# Solenoid Focus of Pions for Superbeams

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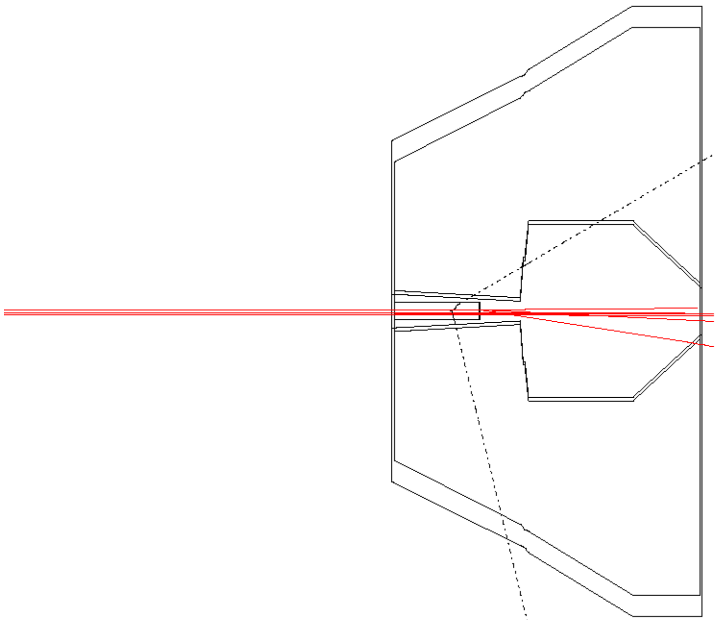
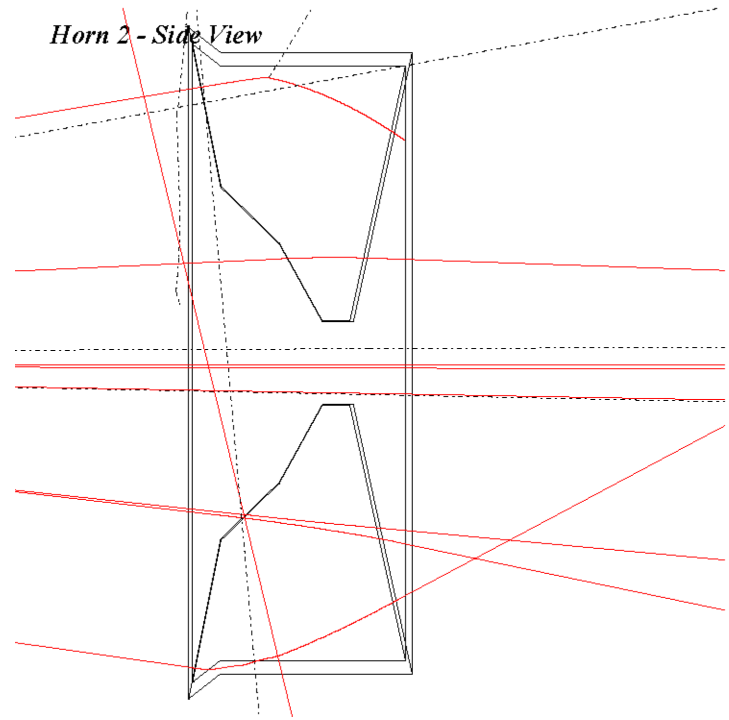
# The Horn Bench Mark

J. Heim, M. Bishai, B. Viren BNL



**Horn 1: Length =2.2m**




**Horn 2: Length =1.6m**

**ΔL Horn 2-Horn 1 =10m**

# Proton Beam/Target Input

Carbon Rod:

$L = 80cm$

$R = 6$ mm

$\rho = 2.2$ g/cm$^3$

Proton Beam:

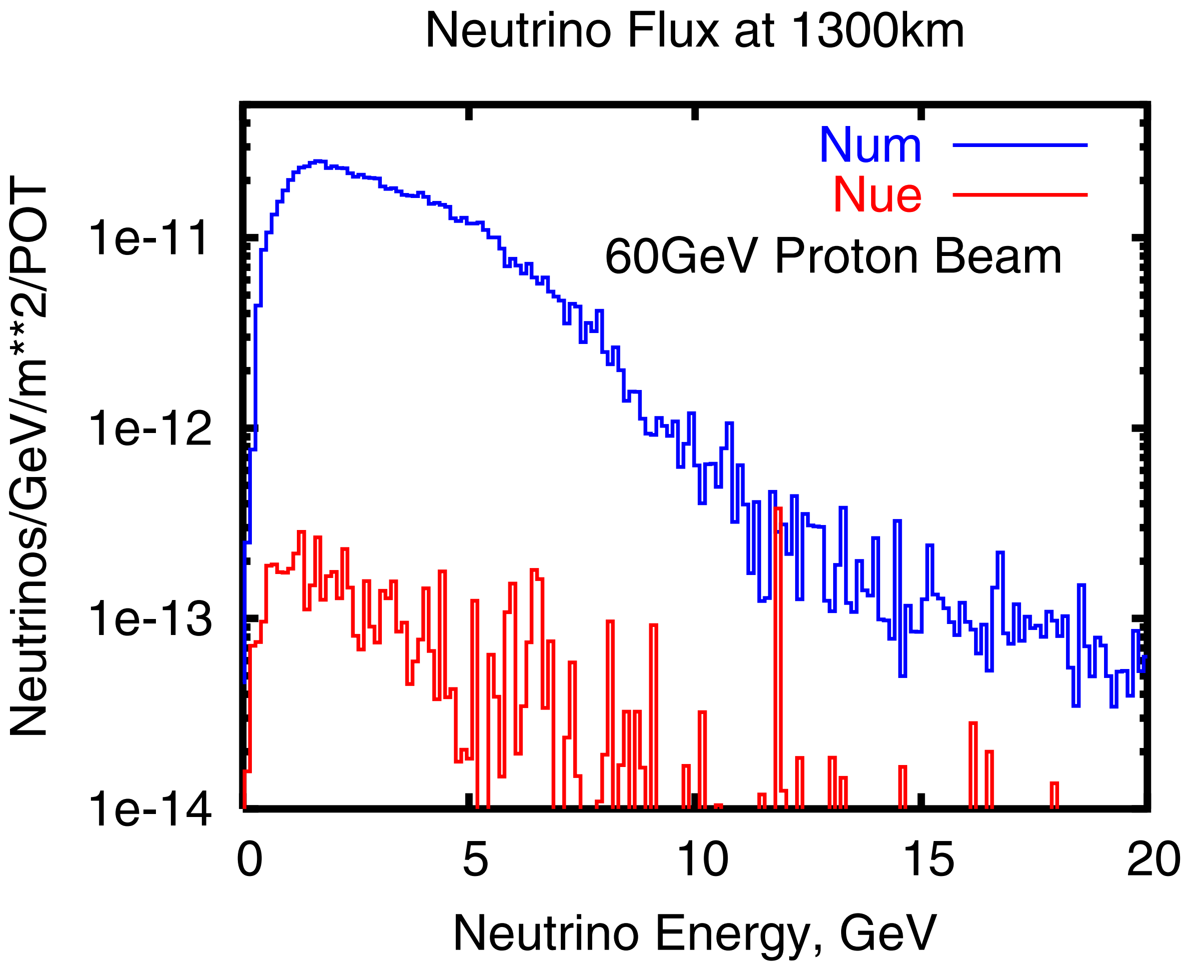
KE = 60 GeV

$\sigma_X = \sigma_Y = 2$mm rms

Model:

MARS 14

# The Neutrino Flux at 1300km




**250kA each horn; 380m, r=2m decay pipe**

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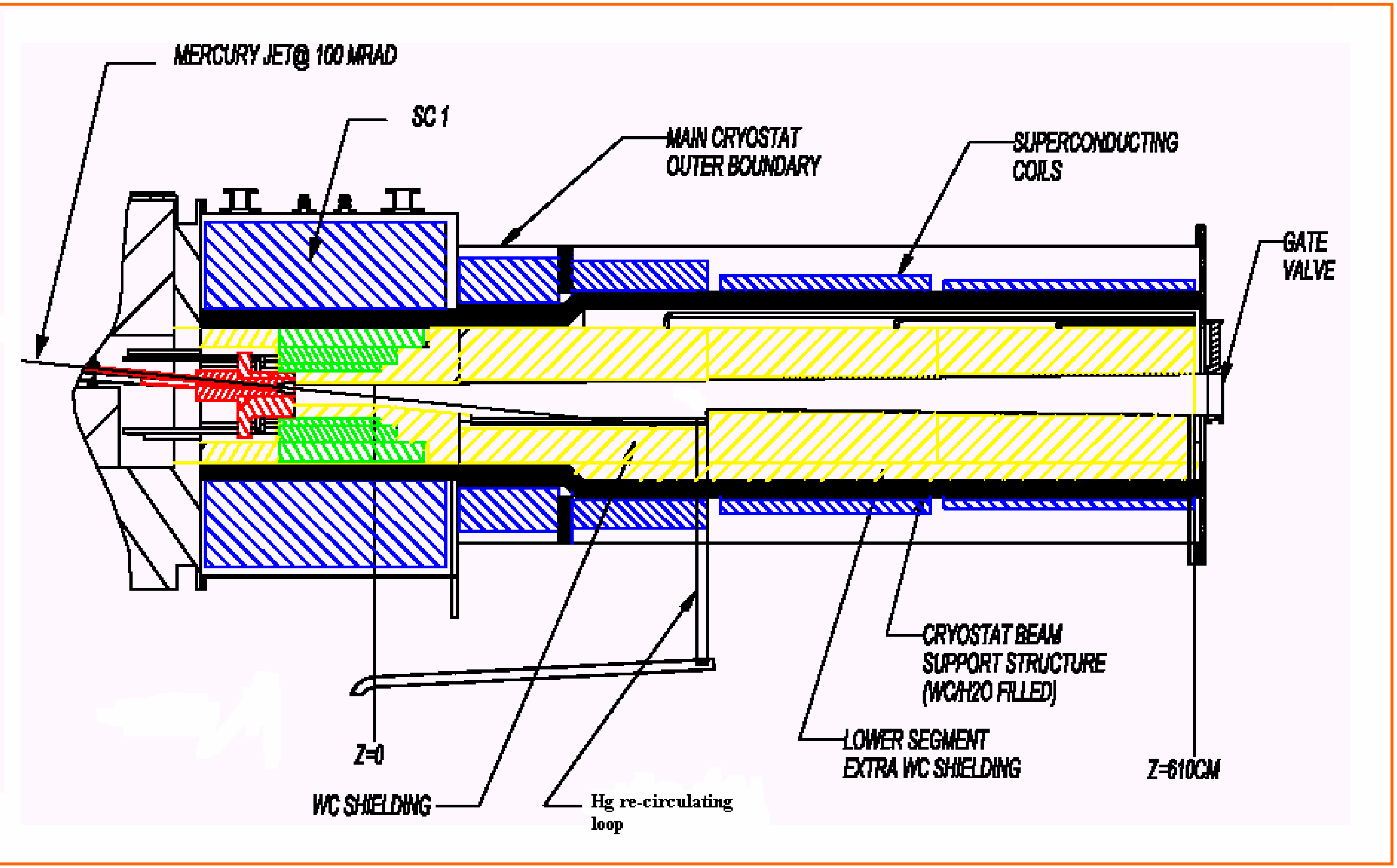
# Neutrino Factory Target Concept

