# A Novel Approach to Low Energy Dosimetry

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# Low-voltage Concerns

Loss of beam in air and window

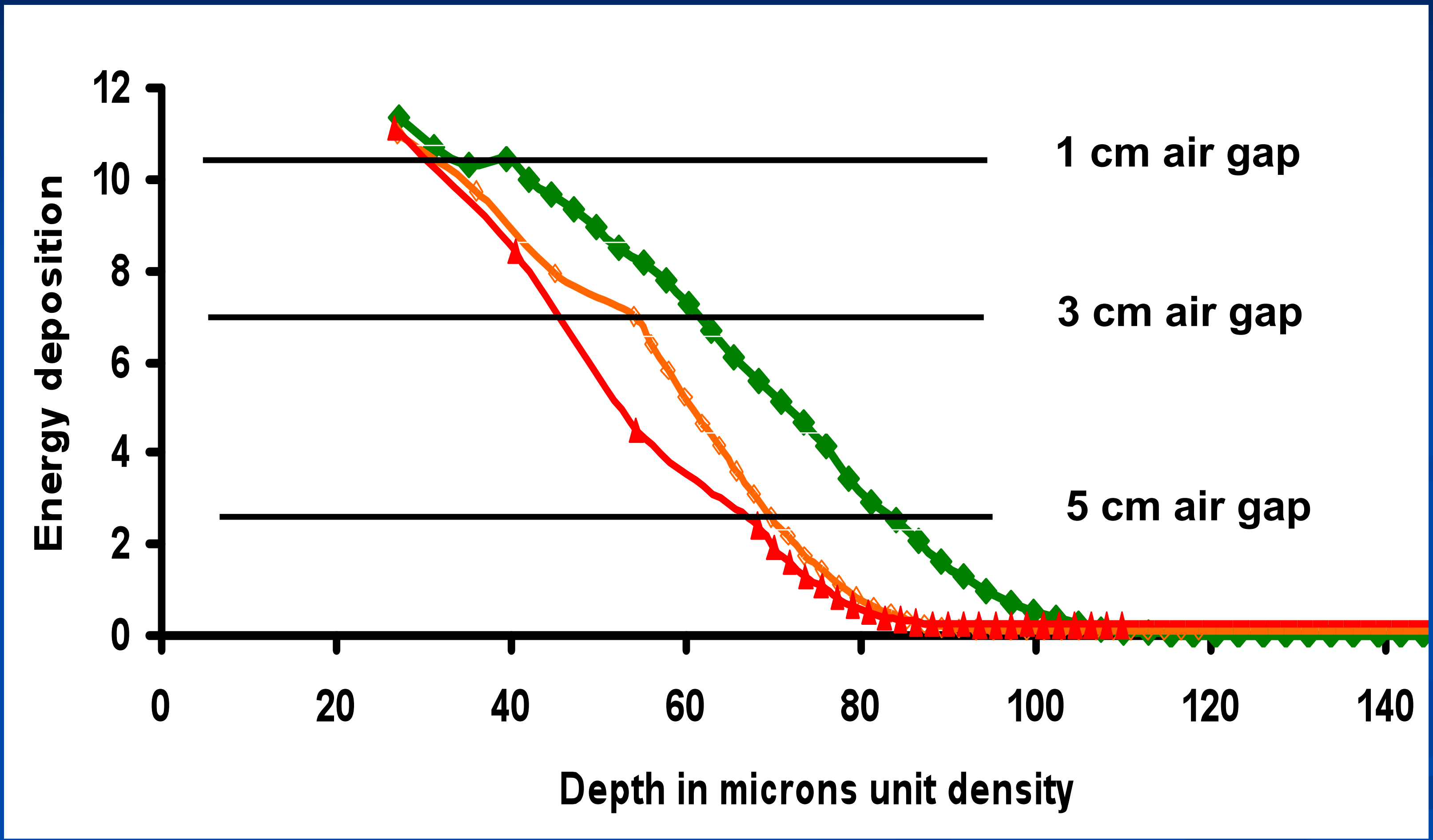
Dose gradient in dosimeters

Problems with polyethylene

# Low-voltage Concerns

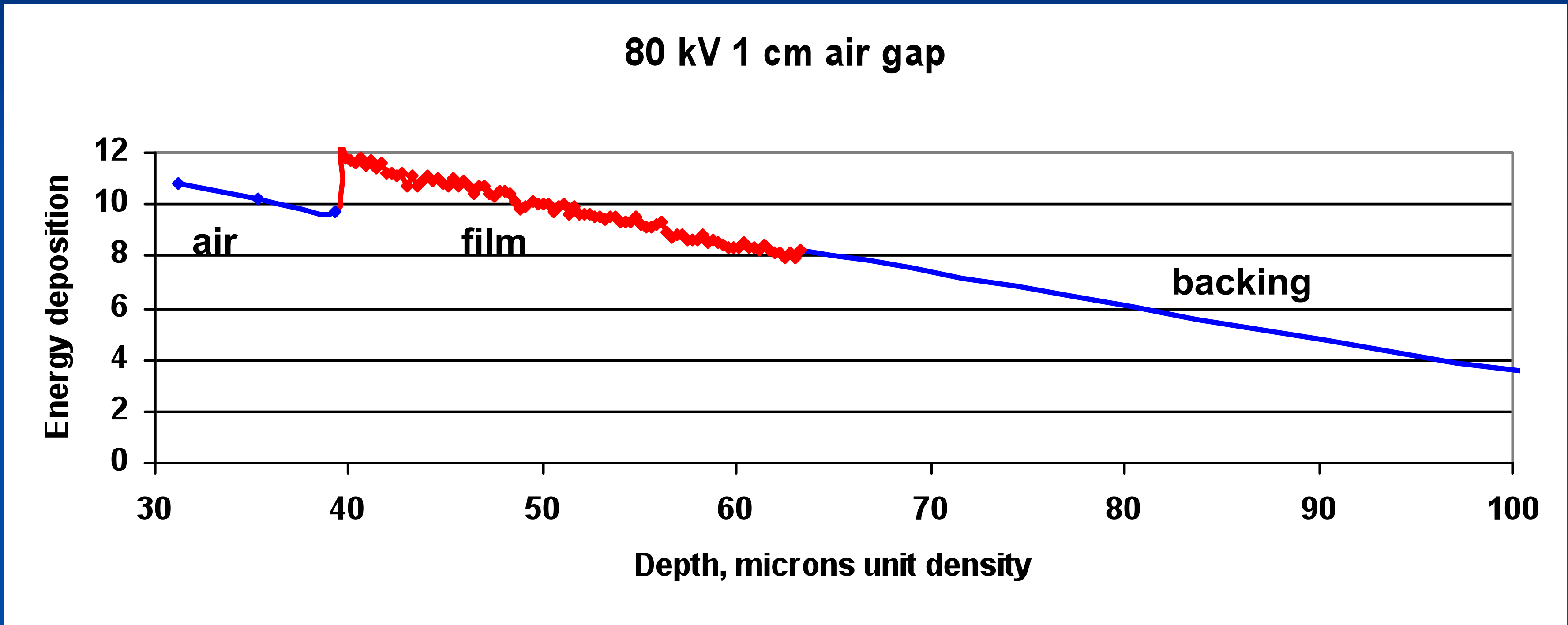
Loss of beam in air and window

