WFPC 90-01

INSTRUMENT SCIENCE REPORT
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TITLE: WFPC Instrument Science Report — Bias Change During TV6

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ABSTRACT

Analysis of WFPC images taken during JPL thermal vacuum tests has always shown a low-level (~0.5 DN) difference of bias level between the odd and the even numbered columns. During TV6 (February – March, 1988) this pattern changed from even columns having the higher bias level to the odd columns being higher. The change occurred steadily over the duration of TV6 and does not show a correlation with UV Flooding or decontamination (bake-out) activity. The mean bias level of the odd and even columns together shows a steady increase of about two DN per day over the twenty-five days of the TV6 test.

*** * * D R A F T 89.11.02 * * ***

I. Background of Odd/Even Column Bias Differences.

The bias offset in CCD exposures is a voltage applied uniformly to all pixels so that the charge collected in the pixels during an exposure can be clocked out of the CCD. In the WFPC CCDs, the bias level is quite uniform across each CCD, and each CCD has a characteristic mean bias level between 250 and 450 DN. The bias may vary by a few DN from one exposure to another and it must be subtracted from the image before flat field correction can be applied. In order to guarantee that the bias level would be known in every exposure, the WFPC CCDs are designed to 'clock out' a number of extra pixels after each row of an image. These pixels don't actually exist and the values read out of CCD coordinates corrsponding to those pixels are not electronic measurements of light levels, but samples of the amount of charge resident in an empty pixel. Eleven such samples are attached to the end of each row of a WFPC CCD image and together they appear as a dark rectangle at the edge of the image, which is called the 'overclocked' or 'overscan' region.

The standard bias removal algorithm is to compute the mean value of the pixels in that rectangular area and subtract that number from all the pixels in the image. However, close examination of the mean value of each column in the overscan region shows a definite pattern: the mean value of the odd columns is different from that of the even columns (Figure 1). The presence of the odd/even column bias pattern was observed in previous thermal vacuum tests. (The change from evens to odds being the higher bias level also ocurred during TV5, but it was not noticed until now.) This pattern is also present in the actual image area, though it is harder to measure there as it is easily masked by structure in the image (Figure 2).

II. TV6 Changes in Bias.

During analysis of TV6 images, it was noticed that the bias pattern changed from even high to even low (Figure 3). Other CCD features in the image, such as blocked columns, did not shift between these exposures, therefore the pattern change was not caused by a failure of the ground simulator to record an odd number of pixels or columns. Further investigation showed that the pattern changed parity on images from all eight CCDs. The change was also gradual, as shown in Figure 4, and is not related to UV Flooding or high temperature decontamination activities. The pattern seems to have stabilized at a new odd/even column bias difference.

The overall mean level of the bias of each CCD increased almost monotonically during TV6 (Figure 5). The variation is similar, but not identical on the various CCDs.

III. Conclusions and Recommendations.

Since the pattern change occurs uniformly across all CCDs of both cameras, the cause of the pattern and of the change in the parity of the pattern must be in a section of the electronics bays which is common to both cameras. We shall obtain electronic bay temperature records of TV6 and examine the data for a correlation with the change in the pattern. However, we do not expect to find one because the change appears to be smooth and gradual over a timescale of two to three weeks, during which time there were several large thermal variations in the cameras and the electronics bays (Figure 6). Several correlations between the bias behaviour and temperatures are suggested by the Figure, but none is clearly and solely indicating what is happening to the bias.

Since TV6 was longer than any other thermal vacuum test, and the mean bias level was still increasing at the end of the test (as were the temperature settings in the WFPC), we expect that the bias level and odd/even difference will vary during the mission for at least the first two months and will probably change slightly whenever the temperature of certain bays of the WFPC change.

At its present level, the pattern poses no problem to most observers. If the pattern changes to a much larger difference, it is possible that the calibration routines will have to correct odd and even columns in the images independently. The odd/even pattern must be monitored in flight so that scientific data reduction and routine calibration algorithms can be corrected, if necessary.

The overclocked area of each image will be included in the data delivered to each observer. The observers can decide for themselves whether their particular scientific objectives need to take odd/even column bias difference into account. We recommend that the description of this pattern be expanded in the next edition of the Instrument Handbook to explain that the column bias difference may vary with time.

To make the trend analysis of this pattern easier, we recommend that the calibration

pipeline for WFPC images compute the odd and even column bias levels of the overscan region separately and store them in the image header for each CCD.

The steady increase of bias level is not a problem for routine image correction because the current pipeline uses the mean value of the overscan region of each image to correct that image. The bias level must be monitored so that decisions about exposure times will be well made. A difference of nearly 100 DN over a month has been observed. The effective dynamic range of the instrument is affected by stability of the bias level over timescales within which the scheduling systems can react.

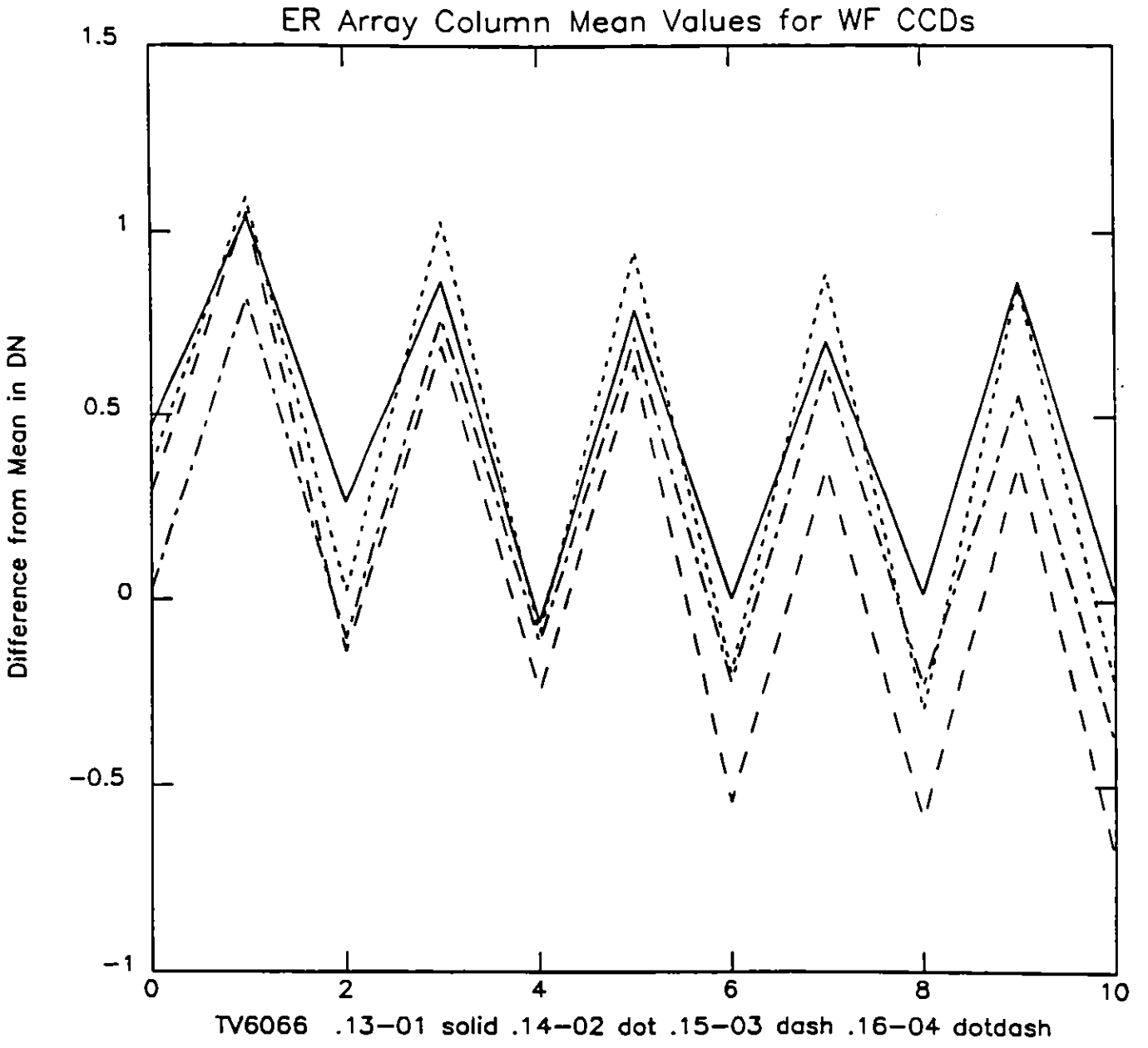


Figure 1a — Extended register ("ER") column mean values for CCDs WF1–4 overplotted. The WFPC TV6 archive images used to generate the figures are indicated according the the naming convention TV6nnn.ff-cc, where 'nnn' indicates the tape volume, 'ff' is the file number on that tape and 'cc' is the CCD number (1–4 for WFC, 5–8 for PC).

