ACIS RADIATION DAMAGE AND ON-ORBIT BACKGROUND

I Initial Radiation Damage
II Background "Flares"
III Is CTI continuing to increase ?
IV Future Prospects

THE CONTRIBUTORS

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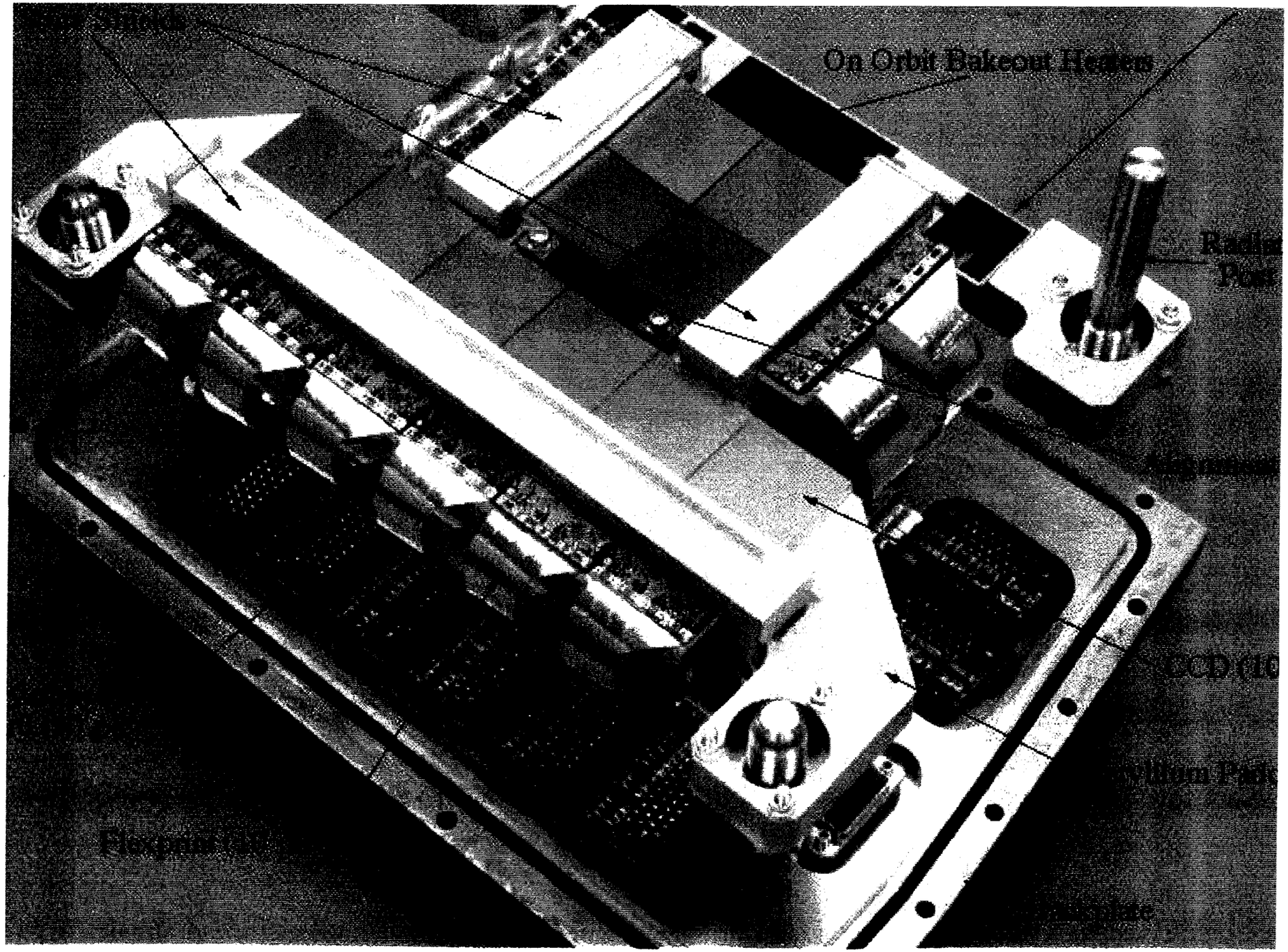
INITIAL DAMAGE EARLY IN THE MISSION

