

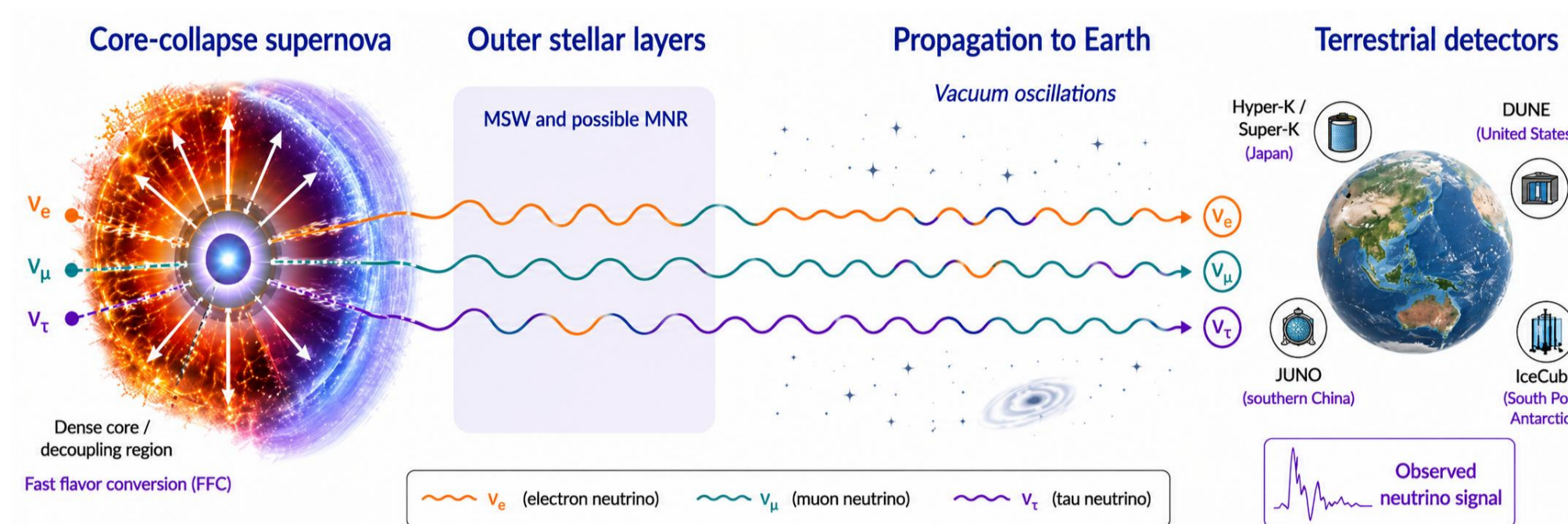
# Fast Neutrino Flavor Conversions and Their Impact on Supernova Neutrino Signal Predictions

