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SSC
Heidelberg, 4 April, 2013

CTA CANDIDATE SITES IN THE USA

Introduction



The CTA-US team proposes two sites for CTA-North in Arizona.



Arizona East, 65 km from Flagstaff and seen here during the installation of the Atmoscope in June 2012. The site is 2 km from the Meteor Crater.

It offers:

- exceptionally easy access, nearby rail*
- almost completely flat terrain*
- dark skies and good meteorological conditions*
- no significant hazards identified*
- unparalleled opportunities for broader impacts*



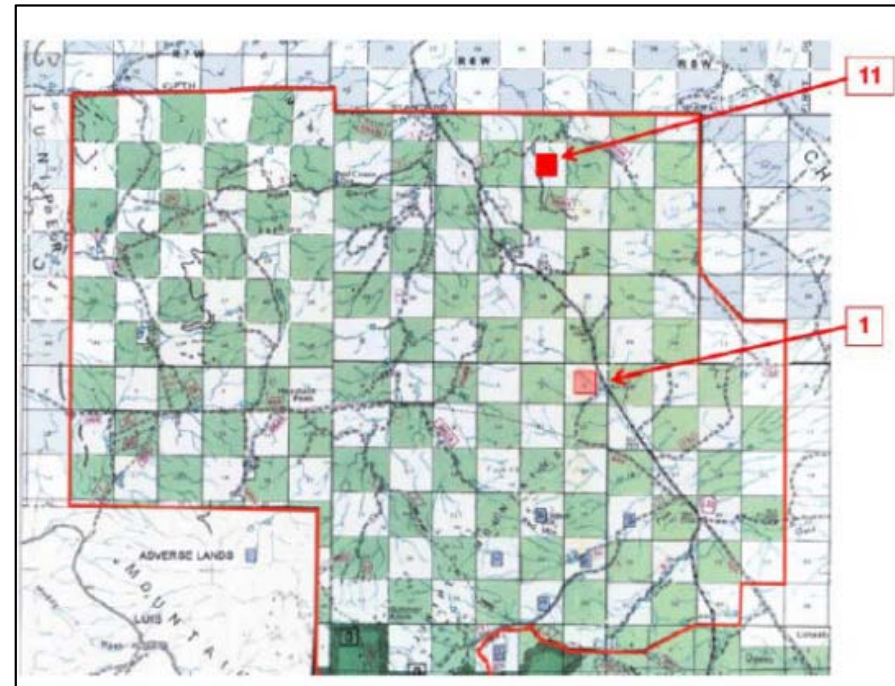
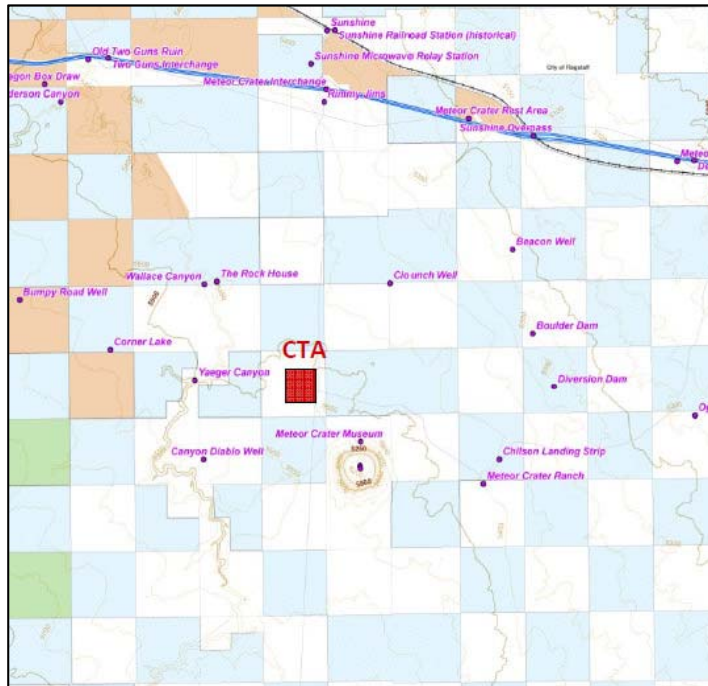
Arizona West, 150 km from Flagstaff and seen here during installation of the Atmoscope . The site is about 20 km south of the small town of Seligman, AZ.

It offers:

- easy access, nearby rail*
- horizons sheltered by low hills*
- exceptionally dark skies and good meteorological conditions*
- no significant hazards identified*

Site Location I

Both proposed sites are on private land on separate parcels of size 1.6 km x 1.6 km.



Arizona East is 7 km south of Interstate 40 (blue line at top). The thinner gray line is the BNSF railroad. White squares are privately owned; light blue are Arizona State land.

