

Accomplishments in Amateur Astronomy And Electronics

WCARC - Sept 2016

Paul Boltwood VE3PLE
with help from Doug Leach VE3XK

Background

- In high school I had electronics & radio hobbies
- Built a sizable Tesla coil for physics class
- Passed all exams for amateur radio except code reception. Also flunked French for similar reasons
- In 1966 earned a BSc in Math at UBC
- Career in computer systems engineering
- Projects included software for sonar tracking of Russian submarines and radar tracking of aircraft
- Developed software for an international Telex exchange. I invented the high level language used, wrote a compiler and linker, and microcoded the HP 2100 and 2114 minicomputers to emulate a stack computer. That controlled the Telex exchange.

Background (cont'd)

- In my astronomy hobby (and later business) I designed most of the items shown. Others fabricated some of them.
- Due to my hydrocephalus (water on the brain) and subdural haematoma (blood collection in tissues surrounding the brain), resultant surgeries, and only partial recovery, I can no longer do this level of work.
- This presentation has been pieced together from earlier presentations to astronomy groups, and so it is a bit unusual for this audience.

Boltwood Astronomical Observatory



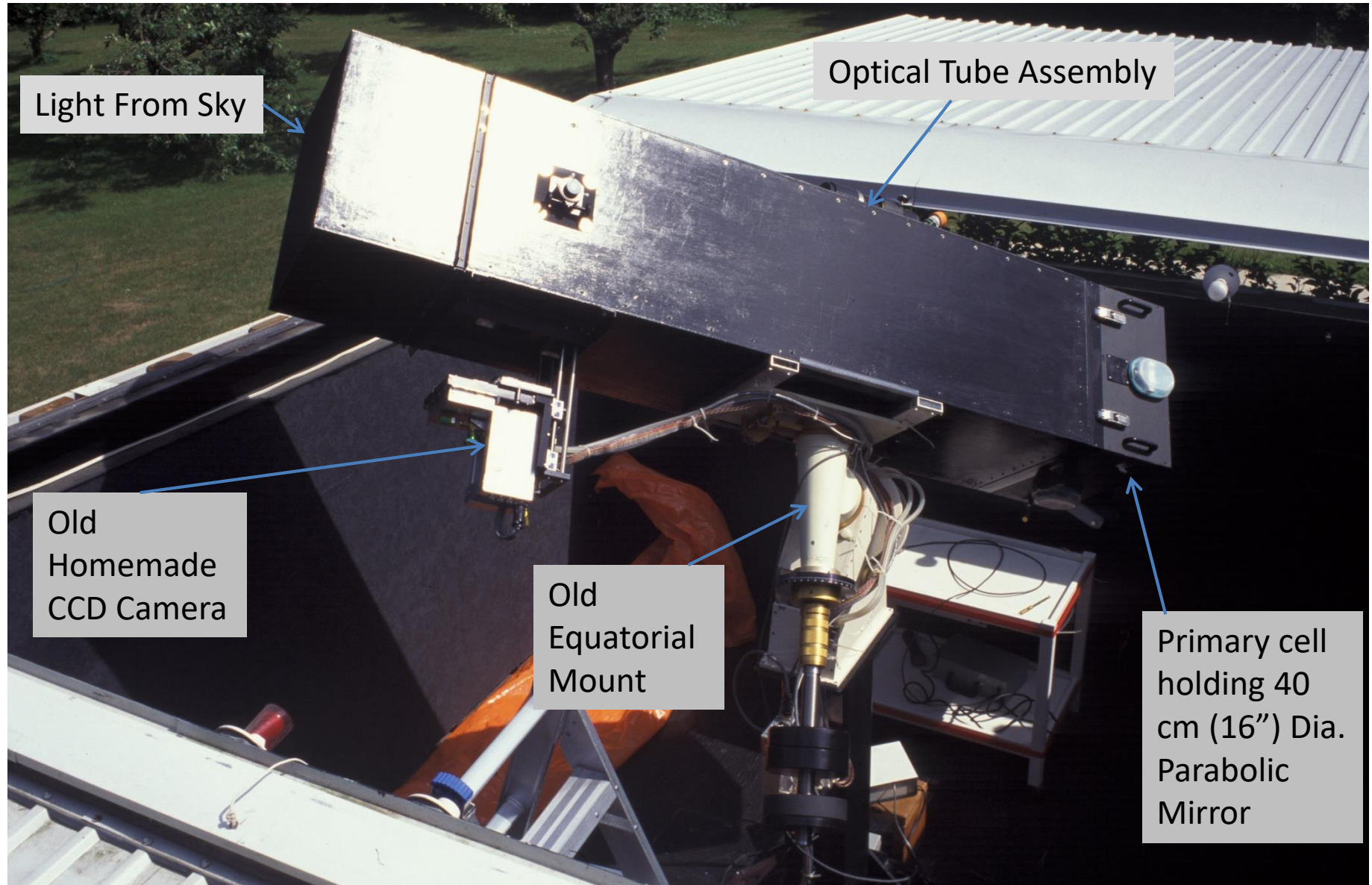
In The Far Backyard (400') At My Home, Has Two Rooms

