DUNE Three Horn Design Study

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Purpose

- Benchmarking G4LBNE/V2 and V3
- Want to study focusing performance for a three horn system based off the optimized design
- Investigate the tunability of this design through the repositioning of Horn 2

Procedure

- 50m POT in V2/V3 for reference design and optimized design at 66 and 120 GeV
- 50m POT in V2 for three horn design at 0.5, 2.0, 4.0, and 6.0 m separation between Horn 1 and Horn 2
- Visualization in HepRep (use 50 POT)

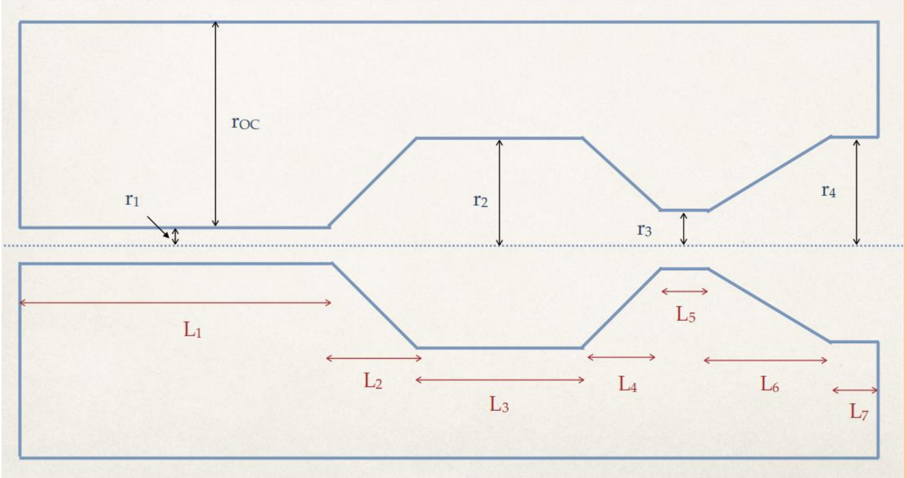
Reference Design Horns

Z(cm)	Upstream 0-44.047	44.047-80.	Neck 80.-83.982	Downstream 83.982-95.128	95.128-300.	300.-354.4
R_{in}^{IC}(cm)	$\sqrt{\frac{92.8484-z}{7.0483}}-0.2$	$\sqrt{\frac{85.7091-z}{7.0483}}$	0.90	$\sqrt{\frac{z-82.2123}{2.1850}}$	$\sqrt{\frac{z-80.}{2.1850}}-0.2$	9.83
R_{out}^{IC}(cm)	$\sqrt{\frac{92.8484-z}{7.0483}}$		1.35	$\sqrt{\frac{z-80}{2.1850}}$		10.03
R_{in}^{OC}(cm)	–	–	15.33	–	–	–
R_{out}^{OC}(cm)	–	–	16.20	–	–	–

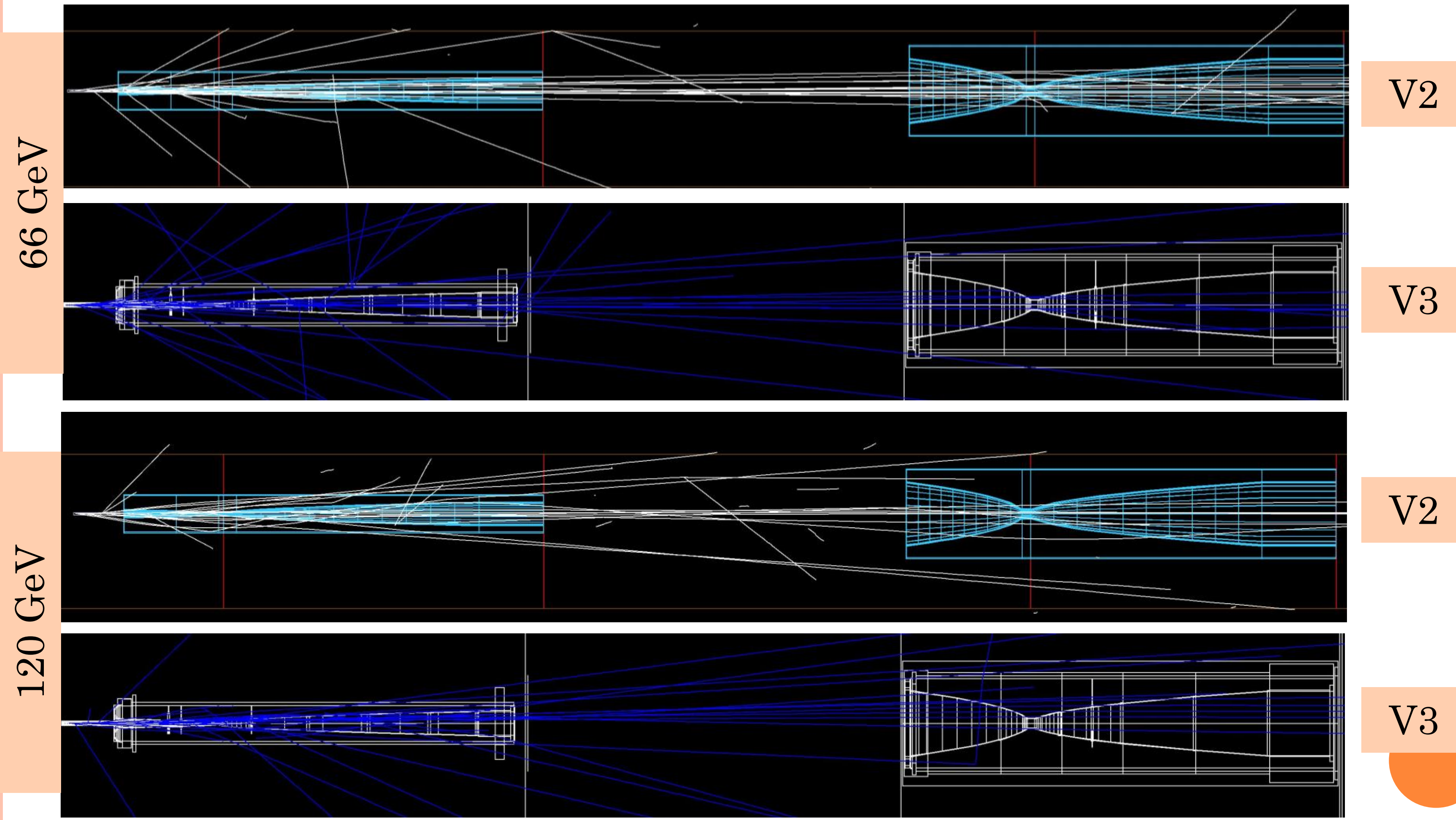
Z(cm)	Upstream 0-97.617	Neck 97.617-104.803	Downstream 104.803-300.	300.-354.4
R_{in}^{IC}(cm)	$\sqrt{\frac{100-z}{0.1351}}-0.3$	3.90	$\sqrt{\frac{z-100}{0.2723}}-0.3$	26.80
R_{out}^{IC}(cm)	$\sqrt{\frac{100-z}{0.1351}}$	4.40	$\sqrt{\frac{z-100}{0.2723}}$	27.10
R_{in}^{OC}(cm)	–	37.0	–	–
R_{out}^{OC}(cm)	–	37.87	–	–

