DEVELOPMENT OF A LARGE ASTRONOMICAL TELESCOPE FOR NY UNIVERSITIES (ATNY)

Status: 22Oct10

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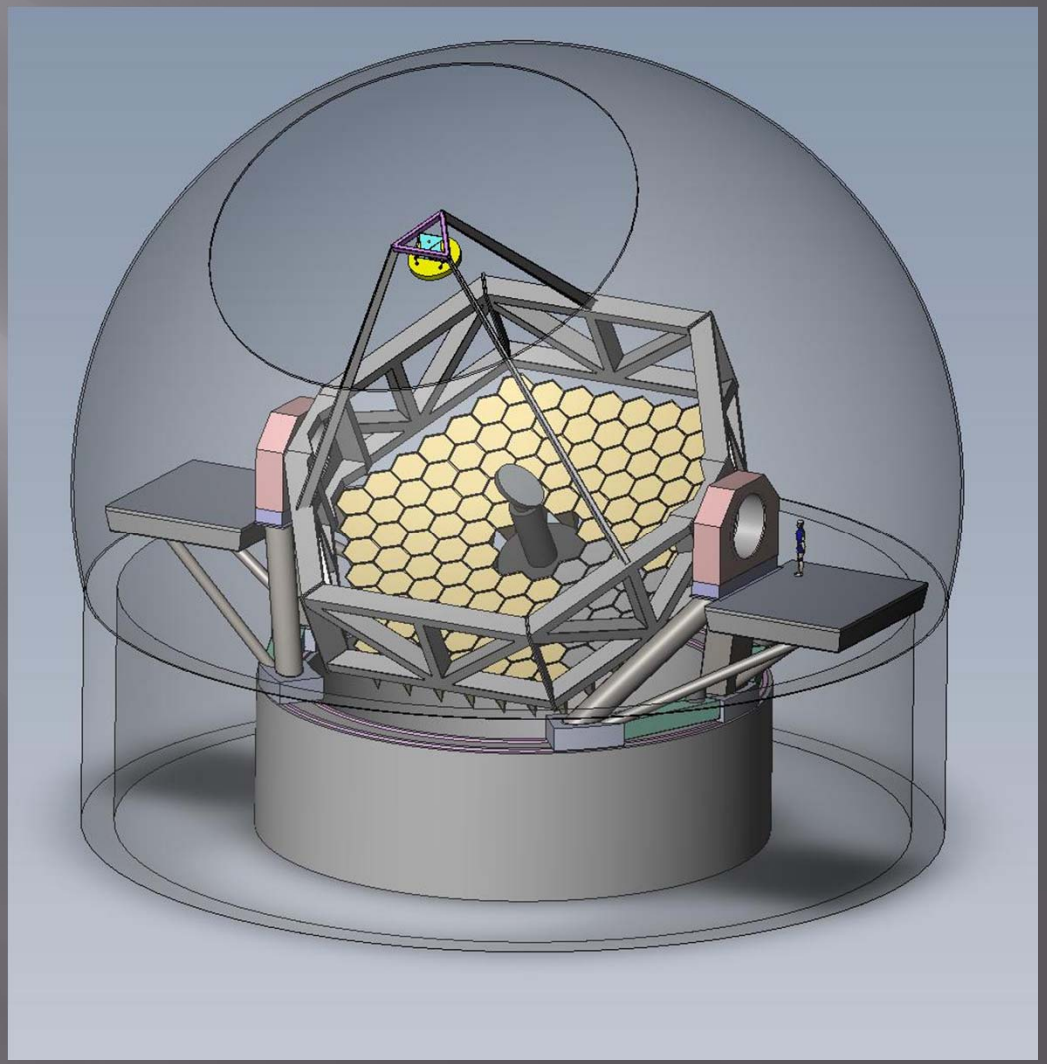

THE CONSORTIUM

RIT: D. Axon, S. Baum, J. Kastner, Z. Ninkov, C. O'Dea, A. Robinson

U of R: R. Forrest, E. Mamajek, J. Pipher, A. Quillen

SUNY Stony Brook: S. Metchev

CUNY Staten Island: C. Li

Industrial Partners:

ITT Geospatial Systems Divison: D. Strafford

Corning Glass: L. Sutton

Xoptx: T. Sebring

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Science Drivers

- The NY State Telescope will be a general purpose telescope with imaging and spectroscopic capability in the optical/near-IR. In addition, because of its large aperture and excellent seeing it will be capable of leading edge science.

- LSST Follow-up: Spectroscopy of variable/transient objects (Supernovae, AGN, neutron star - BH binaries, novae and stellar flares, gamma ray bursts, X-ray flashes, stellar disruptions by BHs, mergers of BHs, microlensing events)

- JWST/ALMA Follow-up: Multiband imaging and spectroscopy of (1) distant galaxies and stars probing the epoch of reionization and assembly of galaxies; (2) planetary systems and planets, including extra solar planet atmospheric spectroscopy

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Science Drivers

- Spectro-polarimetry of:
  - Stellar systems to characterize accretion disks and surface magnetic fields
  - AGN to determine geometries, kinematics and physical properties of compact structures such as the broad-line region, scattering winds and accretion flows, and to investigate the dependence of these structures on fundamental parameters such as black hole mass and accretion rate.
- Spectroscopy to determine Stellar kinematics of Dwarf Galaxies to probe the radial profiles of the Dark Matter.
- Spectroscopy to determine accurate wavelengths of quasar absorption lines to search for variations of fundamental physical constants.

