



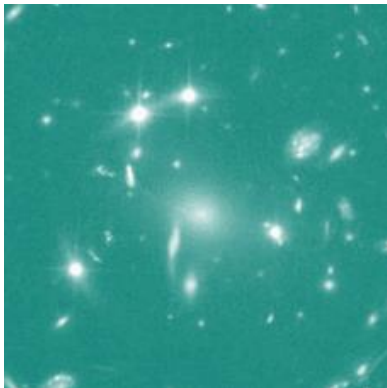
# Signatures of ULTRALIGHT SCALARS in neutrino oscillation experiments

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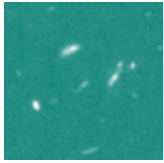
in collaboration with **Abhish Dev**  
and **Pedro A. N. Machado**

First EuCAPT Annual Symposium  
Based on JHEP 01 (2021) 094





Neutrino oscillation experiments could detect **ultralight scalars** via **modulations of the signal with time** and **distorted neutrino oscillations.**



# ULTRALIGHT SCALARS and NEUTRINOS

An ultralight scalar field,

$$\phi(x, t) \simeq \frac{\sqrt{2\rho_\phi}}{m_\phi} \sin [m_\phi(t - \vec{v} \cdot \vec{x})]$$

**A. Berlin.**

PRL 117 (2016) 23, 231801

**G.Krnjaic et al.**

PRD 97 (2018) 7, 075017

**V. Brdar et al.**

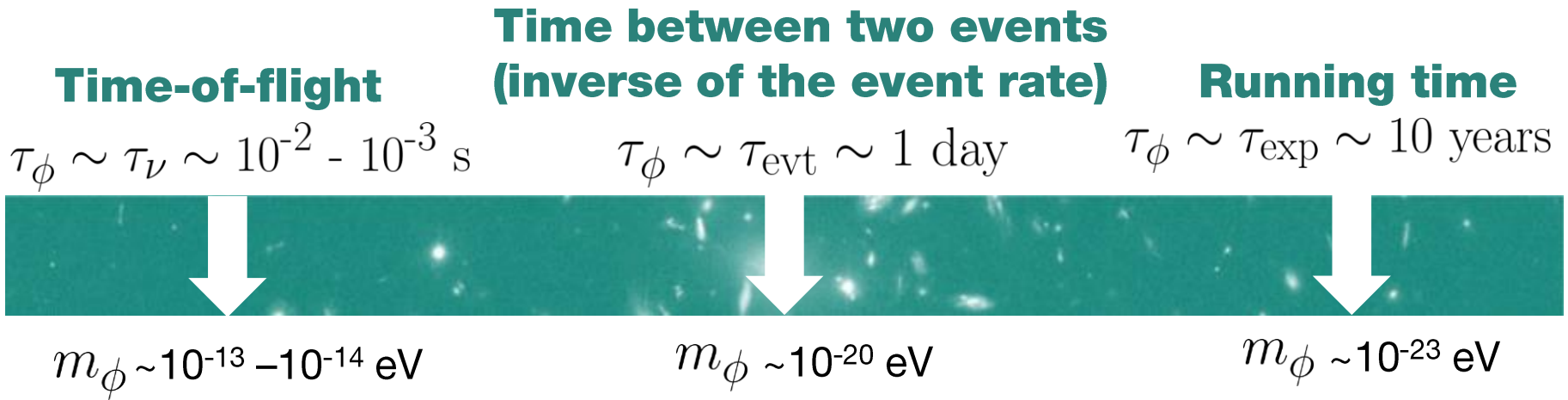
PRL117 (2016) 23, 231801

which couples effectively to neutrinos,

$$\mathcal{L}_{\text{eff}} = -m_\nu \left( 1 + y \frac{\phi}{\Lambda} \right) \bar{\nu} \nu + \text{h.c.}$$

