

# Photographic lighting

CS 178, Spring 2014

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Marc Levoy  
Computer Science Department  
Stanford University

# Outline

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



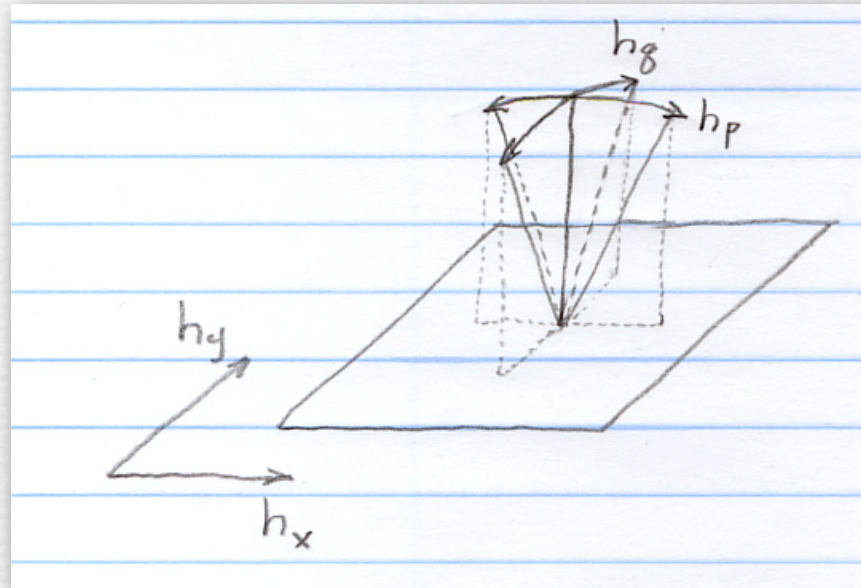
# Taxonomy of light sources

[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	$\infty$	$\infty$	$\infty$	$\infty$	4
Cyberware <sup>TM</sup> scanner		$\infty$	$\infty$	$\infty$	0	3
		$\infty$	$\infty$	0	$\infty$	
fluorescent tube	linear source	$\infty$	0	$\infty$	$\infty$	3
		0	$\infty$	$\infty$	$\infty$	
sunlight	point source at infinity	$\infty$	$\infty$	0	0	2
	uniform distribution of rays in a plane	$\infty$	0	$\infty$	0	2
		0	$\infty$	0	$\infty$	
louvered linear source (see text)	fan of rays perpendicular to a linear source	$\infty$	0	0	$\infty$	2
		0	$\infty$	$\infty$	0	
small panel light	point source	0	0	$\infty$	$\infty$	2
sunlight through crack in doorway	parallel rays in a plane	$\infty$	0	0	0	1
		0	$\infty$	0	0	
rotating spotlight	fan of rays	0	0	0	$\infty$	1
		0	0	$\infty$	0	
spotlight or laser	single ray	0	0	0	0	0

# Geometry for table on previous slide (contents of whiteboard)

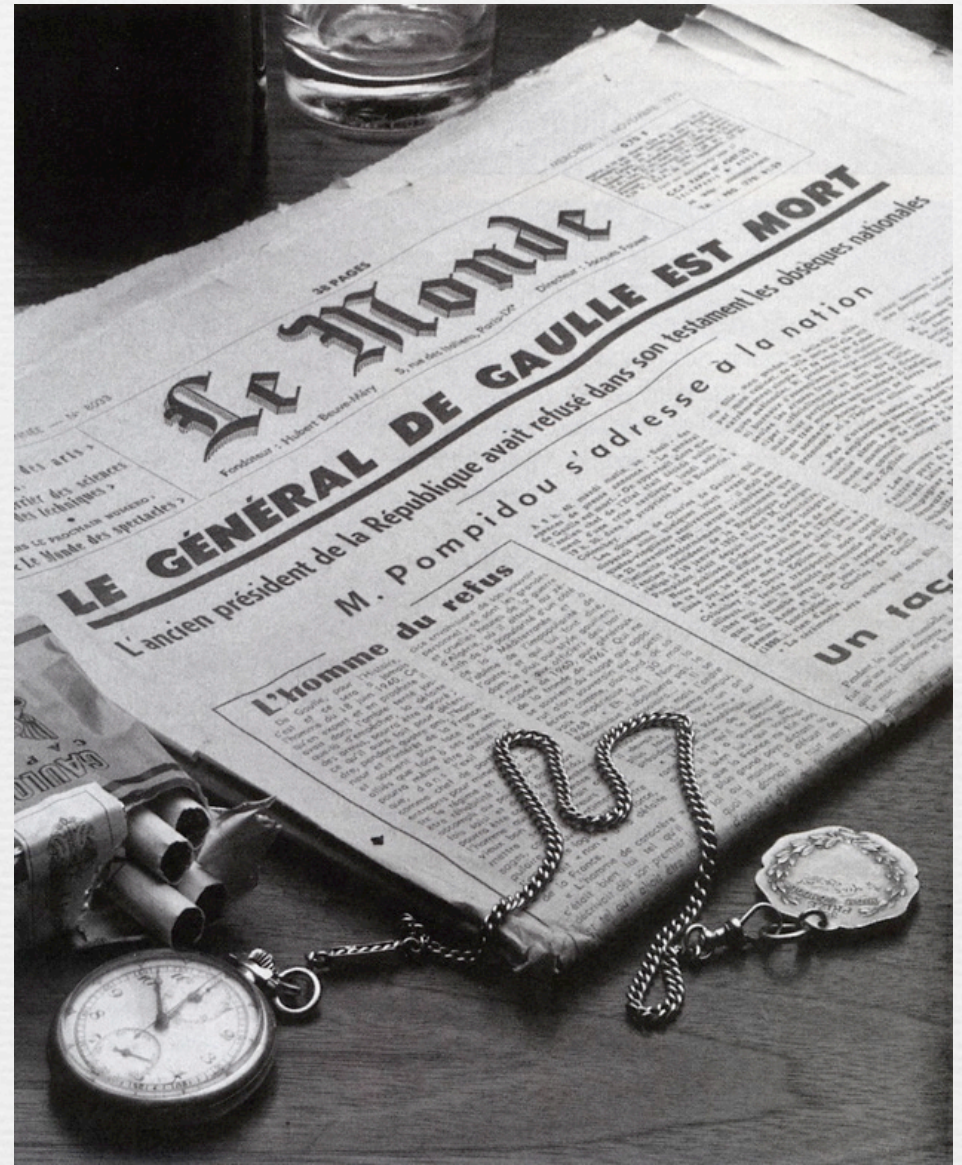
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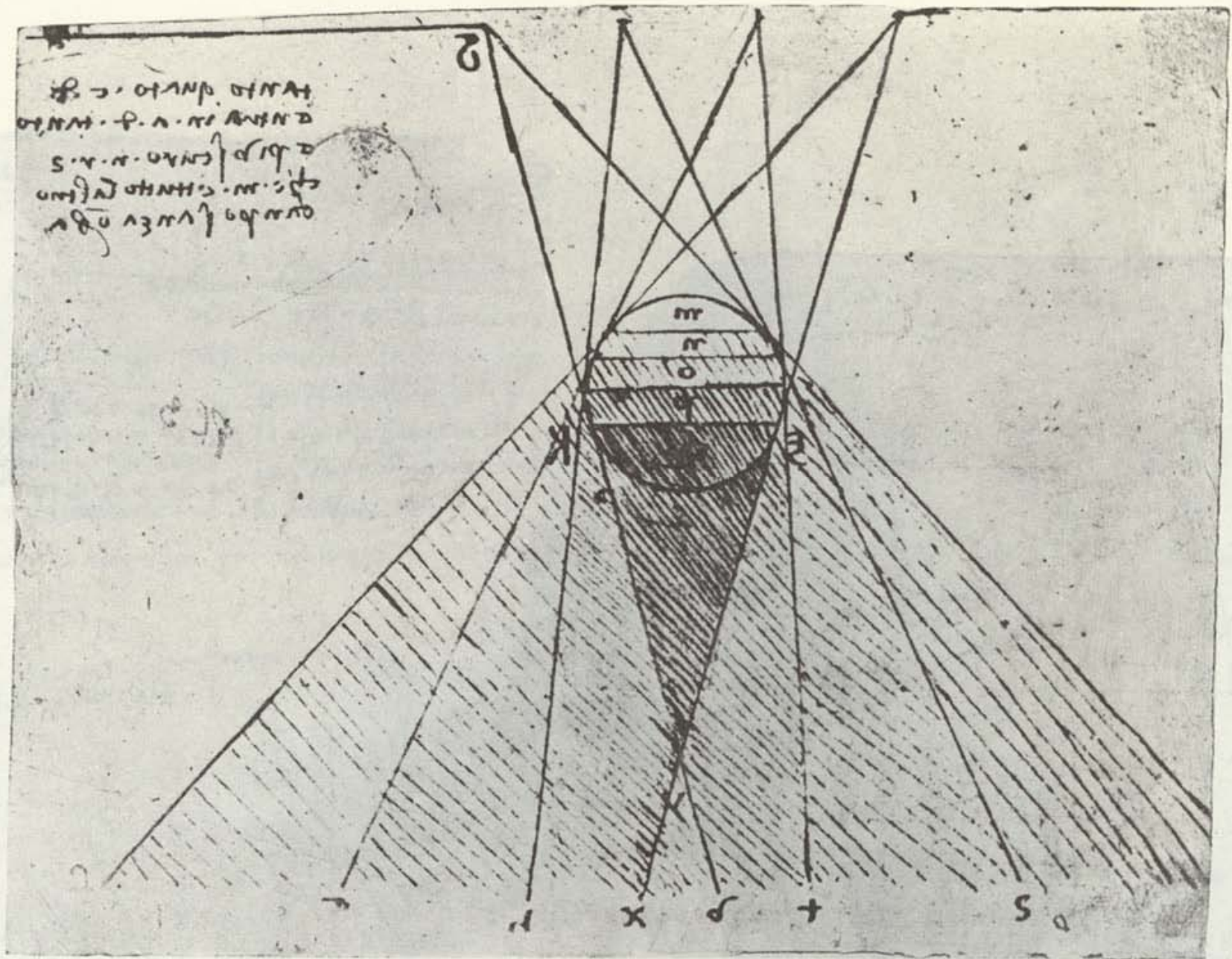
- ◆  $h_x$  and  $h_y$  give spatial extent of light source (zero or infinity, i.e. point or area), and  $h_p$  and  $h_q$  give angular extent (zero or infinity, i.e. parallel beam or fan beam)



# How were these two shots lit?







Leonardo, study of umbra and penumbra



# Lighting for portraiture

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



Yousuf Karsh  
(1908-2002)



Yousuf Karsh,  
Winston Churchill,  
1941





Doodle on May 4 (her 85th birthday)



