GMI Calibration Subsystem On-orbit Performance

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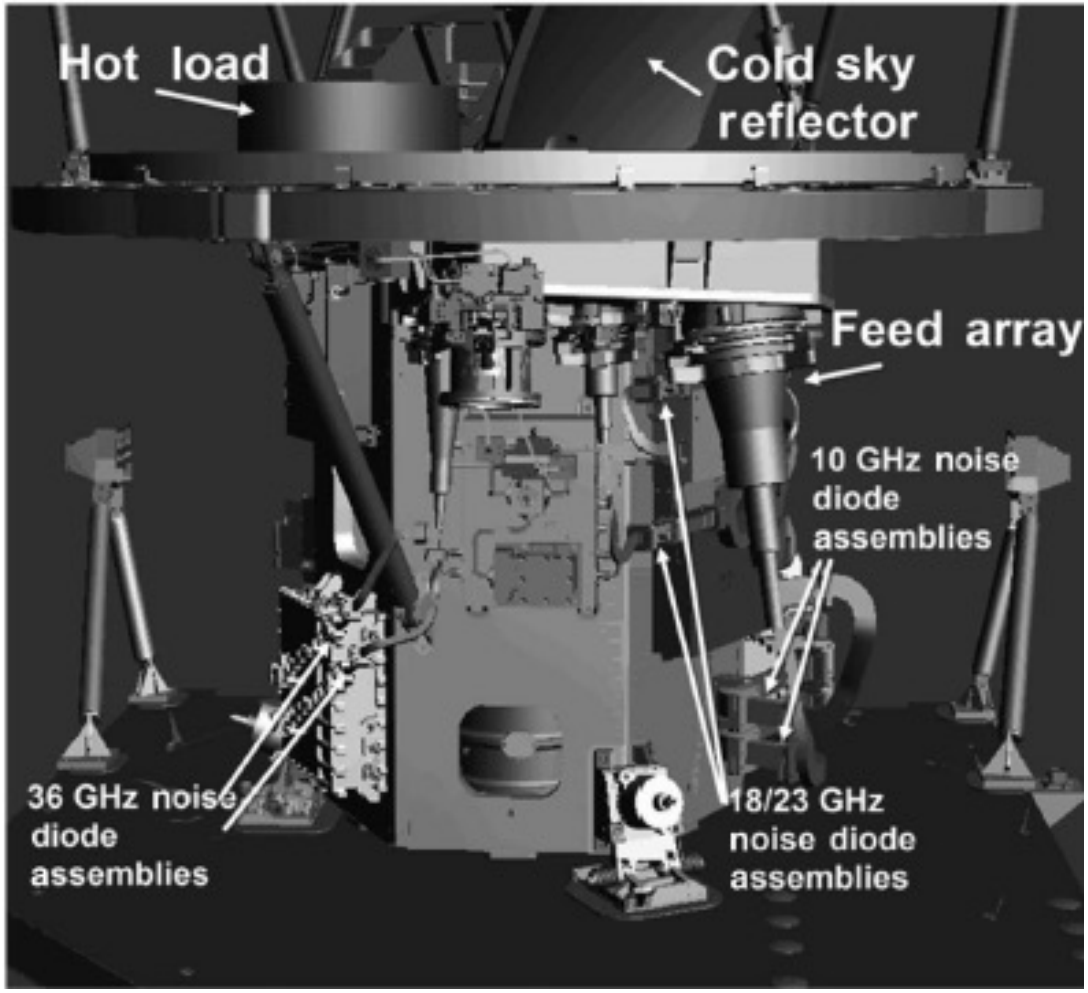
GMI Calibration Subsystem Overview

- The GPM Microwave Imager built by Ball Aerospace includes a number of innovations intended to improve calibration stability and accuracy
  - Additional isolation for on-board warm load (shroud and "race track")
  - Additional thermistors on warm load to look for temperature gradients
  - Shaping of cold sky reflector to avoid s/c reflections
  - Addition of noise diodes for 10, 19, 23 and 36 GHz for:
    - Measurement and trending of non-linearity
    - Backup cold from warm + noise diode
    - Backup warm from cold + noise diode
  - Additional updates to improve calibration:
    - Extensive testing of main reflector to avoid emissive reflector issues
    - Multiple thermistors on main reflector in case it is emissive
    - Low cross-section main reflector supports to reduce reflections into field of view