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First Light Instrumentation

- High Resolution Imager
- Multi Object Spectrometer
- Integral Field Spectrometer
- Natural Guide Star AO
  - Upgrade to Laser Guide Star and Multi-Conjugate AO as Technologies Mature
- Just Getting Started Identifying & Prioritizing Instruments…
- 1st Two Instruments Should be Part of Project

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Initial Requirements for ATNY

- ASNY Survey: 47 Respondents
  - Application: Mostly for PhD Theses, Faculty Research, Undergraduate Training/Research
  - Ground Based Only
  - Targeted Observations (Surveys Not So Much)
  - Purely or Predominantly Multi-Purpose
- And It Should be "Significant" Right?
  - Capable in Ways Which are Unique and Desirable
  - Important to Astronomical Science and the Institutions

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ATNY Should

- Grow Partner Astronomy Departments
- Ensure Significant Observing Quality and Time
- Enable Building Instruments at Partner Institutions to Develop Capability
- Allow NY Institutions to Determine Their Own Observatory's Future Directions
- Engage advocacy of NY State Industry

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Logical Inferences

- A "small" telescope 2-6 meters would be "another" telescope in today's environment
- Surveys are being adequately addressed by LSST, PanSTARRS, 1° FOV imagers, HET DEX
- Astronomy Seems to have Gone from 10 m Telescopes to 30 m Telescopes
- A General Purpose Telescope 1.5 X Larger Than Keck and 3 X Larger than Gemini Might Just Make Sense

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Extrapolation of Keck to ~120 m²

- Segmented Telescopes Spawned New Cost Regime…Can Now be Matured
- RC Design with Segmented PM
- ~1.5 X Keck Collecting Area (single telescope)
- Faster PM (Keck was f/1.75…TMT is f/1.0)
- Fills the Space Between 10 m Telescopes and 30 m Telescopes

General Purpose, Very Large, Optical/IR Telescope Suitable for General Astronomy

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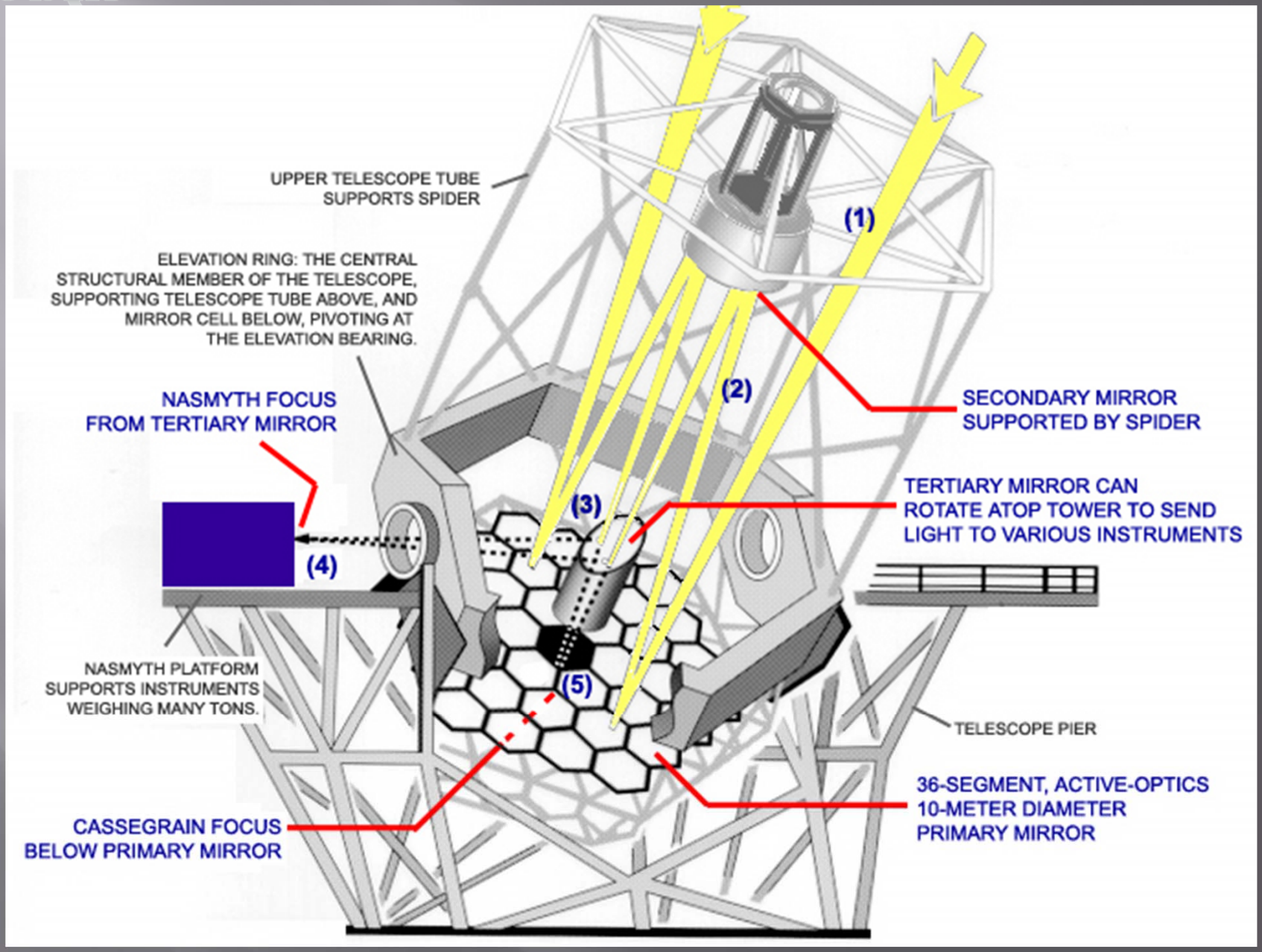
UPPER TELESCOPE TUBE
SUPPORTS SPIDER
ELEVATION RING: THE CENTRAL
STRUCTURAL MEMBER OF THE TELESCOPE,
SUPPORTING TELESCOPE TUBE ABOVE, AND
MIRROR CELL BELOW, PIVOTING AT
THE ELEVATION BEARING.
NASMYTH FOCUS
FROM TERTIARY MIRROR
(1)
(2)
SECONDARY MIRROR
SUPPORTED BY SPIDER
(3)
TERTIARY MIRROR CAN
ROTATE ATOP TOWER TO SEND
LIGHT TO VARIOUS INSTRUMENTS
(4)
NASMYTH PLATFORM
SUPPORTS INSTRUMENTS
WEIGHING MANY TONS.
(5)
TELESCOPE PIER
36-SEGMENT, ACTIVE-OPTICS
10-METER DIAMETER
PRIMARY MIRROR
CASSEGRAIN FOCUS
BELOW PRIMARY MIRROR

