

## LBNO: Long Baseline Neutrino Oscillation experiment

The LBNO collaboration has submitted an Expression of Interest (SPSC-EOI-007) for a next generation neutrino oscillation experiment between CERN and the Pyhäsaumi mine in Finland, 2300 km distant.

Physics program:

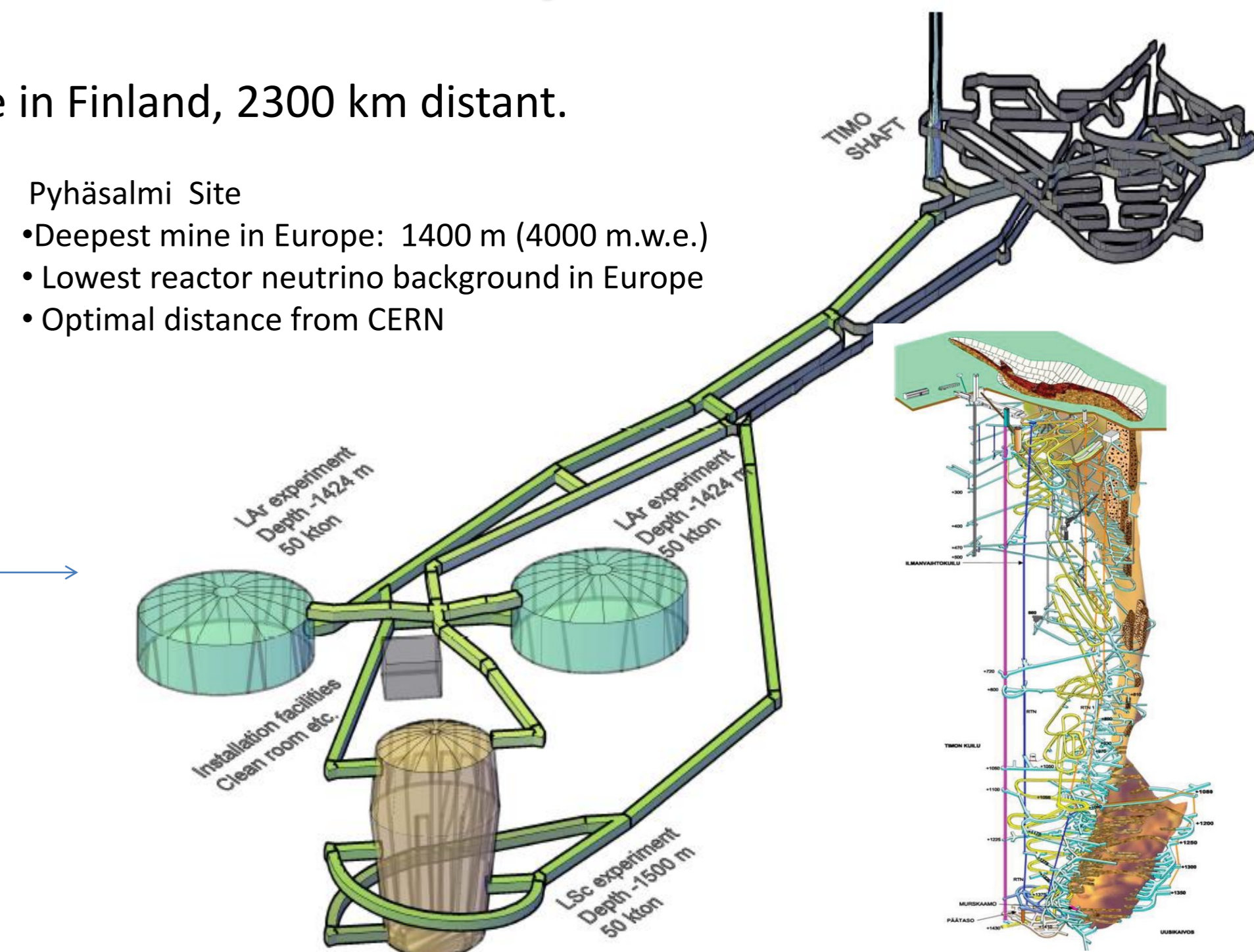
- Determination of the neutrino **Mass Hierarchy**
- Measurement of  $\delta_{CP} \rightarrow$  **CP-Violation** in the leptonic sector with a significant better sensitivity w.r.t. present and near future experiments