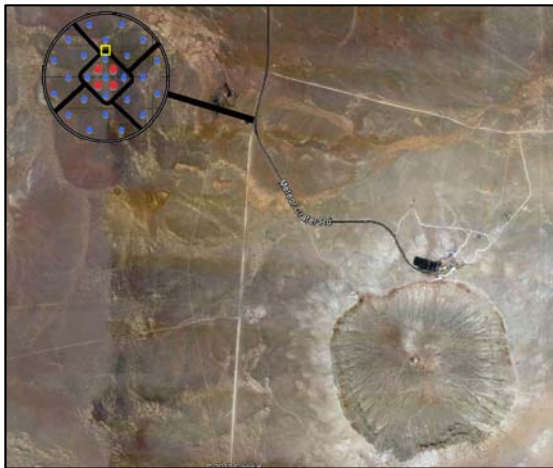
The site sits on an almost completely flat plateau of ancient sea beds; the soil is limestone and sandstone.

Arizona West is #11 on the map, 25 km south of Interstate 40 on Yavapai Ranch (red-bordered area). White squares are the ranch; green are the Prescott National Forest.

The site is dominated by the low Pinon and Juniper pines characteristic of its elevation in Arizona; the soil is limestone and basalt.

Site Location II

Both sites meet all physical requirements for CTA-N.



Arizona East is shown here in its required 800-m configuration; it's roughly the size of Meteor Crater.

In the figure, the yellow square shows the location of the Atmoscope. A short 0.8 km gravel road (thick black line) connects the CTA site with the existing paved road.



Arizona West fits similarly well within a bowl surrounded by low hills.

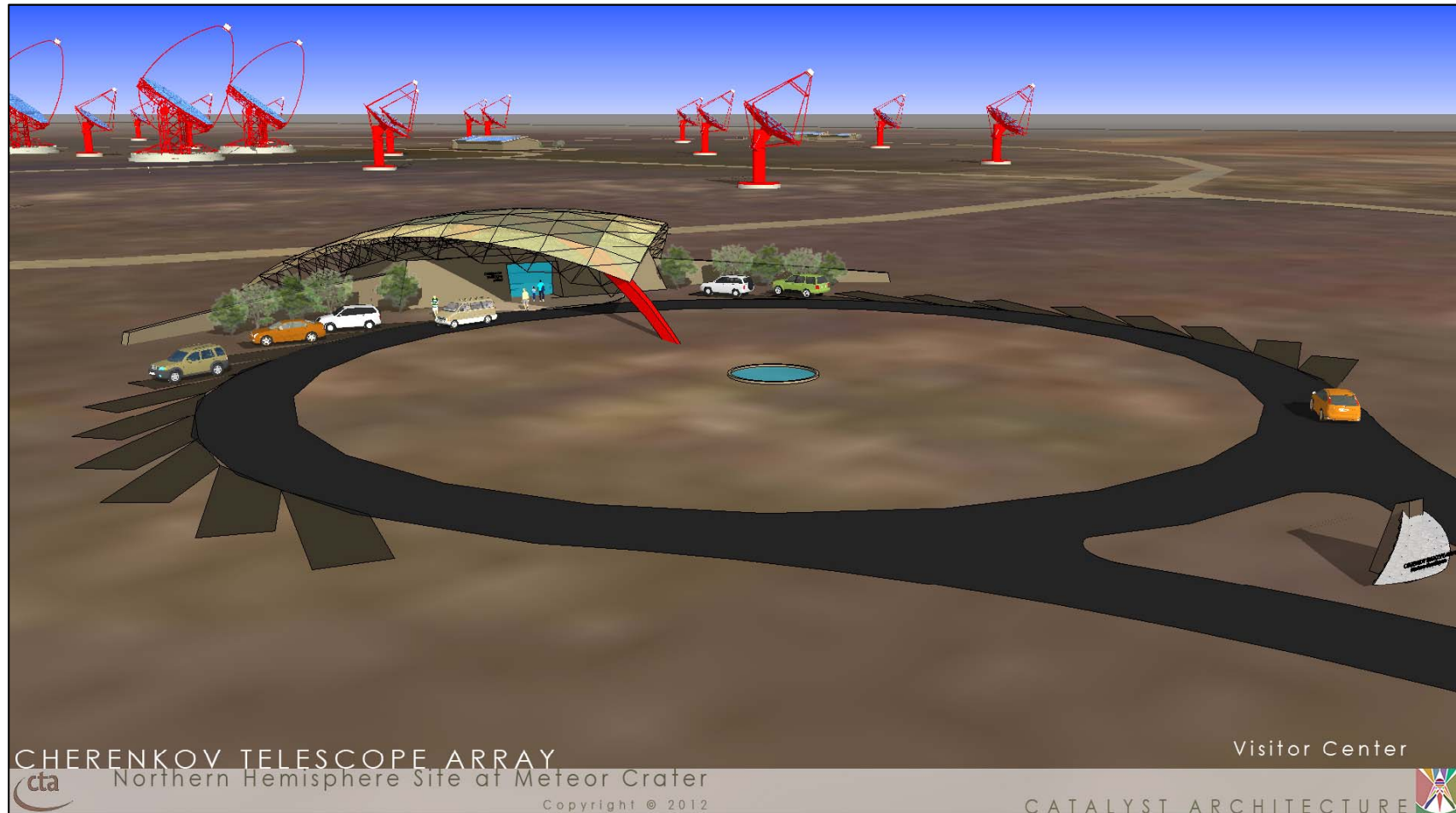
Existing roads are in yellow. New road construction (black) of 2.5 km would be needed to shorten travel off Williamson Valley Road (thick yellow line) and simplify access.

