

Photographic lighting

CS 178, Spring 2010

Recap slides added after the
lecture on 5/20/10.



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Stanford University

Outline

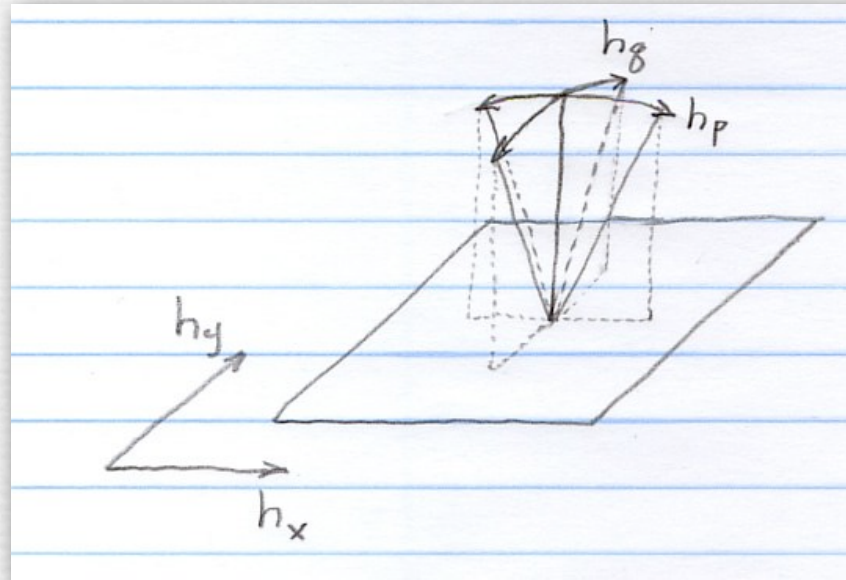
- ◆ taxonomy of light sources
- ◆ lighting for portraiture
- ◆ studio lighting
- ◆ special lighting problems
- ◆ flash photography

Taxonomy of light sources

[Langer and Zucker, CVPR 1997]

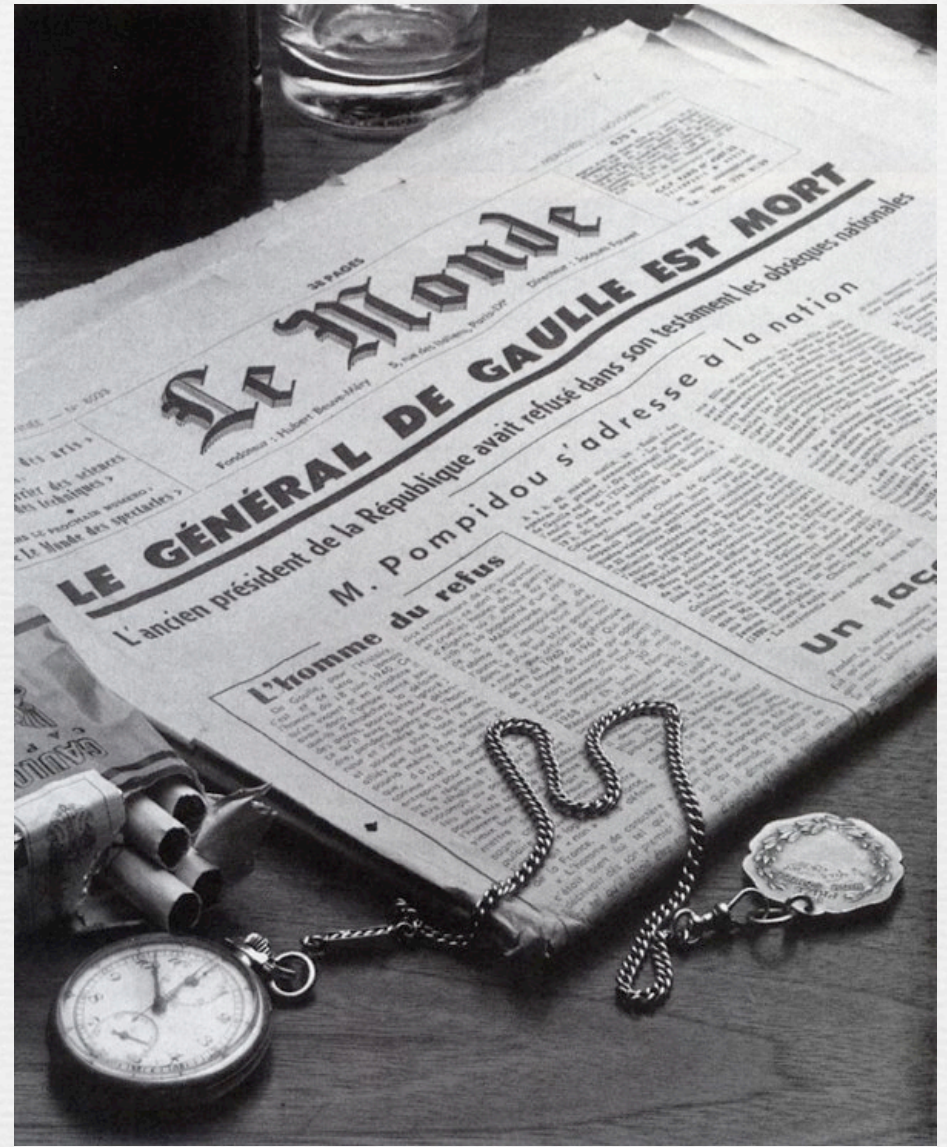
<i>Non-ideal example</i>	<i>Ideal model</i>	h_x	h_y	h_p	h_q	dimension
overcast sky	uniform source	∞	∞	∞	∞	4
Cyberware TM scanner		∞	∞	∞	0	3
		∞	∞	0	∞	
fluorescent tube	linear source	∞	0	∞	∞	3
		0	∞	∞	∞	
sunlight	point source at infinity	∞	∞	0	0	2
	uniform distribution of rays in a plane	∞	0	∞	0	2
		0	∞	0	∞	
louvered linear source (see text)	fan of rays perpendicular to a linear source	∞	0	0	∞	2
		0	∞	∞	0	
small panel light	point source	0	0	∞	∞	2
sunlight through crack in doorway	parallel rays in a plane	∞	0	0	0	1
		0	∞	0	0	
rotating spotlight	fan of rays	0	0	0	∞	1
		0	0	∞	0	
spotlight or laser	single ray	0	0	0	0	0

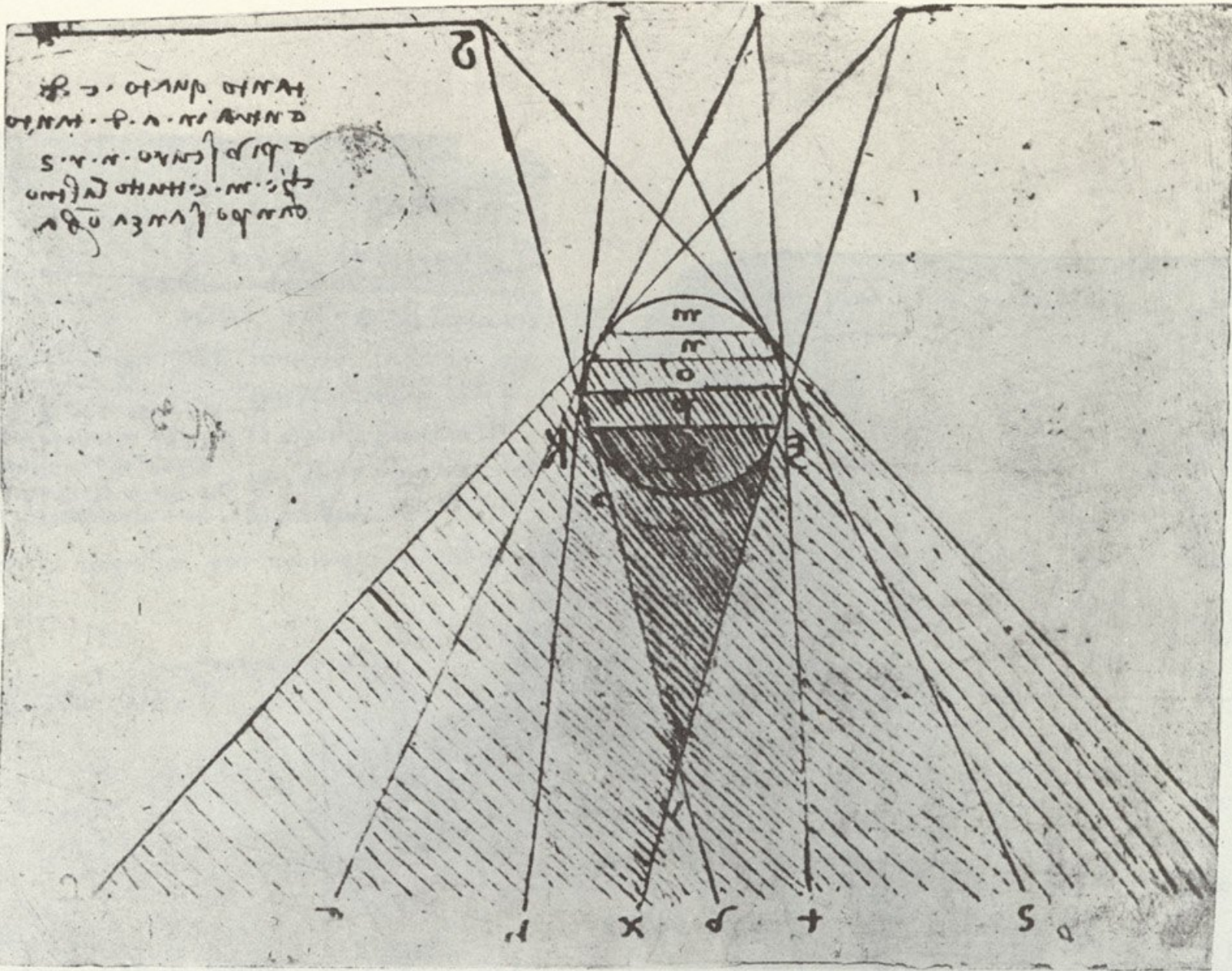
Geometry for table on previous slide (contents of whiteboard)



- ◆ h_x and h_y give spatial extent of light source (zero or infinity, i.e. point or area), and h_p and h_q give angular extent (zero or infinity, i.e. parallel beam or fan beam)

What's different between these two?





Leonardo, study of umbra and penumbra

Lighting for portraiture

- ◆ conventional studio lighting
- ◆ unconventional lighting
- ◆ available light
- ◆ narrative light

