LIME

Line Intensity Mapping Experiment for Optical/Near IR

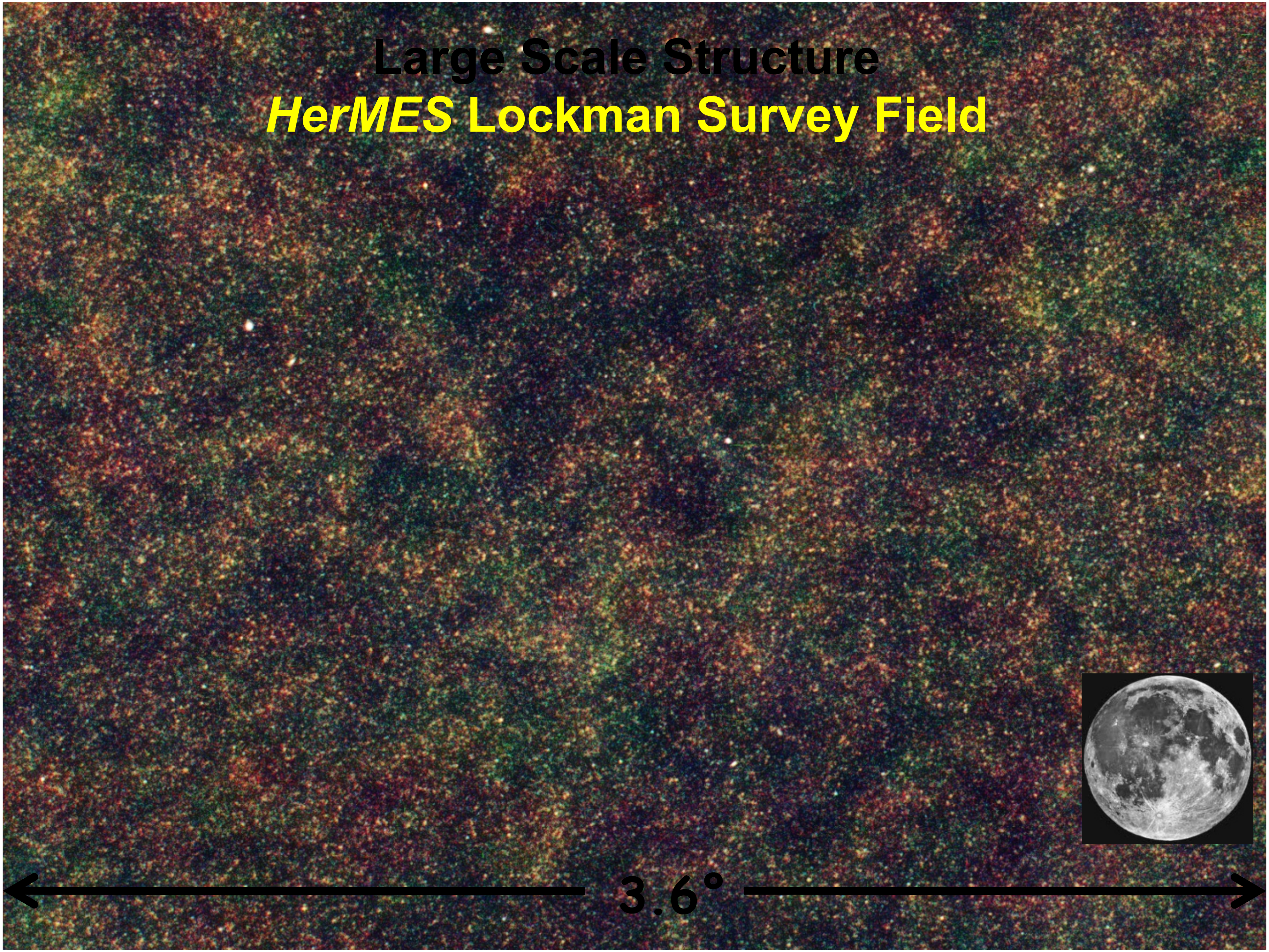
Nguyen Trong Hien

Jet Propulsion Laboratory, California Institute of Technology

50 Years after CMB Discovery, August 20, 2015
ICISE – Quy Nhơn

Why Line Intensity Mapping?

- Traditional Optical/Near IR Methods
  - Photometry, Spectroscopy (and Astrometry) using pointed observations
  - Detect individual sources
  - Requires large aperture for high redshift objects: expensive
- Line Intensity Mapping in Optical/Near iR
  - Spectroscopic sky survey – making 3D map of the universe
  - Detect *fluctuations* of sky background from collection of galaxies
  - Small aperture, fast optics, narrow band filters: low cost
- Science
  - Epoch of Re-ionization and star formation
  - Galaxy formation and role of dark matter
  - Other cosmological applications: BAO and dark enery…


