



The primary air kerma standards for ^{60}Co and ^{137}Cs in the Netherlands

NMI, Van Swinden Laboratorium,

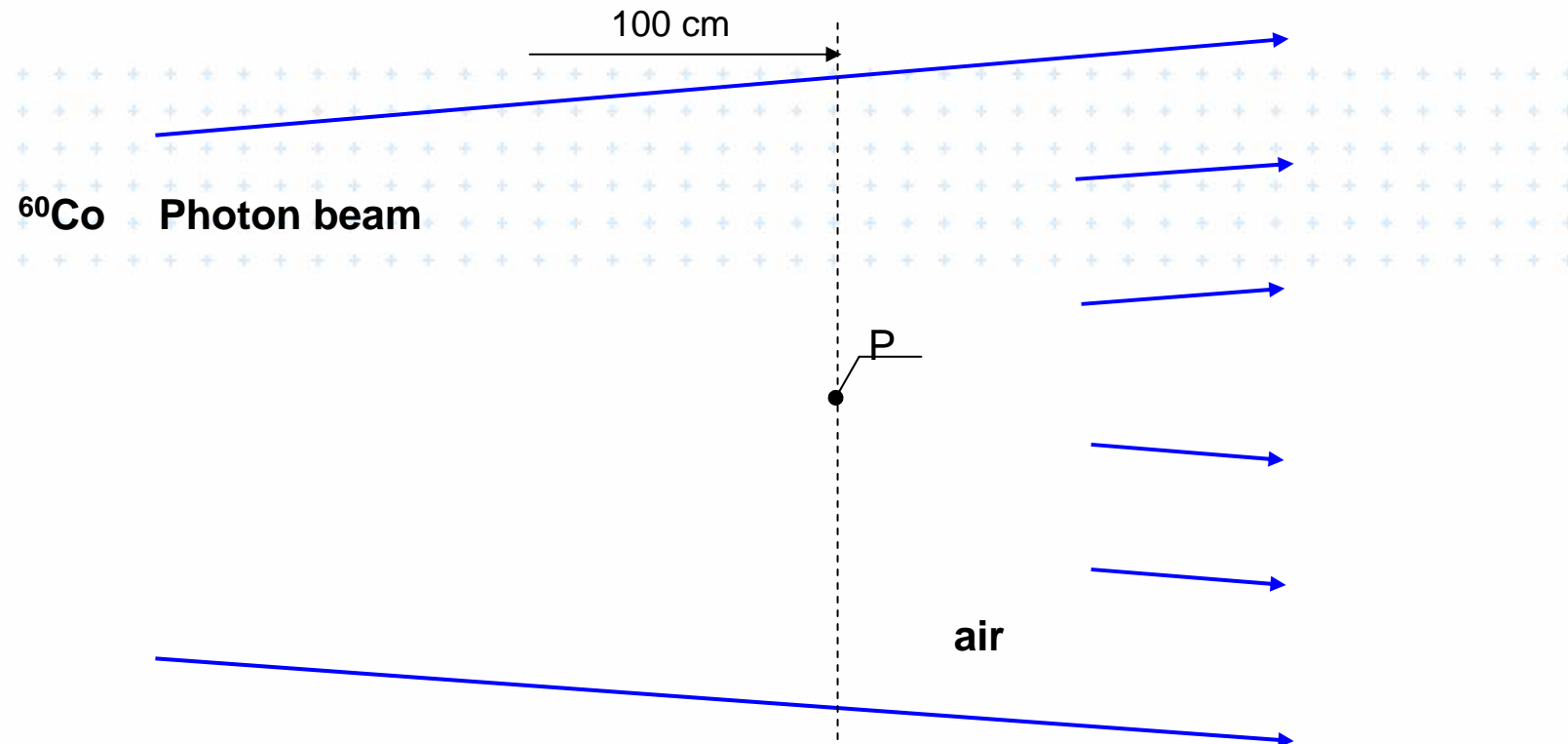
Eduard van Dijk

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Content

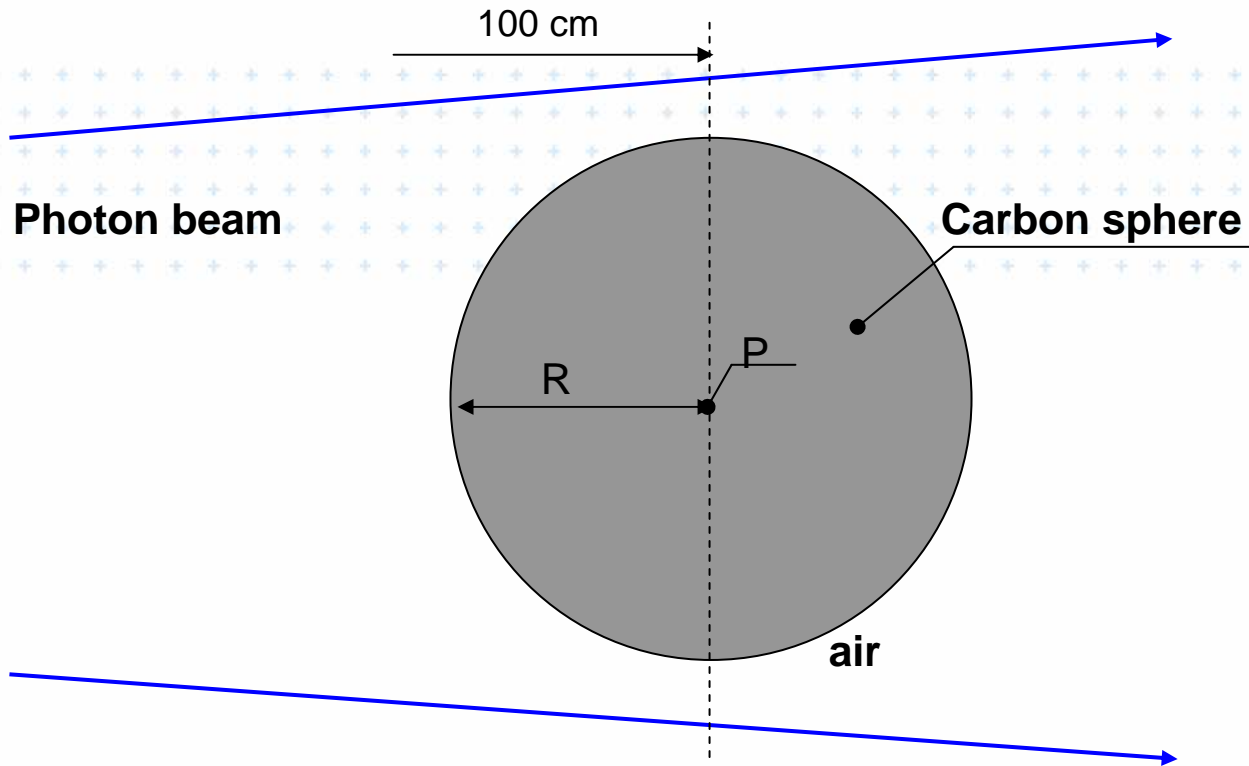
- K_{wall} determination by extrapolation measurements
- K_{wall} determination by Monte Carlo calculation
- Results NMI ^{60}Co
- Results NMI ^{137}Cs (preliminary)

The primary air kerma standard



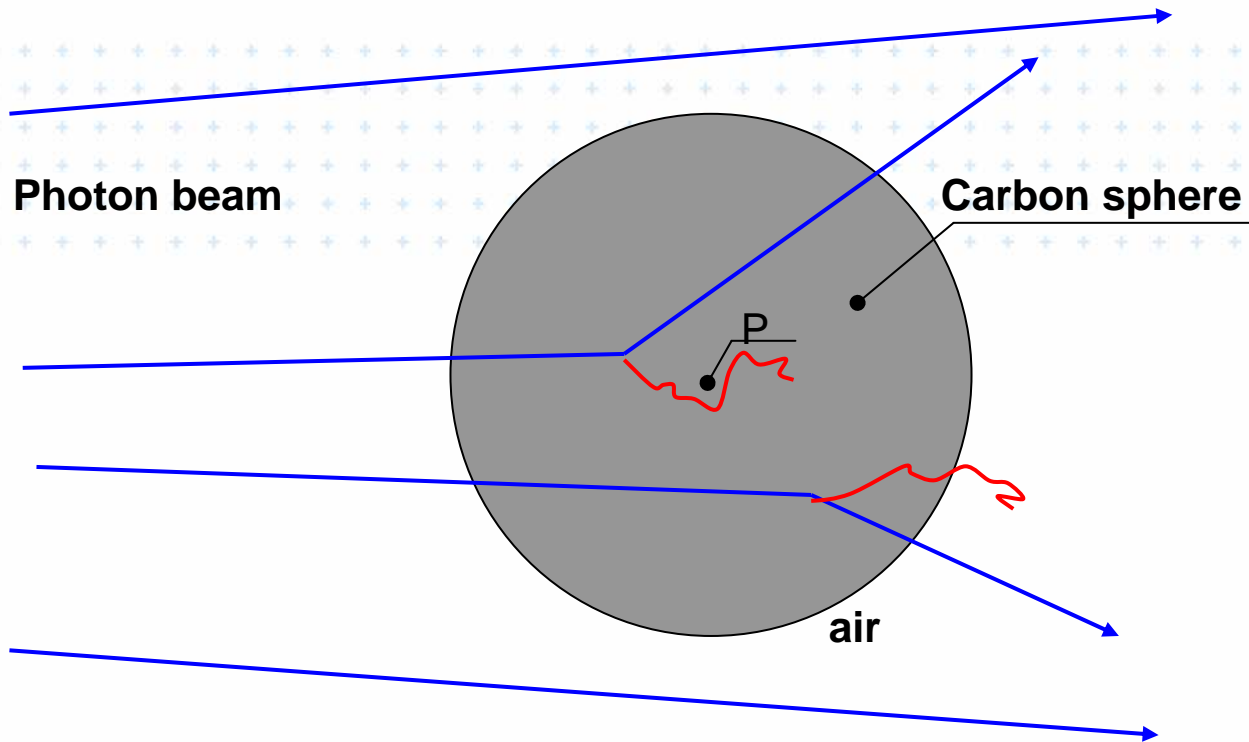
$K_{\text{air}(p)}$: Kerma to air = $\frac{dE}{dm_{\text{air}}}$ (J/kg) at point p