# Loss of 80 kV Beam in Air




Monte Carlo results – 6 µm Ti window

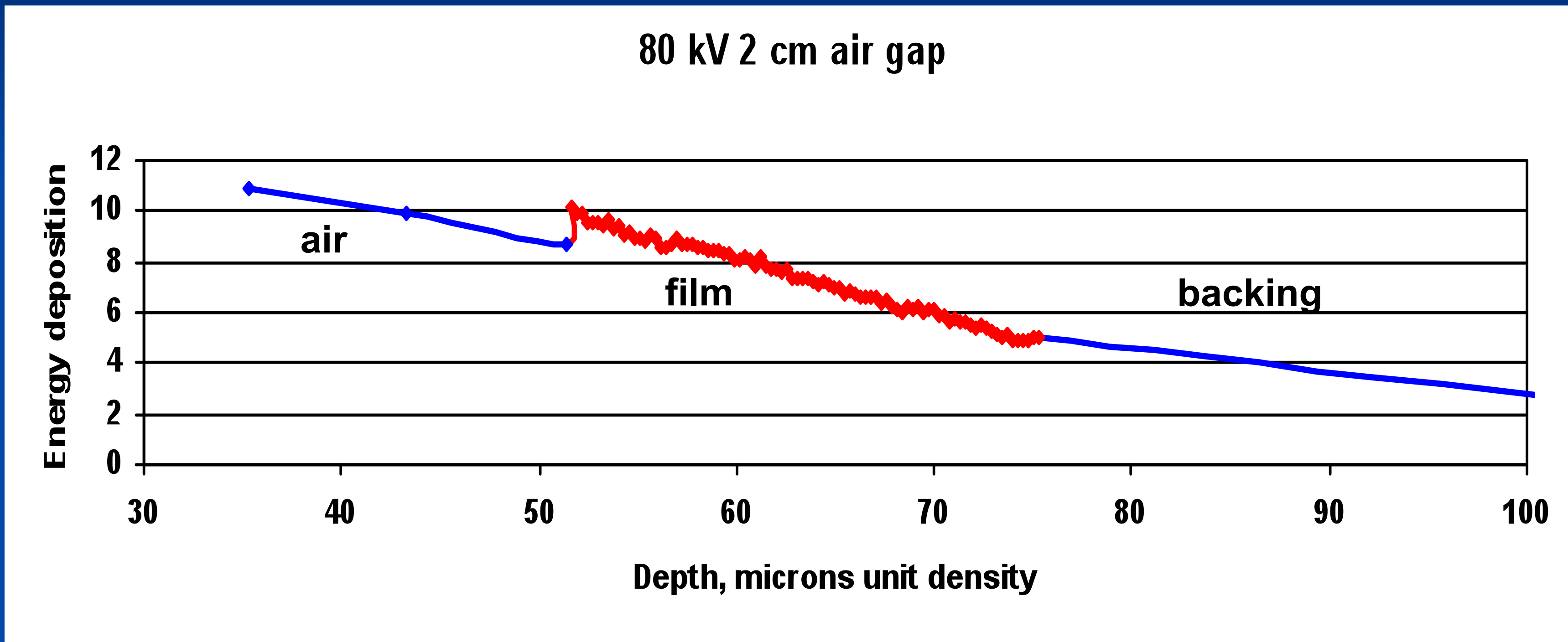
# Monte Carlo Energy Deposition in 25 μm HDPE Film




6 μm Ti window

80 kV dose gradient in film at 1 cm air gap

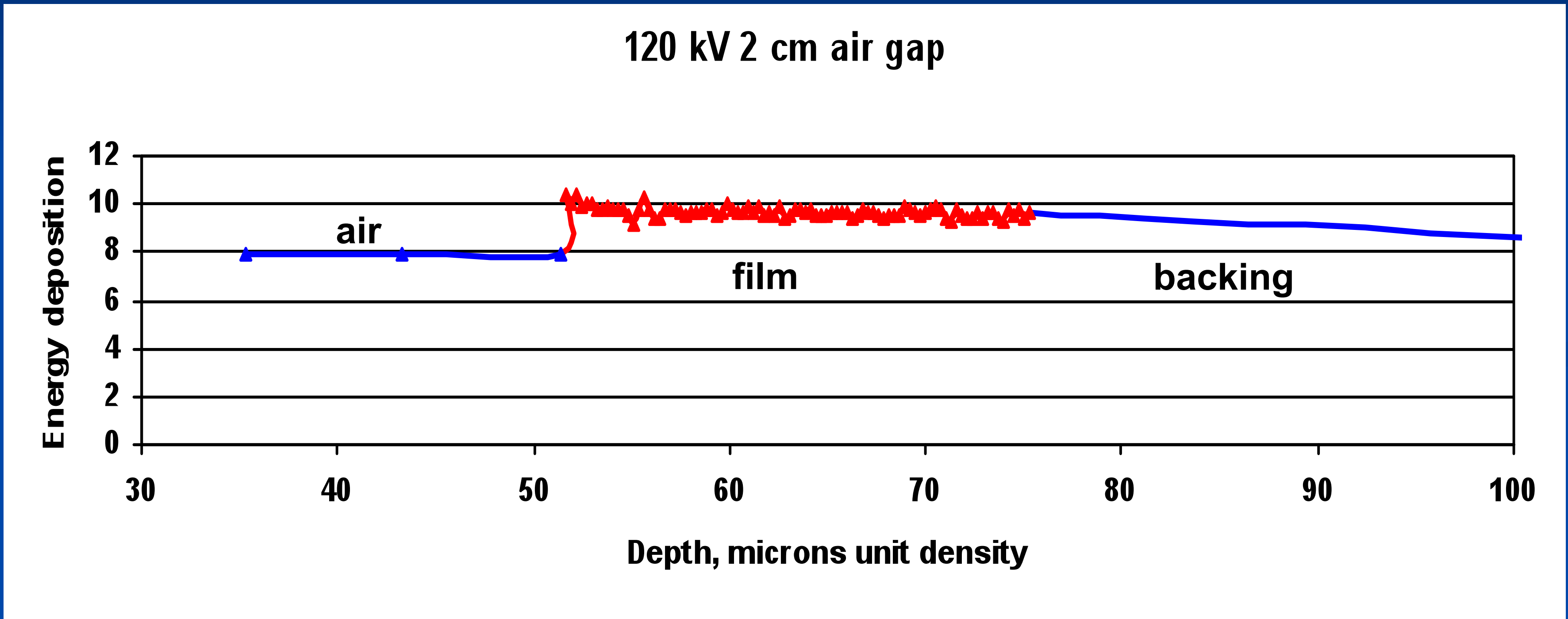
# Monte Carlo Energy Deposition in 25 µm HDPE Film




