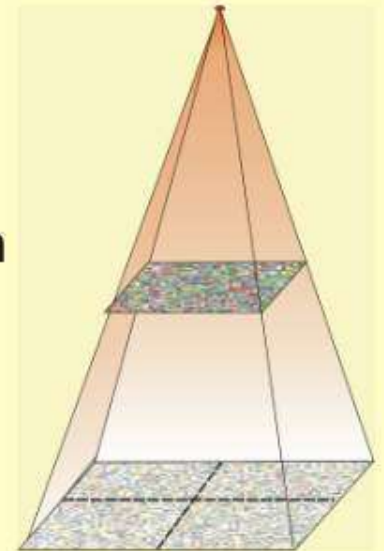


# **Enriching** **Medical Physics Education** **by** **Visualizing the Invisible**

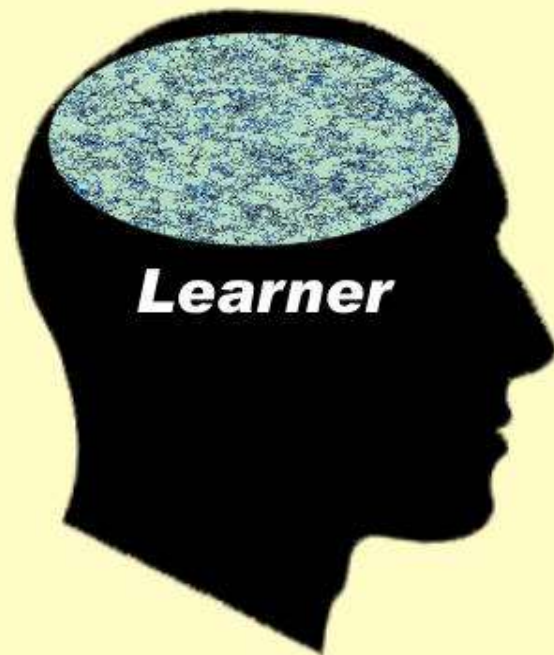


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# **Learning Physics is Building a Knowledge Structure in the Brain**



## **Physical Universe**



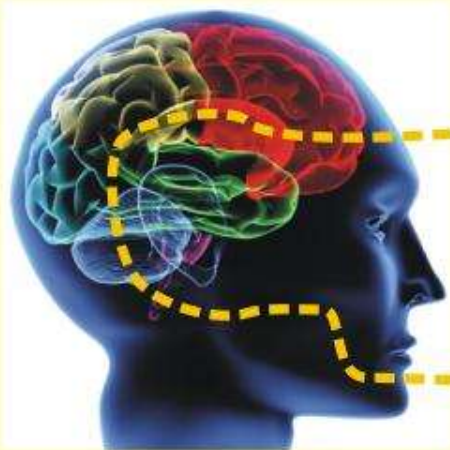
***A mental representation of physical reality***

*Sprawls*

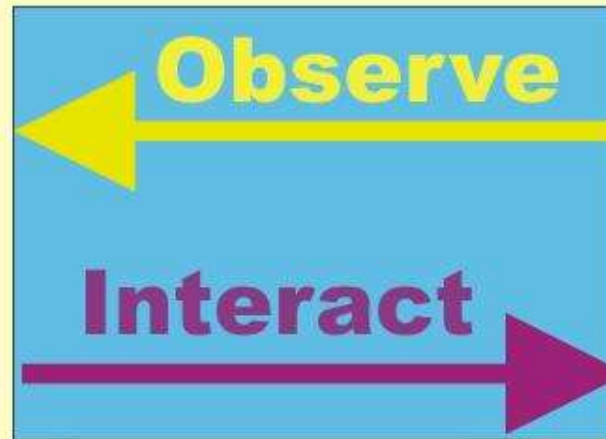


# The Elements of A Highly Effective Educational Session

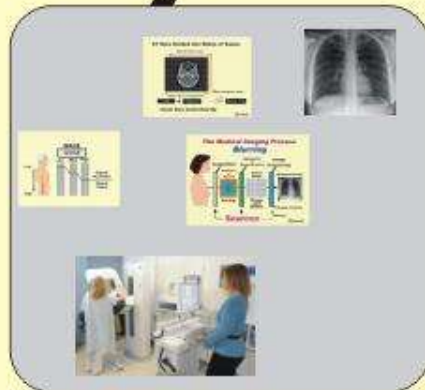
**The Brain**



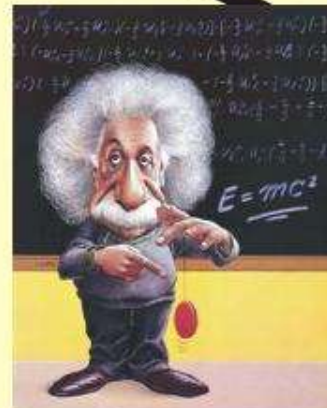
**Connection**



**The Physical Universe**  
(Physics of Medical Imaging)



**“Window”**



**Teacher  
/Guide**

*Sprawls*

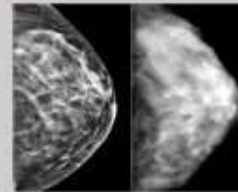
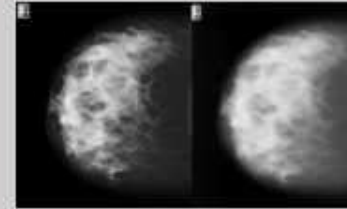
# ***Forming Knowledge Structures***

## ***Physical Universe***

## ***Back Integrative Cortex***



***Sensory***



## ***Visible Physical Objects***

*Sprawls*

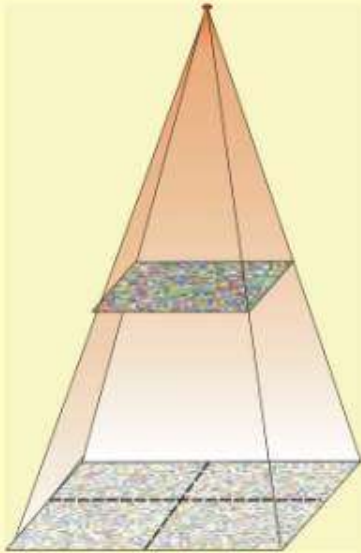
# The **Visible** and the Invisible





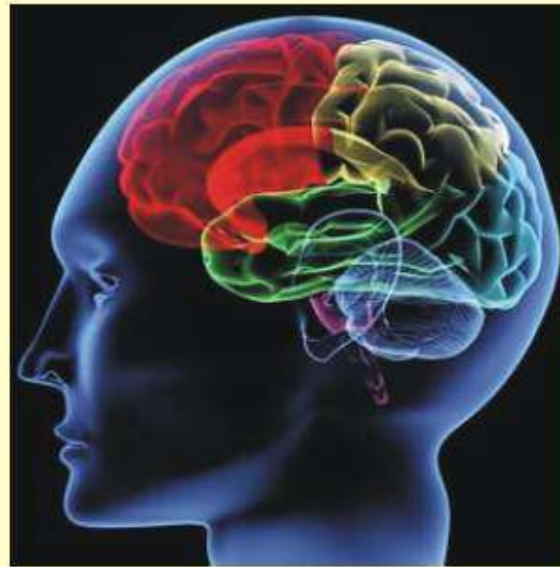
# Medical Physics Knowledge Structures

## Sensory



## Linguistic

The inverse-square law states that the exposure decreases inversely to the square of the distance from the source.

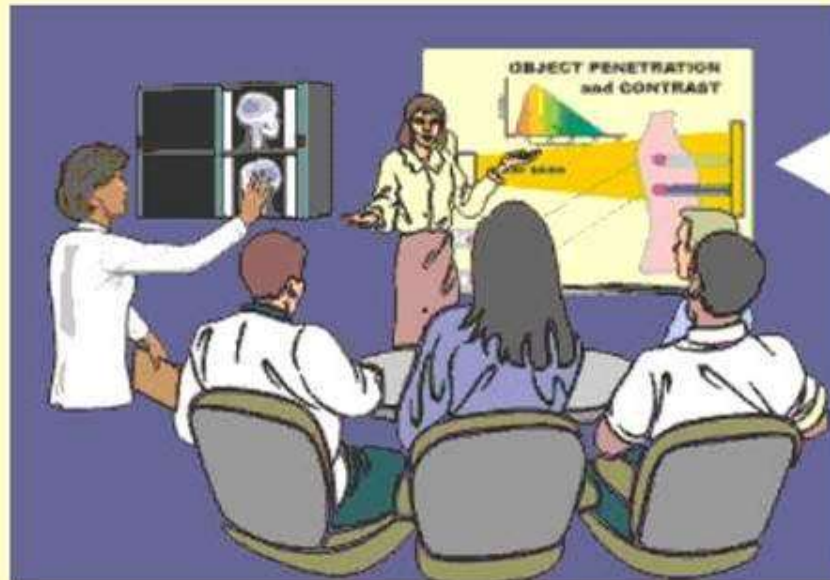


## Quantitative

$$E_2 = E_1 / (d_2/d_1)^2$$

# Rich Classroom and Conference Learning Activities

**Learning  
Facilitator  
“Teacher”**



**Visuals**

**Representations  
of  
Reality**

**Organize and Guide the Learning Activity**  
**Share Experience and Knowledge**  
**Explain and Interpret What is Viewed**  
**Motivate and Engage Learners**