Yousuf Karsh,
Winston Churchill,
1941



Yousuf Karsh,
Audrey Hepburn
1956



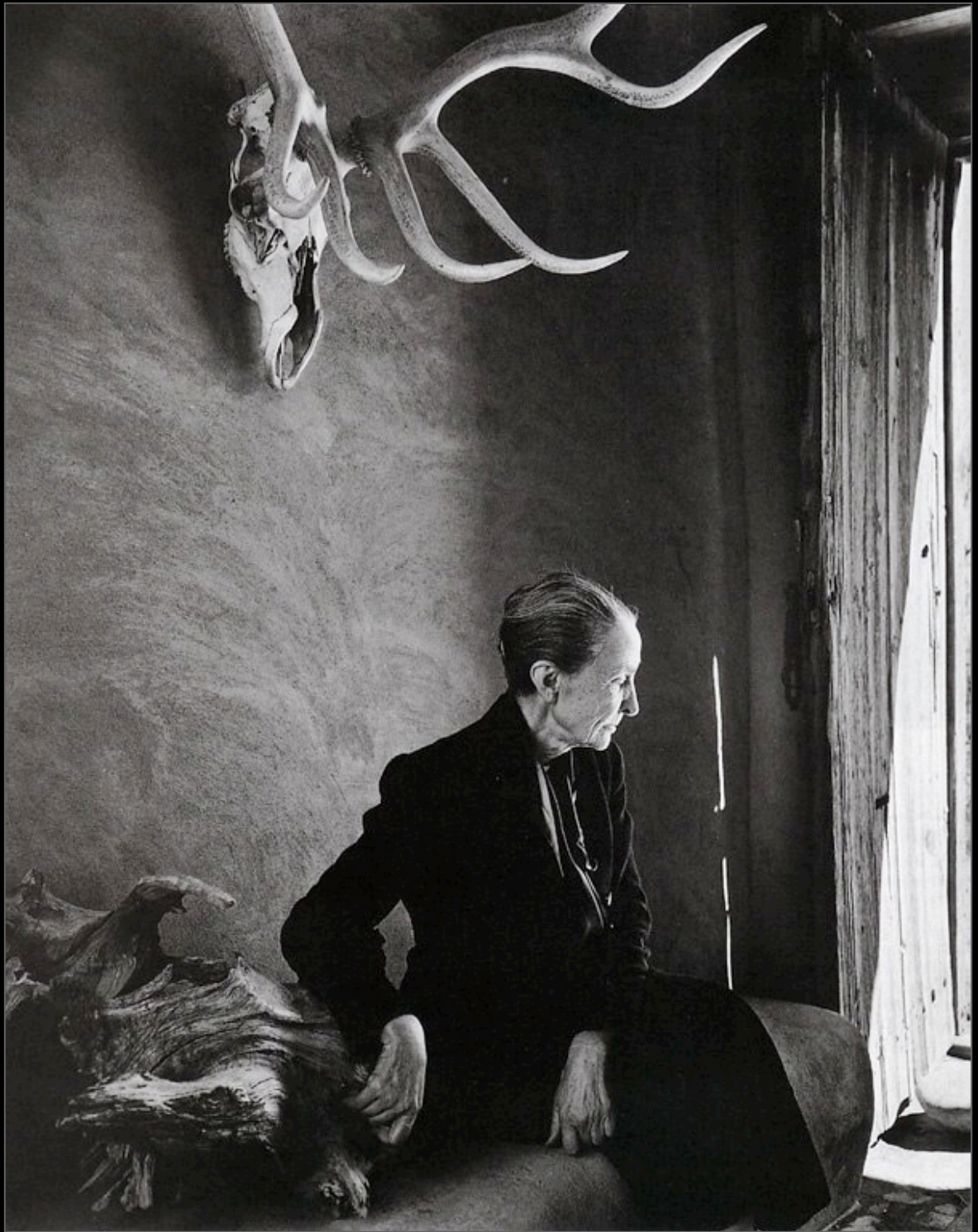


Yousuf Karsh,
Peter Lorre,
1946

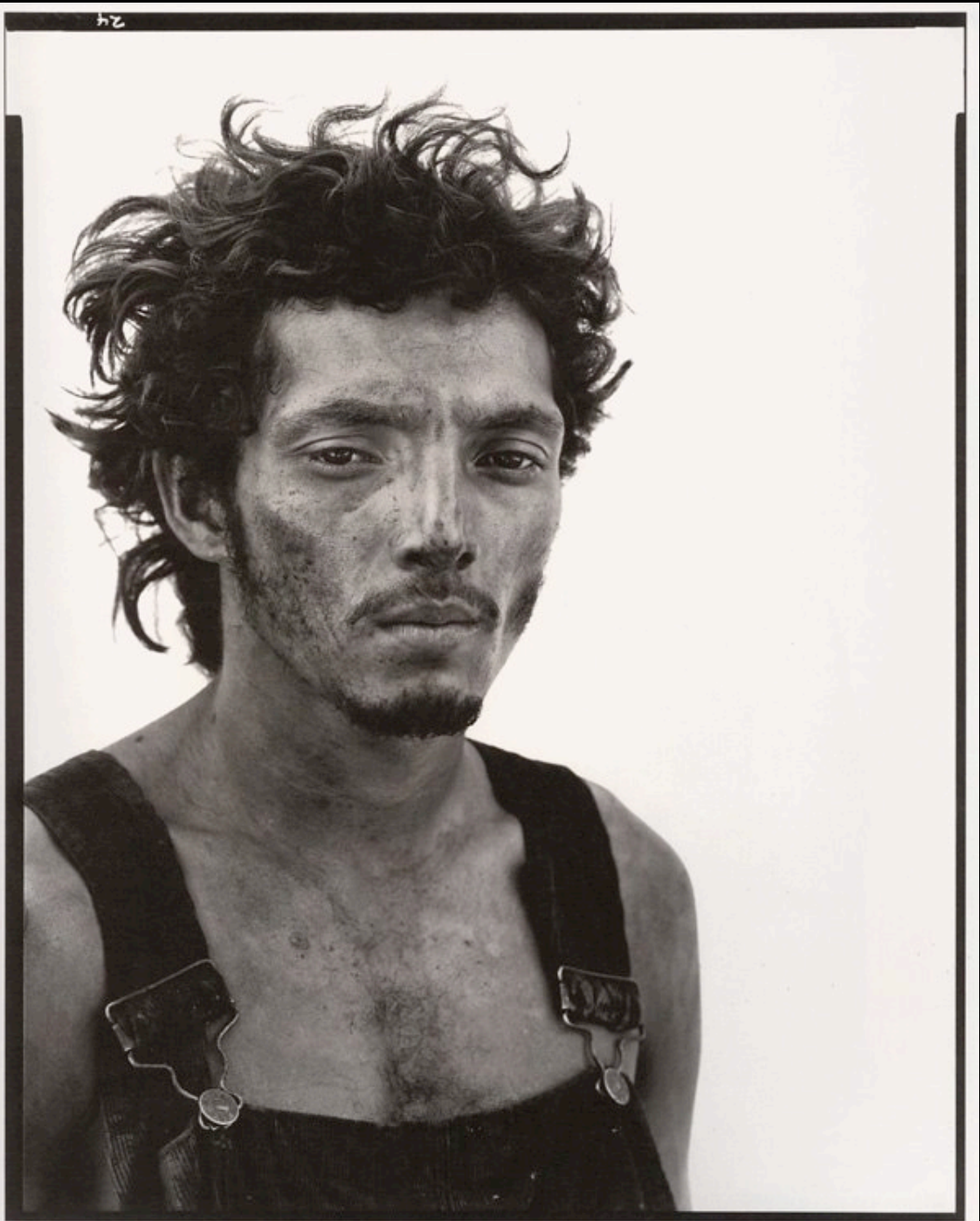
Photography in available light

- ◆ challenging
- ◆ worthwhile
- ◆ requires patience and luck
- ◆ always carry your camera

Yousuf Karsh,
Georgia O'Keeffe,
1956



Richard Avedon,
Oil Field Worker,
1980

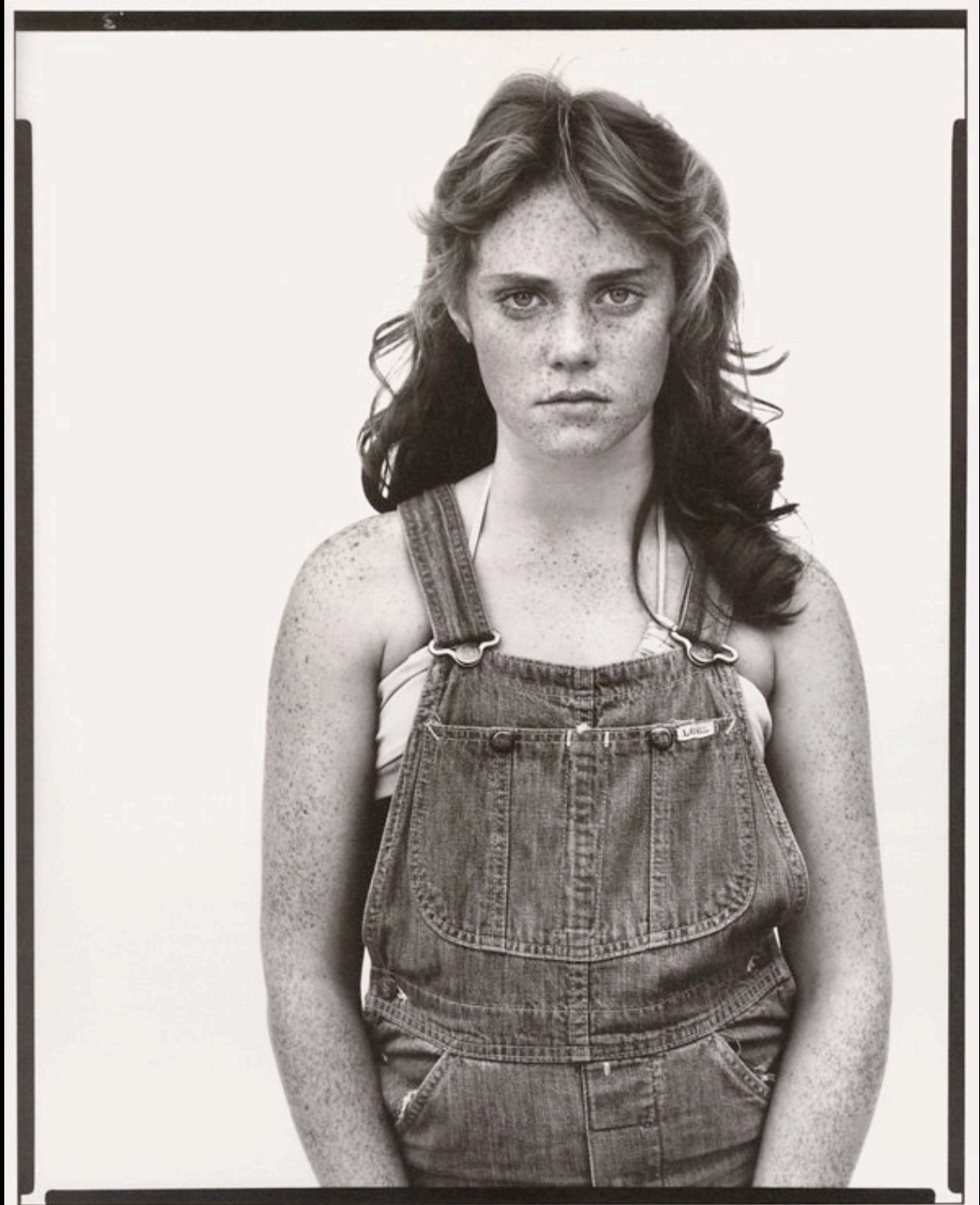


ROBERTO LOPEZ, OIL FIELD WORKER, LYONS, TEXAS, SEPTEMBER 28, 1980



Avedon working outdoors

Richard Avedon,
Sandra Bennett,
1980



SANDRA BENNETT, TWELVE YEAR OLD, ROCKY FORD, COLORADO, AUGUST 23, 1980







Caravaggio, The Calling of St. Matthew, 1599



Rembrandt, Belshazzar's Feast, 1599

Studio lighting

spotlight with
reflective umbrella

floodlight

zebra board

lights with
diffusers



(Kodak)

