UNIVERSITY of MARYLAND MEDICAL SYSTEM

Fluoroscopy Refresher Training

Educational Objectives

- **Training Requirement**
  - **Maryland CoMAR Regulation**
- **Radiation Terminology & Units**
- **Biological Effects of x-ray**
- **Principles of Radiation Protection**
- **Fluoroscopic equipment operation by type**

Regulatory Requirement – MD 12/2005

MDE CoMAR 26.12.01.01, F.5n Qualifications for Users who Energize Fluoroscopic Systems

- **Registrants shall ensure that only a licensed practitioner of the healing arts or radiological technologist be allowed to energize fluoroscopic x-ray systems.**
- **All persons who energize these systems shall have completed a least 4 hours of training prior to clinical use.**
- **Every 24 months, all operators shall demonstrate one hour of in-service training or CME**
- **Permitted Exemptions**
  - **Radiologists**
  - **Licensed practitioner of healing arts or radiation therapy technologist whom utilize fluoroscopy exclusively for the purpose of therapy simulation.**
  - **Mini C-arm users no longer exempt (01/2014)**

MDE staff email 07/16: "The physician, not the technologist, is ultimately responsible for the patient who is undergoing treatment (exposure to radiation.) Therefore, even in instances where the physicians is only directing the case, he/she must fulfill the credentialing requirements."

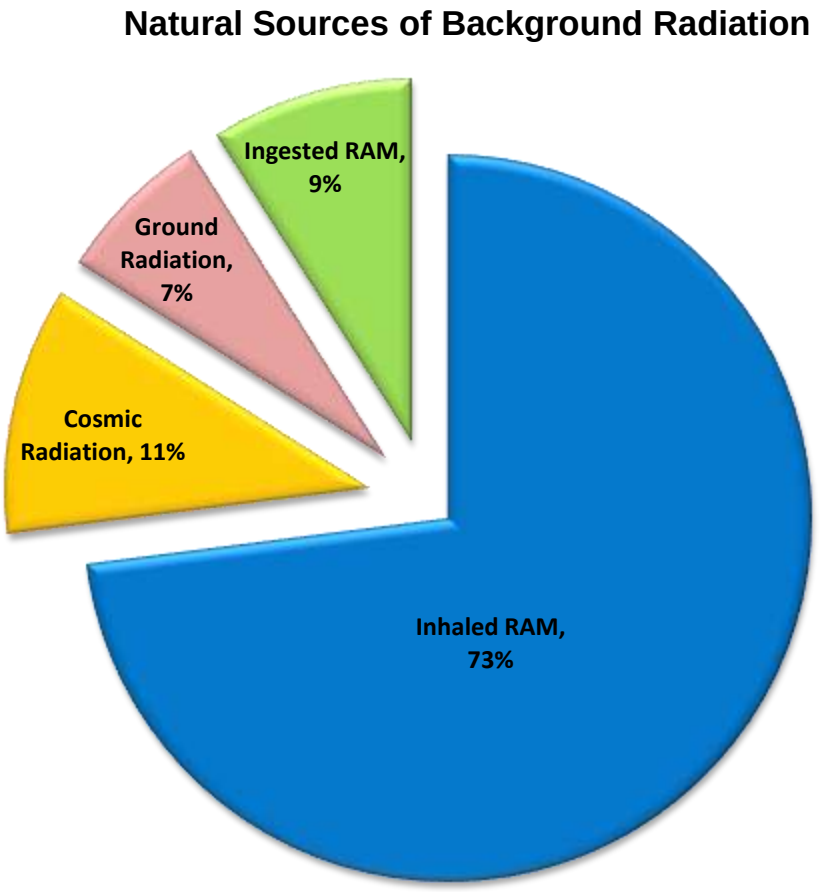
Radiation Terminology & Units

Everyone is exposed to radiation everyday. Most radiation exposure comes from multiple natural sources

An average U.S. resident receives a dose of approximately 3 mSv/y (300 mrem/y) from sources of natural background radiation.

