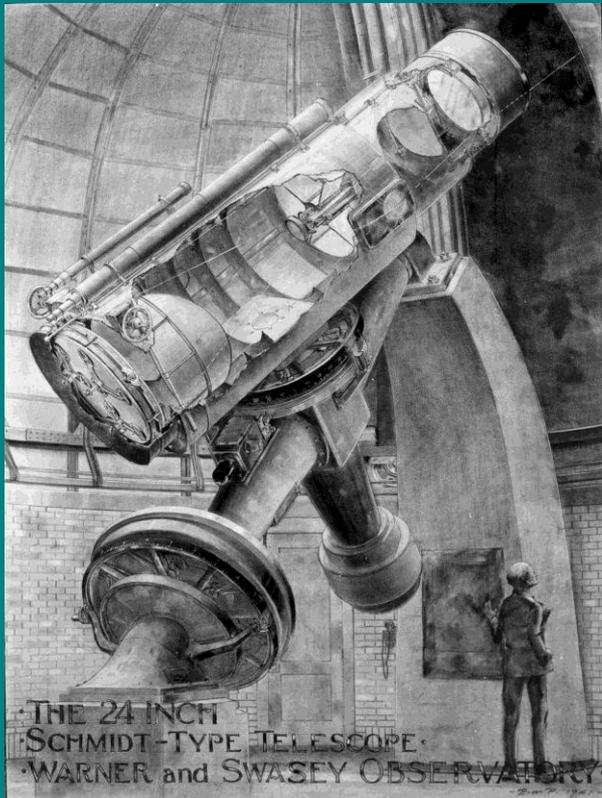
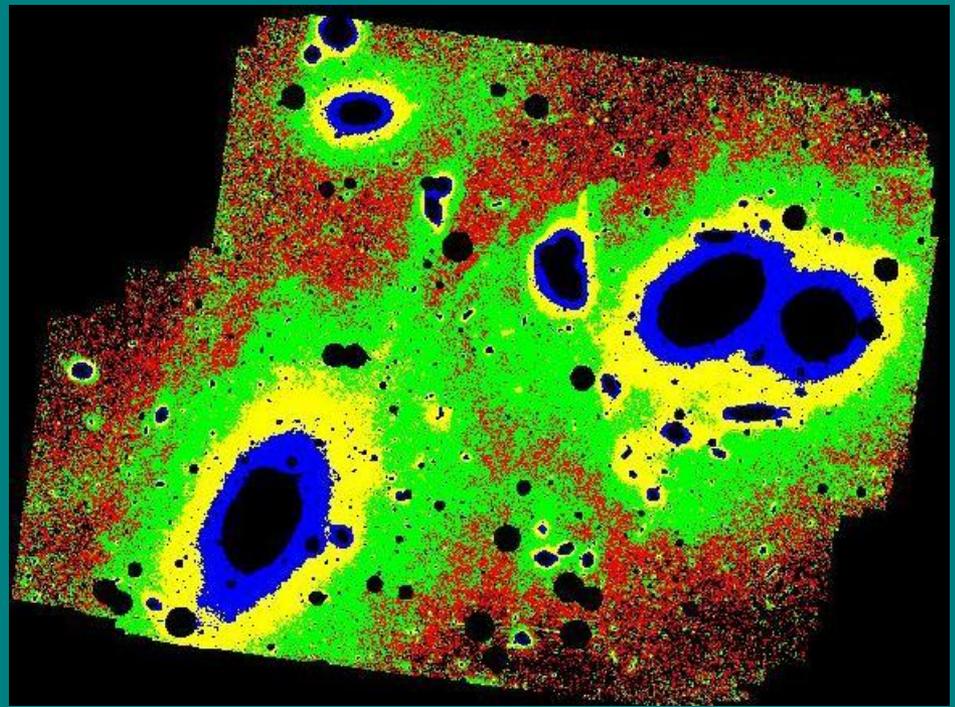


# From Cleveland to the Virgo Cluster:

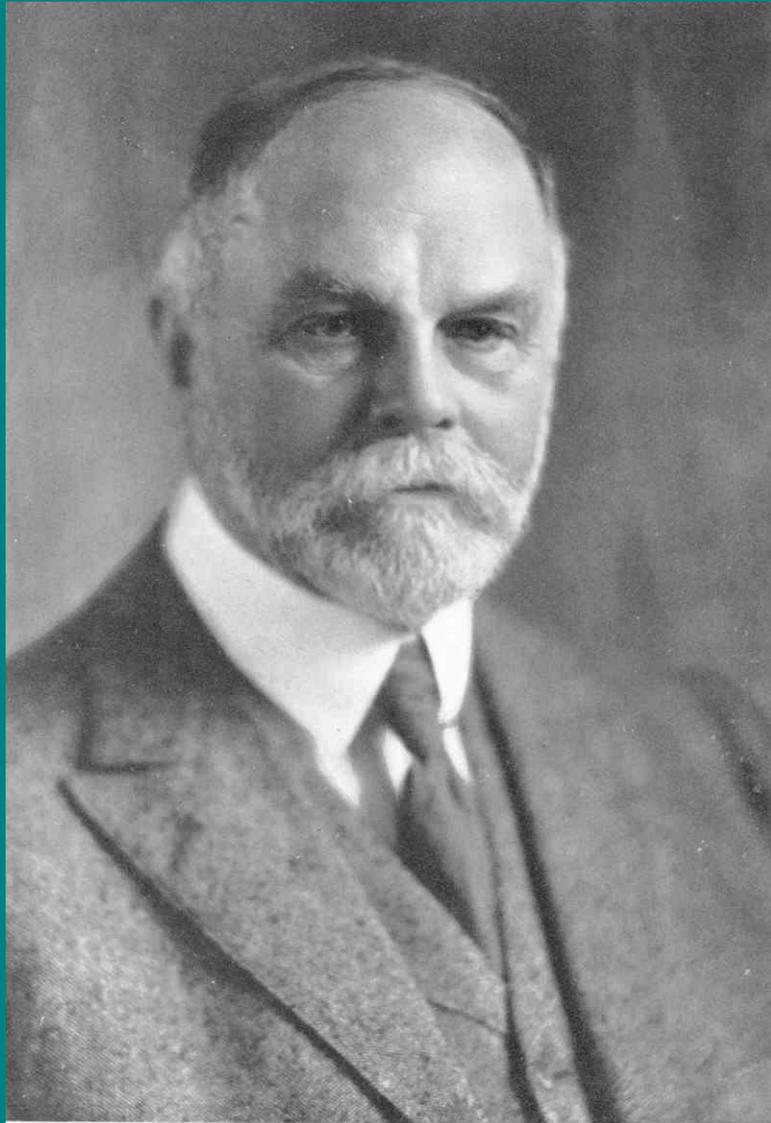


our Burrell Schmidt  
telescope



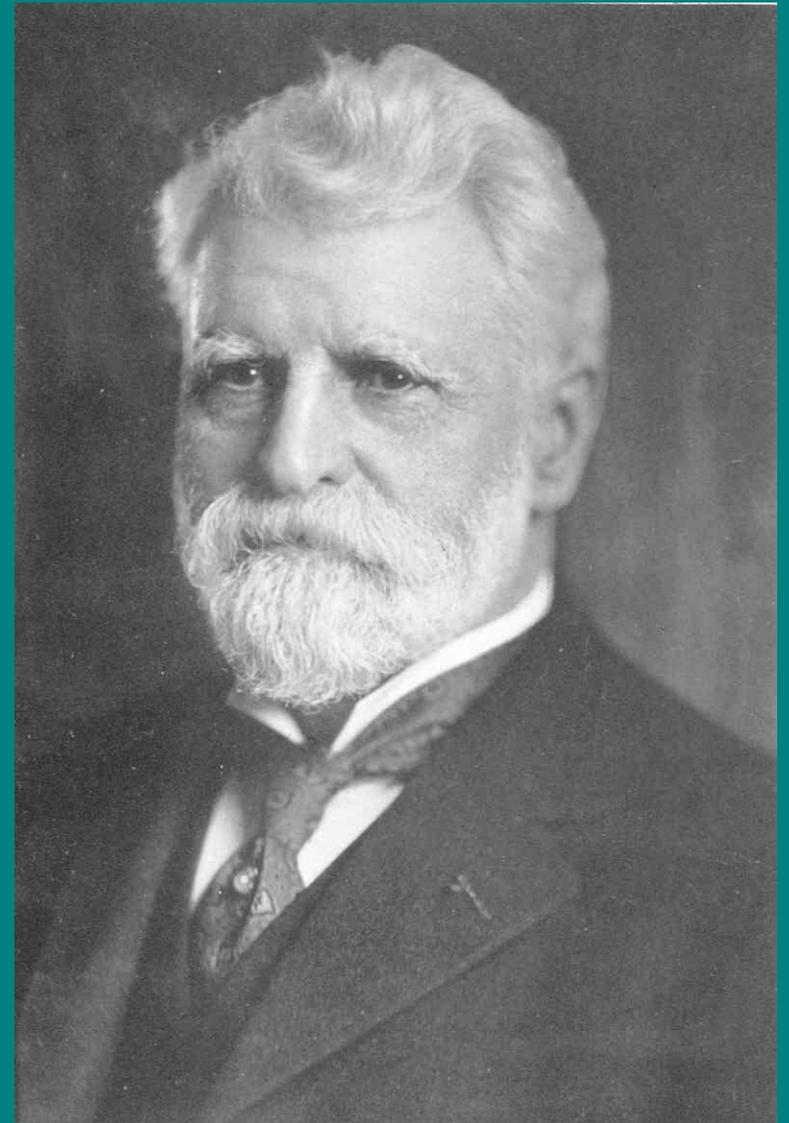
Worcester Warner

(1846-1929)



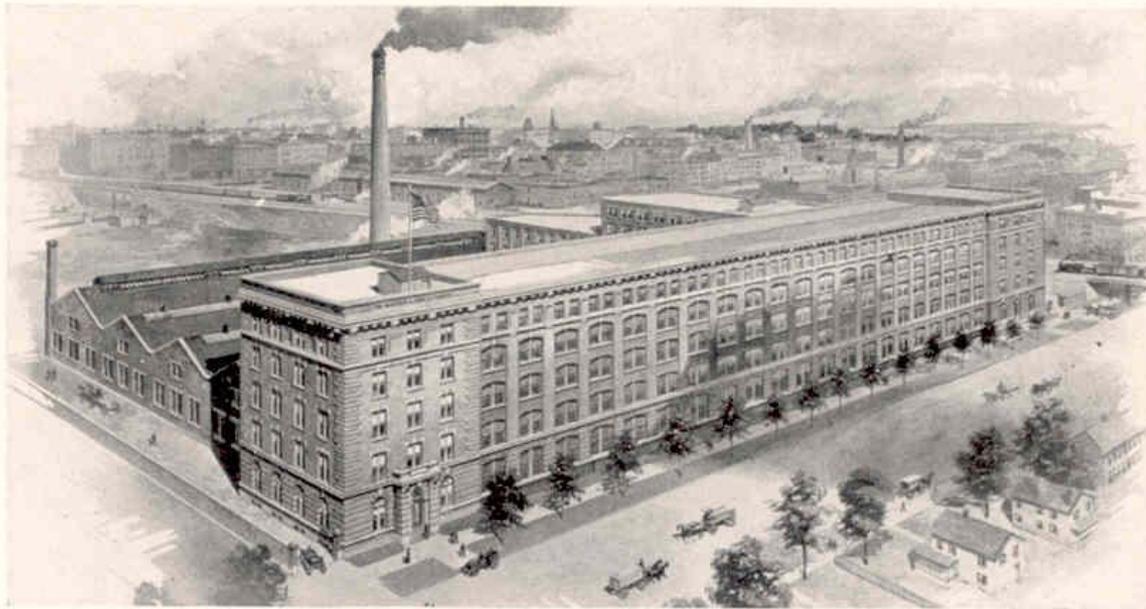
Ambrose Swasey

(1846-1937)



# Warner & Swasey Company

Established a very successful machine tool business in Cleveland in 1881



Works and Main Office, The Warner & Swasey Company, Cleveland, Ohio, U. S. A.  
(Branch Offices: New York, Boston, Buffalo, Detroit and Chicago)

