# Calibration Algorithm

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# Purpose

- The calibration algorithm is assumed to take the measured values and convert them into an instrument-independent form.
- Discussion here will be captured in a Language Independent Description (LID) for review.
  - Design will be formalized for the CDR

# Requirements

- The algorithm must be capable of producing values for each of the five colors that are corrected for backgrounds, data compression, detector non-linearities, variations in flat fielding, etc. and instrument dependent parameters i.e. choice of detector, slit, mirror scan angle, detector high voltage, etc.

# Calibration Product

- The calibration algorithm will provide the binning algorithm with the correction to each individual pixel so that it can be accurately added to produce a gridded superpixel value.
- The calibration algorithm also prepares the data tables for the look-up process used to determine the environmental parameters.

# Count Rate Correction

- There are two major corrections that occur
  - decompression of the data
  - detector non-linearity

# Detector Non-linearity

- The GUVI detector throughput depends on the input rate.
- The true input rate is measured at the output of the detector's intensifier.
- The input rate - output rate is approximately linear to about 100,000 counts $s^{-1}$
- Above 200,000 counts s-1 input rate the output rate is nearly constant

# Backgrounds

- Instrumental backgrounds in the five colors consists of three sources
  - dark counts (thermionic emission, cosmic rays, etc.)
  - scattered light
- Backgrounds are determined from dedicated command-locatable pixels

# Dark Count Rate

- The dark count rate is estimated during normal operations by using measurements of dedicated dark count rate pixels to adjust the dark count rate "scattering mask"
  - we use scattering mask to denote the functional dependence of any background component

# Mapping Dark Count Rate

- The dark count rate is modeled by using observations in the closed slit position to determine the spatial distribution of dark events
  - we may use nightside and near twilight passes for this sequence
  - need relatively long exposure times to build up and accurate "mask"
    - typical rates are about 30 c $s^{-1}$ over the entire tube

# Scattered Light

- There are two major components of scattered light within the instrument
  - in band scattering (Lyman alpha and OI 1304
  - out of band scattering - red leak

# Correction for In-band Scatter

- The current ruled grating exhibits a significant amount of grating scatter in-band.
- The functional form of this scatter has been mapped.
  - The functional dependence of the scattering from the new holographic grating will also be mapped.

# In-band Scatter

- From knowledge of the functional dependence the contribution at every wavelength pixel (and spatial pixel) can be determined.
  - Spatial dependence is nearly non-existent.
- New algorithm will solve a set of coupled linear equations to produce the "true" observed intensity at each of the five colors.

# Out-of-band Scatter

- Out-of-band scatter was a completely unexpected problem for SSUSI.
- Original measurements of the contribution were attributed to problems in the OCF.
  - Revised collection sequences demonstrated that SSUSI was seeing internal out-of-band light
    - we are procuring new detectors and a better grating to manage this problem

# “Red” Leak

- The out-of-band scatter arises from the rapid rise in the Earth radiance at 200nm and near 300nm.
  - Relative contribution depends on the quantum efficiency of the photocathode and the amount of scatter from the grating.
    - “red” component is imaged so it comes from the grating not internal scatter

# Correcting for “red” leak

- The correction for the red-leak is carried out in the same way that the grating scatter is corrected for:
  - dedicate pixels are monitored
- These pixels are at the short wavelength end of the detector where only scattered light will fall
  - contribution from in-band scattering is negligible (but could be modelled)

