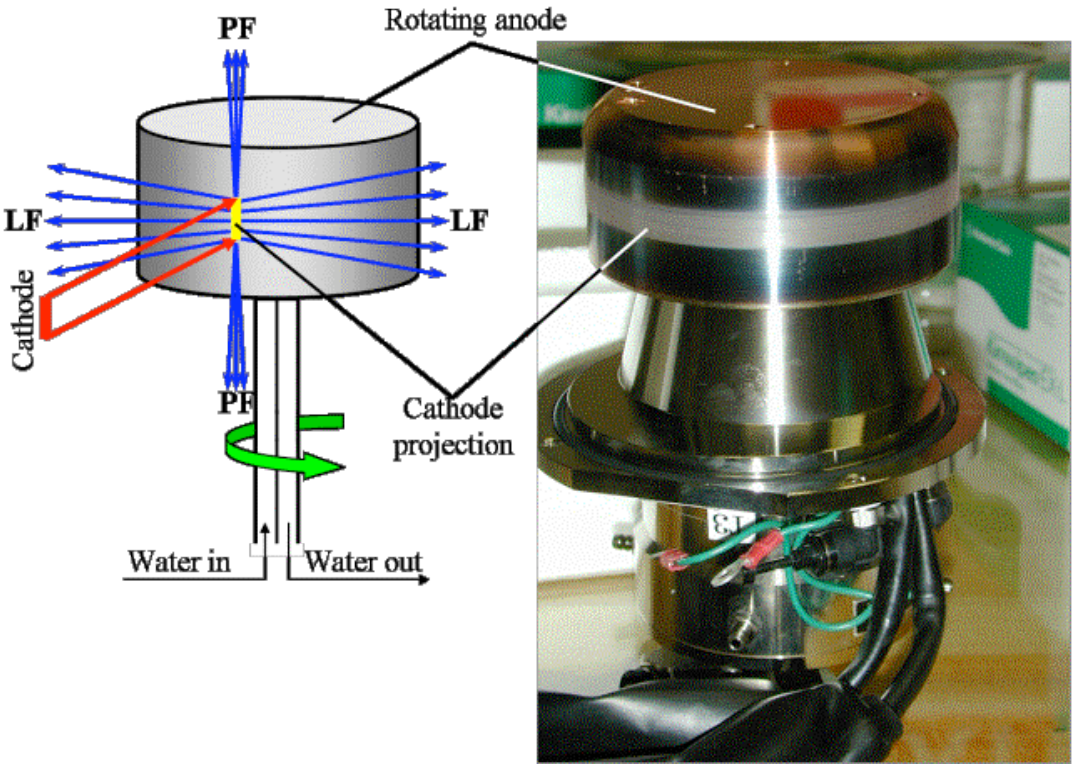
Instrumentation - making & detecting x-rays

Read Roe - Chap 2 through 2.5.1 (ignore neutrons)

