Beam Fluxes, Requirements & Optimization

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Outline

- Fluxes available for CDR Studies
- Outline of Beam Requirements Section of CDR
- Status of Beam Optimization

Introduction

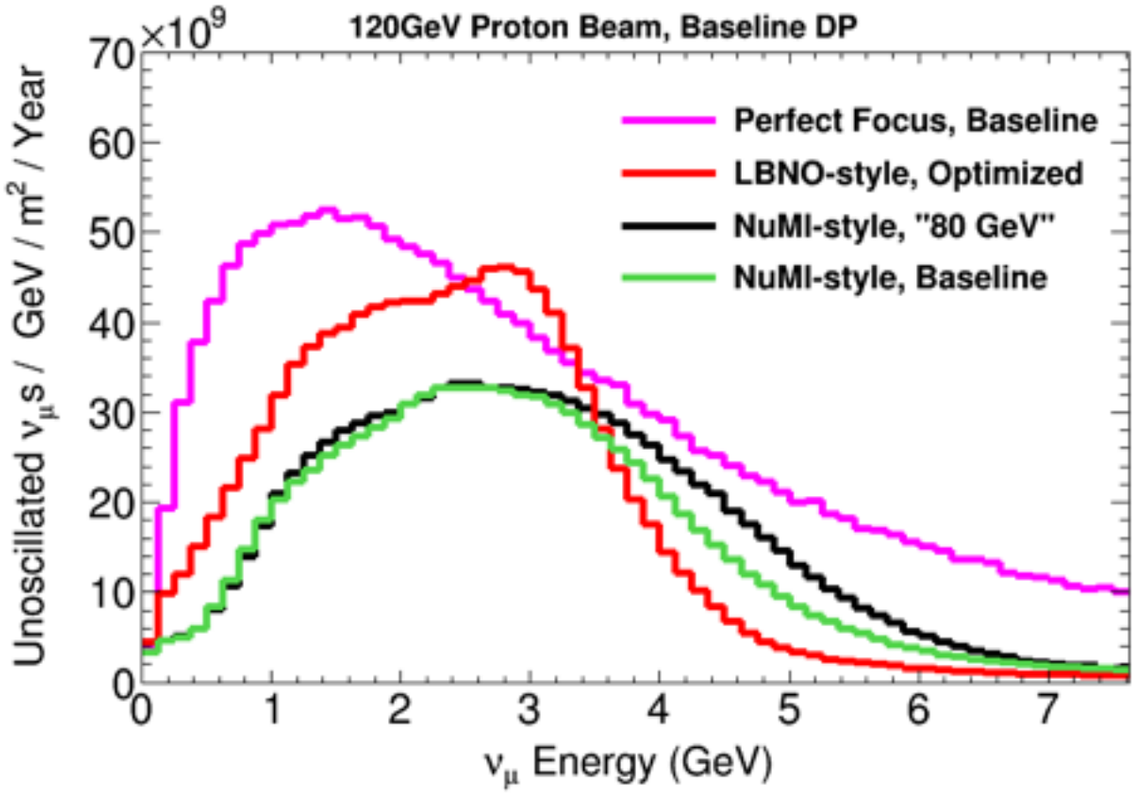
- I have simulated the several flux options for DUNE sensitivity studies. There are four options for the focusing system:
  - NuMI-style beam (Current reference design)
  - NuMI-style beam with improvements (known historically as the "80 GeV beam")
    - Same G4LBNE Default, but 230 kA horn current
  - LBNO-Style Optimized Beam (from genetic algorithm)
    - See http://lbne2-docdb.fnal.gov:8080/cgi-bin/RetrieveFile?docid=10392&filename=BeamSim_LauraF_19January2015.pdf&version=1
  - "Perfect Focus" Beam
    - Hadrons are focused forward upon exit of target can; horn material and fields are not present in simulation; Uses baseline target
- All of the above are available in 4 beam/decay pipe options: 80 GeV + 204 m Decay Pipe, 120 GeV + 204 m Decay Pipe, 80 GeV + 250 m Decay Pipe, 120 GeV + 250 m Decay Pipe