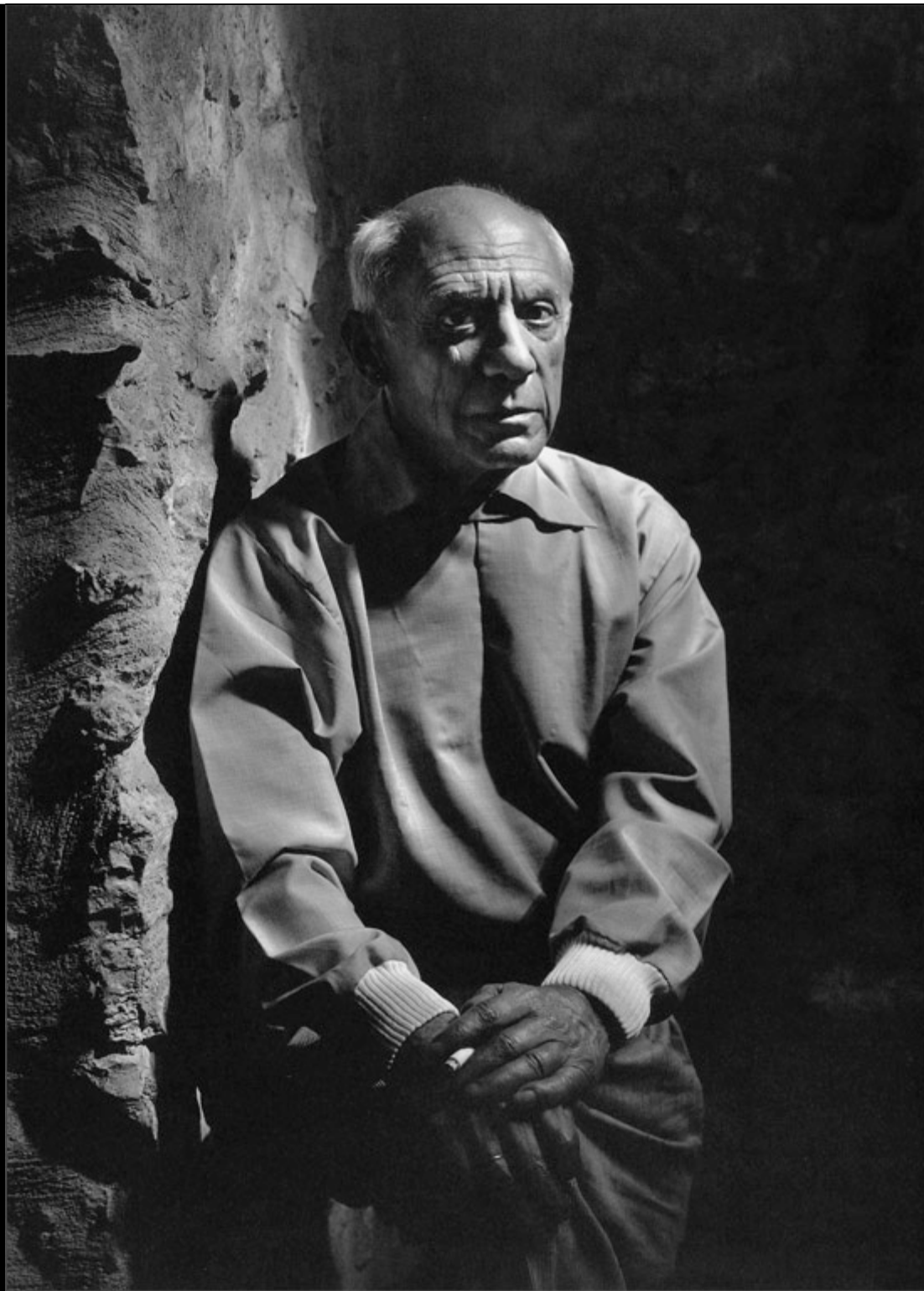
Yousuf Karsh,  
Audrey Hepburn  
1956

Yousuf Karsh,  
Peter Lorre,  
1946

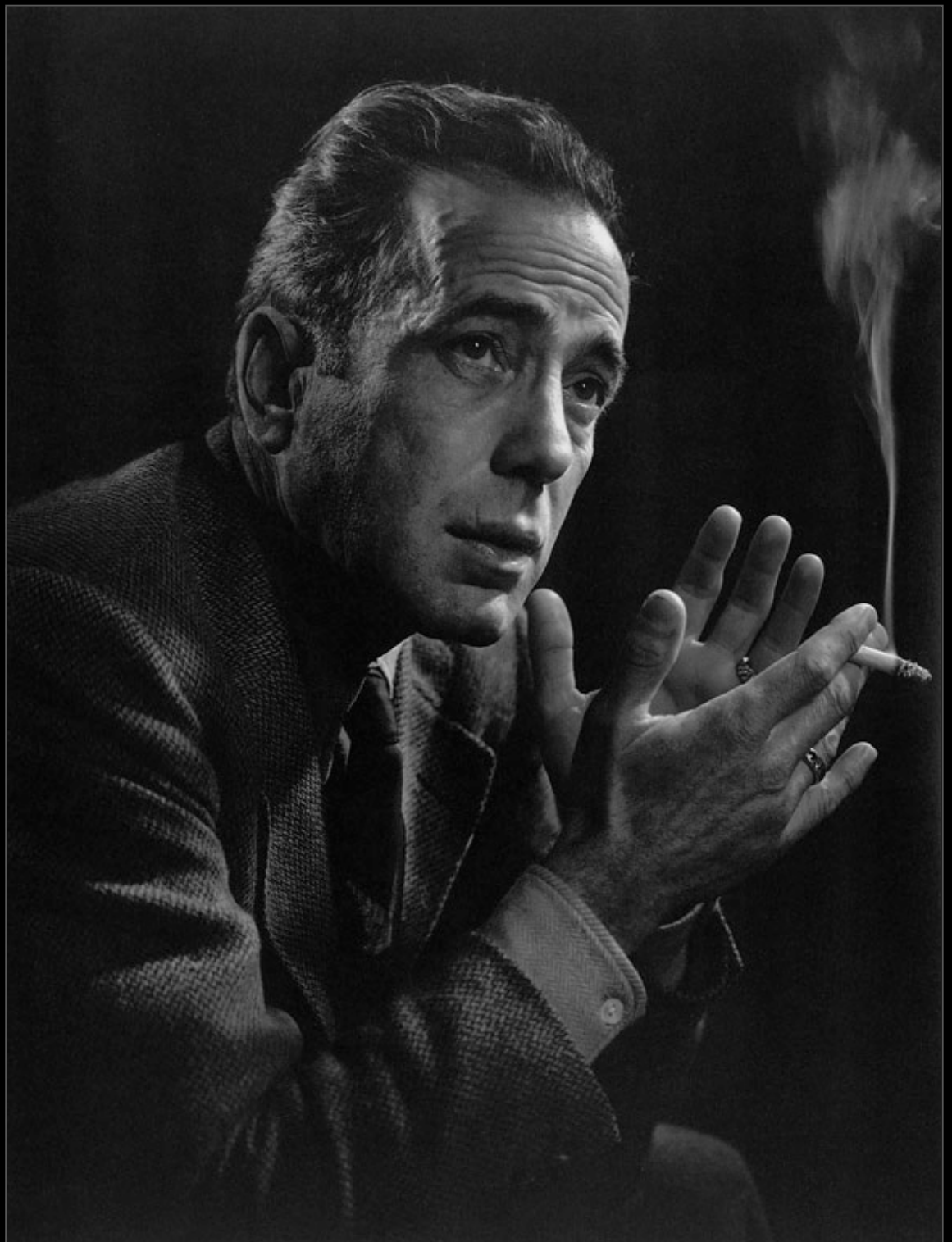




Yousuf Karsh,  
Pablo Picasso,  
1954

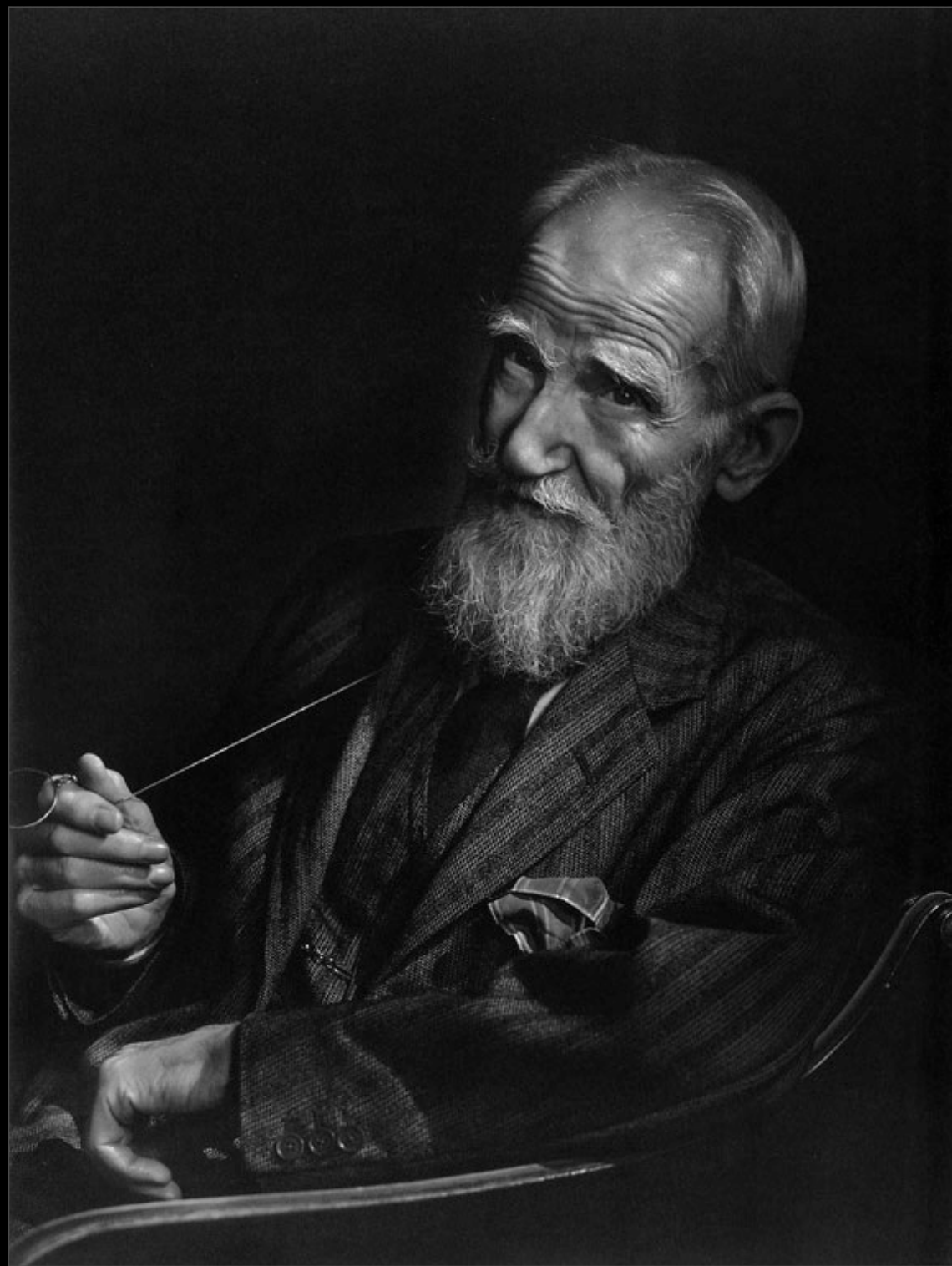


Yousuf Karsh,  
Humphrey Bogart,  
1946





Yousuf Karsh,  
George Bernard Shaw,  
1943



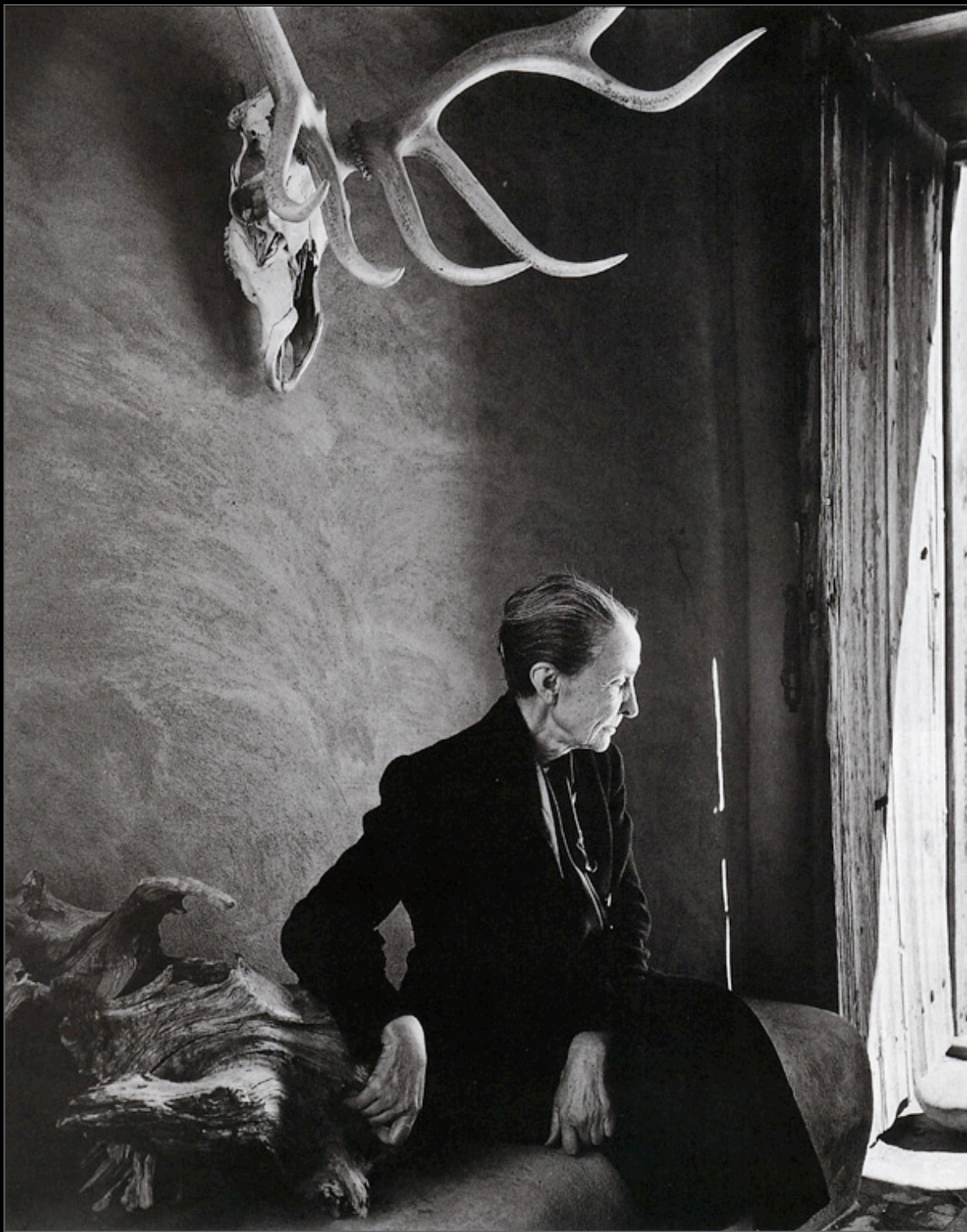
# Photography in available light

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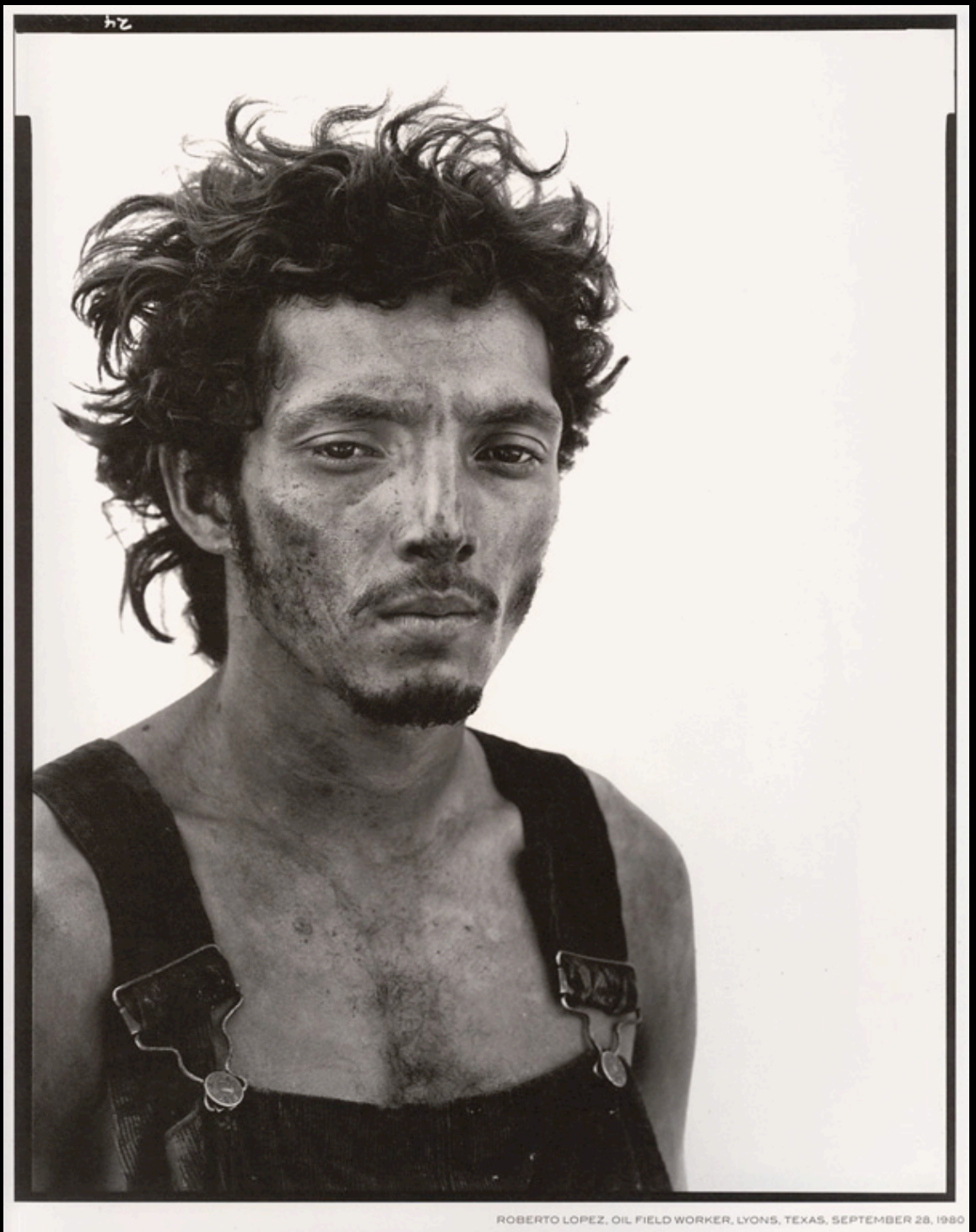
- ◆ challenging
- ◆ worthwhile
- ◆ requires patience and luck
- ◆ always carry a camera



