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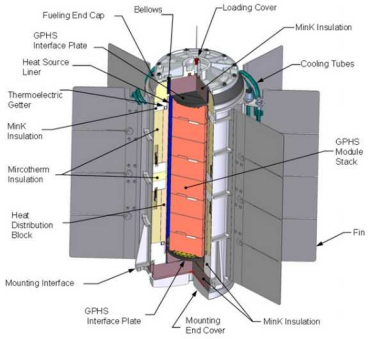

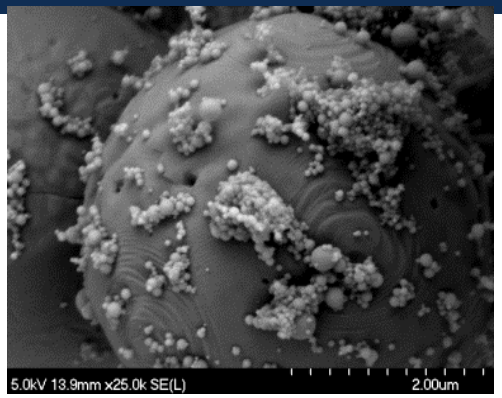

AEROSOL MEASUREMENTS IN SOLID ROCKET PROPELLANT FIRE PLUMES

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Background, Motivation, and Objective

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- Solid rocket propellants are used for space exploration, and there is the potential for an accident in which burning propellant lands on the plutonia fuel pellets that provide electrical power.

- Currently, we assume that if all the protective barriers are breached in an accident, and burning propellant lands on the fuel pellets, all the plutonia will be aerosolized.

- **Objective: Determine aerosol released from a large block solid rocket propellant that could affect transport of potentially aerosolized plutonia fuel.**

Curiosity Rover on Mars

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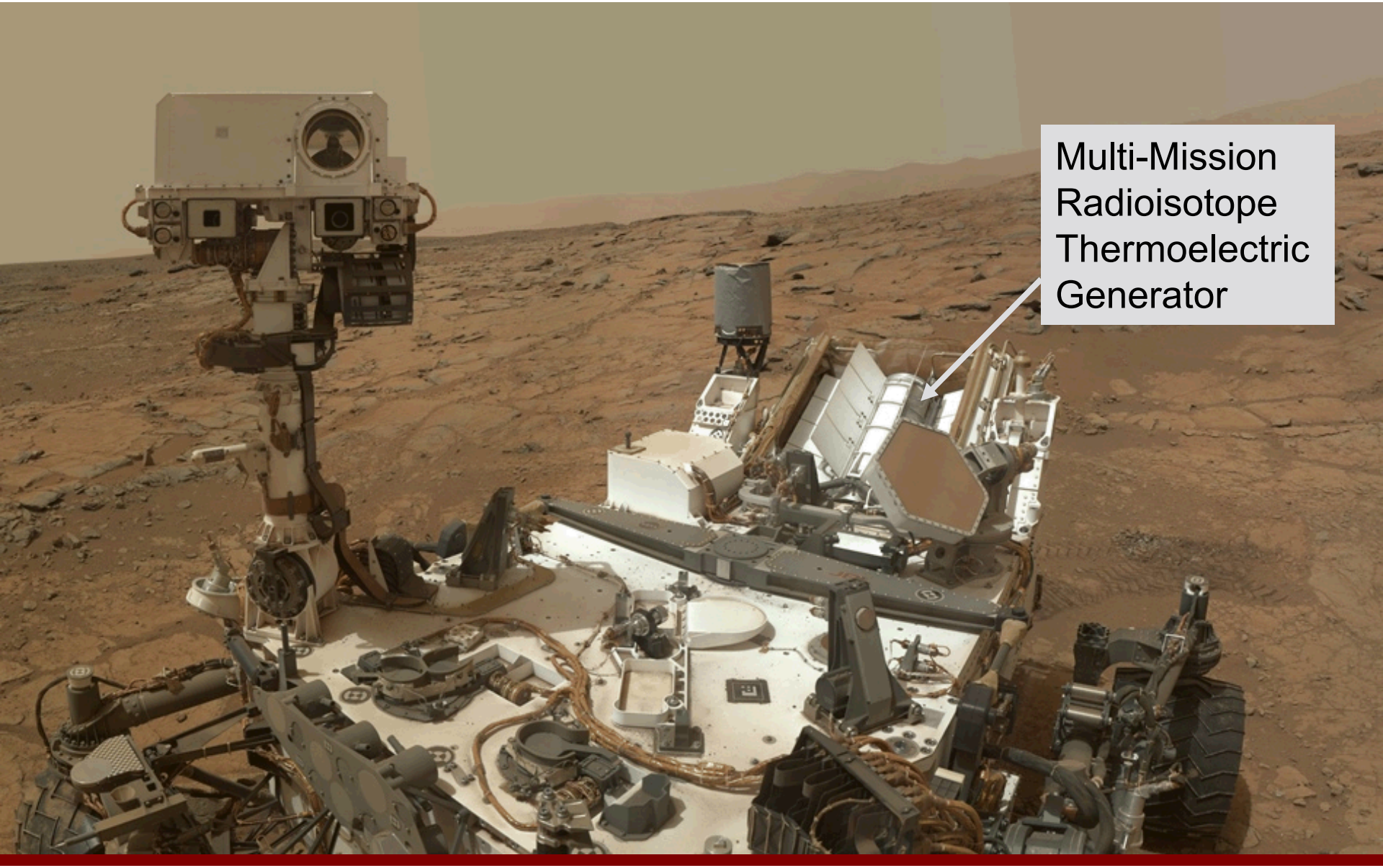

Image Courtesy NASA/JPL

Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)

