Millisecond Suppression of Counter-propagating Optical Signal using Ultrafast Laser Filaments

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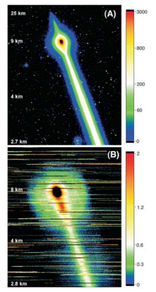
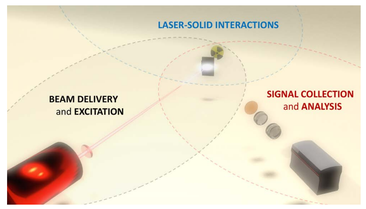
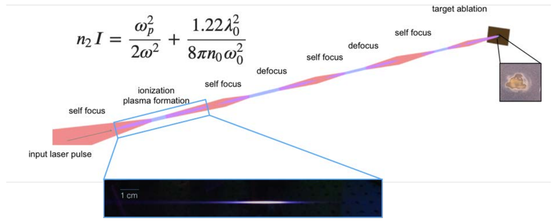
Introduction and Motivation



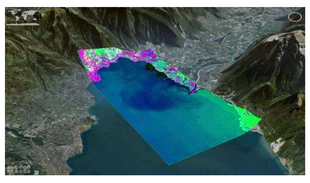
Rodriguez et al., *Phys. Rev. E* (2004)

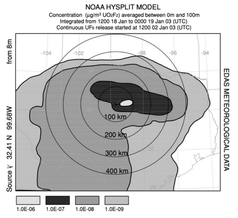




Filamentation solves the problem of extended beam delivery, but how can we overcome challenges in distant signal collection?

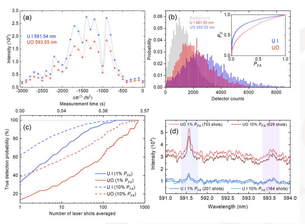
Mission Relevance



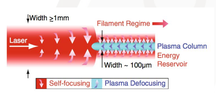


Kemp, *Sci. Glob. Sec.* (2008)

Remote, rapid detection of nonproliferation-relevant materials using optical spectroscopy

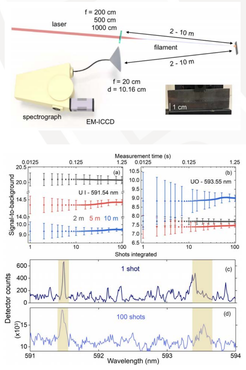


Burger et al., *Haz. Mat.* (2020 submitted)



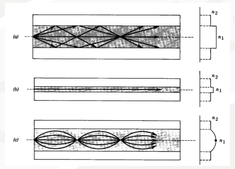
Valenzuela et al., *App. Phys. B* (2014)

Finney et al., *Opt. Letters* (2019)

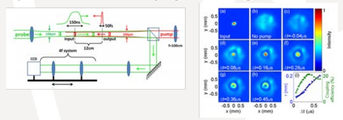


Technical Approach

Optical fiber principle



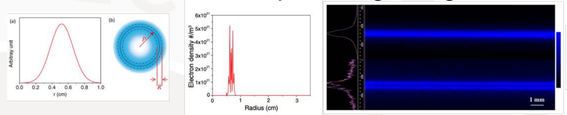
Microsecond acoustic (shockwave) guiding



Lahav et al., *Phys. Rev. A* (2014)

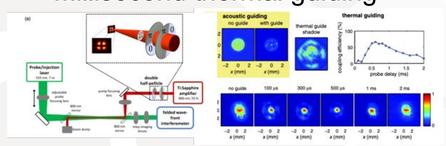
Filaments can be shaped to form dynamic structures analogous to optical fibers