Site Location III



Arizona East is shown here in an architect's conception of the approach to the array and Visitor's Center from Meteor Crater Road.

Site Location III

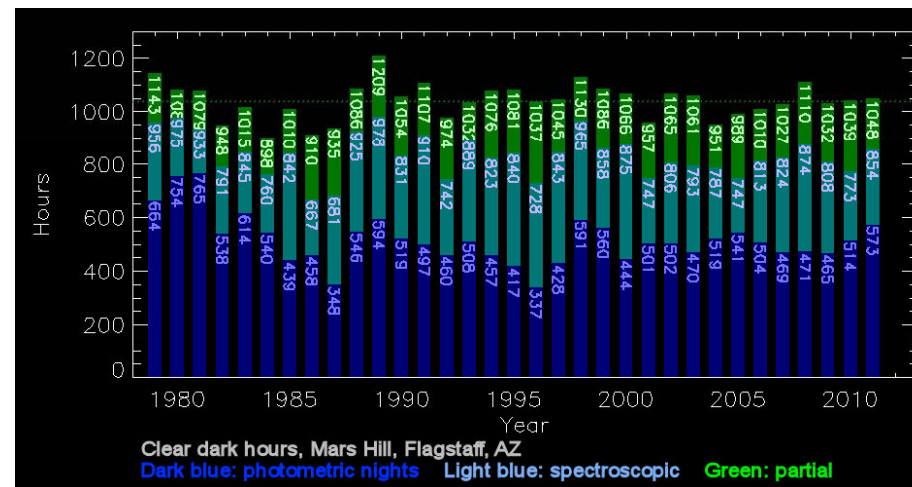


Arizona East is shown here in an architect's conception of the array and visitor center. About 250,000 visitors per year (all during the day, since Meteor Crater closes at 5:00 PM local time) could be expected.

Weather Conditions I : Cloud cover

- Percentage of completely clear nights (0% cloud cover)

72% from 35-year observatory record at Mars Hill (1045 hrs/yr), located some distance from either site. Measurements made by a trained observer, classifying nights as photometric, spectroscopic, or partial. *Results do not agree with MODIS estimation for the same location.*



- Percentage of partially clear nights (<20% cloud cover)

