Flat Fielding

Flat fielding

- Flat fielding is used to remove Fixed Pattern Noise (FPN) from an image. To apply a flat field, a uniformly illuminated featureless image is divided into the image to be calibrated.
- The flat field is normally averaged from a collection of identical such uniformly illuminated featureless images
- The Flat Fielding process will also remove optical illumination variations, dust motes and other such fixed patterns from the image

FLAT FIELD NOISE SOURCES

READ NOISE (σ_{READ})

(NOISE THAT DOES NOT VARY WITH SIGNAL)

SHOT NOISE (σ_{SHOT})

(RANDOM ARRIVAL OF PHOTONS)

FIXED PATTERN NOISE (σ_{FPN})

(PIXEL TO PIXEL SENSITIVITY VARIATION)

SIGNAL TO NOISE

FLAT FIELD SIGNAL TO NOISE

$$\left(\frac{S}{N}\right)_{FF} = \frac{4 \times 10^{11}\, QE_I\, P_A\, T_C\, T_L\, L_{UX}\, t_I\, (1+4f^2)^{-1}}{(N_R^2 + S_{SN}^2\, D_{SN}^2 + S_y^2 + Q_N^2 + R^2 + N_A^2 + P_{FPN}^2 + D_{FPN}^2 + O_{FPN}^2)^{1/2}}$$

Photon shot noise

Read noise

IMAGE SIGNAL TO NOISE

$(S/N)_I$ = IMAGE MODULATION / NOISE

$$\left(\frac{S}{N}\right)_I \approx MTF_D\ \ C_P\ \left(\frac{S}{N}\right)_{FF}$$

Optimize for highest image S/N

MTF_D = DETECTOR MODULATION TRANSFER FUNCTION (MTF_D)

C_P = INCOMING IMAGE MODULATION OR CONTRAST

PHOTON TRANSFER NOISE REGIMES

$$\text{Total noise } (e^-) = \left(\sigma_{READ}^2 + \sigma_{SHOT}^2 + \sigma_{FPN}^2 \right)^{1/2}$$

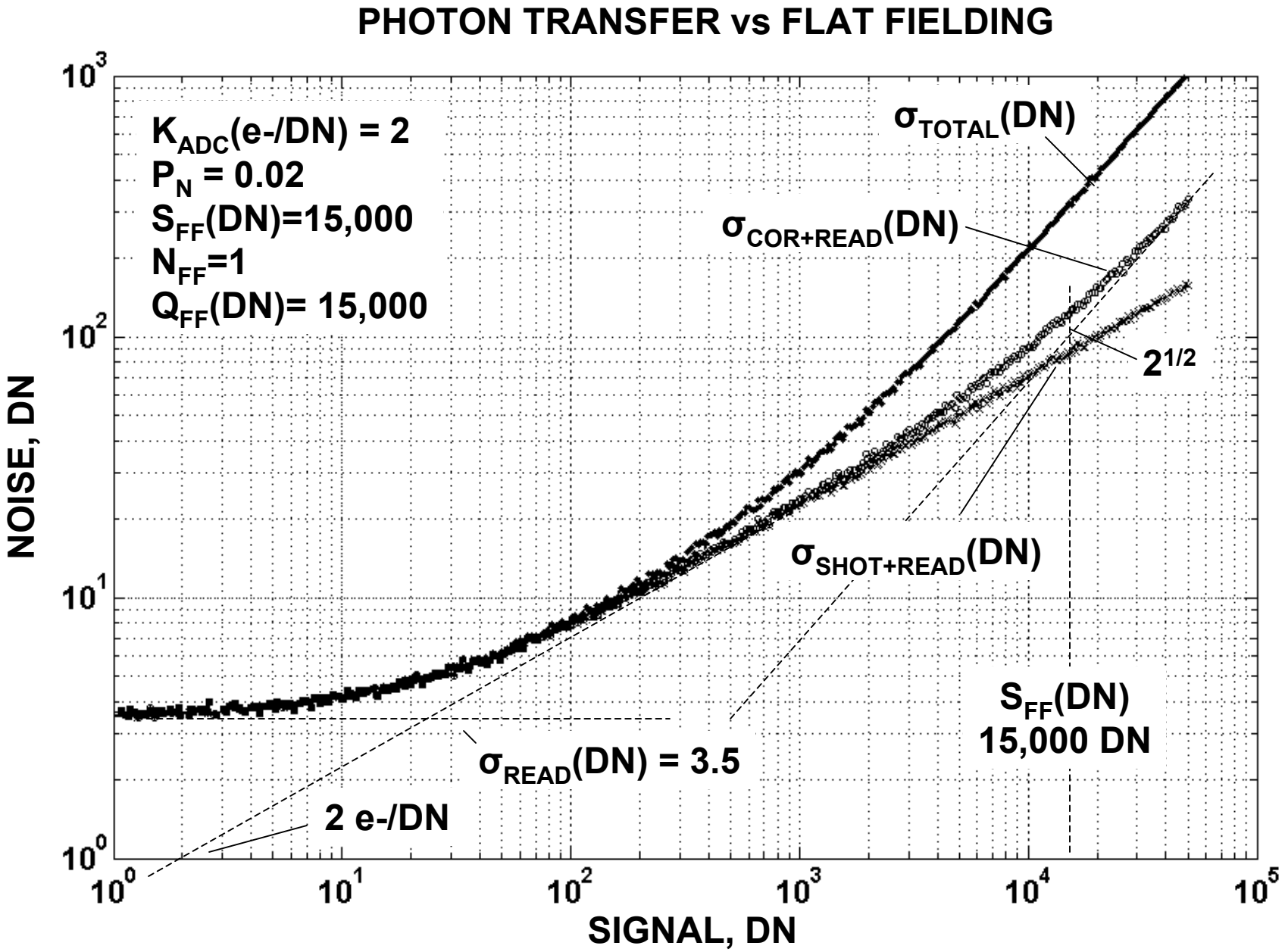
σ_{READ} = Read noise (rms e^-)