- ACIS–S was at the "launch-lock" position, launch on DOY 204 (1999)
- First measurements of internal Fe55 source were nominal on DOY 210
- ACIS Door opened on DOY 220 and Aft Contamination Cover of HRMA opened on DOY 223
- Measurements of calibration sources on the Forward Contamination Cover (FCC) were nominal on DOY 224 (see Elsner *et al.* SPIE 2000)
- FCC opened late on DOY 224, first light with ACIS, first unprotected perigee passage on DOY 225
- ACIS-S at focus for 5 perigee transits, ACIS-I for 3 perigee transits, and ACIS-S/HETG for 2 perigee transits
- Large increase in CTI discovered on DOY 250, DOY 257 was the last "unprotected" perigee transit and DOY 260 was the last ACIS-S/HETG perigee transit


On Orbit Bakeout Heaters

SIM Translation Direction

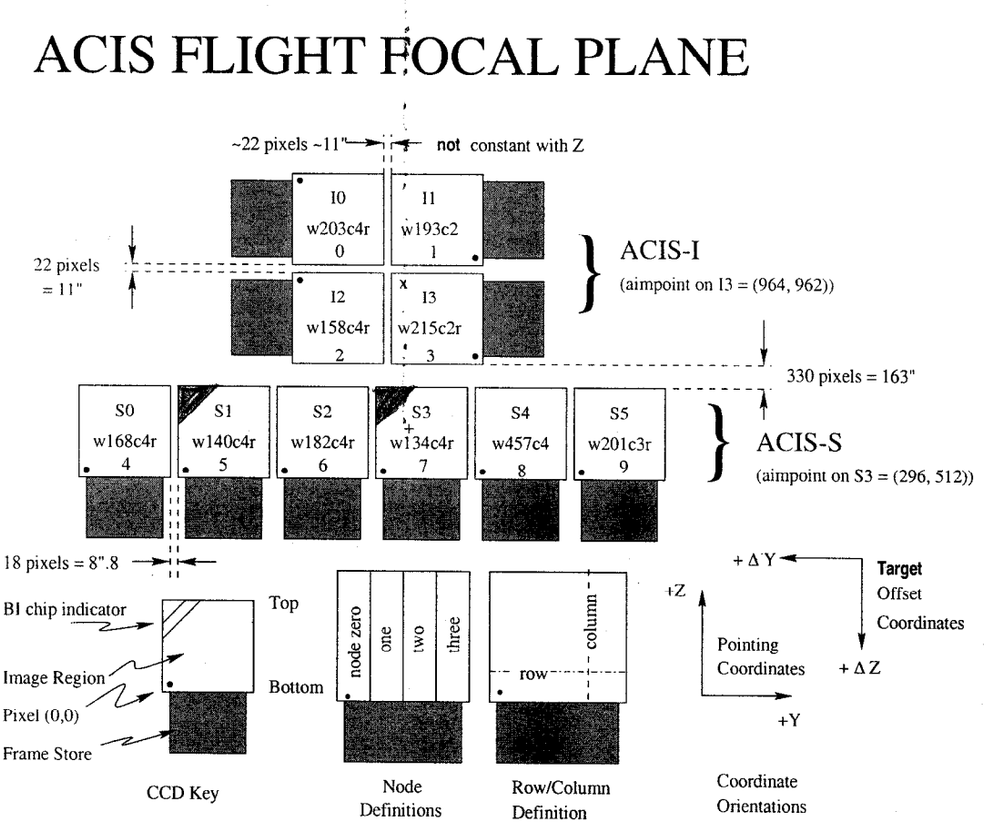
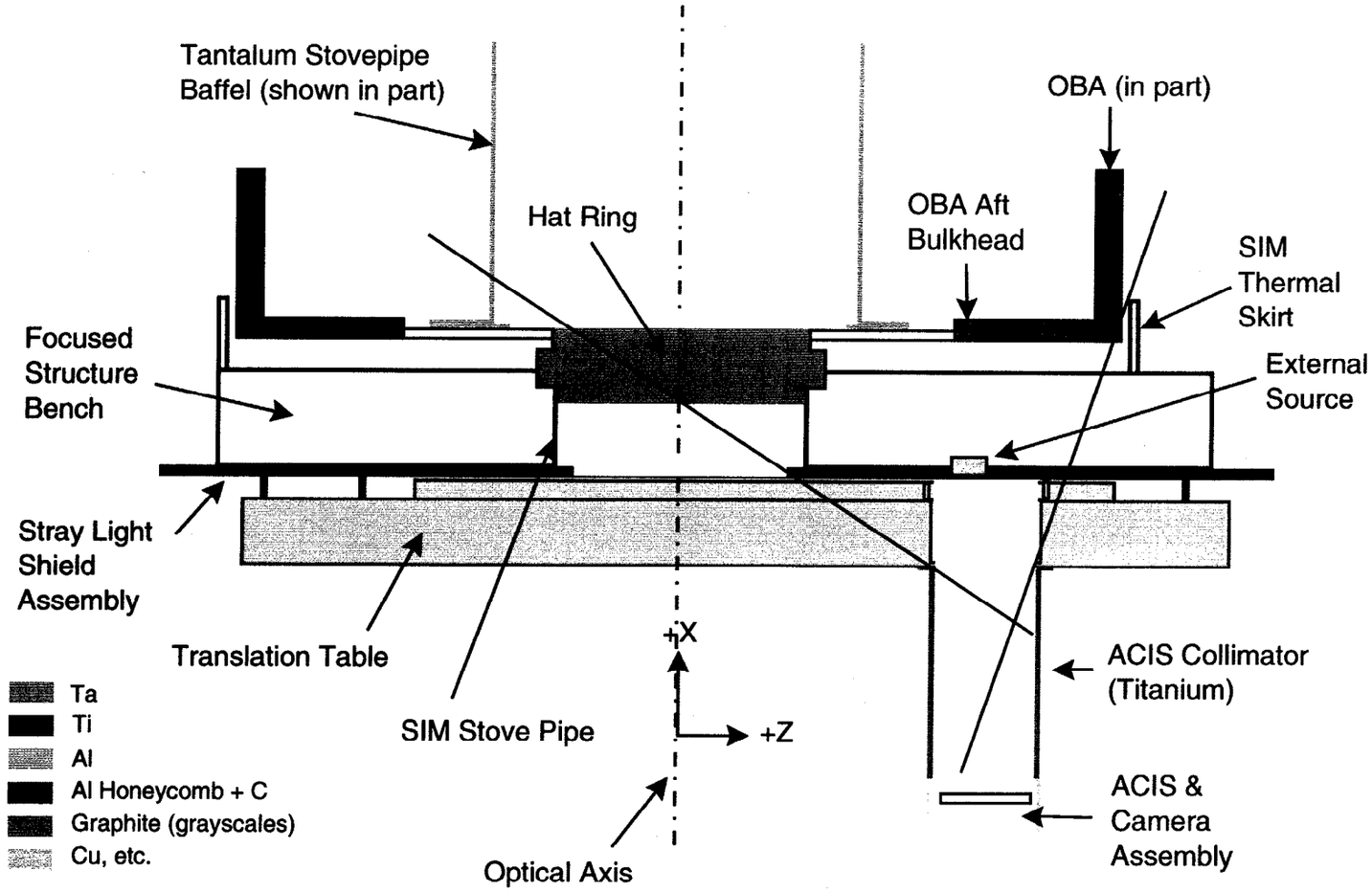


Figure 2.1: A schematic drawing of the ACIS flight focal plane; the key to CCD terminology is shown in the lower left. Note the nominal aimpoints: on S3 (the '+') and on I3 (the 'x'). Note the also the differences in the orientation of the I and S chips, important when using Subarrays (Section **??**. Note the difference between the (Y, Z) coordinate system and the **target offset** system. The view is along the optical axis, from the source towards the detectors, (-X). The numerous ways to refer to a particular CCD are indicated: chip letter+number, chip serial number, and ACIS chip number. The node numbering scheme is illustrated lower center.

