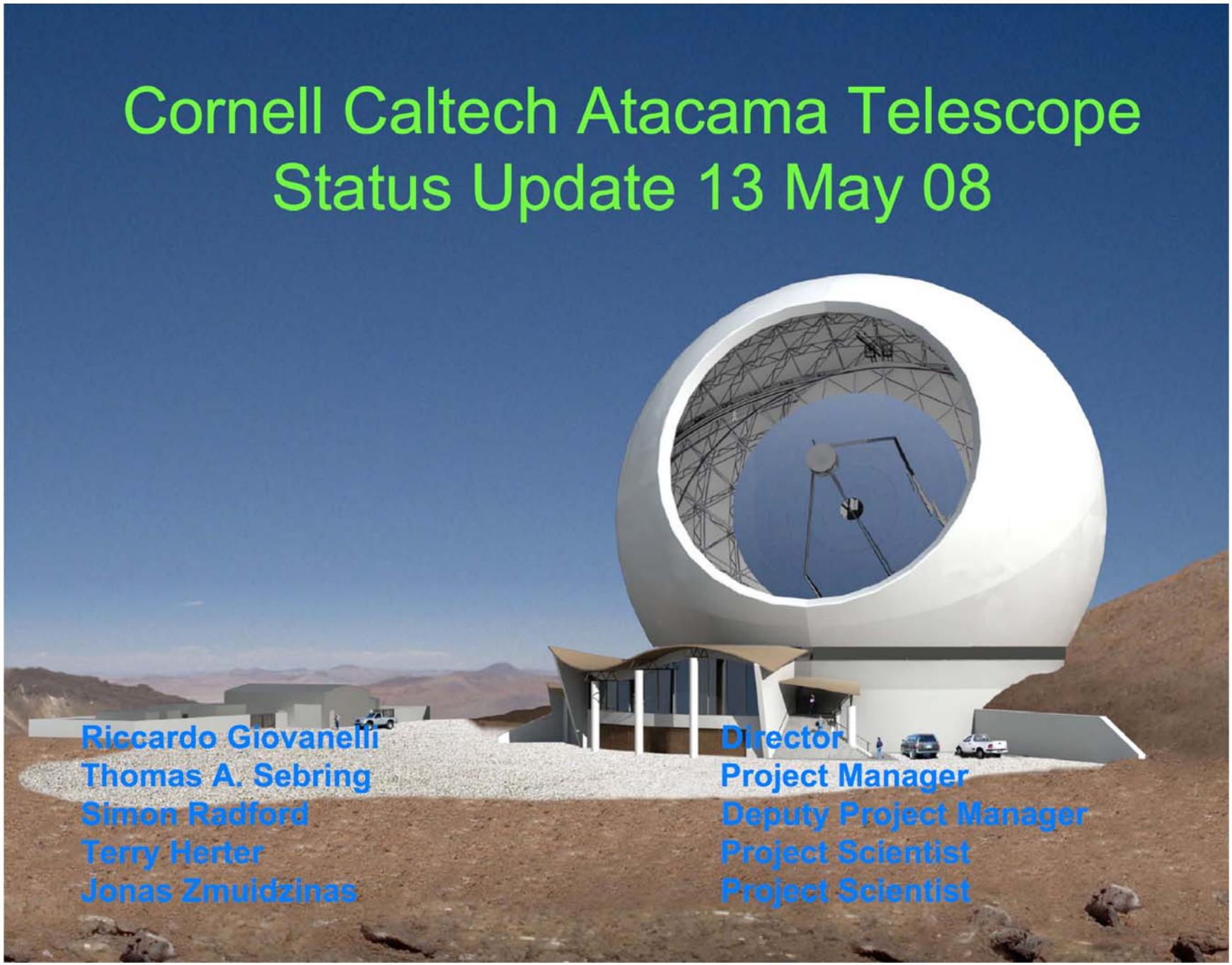
Cornell Caltech Atacama Telescope
Status Update 13 May 08



Riccardo Giovanelli — Director
Thomas A. Sebring — Project Manager
Simon Radford — Deputy Project Manager
Terry Herter — Project Scientist
Jonas Zmuidzinas — Project Scientist

The Recent News

- Partnership & Business Development
- Funding Development
- Technical Development


CCAT
Partnership Development
• Partnership Agreement
– Term Sheet Reviewed by CCAT Partners
– Kerry Dolan (Caltech Counsel) Preparing 1st Draft of Agreement
– Anticipate CCAT Board Discussion of Draft at Next Board Meeting (Summer?)
• Update on U. Cologne/U. Bonn Participation
– Meetings in Germany to Discuss Approach to Obtaining Funding
– Agreement with Vertex (Germany) to Propose Research in Compound Mirror Approach
– Proposal to be Submitted in Fall?

Business Development

- Counsel Retained (Bond Schoeneck & King, Syracuse, NY) to Investigate and Establish Not-for-Profit Entity
  - 1st Draft of Articles of Incorporation and By-Laws Developed
  - Location and Type of Entity Investigated (Most Likely LLC and in Deleware)
  - Anticipate Bringing to Board at Next Meeting
- Cornell Working on Proposal to Host Project
  - Types of Services to be Provided
  - Cost Structure for Services
  - Protocol for Procurements, Purchases, Bookkeeping, etc

Planned Engineering Design Phase

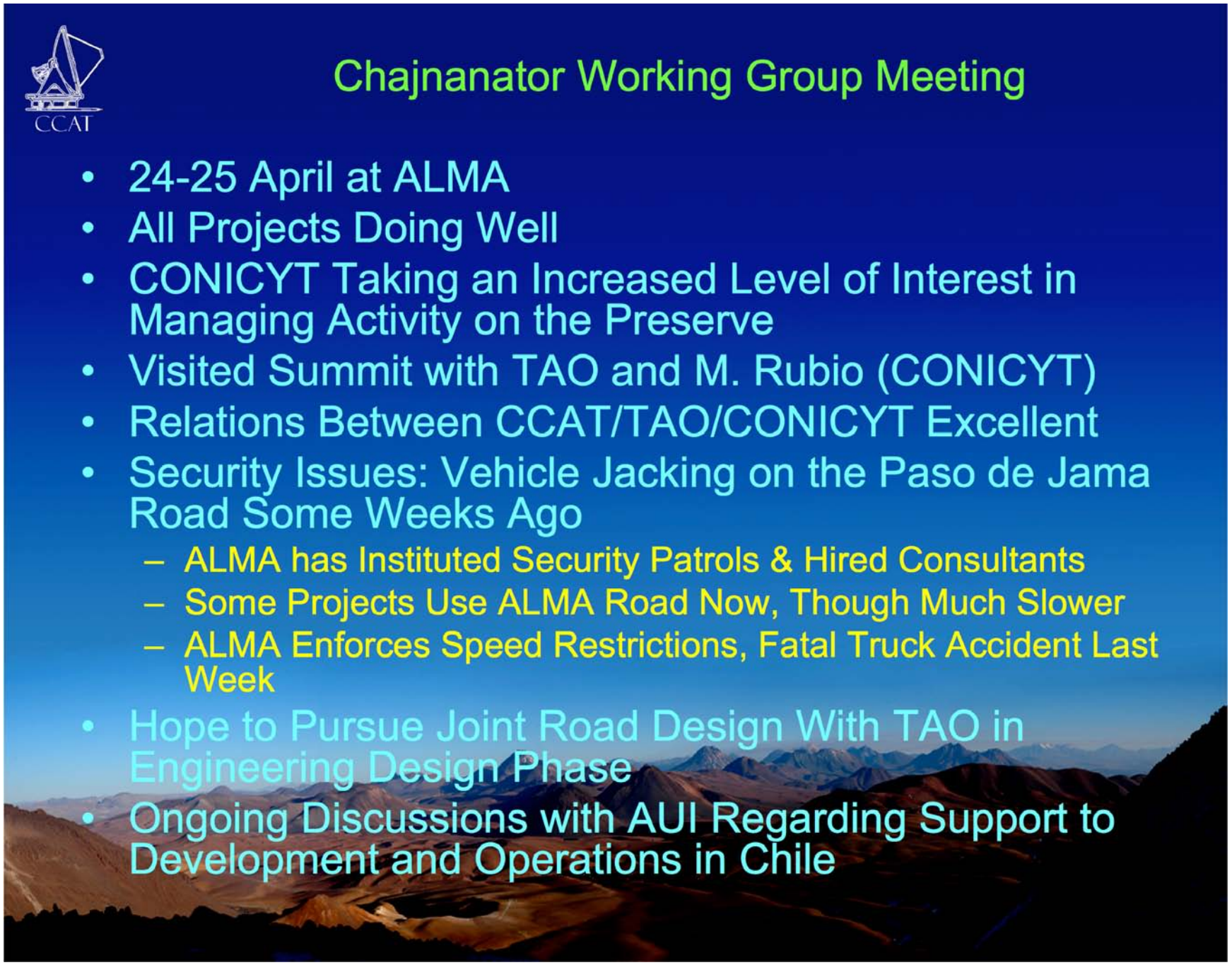
- Seeking Funding for "Engineering Design" Phase
  - Nominally $5-10M (Currently Shooting for the Larger Number
  - Hoped that Partners Will Each be Able to Fund Their Prorated Share
  - Nominal Start in January 2009 and Duration of 2 years
- Objectives:
  - Address Critical Risk Areas and Retire Risk
  - Perform Analytical Trades to Select Best Design Options
  - Make Design Changes to Improve Observatory and Reduce Costs
  - Prepare Documentation to Enable Rapid Start to Construction Phase
- Work to Include Both In-Kind Efforts at Partners and Contracted Technical Development Work
- Hope to Hire Project Engineer for This Phase


CCAT
Activities at Partners
• Canada: Meetings with Industry and UBC and U Waterloo to Discuss Proposal to Canadian Foundation for Innovation (CFI)
– Companies Identified to Perform Dome Design
• Empire Dynamic Structures (Formerly AMEC) for Design of Bearings and Drives
• Triodetic (Ottawa) Geodesic Type Structures for Shell
– Proposal to be Submitted in Fall for ~$5M
• Meeting at U. Cologne & with U. Bonn
– Discussions with Vertex (Duisburg)
– Proposal Submitted for ~$1M to Investigate "Advanced Submillimeter Optics"
– Find out in July Whether Successful

