SPACE PHYSICS RESEARCH LABORATORY

TIDI

The Optical Calibration of TIDI

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TIDI measurement goals

- **PRIMARY**
  - **Obtain global wind measurements from 60 km to 180 km for at least 2 years with an accuracy of a few m/s**

- **Secondary**
  - **Obtain global measurements of temperature and airglow volume emission rates (VER) in the MLTI region.**
  - **Derive concentrations of important minor species, such as O, O_3, and $O(^1D)$.**

TIDI Calibration Rationale

- **Optical calibrations are performed at satellite dusk**
  - **TIMED defines this as solar zenith angle = 90° at the satellite**
  - **Devote the next 5 minutes to performing a calibration segment**

    Approximately 5% of the TIDI duty cycle is calibration related
- **Wind measurements require optical knowledge of**
  - **Instrument drift over time**
  - **Detector gain, read noise, and electronic bias over time**
  - **Channel to channel sensitivity over time**
- **Wind measurements require mechanical knowledge of**
  - **Satellite attitude**

    Statistical checks of airglow altitude
  - **Telescope pointing, filter wheel positioning, shutter motion**

    Force motion between end stops; pass through fiducial markers

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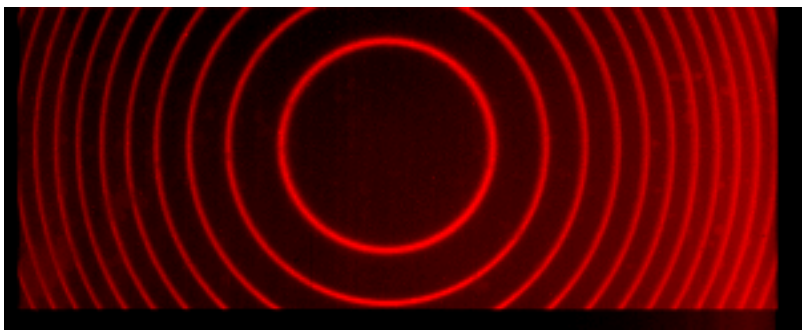
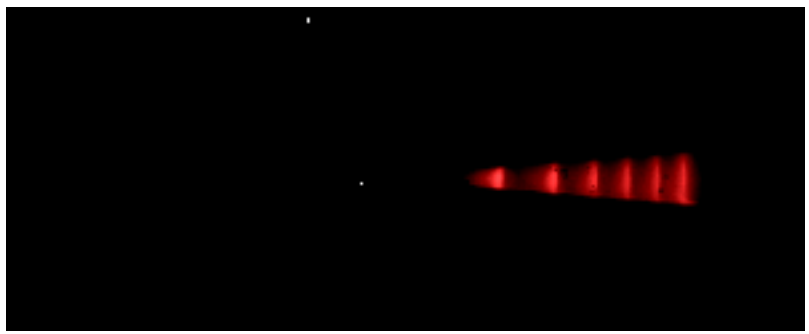
TIDI prototype imagery