Large Scale Structure
HerMES Lockman Survey Field
3.6°

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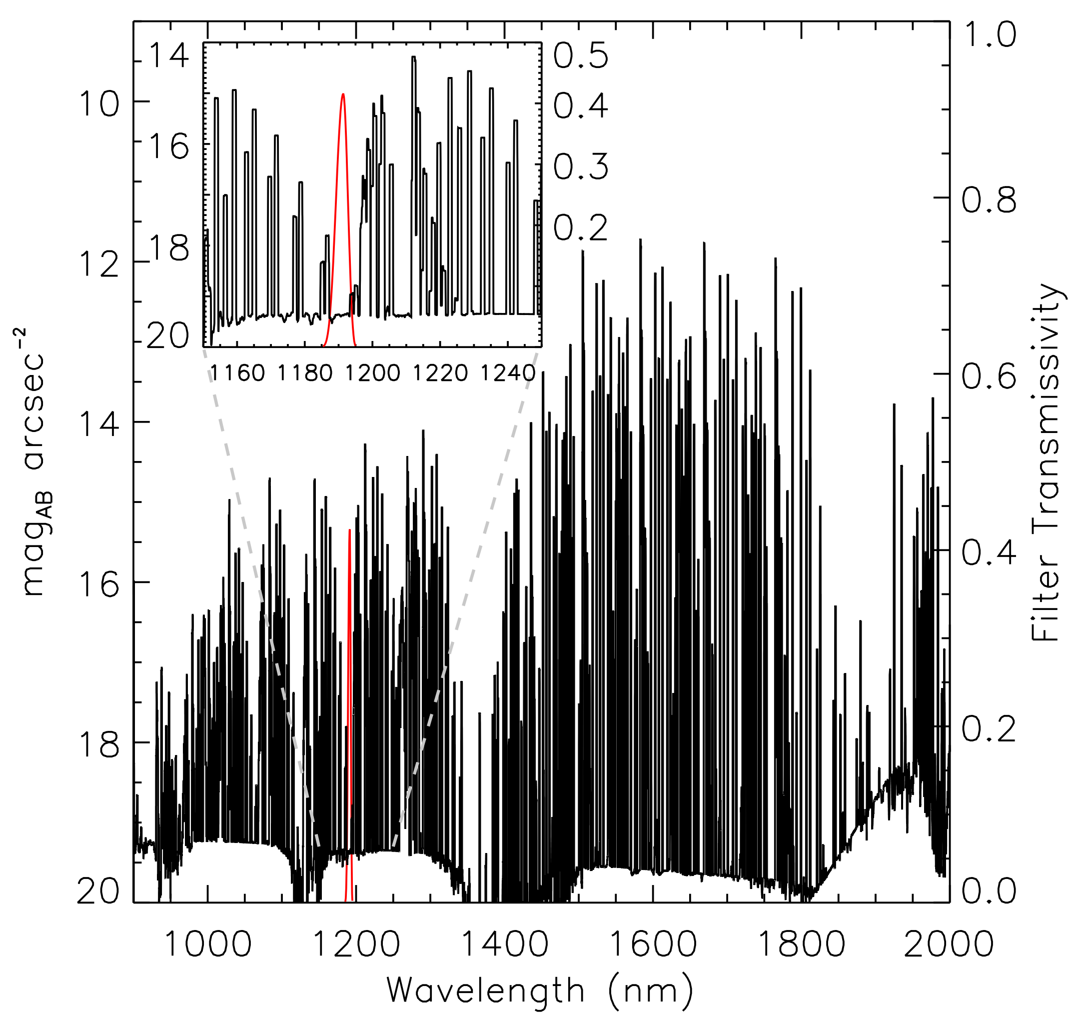
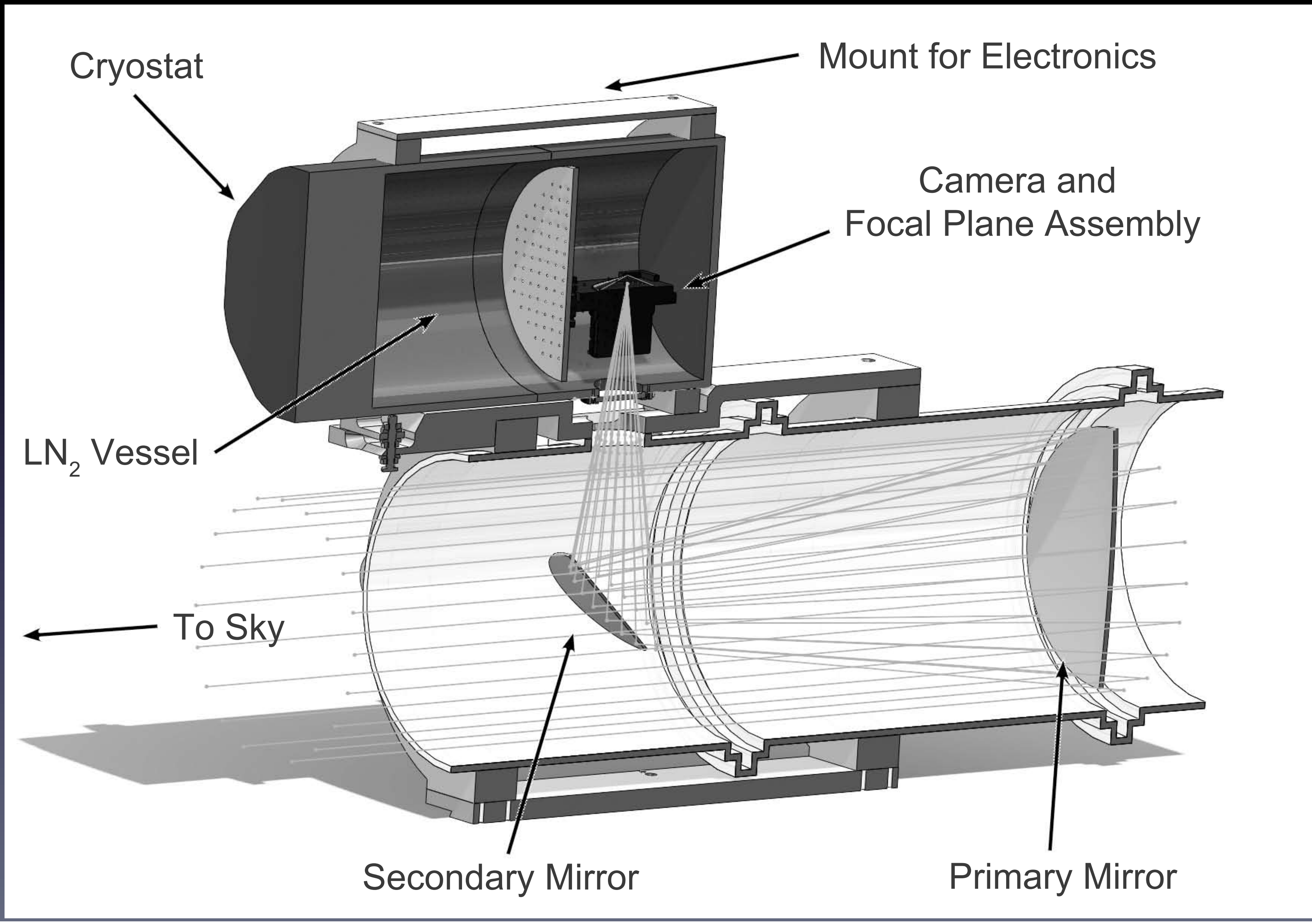
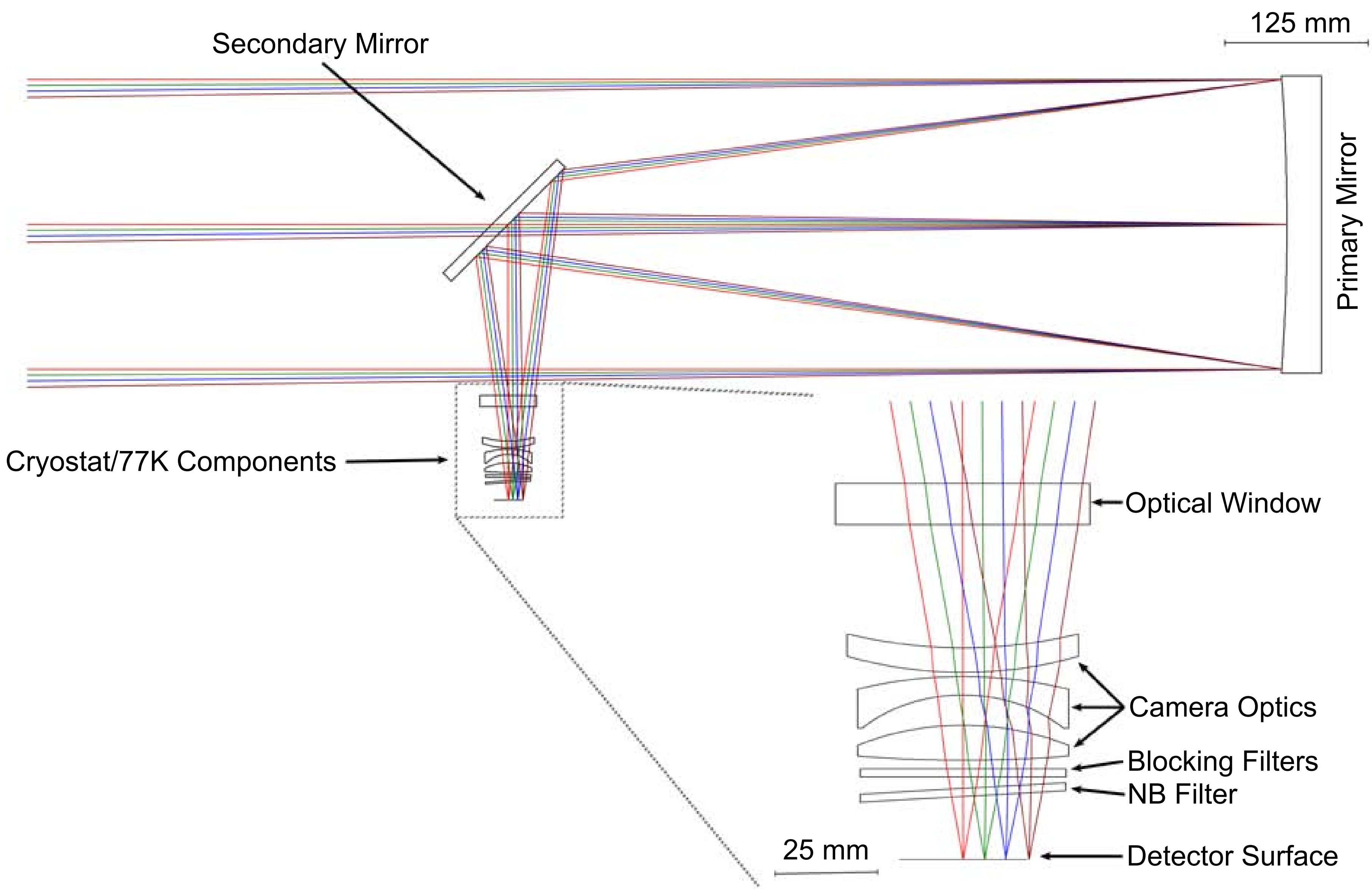
Challenge: OH Lines
Look Between the Lines