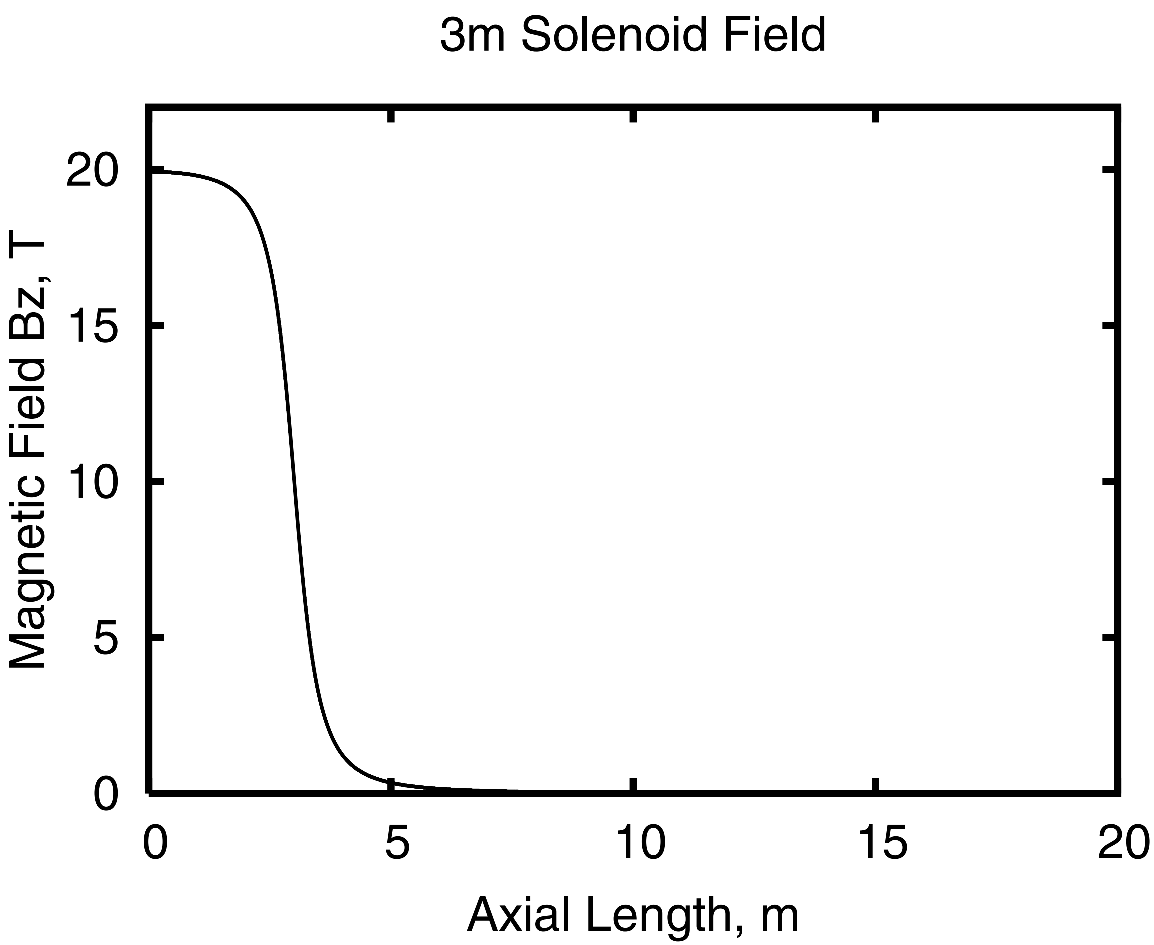



**The Field Taper**

**At Z=0m**
**Bz =20T**
**Bore = 15cm**

**At Z=20m**
**Bz =1.75T**
**Bore =60cm**

# Solenoid without Taper



# Solenoid as a Point to Parallel Lens

K.T. McDonald, *A Neutrino Horn Based on a Solenoidal Lens*, MUCOOL Tech Note 282

### 2.5.1 Neutrino Horn: Point-to-Parallel Focus, $L = (2n+1)\pi c P/eB$

A solenoid magnet provides point-to-parallel focusing for particles produced inside the magnet, on its axis, with a discrete set of momenta $P_n$ given by

$$P_n = \frac{P_0}{2n+1}, \quad (n = 0, 1, 2, ....) \qquad \text{where} \qquad P_0 = \frac{eBL}{\pi c}. \tag{50}$$

