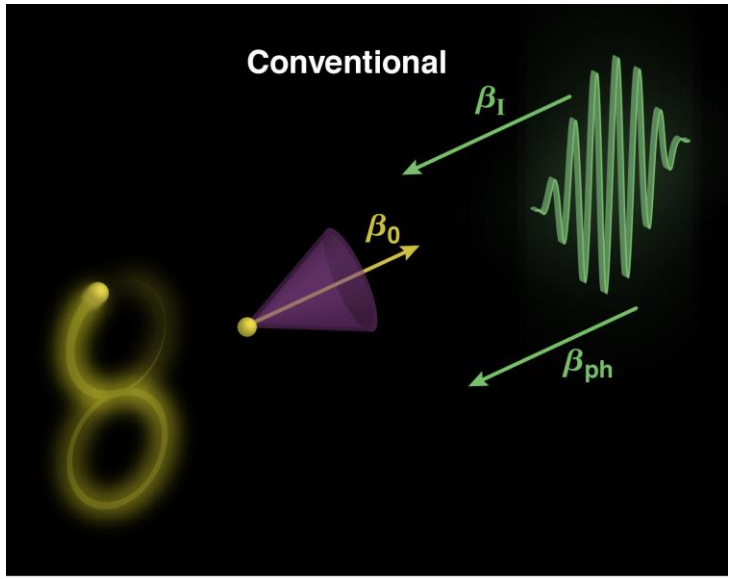
Nonlinear Thomson Scattering with Ponderomotive Control



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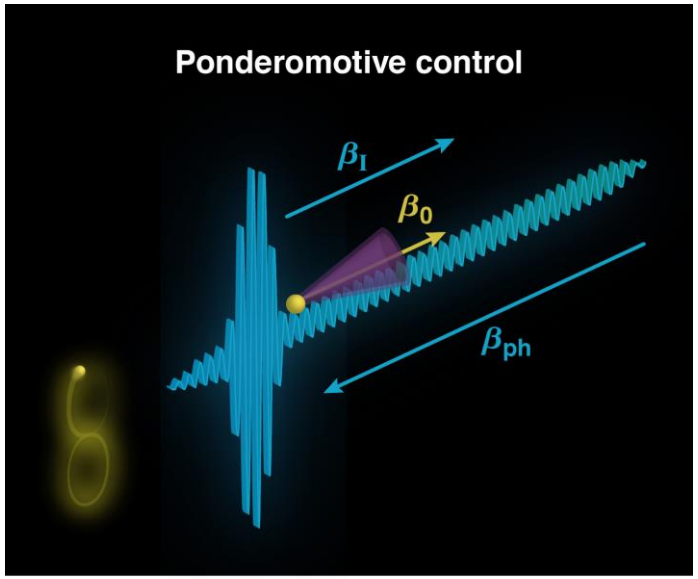

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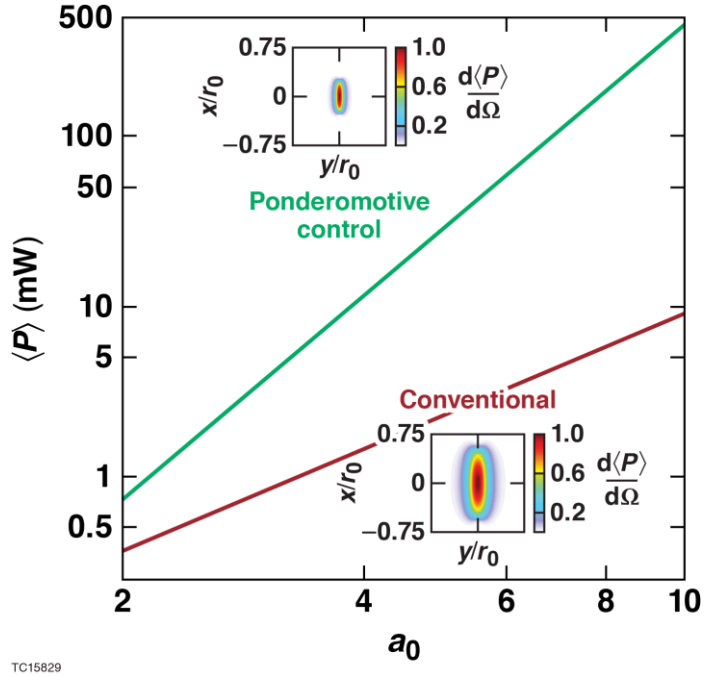

TC15829

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63rd Annual Meeting of the APS
Division of Plasma Physics
Pittsburgh, PA
8–12 November, 2021

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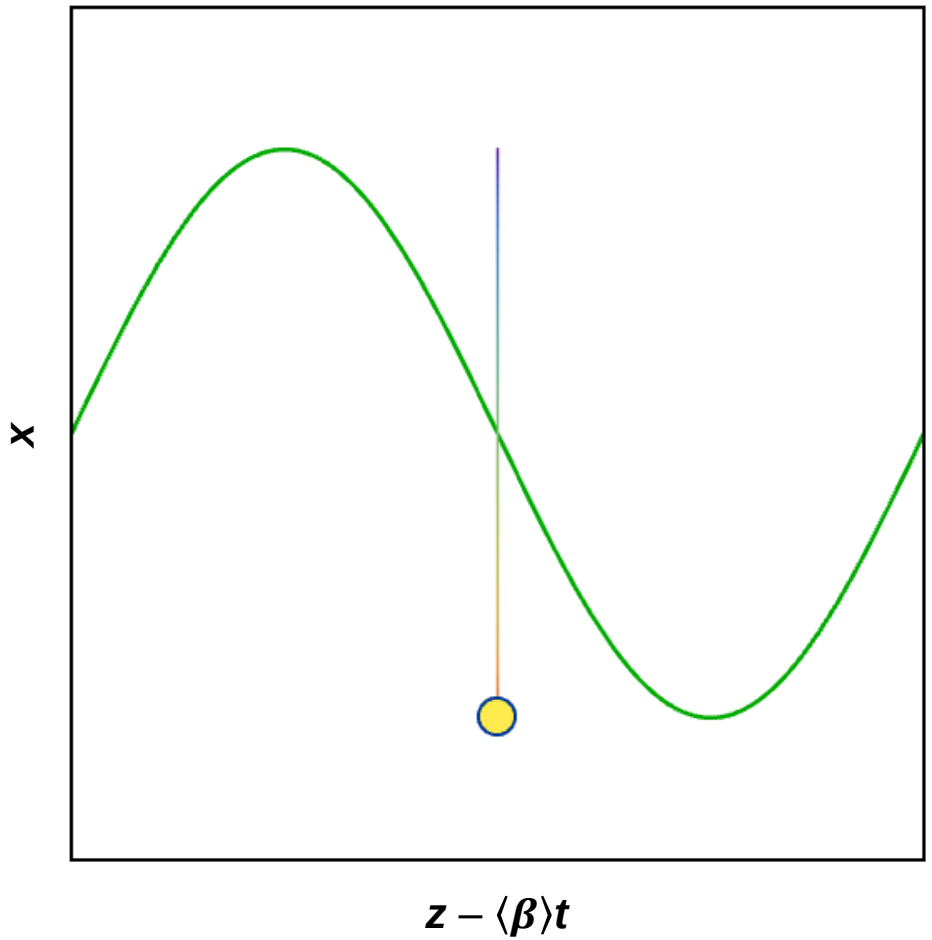
Summary

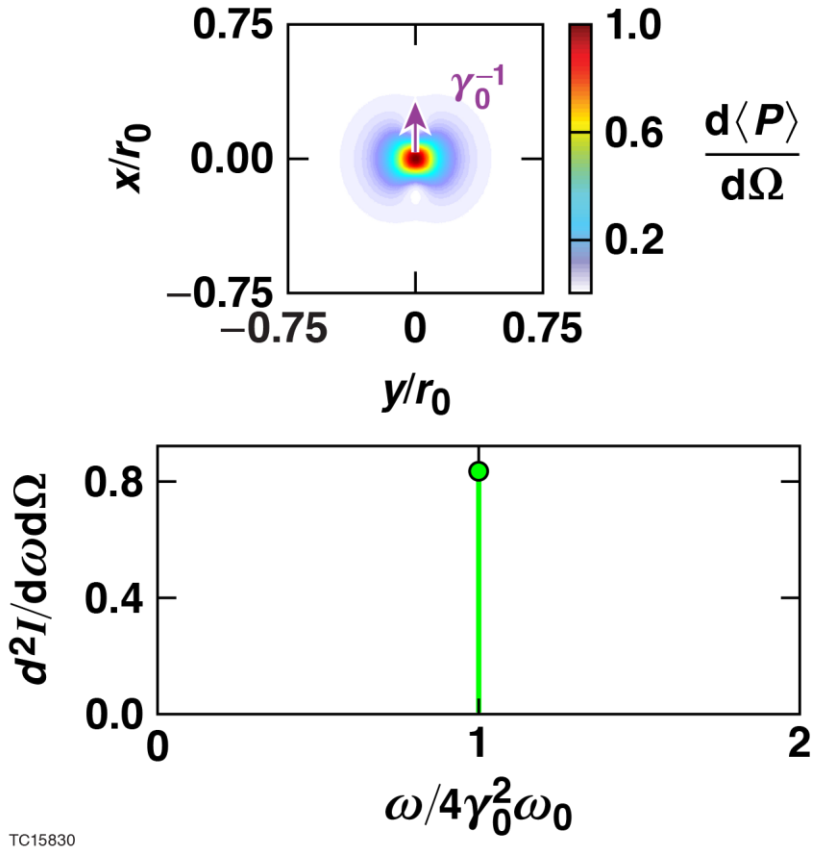
Spatiotemporal control of laser intensity enables novel regimes of nonlinear Thomson scattering that substantially enhance the radiation properties