Instrumentation - making x-rays

'Laboratory' x-ray tubes - rotating anodes

Same mechanism for x-ray production - different anode setup



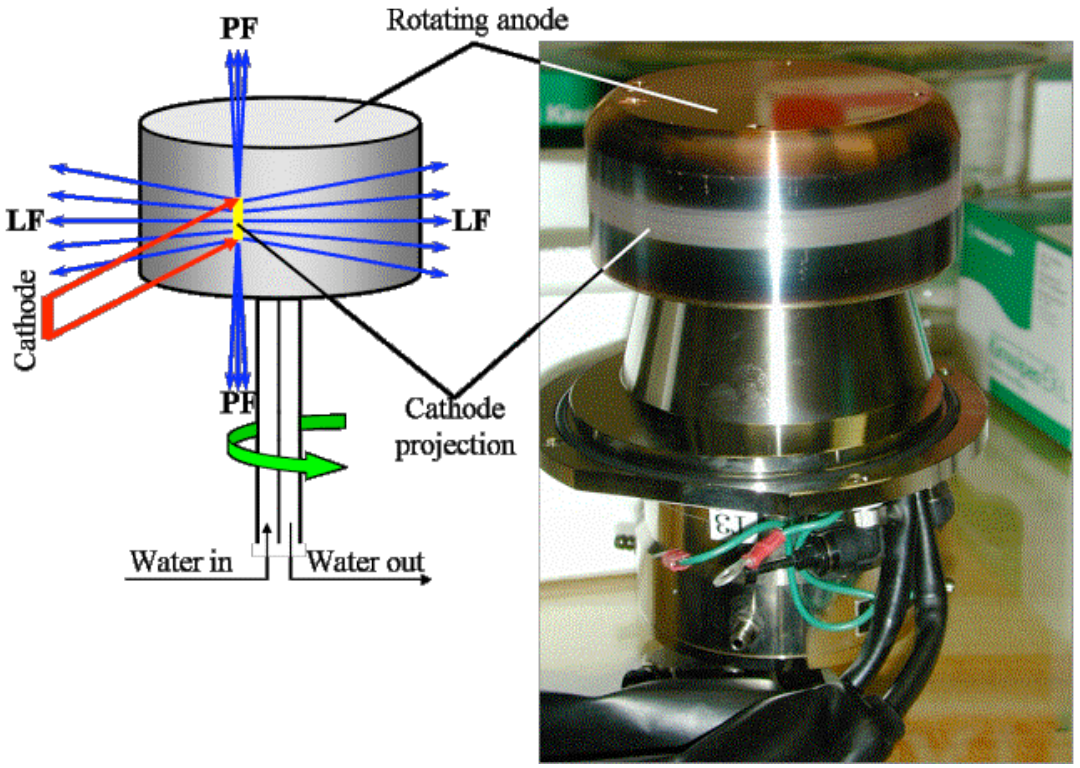
Instrumentation - making x-rays

'Laboratory' x-ray tubes - rotating anodes

Same mechanism for x-ray production - different anode setup

Focal spot spread out over cylinder surface

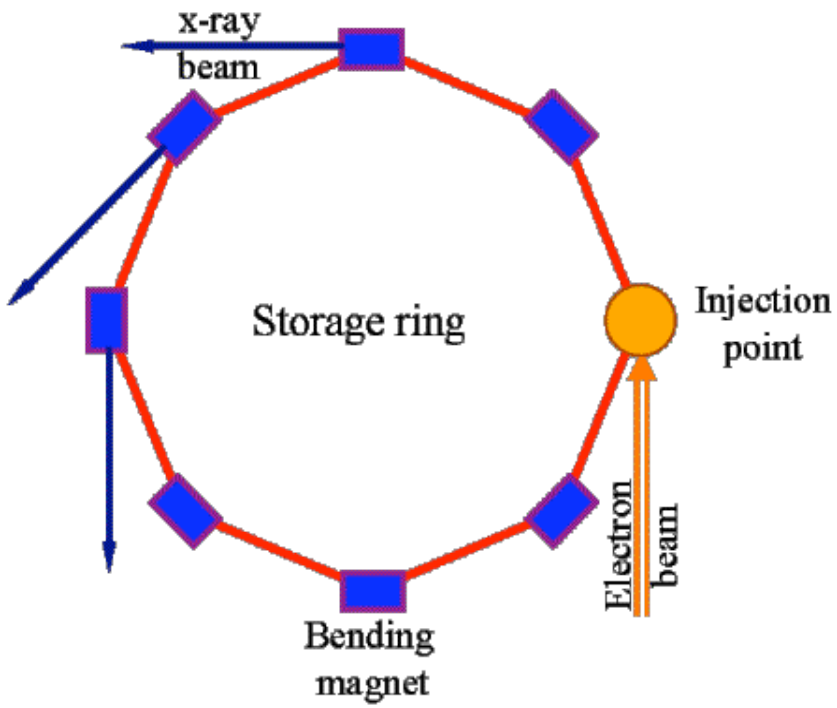
Tube power up to 20X that of Coolidge tube



Instrumentation - making x-rays

Synchrotron

Electrons or positrons injected into ring

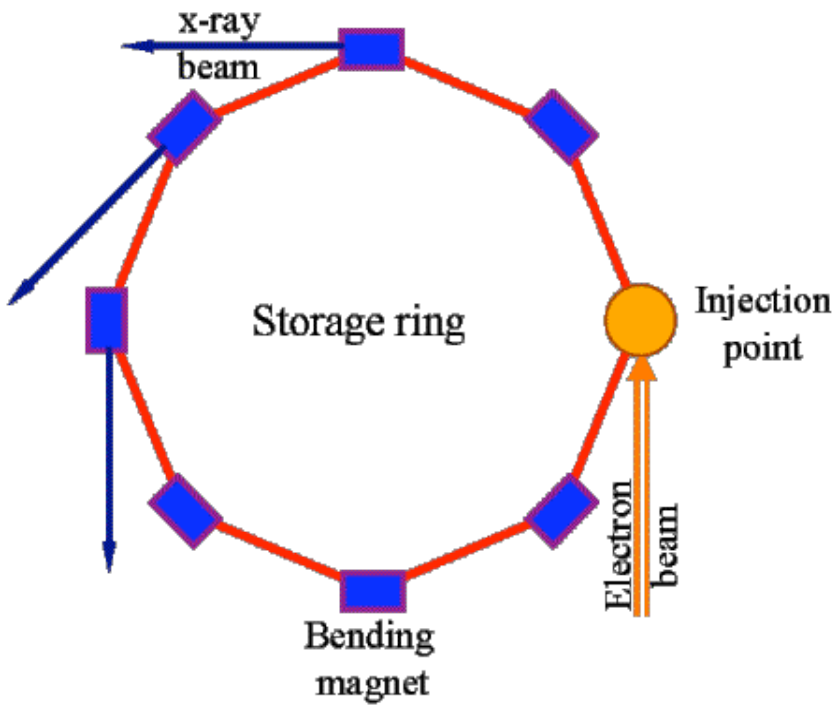


Instrumentation - making x-rays

Synchrotron

Electrons or positrons injected into ring

Where charged particle stream is bent, x-rays are emitted



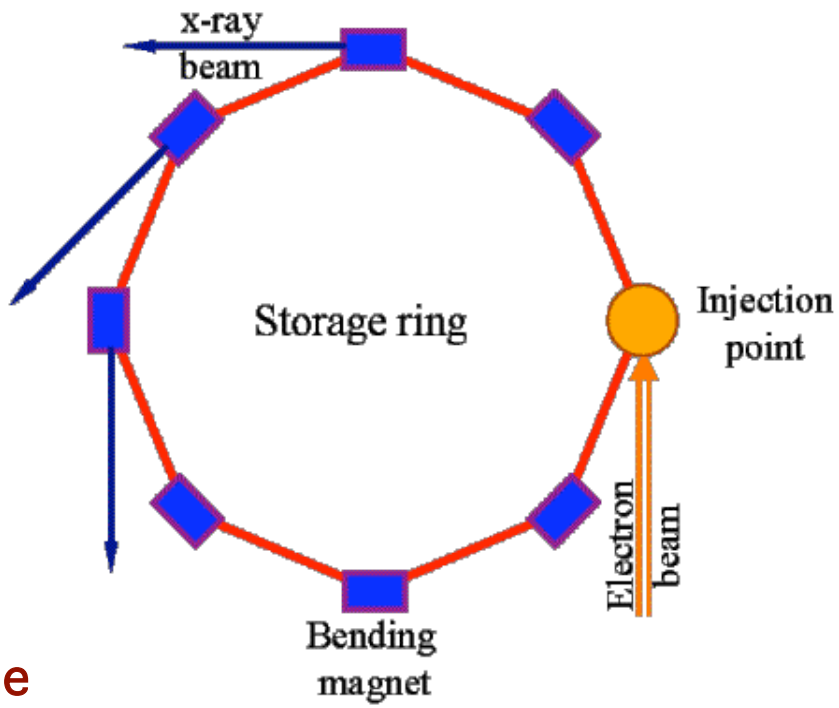
Instrumentation - making x-rays

Synchrotron

Electrons or positrons injected into ring

Where charged particle stream is bent, x-rays are emitted

X-ray beam:
- extremely bright
- very tiny
- low divergence - < milliradian in ring plane