Lyman Alpha Mapper Prototype



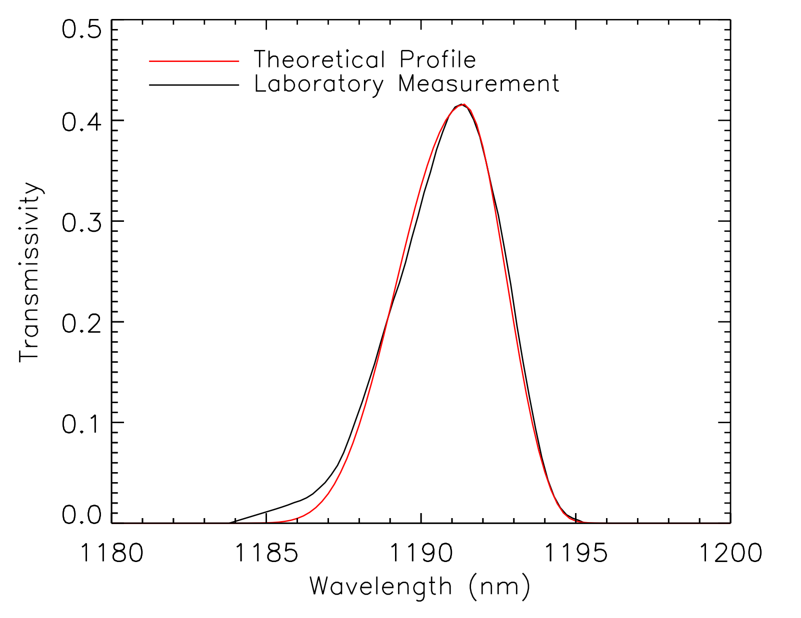
LAMP


125 mm
Secondary Mirror
Primary Mirror
Cryostat/77K Components
Optical Window
Camera Optics
Blocking Filters
NB Filter
25 mm
Detector Surface

LAMP Sensitivity

$$i_{phot} \approx \lambda I_\lambda \left(\frac{\eta A \Omega}{h\nu} \frac{\Delta\lambda}{\lambda} \right)$$

Component	η
Mirrors	0.90
Window	0.95
Optics	0.89
Optics Total	0.76
Science 1191.3 nm Filter	0.75
Blocking Filter 1	0.76
Blocking Filter 2	0.72
Filter Total	0.41
Total Optical Efficiency	0.31



