Dedicated K_s^0 reconstruction studies

Text for the blessed web page – CDF note 6337

The CDF Collaboration

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Abstract

We present dedicated silicon tracking algorithm for reconstruction of particles created at a significant distance from the primary vertex (e.g. outside of the beampipe). This algorithm is designed to deal with daughters of long lived particles such as K_s^0 or lambdas. Adding the correct silicon information to COT tracks is, obviously, very helpful for improving track parameter resolution. For rejecting background in long lived particle reconstruction it is especially beneficial because the improved track's resolution (mostly z) allows to reject random two-track combinations more easily at the vertex fitting stage.

1 Description

Long lived particles like K_s^0 or Λ require special tracking (on average they decay just before the last layer of the SVX detector but within the ISL). Adding just a single ISL small-angle stereo cluster to one of the daughters of a K_s^0 or Λ improves the track's z-resolution from $\approx$ 1cm to $\approx$ 2 mm. This improves the determination of the K_s^0 and Λ vertices and consequently the reconstruction of the parent of those particles (i.e., going upstream $B^0 \to J/\psi K_s^0$, $\Lambda_B \to J/\psi\Lambda$ or $D_s^{\pm} \to K_s^0 K^{\pm}$).

Two special silicon pattern recognitions are used for the daughters of the K_s^0 or Λ. In both of them, in order to compute its inv. mass, hits are added to tracks and energy loss correction is applied taking into account the position of the secondary production vertex for those tracks.

The default pattern recognition has:

- **[1]** minimun # of hits requirement ($>$ 2 hits should be found)
- **[2]** looks 1^{st} for $r\phi$ hits then for z (both $s.a.s$ and 90^ostereo).

The dedicated pattern recognition has:

- **[1]** no minimun # of hits requirement
- **[2]** looks 1^{st} for an ISL $r\phi$-$s.a.s$ hit pair, then SVX $r\phi$-$s.a.s$, then $90^o stereo$.

The default approach might be too agressive for long lived particles.

The dedicated algorithm tends to :

- **[i]** associate less wrong hits
- **[ii]** improve K_s^0 reconstruction when just a single layer is traversed.
- **[iii]** improve z tracking

To stablish the performance of the dedicated algorithm we have compared it with the default alg. in two cases:

- **[i]** Default track pairs without silicon hits (to show ded. improvement)
- **[ii]** Default track pairs with silicon hits (to show ded. is as good as def.)

• We look (K_s^0 by K_s^0) at the K_s^0 mass, K_s^0 vertex and # hits ($r\phi$ and z) difference between default and dedicated tracks-pairs.

• Show z-distance of the two daughter tracks at the default-vertex position in the xy plane [1] ($\Delta z_{\pi^+\pi^-}$) and inv. mass comparison as well.

• Compute the dedicated efficiency wrt default.

• Look at Z-vertexing, in pariuclar, at Δ Z = z0_{Ks} - z$_{PV}$ being z0_{Ks} = z$_{vertex}$ - $\frac{L_{xy} * p_z}{p_t}$ (wo. vertex constrain).

[1] The distance on z of the two daughter tracks was obtained before using CTVMFT, so just using a simple routine to get the xy intersection point of the two tracks.

2 Blessed Numbers

This section summarizes the numbers which have been blessed for this analysis.

Dedicated-default K_s^0 by K_s^0 comparison (starting with def-track pairs without silicon):
$< \Delta mass >$=0.9 MeV (2 MeV width)

$< \Delta V_{xy} >$= 0.1 mm (2.5 mm width)

σ_{mass} = 8.6 MeV (default) / 8.2 MeV (dedicated)

$\sigma_{\Delta z_{\pi^+\pi^-}}$ = 0.82 cm (default) / 0.33 cm (dedicated)

Efficiency of the dedicated alg.:

- 4 % def-track pairs rejected by the dedicated algorithm (none of those are K_s^0)

- 100% efficient in this case + S/N improvement.