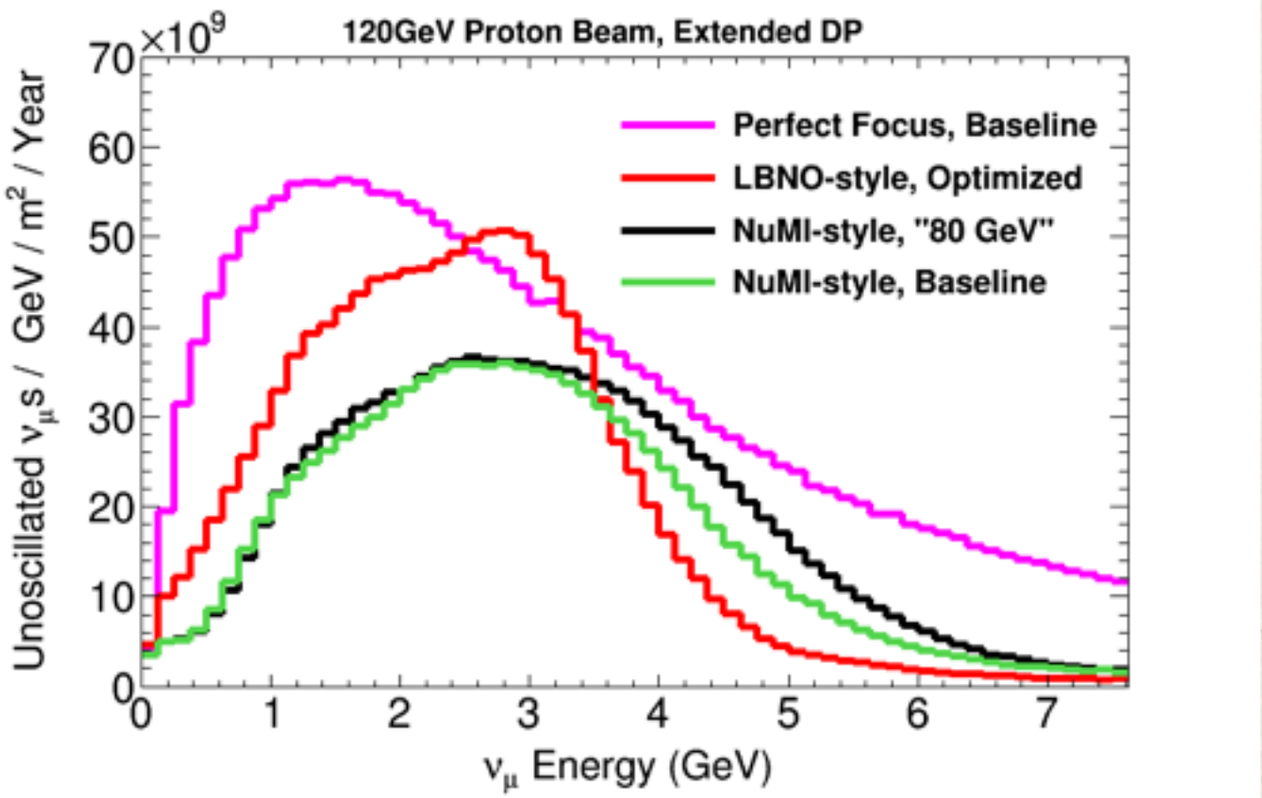
The Plan

- We are planning to use the “80 GeV” option with a 250 m decay pipe in all physics plots (black line in bottom right figure of slide 6)

- Several other fluxes (and their estimated sensitivities) will be considered in the beam requirements/optimization section