The primary air kerma standard



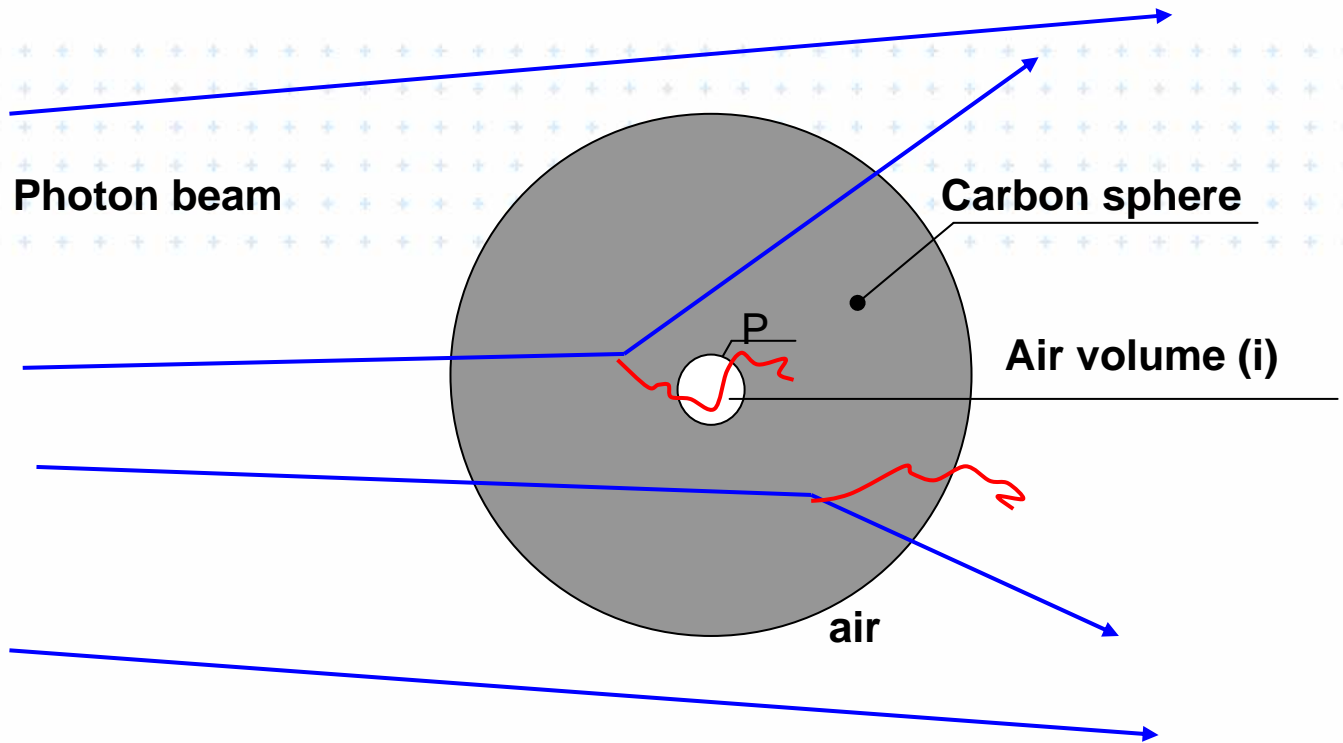
$K_{\text{air}(p)}$: Kerma to air = $\frac{dE}{dm_{\text{air}}}$ (J/kg) at point p

The primary air kerma standard



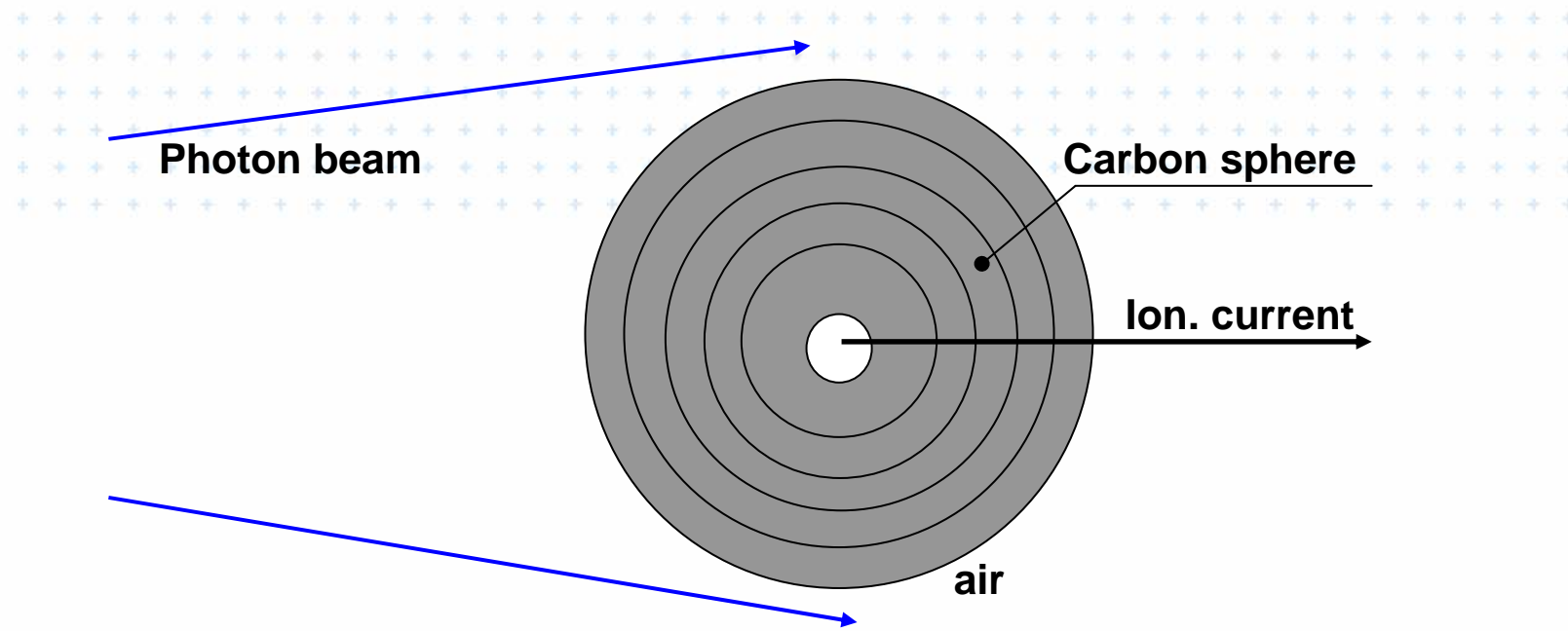
$K_{\text{air}(p)}$: Kerma to air = $\int E / m_{\text{air}}$ (J/kg) at point p

The primary air kerma standard

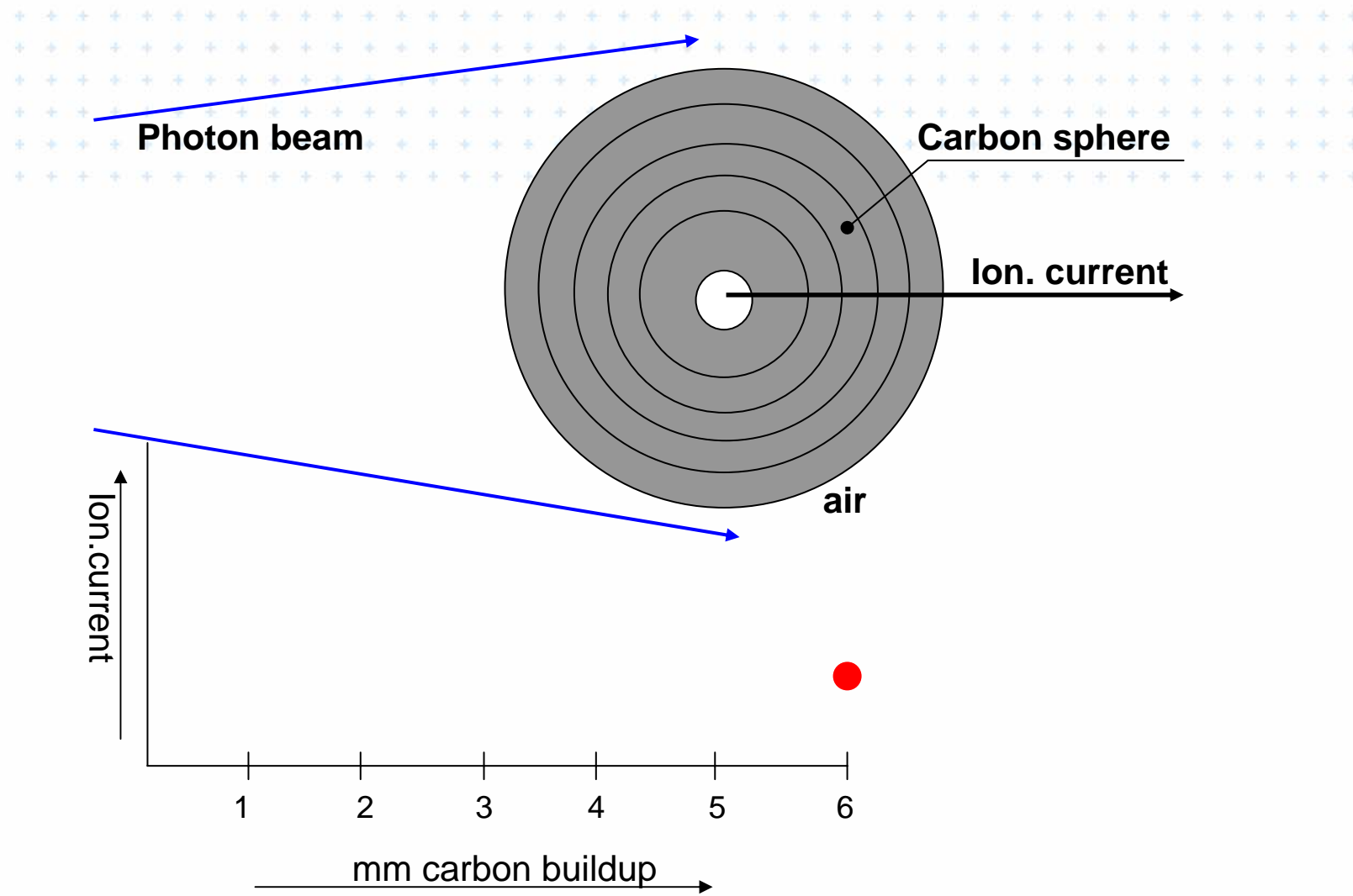


$$K_a = \frac{i}{V \cdot \rho_{air}} \cdot \frac{\bar{W}}{e} \cdot \left(\frac{\mu_{en}}{\rho} \right)_C^{air} \cdot \left(\frac{S}{\rho} \right)_{air}^C \cdot k(sc + att \text{ carbon}) \cdot \prod k_j$$

