communications

SSG-Tinsley

Silicon Carbide Telescope for the Long Range Reconnaissance Imager (LORRI) Mission.

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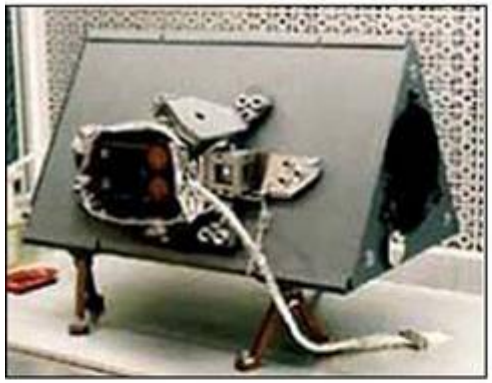
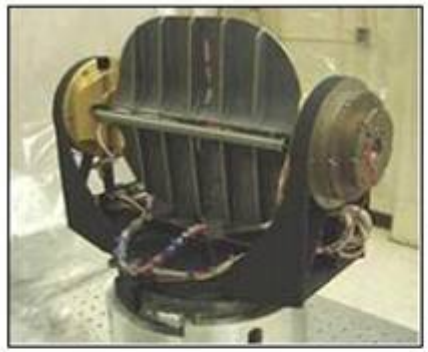
SiC Technology Demos have led to Successful L3-SSG-Tinsley SiC Flight Hardware



MICAS
- All-SiC system for NASA DS-1
- 10 cm aperture
- Mass < 3 kg
- Demonstrated system level stability to visible quality to 130K

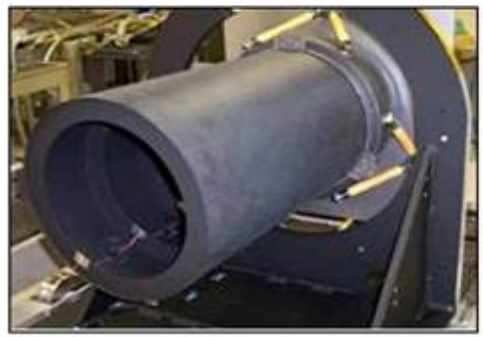
Advanced Land Imager
- WFOV (15 degree) all reflective design
- 12.5 cm aperture
- 0.6 waves (vis) p-v quality
- Stable over + 50 C



HIRDLS
- 20 cm SiC scan flat
- Integrated to Beryllium telescope
- Launched on EOS-Chem platform

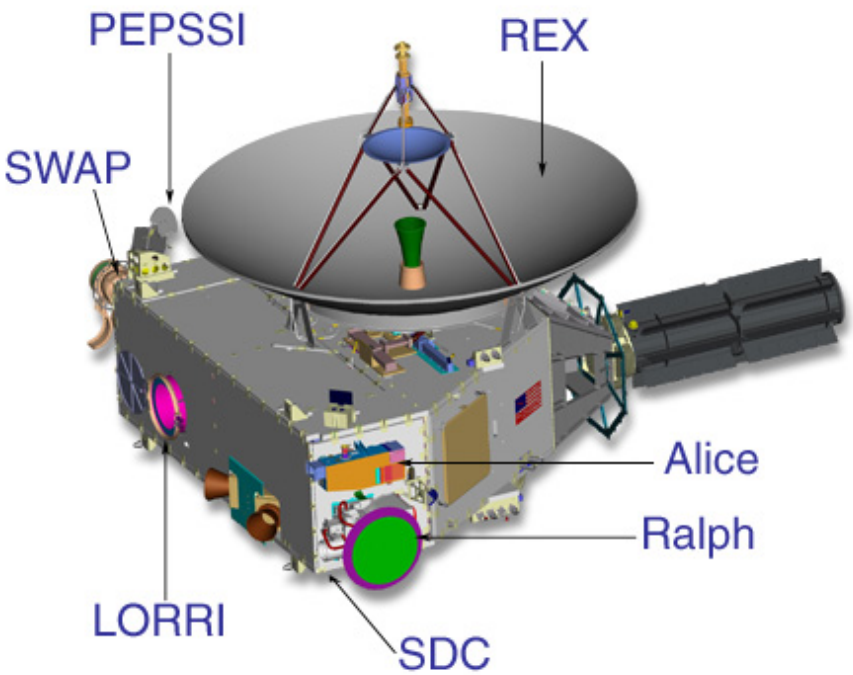
GIFTS PMA
- 45 x 30 cm SiC scan flat
- Integrated to Beryllium yoke
- 100 hz closed loop bandwidth achieved

GIFTS TMA
- All-SiC afocal system for GIFTS-IOMI
- 30 cm aperture
- Mass < 6 kg
- CCOS polished silicon clad RB SiC aspheres
- Athermal operation from 180K to 290K



LORRI
- All-RB SiC imager for imaging of Pluto-Kuiper belt
- NASA New Horizons mission
- 21 cm aperture
- CCOS polished silicon clad RB SiC aspheres
- System thermal testing confirmed by NASA/GSFC

Long Range Reconnaissance Imager Telescope



- *Space flight telescope for NASA New Horizons mission to Pluto (the object formerly known as a planet)*
- *LORRI is the most sensitive of the 7 science instruments on the New Horizons payload*
  - Provides imaging with 50 – 100 meter ground resolution
- *L3-SSG subcontractor for all Reaction Bonded-SiC imaging telescope*
  - Subcontracted to JHU/APL
  - NASA Goddard is mission prime

