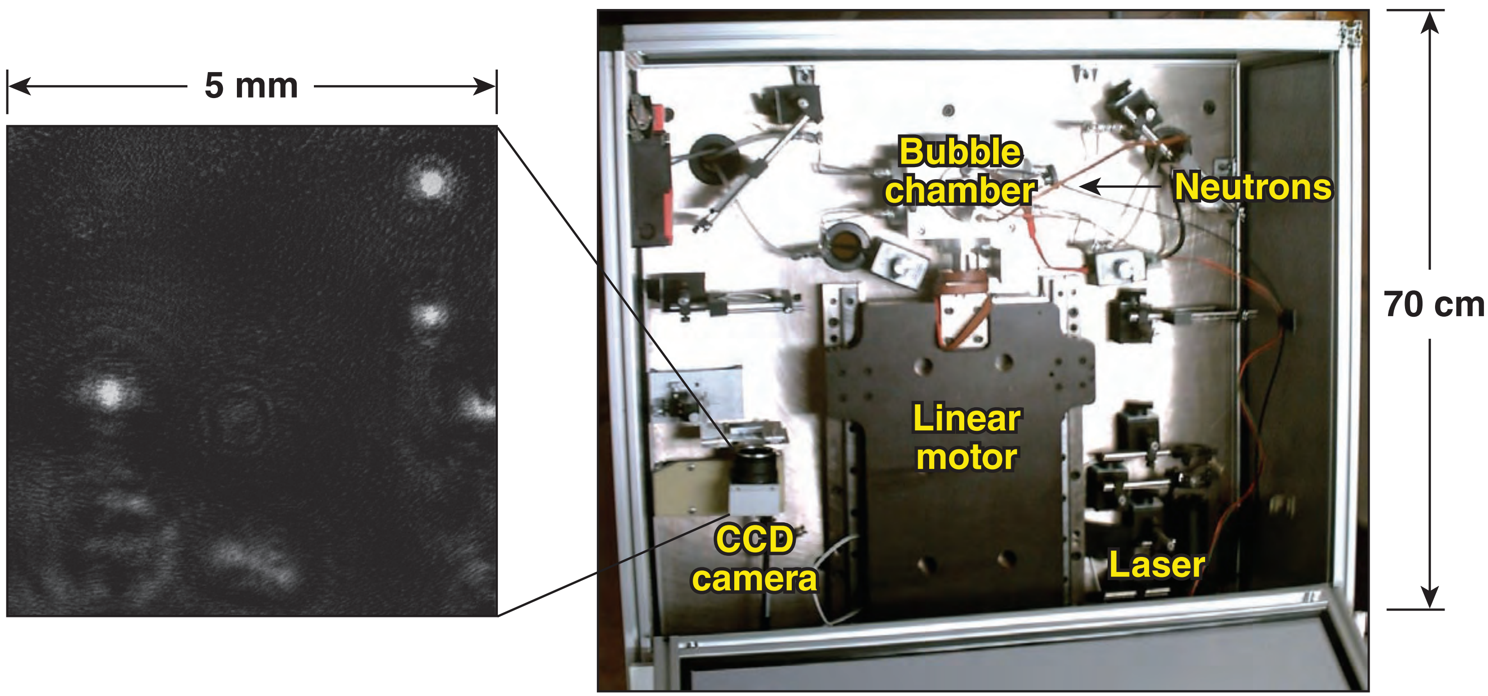
First Tests of a Bubble Chamber for Neutron Imaging on OMEGA



M. C. Ghilea
University of Rochester
Laboratory for Laser Energetics

49th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Orlando, FL
12–16 November 2007

Summary

A liquid-freon neutron detector is being tested for use in a neutron imaging system on OMEGA

- The detection system has been assembled.
- Individual bubbles have been imaged to study bubble growth.
- The published* phase behavior of freon has been confirmed.
- The operational window for producing bubble images has been determined.

E16221

*A. Herve *et al.*, Nucl. Instrum. Methods Phys. Res. 202, 417 (1982).

