NuFact 2016

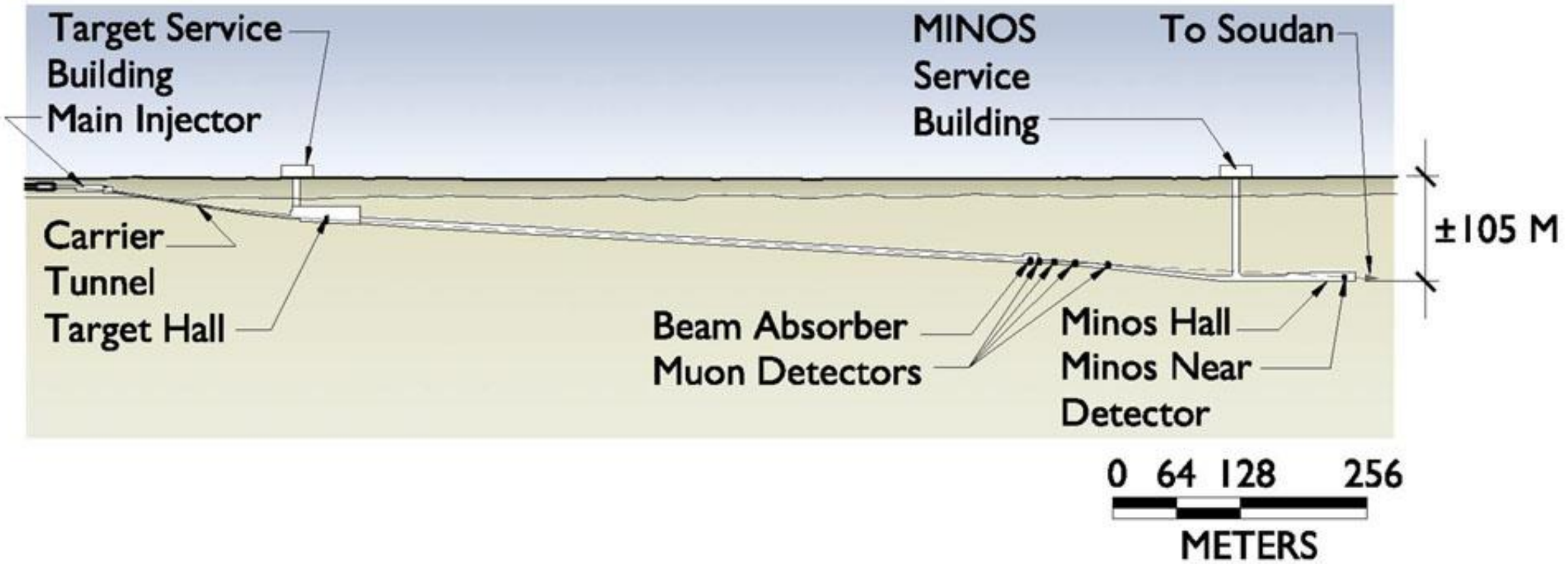
Neutrino beamline prospects, concepts

Milorad Popovic

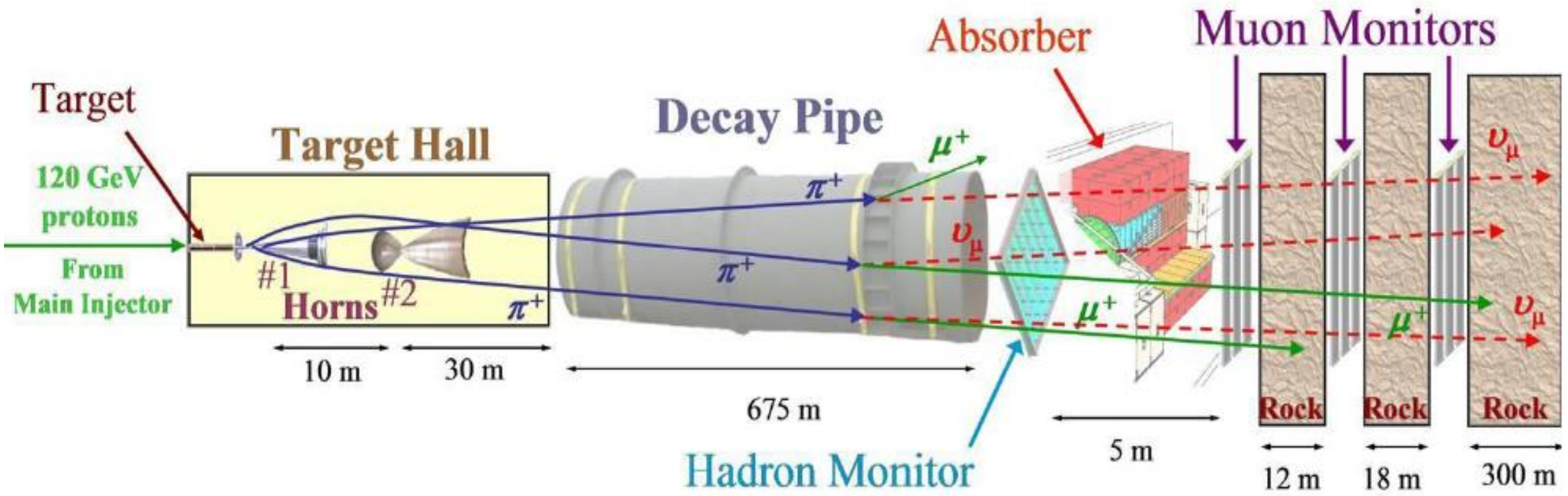
APC- Fermilab, Batavia, IL 60510, USA

August, 21, 2016

Conventional Neutrino Beamline



Conventional Neutrino Beamline



120 GeV protons hit target to produce π^+

Dream or Possibility

Neutrino facility that will have:

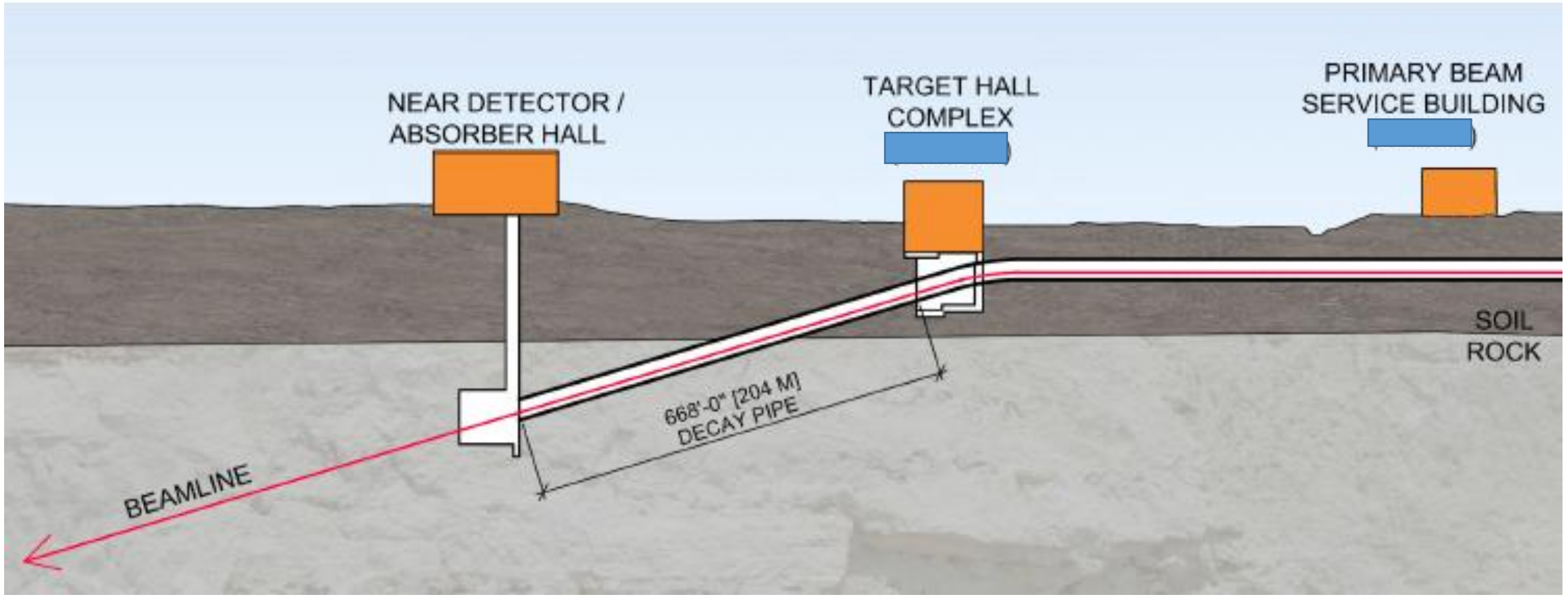
- Upgradable multi MW power proton beam
- Upgradable high intensity pion beam
- Charge selected high intensity pion beam
- Energy selected high intensity pion beam
- On & Off axis beam with same Far detector
- High precision muon energy and flux characterization