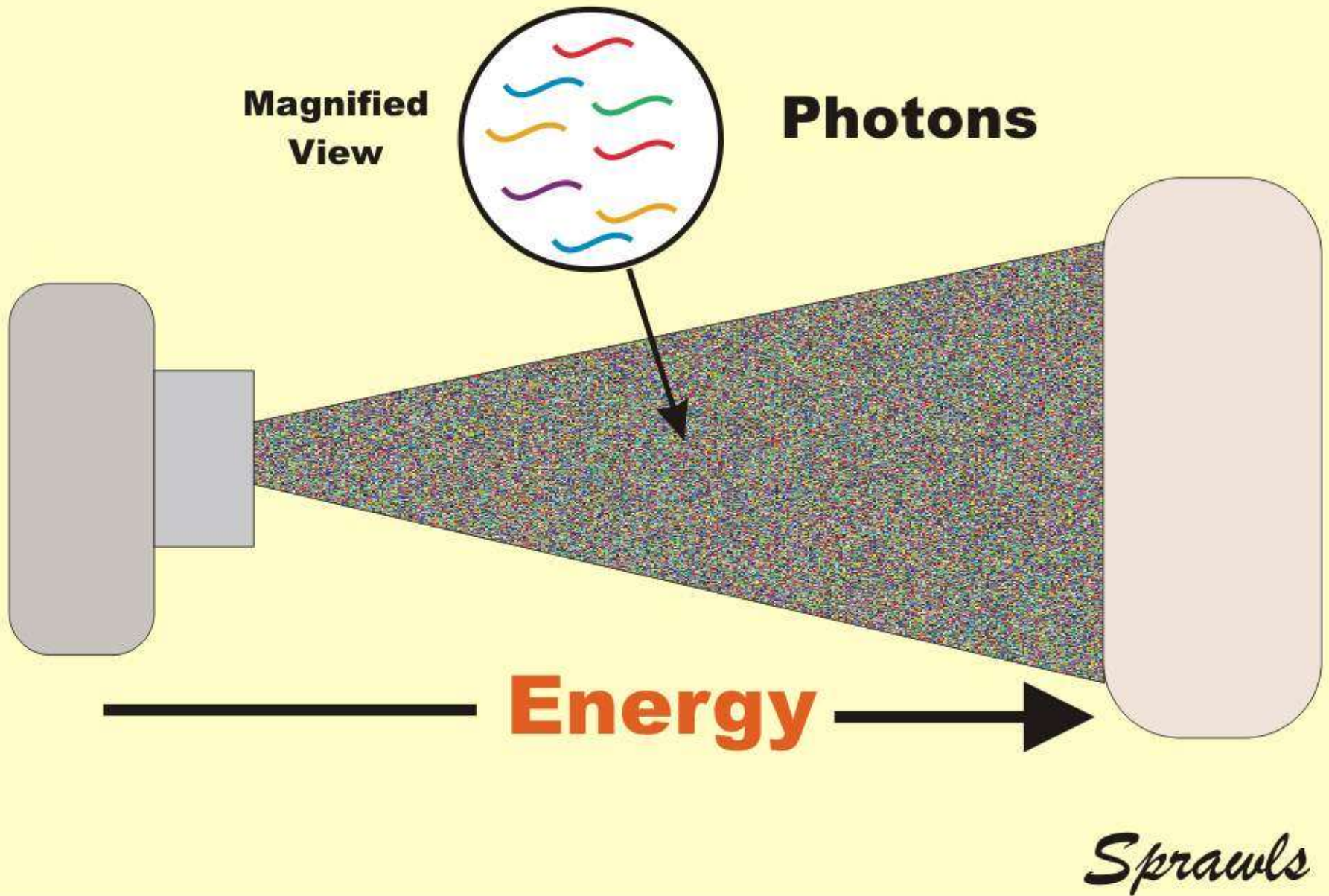
*Sprawls*

**The following are visuals  
to help learners visualize x-radiation  
and develop more effective and useful  
knowledge structures.**

**They are developed to be used  
in classroom or conference  
discussions.**



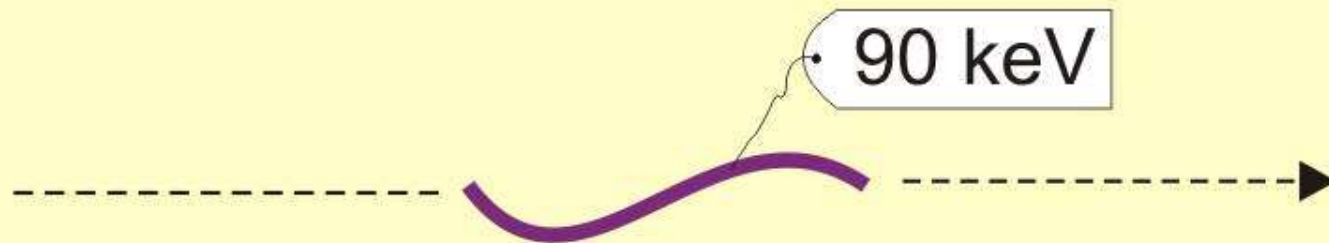
# The X-ray Beam



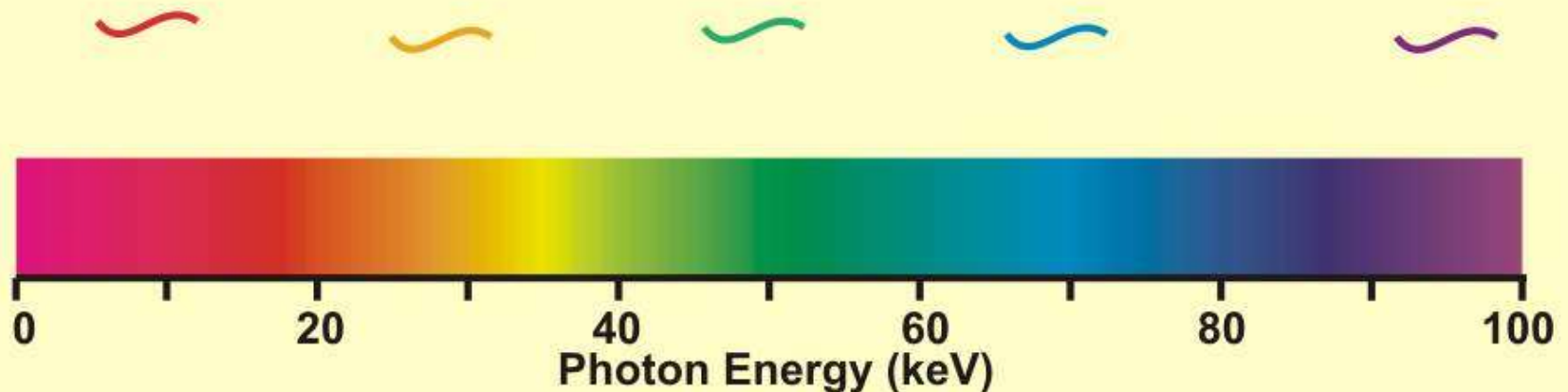
# Photons

## Individual Units (Quanta) of Energy

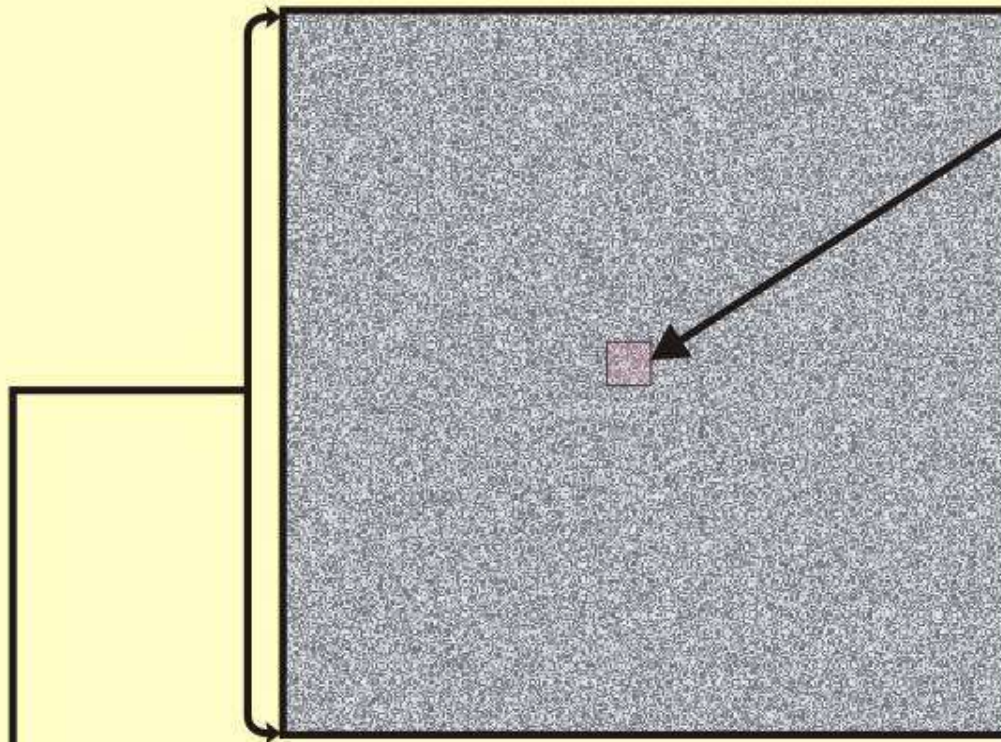
**Each photon is characterized by its specific energy**



