X-ray absorption in a GEM:

- ✓Production of X-ray
- ✓ X-ray absorbsion in GEM detectors
- ✓Calculation of Charge – up effect
- ✓Calibration of single GEM

23-11-2011, RD51 miniweek

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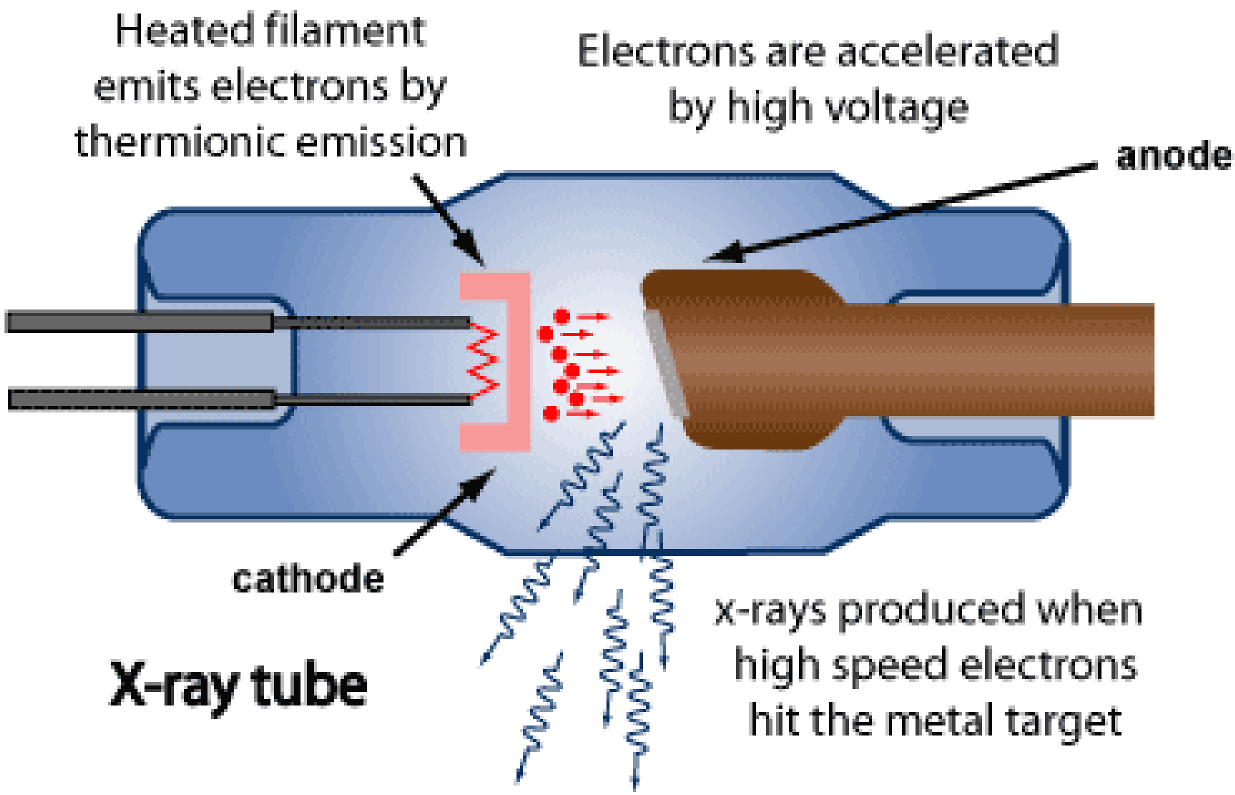
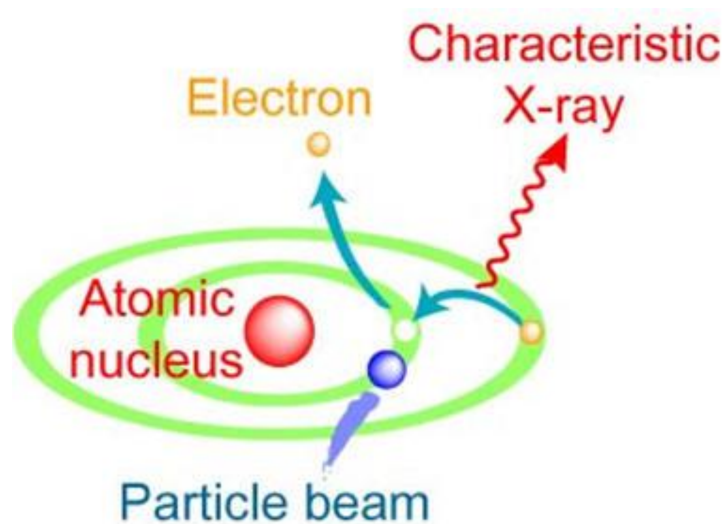
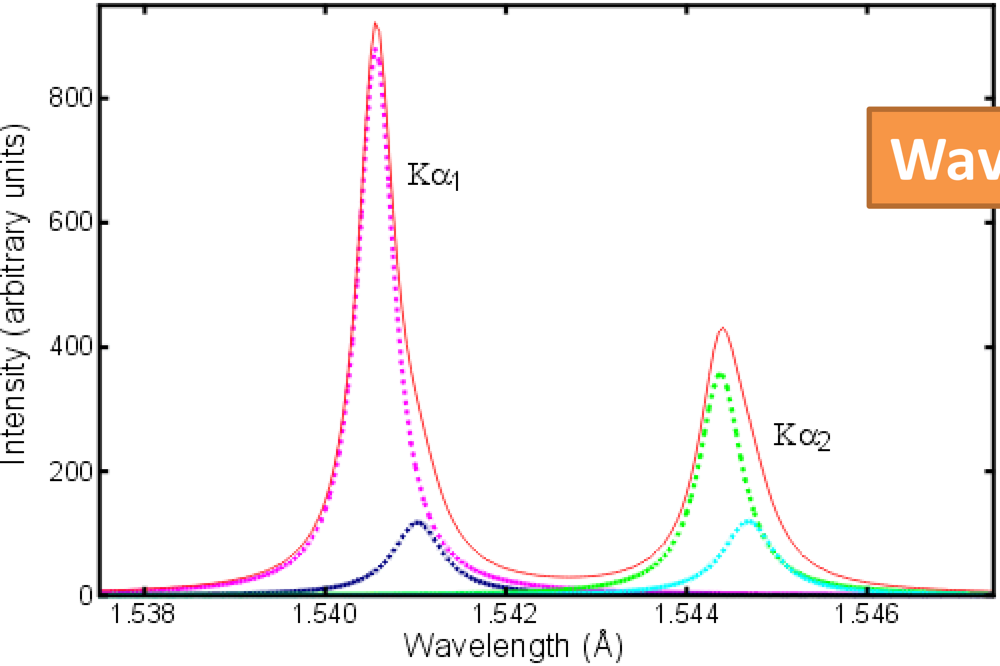
Production of X-ray



