Measured Degradation in Solar EUV Spectrometers SOHO-CELIAS-SEM and SDO-EVE

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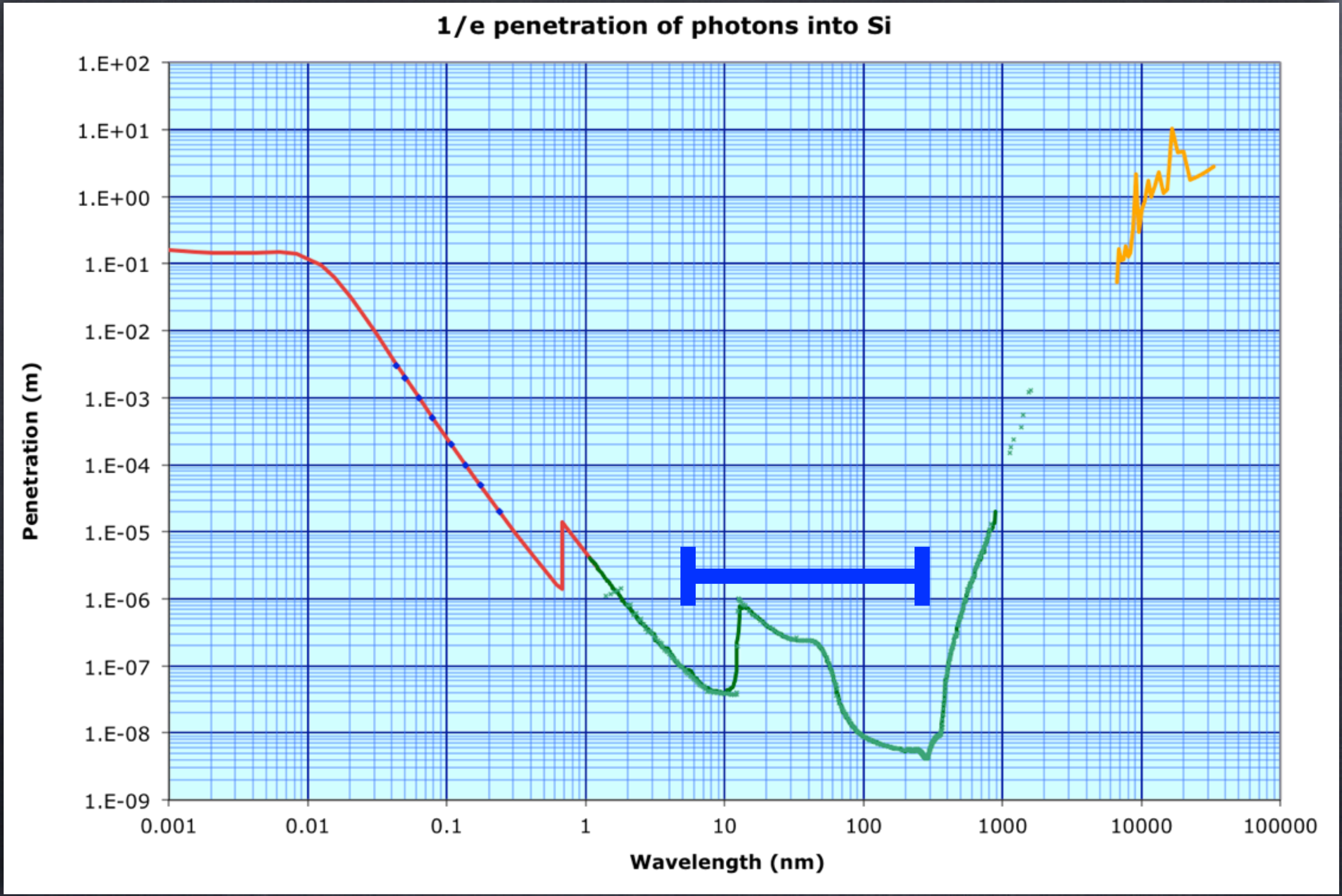
The Problem in EUV

- Photon penetration depth !

