A Precise Measurement of the Infrared Background: Instrumental Requirements

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The EBL ≠ IGL Mystery

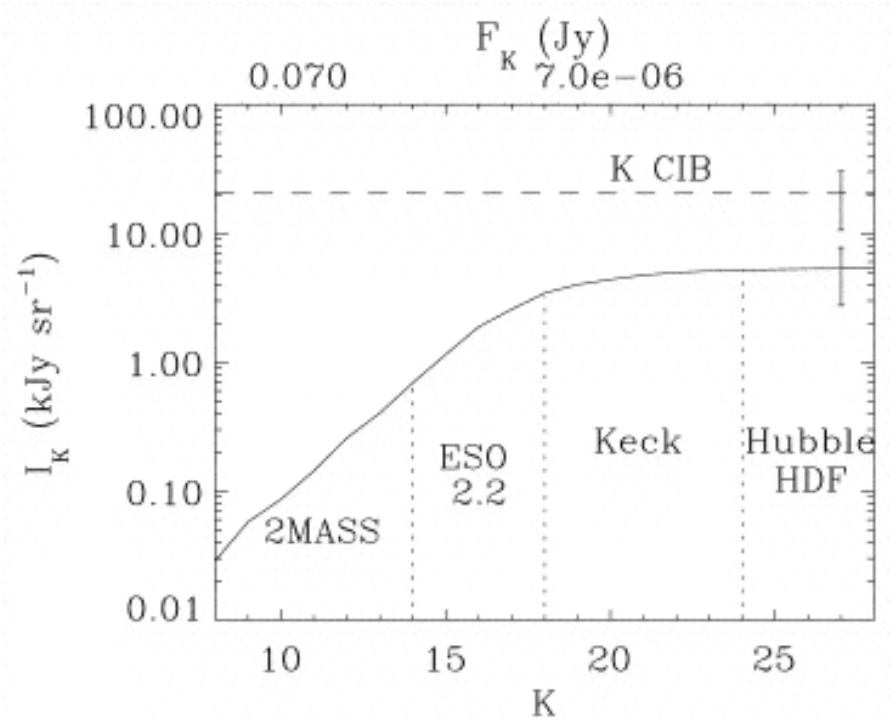
Extragalactic Background Light =
Total Line of Sight Brightness – Stars – Zodiacal Light – Interstellar Medium

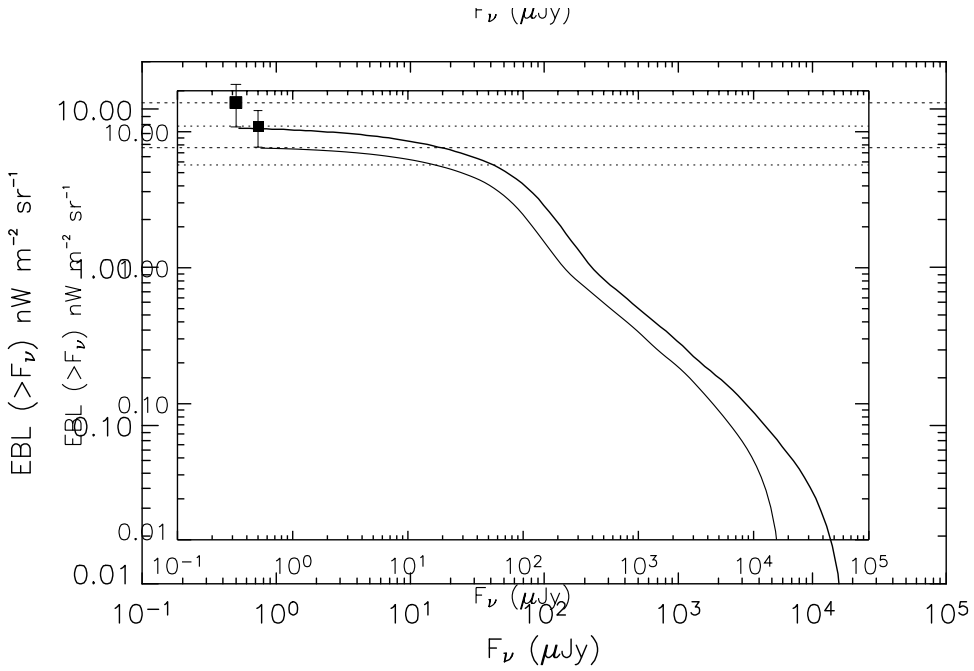
Integrated Galaxy Light =
Sum over light from all individually detected galaxies

IGL =< EBL

Isotropy is a requirement !

