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# Radiation Shielding for the Radiochemist

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# ALARA

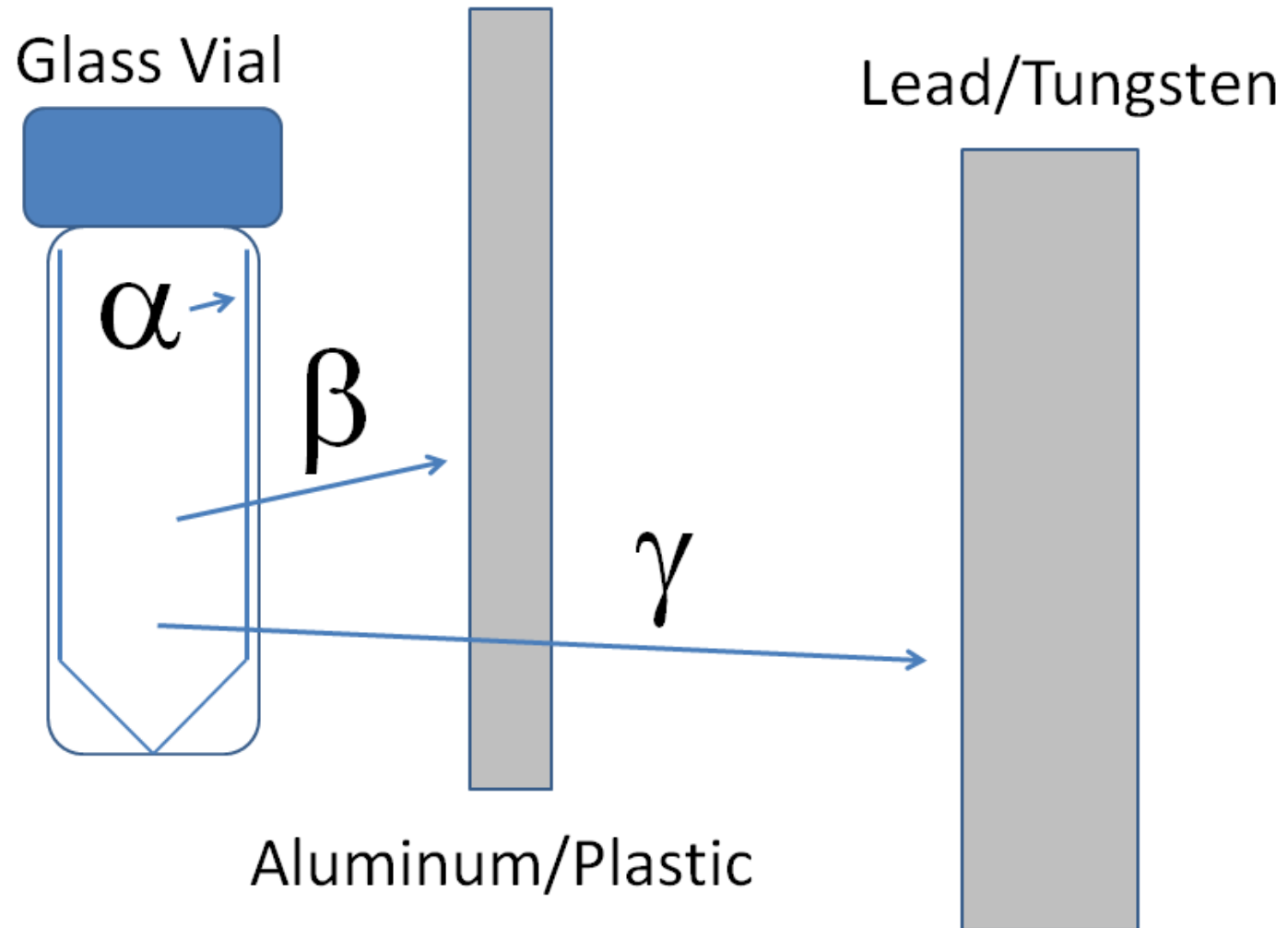
Time

Distance

Shielding



# Refresher on Types of Radiation



# Attenuation (Interaction with matter)

It is important to choose the best type of material to shield the type(s) of radiation with which you are working.

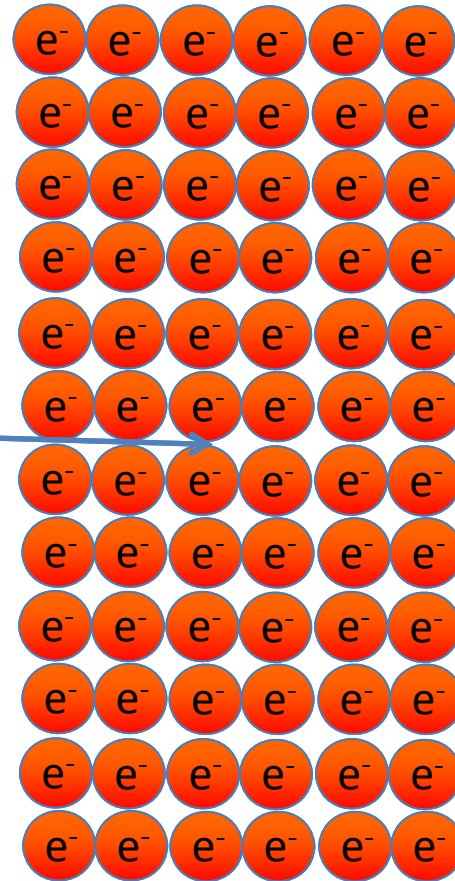
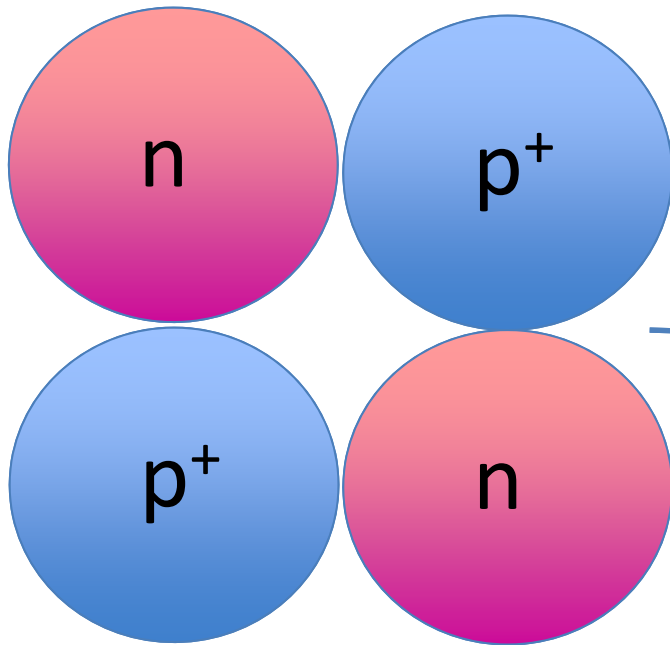
- 1) Attenuation of Primary Radiation
- 2) Secondary radiation produced by interaction with shielding material
- 3) Activation Products
- 4) Physical Form/Damage
- 5) Cost





