The Early-phase Growth of ULF Waves in the Ion Foreshock observed in a Hybrid-Vlasov Simulation

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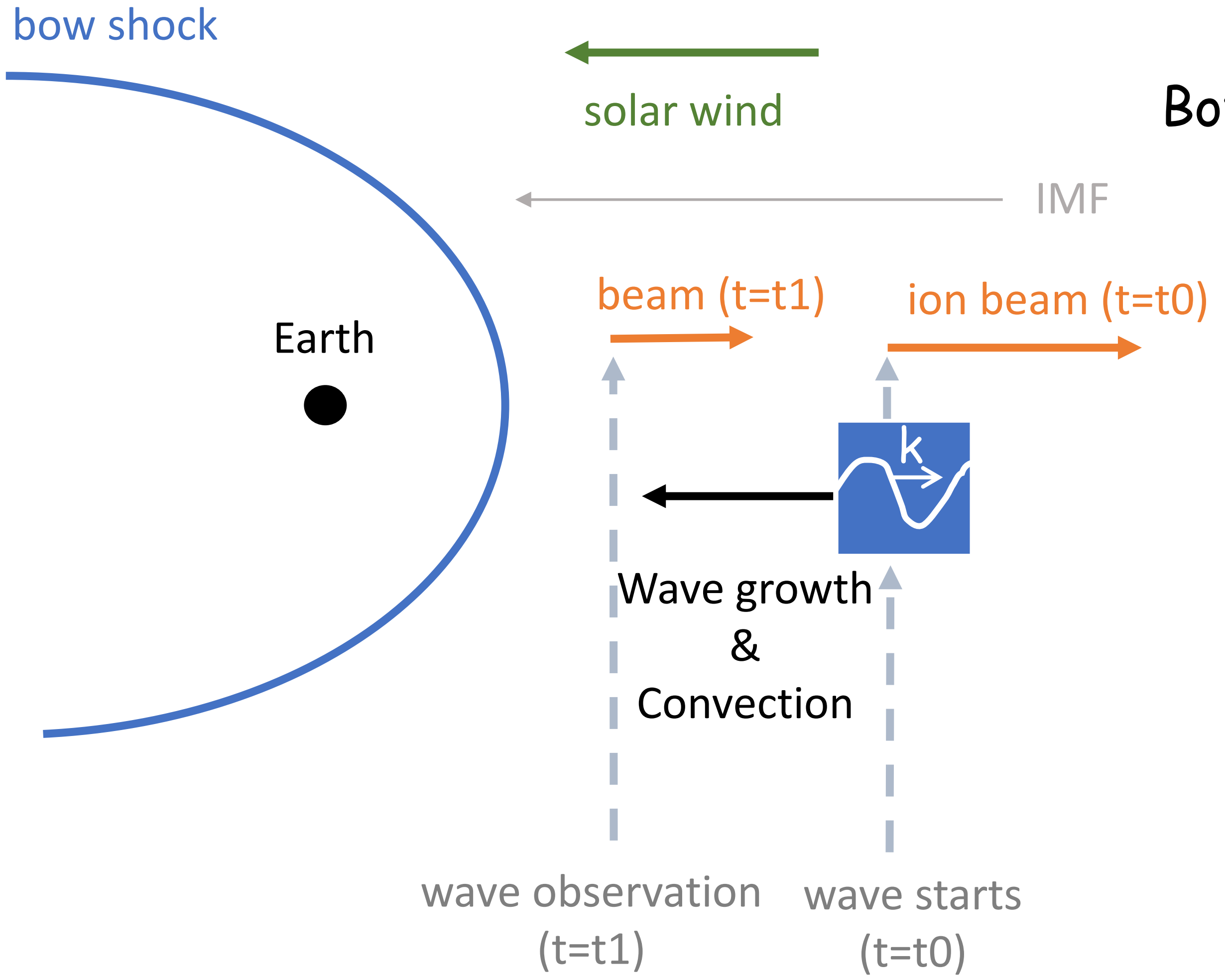
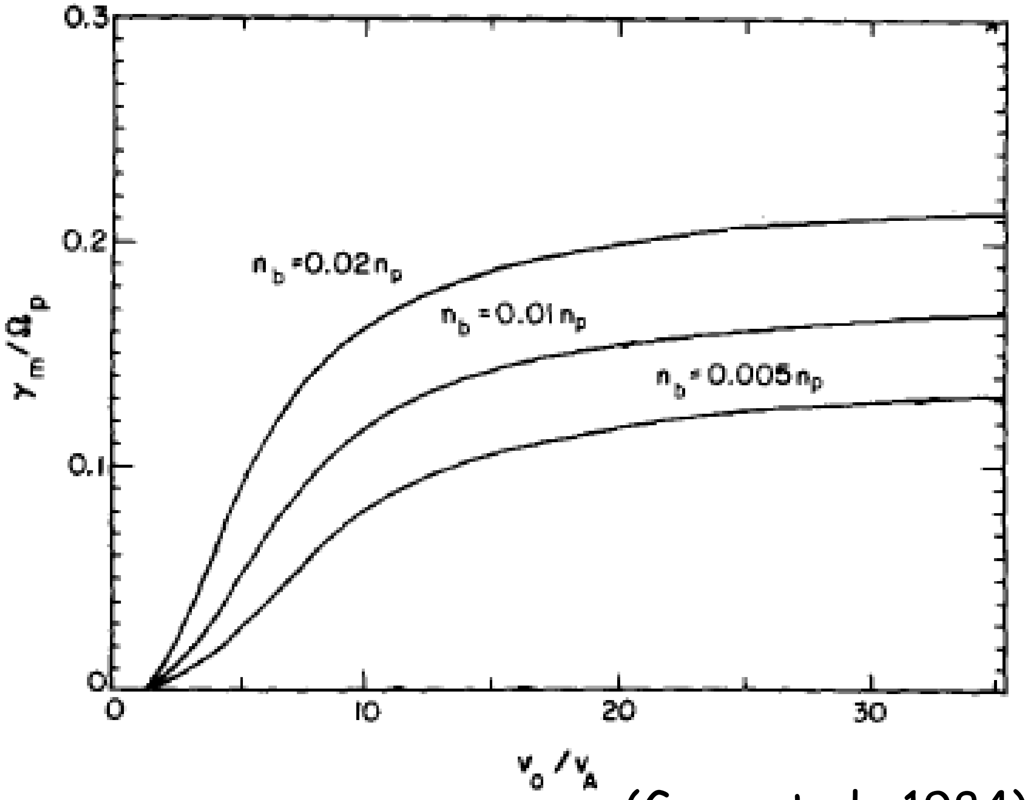
Ion beams in the foreshock generate ULF waves



