

# Single-Shot Visualization and Improved Modeling of Long-Range Laser Filamentation in Molecular Gases and Air

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We experimentally demonstrate single-shot visualization and develop precise modeling of femtosecond laser filamentation in molecular gases and air. Using a pump-probe experiment, we tune the rotational Raman response by adjusting the pump pulse duration and apply single-shot multi-object plane imaging to directly visualize extended plasma channels and measure their plasma density. To interpret the measurements, we perform nonlinear envelope equation simulations with an alignment-dependent molecular ionization model, in which Raman-induced molecular rotation causes the ionization rate to vary dynamically during filamentation. Compared with conventional atomic ionization approximations, this approach offers a more accurate representation of molecular ionization.