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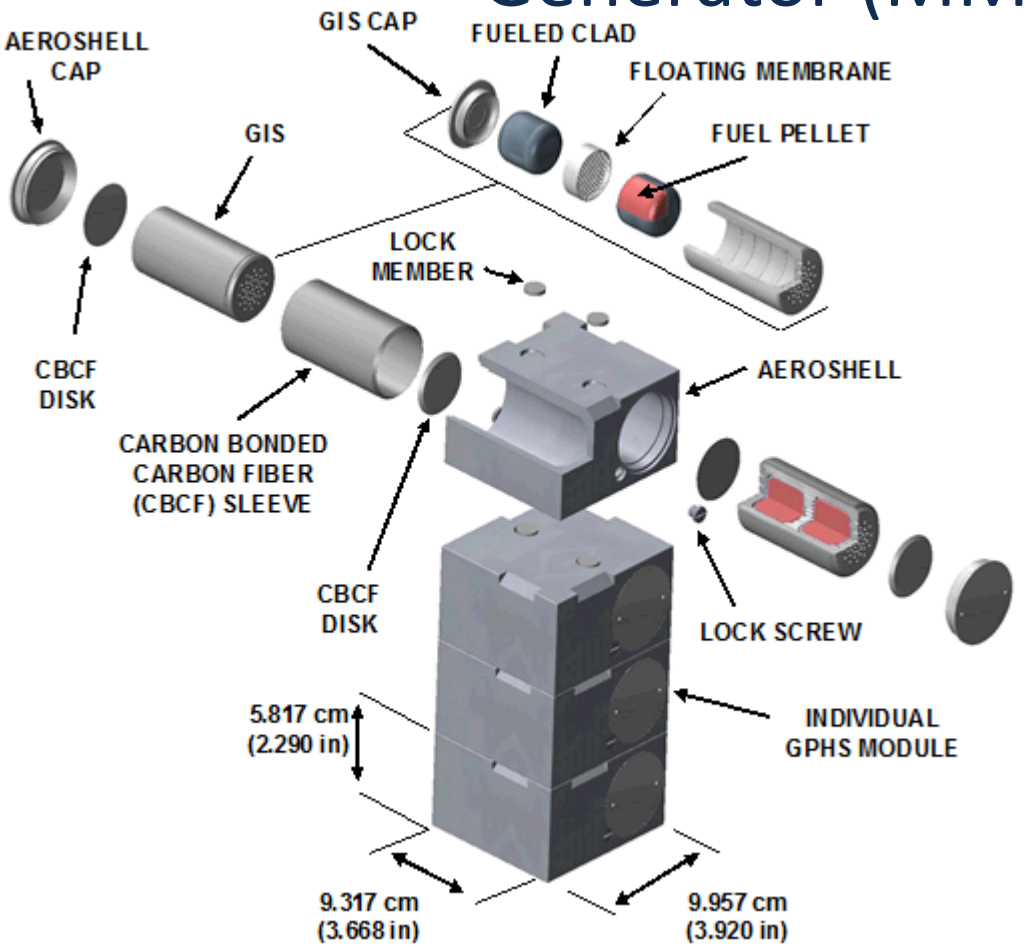

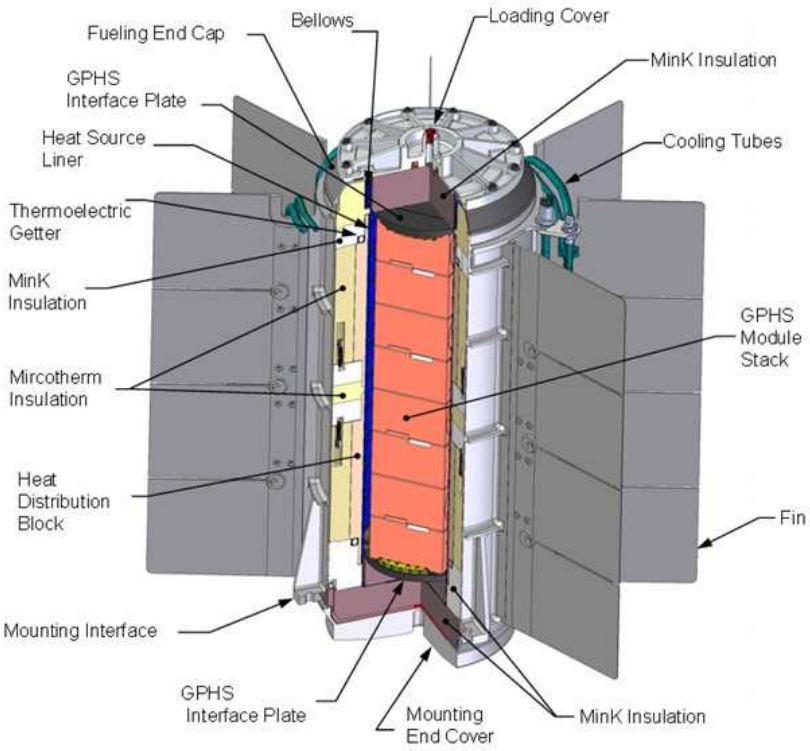

Safety is built from the inside out and from the outside in. Analysis must quantify this for decision makers.

