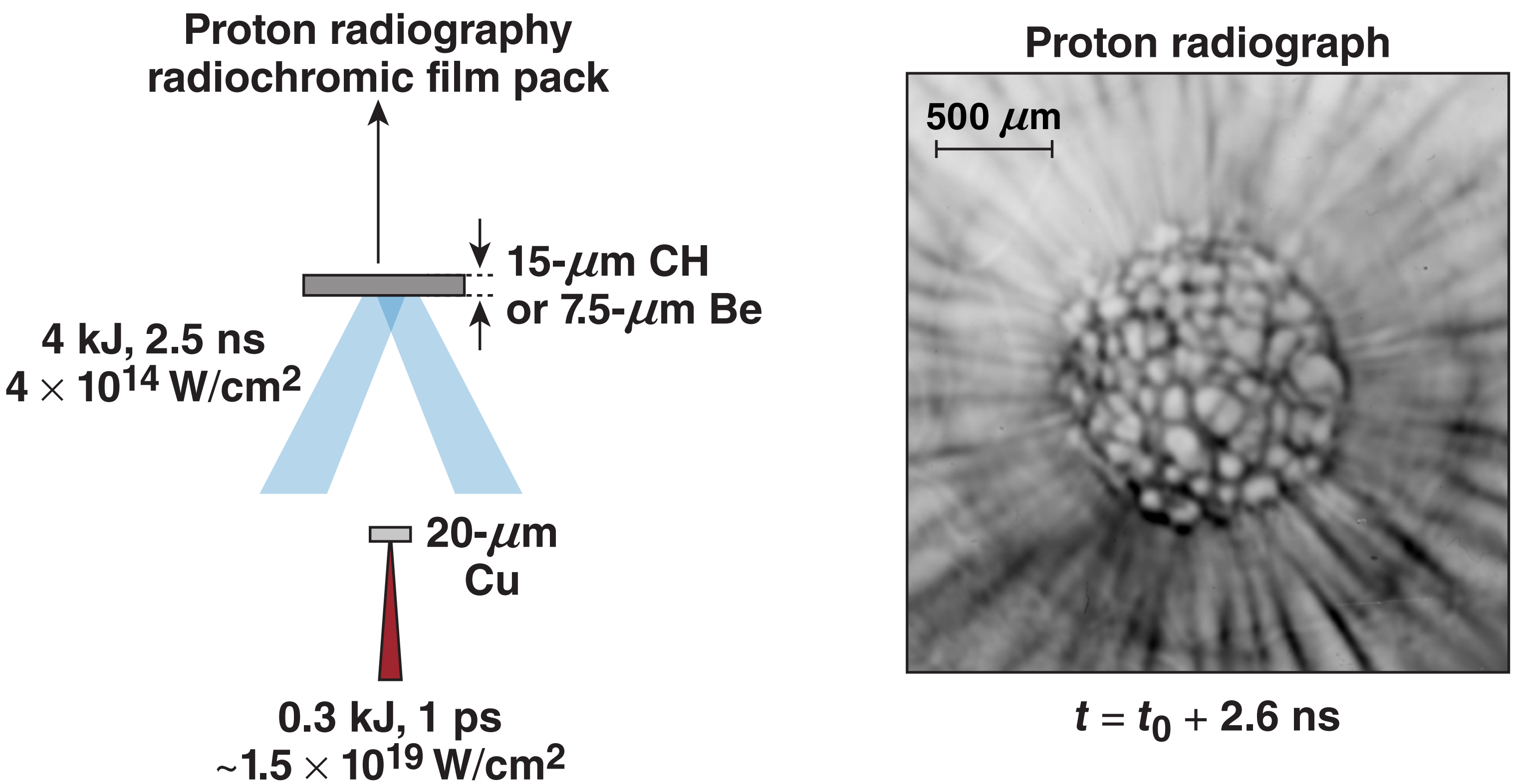
Observation of Self-Similarity in the Magnetic Fields Generated by the Nonlinear Rayleigh–Taylor Instability



L. Gao
University of Rochester
Laboratory for Laser Energetics

54th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Providence, RI
29 October–2 November 2012

Summary

The scale-invariant regime of nonlinear Rayleigh–Taylor (RT) instability has been probed with proton radiography

- The RT-generated magnetic-field distribution and its evolution was investigated using laser-driven CH and Be targets
- The structural evolution was found to be scale invariant
- The data are consistent with a bubble competition and merger model;* the merger rate for Be has been determined

E21629

*O. Sadot *et al*., Phys. Rev. Lett. 95, 265001 (2005).