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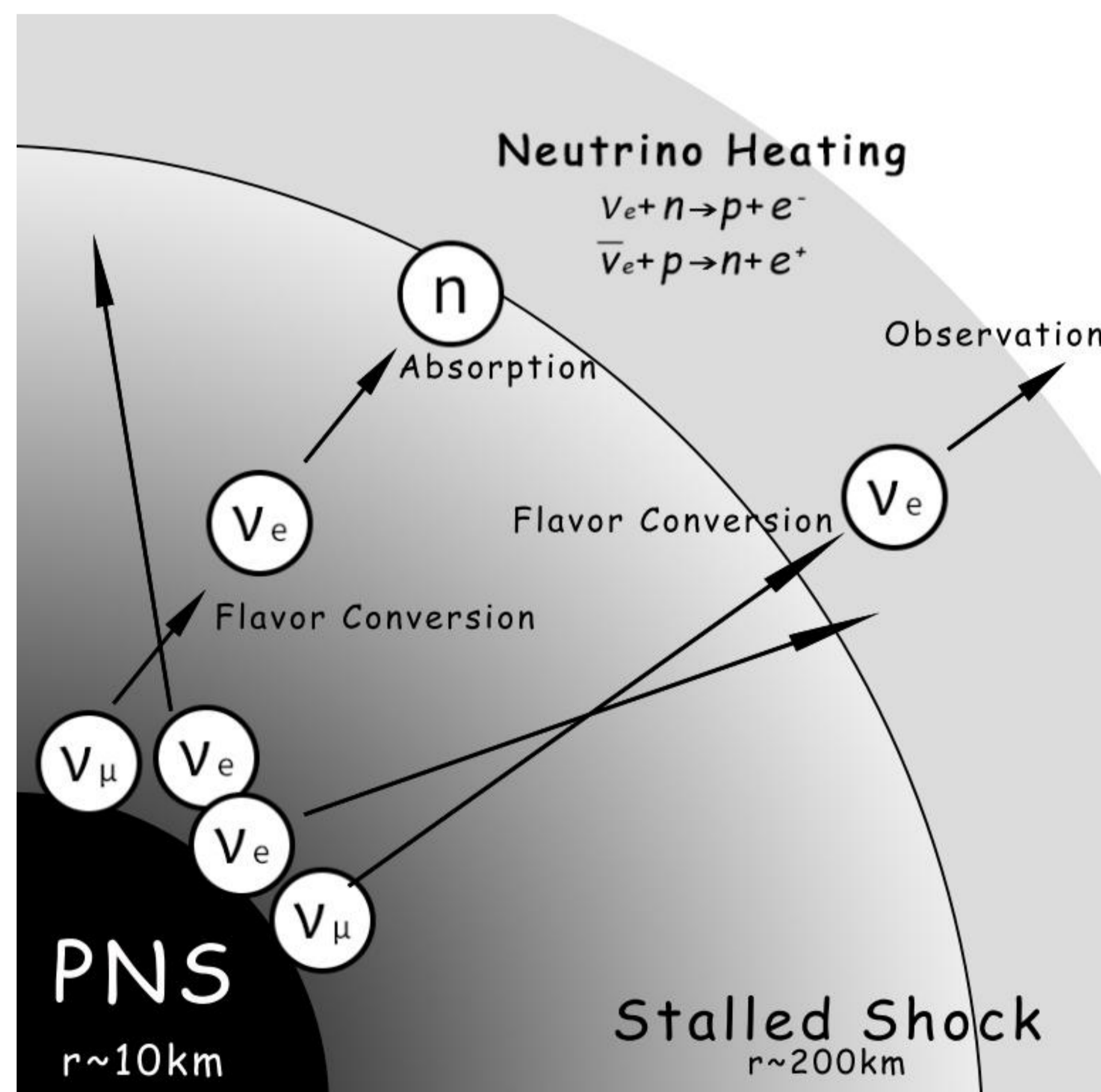
## From a Supernova Core to Earth Detectors



Flavor conversion **reshapes the neutrino signal** before detection.