Reference and Optimized Designs

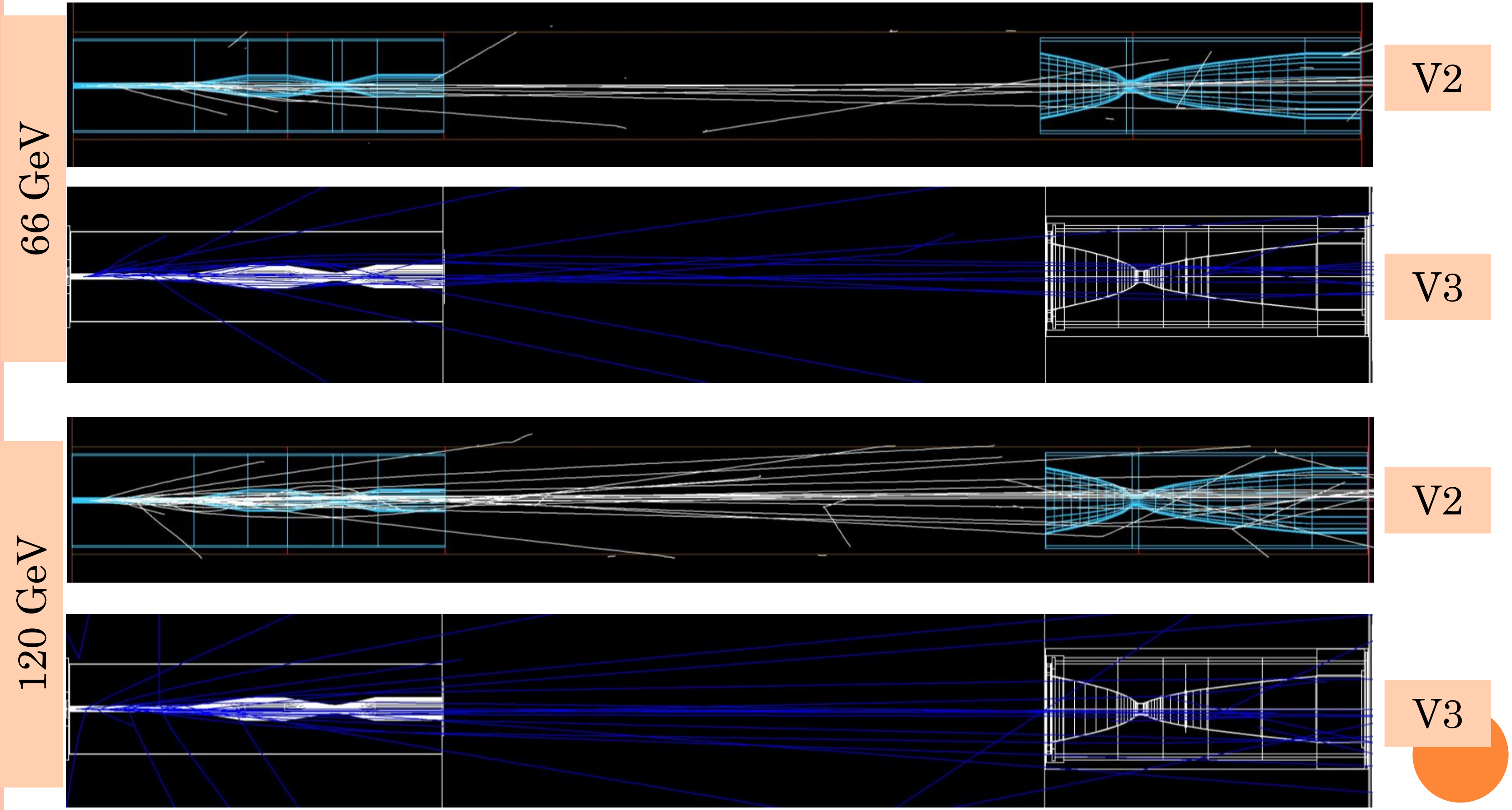
Parameter	Reference	Optimized
R_1(mm) (Horn 1)	–	37.6
R_2(mm) (Horn 1)	–	162.1
R_3(mm) (Horn 1)	–	54.5
R_4(mm) (Horn 1)	–	166.8
R_{out}^{OC}(mm) (Horn 1)	162	670
L_1(mm) (Horn 1)	–	1811.6
L_2(mm) (Horn 1)	–	796.0
L_3(mm) (Horn 1)	–	593.8
L_4(mm) (Horn 1)	–	676.0
L_5(mm) (Horn 1)	–	140.0
L_6(mm) (Horn 1)	–	524.9
L_7(mm) (Horn 1)	–	997.0
Longitudinal Position (m) (Horn 1)	0	0
Longitudinal Scale (Horn 2)	1	1.32
Radial Scale (Horn 2)	1	1.78
Radial Scale Constant (m) (Horn 2)	0	7.612
Longitudinal Position (m) (Horn 2)	6.61	14.5
Target Length (m)	0.95	2.37
Target Longitudinal Position (m)	-0.42	0.1
Proton Energy (GeV)	120	66
Horn Current (kA)	230	298