The proposed experimental setup consists of:

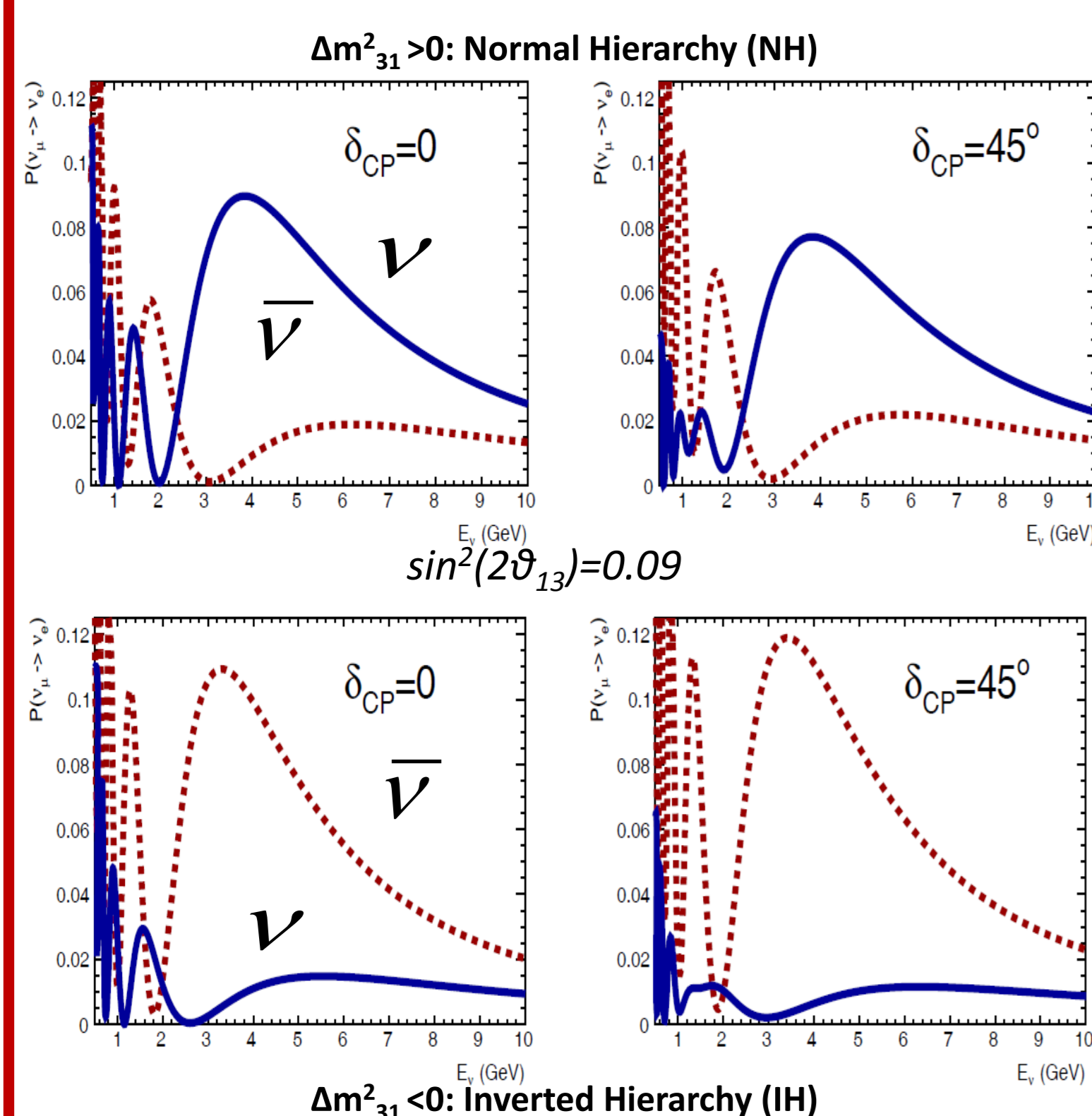
- ✓ New conventional neutrino beam facility
- ✓ Next generation underground neutrino observatory  
Double phase liquid Argon (LAr) detector, 20→100 kton fiducial volume  
Magnetized Iron calorimeter

