Limits on energy recovery for positron acceleration in a warm plasma column

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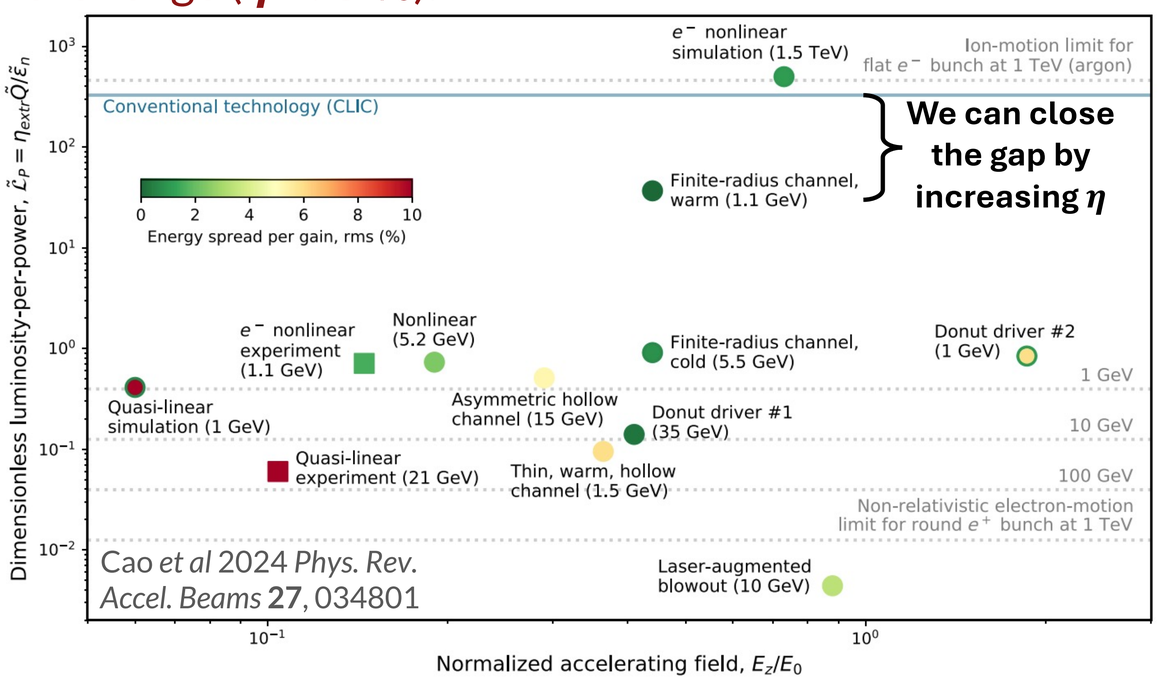
Introduction

Beam-driven plasma wakefield acceleration (PWFA) is a promising candidate for realizing a future linear collider. However, efficient positron PWFA remains a challenge ($\eta < 5$ %).