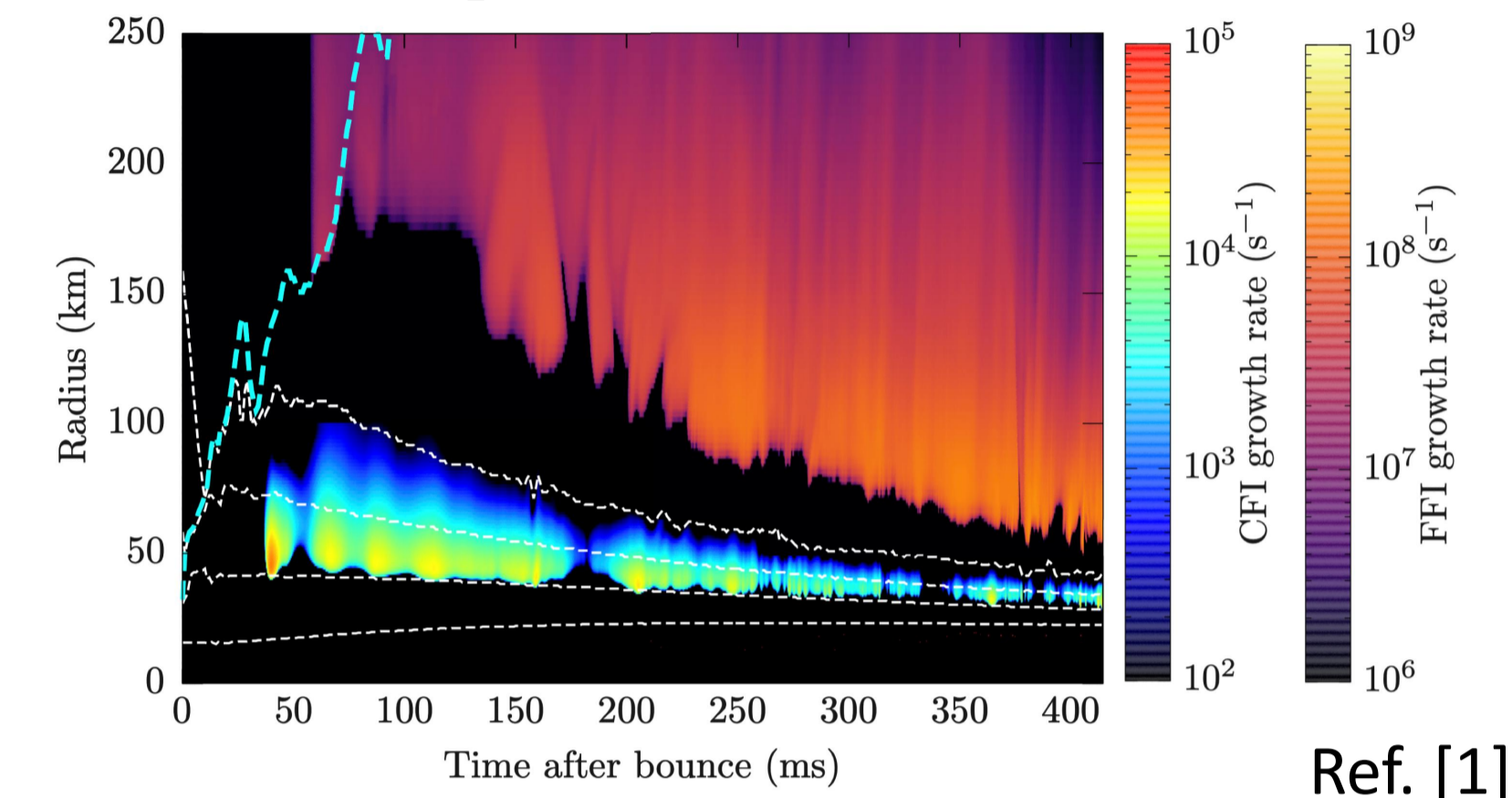
Dense core: FFC near the decoupling region  
Outer layers: MSW / possible MNR  
To Earth: vacuum oscillations

## Collective Flavor Conversions in Dense Media



Near the PNS, neutrino density is high. **Neutrino self-interactions** make flavor evolution **nonlinear**.  
Flavor conversion changes CCSN dynamics and observable signals.

