

# LBNE Beam Design Simulations

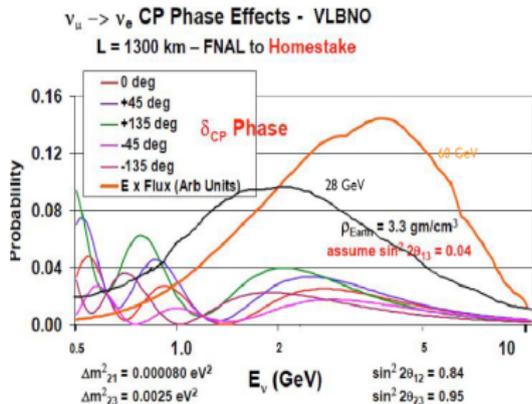
3/24/10

Mary Bishai (BNL), Alysia Marino (UC Boulder)

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# Requirements of the FNAL/Homestake Beam

The design specifications of a new WBLE beam based at the Fermilab MI are driven by the physics of  $\nu_\mu \rightarrow \nu_e$  oscillations:



L = 1300 km

## Requirements:

- Maximal possible neutrino fluxes to encompass the 1st and 2nd oscillation nodes, with maxima at 2.4 and 0.8 GeV.
- High purity  $\nu_\mu$  beam with negligible  $\nu_e$

- Minimize the neutral-current feed-down contamination at lower energy, therefore minimizing the flux of neutrinos with energies greater than 6 GeV is highly desirable.

# Summary of LBNE Beam Design Efforts

LBNE Beam  
Design  
Simulations

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- **Since 2008 a NuMI based design using the 2 NuMI horns, a shortened target chase and cylindrical graphite target fully embedded in Horn 1 has been the default reference design. The DP is evacuated with a radius of 2m and a length of 280-380m. This design was used to estimate physics sensitivities in 2009.**
- **In Fall 2009, Byron Lundberg conducted a detailed study of a 2-horn and 3-horn focusing design and concluded that 2 parabolic horns with an embedded target are sufficient (for a conventional horn focused beam).**
- **In early 2010, a new parabolic 2-horn conceptual design with an embedded water cooled target has been proposed. Alysia has implemented the beamline design in GNUMI and Mary has implemented the new target design in FLUKA08.**
- **In this talk, I will summarize the performance of the new design and compare to the 2008 NuMI-like reference design.**

# Proton Target Designs

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<b>Parameter</b>	<b>2008</b>	<b>2010</b>
<b>Material</b>	<b>Carbon-Composite</b>	<b>Graphite</b>
<b>Density</b>	<b>2.1 g/cm<sup>3</sup></b>	<b>1.8 g/cm<sup>3</sup></b>
<b>Target shape</b>	<b>Cylindrical</b>	<b>Cylindrical</b>
<b>Radius</b>	<b>0.6 cm</b>	<b>0.75cm</b>
<b>Length</b>	<b>80 cm</b>	<b>96.6cm</b>
<b>Cooling material</b>	<b>He</b>	<b>Water</b>
<b>Cooling element</b>	<b>None</b>	<b>SS pipes</b>
		<b>inner wall thickness= 0.02cm</b>
		<b>outer wall thickness= 0.03cm</b>

**The beam is 120 GeV**

**$p^+$ ,  $\sigma_x = \sigma_y = 0.15\text{cm}$ ,  $dy/dz = dx/dz = 0.01\text{mrad}$ .**

# Focusing Horn Designs

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## Horn 1

<b>Parameter</b>	<b>2008</b>	<b>2010</b>
<b>Conductor</b>	<b>Al</b>	<b>Al</b>
<b>Shape</b>	<b>Double parabolic</b>	<b>Cylindrical/Parabolic</b>
<b>Inner Al thickness:</b>	<b>2mm min 4.5mm (max at neck)</b>	<b>4.5mm cylindrical portion 3mm parabolic</b>
<b>Outer conductor</b>	<b>30.66 cm ID 32.40 cm OD</b>	<b>56 cm ID 60 cm OD</b>
<b>Front Al thickness</b>	<b>3mm</b>	<b>4mm</b>
<b>End Al thickness</b>	<b>3mm</b>	<b>4mm</b>
<b>Minimum aperture field-free neck:</b>	<b>0.9cm radius</b>	<b>1.2 cm radius</b>
<b>Length:</b>	<b>3.0 m</b>	<b>3.2m</b>
<b>Current:</b>	<b>250-350 kA</b>	<b>300 kA</b>

