A Monte Carlo Approach to External Dose Uncertainty

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Overview

- Elements of External Dose Reconstruction

- Organ Dose Conversion Factors

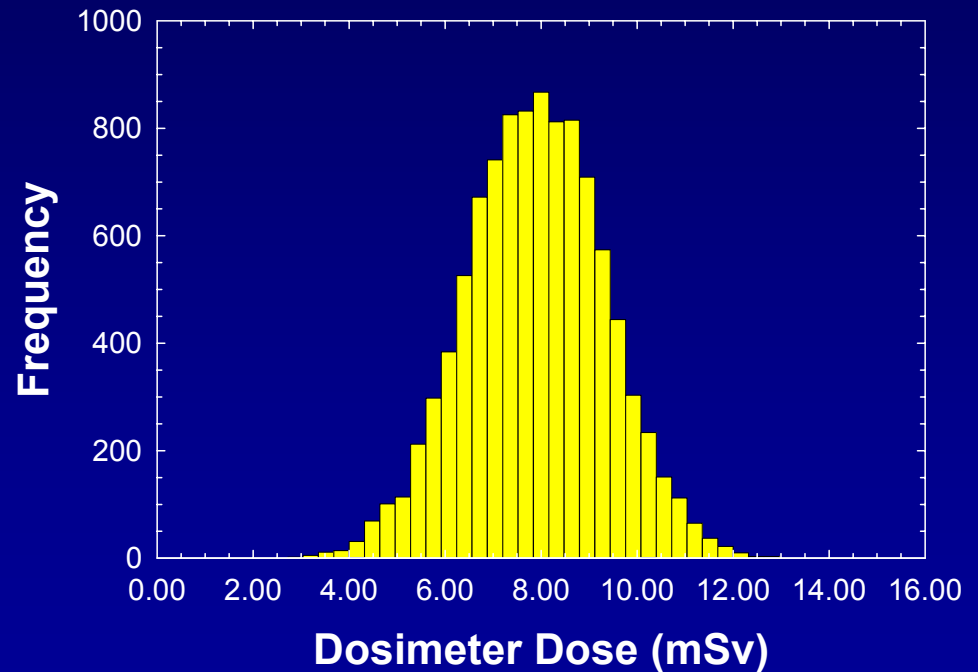- Development of Organ Dose Uncertainty using Monte Carlo Sampling

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Dosimeter Dose

- Summation of dosimeter readings in a given year

  $D_D = D_1 + D_2 + D_3 + \dots D_n$

- Uncertainty

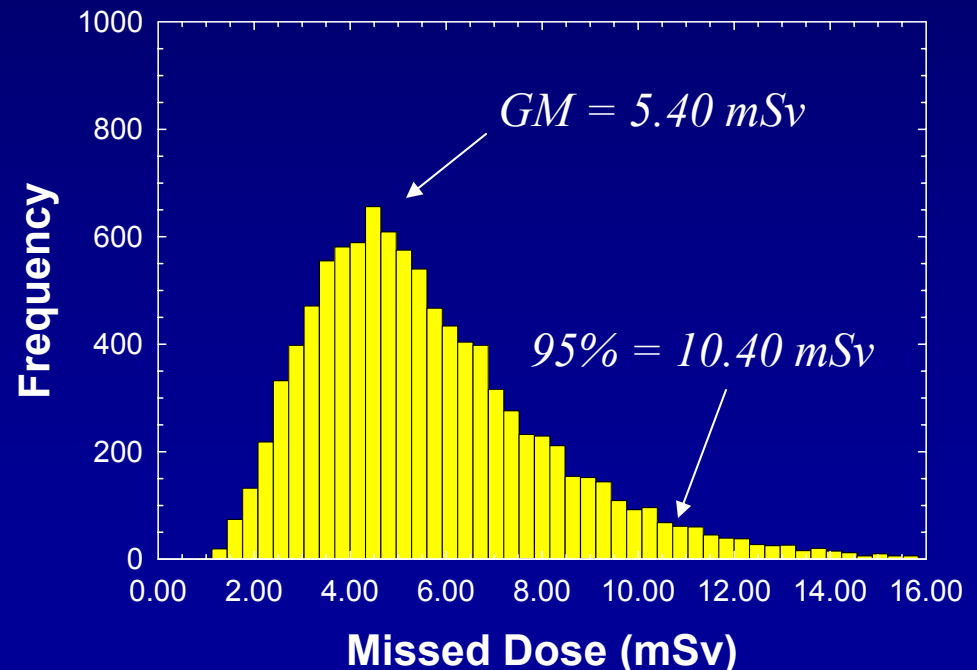 $\sigma_D{}^2 = \sigma_1{}^2 + \sigma_2{}^2 + \sigma_3{}^2 + \dots \sigma_n{}^2$

