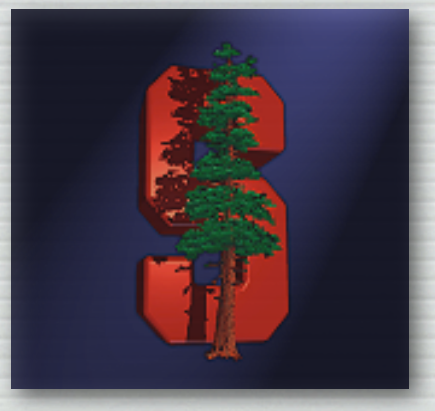
Optics redux

CS 178, Spring 2009

A few extra notes on tradeoffs between camera parameters, on macro lenses, and on zoom lenses, added 4/14/09



Marc Levoy
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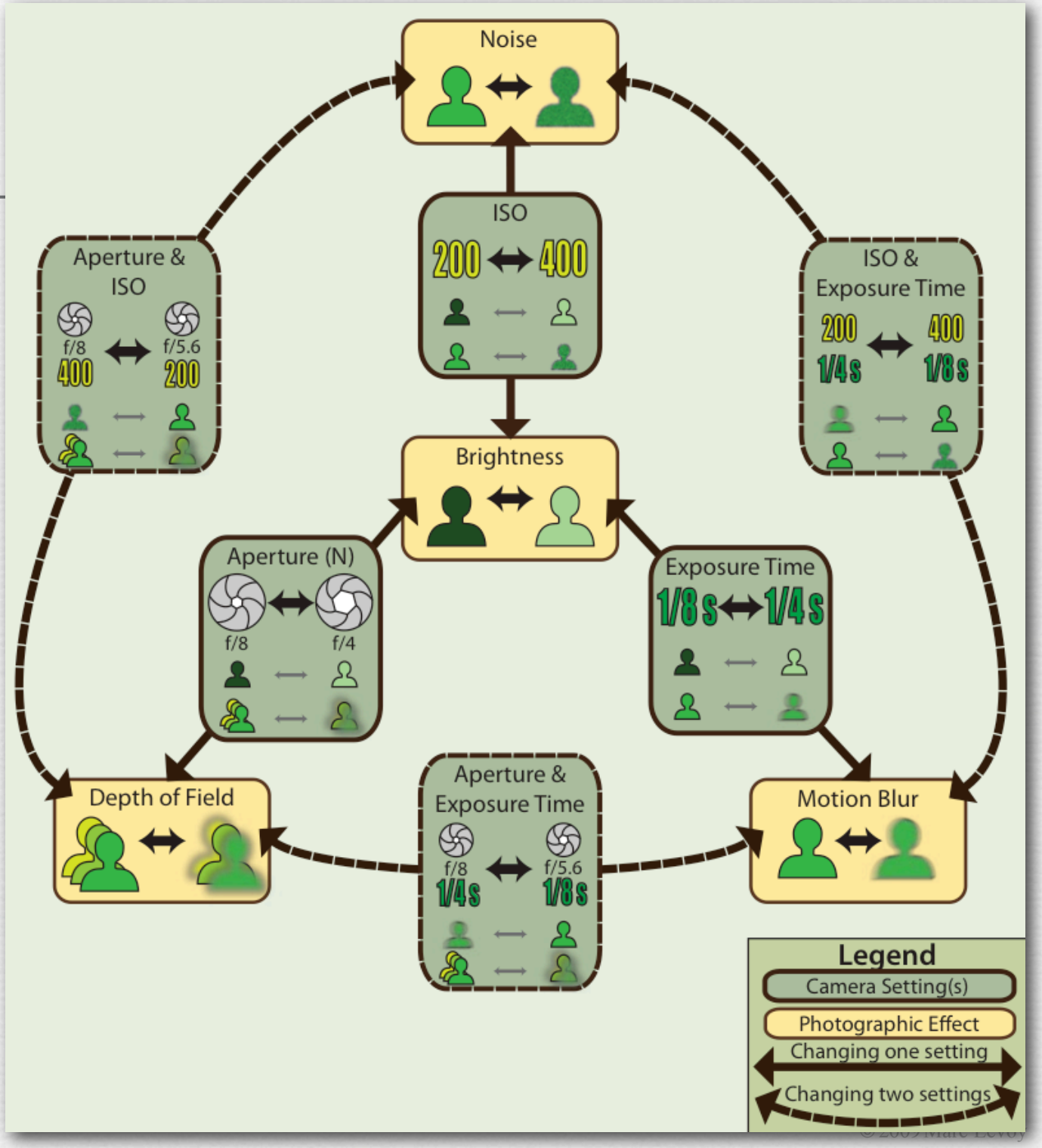
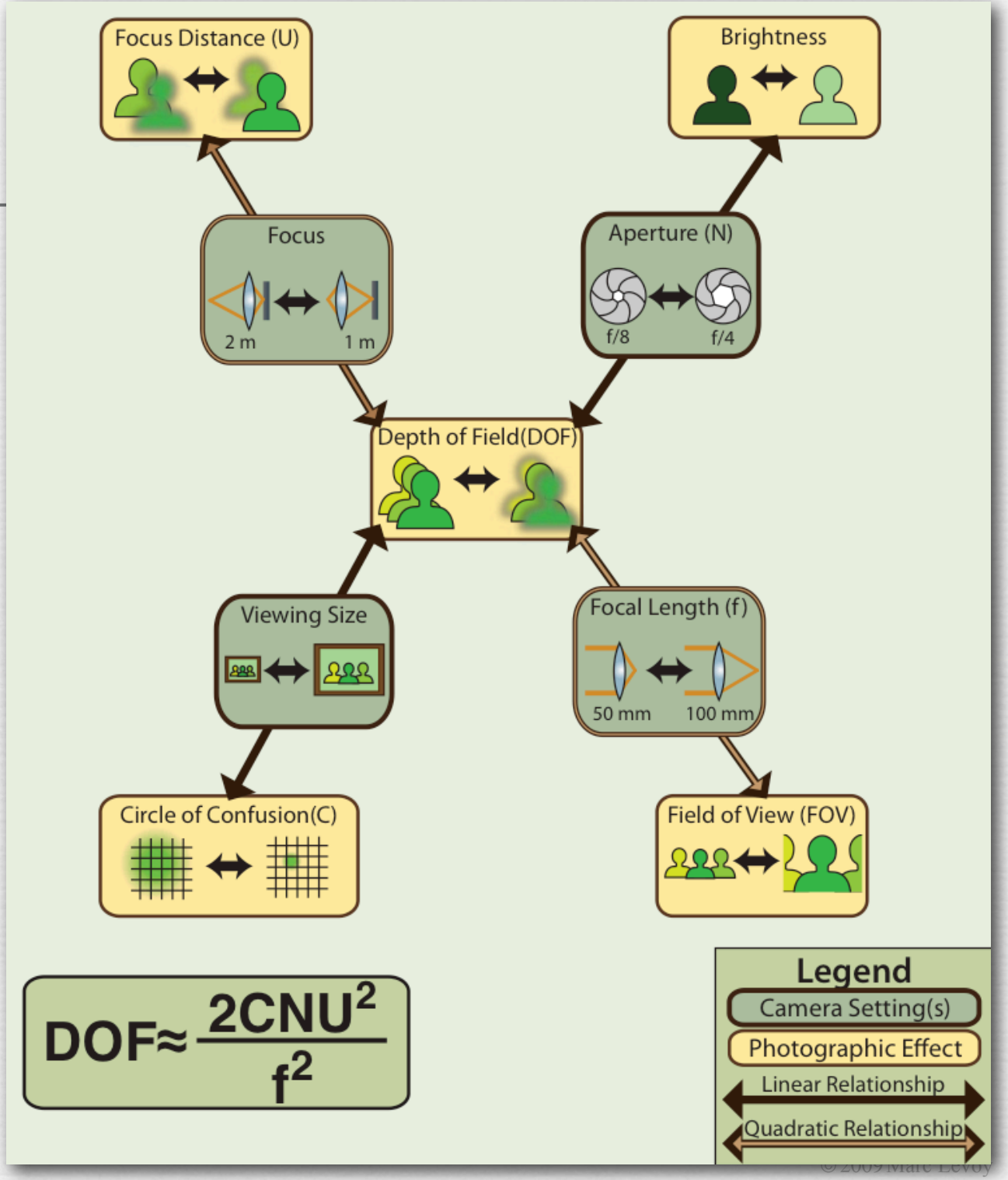
Tradeoffs affecting brightness



