

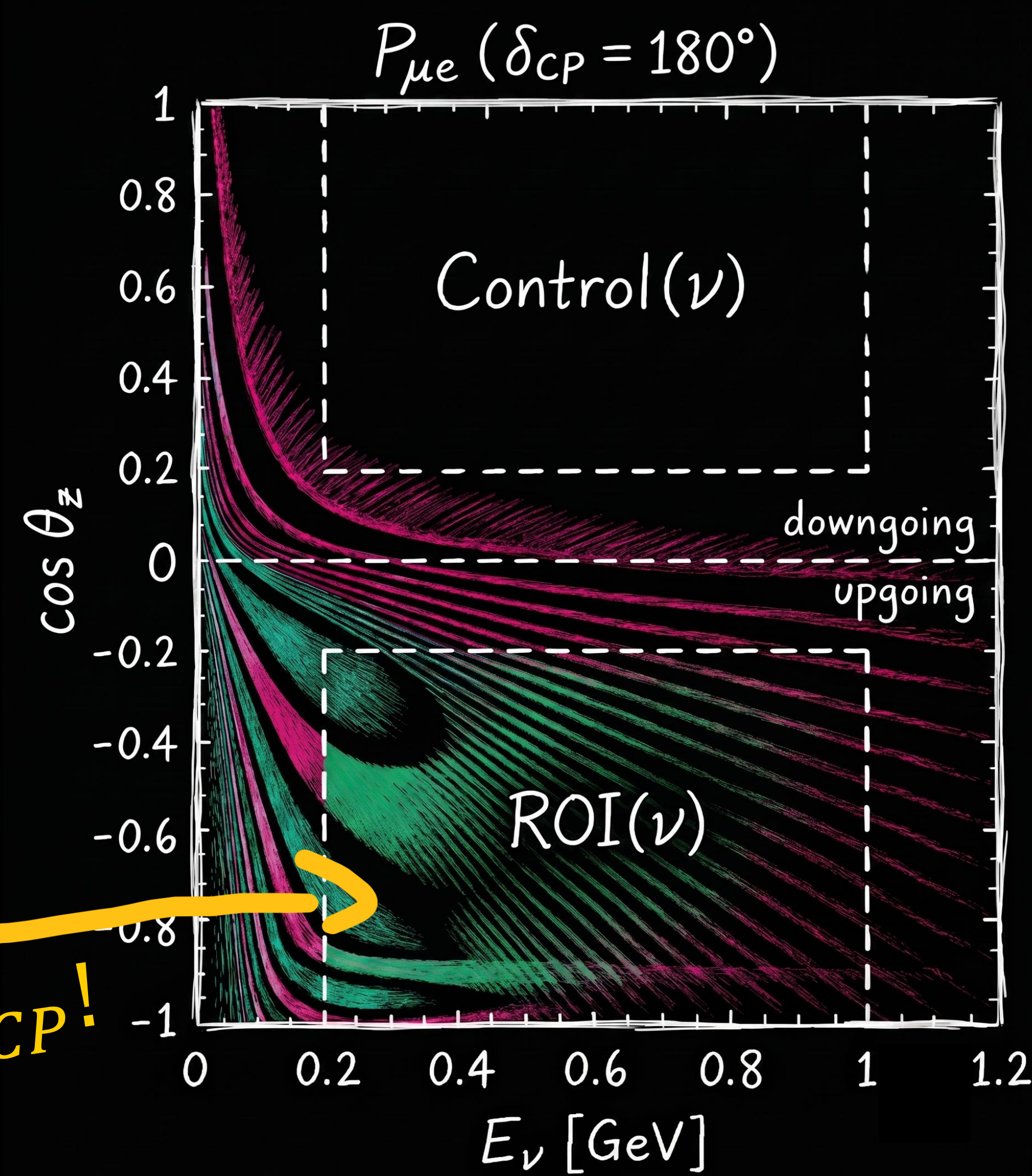
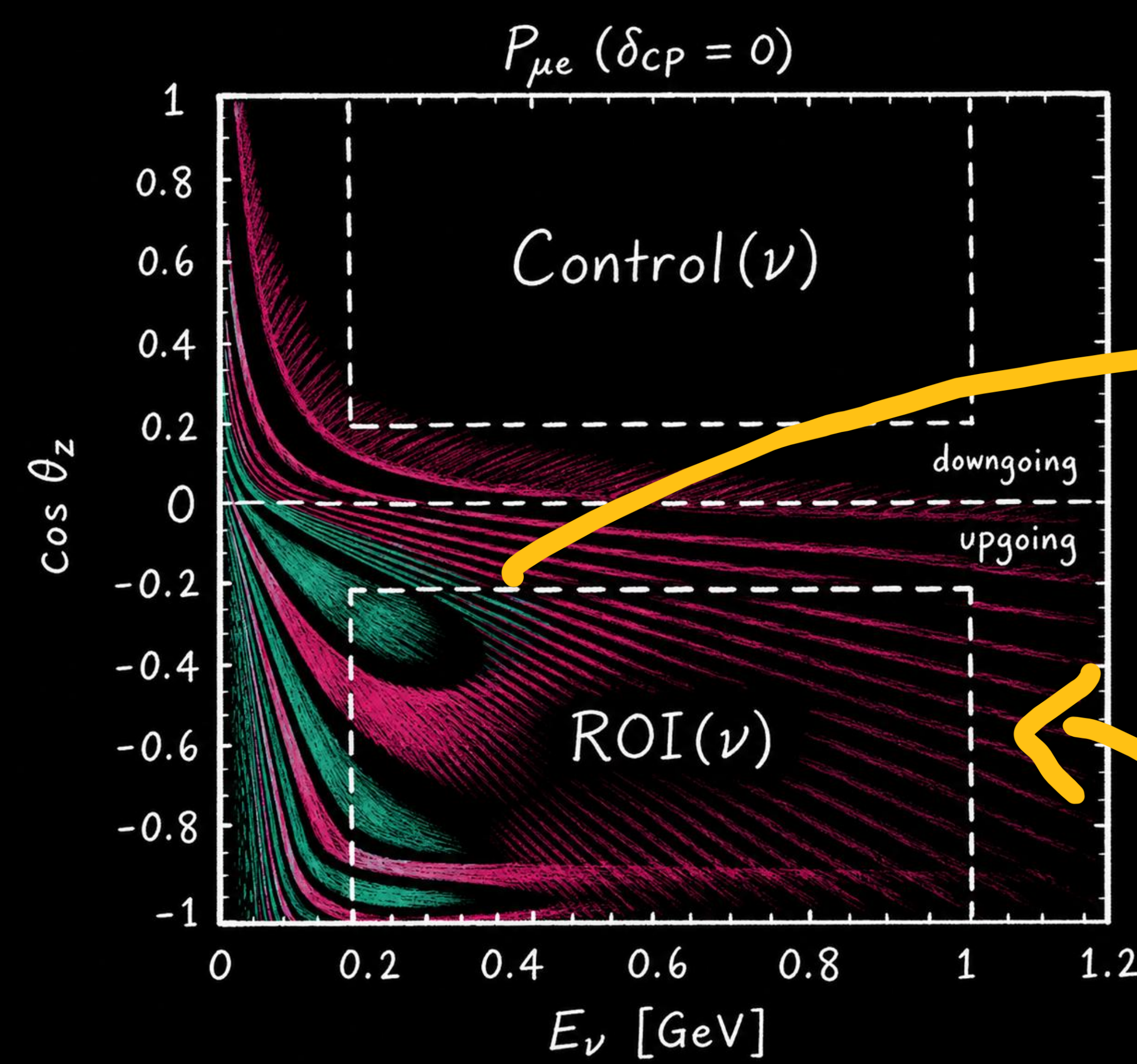
# Towards Measuring the CP-Violating Phase with Atmospheric Neutrinos