Mean = 8.05 ± 1.44 mSv

Missed Dose Determination

- **Critical Components**
  - Limit of Detection *(LOD)*
  - Number of zero recordings *(n)*

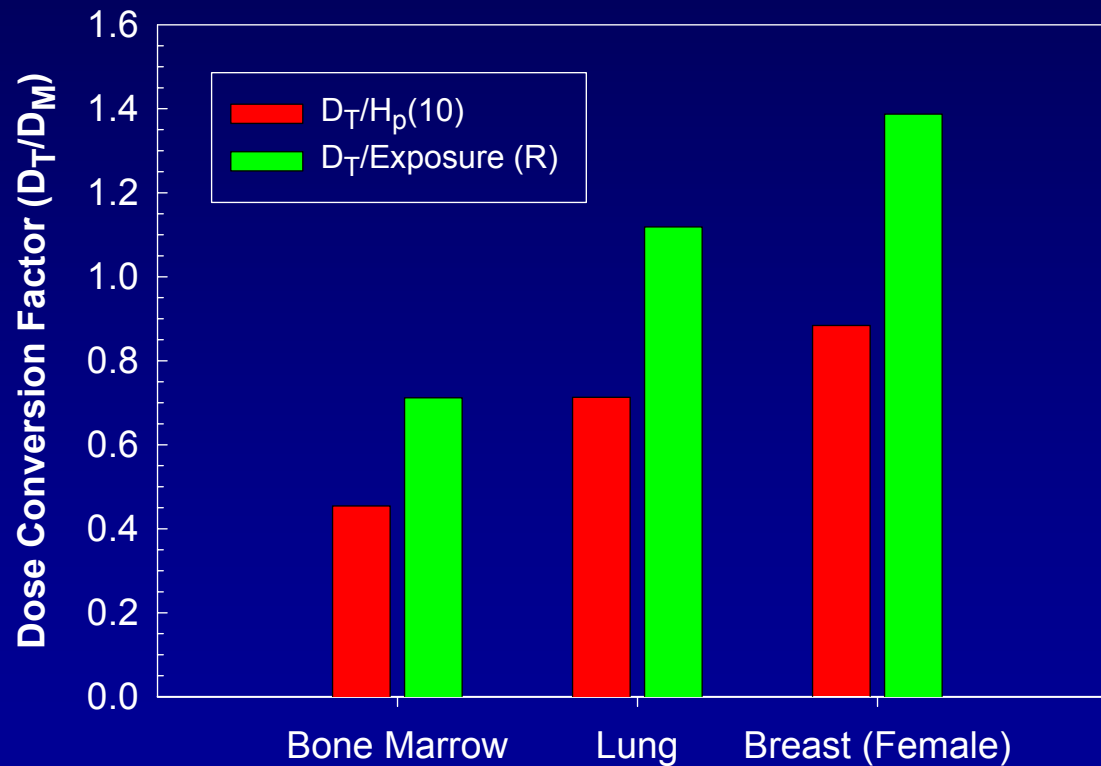$$Geometric\ Mean = n\frac{LOD}{2}$$

$$Upper\ 95\% = nLOD$$

