# Distribution of Committed Effective Dose Coefficients for ICRP 66 from Uncertainty in the Human Respiratory Tract Model


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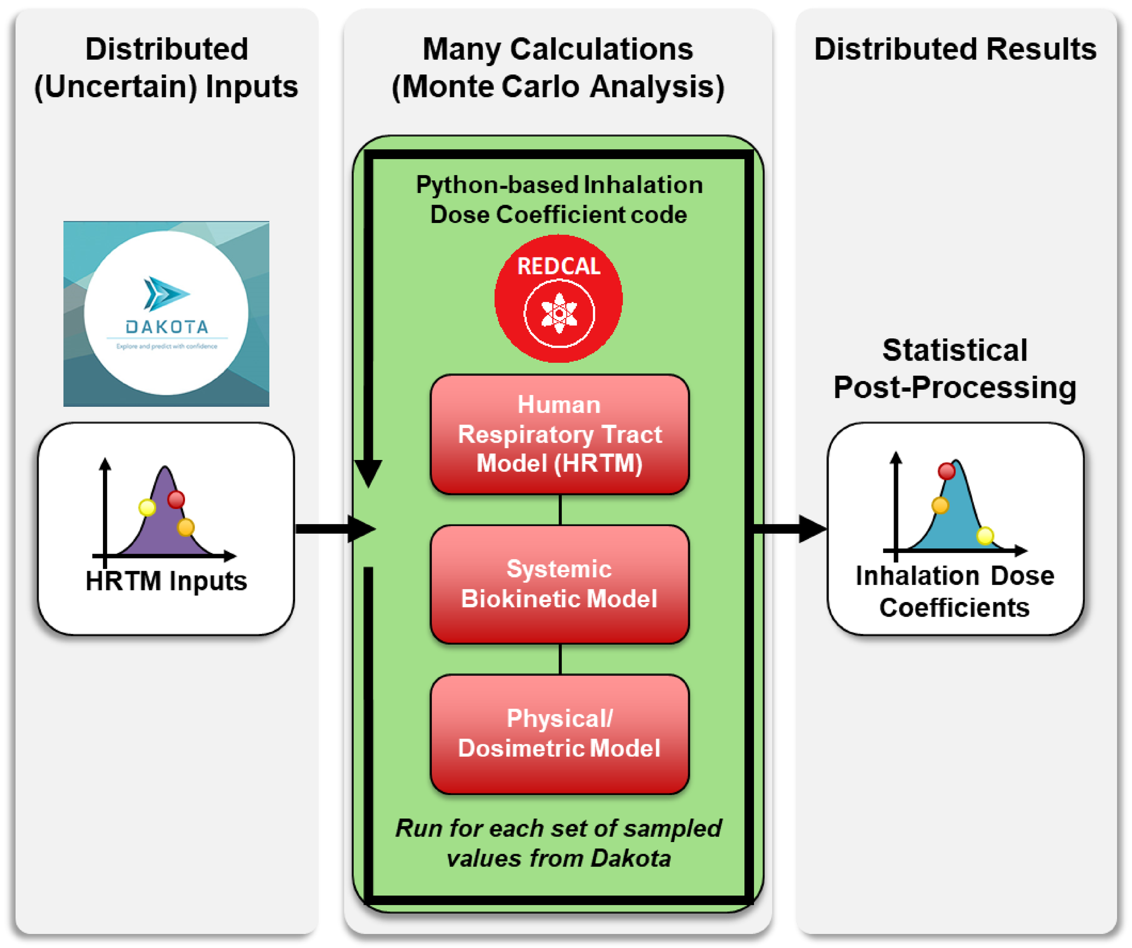
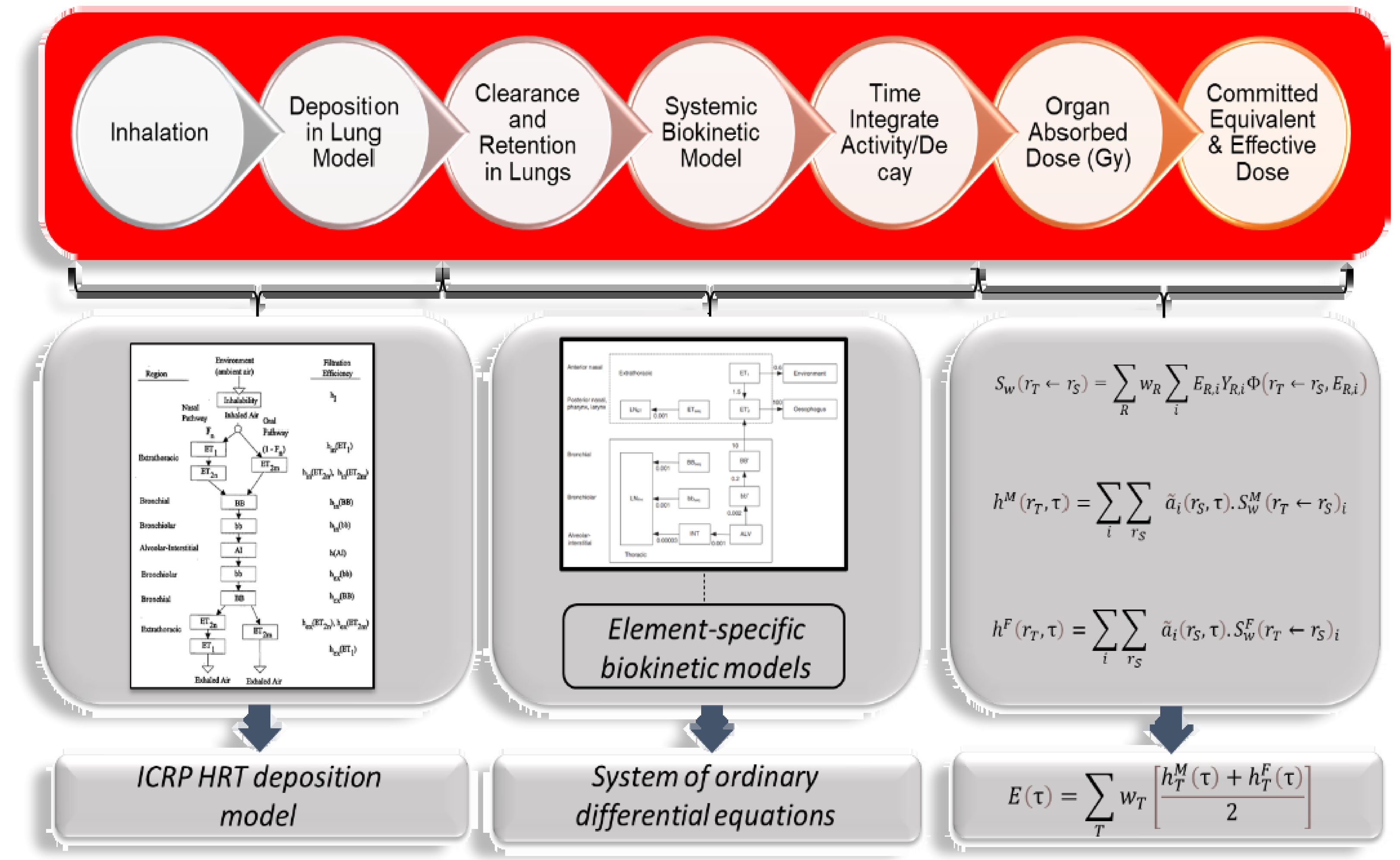
## Overarching Goal: Develop Method for Quantifying Uncertainty for Inhalation Dose Coefficients