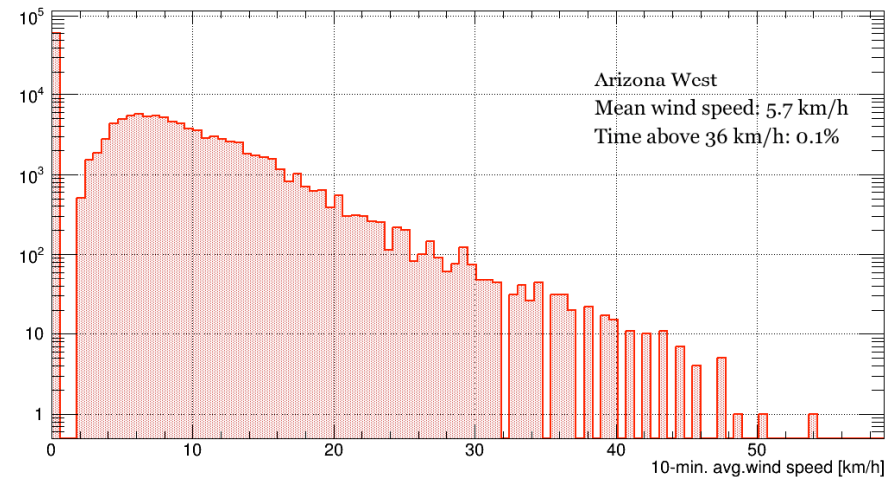
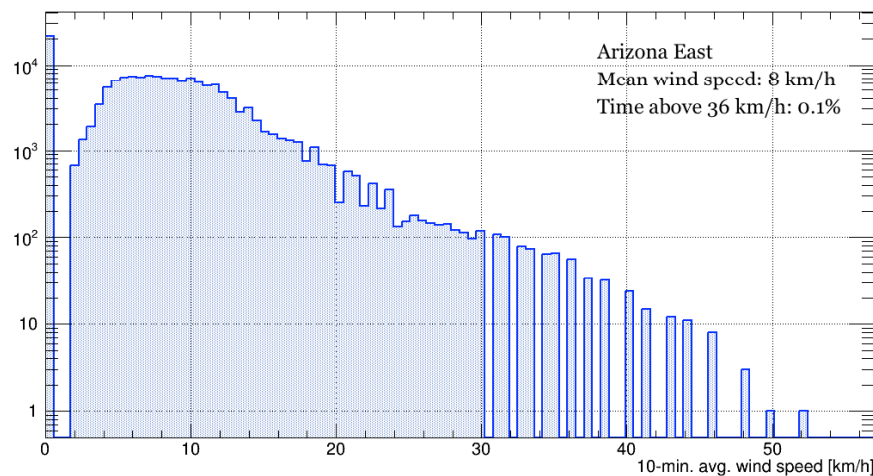
Some disagreement among estimates (range for both sites):

74-75% **SENES**

54-59% **MODIS**

Weather Condition II: Wind

- Percentage of night hours wind > 36 km/hr (10 min average)
0.1% for both sites from 8 months of Atmoscope night time data:



- Probability >200 km/hr (1 sec gust)

Probability appears to be **negligible** at both sites.

For both daytime and night time:

In 8 months of Atmoscope data, no 2-sec gusts at either site above 100 km/hr.

In 50 yr records from weather stations near both sites, a handful of gusts between 120 and 140 km/hr, but no gusts above 140 km/hr.

Weather Conditions III: T, RH, precipitation

- Percentage of time with temperature, humidity within operational range

AZ East: **96.3% temperature, 97.6% humidity**

AZ West: **98.5% temperature, 95.7% humidity**

from 8 months of Atmoscope night time data:

- Percentage of night time with snow on ground

AZ East: ~28 cm/yr with zero average accumulation.

AZ West: ~13 cm/yr with zero average accumulation

SENES predicts **40-50 hrs/yr** with snow on ground – a relatively small number.

- Conformity with extreme temperature, humidity and precipitation survival

Probability for any extreme conditions at either site appears to be **negligible**.

In 8 months of Atmoscope data, no recordings approaching extreme temperature or humidity levels at either site.

In 100 yr records from nearby weather stations, no recordings reported outside of CTA survival specifications.

Night Sky Background

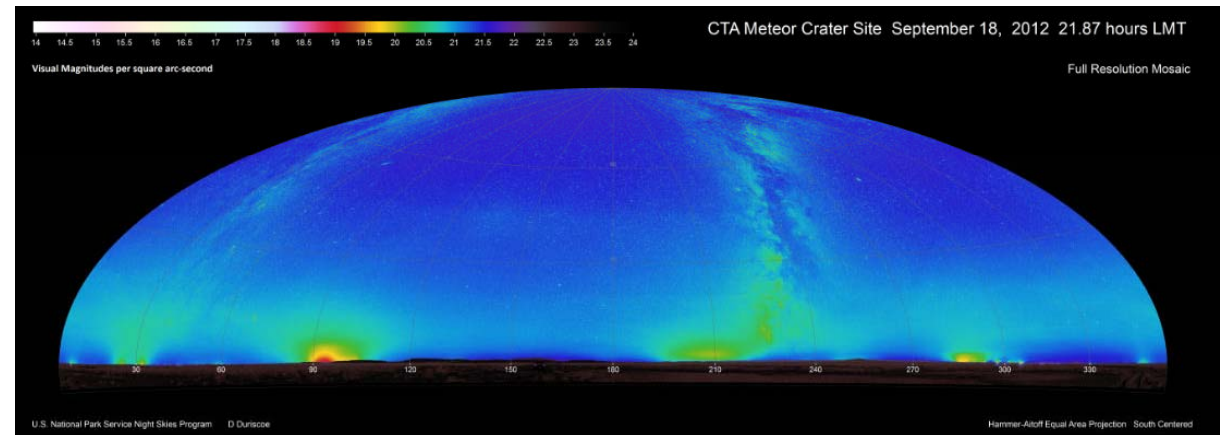
CTA Atmoscope data shows that both sites are *very dark*:

AZ West: **Mag(B) always > 23.**

AZ East: **Mag(B) around 23.**

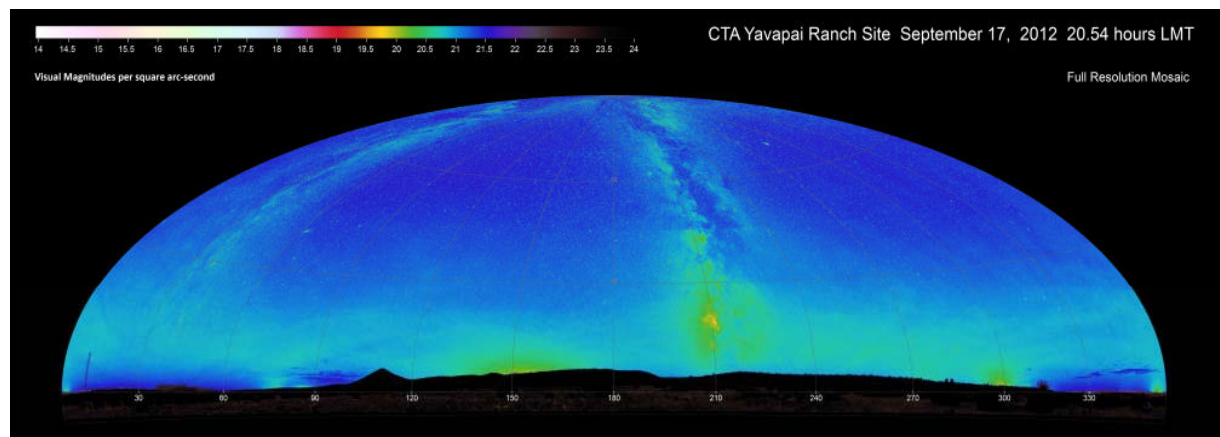
Additional, state-of-the-art NSB measurements made by Dan Duriscoe (US NPS):

Arizona East



Arizona West

(Not a good night, with some cirrus and airglow.)