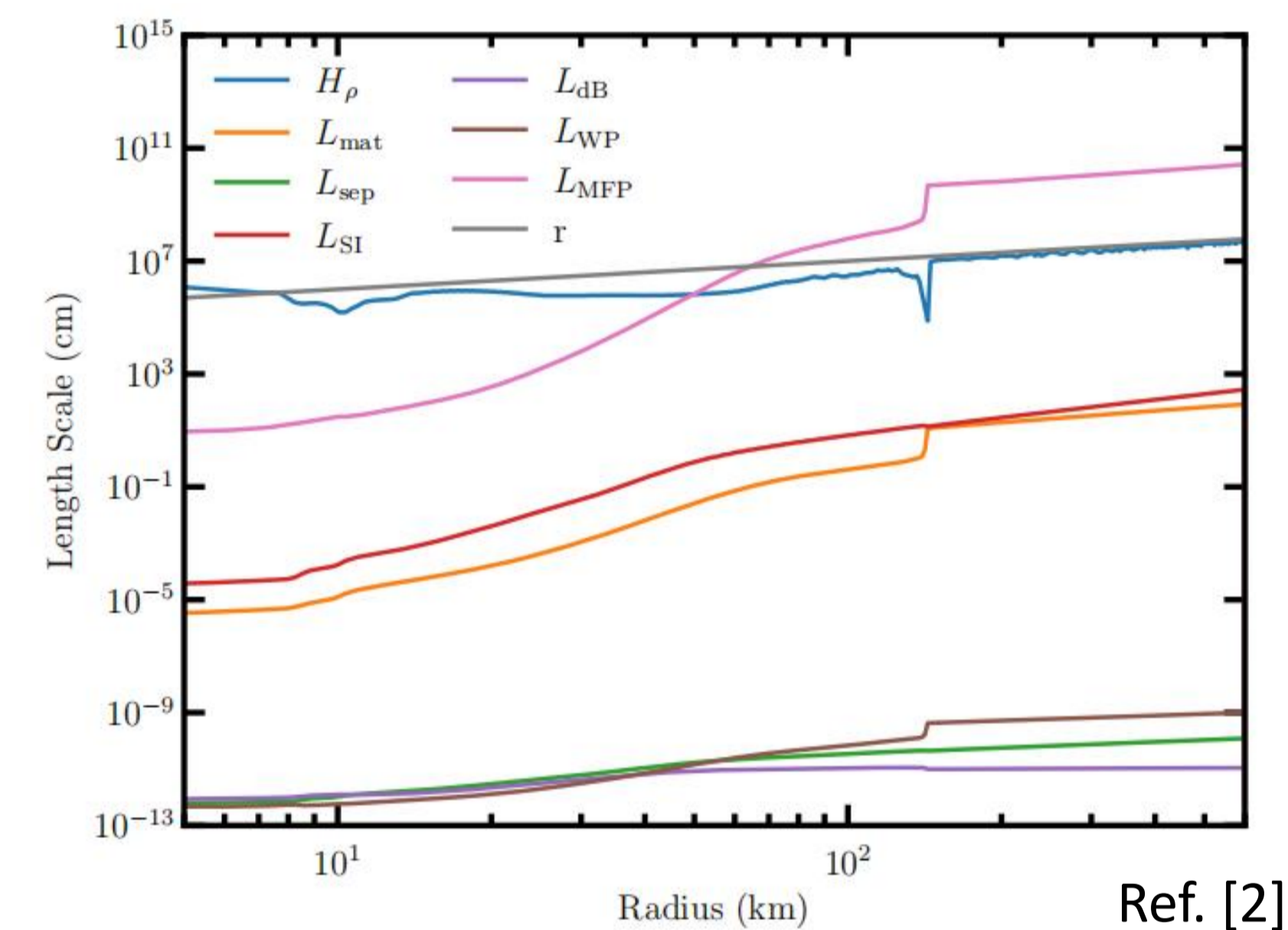
## Flavor Instabilities Are Widespread in CCSNe



Ref. [1]

Fast and collisional flavor instabilities are **ubiquitous in a CCSN core**.