$\sigma_{\Delta(z0_{Ks}-z_{PV})}$ = 6 mm (default) / 4 mm (dedicated)

Dedicated-default K_s^0 by K_s^0 comparison (starting with def-track pairs with silicon):
$< \Delta mass >$=0.024 MeV (2 MeV width)

$< \Delta V_{xy} >$= 5 μm (50 μm width)

σ_{mass} = 4.6 MeV (default) / 4.4 MeV (dedicated)

Dedicated efficiency :

- 8 % def-track pairs rejected by the dedicated alg. (drawback: 1/2 of those are K_s^0)

- misaligned z layers are responsible: using z, 90^o stereo, rejects K_s^0; not using 90^o stereo does not; improved alignment in progress.

$\sigma_{\Delta(z0_{Ks}-z_{PV})}$ = 1.82 mm (default) / 1.48 mm (dedicated)

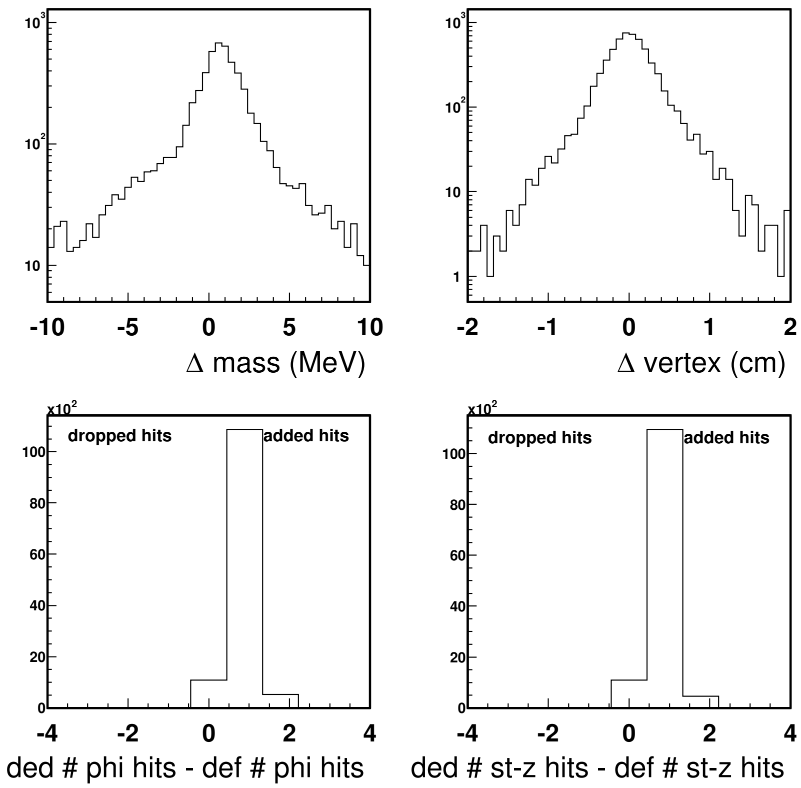

Figure 1: K_s^0 *invariant mass subtraction (top left),* K_s^0 *vertex position in the transverse plane (top right), number of* $r\phi$ *hits (bottom left) and number of* z *hits (small angle stereo and 90 degree stereo hits) (bottom right) subtraction (*K_s^0 *candidates obtained with the dedicated algorithm -* K_s^0 *candidates obtained with default tracks). The sample used corresponds to default track pairs without silicon hits.*

3 Blessed Figures

The following figures have been blessed for the dedicated K_s^0 reconstruction studies. More text can be found in CDF note 6337.

