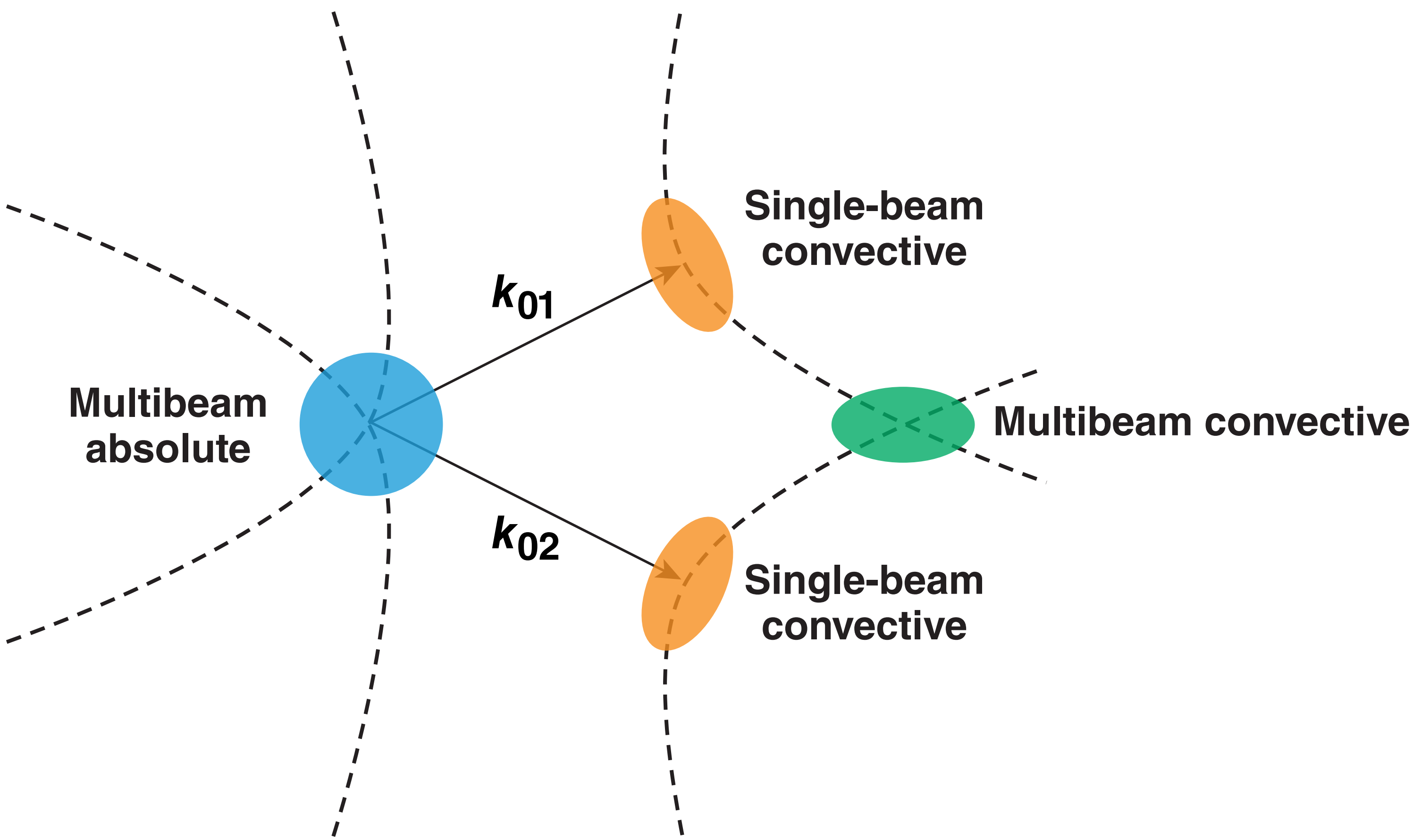
# The Effects of Beam Polarization on Convective and Absolute Two-Plasmon Decay (TPD) Driven by Multiple Laser Beams




R. W. Short
University of Rochester
Laboratory for Laser Energetics

42nd Annual Anomalous Absorption Conference
Key West, FL
25–29 June 2012

Summary

# For multibeam TPD, the relative polarizations of the beams affect the absolute/convective nature of the instability as well as the gain

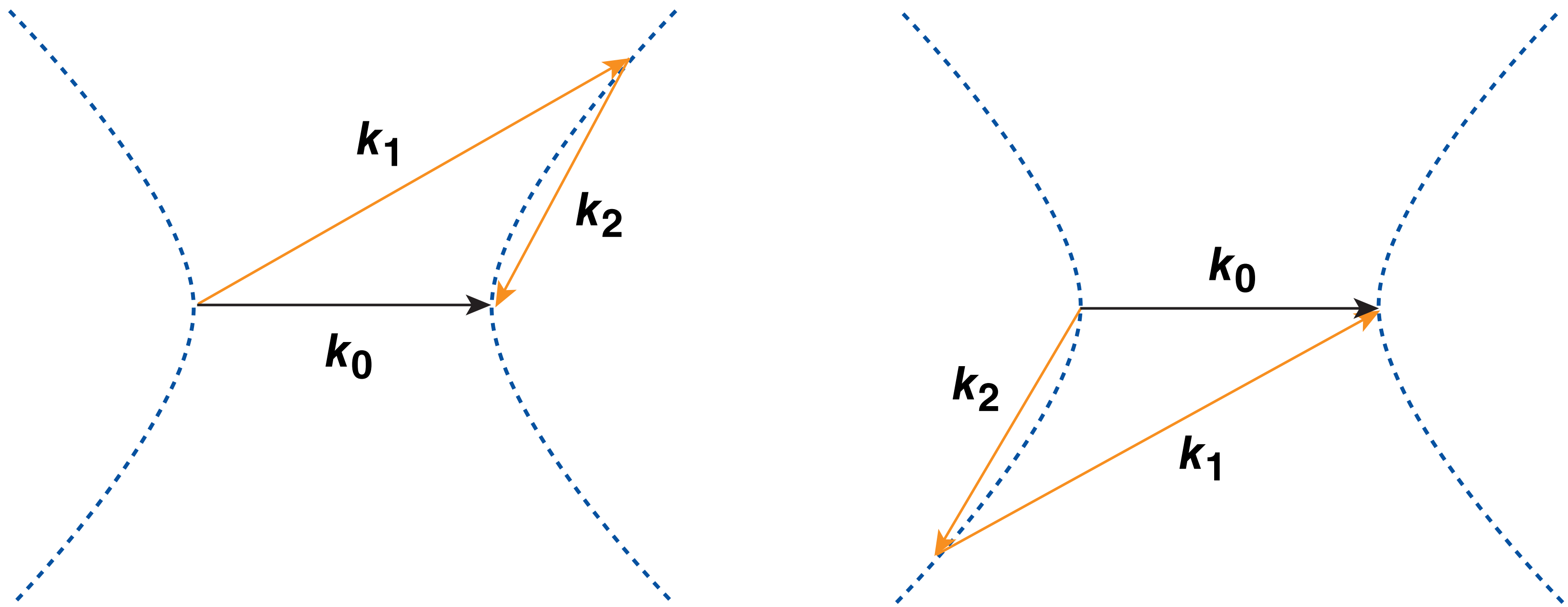
- For two beams polarized in their common plane, there is a collectively driven convective mode at large plasmon wave vectors
- Two beams polarized out of their common plane drive a collective mode near $k = 0$; this mode may be absolute
- Polarization smoothing divides the gain between large- and small-$k$ modes
- For larger numbers of beams, the small-$k$ modes appear to be driven more strongly