An occupational radiation worker, one who has been provided a badge and additional training is allowed up to 50 mSv in each calendar year.

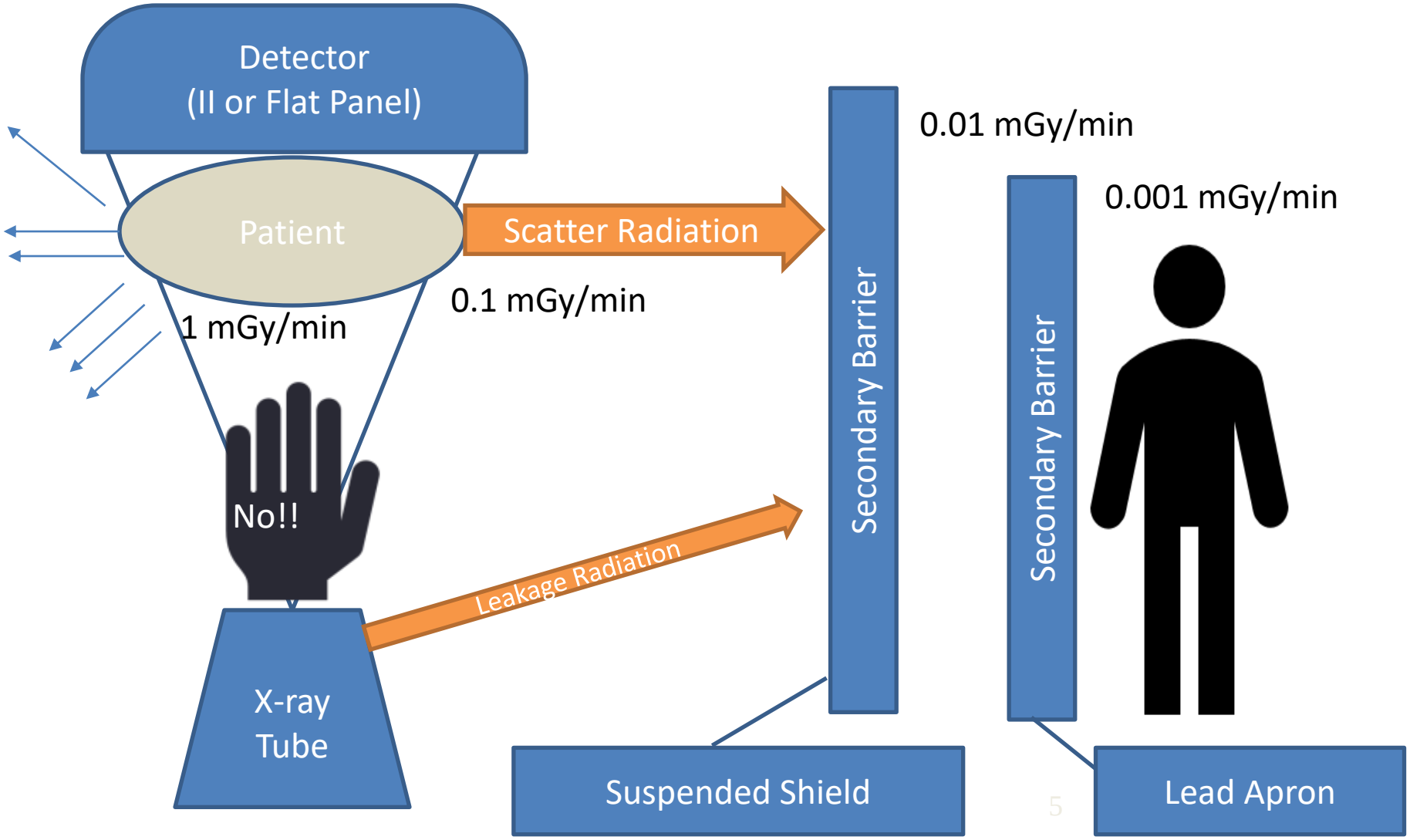
The general public or Non-Radiation (ancillary) personnel's radiation exposure must be maintained below 1 mSv/y. This is easily achieved through shielding and occupancy restrictions.