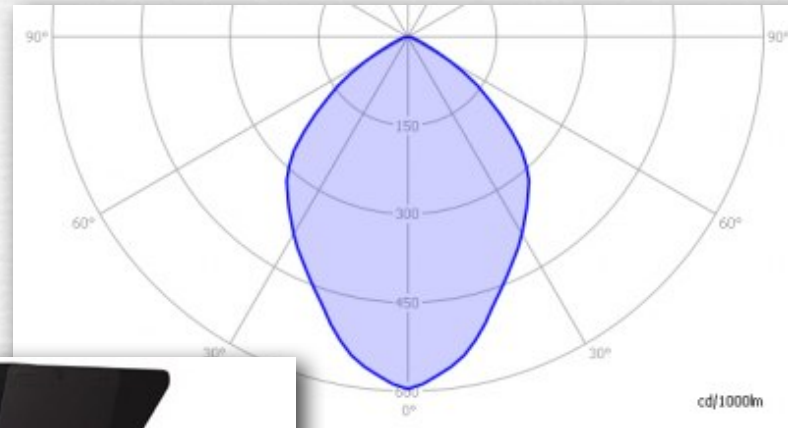
spotlight

strobe

Adjustments on studio spotlights



goniometric diagram showing
luminous intensity at each angle



barn doors



zoom control



filter holder

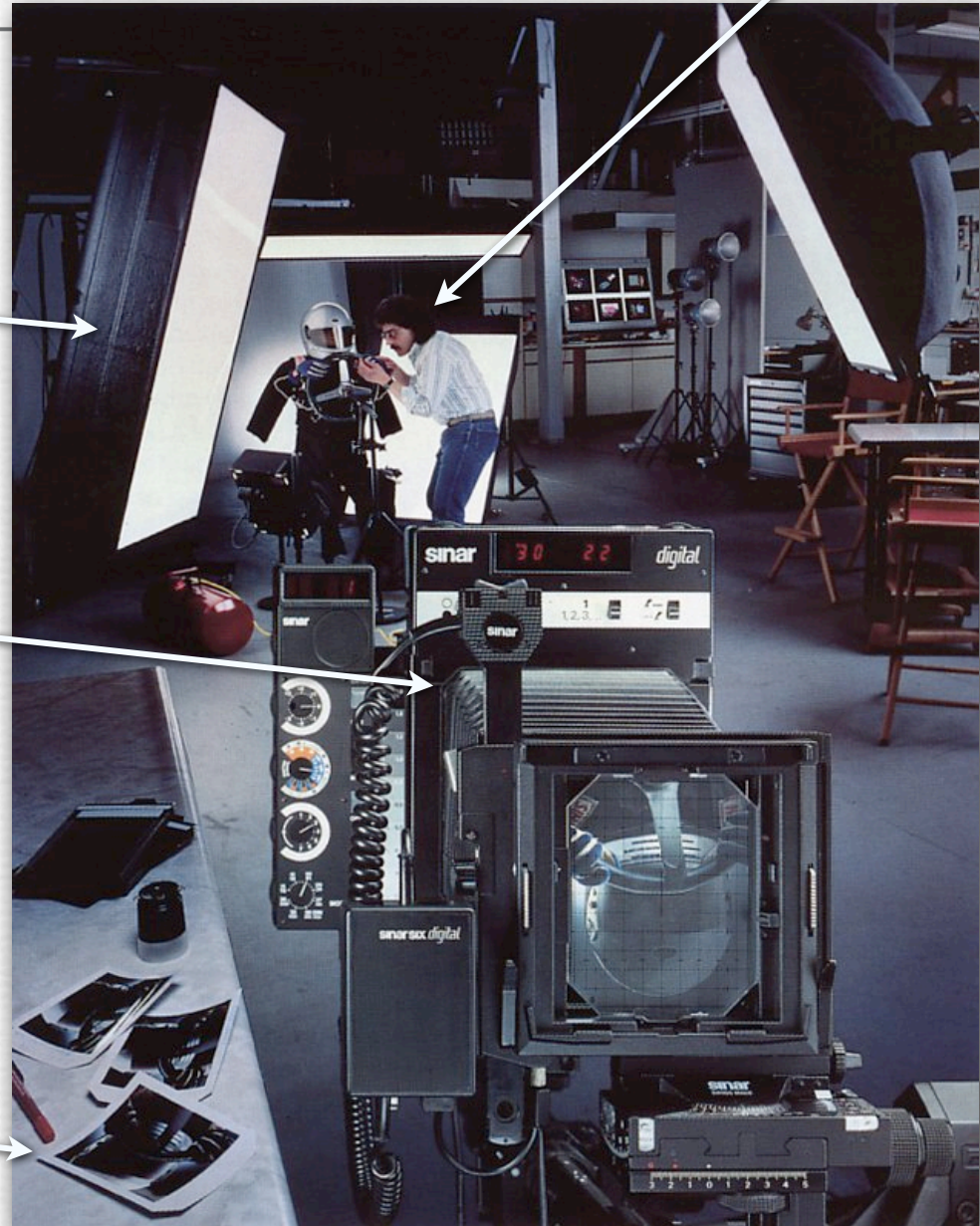
1970's haircut

Lighting rigs can be large

soft box

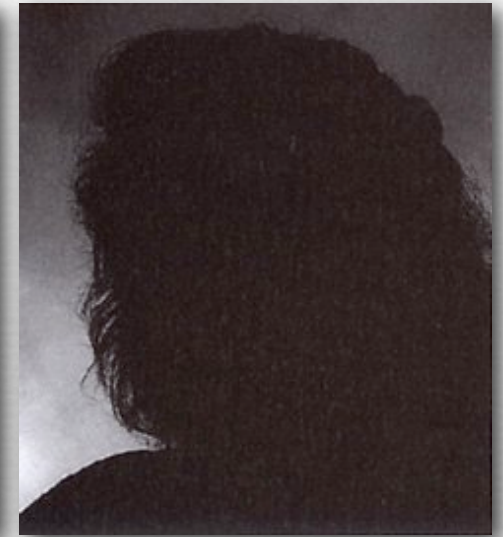
film view camera with
digital light meter

polaroid
preview
pictures



Basic portrait lighting

(London)



main/key



fill



accent/rim



background

Basic portrait lighting

(London)



Alternative lighting arrangements

- ◆ main light on side towards camera - broadens narrow faces
- ◆ main light on side of face away from camera - most common
- ◆ main light directly in front of face - glamour lighting

broad



short



butterfly



Alternative names for arrangements

- ◆ broad lighting is sometimes called Rembrandt lighting
 - note triangular light on her left cheek (right side of image)



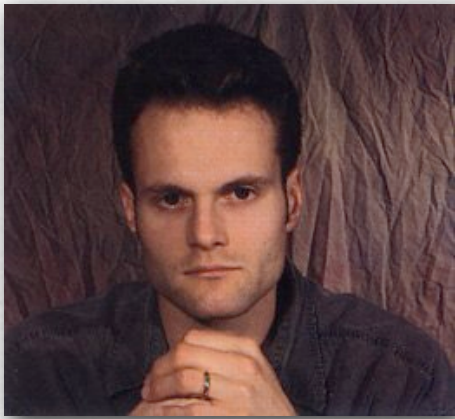
(Varis)



Rembrandt van Rijn,
Self Portrait, 1660

key:fill light ratio

(London)



1:1



2:1



4:1

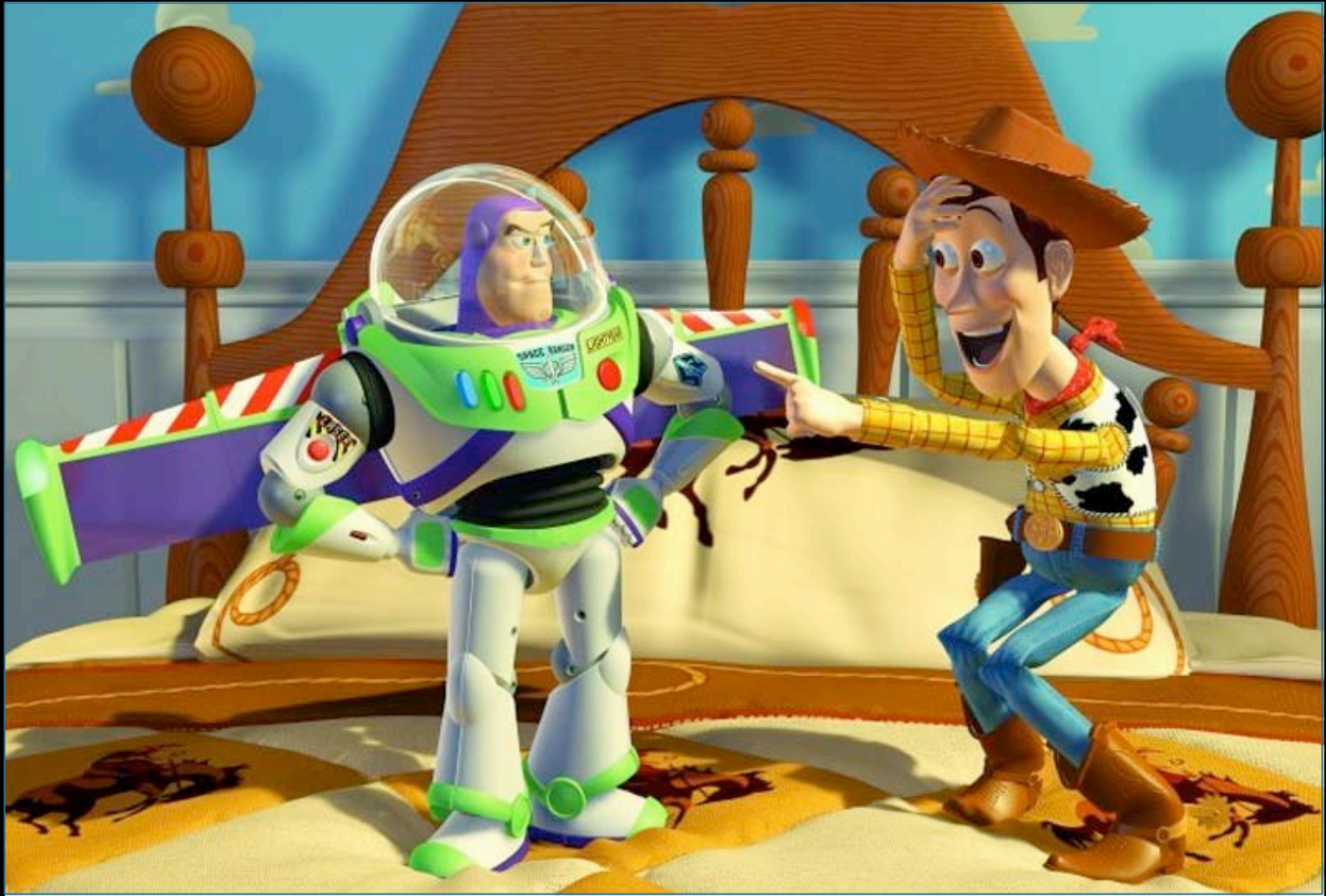


8:1

- ◆ 8:1 means 3 f/stops (3 doublings)
- ◆ think about the mood you want to convey
- ◆ the color of the key and fill lights can be different...