Both beam density and velocity affect wave growth

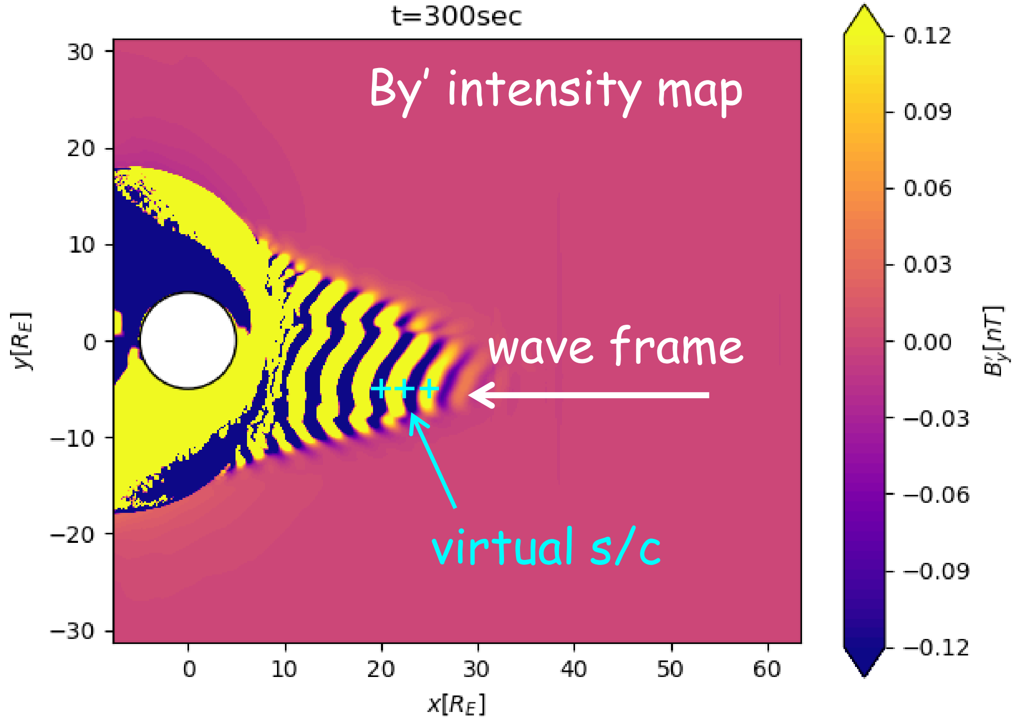


(Gary et al., 1984)

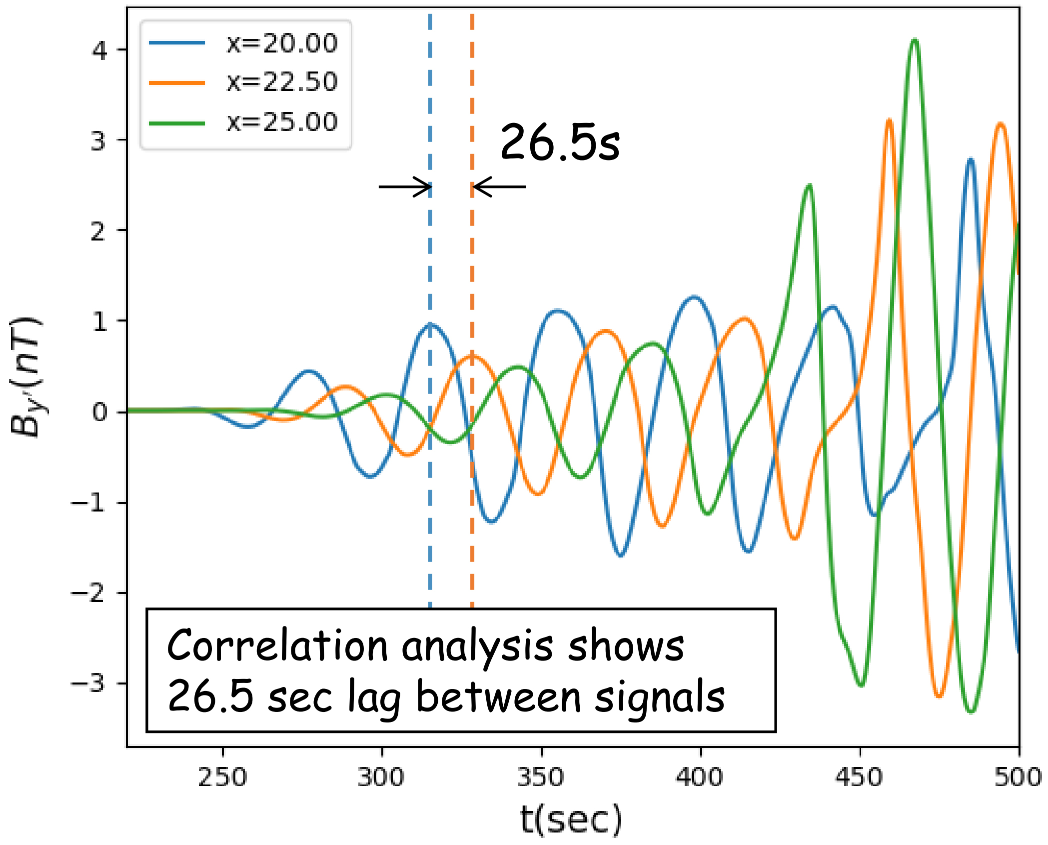
Measurements at multiple points are needed to properly observe the wave growth.