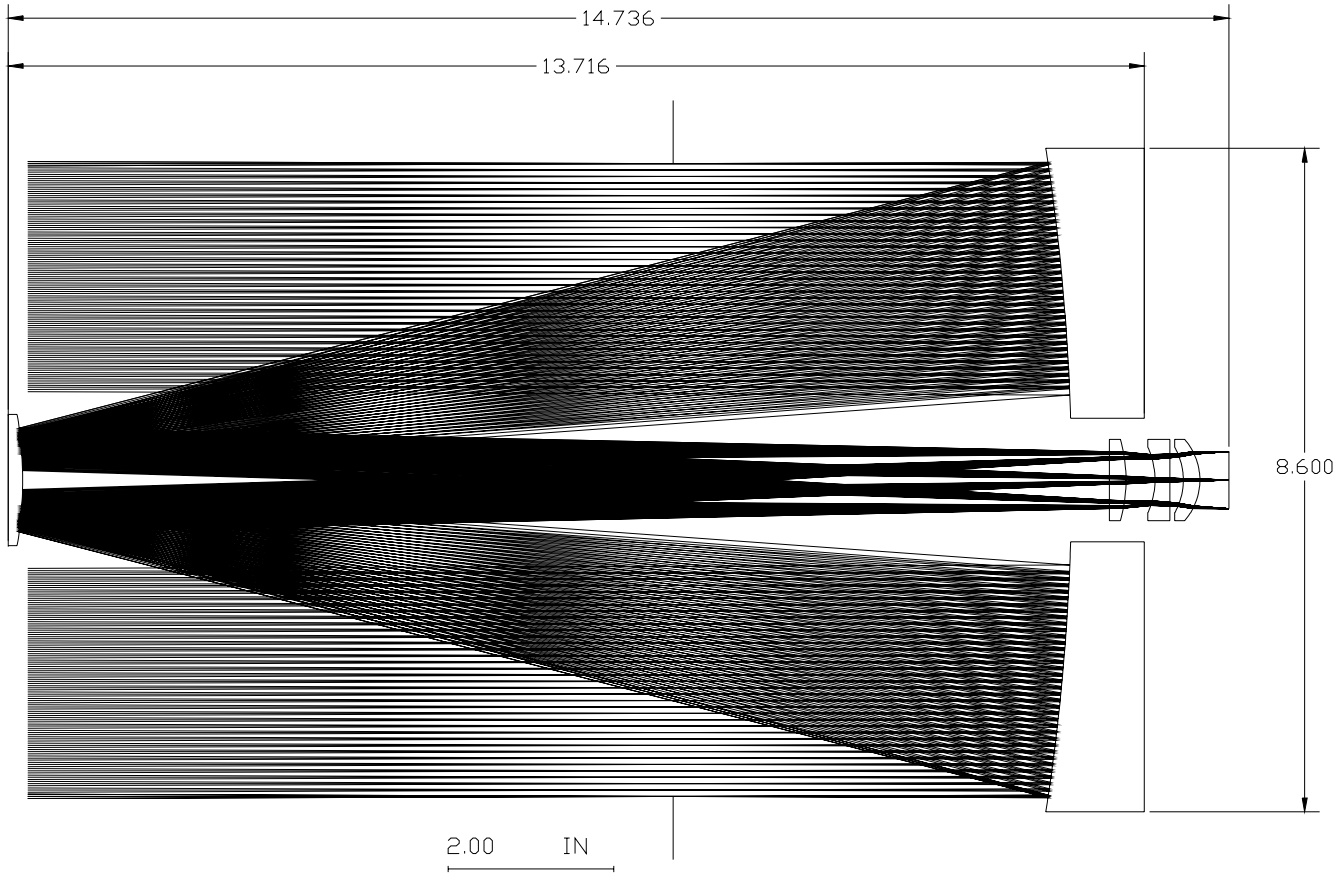
SiC LORRI Imager Overview

LORRI Telescope in alignment at L3-SSG

- SiC Ritchey-Chretien Telescope with refractive field correction
  - *L3-SSG RB SiC mirrors and metering structure*
- Spectral Band: λ = 0.35μm to 0.85 μm
- Focal Length: 2950mm
- 1024x1024 detector array
  - *4.94 μrad ifov*
- Clear Aperture: 21 cm
- Mass: 5.6 kg
- Operating temp 170 K – 230 K
- Atlas Launch Environment

LORRI Telescope in integration @ APL/JHU

LORRI Optical Design



- Architecture based on point design by APL.
- Design form is a field corrected Ritchey-Chretien.
- Primary and secondary are hyperbolic conics
- All refractive components are Fused Silica.
- All refractive surfaces are flats and negative spheres, thereby minimizing back reflections on FPA .