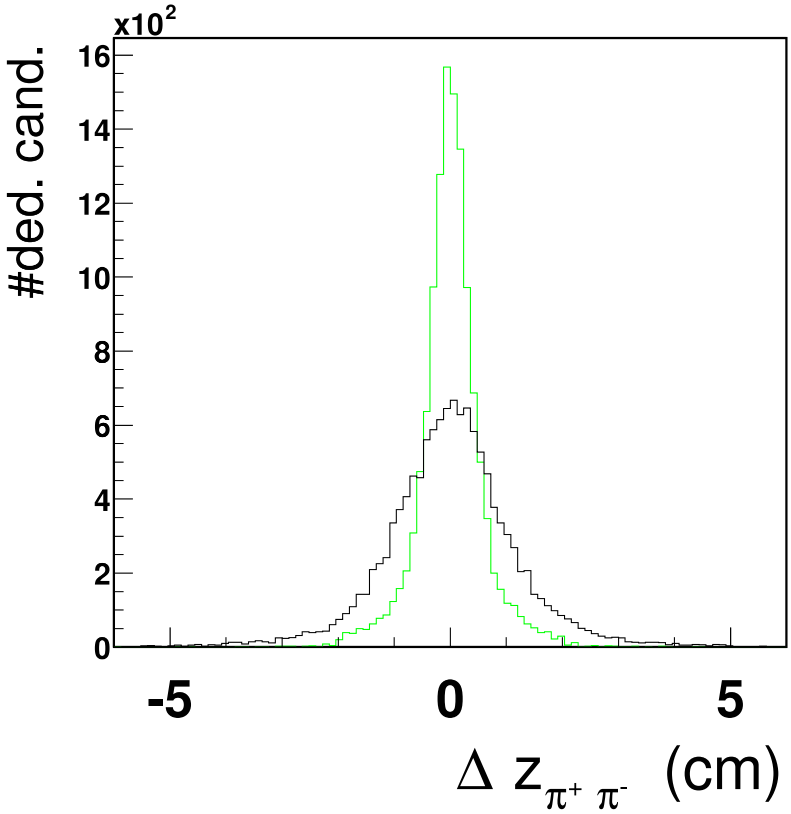

Figure 2: *Distance on z of the two daughter tracks at v_{xy}, before K_s^0 refitting, obtained with the dedicated tracks (light green histogram), so tracks that passed through the dedicated algorithm, and with default tracks (black). The sample used corresponds to default track pairs without silicon hits. $\sigma_{\Delta z_{\pi^+\pi^-}}$ (default) = 0.86 cm. $\sigma_{\Delta z_{\pi^+\pi^-}}$ (dedicated) = 0.36 cm.*

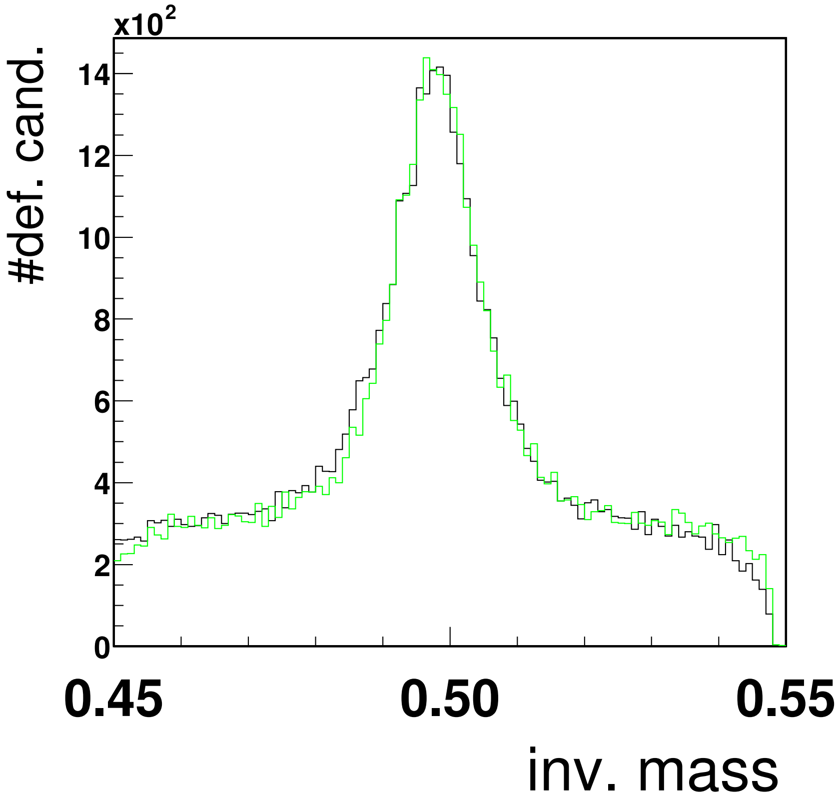

Figure 3: *The K_s^0 invariant mass. The dedicated (default) algorithm has been used for the light-green (black) histogram. The starting sample corresponds to default track pairs without silicon hits. No selection cuts have been applied. $\sigma_{default}$ = 8.6 MeV. $\sigma_{dedicated}$ = 8.2 MeV.*

