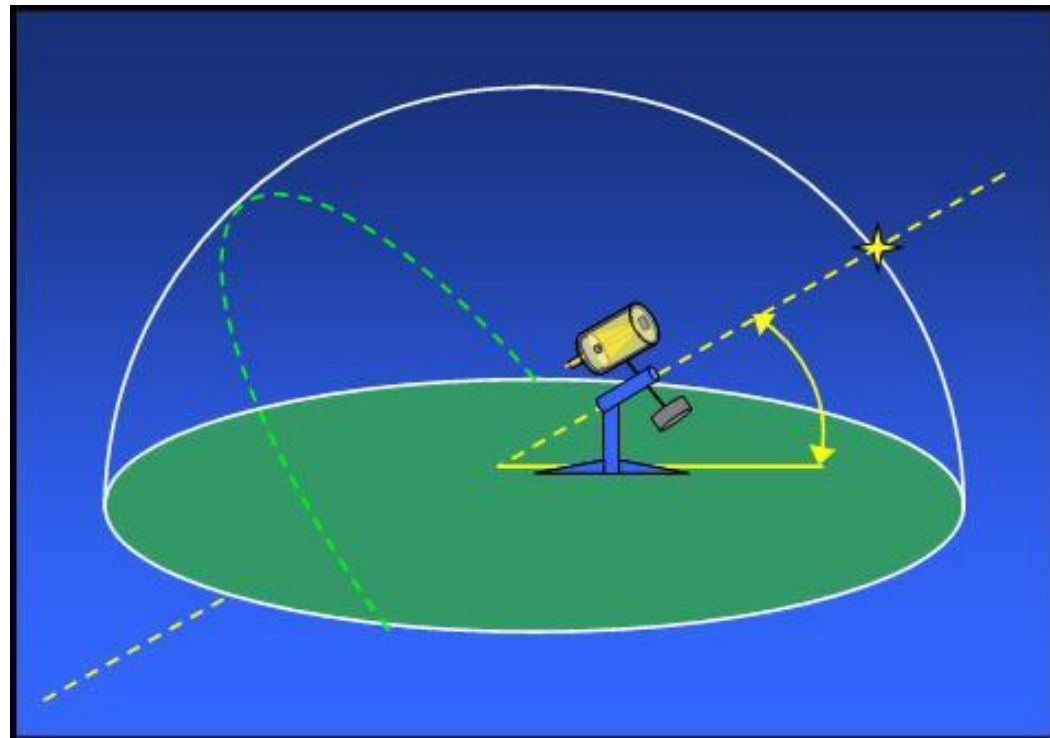
- Equatorial
 - No Field Rotation
 - Accurately Aligned
 - Movement in 1 Axis Only Required
 - Dec Moves to Correct for Polar Alignment Error



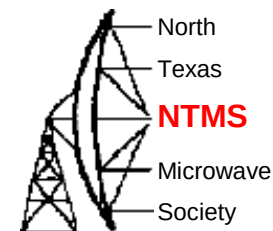
Tracking



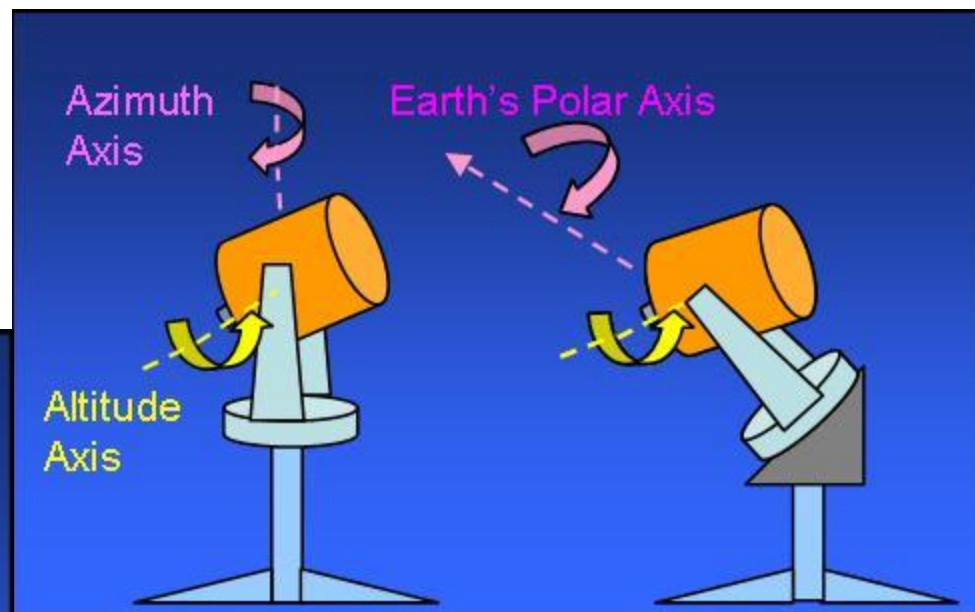
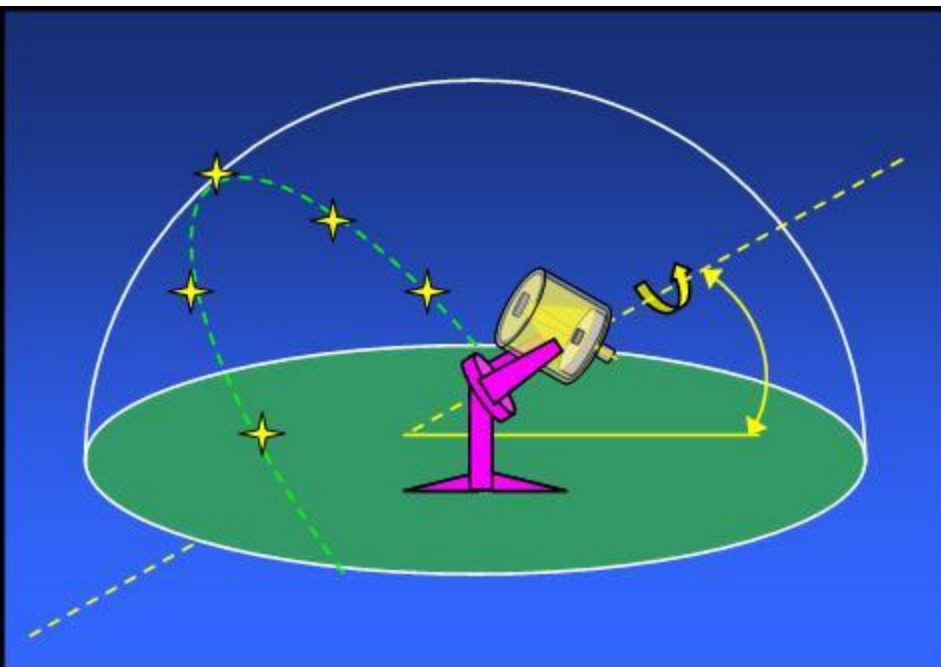
- Polar Alignment
 - Equatorial Mount
 - Right Accession Axis Aligned to Celestial North



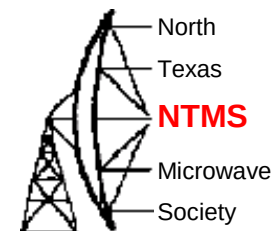
Tracking



- Polar Alignment
 - Alt-AZ Mount
 - Wedge



Effect of Slippage in Mount

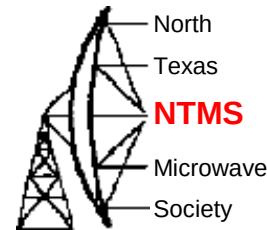


The **ASI533MC Pro** features a back-illuminated Sony CMOS sensor with a resolution of 3008 x 3008. The 3.76 μ pixel accommodates an impressive full well capacity of 50ke. The sensor boasts a quantum efficiency of 91%. **ASI553MC Pro** features 14-bit ADC, delivering a dynamic range output of 14 stops.

