



Plutonium in Tissues of Occupationally Exposed Individuals

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“Learning from Plutonium and Uranium Workers”





U.S. Transuranium and Uranium Registries

Follows up occupationally exposed workers, from exposure through full lifespan, by studying the biokinetics (uptake, translocation, retention, and excretion), and dosimetry of the actinides

- Voluntary tissue donors (posthumous):
 - whole- and/or partial-body donation
- Former nuclear workers from DOE sites
- Documented radiation exposure and work history
- Acceptance criteria:
 - i. actinide internal deposition of ≥ 74 Bq (2 nCi)
 - ii. external dose to whole body ≥ 0.1 Sv (10 rem)



This Study

- Number of cases: 295
- Exposure: $^{239+240}\text{Pu}$ and ^{238}Pu
- Analysis: $^{239+240}\text{Pu}$
- Tissues/organs analyzed
 - i. lung
 - ii. thoracic lymph node (LNTH)
 - iii. liver
 - iv. bone
- Number of samples analyzed: 1,678

Radiochemical Tissue Analysis

Drying/Ashing



Digestion/Dissolution



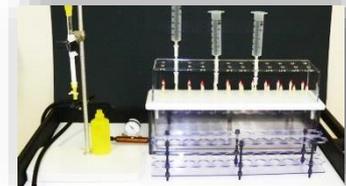
Actinide separation



α -source preparation



Actinide measurement



Concentration and Activity Calculation

Concentration

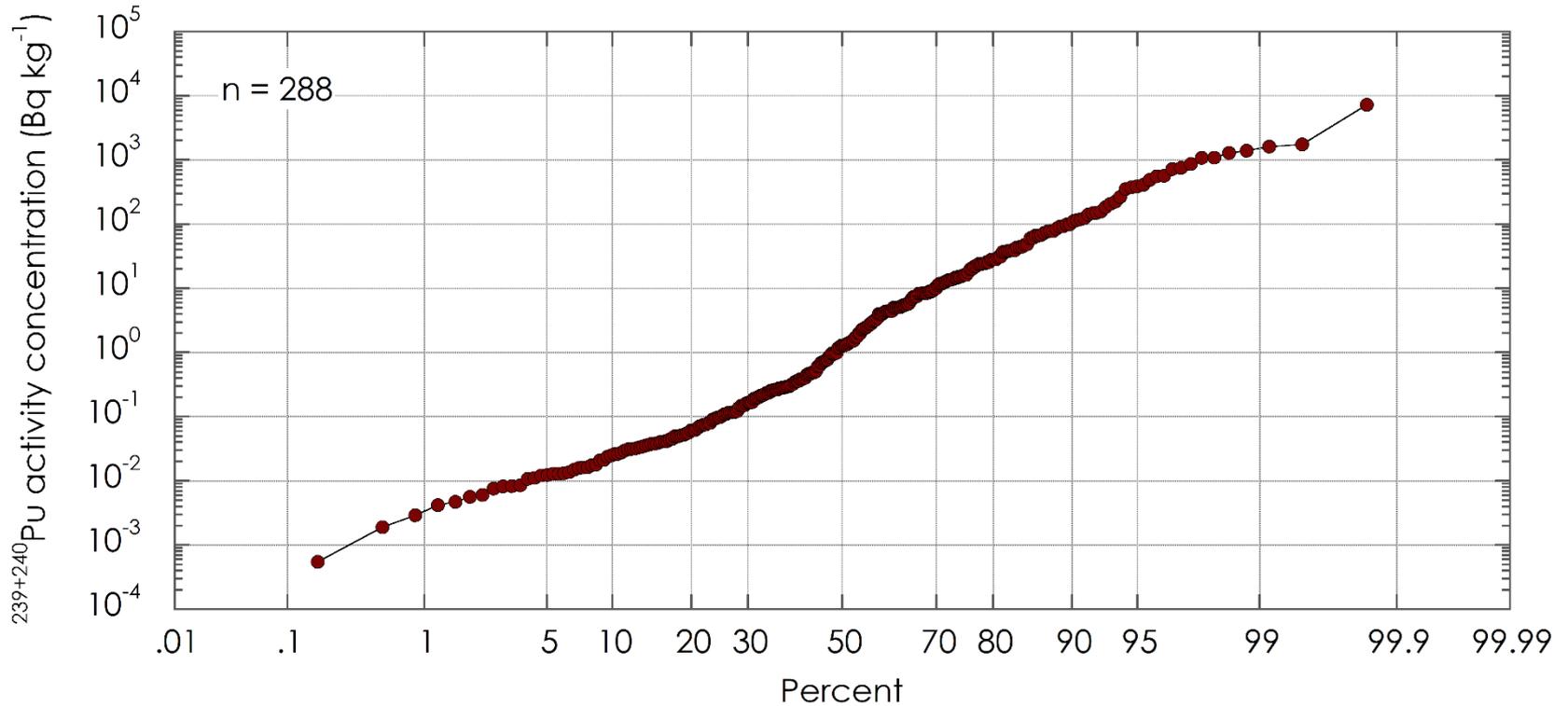
- Lung and Liver: $C = A_{\text{sample}} / M_{\text{sample}},$
- LNTH and Skeleton $\hat{C} = \Sigma A_{\text{sample},i} / \Sigma M_{\text{sample},i}$

