
Characterization of DU aerosols Inside Military Tanks Hit by Friendly Fire

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Sources of information

- ◆ Capstone Depleted Uranium Aerosols: Generation and Characterization, Volumes 1 and 2. PNNL-14168.
 - Parkhurst et al. 2004
- ◆ Human Health Risk Assessment of Capstone Depleted Uranium Aerosols. PNWD-3442
 - Guilmette et al. 2004



Characteristics of various forms of uranium

Uranium Form	^{234}U %	^{235}U %	^{238}U %
Natural	0.0054	0.72	99.2746
Depleted	0.0006	0.2	99.8
Enriched (Reactor grade)	-	3-4	≈ 97
Enriched (weapons grade)	-	>90 %	< 10 %



Purpose of study

- ◆ Many military personnel exposed to DU aerosol from friendly fire (many survivors)
- ◆ Lack of data on aerosols generated during impact of DU shells needed for dose assessment
 - Concentrations
 - Particle size
 - Solubility



Military vehicles used in tests



Figure S.1. Abrams Main Battle Tank

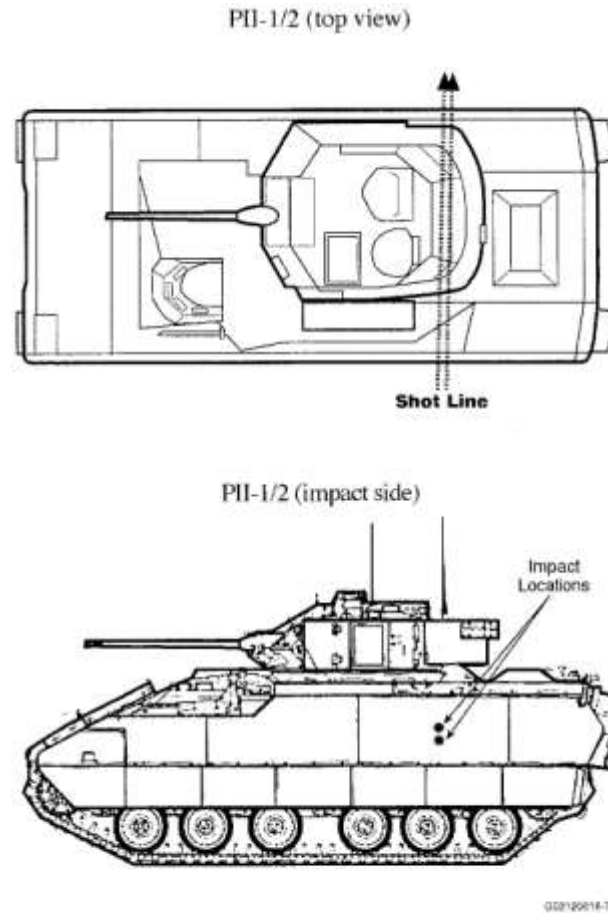


Figure S.2. Bradley Fighting Vehicle

Pictures from Guilmette et al. 2004



Example of shot lines

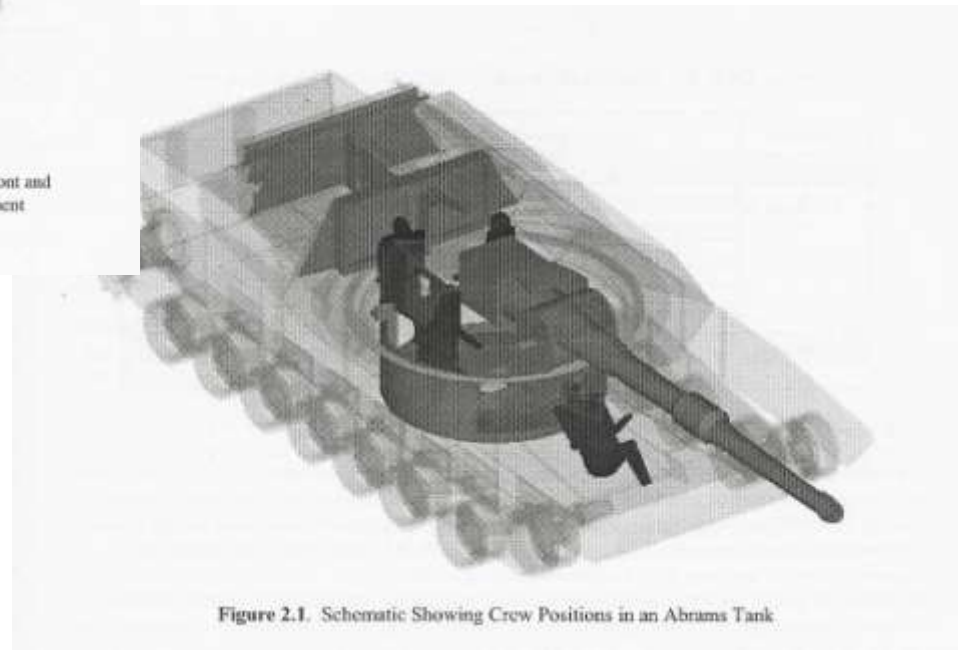
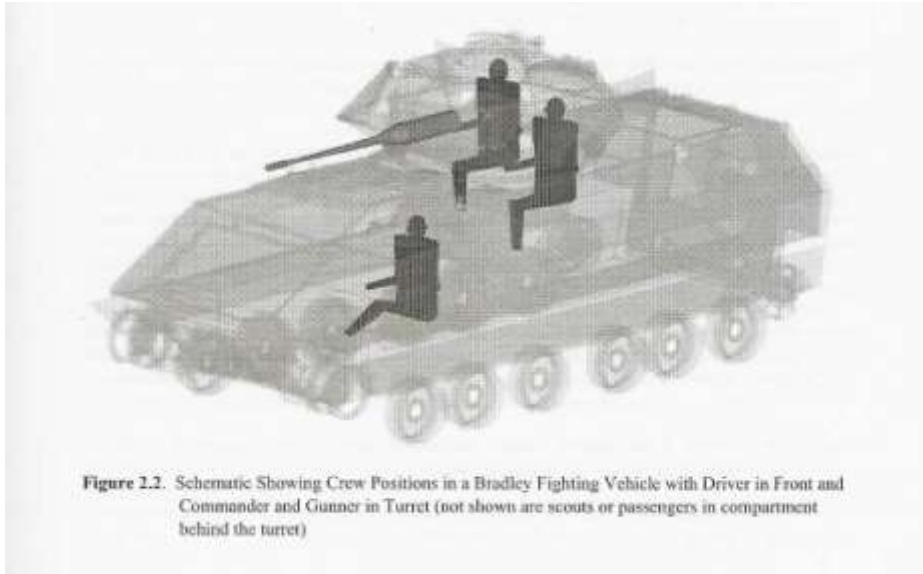


