Track Projection and Fitting Using Kalman and SVX Hits

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Goal of this Project

- Project Cgl tracks from Central Arm
- Build Kalman tracks and associate SVX hits
- Refine tracks by Kalman Fitting and Smoothing
- Find the residuals of track projections to associated hits
- Calculate DCA in X-Y plane
- Compare single-particle track and decay-particle track from D^0
- Help to optimize design, such as radius

Data Source:

60K pi+ & 60K D^0

$1<Pt<7GeV$ $-0.4<y<0.4$ $0<\varphi<2\pi$ initial collision vertex(0,0,0)

Simulation Process:

1) Generate single particle event (pi+ or D^0) as PISA input

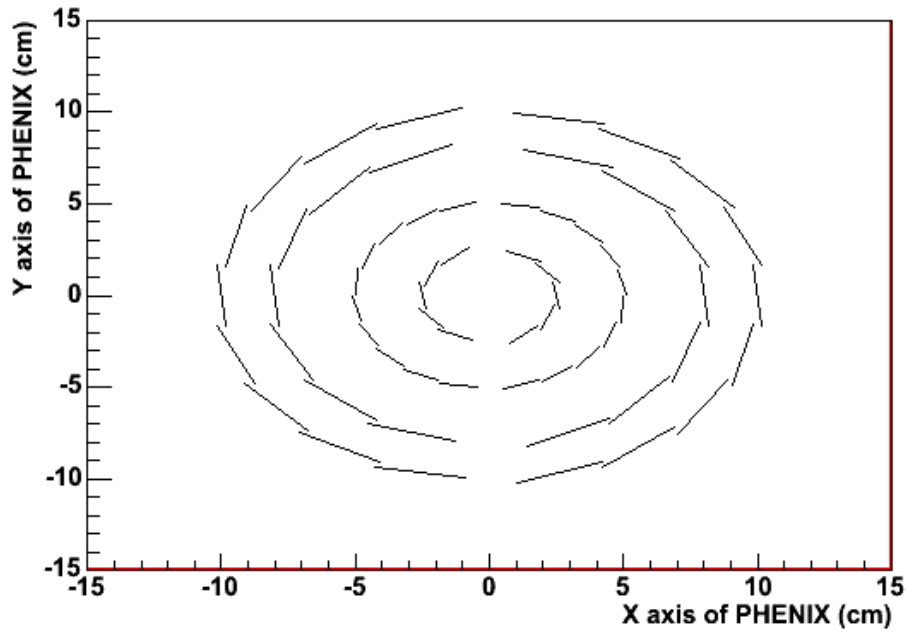
2) Take PISA output (PISAEvent.root) as the input of reconstruction

3) Run in pisaToDST.C each detector reconstruction package (DC, PC and SVX), then run Cgl to use DC&PC1 hits to fit the initial p, phi0 and theta0 of each DC track, and associate detector hits to build a Cgl track.

4) Select those Cgl tracks with quality = 31 or 63, use their p, phi0 and theta0 as the initial input of Kalman Fitting, so as to construct Kalman Tracks, and let it associate SVX hits on each layer, but to use Cgl associating of DC and PC.

5) The Kalman Track will be fitting to each DC, PC and SVX hits by looking at the azimuthal and z residuals, taking into account of the hits' resolution.

The geometry of SVX Detector



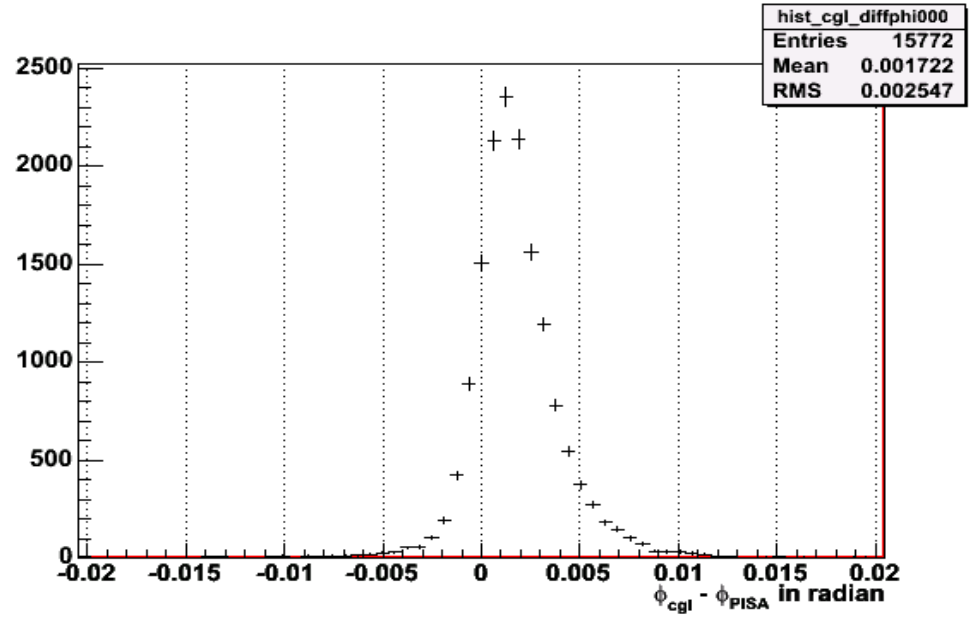
What we changed from default PISA:

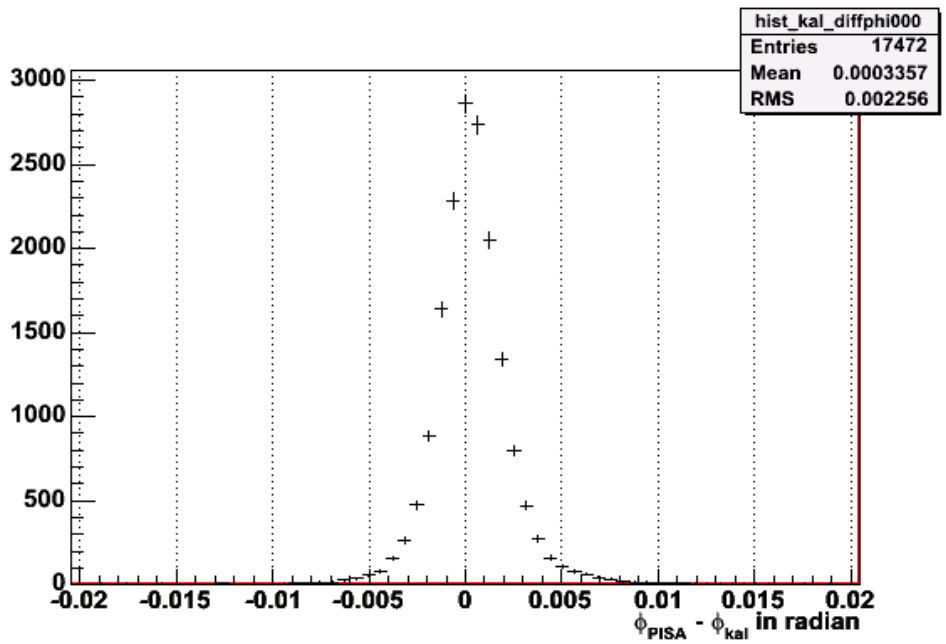
The 2nd layer (r=6.0cm) is now moved to r=5.0cm, and the strip sensors on it are replaced with pixels. This is for the 2-pixel-layer design.

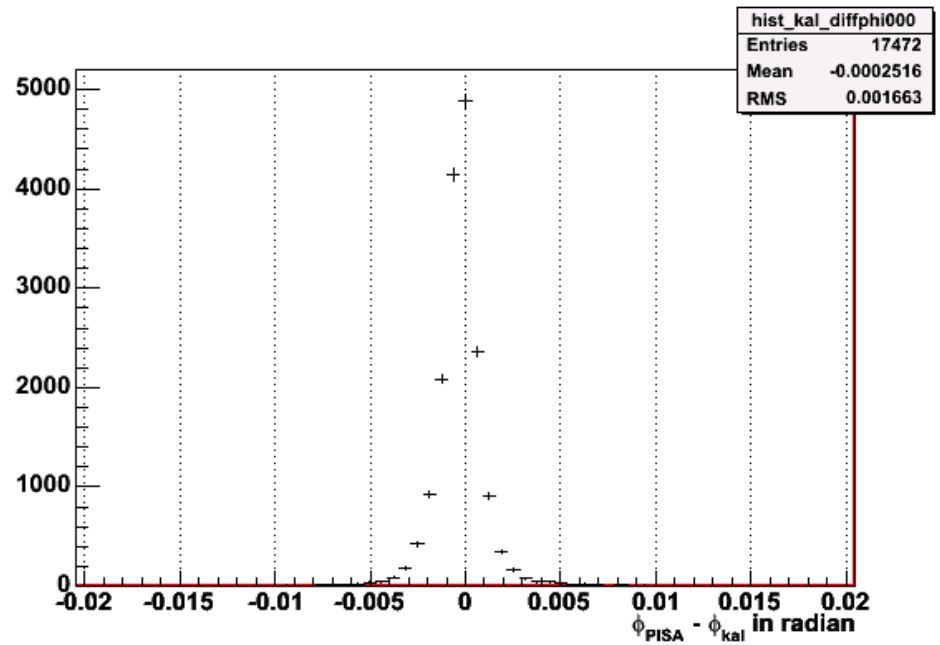
To implement this change, the z-length of 2nd layer changes from 25.8cm to 21.8cm, and all cages are removed in PISA. We also increase the number of ladders of 2nd layer from 10 to 20 so as to have roughly the same φ coverage.