Configuration of Burn Site Aerosol Sampling

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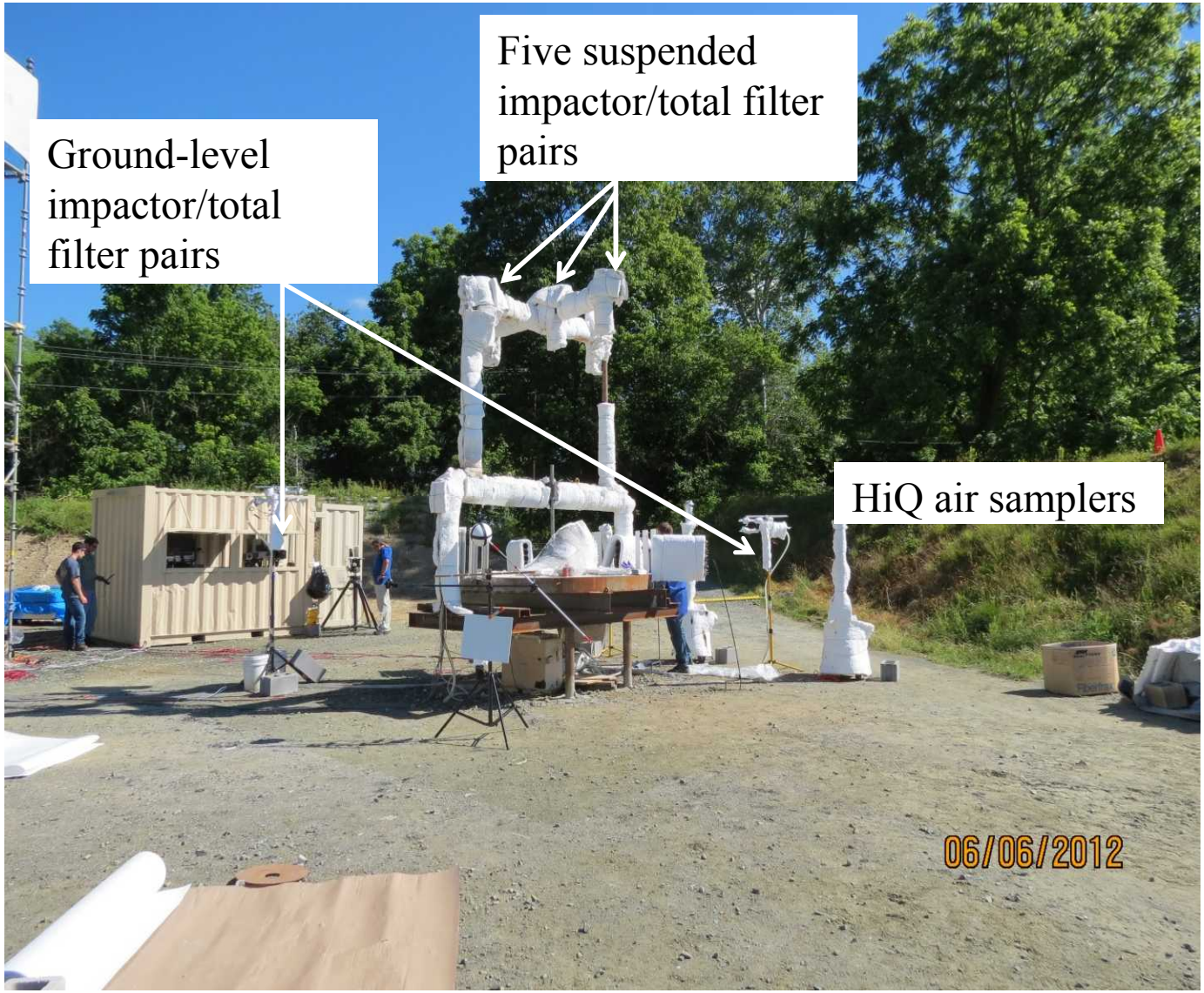

Pre-Burn with Ceria, Yttria tracers and Iridium Shell cemented into Kennedy Space Center concrete, surrounded by Maryland concrete

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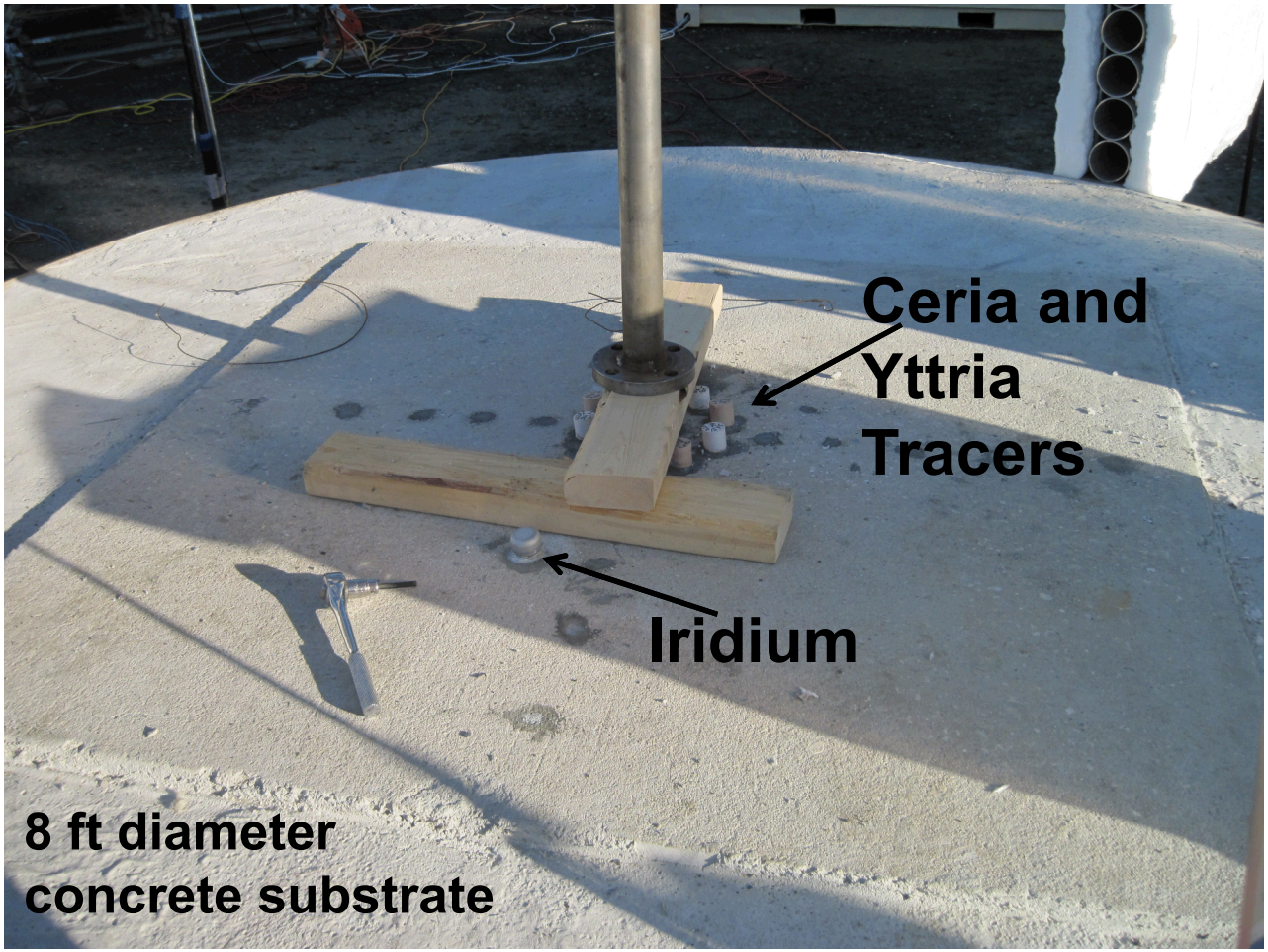