70 to 120 microns

The average human hair thickness ranges between **70 to 120 microns** or **0.08 to 0.12 mm**. Scientifically speaking, human hair measures approximately **75 microns on average**.  youprobablyneedahaircut.com +1

Image Size



- Minolta 50mm Lens f2

The screenshot shows a Windows XP desktop with various icons on the taskbar and desktop. The main focus is on two windows:

FOV Window: Displays a spiral galaxy image. At the bottom, it shows: 10 arcmin - FOV: $85.9 \text{ min} \times 107.1 \text{ min}$.

Ron Wodaski's CCD Calculator - Meade DSI 2 PRO:

New Astronomy Press CCD Calculator

Telescope: **Minolta 50mm Camera Lens**

Aperture: 100 Add

Focal ratio: $f/2$ Remove

Barlow or reducer: 1

Focal length: 200 Recalc

☐ Aperture adjust ☒ Ratio adjust

Camera: **Meade DSI 2 PRO**

Pixel size: 8.3×8.6

Array size: 752×582

Bin mode: 1×1 Add

Exit Remove

Chip size: **5mm x 6.2mm**

Image scale: **8.7 arcsec/pix** Save

Field of view: **85.9 x 107.1 arcmin**

Exp. Target: CFZ (microns)

N/A 8.8

1M51.jpg

Chip compared to 35mm film

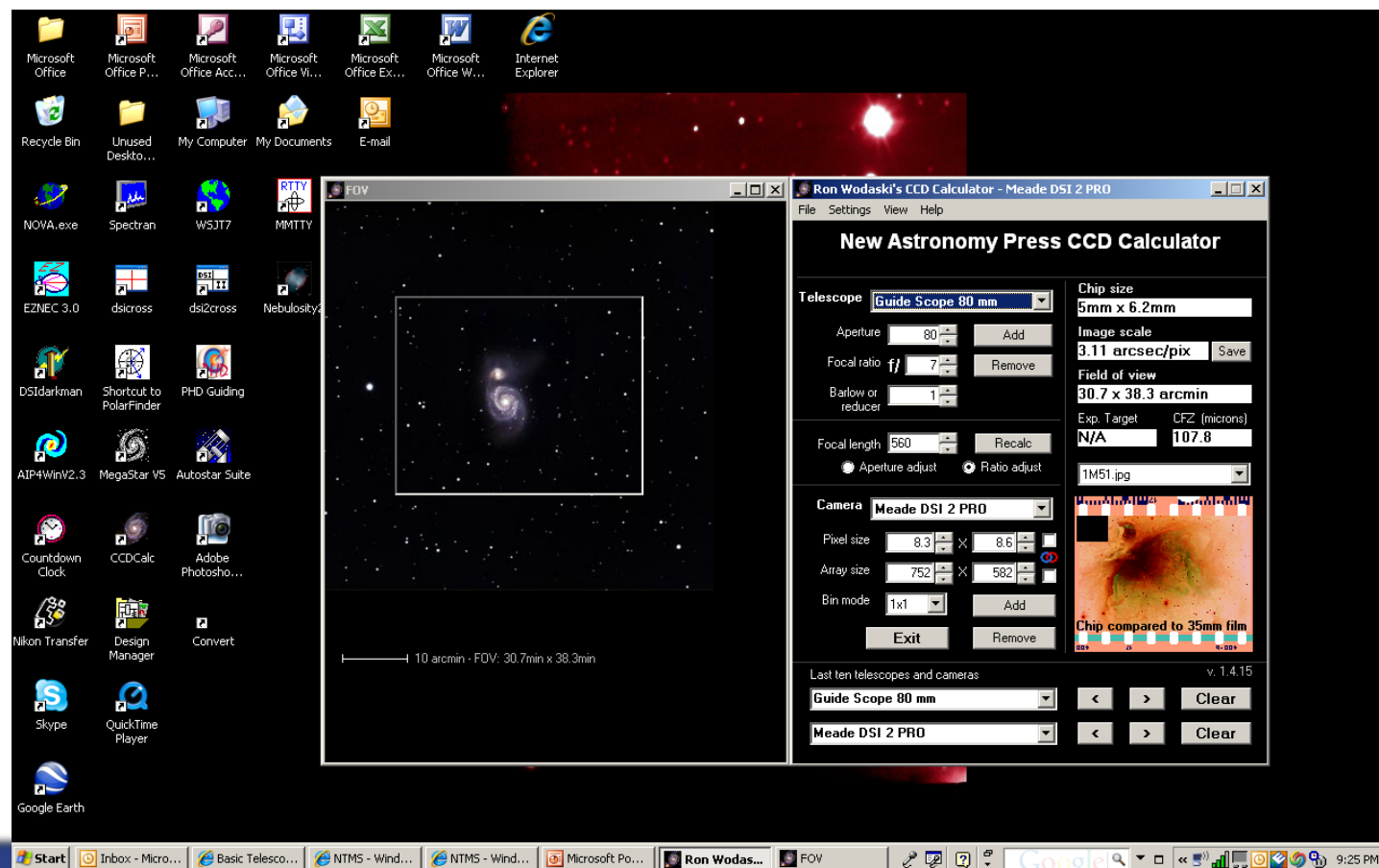
Last ten telescopes and cameras v. 1.4.15

Minolta 50mm Camera Lens < > Clear

Meade DSI 2 PRO < > Clear

Image Size

- Vixen 80mm Refractor f7



New Astronomy Press CCD Calculator

Telescope: **Guide Scope 80 mm**

Aperture: **80** Add

Focal ratio: **f/ 7** Remove

Barlow or reducer: **1**

Focal length: **560** Recalc

Aperture adjust Ratio adjust

Camera: **Meade DSI 2 PRO**

Pixel size: **8.3** x **8.6**

Array size: **752** x **582**

Bin mode: **1x1** Add

Exit Remove

Chip size: **5mm x 6.2mm**

Image scale: **3.11 arcsec/pix** Save

Field of view: **30.7 x 38.3 arcmin**

Exp. Target CFZ (microns): **N/A** **107.8**

1M51.jpg

Chip compared to 35mm film

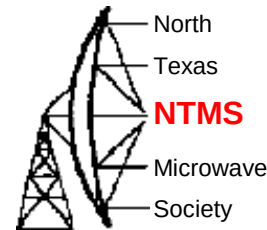
Last ten telescopes and cameras: **Guide Scope 80 mm** < > Clear