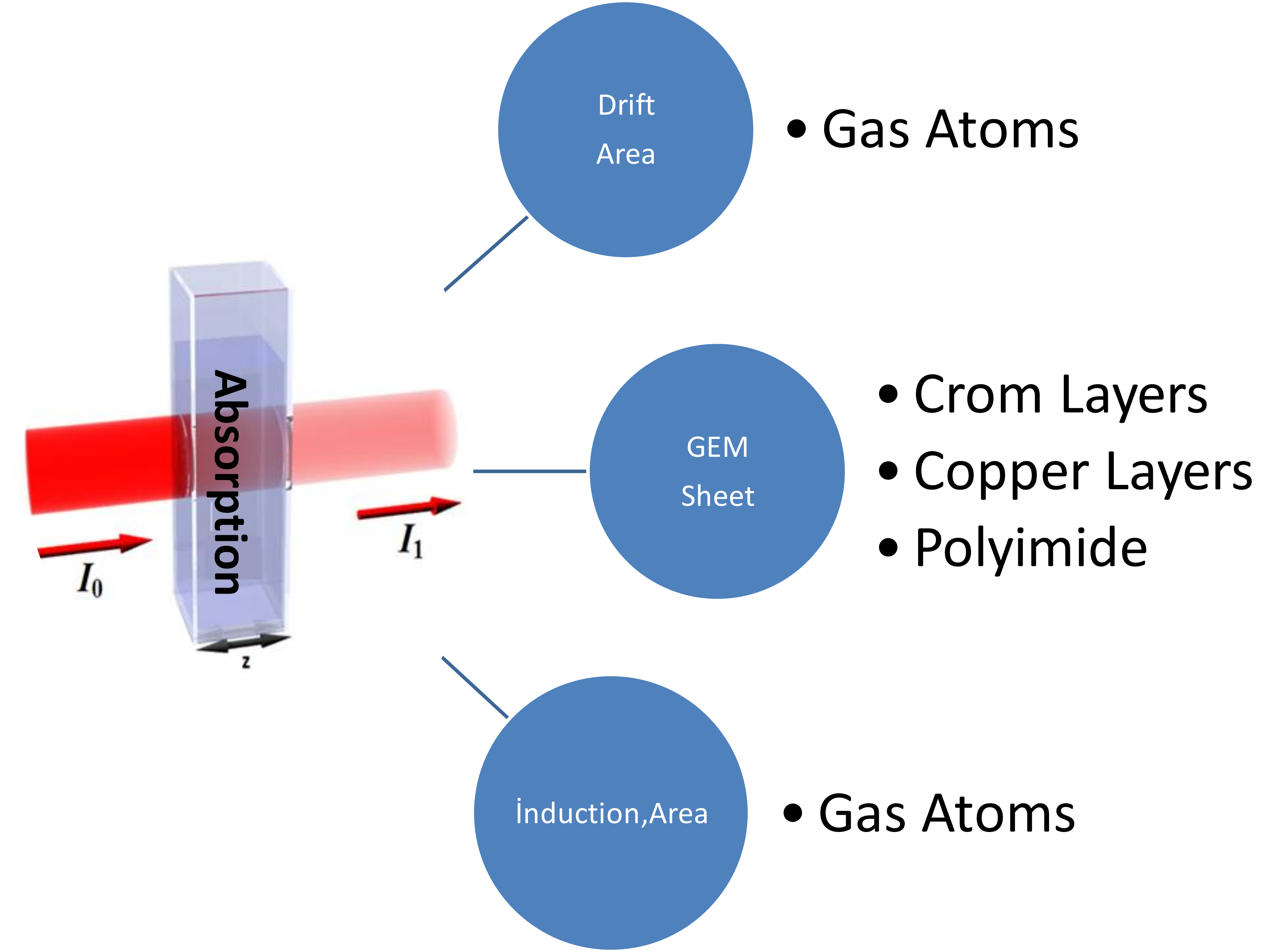


Energy of X-ray photon



Wavelength of X-ray photon ≈ 1.541 A

Energy of X-ray photon ≈ 8 keV



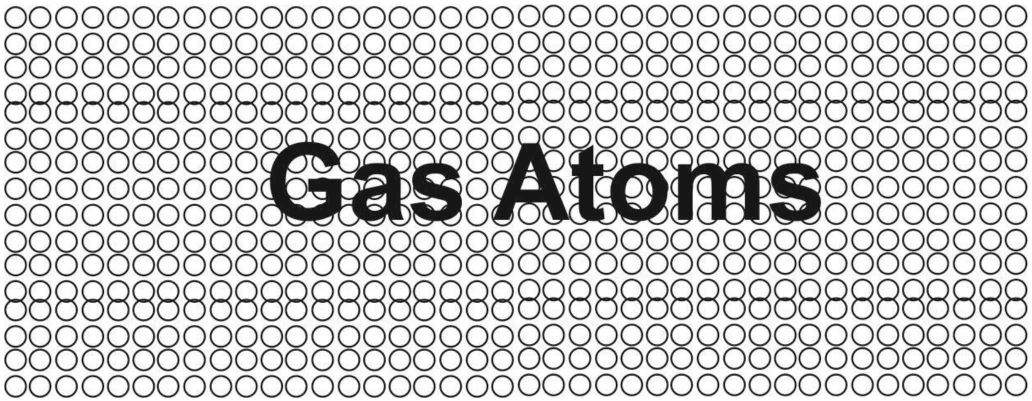
Absorption
I_0
I_1
z
Drift
Area
• Gas Atoms
GEM
Sheet
• Crom Layers
• Copper Layers
• Polyimide
İnduction,Area
• Gas Atoms

