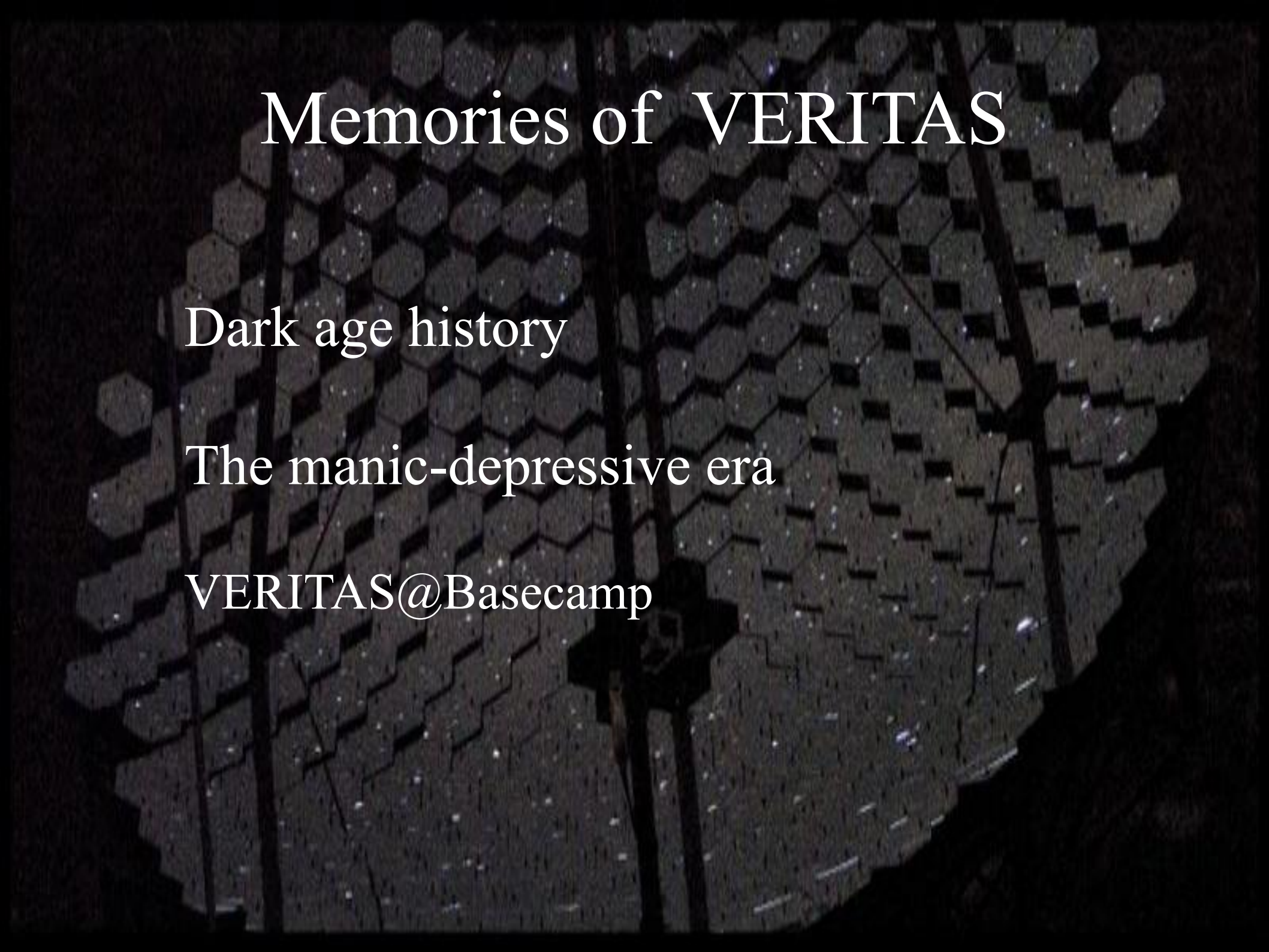


Memories of VERITAS

Dark age history

The manic-depressive era

VERITAS@Basecamp

Pre-IACT (Dark Ages)

Long history exploring various ACT techniques at Whipple starting in 1968 (e.g., double beam, guard ring).

Experiment	Institution	Location	Epoch	Reflector (No. x size in meters)	Field of View (half angle in degrees)	Energy Threshold (GEV)	Technique	Mode	References
E 1	A.E.R.E U.K.	Pic du Midi	1953	2 x 0.61	2.2 4.9	10,000	S	DS	Jelley & Galbraith (1955)
E 2	Lebedev Institute U.S.S.R.	Crimea	1960-64	12 x 1.5	1.75	5,000	S	DS	Chudakov et al. (1962, 1965)
E 3	A.E.R.E., U.K. U.C.D.,Ireland	Glencullen	1964-65	2 x 0.9	2.5	5,000	S	ONF	Fruin et al. (1964)
E 4	A.E.R.E., U.K. U.C.D., Ireland	Glencullen & Malta	1966-70	4 x 0.9	0.5	2,000	PA	DS	Fegan et al. (1968) O'Mongain et al. (1968) Jennings et al. (1974)
E 5	Woodstock College, U.S.A.	Maryland	1966-67	4 x 1.5	7 x 3 (full)	2,000	LDA	TA	Tornabene and Cusimano (1968)
E 6	Smithsonian Institution U.S.A.	Mt. Hopkins (1.2 km)	1967-68	2 x 1.5	0.6	2,000	S	DS	Fazio et al. (1968),1969a,b)
E 7	Smithsonian Institution U.S.A.	Mt. Hopkins (2.3 km)	1968-72	10	0.5	100	S	DS/T	Fazio et al. (1972) Weekes et al. (1972)
E 8	A.E.R.E. U.K.	Harwell	1968-69	2 x 0.9	1.5	13,000	S	TI	Charman et al. (1968) Charman et al. (1969)
E 9	Tata Institute India	Mukurthi (2.2 km) Khandala (0.5km)	1969-70	2 x 0.9	1.5°	10,000	S	TI	Chatterjee et al. (1970) Chatterjee et al. (1971)
E 10	Crimean Astrophysical Observatory U.S.S.R.	Crimea	1969-77	4 x 1.5	0.9	2,000	S	MDS	Stepanian et al. (1972, 1975) Stepanian et al. (1977)
E 11	University of Sydney, Australia	Narrabri	1968-69	2 x 6.5	0.6	1,000	S	DS	Hanbury Brown et al. (1969)
E 12	Smithsonian Institution U.S.A.	Mt. Hopkins (2.3 km)	1970-72	3 x 1.5	0.5	1,000	DB	DS	Grindlay (1971) Grindlay (1972)
E 13	Smithsonian Institution U.S.A.	Mt. Hopkins (2.3 km)	1972-74	1.5 + 10	0.5	700	DB	TI	Grindlay et al. (1976)
E 14	University College Dublin, Ireland Smithsonian Institution U.S.A.	Mt. Hopkins (2.3 km)	1972-73	2 x 1.5	2.5	5,000	S	TI	Porter et al. (1976)
E 15	Smithsonian Institution U.S.A. University of Sydney, Australia	Narrabri	1972-74	2 x 6.5	0.5	200	DB	TI	Grindlay et al. (1975a,b)
E 16	Smithsonian Institution U.S.A.	Mt. Hopkins (2.3km)	1974-75	10	3 x 0.5 7 x 0.5	1,000	S ADA	TI TI	Grindlay et al. (1976)
E 17	Iowa State College U.S.A.	Ames	1975	32 x 0.6	1.2	20,000	S	TI	Erickson et al. (1976)
E 18	Bowie State College U.S.A.	Maryland	1972-75	10 x 1.5	7 x 3 (full)	10,000	LDA	TA	Tornabene (1977)
E 19	Smithsonian Institution U.S.A.	Mt. Hopkins (2.3km)	1974-77	10	10 x 0.5	200	S	MDS	Weekes et al. (1977)
E 20	Tata Institute India	Ootacamund	1976	10 x 0.9	0.5	500	S	TI	Gupta et al. (1977)

1977

Proto-IACT (Archaic Age)

"Gamma-ray astronomy from 10-100 GeV: A new approach," Weekes and Turver, *ESA Recent Advan. in Gamma-Ray Astronomy* (**1977**):

> "... proton induced showers of energy 100 GeV are deficient in Cerenkov light compared with gamma ray showers ... a qualitative description is given of an experiment which ... would use [] **two parallel large reflectors each equipped with multiple detector channels to provide two images of the shower** in Cerenkov light."

Ted Turver (Durham) developed a series of telescopes utilizing the "Three Fold Coincidence" approach. The Mark 6 incorporated two 19 pmt outer "cameras" and a central 109 pmt "camera" but **did not apply** imaging technique.