Single pi+: φ residual of Layer 0 (pixel)

Top-right: Cgl tracks, whose residual is bigger than sensor size (50um/2.5cm=0.002radian)
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting, big improvement







Residuals of Layer0(pixel) and Layer2(strip)

(plots in backup slides)

Layer 0: φ	Cgl	Kalman before fitting	Kalman after fitting
Mean(radian)	0.001772	0.000336	-0.000252
RMS(radian)	0.002547	0.002256	0.001663
Layer 0: Z	Cgl	Kalman before fitting	Kalman after fitting
Mean(cm)	0.000066	-0.000075	0.000012
RMS(cm)	0.014300	0.014860	0.011220
Layer 2: φ	Cgl	Kalman before fitting	Kalman after fitting
Mean(radian)	0.000419	0.000679	0.000170
RMS(radian)	0.002092	0.002016	0.001004
Layer 2: Z	Cgl	Kalman before fitting	Kalman after fitting
Mean(cm)	0.000285	-0.000092	0.000175
RMS(cm)	0.035290	0.043440	0.038930

Comments:

For the φ residual, Kalman track shows obvious improvement over Cgl track, and gives result better than the resolution of SVX sensors: height = 50um (pixel, r=2.5cm or 5cm) and 80um (strip, r=8cm or 10cm)

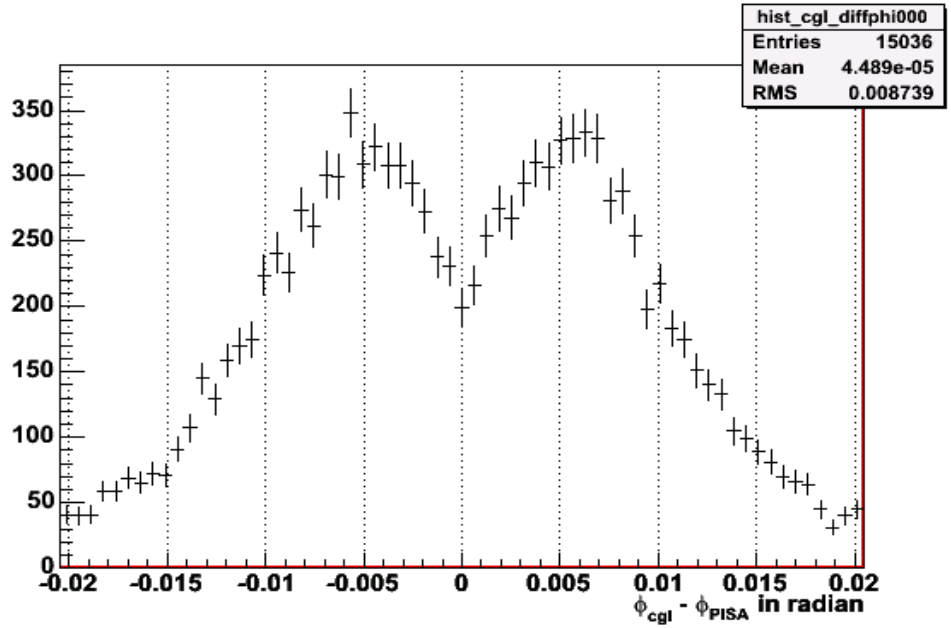
For the Z residual, Kalman tracks improve the residual on pixel layer, but basically not on strip layer. The Z residual gives out such a 'platform' of sensor size, as the width of sensor is 425um (pixel) and 1000um (strip). This means Kalman didn't 'push' track to hits for Z residual as much as for φ residual, which is possibly caused by the error constraints for Kalman: a direct length/sqrt(12), either on height or width.

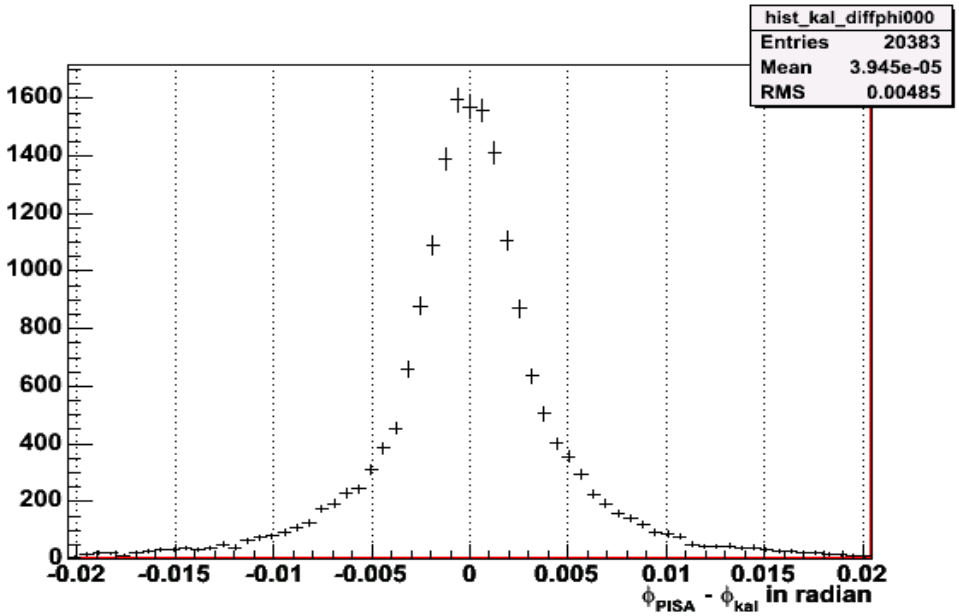
Running D^0 Events

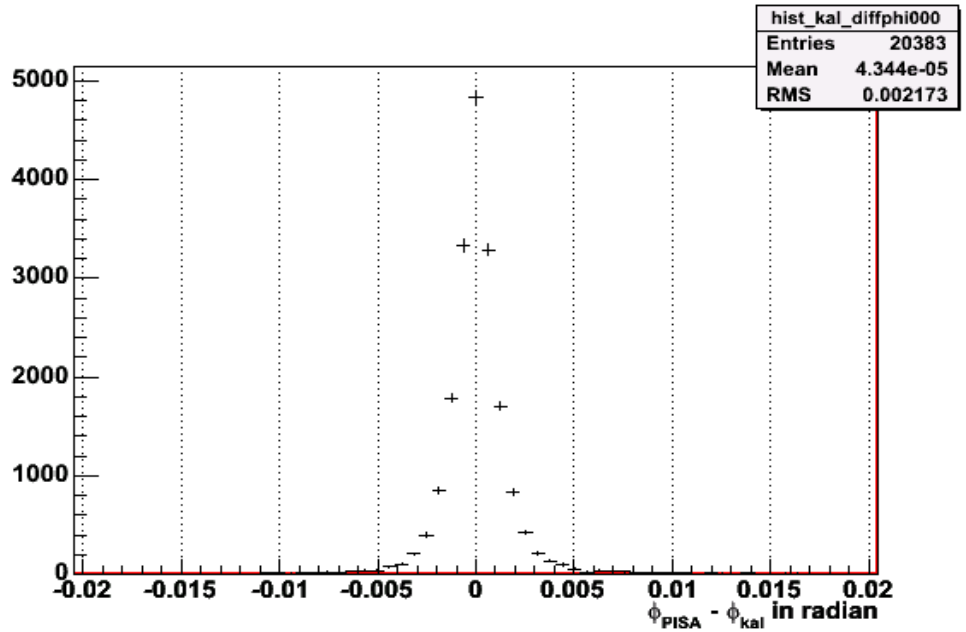
Following will be the residuals of decay tracks from D^0. We expect a broader peak of residuals, for both φ and Z. These could be auxiliary when we use DCA to cut the background in full Au-Au event.

D^0 decay tracks : φ residual of Layer 0 (pixel)

Top-right: Cgl tracks, charge asymmetry?
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting, also improved







Residuals of Layer0(pixel) and Layer2(strip)

(plots in backup slides)

Layer 0: φ	Cgl	Kalman before fitting	Kalman after fitting
Mean(radian)	0.000045	0.000039	0.000043
RMS(radian)	0.008739	0.004850	0.002173
Layer 0: Z	Cgl	Kalman before fitting	Kalman after fitting
Mean(cm)	-0.000161	-0.000048	0.000137
RMS(cm)	0.051400	0.018890	0.014970
Layer 2: φ	Cgl	Kalman before fitting	Kalman after fitting
Mean(radian)	0.000054	0.000086	0.000012
RMS(radian)	0.006099	0.002966	0.001591
Layer 2: Z	Cgl	Kalman before fitting	Kalman after fitting
Mean(cm)	0.000991	0.000033	0.000292
RMS(cm)	0.066290	0.044620	0.039760