Total activity

- Liver $A_{\text{total}} = C_{\text{liver}} \times M_{\text{autopsy}}$
- Skeleton
 - i. whole-body: $A_{\text{total}} = 2 \times \Sigma A_{\text{bone}(R),i},$
 - ii. partial-body: $A_{\text{total}} = \hat{C}_{\text{bone}} \times 10.5 \text{ kg}$



^{239}Pu Activity Concentration: Lung

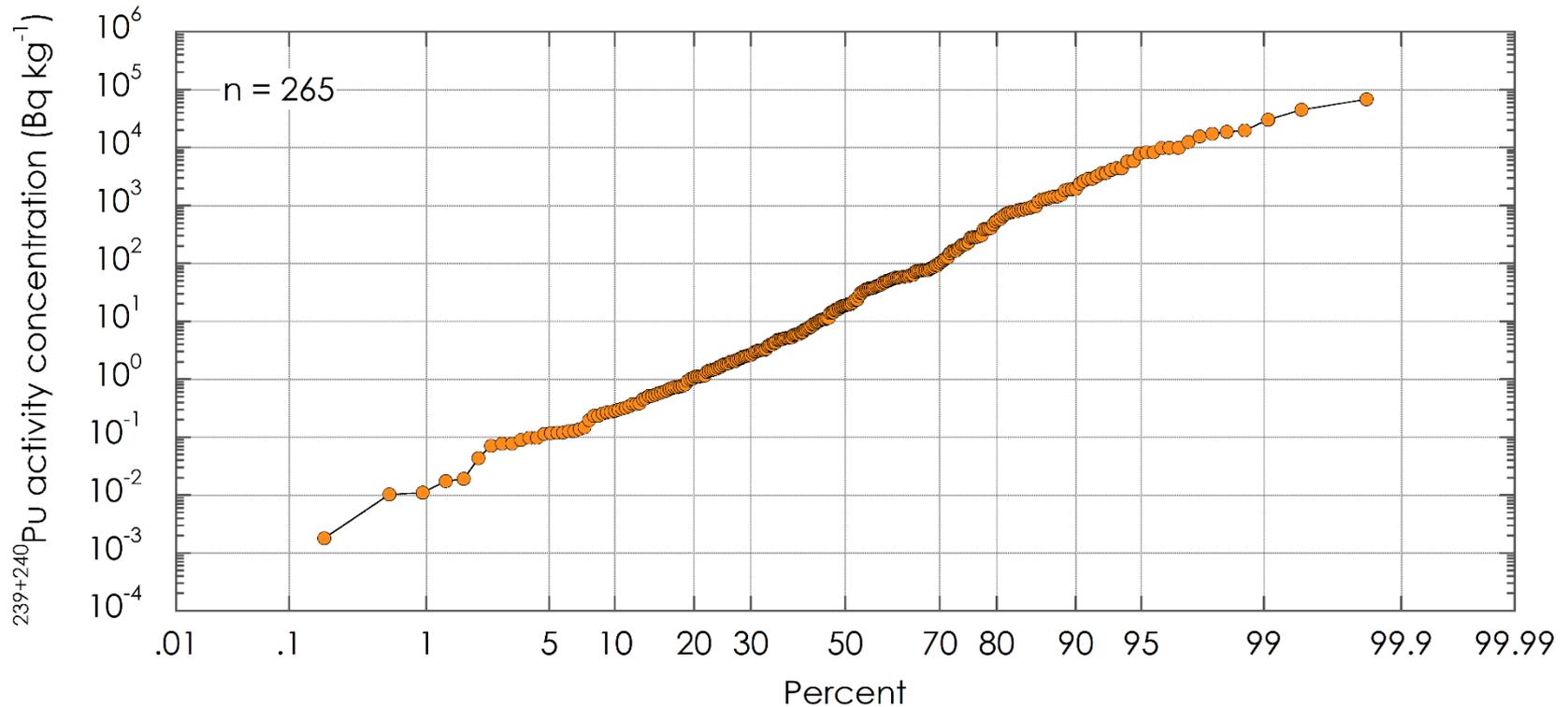


Range	0.0006 – 7,225	Bq kg ⁻¹
Geometric Mean	1.43	
95% CI for Mean	0.98 – 2.09	
Median	1.28	
95% CI for Median	0.52 – 2.61	