Meade DSI 2 PRO < > Clear

v. 1.4.15

FOV: 10 arcmin - FOV: 30.7min x 38.3min

Image Size



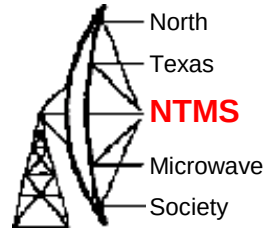
- Celestron 6" (152mm) Newtonian f5

The screenshot shows a Windows XP desktop with various icons on the left. Two windows are open:

- FOV**: A window showing a spiral galaxy with a white box indicating the field of view. Below the image, it reads: "10 arcmin - FOV: 22.9in x 28.6in".
- Ron Wodaski's CCD Calculator - Meade DS1 2 PRO**: A window titled "New Astronomy Press CCD Calculator" with the following settings:
 - Telescope**: Celestron 6 inch Newtonian
 - Aperture**: 150
 - Focal ratio**: f/5
 - Barlow or reducer**: 1
 - Focal length**: 750
 - Camera**: Meade DS1 2 PRO
 - Pixel size**: 8.3 x 8.6
 - Array size**: 752 x 582
 - Bin mode**: 1x1
 - Chip size**: 5mm x 6.2mm
 - Image scale**: 2.32 arcsec/pix
 - Field of view**: 22.9 x 28.6 arcmin
 - Exp. Target**: N/A
 - CFZ (microns)**: 55
 - File**: 1M51.jpg

The taskbar at the bottom shows the Start button and several open applications: Inbox - Micro..., Basic Telesco..., NTMS - Wind..., NTMS - Wind..., Microsoft Po..., Ron Wodaski..., and FOV. The system clock shows 9:27 PM.

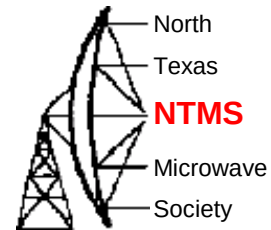
My Mount in 2009



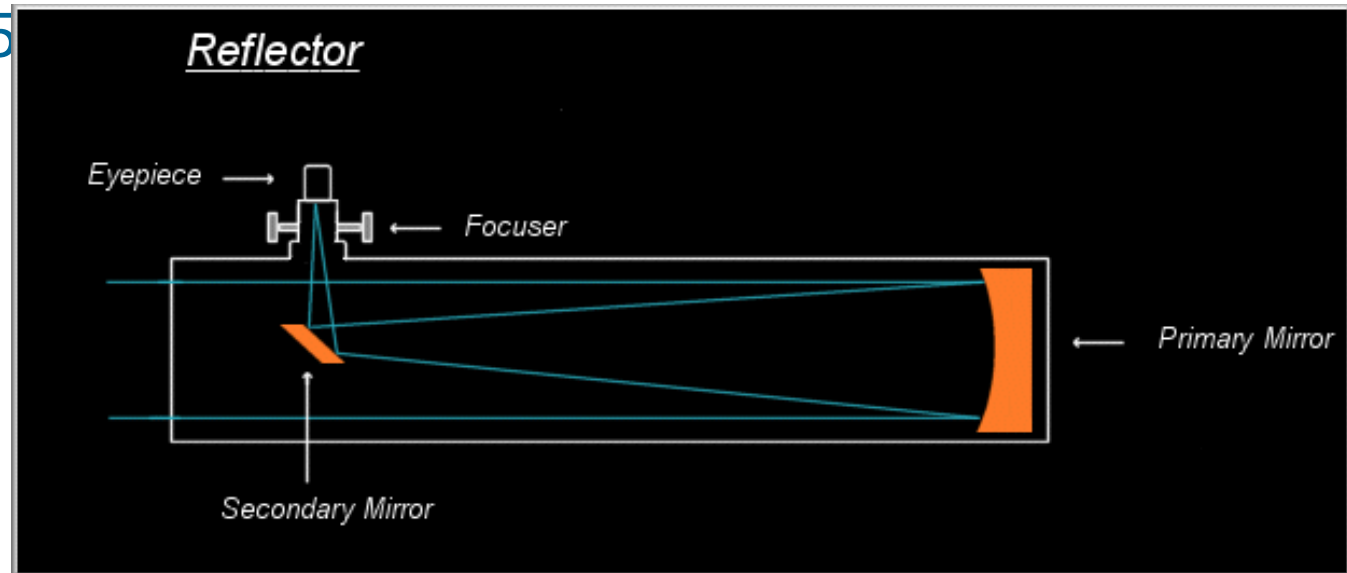
- Equatorial
 - Celestron CI-700
 - Stepper Motor Drive
 - Polar Alignment Scope