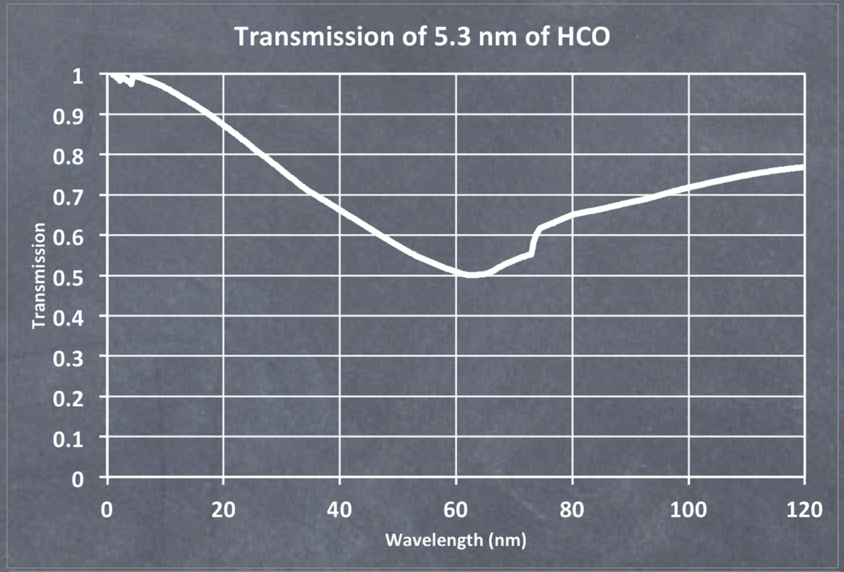


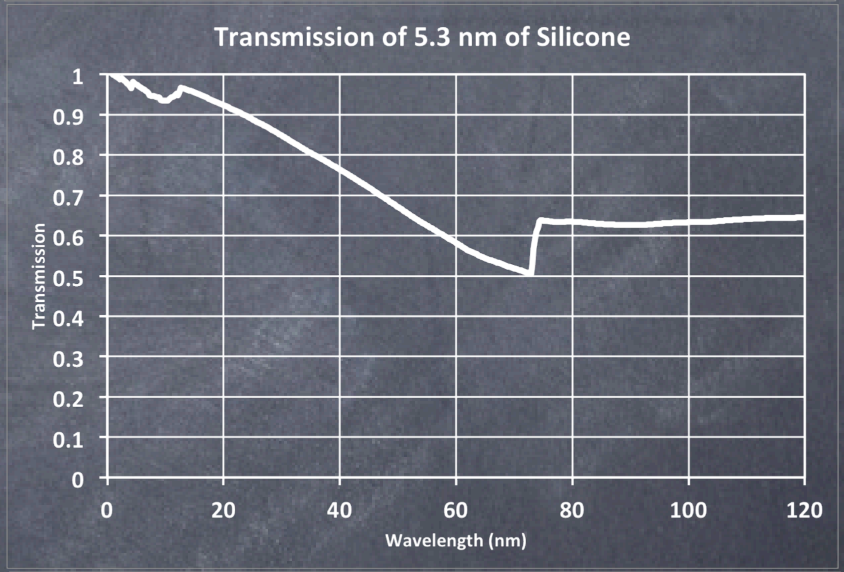
EUV Degradation

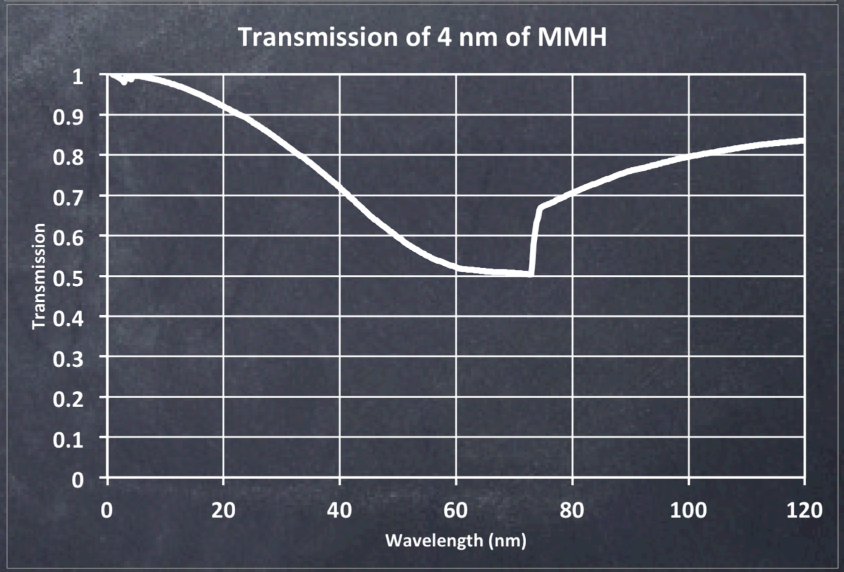
- Contamination
  - Hydrocarbons
  - Siloxanes (silicones, RTV)
  - Fuel
- Detector Degradation
- How do we track the Degradation?
  - Rocket Underflights
  - Multiple optical filters with different exposures
  - Pre-flight Calibration

Common Contaminants

- Hydrocarbons (C H O)
  - ~1.2 µg/cm[2] gives 50% attenuation ~62 nm
- Silioxanes (Silicones) (Si O C_3 H_6)
  - ~1.2 µg/cm[2] gives 50% attenuation ~72 nm
- Propellant (C H_6 N_2)
  - ~ 0.9 µg/cm[2] gives 50% attenuation ~72 nm