^{239}Pu Activity Concentration: LNTH

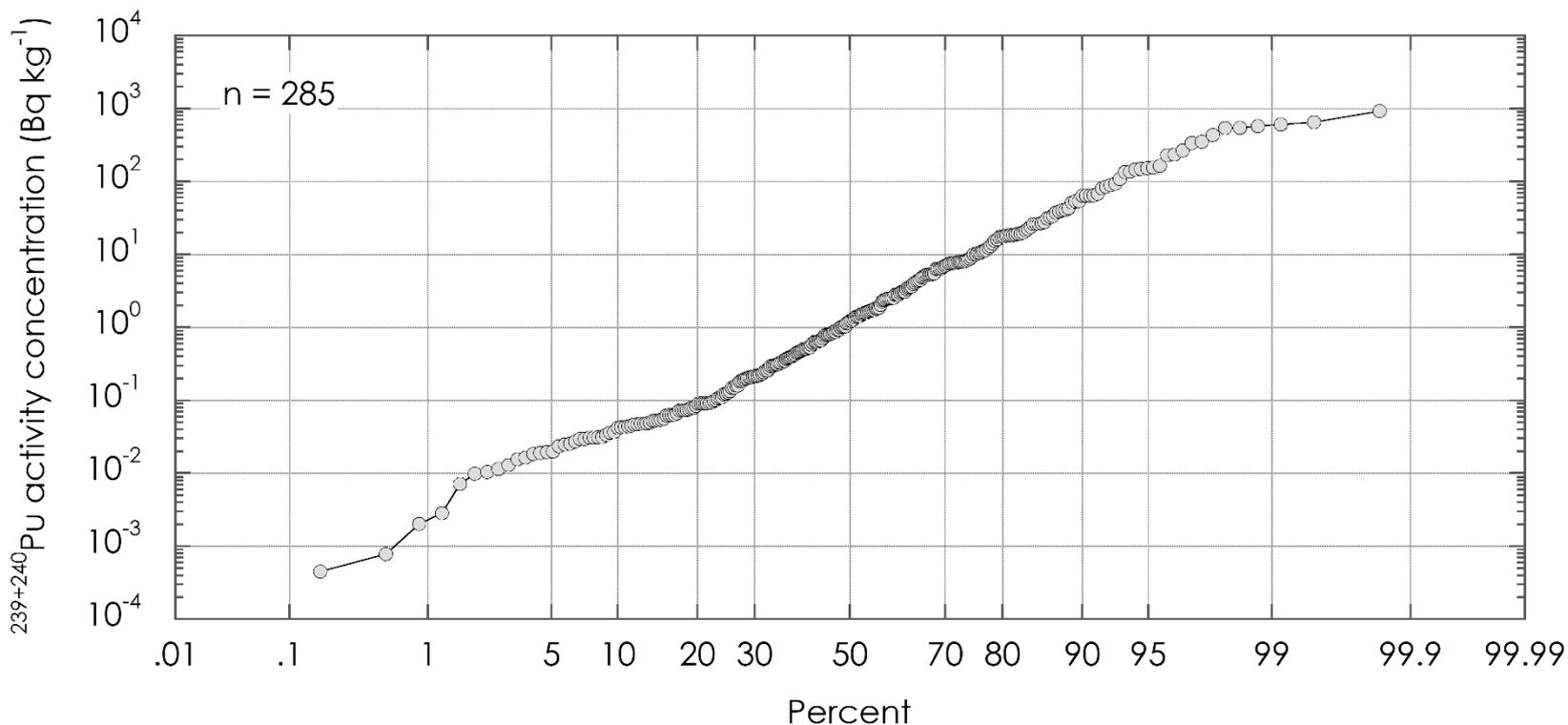


Range	0.002 – 68,400	Bq kg^{-1}
Geometric Mean	20.8	
95% CI for Mean	13.8 – 31.4	
Median	18.8	
95% CI for Median	9.98 – 37.5	