Collaborators

P. M. Nilson, I. V. Igumenshchev, S. X. Hu, J. R. Davies, C. Stoeckl, D. H. Froula, R. Betti, and D. D. Meyerhofer

Laboratory for Laser Energetics
University of Rochester

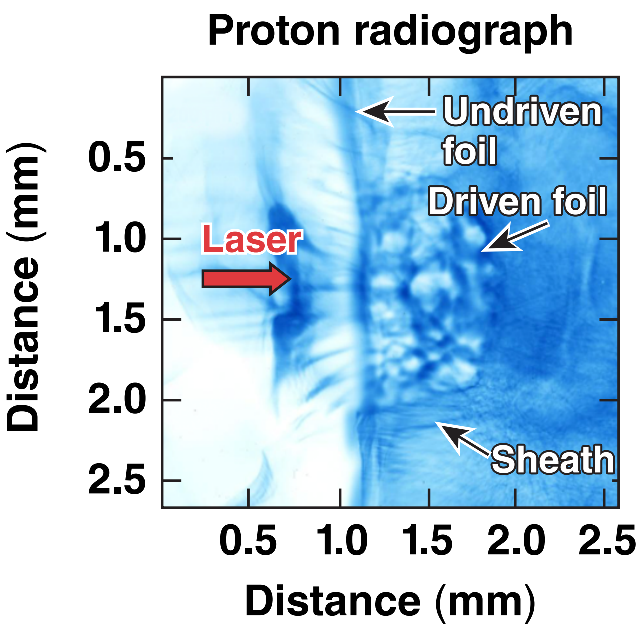
M. G. Haines

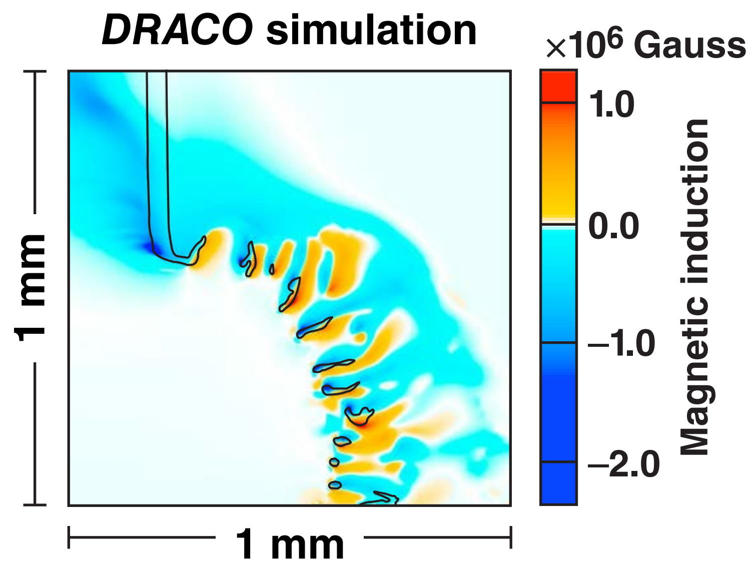
Imperial College, London

V. A. Smalyuk, D. Martinez

Lawrence Livermore National Laboratory

MG-level magnetic fields generated by the nonlinear RT instability were observed in laser-driven foils*