Collaborators

D. D. Meyerhofer, T. C. Sangster, D. J. Lonobile, and A. Dillenbeck

Laboratory for Laser Energetics
University of Rochester

R. A. Lerche

Lawrence Livermore National Laboratory

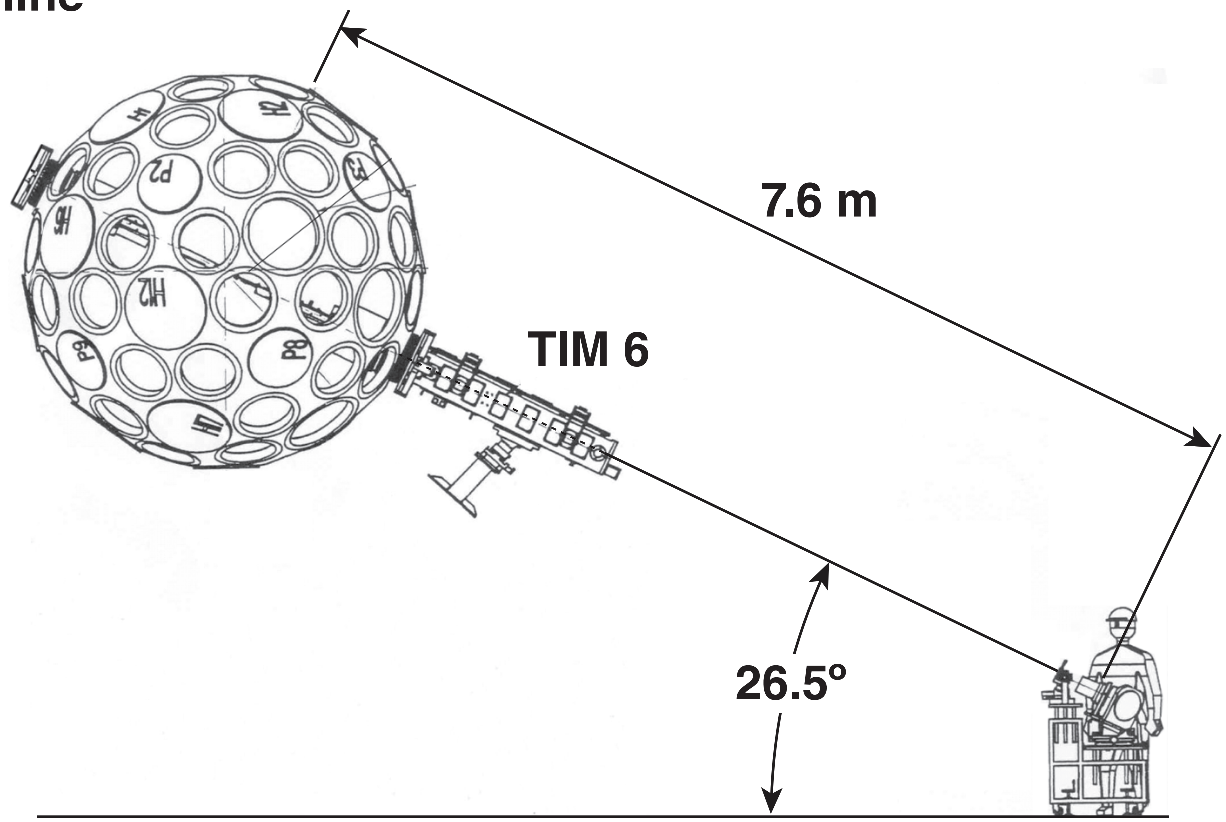
L. Disdier

Commissariat à L'Énergie Atomique

A bubble chamber will be placed in the target bay 7.6 m from TCC to measure the neutron source distribution

Initial tests will determine

- Resolution, using hard edges at the detector
- Flat-field response



E16222

The encoded neutron distribution from an aperture will be measured by the bubble density distribution

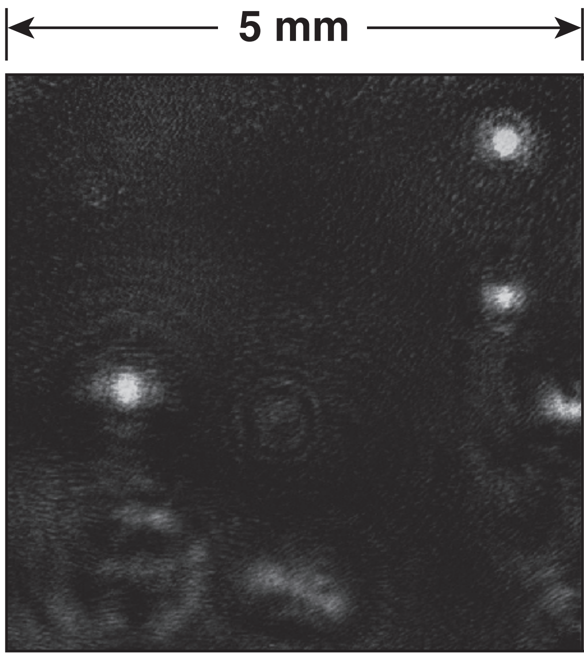
- After decompressing liquid freon below the liquid equilibrium line, a neutron interaction creates a bubble.