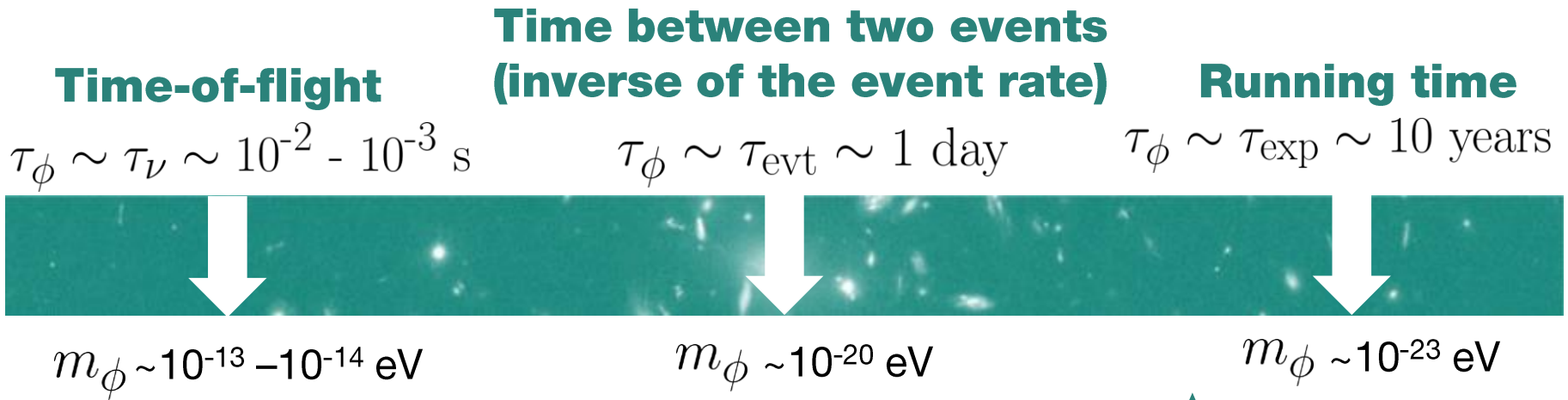
induces a **time dependence** on the **mass splittings**  
(also on the **mixing angles...**)

$$\Delta m_{ij}^2(t) \equiv m_i^2(t) - m_j^2(t) \simeq \Delta m_{ij}^2 [1 + 2\eta \cos(m_\phi t)]$$



The **mass** of the ultralight scalar is related to the **modulation period**

$$\tau_\phi \equiv \frac{2\pi\hbar}{m_\phi} = 0.41 \left( \frac{10^{-14} \text{ eV}}{m_\phi} \right) \text{ seconds.}$$