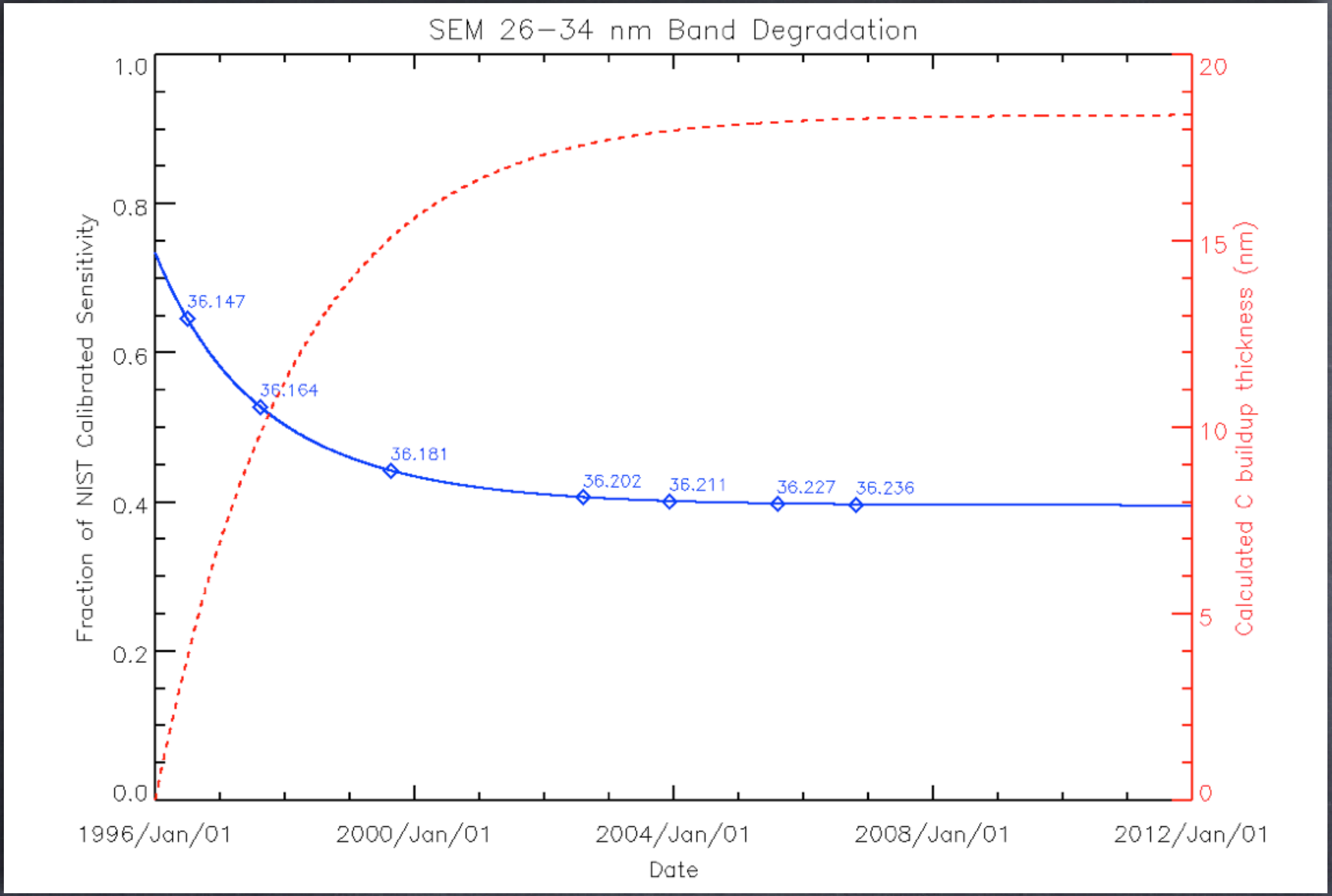




Instruments

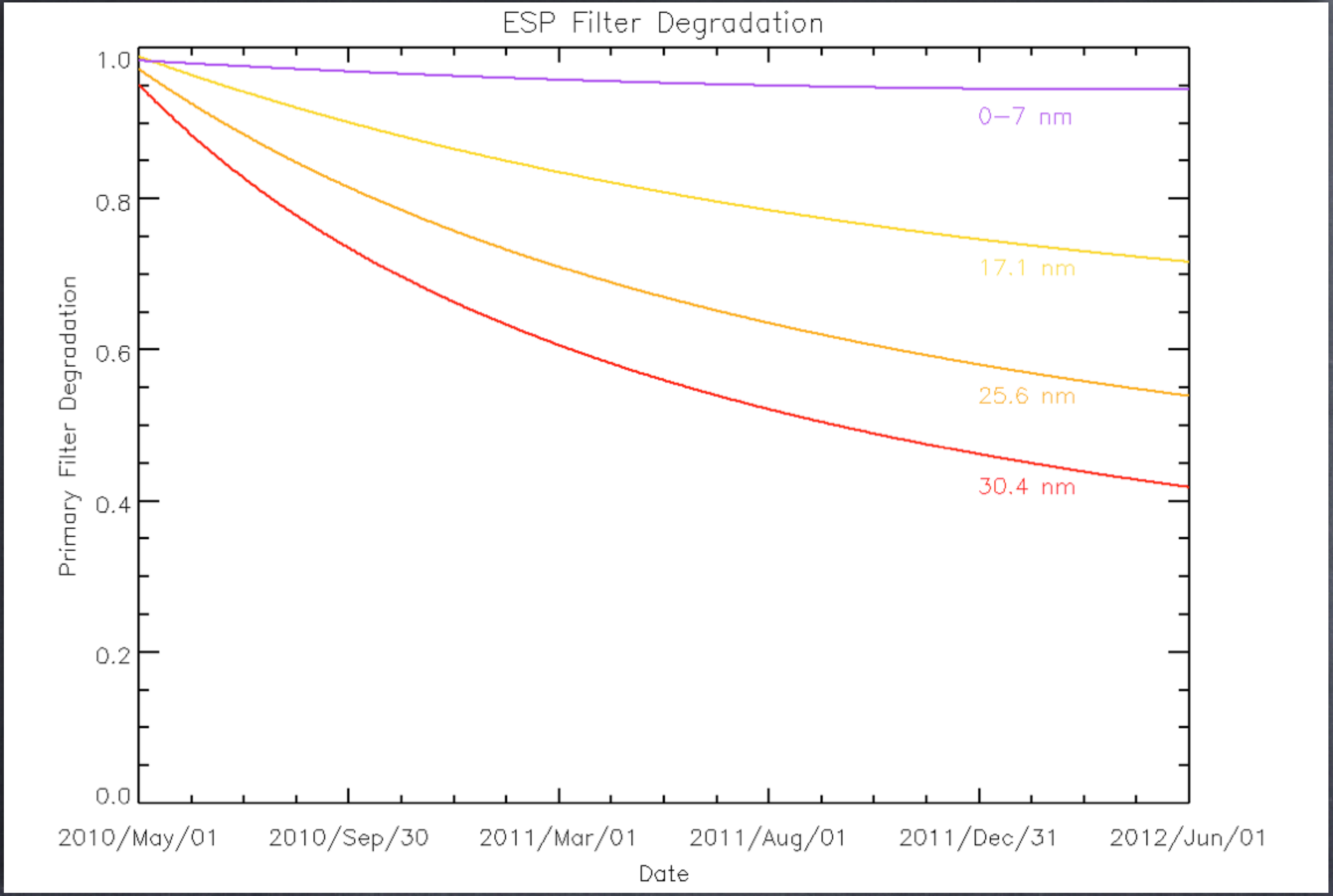
- SOHO-SEM:
  - Transmission grating spectrophotometer
  - Photodiode detectors
  - Single Al entrance filter
  - Sounding rocket calibration under flight program
- SDO-EVE:
  - Reflection (MEGS) and transmission (ESP) gratings
  - CCD and photodiode detectors
  - Filter wheels for all channels
  - Sounding rocket calibration under flight program