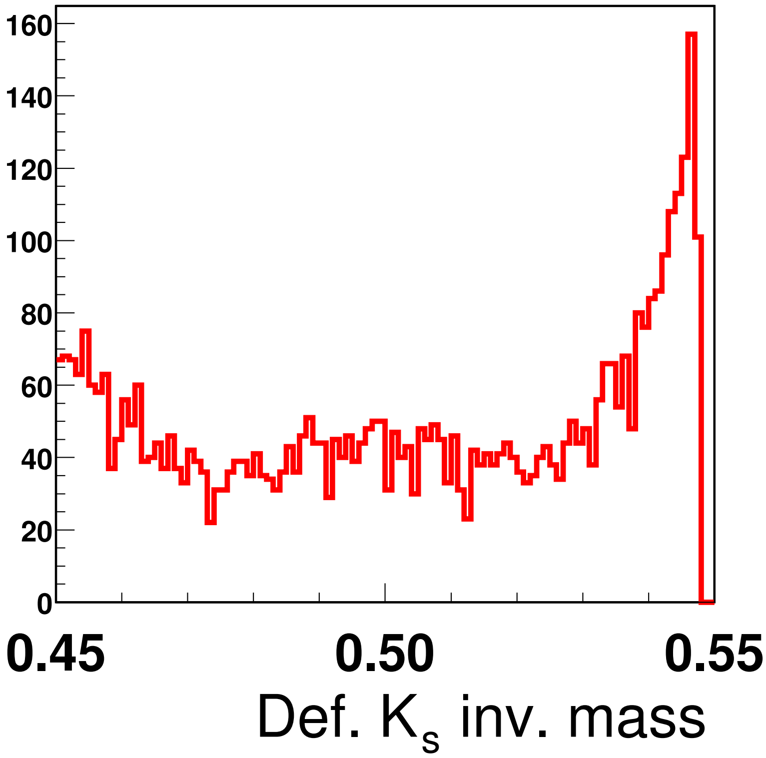

Figure 4: *The invariant mass of those default track pairs rejected by the dedicated algorithm. The starting sample corresponds to default track pairs without silicon hits. The increasement of the background on the edges is a feature of the algorithm (it has a shrinking mass-window selection on every different step taken)*

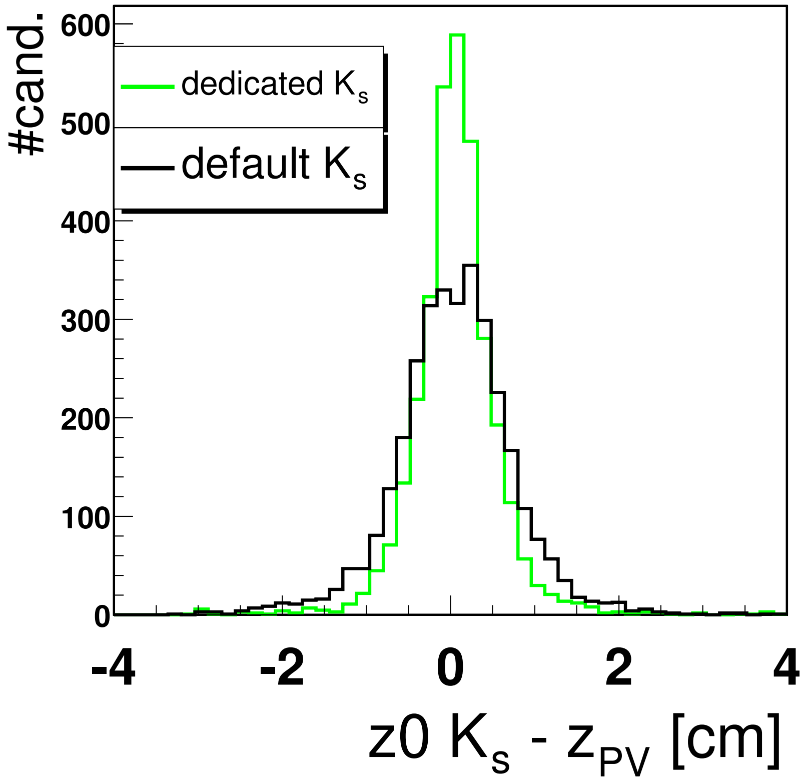

Figure 5: $\Delta\ Z = z0_{Ks}$ - z_{PV} *distribution;* $z0_{Ks} = z_{vertex}$ - $\frac{L_{xy} * p_z}{p_t}$ *(without vertex constrain). The starting sample corresponds to default track pairs without silicon hits. Dedicated* $K_s^0 s$ *point better to PV (this sample contains mostly prompts).*