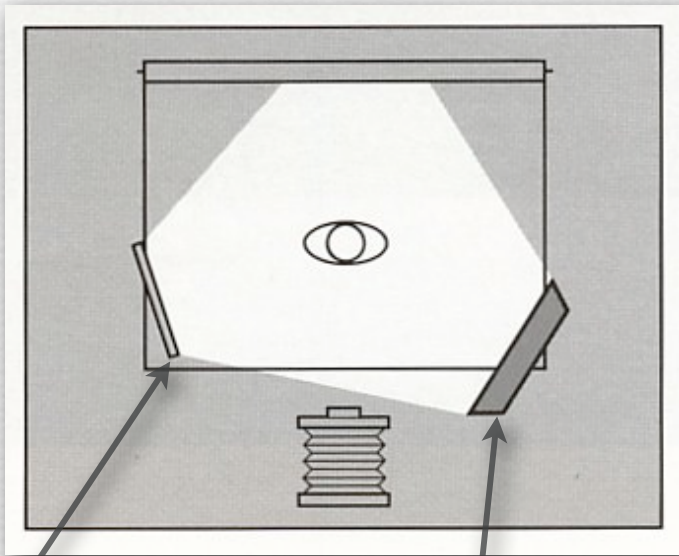
Maxfield Parrish, Daybreak, 1922



Pixar, Toy Story, 1995

Professional photographic lighting manuals

photographed by
D.W. Mellor



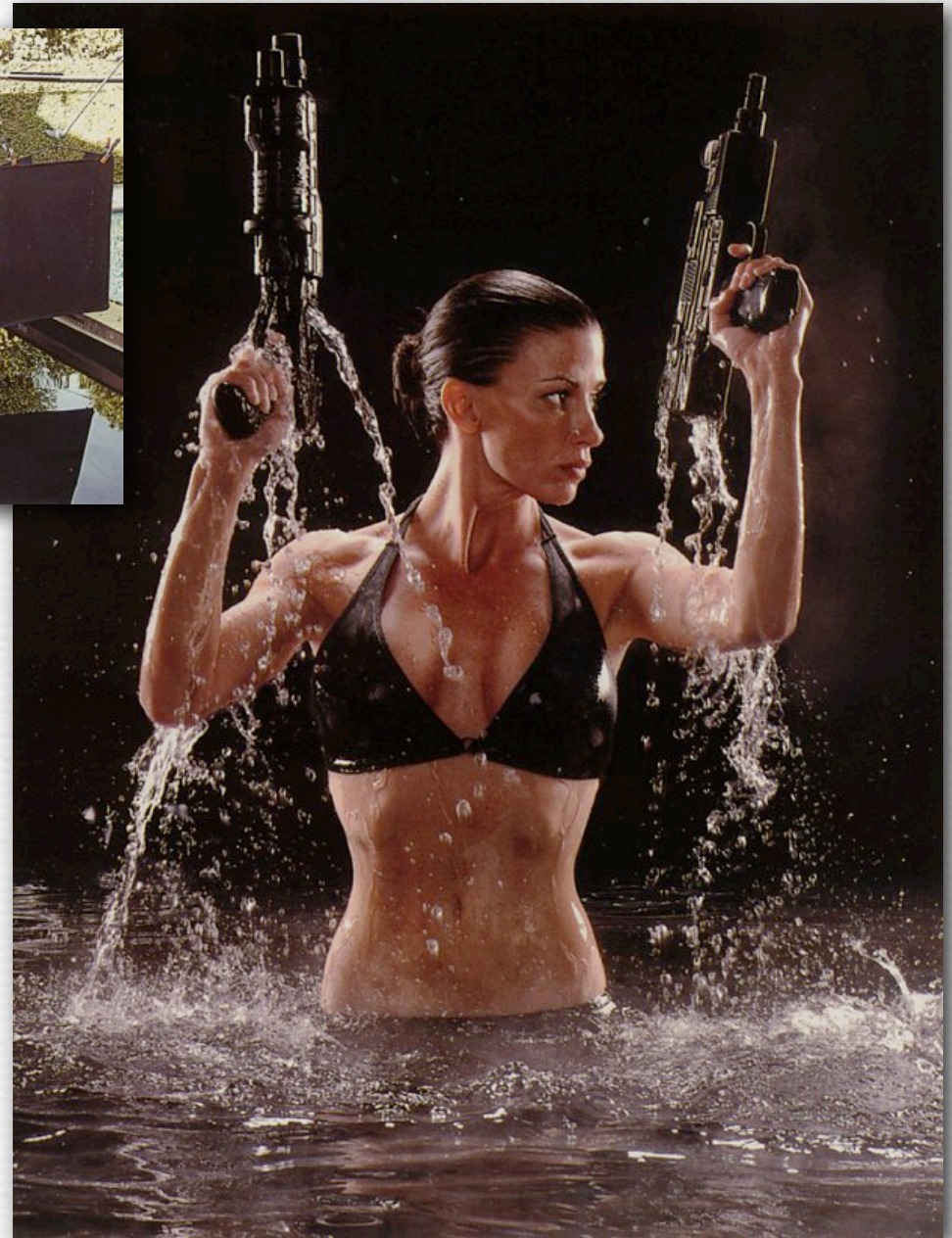
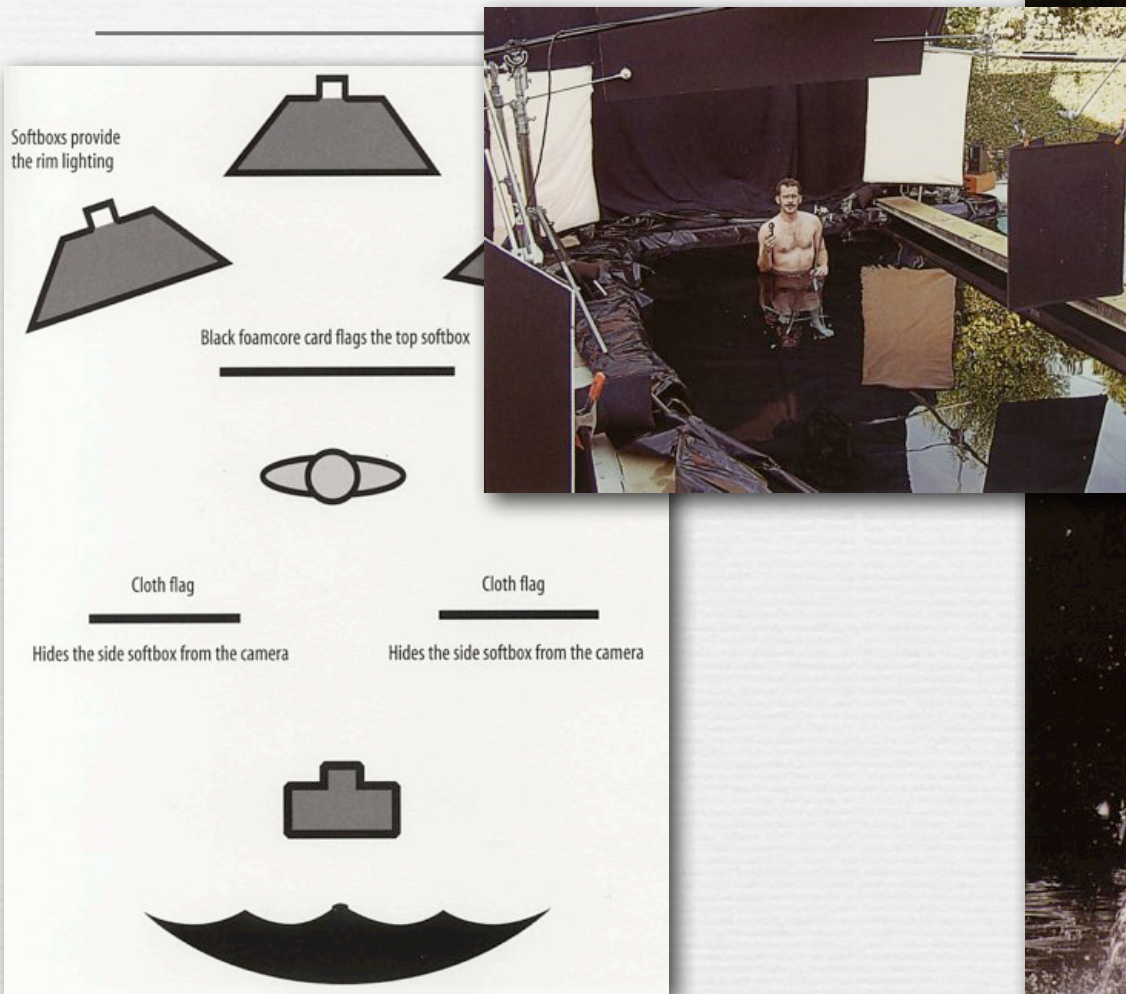
diffuse
reflector

diffused
spotlight

(Kodak)



Professional photographic lighting manuals



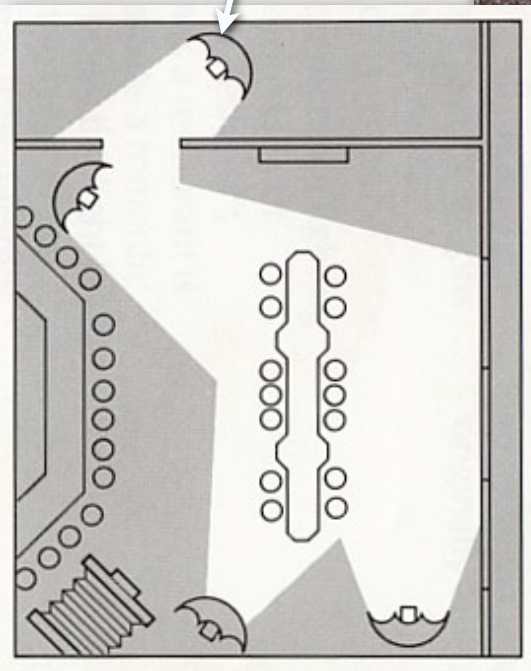
- ◆ darkfield lighting
- ◆ took all day to set up

(Varis)

Special problems: architectural interiors

2-second exposure
to show dusk outdoors

note lighting
in 2nd room

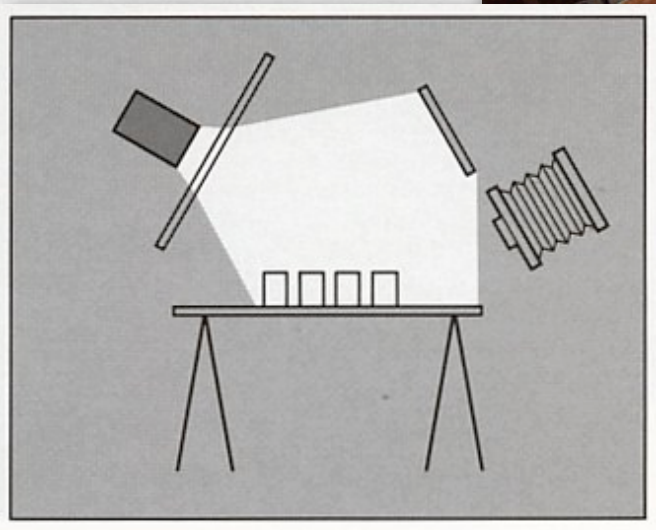


(Kodak)



Special problems: food (without breaking FTC laws)

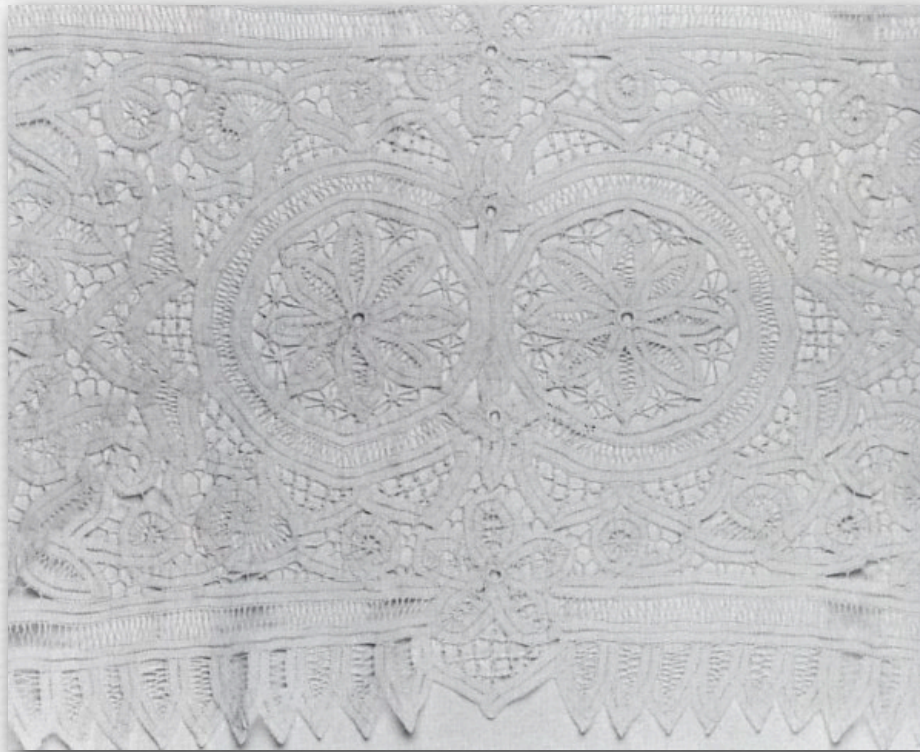
photographed by
Richard Fukuhara



(Kodak)

Special problems: surface details

(Hunter)



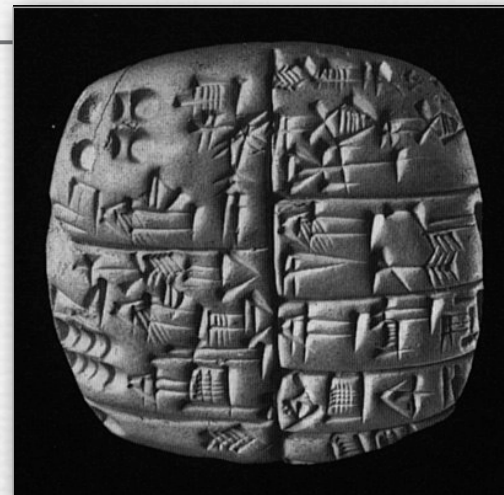
overhead light



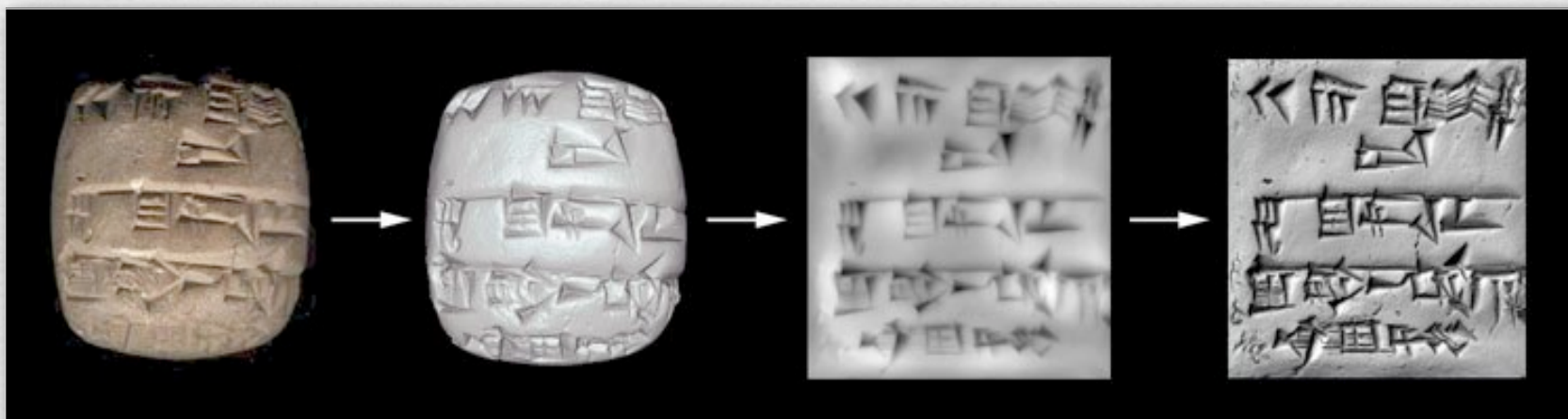
grazing light

Stanford Cuneiform Visualization Project

- ◆ in a photograph, it's hard to see marks along tablet edges
- ◆ also, raking illumination favors strokes of one orientation