Other physics goals achievable with a deep underground massive neutrino detector:

- Search for proton decay (test of GUT)
- Neutrino Astrophysics



## CERN to Pyhäsaumi oscillations



Energy dependence of the oscillation probabilities

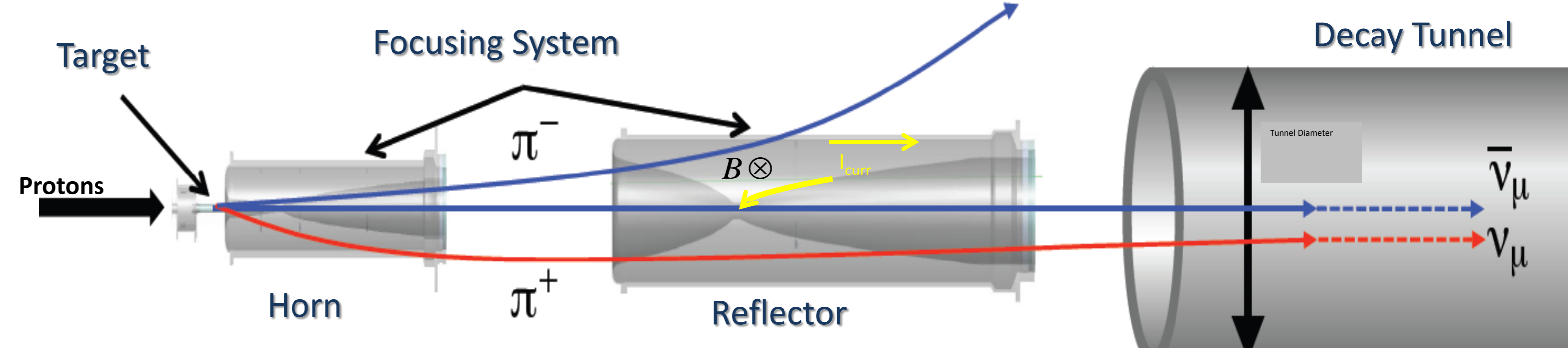
$$P(\nu_\mu \rightarrow \nu_e) \text{ and } P(\bar{\nu}_\mu \rightarrow \bar{\nu}_e) \text{ for a baseline } L=2300 \text{ km.}$$

- NH vs IH asymmetry larger at 1<sup>st</sup> max.
- CP asymmetry larger at the 2<sup>nd</sup>, 3<sup>rd</sup> max.

$\delta_{CP}$  and Mass Hierarchy degeneracy can be solved providing

- A very long baseline to exploit the matter effect
- A wide band neutrino beam to cover several oscillation maxima

## Neutrino beam line



Primary beam: protons from the CERN-SPS @ 400 GeV in the initial phase.

Focusing: at each beam spill horn/reflector are pulsed with a current  $I_{curr} \approx 200$  kA → toroidal magnetic field in the horns/reflector volume.

A  $\nu_\mu$  (anti- $\nu_\mu$ ) beam is produced focusing positive (negative) hadrons produced by proton interactions in the target

Energy range:  $\pi$ 's (K's) between 3 and 10 GeV need to be focused to produce  $\nu$ 's between 1.5 and 4.5 GeV : in the perfect focusing approximation ( $p_t^* = 0$  @ decay):

$$E_\nu^{LAB} = E_\nu^{CM} \gamma_\pi (1 + \beta_\pi) \approx 0.43 E_\pi$$

Angular range:  $\pi$ 's (K's) produced with an angle  $\theta \approx [30, 80]$  mrad ( $\langle p_t \rangle \approx 0.3$  GeV/c @ production).

