

# IMPROVED DOSIMETRY AND RISK ASSESSMENT FOR PLUTONIUM-INDUCED LUNG DISEASE USING A MICRODOSIMETRIC APPROACH

**Principal Investigators:** Fletcher F. Hahn, DVM, PhD, Lovelace  
Respiratory Research Institute, Albuquerque,  
NM, USA

Sergey A. Romanov, Branch N1 of the  
Biophysics Institute, (FIB-1) Ozyorsk, Russia

**Collaborating Scientists:** Anatoly Nifatov, MD, (FIB-1) Ozyorsk, Russia

Raymond A. Guilmette, PhD, Los Alamos  
National Laboratory, Los Alamos, NM USA

# HYPOTHESES

- **The distribution of plutonium particles in human lung will be nonuniform, and the particles will be mostly in the parenchymal region of the lung.**
- **Chronic tobacco-smoke exposure in humans will increase the nonuniformity of Pu particle distribution. The altered spatial distribution will be associated with a higher incidence of fibrosis and scars.**

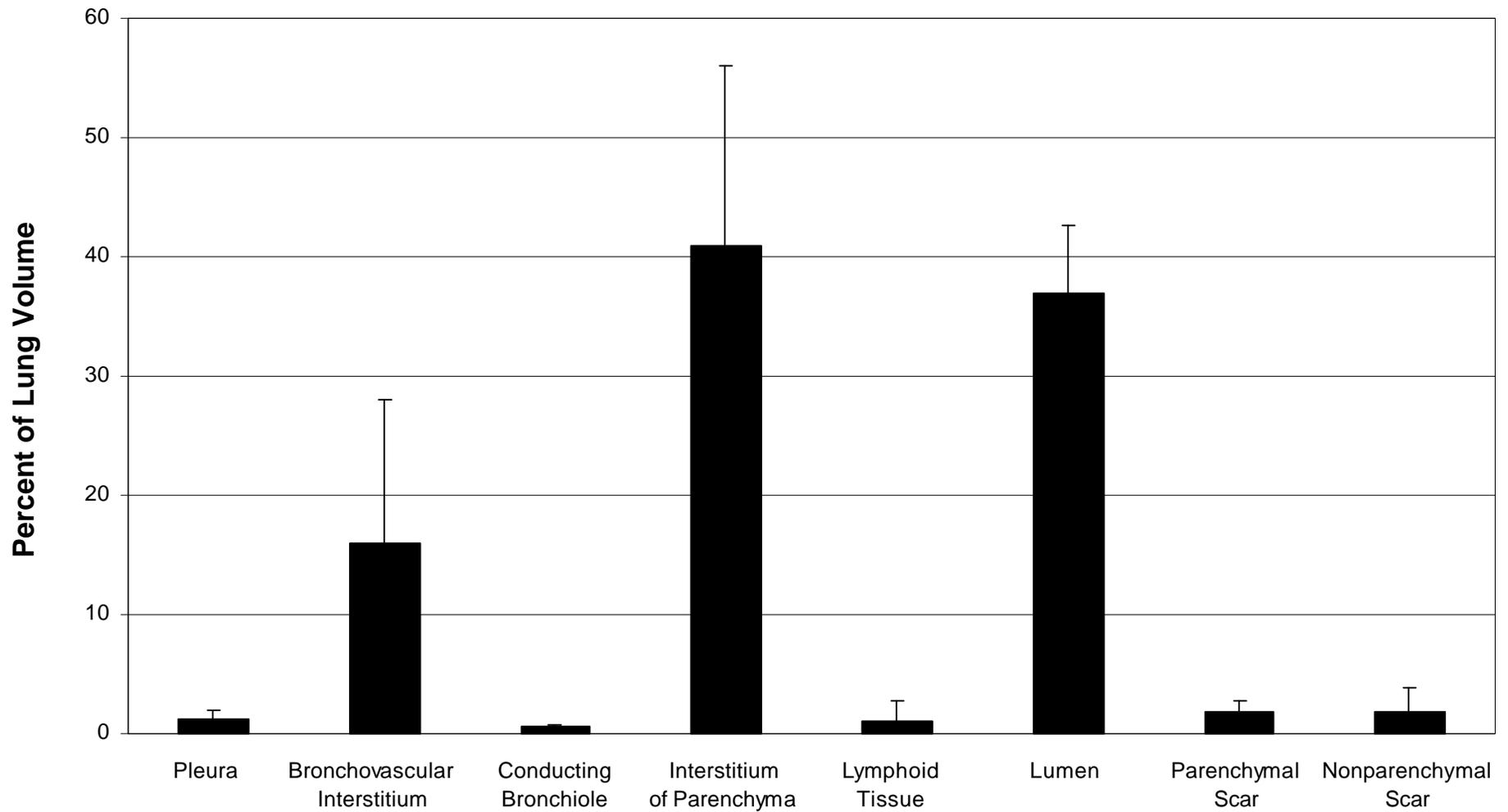
## **SPECIFIC AIMS**

- **Determine the number and activity distributions of Pu in human lung tissue with respect to specific anatomic locations and lung structure.**
- **Determine the effect of chronic tobacco-smoke exposure on the distribution of local radiation dose and the occurrence of lesions within the lung.**
- **Model the dose patterns in human lung using Monte Carlo simulation in which parameterization is based on the experimental data on Pu particle distributions.**
- **Relate the spatial distribution of Pu to the distribution of specific fibrotic lesions within the lung.**

# LUNG COMPARTMENTS USED FOR PARTICLE LOCALIZATION

- Pleura
- Bronchovascular interstitial tissue of bronchi
- Interstitial tissue of conducting bronchioles
- Interstitial tissue of parenchyma
- Lymphoid tissue
- Lumen of conducting airway
- Lumen of parenchyma
- Parenchymal scar
- Nonparenchymal scar