Conversion to Organ Dose

- Primary Factor
  - Target organ – primary cancer
- Additional factors effecting conversion
  - Monitoring device *(Film or TLD)*
  - Energy of emission
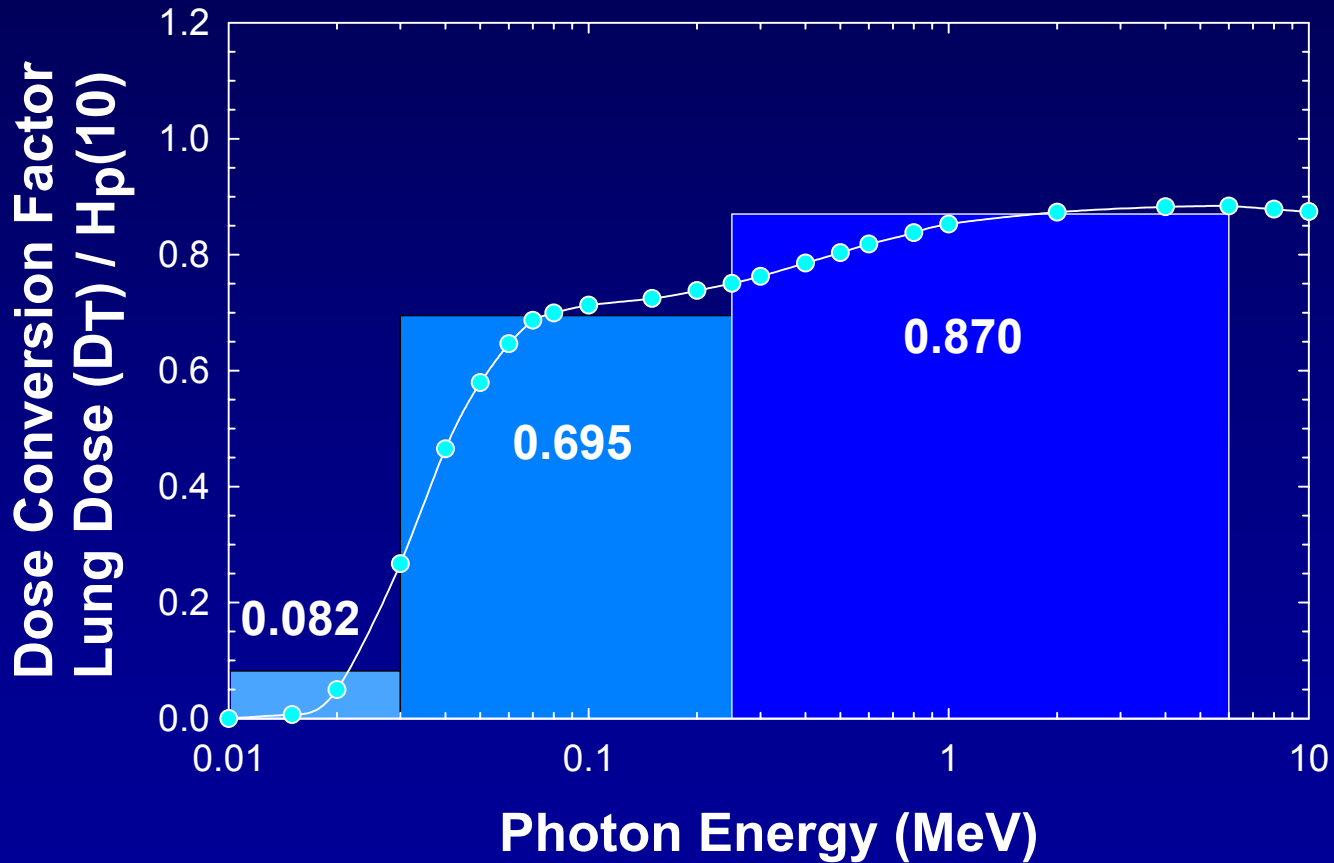 - Exposure geometry