- The bubble location gives the same information as a pixelated scintillator array (i.e. spatial location).

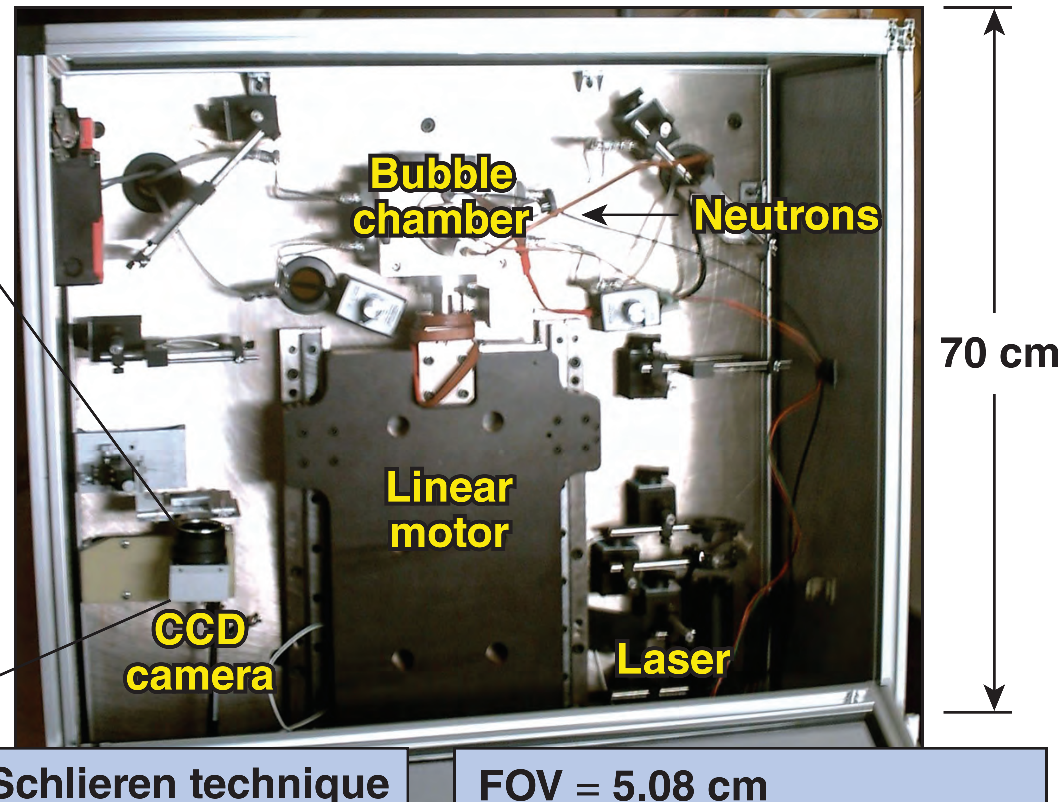
- The bubble density is expected to be too high for individual imaging, so a Schlieren method will be used.

The LLE bubble chamber has been designed to measure the column density of bubbles