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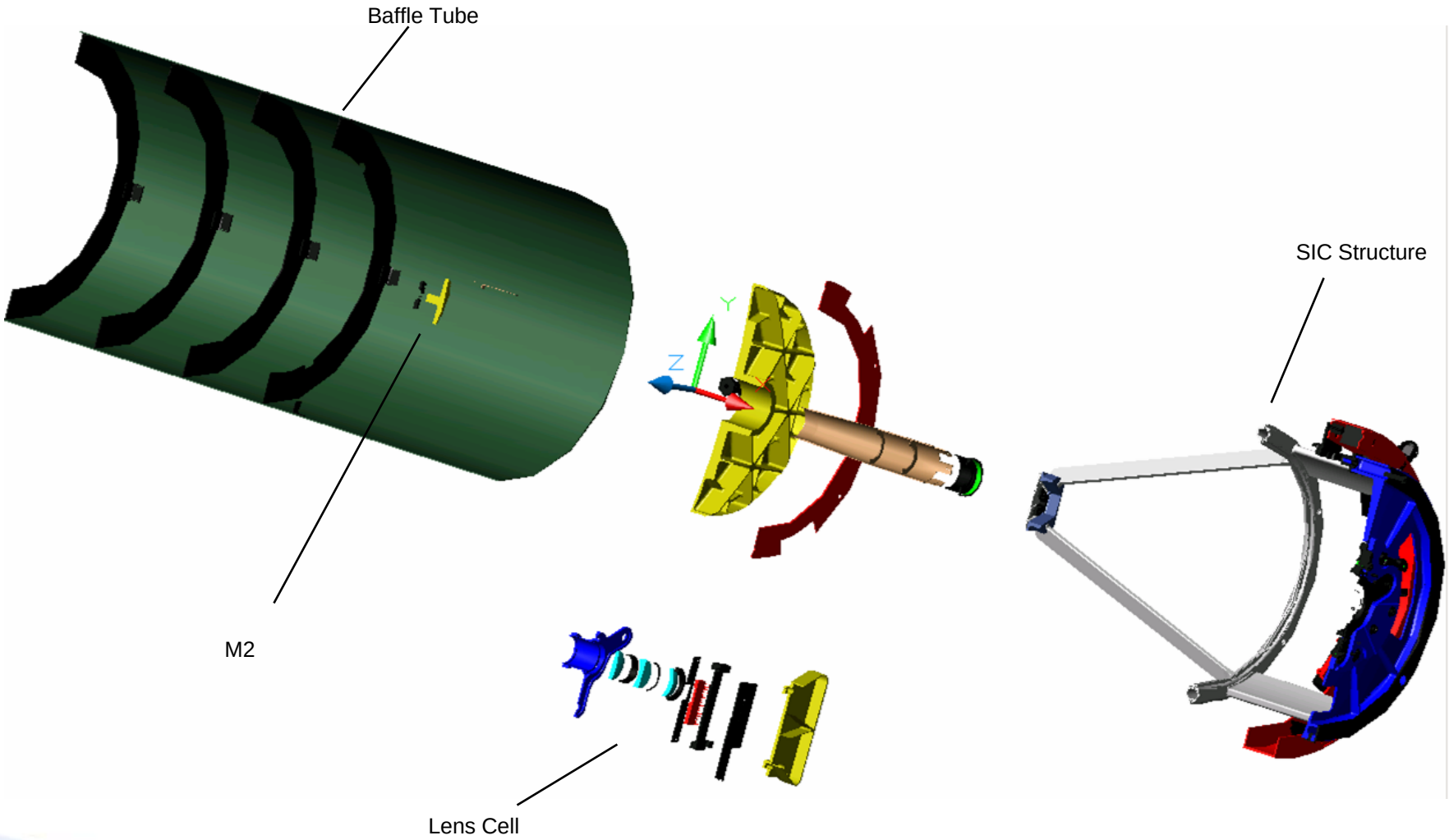
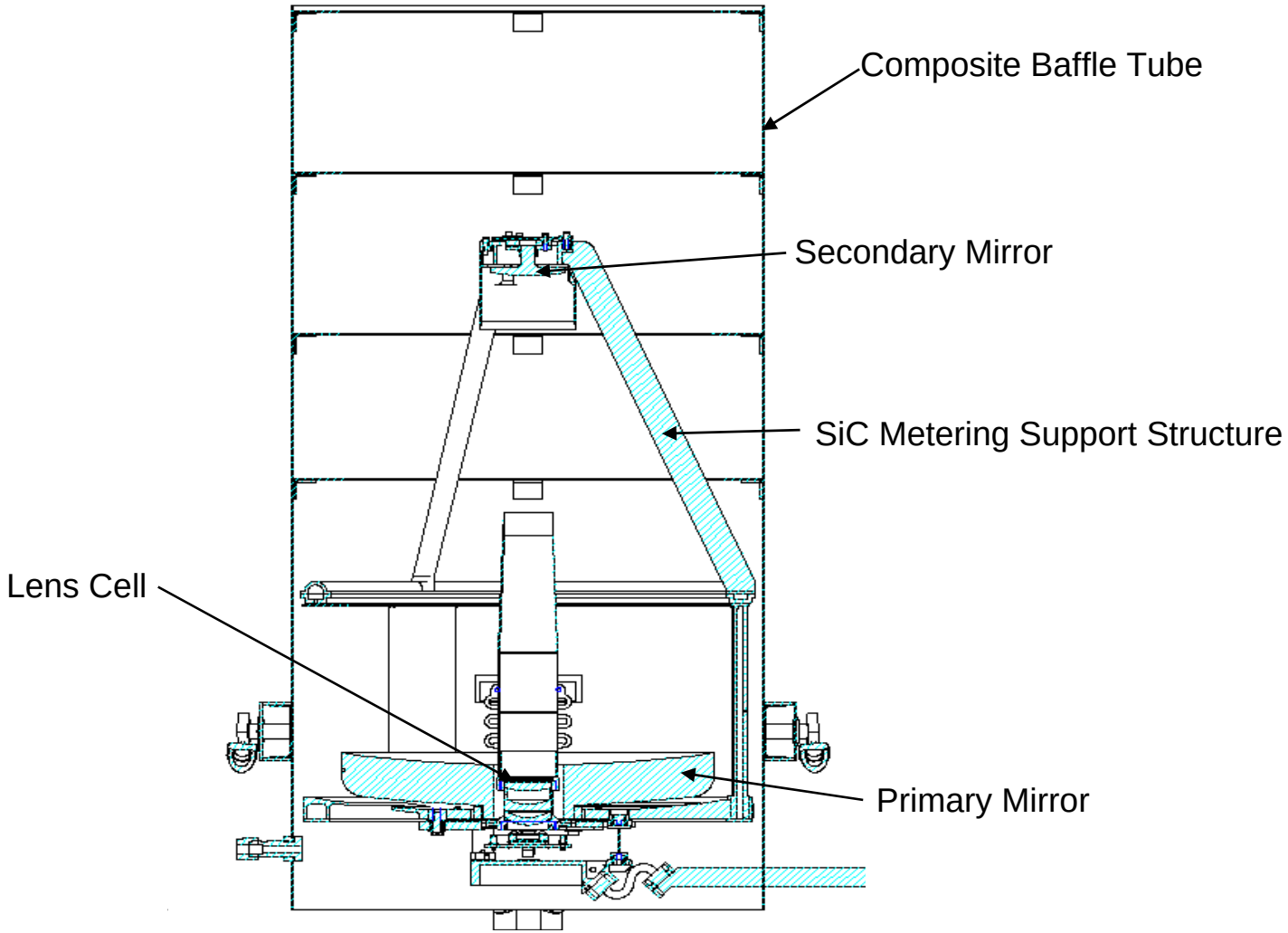
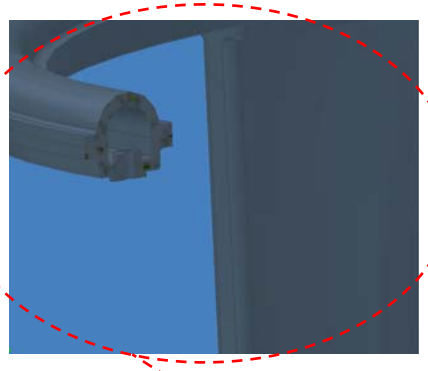
LORRI Mechanical Design Assembly