Instrumentation - making x-rays

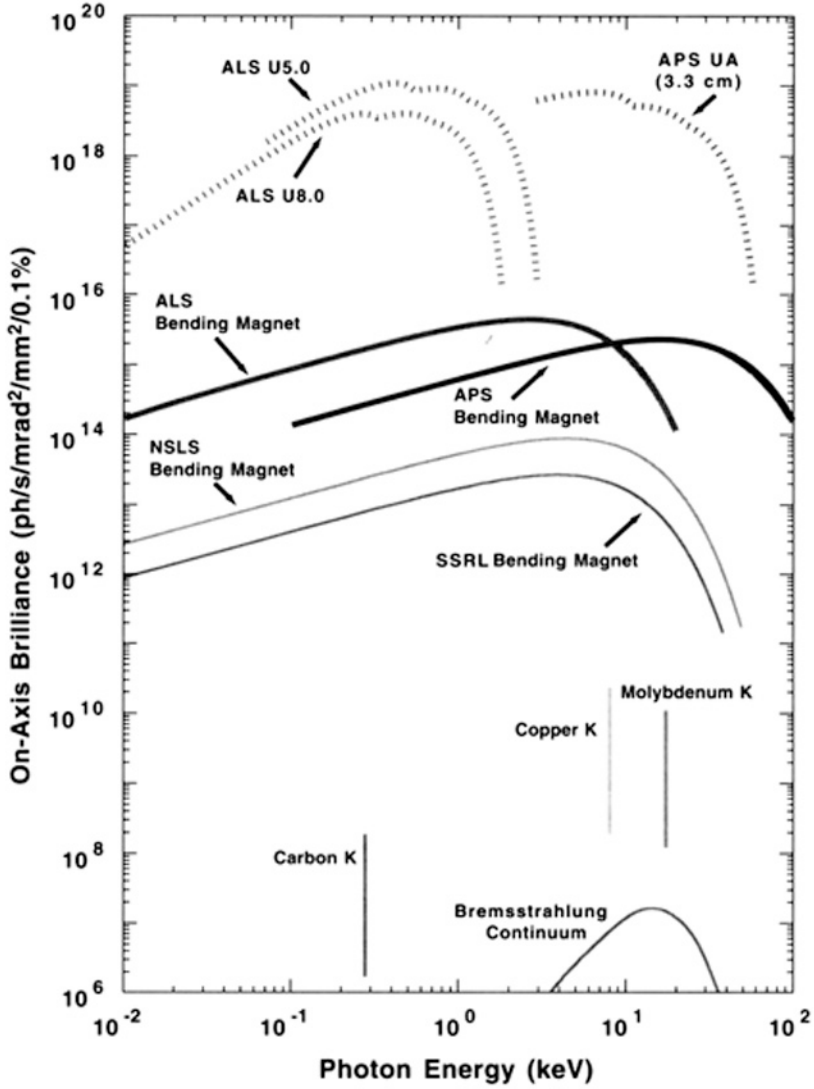
Synchrotron

Electrons or positrons injected into ring

Where charged particle stream is bent, x-rays are emitted

X-ray beam:

- extremely bright
- very tiny
- low divergence - < milliradian
- broad spectrum in ring plane



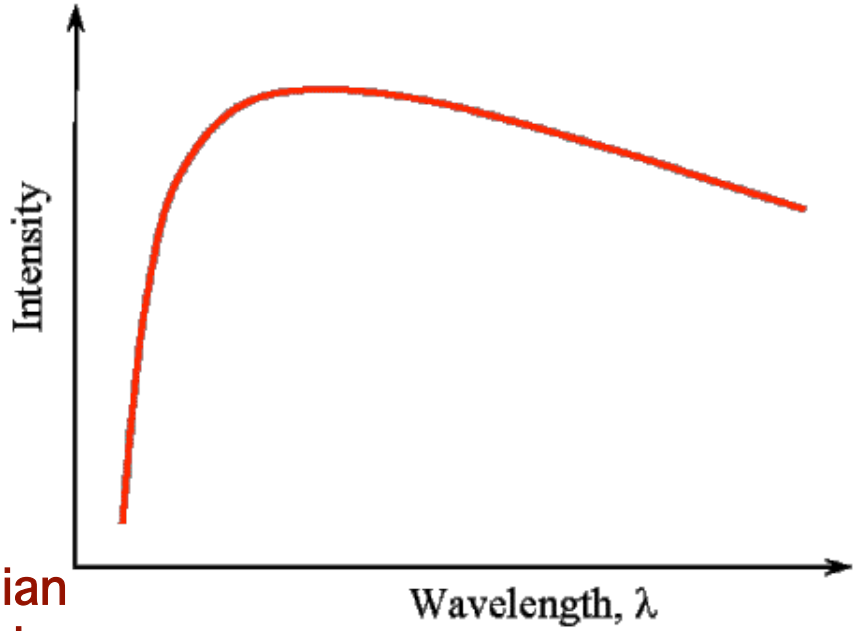
Comparisons of spectra from various synchrotron facilities as well as laboratory $K\alpha$ Cu and Mo radiation, and the white or brehmsstrahlung radiation from X-ray tubes: ALS is the Advanced Light Source at Lawrence Berkeley Laboratory, Berkeley, CA; NSLS is the National Synchrotron Light Source at Brookhaven National Laboratory, Upton, NY; SSRL is the Stanford Synchrotron Research Laboratory, Stanford, CA; and, APS is the Advanced Photon Source at Argonne National Laboratory, Argonne, IL.

Instrumentation - making x-rays

Synchrotron

Electrons or positrons injected into ring

Where charged particle stream is bent, x-rays are emitted



X-ray beam:

- extremely bright
- very tiny
- low divergence - < milliradian
- broad spectrum in ring plane

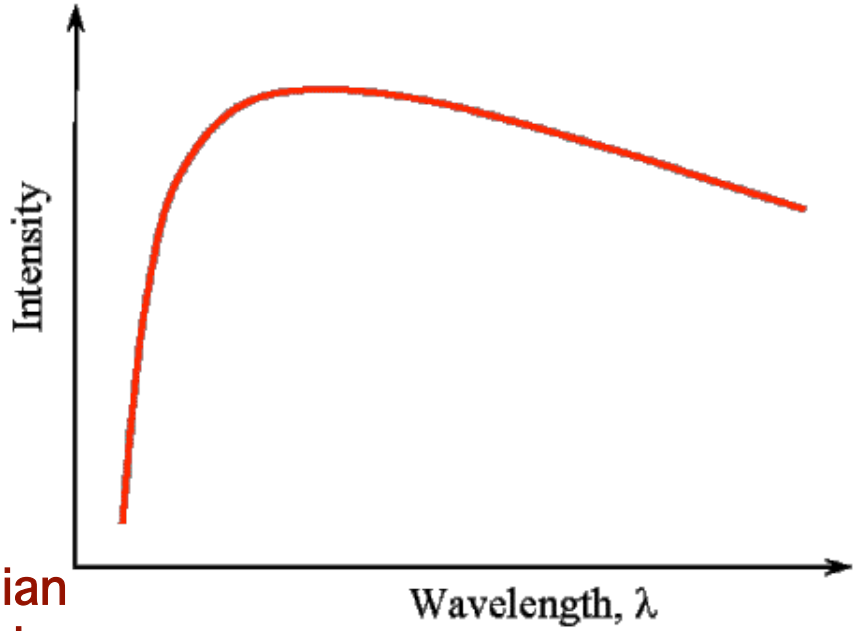
Can choose any λ in 0.1-10 Å using incident beam monochromator
Monochromator often focusing type

