

Development of CubeSat Spacecraft-to-Spacecraft Optical Link Detection Chain for the CLICK B/ C Mission

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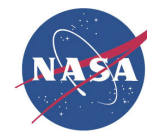
CrossTracEngineering:

John Hanson

- Introduction
- Avalanche Photodiode (APD) Receiver System
- Time-to-Digital Converter (TDC) System
- CLICK Mission Timeline Update

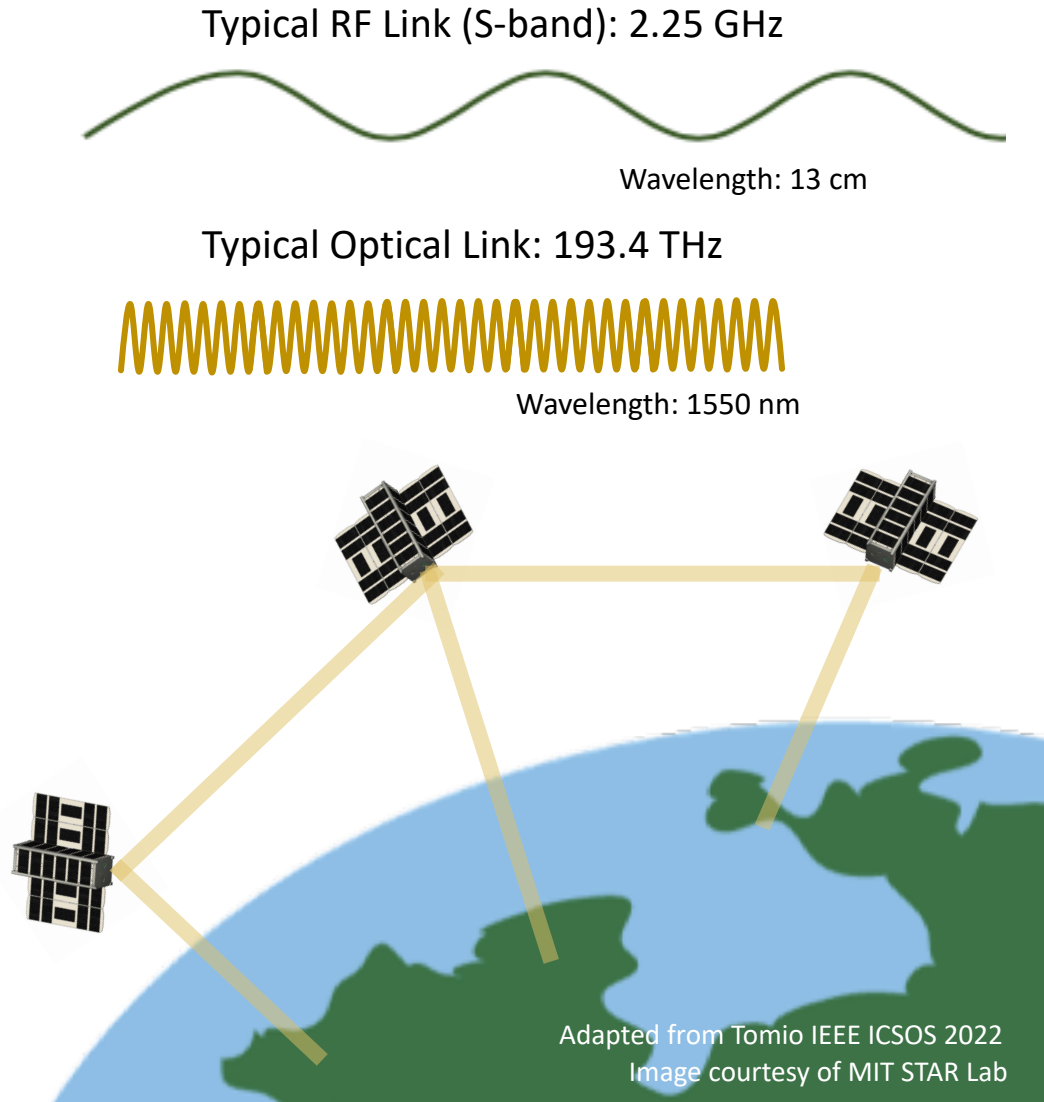
CLICK: CubeSat Laser Infrared Crosslink mission