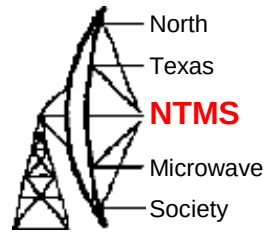
Light Path



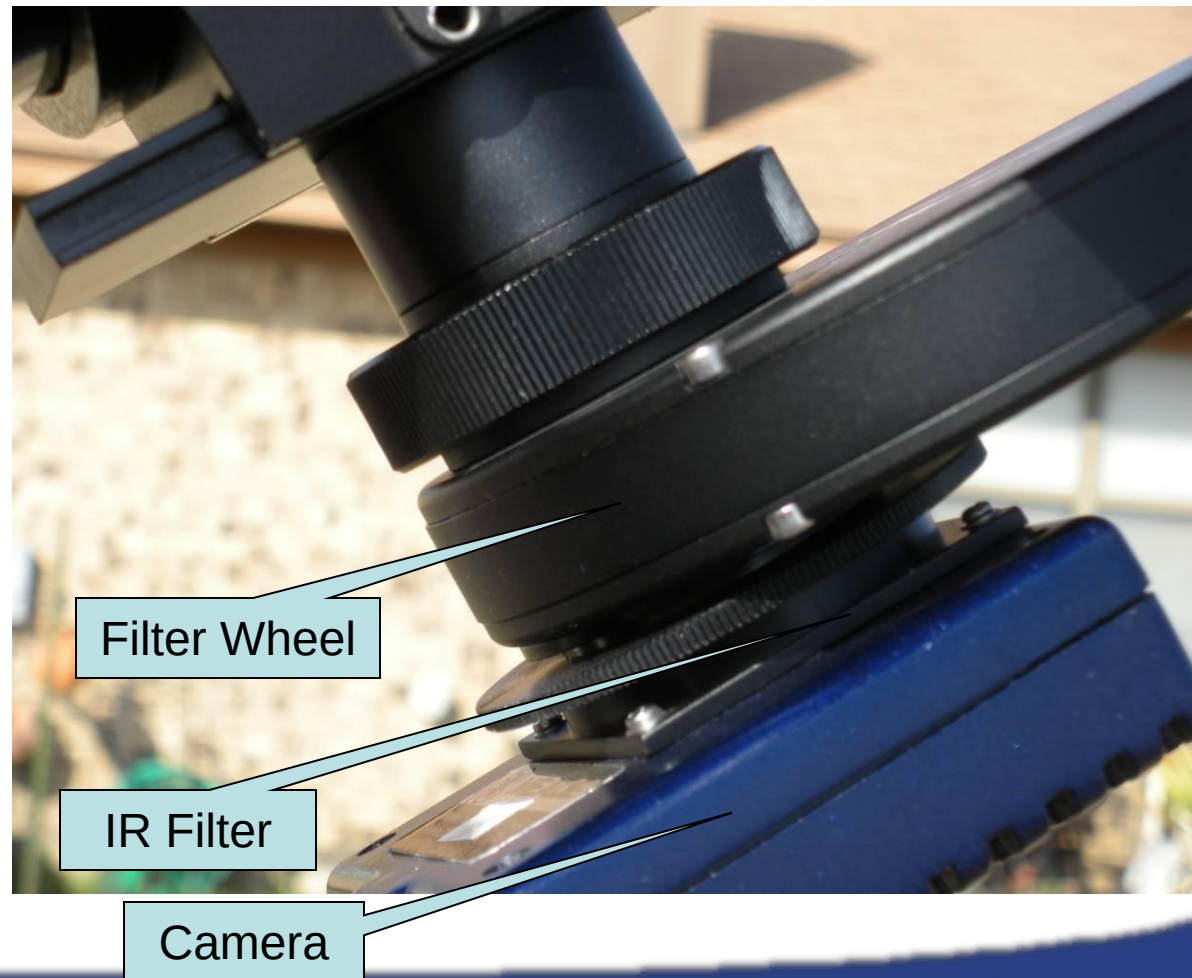
- Celestron 6"
(152 mm) f5
(750 mm)
Newtonian
 - Primary Mirror
 - Secondary Mirror



Light Path



- Scope – 6” Newtonian
 - Main Mirror
 - Secondary Mirror
- Filter Wheel
 - Choose L, R, G, or B Filter
- IR Filter
- Camera – Meade DSI II Pro

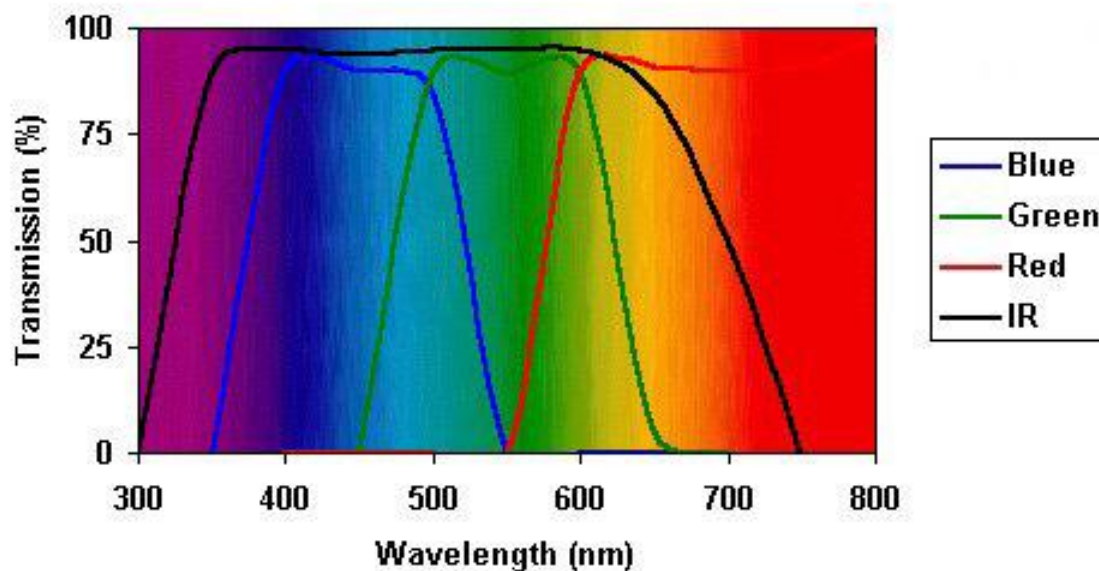


Imaging Filter

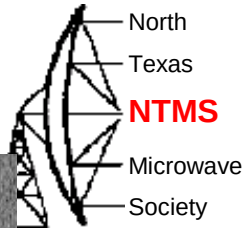
- True Technology Filters

- IR – Infrared
 - 300 – 750 nm
- L – Luminance
 - 300 – 800nm
- R – Red
 - 550 – 800 nm
- G – Green
 - 450 – 650 nm
- B – Blue
 - 350 – 550 nm

True Technology Dichroic Filters



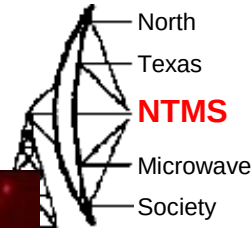
B33 - Horsehead



- Single 2 Minute Frame – Raw Image
- Not Calibrated
 - Noise
 - Dust
 - Hot Pixels



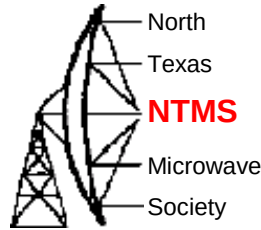
B33 – Horsehead Nebula



- 44 Stacked 2 Minute Frames
- Calibrated
- Vixen Super Polaris Mount
- Unguided
- False Color
- 8 x 6 arcmins
- 1200 Light Years
- Reflection Nebula



