How can theorists get involved in DUNE

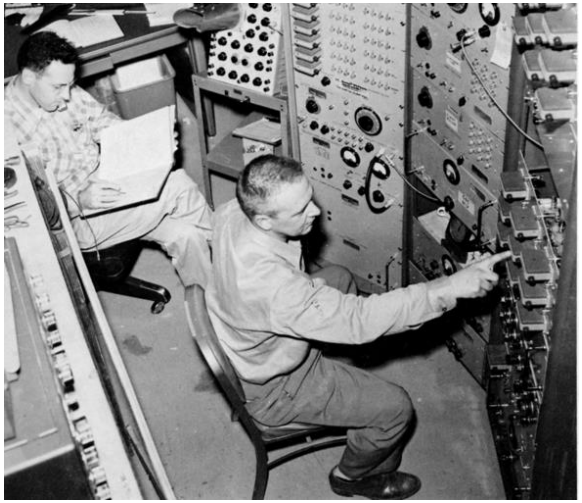
Alberto Gago Medina

Neutrino - Latin America Workshop

Fermilab, 28 April 2016

Introduction

HEP experimentalists



- Design and construction of the experiments (to probe theory).
- Data analysis

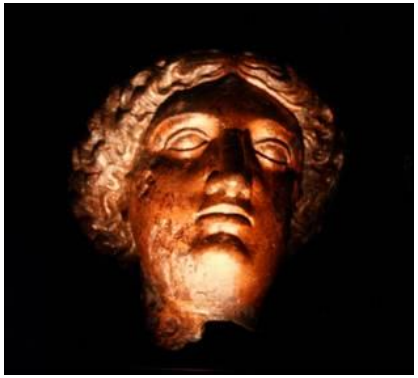
HEP theorists

- Build theories using mathematical models.
- .. and also to put the theories in terms of observable quantities (phenomenologist).

The simulation link

The begining

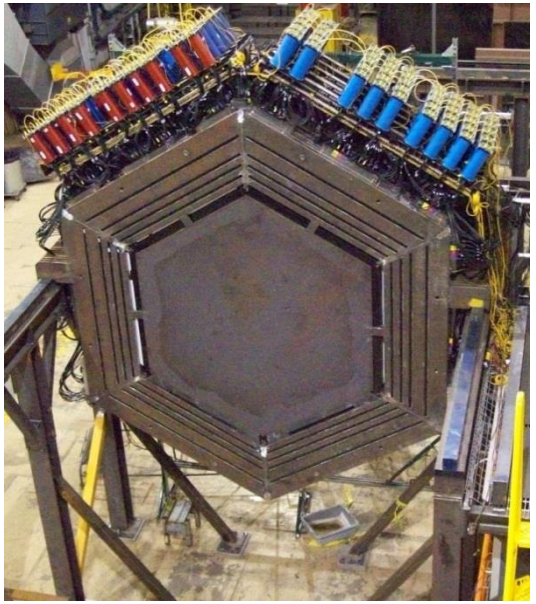
….and for me the story begins with:



De:	"Jorge_G_Morfin" <morfin@fnal.gov>
Para:	Alberto Gago Medina
Copia:	Kevin McFarland
Asunto:	Welcome to MINERvA
Fecha:	Mon, 22 Aug 2005 14:41:21 -0500

Dear Alberto,

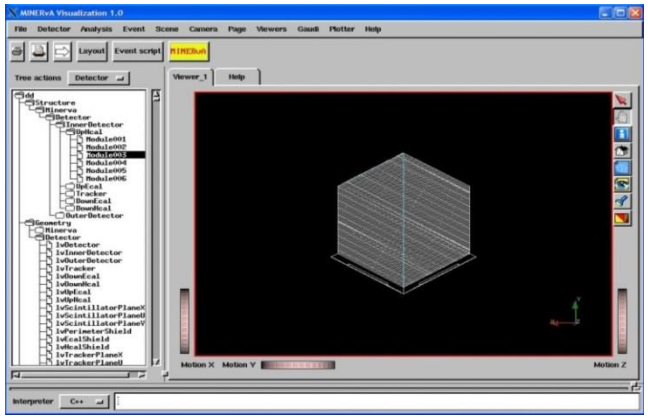
We are very pleased to welcome you into the MINERvA Collaboration. The consensus of the collaboration was overwhelmingly positive and we look forward to a long and fruitful collaborative effort with Pontificia Universidad Catolica del Peru (PUCP)



The day PUCP was admitted at the MINERvA collaboration

The detector simulation path

My entry point was the **detector simulation (software)**:



Development of the initial event display

MINERvA's Gaudi-Geant4 Simulation Vali
Report

J. L. Bazo and A. M. Gago
for the MINERvA Collab.

Pontificia Universidad Católica del Perú

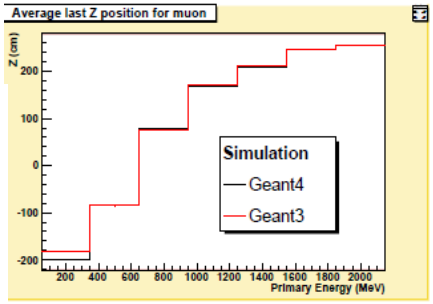
October 31, 2007

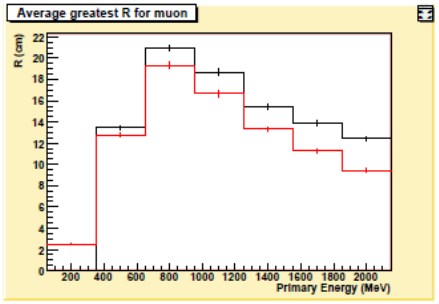
Abstract

In order to validate the Gaudi-Geant4-based MINERvA simulation,

Start	Title	Author(s)	Topic(s)	File(s)	Length	Edit
09:00	Introduction to the Simulation program	Alberto M Gago	Simulation	Workshop_PUCP_...ppt	00:40	Edit
09:40	Making changes in the Simulation programs	Jose L Bazo	Simulation	Changes for Va...ppt	00:40	Edit
10:20	Handling the Visualization	Jose L Bazo	Simulation	Visualizing Vi...ppt	00:35	Edit
10:55	Practical session	Jose L Bazo	Simulation	excercises.pdf	00:30	Edit
11:25	introduction to geant4	Leonidas Aliaga	Simulation	geant4_intro.pdf	00:45	Edit
12:10		None	None	None	00:30	Edit

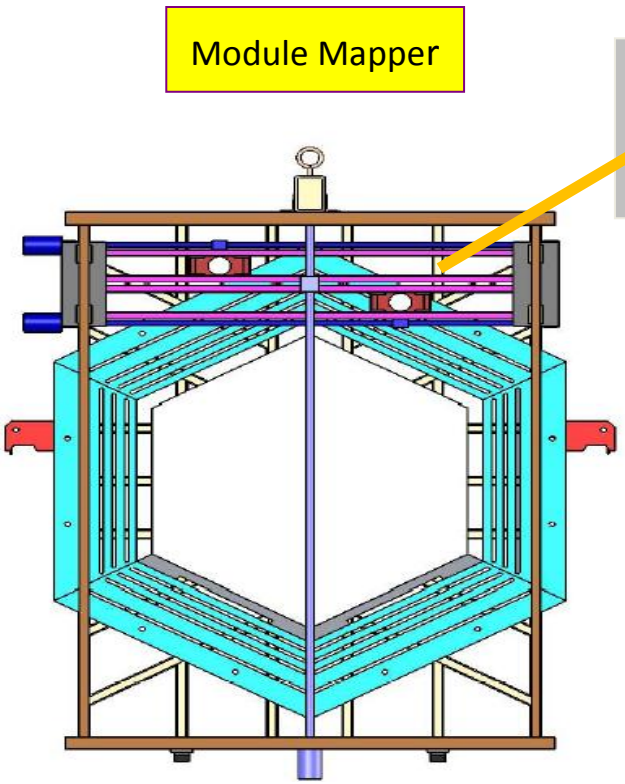
Massive participation of PUCP team at the MINERvA Software Workshop

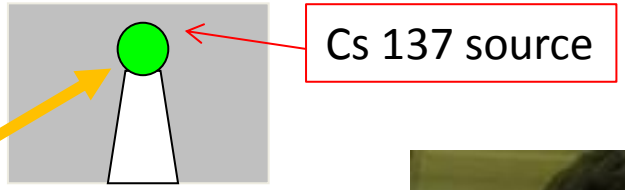




Comparison between Geant3 and Geant4 for hadronic/electromagnetic showers

The detector simulation path

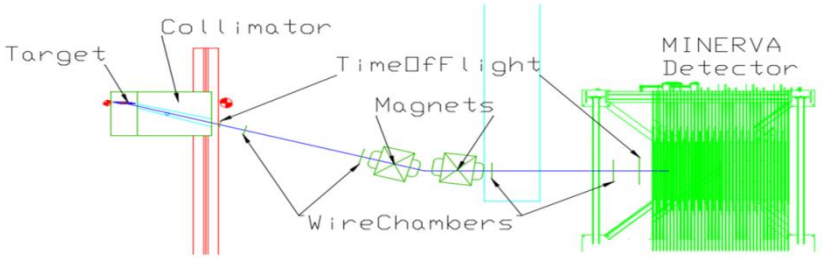




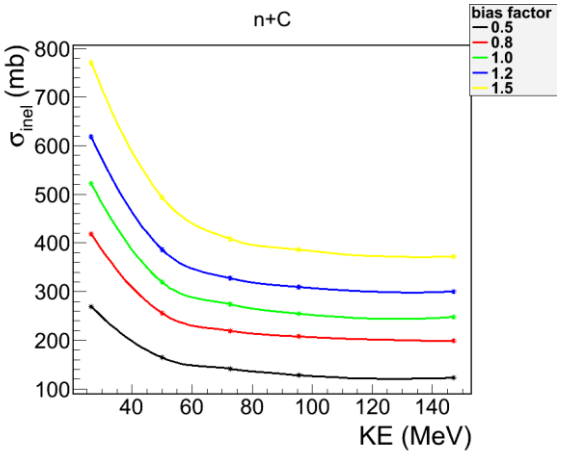
- The Module Mapper measured the resolution in position along the scintillator strip.
- Development of the Module Mapper concept in Gaudi and Geant4.

