# IceSat 2 ATLAS photon-counting receiver - initial on-orbit performance

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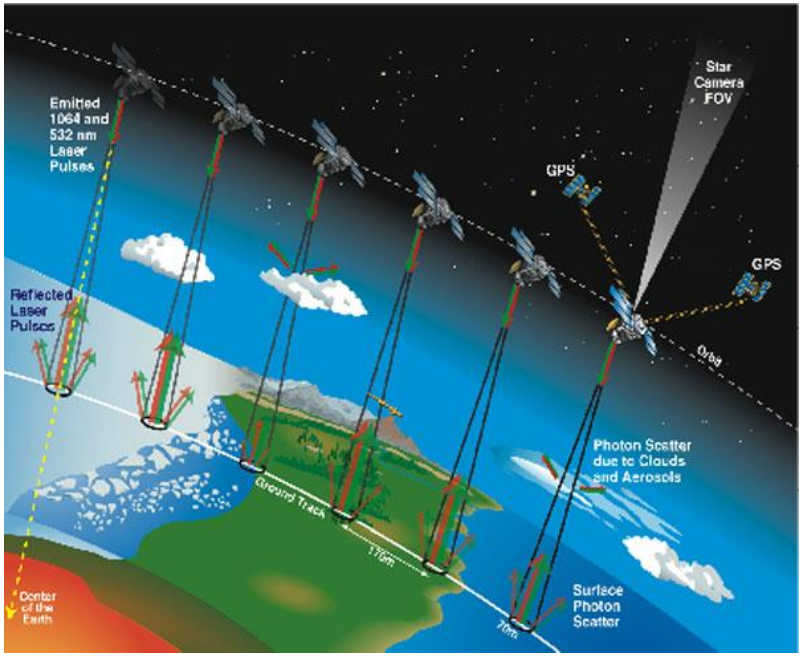
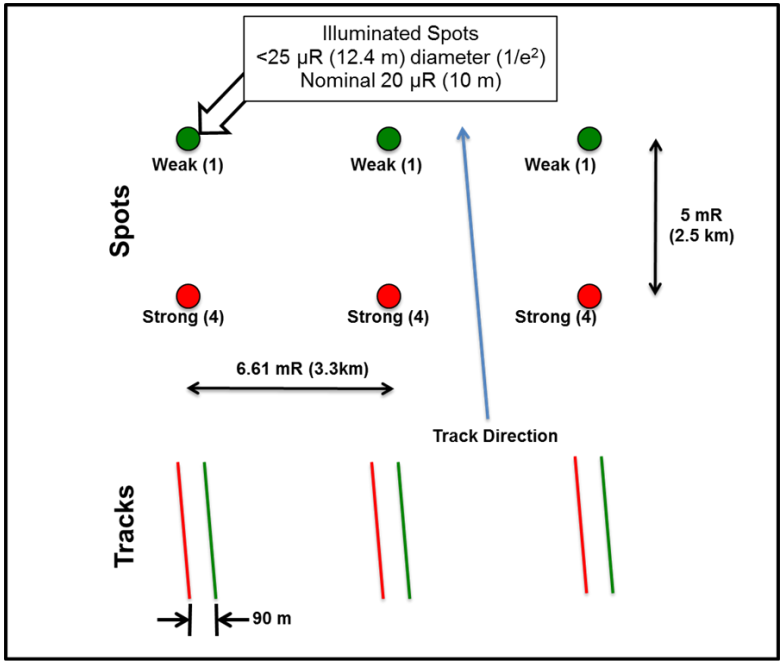
# Current Status

- High level ATLAS Instrument configuration
- Photon counting detector specification and performance
  - Detector Specifications
  - Dark Count Rate
  - Jitter
  - Linearity
- Detector on orbit performance
  - Dark count
  - High dark count rate from the stray light getting in at high latitudes
  - High dark count rate from the South Atlantic Anomaly, where charged particles induced count rate increase in the receiver
- Summary

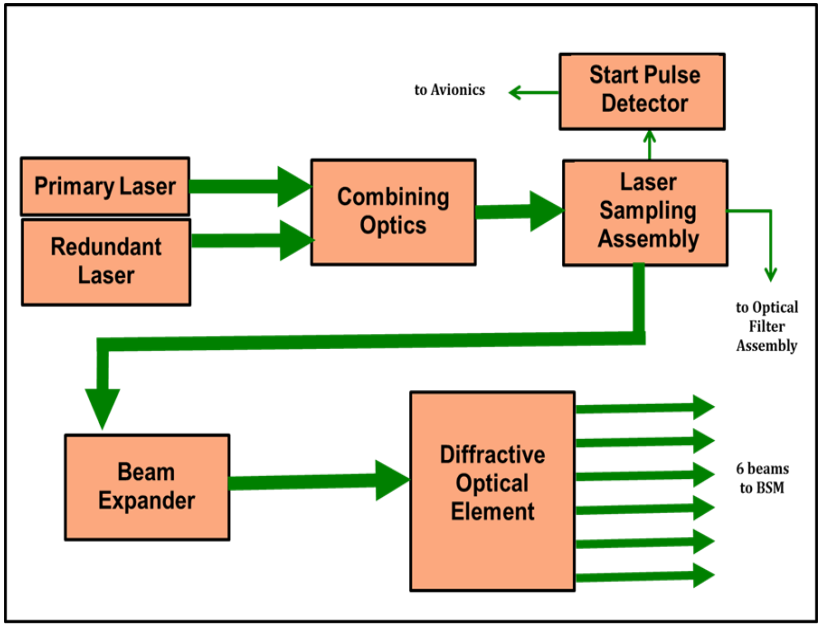
# Orbit and Illumination Pattern

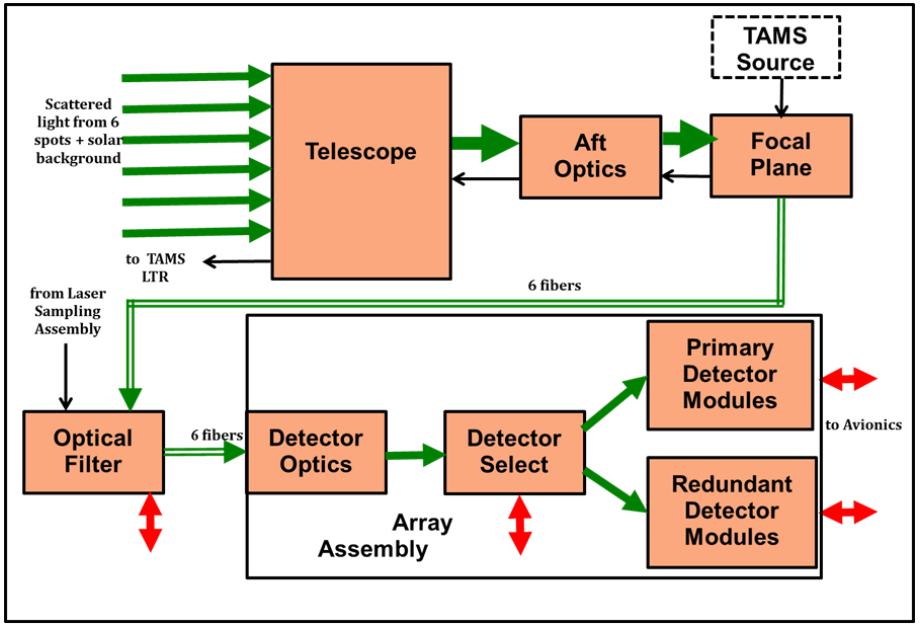



- IceSat-2 has Sun Synchronized Orbit with a single instrument "Advanced Topographic Laser Altimeter (ATLAS)".
- The Altimeter illuminate ground with 3 strong and 3 week spots. The receiver is operating in photon Counting mode.
- The science objectives are: "Ice Sheets, Sea Ice, and Vegetation".