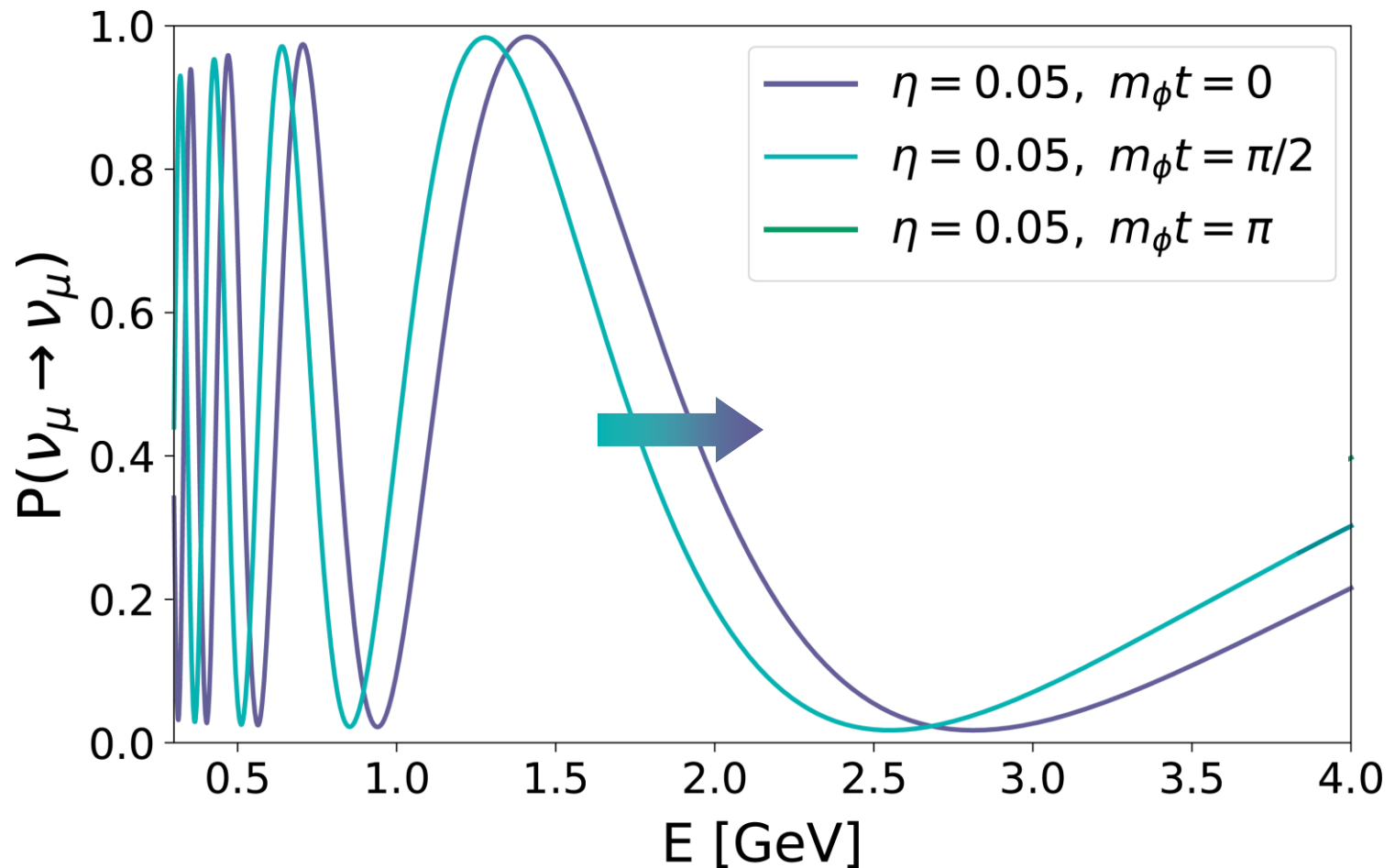


**A SIGNAL TIME MODULATION**  
 could be measured in experiments  
 with large statistics

$\tau_\phi$

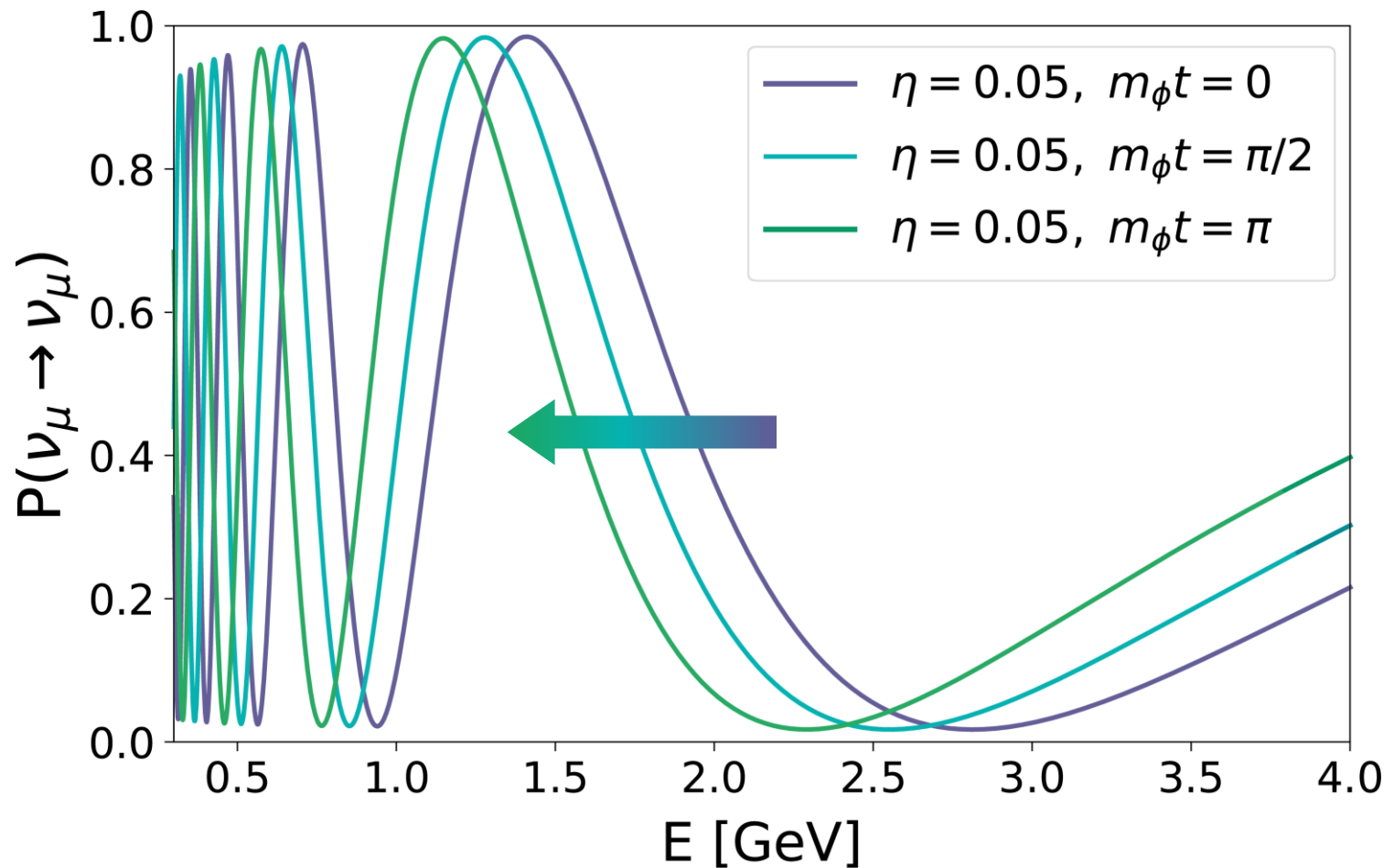
