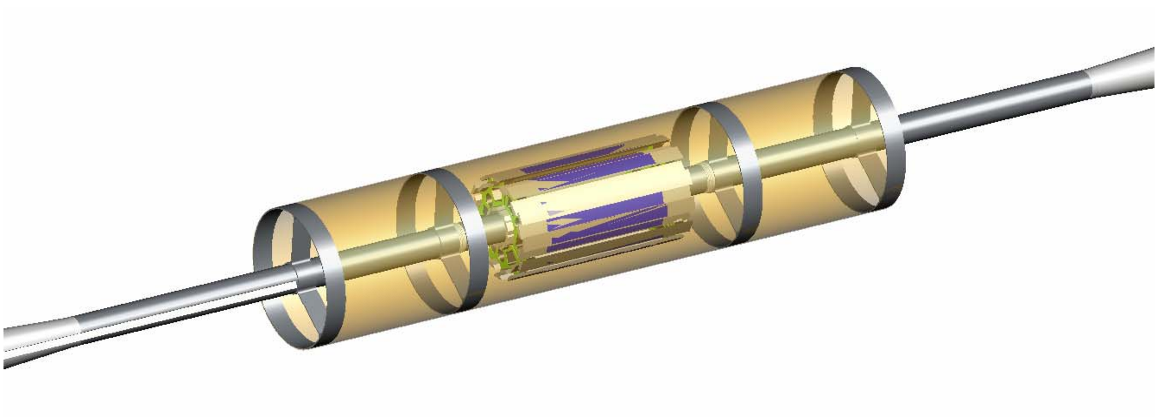
Comparison of two beampipe designs for the HFT:

The HFT detector requires a thin beampipe in order to minimize the contributions from MCS to the pointing resolution of the system. Several designs are possible in order to achieve this goal. Two beampipe designs I have studied include a simple single wall beampipe of approximately 1 mm thickness and/or a very thin ½ mm beampipe with an additional exoskeleton of ½ mm thickness to enhance the stiffness of the pipe and to move mass away from the critical zone between the first layer of the HFT and the interaction point. The double walled design is shown below. It is elegant but how much does it improve the resolution compared to the simple, single wall design?



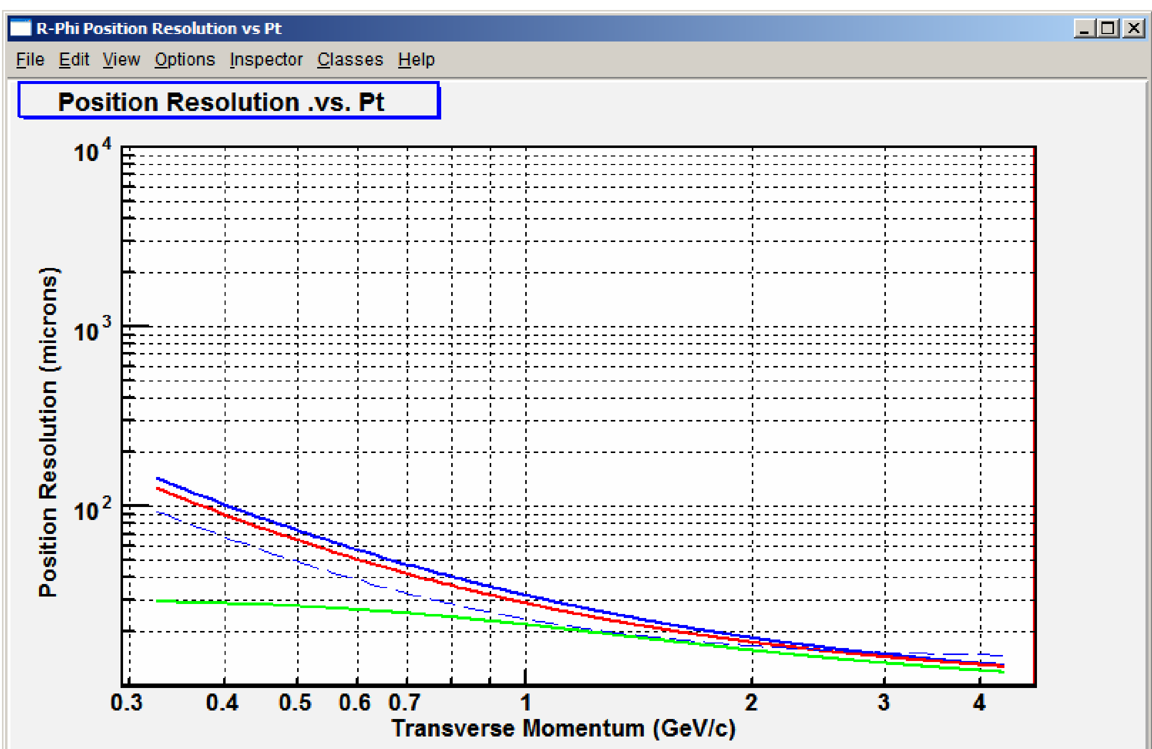


Figure One: The single track pointing resolution for the HFT + IST in STAR using a simple, 4 centimeter diameter, one millimeter thick Be beam pipe (Blue) compared to a more elaborate design with two ½ millimeter thick walls at 4 cm and 16 cm diameter.