Trevor obviously went the other way

Classical Age

By Fall of 1984 at Whipple:

- UCD had constructed a 37-channel camera electronics package, Whipple assembled a 37-pmt camera and "computerized" the 10M tracking system
- Hillas had largely completed his simulations
- Hercules X-1 and Cygnus X-3 seemed both to exhibit periodic signals, but these results did not improve with imaging cuts

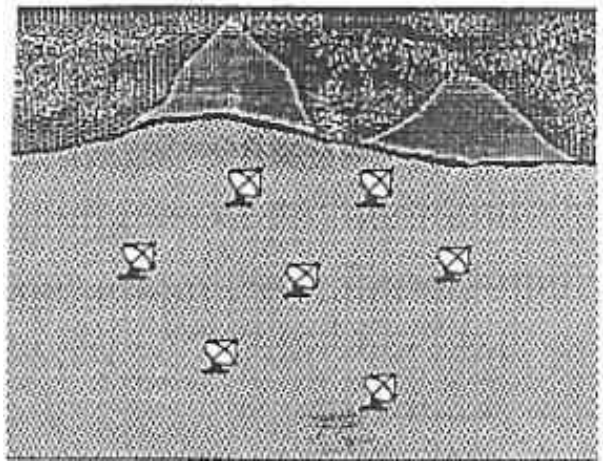
veritas?

"A Third Generation VHE Gamma-Ray Observatory," Weekes, *Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era* (**1984**):

> "The **discovery that Cygnus X-3 was a source of gamma rays** at energies ranging from 10^{12} to 10^{16} eV is probably the most significant observation in cosmic ray astrophysics in the past decade ..."

and went on to propose "veritas":

> "... seven 10 - 15 m aperture optical reflectors ... Each reflector is equipped with a camera similar to that currently in use at the Whipple Observatory."



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by the end of 1986:

- "pedvar" method of image cleaning (skypeds) and improved calibration developed and a ~5σ result from the Crab Nebula emerged

in 1989:

- New electronics, plus new data, produced the >9σ Crab result and publication

"What next?" conference at Palaiseau

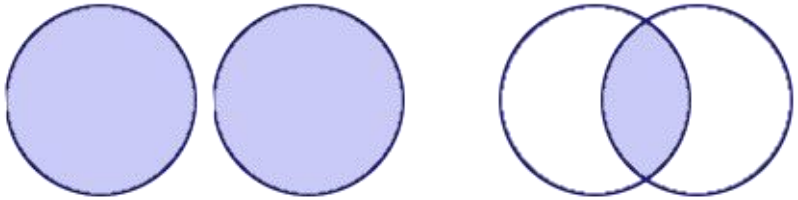
In 1992:

- Fleury and Vacanti kicked-off a series of "where to from here" conferences
- HEGRA (and Whipple via the 11 M) were investing in stereo imaging
- Markarian 421 discovered as the first extra-galactic source

Roaring `90s

- More "future" detector conferences in Calgary, Tokyo, Padova, Kruger, Salt Lake City
- More galactic and extra- galactic sources discovered, and "markarian" sources observed to be "flaring"!
- Non-imaging techniques explored: fast timing, lateral light distribution, three-fold coincidence — none proved particularly effective
- In `96 HEGRA demonstrated stereo imaging with a 4 σ Crab detection

"An interesting question is by how much the net performance of a telescope system is improved using the stereoscopic reconstruction technique, compared to an individual operation and analysis of each telescope. Based on the present analysis, it is however not possible to conclusively address this issue."

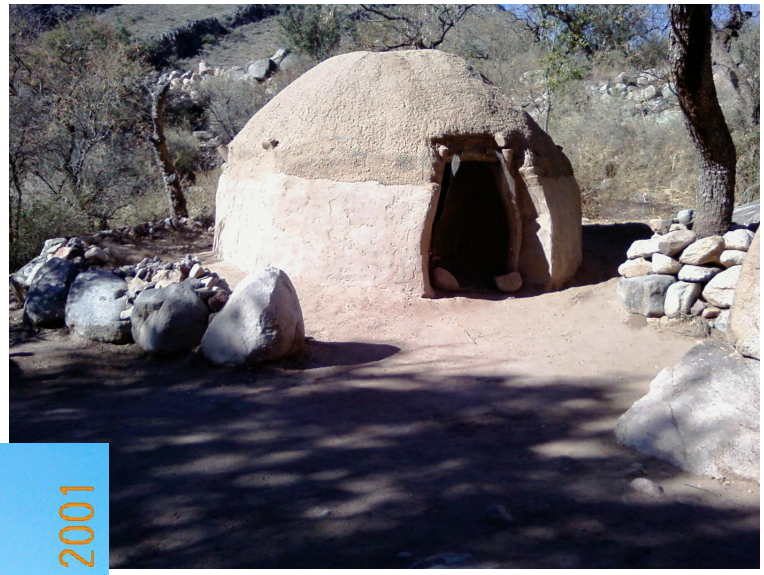


proto-VERITAS

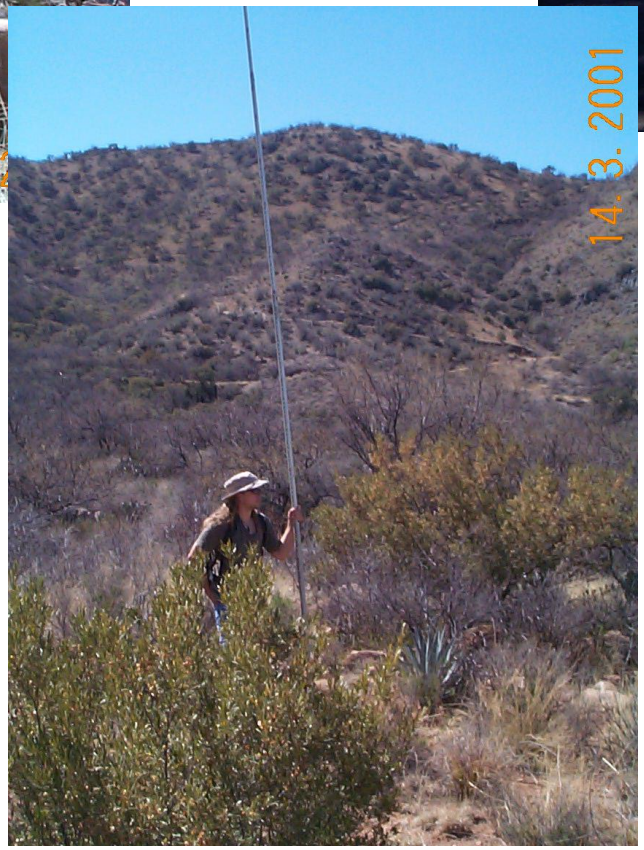
- In `96 Trevor called for interested parties to join the Whipple Collaboration (still only ~10 members)
- Steve Criswell joined as Project Manager in `97, and the first siting meetings were held with the USFS
- Whipple attracted a whole slew of well qualified grad students and postdocs and new collaborating institutions
- In August `99 Mike Catanese was hired by SAO as a Physicist (and as VERITAS' de-facto Deputy PM)
- Proposal completed: technical details (camera, DAQ, trigger, etc.), division of responsibilities as sub-projects, project management (VEC, TAC, PO), etc. ...
- In August 2000 Mike lured away by the "fintech" industry
- In October 2000 Trevor suggested I submit my CV for DPM position