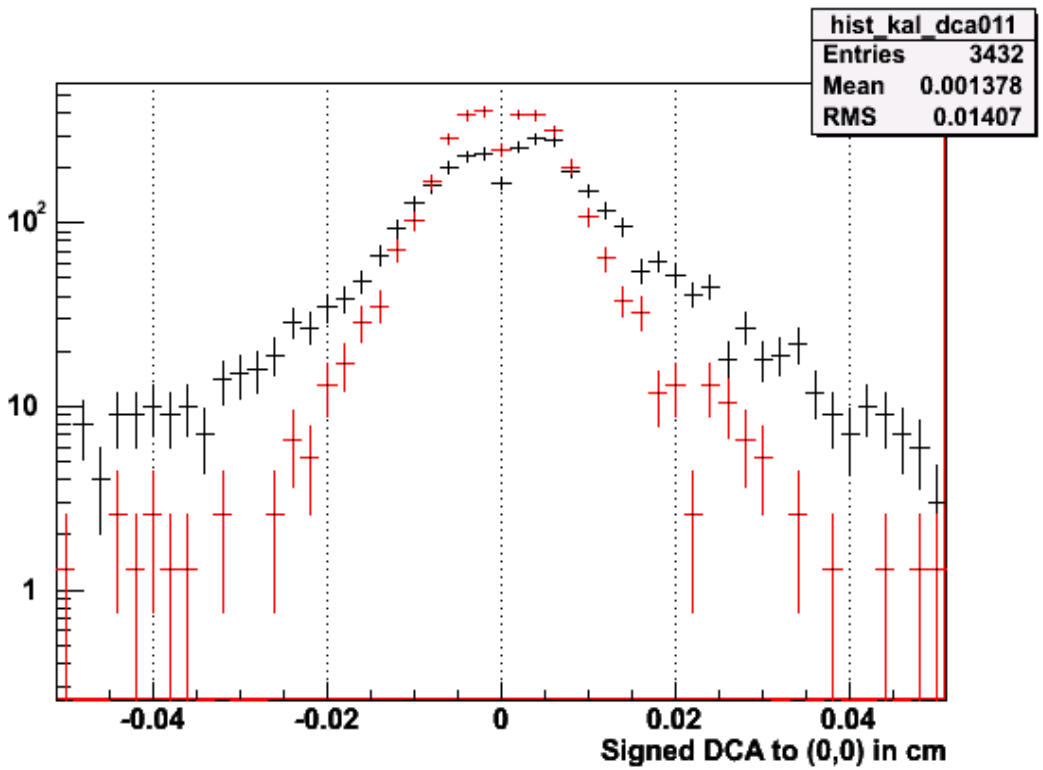
Comments

Thus, we find Kalman also do improvement to the residuals of D^0 decay tracks. And the result is also more obvious on φ residual.

Comparing with single-particle tracks, the peaks of φ residual of decay-tracks look a little broader, while those of Z residual don't change much, mostly constrained by the Z resolution.

Next step: DCA plot

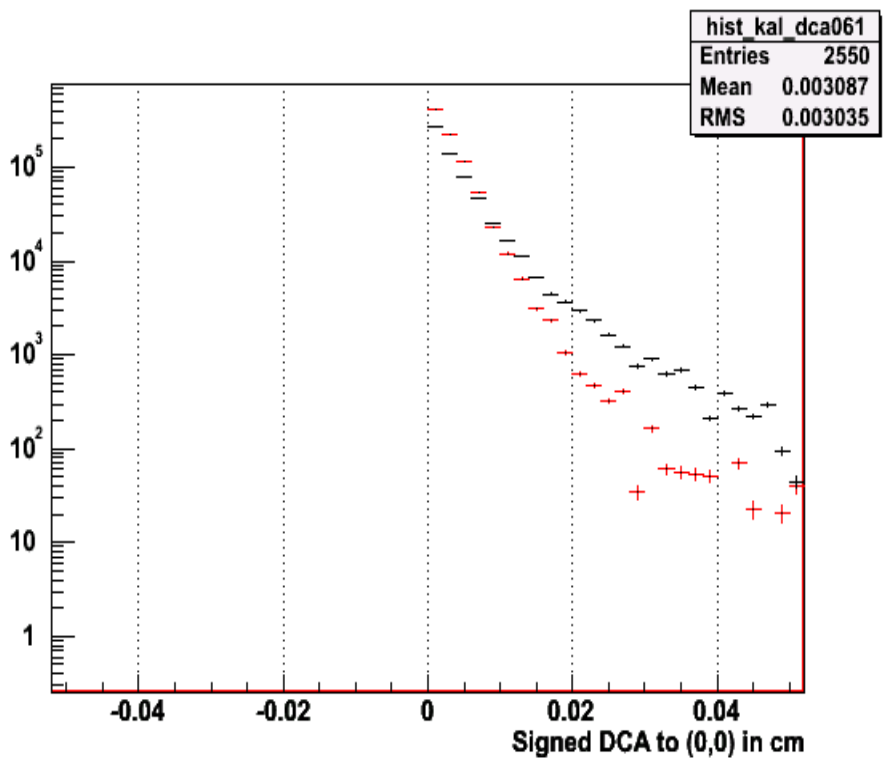
This is done by letting Kalman loop through the part of track nearby the collision vertex and find the nearest point (_x, _y, _z) to it. And I will calculate the DCA in X-Y plane. The sign of DCA is defined as the direction of R x Pt. This plot is normalized so that direct and decayed tracks have same number of entries.



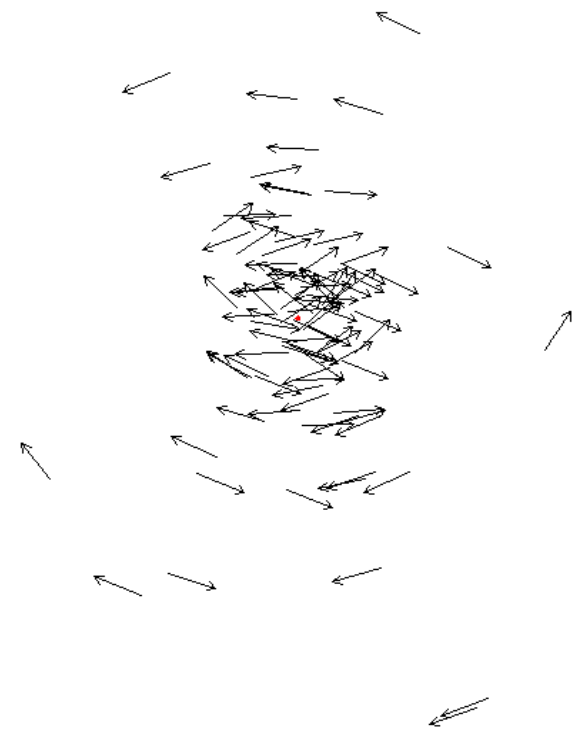
Red: pi+
Black: K-/pi+ from D

Cross check of DCA

1/DCA * dN/dDCA, where DCA=sqrt(_x*_x+_y*_y)



X-P vectors in X-Y plane. Each arrow starts from (_x, _y) and points to (px, py). This is to find if (_x, _y) really means DCA. Red point is the collision vertex.



Future Work

Possibly to make weight ajustment of Z such that Kalman works as well as on azimuthal residuals.

Improve the DCA function of Kalman Fitting.

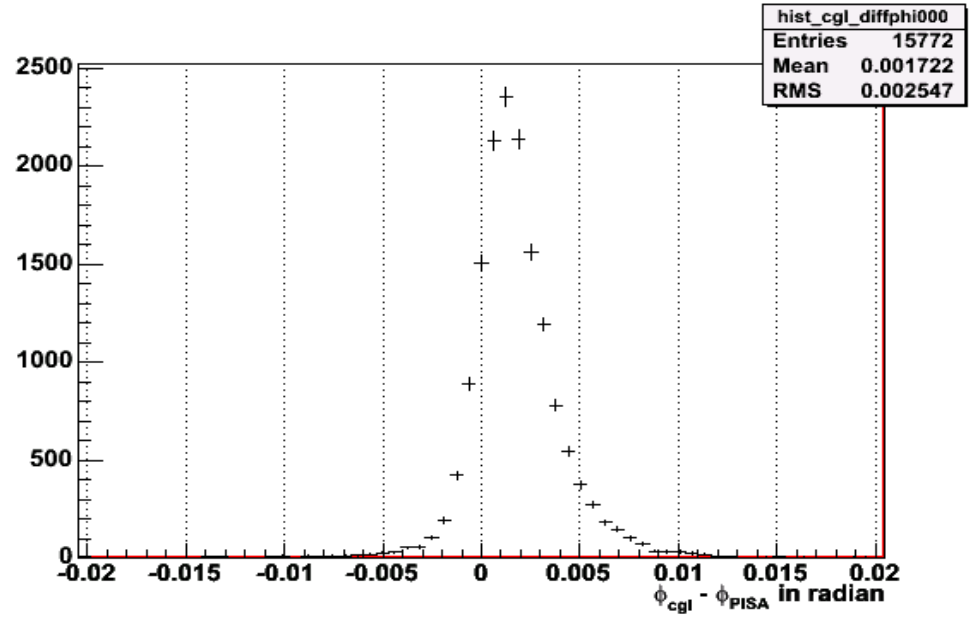
Running full Au-Au event by Exodus, and merge the decay tracks inside. Check how Kalman can help picking decay tracks out by cutting on DCA or residuals.

