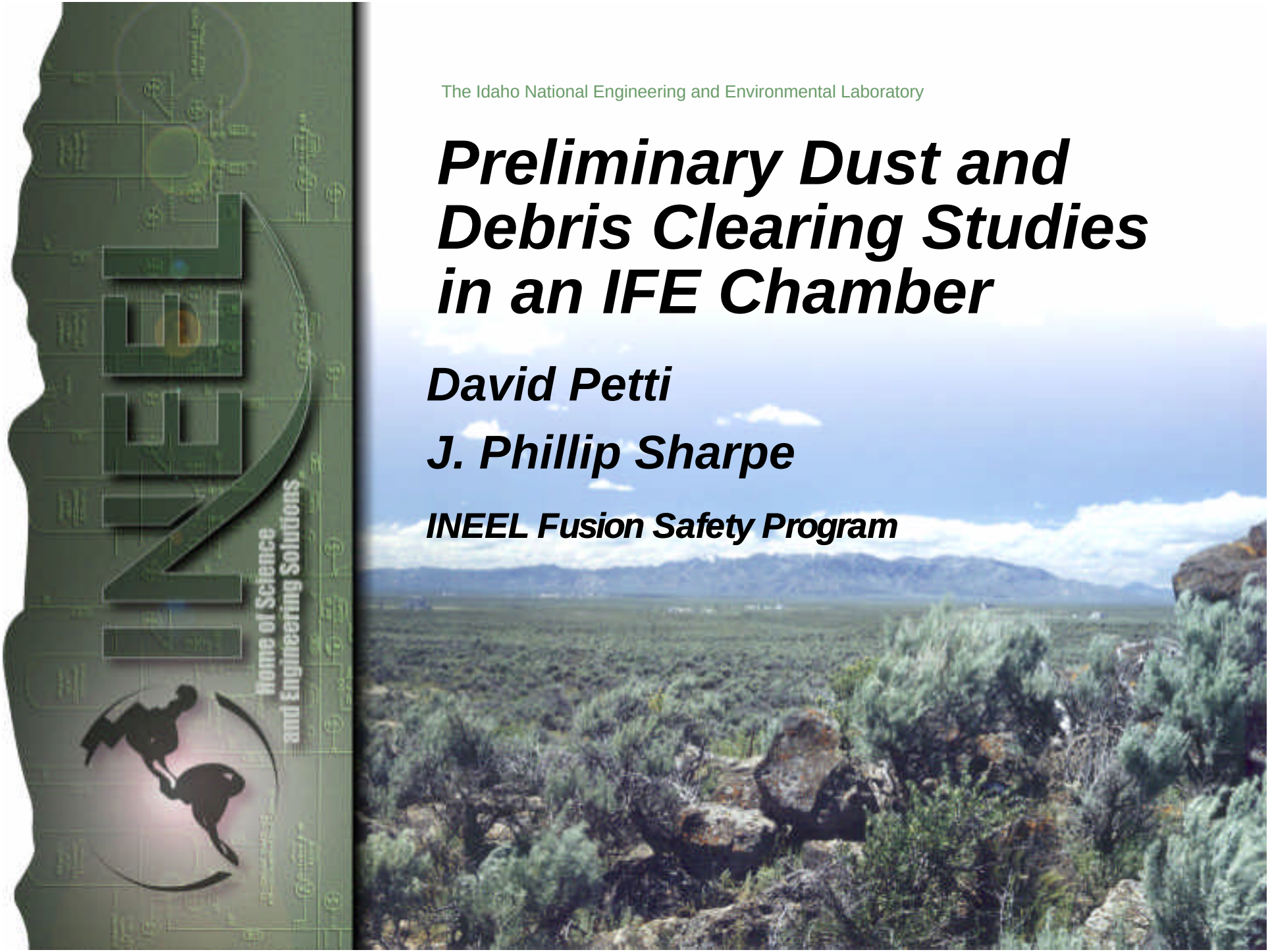

The Idaho National Engineering and Environmental Laboratory

Preliminary Dust and Debris Clearing Studies in an IFE Chamber

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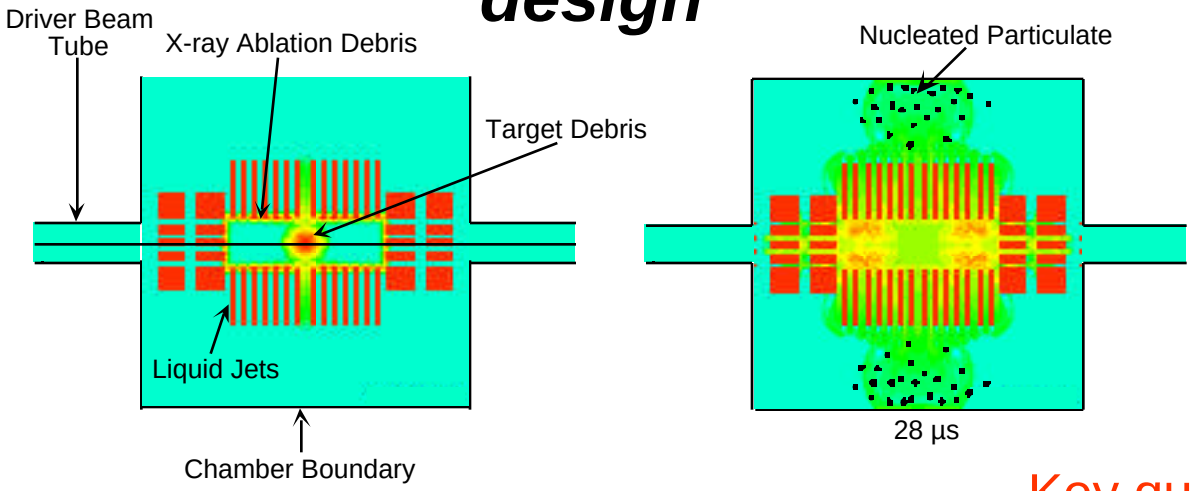
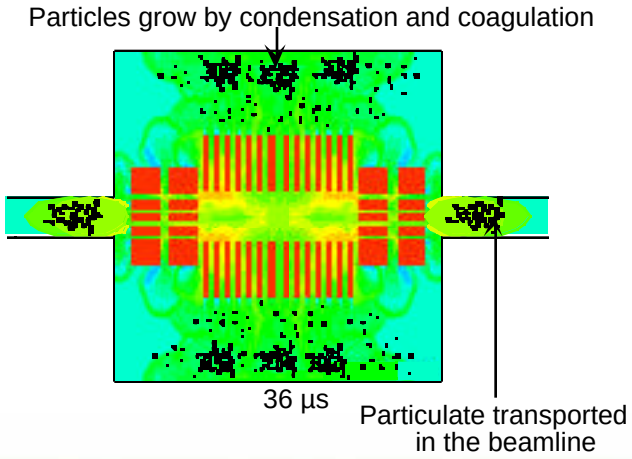
Control of dust and debris is needed in an IFE Chamber

- ***Vaporized wall material could rapidly recondense (i.e. generate dust/particulate) between shots***
- ***Dust production rate is potentially high due to large amounts (~kg) produced from each shot, a high shot repetition rate, and rapid cooling in the chamber***
- ***Removal of dust must be fast and efficient to reduce accumulation at undesirable locations, e.g. beamlines, pumping ducts***
- ***Serious safety consequences in some accident scenarios (dust may be activated and/or chemically reactive)***

Potential mechanisms of formation and growth of dust/particulate for a single shot in the HYLIFE-II design



