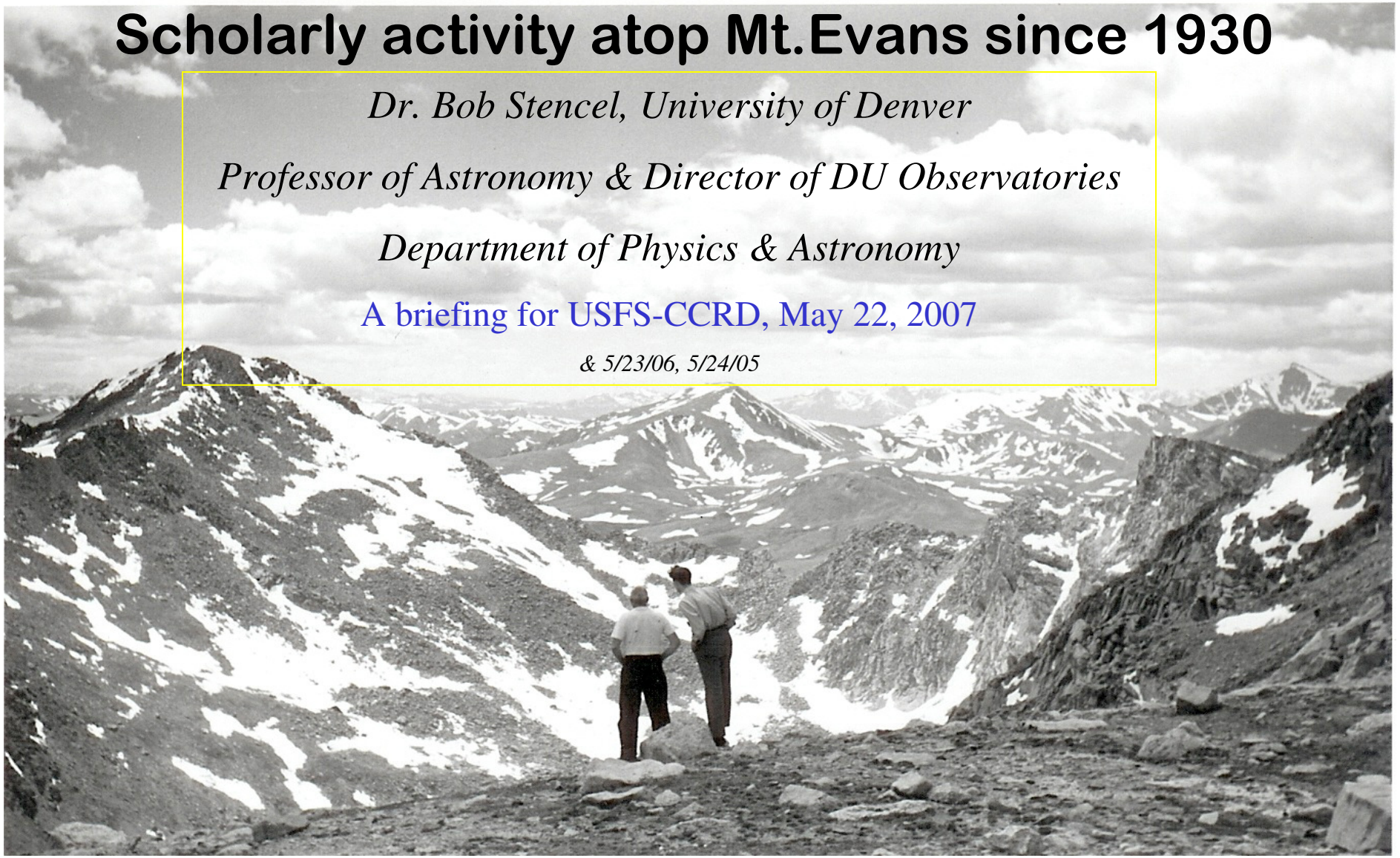
Some history!



Scholarly activity atop Mt.Evans since 1930

Dr. Bob Stencel, University of Denver

Professor of Astronomy & Director of DU Observatories

Department of Physics & Astronomy

A briefing for USFS-CCRD, May 22, 2007

& 5/23/06, 5/24/05

Outline

- Yesterday
  - 1930s: Origins of cosmic ray [CR] research
  - 1946 – 1960s: CR boom years
  - 1972: the first telescope on site
  - 1980s: increased environmental research
  - 1994: proposal to upgrade the observatory
- Today
  - Current Programs, Challenges and Opportunities
- Tomorrow
  - FAQs

1932

Denver Post
1932 Aug 30

A.Compton, Sept.1931 first Mt.Evans C.R.expedition

Beeson, driver; Dr. Stearns, Paul Barth, Dr. Dunham, Dr. Bennett, Wilcox Overbeck, Carl E

DENVER POST 30 AUG 1932

EIGHT SCIENTISTS START MOUNT EVANS COSMIC RAY EXPEDITION

Caravan Heads for Summit Lake to Study Mysterious and Continual Bombardment of Earth; Eclipse Will Have No Effect.

(By GENE LINDBERG.)

While other scientists Tuesday were waiting in tense anticipation for Wednesday's eclipse of the sun, a caravan of eight scientific men left Denver headed for Summit lake on Mount Evans.

Since these men are students of cosmic, not solar rays, the eclipse, Wednesday, will be little more than an interesting incident.

When the moon's shadow swoops across the United States they will be at work setting up and adjusting delicate instruments, observing the downpour of rays more mysterious than sunlight, and entirely independent of sun energy.

EARTH BOMBARDED CONTINUOUSLY BY RAYS.

Night or day, in fair weather or foul, in eclipse or in broad daylight, the penetrating cosmic rays continue to bombard the earth.

Heading the Mount Evans party are Drs. J. C. Stearns of Denver university, and Ralph D. Bennett of Cambridge, Mass., coworkers with Dr. Arthur H. Compton of Chicago in a worldwide checkup of cosmic rays.

Bennett and his party have just returned from Alaska.

They brought with them the instruments used on the towering peaks of the far north. The result of their observations will mean a direct, accurate comparison of cosmic ray intensity at Summit lake, as compared with similar altitudes in Alaska.

WILL PROVIDE DOUBLE CHECK.

Dr. E. H. Bramhall of Cambridge university, England. Scientific students with the party are Paul Barth, who is studying under Dr. Stearns in the Denver university physics department as the winner of a scholarship awarded by Frederick G. Bonfils, publisher of THE DENVER POST.

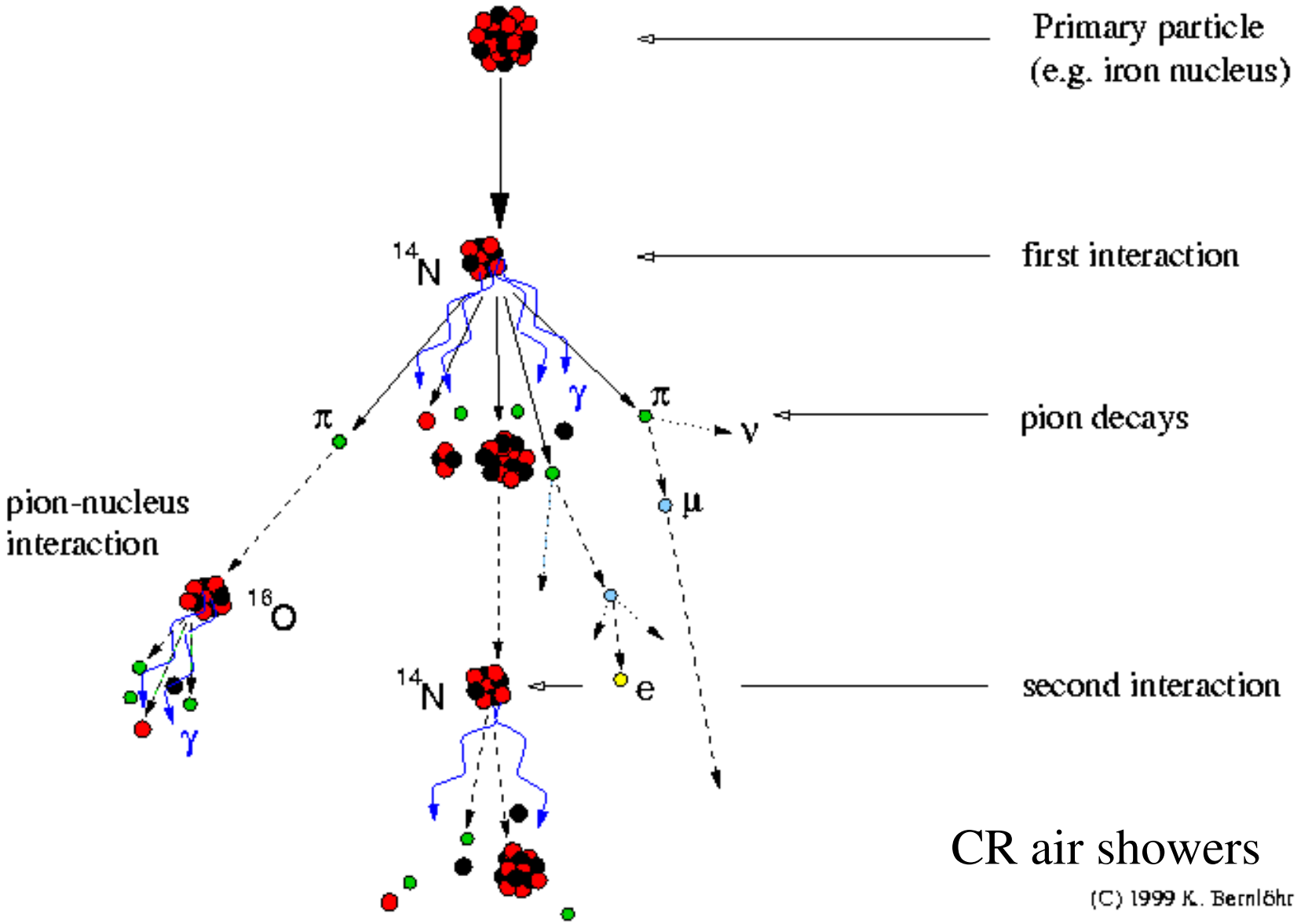
Other students are Wilcox Overbeck, Carl Hedberg and Erwin Gaerttner. To these young men, the scientists of a few years hence, the opportunity to be associated with Stearns and Bennett is the chance of a lifetime.

THERE ARE NO CASTES IN SCIENCE.

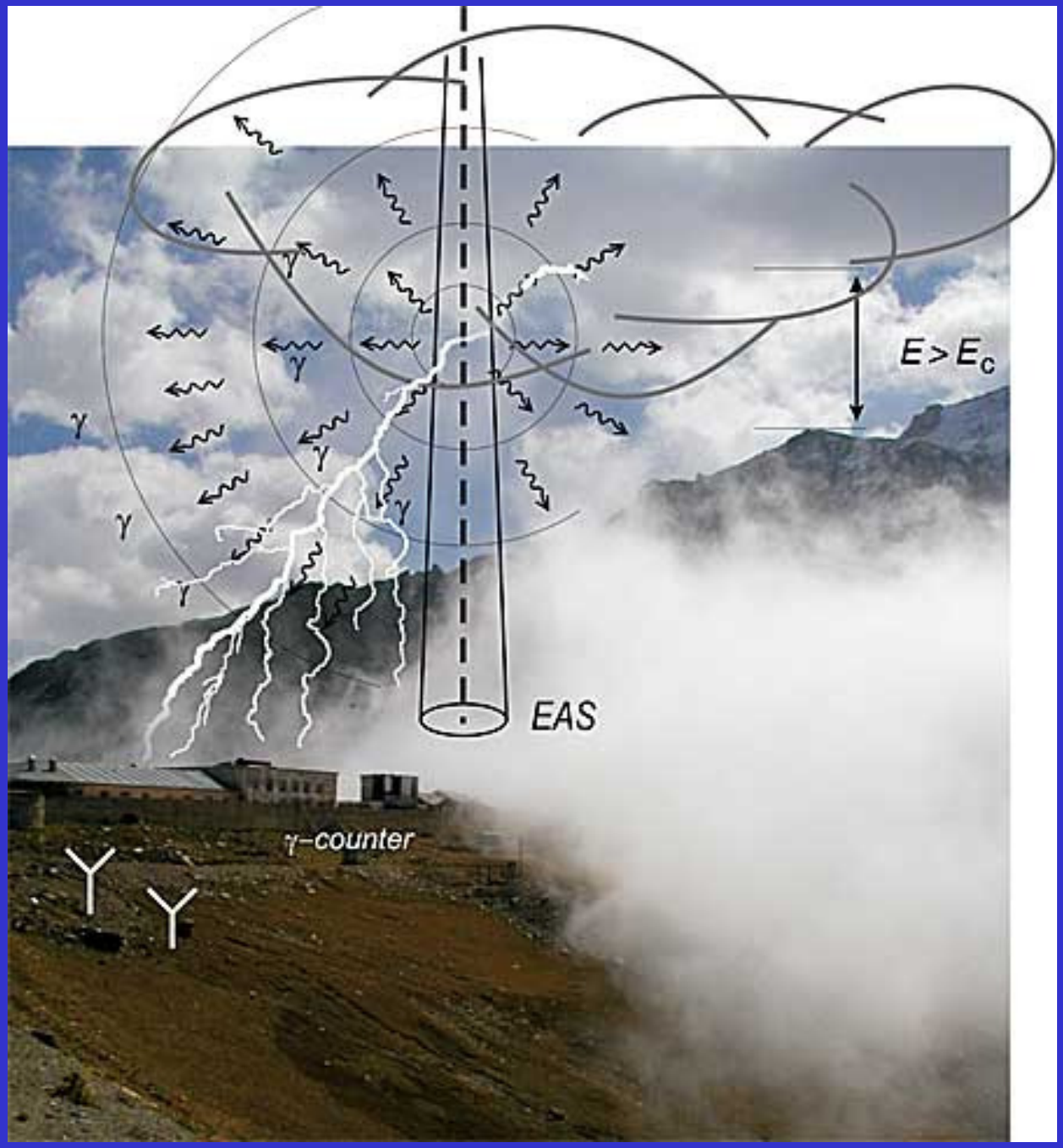
Save for experience and responsibility, there is no caste distinction in science. Classroom discipline is left behind. Stearns, Bennett, Bramhall and Dunham, all winners of high collegiate degrees for scientific accomplishments, are still students, searching earnestly for keys that some day may unlock the riddles of the universe, and open the floodgates of vast reservoirs of power of which the present world knows nothing, but suspects much.