Narrow Band Filter at 1190 um

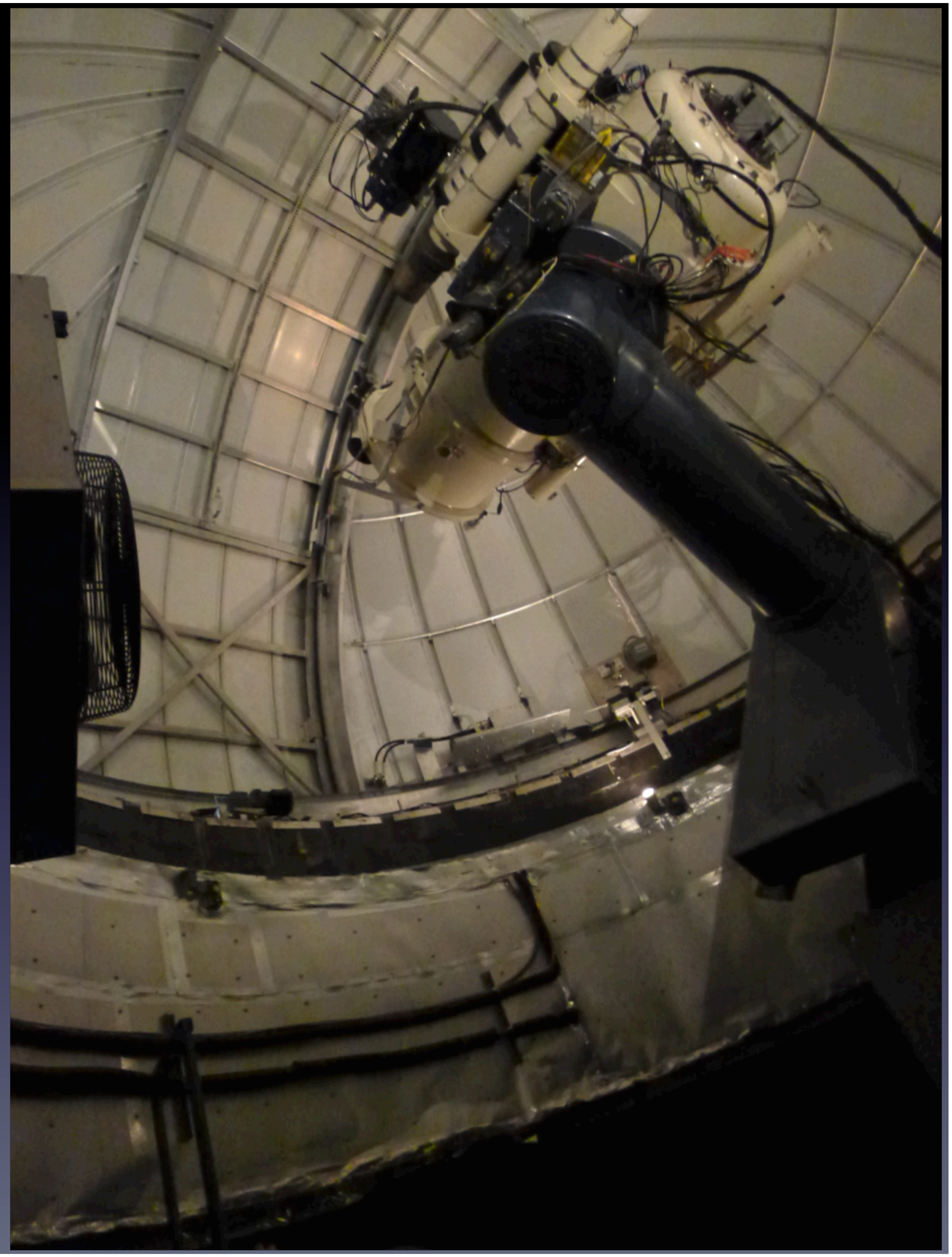

ALL VEHICLES
SHUT OFF ENGINES WHILE
LOADING / UNLOADING
IN THIS AREA
CAHILL CENTER


DO NOT
ENTER
Boxster
JUL
California
2013
6XPV037
dmv.ca.gov

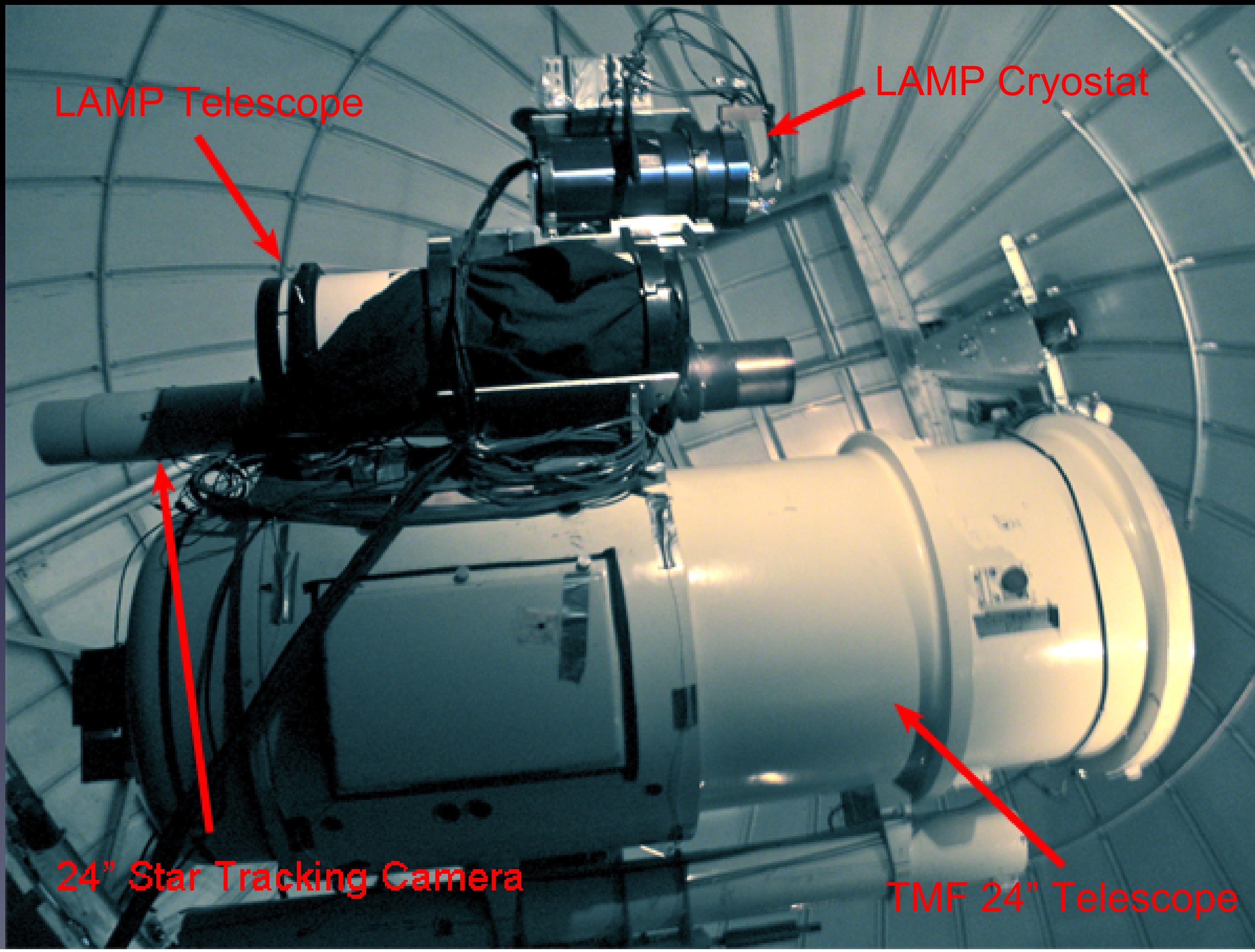
TABLE MOUNTAIN, CALIFORNIA

JPL TABLE MOUNTAIN FACILITY

(circa 2013)