Motivation



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- Laser communication advantages over radio freq. (RF):
 - Lower size/weight/power (SWaP) than RF terminals of similar performance
 - More secure (less divergence)
- Future constellations:
 - Mbps-rate full-duplex crosslinks
 - Precision ranging and timing
- **Goal:** develop CubeSat SWaP-level optical transceiver from COTS components
COTS: commercial off-the-shelf



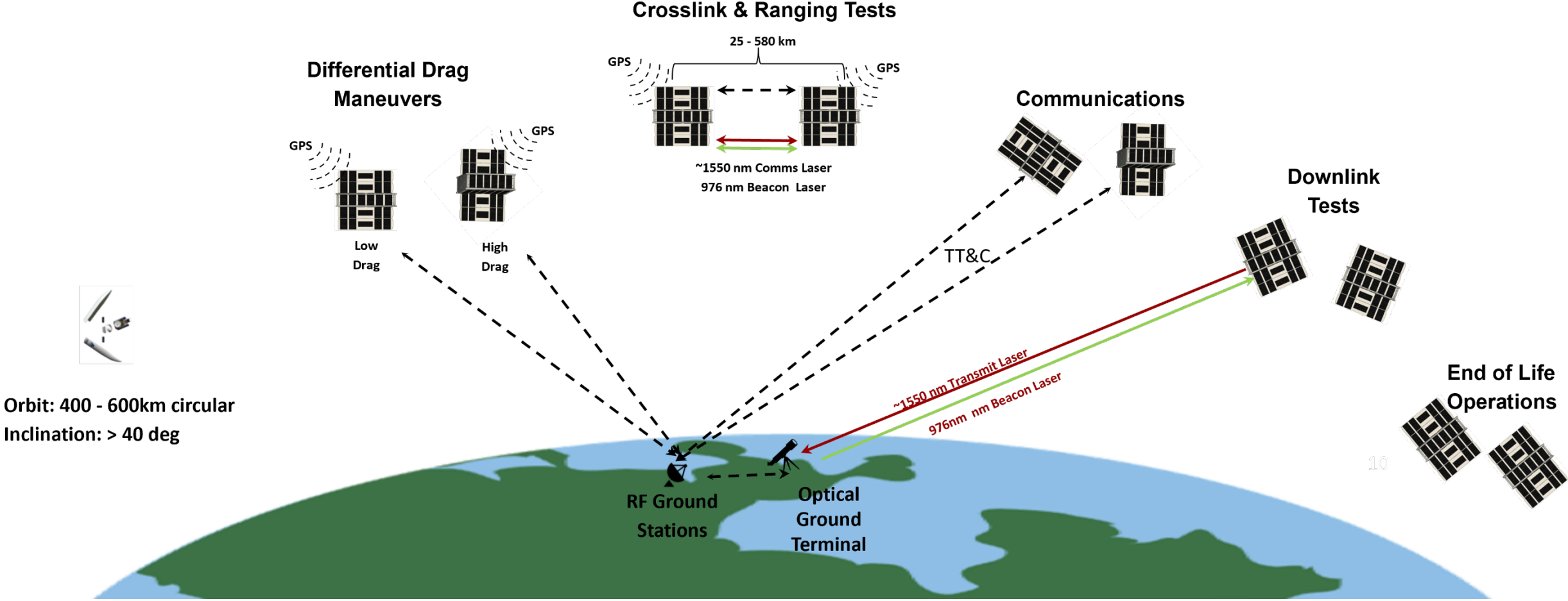
- Pair of identical 1.5U payloads
 - Downlink and crosslink capabilities
 - SWaP: 1.5 kg payload, < 30 W (operational)
- **Mission Objectives**
 - Crosslink range: 25 km – 580 km
 - Full-duplex crosslink ≥ 20 Mbps
 - Ranging error < 0.5 m