Expanential Absorption

$$I_z = I_0 \cdot e^{-z/z_0}$$

$$\frac{1}{z_0} = \rho \times \mu$$

Absorption of Gas Atoms



$$\frac{1}{z_0} = \rho_{gaz} \times \mu_{gaz}$$

$$\rho_{gaz} = \frac{M.P}{R.T}$$

$M_{CO_2} =$	44.009 g/mol
$M_{Ar} =$	39.948 g/mol
$P_{gas} =$	1 Atm
R =	0,08206 $L.Atm/mole.°K$
T =	295 °F

$$\rho_{CO_2} = \frac{44.009 \times 1}{0{,}08206 \times 295} = 1.82 \times 10^{-3}\ g/cm^3$$

$$\rho_{Ar} = \frac{39.948 \times 1}{0{,}08206 \times 295} = 1.65 \times 10^{-3}\ g/cm^3$$

Attenuation Coefficient of Argon

$$\mu_{Ar} = 118\ cm^3/g$$

Attenuation Coefficient of Carbondioxide

$$\mu_C = 4.58\ cm^2/g \qquad \mu_{O_2} = 11.63\ cm^2/g$$

$$\mu_{CO_2} = \mu_C \times \frac{M_C}{M_{top}} + \mu_{O_2} \times \frac{M_{O_2}}{M_{top}}$$

$$= 4.58 \times \frac{40}{72} + 11.63 \times \frac{32}{72}$$

$$\mu_{CO_2} = 7.71\ cm^2/g$$

Absorption of Unit Distance

$$\frac{1}{z_0} = \rho_{gaz} \times \mu_{gaz} = \frac{90}{100}\mu_{Ar}\rho_{Ar} + \frac{10}{100}\mu_{co_2}\rho_{co_2}$$

$$= \frac{90}{100} \times 1.65 \times 10^{-3} \times 11.63 + \frac{10}{100} 7.71 \times 1.82 \times 10^{-3}$$

$$\frac{1}{z_0} = 0.176 \quad 1/cm$$

Drift Area

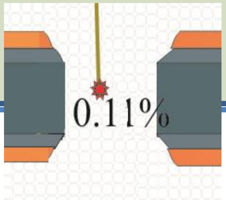
Z = 0.3 cm

$$\frac{I_{z_1}}{I_0} = e^{z/z_0} = e^{0.3\times0.176} = 0.9484$$

İn Hole

Z = 0.006 cm

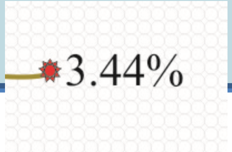
$$\frac{I_{z_1}}{I_0} = e^{z_2/z_0} = e^{6\times10^{-3}\times0.176} = 0.9989$$



İnduction Area

Z = 0.2 cm

$$\frac{I_{z_3}}{I_0} = e^{z_3/z_0} = e^{0.2\times0.176} = 0.9656$$



Absorption of Copper Layer

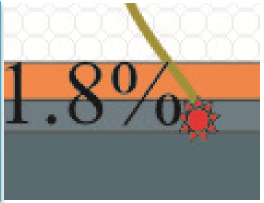
$$\frac{1}{z_0} = \rho_{Cu} \times \mu_{Cu} = 8.96 \times 52.55 = 470.85\ cm^{-1}$$

$$\frac{I_z}{I_0} = e^{-5\times10^{-4}\times470.85} = e^{-0.24} = 0.79$$

Absorption of Crom Layer

$$\frac{1}{z_0} = \rho_{Cr} \times \mu_{Cr} = 7.19 \times 251.3 = 1806.8\ \mathrm{cm}^{-1}$$

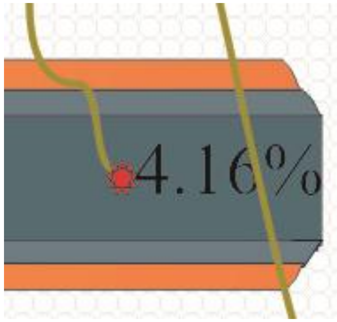
$$\frac{I_z}{I_0} = e^{-1806.8\times10^{-5}} = e^{-0.018} = 0.982$$

