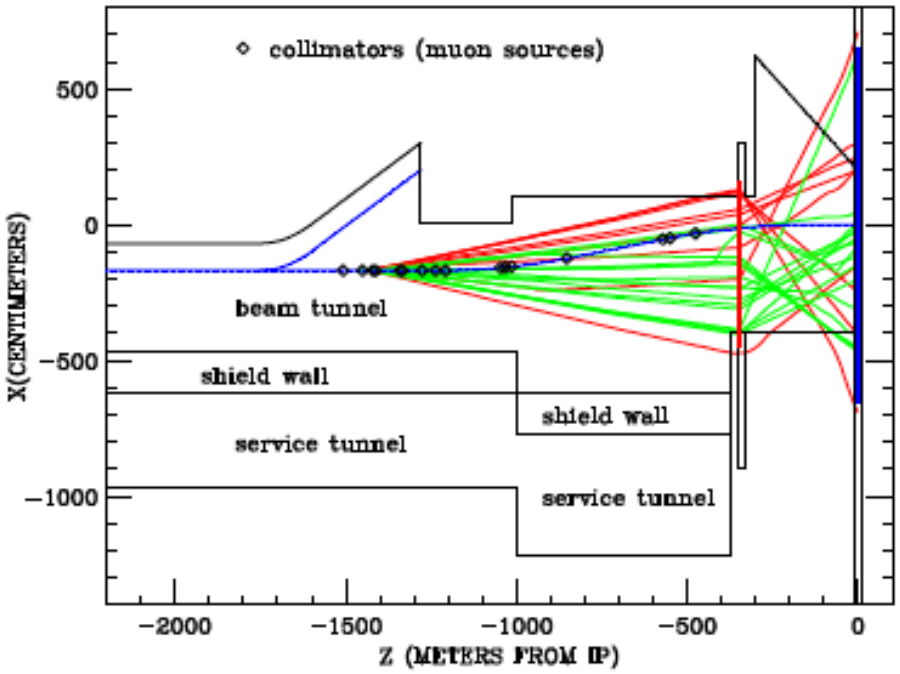
Update Muon Background in Feb. 2016 ILC Tunnel Layout 2/21/16

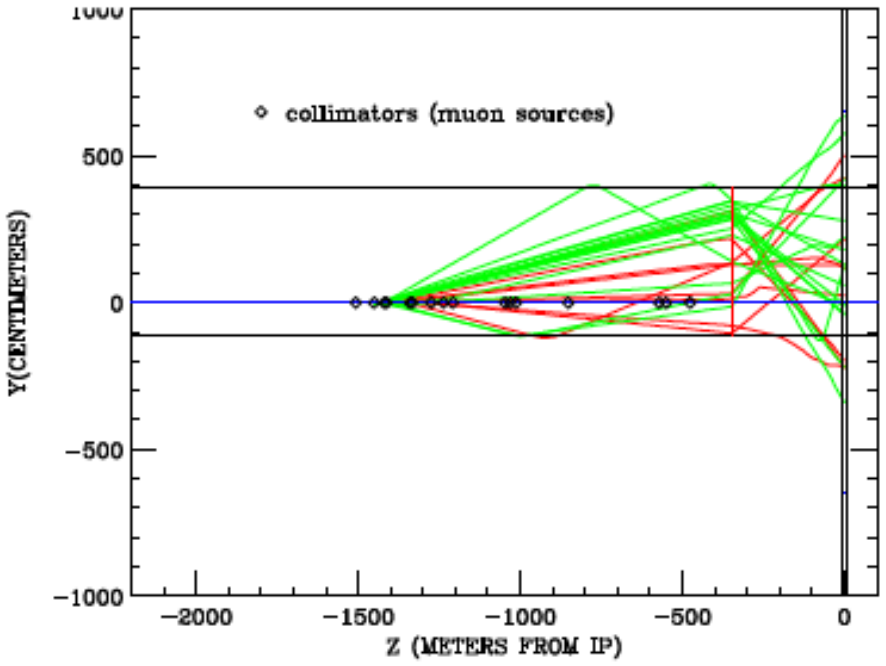
Conditions and Method:

1. **Spoilers SP2 and SP4 are set to 930u (6.4 sig_x) and 400u (44 sig_y). Energy spoiler SPEX is set to 1% del_P/P. Intercepted halo is 0.1% of bunch intensity.**
2. **Run A. Drozhdin program, DISTR.f, to generate trajectories with 5-13 sig_x, 36-93 sig_y and del_P/P = 0.19%.**
3. **Input these trajectories into TURTLE to record the fraction of hits on the spoilers, absorbers (AB's), and protection collimators (PC's). (PC1 intercepts ≈1.5 kW).**
4. **Use MUCARLO to produce and track muons from 0.6 rl SP's and 20 rl AB's and PC's.**
5. **Need four separate MUCARLO decks because the production rates differ for positron and electron beams and for 0.6 rl and 20 rl targets.**
6. **Use the same tunnel model for both positron and electron beams.**
7. **Record the positive and negative muon hits/bunch in a 6.5m radius detector and hits/ 200 bunches in a 2.5m radius TPC for 3 tunnel conditions:**
   - **(a) No magnetic spoilers**
   - **(b) 5m long magnetized spoilers (z = 344-349m) with a 1m gap at the top of the tunnel, and a 1m gap at right wall of the tunnel**
   - **(c) 5m long magnetized spoilers (z = 344-349m) which completely fill the tunnel and extend beyond the left and right walls by 0.5m.**
8. **Record the 4-vectors of muons which reach the detector for input into experiment background study.**

Muon trajectories in the horizontal and vertical planes which hit a 6.5m radius detector for the condition of 5m long magnetized spoilers which fill the tunnel.

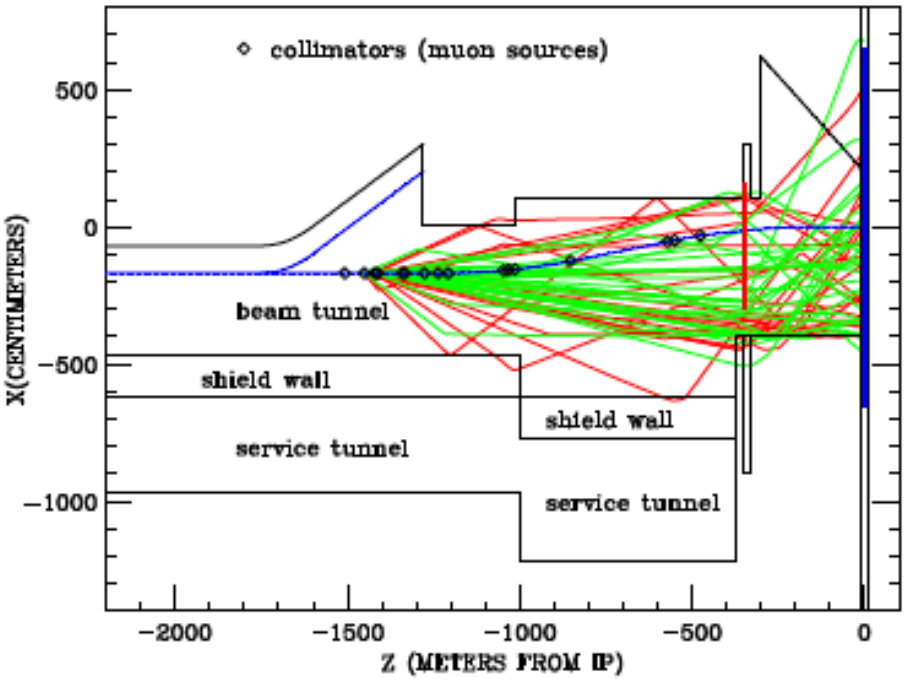
Green = positive, **red = negative**.

