RADIATION SAFETY
Analytical X-Ray Systems
Indiana University - Bloomington

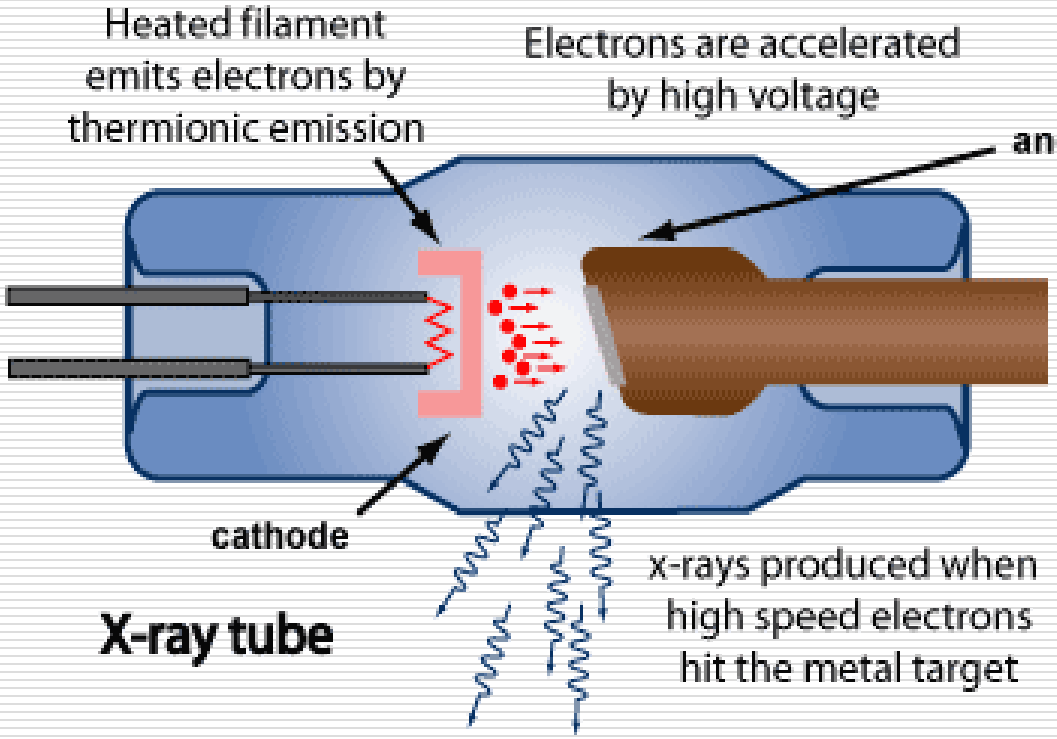
USER TRAINING REQUIREMENTS
Analytical X-Ray Systems

- Complete online training and read associated “Radiation Safety Guide”.
- Review safe operating procedures with Principal Investigator (or Lab Manager).
- Forward to Radiation Safety Office a completed Radiation Safety Exam and Form XS-2 (Documentation of Training).

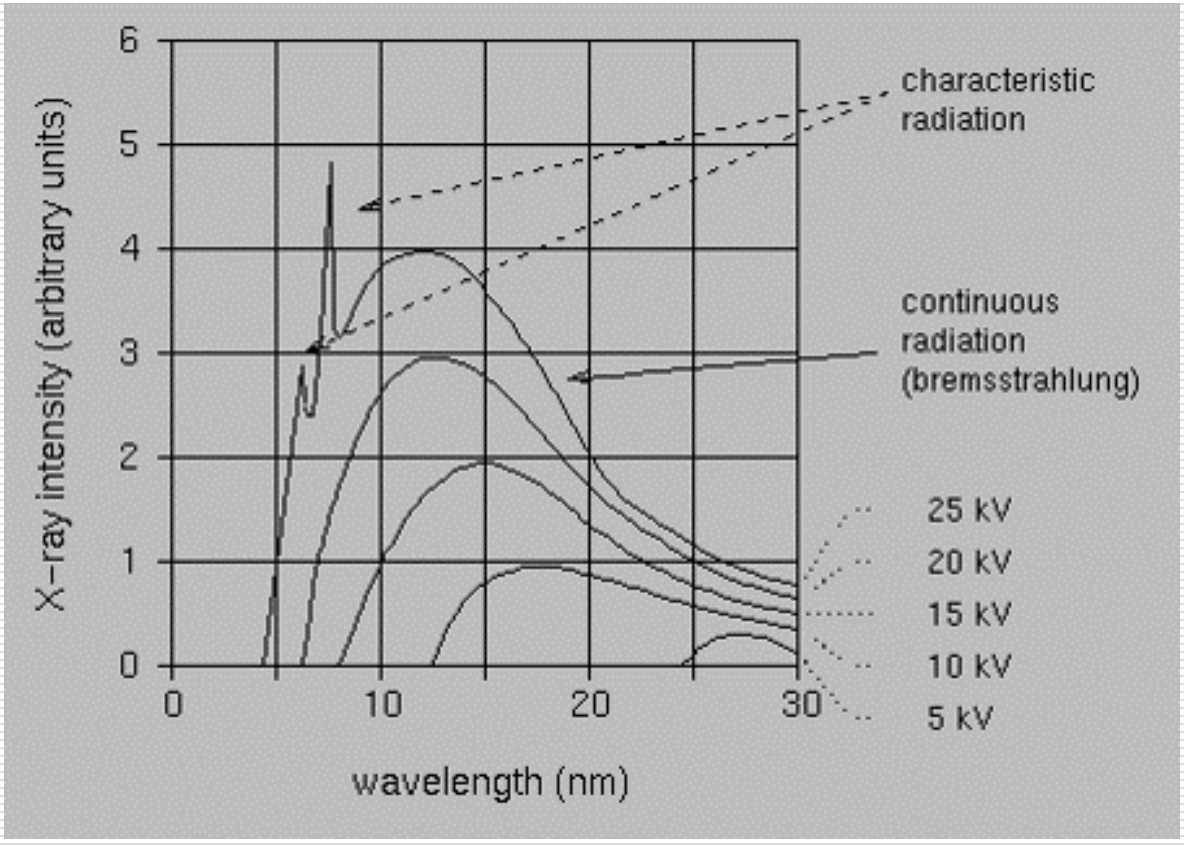
For users of open beam systems:

- Complete an onsite review of safety procedures with the Radiation Safety Officer.
- Obtain ring dosimeter.

X-RAY PRODUCTION



Analytical x-ray systems (unlike diagnostic x-ray systems) make use of “characteristic” x-rays.

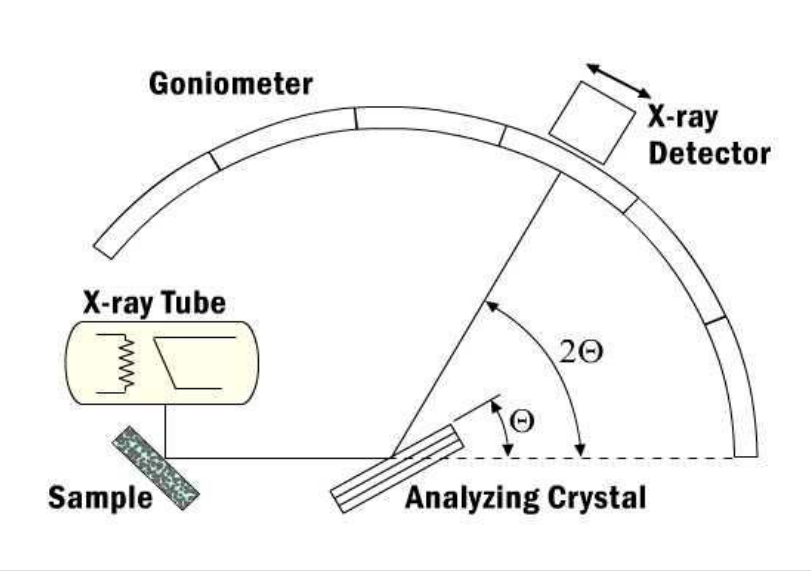


OPERATING PARAMETERS ANALYTICAL X-RAY SYSTEMS (kVp and mA)

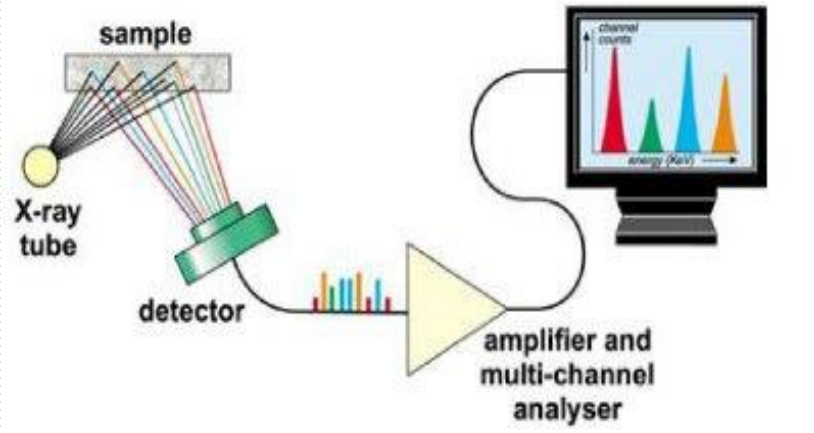
- The energy of x-rays (and their penetration ability) increases with kVp.
- The quantity of x-rays (beam intensity) increases with mA.

