Computational tools for AWAKE

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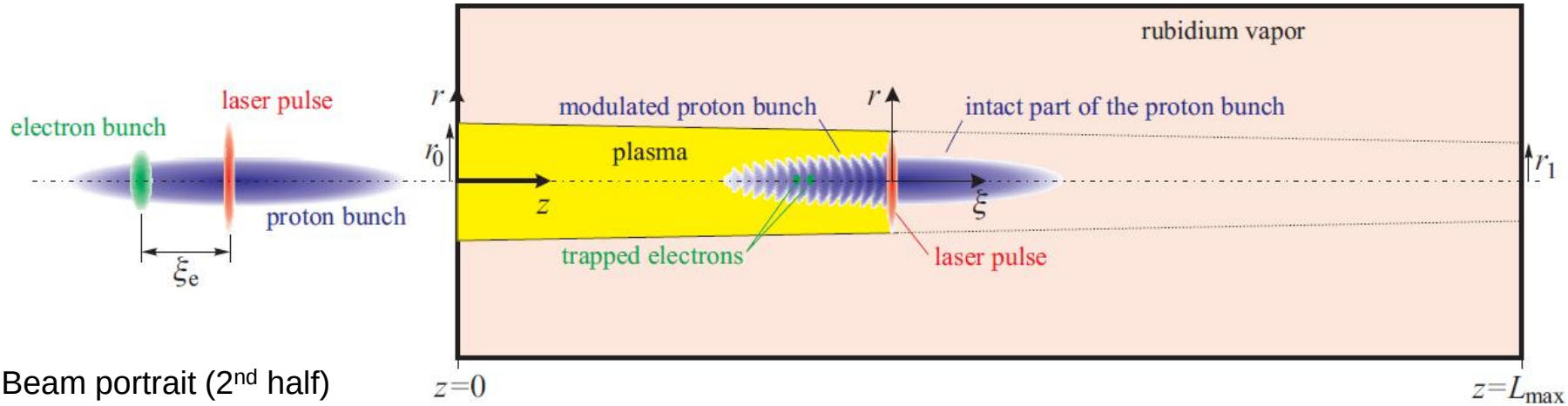
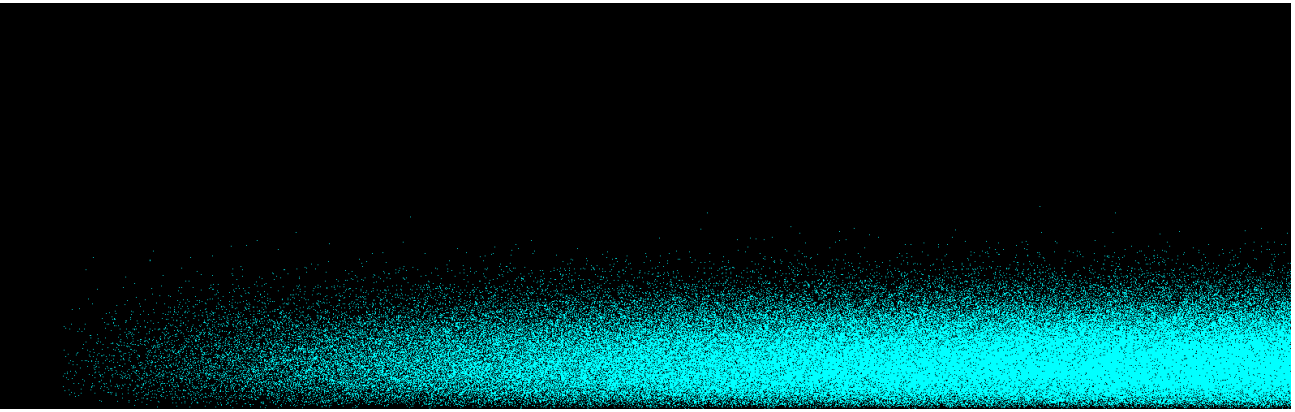
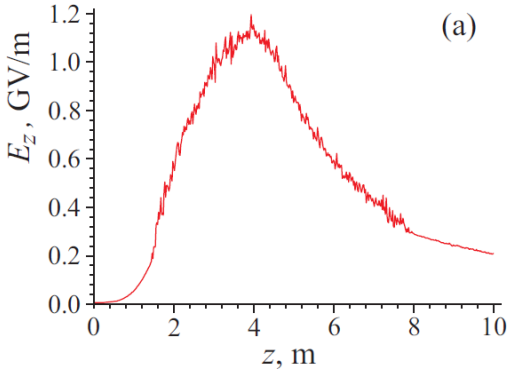
AWAKE Collaboration