**The energies of the different photons cover a wide spectrum**



# The X-ray Beam Delivers Energy



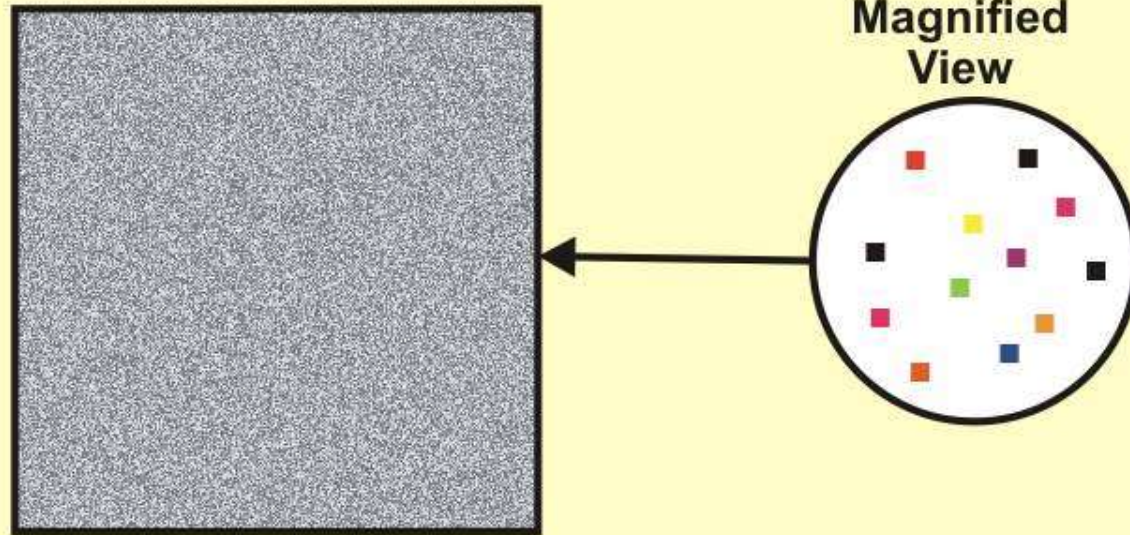
**Concentration** is expressed as:  
air kerma (gray/kg)  
or  
exposure (roentgen)

**Total** is expressed as dose-area product, DAP (gray).



# Image Of An X-ray Beam

## A Random Distribution of Photons

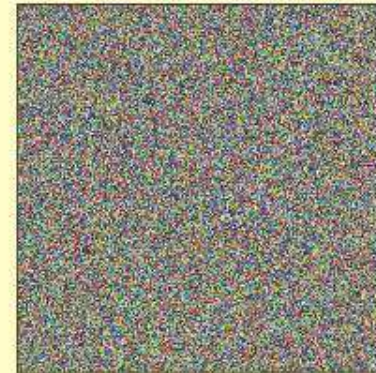
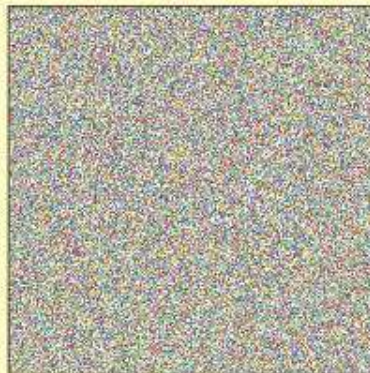
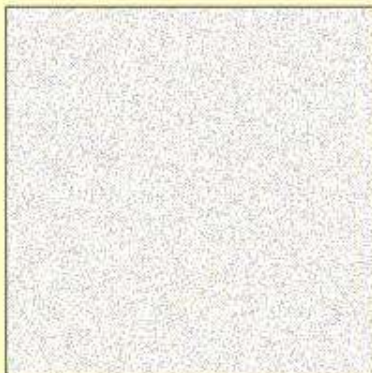


This is visible in an x-ray image as noise (quantum noise).

**High**

**Medium**

**Low**



— Photon Concentration (Exposure) →

*Sprawls*



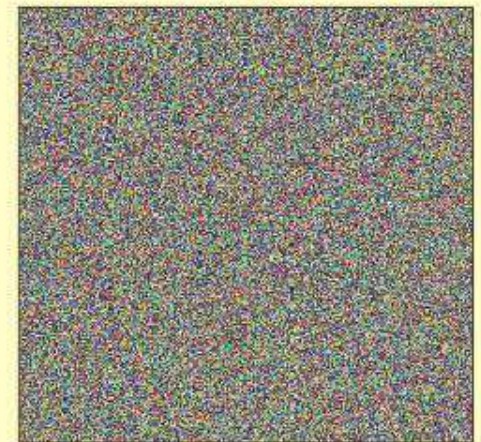
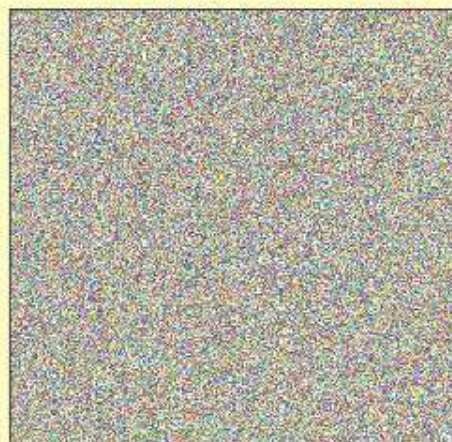
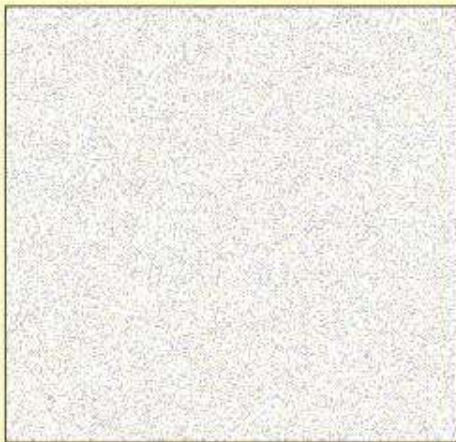
# View of X-ray Beam