Attenuation

# Alpha Particles



4 MeV Alpha  
Particles can  
travel ~2-3 cm  
in air

# Alpha Particles

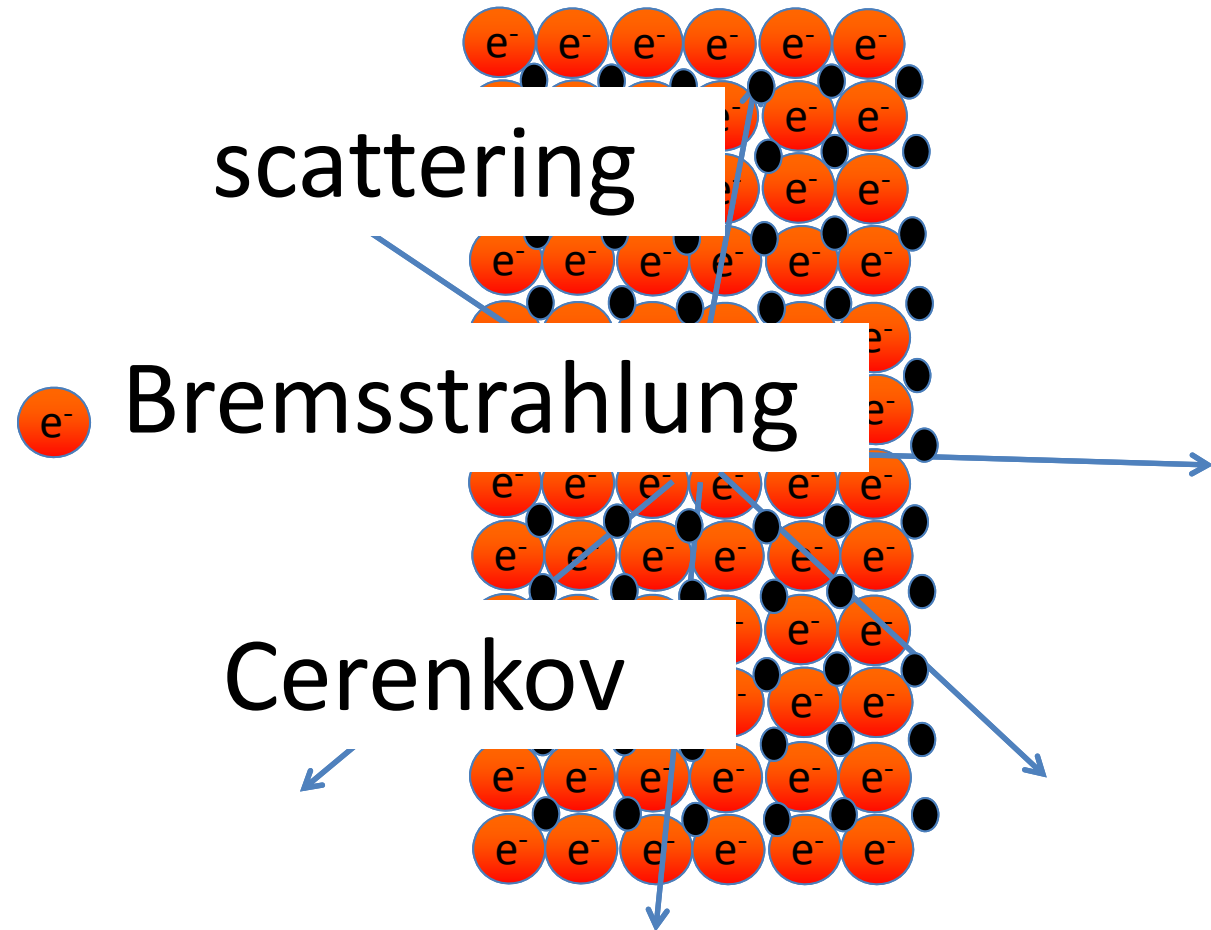
Most alpha particles will be shielded by container, air, or dead layer of skin

Protection from alpha particles focused on preventing uptake into the body

- Direct (spills, wounds, dust)
- Alpha Recoil
- Gaseous daughters (Rn, At)
- Ruptured Sources (He-pressure)
- Embrittled containers



# Beta Particles





## Beta Particle Scattering

smaller mass

Higher velocity

easily deflected

Angles of emission and energies of scattered betas can be used to identify materials

