Zee Trouble with Zee HPD:

It is interesting to compare the performance of the IST1+IST2 tracker to the performance of the HPD+SSD tracker as a pointing device for the HFT.

I will do this under fairly conservative conditions (meaning difficult conditions) … which means RHIC II running conditions and Au-Au minbias collisions. The full parameter set is listed at the end of this note.

Figure one is a graph of the R-Phi resolution for the two cases. The upper blue line shows the pointing resolution of the IST1+IST2 tracker for a kaon entering the outer layer of the HFT (HFT2). The IST detectors are located at 12 cm and 17 cm, respectively. The lower blue line shows the pointing resolution of the HFT2+IST1+IST2 system onto the inner layer of the HFT (HFT1). The pointing resolution onto HFT1 is mostly determined by the intrinsic resolution of HFT2, and the MCS in HFT2, but is not very sensitive to the performance of the IST layers.

The green lines show the performance of the HPD+SSD tracking system. It is better … and you can see the complex interplay between resolution and MCS as a function of pt.

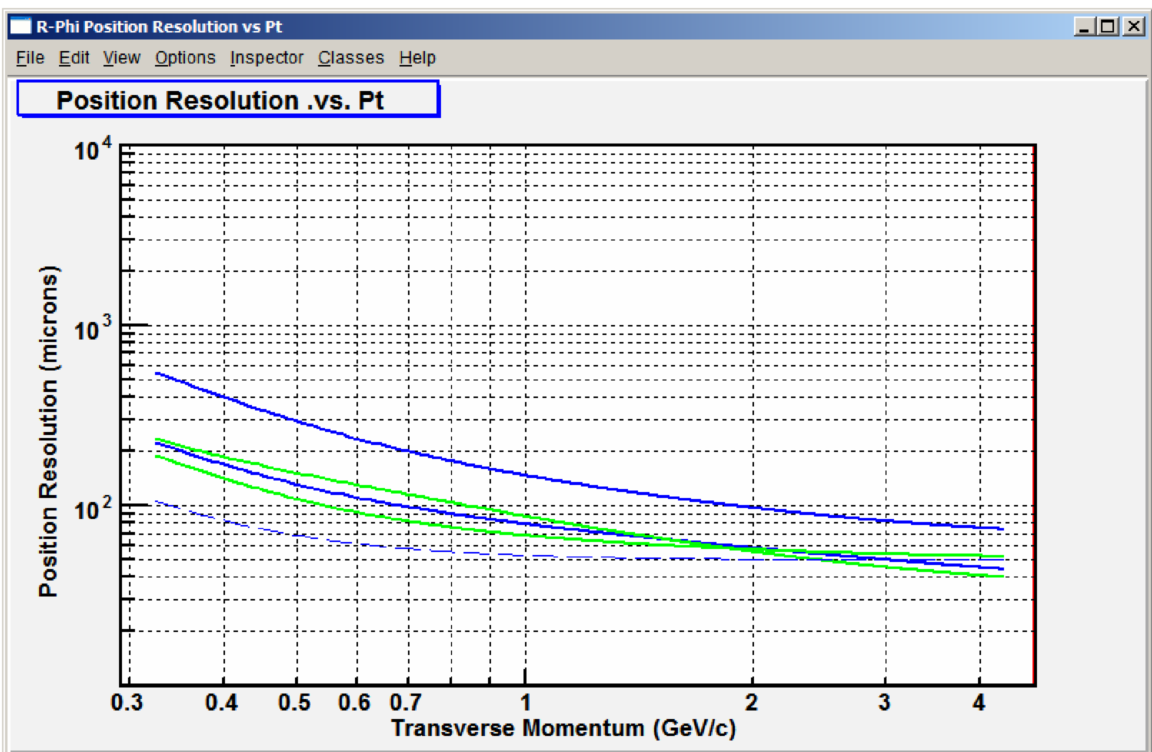

Figure 1: The blue lines show the R-Phi pointing resolution for the IST1+IST2 tracker onto the outer surface of the HFT (upper line) and the inner surface of the HFT (lower line). The green lines show the pointing resolution of the HPD+SSD tracker. The dashed line at the bottom is a theoretical estimate of the HFT vertex resolution if the HFT could act alone … no other detectors, and no other sources of MCS.