Instrumentation - making x-rays

Synchrotron

Electrons or positrons injected into ring

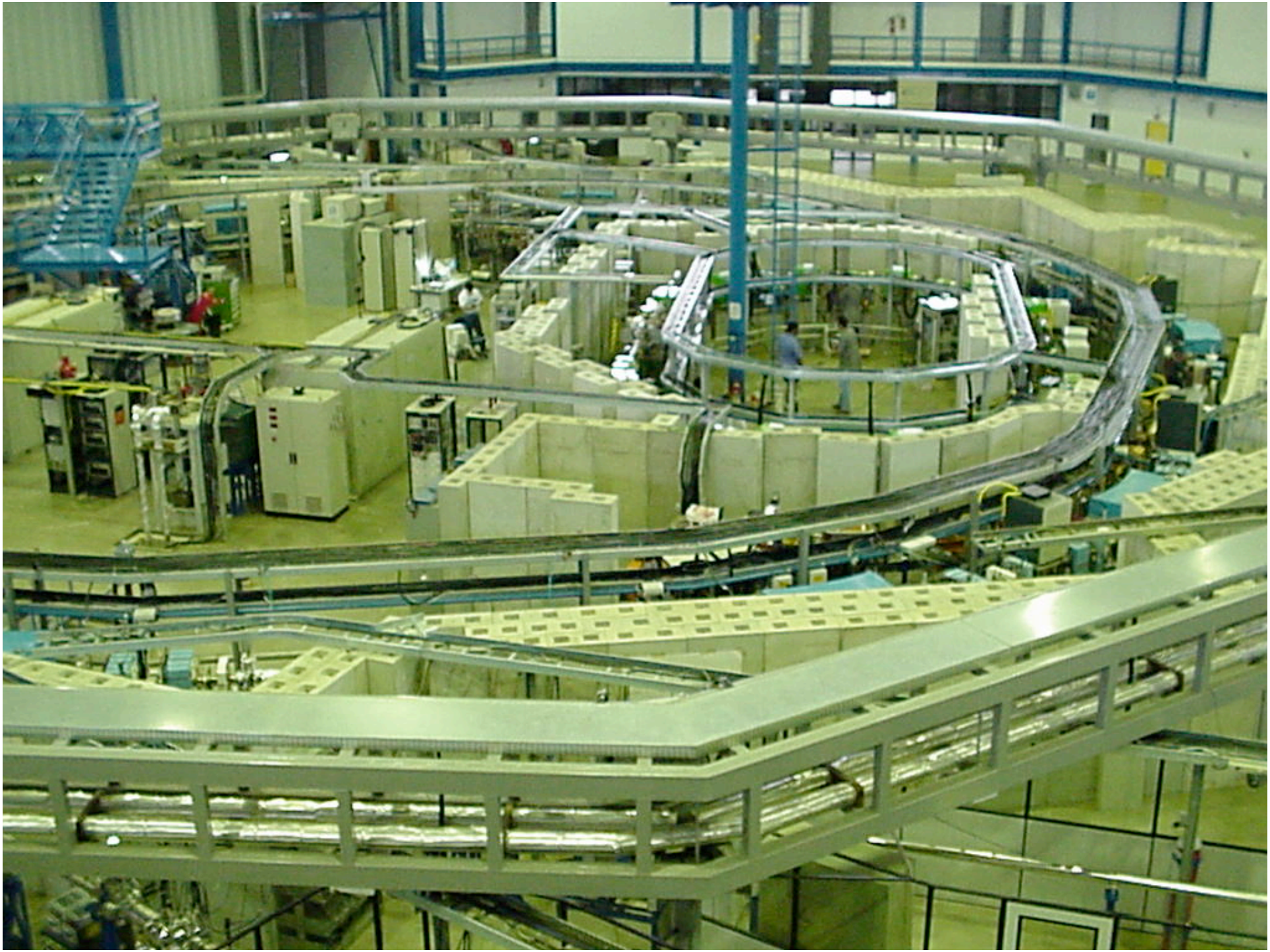
Where charged particle stream is bent, x-rays are emitted



X-ray beam:

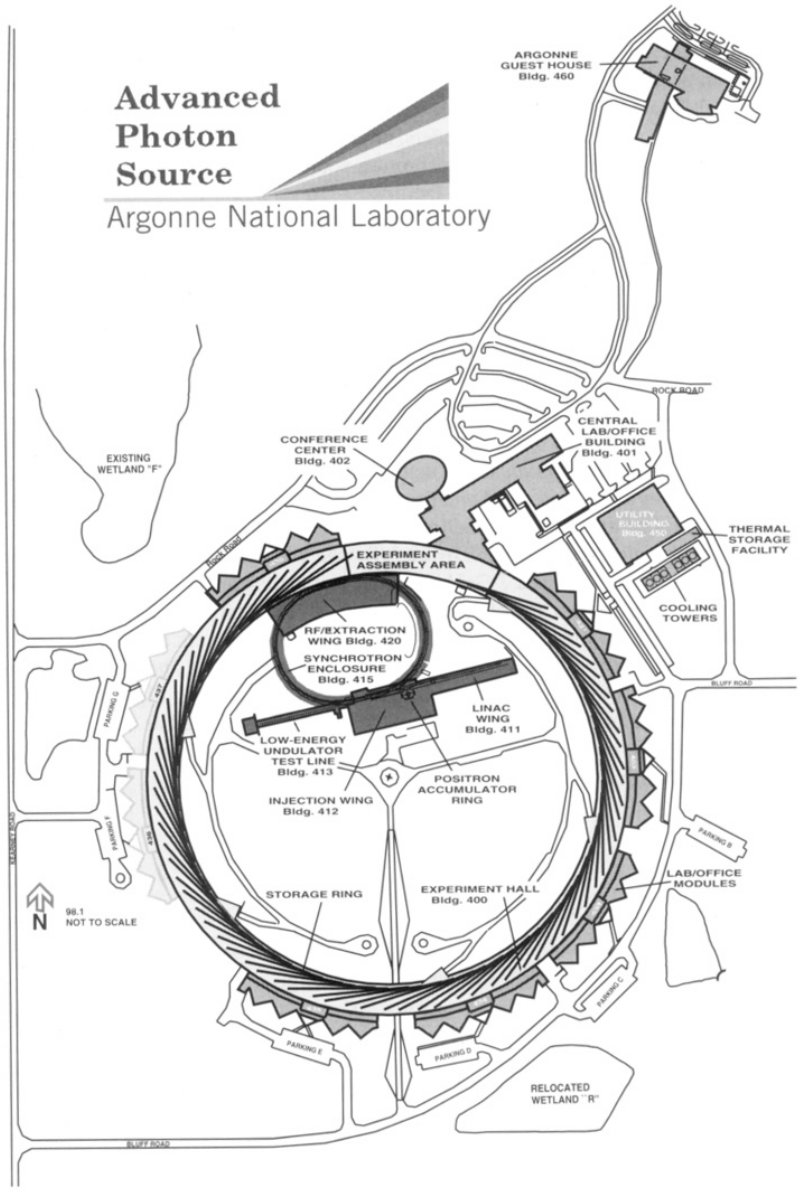
- extremely bright
- very tiny
- low divergence - < milliradian
- broad spectrum in ring plane