σ_{SHOT} = Shot noise (rms e^-)
= (Signal (e^-))$^{1/2}$

All Gaussian Distributed

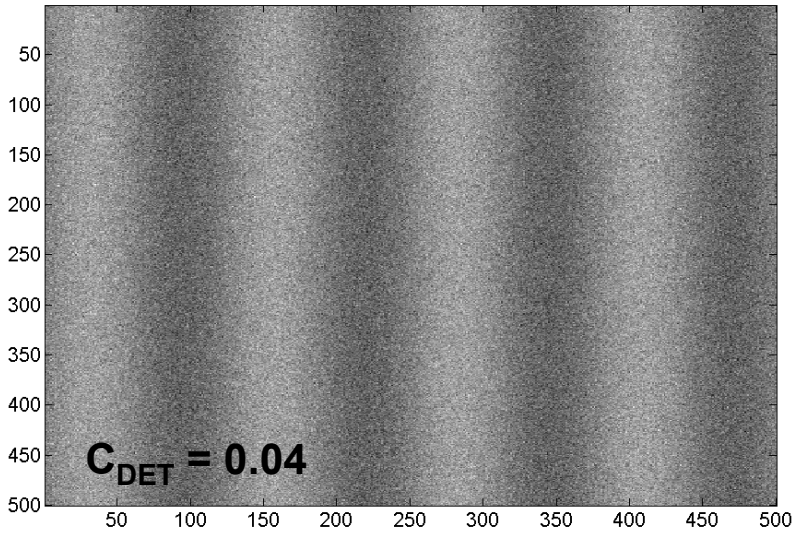
σ_{FPN} = Fixed Pattern Noise (rms e^-)
= P_N x Signal (e-)

P_N = Pixel nonuniformity factor
= Noise / Signal


PHOTON TRANSFER vs FLAT FIELDING
K_ADC(e-/DN) = 2
P_N = 0.02
S_FF(DN)=15,000
N_FF=1
Q_FF(DN)= 15,000
σ_TOTAL(DN)
σ_COR+READ(DN)
2^1/2
σ_SHOT+READ(DN)
S_FF(DN)
15,000 DN
σ_READ(DN) = 3.5
2 e-/DN
NOISE, DN
SIGNAL, DN
10^0
10^1
10^2
10^3
10^4
10^5