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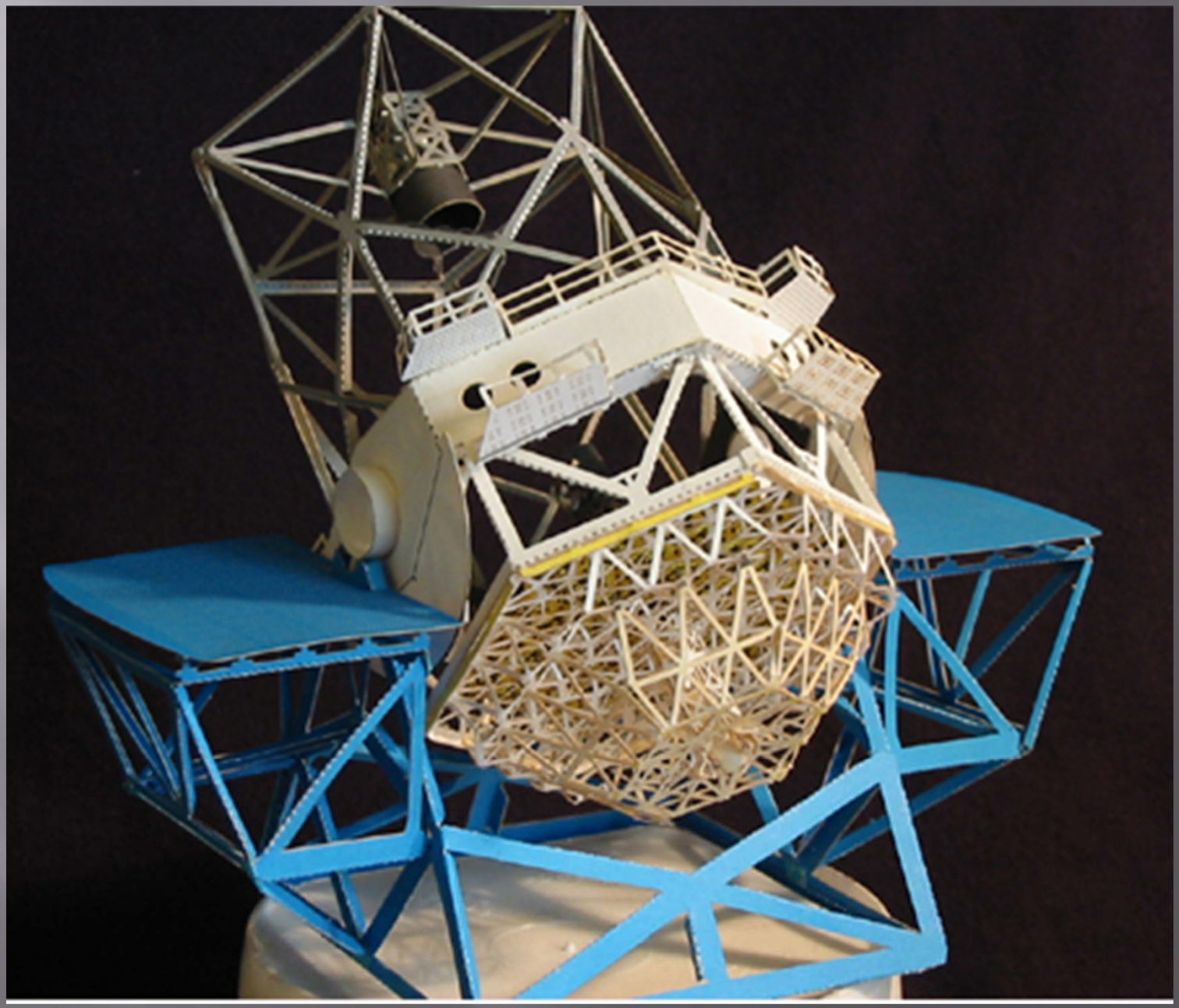
Comparison of ATNY to Keck

Parameter	Keck	ATNY
Equivalent Diameter	10 m	12.2 m
Collecting Area	76 m^2	120 m^2
f/Ratio (M1)	f/1.75	f/1.25
Number of Segments	36	120
Segment Thickness	75 mm	50 mm
Segment Diameter	1.8 m	1.1 m
Moving Weight of Telescope w Glass	270 tons	TBD
Type of Mount	Alt/Az	Alt/Az
Mount Bearings	Hydrostatic	Rolling Element
Weight of Dome	635 tons	<150 tons (est)
Segment Support Points	36	18
Edge Sensors & Actuators	Custom	COTS