The tentative but persistent disconnect between EBL and IGL measurements





Cambresy, WTR et al. 2001
2.2 microns

GOODS 3.6 microns

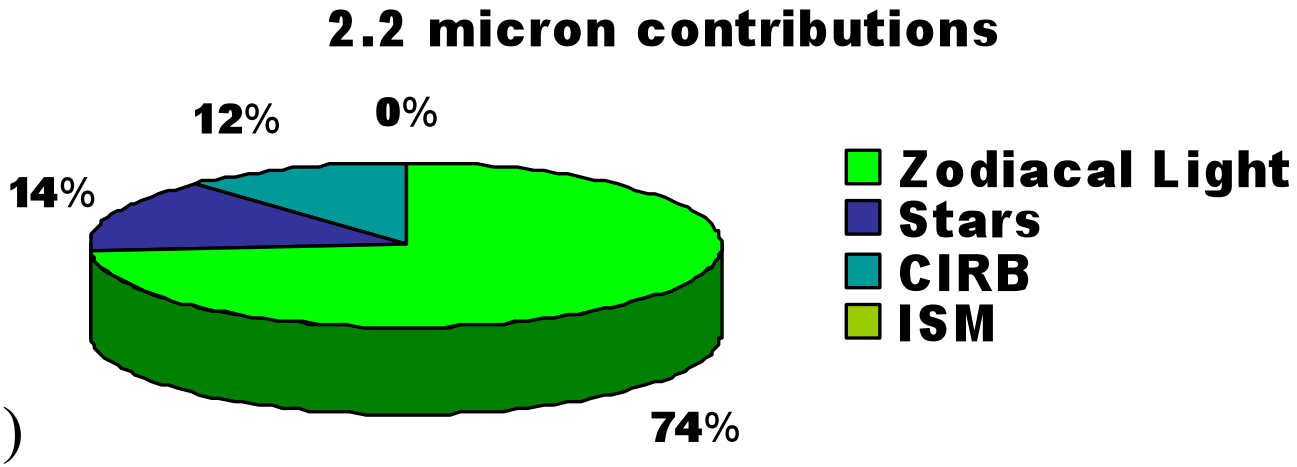
Are we missing sources and/or flux ?
Or are we incorrectly subtracting zodiacal light ?
Or is everything hunky dory within uncertainties

Two Critical Science Questions

- What is the reionization history of the Universe ?
  - Sets metallicity floor for normal stars/galaxies to form
  - 1-3% of current metals formed in first generation of stars
  - Addresses top down vs bottom up galaxy formation
  - Addresses why not all DM halos might form dwarf galaxies

- What is the fractional contribution of comets and KBOs to the dust in the outer solar system ?

Unfortunately Sky Background at Infrared Wavelengths is Dominated By Zodiacal Light at 1 AU



CIRB (nW m^{-2} sr^{-1})

λ νI_ν

2.2: 22.4±6.0 (reionization >0.2)

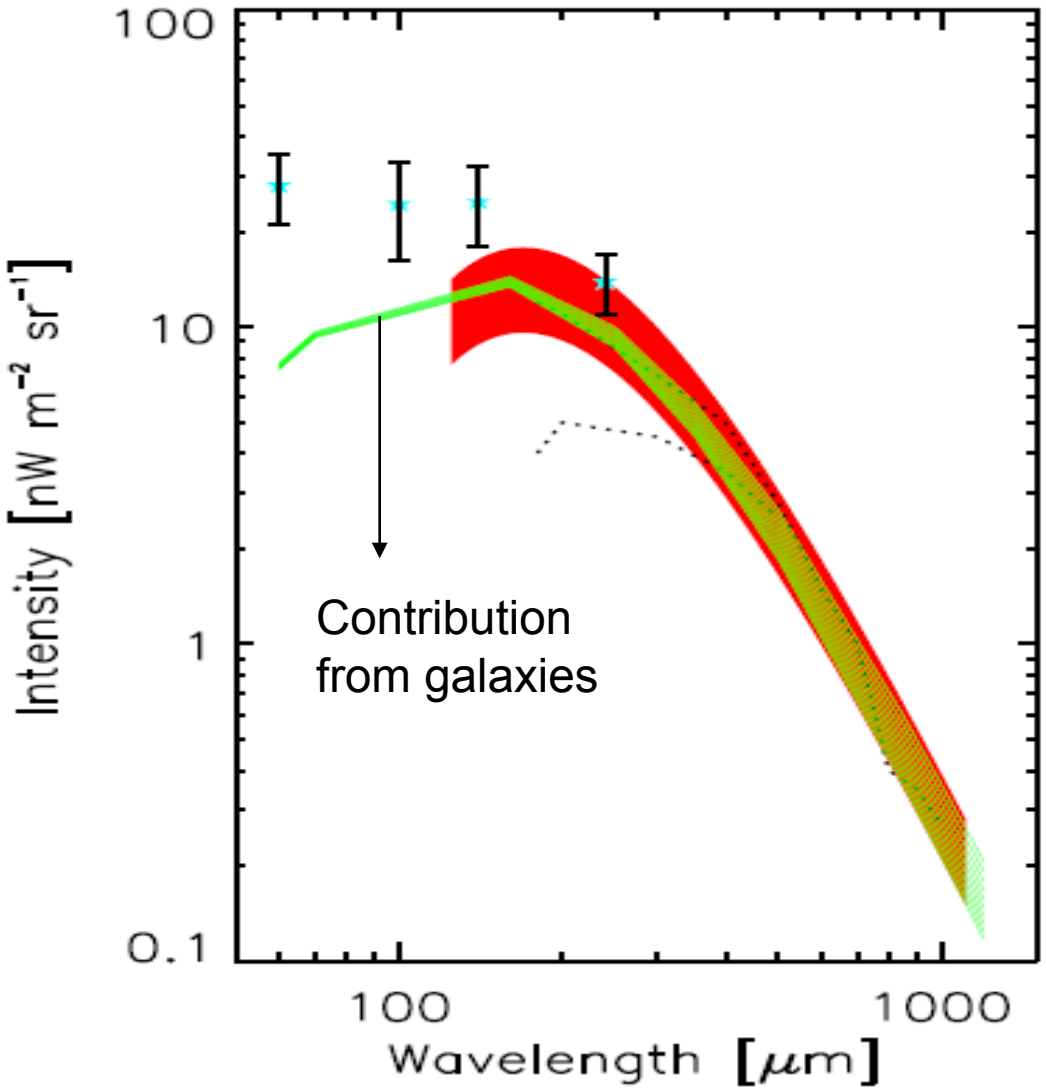
3.5: 11.0±3.3 (reionization >0.1)