SEM Filter Degradation



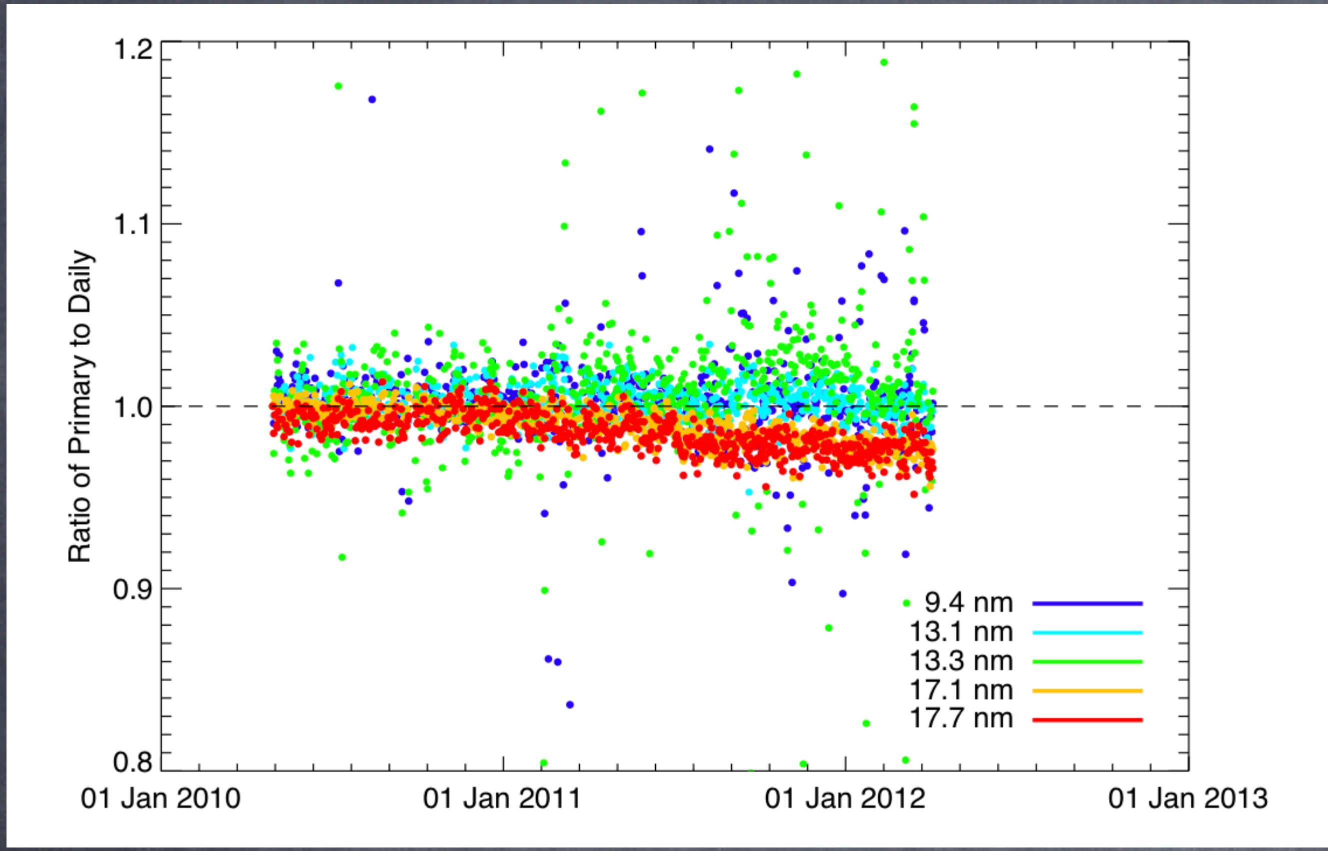
- Degradation tracked with sounding rockets
  - Modeled as C buildup
  - First-light degradation ~ 9 nm C