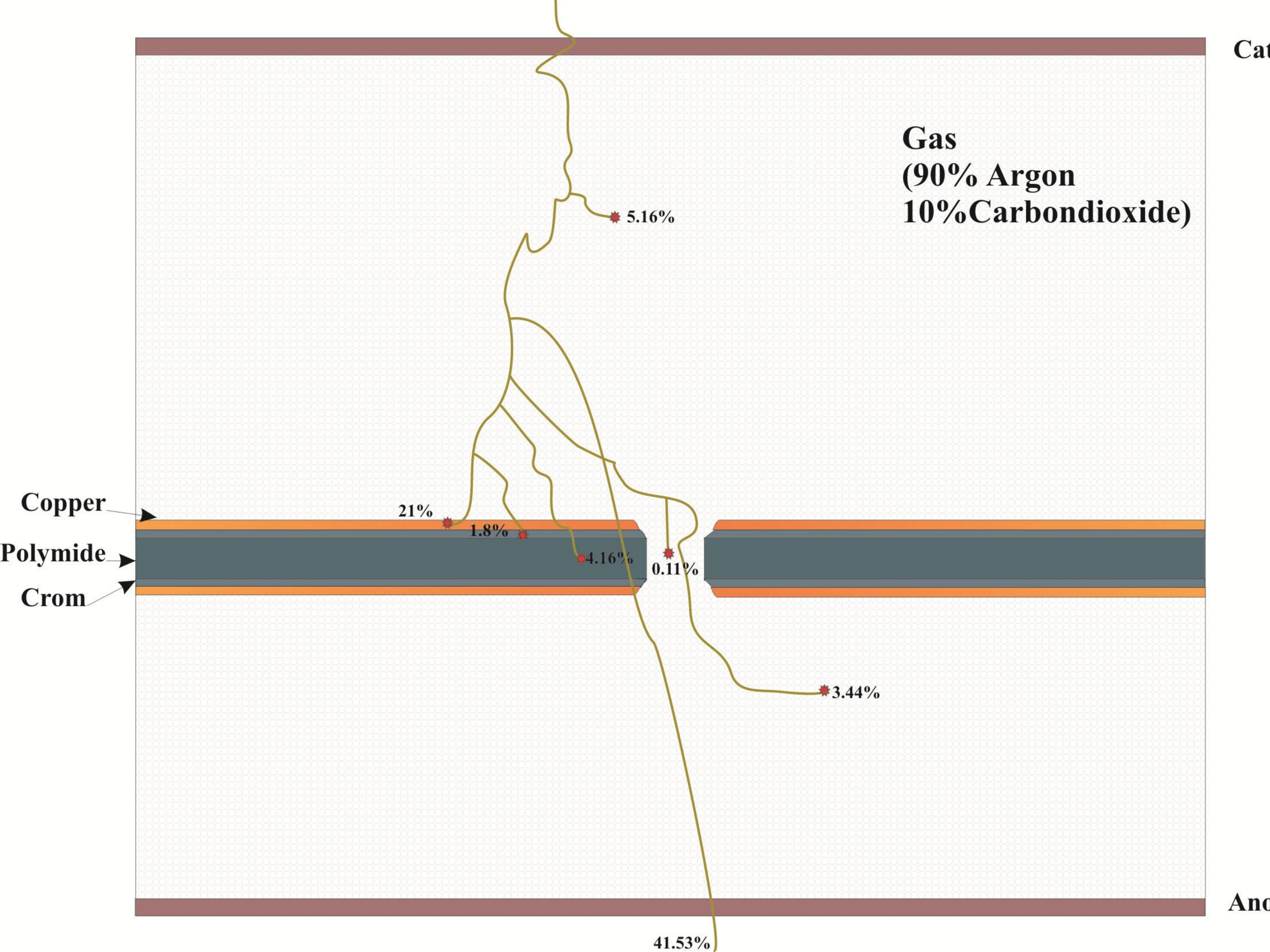


Absorption of Polyimide (Pmda oda)

$$1/z_0 = 8.49 \times 10^{-4}\ \mu m^{-1}$$ (www.beyochem.com)