140: 25±7

240: 14±3

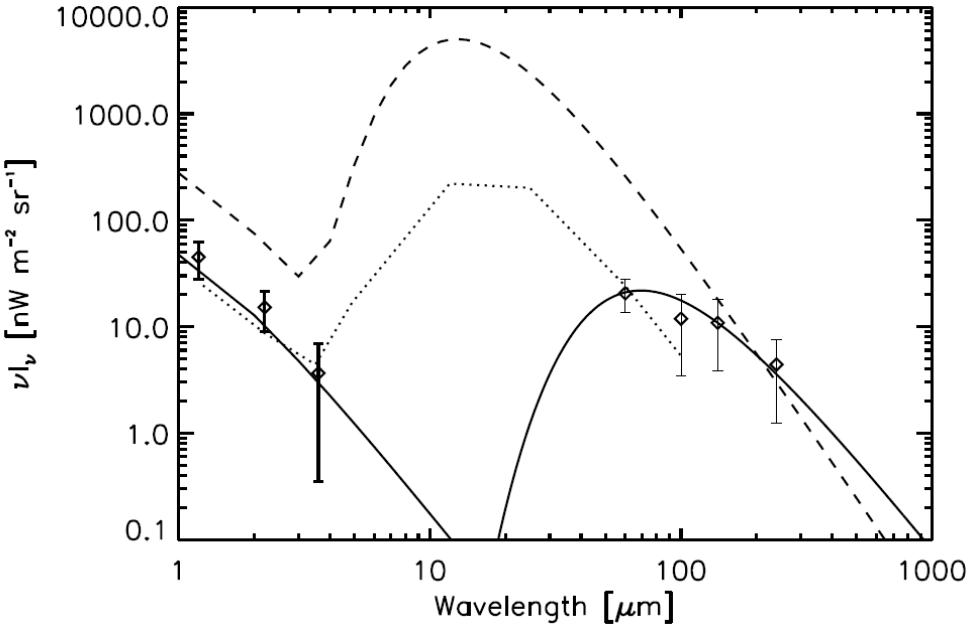
This is a needle in a haystack problem. To get a 5σ measurement of the most pessimistic reionization epoch signal needs a precision of ~0.2% on the EBL. This is a factor of 150 (!) better than current measurements.

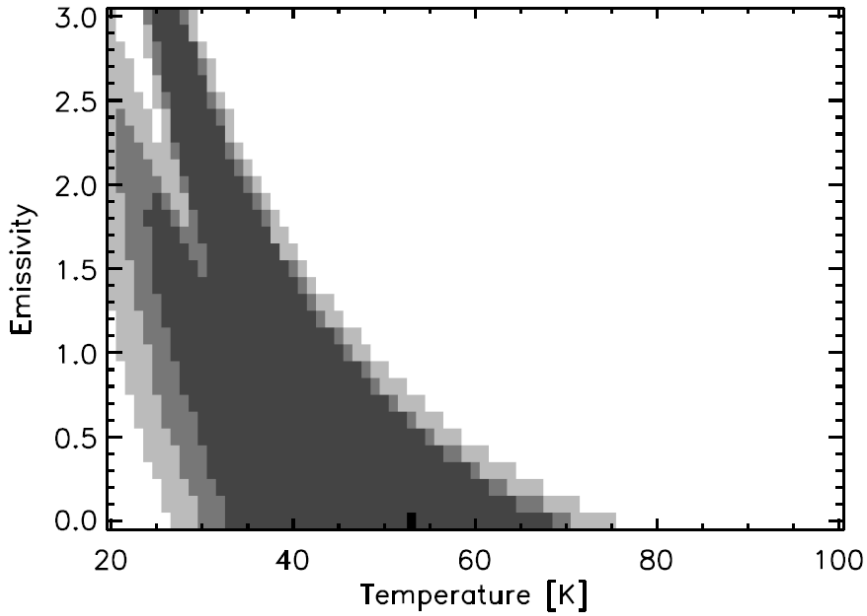
A Clue ?
There is an “Isotropic” Excess even at 60 and 100 μm