**Exposure (Concentration of Photons)**

**Low**

**Medium**

**High**



**High**

**Medium**

**Low**

**Random Distribution of Photons (Noise)**

*Sprawls*

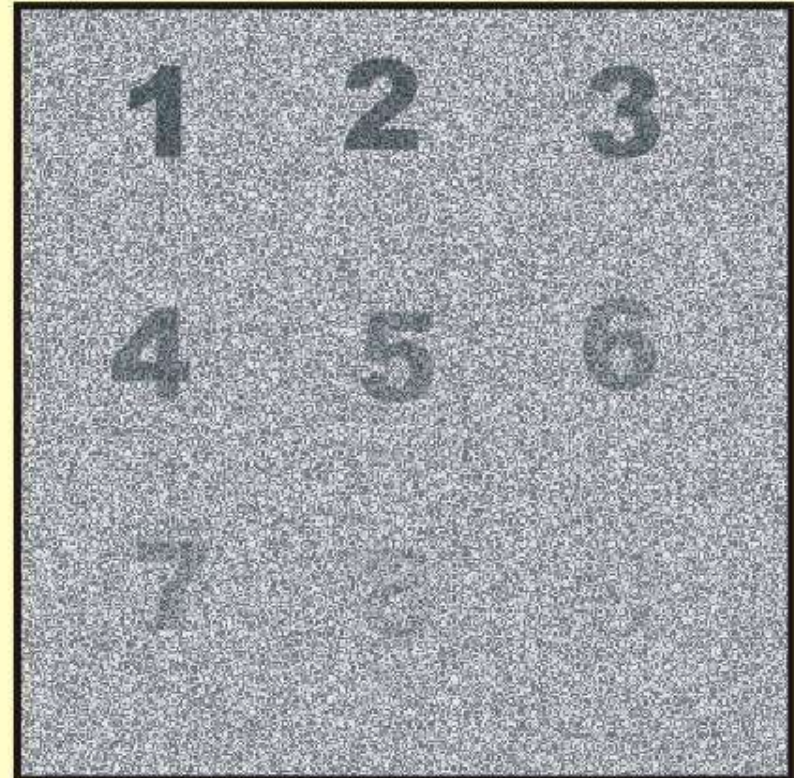
# X-ray Images

**High Exposure**



**Low Noise**

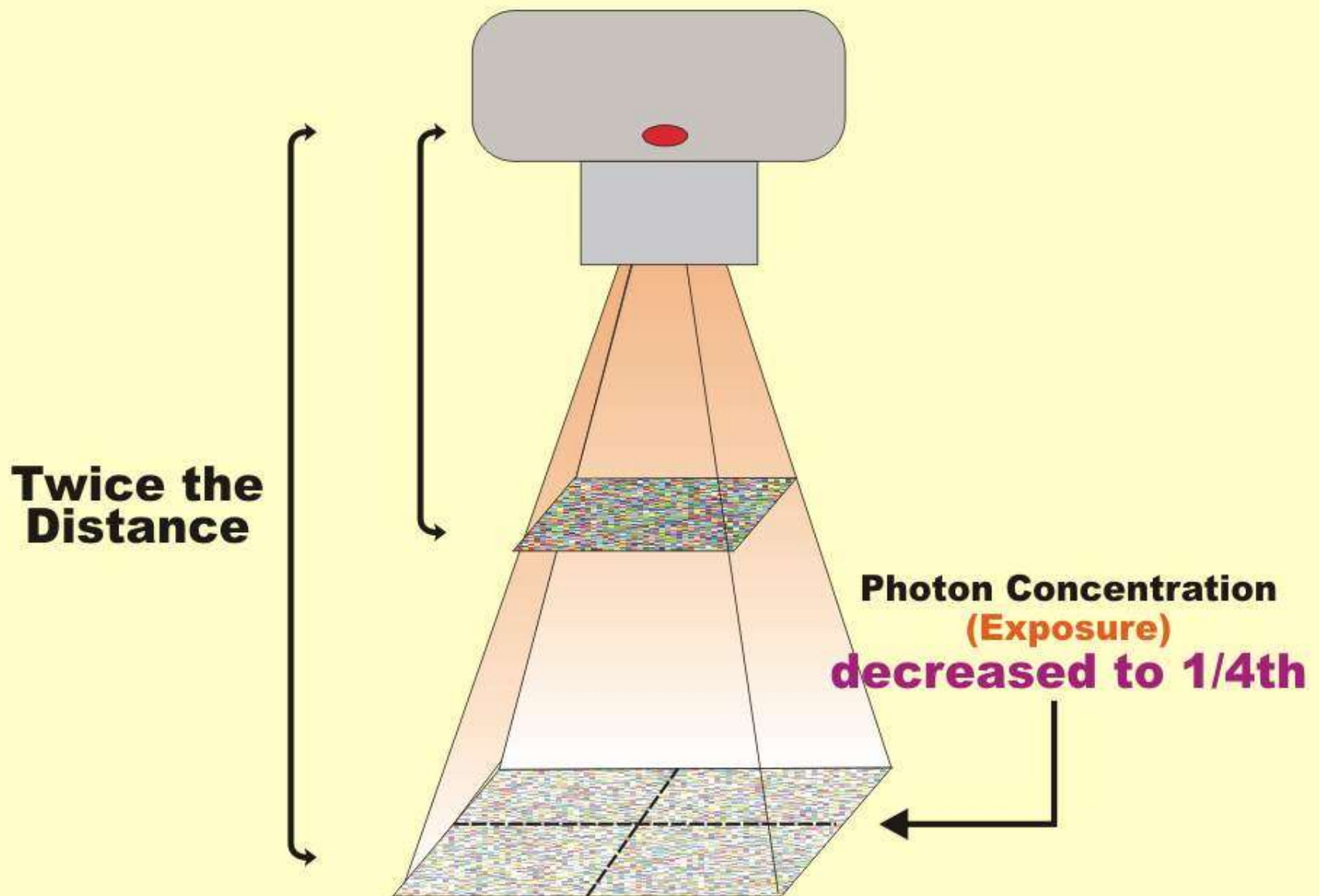
**Low Exposure**



**High Noise**

*Sprawls*



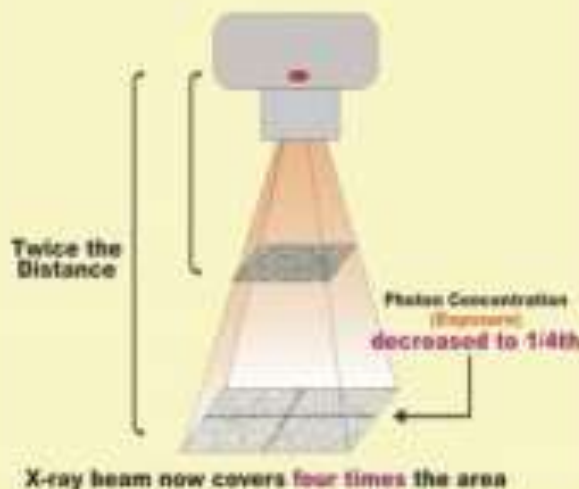


X-ray beam now covers **four times** the area

# The Physical Universe



The inverse square law is.....



The Inverse Square Law

$$\frac{I_1}{(d_1)^2} = \frac{I_2}{(d_2)^2}$$

$I_1$  is the initial intensity of radiation,  $d_1$  is the initial distance, and  $I_2$  is the final intensity, and  $d_2$  is the final distance.