6 µm Ti window

80 kV dose gradient in film

# Monte Carlo Energy Deposition in 25 µm HDPE Film



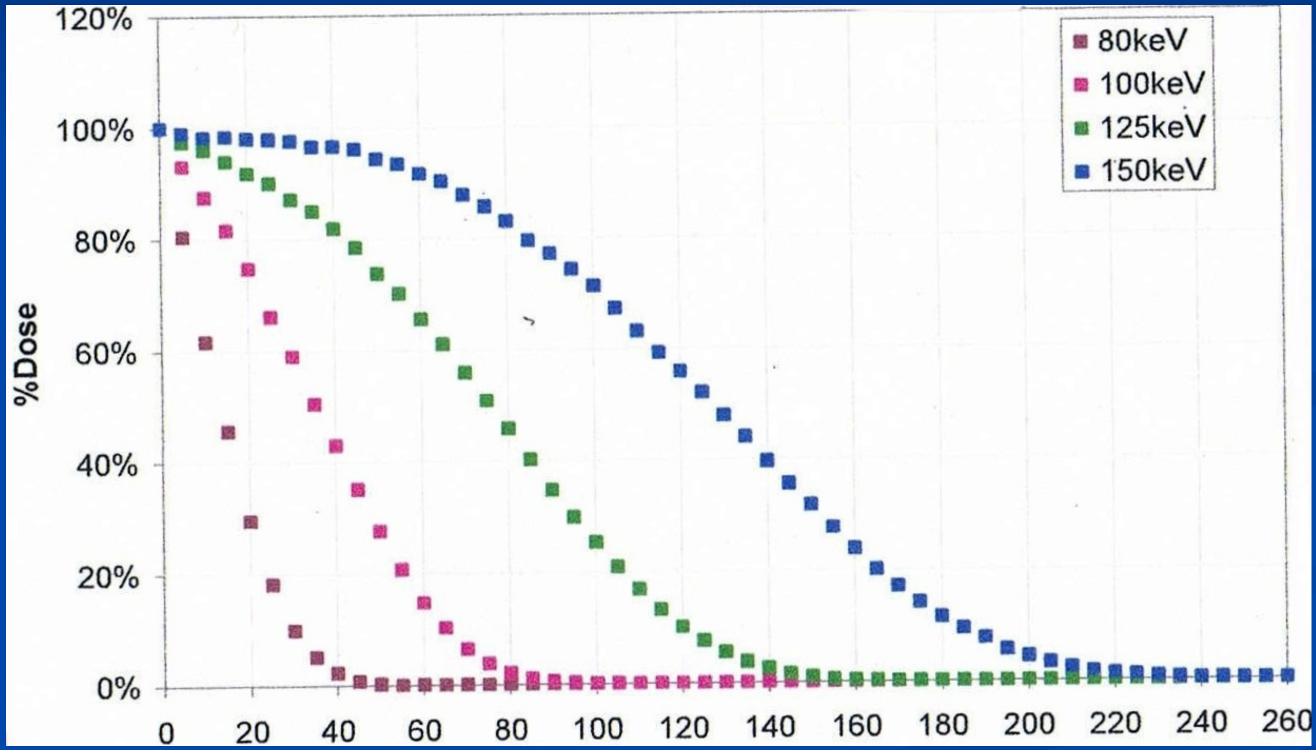

6 µm Ti window

120 kV

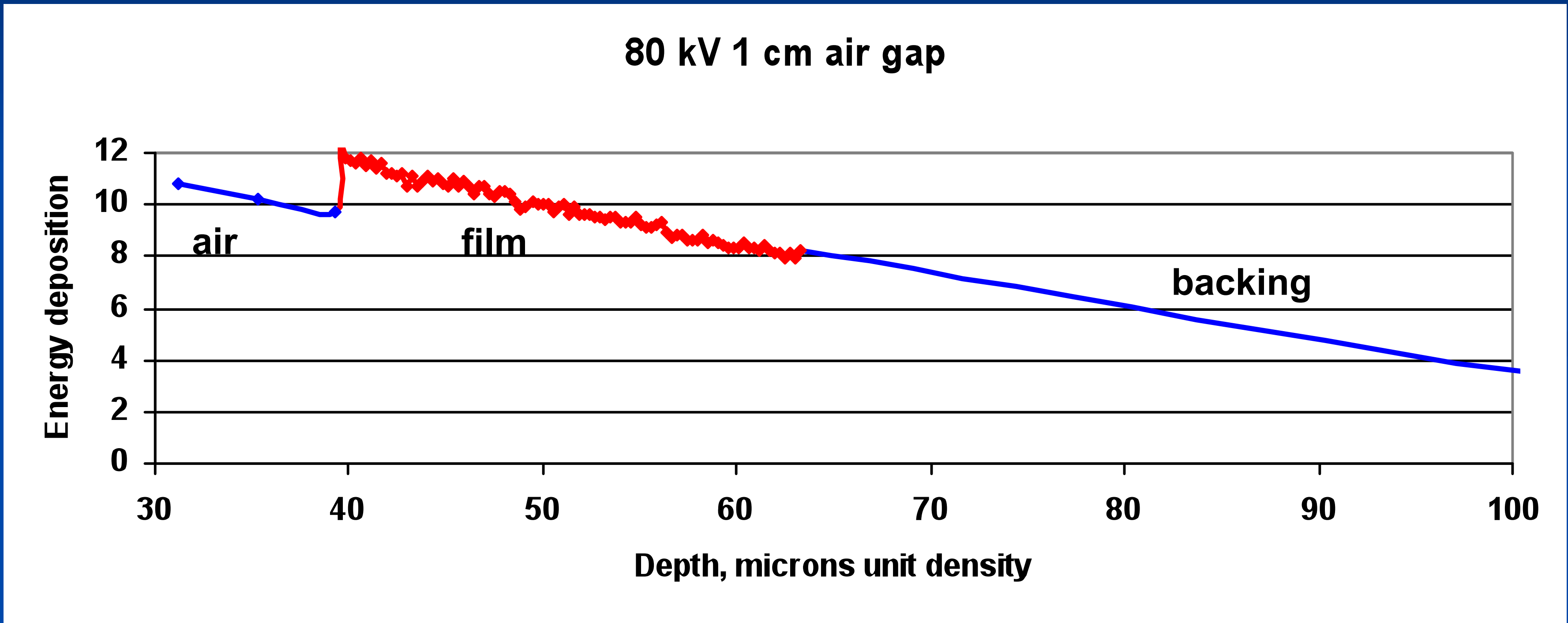
# Low-voltage Concerns

Dose gradient in dosimeters

# Monte Carlo Energy Deposition Depth µm (unit density)



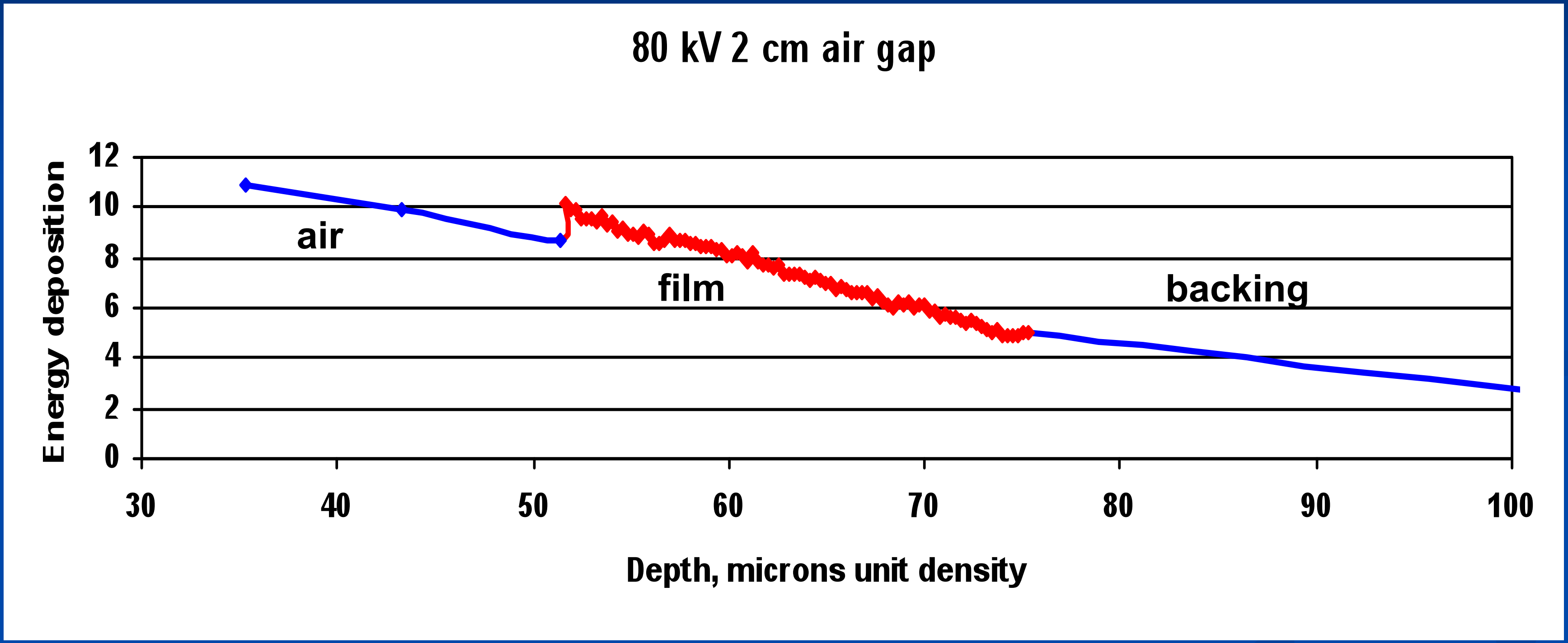
# Monte Carlo Energy Deposition in 25 µm HDPE Film




6 µm Ti window

80 kV dose gradient in film at 1 cm air gap

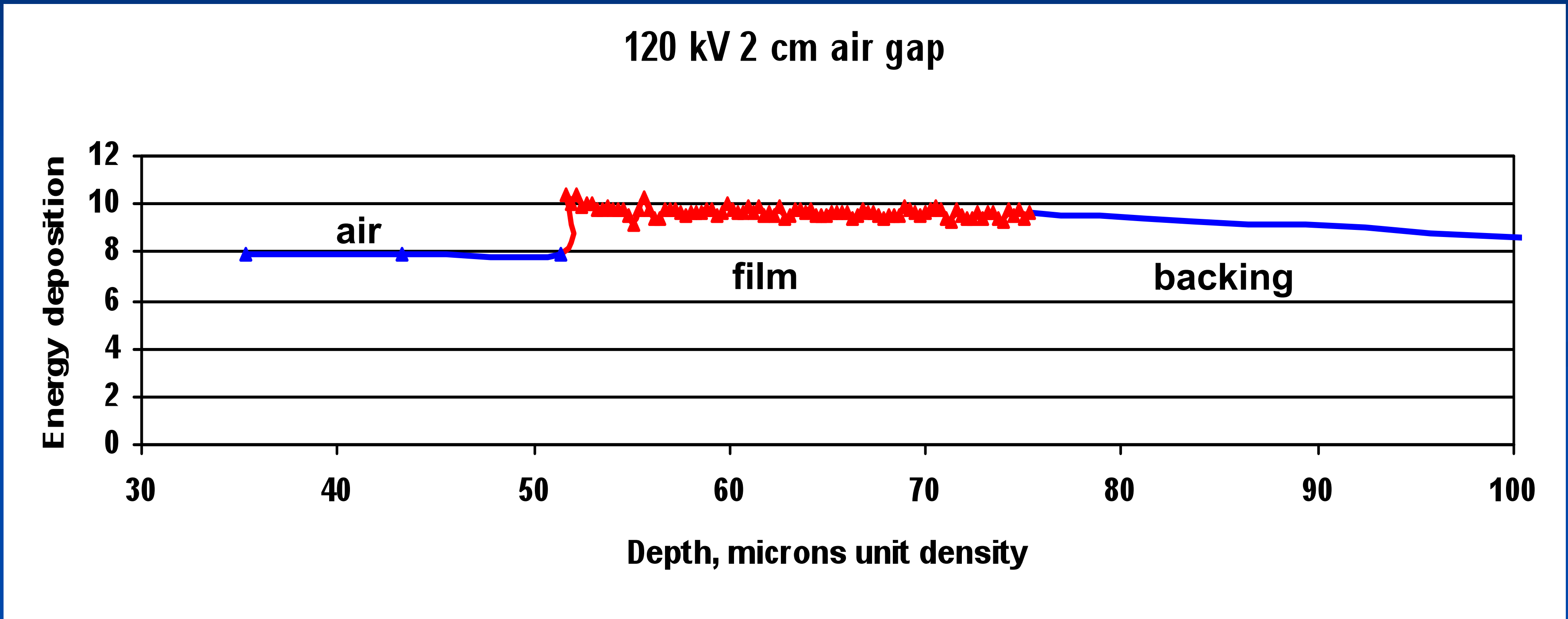
# Monte Carlo Energy Deposition in 25 µm HDPE Film