## Average Volume Density (%) of Lung Compartments (N=5)



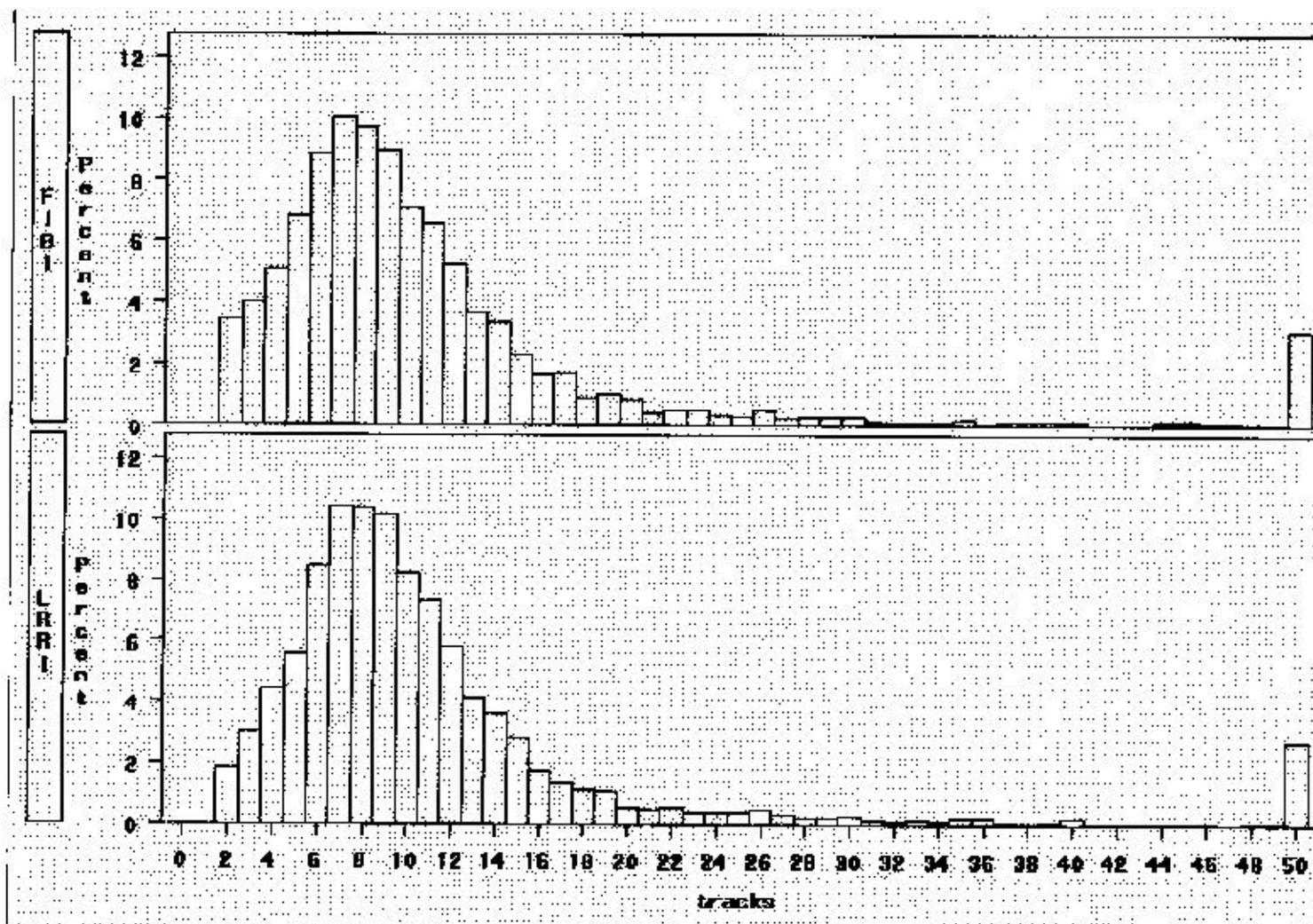
# ESTIMATED NUMBERS AND LOCATIONS OF PARTICLES IN WHOLE LUNG OF CASE 168

<b>Anatomic Compartment</b>	<b>Number of Particles</b>
<b>Pleura</b>	<b>0</b>
<b>Bronchovascular interstitial tissue of conducting airways</b>	<b>266,000</b>
<b>Interstitium of parenchyma</b>	<b>3,970,000</b>
<b>Lymphoid tissue</b>	<b>500,000</b>
<b>Air and alveolar lumens</b>	<b>466,000</b>
<b>Parenchymal scars</b>	<b>2,470,000</b>
<b>Nonparenchymal scars</b>	<b>3,030,000</b>
<b>Total</b>	<b>10,700,000</b>

# COMPARTMENTAL DENSITY OF PARTICLES IN THE LUNG OF CASE 168

Compartment	Particles/cm <sup>3</sup>
Pleura	0
Bronchovascular interstitial tissue	790
Interstitium of parenchyma	8,770
Lymphoid tissue	7,930
Parenchymal scars	111,000
Nonparenchymal scars	48,000