Verbal

Sensory

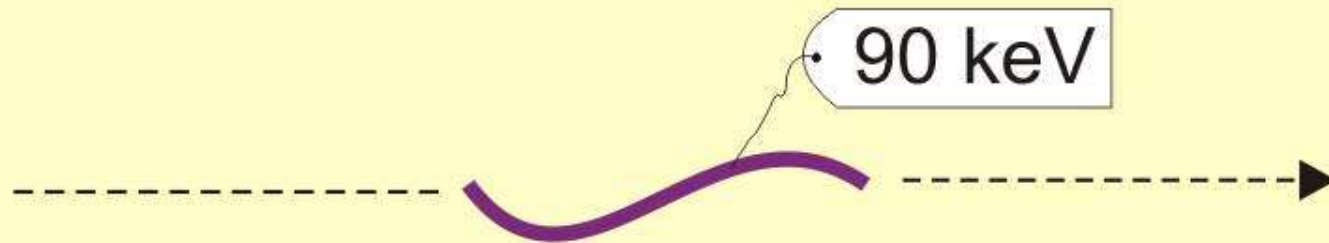
Mathematical

*Sprawls*

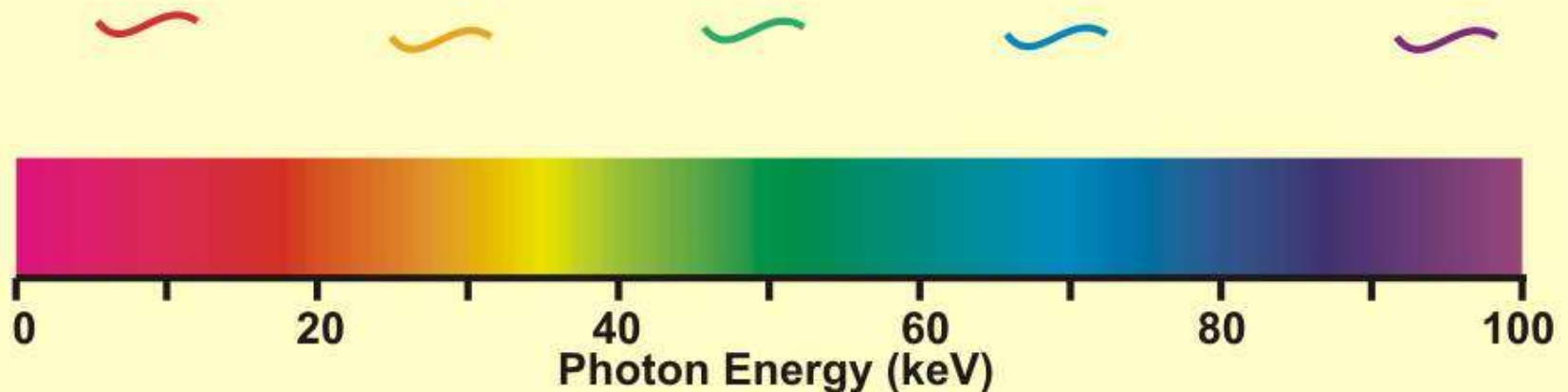
# Photons

## Individual Units (Quanta) of Energy

**Each photon is characterized by its specific energy**

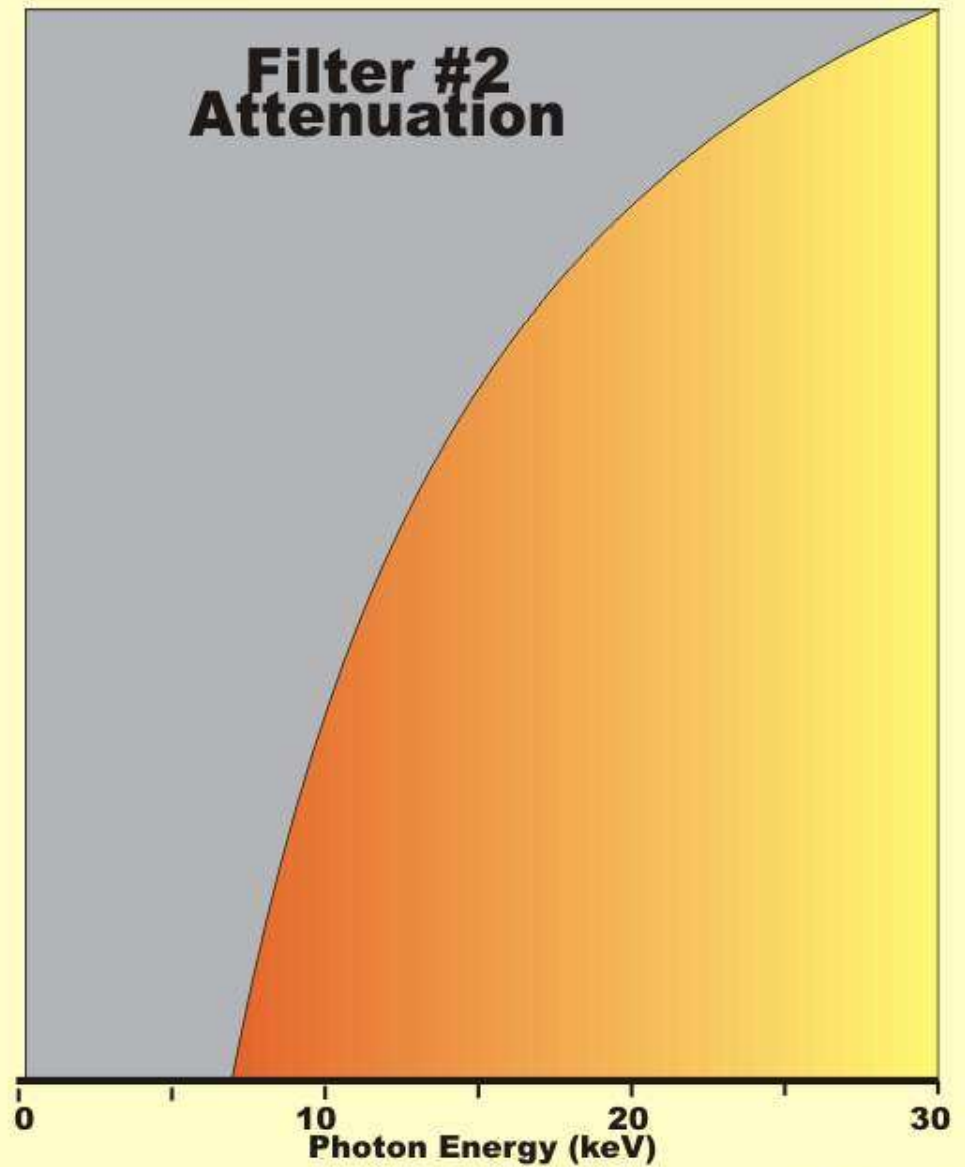
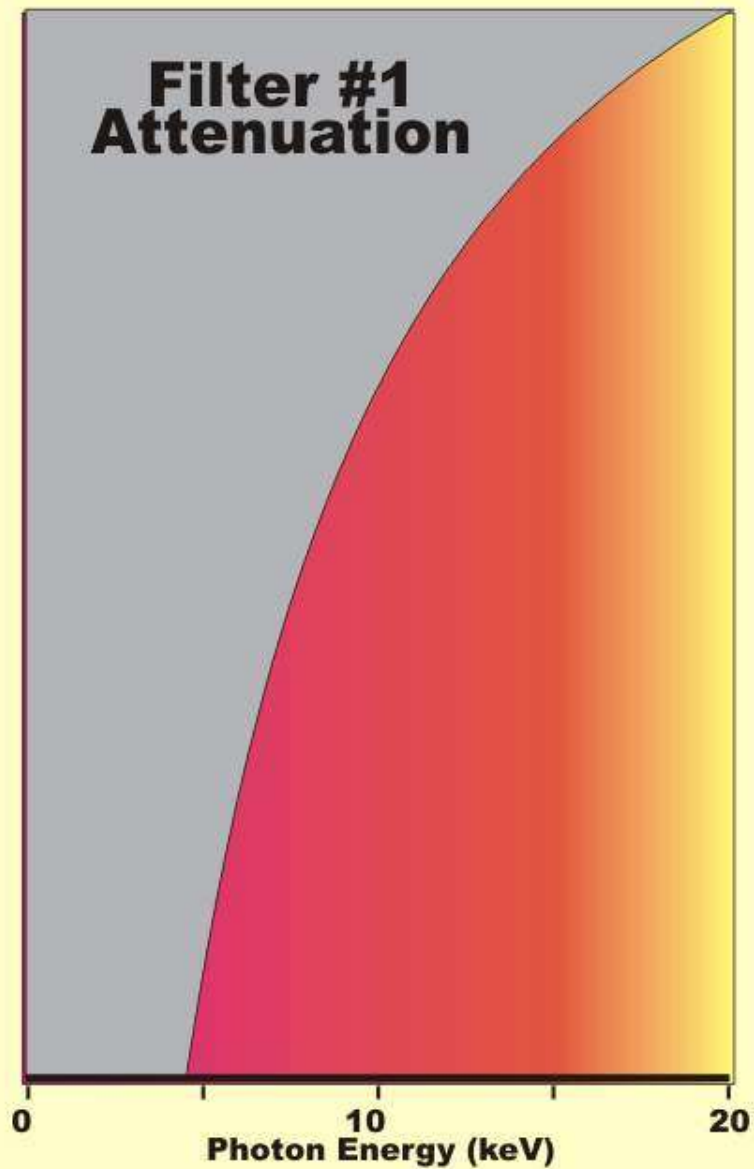


**The energies of the different photons cover a wide spectrum**





# Filters



**KV**

60

80

100

**Filter**

1

2

Relative Exposure

0

20

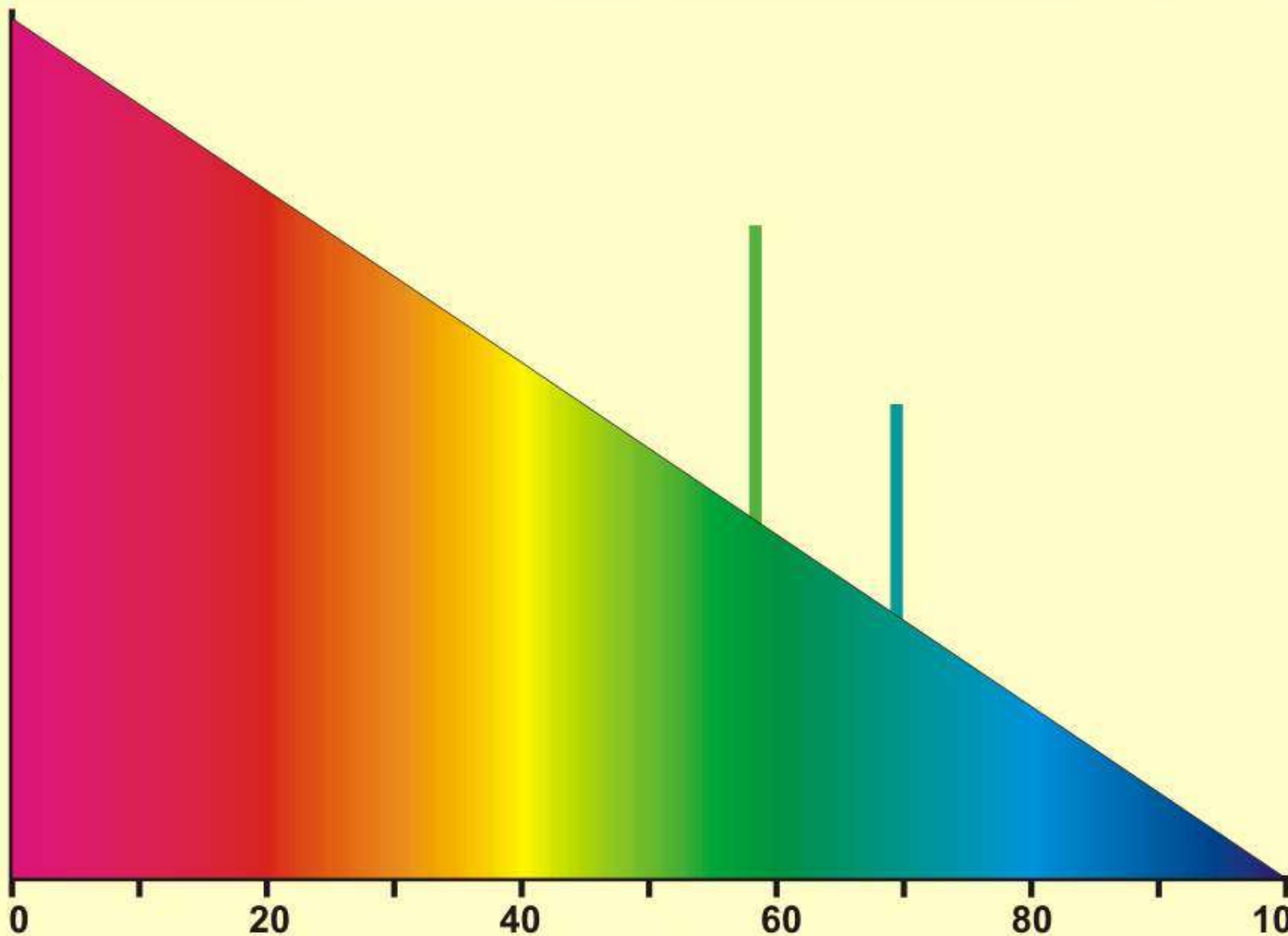
40

60

80

100

Photon Energy (keV)