- In nonlinear Thomson scattering (NLTS) a relativistic electron reflects and re-radiates the photons of a laser pulse, converting optical light to x rays
- In an ultra-intense conventional pulse, the ponderomotive force decelerates an electron, introducing a trade-off between scattered power, spectrum, and emission angle
- Spatiotemporal control of laser intensity provides control over the speed and direction of the intensity peak and therefore the pondermotive force
- This ponderomotive control can accelerate an electron, mitigating the trade-offs in conventional NLTS

Nonlinear Thomson scattering with ponderomotive control can increase the radiated power by orders of magnitude while reducing the emission angle.

When an electron counter-propagates with respect to the phase velocity of a laser pulse, it radiates light at an upshifted frequency





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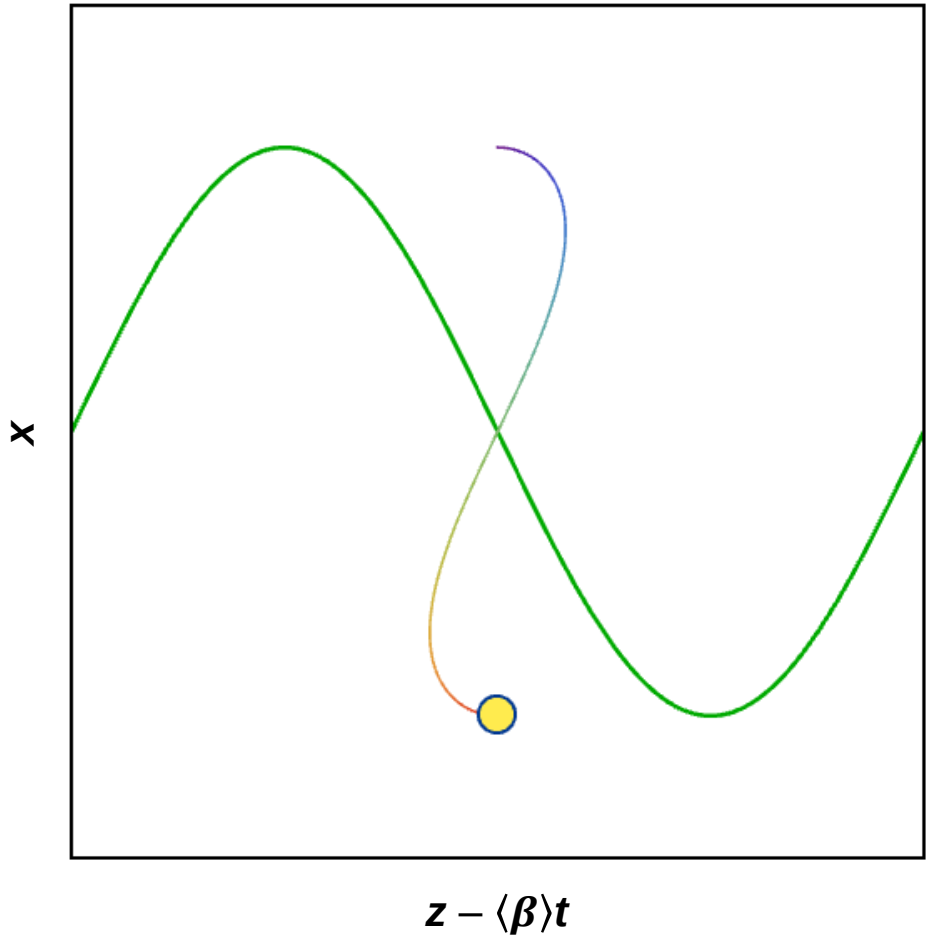
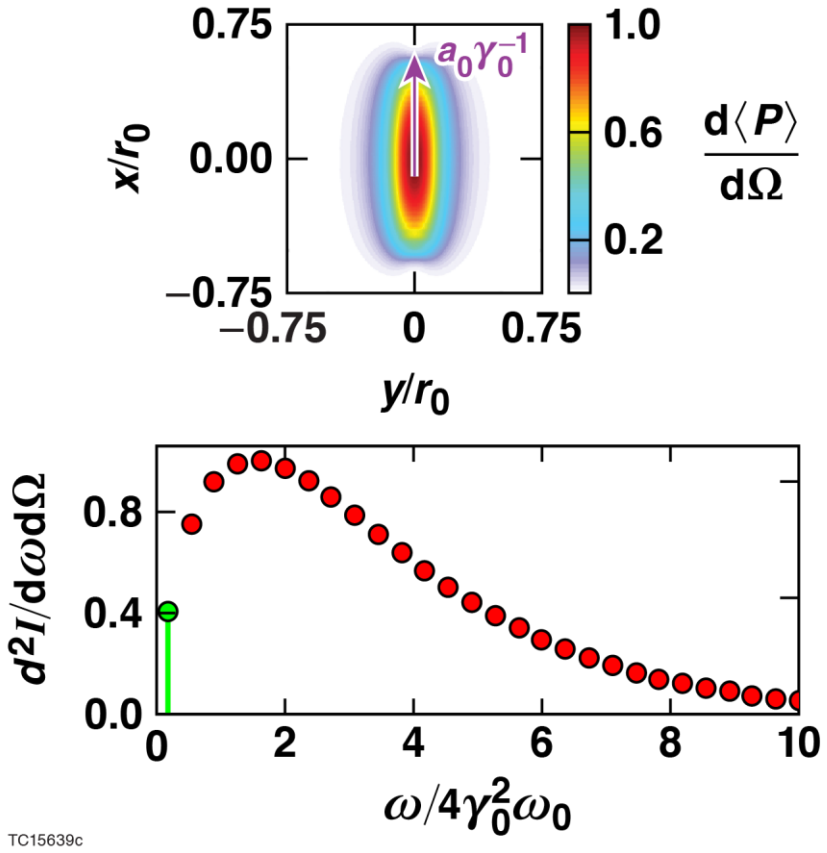
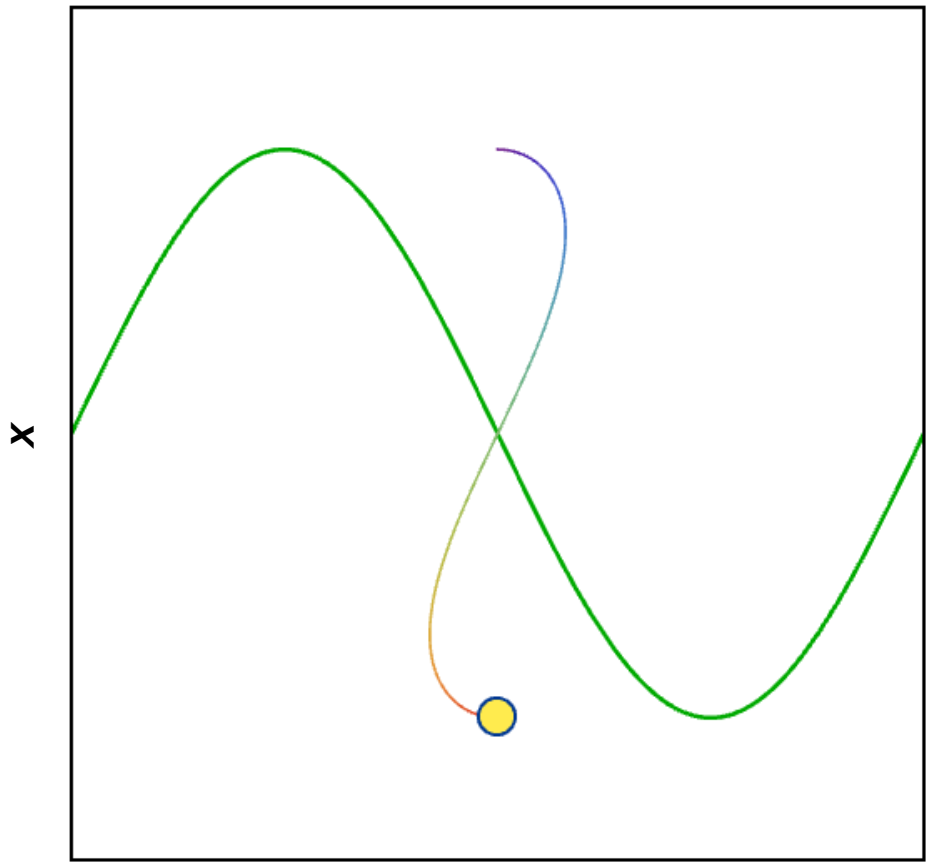
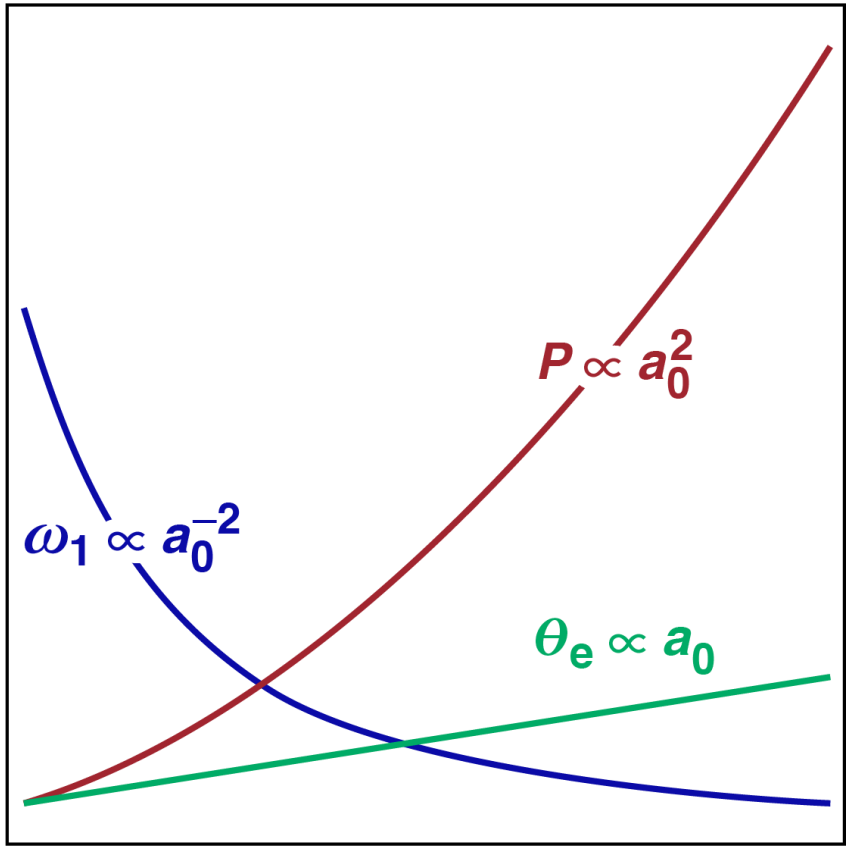