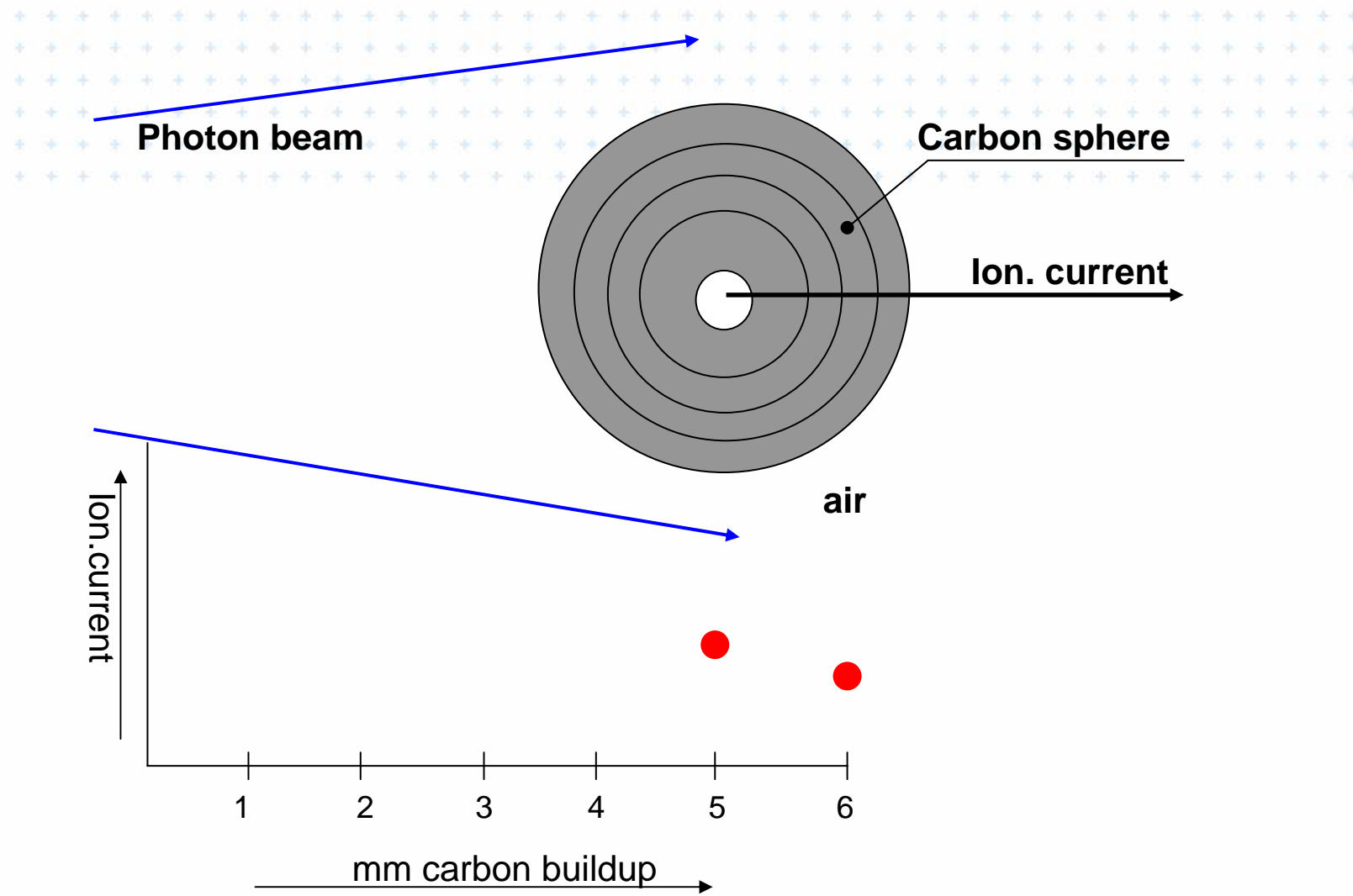
Correction for attenuation and scatter



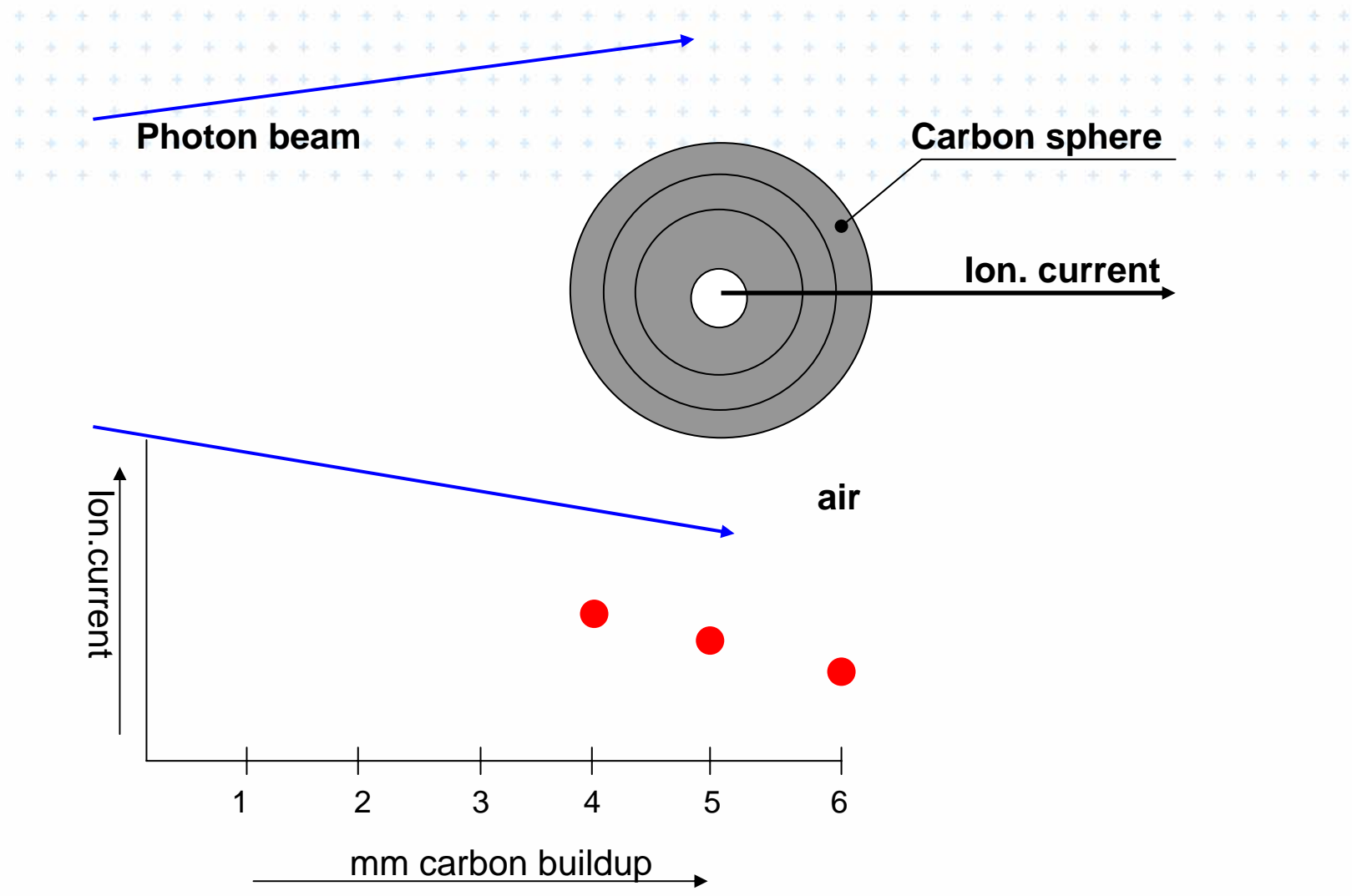
Correction for attenuation and scatter



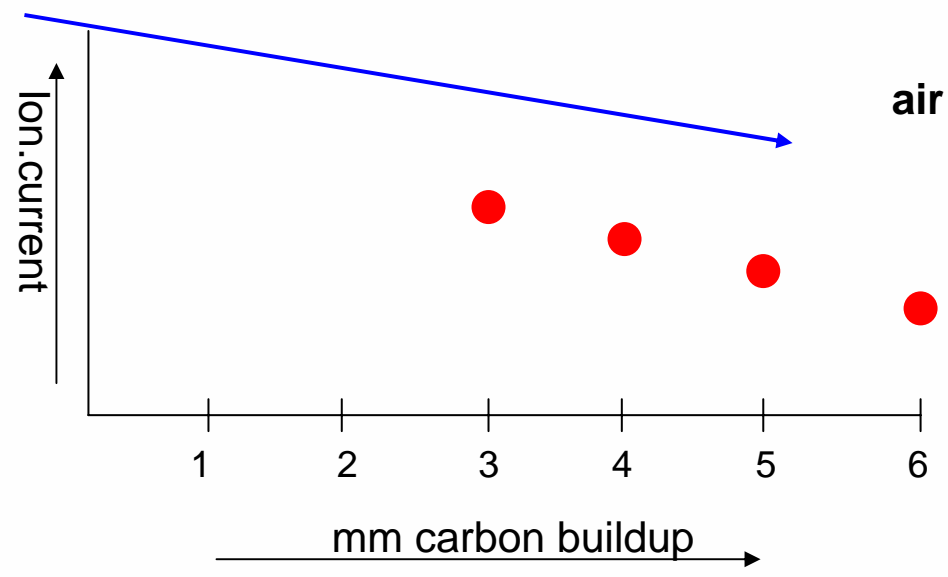
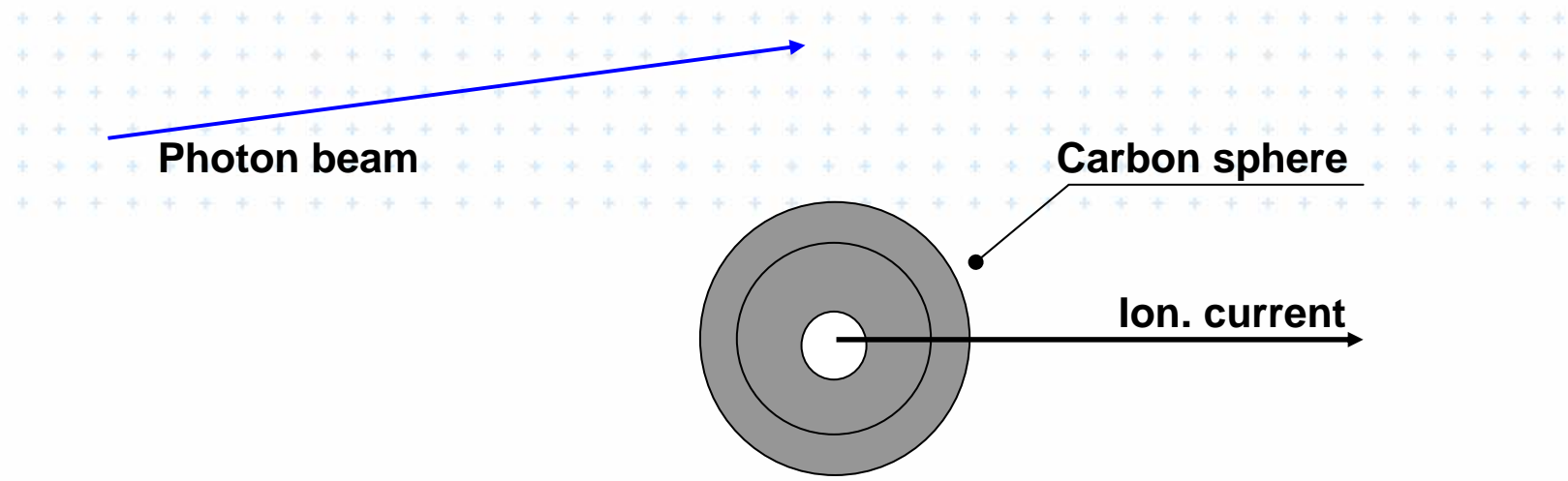