Some contributions

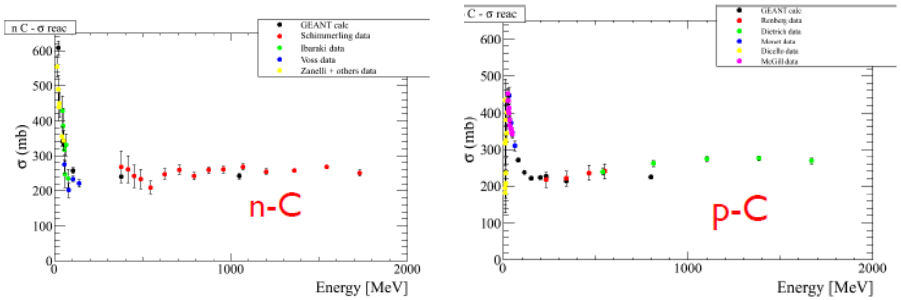
From then on:



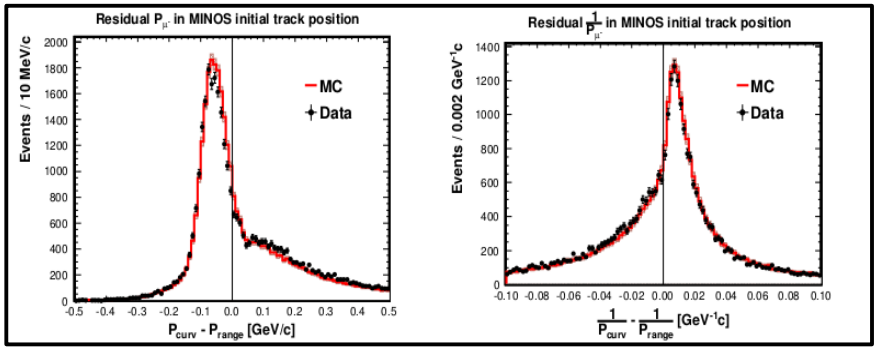
Design of the MINERvA test-beam 1



Implementation of Geant4 bias factor



Uncertainties in the interaction hadronic models



Syst. error from P_{curv} respect to P_{range}

The PUCP group@MINERvA








José Luis Bazo - Assistant professor@PUCP
Leonidas Aliaga - Postdoc @Fermilab
Carlos Pérez – Postdoc @ Stony Brook
Carmen Araujo - Assistant professor@UNSAAC
Juan Pablo Velásquez -PhD student @ Regina U.
Noemi Ochoa – PhD student @ Regina U.
Gonzalo Díaz - PhD student @ Rochester
María J. Bustamante – PhD student @ Texas Austin