The Mount Evans checkup represents little that is new or startling. It is a repetition of observations

Development of cosmic-ray air showers



CR air showers



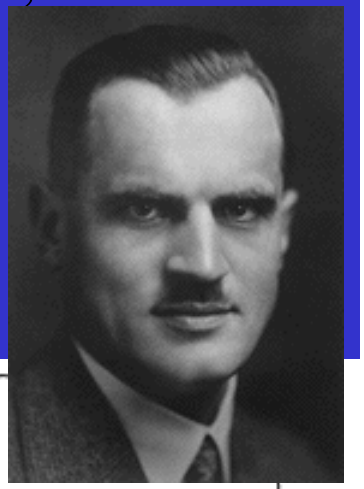
Cosmic rays and lightning

Arthur Compton

For his discovery of the effect of X-ray scattering on electrons, **Compton was awarded the Nobel Prize in Physics for 1927** (sharing this with C. T. R. Wilson who received the Prize for his discovery of the cloud chamber method).

During 1930-1940, Compton led a world-wide study of the geographic variations of the intensity of cosmic rays, thereby fully confirming the observations made in 1927 by J. Clay from Amsterdam of the influence of latitude on cosmic ray intensity. He could, however, show that the intensity was **correlated with geomagnetic rather than geographic latitude. This gave rise to extensive studies of the interaction of the Earth's magnetic field with the incoming isotropic stream of primary charged particles.**

Arthur Compton, 1932



JULY 1, 1932 PHYSICAL REVIEW VOLUME 41

LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this depart-

Variation of the Cosmic Rays with Latitude

Definite differences in the intensity of the cosmic rays at different latitudes are shown by our measurements, which have ranged from 47° north to 46° south. As far as they have gone, these measurements indicate a uniform variation with latitude, showing a

TABLE I. *Cosmic ray intensity at different localities*
(Ions per cc per sec. through 5 cm Pb, 2.5 cm Cu and 0.5 cm Fe)

	Location	Lat.	Long.	Elev.	Barom.	I_C	I_L	Date
1	Mt. Evans	40°N	106°W	14,200ft	17.61in	6.88 ions	0.57	9/31
2	Summit Lake	40 N	106 W	12,700	18.70	5.84	0.34	9/31
3	Denver	40 N	105 W	5300	24.8	2.93	—	9/31
4	Jungfraujoch	47 N	6 E	11,400	19.70	5.08	0.51	10/31
5	Haleakala	21 N	156 W	9300	21.47	3.35±0.05	0.60	4/32
6	Idlewild	21 N	156 W	4200	25.99	2.40±0.05	0.37	4/32
7	Honolulu	21 N	158 W	70	30.09	1.89±0.02	0.11	4/32
8	S. S. Aorangi	4 S	173 W	60	29.65	1.83±0.05	0.32	4/32
9	Southern Alps	44 S	170 E	6700	23.69	3.39±0.05	0.22	4/32
10	Southern Alps	44 S	170 E	3900	26.10	2.70±0.04	0.21	4/32
11	Dunedin	46 S	170 E	80	30.08	2.16±0.03	0.11	4/32
12	Wellington	41 S	175 E	400	29.85	2.16±0.03	0.12	5/32

Hopfield and Dr. E. O. Wollan, Professor J. C. Stearns of the University of Denver with J. A. Longman, L. N. Ridenour and W. Overbeck made the measurements at Denver and Mt. Evans. Dr. Marcel Schein and Dr. Bernhard Frey of the University of Zürich cooperated

Without the cordial cooperation of the various universities where the work has taken us, the measurements would have been much more difficult.

ARTHUR H. COMPTON

University of Chicago,
The Tasman Sea,
May 7, 1932.

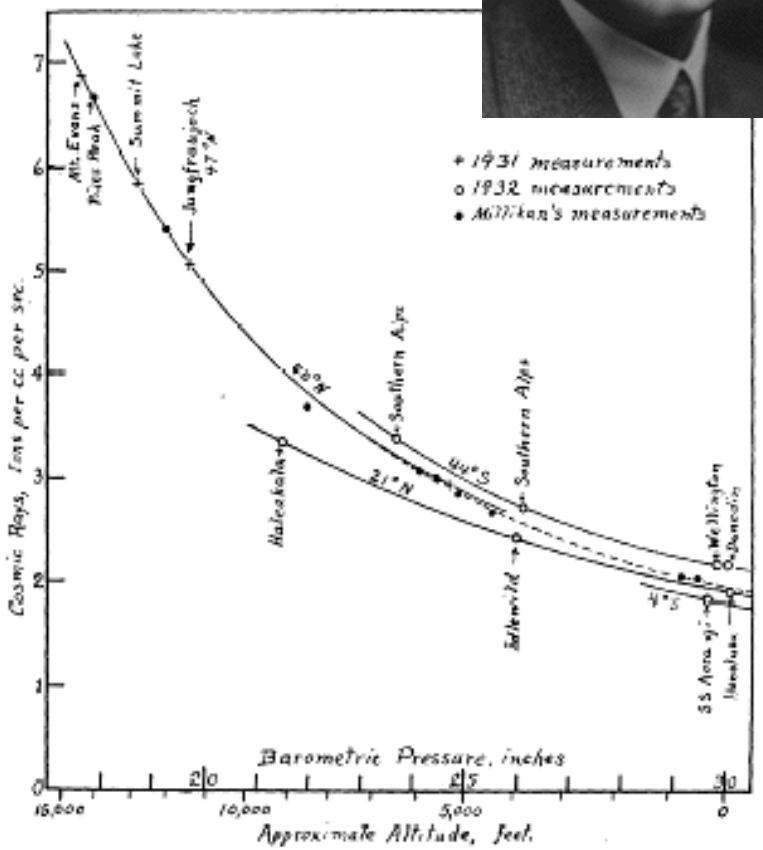
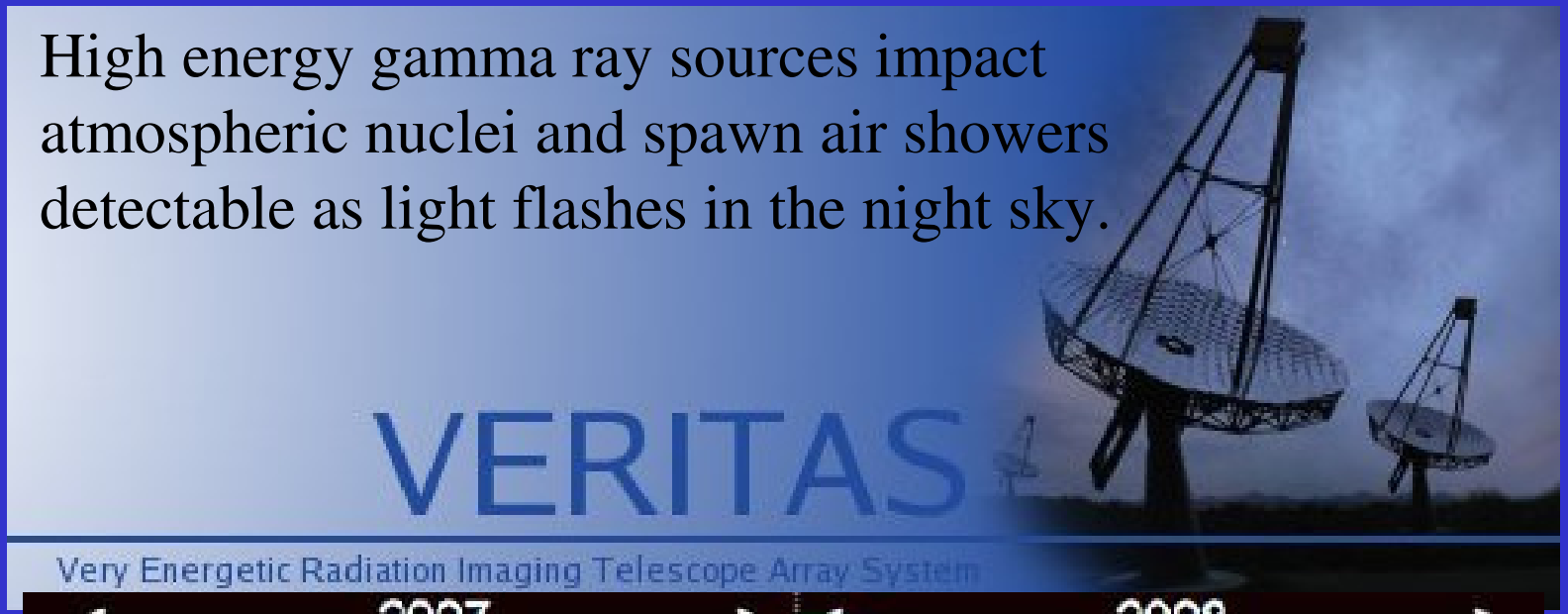


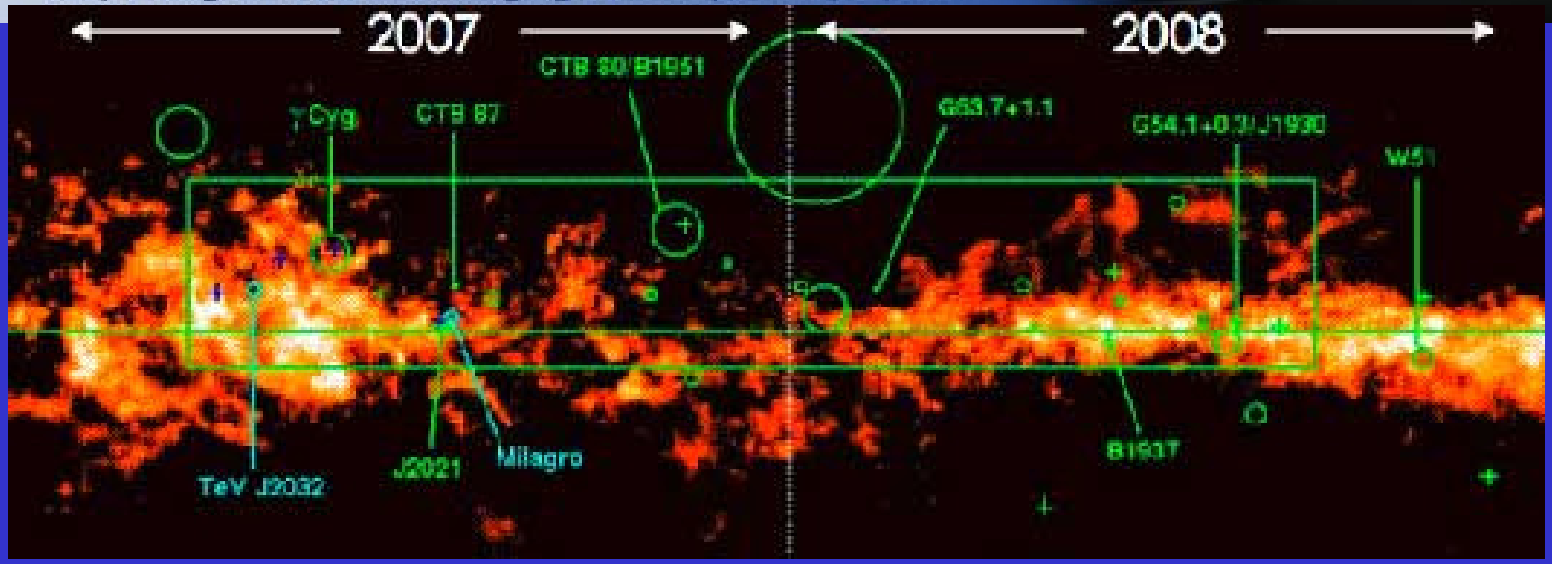
Fig. 1.