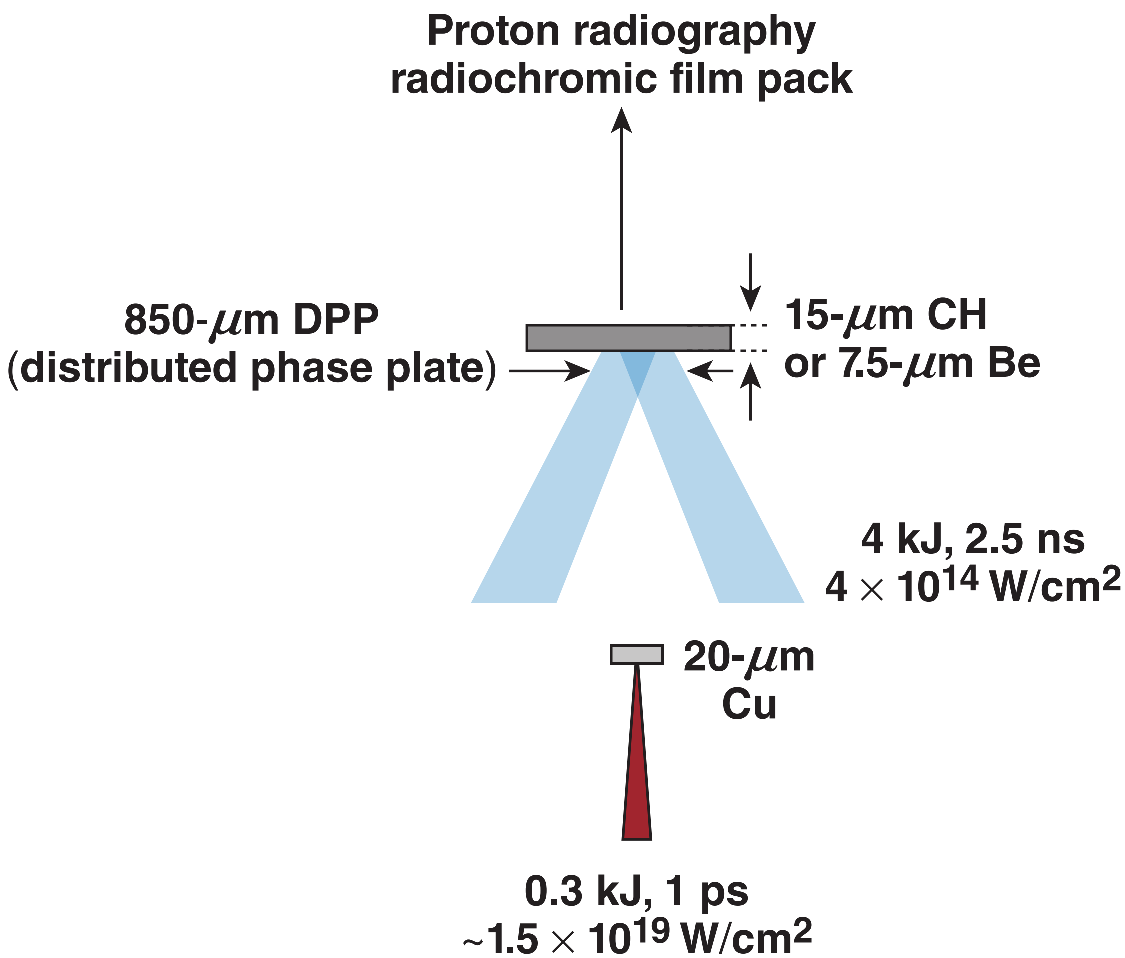


- 15-μm-thick planar CH targets were irradiated at $I \sim 4 \times 10^{14}$ W/cm^2 on OMEGA EP
- Magnetic-field generation was diagnosed using side-on laser-driven proton radiography
- 2-D magnetohydrodynamic (MHD) *DRACO*** simulations predicted a broken foil with 2-MG magnetic fields caused by RT instability

*L. Gao *et al*., Phys. Rev. Lett. 109, 115001 (2012).
**I. V. Igumenshchev *et al*., Phys. Plasmas 16, 082701 (2009).

E21630

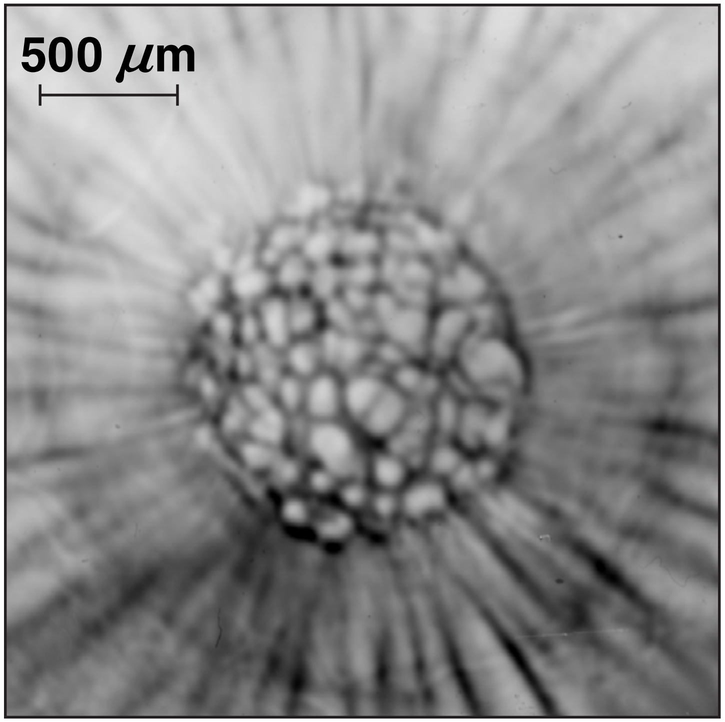
Magnetic-field generation has been studied in face-on geometry using the acceleration of planar targets



