DUNE: Re-optimization of the LBNF neutrino beam

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New Perspectives
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Outline

Motivation and Introduction

Optimizable parameters

Summary & Future plans
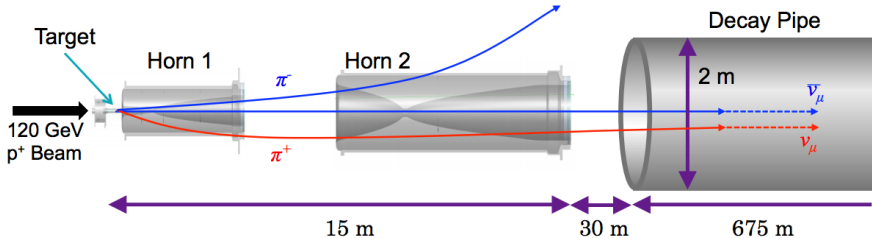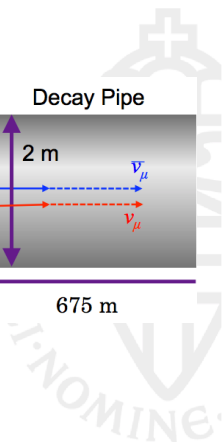
Conventional neutrino beamline designs

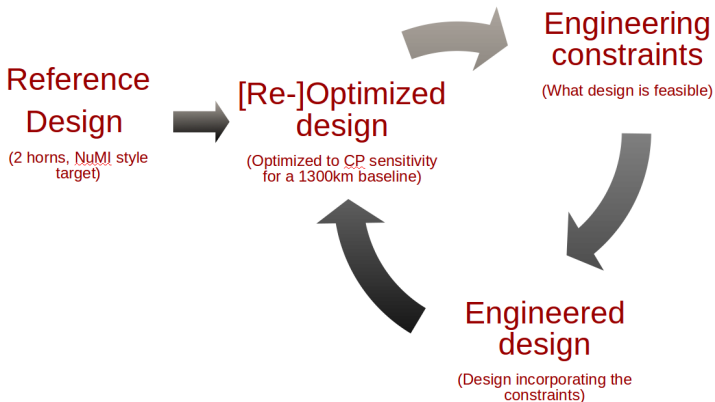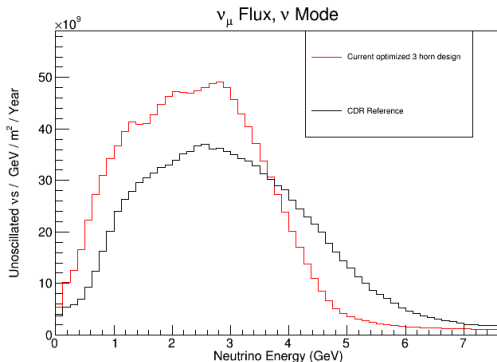Figure: Conventional neutrino beam design

Optimization cycle

Engineering constraints

(What design is feasible)

Reference Design

(2 horns, NuMI style target)

[Re-]Optimized design

(Optimized to CP sensitivity for a 1300km baseline)

Engineered design

(Design incorporating the constraints)

Figure: The optimization process

Reference design vs Current design

Figure: Neutrino flux for the CDR reference design and the current optimized design

- Current design provides significant higher flux than reference design

Reference design vs Current design

Figure: CP Sensitivity for the CDR reference design and the current optimized design
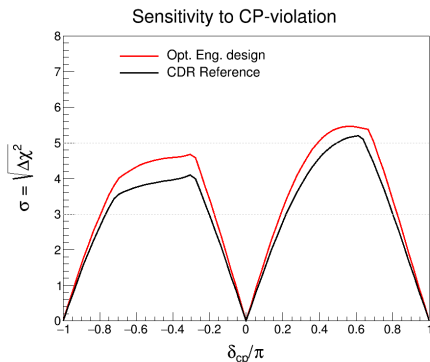
- Current design provides significant higher CP-sensitivity than reference design
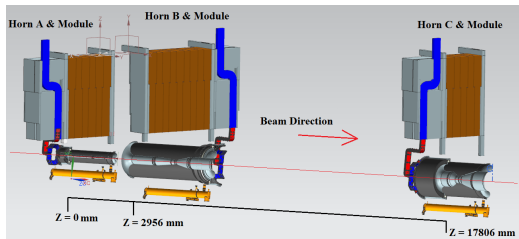
Current state of the optimized beam design

Figure: The current state of the LBNF beamline (C. Crowley)

- A 2m long graphite target, which fits inside horn A
- Three magnetized horns (focusing elements) of different shapes and sizes
- A 200m long decay pipe

Optimizable parameters

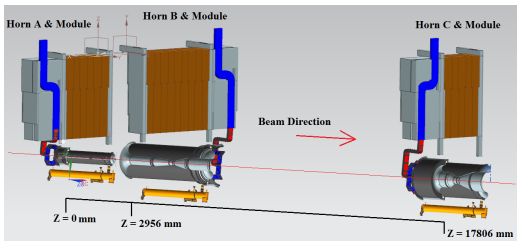*Most parameters have already been highly optimized and are frozen*

