Fluoroscopy Operator Training for Colorado Healing Arts Facilities
There are three general methods for reducing one's personal radiation exposure. The application of each when working around fluoroscopy units will be discussed in more detail.

### Fundamental Methods of Radiation Protection

- **Time** (minimize *time spent in a radiation field*)
- **Distance** (increase *distance from the source of radiation*)
- **Shielding** (Use *appropriate shielding*)
The ALARA concept was introduced decades ago as a result of the linear, no-threshold theory of low dose radiation effects. It is based on the assumption that even the smallest radiation dose carries some finite risk. Thus, while there are maximum limits that shall not be exceeded, regulatory agencies expect facilities to make reasonable attempts to reduce exposures to radiation workers to ALARA levels.

ALARA CONCEPT

Keep all doses As Low As Reasonably Achievable

During a procedure, the physician operating or directing the operation of the fluoroscopy unit is responsible for managing the radiation dose to patient and staff.
Minimizing beam-on time is the most effective method of reducing dose to both the patient and the staff. It is especially important when imaging pediatric patients due to their higher sensitivity to radiation effects. The Alliance for Radiation Safety in Pediatric Imaging encourages practitioners to "step lightly" on the fluoro pedal to reduce doses.

Dose Reduction Techniques

Reduce Time

- Minimize the beam-on time. *This is the most important determinant of patient and staff dose!*
- Image Gently, Step Lightly – tap pedal

http://www.imagegently.org
Dose Reduction Techniques

Reduce Time
- Use Last Image Hold
- Position/collimate with fluoroscopy off
- Be aware of audible fluoroscopy time alerts (every 5 minutes)

Strategies to reduce fluoroscopy on-time include use of Last Image Hold, now a feature that is required on all fluoroscopic units in Colorado. If you do not need dynamic image information, take your foot off the expose pedal and study the static image -- then tap your foot to update the static image rather than use continuous fluoro. Many units now provide methods to position and collimate without needing to keep the fluoro beam on.

The audible alert is a reminder to the operator of how much fluoro time is accumulating.
The distance principle is a very powerful tool in reducing staff exposure. Also called the "inverse square rule," it can mean huge exposure reductions with relatively small changes in the distance one stands from the patient during fluoroscopy. Scattered radiation emanating from the patient is the major source of exposure to staff!

**Dose Reduction Techniques**

**Increase Distance**
- Staff should stand back from patient when possible;
- Dose rate decreases with the square of the distance (double distance and dose reduces to 1/4th);

Dose at \(d_1\) is **4 times** the dose at \(d_2\)
Lead shielding is very effective when working with diagnostic energies of radiation. When worn properly, personal lead shielding devices can reduce dose to sensitive organs to very low levels.

Dose Reduction Techniques

Use appropriate personal shielding

- Wear lead apron and thyroid shield (absorb >90% of scattered radiation)
- Wear leaded glasses
- Do NOT wear leaded gloves in the field (ABC compensates and increases patient dose)
In addition to lead shielding worn by personnel, most fluoro units provide lead shielding devices that can be very effective at reducing the amount of scattered radiation reaching staff. Take advantage of these by positioning them between the patient and staff who need to be close to the patient during procedures.

Dose Reduction Techniques

Use available shielding
- Lead drapes
- Overhead shields
- Mobile shields
Be aware that certain locations in the fluoro room can expose staff to much higher radiation levels than others. The exposure rate to the patient and thus to staff is significantly higher on the side where the x-ray beam enters the patient. Hence, working from the image detector side, where the x-ray beam exits the patient, can save significant dose to staff who need to be close to the patient during the procedure. This can be especially useful when using lateral or oblique gantry angles.

Dose Reduction Techniques

Scatter Distribution (exposure rates ~5' above floor)

Position yourself in areas of lowest exposure rates, if possible.

Scattered radiation rates are much lower on the image receptor side of the patient compared to the x-ray tube side!
The amount of radiation scattered off the patient is directly proportional to the area of the patient's skin being exposed. Reducing the x-ray field size by collimating the beam to the smallest size required will also reduce staff exposure. This action has the added benefit of improving image quality by reducing scatter to the image detector as well.

**Dose Reduction Techniques**

Collimation reduces scattered radiation to personnel

Other benefits of collimation:
- Decreases area and volume of patient exposed to radiation (lower stochastic risk)
- Reduces scatter radiation to improve image contrast
- Can reduce dose to radiation sensitive tissues (eyes, thyroid, gonads, breast)
By utilizing available methods to reduce the dose to the patient (e.g., low fluoro times, use of collimation, not overusing mag modes, use of lower dose rates and frame rates), one can effectively manage staff exposures as well.

Reducing dose to the patient always decreases dose to the staff!
The maximum permissible doses (MPD) to radiation workers in Colorado are mandated by CDPHE regulations. MPD's must not be exceeded by any personnel who work around radiation. Each facility is required to provide monitoring to radiation workers and to assure that none exceed these MPD's.

### Personnel Regulatory Limits

#### Regulatory Dose Limits to Radiation Workers

<table>
<thead>
<tr>
<th>Dose Type</th>
<th>Annual Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDE - Deep or Whole Body</td>
<td>5000 mrem</td>
</tr>
<tr>
<td>LDE – Eye lens</td>
<td>15,000 mrem</td>
</tr>
<tr>
<td>SDE – Skin or Extremity</td>
<td>50,000 mrem</td>
</tr>
</tbody>
</table>
Radiation dosimeters must be provided to radiation workers who are likely to exceed 10% of the MPD, per CDPHE regulatory requirements. The information they provide can be useful in keeping personnel exposures ALARA. Wearing them consistently and properly is key.

**WEAR YOUR DOSIMETER(S)!!**

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**Radiation Dosimeters**

- Dosimeters can provide useful information about machine problems or identify radiation safety practices that can be improved
- If you don’t wear dosimeters, they can not provide useful information
- Wear dosimeters properly:
  - single or primary badge worn at collar level, outside any lead shield;
  - secondary badge worn at waist level, under lead apron

When following good radiation safety practices, it is extremely unlikely any fluoroscopist will exceed the maximum permissible dose, thus this should never be a reason to not wear dosimeters!
Effective Dose to Personnel

CDPHE allows a calculation for Effective Dose Equivalent

**EDE1 Calculation** (two dosimeters, one worn at waist under lead, one worn at collar outside lead)

Assigned Whole Body Dose = (1.5 * waist) + (0.04 * collar)

**EDE2 Calculation** (one dosimeter, worn at collar outside lead)

Effective Whole Body Dose = 0.3 * collar dose (non shielded)
In summary, keeping radiation doses ALARA is every facility’s regulatory responsibility. However, the physician in charge of operating or supervising the operation of fluoroscopic exams is also responsible for maintaining patient and thereby staff radiation doses to the lowest possible levels while achieving the clinical goals of the imaging procedure. Application of dose reduction principles using Time, Distance and Shielding will result in lower doses for everyone.