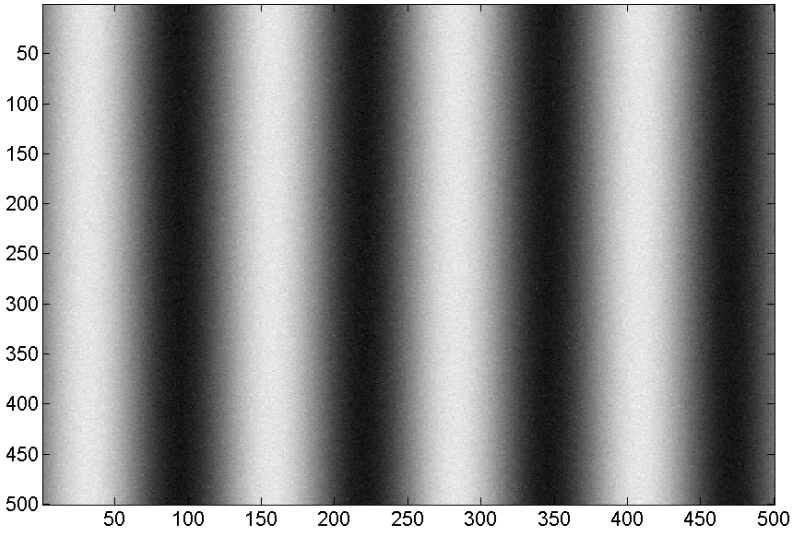
FLAT FIELDING

RAW

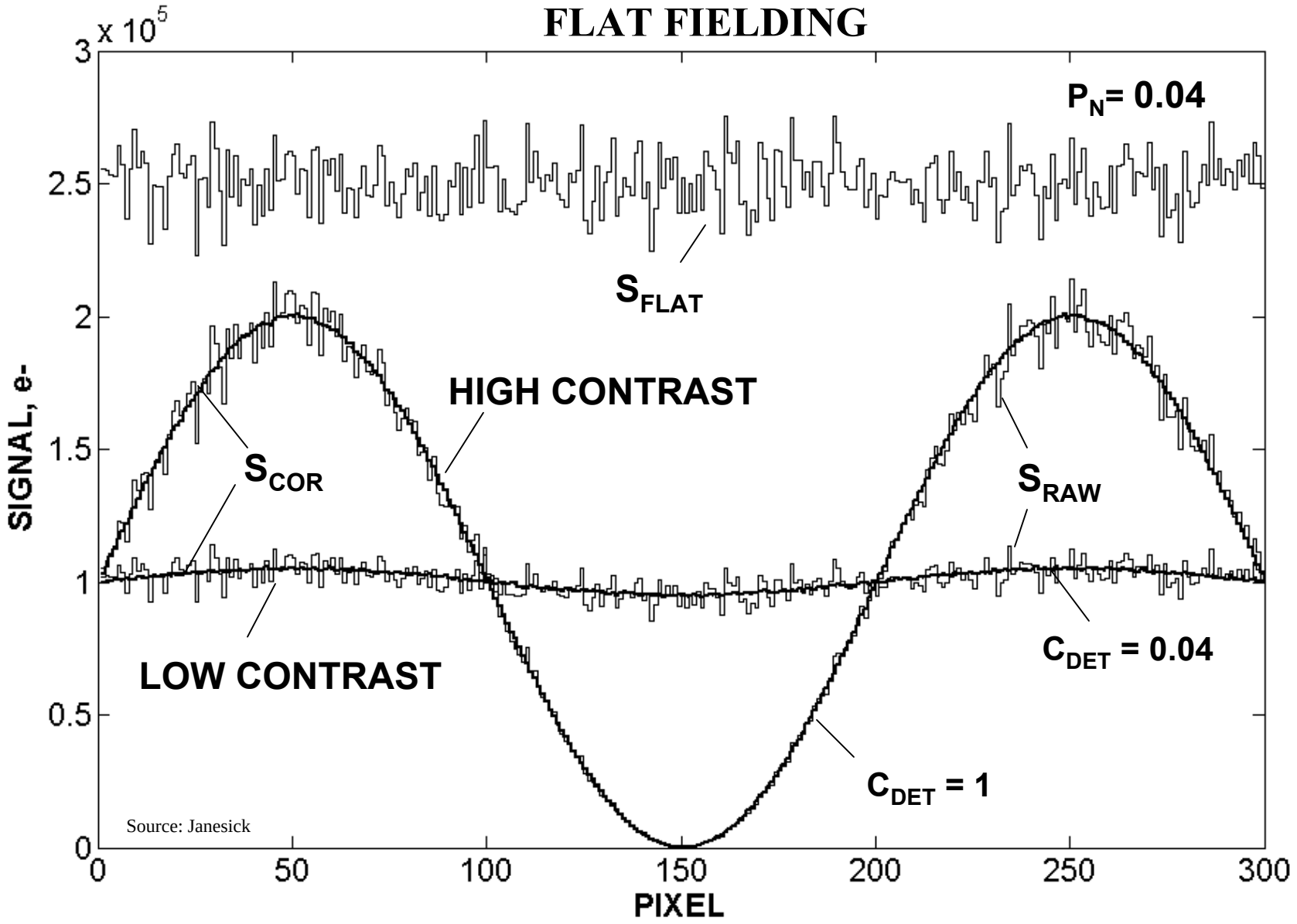


Source: Janesick

CORRECTED



FLAT FIELDING



FLAT FIELDING