Figure: The current state of the LBNF beamline (C. Crowley)

- Proton momentum
- **Target position**
- Horn current
- Horn B position
- **Horn C position**

Optimizable parameters

Most parameters have already been highly optimized and are frozen

Example of a recent engineering change and a possible future upgrade

❶ Position of horn C
- Distance between decay pipe window and horn C was too short for equipment
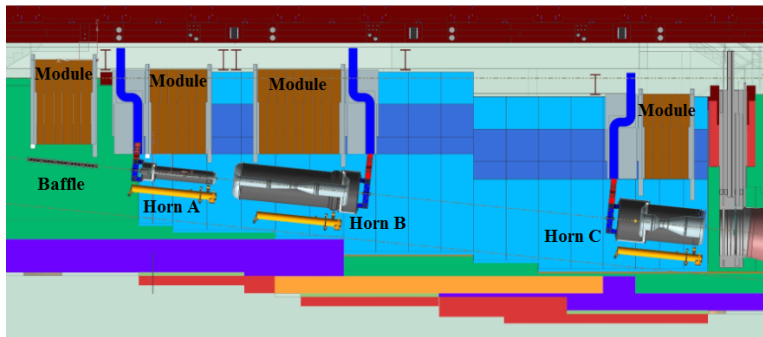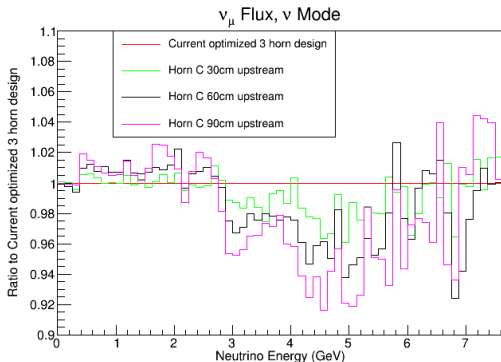
❷ Target position

Horn structure

Figure: Beamline with decay pipe (C. Crowley)
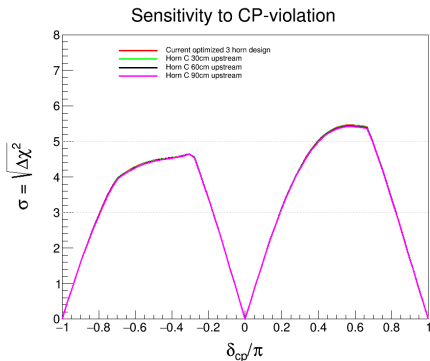
Horn C position and neutrino flux

Figure: Influence of Horn C position on neutrino flux

- Moving Horn C upstream leads to a decrease in neutrino flux for 3-6GeV

Horn C position and CP-sensitivity

Figure: Influence of Horn C position on neutrino flux

- No significant changes to CP-sensitivity

Target position and neutrino flux

Figure: Influence of target position on neutrino flux
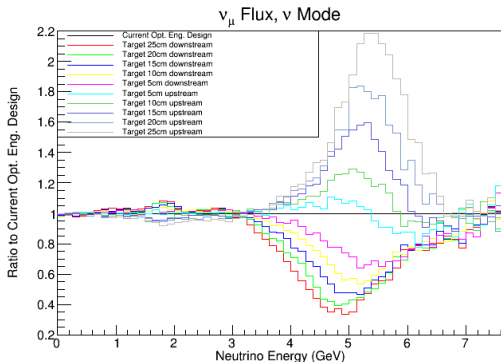
- Moving the target upstream leads to an increase in flux in 3.5-6GeV range

Target position and CP-sensitivity

Figure: Influence of target position on CP-sensitivity
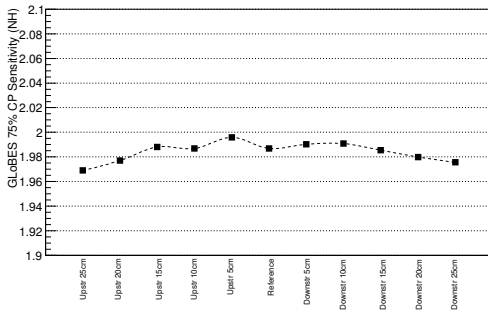
- Moving the target 5cm upstream leads to an small increase in CP-sensitivity

Summary and outlook

- Change to horn C positions has little to no effect
- Horn C was moved 30cm upstream
- Target could be moved upstream by 5 cm
- Design is already highly optimized

Future plans

- Changes to the target design and cooling system
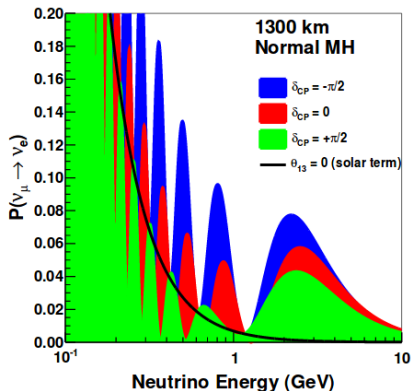- Need a better understanding of the magnetic field between the conductors (Currently disregarding fringe fields, non-uniform currents, etc)

Back-up

Figure: Oscillation probability 1300km baseline