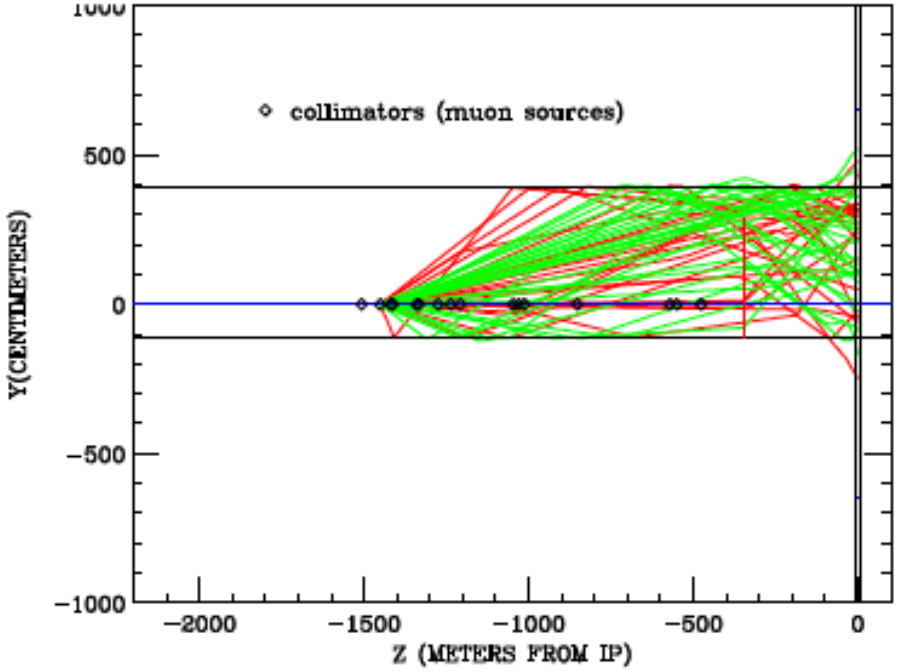




Muon trajectories the horizontal and vertical planes which hit a 6.5m radius detector for the condition of 5m long magnetized spoilers with a 1m gap at the right wall of the tunnel and a 1m gap at the top of the tunnel.

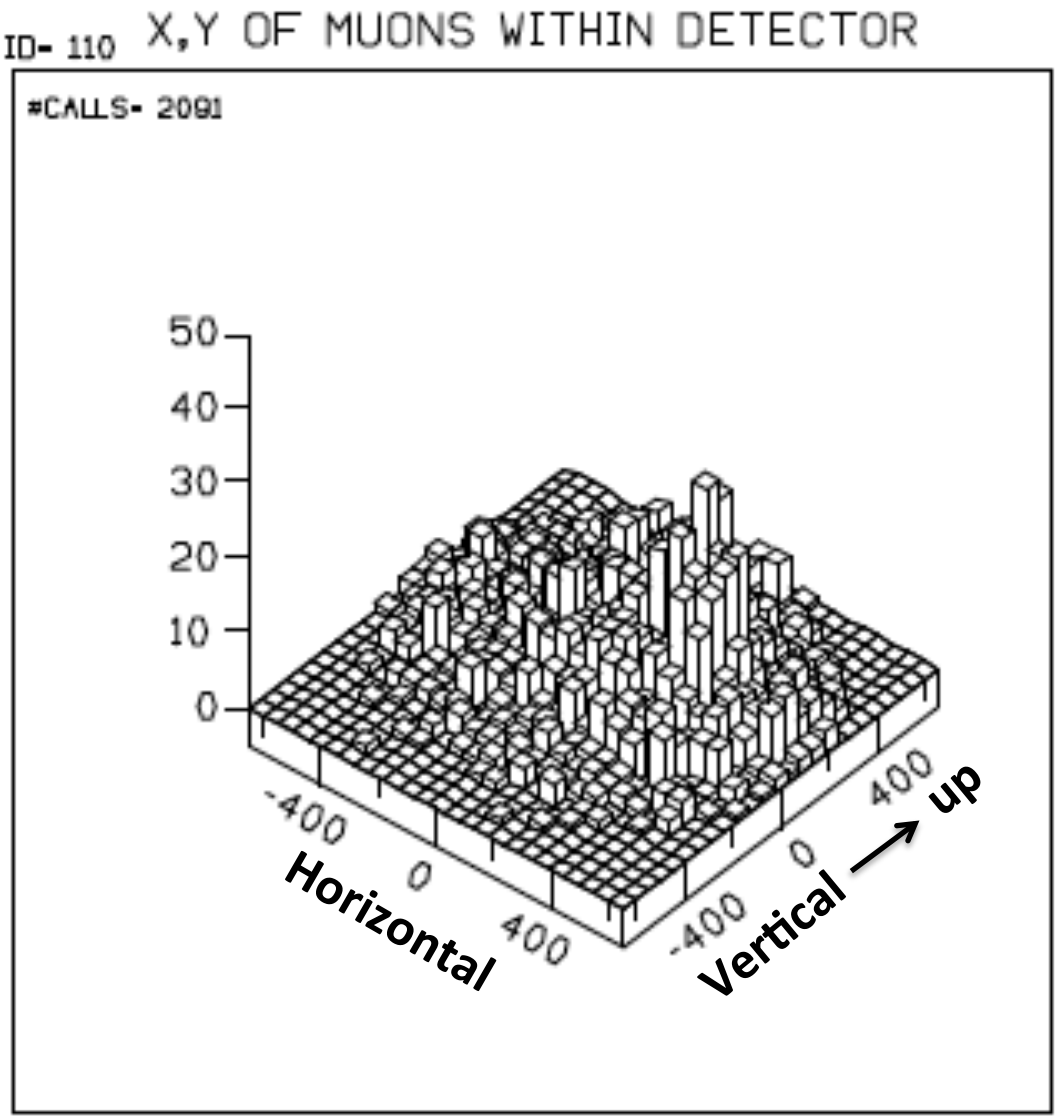
Green = positive, **red = negative**.