Resultant noise for the corrected frame. . ..

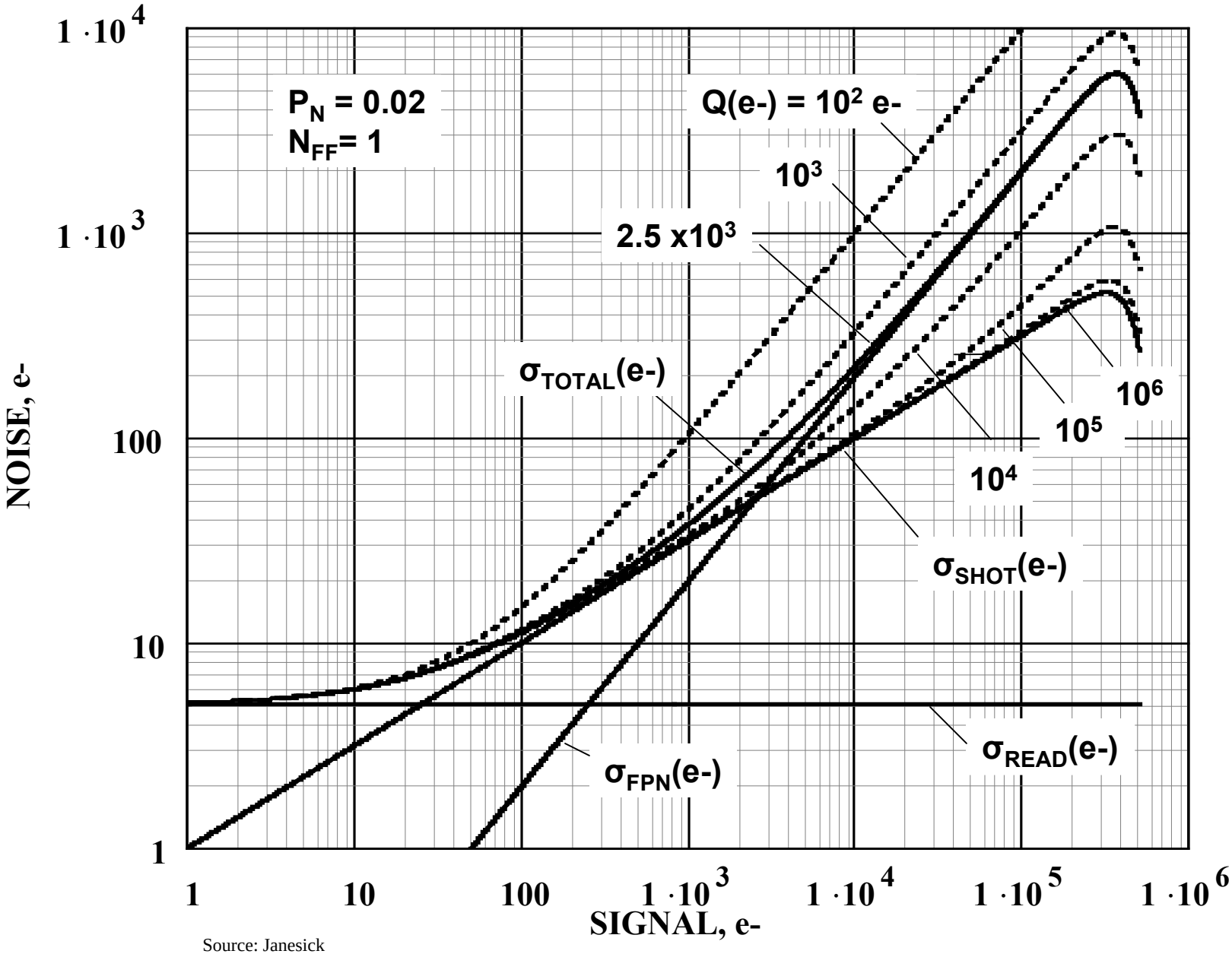
$$\sigma_{SHOT\_COR}(e-) = (\sigma_{READ}{}^{2} + (S_{RAW}(e-)(1 + \frac{S_{RAW}(e-)}{Q(e-)}))^{1/2}$$