6 µm Ti window

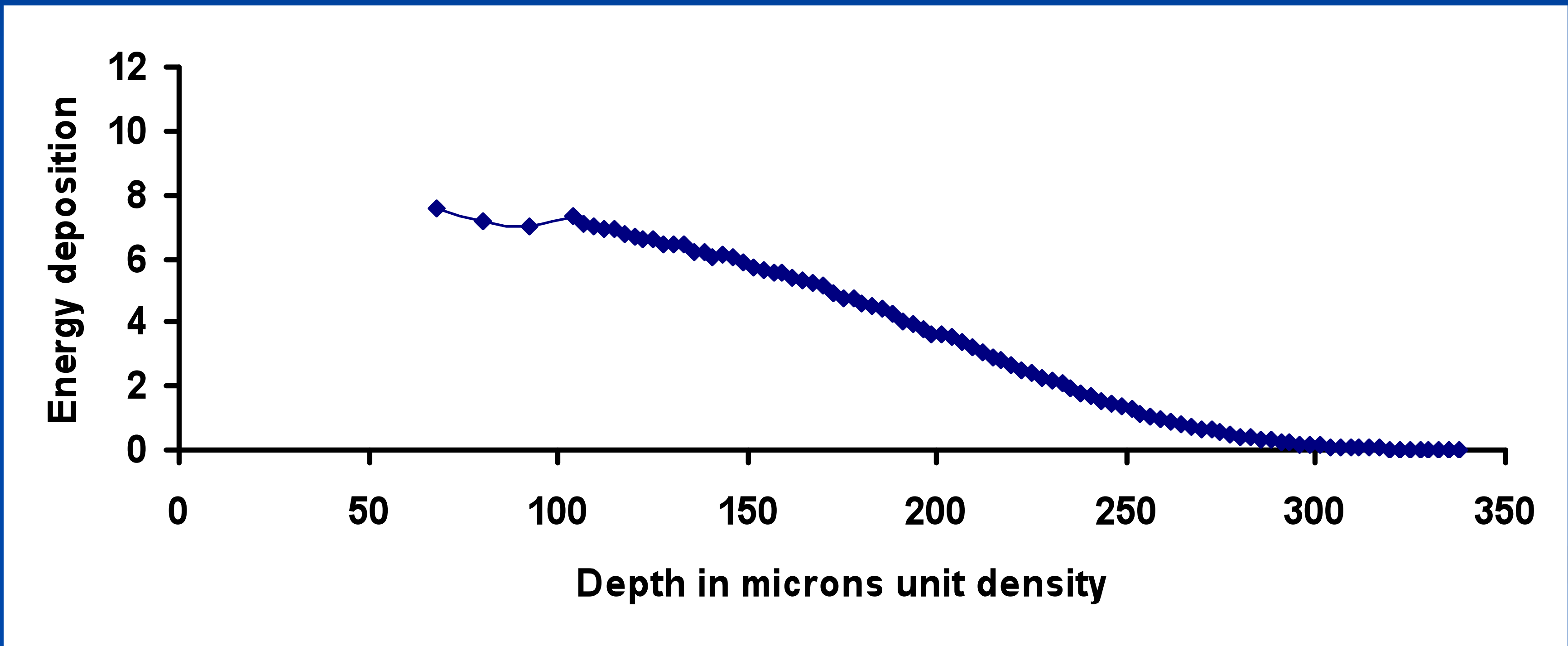
80 kV dose gradient in film

# Monte Carlo Energy Deposition in 25 μm HDPE Film




6 μm Ti window
120 kV

# Monte Carlo Energy Deposition 150 kV, 15 µm Ti window 3 cm air gap



# Low-voltage Concerns

- Dose gradient in dosimeters
  - Thin film FWT and B3 dosimeters should work at 125 kV and above, but alanine will show a gradient even above 200 kV
  - There are some temperature and humidity issues with FWT and B3

