



Particle Focusing Optimization with a Magnetic Horn

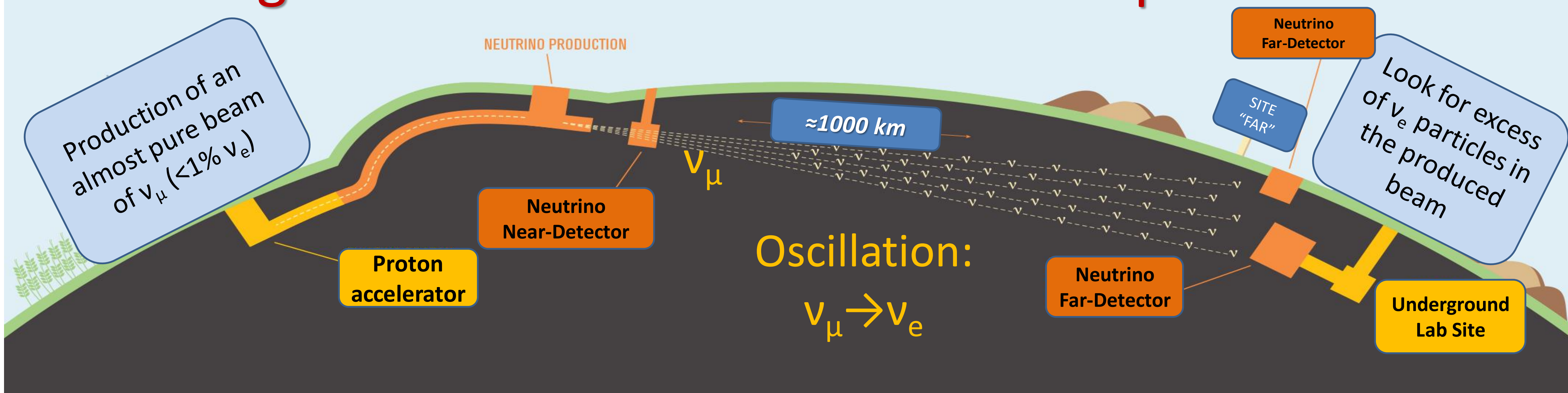
Silvestro di Luise

Swiss Federal Institute of Technology, ETH, Zürich, Switzerland
 CERN, Organisation européenne pour la recherche nucléaire, Geneva, Switzerland
 Silvestro.Di.Luise@cern.ch



Eidgenössische Technische Hochschule Zürich
 Swiss Federal Institute of Technology Zurich

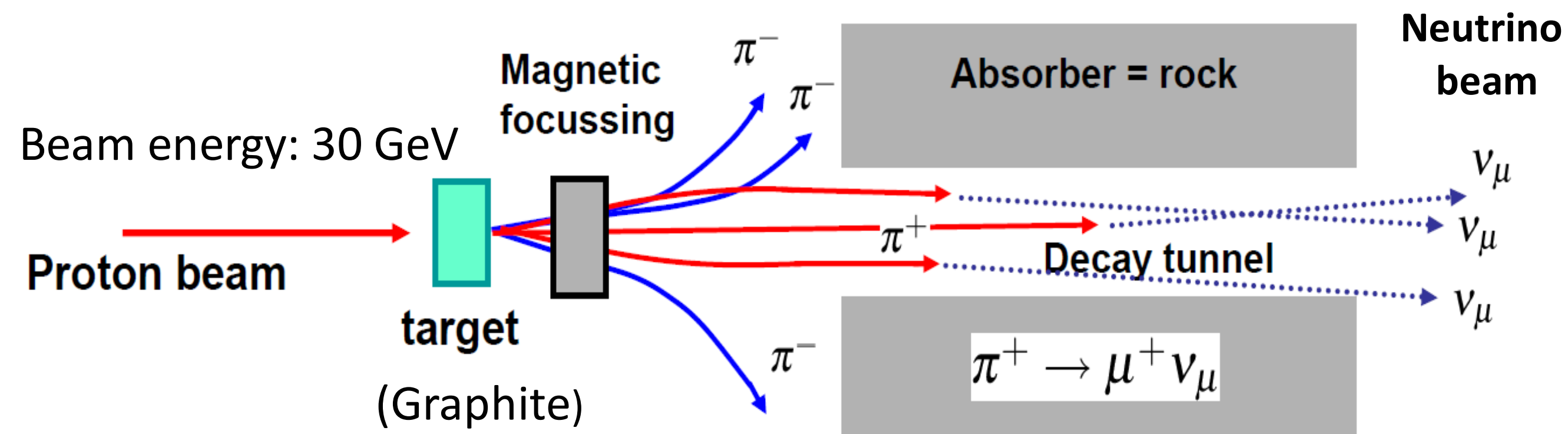
Long Baseline Neutrino Oscillation experiment



