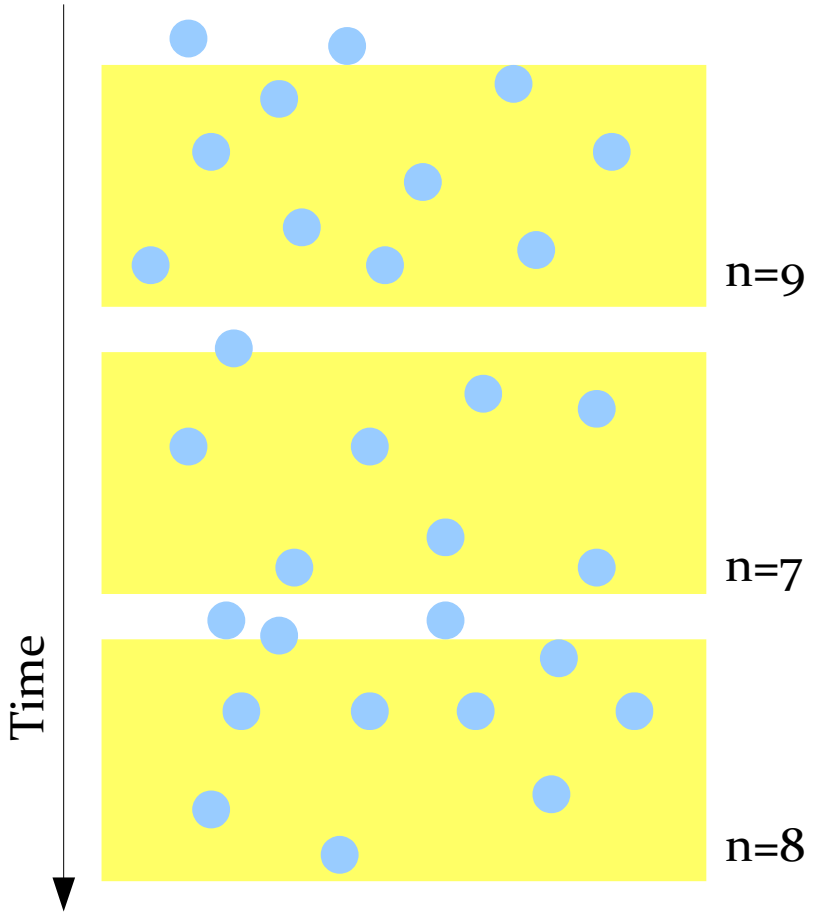
Light is Noisy

- Shot noise

$$\mu_p = \frac{A E t_{\text{exp}}}{h\nu} = \frac{A E t_{\text{exp}} \lambda}{hc}$$