# Transmitter and Receiver




- The transmitter send out 6 beams (3 strong, 3 weak)
- The received 6 returns are fiber coupled to 6 photon detectors for time tag
- Each photon detector has 16 or 4 pixels correspond to strong or weak spots to ensure the single photon per pulse per pixel, and cover the return signal dynamic range

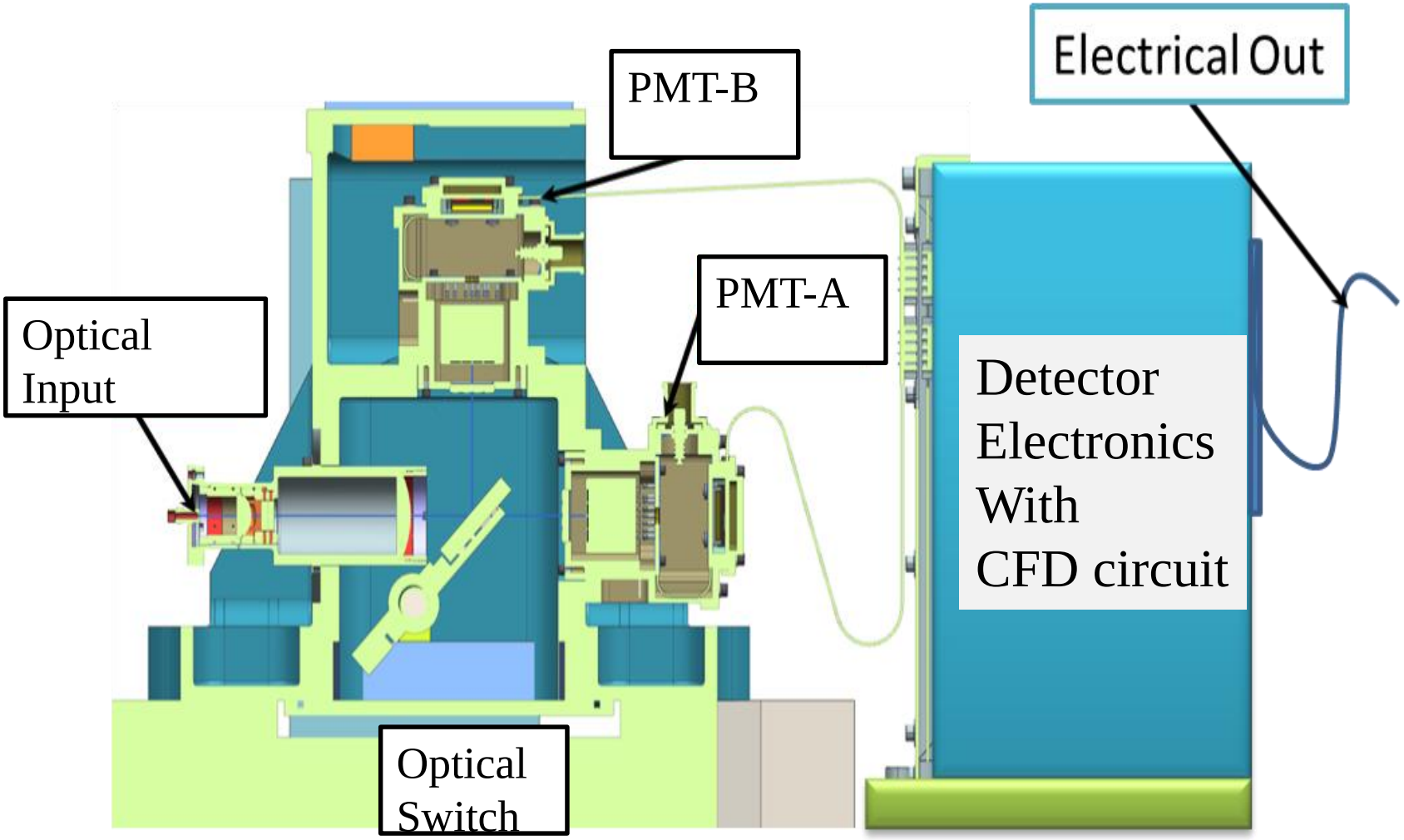
# Detector Requirements

| Parameter | Specification | | Unit | Meet Spec |
|---|---|---|---|---|
| | Min | Max | | |
| Jitter (rms) | | 285 | ps | Yes |
| Wavelength | 532 | | nm | Yes |
| Count Efficiency | 15% | | | Yes |
| Dead Time | 3.1 | 3.3 | ns | Yes |
| Max Photon # per pulse | | 12 | | Yes |
| Max solar back ground | | 20M | Count per second per spot | Yes |
| Dark count rate | | 160K | Count per second per spot | Yes |
| Vibration | 10 | | g-rms | Yes |
| Mission Lifetime | 3.5 | | year | Yes |

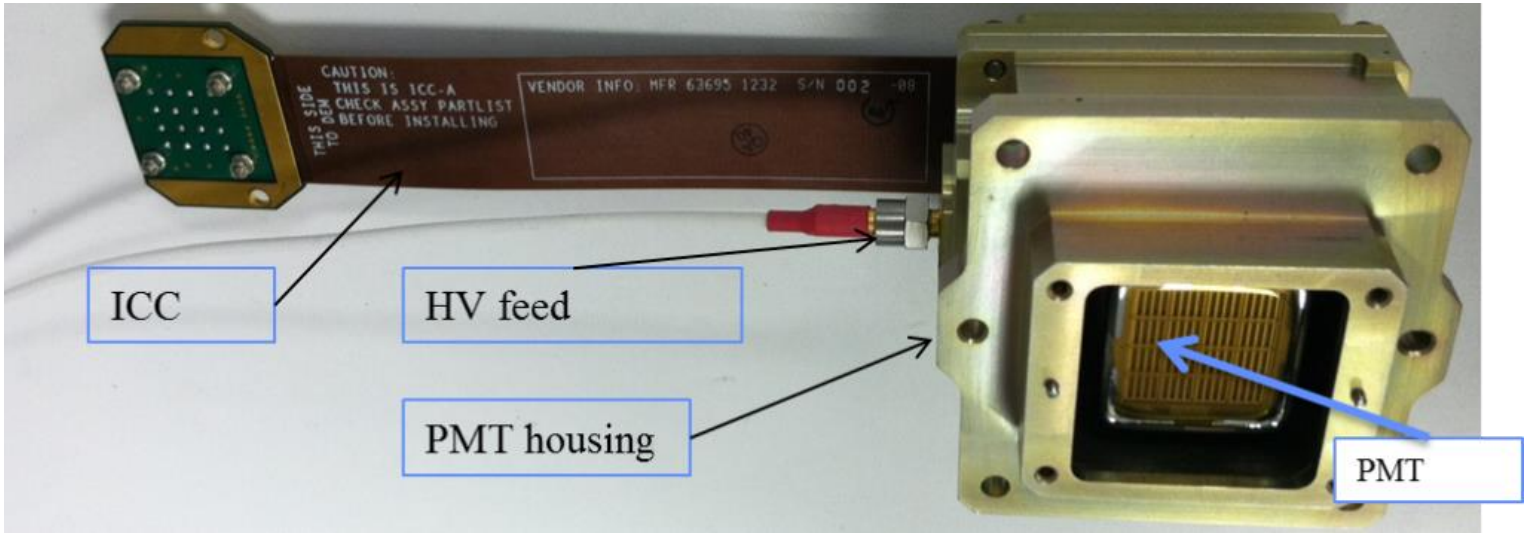
# Detector Qualification

1. Lifetime validation (> 3.5 years)
2. Vibration validated (> 10 grm)
3. Burst mode pulsed laser damage threshold (> 2 uJ per pulse with 30 consecutive pulses of a 10 kHz laser)
4. Magnetic field timing sensitivity and gain test (< 4ps walk for 0.5 Gauss in all orientations)