# Collaborators

**J. F. Myatt, A. V. Maximov, D. T. Michel, D. H. Froula, and J. Zhang**

Laboratory for Laser Energetics
University of Rochester

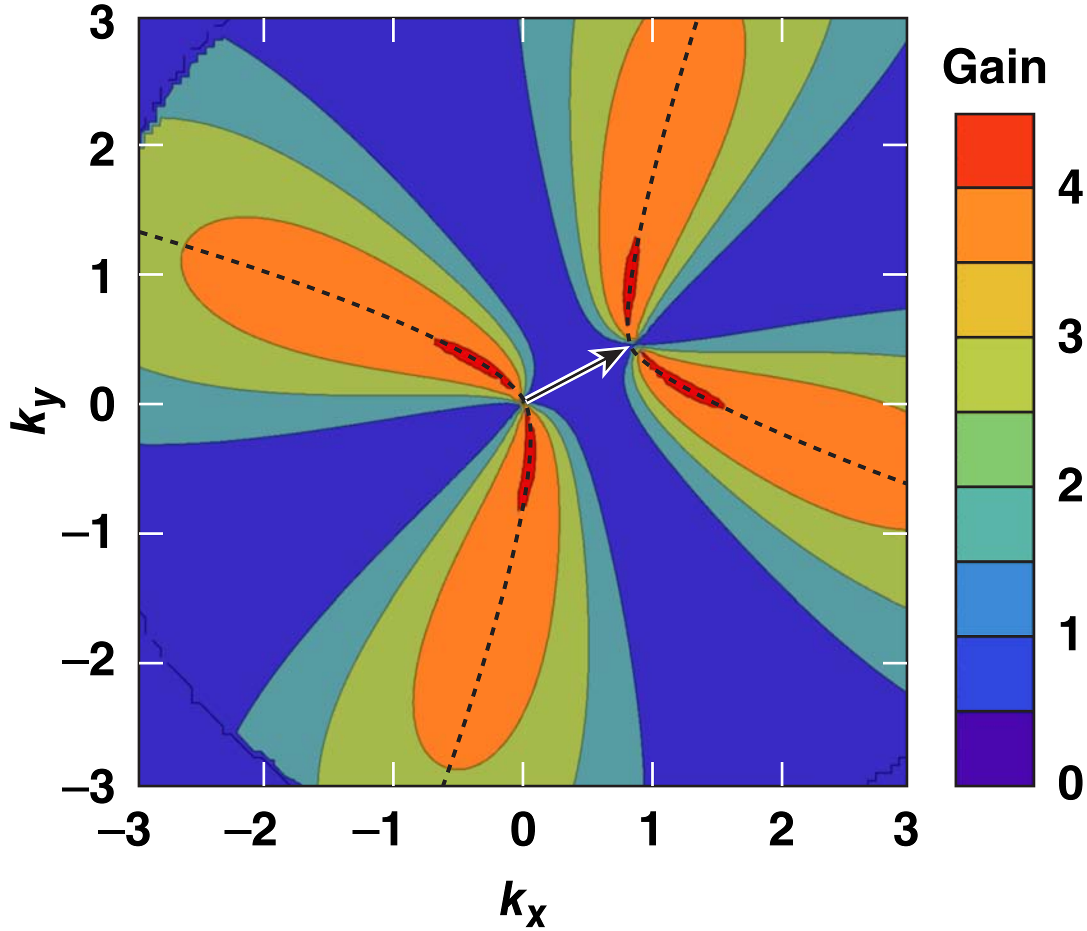
# The temporal growth rate for single-beam TPD is maximized on a hyperbola in *k* space




- The hyperbola lies in the plane of polarization
- Different points on the hyperbola correspond to decays occurring at different densities; larger wavevectors → smaller densities

TC10083

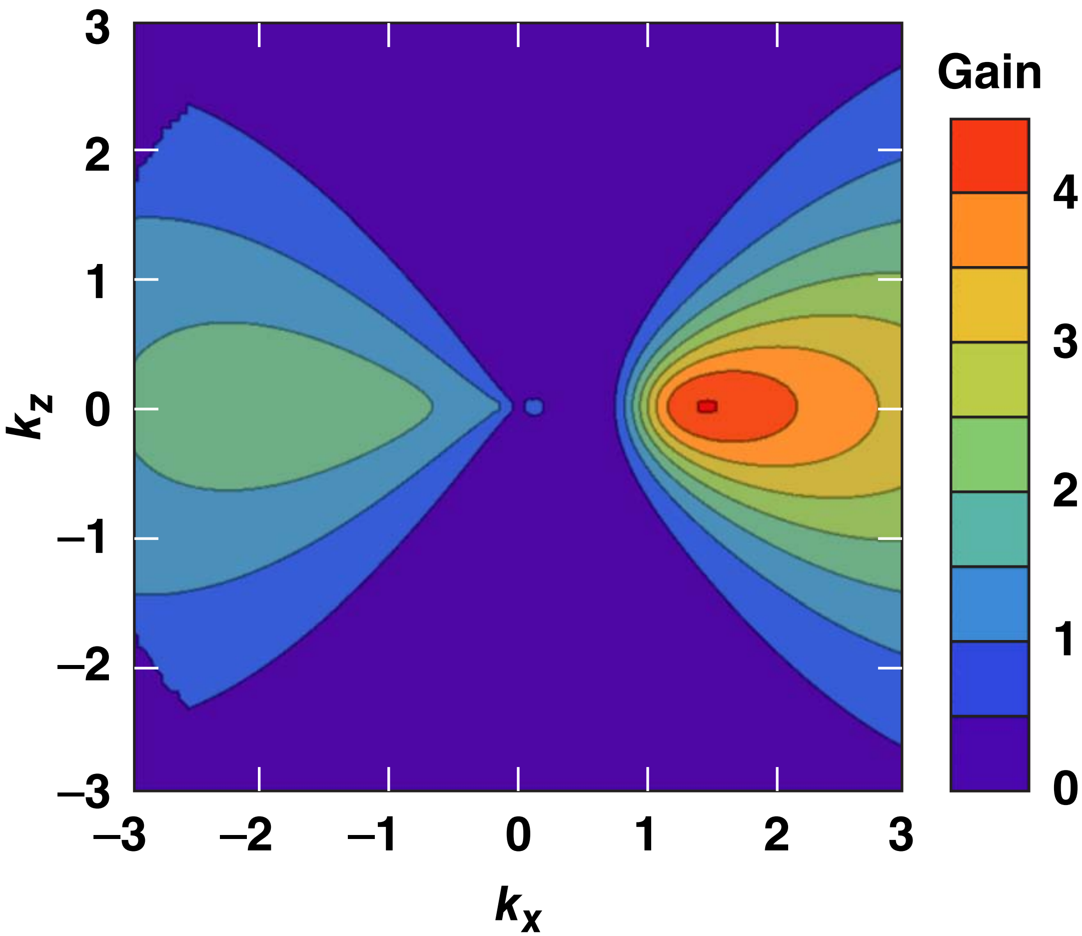
# A single beam shows maximal gain along the hyperbola