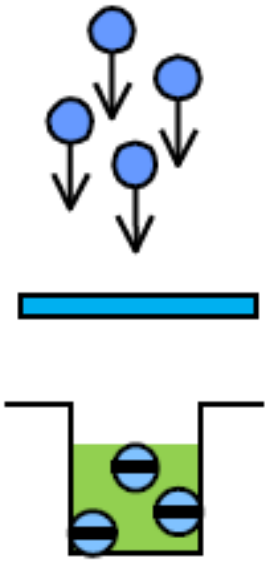
$$\sqrt{\mu_p}$$



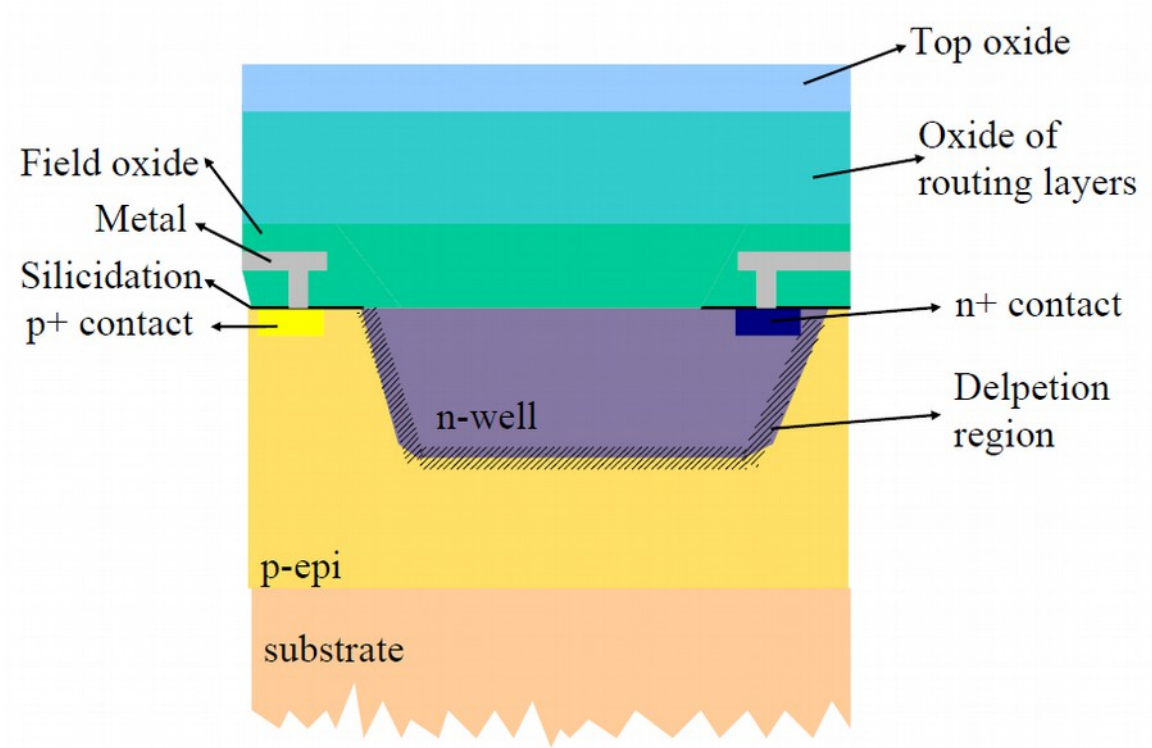
Quantum efficiency

- Sensing node and light-matter interaction

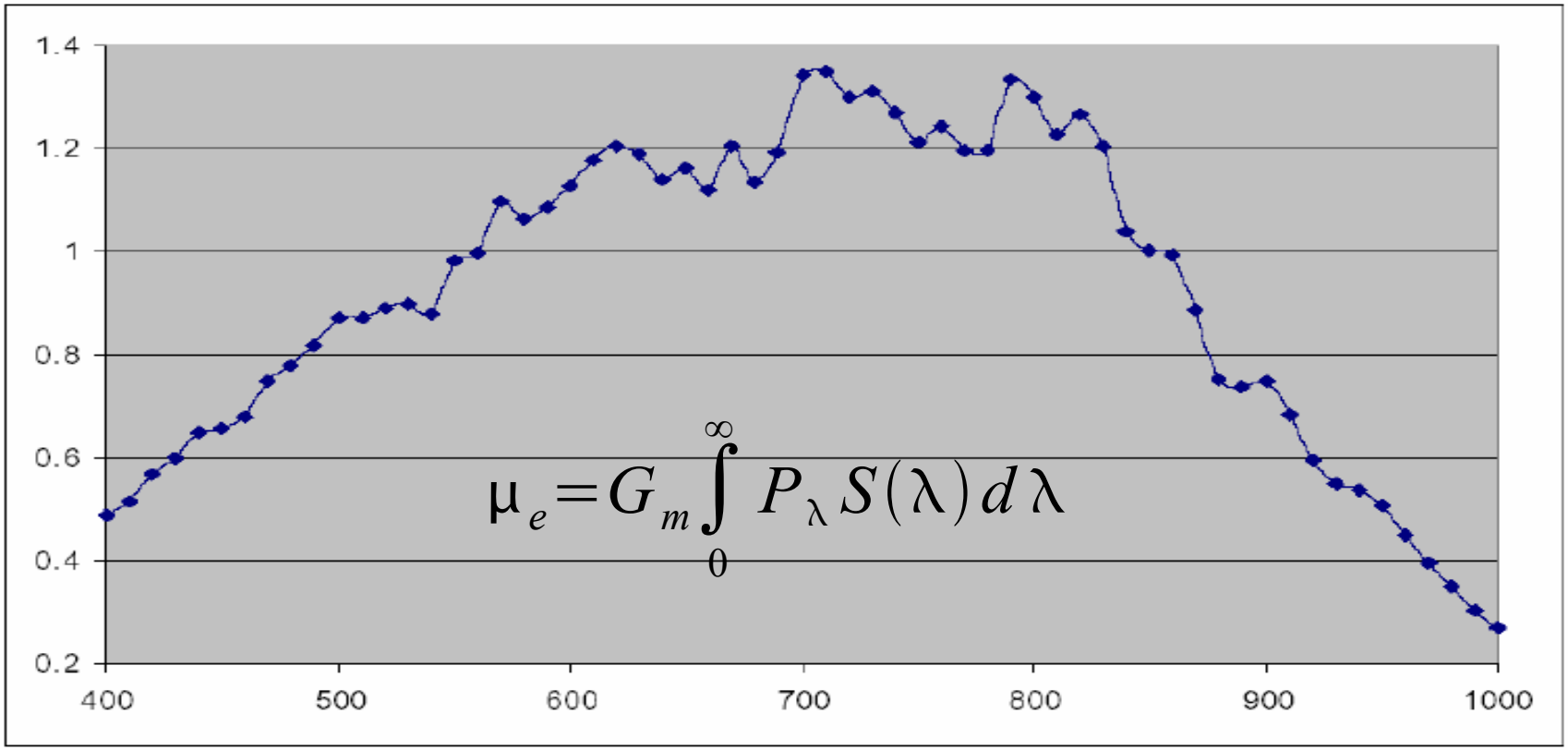
$$\eta(\lambda) = \frac{\mu_e(\lambda)}{\mu_p}$$