Yousuf Karsh,  
Georgia O'Keeffe,  
1956



Richard Avedon,  
Oil Field Worker,  
1980



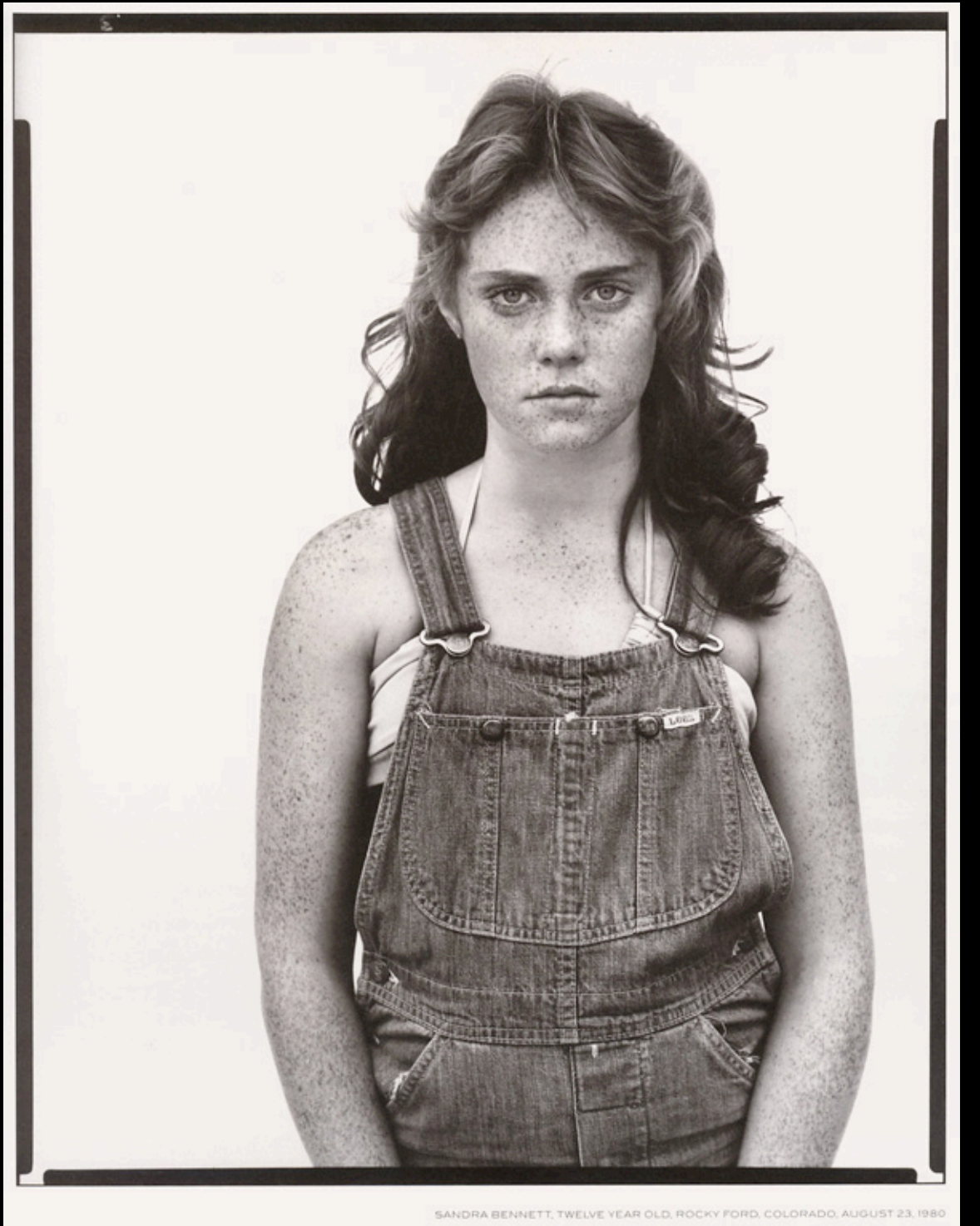
ROBERTO LOPEZ, OIL FIELD WORKER, LYONS, TEXAS, SEPTEMBER 28, 1980





Avedon working outdoors

Richard Avedon,  
Sandra Bennett,  
1980



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



Richard Avedon, for Christian Dior, 1956









Caravaggio, The Calling of St. Matthew, 1599





Robert Mapplethorpe, Skull, 1988

# Studio lighting

spotlight with  
reflective umbrella

floodlight

lights with  
diffusers  
(a.k.a.  
softbox)