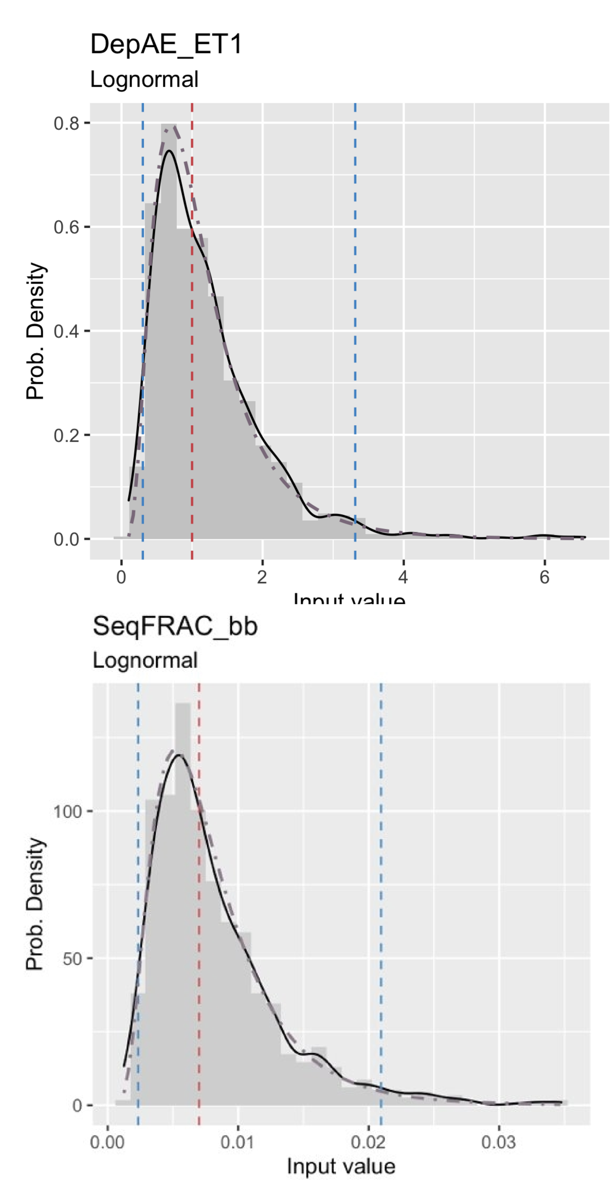

- The goal of this project was to develop a framework for propagating uncertainty through the human respiratory tract model (HRTM) and use it to generate **inhalation dose coefficient probability distributions** for radionuclides of interest for U.S. Department of Energy (DOE) Consequence Management (CM).
- Georgia Tech developed a Python implementation of International Commission on Radiological Protection (ICRP) Publication 66 HRTM, called the **Radiological Exposure Dose Calculator (REDCAL)**, shown to the right.
- Sandia National Laboratories assisted with selecting appropriate uncertainty propagation distributions for variables of interest, as well as created a framework for performing uncertainty analyses, as shown to the left. Input probability distributions were sampled using the **Dakota** software.