## Bremsstrahlung

Coulomb interaction with nucleus of shielding material, loss of energy

More important for high energy betas

More important for High Z absorbers

Raises background in gamma detectors

Cerenkov

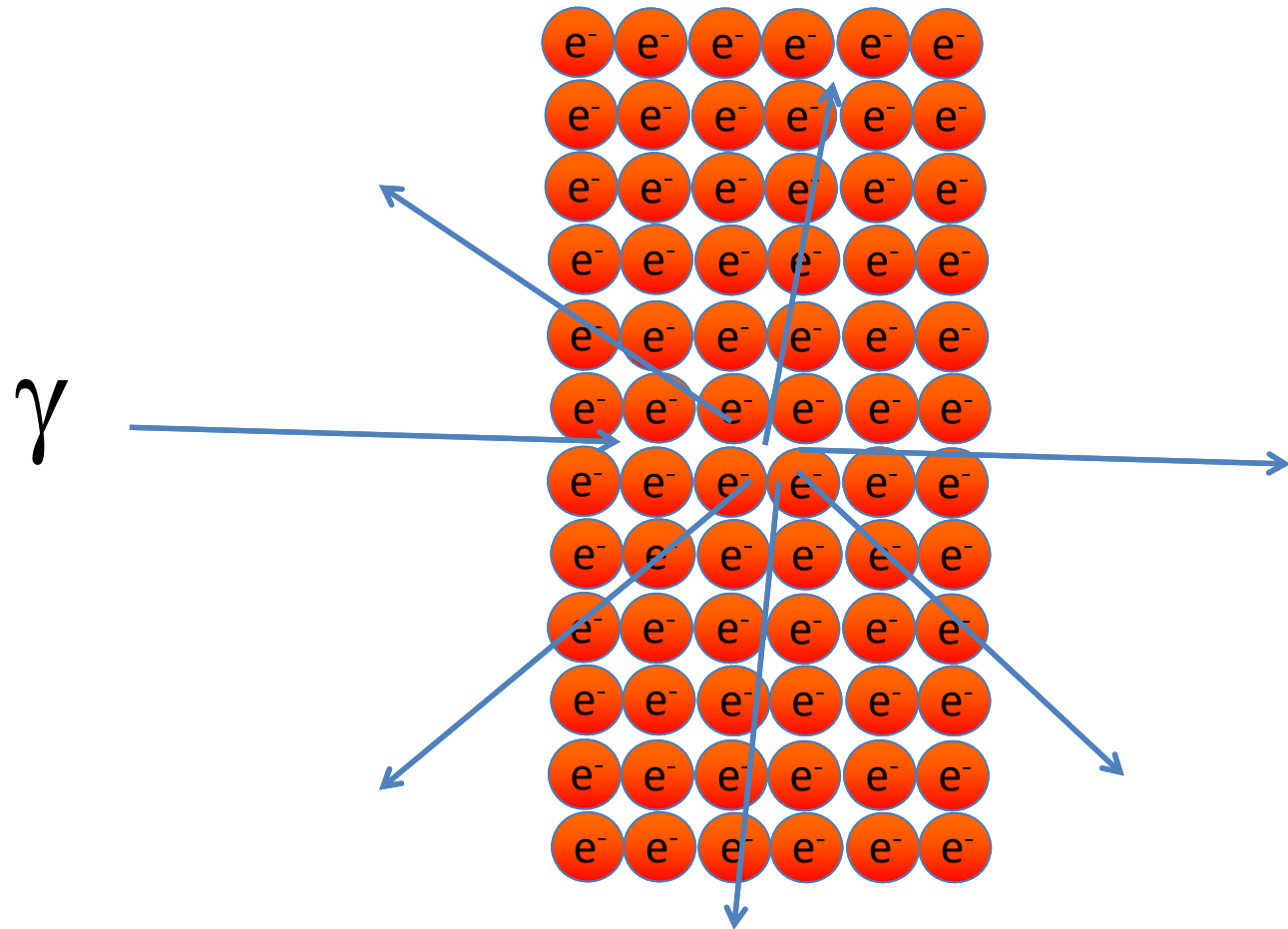
High Energy Beta Particles

Enters medium faster than speed of light

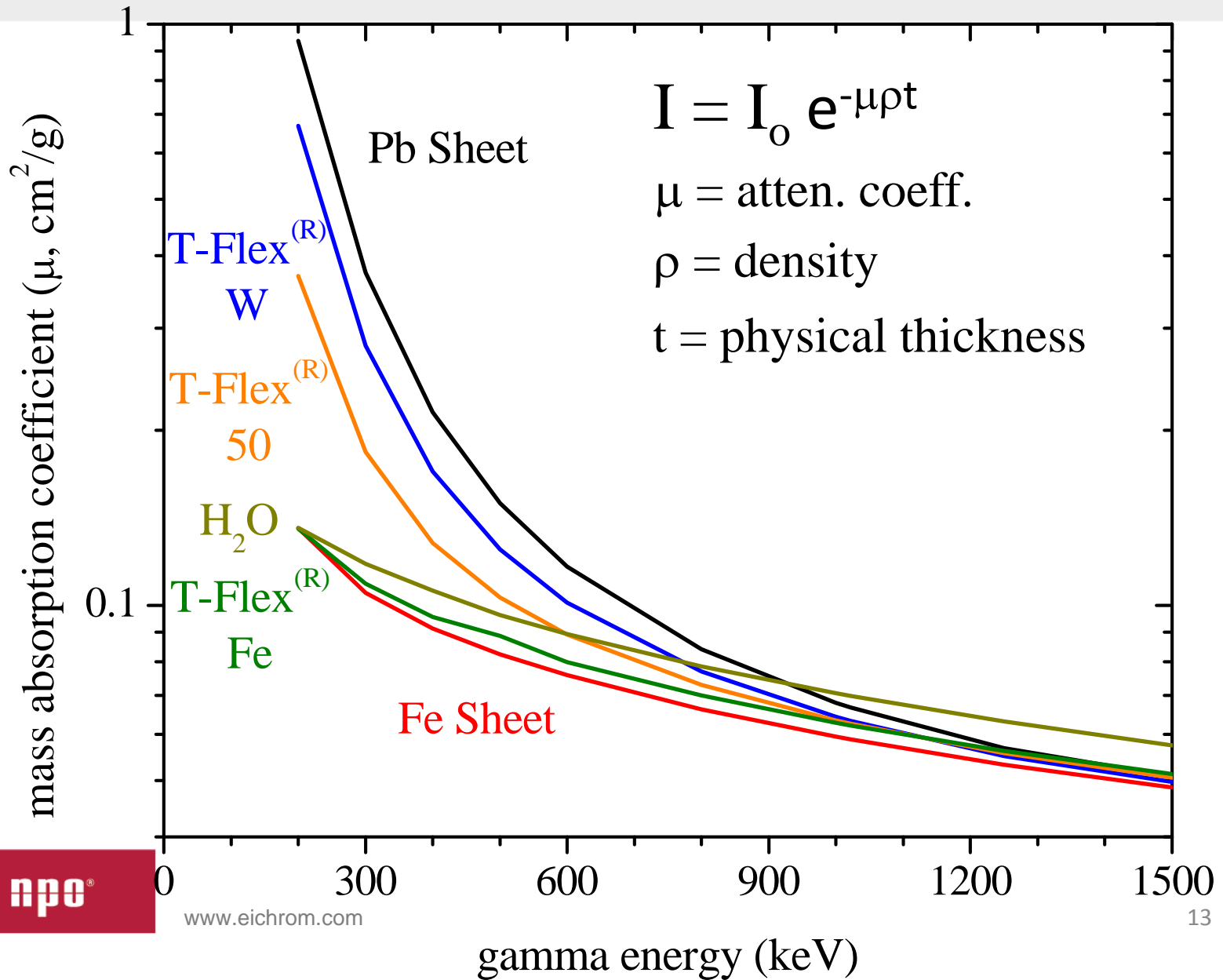