# Focusing Horn Designs

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## Horn 2

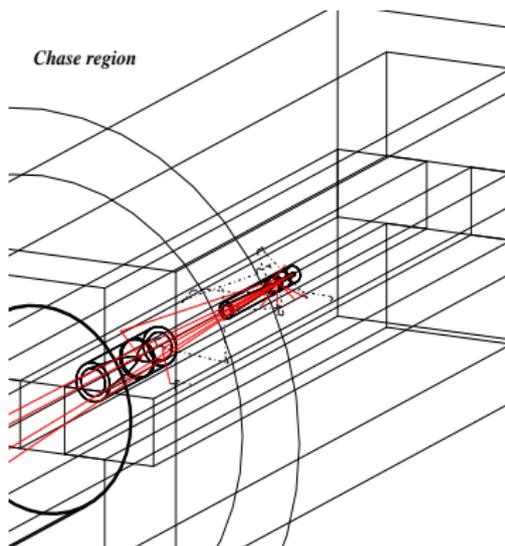
<b>Parameter</b>	<b>2008</b>	<b>2010</b>
<b>Shape:</b>	<b>Double parabolic</b>	<b>Same</b>
<b>Conductor:</b>	<b>Al</b>	<b>Same</b>
<b>Inner conductor thickness:</b>	<b>3mm min</b>	<b>Same</b>
	<b>5mm max</b>	<b>Same</b>
<b>Outer conductor :</b>	<b>74.00 cm ID</b>	<b>Same</b>
	<b>75.74 cm OD</b>	<b>Same</b>
<b>Front conductor thickness</b>	<b>3mm</b>	
<b>End conductor thickness</b>	<b>3mm</b>	
<b>Minimum aperture</b>		
<b>field-free neck:</b>	<b>3.9cm radius</b>	<b>Same</b>
<b>Length:</b>	<b>3.0m</b>	<b>Same</b>
<b>Current:</b>	<b>250-350 kA</b>	<b>300 kA</b>
<b>Distance from H1 upstream end</b>	<b>6m</b>	<b>6.6m</b>

# Comparison of LBNE 2 horn Beamline Designs

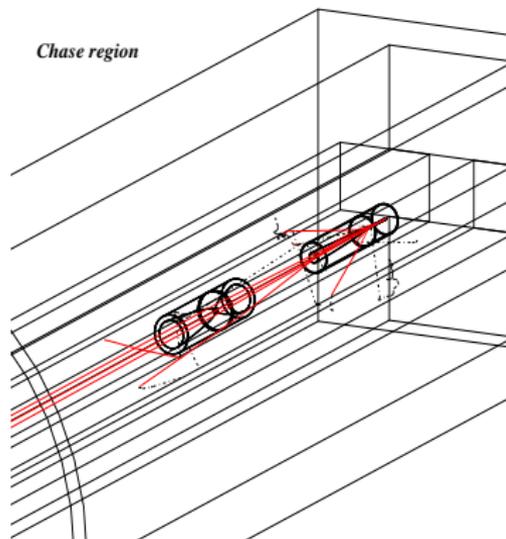
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## NuMI-like 2-horns



## LBNE 2-horns (Byron)



Target chase decay channel  $\Delta x \times \Delta y \times \Delta z$ :

