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Comparison of organ activity estimates based on bioassay monitoring with postmortem tissue analyses



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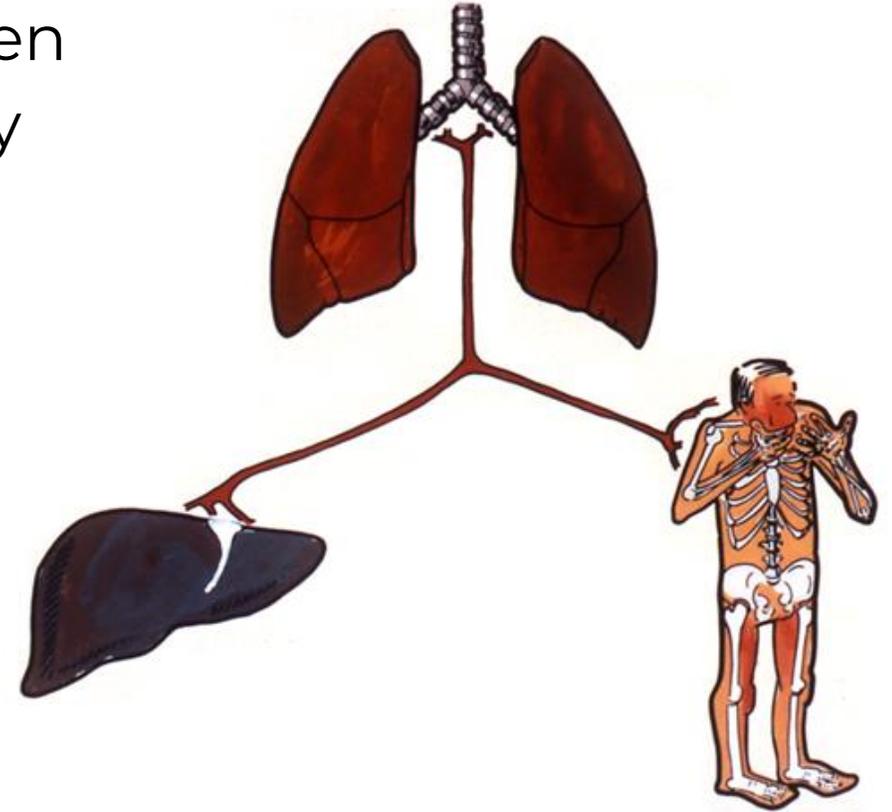
Motivation

- In radiation epidemiology, worksite records and bioassay measurements are used to estimate the radiation doses
- Post-mortem tissue/organ analyses can be used to evaluate the accuracy of the reference biokinetic models and radiation dose estimates for epidemiology



Objectives

- What is the level of agreement between the model predictions of organ activity predictions and the tissue activity measurements



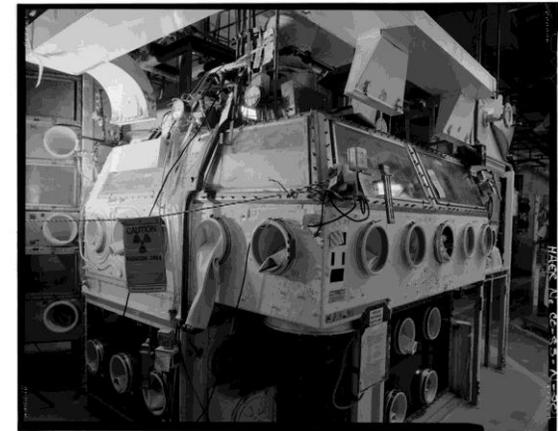
This Study: Rocky Flats Workers

1965 Rocky Flats glove box fire accident†

- High-fired refractory PuO_2 aerosols: $1\ \mu\text{m}$ AMAD
- 23 out of 400 potentially exposed workers are USTUR Registrants
- Nine highest exposed individuals were selected for this study: four (4) whole-body and five (5) partial-body tissue donors



<https://coloradoencyclopedia.org/article/rocky-flats-nuclear-facility>



<https://www.loc.gov/resource/hh.h.co0855.photos/?sp=20>

† Mann and Kirchner. *Evaluation of lung burden following acute inhalation exposure to highly insoluble PuO_2* . Health Physics 13(8): 877–882; 1967