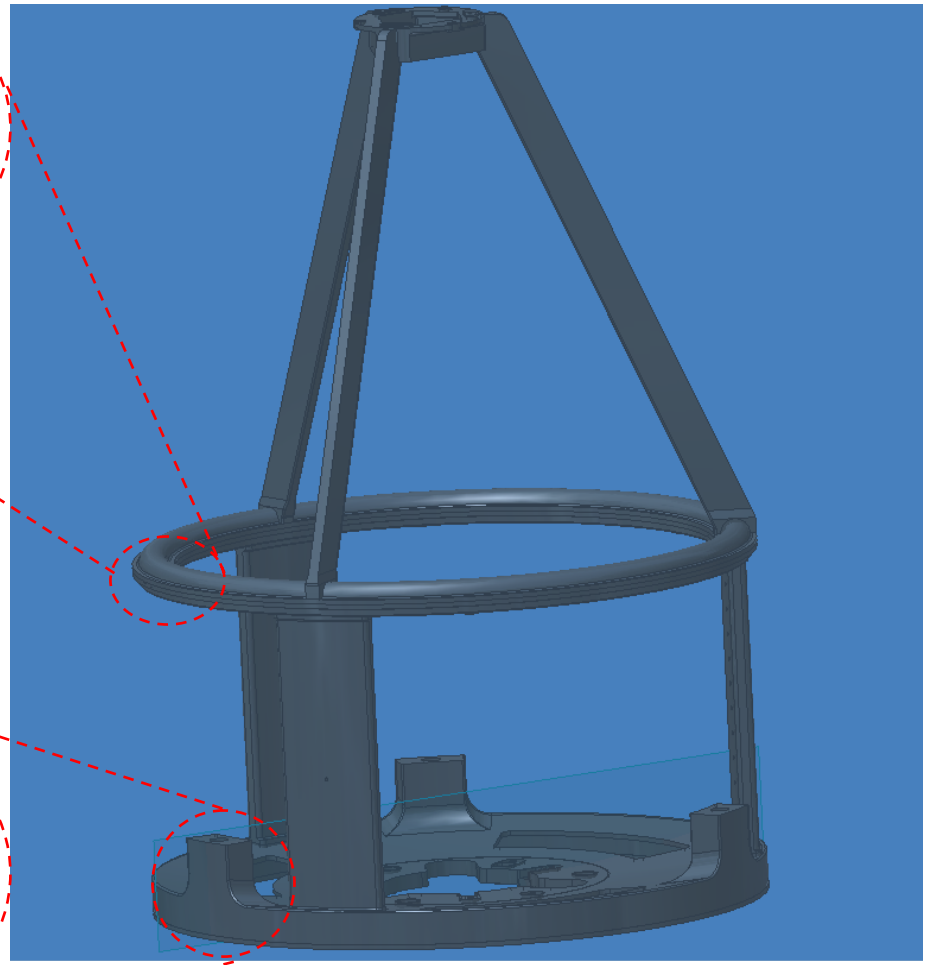


LORRI Mechanical Design

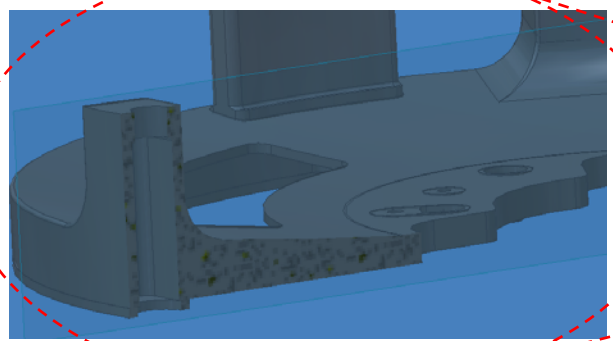


RB SiC Monolithic Metering Structure



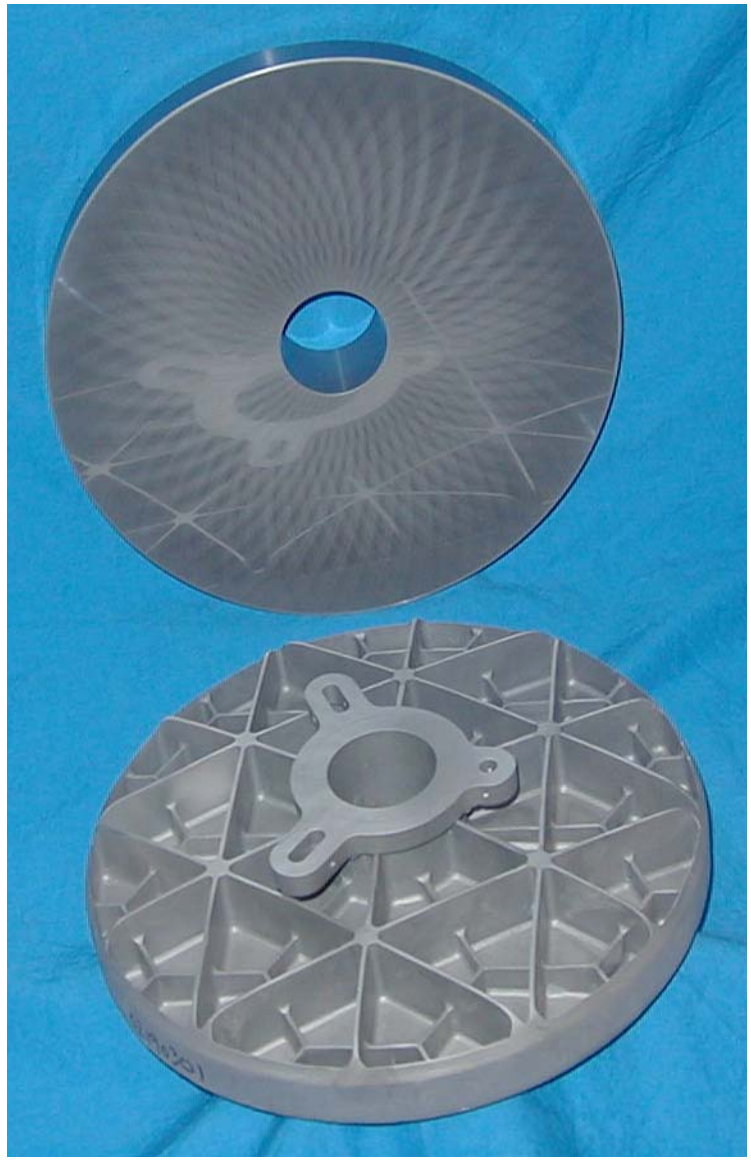


- Monolithic structure is sintered together
- Hollow (vented) tube sections integral to the design
- Materials testing verify strength/reliability of sintered structural elements