Compton Gamma Ray Observatory, 1990

Modern cosmic ray telescopes

High energy gamma ray sources impact atmospheric nuclei and spawn air showers detectable as light flashes in the night sky.





& Henderson mine underground cosmic ray lab proposed 2007

1936
A-
frame

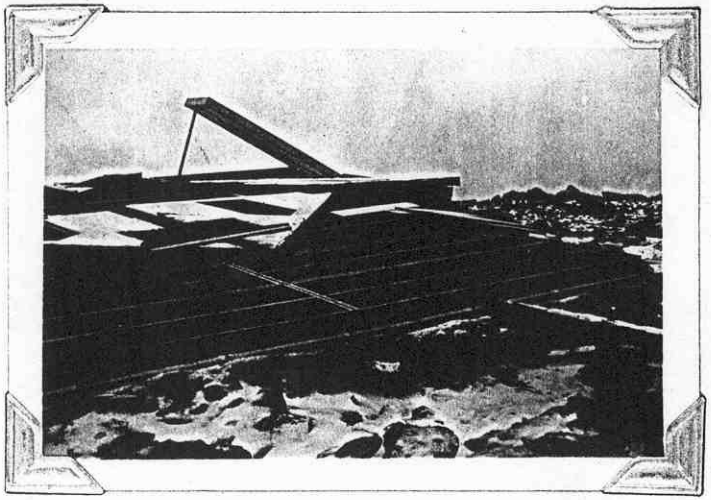
Gaerttner and

FROM THE LOGBOOK OF THE MT. EVANS LAB
1936

Progress Report of the Mt. Evans Laboratory

Pictures of the Construction. B. Hoyt

All work stopped because of Snow Storm.



The Gables shown on the top of joist sections after the Snow Storm.

1938

Reprinted from THE SCIENTIFIC MONTHLY, March, 1938, XLVI,
pages 242–248.

THE MOUNT EVANS LABORATORY

By Professor J. C. STEARNS

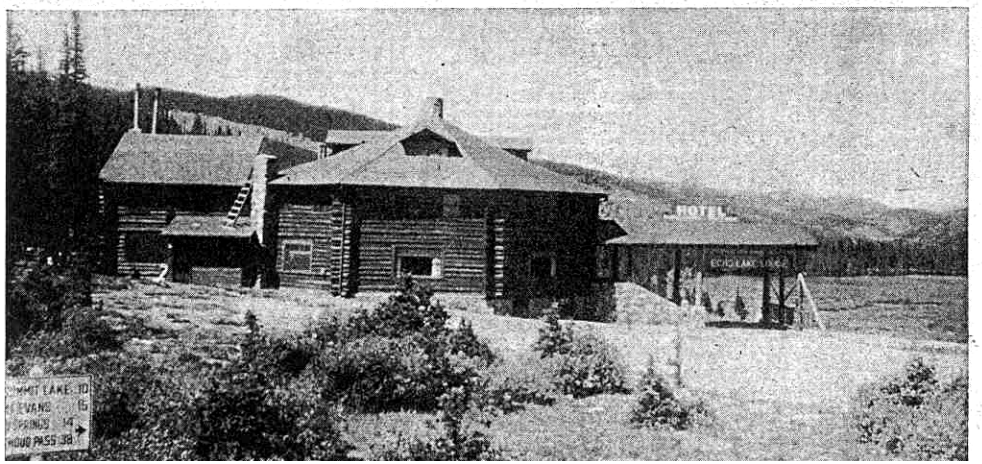
UNIVERSITY OF DENVER

THE construction of Mount Evans Laboratory was begun in May, 1936, and the laboratory was first used for scientific work on June 28, 1937. For those whom this laboratory may serve, the following description of the location, climate, physical plant and policy of operation of the laboratory, as well as the events leading to its establishment, will be of interest.

In September, 1931, A. H. Compton did his first field work in cosmic rays at Summit Lake, which is 1,000 feet below the peak on Mt. Evans. Cosmic ray intensity measurements were made on Mt. Evans for a brief period at this time. The apparatus used was constructed at the University of Chicago and transported to Colorado in an enclosed bus, which served as a cosmic ray laboratory for this first work. The rigors of the climate were such that, with the lack of adequate protection, a trick on the night shift was equivalent to a polar expedition. This expedition was followed by others headed by R. D. Bennett, Massachusetts Institute of Technology; T. H. Johnson, Bartol Research Foundation; J. C. Street, Harvard; D. K. Froman, McDonald College of McGill University; and J. C. Stearns, of the University of Denver.

These early workers and their associates used tents for laboratories and living quarters. The wind velocity at night was often sufficient to level tents and scatter equipment. The fire hazard prevented safe heating of tents, and the indoor temperatures often fell to 30 degrees F. or lower. Both apparatus and workers were without protection from the frequent electric storms.

The intensity of cosmic rays at the alti-



1939

Rocky Mtn News
1939 Feb 26:

"…the world's highest little red schoolhouse… it's importance may have been manifested by the fact that only Nobel prize winners in physics in the US have been those who made studies on this suitable location…

D. U. Lab On Mt. Evans

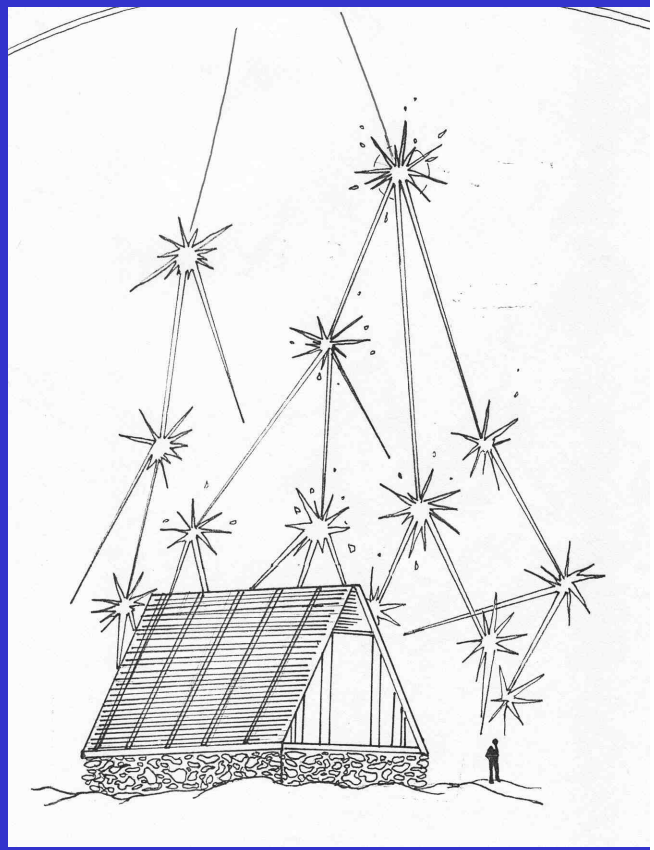
RMN 2-26-39

Study Cosmic Rays At Top of Peak

On the peak of Mount Evans is the world's highest "little red schoolhouse." This lofty institution is considered part of the University campus, for it is here that the science departments conduct exclusive cosmic experiments!

The structure was built in 1936 in Denver and transported to the location by segments. It consists of two rooms, one used as the laboratory and the other as living quarters. It had to be constructed [illegible] such a manner as to withstand [illegible] 150 mile per hour wind velocity, and to prevent electrical storms [illegible]m disturbing the experiments. [illegible] make it windproof, sidewalls [illegible]e eliminated, while the protection from lightning was given by surrounding the building with metal connected to ground wires.

This "little red schoolhouse" has meant more to the country than just "reading, 'riting, 'rithmetic." Its importance has been manifested by the fact that the only Nobel prize winners in physics in the United States have been those who made studies on this suitable location. The laboratory will be of significant importance in research on cosmic rays. It is impossible to make the prolonged accurate observations at such an



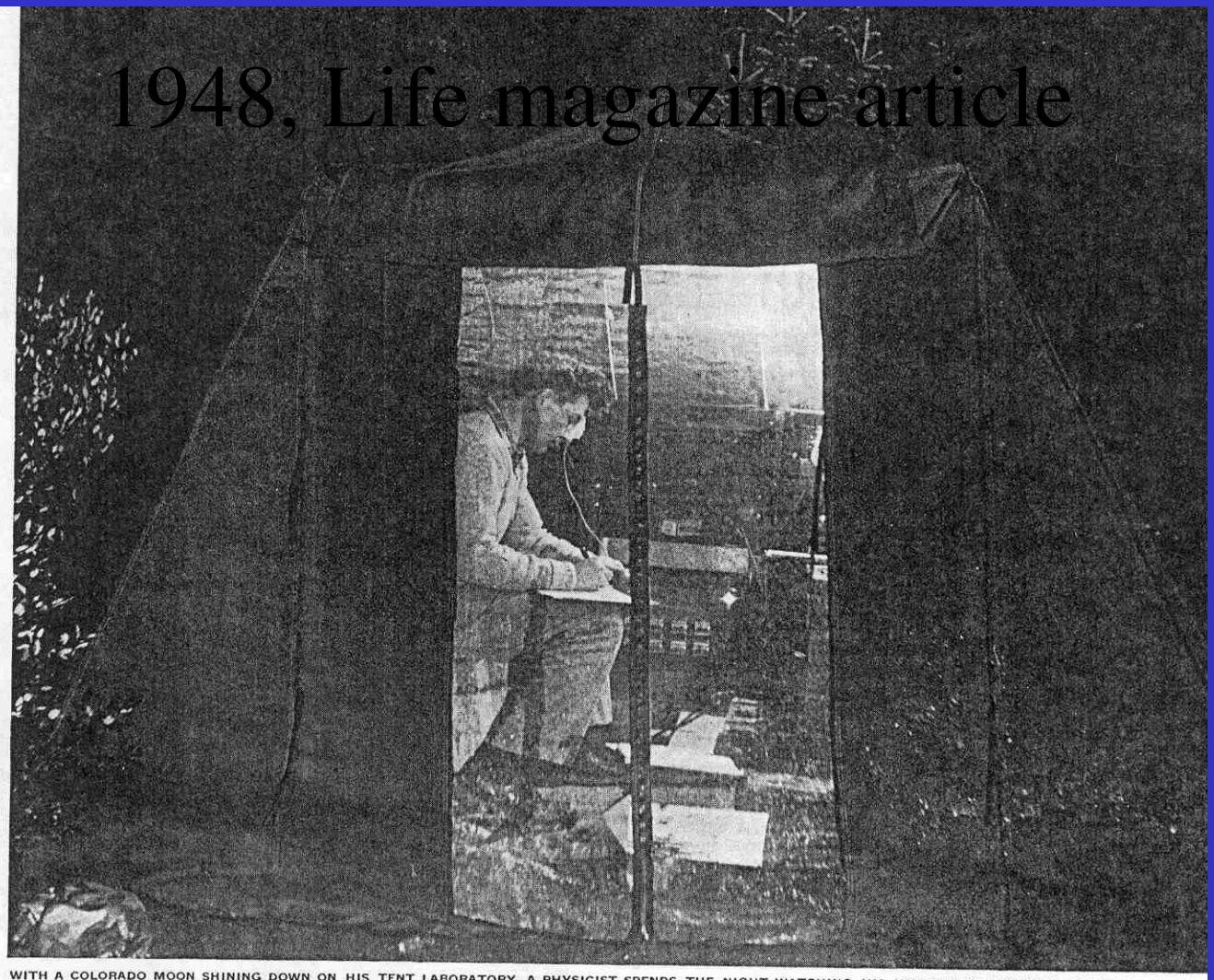
Bruno Rossi, 1939

Dr. Bruno Rossi was an authority on cosmic rays and professor of physics at the Massachusetts Institute of Technology. He started his academic career at the University of Florence and held the chair in physics in Padua from 1932 to 1938, when the Fascist regime dismissed him.

LEADING PHYSICISTS, Dr. Bruno Rossi (*left*) and Dr. G. E. Valley, relax on sunny steps to discuss movie film of meson tracks in a cloud chamber.

He also discovered that individual cosmic rays, colliding with atoms, often generated large numbers of secondary particles, known as showers. His findings gave evidence of the astonishing energies associated with cosmic rays.