FLWO Basecamp

Montosa Canyon

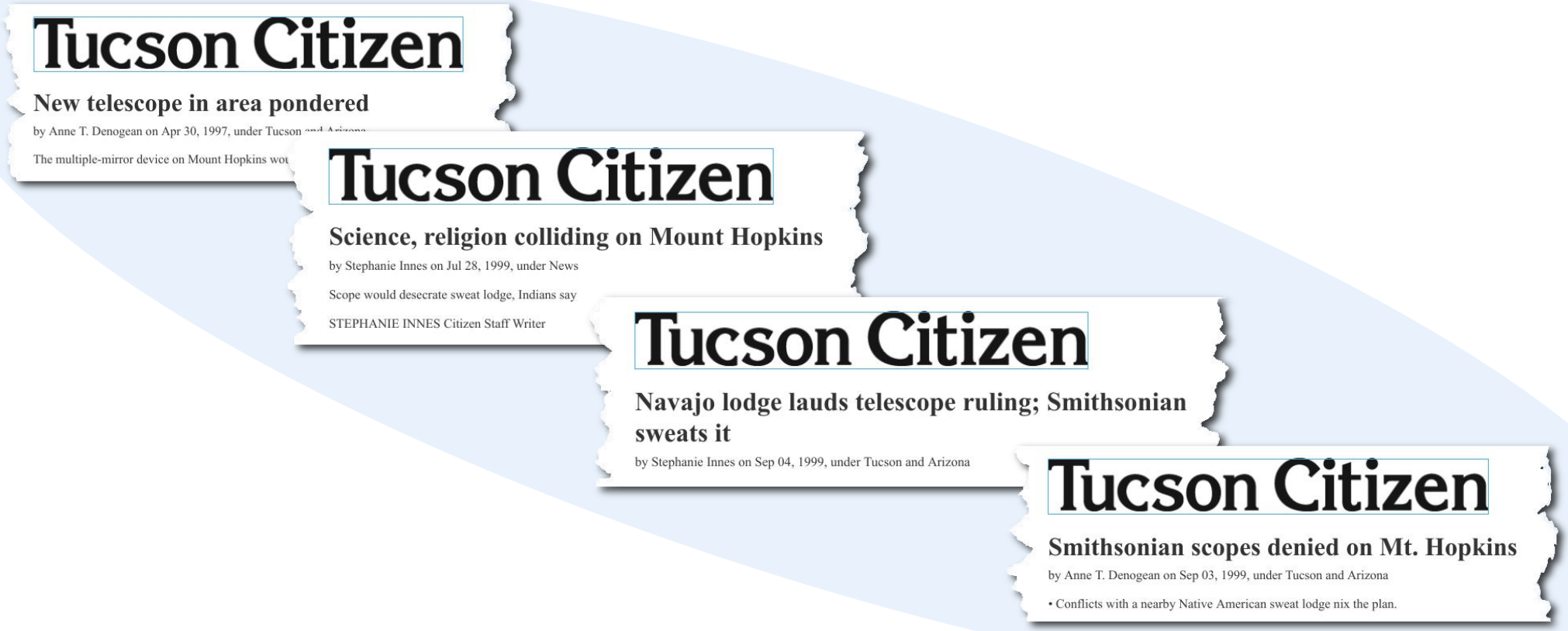


TAOR Sweat Lodge

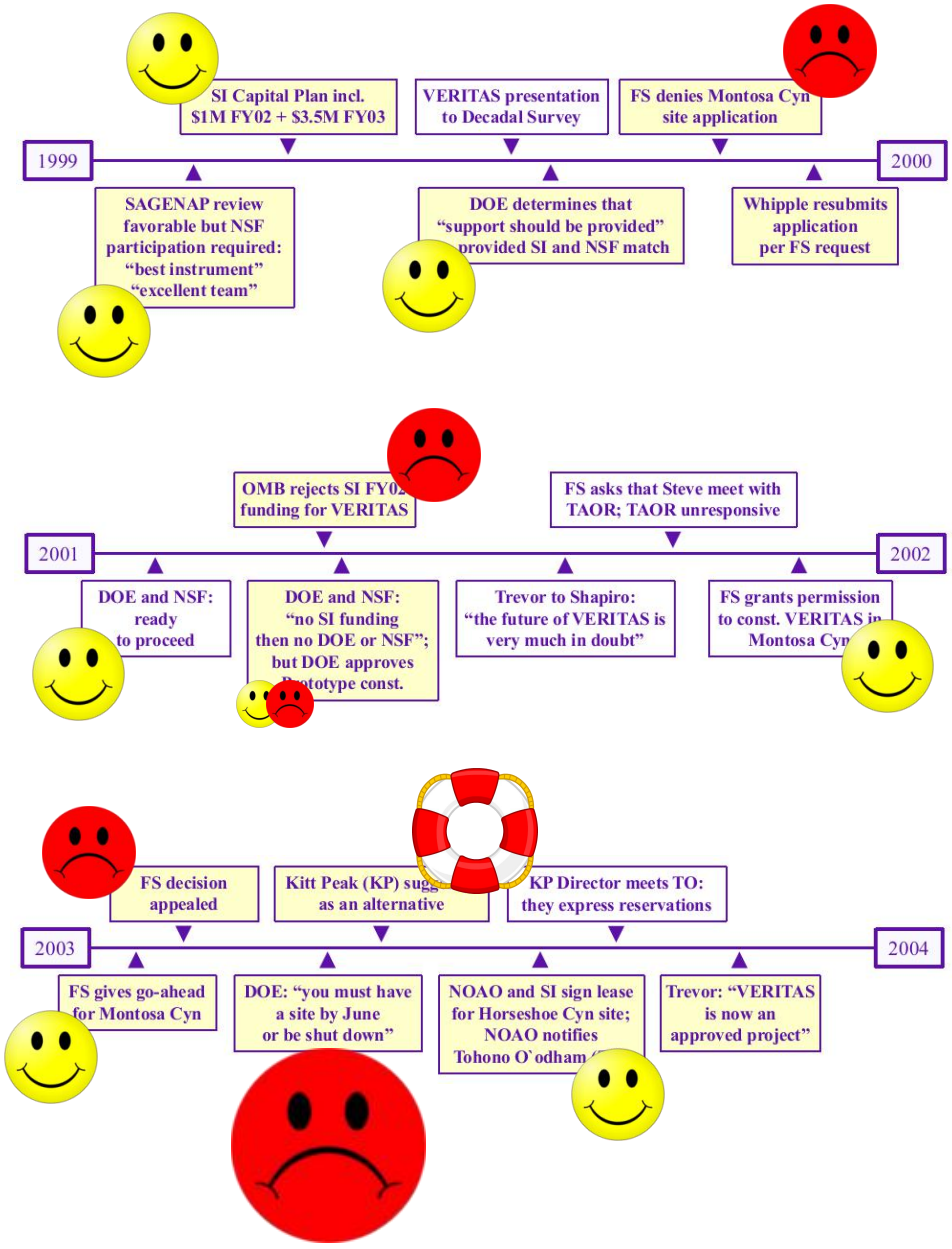


Can you see me now?

Fair and Balanced - Not especially



The "manic-depressive" phase



Horseshoe Canyon (Kitt Peak)

Horseshoe Canyon

Horseshoe Canyon

Horseshoe Canyon

Fair and Balanced - Not especially

Tucson Citizen

New Kitt Peak scopes to study origin of cosmos

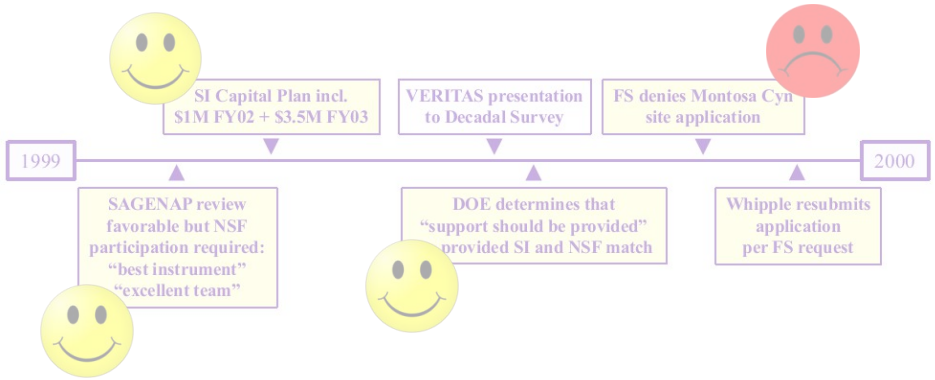
by Larry Copenhaver on Aug 18, 2004, under City/State

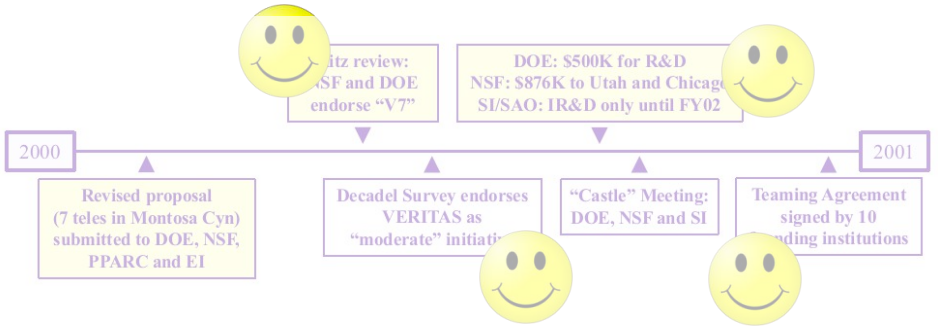
Tucson Citizen

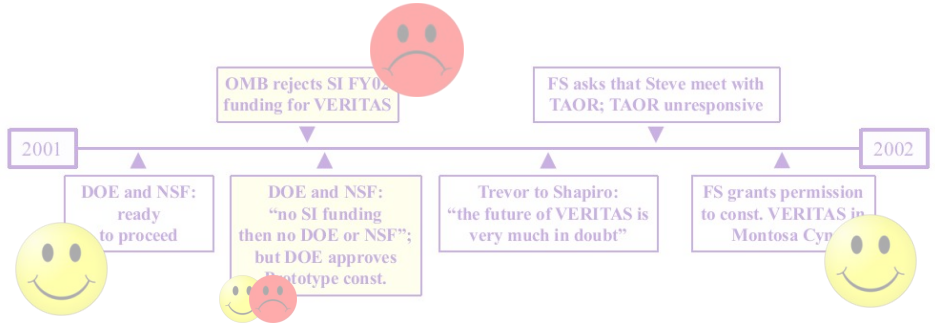
Tribe sues to stop telescope

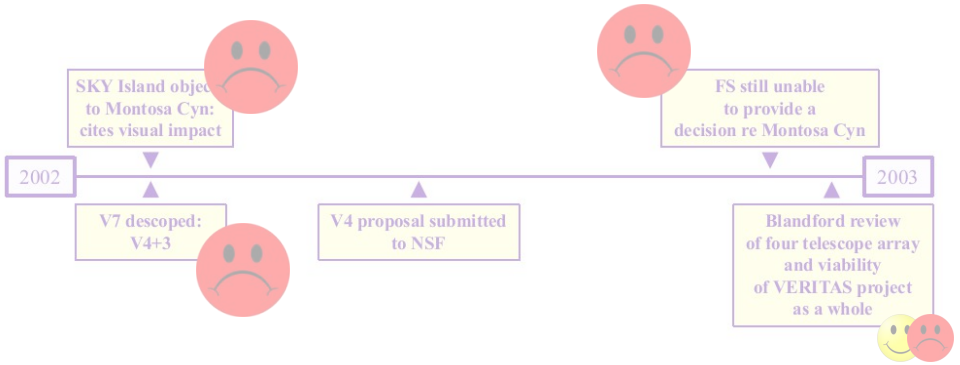
by Paul L. Allen on Mar 24, 2005, under News