## Calculations Within REDCAL



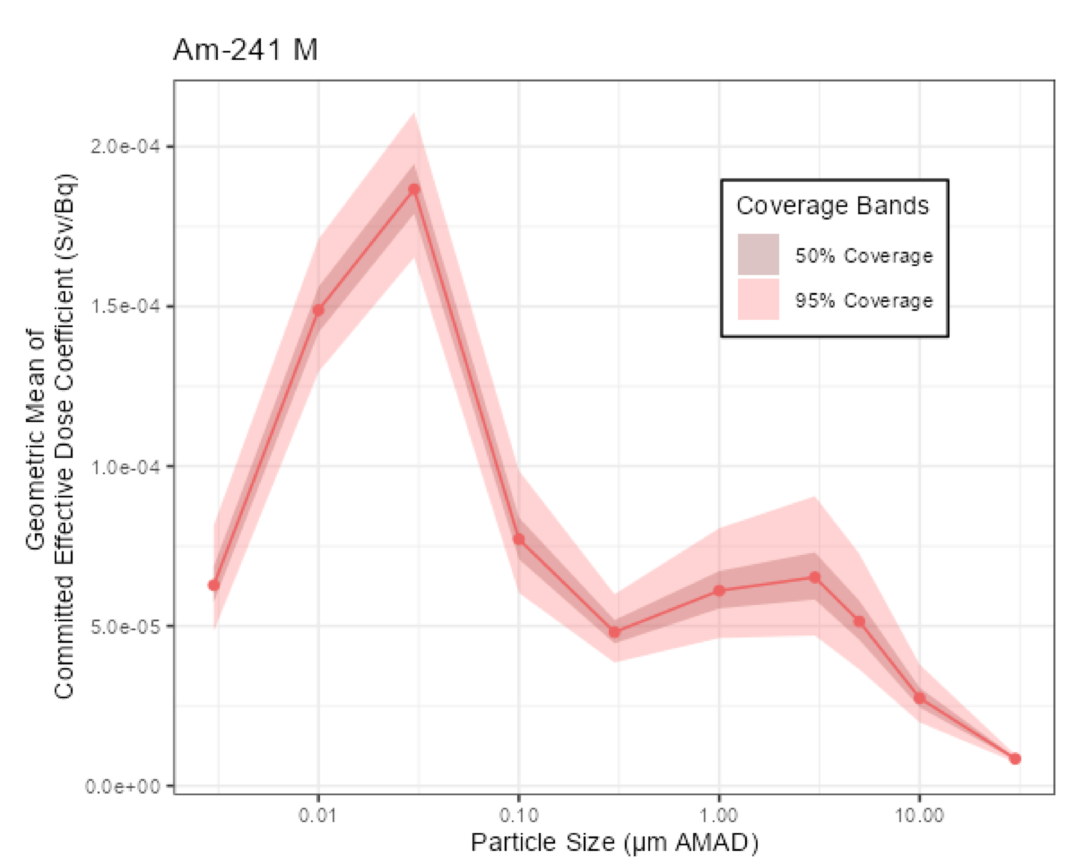

## Propagating Uncertainty Within ICRP 66 HRTM

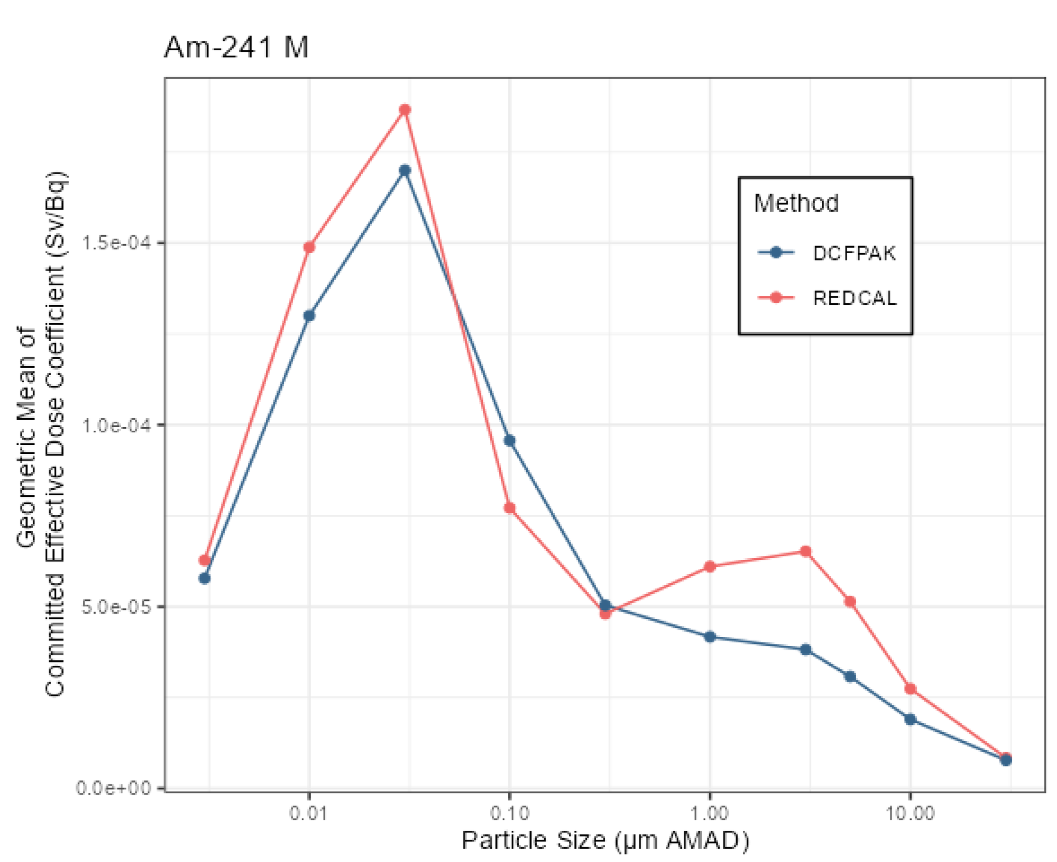
- **27 HRTM parameters treated as uncertain inputs** for computation of inhalation dose coefficients
  - Deposition efficiency error term for aerodynamic and thermodynamic modes
  - Intra-respiratory clearance rates
  - Compartmental fraction breakdown
- **Uncertain inputs sampled from selected distributions**
  - Drawn heavily from ICRP 66 annexes by Bailey and Roy and the authors of LUDUC
  - Performed Latin Hypercube Sampling (LHS) of each input distribution
  - Examples shown to right
    - Aerodynamic deposition scaling factor for ET-1 region
    - Sequester fraction in bronchioles