Post-Burn Concrete Substrate

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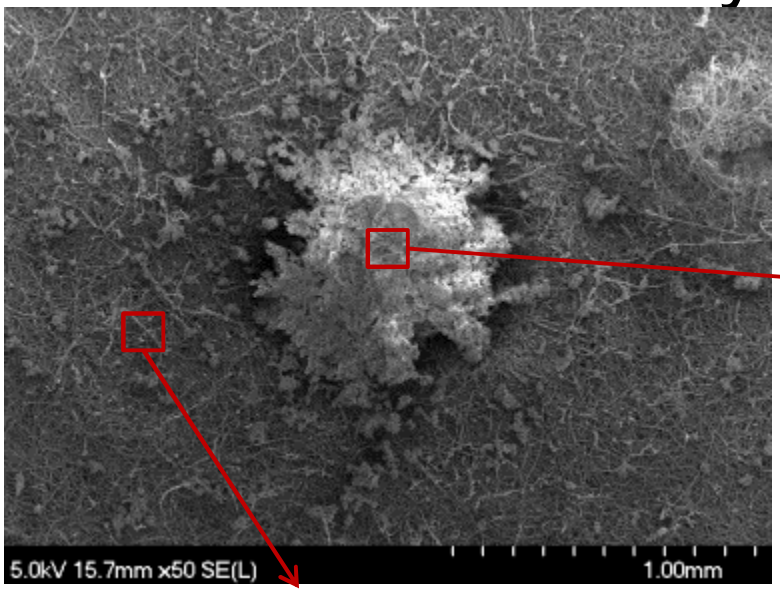
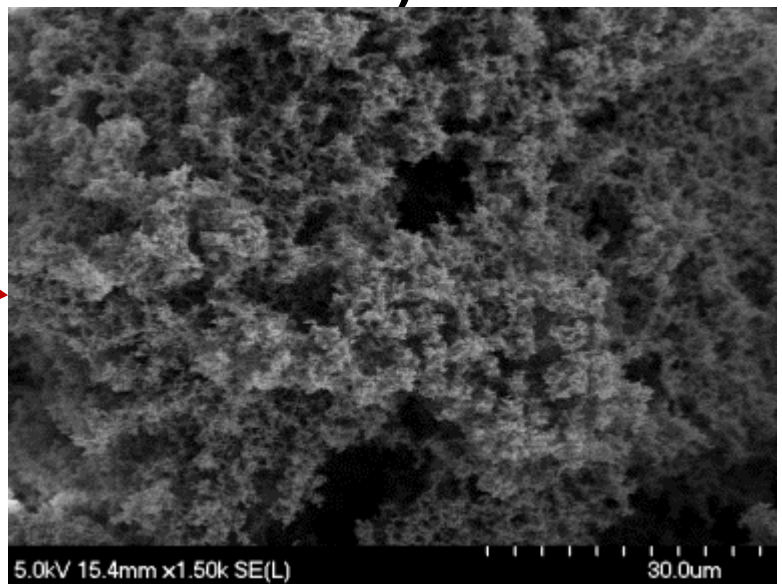
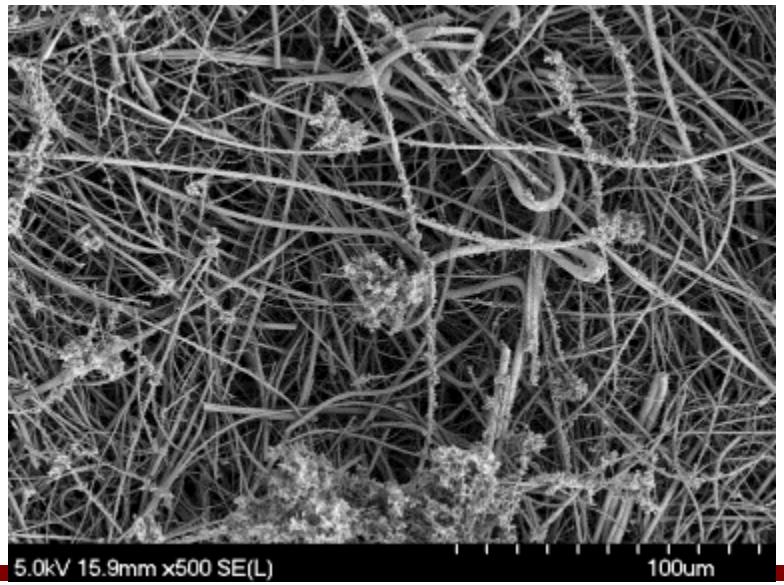
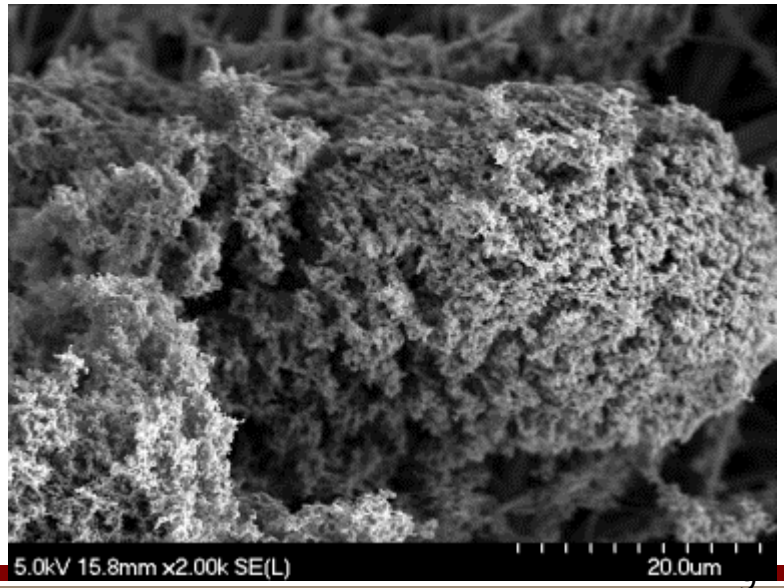
Cascade impactor collected aerosol (0.52-0.66 um aerodynamic diameter)