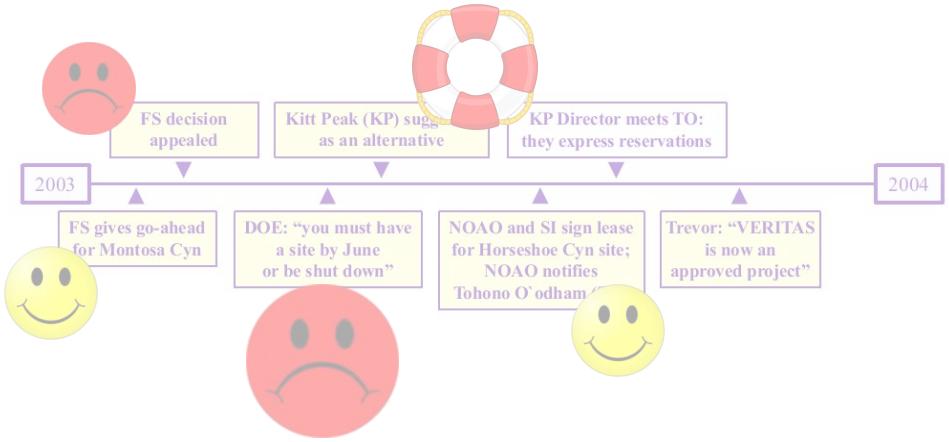
The "manic-depressive" phase

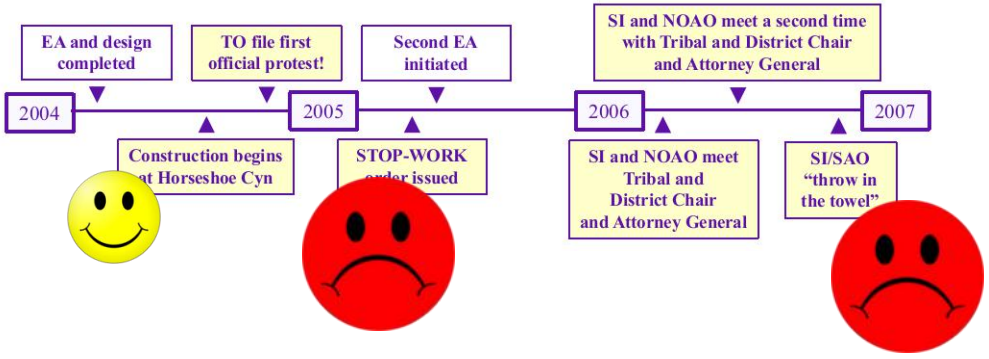




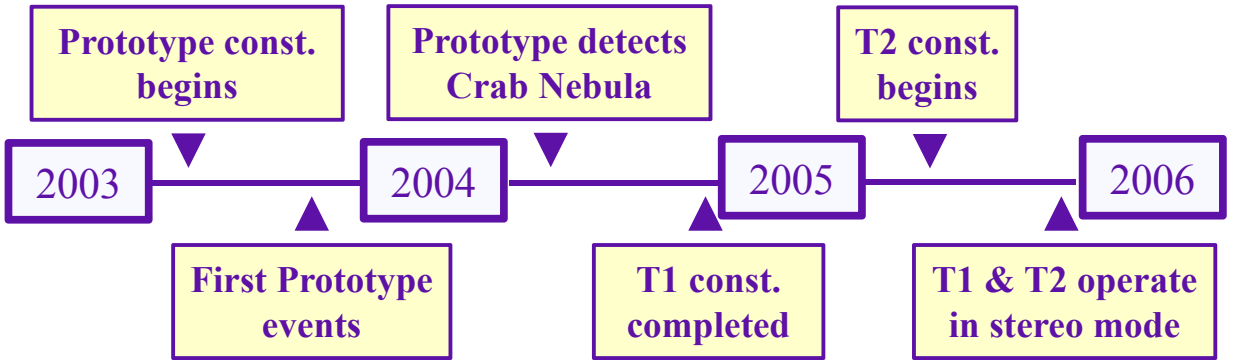




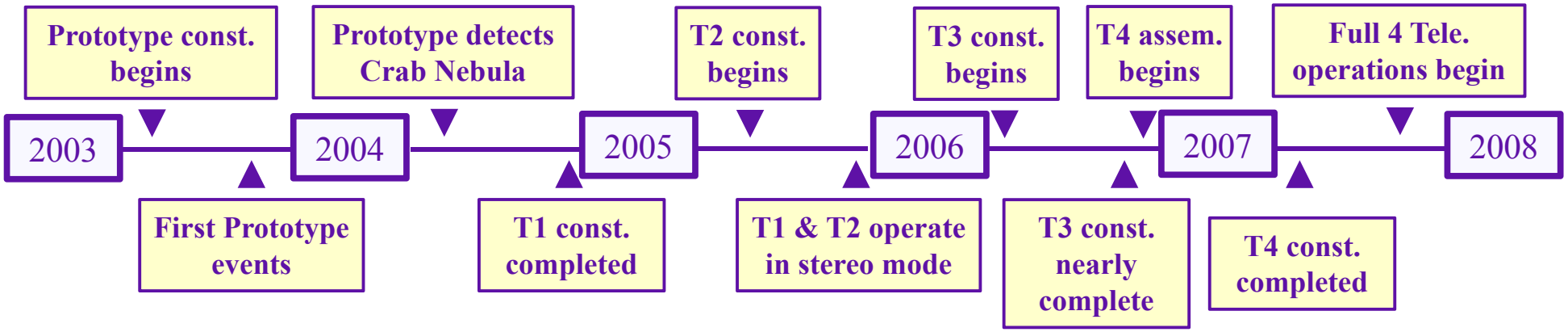




VERITAS@Basecamp

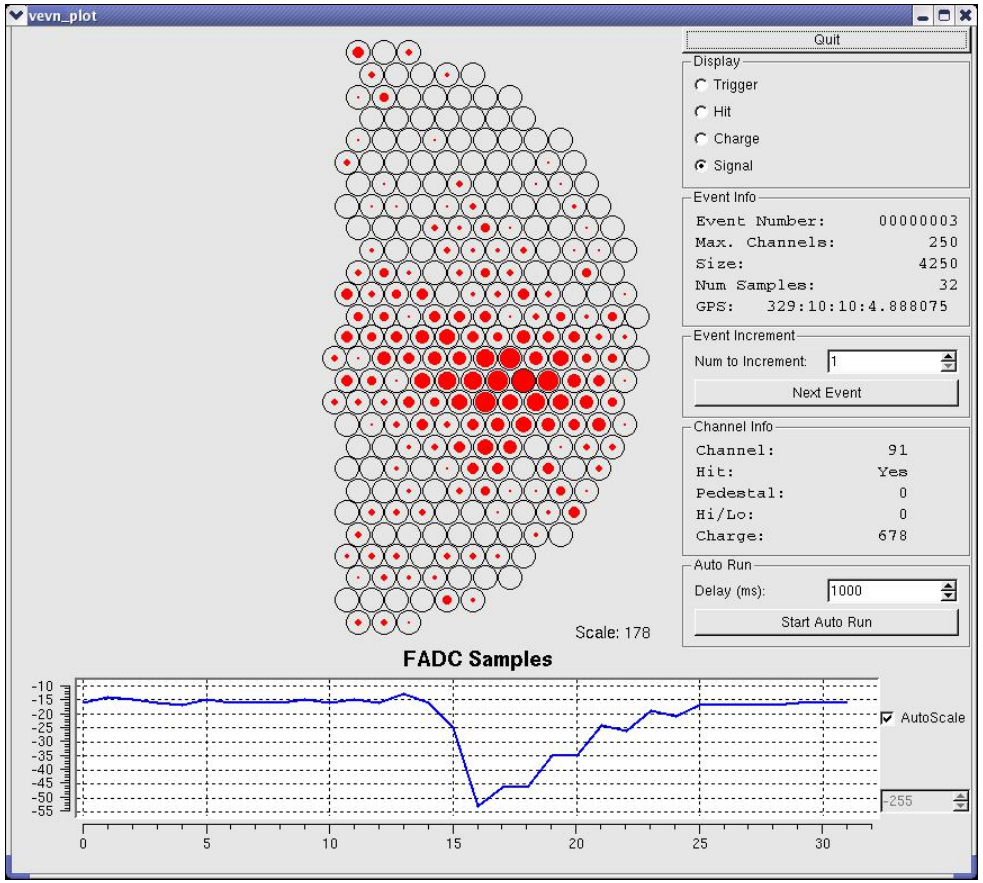


VERITAS@Basecamp



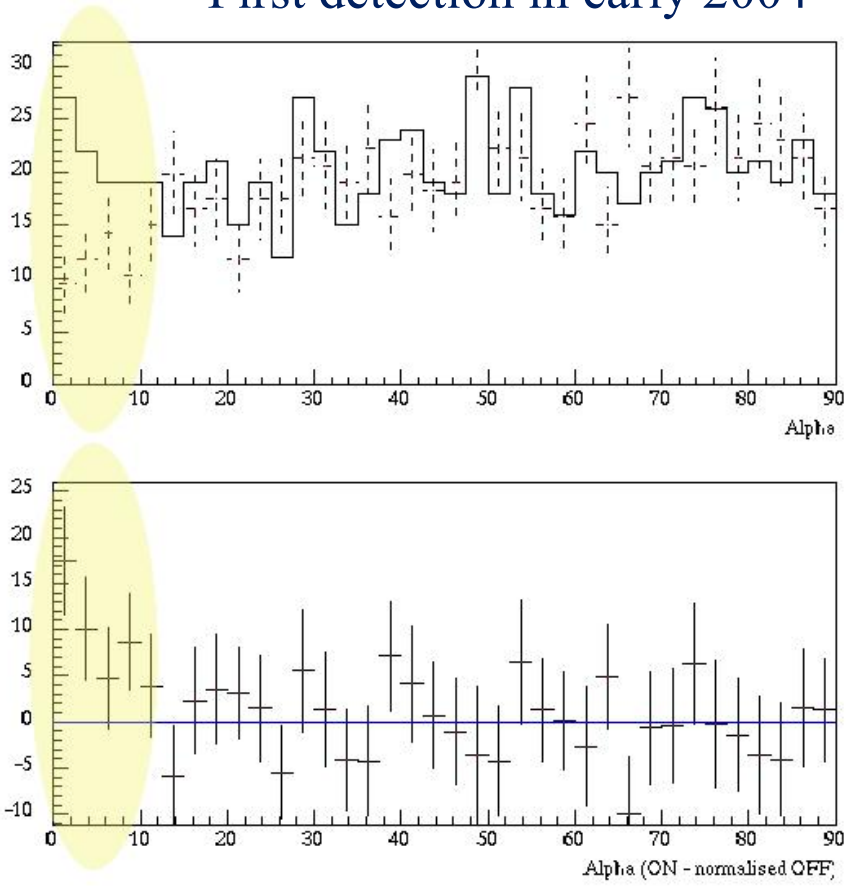
Camera (dis)assembly?

A glass half full!