Currently involved two masters student that are working locally at PUCP

The PUCP group@MINERvA

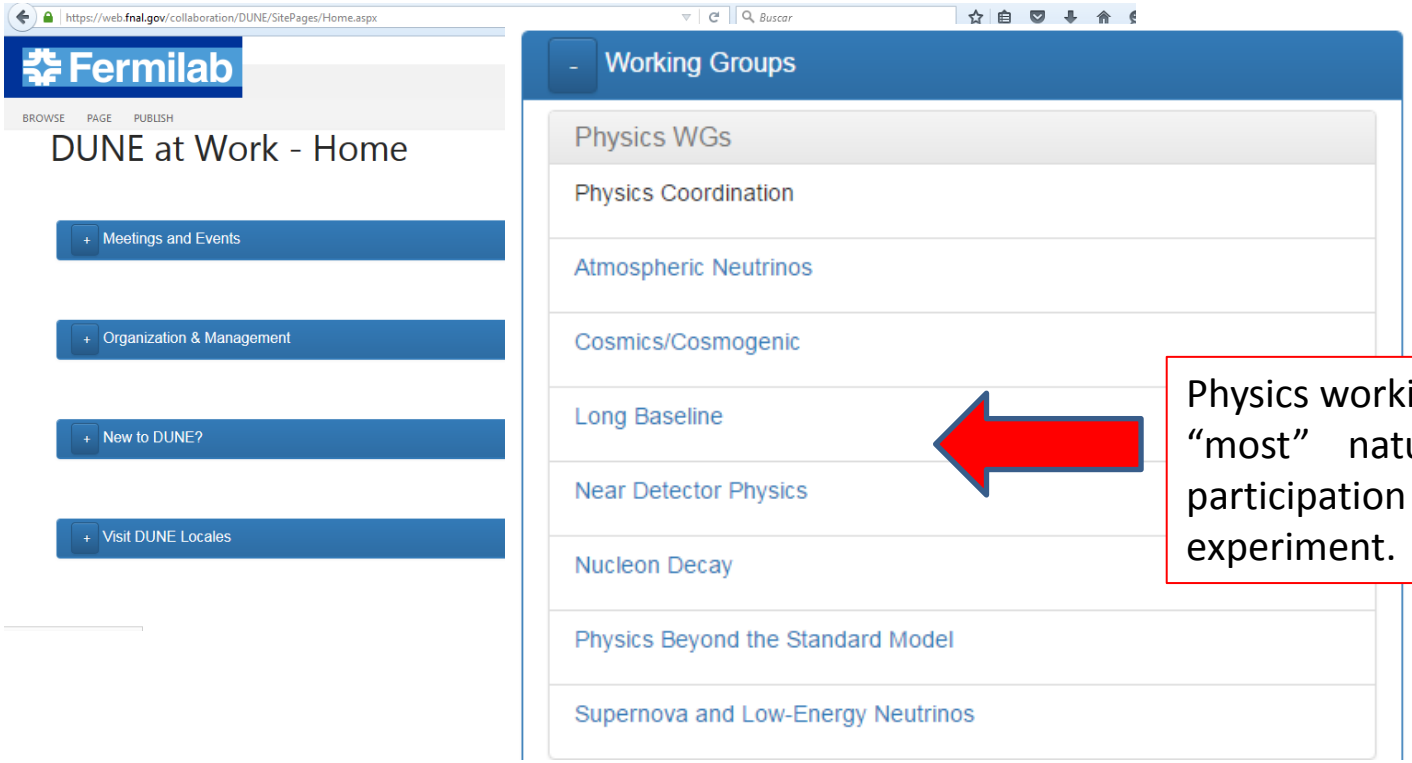
- Since early 2015 is working the MINERvA remote operational control room @PUCP (44 days of shifts).
- Five active shifters – many undergraduate students interested.
- Students from UNI has already taken shifts at the PUCP station.

MINERvA Analysis week 2013
@ PUCP

Some comments

- It is possible that theorists get involved in the physics validation, design or analysis performance of detectors, but, the requirement is to learn the simulation packages.
- It is indispensable to have an interaction with the experimental colleagues.
- There are various Latin American theorists that are involved in experiments.
- But there are other ways for a theorist to get into an experiment……

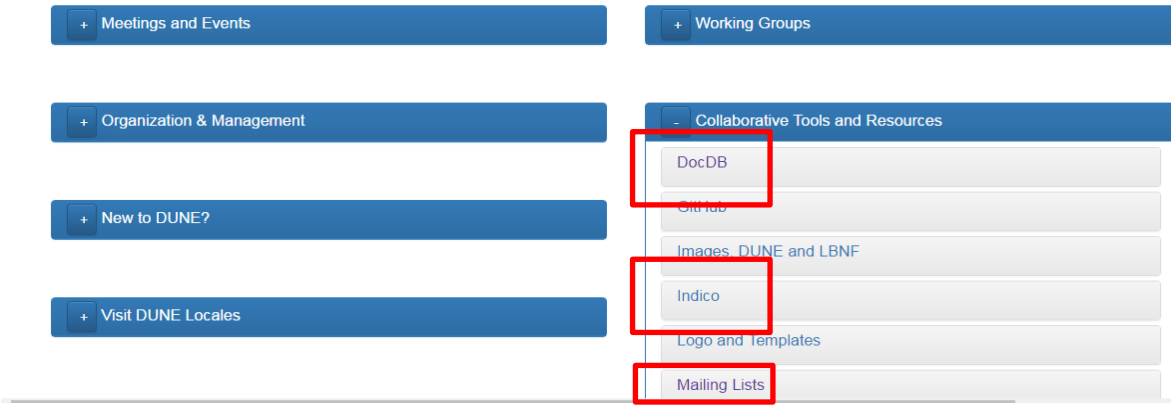
DUNE at Work



Physics working groups (WG) the "most" natural place for the participation of theorists in the experiment.