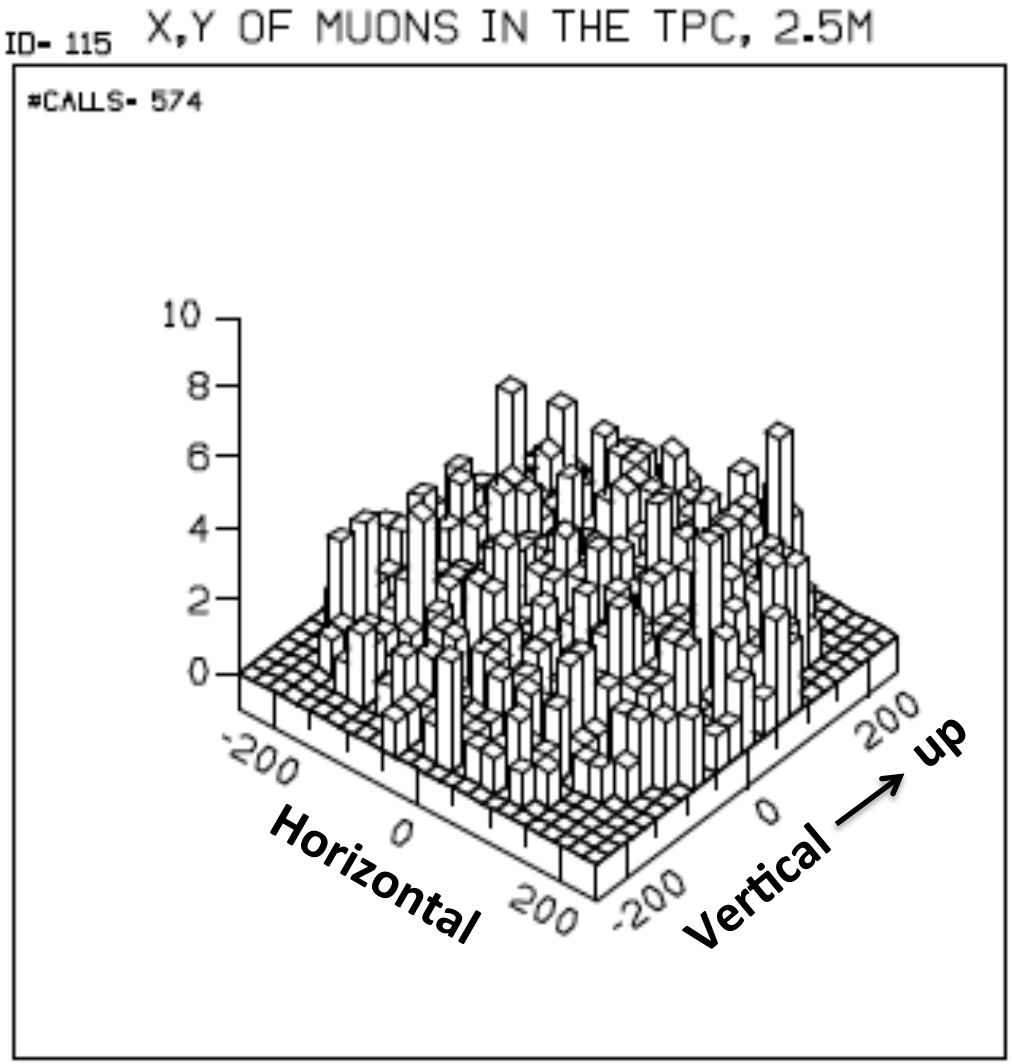


There are approximately twice as many muons which reach the detector compared to the condition where the magnetized spoilers completely fill the tunnel.