# Correction Approach

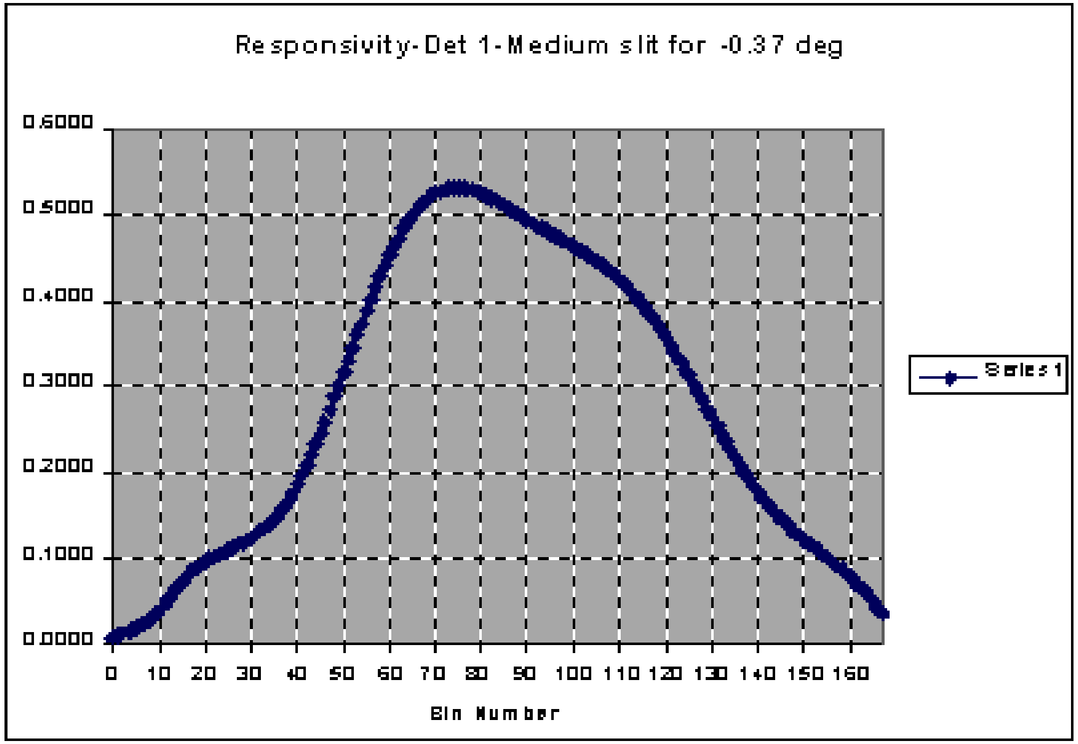
- Dedicated "pixels" are monitored seven times on each scan for each of three segments in the along track direction to provide the points used for a model of the backscattered MUV light.
  - MODTRAN runs show that the 200 nm region responds weakly to the variation in ozone and aerosols and not at all to ground albedo or clouds.

# Preparation for Binning

- The data are first binned as a function of along orbit angle ($\alpha$) and cross-scan angle ($\beta$).
  - In order to co-add the contributions from individual spatial pixels the variation in responsivity has to be accounted for.
  - This will be a change in the calibration algorithm and in the way that the data tables are formed.

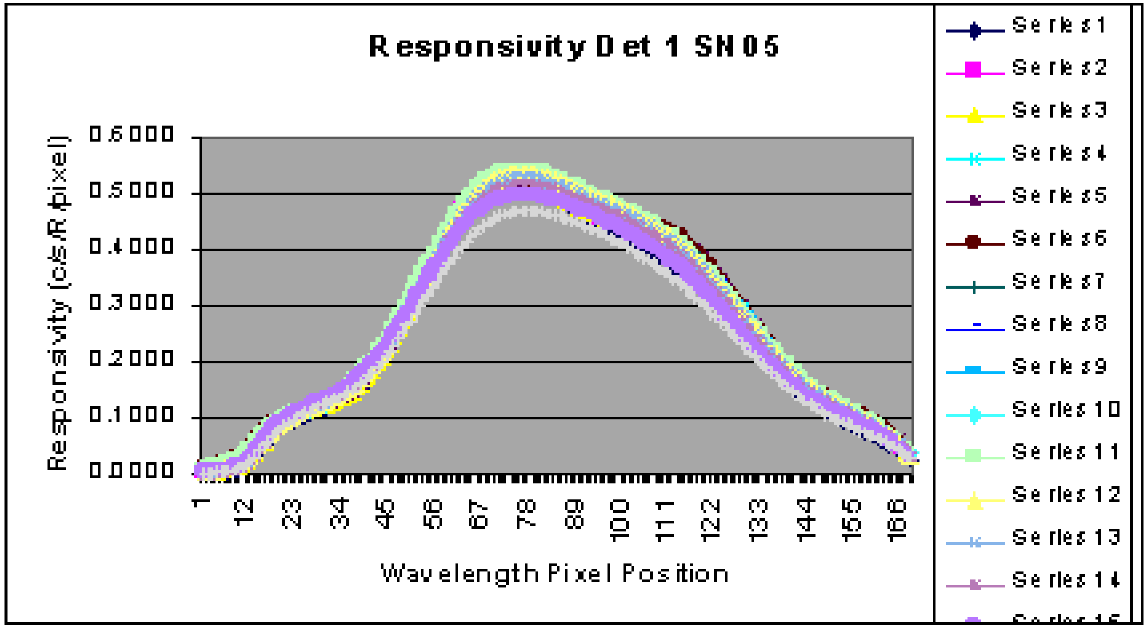
# Responsivity

- Responsivity is determined as a function of mirror angle, spatial pixel, slit, detector and wavelength.