(Eddy Talvala)

Tradeoffs affecting depth of field



(Eddy Talvala)

$$D_{TOT} \approx \frac{2NCU^2}{f^2}$$

- N = f/4.1
  C = 2.5µ
  U = 5.9m (19')
  f = 73mm (equiv to 362mm)
  D_{TOT} = 132mm

- 1 pixel on this video projector
  C = 2.5µ × 2816 / 1024 pixels
  D_{EFF} = 363mm

Canon MP-E
65mm 5:1 macro

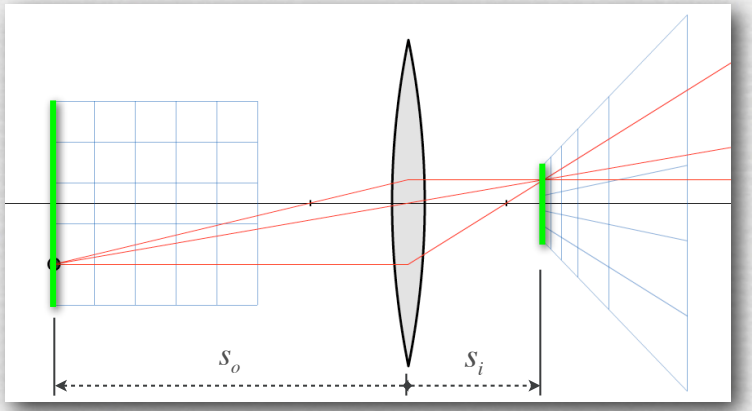
- N = f/16
  C = 6.4µ
  U = ~9mm
  f = 65mm
  (use $N' = (1+M_T)N$ at short conjugates (M_T=5 here))
  D_{TOT} = 0.02mm! (20µ)

(Mikhail Shlemov)

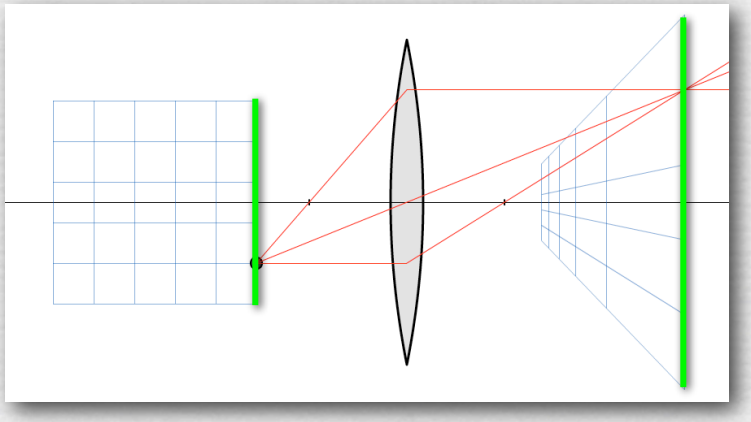
Sidelight: macro lenses

$$\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}$$

Q. How can the Casio EX-F1 at 73mm and the Canon MP-E 65mm macro, which have similar *f*'s, have such different focusing distances?