Monitoring Device

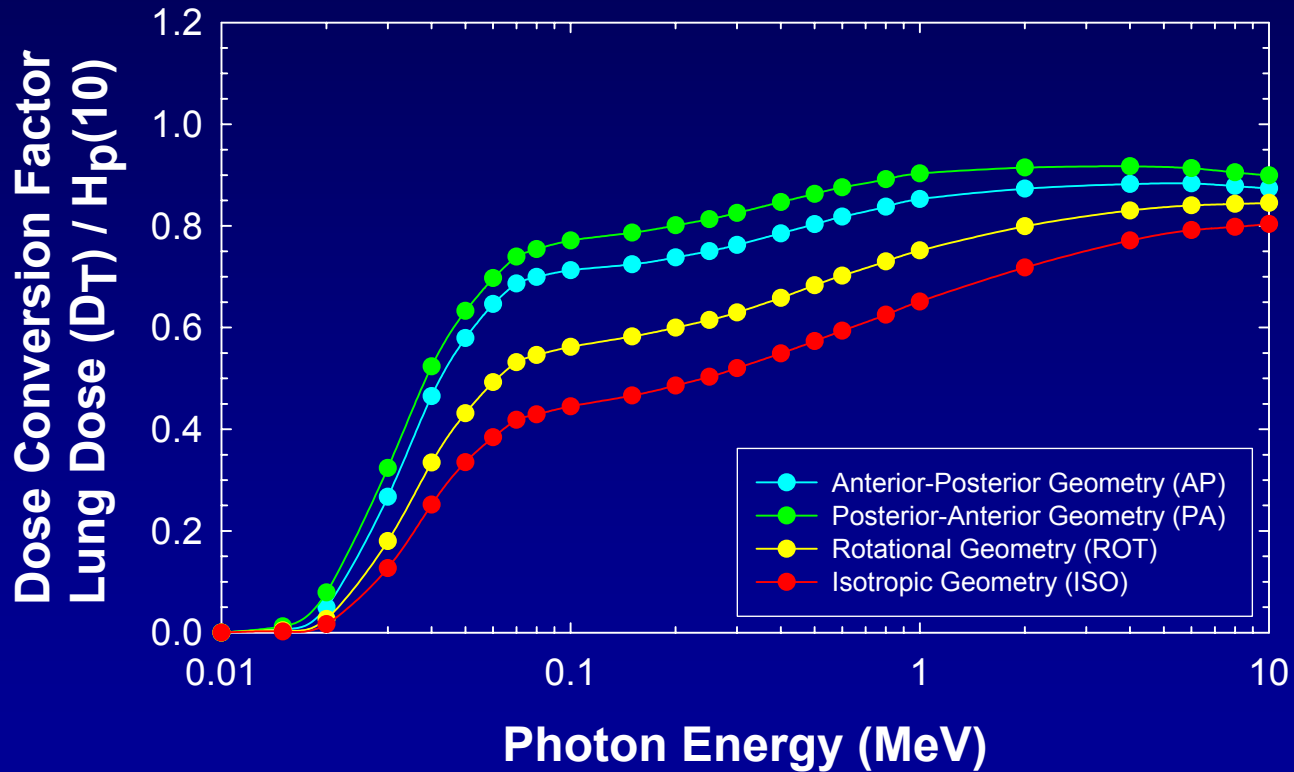*100 keV – AP Geometry*

Data from ICRP 74 (1996)

Energy Banding

DCF for Hp(10) to Lung Dose – AP Geometry

Data from ICRP 74 (1996)

Exposure Geometry

Data from ICRP 74 (1996)