RAM = Radioactive Material

NCRP Report 160

Radiation Terminology & Units



Radiation Induced Cataracts

- Current threshold dose (NCRP 116, 1993)
  - Acute: 2 Gy (200 rad)
  - Protracted: 5 Gy (500 rad)
  - MDE* dose limit:
    - 0.15 Sv/y (15,000 mrem/y)
- ICRP (Apr 2011)
  - Considers threshold to be 0.5 Gy (50 rad)
  - ICRP Recommended dose limit:
    - 0.02 Sv/y (2,000 mrem/y)
- Very important that physicians in higher exposure environments (CVIR, Neuro, Cysto) utilize suspended shielding or lead glasses

*MDE – Maryland Department of the Environment

Radiation Protection

Radiation Protection is a top-down approach

- Prevent deterministic effects (those with a dose threshold) by adhering to dose limits set below the observed thresholds
- Limit risk of stochastic effects (those with no dose threshold) to acceptable levels observed in other industries
- Regulatory limits set at a maximum permissible dose (MPD)
- Participants are asked to maintain exposure as low as reasonable achievable ALARA

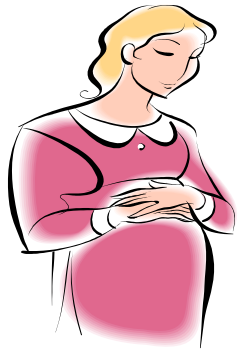
As
Low
As
Reasonably
Achievable

ALARA Program is the "**STANDARD OF EXCELLENCE**" utilized to minimize radiation exposure.

- ALARA Investigational levels are set by RSO/RSC to identify unusual exposure condition or trends.
- When investigational exceeded investigations may be warranted and remedial action may be necessary
- Typical levels are set at 10% and 30% of MPD

Pregnant Worker

- A declared pregnant worker is defined as a woman who voluntarily informed her employer, in writing, of her pregnancy.
- The dose limit is 500 mrem/gestational period of 9 months.
- Declared pregnant workers are given fetal badges that are worn at the abdomen level (under lead apron when indicated.)



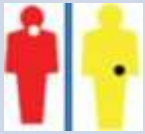
Radiation Protection

Measuring Occupational Exposure:

- Regulatory Requirement: Individuals who have the potential to receive 10% of the regulatory limit (500 mrem/y) are required to be monitored with radiation dosimetry devices.
- Can be an indicator of good/poor work habits.
- Dosimetry Program Principal Assumptions

i. Participant is never exposed to radiation without device present &

ii. Device is never exposed to radiation without participant present

Single Badge Participants		Dual Badge Participants	
	Wear between collar & waist, <u>outside</u> of lead apron		Collar badge – wear <u>outside</u> of lead apron Waist Badge – wear at waist, <u>under</u> lead apron
Fetal Badge		**Ring Badge**	
	Wear low in center of abdomen, underneath lead apron		Wear on hand, Under gloves, Facing source of radiation

Time

- Reduce time of exposure, direct relationship between the amount of time a person is near a radiation source and the radiation dose.

Distance

- Inverse Square Law - doubling the distance from the source will decrease the exposure fourfold.
  - The major source of staff exposure is scatter radiation originating from the patient.

Shielding

- Utilize shielding between yourself and x-ray source

Dosimetry

- Utilize assigned dosimetry devices





Distance

- Take a step or two back if you can!