UR LLE



Test image of individual bubbles in parallel light



Schlieren technique is used for bubble density detection

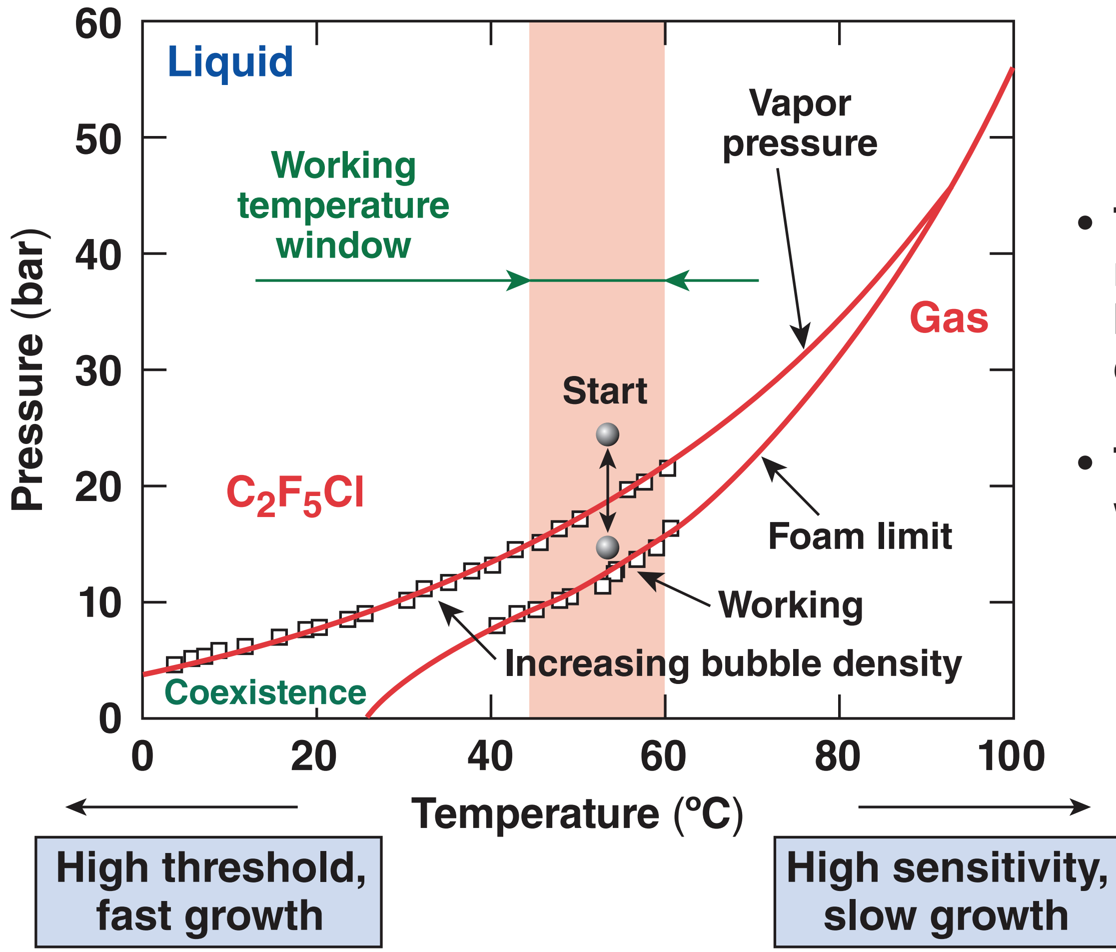
FOV = 5.08 cm

Expected sensitivity = 2.3×10^{-6} bubbles/n source

Expected detector-plane resolution $\leq 300\ \mu$m

E16224

The operation pressure cycle depends on the phase behavior of freon

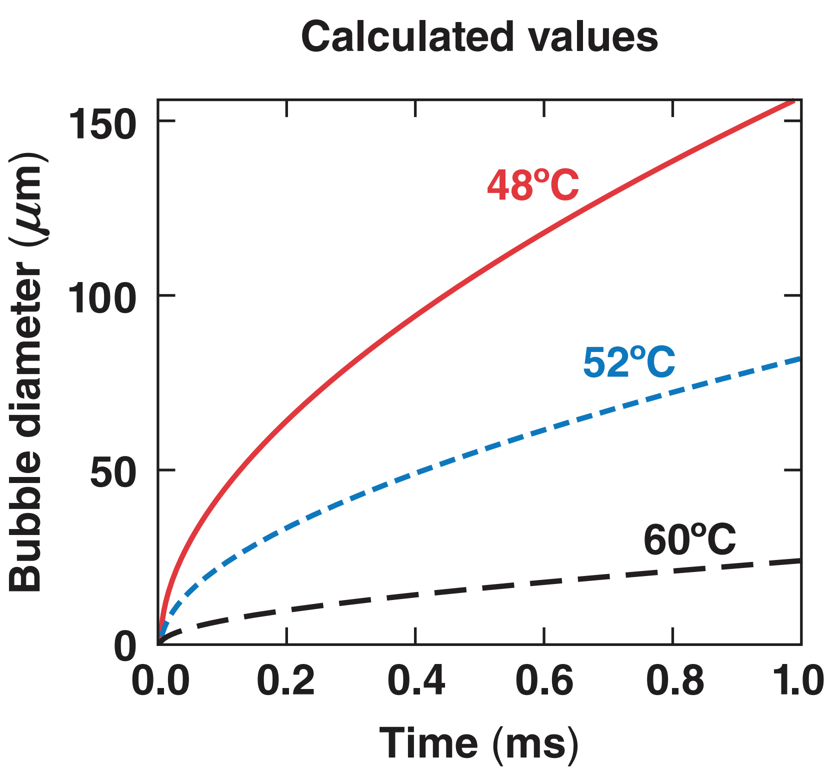


