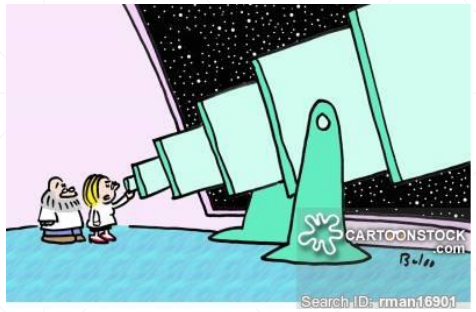
Bubble Growth Dynamics

Alexandre Le Blanc

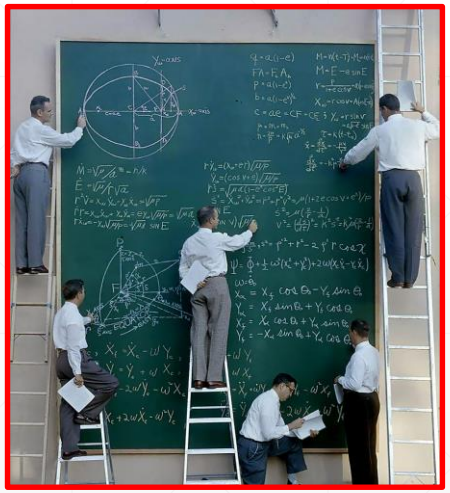
My “Track”

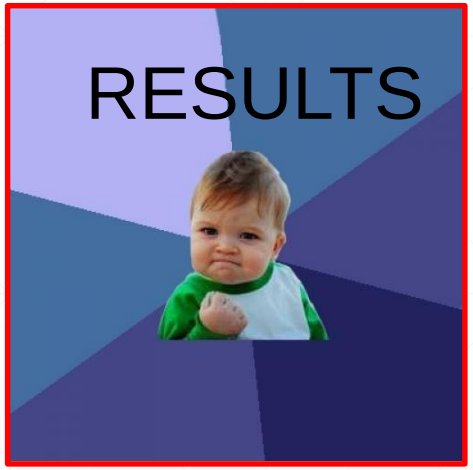


Dark Matter Evidence

Idea

Model





Future

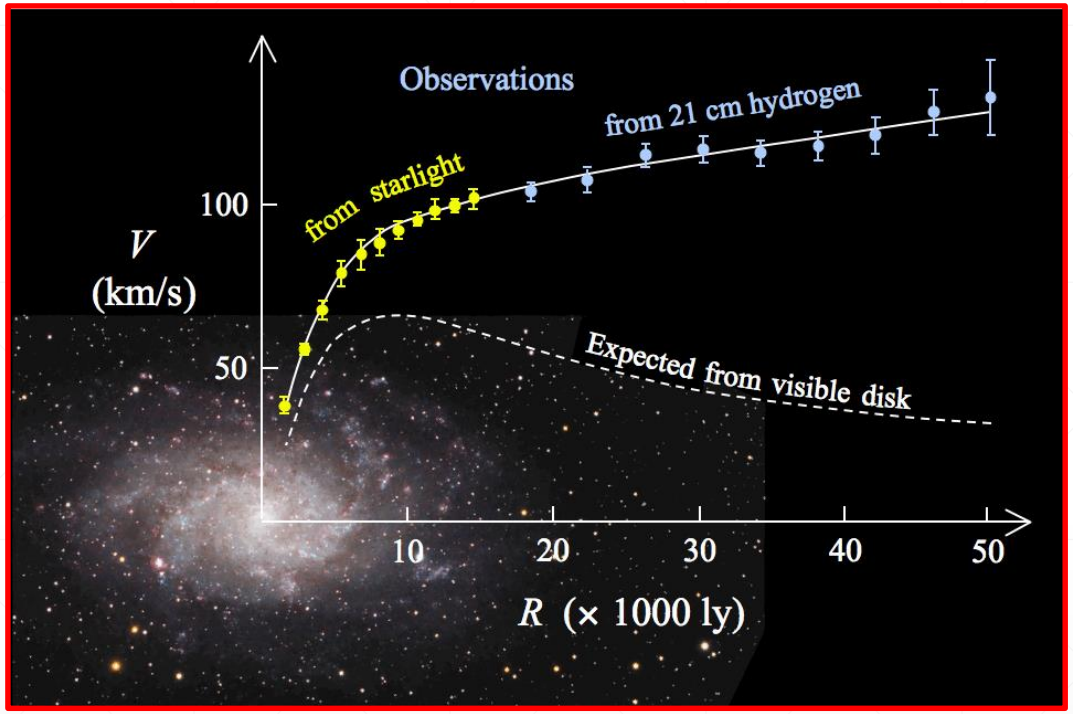
How Much Evidence do we Need?

Light ≠ Mass

Zwicky 1930's

Image, https://ned.ipac.caltech.edu/level5/March02/Abell/Abell3_3.html

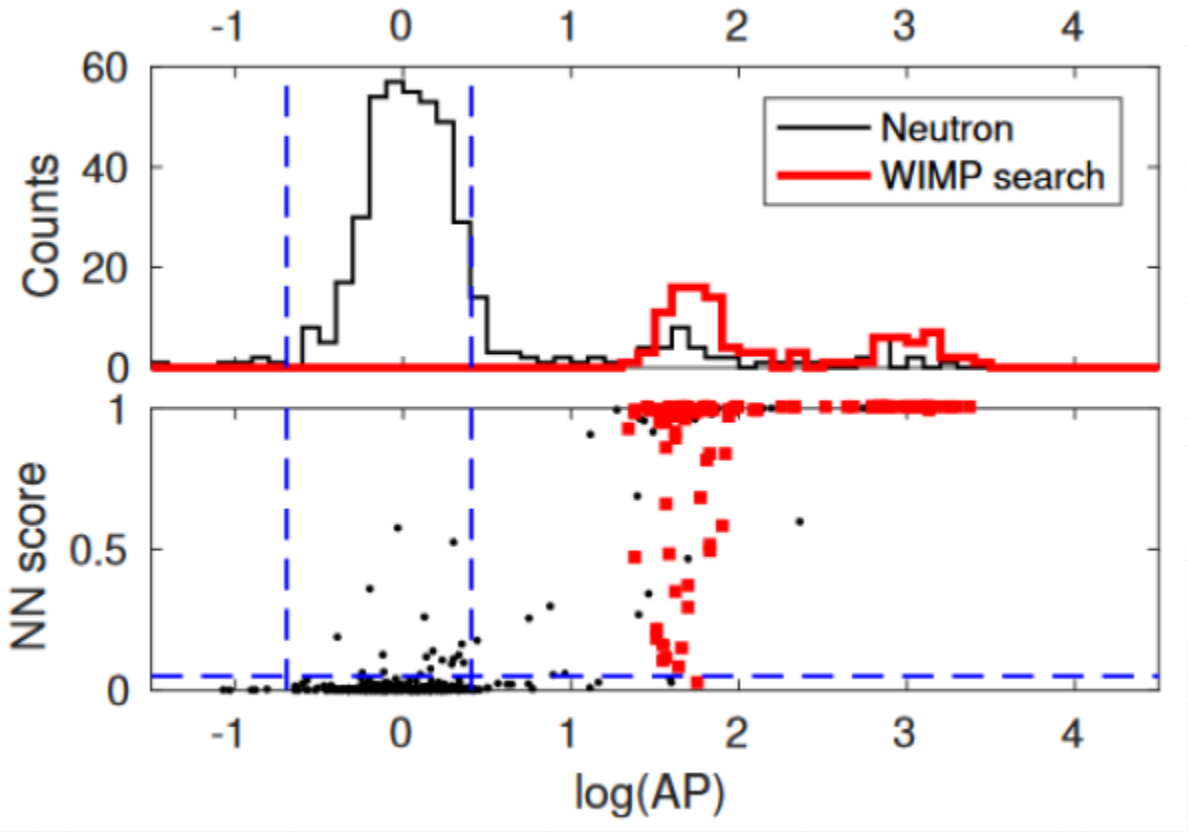
$$V_{rot} \not\propto \frac{1}{\sqrt{r}}$$



Rubin 1970's

Image, *Corbelli, E. & Salucci, P. (2000). "The extended rotation curve and the dark matter halo of M33". Monthly Notices of the Royal Astronomical Society. **311** (2): 441–447*