Keck 10 m Telescope



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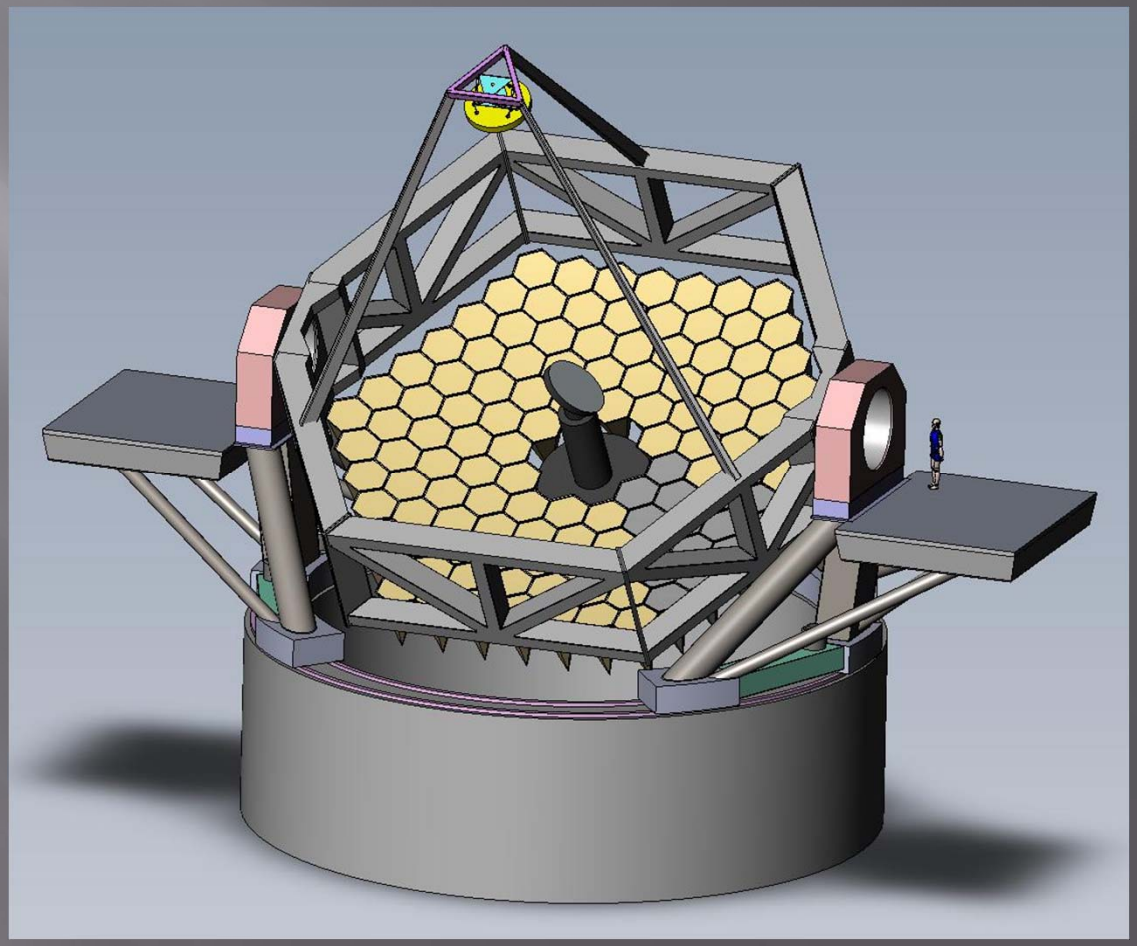
ATNY Telescope Mount

- Compact (f/1.25 PM)
- Rolling Element Bearings
- Direct Drives
- Rotated PM Lowers Mount
- CFRP Struts to M2 (no PF Instruments)
- Modular Structures Lowers Integration Cost



Design by Sebring Mechanical Design www.sebringdesign.com

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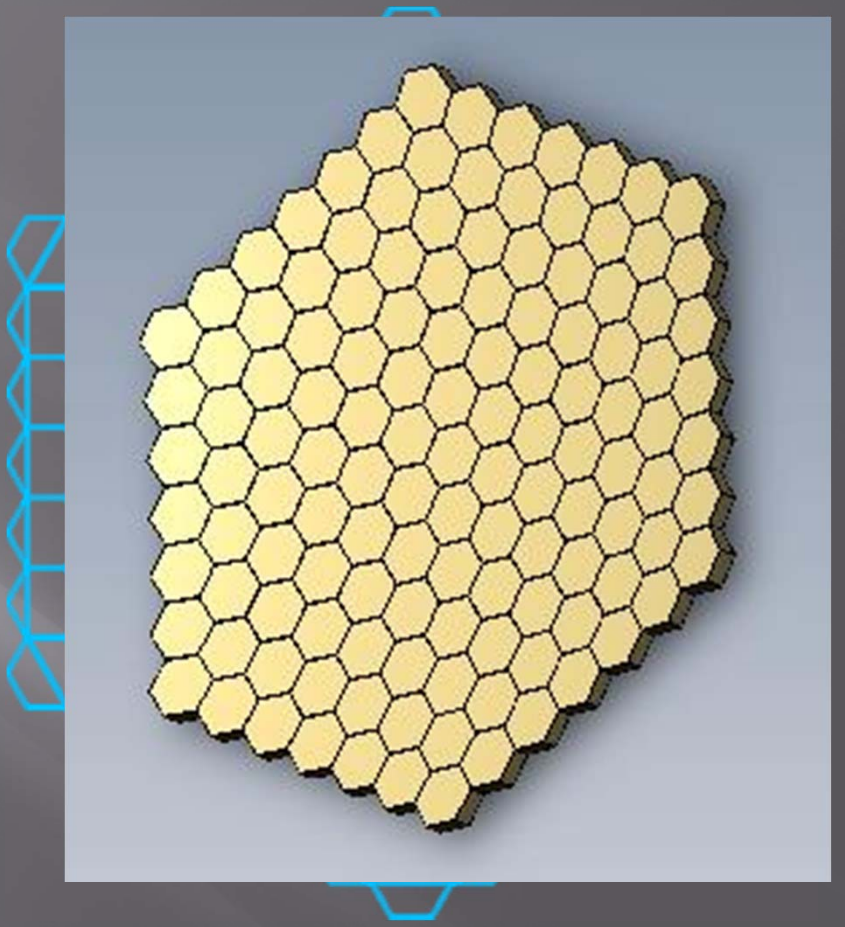
Segmented w Active Control

- 120 Segments,
- 11.4 m Flat-to-Flat Overall
- 3-5 mm gaps
- Smaller & Thinner Segments
  - Keck: 5.7m^3 of Zerodur
  - ATNY: 6 m^3 of ULE



Effect of Segment Size on Aperture

Diameter (minor)	Diameter (major)	Length of Side (L)	Area	120 segment Area	Ratio to Keck
0.8	0.92	0.46	0.55	66.51	0.88
0.9	1.04	0.52	0.70	84.18	1.11
1	1.15	0.58	0.87	103.92	1.37
1.1	1.27	0.64	1.05	125.74	1.65
1.2	1.39	0.69	1.25	149.64	1.97