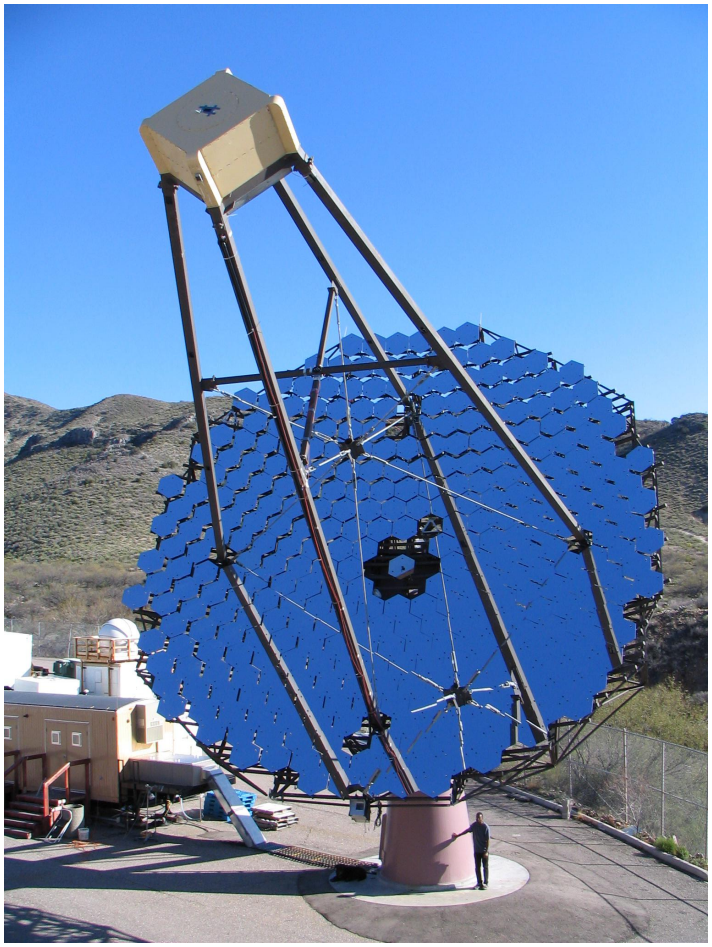
First events in Fall 2003

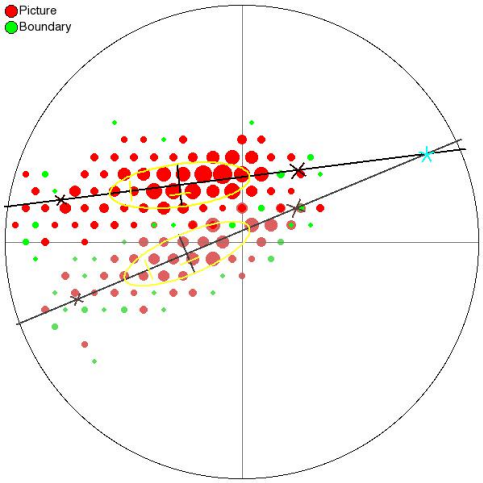
First detection in early 2004



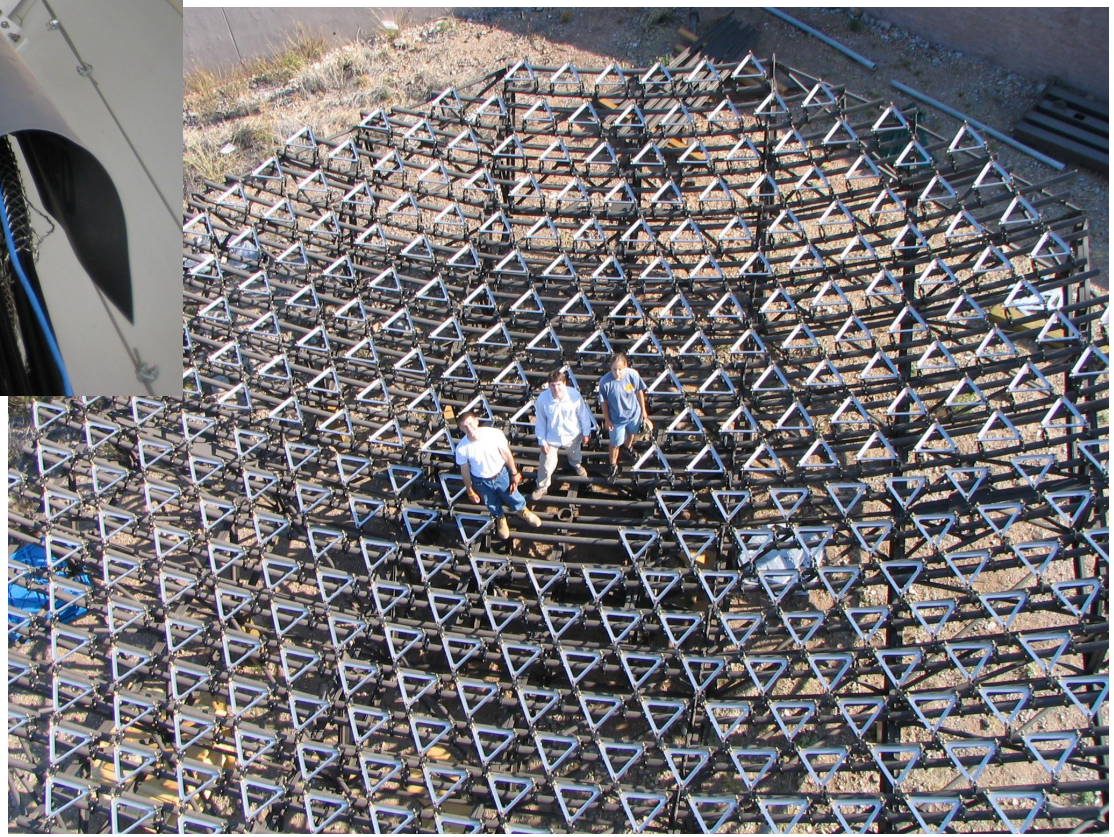
Not always a dry heat

One telescope is no array (e.g., no L3)





Not a barrel of laughs!



"T2" Crew

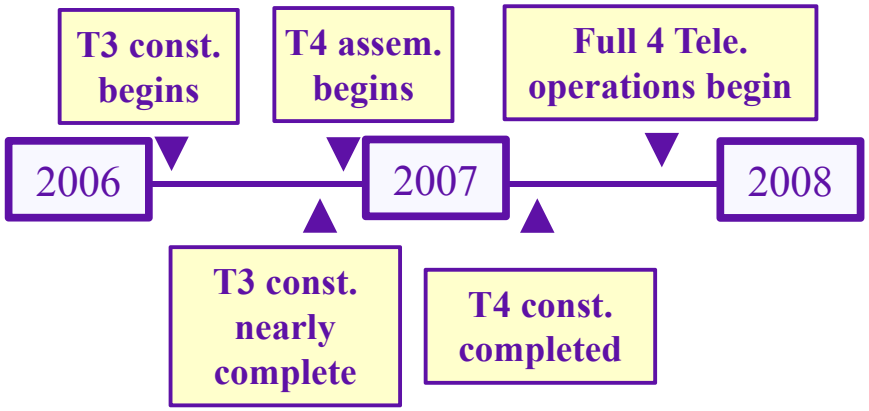
Required frequent BBQs ...