E20340c

Face-on probing reveals magnetic-field generation by the RT instability

Proton radiograph

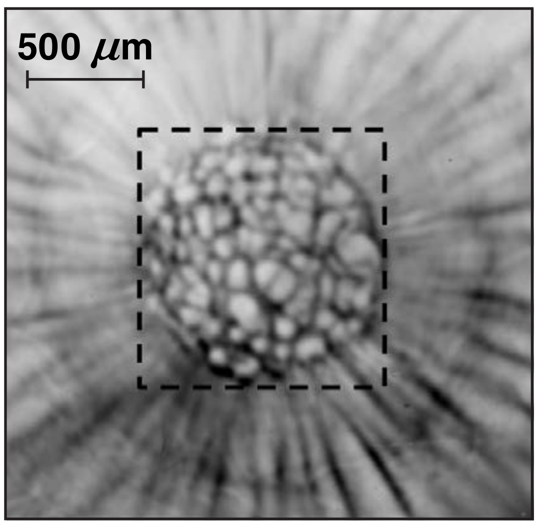


$t = t_0 + 2.6$ ns

E21631

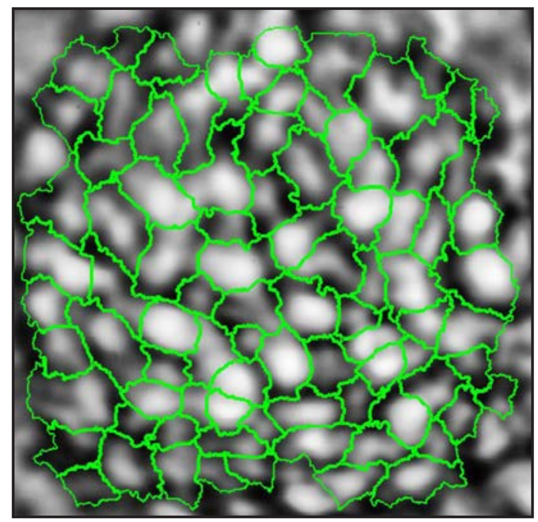
The magnetic-field spatial distribution was characterized using the watershed algorithm