$I_{14}$ (single beam) = 1.0
$L_{\mu}$ = 300
$T_{keV}$ = 1.5
In-plane polarization

TC10084

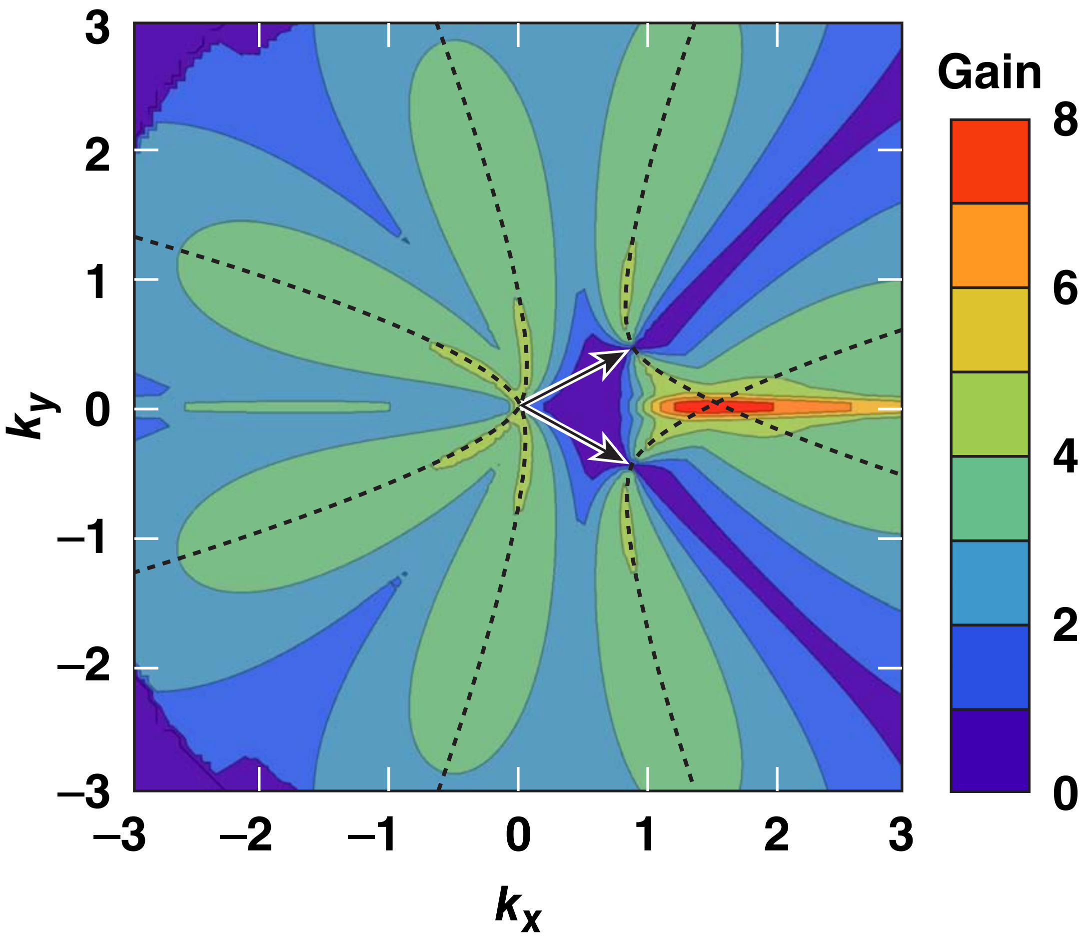
# The gain extends out of the plane of polarization




$I_{14}$ (single beam) = 1.0
$L_{\mu}$ = 300
$T_{keV}$ = 1.5
Out-of-plane polarization

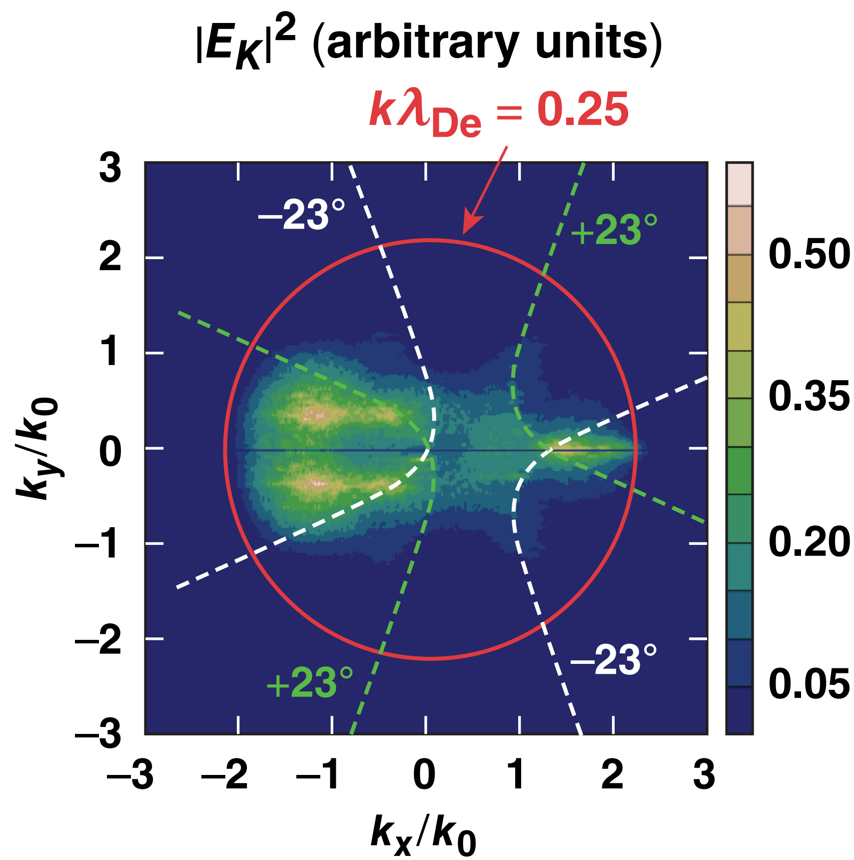
TC10085

# The expected gain enhancement is seen for two pump beams polarized in their common plane




$I_{14}$ (single beam) = 1.0
$L_{\mu}$ = 300
$T_{keV}$ = 1.5
In-plane polarization