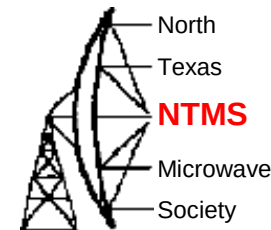
M57 – Ring Nebula



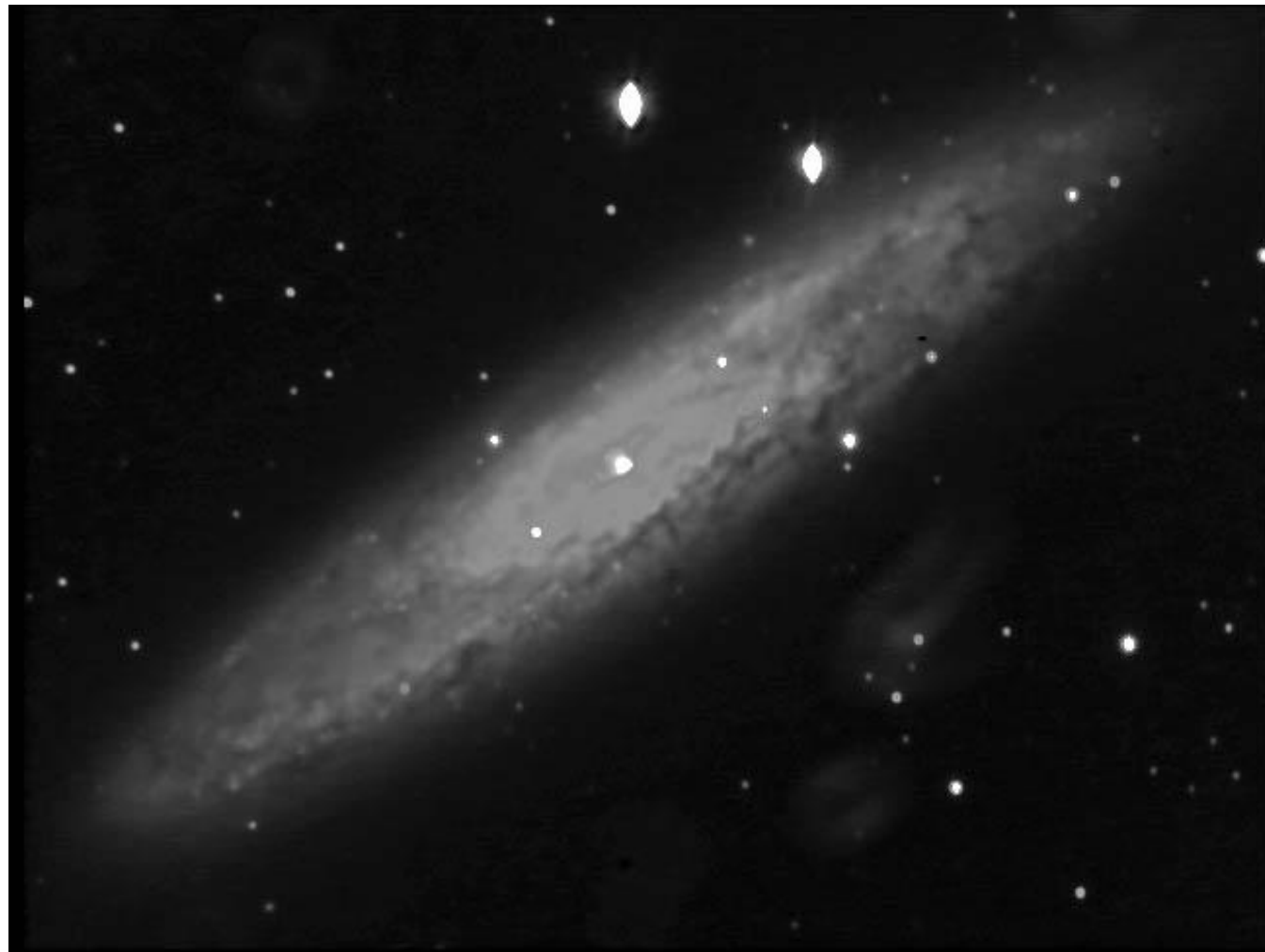
- LRGB – 50
Stacked 2
minute
Frames
 - L= 20, R=
10, G= 10,
B= 10
Minutes
Each
- 4100 Light
Years
- 230 x 230
arcsecs



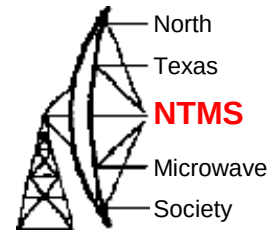
NGC 253 – Sculptor Galaxy



- 16 Stacked 5 Minute Frames
- 11.4 Million Light Years
- 27.5 x 6.8 arcmins



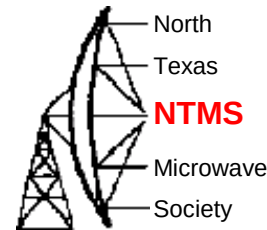
M51 – Whirlpool Galaxy



- 27 Stacked 1 Minute Frames
- 23 Million Light Years
- 11.2 x 6.9 arcmins



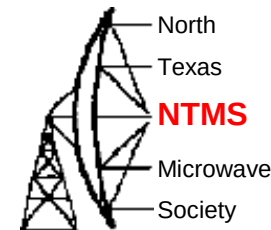
NGC 891 – Edge on Galaxy



- 25 Stacked 2 Minute Frames
- 27.3 Million Light Years
- 13.5 x 2.5 arcmins
- Unguided



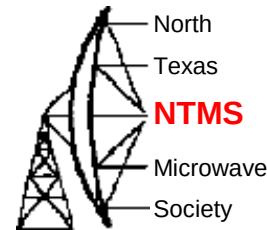
Star Party Setup 2008



- Windshield
- Laptop Shield
- CI-700 Mount
- 6" Newtonian
- 80mm Guide Scope
- DSII camera w HB cooler



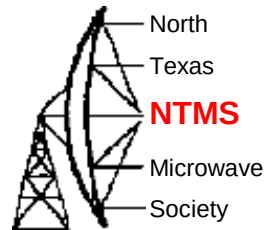
Star Party Setup Okie-Tex 2008



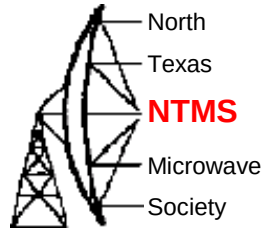
- Campsite
- Windshield Frame
- Johns Scope Trailer
- My Popup Trailer



Star-Gazers Group Okie-Tex 2008



Narrow Field Setup - 2021



Mount - AstroPhysics AP900

Imaging Scope – AT6RC – 6" f9, 1370mm fl

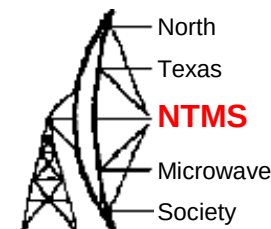
Guide Scope – 80mm f7 Refractor, 560mm fl

Imaging Camera – ZWO ASI533MC

Guide Camera – ZWO AST120



Narrow Field FOV



Ron Wodaski's CCD Calculator - ZWO AST533MC...

File Settings View Help

New Astronomy Press CCD Calculator

Telescope: **AT6RC**

Aperture: **1370** Add

Focal ratio: **f/ 9** Remove

Barlow or reducer: **1**

Focal length: **12330** Recalc

☐ Aperture adjust ☒ Ratio adjust

Camera: **ZWO AST533MC-Pro**

Pixel size: **3.76** × **3.76** ☒

Array size: **3008** × **3008** ☒

Bin mode: **1x1** Add

Exit Remove

Chip size: **11.3mm x 11.3mm**

Image scale: **0.06 arcsec/pix** Save

Field of view: **3.1 x 3.1 arcmin**

Exp. Target: **N/A** CFZ (microns): **178.2**

horsehead_color.jpg

11.3mm x 11.3mm

Chip compared to 35mm film

Last ten telescopes and cameras v. 1.5.0

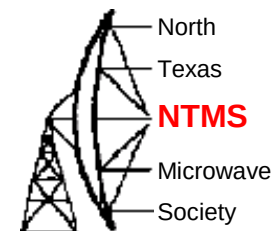
AT6RC < > Clear

ZWO AST533MC-Pro < > Clear



Wide Field Setup

9/02/2021



Mount – AstroPhysics
AP900

Imaging Scope – AT72ED

Guide Scope – SvBony
60mm

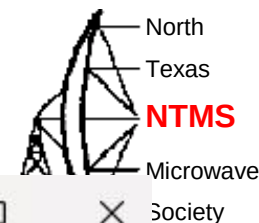
Imaging Camera – ZWO
ASI533MC

Guide Camera – ZWO ASI
120

Polar Alignment Scope -
PoleMaster



Wide Field FOV



Ron Wodaski's CCD Calculator - ZWO AST533MC...