GMI Overview

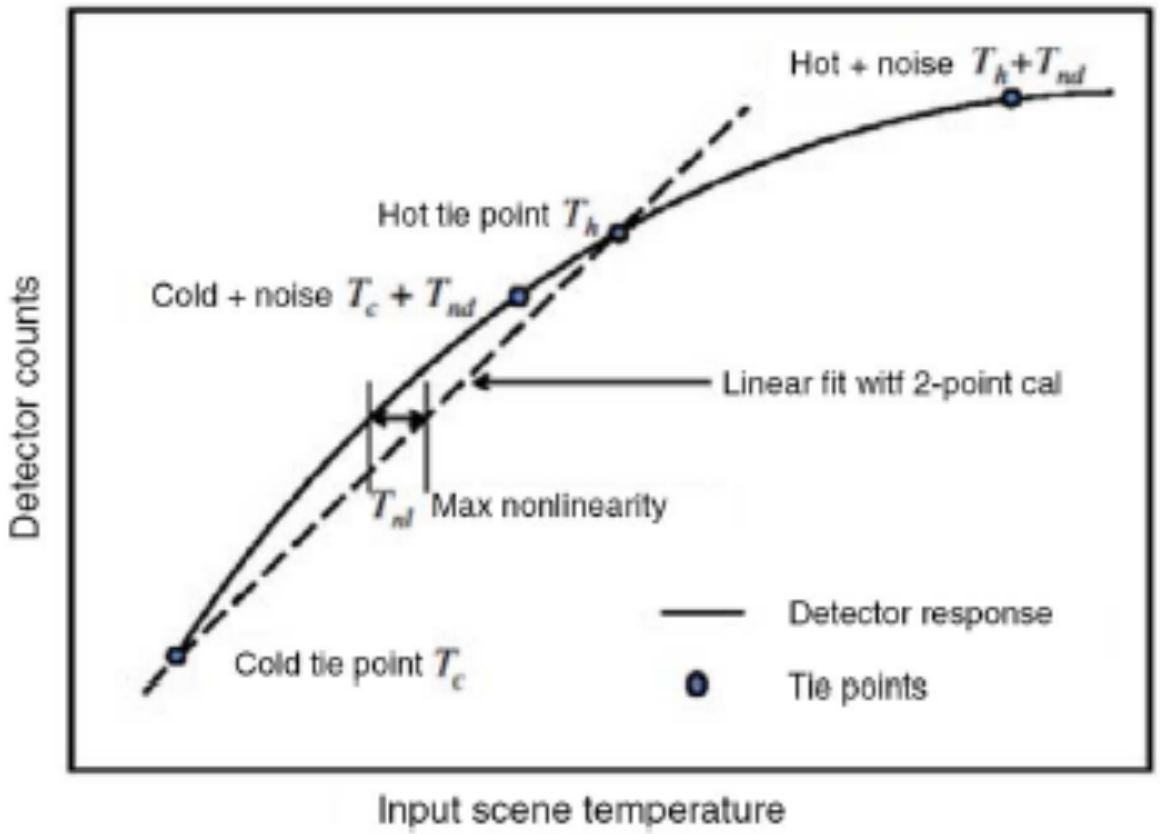
Calibration Subsystem



Calibration Scheme

- Calibration performed once every rotation of instrument
  - Purpose is to compute gain and offset of radiometer to convert scene counts to antenna temperature
  - Every other rotation: 2-point cal (cold and warm alone)
  - Every other rotation: 4-point cal (cold, cold+noise, warm, warm+noise)
  - → For accurate, stability calibration: warm load, cold sky view, and noise diodes need to be stable over 2 rotations (~ 4 seconds)
    - Not a very hard requirement to make, but still want to look at stability over this period and over long term
- Early on-orbit stability of calibration subsystem (warm load, cold sky reflector, noise diodes) performed by Draper, Newell, McKague, and Piepmeier (JSTARS, 2015)
  - Used first 6 months of data
  - Want to look at long term performance with all data to-date …

4-point/2-point Calibration



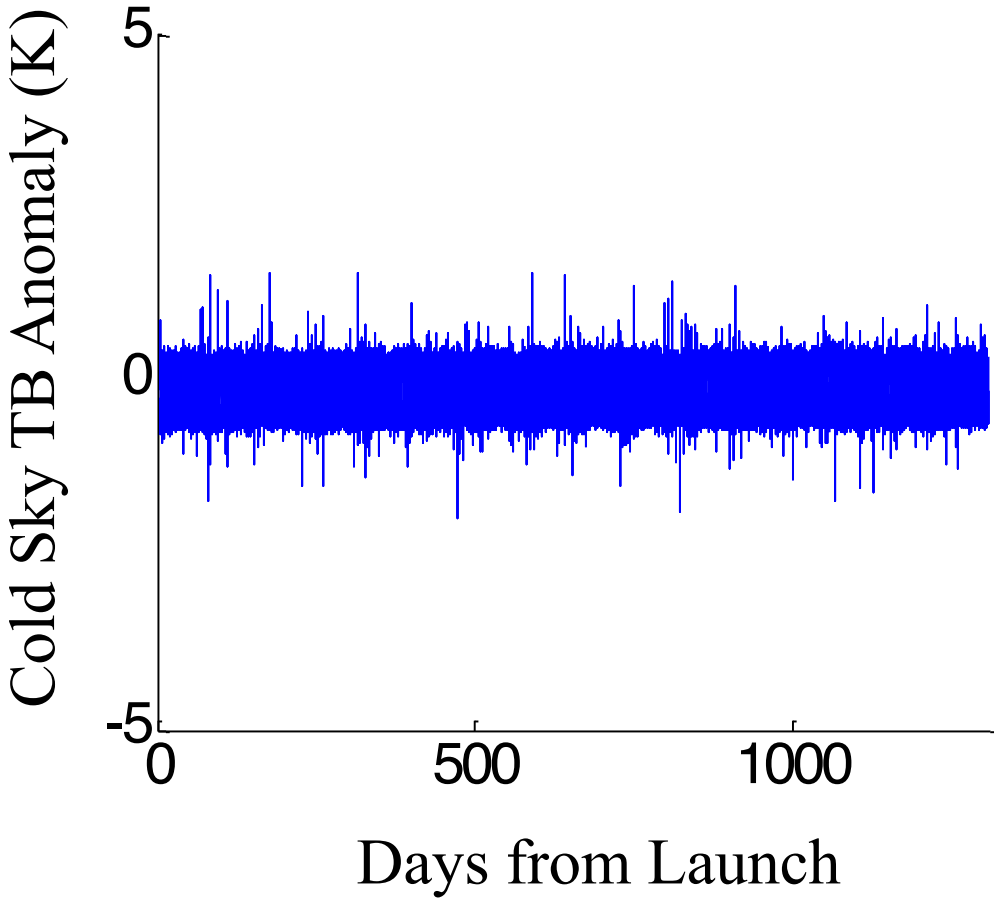
The Utility of Noise Diodes …

- Noise diodes added to measure and trend non-linearity as well as backup to check stability of warm and cold sky calibration
  - Non-linearity computed with 4-point calibration
    - New to spaceborne radiometers
      - Typically use 2-point calibration: cold, warm = linear
  - Can also do 2-point calibration three ways to check all three calibration elements:
    - Cold, warm (traditional way)
      - Check stability of noise diodes
    - Cold, noise diode
      - Check stability of warm load
    - Warm, noise diode
      - Check stability of cold sky view