In **DUNE**

for a modulating mass splitting only,  $\Delta m_{31}^2$ .



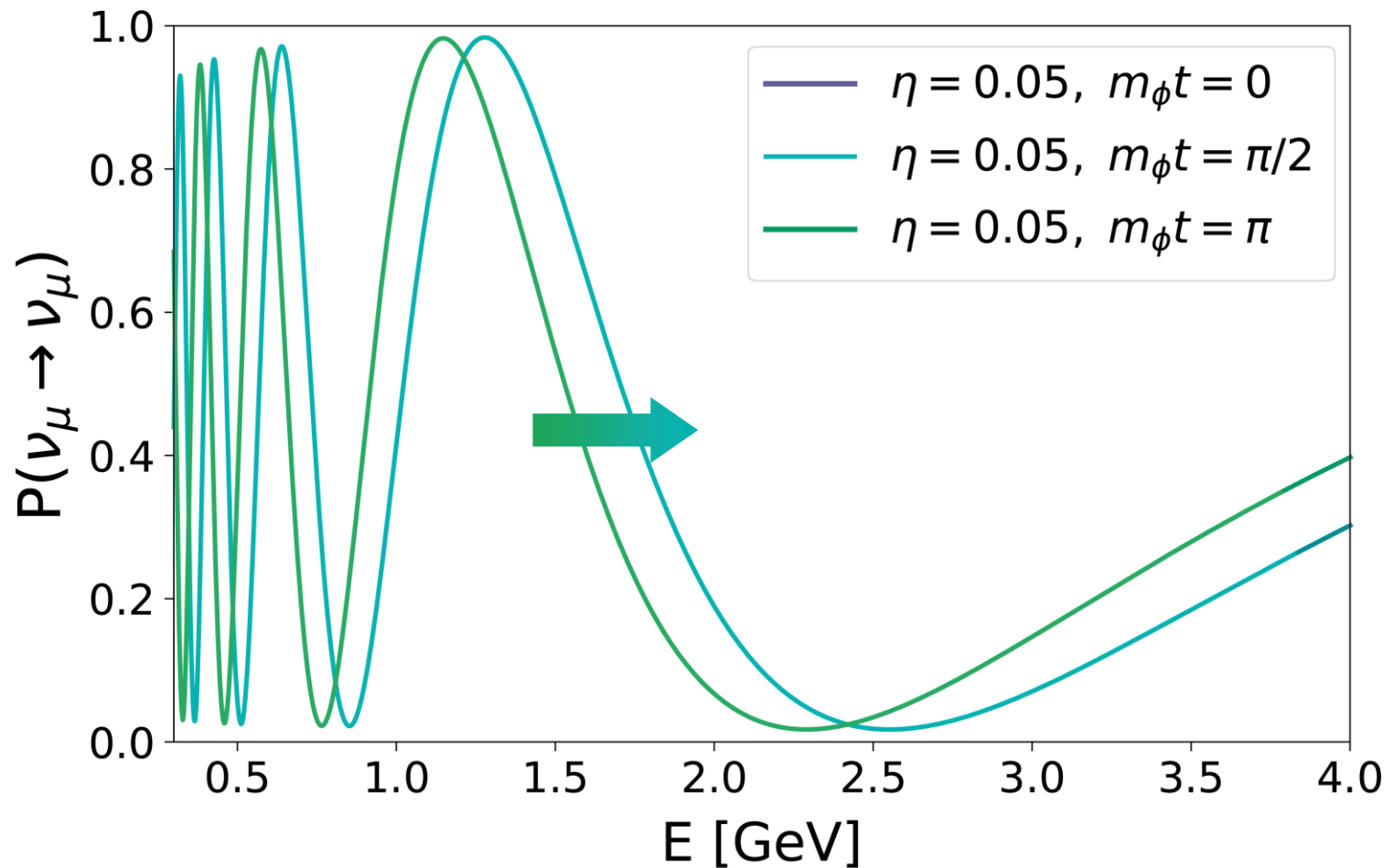
In **DUNE**

for a modulating mass splitting only,  $\Delta m_{31}^2$ .