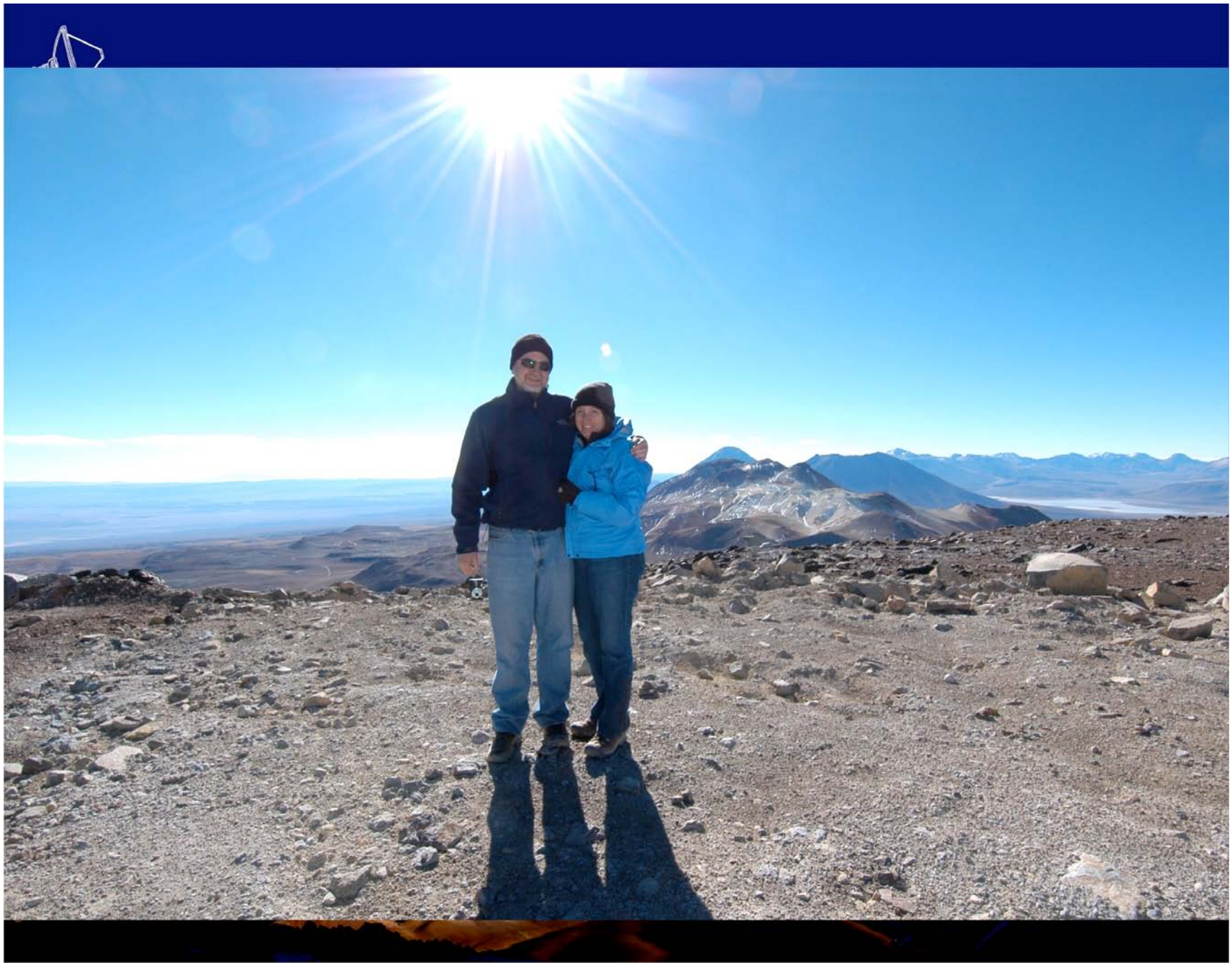
Activities at Partners

- UK ATC: Study of Control System
  - P. Wallace et al @ Rutherford Appleton Lab
  - Developers of SLALIB and TPOINT Software (Pointing and Mount Model/Correction Packages)
  - SOW in Hand; Awaiting STFC Funding
  - Survey Existing and Planned Telescope Control Architectures and Other Emerging Technologies
  - Trade and Recommend Architecture for CCAT
- Caltech/JPL
  - Continuing Development of Segmented Optic Control Model
  - System Engineering, Error Budgets, Performance Modeling
  - Work on Development of Optics
  - Calibration Alignment Sensor


CCAT
Development at Partners
• Cornell:
– Optical Analysis and Modeling
– Management of Contracts
– Support to Partners Fund Raising and Technical Efforts
– Contractor Interface
– Optical Fabrication Efforts
– Optical Guiding Investigation
• U. Colorado
– Opto-Mechanical Design and Analysis of Segment Support Systems


CCAT
Chajnanator Working Group Meeting
• 24-25 April at ALMA
• All Projects Doing Well
• CONICYT Taking an Increased Level of Interest in Managing Activity on the Preserve
• Visited Summit with TAO and M. Rubio (CONICYT)
• Relations Between CCAT/TAO/CONICYT Excellent
• Security Issues: Vehicle Jacking on the Paso de Jama Road Some Weeks Ago
– ALMA has Instituted Security Patrols & Hired Consultants
– Some Projects Use ALMA Road Now, Though Much Slower
– ALMA Enforces Speed Restrictions, Fatal Truck Accident Last Week
• Hope to Pursue Joint Road Design With TAO in Engineering Design Phase
• Ongoing Discussions with AUI Regarding Support to Development and Operations in Chile


SCHEUERLE
ALMA
ESO
SCHEUERLE

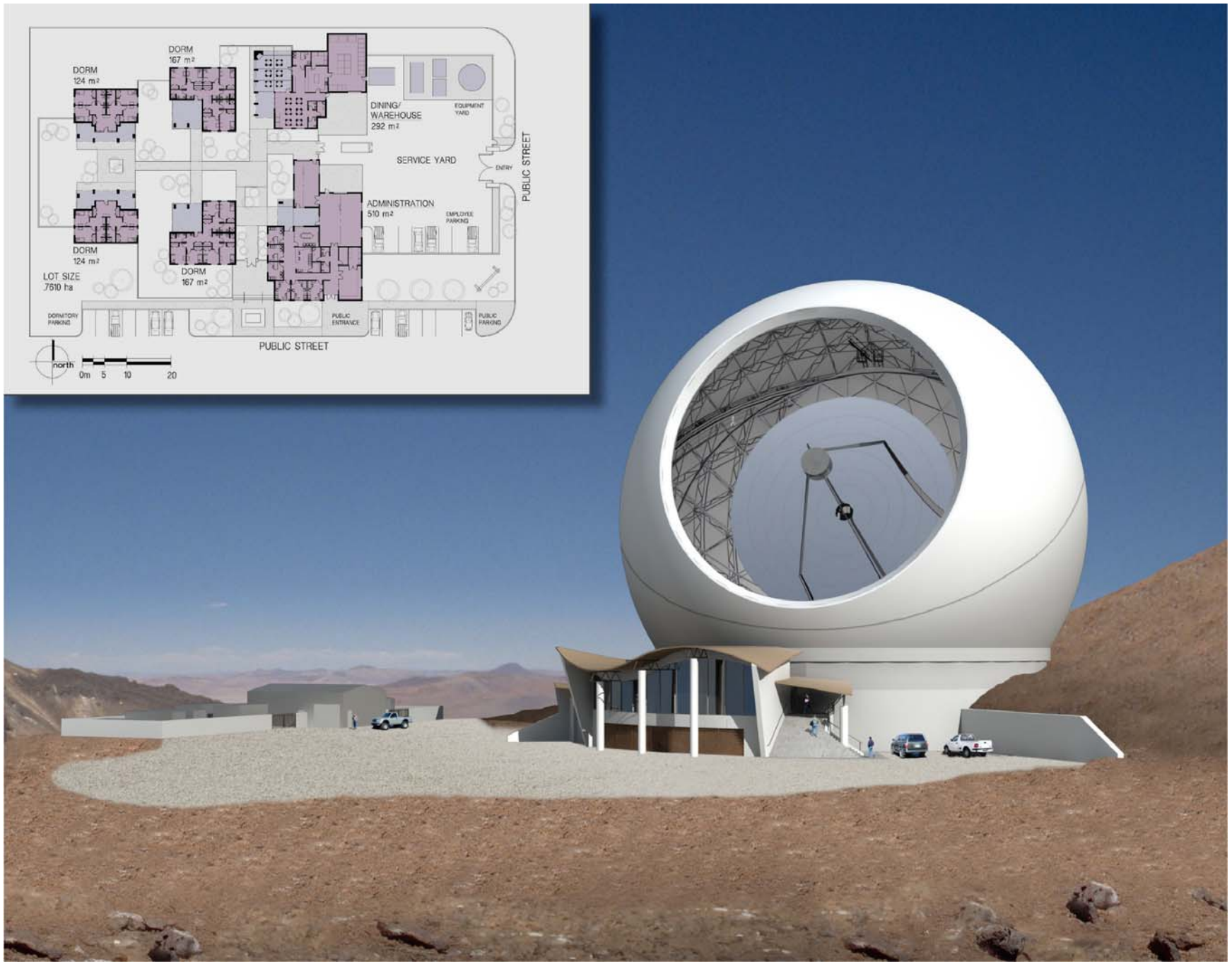


CCAT Requirements

	Requirement	Goal	remark
Wavelength	350 – 1400	200 – 2500	μm
Aperture	25 m		
Field of view	10'	20'	
Half WFE	< 12.5 μm	< 9.5 μm	rms
Site condns.	< 1.0 mm	< 0.7 mm	median pwv

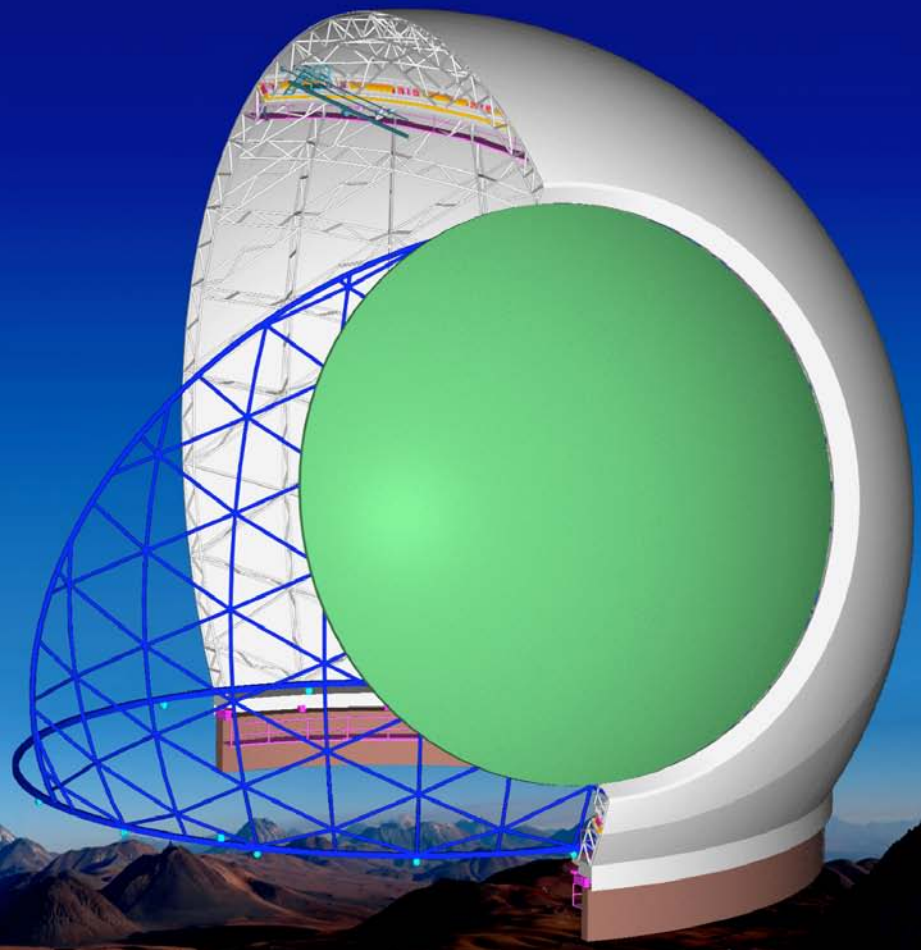
It is the Combination of These Features Along with Advanced Detector Arrays that Make CCAT a Revolutionary New Observatory


