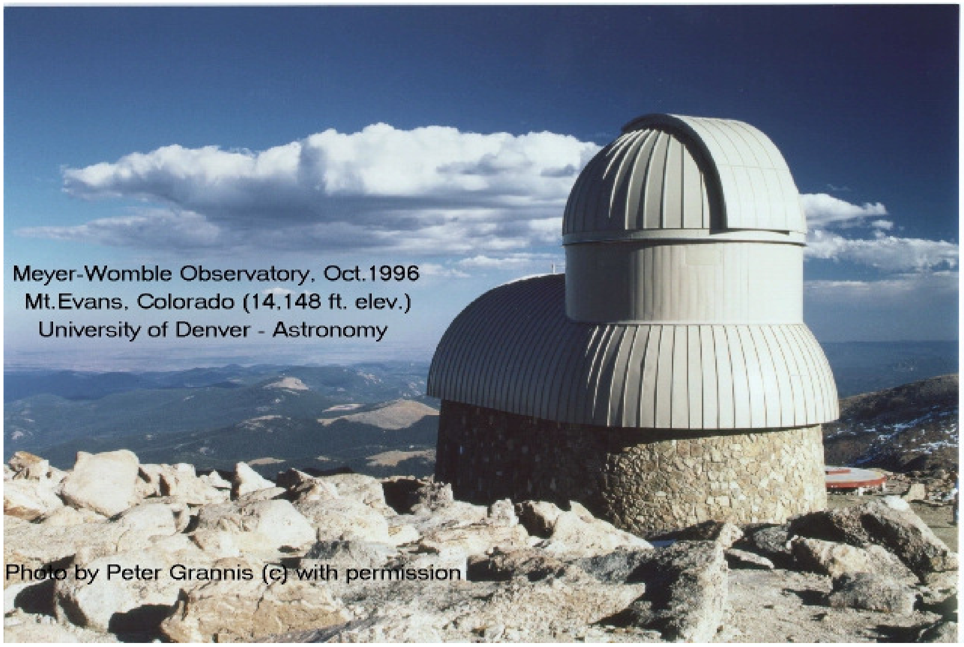
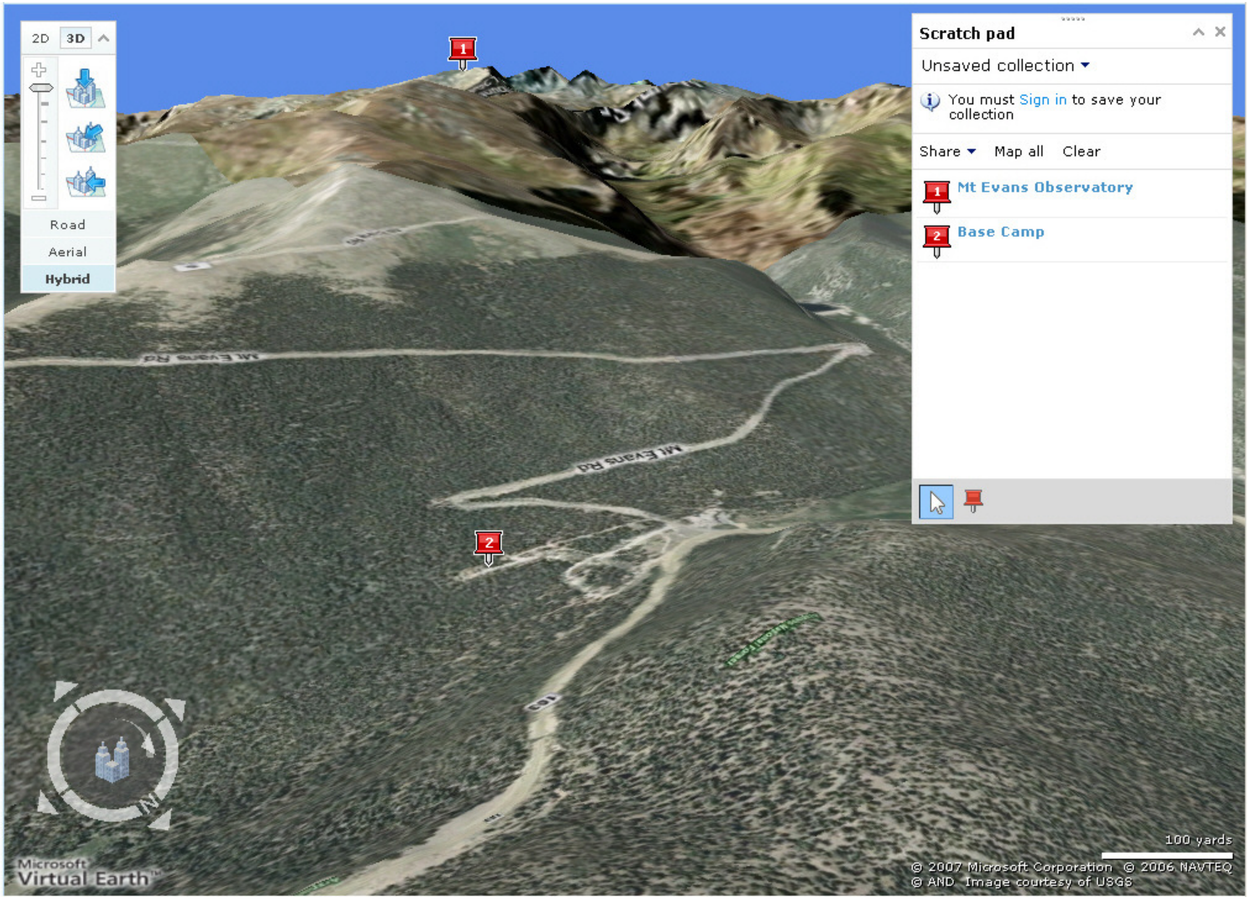
<u>INFRASTRUCTURE ENHANCEMENTS AND UPGRADES 2007</u>