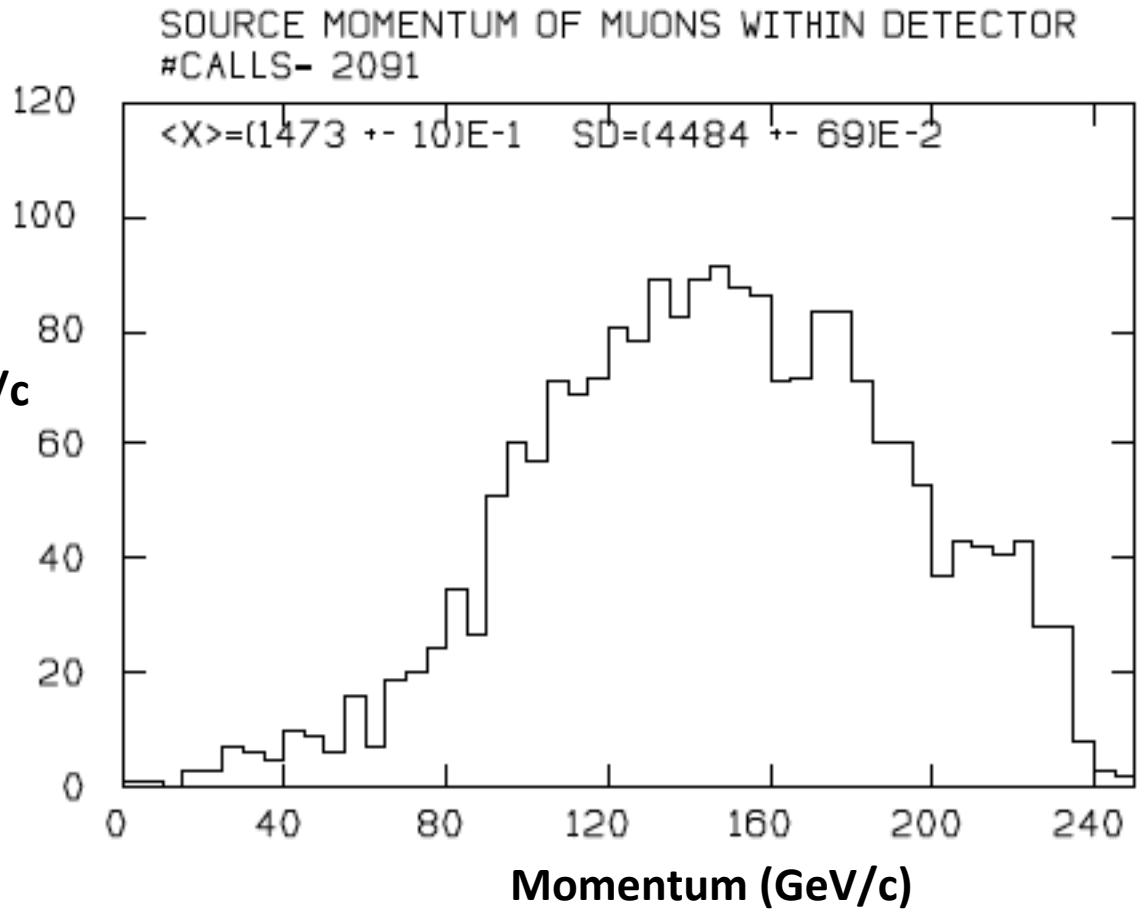
3-D histogram showing the spatial distribution of muons which hit the detector. There is a concentration on the aisle side and at the top.