ESP Filter Degradation

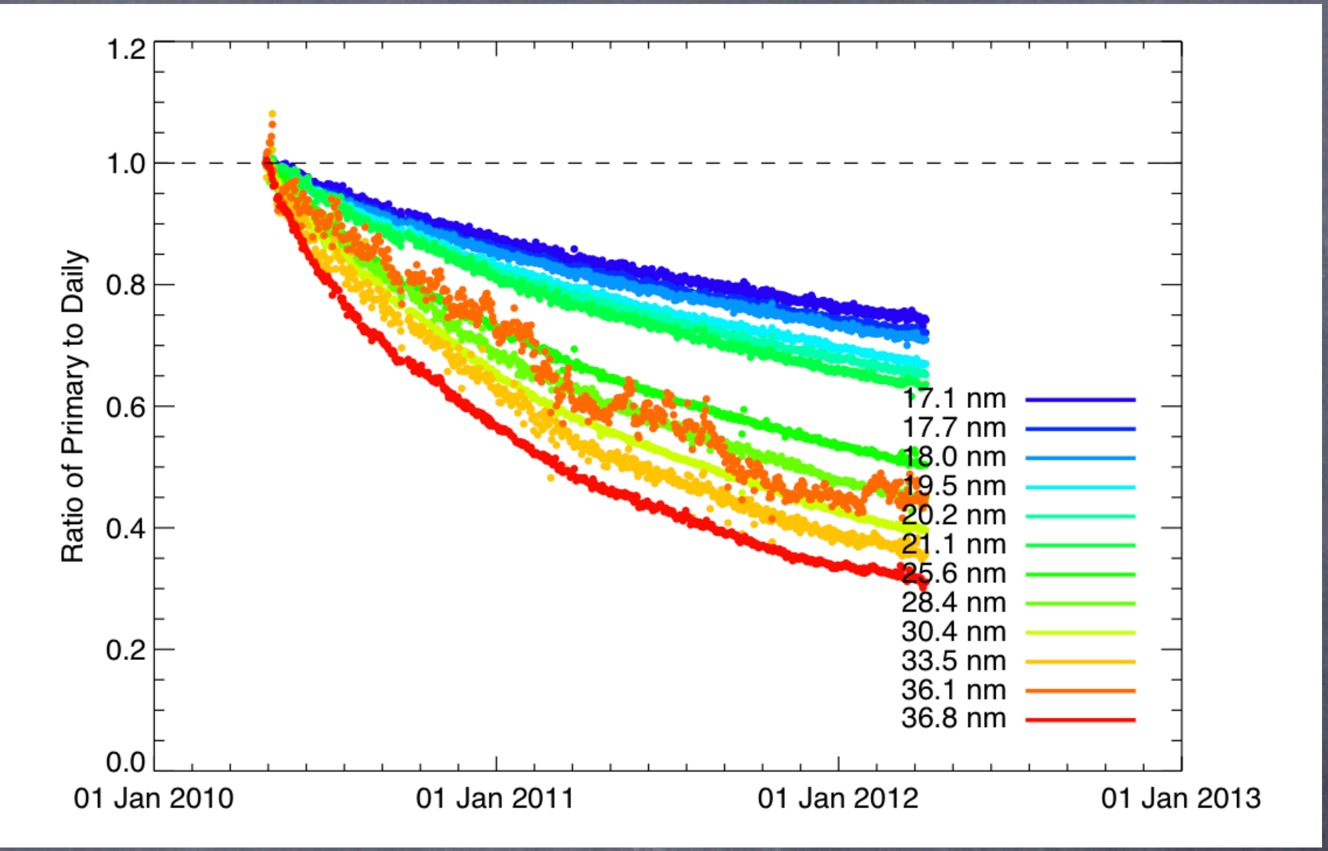


- Degradation tracked with sounding rockets and redundant filters
  - Consistent with absorption of ~25 nm C