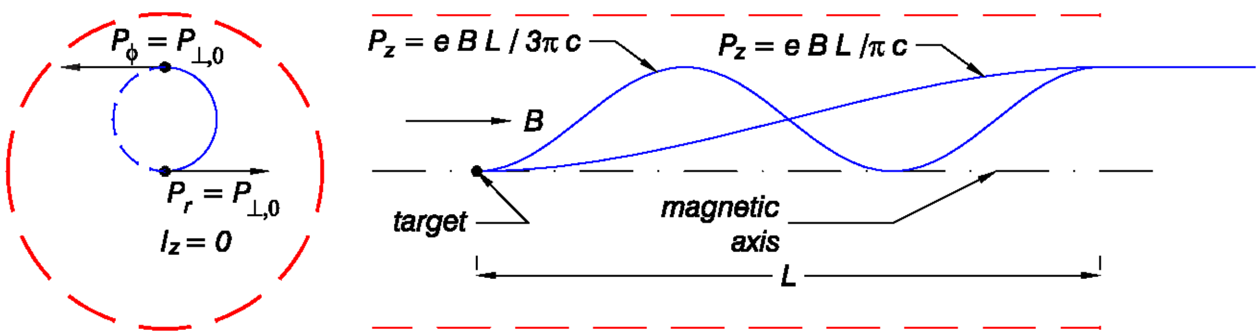
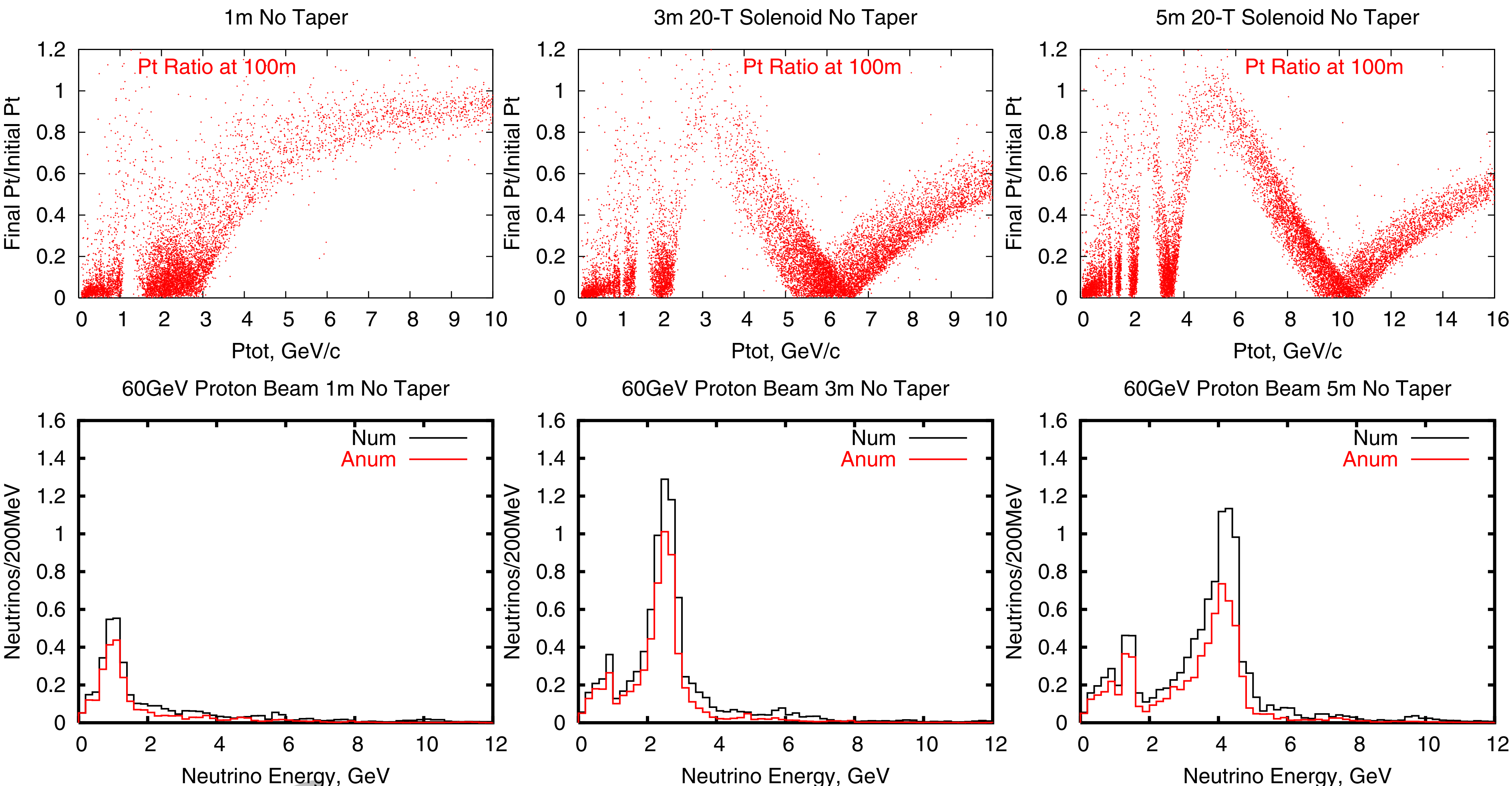



Figure 2: Concept of a neutrino horn based on solenoid focusing. The pion production target is inside the uniform field region of the solenoid. The focusing effects of the fringe field at the exit of the magnet (at distance $L$ from the target) act as ideal thin lens of focal length $L$ for a discrete set of particle momenta, given in eq. (50).