# HISTOGRAMS OF THE ALPHA TRACKS PER Pu PARTICLE FOR FIB-1 AND LRRI

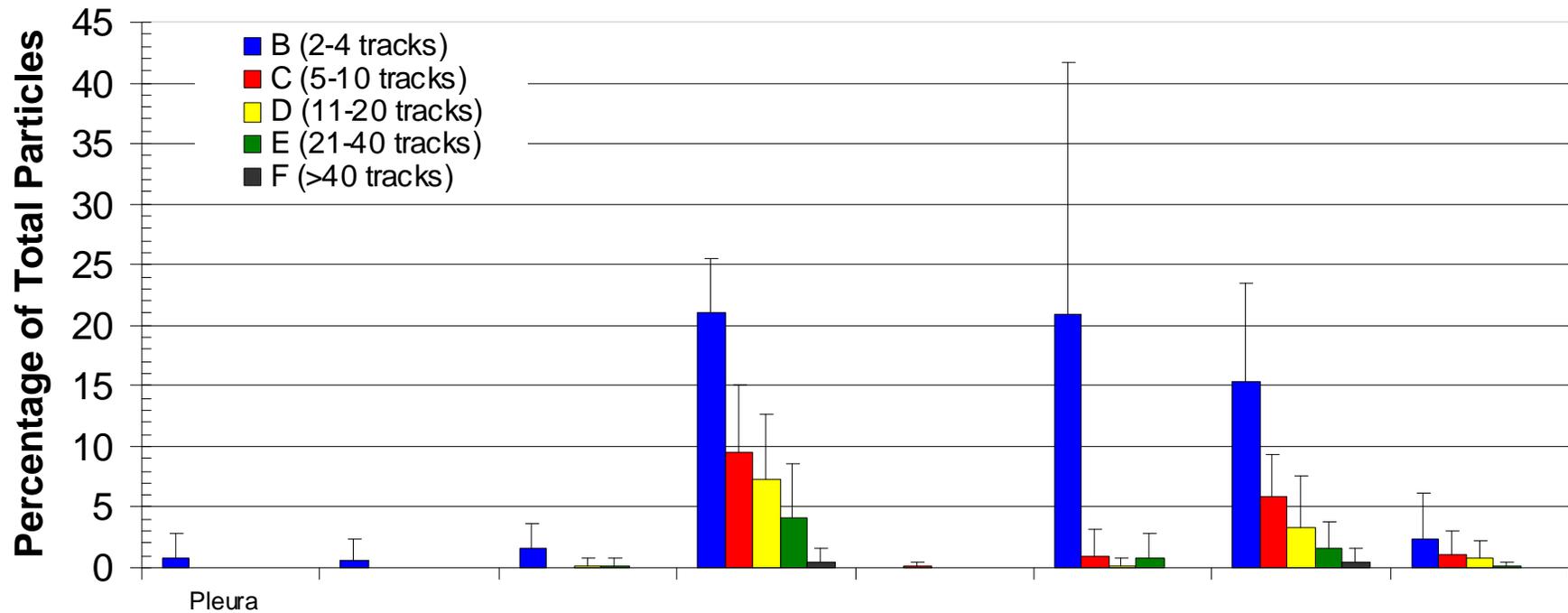


# SUBJECTS SAMPLED

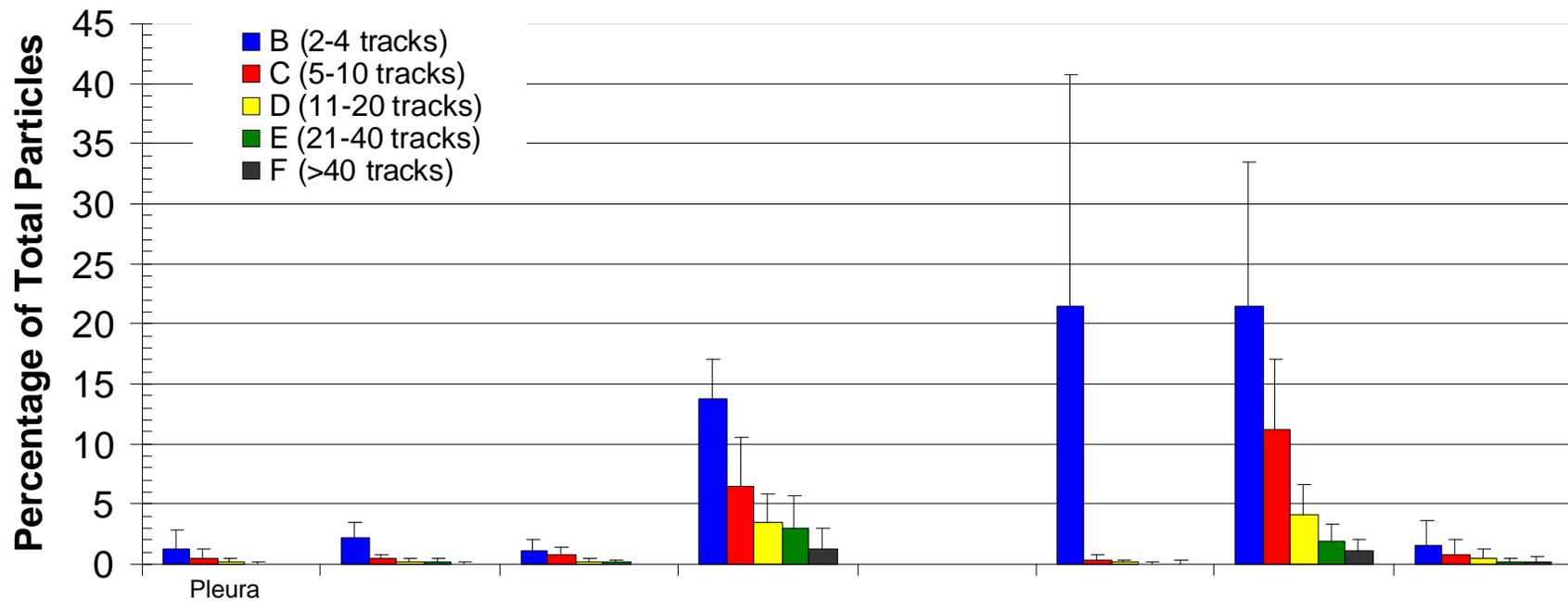
## PHASE I and PHASE II – YEAR 1

Case	Sex	Pu Body Content (nCi)	Pu Lung Content (nCi)	Years at Risk to Pu Exposure	External Dose (cGy)	Smoking History (pack/d)
<b>Phase I</b>						
169	F	317	11.0	1949-71	77	0
168	M	307	101.0	1949-67	168	1
<hr/>						
<b>Phase II</b>						
005	M	223	9.5	1948-61	543	1
027	M	529	11.0	1948-53	553	1
102	F	79.2	13.4	1954-67	—	0
077	M	236	27.5	1949-63	68.3	1
095	M	663	36.8	1948-57	321	0.25; 1943-57
044	M	334	37.0	1949-61	200	1
148	M	408	46.7	1948-52	216	1
170	M	525	72.1	1948-78	72.8	1