120 GeV Fluxes

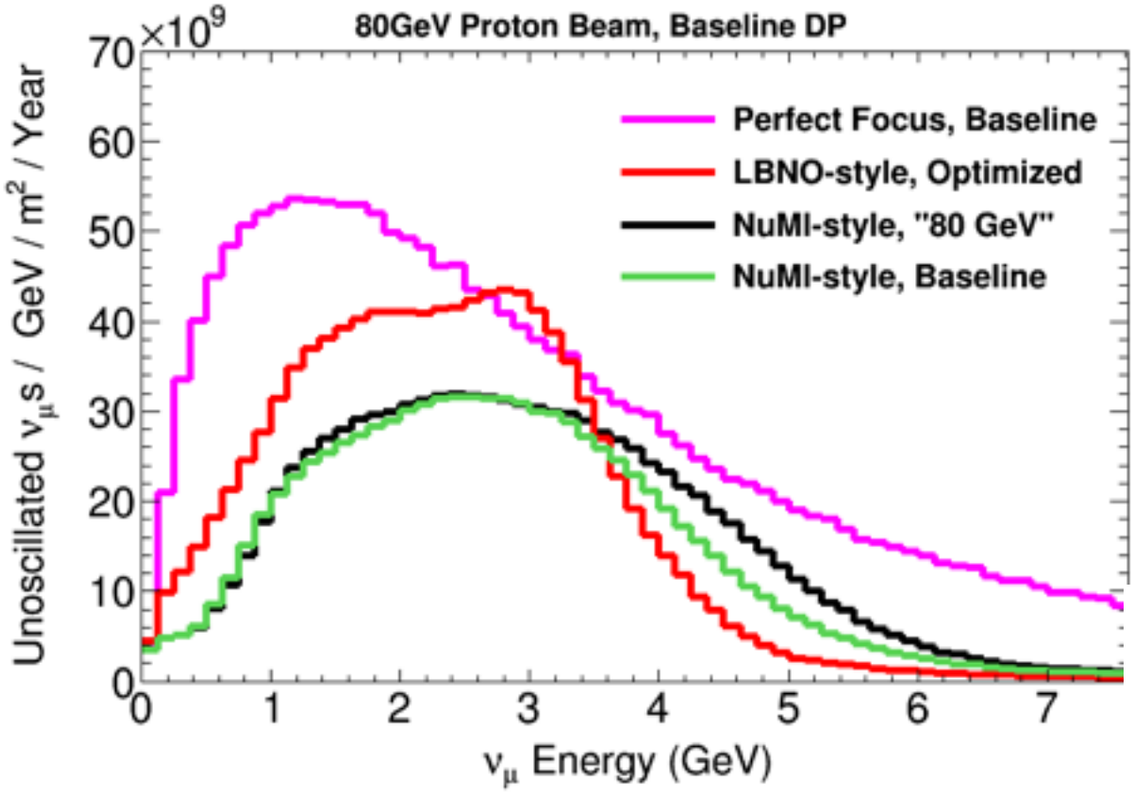




Estimated 75% CP Sensitivity

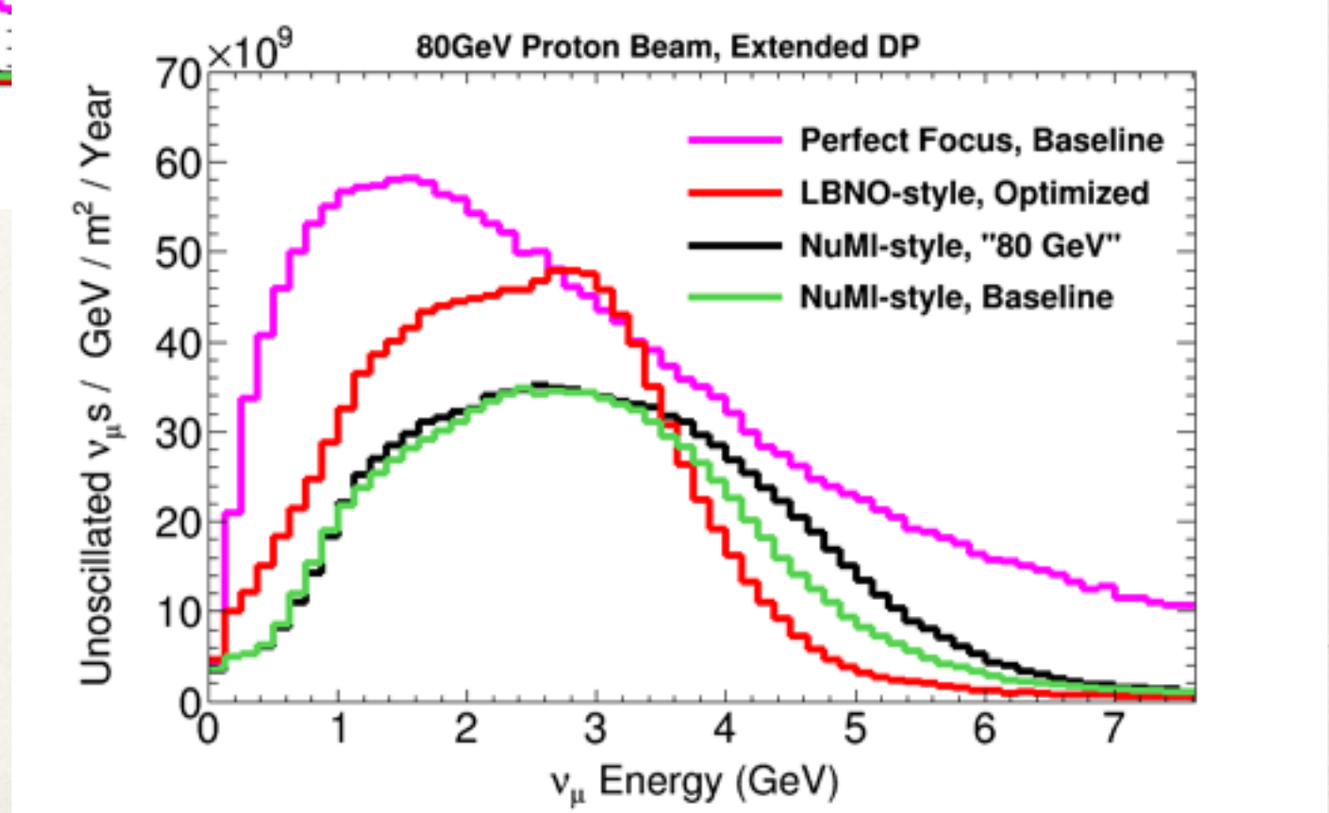
	Baseline DP	Extended DP
LBNO Optimized	1.84	1.91
80 GeV	1.48	1.52
Baseline	1.46	1.50

80 GeV Fluxes



Estimated CP 75% Sensitivity

	Baseline DP	Extended DP
LBNO Optimized	1.84	1.91
80 GeV	1.51	1.55
Baseline	1.49	1.54



Where to Find the Files

- All of these fluxes have been copied into the Fast MC flux area /lbne/data/users/lblpwg_tools/FastMC_Data/flux_files/v3r2p4b/X_Y_Z
  - X = Baseline, NuMI Improved (“80 GeV”), LBNO Optimized or Perfect
  - Y = 80 GeV or 120 GeV
  - Z = ExtendedDP or StandardDP
- There are two formats available for all of the options
  - Histograms (for plotting or input to Fast MC)
    - g4lbne_v3r2p4b_A_B.root
  - GLOBES flux files
    - g4lbne_v3r2p4b_A_B_globes_flux.txt
    - A = FHC (“neutrino mode”) or RHC (“antineutrino mode”); B = FD (far detector) or ND (near detector)

Outline of Beam Requirements Section of CDR

Contents

We are in the "Long-baseline Neutrino Oscillation Physics Section of the Physics Volume