Correction for attenuation and scatter



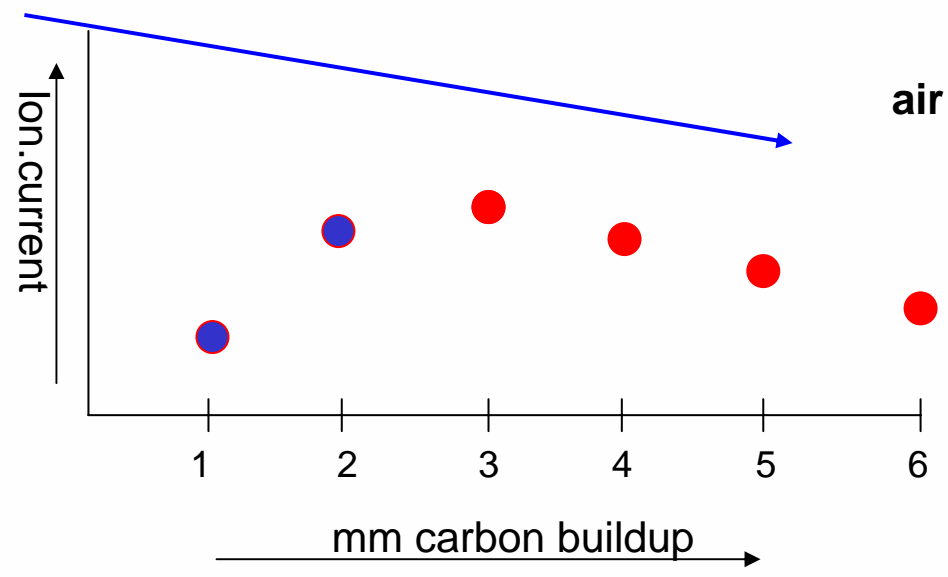
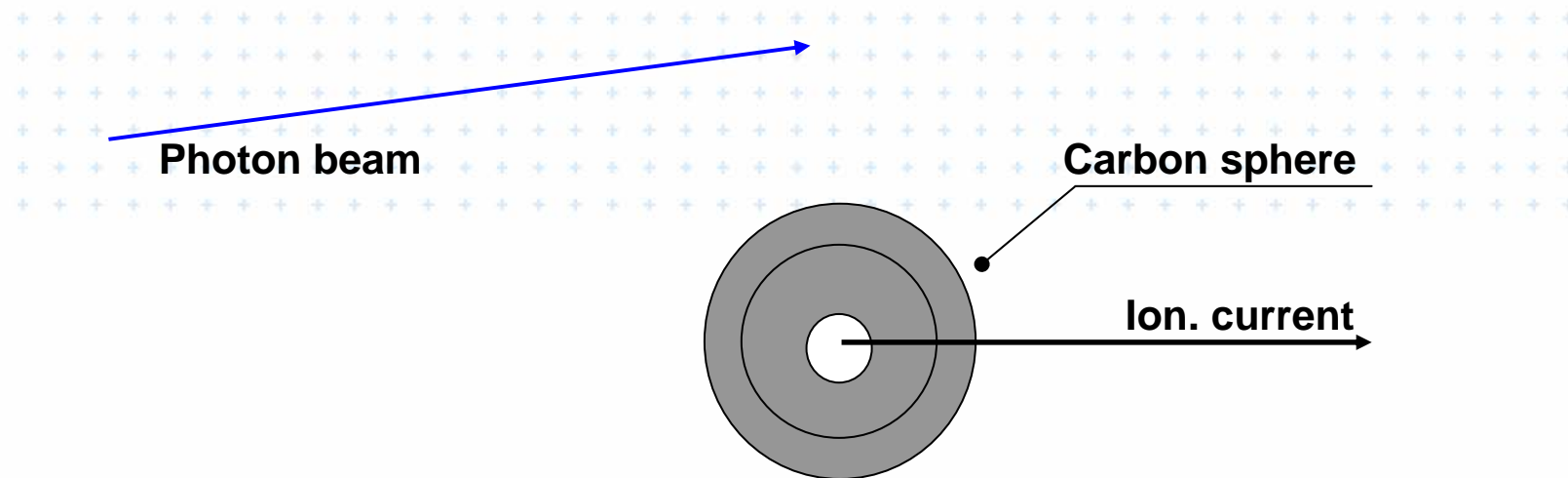
Correction for attenuation and scatter



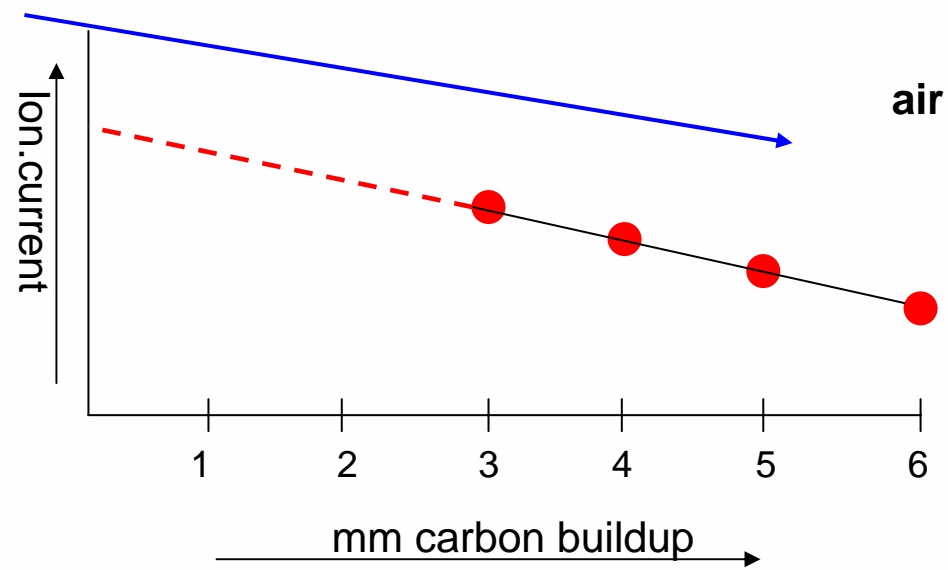
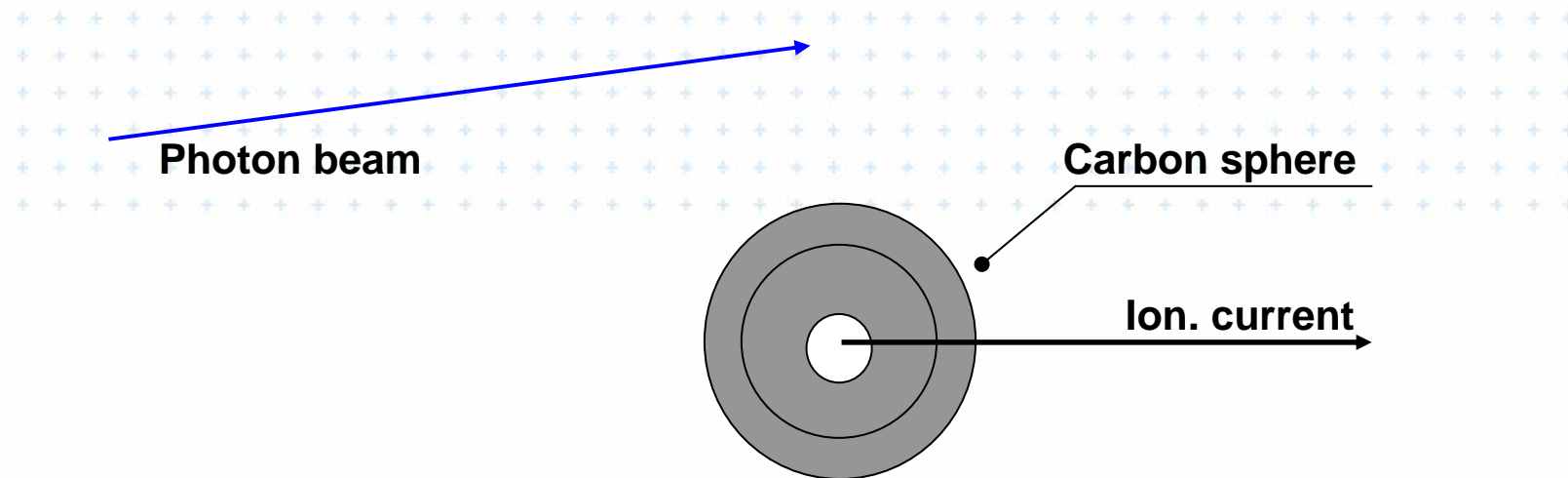
Correction for attenuation and scatter