Picture from Parkhurst et al. 2004

Figure 4.7. Trajectory of the PII-1/2 Shots



Positions in Abrams tank and Bradley fighting vehicle



Pictures from Guilmette et al. 2004

Sampler positions

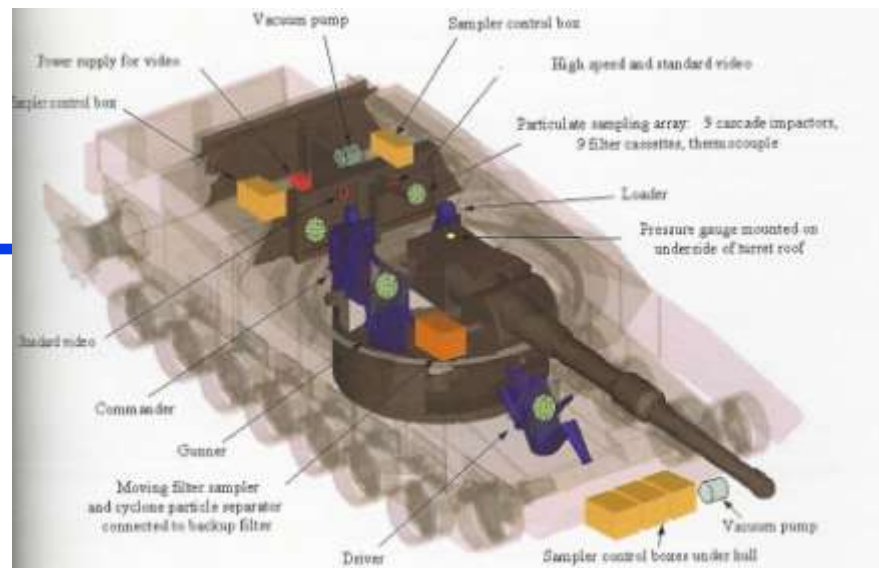


Figure 3.10. Placement of Testing Equipment in an Abrams Tank, Phase I

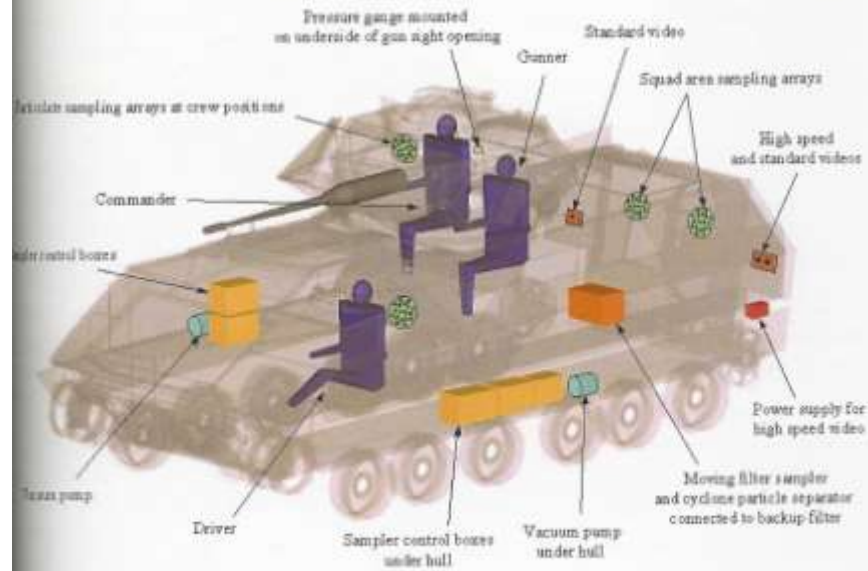
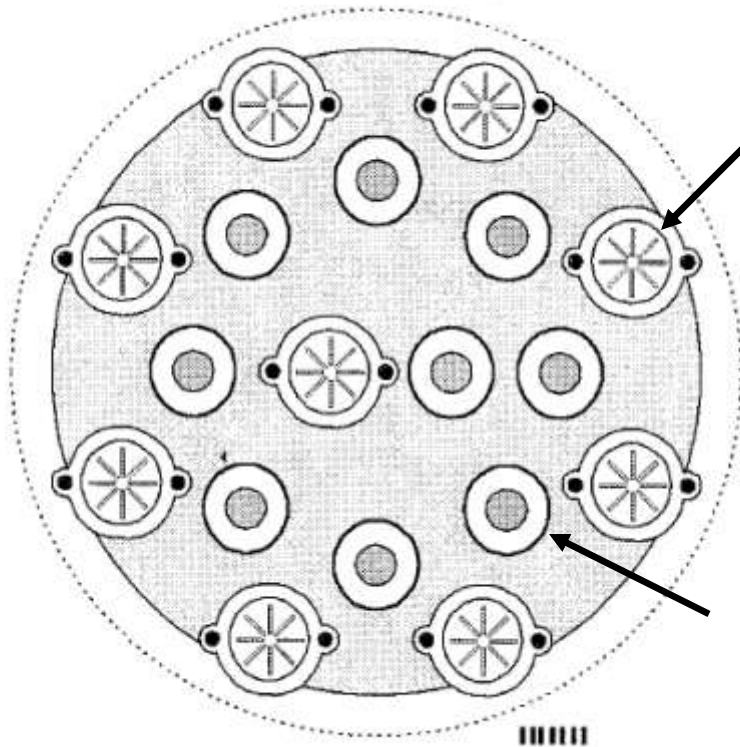


Figure 3.11. Placement of Testing Equipment in a Bradley Vehicle for Crossing Shots

Picture from Parkhurst et al. 2004



Schematic of samplers used for sequential sampling



Nine 8-stage Marple cascade samplers
(one is background)

Nine TSP filter samplers
(one is background)

Measurement intervals:example

- ◆ 0-10 seconds
- ◆ 1 – 1.25 minutes
- ◆ 3 – 3.25 minutes
- ◆ 7 – 8 minutes
- ◆ 15 – 17 minutes
- ◆ 31- 35 minutes
- ◆ 61 – 69 minutes
- ◆ 121 – 129 minutes