$1 \times 1.3 \times 18.28$  m

Horn 1 starts 7m downstream

$1 \times 1.3 \times 28.00$  m

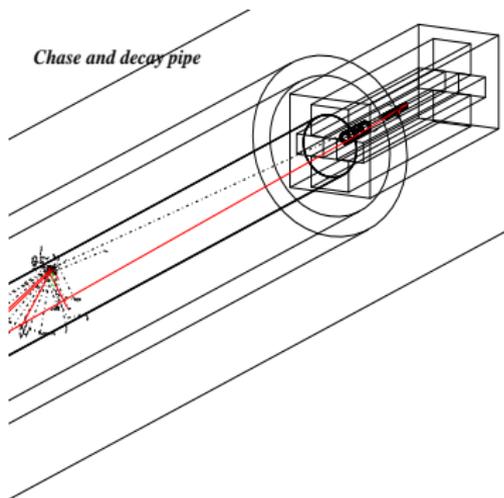
Horn 1 starts 3m downstream

# Comparison of LBNE 2 horn Beamline Designs

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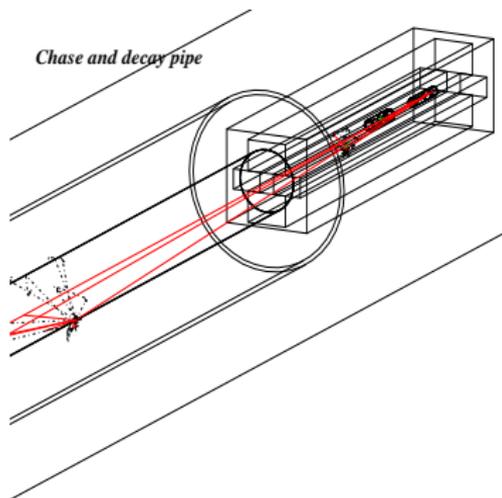
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## NuMI-like 2-horns



Decay pipe  $r=2\text{m}$ ,  $L=280\text{m}$   
shielding thick= 2.5m, evacuated

## LBNE 2-horns (Byron)



Decay pipe  $r=2\text{m}$ ,  $L=250\text{m}$   
shielding thick =3.5m, air 1atm

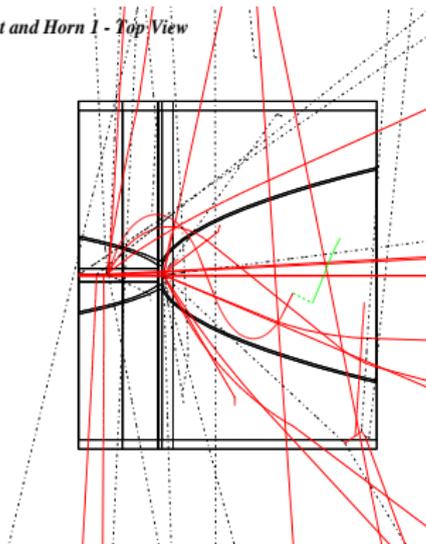
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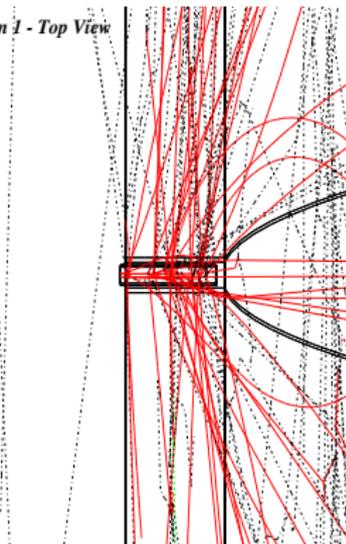
## NuMI-like 2-horns