Original image



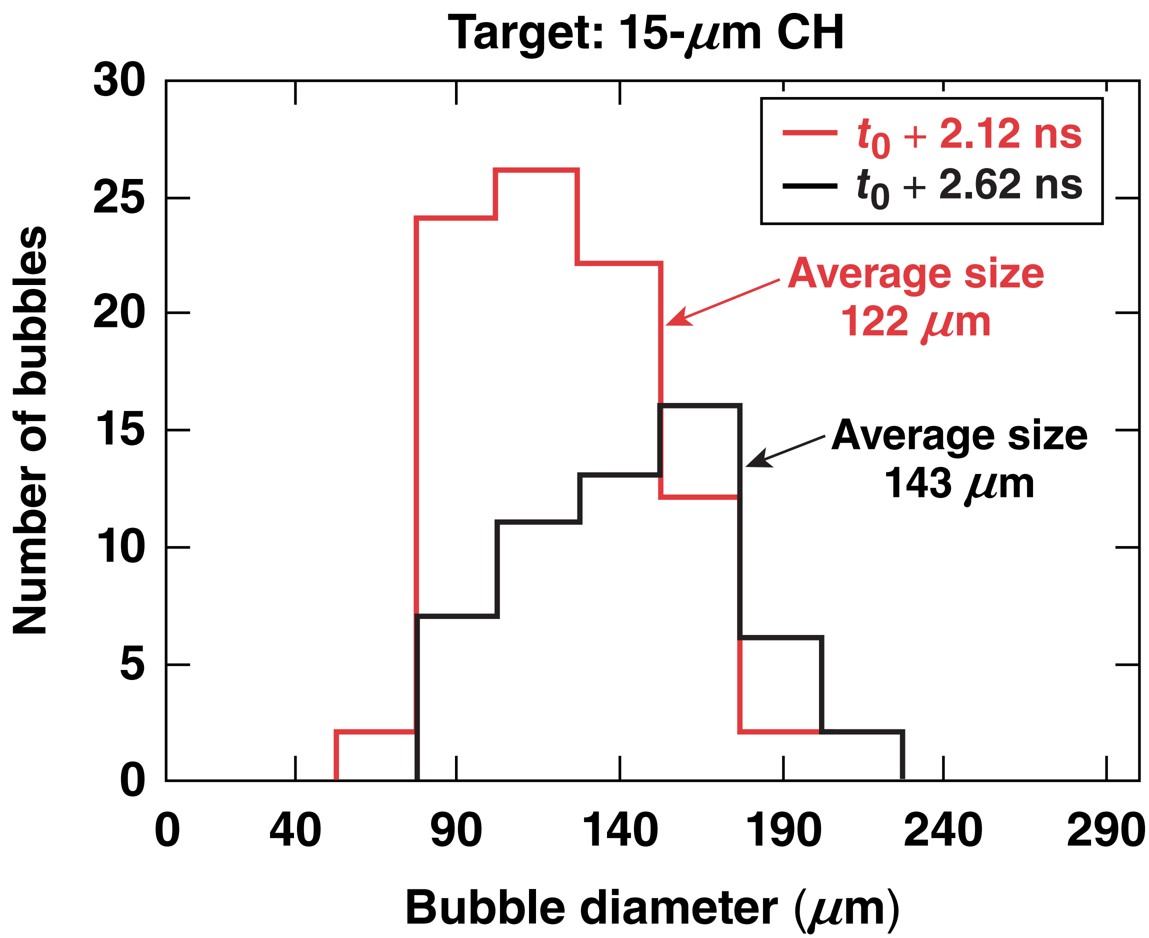
Cropped image
1256 μm × 1184 μm

Watershed segmentation
$t = t_0 + 2.6$ ns