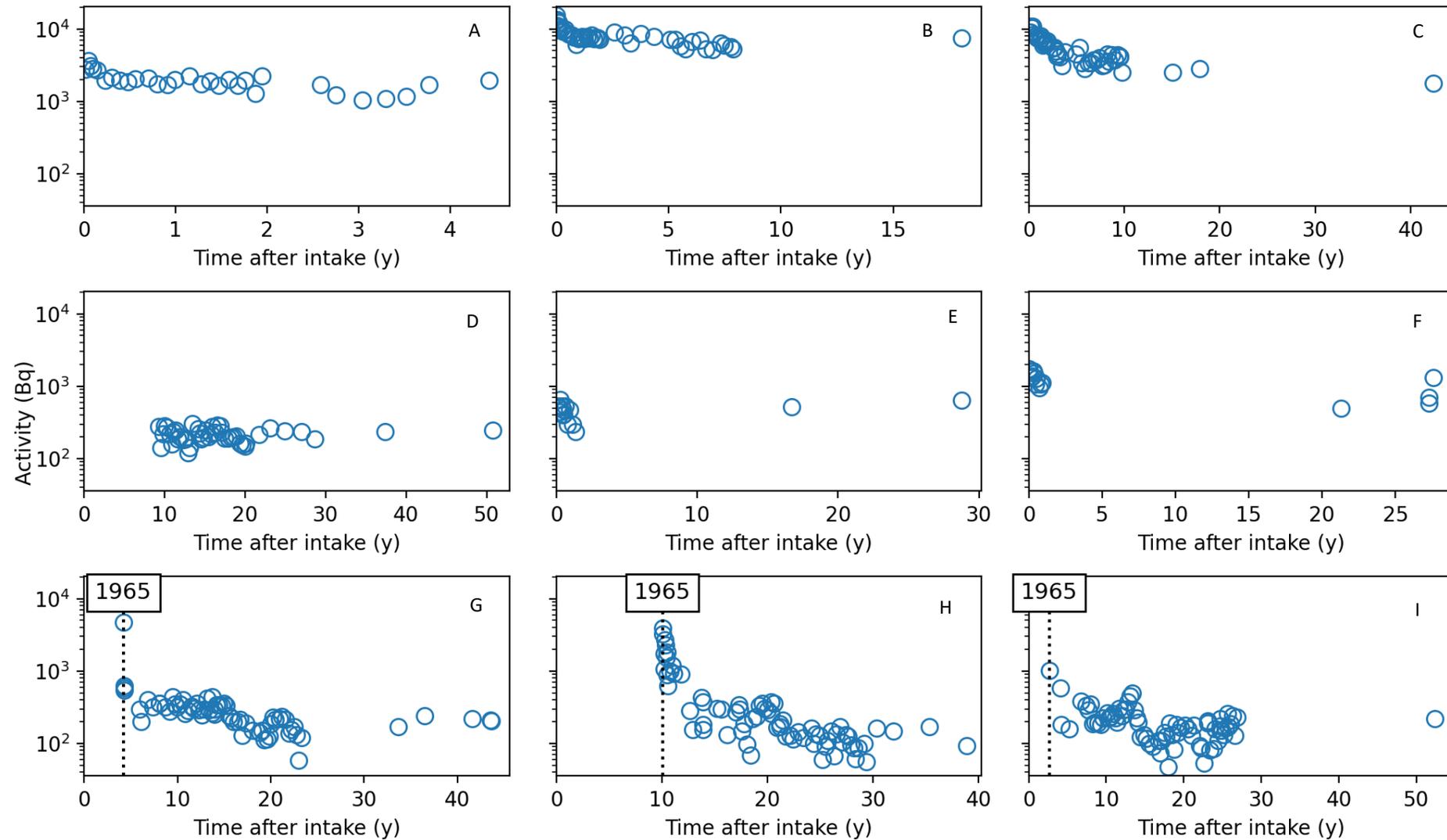


Study Group Overview

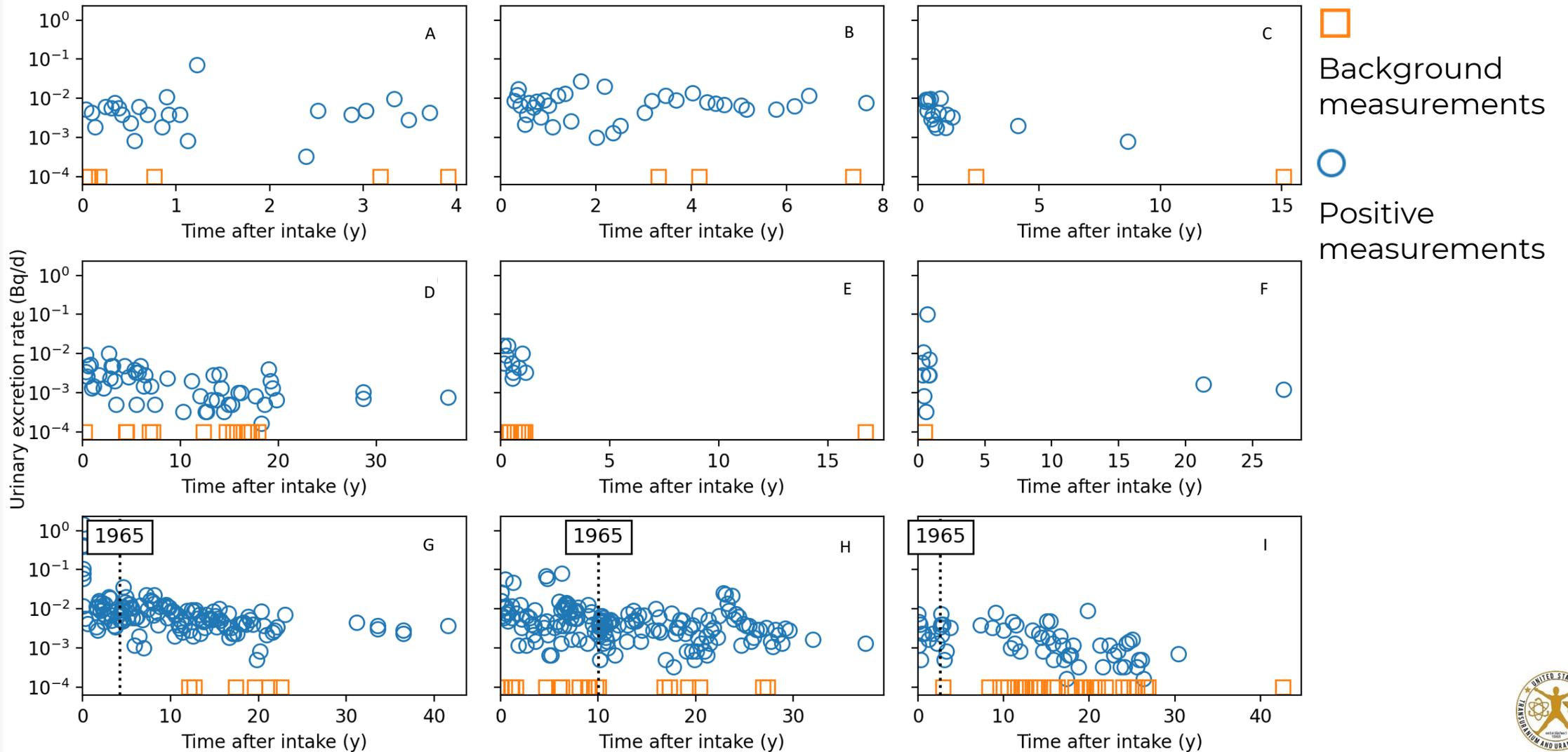
- Intake regimes:
 - ✓ Single acute inhalation due to fire – 6 cases
 - ✓ Additional wound prior to fire – 1 case
 - ✓ Additional inhalation prior to fire – 2 cases
- Follow-up ranged from 5 to 50 years after fire accident
- Bioassay data: chest counts, urine
- Measured ^{239}Pu activities in lungs, thoracic lymph nodes (LNTH), liver, and skeleton