## Flavor Scales Are Unresolved

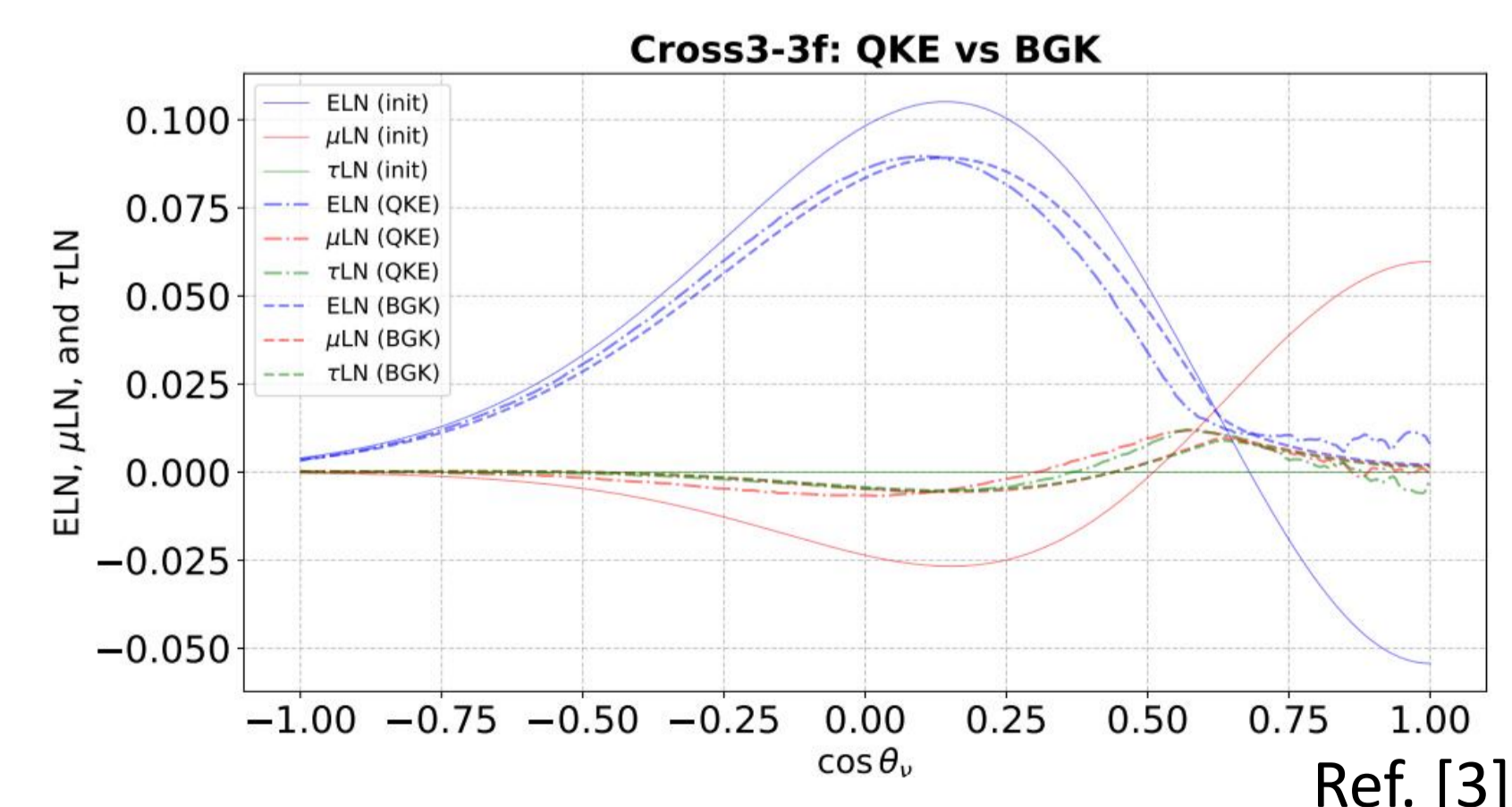


Ref. [2]

Flavor conversion scales are much **shorter** than hydrodynamic and transport scales.

Full QKE evolution is too expensive for global CCSN simulations.

## Asymptotic-State Prediction



Ref. [3]