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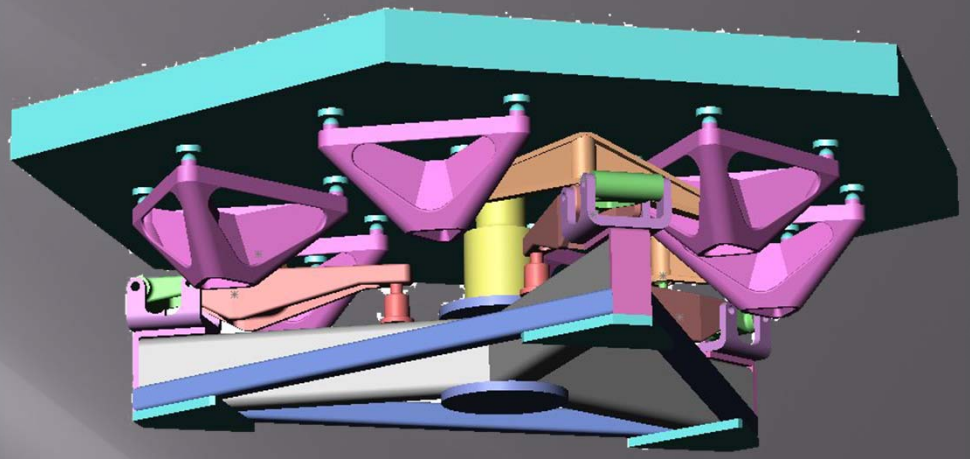
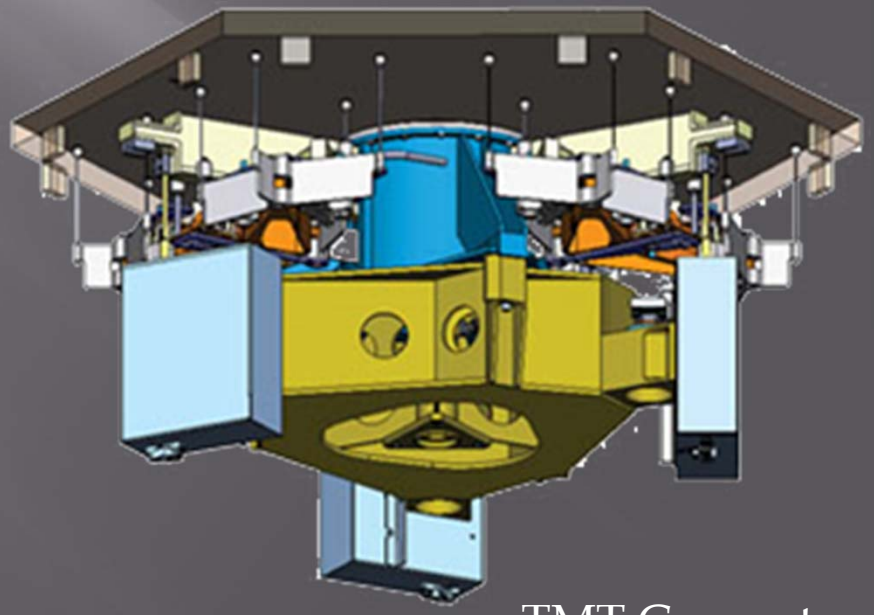
Mirror Mounts

- Keck had 36 Support Points for 1.8 m Segment
- 18 Points May Be Acceptable for 1.1 m Segments
- TMT Uses 1.4 m Segments and 24 Support Points
- Industrial Concept
- ~$800,000 for 125 Mounts

ATNY Concept





TMT Concept

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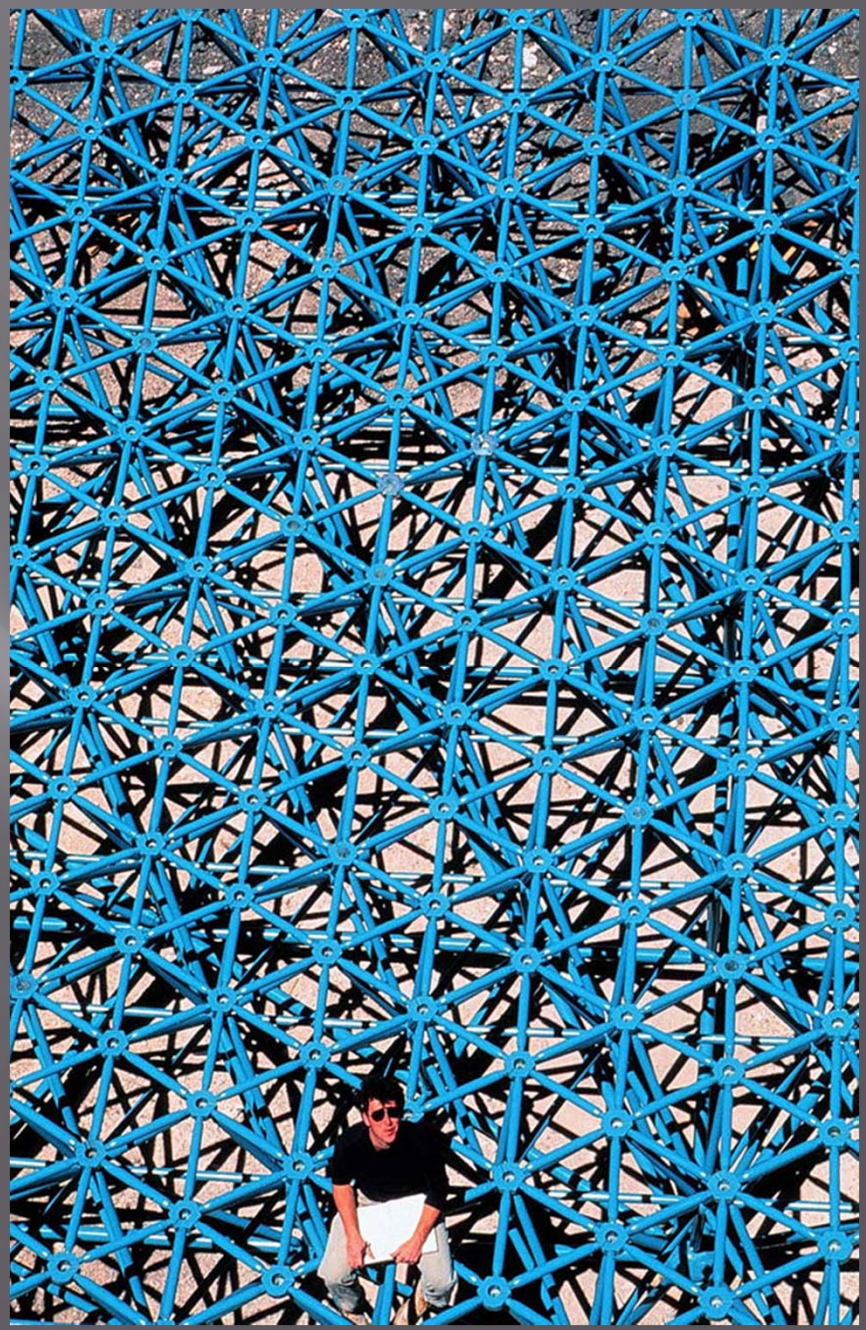
Primary Mirror Truss