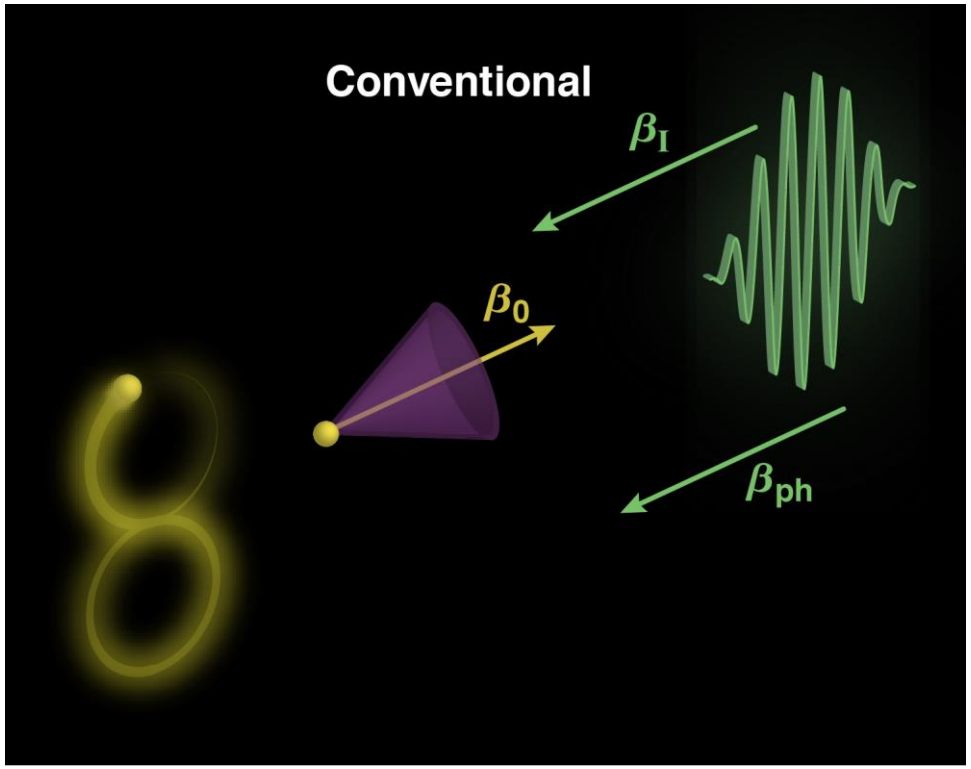
In conventional NLTS, the laser intensity constrains the radiation properties





The ponderomotive deceleration determines the scaling of the radiation properties with respect to laser intensity

The counter-directional intensity peak ponderomotively decelerates the electron as it enters regions of high intensity



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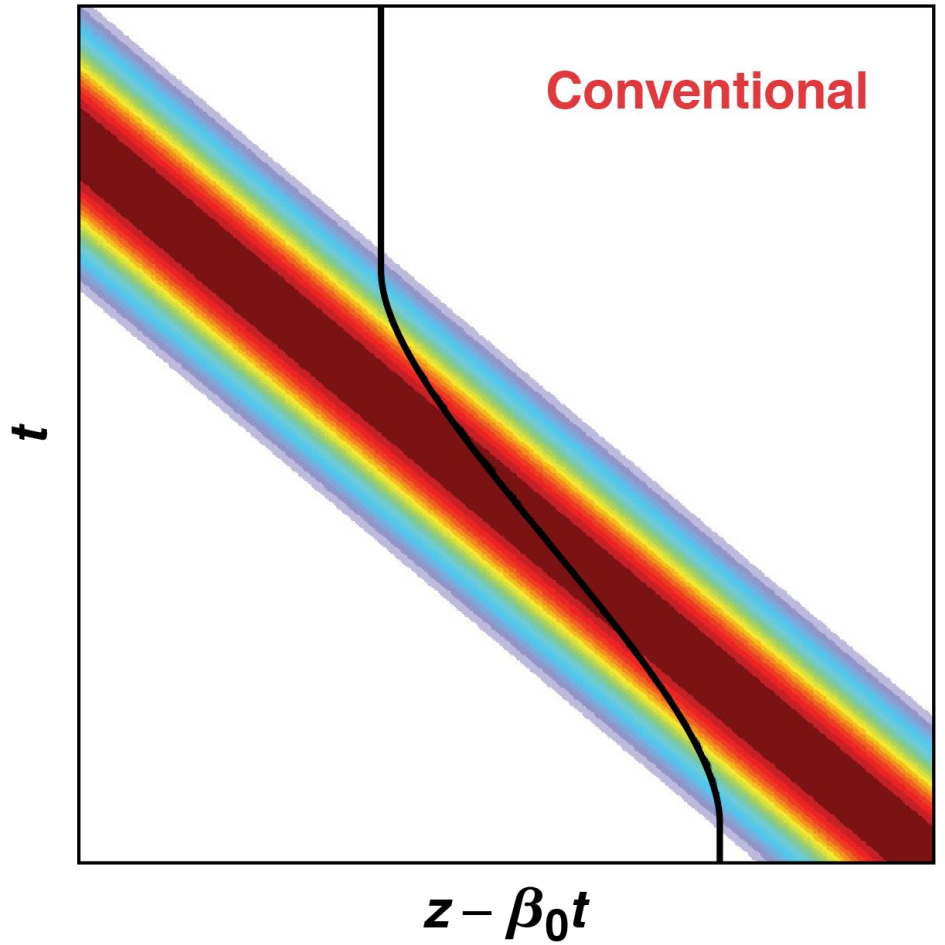