- SITe ST-005A chip
- PixelVision camera
- HeNe 632.8nm laser source



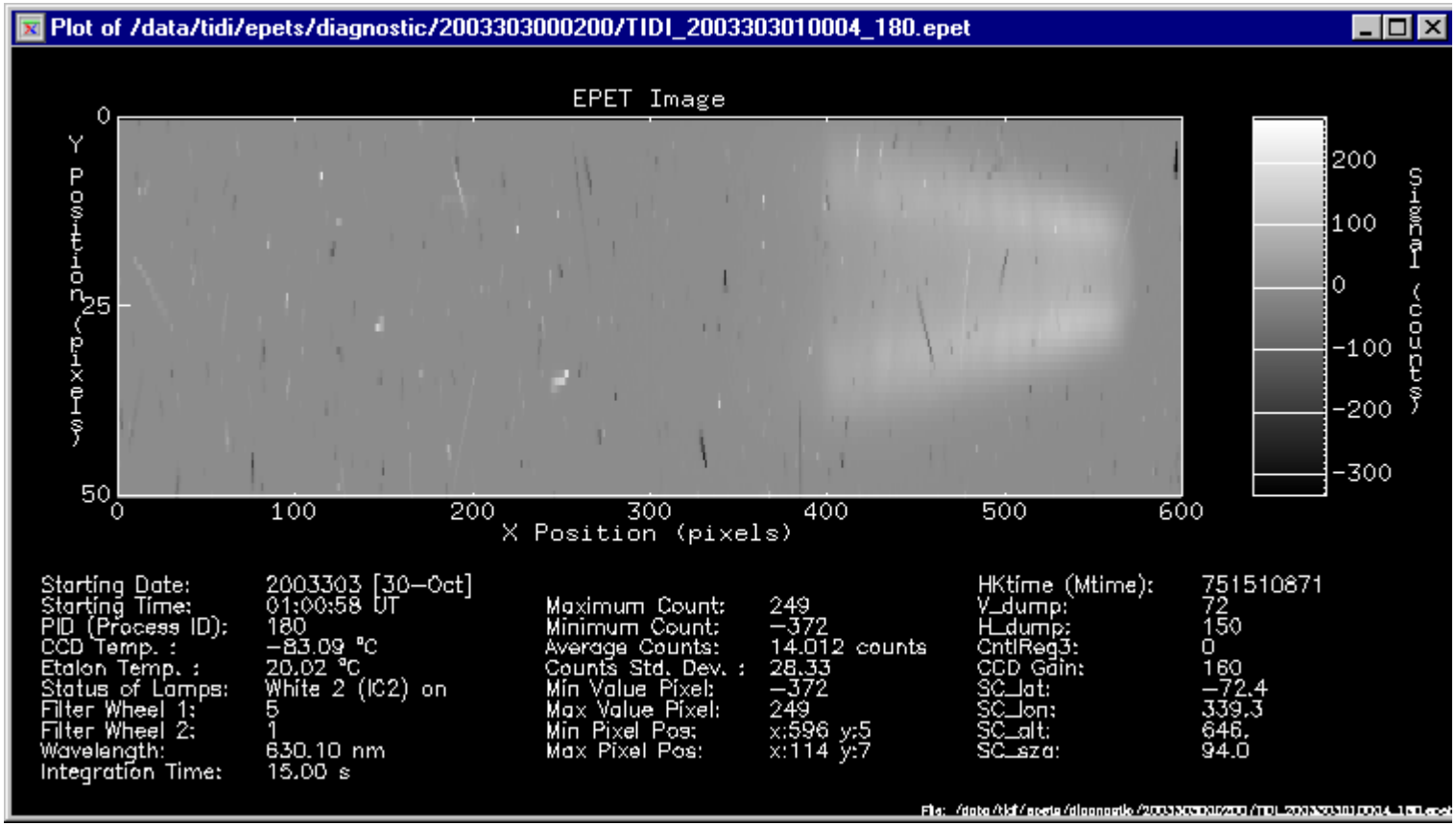
without CLIO mirror



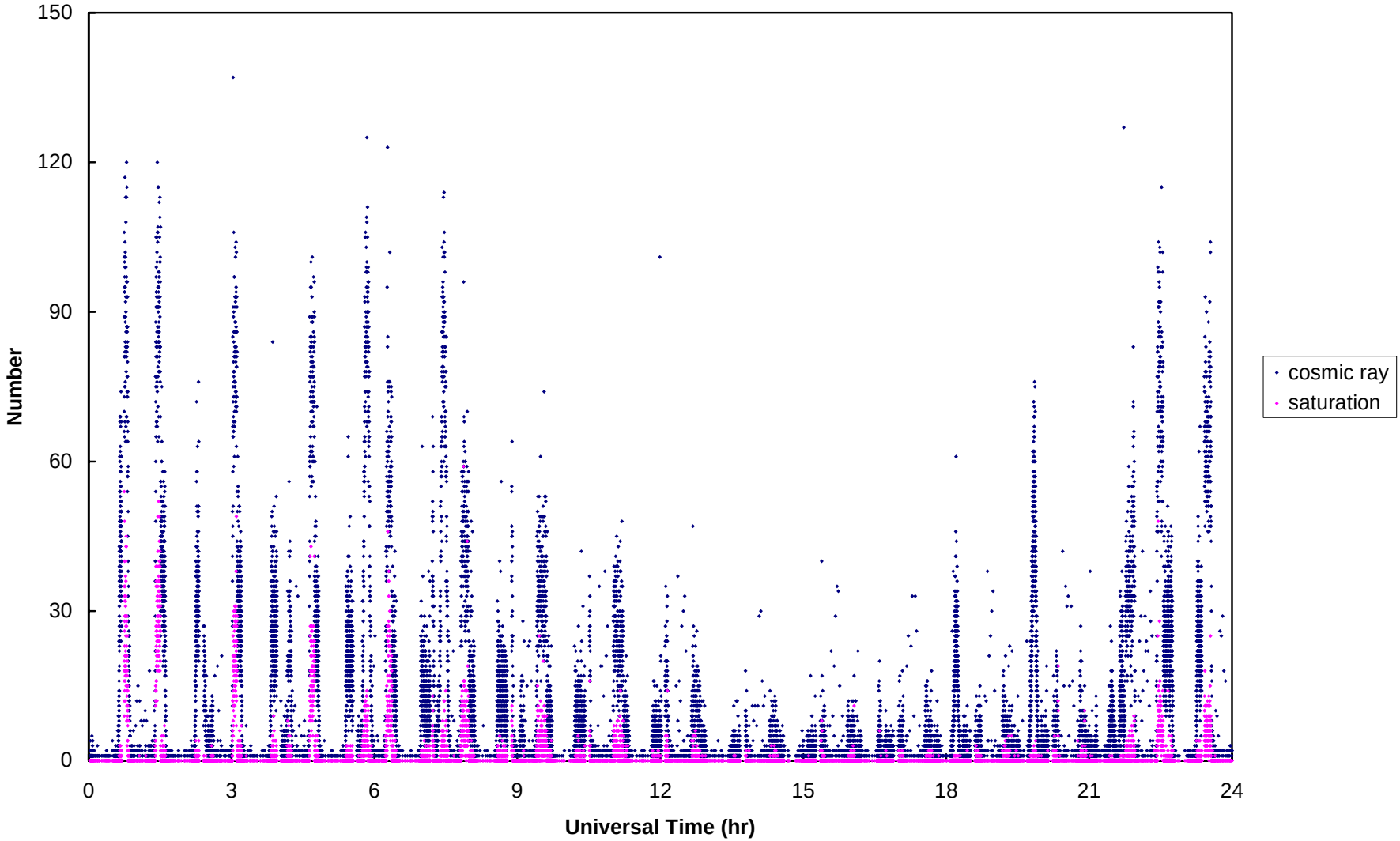
with CLIO mirror

Optical calibrations

- **Calibration stack includes 4 lamps**
  - **Strong white light for imaging tests**
  - **Weak white light for spectral channel radiometric tests**
    Photon Transfer Function test
  - **Neon lamp for etalon drift tests**
  - **HAK lamp for corroborative etalon drift tests**
    Burned out in 2003


Plot of /data/tidi/epets/diagnostic/2003303000200/TIDI_2003303010004_180.epet
EPET Image
Y Position (pixels)
X Position (pixels)
Starting Date: 2003303 [30-Oct]
Starting Time: 01:00:58 UT
PID (Process ID): 180
CCD Temp. : -83.09 °C
Etalon Temp. : 20.02 °C
Status of Lamps: White 2 (IC2) on
Filter Wheel 1: 5
Filter Wheel 2: 1
Wavelength: 630.10 nm
Integration Time: 15.00 s
Maximum Count: 249
Minimum Count: -372
Average Counts: 14.012 counts
Counts Std. Dev. : 28.33
Min Value Pixel: -372
Max Value Pixel: 249
Min Pixel Pos: x:596 y:5
Max Pixel Pos: x:114 y:7
HKtime (Mtime): 751510871
V_dump: 72
H_dump: 150
CntlReg3: 0
CCD Gain: 160
SC_lat: -72.4
SC_lon: 339.3
SC_alt: 646.
SC_sza: 94.0