Boltwood Astronomical Observatory



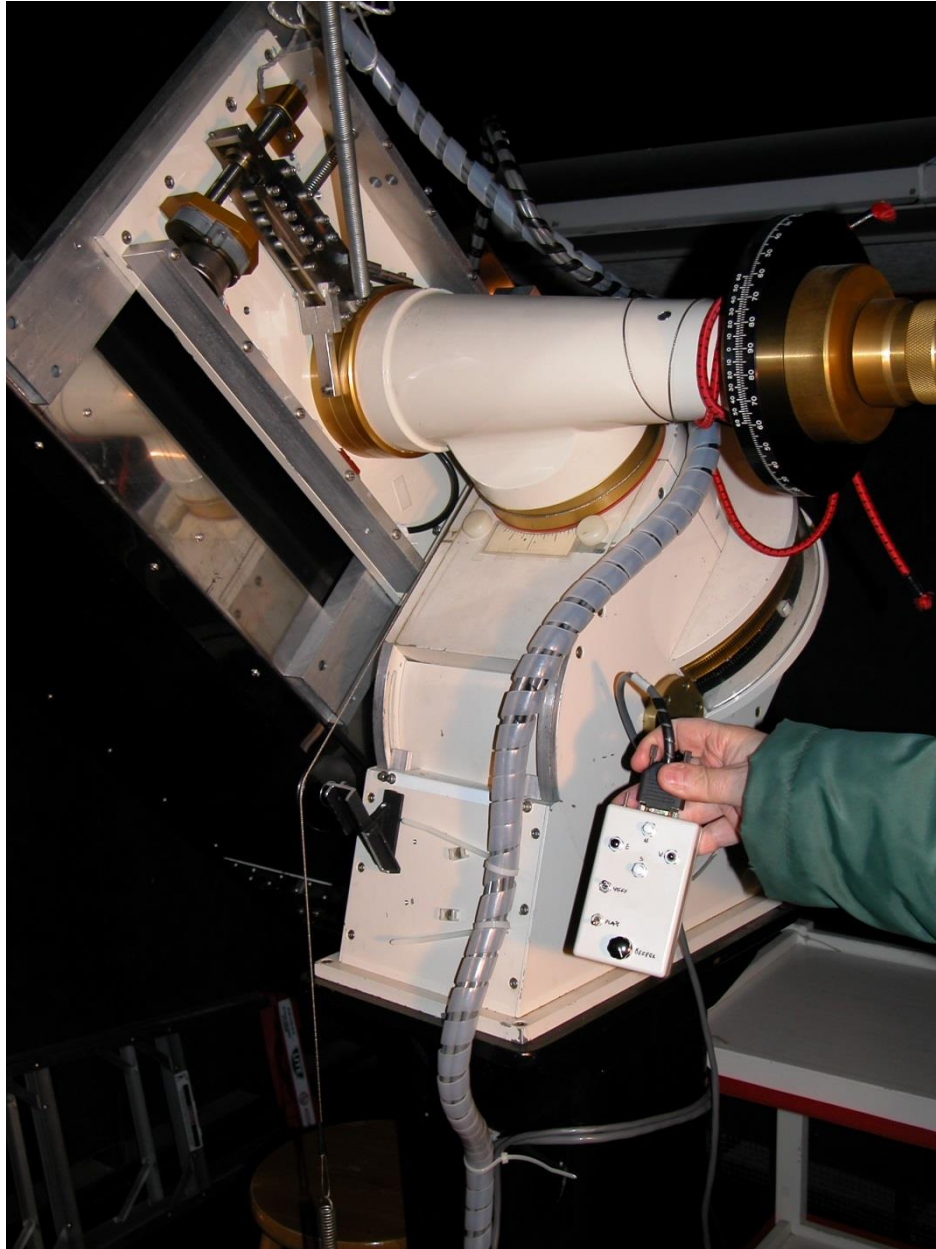
Roof Rolled Off To The South Showing The Telescope

Telescope As Seen From The Equipment Room Roof



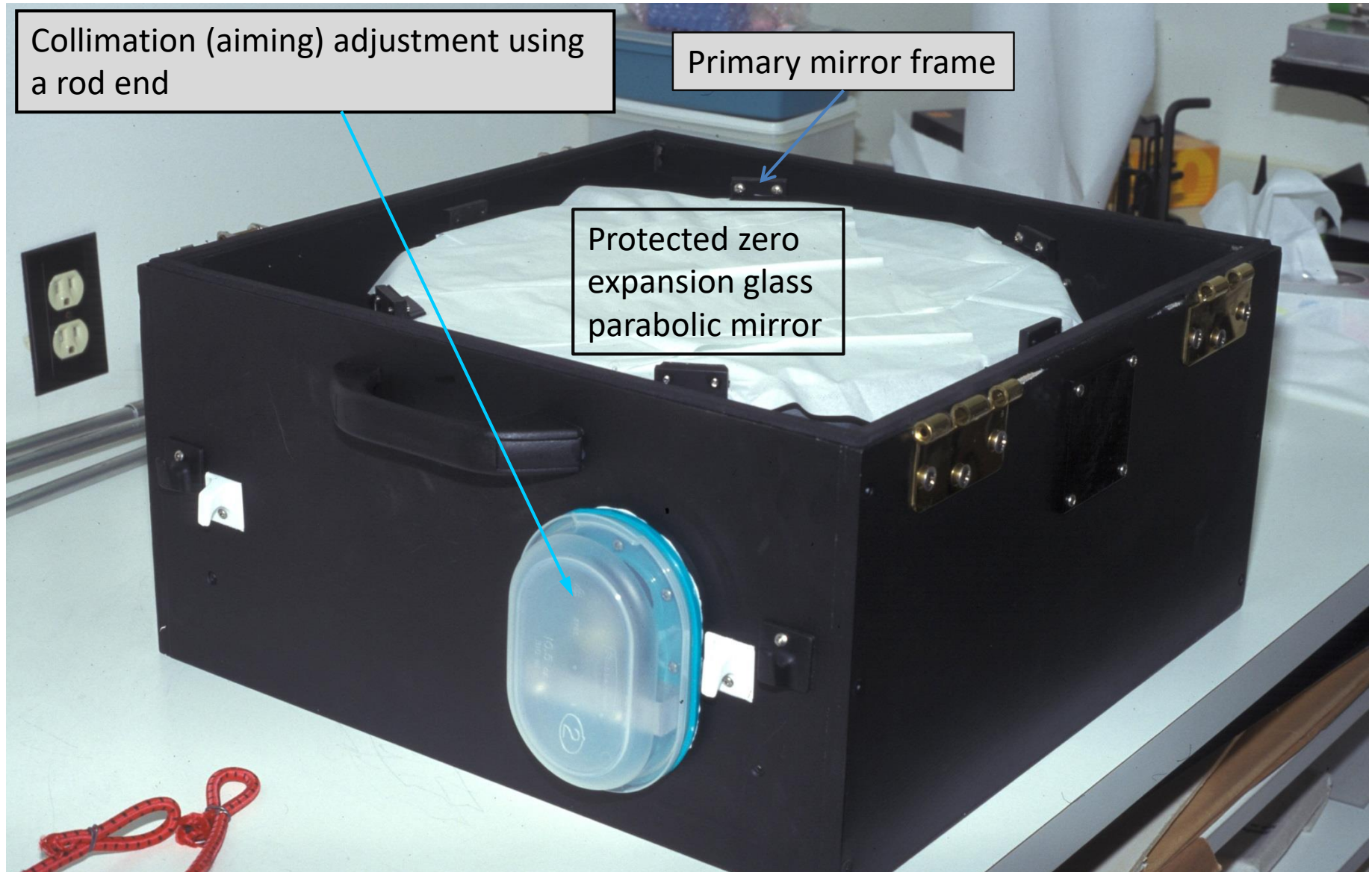
40 cm (16") Diameter Partially Homemade Newtonian Telescope