What is AWAKE

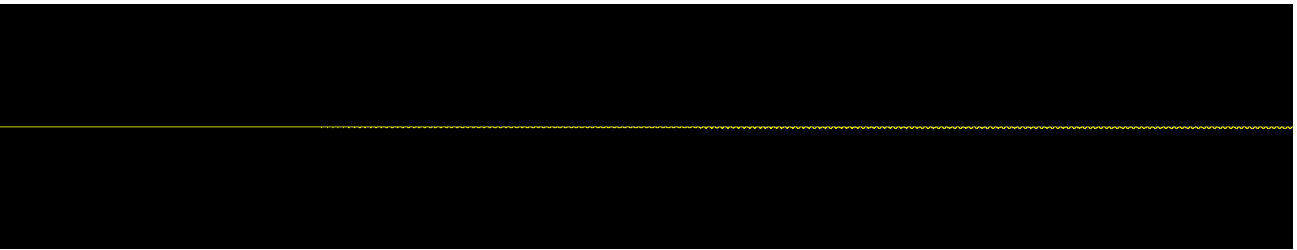


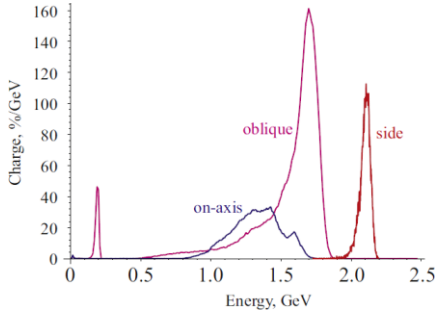
Beam portrait (2nd half)