# Detector Subsystem

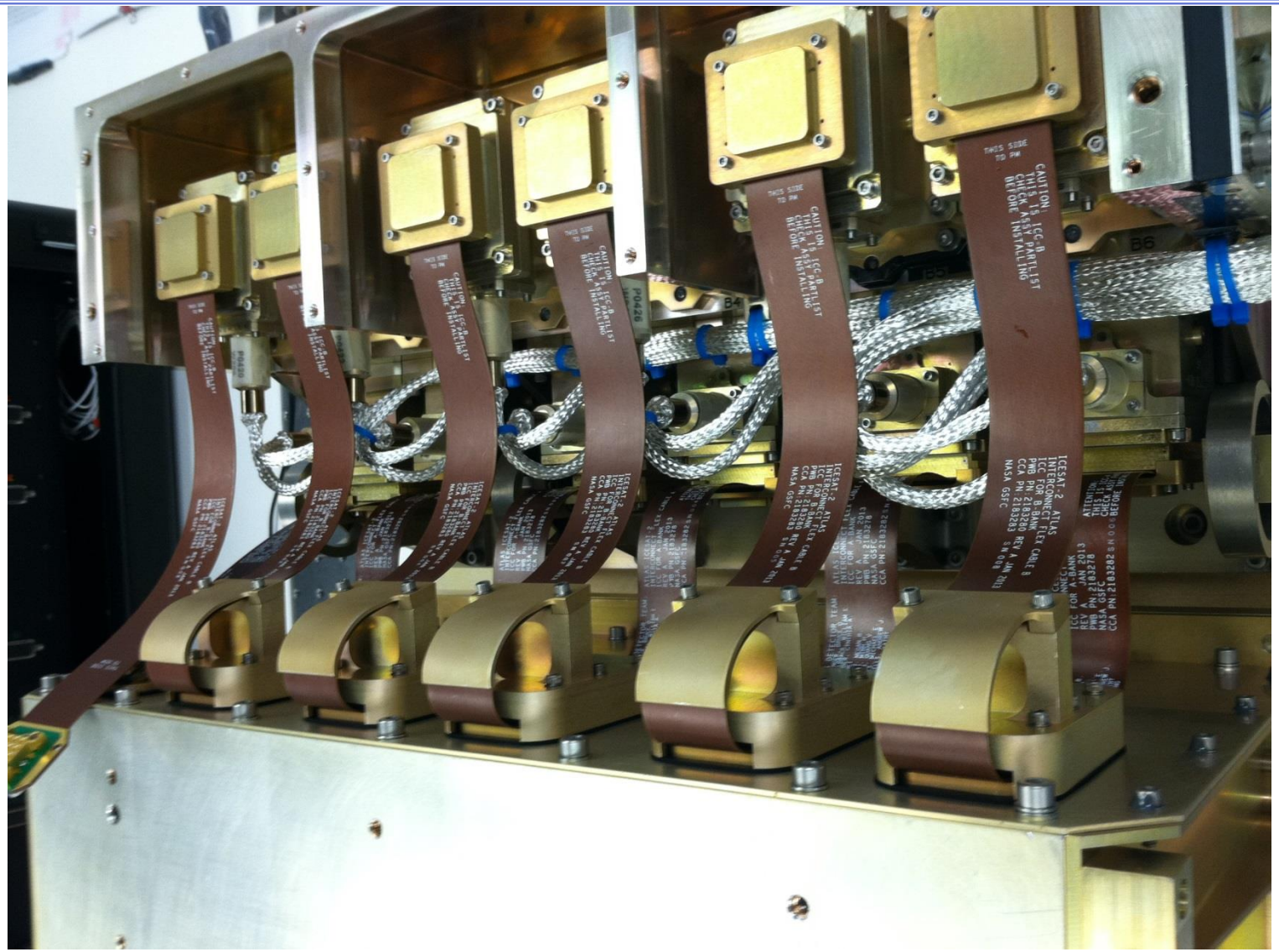


# Subsystem Definition Quad

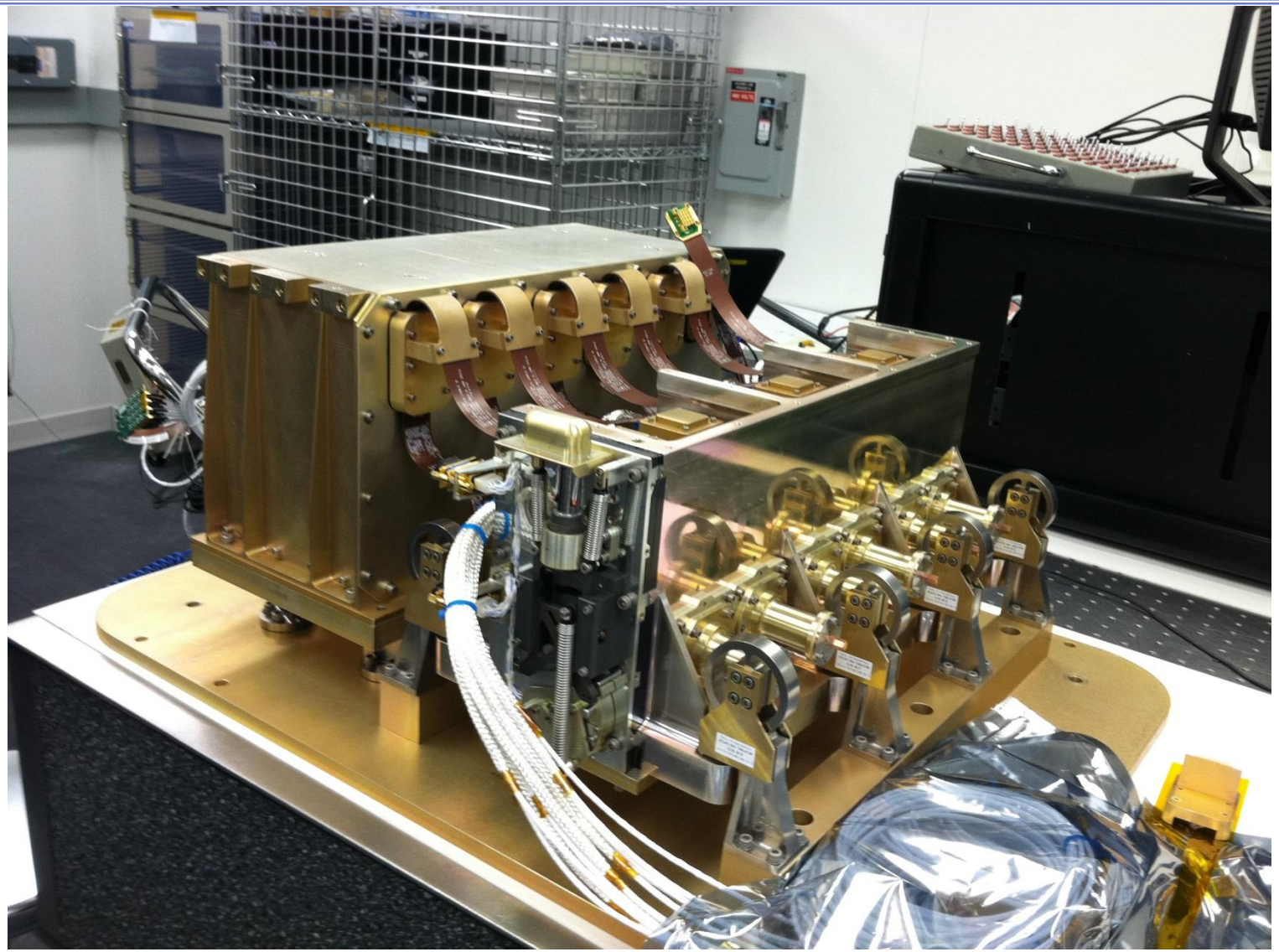



- PMT: R7600-300-M16 Green Extended Cathode
- 16 channels Constant Fraction Discriminator (CFD) design for strong spot
- 4 channels Constant Fraction Discriminator design for strong spot (4 PMT pixels are combined as one CFD channel.