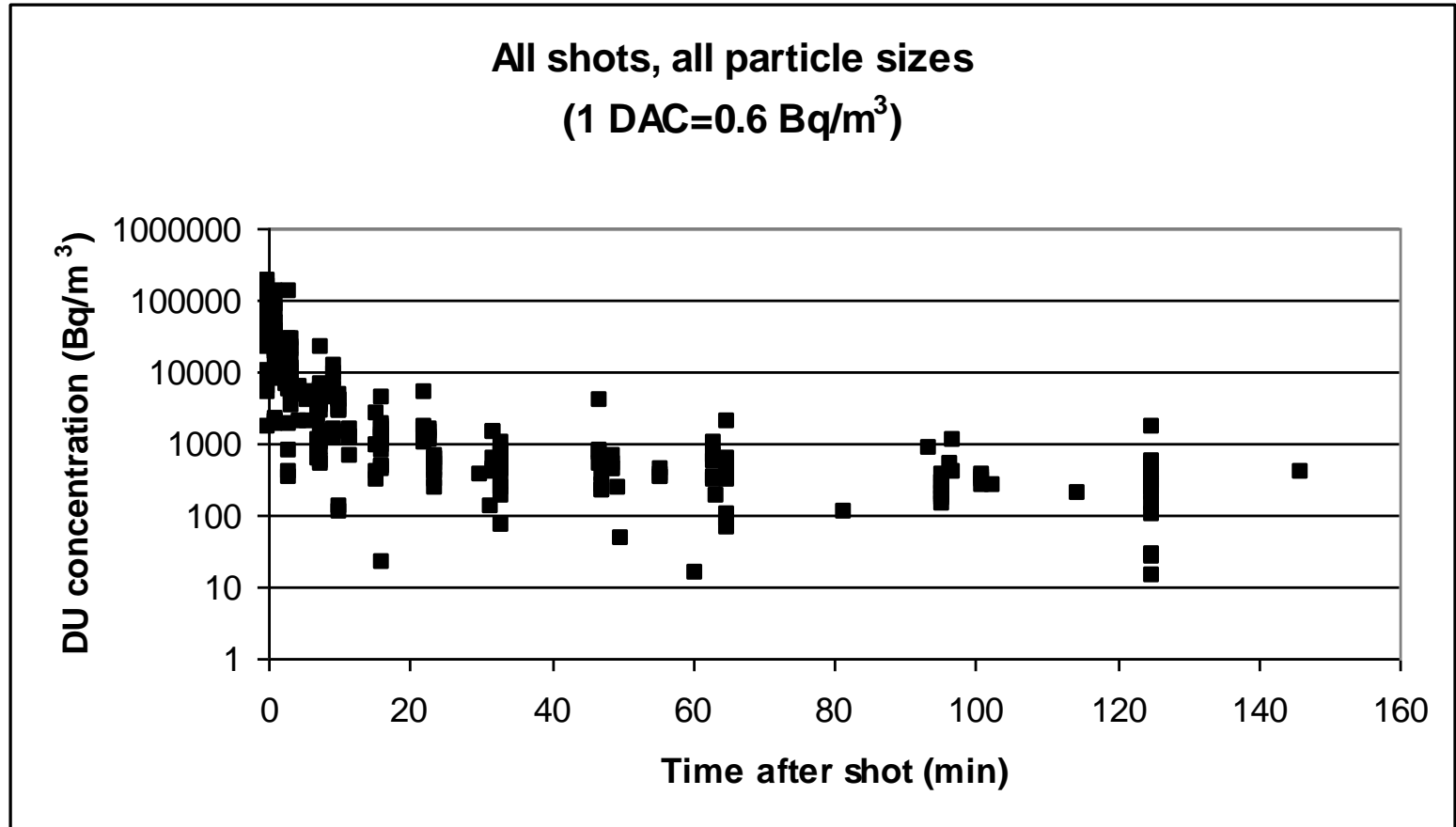


Example of data:

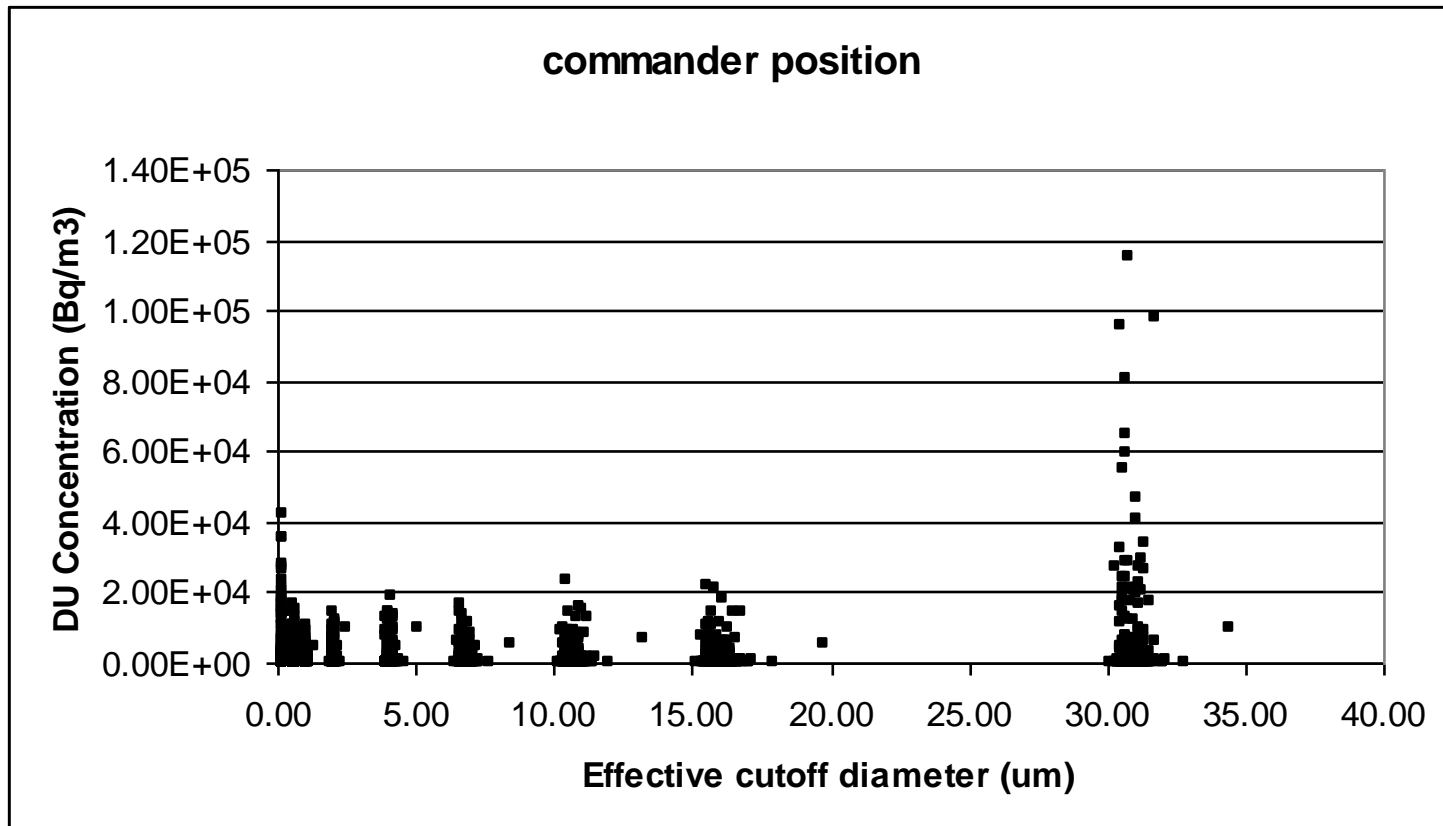
Sample ID	Collection	Elapsed	Total Mass	Calc'd U
	Interval	Time	(mg)	(μg)
PII-1/2I-L-1-CI-1	Shot 1: 0-10 sec	10 sec	2.410	108
PII-1/2I-L-1-CI-2	Shot 1: 0-10 sec	10 sec	0.108	18
PII-1/2I-L-1-CI-3	Shot 1: 0-10 sec	10 sec	-1.402	15
PII-1/2I-L-1-CI-4	Shot 1: 0-10 sec	10 sec	-0.825	18
PII-1/2I-L-1-CI-5	Shot 1: 0-10 sec	10 sec	-0.124	38
PII-1/2I-L-1-CI-6	Shot 1: 0-10 sec	10 sec	-0.452	36
PII-1/2I-L-1-CI-7	Shot 1: 0-10 sec	10 sec	0.346	39
PII-1/2I-L-1-CI-8	Shot 1: 0-10 sec	10 sec	-1.857	104
PII-1/2I-L-1-CI-9	Shot 1: 0-10 sec	10 sec	0.946	162