File Settings View Help

New Astronomy Press CCD Calculator

Telescope: **AT72ED**

Aperture: **72** Add

Focal ratio: **f/ 6** Remove

Barlow or reducer: **1**

Focal length: **432** Recalc

☐ Aperture adjust ☒ Ratio adjust

Camera: **ZWO AST533MC-Pro**

Pixel size: **3.76** × **3.76** ☒

Array size: **3008** × **3008** ☒

Bin mode: **1x1** Add

Exit Remove

Chip size: **11.3mm x 11.3mm**

Image scale: **1.79 arcsec/pix** Save

Field of view: **89.9 x 89.9 arcmin**

Exp. Target: **N/A** CFZ (microns): **79.2**

horsehead_color.jpg

11.3mm x 11.3mm

Chip compared to 35mm film

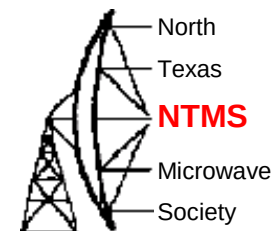
Last ten telescopes and cameras v. 1.5.0

AT72ED < > Clear

ZWO AST533MC-Pro < > Clear



NGC891



Silver Sliver Galaxy

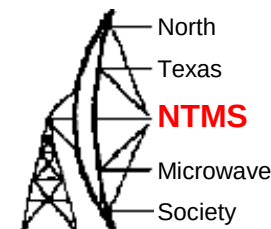
Imaged 9/29/2024
@-5° for 120
Minutes (34
frames x 5
minutes)

ZWO ASI533MC
Camera with
AT6RC Scope

Mount – AP900
Auto-Guided with
80mm refractor &
ASI120 camera



NGC 7380



Wizard Nebula

Imaged 10/01 –
10/04/2024 for 520
minutes @ -5C°
(260 frames x 2
minutes)

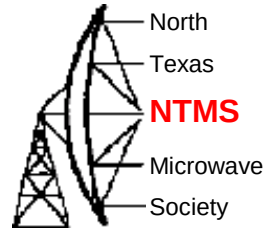
ZWO ASI533MC
Camera with
AT6RC Scope

Mount AP900

Auto-Guided with
80mm refractor &
ASI120 camera



IC 5146



Cocoon Nebula

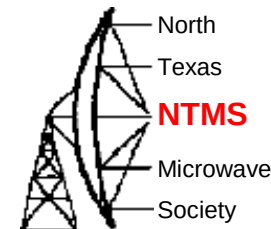
Imaged – 9/25/2022
for 240 minutes @ -5°C
(60 frames x 4 minutes)

ZWO ASI533 MC
camera on AP900

Auto-Guided with 80mm
refractor & ZWO ASI120
camera



NCG 7023



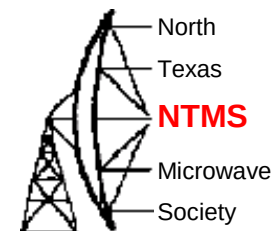
Iris Nebula

Imaged 9/29 & 30/ 2022
With ZWO ASI533MC &
AT6RC @ -5°C for 240 minutes
(60 Frames x 4 minutes)

Mount AP900 Auto-Guided
ZWO ASI 120



NGC6960



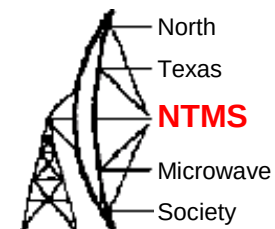
Eastern Veil

Imaged 9/8 & 9/2023 with
ZWO ASI533MC & AT6RC
for 375 minutes at -5°C (300
frames x 2 minutes)

Auto-Guided with 80 mm
Refractor & ZWO ASI120
camera



NGC 6960



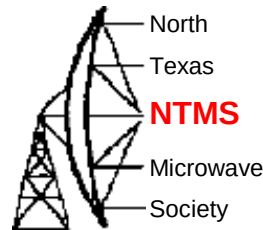
**Western Veil –Witches
Broom**

**Imaged 9/8 & 9/9/2023
for 375 minutes -5 C°**

**ZWO ASI533MC
Camera with AT6RC
Scope**



Cameras



- Film

- Slow to see results

- Very long exposures - Very noisy – No Stacking

- Little Processing Latitude

- CCD

- Instant results

- Short exposures

- Stacking of images

- Less noise

- CMOS

- Very low noise

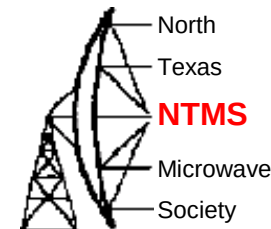
- Instant results

- Shorter exposures

- Stacking of images

- Lower Noise

CCD vs CMOS Camera



Camera Type	CCD (back illuminated)	sCMOS
Camera Model	iKon-XL 231 BEX2	ZL41 Cell sCMOS
Read Noise	2.1 e-@100kHz	~ 1 e-
Dark Current e-/pixel/sec	0.6 at -60° C 0.00013 at -100° C	0.1 At 0°C 0.019 at -10° C

Signal to Noise

$$\text{SNR(EM, ICCD)} = \frac{\text{QE.P}}{\sqrt{\left(\frac{N_{RN}}{G}\right)^2 + F^2 \cdot (N_{SN}^2)}}$$

QE = Quantum Efficiency (Measure of Conversion Photon to Voltage/Pixel)

P = Photons/Pixel

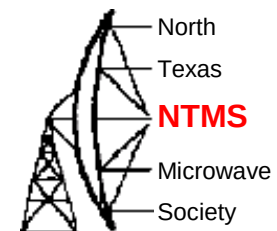
Nrn = Read Noise

G = Gain

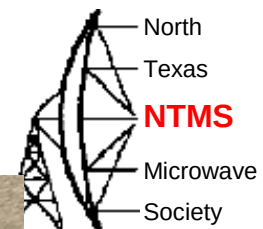
F = Noise Factor

Nsn = Photon Shot Noise

Okie-Tex 2024



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Processing Tools

- Photoshop

Large learning curve

Expensive ~ \$23 / Month

General use tools

No Capture

- Pixinsight

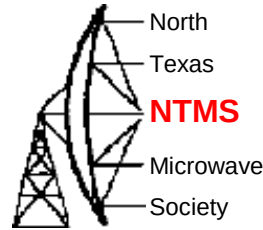
Expensive ~ 300Eu

Long Learning Curve

Designed for Astro Imaging

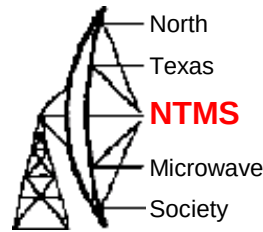
No Capture

Processing Tools



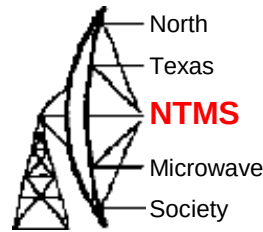
- AstroArt
 - Moderate Cost ~ \$165 US – initial then ~ \$90 major upgrades
 - Moderate Learning Curve
 - Capture Tools Included
- Registack
 - Free
 - Easy Learning
 - No Capture
- Deep Sky Stacker
 - Free
 - Easy Learning
 - No Capture