In **DUNE**

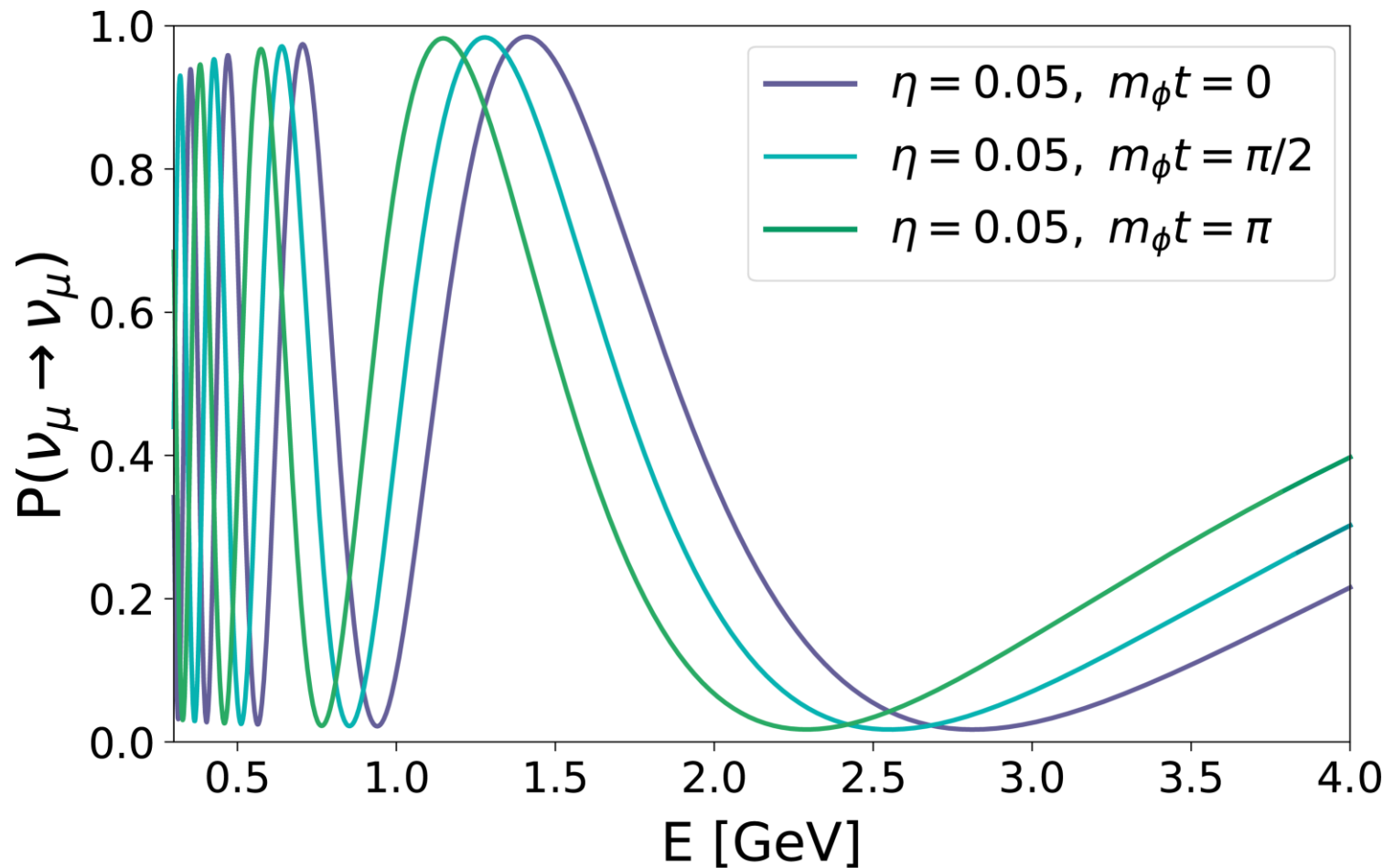
for a modulating mass splitting only,  $\Delta m_{31}^2$ .