(Nissen)



original
tablet

scanned
3D model

unwrapped
surface relief

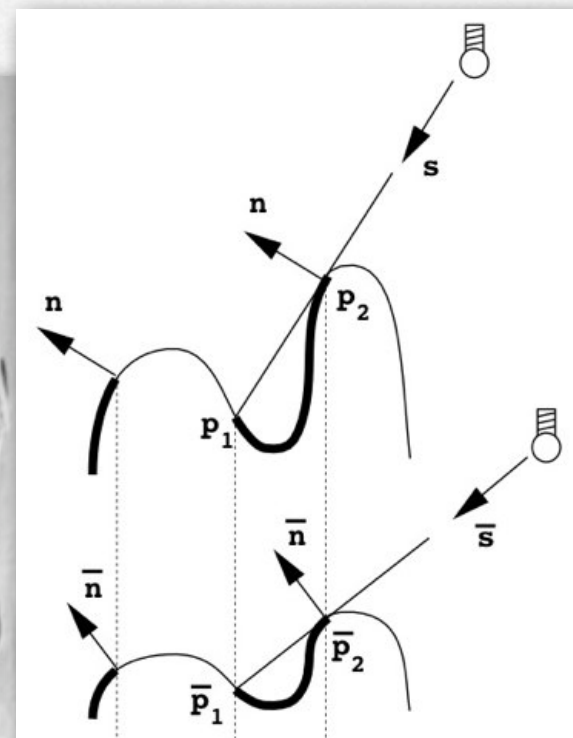
non-photorealistic
shading

How is this sculpture lit?



The bas-relief ambiguity

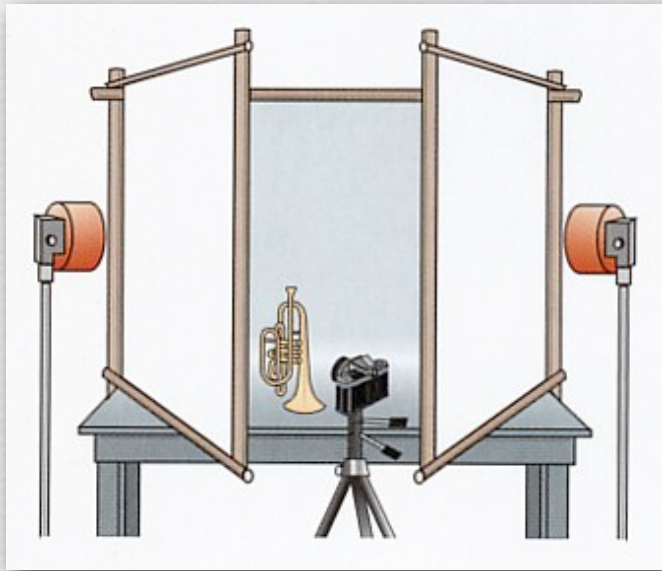
[Belhumeur CVPR 1997]



- ♦ changing the depth of an object is equivalent to changing the angle of lighting on it - they produce the same image
 - otherwise, bas-relief sculpture wouldn't work

Special problems: shiny objects

photographed by
Fil Hunter



(London)

Recap

- ◆ lighting can be classified by its *spatial spread* (point vrs. line vrs. area) and by its *angular spread* (parallel rays vrs. diffuse)
- ◆ point lights (like flash) or parallel rays (like sunlight) create hard shadows, while diffuse area lights create soft shadows (containing both *umbra* and *penumbra*)
- ◆ to change its character, lighting can be focused by lenses, diffused by cloth or by reflection from *boards* or *umbrellas*, colored by *gels*, etc.
- ◆ portrait lighting is typically divided into *key* and *fill* lights, with varying positions, ratios, & colors, plus *rim* or *background* lights
- ◆ special subjects require special treatment, such as *darkfield* lighting, diffuse reflectors, cards, flags, grazing light, etc.

Questions?

When to use flash?

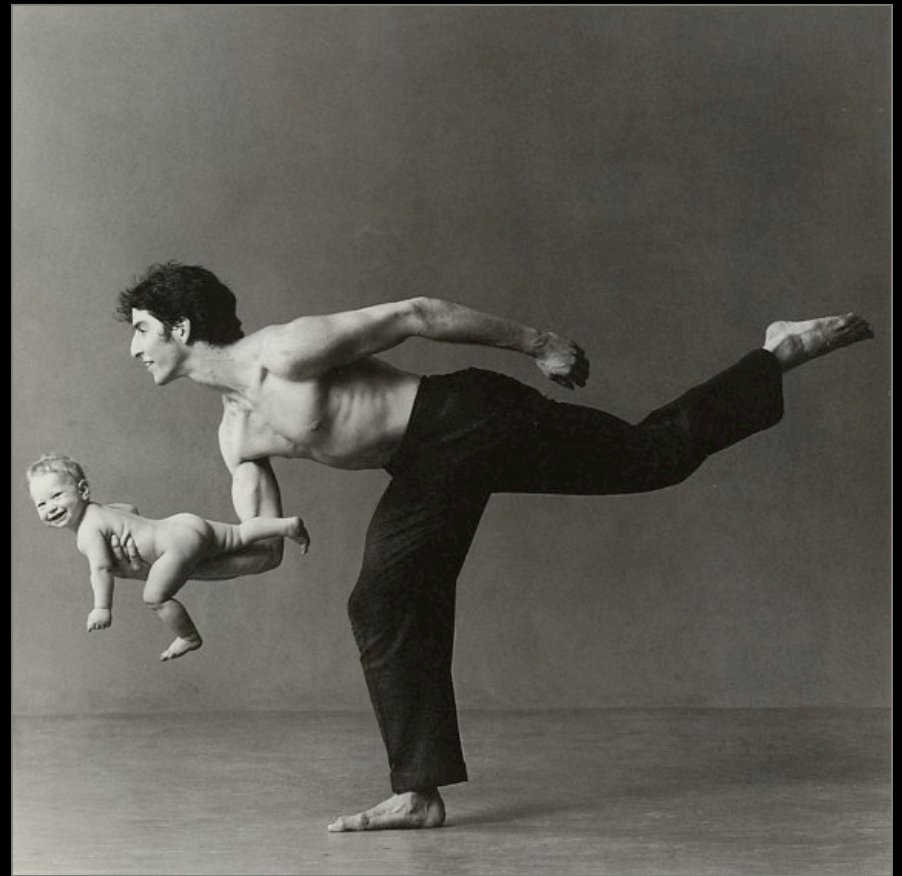
- ◆ freezing the action
- ◆ fill-flash
- ◆ flash-plus-ambient
- ◆ flash as a fill light
- ◆ ways to avoid using flash

Lois Greenfield,
dance photography,
1983-1988



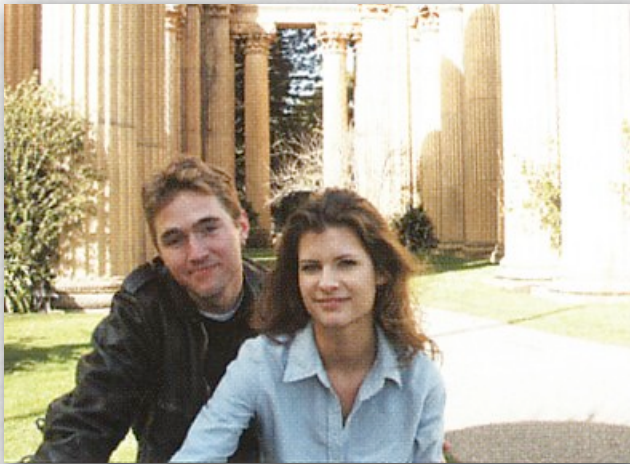


Lois Greenfield,
dance photography,
1983-1988

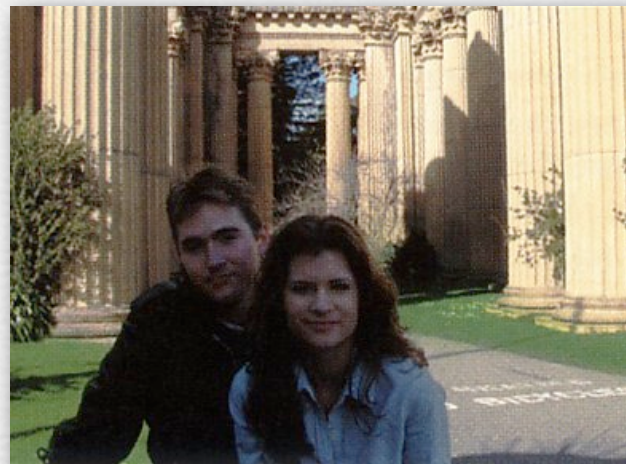


Fill-flash (for brightly lit backdrops)

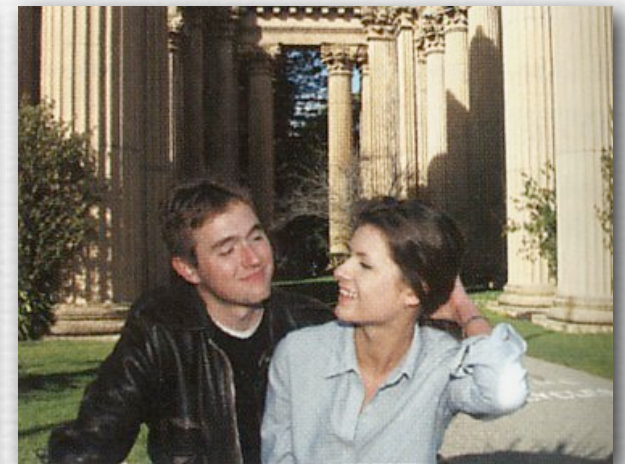
(London)



exposed for
foreground



exposed for
background



exposed for
background,
with fill flash

- ◆ shorten exposure, then add flash
- ◆ could instead use HDR, but that requires multiple shots

Flash-plus-ambient (in low light)

(Ang)



standard flash
exposure



1/4 second
with flash

- ◆ use flash, and lengthen exposure
- ◆ avoids isolating the foreground from its background