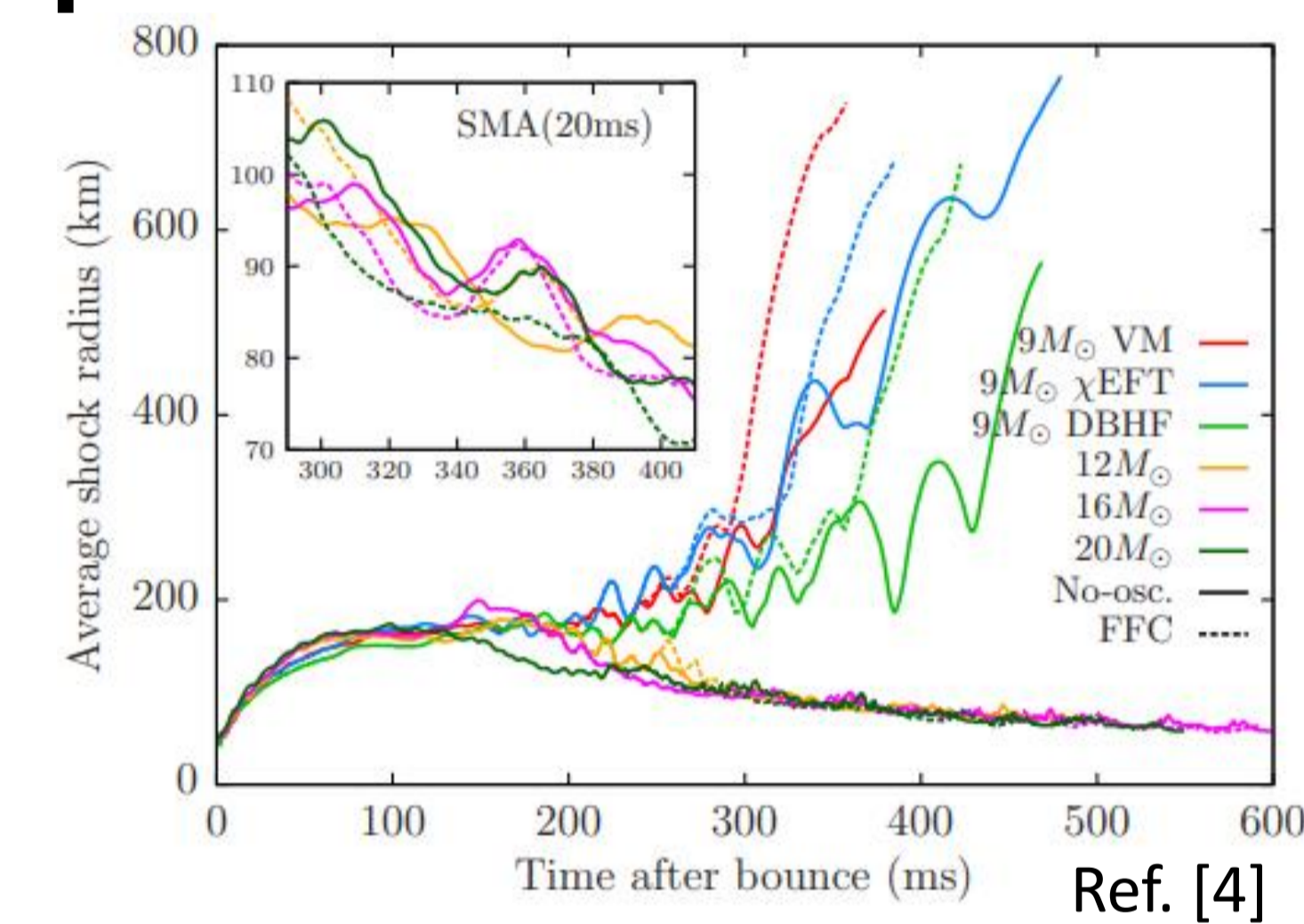
Predicts the late-time flavor state without resolving microscopic oscillations.

## Subgrid Implementation in CCSN Simulations

Classical neutrino transport  
↓  
Check instability conditions  
↓  
Predict local asymptotic flavor state  
↓  
Relax toward asymptotic state