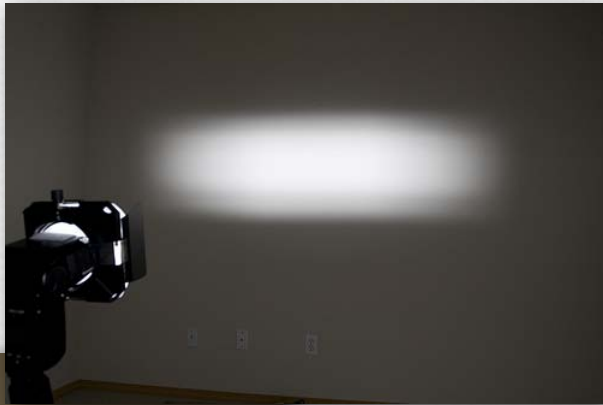
(Kodak)

spotlight

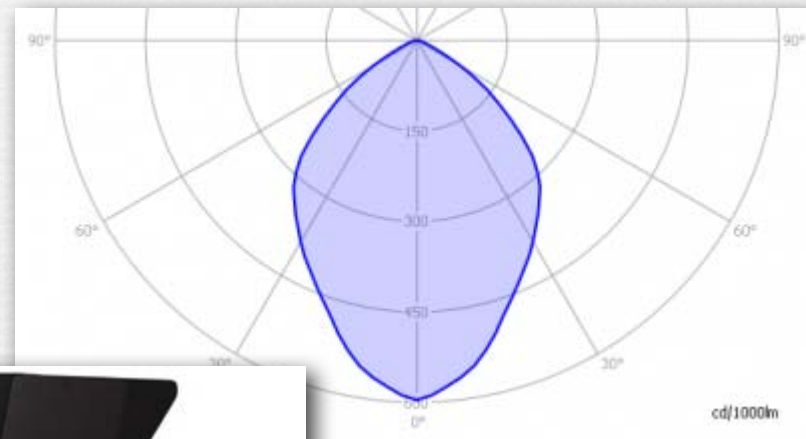
strobe



# Adjustments on studio spotlights



goniometric diagram showing  
luminous intensity at each angle



barn doors



zoom control



filter holder

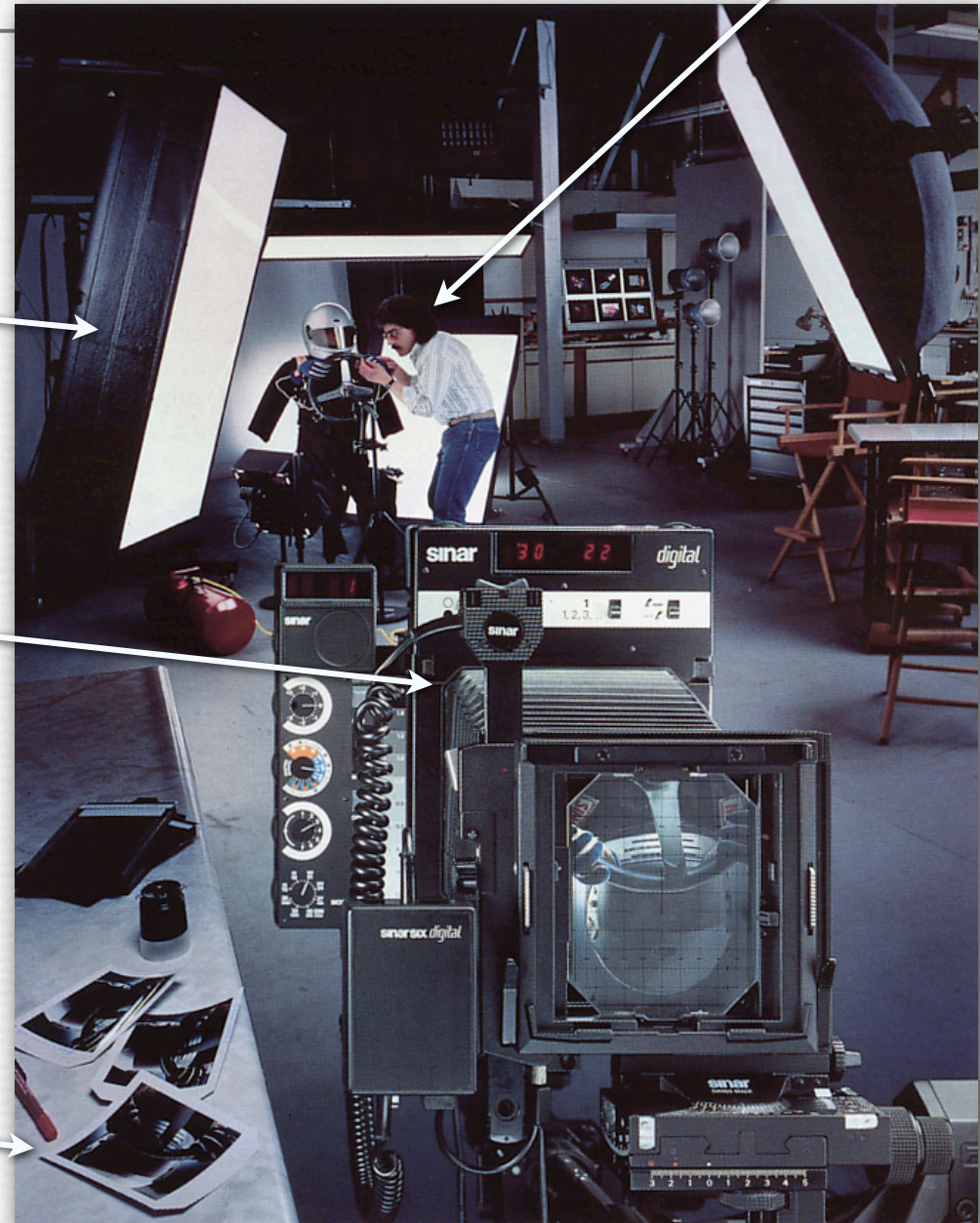
# Lighting rigs can be large

1970's haircut

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

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- ◆ 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

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- ◆ 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

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(London)



1:1



2:1



4:1



8:1

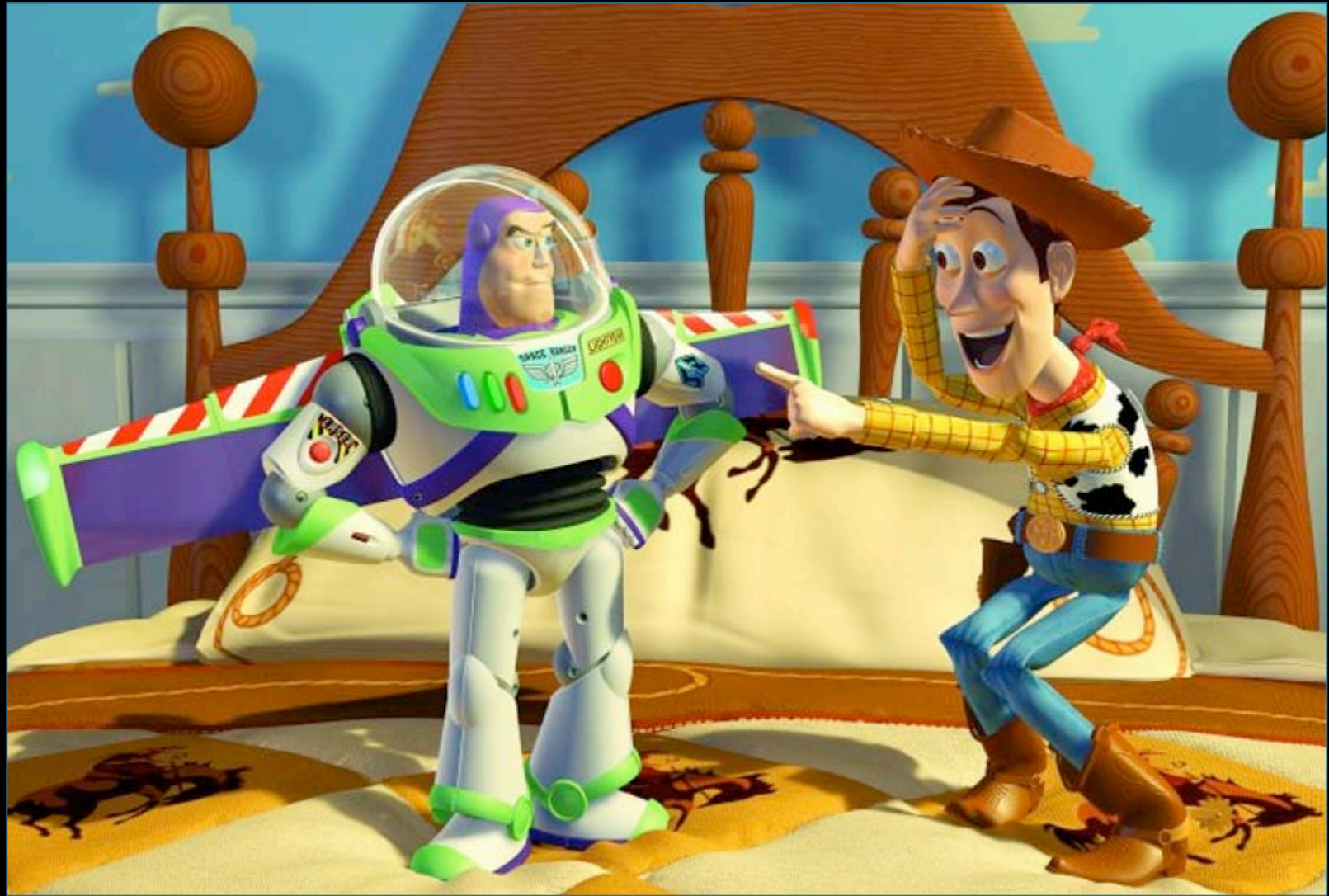
- ◆ 8:1 means 3 f/stops (3 doublings)
- ◆ think about the mood you want to convey
- ◆ the color of the key and fill lights can be different...





Maxfield Parrish, Daybreak, 1922



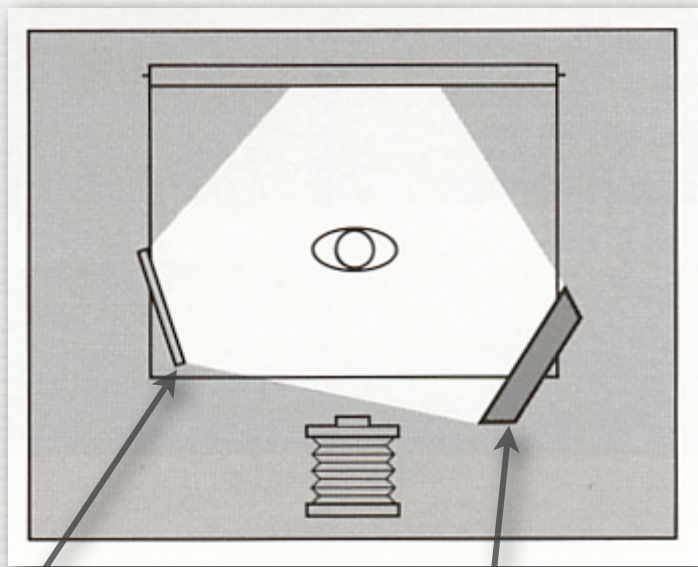


Pixar, Toy Story, 1995



# Professional photographic lighting manuals

photographed by  
D.W. Mellor



diffuse  
reflector

diffused  
spotlight

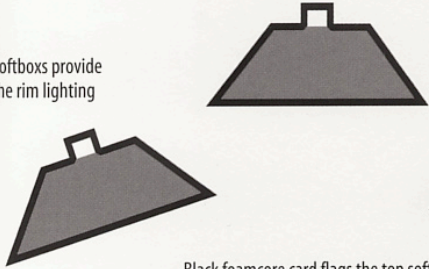
(Kodak)