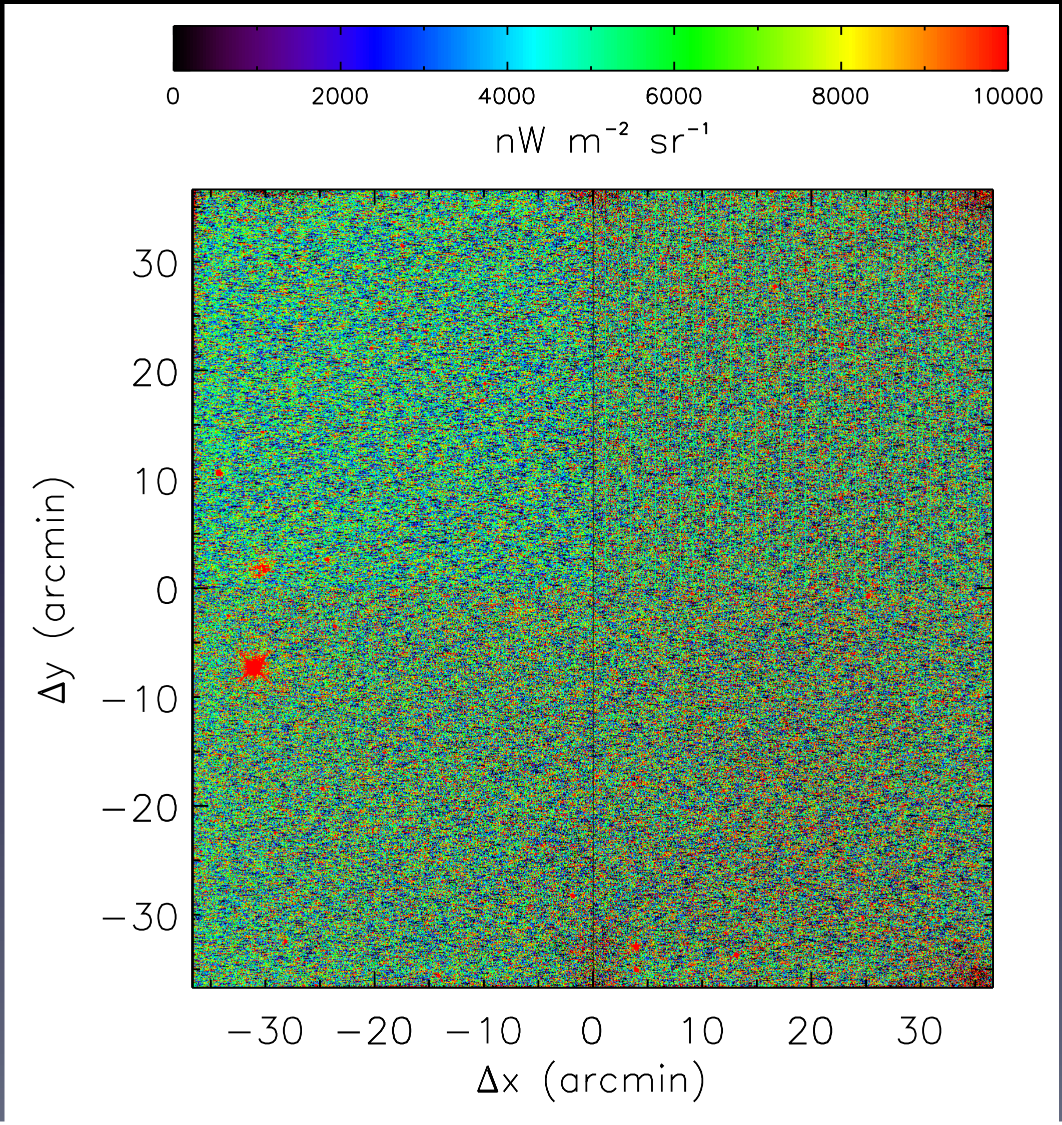
LAMP on 24" Telescope



LAMP - First Light

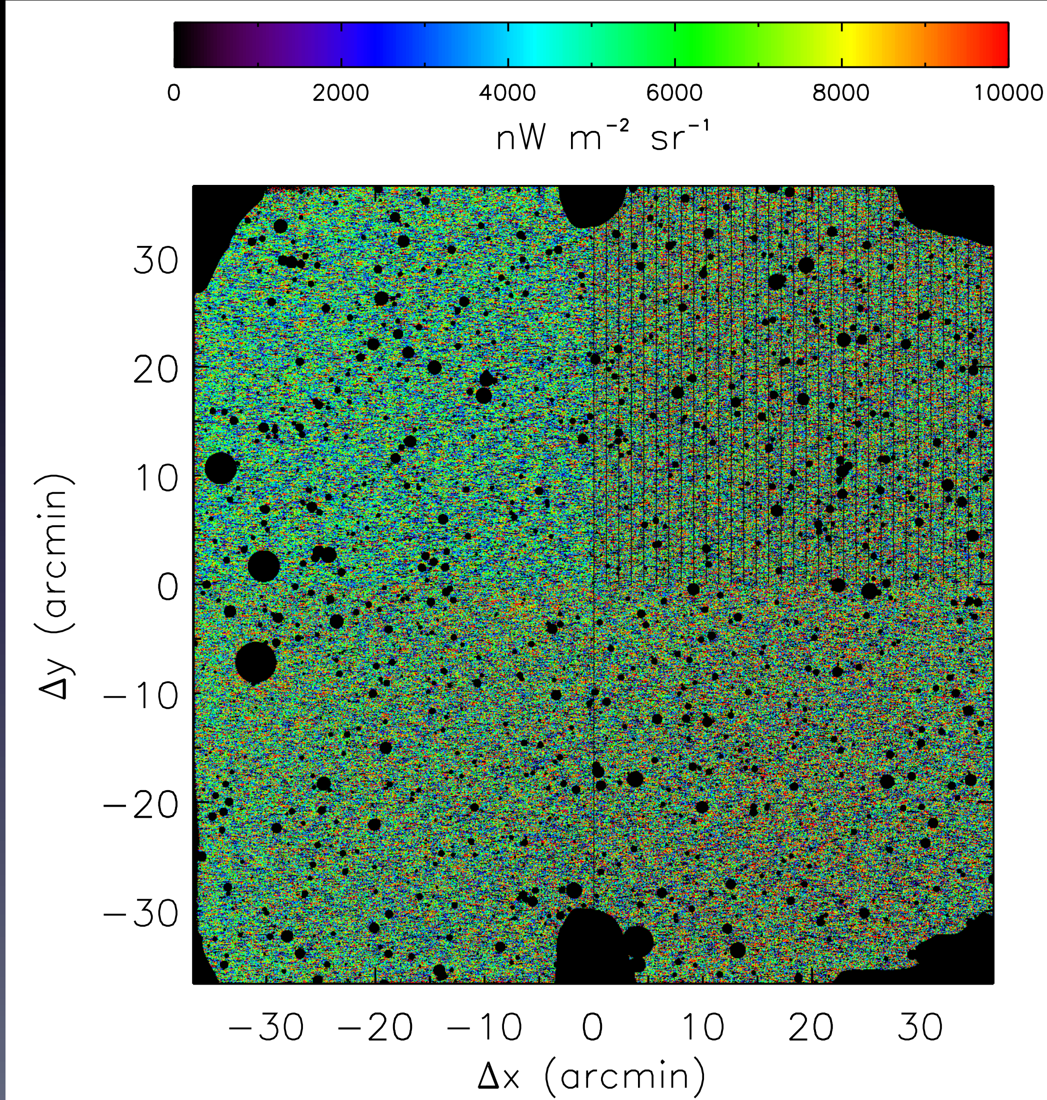
Jupiter and its Moons – Jan 28th, 2013

LAMP Observing Field
Lockman Hole

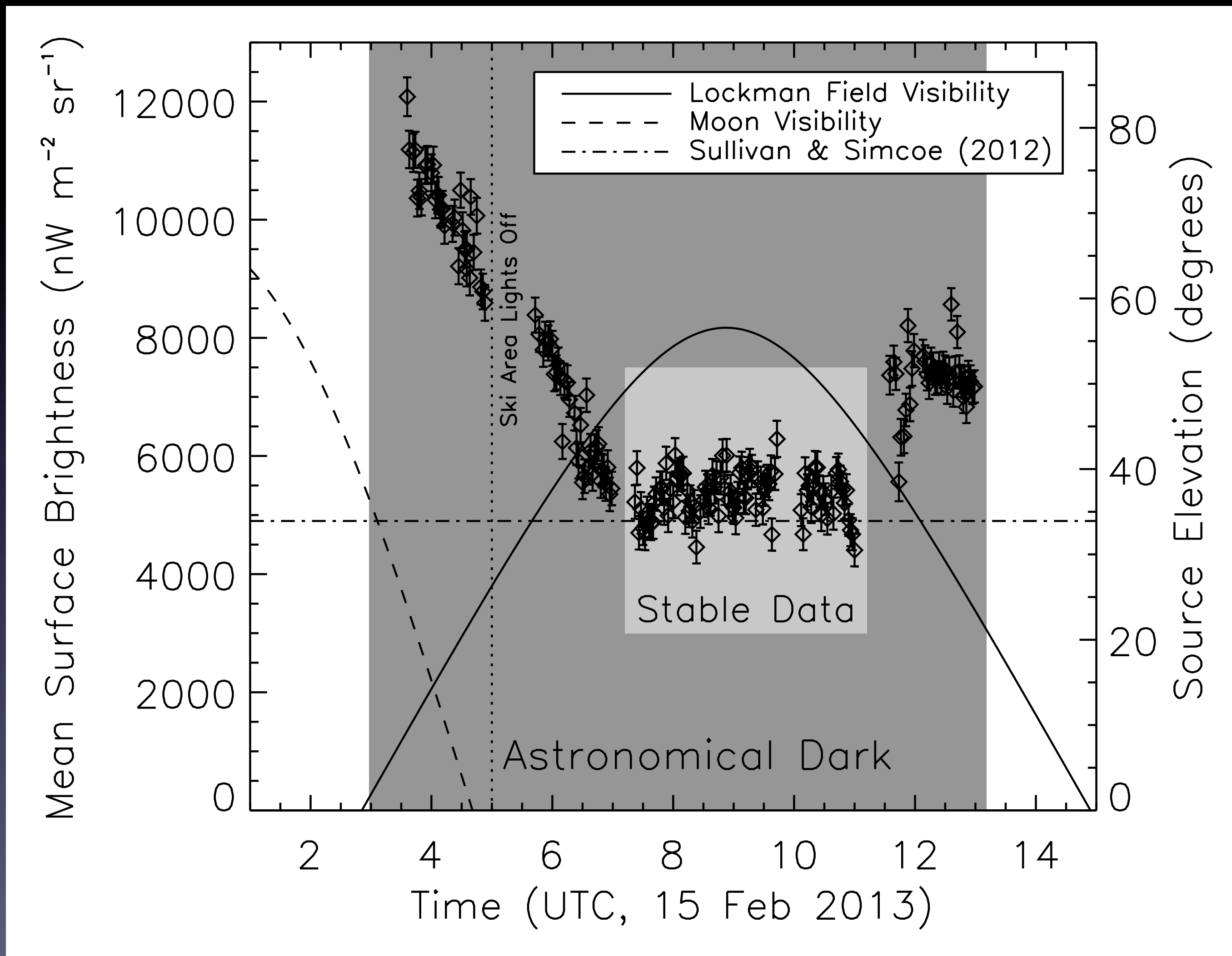


Moonless
Feb 15, 2013