Can choose any λ in 0.1-10 Å using incident beam monochromator
Monochromator often focusing type
Can tune λ for absorption by specific atoms in specimen



Instrumentation - making x-rays

Synchrotron

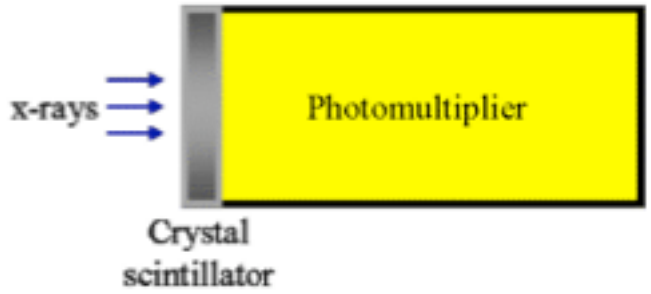


Instrumentation - x-ray detectors

Point - requires scan

Scintillation counter

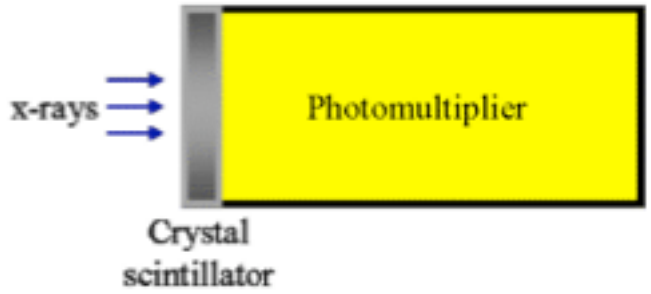
x-rays converted to light



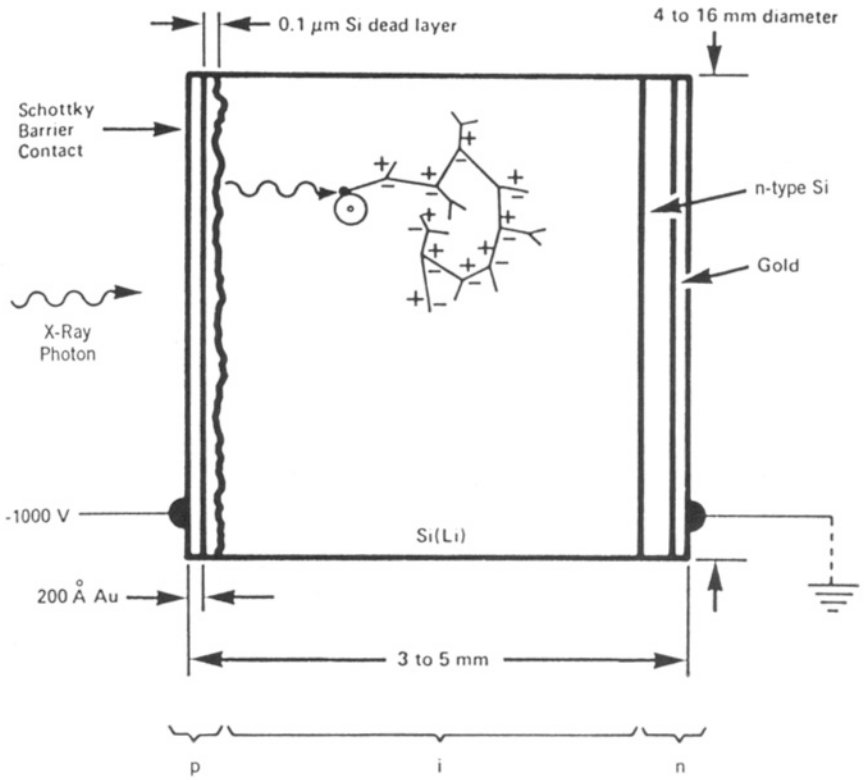
Instrumentation - x-ray detectors

Point - requires scan

Scintillation counter
x-rays converted to light



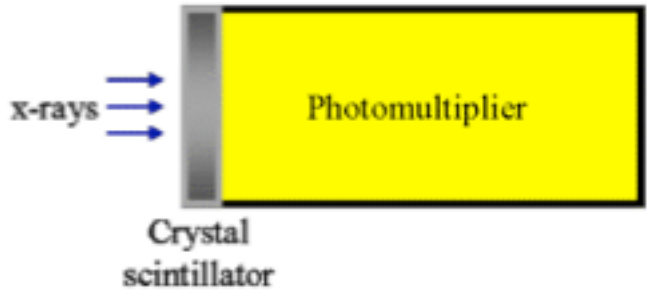
Solid state (SiLi) detector
x-rays –-> electron-hole pairs



