The Nuclear Engineer - Friend of the Health Physicist (or not)

10 ways Nuclear Engineers can contribute to keeping doses As Low As Reasonably Achievable

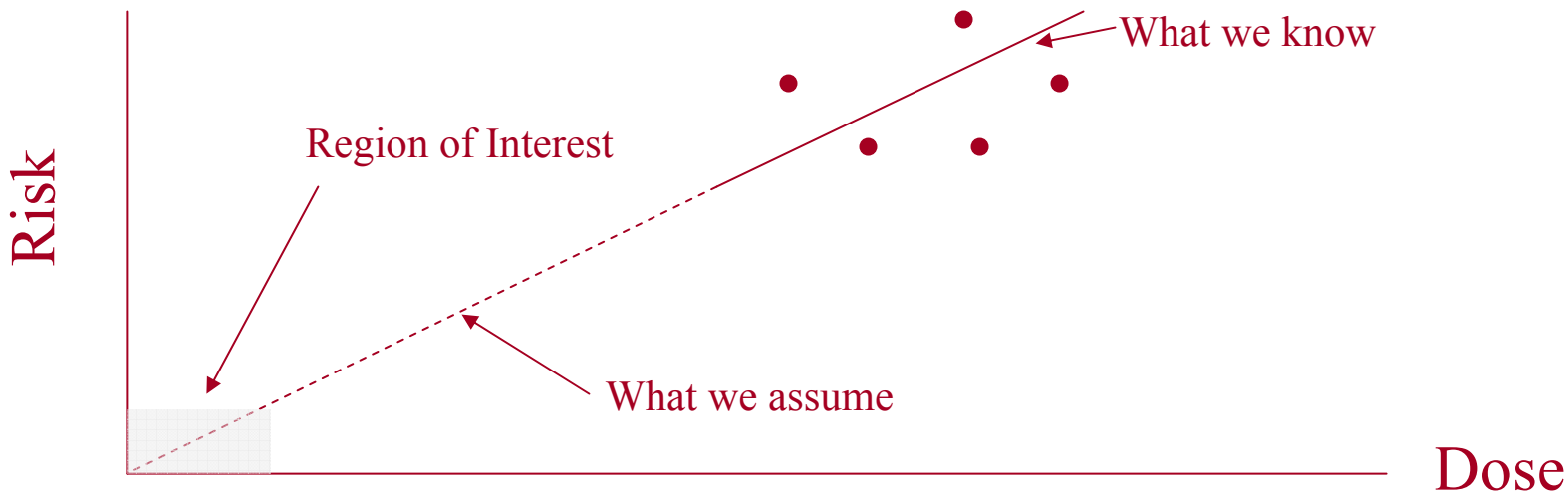
Radiation Safety 101

- External Exposures
  - ⇒Whole Body
  - ⇒Surface
  - ⇒Extremities
- Internal Exposures
  - ⇒Inhalation
  - ⇒Ingestion
  - ⇒Absorption
  - ⇒Wounds
  - ⇒Injection

Biological Effects of Ionizing Radiation

⇒radiation injuries - deterministic

⇒cancer and genetic effects - stochastic



ICRP Framework

⇒Justification

- Every activity shall produce more good than harm

⇒Optimization

- Doses shall be maintained As Low As Reasonably Achievable, social and economic factors being taken into consideration

⇒Dose Limits

- Doses shall be maintained below regulatory dose limits

Sources of Radiation

- Prompt radiation
  - $\Rightarrow$Fission gammas and neutrons
  - $\Rightarrow$n,γ reactions
  - $\Rightarrow\gamma$, n reactions
- Fission Products
- Activation Products

Radiation Protection Principles

- Remove the Hazard
  - ⇒Avoid creating the hazard in the first place
  - ⇒Create as little of it as possible
  - ⇒Get the hazard out of the workplace
- Guard the Hazard
  - ⇒Shielding
  - ⇒Containment
- Guard the Worker
  - ⇒PPE, work controls, etceteras