Vlasiator (hybrid-Vlasov simulation)

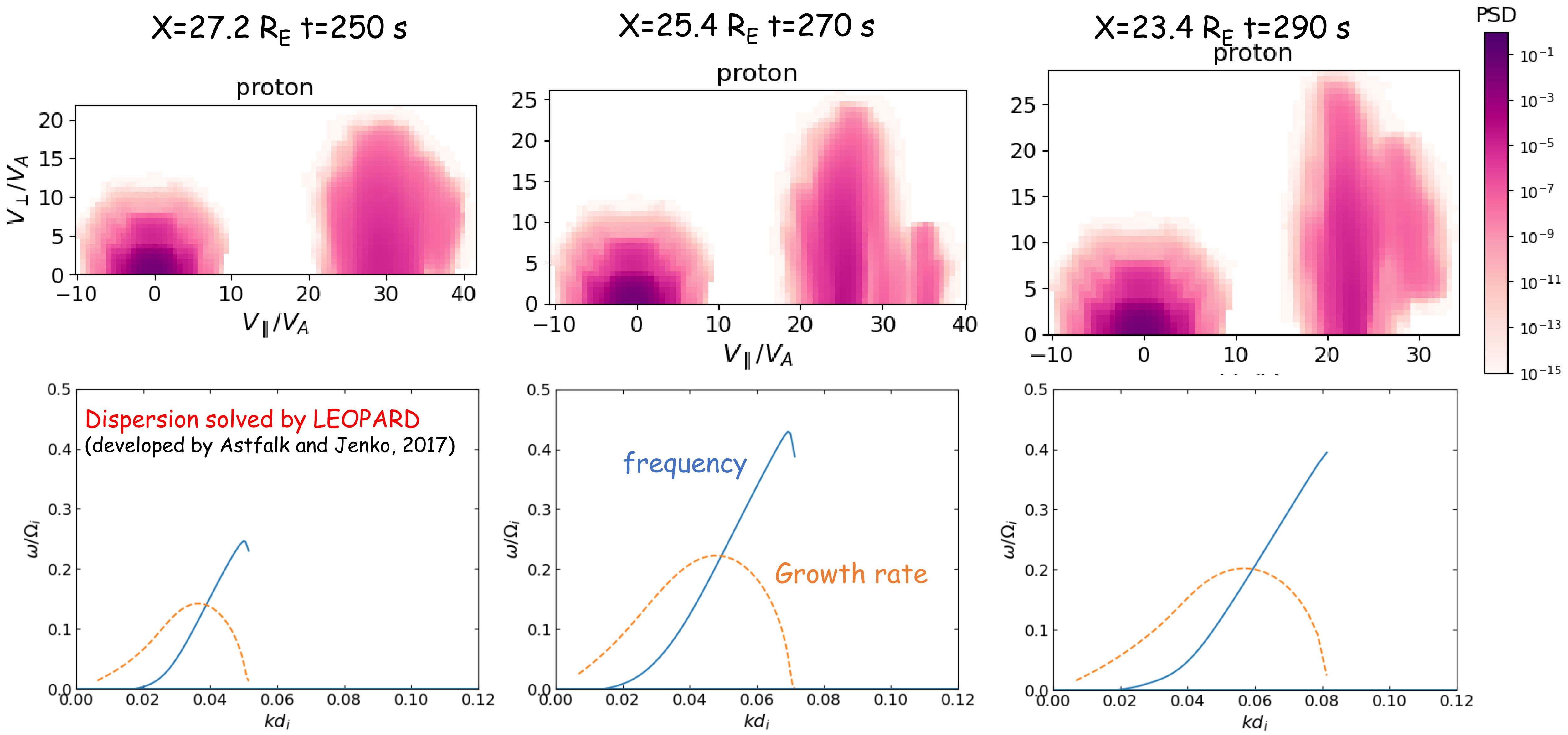
- Can resolve ion kinetic physics
- Electrons as charge-neutralizing fluid
- IMF: 5nT, v_{sw}=600 km/s,
  Mach number=10
- Provides both field and particle (ion) data throughout the simulation domain