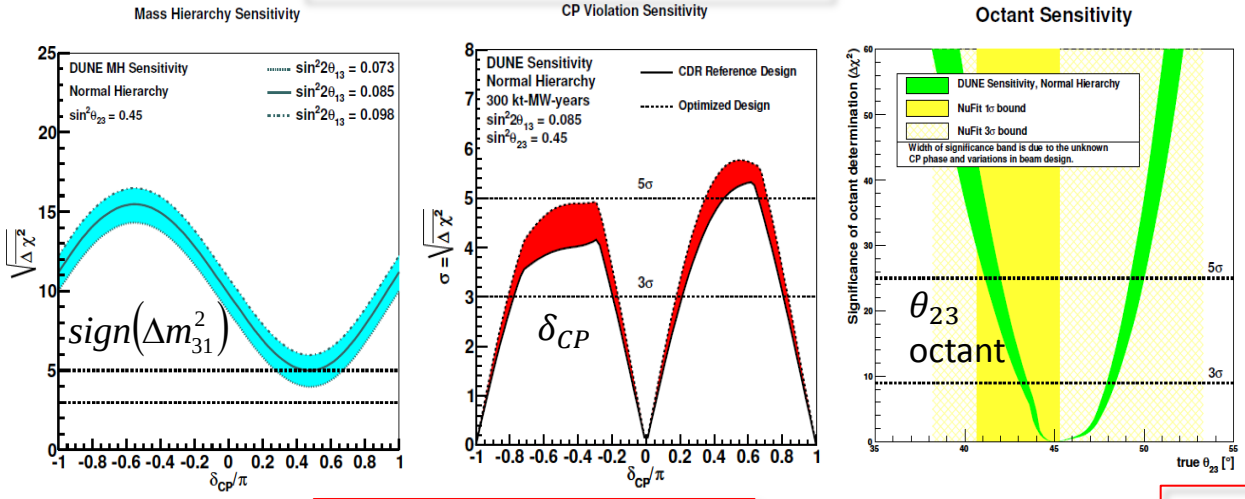
DUNE at Work - Home

The DocDB and the indico page are useful tools for following the ongoing discussions. Suscription to the WG through the mailing lists.



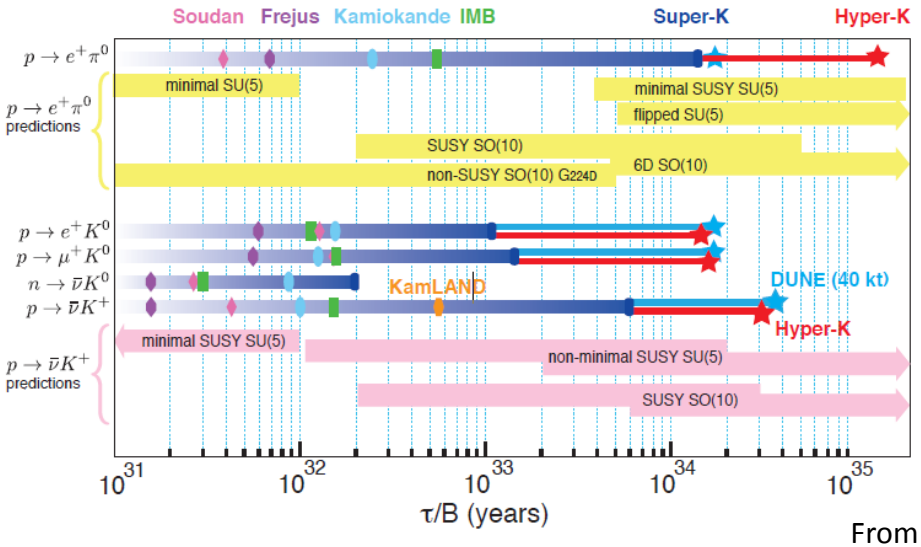
DUNE- Primary scientific goals

Neutrino oscillation physics

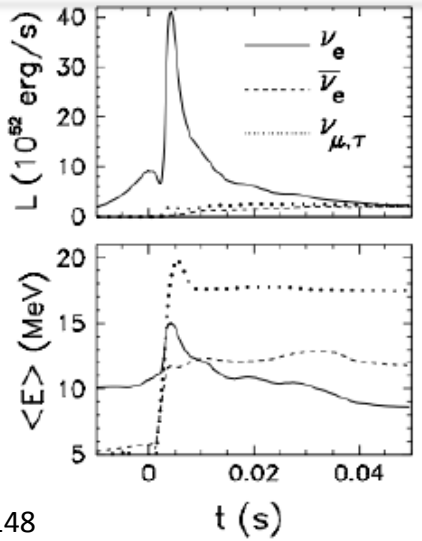


Plus precision oscillation parameter measurements.