Cascade impactor collected aerosol (0.52-4.9 um aerodynamic diameter)

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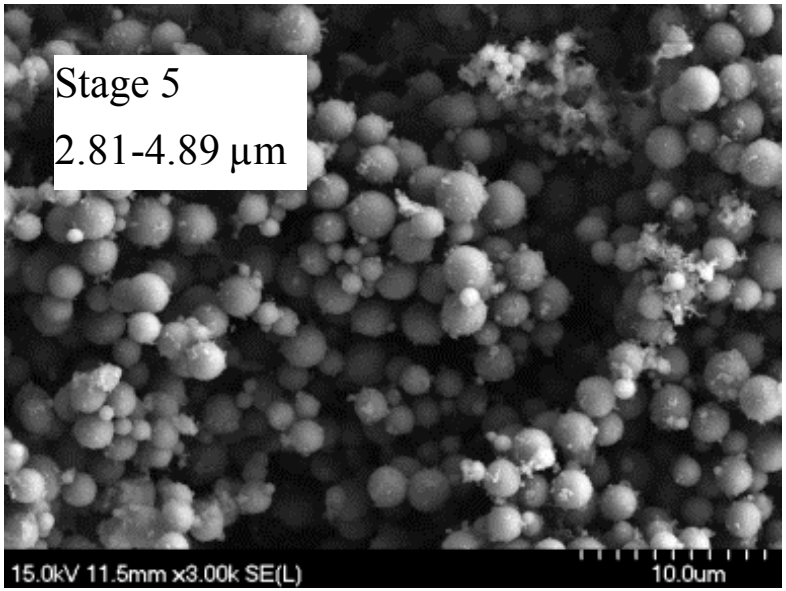

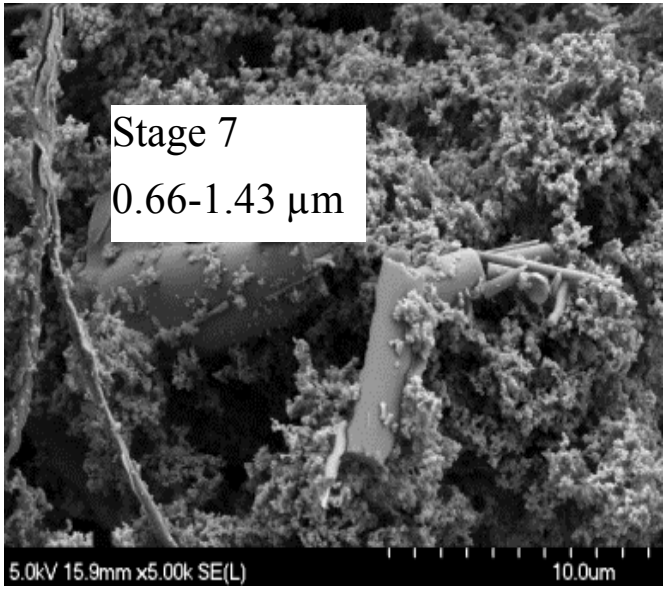

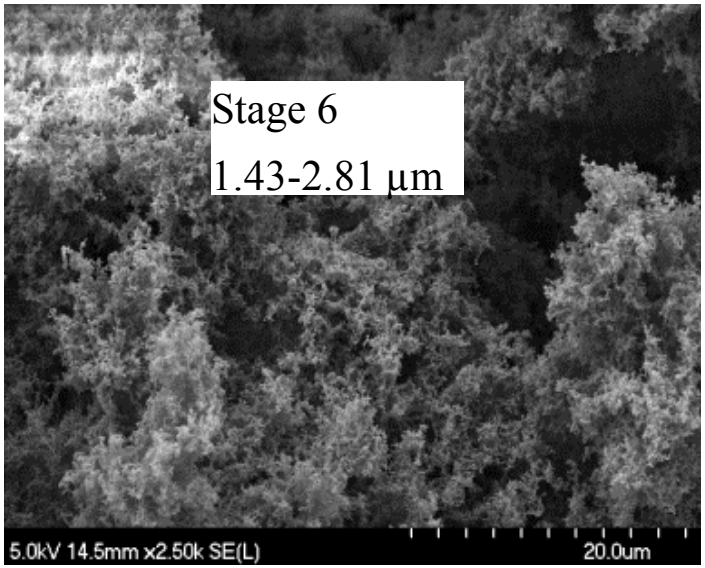

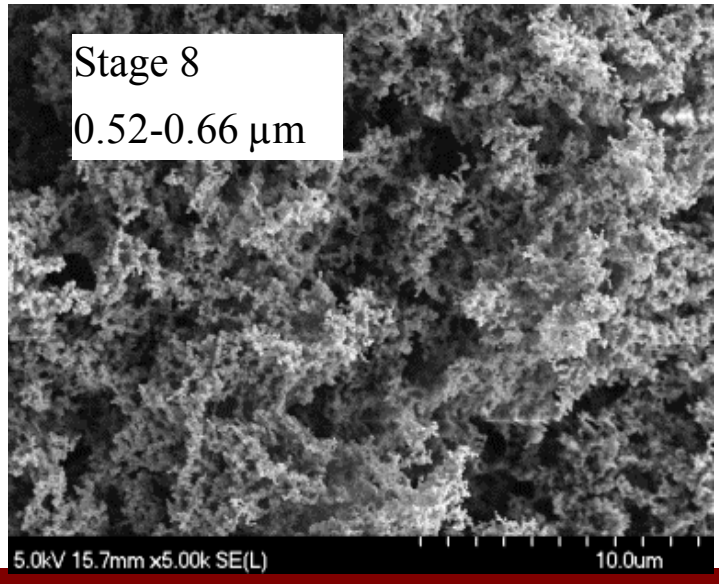

Cascade Impactor Collected Aerosol (4.9 – 35 um aerodynamic diameter)