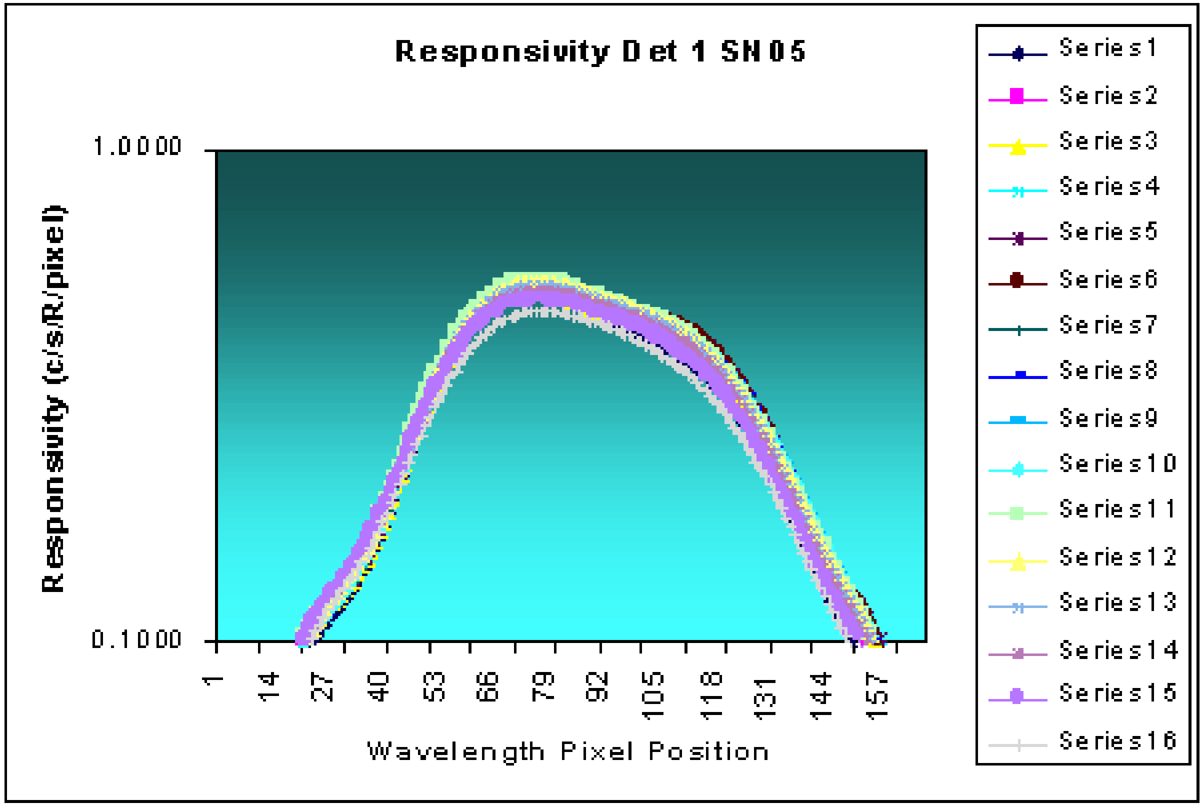
# Spatial Pixel Dependence

- Spatial dependence of pixel response will alter the measured value in a superpixel