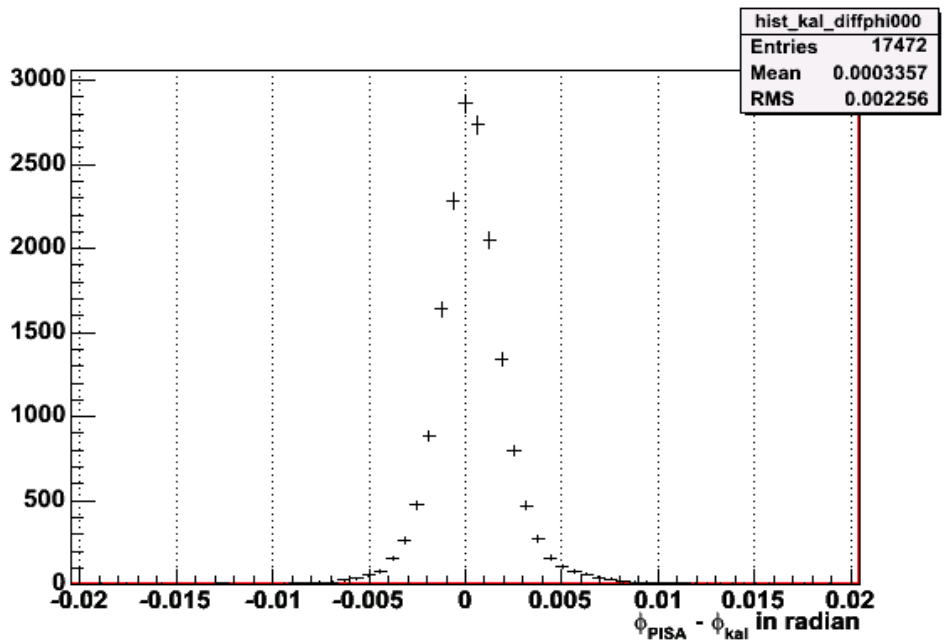
Backup

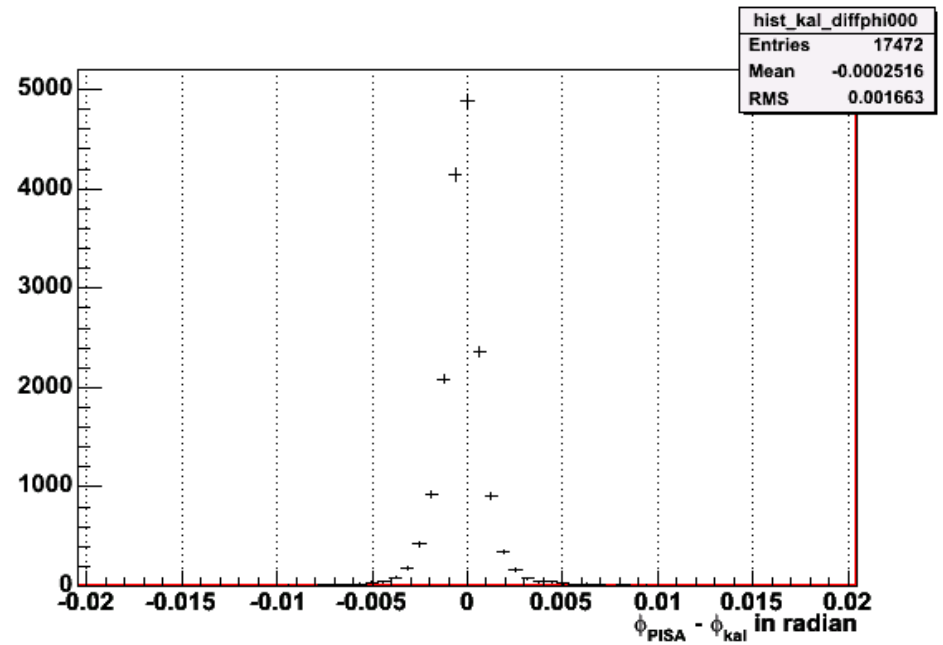
The following slides are the residuals of both single and decay tracks. The mean and RMS values of each plot have been show in previous slides.

Single pi+: φ residual of Layer 0 (pixel)

Top-right: Cgl tracks, whose residual is bigger than resolution (50um/2.5cm=0.002radian)
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting, big improvement

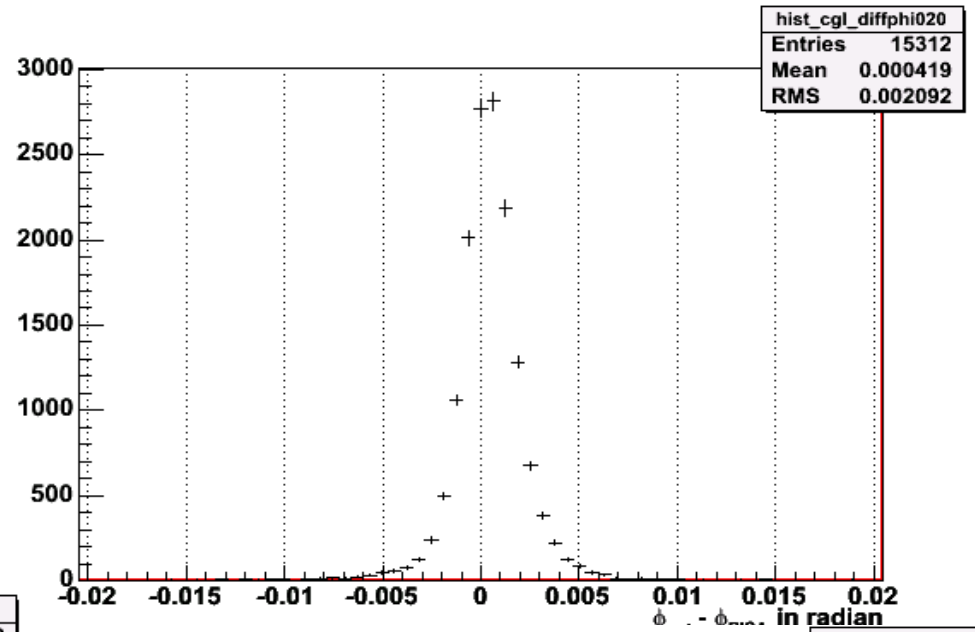


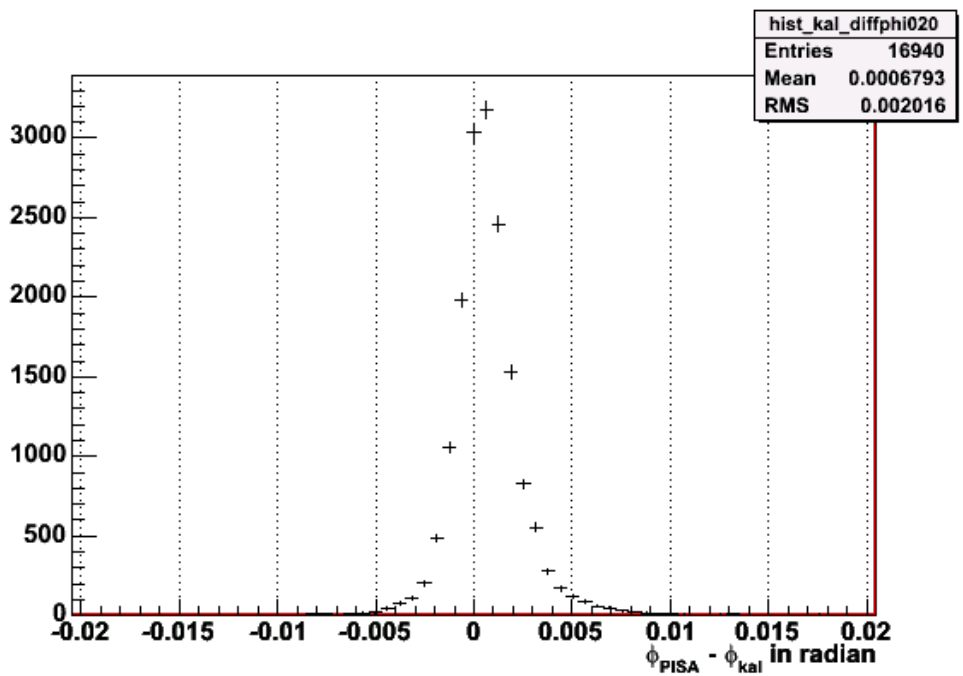


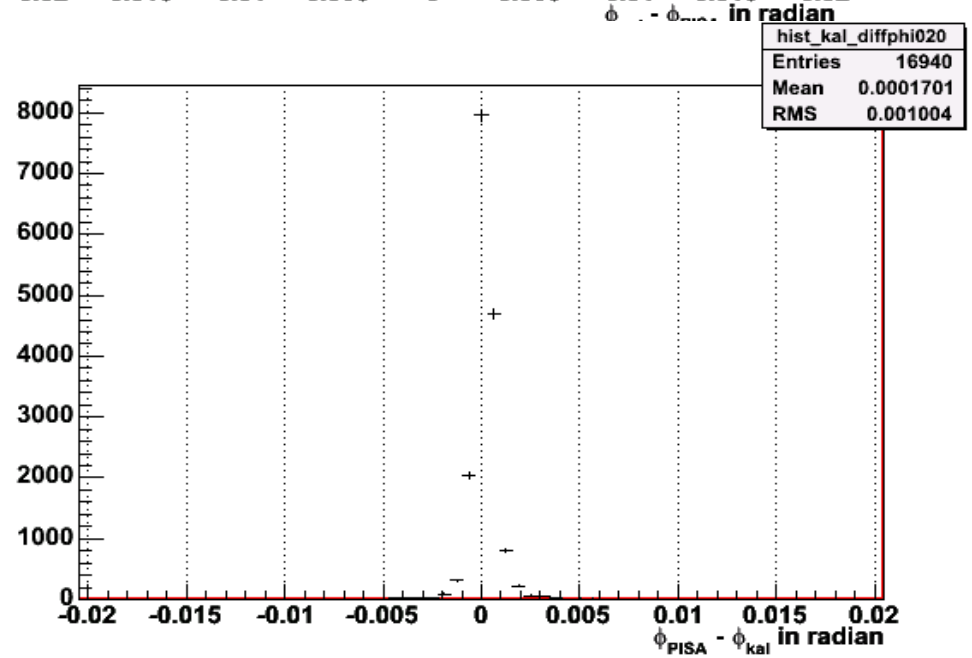


Single pi+: φ residual of Layer 2 (strip)