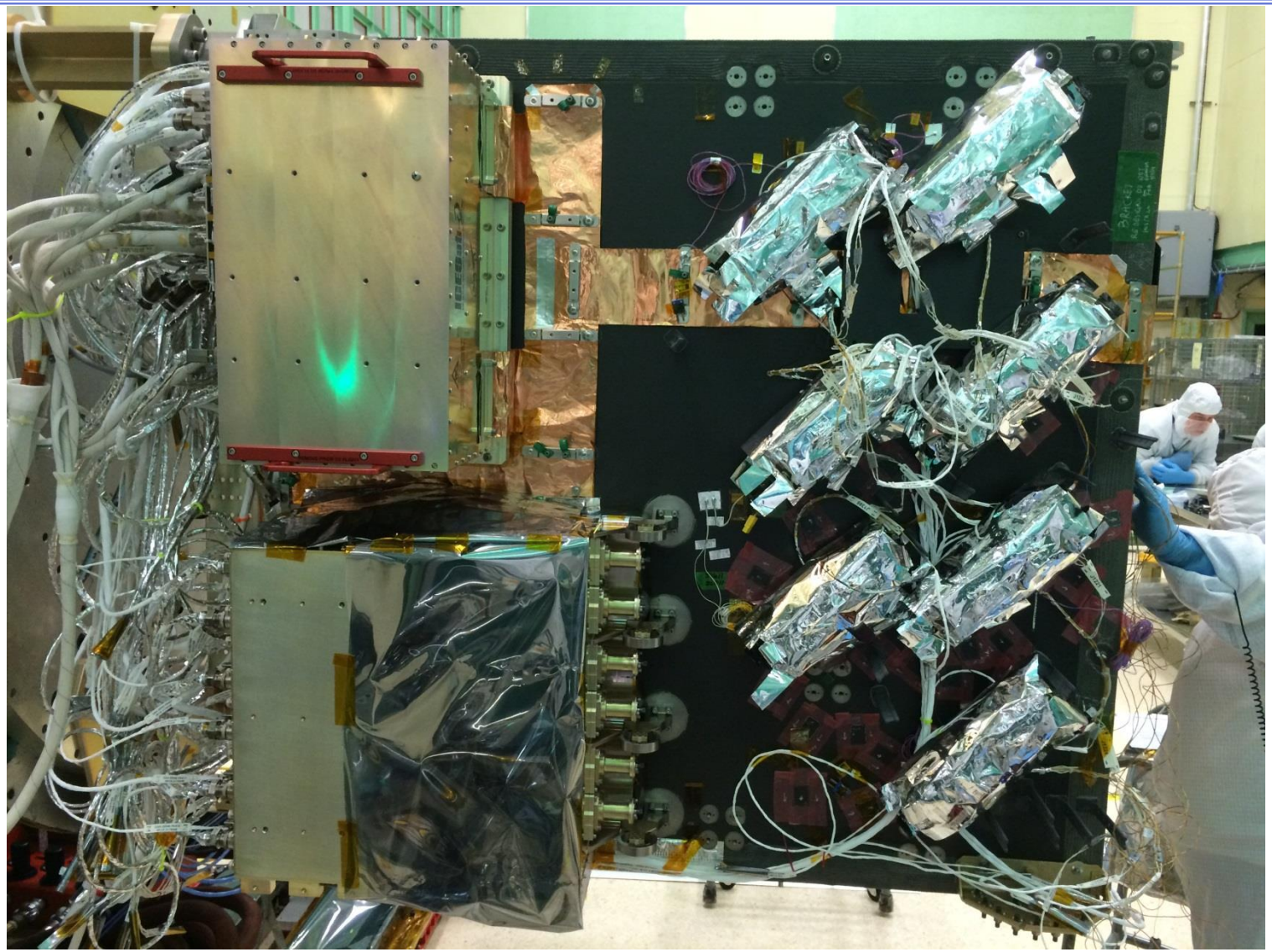
# Detector and Electronics interface



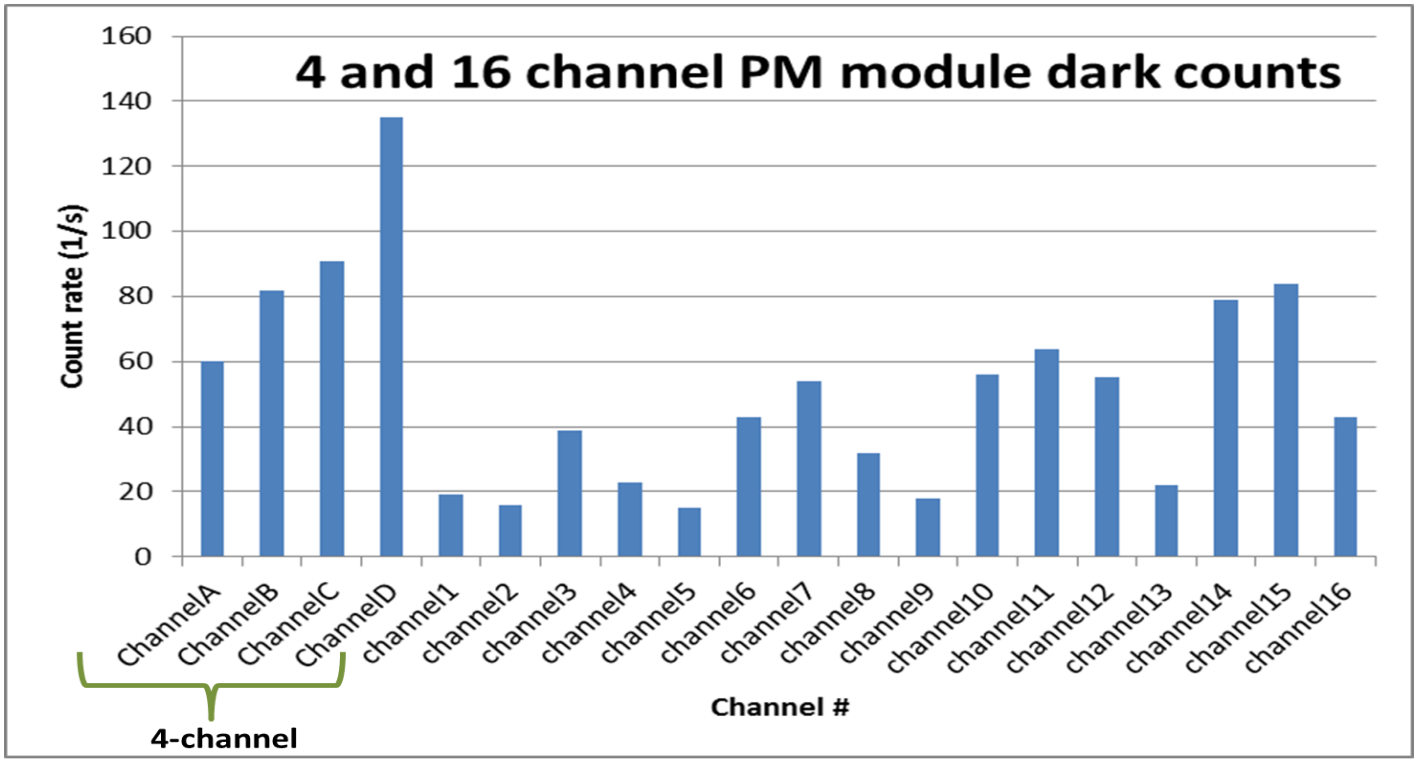
# Detector Array Assembly



# Detector integrated to Instrument

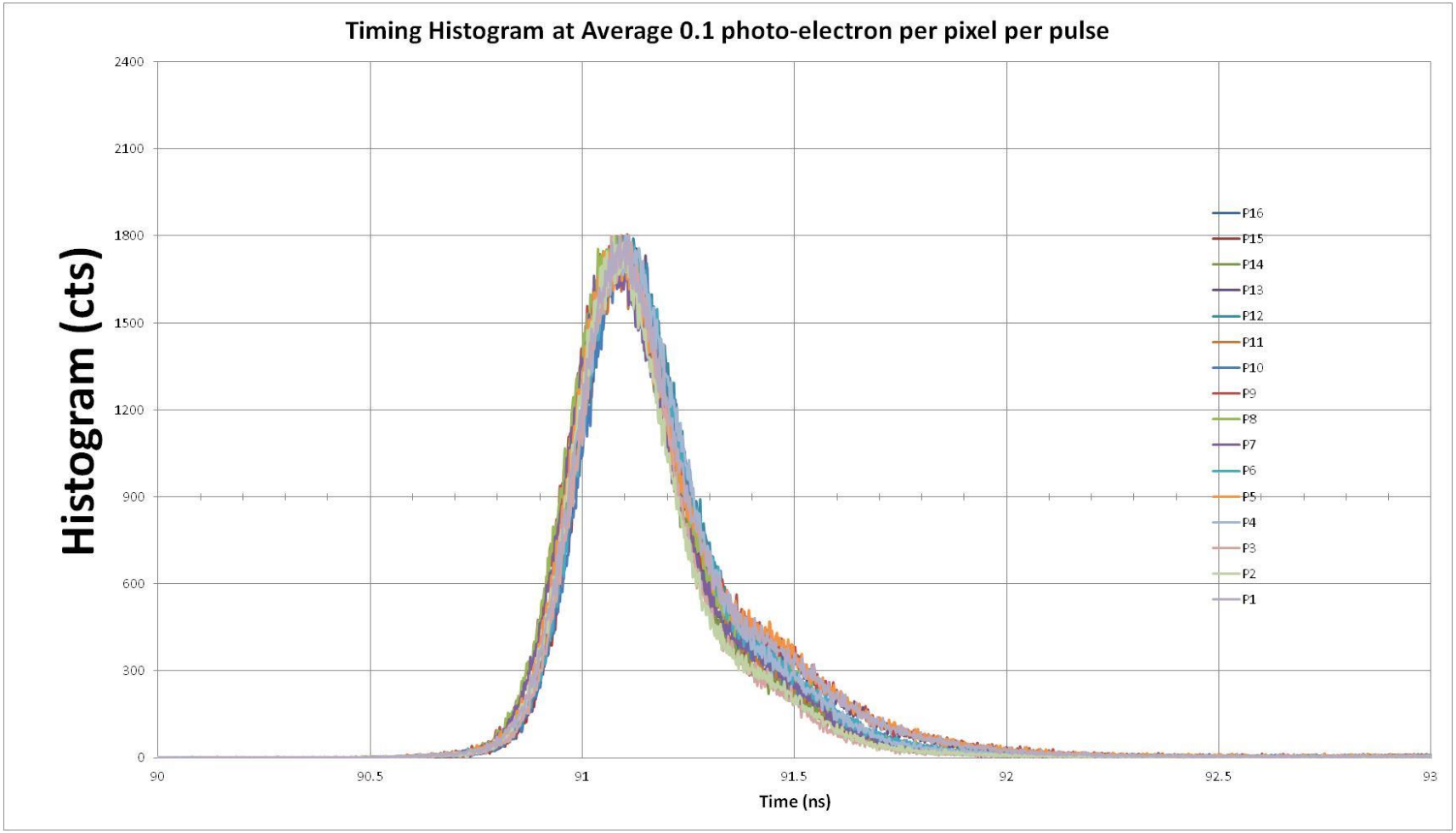


# Dark Count Rate




PMT dark count rate. Each PMT tube has 16 individual photon detection channels. Channel1 to channel16 is the performance of 16 channel receiver configuration. ChannelA to channelC is for 4 channel receiver performance, where 4 PMT channels are combined into 1 photon counting channel for weak lidar tracks.

