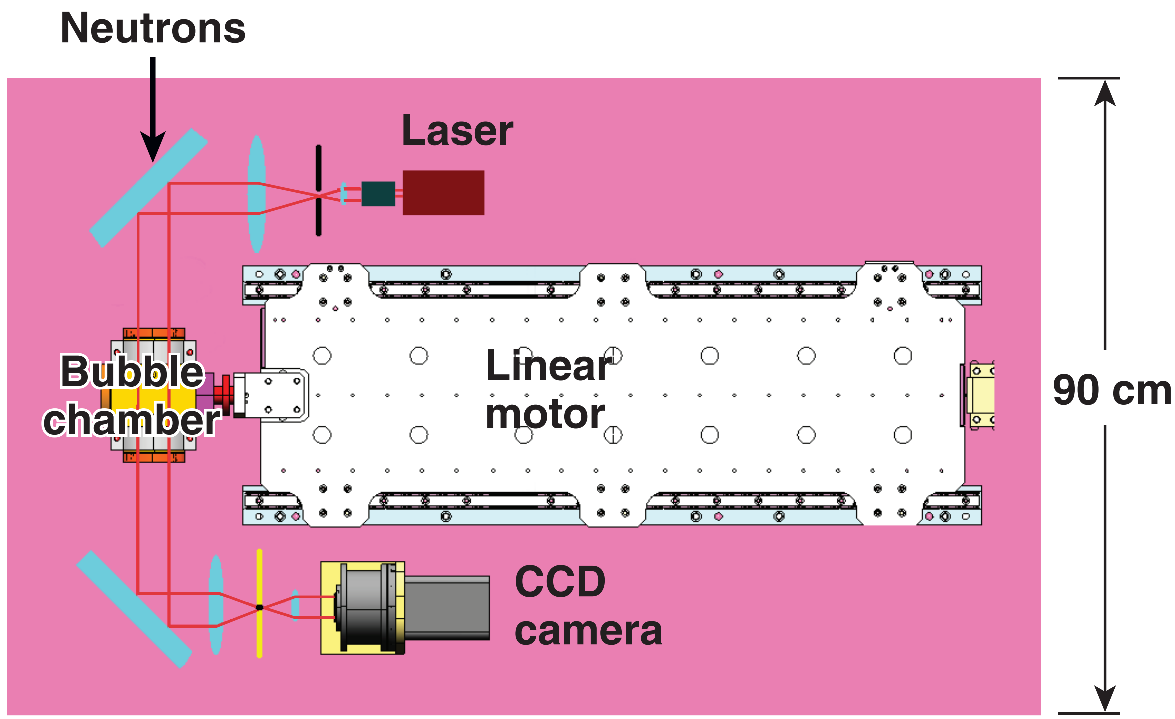
Developmental Status of a Liquid-Freon Bubble Chamber for Neutron Imaging



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48th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Philadelphia, PA
30 October–3 November 2006

Summary

A high-spatial-resolution neutron-imaging detector is being developed at LLE

- The neutron-induced bubble-density distribution will be measured in a chamber filled with liquid freon.*
- A prototype system is being tested at LLE for concept validation.
- Preliminary calculations and tests show promising results.

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*R. A. Lerche *et al*., Rev. Sci. Instrum. 74, 1709 (2003).

