HDI

LUVOIR High Definition Imager (HDI) Instrument

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For HDI Instrument Team

LUVOIR STDT F2F3 – 09 November 2016

STScI | Space Telescope Science Institute

HDI SCIENCE TEAM

HDI

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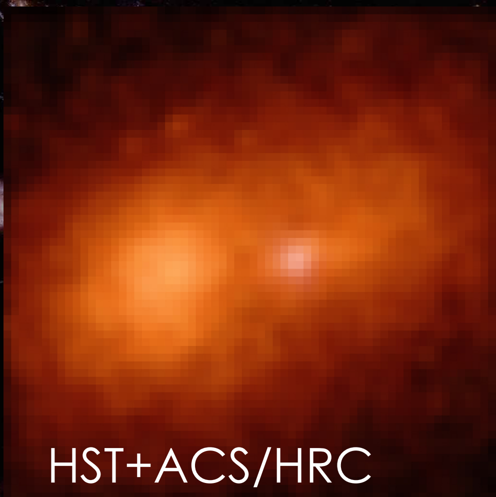
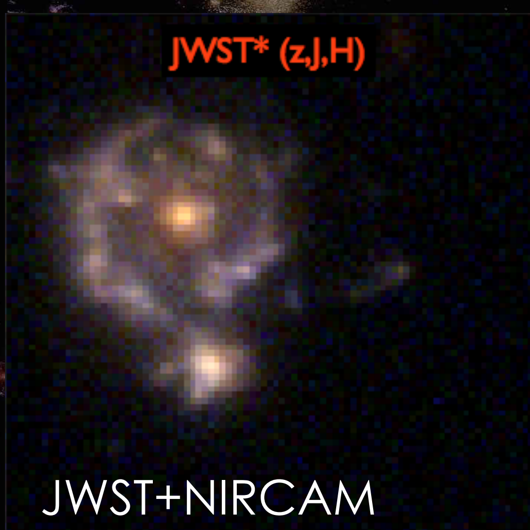
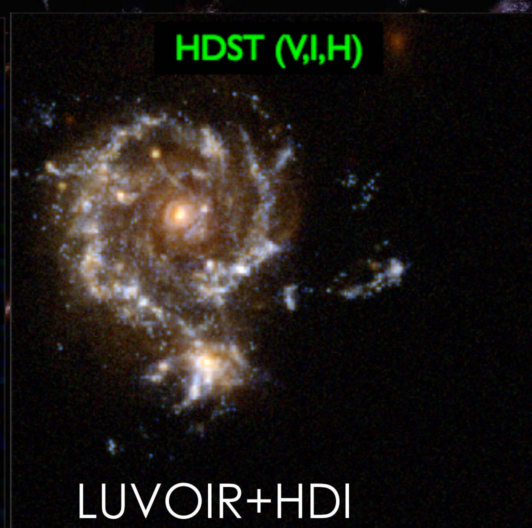
1. HDI SCIENCE

HDI

Ultra Faint … Ultraviolet … Ultra Precise … Ultra High Resolution







Characterize stellar populations to rigorously test star formation theories

Measure cosmological parameters with well-calibrated distance indicators out to the distance of the Coma Cluster

Explore outer planet atmospheres, discover distant objects in the solar system

Reveal the impact of the epoch of reionization on galaxy formation and visualize the evolution of galaxies

Map dark matter by measuring proper motions of galaxies

Astrometric detection of 100s of exoEarths

1. HDI OVERVIEW

HDI

Multi-channel instrument:

1) UV imaging channel (200 – 300 nm) – overlap with LUMOS instrument but FOV will be >4x larger.

2) Visible channel (300 – 1000 nm) – may be possible to combine with UV channel if suitable detector is used.

3) NIR channel (1000 – 1800 nm)

4) Each channel will contain a suite of narrow (R~50 - 100), medium (R~20 - 40), and broadband (R~3 - 5) filters. Likely also to desire at least one grism/prism option (R ~ 200 – 500).