The R-Phi resolution of the HPD+SSD system is better than the IST1+IST2 system because the HPD has very fine strips (50 microns) and it is closer to the outer surface of the HFT and thus also has a shorter lever arm to amplify the effects of MCS. The HPD does not suffer from a serious occupancy problem because the strips are relatively short (425 microns) and the total area presented to the flight of a particle is small.

However, the relative performance of the detectors is reversed when we consider the pointing resolution in the Z direction.

Figure two is a graph of the Z pointing resolution for the two cases. The upper blue line shows the pointing resolution of the IST1+IST2 tracker onto the outer surface of the HFT (HFT2). The lower blue line shows the pointing resolution of the HFT2+IST1+IST2 system onto the inner layer of the HFT (HFT1). The green lines represent the same two cases for the HPD+SSD tracker. Zee problem is that zee strips in the HPD are aligned with zee strips in the SSD … and so the Z resolution on the outer surface of the HFT is merely the length of the HPD strips and is constant as a function of pt.

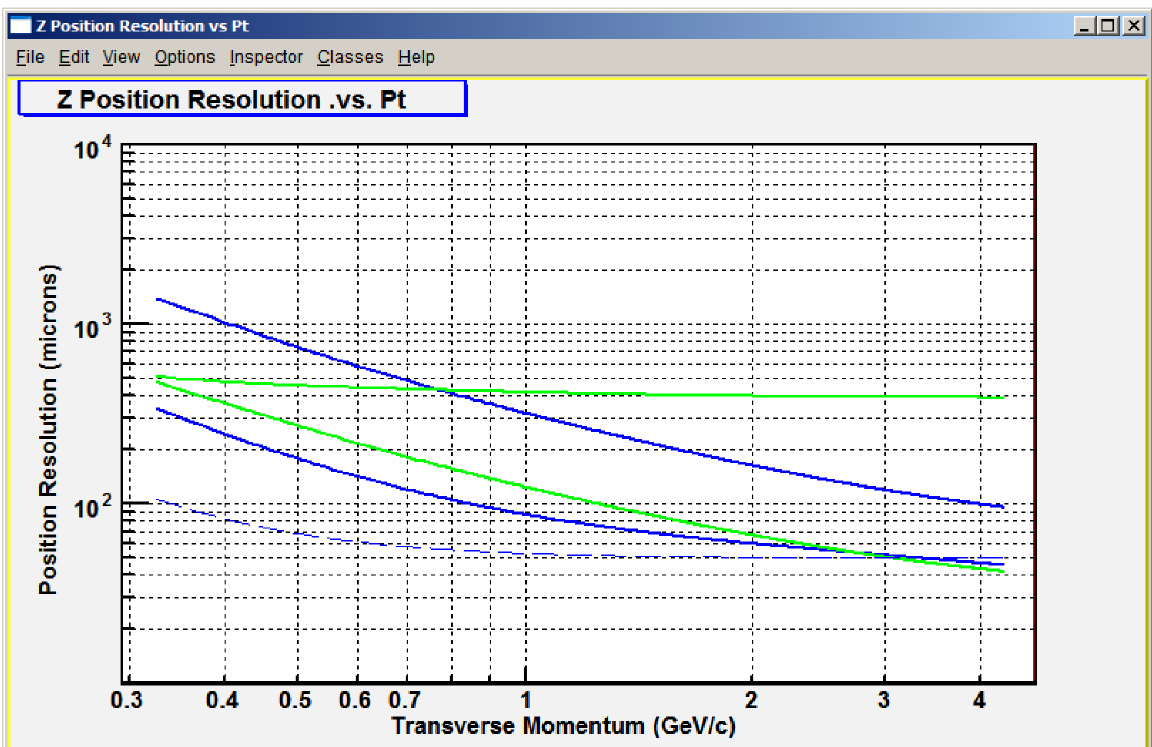

Figure 2: The blue lines show the Z pointing resolution for the IST1+IST2 tracker onto the outer surface of the HFT (upper line) and the inner surface of the HFT (lower line). The green lines show the pointing resolution of the HPD+SSD tracker.

The essential difference between the two cases shown in figure 2 is that the HPD+SSD system doesn't have any Z resolution (relatively speaking). The TPC has 500-600 micron resolution. The SSD has worse Z resolution than the TPC, and the HPD is limited by the length of its strips. So the Z resolution is barely improved over what the TPC can do, alone. On the other hand, the IST1+IST2 tracker achieves relatively good Z resolution because IST layer 2 is assumed to be rotated by 90 degrees.