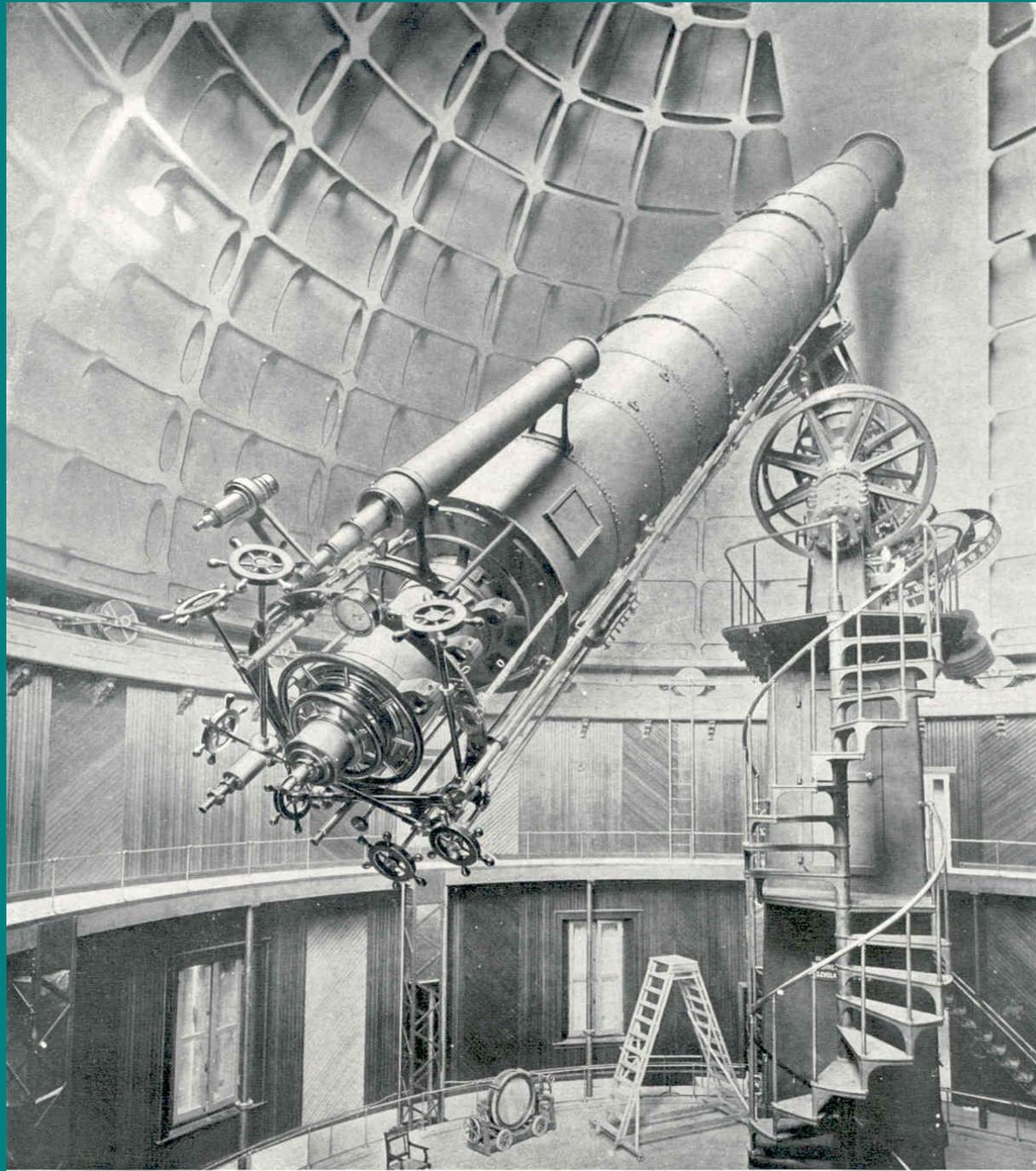
# Amateur astronomers Professional Telescope Makers

“Mr Warner and I have often been asked if building astronomical instruments is our only business, and sometimes I have answered, ..... that we get our money out of machinery and our glory out of telescopes.”

(A. Swasey)

Jan 1888  
Lick Obs (CA)  
36" refractor

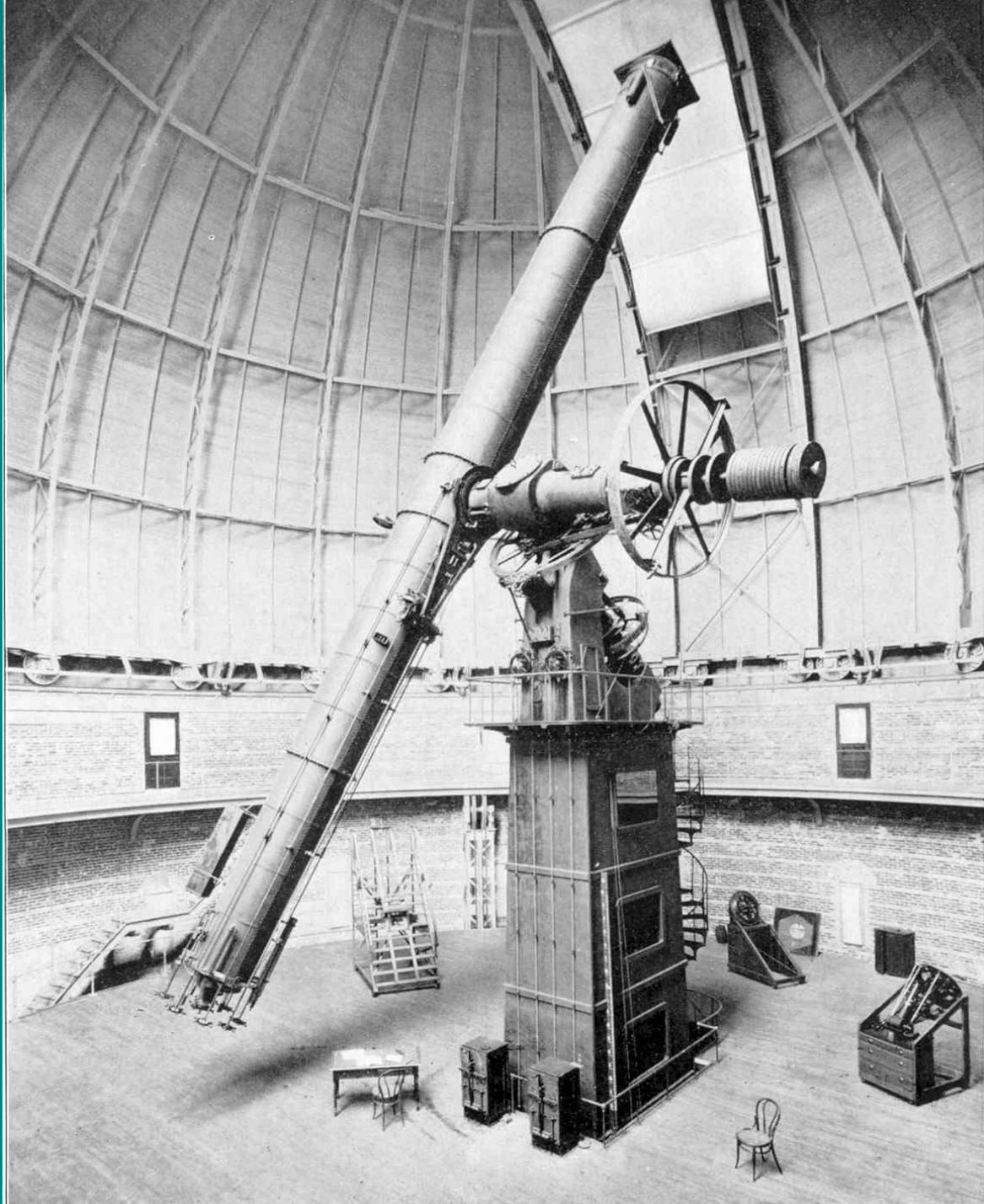
Largest telescope in the  
world at the time