OPERATION MODES OF ANALYTICAL X-RAY SYSTEMS

X-Ray Diffraction (XRD)



X-Ray Fluorescence (XRF)



RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

In general, XRD systems pose more significant potential radiation hazards than do XRF systems because:

- XRD systems operate at higher mA producing more intense x-rays; and
- The primary beam of an XRD system emerges from the collimator to strike the sample, whereas for most stationary XRF systems, the primary beam strikes the sample inside a shielded enclosure.

ANALYTICAL X-RAY SYSTEMS

Enclosed

Interlocked enclosure which eliminates radiation hazards.

Open

No enclosure; radiation hazards controlled by strict procedures.

RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

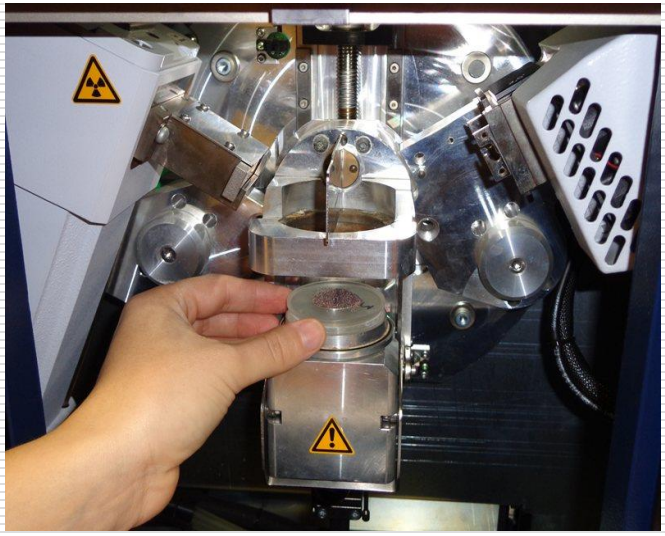
Primary Beam (XRD) – intense, narrow (< 1 cm diameter), and capable of producing skin burn doses in only seconds within 30 cm of tube housing port).

Diffracted Beam (XRD) – much less intense (than primary beam) but still narrow and capable of producing overexposures to the hands (though not burns) in a few minutes within 30 cm of sample.

Scattered and Secondary X-rays – undetectable at outer surface of enclosure (for enclosed systems); for open systems at 1 meter, well below occupational dose limits.

RADIATION HAZARDS OF ANALYTICAL X-RAY SYSTEMS

The greatest potential radiation hazard for analytical x-ray systems is the accidental exposure of the hands to the primary beam during the placement of the sample in an open beam system.



RADIATION DOSE
Quantities and Units

ABSORBED DOSE – Amount of energy imparted by ionizing radiation to a given mass of matter.

Units: rad = 100 ergs/gram
gray = 100 rad

DOSE EQUIVALENT – Absorbed dose adjusted for biological significance by a Quality Factor (QF).

Units: rem = rad x QF
sievert = gray x QF

BIOLOGICAL EFFECTS OF ACCIDENTAL EXPOSURE TO PRIMARY X-RAY BEAM

Acute (prompt) Effects –

- Erythema (skin reddening) within 24 hours with accompanying pain; > 300 Rad (3 Gray)
- Blood flow problems leading to atrophy and ulcerations; > 5000 Rad (50 Gray)

Chronic (late) Effects

- Skin sensitivity to UV and dermatitis
- Skin Cancer

OCCUPATIONAL DOSE LIMITS
Indiana (410 IAC Section 5-4-2)

Whole Body	5 rem (50 mSv) per year
Hands	75 rem (750 mSv) per year

Current dose limits have been established to:

- Prevent all acute effects (such as skin burns); and to
- Limit the risk of any late effects such as cancer to very low “acceptable” levels.

However, dose limits are “upper” limits. All personnel doses are required to be maintained:

As Low As Reasonably Achievable (ALARA).

X-RAY REGULATORY REQUIREMENTS
INDIANA STATE DEPARTMENT OF HEALTH
(410 IAC Section 5-8)

- Status lights for x-ray tube and shutter
- “Caution” label on tube housing and near “on” switch
- Area radiation levels < 2 mrem in any one hour
- “Caution” posting of door to area
- Written Standard Operating Procedures
- Ring dosimeters for open beam XRD users
- Prohibition against altering system safety features

ANALYTICAL X-RAY SYSTEMS
User Safety Rules

- Understand the function of all safety features (status lights, interlocks, and shielding).
- Immediately notify the Principal Investigator (or Lab Manager) of any problems with a safety feature.
- Never by-pass an interlock or alter a safety feature without prior written approval from the Radiation Safety Officer.
- Confirm proper function of safety features by surveys with “thin crystal” NaI detector (required for users of open beam systems).
- Monitor any “external” exposure to your hand by always wearing your ring dosimeter (required for users of open beam systems).