And all these for:

- Physics rich as good and even better that existing/planed facility
- Manageable cost, comparable to the cost of present facility
- Environmentally acceptable facility

NON-Conventional Neutrino Beamline Pion/Neutrino Beam Modified

Suggestion is to consider multi GeV protons on Target and then bent and collect “useful” Pions



- For modern neutrino experiments ‘useful’ pions are 2-15 GeV
- Pions coming from horn look like ‘beam’

In 2012 I tried to connect NuSTORM with LBNE following requirement define in NUMI CDR (1998)

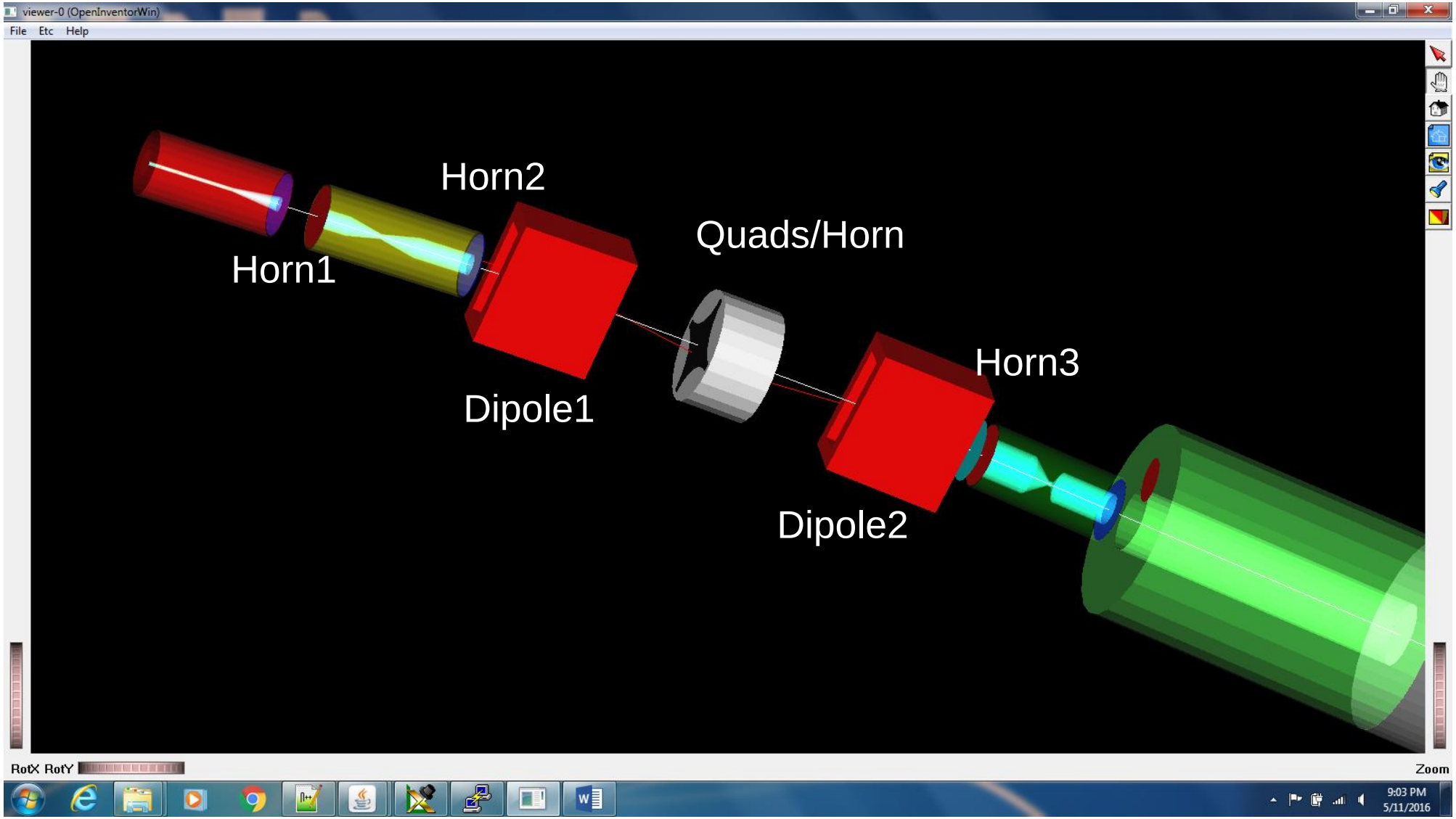
“..The neutrino beams have the following objectives:
Potentially cover the energy range 1 to 20 GeV.
This is accomplished by a hadron focusing system that can be optimized to 1-3 GeV, 3-8 GeV or 8-20 GeV in neutrino energy……”

- At NuFACT2015, JB Lagrange suggested much better solution:
  Large Momentum Acceptance Beam Line
  (almost) ONLY “useful” Pions enter Decay Pipe

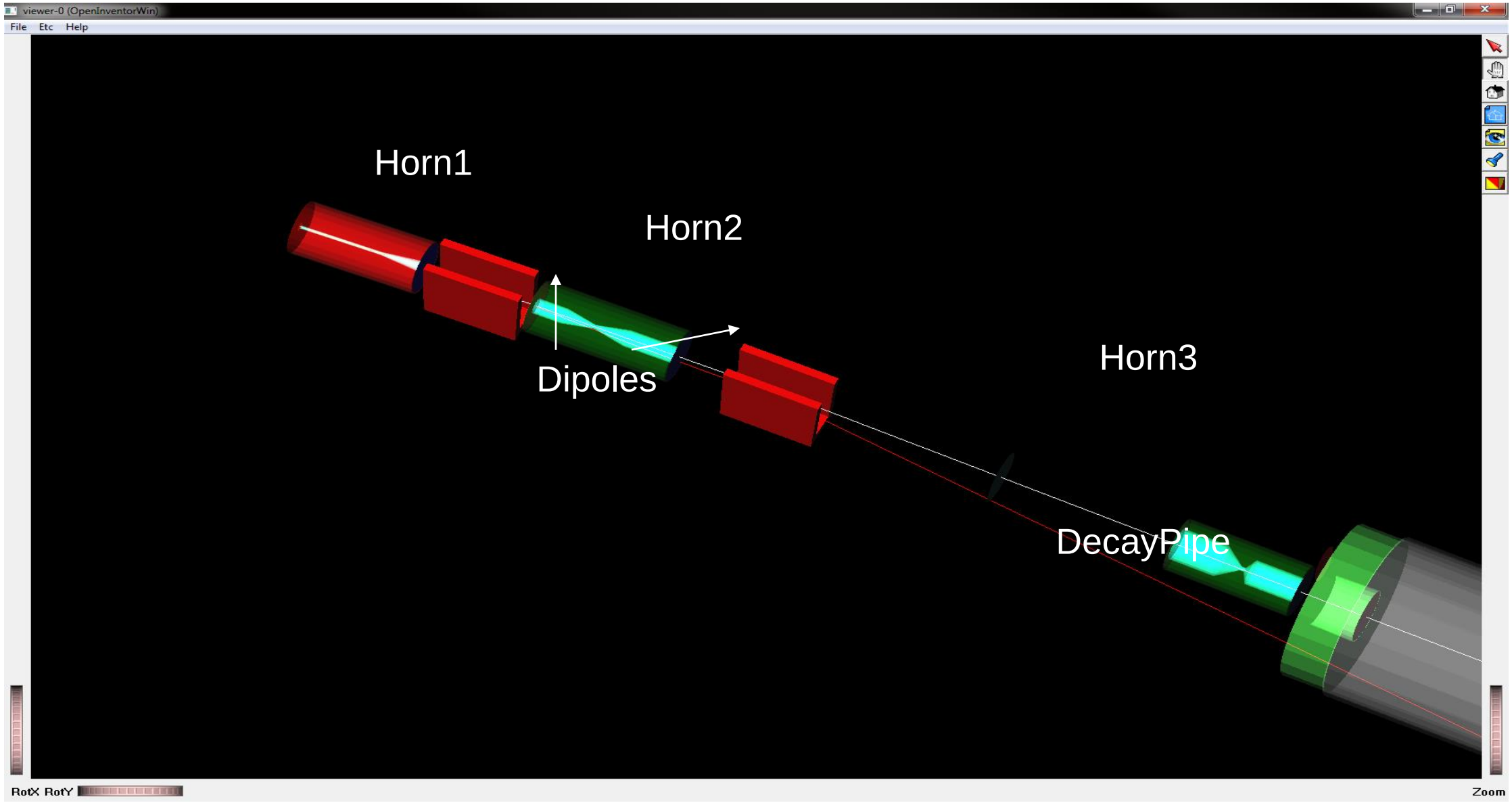
How to Evaluate Concept

- Take best possible setup for conventional concept, for purpose of this talk take
- Optimized three horns system
- Make minimal change of configuration but include bend
- Evaluate physics potentials and compare two approaches.