OVERVIEW: The University of Denver's Meyer-Womble Observatory observatory is situated at 14,148 ft elevation in the Colorado Front Range, 52 km west of Denver, and was listed in the Astronomical Almanac as highest in the world during the final quarter of the 20th century [Mauna Kea, for instance, is 300 feet lower]. The current twin-0.72 meter twin f/21 R-C telescopes were installed in 1997, replacing a 1972 vintage Ealing-Beck 0.6 meter f/24 Cassegrain located on the same site. The site itself, prior to astronomical uses, was a cosmic ray laboratory going back to the time of Arthur Compton and Bruno Rossi in the 1930s. A summary of the observatory can be found in Stencel, 1999 JAAVSO 27:61 & Stencel 2006 OSA VI: 97.

Observing classes and guest observers attracted from numerous states have used the facility each summer season since first light in 1997. Significant observations include support of the Cassini Venus flyby, monitoring of the Deep Impact probe in 2005, assorted near-earth asteroid observations, variable star studies and most recently near-infrared photometry. For a summary of site characterizations, see webpages: www.du.edu/physastron and http://www.du.edu/~rstencel/MtEvans/SiteSurv.html , along with links to additional illustrations of the site and telescopes.

While the observatory enjoys excellent conditions AT TIMES, it faces many challenges: mid-latitude weather can be fierce; the observatory is 15 miles from any electrical or telephone hard-line service and some measure of light pollution comes up from metro Denver. The access road is a paved state highway – wonderful in summer, but not maintained after tourist season. For electrical energy, we employ a 1500 watt solar photovoltaic system with battery storage at the observatory. We use a line of sight wireless internet to/from campus 35 miles away. Denver University also owns base camp located 14 miles away by paved road, at Echo Lab (elev. 10,600 ft).



PROJECT JUSTIFICATION: Enhancing use and outreach of the Mt.Evans Observatory – highest in North America at 14,148 ft and including twin 28.5 inch f/21 R-C telescopes. Website for details: http://www.du.edu/~rstencel/MtEvans

We propose the following categories of improvements: (1) telescope performance upgrades; (2) instrumentation performance upgrades; (3) remote operations upgrades to expand use during more of the year, and (4) outreach enhancements.