Cold Sky View Stability Assessment

- Use warm and warm + noise to predict cold sky brightness temperature
  - Data filtered for known warm intrusions in cold sky view – Moon, galactic plane, etc.
  - Then compute difference between cold and prediction of cold (cold sky anomaly) to look at cold sky stability …

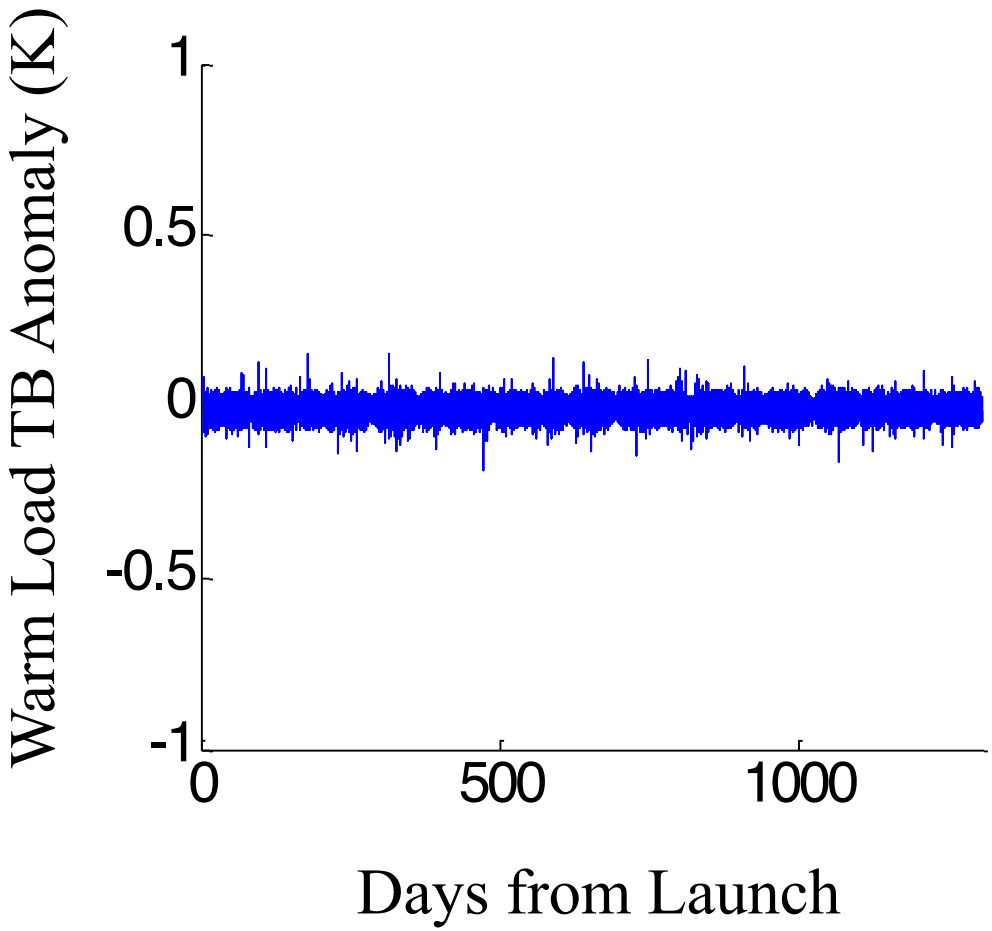
Cold Sky Brightness Temperature Anomaly From 19V Data (others similar)



Warm Load Stability Assessment

- Use cold and cold + noise diode to predict warm
  - Data filtered for known warm intrusions in cold sky view – Moon, galactic plane, etc.
  - Then compute difference between warm and prediction of warm (warm load anomaly) to look at warm load stability …

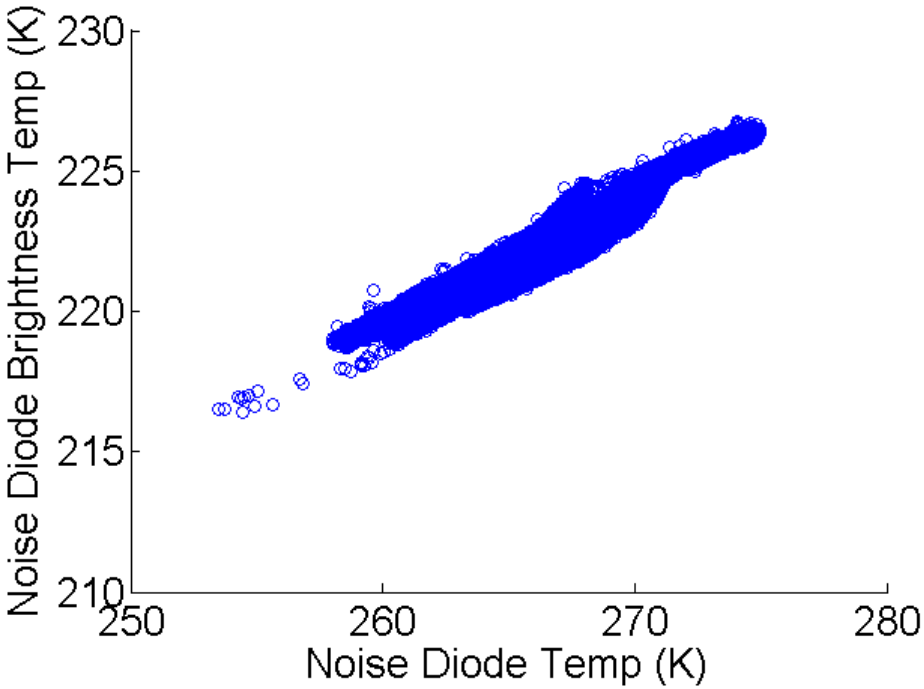
Warm Load Brightness Temp Anomaly From 19V Data (others similar)