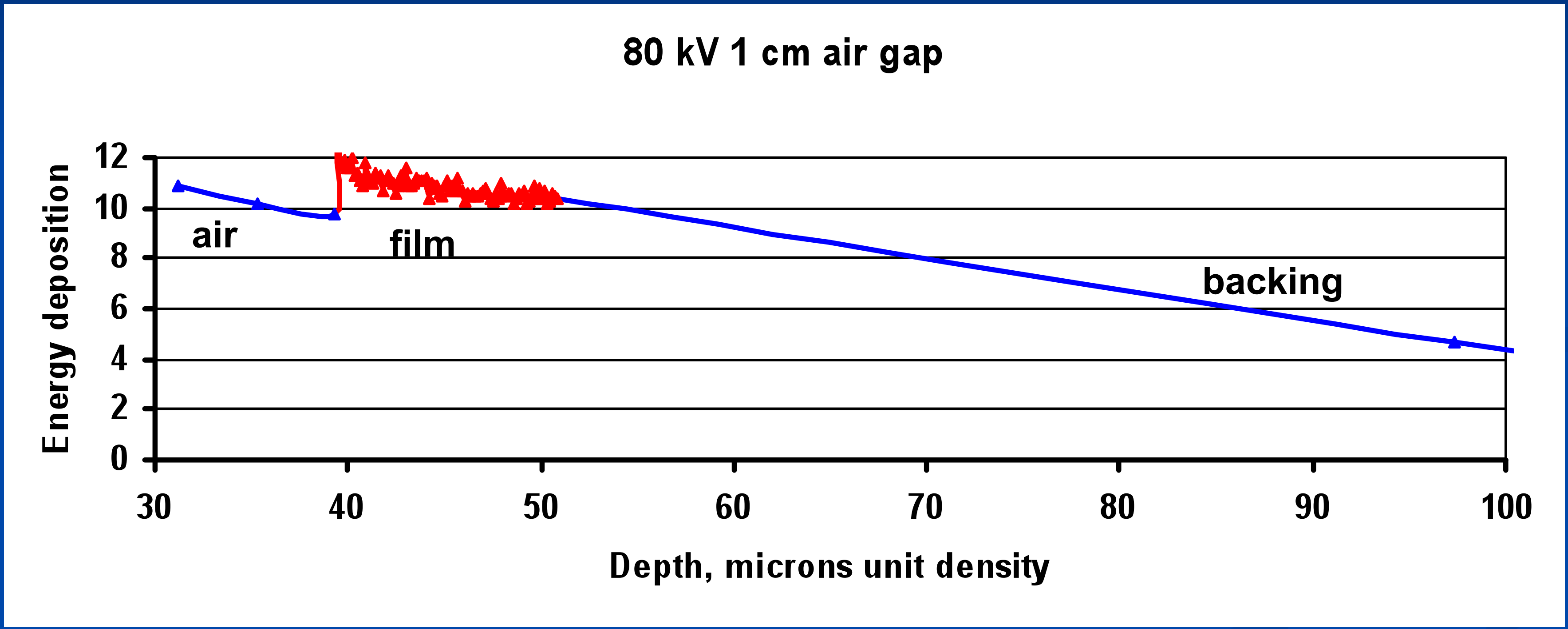
# Low-voltage Concerns

## Problems with polyethylene

# Low-voltage Concerns

- Problems with polyethylene
  - Transmission IR

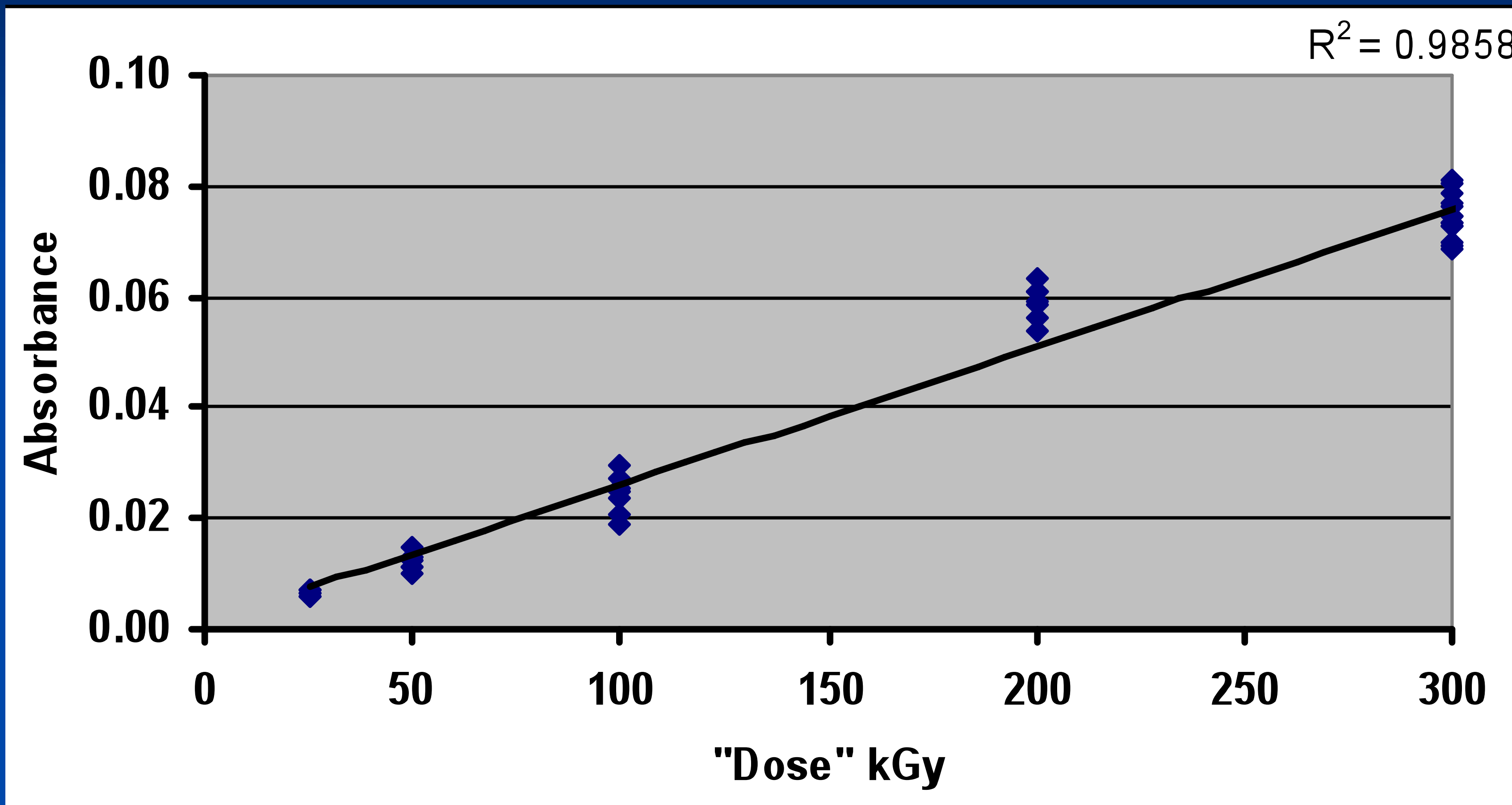
# Monte Carlo Energy Deposition in 12 µm HDPE Film




6 µm Ti window

80 kV dose gradient in film at 1 cm air gap

# Transmission FTIR Absorbance at 965 $cm^{-1}$ in 25 µm HDPE Film

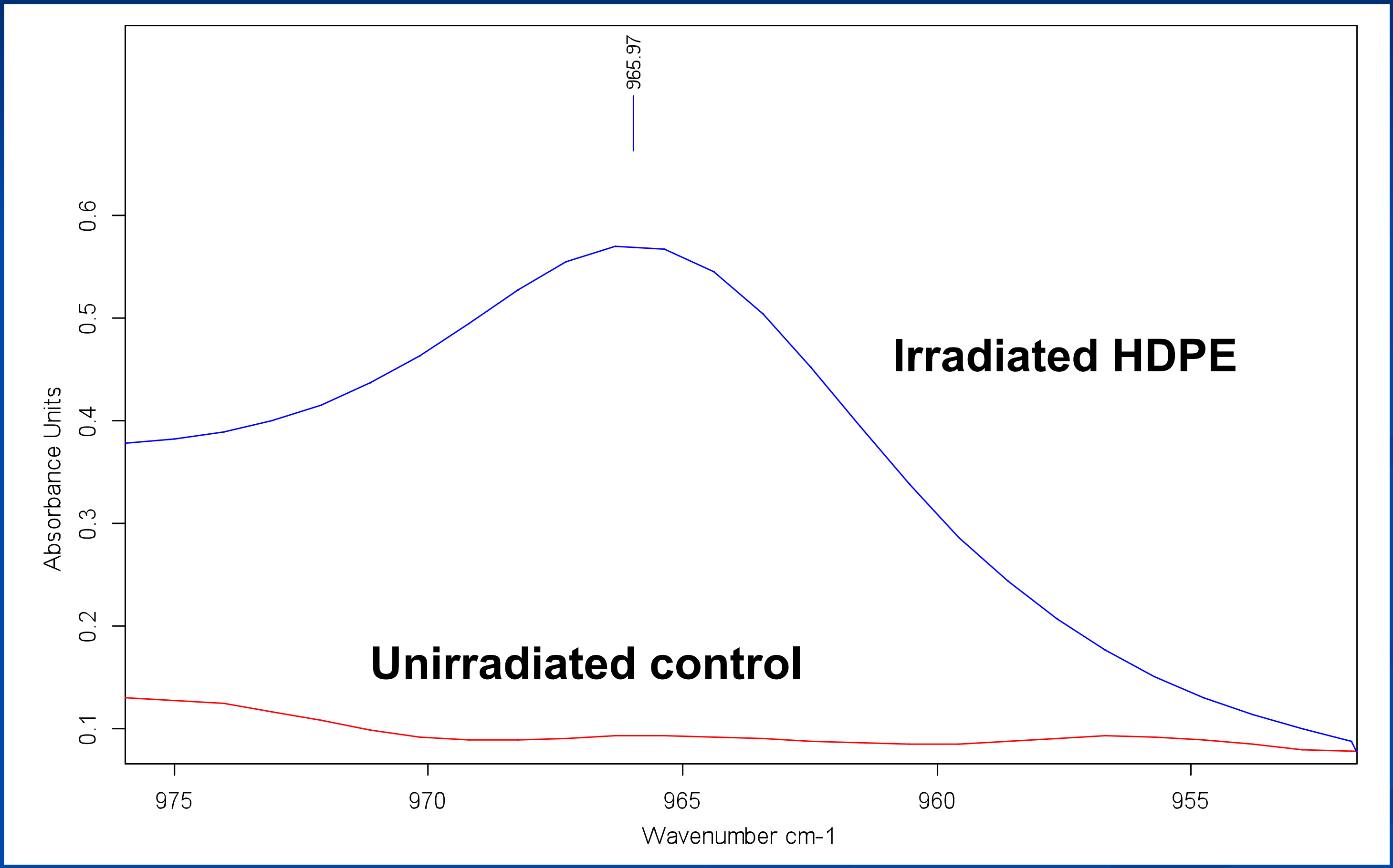



125 kV, 6 µm Ti window, 2 cm air gap

# Low-voltage Concerns

- Problems with polyethylene
  - Transmission IR
  - ATR

# ATR FTIR Absorbance at 965 $cm^{-1}$ in 890 μm HDPE Sheet




~30 kGy at 3.0 MV

# FTIR Spectrometer

# Monte Carlo

- As you can see from the earlier slides Monte Carlo simulation can be used to determine the energy deposition of electrons into matter.

- **BUT!**

# Monte Carlo

- To use Monte Carlo simulation we need to know a few things.
  - Window thickness and makeup
  - Air gap
  - Beam voltage
  - Beam amperage

# Monte Carlo

- **Thus if you set up a number of identical accelerators with the same window thickness, air gap and set the voltage and amperage the same; you should get the same dose (energy deposition) reading on all the instruments.**

# Monte Carlo

- To use Monte Carlo simulation we need to know a few things.
  - Window thickness and makeup
  - Air gap
  - Beam voltage
  - Beam amperage

# The Big Question

- How do we determine the beam voltage and amperage?