Data: Chest Counts



Data: Urine Bioassay



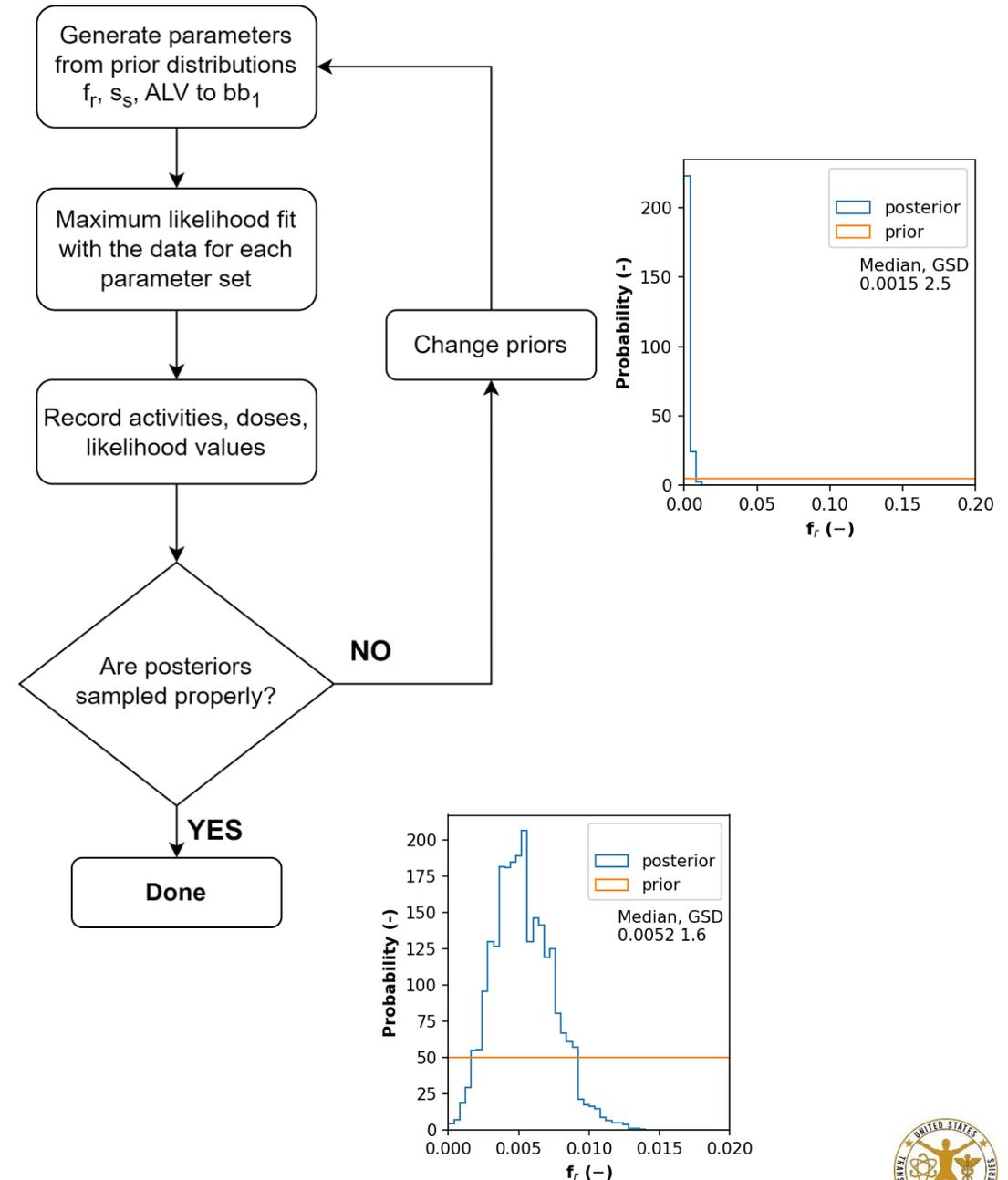
Data: Radiochemistry Results

Case	Measured activity (Bq)		
	Lungs+LNTH	Liver	Skeleton
A	1887	9.64	20.56
B	6550	102	217.7
C	1957	123	197
D	244	28.3	26.95
E	528	25.79	9.19
F	1046	28.58	19.31
I	155	19.97	19.10
H	93	29.97	87.1
G	241	70.9	110.9



Bayesian Approach

- Prior probability is the estimated probability before the data
- Posterior probability is updated by the fit of bioassay
- Can be used to find specific parameters for a group
- The result is not a point estimate, but a distribution