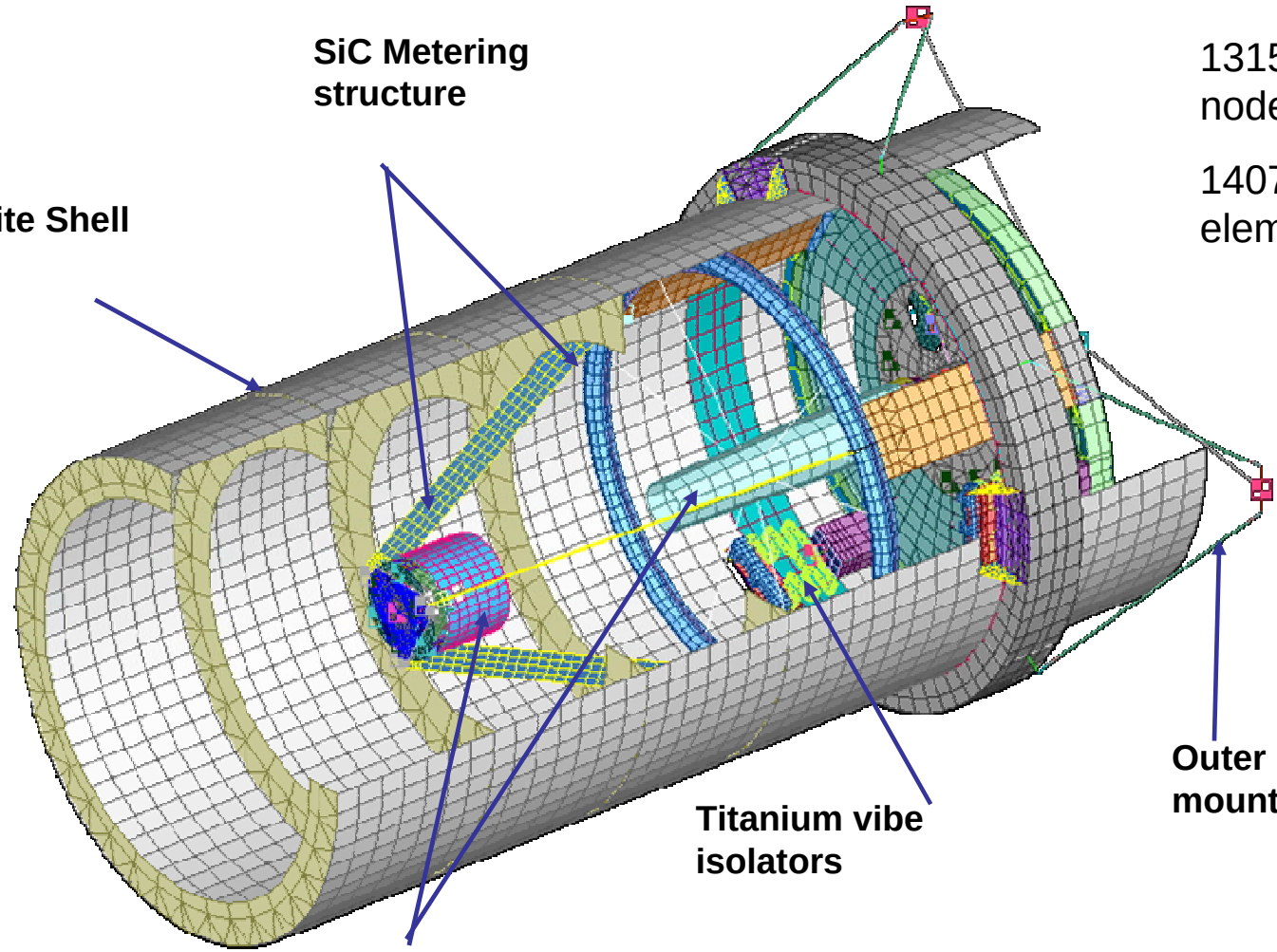


SiC Primary Mirror Design

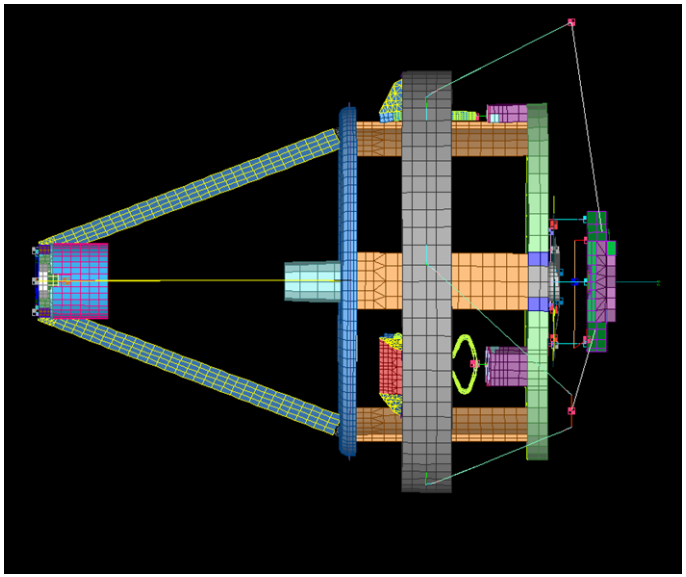
- *SiC LORRI Primary Mirror*
  - 22 cm aperture
    - Mass: 0.67 kgs
    - Approx 77% lightweighted
  - *Integral central hub to minimize mount induced deformation*



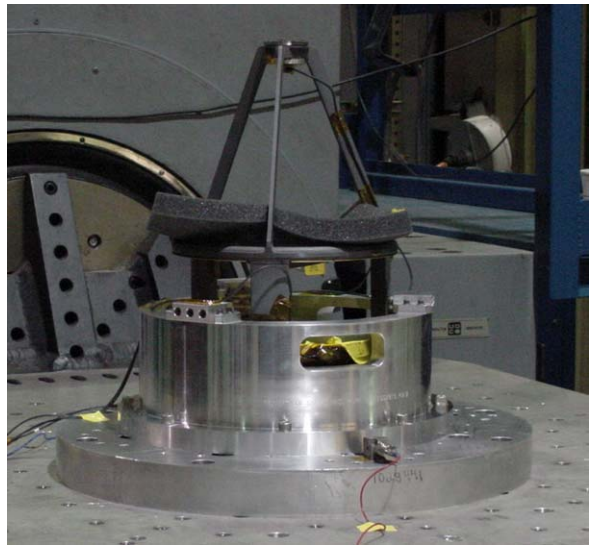
Main Finite Element Model



LORRI FEA Validated by Vibration Testing

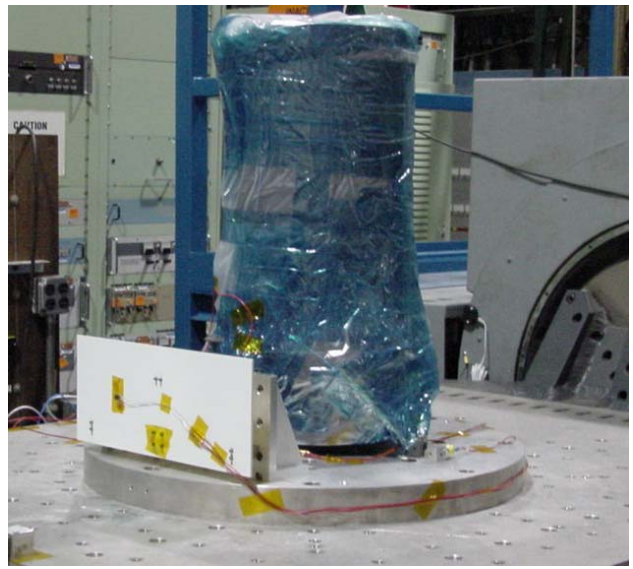