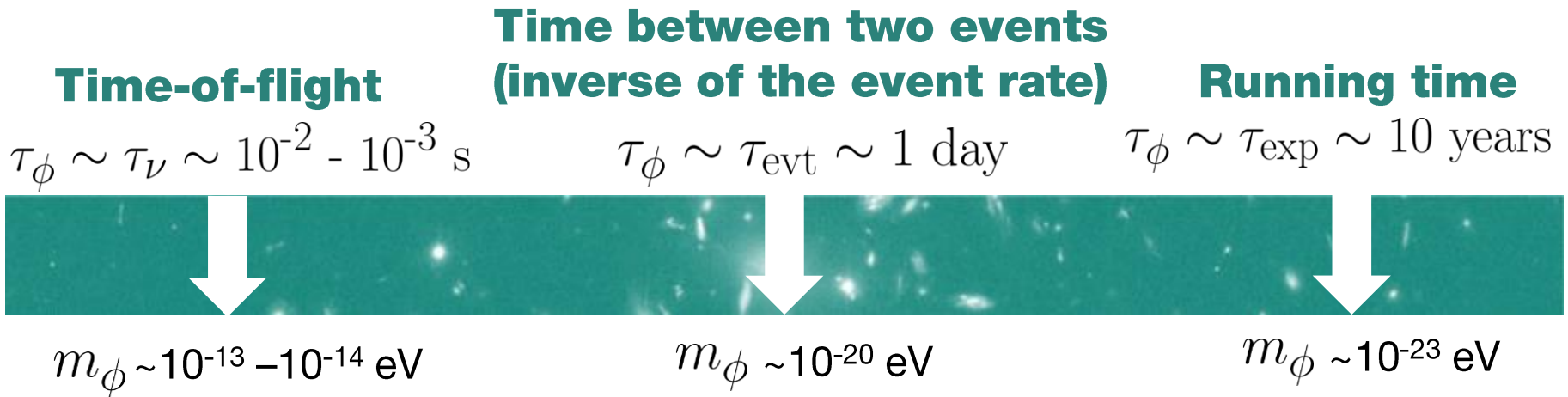




In **DUNE**

for a modulating mass splitting only,  $\Delta m_{31}^2$ .

