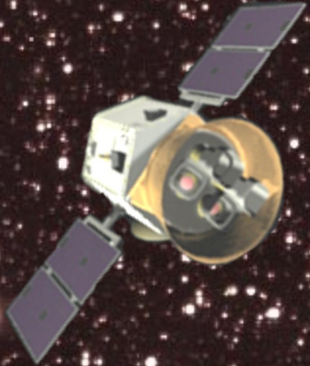
Expanding the Search for Earth-size Planets Orbiting Sun-like Stars by Compressing Image Data Onboard Space Telescopes



Jon M. Jenkins
NASA Ames Research Center

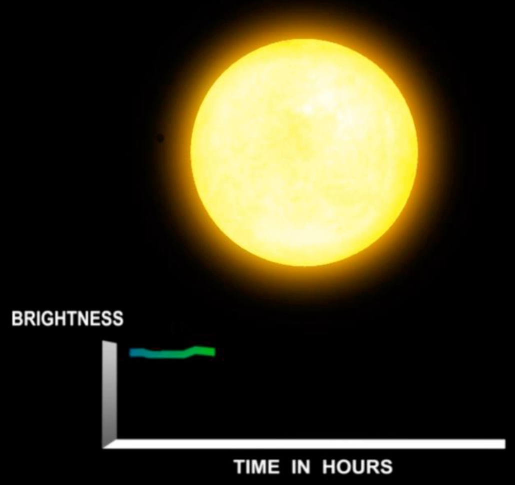
Wednesday August 9, 2023

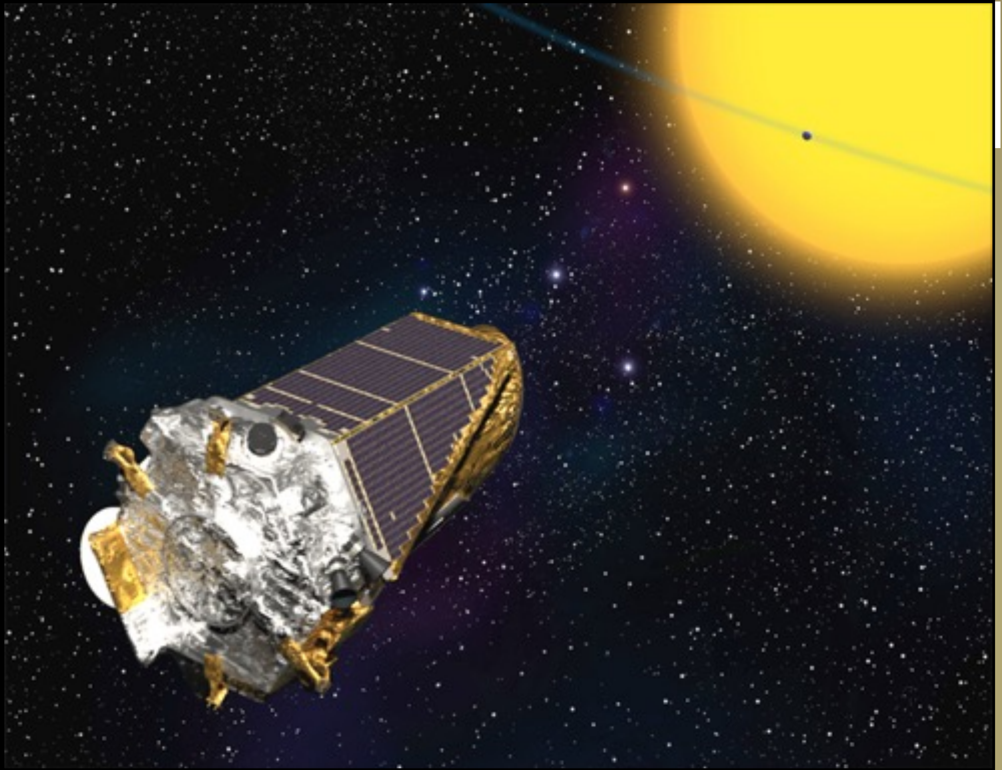
Flash Memory Summit 2023
Santa Clara Convention Center

The *Kepler* Mission

How many stars like the Sun have Earth-like planets orbiting them?