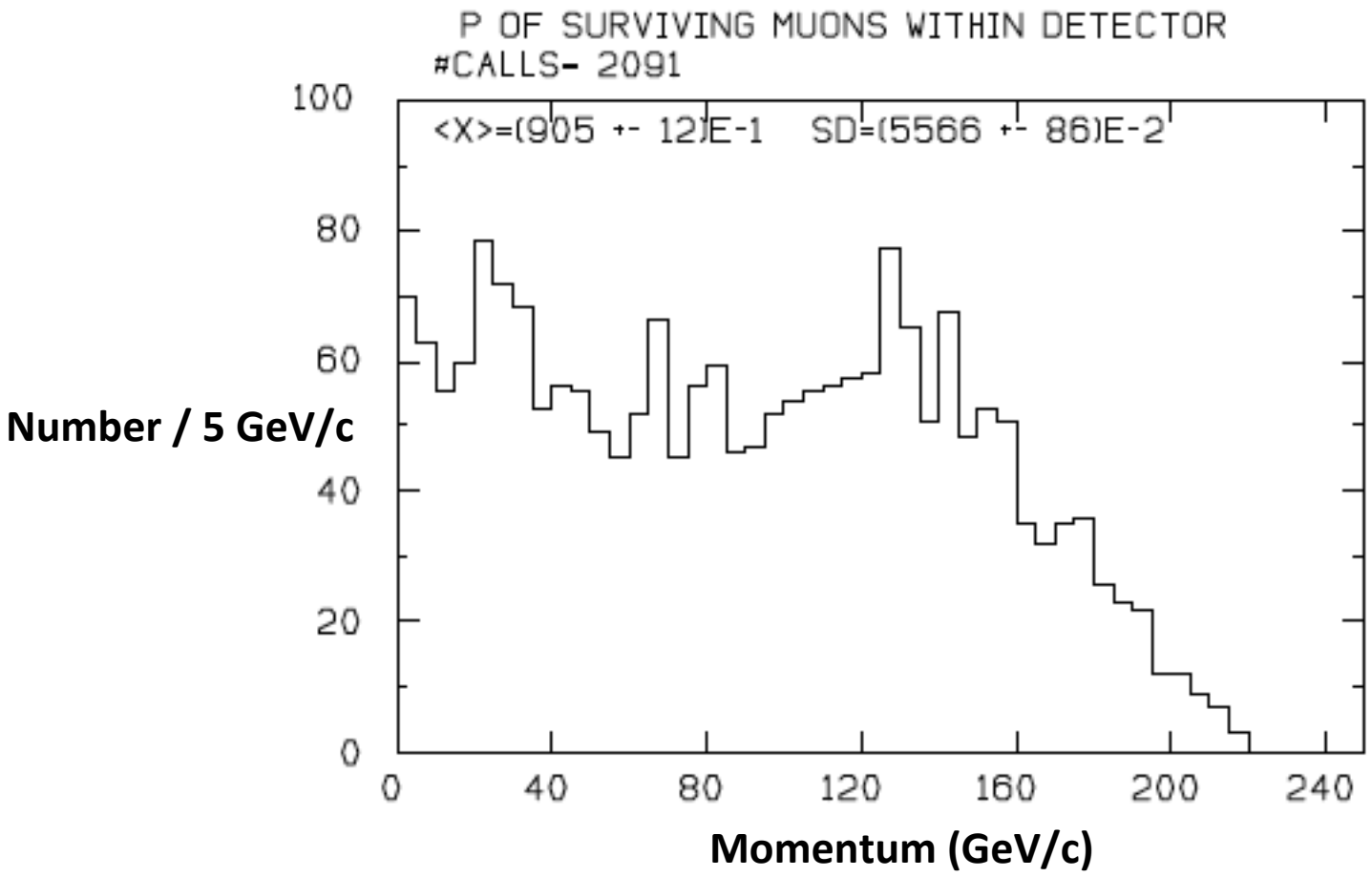
3-D histogram showing the spatial distribution of muons within a 2.5m radius. There is a slight concentration on the aisle side and at the top.



Source momentum of muons from PC1 which hit the detector.



Final momentum of muons from PC1 which hit the detector.



Results

Tunnel Condition	#/bunch in 6.5m radius detector	#/200 bunches in 2.5m radius TPC
1. No spoilers	138	9648
2. 5m magnetized spoilers (z = 344-349m) 1m gap at top of tunnel, 1m gap at right wall of tunnel	61	2321
3. 5m magnetized spoilers (z = 344-349m) fill tunnel	25	1008

Summary

1. **With the TDR design which includes 5m long tunnel-filling magnetized spoilers, there are a total of about 25 muons/bunch hitting the detector and about 1000 muons hitting a 2.5m radius TPC in 200 bunches from all sources, both beams. This is about 50% more than in the ILC tunnel design in 2006.**
2. **There is a concentration of muons on the aisle side and top of the detector and a slight concentration on the aisle side and top in a 2.5m radius.**
3. **The rate without tunnel spoilers is about 5x worse in the entire detector and 10x worse in the TPC.**
4. **Trying different polarity combinations in the two side-by-side spoilers has little effect on the total number of detector hits, it only changes the charge ratio of muons which reach the detector.**
5. **Adding magnetized, solenoid spoilers (doughnuts) downbeam from the main sources, SP2, PC1, and AB3 would help.**