# Professional photographic lighting manuals

Softboxes provide the rim lighting



Black foamcore card flags the top softbox



Cloth flag

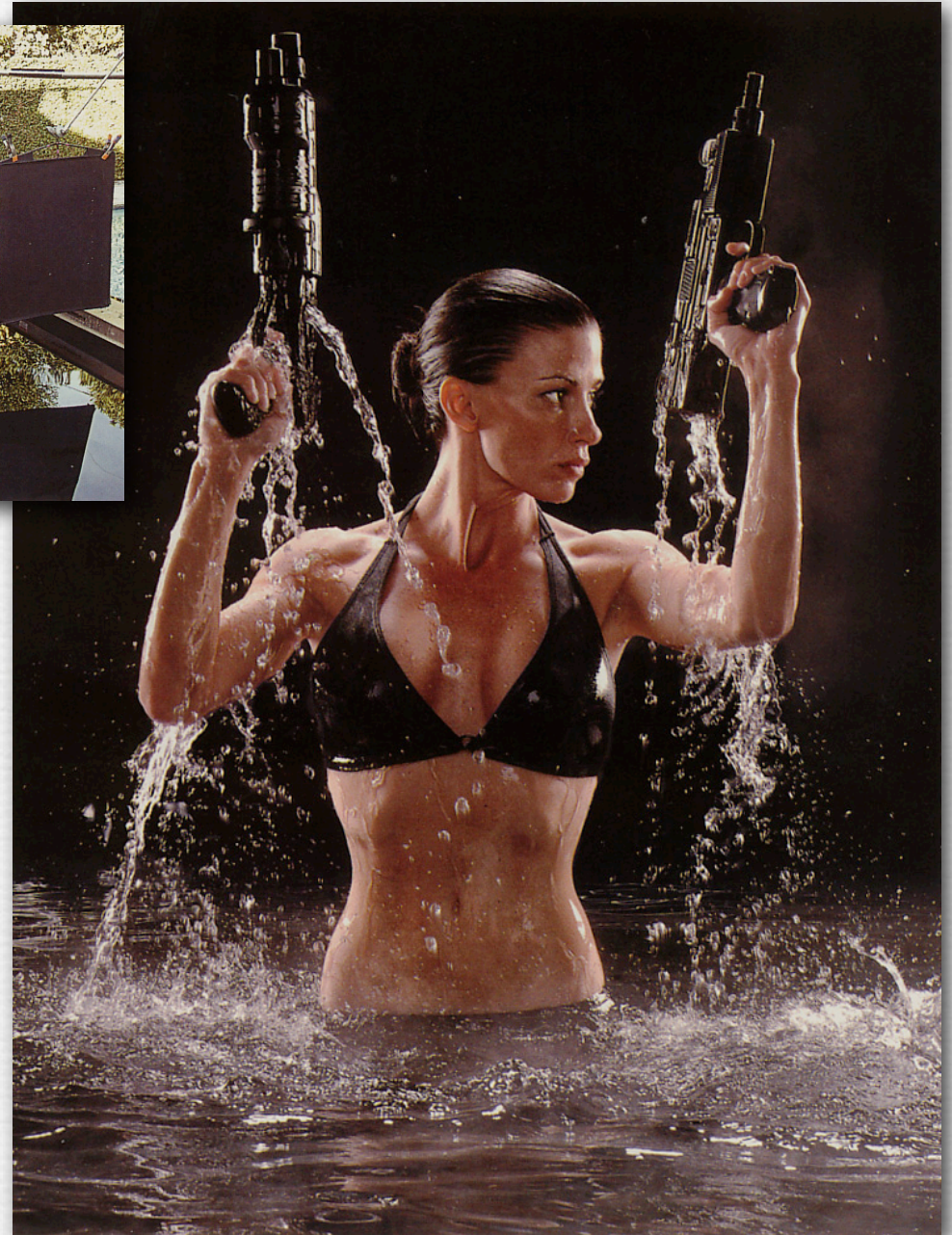


Hides the side softbox from the camera

Cloth flag



Hides the side softbox from the camera



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

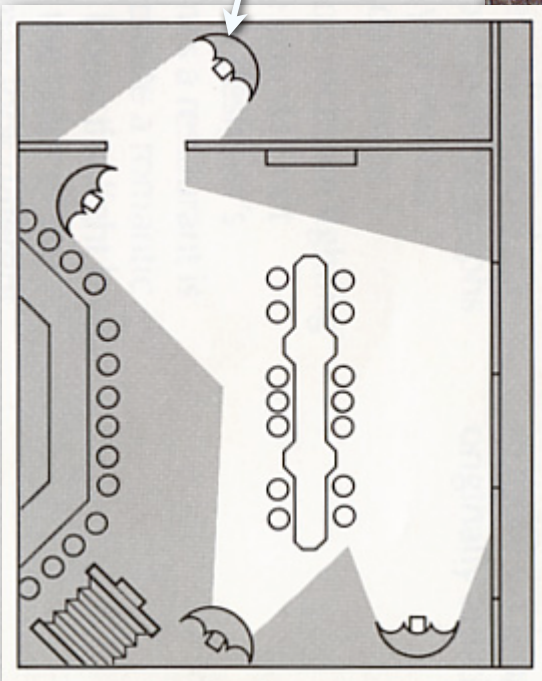
(Varis)



# Special problems: architectural interiors

2-second exposure  
to show dusk outdoors

note lighting  
in 2<sup>nd</sup> room



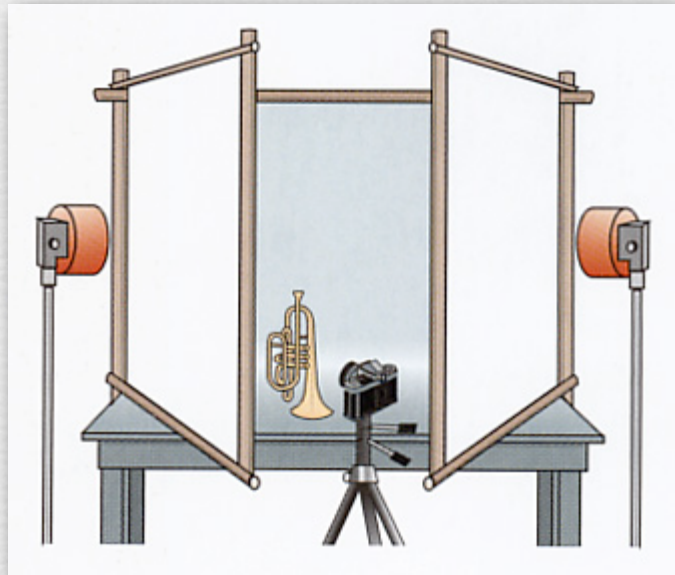
(Kodak)



# Special problems: shiny objects

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photographed by  
Fil Hunter

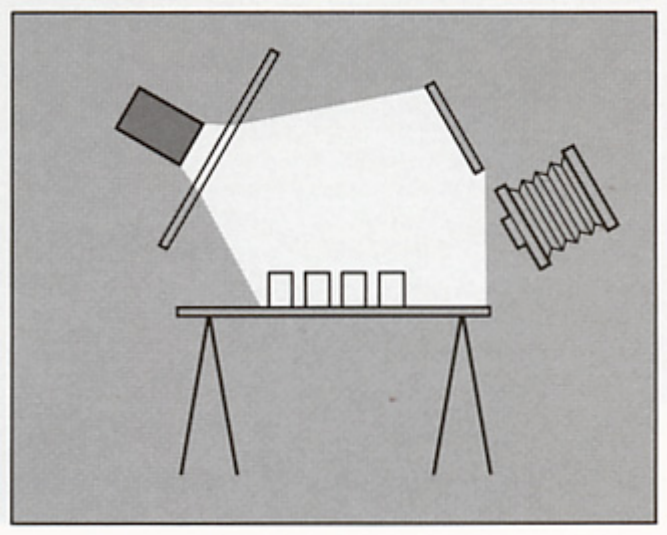


(London)



# Special problems: food (without breaking FTC laws)

photographed by  
Richard Fukuhara



(Kodak)



# Recap

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- ◆ 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, etc.

## Questions?

# When to use flash?

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

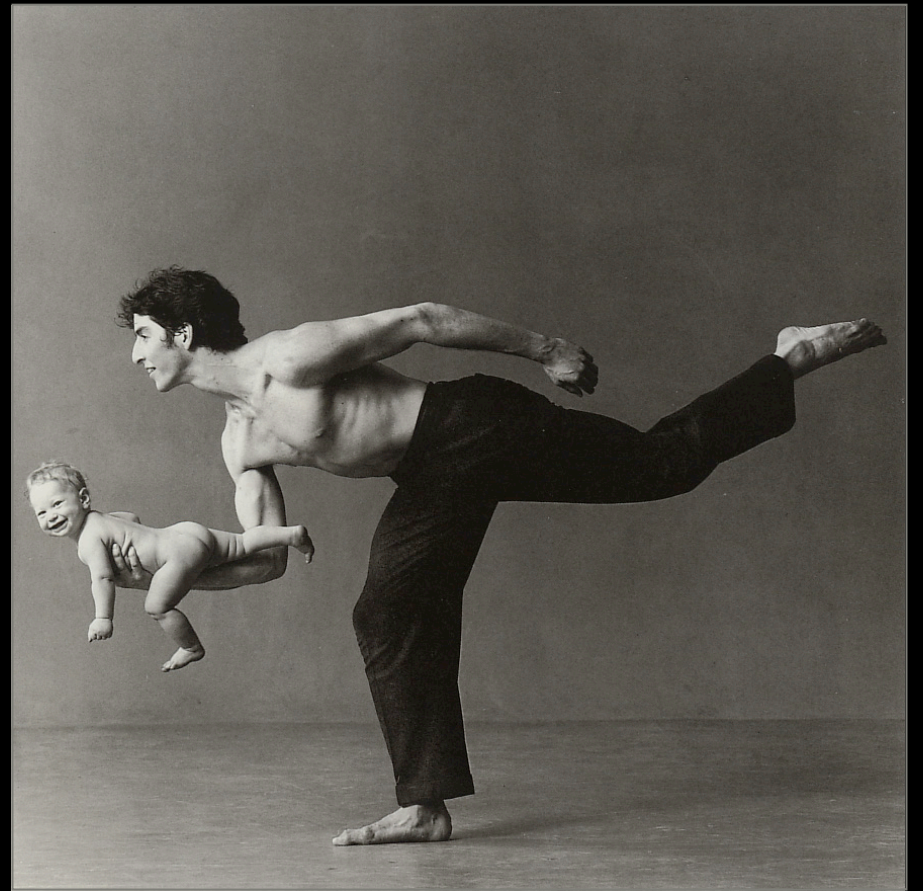


Lois Greenfield,  
dance photography,  
1983-1988





Lois Greenfield,  
dance photography,  
1983-1988

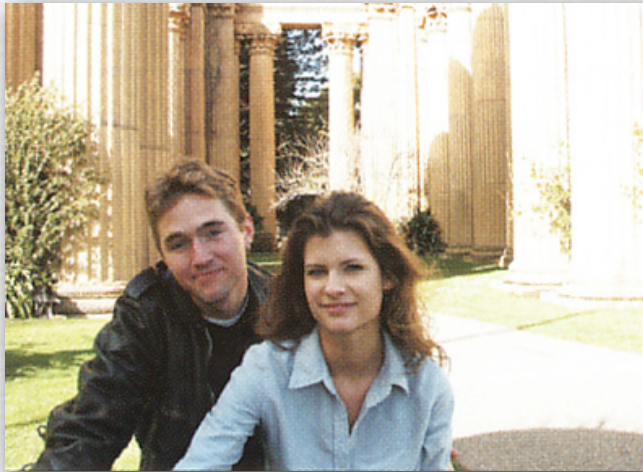




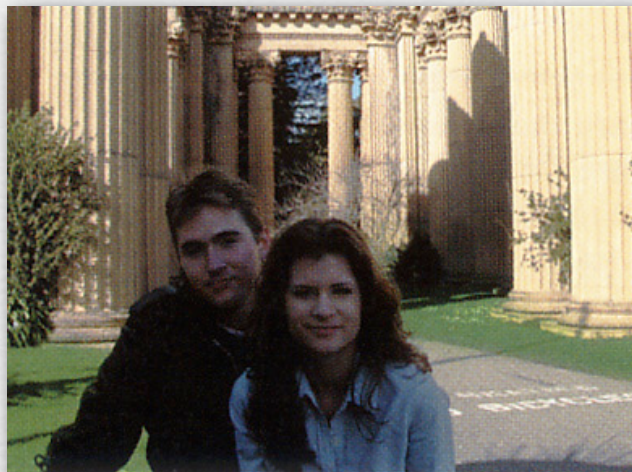
# Fill-flash (for brightly lit backdrops)

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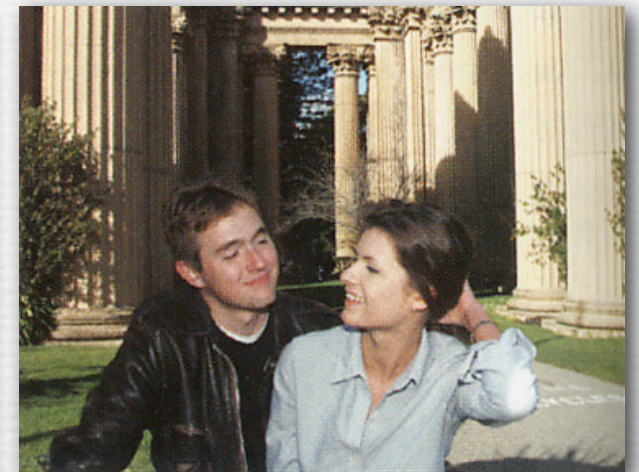
(London)



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





Nexus 5, single shot





Nexus 5, HDR+ mode (merged burst)



# Flash-plus-ambient (in low light)

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(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