Produced neutrinos travel through the crust towards the far detector

For neutrinos of few GeV's energy the oscillation probability is maximal at a distance of $1-2 \cdot 10^3$ km

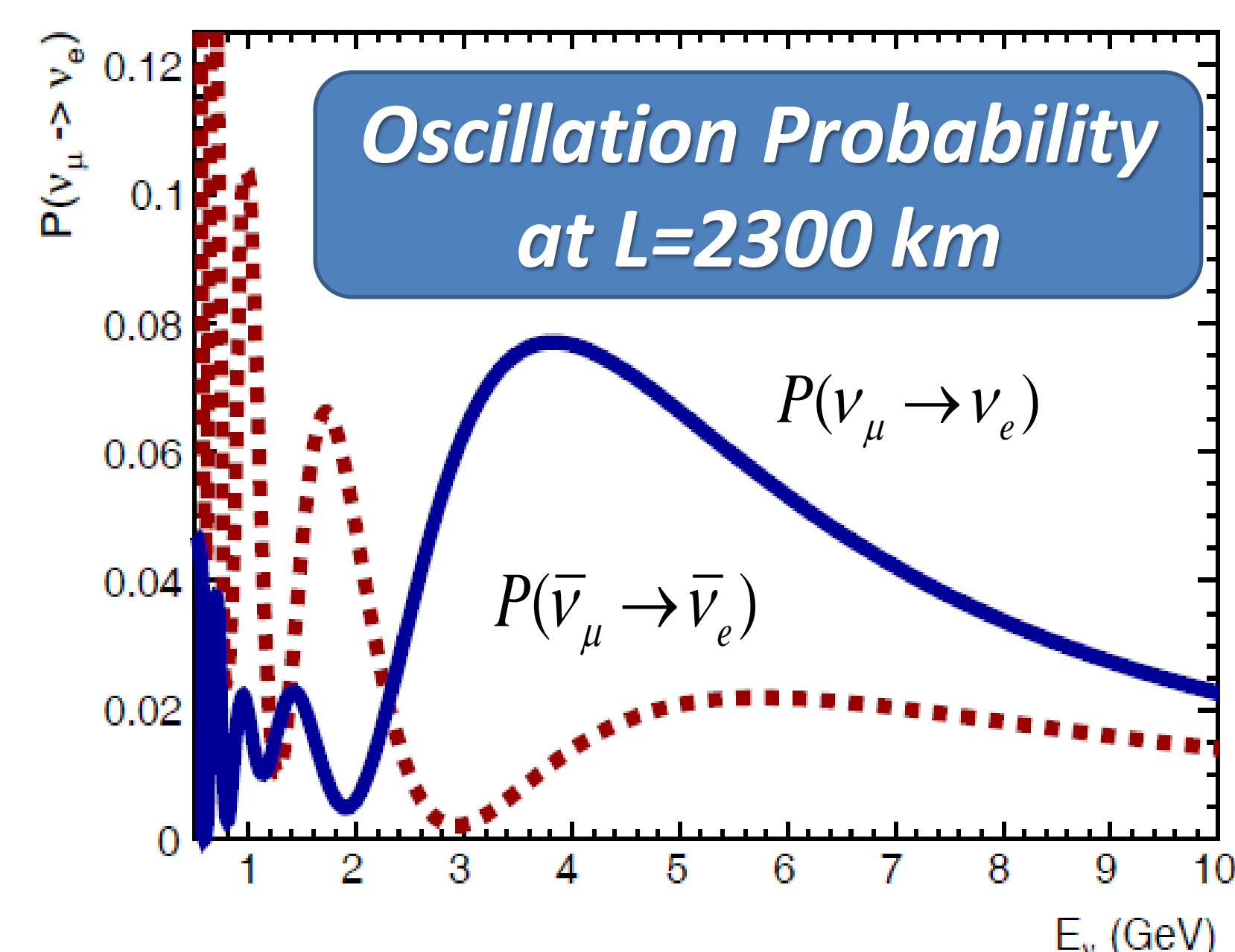
NEUTRINO PRODUCTION



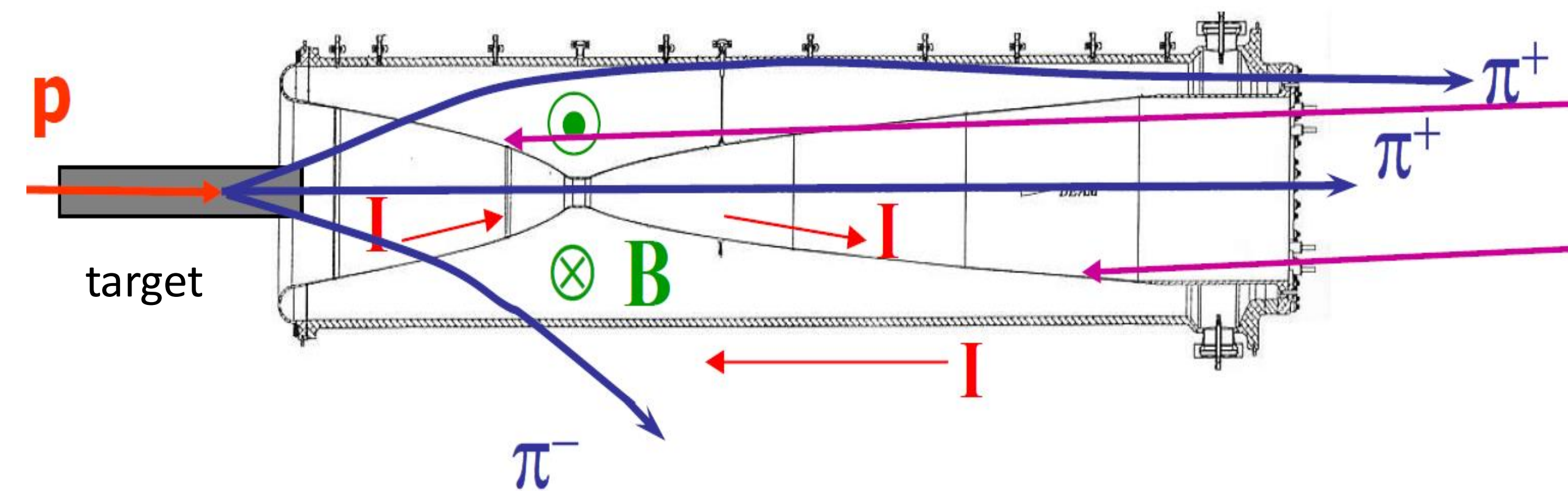
Neutrino Energy Spectrum at a distance L over a surface A is determined by the **Divergency** (θ) of the focused parent π 's beam, the solid angle **Acceptance** and the **Lorentz boost** (β_π) relativistic effect.

$$E_\nu = \frac{M_\pi^2 - m_\mu^2}{2(E_\pi - p_\pi \cos \theta_{\pi\nu})} \Omega_\pi$$

$$\Omega_\pi = \frac{1}{4\pi} \frac{A}{L^2} \frac{1 - \beta_\pi^2}{(\beta_\pi \cos \theta_{\pi\nu} - 1)^2}$$