CLICK-B/C CONOPS



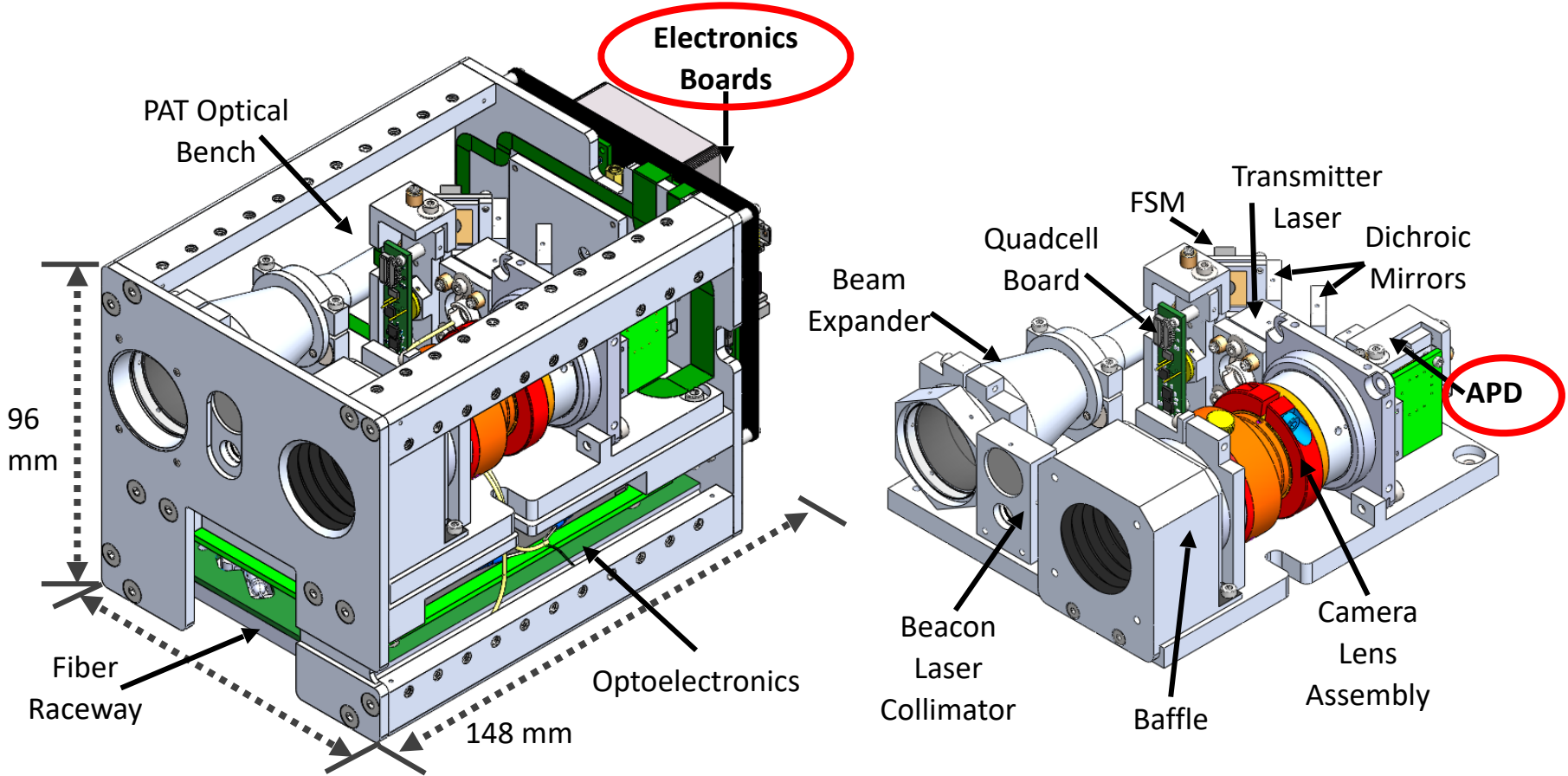
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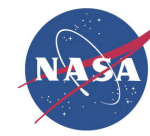
CLICK-B/C Payload