Distance from Beam	1 step	2 steps	3 steps	4 steps
Relative Exposure Rate	100	25	11	6

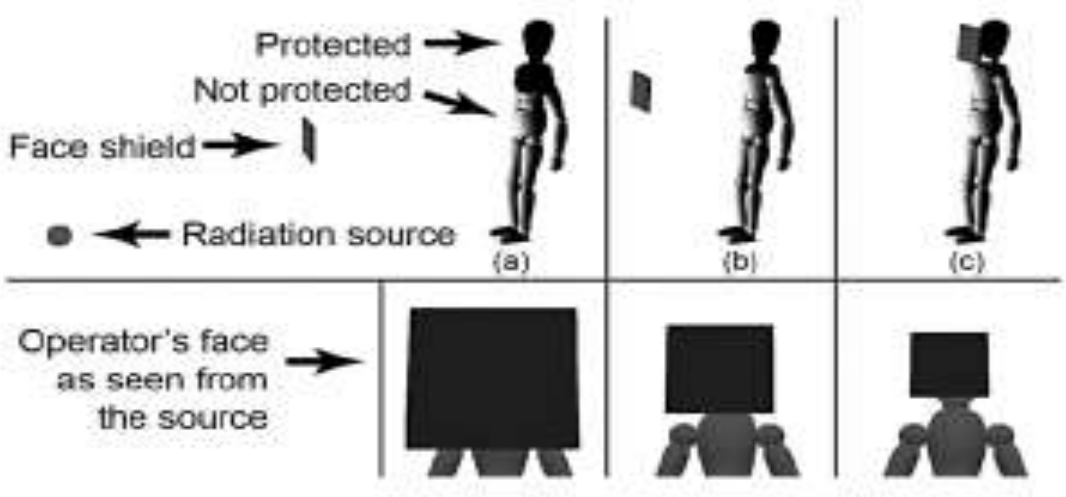
Physician	Technologist	Nurse
1250	200	55
Measured annual DDE readings at one institution's CVIR Lab		

Shielding: Indirect relationship, increase shielding, decrease exposure.

- Standard lead apron reduces radiation exposure by 90%
- MDE Shielding Requirements: All persons shall be protected from direct scatter radiation by not less than 0.25 mm lead equivalent
- Aprons must be stored properly & are evaluated on annual basis

Suspended lead shielding - Important for lens of eye protection, not achieved with lead aprons!

Measured Example (fluoro mode)	Scatter @ 1 m (mR/hr)	Scatter @ 1 m w/ suspended shield (mR/hr)
EV Lab 40 cm II	45	4
CV Lab 20 cm II	80	8



The closer one can place the shield towards the patient, results in a large area protected for the operator.

Images from NCRP 168

Patient Radiation Dose Factors

Modes of Operation

Fluoroscopy

- Low dose, often 3 different level (flavors)
- Noisy, variable frame rates

High Level Fluoroscopy

- Moderate dose rate: x2-10 higher
- Less noisy, higher frame rates
- Audible/visible signal while in this mode

Acquisition/CINE/Fluorography

- High dose rate: x5-50
- Diagnostic quality, low noise, lower frame rates

DSA

- Very high dose rate: x10-80
- Subtraction images, low noise, lower frame rates

Mode	Maximum AKR (mGy/min)
Fluoro	88 (44 w/o AEC)
High Level Fluoro	176
Acquisition	No Limit!
DSA	No Limit!

Patient Radiation Dose Factors

Image Gently - Step Lightly campaign.