Proton decay searches



ν_e flux detection and measurement at the core-collapse supernova



From DUNE CDR arXiv:1512.06148

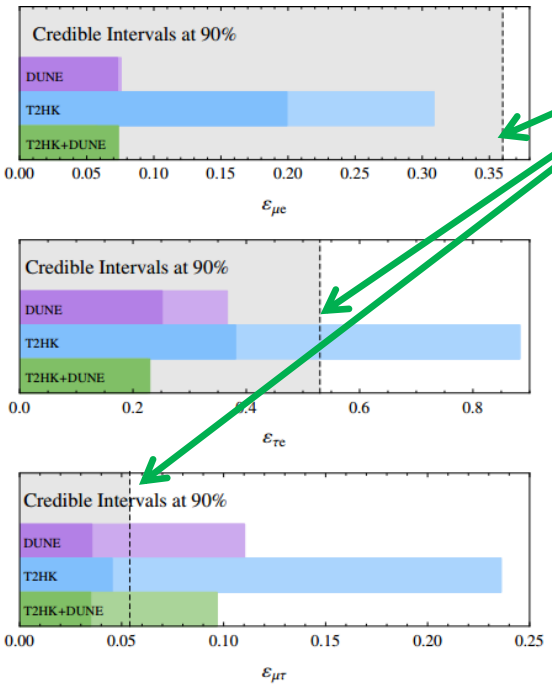
DUNE- Non-Standard Interactions(FD)

Non-Standard Interactions in the propagation

NSI

$$i\frac{d}{dt}\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix}=\frac{1}{2E}\left[U\begin{pmatrix}0&0&0\\0&\Delta m^2_{21}&0\\0&0&\Delta m^2_{31}\end{pmatrix}U^{+}+2\sqrt{2}G_F n_e\begin{pmatrix}1+\varepsilon_{ee}&\varepsilon_{e\mu}&\varepsilon_{e\tau}\\ \varepsilon^{*}_{e\mu}&\varepsilon_{\mu\mu}&\varepsilon_{\mu\tau}\\ \varepsilon^{*}_{e\tau}&\varepsilon^{*}_{\mu\tau}&\varepsilon_{\tau\tau}\end{pmatrix}\right]\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix}$$

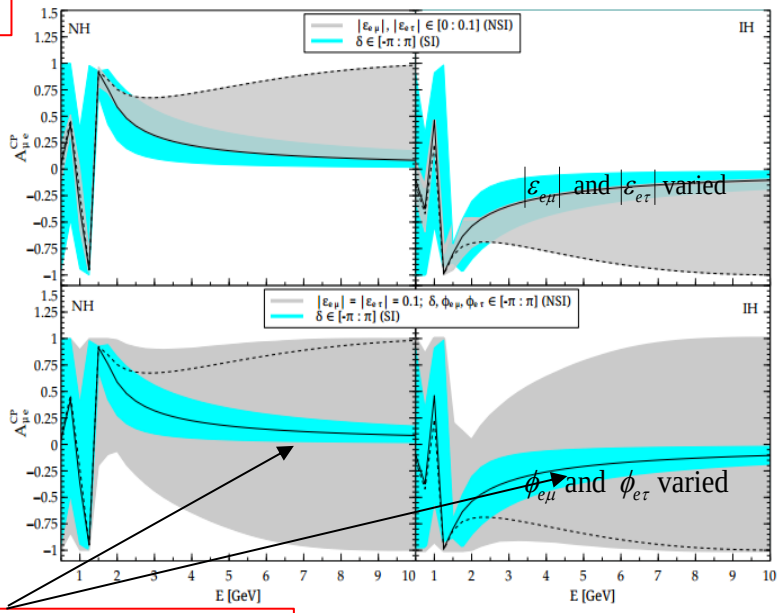
DUNE sensitivities



P. Coloma, arXiv: 1511.06357

Current constraints

M. Masud, A. Chatterjee, P. Mehta, arXiv: 1510.0826

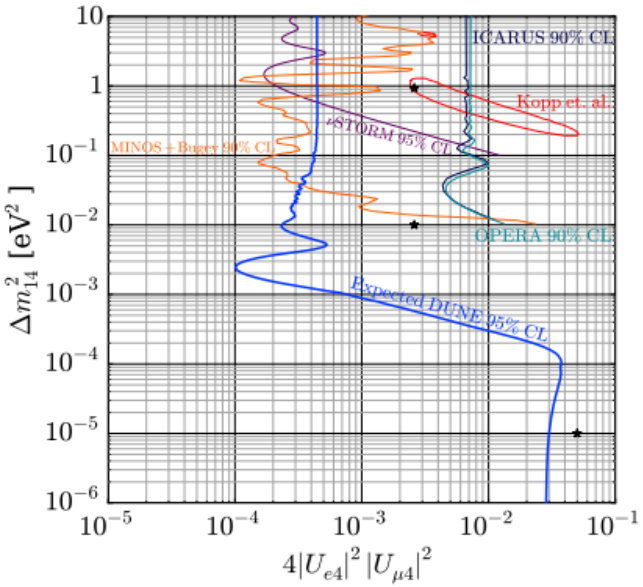


Degeneracies between
NSI –SI parameters and CP

DUNE- Search for sterile neutrinos(FD)