UV-Vis array likely to be >2 Gpixels (depends on aperture)
NIR array likely to be 500 – 750 Mpixels (depends on aperture)

2. HDI Instrument Requirements

HDI

Spectral Bandpass:
Target: 200 – 1800 nm
(Stretch: 200 – 2500 nm)

Field-of-View:
Target: 4’ x 4’
(Stretch: 6’ x 6’)

Angular Resolution:
Target: Nyquist sampled down to 400 nm (stretch: 200 nm)
Diffraction limited down to 500 nm (stretch: 400 nm)
WFE across FOV ≤ 36 nm
For 12m, Nyquist @ 400 nm = 3.4 mas (5 Gpix)
D.L. @ 500 nm = 10.5 mas

2. HDI Instrument Requirements

HDI

Special Modes

High-Speed Photometry

Temporal Resolution:

Target: 100 msec

(Stretch: 50 msec)

HSP may not require entire FOV

High Precision Astrometry

Astrometric Precision:

Target: 5×10^{-4} pixels

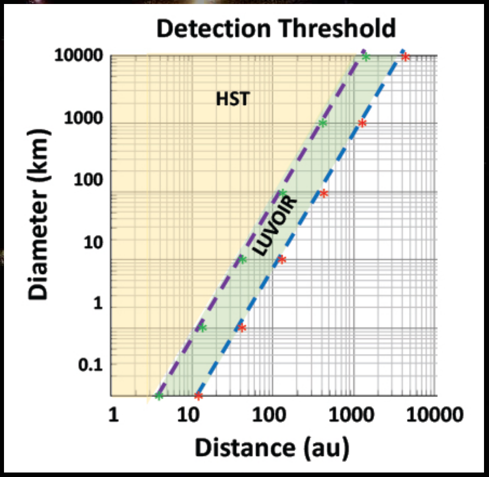
(Stretch: $10^{-4} – 10^{-5}$ pix)

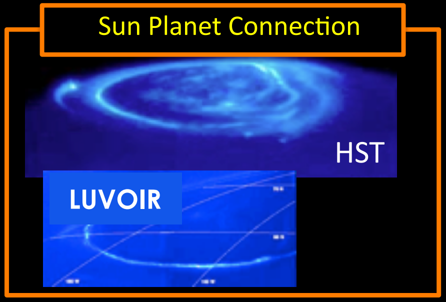
High astrometric precision will require pixel geometry calibration system (e.g., Shao et al.)

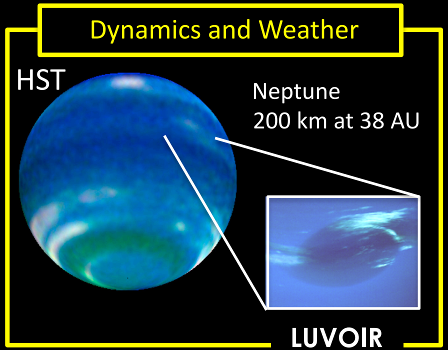
2. HDI Instrument Requirements

Solar System Imaging considerations:

- Solar blind performance: UV imaging requires high red leak rejection (10^{-8})
- Region in array with reduced sensitivity will enable high dynamic range near bright planetary targets.

