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INSTRUMENT SCIENCE REPORT

FOS-CAL-001

TITLE: Lab. Calibration of the FOS: Absolute Sensitivity (1st Results for the Blue Side)

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ABSTRACT

First results on absolute sensitivity of FOS Blue Tube Flight #7.

The data presented here were used as an input in deciding to proceed with a replacement program for this tube.

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# Laboratory Calibration of the Faint Object Spectrograph: Absolute Sensitivity (First Results for the Blue Side)

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06/17/83

Summary: The present (03/25/83) peak Q. E. of the blue tube (Flight #7), as based on measurements of a deuterium lamp through the FOS-spectrograph, is calculated to be 14.2% between 2500 and 3200Å. A similar value (of 13.8%) was found by Ed Beaver on 04/12/83 by directly illuminating the Digicon with a Mercury PEN-lamp through an interference filter (2537Å). These results are to be compared with the initial value of Q.E. ≅ 20% at 2537Å as derived by $M^2C$ (07/08/81 & 09/14/81). In interpreting the the apparent loss in Q.E., it has not been taken into account that the standard photocathode voltage has been lowered from 22 to 18 KV since the initial 1981 measurements. This causes a drop in count rate in the blue of app. 15% (Ed Beaver; priv. comm. 05/27/83).

A much larger temporal drop in Q.E. is found for the red end of the sensitivity curve. This is demonstrated in Table 4, where the "Visible Current Mode Quantum Efficiency" measurements of 07/06/81 are compared with the data of 03/25/83 as interpolated from the attached Tables 2 and 3. The loss-factor appears to turn up very steeply going towards the red. [Note that it is not known whether the count-rate loss caused by the lower high-voltage is wavelength dependent].

Details: On 03/25/83, measurements of the blue tube were obtained (see FOS Scientist's Notebook pg.70). These were the first measurements of the FOS Q.E. using the ambient STOS after earlier vignetting problems were solved. The various exposures can be summarized as follows:

| grating | ap | λλ (Å) | exp. time (sec) | Lamp & Diffuser |
|---|---|---|---|---|
| H27 | B3 | 2240 - 3290 | 10 | D116 #2 |
| H40 | B3 | 3260 - 4800 | 1 | W179 #2 |
| H57 | B3 | 4630 - 5550 | 1 | W179 #2 |

Wavelength calibration for these images was done using exposures of the internal lamp obtained on 03/23/83. A number of lines were identified on each of these exposures using the August 82 report on the FOS calibration source spectral scans by G. F. Hartig. Linear least square fits resulted in the following parameters:

| grating | dispersion constant (Δλ/px) | λ(Å) for channel #0 | No. of spectral lines used for the fit | Å r.m.s. |
|---|---|---|---|---|
| H27 | 2.10 | 2228 | 17 | 0.9 |
| H40 | 3.08 | 3244 | 12 | 1.7 |
| H57 | 4.50 | 4609 | 9 | 2.3 |

The dispersion constants are slightly, but significantly, different from those used so far (2.12, 3.1 and 4.48 for H27, H40 and 57, respectively). The data-points were read out (using a ruler) from Tektronix hard-copy. No cubic terms are needed at that level of accuracy as the quoted r.m.s. residuals are non-systematic.

Flux values at the relevant wavelengths for the two lamps used (D116 & W179) were interpolated from the NBS-report of calibration. Extrapolation to 3275Å was done for D116 on the long-wavelength side (the last NBS data-point is at 3000Å). The

log flux vs. wavelength is approximately linear, and a slope of 1 decade/1500Å was found from Saunders et al., Applied Optics 17, 593 (figure 4). This extrapolation is shown as a broken line in the attached figure 1.

Optical efficiencies ($\varepsilon$) were taken from the memo by R. Pembroke (04/19/83). These values appear to differ somewhat from the values used so far (e.g. on page 70 of the FOS - Scientist's Notebook). The largest discrepancy occurs at 2500Å, where the "old" value equals 0.368, whereas Pembroke gives $\varepsilon = 0.435$.

