National Aeronautics and Space Administration

Early Stage Technology Workshop

Astrophysics and Heliophysics

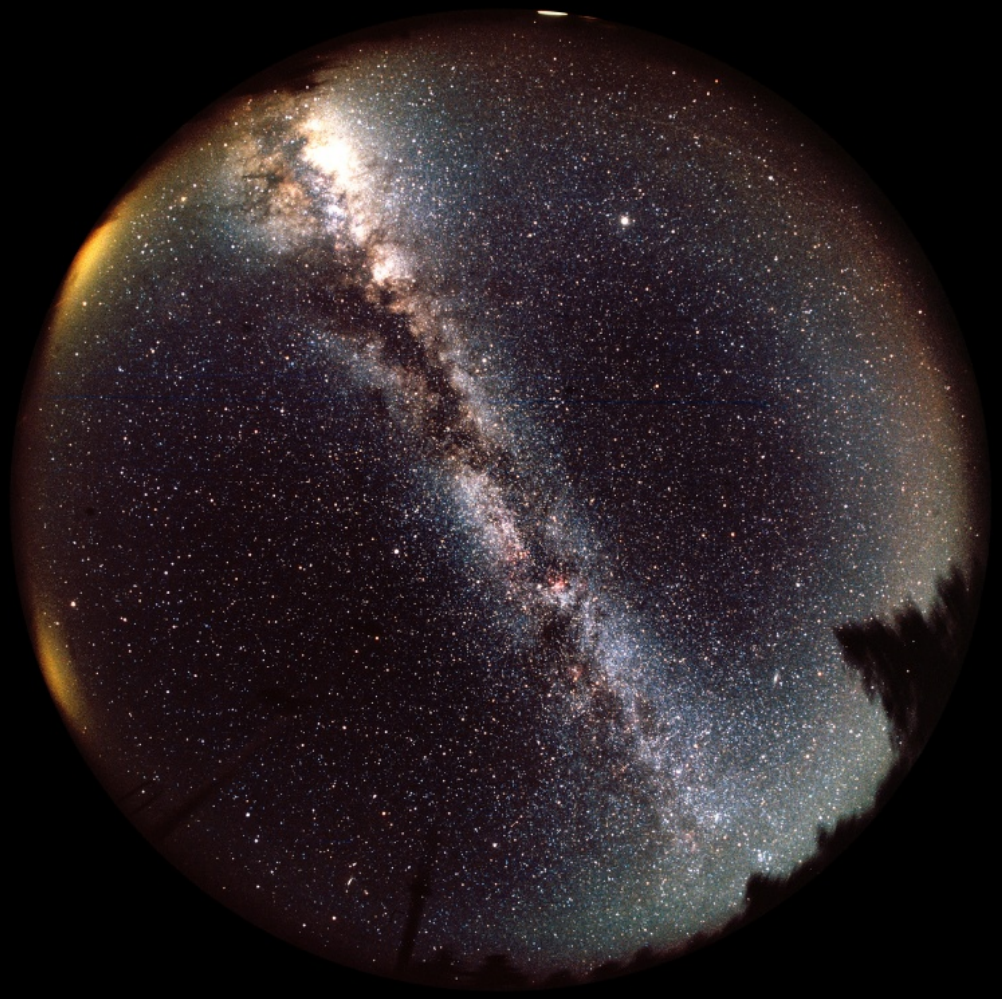
March 3-4, 2015

10 meter Sub-Orbital Large Balloon Reflector

UofA, SwRI, APL, JPL, ASU, Cornell
Chris Walker
Prof. of Astronomy, Optical Sciences,
& Electrical Engineering (UofA)

TECHNOLOGY DRIVES EXPLORATION

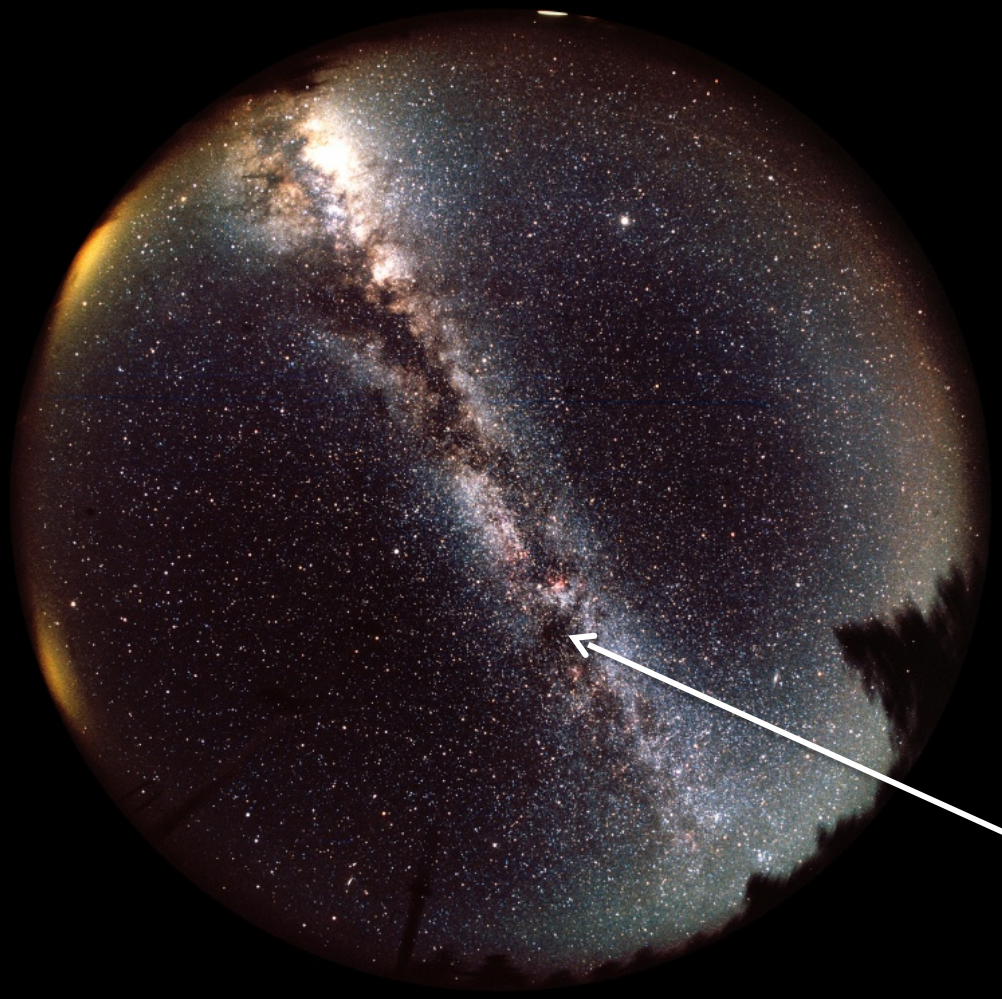
THz Explores Cosmic Origins



We live in a Galaxy comprised of stars, planets, and people.

Where did it all come from?

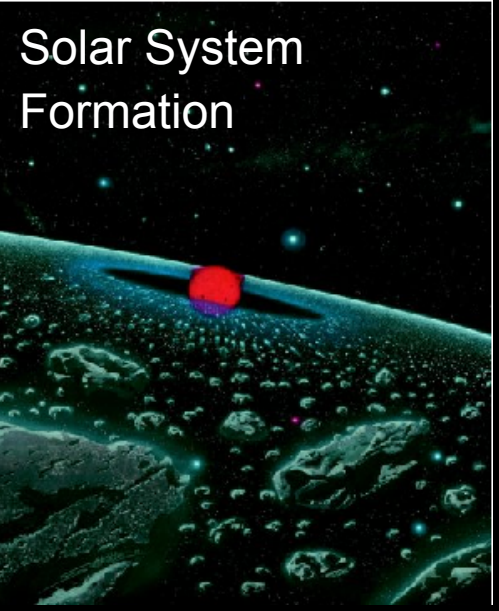
THz Explores Cosmic Origins



We live in a Galaxy comprised of stars, planets, and people.

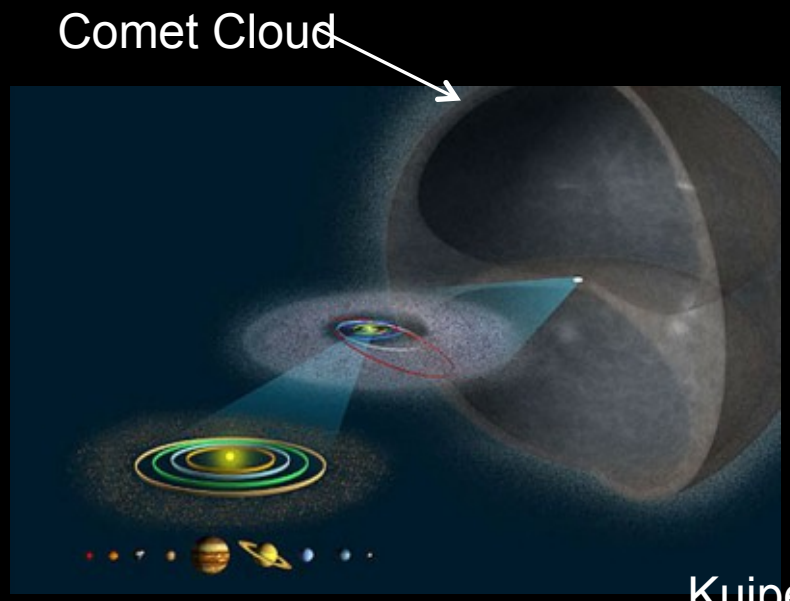
Where did it all come from?