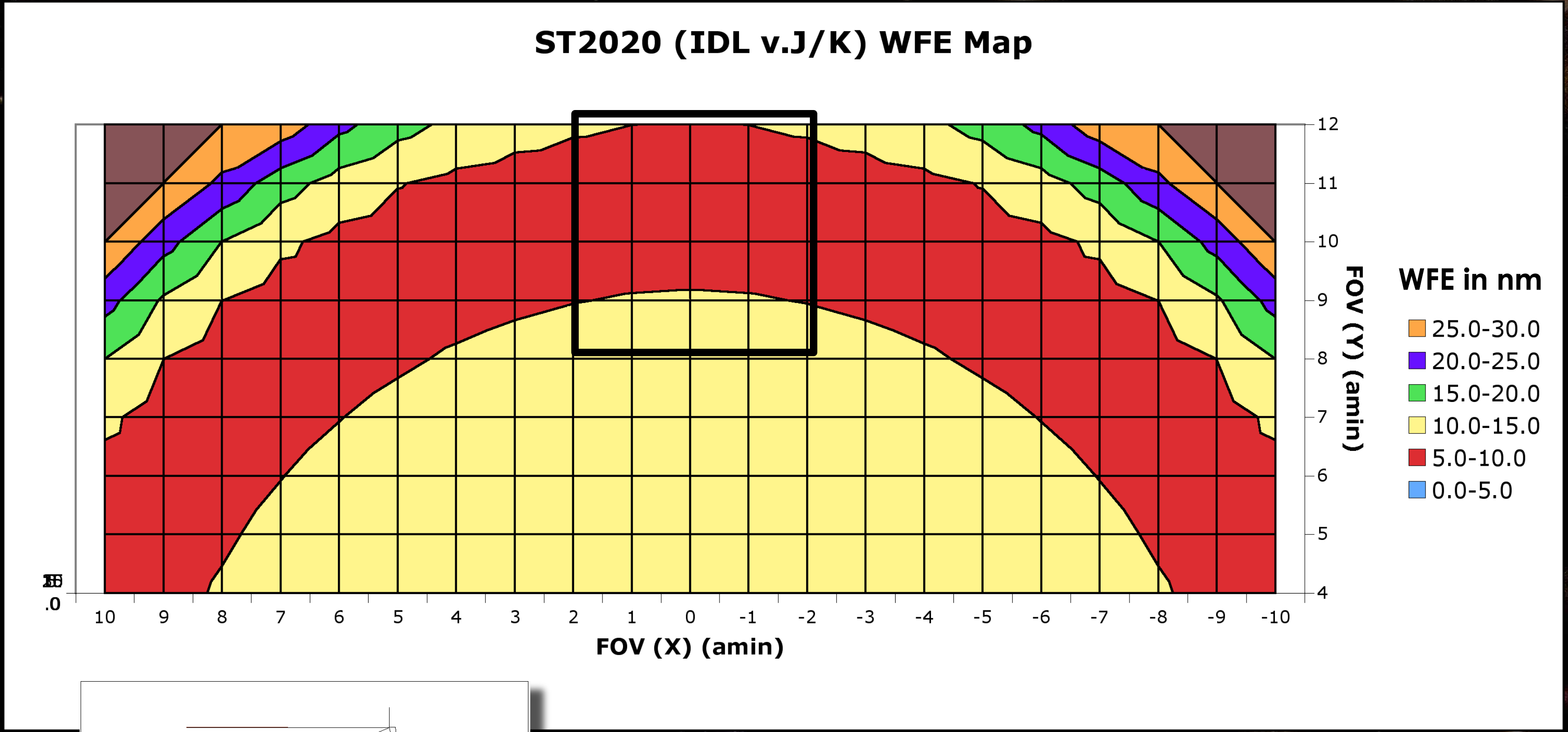


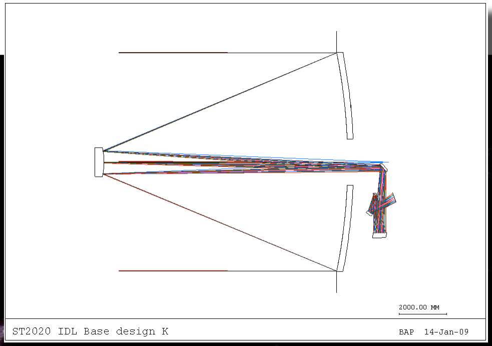




3. HDI – Notional Design

Achieving diffraction-limited performance over desired FOV is feasible in TMA design