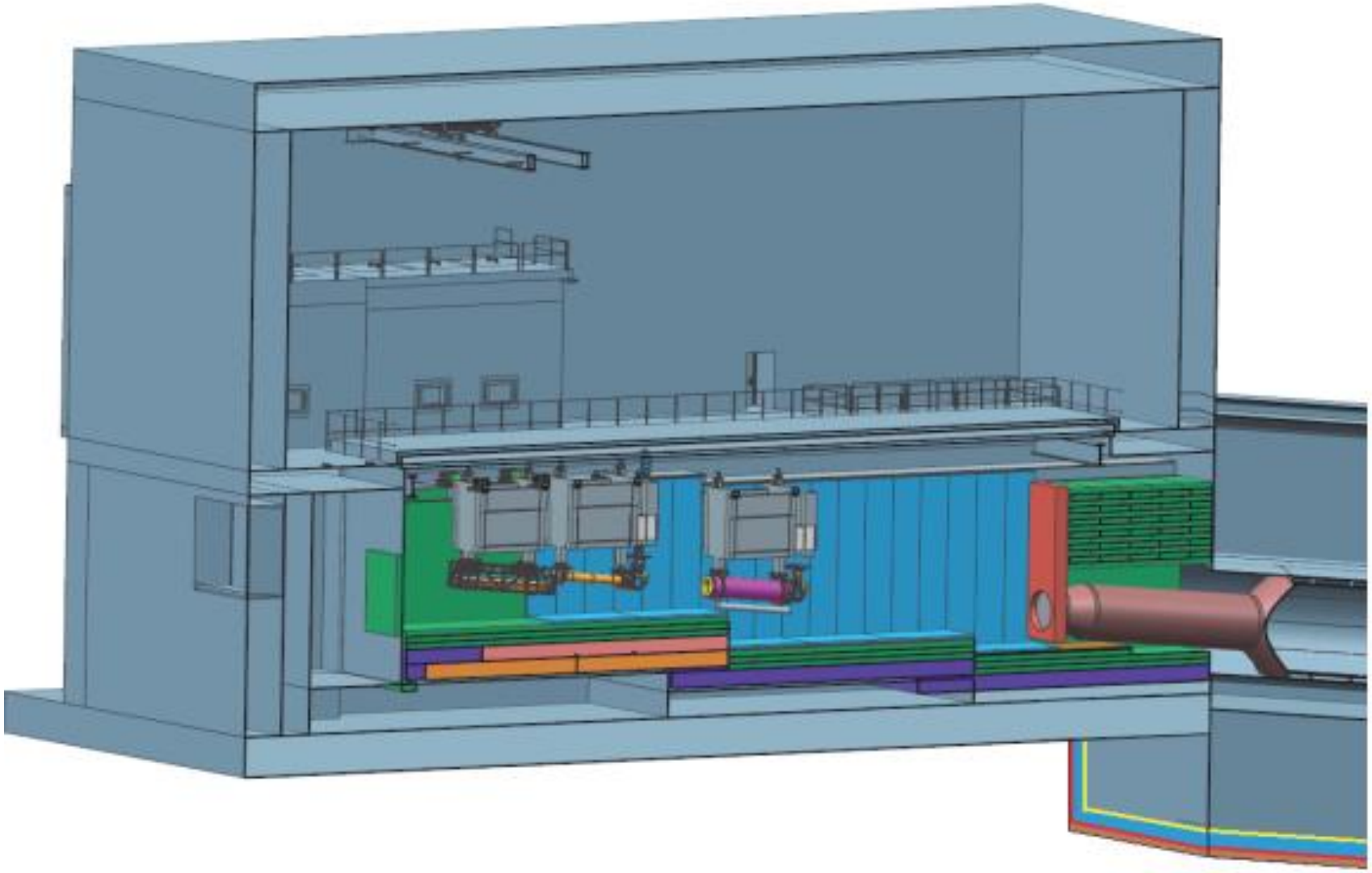
Concept, “Old” Configuration (from March - April 2016)



Working Configuration (June 2016)



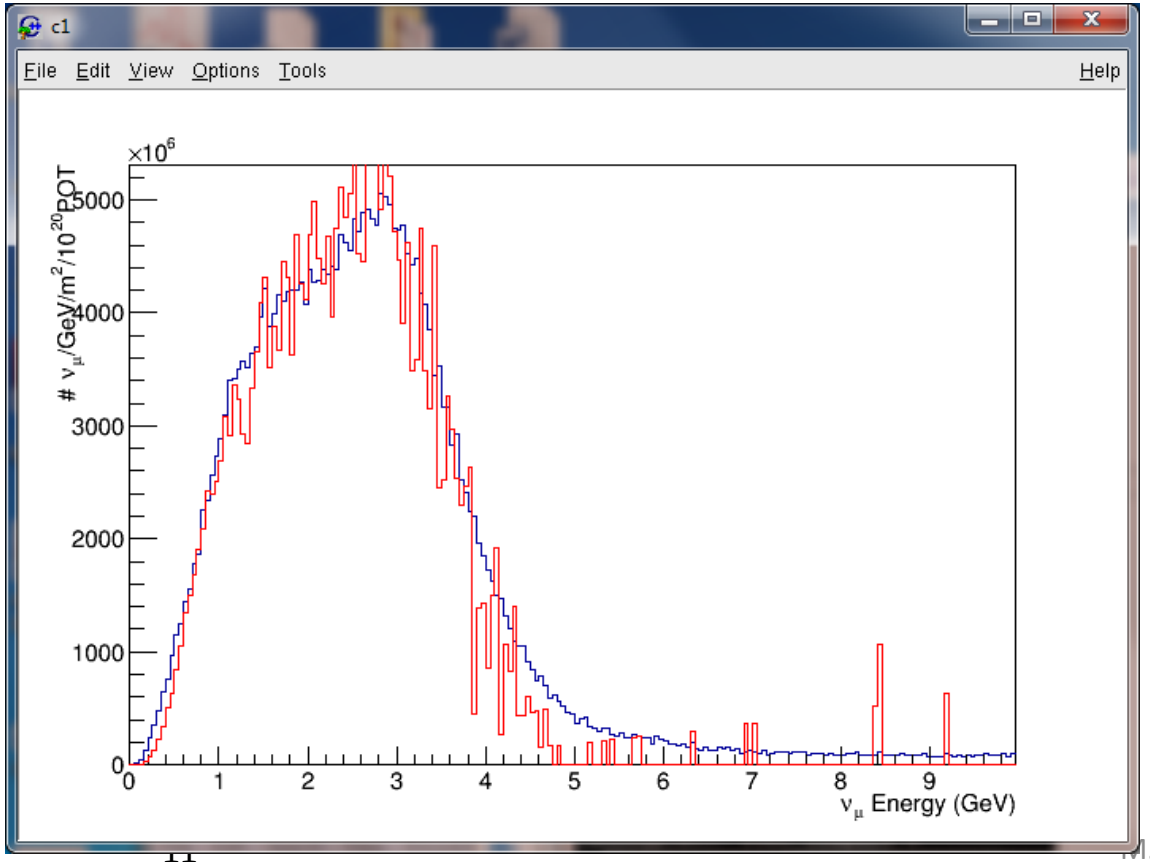
In any existing neutrino facility there is about 25 meters from start of Target to the entrance to Decay Pipe inside of Target Hall. The aim is to make minimal modification and utilized existing/planed facility