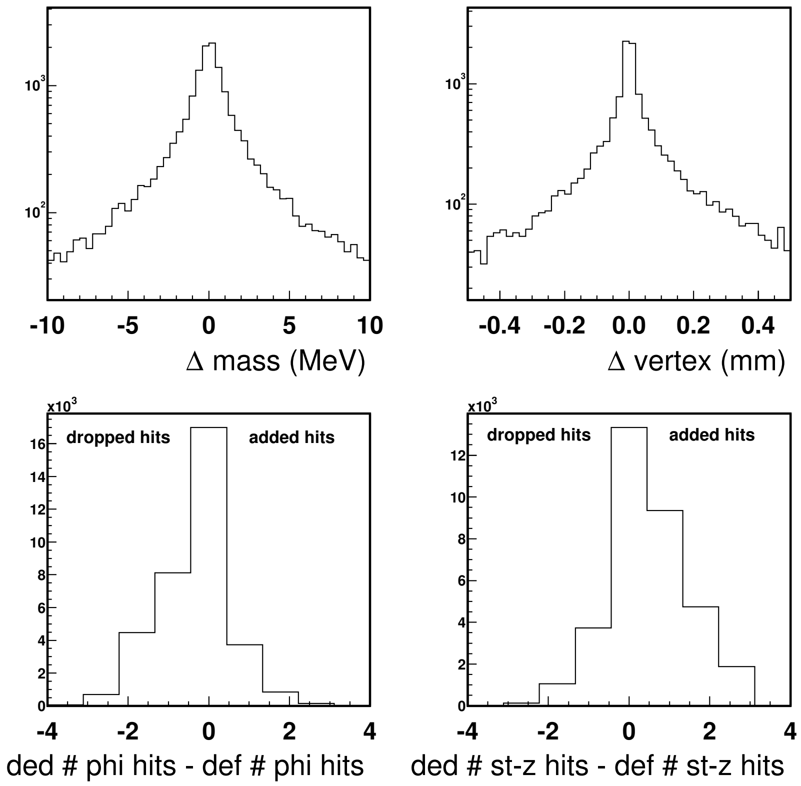

Figure 6: K_s^0 *invariant mass subtraction (top left),* K_s^0 *vertex position in the transverse plane (top right), number of* $r\phi$ *hits (bottom left) and number of* z *hits (small angle stereo and 90 degree stereo hits) (bottom right) subtraction (*K_s^0 *candidates obtained with the dedicated algorithm -* K_s^0 *candidates obtained with default tracks). The sample used corresponds to default track pairs with silicon hits (in addition an ISL hit should be present in every track).*