*Sprawls*

**KV**

60

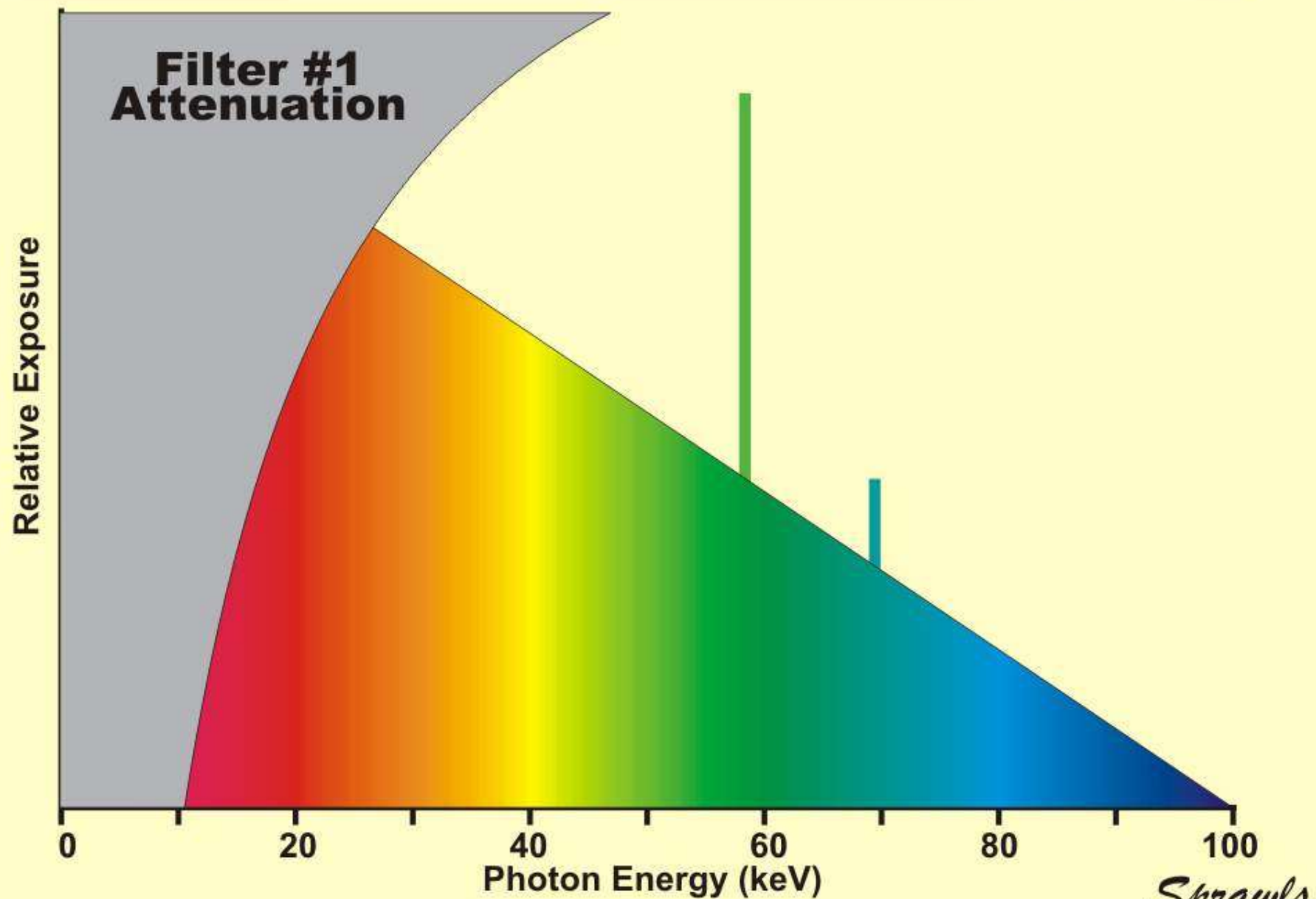
80

100

**Filter**

1

2





**KV**

60

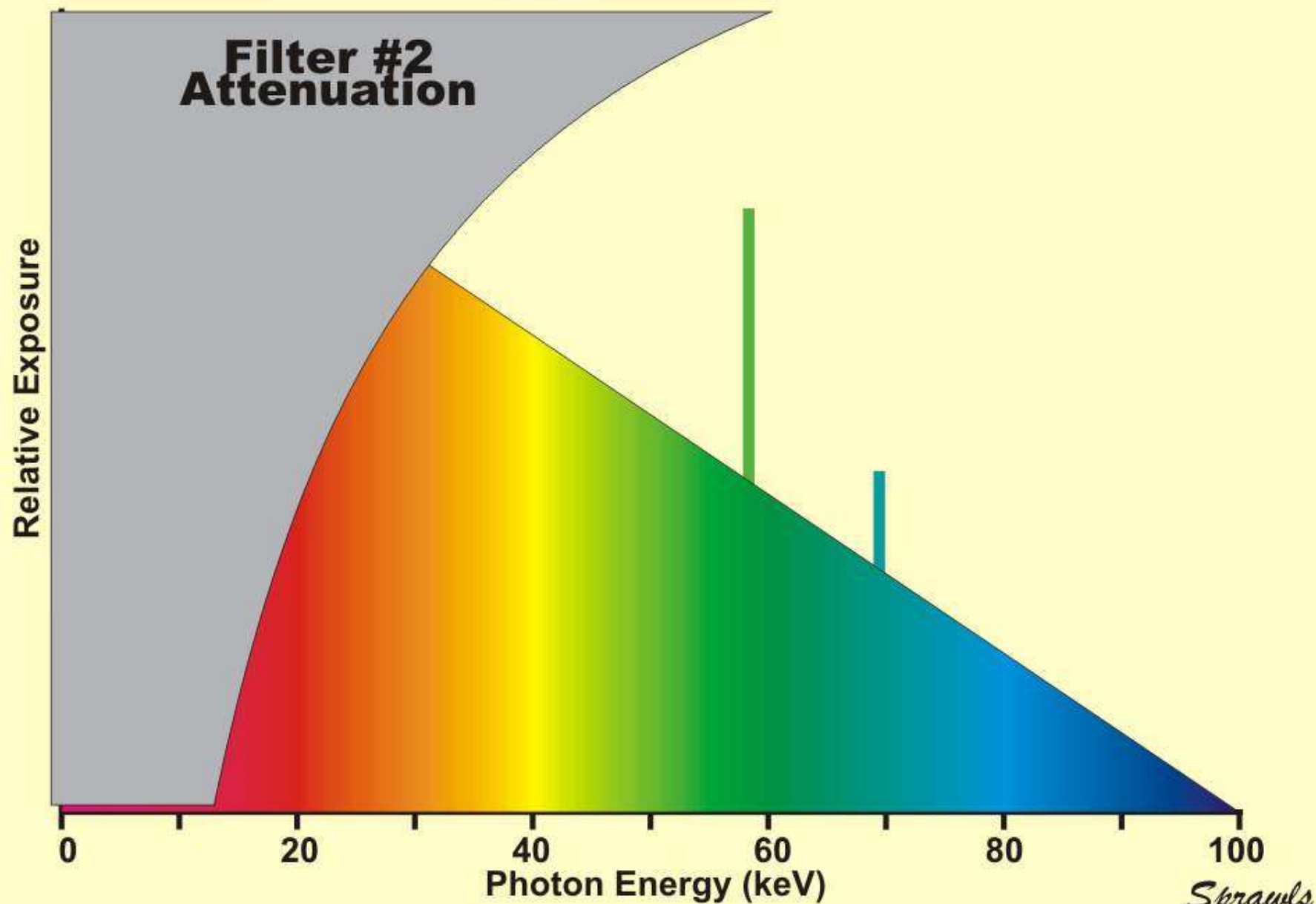
80

100

**Filter**

1

2



**KV**

60

80

100

**Filter**

1

2

**Filter #1  
Attenuation**

Relative Exposure

0

20

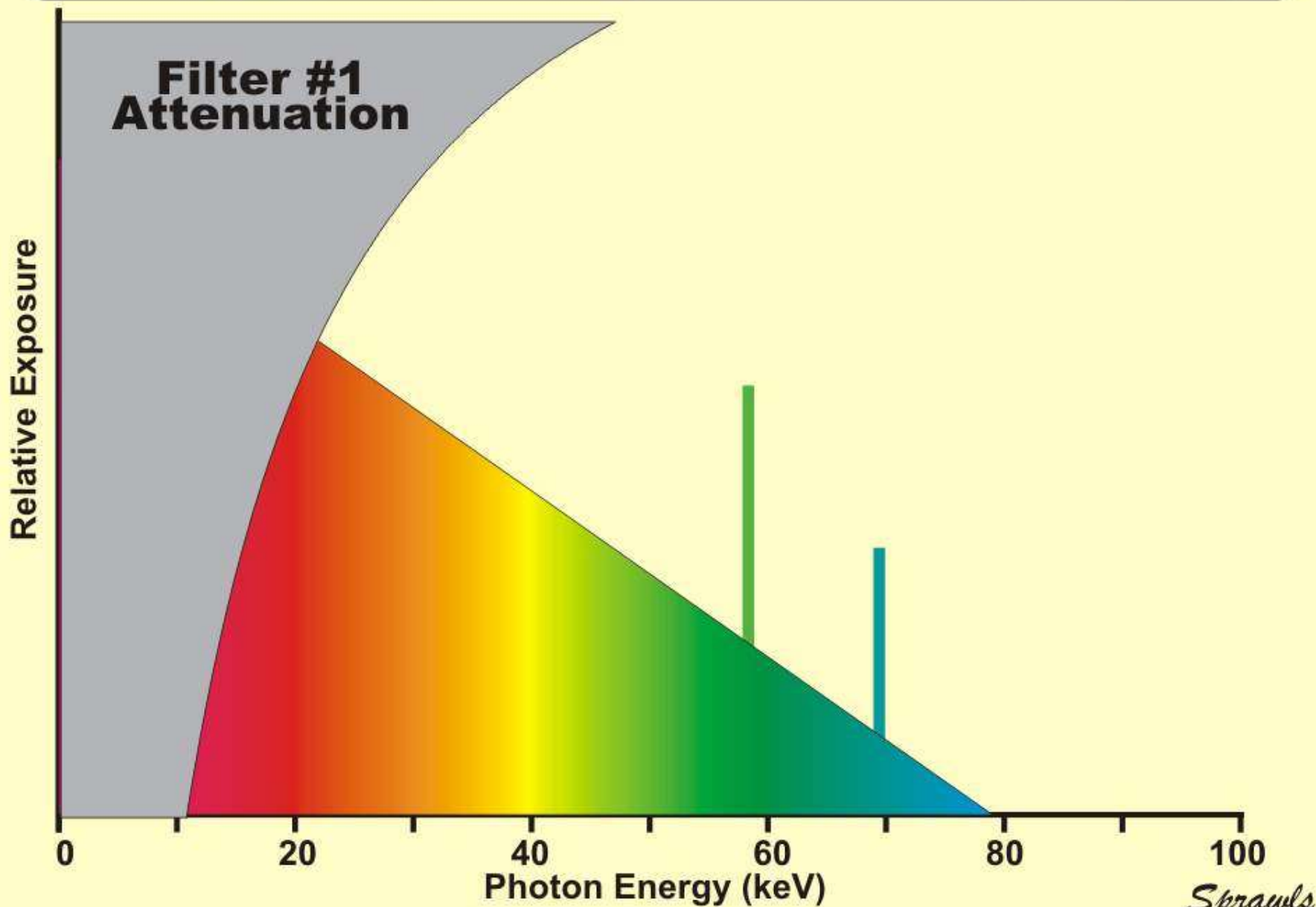
40

60

80

100

Photon Energy (keV)