Energy released as particle slows

Can be used to detect high energy betas

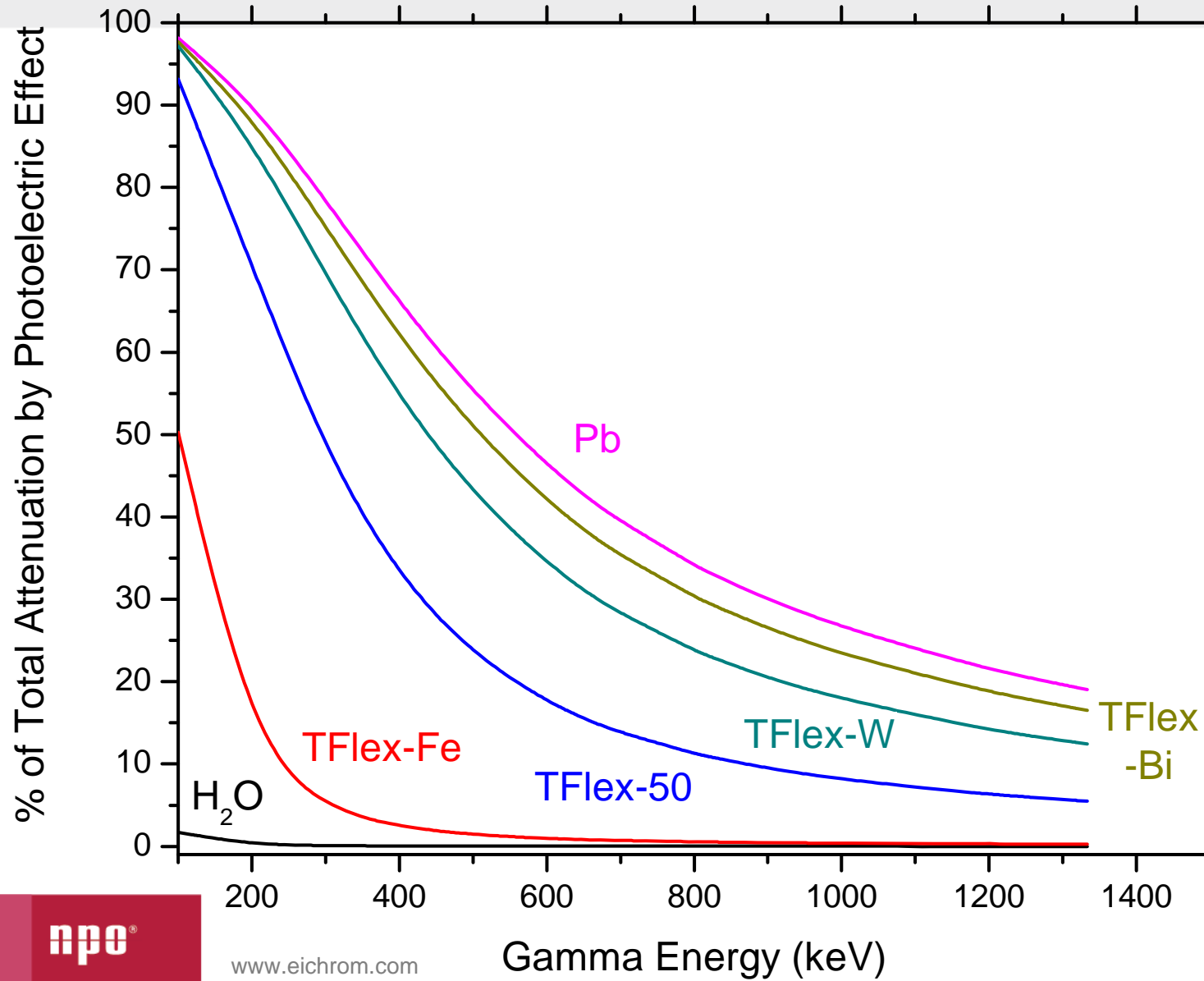
# Gamma and X-Rays



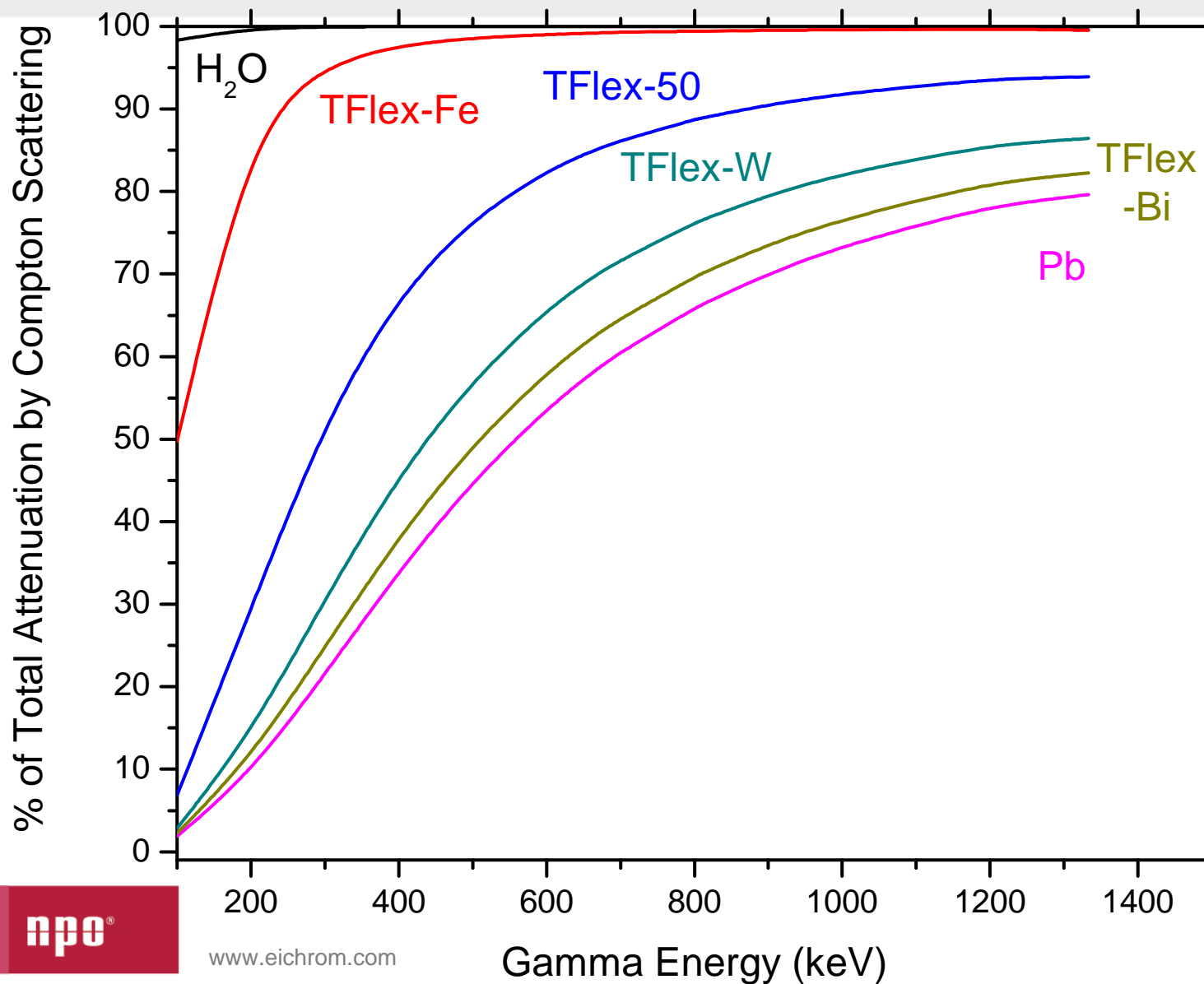
# Attenuation



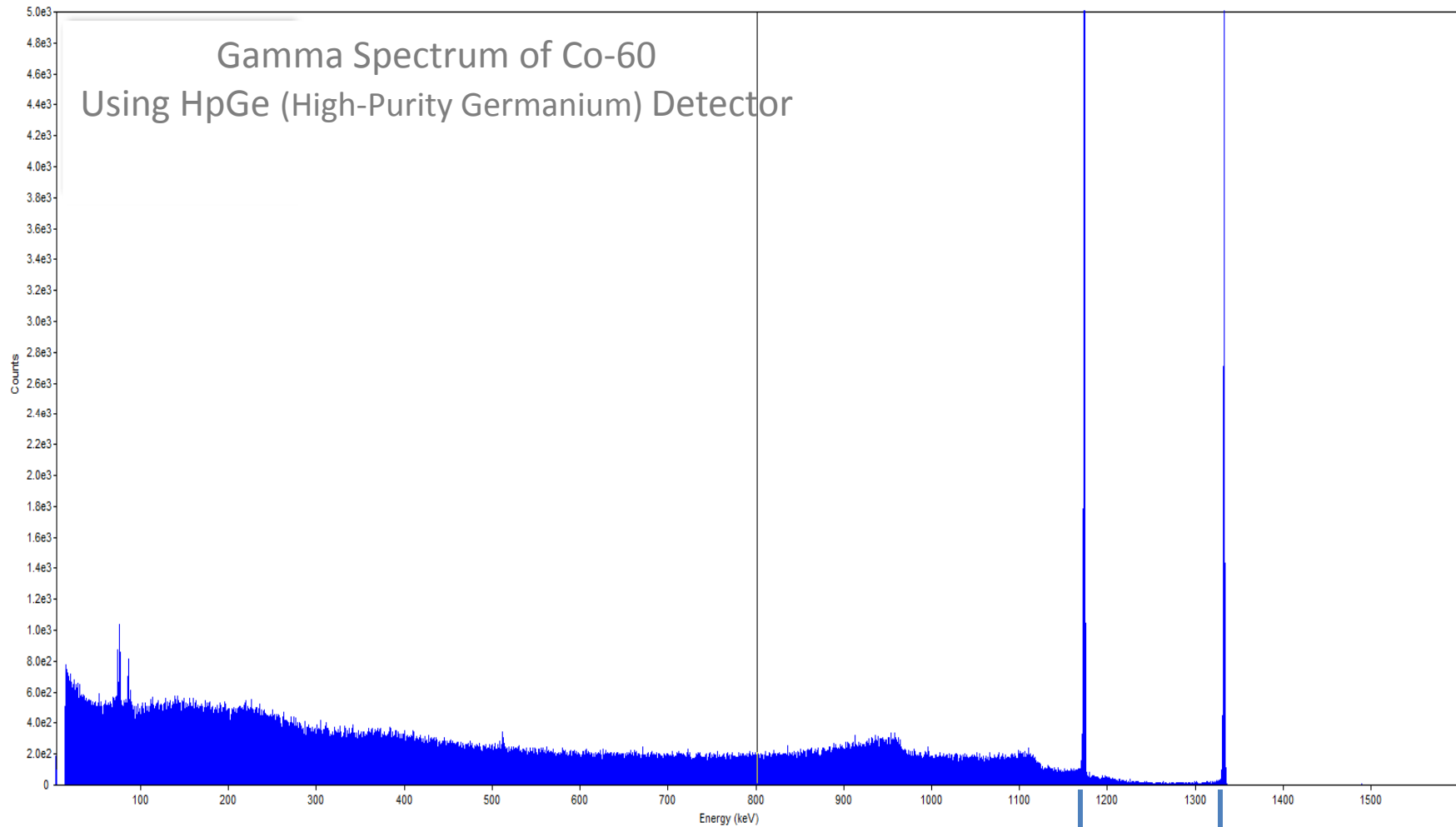
# PhotoElectric



# Compton Scattering



# What are you seeing?

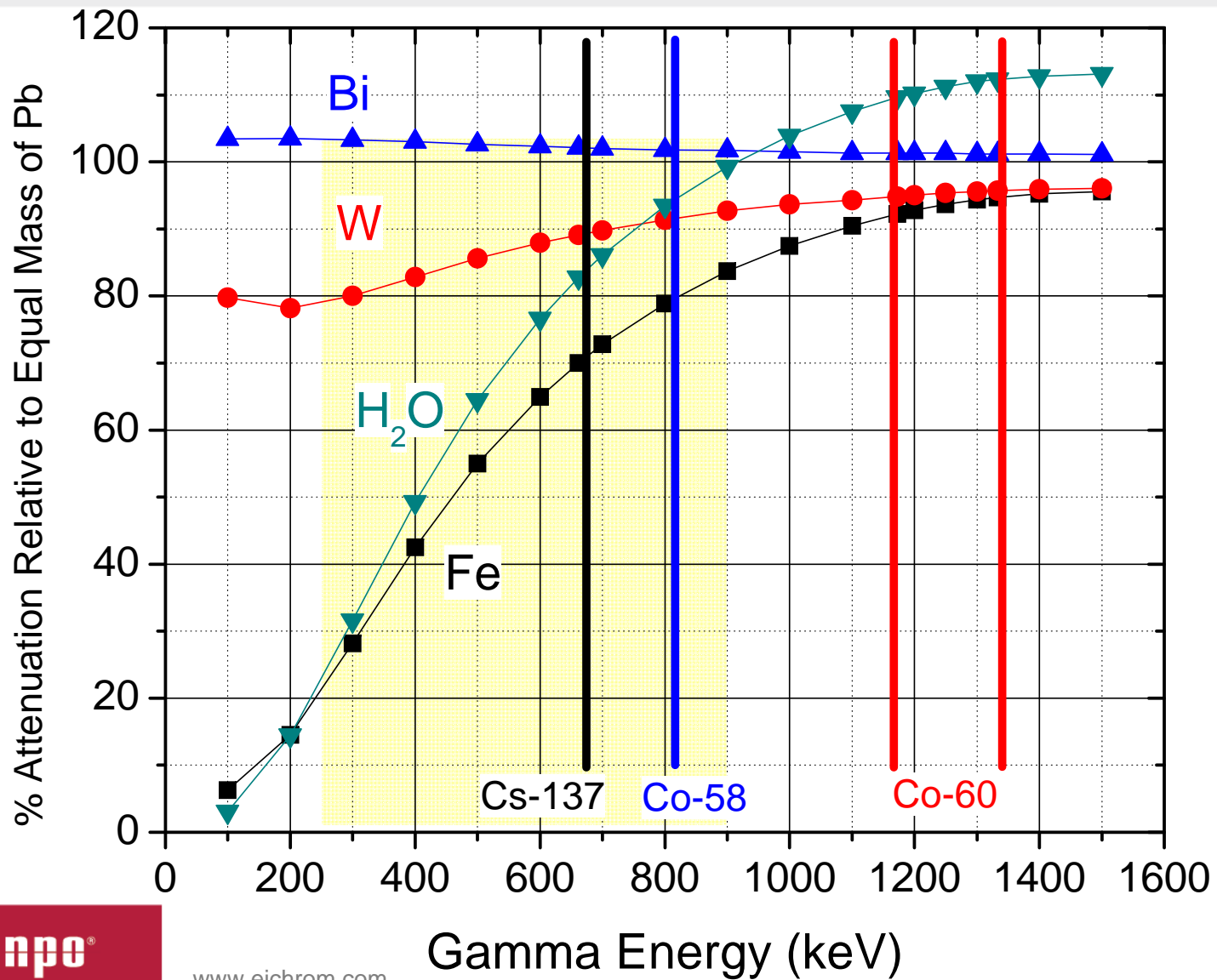


1173 keV