- The bubble chamber records data with freon brought into the coexistence phase
- The operating temperature window is 15° wide

The detector operates in cycles between the "start" and "working" points.

E16225

The bubble growth rate is determined by the freon temperature



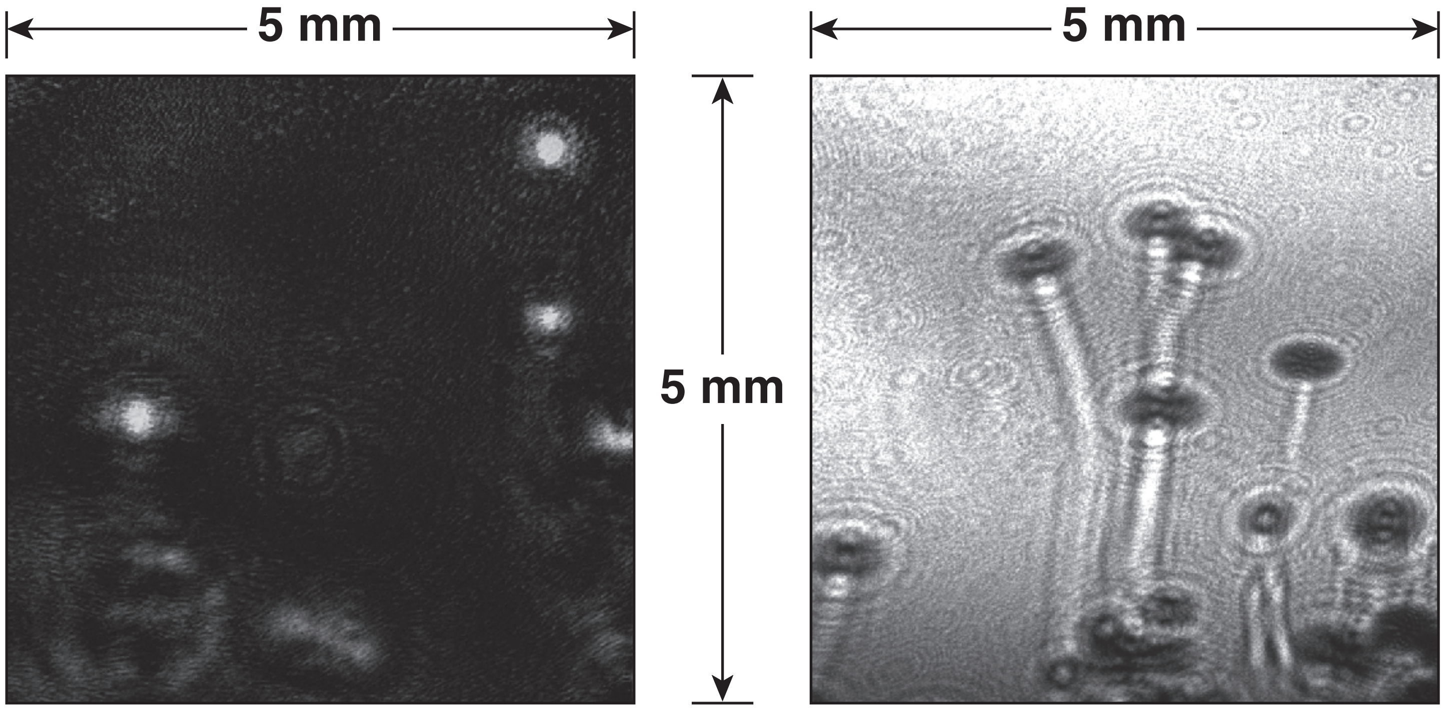
- Measured bubble speed (due to buoyancy) ≅ 12 cm/s ≅ 1200 bubble radii/s
- Measured final bubble diameter ≅ 200 μm (stable)
- Estimated bubble growth time ≅ 1.4 ms