# Similar features are seen in Zakharov simulations*, indicating that they persist in the nonlinear regime

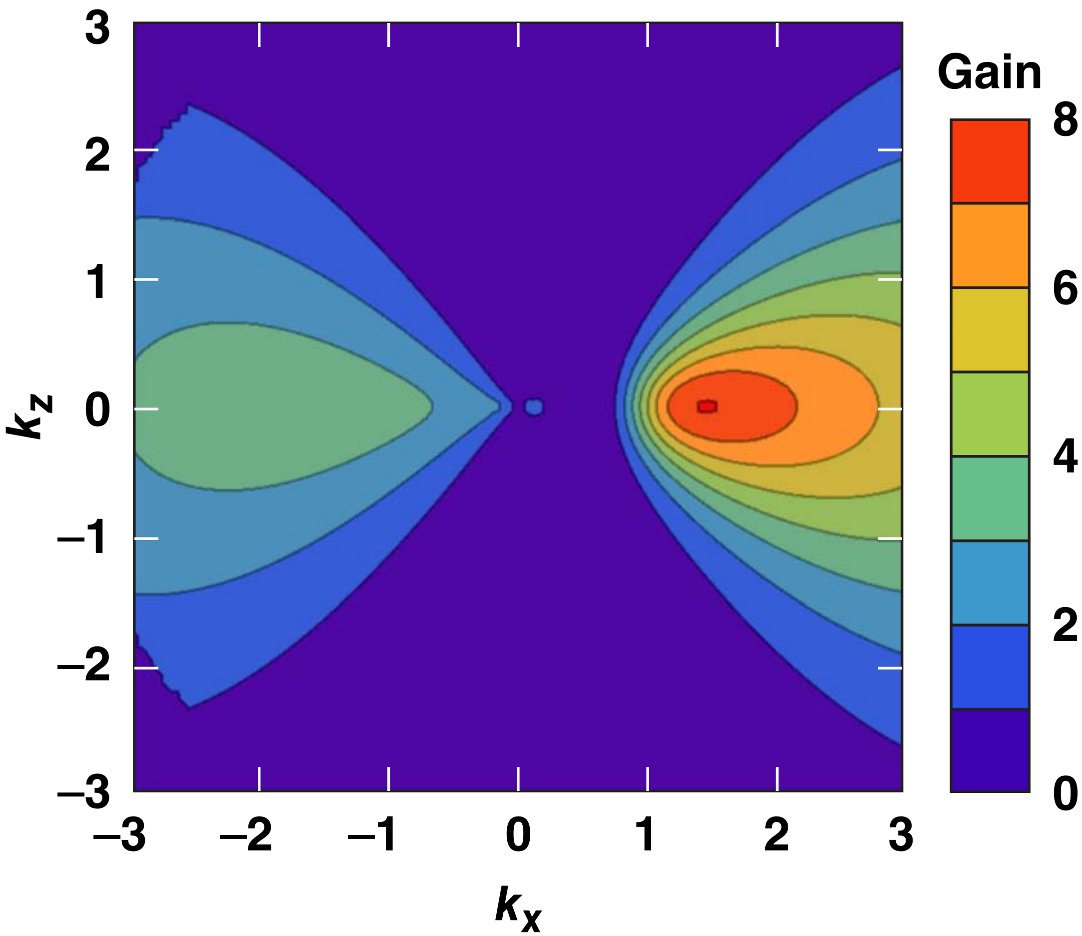



In-plane polarization

TC10087

* J. F. Myatt *et al.*, Phys. Plasmas 19, 022707 (2012).

# Out of the plane of polarization, the gain extends over a larger range of *k*



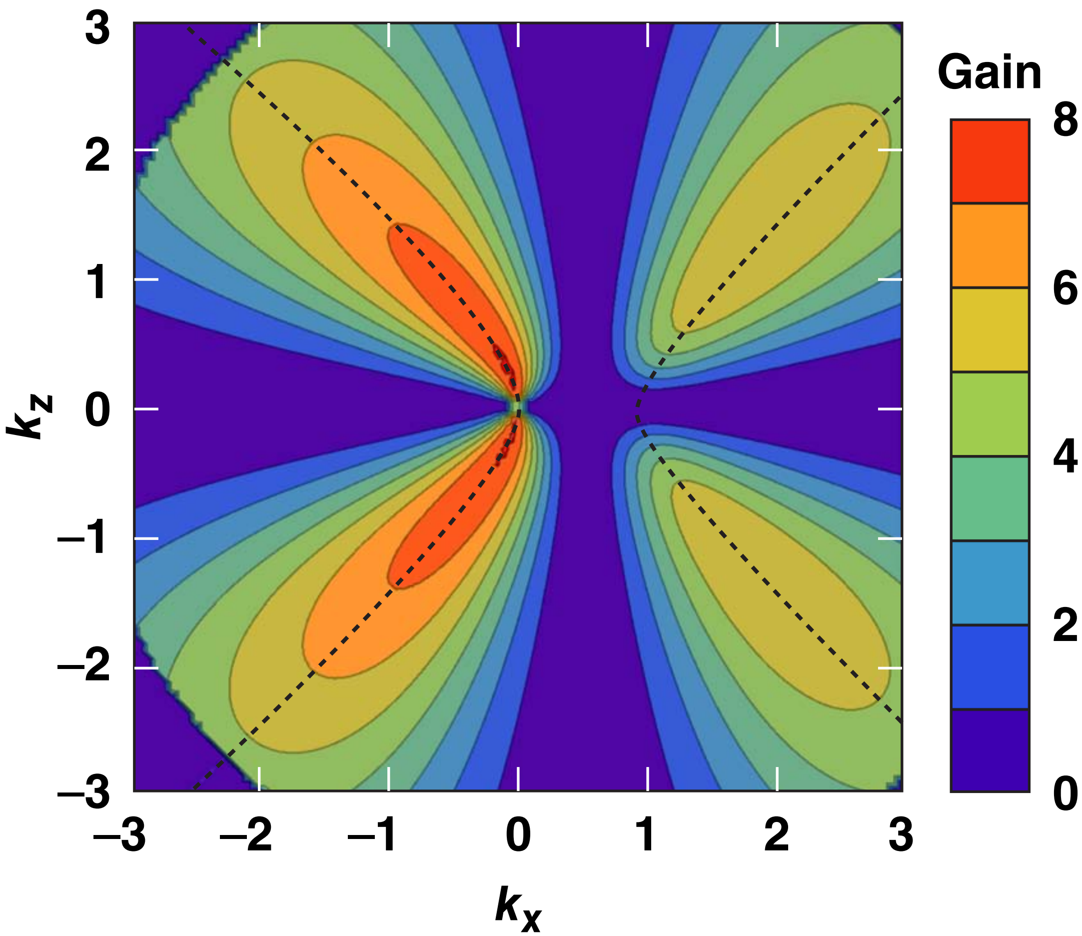

$I_{14}$ (single beam) = 1.0
$L_\mu$ = 300
$T_{keV}$ = 1.5
Out-of-plane polarization