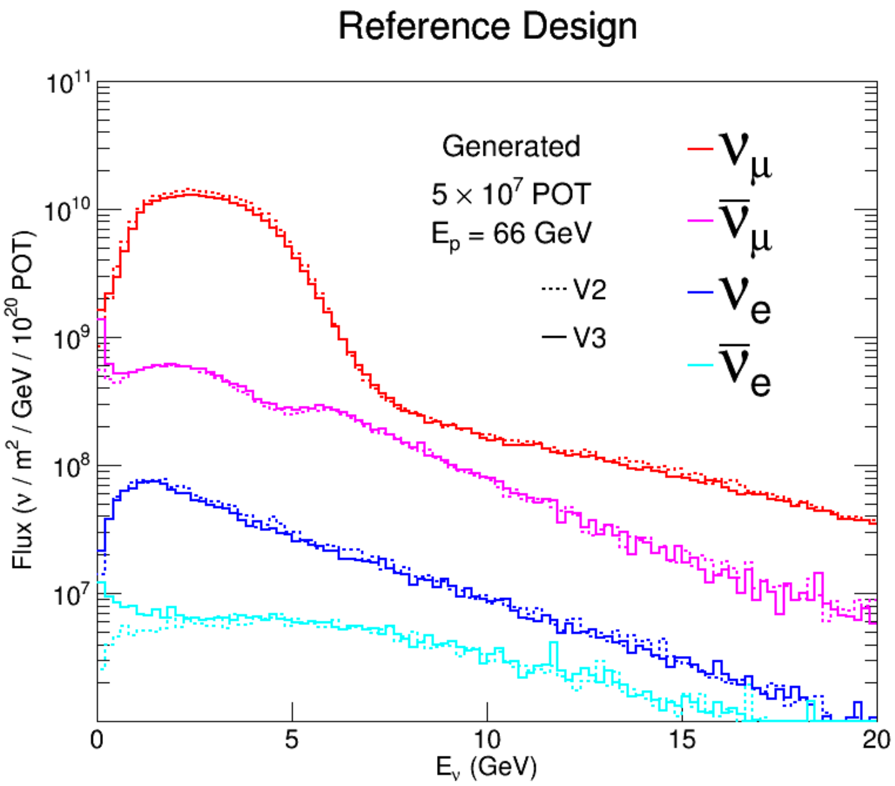
Reference Design: π+ (1-10 GeV)

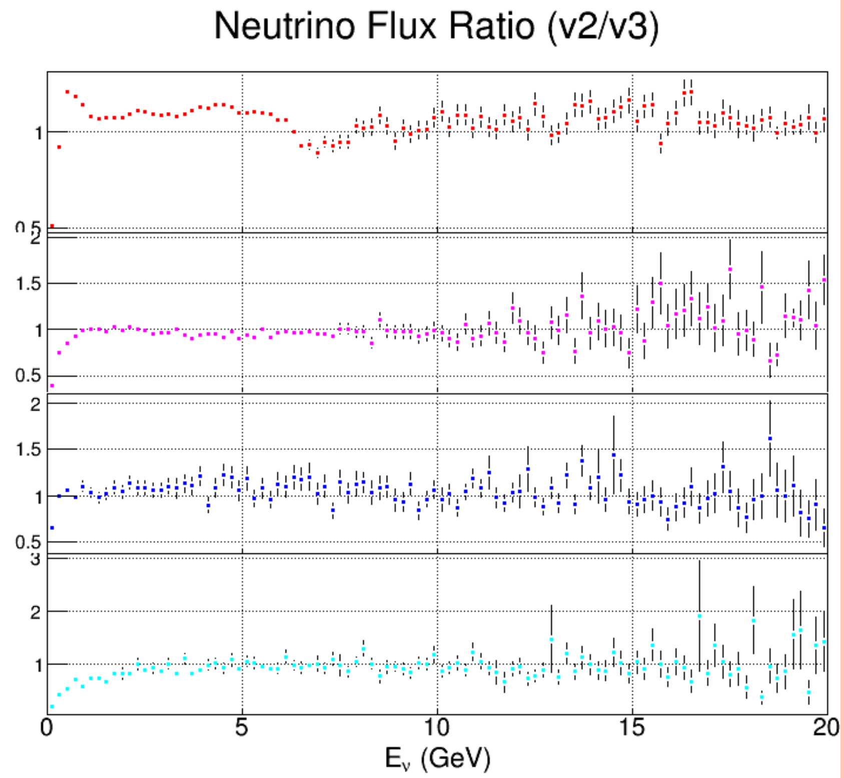


Optimized Design: π+ (1-10 GeV)