Collaborators

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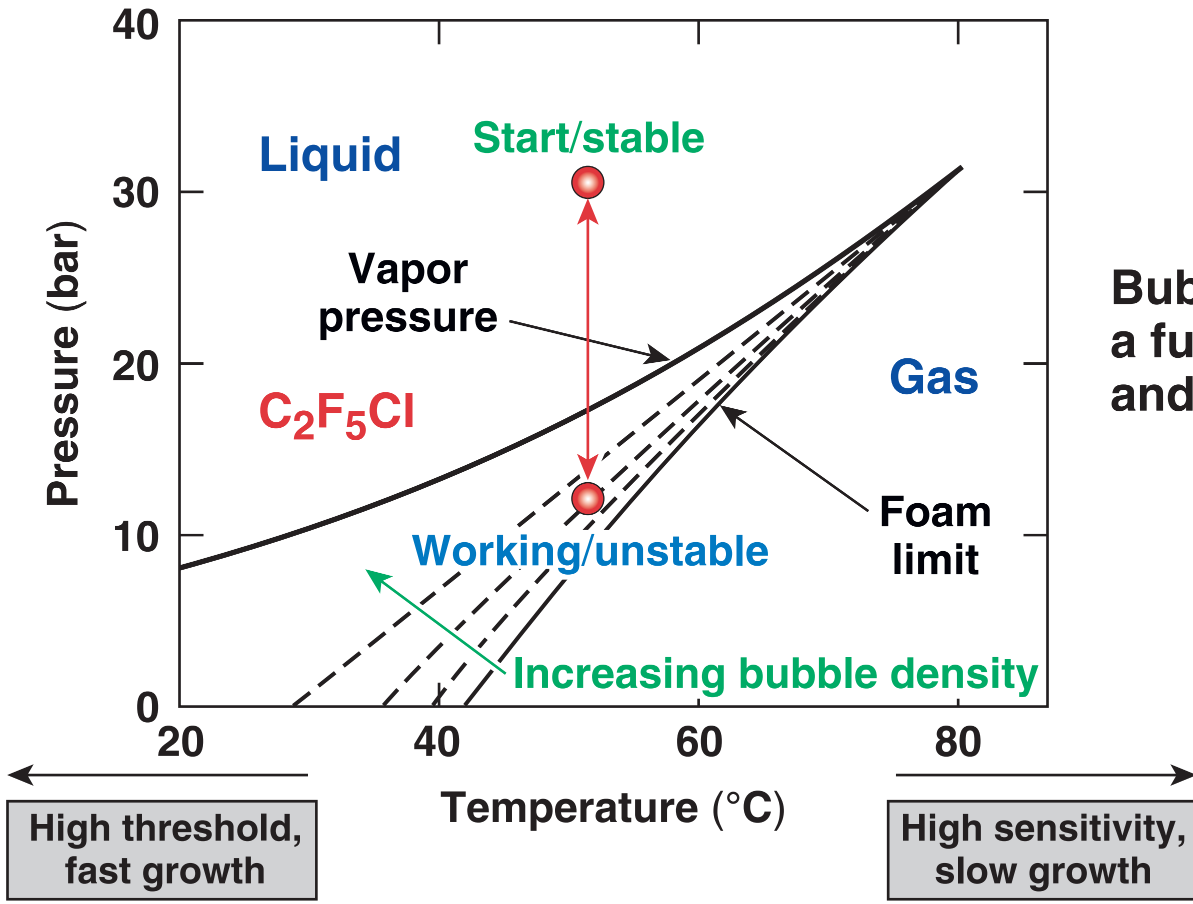
Freon bubbles will be initiated by 14-MeV neutron scattering in super-critical liquid

- Freon 115 (C_2ClF_5) has ideal properties for a bubble-chamber working medium (temperature range of 45°C to 60°C and pressure 7 to 27 atm).
- Since the range of the recoil ions is <5 μm, the bubble-density distribution is directly related to the spatial distribution of the incoming flux of neutrons.
- Various parameters must be estimated to design a readout system for experiments on OMEGA (number of bubbles, bubble size, and bubble lifetime).

Bubbles form in the superheated freon if ~300 eV of energy is deposited by incident radiation interactions



Bubble production is a function of pressure and temperature.

Slow bubble growth is preferable for high-neutron yields and fast bubble growth for low-neutron yields.

