Introduction to the Winer Observatory

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AMU Telescope

Topics

- Introduction to Mark Trueblood
- Winer Observatory Operations
- NEO Research
- Vatican Advanced Technology Telescope

Introduction to Mark Trueblood

Mark at the Bok 1.3m telescope

Brief CV

- BS Physics, 1971
- MS Astronomy, 1983
  - Mike A'Hearn advisor
  - "Small Telescope Automation" thesis
- Program Manager, HST control center at GSFC
- IR instrument project manager, NOAO

Winer Observatory Operations

Introduction to the Winer Observatory

- Winer is a non-profit public charity (tax exempt)
- Purpose is to advance both science and public education about science, with focus on astronomy
- We host telescopes from institutions and individuals from places where the weather is not conducive to astronomy (mostly mid-western US)
- Vigorous public outreach program
- Winer Director observes on Kitt Peak and VATT
- Videos on Site web page taken by Dr. Krzysztof Kaminsky show roof operations
- Learn more at http://www.winer.org

Where Are We?

St George
Las Vegas
Bullhead City
Flagstaff
Lake Havasu City
Prescott
ARIZONA
Phoenix
San Tan Valley
Yuma
Tucson
Sierra Vista

What Are We?

What Are We?

Telescopes in Our Observatory

- Univ. of Iowa, MACRO consortium -- 0.5 m PlaneWave used for student labs and projects
- Ohio State Univ. – 0.5 m PlaneWave between programs
- TransAstra asteroid mining company four-telescope asteroid survey to find and track candidates for mining; uses high speed processing
- AMU – 0.7 m PlaneWave
- Private individual – 0.3 m Celestron for imaging, interested in spectroscopy
- NO telescopes owned or used by Winer Obs

What We Provide

- Physical space:
  - Telescopes are located on isolated concrete pads
  - Computers in cabinets or on carts
- Utilities:
  - Power (US – 120 VAC, 60 Hz)
  - Internet
- Data (machine-readable web page):
  - Weather
  - Seeing
  - All-sky camera images
  - Roof status (open / closed)
  - Sky brightness (V mag/arc-sec^2)

Internet Details

- Rural setting means slow Internet
- We are a source of data, not a sink, counter to most ISP models of data flow
- Difficult to find providers with fast uplink speeds
- Use Wi-Power microwave link; their omni-directional antenna is 3 km away
- Speeds “up to” 20 Mbps full duplex; users share
- Perform routing in our PC running Ubuntu Linux
- Firewall in Linux – iptables and close unused ports