3+1 Model

250 kton – MW –yr



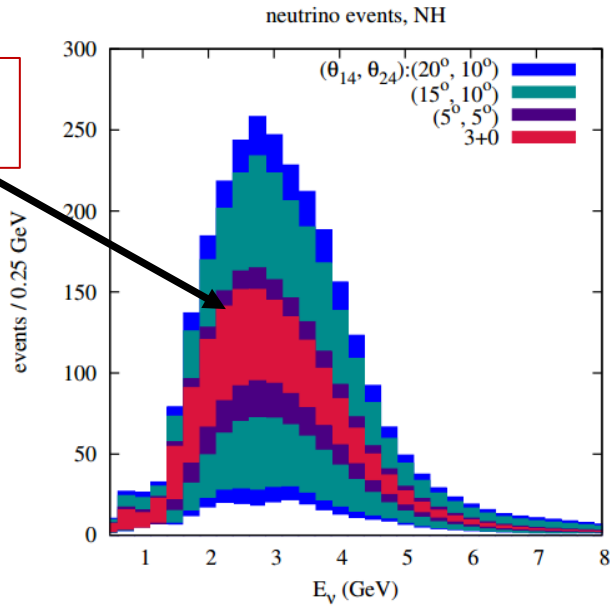
J.M. Berryman, A. de Gouvea, K.J. Kelly, A. Kobach, arXiv: 1507.03986

Degeneracy between 3+0 CP and 3+1 for small mixing angles

$\Delta m^2_{14} = 1.0\ \text{eV}^2$

θ_{34}, all CP phases varied

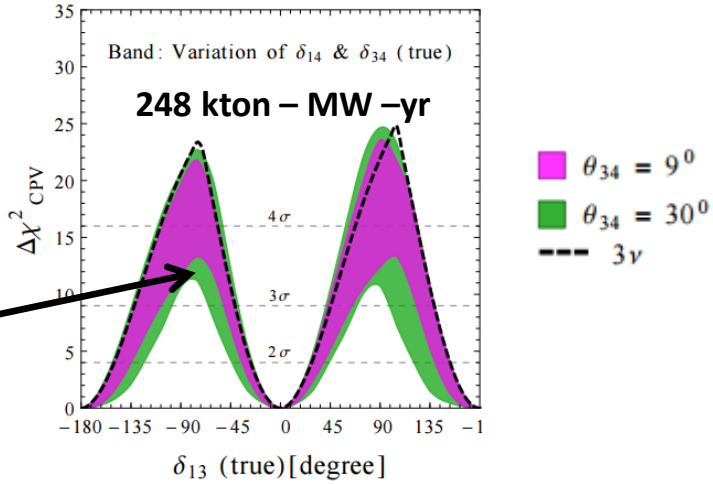
210 kton – MW –yr



R. Gandhi, B. Kayser, M. Masud, S. Pakrash, arXiv: 1508.06275

Disappearance and appearance channels

$\theta_{14} = \theta_{24} = 9^\circ$

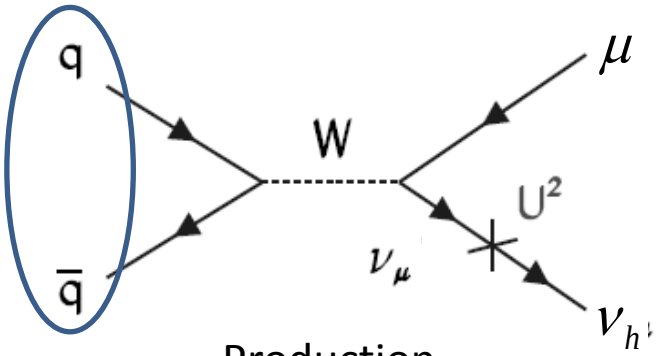


Degradation in the statistical significance of the CP δ phase also present in the mass hierarchy

S. K. Agarwalla, S. S. Chaterjee, A. Palazzo, arXiv: 1603.03759

DUNE- Search for heavy neutral leptons (ND)