CCAT
Site and Facility Work
• Road Design Study
– Jointly with TAO & Conicyt
– Investigate Whether Better Route Exists
– Use Chilean Engineering and Construction Resources
• Site Characterization
– Geotechnical Survey to Determine Bearing Strata
– Micro-topographical Survey for Terrain
• Update Facility & Site Design
– e.g. Facility Too High, Too Much Concrete
– Possible to Reduce Scope?
– Place Electrical Generation at Base of C. Cajnantor

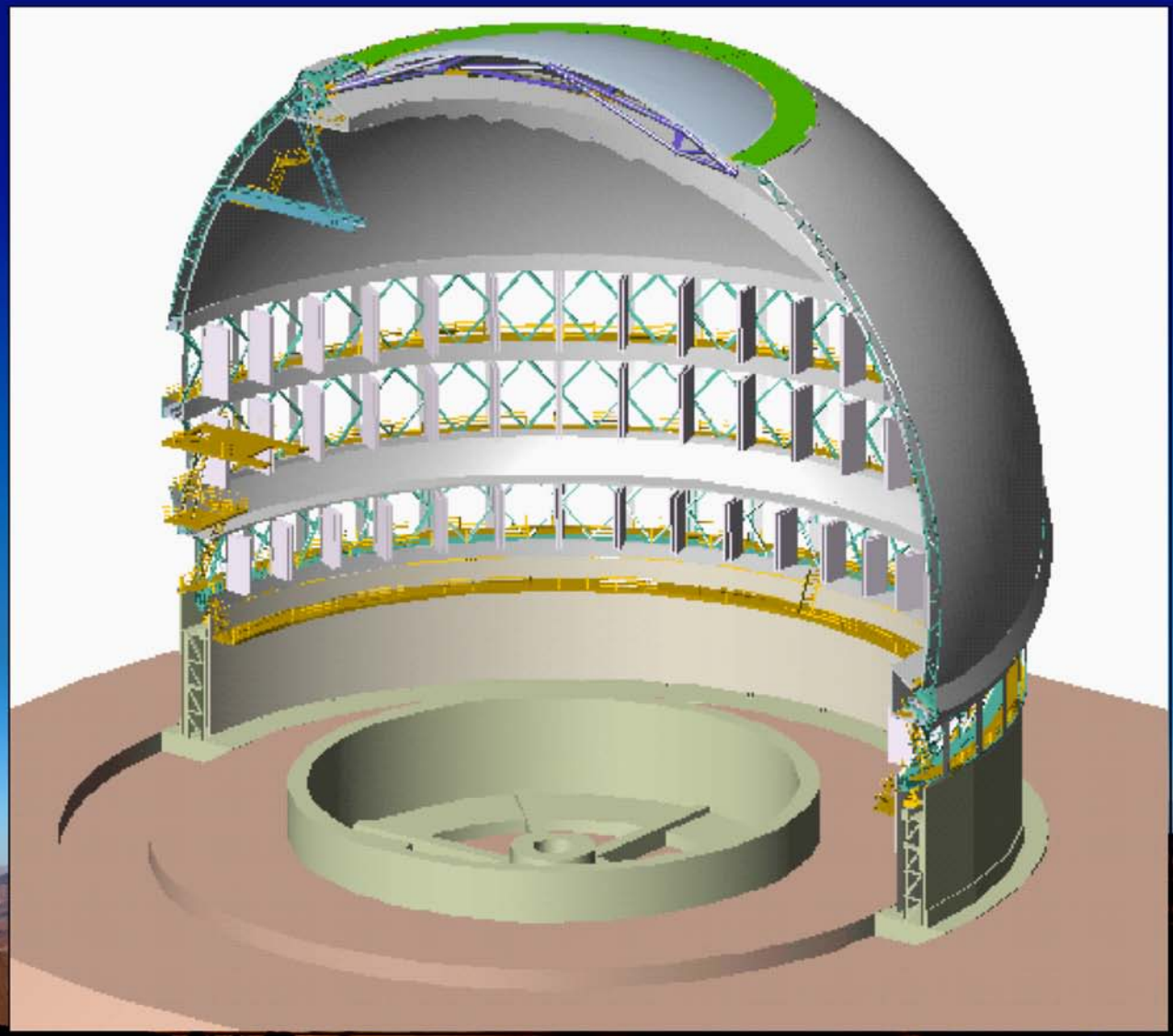

DORM
124 m²
DORM
167 m²
DINING/
WAREHOUSE
292 m²
EQUIPMENT
YARD
SERVICE YARD
ENTRY
PUBLIC STREET
ADMINISTRATION
510 m²
EMPLOYEE
PARKING
DORM
124 m²
DORM
167 m²
LOT SIZE
7510 ha
DORMITORY
PARKING
PUBLIC
ENTRANCE
PUBLIC
PARKING
PUBLIC STREET
north
0m 5 10 20

Telescope Dome Concept

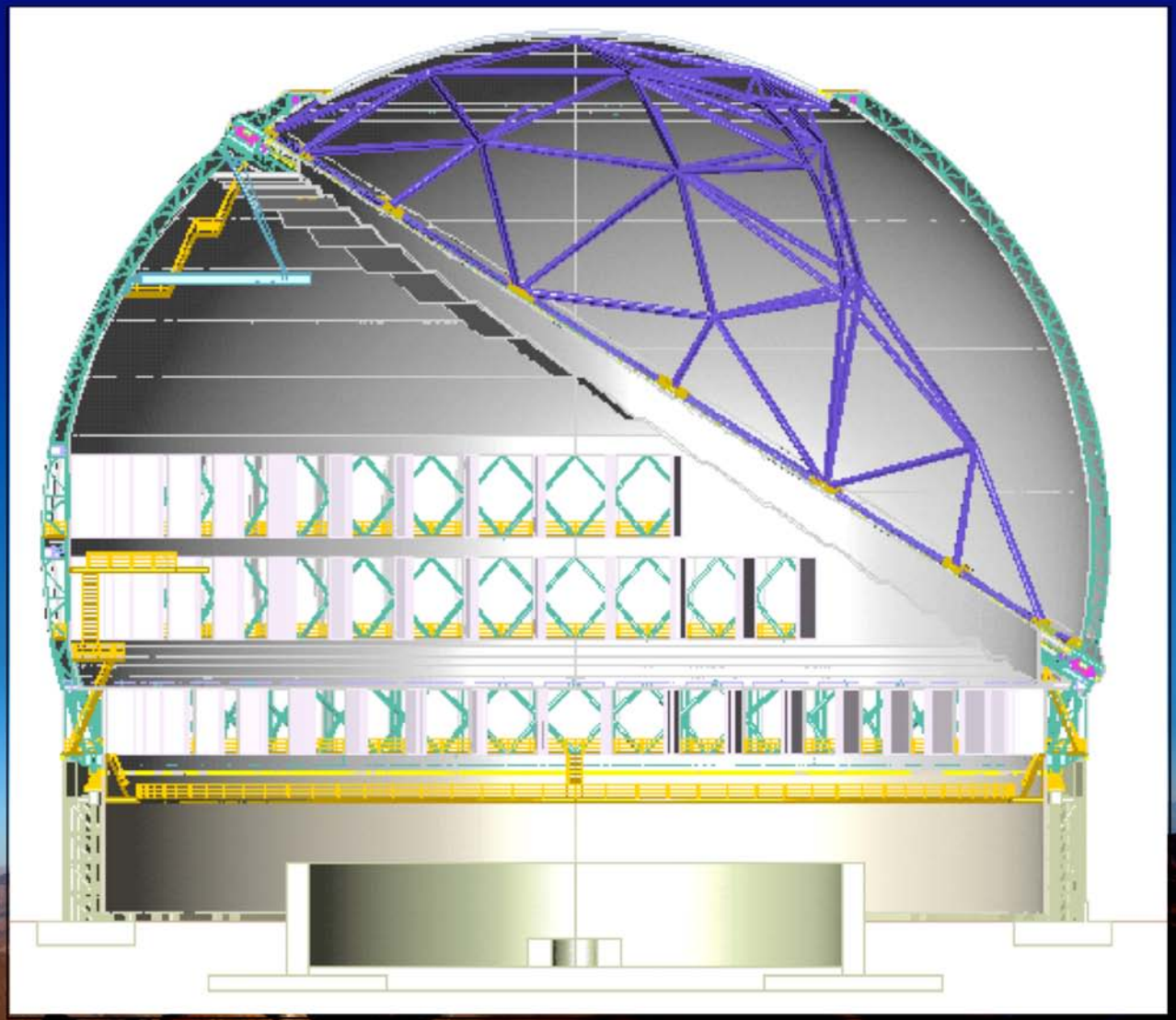
- 4 Meetings with AMEC Since Study
- Much Funded Work by TMT Project
- Tilted Rotation Stage Major Technical Challenge
- 2 Meetings with MERO TSK, Germany
- Meeting with Triodetic, Ottawa