... and hikes

Relatively smooth sailing ...

- Solid relationships between Trevor, the VEC chairperson, and the three funding agencies (DOE, NSF and SI); and between Steve and the Forest Service and SI in DC
- Agency program managers were supportive despite VERITAS' square peg in round hole nature, and the site saga
- Sub-projects clearly delinated in the VERITAS proposal (not too much stepping on of toes or finger pointing)
- Sub-project leaders delivered on time and on budget without too much whinging (except perhaps the budget bit)
- Mostly good participation in the unglamorous "grunt-work" by members of the collaboration, and others (notably Kieda's crews)
- Expertise and "all hands" effort by Whipple Observatory's Support staff (esp. Danny, Cesar, Tom and Grace++)

Things look grim ...



In Fall 2006 **no one** was happy: Not the Tohono O'odham, not the funding agencies, and not the Collaboration.

- Sunk cost in Horseshoe Canyon
- Operations proposal called for operations at Horseshoe Canyon (i.e., relocate T1 and T2)
- TO Tribal Authority not swayed by legal and other arguements
- Questions whether Basecamp could be a suitable site

T3 from bare dirt ...

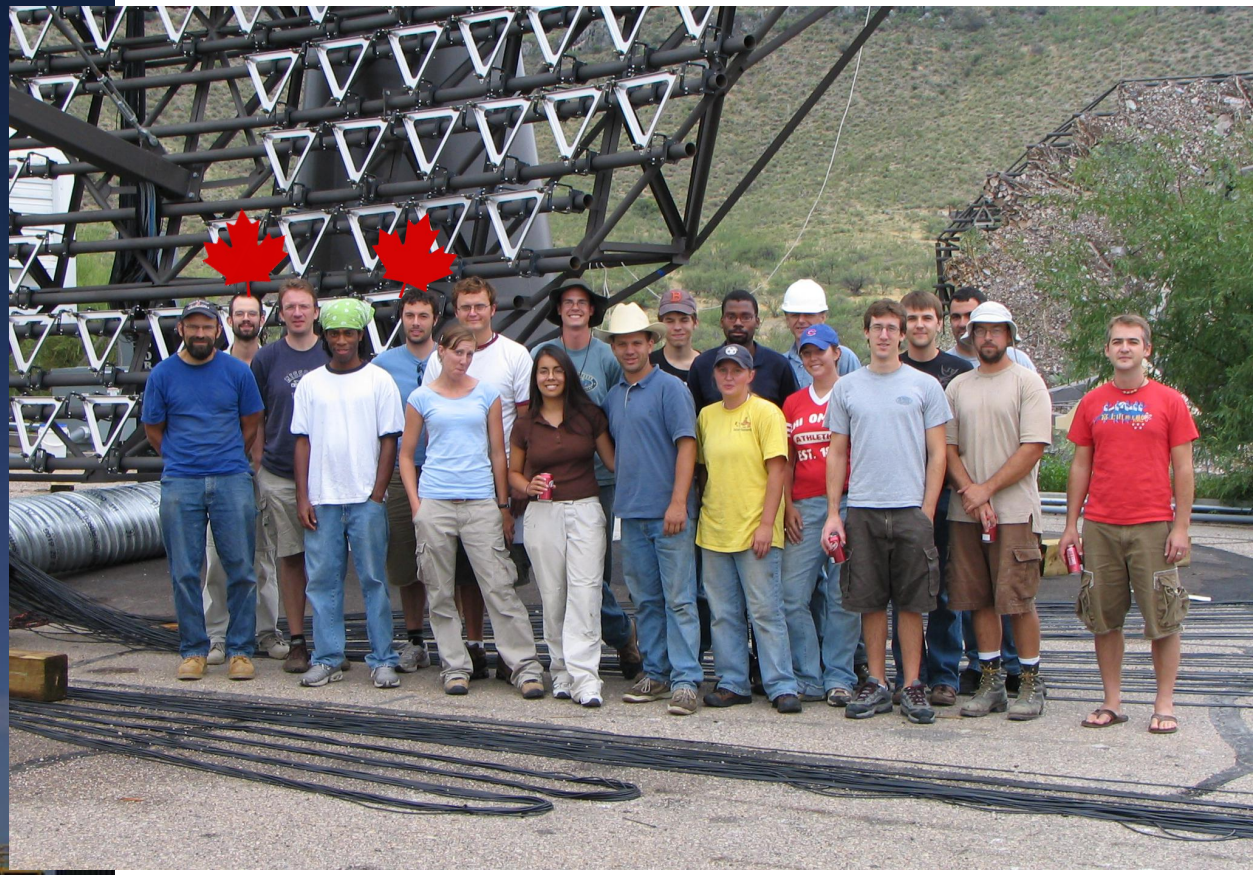
... to finished in ~ 6 months

Required lots of hustle

~10 am

~12:00 pm

T4: more of the same



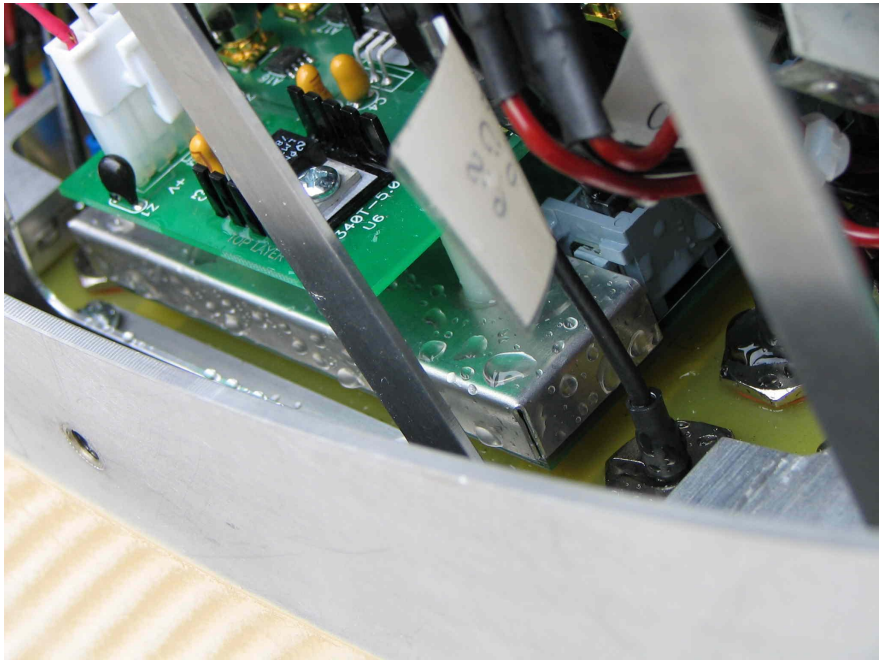
Utah Crew, a couple from north of the border and the usual Whipple suspects

Not quite so orderly

Not always smooth sailing!

Hardware (mostly commercial) and software/operations failures:

- Crate power supplies repeatedly failed (faulty Wiener engineering)
- Heat load requires complicated cooling system and care when operating (overheated T3 nearly lead to heart failure, scripts are your freinemy)
- In attentive operators, e.g., sending a telescope to stow even though it doesn't know where its pointing (trust but verify)
- Leaky cameras (won't mention shutter)



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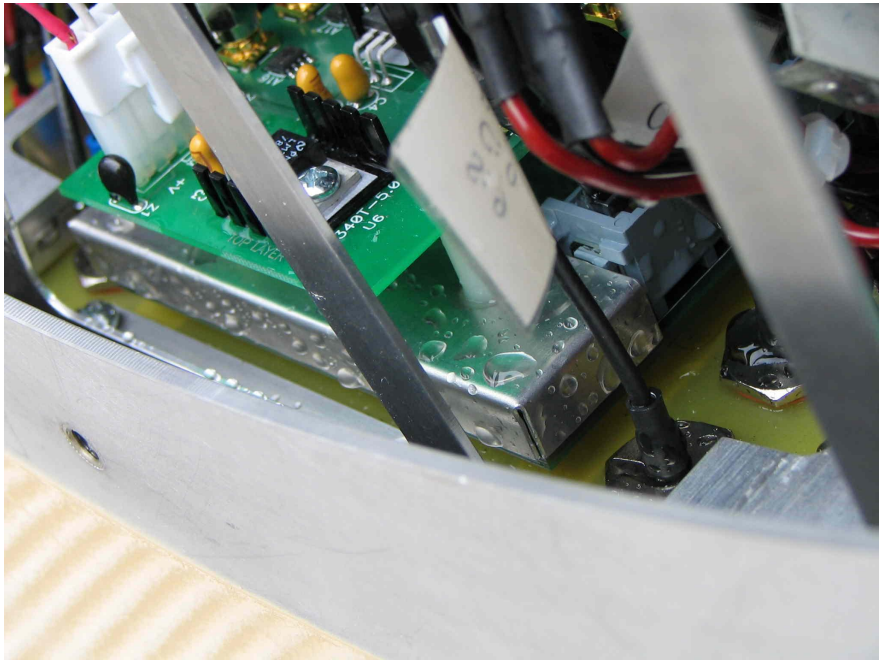
- Leaky cameras (oops)