- Use Factory Made Bolted Truss
- Keck was Welded & Very Difficult
- <$1 M Estimate from Mero for 25 m Truss



Segment Actuators: PI (Auburn, MA)

- Used on SALT PM, Work Well
- Large Fine Pitch Ball Screw
- Compact Design
- ~$4500 per Axis ~$1.7 M for 126 Segments
- Includes All Cabling, Electronics, Control Computer etc.

PI (Physik Instrumente) M-235K High Load Linear Actuator

SALT Telescope Using M-235K

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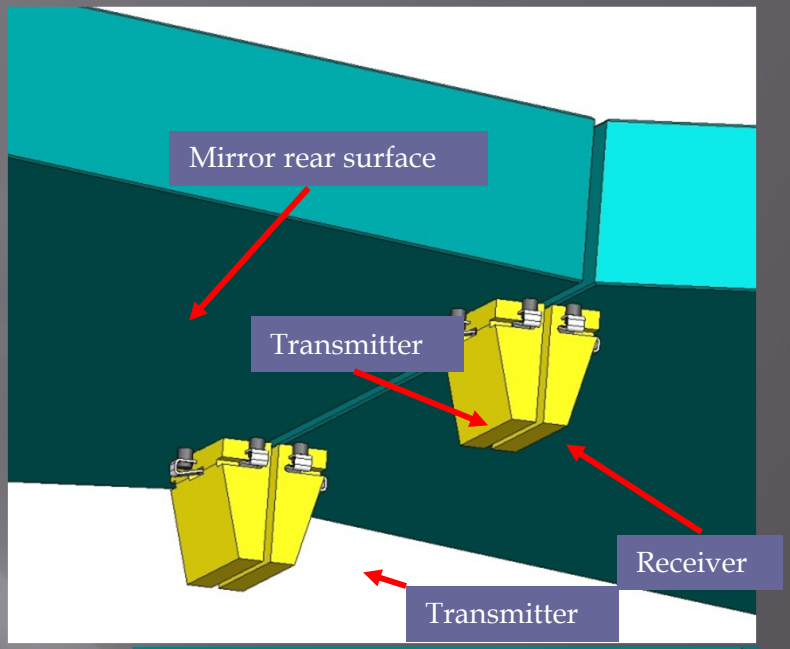
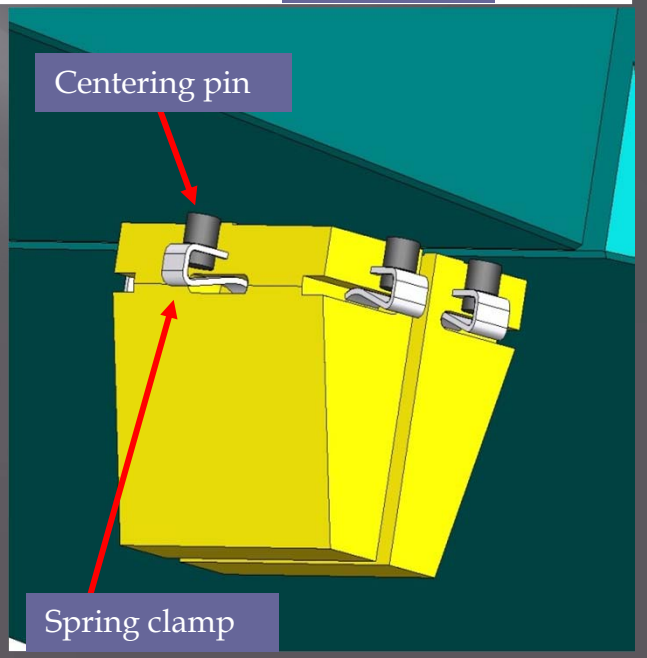
Segment Edge Sensors: Fogale Nanotech

- Inductive Sensors
  - Relatively Immune to Dust & Moisture
- Two Sensors on Each Gap
- Sense Relative Piston, Dihedral Angle, Gap
- Cost Estimate: Complete System ~$1M Quote from Fogale