Machine Readable Data


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  <FONT COLOR=yellow>
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<! WINDSPEED=11 MPH >
<! WINDDIR=225 EofN >
<! HUMIDITY=66.00 %>
<! RAIN=0.00 in>
<! PRESSURE=25.09 inHg>
<! TEMPERATURE=78.00 F>
<! BRIGHTNESS=20.57 Vmag/sq.asec>
   <! >
   <! Corrected 10-Dec-2009 (pnd@noao.edu)>
   <! >
<! LASTUPDATED=+2456041.726180930621922O>
<! WEATHER_STATE=0x0>
<! DPM_PRESS_IN=25.09 inHg>
<! DPM_TEMP_C=26.00 C>
```

What Customers Provide

- Telescope, instruments, cables, filters, etc.
- Means to convert US power to their needs
- Expertise and labor to install their telescope, get it working (commissioning)
- Expertise and labor to maintain and upgrade their telescope and instruments
- Computers and software to control their telescope, and, in some cases, analyze their data
- Our fee to enable us to provide our services

Operations

- Roof rolls north to open, blocking light from Tucson
- Flats may be taken while the roof is closed; you provide a flat screen that we mount to the roof and lights on your secondary mirror support ring
- Roof opens when Sun is 1° below the horizon in the west, to enable taking twilight flats
- Roof closes when Sun is 1° below the horizon in the east in the morning
- Customer controls what the telescope observes; we do not monitor data from your telescope
- We rely on Customers to report when something we provide isn't working

How Weather Affects Roof Opening

- The roof opens automatically unless we put the roof into manual mode to prevent its opening
- Each afternoon we check the weather forecast and make the decision to open or not
- Roof control computer checks weather data each minute:
    - Wind speed < 20 kts
    - Relative humidity < 90%
    - If exceeded, computer does not open the roof, or closes it during the night and stays closed for 30 minutes, then checks again
- Open 180-240 nights per year; we do NOT close due to clouds