Storytelling



C. Amole et al. *Dark Matter Search Results from PICO-60 C_3F_8 Bubble Chamber, Phys*. Rev. lett. 118, June 2017

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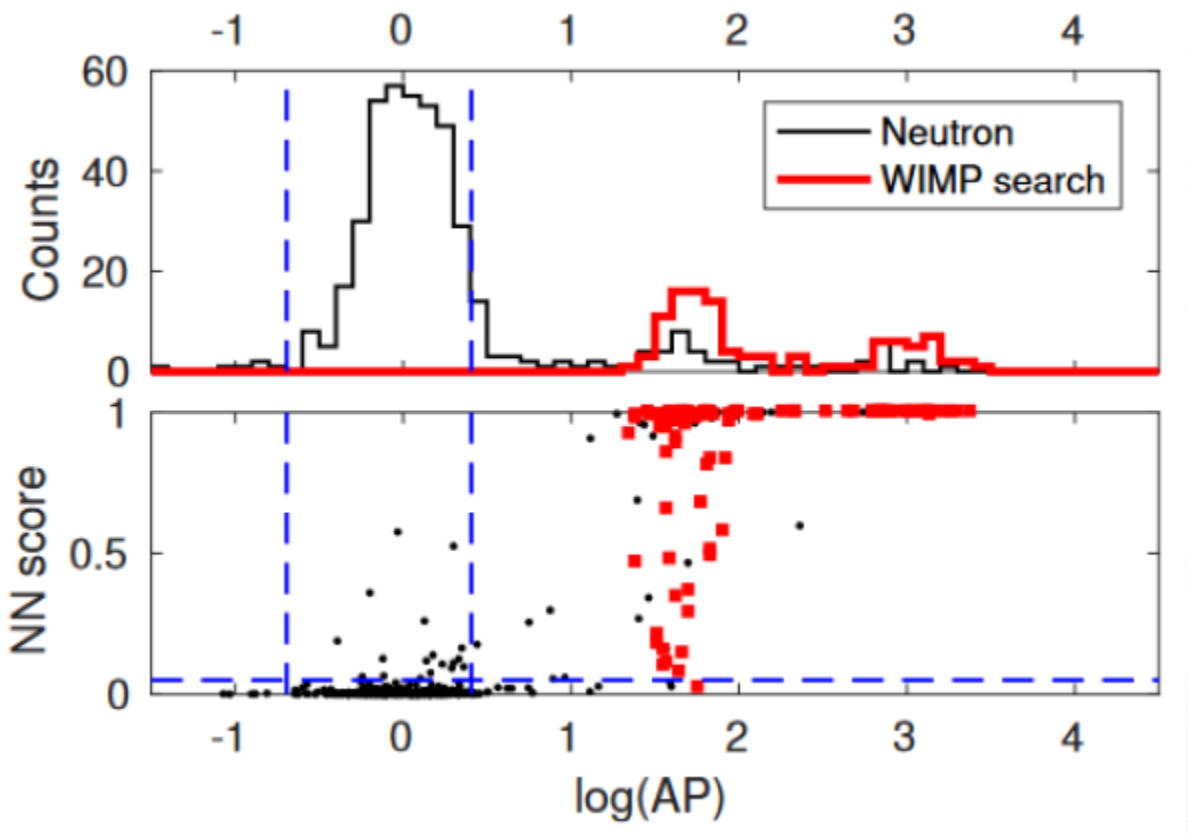
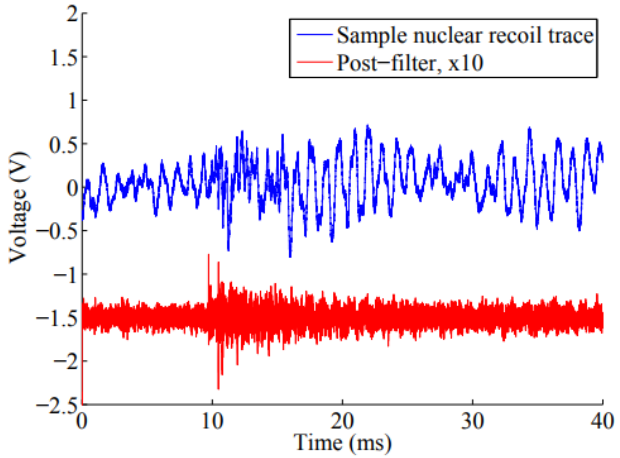


How does this



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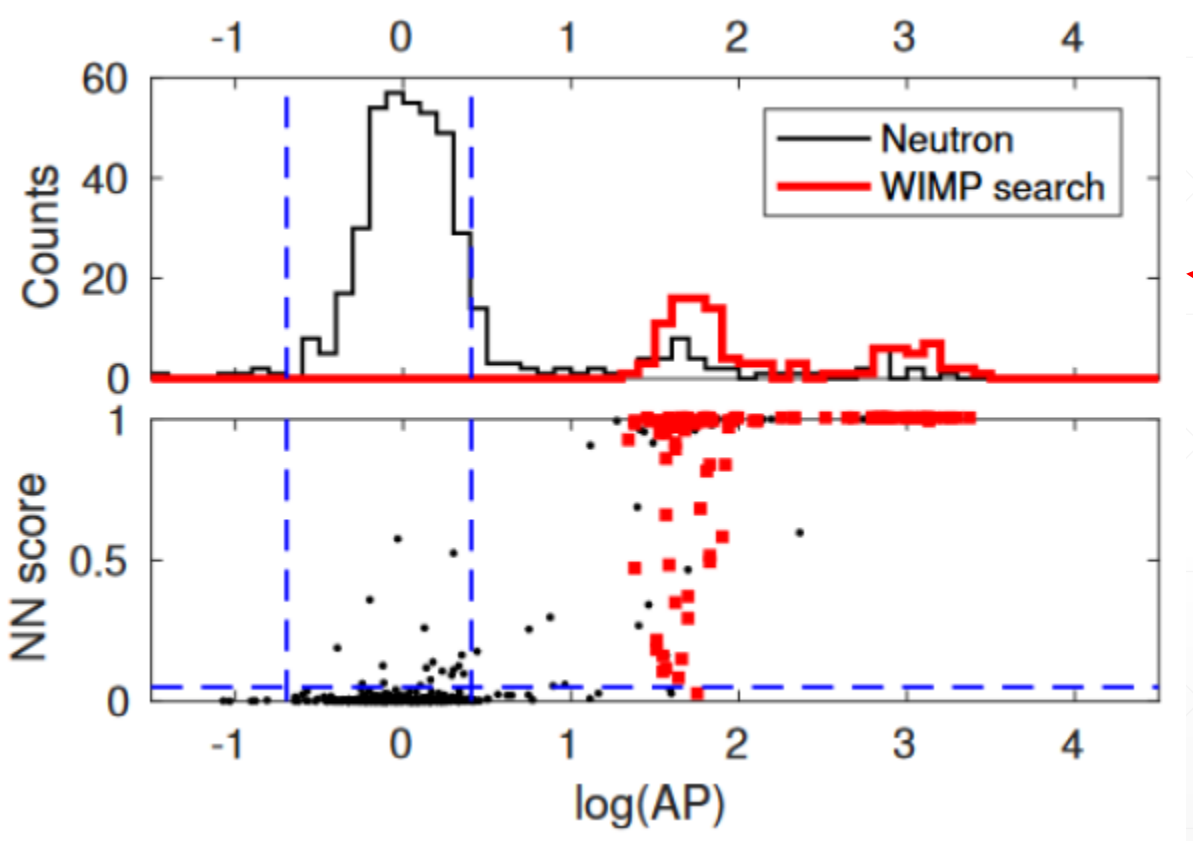

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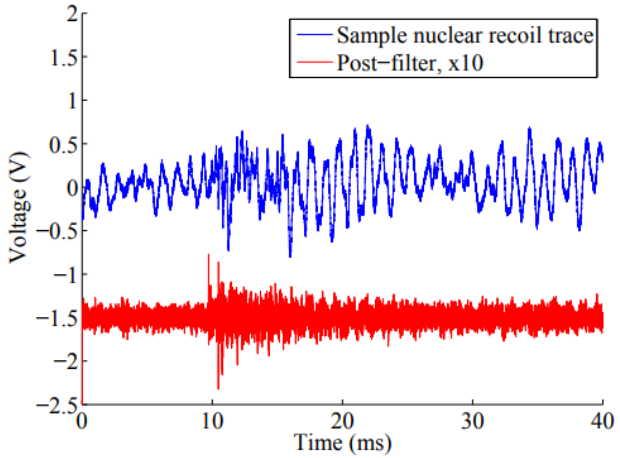