TC10088

# The multibeam gain enhancement depends on the polarization of the beams

- When the beams are polarized in the plane of their wave vectors, enhanced gain is seen near the intersection of their associated hyperbolas
- The hyperbolas lie in the plane of polarization of the beams
- When the beams are polarized out of the plane of their wave vectors, one expects less enhancement because the hyperbolas no longer intersect (except for the singular point at the origin)
- But near the origin they are very close….

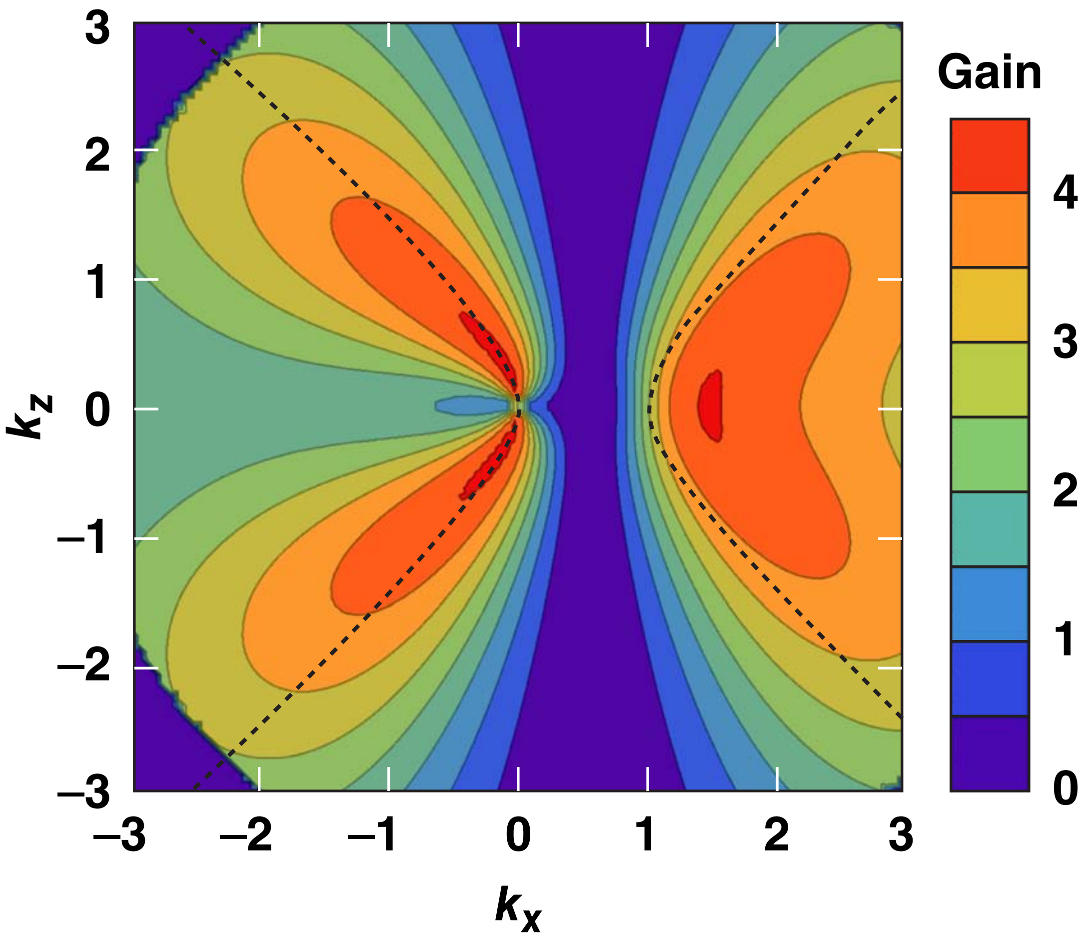
# When the beams are polarized out of their common plane, enhanced gain is seen near the origin (but not on the axis of symmetry of the beams)




$I_{14}$ (single beam) = 1.0
$L_\mu$ = 300
$T_{keV}$ = 1.5
Out-of-plane polarization

TC10090

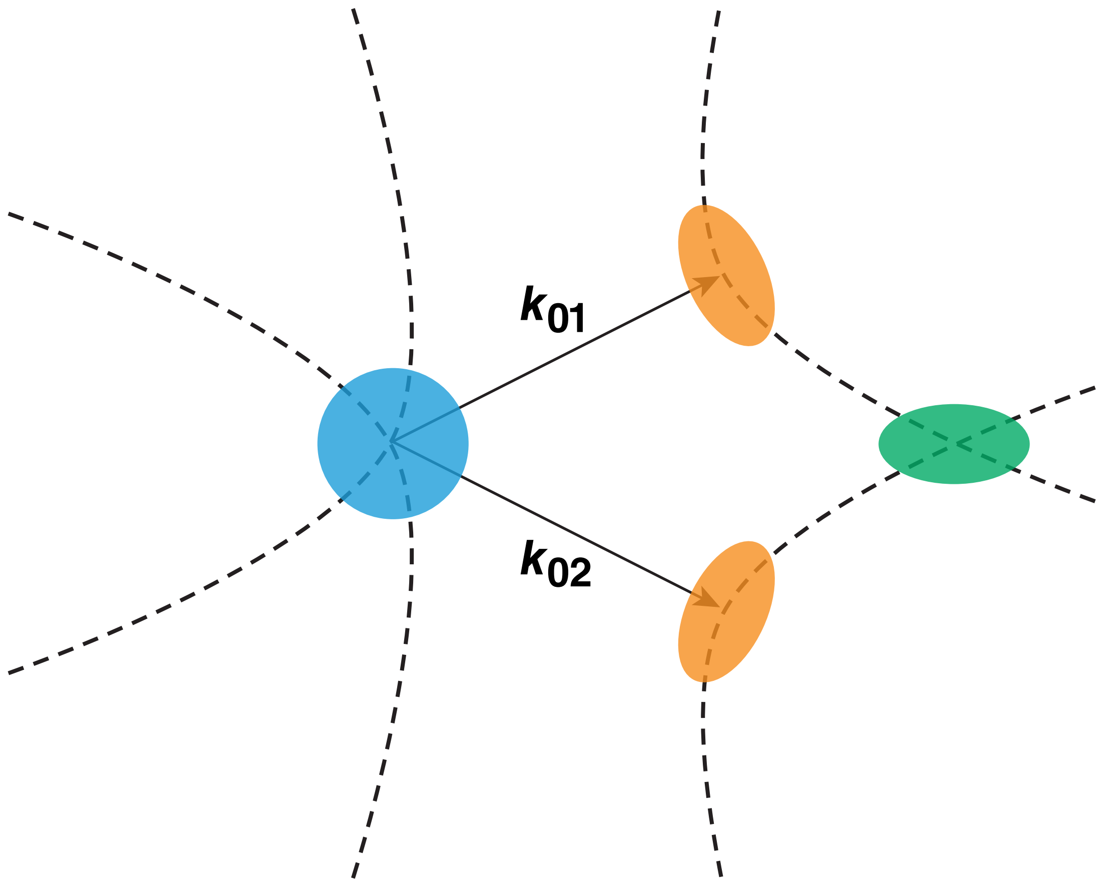
# Polarization smoothing distributes the gain between the large- and small-*k* modes