*Sprawls*

**KV**

60

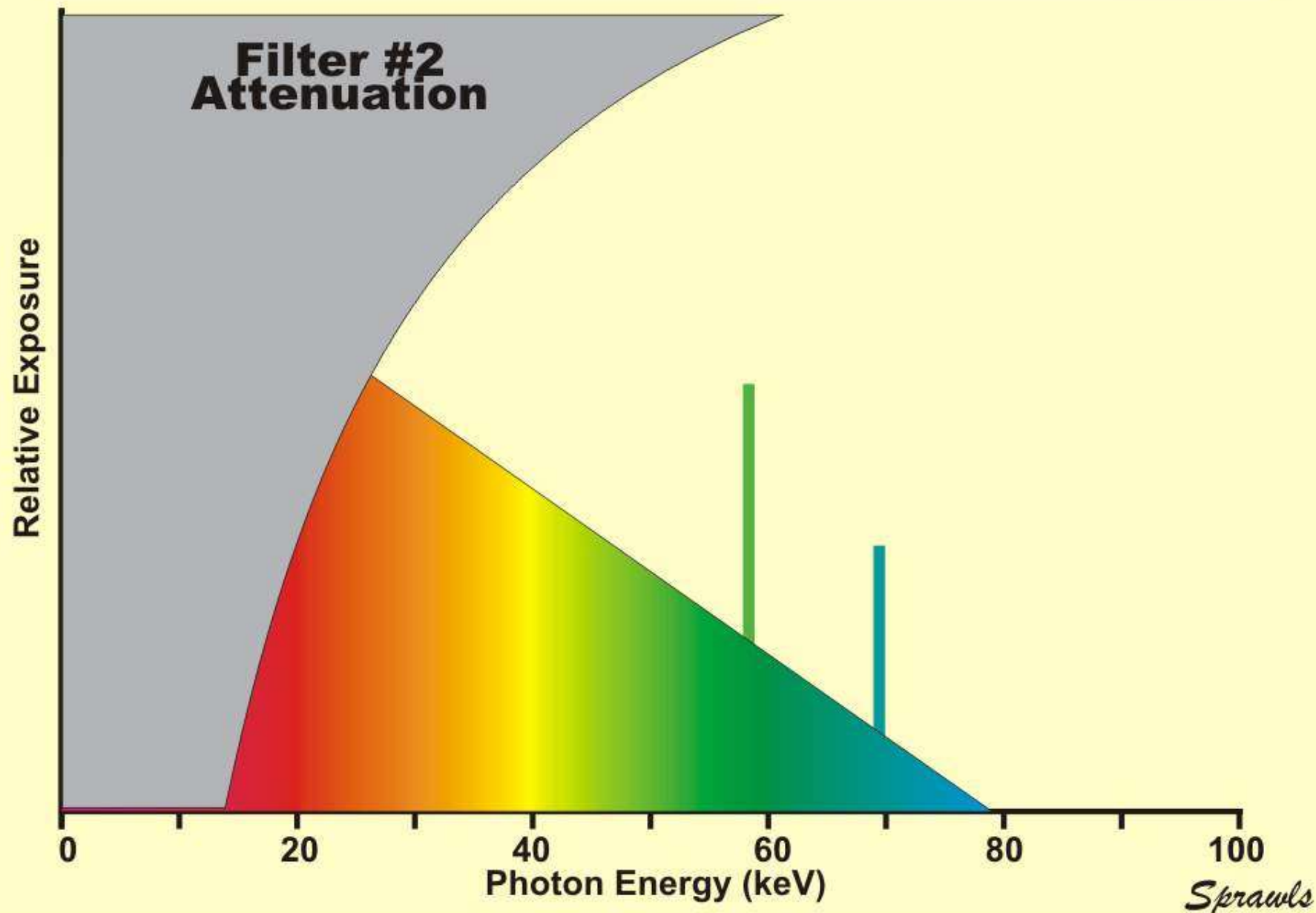
80

100

**Filter**

1

2





**KV**

60

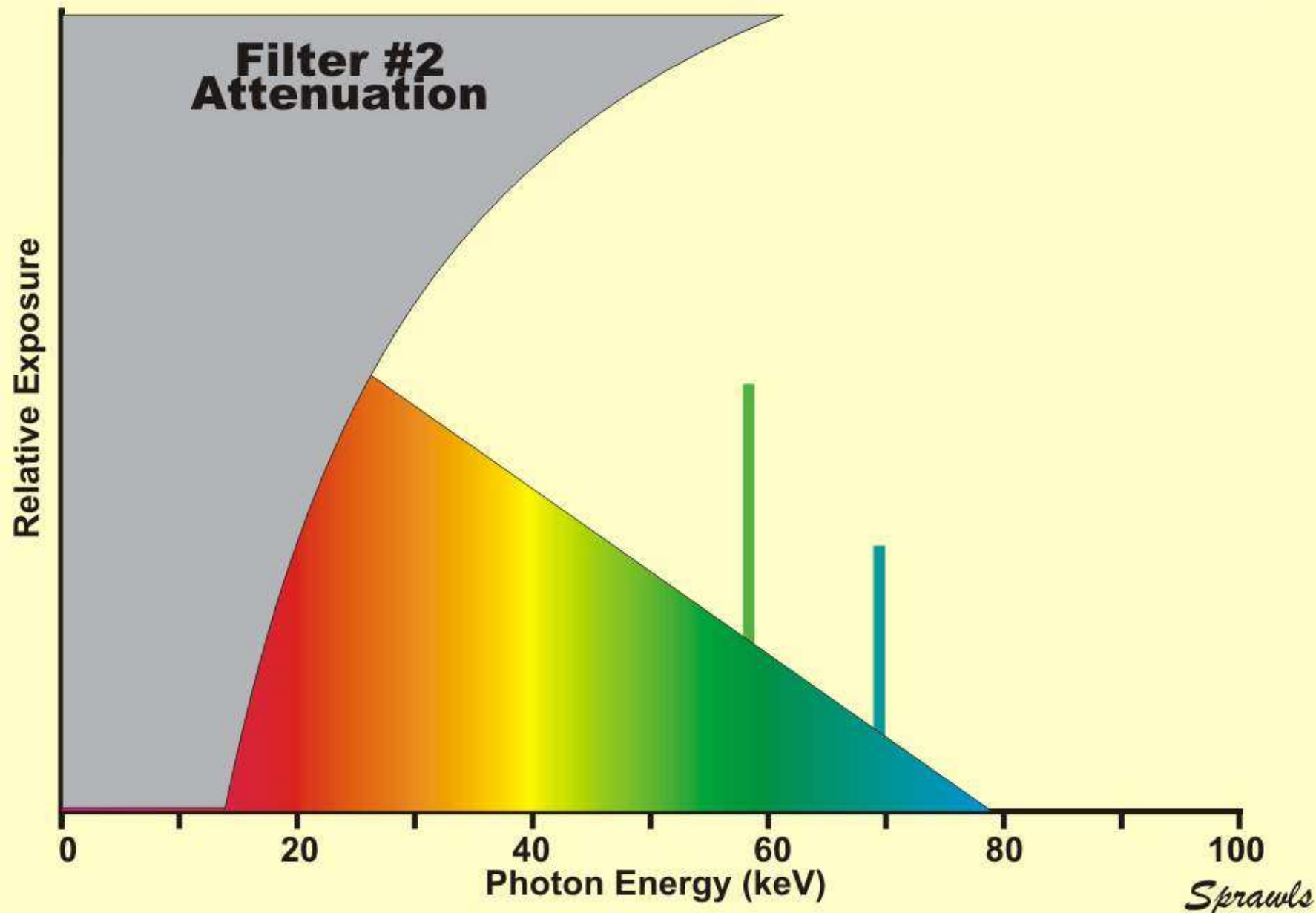
80

100

**Filter**

1

2



**KV****60****80****100****Filter****1****2****Filter #1  
Attenuation**

Relative Exposure

0

20

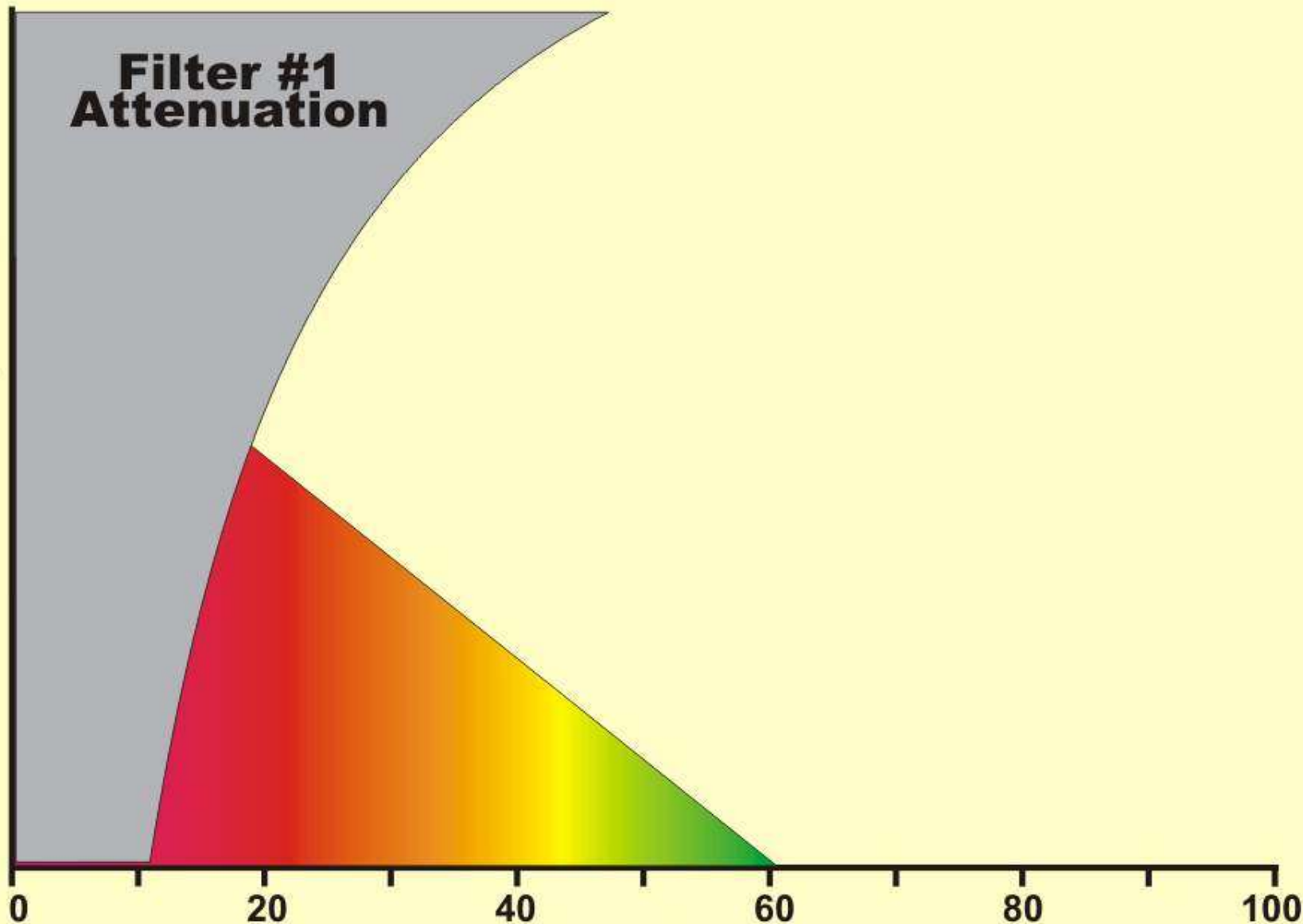
40

60

80

100

Photon Energy (keV)