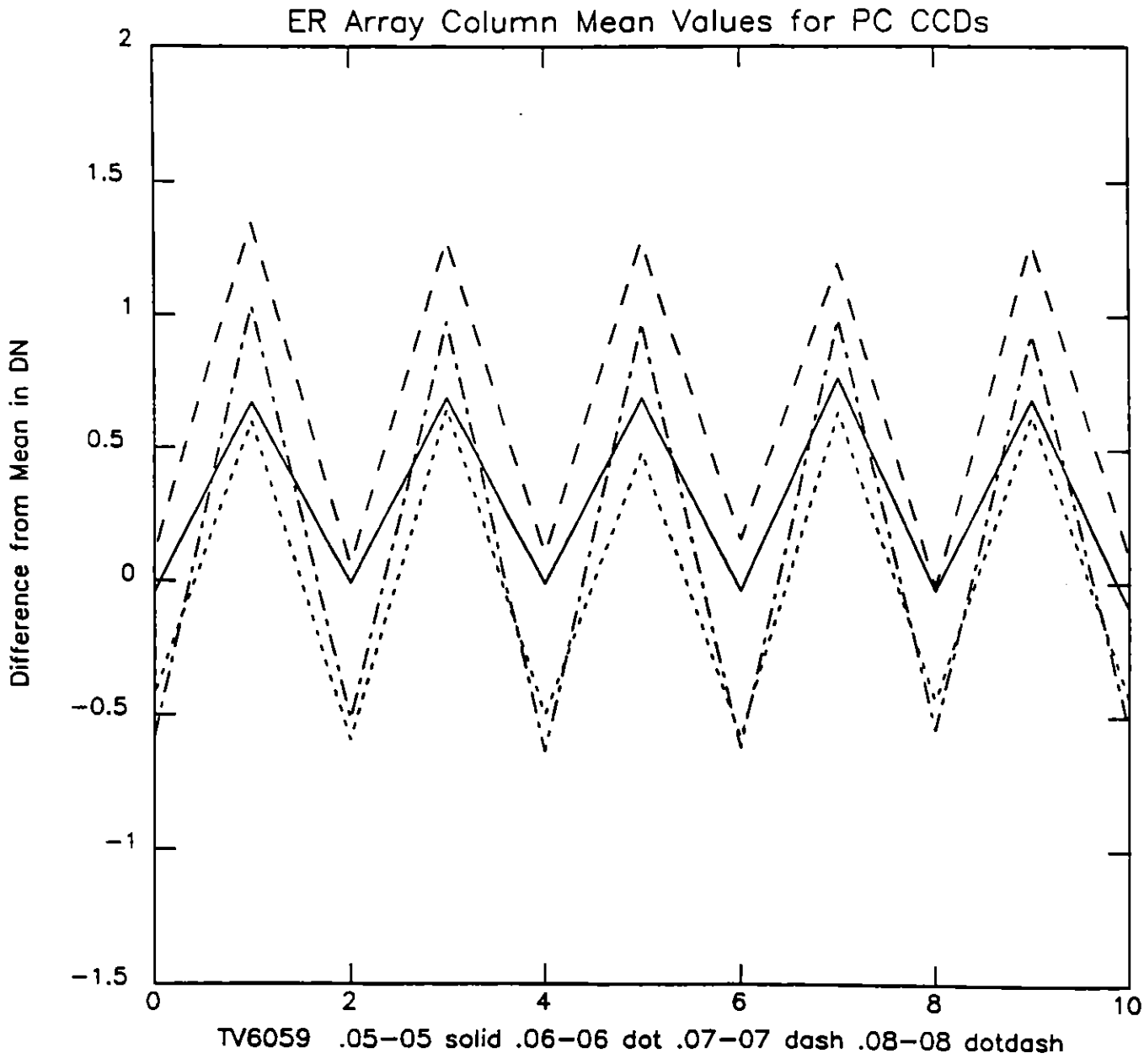


Figure 1b — Extended register column mean values for CCDs PC5-8 overplotted.

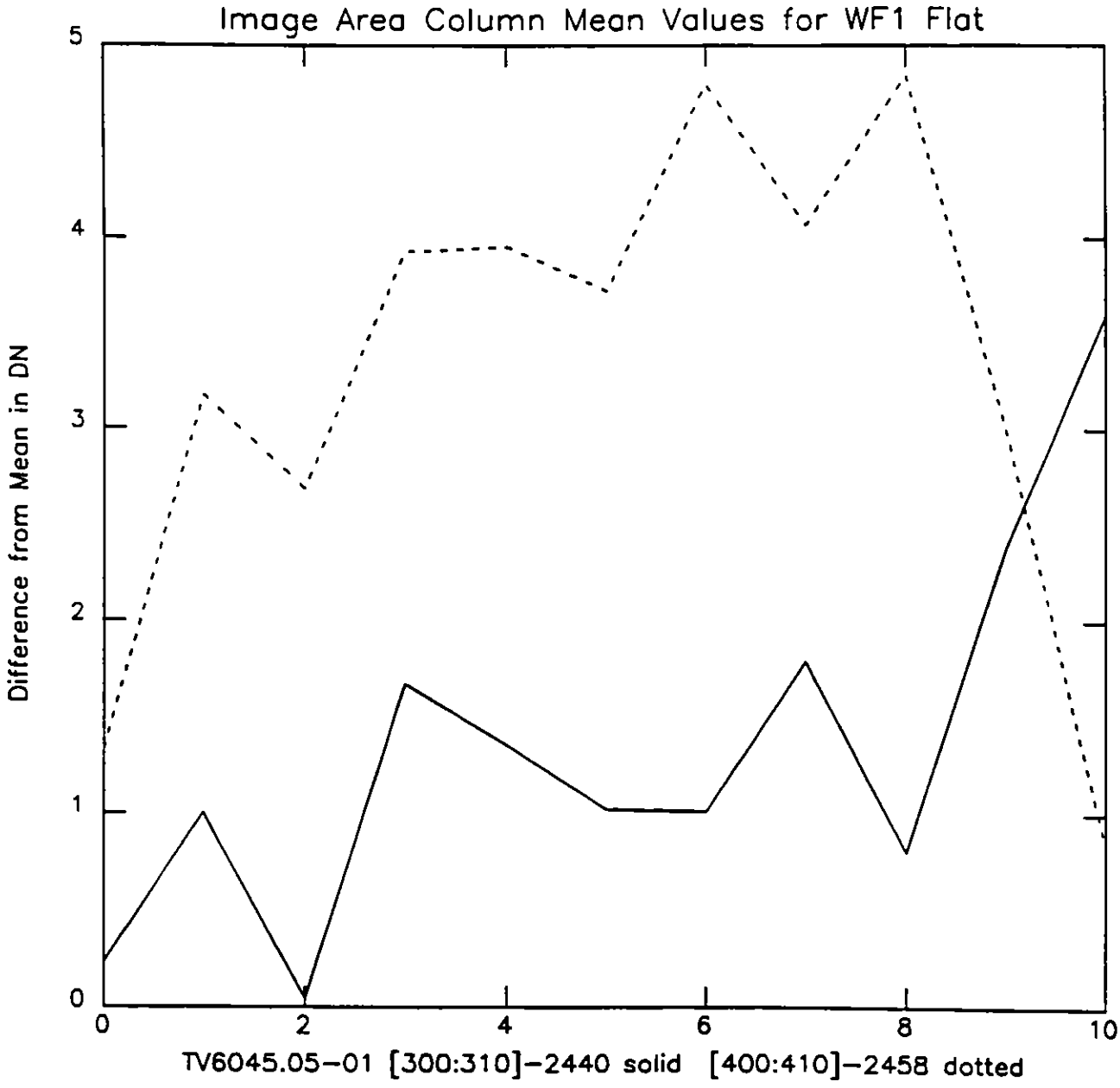


Figure 2 — Image area column mean values for columns 300–310 of a flat field. The zig-zag pattern is present, although it is less discernible because of the structure of the flat field image.