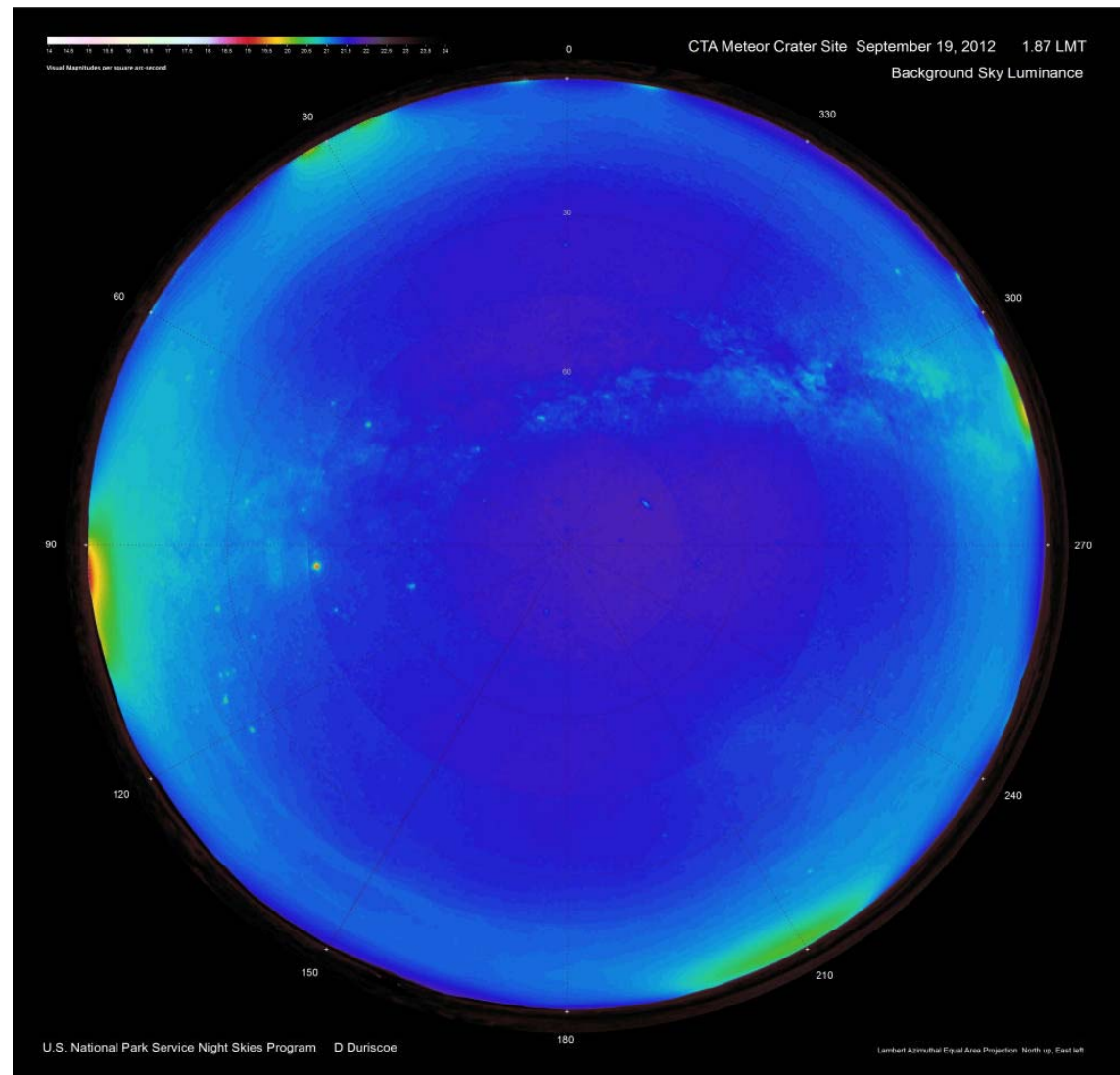


Night Sky Background

NSB measurements by Dan Duriscoe, U. S. National Park Service.

Arizona East

Nearly free of anthropogenic sky glow at zenith.



Natural Hazard Risks

See U.S. Site proposal (01/12), Response to Internal Site Review 2 (03/13).

Earthquakes

Not an issue. Neither site is in an earthquake prone region
(no mag>6 earthquakes within 250 km of either site in 50 years).

Wind Storms

AZ East: 60 yr database at Winslow nearby shows infrequent winds above 100 km/hr.
Predominant wind direction S/SW (mirrors face N in stow position).
AZ West: Moderate winds, sheltered in slight bowl.

Hail Storms

Not a significant risk. Only a small number of hail events (any size) near either site reported over last 60 years.

Sand Storms

Somewhat difficult to quantify; see response to Internal Site Review 2.

Tornadoes

Using 54 yr record, calculated small probability (<0.5%) for strike at either site.

Social/Political Risks

Political stability of country

Not an issue.

Crime

Low crime rates. Violent crime (including robbery) is below the US national average (Coconino Co: 377/100,000, Yavapai Co: 325/100,000) and concentrated in the population centers, far from either site.

Import regulations

Standard US regulations apply. Section 9810.00 of the U.S. Tariff Schedule stipulates that no tariffs are applied on imported material for scientific and educational purposes.

Broad County and City Support

Coconino and Yavapai Counties fully support CTA (see support letters). They have a combined area of 70,000 km², providing a large physical buffer of NSB-protected space around the sites. Night-sky regulations have existed for a long time in both counties.

The cities of Flagstaff (host city for either site) and Winslow are similarly highly supportive of CTA and have night-sky regulations in place.

Infrastructure

Electricity

2 MW possible at both sites from Arizona Public Service (APS) utility.

AZ East: 10.3km from Sunshine substation.

Upgrades to substation and feeder lines required.

AZ West: 30-35km from nearby substations.

Upgrades to substation and feeder lines required.

More uncertainty in costing compared to AZ East.

Water

Water readily available at both sites.

AZ East: Water can be trucked in from Flagstaff or a well and storage tank constructed; both options have moderate cost.

AZ West: Water available from existing wells.

Data Network

AZ East: Microwave connection at 175 Mbps, 700 Mbps, or 1.5 Gbps from two commercial vendors.

AZ West: Microwave connection at 175 Mbps, 700 Mbps, or 1.5 Gbps and Fiber at 1.0 Gbps from two commercial vendors.

Accessibility

Distance to airports

Flagstaff Pulliam Airport

*5-6 daily flights on 50-seat regional jets
~25-minute flight to Phoenix (U.S. Airways [American])*

Phoenix Sky Harbor International Airport

*3.5 hr drive from either site
Major hub (23rd busiest in world), >100 non-stop flights/day*

Las Vegas McCarran International Airport

*3.5 hr drive from Az West, 5.0 hr drive from Az East
Major hub (20th busiest), many non-stops to Europe, & Asia*



Flagstaff Airport from visual approach to rwy 3. Rwy is 2.700 m; rwy 21 is ILS-equipped.