MEGS Filter Degradation



A1: C/Zr/C filter

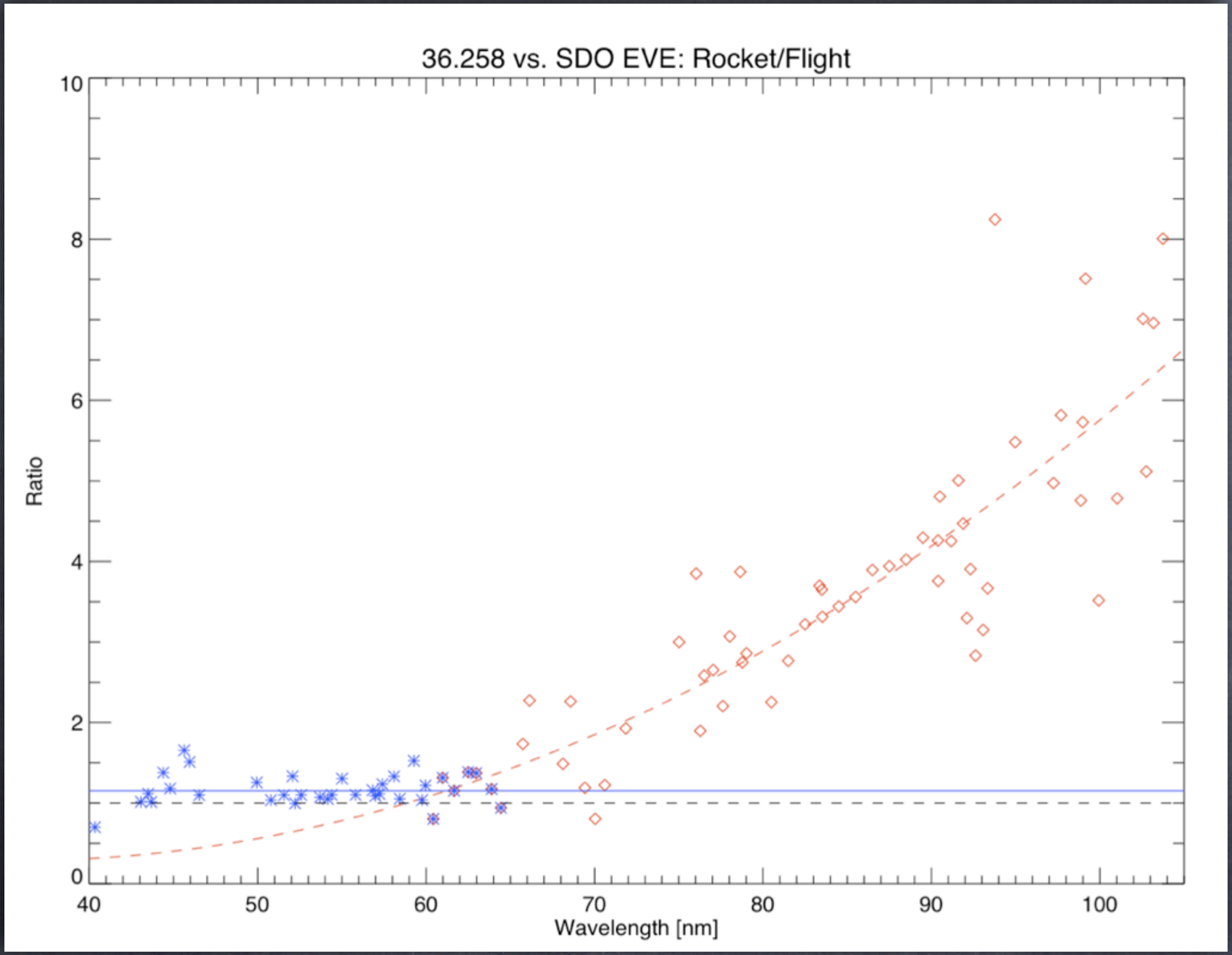


A2: Al/Ge/C filter

A2 consistent with hydrocarbon absorption and very similar to ESP

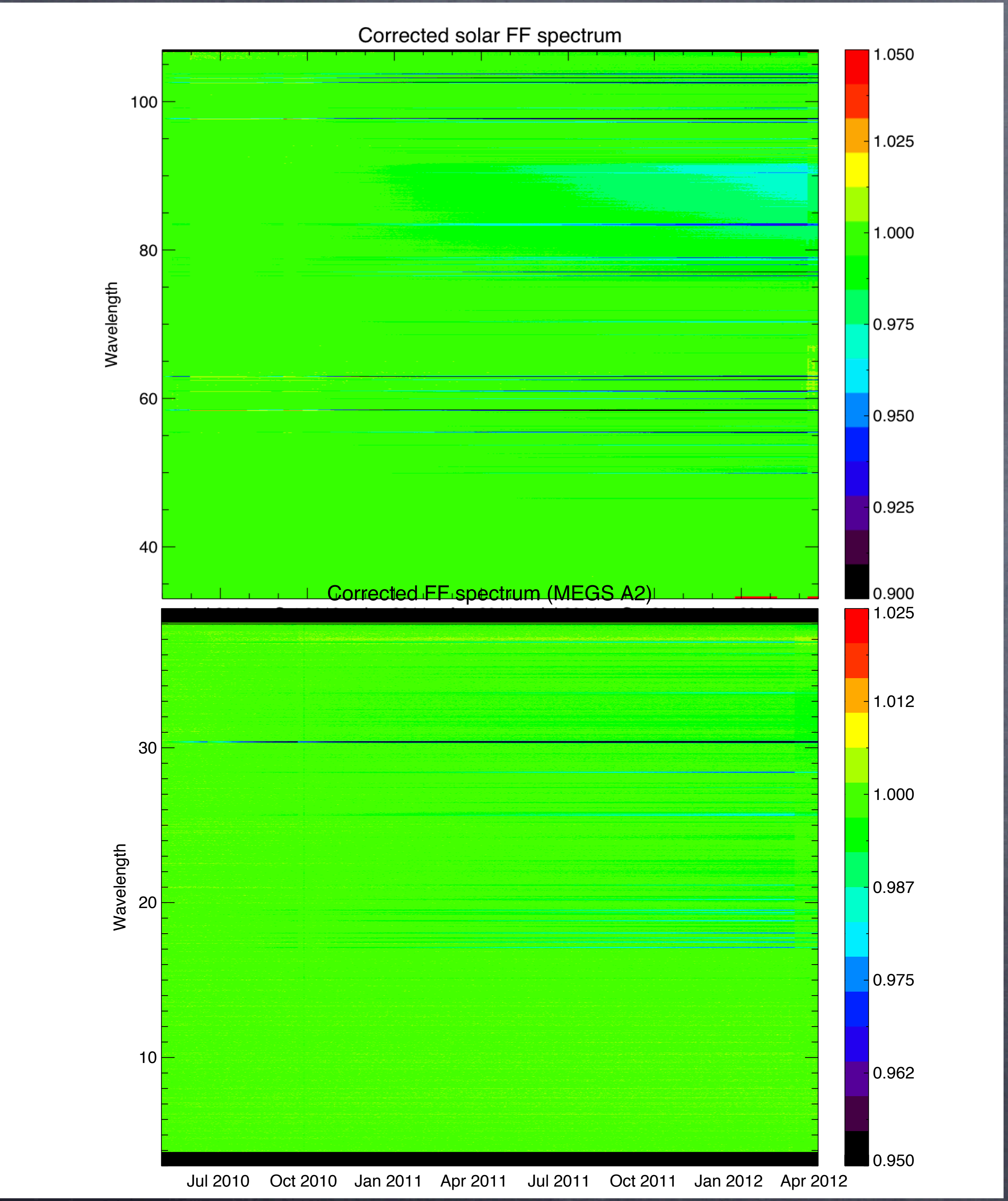
A1 <1% degradation even at 17 nm !