Heavy mesons from the reaction p+target



Production

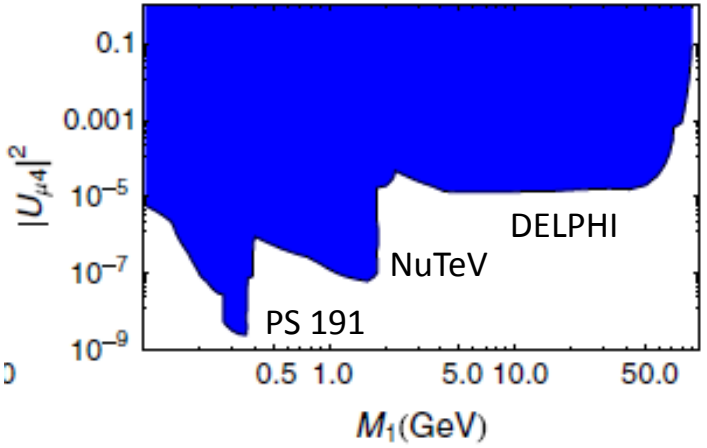
They also can be produced in NC DIS

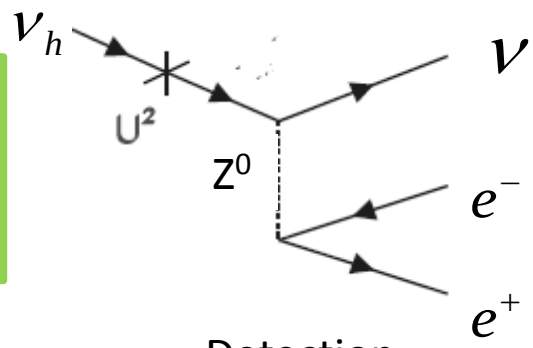
$$\nu_\mu N \to \nu_h X$$

$$\nu_h \to \nu_\alpha l^+ l^-$$

$$\alpha = e, \mu, \tau$$

Constraints



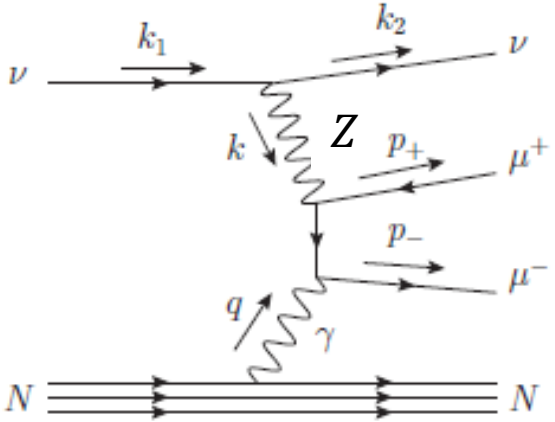


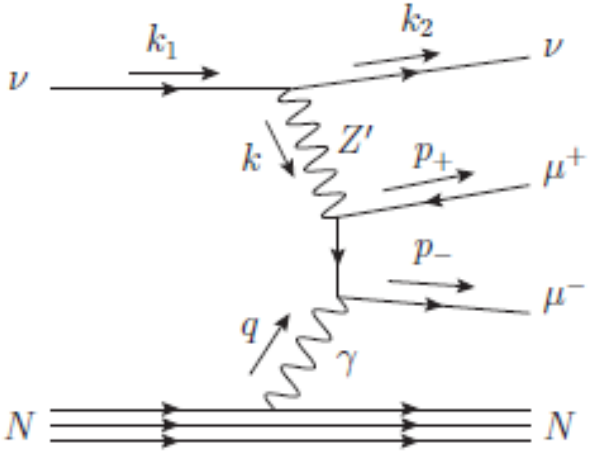
Detection

- The ND still requires physics studies for final design (E. James)
- There is room for beamline optimization (A. Marchionni)

DUNE- Neutrino trident production(ND)

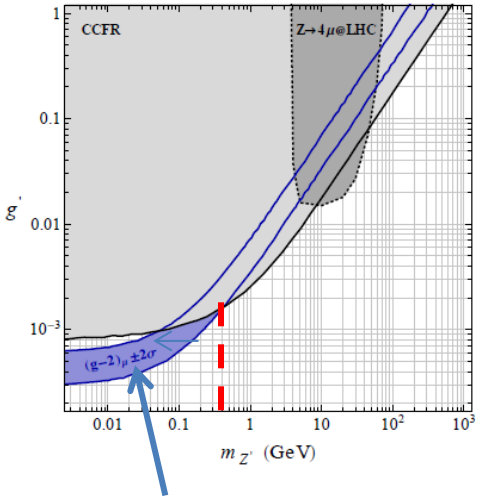
Similar contribution with W





There is a constructive Interference between diagrams

Constraints



Neutrinos beams with few GeV can probe this region but requires few x 10^7 cc events

W. Altmannshofer, S. Gori, M. Pospelov, I. Yavin, PRL. 113(2014) 091801

- The ND still requires physics studies for final design (E. James)

Useful tool for DUNE simulation (to be available soon)

$$N_\nu = \Phi_\nu \otimes \sigma \otimes P_{osc} \otimes \varepsilon_{ff} \otimes E_\nu^{smear}$$

G4LBNF GENIE

Fast MC

Inputs for GLoBES

Modifications to oscillation physics can be introduced through GLoBES

Final remarks

- The PWGs at DUNE constitutes an excellent scenario for the theorists to start with his relationship with the experiment, it represents an opportunity to push forward your ideas within the DUNE Physics Program.

- Of course, it is also possible to get involved in software and hardware development. In the case of hardware with the appropiate help (hired postdoc) and time to invest.

- The knowledge you acquire in packages such as: GEANT4, Root, GENIE, etc, and in experimental HEP itself, give you useful tools for the development of your theoretical (phenomenological) work.

Final remarks

- In order to have an adecuate ratio (theo/expt) of HEP physicists community, the development of experimental HEP in Peru is mandatory (Leon Lederman´s view).
- The benefits to society that could derive from experimental HEP may help us to convince our funding agencies about how important is to invest in basic science.

Thank you for your attention