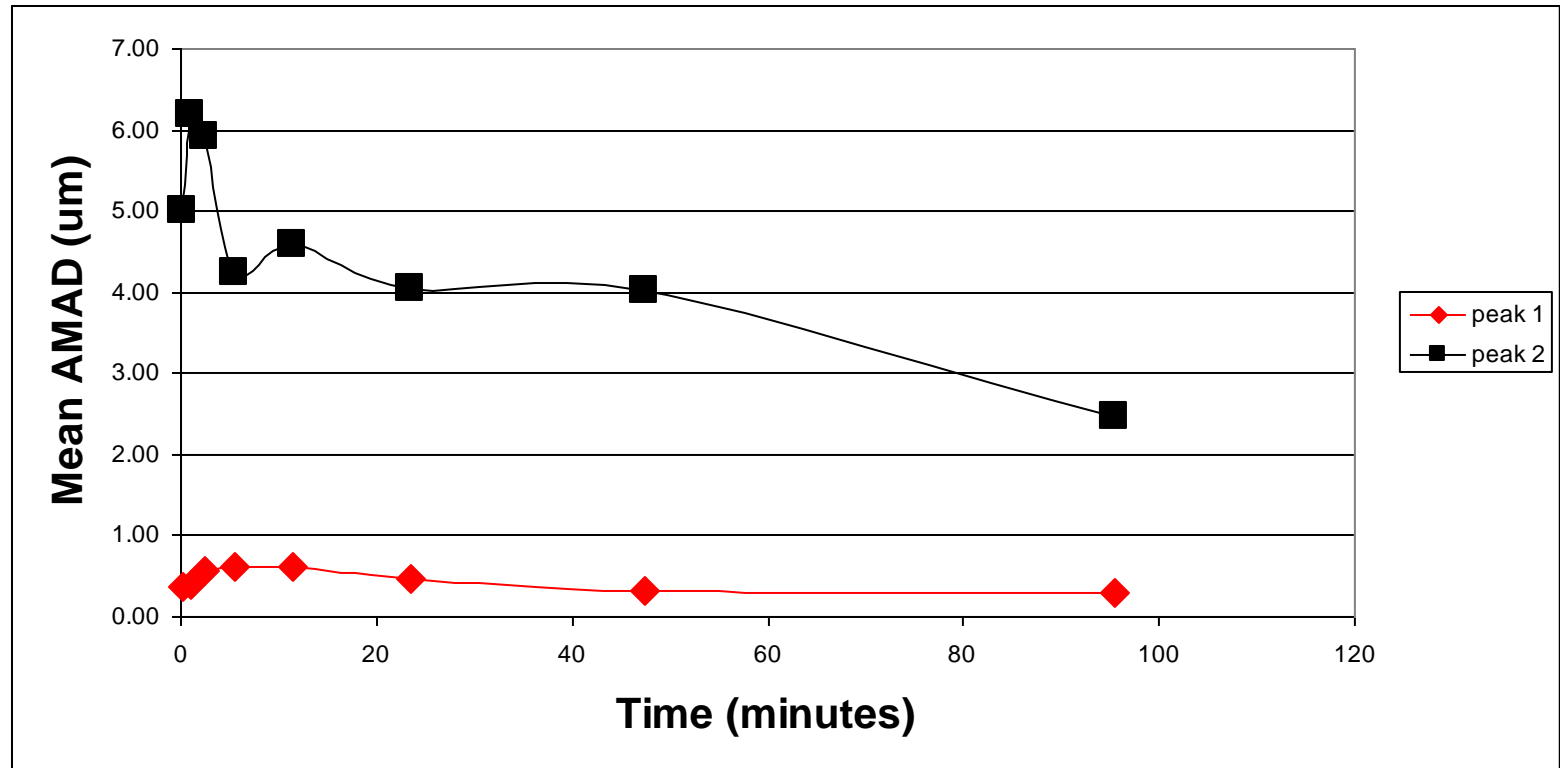
DU concentrations decreased quickly



Concentration of particles by particle size: dose estimated in particle size bins