1948, Life magazine article



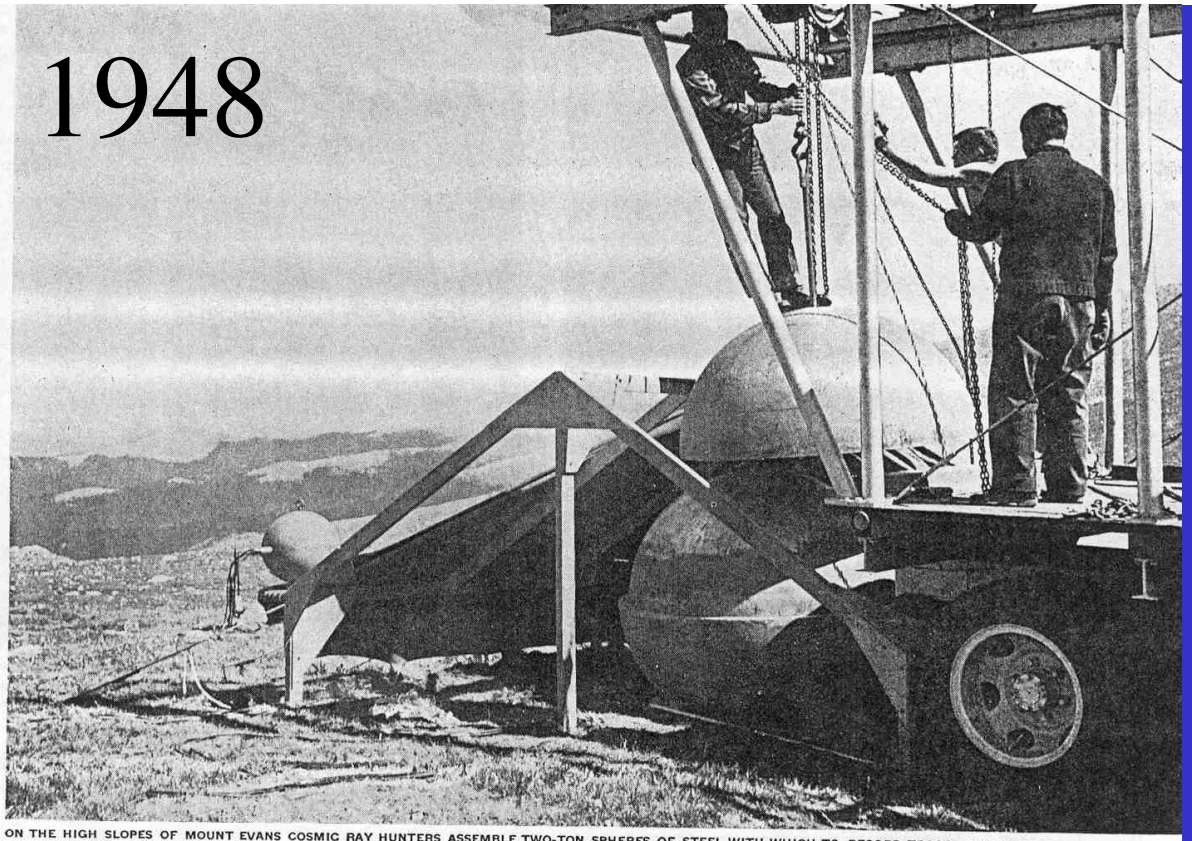
WITH A COLORADO MOON SHINING DOWN ON HIS TENT LABORATORY, A PHYSICIST SPENDS THE NIGHT WATCHING HIS INSTRUMENTS RECORD COSMIC RAYS

COSMIC RAY RESEARCH

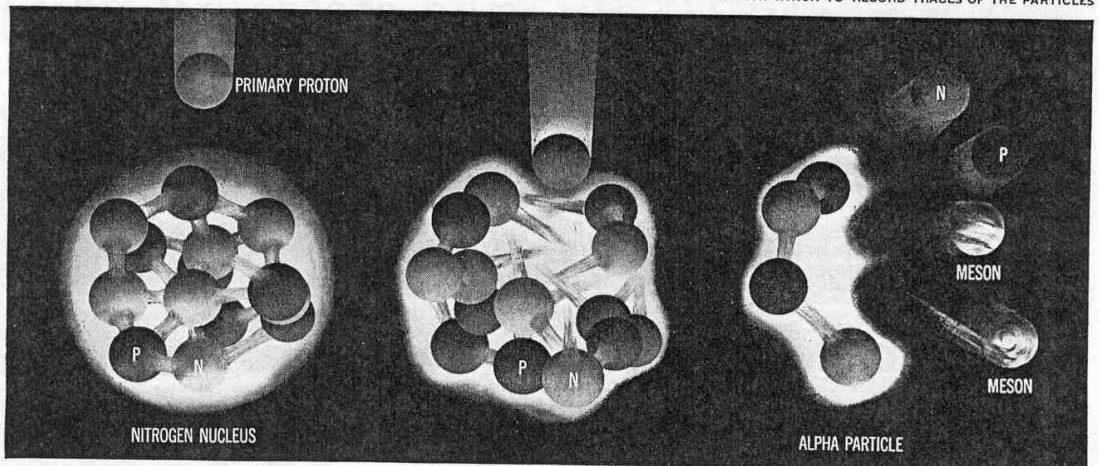
SEVEN COLLEGES JOIN TO STUDY NATURE'S MIGHTIEST FORCE

PHOTOGRAPHS FOR LIFE BY JOHNNY FLOREA

1948



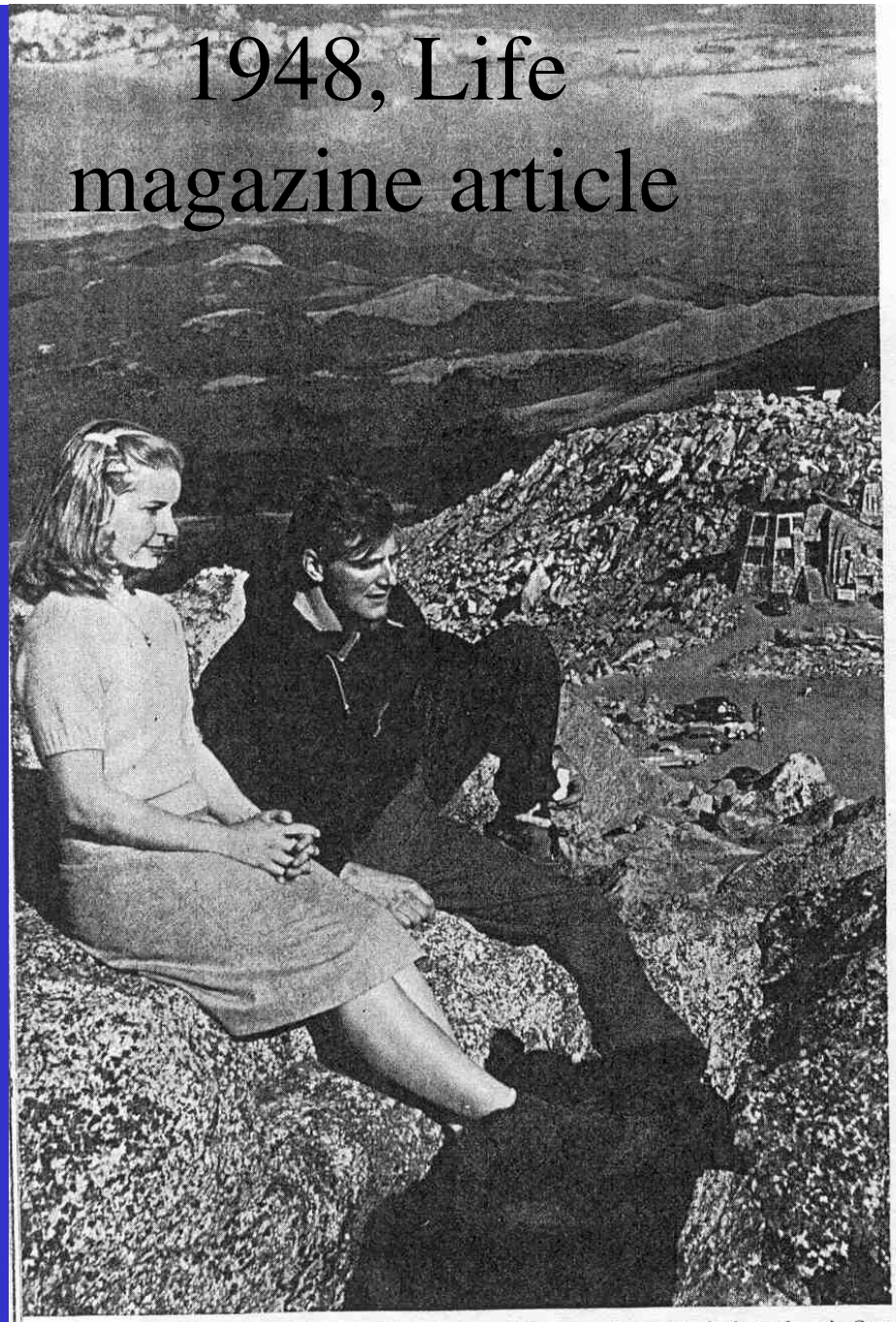
ON THE HIGH SLOPES OF MOUNT EVANS COSMIC RAY HUNTERS ASSEMBLE TWO-TON SPHERES OF STEEL WITH WHICH TO RECORD TRACES OF THE PARTICLES



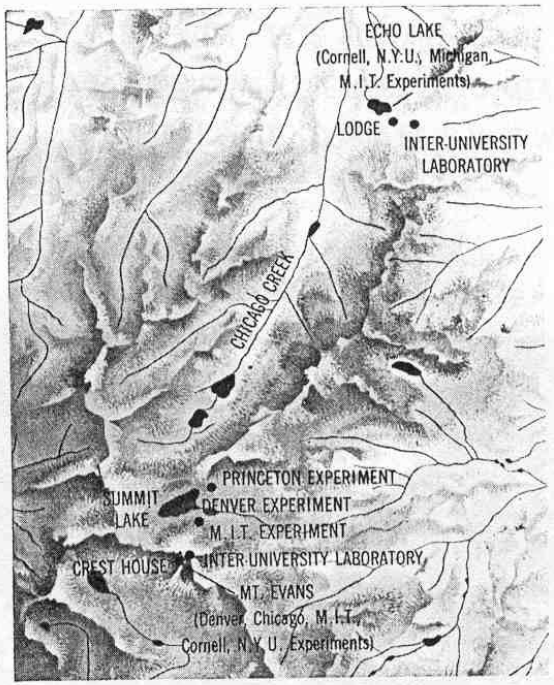
DESTRUCTION OF NUCLEUS by a primary cosmic ray can result in the creation of any of the known subatomic particles. Above: a primary proton, moving at almost the speed of light, approaches the nucleus of a nitrogen atom in the atmosphere (*left*). As the proton collides with it (*center*), the nucleus cracks open and flies apart, forming in this particular case a heavy alpha particle, a proton (P), a neutron (N) and two mesons (*right*)—the latter apparently created out of nothing at all but actually formed by the sudden conversion into matter of the tremendous binding energy which originally held particles of this nucleus together.

CONTINUED ON NEXT PAGE 121

1948, Life magazine article



ON SUMMIT of Mt. Evans, Physicist Bernard Gregory and a girl friend, who works at the Crest House below them at right, relax after a climb. Building serves as restaurant for many scientists.