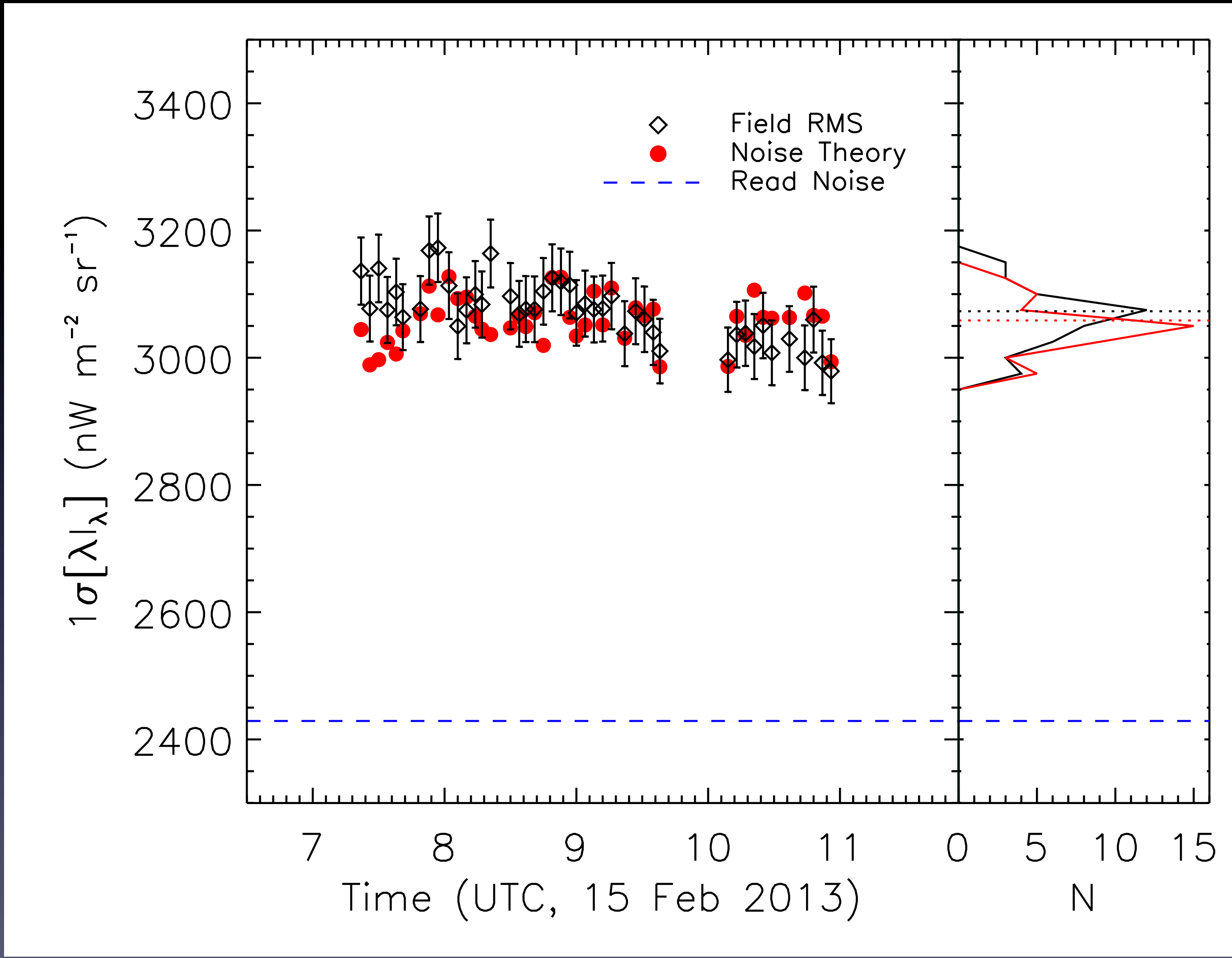
LAMP Observing Field
Lockman Hole



The Observation



The Data



Field RMS
Noise Theory
Read Noise
$1\sigma[\lambda I_\lambda]$ (nW m^{-2} sr^{-1})
3400
3200
3000
2800
2600
2400
7
8
9
10
11
Time (UTC, 15 Feb 2013)
0
5
10
15
N