Finkbeiner et al. 2000
Chary & Pope 2010

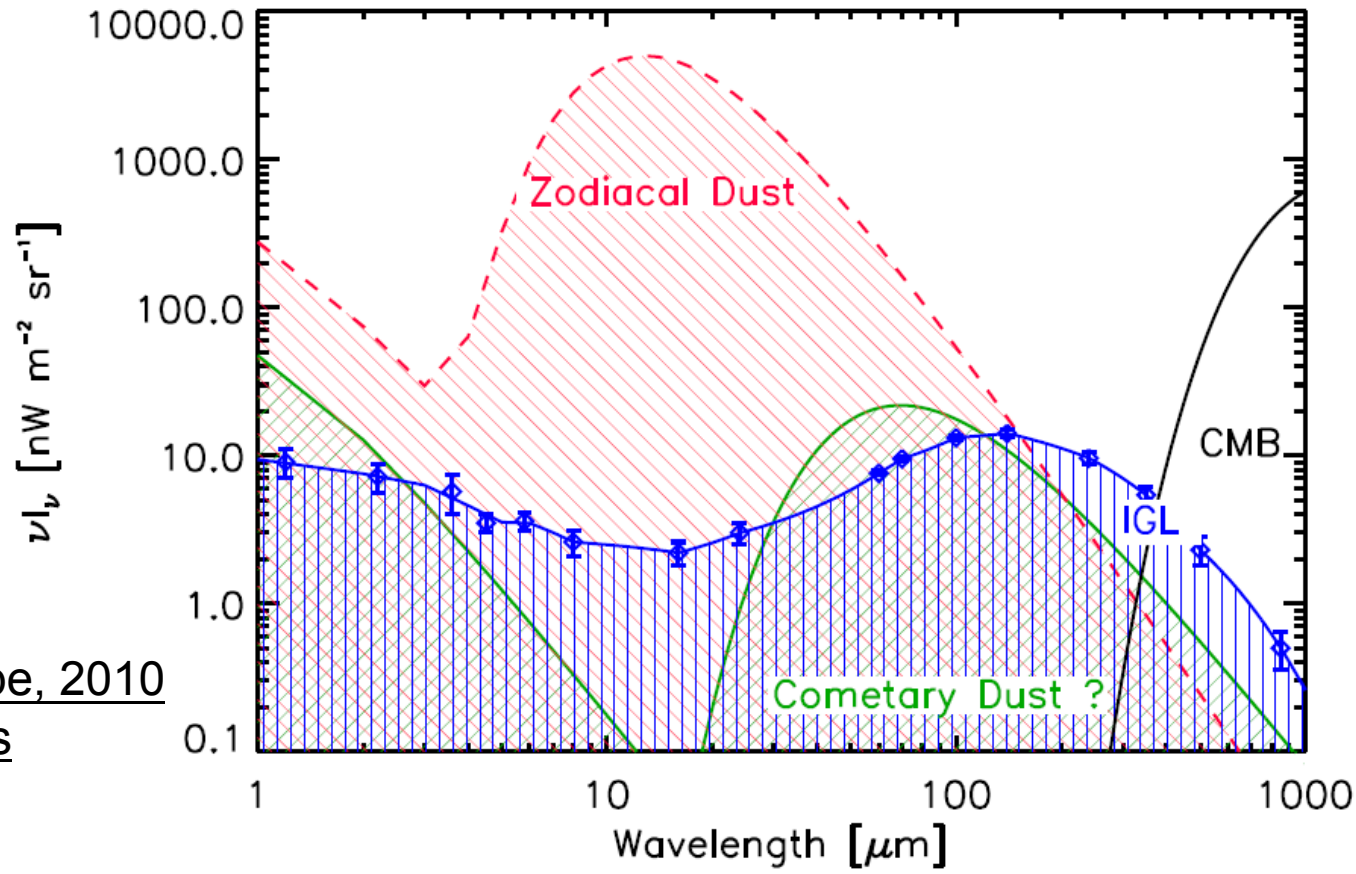
High Albedo Cometary Dust at Kuiper Belt Distances ?





Chary & Pope, 2010, ApJ, in press (astroph/1003.1731)
Hahn et al. 2002
A. Stern 1996