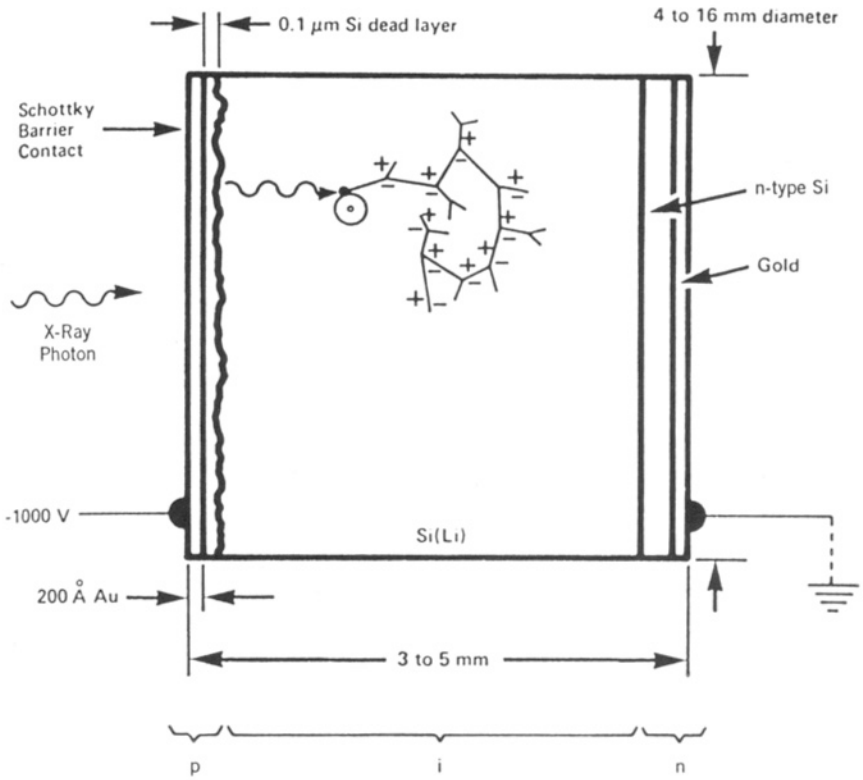
Instrumentation - x-ray detectors

Point - requires scan

Scintillation counter
- x-rays converted to light

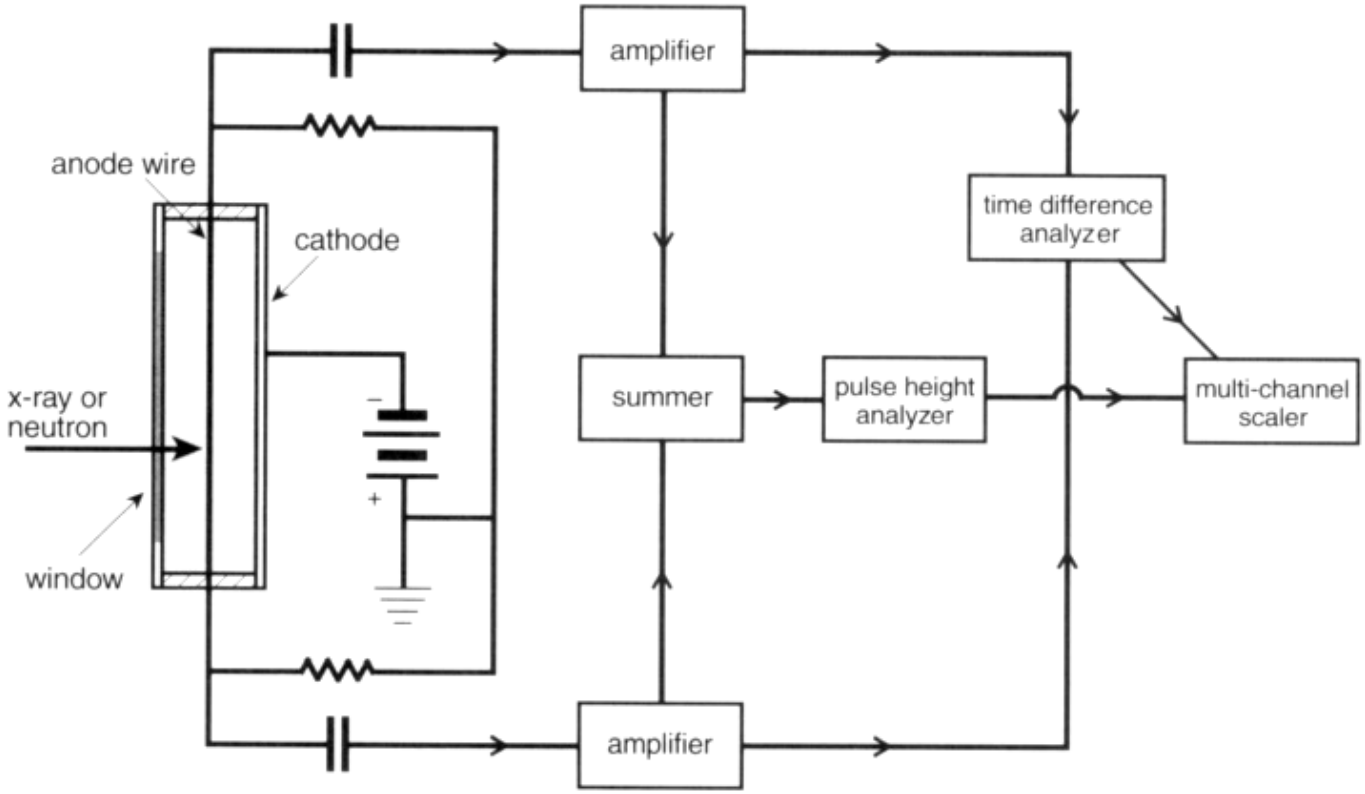


Solid state (SiLi) detector
- x-rays –-> electron-hole pairs
- very high resolution
- very low noise
- dead time problem
- liq N_2 temp required



Instrumentation - x-ray detectors

Linear - may require scan, depending on instrument



Schematic illustration of a one-dimensional position-sensitive detector. The gas-filled detector operates as a proportional counter, and the position information is encoded in the difference in the rise time between the pulses coming out of the two ends of the anode wire.