Shared Priors

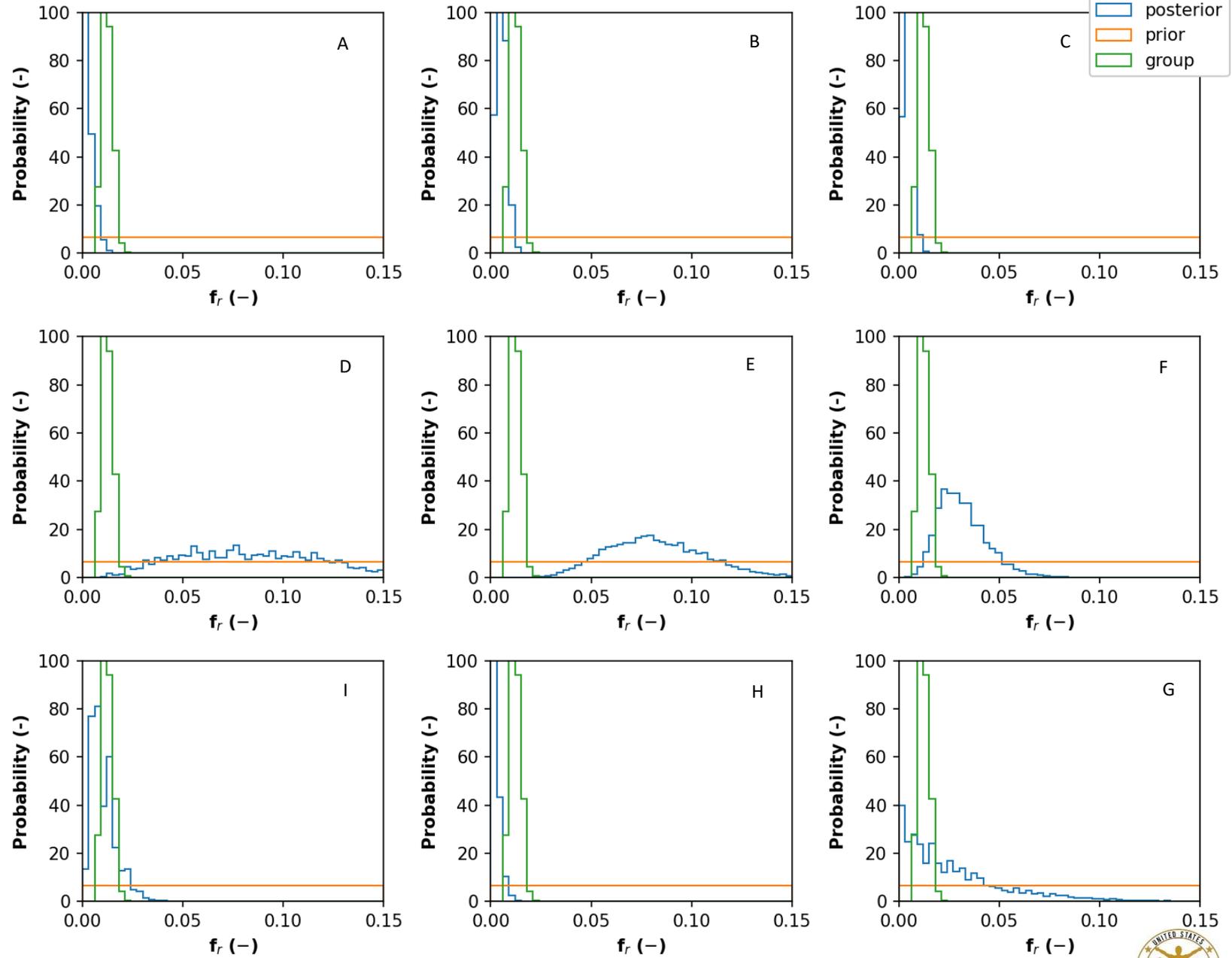
- Latin hypercube sampling
- Sample size: 10,000

Parameter	Distribution
f_r – fraction dissolved rapidly	Uniform(min=0,max=0.15)
s_s – slow dissolution rate	Lognormal(median= 1×10^{-5} , GSD=2)
ALV to bb – particle transport rate	Lognormal(median=0.0027, GSD=2.5)
AI – deposition fraction	Lognormal(median=0.1066, GSD=2)