The detector Q.E.'s follow from the data gathered so far by taking (FOS Notebook pg. 70):

$$Q.E. = \frac{0.0414 * (\text{counts} \cdot s^{-1} \cdot d^{-1})}{\lambda(Å) * F_\lambda(Wcm^{-3}) * \Delta\lambda(Å) * \varepsilon}$$

All the data are assembled in Tables 1 through 3 and plotted as Figure 1.

Table 1: H27

| px | $cs^{-1}d^{-1}$ | λ(Å) | $F_\lambda (Wcm^{-3})$ | ε optical | QE % |
|---|---|---|---|---|---|
| 0 | 46 | 2228 | 1.02 E-4 | .361 | 11.05 |
| 50 | 67 | 2333 | 1.19 E-4 | .396 | 12.01 |
| 100 | 82 | 2437 | 1.19 E-4 | .428 | 13.02 |
| 150 | 86 | 2542 | 1.06 E-4 | .439 | 14.33 |
| 200 | 81 | 2647 | 9.42 E-5 | .450 | 14.23 |
| 250 | 74 | 2752 | 8.15 E-5 | .453 | 14.36 |
| 300 | 64 | 2856 | 6.90 E-5 | .456 | 14.04 |
| 350 | 55 | 2961 | 5.71 E-5 | .455 | 14.09 |
| 400 | 46 | 3066 | 4.78 E-5: | .441 | 14.03 |
| 450 | 39 | 3171 | 4.07 E-5: | .42: | 14.18 |
| 500 | 33 | 3275 | 3.47 E-5: | .41: | 13.96 |

Table 2: H40

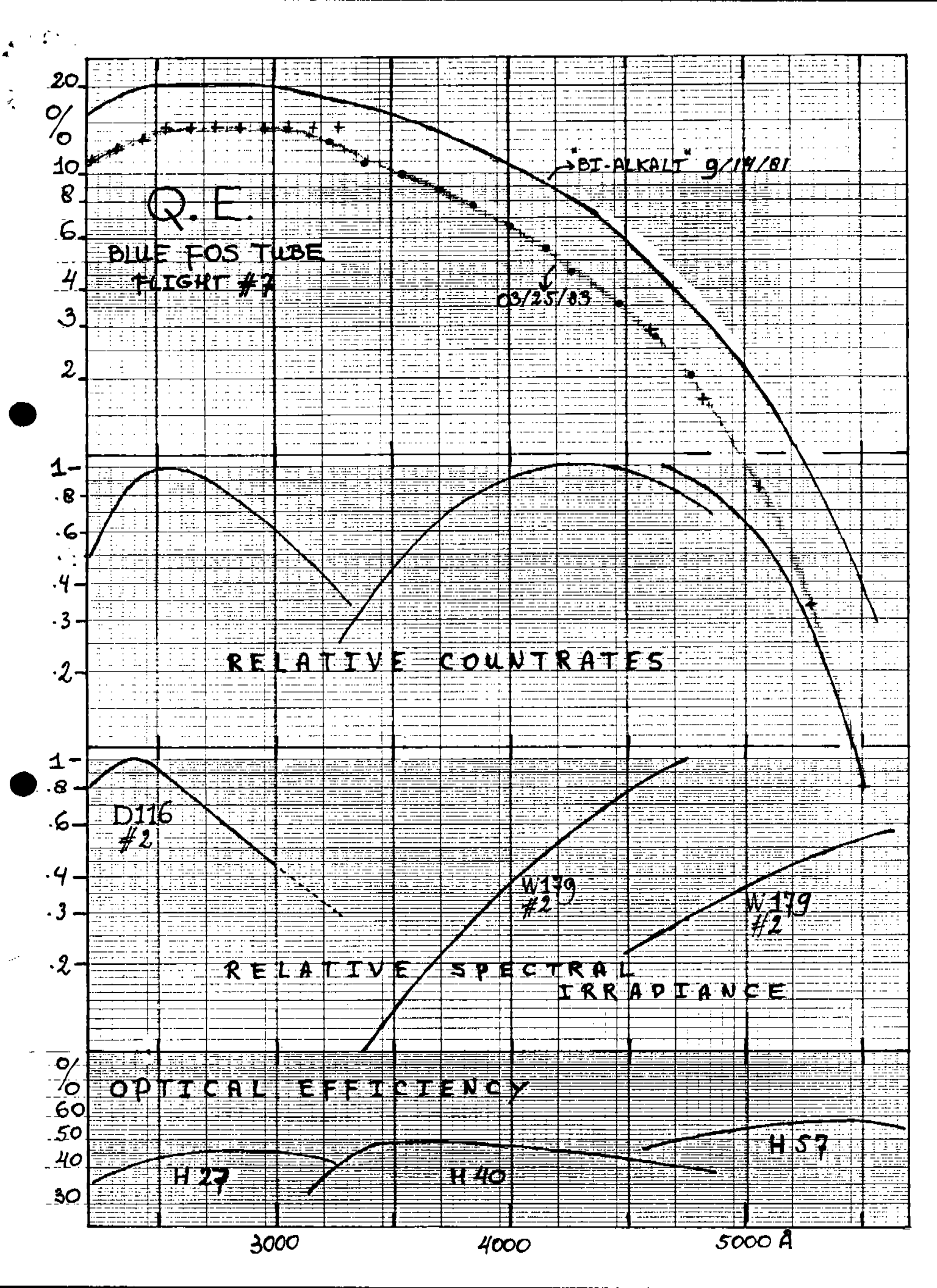
| | | | | | |
|---|---|---|---|---|---|
| 0 | 1750 | 3244 | 1.39 E-3 | .403 | 12.94 |
| 50 | 2750 | 3397 | 2.14 E-3 | .471 | 10.80 |
| 100 | 3900 | 3551 | 3.12 E-3 | .498 | 9.68 |
| 150 | 5250 | 3705 | 4.40 E-3 | .491 | 8.85 |
| 200 | 6300 | 3858 | 5.89 E-3 | .481 | 7.75 |
| 250 | 7100 | 4012 | 7.71 E-3 | .469 | 6.58 |
| 300 | 7700 | 4166 | 9.85 E-3 | .457 | 5.52 |
| 350 | 7900 | 4319 | 1.22 E-2 | .446 | 4.52 |
| 400 | 7450 | 4473 | 1.47 E-2 | .432 | 3.53 |
| 450 | 6900 | 4626 | 1.76 E-2 | .415 | 2.74 |
| 500 | 5900 | 4780 | 2.07 E-2 | .398 | 2.01 |