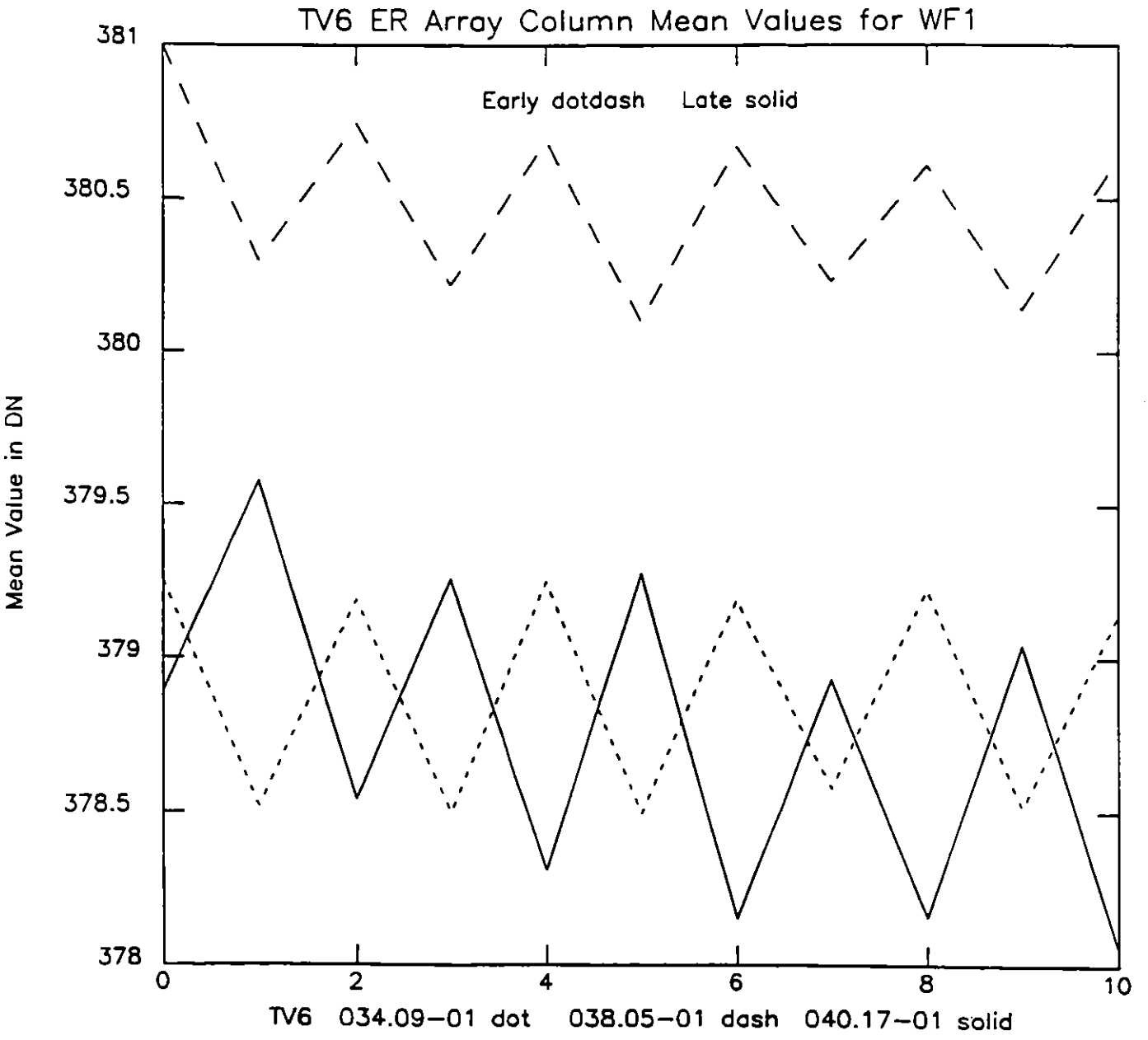


Figure 3a — Two early TV6 WF1 bias patterns and one later one overplotted. The images from tapes 34 and 38 have the same odd/even parity. The alternating pattern has switched parity by tape 40.

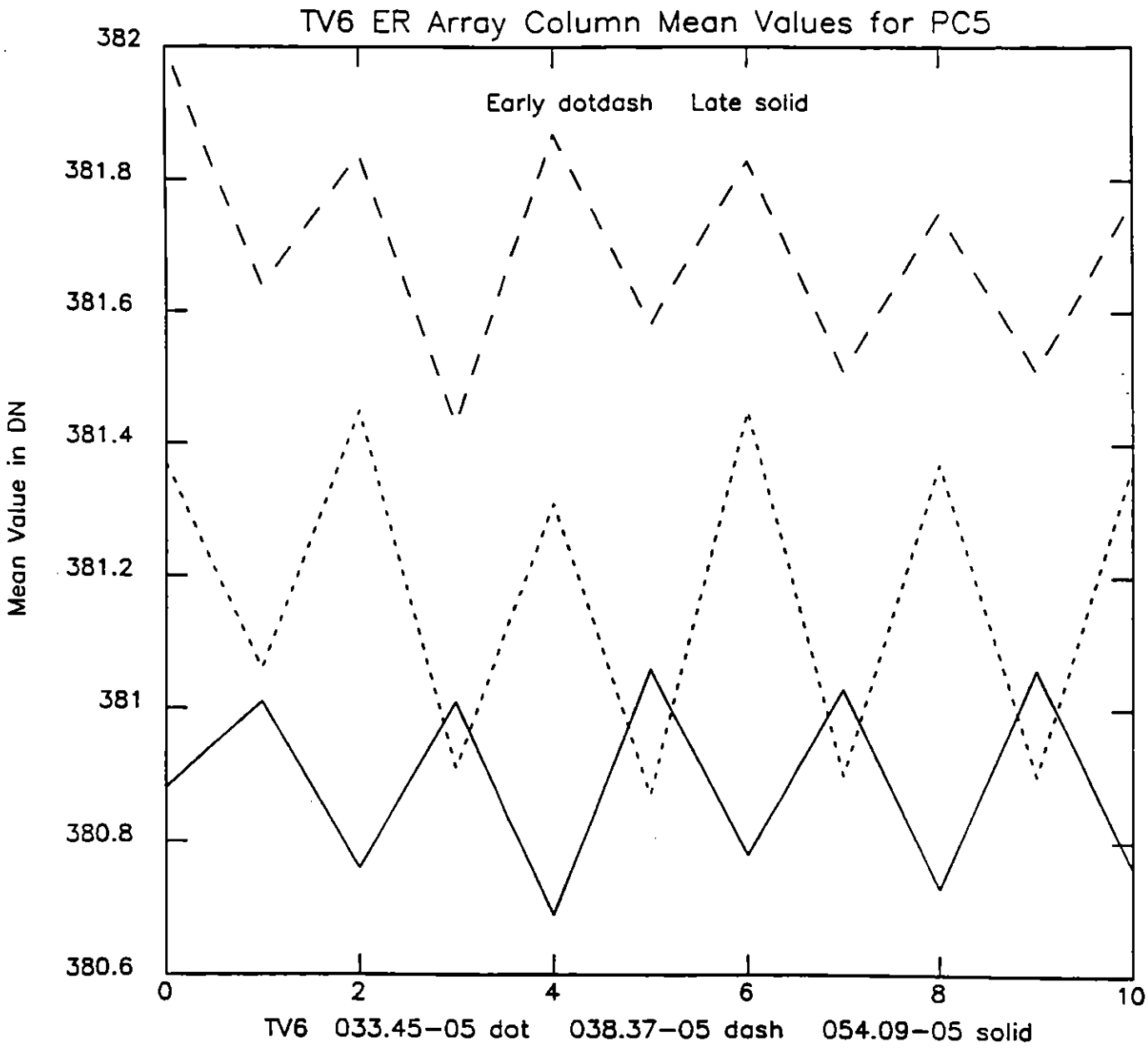


Figure 3b — Two early TV6 PC5 bias patterns and one later one overplotted.