normal



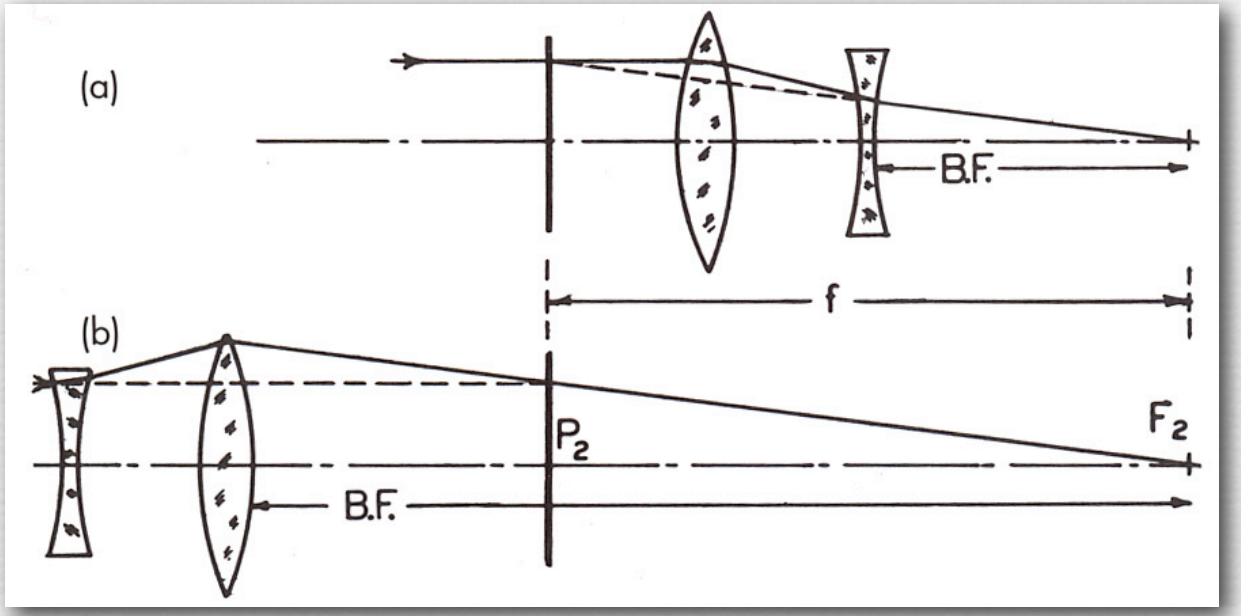
macro

- A. Because they are built to allow different s_i
  - this changes s_o, which changes magnification $M_T \triangleq -s_i / s_o$
  - macro lenses are well corrected for aberrations at short s_o

Extension tube:
converts a normal lens to a macro lens

- toilet paper tube, black construction paper, masking tape
- camera hack by Katie Dektar (CS 178, 2009)

Lens combinations: telephoto



(Kingslake)

- telephoto (a) reduces the back focal distance B.F. relative to *f*
  - for long focal length lenses, to reduce their physical size
- reversed telephoto (b) increases B.F. relative to *f*
  - for wide-angle lenses, to ensure room for the reflex mirror