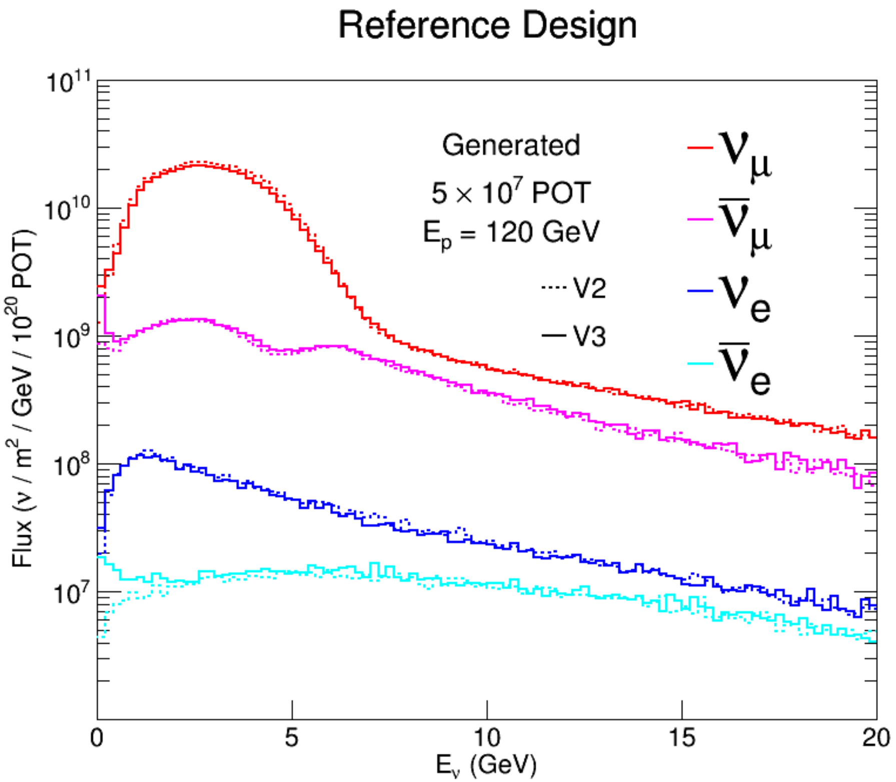


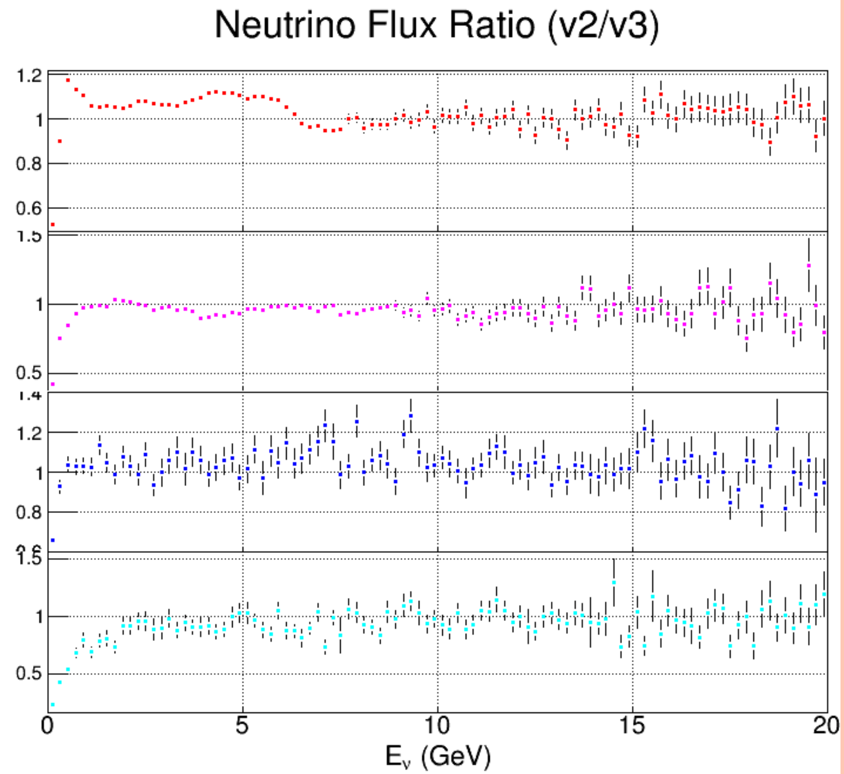
Reference Design



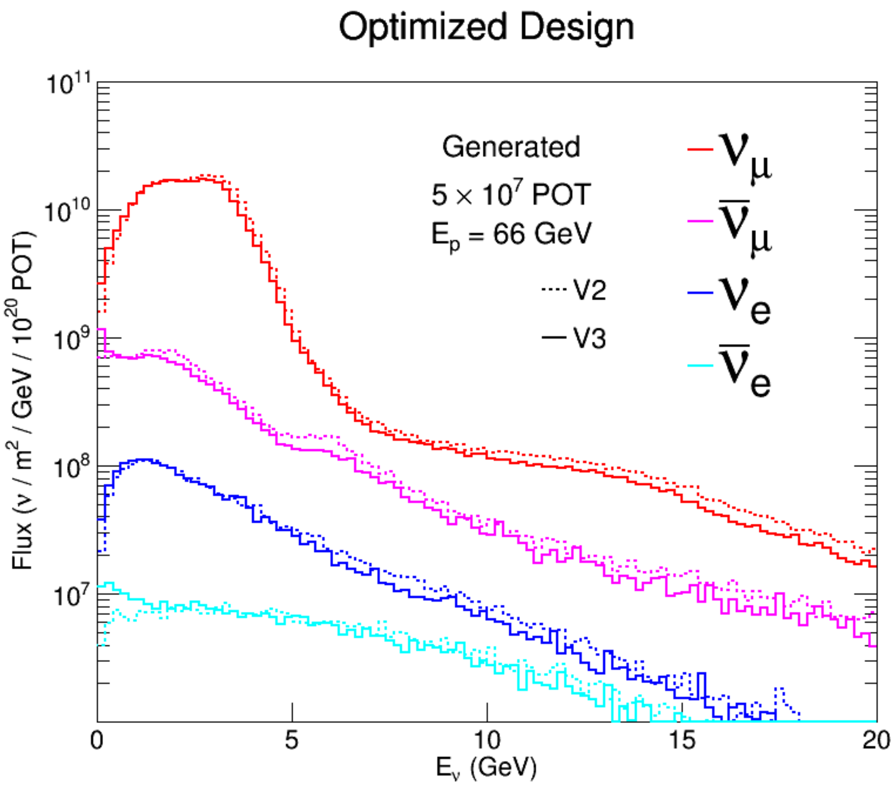


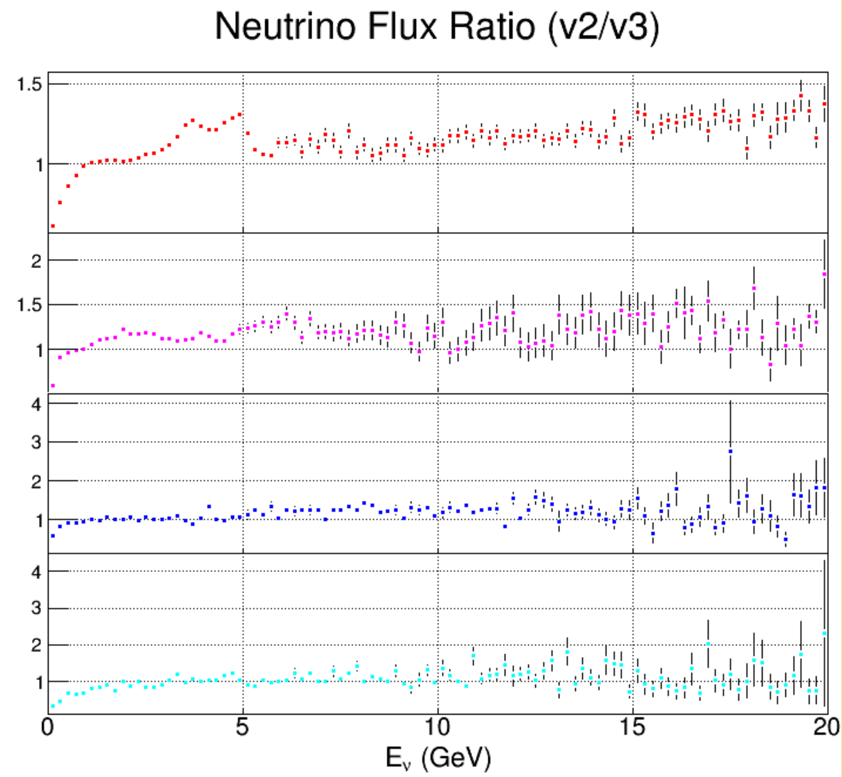
Reference Design