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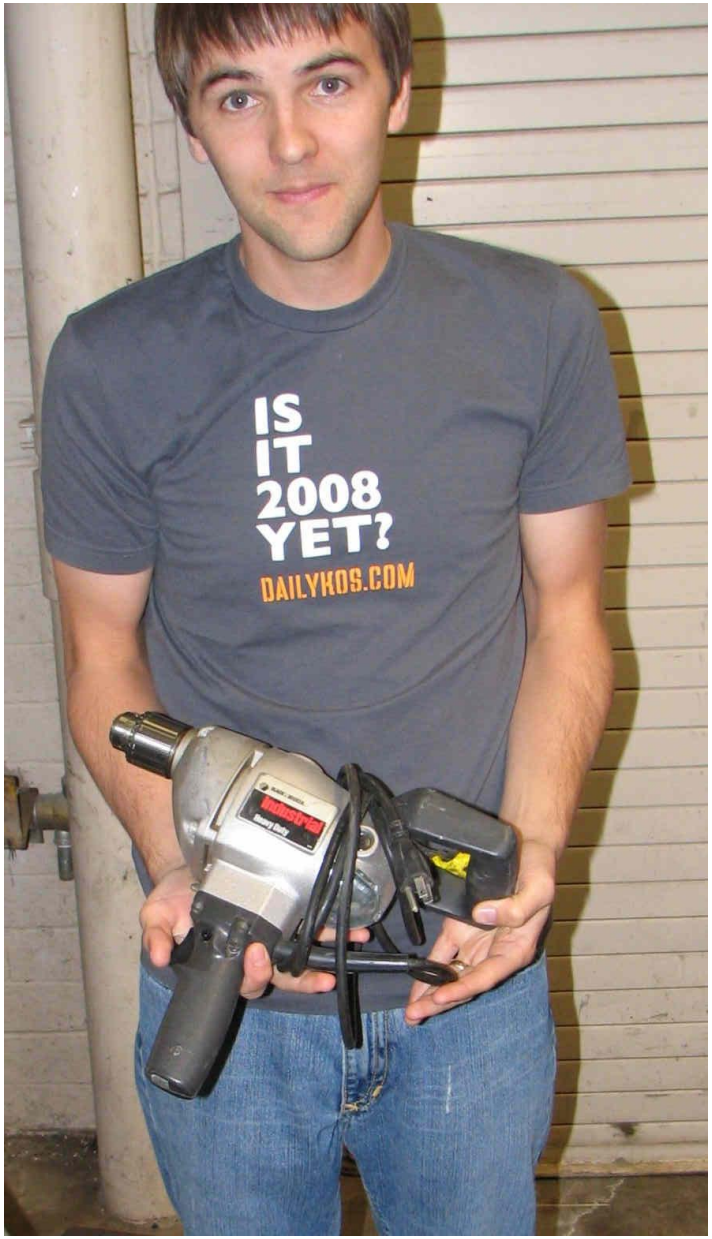
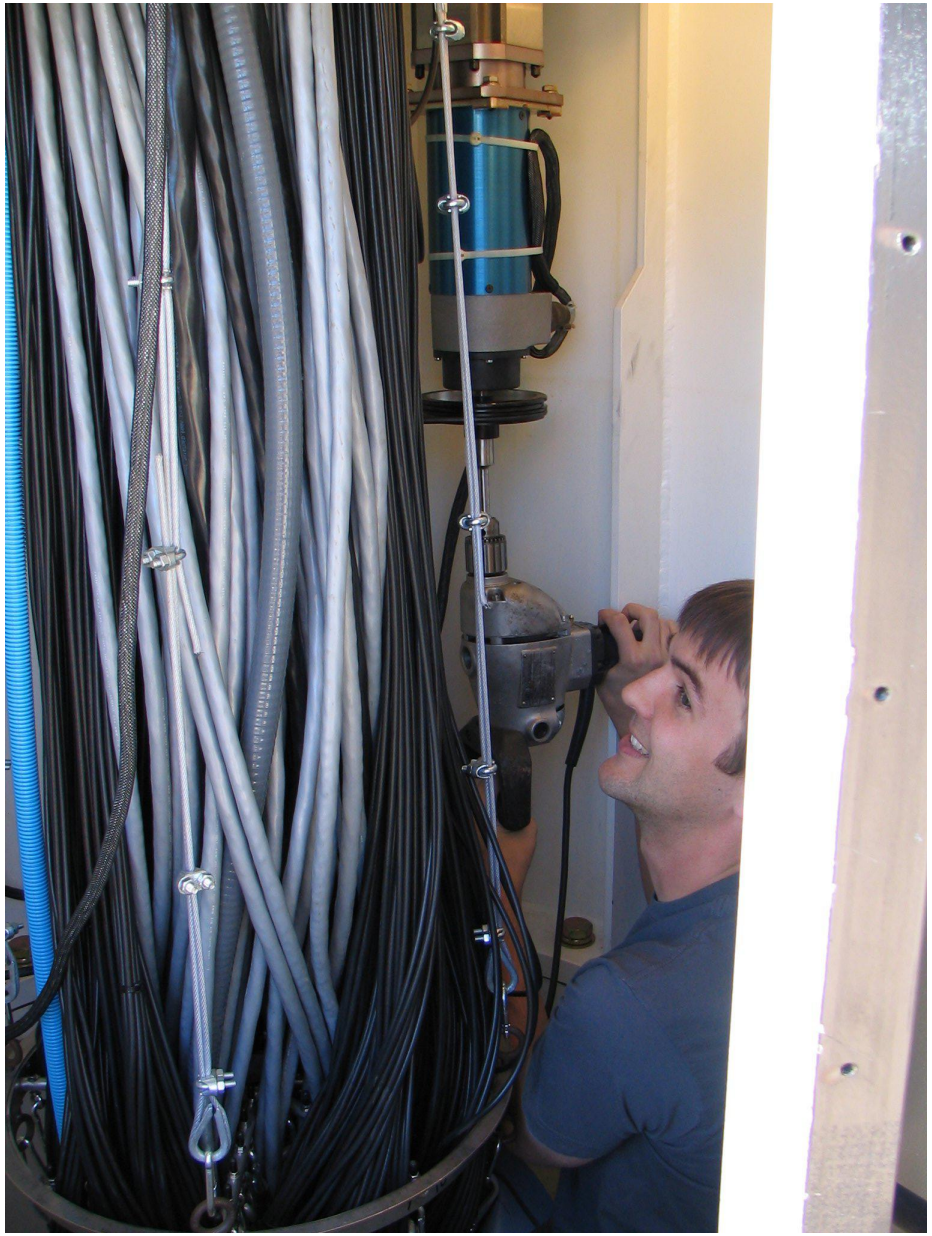
- Leaky cameras (oops)

Dreaded 3AM calls ... "The telescope is stuck!!"

- **busted brake**
- **"torqued" cable drape**
- **bad power-amp, servo board, encoder, ...**

... almost looks fun!

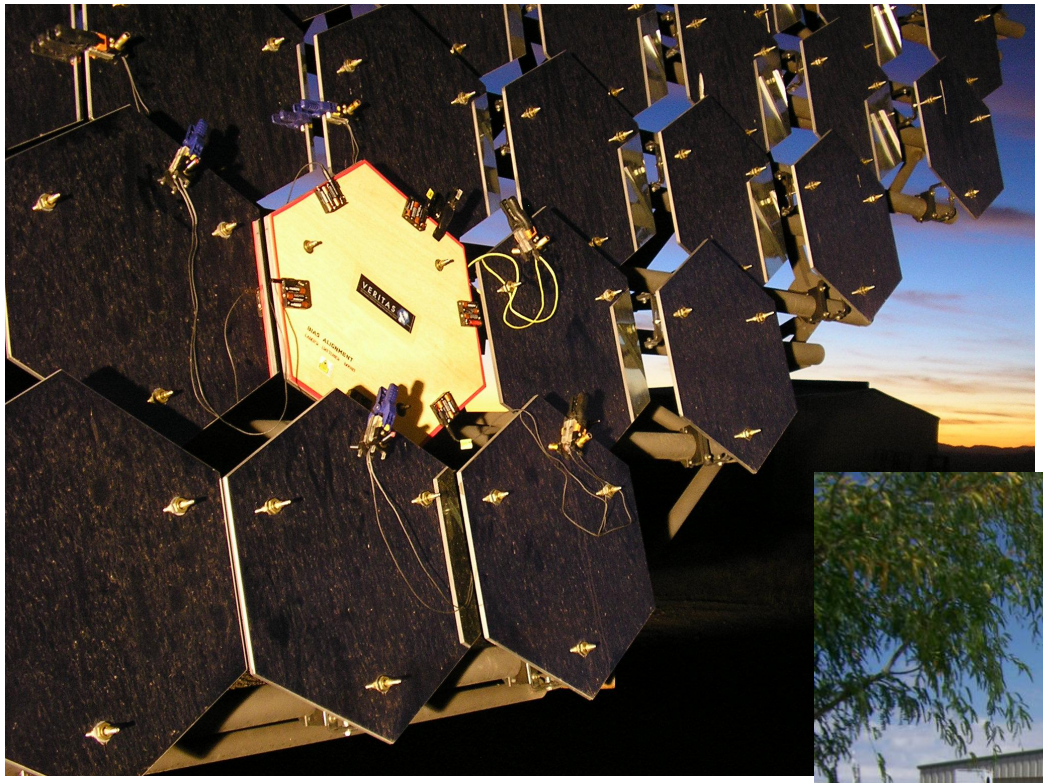




Scary moments!