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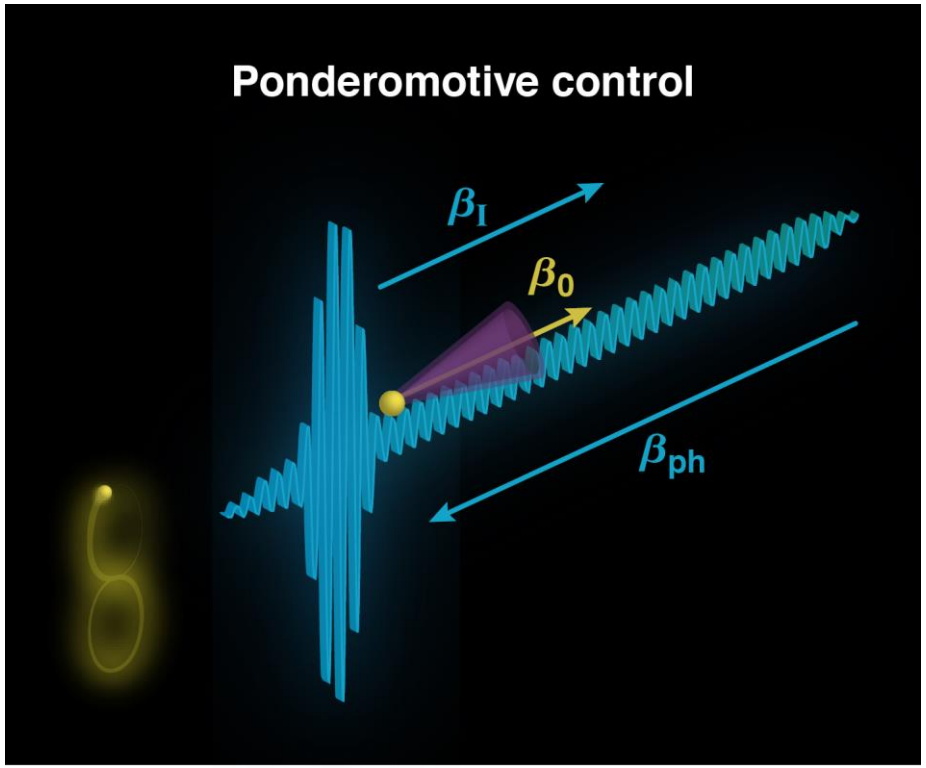
Controlling the velocity of the ponderomotive force provides tunability over the radiation parameters

The co-directional intensity peak ponderomotively accelerates the electron against the phase velocity



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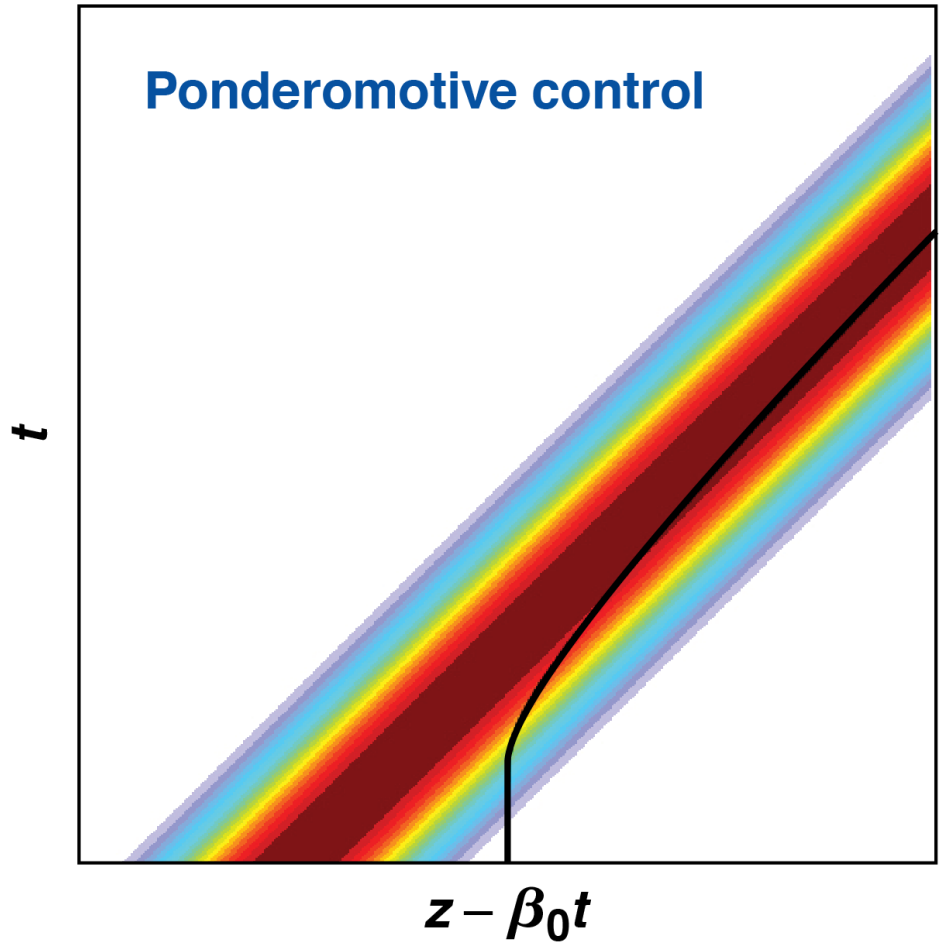

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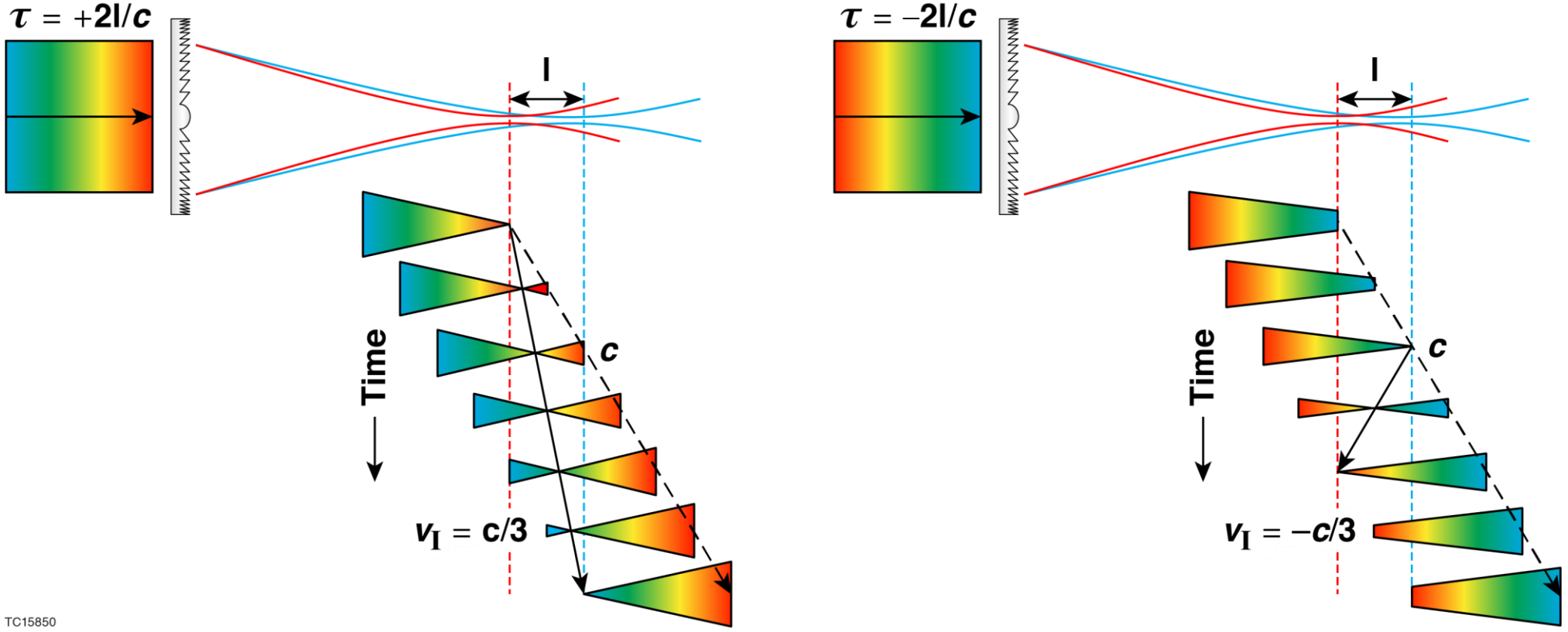
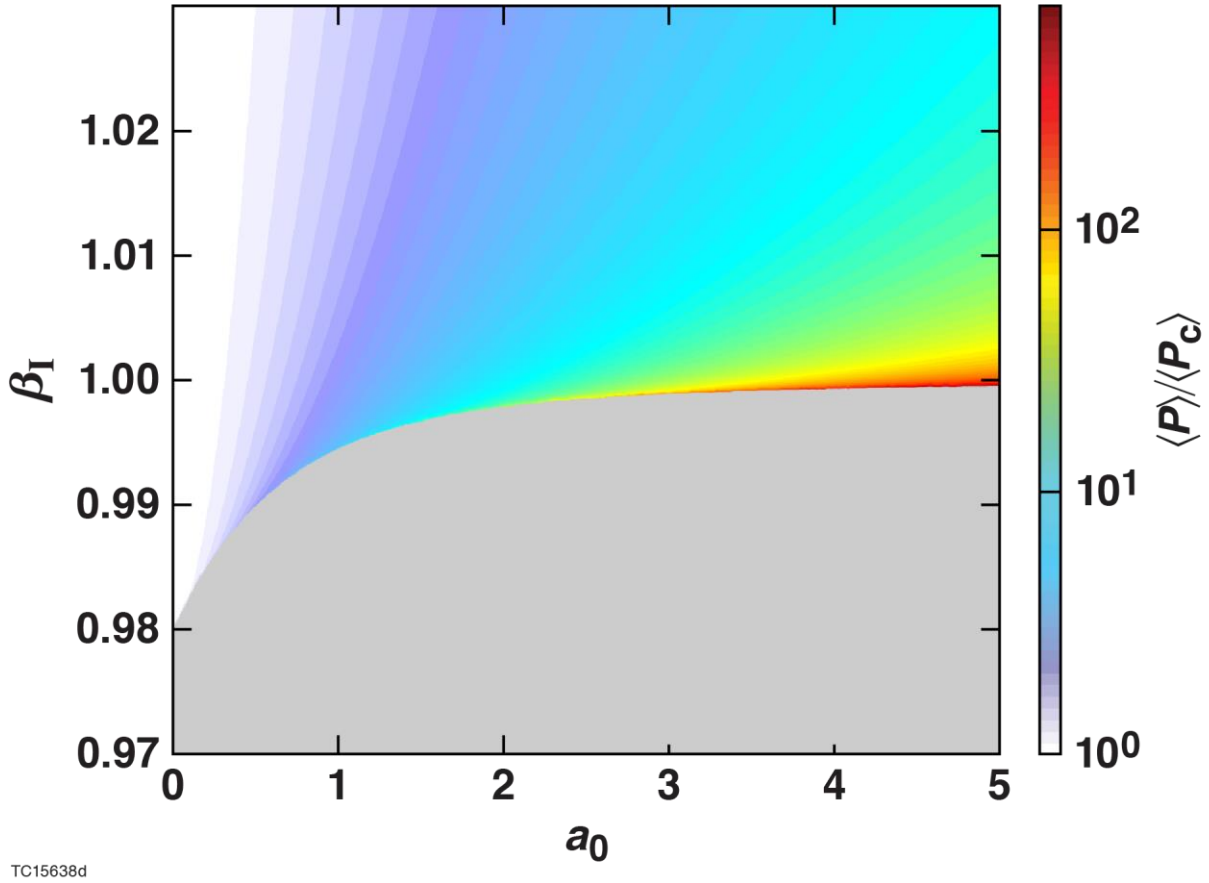
The flying focus combines a chromatic optic with a chirped laser pulse to control the velocity of the intensity peak