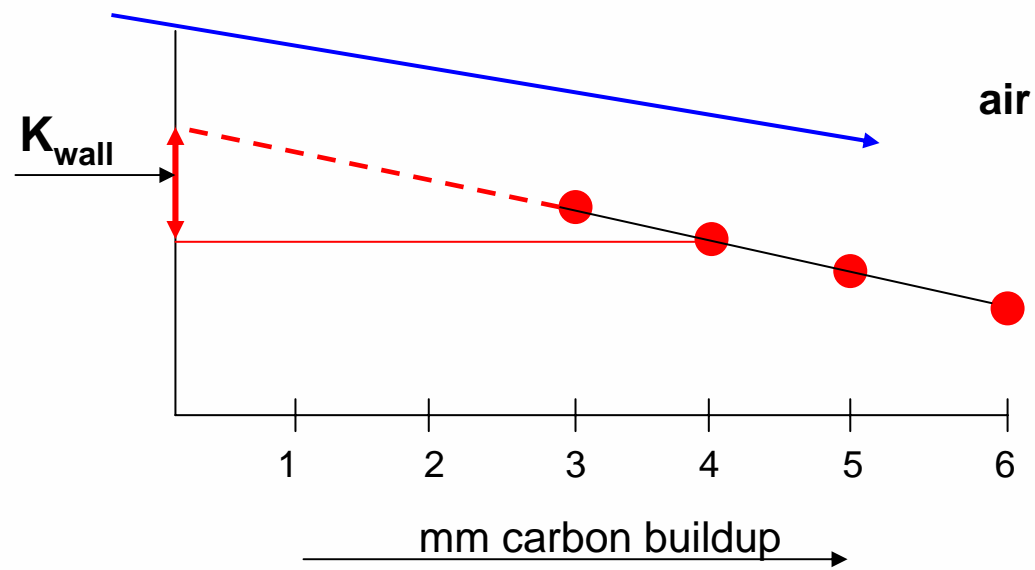
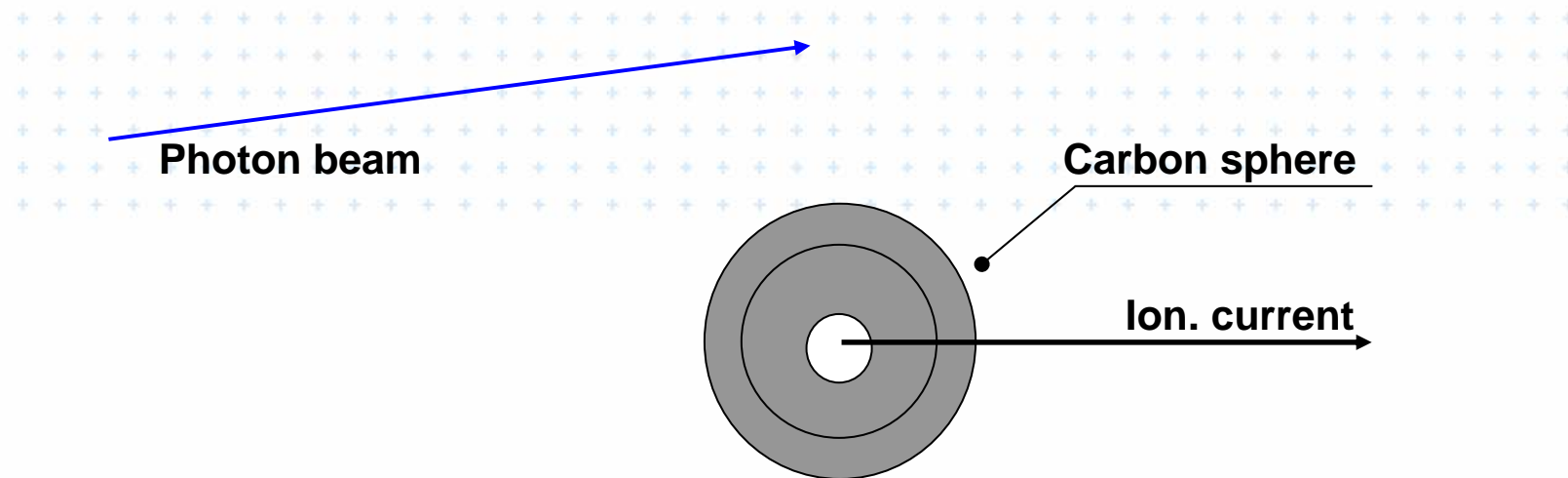
Correction for attenuation and scatter



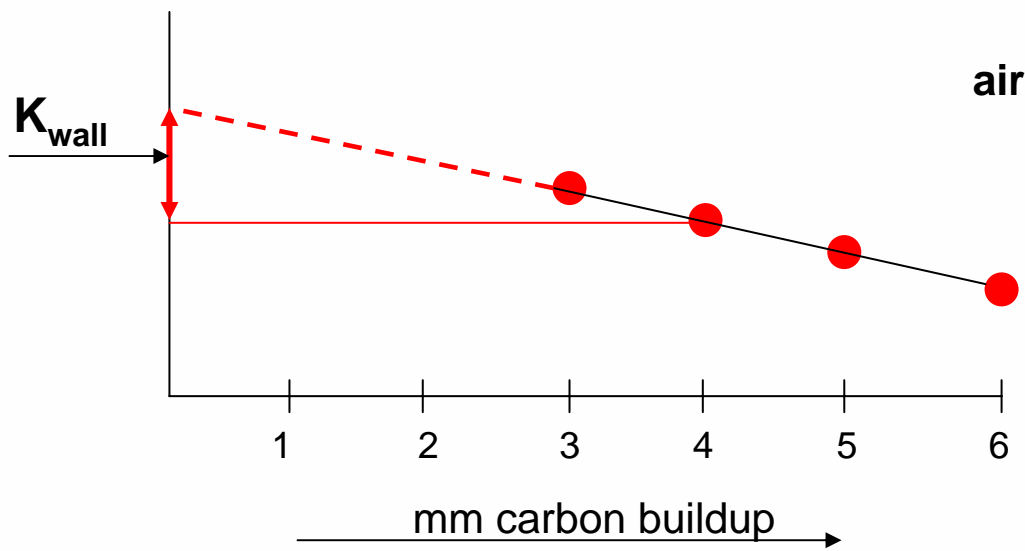
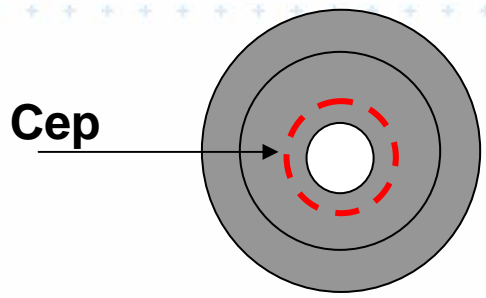
Correction for attenuation and scatter



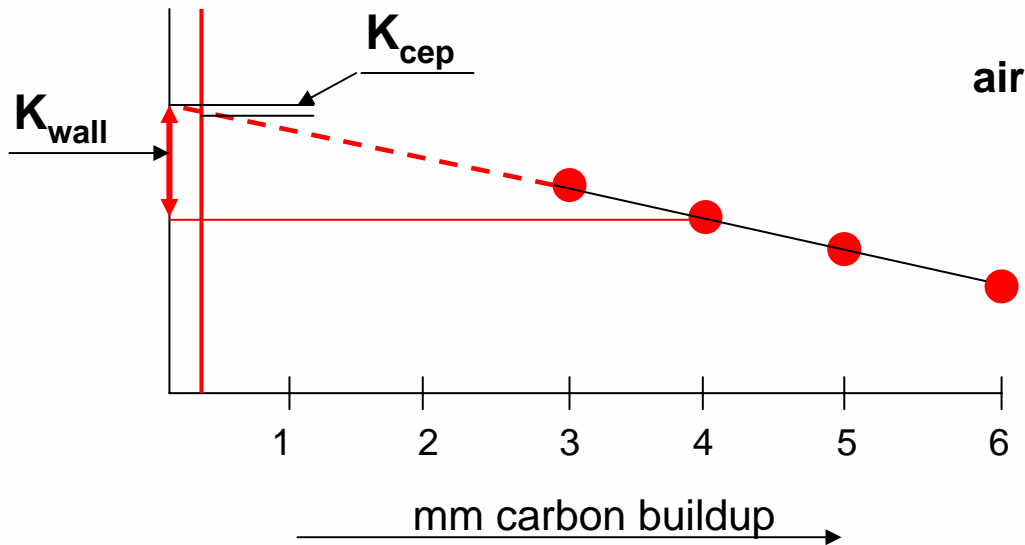
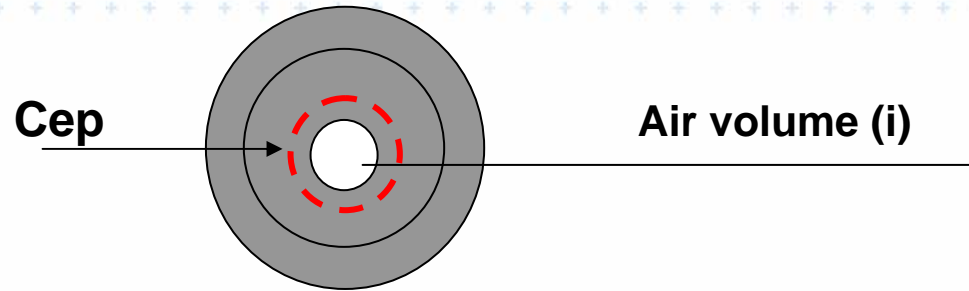
Correction for attenuation and scatter