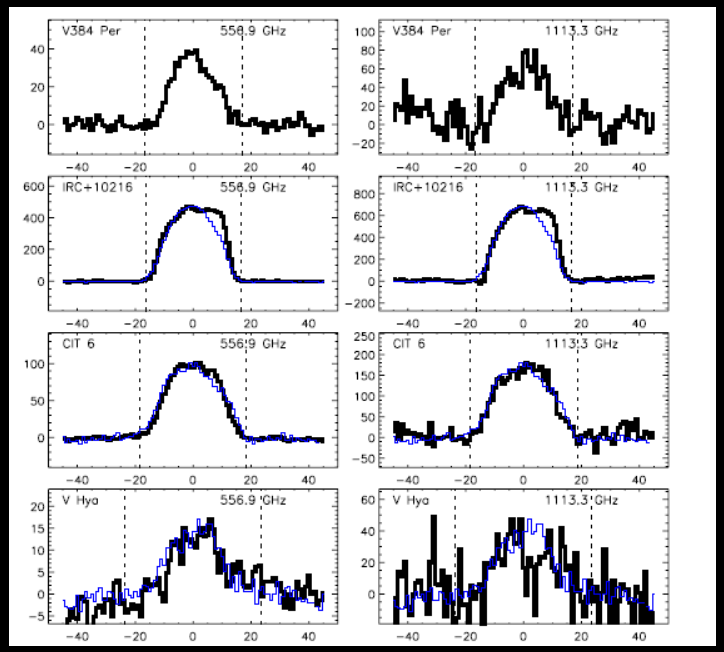
Interstellar Medium (ISM)



LBR: Prospecting for *Cosmic Origins*

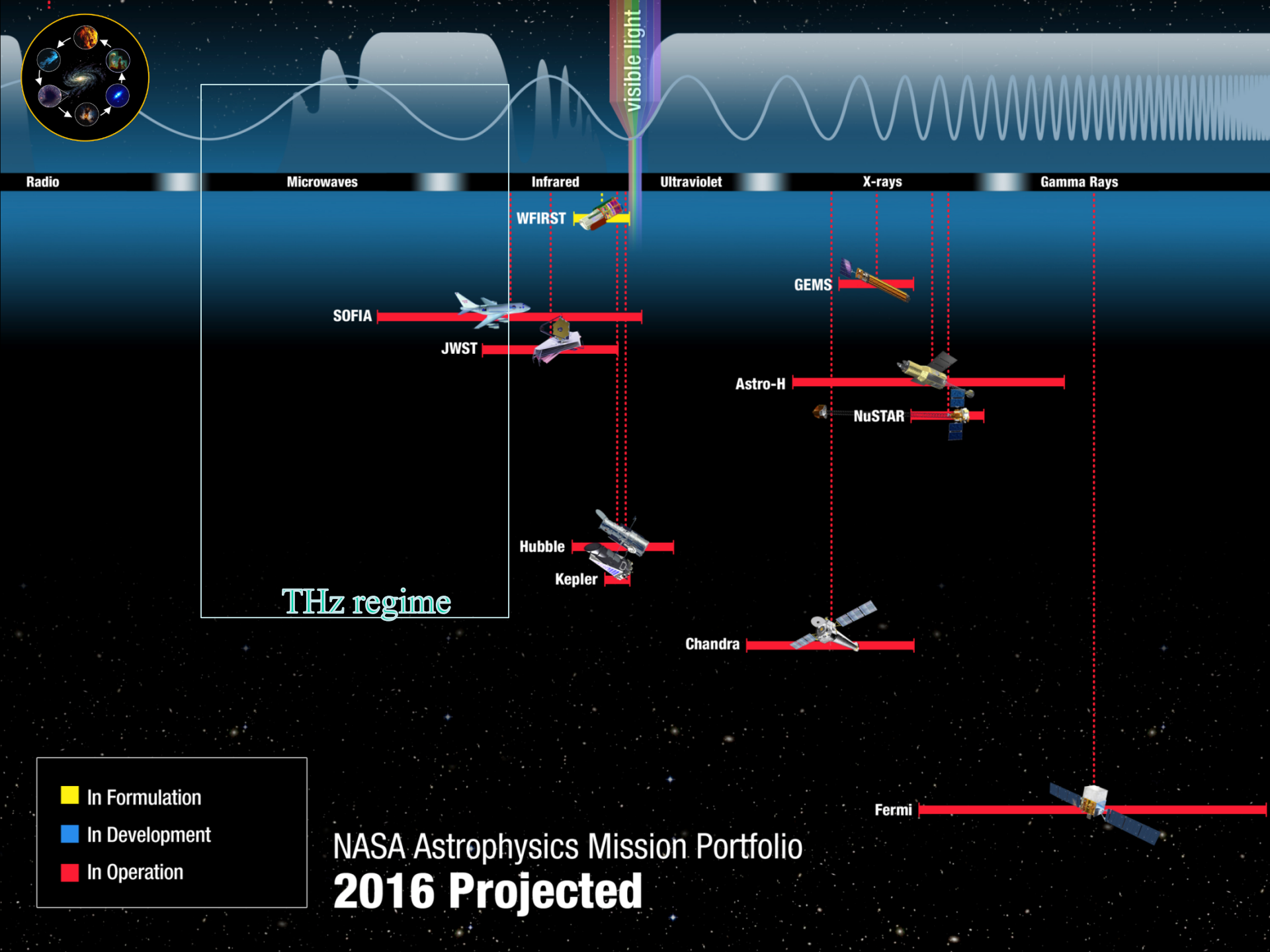
Cosmic Evolution: Probing Lithium abundance (444 GHz)
Stellar Evolution & Planet Formation: Probing Water (557 GHz)
External Galaxies: Normal, Starburst, High z, etc.

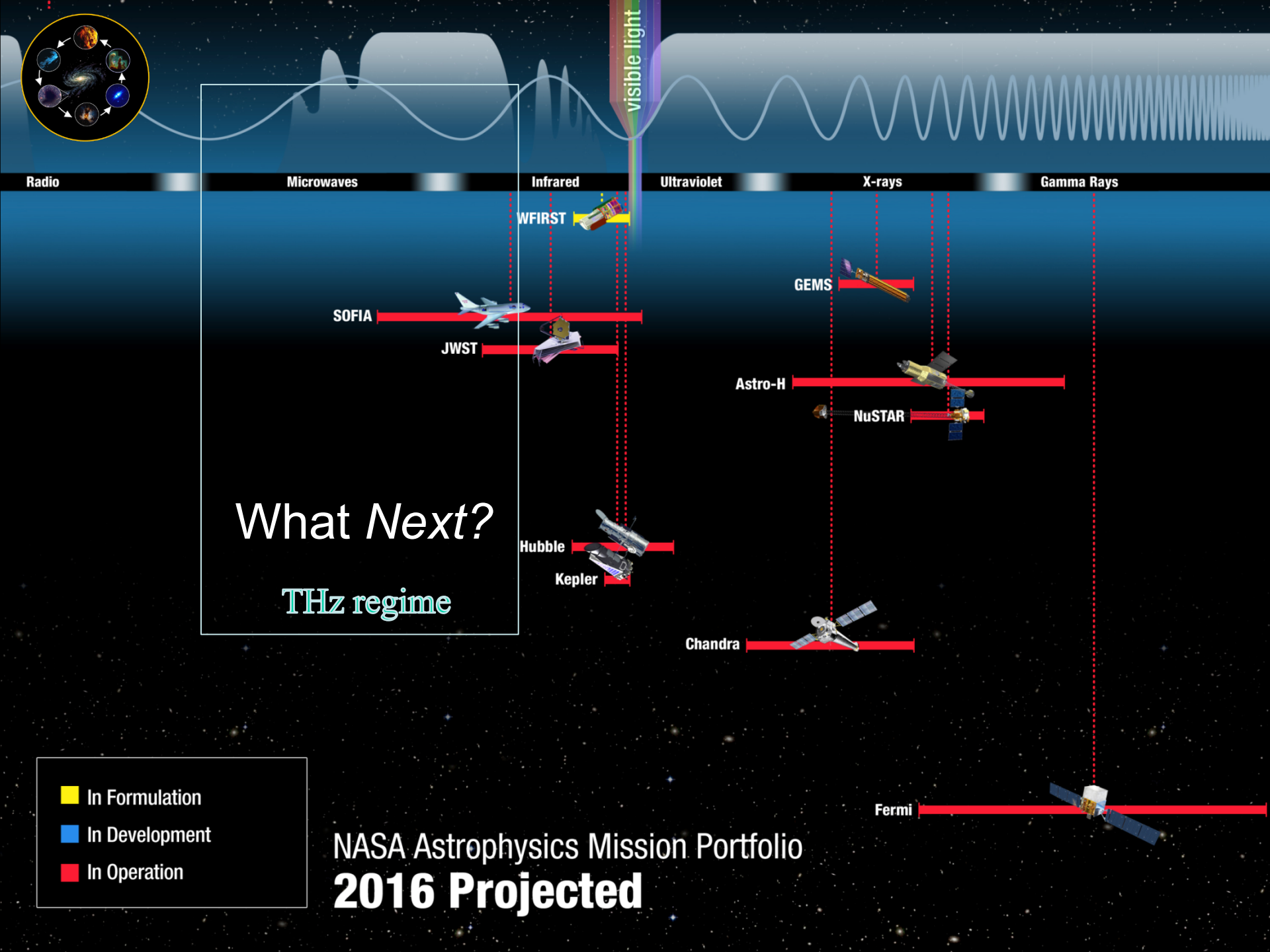




557 GHz Water line toward evolved stars

Neufeld e al. 2011


visible light
Radio
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Rays
WFIRST
GEMS
SOFIA
JWST
Astro-H
NuSTAR
Hubble
Kepler
THz regime
Chandra
Fermi
In Formulation
In Development
In Operation
NASA Astrophysics Mission Portfolio
2016 Projected


visible light
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What Next?
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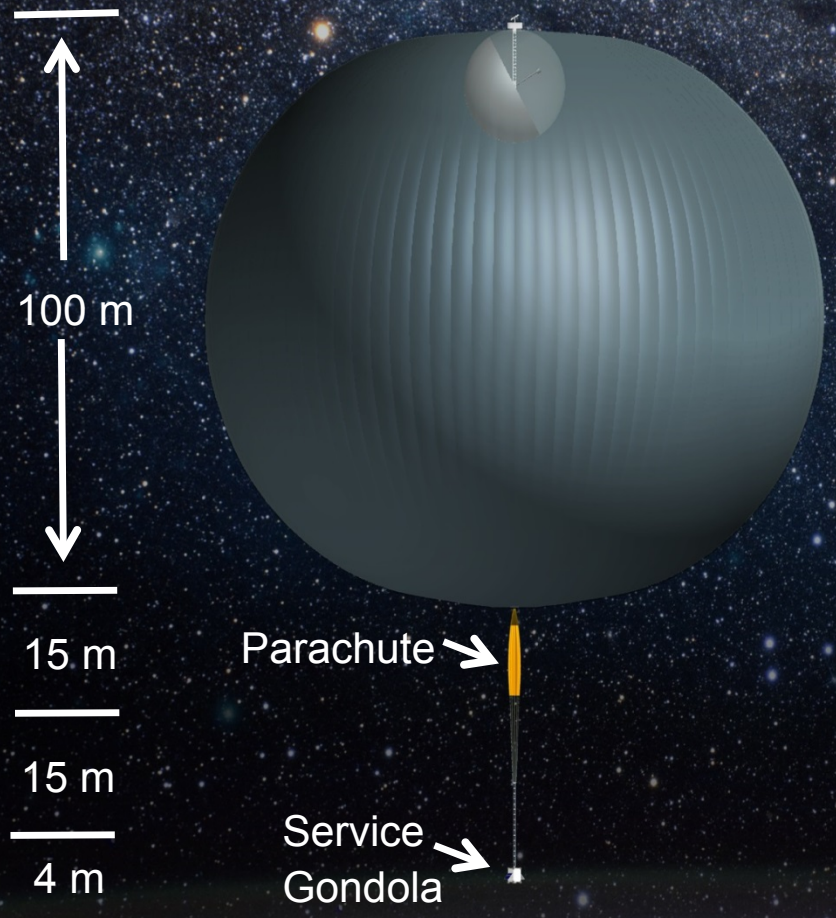
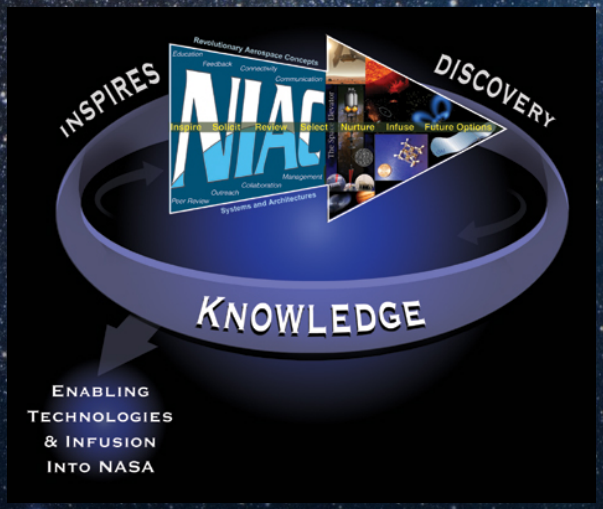
10 meter Large Balloon Reflector