- **The chromatic optic and chirp determine the focal location and time of each color, respectively, resulting in a peak intensity with a dynamic trajectory**

Nonlinear Thomson scattering with ponderomotive control increases the radiated power by orders of magnitude



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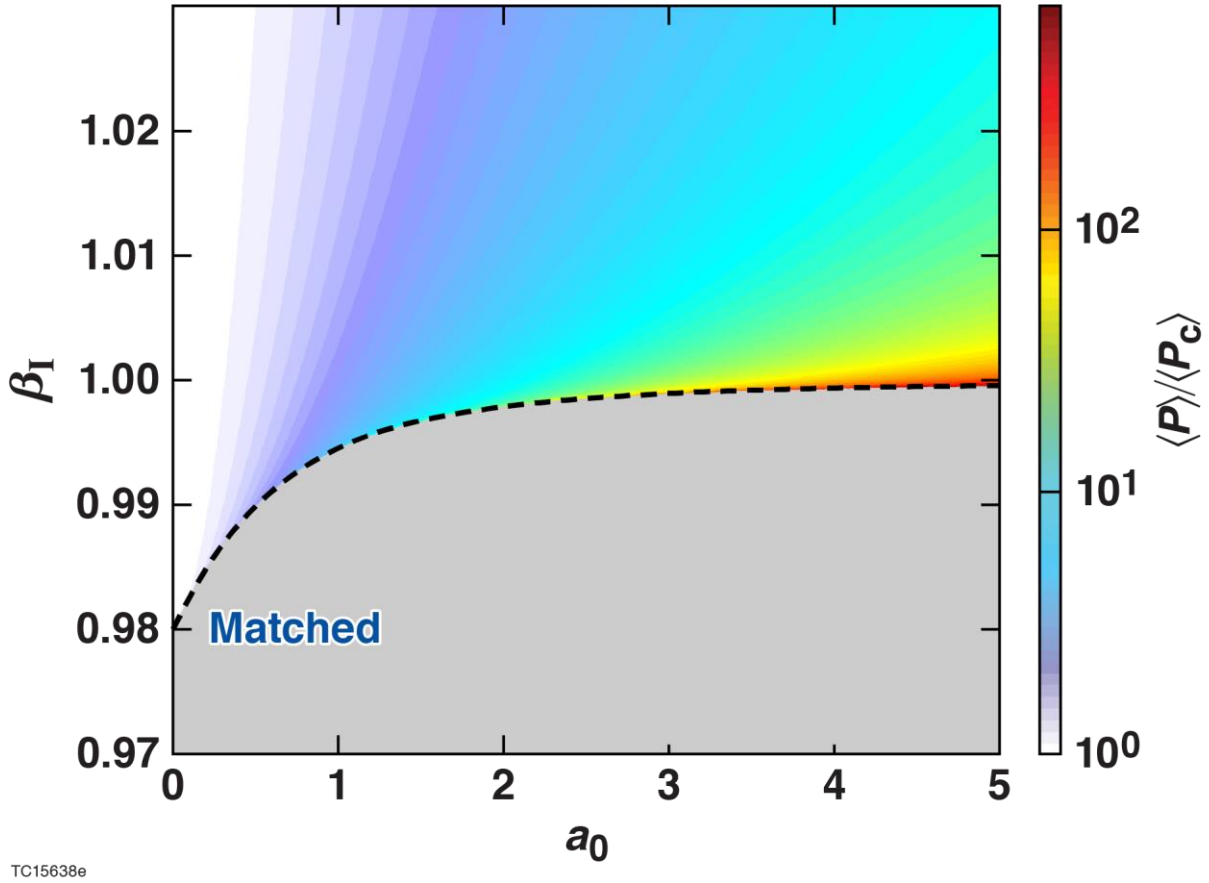