Pasquale 2008 ATLAST 9.2m

4. HDI – Detectors

HDI

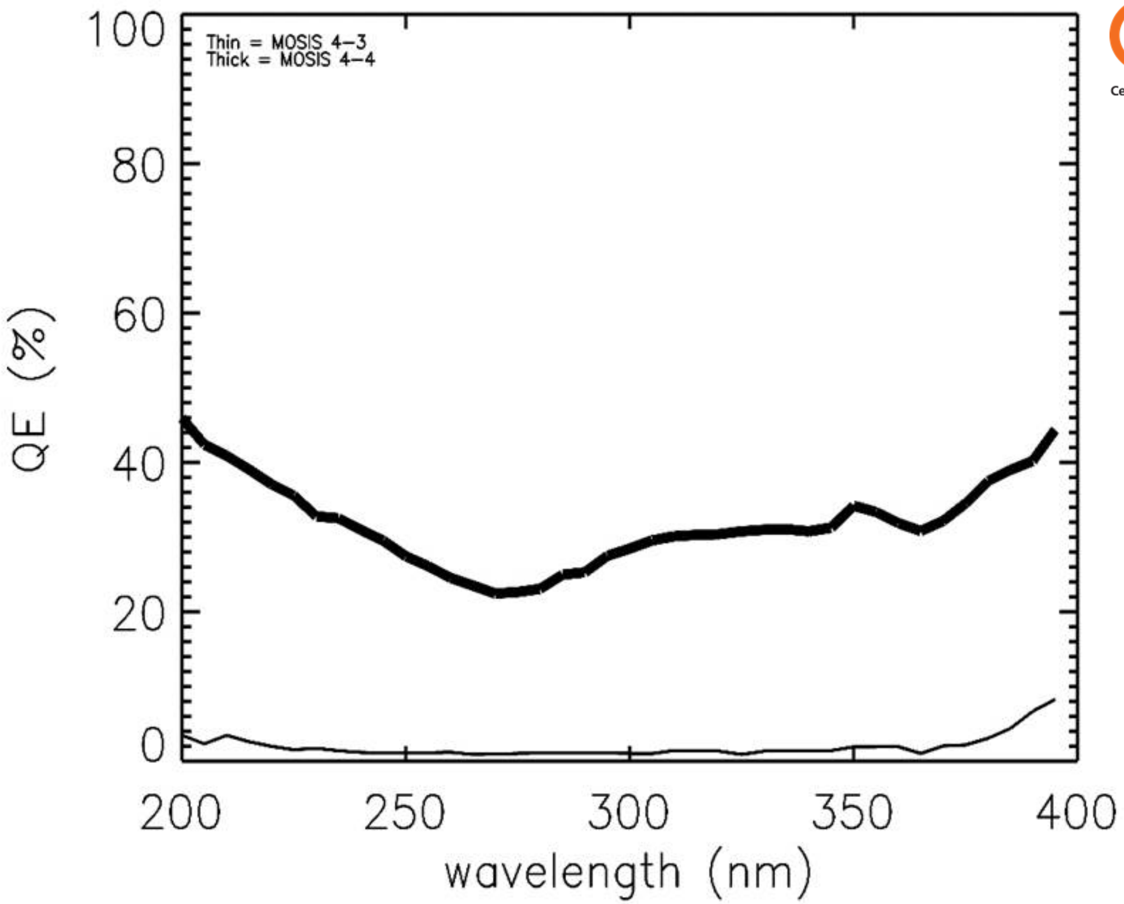
RIT has been developing CMOS detectors that have good sensitivity in NUV and in visible. They also exhibit very low read noise.

Graph credit: D. Figer, RIT

FUTURE PHOTON INITIATIVE

ritphotonics

Center for Detectors



\\python\Buffalo1\M4_3_v_M_4_4\QE_MOSIS4_4_vs_MOSIS_4_3_200_400.jpg

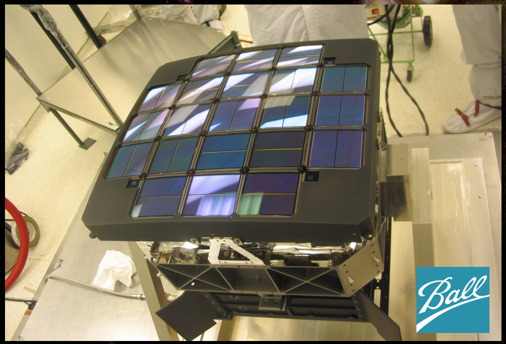
Challenge: thinned devices don't work as well at longer wavelengths.