Mean center of electron production



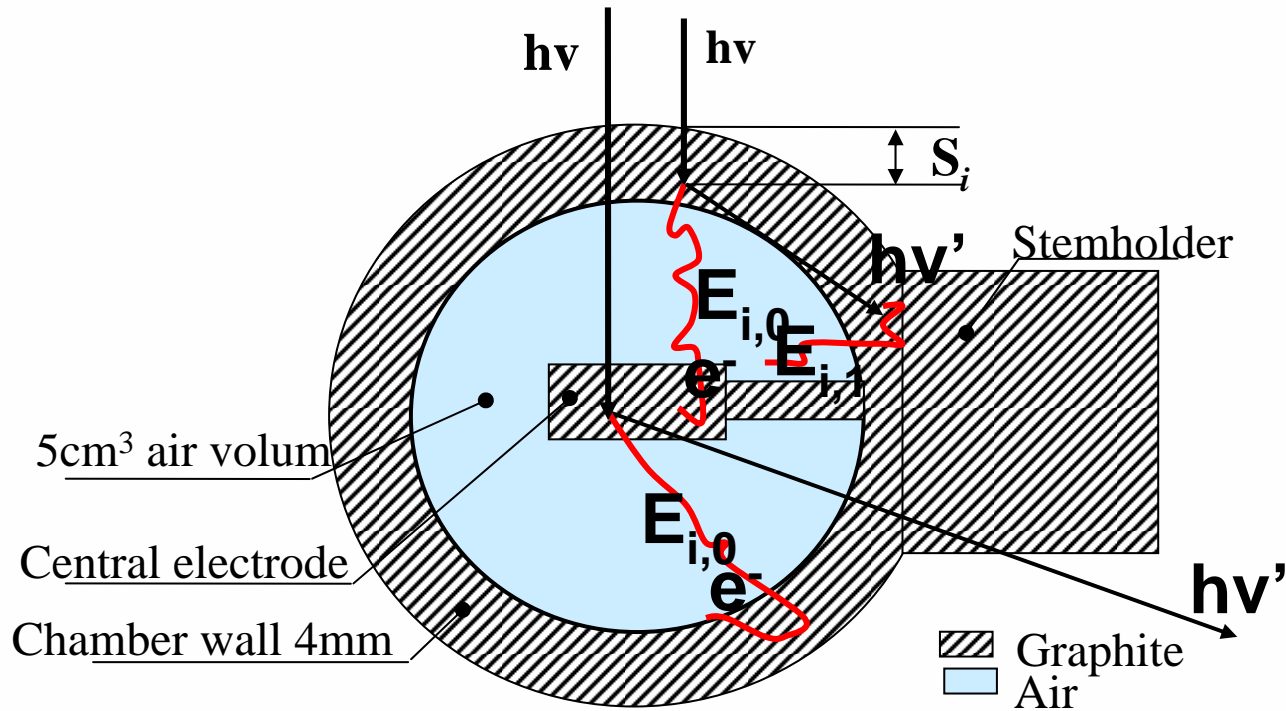
Mean center of electron production



5 cm³ spherical standard

$$k_{\text{att}} = \frac{\sum_i E_{i,0} \cdot e^{\mu_i s_i}}{\sum_i E_{i,0}}$$

$$k_{\text{sc}} = \frac{\sum_i E_{i,0}}{\sum_i (E_{i,0} + E_{i,1})}$$

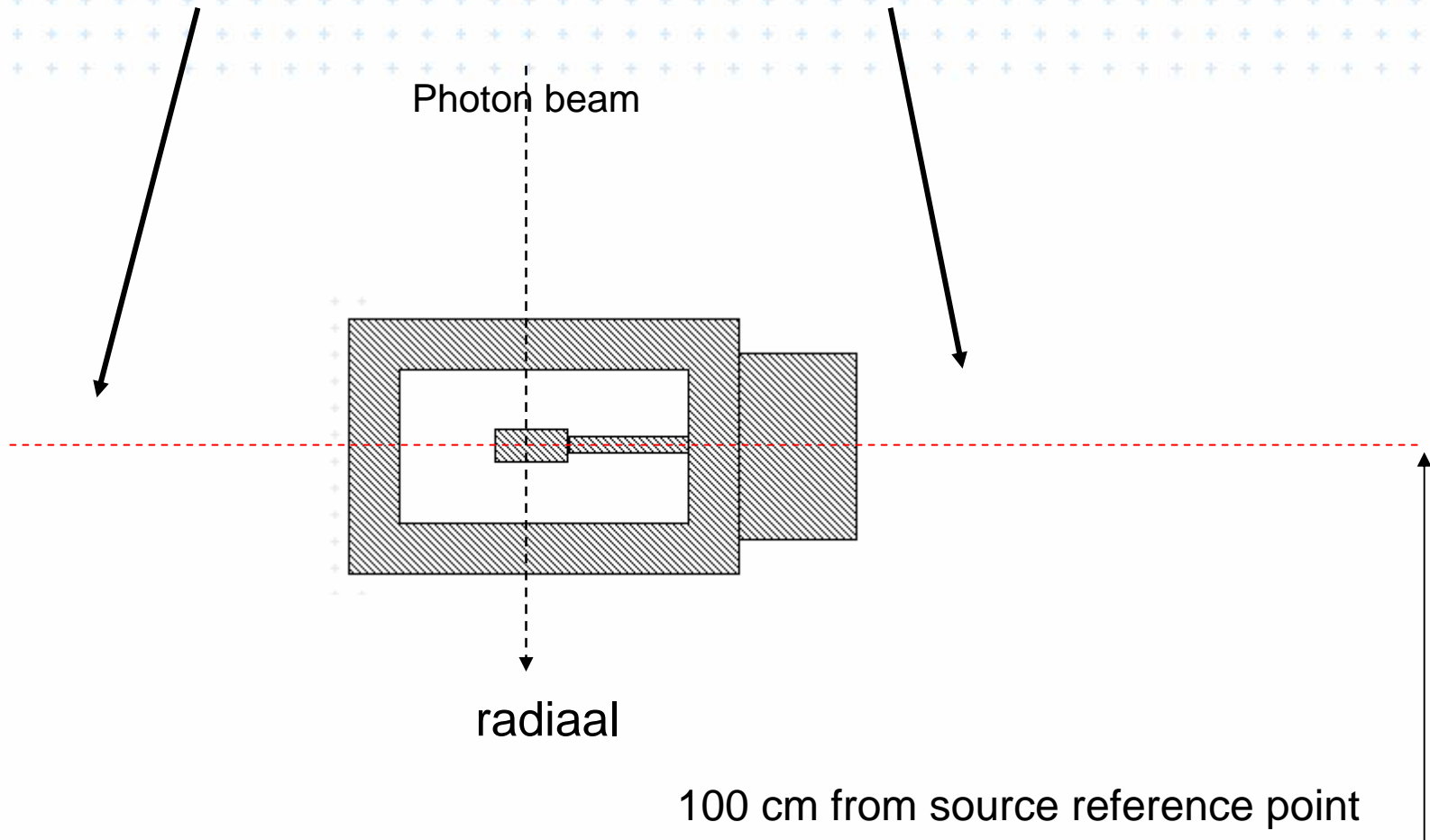


$$K_{\text{wall}} = K_{\text{att}} \cdot K_{\text{sc}}$$

MC calculation of attenuation and scatter

2.5 cm³ cylindrical standard

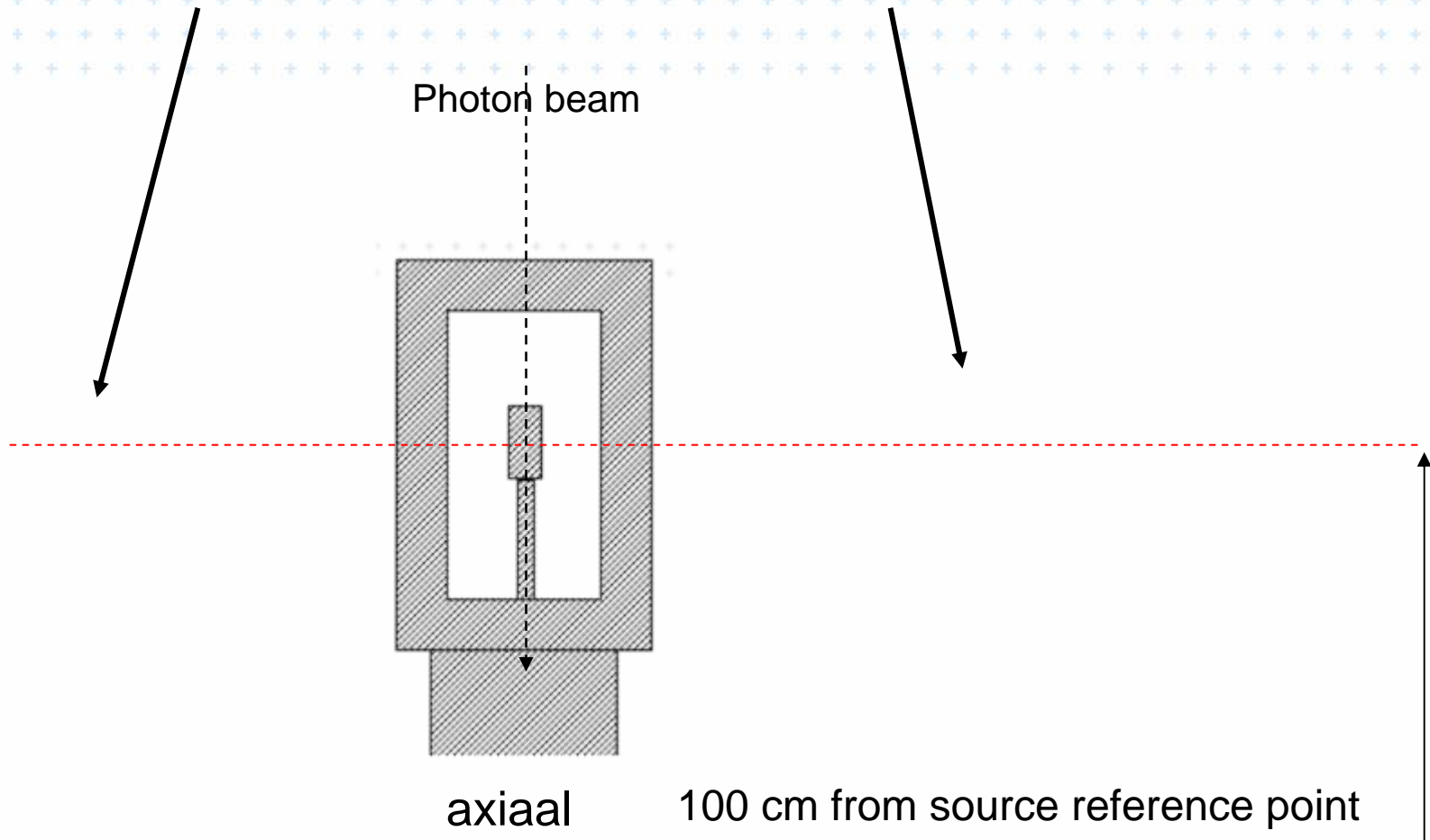
Radial orientation calculated with:
3mm, 4mm, 5mm and 6mm wall thickness