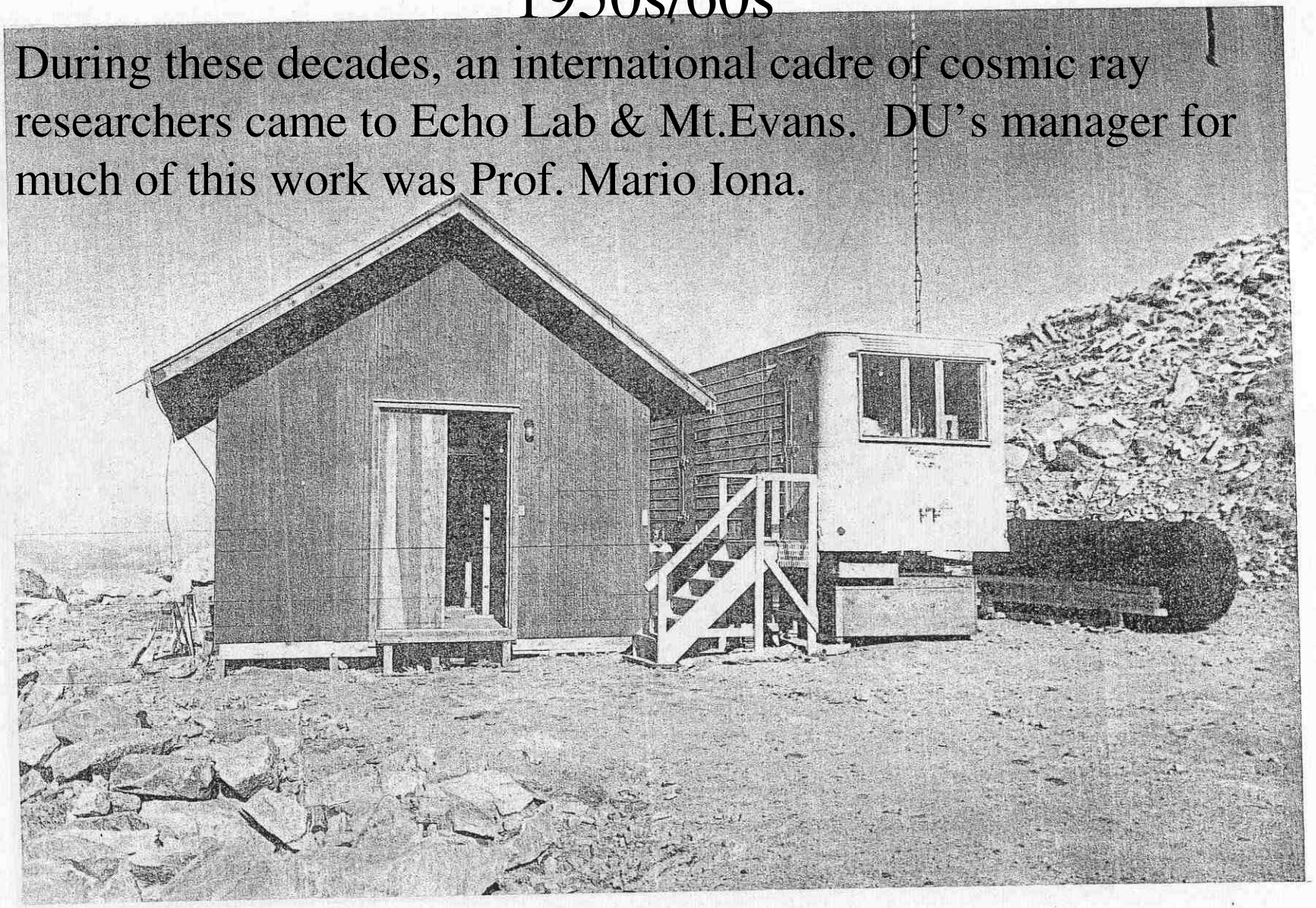
COLLEGES RUN THEIR OWN EXPERIMENTS AT DIFFERENT SITES

SCIENTISTS LIKE THE RUGGED LIFE

Despite the serious nature of their research, the cosmic ray scientists managed to create a kind of outing atmosphere in their bleak mountain camps. Most brought their families with them for the summer months. Since living facilities at the three main camp sites (*map, above*) were meager, most scientists lived in trailers or tents. One resourceful wife heated water for washing on one of the big electromagnets. Children playing around the equipment sometimes became a problem: one 3-year-old child burned his britches when he sat down on a hot transformer. For recreation, husbands and wives played bridge or took hikes along mountain trails. Even during working hours the scientists were not above a little fun. Dressed in a protective waterproof suit worn in the hunt for cosmic rays on icy Summit Lake, Dr. Mario Iona of the University of Denver plunged into the water and paddled placidly about like an overturned turtle (*opposite*).

1950s/60s

During these decades, an international cadre of cosmic ray researchers came to Echo Lab & Mt.Evans. DU's manager for much of this work was Prof. Mario Iona.



7. Quark search experiment, Mt. Evans summit, 1966.

II. Current Programs, 1972 & on

- Astronomy
- Biology
- Environomental sciences
- Atmospheric studies
- Cosmic ray studies

http://www.du.edu

Denver Post
1973 July 3

Denver Post Photo by Bill Wunsch

WORKMEN FIT 1,400-POUND SECTION OF A NEW 24-INCH REFLECTING TELESCOPE INTO PLACE

The facility, costing about $160,000, on Mt. Evans will be the world's highest fixed astronomical telescope.

WORLD'S HIGHEST FIXED STARGAZER

DU Installing Telescope on Mt. Evans

The University of Denver (DU) Monday began installation of a 24-inch reflecting telescope near the summit of 14,264-foot-high Mt. Evans.

The four-ton Ealing-Beck instrument was lifted in sections into an 18-foot-diameter observatory dome adjacent to the university's high-altitude observatory.

bodies and examination of the earth's atmosphere.

Dr. Janet R. Lesh, research astronomer at DU and an authority on infrared waves, explained that the site offers less water in the air than any other earth-based observatory. This permits clearer, more exact studies, she said.

ties, including several European institutes, Dr. Lesh said.

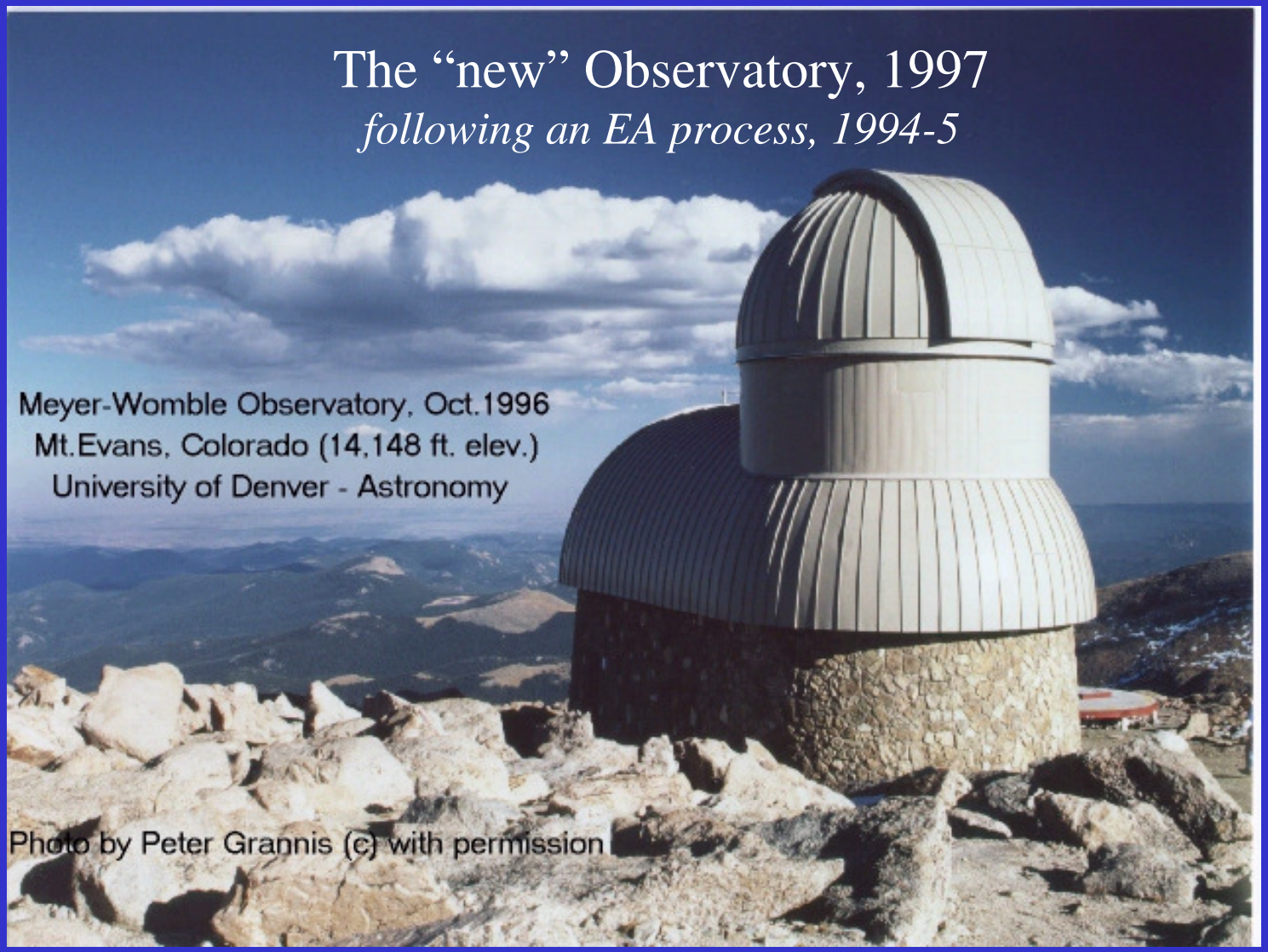
One of the mirrors for the instrument yet has to be installed. Once the 150-pound reflector is in place, the telescope will be plugged into an electronic console, which will direct operations.