BI CCDs



Geometry of Key Structures in ACIS Radiation Shielding Model (Approximately to Scale)

Shown in HRC-S observing position with two critical light paths drawn: Through the Focused Structure Baffle and through the 'light gap' between SIM Thermal Skirt and the OBA. The Thermal Skirt is a ring circling the OBA Aft Bulkhead

--Focal Plane (FP) to top of Hat Ring is 28.5 in.

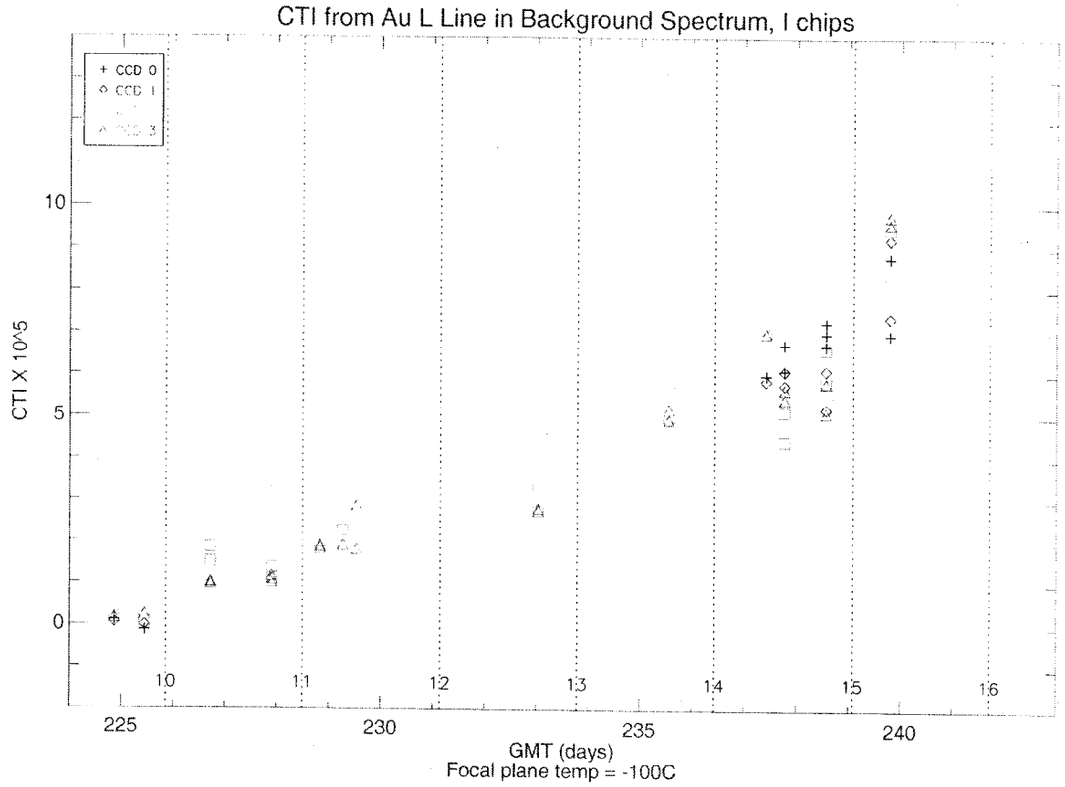
--FP to Stray Light Shield Assembly is19.75 in.