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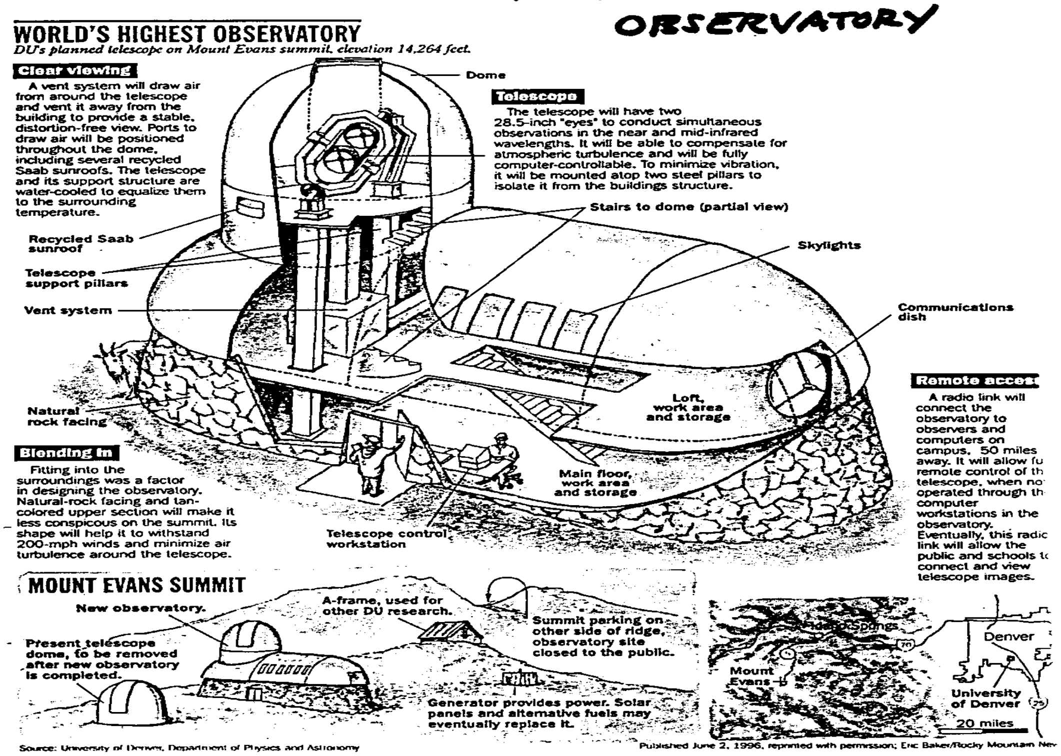
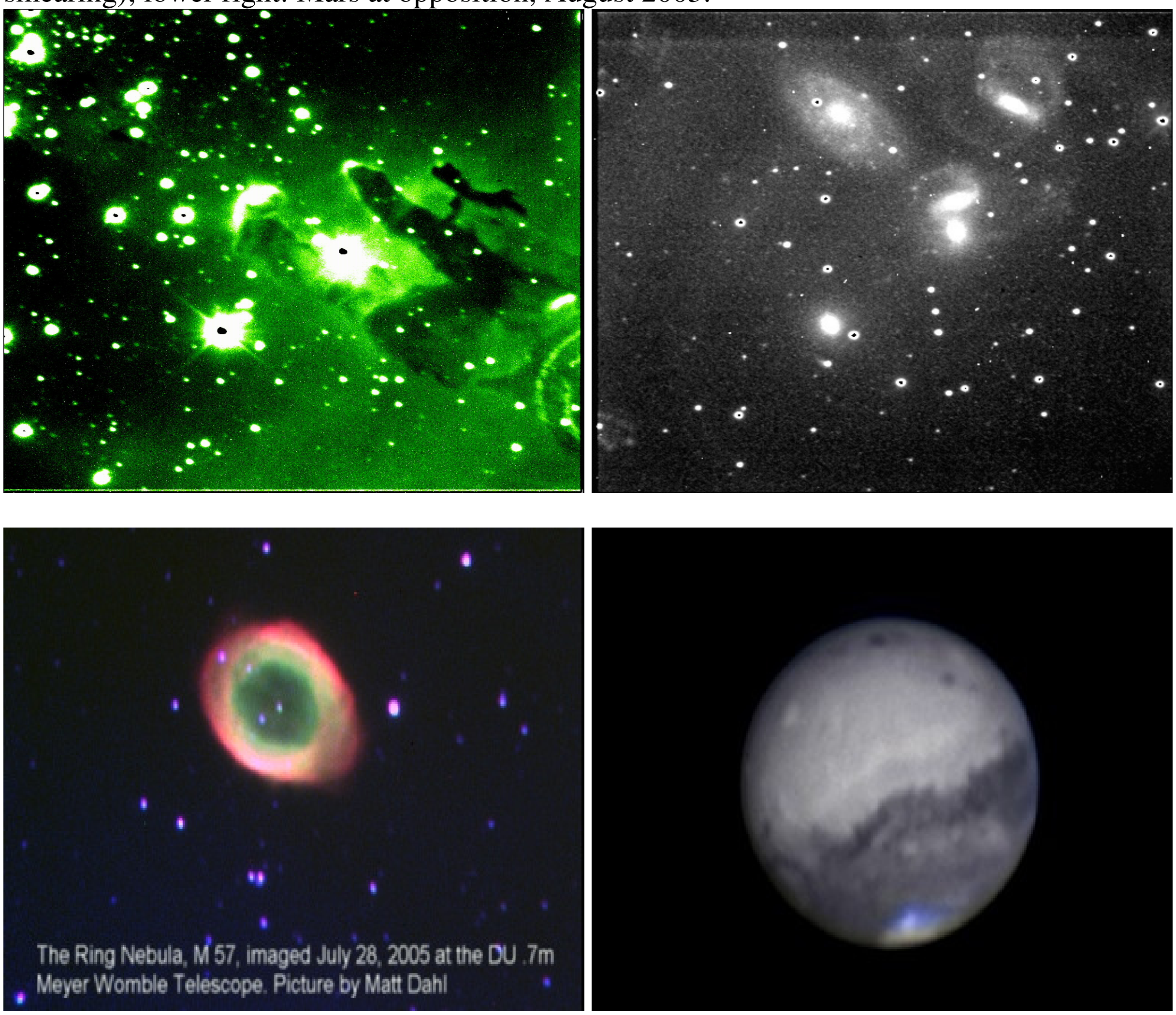