1897

Yerkes Obs (WI)  
40 inch refractor

Largest telescope in the  
world at the time

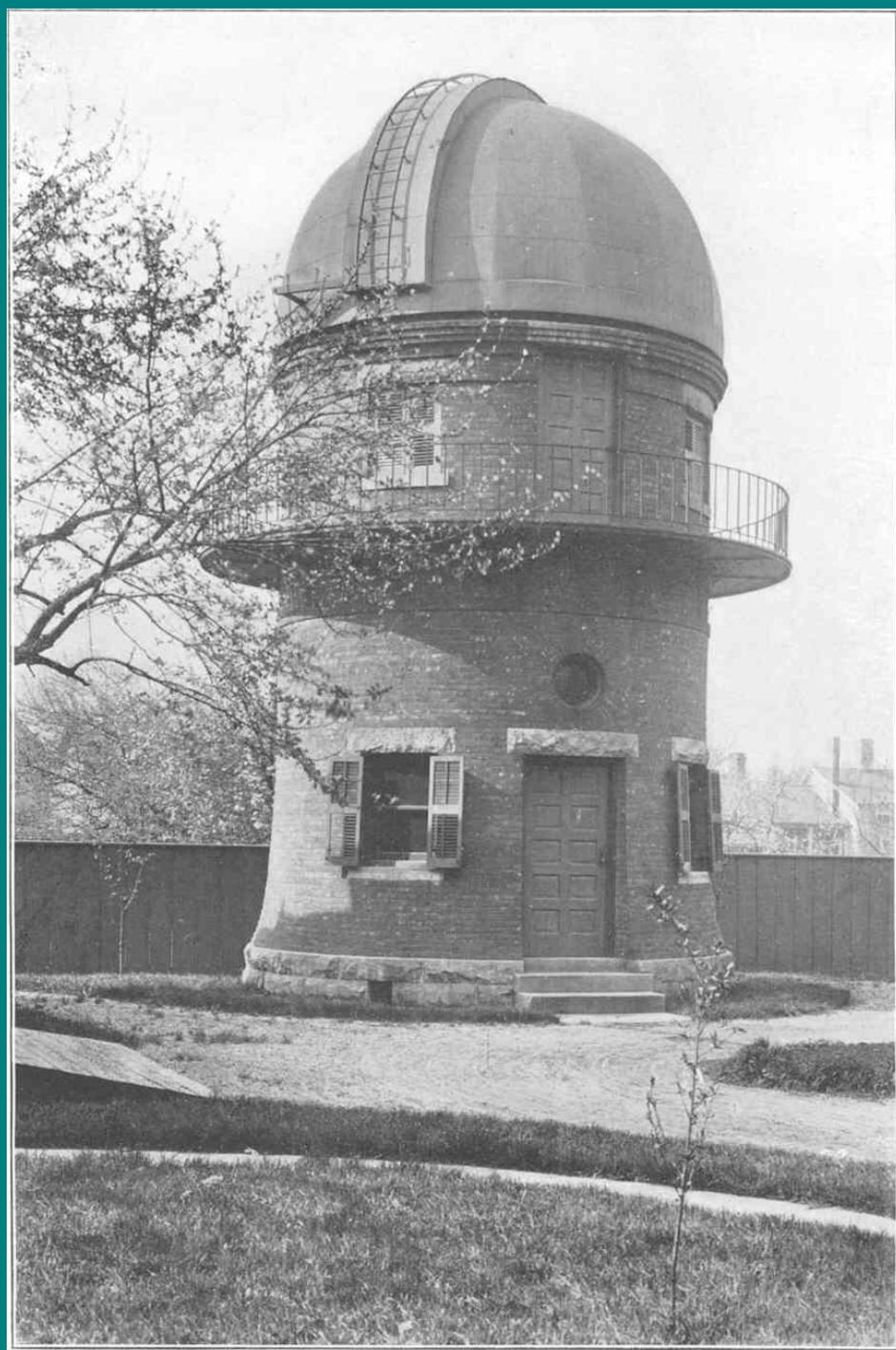


1919

Victoria BC DAO  
72" Reflector

Largest telescope in the  
world for a few months



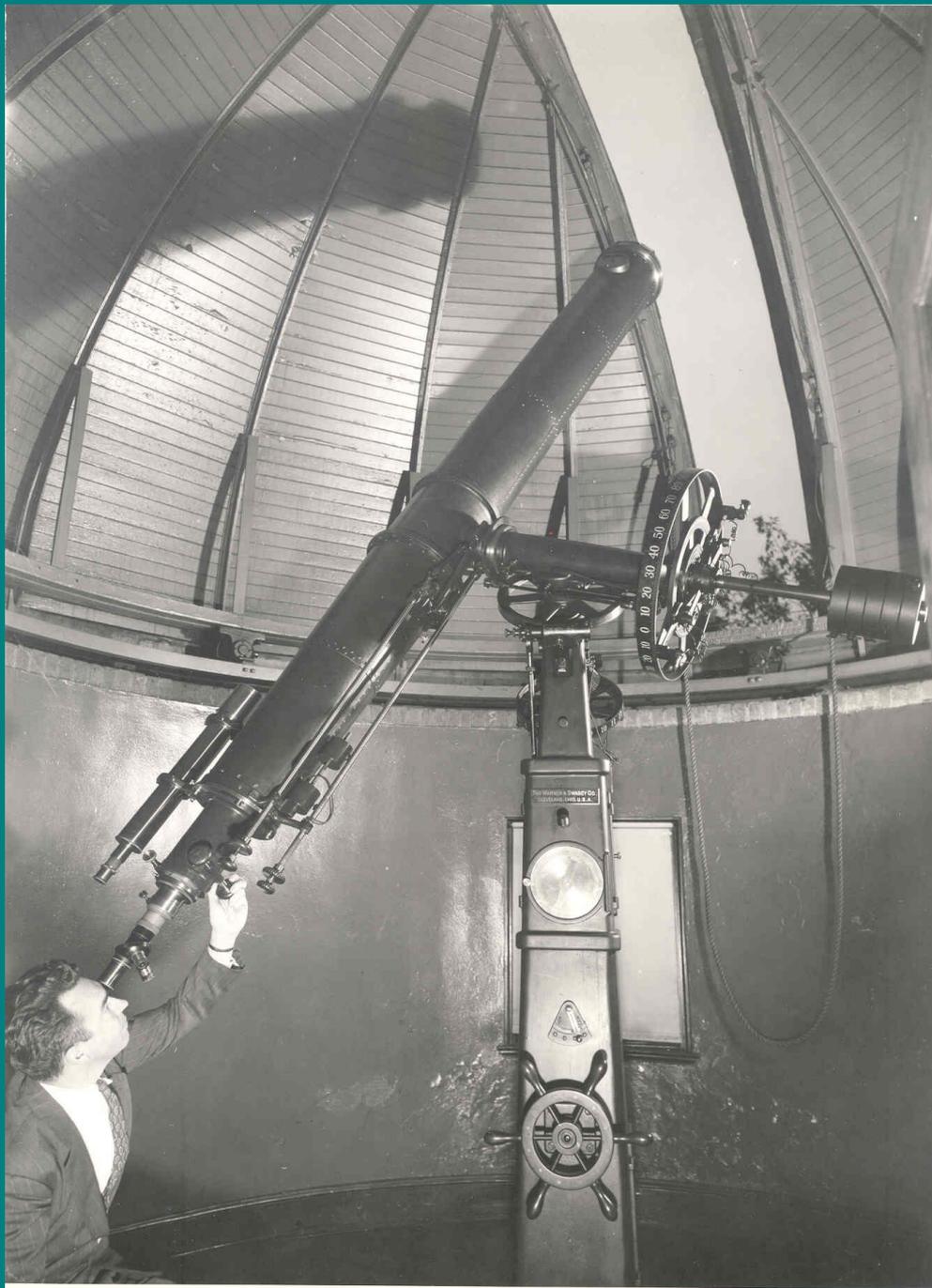


Warner and Swasey's  
backyard observatory on  
Euclid Ave

Built in 1893

# The Warner and Swasey Observatory at Case





Warner &  
Swasey gave the  
9 ½ inch  
telescope to  
Case in 1919.

Shown at the  
observatory at  
Taylor Road

Now on A.W.  
Smith Building,  
Case quad.

# Jason Nassau

In 1939 Nassau (the observatory director) initiated a fund raising campaign to enlarge the observatory and equip it with a new telescope.

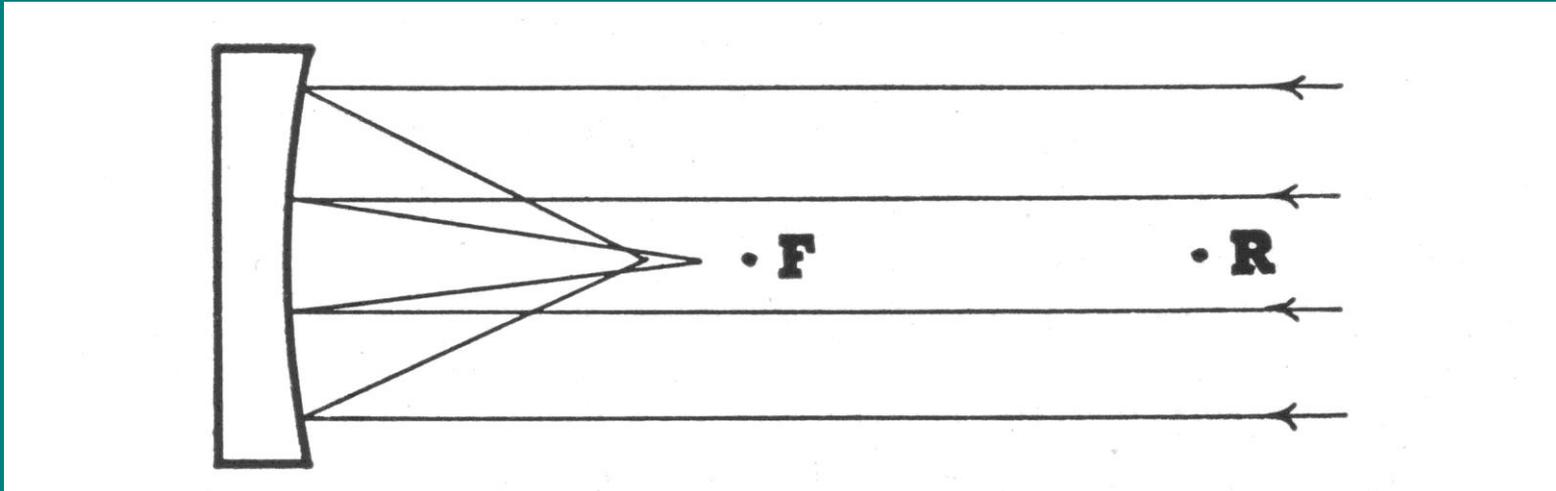
New, exciting design: Wide field Schmidt telescope

Edward Burrell – chief engineer at Warner and Swasey -- received a honorary doctorate from Case Institute in 1936.

His widow Katherine made a donation in his memory for the telescope

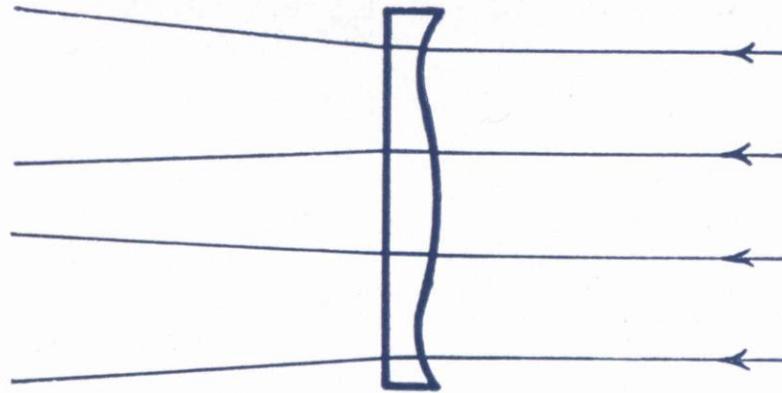


# Schmidt Optics

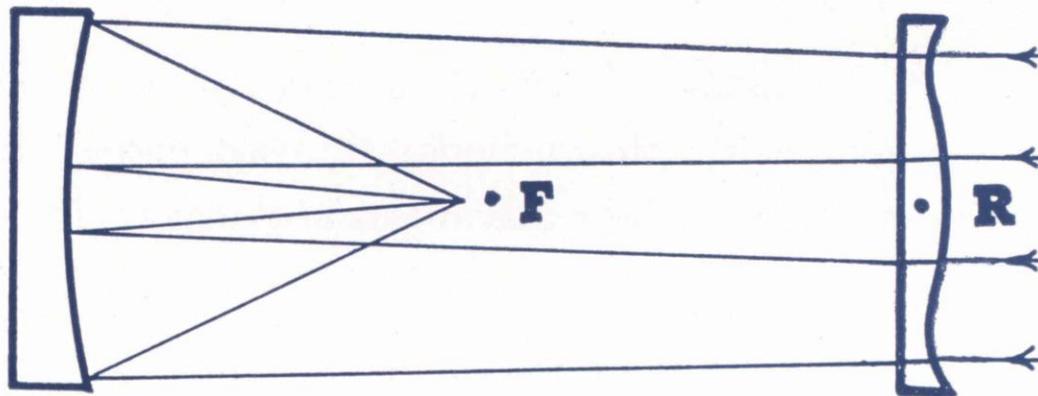


Wide field telescope for surveys

From the 1947 observatory booklet



In this case, the outer rays are less divergent and the center rays slightly convergent. The resulting combination with the focus now a little closer to the mirror follows:



If the parallel rays are directed to the telescope from an angle different from the one shown in the above figures, they will

The optical design of the Schmidt was still a novel idea in 1939

ALL FEATURE SECTION

# CLEVELAND PLAIN DEALER

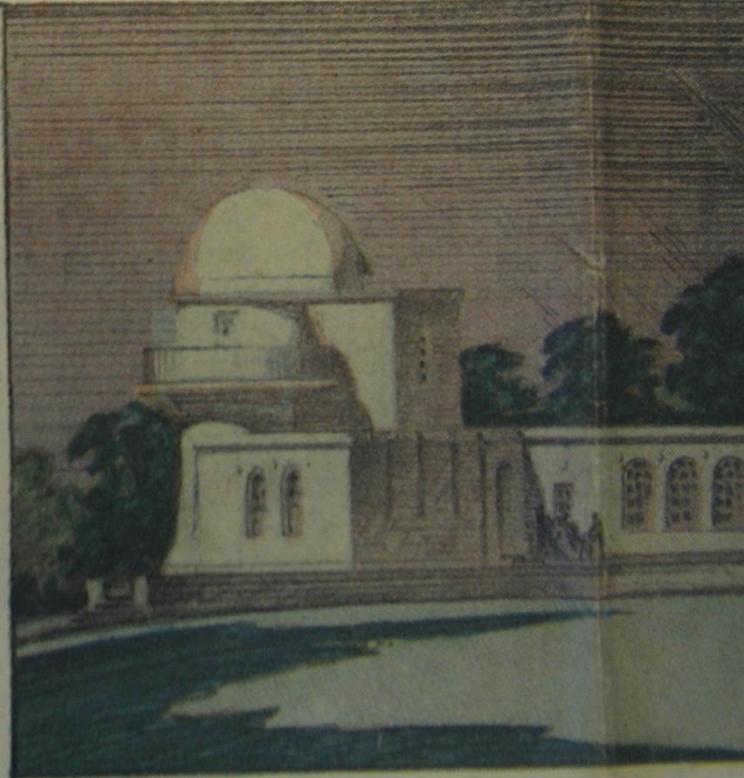
SUNDAY, JANUARY 14, 1939

## *The STARS* *Come DOWN* *to CLEVELAND*

Sensational Development  
in Telescopes Revealed  
by Case School's Plans  
for a New Observatory

By Edwin T. Randall

THE announcement that Case School of Applied Science will expand the observatory on Taylor Road and build a new



Architect's drawing  
The auditorium w  
and manu

In 1931 Bernhard Schmidt made the first telescope that combined a mirror and a lens design overcame most optical aberrations.