$I_{14}$ (single beam) = 1.0
$L_\mu$ = 300
$T_{keV}$ = 1.5
Polarization smoothing

TC10091

# The presence of enhanced gain near the origin raises the possibility of absolute instability there



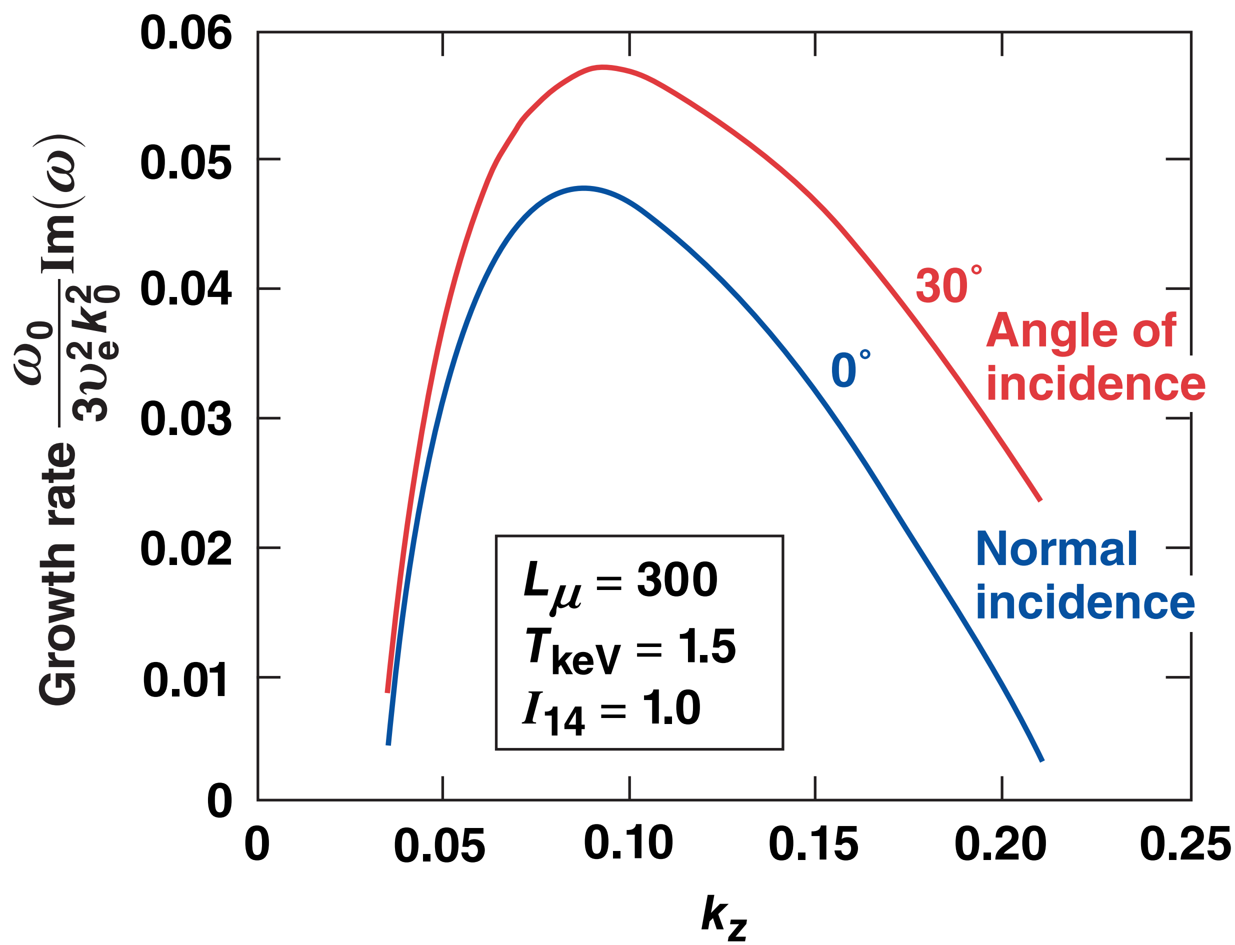

Two beams polarized in their common plane

Orange: region of absolute instability
Green: region of overlapped convective gain