1. <u>Telescope performance and proposed improvements</u>

The Meyer Binocular Telescope at the University of Denver's Meyer-Womble Observatory is an equatorially-mounted English yoke design of heavy steel construction. The overall mass of the telescope is 9,000 kg. with a moving mass of 4,100 kg. The declination drive incorporates a 0.9m worm gear while the right ascension worm gear is 1.25m in diameter. The dual Ritchey-Chretien optical systems were fabricated by Contraves USA. They incorporate a 0.7m f/3 primary mirror and a 12cm, 7 power secondary mirror for a combined focal length of 14.92m. This focal length delivers an astonishing 0.1 arcsec per 10 micron pixel image scale at Cass focus. While seeing is typically ¾ arcsecond, this image scale allows for binning on the CCD chip. It is noteworthy that these two telescopes are nearly identical in focal length and aperture thus simplifying the exchange of instrumentation between, and comparison of data obtained at, the two telescopes.

The specific telescope improvements proposed include: replacing the RA drive worm gear; T-point tracking correction software implementation; double shift scheduling to exploit clear morning hours for infrared astronomy. We are fortunate to have Software Bisque nearby, and their talented machinist, Rob Miller, co-inventor of the Paramount, who has bid on this job to replace our elliptically-errored worm with a new one [http://www.bisque.com/Products/Paramount/]. A related software package called T-Point, available from Bisque.com provides telescope analysis and pointing correction software that identifies, quantifies and automatically compensates for systematic errors in goto telescopes [http://www.bisque.com/Products/TPoint/]. This software is compatible with our Sky6 telescope control system. Finally, diurnal weather patterns in summer are such that hours near dawn are often the clearest and steadiest observing times. We propose to add staffing to take advantage of this "second shift" of astronomical photometric conditions by supporting and training student help for a dawn to noon observing shift using an infrared instrument described below. This staff can also help with daytime public access described later.

BELOW: Montage of better images obtained with SBIG ST-7 and ST-10 CCD cameras. Upper left: M16 and the dark nebulae dubbed "Pillars of Creation"; upper right: Stefan's Quintet; lower left: M57 showing both the 15th mag central star and some issues with existing tracking (image smearing); lower right: Mars at opposition, August 2003.



2. <u>Instrumentation improvements: automation of SSP4 device to promote wider utilization</u>

In recent years, Optec has introduced the SSP-4 near infrared J&H band photometer – see http://optecinc.com/optec_011.htm . The InGaAs PIN photodiode, manufactured by Hamamatsu Corp, is the heart of the SSP-4. The series G5851-13 with a one mm detector diameter is mounted in the instrument, and allows numerous stars down to J band magnitude +5, to be observed accurately in the J (1250nm) and H (1650nm) photometric bands.. The one mm detector is the recomended choice by the SSP-4 users group affiliated with www.AAVSO.org – which has provided a grid of calibration stars for this work (see JHK Standards for Small

Telescopes - By Arne Henden, JAAVSO, Vol. 31, No. 1, July 2003, pages 11-20). We have been making use of an SSP4 in order to provide monitoring of variable stars in the queue for the Palomar Test-bed Interferometer (http://pti.jpl.nasa.gov/) and in preparation for the 2009 eclipse of the very long period binary epsilon Aurigae. The SSP-4 photometer is illustrated below.

