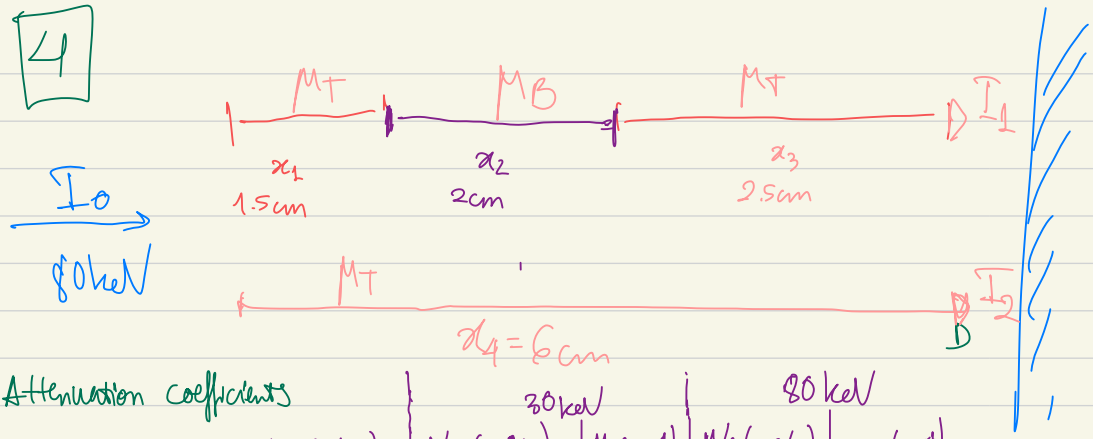
4



Attenuation coefficients

		30 keV		80 keV	
	ρ (g/cm³)	μ/ρ (cm²/g)	μ (cm⁻¹)	μ/ρ (cm²/g)	μ (cm⁻¹)
Tissue	1.060	0.3790	0.4018	0.1823	0.1933
Bone	1.920	1.331	2.5555	0.2229	0.4279

a)

At 80keV

$$I_1 = I_0 \cdot \exp\left[-\int_0^x dx\,\mu(x)\right]$$

$$= I_0 \cdot \exp\left[-\left(\mu_T \cdot x_1 + \mu_B x_2 + \mu_T \cdot x_3\right)\right]$$

$$= 0.196\, I_0$$

$$I_2 = I_0 \cdot \exp\left[-\mu_T x_4\right]$$

$$= 0.313\, I_0$$

The bone added an extra $\frac{I_2 - I_1}{I_2} \times 100 = \frac{(0.313 - 0.196) I}{0.313\, I_0} \times 100\% = 37\%$ attenuation compared to having the tissue only.

b) At 30 keV

$I_1 = 1.2 \times 10^{-3} I_0$

$I_2 = 89.7 \times 10^{-3} I_0$

1) For Copper (Cu):