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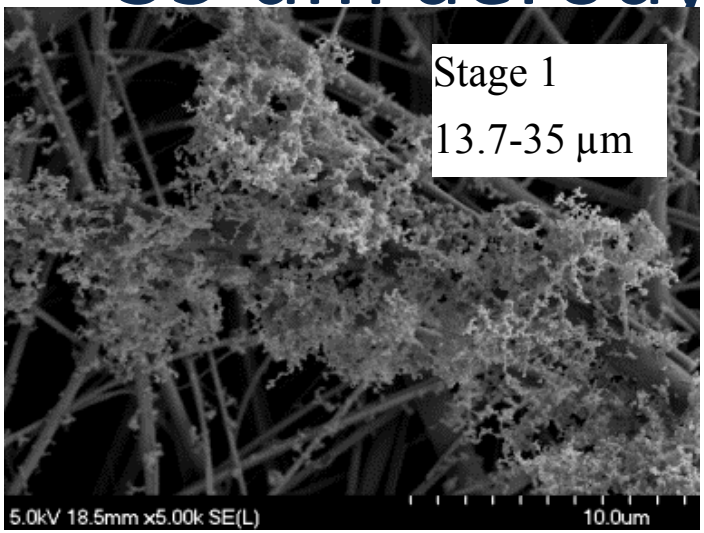