$$\pi^+ \rightarrow \mu^+ \nu_\mu$$

$$K^+ \rightarrow \mu^+ \nu_\mu$$

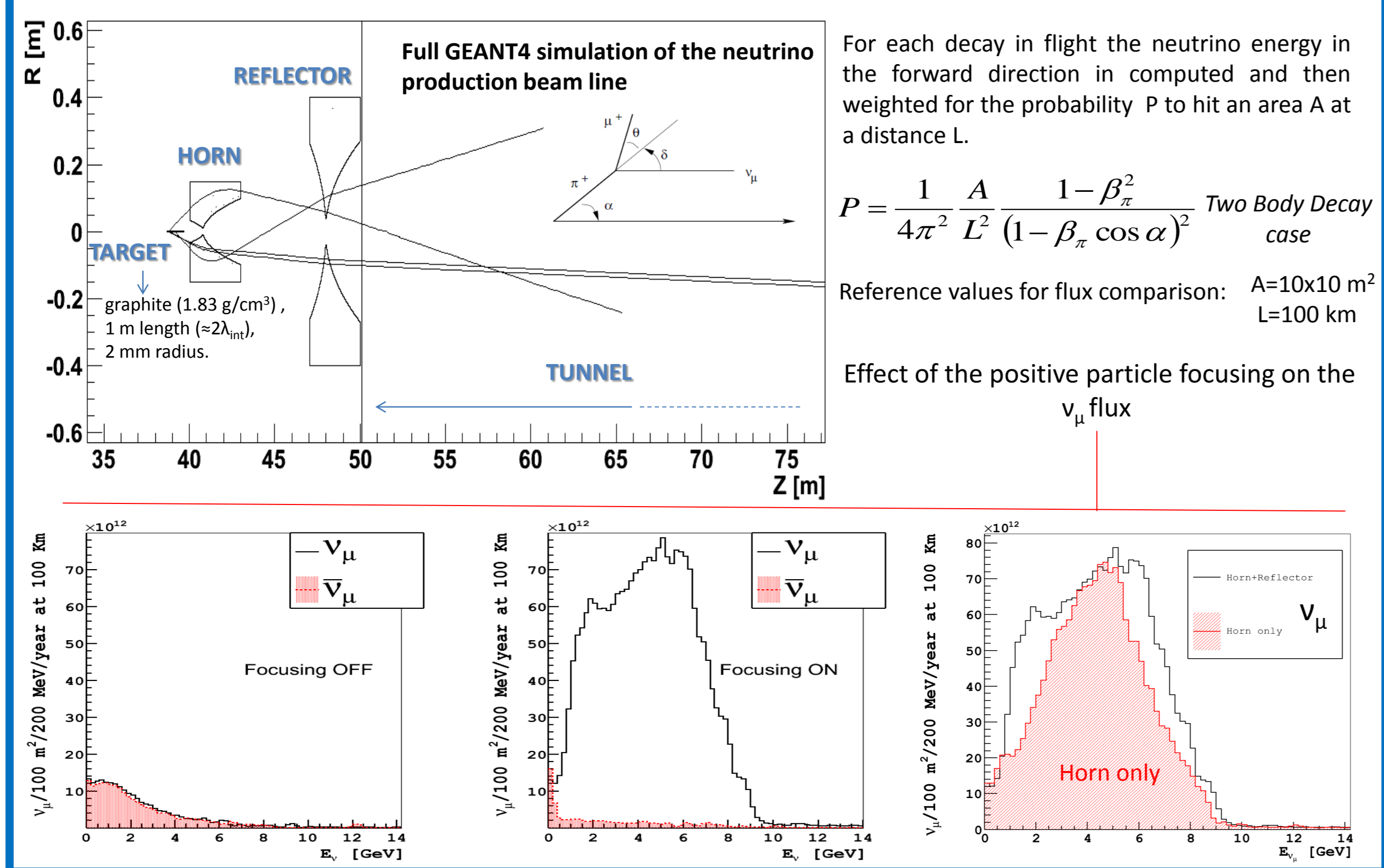
Background:  $\nu_e$  contamination