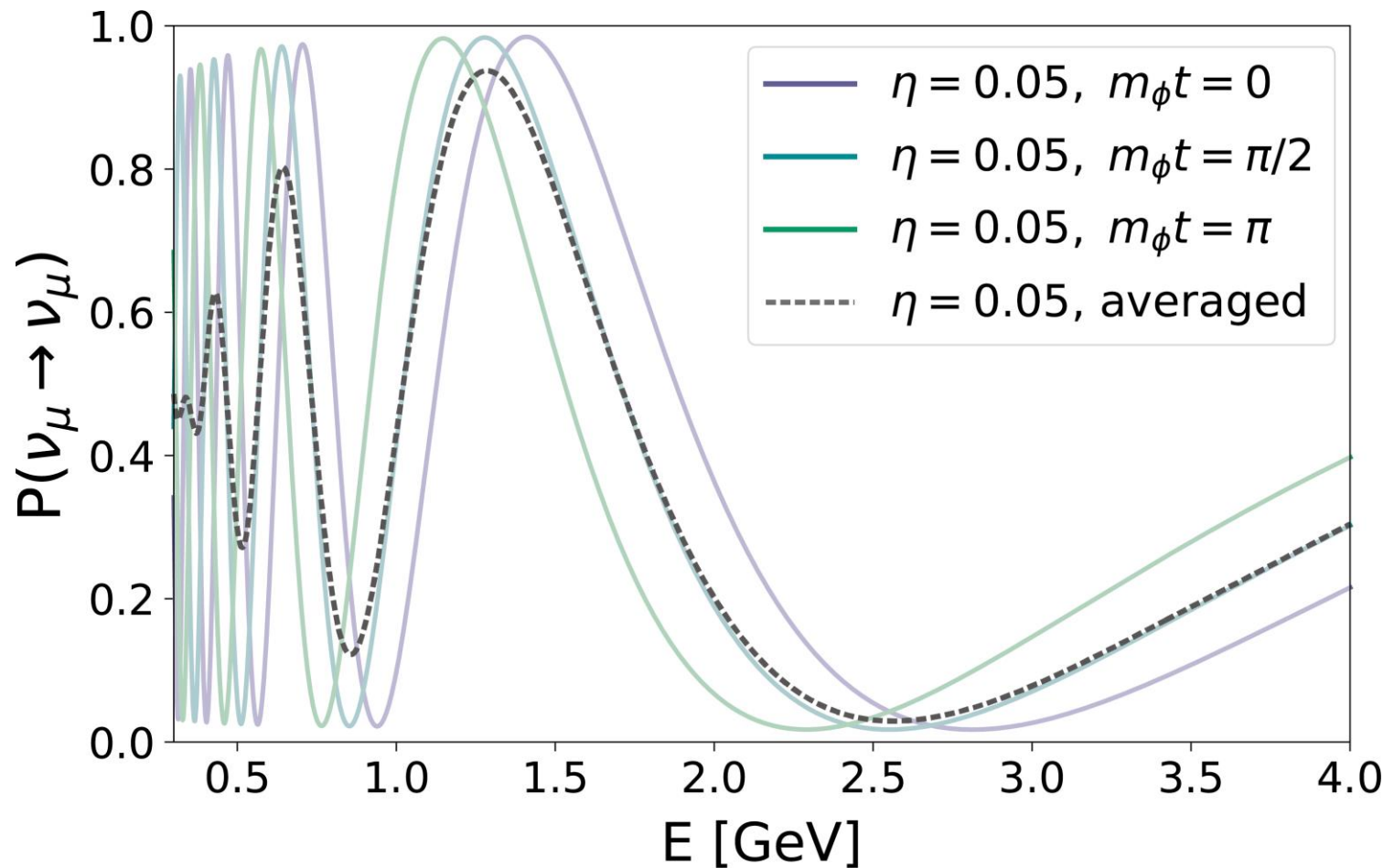


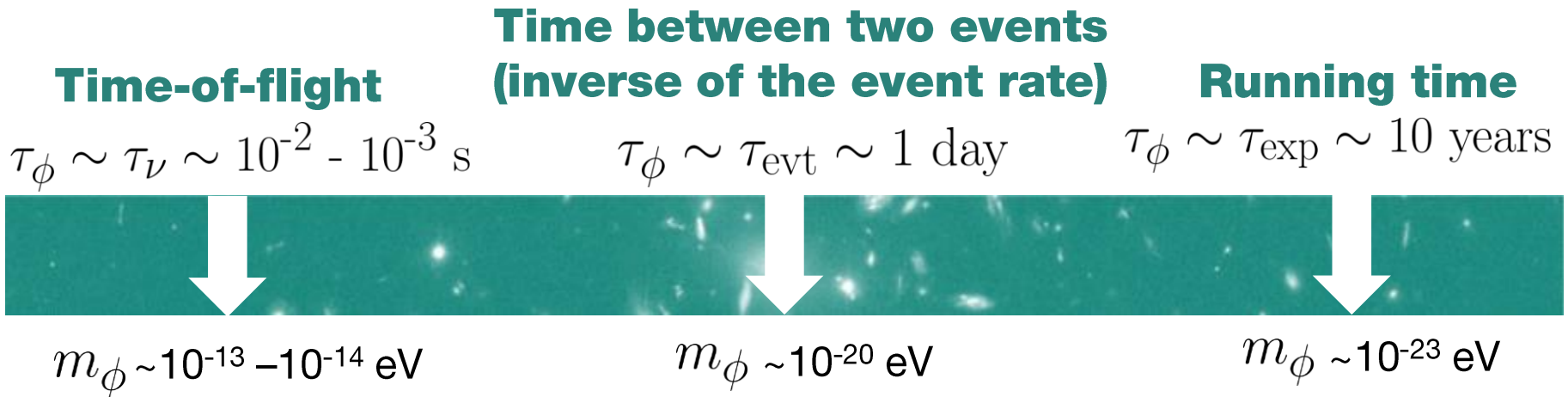


$\tau_\phi$  ↑ Modulation gets averaged  
 leading to **DISTORTED**  
**NEUTRINO OSCILLATIONS**

In **DUNE**

for a modulating mass splitting only,  $\Delta m_{31}^2$ .