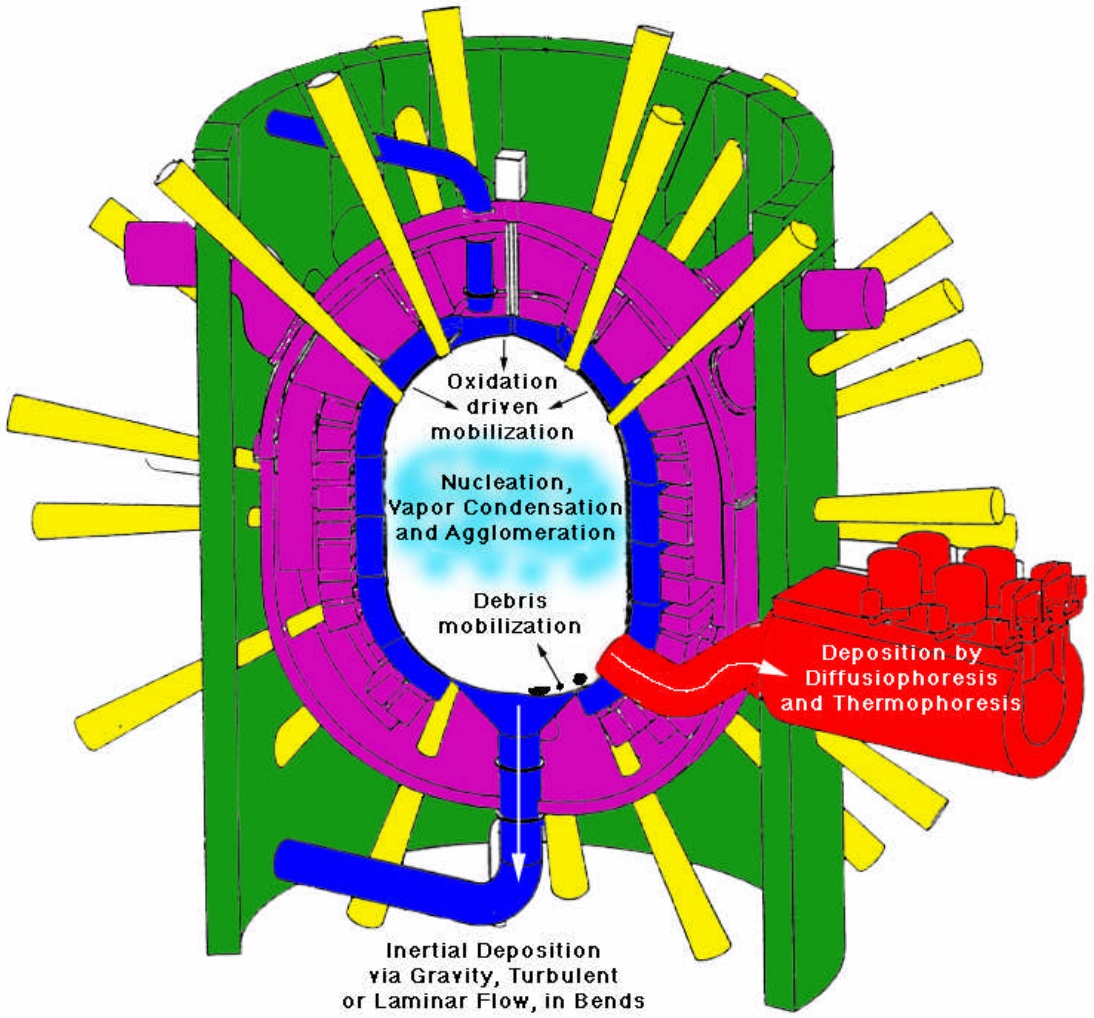


Dust may be formed by homogeneous nucleation of saturated vapor, and it may grow by condensation and coagulation.