Steel is heavy and hard, loose steel is both **and** scary!

Mirror alignment ... Ugh!!



Use clamp-on lasers to measure "bias" .... SIX AT A TIME.

Feed "bias" values to "2F" alignment system.

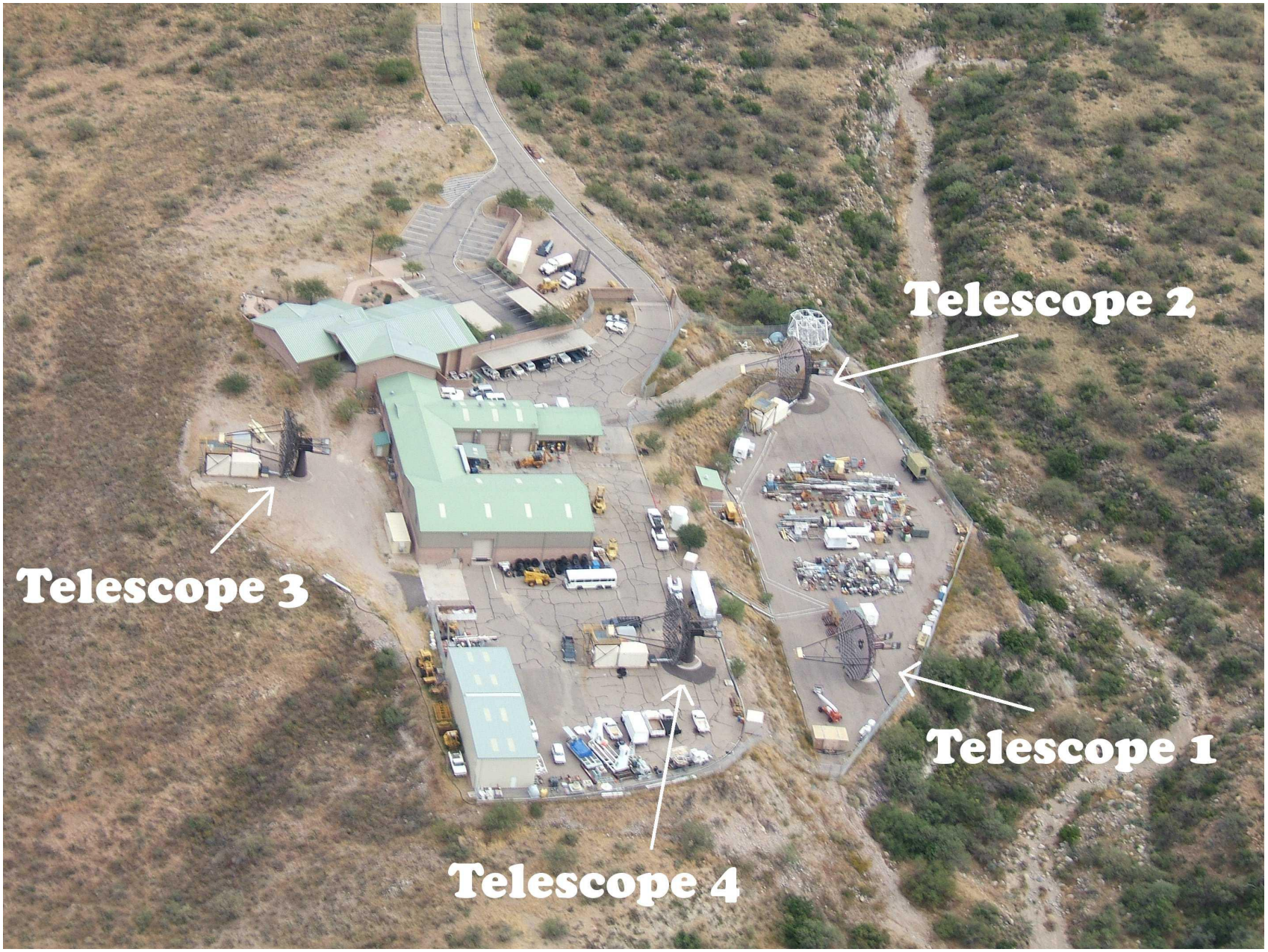
McCann mirror alignment ... Ahh!!

Raster scans (thanks Steve) from the warmth of the control room ...

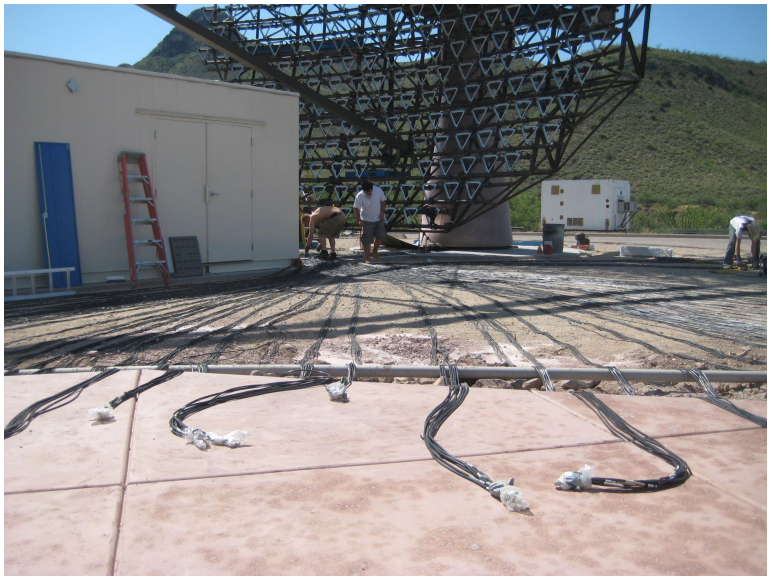
Adjust "1/8th CCW ... no, that was 1/4 CW!"

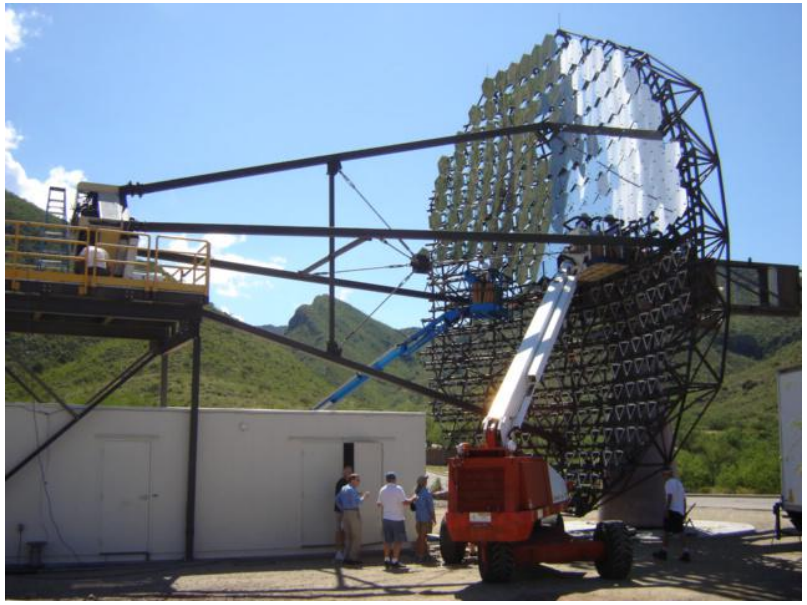
FWHM of previously aligned telescopes improve by as much as 40%!

VERITAS at FLWO – July 2007



T1 relocated in ~ 12 weeks





- Practice (T5 and T6)
- Hustle, hustle, hustle (e.g., 250 facets stripped from T1 in < 5 hours)
- Committment of necessary resource (Support, Utah ... everyone)

VERITAS' unsung heros

Steve Criswell — absolutely imperturbable whose long experience with SI and the Forest Service was utterly critical

Grace Alegria — for whom the impossible just takes a little bit longer

Danny West and Cesar Lopez — demonstrated again and again that practical experience trumps those silly physicists every (and many a time saved our bacon)

Emmet, Jack and George — the glue that holds the array together. Without their efforts the whole enterprise would grind to a halt in very short order (probably over night)

Funding agencies — PK Williams, Steve Murray, Jim Stone, Kathy Turner, Vern Pankonin, etc. — supported VERITAS through thick and thin

Conclusion

VERITAS came together because "its people" came together with a common vision and (mostly) a common set of goals

Trevor, Steve and the VEC Chairpersons (especially Simon, Rene and Frank when things were particularly "unsettled") managed to keep the authorities on side

VERITAS has gone from strength to strength

NO (repeat NO) science is settled, corollary being there is much science to be done

Increasing multi-wavelength, multi-carrier results/publications demonstrate both the confidence in VHE observatons and the demand for access to them

There will not be any new equally sensitive instruments for ~ 1 graduate student lifetime

Friends whom we've lost