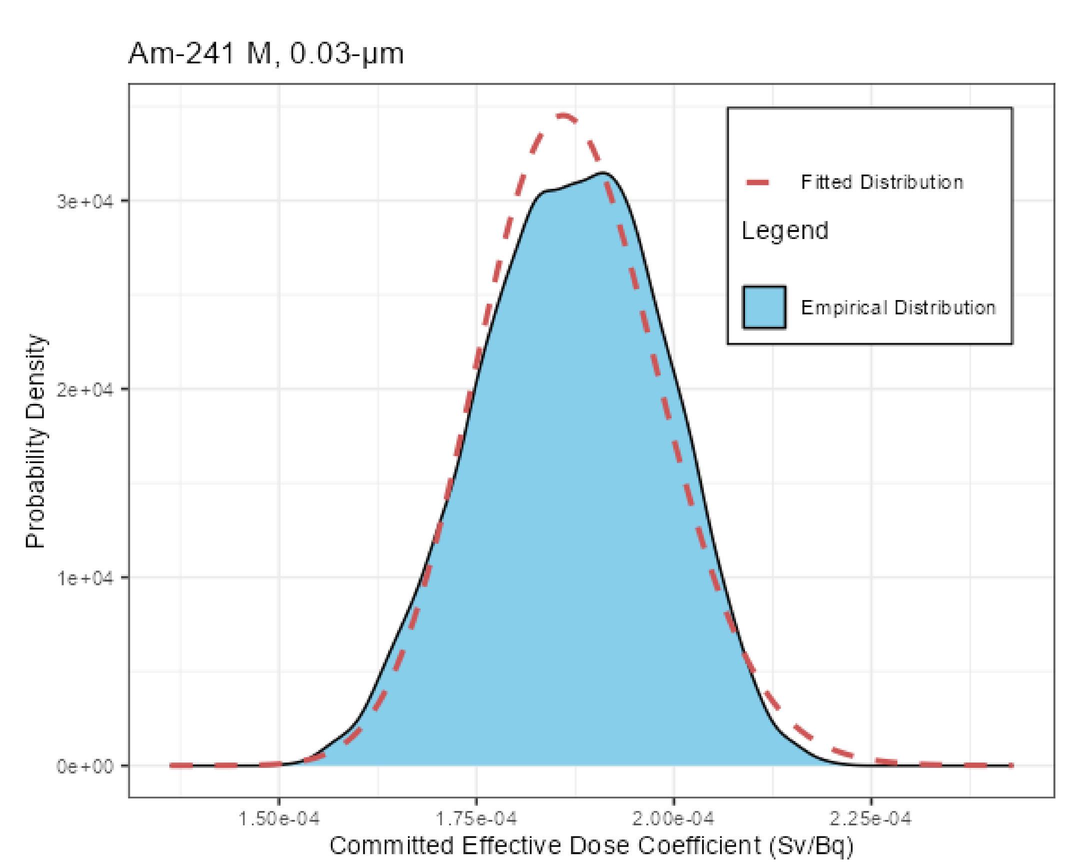


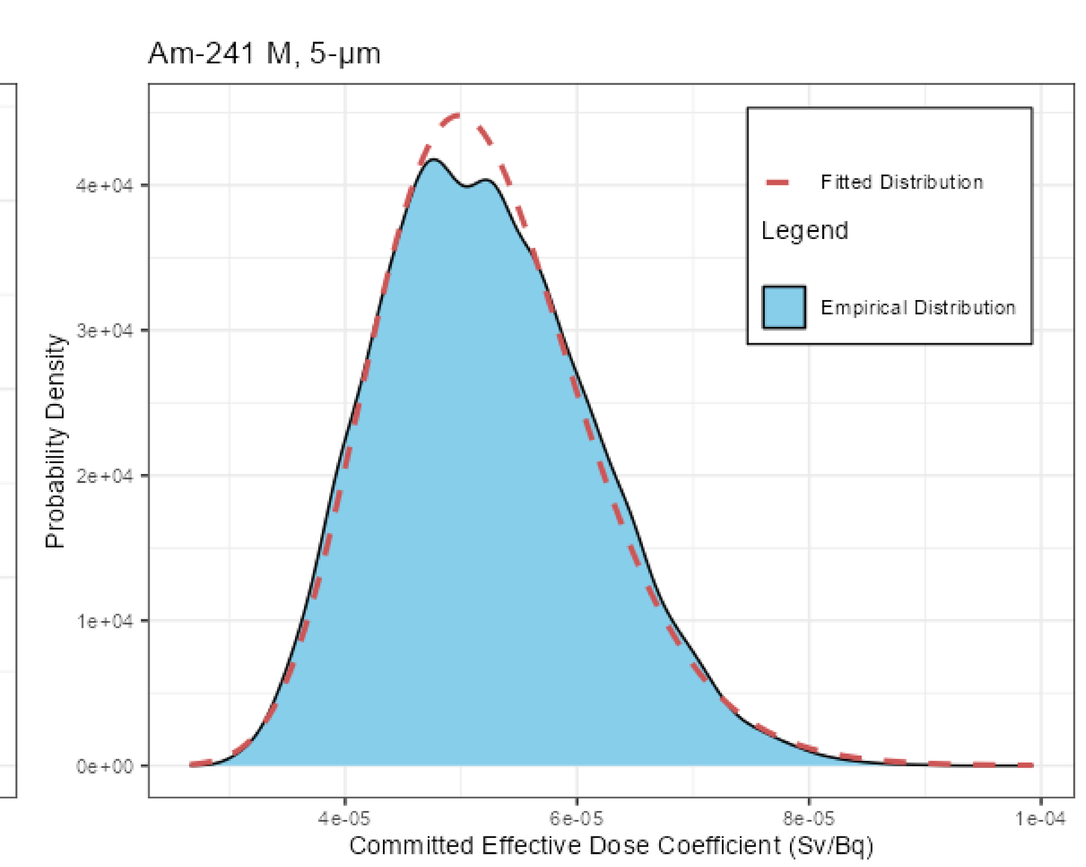

- Modeled dose coefficients for **31 prioritized radionuclides** of interest to DOE CM that cover a range of emission types, lung clearance types, half-lives, and decay chain complexity
- **10 sets of Adult committed effective dose coefficients** were generated for particle sizes ranging from 0.003 to 30 µm.
- **10,000 simulations** were run for each radionuclide, lung clearance type, and particle size, resulting in over **3 million results** to analyze.

## Committed Effective Dose Coefficient – Resulting Distributions




- All results were analyzed for potential distribution fit for future sampling and use in DOE CM software like Turbo FRMAC.
- **A log-normal distribution was selected** to characterize the uncertainty in the dose coefficient.
- Example committed effective dose coefficient results are shown for Am-241 Type M, a radionuclide and lung clearance type of interest to DOE CM.
- The **top-left coverage bands plot** shows how the results are distributed as a function of particle size.
- The **top-right plot** shows the mean of the fitted log-normal distribution compared to the discrete value currently available in DCFPAK as a function of particle size for a given radionuclide and lung clearance type. The majority of results for the considered radionuclides agreed well with DCFPAK.
- The bottom plots show how the empirical distribution of results for the specific particle size compare to the fitted log-normal distribution.
- Fit quality was assessed using the **Kullback-Leibler divergence** for each radionuclide and particle size.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