$$\sqrt{\mu_e}$$

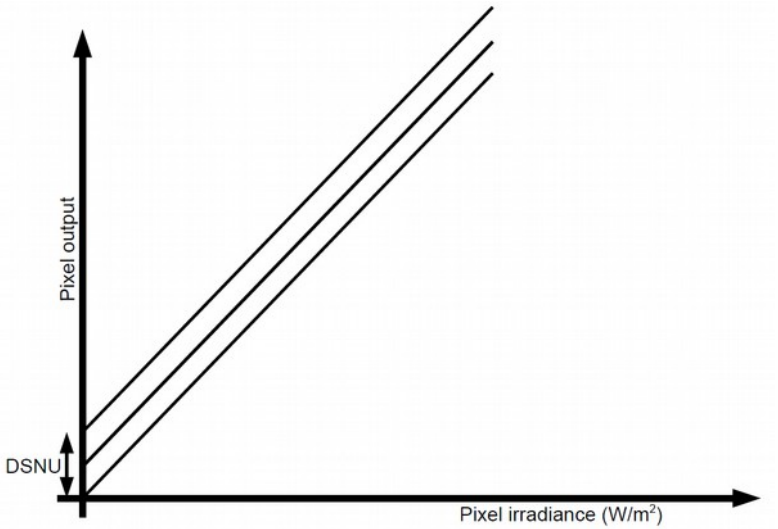


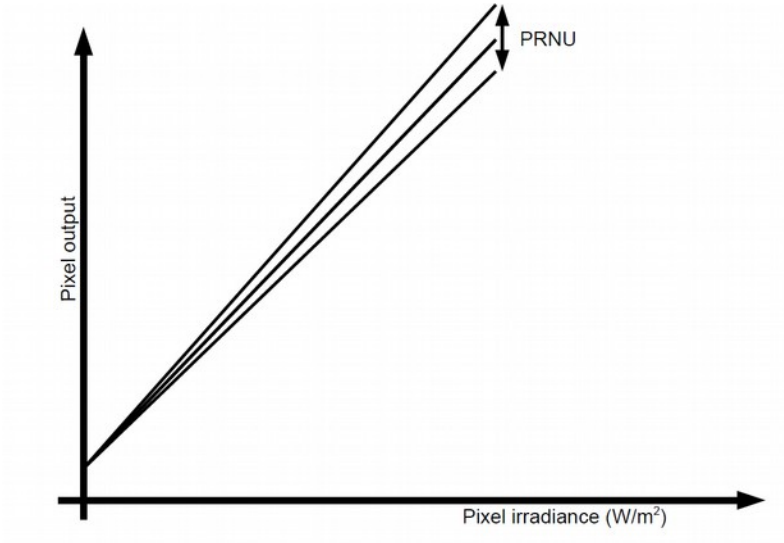
Spectral Response



This curve is normalized to 850nm, the peak of sensitivity is around 700nm.

