Effect of Drain holes for LBNF on neutrino flux

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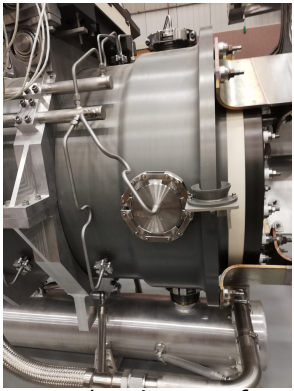
Outline

LBNF Magnetic horns

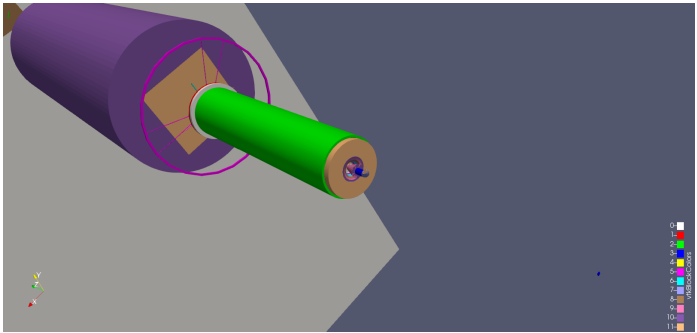
My goal is to understand the effect of the drain holes on the neutrino flux



These pictures are for horn 2 of NuMI beam, 3 drain holes are used as inputs of water and argon.

LBNF Magnetic horns

We saw in the simulation that the Drain holes are not simulated



Visualization for Horn A in ParaView (Inner conductor)

LBNF Magnetic horns

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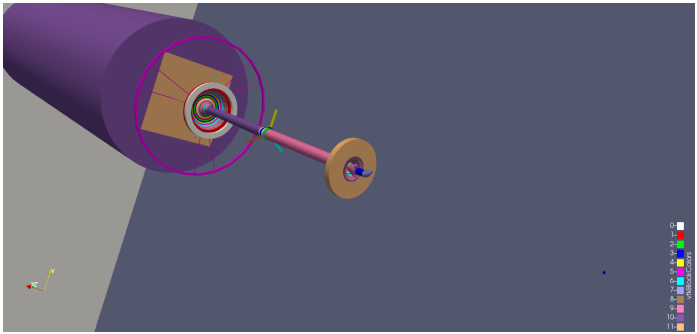
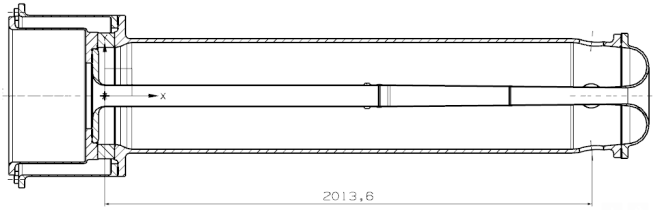


Visualization for Horn A in ParaView (Inner conductor)
The physical Drain Hole and the effect on the B field is not simulated. My goal is to add the effect of Drain holes on the B field, even when the physical hole is not there.

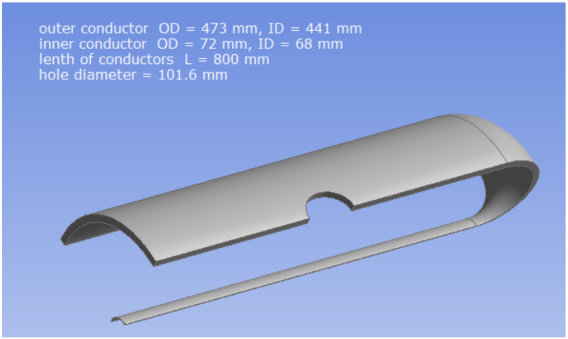
Zhijing Tang started to work on the simulation of the magnetic field near to the hole



Schematic of the horn A, the distance for the zero to the center of the drain holes is equal to 2013.6 mm

LBNF Magnetic horns

He made a simulation in ANSYS taking a quarter of the horn



The diameter of the hole is equal to 101.6 mm (image from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)