The calculations shown in figures one and two were done for Kaons using the Matrix5Resolution.C macro for ROOT. The macro simulates the STAR TPC acting in concert with the HFT and the IST (nominal configurations). Figure one shows the single track pointing resolution for the simple beam pipe design (in blue) and the more elegant double walled beampipe design (in red). The double walled beampipe is better. The green line shows the effect of a 30 micron vertex constraint that could presumably be applied to the data if we were able to refit the vertex after the primary track fitting and vertex finding was achieved. The dashed blue line in figure one represents the pointing resolution of the HFT, alone, if the hits could be associated with the tracks by magic and no beam pipe, no other detectors, and no other sources of MCS are used in the calculation.

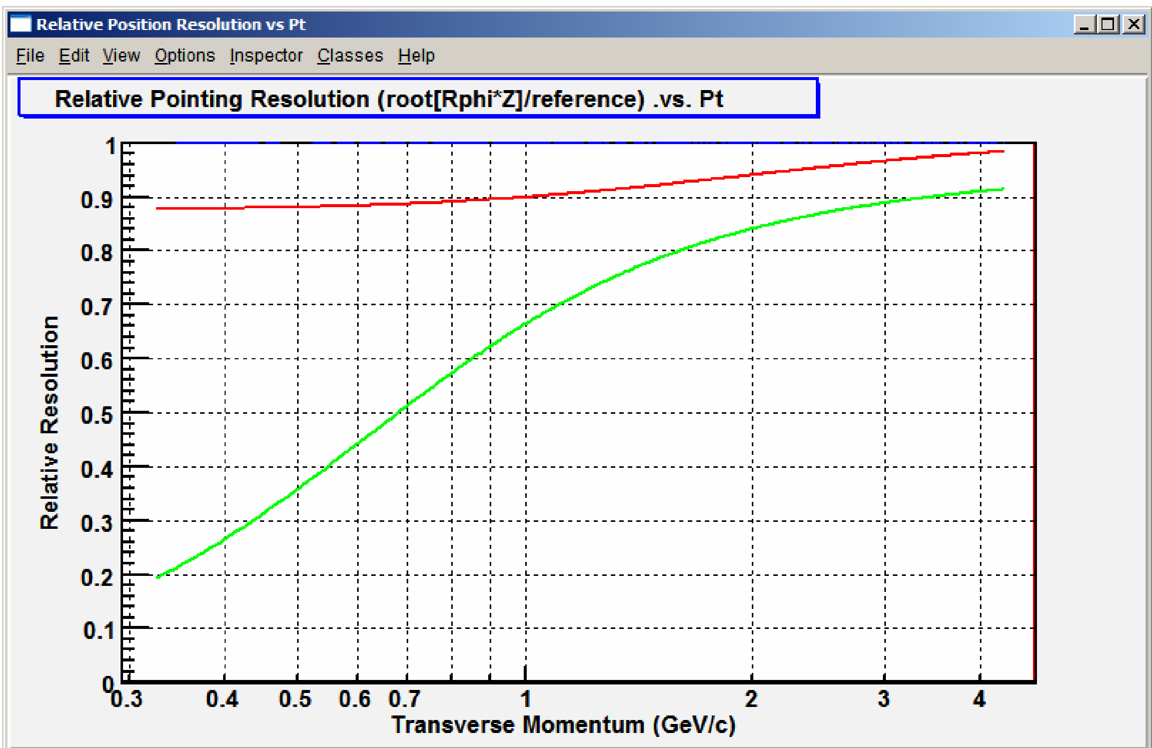


Figure Two: Relative comparison of the single track pointing resolution in Fig 1. The blue line in Fig.1 is the reference so that the red line in this figure is the relative improvement that is achieved by the double walled beam pipe compared to the single wall beam pipe. The green line shows the effect of a 30 micron vertex constraint.

How much better is the double walled beam-pipe? A good figure of merit is to look at the point at 750 MeV which is approximately the mean p_T for the kaon from a D_0 decay. The pointing resolution for the 1 mm thick beampipe is about 42 microns and the pointing resolution for the double walled design is 38 microns. Figure 2 shows the relative comparison between the two designs. The double walled design is about 10% better than the single walled design.

It is interesting to compare the improvement due to the double walled design to the improvement that can be achieved by refitting the vertex with the HFT data once the tracks have been found. The calculation assumes that a 30 micron vertex constraint is possible. Figures 1 and 2 show a large improvement in the effective pointing resolution if we are allowed to use a 30 micron vertex constraint; approximately a factor of 2 improvement.

Is the double walled beam pipe design worth the extra effort? The difference between 38 and 42 microns is not large. The improvement that can be achieved in software using a vertex constraint is much larger. A good vertex constraint would allow a single track pointing resolution down to about 23 microns.

The engineering difficulties associated with designing and building the double walled beam pipe are not large; but it is more complex and more expensive. Therefore, it would appear that a significant investment in software may be a better use of the time and energy required to build the more complex beam-pipe. What do you think?