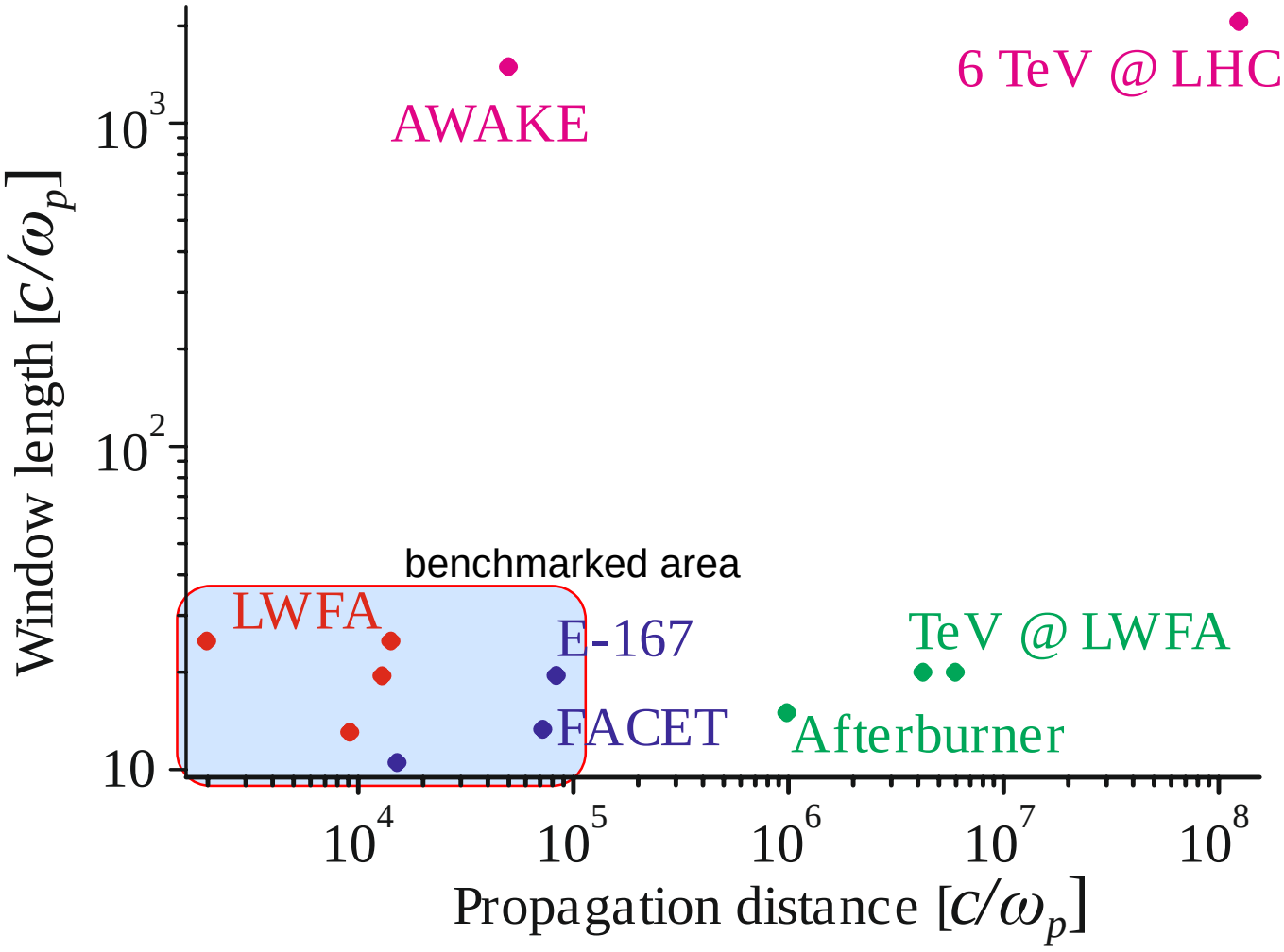


Excited field (Φ)