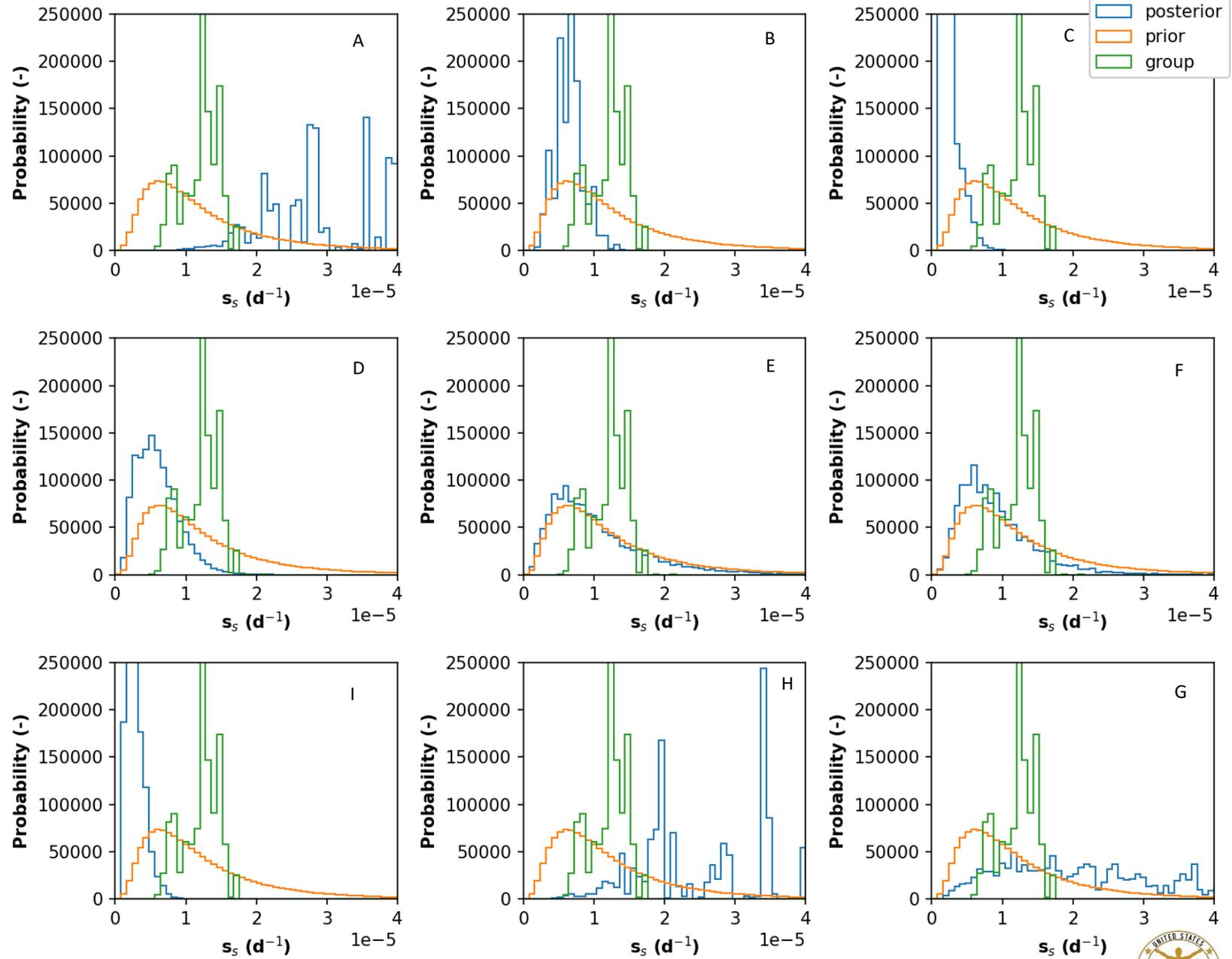
Results: f_r

Fraction dissolved rapidly



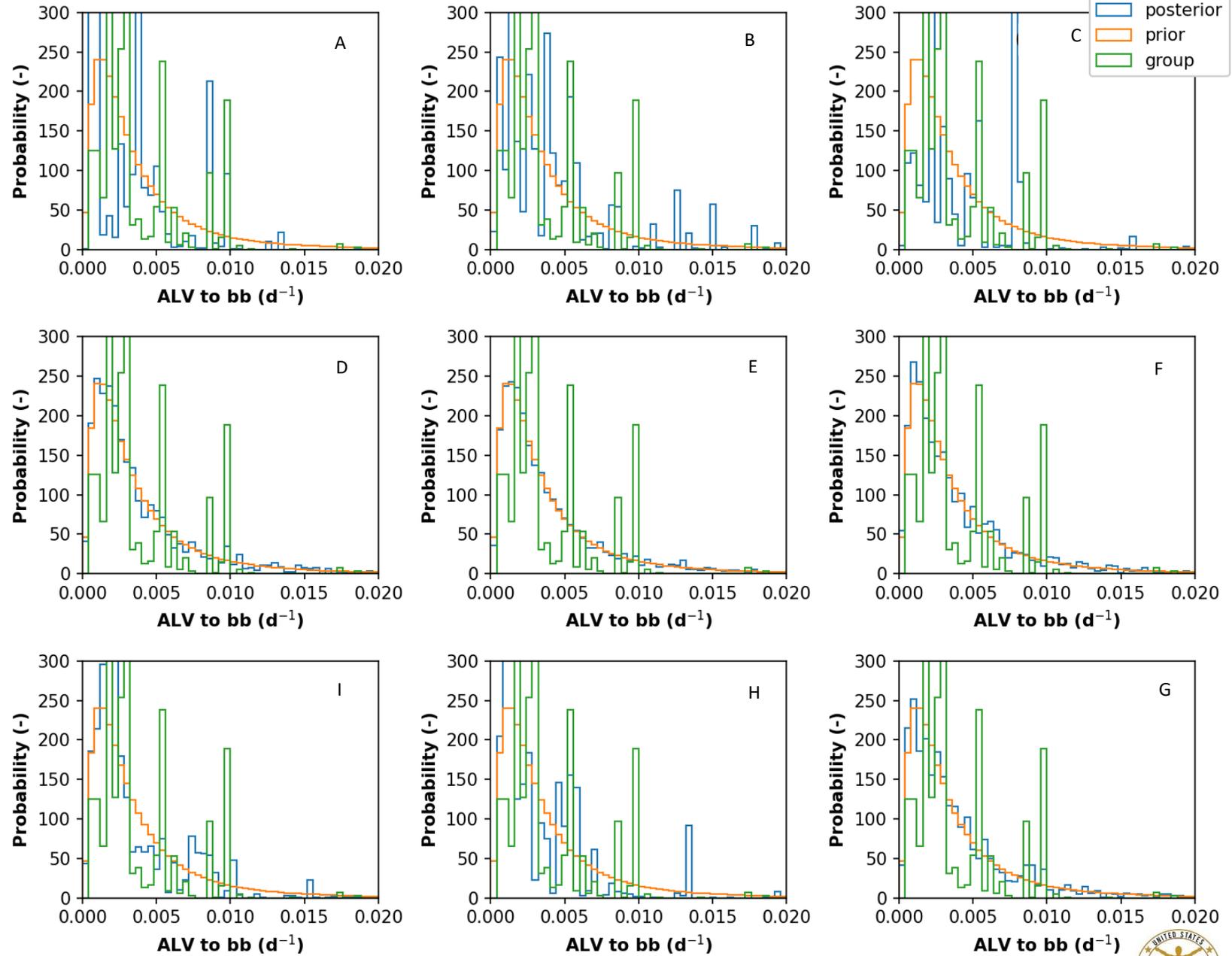
Results: s_s

Slow dissolution rate



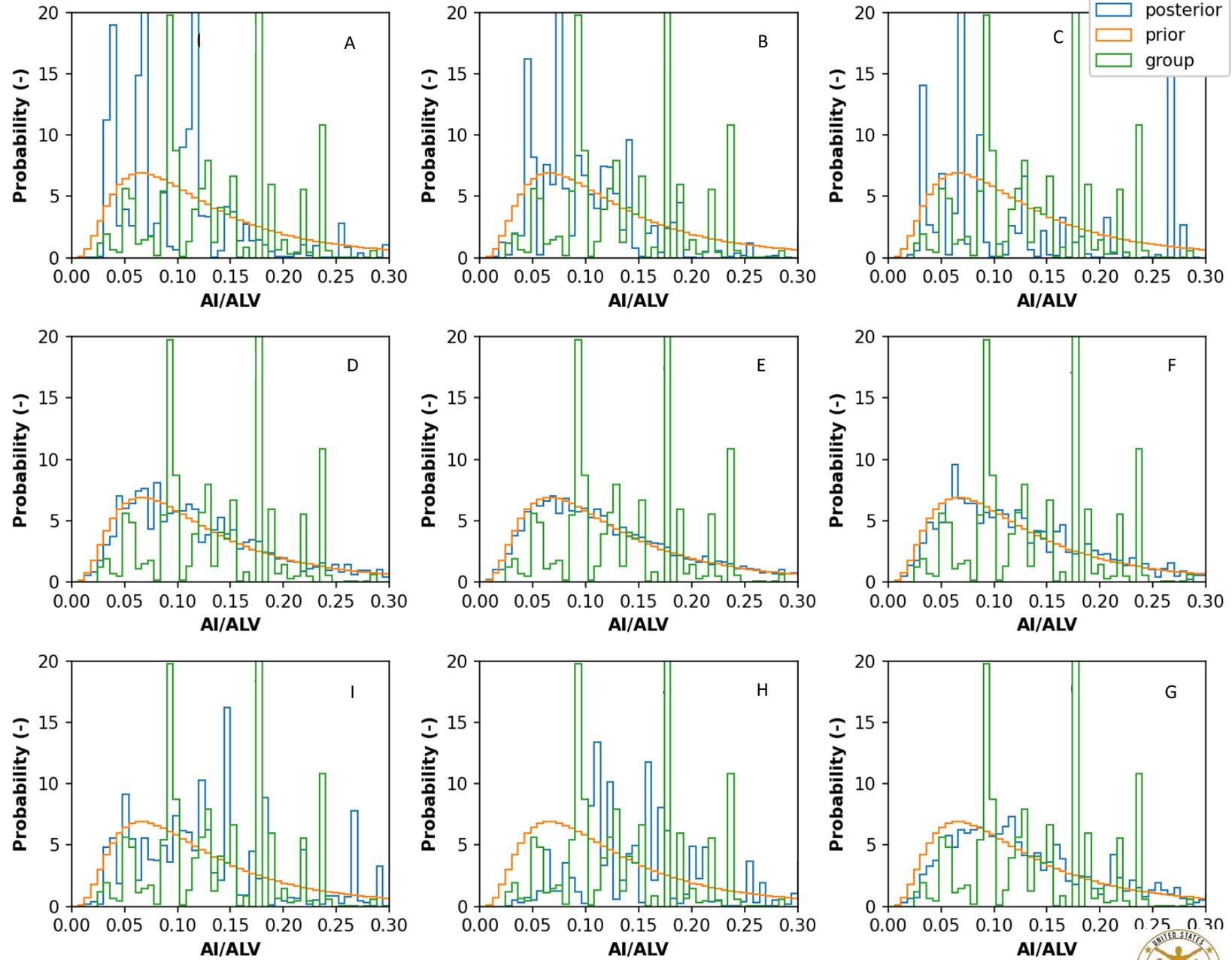
Results: ALV to bb