Processing Tools



- Need other free tools for capture, Calibration and editing images
- No Curves
- Little Color adjustments
- Require several tools for complete processing
- List is not comprehensive

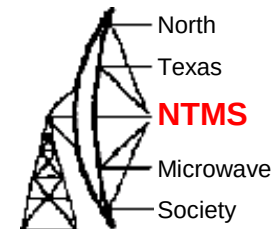
Local Groups



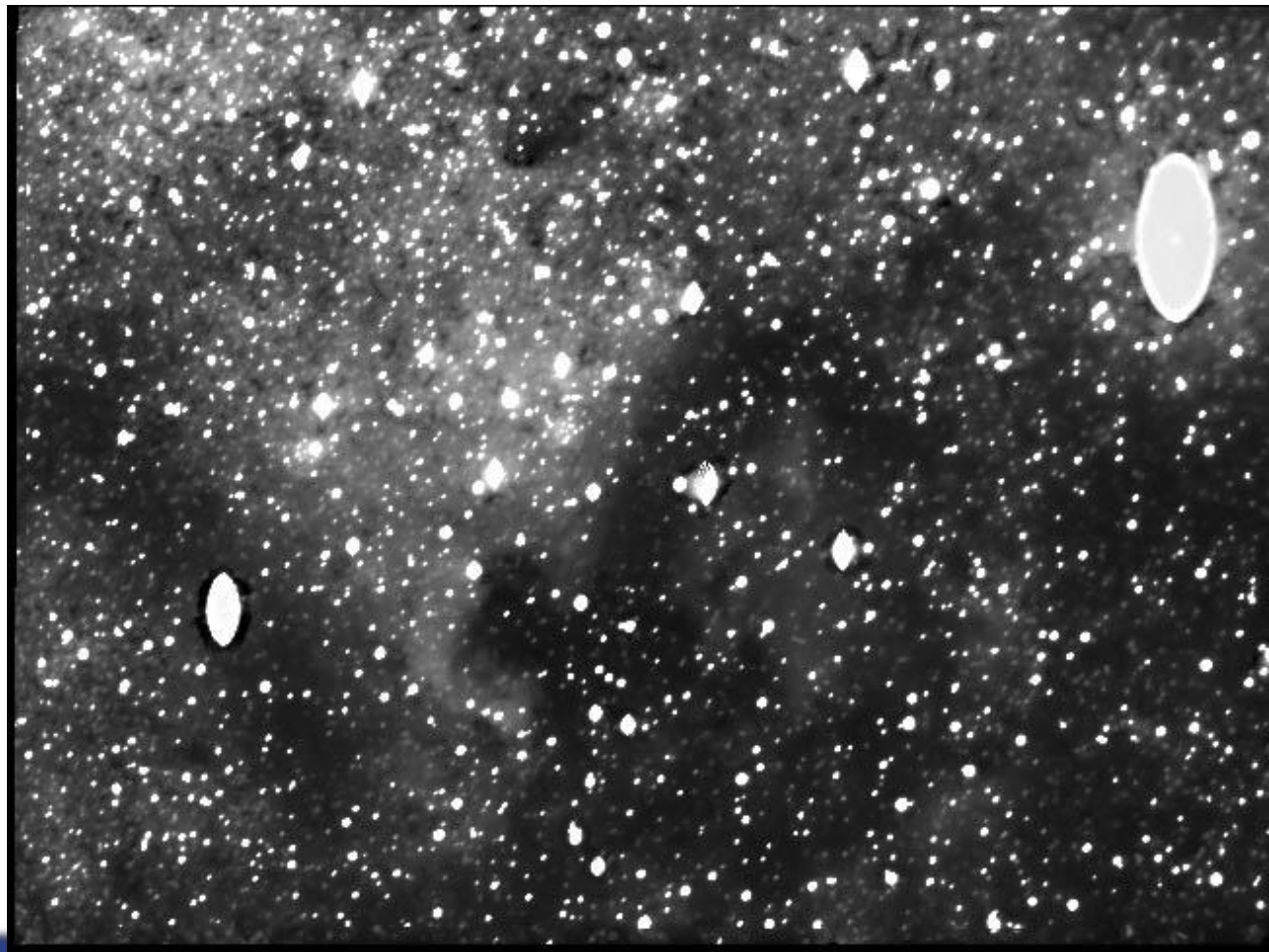
- Texas Astronomical Society
 - <http://www.texasastro.org/>
- Star-Gazers
 - Goggle Groups IO – Star-Gazer

<https://wa5tku.blogspot.com>

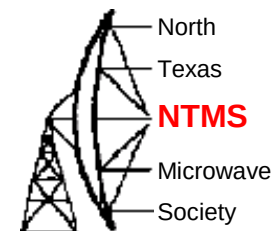
NGC 7000 – North American Nebula



- 13 Stacked 5 minute Frames
- 2200 Light Years
- 30 arcmins
- 50 mm Camera Lens
- Unguided