FEA Output Prediction: X translation 101 Hz



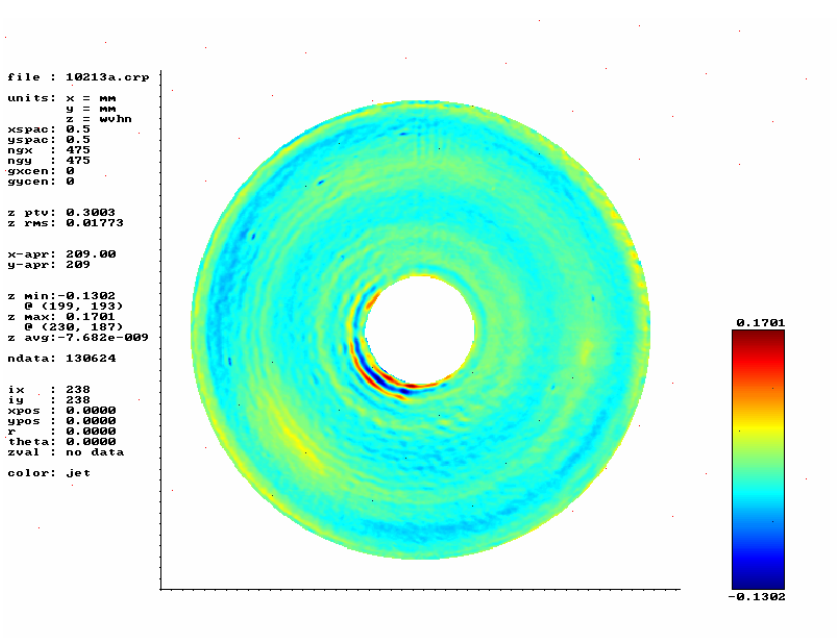
Sine Burst Setup

- **Key Vibration Testing Requirements:**
  1. *Sine Burst Proof Loading of SiC Bonded Structure with Mass Surrogates.*
     - Validate stability of structure before/after proof loading
  2. *Environmental testing of completed hardware including Random Vibration and Sine Vibration in all three axes.*
     - Validated FEA output