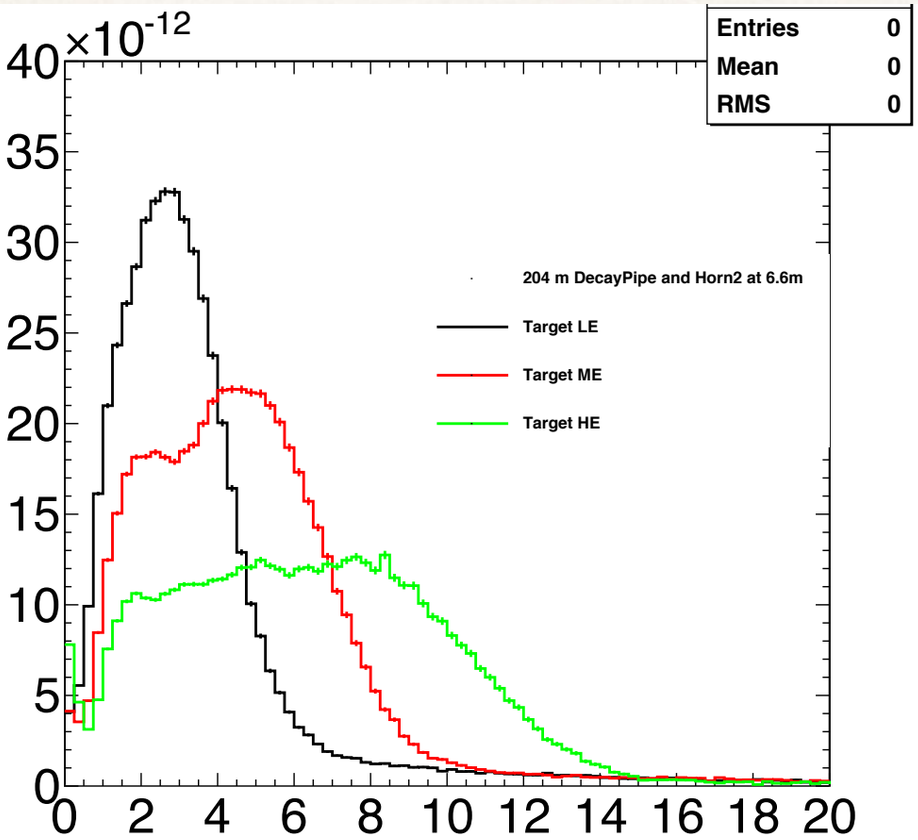
We have been allocated only 3 pages

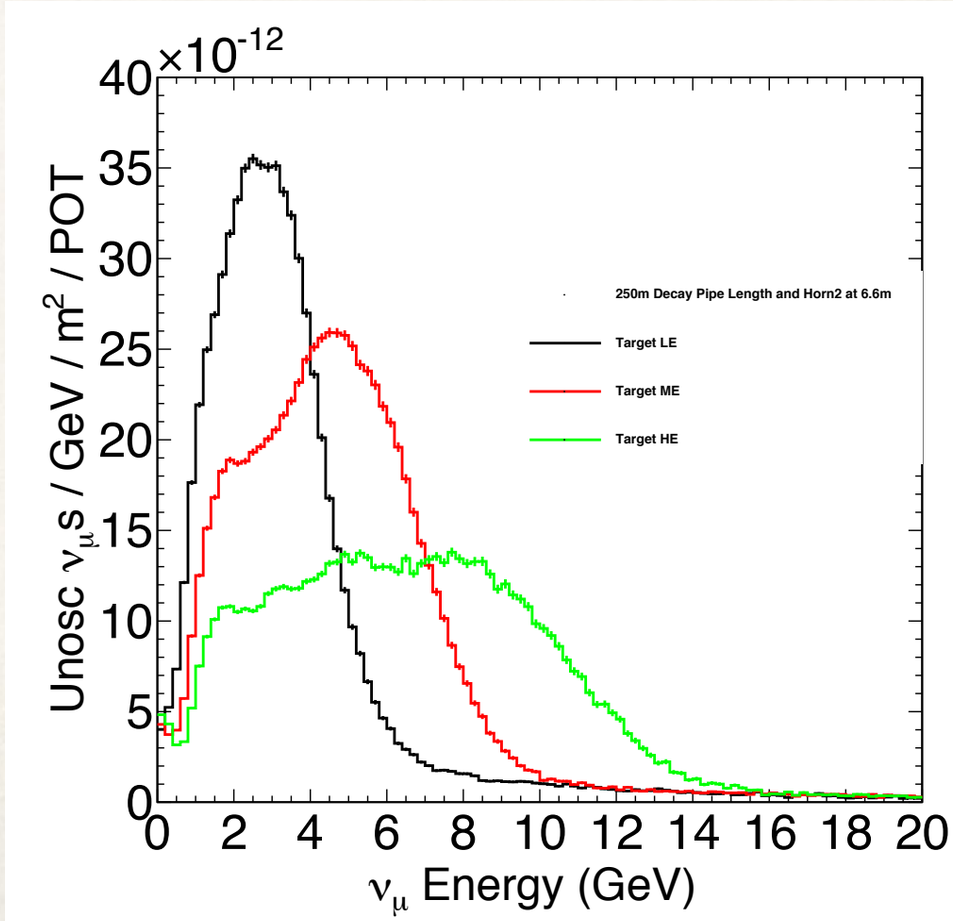
Outline of Beam Requirements Section of CDR

- We are planning three basic sections
  - (1) An introduction giving a qualitative summary of the requirements
    - Optimal range for measuring delta_CP and MH
    - Importance of flexibility for physics goals beyond delta_CP and MH
    - Importance of having small systematic uncertainties on neutrino flux estimate

Outline of Beam Requirements Section of CDR

- We are planning three basic sections
  - (2) A discussion of flux options with the reference focusing system
    - Including discussion of impact of decay pipe length, target chase length and what is currently known about systematics of the reference focusing system