LBNF Magnetic horns

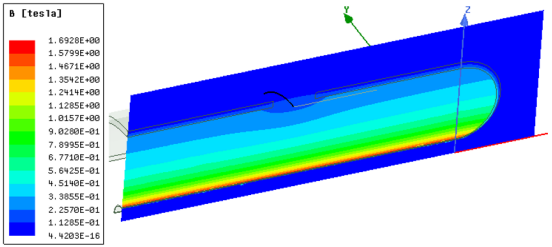


Figure 4. Static magnetic field over longitudinal cross section

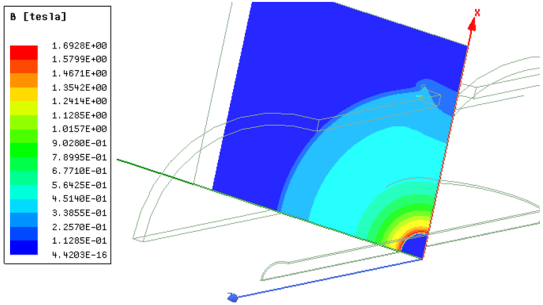


Figure 5. Static magnetic field over transverse cross section

(images from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)

Field Map

He simulated the magnetic field at points on a grid

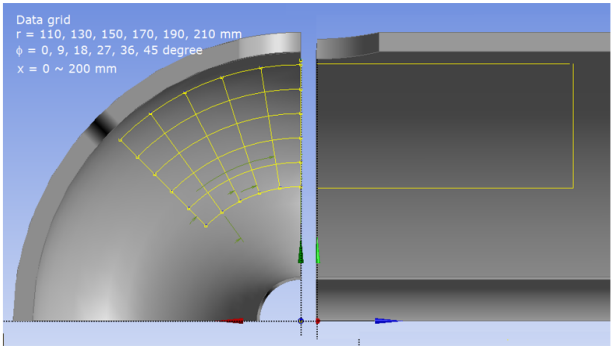


Figure 12 Grid shows where transient magnetic field data are provided

(image from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)
Grid with 6 ϕ steps, 41 z steps and 6 R steps

Field Map

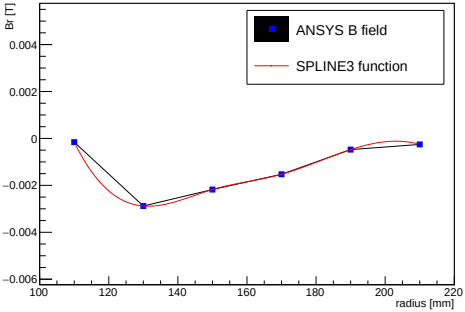
The Nominal B field inside the horn is equal to

$$B_0 = \frac{\mu_0 I}{2\pi R} = \frac{60}{R}$$

where R is in mm and B in T
The magnetic field only has component in the polar direction (toroidal field)
When we add the drain holes, the magnetic field has radial and longitudinal components.

Field Map

I need to make a field map with the characteristics of the ANSYS simulation



I took the points for the ANSYS simulation and I made a fit with Spline function in ROOT for B field

Magnetic field comparison

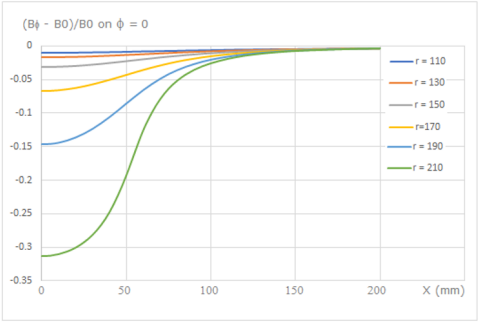
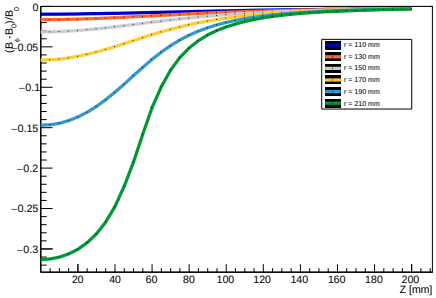