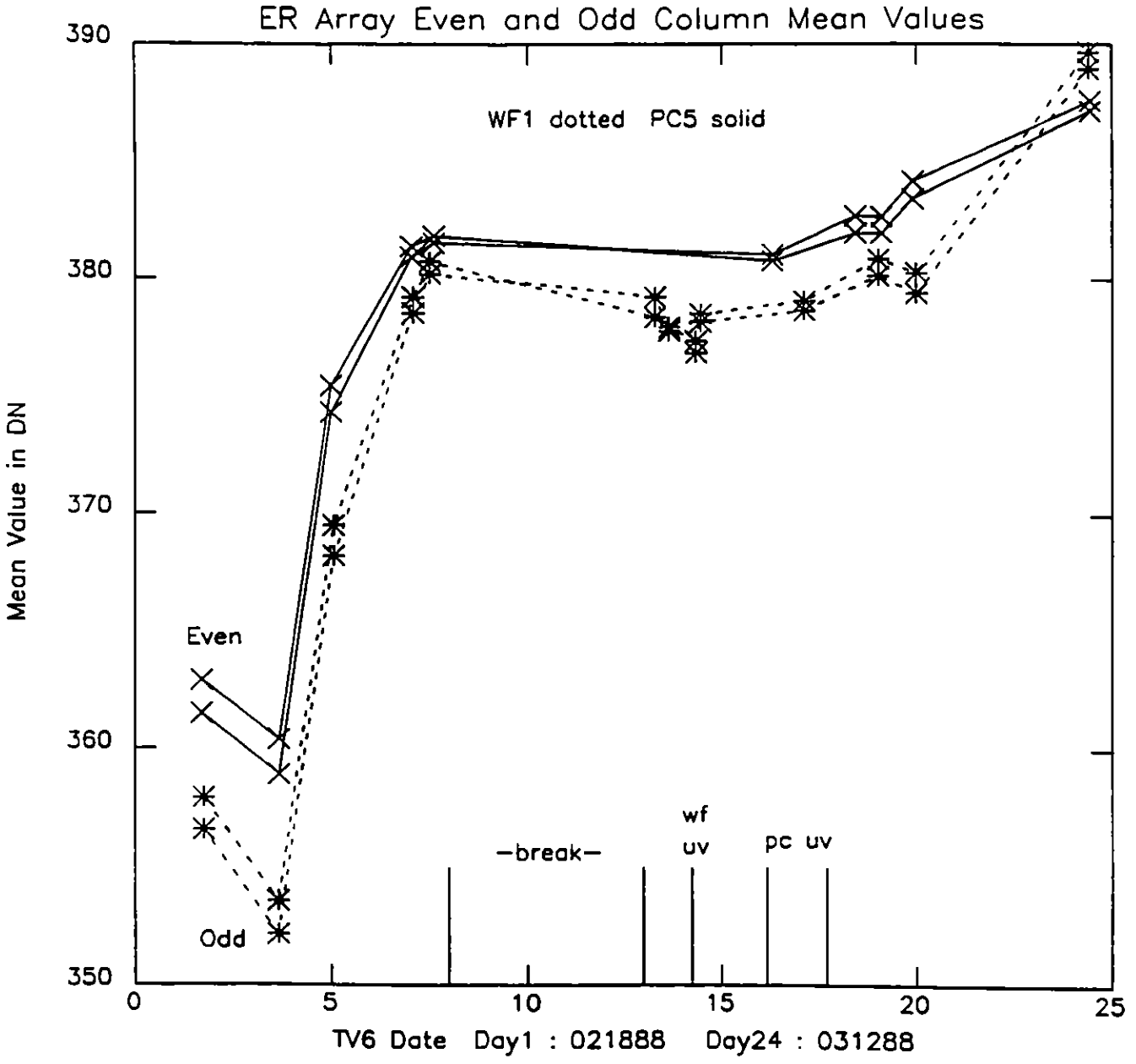


Figure 4 — TV6 extended register even and odd bias levels for WF1 and PC5 are shown as a function of day number during the test. Tic marks along the time axis indicate the beginning and end dates of a decontamination excercise during which no science images were taken, and the dates of one WFC and two PC UV Floods. This figure shows that the bias levels were increasing before the decontamination break, and that the crossing over from even columns having higher bias to odds being higher occurred before, and is thus independent of, UV flood activity.