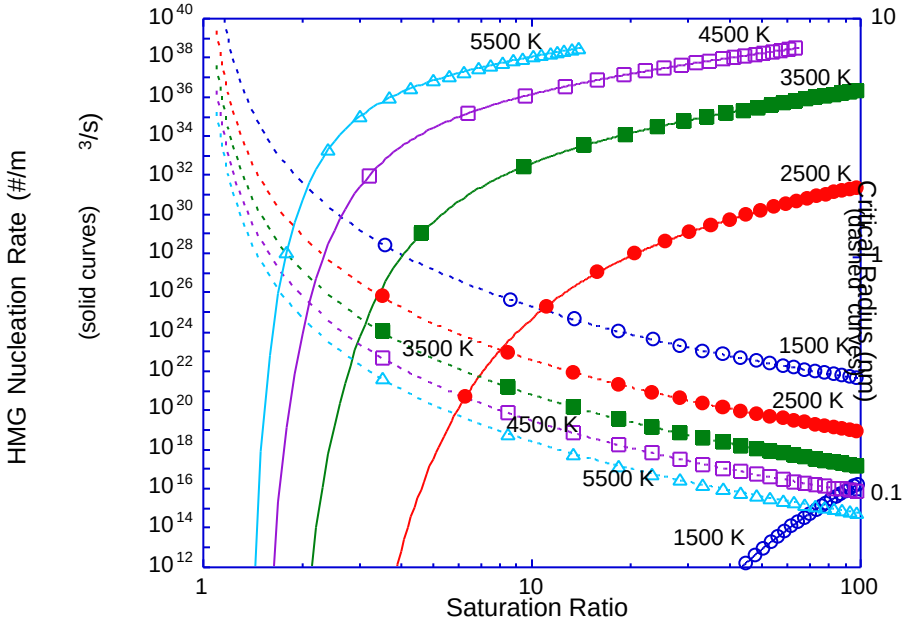
Key question: Can dust/particulate form and transport down the beam lines between shots?

This figure was adapted from TSUNAMI code results and is for illustrative purposes only.

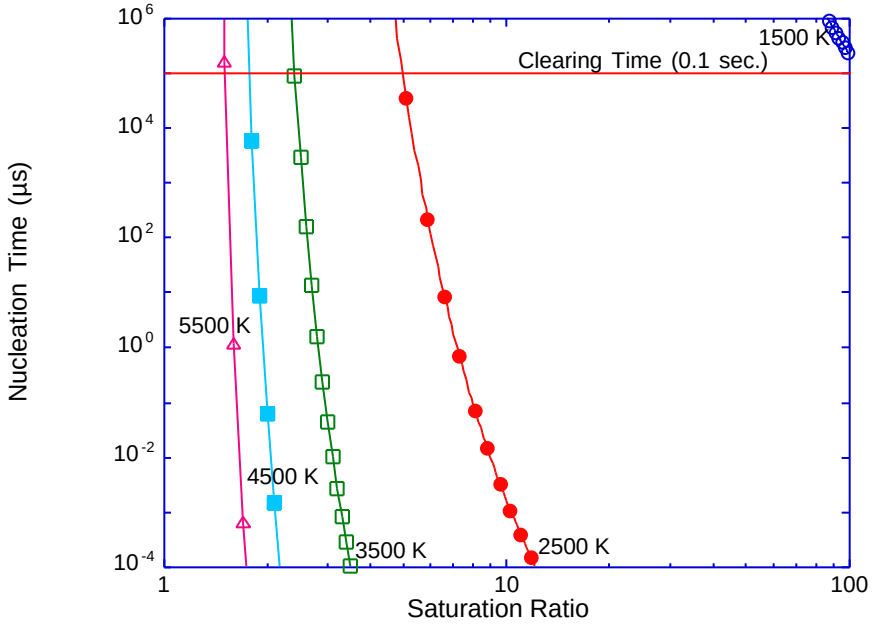
Possible mobilization mechanisms in an accident