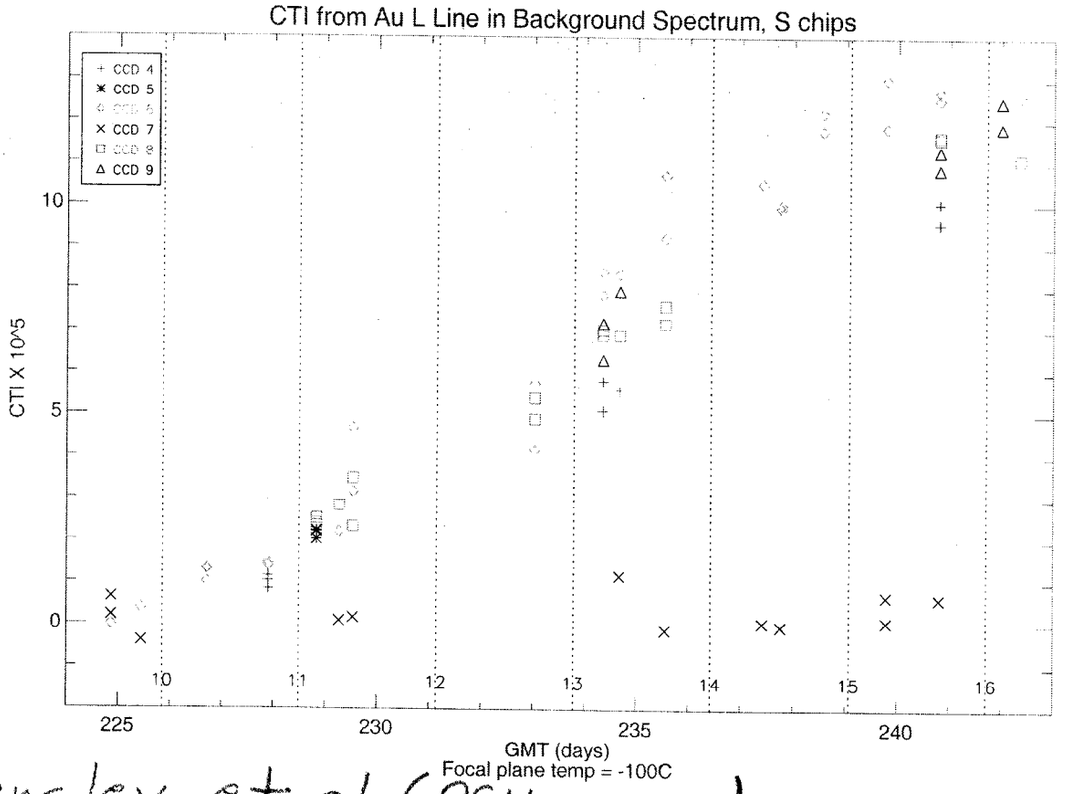
--The Tantalum Stovepipe extends 88.75 in. above FP

--The Titanium Collimator is 12.8 in. in height.

CHARACTERIZATION OF THE DAMAGE

- All 8 FI CCDs exhibit a large increase in CTI, damage is restricted to the imaging region, the framestore regions are unaffected
- Both BI CCDs show no change
- S0 CCD shows the largest increase in CTI, I0 and I1 show the least
- Presumably highest flux of damaging radiation was *not* on-axis and pattern is not azimuthally symmetric (S0 worse than S5)
- No increase in the dark current of the FI CCDs
- Irradiation of flight-like CCDs with 100-150 keV protons produces similar damage
- Prigozihn *et al.* (SPIE 2000) identify 4 types of traps, two with timescales of tens to hundreds of μs, one with hundreds of ms, and a long time constant trap on the order of seconds
- Kolodziecjzak *et al.* (SPIE 2000) simulated the scattering of protons off the HRMA and transmission to the focal plane, they conclude it is plausible but their model underpredicts the damage by a factor of 3-4 and preliminary ground measurements indicate the scattering efficiency is not high enough





Townsley et al. (PSU memo)

Figure 6: Plot of the CTI over time from the Au L line, for the entire I (top) and S (bottom) arrays. Earlier orbits are presented here. These data cover the time period of roughly 13 August (Day 225) to 31 August (Day 243) 1999.

Lallam et al (MIT memo)