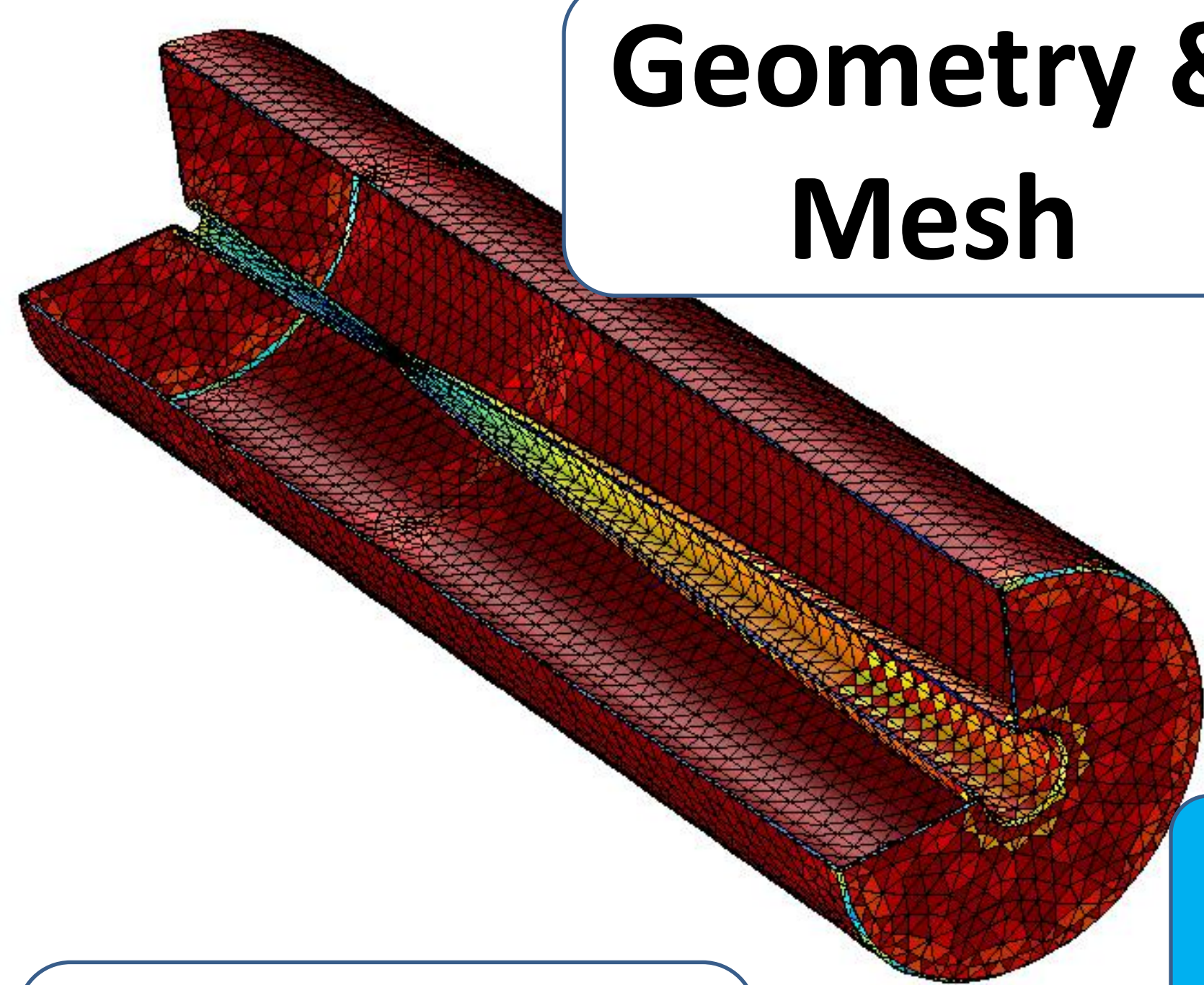


- Horn: two coaxial conductors (Aluminium, thickness ~3 mm)
- Pulsed with current $I \approx 200$ kA
- Toroidal Magnetic Field $B \sim I/r$ (max ≈ 2 T)