NEO Research

Science by Winer Director

- Observe Near Earth Objects (NEOs) to help NASA and others classify them according to the risk of Earth impact they pose
- Use 1.8-m VATT telescope near LBT on Mt. Graham
- Focus on the most hazardous objects

Acknowledgements

- This presentation is based upon work partially supported by two grants from the National Aeronautics and Space Administration Near-Earth Object Observation Program of the Science Mission Directorate
- Space art by Don Davis, funded by NASA and in the public domain
- Team includes Robert Crawford and Larry Lebofsky; additional help from Dave Bell, Morgan Rehnberg, and Ken Mighell
- The opinions expressed herein are those of the author and do not necessarily reflect those of NASA

NEO Topics

- Brief review of NEOs
- Process of NEO Risk Assessment
    - NEO Discovery
    - What Happens After Discovery
    - The asteroid numbering and naming process
    - What are VIs and PHAs?
    - Why extend NEO orbits?
- Our Long-term Follow-up Program

Review of NEOs

- NEOs are asteroids and comets whose orbits bring them within 1.3 AU of the Sun
- Most are asteroids that originate in the asteroid belt through collisions; the remainder are comets
- Orbit lifetime ~ 10 million years, so supply is continuously being replenished
- R. Jedecke predicted in 1990s best place to scan to discover NEOs is the ecliptic; even though high apparent inclinations are common for nearby objects
- Numerous impact events from Chicxulub to Barringer Crater to Chelyabinsk remind us the risk is real

Close Calls

Date	Object	*Distance (LD)*	*Diameter (m)*
Jun-2011	2011 MD	0.05	8
Nov-2012	2010 WA	0.1	3
Oct-2012	2010 TD54	0.16	7
Sep-2012	2010 RF12	0.2	7
20-Feb-12	2012 DY13	0.29	9
Sep-2012	2010 RX30	0.5	12
Nov-2011	2005 YU55	0.85	360
Oct-2012	2010 TG19	1	75
Mar-2012	2012 DS32	1.87	19
Feb-2012	2012 DX13	1.96	13
Feb-2012	2011 AX22	97*	40

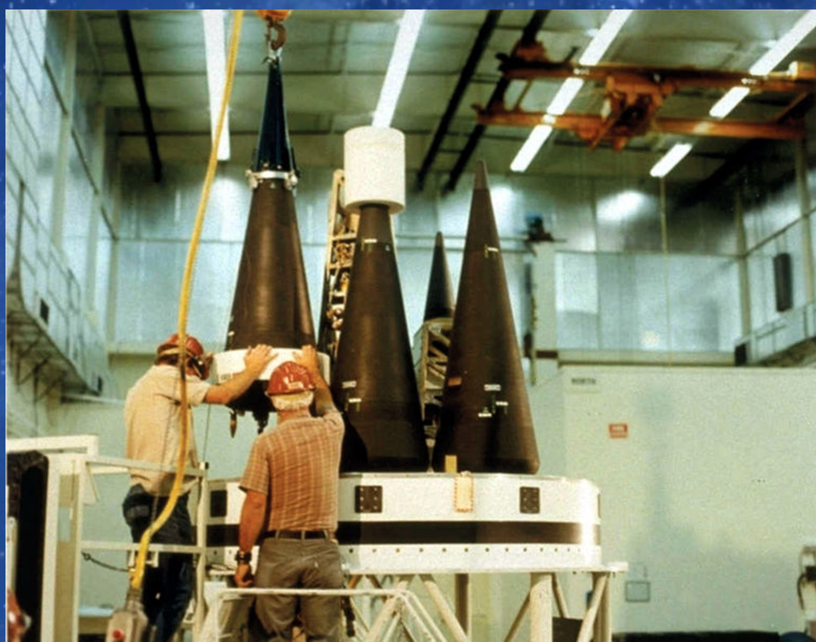