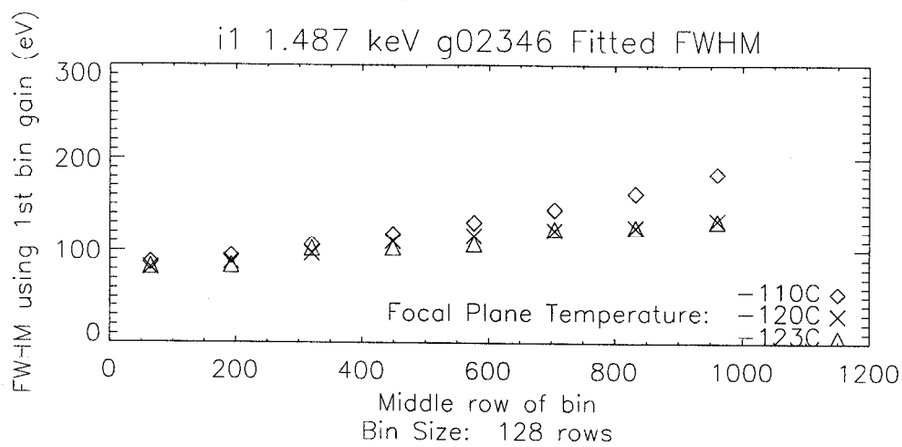


Figure 4: Front-illuminated Detector I1 Resolution Vs Row Number, 1.487keV

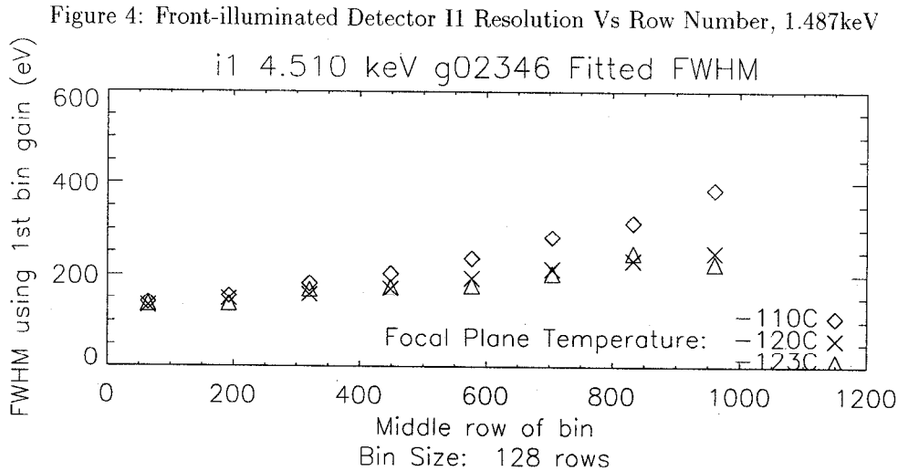


Figure 5: Front-illuminated Detector I1 Resolution Vs Row Number, 4.510keV