Muon Collaboration

# Varying the Length of the Solenoid

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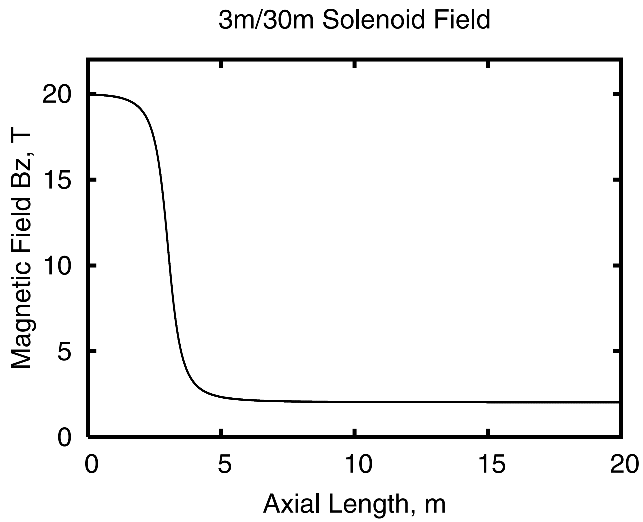
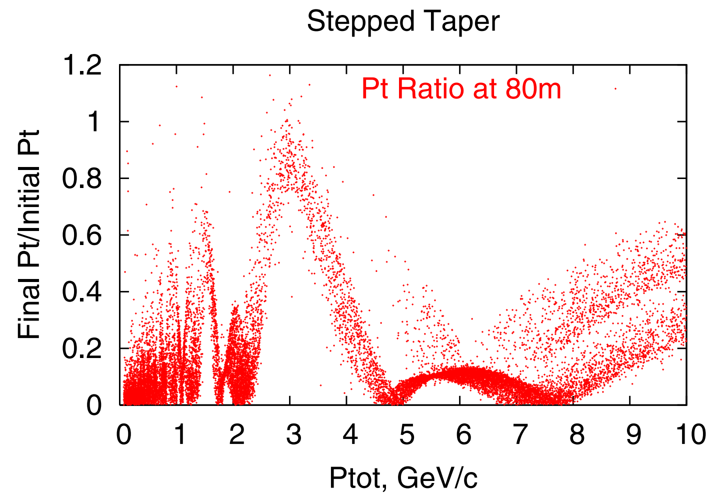
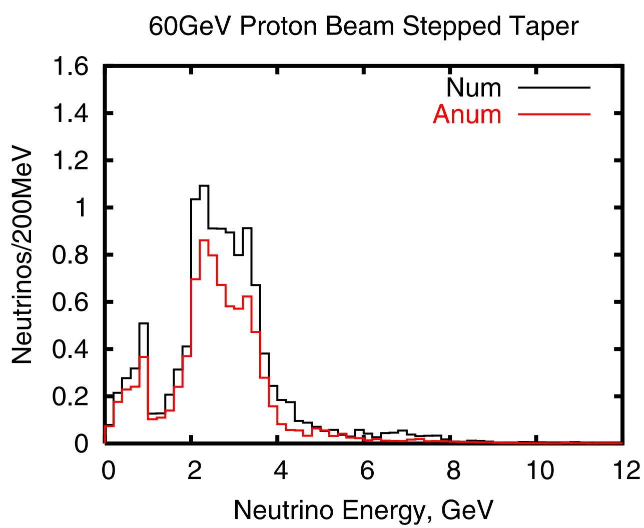
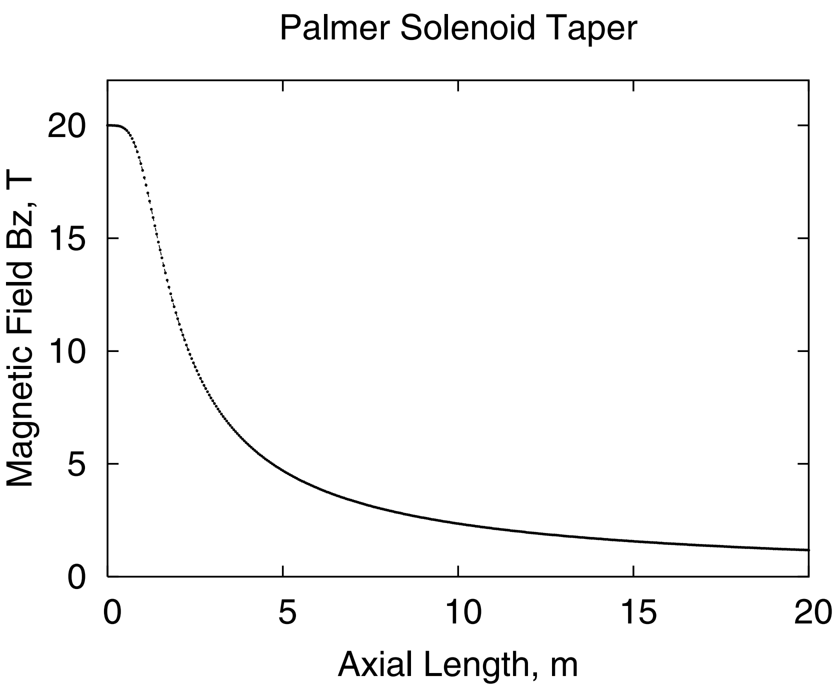
# Broaden the Focal Momenta