Nearest town to live

Flagstaff

*65 km to AZ East
150 km to AZ West
Population: 66.000*

Winslow

*30 km to AZ East
Population 9.500*

Hospital

Flagstaff Medical Center

*267 in-patient beds; Level 1 trauma center
50 specialties including NICU, cancer center,
heart/vascular center, spine/joint surgery center,
orthopedics, neurology/neurosurgery.*



Flagstaff Medical Center (complex at lower center and center right), seen from the Lowell campus.

Site Ownership



Procedure to obtain permission for use

Permission to use land has been granted by:
Judy Prosser, owner, Bar-T-Bar Ranch (AZ East)
Fred Ruskin, owner, Yavapai Ranch LLP (AZ West)

Access would be granted via lease agreement
*MOU with owners to specify term (e.g. 25 yr),
lease rate, and all legal requirements*
*For AZ West, specific language to protect
CTA-N from future development*

Construction permits needed

Conditional Use Permit (CUP)
Building permits for each structure
Time to obtain both permits: 12-14 months

For AZ West only:
U. S. Forest Service Special Use Permit (SUP)
Time to obtain SUP: approximately 1 year



*Lowell Putnam, Rene Ong, **Judy Prosser**,
Brad Andes (CEO, Meteor Crater Enterprises)*



***Fred Ruskin**, Tom Thurman (Yavapai County
Supervisor), Dave Kieda, Jeffrey Hall*

Political support of Host Country

National Level

US: very strong program in particle astrophysics (VERITAS, IceCube, HAWC, Fermi, etc.).
has long & pioneering history in VHE gamma-ray astronomy.

Funding provided by: U.S. National Science Foundation, U.S. Department of Energy,
Smithsonian Institution, University, & private sources.

Very successful operation of VERITAS telescope array in southern Arizona.

CTA is a prioritized project in recent Decadal Survey (Astro2010).

State Level

Close connections to the large astronomical community in Arizona; astronomy is
a high priority in the state (e.g. recent veto of billboard legislation by governor).

Regional university partners at Arizona State University, Northern Arizona University
and University of Nevada, Las Vegas.

CTA-US

CTA-US: strong group of 23 institutions (universities and two national labs).

US group proposes to provide funding for all infrastructure costs (power, road, water,
and data network) for the Arizona East site. Would offset costs for Arizona West site.

Political support of Host Country

Lowell Observatory – Potential Managing Partner for CTA-North

Research

20 PhD-level astronomers with expertise from planetary to extragalactic, some staff will work actively with CTA

Fully equipped instrument/machine shop, provides support to all Lowell facilities and projects including CTA

Three sites: 30-acre main campus in Flagstaff; Anderson Mesa (5 telescopes + Navy interferometer; Happy Jack (4.3-meter Discovery Channel Telescope)



Lowell's Anderson Mesa observing station

Outreach

80,000 visitors/year at Mars Hill; extensive secondary school programs; partnership with Discovery Communications

Can be local managing partner/operator for CTA Visitor Center, possibly in collaboration with Meteor Crater

Management

M&O and scientific partner for Navy Precision Optical Interferometer; Lowell would serve as local managing organization to support CTA operations



The 4.3-meter, \$53M Discovery Channel Telescope

Conclusion

Considering all factors, we recommend **Arizona East** for CTA-N.

Sky brightness is well quantified and quite dark

Cloud cover is acceptable

Outstanding access; excellent living conditions in Flagstaff make it attractive for staff.

Reliable estimates of construction costs because of proximity to Flagstaff and Winslow

Well-understood operations costs, again because of access

Unparalleled outreach potential

US group backs project and taps potentially large contribution to CTA

Lowell Observatory will join as managing and scientific partner for the project.