# Jitter Performance: 16-Pixel Configuration



# Jitter Performance: 4-Pixel Configuration

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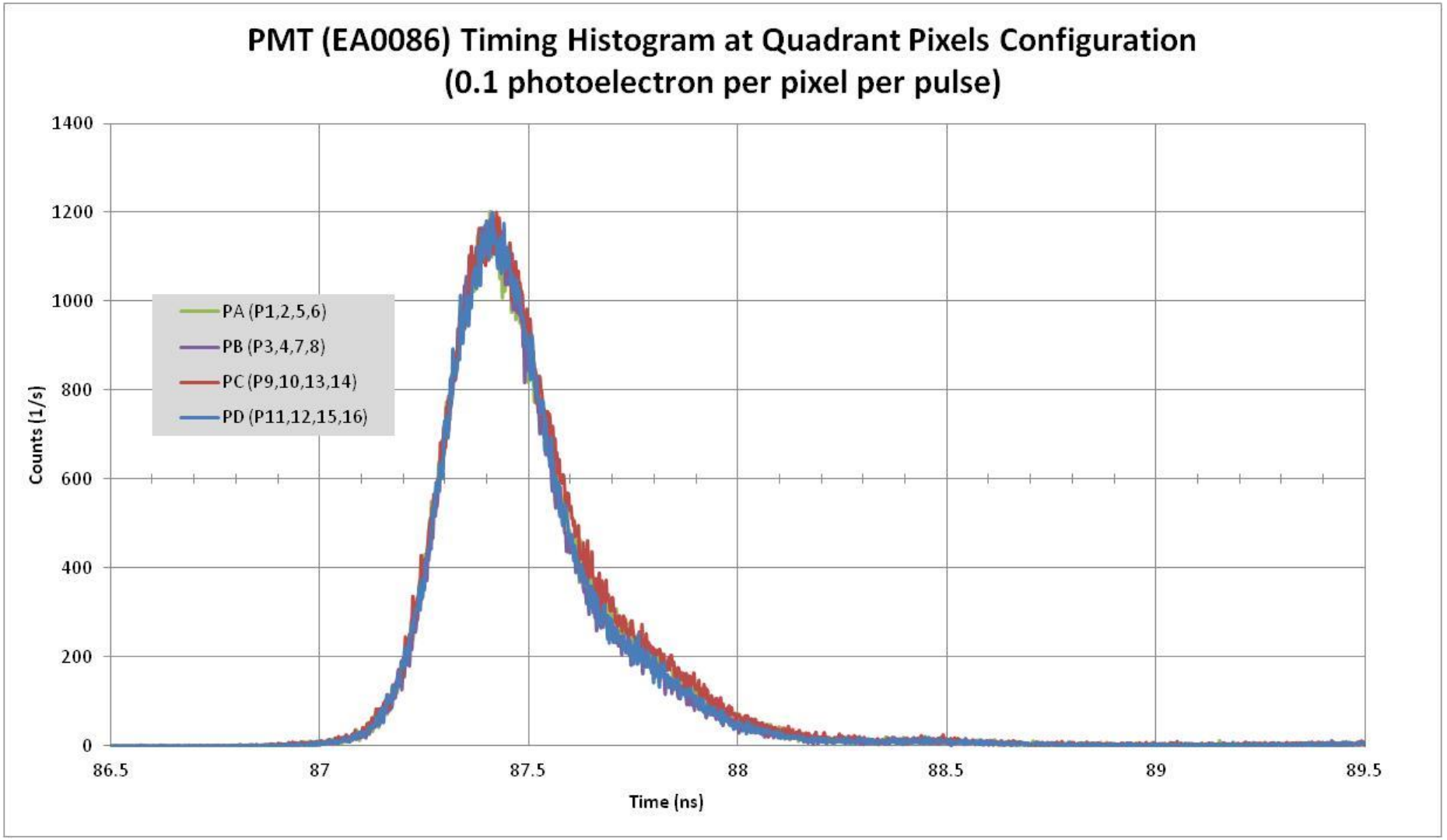
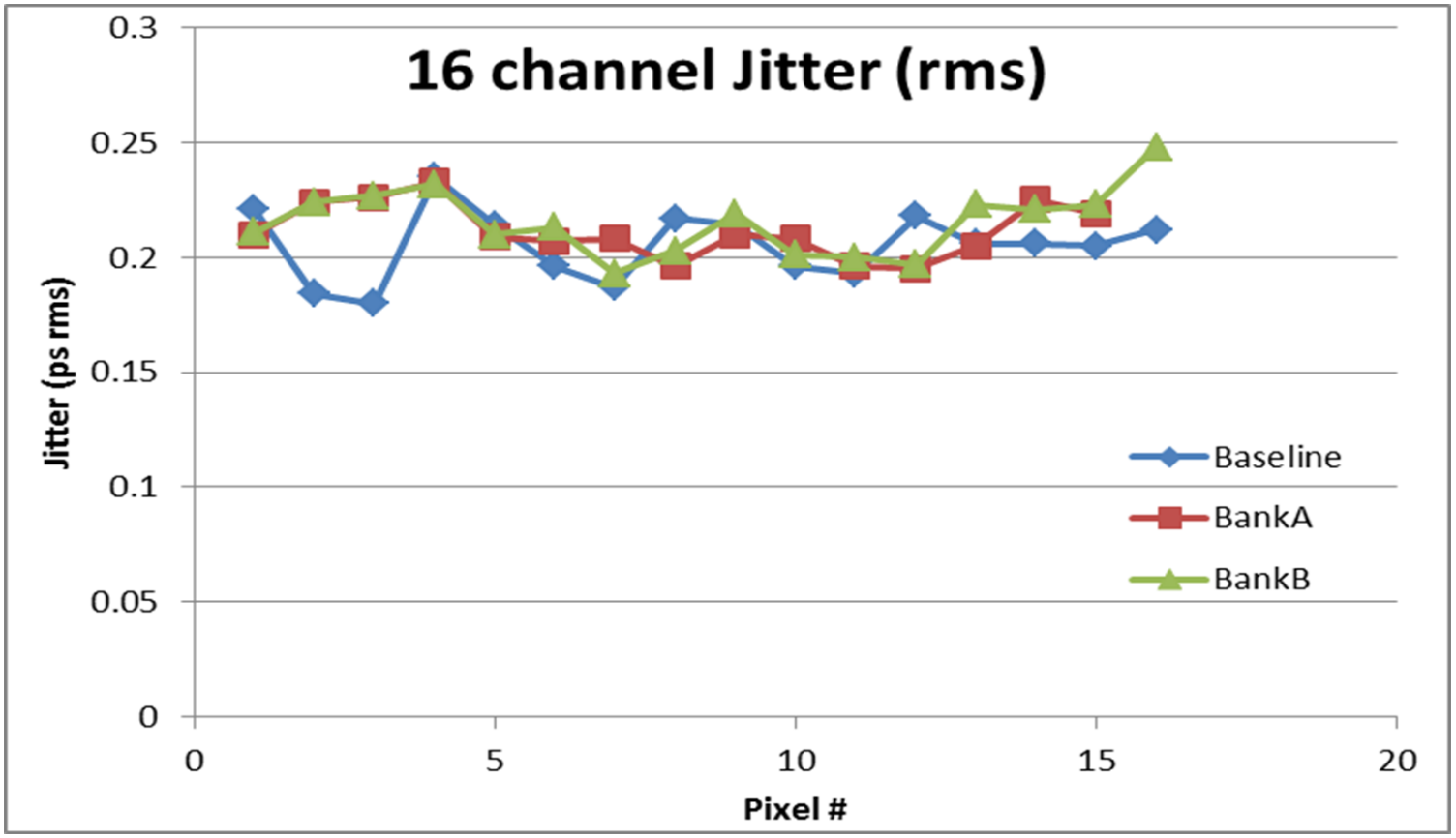
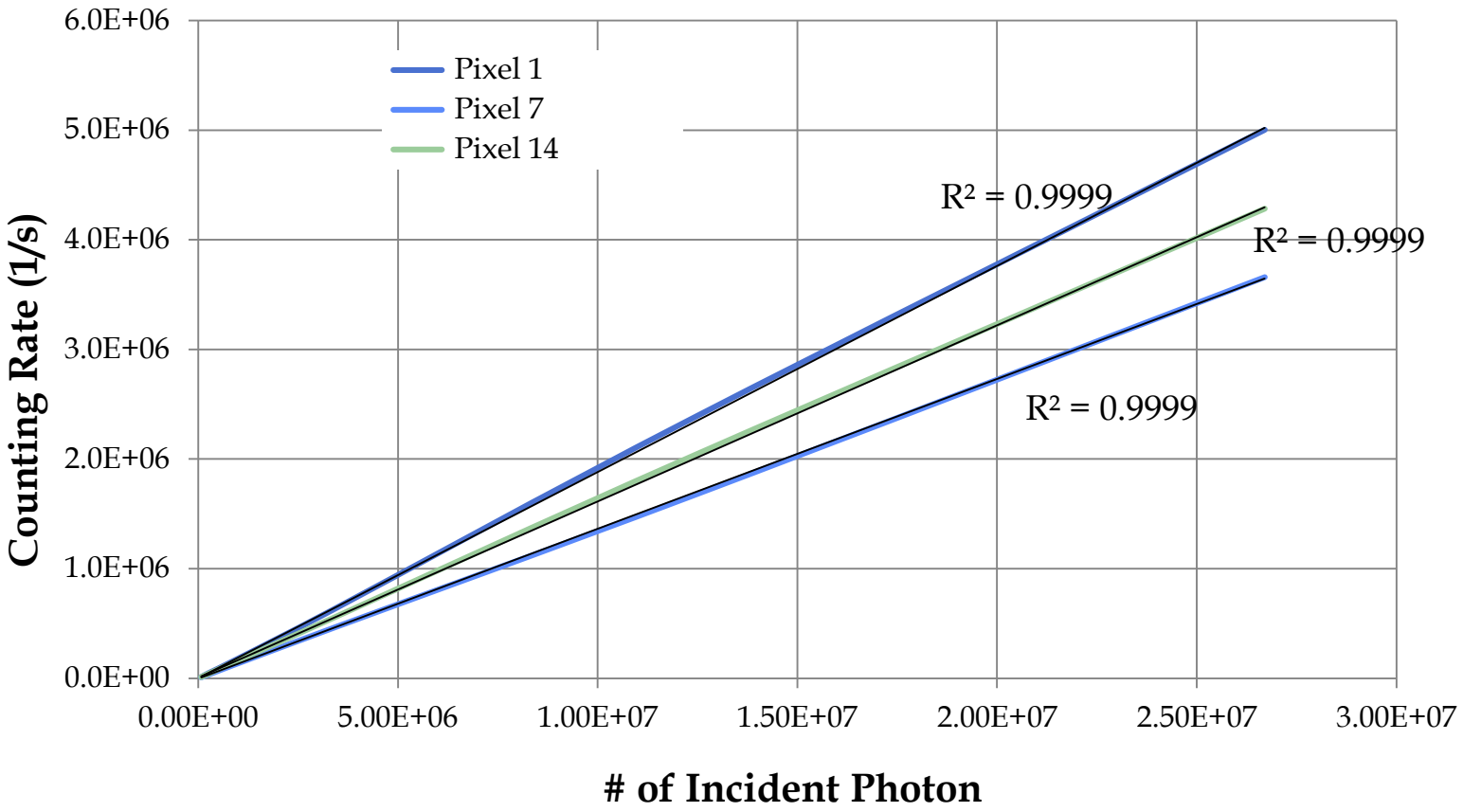