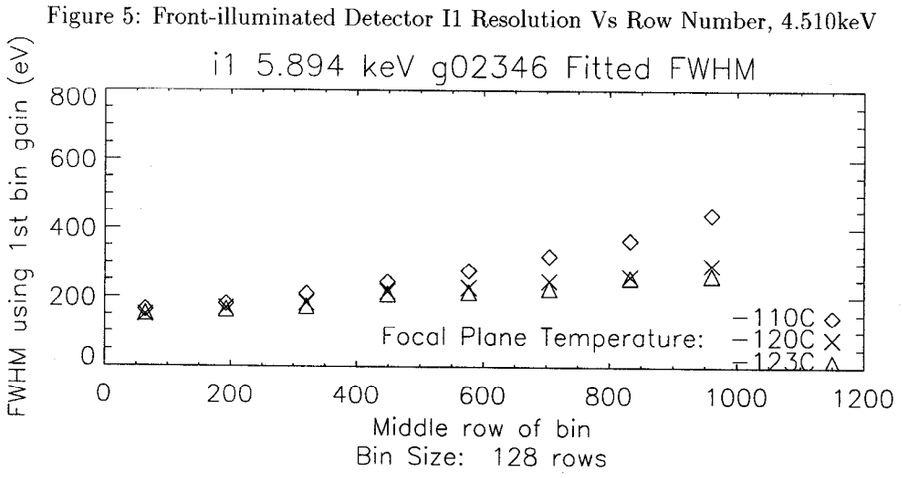
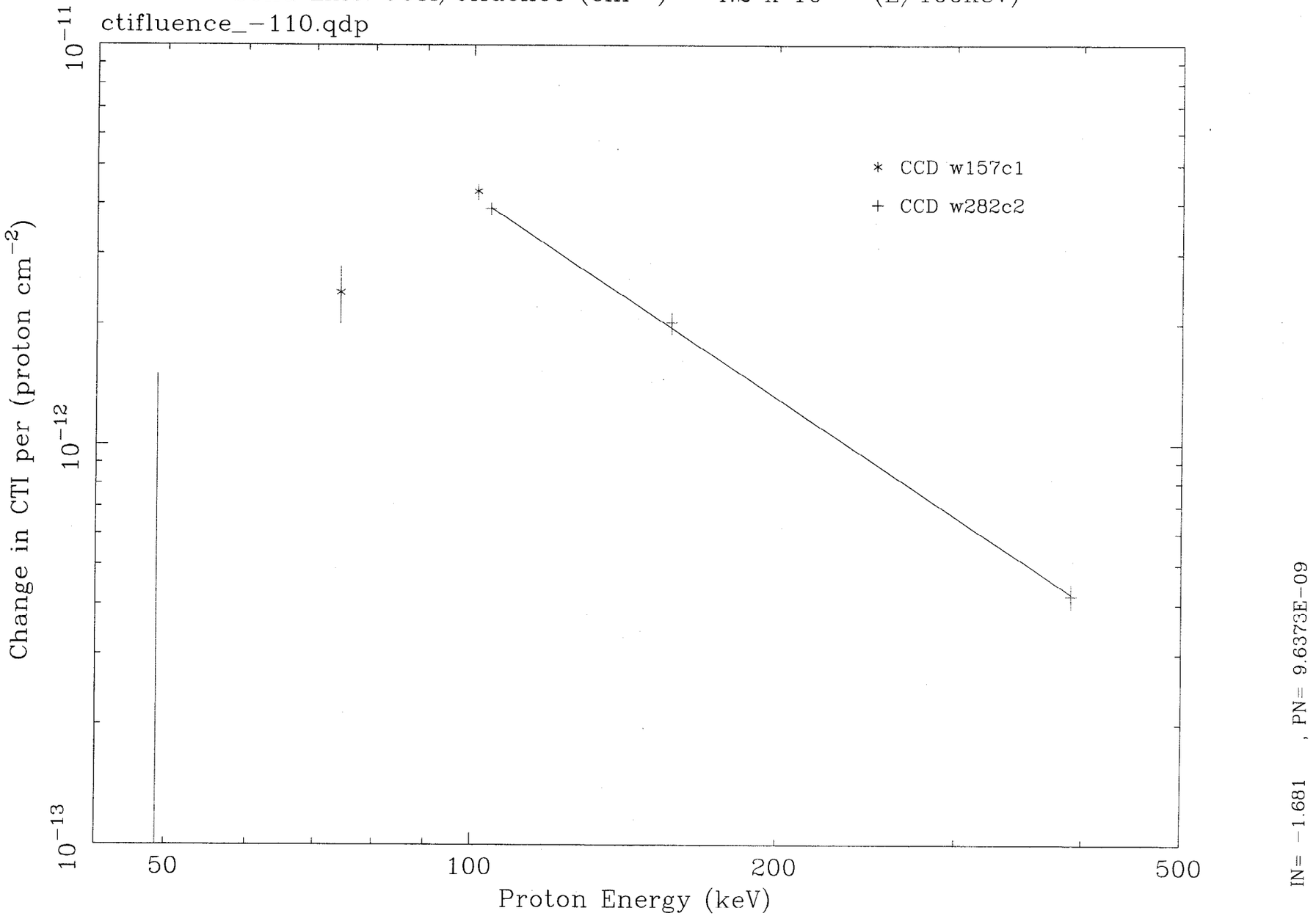


Figure 6: Front-illuminated Detector I1 Resolution Vs Row Number, 5.894keV

Bautz et al (MIT MIT/MIT)