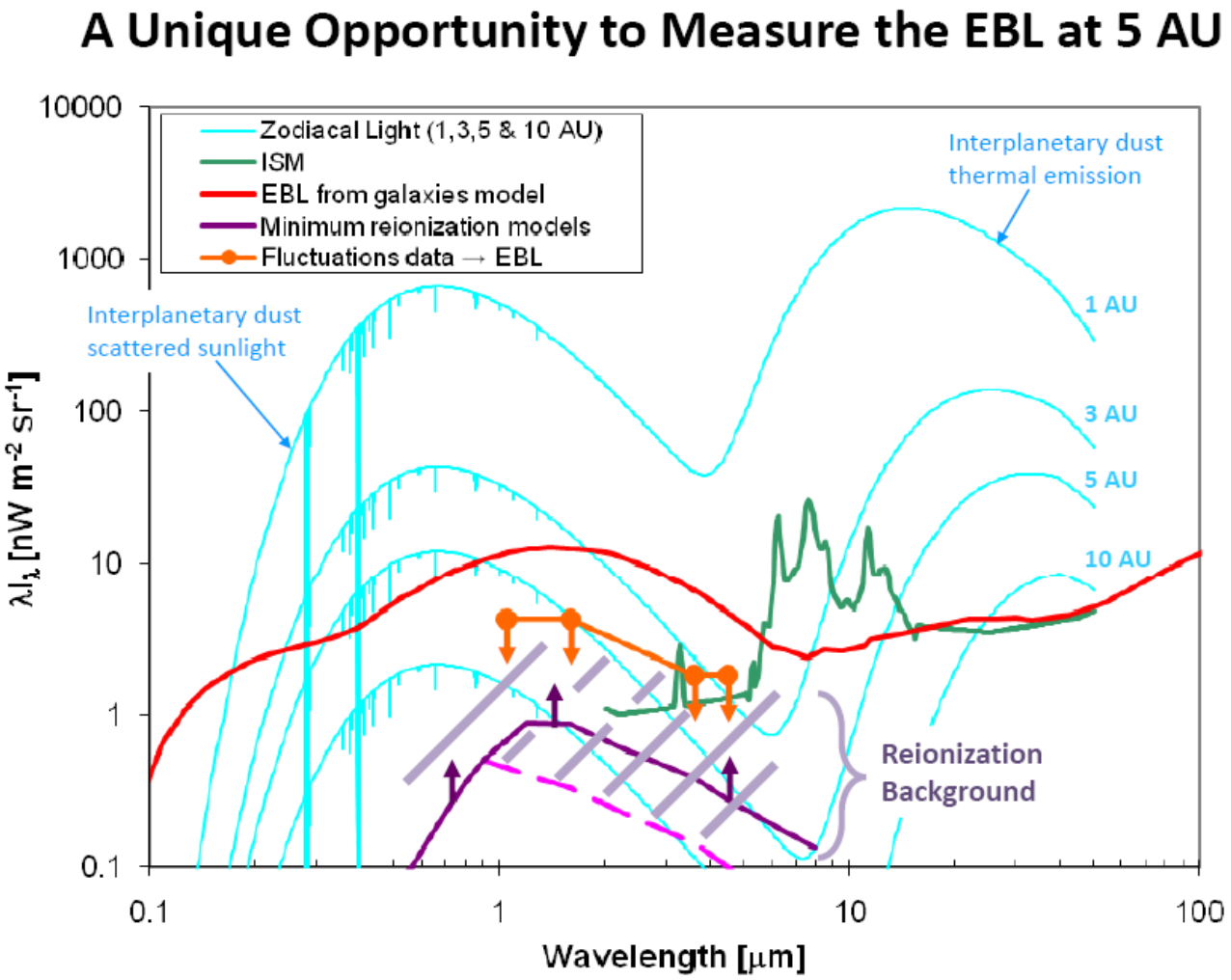
Chary & Pope, 2010
ApJ, in press



This is NOT a needle in a haystack problem. To get a 5σ measurement of the likely cometary dust signal needs a precision of ~10% on the EBL @ 2.2micron. This is a factor of 3 better than current measurements.

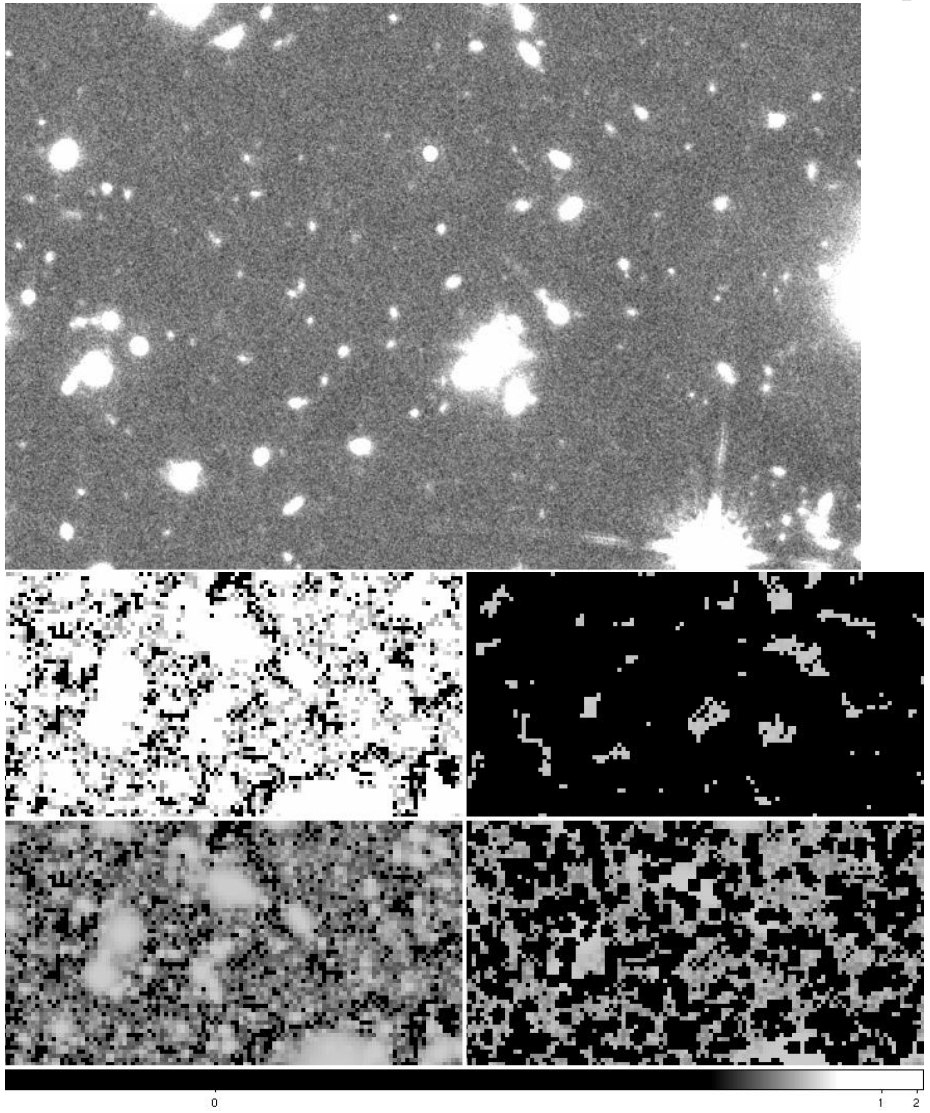
NIR Spectrum is different compared to reionization signal