where

$$Q(e-) = S_{FF}(e-)N_{FF}$$

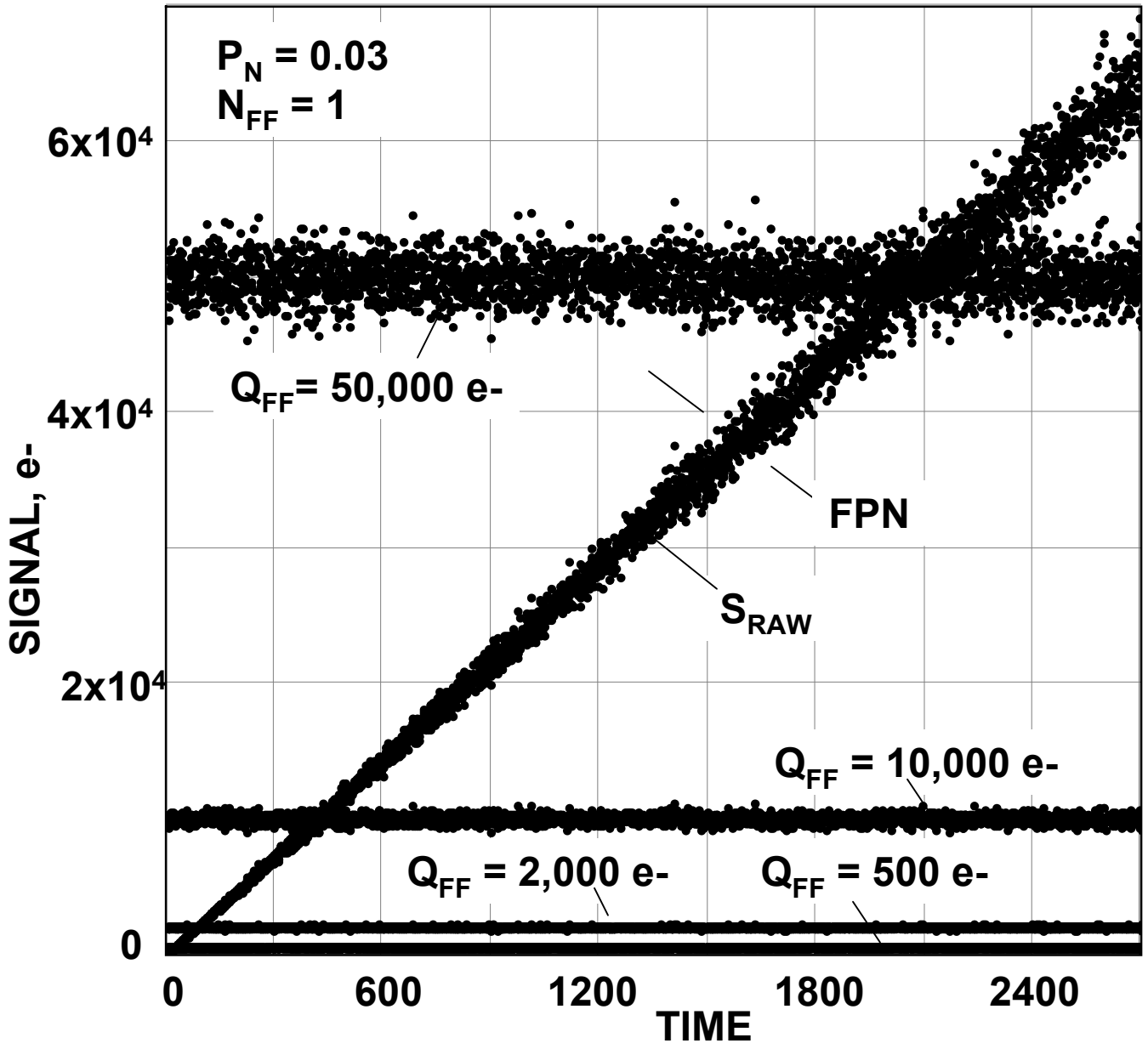
N_{FF} is the number of flat fields averaged