*Less than 0.3 LD in 2055 (possibly much closer)

Lunar Distance (LD): 0.00257 AU = 384,399 km; Comm Sats: 0.1 LD

Effects of an NEO Impact on Earth

Equivalent Yield Megatons	*Interval Years*	*NEO Diam. Meters*	*Consequences*
Less than 10			Upper atmosphere detonation of stones and comets
10-100	1000	75	Meteor Crater, Tunguska; destroy Washington, DC
100-1000	4000	160	Destroy large urban area, e.g., New York City
1000-10,000	16,000	350	Destroy small state, e.g., Delaware
10,000-100,000	60,000	700	Destroy moderate state, e.g., Virginia
100,000-1 million	250,000	1,700	Affects climate, freezes crops, global destruction of ozone; destroy large state, e.g., California
1 million-10 million	1 million	3,000	Raise dust, change climate, widespread fires; destroy large nation, e.g., India
10 million-100 million	4 million	7,000	Prolonged climate effects, global conflagration, probable mass extinction; direct destruction approaches continental scale, e.g., Brazil, U.S., Australia
100 million-1 billion	16 million	16,000	Large mass extinction of the sort 65 million years ago
Greater than 1 billion			Threatens all advanced forms of life

An NEO Impact Can Be Devastating



- 10 Megatons is on the LOW end of the scale for objects larger than meteors
- The W87 MIRV warhead used in the Minuteman III missile is 1/3 Mton, yet it could devastate all of Poznań
- This shows how powerful NEOs are!

Risk = Probability x Consequences

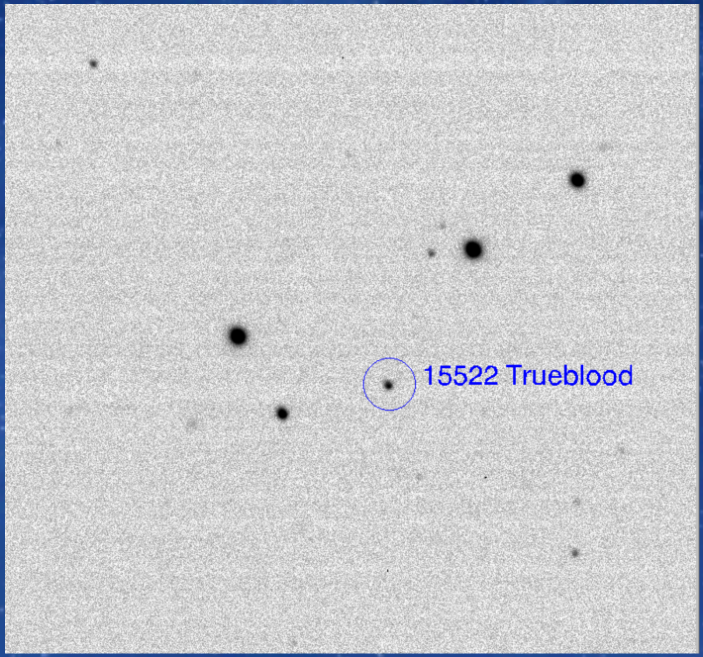
- Many people think low probability events like NEO strikes, are *low-risk* events
- **Probability** does not equal **risk,** both the probability of the event **and** the resulting cost or damage need to be accounted for
- Chance of dying from NEO impact ~ 1/10 chance of dying in an airliner crash
- Experts in risk assessment say NEOs should be treated as *moderate* risk events, and ***should be given far more resources than currently allocated***