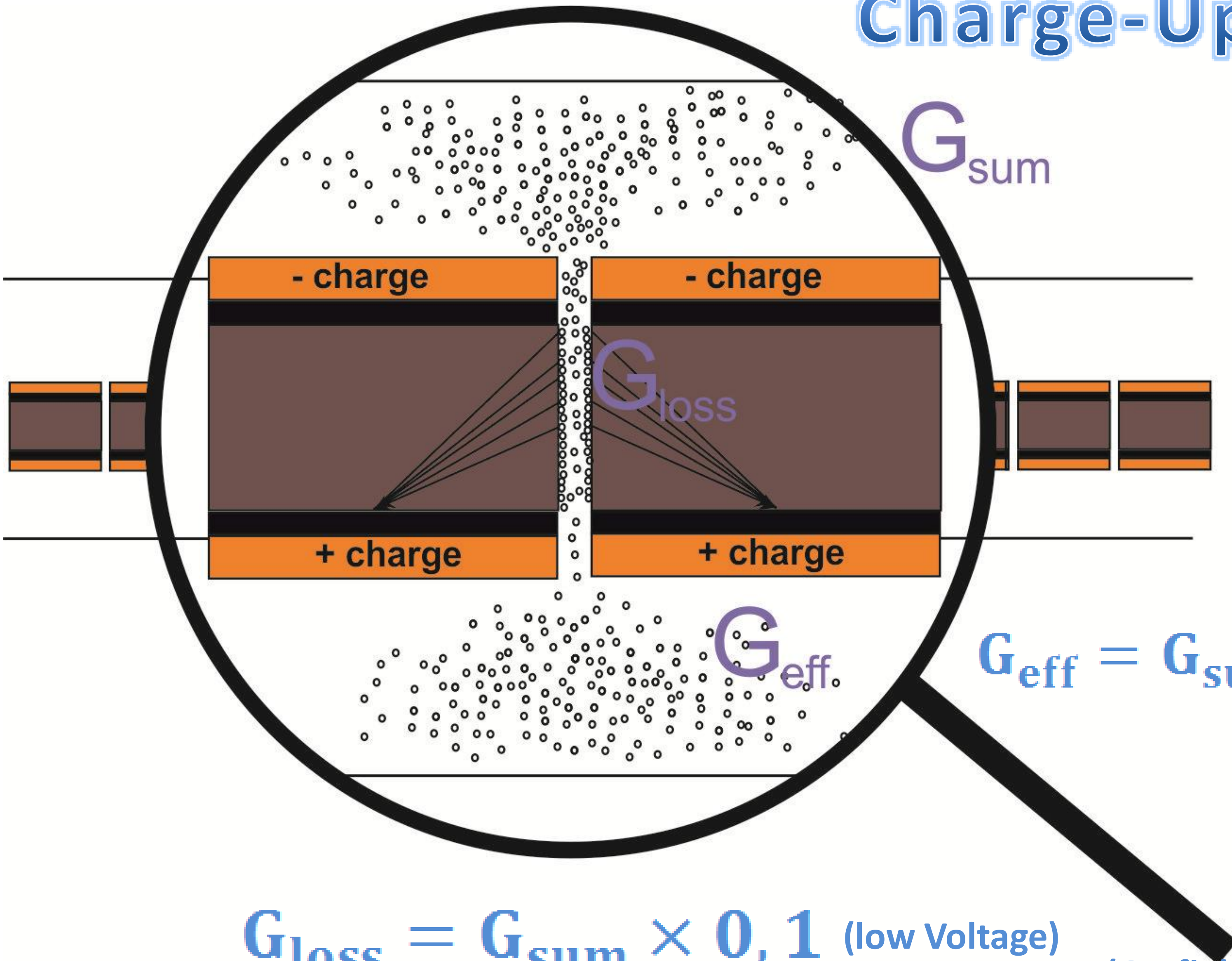
$$\frac{I_z}{I_0} = e^{-8.49\times10^{-4}\times50} = e^{-4.25\times10^{-2}} = 0{,}9584$$





Cat
Gas
(90% Argon
10%Carbondioxide)
5.16%
Copper
21%
1.8%
Polymide
4.16%
0.11%
Crom
3.44%
Anc
41.53%