October 29, 2003



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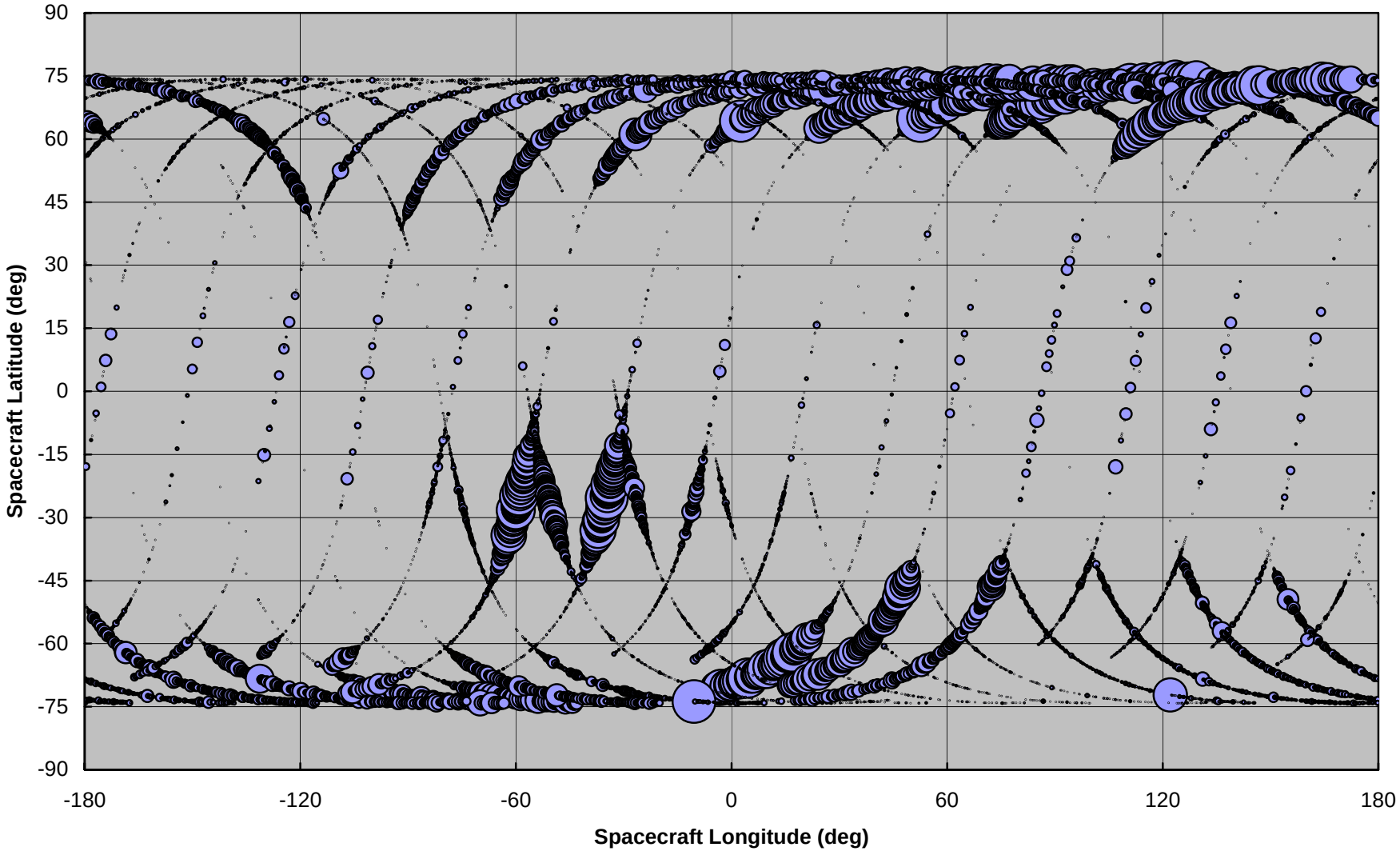
October 29, 2003 - cosmic ray strikes



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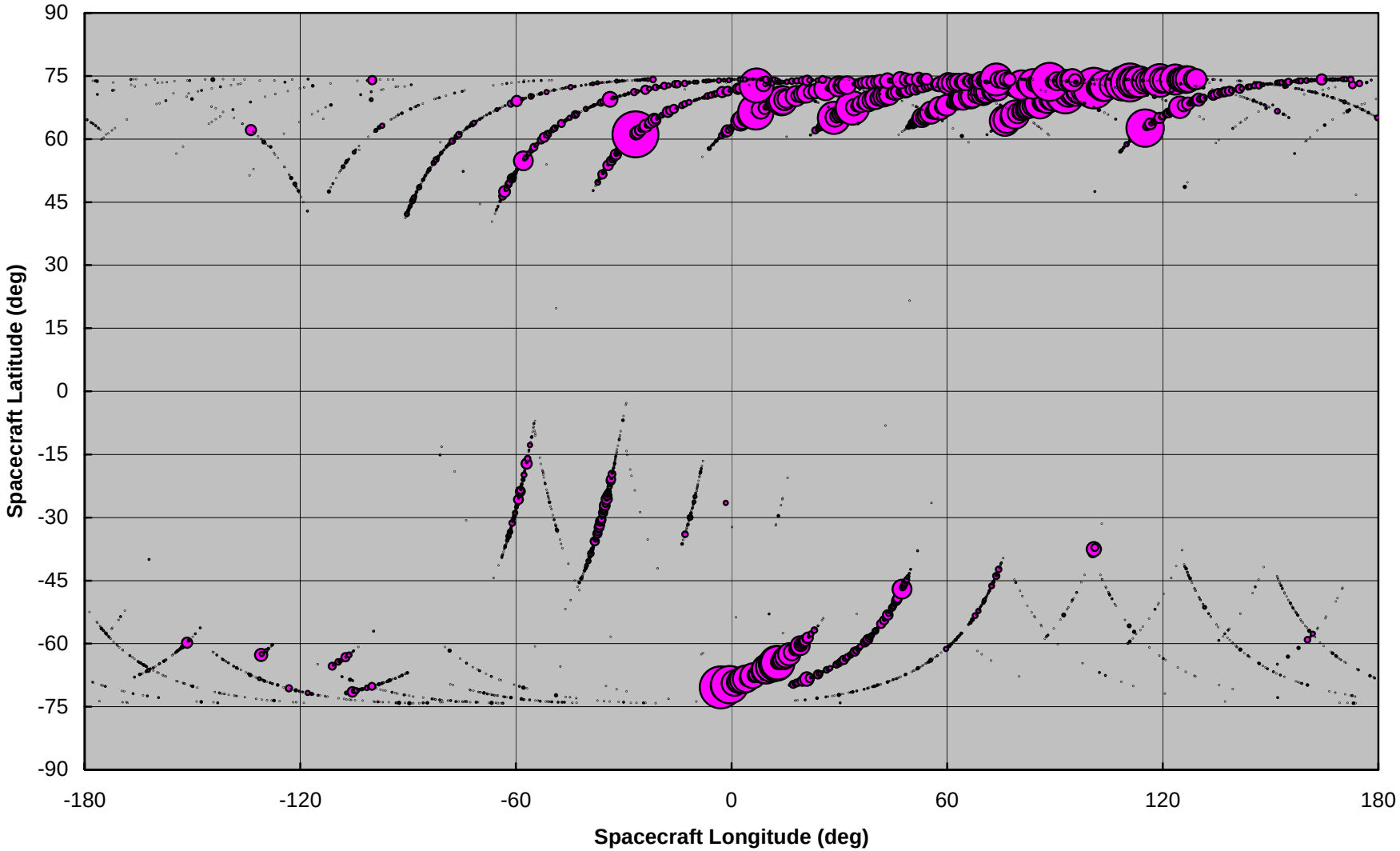
October 29, 2003 - saturation events