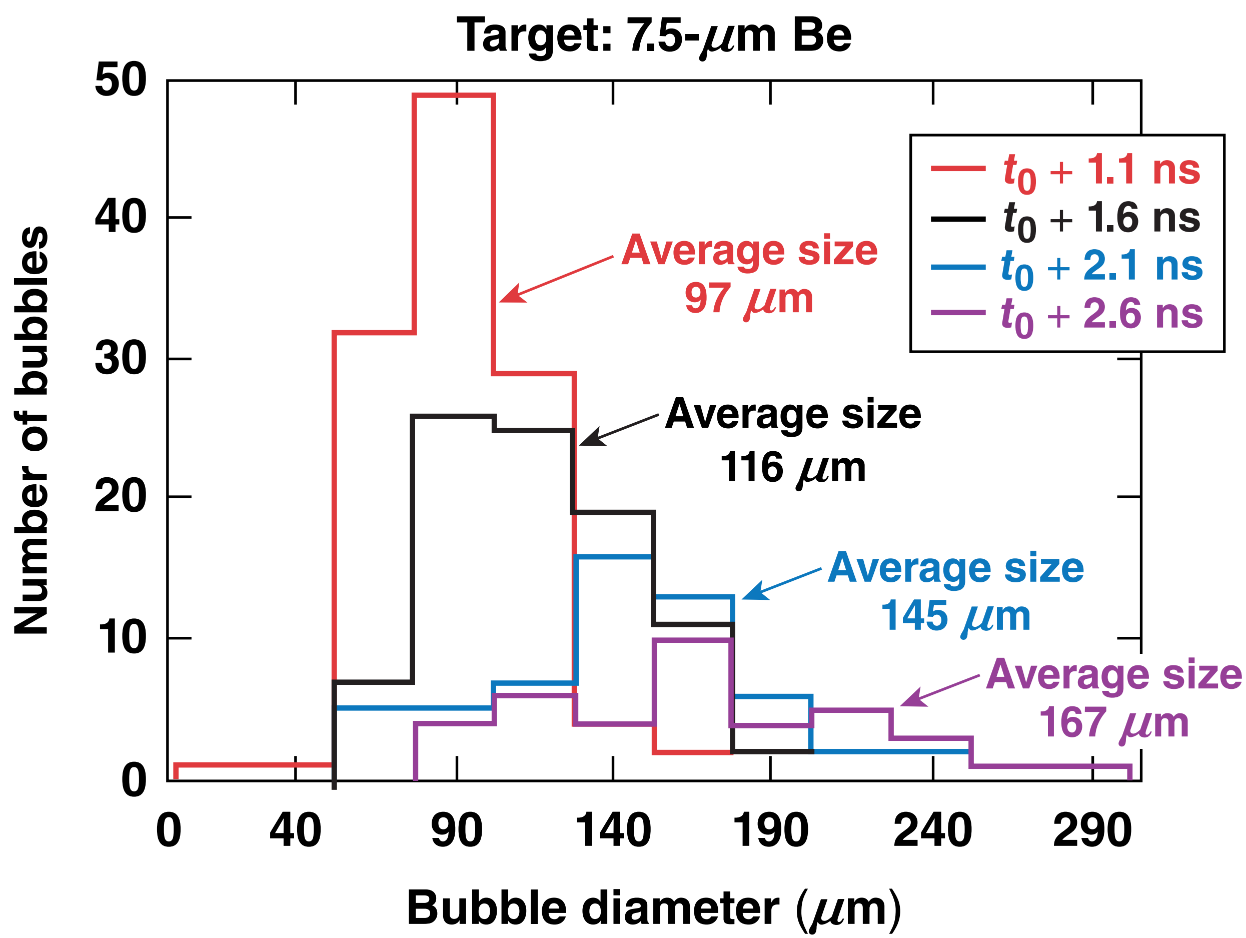


E21632

For CH, the number of bubbles decreases and the bubble diameter increases with time