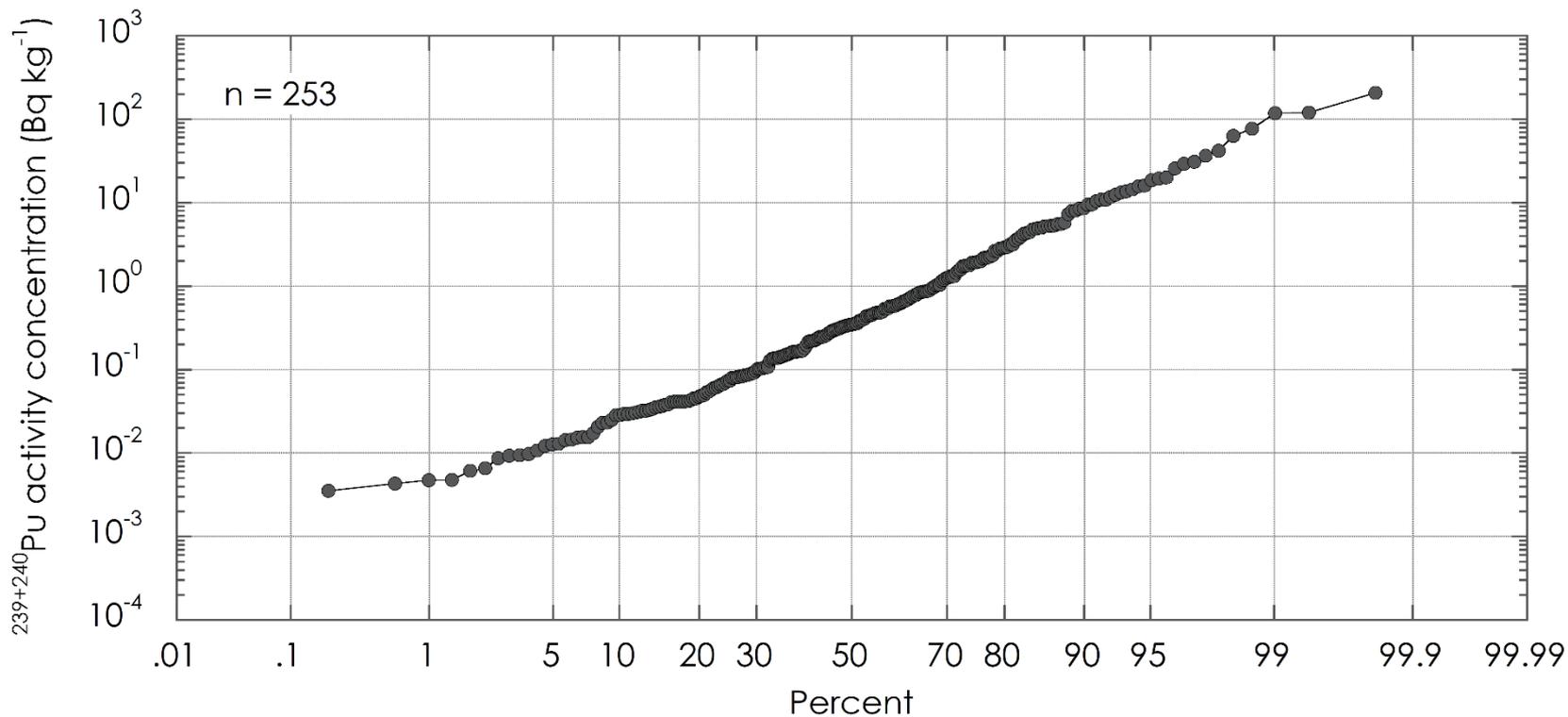
^{239}Pu Activity Concentration: Liver



Range	0.0005 - 924	Bq kg^{-1}
Geometric Mean	1.28	
95% CI for Mean	0.92 - 1.78	
Median	1.23	
95% CI for Median	0.74 - 1.85	