Become

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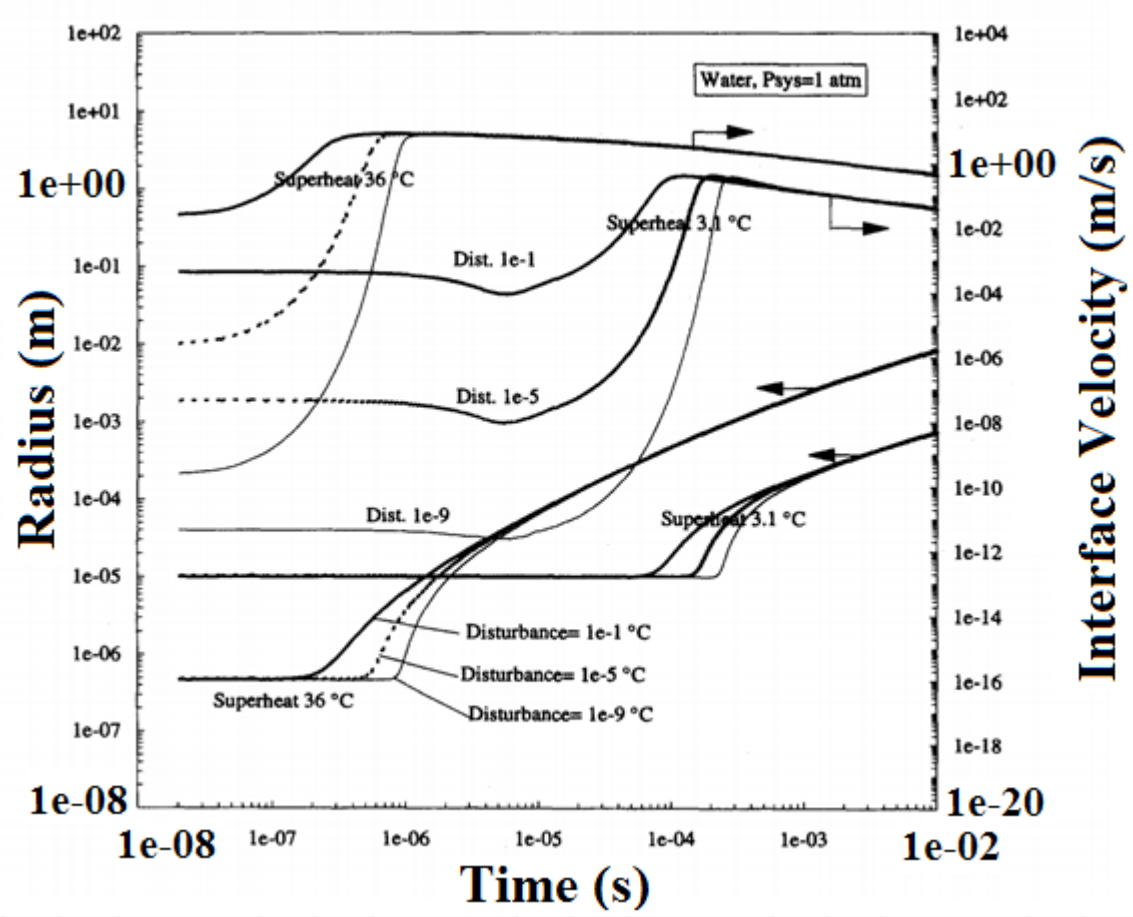

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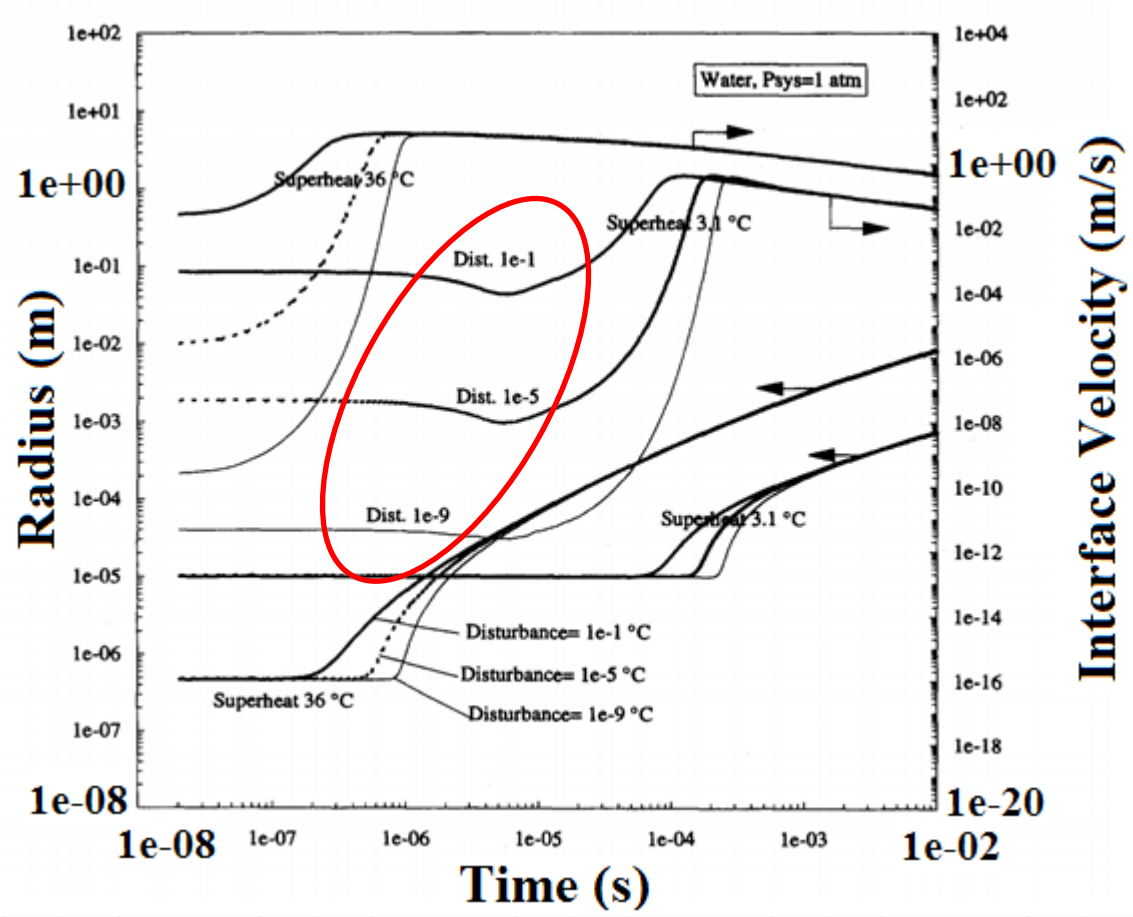
Storytelling



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- A disturbance is a small perturbation of the equilibrium condition to start the bubble growth

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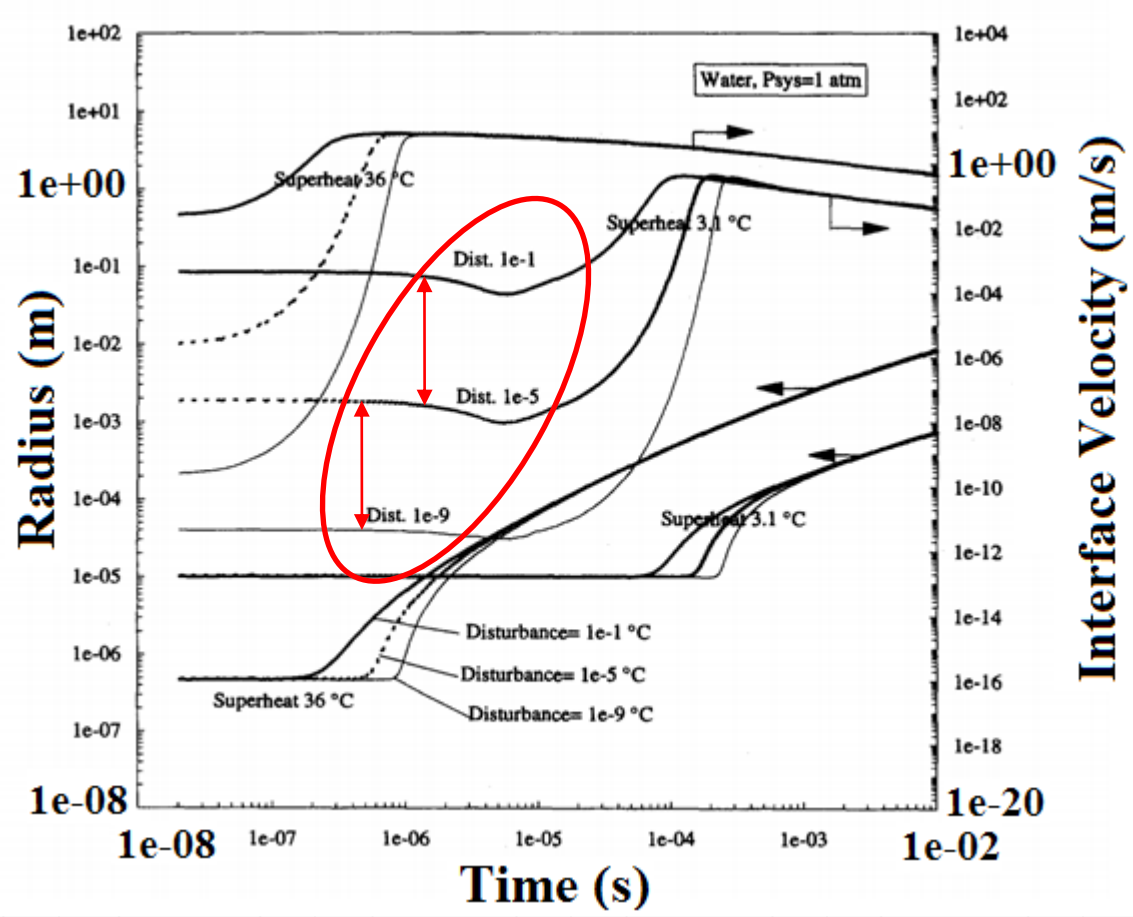