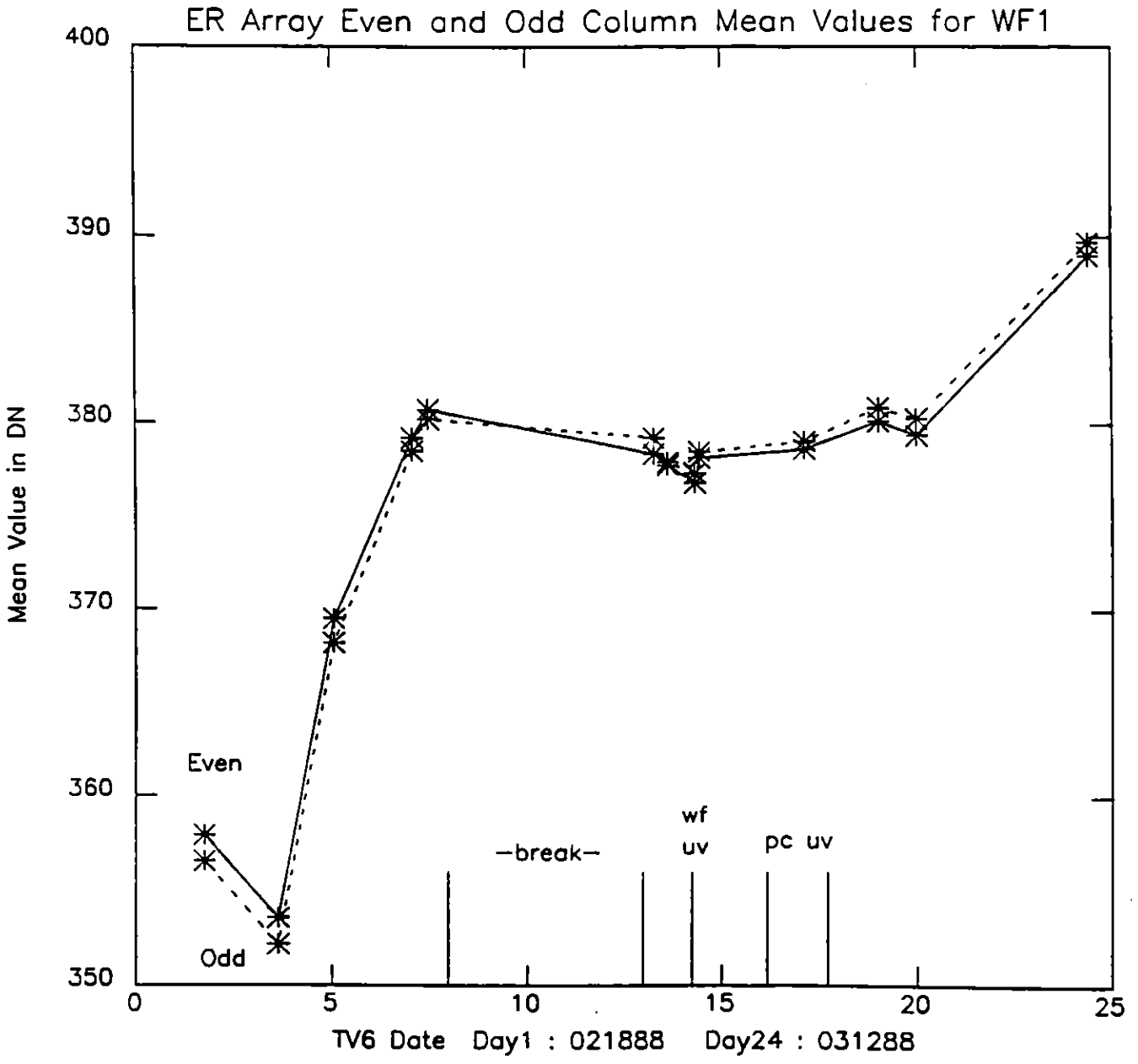
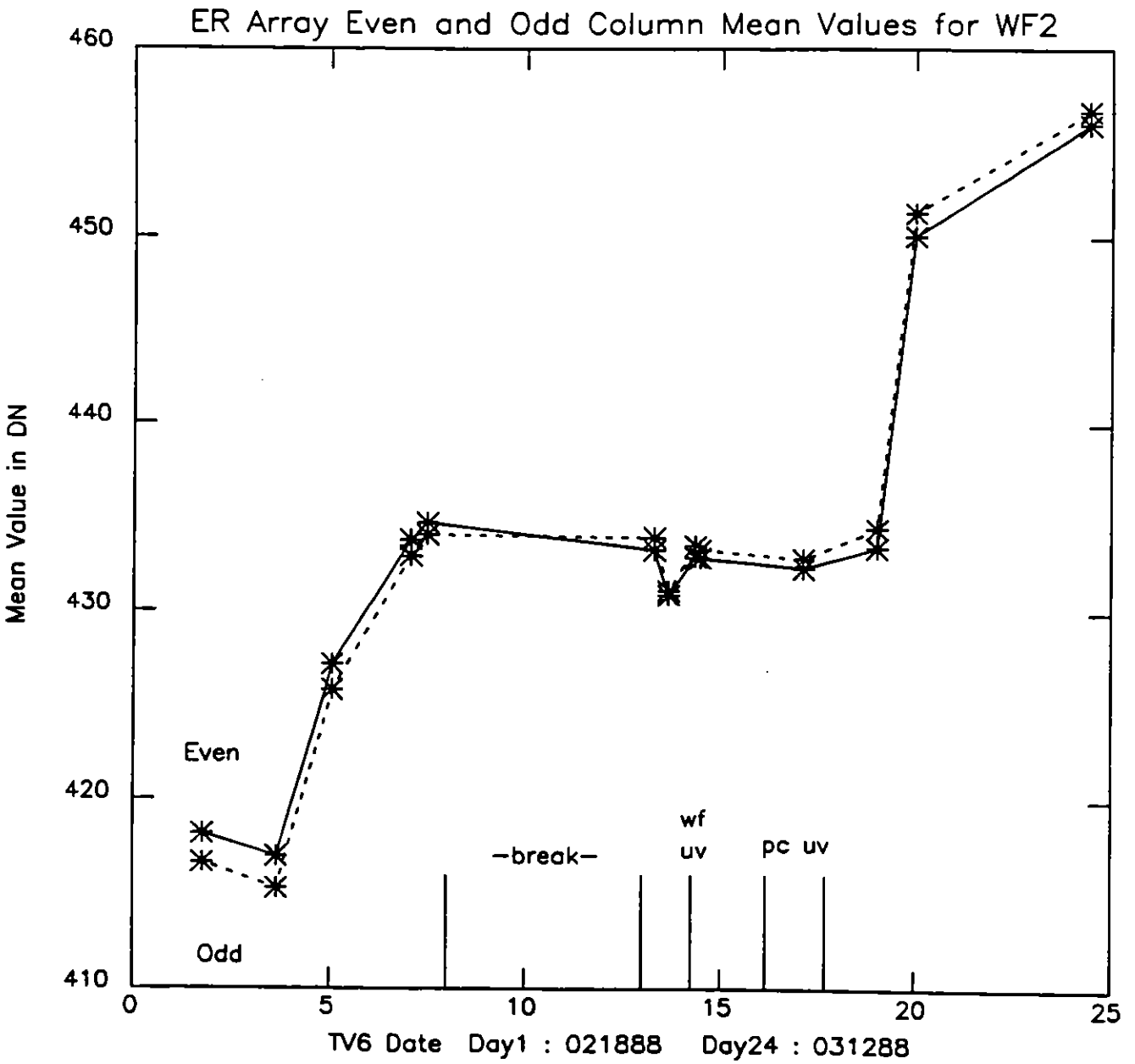
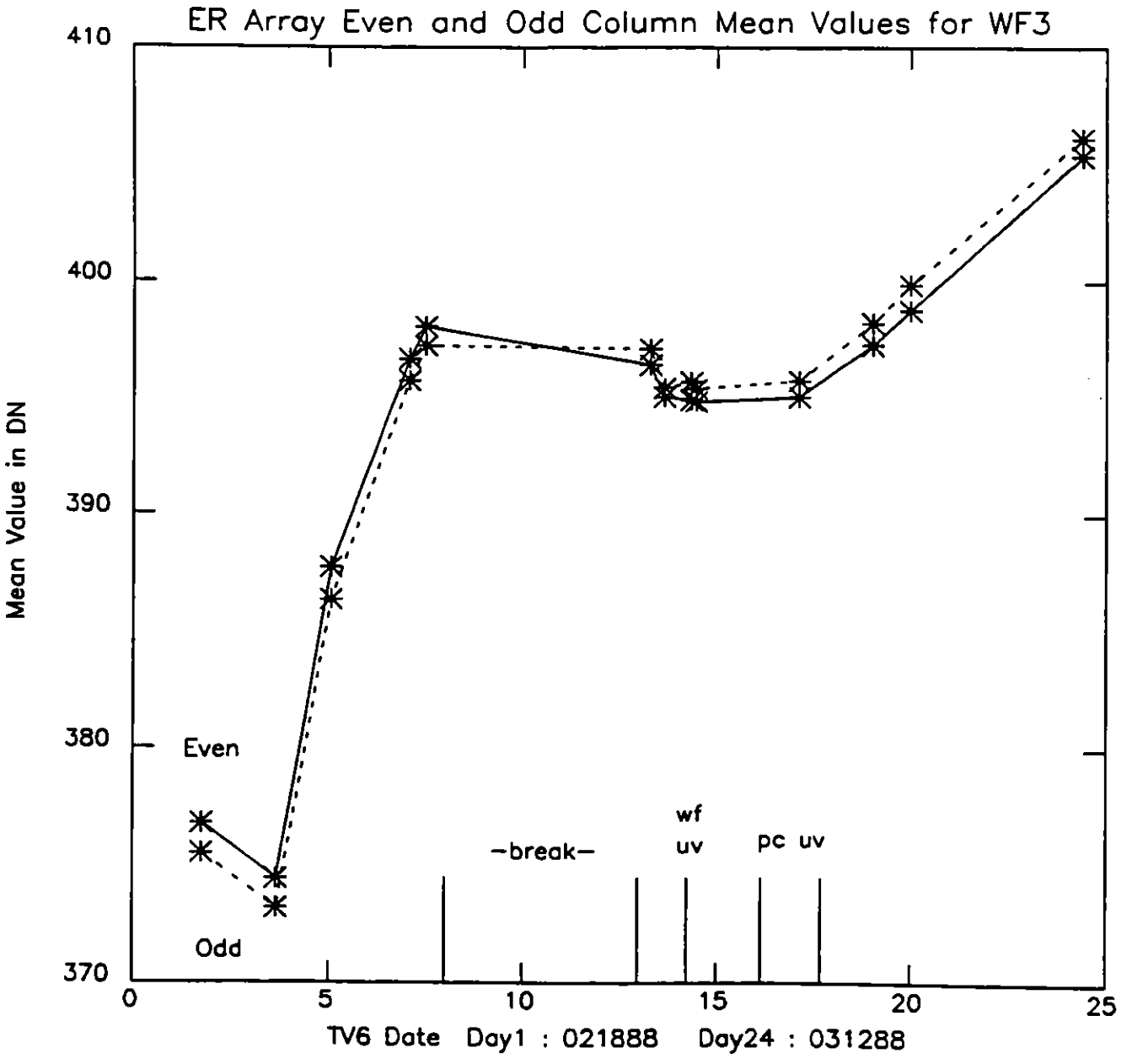
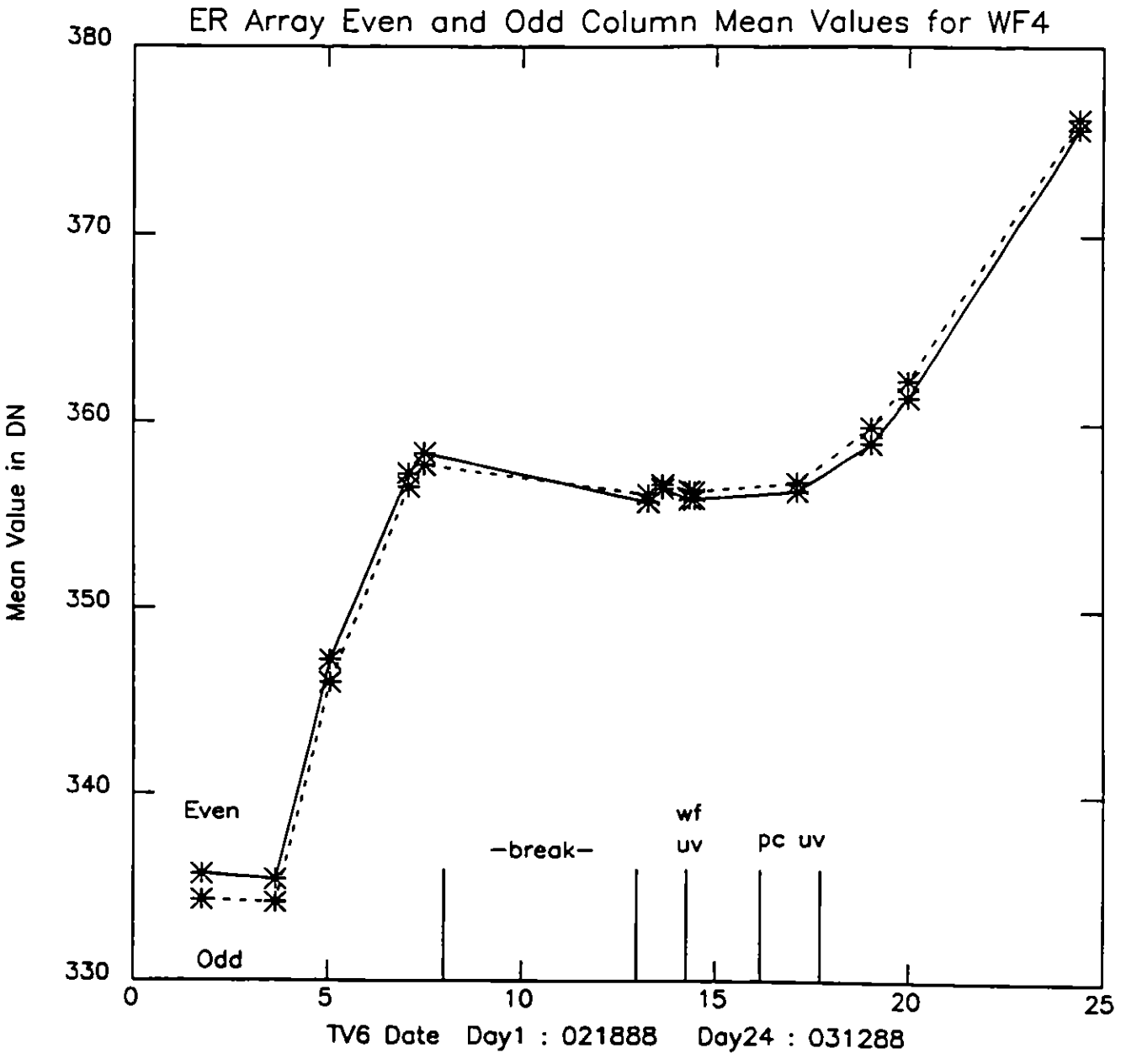