Is the poor Z resolution of the HPD+SSD important? Yes, it turns out to be noticeable. The reason it become important is because the intermediate tracker is used to define an 'area' on the outer surface of the HFT and this area searched for good hits. The area is elliptical in shape, where $A = 2\pi R_{R\text{-}Phi} R_Z$, and if this area is large enough relative to the occupancy and pileup in the HFT, then we can begin to collect false hits. This effect is shown in Figure 3.

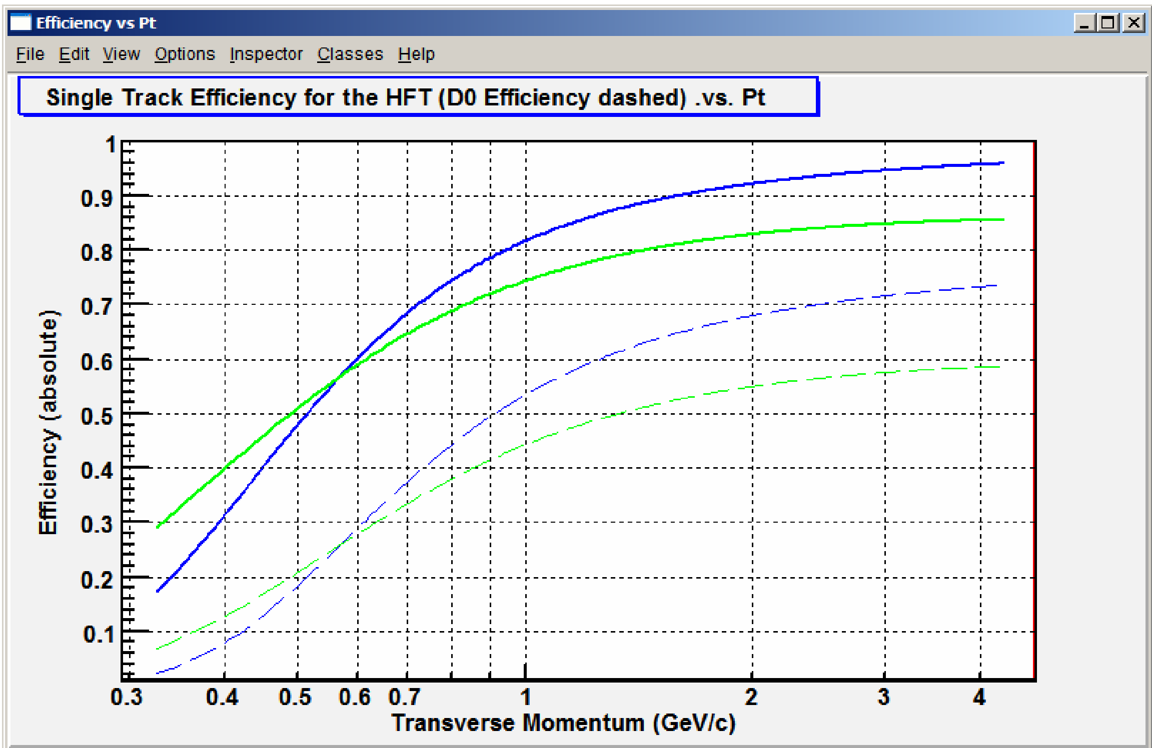

Figure 3: The solid blue line shows the efficiency for finding a kaon in both layers of the HFT with the IST1+IST2 tracker. The green line shows the efficiency for finding the kaon with the HPD+SSD tracker. The dashed lines represent the square of the solid lines (times 0.8 to displace the curves) and is a very crude estimate of the D0 track finding efficiency in each case.

I don't know what effect an elliptical search zone has upon the ITTF tracker when the major and minor axes differ by a factor of 5 … but on paper, at least, it is the same as a circle of the same area.

The bottom line is that the HPD is a beautiful detector, however, its performance is limited by the fact that its strips are aligned with the strips in the SSD and it could, in principle, do better if we could rotate the direction of the strips of the SSD.

The wonderful thing about hand calculations is that I can do it … and that is what is shown in Figure 4.