To avoid needing separate UV and Vis channels for HDI, should strive to engineer devices that get excellent response from 200 – 900 nm.

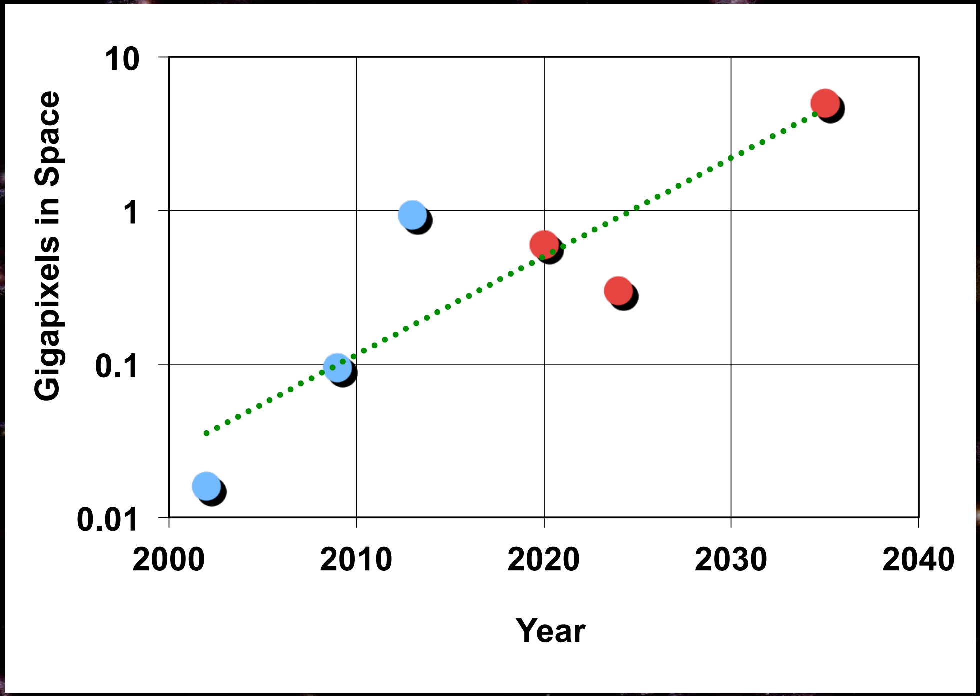
4. GIGAPIXEL CAMERAS IN SPACE

HDI

- Recent space heritage:
  - ACS/HST: 16 Megapix (2002)
  - Kepler: 95 Megapix (2009)
  - Gaia: 937 Megapix (2013)
- Near future space FPA:
  - EUCLID: 604 Megapix (~2020)
  - WFIRST: 302 Megapix (~2024)
  - LUVOIR: 5 Gigapix (~2035)