Kepler searches for transiting planets

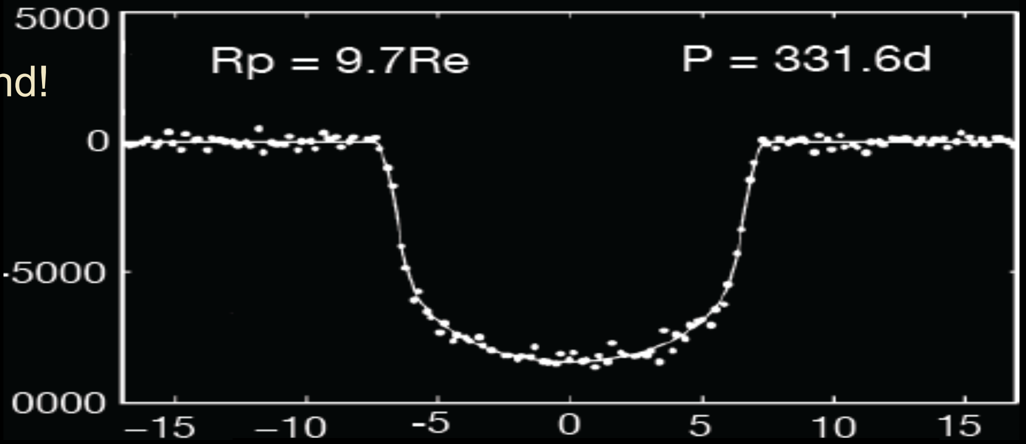




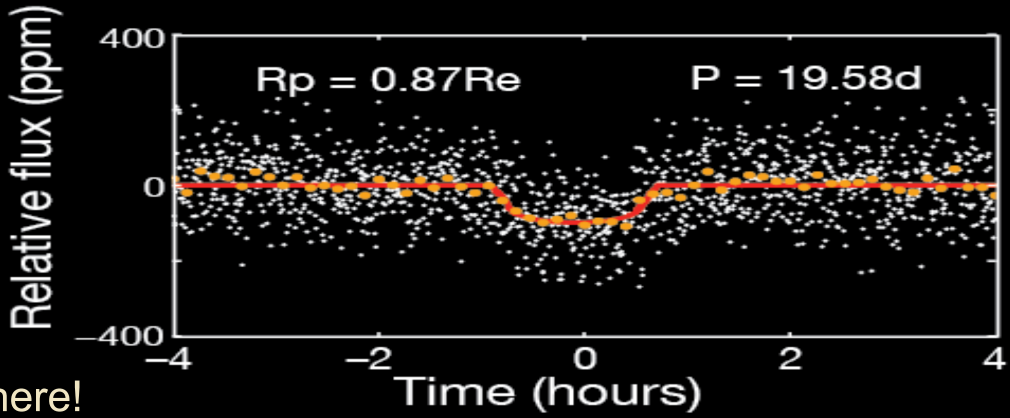
How Hard is it to Find Good Planets?

Easy to find from the ground!

Jupiter (~1%)