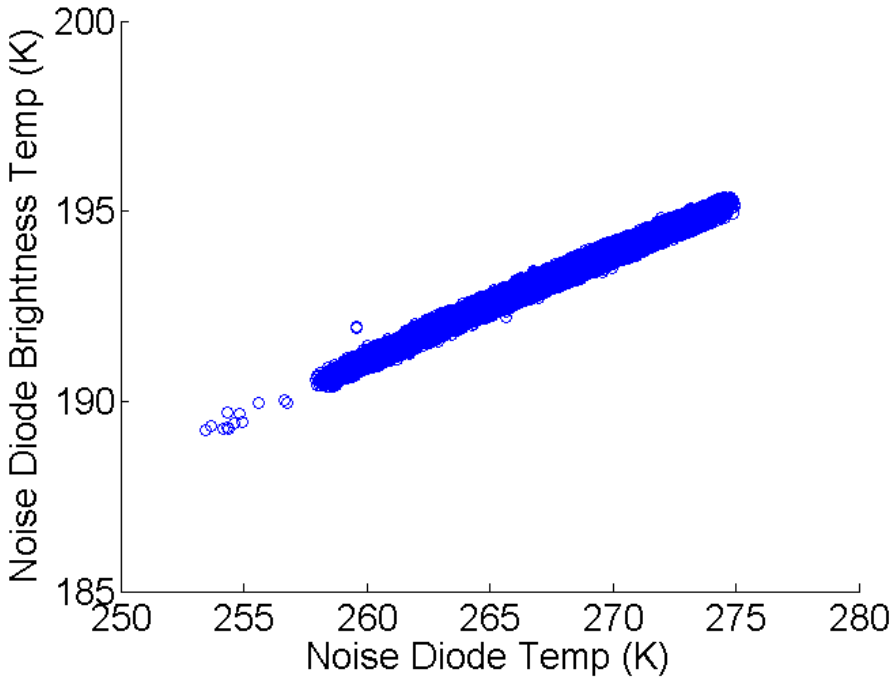
Noise Diode Stability

- From 4-point calibration, can get estimate of brightness temperature of noise diodes
  - Brightness temperature a function of physical temperature
  - Characterize relationship between noise diode temperature and brightness temperature
    - Linear fit to data between two parameters over mission to date
  - Then compute noise diode brightness temperature anomaly from mean behavior as a function of time …