Tracking



- Equatorial
 - No Field Rotation
 - Requires Accurate Polar Alignment

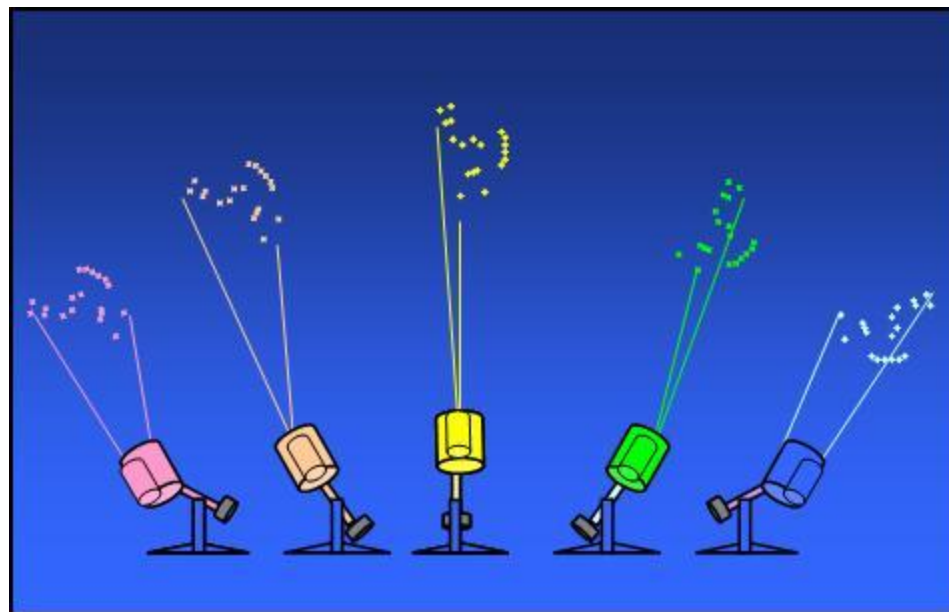
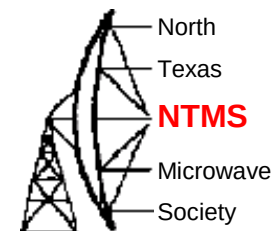
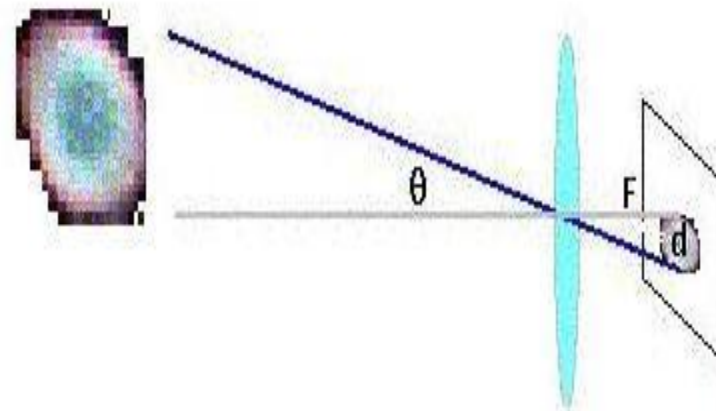


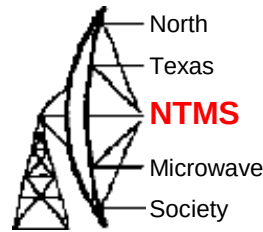
Image Scale



- F = Focal Length
- θ = Angular Size of Object
- d = Image Size @ Focal Distance
- $d = F \times \theta / 57.3$ Radians



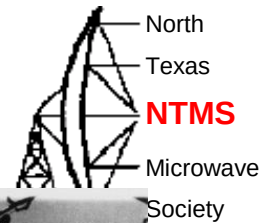
Radio Telescope



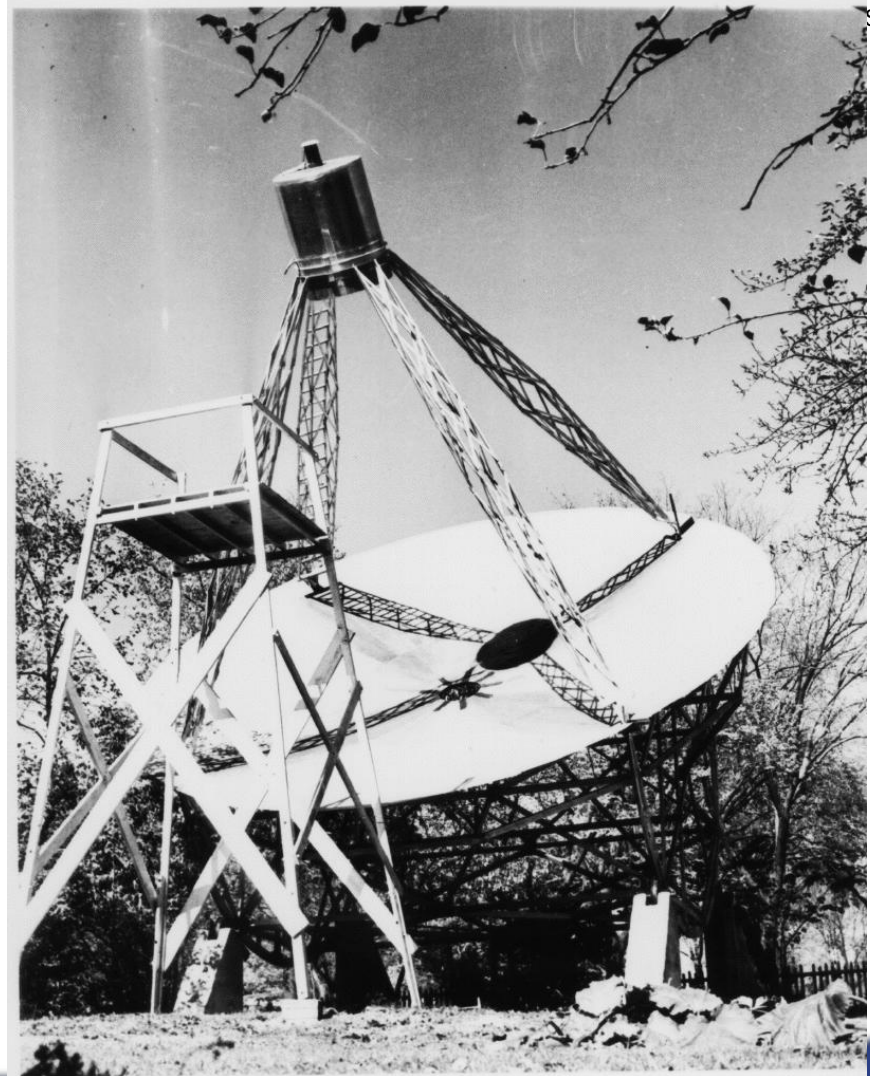
- Jansky
 - 1931 1st
 - 20.5 MHz
 - 100 Feet x 20 Feet
 - Photo of Replica



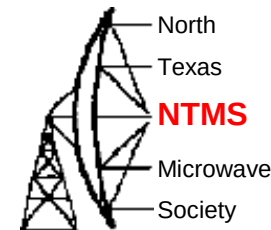
Parabolic Radio Telescope



- Reber
 - 1937 Built 1st
 - 9 Meter Diameter
 - Feed @ 8 Feet
 - $f/d = 0.8$
 - Built 3300 MHz and 900 MHz Receivers Failed
 - 160 MHz Receiver Successful
 - Completed RF Sky Map 1941



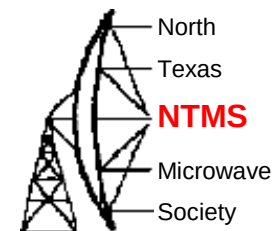
NGC 1977 – Running Man Nebula



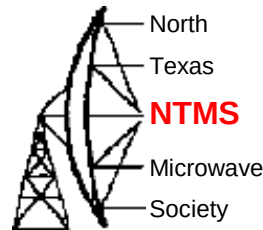
- 49 Stacked 1 Minute Frames
- 1500 Light Years
- 40 x 25 arcmins
- Guided



Okie-Tex Overview



M16 – Eagle Nebula



- 12 Stacked
2 Minute
Frames
- Unguided
- $\frac{1}{2}$ Degree
Diameter
- 7000 Light
Years