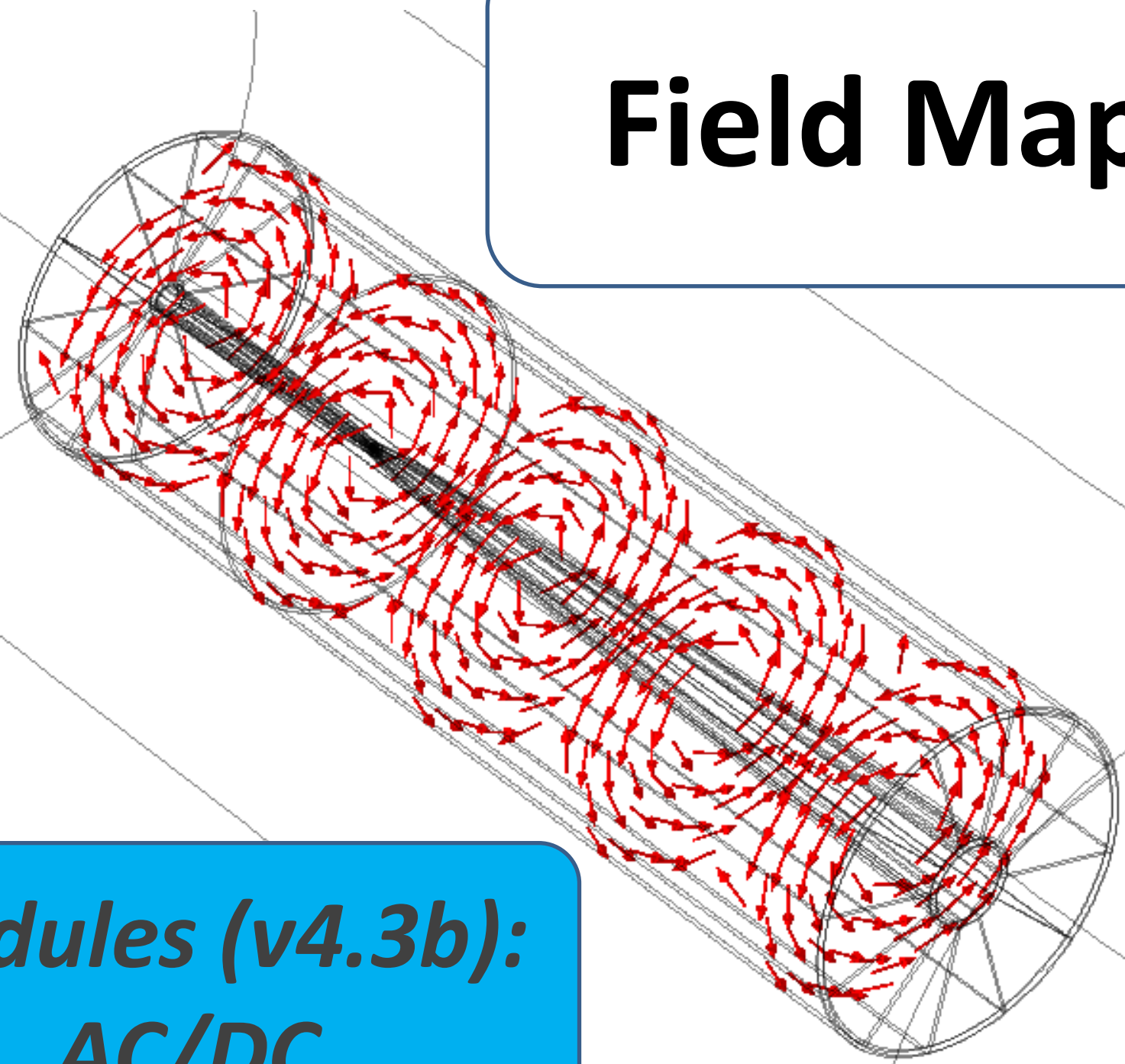


Internal Horn conductor and the full device instrumentation (FNAL)

Geometry & Mesh



Field Map



Optimization

PROGRAM

Optimize Horn/Target design to minimize π 's divergency in the energy (E_ν) range correlated to the oscillation probability ($P(\nu_\mu \rightarrow \nu_e)$) peaks