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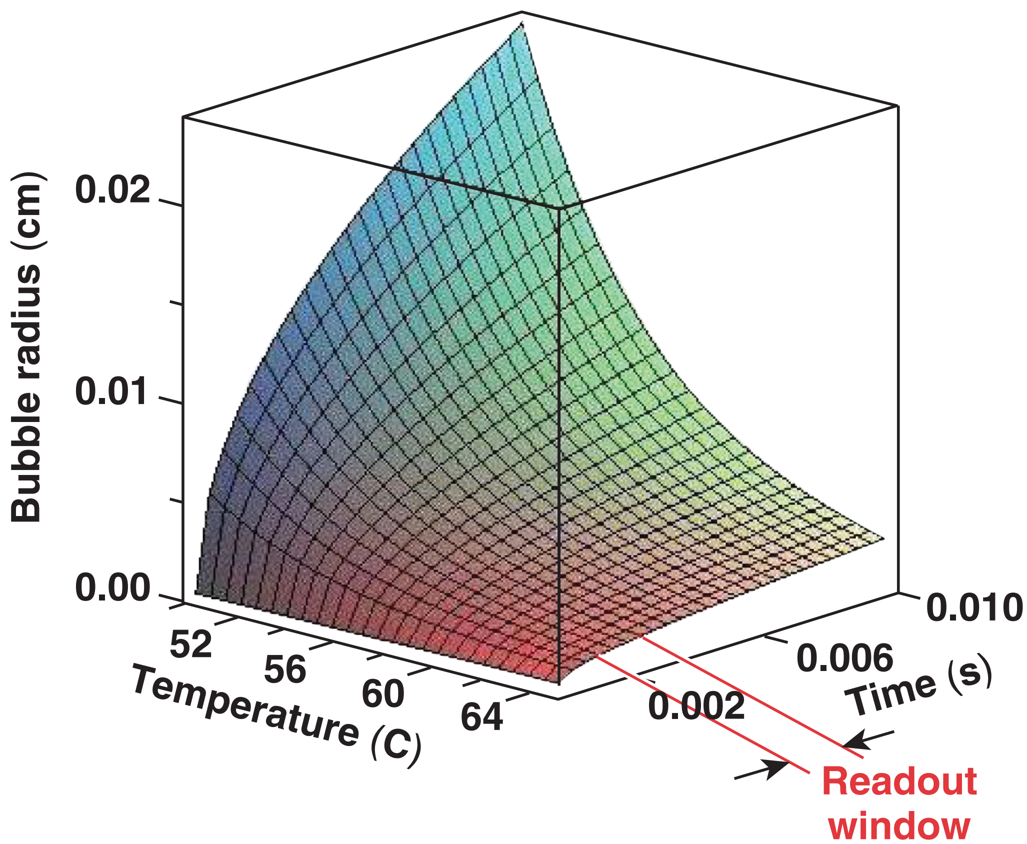
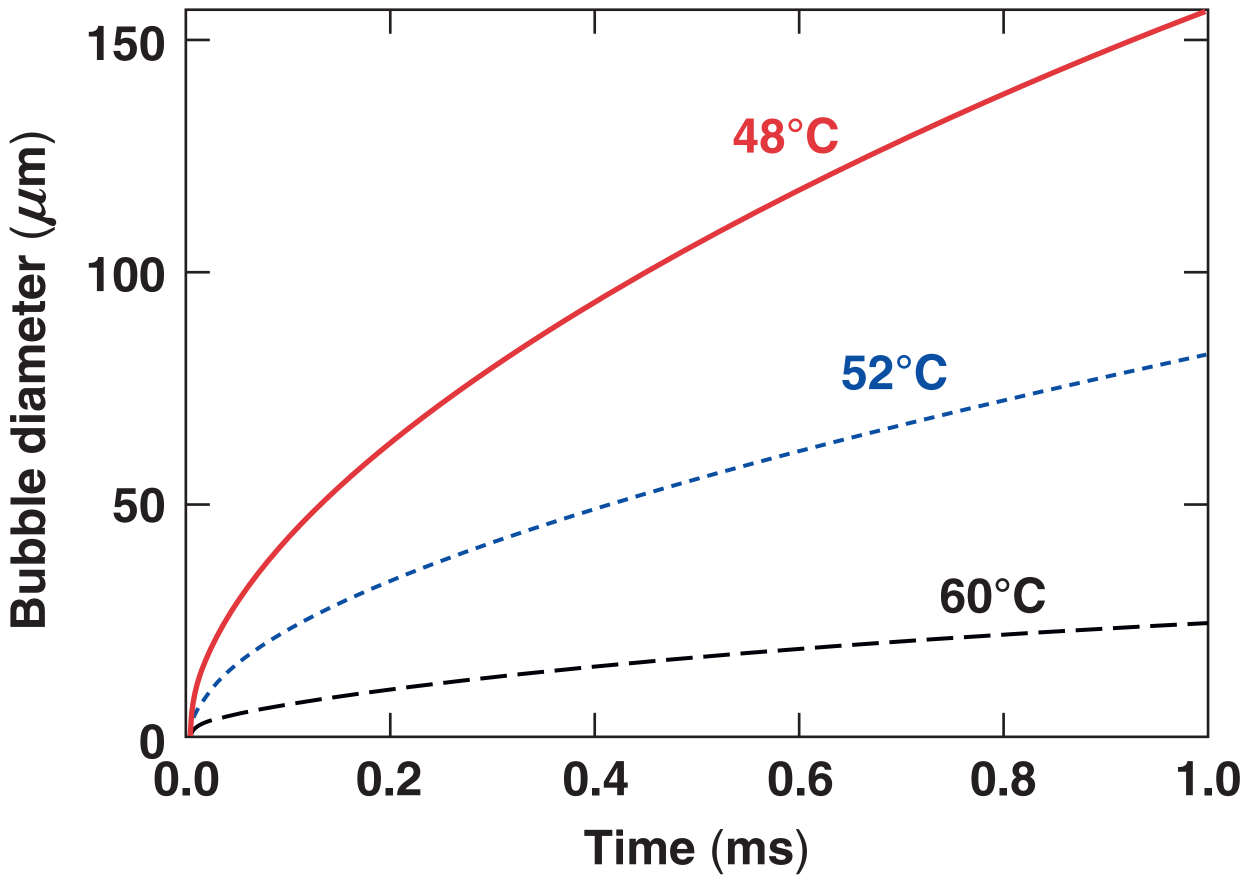
A simple model can be used to establish the requirements of a readout system

- Most of the bubbles have similar size and growth rates
- Small bubbles ⇒ higher resolution
- Bigger bubbles ⇒ easier to readout



The readout window is set by:
- bubble diameter
- bubble-growth speed
- camera sensitivity

The bubble-growth speed is determined by the freon temperature



The temperature will be tuned to optimize the bubble size given readout duration.