Bubbles have to be photographed as soon as they reach their final diameter (1 to 2 ms after formation) in order to avoid thermal trails

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

E16226

Test images show the importance of the time sequence of the decompression cycle and the probe laser with respect to T_0

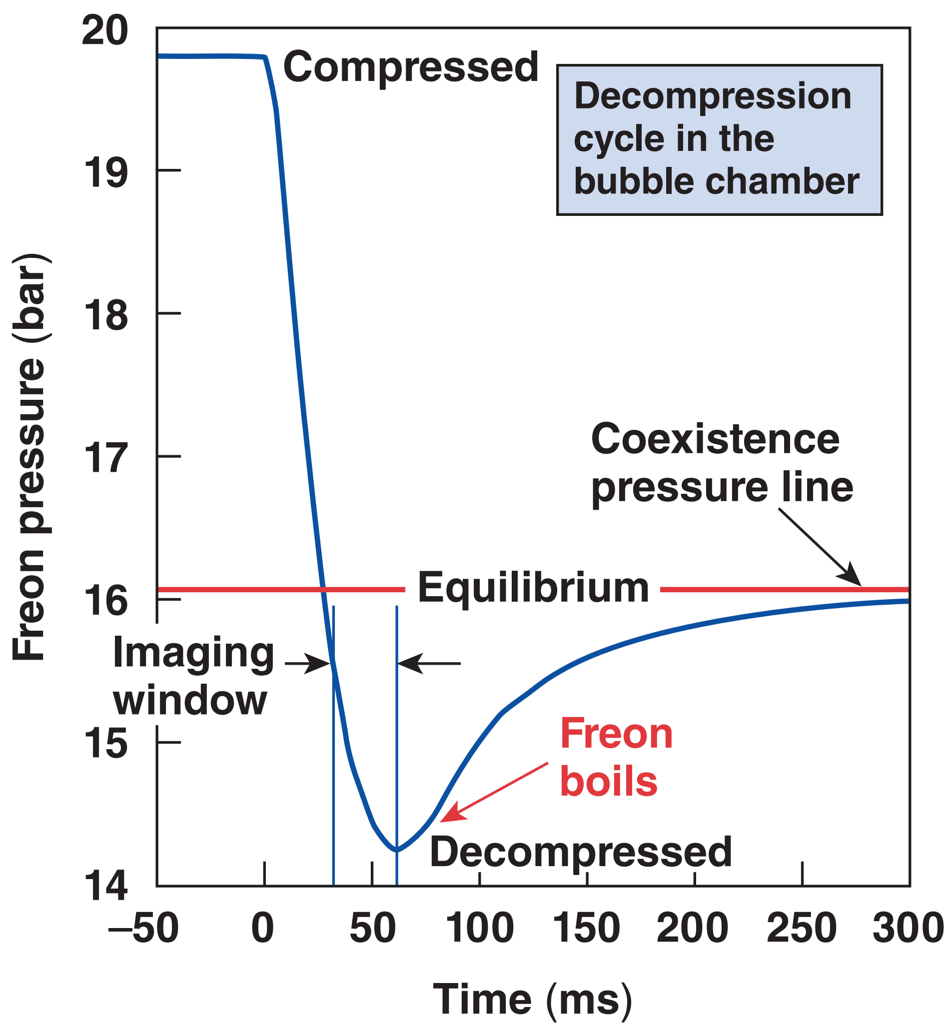


Bubbles ~1 ms old

Bubbles tens of ms old, with thermal trails

The rising bubbles leave a thermal trail that will likely affect the image resolution.

There is a window of about 40 ms for imaging before the freon begins to boil



The probe laser is pulsed for 1 ms and the relative accuracy of timing with OMEGA can be controlled to within 0.1 ms.

E16228

Summary/Conclusions

A liquid-freon neutron detector is being tested for use in a neutron imaging system on OMEGA

- The detection system has been assembled.
- Individual bubbles have been imaged to study bubble growth.
- The published* phase behavior of freon has been confirmed.
- The operational window for producing bubble images has been determined.

E16221

*A. Herve *et al.*, Nucl. Instrum. Methods Phys. Res. 202, 417 (1982).