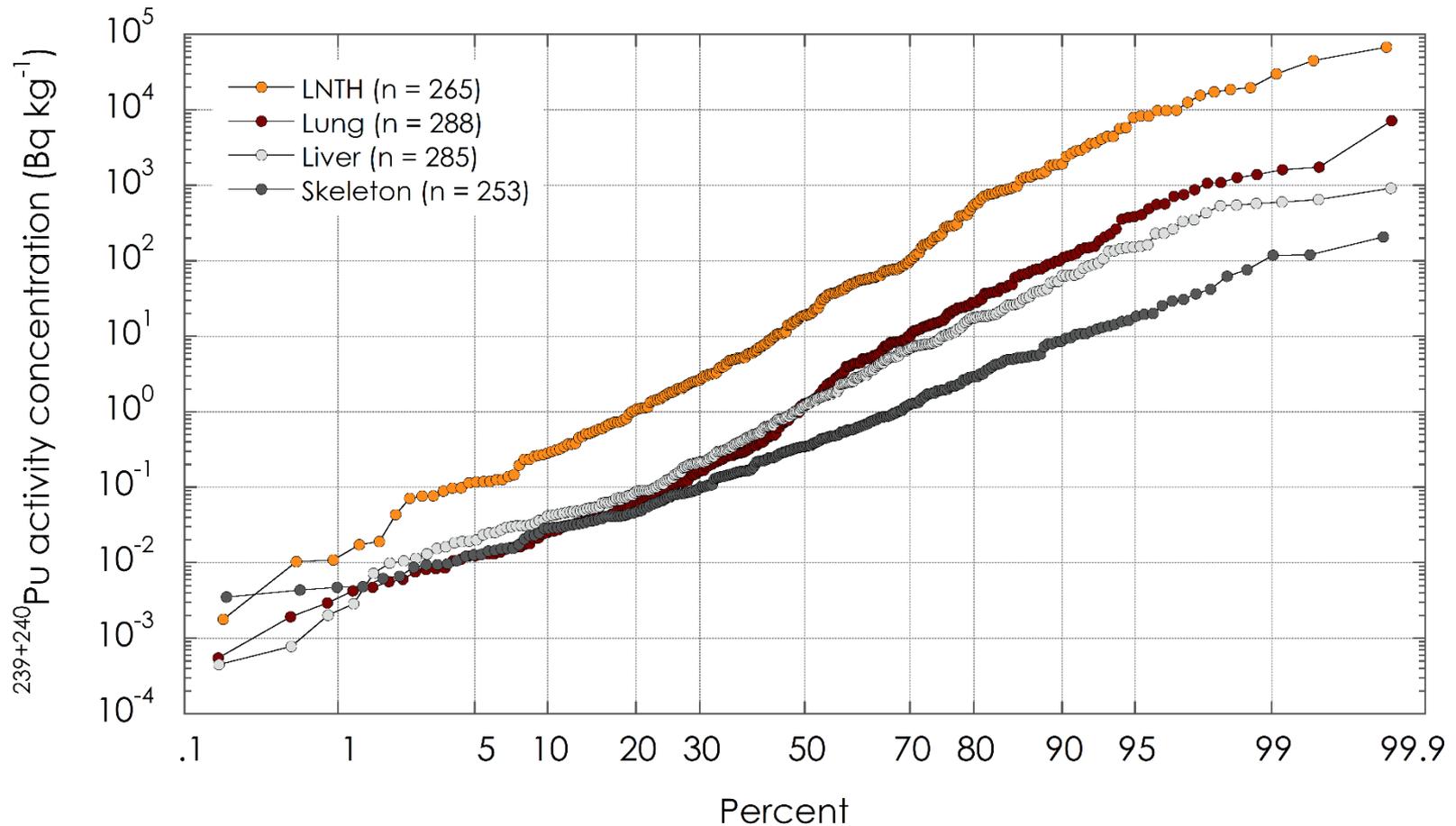


^{239}Pu Activity Concentration: Skeleton



Range	0.004 – 209	Bq kg ⁻¹
Geometric Mean	0.40	
95% CI for Mean	0.30 – 0.53	
Median	0.35	
95% CI for Median	0.25 – 0.49	