Top-right: Cgl tracks
Bottom-left: Kalman track before fitting, no big change
Bottom-right: Kalman track with fitting, improvement

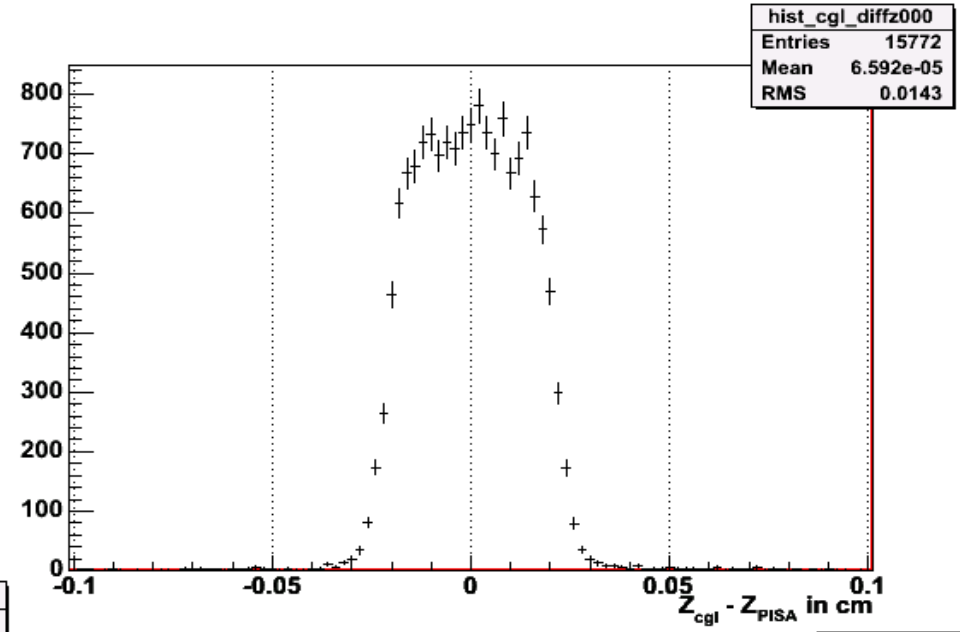


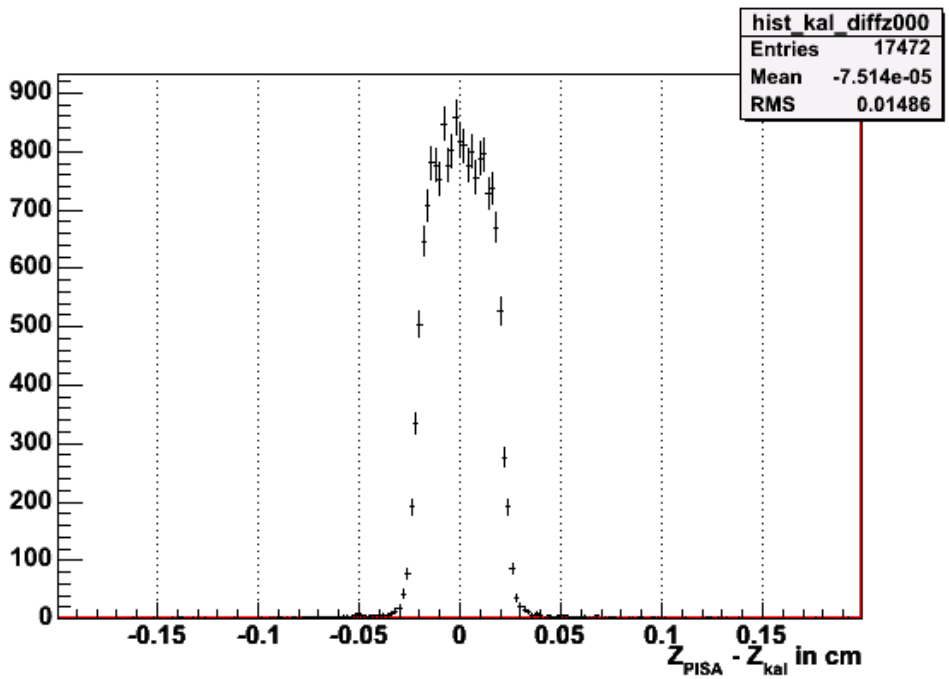


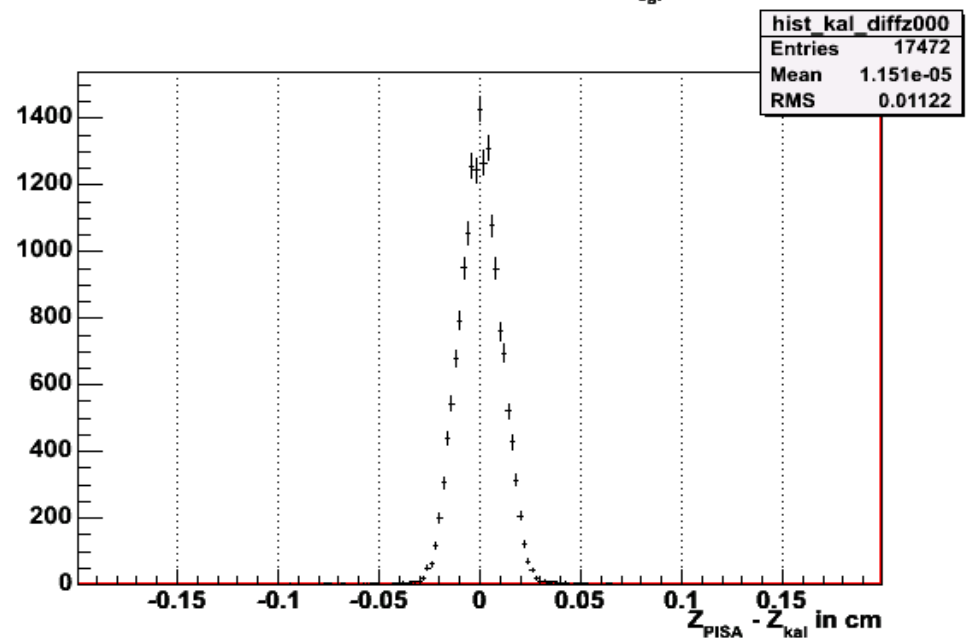


Single pi+: z residual of Layer 0 (pixel)

Top-right: Cgl tracks, a platform of 425um(resolution)?
Bottom-left: Kalman track before fitting, looks same
Bottom-right: Kalman track with fitting, improved