Nanosecond plasma guiding



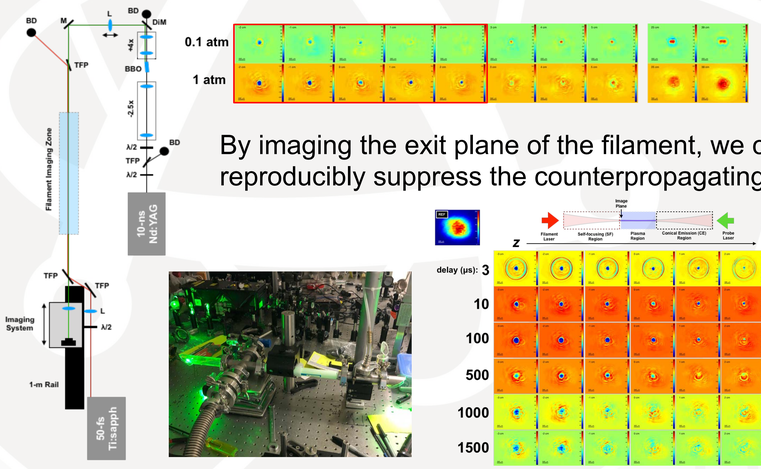
Wen et al., *J. Phys. D* (2012)

Millisecond thermal guiding



Jhajj et al., *Phys. Rev. X* (2014)

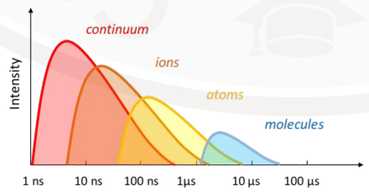
Results



By imaging the exit plane of the filament, we can reproducibly suppress the counterpropagating probe light

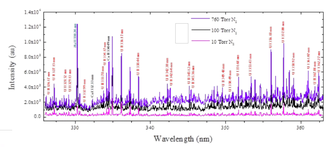
This suppression is long-lived (millisecond scale) and probably enabled by thermal relaxation of air

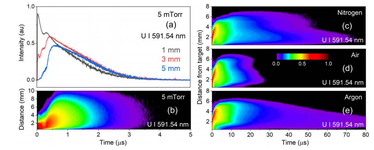
Expected Impact

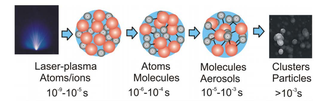


We demonstrate strong suppression of on-axis signal without beam shaping which can be used to facilitate background rejection

MTV Impact



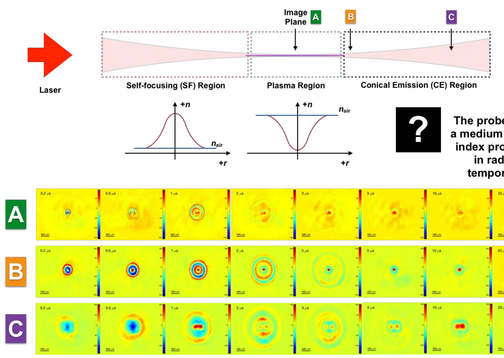




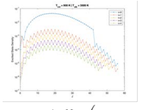
Skrodzki et al., *Phys. Plasmas* (2019)

Uranium exhibits complex spectrum with complicated temporal behavior, and strong early continuum

Conclusion



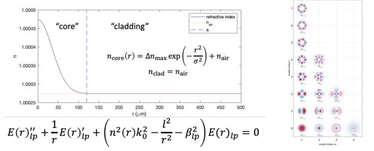
Next Steps



Modeling & simulation

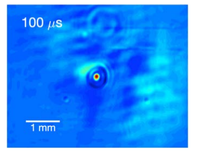
$$n - 1 = \rho K^{GD}$$

$$K^{GD} = \frac{1}{2}\frac{N_A}{M_G \varepsilon_0}\left(\sum_{V,J} 4\pi\epsilon_0 \alpha_{V,J} N_{V,J} + \sum_V \frac{\mu^2_{V,J=0}}{3hB_e} N_{V,J=0}\right)$$



$$E(r)''_{lp} + \frac{1}{r}E(r)'_{lp} + \left(n^2(r)k_0^2 - \frac{l^2}{r^2} - \beta^2_{lp}\right)E(r)_{lp} = 0$$

Beam structuring to enable waveguiding of optical signals



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National Nuclear Security Administration