# The Primary Mirror Saga

W&S to Corning upon finding defects in the mirror blank (Oct 7 1940)

“We must tell you that we are not a little concerned with the results of our inspection”

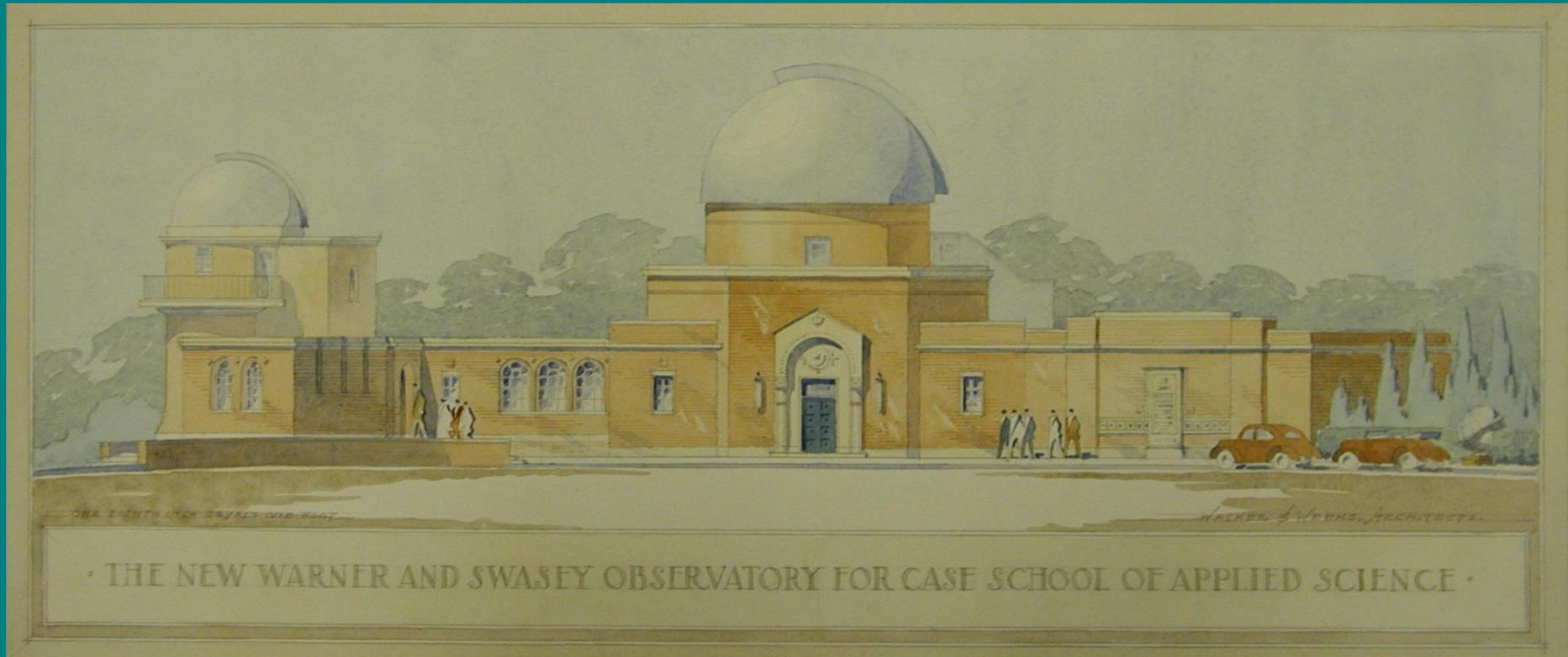
Corning reply to W&S (Oct 8)

“We are sorry to learn the 37” disk which we shipped you has not proven altogether satisfactory”

Corning to W&S (Oct 29)

“Unfortunately, through some unexplainable error in weighing, ..... resulted in a blank only 6” thick.....with the full 37” diameter ”

# First home of the Burrell Schmidt



Taylor Rd, East Cleveland

Now being renovated by Nayyir al Mahdi and Stacey Stoutemire

The Schmidt being installed in its new dome at the Warner and Swasey Observatory.

Taylor Rd



The enlarged observatory and Burrell Schmidt telescope dedicated in 1941 with a meeting of the American Astronomical Association.



# Burrell Schmidt Telescope Warner & Swasey Observatory

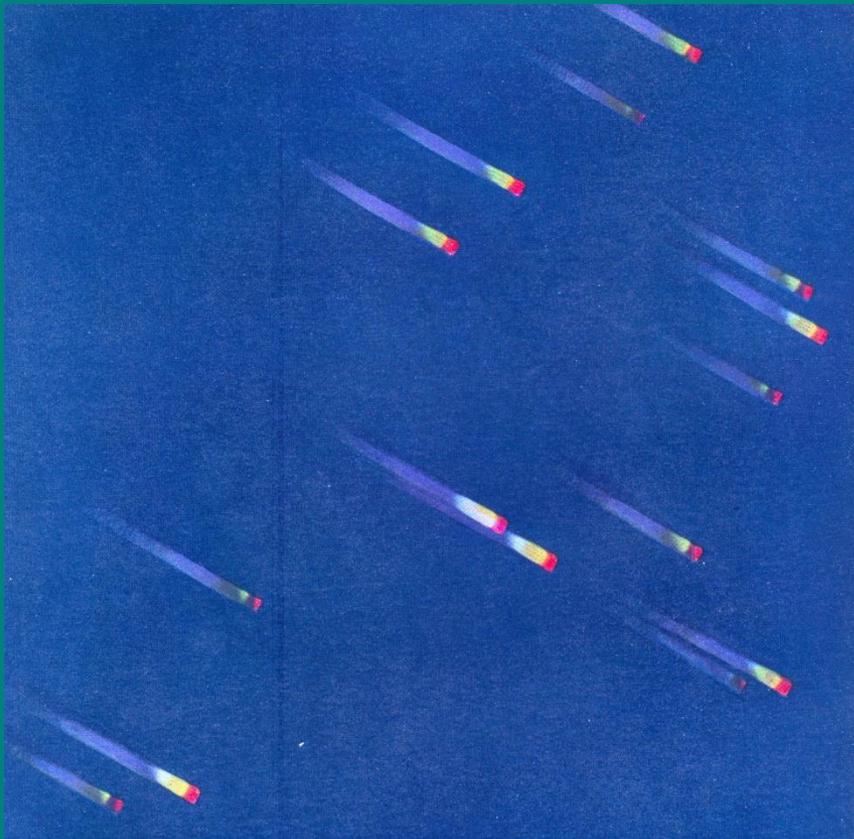
Taylor Rd

Nassau & Seyfert (1944)  
pointing the telescope.  
Coordinates are read  
from the setting circles.

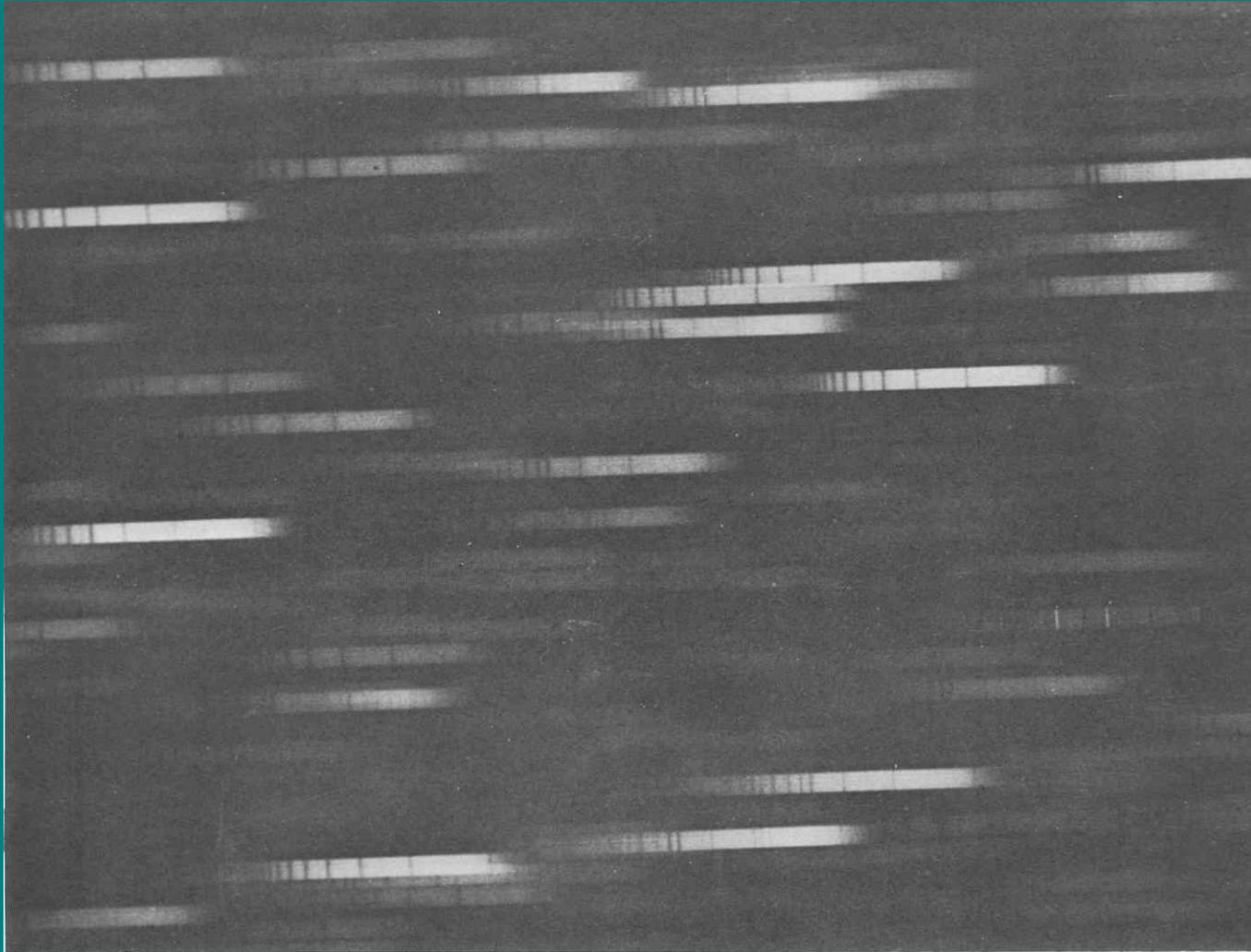


Nassau & Seyfert (1944)  
installing the prism.

With the prism installed  
each star's image is  
dispersed, forming a  
spectrum (rainbow).



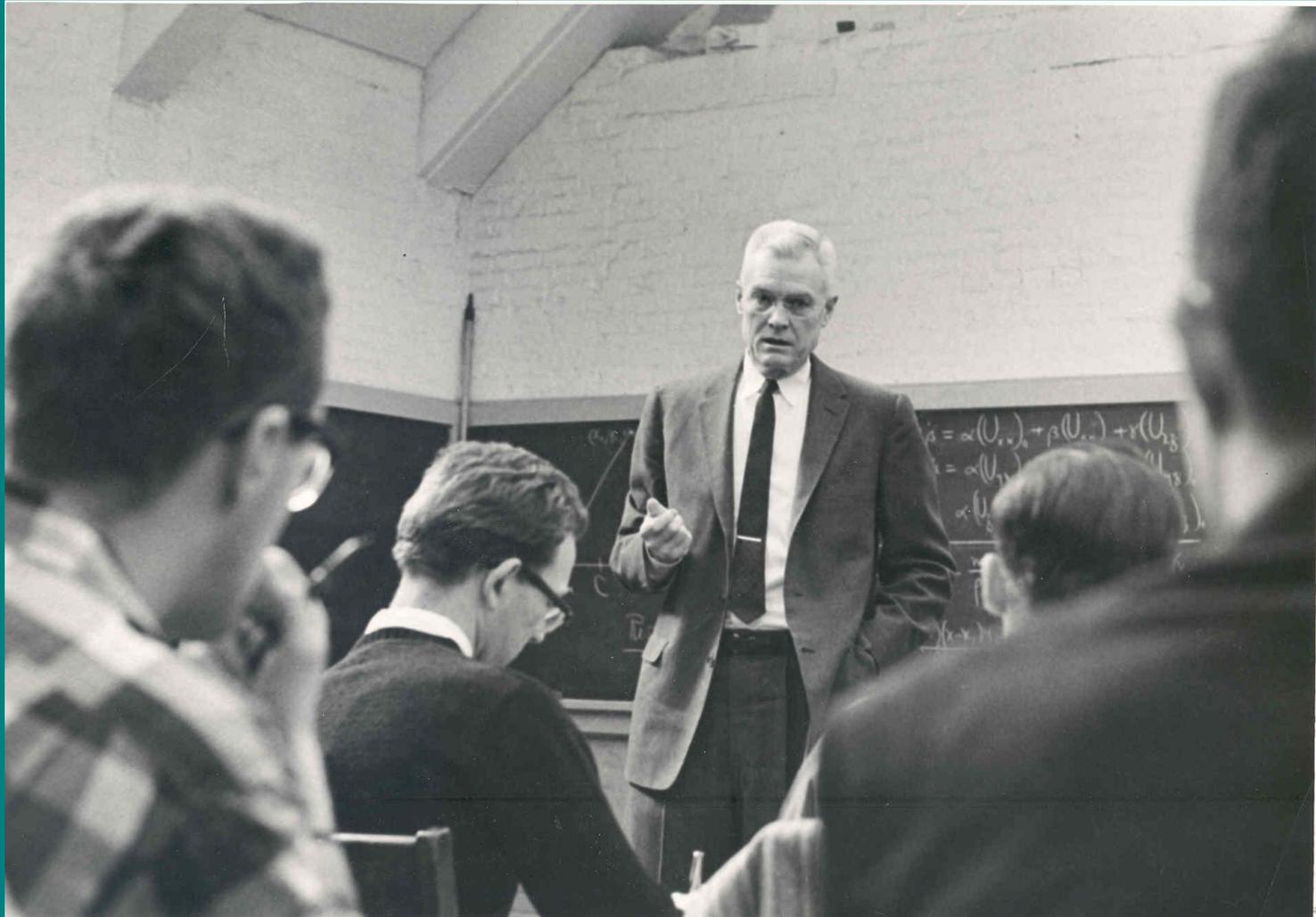
Burrell Schmidt Prism plate, most of the spectra in this field are of young stars with strong hydrogen lines