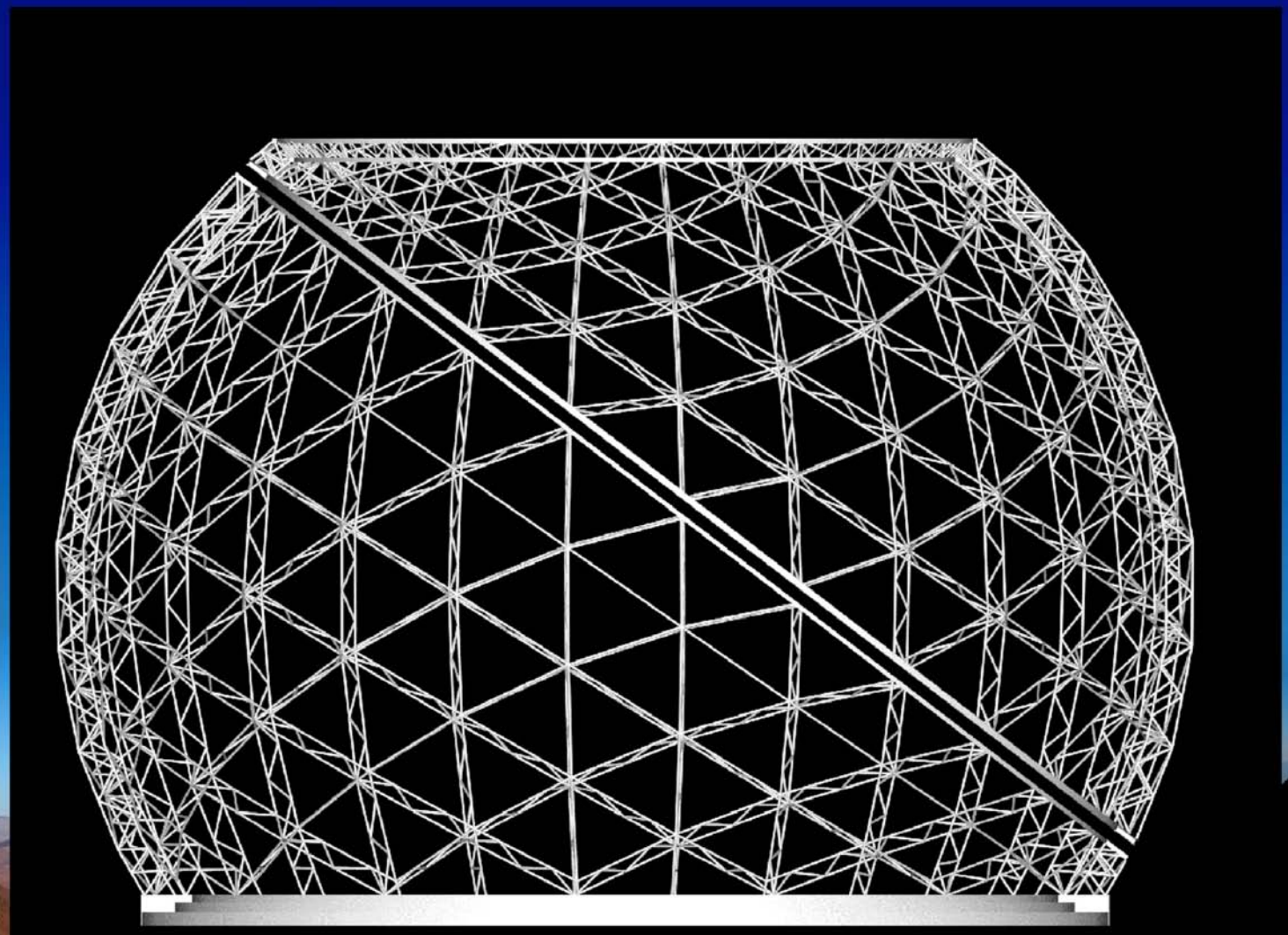
TMT Design



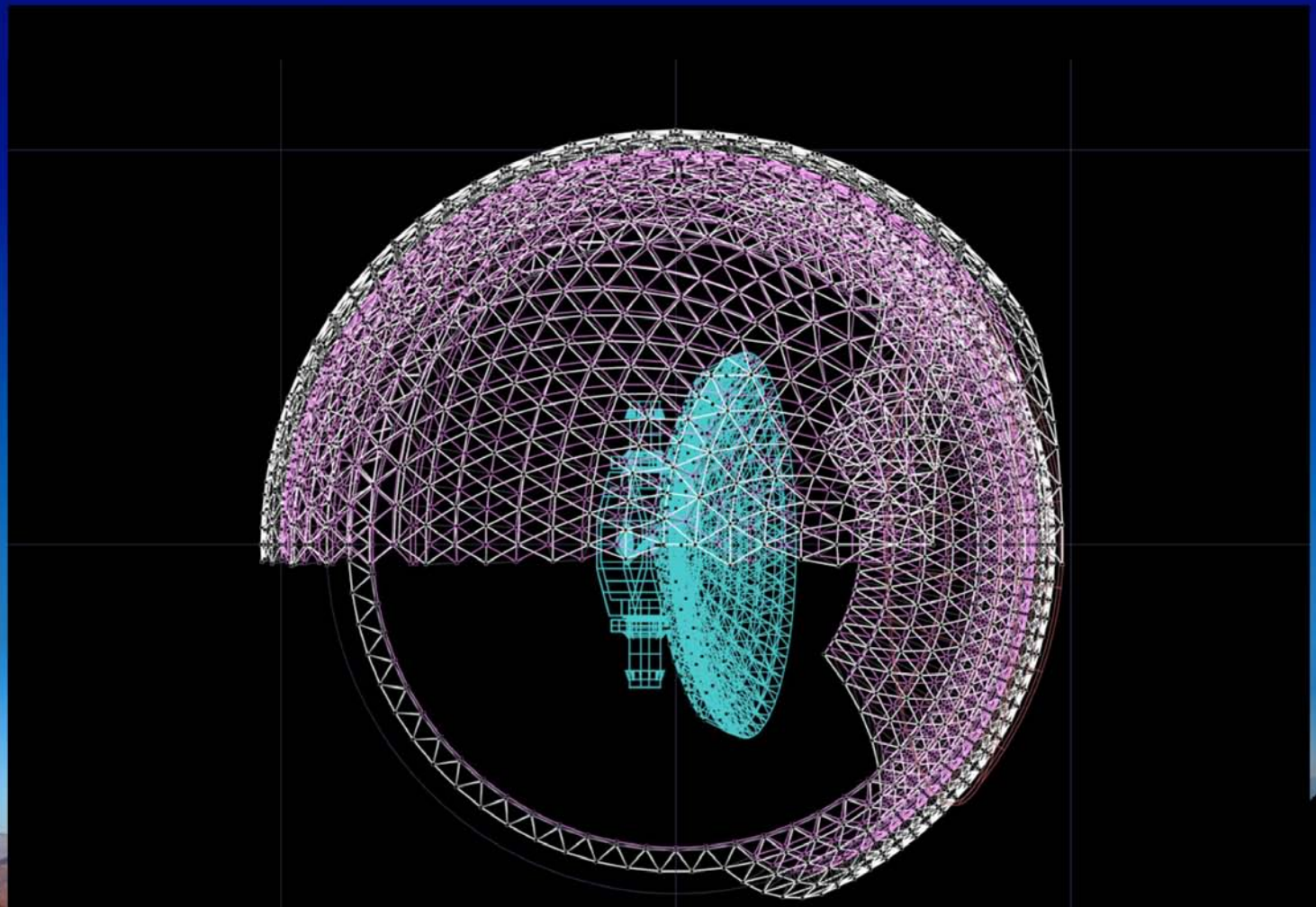
TMT Design



AMEC and Mero TSK Designs

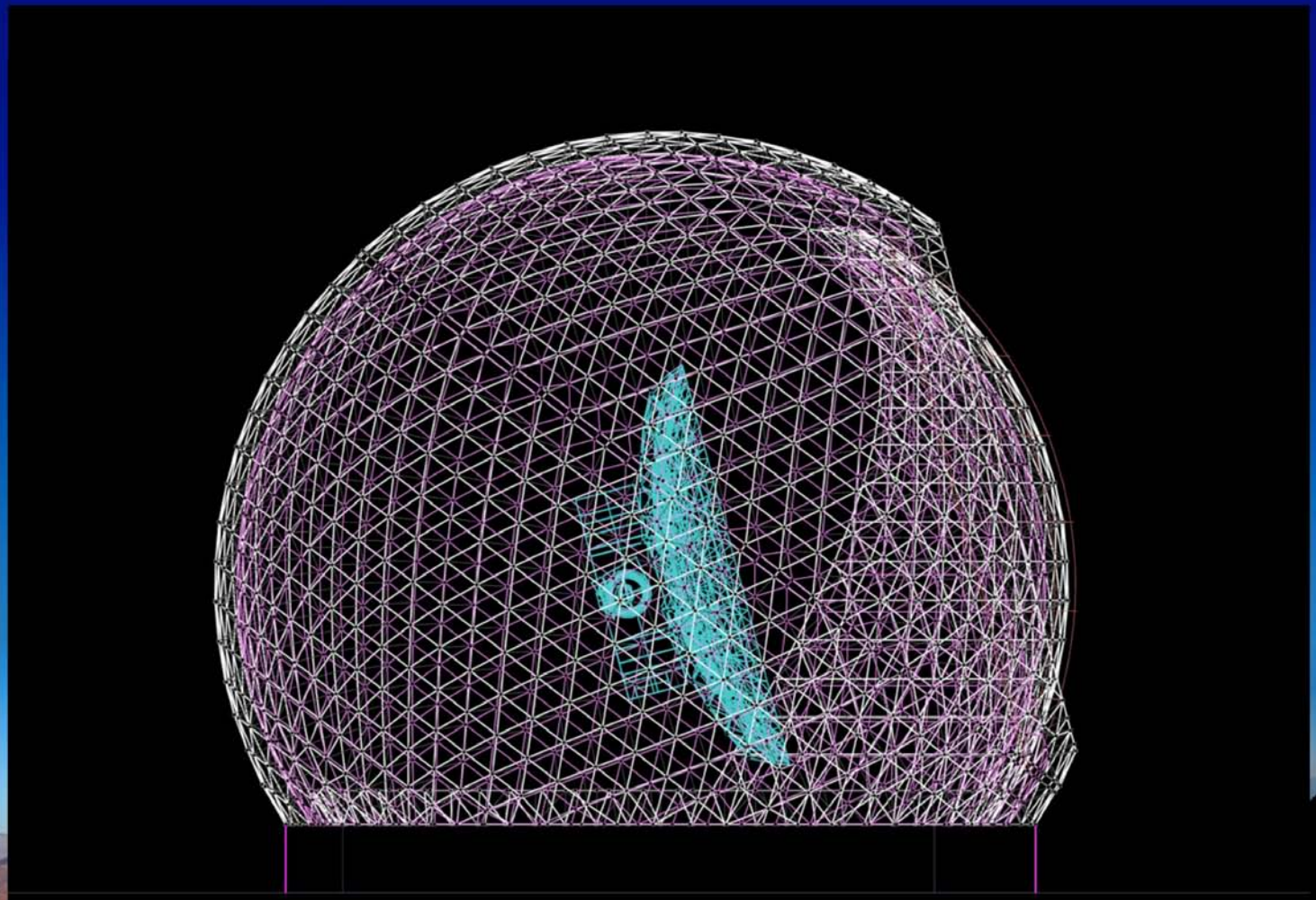


AMEC and Mero TSK Designs



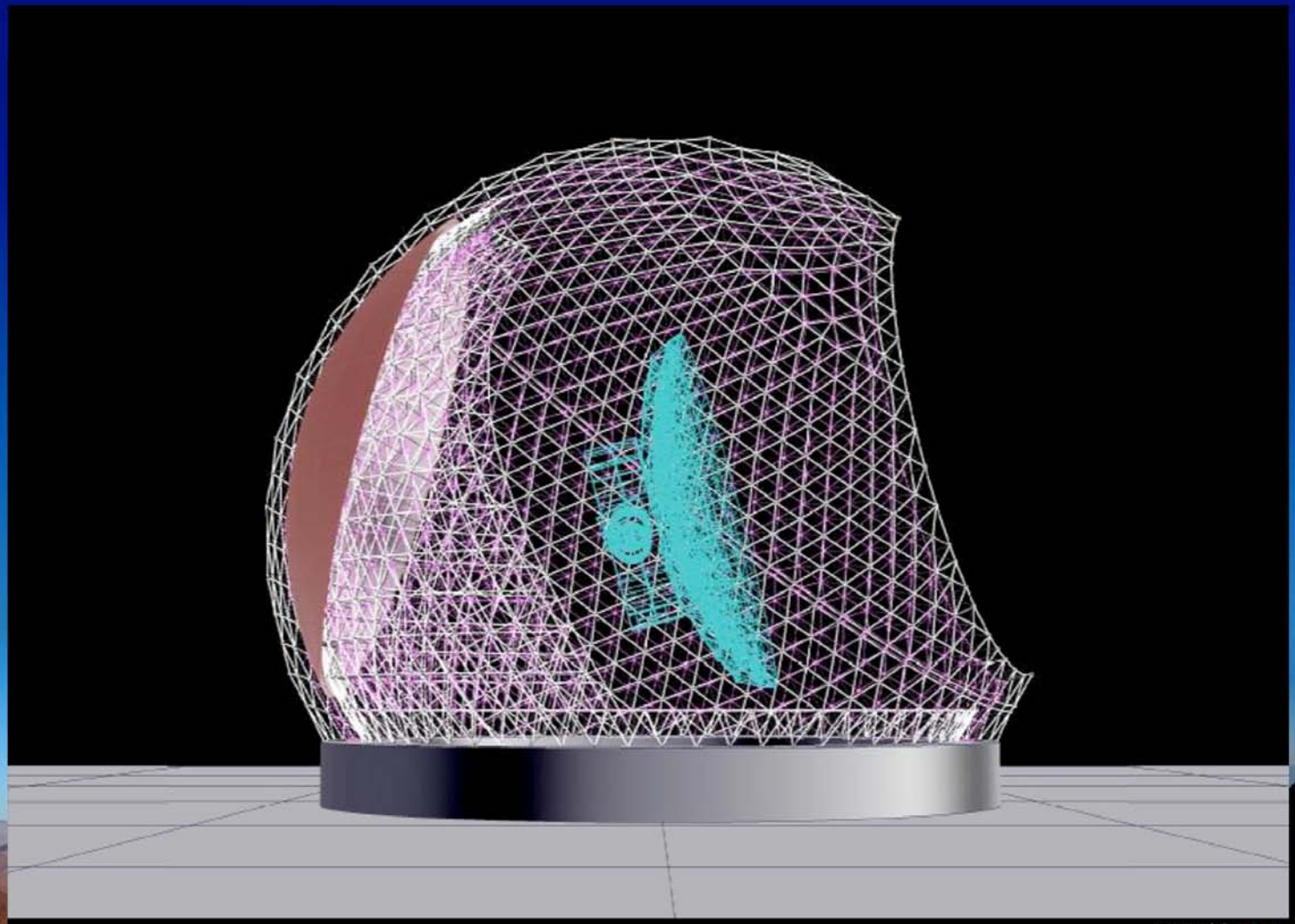
CCAT - Dome (1/2) + Shutter Structures Do01(1/2) + Shut01 : 2-layered triangulated space truss. Plan