Lens combinations: telephoto

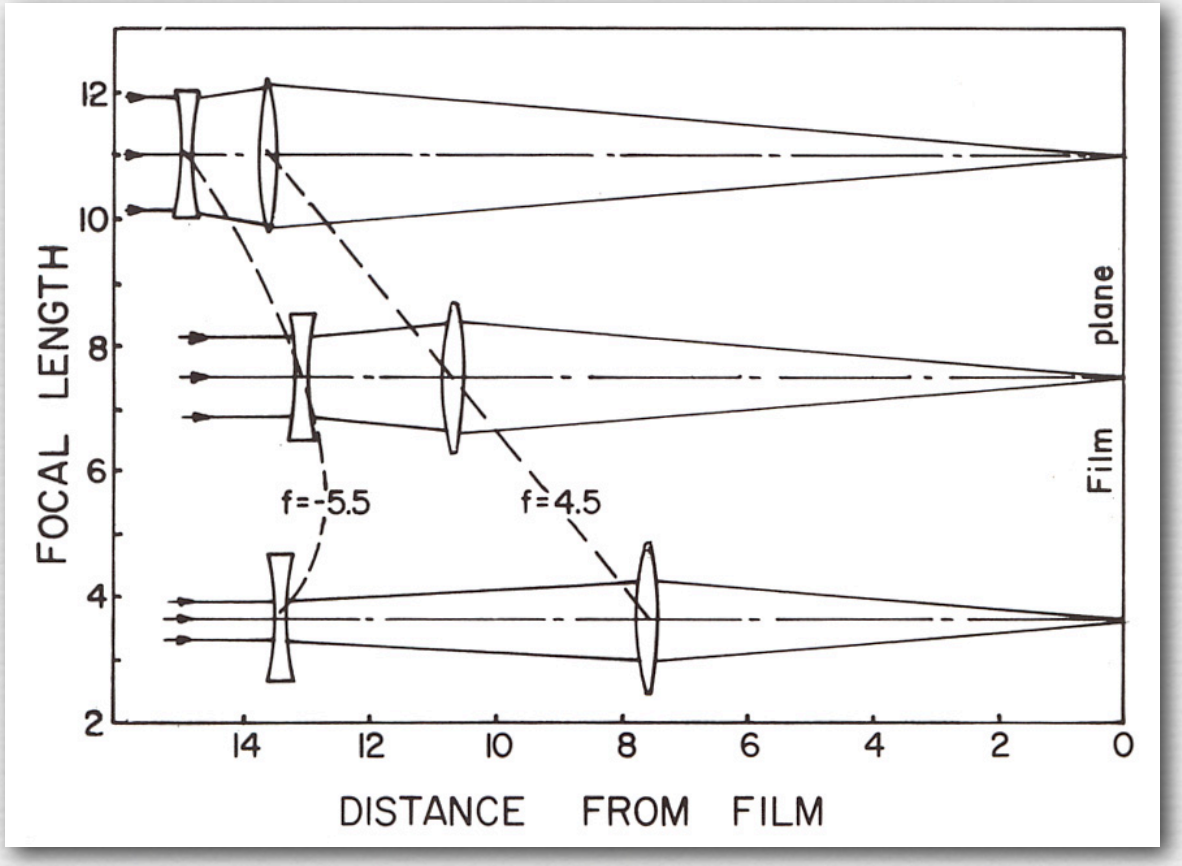
(wikipedia)

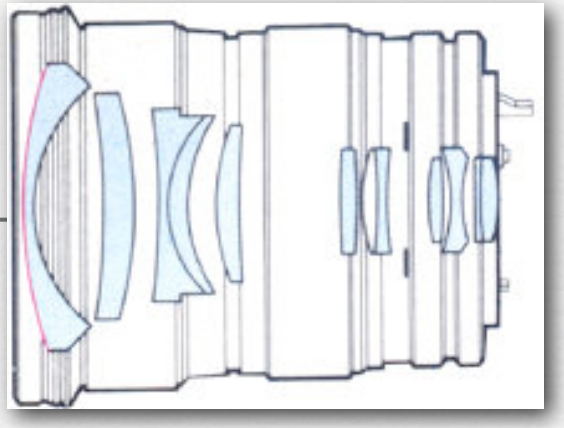
500mm <u>non</u>-telephoto

Canon 1200mm telephoto

Canon 500mm telephoto

Lens combinations: zoom





Canon FD 24-35mm
f/3.5 L manual focus lens

(FLASH DEMO)

http://graphics.stanford.edu/courses/cs178-09/applets/zoom.swf

- called *optically compensated zoom*, because the in-focus plane stays (more or less) stationary as you zoom
- to change focus, you move both lenses together