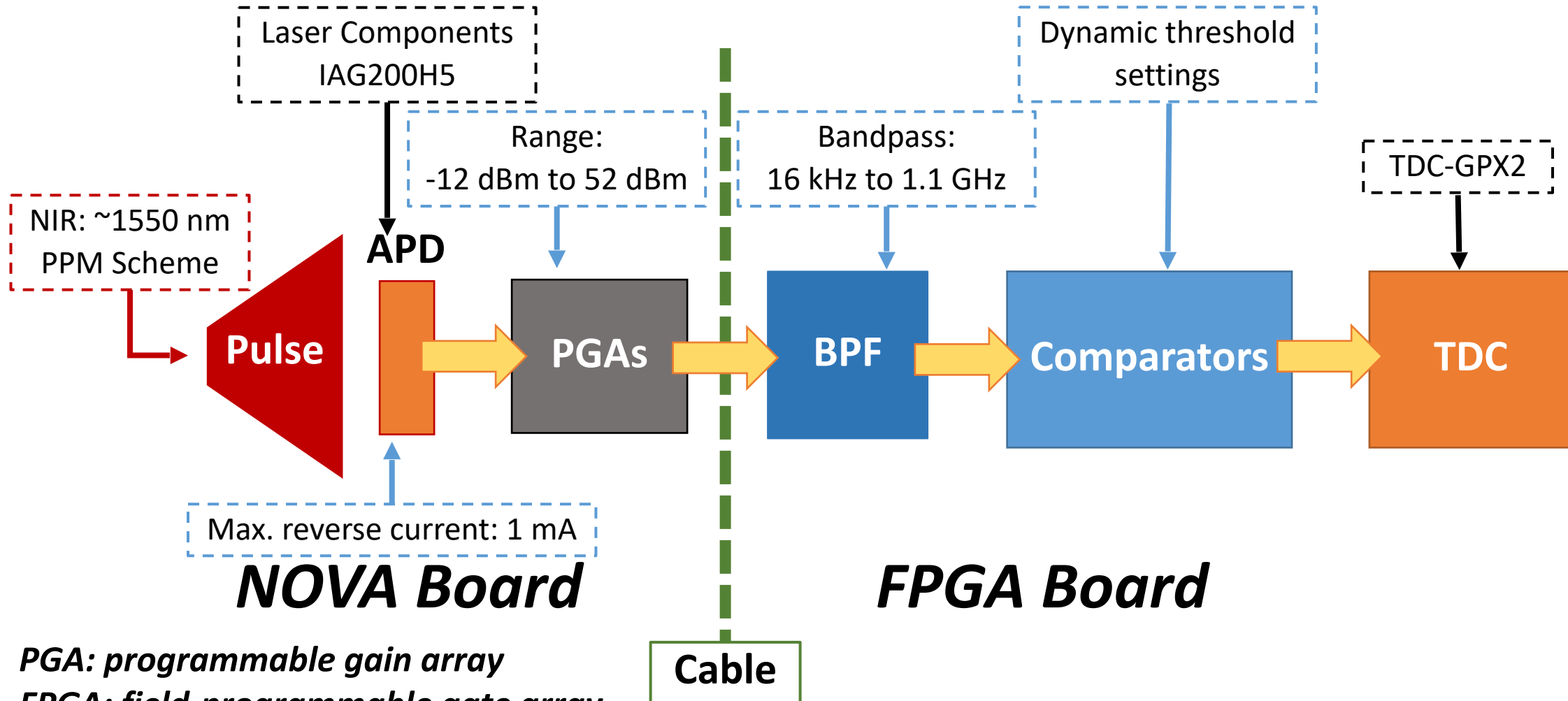
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Full APD Rx Chain