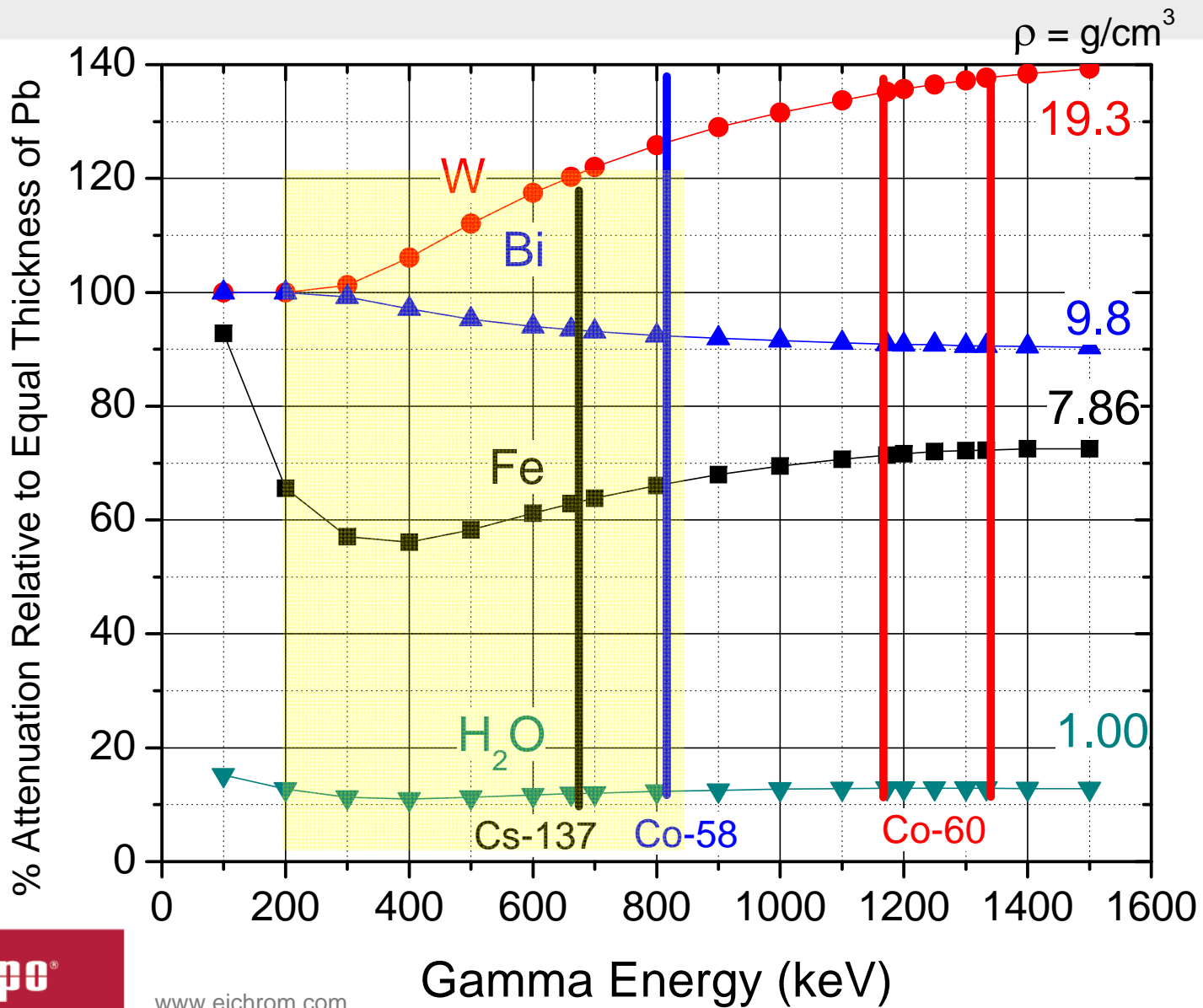
1333 keV



# Mass in the Path



# Shielding Thickness





T-Flex®

# T-Flex® Products



- Several materials
  - Tungsten
  - Iron
  - 50/50 – 50% Tungsten/50% Iron
  - Boron (neutron)
  - Bismuth – we can do it....
- Multiple durometers
  - D10
  - D20
  - D40
  - Experimented with D50
- Layers of color
- Embedded hardware