Physical characteristics and time scale of Homogeneous Nucleation



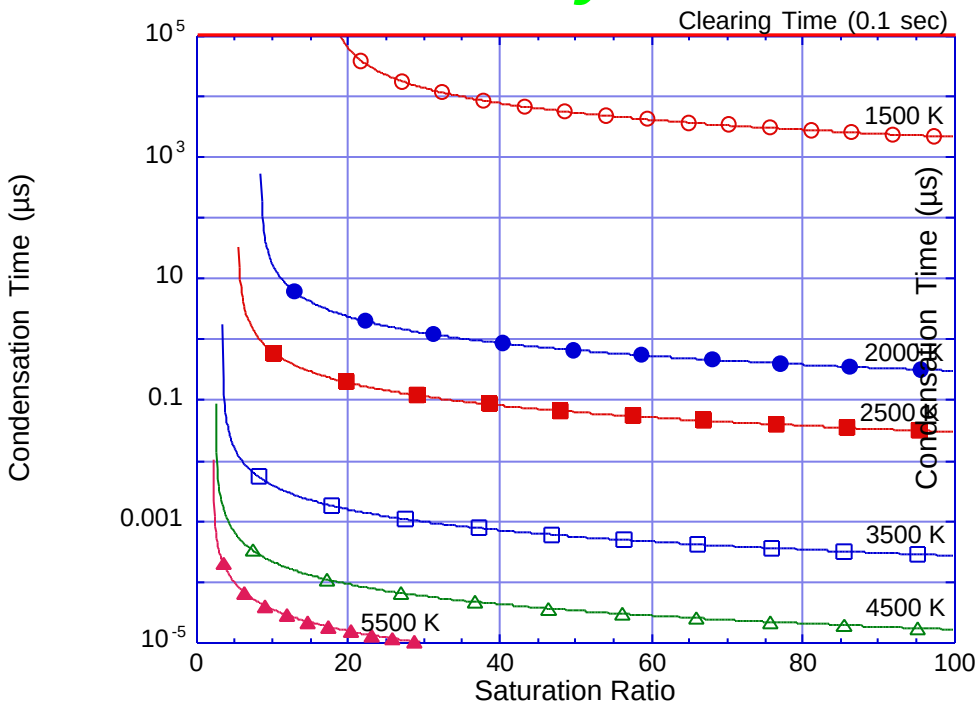
Nucleation rate and critical radius of Au at various saturation temperatures



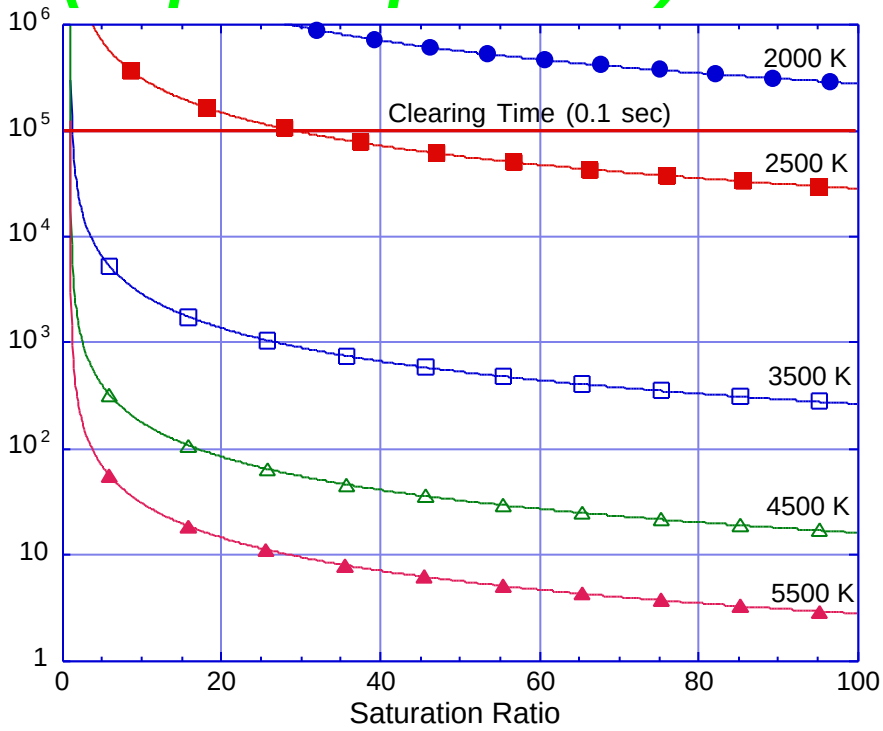
Time required to form 10^{15} Au particles/m^3 (where coagulation becomes increasingly important)

Key result: ***A wide range of conditions based on expected values in an IFE chamber yield nucleation times much smaller than estimated clearing times.***

Physical characteristics and time scale of Growth by Condensation (Vapor Deposition)