Likeliest Dose Conversion Factor
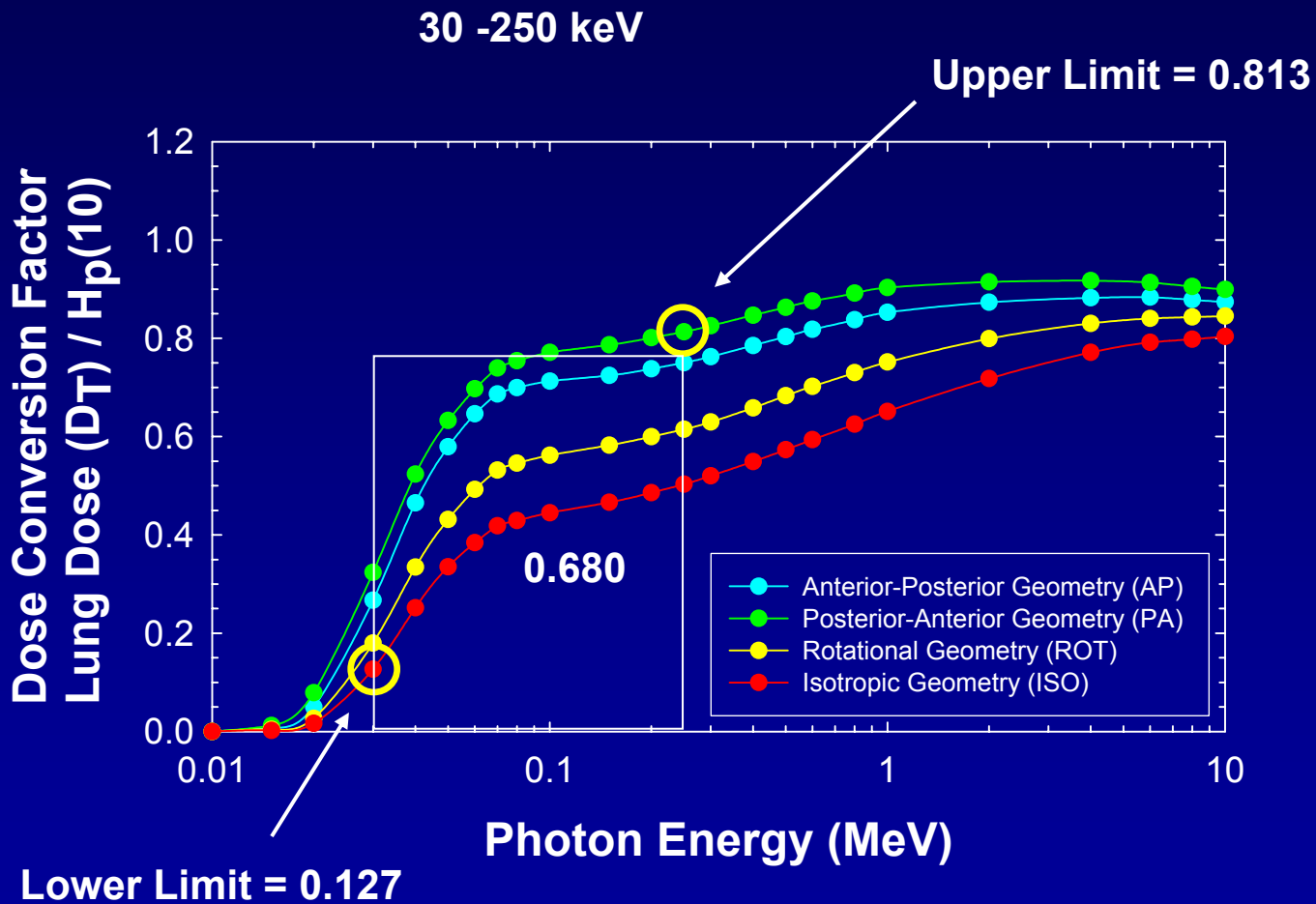
- Weighted approach based on job and or interview