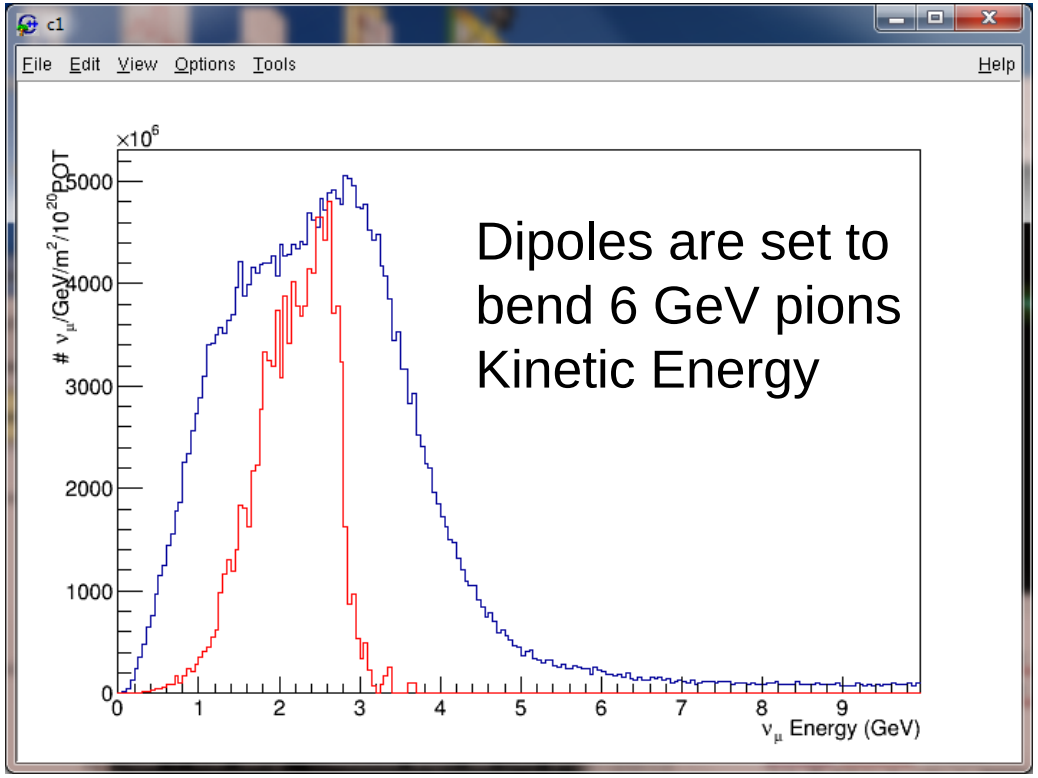
Simulations: 120 GeV proton (10k particles) beam on 2m long C target housed in the neck of Horn1

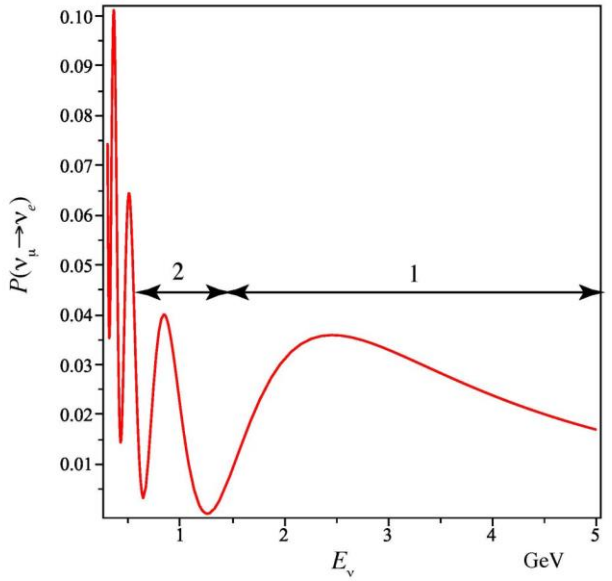
To speed up simulations, the horns are modeled as fields only (there is no horn material in the simulations). Because the horn geometry is identical to 'the three horns optimized configuration' we can compare the number of non-oscillating neutrinos in the far detector with 'the optimized configuration' results and this gives us the opportunity to fix the normalization and correct for the lack of materials in our simulations.

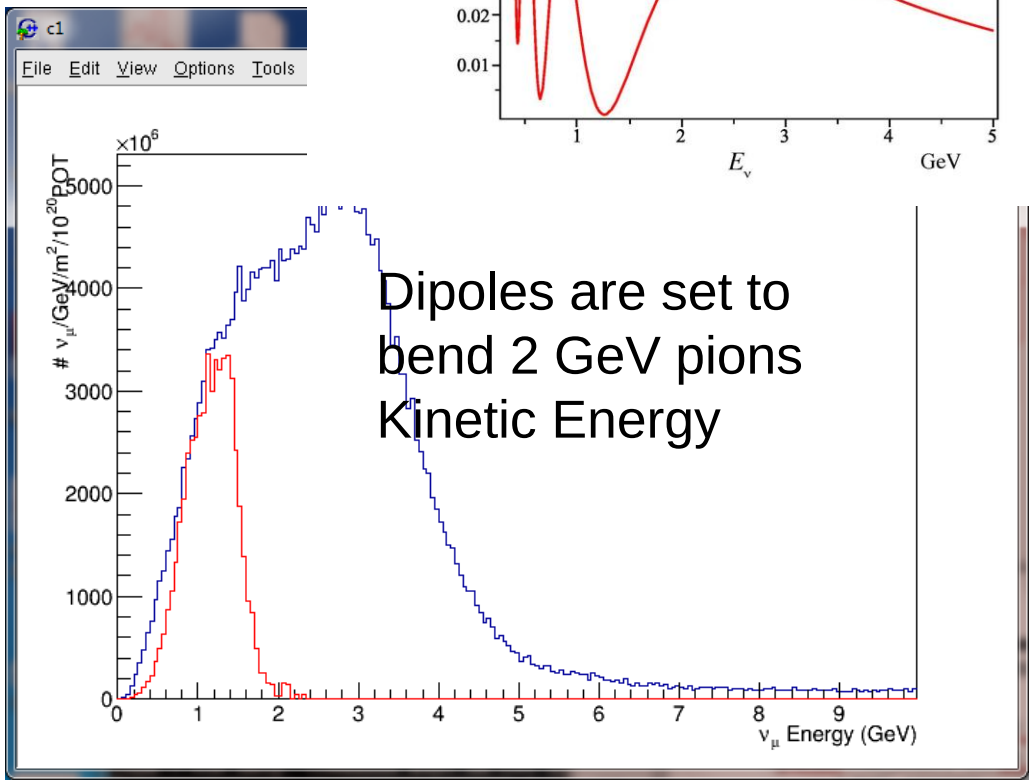
The blue curve is the result of the simulation for the optimized configuration The red curve is result of our simulation with normalization factor fixed to adjust the scale.



Option 1, pions are bent for 100 mr (5.7 degree)