Instrumentation - x-ray detectors

Area

Film - old technology

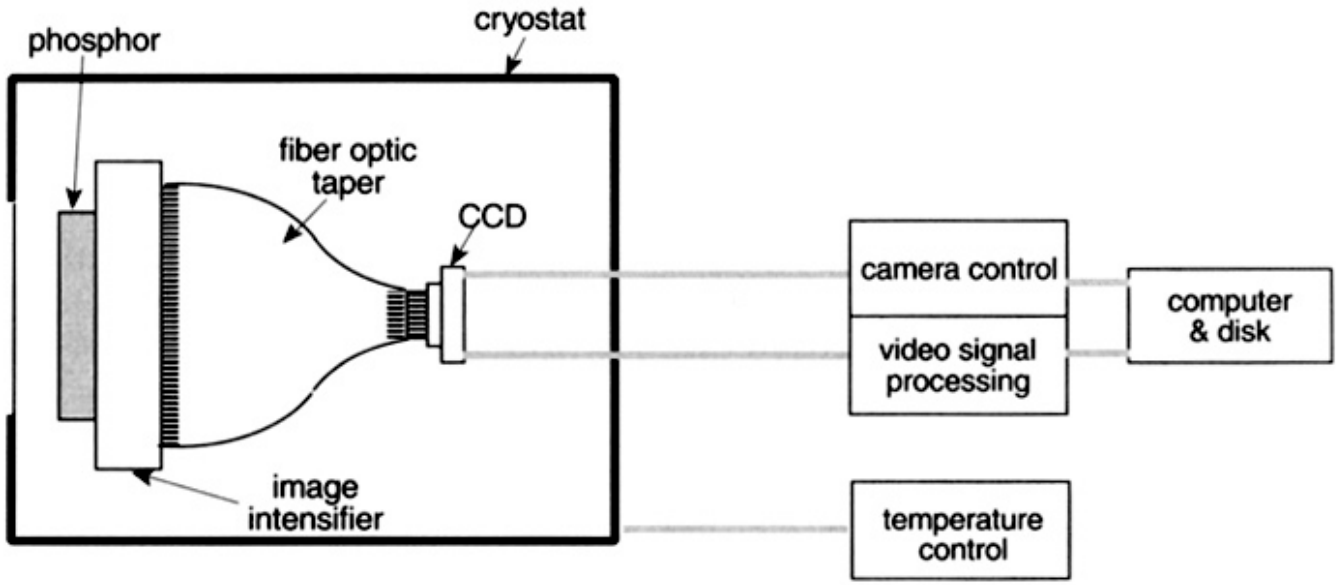
still used, especially Polaroid

Instrumentation - x-ray detectors

Area

Film - old technology
still used, especially Polaroid

CCD



Schematic of a CCD-based area detector.

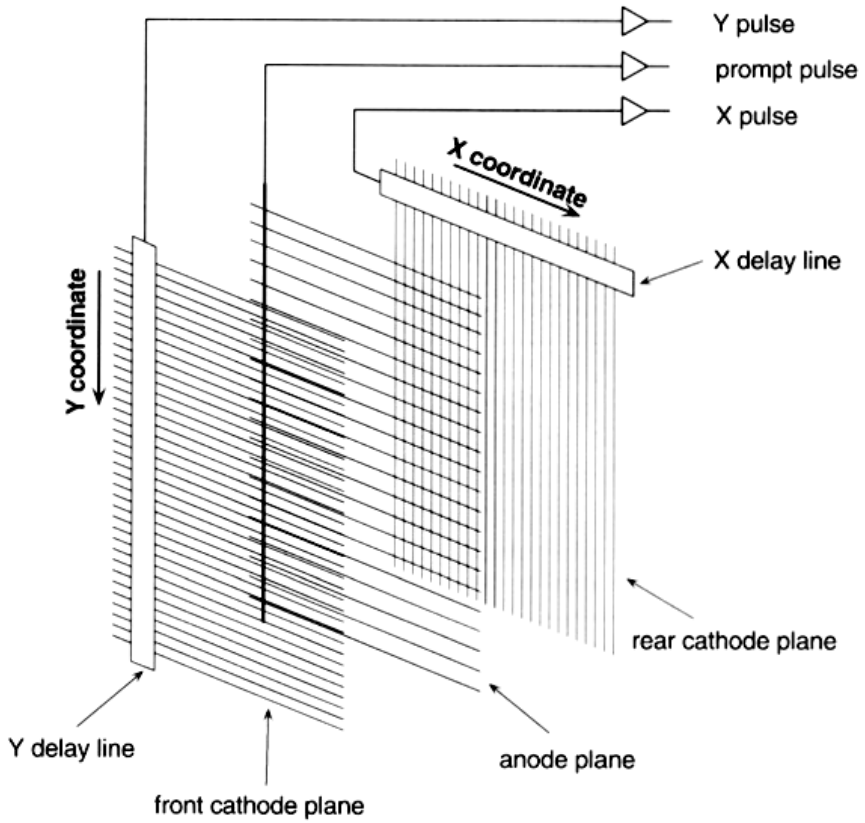
Instrumentation - x-ray detectors

Area

Film - old technology
still used, especially Polaroid

CCD

Multiwire



Schematic of a two-dimensional position-sensitive multiwire proportional counter (MWPC). (The spacing between electrode planes is not to scale.)

Instrumentation - x-ray detectors

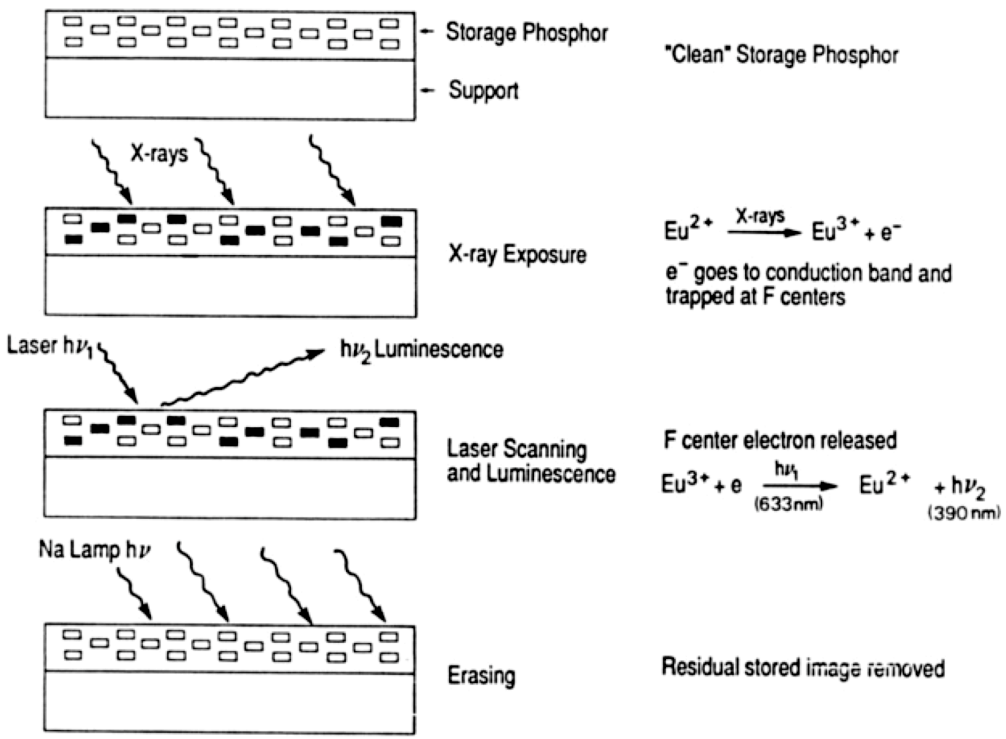
Area

Film - old technology
still used, especially Polaroid

CCD

Multiwire

Image 'plates'
(BaBrF:Eu^{+2})



Steps in collecting, reading, and erasing a storage phosphor imaging plate.