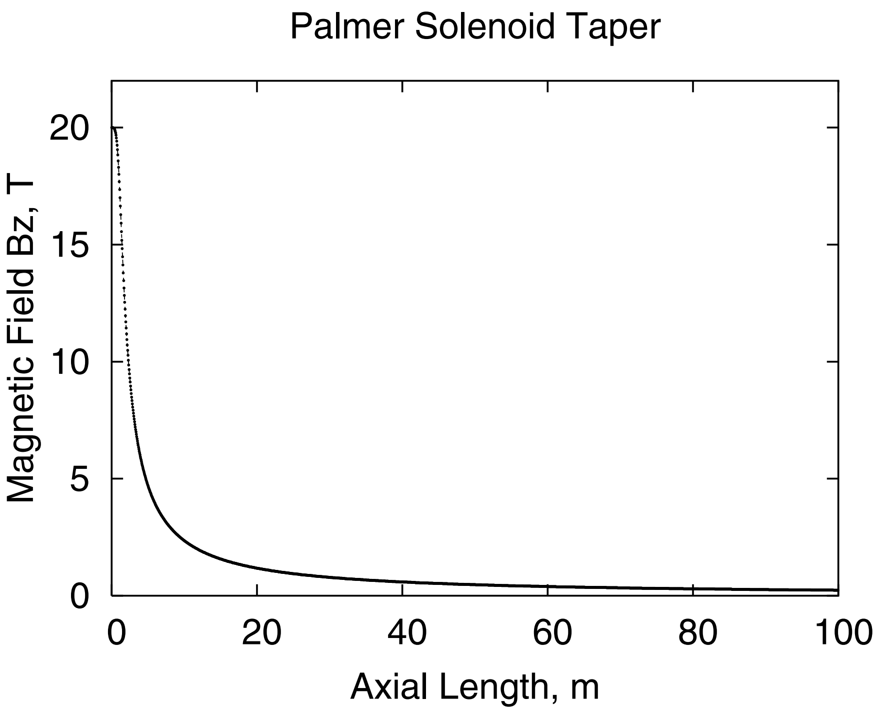


# Taper for Wide Band Collection



# Transverse Momentum Considerations

For $\pi \rightarrow \mu\nu$ $\langle P_T \rangle$ is 23.4 MeV

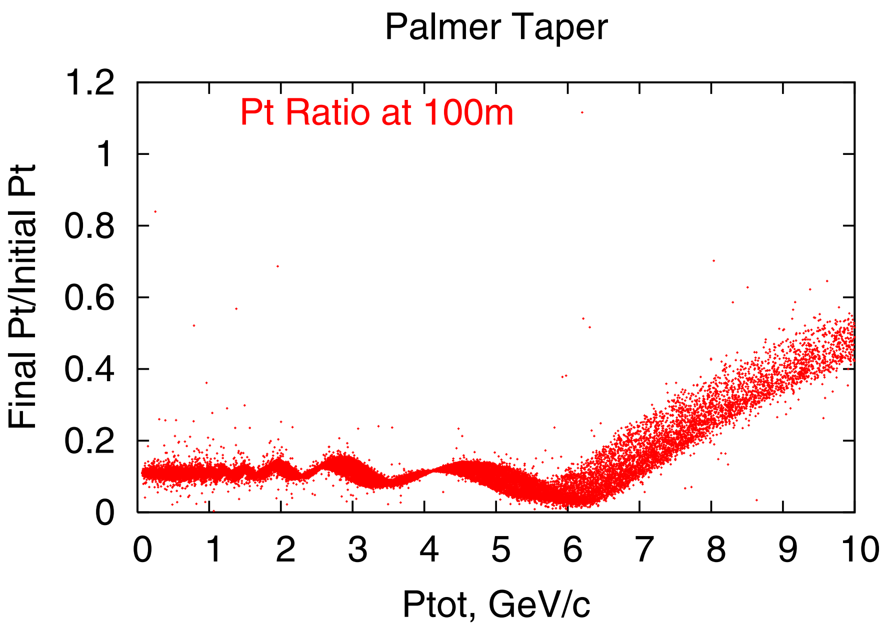
For $B_Z = 20T$ and $R_{Max} = 7.5cm$ $P_{T\,Max} = 225$ MeV and $\langle P_T \rangle$ is ~ 200 MeV

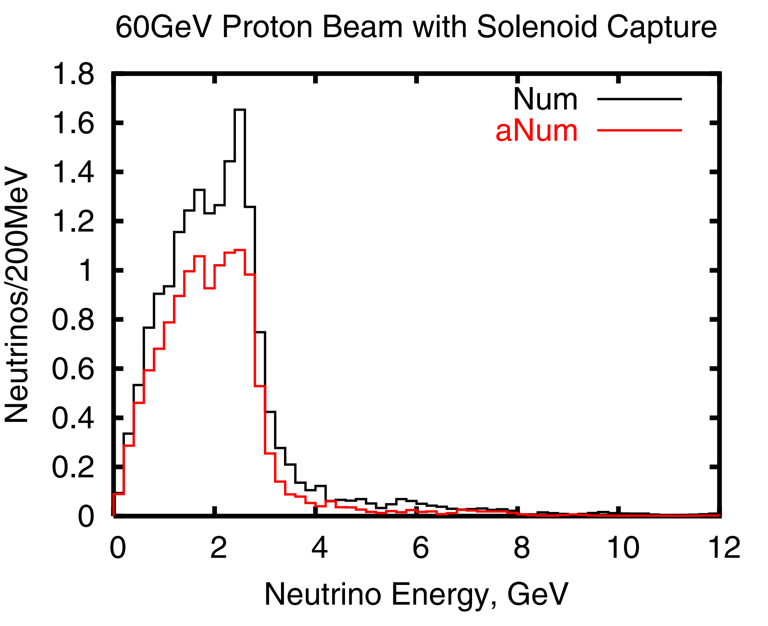
For $B_Z = 1.25T$ and $R_{Max} = 30cm$ $\langle P_T \rangle$ is ~ 50 MeV