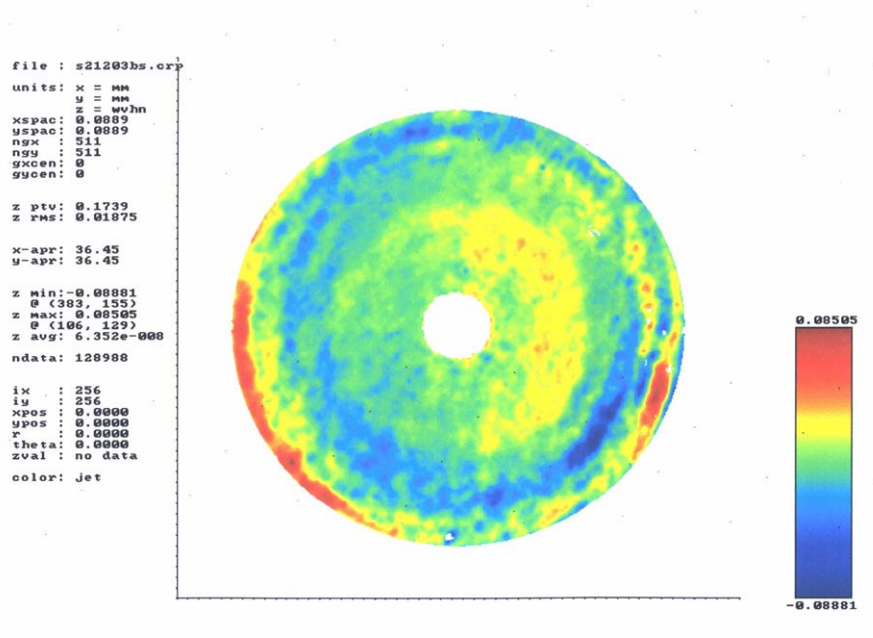
Random/Sine Vibration Setup

Component Interferogram Results



LORRI Flight Primary Mirror:

•11 nm RMS Figure

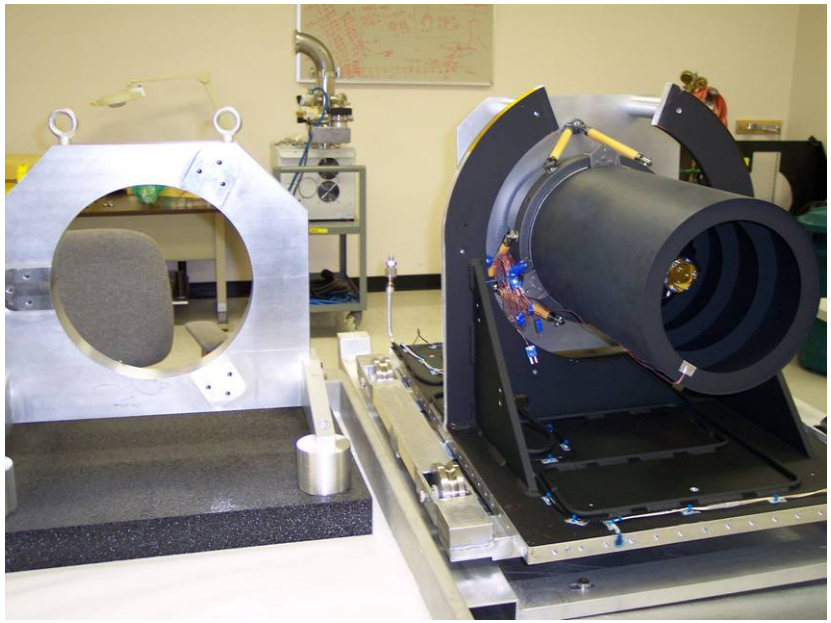


LORRI Flight Secondary Mirror:

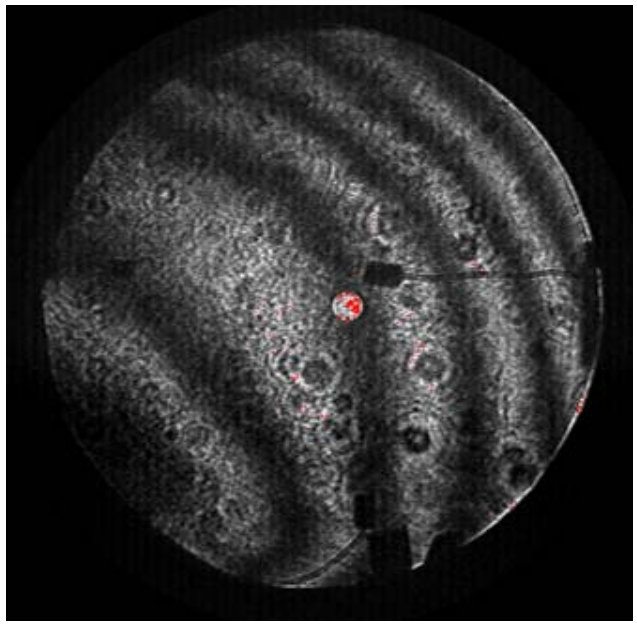
•12 nm RMS Figure

- *SiC aspheres polished by Tinsley's CCOS process*
  - *Silicon coated RB SiC mirrors*