# Jitter Performance



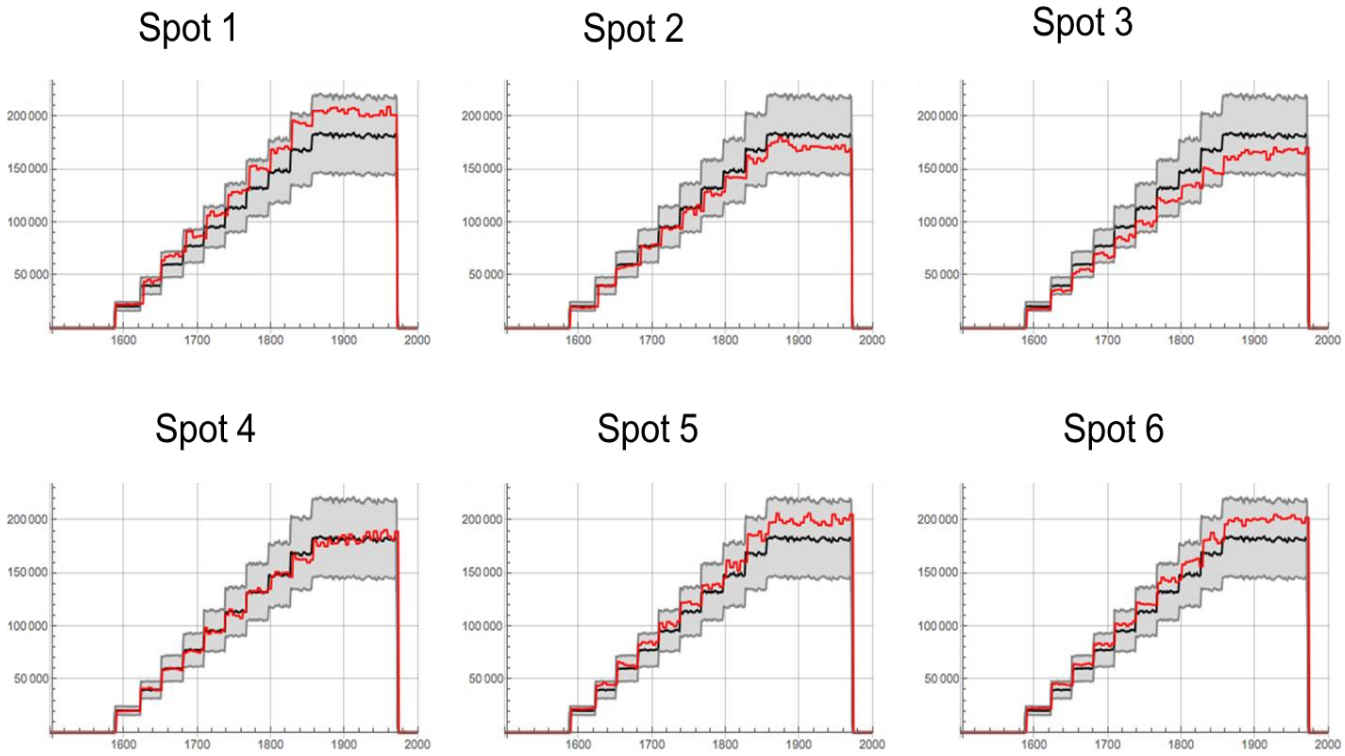

PMT receiver jitter performance for three different receiver assemblies. Baseline, BankA and BankB, the all have jitter less than 250 ps (rms)

# Counting Rate Linearity



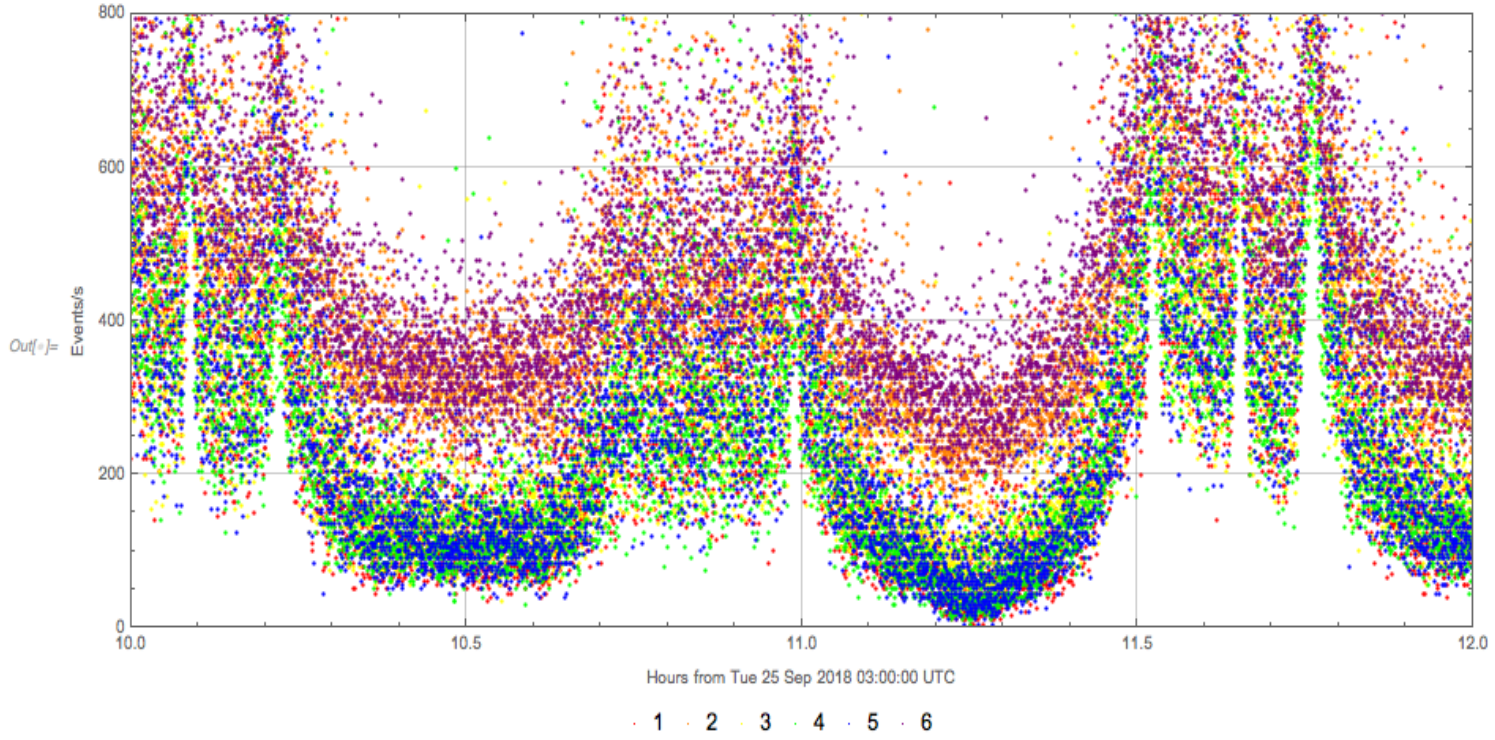

- Worst Operating Case Count Rate per PMT is 20Mcts or 1.625Mcts per pixel.
- Tested upto 3.5 Mcts per pixel
- Linear fix shows a good linearity at entire range.