- See, for example, Christian Gritzner and Stefanos Fasoulas, "Justification of NEO Impact Mitigation Activities by Risk Management", Mem. S.A.It., 2002, Vol. 73, No. 3, pp. 747-750.
- Most significant preventable natural disaster

US Congress Believes Risk is Real

US Congress has acted:

- Amended 1958 Space Act to require NASA to discover and track NEOs
- Set goal for NASA to find 90% of NEOs > 1 km by 2008
- Set goal for NASA to find 90% of NEOs > 140 m by 2020 (now ASAP)
- NASA/ROSES/NEOO program funded at $4M/year
- NASA concentrates its NEO funding on surveys to ***discover*** new objects

Process of NEO Risk Assessment



Step 1. Discover the new asteroid or comet

Step 2. Track (astrometric follow up) the new object for days to weeks to confirm the NEO discovery

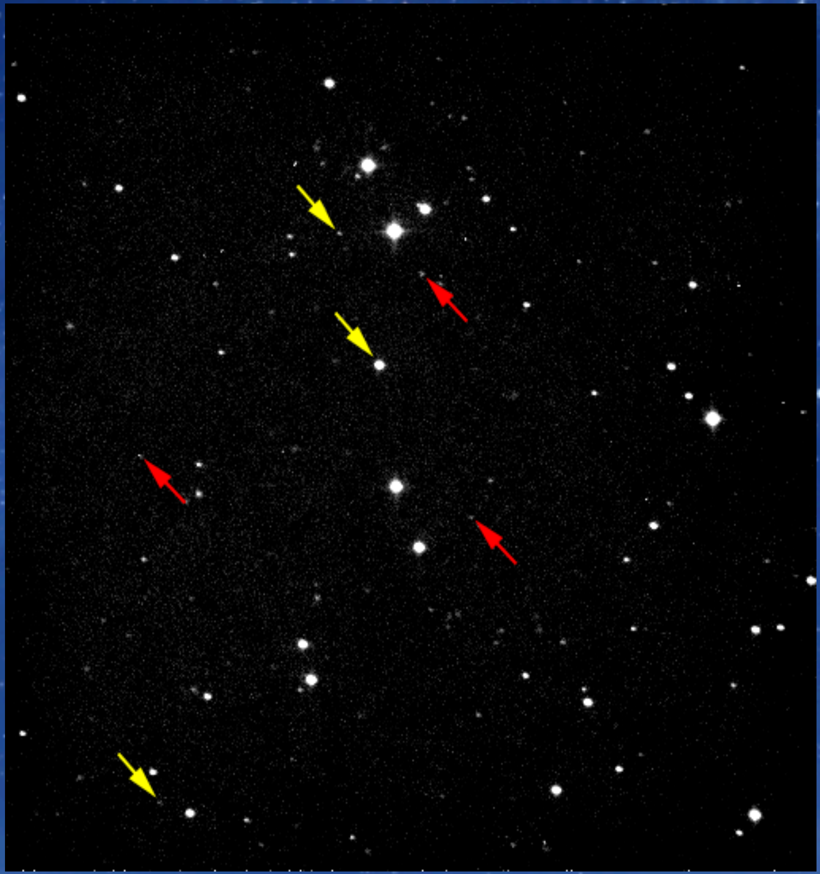
Step 3. Compute an initial orbit and determine if an Earth impact is possible

Step 4. Continue follow-up of hazardous objects to improve risk assessment and ensure future recoveries

Step 1 – Discover the NEO

- Catalina Sky Survey (CSS) 1.5 m and the Pan-STARRS 1.8 m telescopes are currently the most productive NEO survey telescopes
- CSS does *not* do all of its own follow-up (Step 2)
- Surveys are very effective at discovery, but not follow-up

What Happens After Discovery?



- Confirmation follow-up astrometry next night or two
- Minor Planet Center designates the object and computes its orbit
- Initial risk assessment can be performed

Naming and Numbering Asteroids

- Survey submits discoveries to MPC using its own code number (e.g., TQ1935E)
- MPC computes preliminary orbit and posts it on the NEO Confirmation Page website
- If follow-up confirms it and the error is sufficiently small, MPC "designates" it (e.g., 1999 RQ36 – year, half month period [R], letter in order of discovery during that period [Q], # times used that letter [36])
- When additional observations reduce the errors so the asteroid can be found in the future, it is numbered (e.g., 101955)