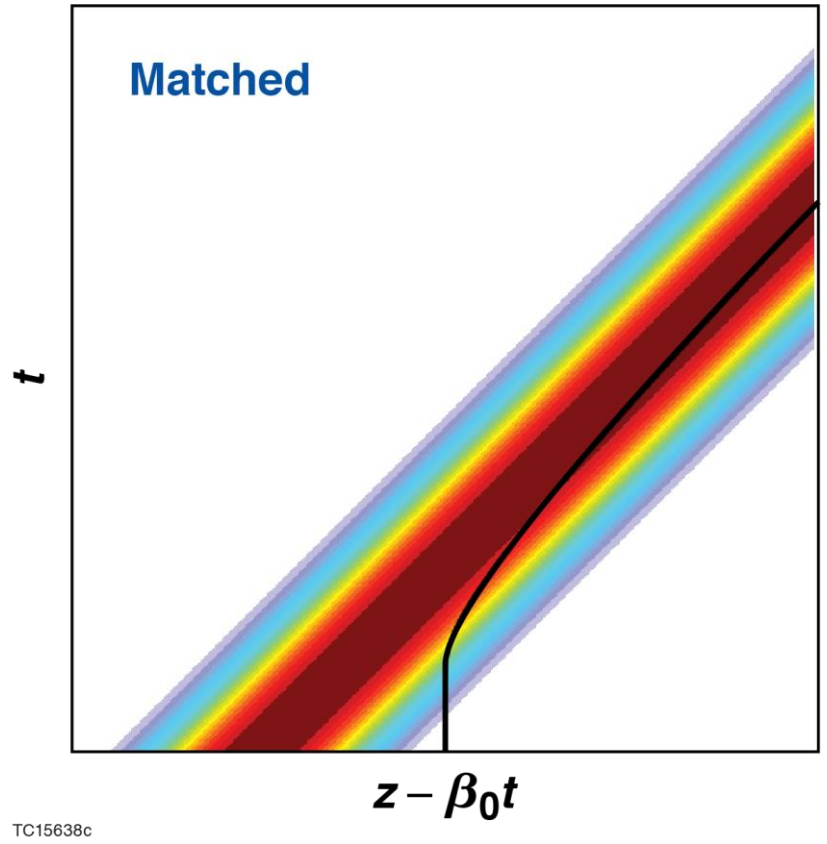

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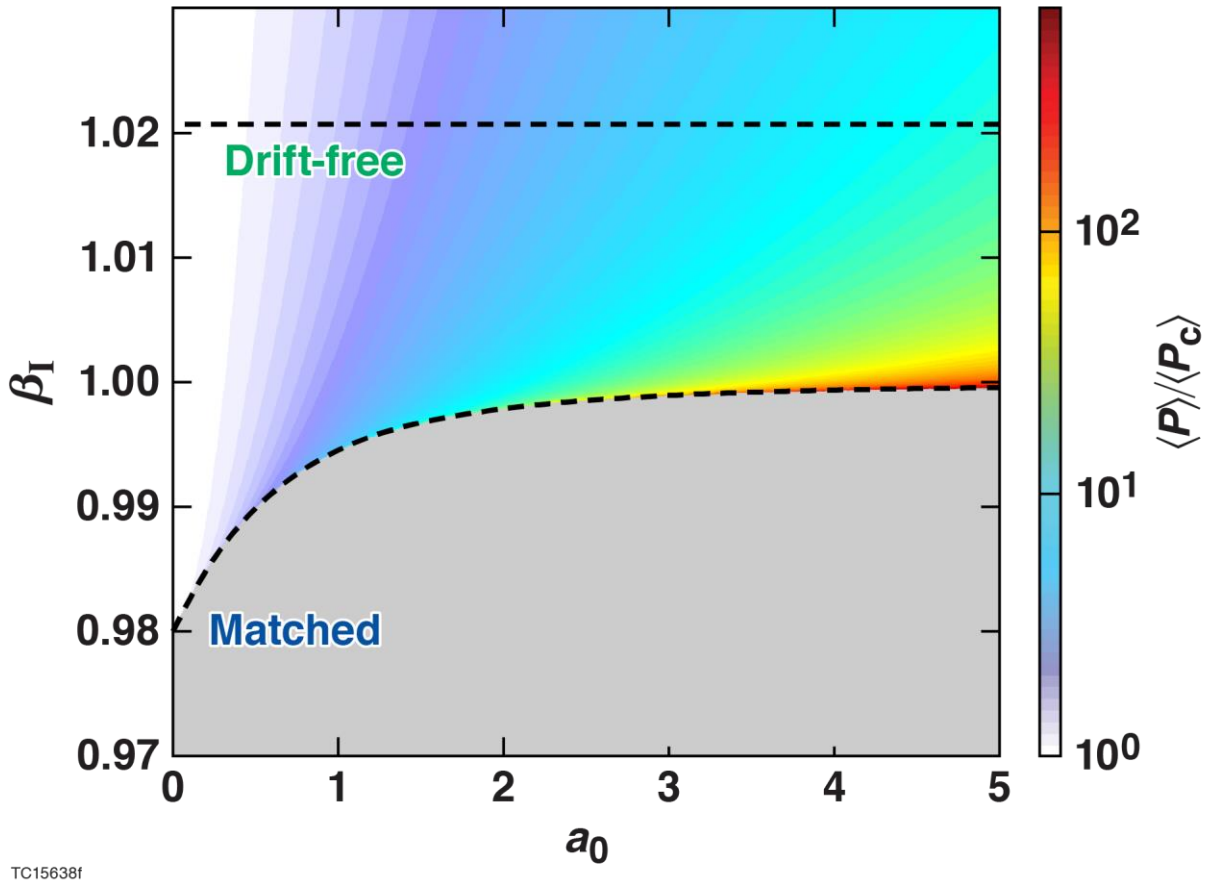
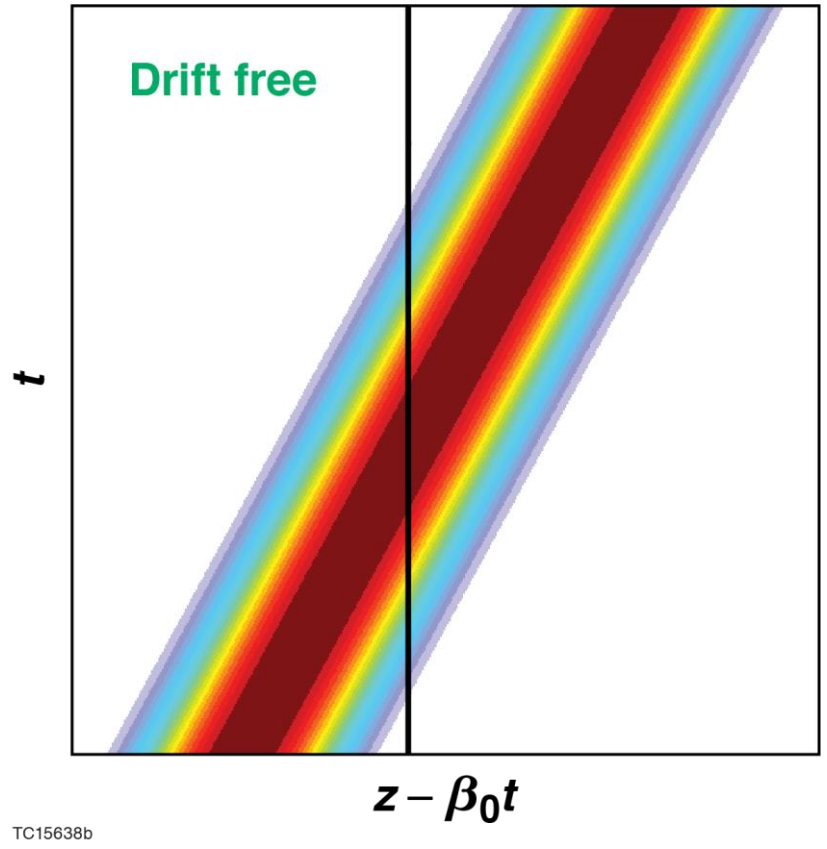
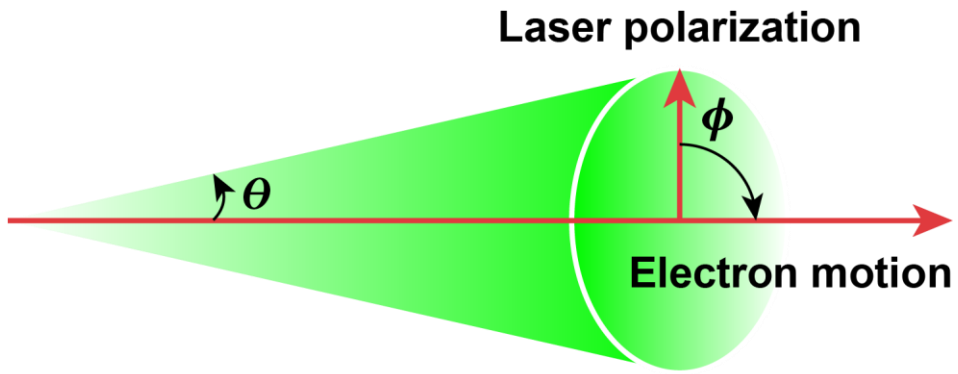