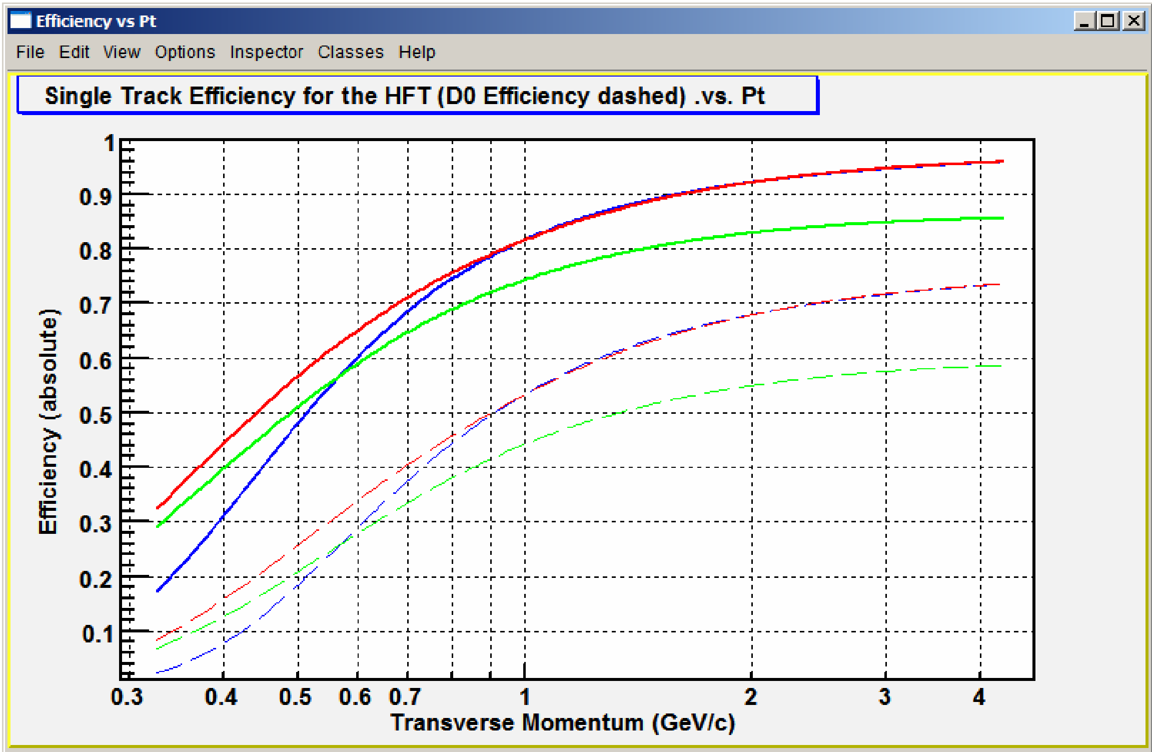

Figure 4: The solid blue line shows the efficiency for finding a kaon in both layers of the HFT with the IST1+IST2 tracker. The green line shows the efficiency for finding the kaon with the HPD+SSD tracker. The red line shows the efficiency for finding the kaon with the HPD+SSD tracker under the hypothesis that the SSD layer has been rotated 90 degrees. The region of most interest is from 750 MeV to 1 GeV.