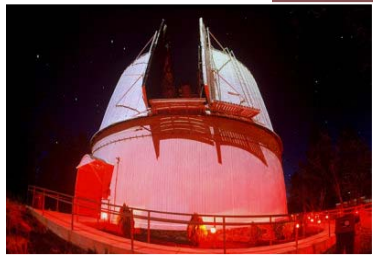
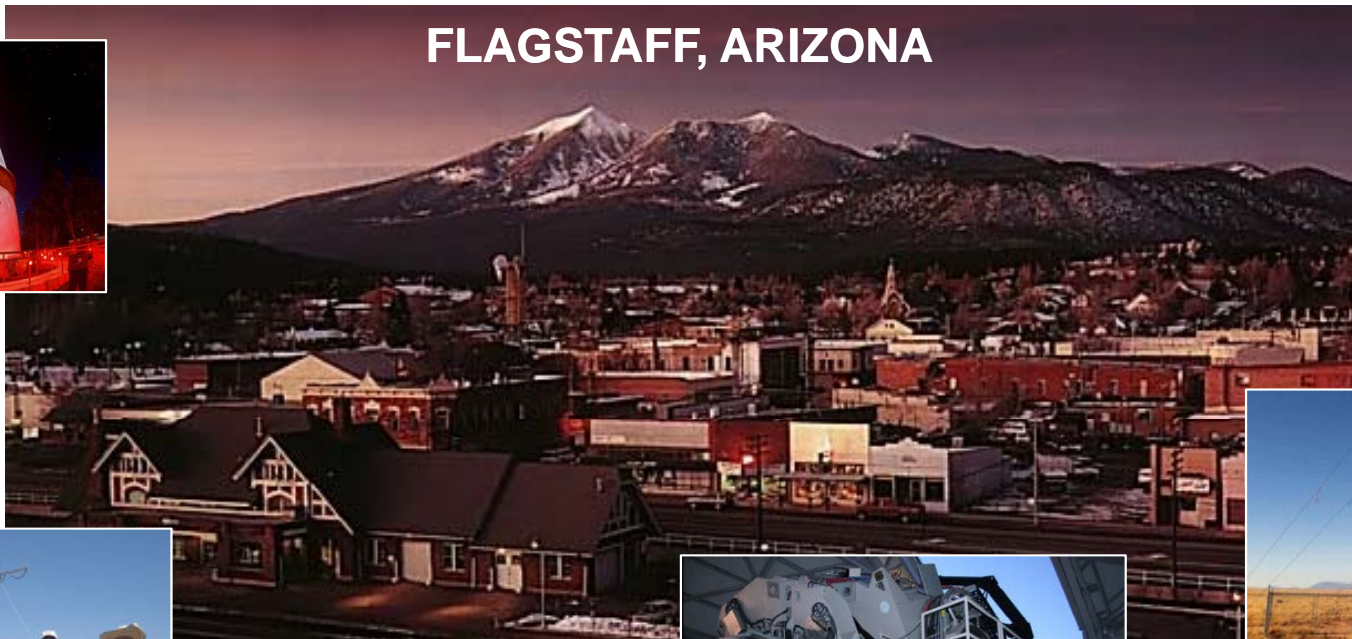
Conclusion

Arizona East is a safe, well-understood site operating within requirements and with meteorological conditions understood from over 100 years of records.



Conclusion

Arizona East offers easy logistics, experienced local management, dark skies with protective legislation in place, extensive existing astronomical facilities, and an appealing place to live and work.



Lowell main campus 2 km



AZ West 150 km



Lowell 4.3-meter Discovery Channel Telescope 70 km



AZ East 65 km

Political support of Host Country



Strong support from:

City of Flagstaff
City of Winslow
Coconino County
Yavapai County

Dark-sky controls in place:

The international model ordinance in Flagstaff;
comparable ordinance in Coconino County,
Yavapai County, City of Winslow



January 4, 2012

Carl Taylor
District 1

To the Cherenkov Telescope Array Site Committee:

Elizabeth C. Archuleta
District 2

This letter is to affirm our awareness and full support of the possibility of locating the northern array of the CTA in Coconino County, Arizona, USA.

Matt Ryan
District 3

Mandy Metzger
District 4

Lena Fowler
District 5

We have been pleased to assist Drs. Rene Ong of UCLA and Jeff Hall of Lowell Observatory in surveying potential sites east and west of Flagstaff. There have been significant expressions of interest from landowners in leasing a section of land for the CTA's use, and if a site in Coconino County is selected we will assist the permitting and development process to the greatest extent we can. We will also assist in any way that would be helpful during the site analysis phase in 2012.

As you know, astronomy has a long heritage in Arizona, commanding significant public interest and protected by city, County, and statewide dark-sky ordinances. The CTA would be a significant new astronomy asset both



STATE OF ARIZONA

JANICE K. BREWER
GOVERNOR

March 28, 2012

EXECUTIVE OFFICE

Re: House Bill 2757 (billboards; changing message; authorization)

Dear Speaker Tobin,

Today, I vetoed House Bill 2757. This bill allows electronic billboards capable of changing messages to be placed in public rights-of-way along state highways, and sets standards for display transition times.

I am also mindful, however, of Arizona's unique position as a national leader in astronomy and stargazing, thanks to our dark skies. Arizona is fortunate to be home to important astronomy installations across the state, including Lowell Observatory, in Flagstaff, Kitt Peak National Observatory, outside Tucson, and Mount Graham International Observatory, near

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dave.hunt@co.yavapai.ar.us

January 9, 2012

Dear members of the CTA consortium:

In the past few months we have met with representatives of your scientific consortium regarding establishing one of the CTA sites in Arizona. According to their information, there are locations in northwest Yavapai County that meet the essential requirements for the telescope array.

We regard the CTA siting one of its arrays in Yavapai County as a significant and