$$DCF\left(D_M, E_\gamma\right)_W = w_{AP} DCF\left(D_M, E_\gamma\right)_{AP} + w_{PA} DCF\left(D_M, E_\gamma\right)_{PA} +$$
$$w_{ROT} DCF\left(D_M, E_\gamma\right)_{ROT} + w_{ISO} DCF\left(D_M, E_\gamma\right)_{ISO}$$
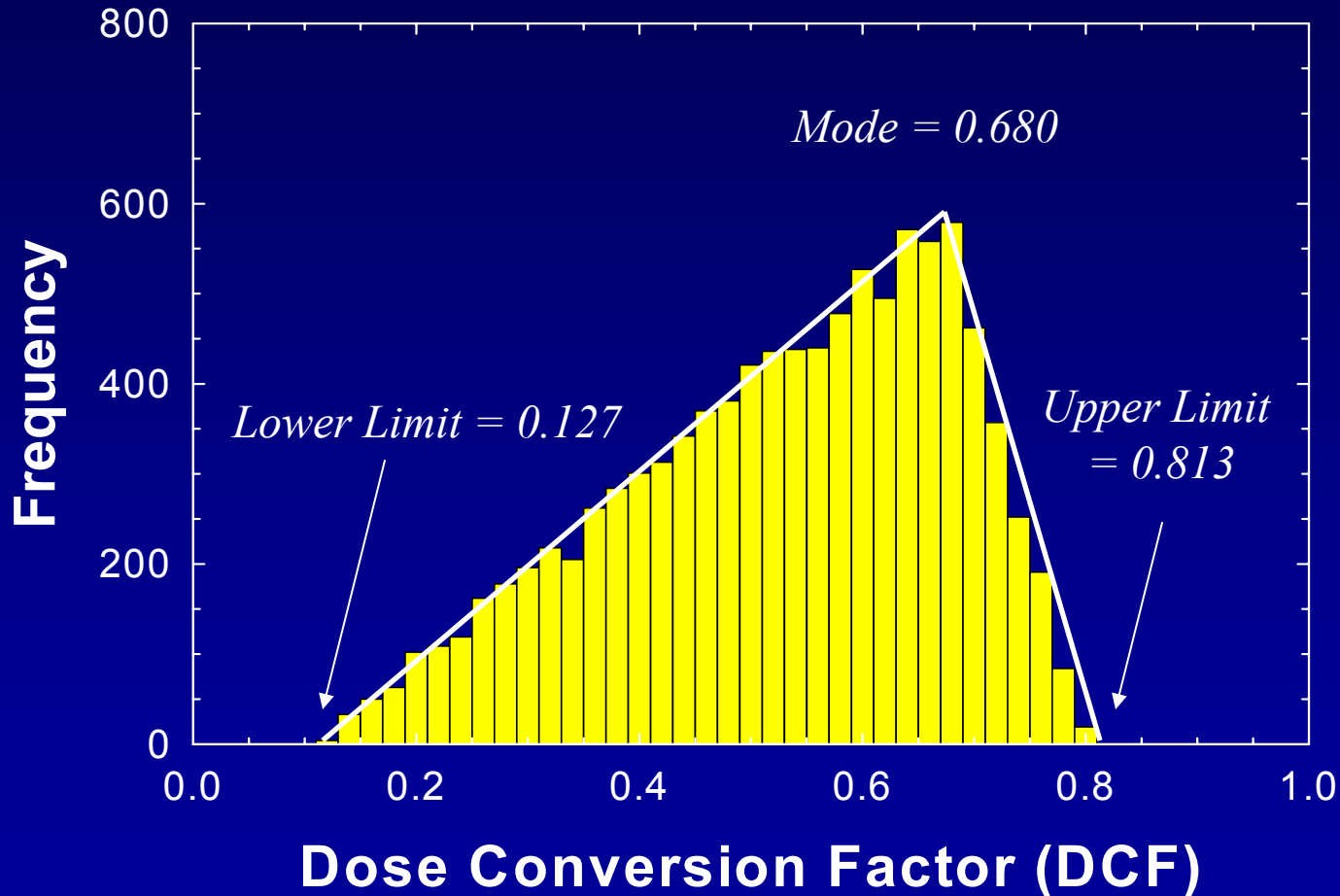
- *Example: 90% AP geometry and 10% ROT Geometry*

$$DCF_W = 0.90(DCF_{H_p(10), E_{\gamma, 30-250 keV}, AP}) + 0.10(DCF_{H_p(10), E_{\gamma, 30-250 keV}, ROT})$$
$$= 0.90(0.695) + 0.10(0.552)$$
$$= 0.680$$