# Counting Rate Linearity



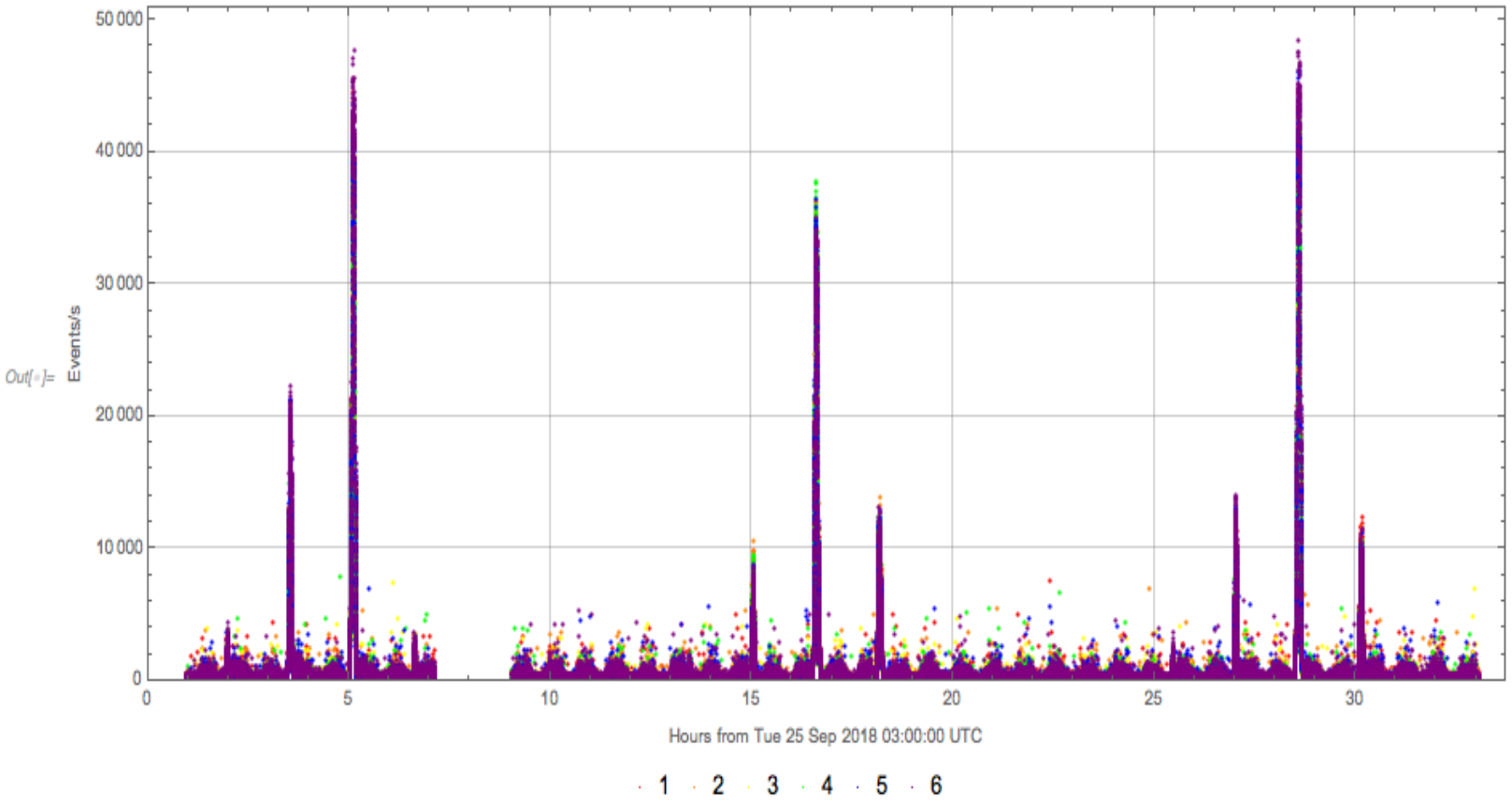

Plots are of return events/shot vs. sample number. Blue is the commanded value – represents the target number of photoelectrons/shot.Black is the expected number of events/shot, based on a deadtime model. Gray is uncertainty, partly from knowledge of the dead time but mostly from our ability to control the input. Red is observed events/shot

# Dark Count short time span (2 hours door closed)



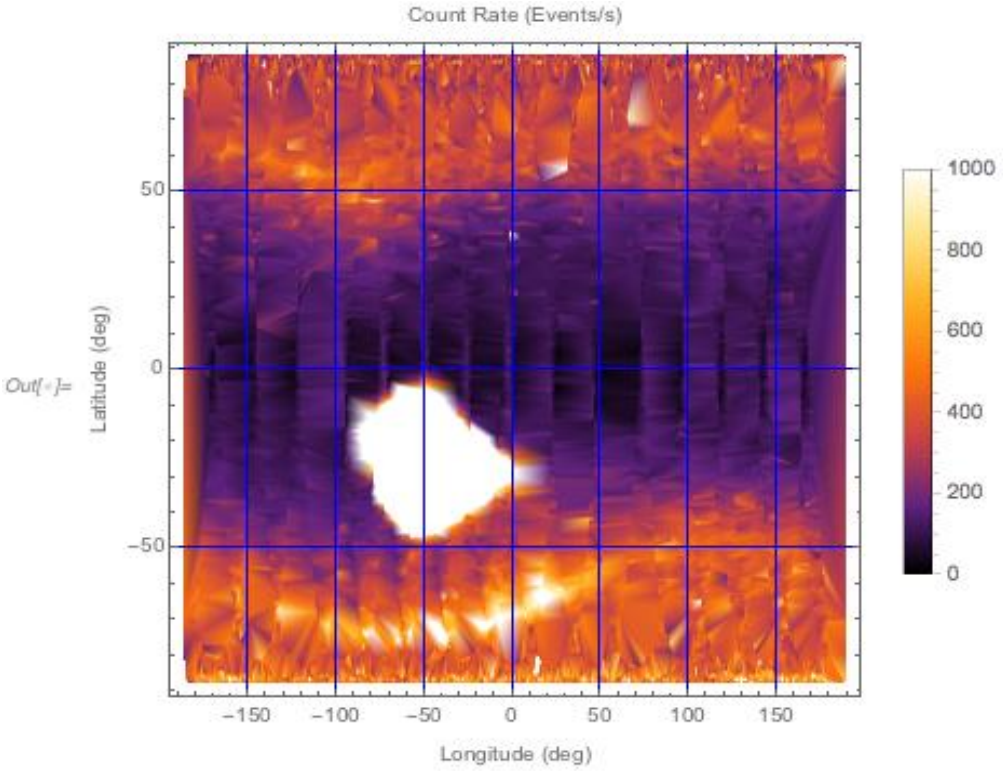

On orbit receiver dark count, x-axis is time in hours, y-axis in per track dark count rate in count per second. It shows true dark counts at the minimum (Colors ROYGBV correspond to Spots 1-6), at order of 300 CPS, it match the PMT data count rate.

# Dark Count Long time span (30 hours door closed)



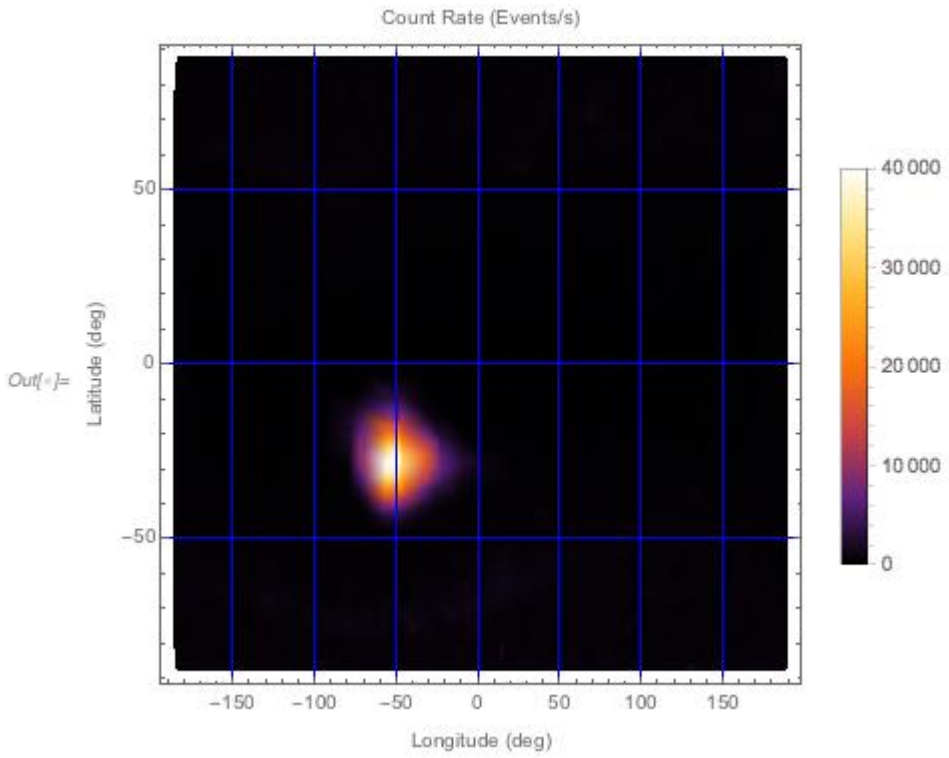

On orbit receiver dark count, x-axis is time in hours, y-axis in per track dark count rate in count per second. This long span count rate over 30 hours shown two types of peaks, a high spike over 20,000 CPS, and low humps at order of 800 CPS.

# Count from stray light at high latitudes




The count rate plot as geographic distribution. The lower humps in figure 5 is due to the stray light getting in at high latitudes. The high spike in figure 5 is due to the South Atlantic Anomaly, where charged particles induced count rate increase in the receiver

# Count from charged particles at the South Atlantic Anomaly




The count rate plot as geographic distribution. The lower humps in figure 5 is due to the stray light getting in at high latitudes. The high spike in figure 5 is due to the South Atlantic Anomaly, where charged particles induced count rate increase in the receiver

# Conclusions

- ICESat2-ATLAS multi-channel photon counting detectors have been successfully deployed in the space and operate normal.
- It has survived satellite launch shock and vibration.
- The in space receiver performance data are presented and compared with the on ground testing data.
- The dark count rate in space matches the on ground testing data at the order of ~400 CPS for each spot.
- Higher dark count rates are also observant