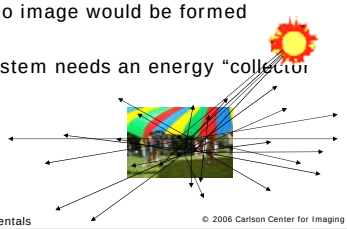
Imaging Chain Link #3

Propagation and Collection of Energy

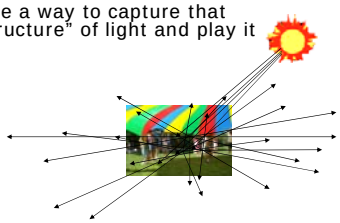
Imaging Chain: Collection

- Energy interacts with typical objects, and then "diverges" (spreads out) as it propagates
- An observation screen (or a piece of film, or a CCD detector, …) held nearby would detect the diverging energy, but no image would be formed
- Imaging System needs an energy "collector"



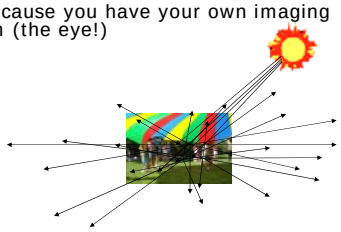
Imaging Chain: Collection

- Q1) If the information is lost during propagation, then how can I see the objects in an image?
- Q2) Is there a way to capture that "chaotic structure" of light and play it back later?



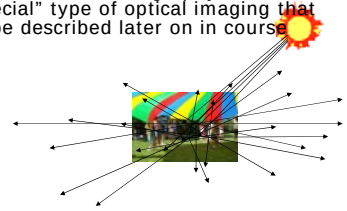
Imaging Chain: Collection

- Q1) If the information is lost during propagation, then how can I see the objects?
- A1) Because you have your own imaging system (the eye!)



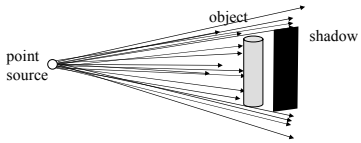
Imaging Chain: Collection

- Q2) Is there a way to capture the structure of light and use it to make an image?
- A2) Yes — this is *holography*, which is a "special" type of optical imaging that may be described later on in course



Imaging Chain: Collection

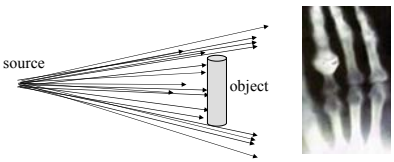
- Simplest system: *shadowgraph*
  - Light as "Ray"



- Image quality is best for small source and if object placed directly on image plane

Imaging Chain: Collection

- Simplest way to collect information from an object is to capture its *shadow* from point source
- Light as "Ray"
- Medical X-ray systems based on *shadowgraphs*



Pop quiz (1): Which is the X-ray Image?

A.

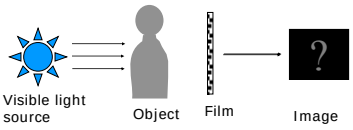
B.

Answer: B!!! (But You Knew That)

A.

B.

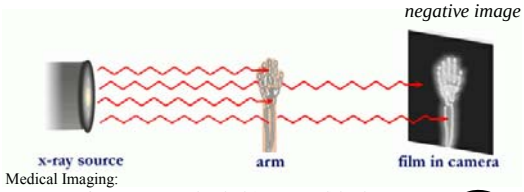
Simple imaging system: Medical X ray



- X rays either penetrate the object being imaged and are then detected by film, or they are absorbed by object. Result is a *shadowgram*.
- What if we replaced the X-ray source with a visible light source?

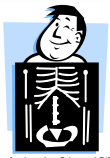
Medical X-Ray Imaging

negative image



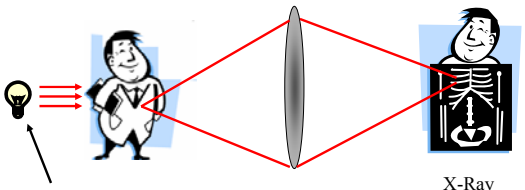
Medical Imaging:

1. X Rays from source are absorbed (or scattered) by dense structures in object (e.g., bones). Much less so by muscles, ligaments, cartilage, etc.
2. Most X Rays pass through object to "expose" X-ray sensor (film or electronic)
3. After development/processing, produces *shadowgram* of dense structures
   (X Rays pass "straight through" object without "bending")



Lenses for X Rays Don't Exist!