Figure 5 a–d — The extended register bias level of each of the WFC CCDs is presented separately. Each CCD shows a similar, though not identical, trend of increasing bias level and all show the odd/even parity reversal at the same time. This indicates that the cause of the odd/even bias level difference is in circuitry common to all CCDs of both cameras and that some other bias variations have causes specific to the individual CCDs.


ER Array Even and Odd Column Mean Values for WF2
460
450
440
430
420
410
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288


ER Array Even and Odd Column Mean Values for WF3
410
400
390
380
370
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288


ER Array Even and Odd Column Mean Values for WF4
380
370
360
350
340
330
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288

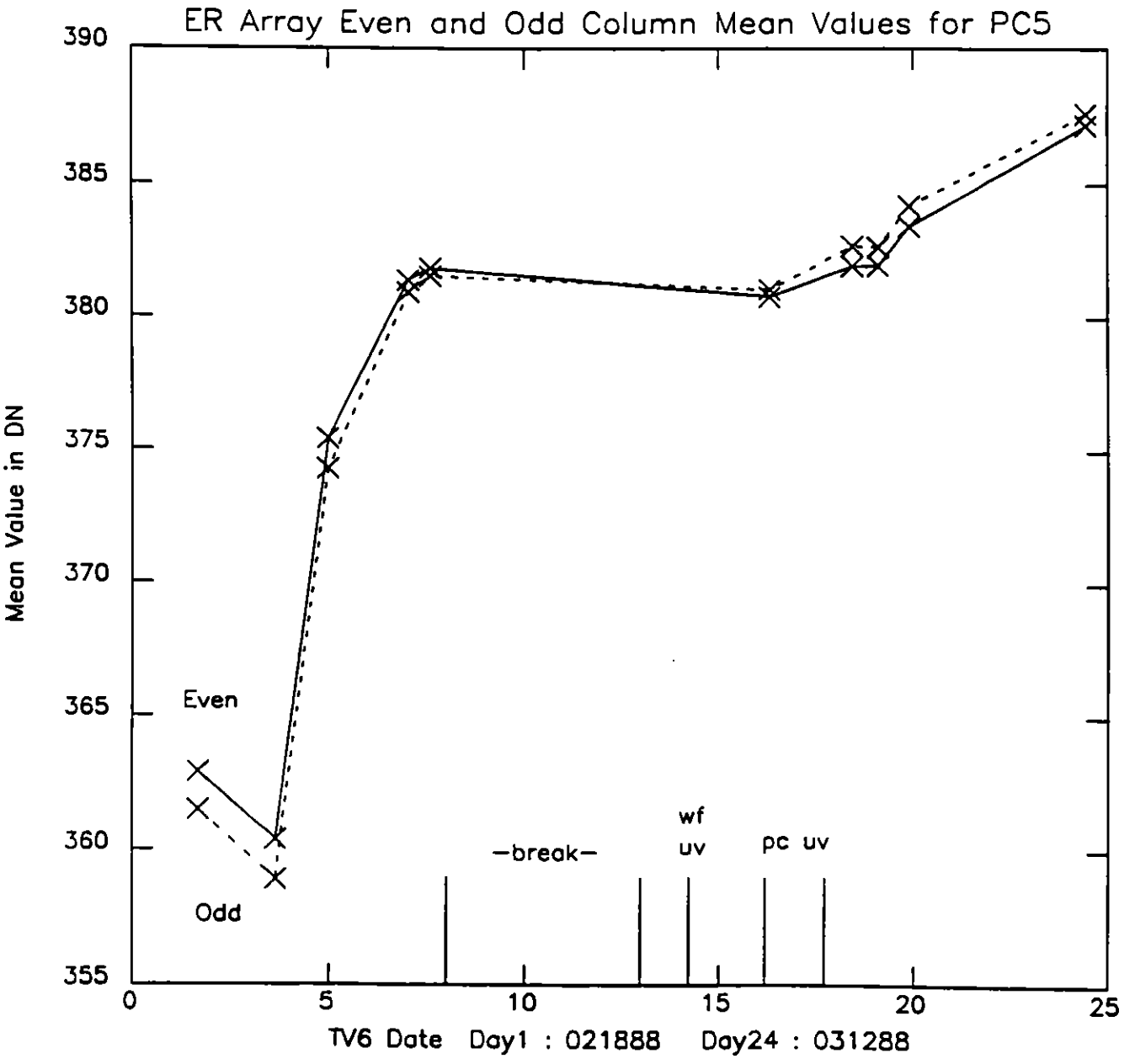
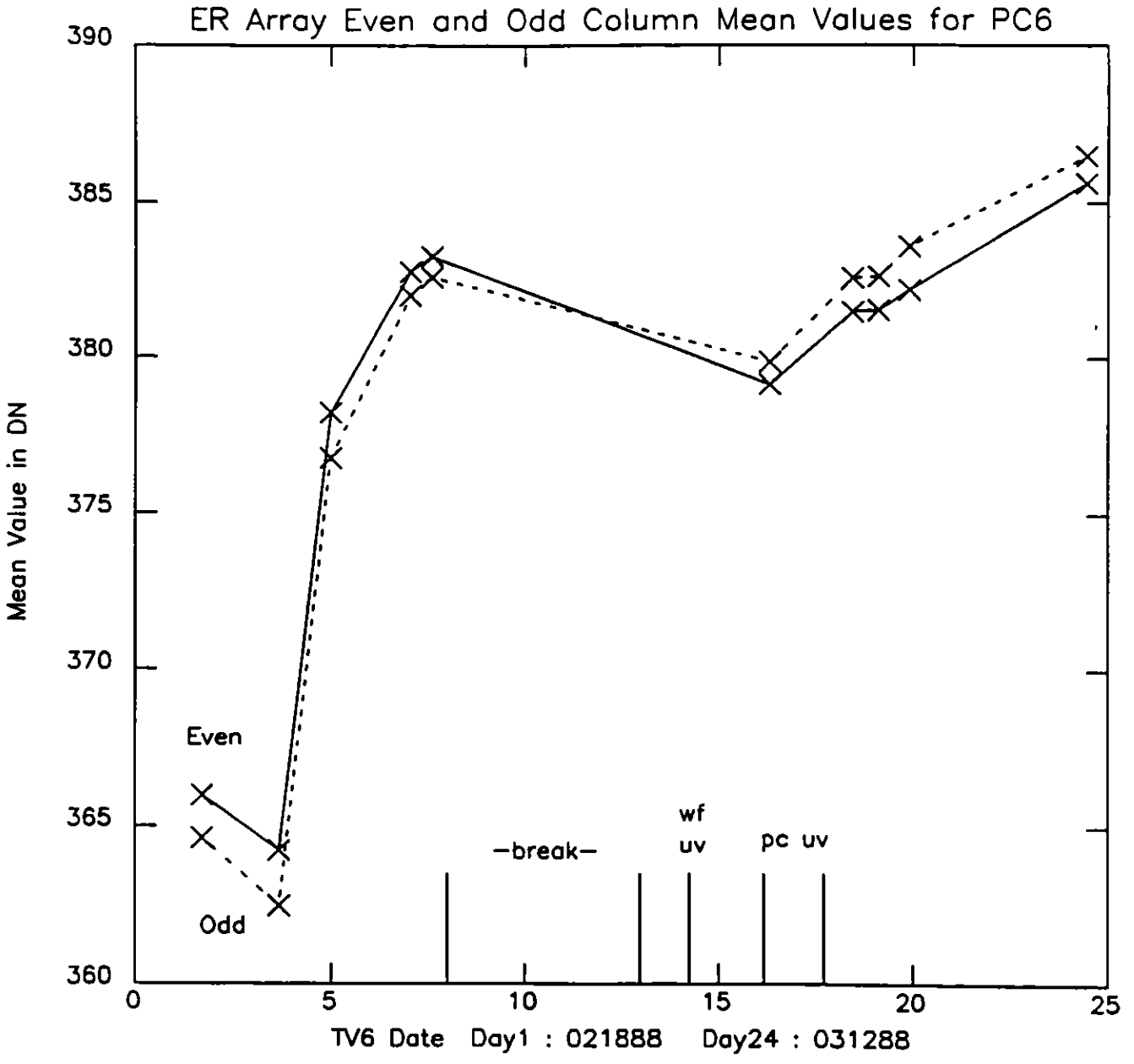
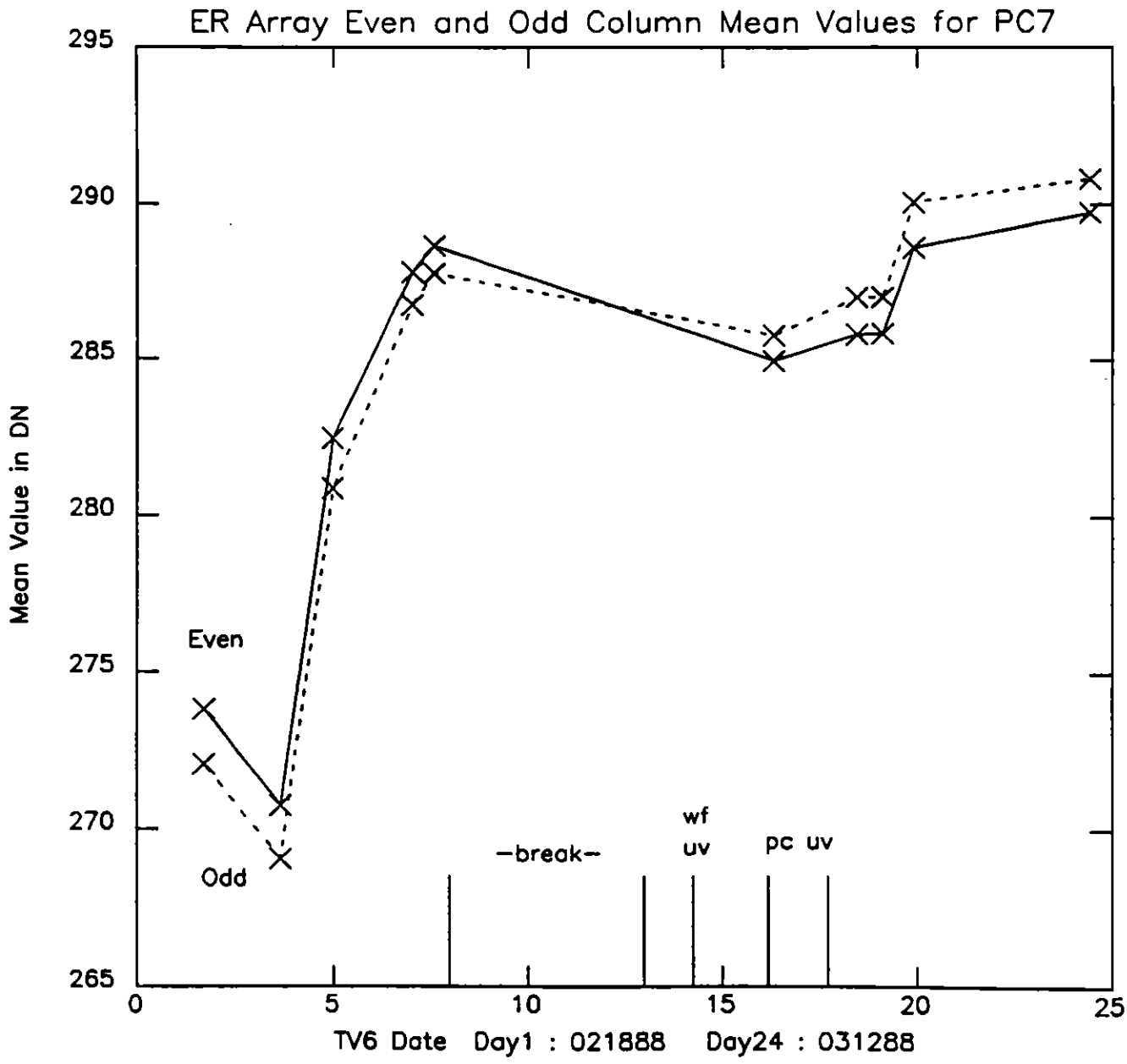
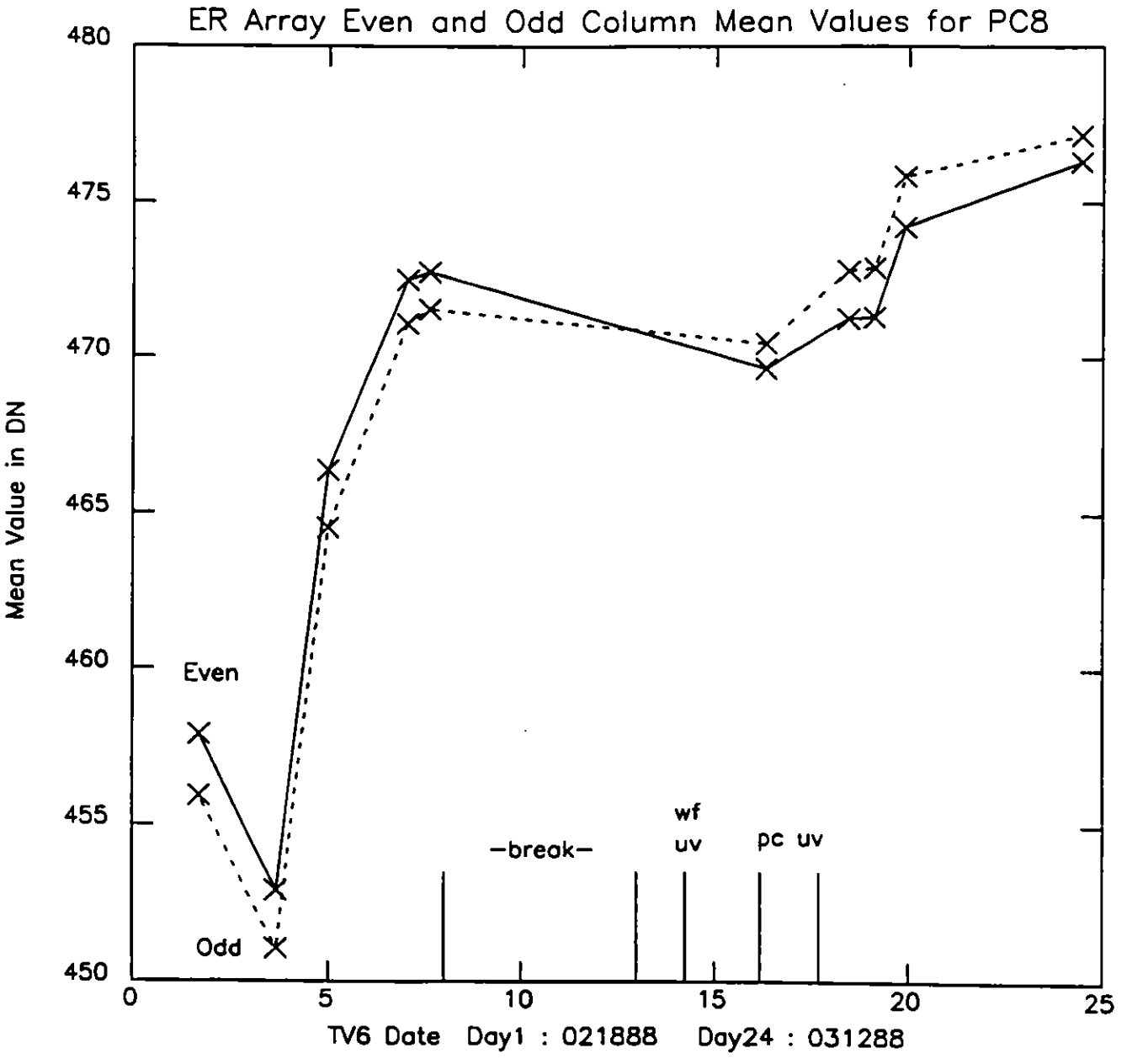