$E_K \simeq 8.98$ keV

$\overline{E_L} \simeq 0.95$ keV

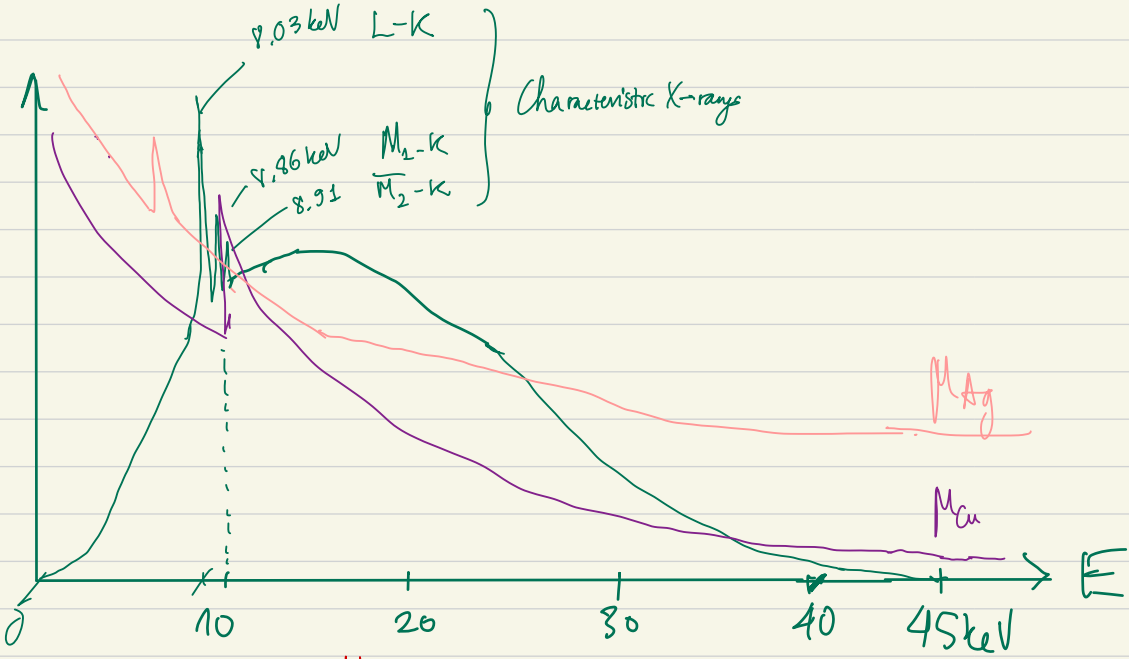
$E_{M_1} \simeq 0.12$ keV

$\overline{E_{M_2}} = 0.07$ keV

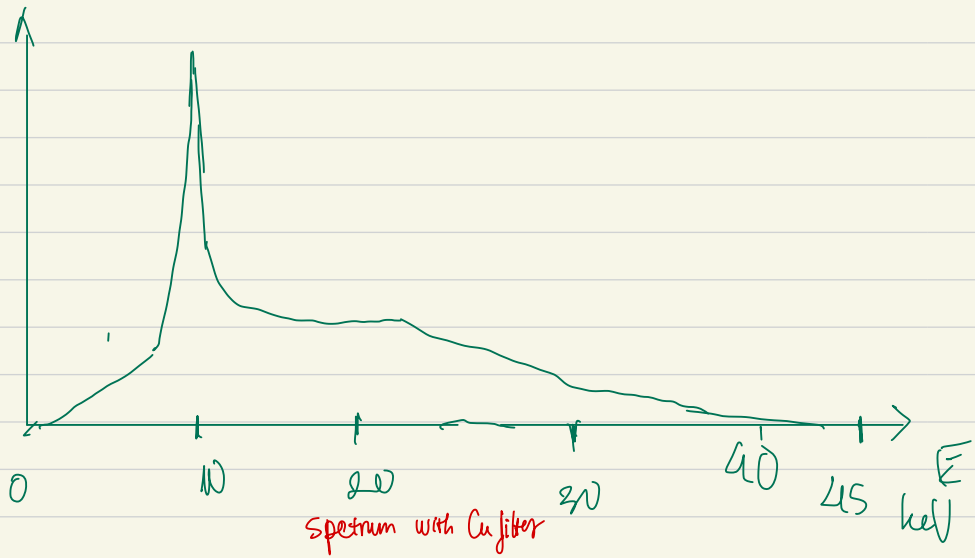
$E_{L-K} = 8.03$ keV

$E_{M_1-K} = 8.86$ keV

$\overline{E_{M_2-K}} = 8.91$ keV



Unfiltered spectrum

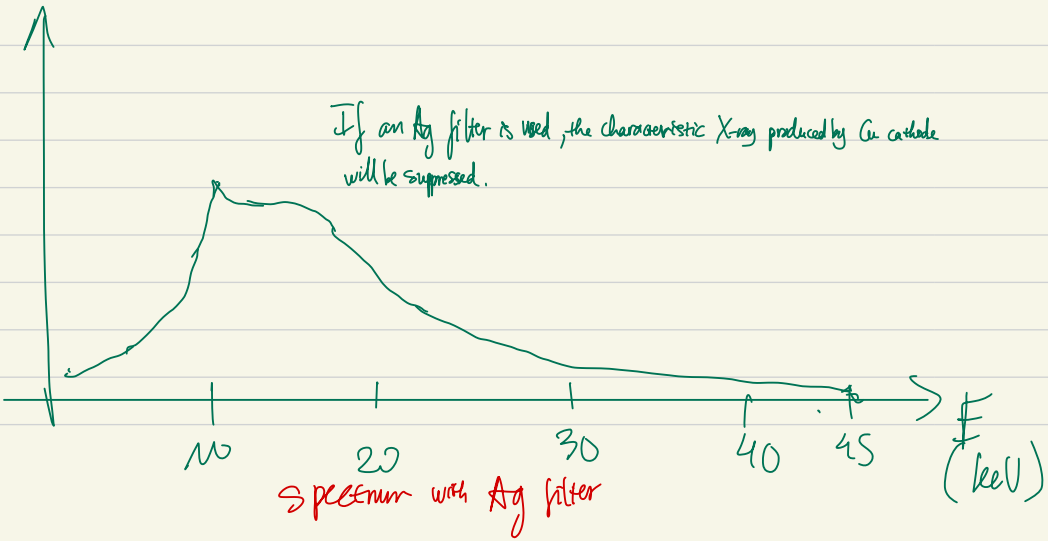


Spectrum with Cu filter

We obtain the unfiltered spectrum due to the combination of Bremsstrahlung effect & characteristic X-rays (caused by the L-K & M-K shell electron transitions).

With the Cu filter we have the attenuation coefficient μ_{Cu} as above, where we have a low-attenuation window right before the K-edge energy.

Thus, we obtain a filtered spectrum that mainly concentrates at Cu L-K energy, and the majority of low & high energy X-rays are eliminated.



Spectrum with Ag filter

3. The *effective dose* is proportional to the ***weighting factors*** for different organs, and the *dose equivalent*. The effective dose is also proportional to the *dose*, thus the X-Ray *exposure*. So based on the table below, given the same *exposure*, greater ***weighting factors*** for organs in the abdomen

Weighting factors for different tissues[12]

Organs	Tissue weighting factors		
	ICRP26 1977	ICRP60 1990[13]	ICRP103 2007[14]
Gonads	0.25	0.20	0.08
Red Bone Marrow	0.12	0.12	0.12
Colon	–	0.12	0.12
Lung	0.12	0.12	0.12
Stomach	–	0.12	0.12
Breasts	0.15	0.05	0.12
Bladder	–	0.05	0.04
Liver	–	0.05	0.04
Oesophagus	–	0.05	0.04
Thyroid	0.03	0.05	0.04
Skin	–	0.01	0.01
Bone surface	0.03	0.01	0.01
Salivary glands	–	–	0.01
Brain	–	–	0.01
Remainder of body	0.30	0.05	0.12
Total	**1.00**	**1.00**	**1.00**

2. The intensifying screen exists to improve the absorption efficiency compared to having only the film, where only 2% of incoming Xray will contribute to the output image. However, X-ray photons going through the intensifier will be scattered in all directions. Thus the **thicker** the intensifier, the smoother the light spot we receive on the film, and consequently **more** image **blurring**.