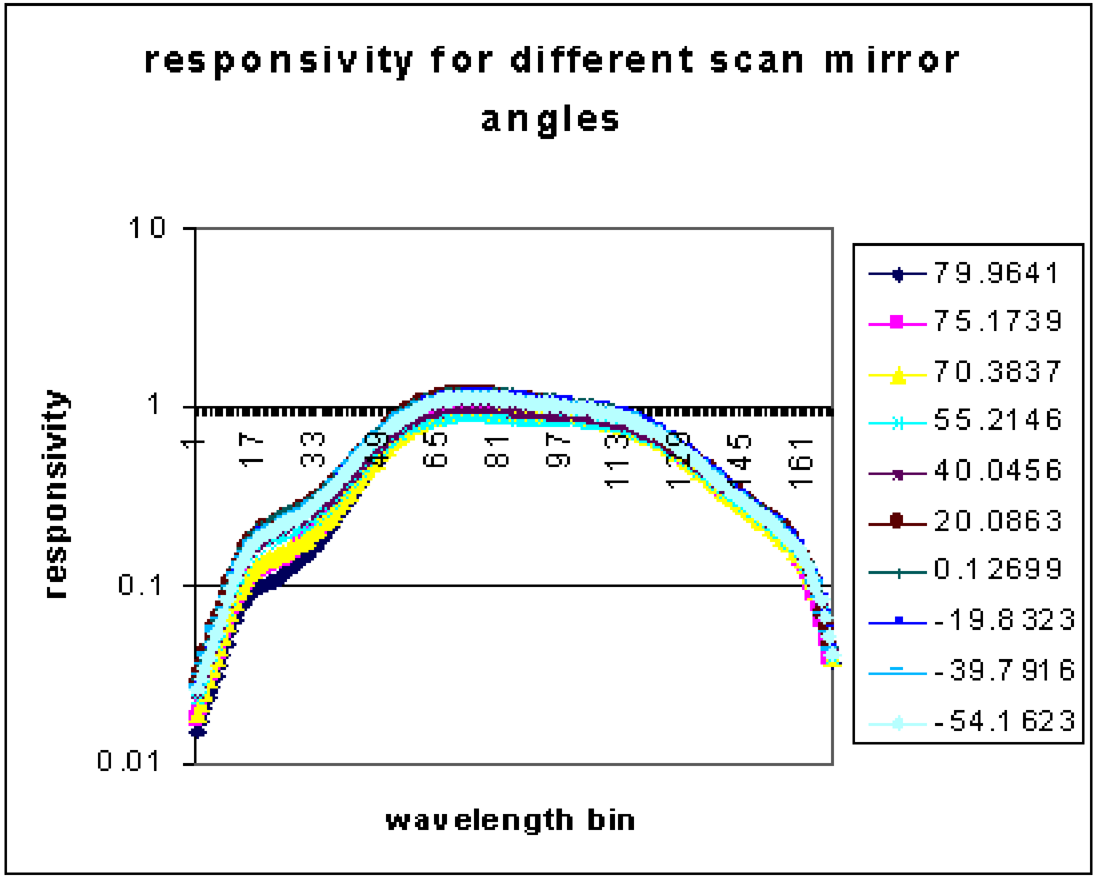
# Spatial Pixel Linearity

- Responsivity is scaled to a reference shape.



# Scan-Mirror Angle Dependence

- The responsivity changes for scan-mirror angle.
  - Corrected for in binning by scaling a reference dependence
  - Binning algorithm "knows" the scan angle



# Color Definitions

- Due to bandwidth limitations GUVI sends down five “colors”:
  - Lyman alpha, OI 1304, OI 1356, LBH1 (145 - 160 nm) and LBH 2 (165 - 180 nm)
- Color definitions in focal plane space are used to define the extent of the spectrum that is actually downlinked in these co-added bands

# Reported Intensities

- The downlinked values are in counts but users prefer "Rayleighs"
- The algorithms will produce calibrated SDRs in Rayleighs by locating the "best" match spectrum and returning the corresponding geophysical parameter
  - for each determined geophysical parameter a spectrum in the database was located
  - the returned intensity and its error bar will be in Rayleighs which represents this value

# Calibration of Spectrograph Mode Data

- 168 wavelength pixels are downlinked in the spectral mode every 3 s.
- Calibration algorithm takes the observed spectrum and adjusts the observed spectrum to R/pixel.
- Five color binning can be testing in spectrograph mode.
- On-orbit calibration will provide a measure of the absolute radiometric calibration.

# On-orbit Calibration

- On-orbit calibration will be achieved using bright hot stars.
  - summarized in GUVI Calibration and Characterization Plan
  - see CDR and PDR presentations
- Stars enable calibration over range from 20 c $s^{-1}$ to 200,000 c $s^{-1}$.
- Accuracy goal is 8%.
  - Many stellar sources are known to about ±3%.

# Changes in Instrument Responsivity

- The instrument responsivity will change over time at a rate proportional to the total charge extracted at the location of bright lines.
  - changes will occur in the pulse height distribution
  - adjusted for by changing the voltage across the tube

# Pulse Height Distribution

- The pulse height distribution (PHD) is monitored continuously
  - we have requested an increase in the GUVI data rate to accommodate this
  - the GUVI FPE design has been changed to allow more of the PHD to be analyzed
    - SSUSI could see about 75% of the distribution
    - GUVI sees about 95%
    - see GUVI CDR package for details

# Summary

- Calibration algorithm takes allows the science algorithm to accurately determine the “best” fit to the observations
  - designed to mimic how the instrument responds to the upwelling radiation from the atmosphere
    - uses databases of intensities which are functions of geophysical parameters