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Photon Transfer Test

- **Statistical test to characterize the CCD**
  - **May be performed on an individual pixel (photomultiplier tube)**
  - **May be performed on a binned CCD area (spectral channel)**
- **Illuminate the CCD in a controlled fashion**
- **Measures electronic bias, system gain, read noise**

- **Bias is a common DC offset to all measurements**
  - **Dependent on CCD gain**
  - **Inferred by comparing two measurements acquired with different integration periods**
- **Gain is the effective conversion from photons to electrons to analogue to digital units (ADU)**
- **Read noise is the signal uncertainty introduced by the CCD electronics**

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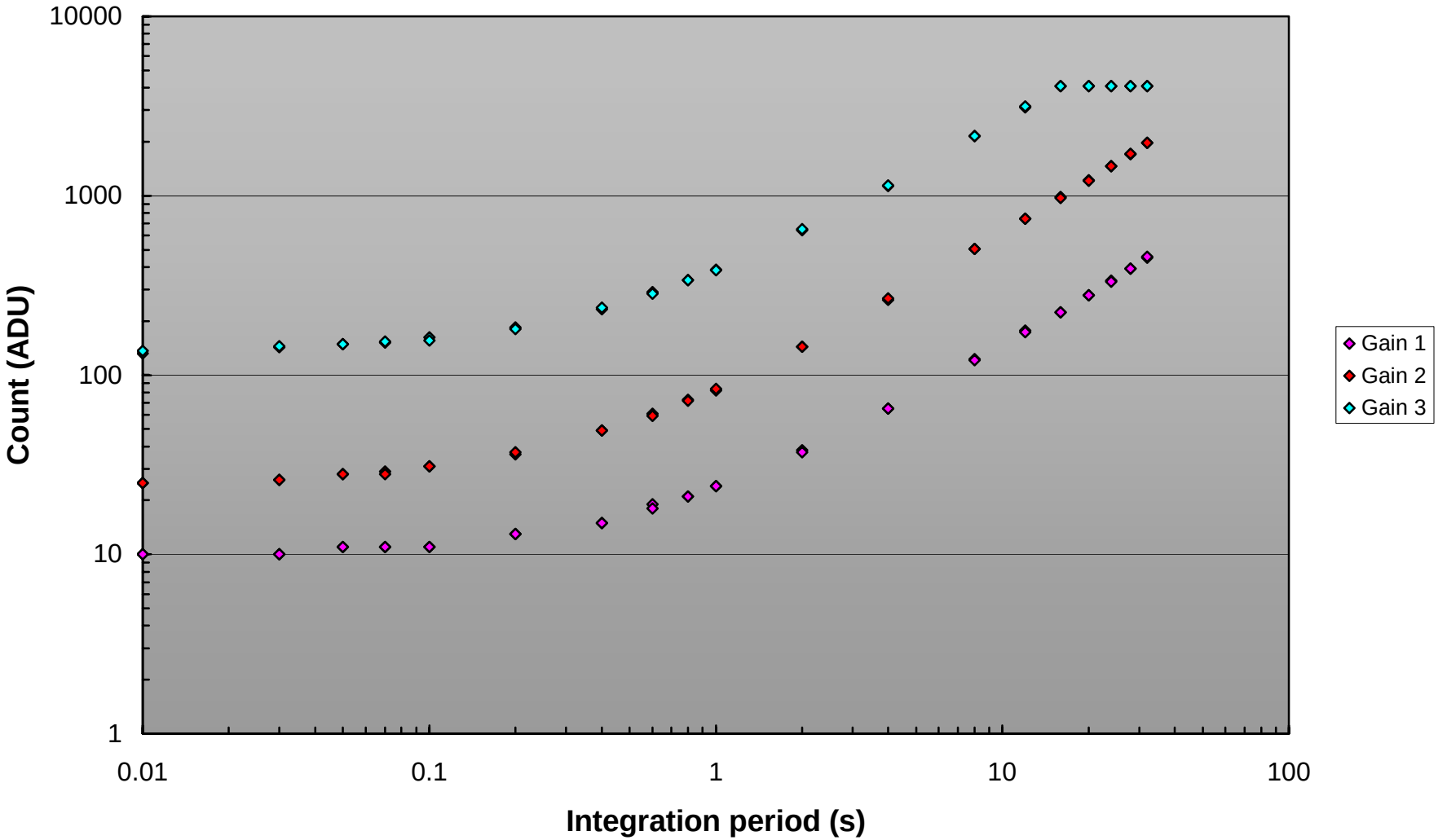
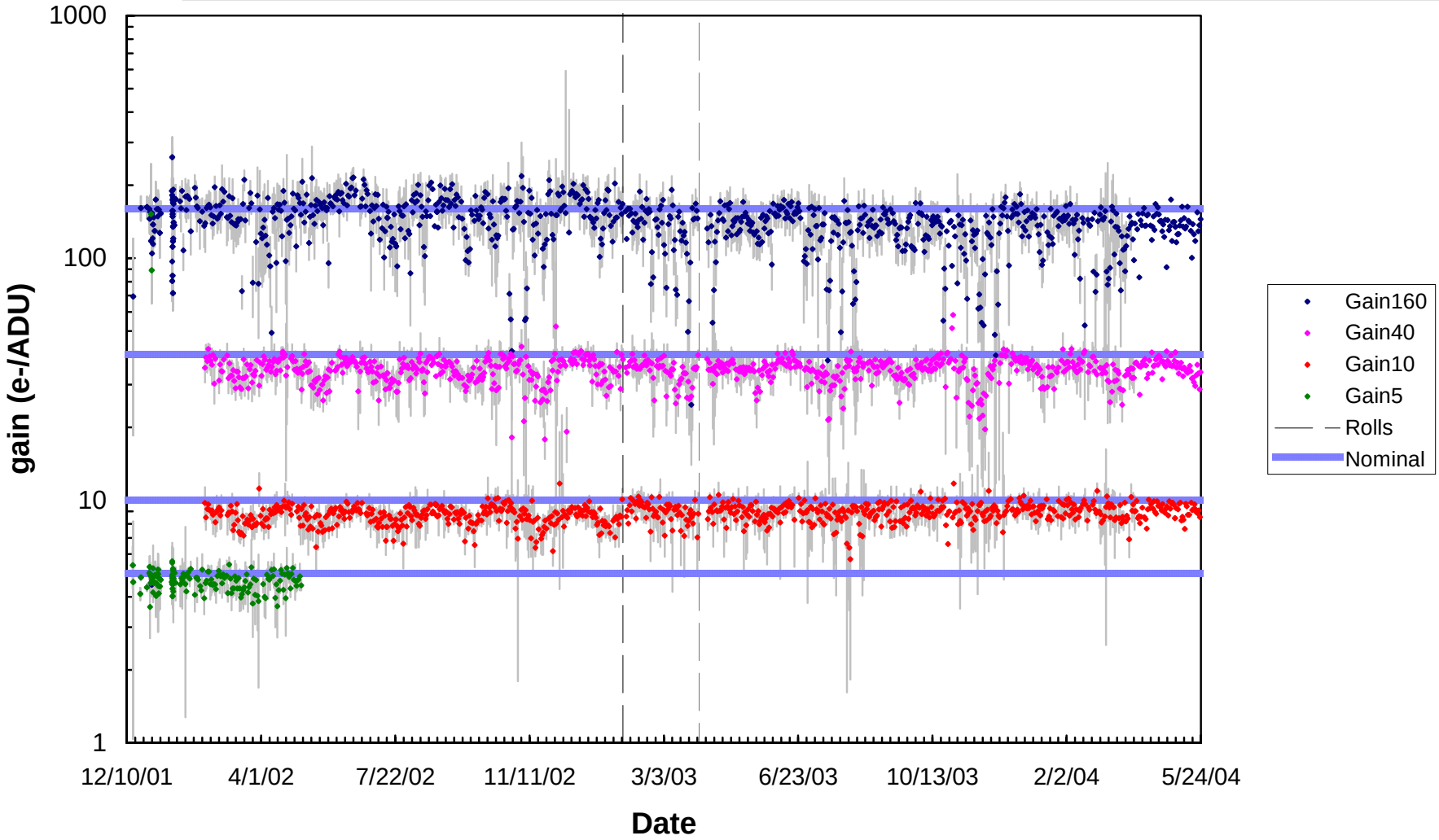
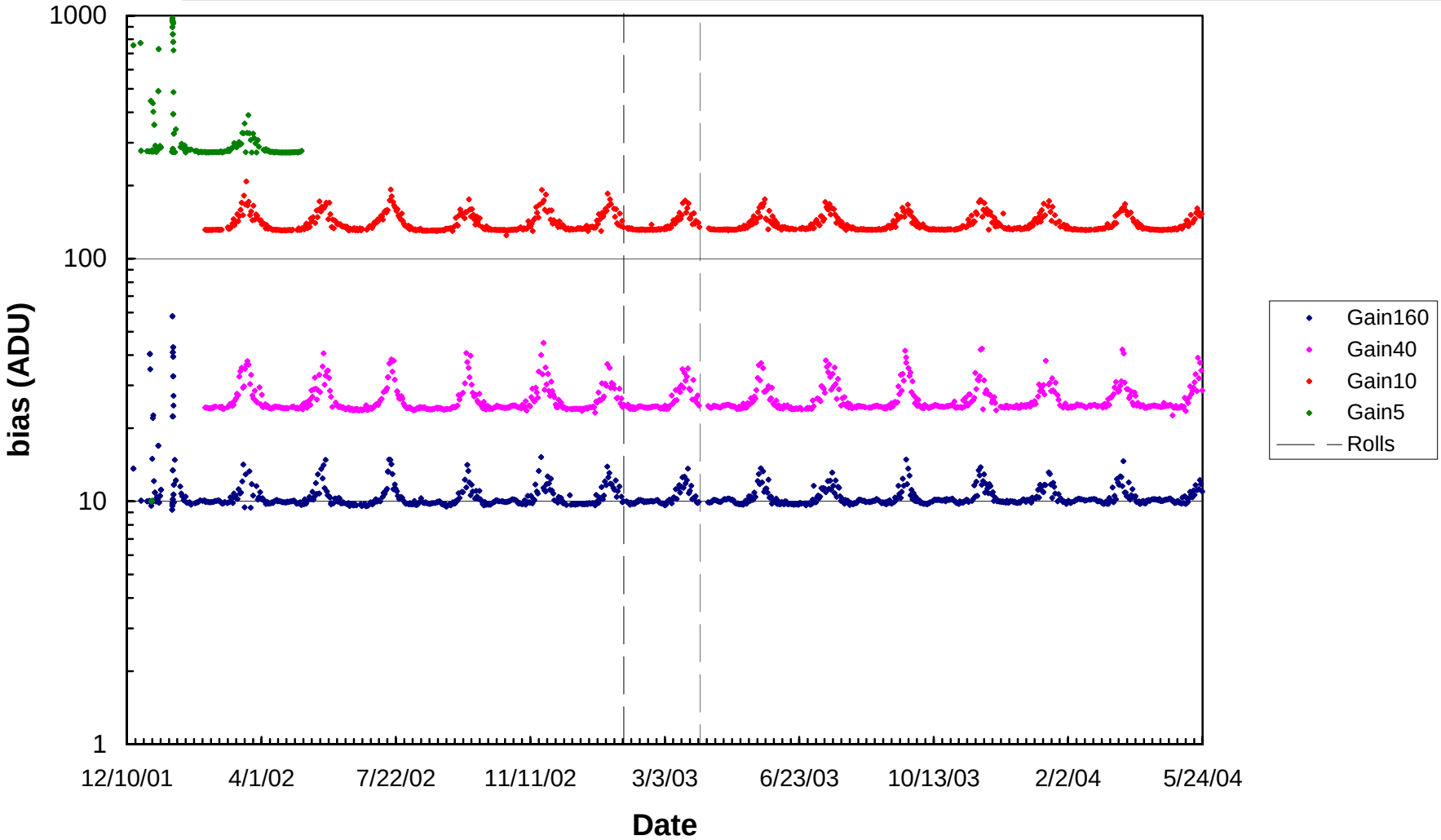
Photon transfer data - channel 075