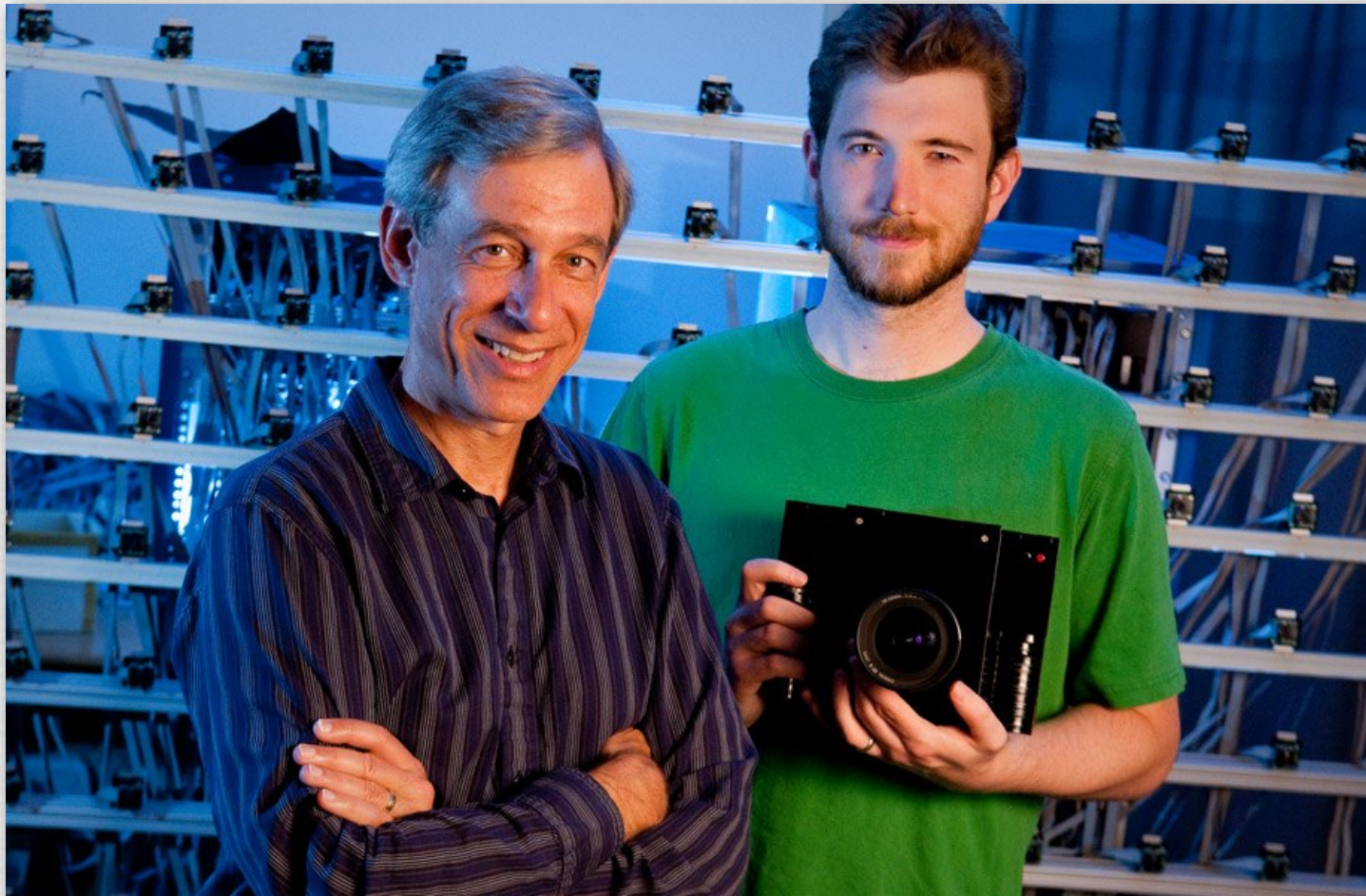
Flash as a fill light



as cameras get more sensitive, flash is less frequently needed when the scene is dark, but it's still useful for changing the light balance or color

- ◆ golden hour sun + off-camera fill flash
(Canon 5D Mark II, Speedlite 580EX, orange gel)

How was this shot lit?



(Linda Cicero)

- ◆ key flash (on right side of scene) with orange gel & umbrella
+ fill flash (extreme left side of scene) with no gel or diffuser
+ background flash (pointed at back wall) with blue gel

How was this shot lit?

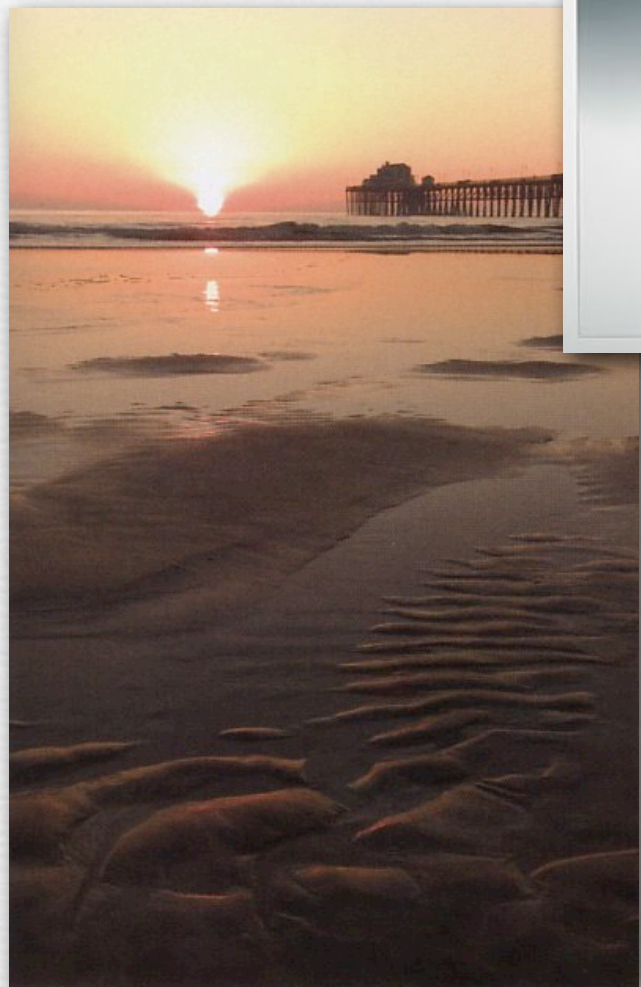
- ◆ flash with orange gel bounced off wall behind camera + rim light from nearby desk lamp
- ◆ flash behind camera controlled from camera by radio (e.g. Pocket Wizard)



(Fredo Durand)

Avoiding flash

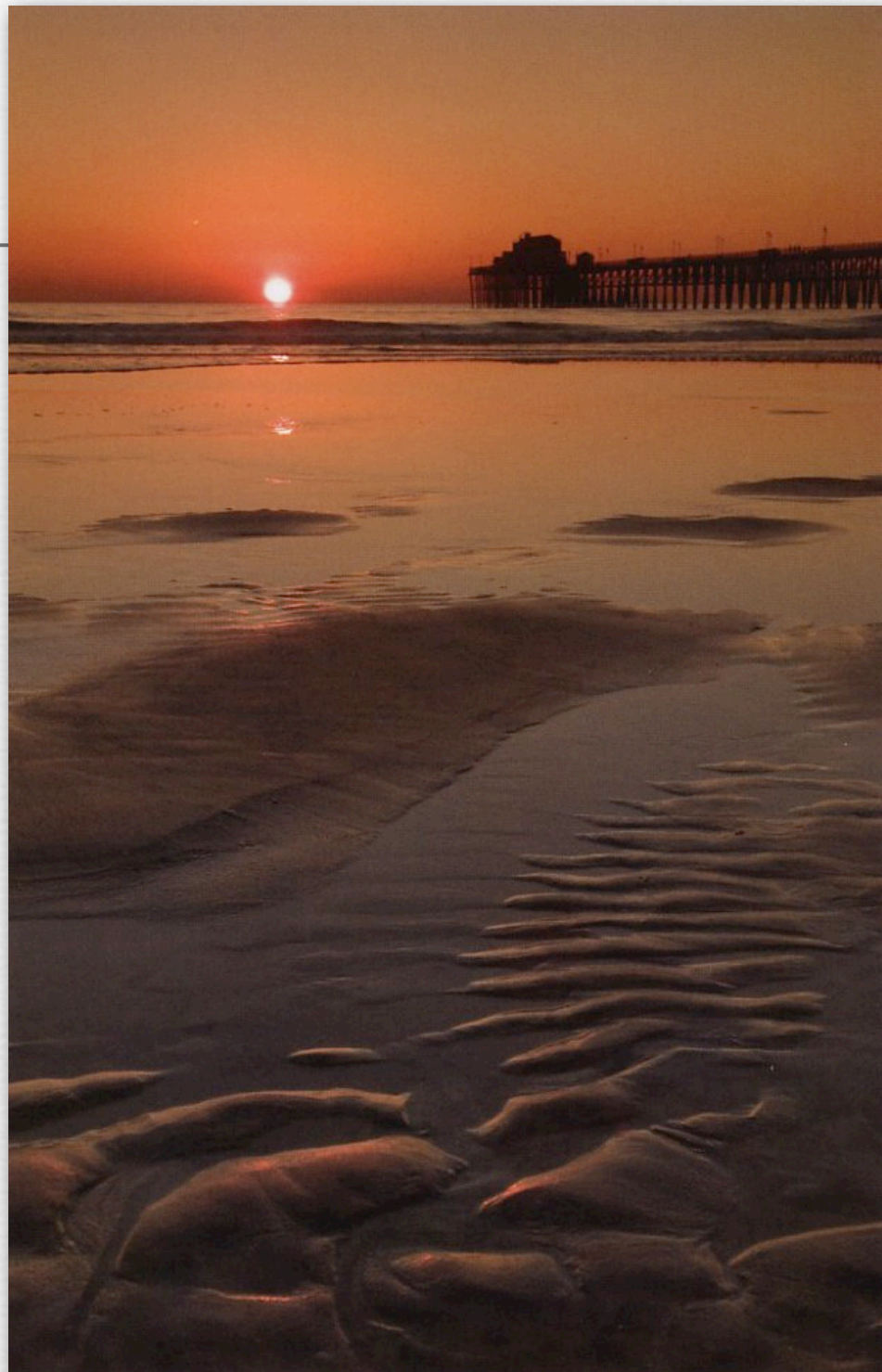
(Peterson)



straight shot

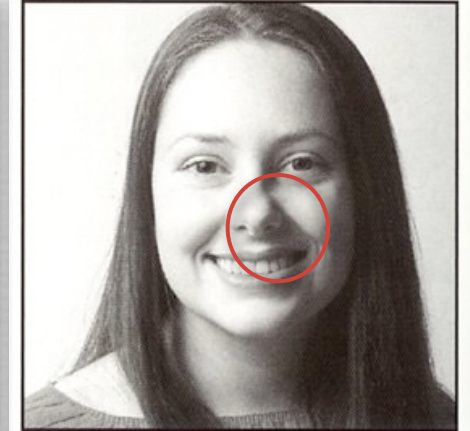
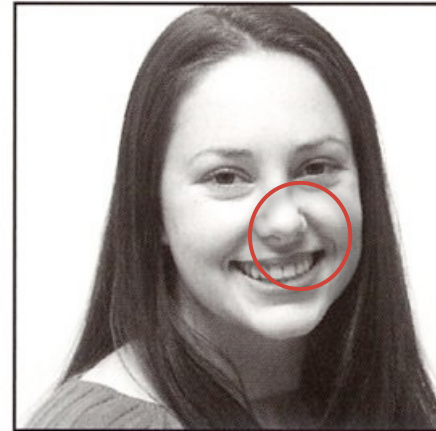
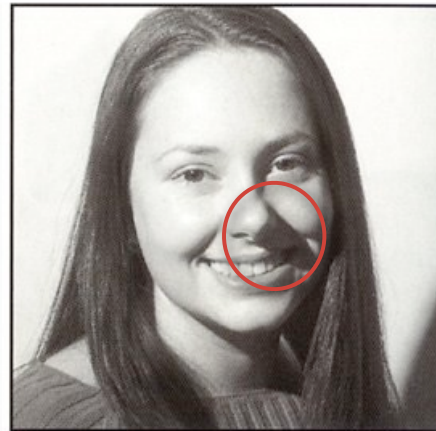
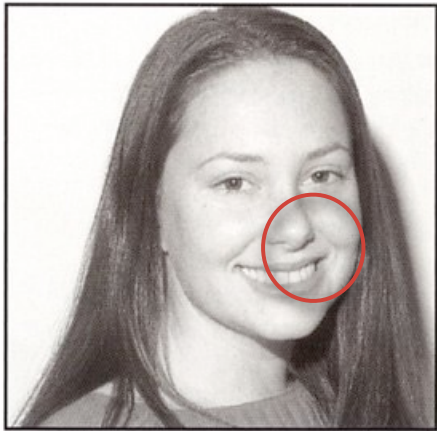


with graduated
neutral-density filter



Flash placement

(London)



direct flash,
on camera

direct flash,
off camera

bounce flash,
from above

bounce flash,
from the side

Flash technology

(Race Gentry)



1880: flash powder

powdered magnesium +
potassium chlorate +
antimony sulfide



1927: flashbulbs

aluminum foil in oxygen,
later tungsten or zirconium filament
coated in explosive primer paste