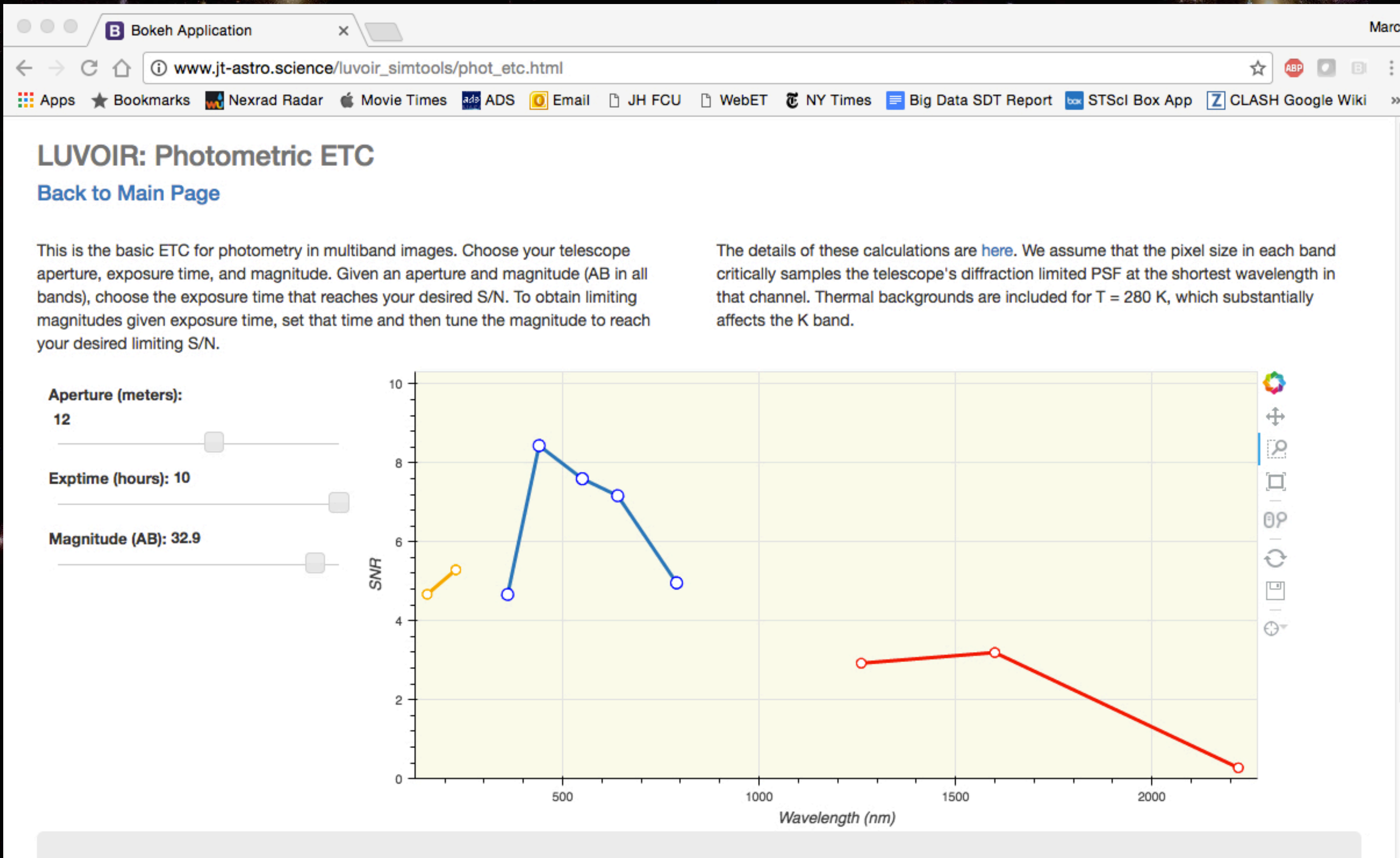
Kepler Focal Plane Array (95 Mpix)




Gaia Focal Plane Array (937 Mpix)

5. HDI – Exposure Time Calculator (Marc Postman, Jason Tumlinson)

HDI



http://www.jt-astro.science/luvoir_simtools/phot_etc.html

SUMMARY

HDI

HDI: High Definition Imager Concept For LUVOIR

1) High-Angular resolution Imager for General Astrophysics Covering Range 200 – 1800 nm.
   A. Nyquist sampling important for optimal (noiseless) image co-addition. Implies need for Gigapixel array.
2) Special Modes include:
   A. High Astrometric Precision Mode for observations of Nearby Stars for Exoplanet detection; Galaxy Proper Motions.
   B. High Speed Photometric Mode for observations of Stellar Pulsation Phenomena and Solar System Occultations
3) Detector Developments in work but additional studies needed to assess feasibility of Gigapixel array in Space.