AMEC and Mero TSK Designs



CCAT - Dome (1/2) + Shutter Structures: Do01(1/2) + Shut01 : 2-layered triangulated space truss. Section

AMEC and Mero TSK Designs



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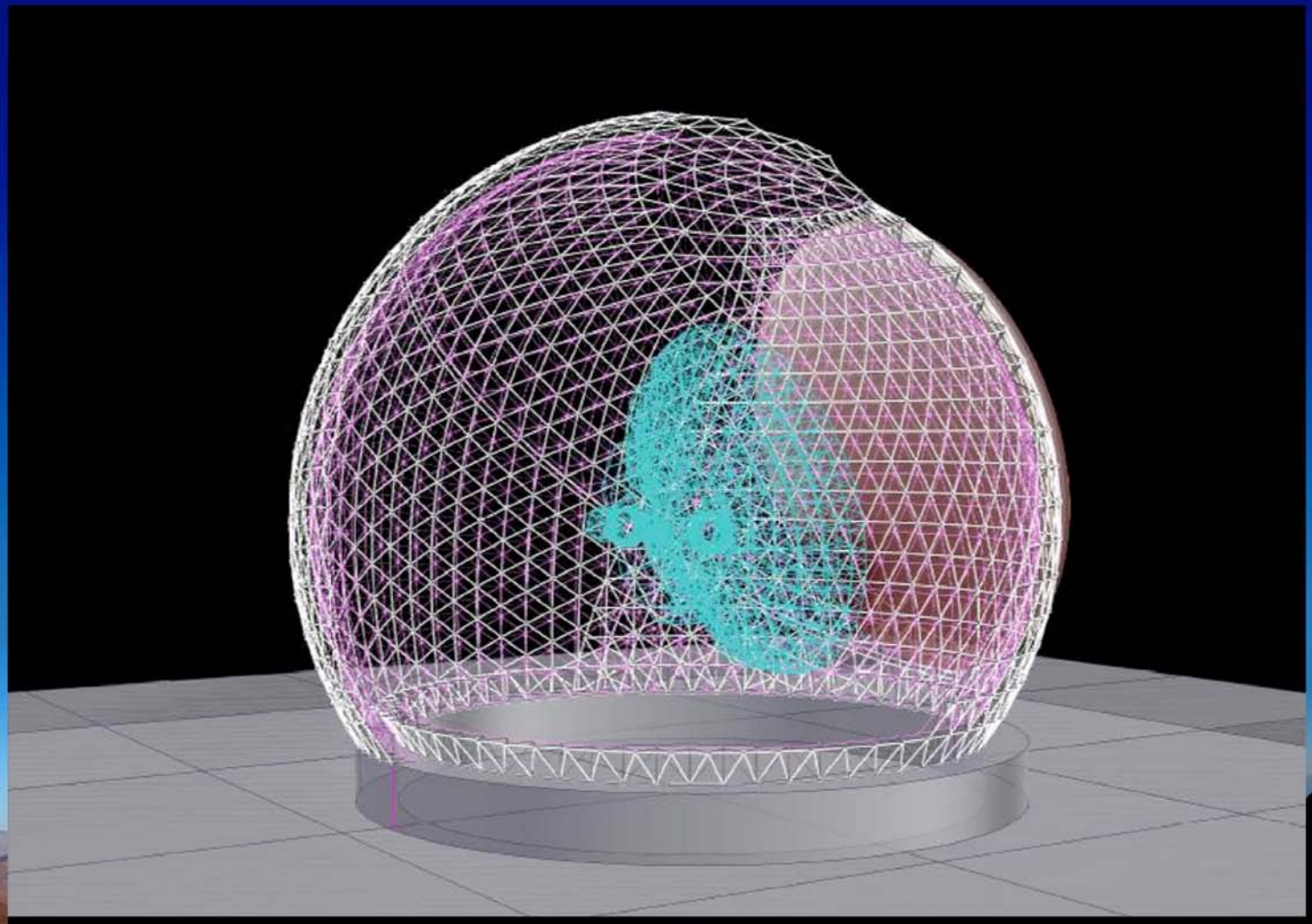

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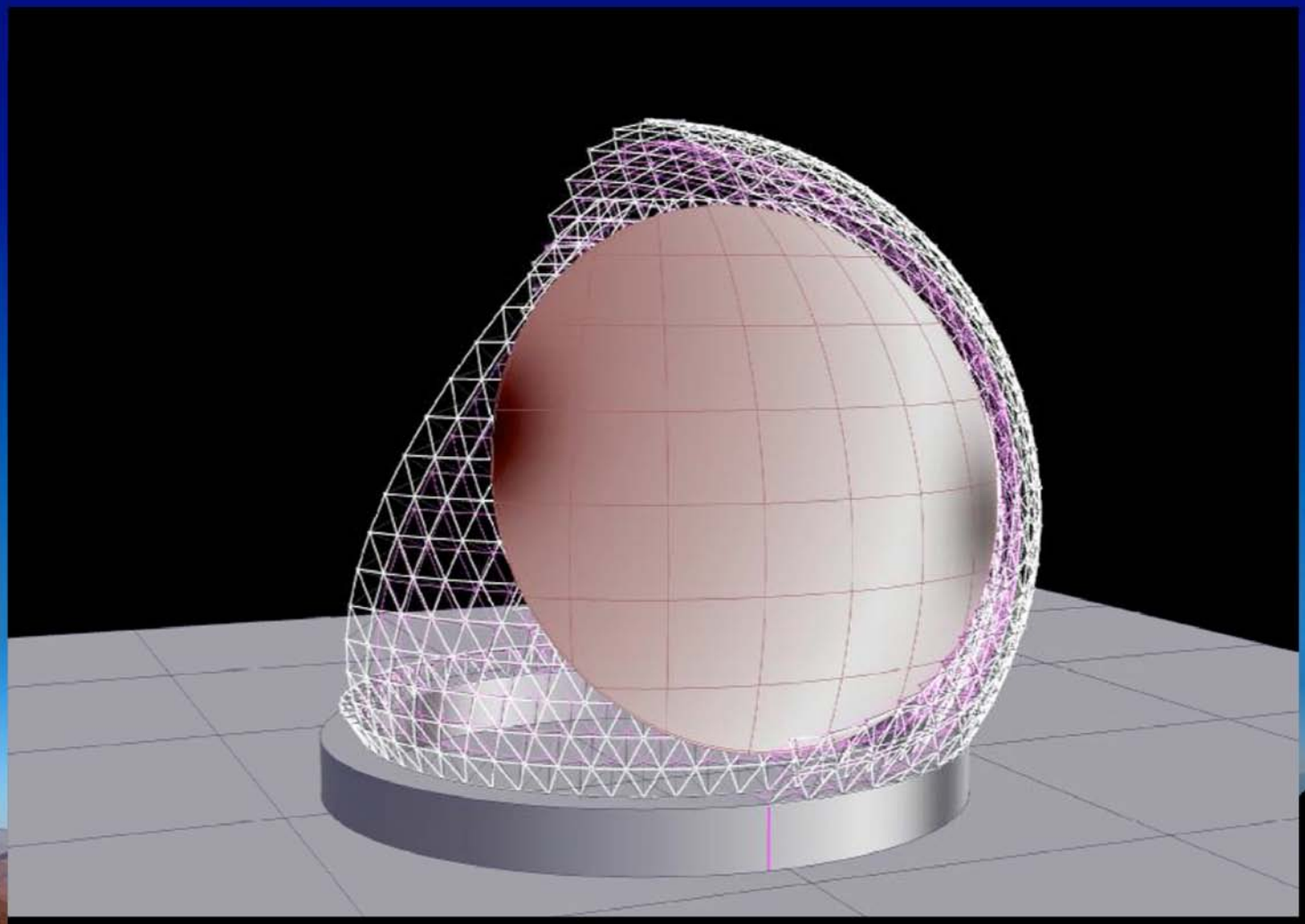
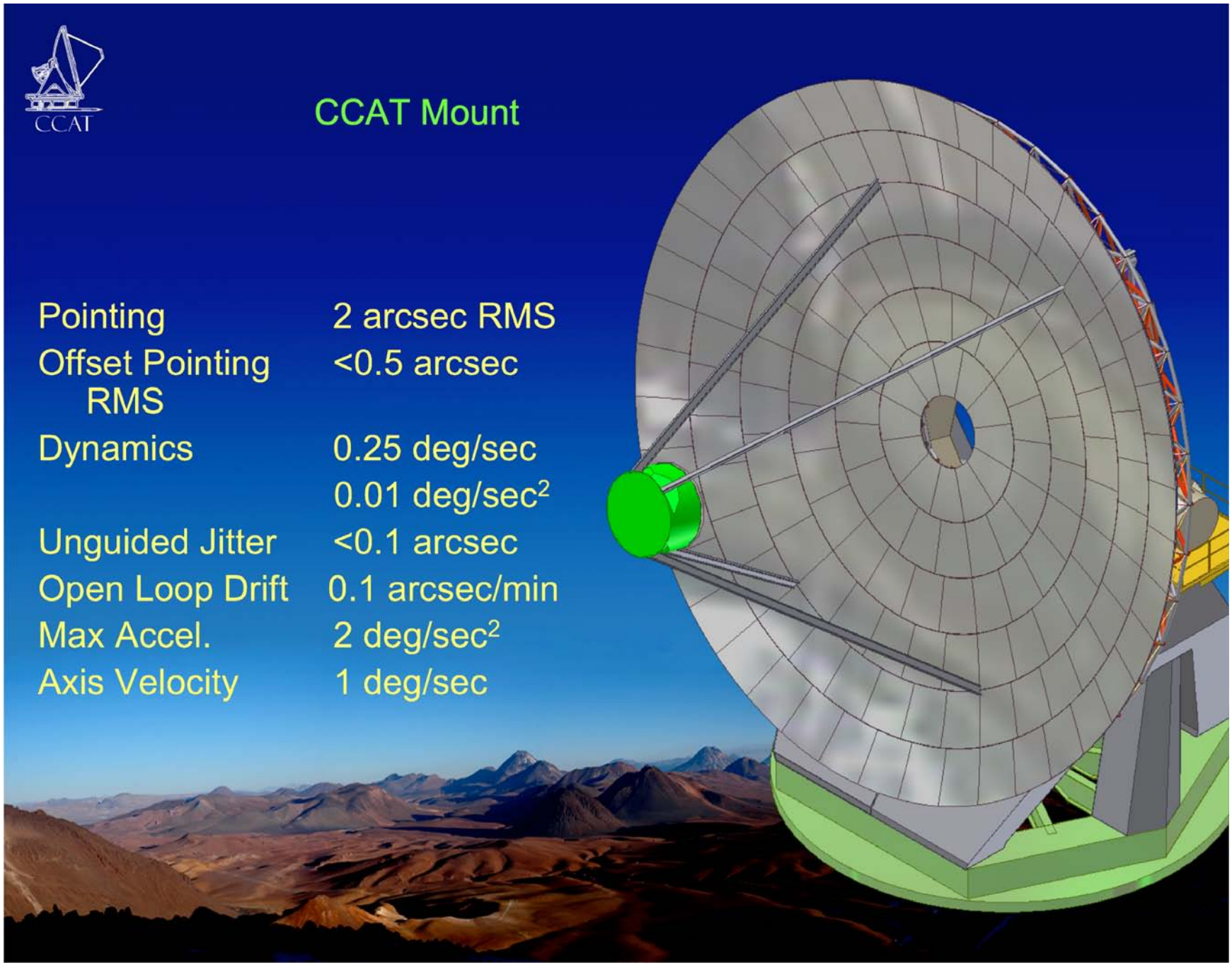