Two beams polarized out of their common plane

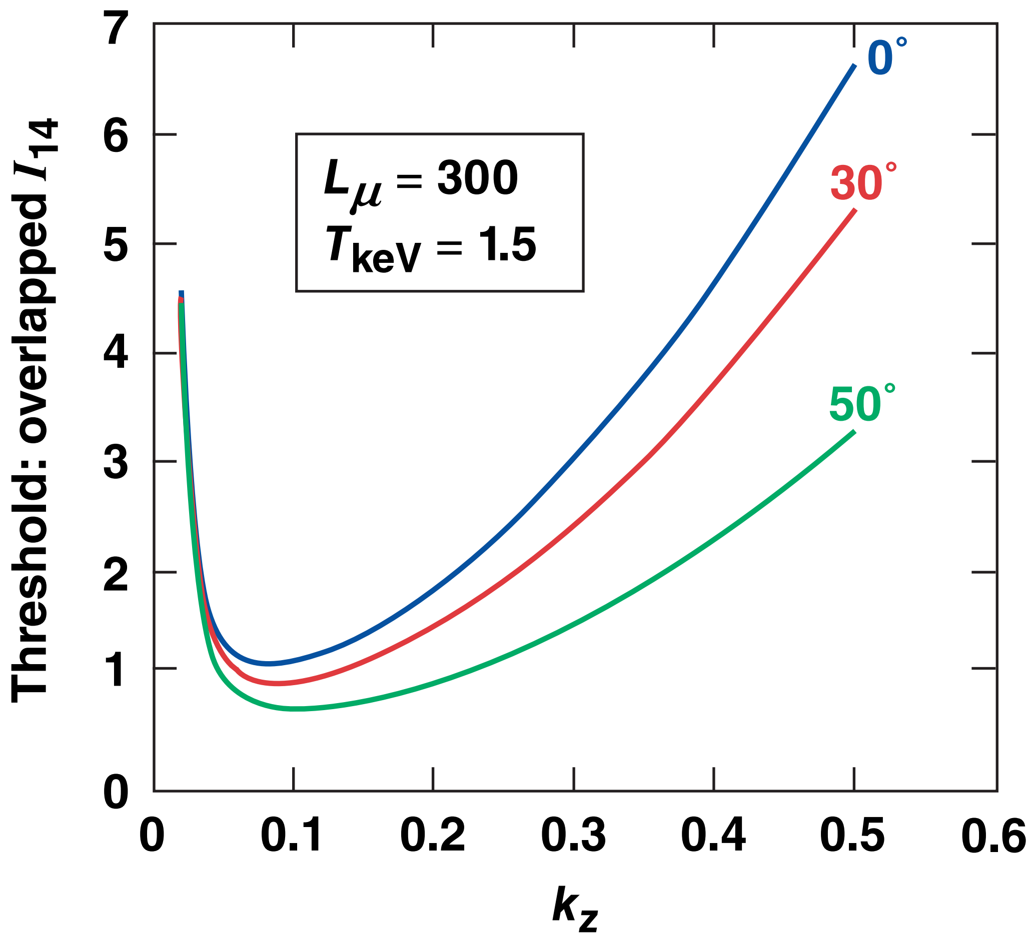
Blue: region of overlapped absolute instability