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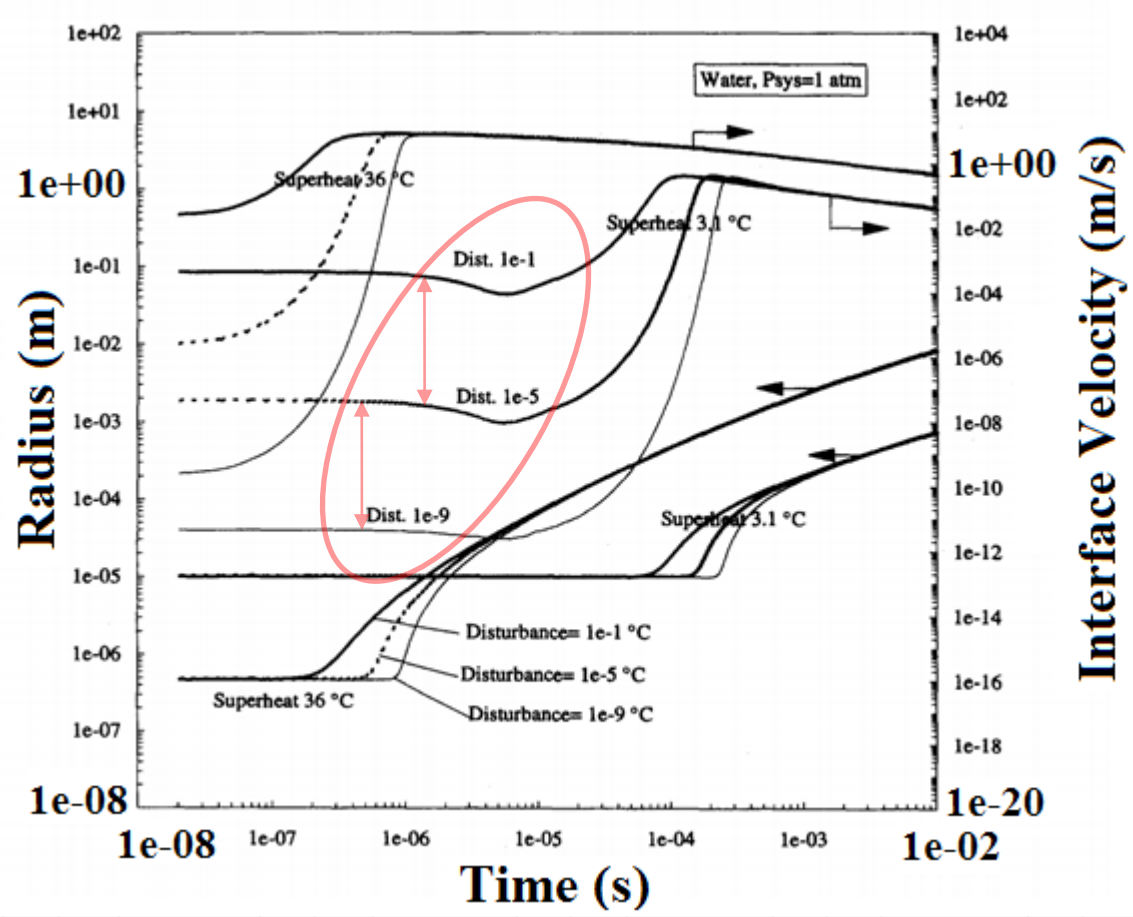
- A disturbance is a small perturbation of the equilibrium condition to start the bubble growth
- Separation between disturbances
- ≈11 orders of magnitude of difference for the interface velocity

Storytelling



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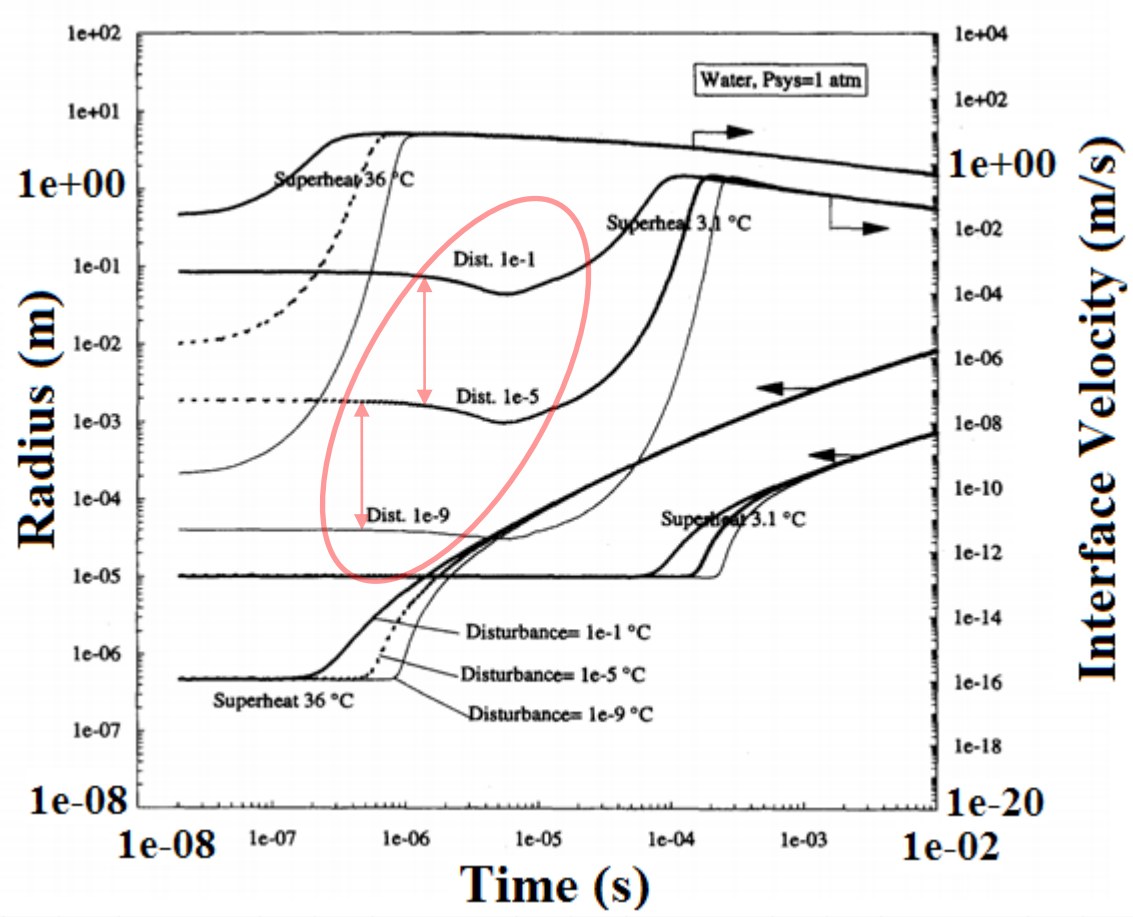
- Separation between disturbances
- ≈11 orders of magnitude of difference

Slight side-track… There seems to be information contained in the bubble growth

Storytelling



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What about C_3F_8???

The Model

Detector: → 1. Temperature
2. Pressure → 1. Energy threshold
2. Equilibrium bubble radius

The Model

SUPERHEAT

Detector: → 1. Temperature
2. Pressure → 1. Energy threshold
2. Equilibrium bubble radius

The Model

SUPERHEAT

Detector: → 1. Temperature, 2. Pressure → 1. Energy threshold, 2. Equilibrium bubble radius