MC calculation of attenuation and scatter

2.5 cm³ cylindrical standard

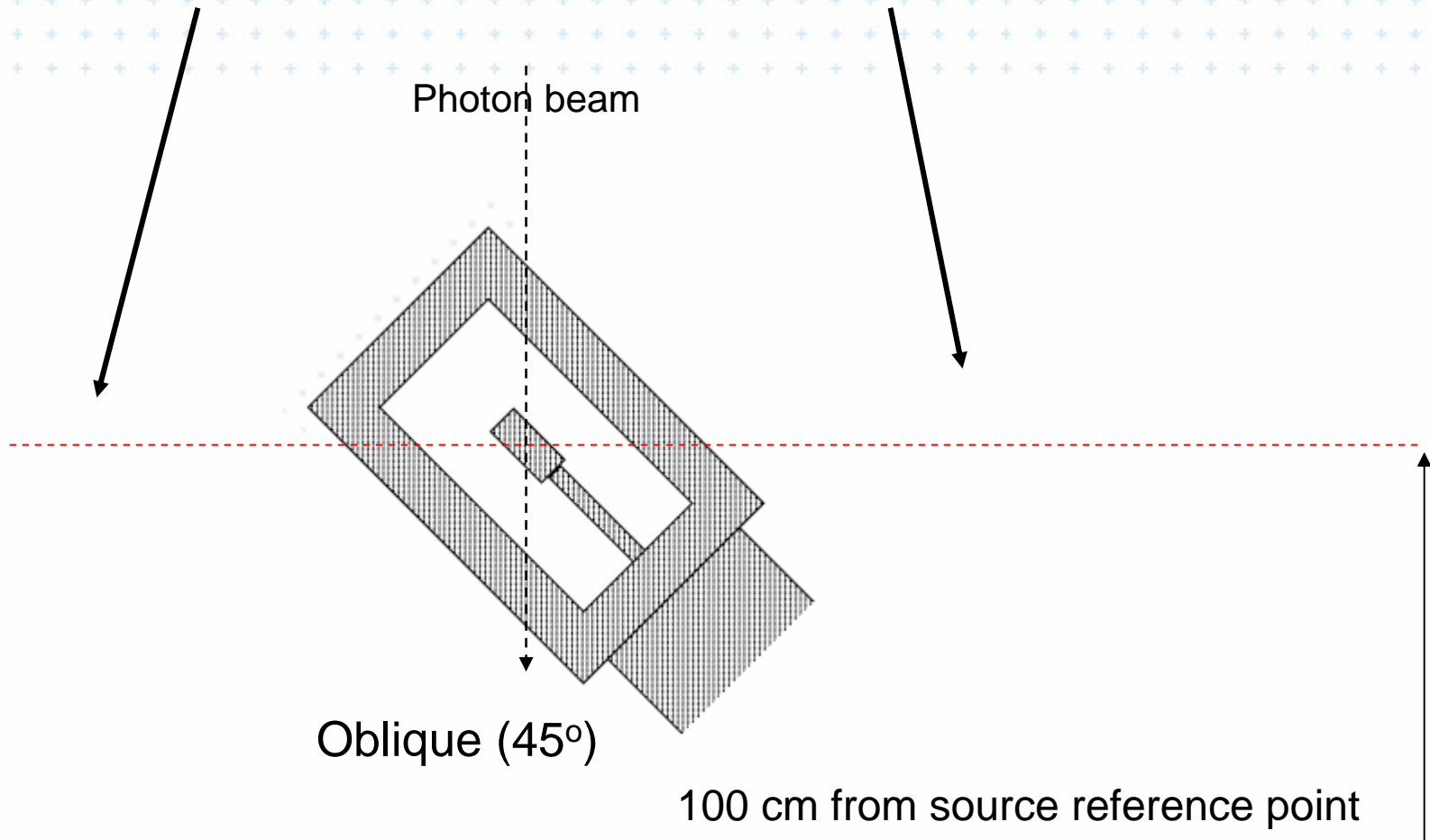
Axial orientation calculated with:
3mm, 4mm, 5mm and 6mm wall thickness