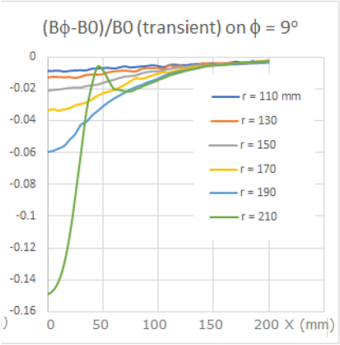
Figure 9 Relative transient magnetic field on $\phi = 0$

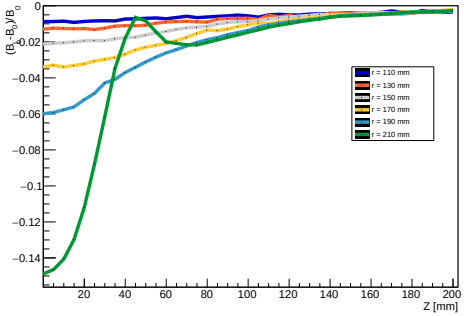


Left: relative magnetic field with an angle equal to zero (image from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)— Right: relative magnetic field produced with the field map in the LBNF beam simulation (GEANT4)

$Z = 0$ center of drain hole

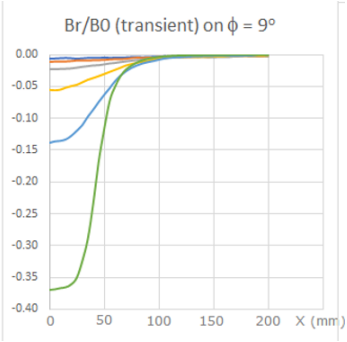
Magnetic field comparison

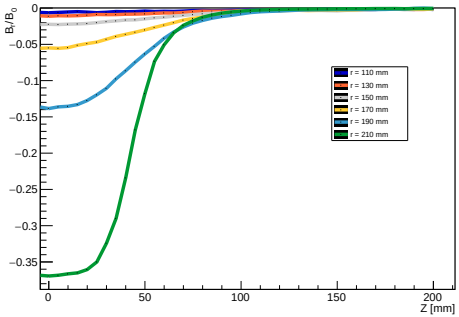




Left: relative magnetic field with an angle equal to 9 degrees (image from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)— Right: relative magnetic field produced with the field map in the LBNF beam simulation (GEANT4)

Magnetic field comparison





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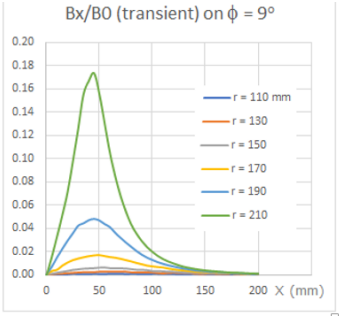
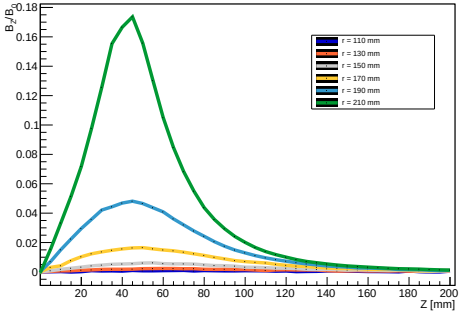
Magnetic field comparison