- Discoverer has the right to name the asteroid for a period of 10 years (e.g., 1 Ceres or 15522 Trueblood)

NEO Confirmation Page

The NEO Confirmation Page

TQ9135E	95	2	[2012 Aug. 28.1 UT. R.A. = 22 12.3, Decl. = +15 20, V = 18.9]
TQ9151E	78	2	[2012 Aug. 28.2 UT. R.A. = 21 46.5, Decl. = +08 24, V = 20.4]
TQ149C6	99	1	[2012 Aug. 28.2 UT. R.A. = 00 01.8, Decl. = +27 55, V = 17.8]
TQ91389	100	1	[2012 Aug. 28.1 UT. R.A. = 22 01.5, Decl. = +16 59, V = 20.0]
TQ91368	99	1	[2012 Aug. 28.1 UT. R.A. = 22 03.5, Decl. = +13 51, V = 21.1]
P104cGl	56	3	[2012 Aug. 27.3 UT. R.A. = 21 40.2, Decl. = +06 13, V = 20.2]
P104csG	54	3	[2012 Aug. 27.3 UT. R.A. = 22 15.1, Decl. = +02 55, V = 19.9]
P104aTe	55	3	[2012 Aug. 26.3 UT. R.A. = 20 31.9, Decl. = +05 52, V = 20.0]
P104aoQ	65	2	[2012 Aug. 26.5 UT. R.A. = 00 04.7, Decl. = +09 59, V = 21.5]
P104app	51	3	[2012 Aug. 26.5 UT. R.A. = 23 36.1, Decl. = -02 42, V = 21.2]

http://www.minorplanetcenter.net/iau/NEO/toconfirm_tabular.html

Step 2 – Confirmation Follow-up

- Before 2000, several dozen amateurs with the type of equipment shown here provided most tracking follow-up
- New discoveries are fainter and now a small number of astronomers are doing follow-up
- ***We are losing 10-20% of all new NEOs shortly after discovery***

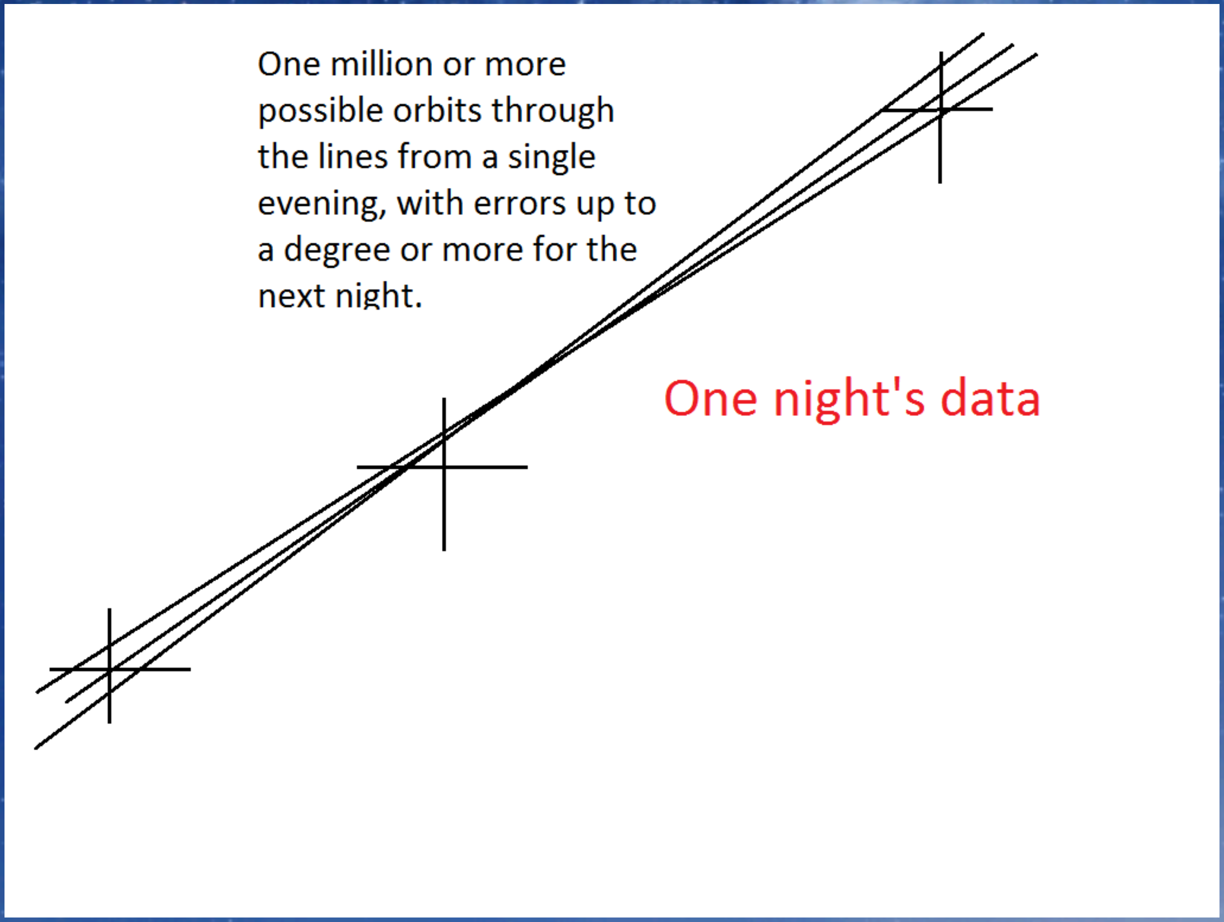
Step 3 – Compute the Orbit

- The International Astronomical Union has located the Minor Planet Center (MPC) at the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA, USA
- The MPC receives observations and posts new NEO orbits each day on the Web; it does excellent and effective work

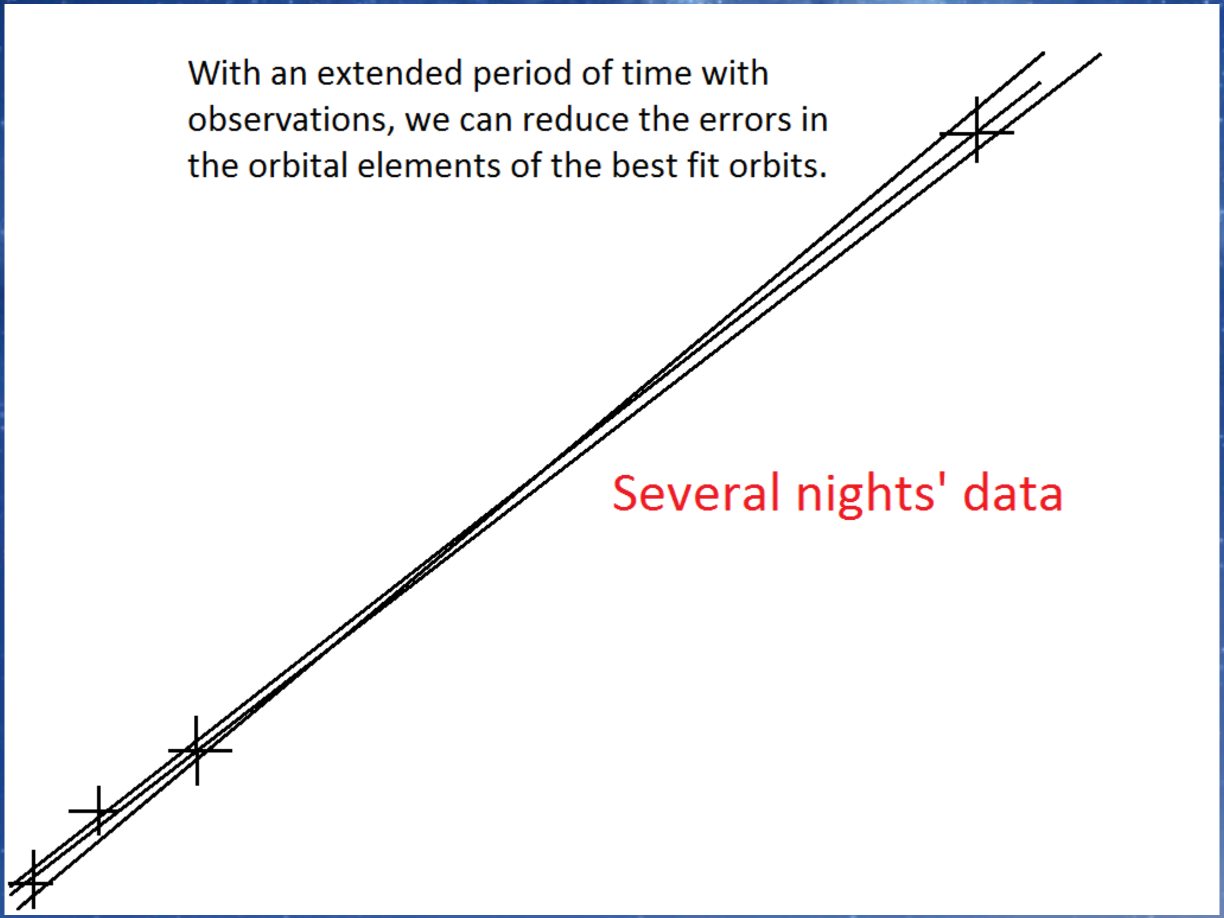
Step 4 – Follow-up Hazardous Objects

- MPC, JPL, NEODyS perform orbit calculations and risk assessments (compute probability of Earth impact)
- Generate millions of Virtual Asteroids, each with an orbit fitting within the observational error bars – on-sky error ensemble resembles an ellipsoid