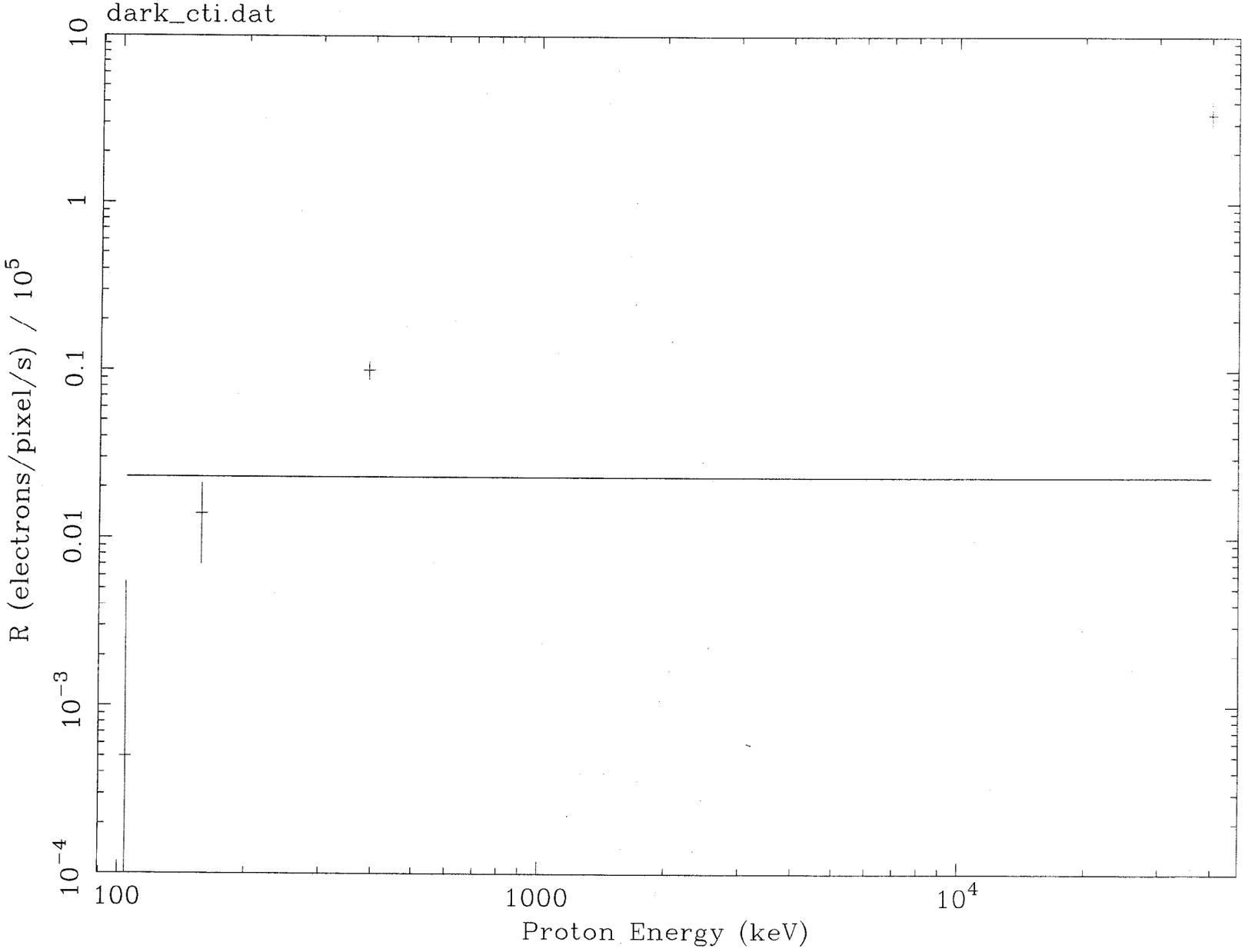
ACIS CCD CTI Change (−110C) per Unit Proton Fluence

Solid Line: $\delta CTI/\delta fluence\ (cm^{-2}) = 4.2 \times 10^{-12}\ (E/100keV)^{-1.68}$



Bautz et al (MIT memo)

Ratio (R) of Dark Current Change (at −60C) to CTI Change (at −110C)
Points: ACIS CCD Ground Test Results; Line: Observed Flight Level



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OPERATIONAL RESPONSE

- The SIM is always translated before perigee transits to place ACIS out of the focal point.
- A "10 ks pad" has been added on either side of perigee to ensure ACIS is not exposed at the fringes of the belts (see Virani *et al.* SPIE Vol 4012, p669)
- CTI measurements are made during these 10 ks pad times, data are processed and analyzed automatically
- The autonomous on-board safing thresholds for EPHIN have been adjusted
- Data from other satellites are routinely monitored to provide early warning of radiation events