System Level Wavefront Testing



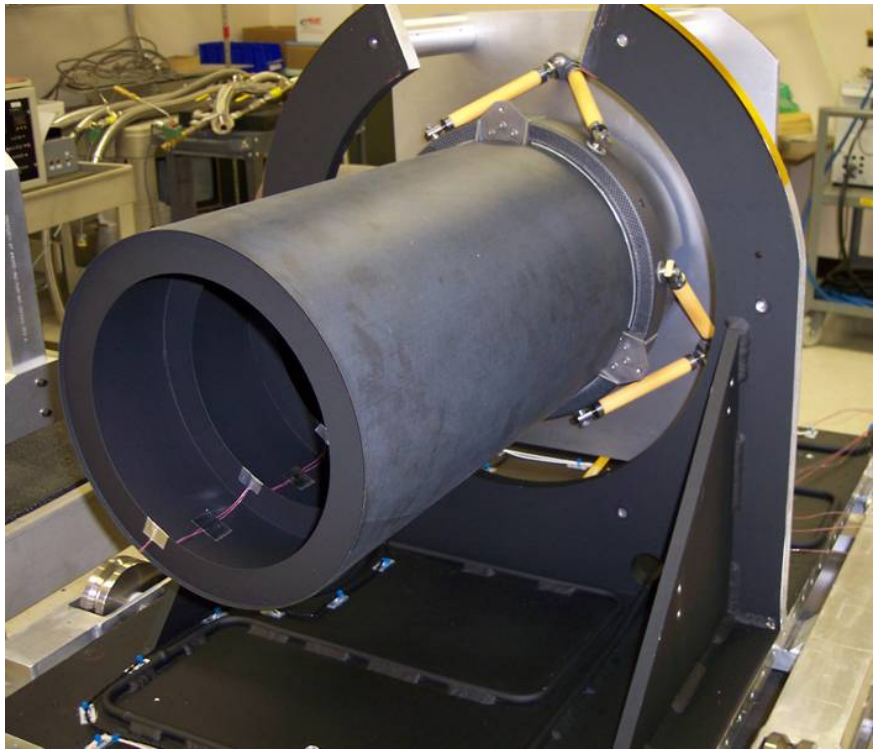
OTA Prior to Thermal Test



System Level Interferogram at Temp

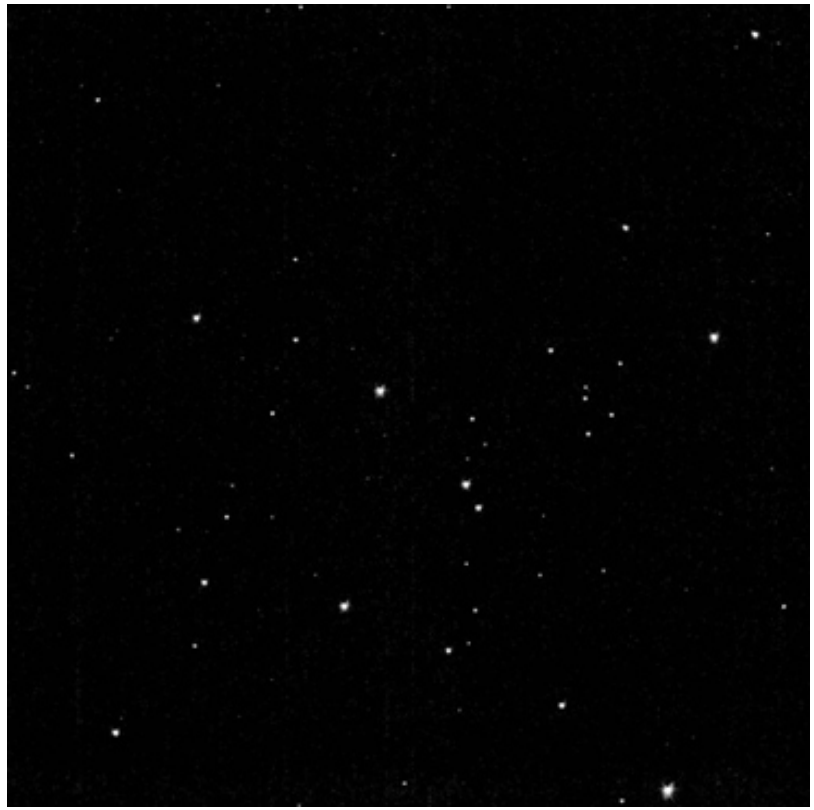
- System level wavefront error confirmed @ 135 Kelvin through cryo-testing
  - *0.15 λ RMS @ 633 nm*
  - *Includes test error, dissimilar lens cell, etc.*
  - Double pass interferogram shown

Hardware Pictures



Status

- *Jan 2006: Successful Atlas launch from Cape Canaveral*
- *August 2006: LORRI sensitivity and noise levels validated in space*
- *Feb 2007: Jupiter encounter planned*
- *July 2015: Pluto encounter planned*



LORRI First Light (Aug. 29, 2006)

The image shows the center of Messier 7. Stars to at least 12th magnitude are clearly visible, meaning LORRI's sensitivity and noise levels in space are consistent with its pre-launch calibrations on the ground.

Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute

Summary / Acknowledgements

- L3-SSG-Tinsley team led by Kris Kosakowski, Deepak Sampath, Fash Azad, and Evan Stryjewski
  - *L3-SSG Ceramics Division responsible for SiC fabrication (D. Landry)*
  - *L3-SSG-Tinsley responsible for optical polishing and component metrology*
- L3-SSG-Tinsley wishes to express appreciation to JHU/APL and NASA/GSFC for support of the LORRI hardware development/delivery
  - *S.J. Conrad, J.D. Boldt, A.F. Cheng, K. Cooper, H Darlington, M.P. Grey, J.R. Hayes, P.G. Hogue, T.C. Magee, R. Barkhouser, F. Morgan, J. Rossano, C.E. Schlemm, H.A. Weaver*