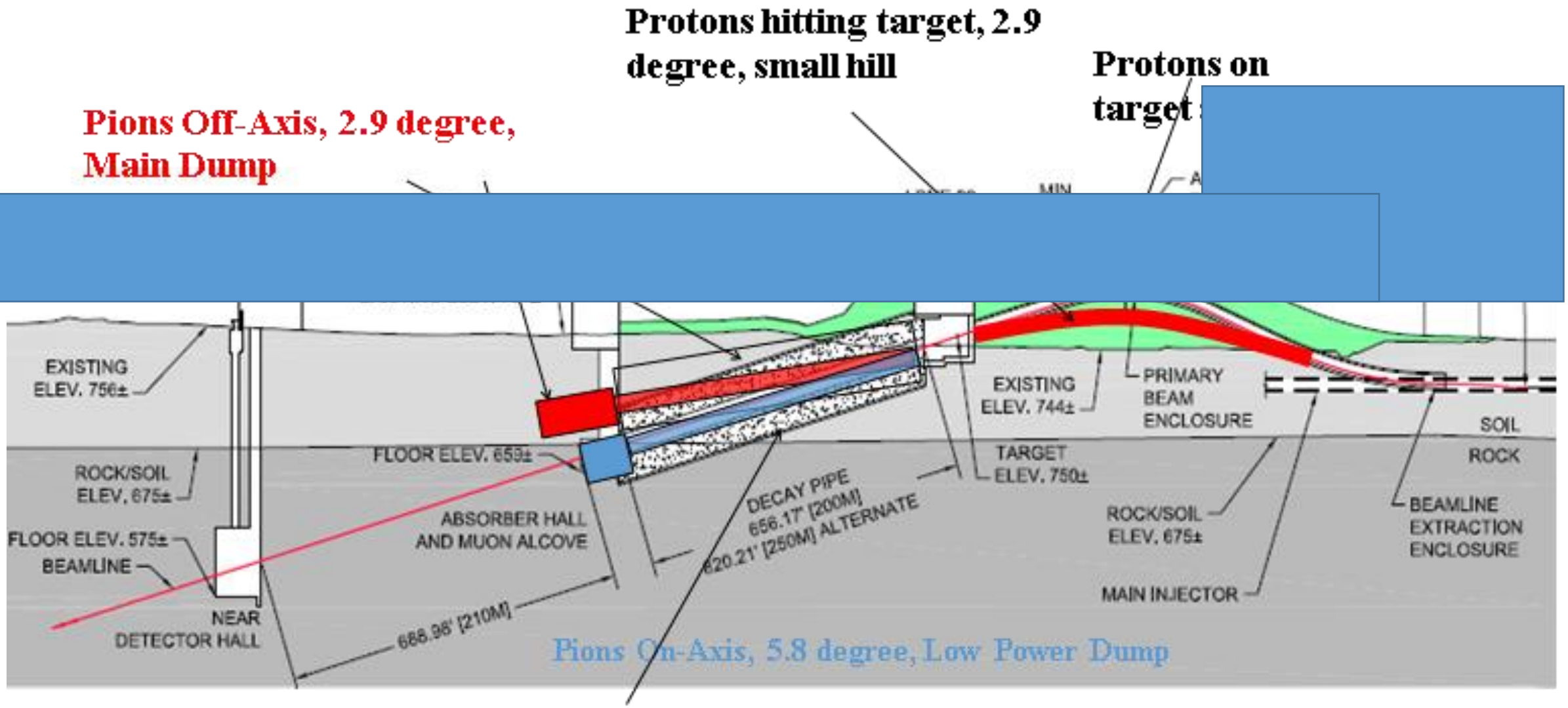




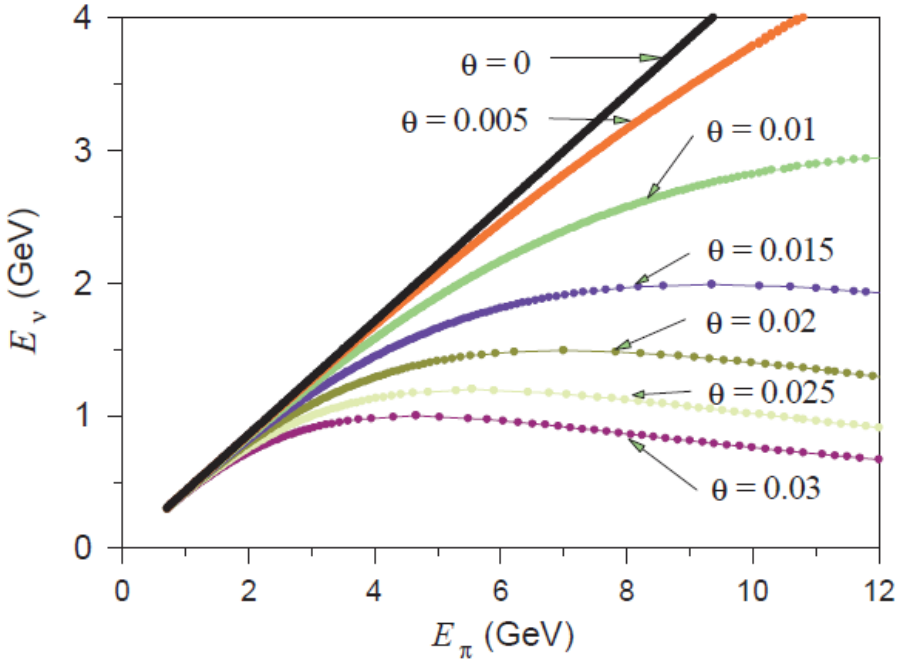


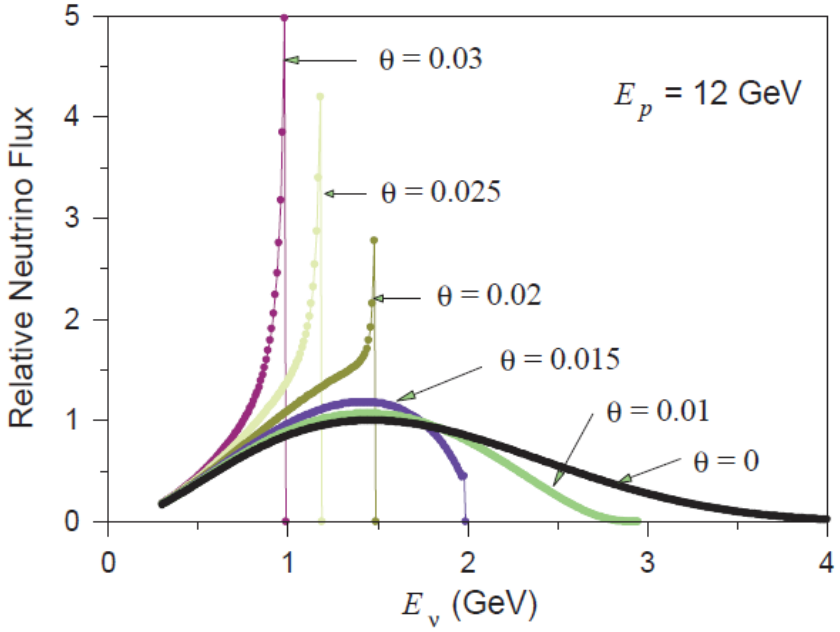
In presented concept, two bending magnets are identical, C-dipoles, conventional, iron dominated with field ~0.5T, ~2.4m long, gap 0.6 m and 1m field width. The first dipole is 0.2m separated from both horns. None of used parameters are optimized.