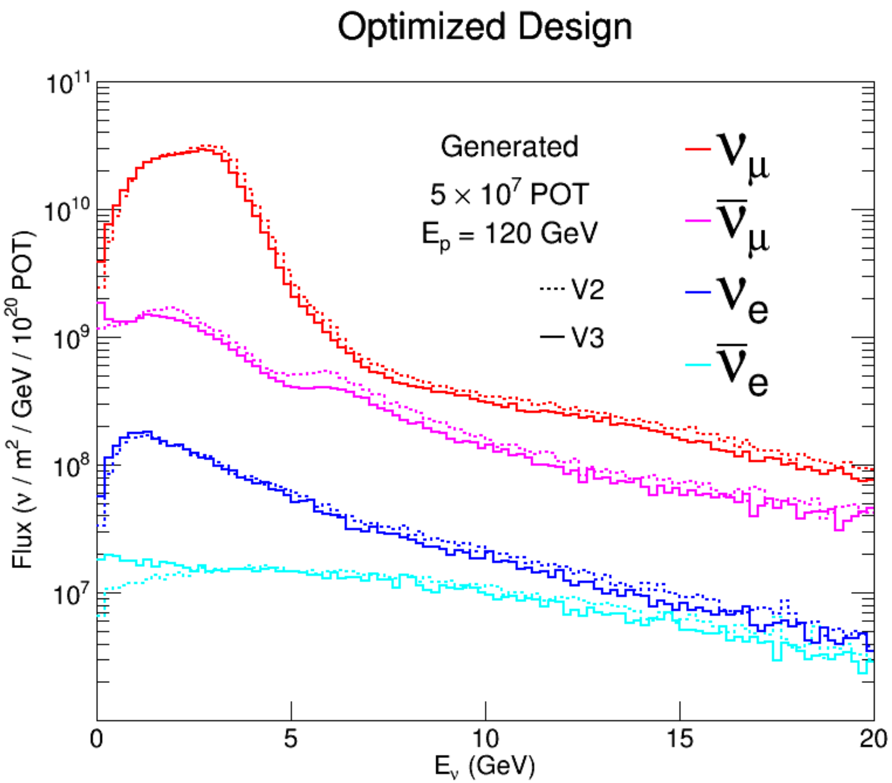


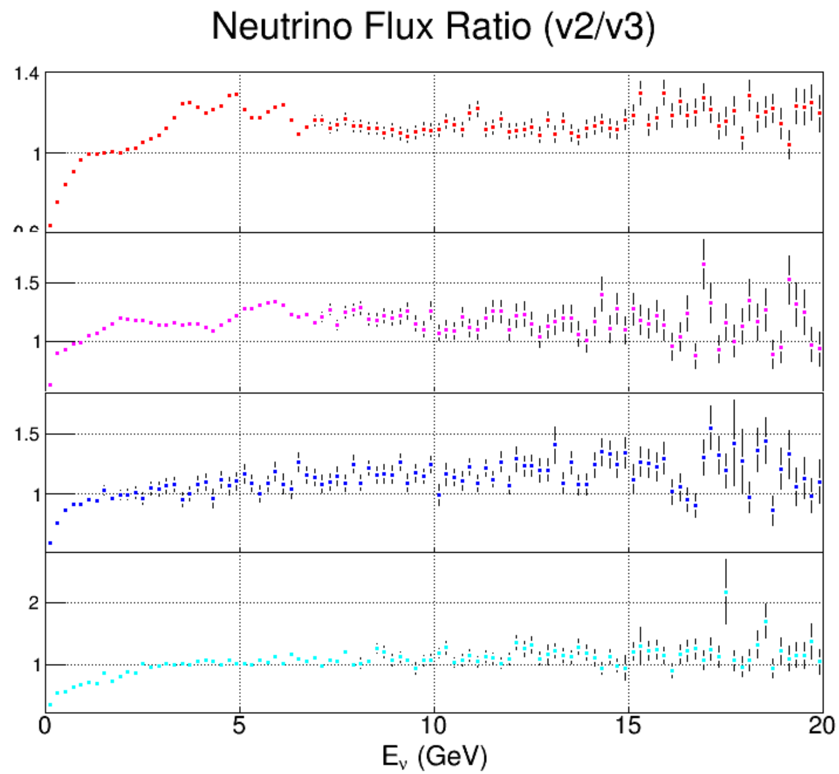
Optimized Design





Optimized Design



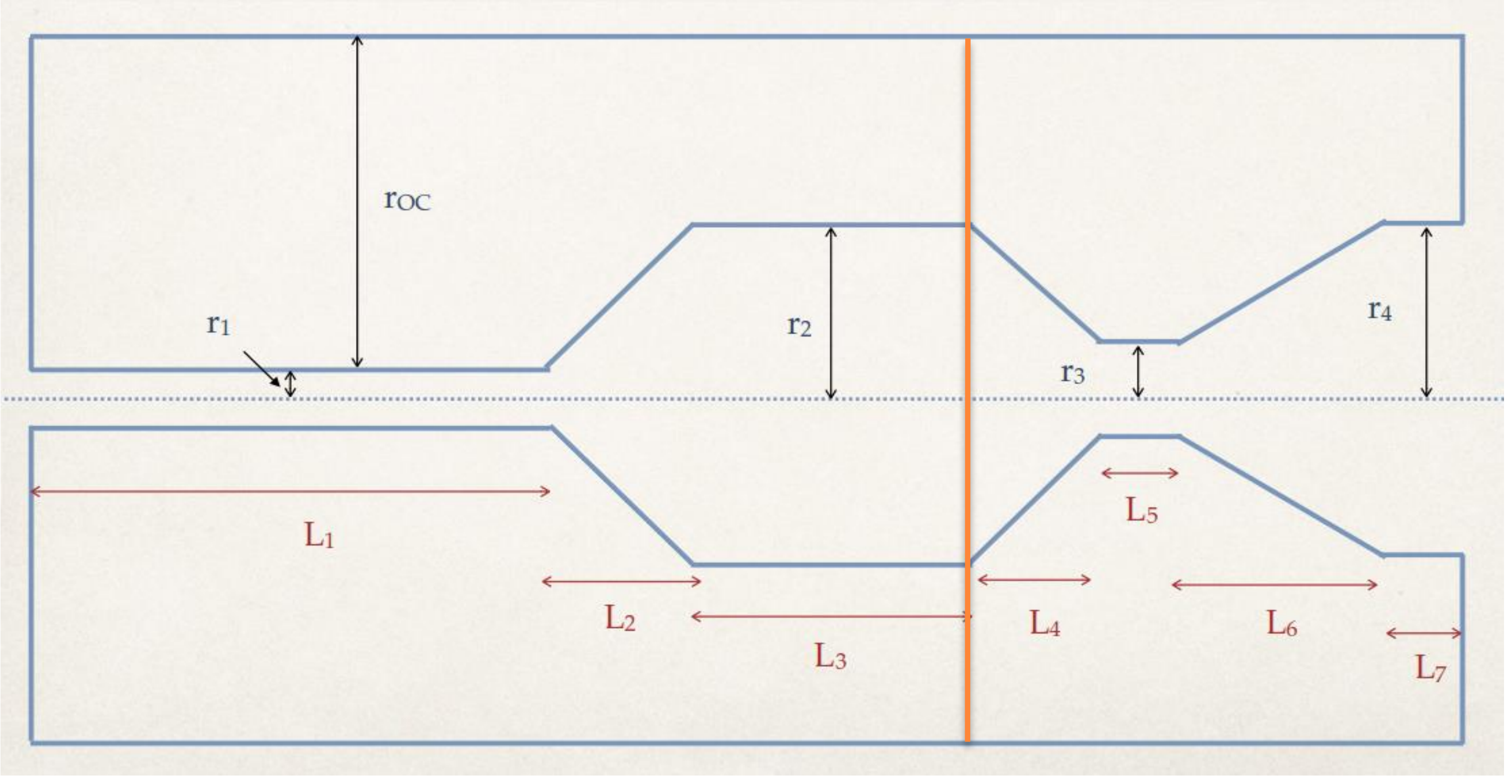


Observations

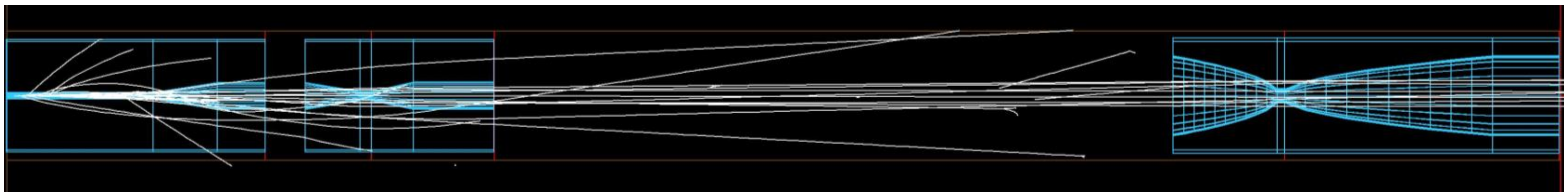
- Verify that optimized design outperforms reference
- V3 has overall lower flux due to the more accurate use of beamline components
- V3 low energy bins are higher because V2 has automatic low energy cuts