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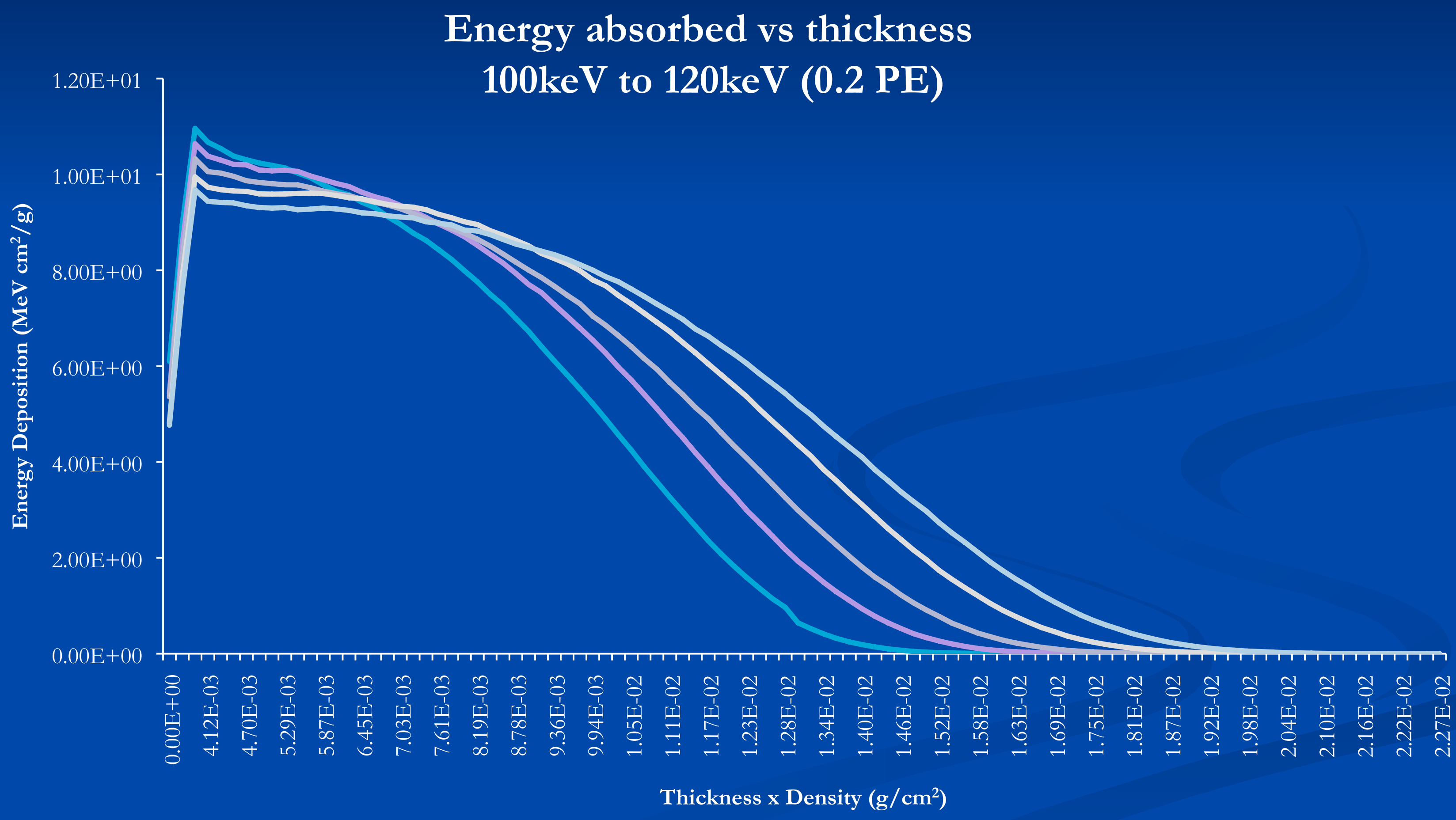
- How do we determine the beam voltage and amperage?

- The amperage is not important with this method.

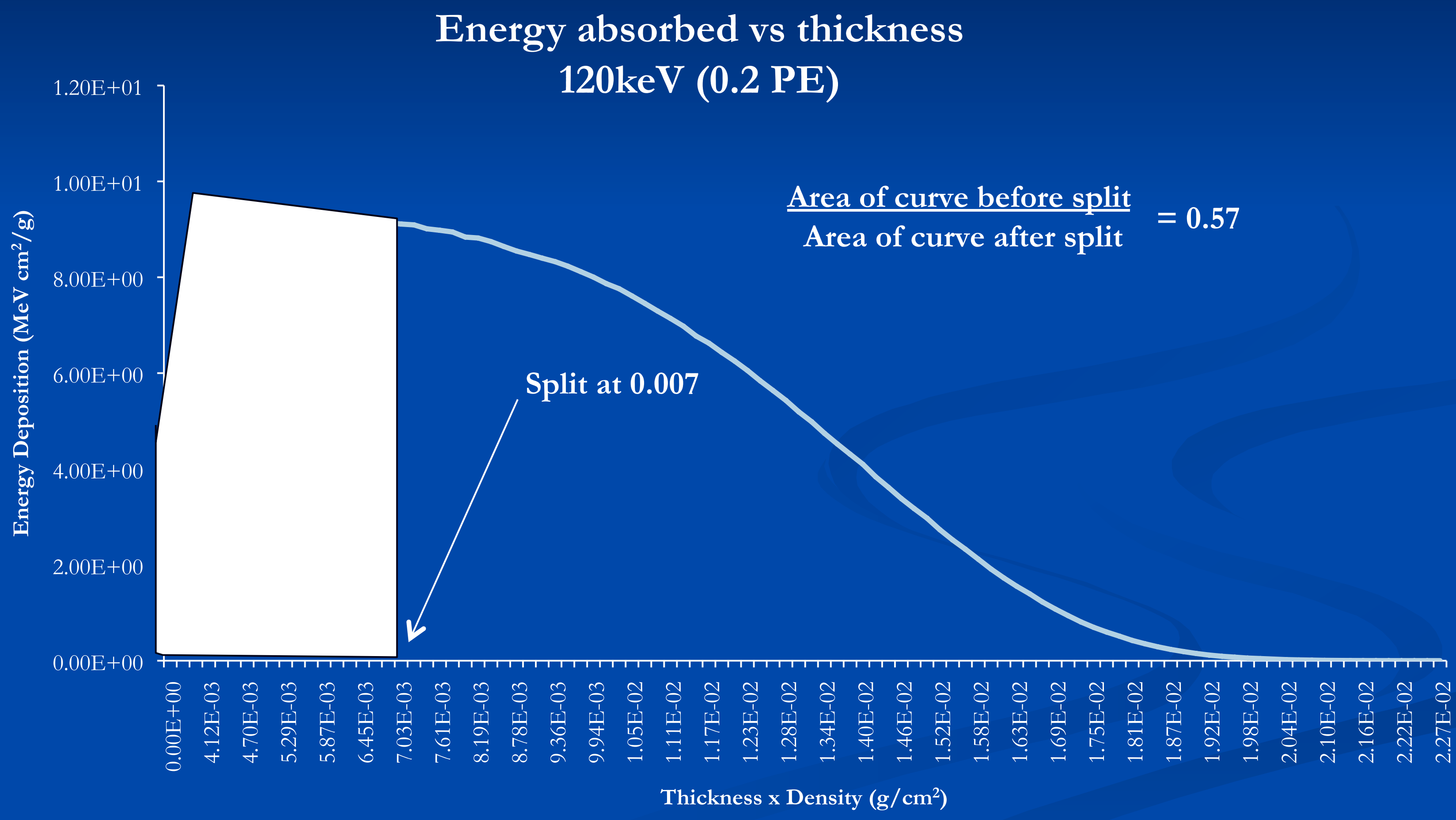
# How to Determine Beam Voltage

- Use area ratios.

# Area Ratios


Energy absorbed vs thickness
100keV to 120keV (0.2 PE)
Energy Deposition (MeV cm²/g)
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0.00E+00
4.12E-03
4.70E-03
5.29E-03
5.87E-03
6.45E-03
7.03E-03
7.61E-03
8.19E-03
8.78E-03
9.36E-03
9.94E-03
1.05E-02
1.11E-02
1.17E-02
1.23E-02
1.28E-02
1.34E-02
1.40E-02
1.46E-02
1.52E-02
1.58E-02
1.63E-02
1.69E-02
1.75E-02
1.81E-02
1.87E-02
1.92E-02
1.98E-02
2.04E-02
2.10E-02
2.16E-02
2.22E-02
2.27E-02
Thickness x Density (g/cm²)