Summary: ^{239}Pu Activity Concentration



Skeleton < Liver \approx Lung \ll LNTH

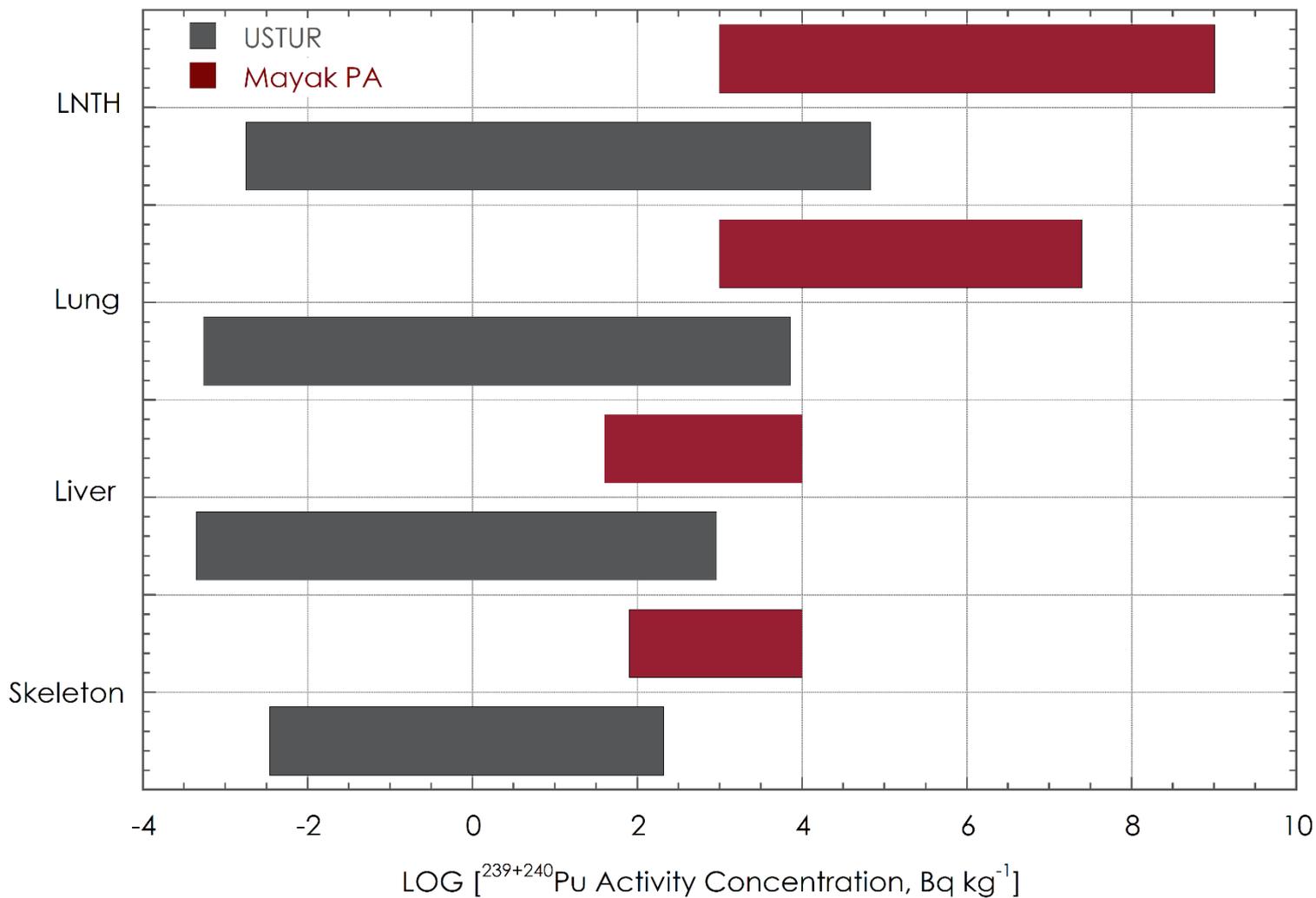
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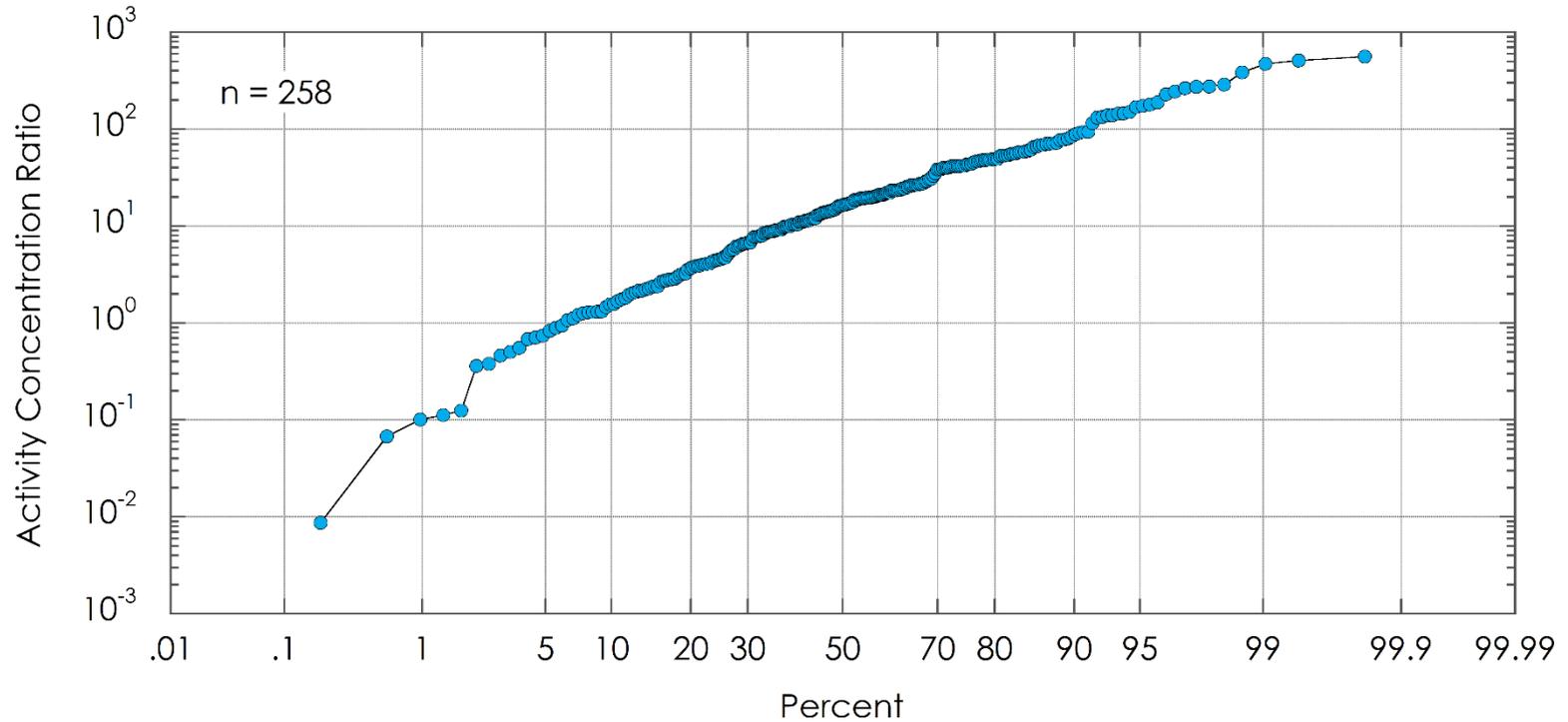
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^{239}Pu Activity Concentration in Organs: USTUR vs Mayak PA