General characteristics of the bubble-chamber operation

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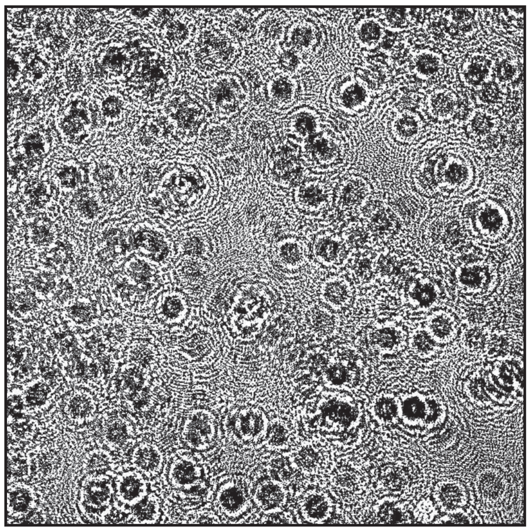
- The chamber works in single-shot mode.
- A linear motor (LIM) is used for the compression/ decompression cycle.
- Parallel light is generated for bubble detection.
- An independently pulsed laser will be used to create a stream of bubbles for preliminary testing.

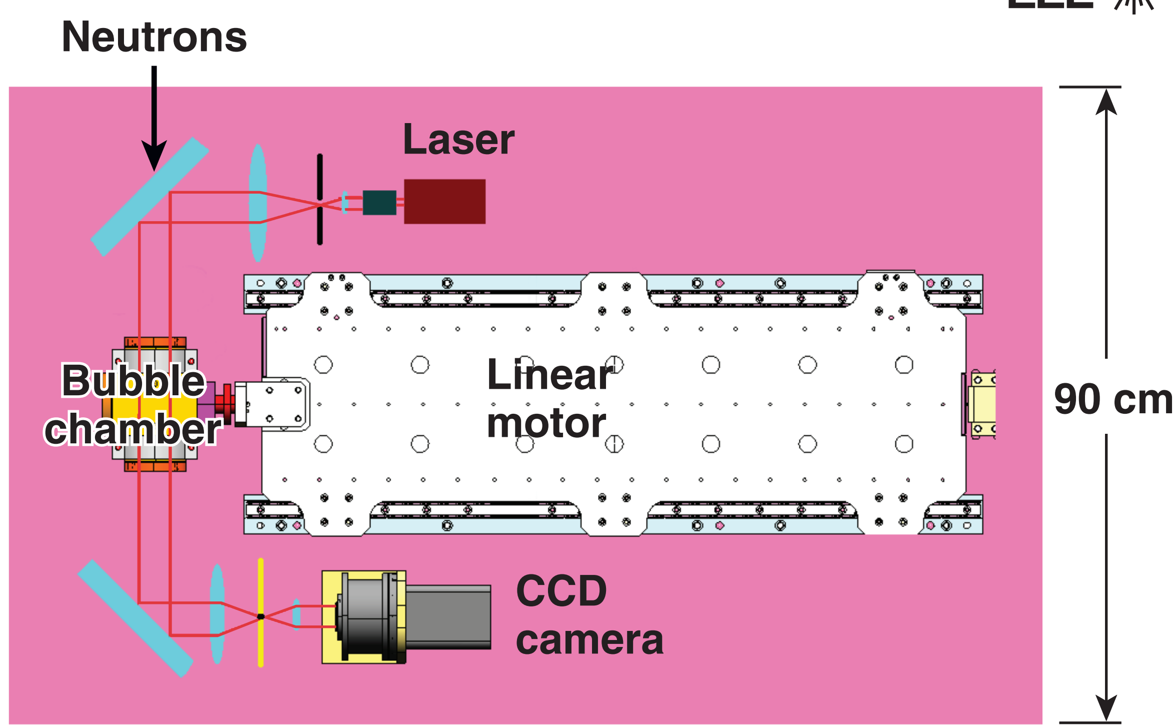
Only the column density of the bubble distribution can be measured for the yields on OMEGA

- In the freon detector, one bubble is created for every 10 incident neutrons.
- Schlieren imaging will be used to infer the column density of the bubbles.
- Only about 10^{-3} of the incident light passing through a bubble is scattered and can be detected, so a minimum pulsed-laser power of 3 mW is needed for a signal-to-noise ratio of at least 10.
- The minimum number of bubbles necessary to get a clean image is 8×10^5 and the maximum value is $\sim 10^8$.

The LLE bubble chamber has been designed to measure the column density of bubbles instead of counting them individually as in the original Fisher experiment*



Test image using 50-μm pollen grains on a slide.



Schlieren technique is used for bubble density detection.

Expect to field on OMEGA soon

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