Why AWAKE is so special? It is far from the benchmarked area

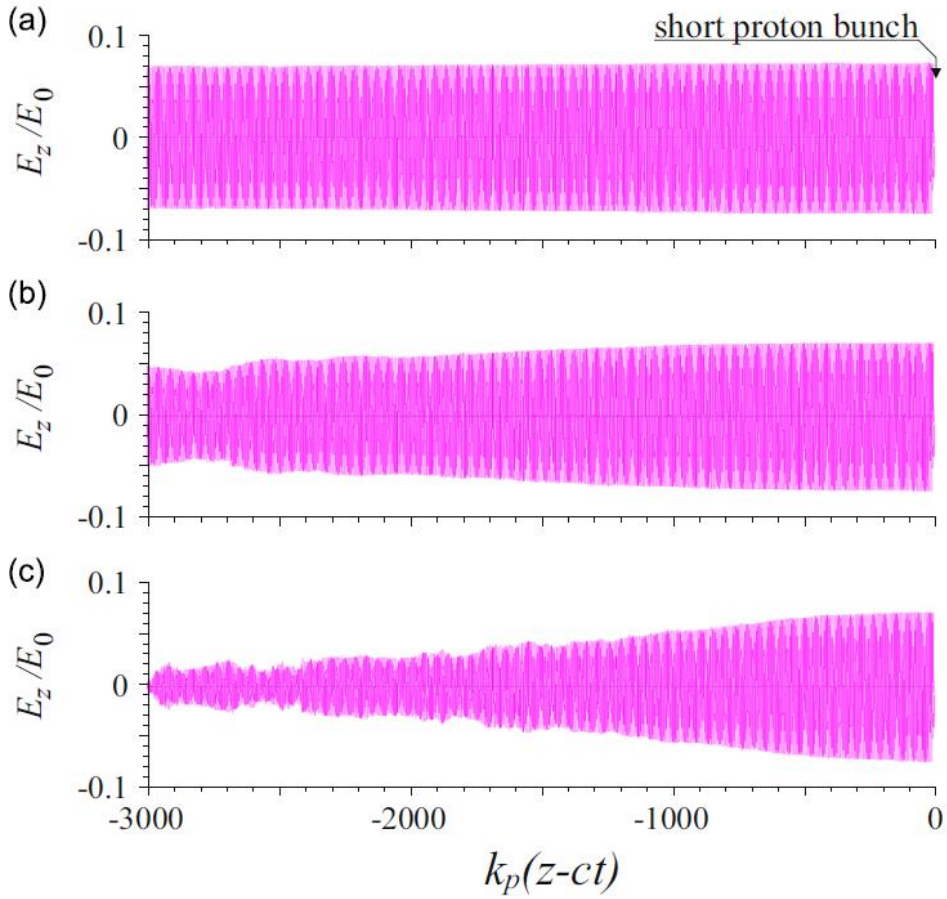


So AWAKE became a testing area for PWFA codes

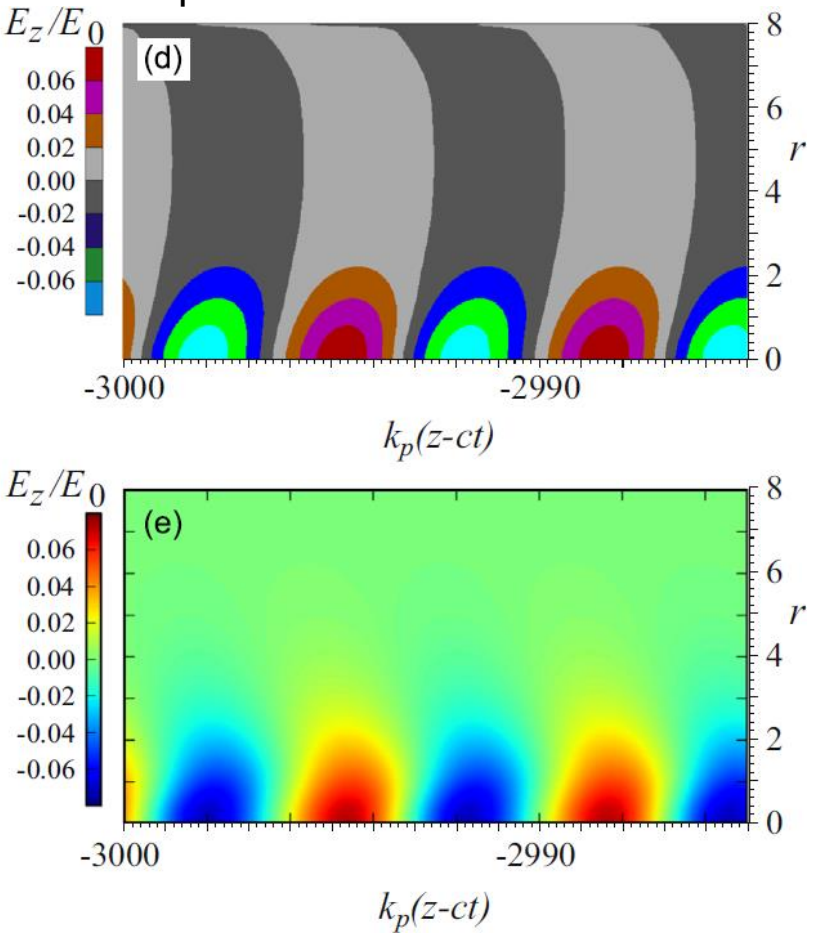
Special tests were developed to make sure the codes simulate basic physical effects correctly

Test 1: Long term behavior of a small-amplitude plasma wave

The amplitude must remain constant:

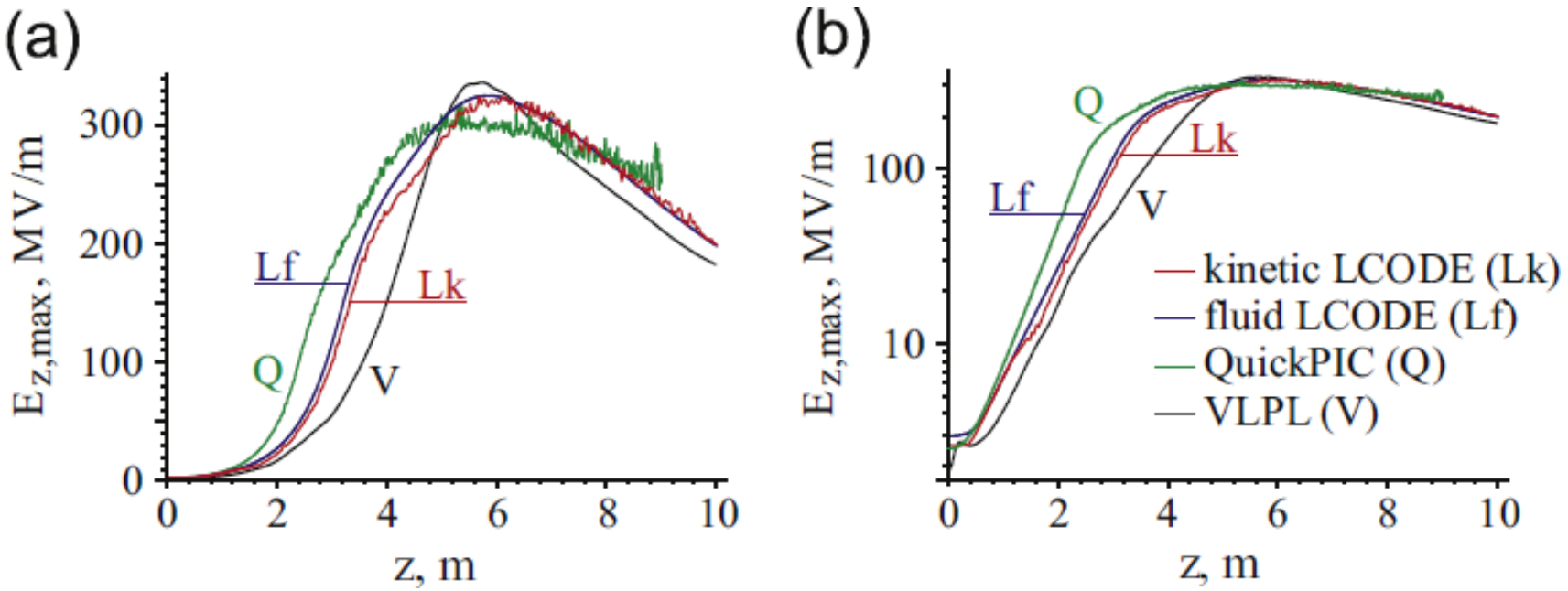


The period must be close to 2π,
no phase shift after 500 oscillations:



Special tests were developed to make sure the codes simulate basic physical effects correctly

Test 2: Growth of the seeded self-modulation instability.

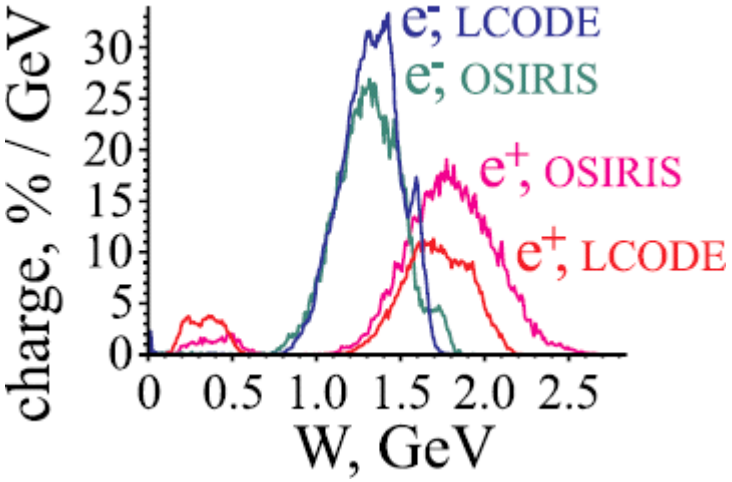


The growth rate and saturation amplitude must be the same

Finally, a good agreement was reached

Same instability growth rates
Same saturation fields
Same dynamics of injected electrons
Same beam loading effects

Same final energy spectra of accelerated electrons:



Codes participated in AWAKE studies and cross-checks:

LCODE 2d PIC quasistatic – fast, now used for parameter scans and predicting results of experimental diagnostics
OSIRIS 2d PIC – used for cross-checks and for studies at low plasma densities
VLPL 3d PIC – fundamental studies at lower plasma densities
LCODE 2d fluid quasistatic – very fast, earlier studies at lower beam populations
QuickPIC 2d – fast quasistatic, used for benchmarking only
VLPL 3d PIC quasistatic – fast, recently developed, studies of non-axisymmetric problems

If the experiment will confirm predictions made with the codes, then we can safely use these codes for attacking new parameter areas (higher energies, longer propagation distances, HEP applications)

Messages of my talk:

Even old and reliable codes need cross-checks when entering new parameter areas

Several codes agree between themselves in AWAKE-like studies, and any new code willing to enter this area must pass basic tests before its results can be taken seriously.

Experiments in new parameter areas are important not only for new physics, but also as ultimate tests for codes. These tests make possible next steps into new unexplored areas.

Thank you