P → Boiling Temperature (T_b) → $T-T_b$=Superheat

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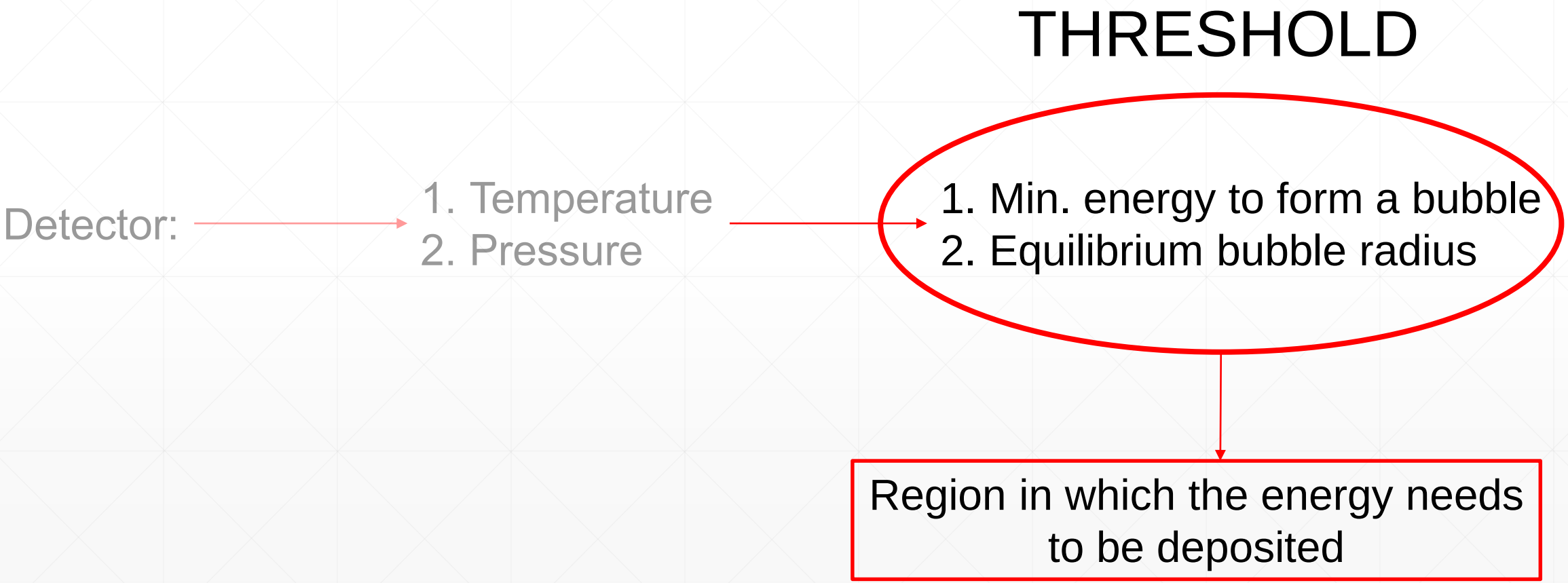
The Model

THRESHOLD

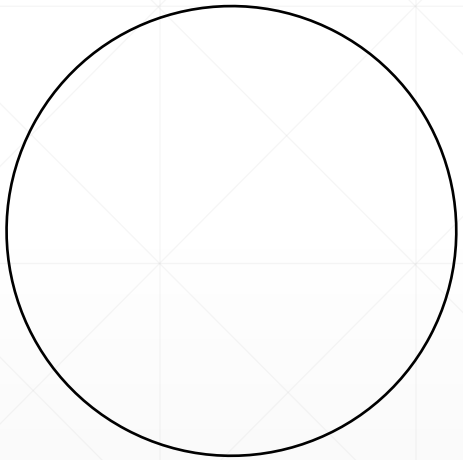
Detector: → 1. Temperature
2. Pressure → 1. Min. energy to form a bubble
2. Equilibrium bubble radius

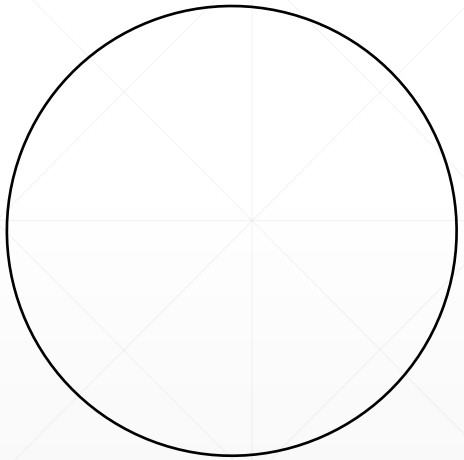
The Model

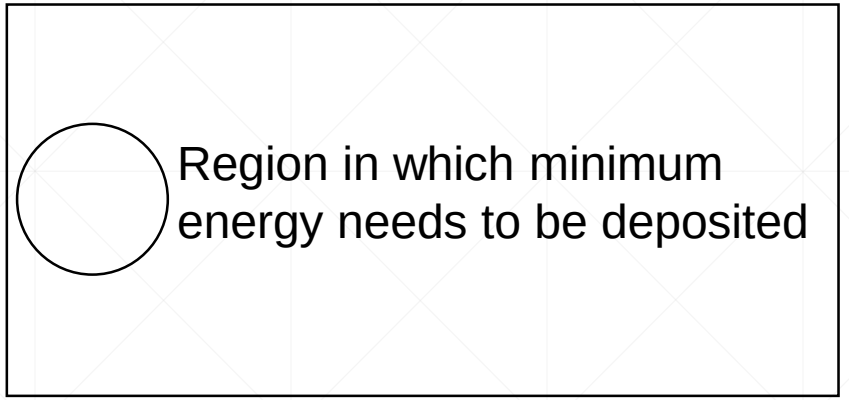

THRESHOLD
Detector:
1. Temperature
2. Pressure
1. Min. energy to form a bubble
2. Equilibrium bubble radius
Region in which the energy needs to be deposited

The Model

Detector: → Superheat: 1. Temperature, 2. Pressure → Region: 1. Min. energy to form a bubble, 2. Equilibrium bubble radius







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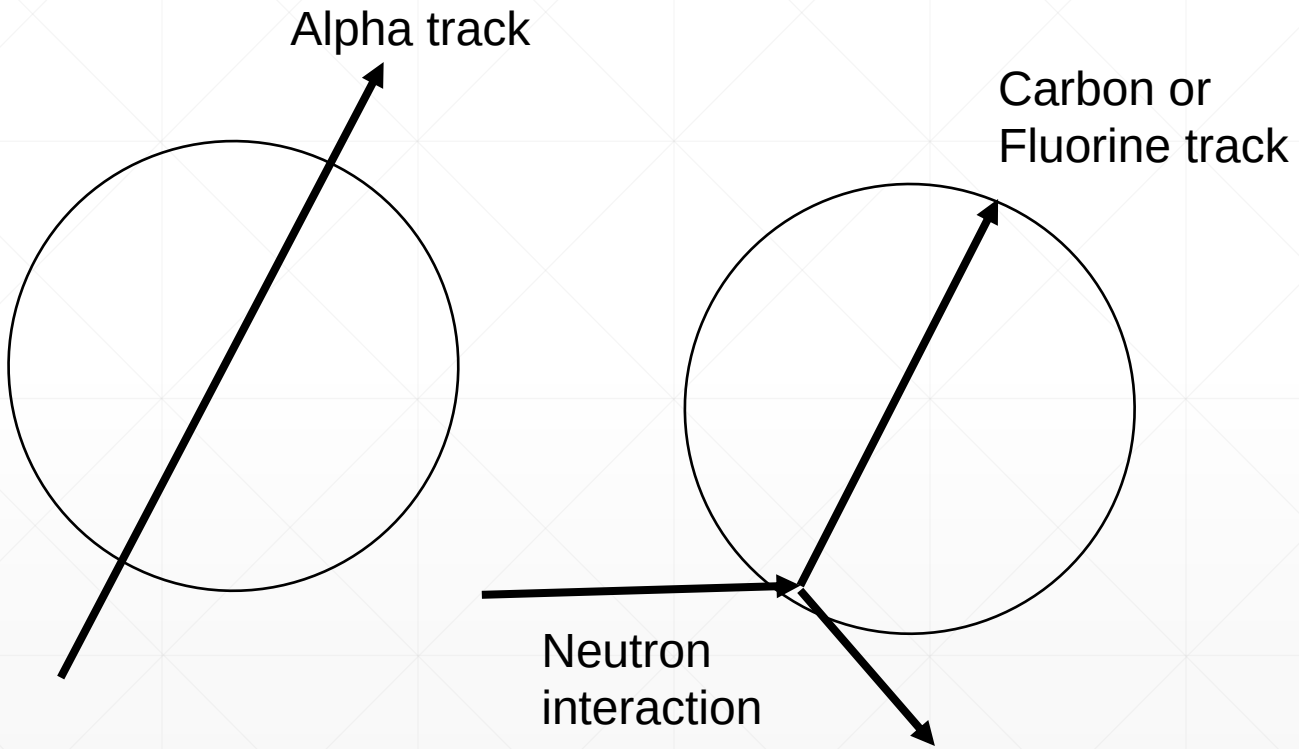