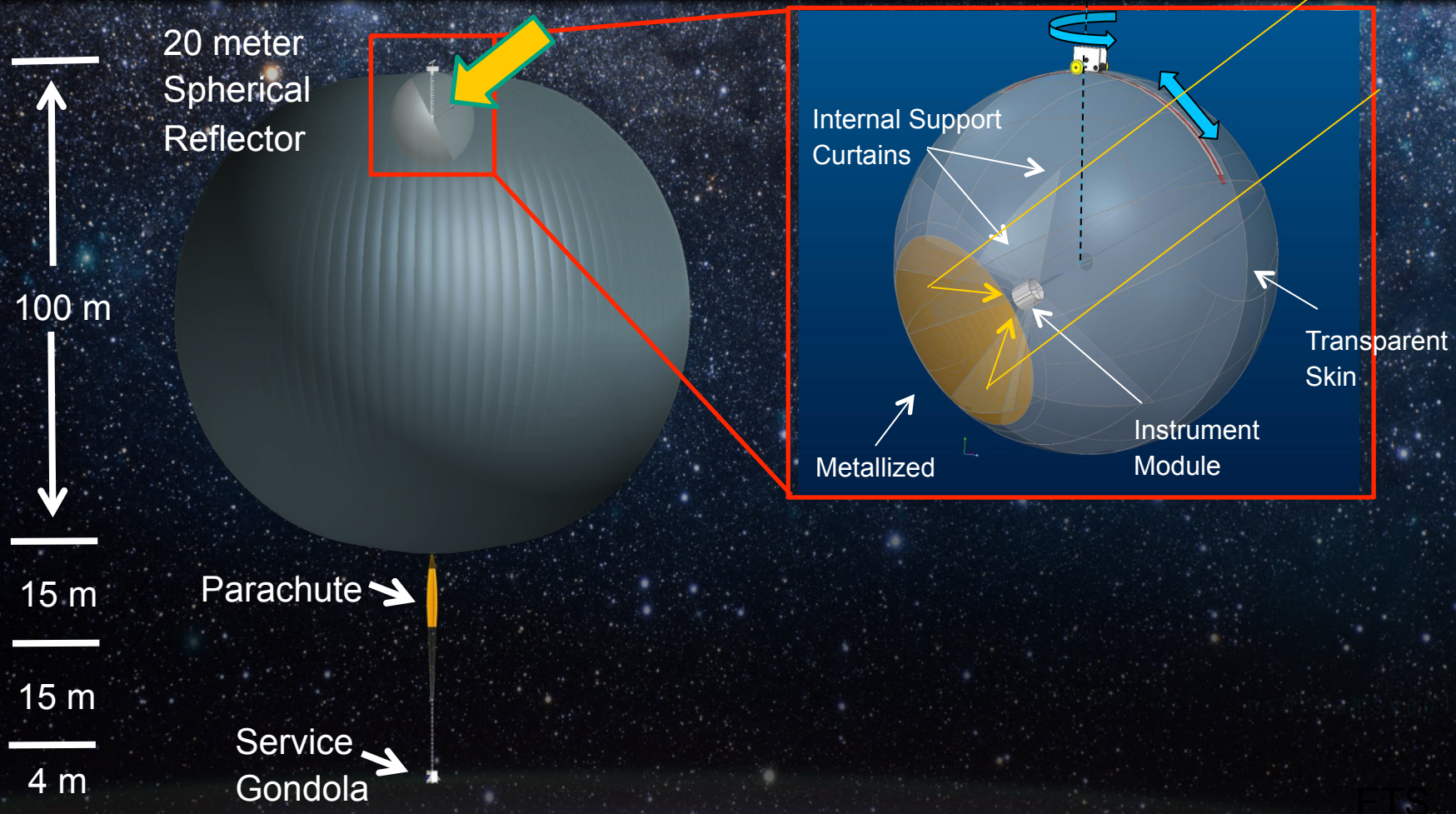




LBR Selected for Phase I Study: 2013

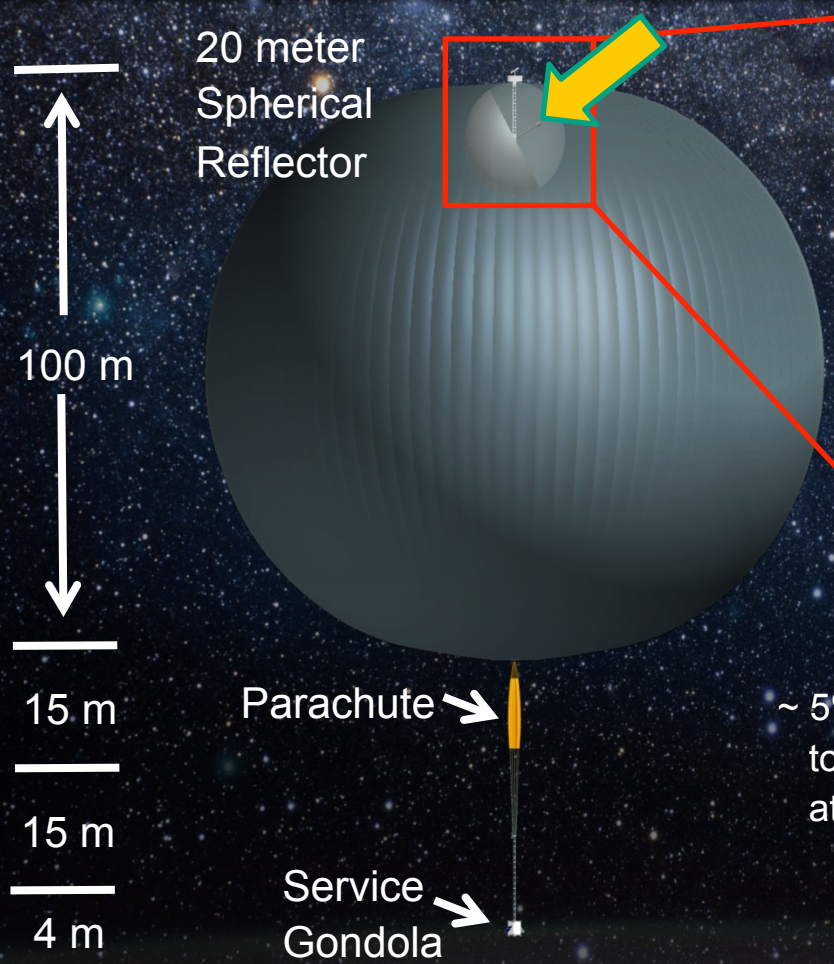
Float altitude ~135,000 ft

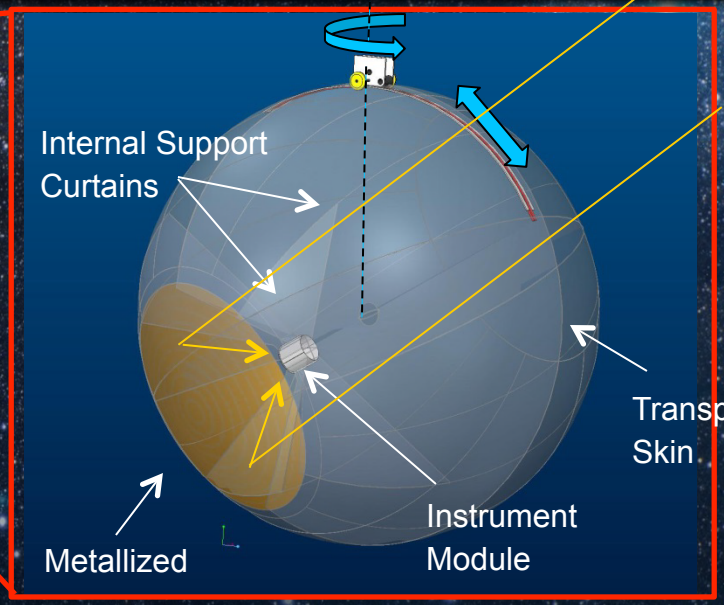
Large Balloon Reflector (LBR)*



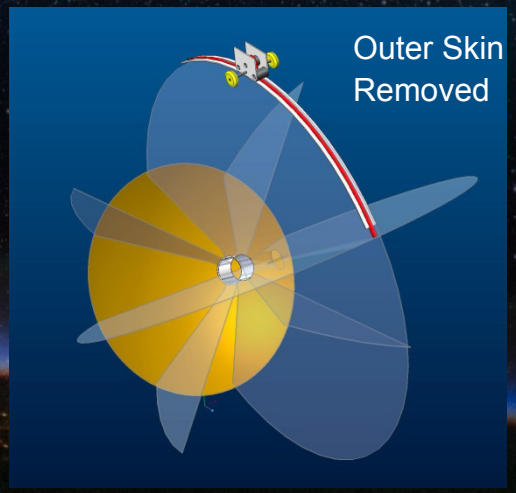
FTS

Large Balloon Reflector (LBR)*





~ 5% signal loss
to dish surface
at 557 GHz.