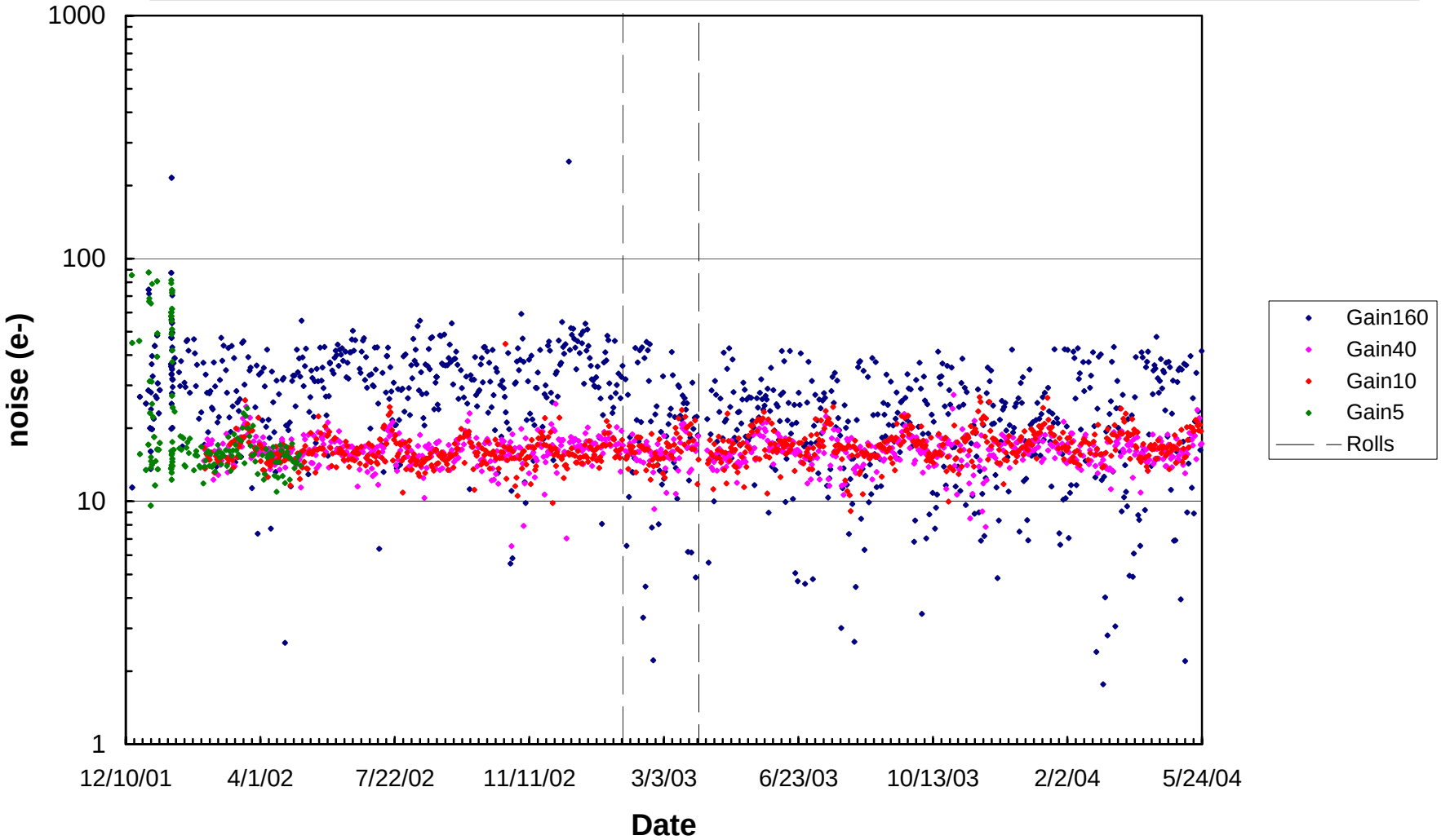
Photon Transfer Functional - Gain



Photon Transfer Functional - Bias



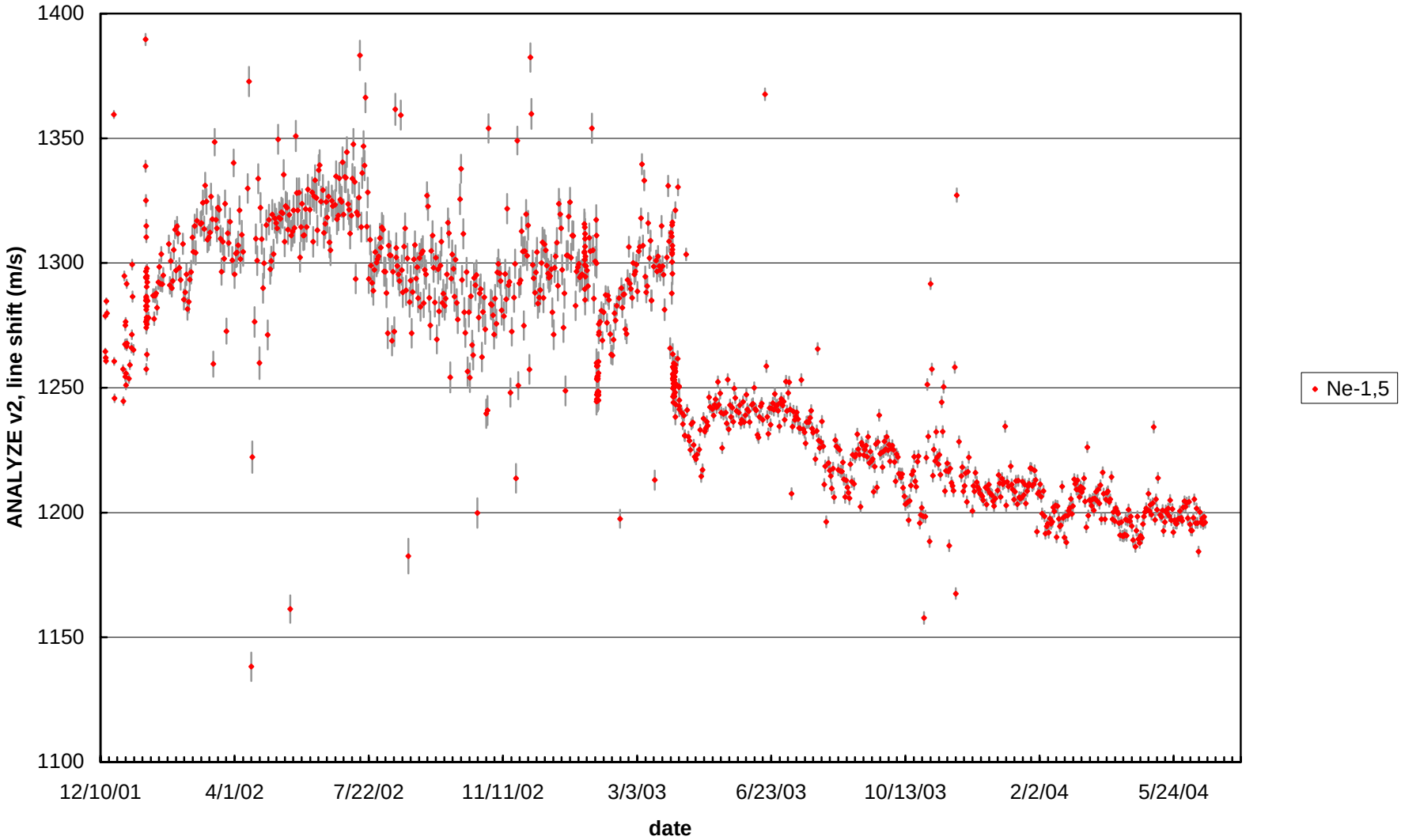
TIDI Photon Transfer Functional - RMS read noise