Three Things that Help You

- Time
  - ⇒Reduce time in field
  - ⇒Wait for decay
- Distance
  - ⇒Fields fall off with distance
- Shielding

The Top Ten Ways

- It's a material world
- Keeping it all bottled up inside
- Location, location, location
- Redundancy and Redundancy
- Make it so it never breaks
- Assume it will anyway
- A little fresh air please
- Hands Off!
- Consider your tool
- Do the math (optimization)

It's a Material World

- Avoid creating long lived activation products (Co, Ir)
- Consider the production of hot particles

Keeping it All Bottled Up

- Containment is critical to avoid work place hazards
- Leaks lead to
  - ⇒ volatile airborne contamination
  - ⇒ liquid contamination
  - ⇒ airborne particulate or aerosol contamination
- Provide multiple levels of containment
  - ⇒ E.G. Glovebox inside a ventilated enclosure
- Consider portable glove box designs for field use

Location, location, location

- Layout is critical
- Separate high dose rate equipment from occupied areas
- Consider the impact of other equipment in the area
  - ⇒contamination
  - ⇒radiation
- Consider various uses of a space when locating equipment
- Think about what is above, below and around

Redundancy and Redundancy

- Build in systems that allow repairs to be delayed or simply not made
- Use of back-up systems allows for decontamination or decay before repairs
- Examples:

  ⇒run extra wires

  ⇒run extra pipes

  ⇒have backup pumps in the system

Make it so it Never Breaks

- Most doses result from maintenance
- Design equipment which requires a minimum of preventative maintenance and repairs
- Consider corrosion and radiation effects
- Examples
  - ⇒underground piping
  - ⇒cranes in hot cells

Assume it will anyway

- Design equipment for maintenance
- Modular design allows items to be removed from high dose areas
- Design the room considering maintenance activities

  ⇒layout

  ⇒containment
- Configure to allow removal of high hazard items

  ⇒example - irradiation sources

A Little Fresh Air Please!

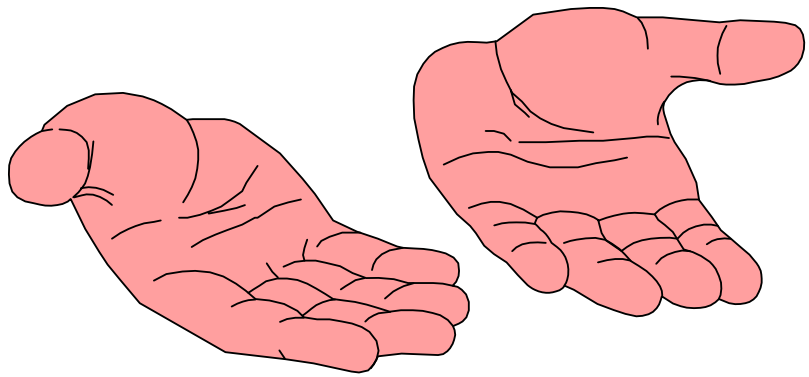
- Ventilation must move air from less contaminated to more contaminated
- Plan for future use!!!!
- Provide plenty of ventilation trunks for maintenance activities
- Energy conservation is your enemy

Consider your tool

- Design tools that help maintenance personnel avoid exposures
  - ⇒Work quickly
  - ⇒Work at a distance
  - ⇒Incorporate shielding
  - ⇒Avoid touching activated/contaminated components
  - ⇒Use less people
- Observe high dose maintenance activities

Hands Off!

- Extremity doses can be the hardest to control
- Inverse square law - dose rate raises rapidly in approaching contact
- Design systems so that they do not require handling in activated/contaminated areas



Do the math (optimization)

- Consider your options
  - ⇒develop different approaches to a design/job
  - ⇒ analyze them
  - ⇒choose the lowest collective dose option
  - ⇒make sure you're under the dose limits
- Consider the entire life cycle of the facility
  - ⇒pay now or pay later?