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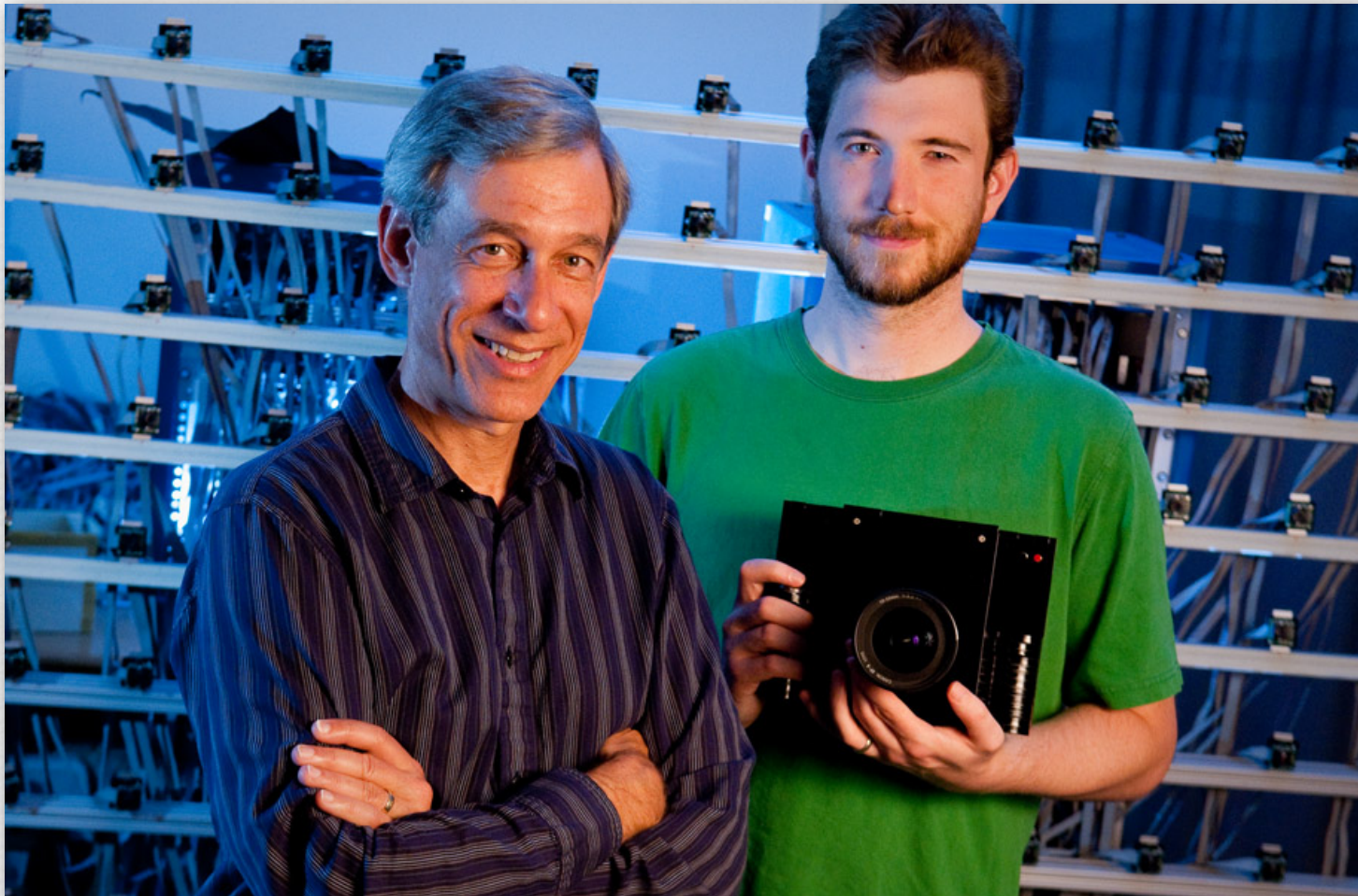
as cameras get more sensitive, flash is less frequently needed when the scene is dark, but it's still useful for changing the light balance or color

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



# How was this shot lit?

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(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



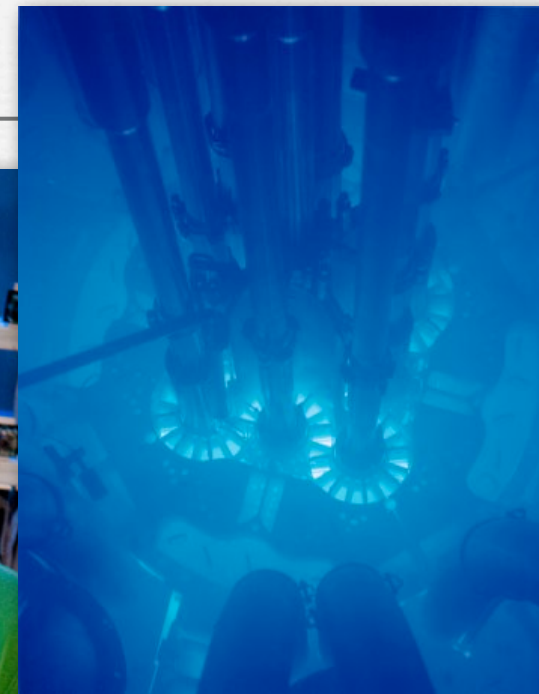
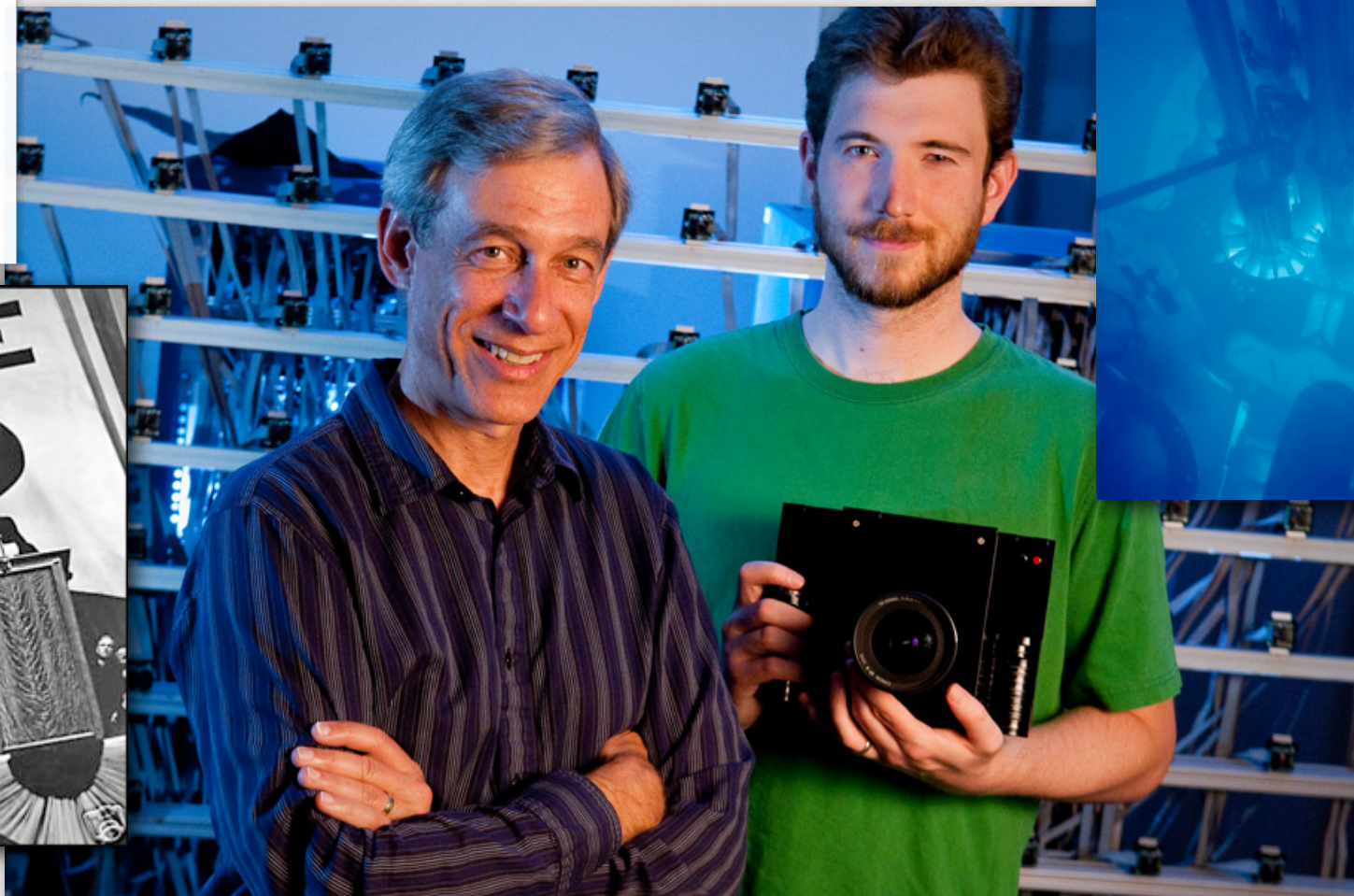
# How was this shot lit?

(Idaho National Laboratory)

note slight dutching (rolling) of camera



Citizen Kane,  
Orson Wells,  
1941

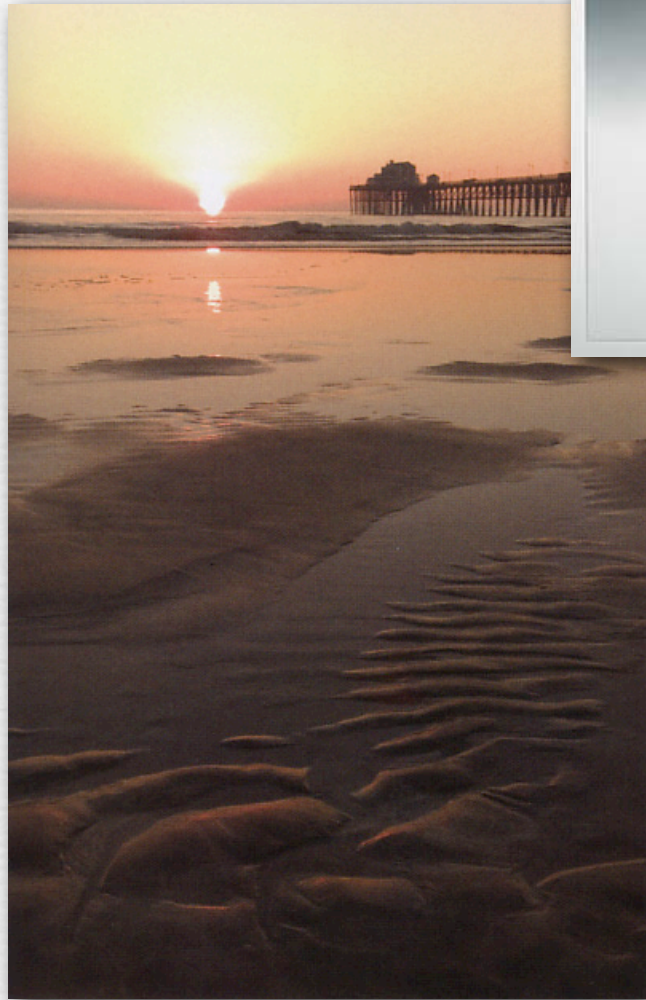


- ◆ key flash (on right side of scene) with orange gel & umbrella + fill flash (extreme left side of scene) with no gel or diffuser + background flash (pointed at back wall) with blue gel