Energy recovery in a plasma column

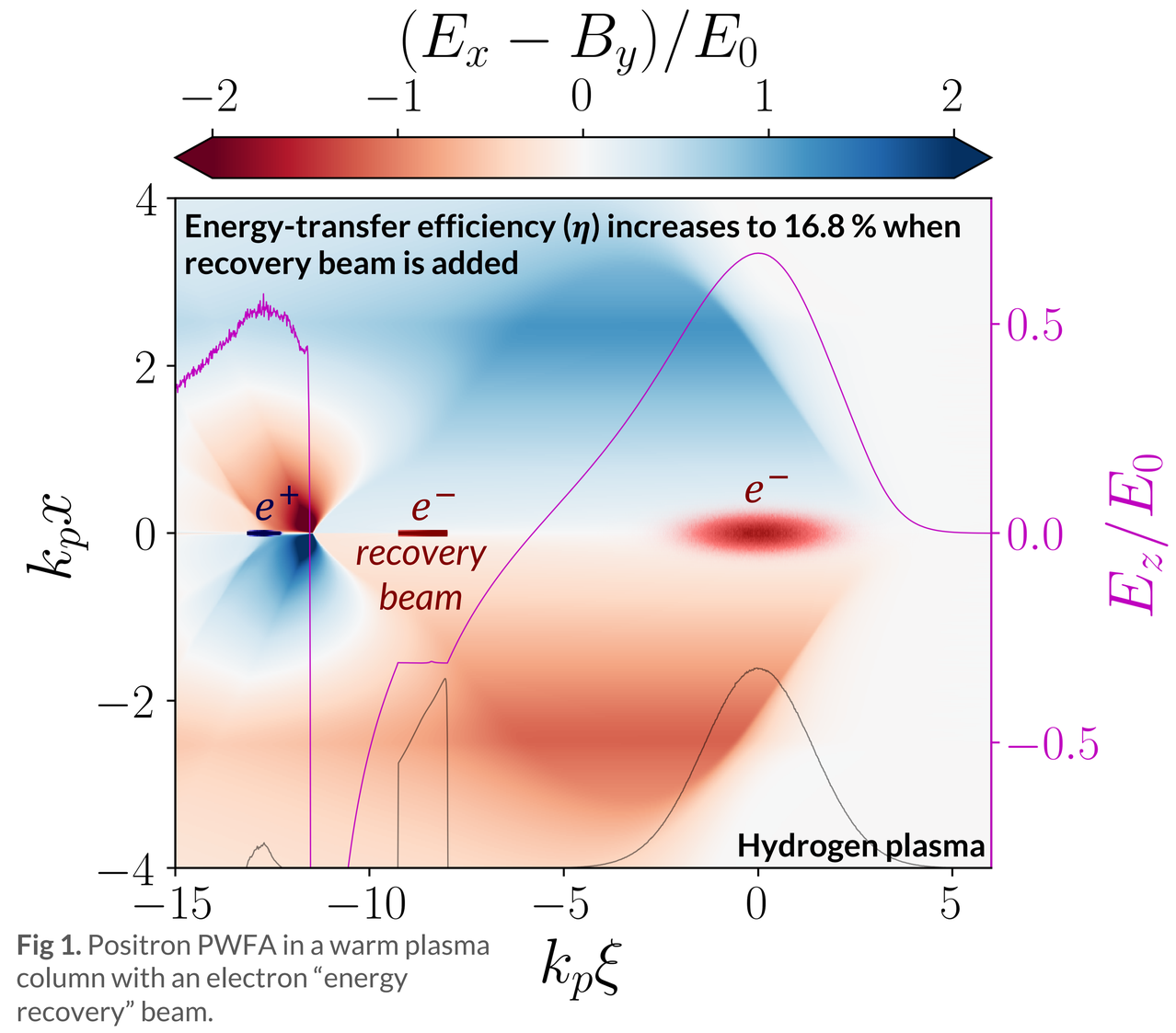


Fig 1. Positron PWFA in a warm plasma column with an electron "energy recovery" beam.

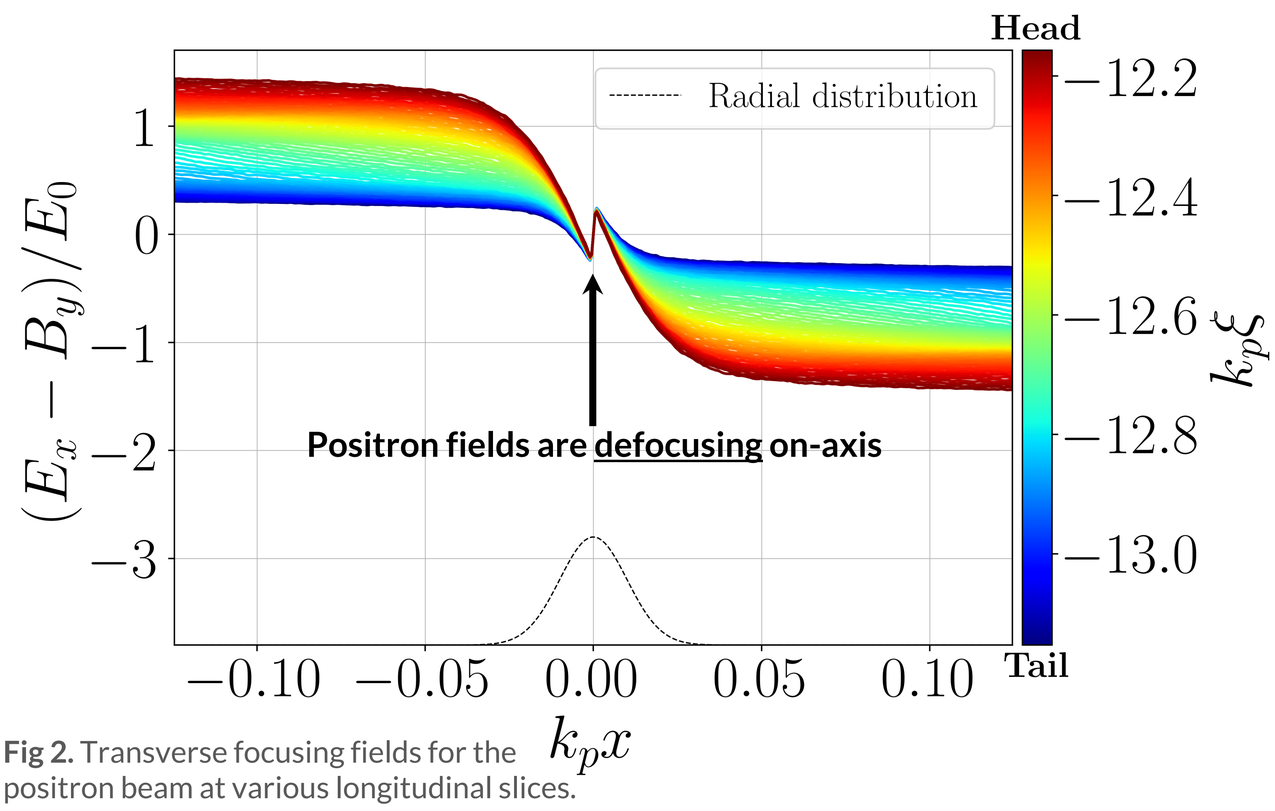


Fig 2. Transverse focusing fields for the positron beam at various longitudinal slices.