Particle size distributions varied significantly: Bimodal example



Solubility results

- ◆ Generally ICRP 66 Type M (Moderate)
- ◆ Some Type S (Slow)



Data from Parkhurst et al. 2004

Median E(50) doses by exposure scenerio

Table S.5. Summary of Median 50-yr Committed Effective Doses by Scenario

Scenario	E(50), rem			
	Abrams Tank			Bradley Vehicle, Through Conventional Armor, No Ventilation
	Through Non-DU Armor, No Ventilation	Through DU Armor, No Ventilation	Through DU Armor, EC/NBC Ventilation	
Crewmembers				
Most Likely Scenario				
A – Exit in 1 min	2.0	2.2	0.090	0.59
B - Exit in 5 min	3.7	6.0	0.44	1.7
Upper Bound Scenario				
C - Exit in 1 h	4.8	8.3	1.02	2.1
D - Exit in 2 h	5.0	8.7	1.20	2.4
First Responders				
E - Entry 5 min post shot, exit 10 min later	0.92	1.9	0.41	0.89

Data from Guilmette et al. 2004

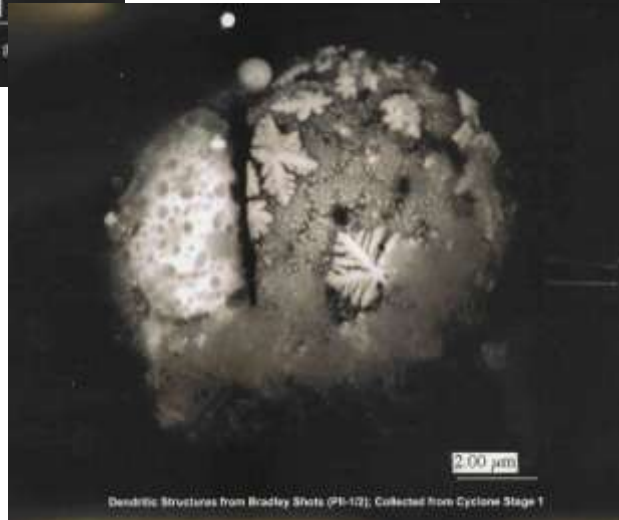
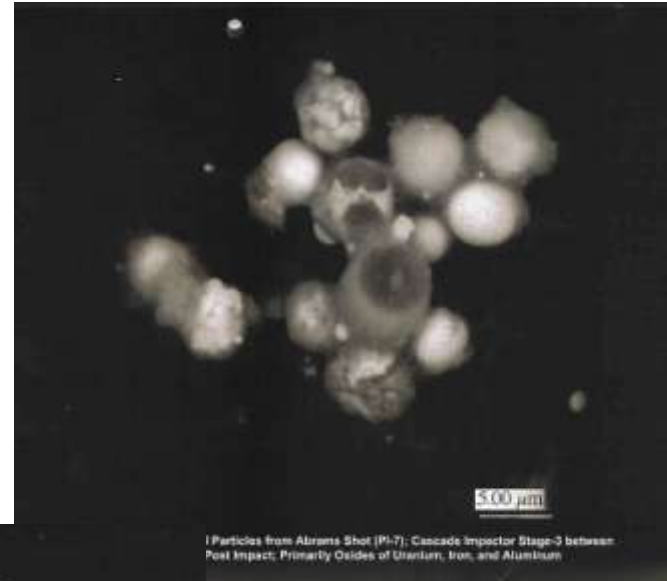


Conclusions:

- ◆ Concentrations of DU inside tanks were significant and particles were of respirable sizes, but exposure times were generally short
- ◆ Concentrations decreased rapidly with time
- ◆ Little variation in concentrations among positions
- ◆ Particle size distribution measurements varied (unimodal, bimodal) but peaks generally less than 10 μm in aerodynamic diameter
 - dose assessment was done using individual impactor stage data. Potential doses generally less than 10 rem.



SEM pictures of DU particles and agglomerates



Pictures from Parkhurst MA
and Krupka K. PNL