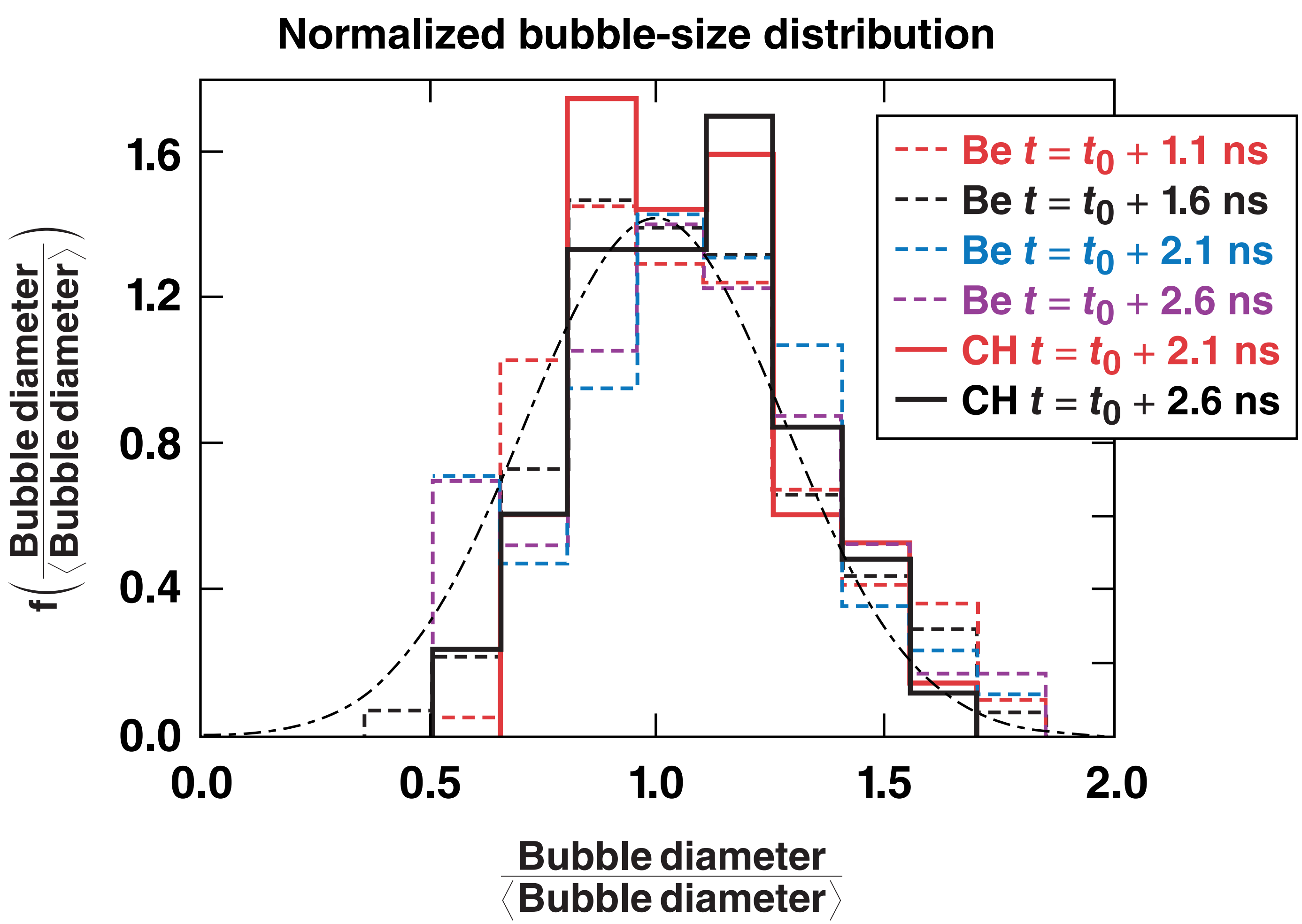


The same trend is observed for Be targets



E21637

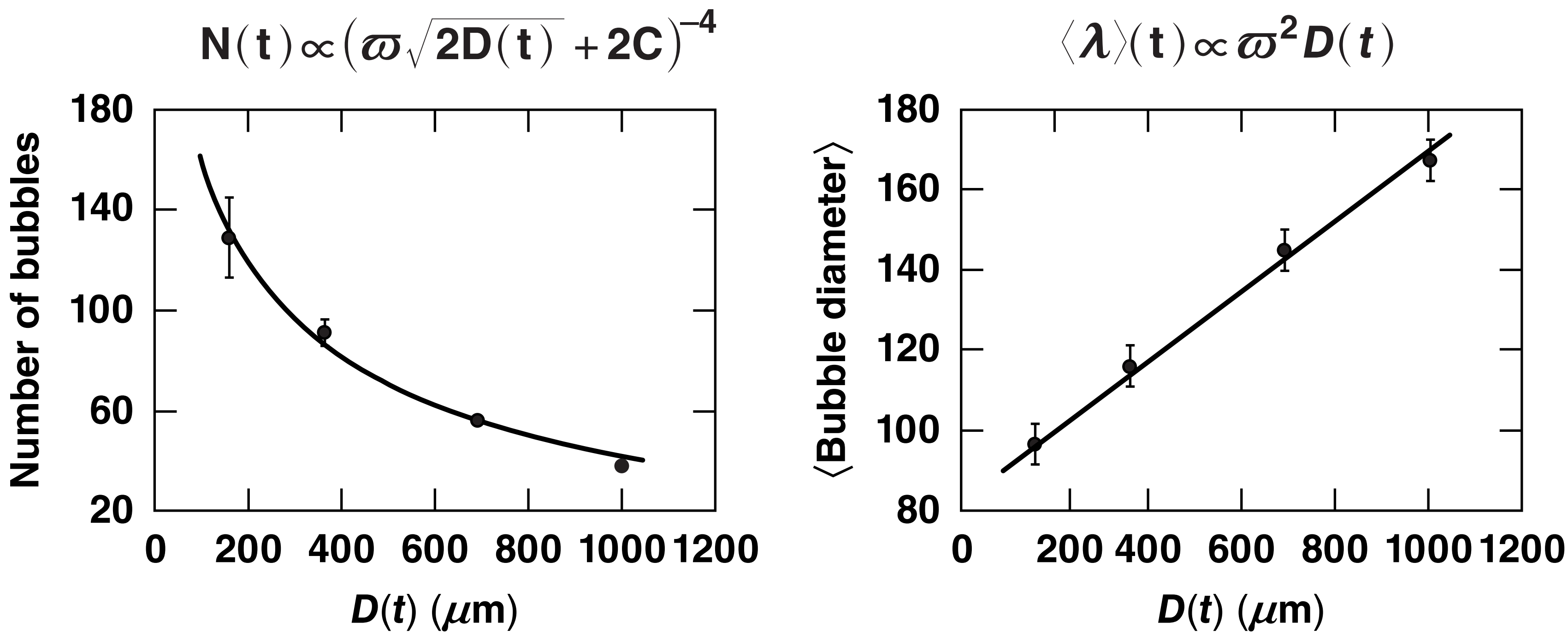
The normalized magnetic-field spatial distribution evolves self-similarly, independent of target material