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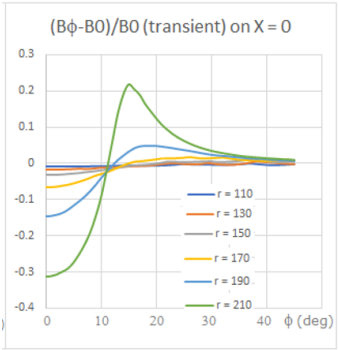
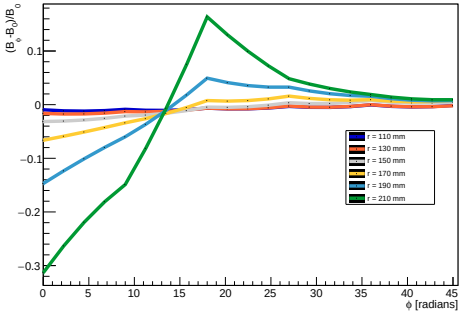
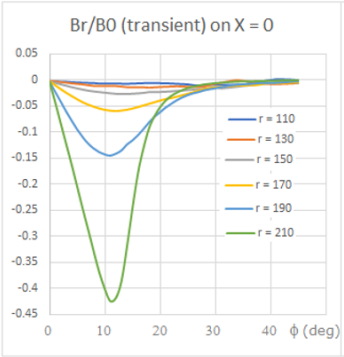
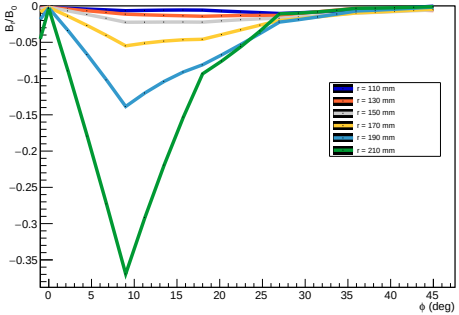




Left: relative magnetic field at the center of the drain hole (image from The Magnetic Field of Horn near Drain Hole; Zhijing Tang, October 22, 2018)— Right: relative magnetic field produced with the field map in the LBNF beam simulation (GEANT4)

Magnetic field comparison





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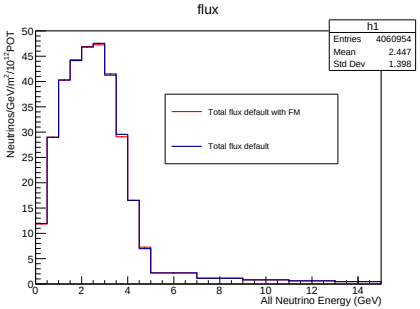
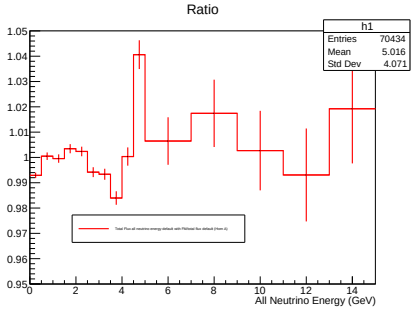
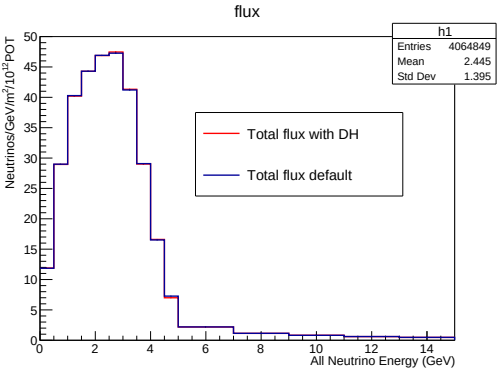


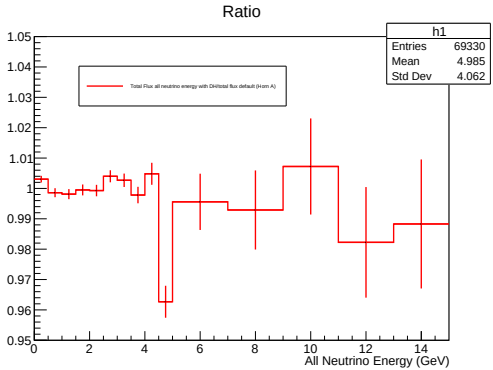


Left: Total flux LBNF far detector (Red: total flux with Field map, default magnetic field. Blue: total flux default simulation)— Right: Ratio (flux with FM over default flux) (Note: I change the radius of Outer conductor of horn A to 210 mm in both simulations).

For the next slides I take the simulation with field map as Default simulation for the reminder of this talk.