On & Off Axis Experiments Combined - Option 2



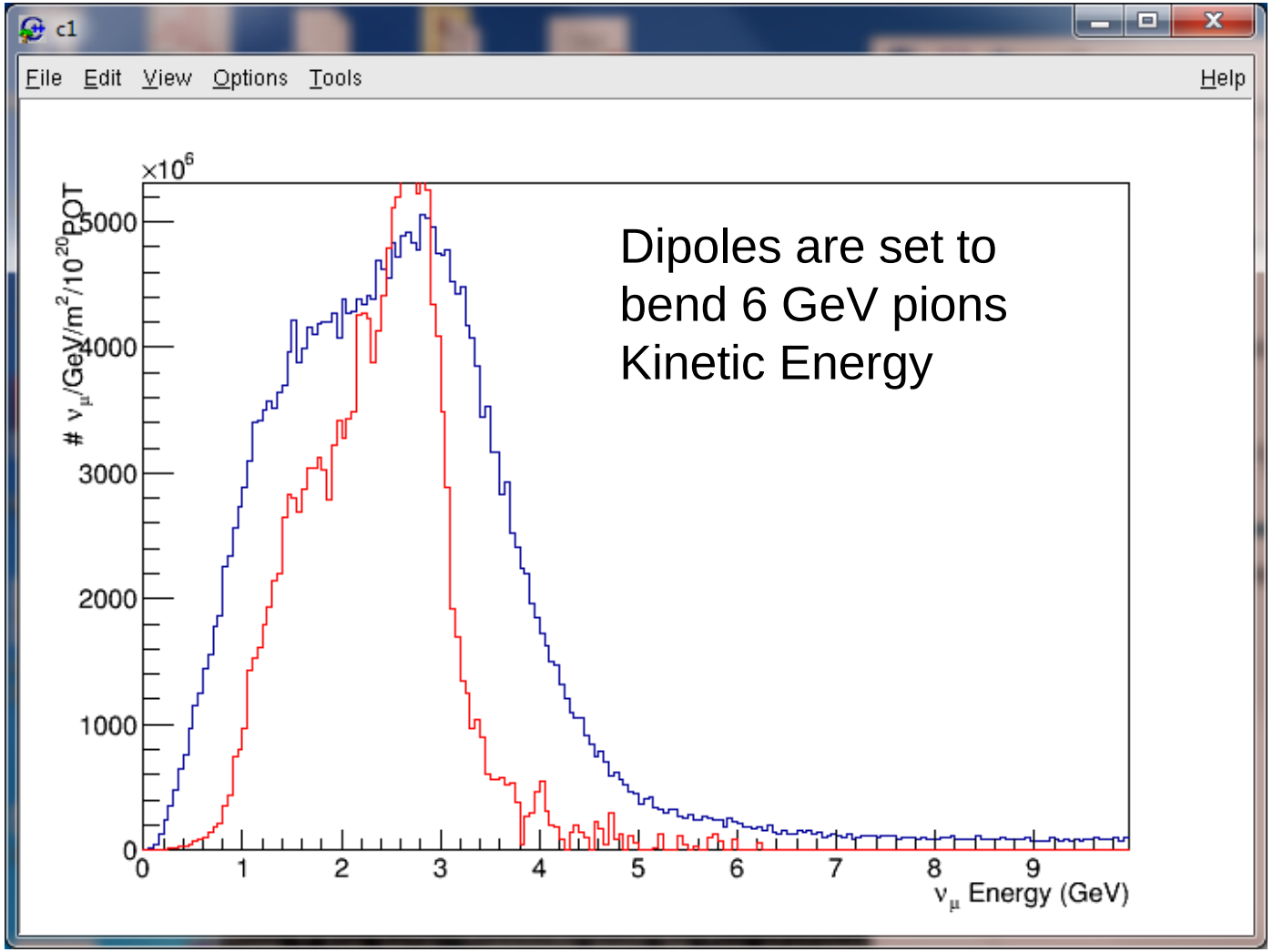
Kirk McDonald Note from 2001



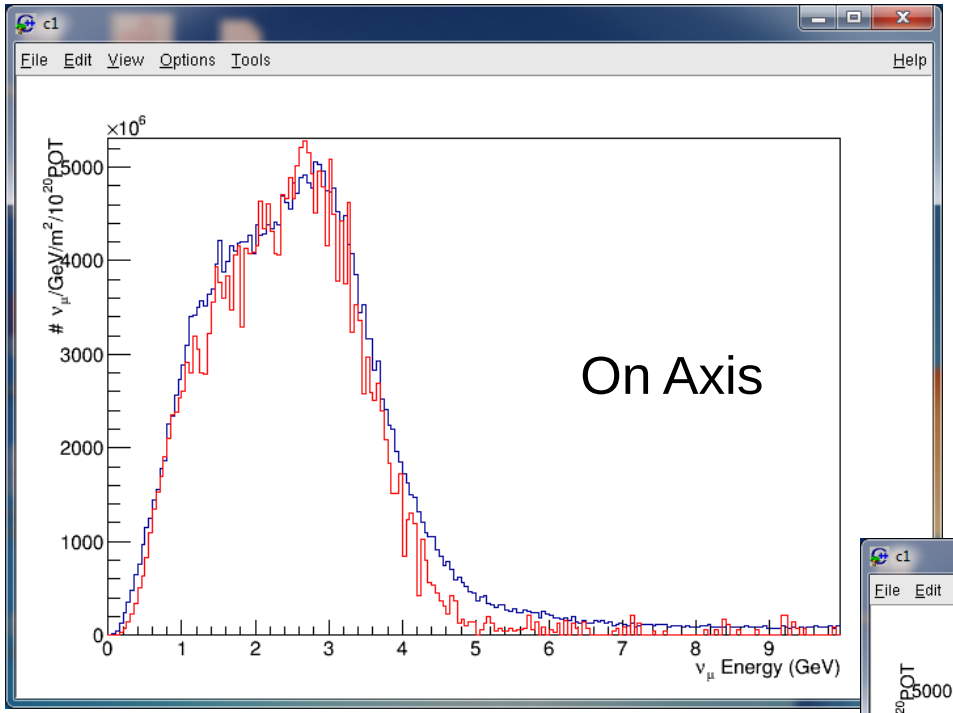


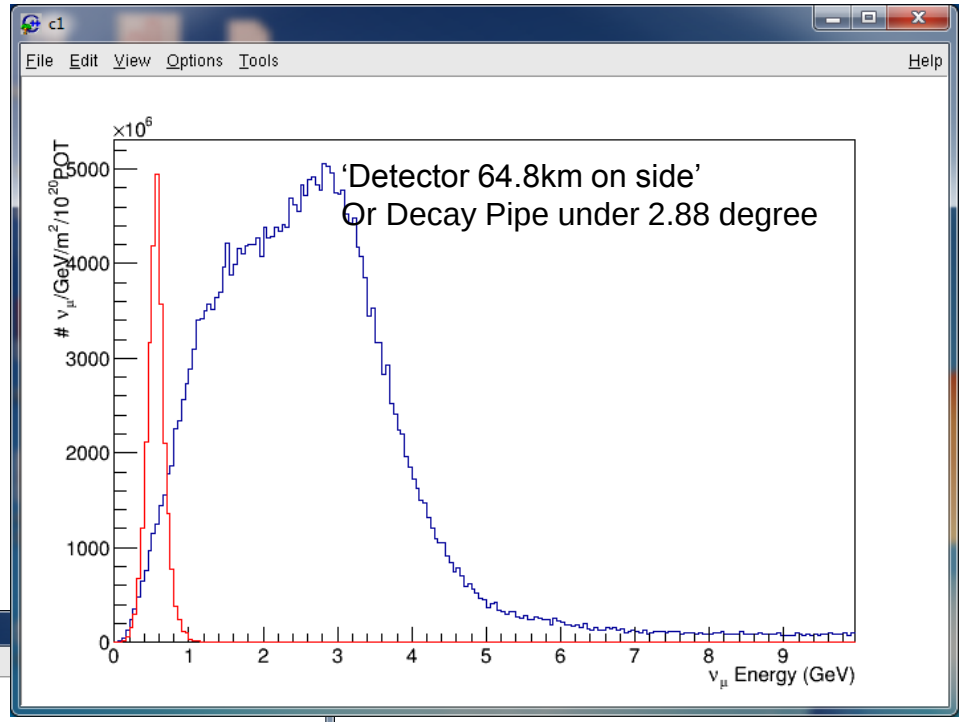
Off Axis High Energy Pions Contribute to Neutrinos at some energies at Fixed distance

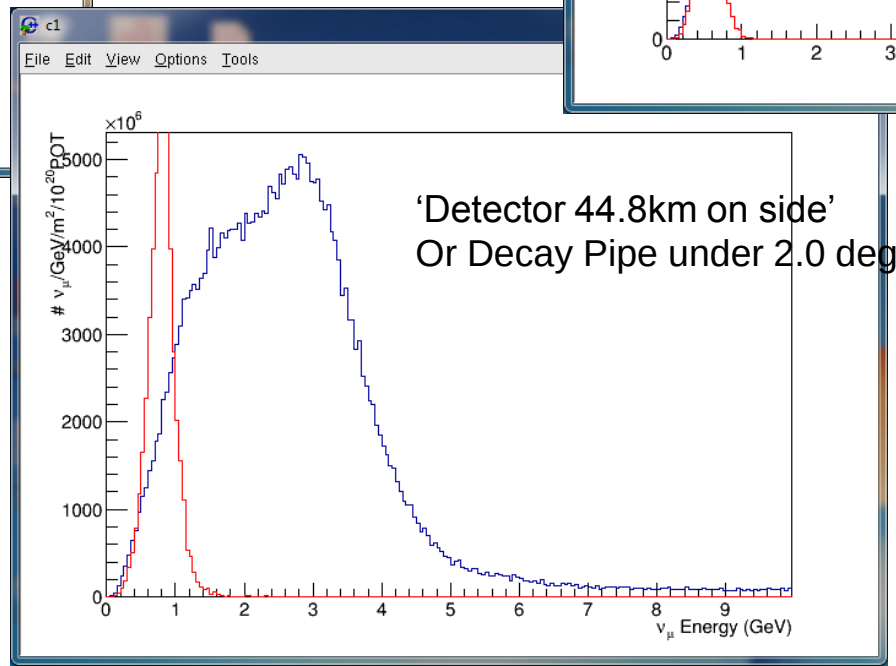
Proton & Pion both beams are bent for 2.88 degrees



Very Preliminary On & Off Axis







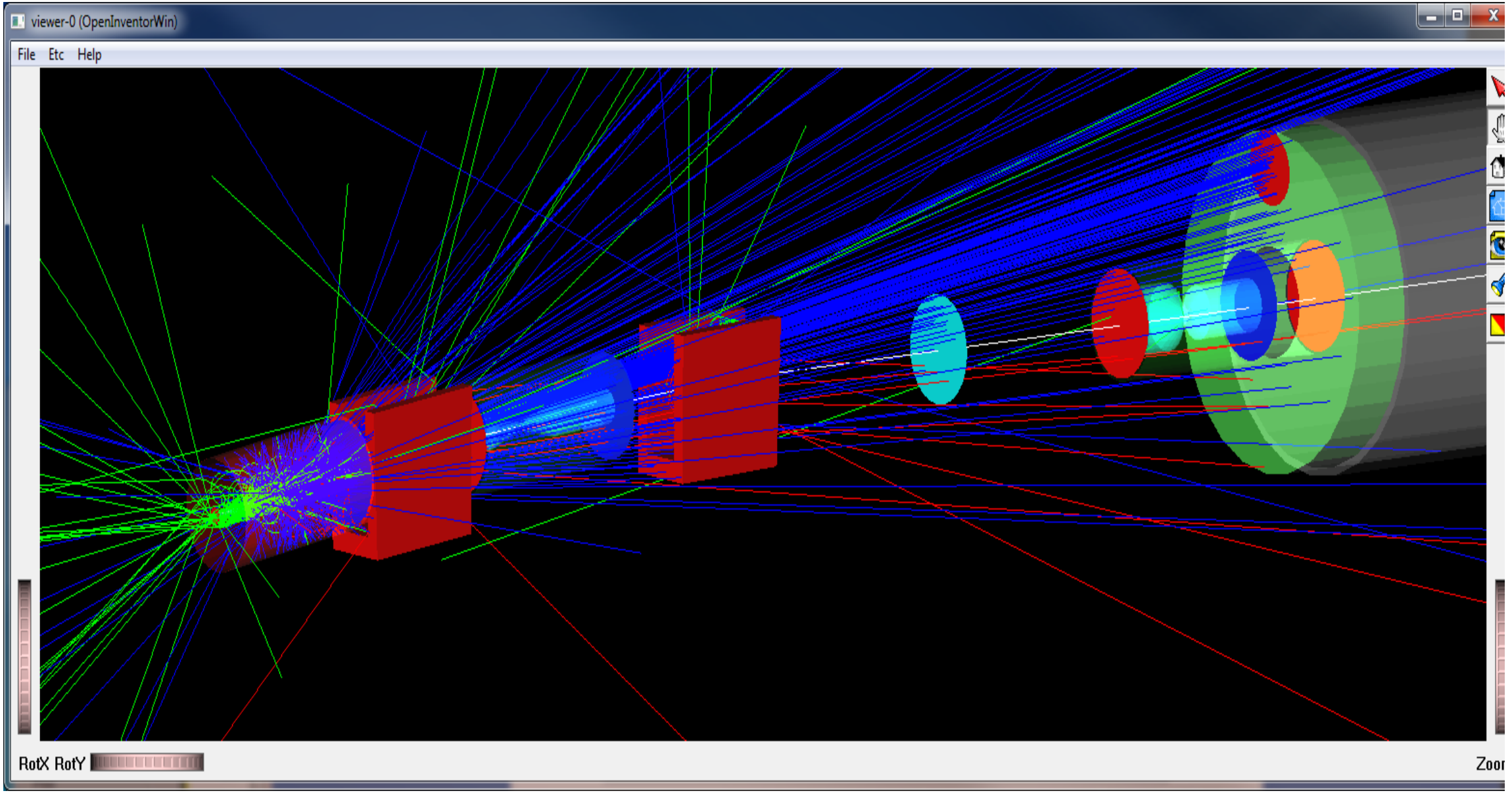
Same normalization factor

M. Popovic

What can be done next?