# Case astronomy students circa 1946

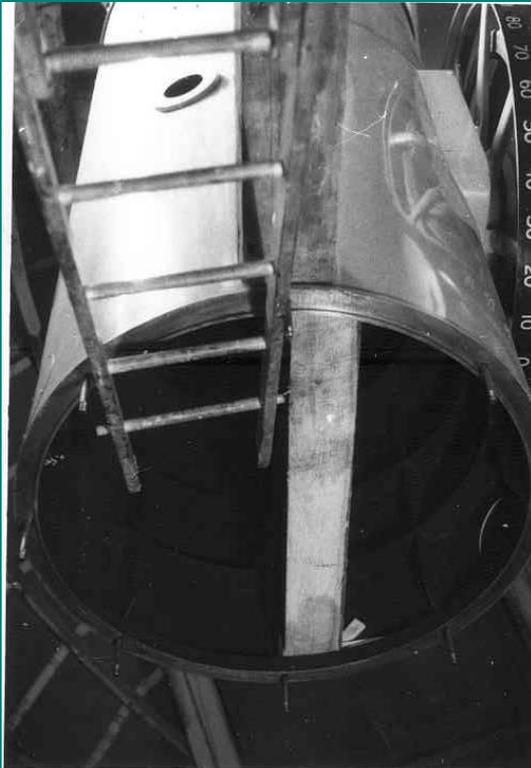


Astronomy classes for Case Institute and Western Reserve students were taught at the Warner & Swasey Observatory on Taylor Rd (Prof McCuskey, then director)



# The move to the Nassau Station

By the mid 1950s city lights had become too bright at Taylor Rd for the type of observations made by the Burrell Schmidt



**The telescope was  
carefully dismantled...**



# Schmidt telescope at Nassau Station, Montville 1957-1978



# Schmidt Optics Refurbished

In 1978 prior to the move to Kitt Peak the optics of the Schmidt were refurbished by Perkin-Elmer

Primary mirror refigured to  $1/10^{\text{th}}$  wave accuracy and a new corrector was constructed.

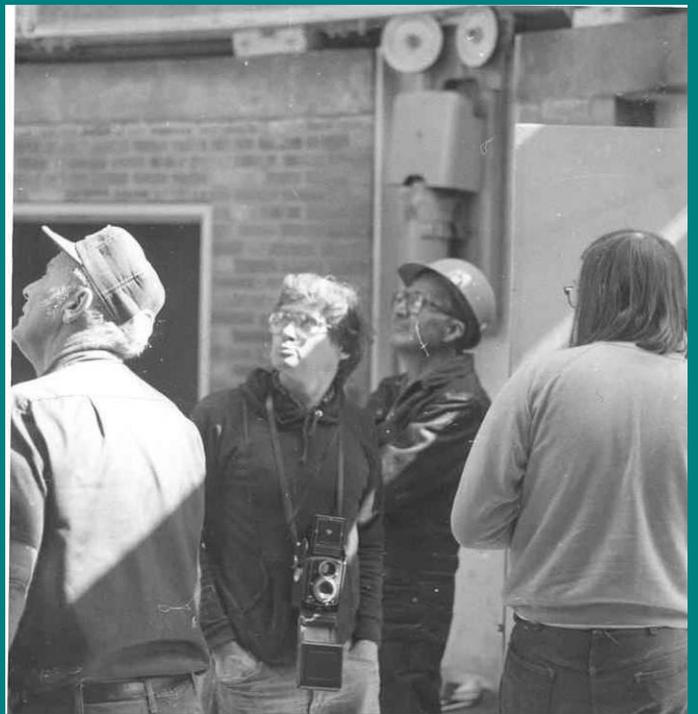
# The “Snow-Bird” Telescope

Ohio weather, city lights, bad seeing:  
needed a better site for competitive  
research

Telescope moved to Kitt Peak National  
Observatory, W of Tucson, Arizona

Photographic plate replaced by modern  
CCD detector (used Newtonian flat)

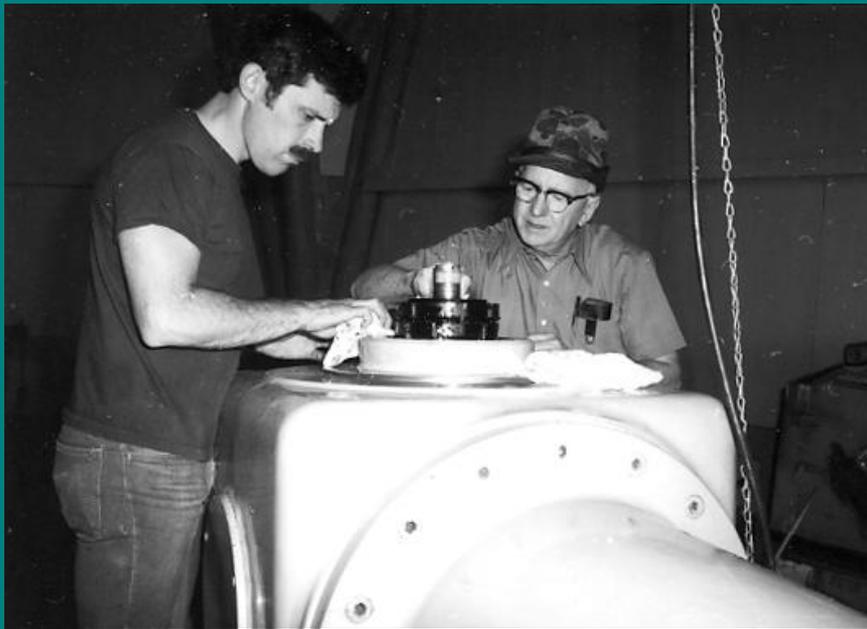
Much demand for time on Burrell Schmidt  
from US astronomical community