- Imaged Gently, www.imagegently.org, campaign to improve safe and effective imaging care of children.
- Step Lightly:
  - Interventional radiology helps us save kids' lives!
    - But, when we treat patients, radiation matters!
    - Children are more sensitive to radiation.
    - What we do now lasts their lifetimes
  - Treat kids with care:
    - Step lightly on the fluoroscopy pedal.
    - Stop and child-size the technique.
    - Consider ultrasound or, when applicable, MRI guidance

Image take from Image Gently website 12/21/2018: https://www.imagegently.org/Procedures/Interventional-Radiology/Image-Safely-Resources

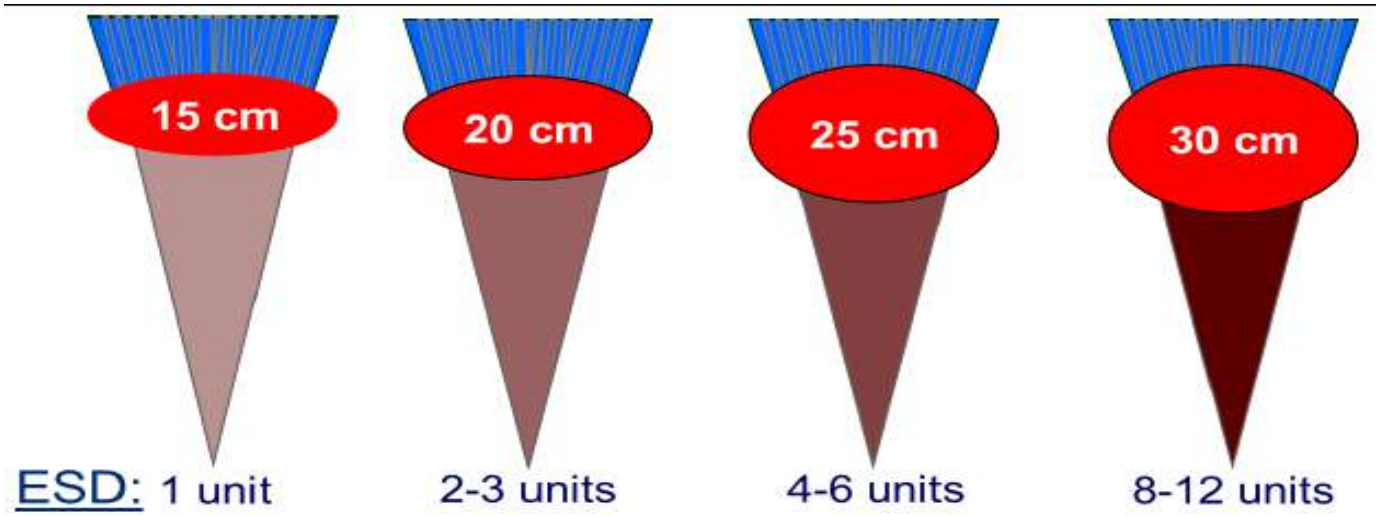
Safe Practices in Fluoroscopy

Precautions operators shall use to reduced patient exposure during fluoroscopy:

1. Confirm patient identify, verify procedure and procedure site
2. Utilize approved standardized protocols
3. Monitor patient dose in real time
4. Minimize use of CINE
5. Minimize use of steep imaging projection angles
6. Minimize use of magnification modes
7. Minimize frame rates
8. Keep image receptor close to the patient
9. Utilize collimation to the fullest extent possible
10. Maximize distance between the x-ray tube and the patient to the extent possible
11. Vary imaging beam angle to minimize exposure to any single skin area
12. Keep patient's extremities out of beam