Exposure Geometry Uncertainty

30 -250 keV

Upper Limit = 0.813

Lower Limit = 0.127

0.680

- Anterior-Posterior Geometry (AP)
- Posterior-Anterior Geometry (PA)
- Rotational Geometry (ROT)
- Isotropic Geometry (ISO)

Dose Conversion Factor Lung Dose (D_T) / H_p(10)

Photon Energy (MeV)

Data from ICRP 74 (1996)

DCF Triangular Distribution

Development of the Organ Dose Uncertainty Distribution

- Organ dose uncertainty is determined using Monte Carlo sampling from each of the dose component distributions and the associated dose conversion factor uncertainty.

- Recall
  - Dosimeter Dose – Normal
  - Missed Dose – Lognormal
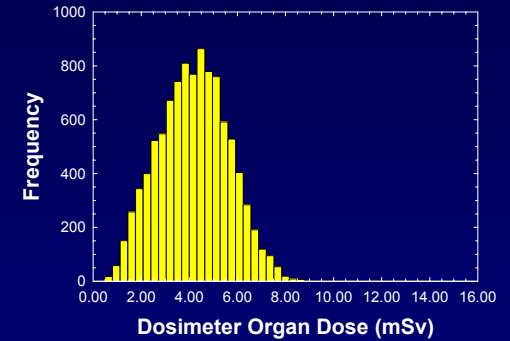 - Dose Conversion Factor - Triangular
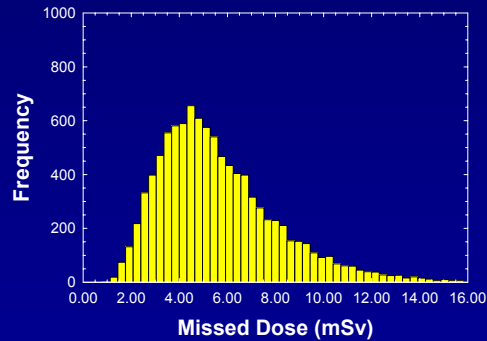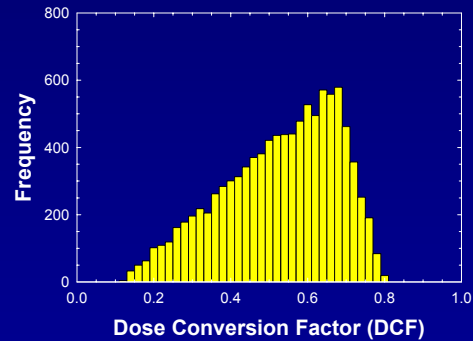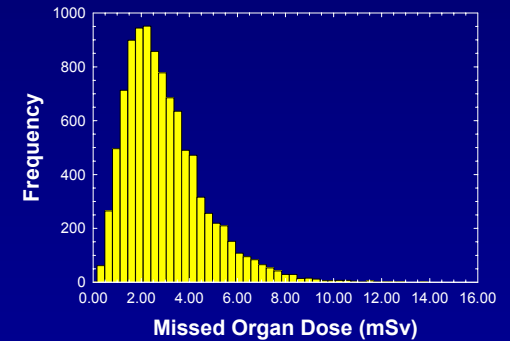
Uncertainty Distribution
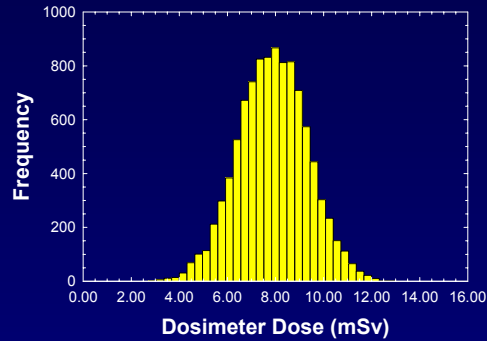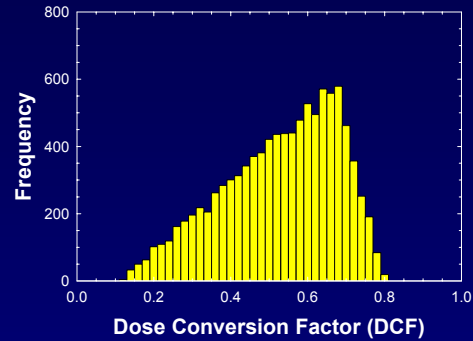
Organic Dose Distribution