MC calculation of attenuation and scatter

2.5 cm³ cylindrical standard

Oblique orientation calculated with:
3mm, 4mm, 5mm and 6mm wall thickness



Gammatron3 ^{60}Co radiator head



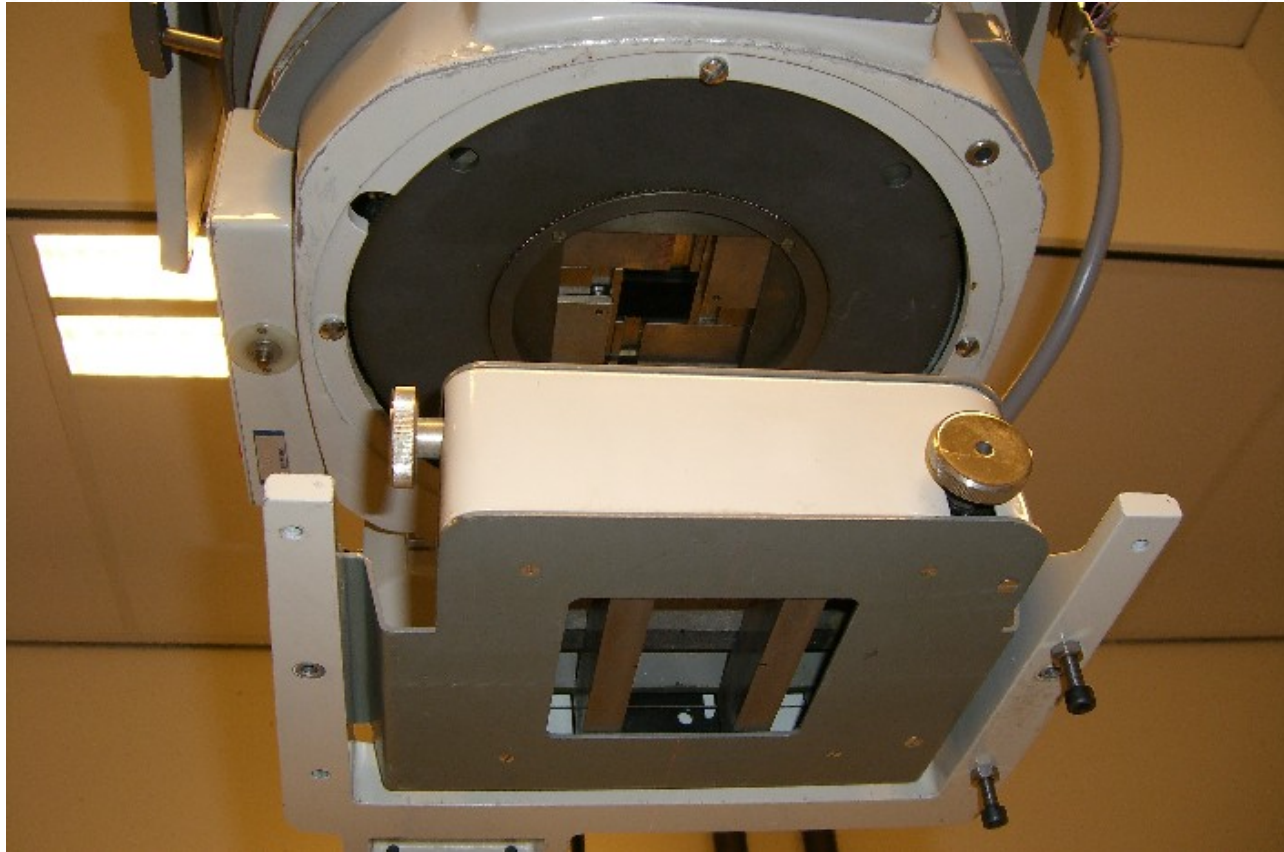
60Co source holder

Set diaphragm

Beam sharpener

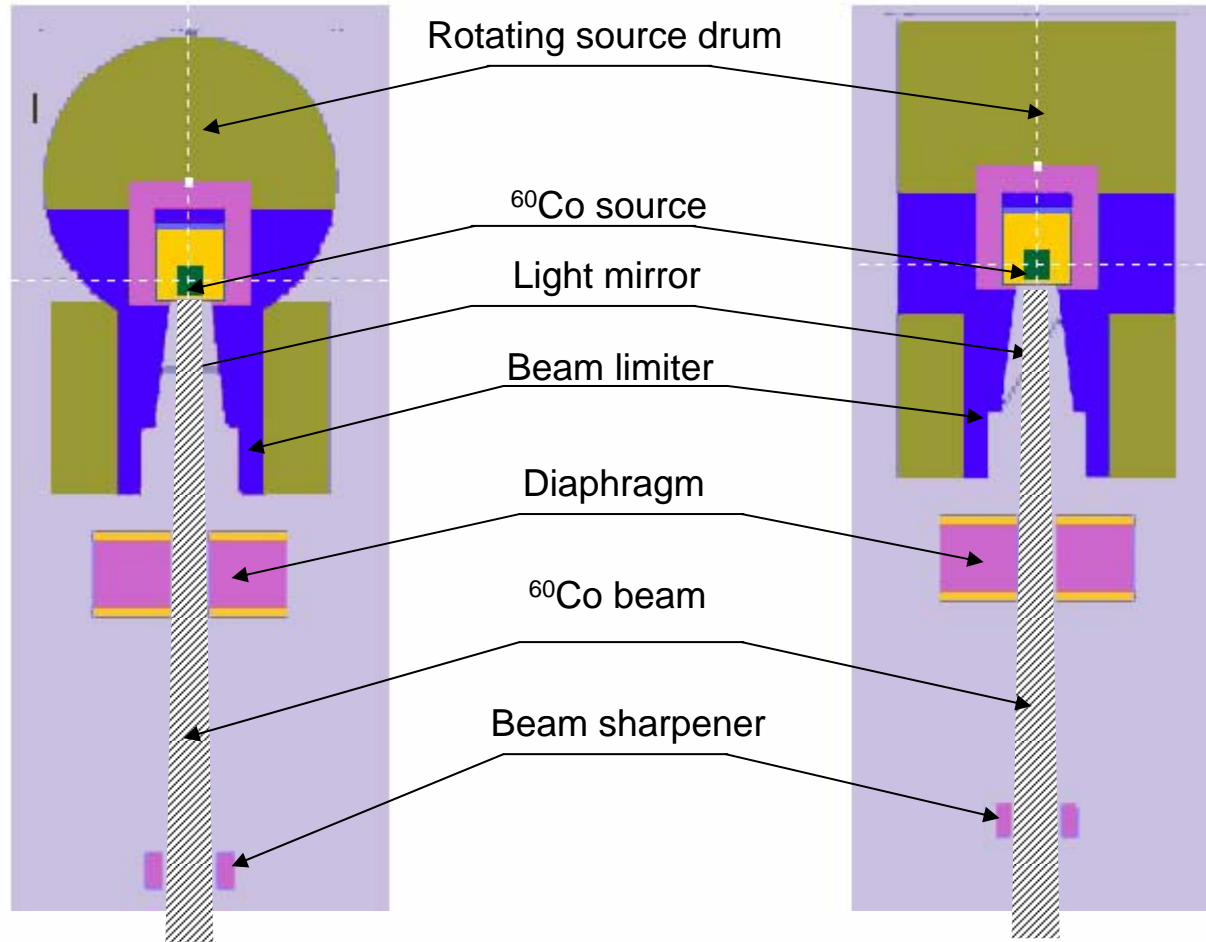
5 cm3 NMI standard

Diaphragm and beamsharpenener Gammatron3

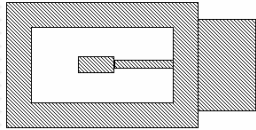


MC simulation Gammatron3 radiation head

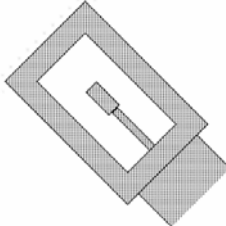
- Uranium
- Stainless steel
- Lead
- Tungsten

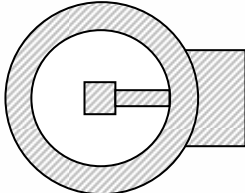


Results ^{60}Co measurements and calculations

Standard	Orientation	Wall thickness	K_{wall}	I_{measured} (pA)	K (Gy/h)
2.5 cm ³		3 mm	1.0111	802.06	34.058
		4 mm	1.0151	798.04	34.024
		5 mm	1.0193	794.38	34.006
		6 mm	1.0232	790.72	33.979

Standard	Orientation	Wall thickness	K_{wall}	I_{measured} (pA)	K (Gy/h)
2.5 cm ³		3 mm	1.0491	774.11	34.109
		4 mm	1.0510	772.64	34.104
		5 mm	1.0545	769.66	34.088
		6 mm	1.0563	767.07	34.030

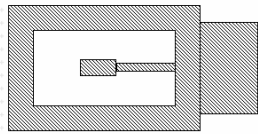
Standard	Orientation	Wall thickness	K_{wall}	I_{measured} (pA)	K (Gy/h)
2.5 cm ³		3 mm	-	-	-
		4 mm	1.0255	790.30	34.037
		5 mm	1.0345	784.11	34.065
		6 mm	1.0409	778.50	34.033

Standard	Orientation	Wall thickness	K_{wall}	I_{measured} (pA)	K (Gy/h)
5 cm ³		4 mm	1.0214	1581.12	34.019

Results ⁶⁰Co measurements and calculations

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

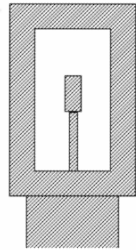
5 mm

6 mm

Average: **34.017 Gy/h** st.dev. 0.1%

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

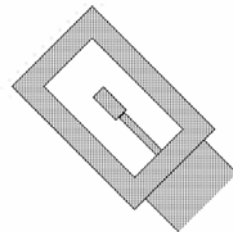
5 mm

6 mm

Average: **34.083 Gy/h** st.dev. 0.1%

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

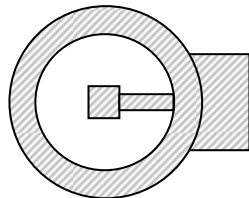
5 mm

6 mm

Average: **34.045 Gy/h** st.dev. 0.1%

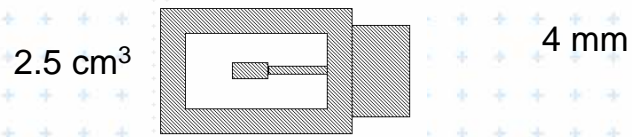
Standard Orientation Wall thickness

5 cm³

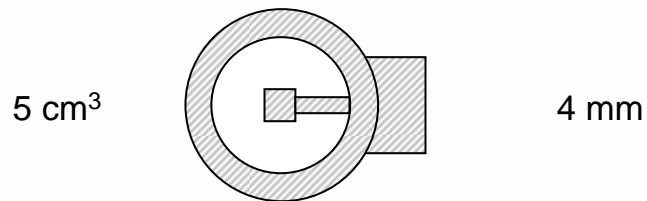


4 mm

34.019 Gy/h st.dev. 0.1%

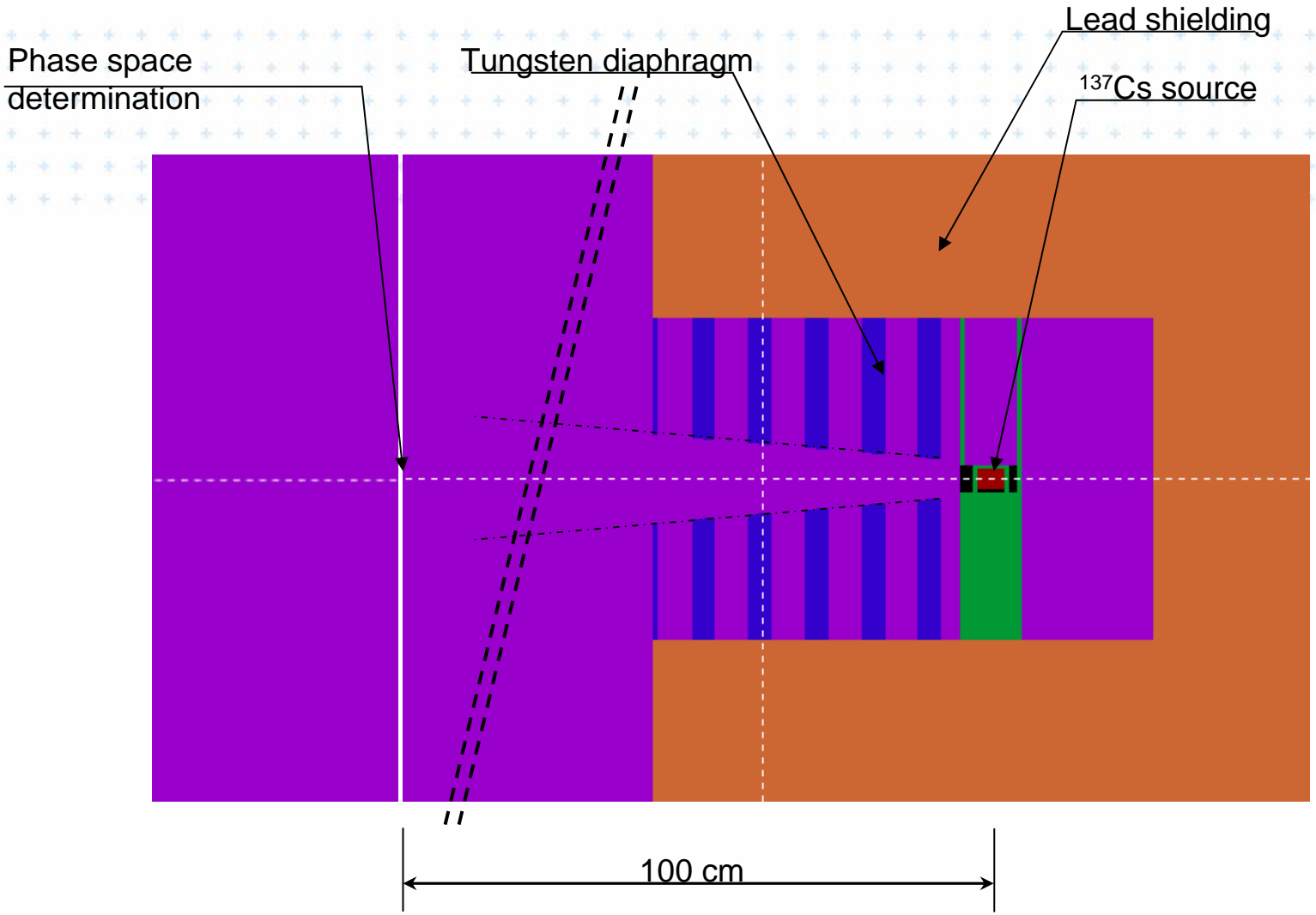


**Ratio 5 cm³ and 2.5 cm³ = 1.0002,
with an expanded uncertainty of 0.36 % (coverage factor k = 2).**





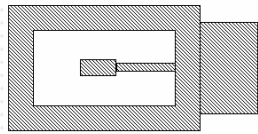




Results ¹³⁷Cs measurements and calculations

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

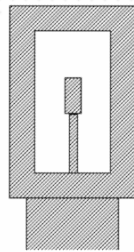
5 mm

6 mm

Average: **21.396 Gy/h st.dev. 0.1%**

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

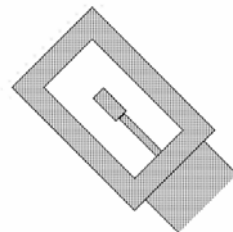
5 mm

6 mm

Average: **21.441 Gy/h st.dev. 0.1%**

Standard Orientation Wall thickness

2.5 cm³



3 mm

4 mm

5 mm

6 mm

Average: **21.462 Gy/h st.dev. 0.1%**

Average ¹³⁷Cs 2.5 cm³ = 21.433 Gy/h (1m STP)

with an expanded uncertainty of 0.60 % (coverage factor k = 2).