Patient Size

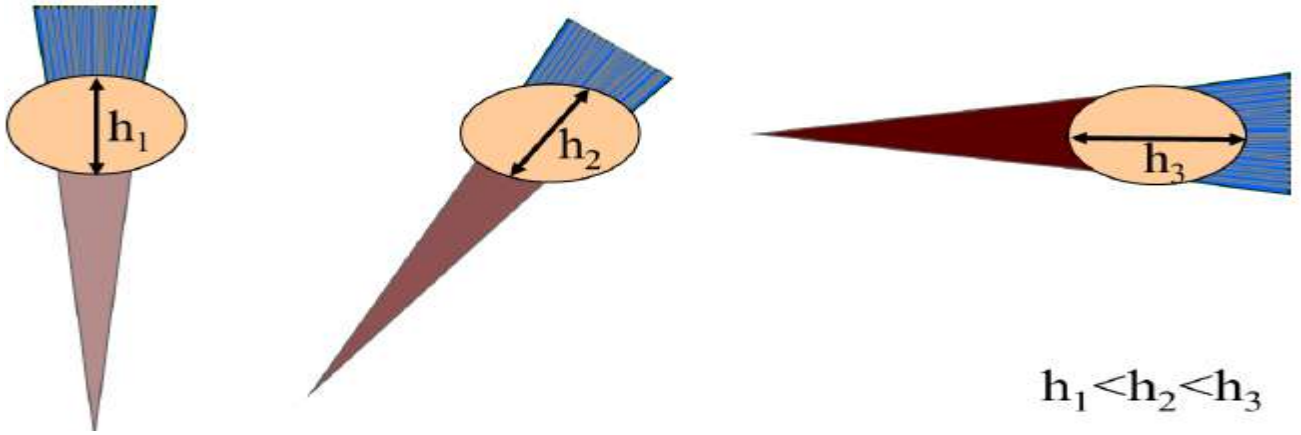
- Larger patients result in high techniques & more scatter
- Image Wisely: ↑ thickness by 3.5” – double # of x-rays needed to penetrate patient (@60 keV)



Images from IAEA

AP vs. Oblique vs. Lateral Projections

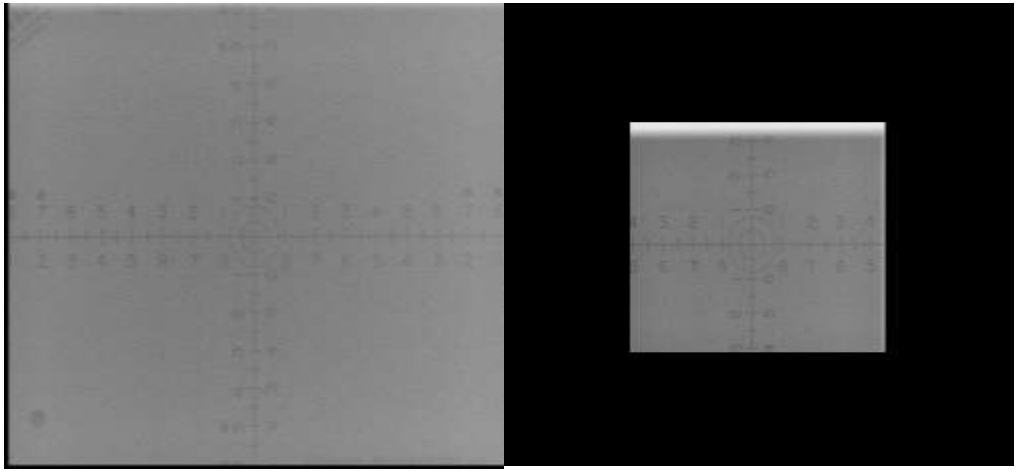
- As the x-ray tube moves towards a lateral projection the patient profile typically becomes larger leading to an increase in ESD and higher scatter rate.

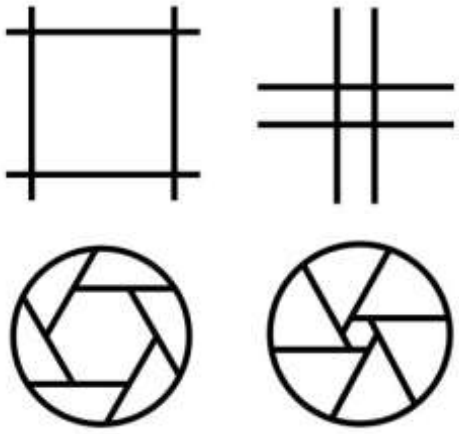


Images from IAEA

Collimation:

- Decreases the area of the patient being irradiated, significantly reduces patient dose.
- Reduces operator dose through the production of less scatter radiation; improves image quality