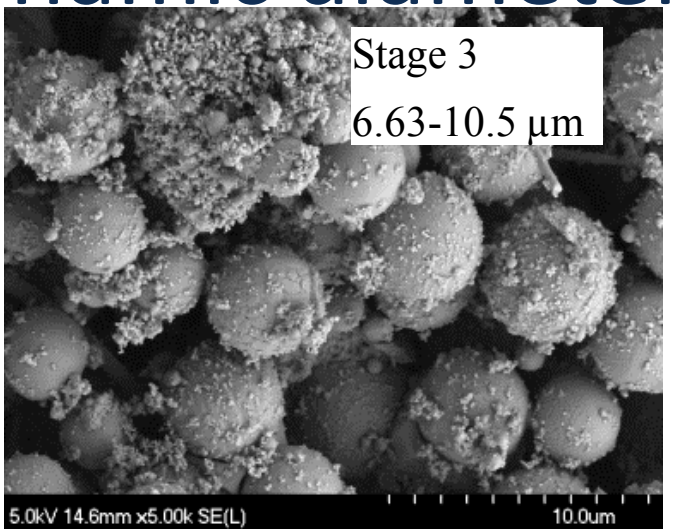

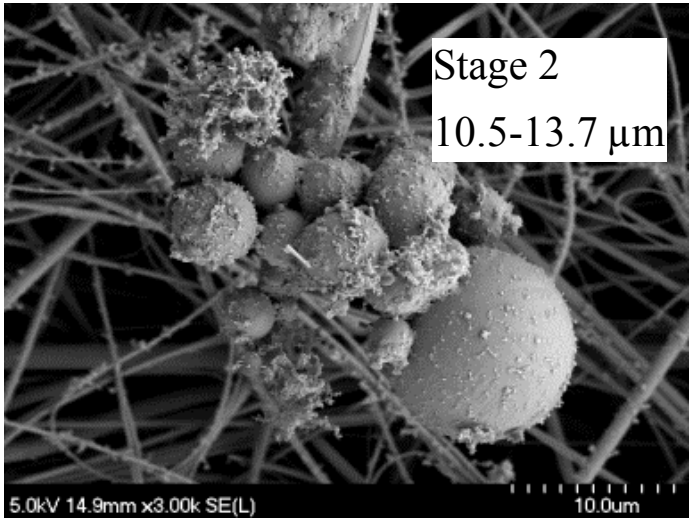

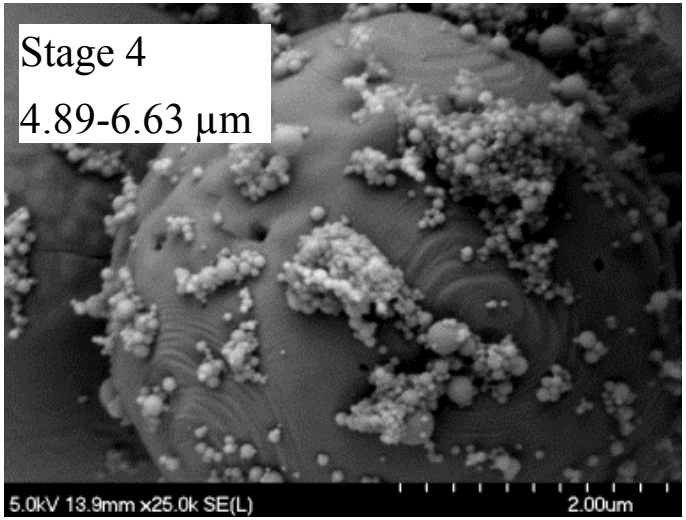

Measured Initial Particle Mass Distribution

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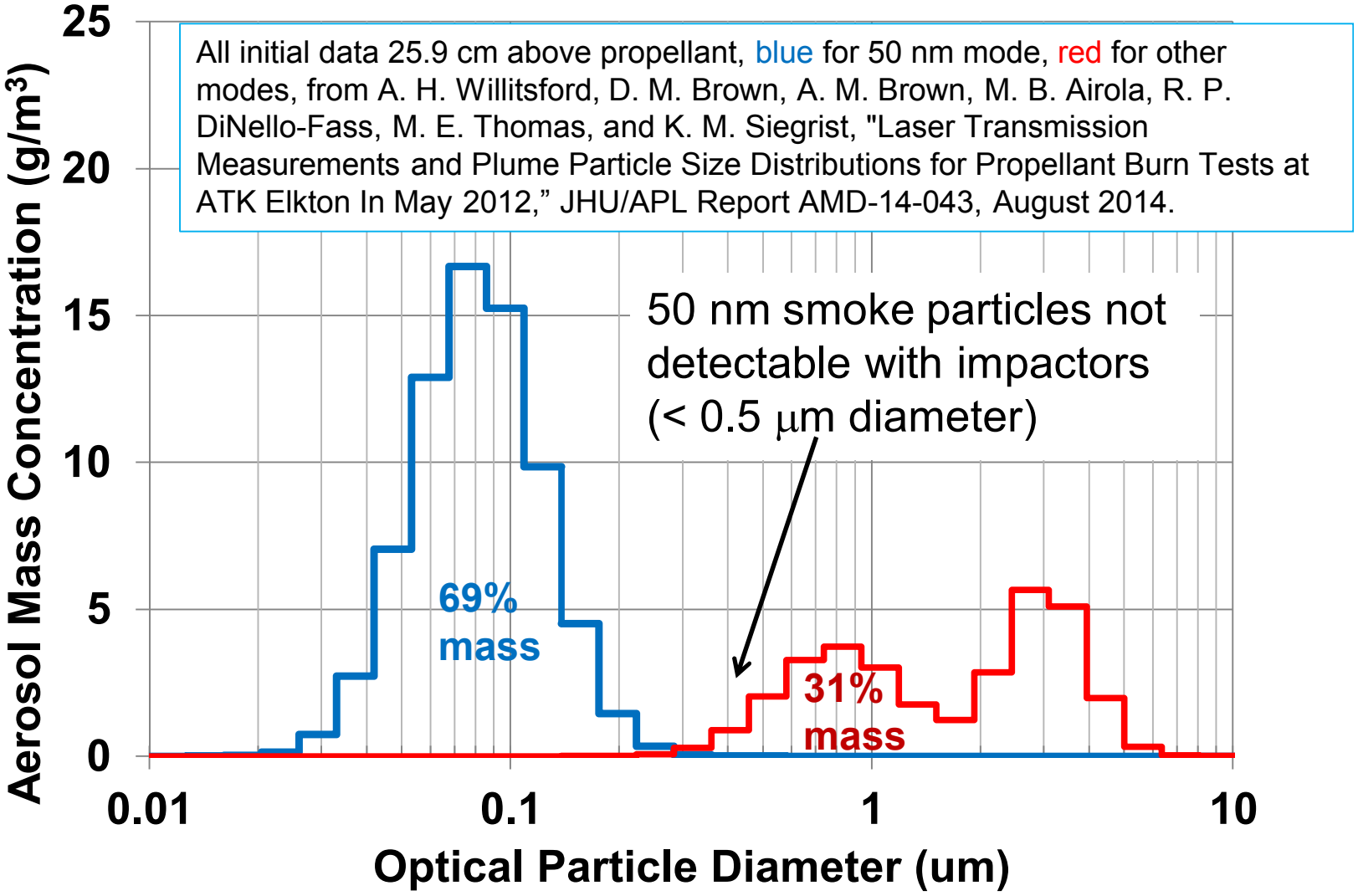
Observation: 10^{17} smoke particles/m^3, ~50 nm diameter

$1/(10^{17})^{1/3}$ = 2 µm average distance between particles



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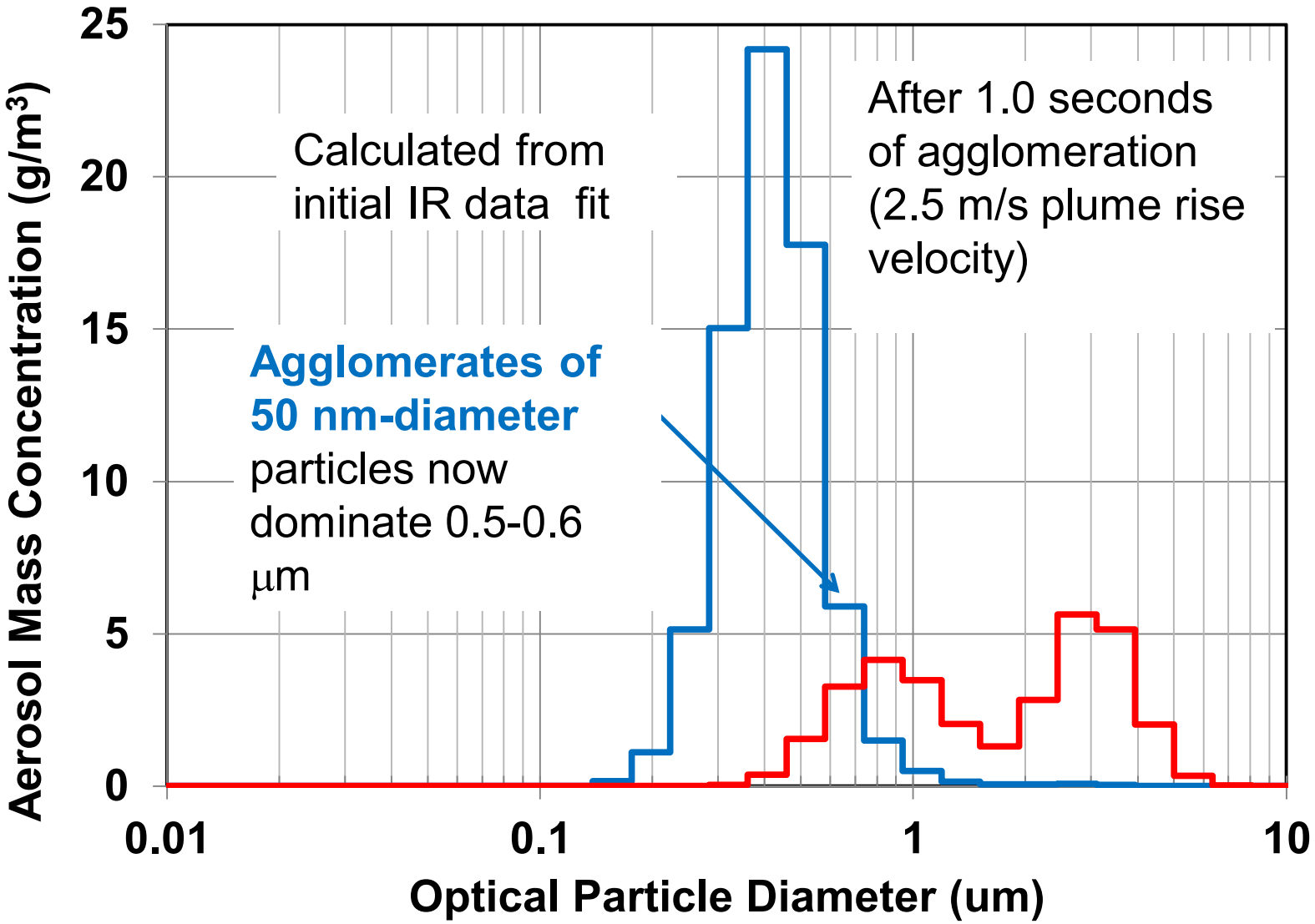
Calculated Particle Mass Distribution Evolution