Particle transfer rate from alveoli to bronchioles

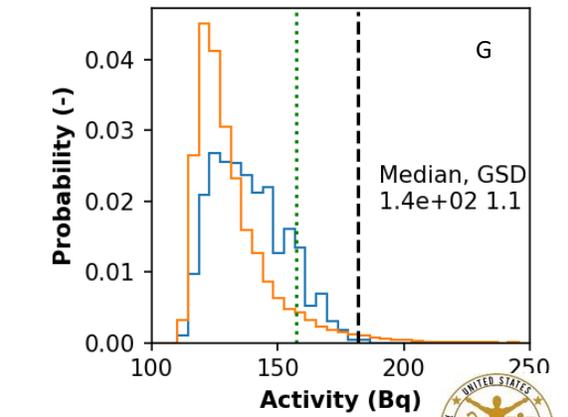
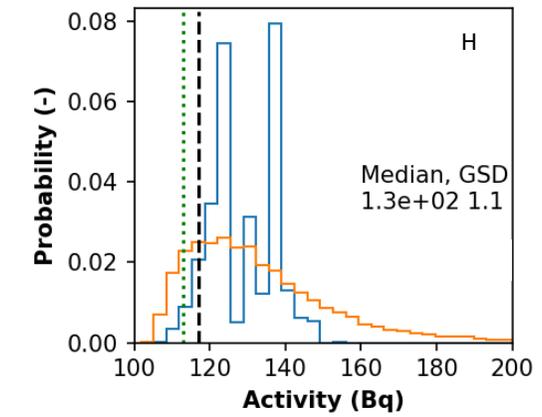
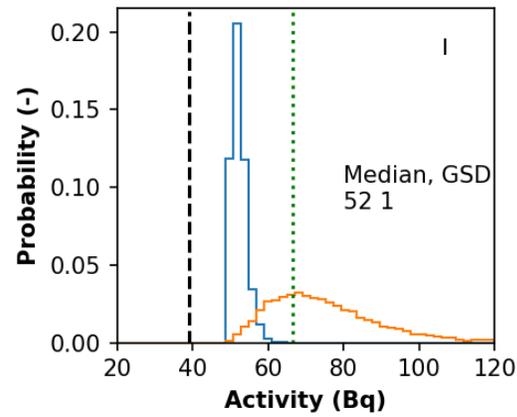
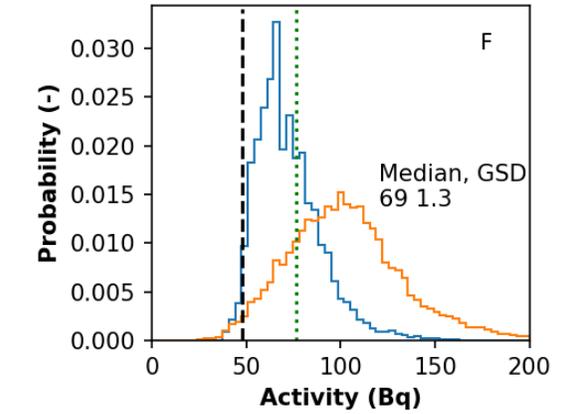