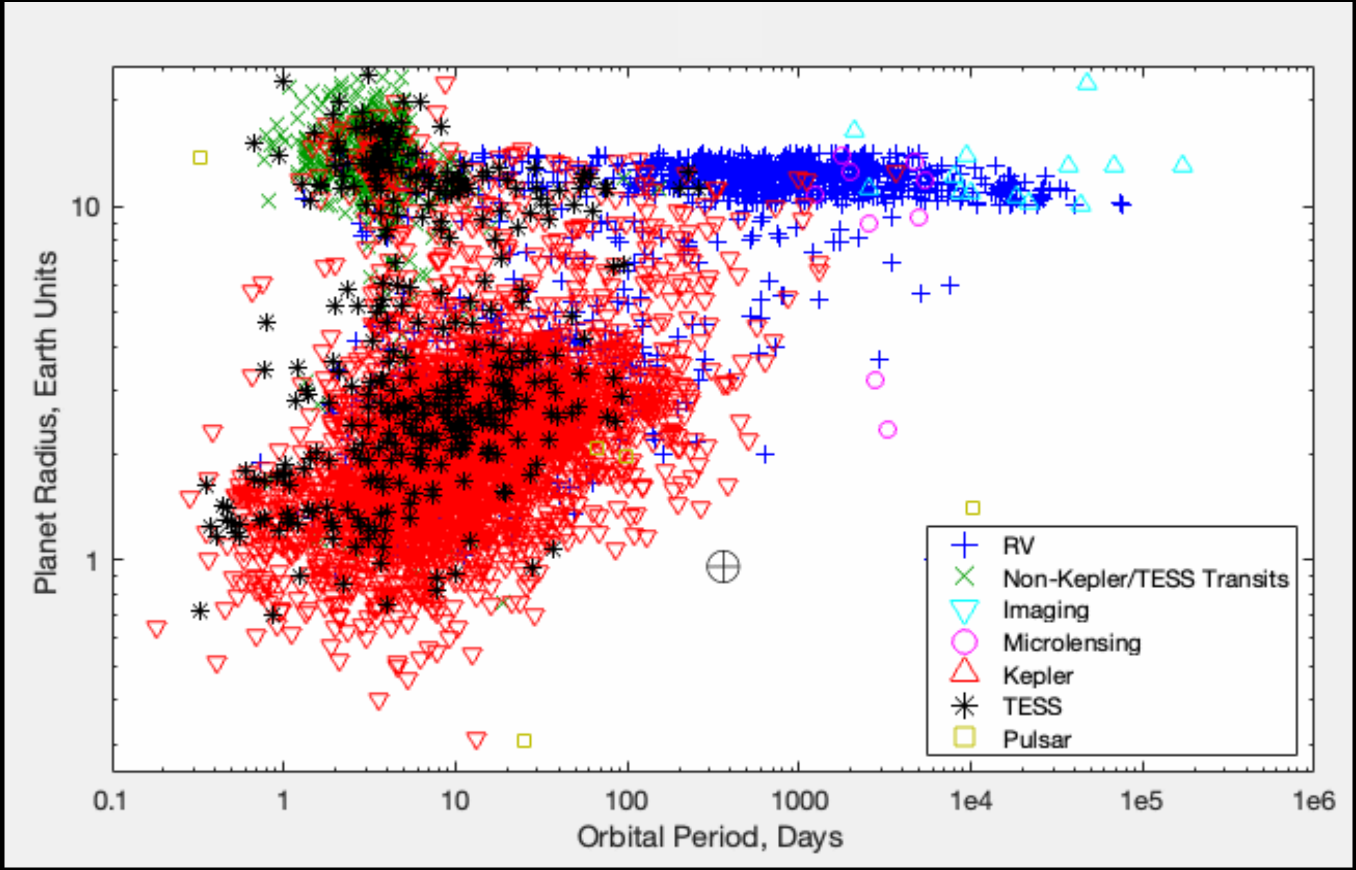


Earth (~0.01%)



Hard to find from anywhere!

Exoplanet Discoveries – Over 5470 and Counting!