E21638

The evolution of the magnetic-field spatial distribution is consistent with a bubble competition and merger model*

Target: 7.5 μm Be



$\varpi_{Be} = 0.8 \pm 0.1$

*O. Sadot *et al.*, Phys. Rev. Lett. 95, 265001 (2005); D. Oron *et al.*, Phys. Plasmas 8, 2883 (2001); U. Alon *et al.*, Phys. Rev. Lett. 72, 2867 (1994).

E21745

The scale invariant regime of nonlinear Rayleigh–Taylor (RT) instability has been probed with proton radiography

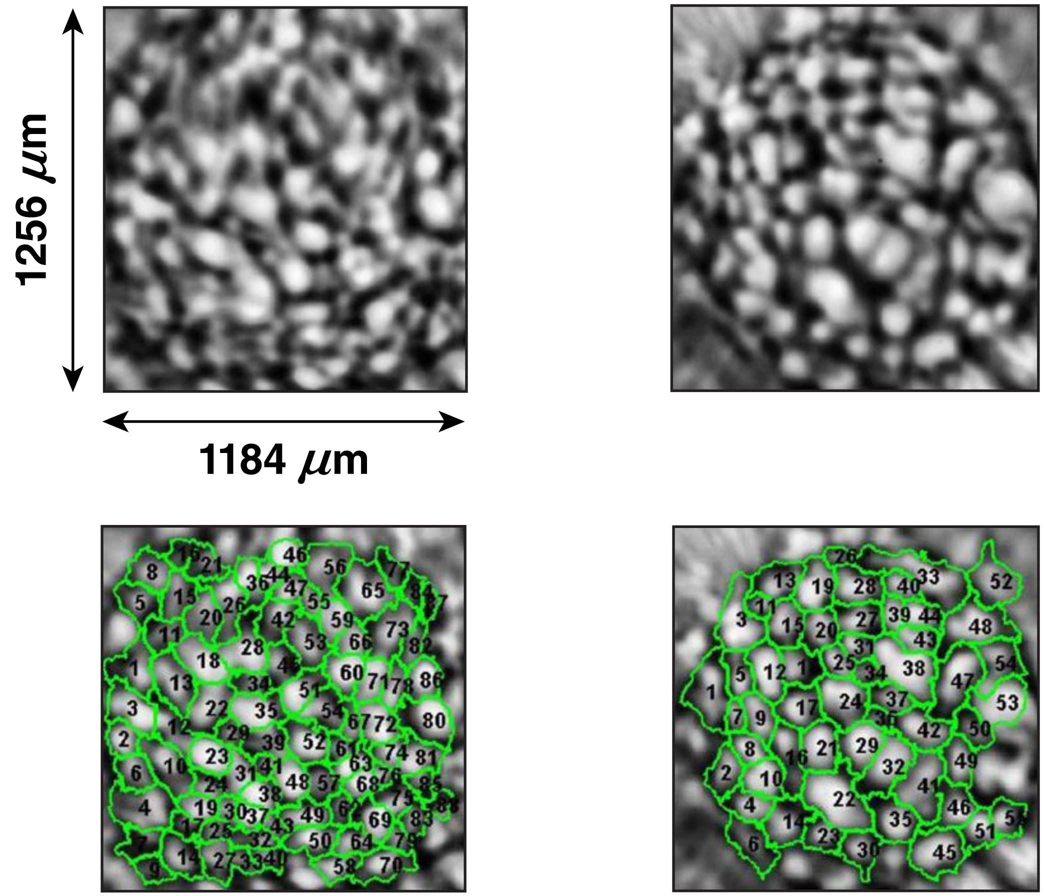
- The RT-generated magnetic-field distribution and its evolution was investigated using laser-driven CH and Be targets
- The structural evolution was found to be scale invariant
- The data are consistent with a bubble competition and merger model;* the merger rate for Be has been determined

E21629

*O. Sadot *et al*., Phys. Rev. Lett. 95, 265001 (2005).

The distribution of magnetic-field ringlets in CH targets shifts to longer wavelengths

Cropped image | Cropped image



$t = t_0 + 2.1$ ns | $t = t_0 + 2.6$ ns