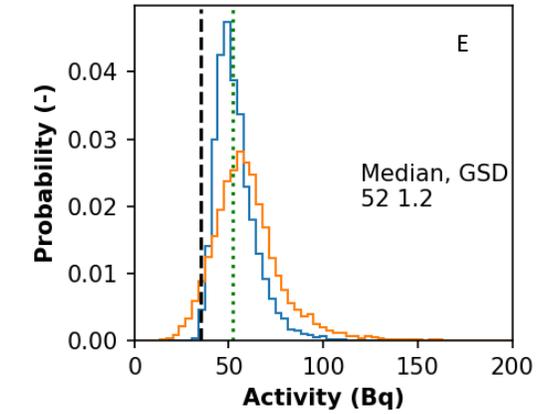
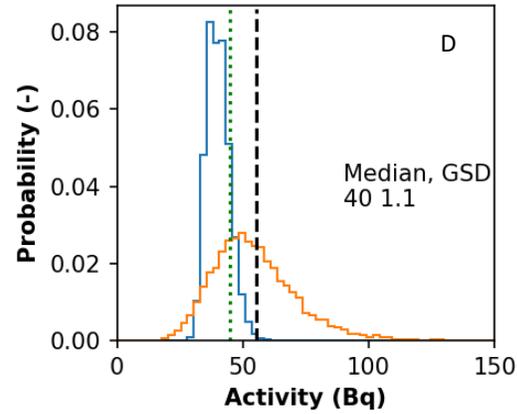
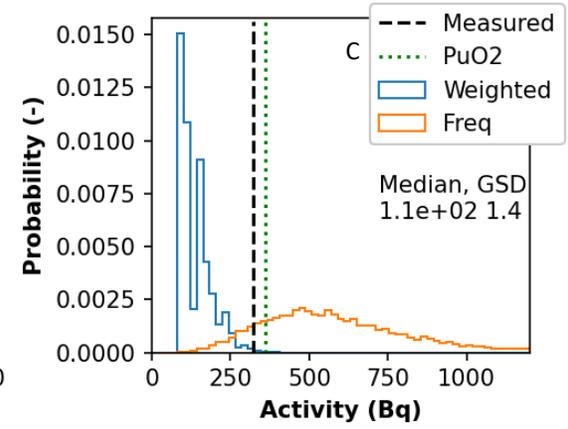
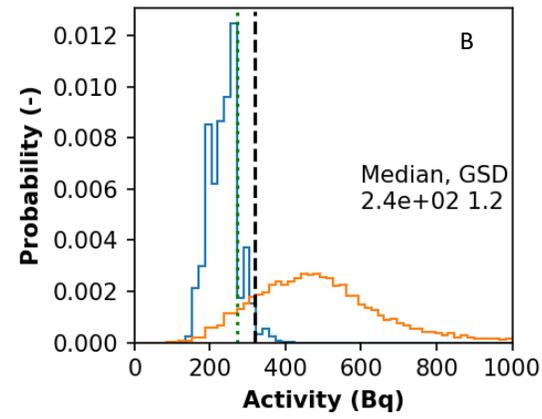
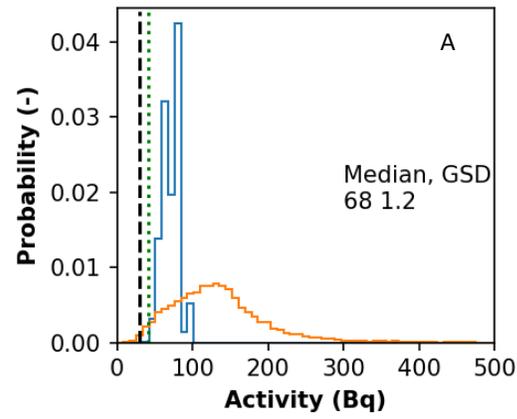