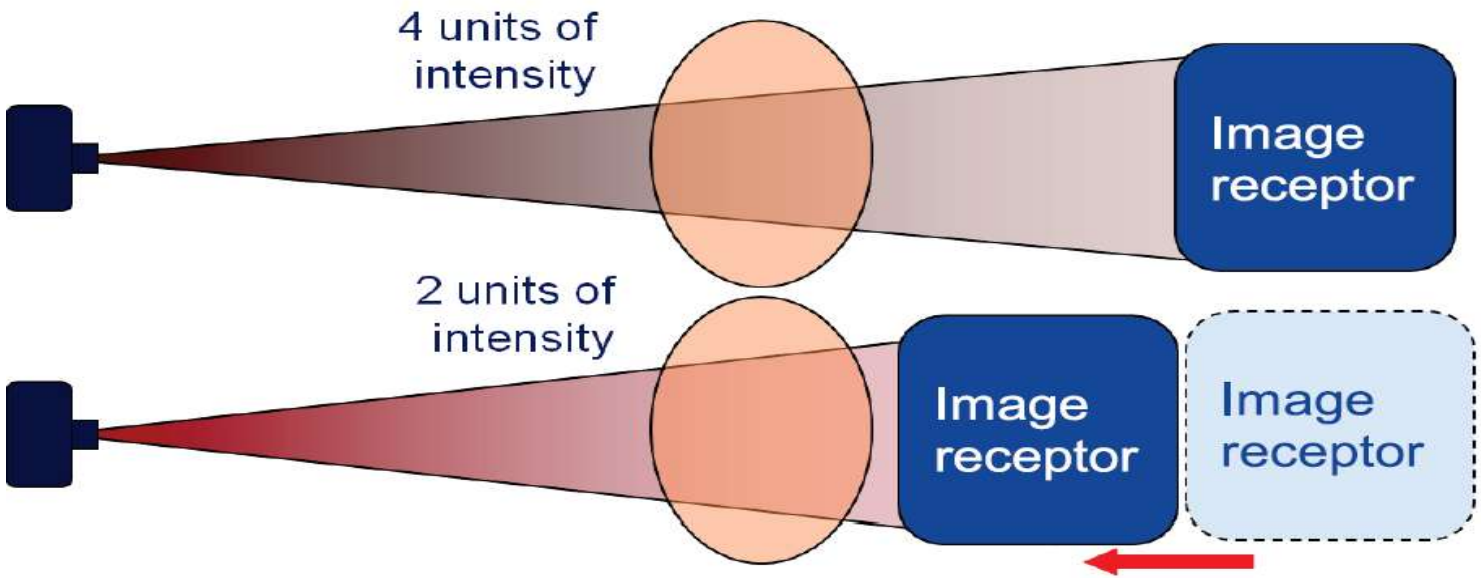




Field Size	Scatter (mR/h) at 30 cm (Modified ANSI phantom)		
	Normal	Mag 1	Mag 2
Full Field	70	96	107
Half Field	19	24	29

Image Receptor Distance: maintain close to the patient

- Inverse square law, increased distance requires AEC systems to increase the radiation output to maintain image quality