Installation was directed by Tony Car-

1993

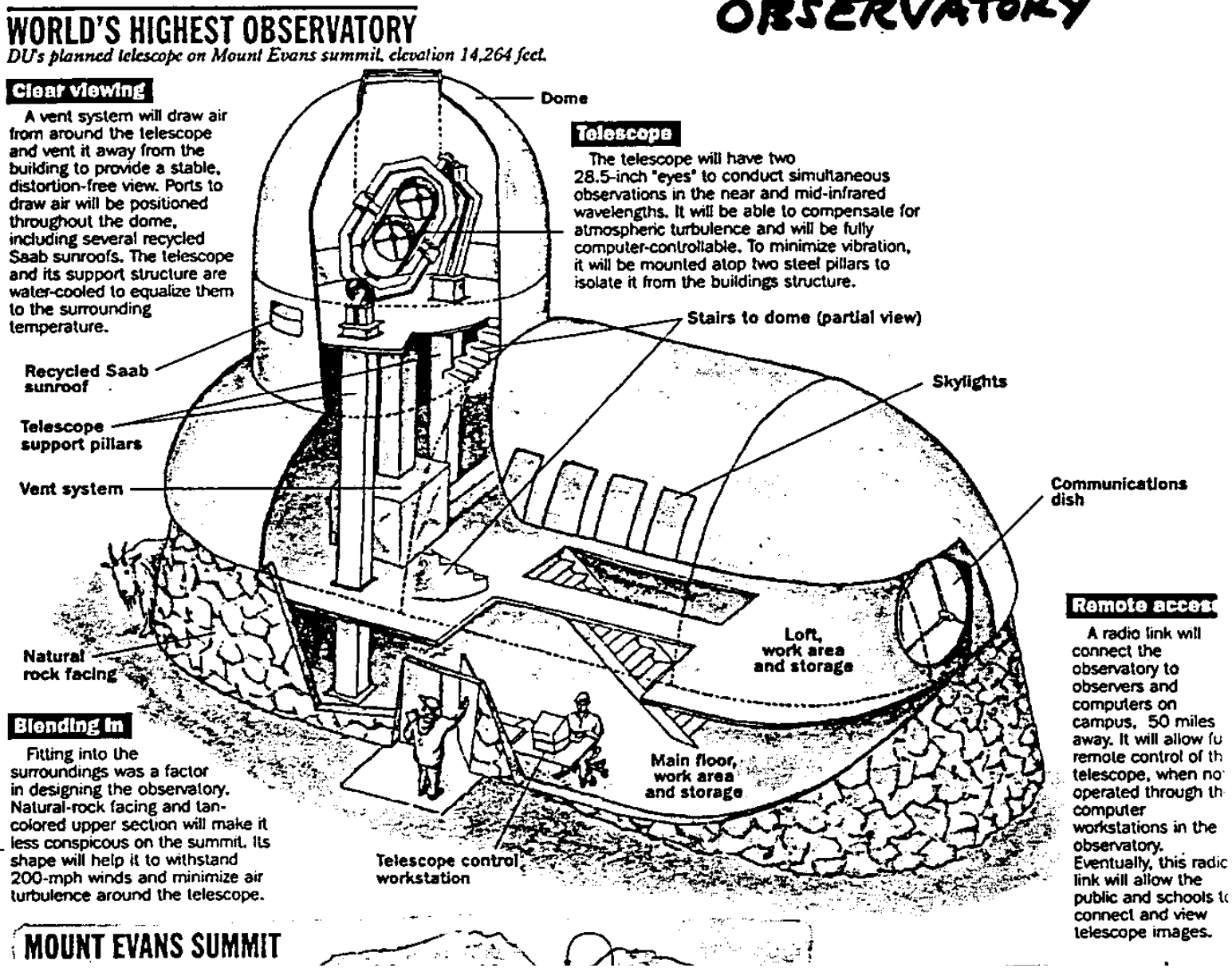
The "new" Observatory, 1997

following an EA process, 1994-5

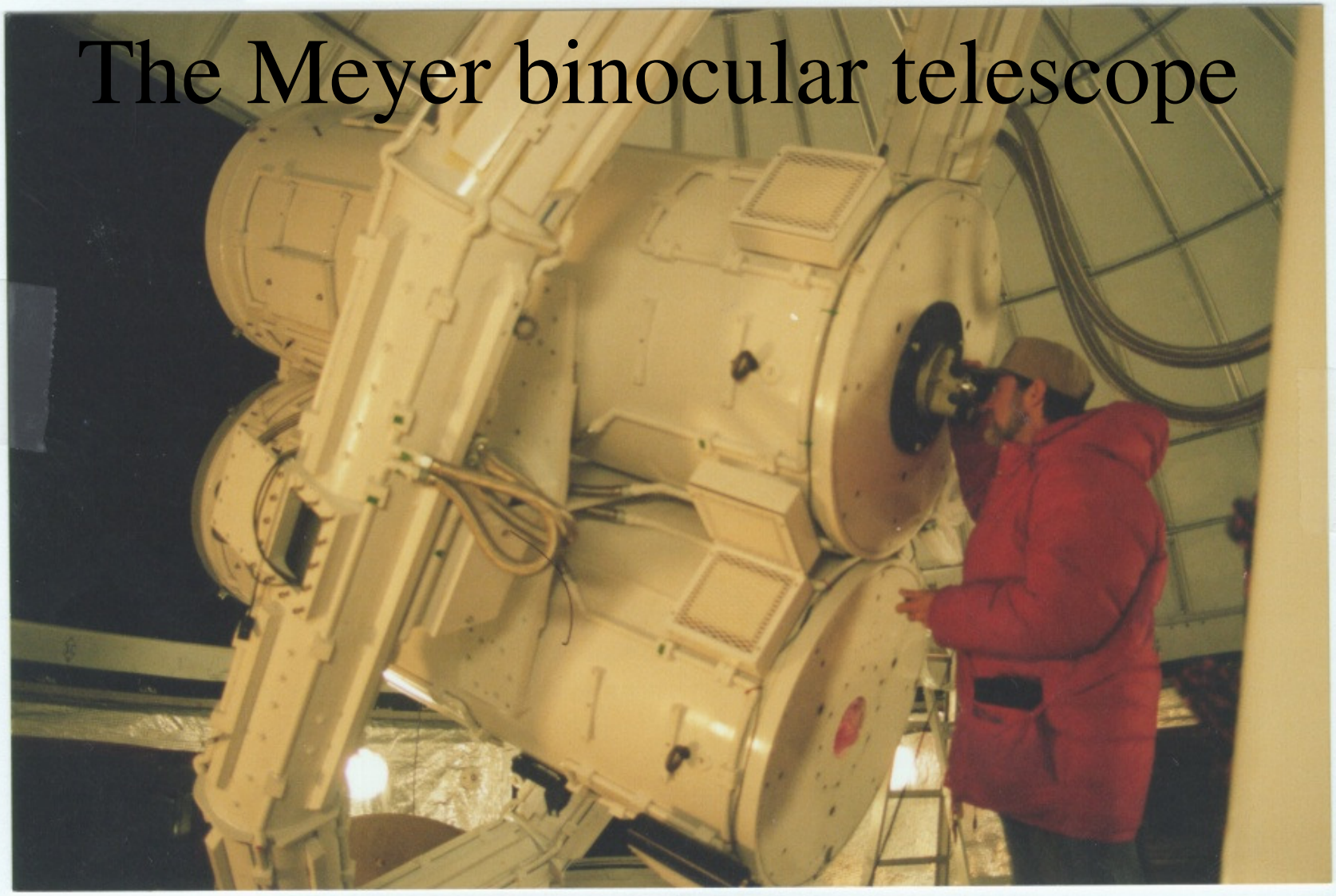


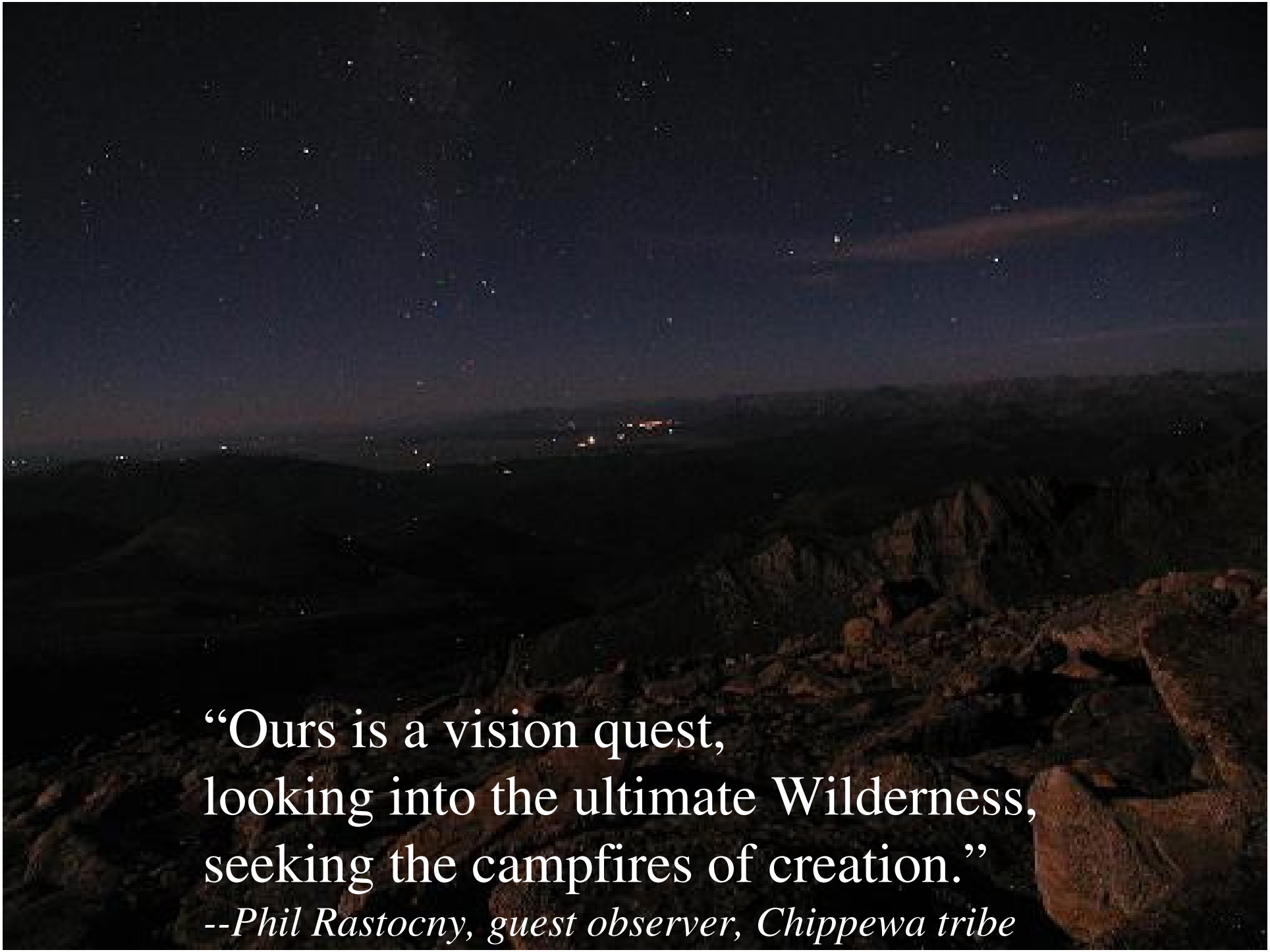
A look inside:

UNIV. DENVER
MEYER · WOMBLE
OBSERVATORY



The Meyer binocular telescope




“Ours is a vision quest,
looking into the ultimate Wilderness,
seeking the campfires of creation.”
--Phil Rastocny, guest observer, Chippewa tribe

Students & guest observers

Science at the Summit

Our Atmosphere

-The summit of Mt. Evans places you above 40% of the earth's atmosphere and 90% of the water vapor present at sea level.

- Water vapor is one of the major greenhouse gases. Should global warming be occurring, water vapor levels will begin to rise like steam in a hot shower, and this effect can be sensitively measured from Mt.Evans.

- Infrared monitoring of the atmosphere have been conducted from this site since the 1950s. This record will help evaluate the long-term effects of society's emissions of carbon dioxide and chlorofluorocarbons.

Astronomy

-Telescopes at high altitudes have less of the hazy atmosphere to look through, providing a clearer view of the "cosmic wilderness" above the Earth.

-The dome near the Crest House contains a 24 inch telescope built in 1973. The site is operated by the University of Denver, under a USFS Special Use permit.

-Research conducted from this telescope includes study of the life cycle of stars -- from their birth in cold interstellar clouds, to their fiery deaths as supernovae. DU astronomers are investigating these and related phenomena. Additional information is on display near the dome itself.

Cosmic Rays

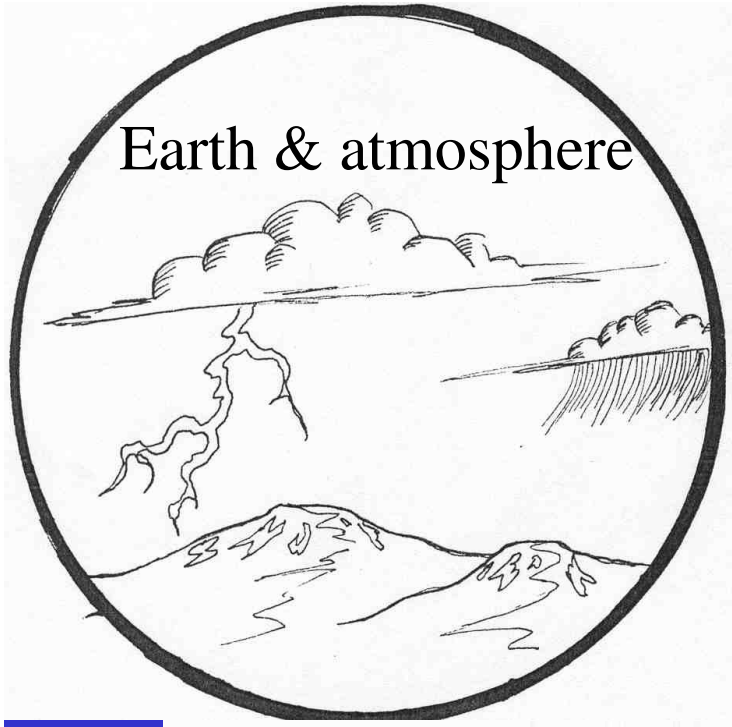
-Cosmic rays are charged particles from the Sun and deep space that constantly rain down on earth at nearly the speed of light and with tremendous energy

-Cosmic rays can shatter atoms in our upper atmosphere, like miniature high-energy "atom smashers". Some showers of by-products can reach the ground and cause a range of effects, from charging the air to biological mutation.

-The dense atmosphere near sea level shields life from cosmic rays, but not at high altitudes where the air is thinner.

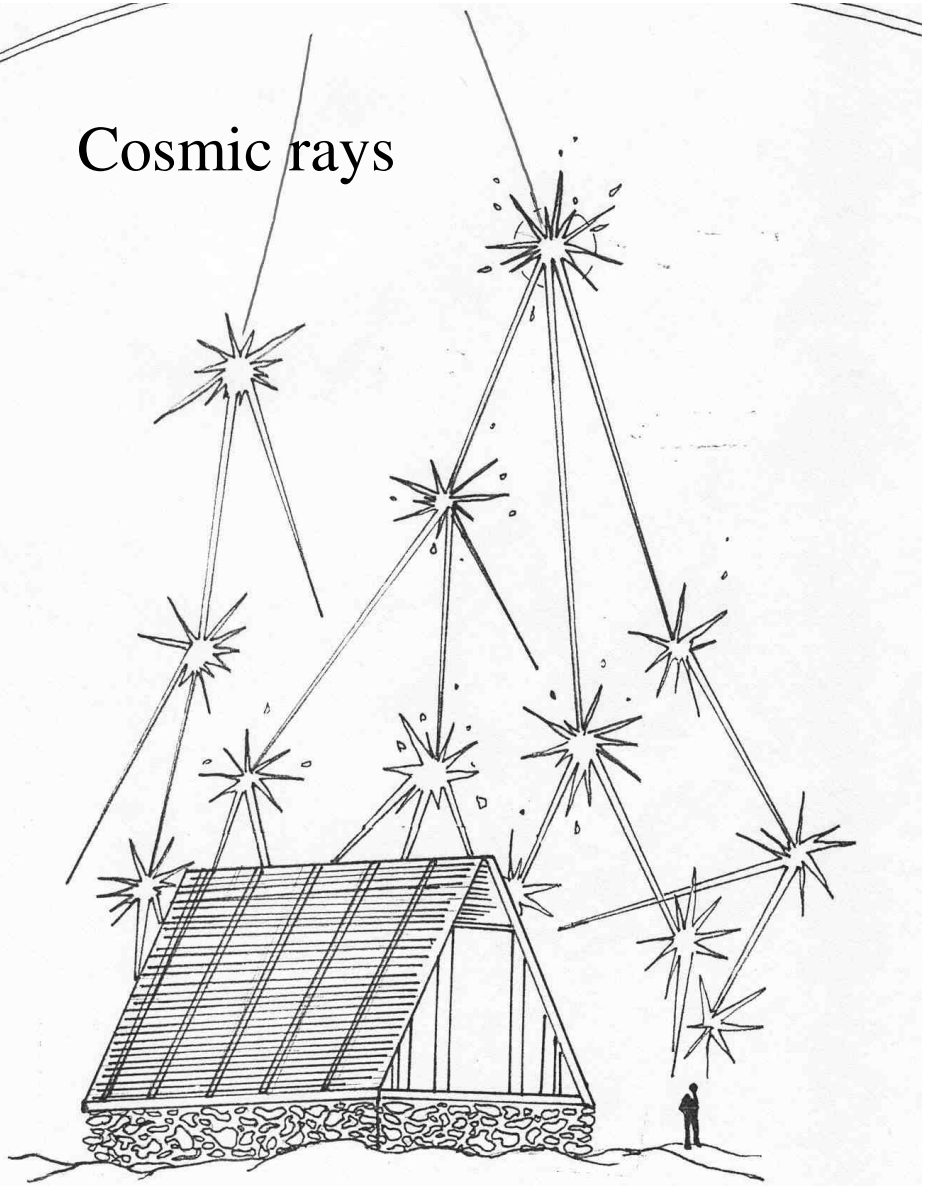
-Mt.Evans has been a research site for cosmic ray physics, since the 1930's