Instrumentation - x-ray detectors

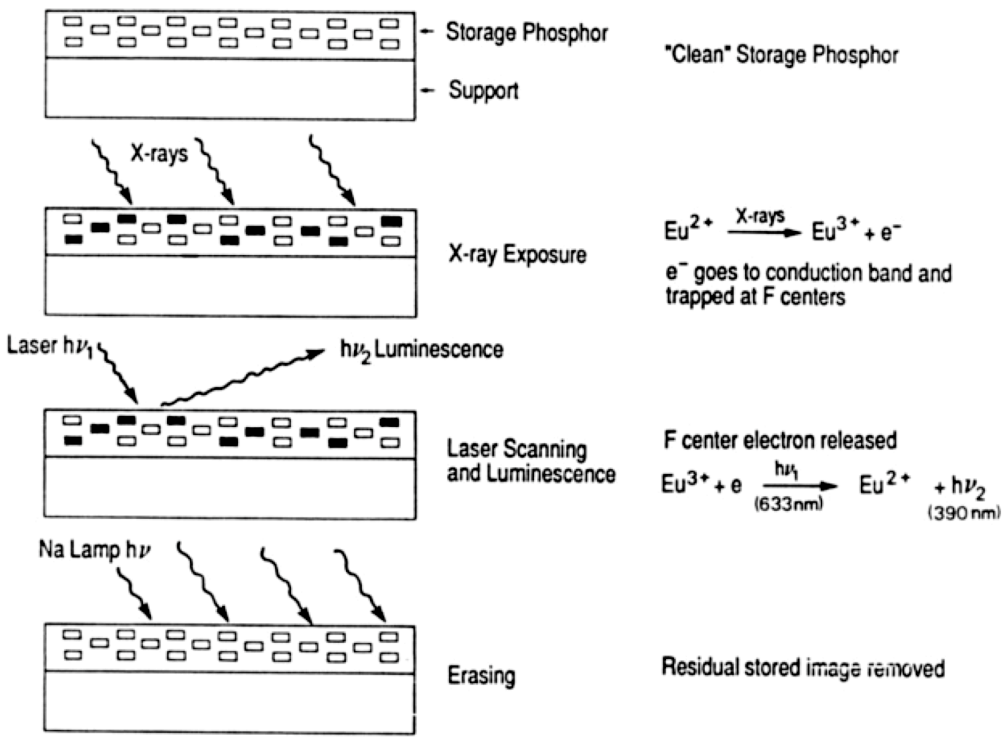
Area

Film - old technology
still used, especially Polaroid

CCD

Multiwire

Image 'plates'
(BaBrF:Eu^{+2})



Steps in collecting, reading, and erasing a storage phosphor imaging plate.

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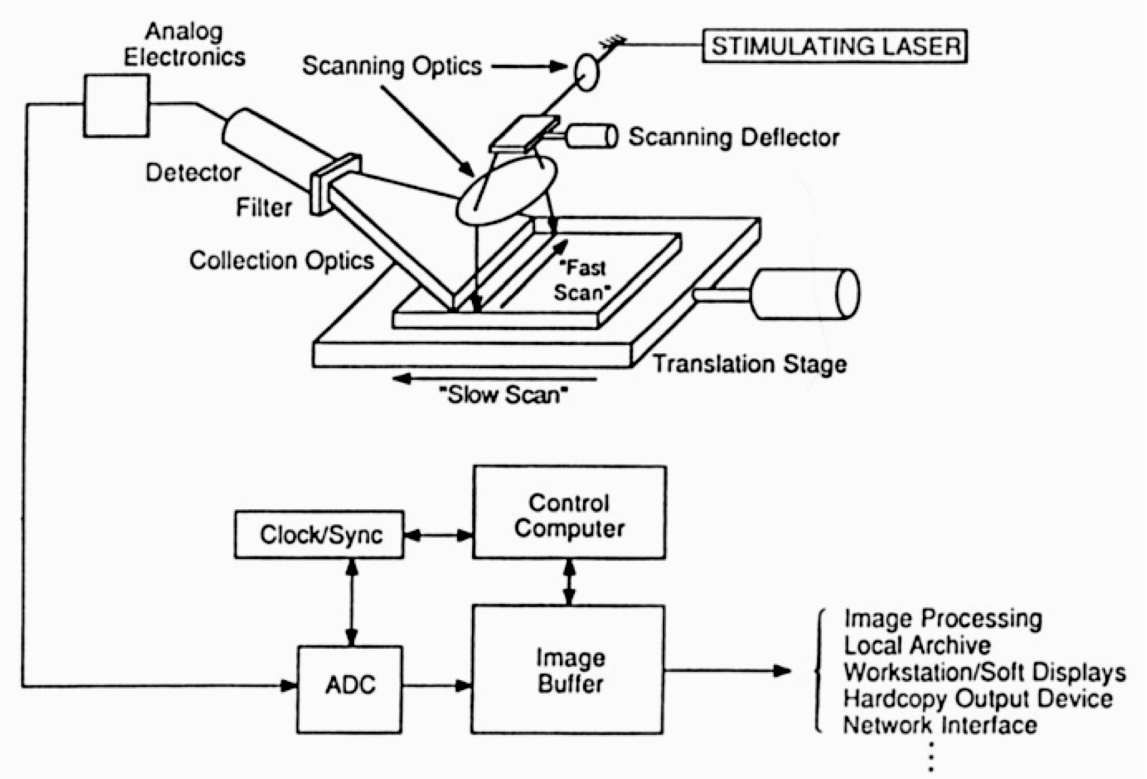

Schematic of the scanner used to read a stored image on a storage phosphor (ADC = analog–digital converter).