CCAT
Dome Work for EDP
• Dome Engineering Design Study
– Planning on Funding by CFI
– Includes EDS and Triodetic as Industrial Partners
– Address Critical Dome Design Issues
– Thorough Analysis
• Dome Facility Interface Design
– Integrate Dome Design with Architecture
– Add M3 as Industrial Participant
• Develop Design for Dome Ventilation
– Control Heating from Daytime Insolation
– Promote Thermal Uniformity Within Dome

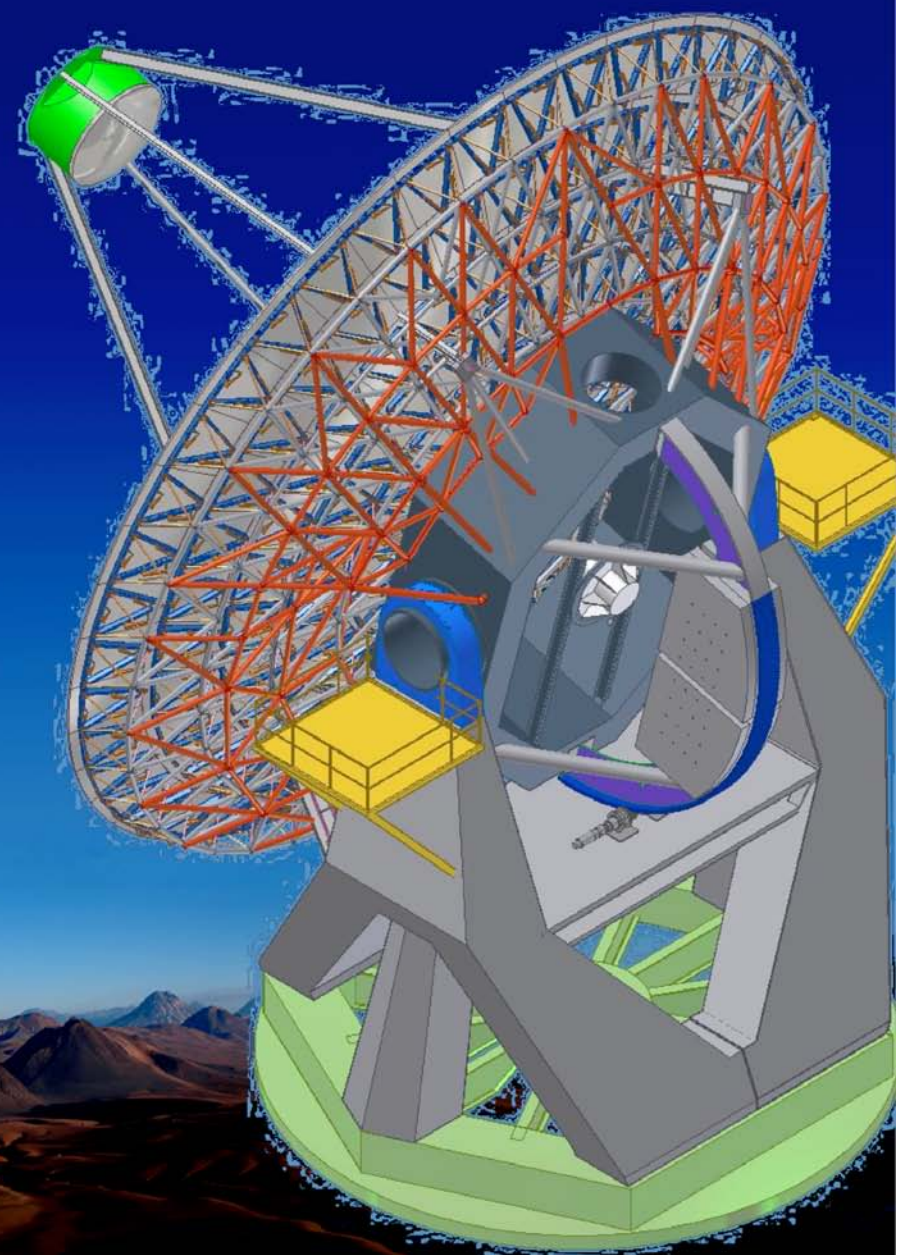
CCAT Mount

Pointing	2 arcsec RMS
Offset Pointing RMS	<0.5 arcsec
Dynamics	0.25 deg/sec
	0.01 deg/sec^2
Unguided Jitter	<0.1 arcsec
Open Loop Drift	0.1 arcsec/min
Max Accel.	2 deg/sec^2
Axis Velocity	1 deg/sec



CCAT Mount

- Plan Contract to Vertex
- Participation by Vertex, Germany
- More Detailed and Optimized Design
- Integrate Truss and M2 Supports
- Full FEM Modeling of Complete Mount
- Controls Model to Characterize Pointing and Scanning Performance

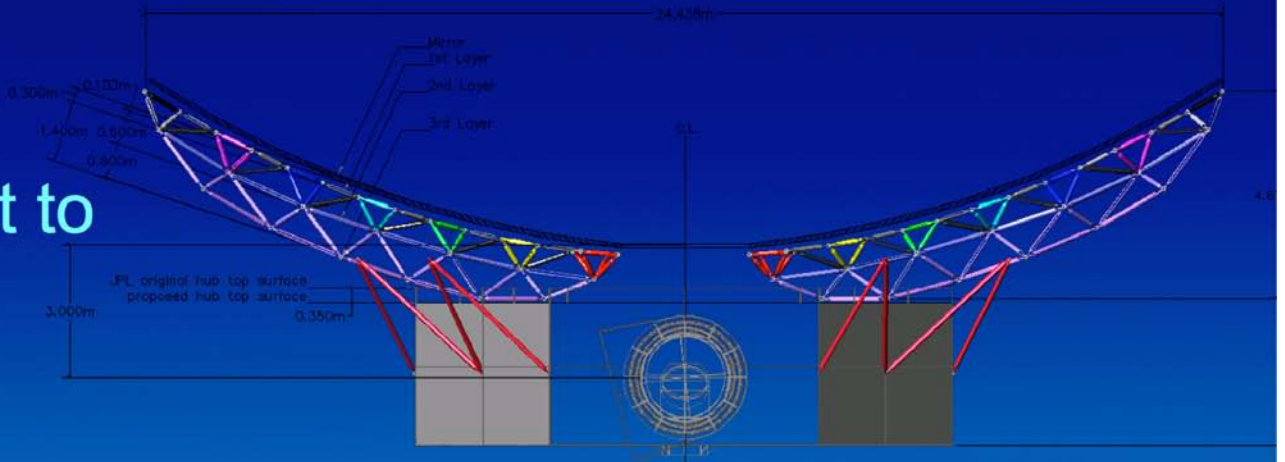


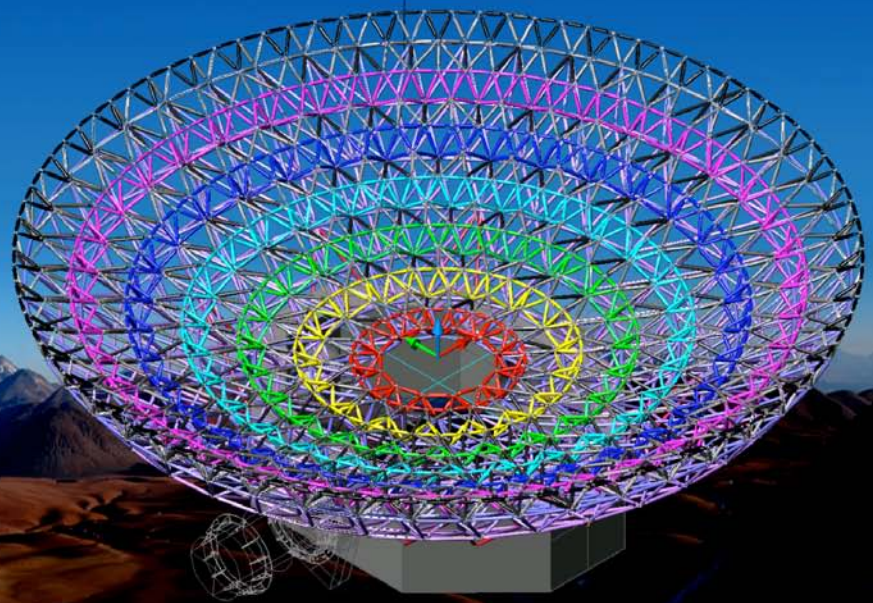
Primary Mirror EDP Work

- Primary Mirror Truss Design
  - Further Develop and Model Design
  - Integrate with Mount Design
  - Add Detail wrt Actuator Mounting
- Monolithic Segment Design, Analysis, Validation
  - Contracts with Composites Mfgs.
  - Full Design and FEM of Segments
  - Demonstration of Segment Performance
- Compound Panel Study
  - Advanced Submillimeter Optics
  - D. Woody Concept Studied by Vertex, Germany
  - Complete Design, Analysis, Demonstration
  - Technology Applicable to M2 & M3
  - Includes M2 Struts

Primary Mirror Truss Design

- Optimize Attachment to Mount
- Add Detail
- Better Performance Analysis
- Manufacturing Engineering