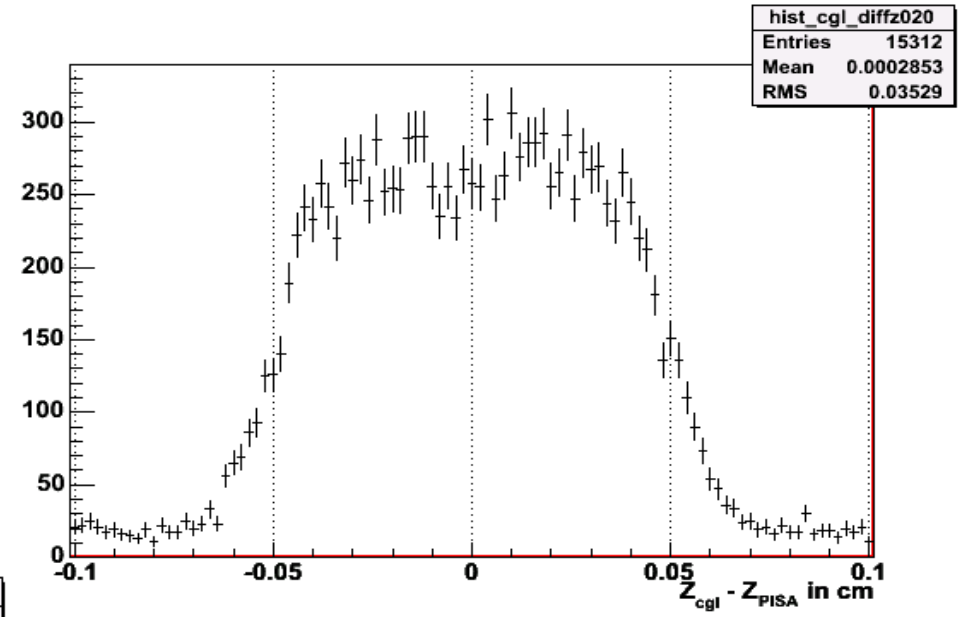


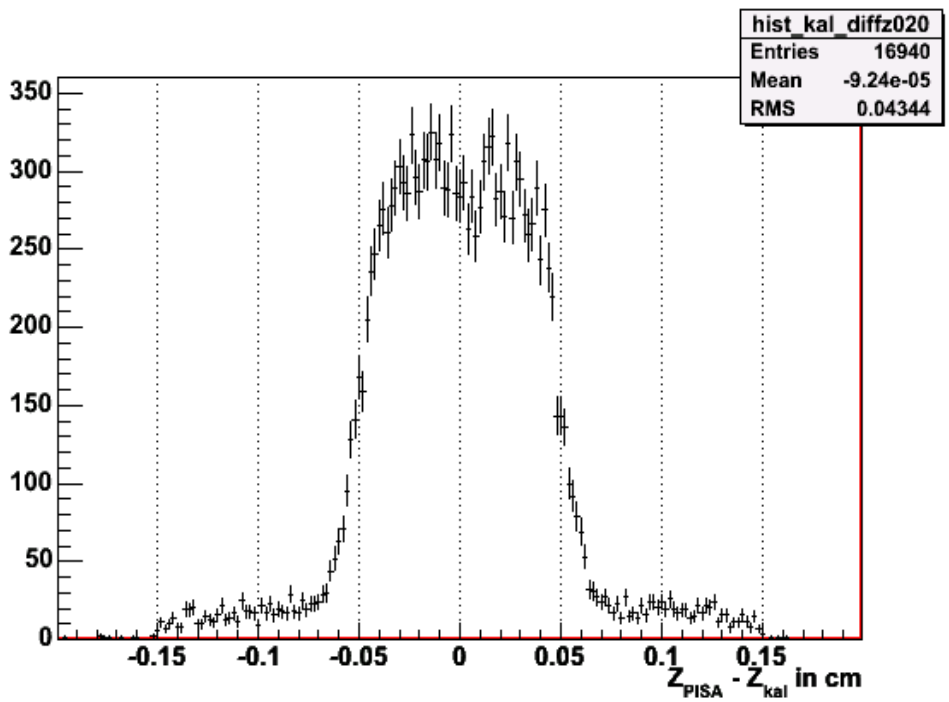


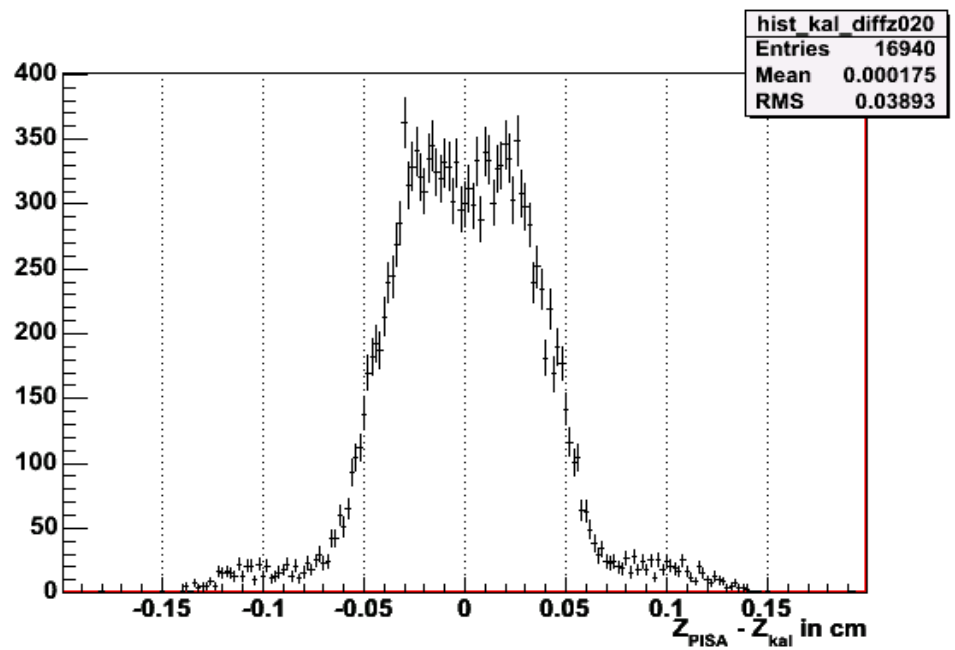


Single pi+: z residual of Layer 2 (strip)

Top-right: Cgl tracks, another platform of 1000um(resolution)
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting, basically don't change

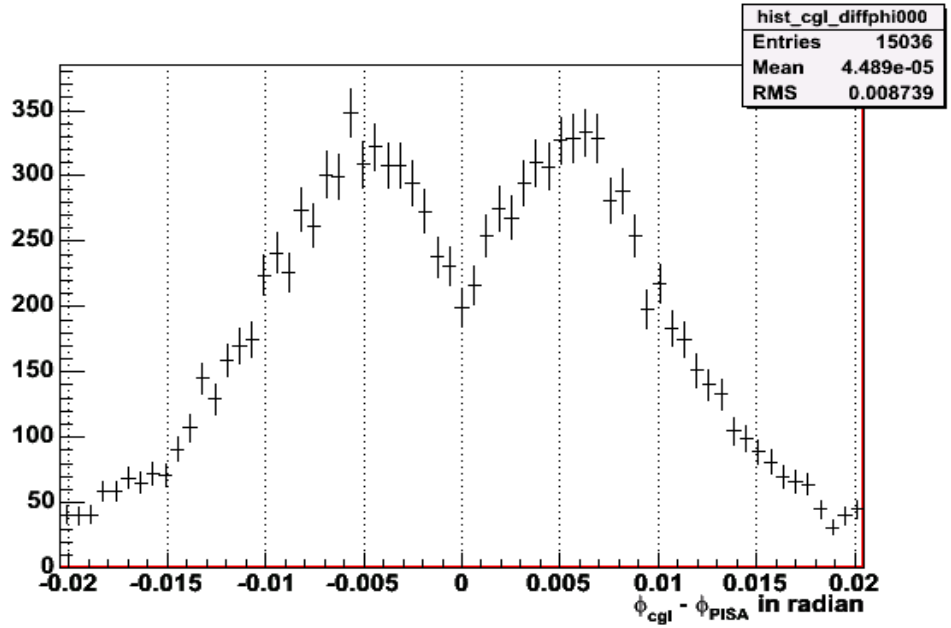


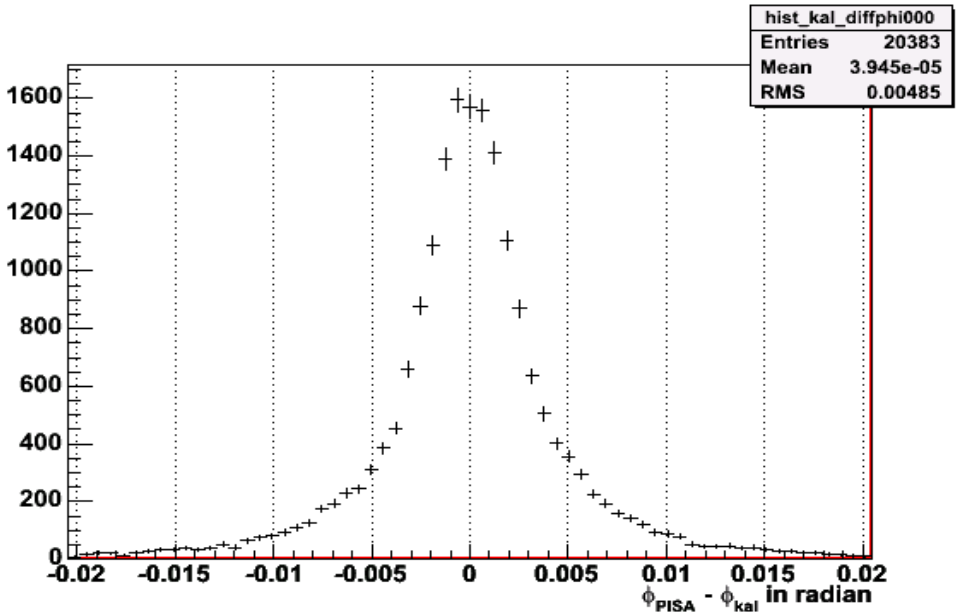


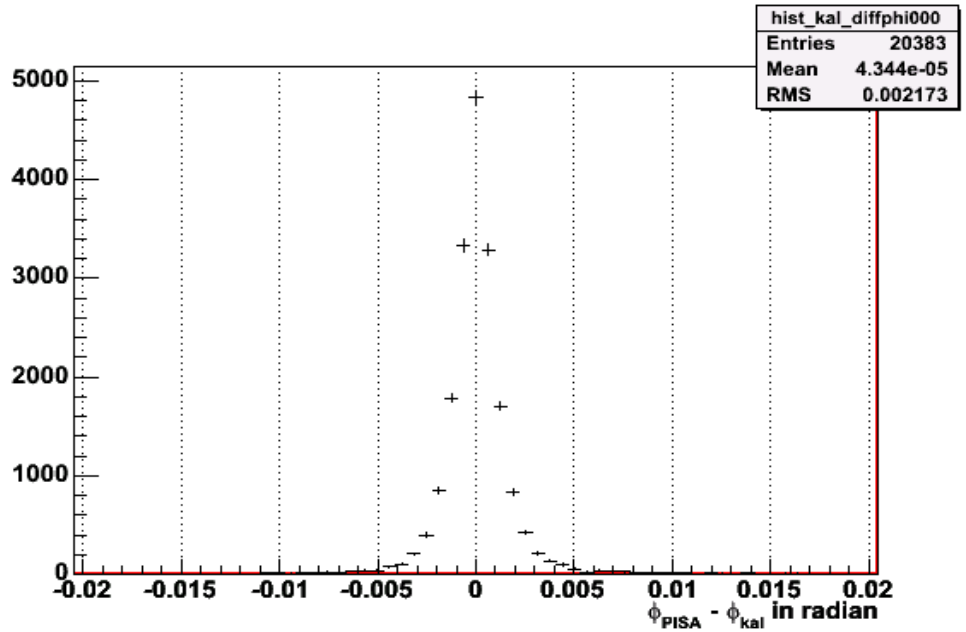


D^0 decay tracks : φ residual of Layer 0 (pixel)