# Area Ratios



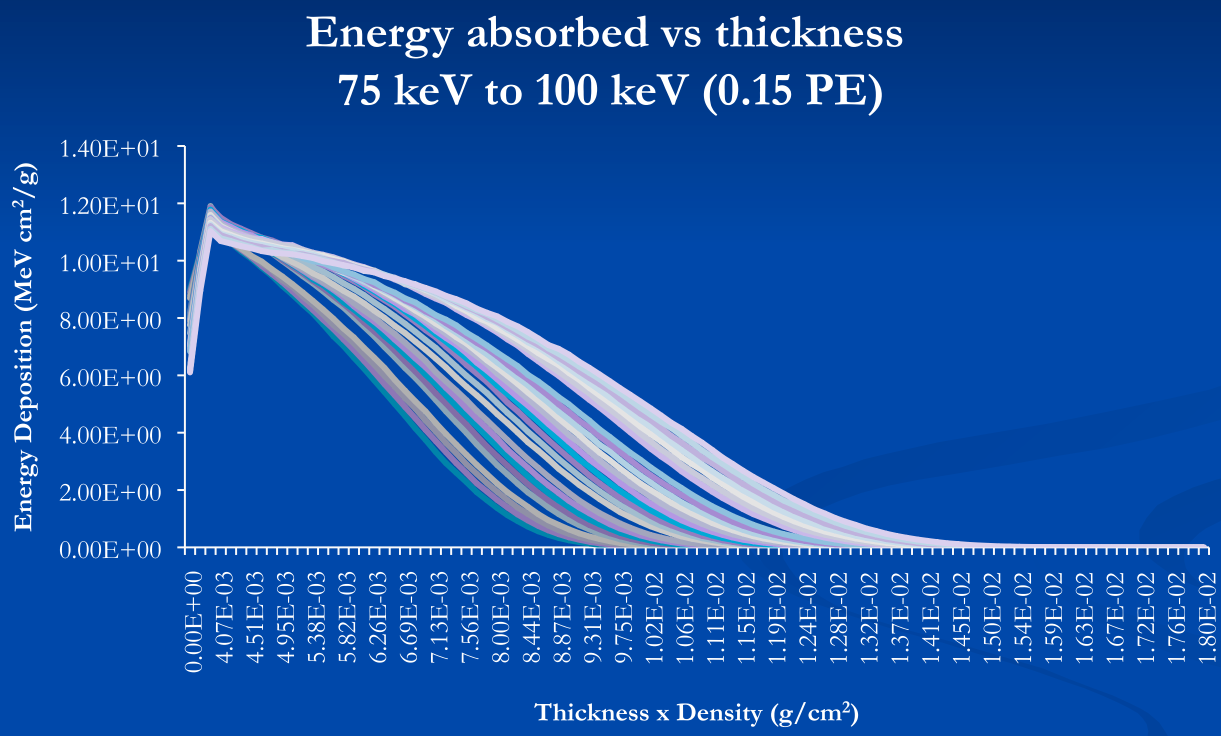
Energy absorbed vs thickness
120keV (0.2 PE)
Area of curve before split
Area of curve after split
= 0.57
Split at 0.007
Energy Deposition (MeV cm2/g)
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0.00E+00
4.12E-03
4.70E-03
5.29E-03
5.87E-03
6.45E-03
7.03E-03
7.61E-03
8.19E-03
8.78E-03
9.36E-03
9.94E-03
1.05E-02
1.11E-02
1.17E-02
1.23E-02
1.28E-02
1.34E-02
1.40E-02
1.46E-02
1.52E-02
1.58E-02
1.63E-02
1.69E-02
1.75E-02
1.81E-02
1.87E-02
1.92E-02
1.98E-02
2.04E-02
2.10E-02
2.16E-02
2.22E-02
2.27E-02
Thickness x Density (g/cm2)

# Area Ratios

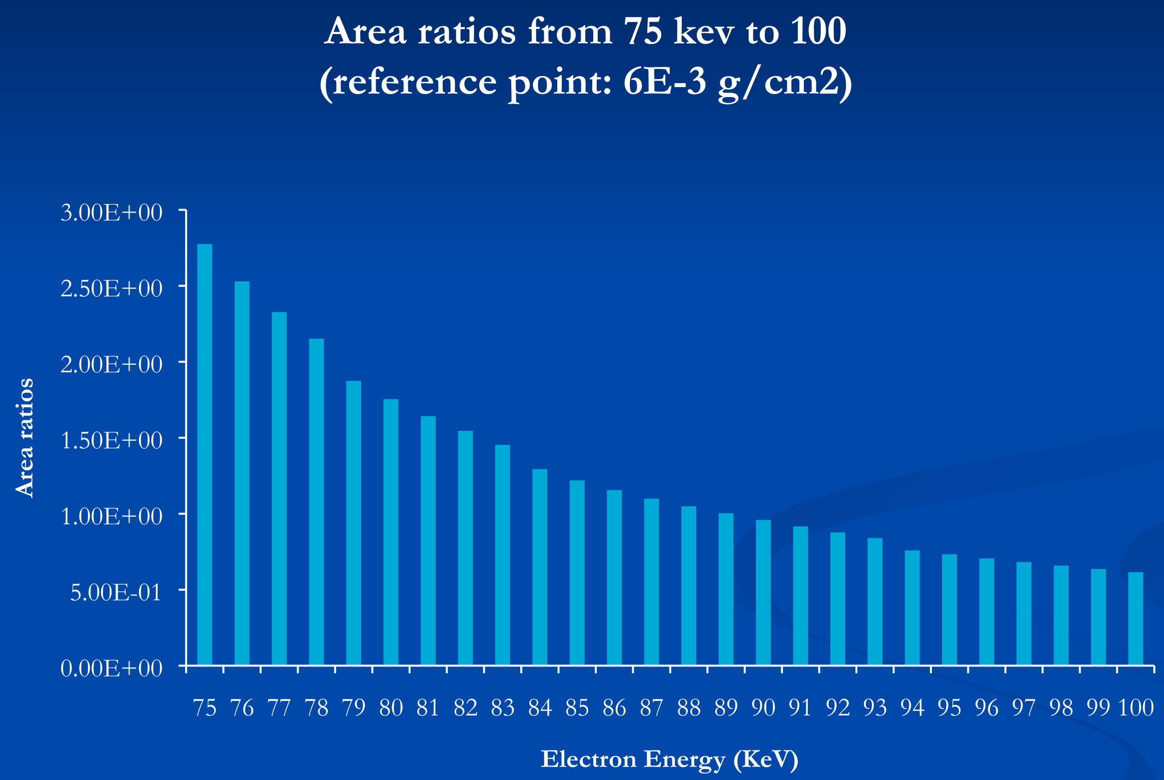
## Area ratios for 100-120keV curves

| Energy (keV) | Area ratio | %Difference |
|---|---|---|
| 100 | 1.22 | 23.00 |
| 105 | 0.94 | 14.97 |
| 110 | 0.80 | 18.16 |
| 115 | 0.65 | 12.56 |
| 120 | 0.57 | |

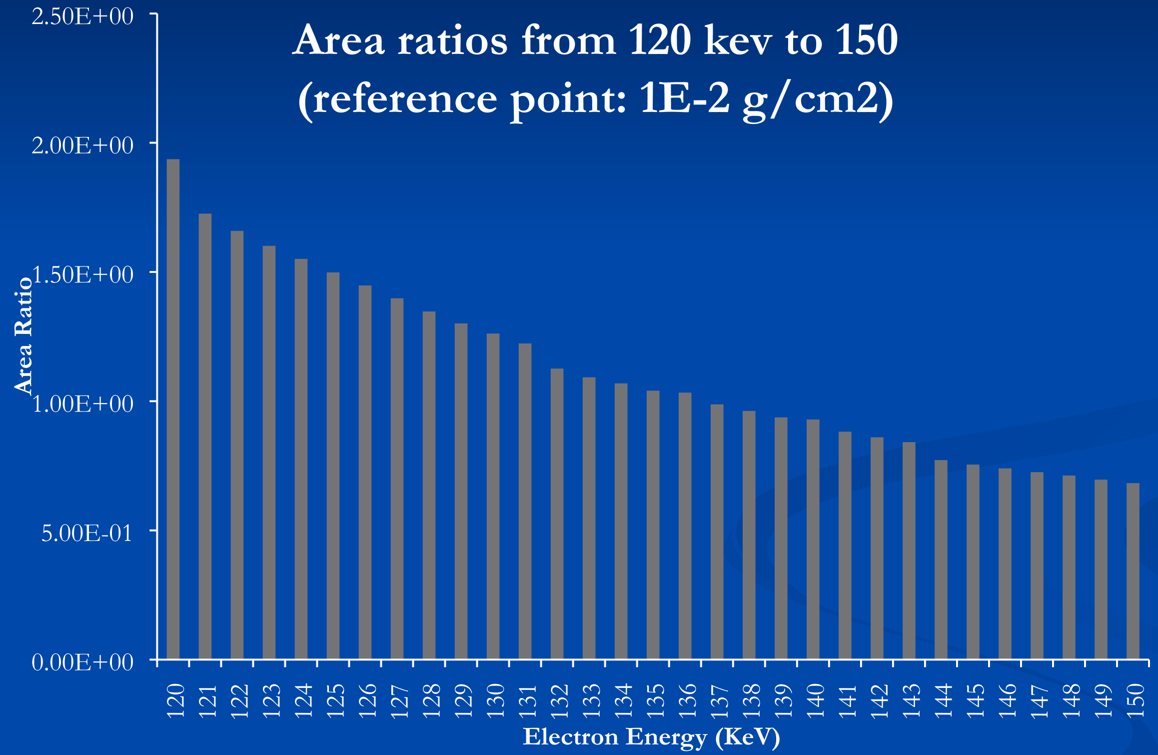
# Area Ratios


Energy absorbed vs thickness
75 keV to 100 keV (0.15 PE)
Energy Deposition (MeV cm²/g)
1.40E+01
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
0.00E+00
4.07E-03
4.51E-03
4.95E-03
5.38E-03
5.82E-03
6.26E-03
6.69E-03
7.13E-03
7.56E-03
8.00E-03
8.44E-03
8.87E-03
9.31E-03
9.75E-03
1.02E-02
1.06E-02
1.11E-02
1.15E-02
1.19E-02
1.24E-02
1.28E-02
1.32E-02
1.37E-02
1.41E-02
1.45E-02
1.50E-02
1.54E-02
1.59E-02
1.63E-02
1.67E-02
1.72E-02
1.76E-02
1.80E-02
Thickness x Density (g/cm²)