- **Normal Distribution**
  - *7.49 ± 2.23 mSv*
  - $\chi^2 = 425,\ KS = 0.435$

- **Lognormal Distribution**
  - GM = 7.15 mSv
  - GSD = 1.36
  - $\chi^2 = 283,\ KS = 0.349$
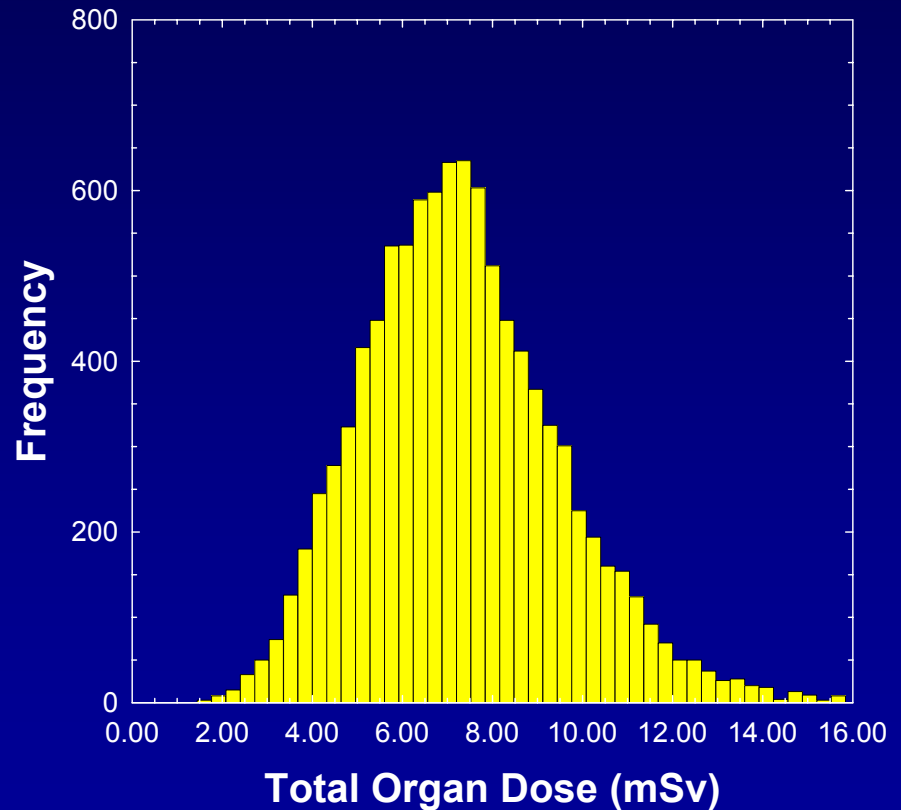
Summary
Organ Dose Uncertainty

- Laboratory Uncertainty
  - Dosimeter Reading
  - Missed Dose Uncertainty
- Field Uncertainty
  - Photon Energy
  - Exposure Geometry

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