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Calculated Particle Mass Distribution Evolution

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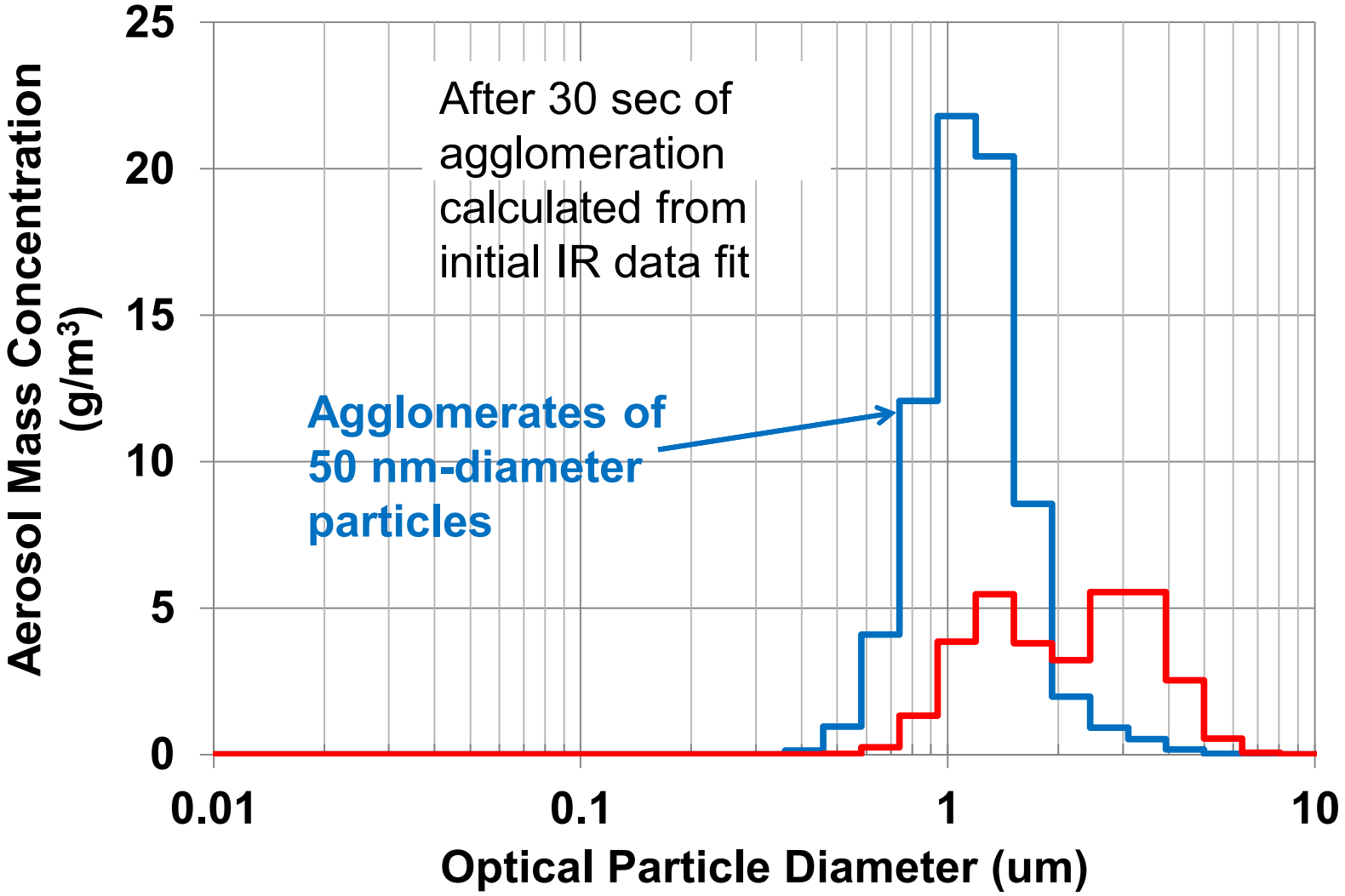
Aerosol mass still < 10 um diameter



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Summary & Conclusions

- Obtained for first time aerosol size distribution from large block (>18 inch diameter) burning solid rocket propellant at atmospheric pressure.
- Observed particle clusters that are 0.5 – 0.6 μm in diameter on impactor stage, can be explained by the 50 nm smoke particles agglomerating within a second.
- Observed “dusting” of 50 nm particles on to 5-10 μm particles due to agglomeration.
- If saturation vapor pressure changes in less than millisecond, then plutonia vapors first condense on smoke, and then agglomerate to larger sizes that are < 10 μm diameter.

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