# Area Ratios

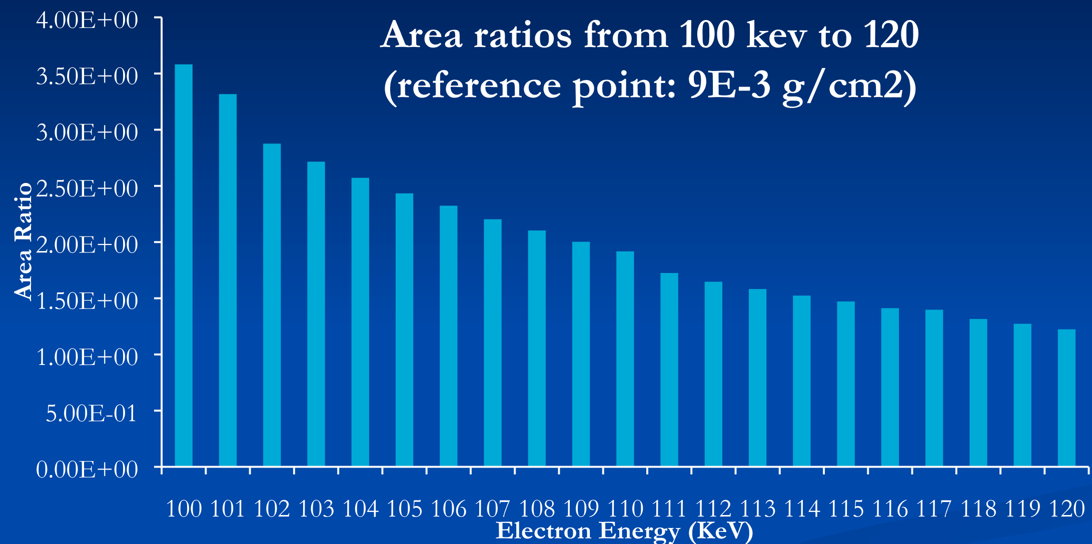

Area ratios from 75 kev to 100
(reference point: 6E-3 g/cm2)
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
Area ratios
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Electron Energy (KeV)

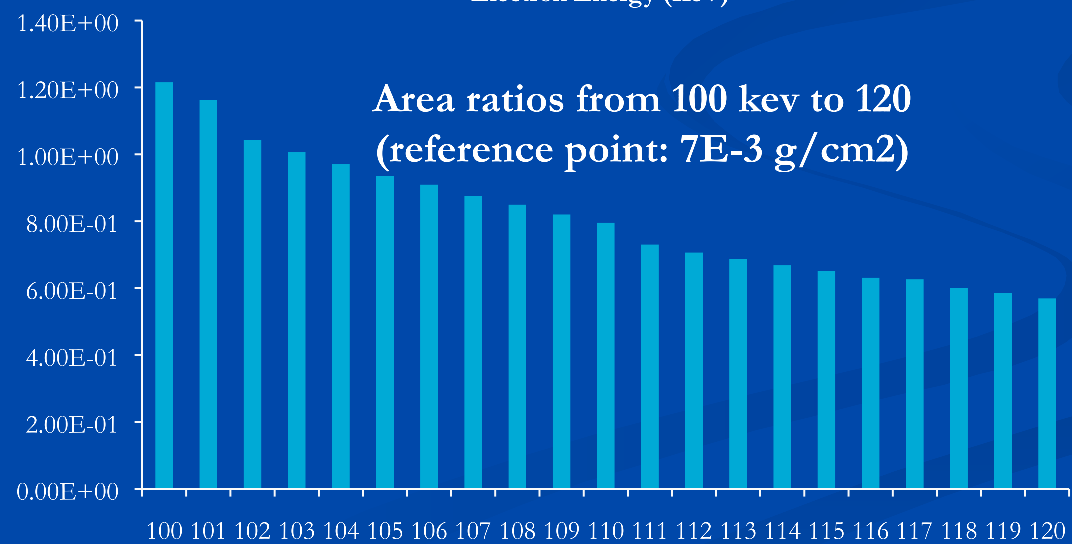
# Area Ratios



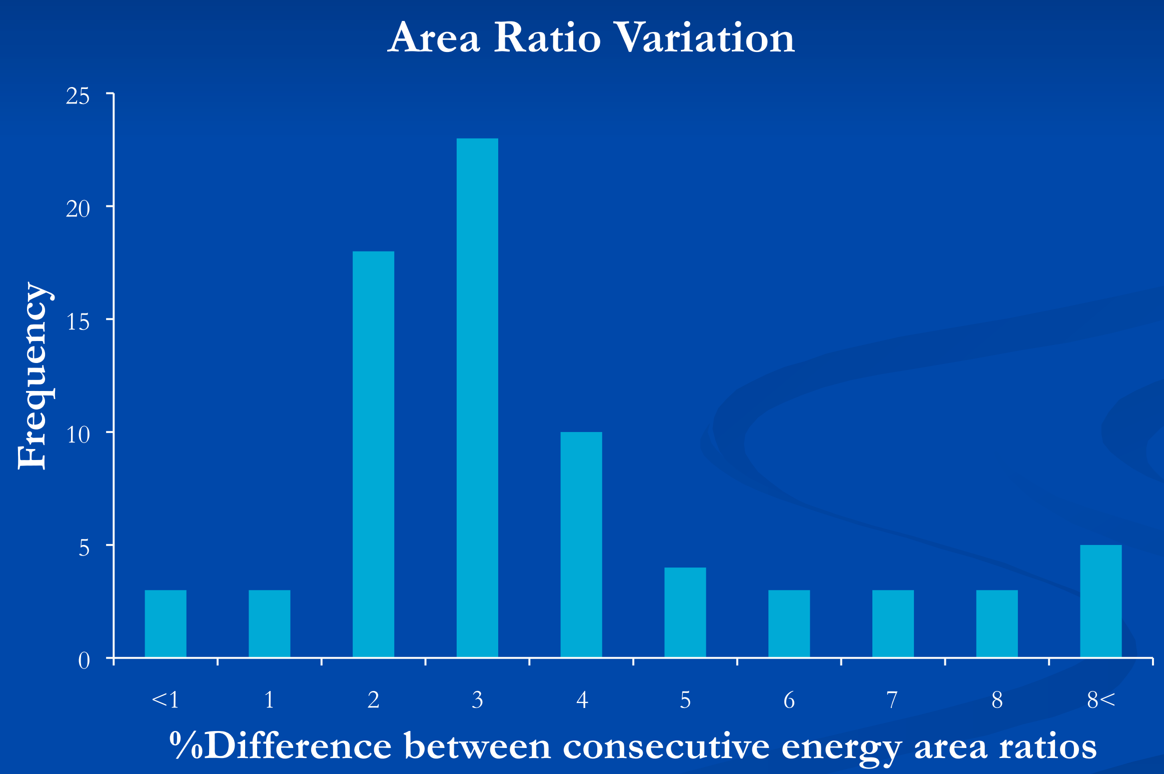
Area ratios from 120 kev to 150
(reference point: 1E-2 g/cm2)
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
Area Ratio
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
Electron Energy (KeV)

# Area Ratios


Area ratios from 100 kev to 120
(reference point: 9E-3 g/cm2)
Area Ratio
4.00E+00
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
Electron Energy (KeV)


Area ratios from 100 kev to 120
(reference point: 7E-3 g/cm2)
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120

# Area Ratios


Area Ratio Variation
Frequency
25
20
15
10
5
0
<1
1
2
3
4
5
6
7
8
8<
%Difference between consecutive energy area ratios

# How Would This be Used

- Use a thick dosimeter.
- Run one dosimeter without an absorber.
- Run one dosimeter with a standard thin PE absorber.

# How Would This be Used

- From the ratio you can determine the energy of the beam.
- You do not need the amperage of the unit since your dose at any thickness will be a percentage of the total energy deposited.

# Additional Work

- Conduct work with dosimeters and absorbers to determine the reproducibility of the rations obtained.
- Determine the energy resolution that can be obtained with the dosimeters.
- Would using two or more ratios increase the reliability of this method.

# Acknowledgements

Anthony Berejka.

IBA Industrial: Dr. Marshall Cleland and Richard Galloway.

NYSERDA.

SUNY ESF.

RadTech.

# Questions?

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