20 Henden, *JAAVSO Volume 31, 2002*

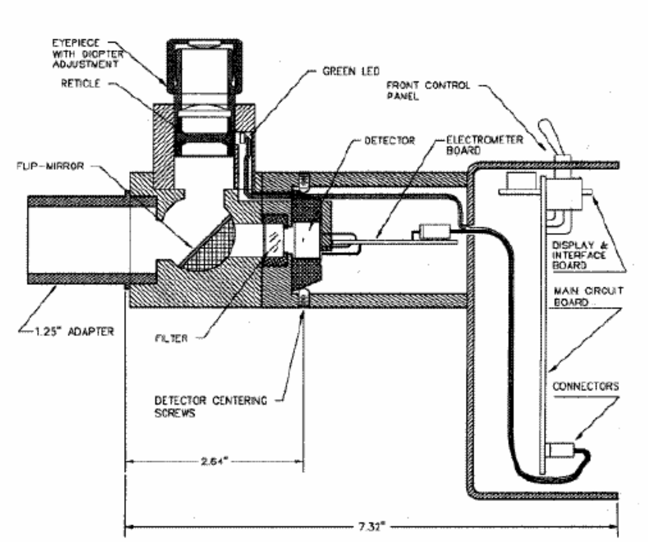


Figure 3. Cross-sectional view of the SSP-4. *Courtesy of Optec Corp.*

Although the SSP-4 is a research-quality instrument, we propose to modify the SSP4 to address some of its limitations: (1) Machining a capture cage with a more robust attachment to the back plate of our telescope. This $3,000 instrument is attached to a telescope with 25 cent retaining screws – the latter are found to loosen as a result of its manual operation;
(2) Replace the flip mirror with a selectable, computer-linked mechanism, and the visual eyepiece with a video system – both of which will allow operators to be more comfortably located in the observatory control room; an additional improvement would involve a selectable reticle aperture – the fixed reticle circle does not equally well accommodate roll-off of signal associated with both bright and faint stars with our particular large image scale;
(3) Replace the manual 2-position filter slide with an additional computer linked mechanism;
(4) Convert the output to LabView software control in order to make a more efficient interface that is less prone to data loss. The existing data taking software is primitive – consisting of a simple but highly user-dependent GUI that requires constant updates by the operator;
(5) As a next step: explore whether a K band detector for this system could be added, recognizing that this complicates the cooling requirements.
We would closely coordinate the development with both Optec and AAVSO in the event that mutual benefit can come from the improvements.

3. Automation and remote operation from Echo Lab

While the Mt.Evans observatory provides excellent skies, the thin air at 14,000 ft and cold weather at the summit is challenging for many visitors. A remediation for this includes remote-attended observing, using a heated, oxygenated control room at the University's nearby Echo Lake Lab at 10,600 ft. This proximity enables both visits to the telescope and remote attended access that would extend access to a larger population, including ADA special needs persons. Additional advantages include improved safety for guest observers (reduced distance to emergency services); increased productivity (not struggling with the thin air and degraded mental capabilities). Well-rested and not physically stressed observers are more productive. Our regular staff is used to the rigors of altitude and can host the virtual guest observers.

To achieve this, we need Echo Lab area wireless internet. Because of the topology, there are no ground-based lines of sight to antenna, and phone service is primitive (sub-par for DSL). Hence, the ideal solution is satellite internet. Our neighbor, Echo Lake Lodge, already uses HughesNet/EarthLink services and this appears viable for us as well. Address for mapquest.com searching: 16 Mount Evans Highway, Idaho Springs, CO 80546.

A related need involves purchase of a robust vehicle for extending the autumn access season from Echo Lab to the summit observatory. We have worked with a UNIMOG vehicle club for expeditions and request $10k to purchase one of these hardy post-war vehicles. See: http://www.rockymountainmoggers.com/2005110405mtevans13.html

Award of these funds will also enable us to seek university matching funds for Echo House remodeling (furnace, windows, residential spaces) and pursue purchasing the land title from our Forest Service overlords.

4. Expanded outreach

Mt.Evans is one of two high altitude peaks in Colorado accessible by car. Each summer, over 250,000 visitors travel state highway 5 to the summit and are within sight of the observatory. Due to limited staffing, we are normally only present during nights and do not interact with most, daytime, visitors. Some limited signage informs, but we propose hiring students to enhance summer daytime outreach and provide informative tours of the observatory. Because we also operate astronomy outreach for thousands of guests at our campus, Chamberlin observatory year round, that experience base informs us of the public interest and methods that help people appreciate our science. To this end, we also request the funds for a Paramount and stiffened 16 Celestron telescope to share evening views of the cosmos with visitors. This adds to telescope capacity without disrupting the observing time of the main instruments.

An additional advantage of daytime staffing increases the potential for more research productivity: with the proposed automated JH(K) photometry plus accurate pointing, observing could be extended into morning hours - when mountaintop seeing and transparency are often the best (measured to be comparable to Mauna Kea conditions).

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