It would be very nice if they did!



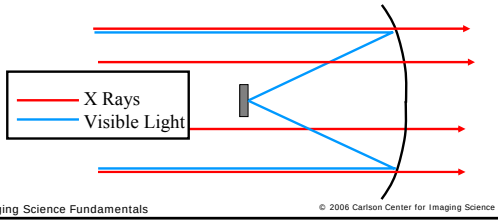
Nonexistent X-Ray "Light Bulb"

Nonexistent X-Ray Lens

X-Ray Image

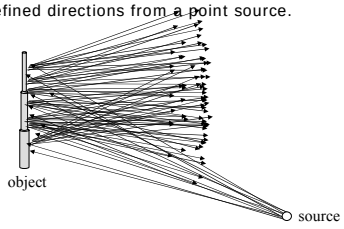
How Can X Rays Be "Imaged?"

- X Rays are too energetic to be refracted or reflected, as is possible for visible photons



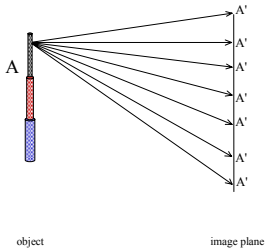
Imaging Chain: Collection

- Shadowgraphs cannot be used in reflection
- Formed of "many" point sources
  - Reflected energy travels in many directions rather than the well-defined directions from a point source.



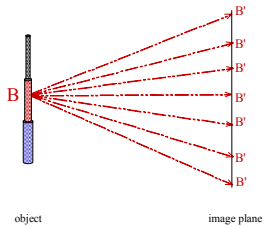
Imaging Chain: Collection

- Single point 'A' on object reflects light in all directions across entire observation plane



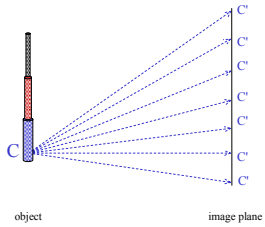
Imaging Chain: Collection

- Light from point ‘B’ is *also* reflected in all directions and spread across entire image plane



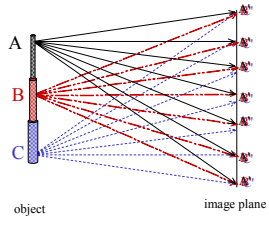
Imaging Chain: Collection

- Same for light from point ‘C’



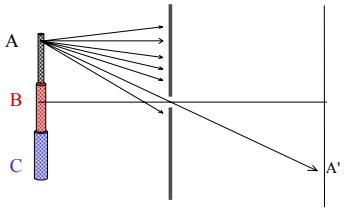
Imaging Chain: Collection

- “Extended” object is a set of reflecting points
  - Energy from al points is mixed together
  - Cannot create image from this light (except in special case of holography)



Imaging Chain: Collection

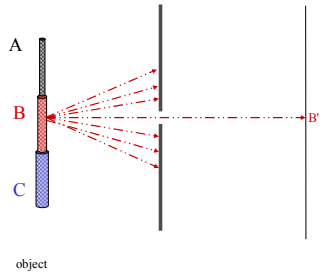
- Solution: *"Select"* the rays of light to be imaged!



"Pinhole Camera"

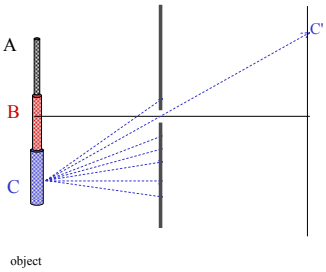
Imaging Chain: Collection

"Pinhole Camera"



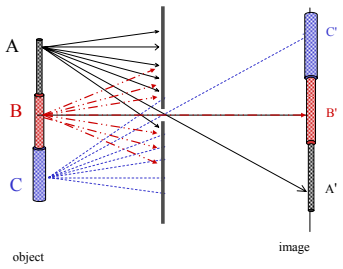
Imaging Chain: Collection

"Pinhole Camera"



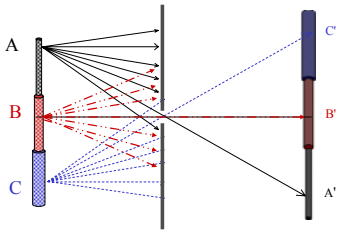
Imaging Chain: Collection

"Pinhole Camera"



Imaging Chain: Collection

"Pinhole Camera"



Disadvantage: throws away most light ⇒ *inefficient*

Typical imaging chain for pinhole camera