Noise Diode Physical Temp vs Brightness Temp
10V and 10H Channels

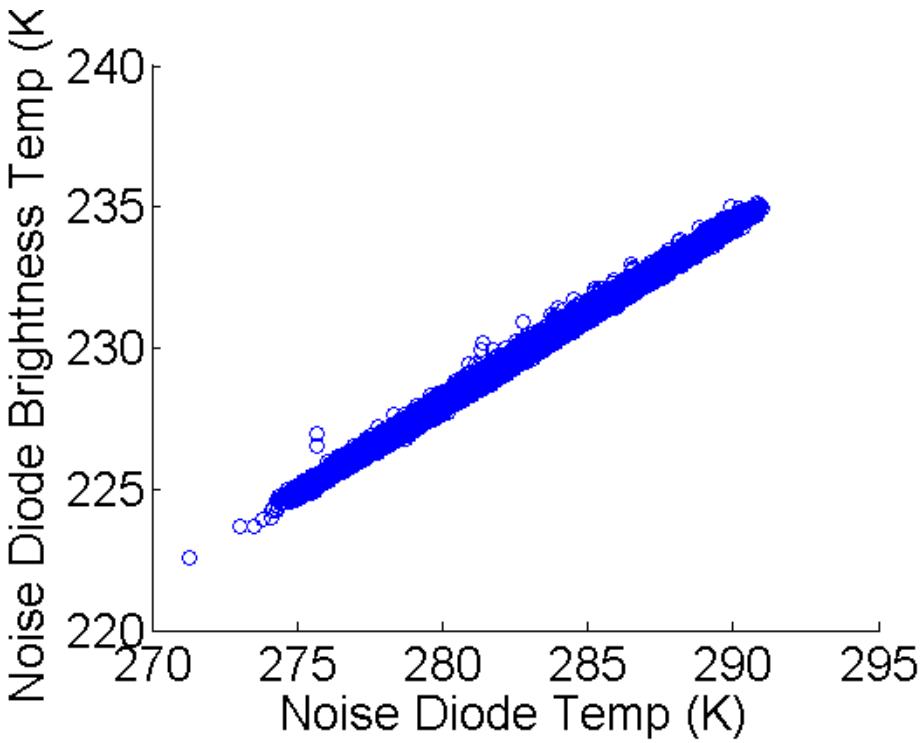


10V

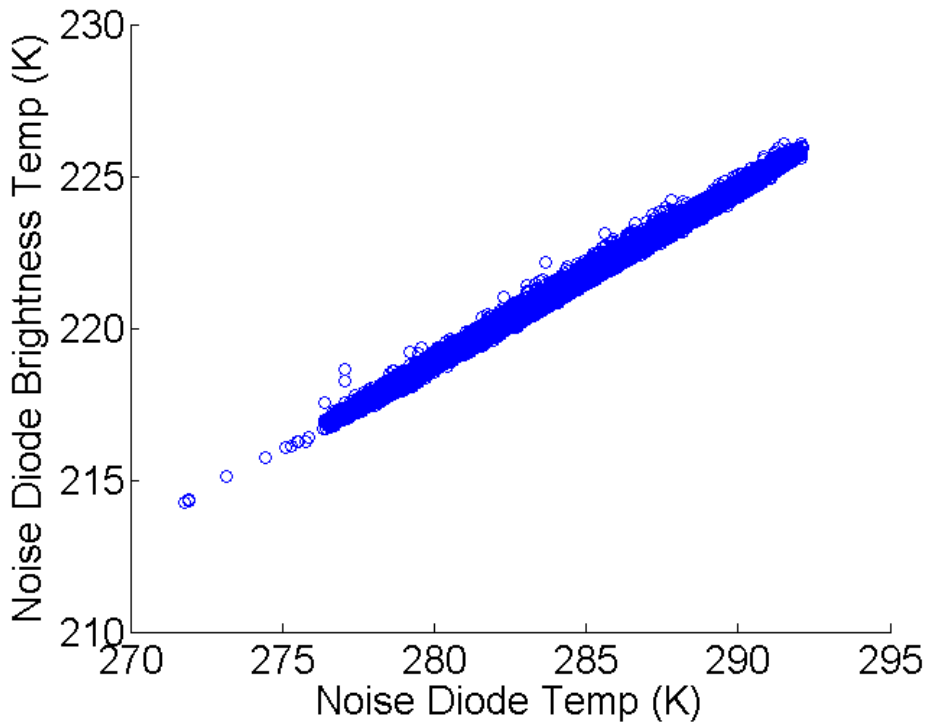


10H

Noise Diode Physical Temp vs Brightness Temp 18/23V and 18H Channels

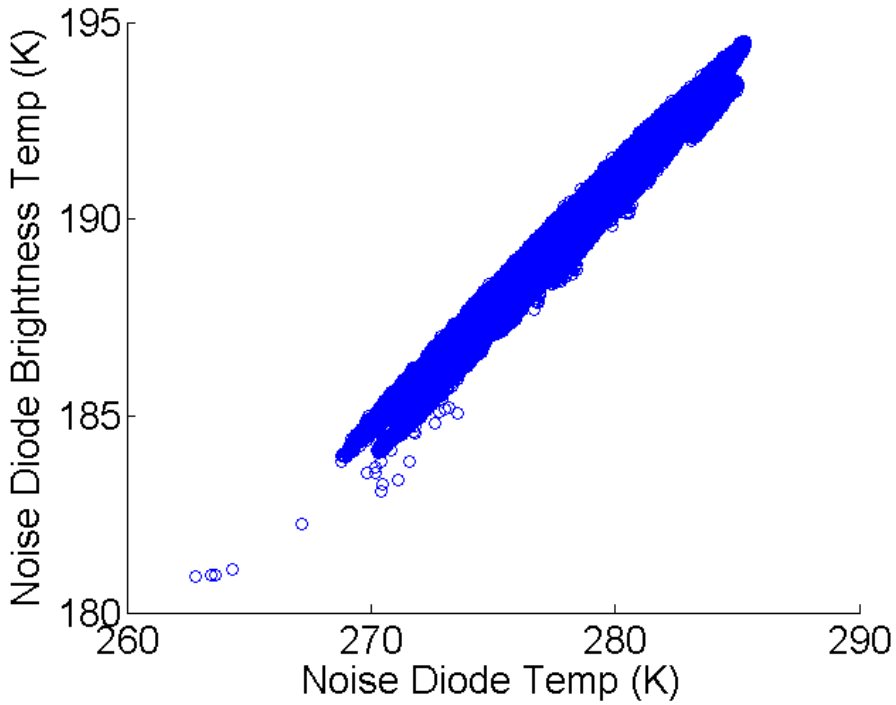


18/23V

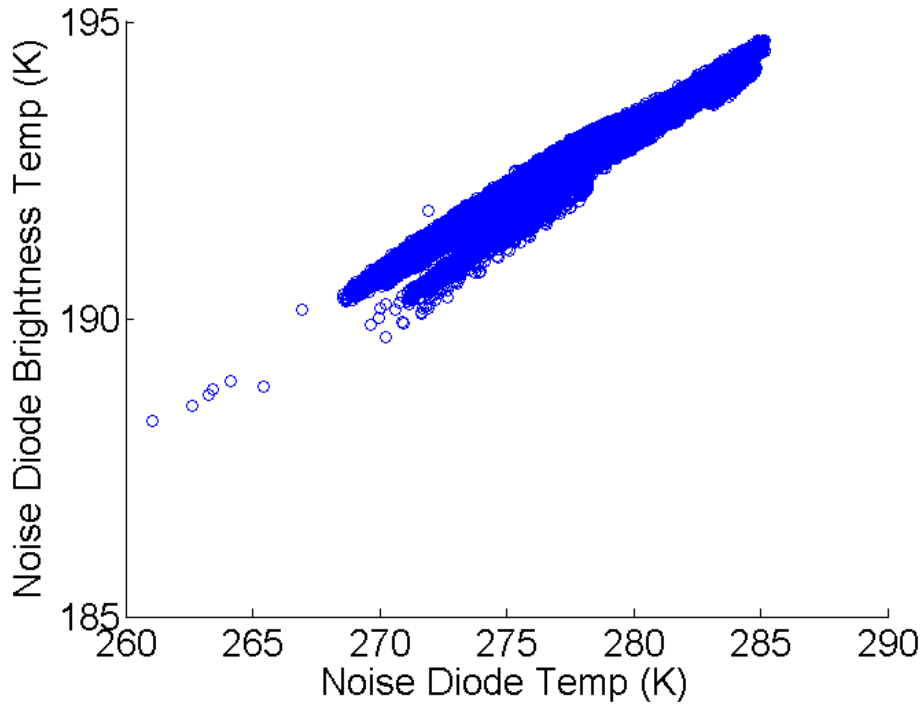


18H

Noise Diode Physical Temp vs Brightness Temp 36V and 36H Channels

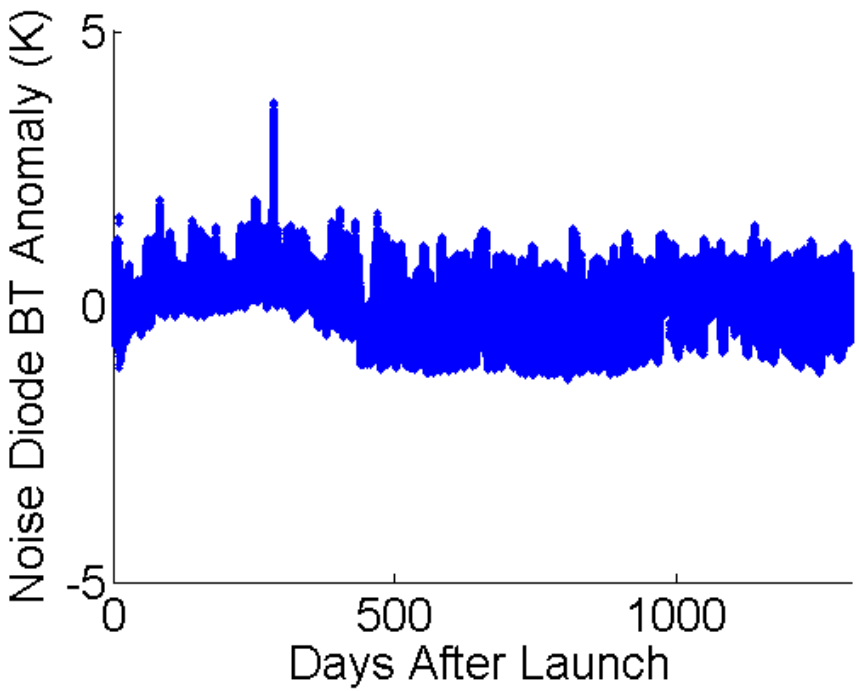


36V