Old Telescope Mount



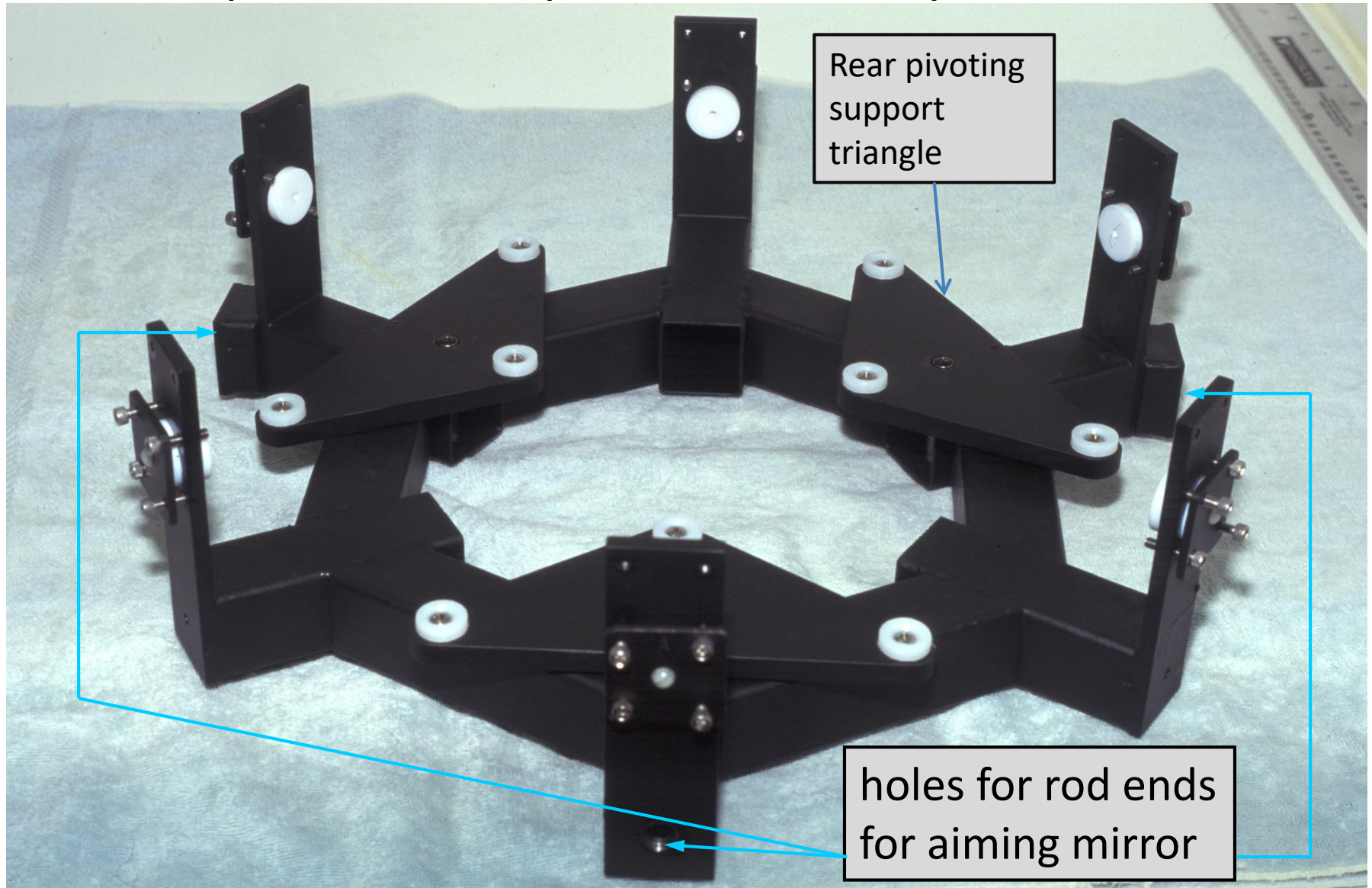
- Byers Series 2, with modifications:
 - backlash removal
 - stiffened declination drive (15 times better than Byers)
 - stiffened mounting plate
- overloaded with the 180 lb optical tube assembly
- tracking error in a 2 minute exposure is imperceptible
- stepping motors are limited to 15 times sidereal rate so moving to a new target requires grabbing telescope