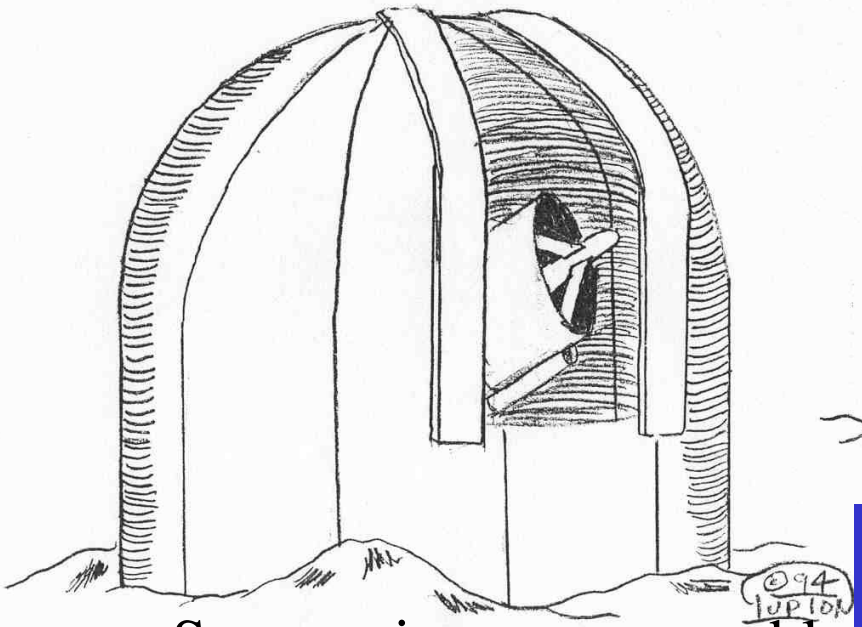
Earth & atmosphere



The big 3

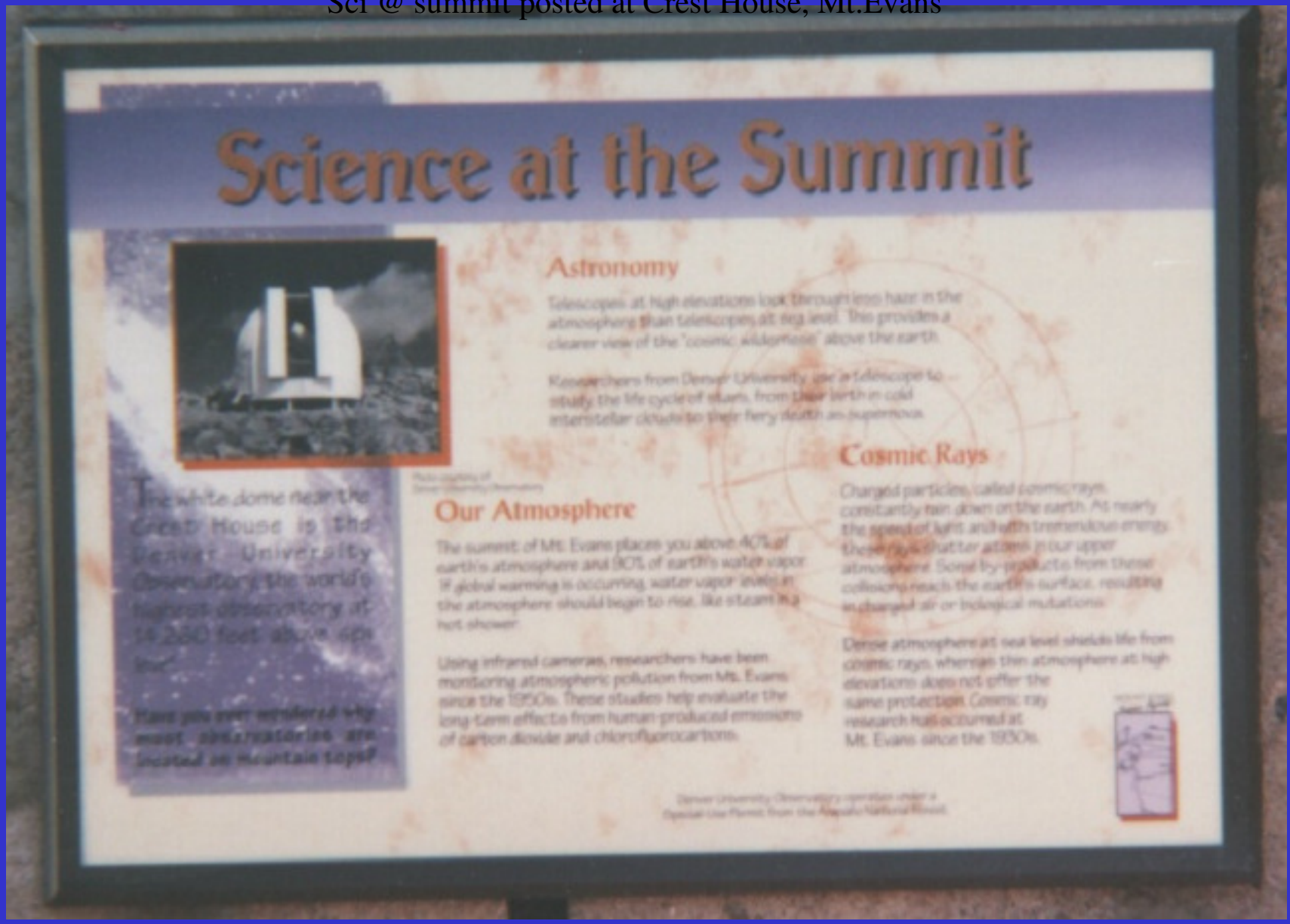
Cosmic rays





Space sciences, renewable energy & more…

Sci @ summit posted at Crest House, Mt.Evans



Professional, external research guests at DU's Mt.Evans Observatory (other than astronomers)

2007 -- Dan Birkenheuer, Ph.D.
NOAA Earth System Research Laboratory
high-altitude water vapor and radiance data

2006 -- Bob Musselman
Rocky Mountain Research Station
USDA Forest Service, Ft.Collins
continuous ozone monitor

2005 -- Brenda L. Dingus
Los Alamos National Lab
cosmic ray, photometric tube testing at altitude

continued on next slide →

2004 -- David R. Lincks
Senior Test Engineer, ReliOn Inc.
Avista Labs performing an altitude test on fuel cell system

2003 -- Daniel Winester, Geodesist
NOAA - NOS - National Geodetic Survey
absolute gravity measurements, tectonics

2003 -- Keith Emery, Calibration Scientist
National Renewable Energy Lab
NREL absolute cavity intercomparison

Prior years:
NASA - Cassini Venus encounter observational support
Univ. Alaska - sprites lightning support observations
SouthWest Research Lab - near earth asteroid observation

We collect sunlight during the day, so we can collect starlight at night…

In the sky – summer 2007

- Evening star, setting = VENUS
  (June & July - up to 48 degrees from the Sun)
- Evening star, rising = JUPITER

* Perseid meteor shower Aug. 11-12-13:
  (best at/after midnight, moon phase=NEW!)

- Total lunar eclipse Aug.28, 3am-sunrise
- & surprises!

Challenges

"Everything up here is experimental…

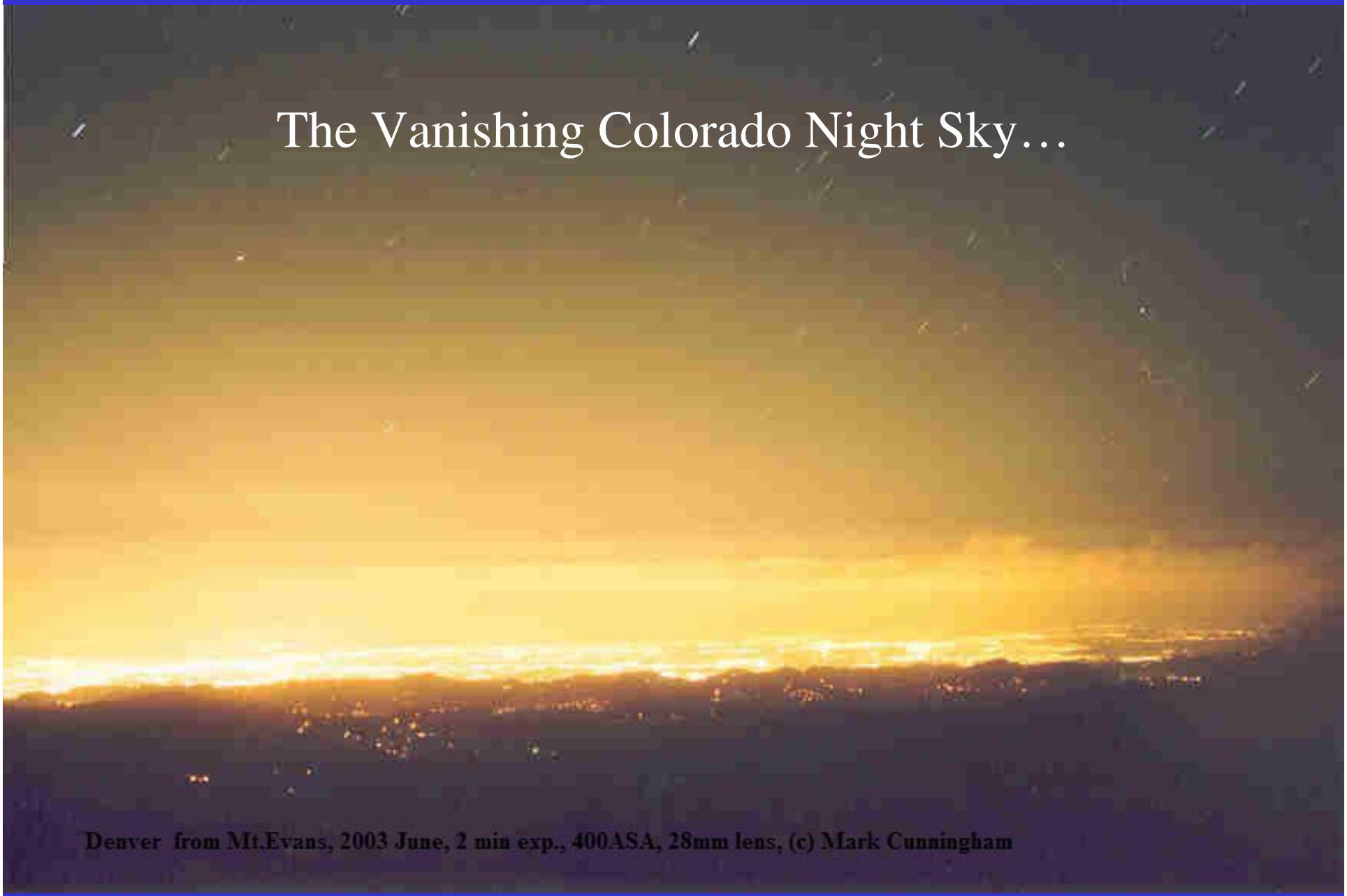
Access…

Power…

Light pollution…

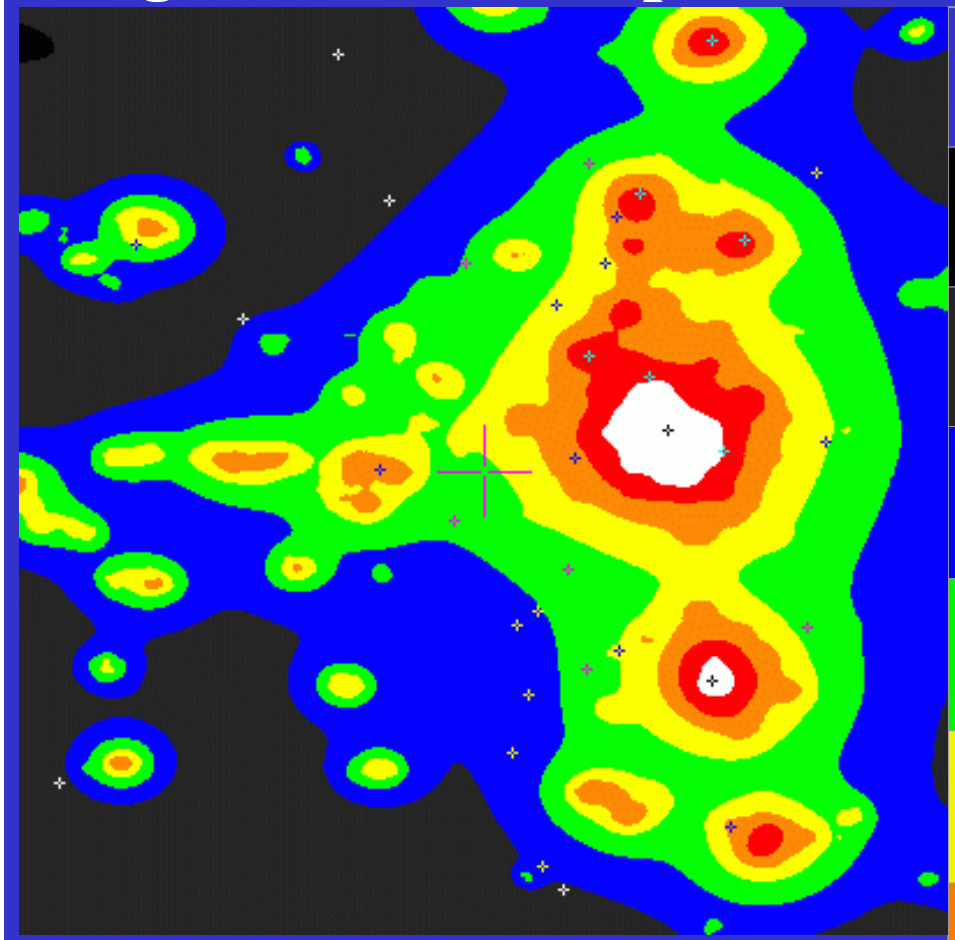
Summit parcel special use permit expires 2015.