Magnetic field comparison





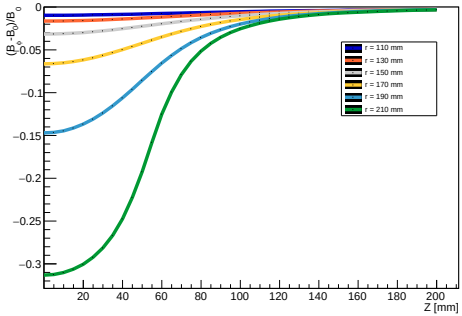
Left: Total flux LBNF far detector (Red: total flux with Drain Holes. Blue: total flux default simulation)— Right: Ratio (flux with DH over default flux)

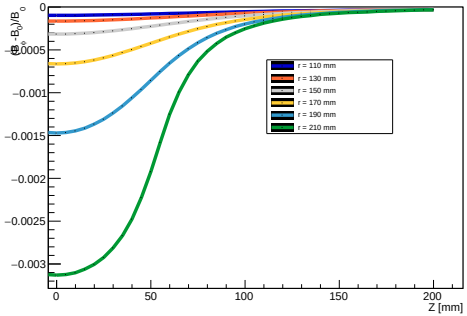
The flux is produced with the 4 Drain holes on GEANT4 simulation.

Magnetic field comparison

We reduce the effect of the drain holes to 1% to see if we recover the default simulation

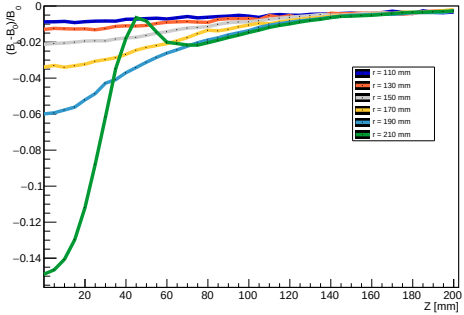
Magnetic field comparison

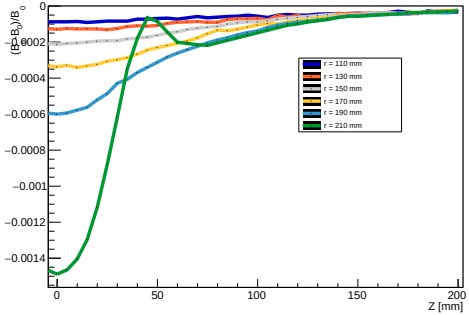




I reduce the effect of the drain holes to 1% to see if we recover the default flux and all the effect is a consequence of the drain holes. (left: relative B field for Drain holes. Right: relative B field at 1%)

Magnetic field comparison





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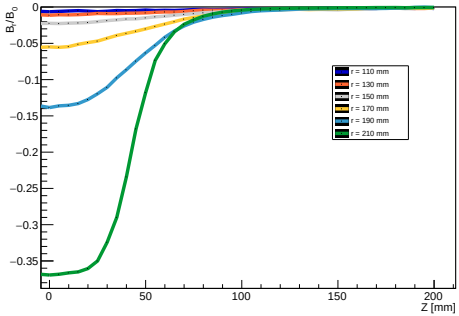
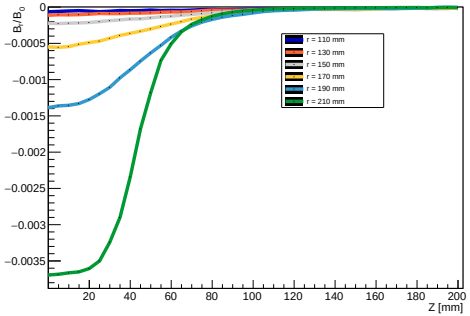
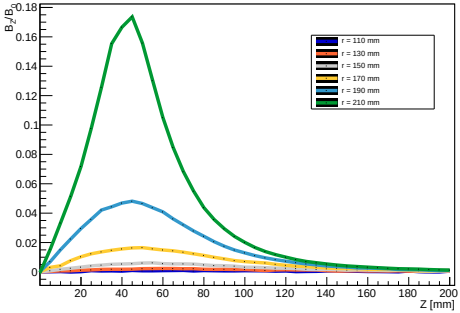
Magnetic field comparison