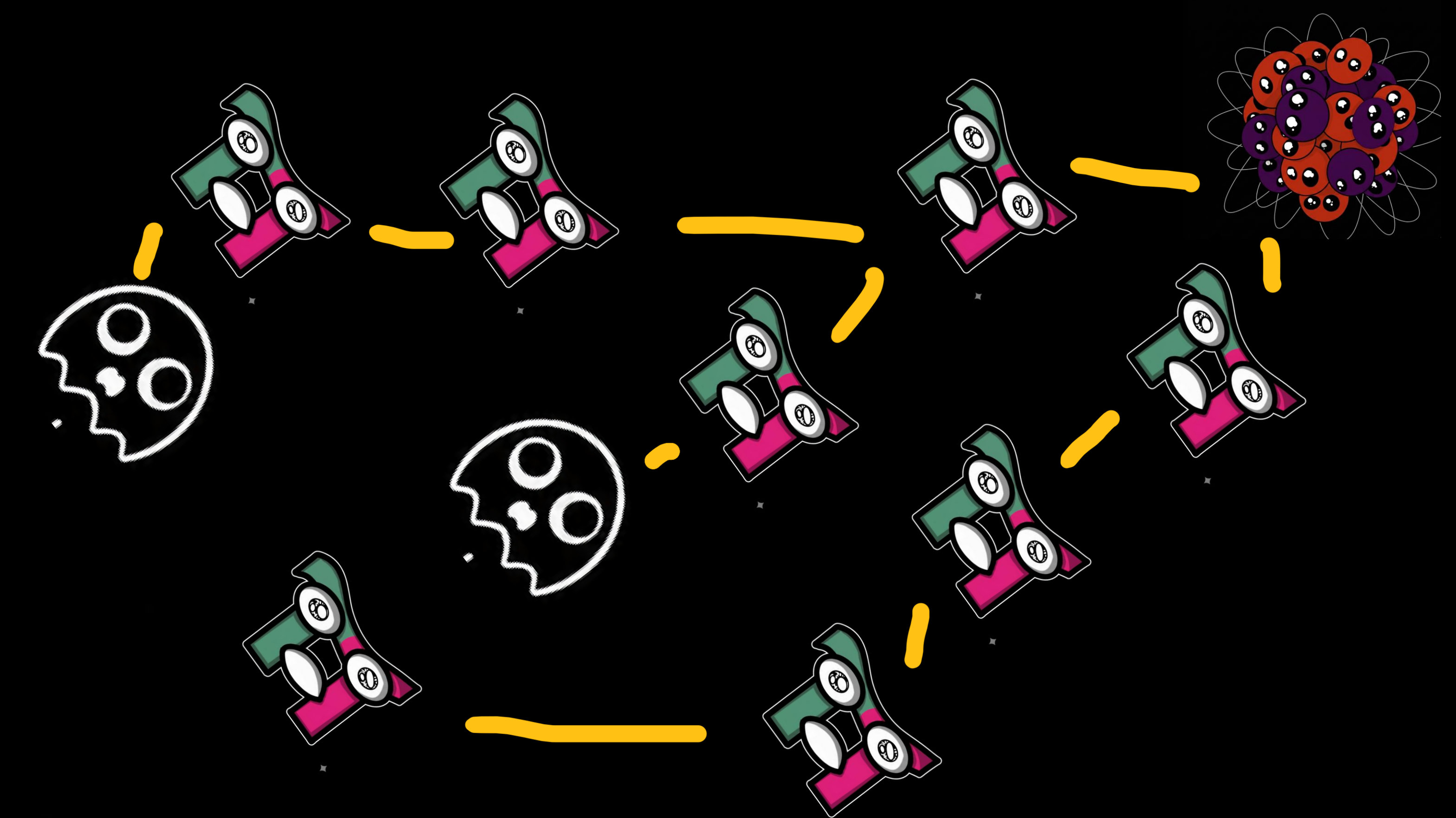
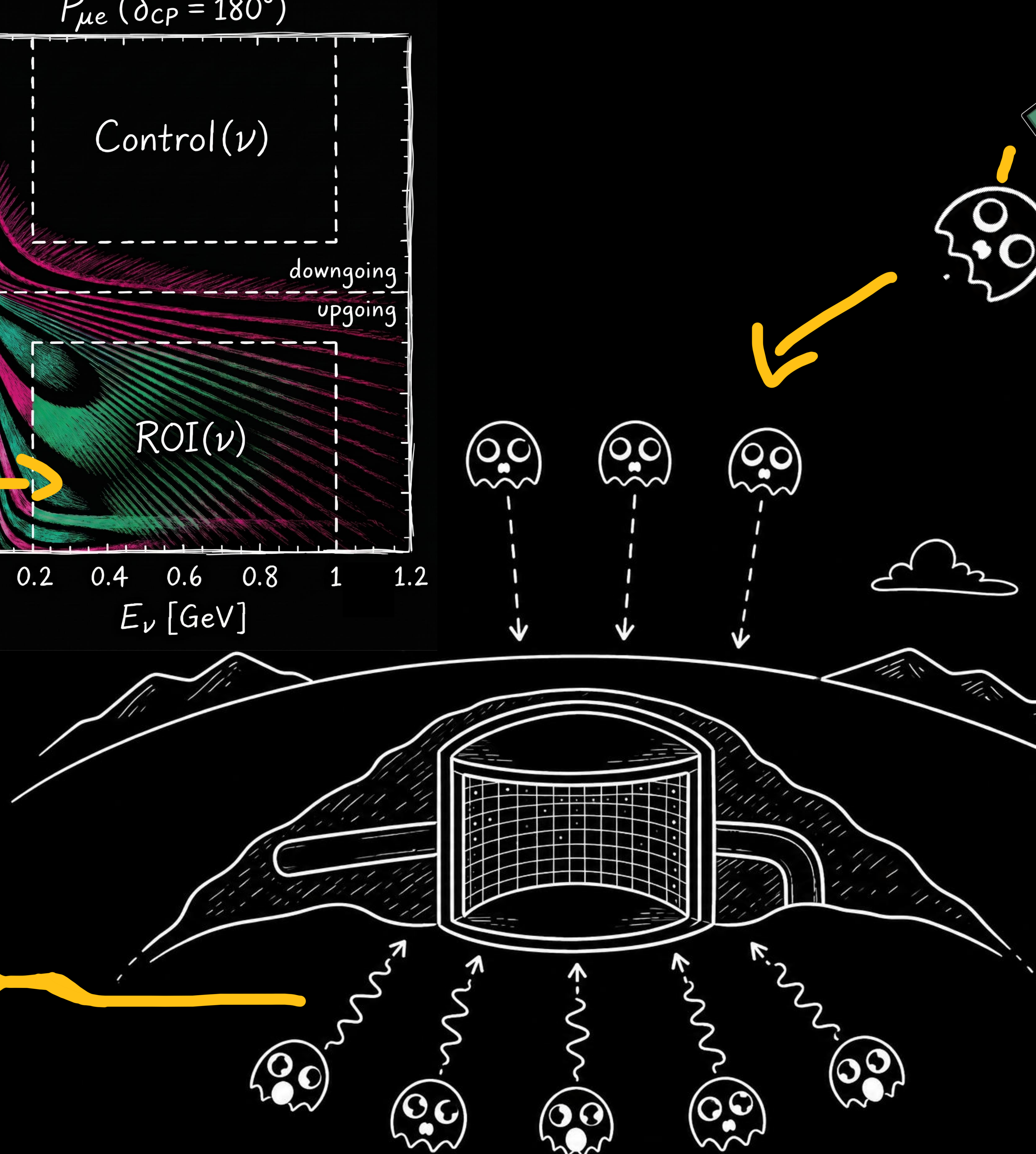
IOWA

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## Oscillations



$\delta_{CP}!$



## The probability

$$P_{\alpha\beta} = \delta_{\alpha\beta} - 4 \sum_{k>j} \text{Re} [U_{\alpha k}^* U_{\beta k} U_{\alpha j} U_{\beta j}^*] \sin^2(\Phi_{kj}) \propto \cos \delta_{CP}$$

$$+ 2 \sum_{k>j} \text{Im} [U_{\alpha k}^* U_{\beta k} U_{\alpha j} U_{\beta j}^*] \sin(2\Phi_{kj}) \propto \sin \delta_{CP} \times$$

Here

$$R_{\uparrow\downarrow} \propto \cos \delta_{CP}$$

Normally Jarlskog!

$$\mathcal{J}_{CP} \propto \sin \delta_{CP}$$

$\sin(\delta_{CP})$  averages out!

## Results for Hyper-K

By comparing up- and down-going neutrino rates we find competitive and complimentary sensitivity to current searches