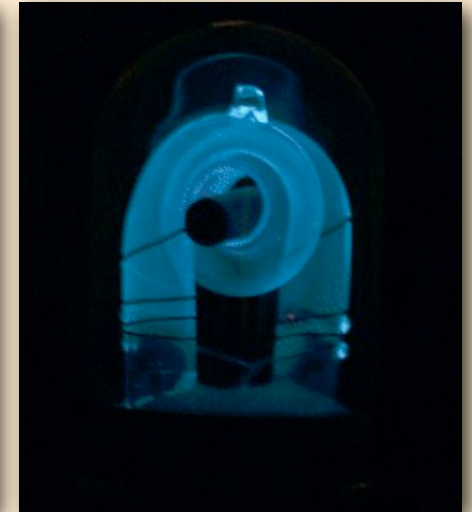
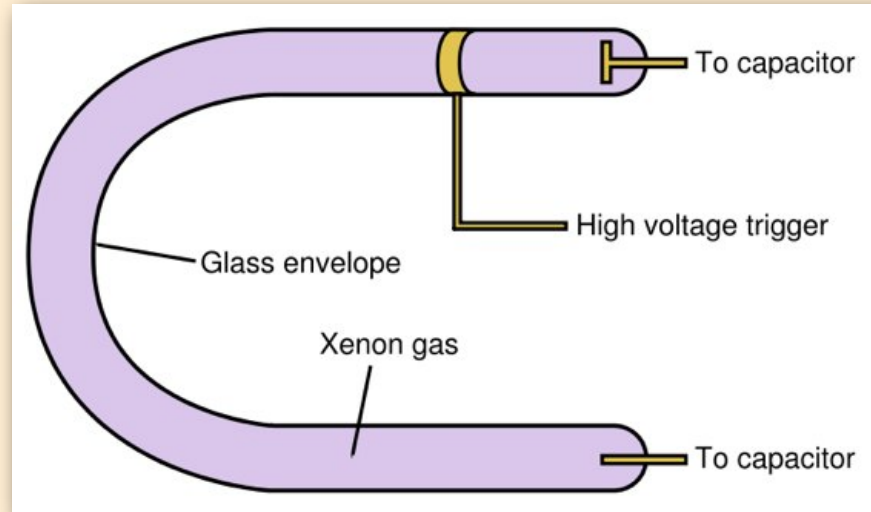


1960s: flashcubes

Electronic flash



Canon 580EX

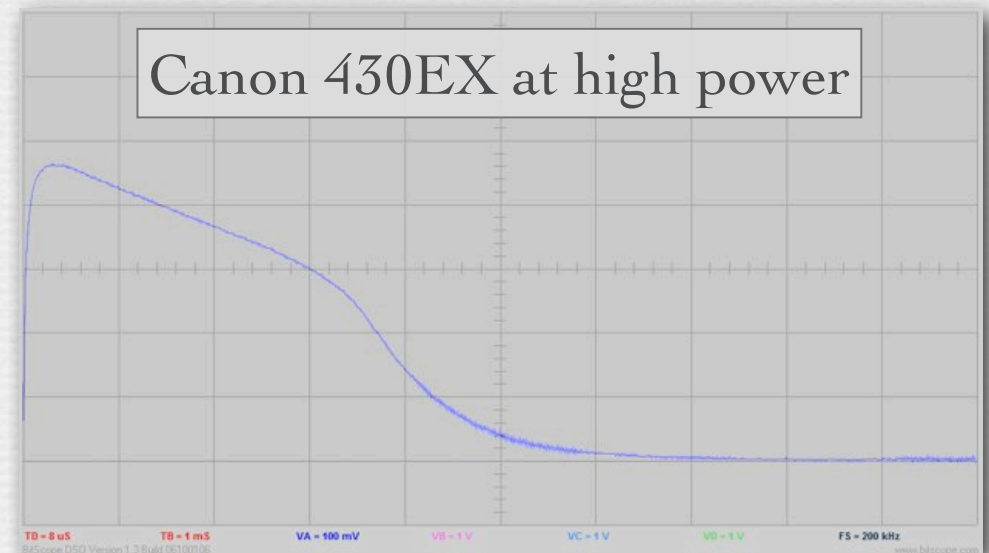
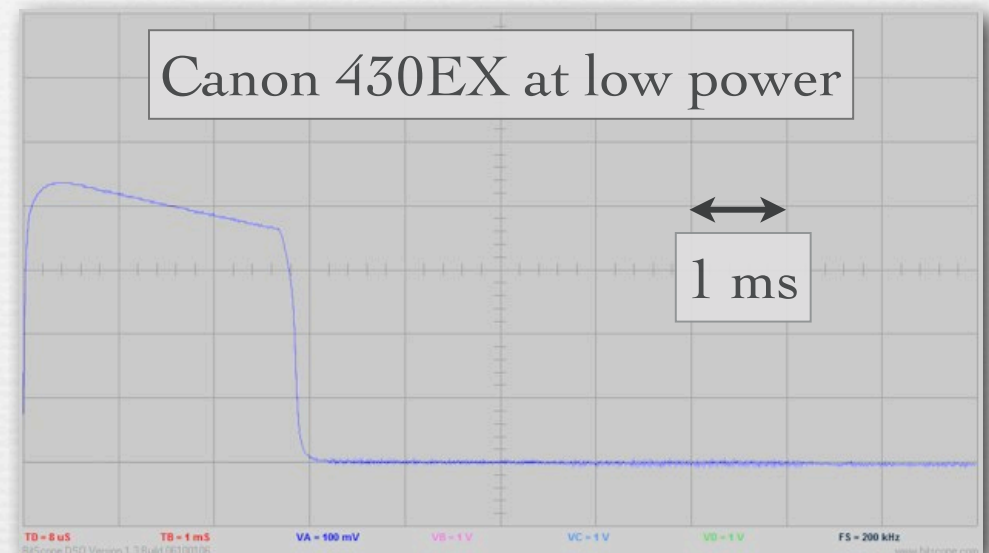


(wikipedia)

- ◆ battery charges up a capacitor (dangerous when disassembled!)
- ◆ high-voltage trigger ionizes the gas inside the tube, reducing its resistance to the flow of electricity and causing streamers of ionized gas to form (like “leaders” in lightning)
- ◆ the capacitor discharges through the ionized gas, heating it to a plasma state and causing an intense but brief discharge of light

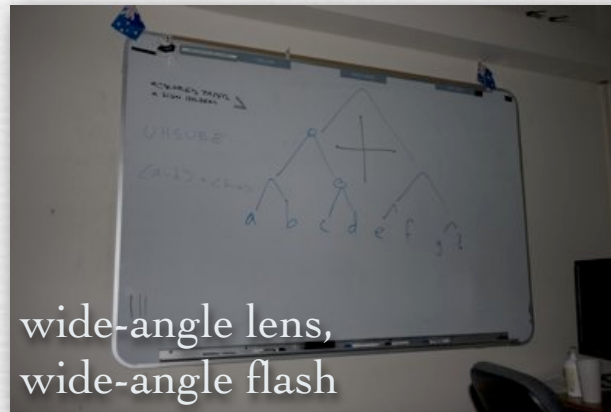
Controlling exposure in flash photography

- ◆ the luminous intensity of a particular xenon flash tube is fixed
- ◆ flash is briefer than the shutter, so you can't use shutter speed to control illuminance on sensor
 - you can still use it to control ambient light
- ◆ aperture and ISO affects recording of both flash and ambient light
- ◆ instead, adjust duration of the flash pulse

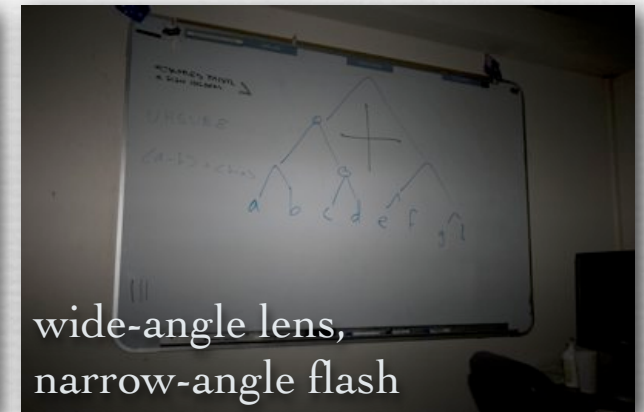


Guide numbers

- ◆ flash power is measured in *guide numbers*
 - proper aperture size = guide number / distance to subject
 - varies with focal length for zooming flashes
 - assumes ISO 100



wide-angle lens,
wide-angle flash



wide-angle lens,
narrow-angle flash

- ◆ examples

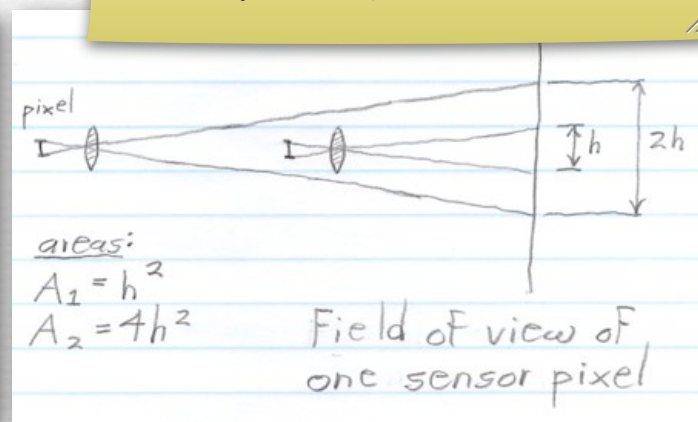
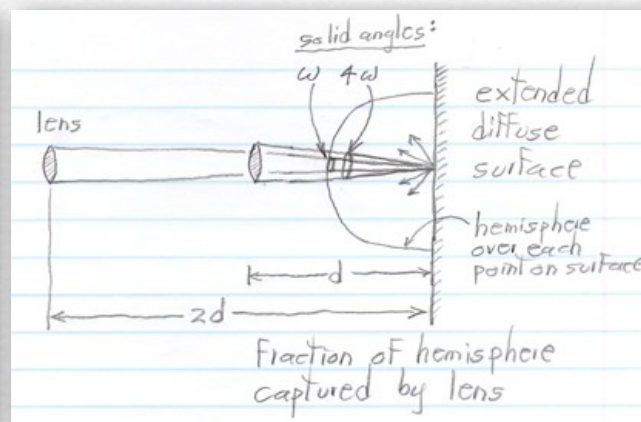
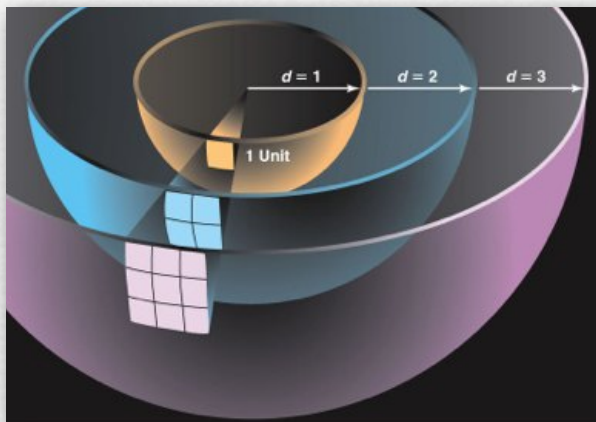
- Canon 580 EX hot-shoe flash: guide number 58
- Nikon D40 pop-up flash: guide number 15
- Canon SD800 point-and-shoot: guide number 4

- for Canon 580EX and a subject 10' away, use f/5.6
- for Canon 580EX and f/1.4 lens, subject can be 41' away !

4× distance needs
16× as much light

The effect of distance to the subject (contents of whiteboard)

(Thomson)

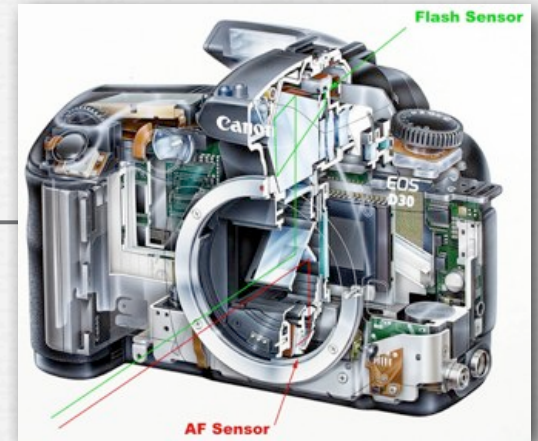


The canceling effect in the right drawing only applies for objects larger than a pixel even when far away. Objects smaller than a pixel (like a candle or star) don't enjoy this effect, so they *do* dim quadratically with distance.