(a) 0.001 μm particle- order of critical radius for nucleation



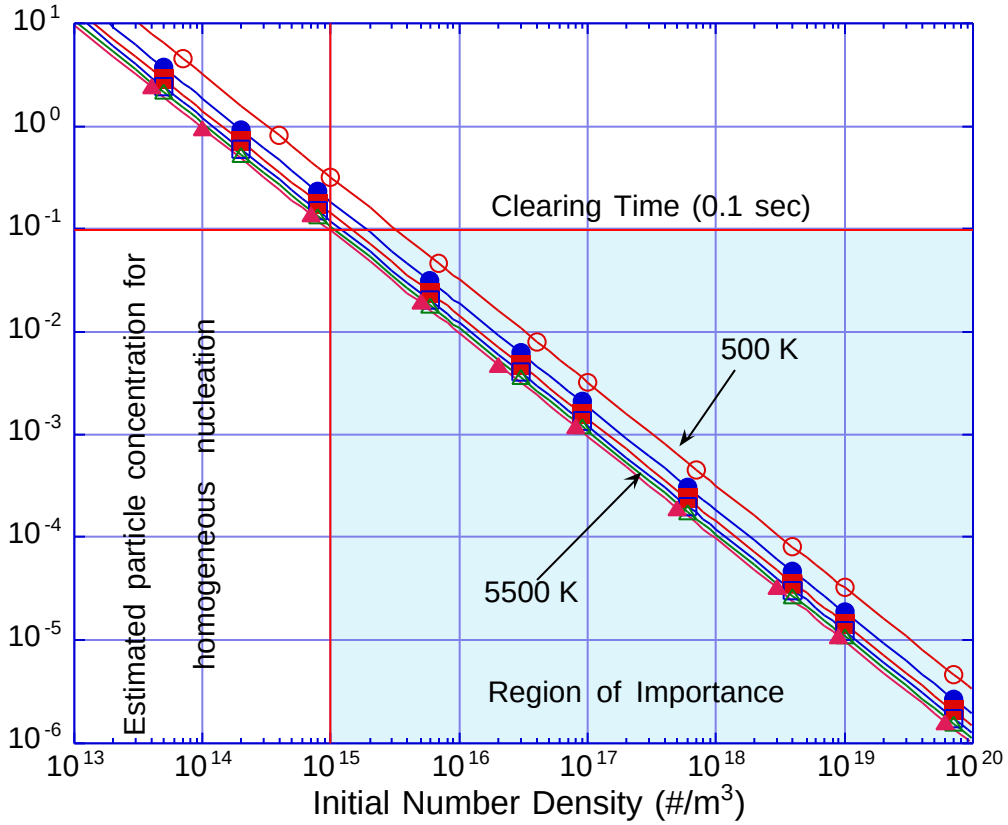
(b) 0.1 μm particle

Time needed for particles in saturated vapor to increase volume by 10%
(and significantly change the dust size distribution)

Key result: ***Changes in dust transport properties related to size distribution occur faster than clearing times due to condensation growth. Such effects must be considered when designing/evaluating clearing strategies.***

Physical characteristics and time scale of Coagulation

Time required for 1 μm dust particles to change total number by 10%



Key result: ***Dust particle concentrations generated from homogeneous nucleation are sufficiently large so that particle coagulation occurs faster than chamber clearing times, providing another mechanism that contributes to changing dust transport properties.***

Other mechanisms to consider in IFE transport studies

- ***Gravitational settling***
- ***Inertial deposition***
- ***Turbulent deposition***
- ***Longer term mechanisms such as thermophoresis, diffusiophoresis and electrophoresis***

These mechanisms are influenced to a lesser degree by the unique and extreme conditions present in the chamber. They are important at longer times, for example in determining transport down beam lines.

This quick scoping analysis suggests that debris/particulate formation must be considered in more detail. So What's Next?

- ***Upgrade INEEL models on aerosol formation and transport for IFE conditions***
- ***Analyze the simultaneous effects of the 3 main dust formation mechanisms in an IFE chamber in an integrated sense***
- ***Determine size and mass distribution, and total amount, of dust generated for 1 shot***
- ***Determine amount of material that can travel down beam lines and deposit on mirrors etc.***
- ***Examine impact of possible dust accumulation in the chamber***
- ***Address effectiveness of chamber clearing strategies and develop new strategies if needed***