Data from Fogale Nanotech, Nimes, France

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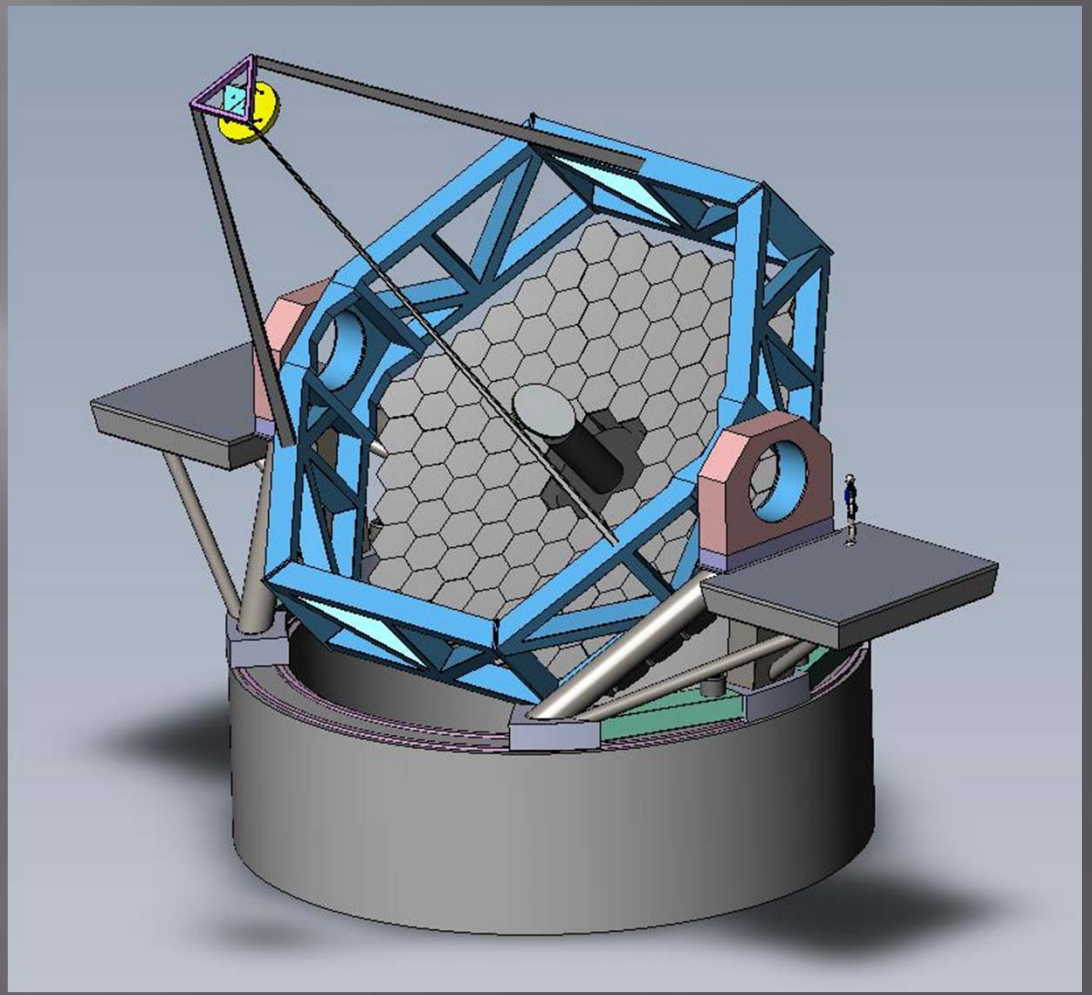
Telescope Mount Concept

- Linear Rolling Element Guides for Azimuth
- Direct Servo Drives
- Rolling Element Elevation Bearings
- Simple M2 Support