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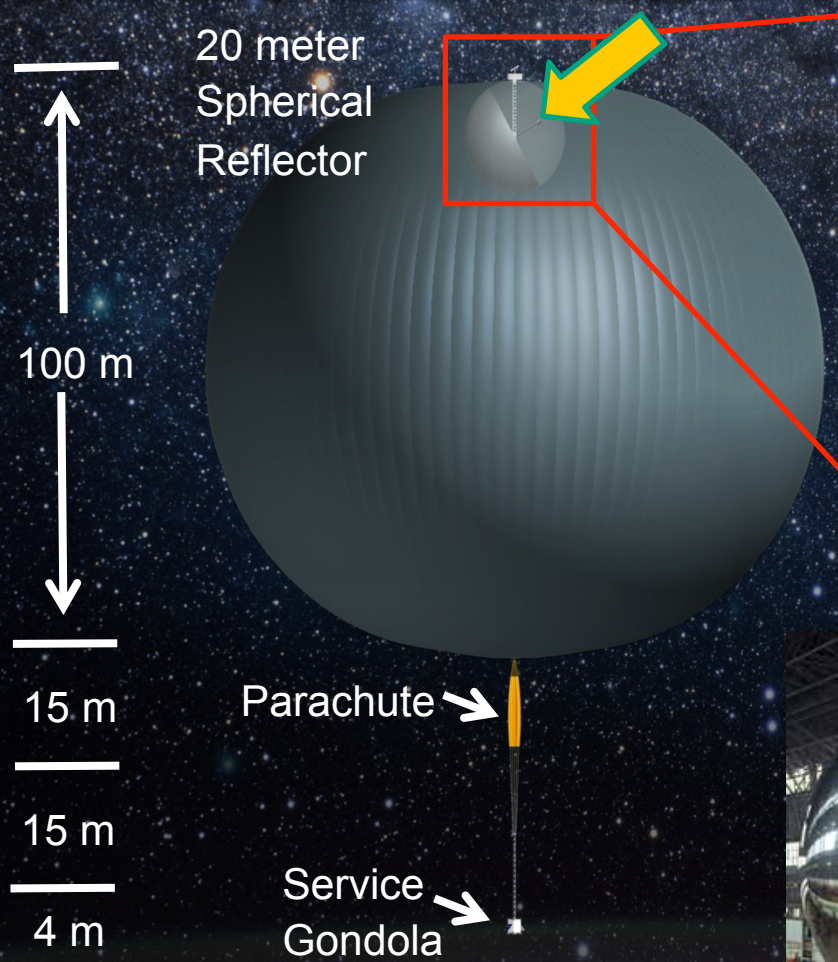
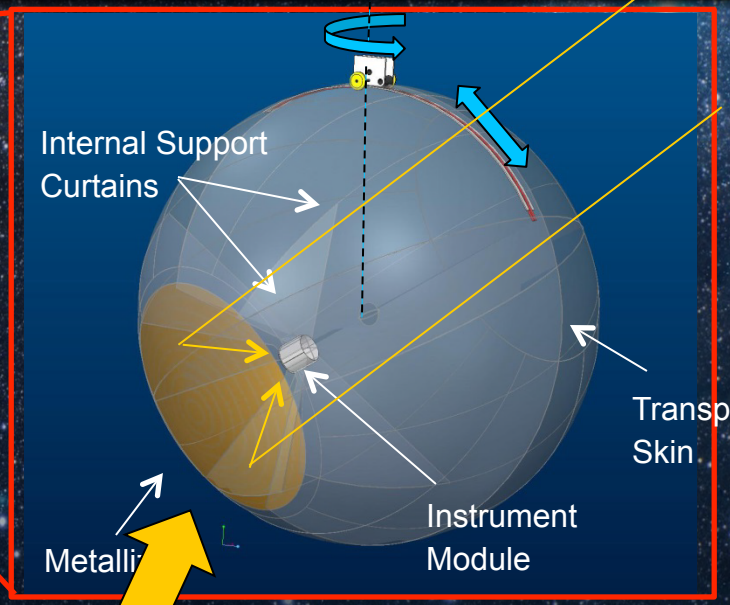
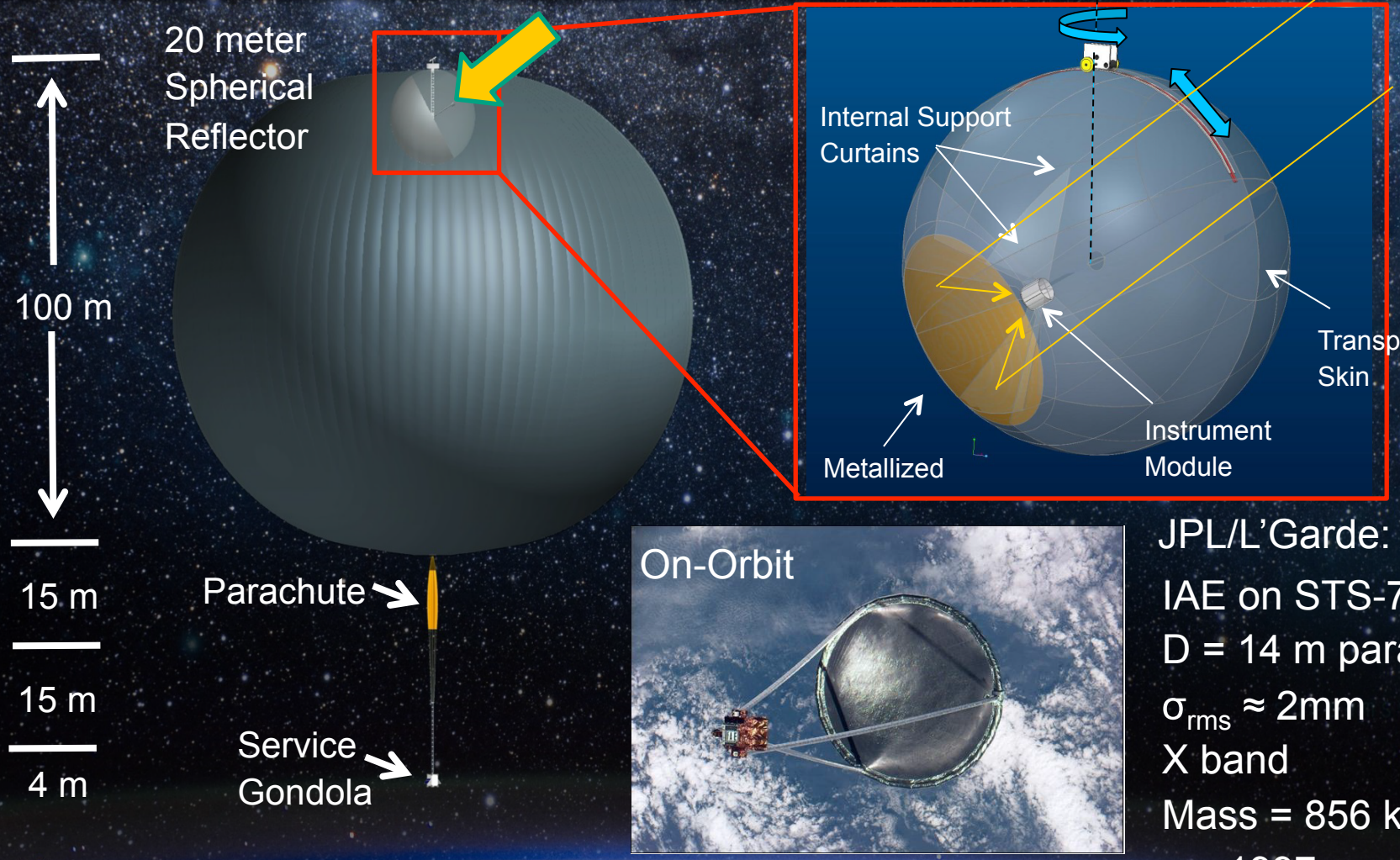




Echo I Satellite
30.5 m sphere
L band
ca. 1960

Large Balloon Reflector (LBR)*



JPL/L'Garde:

IAE on STS-77

D = 14 m parabola

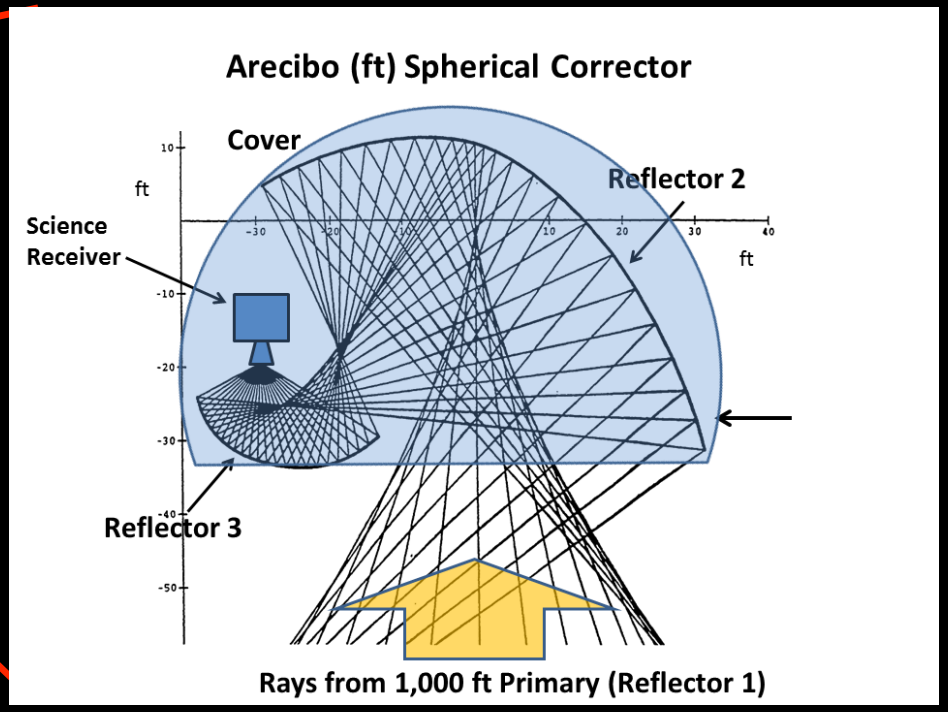
$\sigma_{rms} \approx 2$mm

X band

Mass = 856 kg

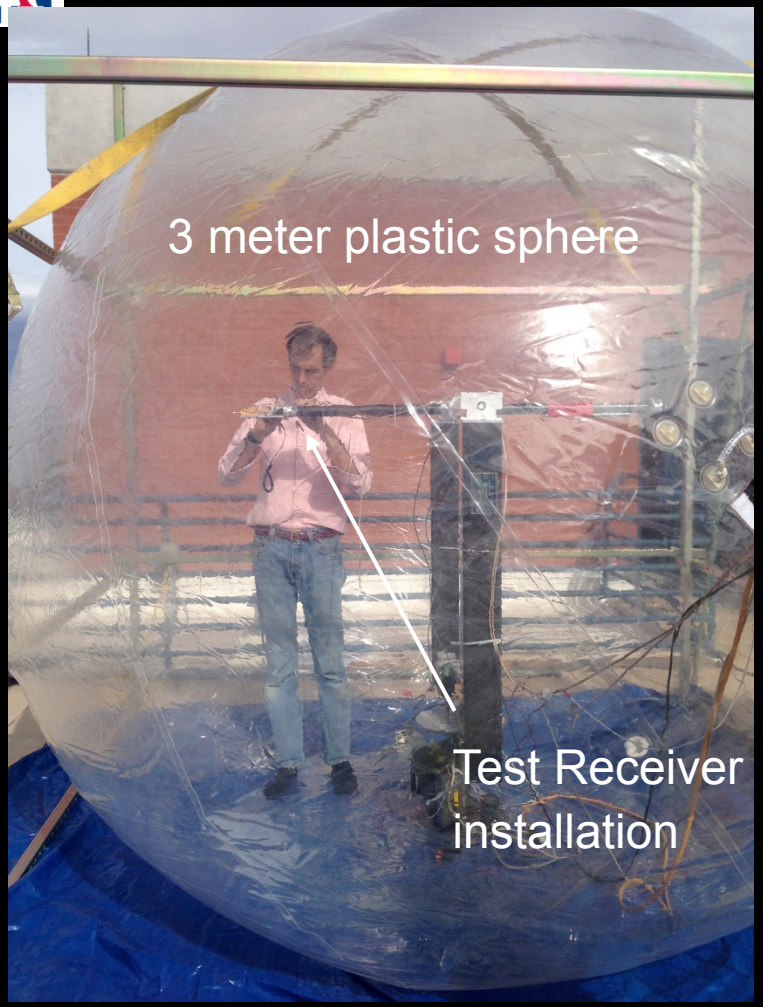
ca. 1997

Spherical Corrector



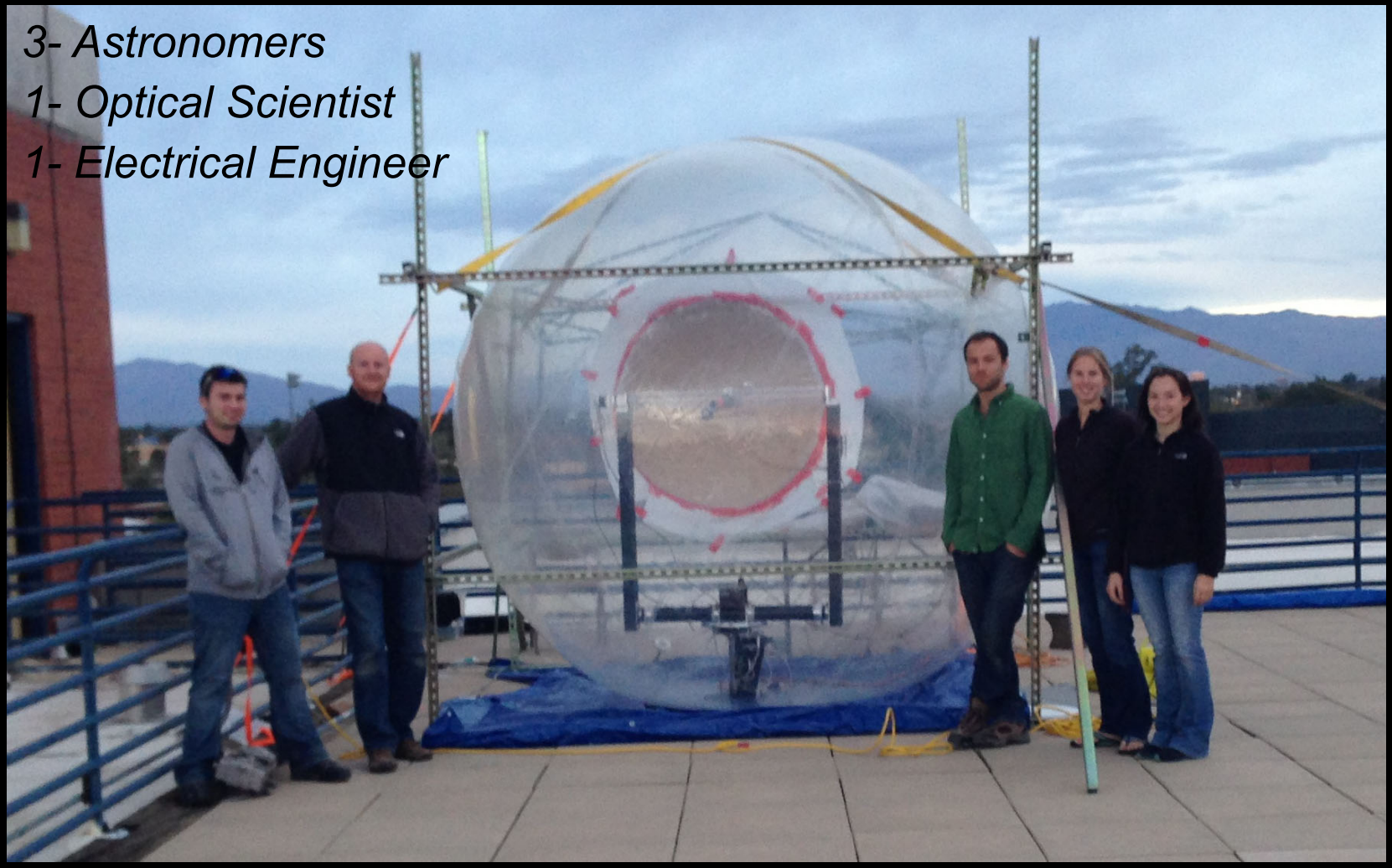
Arecibo

LBR Phase I:
3 meter Rooftop Prototype

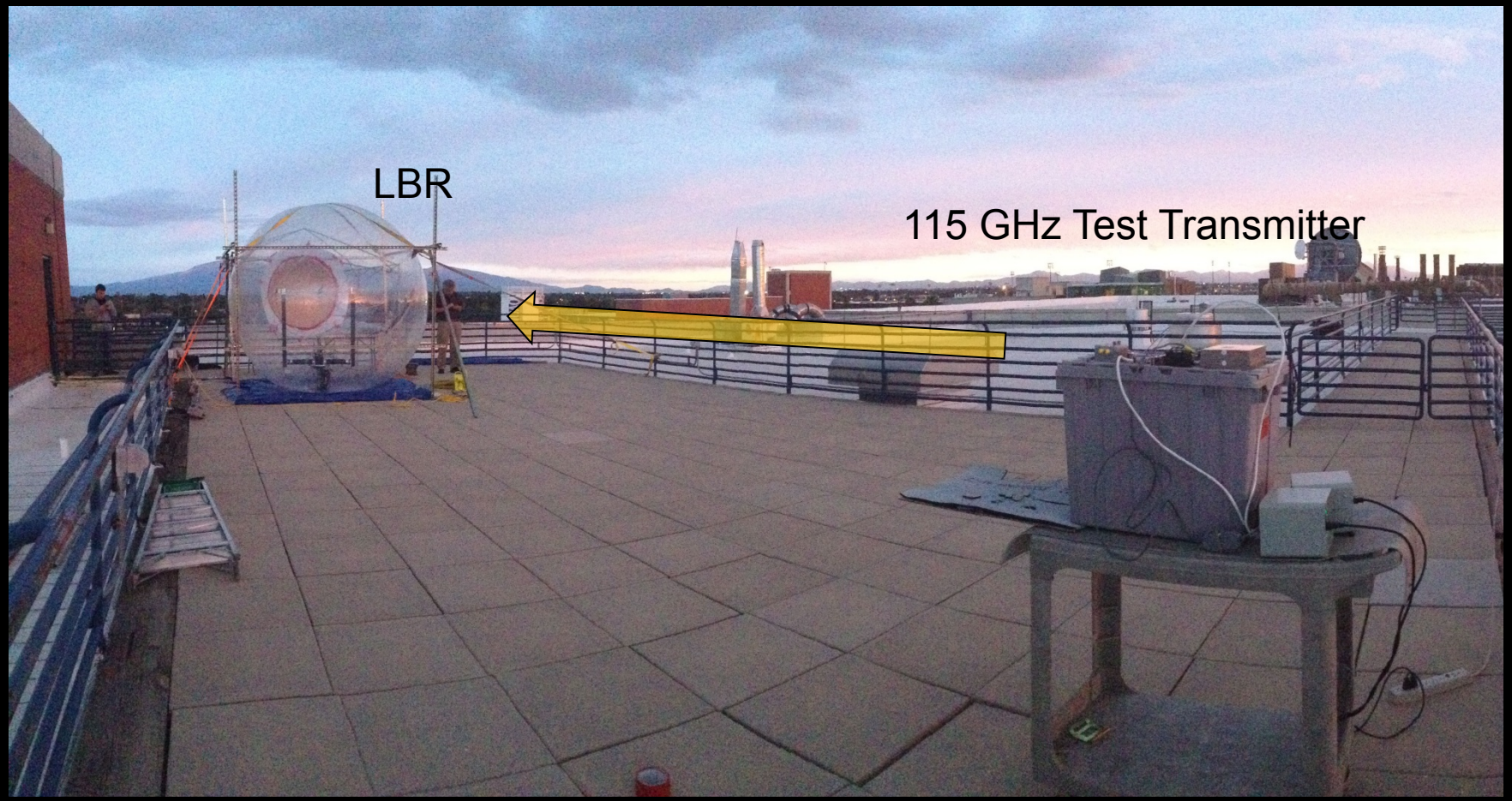


Metallizing Surface with silver spray paint!

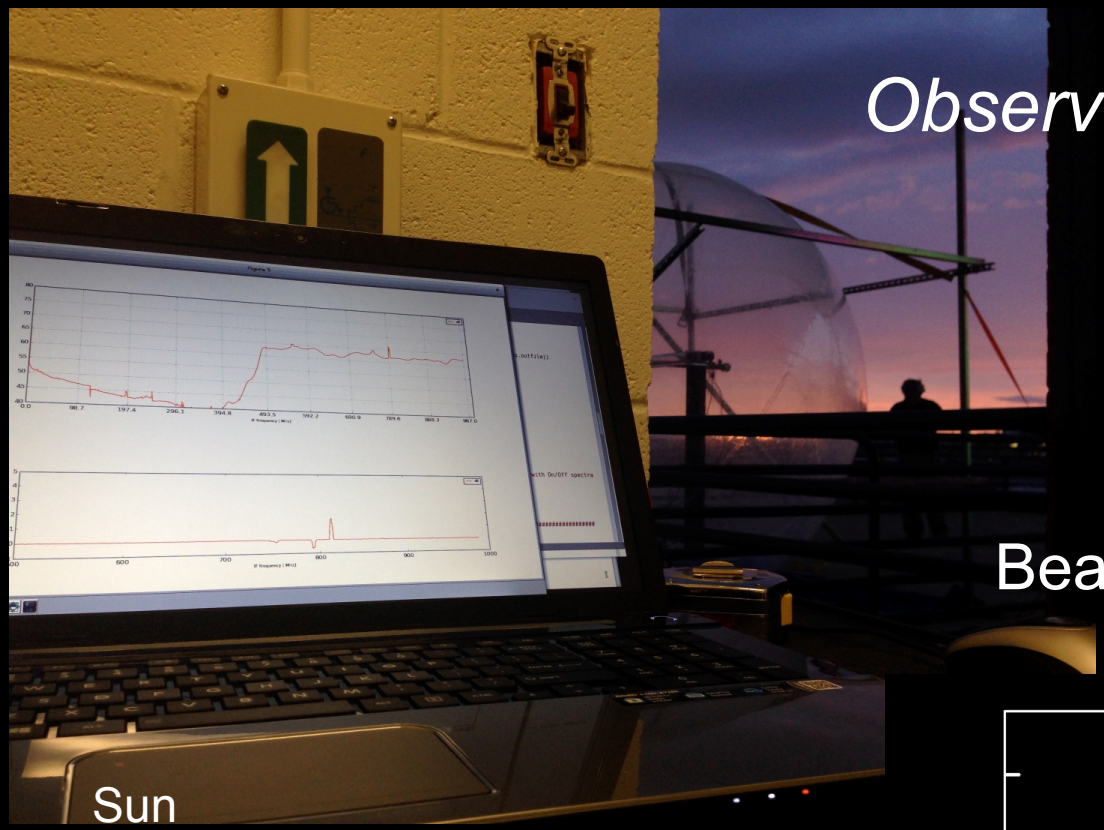
LBR Student Team



LBR Test Range

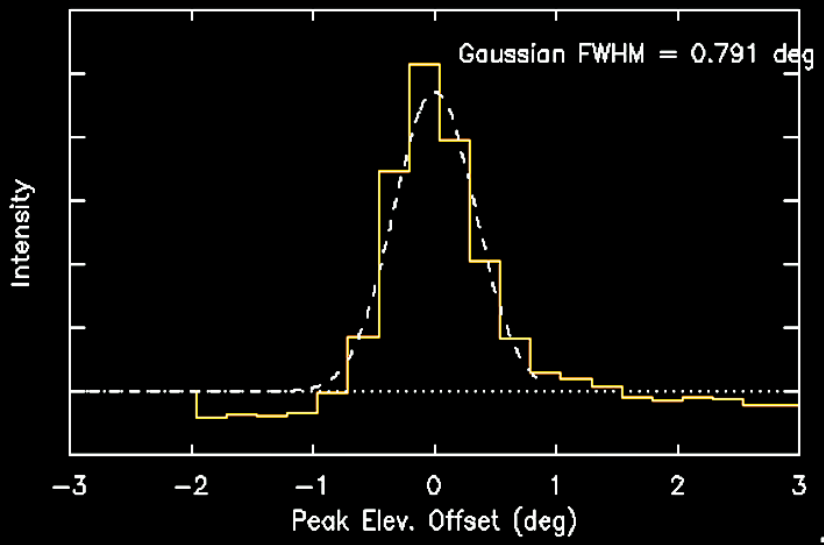


LBR First Light:

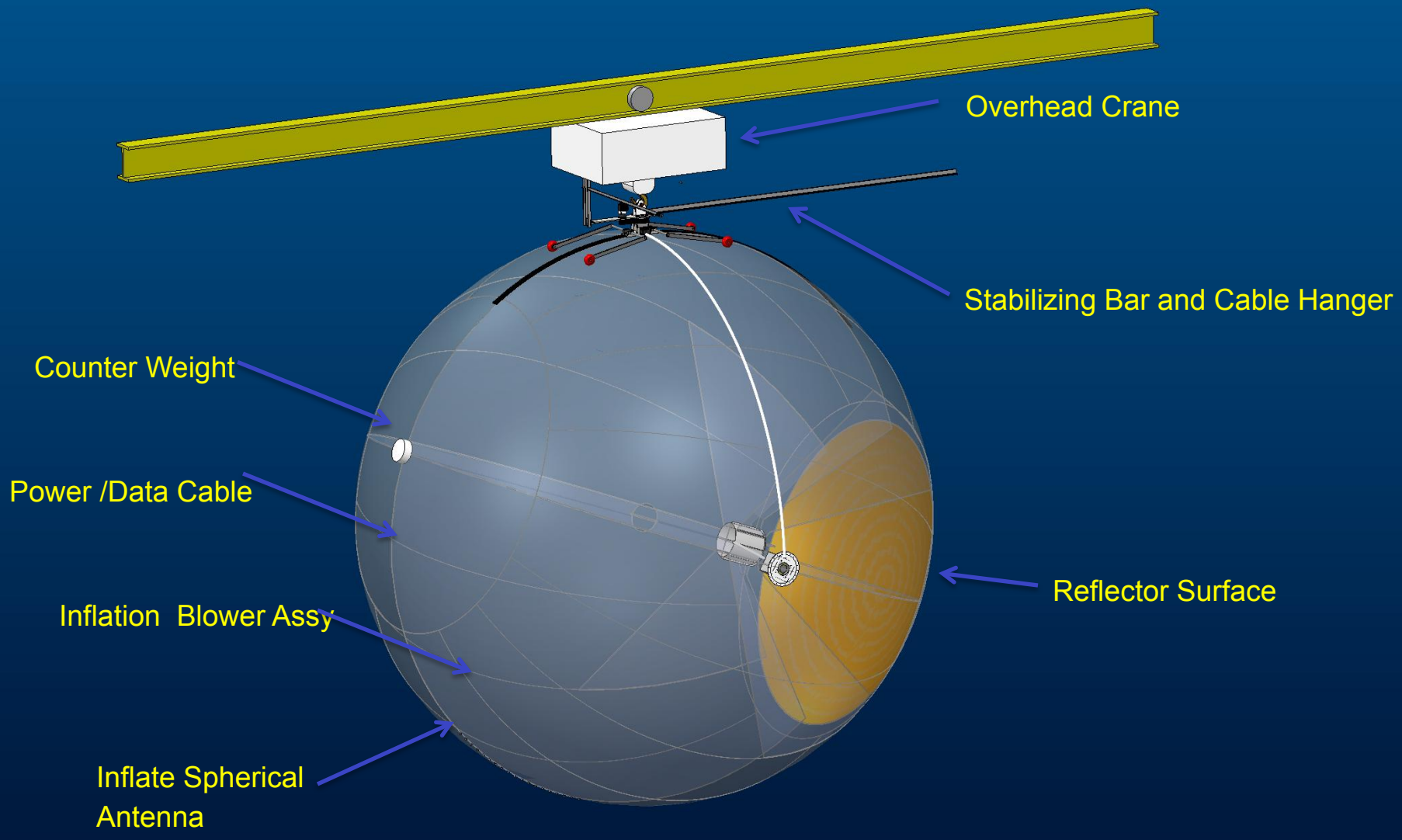


Observed Test Tone

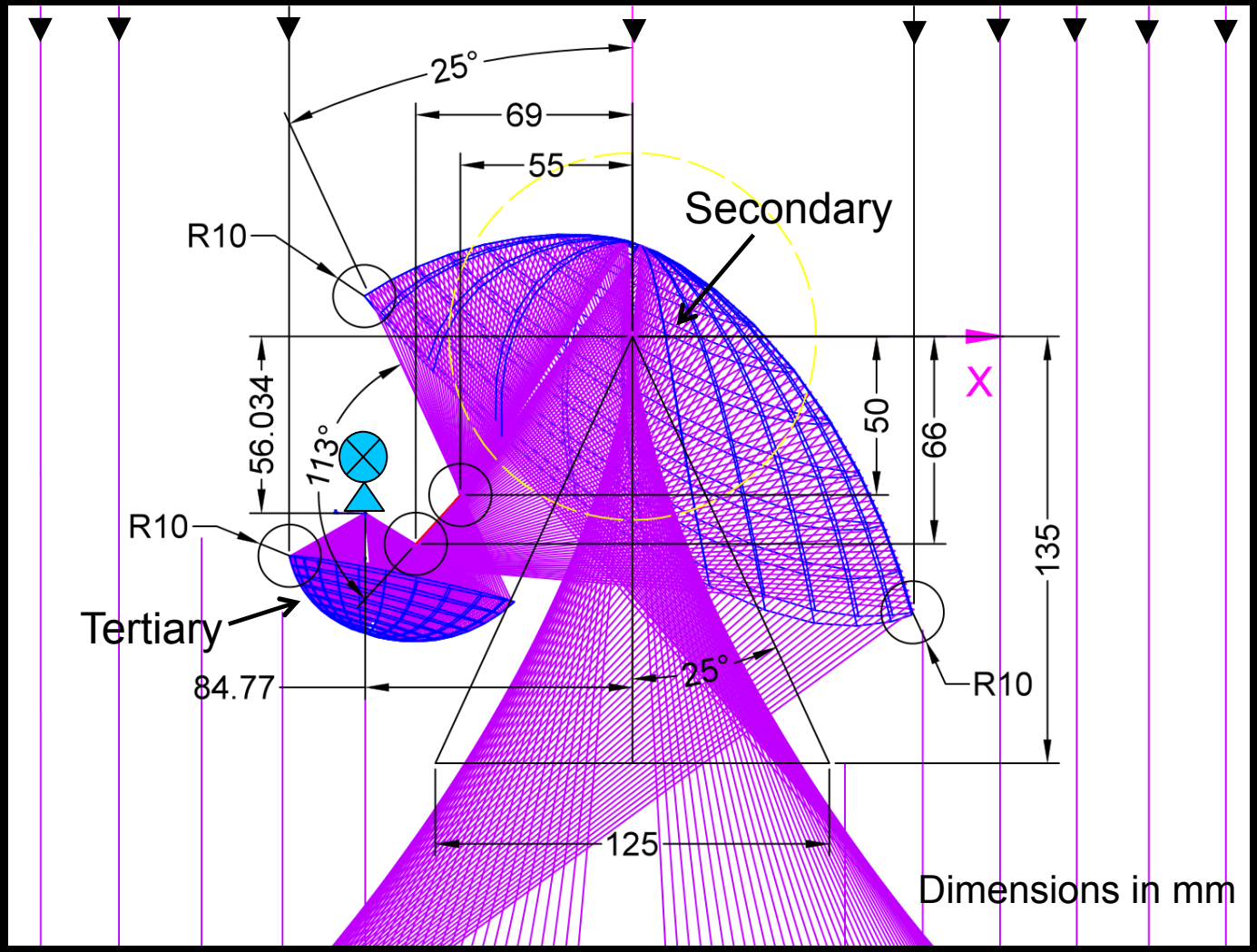
Beam Scan on Sun



LBR Phase II: 5 meter Prototype

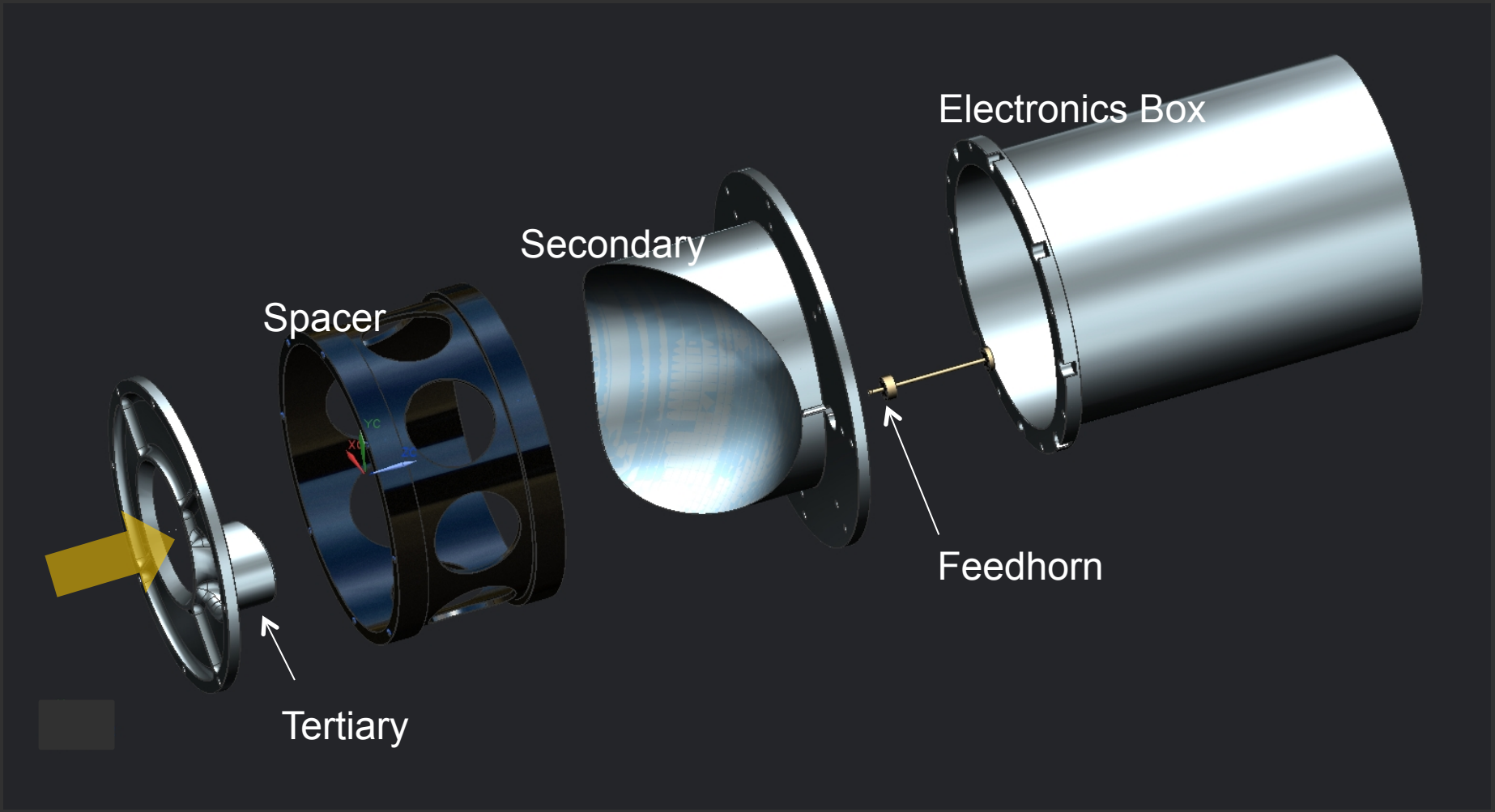


LBR Spherical Corrector Design

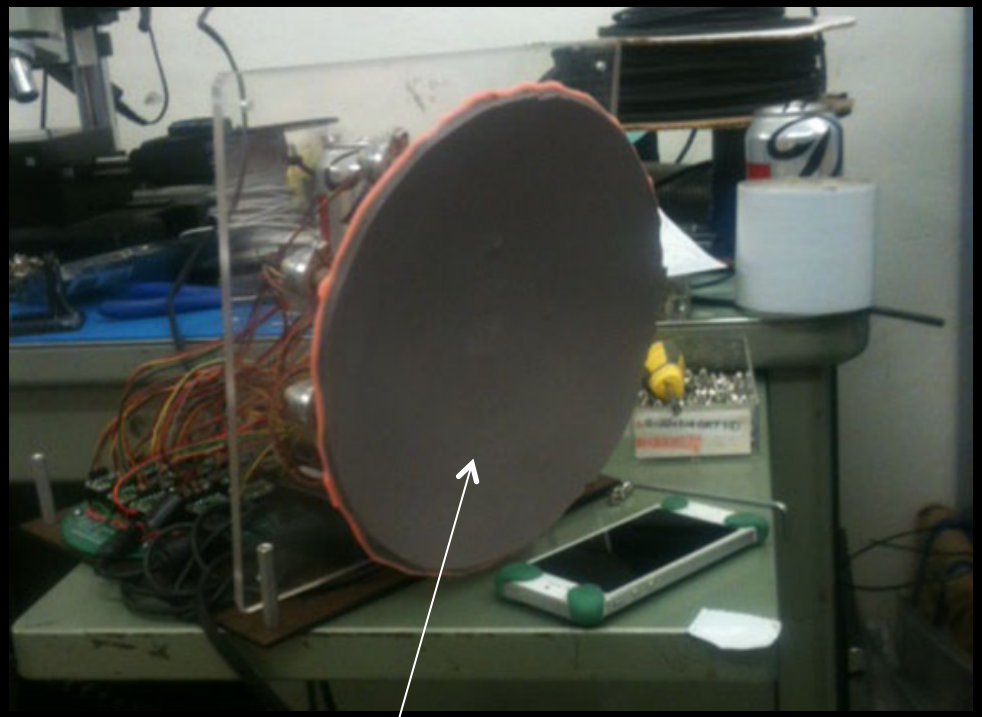


Light from Spherical Primary

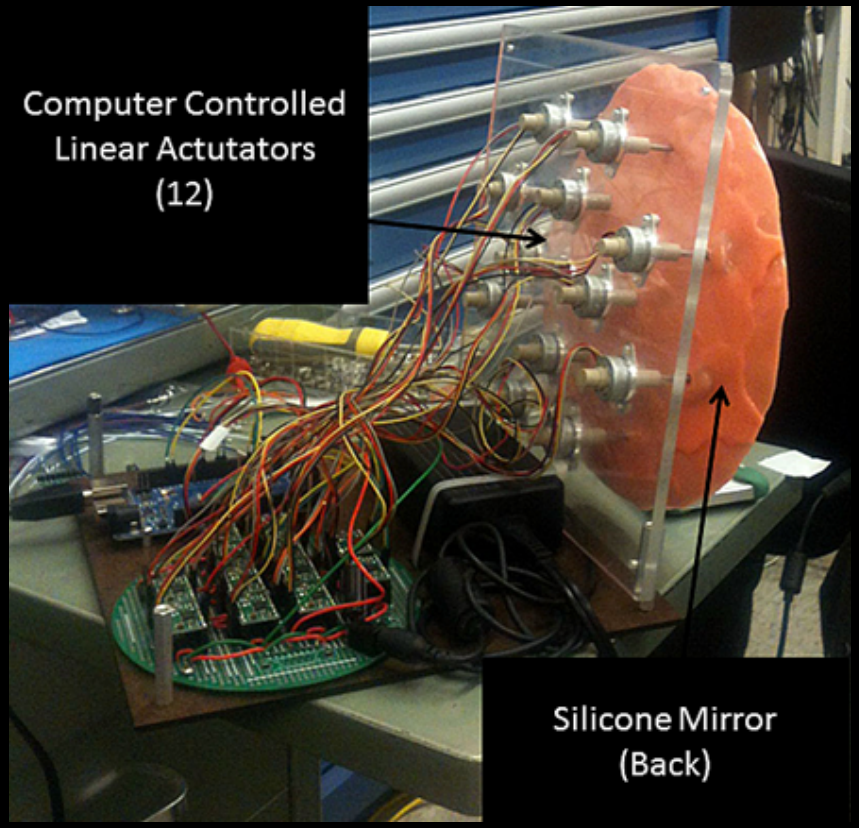
LBR Corrector/Instrument Module



Active Spherical Corrector