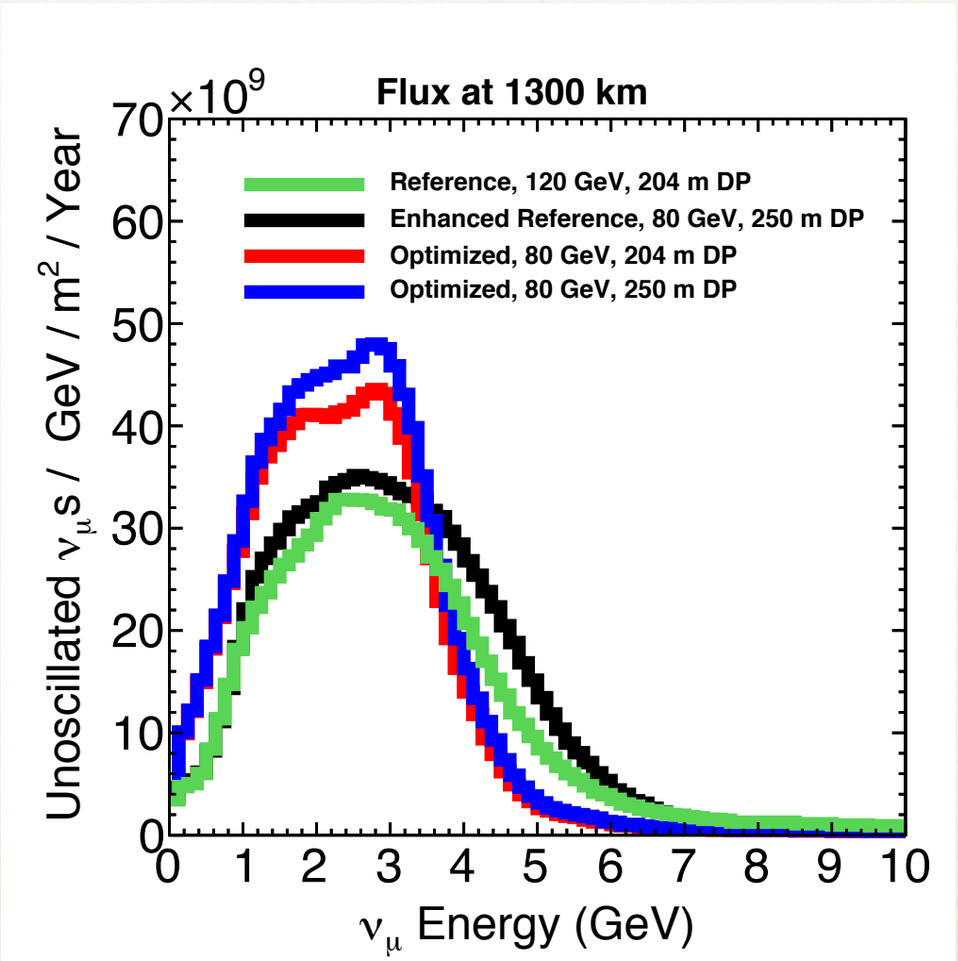




A. Bashyal

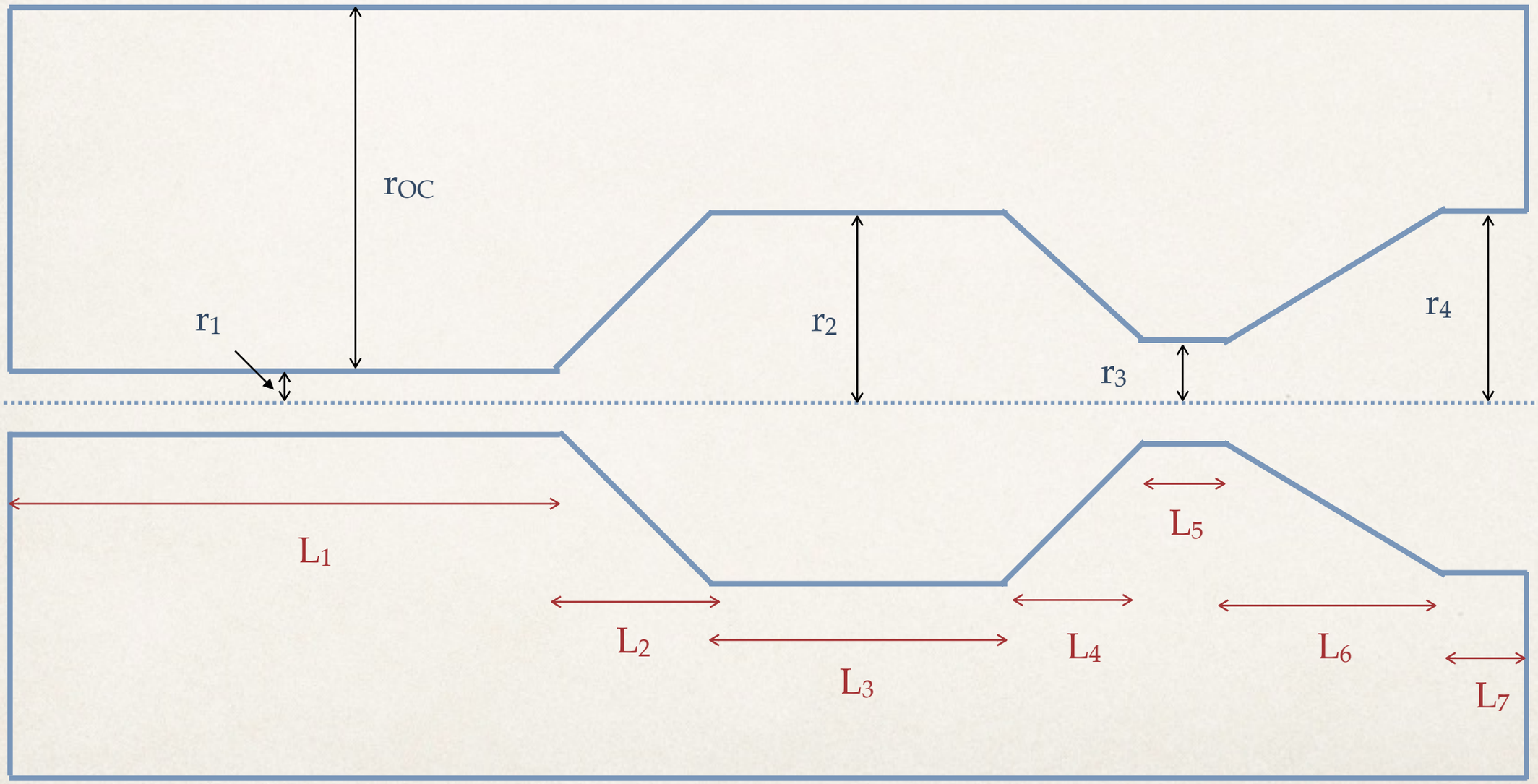
Outline of Beam Requirements Section of CDR