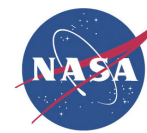


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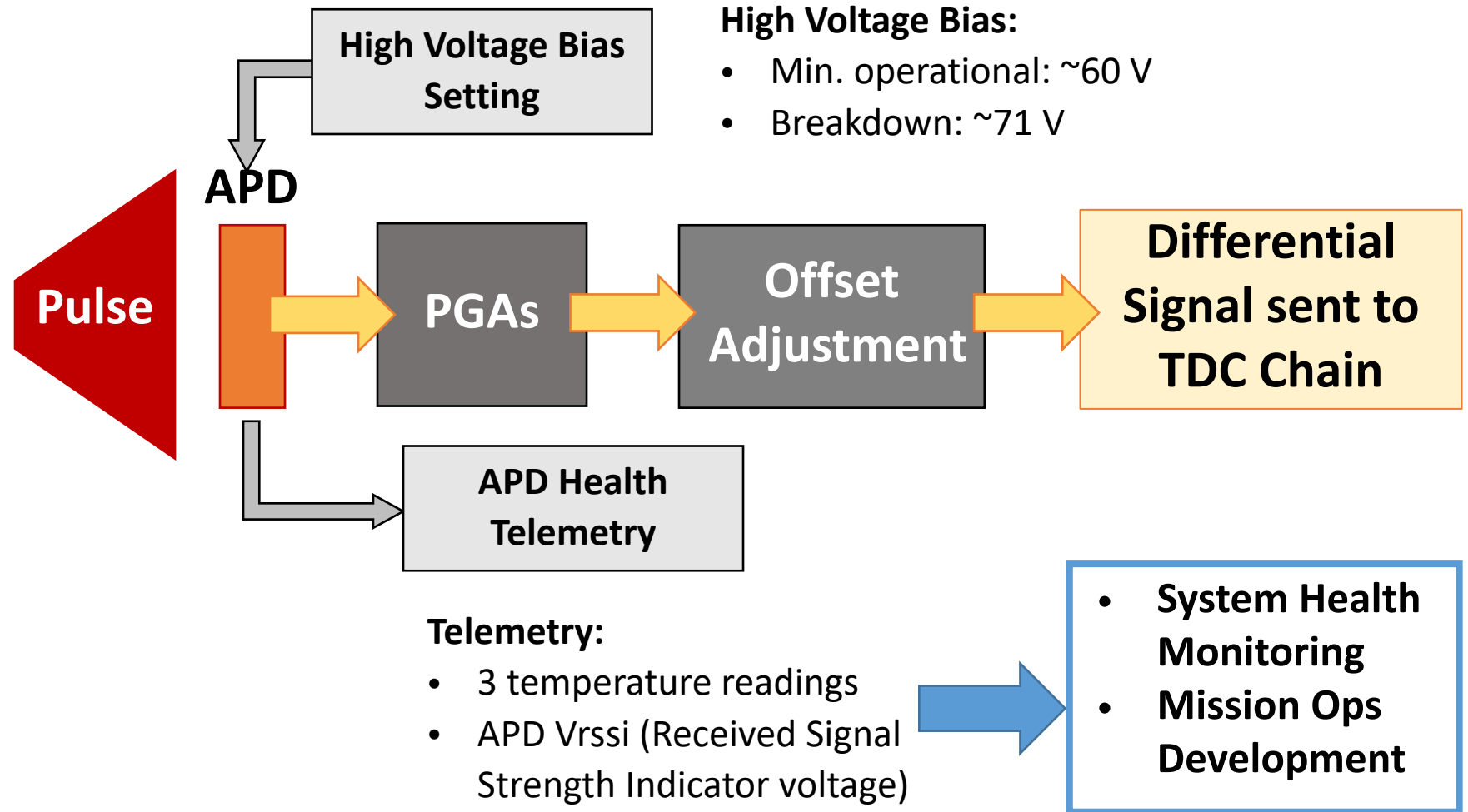


PGA: programmable gain array
FPGA: field-programmable gate array
BPF: bandpass filter
NOVA: Near-Infrared Detection with Variable Amplification