Figure 5 e–h — The extended register bias level of each of the PC CCDs is presented separately.


ER Array Even and Odd Column Mean Values for PC6
390
385
380
375
370
365
360
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288


ER Array Even and Odd Column Mean Values for PC7
295
290
285
280
275
270
265
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288


ER Array Even and Odd Column Mean Values for PC8
480
475
470
465
460
455
450
Mean Value in DN
Even
Odd
-break-
wf
uv
pc uv
0
5
10
15
20
25
TV6 Date Day1 : 021888 Day24 : 031288

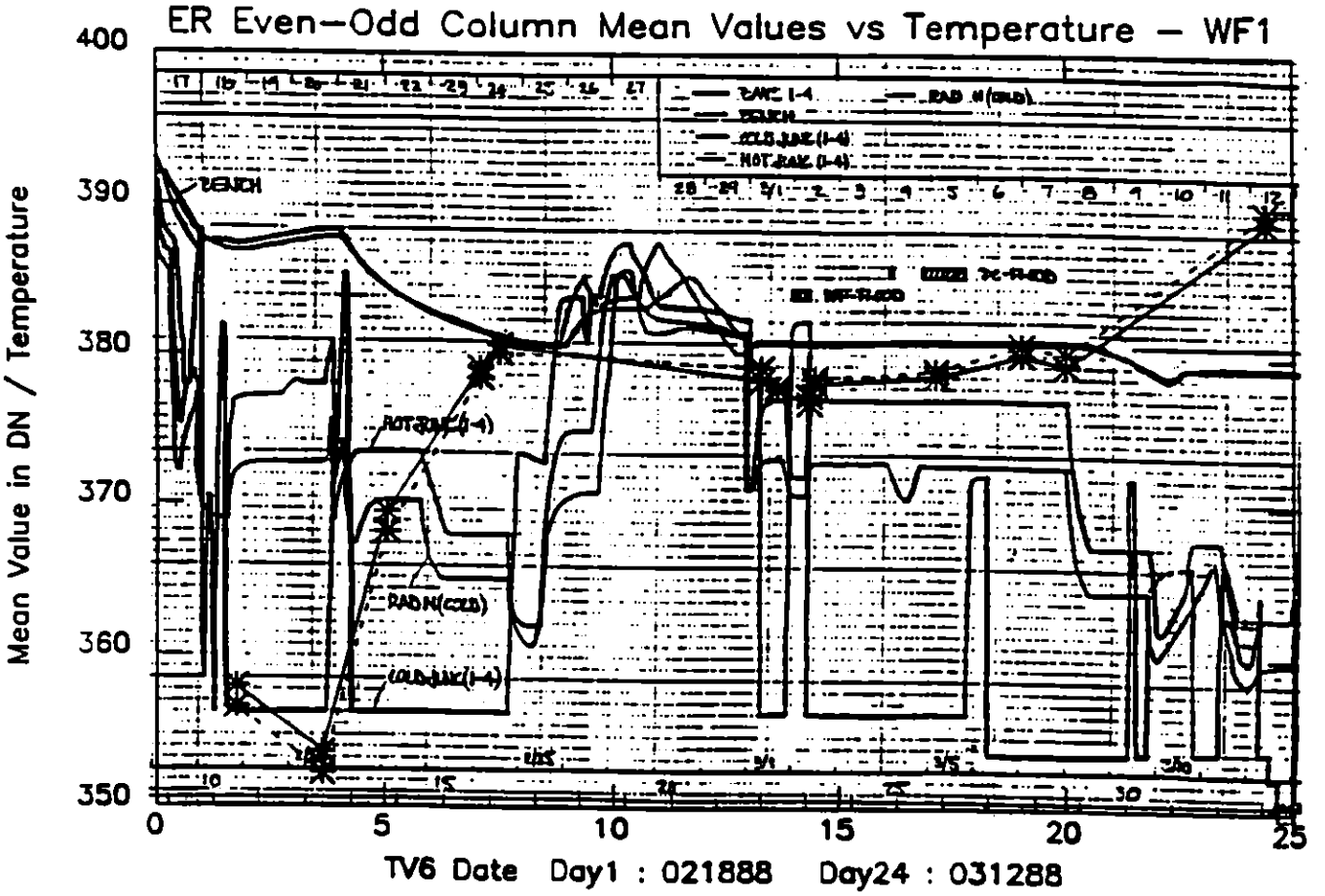


Figure 6 — The extended register mean value for WF1 through TV6 is plotted over a figure from the post-TV6 review which shows the temperatures of several components of the WFPC.