- ◆ if you treat flash as a point source, then illuminance (power per unit area) arriving on a subject from the flash falls as d^2 (left drawing above)
- ◆ for extended diffuse area sources (larger than a pixel in the photograph):
 - the solid angle captured from each point falls as d^2 (center drawing)
 - but the number of points seen by the pixel rises as d^2 (right drawing)
 - these effects cancel, so the illuminance at a pixel is independent of d
- ◆ hence, under ambient light subjects don't dim with distance from the camera, but if illuminated by on-camera flash they dim quadratically; to double the distance a flash can reach, increase its power per sr by $4\times$

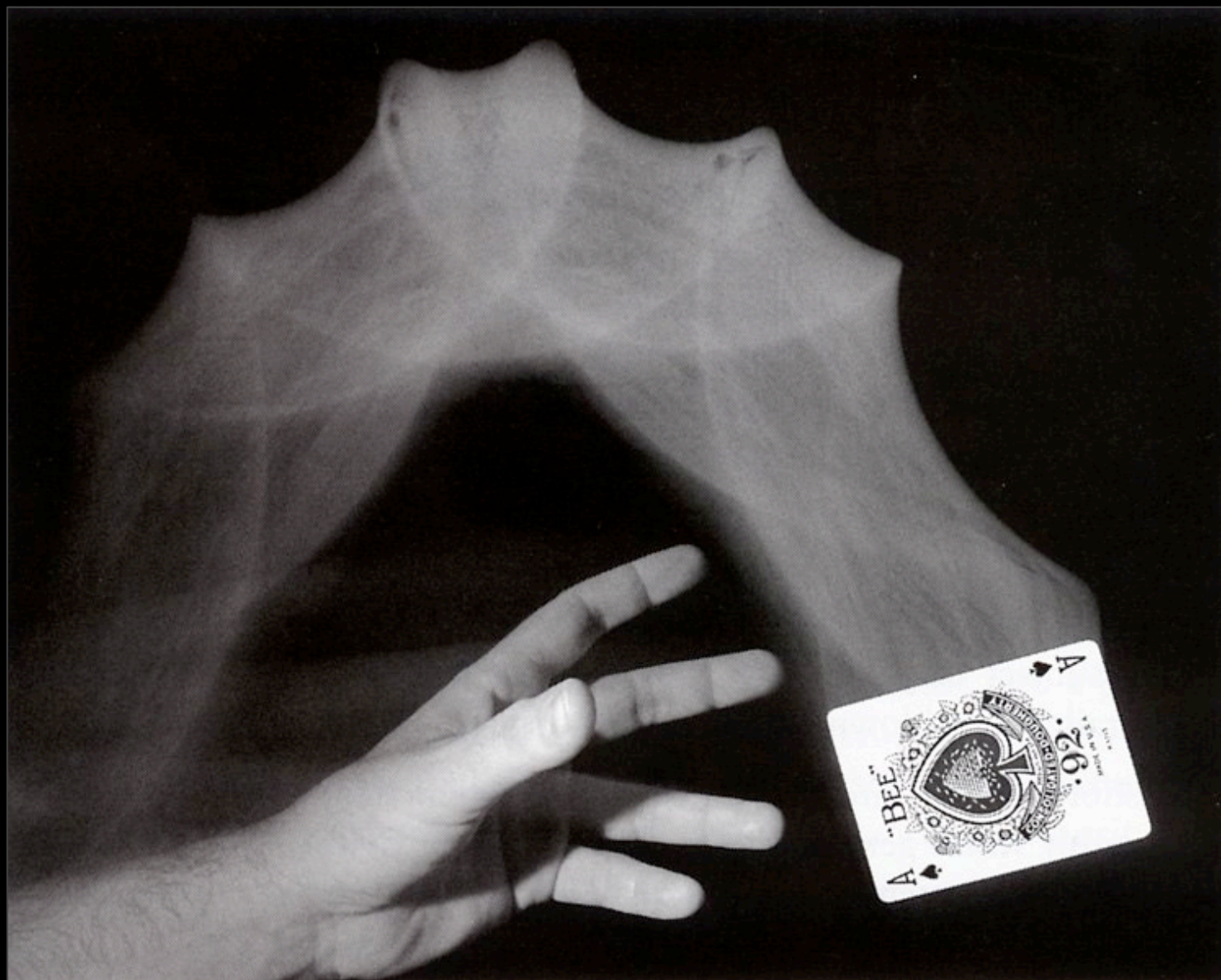
Metering for flash photography

(Canon E-TTL or Nikon iTTL, including Nikon D40)



- ◆ on shutter half-press, focus under ambient light (or AF assist light) and meter for ambient light
- ◆ on shutter press, fire weak preflash and record on flash sensor
- ◆ compute some combination of aperture, flash duration, and ISO
 - decision uses multi-point metering of ambient light, multi-point autofocusing, shooting mode, etc.
- ◆ flip up mirror, open shutter, and fire flash

- ◆ drawbacks
 - fooled by specular objects, scenes that fool metering and focusing,...
 - delay between pre-flash and flash is long enough to cause some people to blink, especially if using 2nd curtain sync



Derrick Story, card flip using second-curtain flash

Stanford programmable Frankencamera with 2 flash heads attached

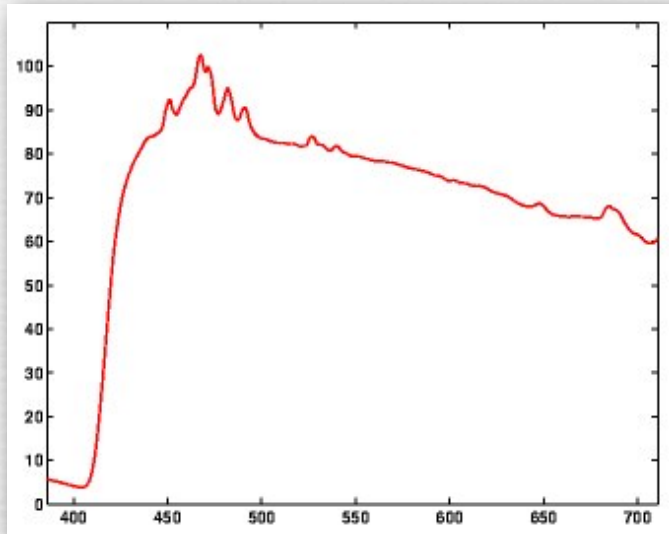


- Canon 430EX (smaller flash) strobed continuously
- Canon 580EX (larger flash) fired once at end of exposure



Color temperature of xenon flash

(graphics.cornell.edu)



- ◆ broad spectrum, approximates daylight (6500°K, i.e. D65)
- ◆ if mixed with ambient tungsten light, flash will look blue if WB is Tungsten, or background will look orange if WB is Flash
 - can compensate with color correction filter on the flash
 - filters are enumerated in °K of correction
 - filters reduce effective flash power

Other flash features

- ◆ flash exposure lock (FEL)
- ◆ flash exposure compensation (FEC)
- ◆ flash exposure bracketing (FEB)
- ◆ strobe modes
- ◆ speciality flashes, like ring flash
- ◆ wireless master-slave
 - uses light pulses to pass messages
 - radio controls are also available (e.g. Pocket Wizard)
- ◆ check out <http://photonotes.org/articles/eos-flash/index2.html>

Problems with flash

- ◆ power falls as distance squared
 - subject is too bright
 - background is too dark
- ◆ in-camera flash is too close to lens
 - no shadows on subject
 - shadow of lens in wide-angle view
- ◆ red-eye
 - worse with in-camera flash
 - worse in low light (pupils are wide open)
 - pre-flash to shrink pupils, which looks better anyway
- ◆ shutter speed must be low enough that shutter is completely open
 - 1/90 - 1/250 sec on Canon EOS cameras (“flash synch speed”)
 - limits the range of shutter speeds for fill-flash
- ◆ don't shoot perpendicularly into glass



Recap

- ◆ flash can be used to freeze the action, as *fill-flash* for bright scenes, as *flash+ambient* for dark scenes, or as a fill light to change the balance or color of the lighting
- ◆ to avoid the deer-in-the-headlights look of on-camera flash (and its lack of shadows, and red eye), use *off-camera flash*, via a cord or remote control, or *bounce flash* off a wall or umbrella
- ◆ to adjust flash intensity, change its pulse duration; to adjust the amount of ambient light in the mix, adjust the shutter speed
- ◆ flash intensity is specified by a *guide number*
 - $F\text{-number} = \text{guide number} / \text{distance to subject}$
 - $2\times \text{distance to subject} \rightarrow 2\times F\text{-number} \rightarrow 4\times \text{illuminance}$
 - but under ambient light, large subjects don't dim with distance

Questions?

Flash-noflash photography

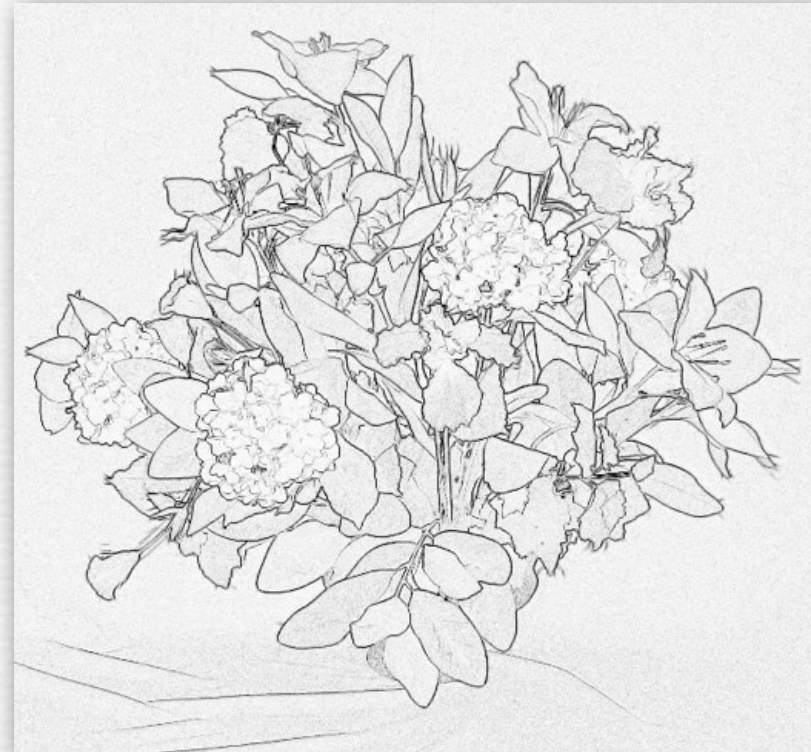
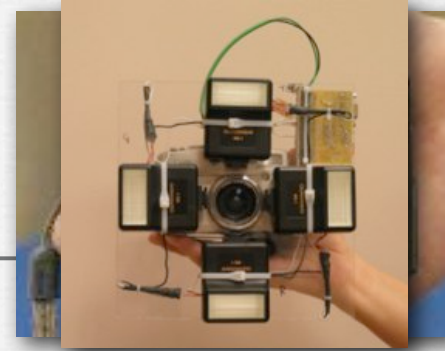
[Agrawal SIGGRAPH 2005]



- ◆ compute ambient + flash – features in sum that don't appear in ambient alone (as determined from image gradients) (except where ambient image is nearly black)

Multi-flash photography

[Raskar SIGGRAPH 2004]



- ◆ flash photographs cast small shadows in one direction
- ◆ flash image minus no-flash image = shadow-only image
- ◆ repeat from several directions and add shadow-only images

Slide credits

◆ Andrew Adams

- ◆ Stone, M., *A Field Guide to Digital Color*, A.K. Peters, 2003.
- ◆ Reinhard et al., *High Dynamic Range Imaging*, Elsevier, 2006.
- ◆ Minnaert, M.G.J., *Light and Color in the Outdoors*, Springer-Verlag, 1993.
- ◆ Hunter, F., Fuqua, P., *Light Science and Magic* (2nd ed.), Focal Press, 1997.
- ◆ Tanser and Kleiner, *Gardner's Art Through the Ages* (10th ed.), Harcourt Brace, 1996.
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