The Vanishing Colorado Night Sky…

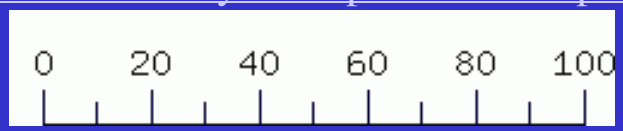


Denver from Mt.Evans, 2003 June, 2 min exp., 400ASA, 28mm lens, (c) Mark Cunningham

Light Pollution Map, centered on Mt.Evans



http://cleardarksky.com/lp/DenverCOlp.html



L.P. Map

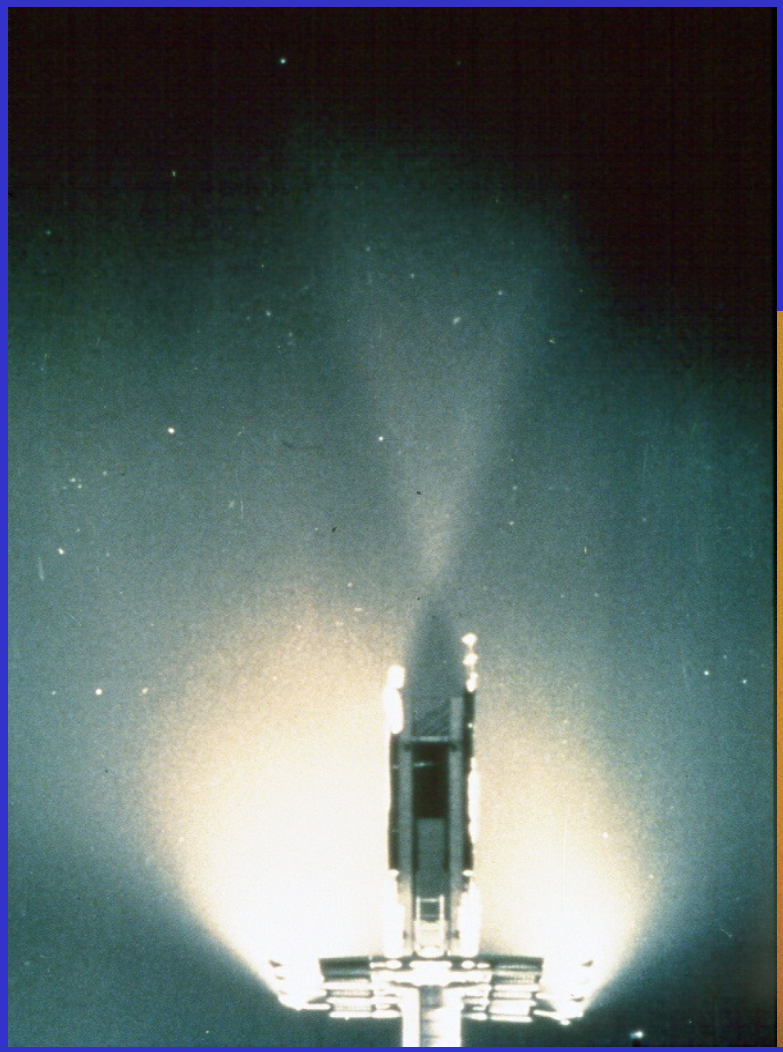
Color	Artificial / Natural Sky Brightness	Sky Brightness mags / sq arcsec	Description (Courtesy of Russell Sipe)
	< 0.01	>21.6	Natural sky brightness
	0.01 to 0.11	21.6 to 21.5	
	0.11 to 0.33	21.5 to 21.3	Long exposure astrophotos might show some light pollution gradient, but visual observing is relatively unimpaired.
	0.33 to 1.0	21.3 to 20.8	Modest impact on deep sky observing and imaging. Milky Way shows structure
	1.0 to 3.0	20.8 to 20.1	Serious impact to deep sky observing and imaging. Milky Way visible but not crisp.
	3.0 to 9.0	20.1 to 19.1	Milky Way not visible
	9.0 to 27.0	19.1 to 18.0	Less than 100 stars visible over 30 degrees elevation
	>27.0	<18.0	Hopeless?

How much energy loss? Measured: ~100 MEGAWATTS
Approximately 5% of Xcel production [5000+ MW]

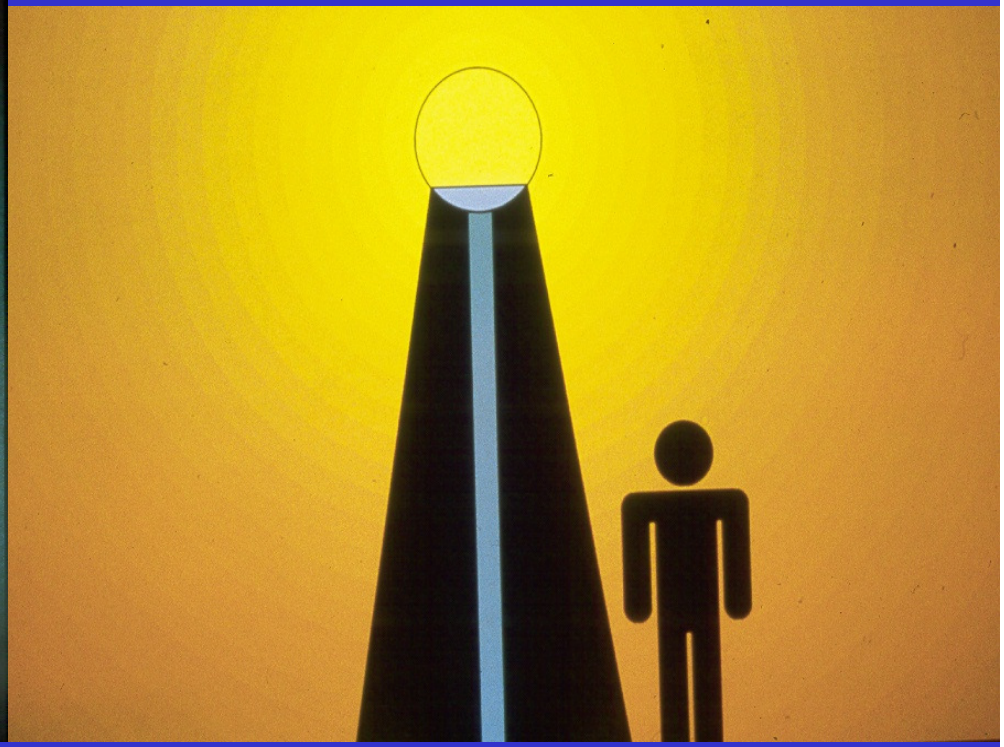
View of metro Denver from western foothills, Aug. 1999
Note cloud brightness due to metro lights.
(This is ~5% Xcel/PSCo, ~100% Calif shortfall)

Cumulative effects:

Wasted lighting energy, from uplighted signs…

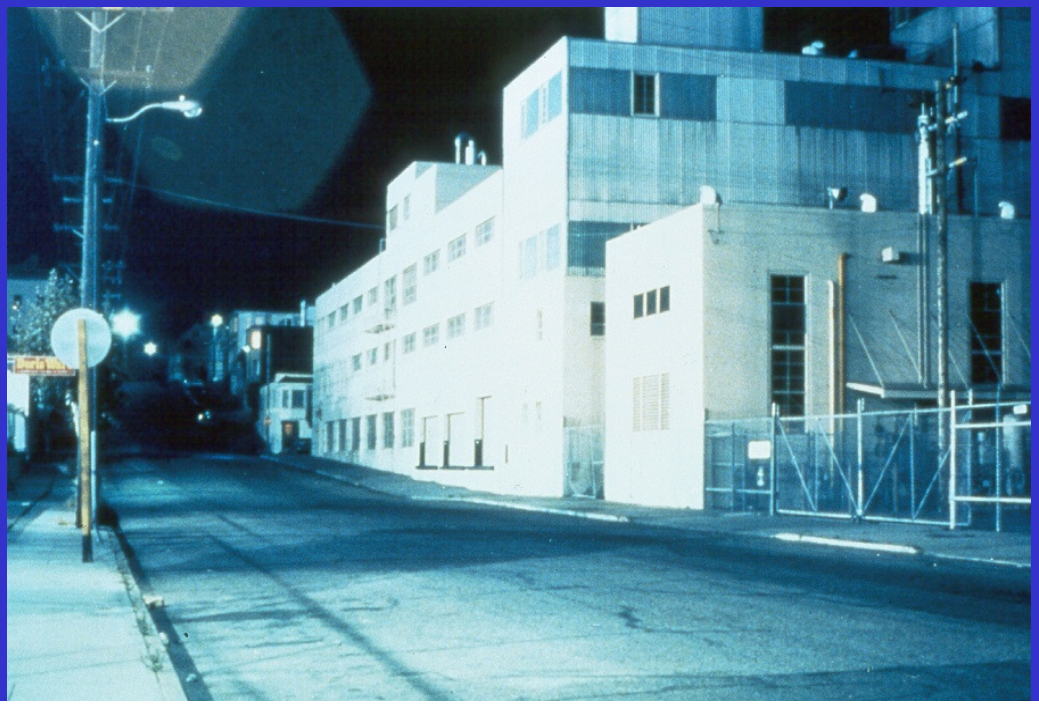


…and unshielded lamps
→ glare & trespass



GLARE:
discomforting and disabling, esp. for older folks

***LIGHT TRESPASS*:**
The light sources are to the left in this picture --
… is this a good neighbor?



Before and after shielding lamps

Plenty of light, just much better aimed!

To summarize…

YOU CANNOT STAY ON THE SUMMIT FOREVER:

YOU HAVE TO COME DOWN AGAIN…

SO WHY BOTHER IN THE FIRST PLACE?

JUST THIS: WHAT IS ABOVE KNOWS WHAT IS BELOW,

BUT WHAT IS BELOW DOES NOT KNOW

WHAT IS ABOVE.

ONE CLIMBS, ONE SEES.

ONE DESCENDS, ONE SEES NO LONGER

BUT ONE HAS SEEN.

THERE IS AN ART OF CONDUCTING ONESELF

IN THE LOWER REGIONS BY THE MEMORY

OF WHAT ONE SAW HIGHER UP.

WHEN ONE CAN NO LONGER SEE,

ONE CAN AT LEAST STILL KNOW.

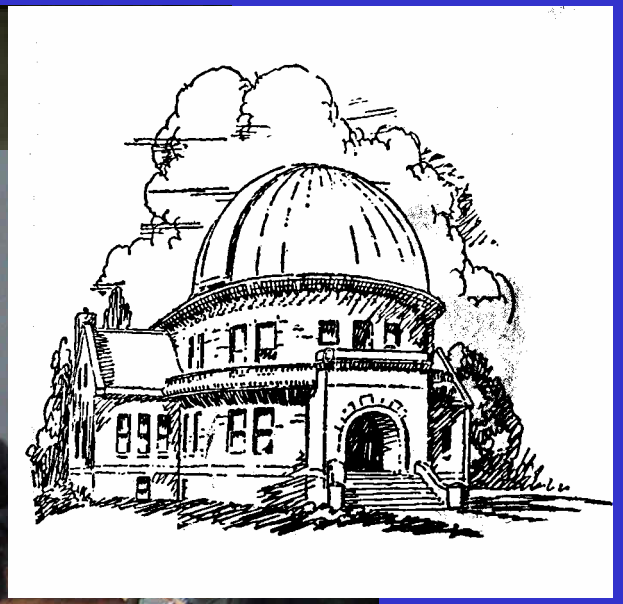
RENE DAUMAL

III. Summit FAQs

The Big 3 questions:

- Where are the restrooms?
- Where are the mountain goats?
- When is the observatory open to the public?

Answer: D.U. campus observatory in south Denver, open year-round



A continuing tradition of education and public outreach, since 1880!

Thanks for listening.

Questions?