Compensates for non-Spherical Distortions

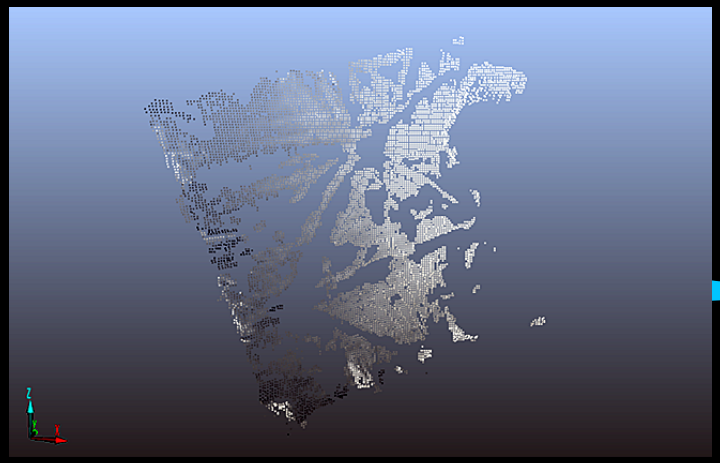


Silicone with Aluminum Powder



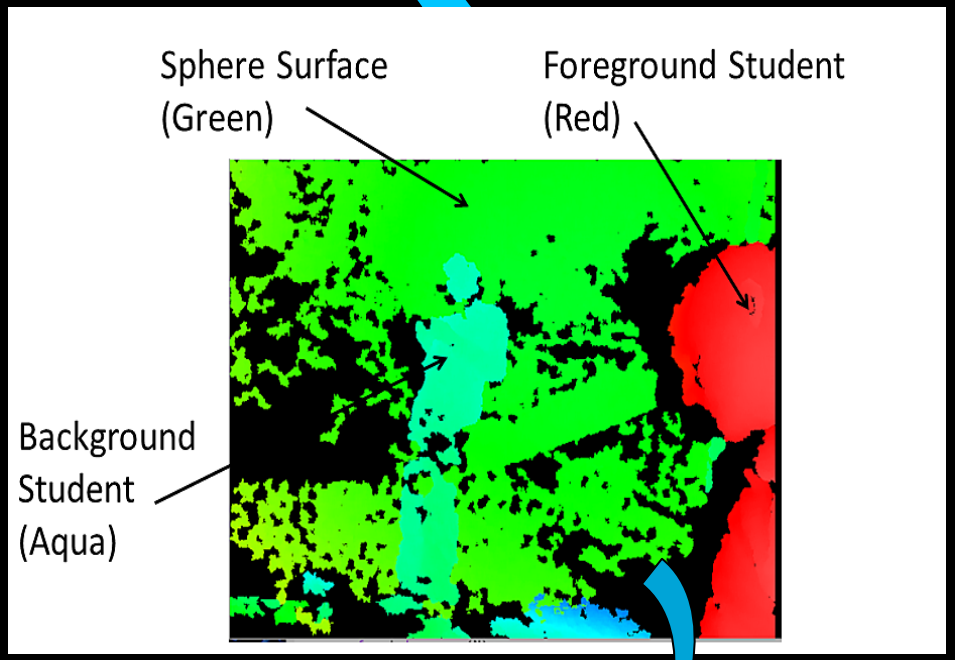
LBR in-Flight Surface Metrology

Laser: Time of Flight

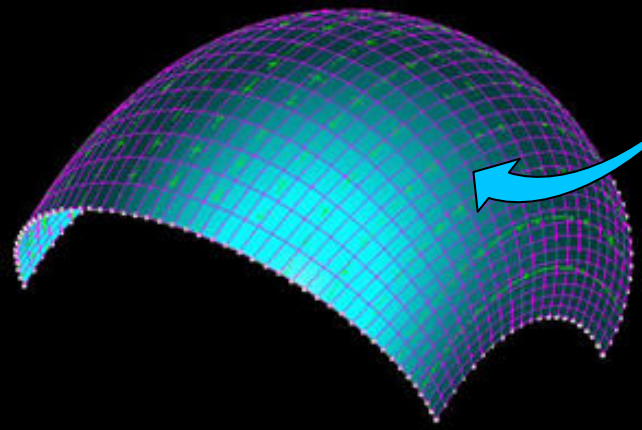


FARO TOF ranger (and operator!) within 3 meter prototype LBR plastic sphere. Right: TOF ranger image of full sphere in lab. Achieves ~ 1 mm accuracy in just a few seconds.