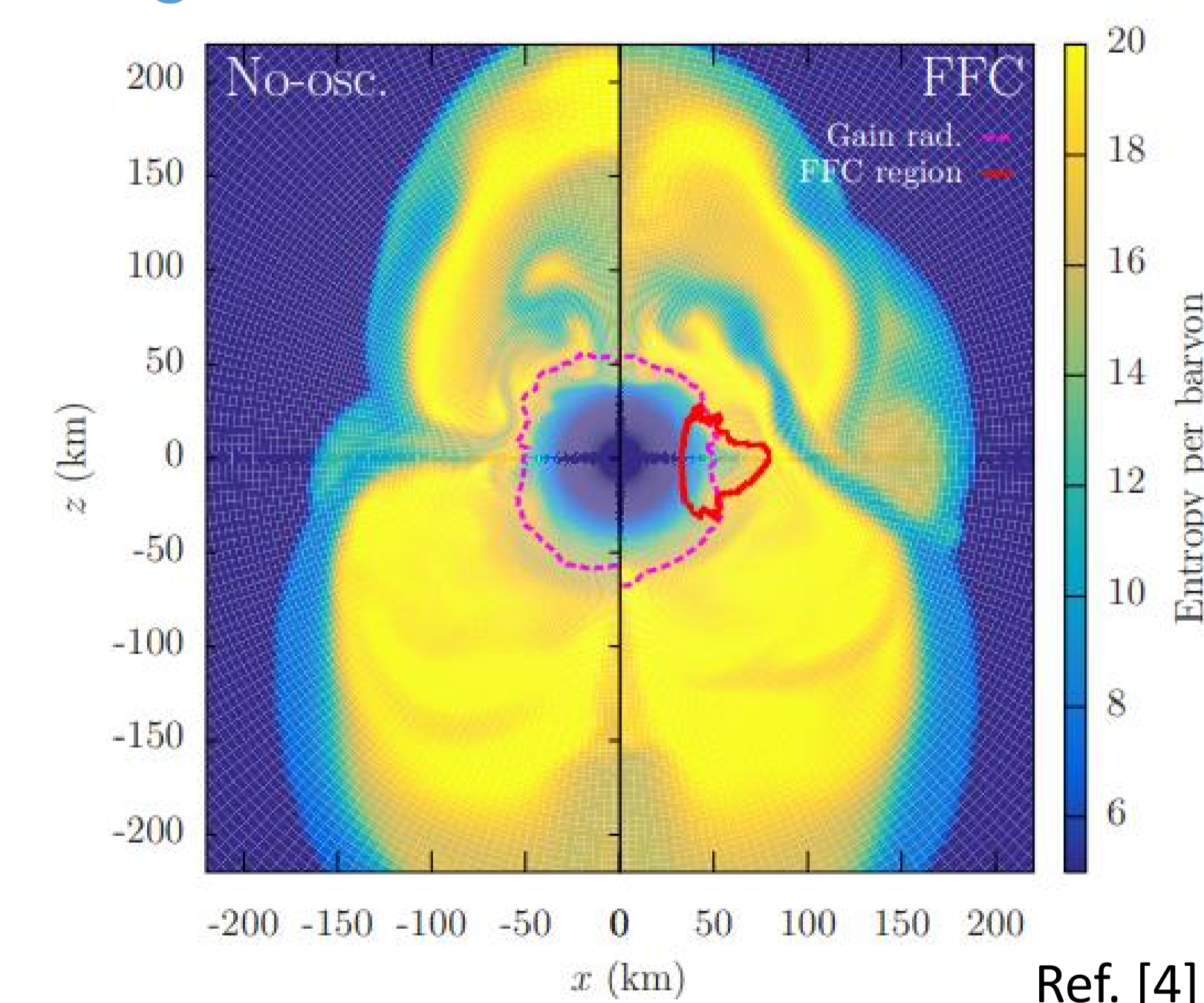
$$C_{\text{FFC}}[f_{\nu\alpha}] \approx -\frac{f_{\nu\alpha} - f_{\nu\alpha, \text{asy}}}{\tau_{\text{FFC}}}$$

## Impact on CCSN Evolution



Ref. [4]