# Avoiding flash

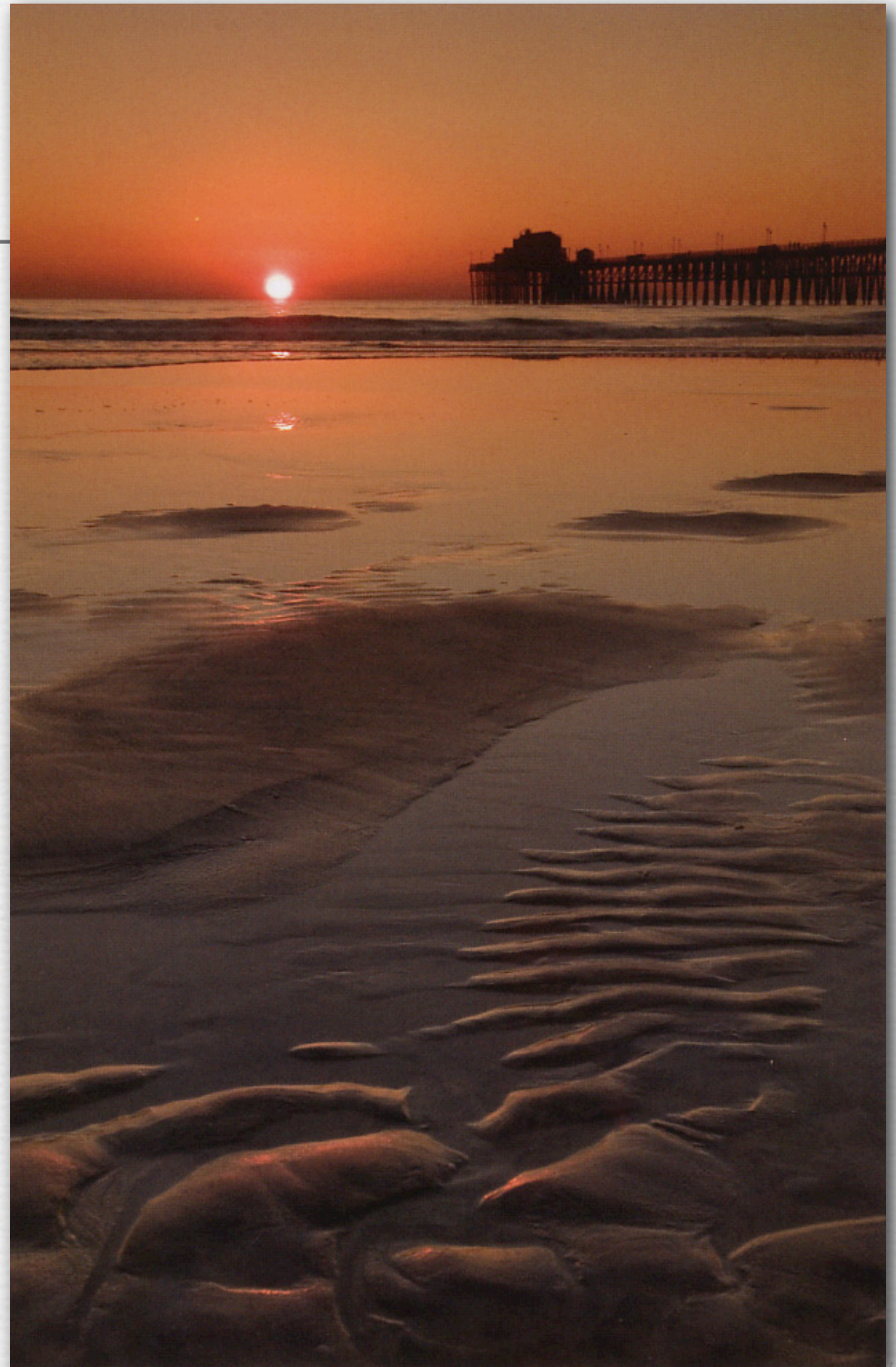
(Peterson)



straight shot



with graduated  
neutral-density filter







Nexus 5, single shot





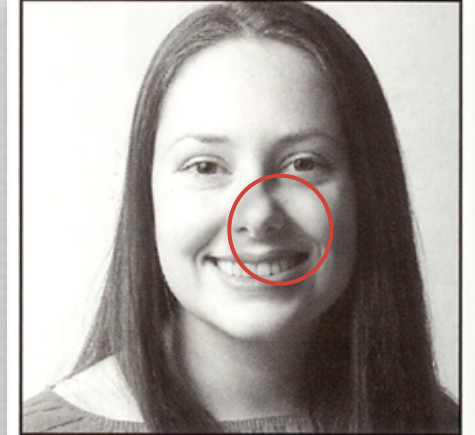
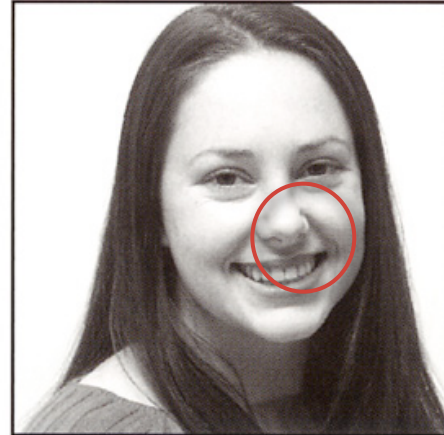
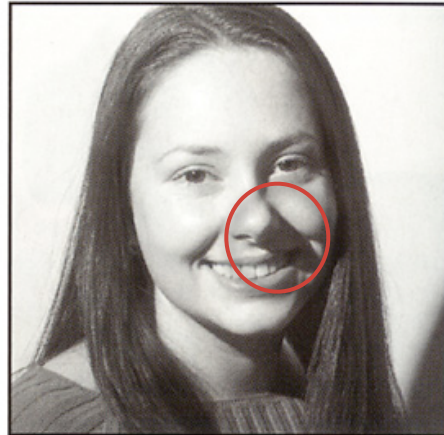
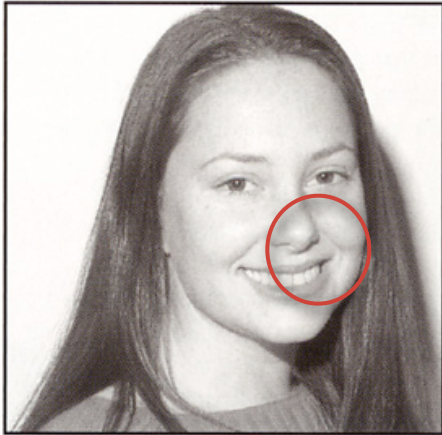
Nexus 5, HDR+ mode



# Flash placement

look at  
[strobist.com](http://strobist.com)

(London)



direct flash,  
on camera

direct flash,  
off camera

bounce flash,  
from above

bounce flash,  
from the side



# Flash technology

(Race Gentry)



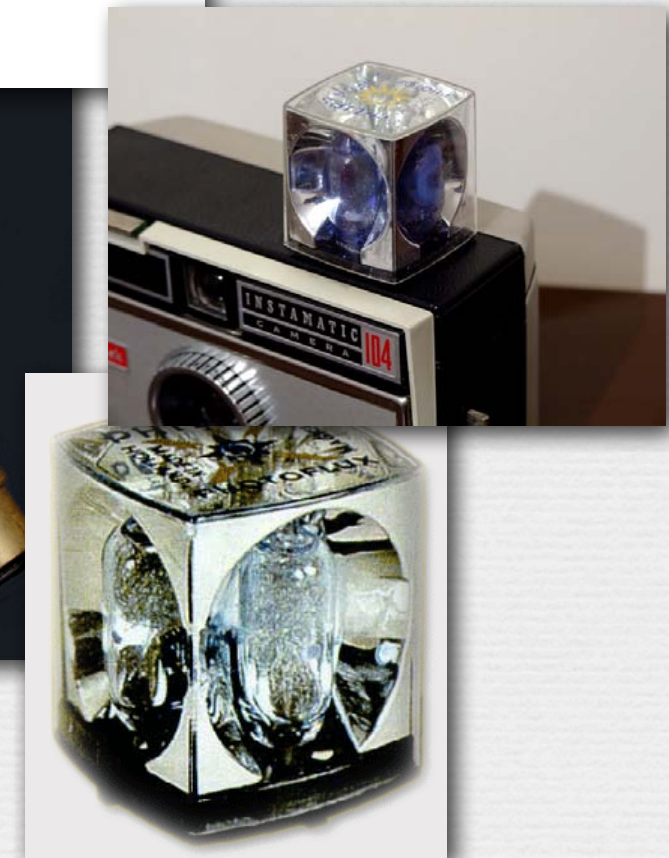
1880: flash powder

powdered magnesium +  
potassium chlorate +  
antimony sulfide



1927: flashbulbs

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



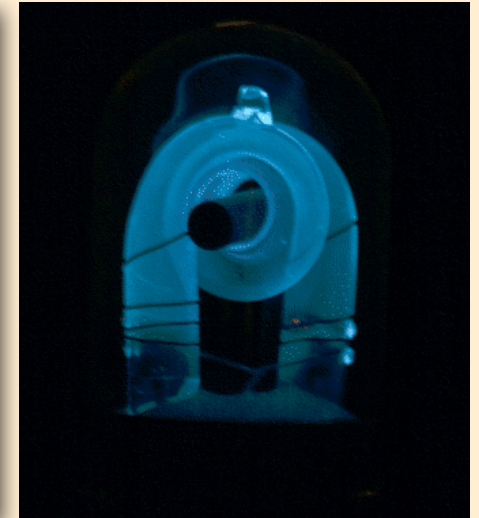
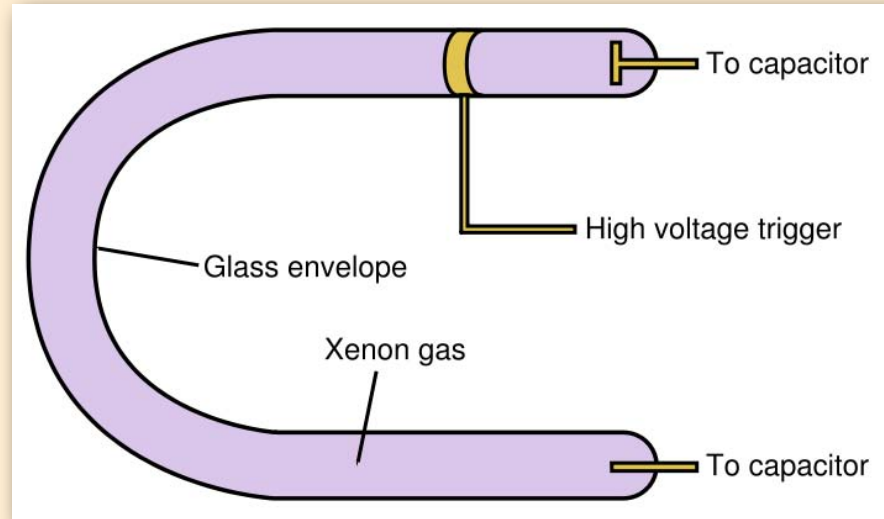
1960s: flashcubes