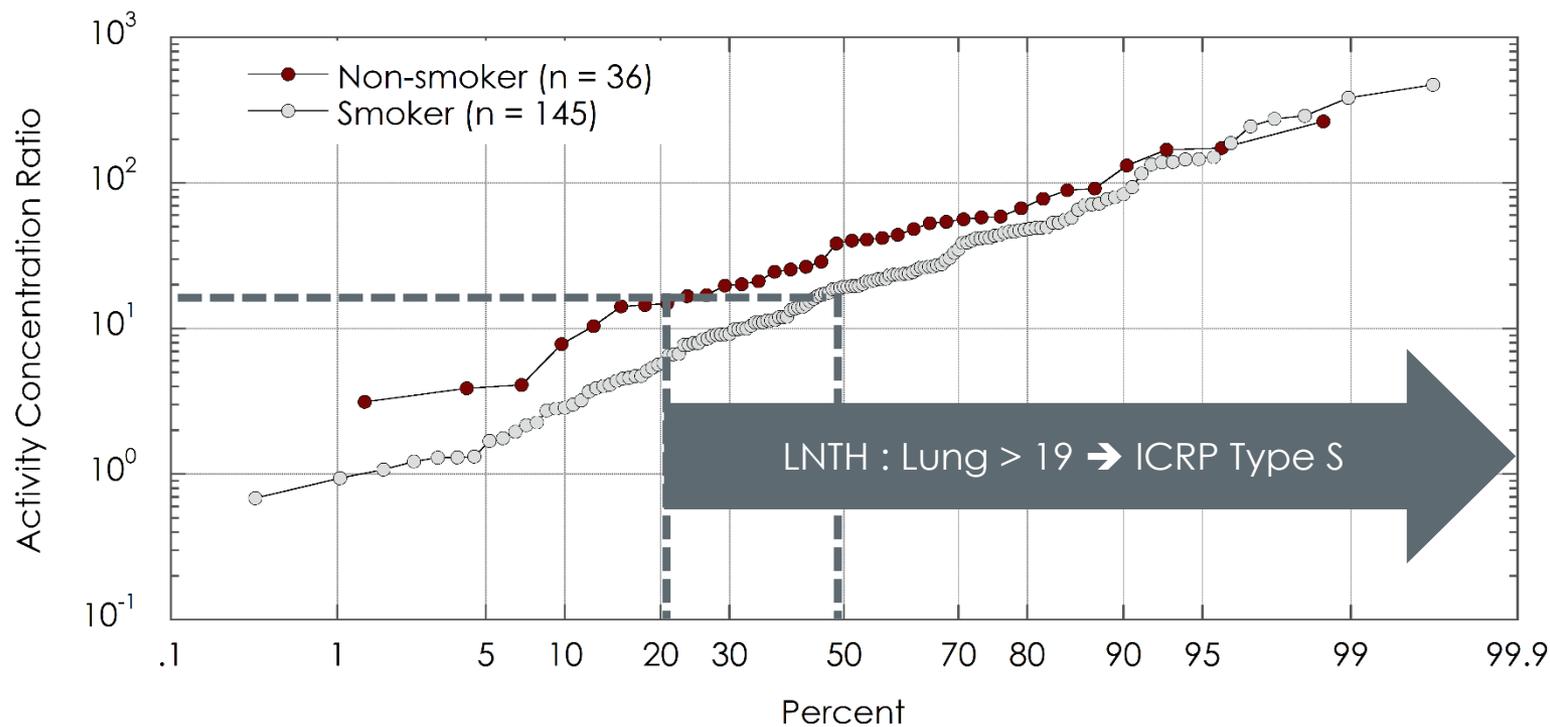


LNTH-to-Lung: ^{239}Pu Concentration Ratio



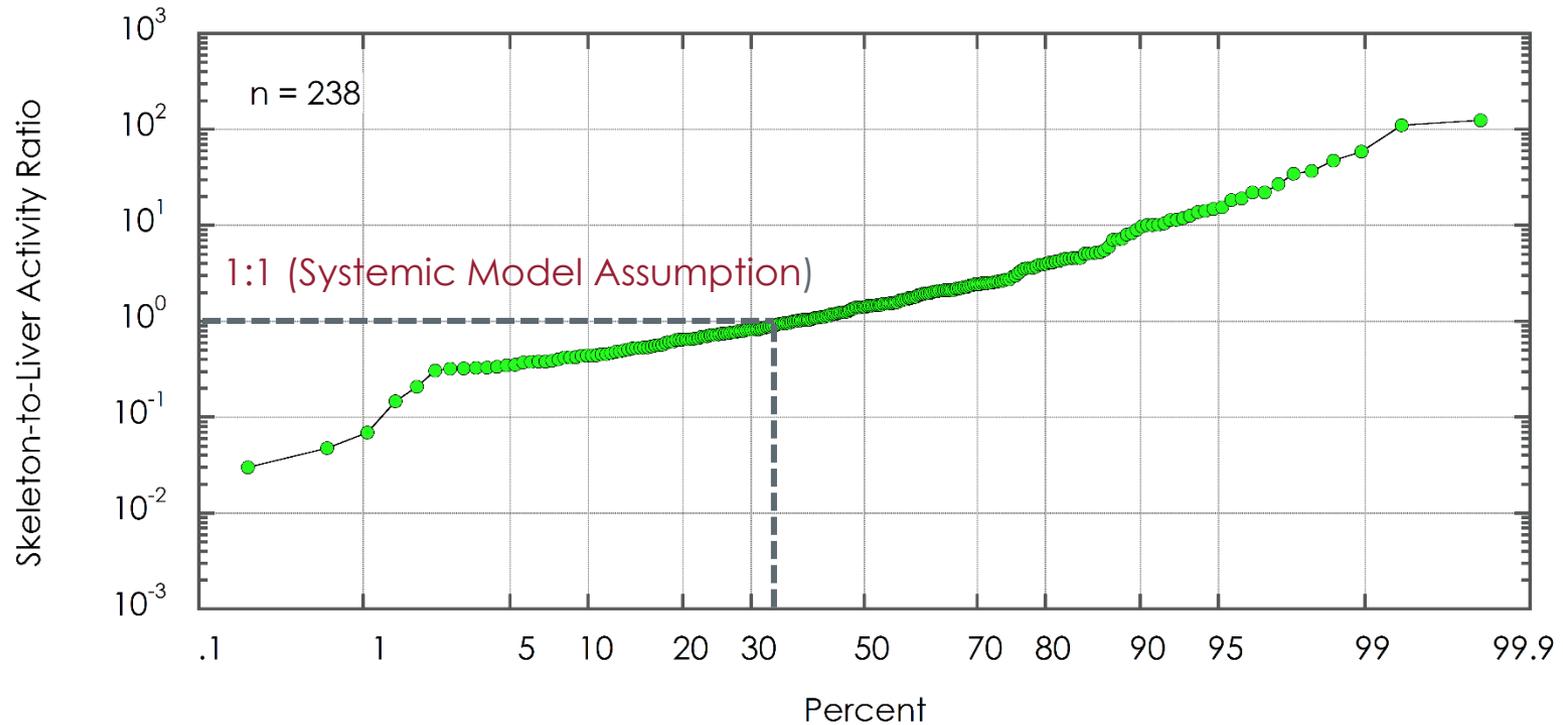
Range	0.009 – 561
Geometric Mean	13.4
95% CI for Mean	10.9 – 16.5
Median	16.5
95% CI for Median	12.1 – 19.8

LNTH-to-Lung: Smoking Status



Smoking	Yes	No
Range	0.68 – 473	3.15 – 265
Geometric Mean	17.4	32.3
95% CI for Mean	14.0 – 21.6	22.6 – 46.0
Median	19.5	39.4
95% CI for Median	14.0 – 23.0	20.8 – 53.3

Skeleton-to-Liver: ^{239}Pu Activity Ratio



Range	0.03 – 125
Geometric Mean	1.63
95% CI for Mean	1.39 – 1.91
Median	1.41
95% CI for Median	1.17 – 1.63



Summary

- ^{239}Pu activity concentrations were measured in thoracic lymph nodes, lungs, livers, and bones for 295 USTUR donors
- Median ^{239}Pu activity concentration (Bq kg^{-1}) were 0.35, 1.23, 1.28, and 18.8 in skeleton, liver, lung and LNTH, respectively.
- LNTH-to-Lung ^{239}Pu activity concentration ratio of 16.5 (median) was derived from 258 USTUR cases.
Statistically significant difference was found between smokers (19.5) and non-smokers (39.4)
- Skeleton-to-Liver ^{239}Pu activity ratio of 1.4 (median) was calculated for 238 USTUR cases



References

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Thank you for your attention!