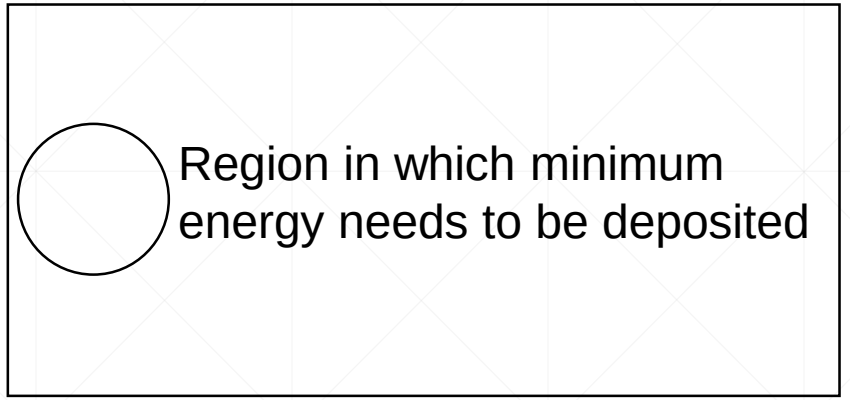

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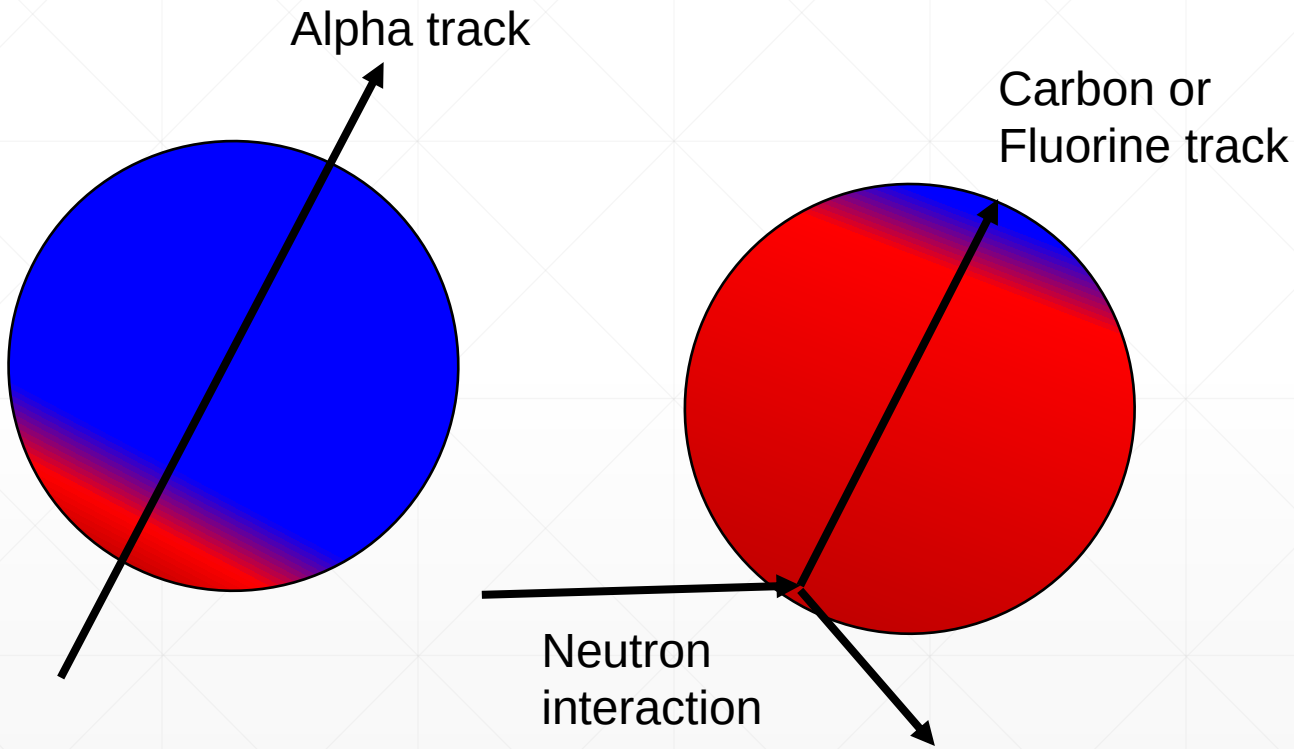

Threshold Energy

Excess Energy

Region in which minimum energy needs to be deposited

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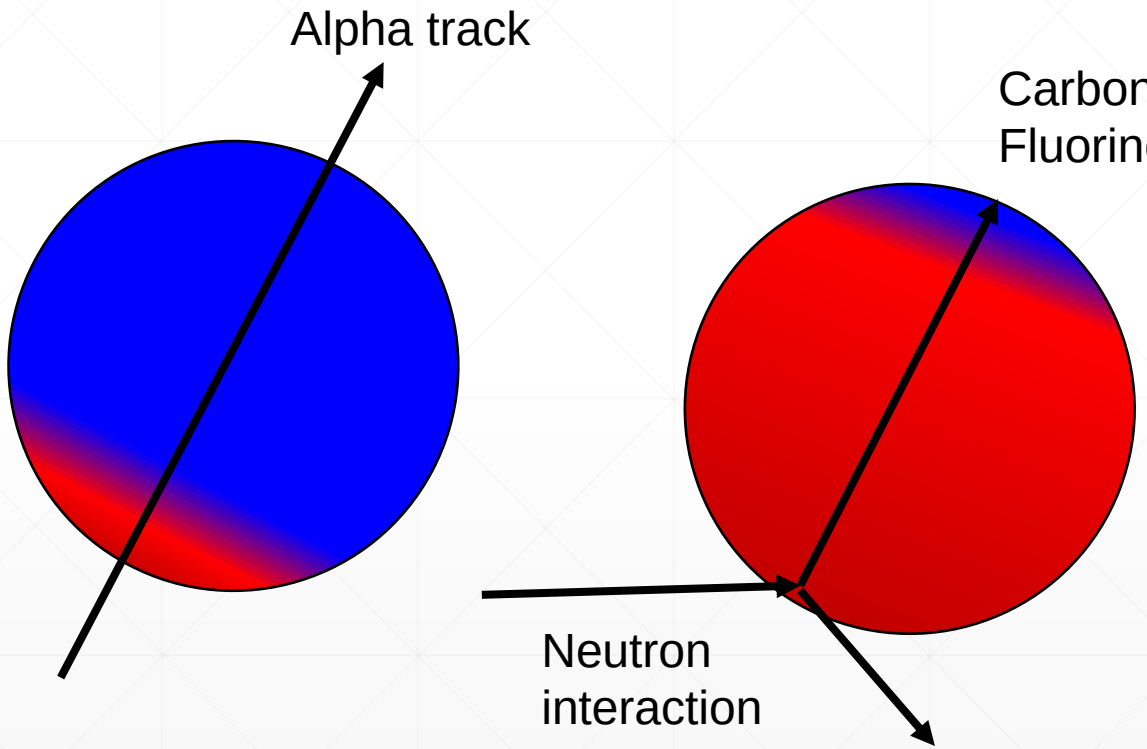

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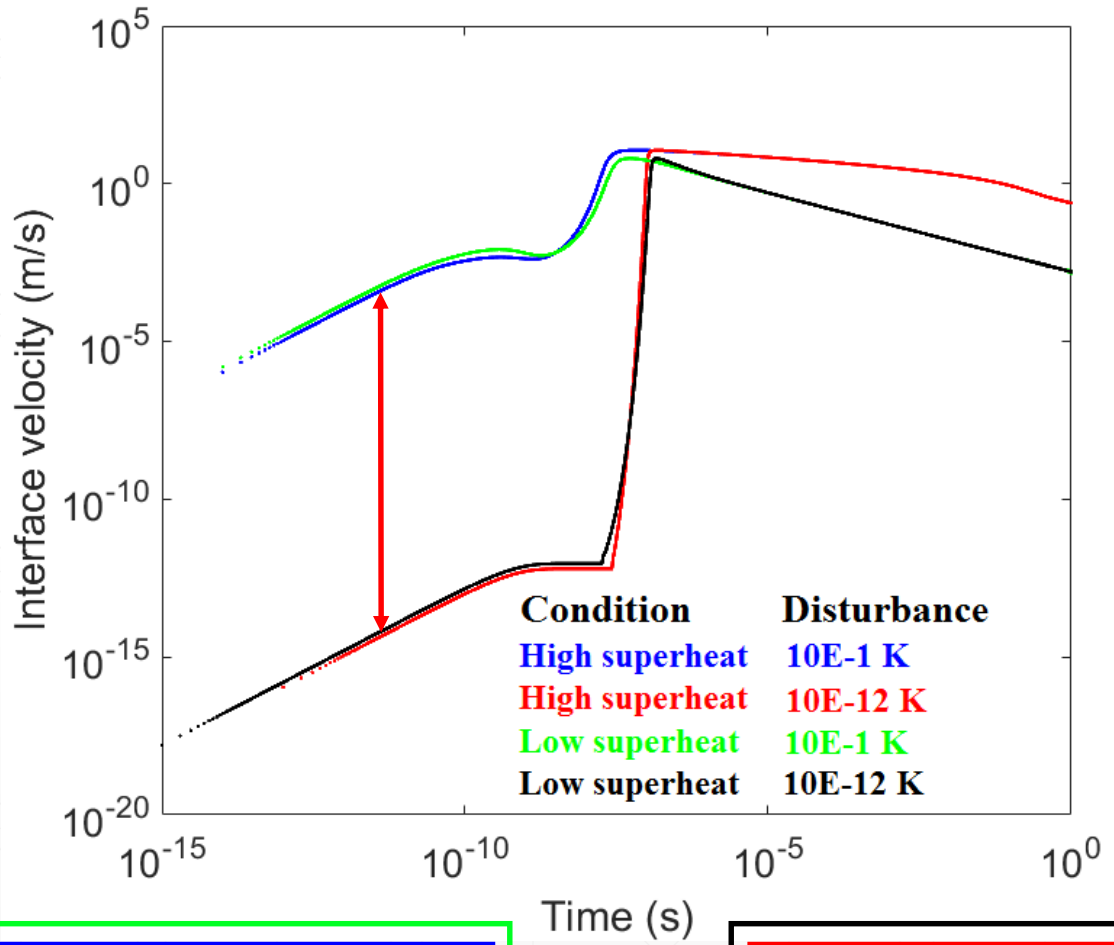
Region in which minimum energy needs to be deposited

The excess energy can be converted into the temperature disturbance!