An electron accelerated by the intensity peak will radiate into a smaller cone



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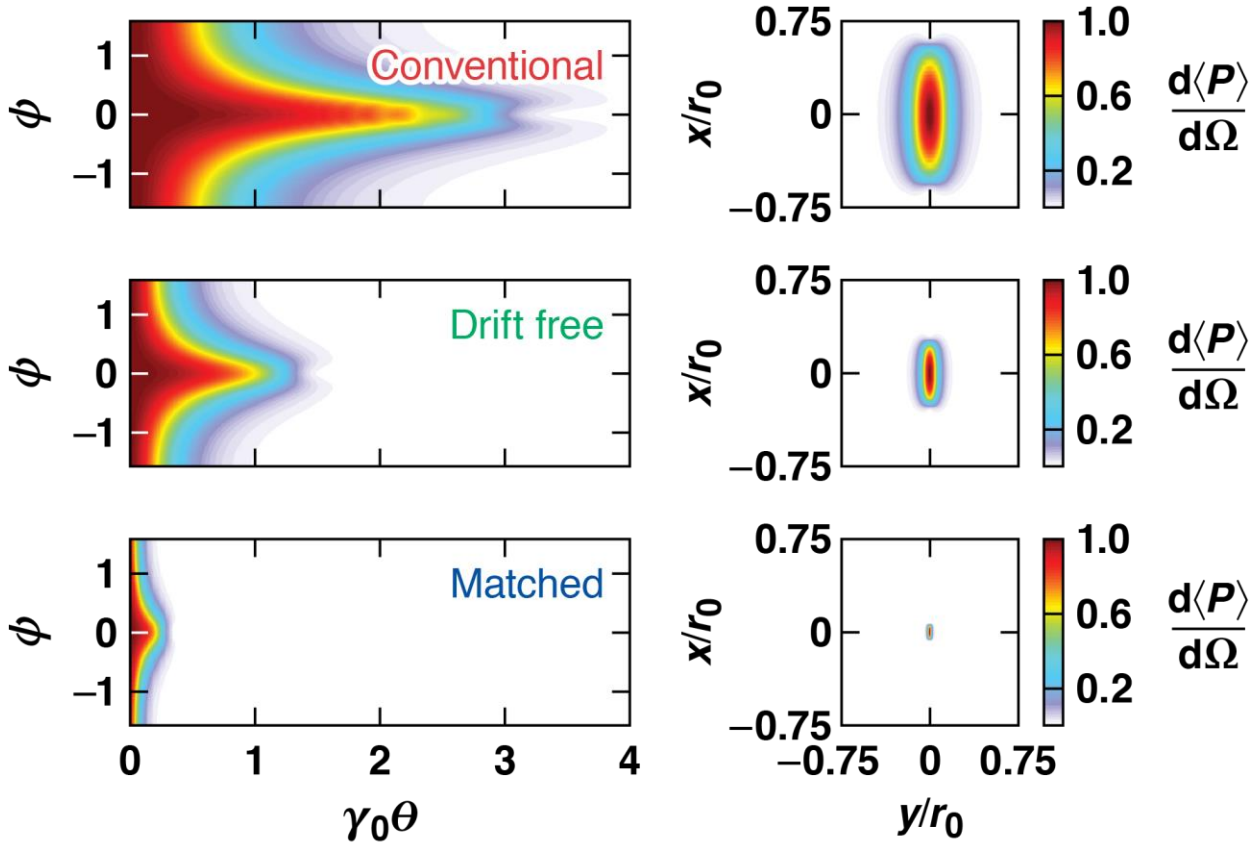

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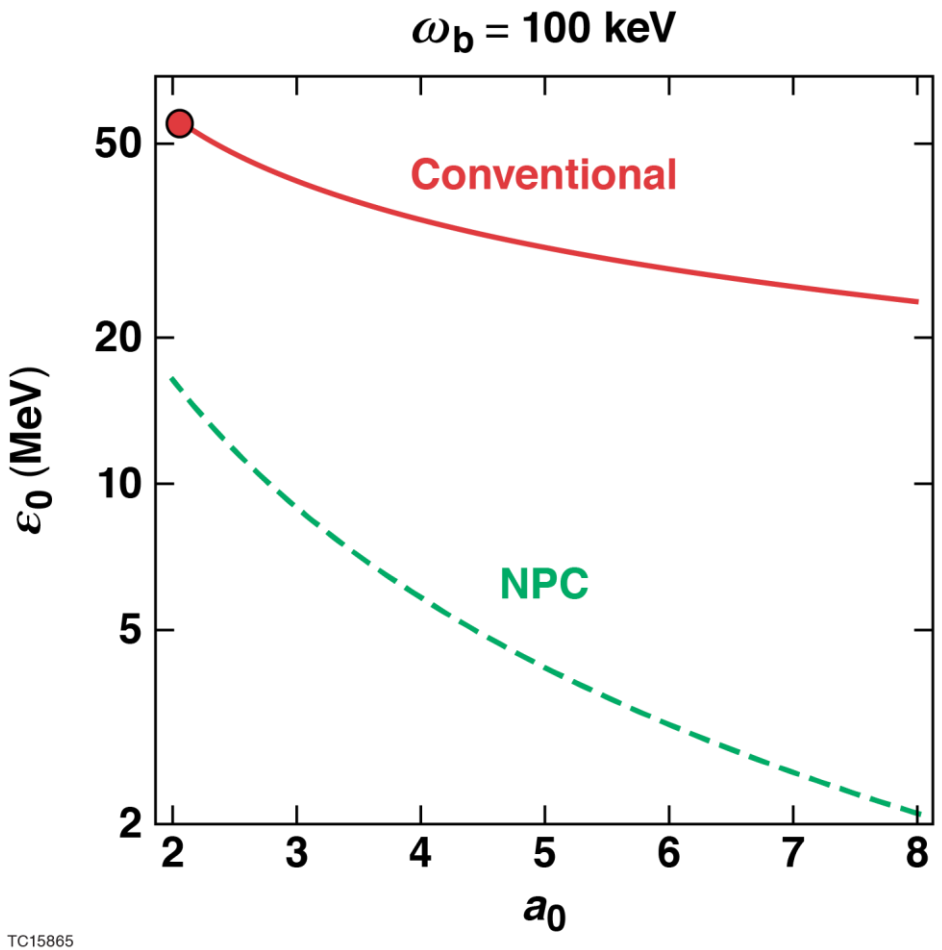
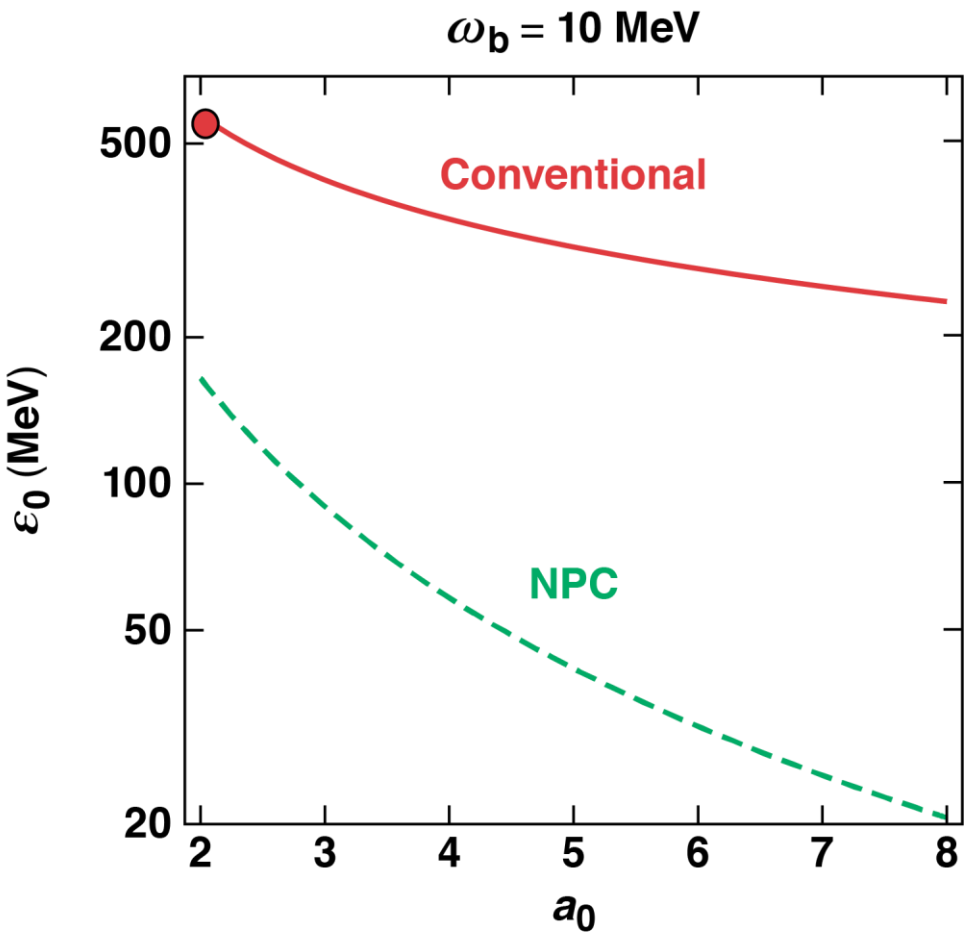
The enhanced scalings with laser intensity switch the burden in NLTS from the accelerator to the laser