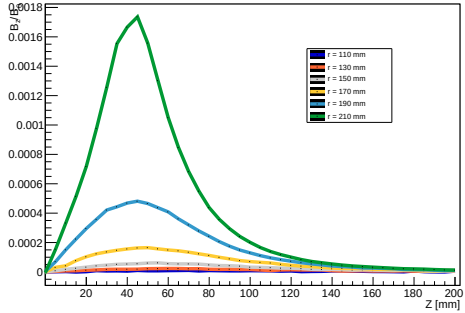




I reduce the effect of the drain holes to 1% to see if we recover the default flux and all the effect is a consequence of the drain holes. (left: relative B field for Drain holes. Right: relative B field at 1%)

Magnetic field comparison





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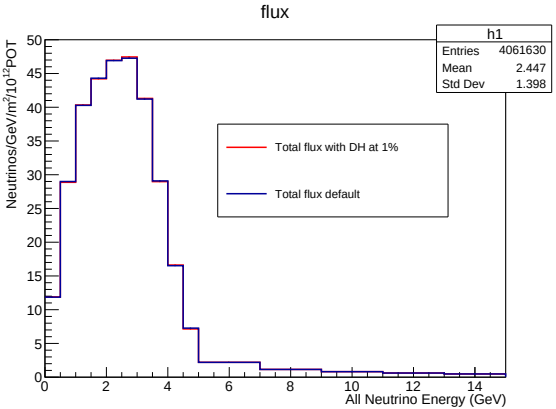
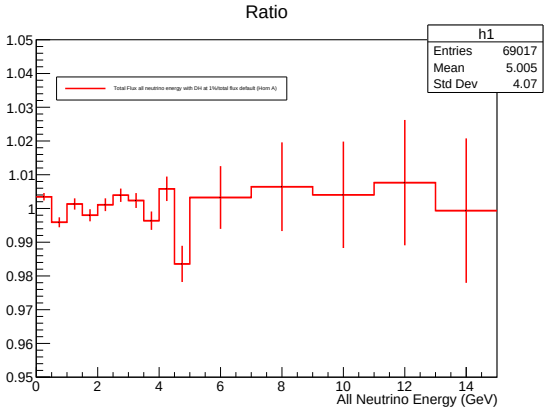
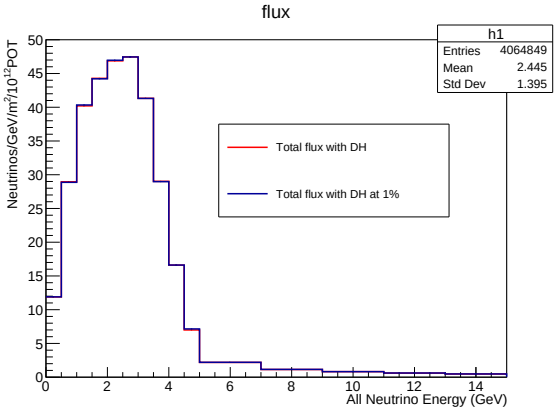
Magnetic field comparison

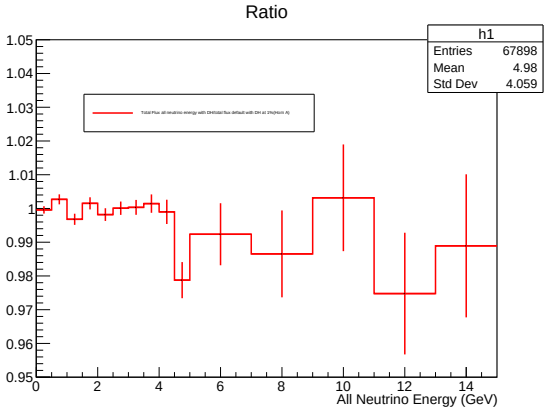




Left: Total flux LBNF far detector (Red: total flux with Drain Holes effect of 1%. Blue: total flux default simulation)— Right: Ratio (flux with DH at 1% over default flux)