Laser: Parallax

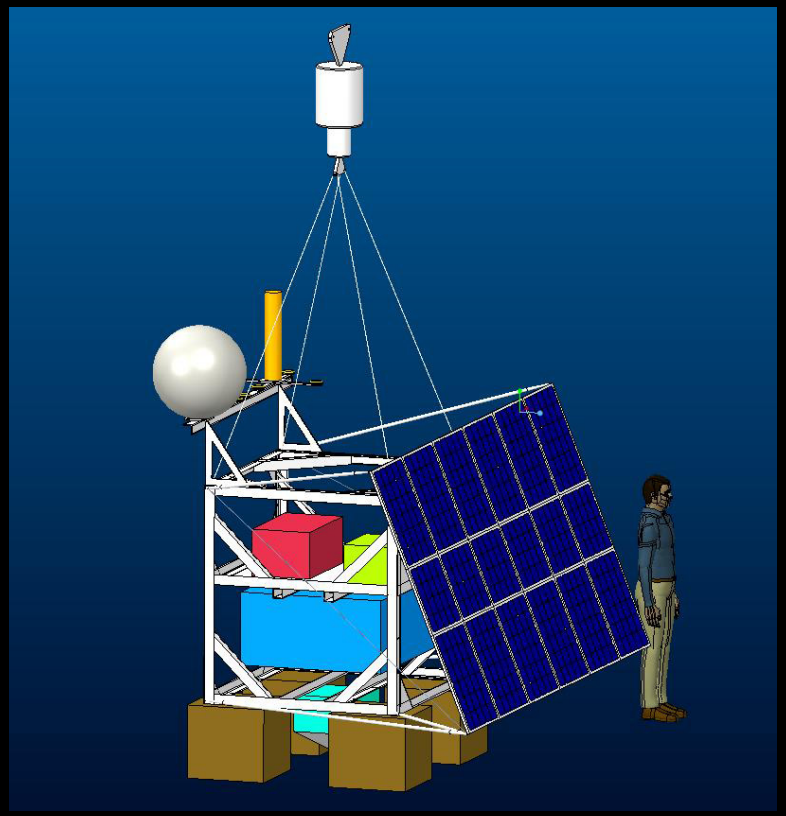


The Kinect system uses two IR cameras located several inches apart to determine the parallactic angle and distance to each spot. This system was also able to measure distances to an accuracy of ~ 1 mm with ***no moving parts in <1 sec.***



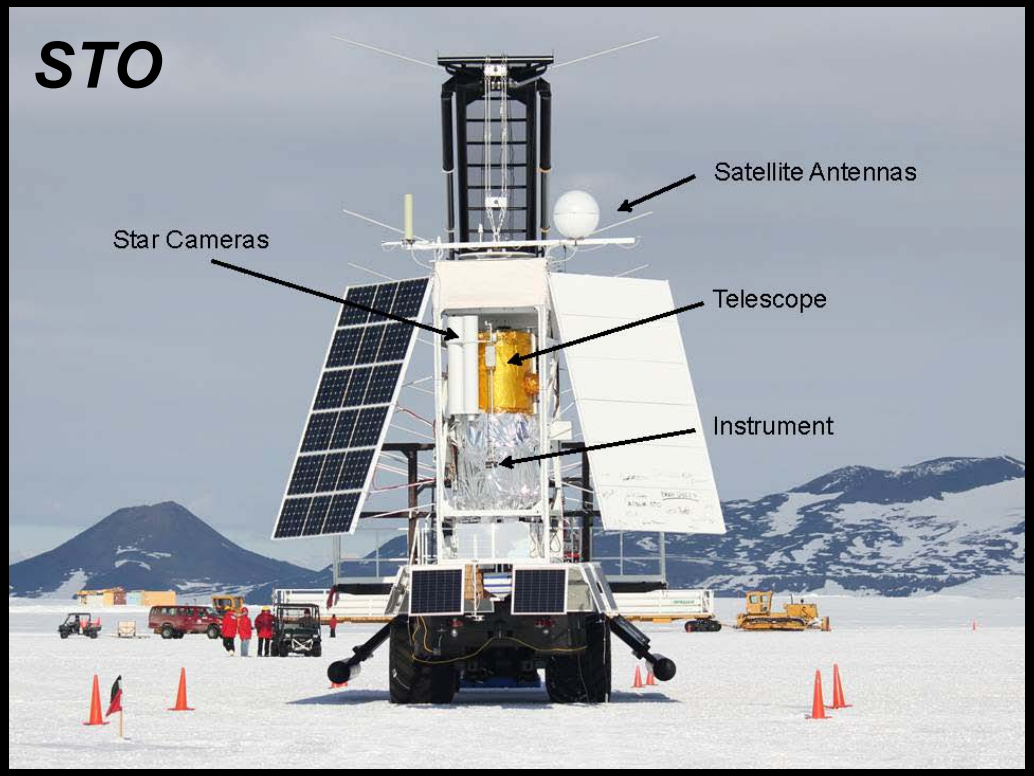
3D Surface Fit from which corrector actuator movements are computed.

LBR Service Gondola: (Spacecraft Bus)



- Power (1,510 W)
- Telemetry (134 kbps)
- Telescope: 600 lbs
- Service Gondola: 1,855 lbs

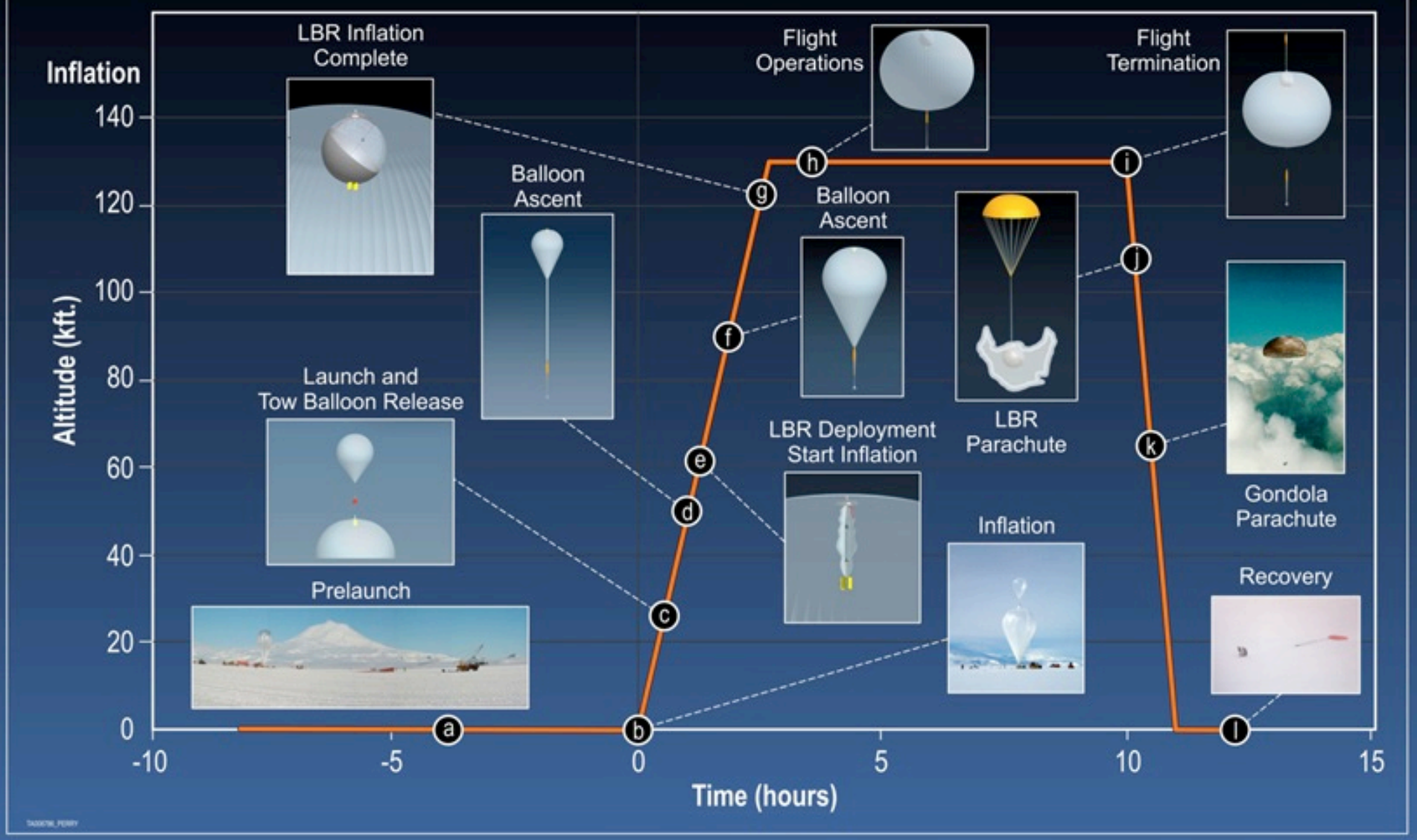
LBR Heritage: (TopHat; STO)



STO:
Telescope: 0.8 meter
Power: ~ 1,500 W
Weight: ~3,800 lbs

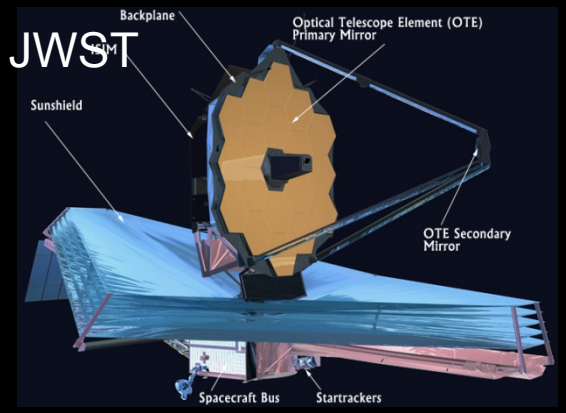
LBR >10X diameter for ~ same weight & power

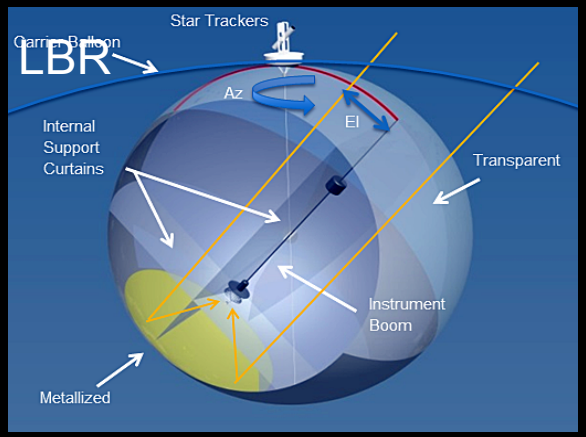
LBR Test Flight Profile



LBR: Ready for the next step….

- Now in NIAC Phase II
- Propose for test flight in 2018





LBR Cost Benefit Ratio:

Top: *JWST* is the NASA flagship IR/FIR mission with a 6.5 m telescope for >$5B.

Middle: *SOFIA* is a 2.5 m airborne IR/FIR telescope for >$1B.

Bottom: *LBR* is a 10 m FIR/THz sub-orbital telescope for <$0.01B.

LBR Cost < 1% of *SOFIA*

TITAN

High Rate Data Link to Earth

Inflated Parabolic 5m Dish Antenna

Carrier Balloon

LBR enables
Game Changing
Planetary Science

Gondola with Science Instruments

Down-looking Telescopic Camera View

SwRI®

Ta009463-Perry

Astronomy with *LBR* ….
The sky is no longer the limit!