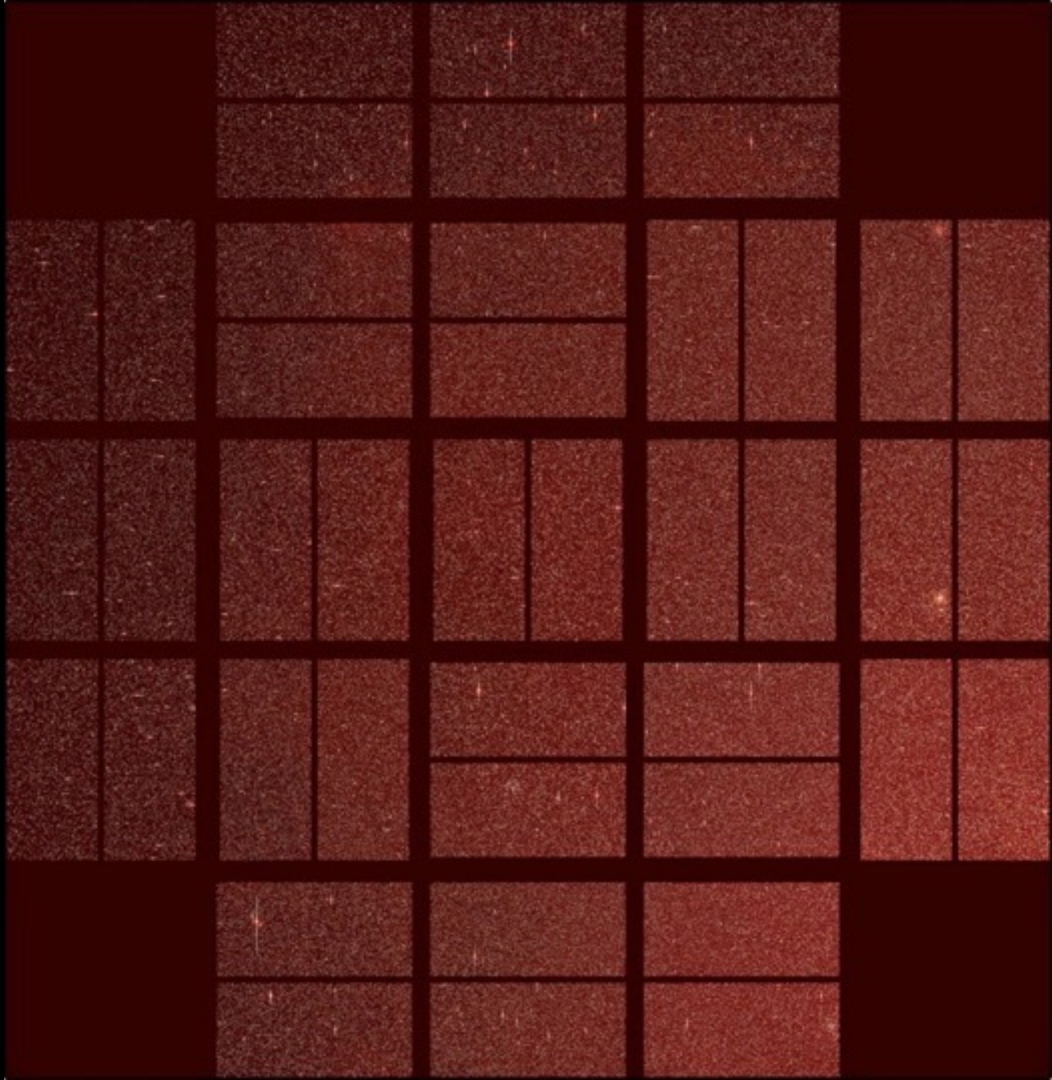


75% of exoplanets have been discovered using the transit method!