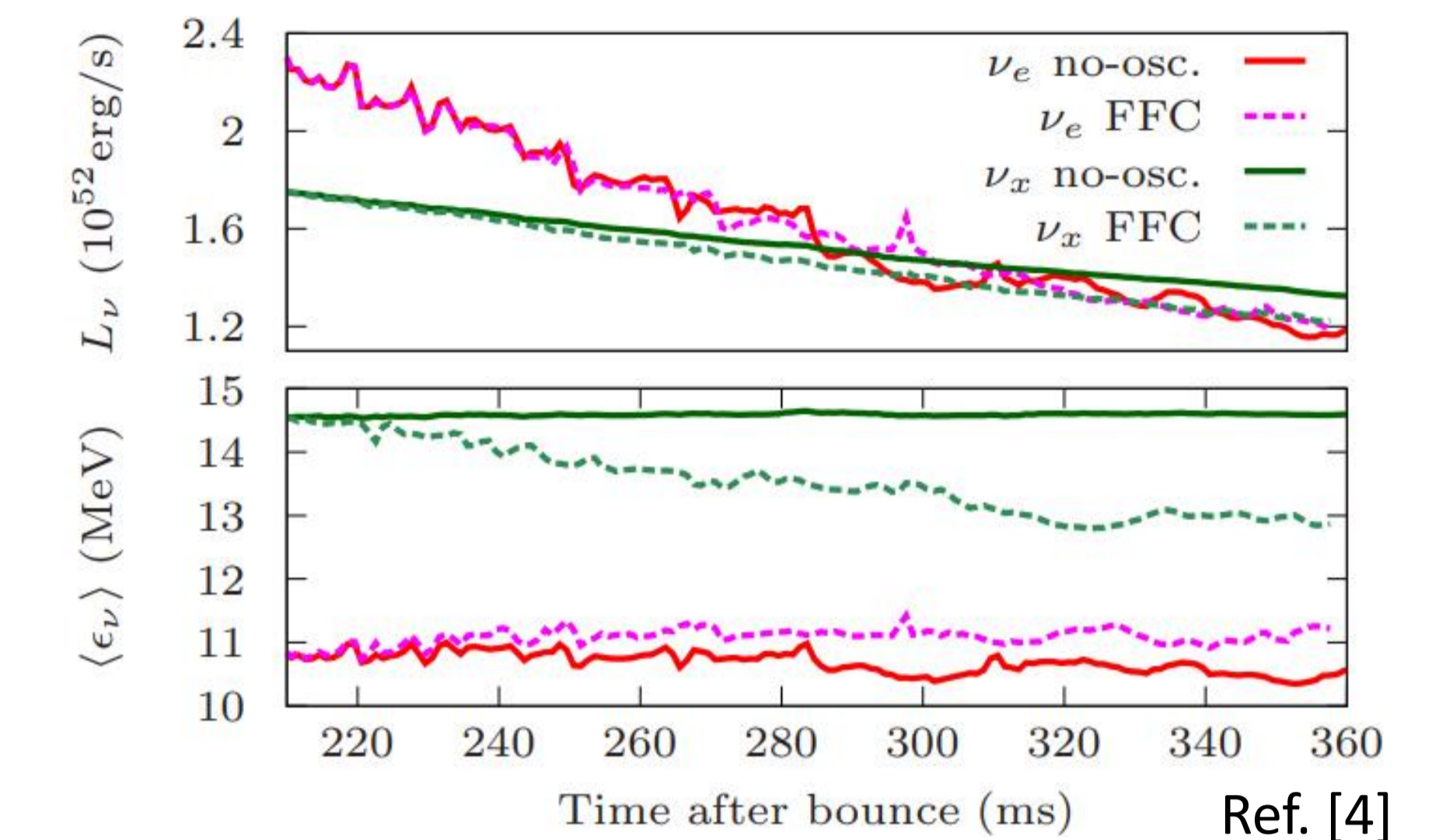
Flavor conversion can modify **neutrino heating** and alter **shock evolution**.



Ref. [4]

Flavor conversion can reshape the CCSN environment and induce **nontrivial asymmetries**.

## Impact on Neutrino Signals



Ref. [4]

Fast flavor conversion alters flavor-dependent **luminosities** and **mean energies**, affecting detector signal predictions.

The trend depends nontrivially on the progenitor and EOS properties.

## Takeaway

Fast flavor conversion connects **microscopic QKE physics** to **observable supernova neutrino signals**.

## References

- [1] R. Akaho, J. Liu et al., Phys. Rev. D 109, 023012 (2024).
- [2] L. Johns, S. Richers, and M.-R. Wu, Annu. Rev. Nucl. Part. Sci. 75, 399 (2025).
- [3] J. Liu, H. Nagakura et al., Phys. Rev. D 111, 123004 (2025).
- [4] R. Akaho et al., Phys. Rev. Lett. (2026), doi:10.1103/fksy-1jtw.

## Acknowledgements / Contact

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