How can we measure this signal?



Getting out to 5AU is a minimum requirement. 10 AU might be preferred.

Instrument Specs at 5-10 AU



Pipe Dream
2.5m telescope, 0.06” pix
absolute dark/bias calibration
degree FOV
R~500 spectrometer

Reality
10-30cm telescope, 0.6-2” pix
absolute dark/bias calibration
degree FOV
R~500 spectrometer
Requires ancillary deep imaging

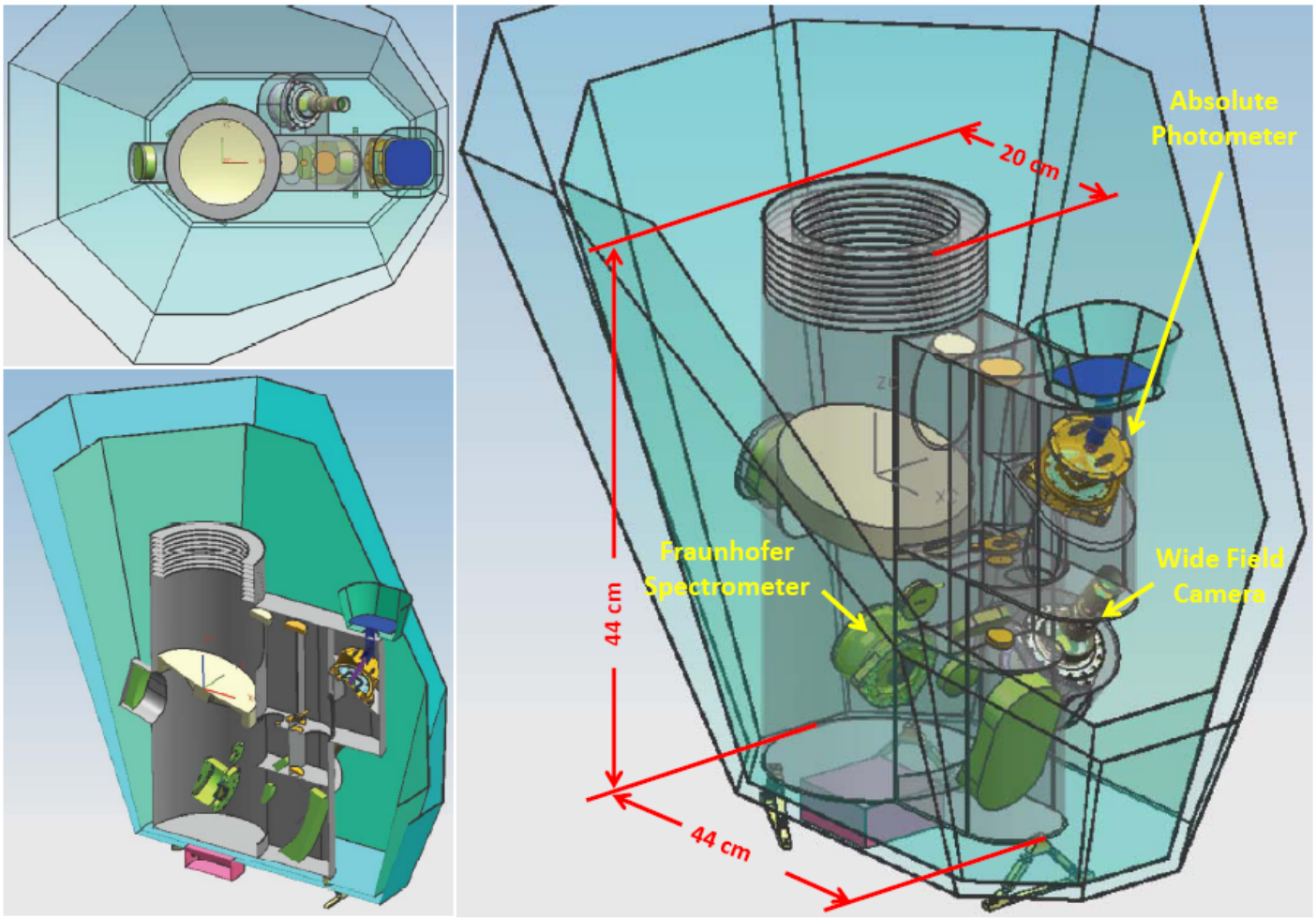
4%, 10%, 34% unmasked pix
With 10, 15, 30 cm and 0.6”