Source: Janesick

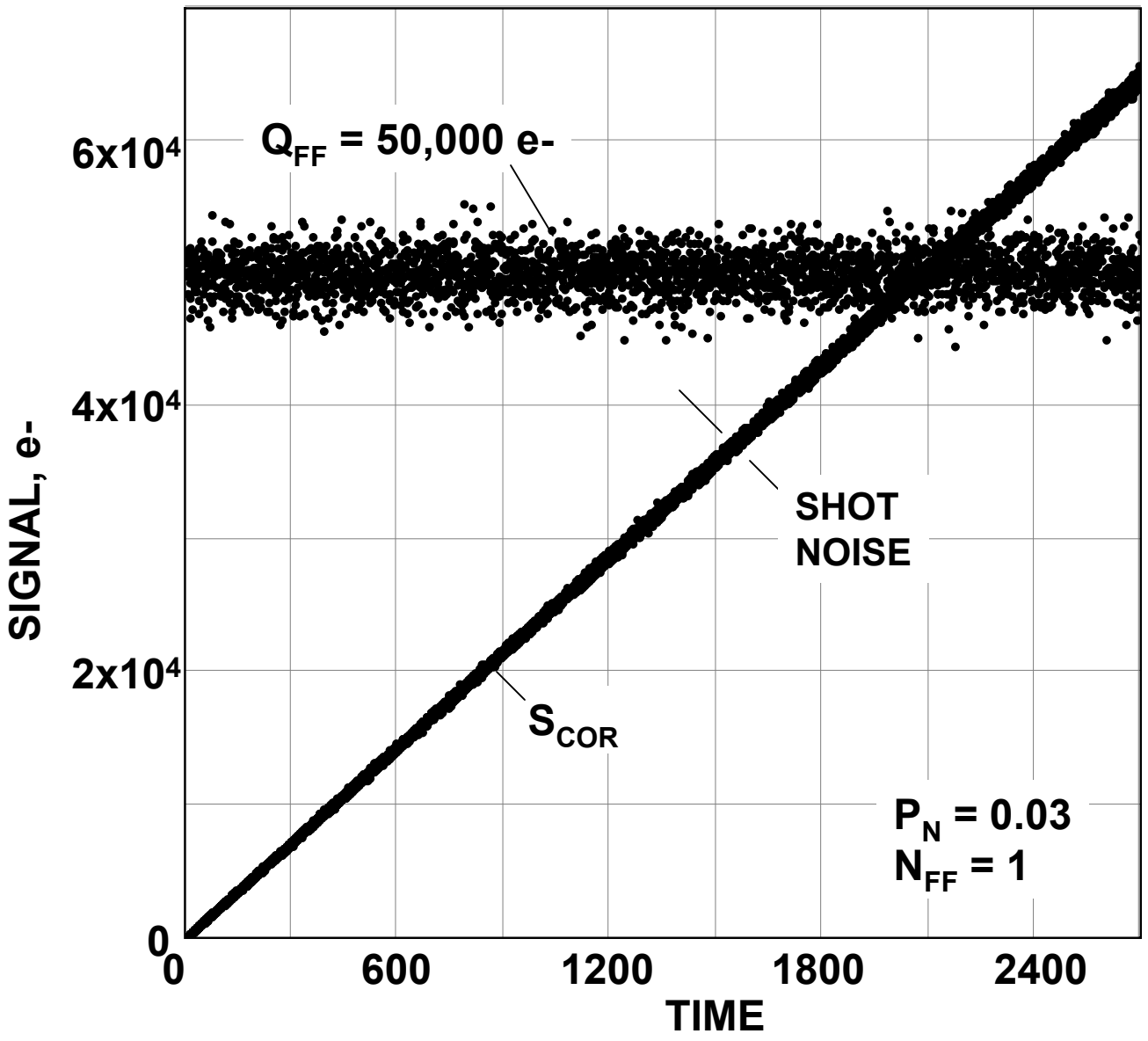


Source: Janesick

FLAT FIELDING



FLAT FIELDING



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