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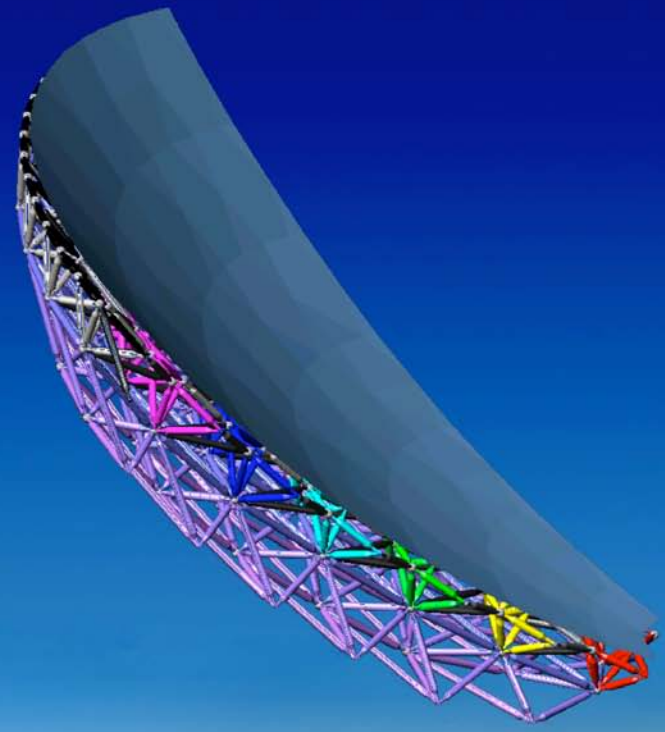
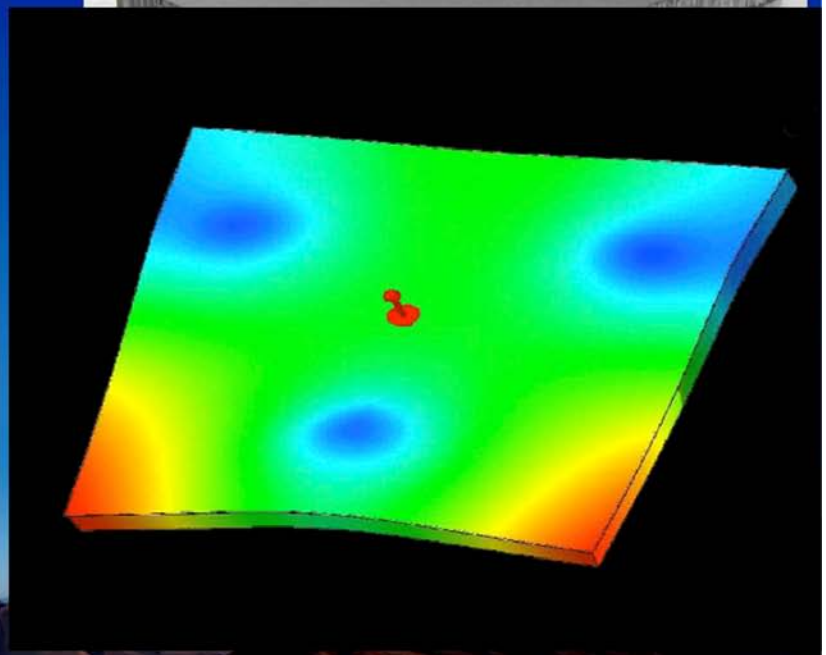


Monolithic Primary Mirror Panels

- Composite Design and Analysis
- Dual Award for Study and Analysis

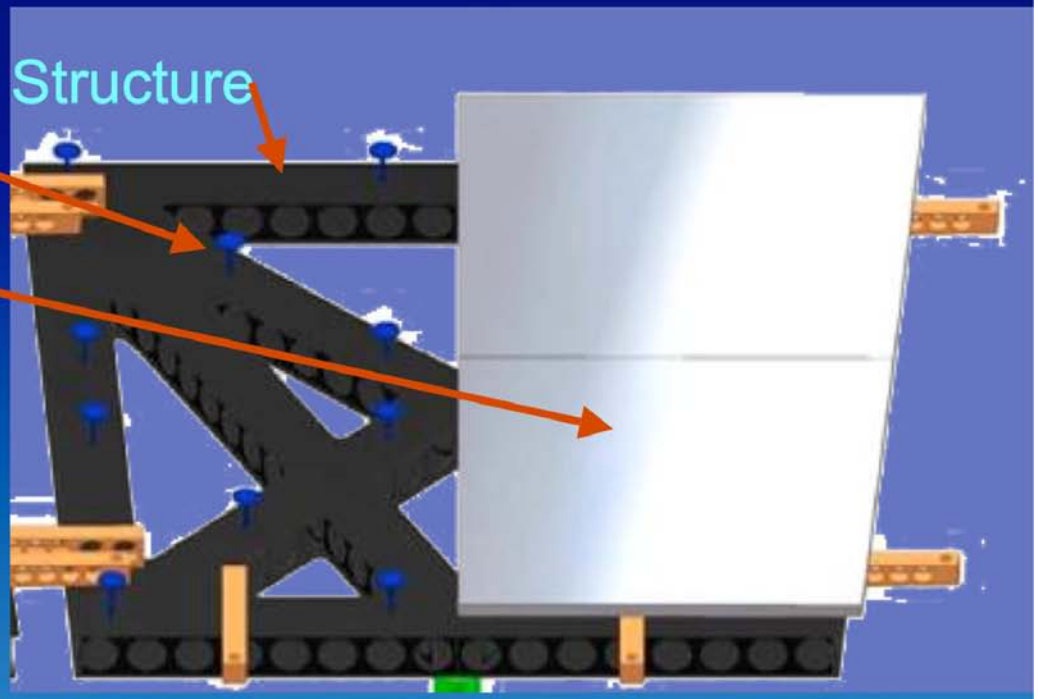
Monolithic Primary Mirror Panels

- Composite Design and Analysis
- Dual Award for Study and Analysis
- Down select or two awards for Demonstration Segment Fabrication & Test



Compound Panel Concept

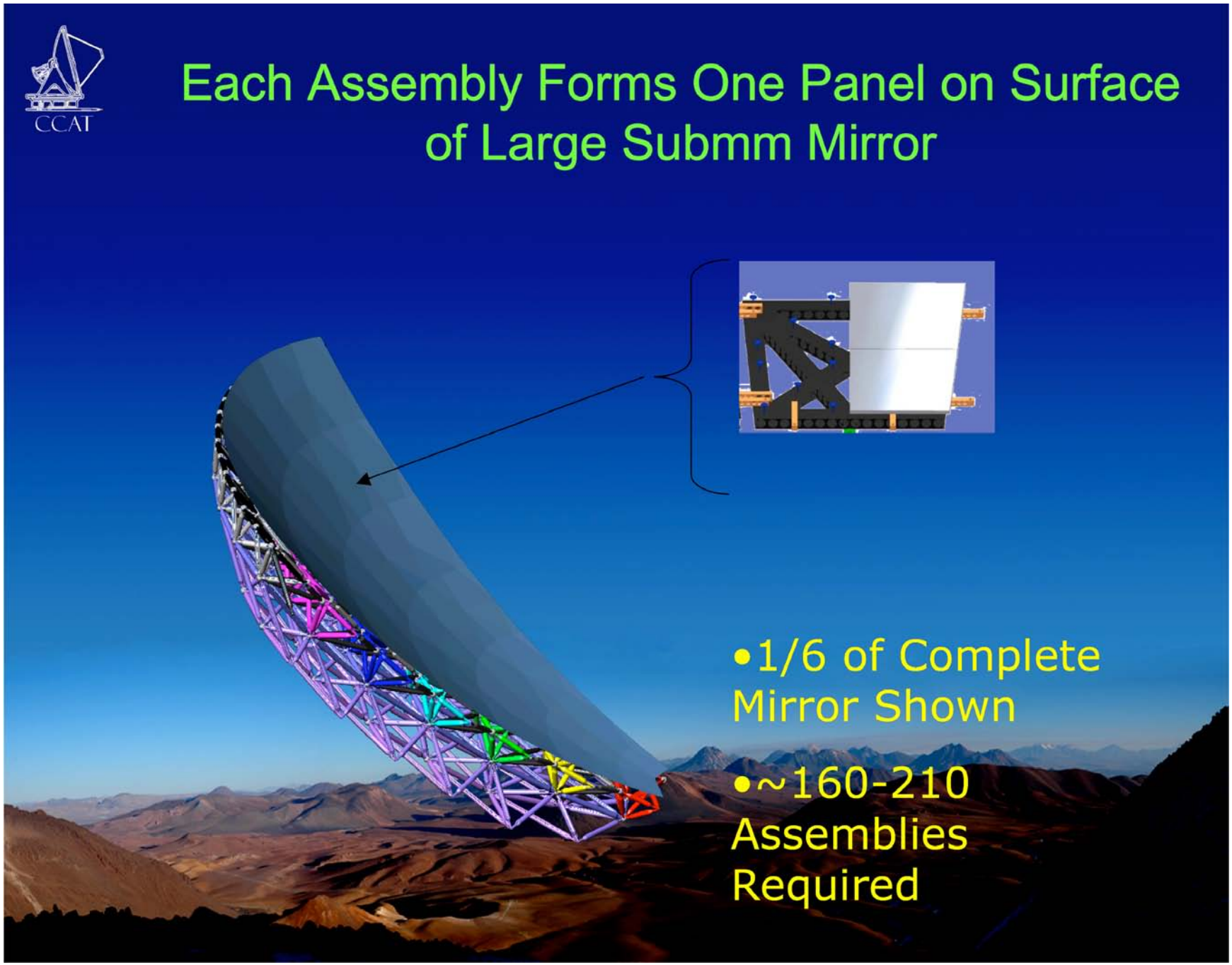
- Composite Support Structure
- Panel Adjusters
- Panels



Concept Allows Segments of Parent Optics to be Made Up From Small, Highly Accurate Replicated Panels

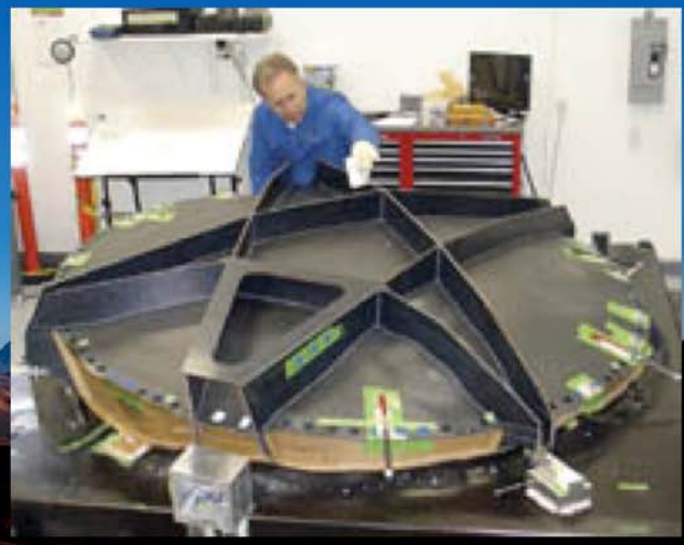
Multiple Assemblies Can Then Be Assembled into Larger Optics Using Active Positioning

Each Assembly Forms One Panel on Surface of Large Submm Mirror



Other Possible M2/M3 Approach

- Ku/Ka Band Satellite Reflectors
  - "Volume" Production
  - ~.001 Inch PV Precision
  - ~2 m Diameter
- 3.0 Meter Parabolic Antenna
  - ~5 kg/m^2
  - 400 gHz
  - About 2.5x Worse Surface Quality Than Required for CCAT
  - Right Size for M2 & M3 for CCAT
- Metrology Limits Precision for Companies Making Reflectors
  - Laser Trackers Only Permit ~0.001 inch Measurement