- Potentially Hazardous Asteroid (PHA) has a Minimum Orbital Intersection Distance (MOID) from the Earth of < 0.05 AU and *absolute magnitude* H < 22.0
- Virtual Impactor (VI) is a PHA with at least one computed orbit through the observational error bars that permits it to intersect the "tube" of Earth's orbit
- Reducing orbital element uncertainty by extending the observed orbital arc tends to rule out potential impacts (so far)

Why Extend NEO orbits?



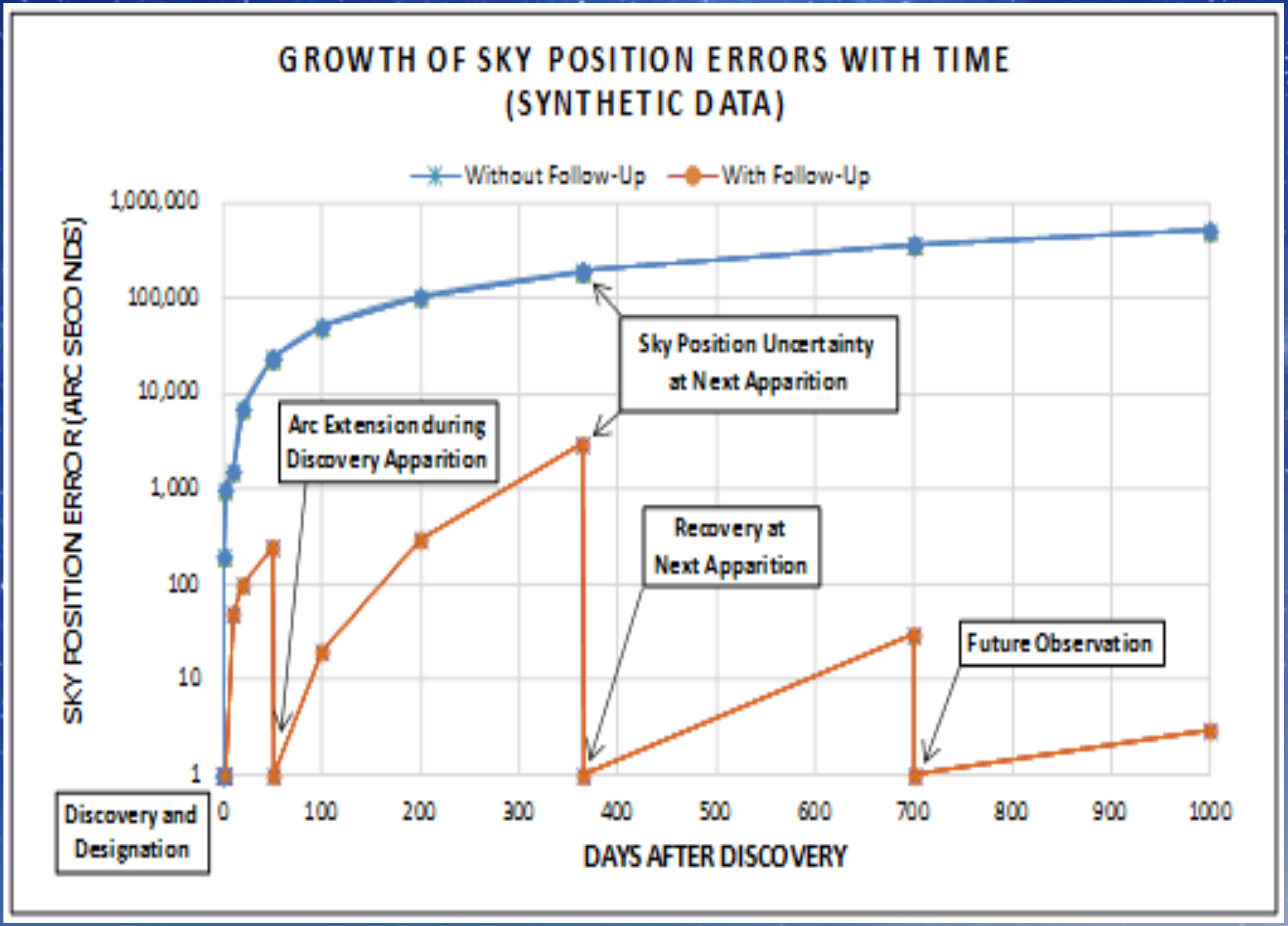
Why Extend NEO Orbits?



NEO Recovery

- Recovery is defined as successfully observing an NEO on a future apparition from discovery
- Apparition is when the NEO is bright enough to observe on a future orbit from discovery; determined by Earth-NEO-Sun angle
- NEOs with, e.g., 1.5-year orbit might have an apparition every 3 years or longer
- Goal of arc extension observations is to enable recovery at the next apparition
- Goal of recovery is to reduce on-sky errors so the NEO is observable for at least a century

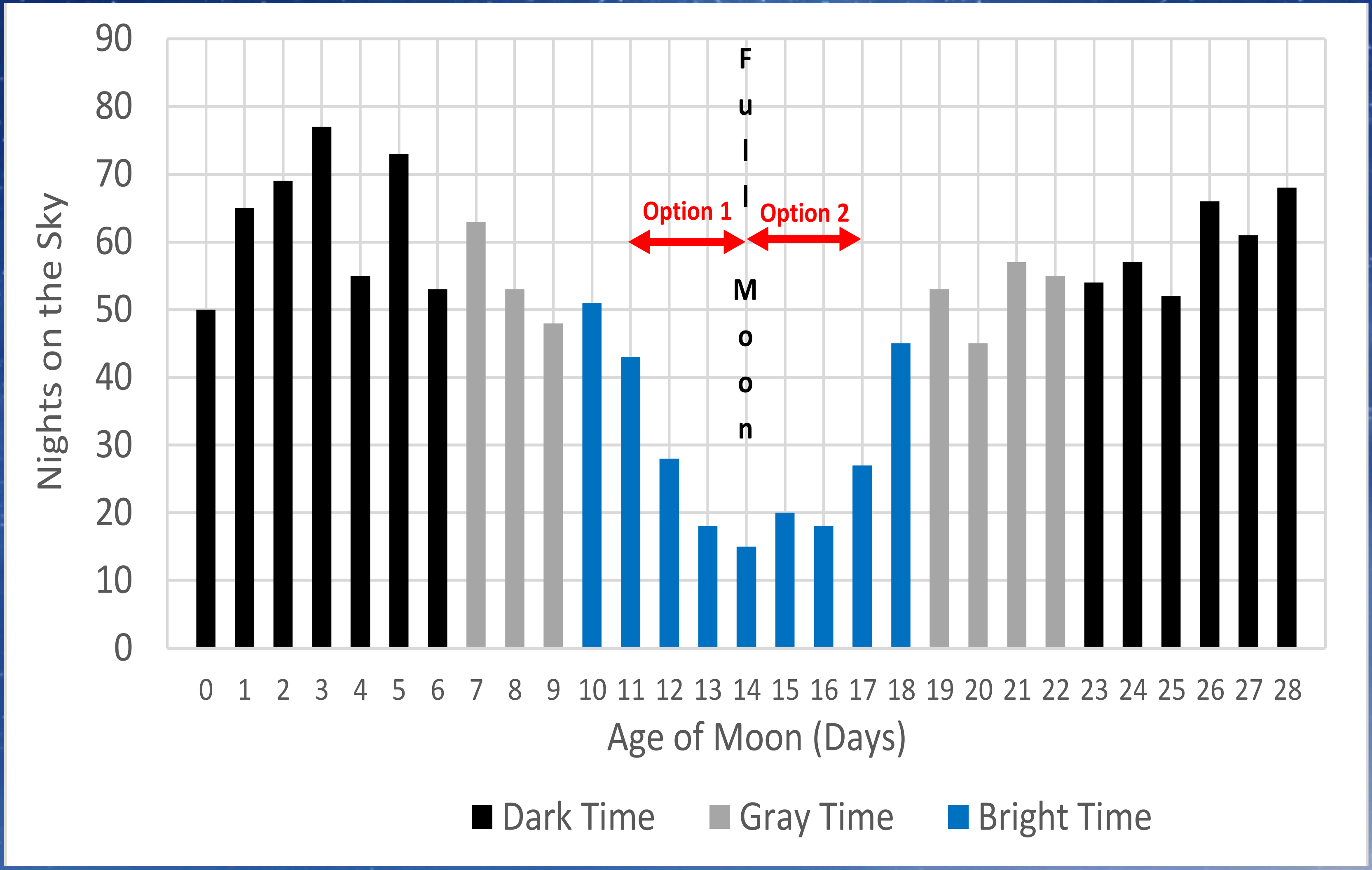
NEO Error Growth with Time



2016 Study by R. Crawford

- Using the NEODyS database, looked at follow-up observations reported for each day of the lunar cycle for 16 months beginning in January 2016
- Included data from the top 19 most active groups
- Concluded there was a gap in follow-up astrometric observations near Full Moon (as expected!)
- This means new objects discovered near New Moon were not being followed up as often as other discoveries

Results of 2016 Study by R. Crawford



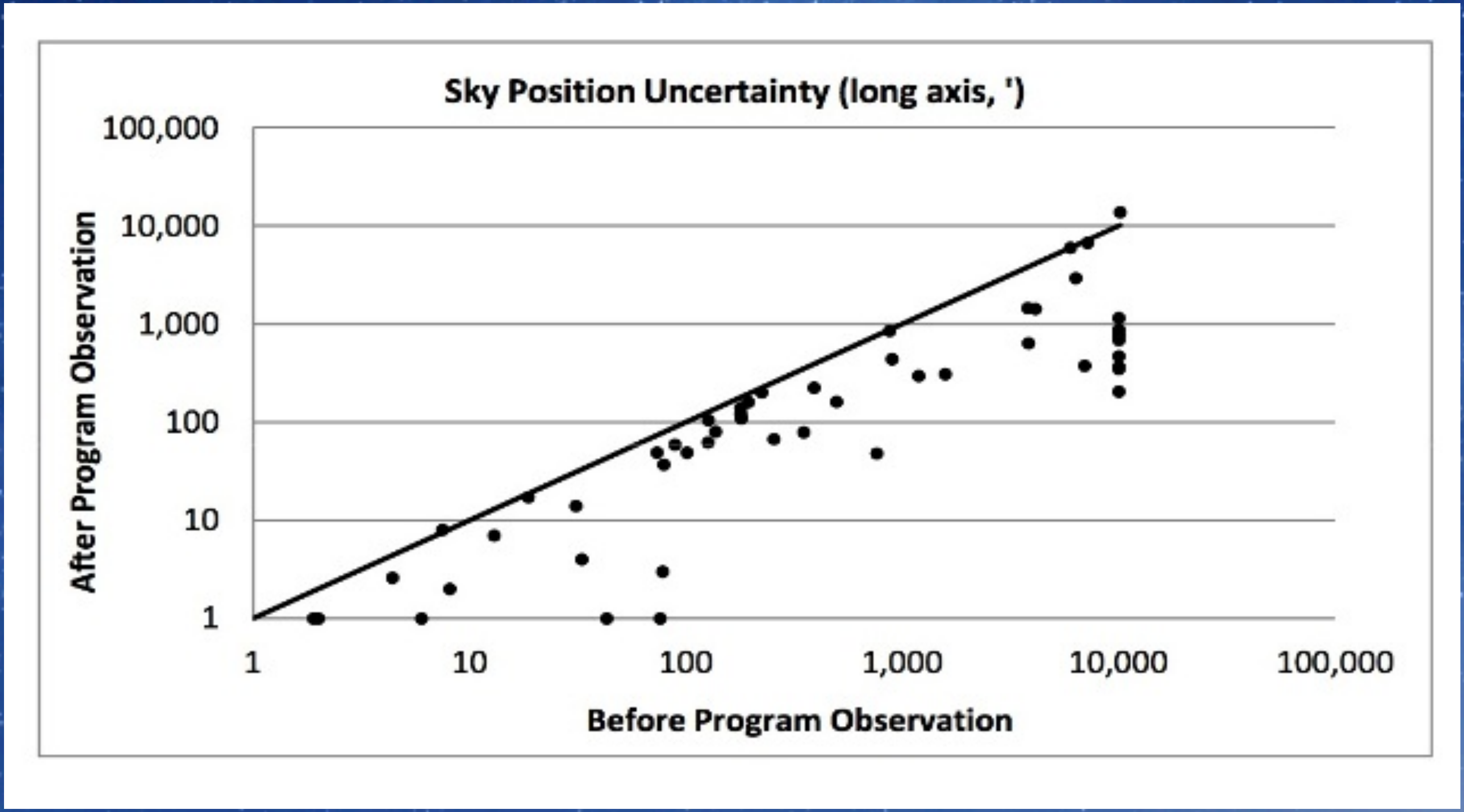
Our Long-Term Follow-up Program

- Use 2-m class telescopes to extend the orbital arcs for previously-discovered VIs and PHAs
- NEOs are brightest at opposition, decrease rapidly (~ weeks) in brightness according to Sun-Object-Earth angle
- Need 2-m (or larger) telescope to find objects 18 < V < 23 moving 0.5”/min to 3600”/min (!) with S/N ratio of 5 - 10
- Most of our targets are 20 – 50 days post-discovery