- We are planning three basic sections
  - (3) A discussion of alternate focusing systems
    - Brief description of recent beam optimization work
    - Comparison of fluxes, signal rates, background rates and sensitivities with several beam options



Optimization Update

- The "Optimized" fluxes on previous slides are the output of a genetic algorithm inspired by LBNO and developed by that optimizes CP sensitivity. I've done several versions of this algorithm including one LBNO-style Horn 1:



Optimization Update

- Parameters optimized in most recent version of the algorithm:

"LBNO-Style"

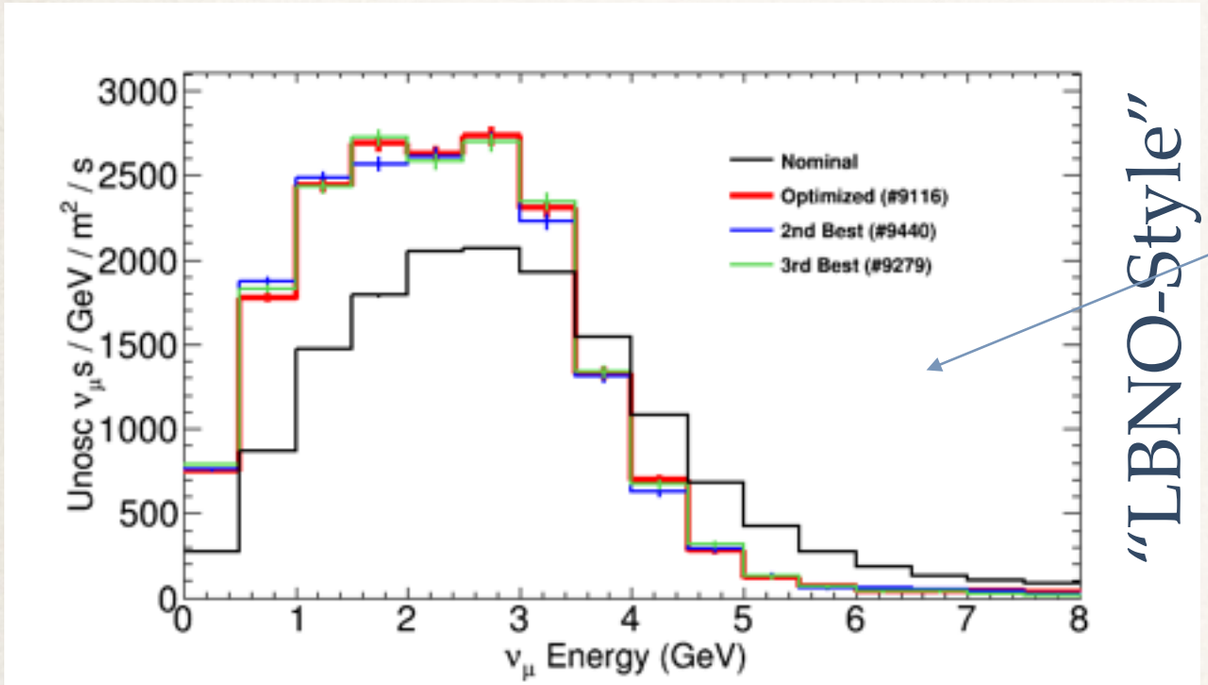
Parameter	Lower	Upper	Unit	Preferred
Horn 1 Shape: r1	20	50	mm	38
Horn 1 Shape: r2	35	200	mm	162
Horn 1 Shape: r3	20	75	mm	54
Horn 1 Shape: r4	20	200	mm	167
Horn 1 Shape: rOC	200	800	mm	670
Horn 1 Shape: l1	800	2500	mm	1811
Horn 1 Shape: l2	50	1000	mm	796
Horn 1 Shape: l3	50	1000	mm	594
Horn 1 Shape: l4	50	1000	mm	676
Horn 1 Shape: l5	50	1000	mm	140
Horn 1 Shape: l6	50	1000	mm	525
Horn 1 Shape: l7	50	1000	mm	997
Horn 2 Longitudinal Scale	0.5	2	NA	1.32
Horn 2 Radial Scale	0.5	2	NA	1.78
Horn 2 Radial Offset	-78	100	mm	7.6
Horn 2 Longitudinal Position	3.0	15.0	m	14.4
Target Length	0.5	2.5	m	2.37
Target Fin Width	9	15	mm	9.74
Proton Energy	40	130	GeV	66
Horn Current	150	300	kA	297

"NuMI-Style"

Parameter	Lower	Upper	Unit	Preferred
Horn1LongRescale	0.5	2	NA	0.88
Horn2Radial Rescale	0.5	2	NA	1.44
Horn2LongRescale	0.5	2	NA	1.28
Horn2RadialRescale	0.5	2	NA	1.57
Horn2RadialRescaleCst	-78	100	mm	9.99
Horn2LongPosition	3.0	15.0	m from	10.6
GraphiteTargetLength	0.5	2.5	m	5.2
GraphiteTargetFinWidth	9	15	mm	9.8
ProtonEnergy	40	130	GeV	63
HornCurrent	150	300	kA	294