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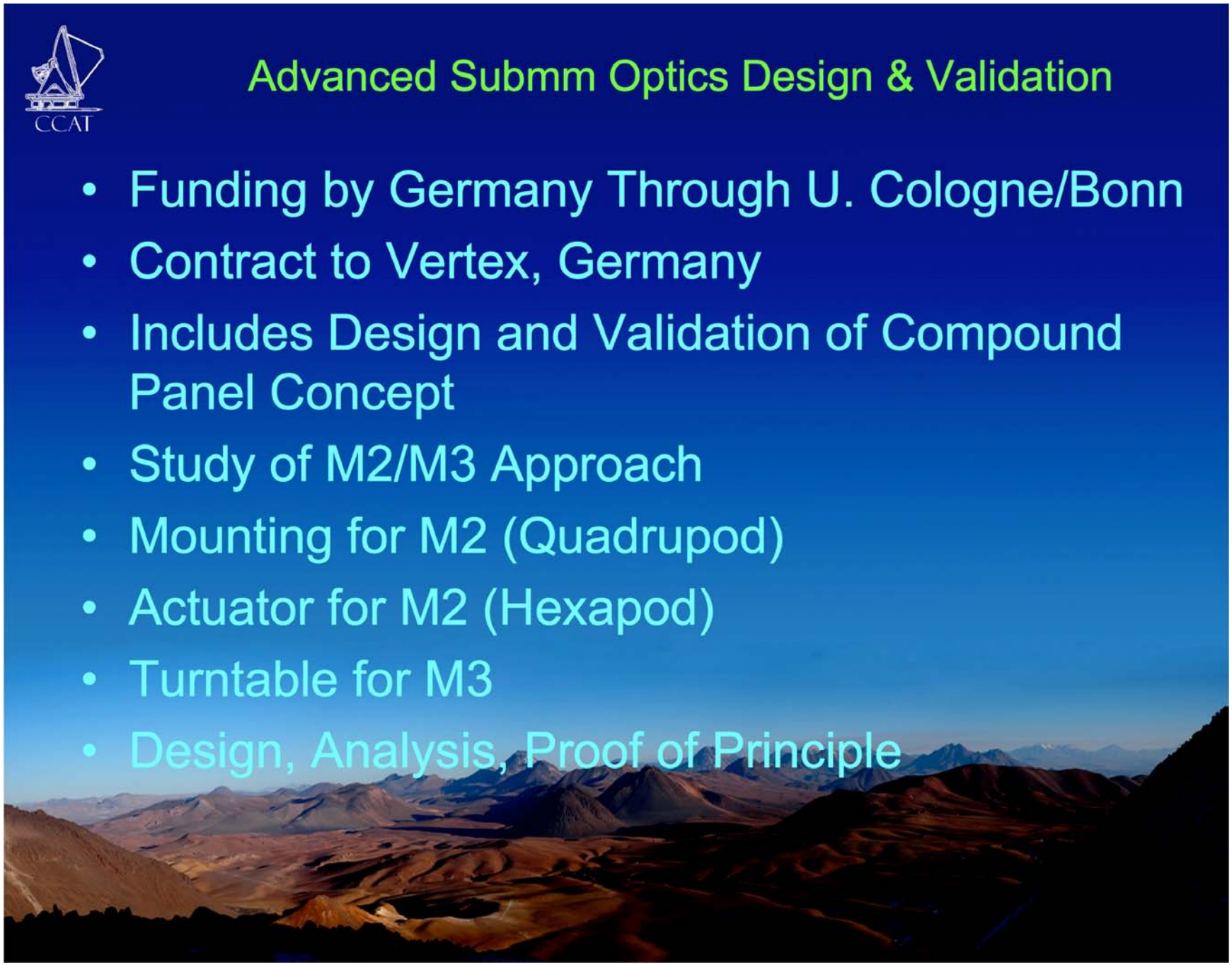
3.0-meter High Gain Antenna
with 0.5-meter Sub Reflector


CCAT
Advanced Submm Optics Design & Validation
• Funding by Germany Through U. Cologne/Bonn
• Contract to Vertex, Germany
• Includes Design and Validation of Compound Panel Concept
• Study of M2/M3 Approach
• Mounting for M2 (Quadrupod)
• Actuator for M2 (Hexapod)
• Turntable for M3
• Design, Analysis, Proof of Principle

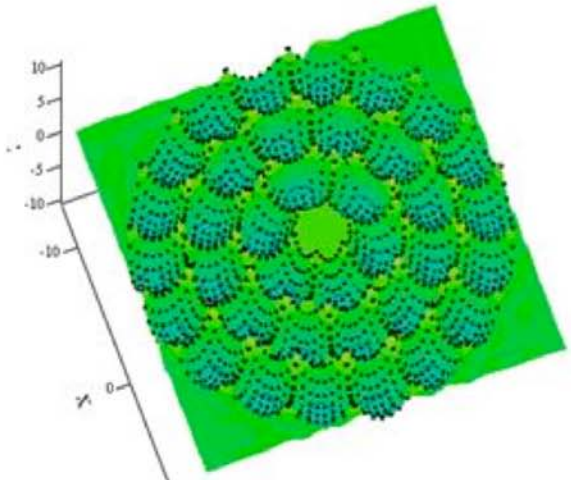
If the Front to Back Gradient is the Same for All Segments

- 36 panel telescope with edge and dihedral sensors
- Uniform curvature for all panels
- Effect of thermal cupping

nZerSupport= 0 nmpZerSupport= 0 nZerCurve= 0 nmpZerCurve= 1 NumPanel= 96 Nabsolute= 1

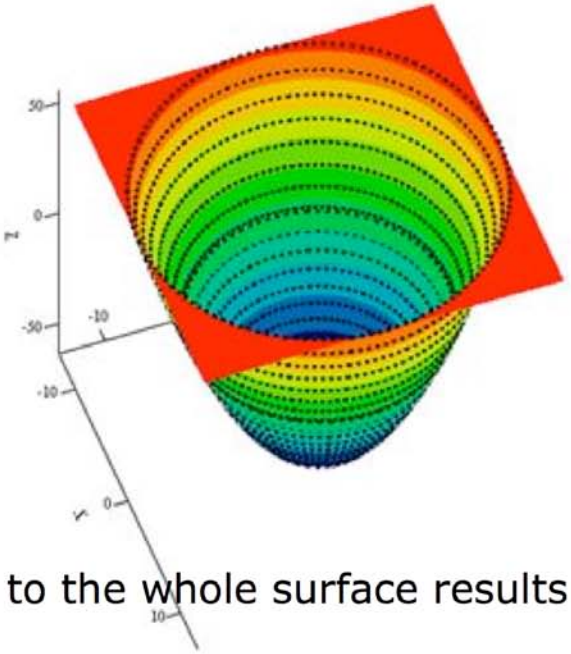
$Stdev(pnB^{(2)}) = 1.35$ surface RMS [microns]

surface before



$Stdev(pnA^{(2)}) = 33.407$ surface RMS [microns]

surface after control correction



$$nsens = \begin{pmatrix} 1 \\ 1 \\ 1 \times 10^{3} \\ 1 \times 10^{3} \\ 6 \\ 5.629 \end{pmatrix}$$

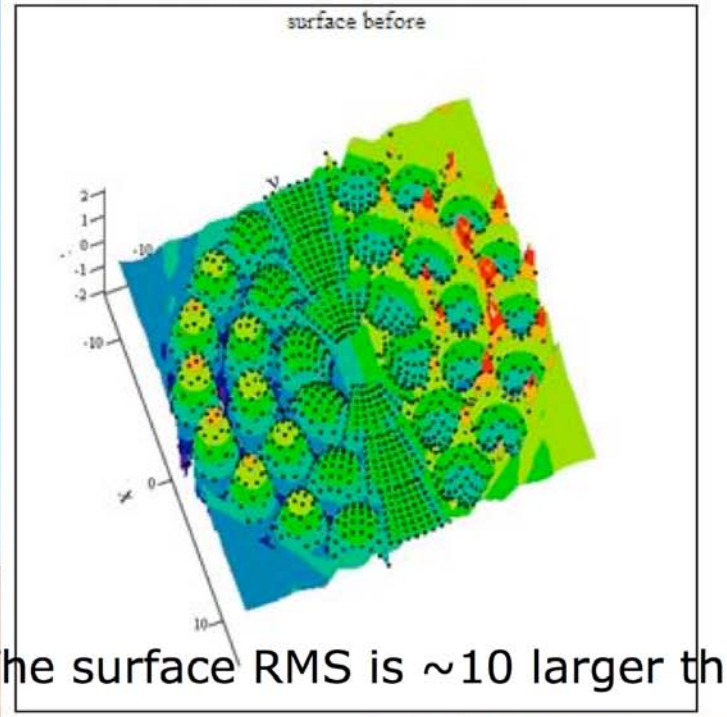
Applying the panel curvature coherently to the whole surface results in sensor readings of zero.

If the Gradient Varies Across PM Aperture

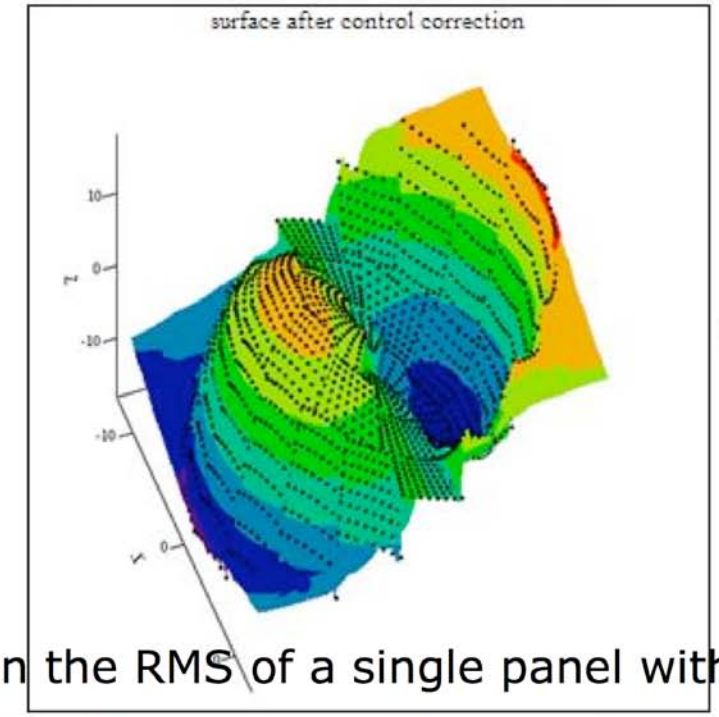
- 36 panel telescope with edge and dihedral sensors
- Curvature amplitude given by Zernike #2
- Curvature varies across telescope

nZerSupport= 0 nmpZerSupport= 0 nZerCurve= 1 nmpZerCurve= 1 NumPass= 96 Nabsolute= 1

$\text{Stdev}\left(\text{puB}^{\langle 2\rangle}\right) = 0.766$ surface RMS [microns]



$\text{Stdev}\left(\text{puA}^{\langle 2\rangle}\right) = 7.005$ surface RMS [microns]



$$\text{norms} = \begin{pmatrix} 1 \\ 1 \\ 1 \times 10^{3} \\ 1 \times 10^{3} \\ 6 \\ 5.629 \end{pmatrix}$$

The surface RMS is ~10 larger than the RMS of a single panel with curvatur

JPL-Caltech Continued Work

- Systems Engineering: e.g. Error Budgets
- Active Optical System Performance Modeling and Projections
- Development of Calibration WFS & Possible Brassboard Testing on CSO
- Development of Supplementary Panel Alignment System: Potential Follow up on AOA Designs

Summary

- An Ambitious Program to Further Develop the CCAT Design
- Retire Most Prominent and Significant Risks
- Ensure that Performance Will Meet Specifications
- Prepare Contractors to Bid and Perform Contracts
- Give All Partners Confidence that CCAT Can Meet Requirements and be Developed Within Cost Constraints
- Take the Next Significant Step Forward Toward Initiation of Construction