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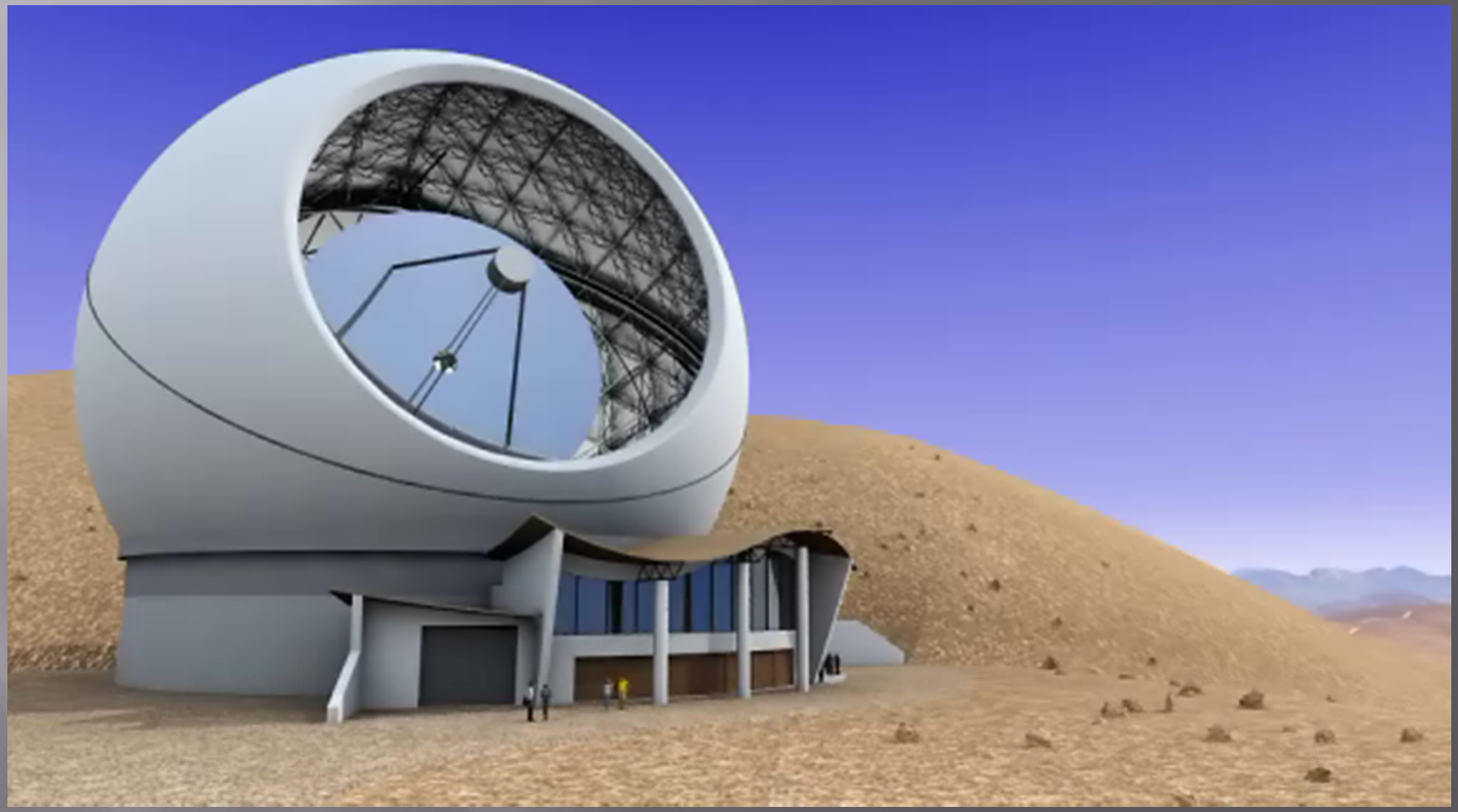
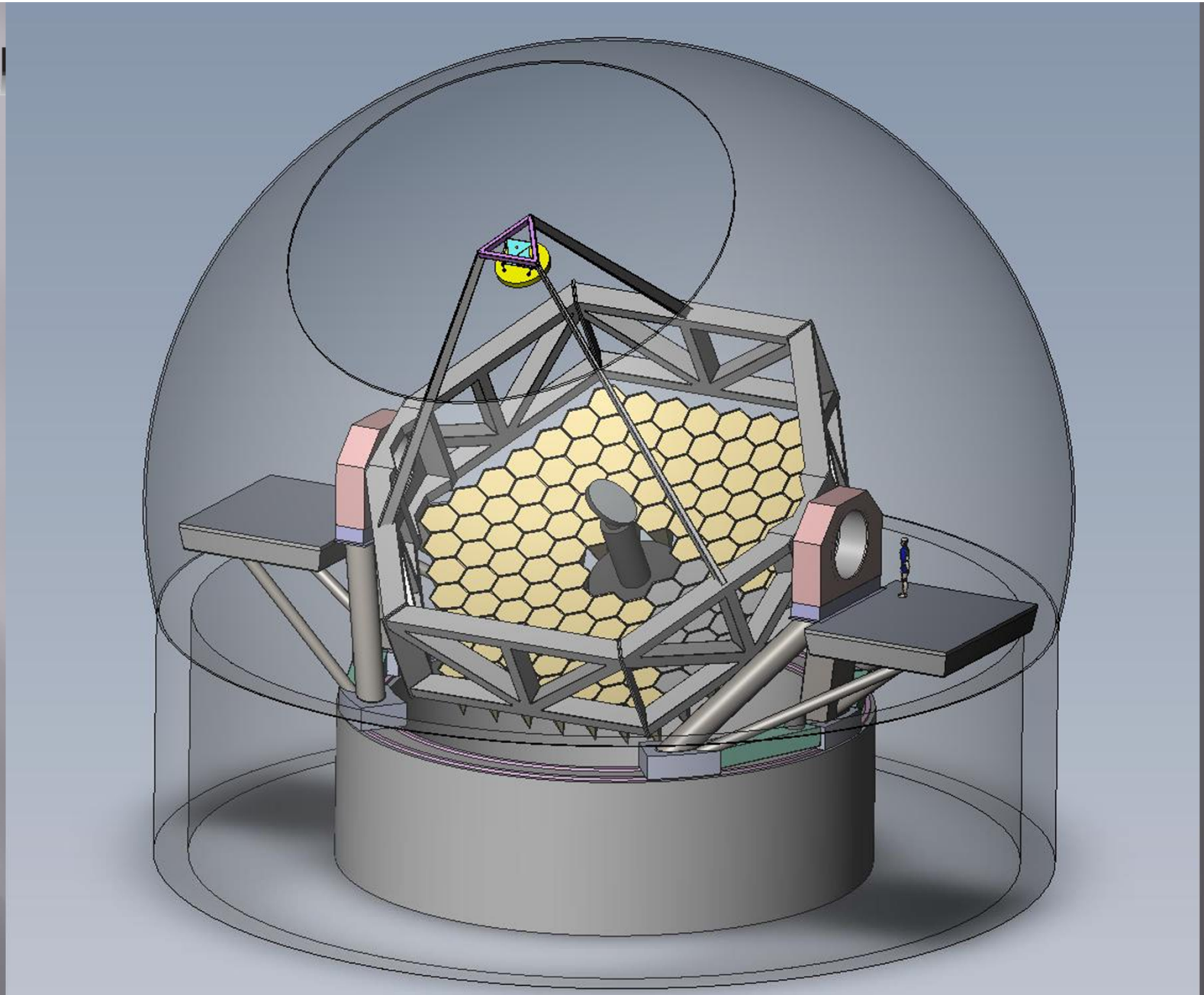
Dome Concept: Calotte





Cost Element	Amount		Basis	
Primary Mirror				
ULE Segments	$4,375,000		$35k/segment * 125 segments	Corning
Optical Fab & Test	$9,375,000		$75,000/segment*125 segments	ITT
Segment Mounts	$812,500		$6500/mount*125 segments	
Actuator System	$1,620,000		$4500/actuator * 360 actuators	PI
Edge Sensor System	$945,000		$750/sensor*1260 sensors	Fogale Na
PM Truss	$1,000,000		Quote for 25 m Truss	Mero
Total PM		**$18,127,500**		
Secondary Mirror				
2 M LW ULE Substrate	$5,500,000		Lightweighed ULE 2m Diameter	Corning
Optical Fab and Test	$2,000,000			WAG
Hexapod	$750,000		Uses components from PI	WAG
M2 Support System	$1,500,000		CFRP Wound on Mandrels	WAG
Total SM		**$9,750,000**		
Telescope Mount		**$12,500,000**	250 tons @ $50k/ton	Historical
Dome				
Dome Structures	$1,000,000		Estimate for Structures for CCAT	Triodetic
Dome Mechanisms	$3,000,000		Estimate Based on Concept	WAG
Total Dome		**$4,000,000**		
Facility		**$4,500,000**	SOAR Actuals Scaled at 1.03/yr	Historical
Software & Controls		**$2,010,000**	SOAR Actuals Scaled at 1.03/yr	Historical
Integration & Assembly		**$2,680,000**	2x SOAR Scaled at 1.03/year	
Project Labor & Management		**$10,000,000**	2.5x SOAR Labor	
Contingency		**$10,000,000**		
Total Cost		**$73,567,500**		

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Next Steps

- Concept Design of PM Truss and Dome
- Refine Cost Estimate
- Perform Risk Assessment
- Complete Inputs for Proposal mid December
- Continue to Build Consortium
- Further Define Science and Instrumentation

To Date the Concepts Appear Feasible and Worthy of More In-Depth Study and Development