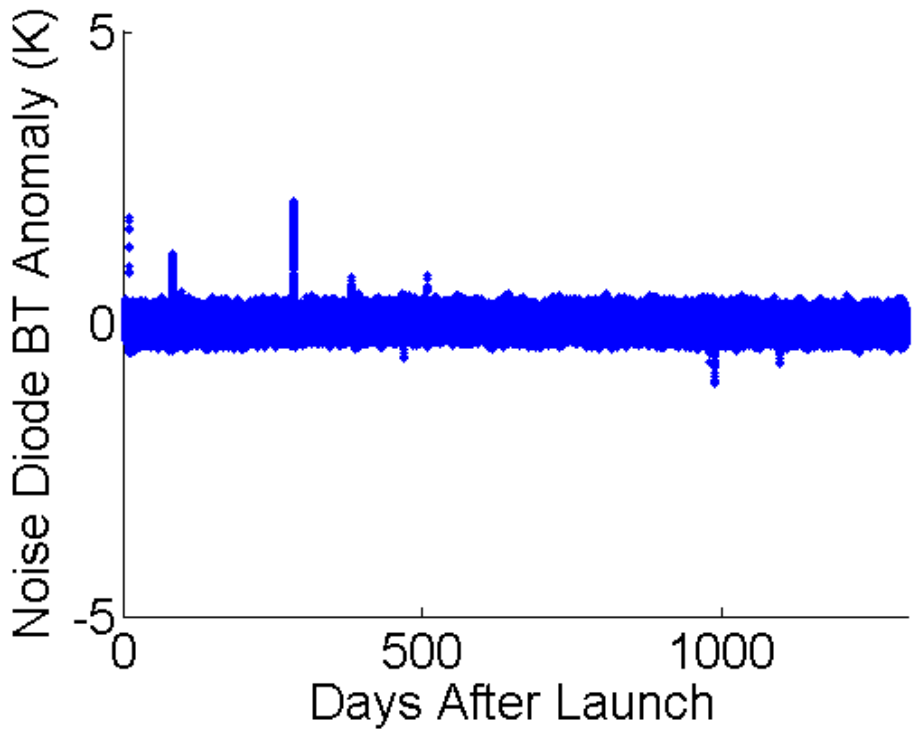


36H

Noise Diode Brightness Temperature Anomalies 10V and 10H Channels

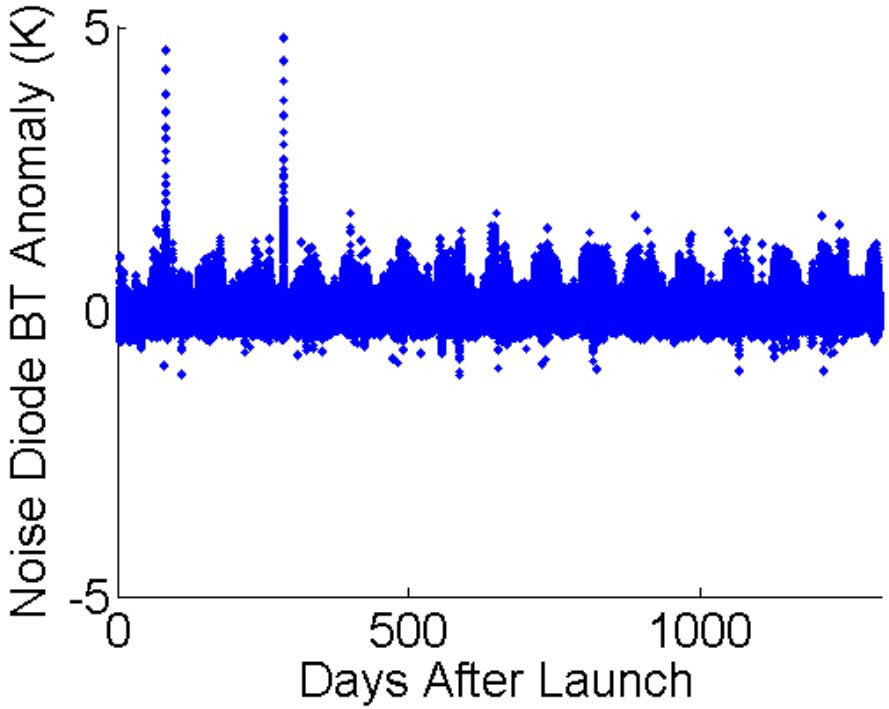


10V

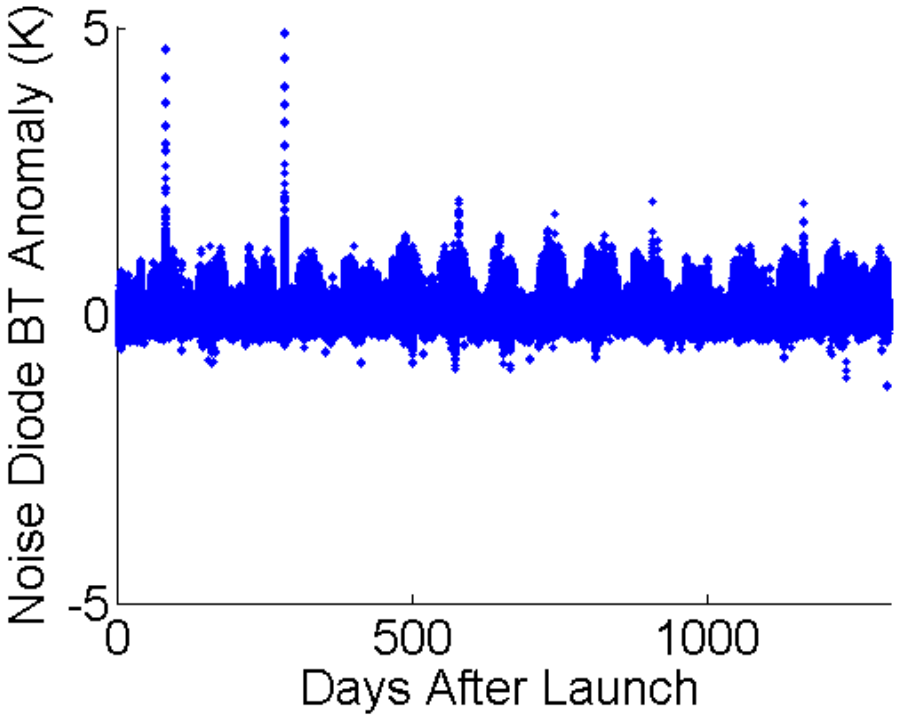


10H

Noise Diode Brightness Temperature Anomalies 18/23V and 18H Channels

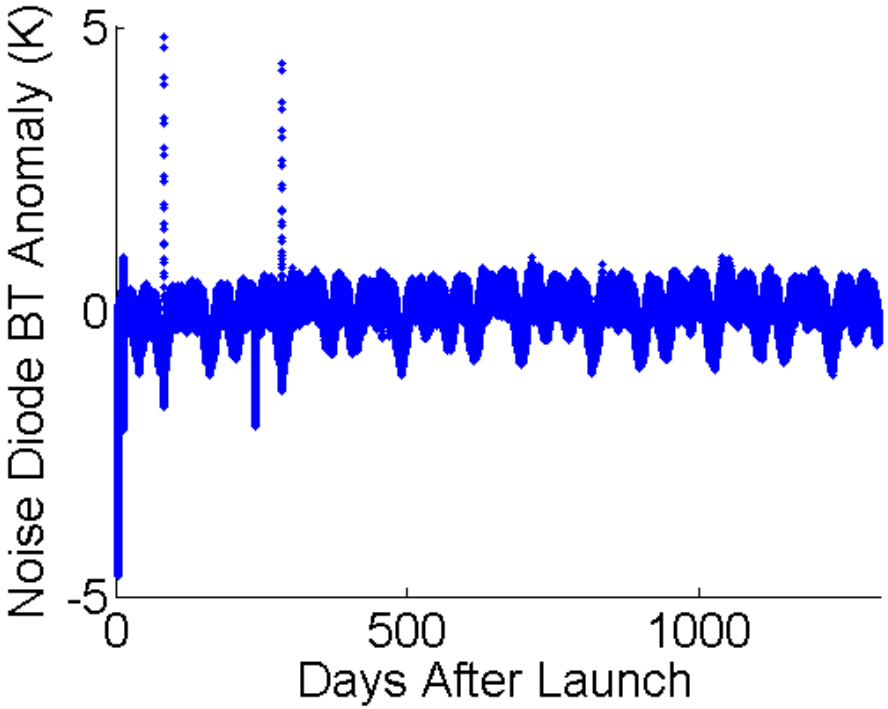


18/23V

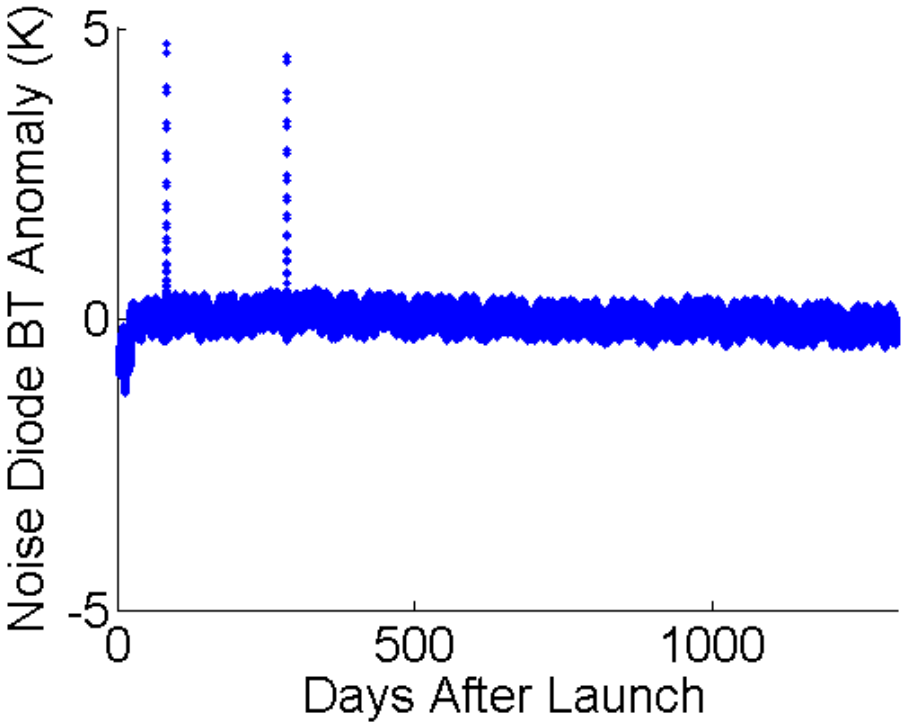


18H

Noise Diode Brightness Temperature Anomalies 36V and 36H Channels

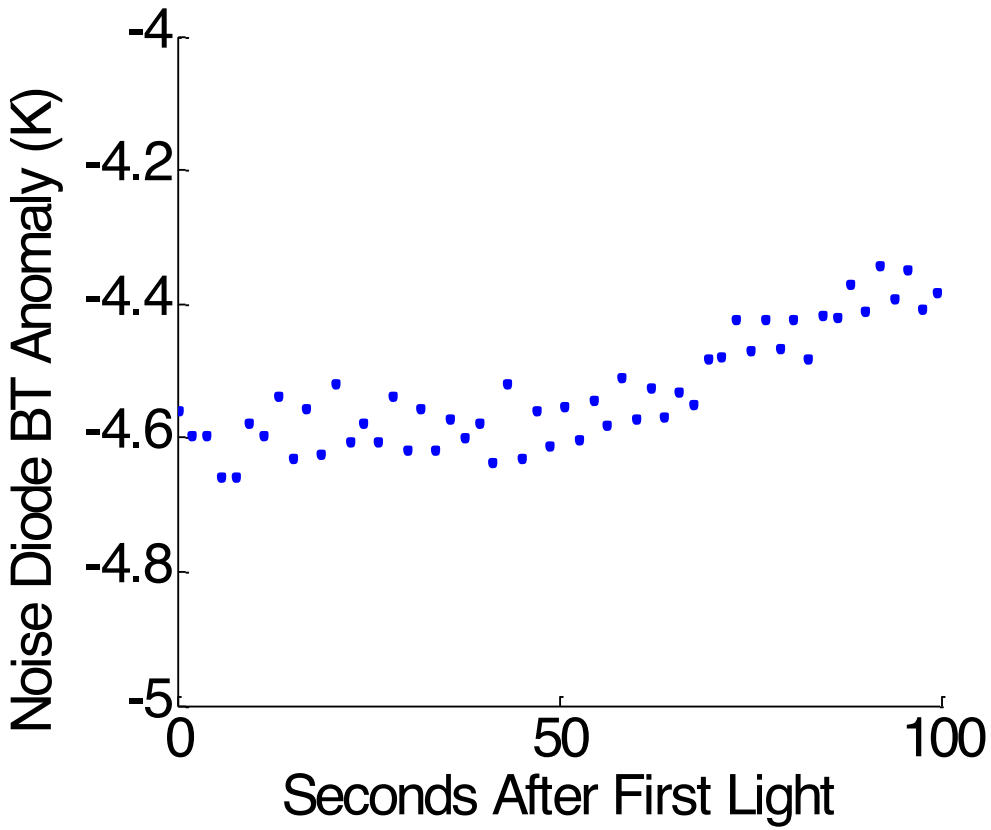


36V



36H

Noise Diode Short-term Stability
Worst Case: Early Orbit 37V



Summary

- GMI calibration subsystem very stable
  - Cold load and hot load brightness temperatures extremely stable over 3.5 years on-orbit to date
  - Noise diodes are relatively stable (some channels more than others)
    - More than stable enough for purpose: non-linearity and hot/cold load checks
    - Will investigate residual instabilities: see if correlated temperature gradients, solar beta angle, orbit phase, etc.
    - Once update, will look at remaining secular trends and quantify
    - Future radiometers will use noise diodes as primary calibration standard – GMI noise diode trends will be of tremendous interest to developers of these instruments
- For receiver stability/trending, see CSU trending data at: http://rain.atmos.colostate.edu/XCAL/monitor_1Base.html
  - Summary: recievers are also very stable