Charge-Up Effect



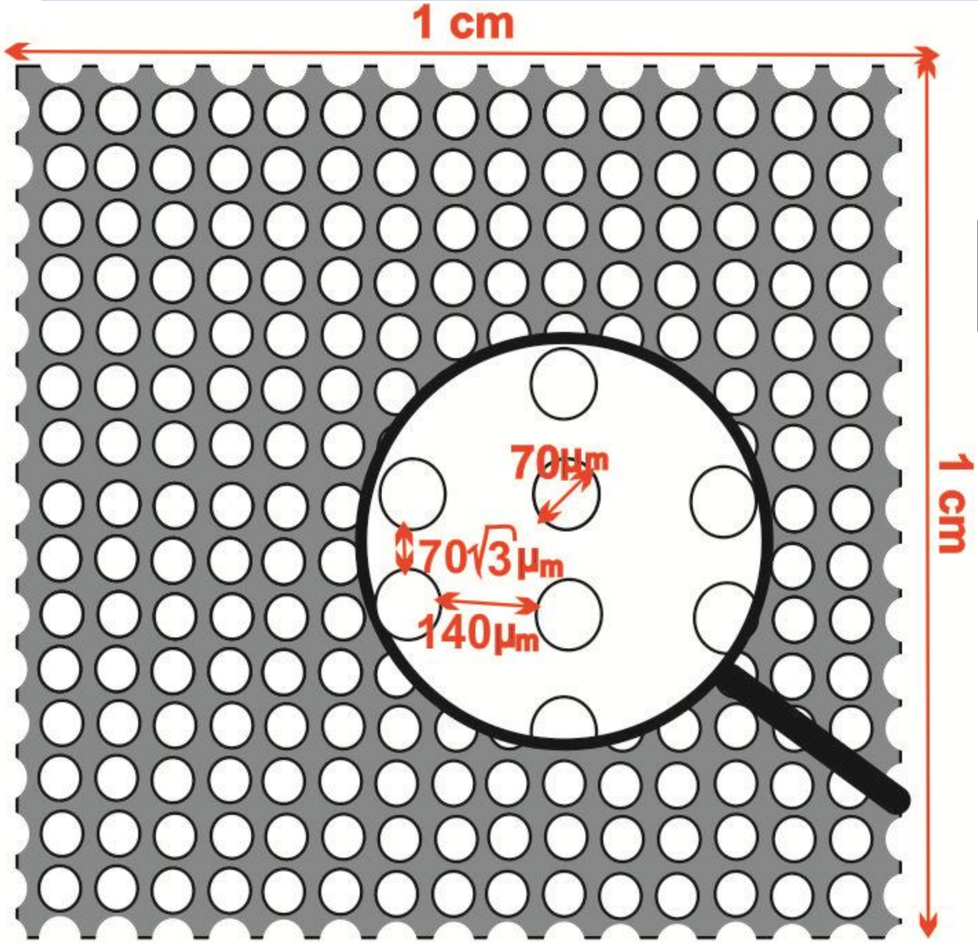
$$G_{eff} = G_{sum} - G_{loss}$$

$$G_{loss} = G_{sum} \times 0,1$$ (low Voltage)

(Garfield ++)

$$G_{loss} = G_{sum} \times 0,2$$ (High Voltage)

Charge-up Effect (Bulk)



Polyimide

Bulk Resistivity

$$\rho_v = 2.3\ 10^{16}\ \Omega.\mathrm{cm}$$

Bulk Resistance

$$R_v = 1.5\ 10^{14}\ \Omega$$

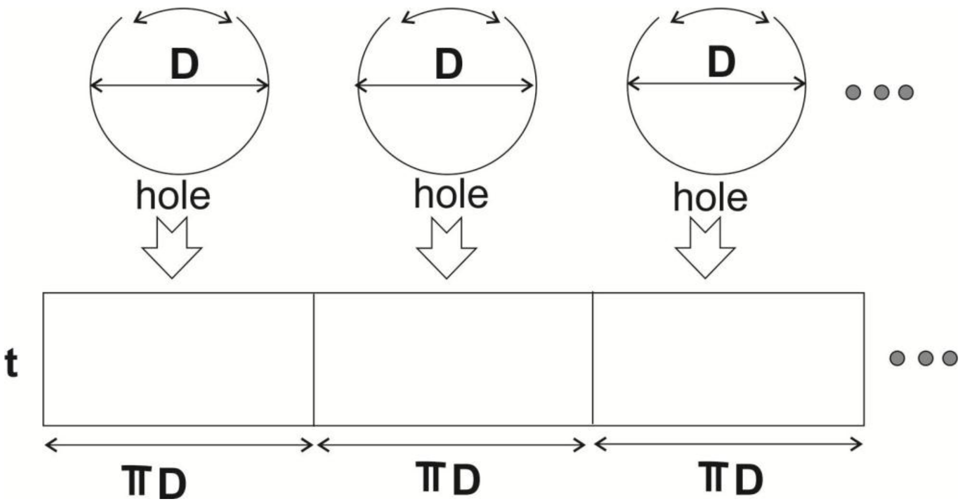
Capacitance

$$C = 57\ pF$$

Relaxation Time

$$\tau_v = 8600\ s$$

Charge-up Effect (Surface)