Table 3: H57

| | | | | | |
|---|---|---|---|---|---|
| 0 | 11900 | 4604 | 1.71 E-2 | .484 | 2.88 |
| 50 | 9750 | 4829 | 2.16 E-2 | .518 | 1.66 |
| 100 | 6700 | 5054 | 2.65 E-2 | .546 | 0.84 |
| 150 | 3450 | 5279 | 3.12 E-2 | .568 | 0.34 |
| 200 | 950 | 5504 | 3.60 E-2 | .566 | 0.08 |
| 250 | 200: | 5729 | 4.11 E-2 | .546 | 0.01: |

Table 4

| Å | Q.E. 07/06/81 | Q.E. 03/25/83 from Tables 2 & 3 | Ratio 1981/1983 |
|---|---|---|---|
| 3600 | 14.54 | 9.45 | 1.54 |
| 3800 | 13.6 | 8.19 | 1.66 |
| 4000 | 11.0 | 6.67 | 1.65 |
| 4200 | 8.8 | 5.29 | 1.66 |
| 4400 | 6.69 | 3.99 | 1.68 |
| 4600 | 4.80 | 2.87 | 1.67 |
| 4800 | 3.28 | 1.87 | 1.75 |
| 5000 | 2.08 | 1.01 | 2.06 |
| 5200 | 1.19 | .49 | 2.4 |
| 5400 | .568 | .17 | 3.9 |
| 5600 | .197 | .035: | 5.6: |


Q.E.
BLUE FOS TUBE
FLIGHT #7
BI-ALKALI 9/19/81
03/25/83
RELATIVE COUNTRATES
D116 #2
W179 #2
W179 #2
RELATIVE SPECTRAL IRRADIANCE
OPTICAL EFFICIENCY
H27
H40
H57
20
%
10
8
6
4
3
2
1
.8
.6
.4
.3
.2
60
50
40
30
3000
4000
5000 Å