$$\mu^+ \rightarrow e^+ \nu_e \bar{\nu}_\mu$$

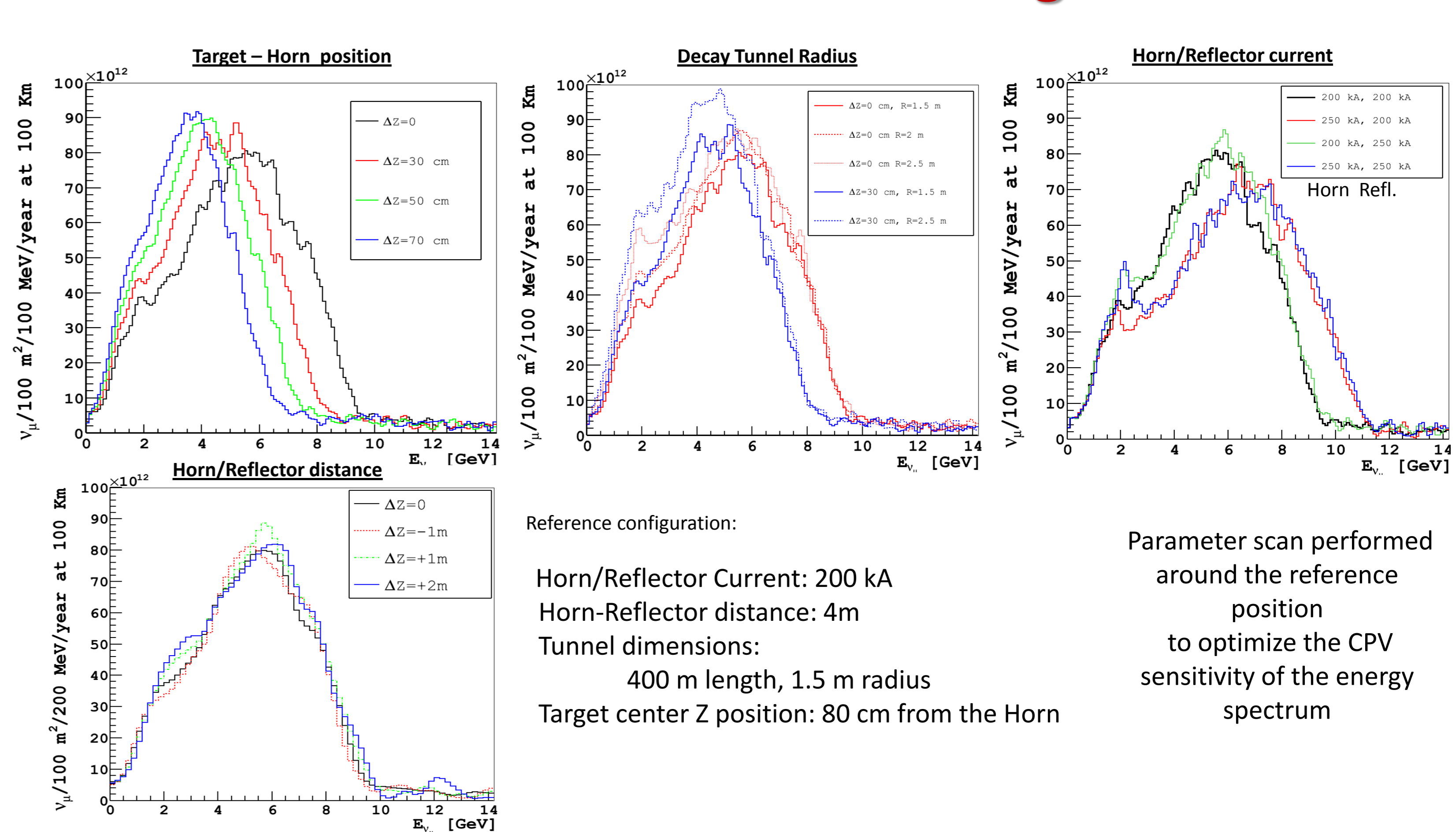
$$K_L \rightarrow \pi^+ e^- \bar{\nu}_e$$