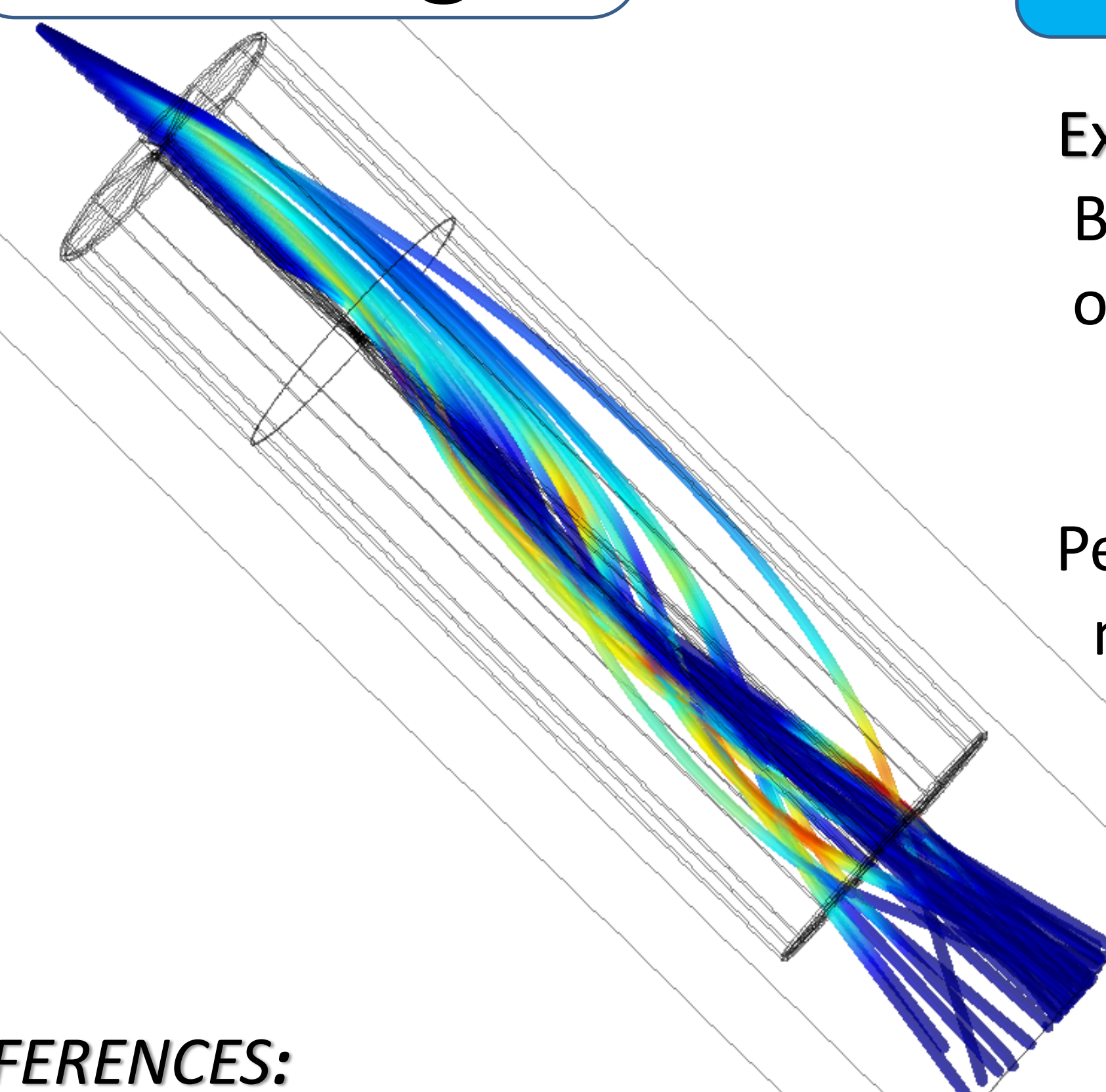
Control variables:

- Horn profile, parameterized as a double parabola
- Target position

Objective Function:

- Relative integrated energy flux in the range where oscillation probability is maximal