Top-right: Cgl tracks, charge asymmetry?
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting, also improved







D^0 decay tracks : φ residual of Layer 2 (strip)

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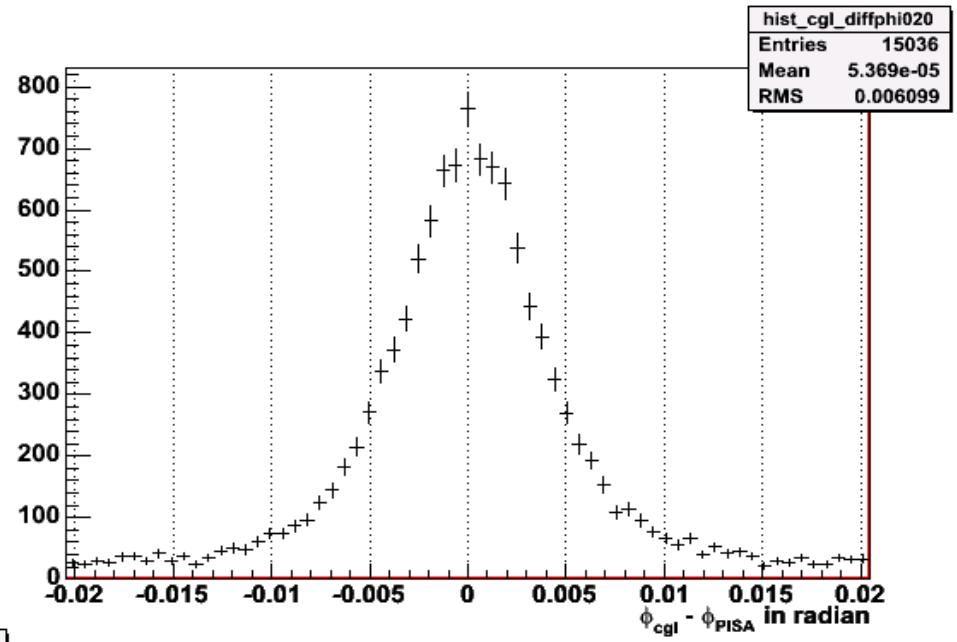
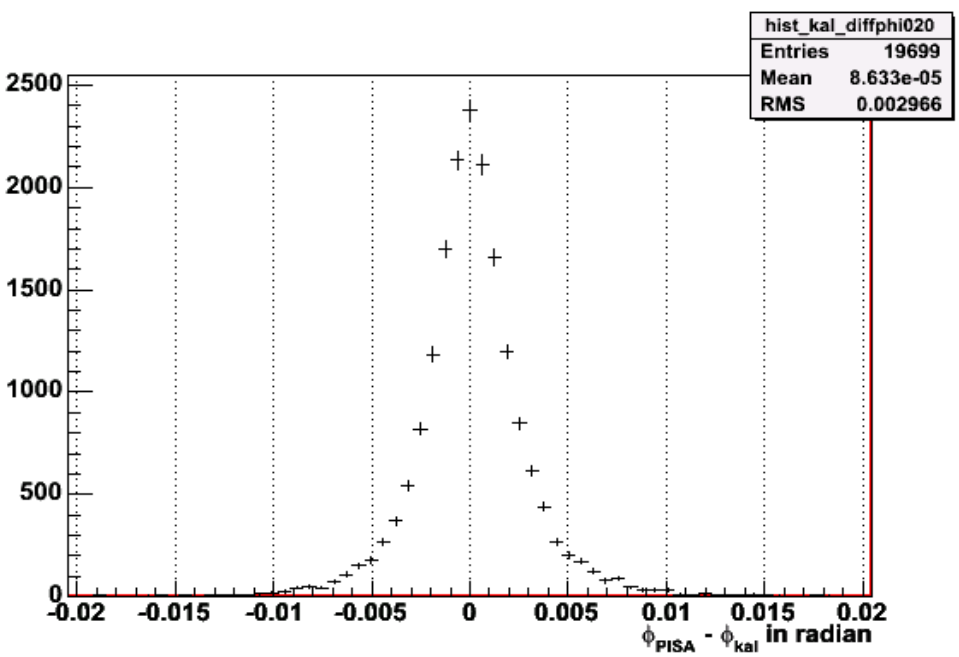
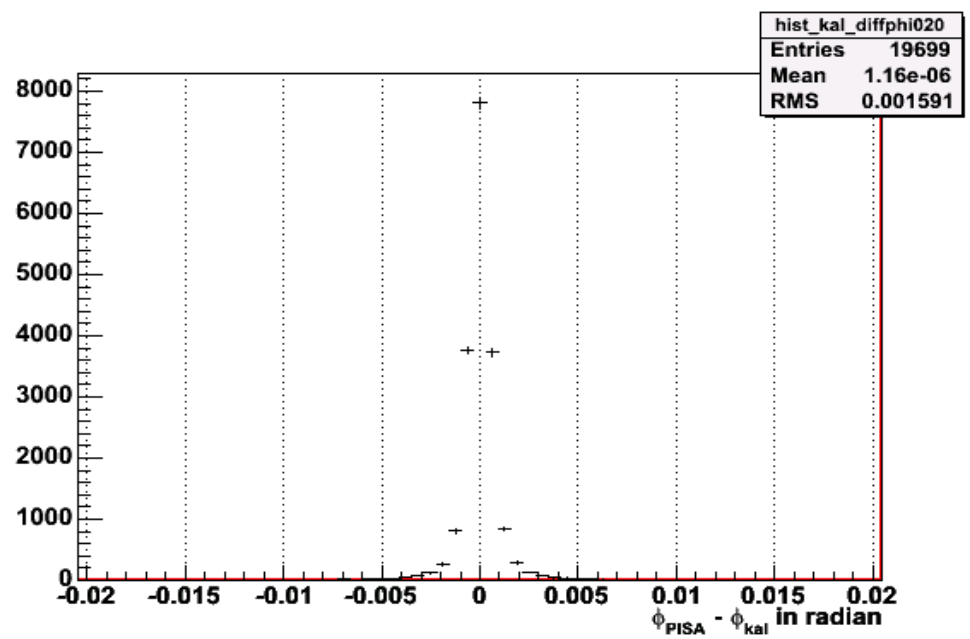
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting







D^0 decay tracks : Z residual of Layer 0 (pixel)