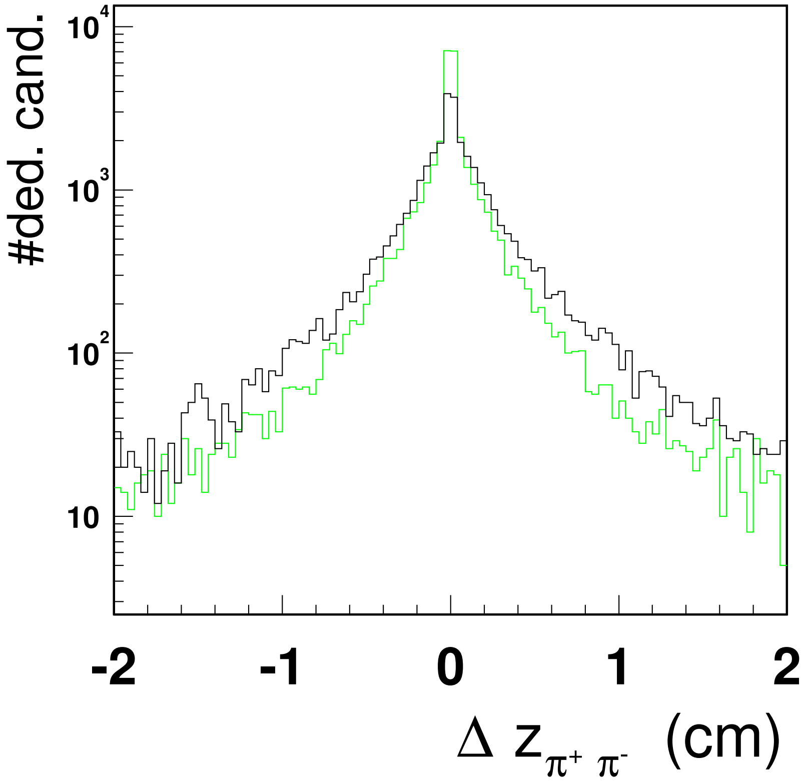

Figure 7: *Distance on z of the two daughter tracks at v_{xy}, before K_s^0 refitting, obtained with the dedicated tracks (light green histogram) (so tracks that passed through the dedicated algorithm) and with default tracks (black). The sample used corresponds to default track pairs with silicon hits (in addition an ISL hit should be present in every track).*

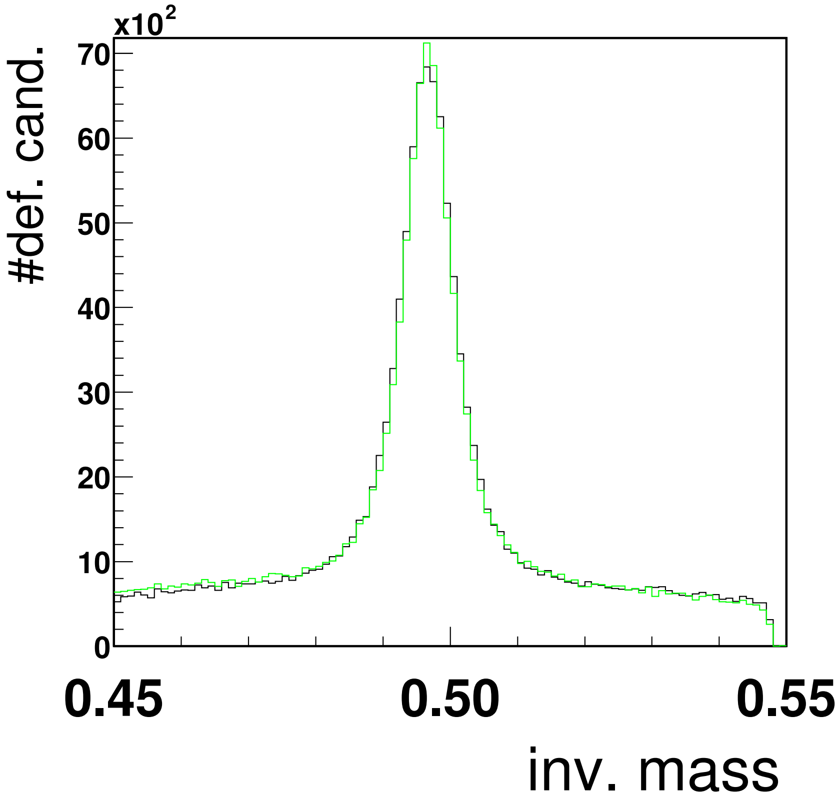

Figure 8: *The K_s^0 invariant mass. The dedicated (default) algorithm has been used for the light-green (black) histogram. The starting sample corresponds to default track pairs with silicon hits. No selection cuts have been applied. See CDF note 6337 for more details.* $\sigma_{default}$ *=* 4.6 *MeV.* $\sigma_{dedicated}$ *=* 4.4 *MeV.*