Primary Mirror Cell



Cell Designed And Built By Max Stuart, Accurate Mirror By Ceravolo

Temperature Compensated Primary Mirror Frame



With nine rear & six edge supports for 5.1 cm (2") thick mirror

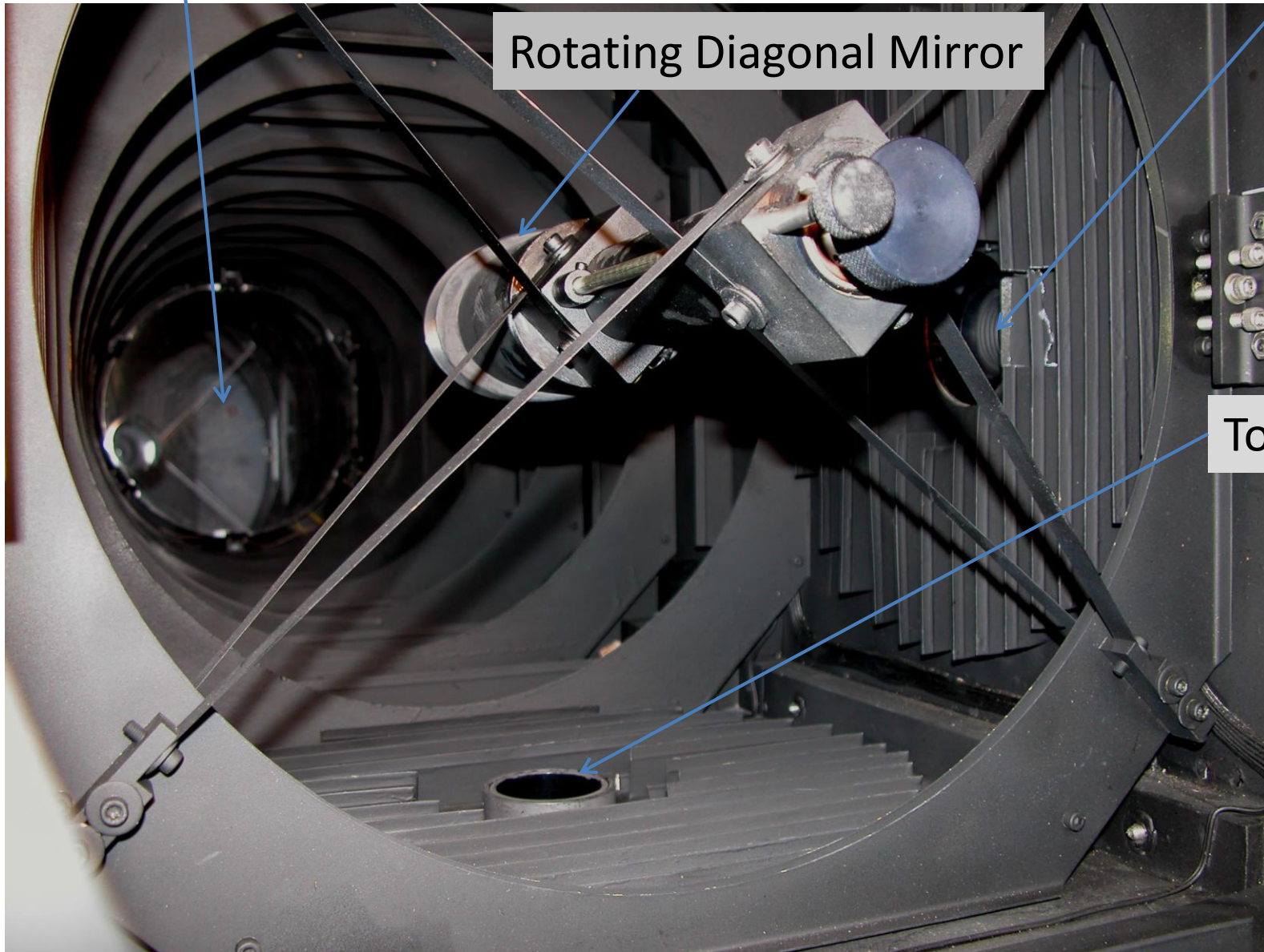
Primary Mirror

Optical Tube Assembly

To CCD Camera

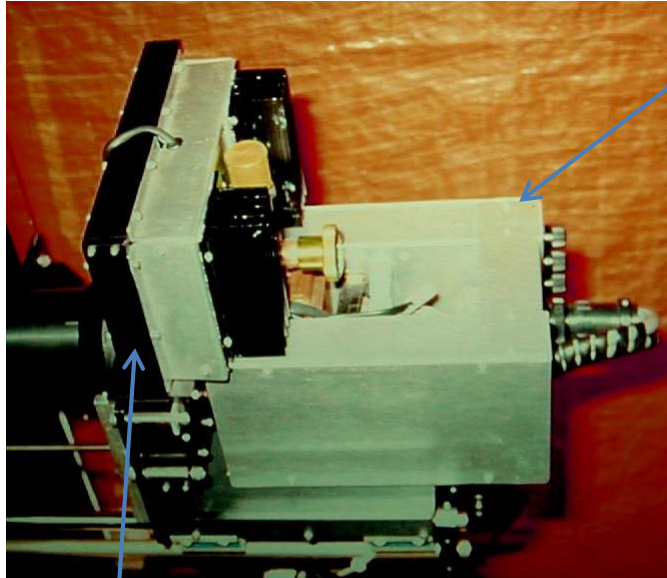
Rotating Diagonal Mirror

To Eyepiece

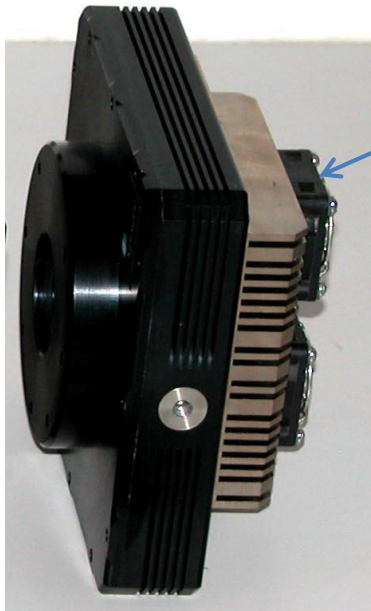


Spider assembly to hold diagonal mirror. Baffles suppress reflections

Scientific CCD Cameras With Photometric Optical Filter Wheel



Filter
Wheel



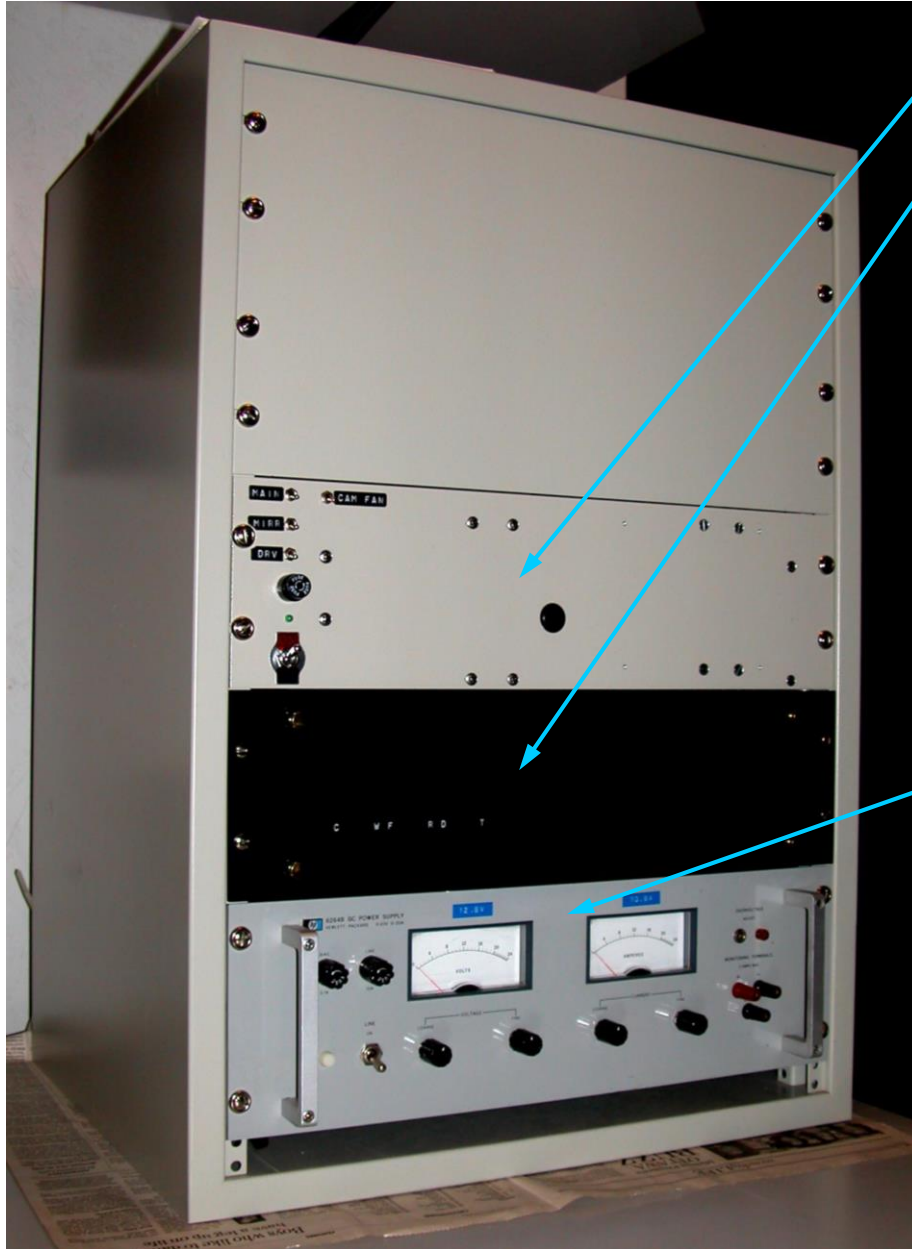
- First (homemade) camera with *Thomson* TH7883 chip in vacuum, liquid cooled, chip at -72°C , low thermal noise and very few hot pixels
- Has little blue sensitivity, 40% peak quantum efficiency, excellent flatness, good temperature control, 382 X 574 pixels. Used for photometry and *Sky & Telescope* Deep Field Contest
- My next camera was an *Apogee* AP7p with a SiTe 502A chip. Used for photometry. Filter wheel not shown.
- Has blue sensitivity and 80% peak quantum efficiency, more thermal noise and hot pixels, but poor temperature control, 512 X 508 pixels

Boltwood Observatory



Equipment Room With Computer (room was insulated and heated)

Electronics for Telescope Control and Signal Processing



- power
- rack of microprocessor boards with *Microchip* PIC microcontrollers, one per function
- complex stepping motor control firmware in 4 of them
- all time critical functions were done in the microcontrollers
- CCD calibration power supply
- almost all electronics are in the equipment room to ease doing repairs, and to reduce thermal wear and tear