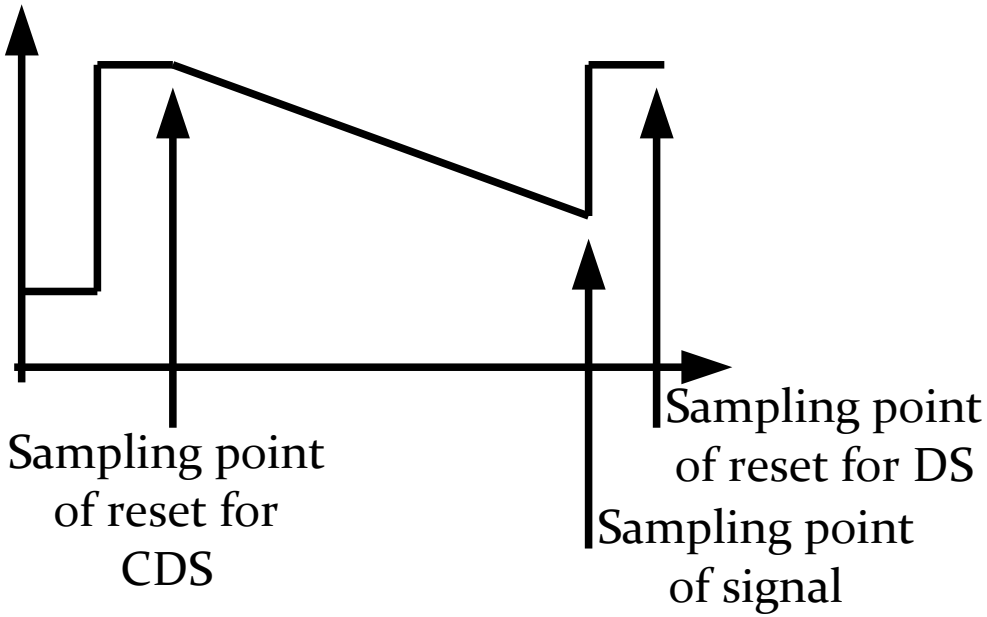
PRNU vs DSNU


Pixel output
DSNU
Pixel irradiance (W/m²)


PRNU
Pixel output
Pixel irradiance (W/m²)

Low Light Imaging Limitations

- Reset noise (kTC)
  - Uncertainty of the amount of charge in a capacitor when it is charged through a resistor



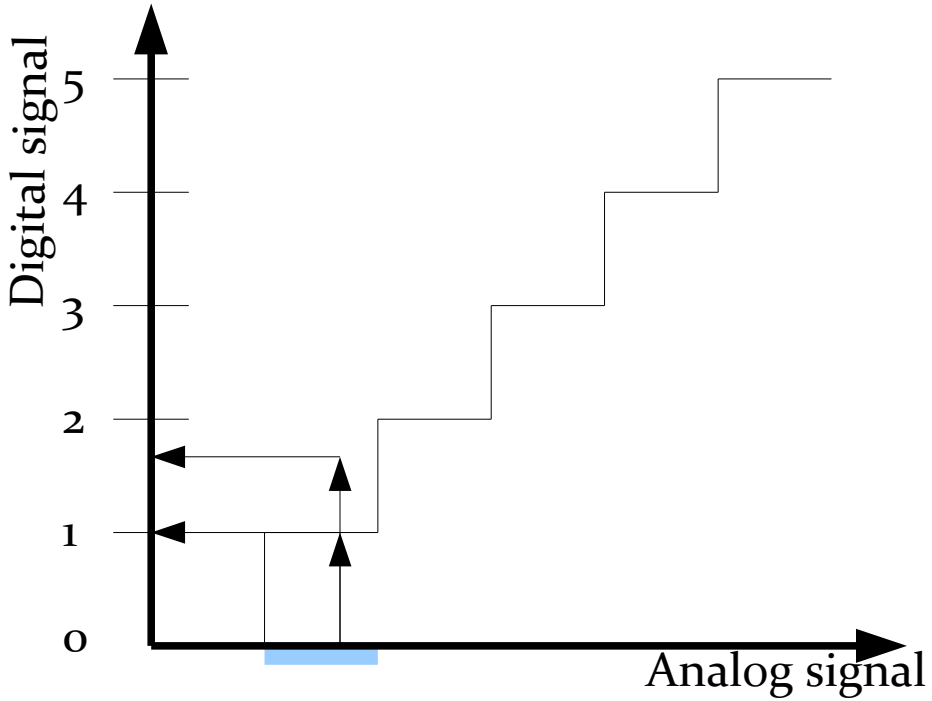
$$\sigma_{e,reset} = \frac{\sqrt{kTC}}{q}$$

$$V_{e,reset,rms} = \sqrt{\frac{kT}{C}}$$

Low Light Imaging Limitations

- Quantization noise

$$\sigma_q = \frac{1}{\sqrt{12}}$$



Aphesa

Integrating Linear Pixels

- Dynamic range

$$DR = \frac{i_{max}}{i_{min}} = \frac{q_{max} - i_d t_{int}}{\sqrt{q\, i_d t_{int} + \sigma_r^2}}$$

- Signal to noise ratio

$$SNR(i_{ph}) = \frac{i_{ph} t_{int}}{\sqrt{q(i_{ph} + i_d) t_{int} + \sigma_r^2}}$$

- The response curve has the form y=a*x+b with an incremental gain of g=a and an information transfer function of I=a for i>i_min and o below.

Aphesa

Dark current compensation