Optimization Update

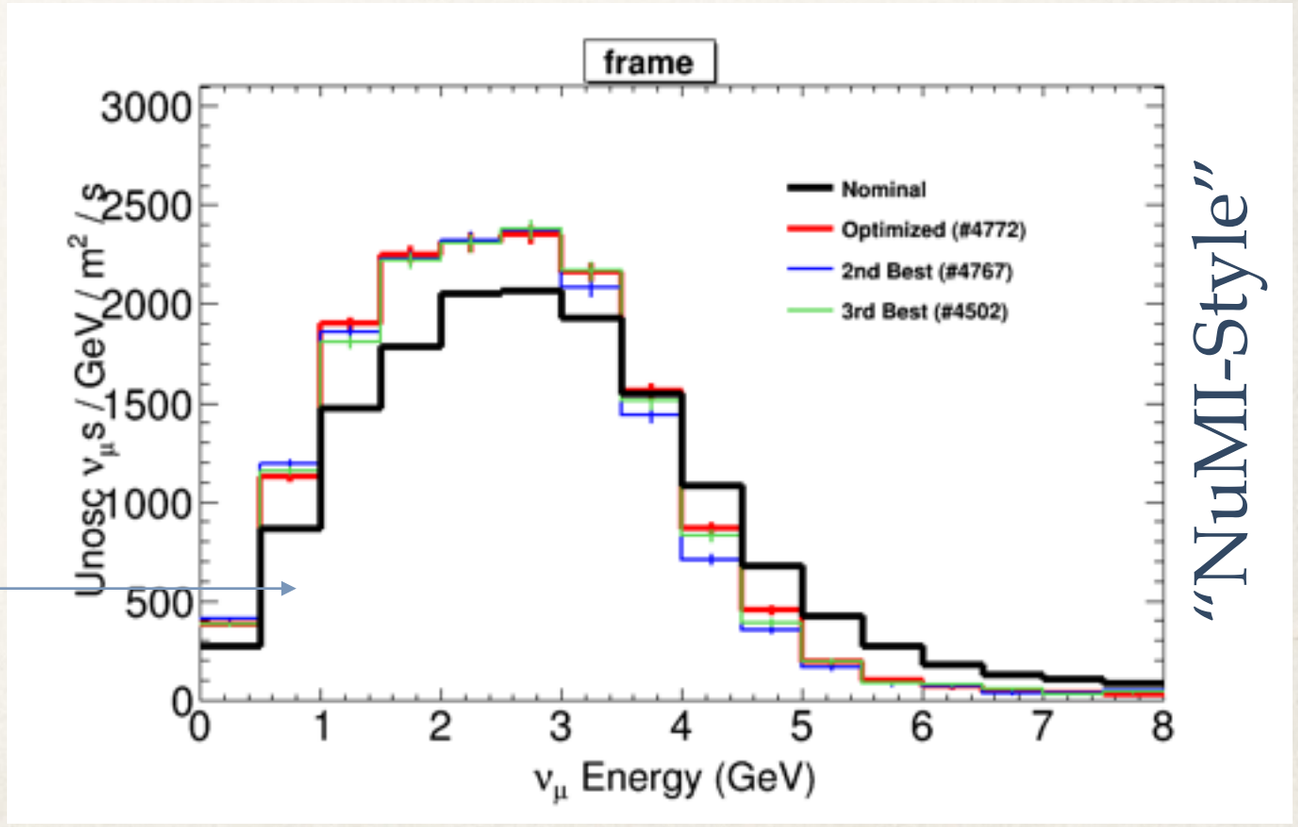
- Best fluxes from the two optimizations:



"LBNO-Style"

75% CP sensitivity increases
from 1.47 to 1.95 (33%)

75% CP sensitivity increases
from 1.47 to 1.74 (18%)