Electronics Rack



- control of telescope fans and heaters, button box, sound, temperature readouts
- mount right ascension and declination stepping motor drives, button box
- filter wheel and focuser motor drives
- serial backplane controller with parallel port interface to computer

Telescope Control Software Display

Target

Clear Get .aux 3C66A b0078849.pos Get .pos

Mount

RA	DEC	Epoch	Current Position
02:23:00.6	+41:24:31	2002.8	
02:22:42.0	+43:03:00	2000.0	<input type="radio"/> Desired Center
02:22:39.7	+43:02:08	2000.0	<input type="radio"/> Target
02:22:50.1	+41:23:46	2000.0	<input checked="" type="radio"/> Finder Star
02:21:02.7	+42:56:37	2000.0	<input type="radio"/> Focus Star

RA Rate deg/s DEC Rate deg/s

0 0 ☐ Lunar ☐ West Of Pier ☐ East Of Pier

Focuser

Pos. 504822 Err. 0 Auto In Focus Init Init Slow

Status Not Slewing

Temp.

Configs: normal

Filters: none V clear blue B U I red green R OIII

Optics: 1.14X 2.4X 5.6X

Temperatures: Air 5.3 Mirror 5.2 GPS OK

Bias b0134838.bia Therm b0134840.th1 Flat b0134843.fdv

CI Commands

Recall Execute CI Status

Stop CI Stop Group CI Word

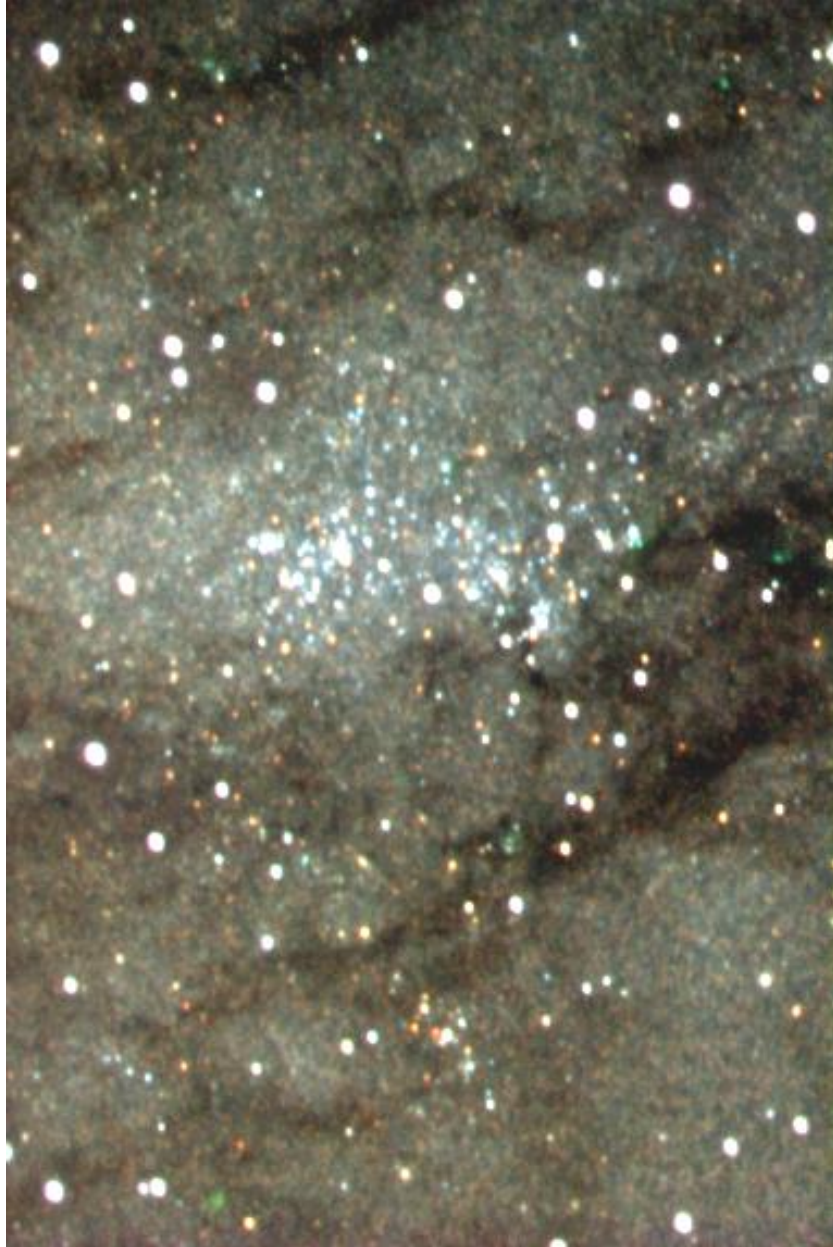
CI Queue

- *Visual Basic* and *C++* software
- position and exposure information usually from “.aux” files or scripts
- used *MaxIm* for camera driver, auto-focus, mount jogger, image display
- corrects for refraction and for flexure
- corrects for position and focus
- compensates focus for temperature
- optionally runs scripts in my own language
- images are rotated to have north at the top immediately upon readout
- often not attended for 90 minutes
- normal exposure is 2 minutes with many frames merged in reduction