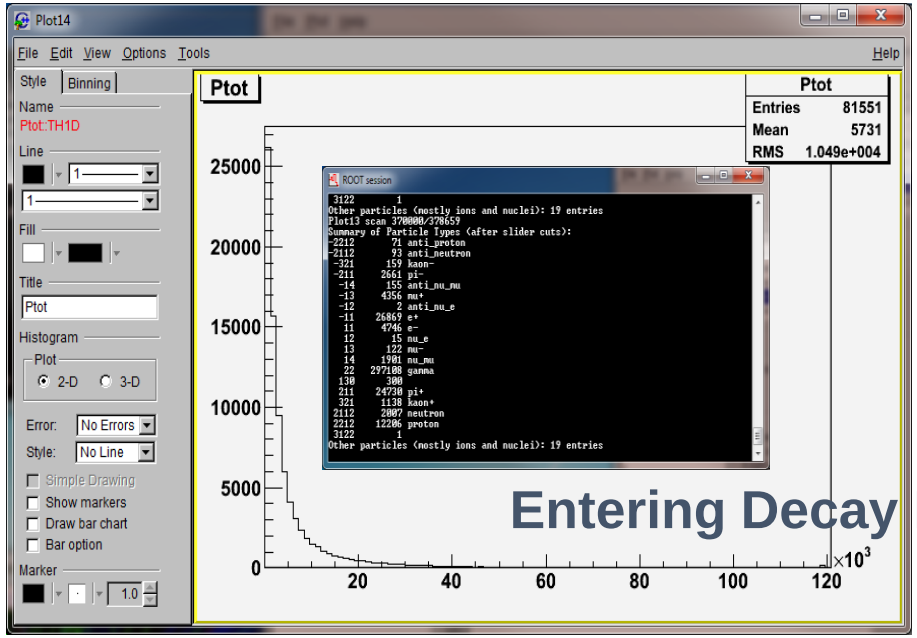
- Horn3, do we need it?
- Wires in Decay Pipe, are there useful?
- Combine Function Dipole, more realistic magnet simulation?
- To run 16GeV/c for Tau Neutrino we need 1.3 T field. Is 1.3T field to high, or do we need 16GeV/c particles