# Kitt Peak National Observatory

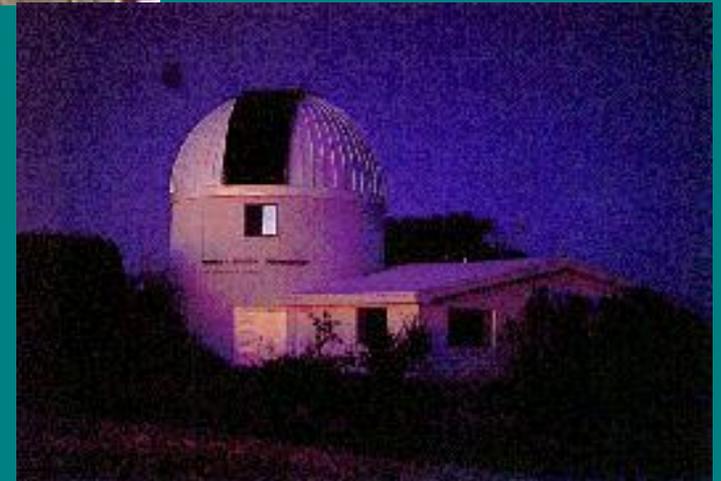


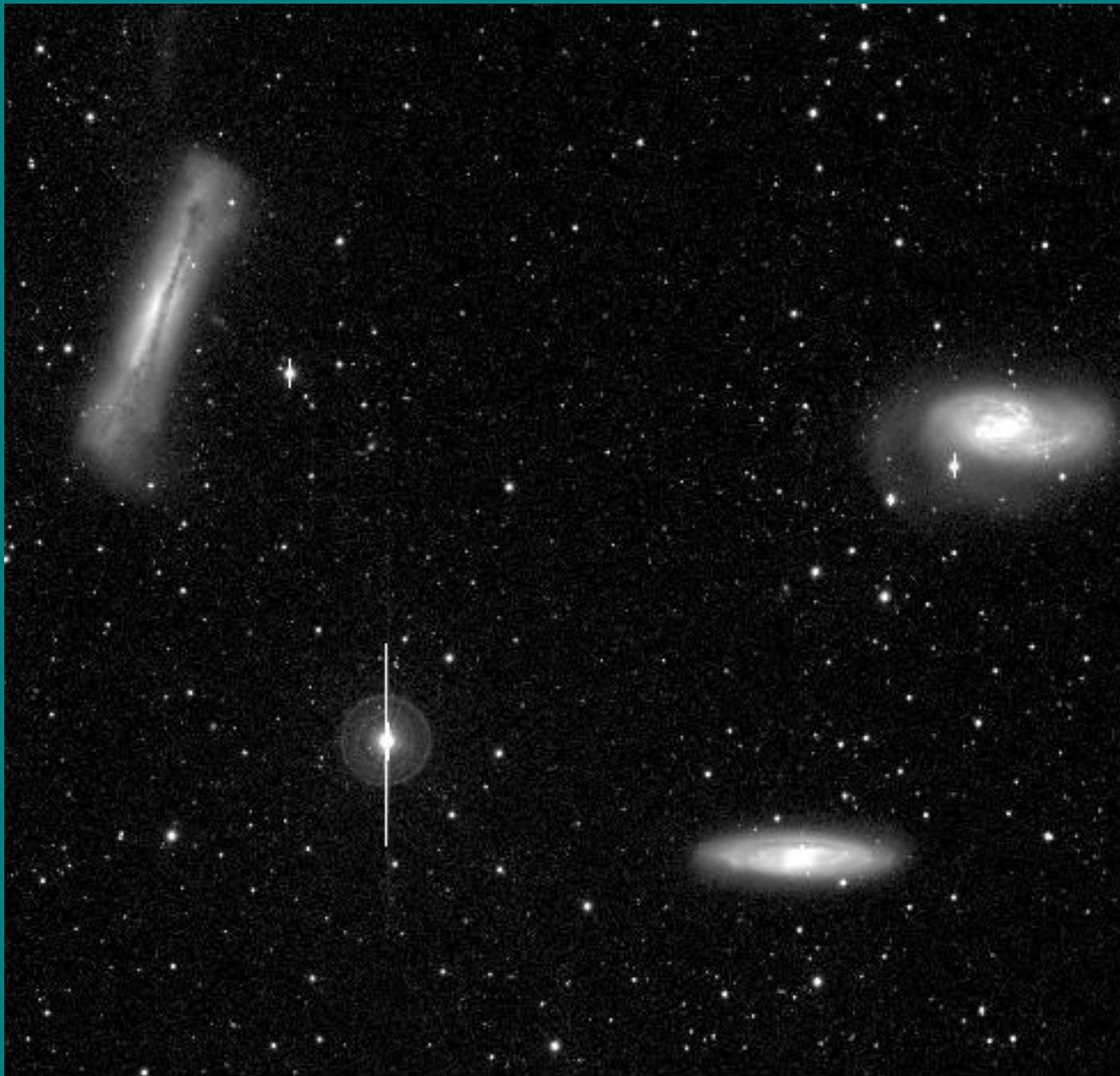


Working out how to  
put the telescope  
back together at  
Kitt Peak



The refurbished Schmidt  
at Kitt Peak





# Leo Triplet

Chris Mihos  
Burrell Schmidt



M101

Chris Mihos  
Burrell Schmidt



M13

Chris Mihos  
Burrell Schmidt

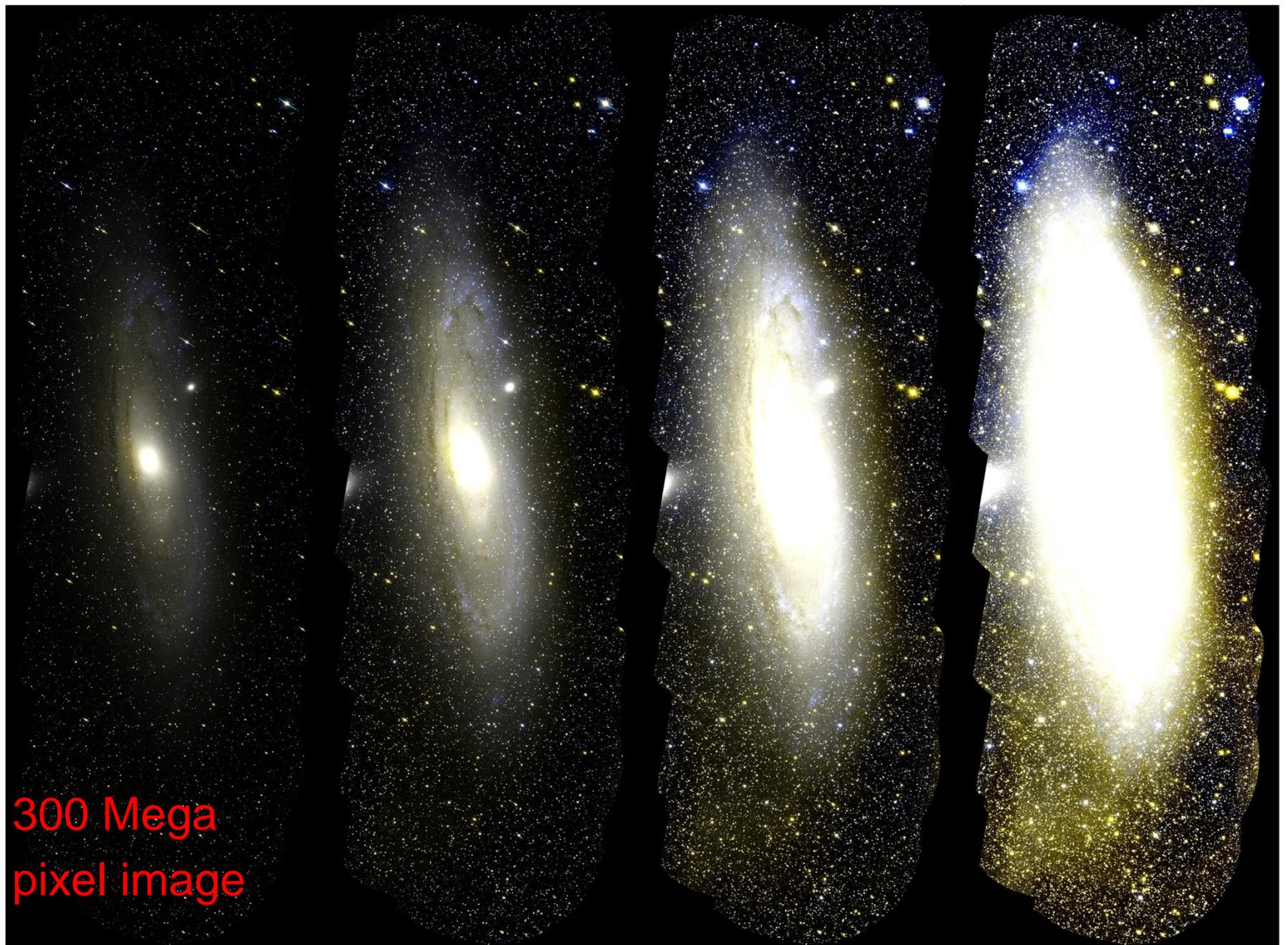
# Comet Neat



Chris Mihos Burrell Schmidt

# M31

(Raja Guhathakurta Lick Observatory)



300 Mega  
pixel image

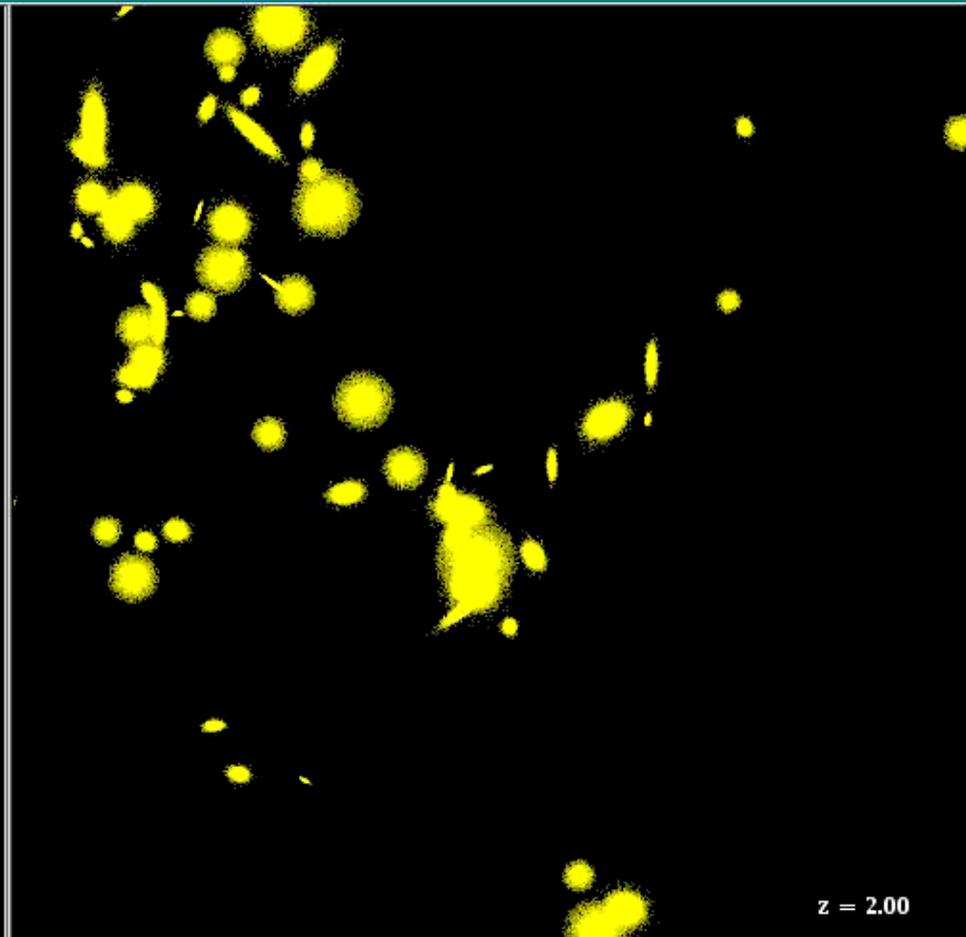
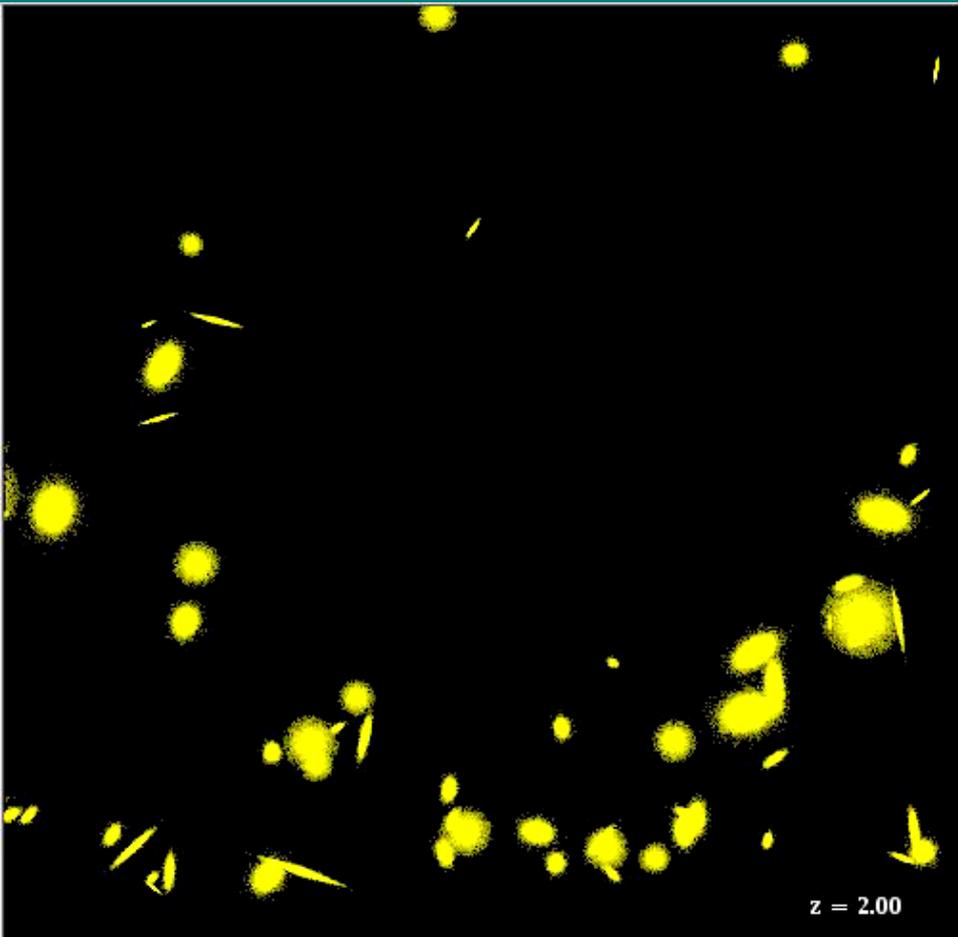


As new astronomers joined the Astronomy department in recent years—

Heather Morrison, Chris Mihos, Paul Harding

--research with the Burrell Schmidt telescope has moved from stellar surveys to the study of the formation of galaxies and clusters of galaxies.