SDO-EVE CCD First-Light Degradation



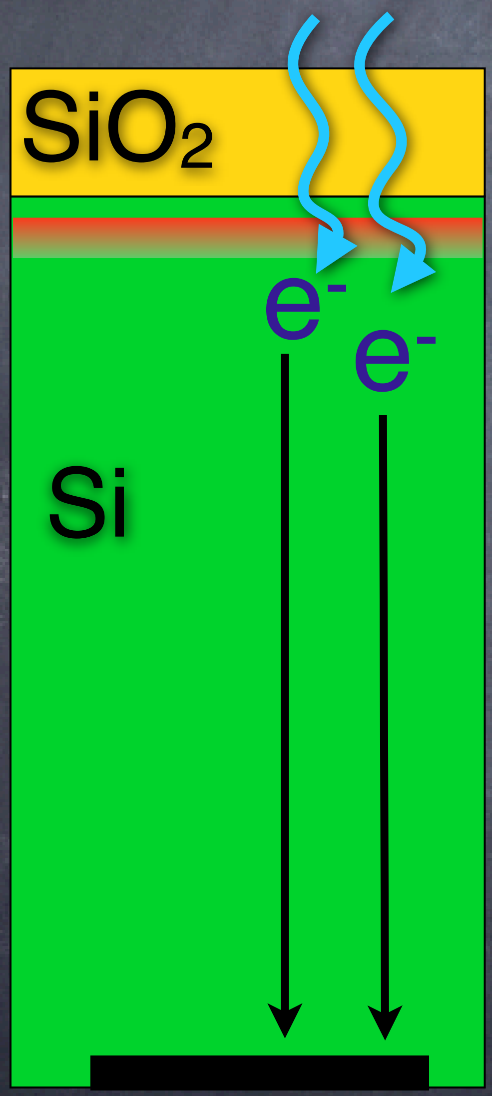
Consistent with Si absorption
due to dead-layer at the top of the CCD

SDO-EVE CCD Flat Fields



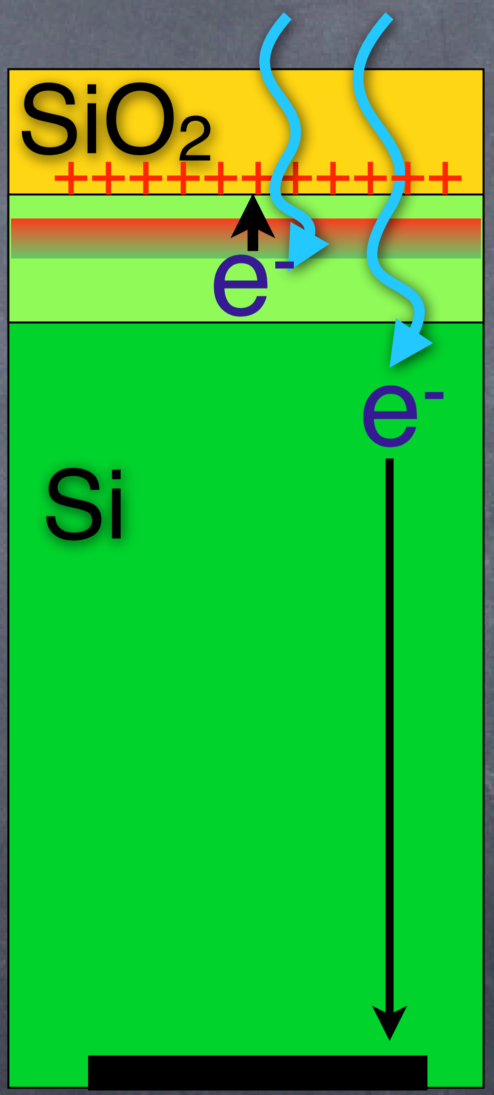
- Burn-in due to local surface charging
- Some recovery from bakeouts

CCD Back-Side Charge QE Reduction Mechanism



P-type implant deliberately creates ~7 nm 'dead-layer' to isolate the Si/SiO_2 interface

Charge Collection



Charge induced 'dead-layer' due to proton interactions extends 'dead-layer'

Further charging due to photon interactions continue to locally extend 'dead-layer'

Charge Collection

Lessons Learned

- No epoxies / silicones in the optical cavity or with path to optical cavity
  - Well... only clean ones (Stycast 2850, Scotchweld 2216)
- No oil pumps—anywhere anytime
- Meticulous cleanliness program: at instrument and spacecraft level
- Treat like a UHV system, bake all items and test for contaminants
  - Flex cables are easier to clean than harnesses
  - Careful with coatings (no organics, temperature limits etc.)

LESSONS LEARNED -2

- Constant N2 purge (we use filtered N2 dewar boil-off)
  - Instrument
  - Optics / subassembly storage
  - Make sure the tubing is clean too
- Constant monitoring (witness samples, RGA, TQCM...)
- Consider radiation damage in risk assessments
- Fly calibration rocket as soon as possible after start of mission

NASA Suggestions from SSI Validation Workshop

- Have vents towards anti-Sun side and out past any radiator plate
- Provide means to warm up optics and detectors during flight
- Fly a cold trap / cold plate near sensitive optics
- Fly a TQCM (Thermoelectric Quartz Crystal Microbalance) to monitor contamination deposition rate real-time during flight
  - Important for early orbit commissioning and any propulsion use

FUTURE WORK

- Understand difference in Zr and Al filter behavior
- Continue to refine EVE and SEM degradation models
- Collaboration with other instruments / missions

Resources

- CXRO-Henke
- HOCS-Palik
- NIST: X-Ray Form Factor, Attenuation and Scattering Tables (FFAST)
- NIST: Photon Cross Section Database (XCOM)