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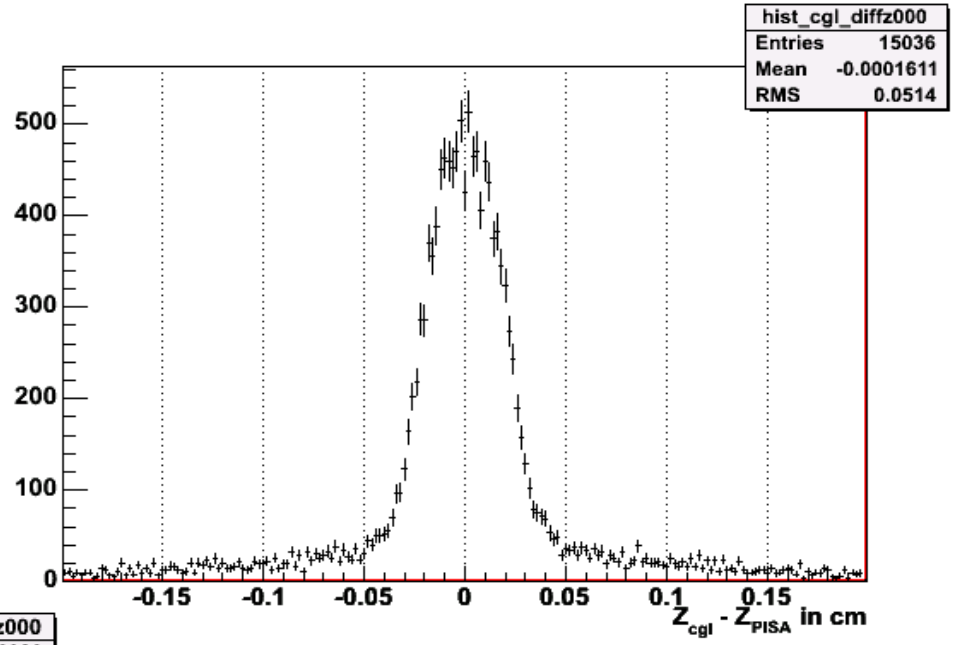
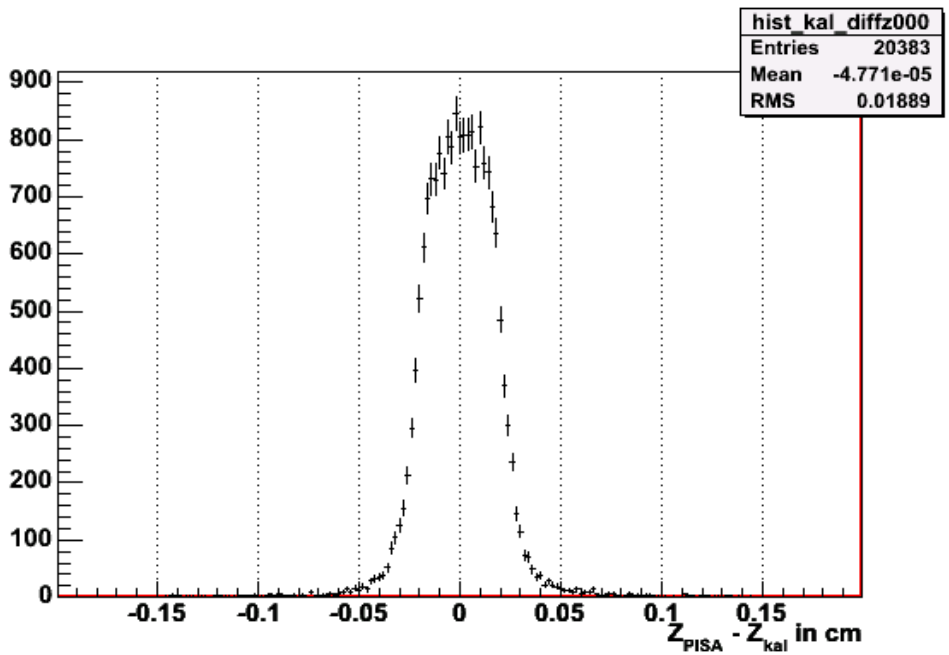
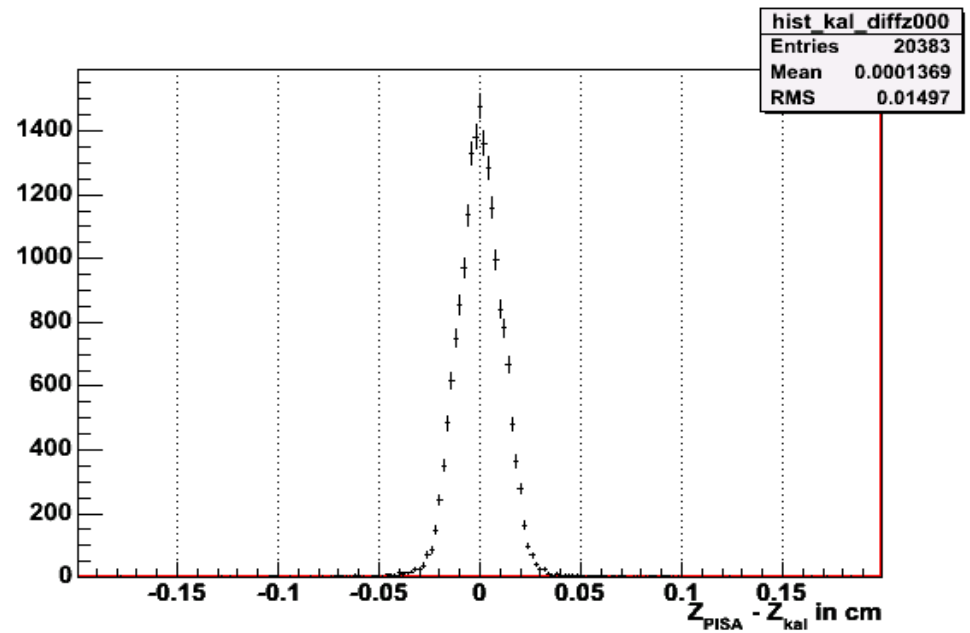
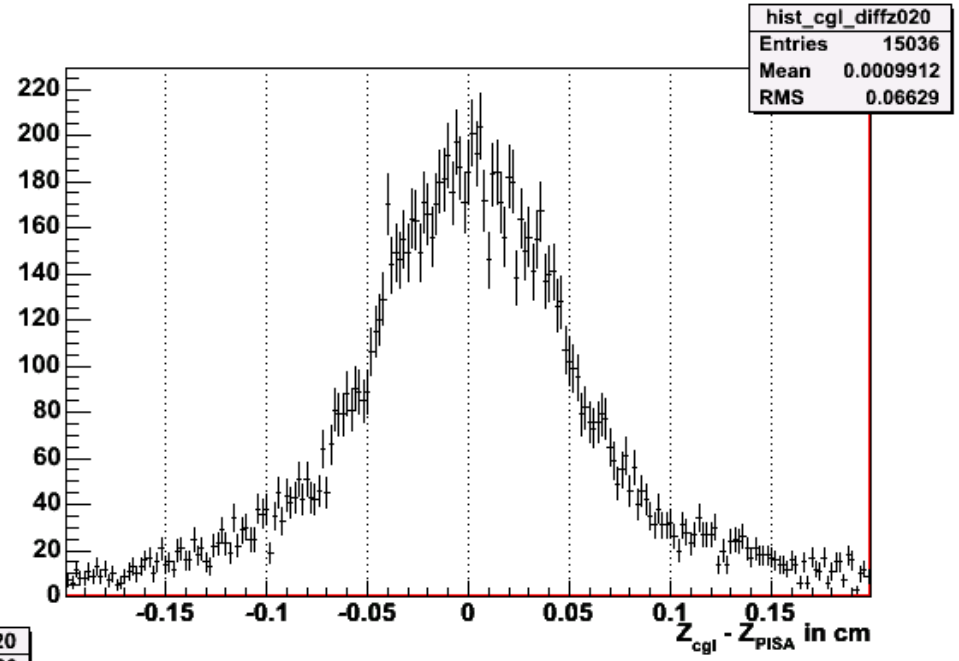
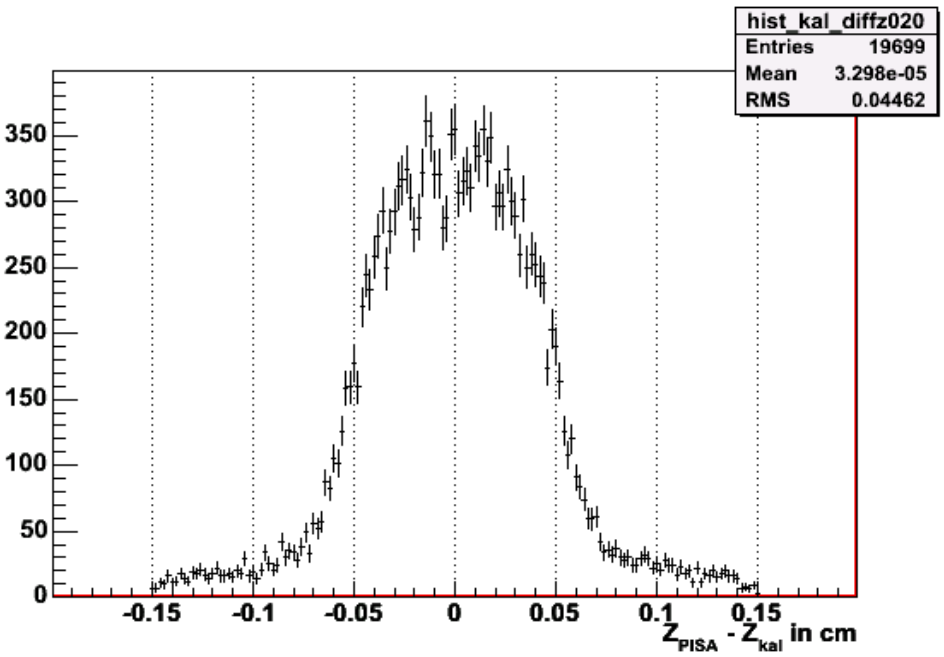
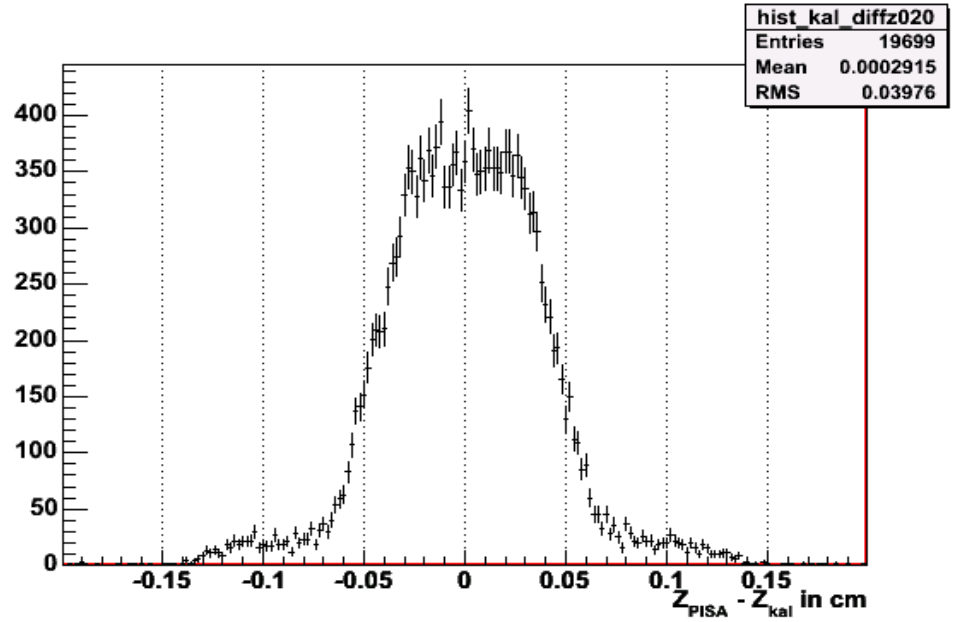
Bottom-left: Kalman track before fitting
Bottom-right: Kalman track with fitting







D^0 decay tracks : Z residual of Layer 2 (strip)

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