Astronomy Interests

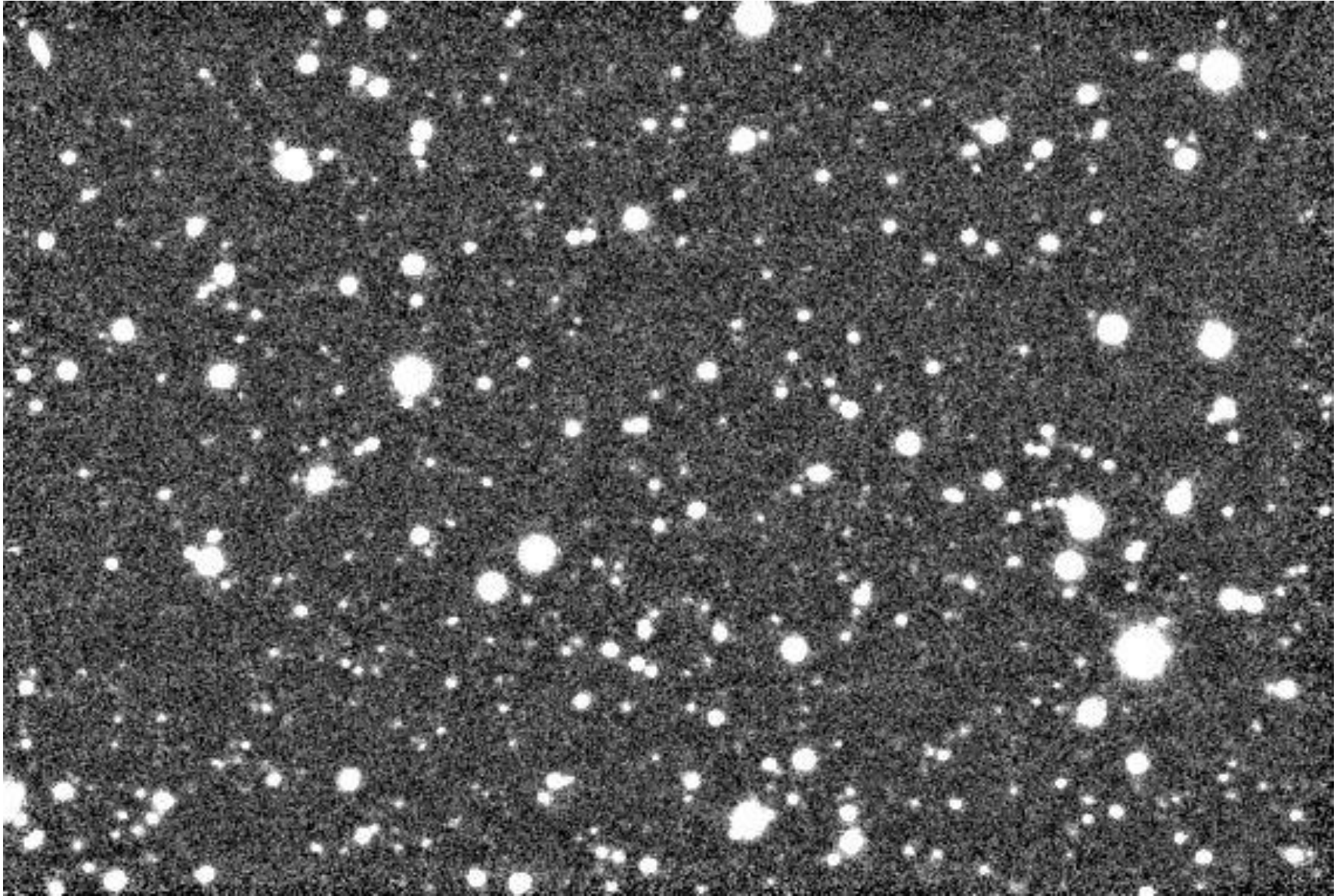
- My designing and building my own CCD camera allowed me to do the following semi-professional level work.
- As my astronomical experience, equipment and software grew, I developed an interest in the optical measurement of brightness of astronomical objects (photometry).
- Over the years, I have observed several Blazars (compact quasi-stellar radio sources associated with presumed super-massive black hole at the centre of an active elliptical galaxy). Many observations were done.
- I made several presentations on my work at astronomy conferences here, in Finland, UK, Spain and the USA.
- I also was a minor co-author of ~50 papers relating to Blazars and my photometric equipment and software.
- I participated in the *Sky & Telescope* magazine challenge to amateur astronomers to image the faintest object possible.

Example of an unusual view of NGC 206 in M31 (Andromeda)



- Images taken with Infra-red, Red, and Visual (Green) filters are rendered here as Red Green Blue format
- Faintest star visibility is limited by confusion (more resolution is needed to do better, not more exposure)
- Pixel size is 1.09 arcseconds
- Exposures: 30 hours total
- 40 cm (16") Newtonian telescope with homemade CCD camera
- weighted merge of images based on measured noise was used to enhance sharpness

Finished image for *Sky & Telescope* Deep Field Contest



Magnitude 24.5 objects have SNR of 3 according to Bradley Schaefer

Multiwavelength Observations of Strong Flares From the TeV-Blazar 1ES 1959+650

H. Krawczynski¹, S. B. Hughes¹, D. Horan², F. Aharonian³, M. F. Aller⁴, H. Aller⁴,
P. Boltwood⁵, J. Buckley¹, P. Coppi⁶, G. Fossati⁷, N. Götting⁸, J. Holder⁹, D. Horns³,
O. M. Kurtanidze^{10,11}, A. P. Marscher¹², M. Nikolashvili¹⁰, R. A. Remillard¹³, A. Sadun¹⁴,
M. Schröder²

ABSTRACT

Following the detection of strong TeV γ -ray flares from the BL Lac object 1ES 1959+650 with the Whipple 10 m Cherenkov telescope on May 16 and 17, 2002, we performed intensive Target of Opportunity (ToO) radio, optical, X-ray and TeV γ -ray observations from May 18, 2002 to August 14, 2002. Observations with the X-ray telescope *RXTE* (*Rossi X-ray Timing Explorer*) and the Whipple and HEGRA (*High Energy Gamma Ray Astronomy*) γ -ray telescopes revealed several strong flares, enabling us to sensitively test the X-ray/ γ -ray flux

The WCARC VHF/UHF Beacons are now housed in the empty observatory building's telescope room.
The antenna array is mounted to the building.