*According to https://exoplanetarchive.ipac.caltech.edu as of 7/17/2023

First Light Image

Launched
March 7 2009



First Light Image

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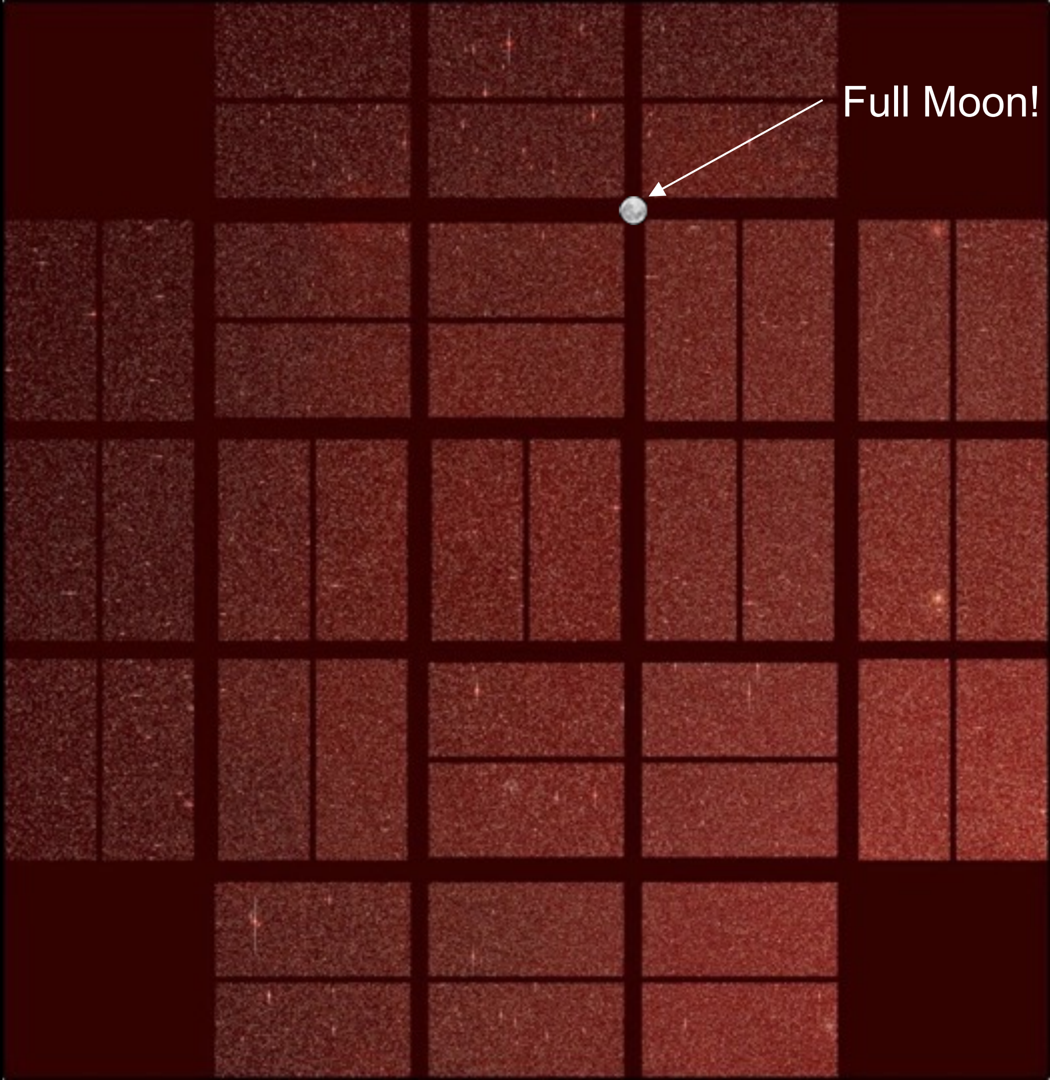


Full Moon!

Managing Kepler's Data Volume

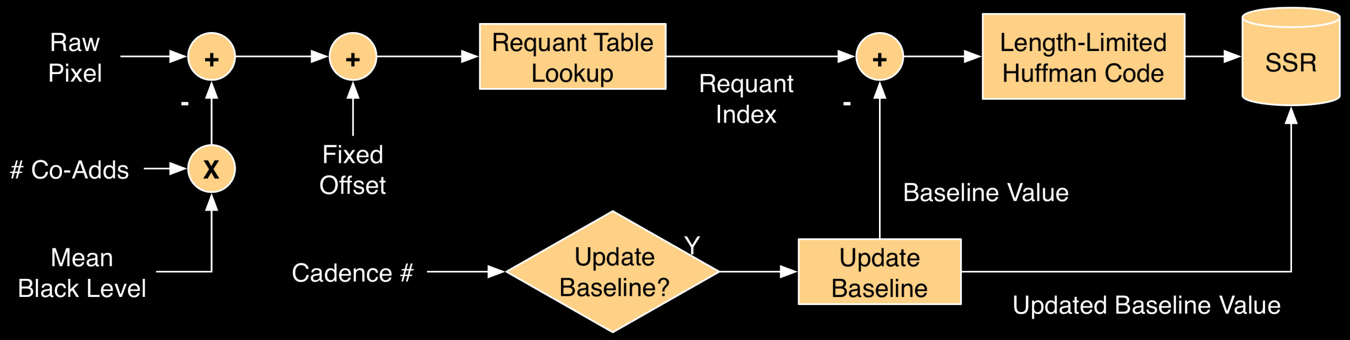
Key Requirements:

Collect and store image data for up to 170,000 stars for up to 66+ days

Downlink 31 days of data in less than 24 hours

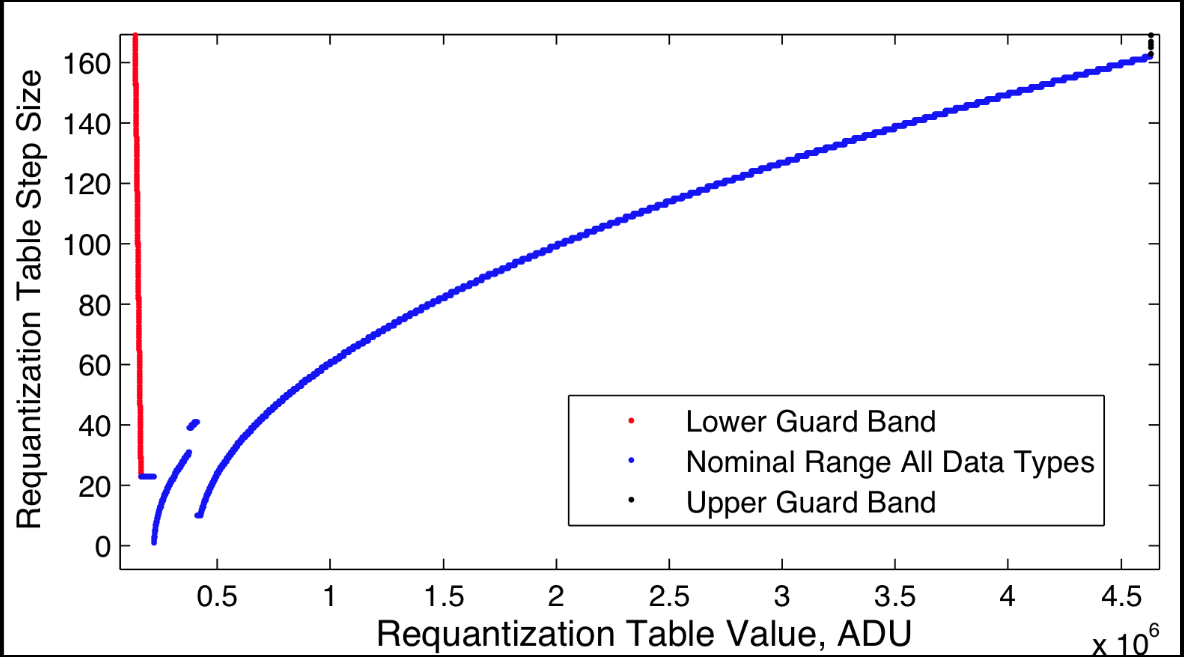
Solution:

- Collect ***only*** pixels of interest
- Compand data to manage quantization noise as a term in noise budget
- Detrend the data to centralize the measurements to be transmitted
- Entropically encode the data before CCSDS packetization (must be robust)



Step 1: Requantization

- Manage quantization noise in noise budget – ¼ of intrinsic measurement noise
- Must account for dispersion of read noise, gain, and bias across 84 channels
- Raw pixel measurements are represented with 23 bits
- Requantization compresses the data to 16 bits from 23



Step 2: Huffman Coding

- Subtract a baseline measurement (changes on a daily basis)
- Entropically encode residuals with a Length-Limited Huffman Code
- Compresses the data to 4.4 bits/symbol for Kepler
- First difference baseline for TESS compresses data to ~3.5 bits/symbol