# T-Flex® Products

- Ribbons or Ribbon Wrap



# T-Flex® Products

- Pipe Shields



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# T-Flex® Products

- Heater Shields or Penetration Shields



# T-Flex® Products

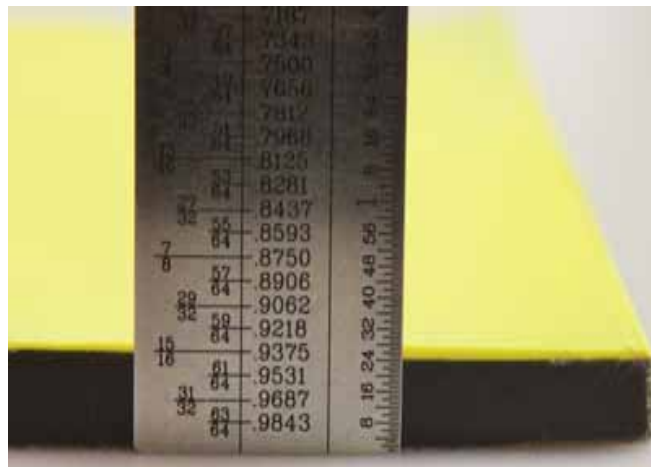
- Elbow and Valve Shields





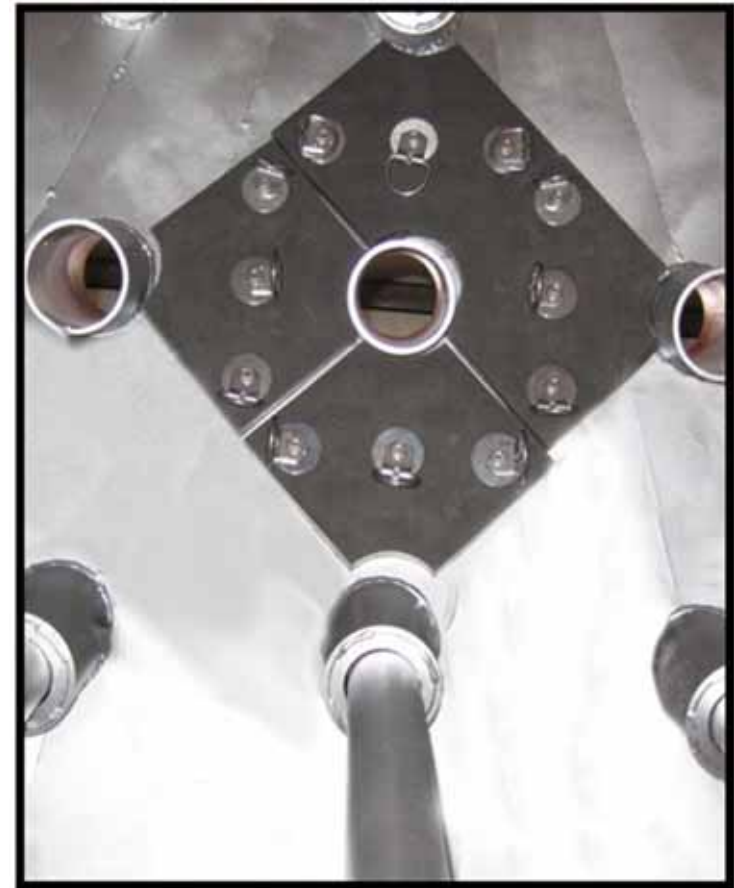
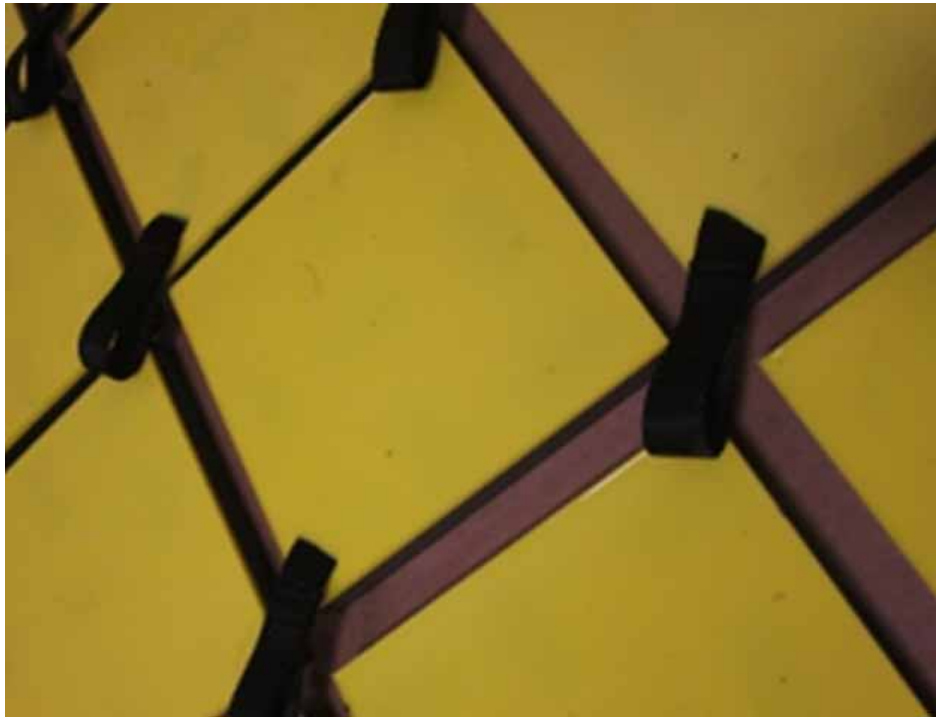
# T-Flex® Products