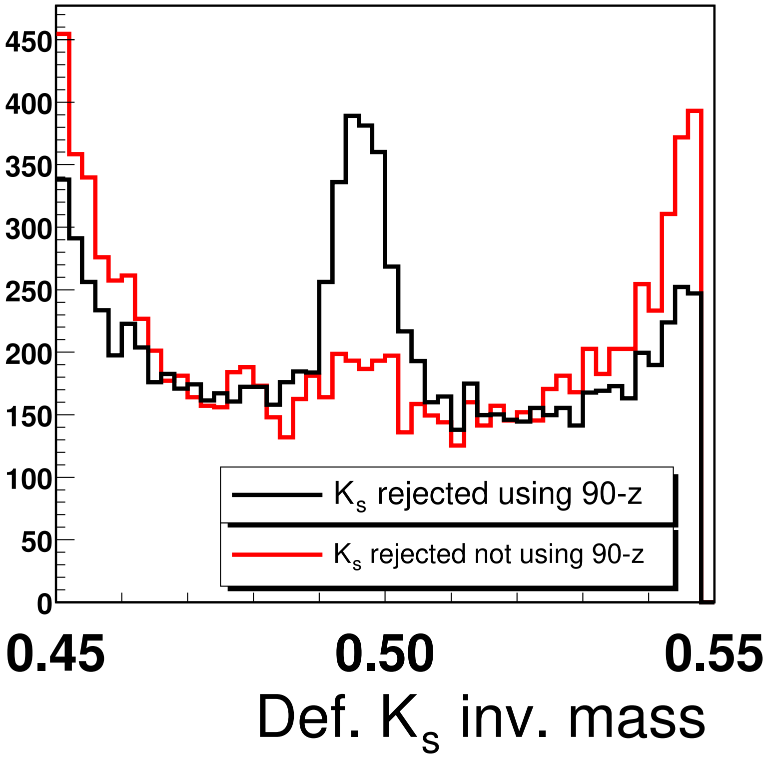

Figure 9: *The invariant mass of those default track pairs rejected by the dedicated algorithm. The starting sample corresponds to default track pairs with silicon hits. The 90 degree z-hits have been used on the black histogram and not on the red histogram by the dedicated algorithm.*

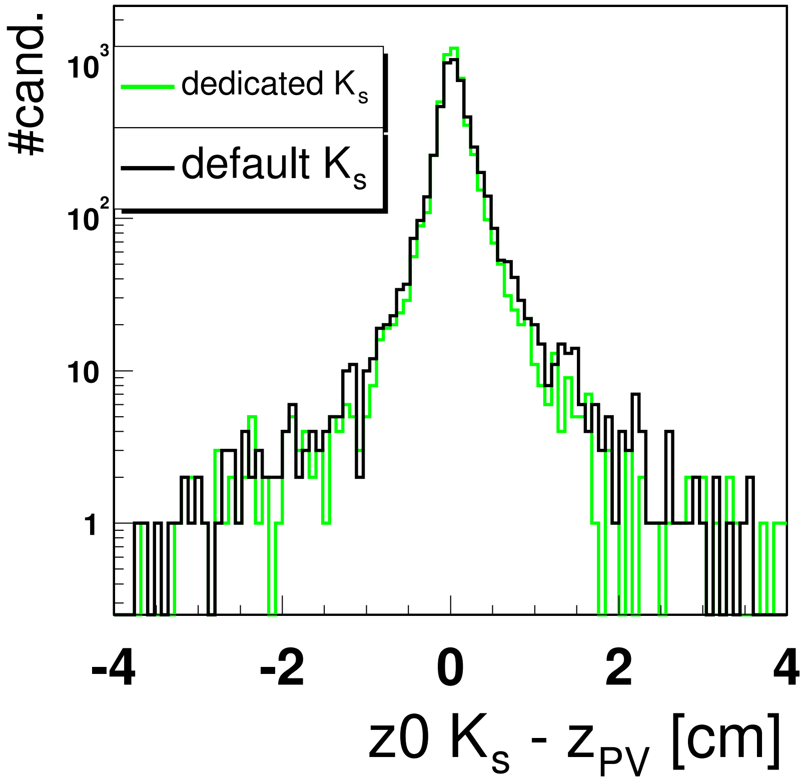

Figure 10: $\Delta\ Z = z0_{Ks}$ - z_{PV} *distribution;* $z0_{Ks} = z_{vertex}$ - $\frac{L_{xy} * p_z}{p_t}$ *(without vertex constrain). The starting sample corresponds to default track pairs with silicon hits. Dedicated* K_s^0*s point better to PV (this sample contains mostly prompts).*