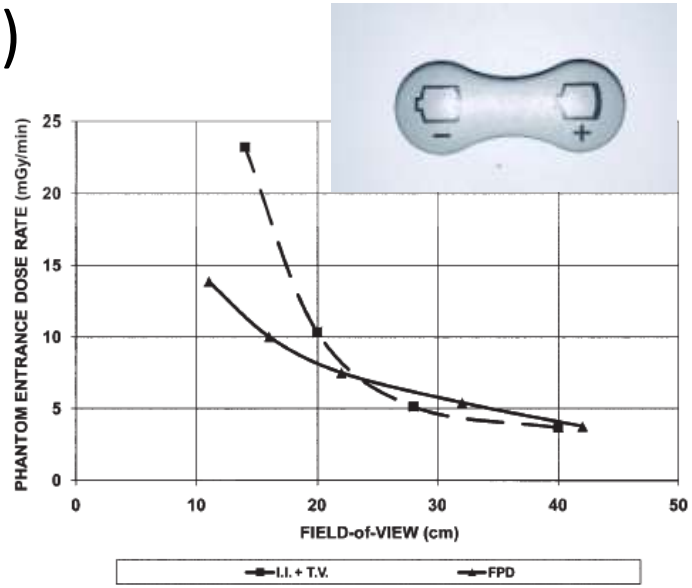


Images from IAEA

Magnification / ↓ Field of View (FOV)

Increasing magnification or ↓ the FOV will result in better spatial resolution; enabling better visualization of smaller anatomic structures.

↑ Magnification or ↓ FOV will result in ↑ patient radiation dose rates. The magnitude varies by technology.



Nickoloff E.L. RadioGraphics 2011; 31:591-602

The Grid

- While the grid improves image quality by absorbing scatter radiation before it reaches the Image Intensifier (II), the grid also increases the dose to the patient.

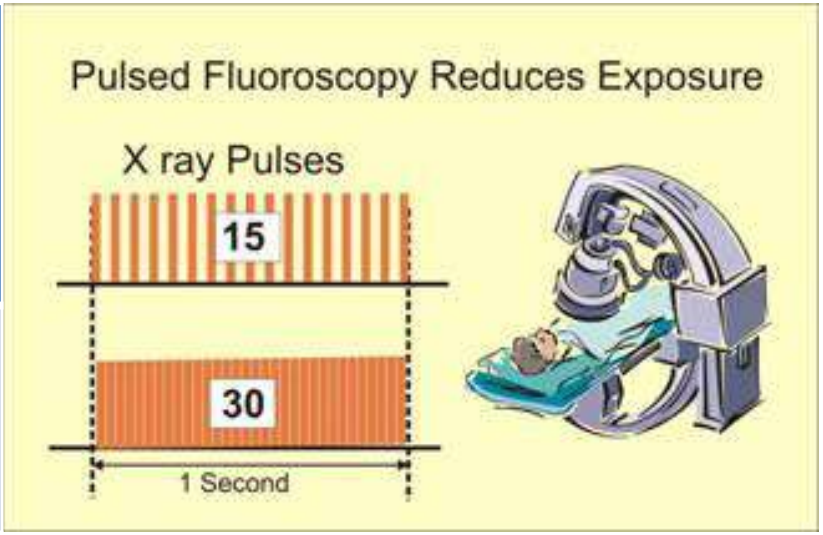
- This means more mA or beam on-time is needed.

- The grid can be removed when the patient is a child or small adult or when the II is more than 25 cm away from the patient.

Pulse Fluoroscopy

Huang et.al. Image Wisely accessed 01/2019

Pulse Setting	30 f/s	15 f/s	7.5 f/s
Relative Dose Index	1.0	0.5	0.25



Images from IAEA

Above Table Fluoroscopy Systems

The x-ray tube is mounted over the table with the image receptor (II or FPD) below the table.

Allows the benefit increased patient access.

This configuration results in increased radiation exposure for personnel, since scattered radiation from the patient is more concentrated back toward the x-ray tube. Position oneself wisely or use mobile shields.

When practical

- Use remote operation, or
- Step away during exposures

VS.

Where to stand?

Fluoroscopic Equipment Operation

Mini C-Arm:

- Short source to image-receptor distance
- Small FoV
- Maximum kVp ≤ 80
- Maximum mA ≤ 0.25

Use must be limited to imaging extremities.

Less scatter than larger C-arms but lead protection (apron) should be worn.

COMAR 26.12.01.01 Sec F.3(1)(v)(b).

Typical measured scatter rates:

- 2 mR/hr @ 1 m