We live in a universe where big objects are  
built up from smaller ones

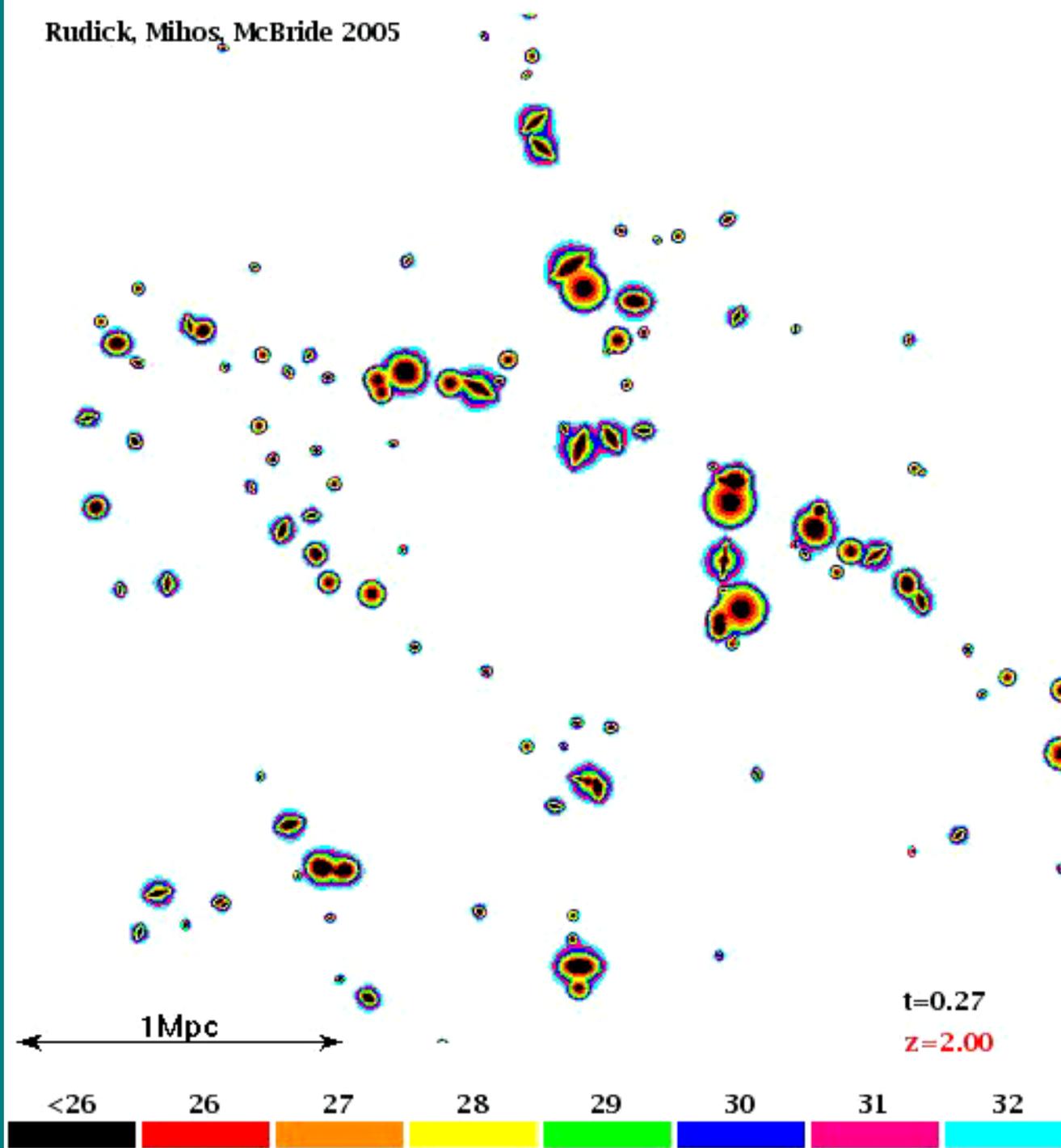


(Mihos, McBride 2004)

# Intra Cluster Light

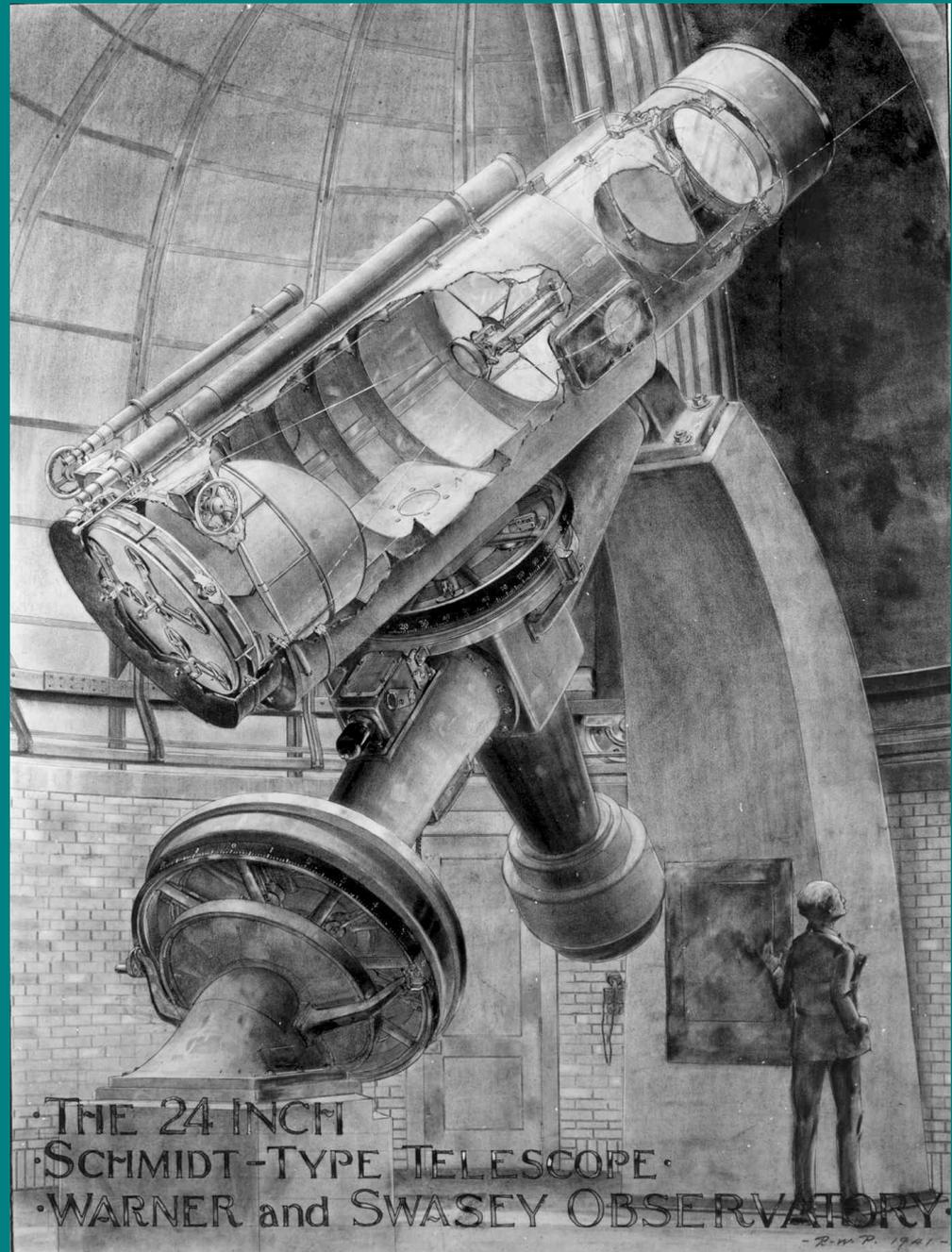
The Virgo cluster is ideal to study with the Schmidt

- Nearest cluster of galaxies
- Spread over a wide field
- A “young” cluster... still forming



# Optimizing the Schmidt for Ultra-Deep Imaging

- Needed to make the optical path as clear as possible.
- Minimize scattered light
- Correct optical problems



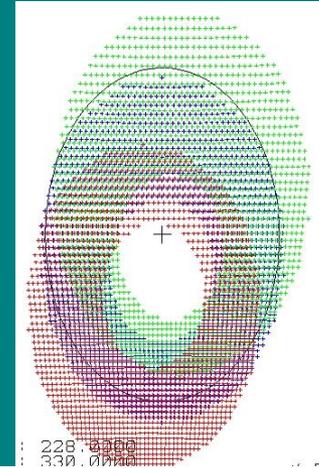
## Step 1: Weight loss program

- Removed over 600 lbs of unneeded “features” on the telescope

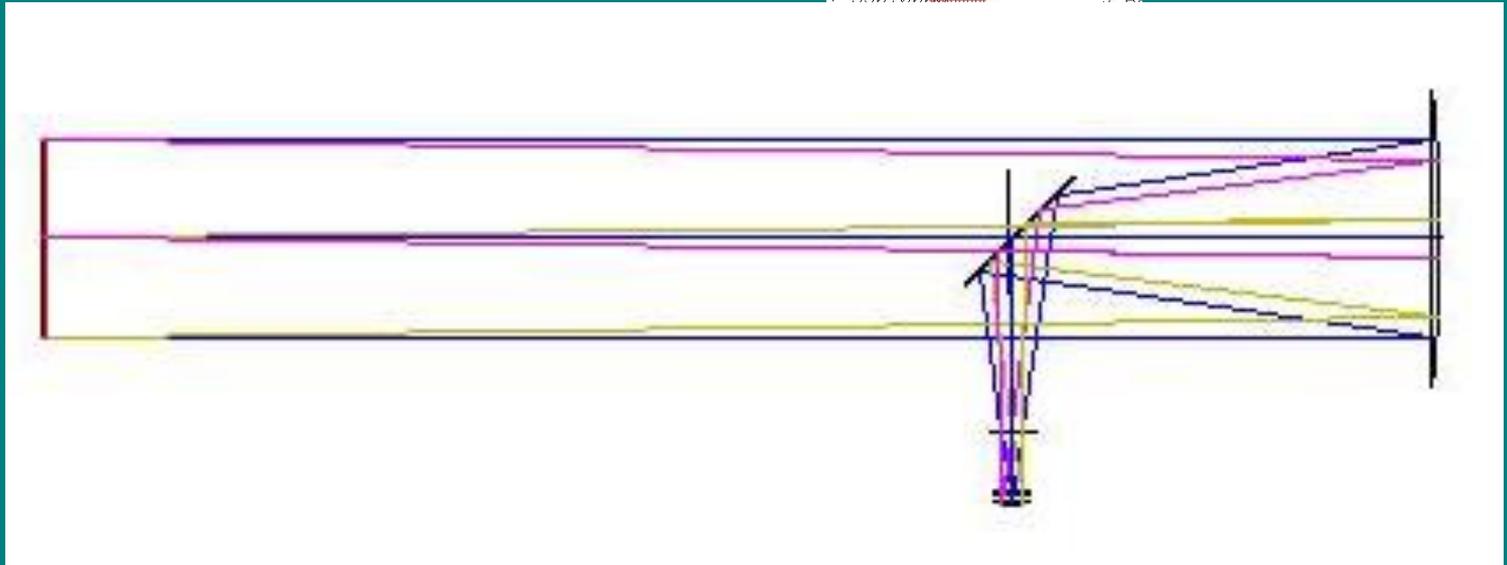


# Step 2: What to do about the Newtonian

- Original Newtonian mirror was not large enough for the field of view of our CCD

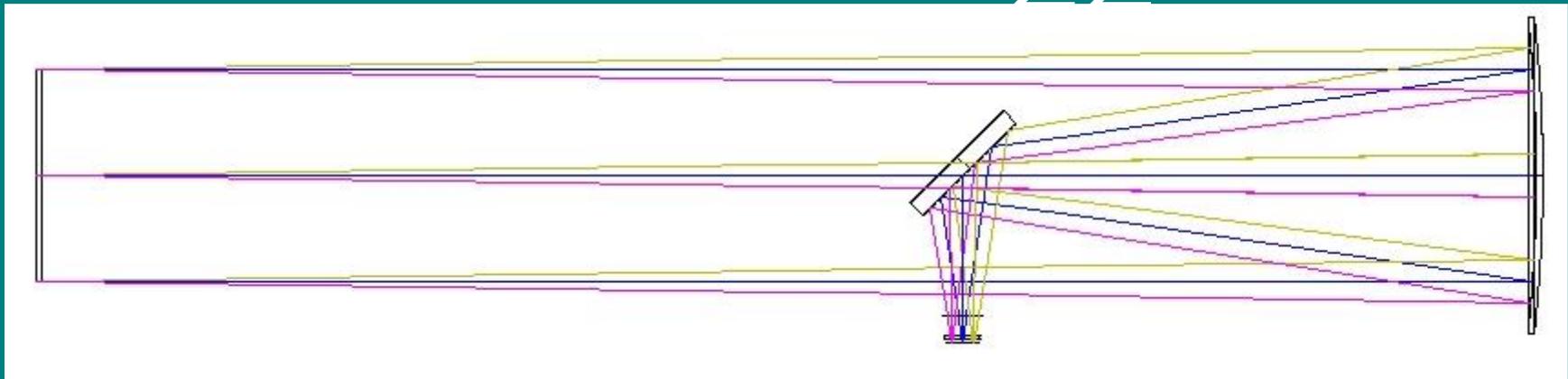
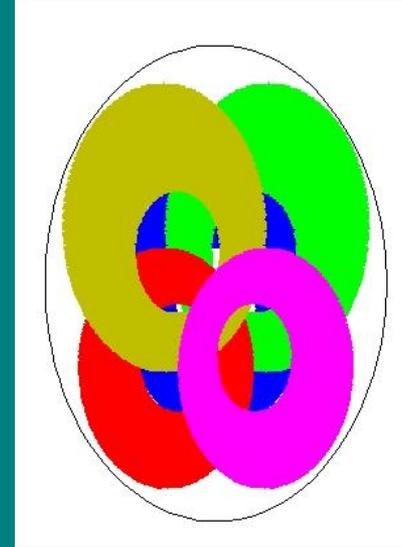