Spectral lamp runs

- **Drift in the instrument is obtained by monitoring spectral lamps**
  - **Airglow filters chosen to admit at least one line of either the**
    HAK lamp
    Ne lamp
- **Lamps are viewed through the same optical train as the airglow**
  - **Drifts in the spectral line position, whether due to the etalon or otherwise, are assumed common to the airglow spectra as well**

Calibration lamp shift - Ne lamp



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Scattering characterization

- All optical instruments can impart unwanted scattering to input radiation
- TIDI suffers from a “frost” buildup, likely at the window separating the cold detector volume from the warm interferometer volume
- Much of the frost has been removed through two special TIMED maneuvers, and the remnant continues to sublimate away at a slow but measurable rate

- Characterize the optical scattering by viewing Rayleigh scattered radiation from the top of the atmosphere during daylight conditions

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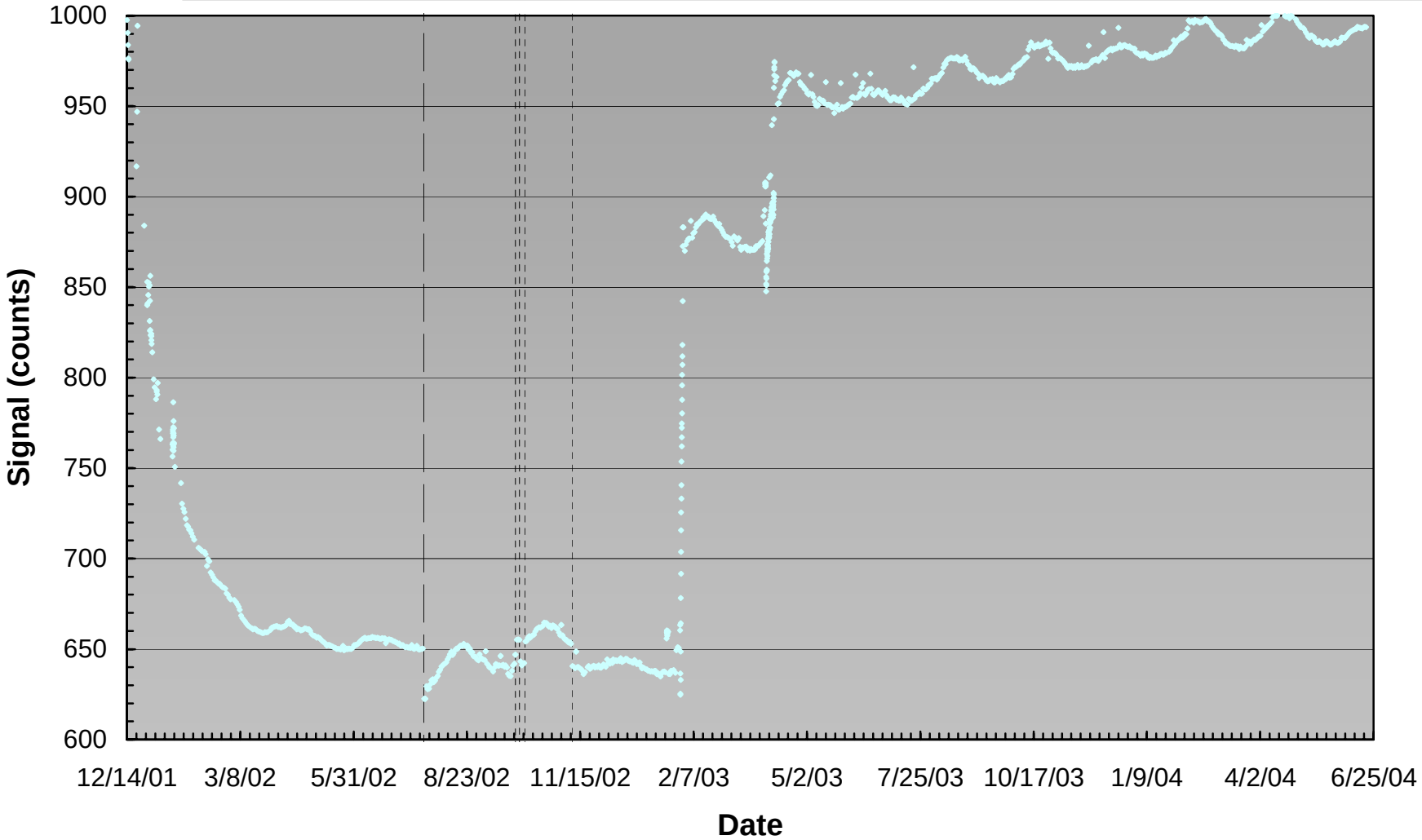
TIDI white light trend