- Tiles and Slabs



# T-Flex® Products

- Embedded magnets



# T-Flex® Products

- Embedded Hardware



# T-Flex® Products

- Custom Shapes



Probe Shield



Conductivity Cells



Vial Shields



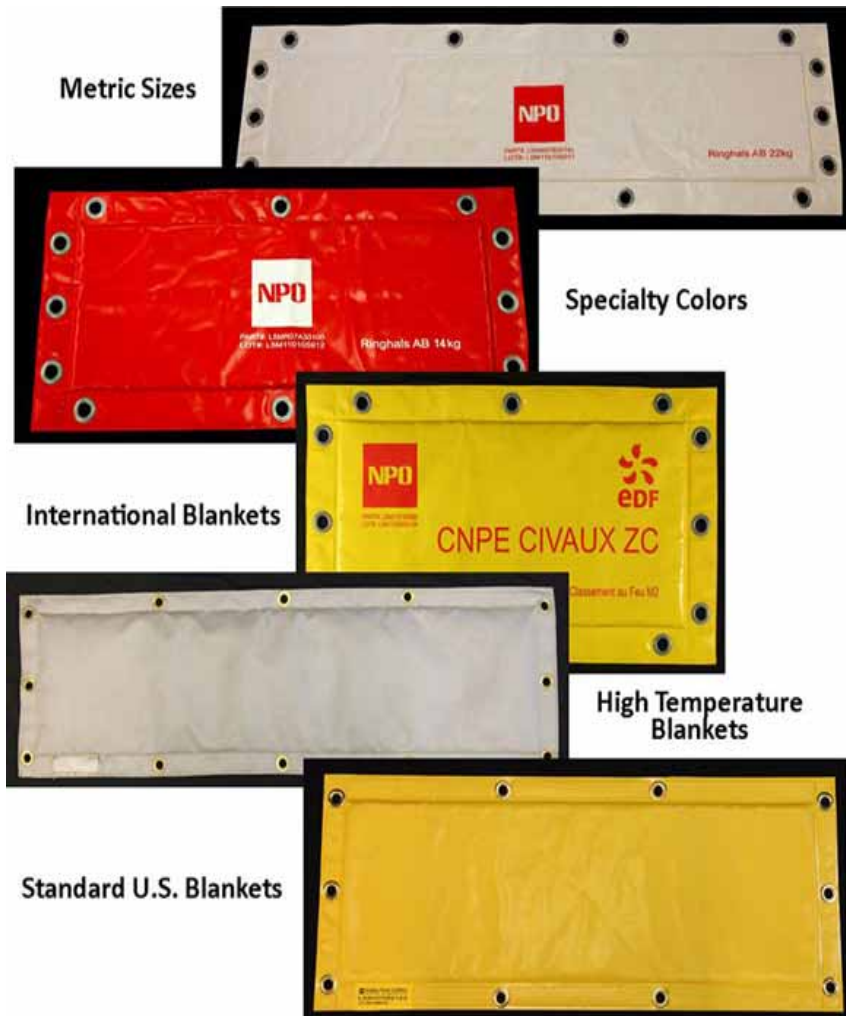
Vial Carrier





Lead

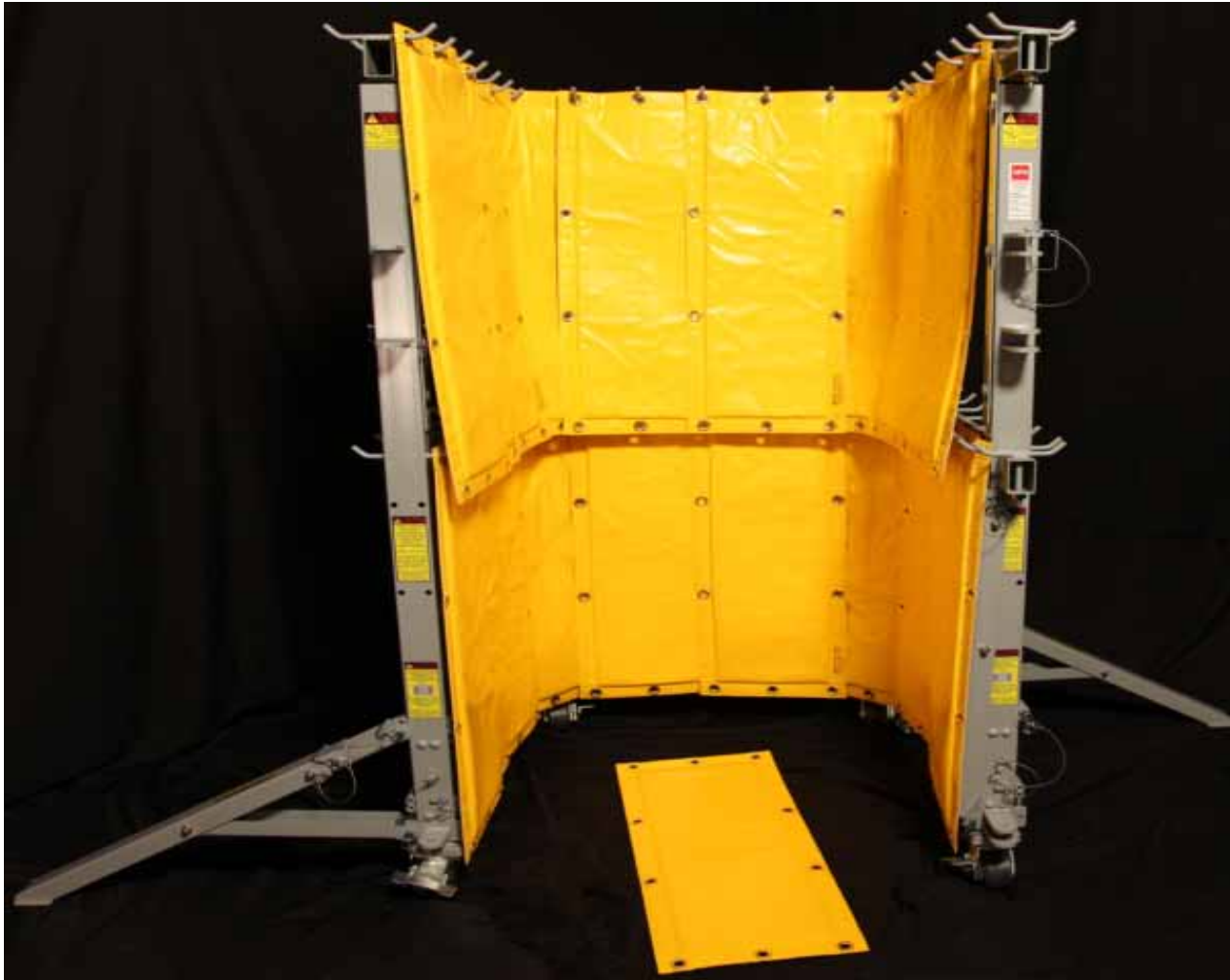
# Lead Blankets



- Standard sizes
  - 1'x3', 10 lb/ft<sup>2</sup> or 15 lb/ft<sup>2</sup>
  - 1'x4', 10 lb/ft<sup>2</sup> or 15 lb/ft<sup>2</sup>
  - 1'x5', 10 lb/ft<sup>2</sup> or 15 lb/ft<sup>2</sup>
  - 1'x6', 10 lb/ft<sup>2</sup> or 15 lb/ft<sup>2</sup>
- High-temperature Alpha Maritex covers – sewn
- Multiple colors for cover
- Printing can be applied