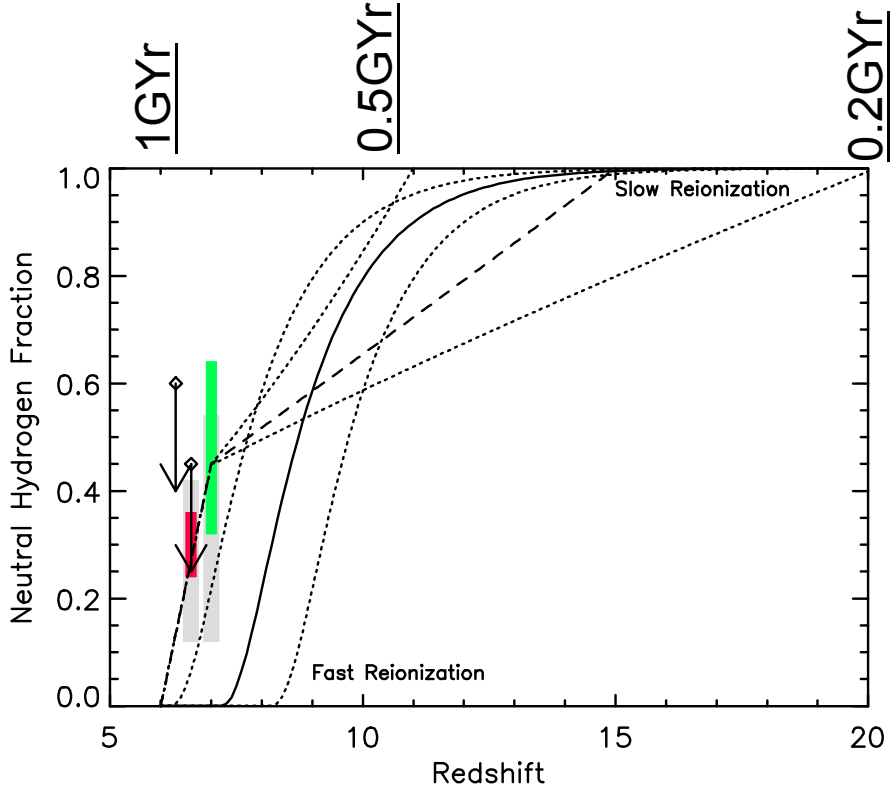
An Imager and/or a Spectrometer ?

- We need to have a spectrometer to measure Fraunhofer lines and calibrate out residual foreground signal even at 5-10 AU.
  - Spectral resolution of ~300
  - Get critical lines e.g. Ca
- Goal for absolute flux calibration of 0.1% @ 2 microns.
- 5sigma requirement @ 2 microns = 0.2 nW/m2/sr
- Minimum wavelength range of 0.5-3 microns with multiple filters
  - To distinguish solar spectrum from reionization spectrum
- Telescope aperture and pixel scale trade off
  - Small pixel scale to avoid confusion of pixel flux from nearby sources
  - Large pixel scale to cover wide area
  - Large aperture so PSF does not result in spill over of flux from brighter sources
  - Small aperture to piggyback on to an existing spacecraft