*Sprawls*

**KV**

**60**

80

100

**Filter**

1

**2**

**Filter #2  
Attenuation**

Relative Exposure

0

20

40

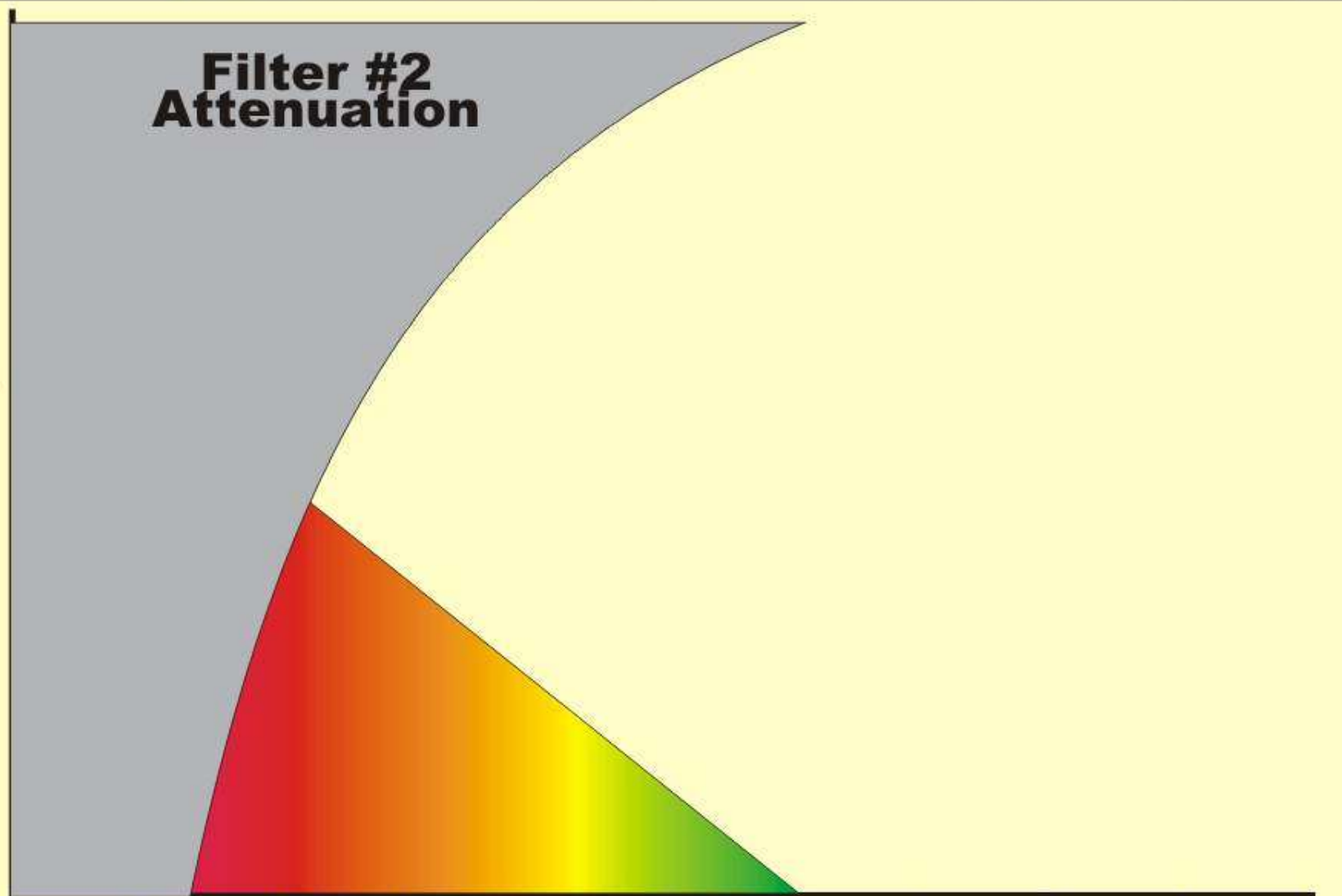
60

80

100

Photon Energy (keV)

*Sprawls*





# **Enriching** **Medical Physics Education** **by** **Visualizing the Invisible**



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