Concerns, additional radiation of second horn

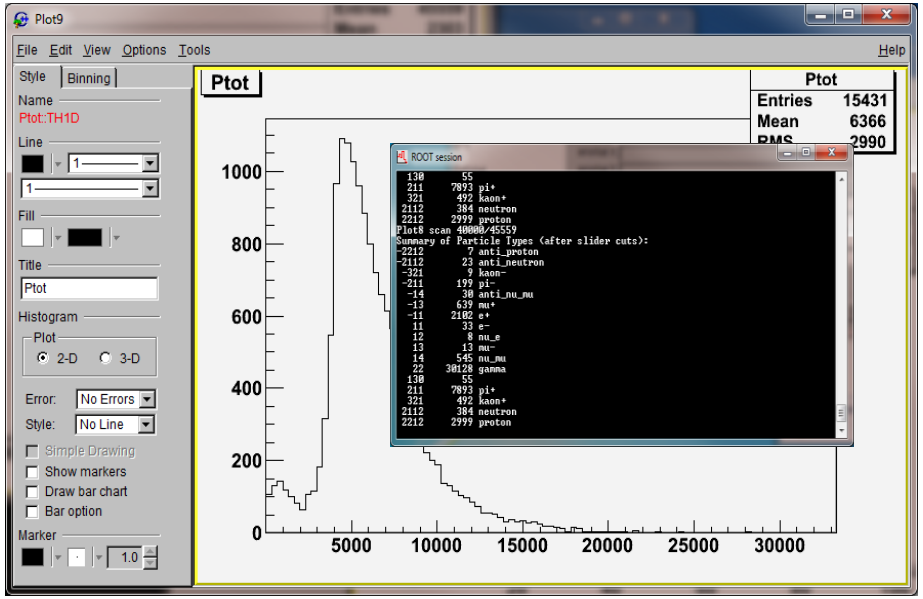


10k POT 120GeV

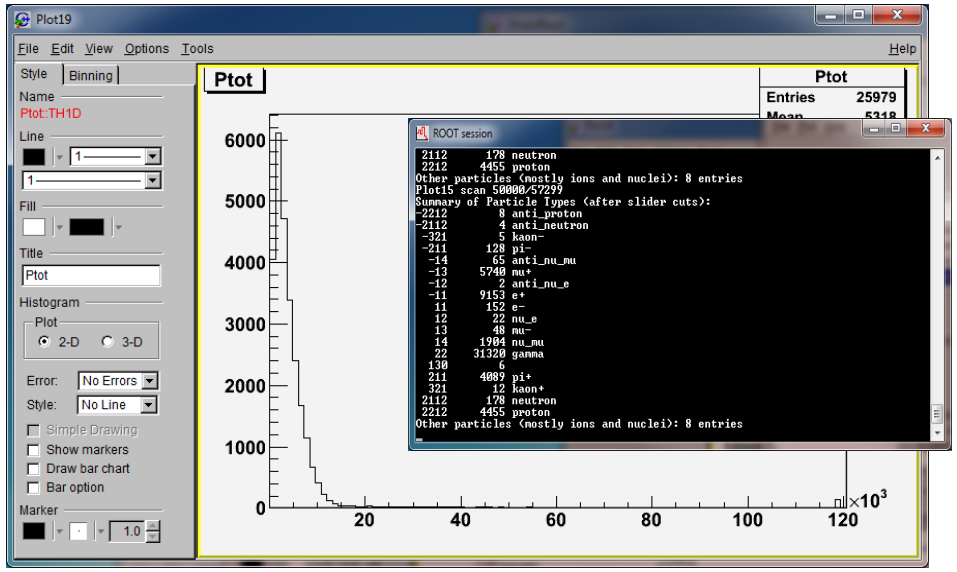
Optimized 3 Horns

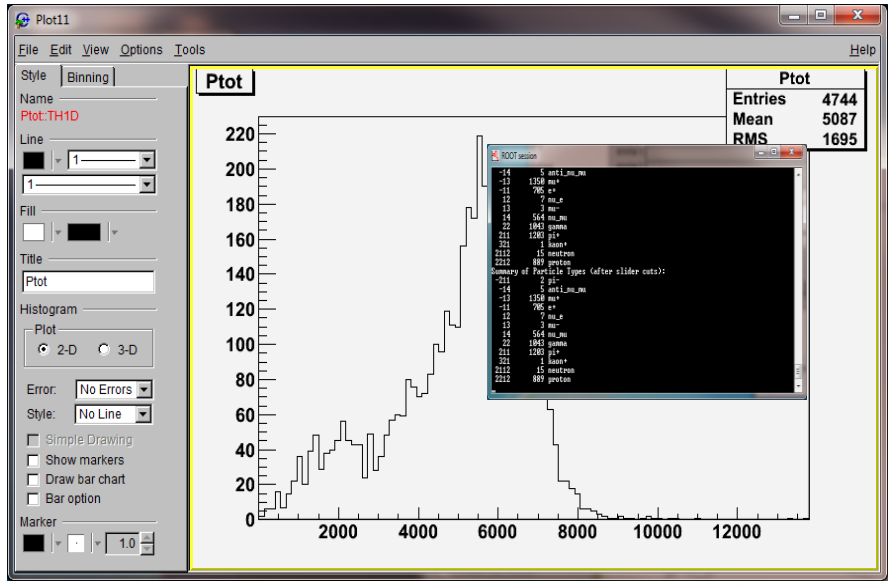


Modified, Option 1



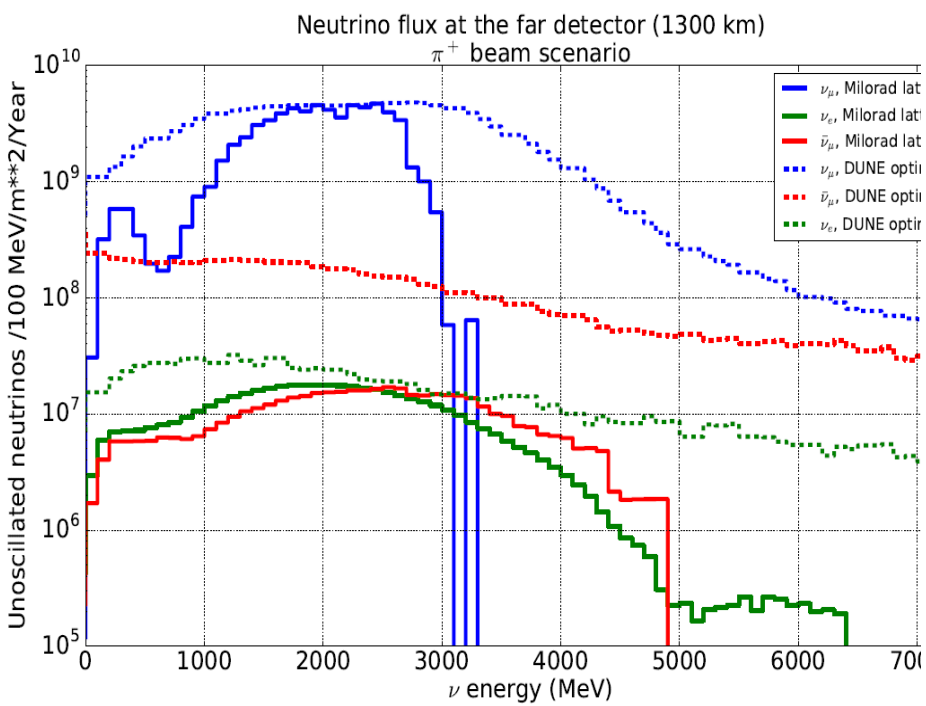
Entering Decay Pipe

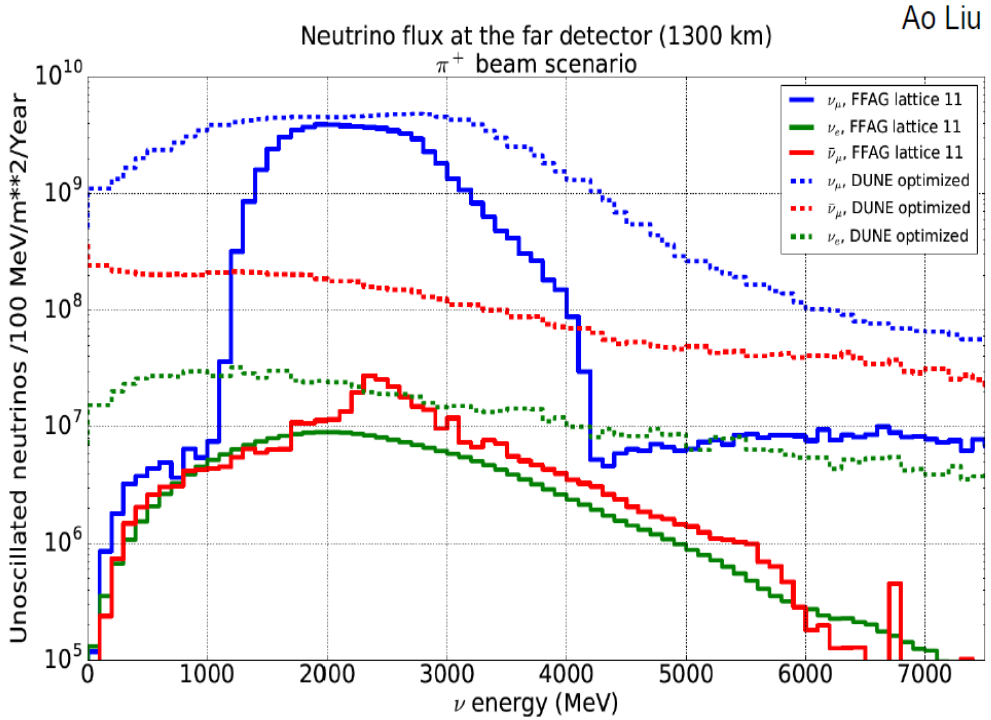




At Bottom of Decay Pipe

Physics???

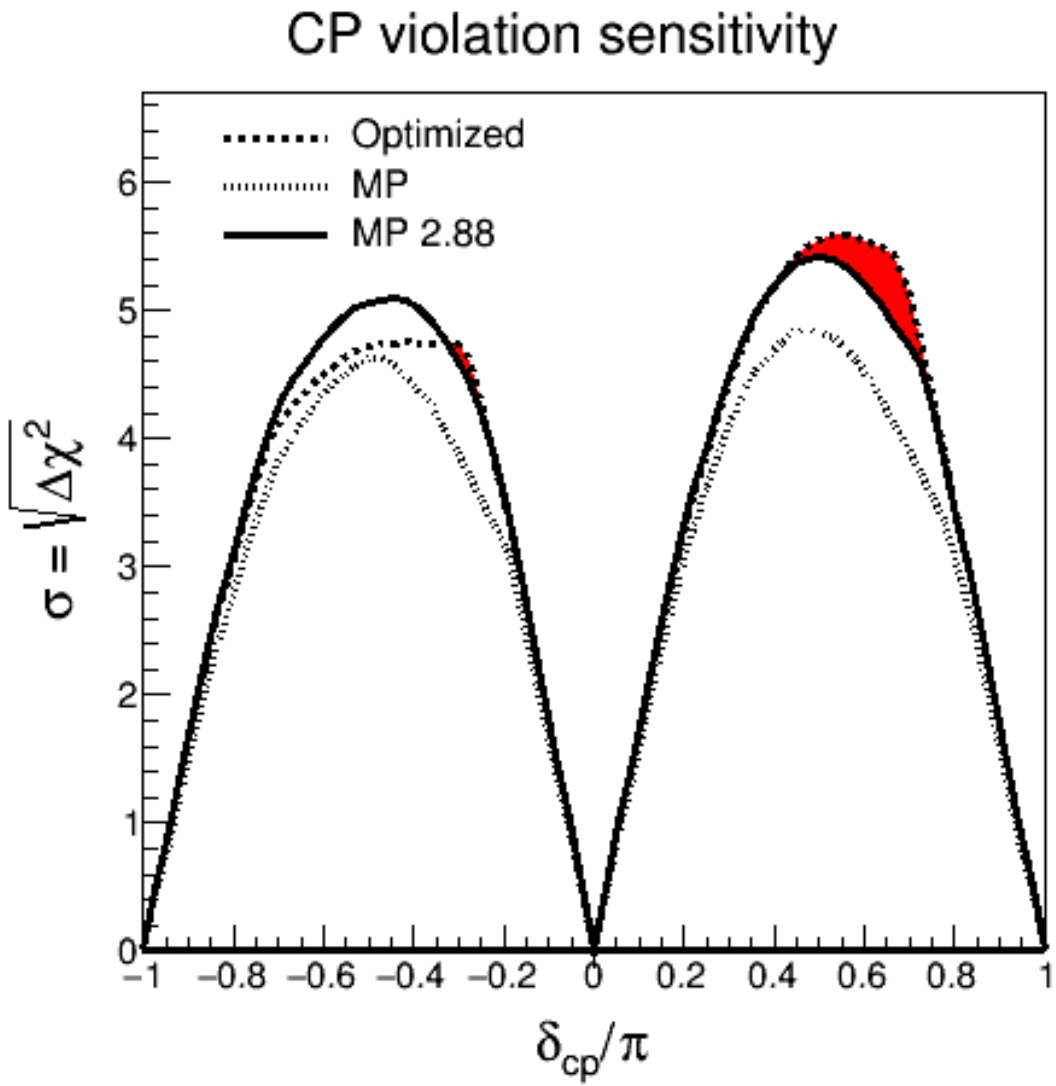




In Alan Bross presentation of nuPIL at DUNE Collaboration meeting there are plots showing physics analysis from Pilar Coloma, Elizabeth Worcester …

My flux and nuPIL flux look similar, but ???? It will be nice if somebody does real evaluation.

Very, Very Preliminary



From Zarko Pavlovic

Possible ways to improve concept

- Smaller Bending angle?
  (Bend protons & pions)
- Pion central energy?
- Longer/shorter dipoles?
- Horn or quads?
- Longer DBA?
- High Current Wire?

Conclusions

Modification of beams for optimized 3 horns system is minor;

- addition of two conventional dipoles and
- larger separations of Horn1 and Horn2.

Neutrino flux at far detector is similar comparing to the Optimized configuration around two oscillation maxima for just two different settings of dipoles.

Advantage of presented concept are:

- removal of high power beam in the Decay Pipe,
- removal of high power absorber from the proximity of any water table,
- full charge separation,
- possibility of muon flux characterization,
- possibility of Off Axis run