Bubble Growth in C_3F_8, Interface Velocity



1.75 keV

High Superheat: 88 K 1/10 atm.

Low Superheat: 22 K ~5 atm.

- There is still a 10 order magnitude separation

Alpha Temp. dist.: 10^{-1} K

Neutron Temp. dist.: 10^{-12} K

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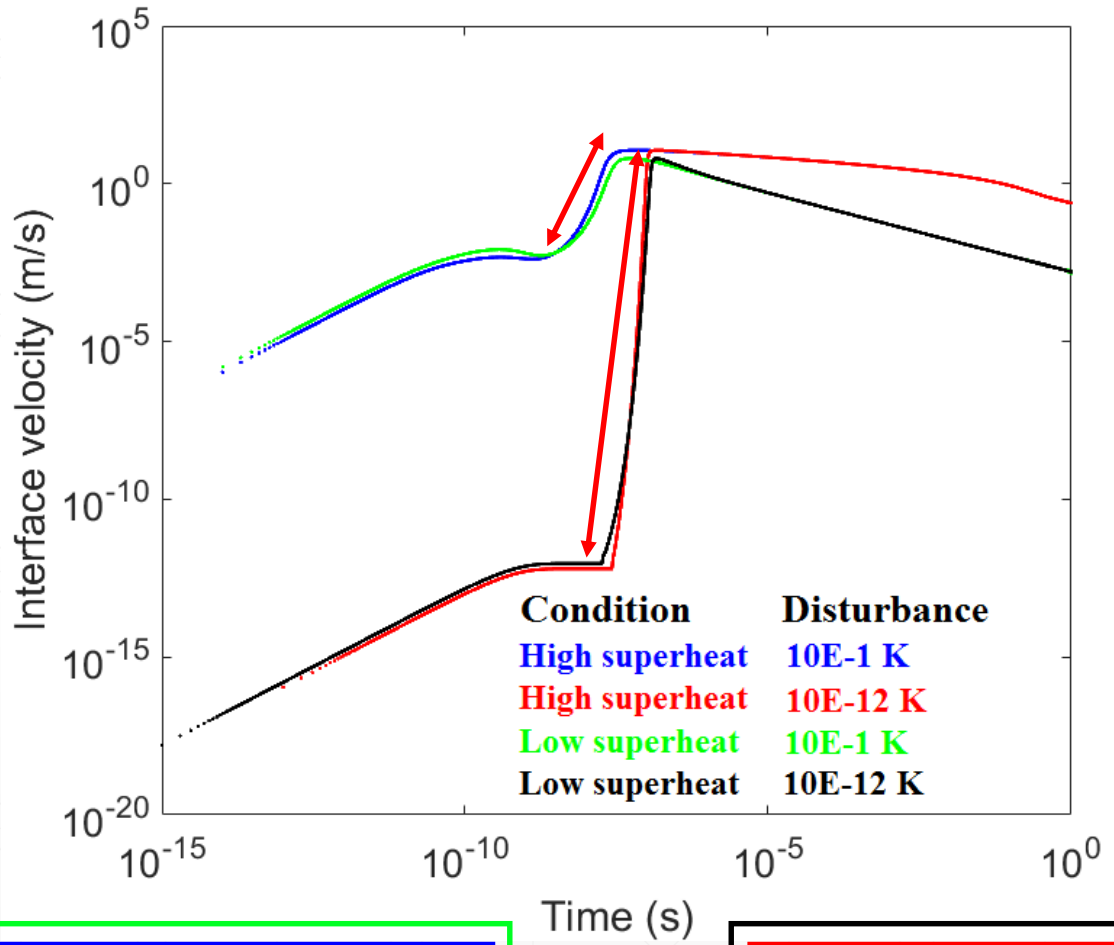

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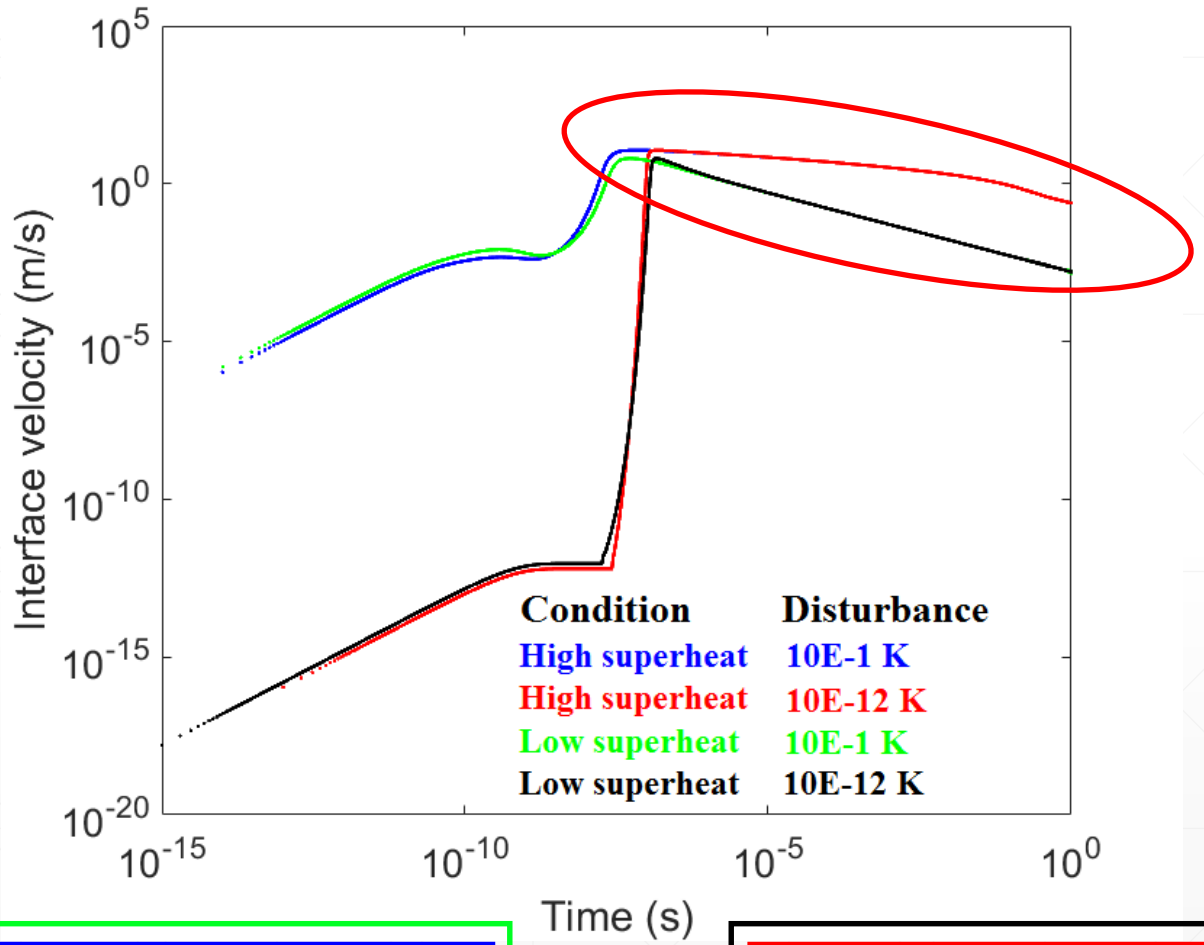