Magnetic field comparison



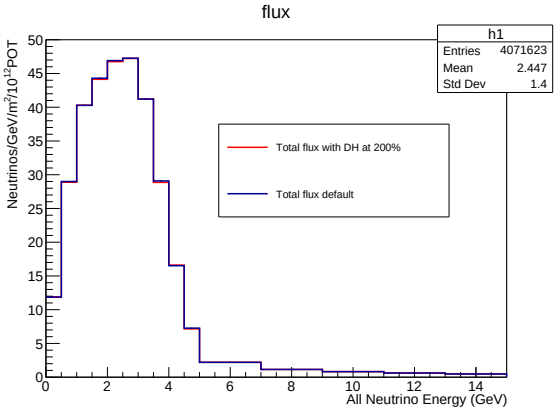


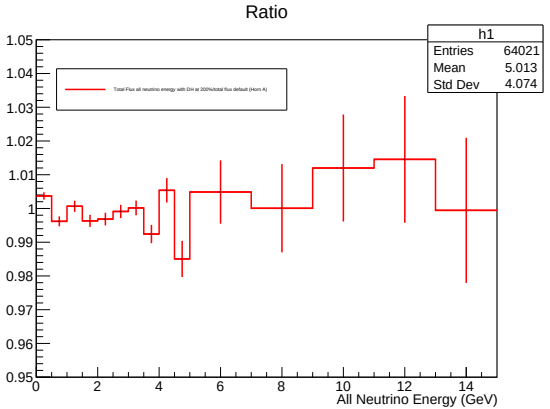
Left: Total flux LBNF far detector (Red: total flux with Drain Holes effect of 1%. Blue: total flux default simulation)— Right: Ratio (flux with DH at 1% over default flux)

Magnetic field comparison

We increased the effect of the drain holes to 200% to see how the flux is ...

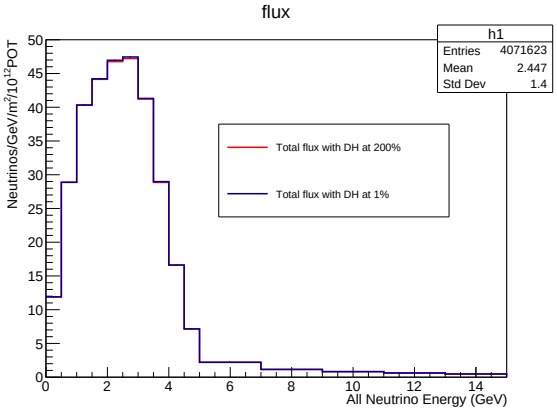
Magnetic field comparison

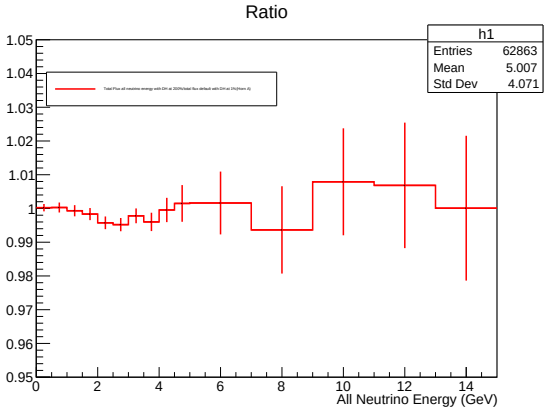




Left: Total flux LBNF far detector (Red: total flux with Drain Holes effect of 200%. Blue: total flux default simulation)— Right: Ratio (flux with DH at 200% over default flux)

Magnetic field comparison





Left: Total flux LBNF far detector (Red: total flux with Drain Holes effect of 200%. Blue: total flux with DH at 1%)— Right: Ratio (flux with DH at 200% over flux with DH at 1%)

To Do

- Understand the effect of the drain holes over the flux
- Create a field map only for the drain holes region and use the default simulation for the rest of horn A.
- Add the effect of drain holes to the NuMI beam simulation.