Its hard but that's the challenge

ZEBRA: Zodiacal dust, Extragalactic Background, & Reionization Apparatus

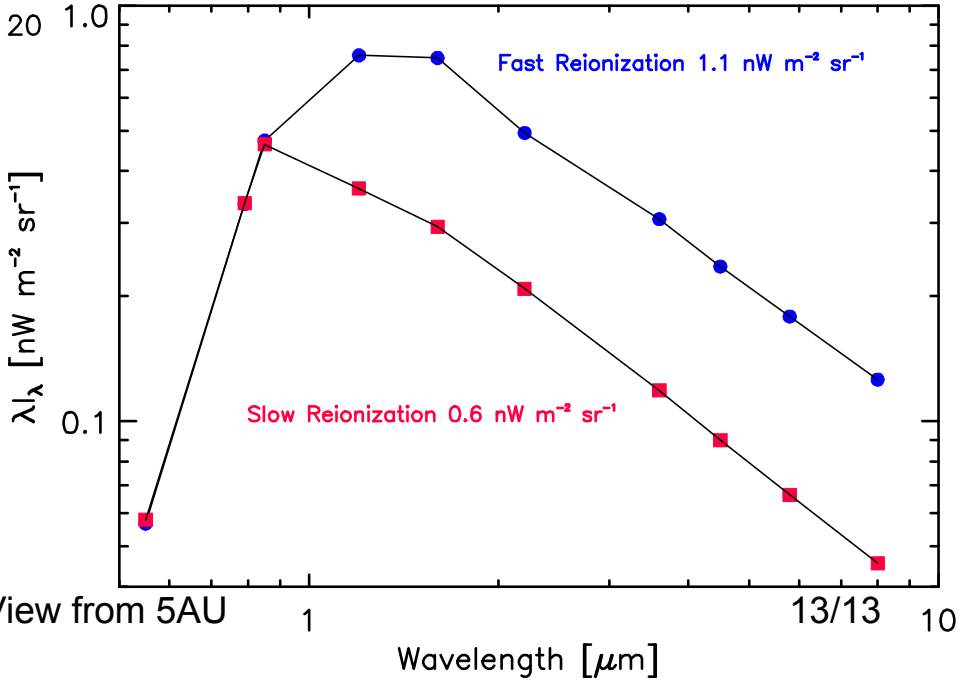




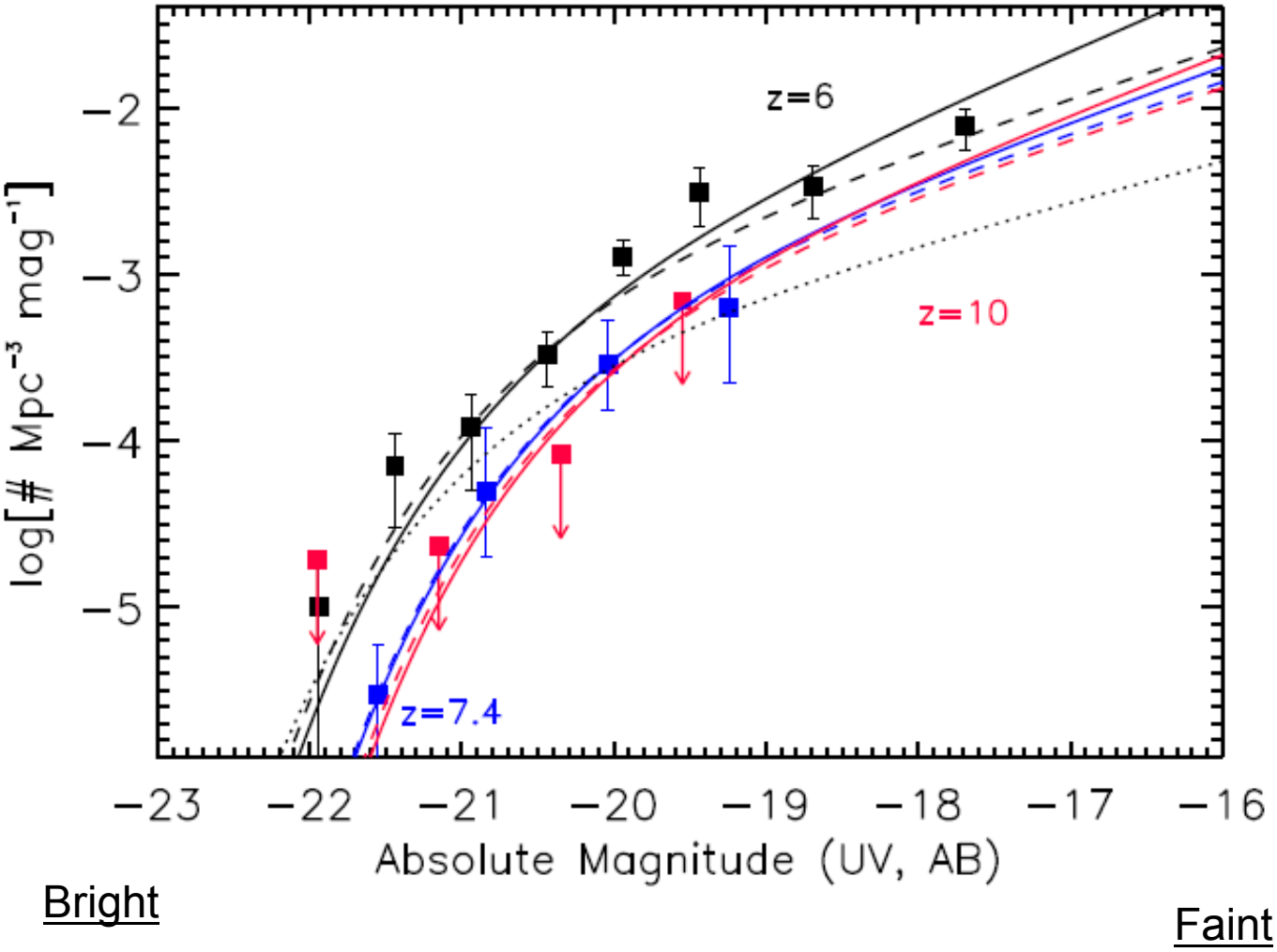
Reionization
-The conversion of neutral hydrogen to ionized Hydrogen
-Thought to be due to the photons from star-forming galaxies
-QSOs/AGN are thought to be a negligible contributor
-Other exotic candidates have been proposed e.g. decaying dark matter, cosmic strings

The Problem:

The total ionizing photon budget from detected star-forming galaxies falls x10 short of addressing reionization.



Chary & Cooray 2010, in prep.



Bouwens et al. 2009; Chary & Conray 2010