$$K_L \rightarrow \pi^- e^+ \nu_e$$

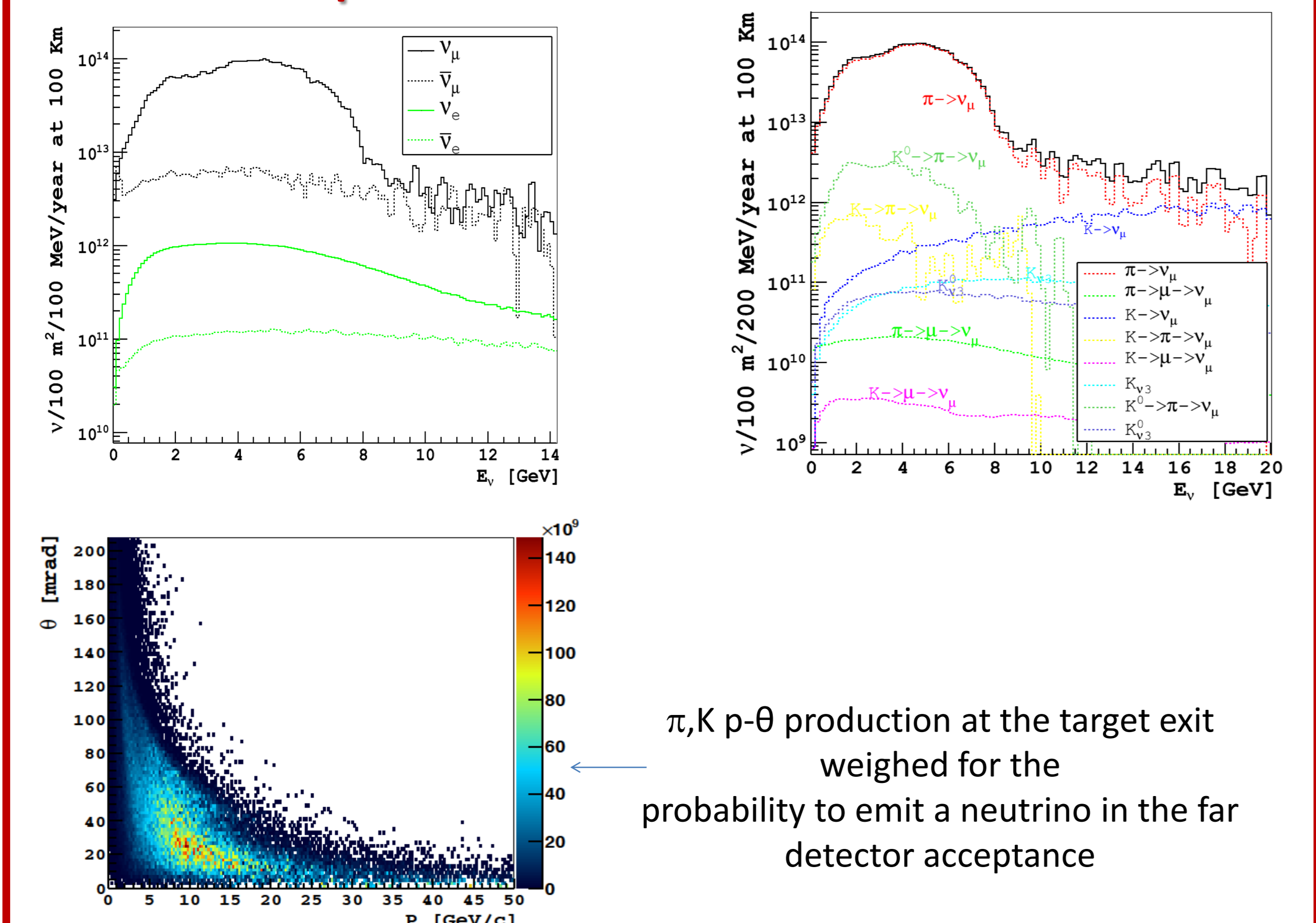
## Neutrino beam simulation



## Neutrino beam tuning



## Improved neutrino beam



## Sensitivity to CP-Violation

Improved beam neutrino flux considered

Neutrino energy reconstructed from final state events.

$\nu_\tau$  background treated with kinematical analysis.

Integrated pot:  $1.5 \times 10^{21}$   
Target Mass: 20 kton

Running mode: 25%:75% sharing neutrino:anti-neutrino

Systematic errors  
signals normalizations 5% ( $\nu_\tau$ :50%)  
horn polarity 5%  
NC, CC background 5%  
matter density 4%