- Since Nov. 2008, 173 MPECs for 457 objects

Our Long-Term Follow-up Program

- Request 3-night runs spread a lunation apart, to get new objects in need of orbit extension and to recover VIs
- Request time near Full Moon to address an underserved period of time
- Use custom software to select the next target in real time, based on conditions and needs
- Target priorities can vary throughout the night
- Real-time data reduction tells us if we need another image or two
- Send reduced astrometry/photometry that night to MPC
- MPEC might be published that night or next day! (Still deal with “referees”!!)

Our Long-Term Follow-up Program



Reduction in Ephemeris Uncertainty at next apparition for VI and PHA Targets Observed in Semesters 2010B and 2011A.

Vatican Advanced Technology Telescope

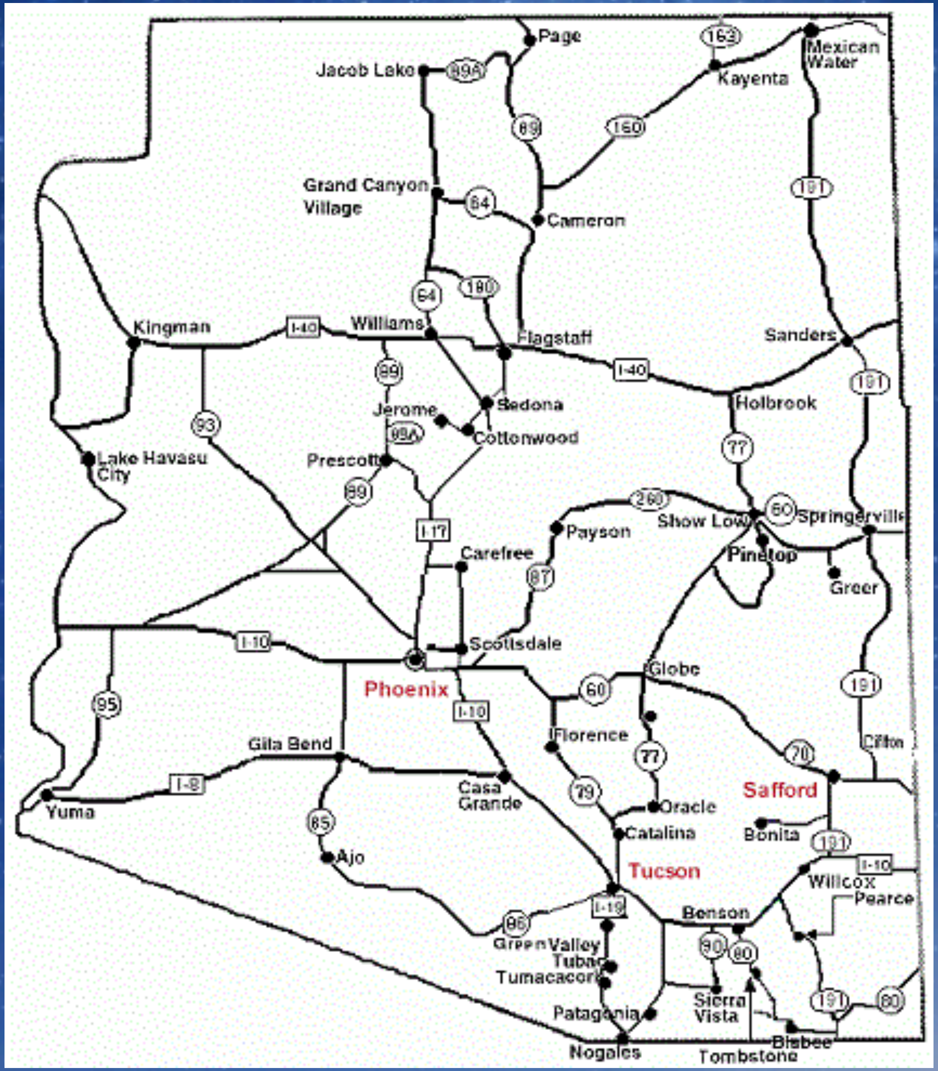
VATT

- Located on summit of Mt. Graham near Safford, AZ
- Altitude of 3178 meters
- VATT seeing often ~ 1.0 arc sec
- Near the 10 m Heinrich Hertz Submillimeter Telescope (SMT) and the 2 x 8.4 m Large Binocular Telescope (LBT)
- These three telescopes comprise the Mount Graham International Observatory (consortium of partners). Support is given by the University of Arizona for operations and staffing.

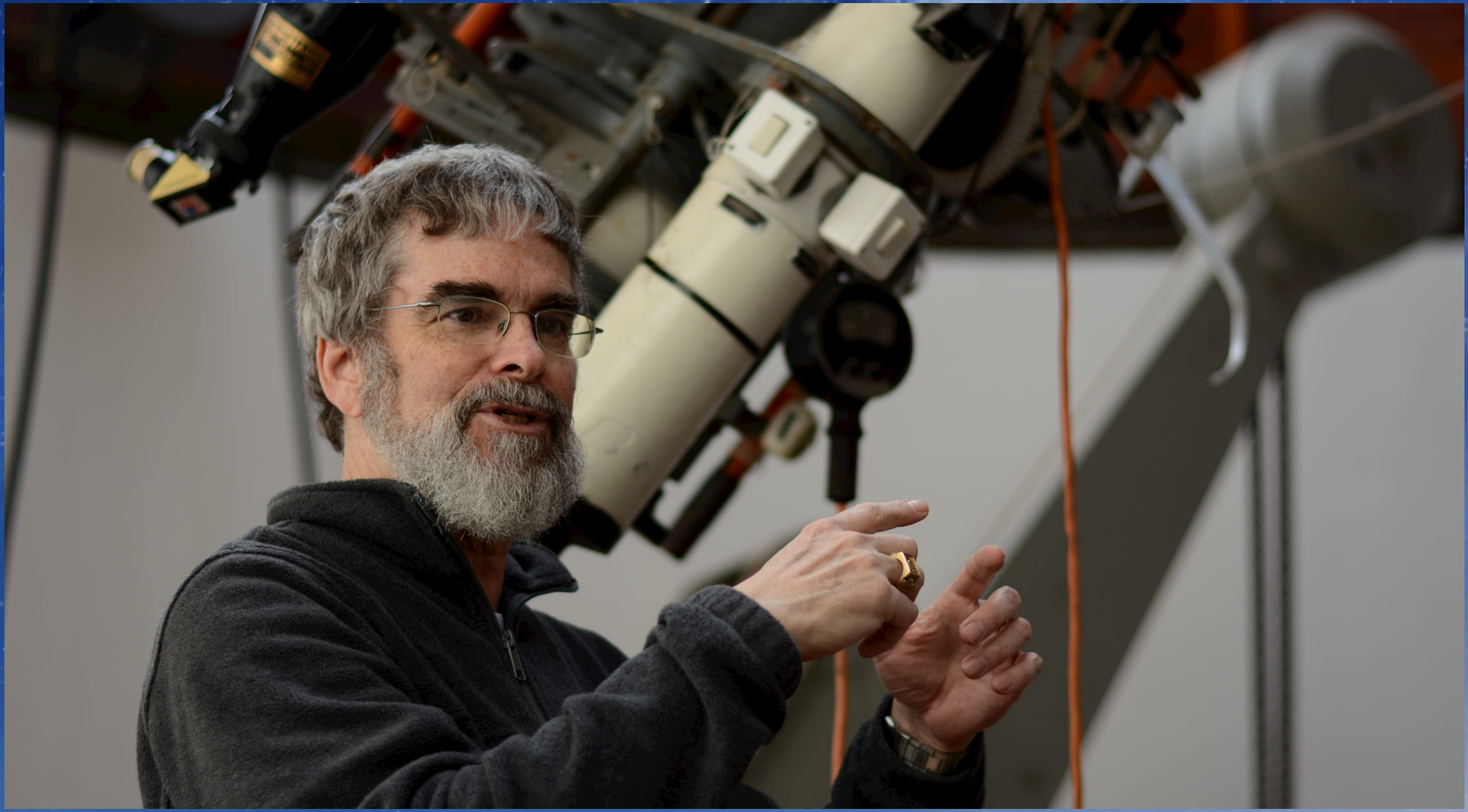
VATT Specifications

- Design:
  - M1: 1.83 m diameter, f/1.0 (Mirror Lab test mirror)
  - M2: 0.38 m, Gregorian gives 16.48 m Efl, f/9 overall
  - Vignetting-free field: 72 mm diameter
  - Image scale: 12.52 arcsec/mm
- Mount: Alt-Az w/ derotator, oil bearing for Az
- Chilled water cooling of M1
- Instruments:
  - 4k X 4k CCD imager
  - CCD visible spectrograph
  - GUFI − Galway Ultra Fast Imager (lucky imaging)

Location of Mt. Graham



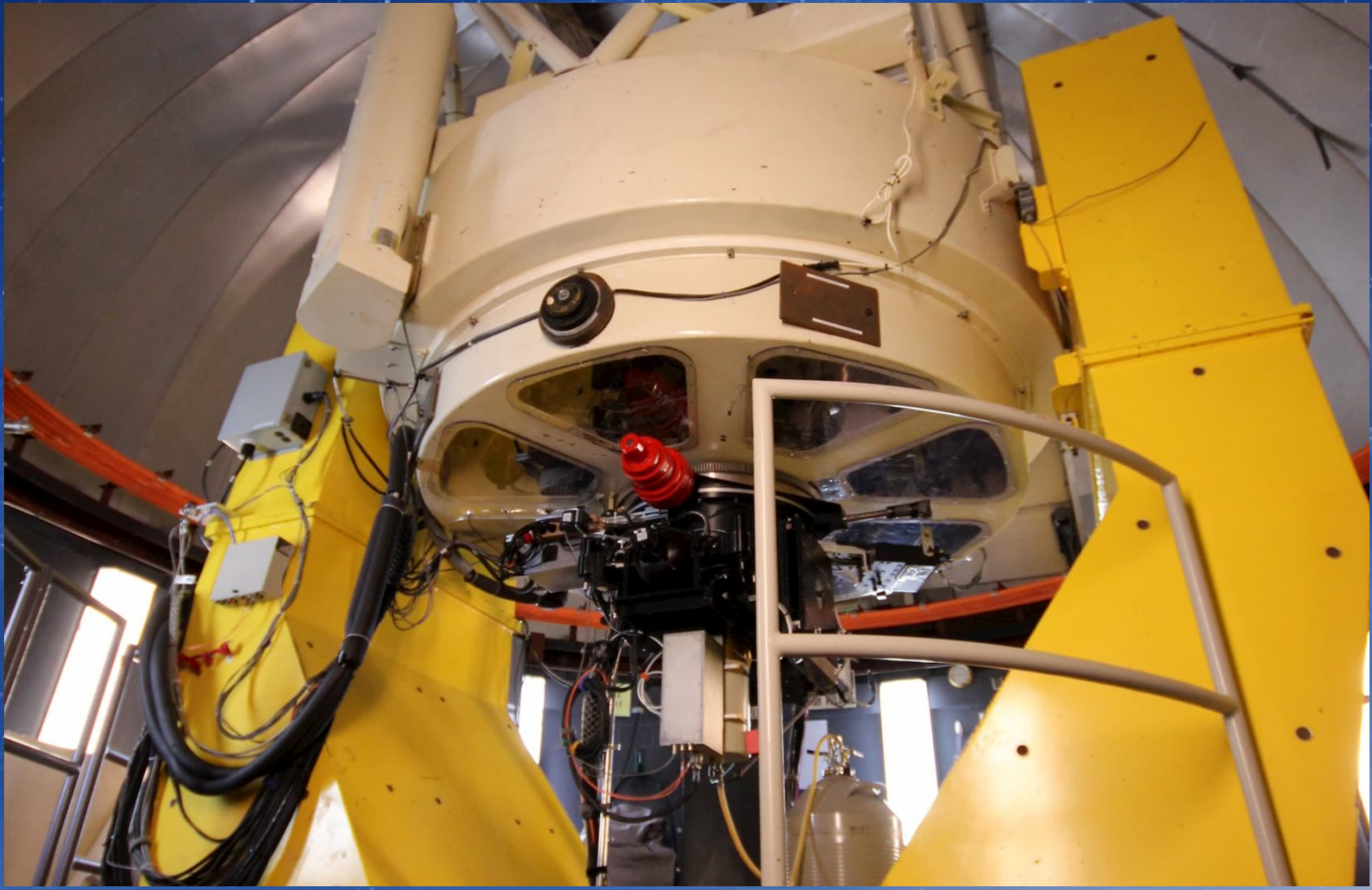
Vatican Observatory Director
Guy Consolmagno



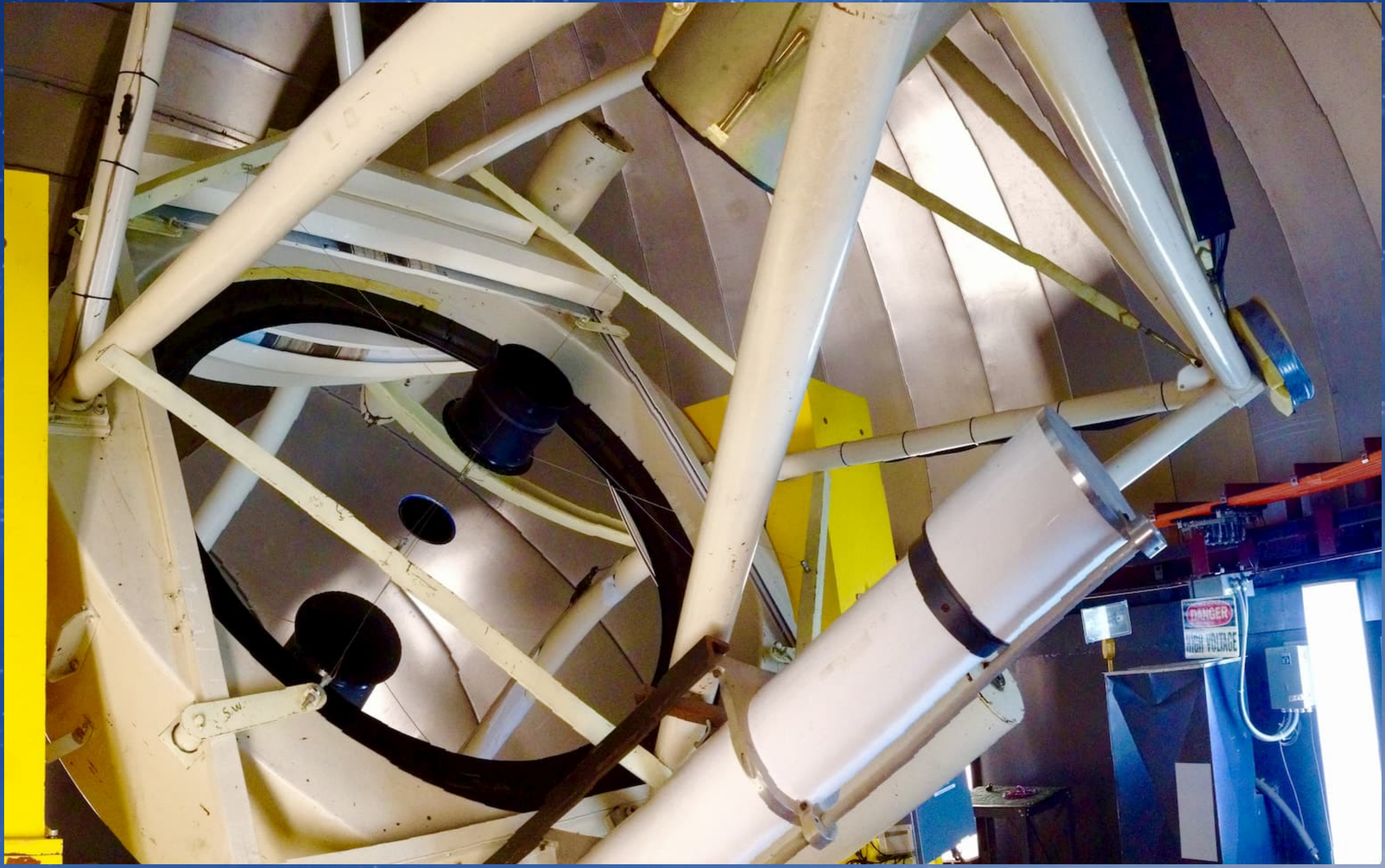
Other Telescopes at the Summit

VATT Enclosure

VATT Showing Alt-Az Mount



VATT Optics



Questions?