\*



# Move the Newtonian further from Primary

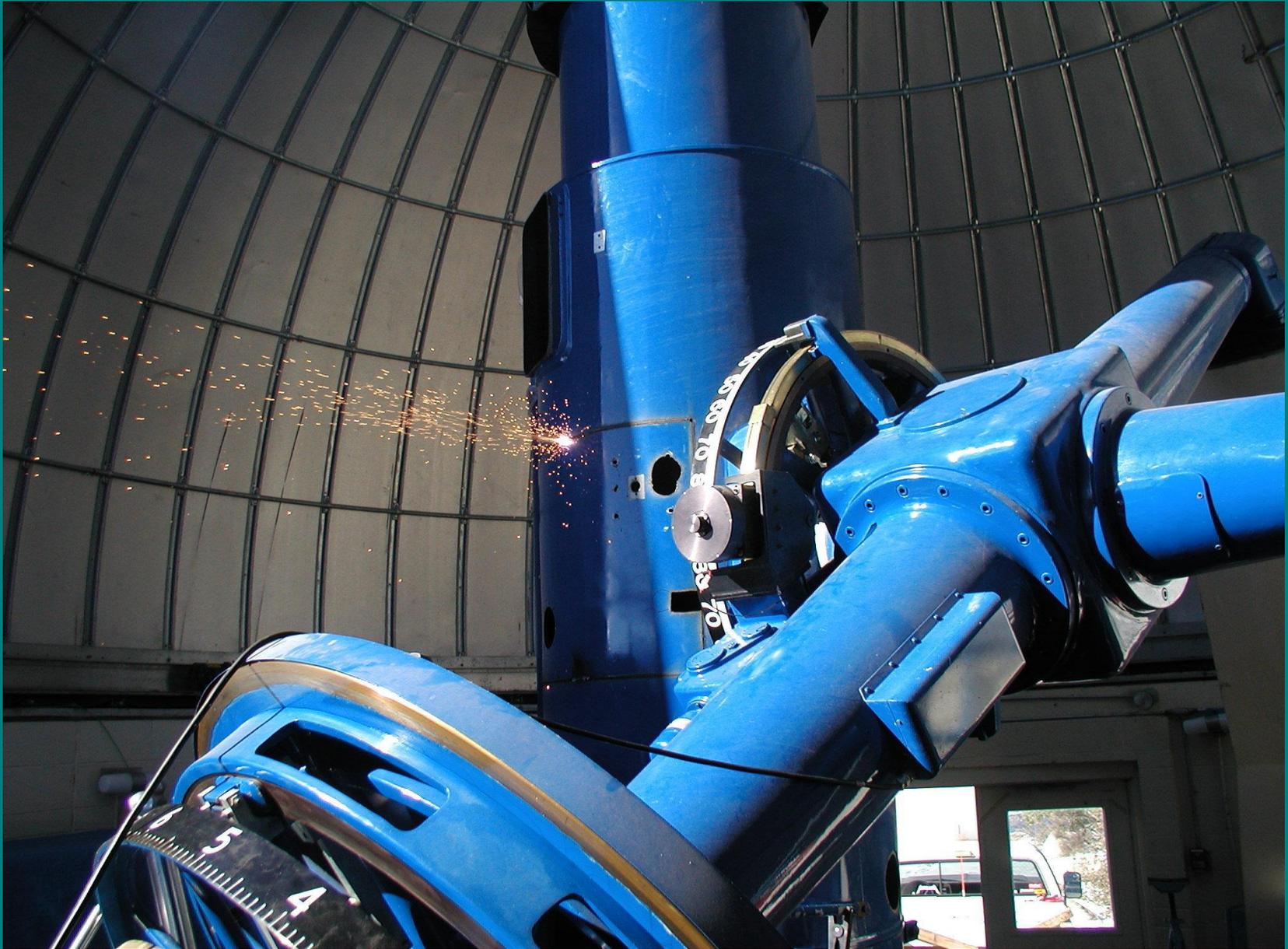
- Move of 14 inches towards the corrector increases Newtonian apparent size by 2 inches in  $f/3.5$  beam
- Have to move the focus to compensate which means cutting into the telescope tube



Mark out the  
hole to be  
cut



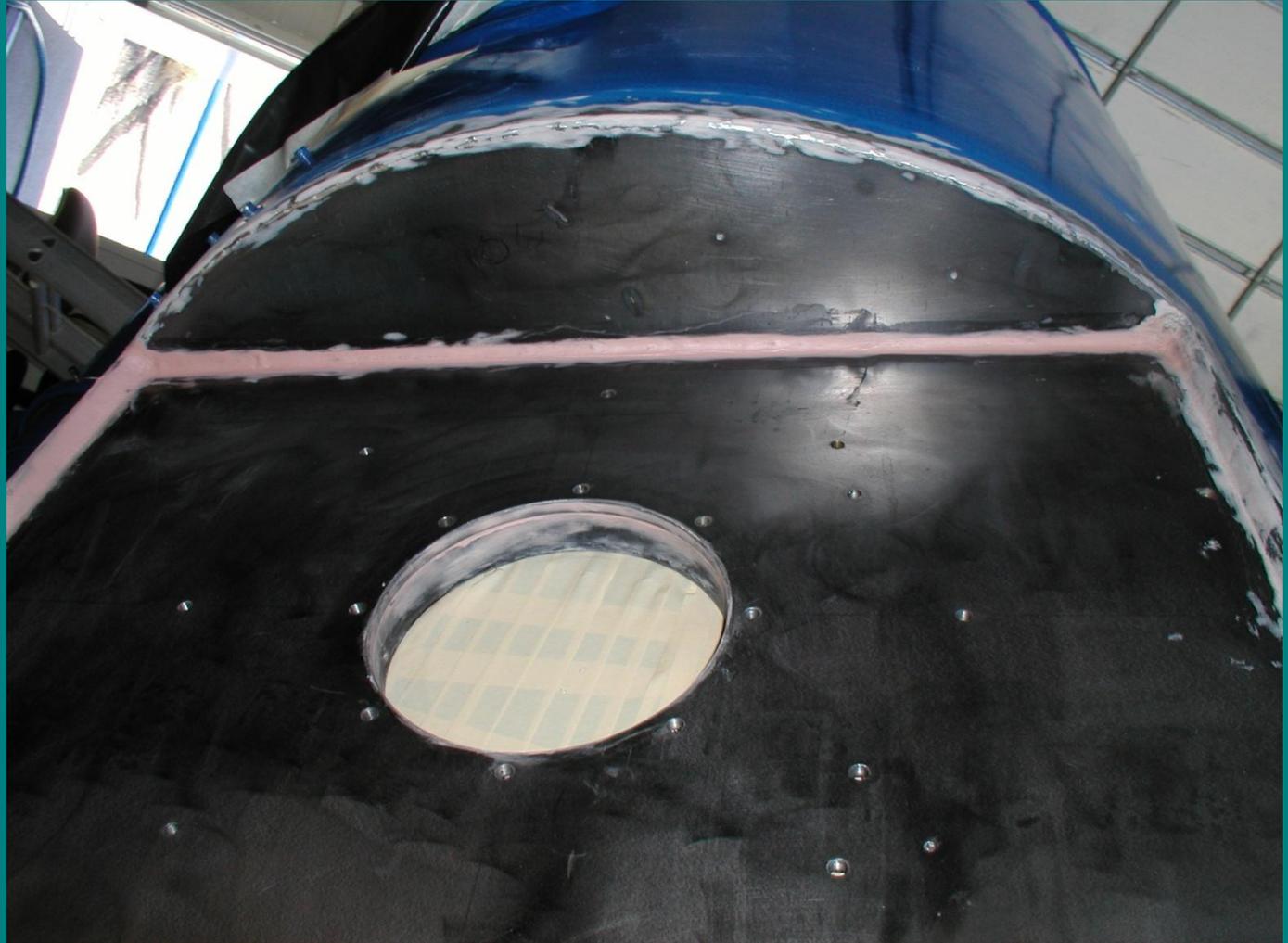
# Time to start cutting

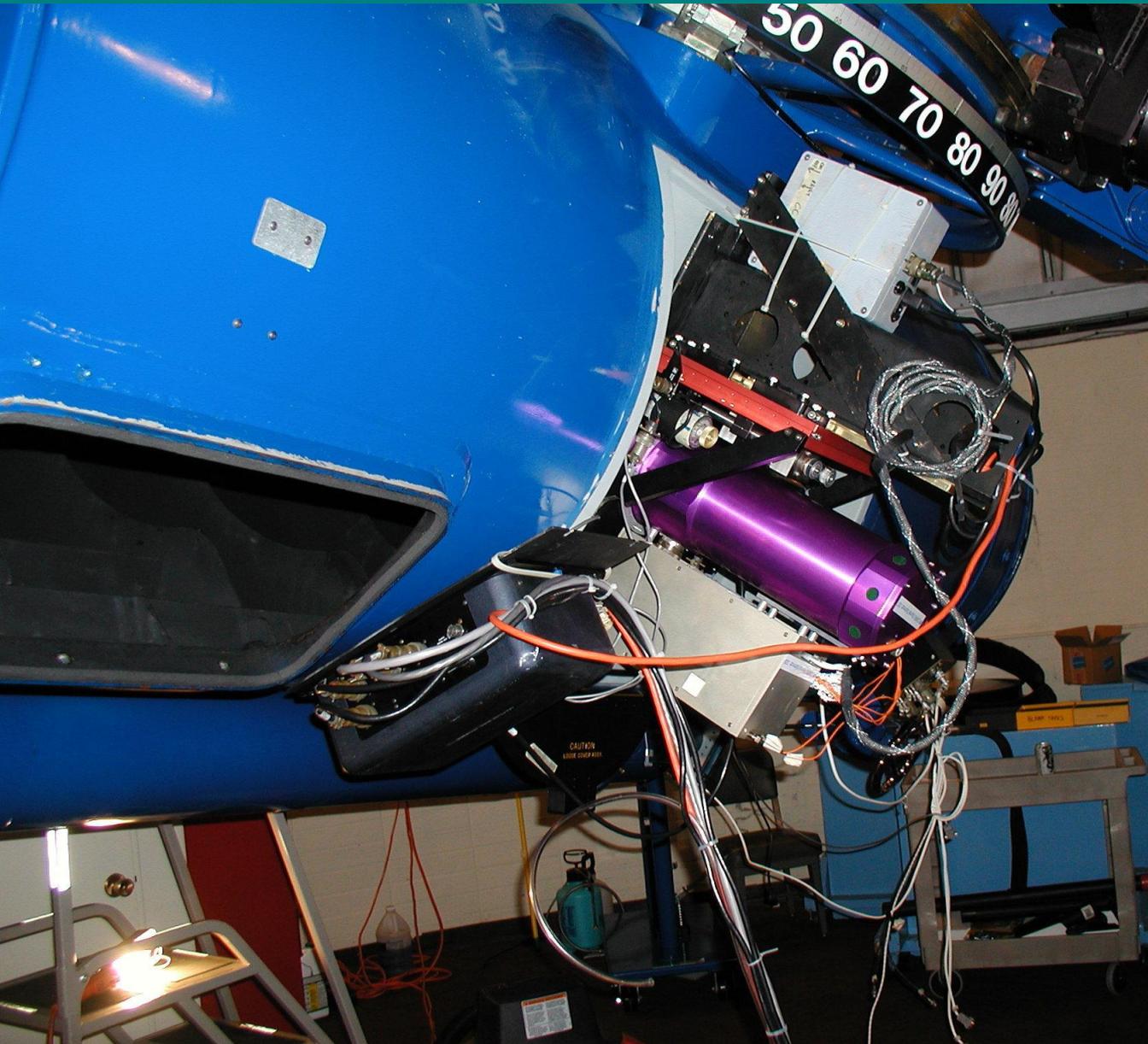


I hope we cut the  
hole in the  
correct place



All back in  
one piece





Detector  
back on  
the  
telescope  
and  
working

# Deepest image ever of Virgo Cluster (Mihos et al)

3 dark runs, 6 weeks total observing for 1  
image

Image featured in New York Times

$\mu(V) < 21.5$

Mihos et al 2005



# Summary and Future

“The little telescope that could” has been producing good science since 1941.

Plans for more improvements:

- New Newtonian flat this summer

- CCD mosaic

- Specialized coatings for optics

Warner and Swasey’s legacy continues to this day.