*Target and Horn 1 - Top View*



## LBNE 2-horns (Byron)

*Target and Horn 1 - Top View*



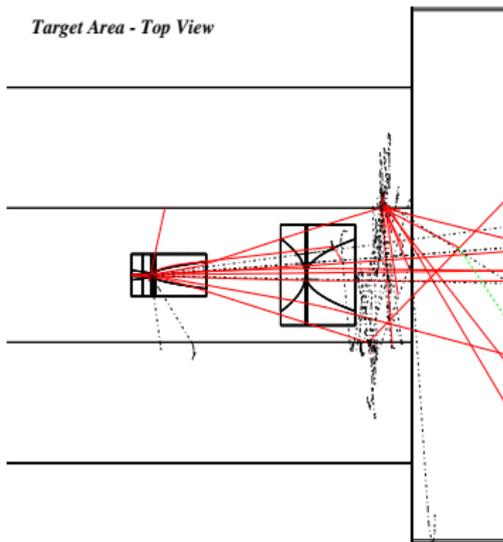
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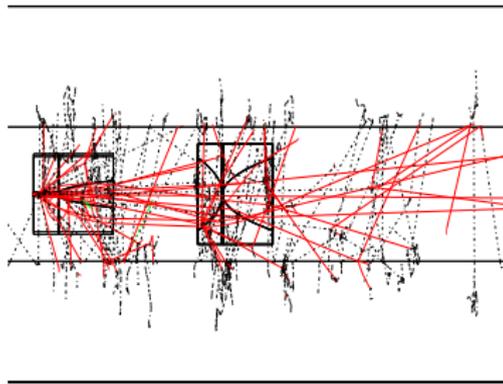
## NuMI-like 2-horns

*Target Area - Top View*



## LBNE 2-horns (Byron)

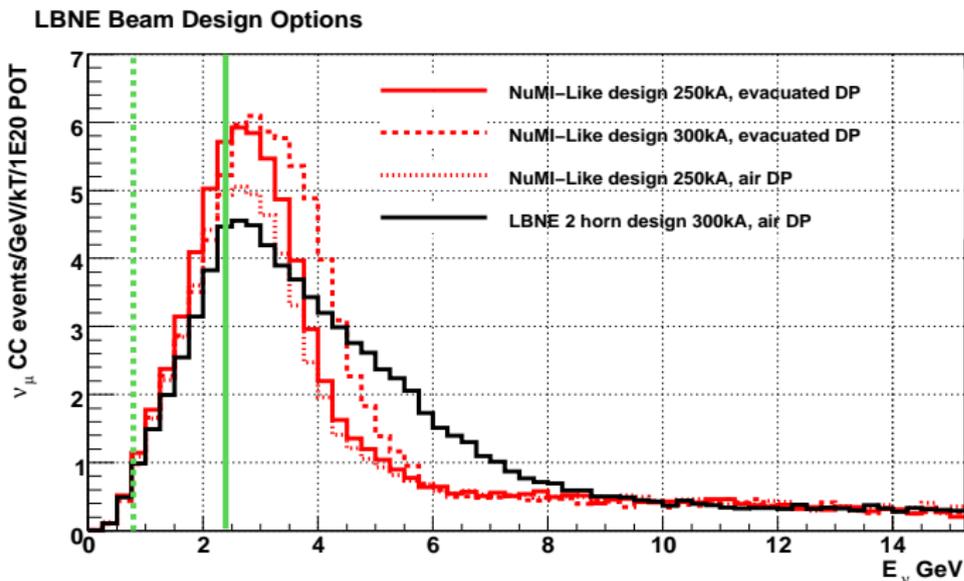
*Target Area - Top View*



# Comparison of NuMI-like/LBNE 2-horn designs

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Simulation	0.8 GeV Rate CC events/GeV/kT/MW.yr at 1300km	Peak Rate (E)	6 GeV Rate
NuMI-like, 250kA, vacuum DP	12	60 (2.5 GeV)	7
NuMI-like, 250kA, air DP	10	50 (2.5 GeV)	7
NuMI-like, 300kA, vacuum DP	12	68 (3.0 GeV)	7
LBNE 2-horn, 300kA, air DP	10	45 (2.5 GeV)	17

# Summary/Conclusions

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- **The current 2-horn focusing system design being considered for LBNE is not as efficient as just using the NuMI horns.**
- **We need to iterate further on the 2-horn design.**
- **We do not yet have a study to determine the desirable layout of the target chase and deployment of the shielding that meets the physics specifications of the experiment.**