Parameters used in these calculations:

```
#define        Mass                     0.540       // Mass of the test particle in
#define        BFIELD                   0.5         // Tesla  (test data taken at 0.25
#define        AvgRapidity              0.5         // Avg rapidity, MCS calc is a
#define        Luminosity               1.e28       // Luminosity of the beam (RHIC I ==
#define        Sigma                    15.0        // Size of the interaction diamond
#define        dNdEta                   170         // Multiplicity per unit Eta  (AuAu
#define        CrossSection             10          // Cross section for event under
#define        IntegrationTime          0.2         // Integration time for HFT chips (
#define        BackgroundMultiplier     4.0         // Increase multiplicity in detector
#define        SiScaleFactor            1.0         // For scaling Si pad sizes.  (eg
#define        EfficiencySearchFlag     0           // Define search method. ChiSquare =

// Most likely Detector parameters you may want to tune are in the block starting here:

#define        VtxResolution            0.3000      // cm   Test data wants 3 mm vertex
#define        VtxResolutionZ           0.3000      // cm   Test data wants 3 mm vertex

#define        NewVtxResolution         0.0300      // cm   NewVertex to study effect of a
#define        NewVtxResolutionZ        0.0300      // cm   NewVertex to study effect of a

#define        RefitVtxResolution       0.0030      // cm   Refit Vertex to study effect
#define        RefitVtxResolutionZ      0.0030      // cm   Refit Vertex to study effect

#define        BeamPipe1Resolution      RIDICULOUS  // Beampipe is not active as a

#define        Hft1Resolution           0.0030      // cm   30 x 30   micron pixels
#define        Hft1ResolutionZ          0.0030      // cm   30 x 30   micron pixels
```

```
#define        Hft2Resolution          0.0030     // cm  30 x 30   micron pixels
#define        Hft2ResolutionZ         0.0030     // cm  30 x 30   micron pixels

#define        BeamPipe2Resolution     RIDICULOUS  // Beampipe is not active as a

#define        HpdResolution           0.0050     // cm  50 x 425  micron pixels ...
#define        HpdResolutionZ          0.0425     // cm  50 x 425  micron pixels ...

#define        Ist1Resolution          0.0060     // cm  60 x 1920 micron pixels ... Z
#define        Ist1ResolutionZ         0.1920     // cm  60 x 1920 micron pixels ...
//#define        Ist1Resolution          0.1920     // cm  60 x 1920 micron pixels ...
//#define        Ist1ResolutionZ         0.0060     // cm  60 x 1920 micron pixels ...

//#define        Ist2Resolution          0.0060     // cm  60 x 1920 micron pixels ...
//#define        Ist2ResolutionZ         0.1920     // cm  60 x 1920 micron pixels ...
#define        Ist2Resolution          0.1920     // cm  60 x 1920 micron pixels ...
#define        Ist2ResolutionZ         0.0060     // cm  60 x 1920 micron pixels ...

#define        SsdResolution           0.0095     // cm  95 x 4200  microns double
#define        SsdResolutionZ          0.2700     // cm  95 x 4200  microns double

#define        IFCResolution           RIDICULOUS  // IFC is not active as a detector

#define        TpcResolution           0.0575     // cm  600 x 1500 microns ...Test
#define        TpcResolutionZ          0.1500     // cm  600 x 1500 microns ...Test

// End of 'most likely' block, but there are more parameters, below.

#define        VtxIndex                0
#define        BeamPipe1Index          1
#define        Hft1Index               2
#define        Hft2Index               3
#define        BeamPipe2Index          4
#define        HpdIndex                5
#define        Ist1Index               6
#define        Ist2Index               7
#define        SsdIndex                8
#define        IFCIndex                9
#define        TpcIndex                10
#define        VtxThickness            0.0000  // % Radiation Lengths
#define        BeamPipe1Thickness      0.0015  // % Radiation Lengths (as in 0.01 == 1%)
#define        Hft1Thickness           0.0028  // % Radiation Lengths (0.0028 new 0.0036
#define        Hft2Thickness           0.0028  // % Radiation Lengths (0.0028 new 0.0036
#define        BeamPipe2Thickness      0.0015  // % Radiation Lengths
#define        HpdThickness            0.0100  // % Radiation Lengths
#define        Ist1Thickness           0.0150  // % Radiation Lengths
#define        Ist2Thickness           0.0150  // % Radiation Lengths
#define        SsdThickness            0.0100  // % Radiation Lengths
#define        IFCThickness            0.0052  // % Radiation Lengths
#define        TpcAvgThickness         0.00026 // % Radiation Lengths ... Average per
#define        VtxRadius               0.0     // cm
#define        BeamPipe1Radius         2.05    // cm (2.05 new 1.50 old)
#define        Hft1Radius              2.50    // cm (2.5  new 1.55 old)
#define        Hft2Radius              7.00    // cm (7.0  new 5.00 old)
#define        BeamPipe2Radius         8.55    // cm (8.55 new 6.05 old)
#define        HpdRadius               9.2     // cm (9.2  HPD,6.0  SVT)
#define        Ist1Radius             12.0     // cm (12.0 IST,10.0 SVT, option 9.5 IST)
#define        Ist2Radius             17.0     // cm (17.0 IST,14.0 SVT)
#define        SsdRadius              23.0     // cm
#define        IFCRadius              47.25    // cm  Middle-Radius of the IFC ... its
#define        TpcInnerRadialPitch1    4.8     // cm
#define        TpcInnerRadialPitch8    5.2     // cm
#define        TpcOuterRadialPitch     2.0     // cm
#define        TpcInnerPadWidth        0.285   // cm
#define        TpcOuterPadWidth        0.620   // cm
#define        InnerRows1              8
#define        InnerRows8              5
#define        InnerRows              (InnerRows1+InnerRows8)
#define        OuterRows              32
#define        TpcRows                (InnerRows1 + InnerRows8 + OuterRows)
#define        RowOneRadius           60.0     // cm
```