# Electronic flash



Canon 580EX

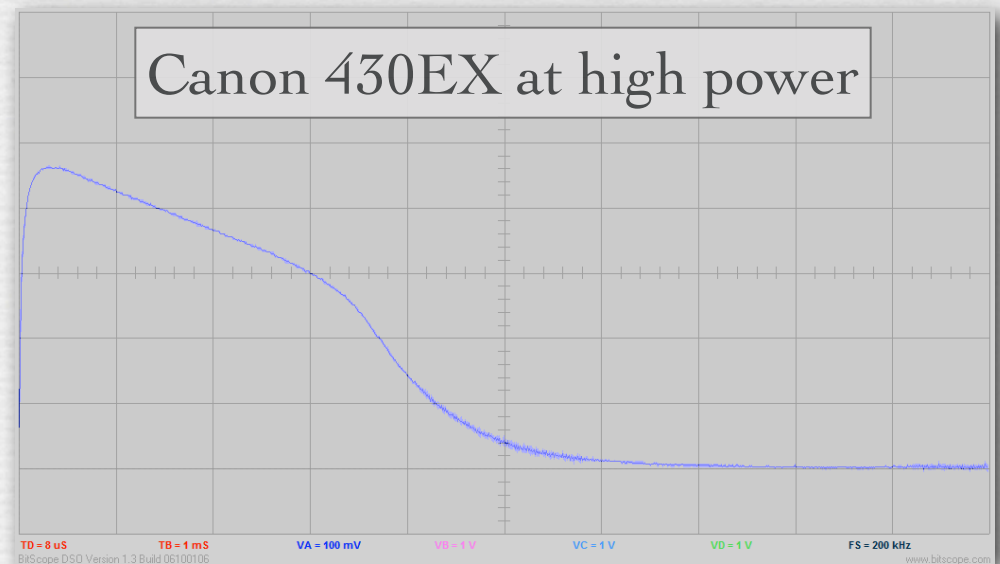
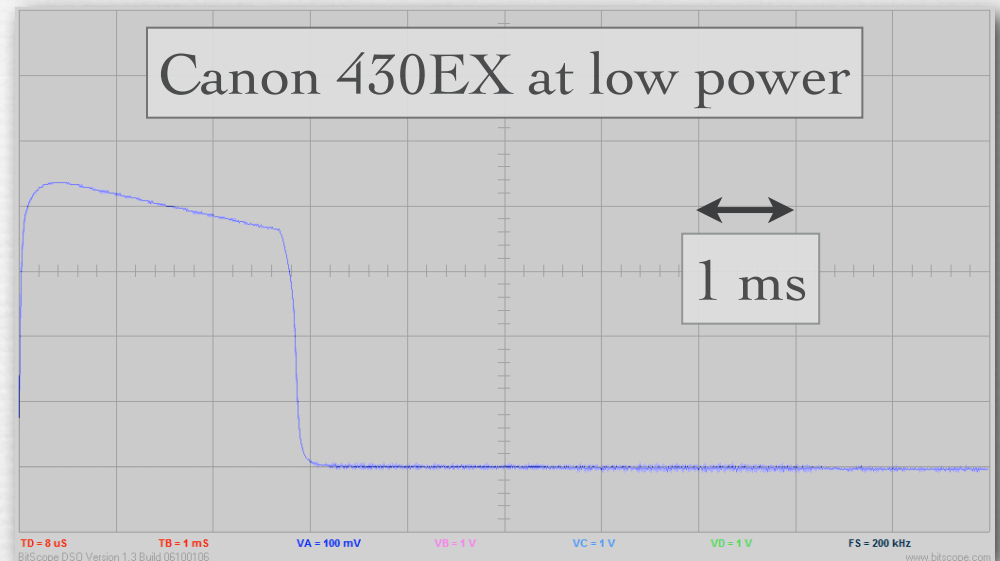


(wikipedia)

- ◆ 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

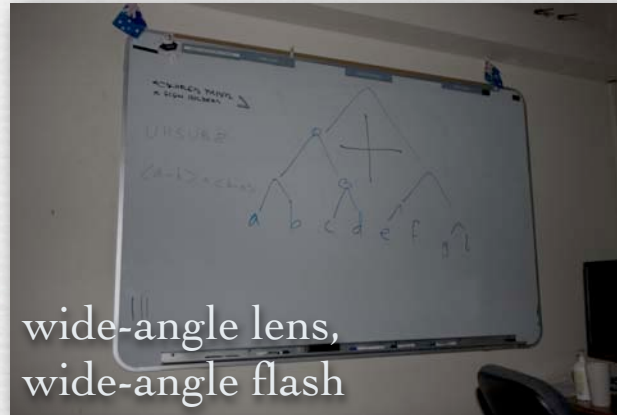
- ◆ the luminous intensity of a particular xenon flash tube is fixed
- ◆ flash is briefer than the shutter, so you can't use shutter speed to control illuminance on sensor
  - you can still use it to control ambient light
- ◆ aperture and ISO affects recording of both flash and ambient light
- ◆ instead,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



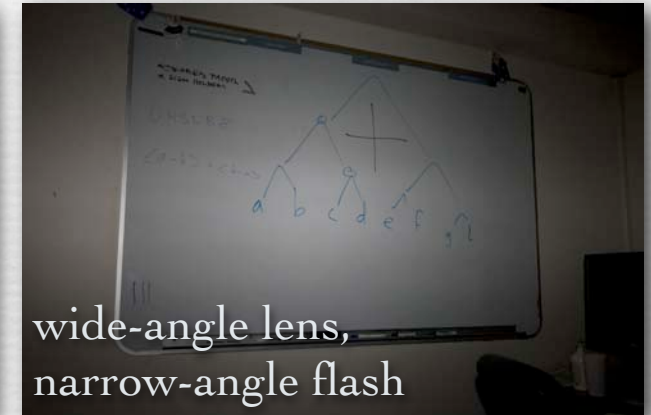


# Guide numbers

- ◆ flash power is measured in *guide numbers*
  - proper F-number = 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

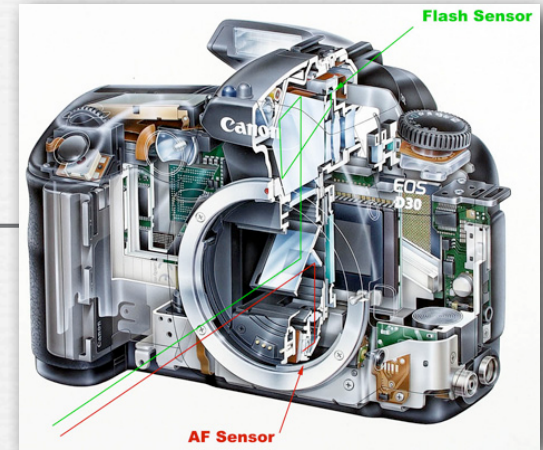
- ◆ examples

- Canon 580 EX hot-shoe flash: guide number 58
- Panasonic GX1 pop-up flash: guide number 19
- 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 40' away !

16× as much light  
allows 4× distance

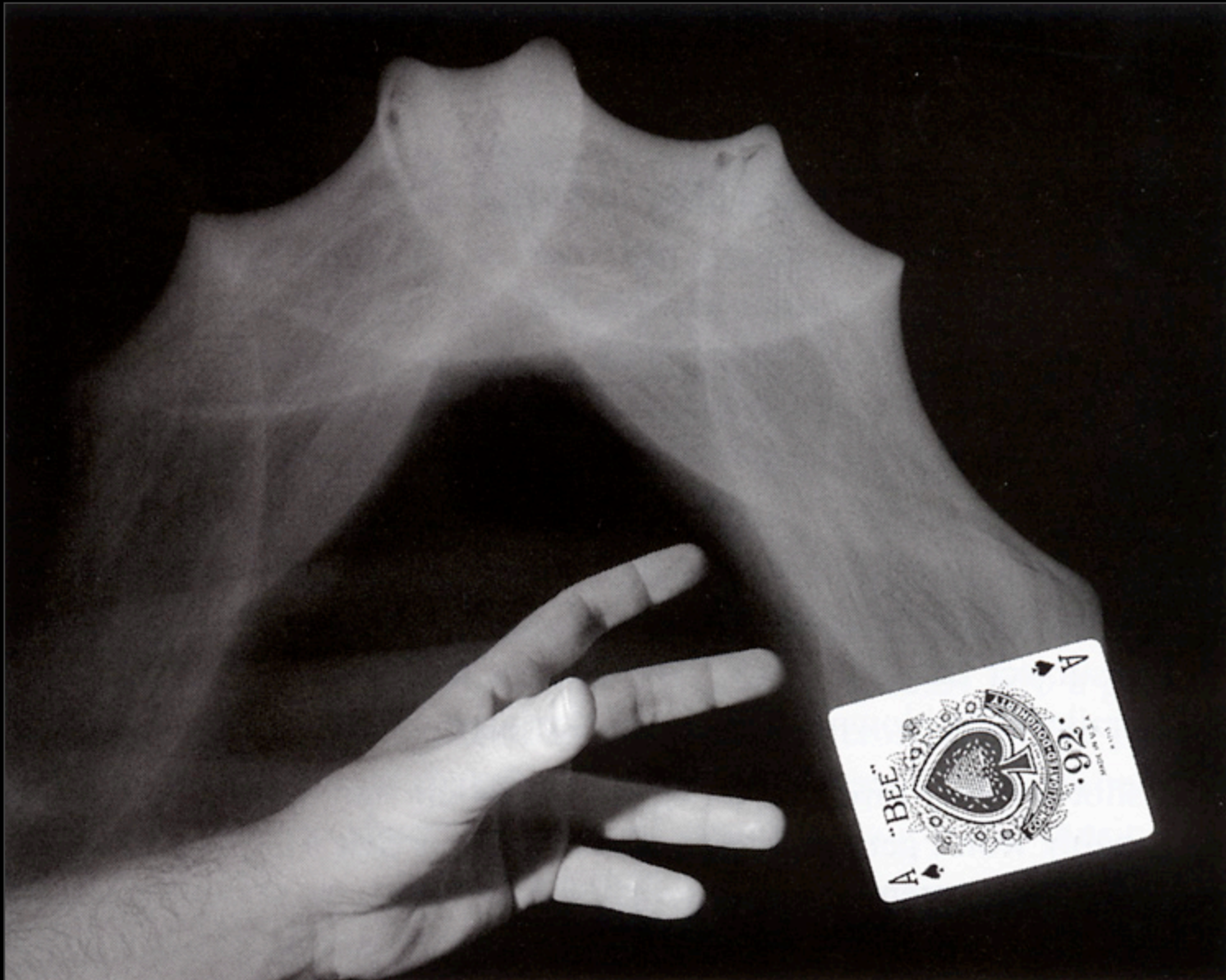
# Metering for flash photography

(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 2<sup>nd</sup> curtain sync





Derrick Story, card flip using second-curtain flash

# Stanford programmable Frankencamera with 2 flash heads attached

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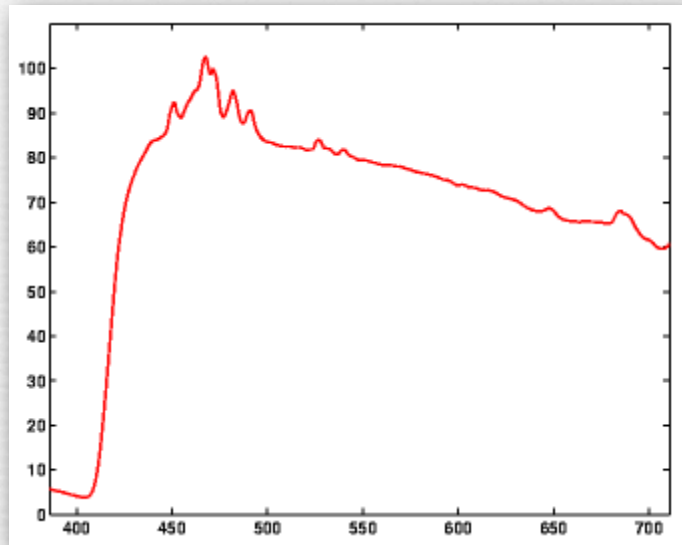
- Canon 430EX (smaller flash) strobed continuously
- Canon 580EX (larger flash) fired once at end of exposure





# 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

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- ◆ 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

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- ◆ 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*
  - $F\text{-number} = \text{guide number} / \text{distance to subject}$
  - $2\times \text{distance to subject}$  or  $2\times F\text{-number} \rightarrow \text{need } 4\times \text{illuminance}$

## Questions?



# Flash-noflash photography

[Agrawal SIGGRAPH 2005]

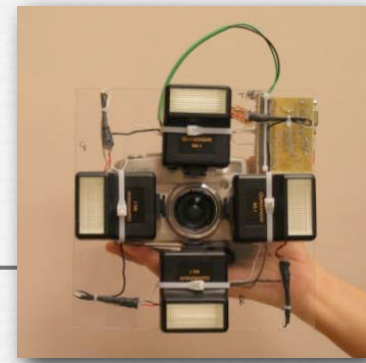


- ◆ compute ambient + flash – features in sum that don't appear in ambient alone (as determined from image gradients) (except where ambient image is nearly black)



# 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

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## ◆ 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.
- ◆ London, Stone, and Upton, *Photography* (6th & 9th editions), Prentice Hall, 2008.
- ◆ Ang, T., *Digital Photography* (2nd ed.), DK Publishing, 2007.
- ◆ LoSapio, A., *Professional Photographic Illustration*, Eastman Kodak, 1989.
- ◆ Story, Derrick, *Digital Photography Hacks*, O'Reilly, 2004.
- ◆ Varis, L., *Skin*, Wiley, 2006.
- ◆ Nissen, H.J., Damerow, P., Englund, R.K., *Archaic Bookkeeping*, University of Chicago Press, 1994.
- ◆ for a great tutorial on off-camera flash lighting, see <http://strobist.blogspot.com>