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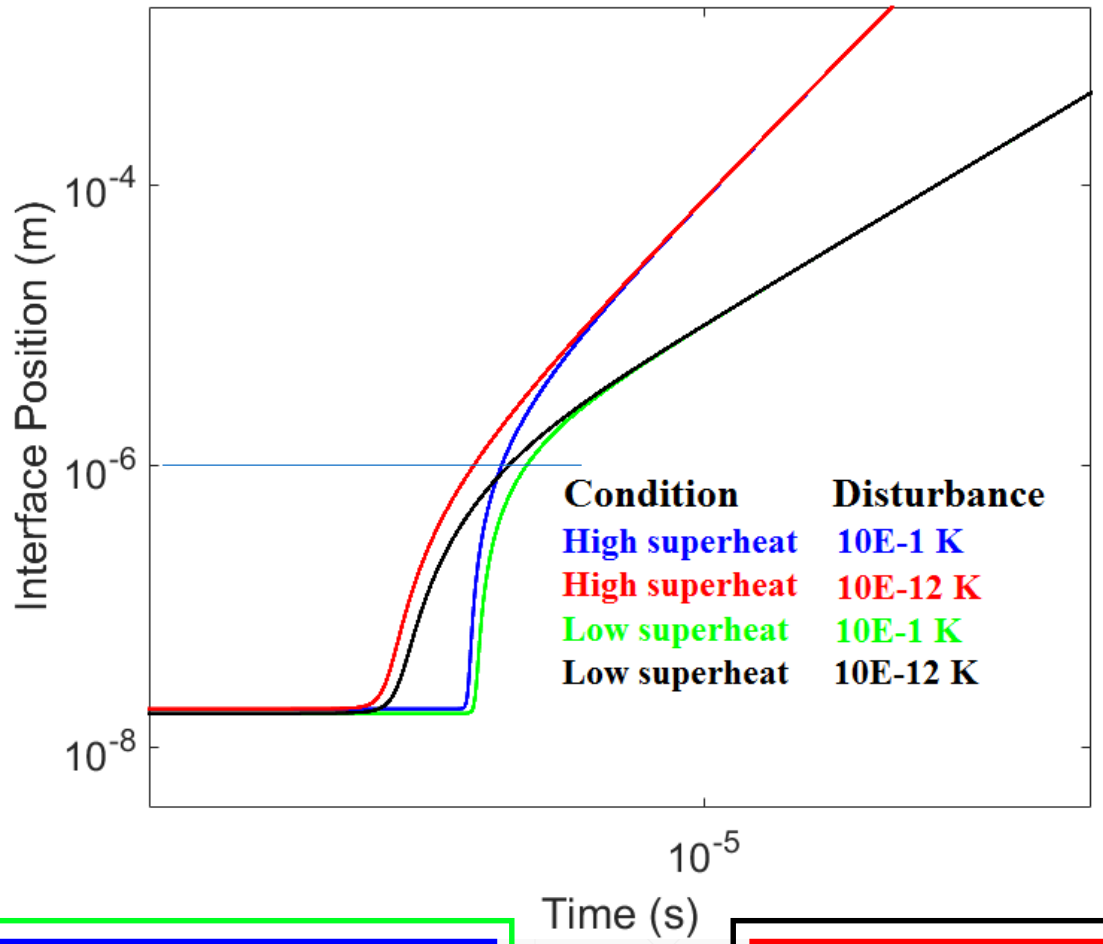

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- There seems to be a possibility to distinguish
- But extremely hard

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Bubble Growth in C_3F_8, Acoustic Intensity

- Pressure waves propagate through the medium
- Energy is transmitted to the materials and can be measured
- The amount of energy traversing a unit surface per unit time in a fluid is the Acoustic Intensity

$$I = P * \nu$$

P is the hydrodynamic pressure
v is the velocity field

For an incompressible fluid the velocity is given by

$$\nu = \left(\frac{R}{r}\right)^2 \dot{R}$$

R is the interface position (bubble wall)
r is the radial position
$\dot{R}$ is the interface velocity

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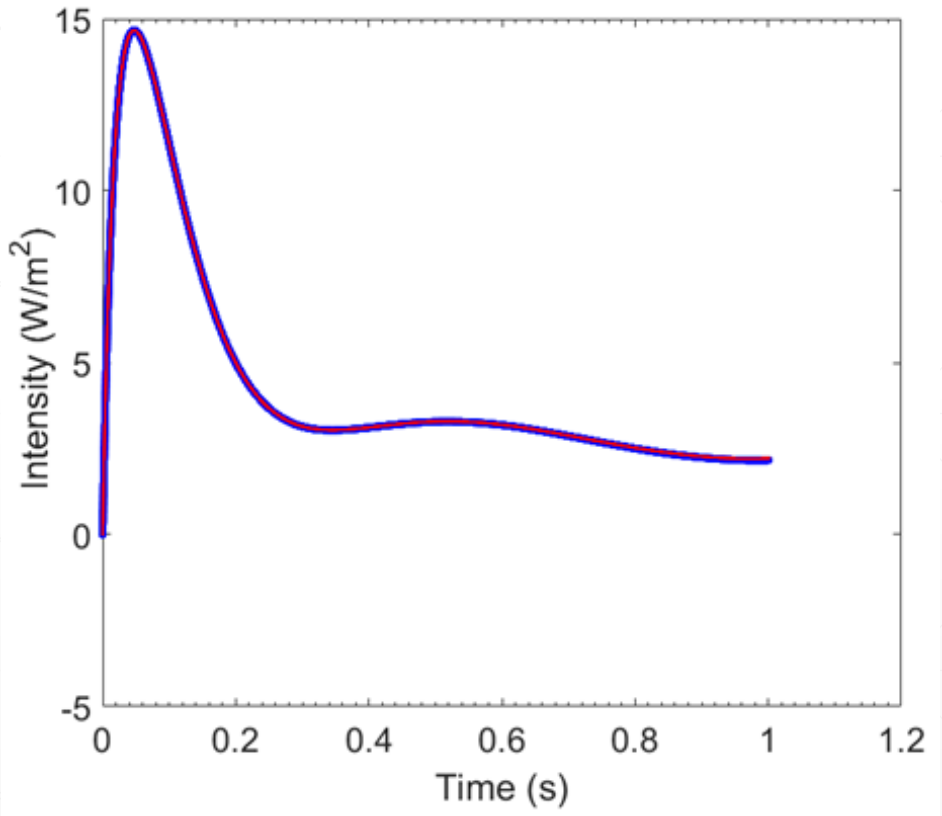
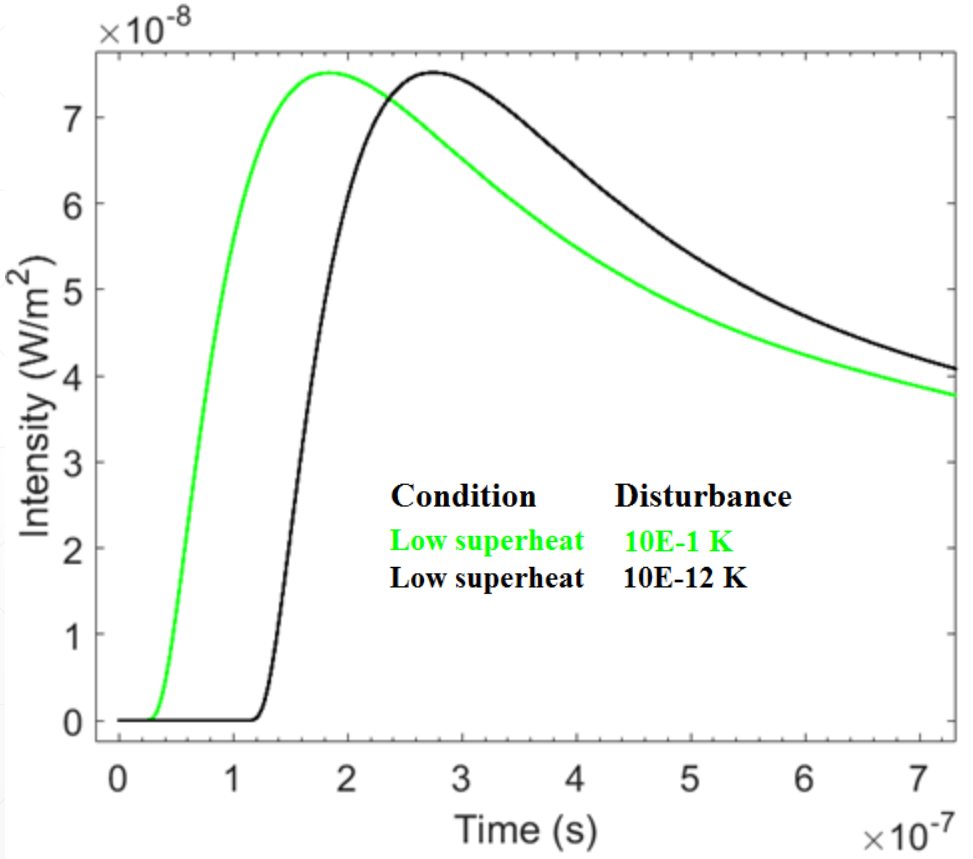


Neutron T dist.: 10^{-12} K

Alpha T dist.: 10^{-1} K



Complete loss of separation

Future Work

THERE IS STILL HOPE

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- There is more than one model for what happens with the excess energy
- 1-D and incompressibility might be too stringent of a simplification
- 3-D and fluid compressibility would naturally have acoustic waves
- There might work-arounds with two cameras to see a separation