Particle (π^+) Tracing

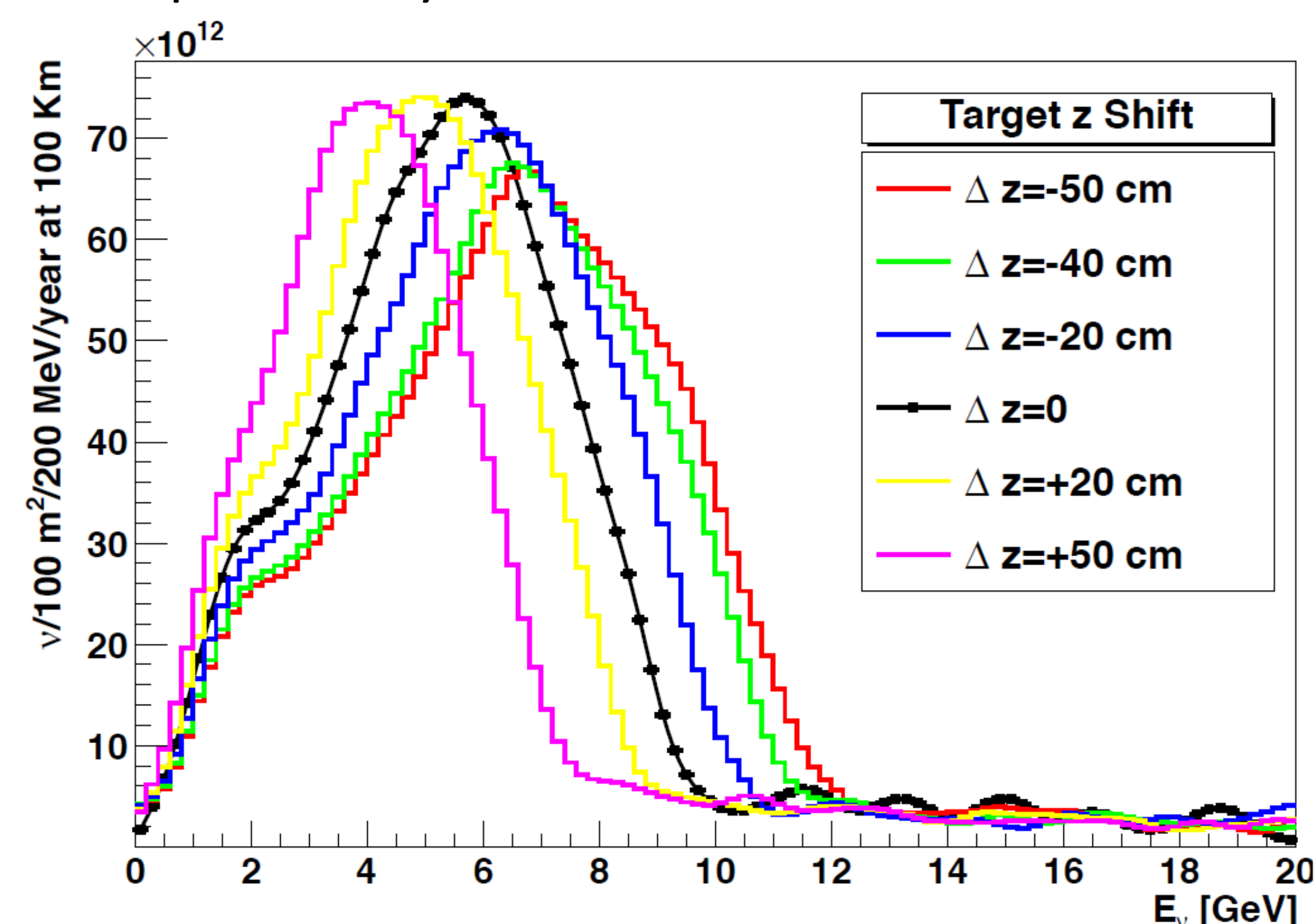


Modules (v4.3b):
 AC/DC
 Particle Tracing
 Optimization

External Input to the Particle Tracing:
 Bi-dimensional Momentum-angle spectrum of π 's produced off the target

CAVEAT:

Perfect focusing is possible for particles of a fixed momentum (and for all the production angles) while π 's are produced in a wide range of momenta and from a non point-like source (the finite-length target)



REFERENCES:

S. di Luise et al.: PoS ICHEP2012 (2013), C12-07-4