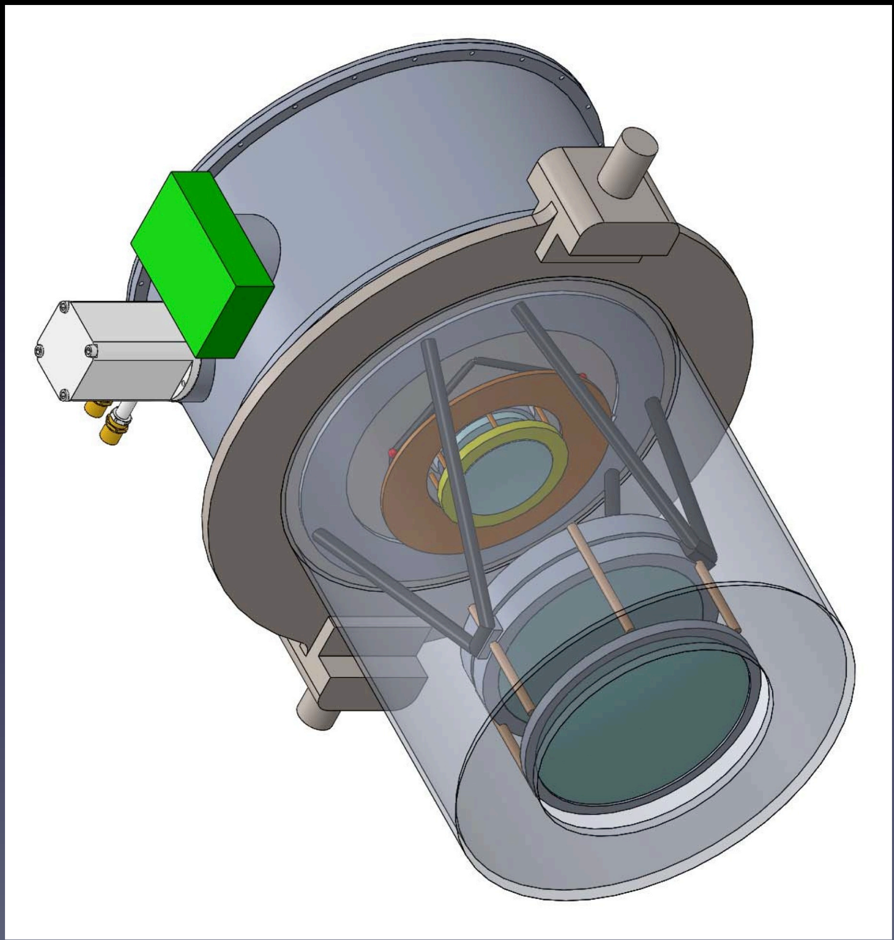
Summary

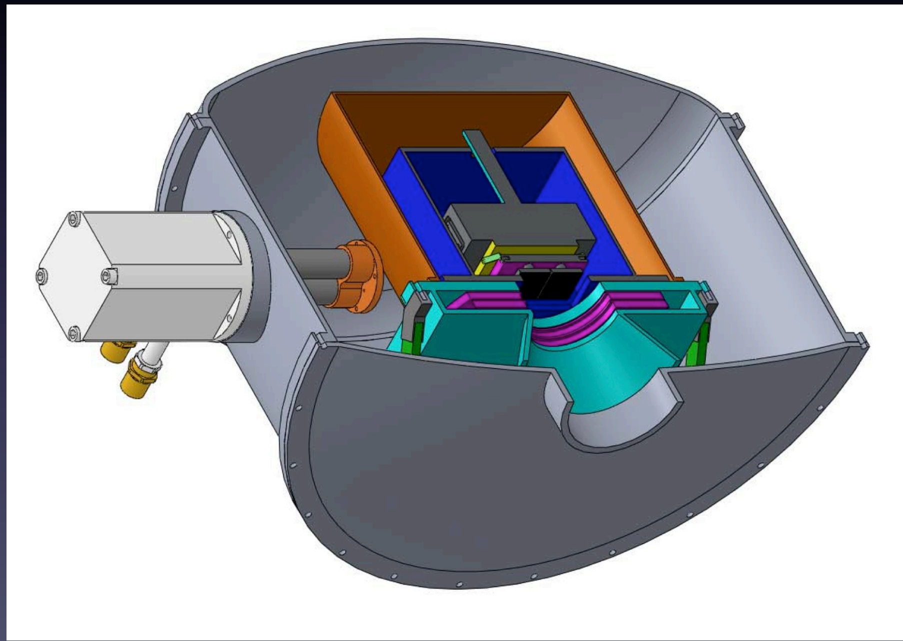
Atmospheric noise is minimal if observing in selected narrow bands. Ground-based study via line intensity mapping in the optical/near IR appears feasible.

Approach for a full science instrument:

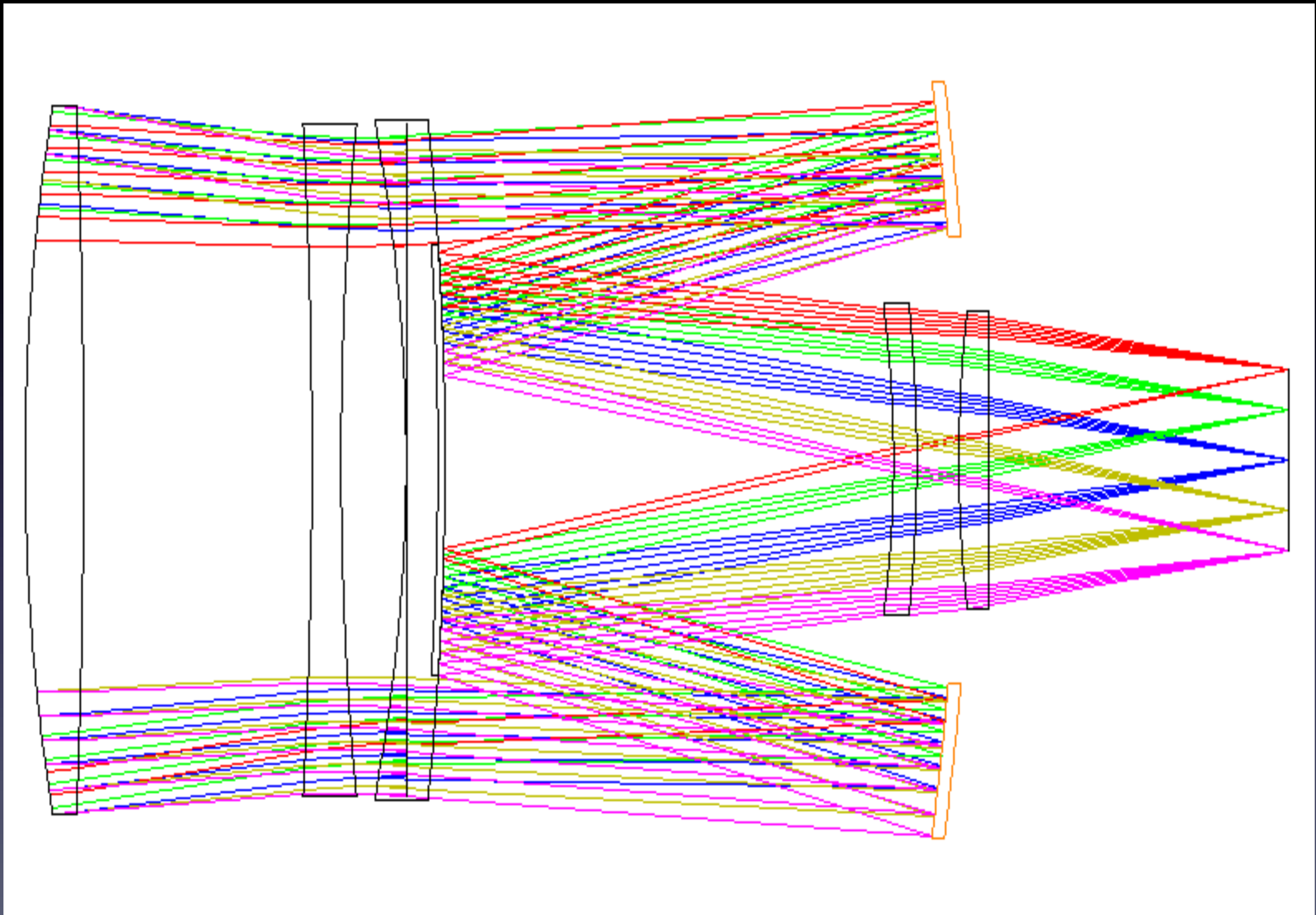
- Narrow band filters to go between the lines
- Fast optics for large AΩ
- Large optical and near IR arrays

LIME – Line Intensity Mapping Exp.