And now onto Boltwood Systems Corporation's products. These were created from my astronomy hobby.

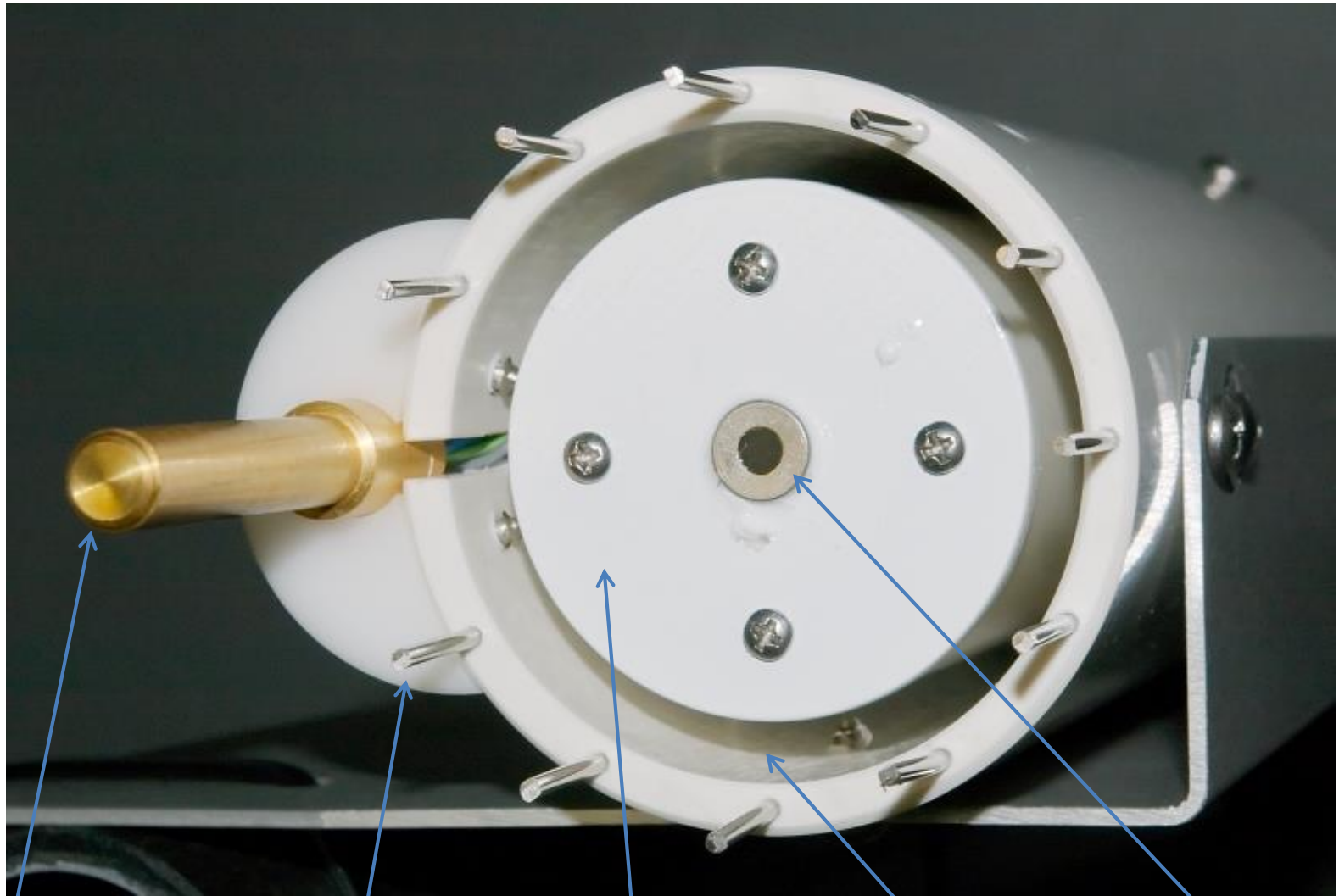


Cloud Sensor for Astronomers

- Detects clouds in a dark sky so tells astronomers with possibly distant Interneted observatories if it is safe and worthwhile to open up roof
- Uses an infrared interference filtered thermopile to detect clouds
- Also senses rain, temperature, humidity, and wind speed
- Weather & winter proof; bird proof
- Uses specially designed and manufactured cable (minimum order 25,000 foot pallet in my driveway!)
- I invented, designed, and manufactured these units including the electronics and software
- *Diffraction Limited* now makes these under my licence



Cloud Sensor Sky End



anemometer

anti-bird

rain sensor

heat shield

thermopile

Cloud Sensor Circuit Board



Microvolt thermopile analog signals are adjacent to 5 volt fast digital signals. That made this interesting to design and debug. I hand built the first 10.

There is also a computer interface box and a weather proof cable with two twisted pairs, one pair carrying several watts of power to heat the rain sensor to remove water and ice.

Portable Cloud Sensor for camping astronomers



and finally ...

- Two years ago, after partial recovery from my brain problems, I decided to finish what I had started in the 1950's and passed my Amateur Radio exams (no code)
- Bought a Flex 1500 SDR Transceiver with various accessories, and with WCARC help, installed a Cushcraft R8 Vertical (twice when it fell apart!)
- Operate mostly digital: WSPR and related modes.

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- To those of you still awake, THANK YOU for your interest and attention.

Paul Boltwood VE3PLE