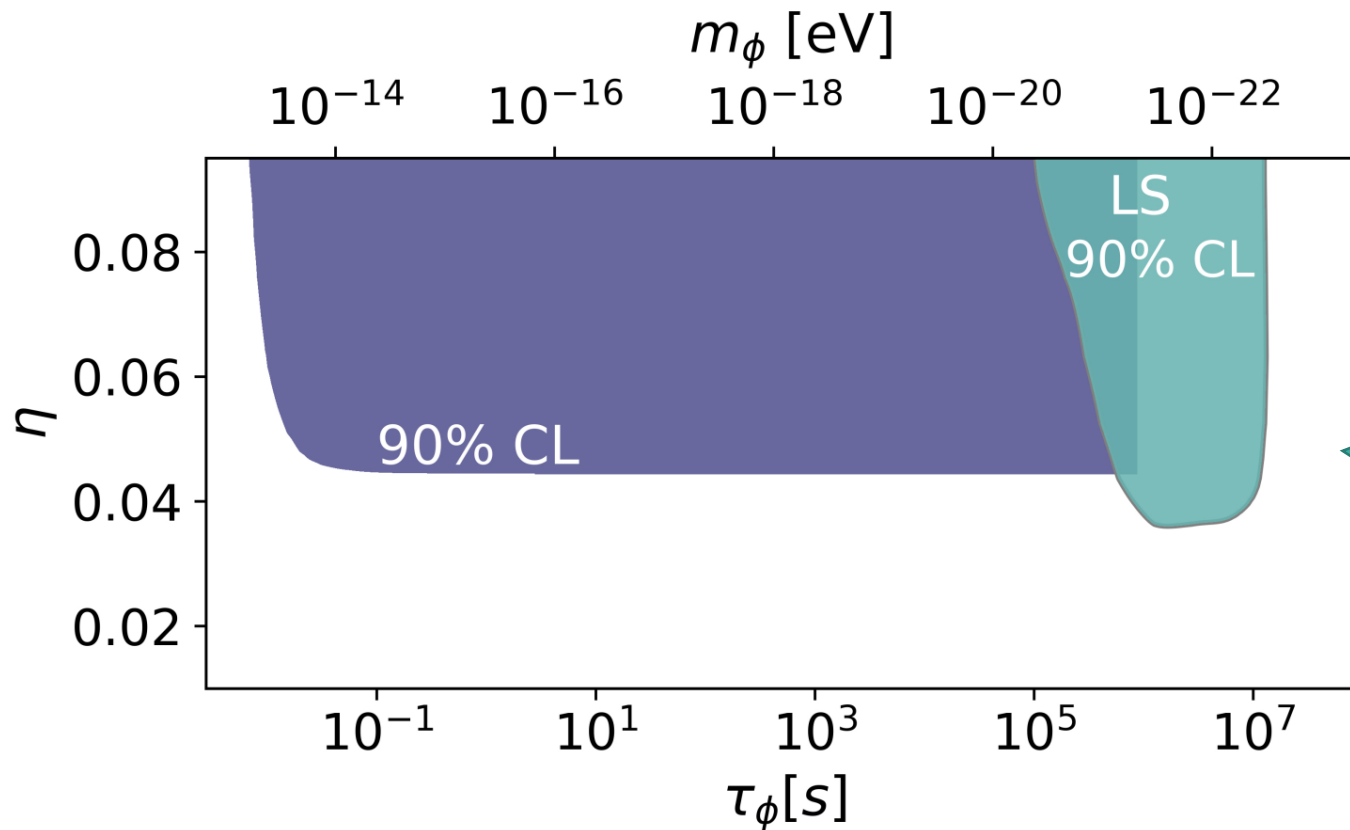




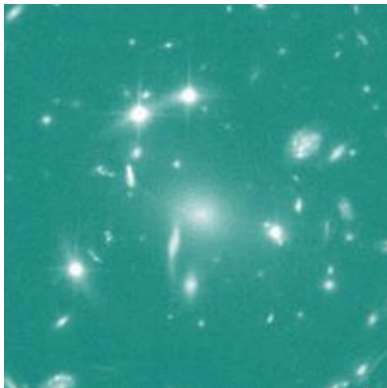
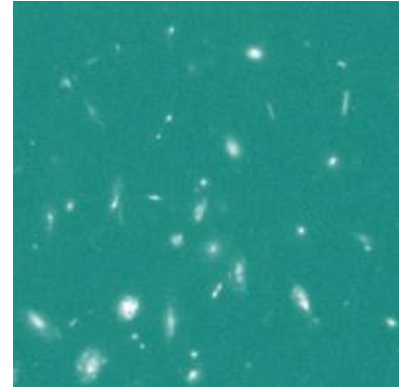
Modulation becomes too fast  
and manifests as a **fast-varying  
matter potential**

and eventually one can not distinguish it from  
standard oscillations.

For a more detailed discussion of the signatures and a particular example (**DUNE**), see [\*\*JHEP 01 \(2021\) 094\*\*](#) .



# TAKE HOME MESSAGE



Neutrino oscillation experiments could detect **ultralight scalars** via **modulations of the signal with time** and **distorted neutrino oscillations.**