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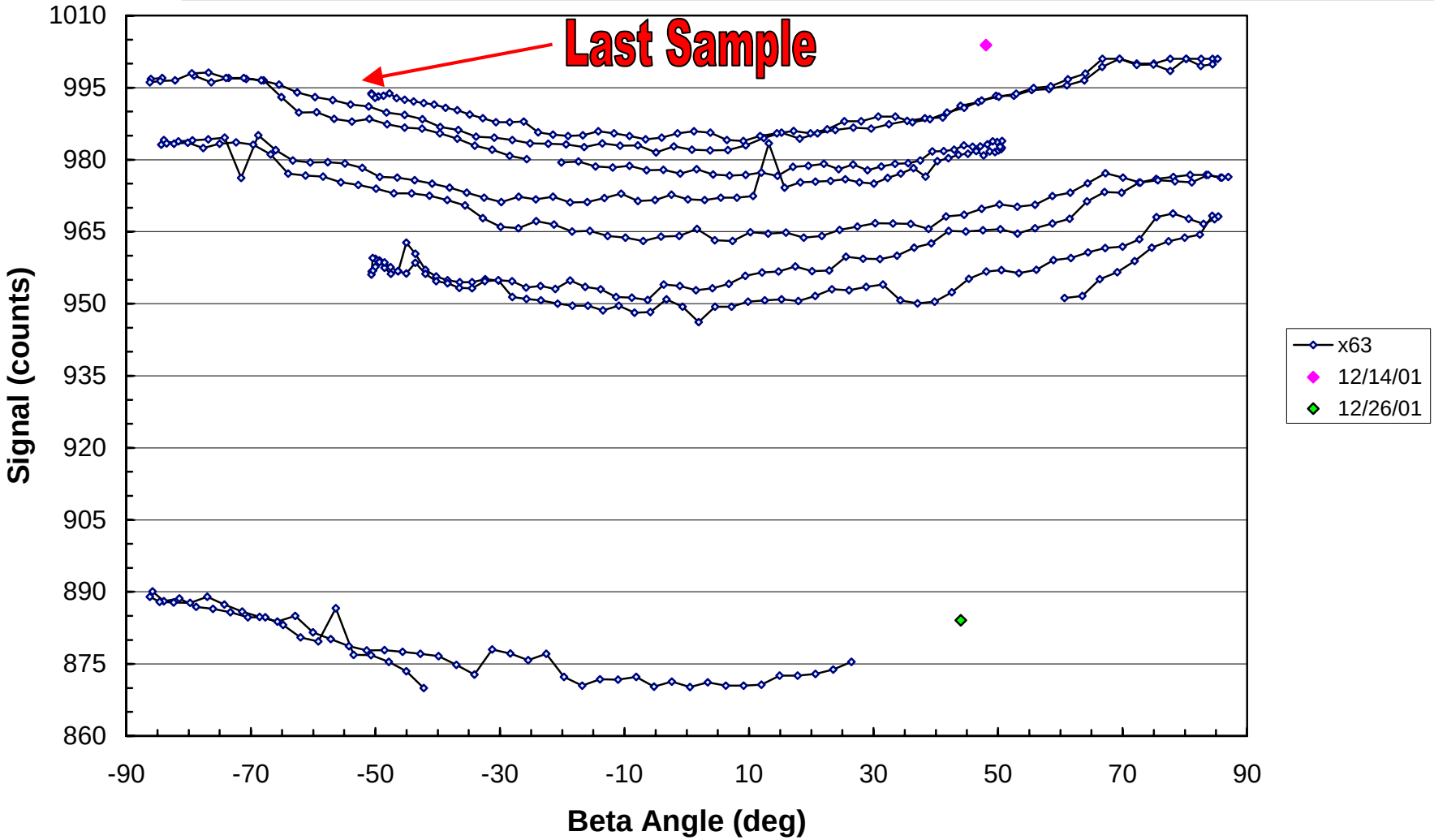
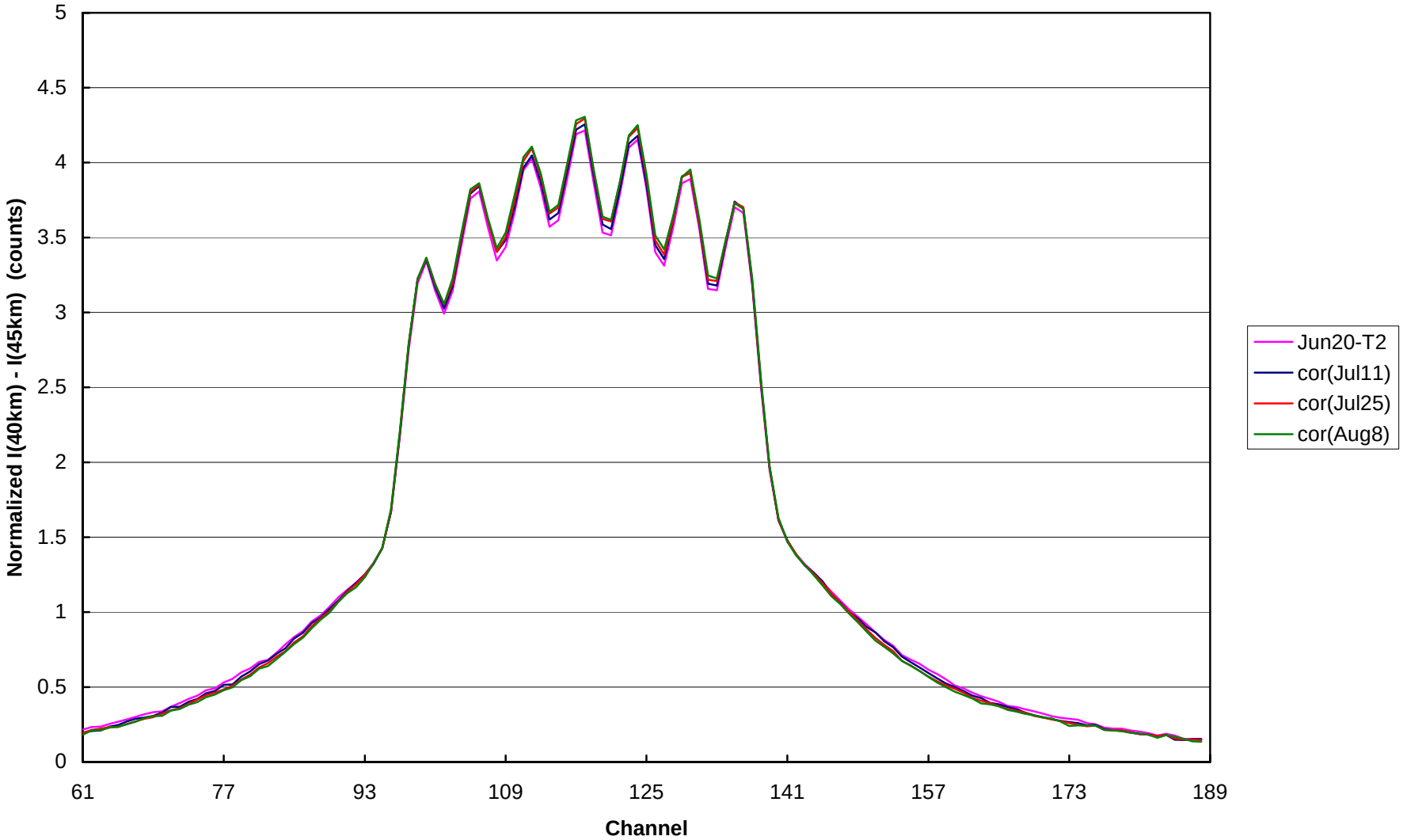
TIDI white light trend



TIDI NOR-CAL Telescope 2



Conclusions

- **For a dedicated wind measuring Doppler interferometer, true absolute intensity calibrations are not required**
  - **However, stability of detector must be shown**
  - **Relative intensity calibrations must be performed, especially for a multichannel detector such as a CCD**
- **Instrumental contributions to spectral line position must be calibrated**
  - **TIDI began with two different lamps which could be cross-checked against each other through a few airglow filters**
  - **Transmit spectral lamp radiation through the same optical path as that used by airglow**