# As in the normal incidence case, the absolute instability is localized at small $k$



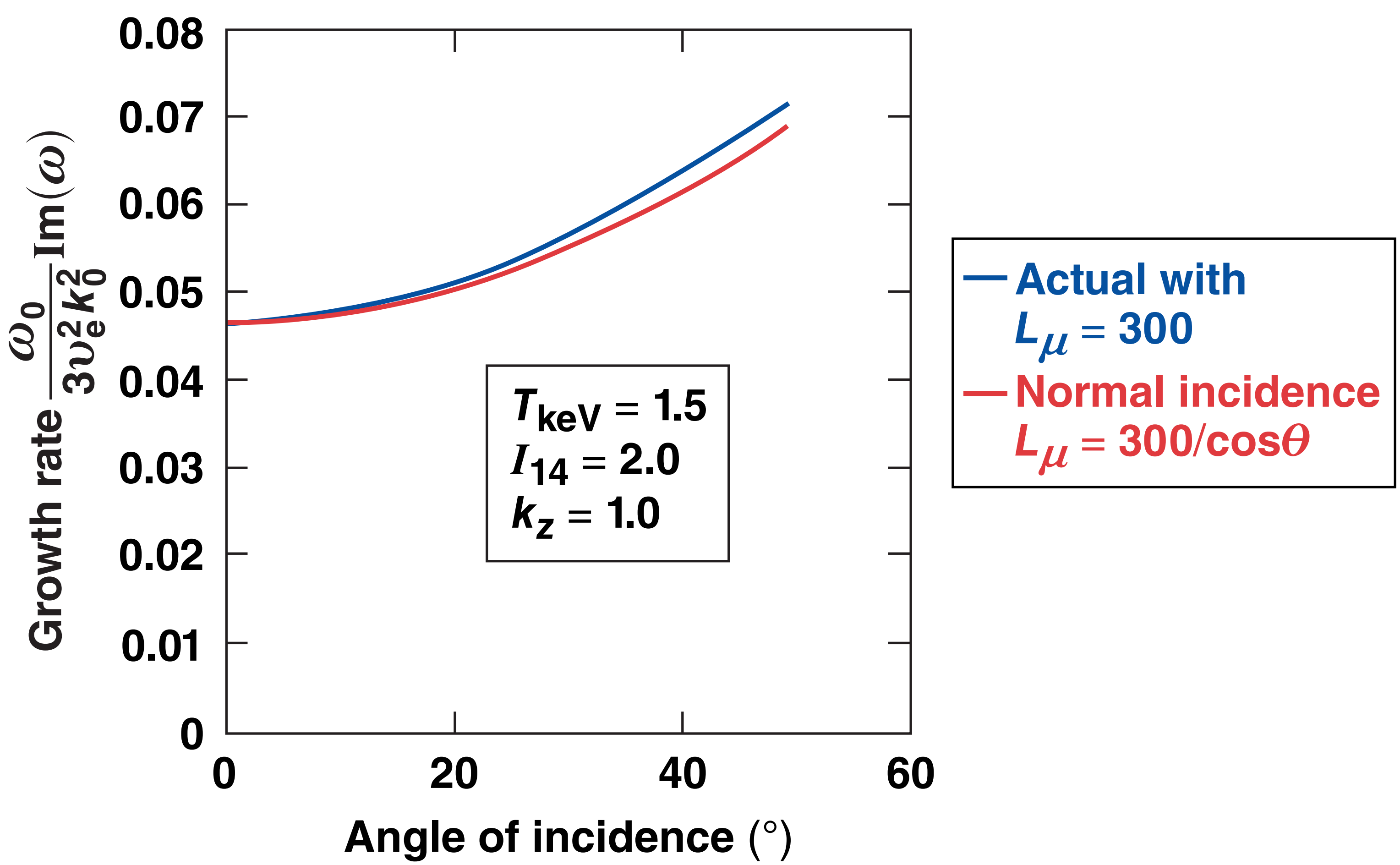

TC10093

# The absolute TPD thresholds diminish with increasing angle of incidence



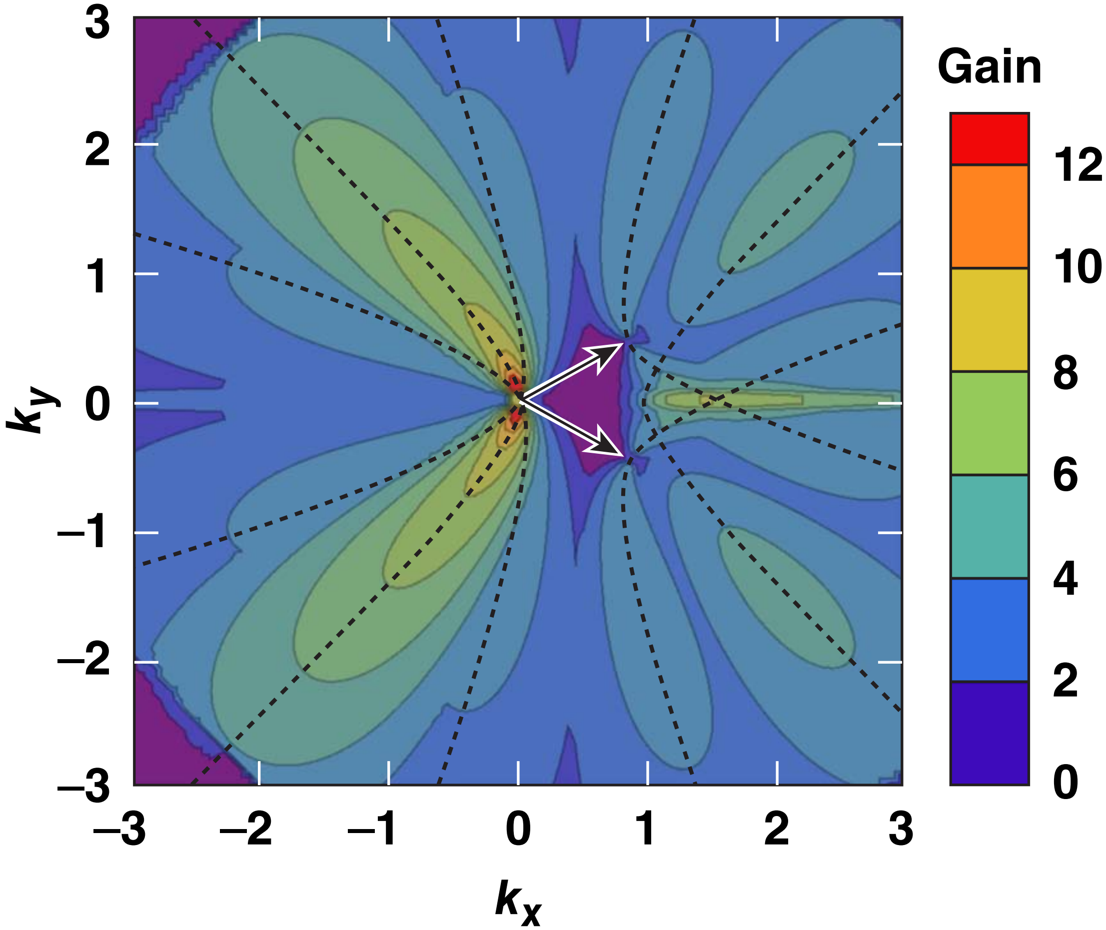

TC10094

# The enhancement of TPD with increasing angle of incidence appears to result largely from the increasing effective scale length




TC10095

# For four beams the maximum TPD gain occurs off the axis of symmetry

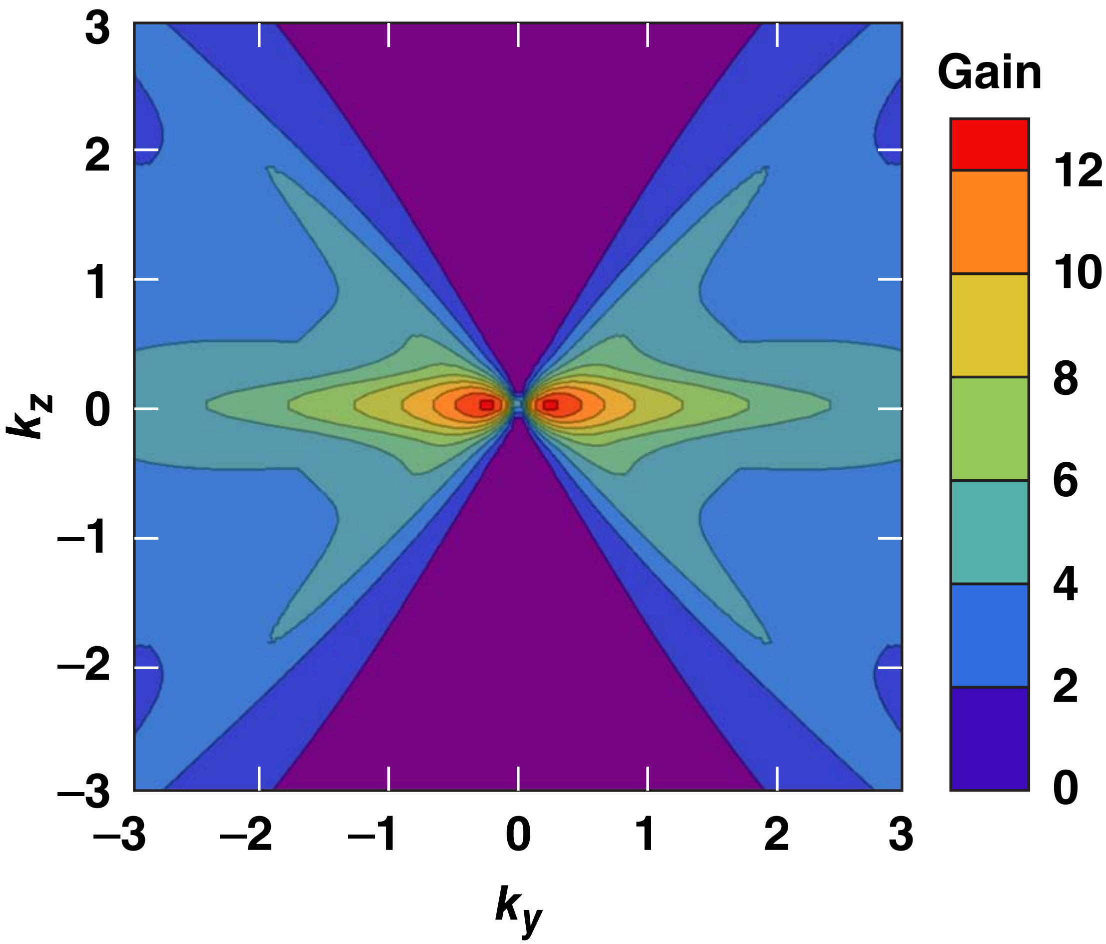



**All beams polarized in the x–y plane**

**$I_{14}$ (single beam) = 1.0**
**$L_\mu$ = 300**
**$T_{keV}$ = 1.5**

TC10096

## For four beams, the maximum convective gain (~75% of single-beam gain) occurs at small *k*; these modes are likely above the absolute threshold (infinite gain)




All beams polarized in the x–y plane

$I_{14}$ (single beam) = 1.0

$L_{\mu}$ = 300

$T_{keV}$ = 1.5

TC10097

Summary/Conclusions

# For multibeam TPD, the relative polarizations of the beams affect the absolute/convective nature of the instability as well as the gain

- For two beams polarized in their common plane, there is a collectively driven convective mode at large plasmon wave vectors
- Two beams polarized out of their common plane drive a collective mode near $k = 0$; this mode may be absolute
- Polarization smoothing divides the gain between large- and small-*k* modes
- For larger numbers of beams, the small-*k* modes appear to be driven more strongly