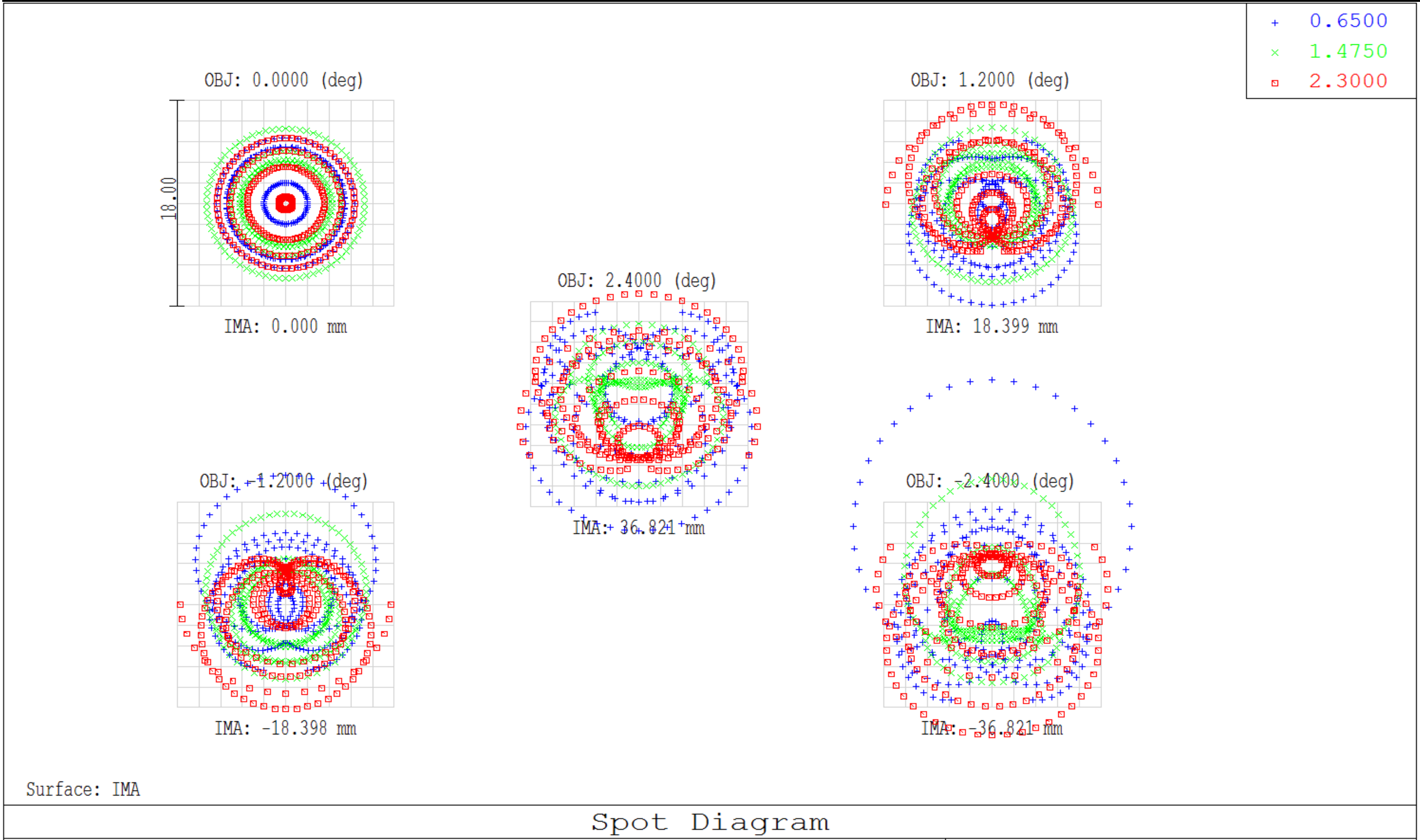




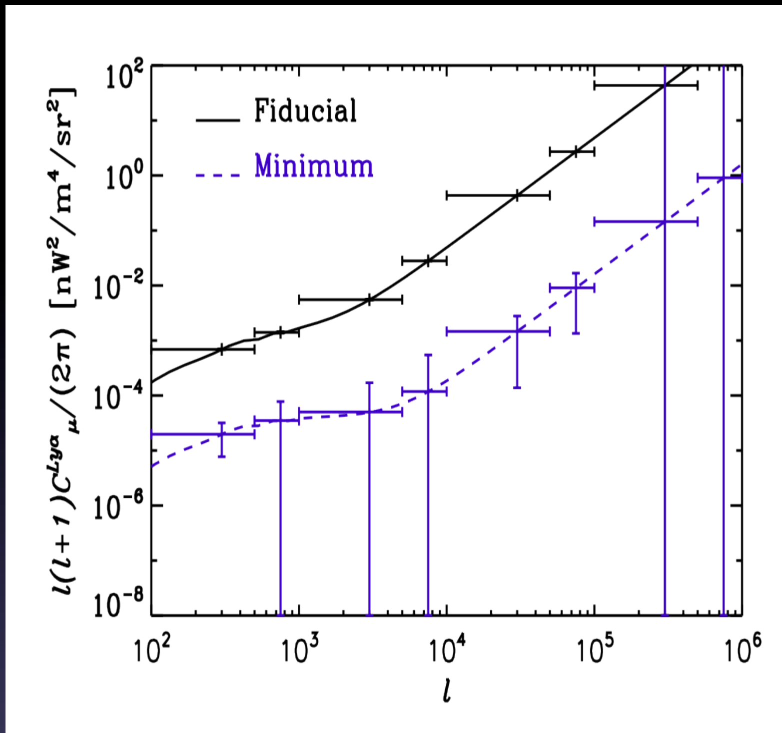
LIME – Telescope Design

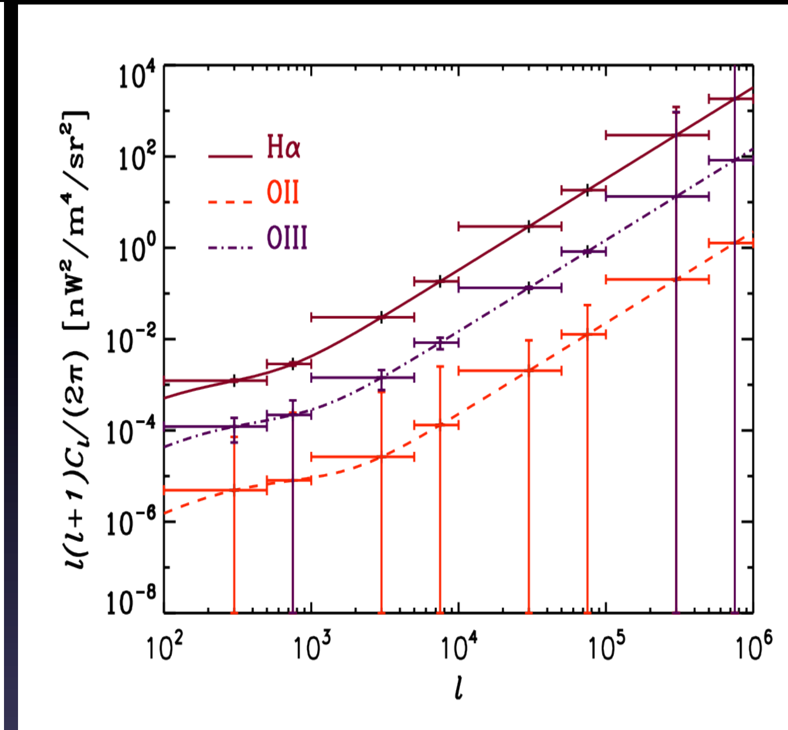


LIME – Optical Design



LIME Sensitivity





Predicted power spectrum and LIME sensitivity. **Left:** The power spectrum of Lya measured at redshift 4.2 (lambda = 0.63 um, delta/lambda = 100). The error bar are LIME sensitivity after the first season (~ 100 days) taking into count the atmospheric noise. The upper line, in black, is estimated for the fiducial model, which includes emission from both gas within massive, star-forming dark matter halos and the diffuse intergalactic medium. The dash line is for minimal model, The minimum model includes only the emission from dark matter halos. The large theoretical uncertainty, i.e., the difference in the prediction between the two model, underscores the need for such measurement. **Right**: Power spectrum predicted for Ha, OII and OIII measured at 1.2 um, for R=200, (z = 1, 2, and 3, respectively). These power spectra predictions are based on luminosity function measurements from Colbert et al 2013 (Ha, OIII), and Zhu et al 2009 (OII).