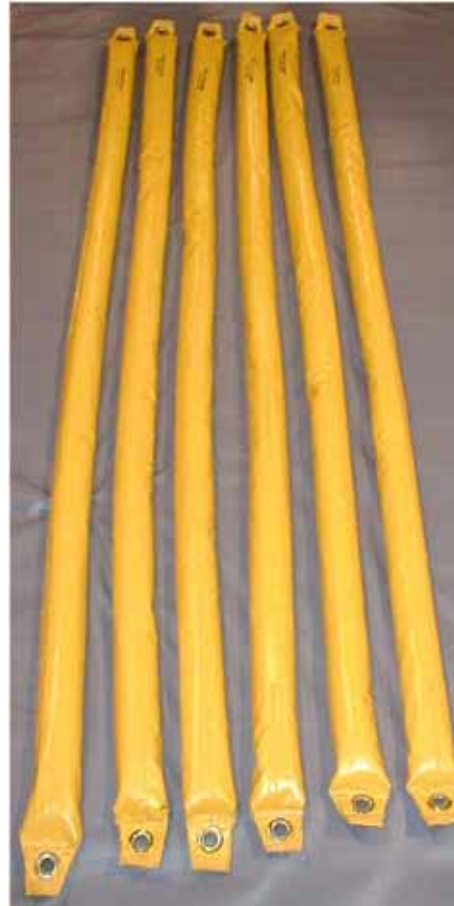


# Lead Blankets



# Lead Blankets

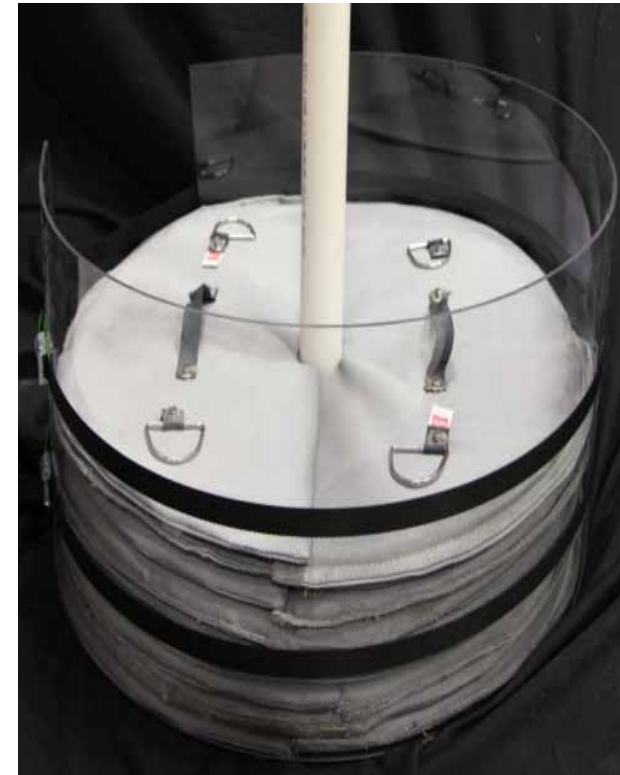
- Segmented
- Snakes





# Lead Blankets

- Custom shapes



# Lead Products

- Encased



# Lead Products

- Magnetic





Water

# Water Shields

- 1' of water = 1" of lead



**npe**<sup>®</sup>

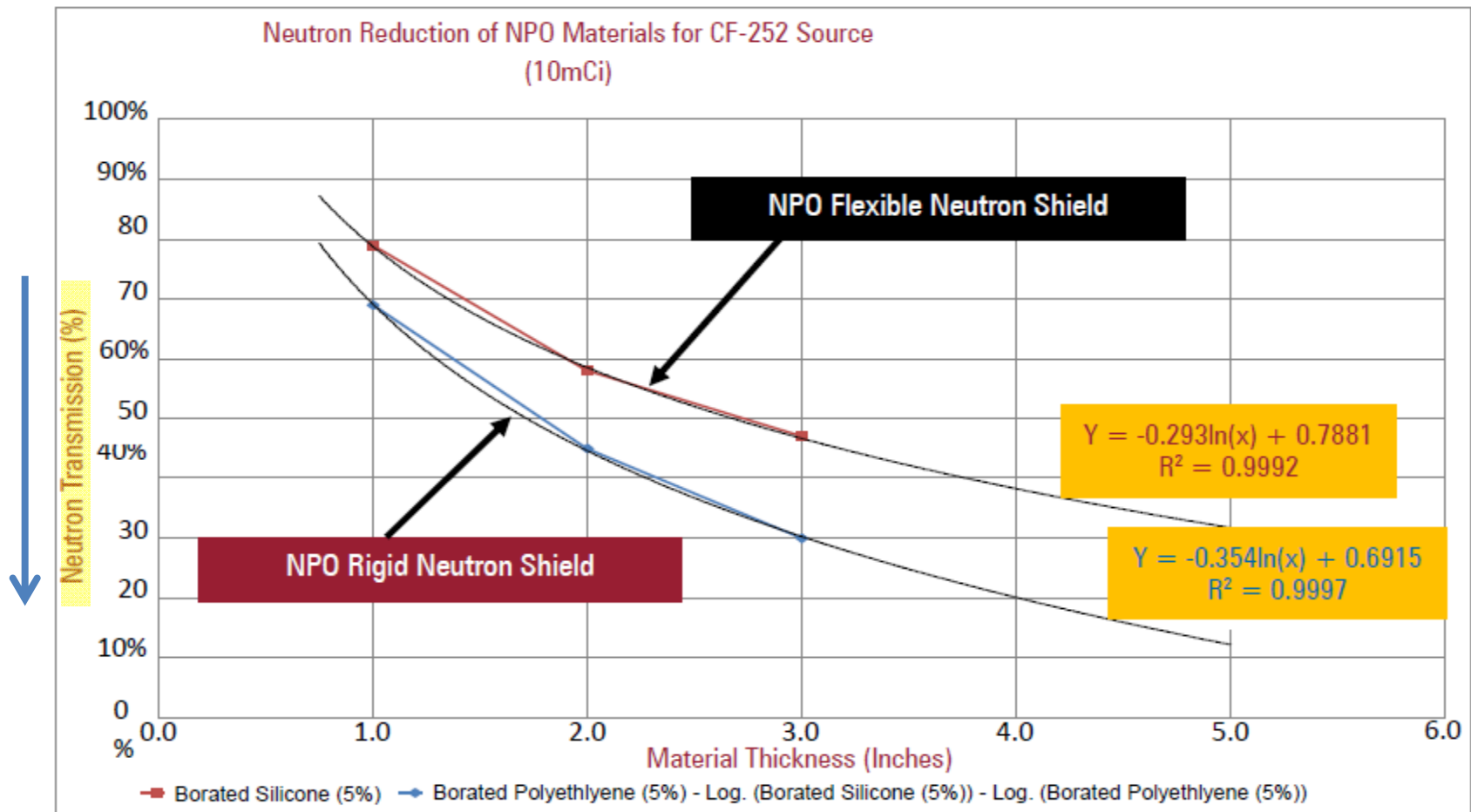
[www.eichrom.com](http://www.eichrom.com)



Attenuating Neutrons

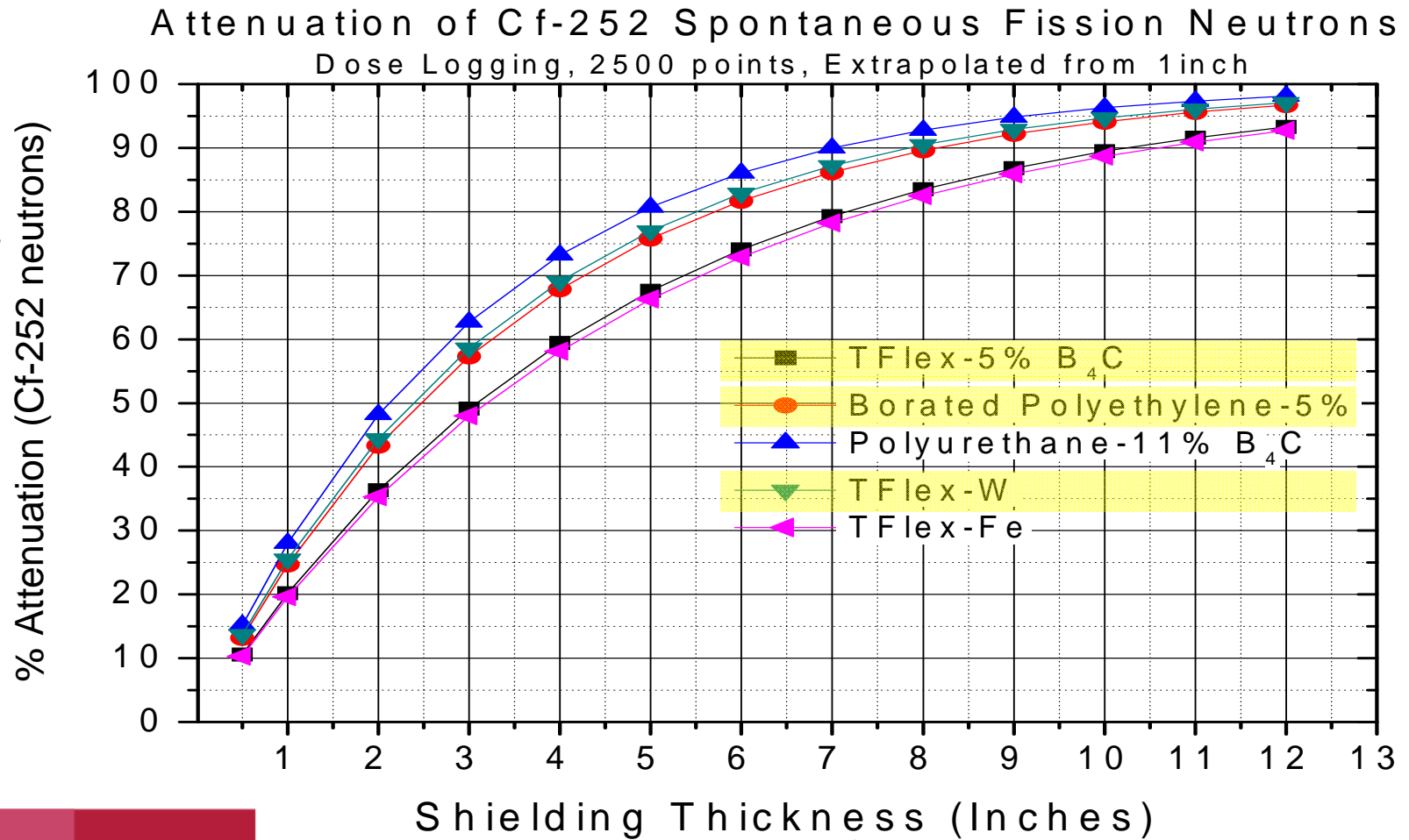
# Dry-Cask cont'd

- Neutron Attenuation



# Dry-Cask cont'd

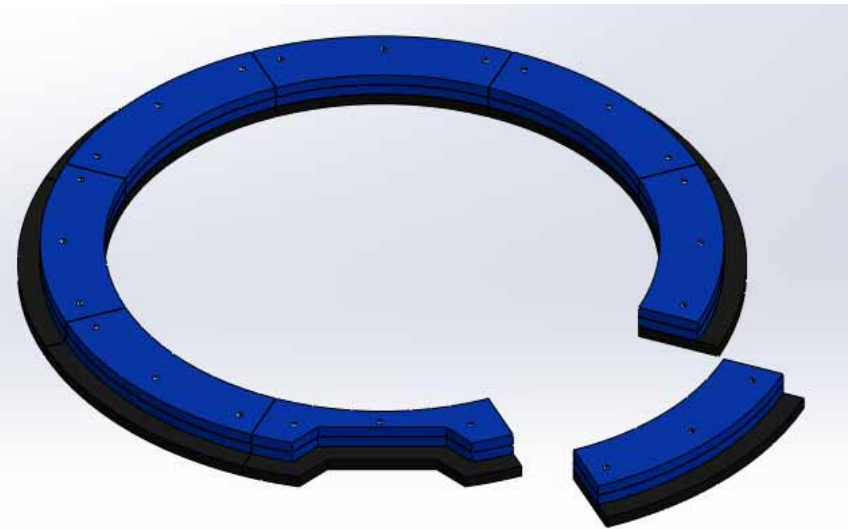
- Neutron Attenuation





# Dry-Cask cont'd

- Cask Lid



# Dry-Cask cont'd

- The Ring Design