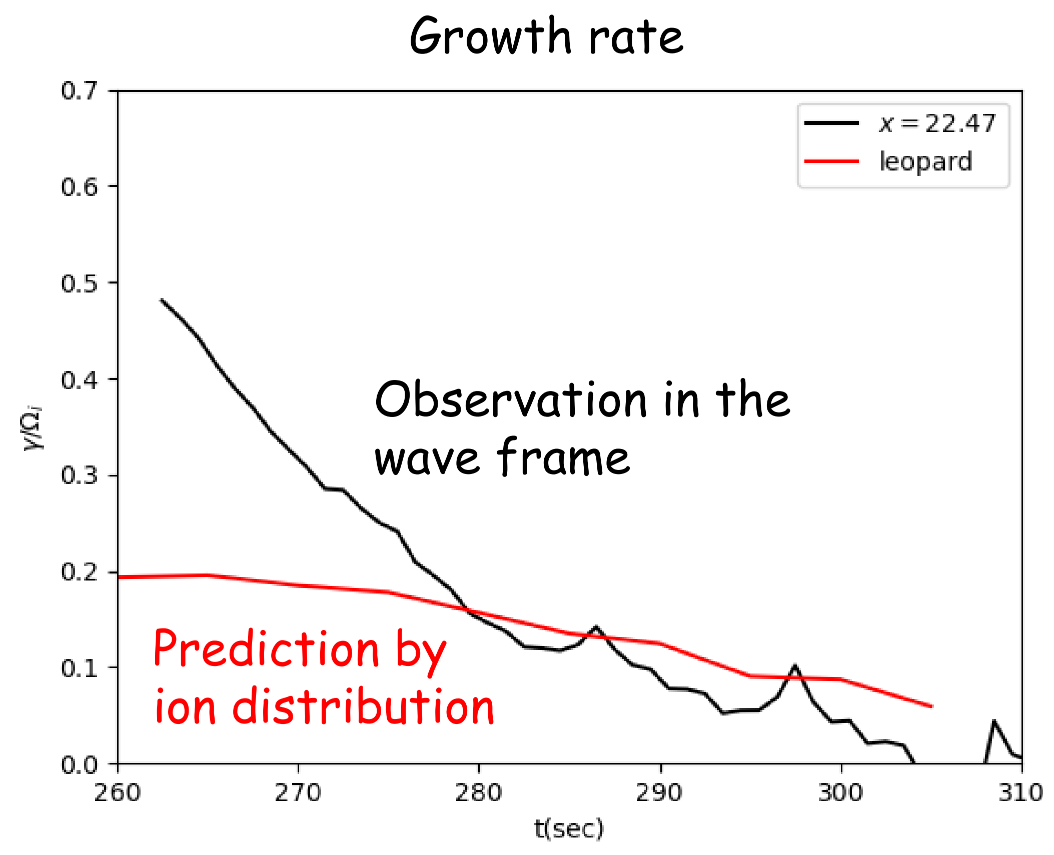
Determine the wave speed

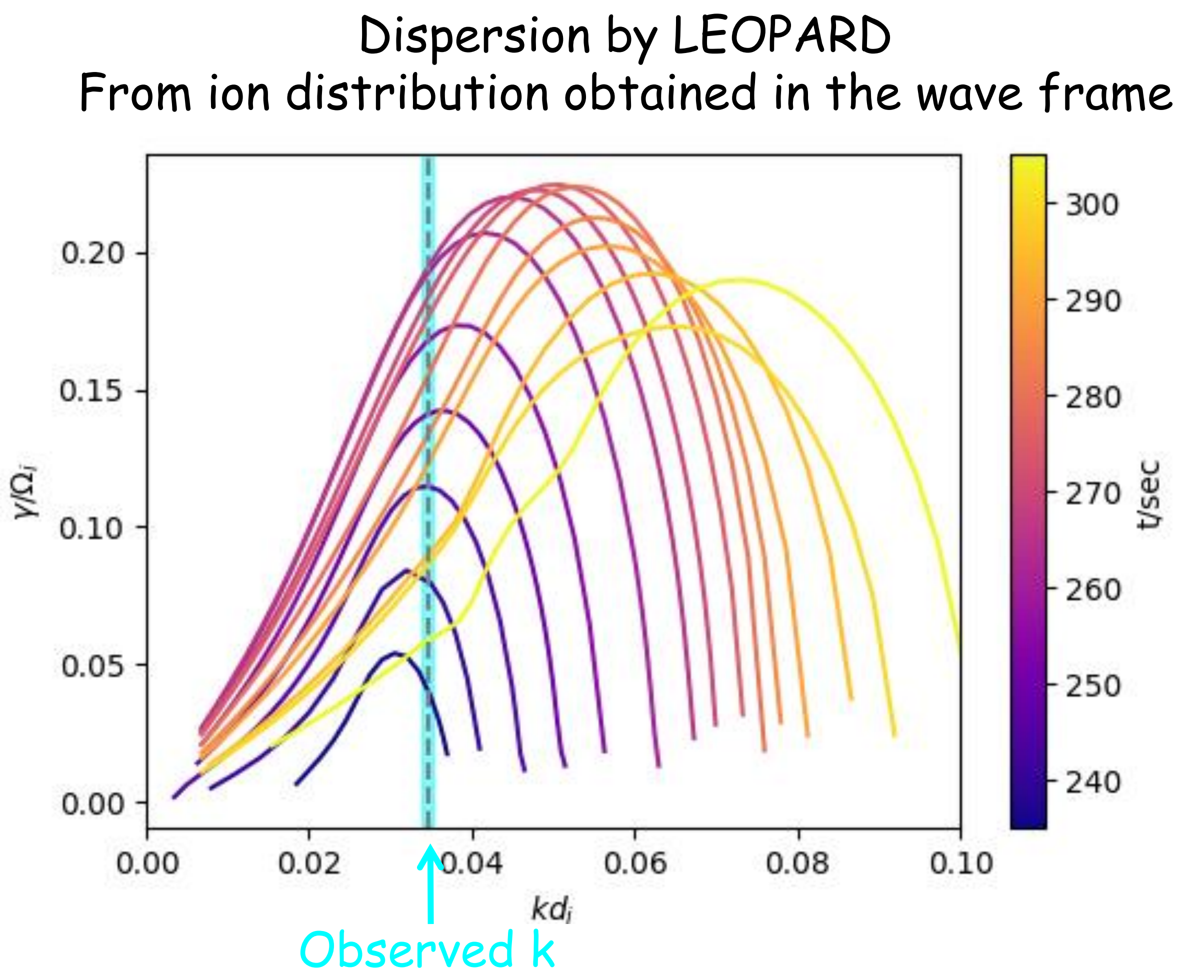


Tracking the beam property variation in the wave frame



Wave growth observed in the wave frame compared to theoretic prediction





- The observed growth rate agrees with theoretic prediction at later times (t>~280 sec)
- The discrepancy at the beginning is not understood yet.

Summary

1. Proper measurements of the wave growth need to be done in the wave frame and requires measurements at multiple locations, so it's easier with global simulations.
2. Vlasiator simulation shows ion beams responsible for the ULF wave growth have very different distributions at different times, resulting in a varying wave growth rate.
3. For the first time, we measured wave growth in the wave frame and found the observed growth rate agrees with theoretic prediction at later times.

Thank you!