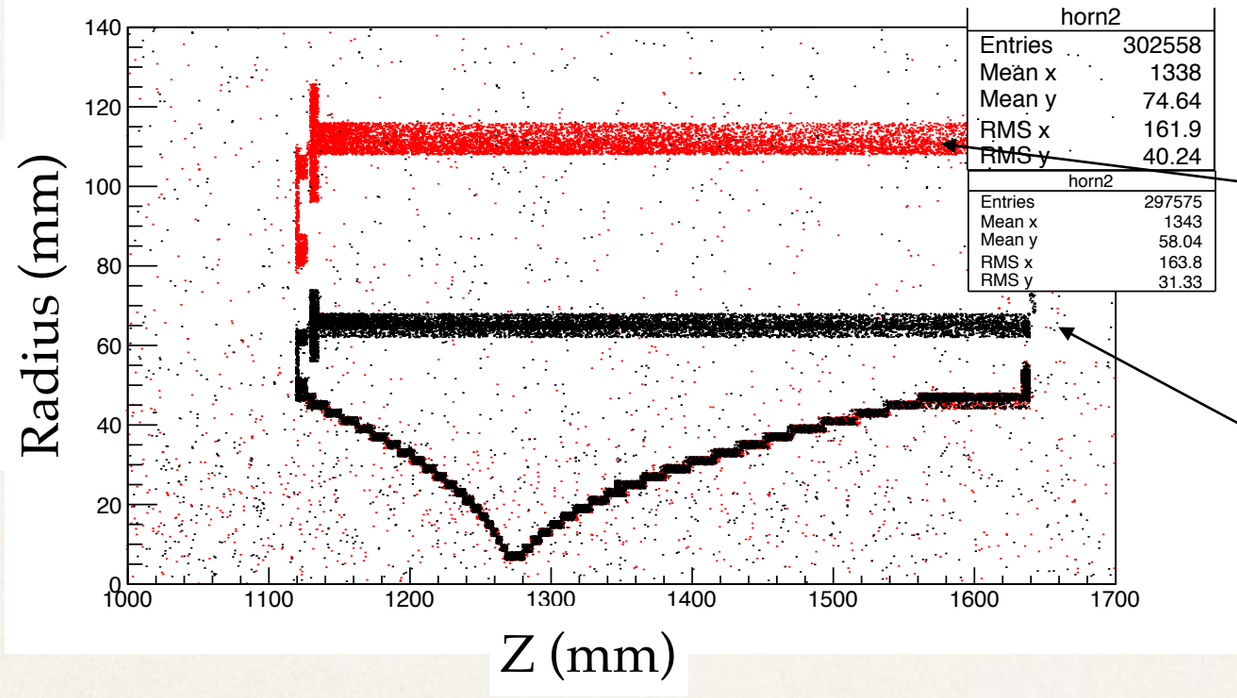


"NuMI-Style"

Optimization Update

- A problem with both of the optimizations:
  - The outer conductor of Horn 2 was scaled by the square of the Horn2 radial scale factor

Radial view of Horn 2 (A. Bashyal)



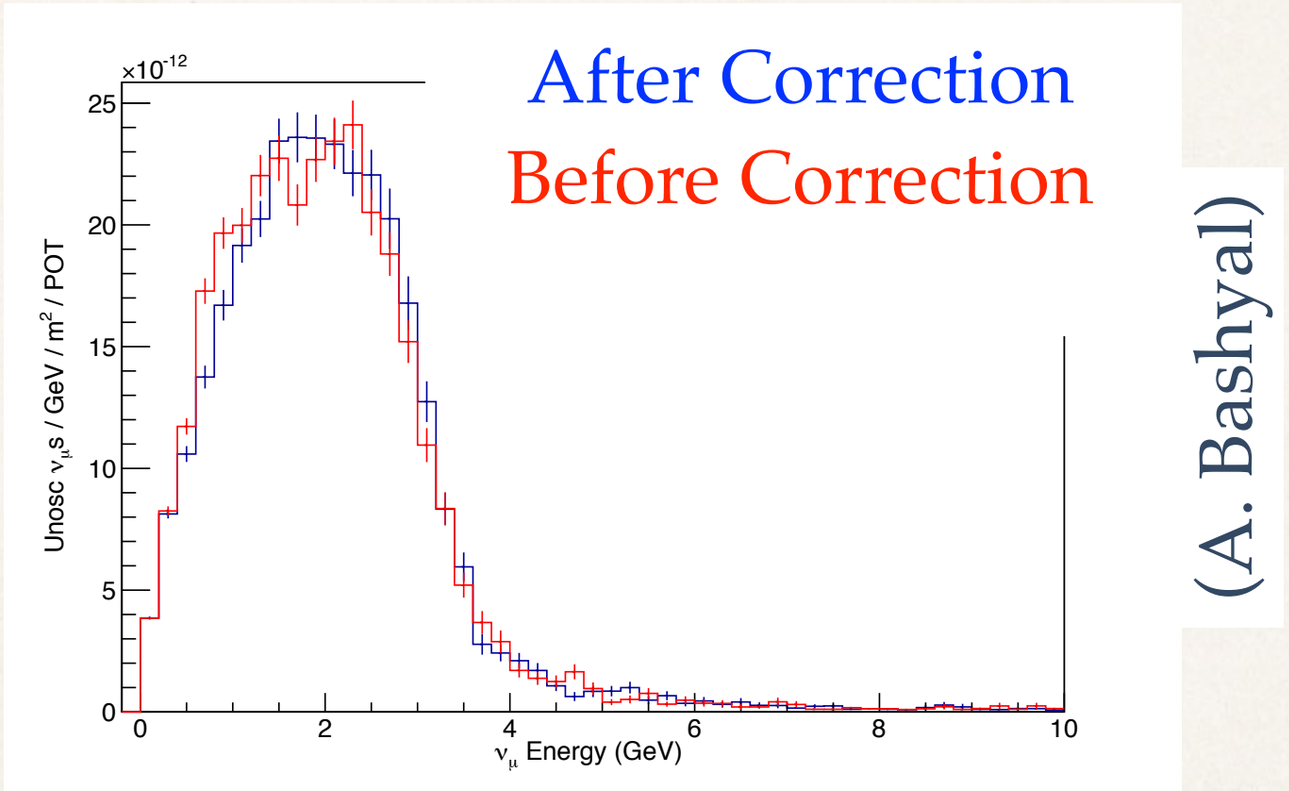
Where the outer conductor actually was

Where the outer conductor should have been

- The optimization was driving the outer conductor to large radii (because it increases flux at low energy)
  - But an outer conductor > 1 m is probably unbuildable

Optimization Update

- The fluxes I produced for the CDR (including those on slides 5, 6 and 11 and the ones Elizabeth and Dan are running sensitivities with) use a slight modification of the optimized flux with the horn 2 outer conductor



(A. Bashyal)

- This means those fluxes aren't as high at low energies as the ones that came out of the optimization
  - But we don't want to include anything in the CDR that we think is unbuildable

The End