Three Horn Design

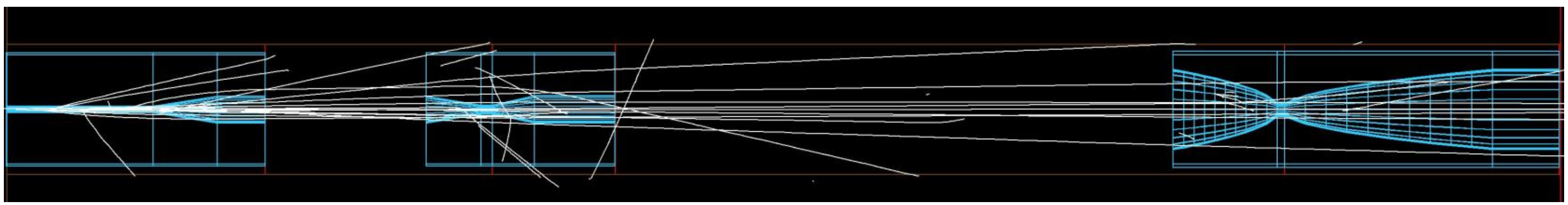
- Same beam specifications as optimized design, except Horn 1 is cut between L_3 and L_4



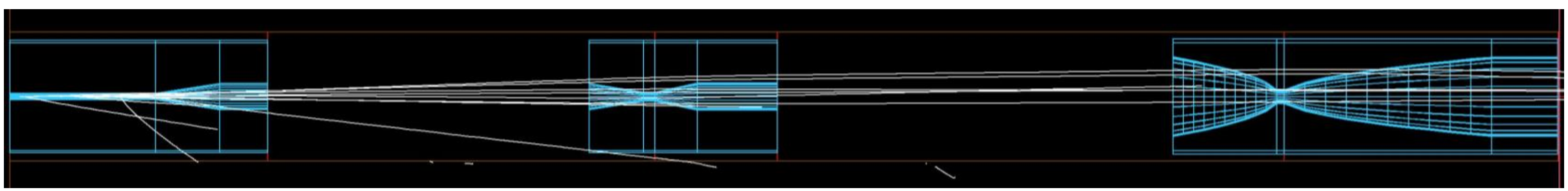
Visualization of Three Horn Design



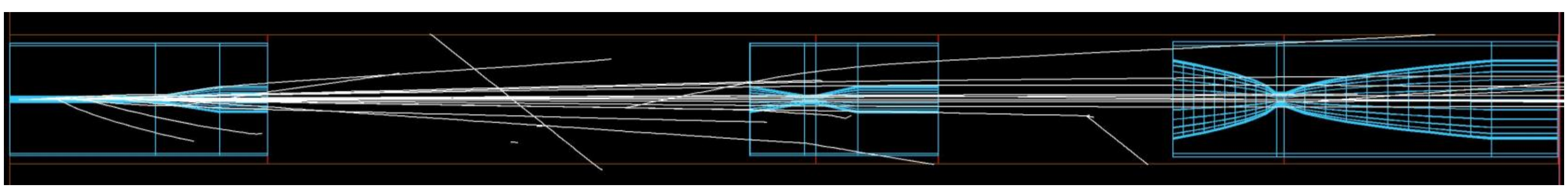
0.5m



2.0m

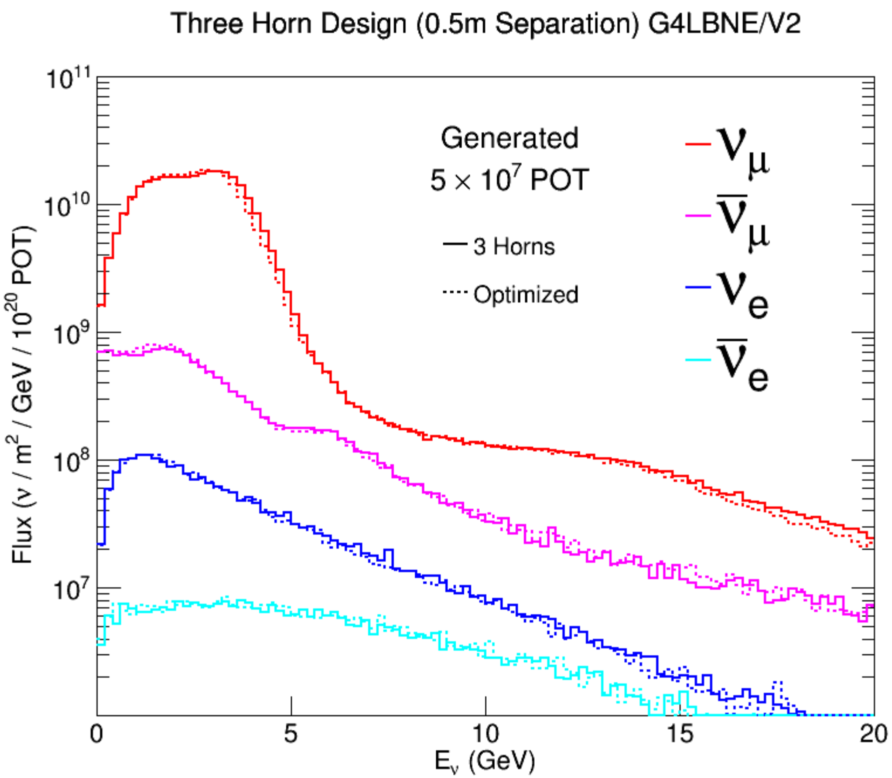


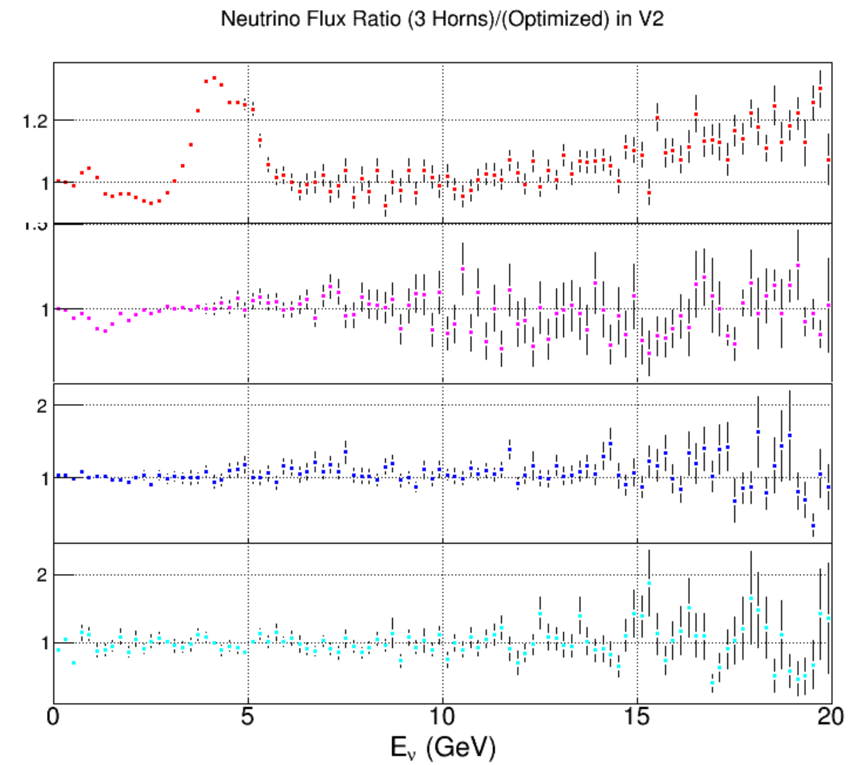
4.0m



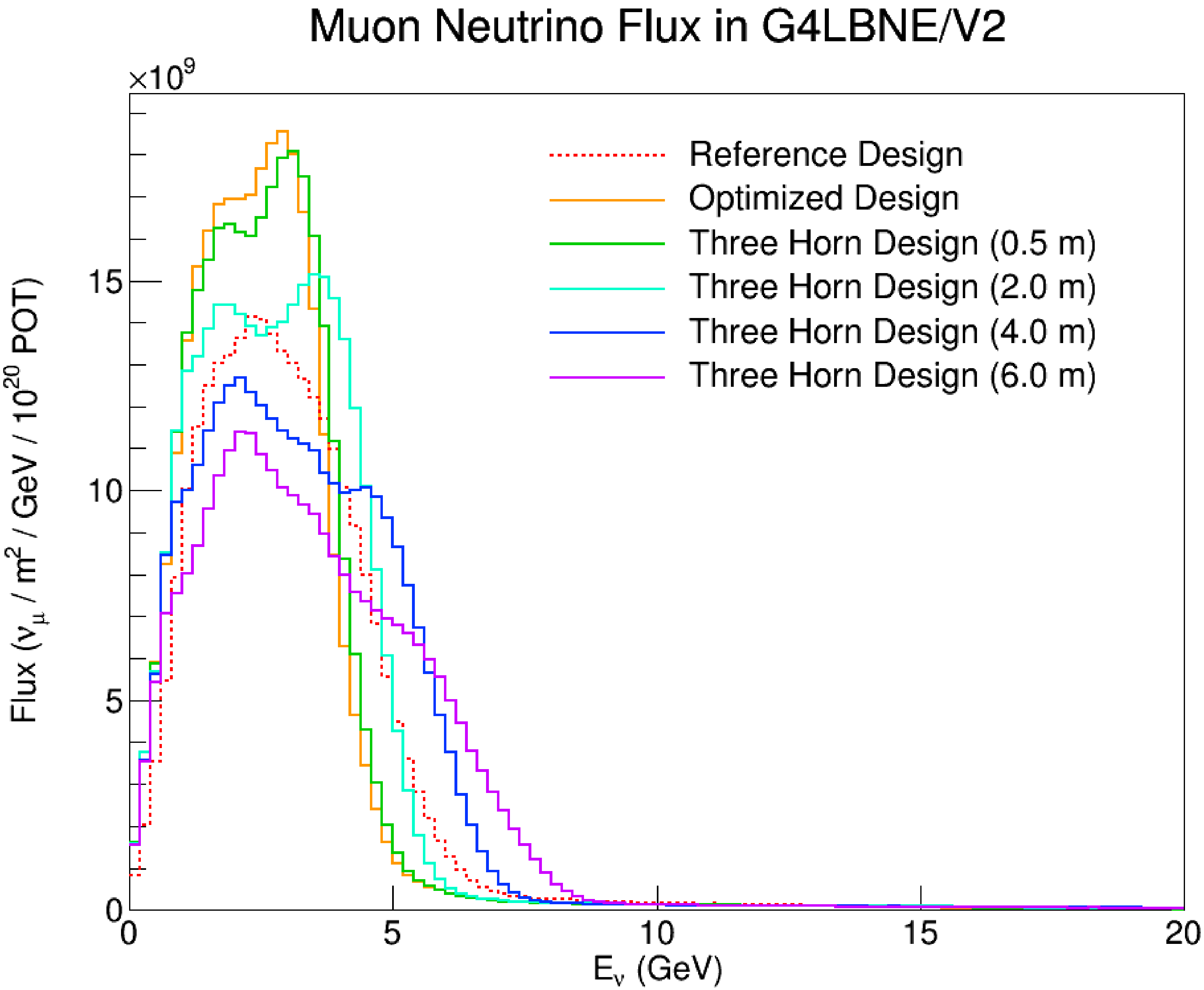
6.0m

0.5 meter Separation





Three Horn (all separation lengths)



66 GeV

Conclusions

- The 0.5 m separation design yields comparable neutrino flux to the optimized design - a three horn design can be found that has equal or better flux
- Simply moving the location of Horn 2 doesn't give quality tuning. Likely will be the case for other Horn 2 OC radii

Future Work

- Study anti muon neutrino beam
- Implement three horn design in G4LBNE/V3
- Use a genetic algorithm to optimize the three horn geometry – Horn 2 OC radius and separation distance increase complexity by 2 degrees of freedom

End