For cm² area (5900 holes)

Polyimide

Surface Resistivity

$$\rho_s = 3.6\ 10^{16}\ \Omega/\blacksquare$$

Surface Resistance

$$R_s = 1.4\ 10^{12}\ \Omega$$

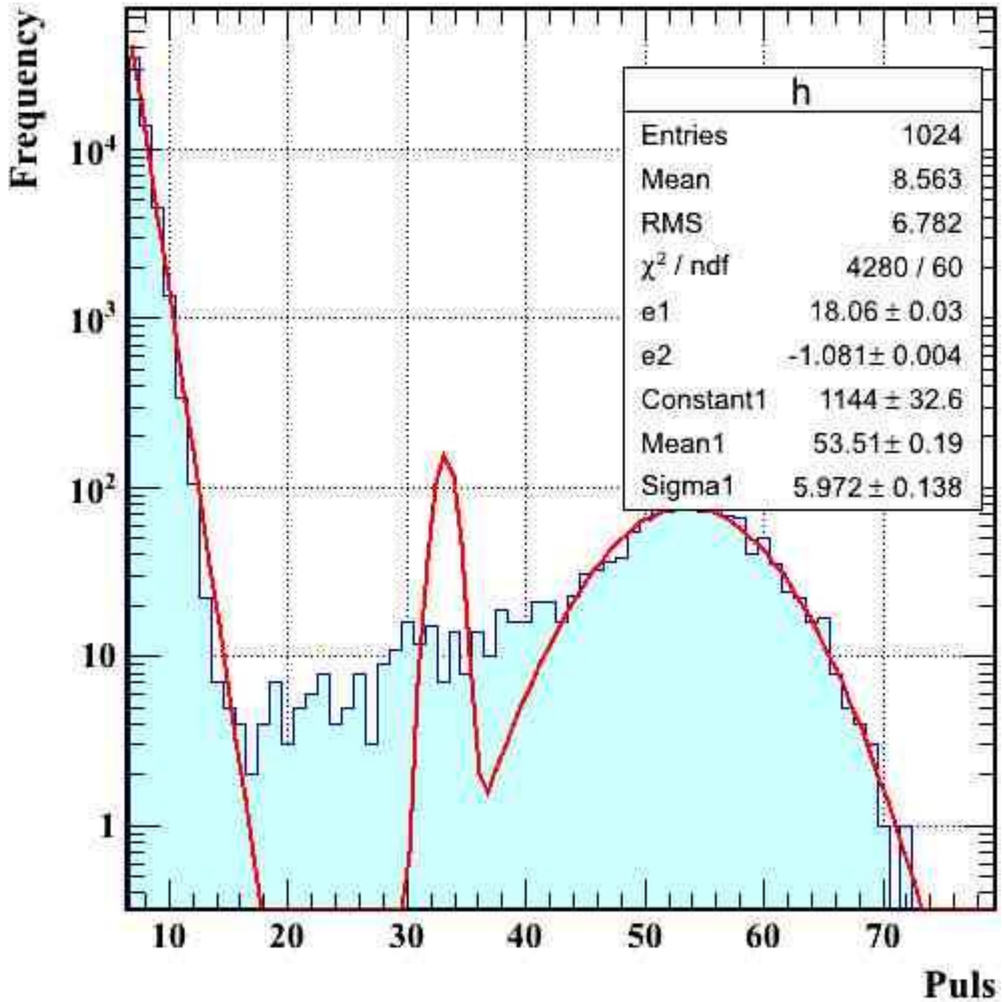
Capacitance

$$C = 57\ pF$$

Relaxation Time

$$\tau_s = 79\ s$$

Calibration of Single GEM



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