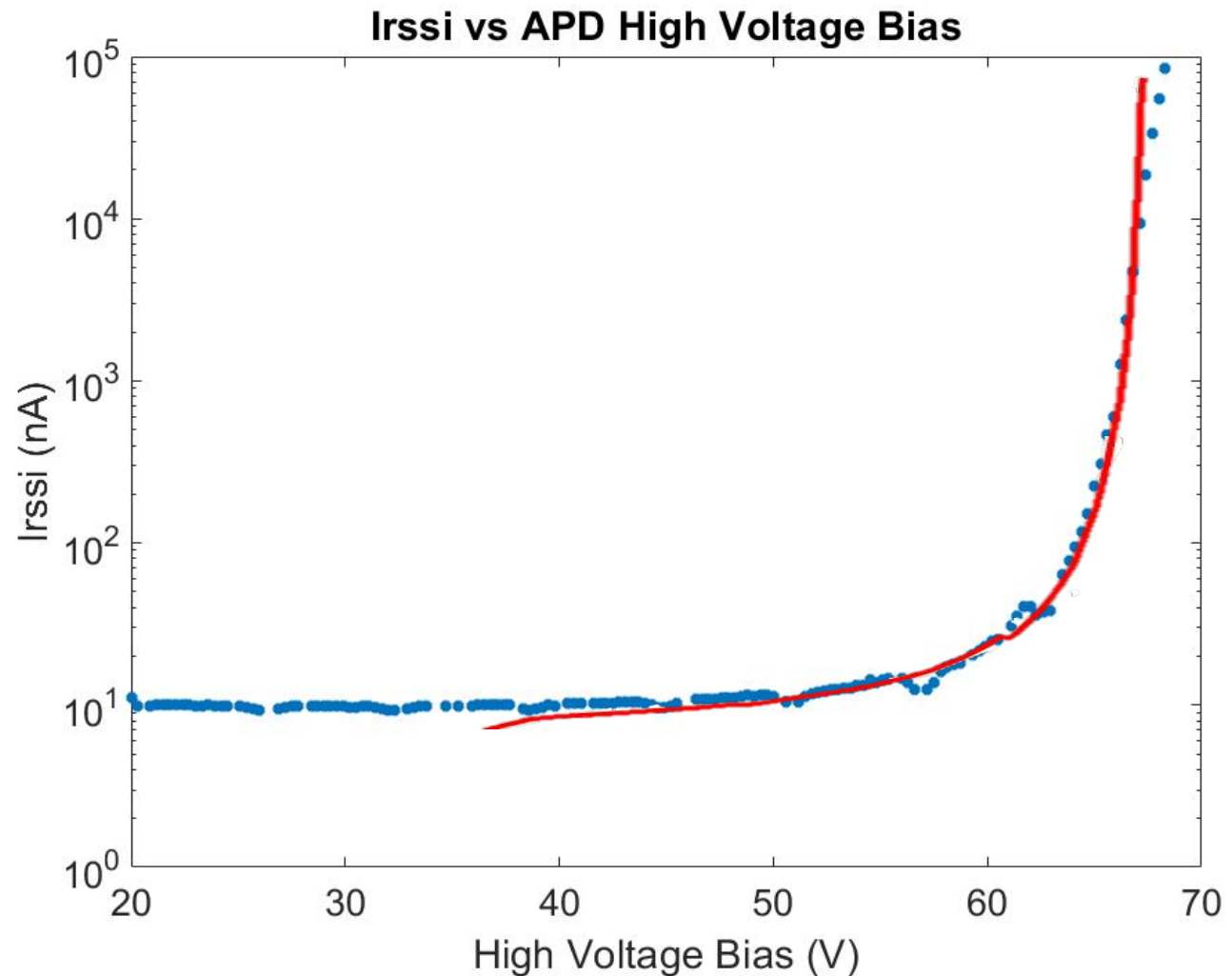
APD Chain Hardware



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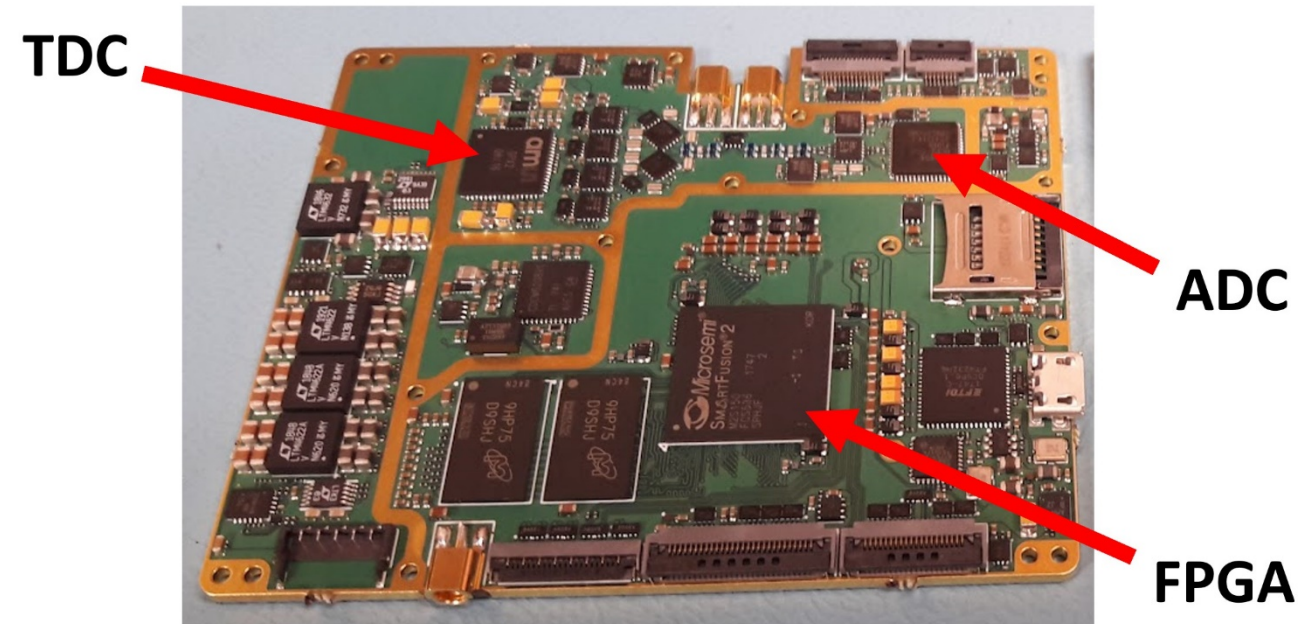
- Dark current measurement
Irssi follows expected
responsivity shape
- Datasheet nominal dark
current 25 nA at $M = 10$
 - Testing confirmed:
25.5 nA at $V_{\text{bias}} = 60.5 \text{ V}$
✓ Within V operational range
- Goal: model gain curve (M)
from data for calibration use



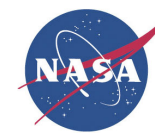
**rssi: received signal strength indicator*

TDC Chain Hardware

- Four events per detected optical pulse at two configurable thresholds (2x rising edge, 2x falling edge)
- FPGA decodes, synchronizes, and combines the four events into a timestamp
- Timestamps can be used for PPM Rx up to 50 Mbps
 - Precision Range: 6 cm
 - Precision Timing: < 200 ps