Beam quality concerns

Dense recovery beams induce ion motion which causes defocusing in the positron beam centroid (see Fig. 2).

Argon plasma & wide recovery beam suppresses the ion motion

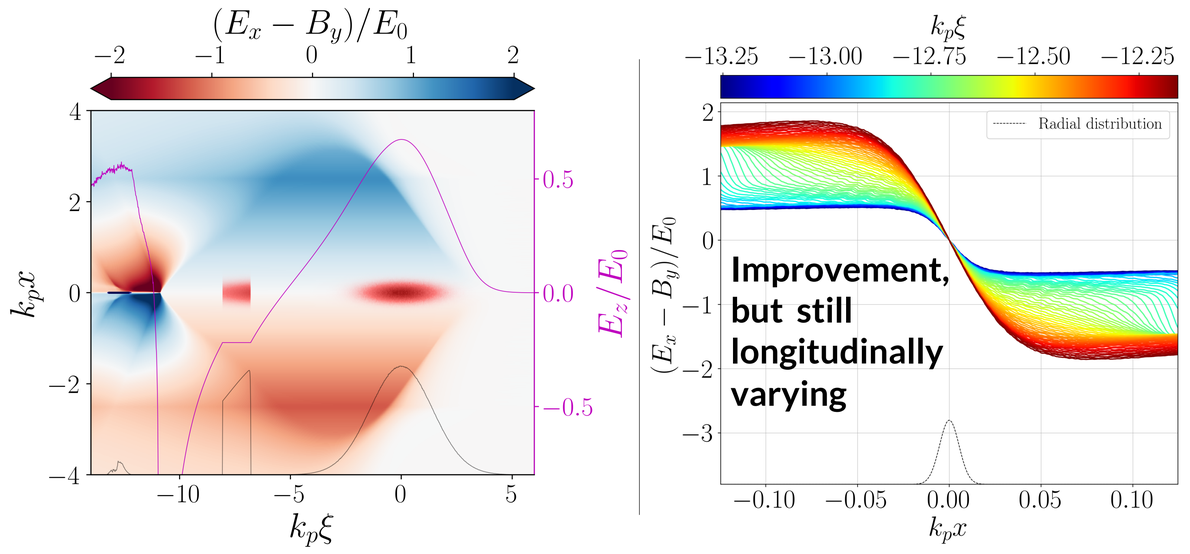


Fig 4. Adjusted energy recovery scheme to mitigate ion motion (left) and resulting focusing fields for positron beam (right).

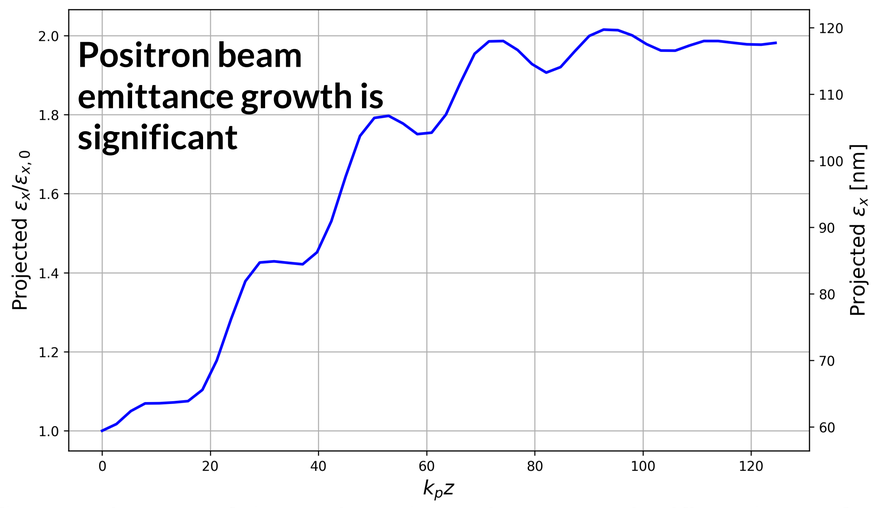


Fig 5. The x-emittance of the positron beam increases significantly as a function of propagation distance, likely due to poor matching.

Remaining challenges

Although our efforts reduce ion motion, the longitudinally varying focusing fields for the positron beam create challenging matching conditions.

A delicate selection of parameters might allow the positron beam to quasi-match to the wakefield, which may enable efficient, self-stable, high-quality positron PWFA.

Our work demonstrates a sensitivity to the plasma column regime, highlighting a trade off between positron beam quality and energy-transfer efficiency.

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References

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