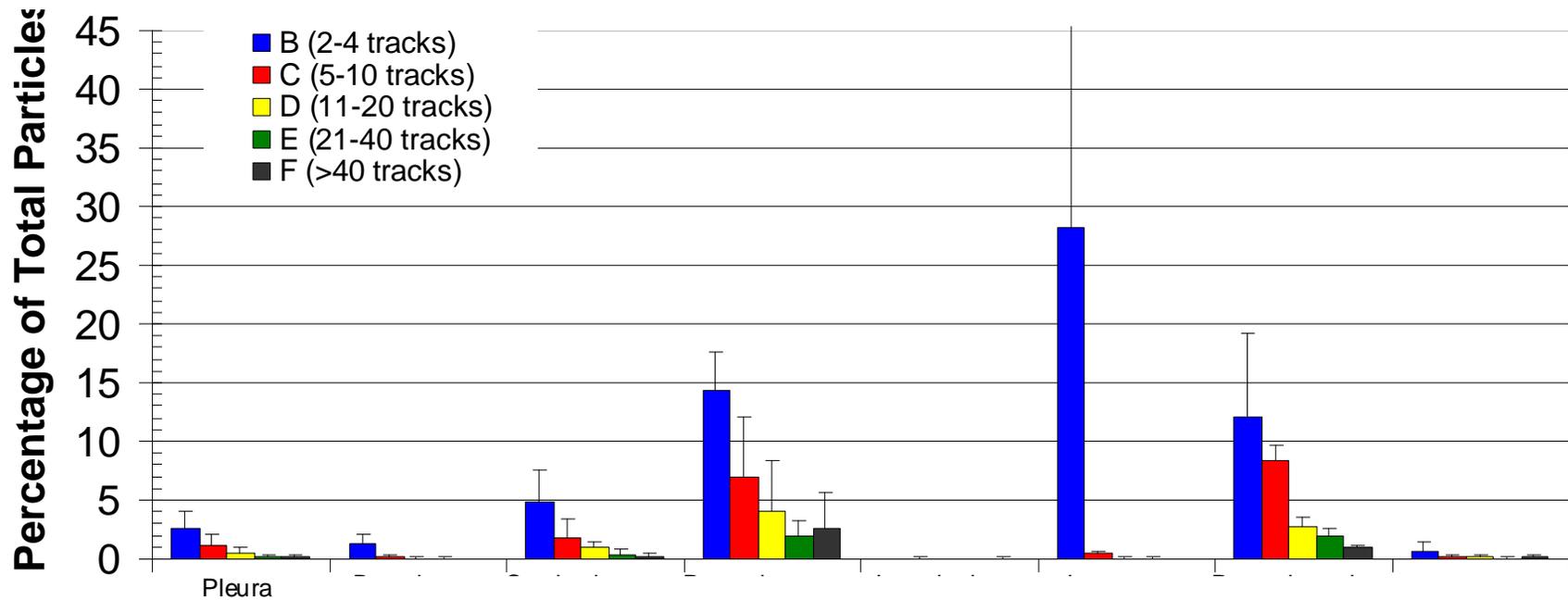
## IMPDOS Average Distribution of Particles in Lung Compartments (1 day AR)



## IMPDOS Average Distribution of Particles in Lung Compartments (14 day AR)



## IMPDOS Average Distribution of Particles in Lung Compartments (90 day AR)



## SUBJECTS SAMPLED — PHASE II – YEAR 2

Case	Sex	Pu Body Content (nCi)	Pu Lung Content (nCi)	Years at Risk to Pu Exposure	External Dose (cGy)	Smoking History (pack/d)
072	M	43	2.6	1951-78	—	1-1.5
160	M	53.0	2.7	1948-51	—	1/3
109	M	58.4	4.0	1957-79	—	1
171	M	21.9	4.0	1948-77	—	not much
119	M	46.6	4.0	1954-79	—	1
083	M	156	5.5	1954-63	—	>1
104	M	64.3	6.4	1950-67	—	1
191	M	366	7.2	1952-59	—	1-2
110	M	244	7.4	1949-58	—	1
080	M	20.3	8.5	1954-59	—	<1
113	F	417	13.7	1955-59	—	0
147	F	2887	36.6	1949-57	—	0
020	F	2374	44.6	1953-58	—	0
089	M	86.5	50.3	1949-63	—	1
011	M	389	54.0	1956-74	—	1
070	F	3894	132.0	1948-56	—	0

# TRENDS IN PARTICLE DISTRIBUTION

- Large fraction in parenchyma
- Large fraction in parenchymal scars
- Scars with particles related to:
  - Pu lung burden
  - Tobacco smoking
- Small fraction in conducting airways

# CONCLUSION

- Long-term retained Pu particles not uniformly distributed
- New dosimetric approaches needed for calculation of alpha radiation doses from Pu and Am