Need to reduce field and increase Bore diameter further,

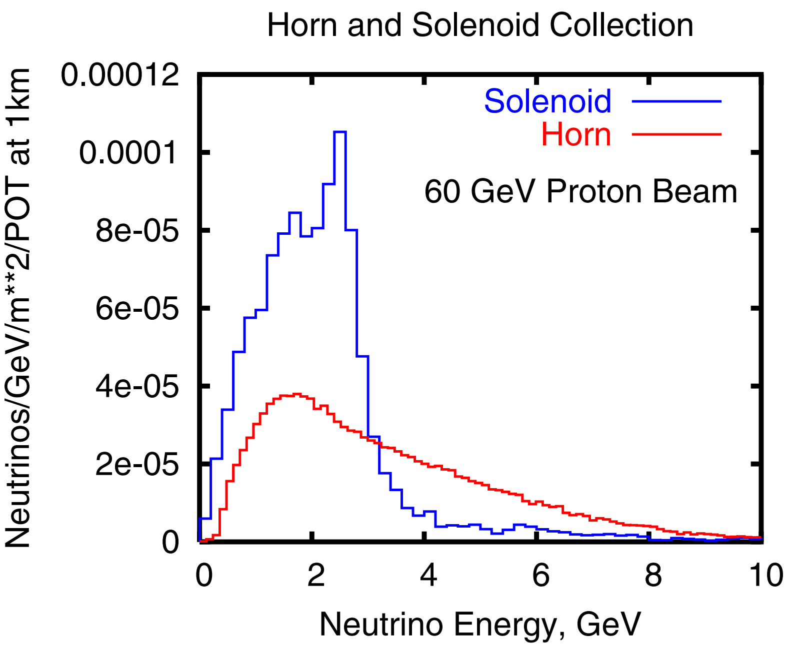
For $B_Z = 0.078T$ and $R_{Max} = 120cm$ $\langle P_T \rangle$ is ~ 12.5 MeV

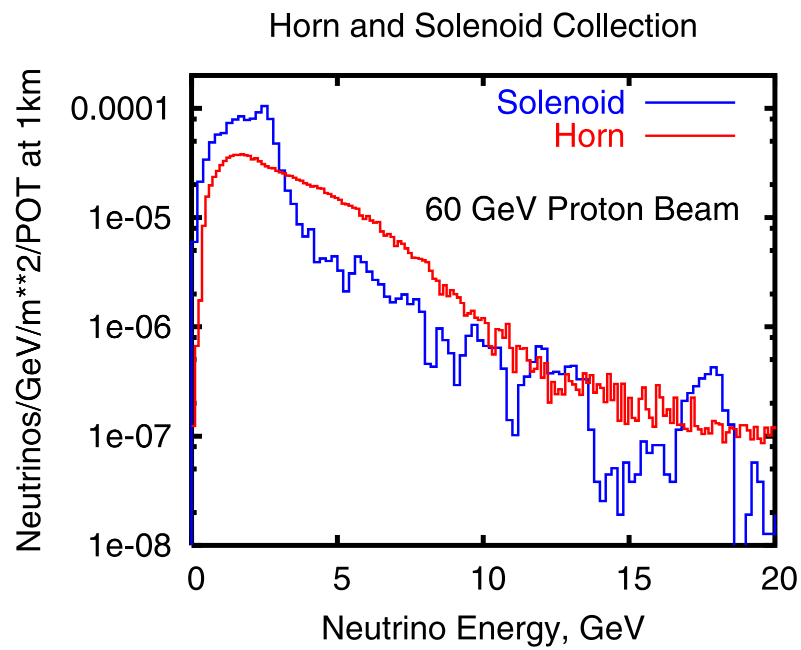
# Broadband Low Energy Capture



# Compare Horn/Solenoid Neutrino Fluxes




## Neutrino "Pointlike" Fluxes scaled to 1km