Results: AI fraction

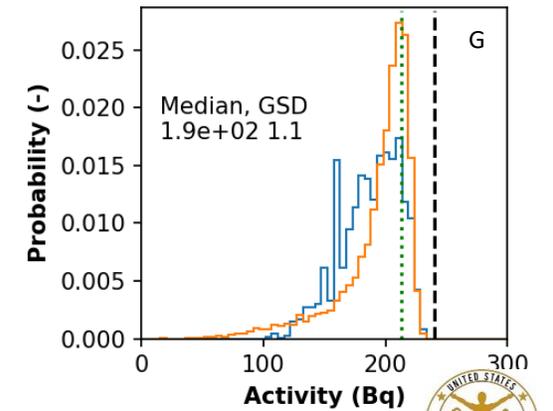
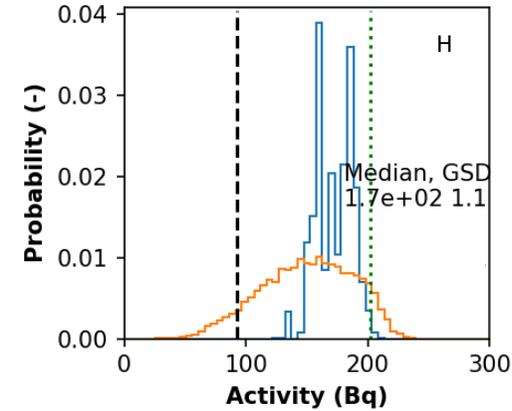
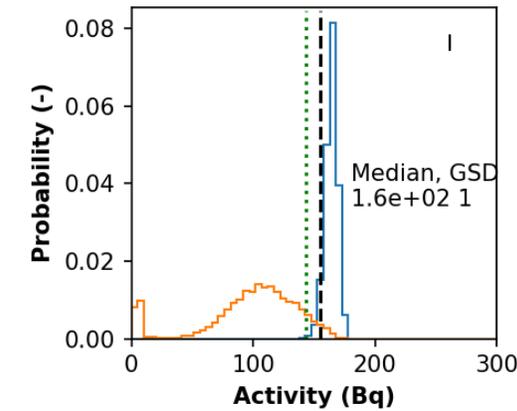
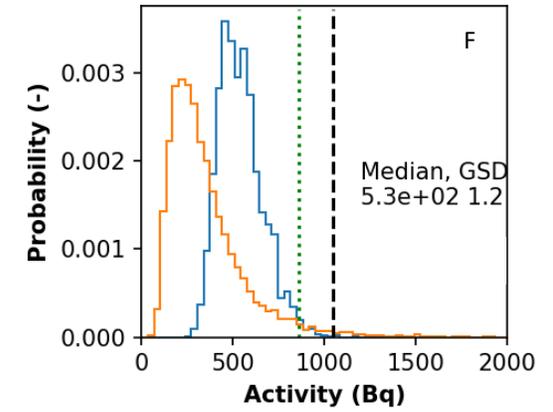
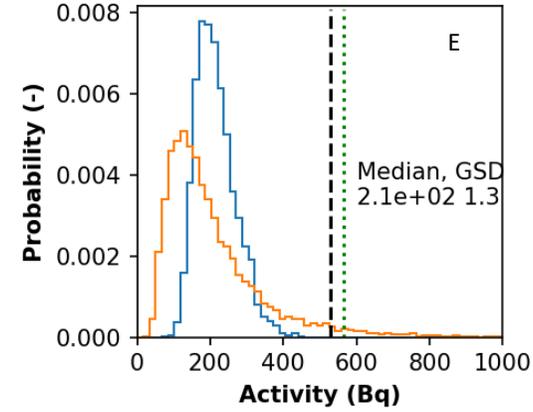
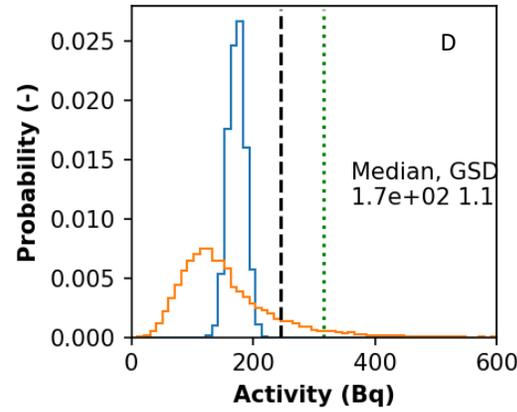
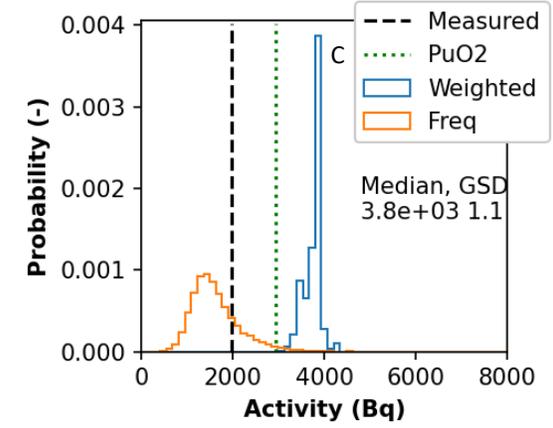
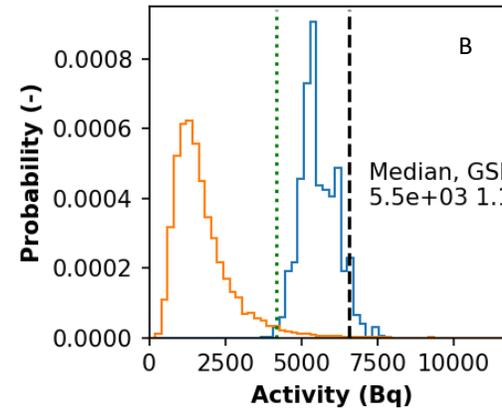
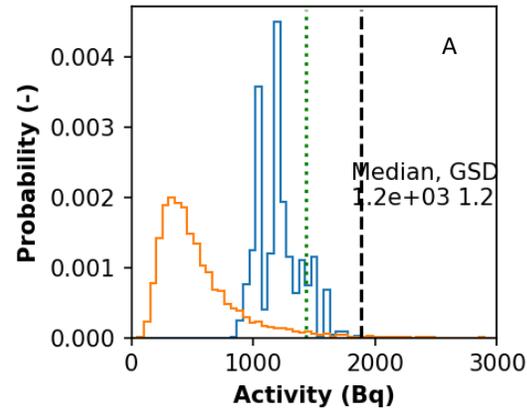
Fractional
deposition
parameter



Liver+ Skeleton



Lungs +LNTH



Conclusions

- Nine individuals involved in the same accident with 'high-fired' PuO_2 inhalation were modeled
- Posterior means for liver+skeleton and lungs+LNTH activity predictions differ from measured values by 45% and 46%, respectively
- Most of activity posterior distribution does not cover post-mortem measured organ activities
- Publishing the whole distribution should be preferred over just distribution parameters



Thank you for your attention