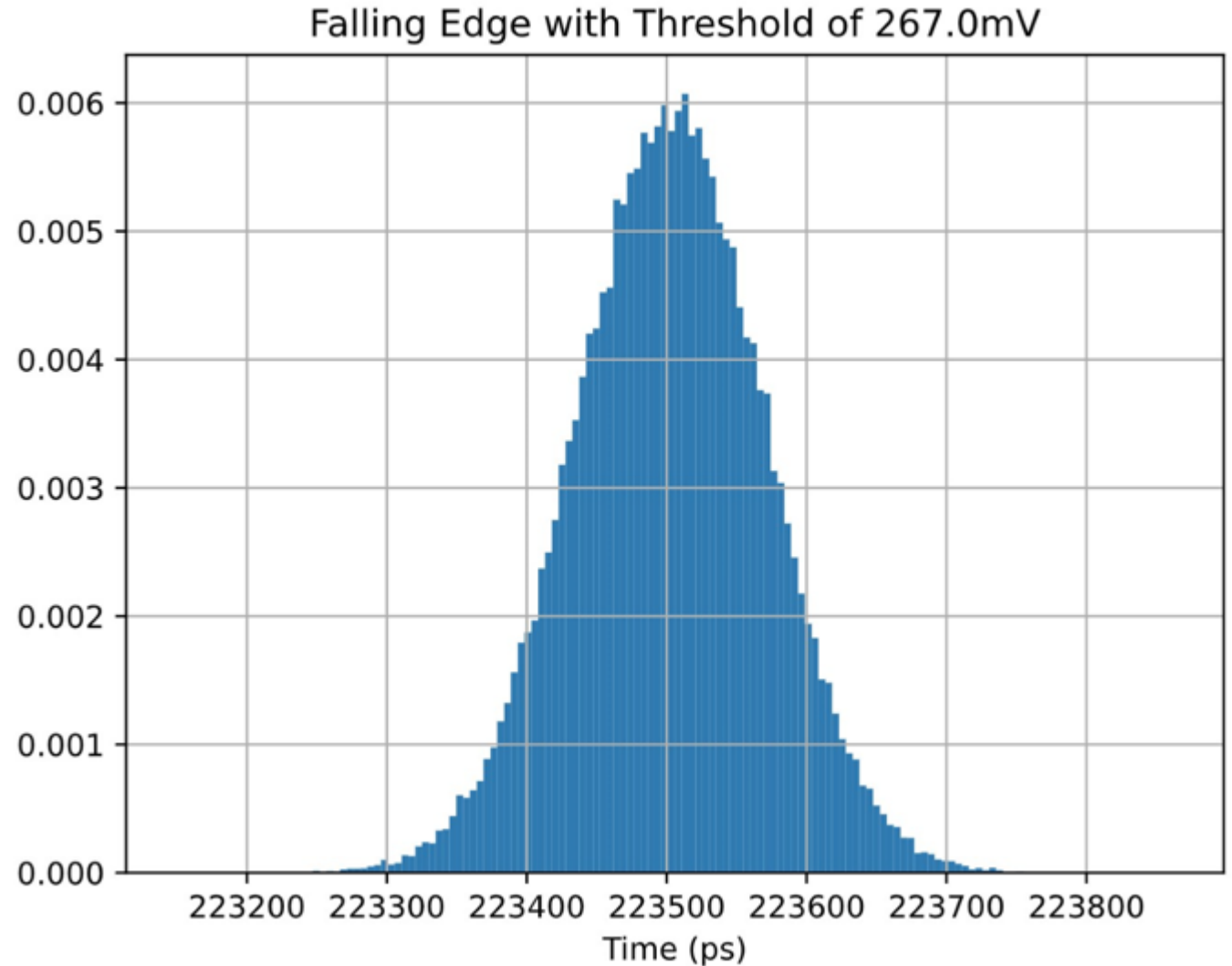
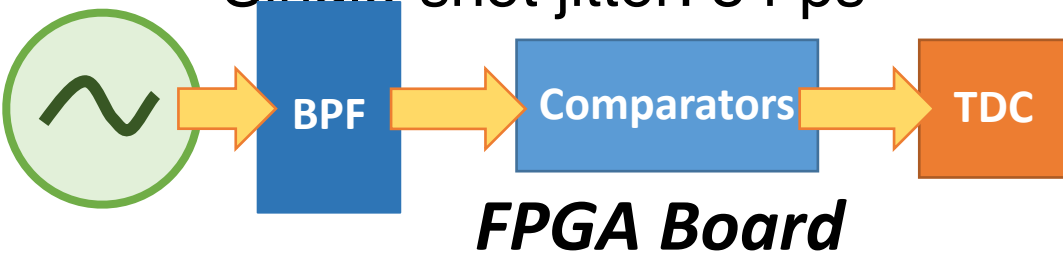


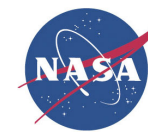
TDC Chain Performance Testing



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- Single channel triggering on falling edge
 - Input 4.5 MHz
 - Input from FPGA modulator, wired connection
 - Difference taken between adjacent timestamps
- Standard Deviation: ~76 ps
 - Single-shot jitter: 54 ps





- **CLICK A**

- Launched to ISS: July 14, 2022 (SpaceX CRS-25)

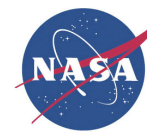
- Expected ISS deployment: September 2022

- **CLICK-B/C**

- Payload delivery to Blue Canyon Technologies: January 2023

- Bus delivery to Nanoracks: Summer 2023

- Launch to ISS: October 2023



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Thank you!

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