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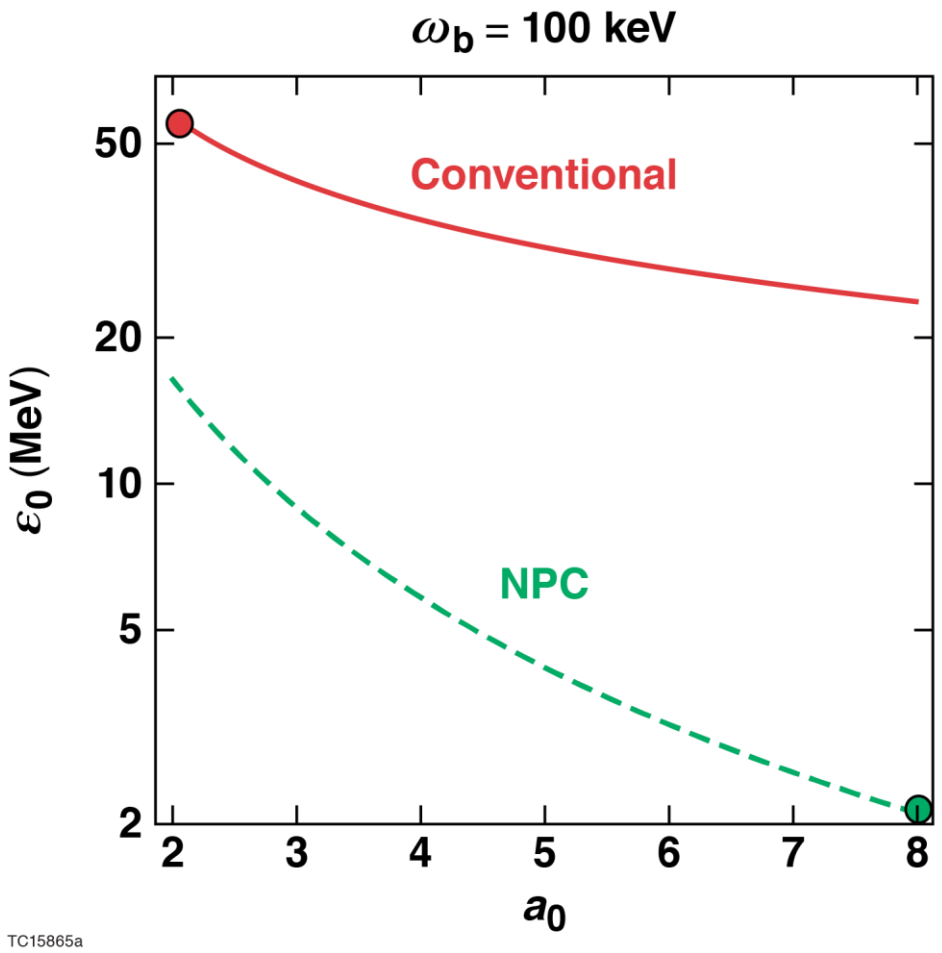

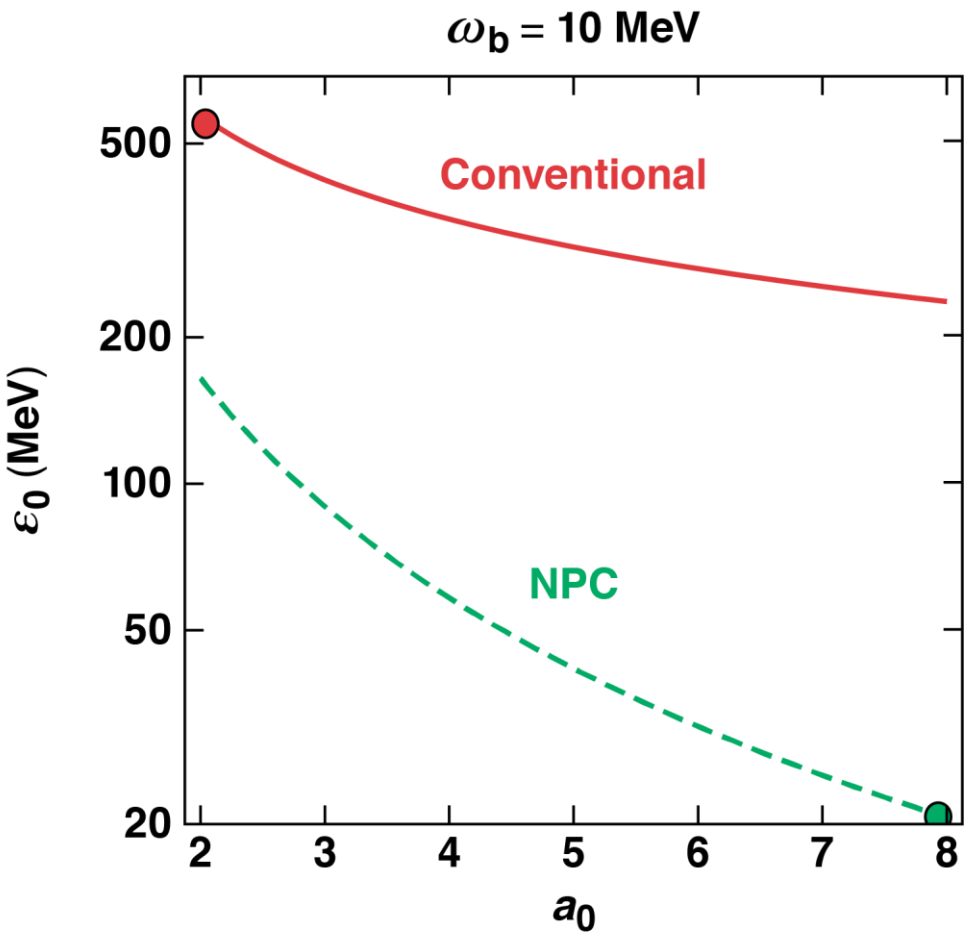

Summary/Conclusions

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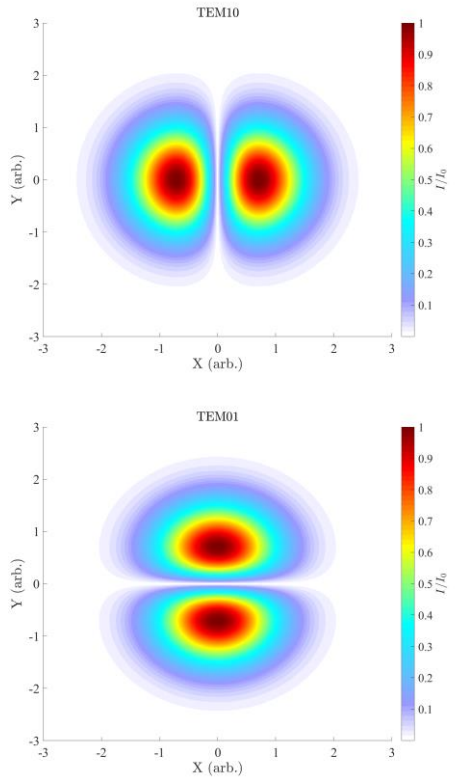
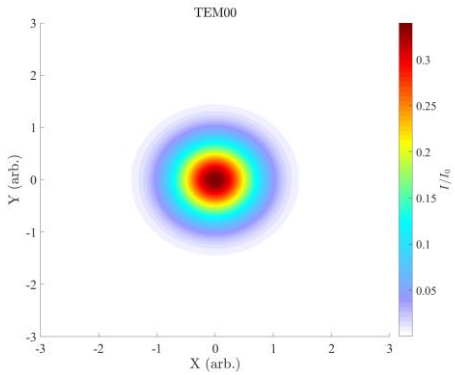
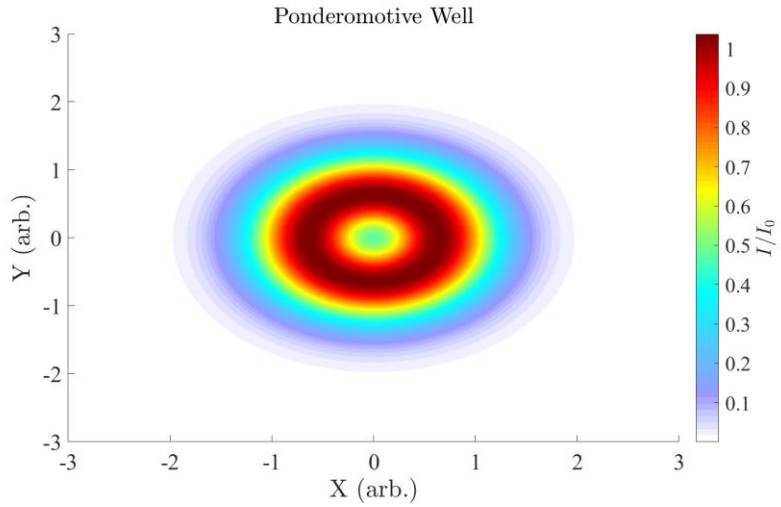
Transverse pulse shaping can be used to create a ponderomotive well

$\hat{\mathbf{x}}$ $\hat{\mathbf{y}}$







$$\phi_{TEM01} - \phi_{TEM10} = \pi / 2$$