Study of Kaon Tracking Efficiency

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Data set and MC samples

Control sample: $J/\psi \to K_s^0 K^{\mp} \pi^{\pm} \to \pi^+ \pi^- K^{\mp} \pi^{\pm}$

Data sets:

- 2018, 2019 J/ψ data.

Boss Version:

- 708

MC samples:

- 2019 inclusive MC
- 2018, 2019 DIY signal MC

Event selection

Good charged tracks:

- $|cos\theta| < 0.93$
- N_{Good} =3, $\sum Q_{track} = \pm 1$ for tagging $K^{\pm}$. N_{Good} =4, $\sum Q_{track} = 0$

Vertex Fit:

- Using the second vertex fit to reconstruct K_s^0
- Retain the combination with the mass closest to K_s^0.
- $L/\sigma_L > 2$
- $|M_{\pi^+\pi^-} - K_s^0| < 10$ MeV

PID:

- Tracks from K_s^0 and the π from J/ψ: $\mathcal{P}_\pi > \mathcal{P}_K \&\& \mathcal{P}_\pi > \mathcal{P}_K$

Kinematic Fit:

- Missing K and doing 1c kinematic fit: $\chi^2_{1c} < 5$.
- Exchanging K and π and getting χ^2_{Exc}. $\chi^2_{1c} < \chi^2_{Exc}$.

Event selection

Further Selection:

- For the events with $N_{Good} = 4$, **the angle between the reconstructed Kaon track and the recoiled track should be smaller than** 2°.
- $|V_z| < 20$ cm, $V_r < 5$ cm for the tracks from K_s^0
- $|V_z| < 10$ cm, $V_r < 1$ cm for the tracks from J/ψ

Then tracking the Kaon as the nominal $e^+e^- \to K^+K^-\gamma_{\mathrm{ISR}}$ selection:

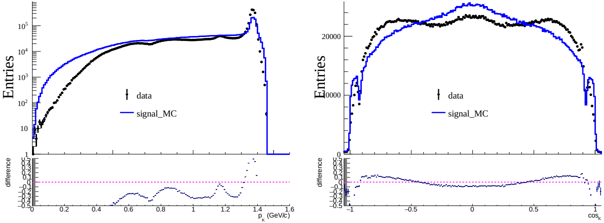
Tracking method:

- $|cos\theta| < 0.93$
- $|V_z| < 10$ cm, $V_r < 1$ cm
- $E/p < 0.8$, here E is the deposited energy in EMC.

The event number got without tracking the Kaon is N_1 and that after tracking Kaon is N_2. The tracking efficiency is:

$$\epsilon = N_2/N_1, \text{ and the error is } \sigma_\epsilon = \sqrt{\frac{\epsilon(1-\epsilon)}{N_1}}$$

Comparison between inclusive MC and data

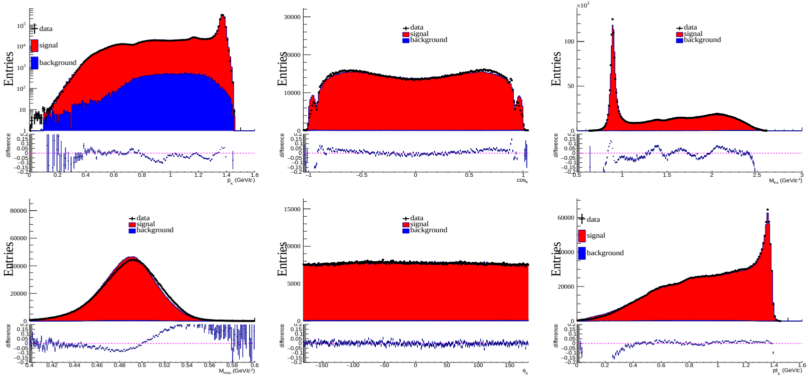


- The inclusive MC can't describe the data well enough.

Selection criteria	background ratio	Signal lost	N_{signal}
Original selection	5.5%		4212687
$\chi^2_{1c} < \chi^2_{Exc}$	4.5%	7.4%	3979619
$\chi^2_{1c} < \chi^2_{Exc} \&\& matchangle < 2$	2.5%	16.9%	3855789
$\chi^2_{1c} < \chi^2_{Exc} \&\& matchangle < 2 \&\& N_\gamma < 2$	1.0%	41.0%	2742770

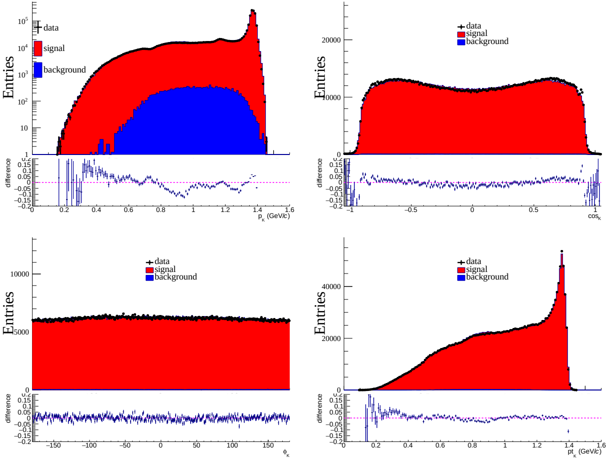
- More cuts to suppress the background. The photon is tagged same as $e^+e^- \to K^+K^-\gamma_{\mathrm{ISR}}$, except that the open angle should be smaller than 10.
- The last cut is chosen for now, since we need to minimize the impact of background description as much as possible.

Comparison between MC and data (missing)



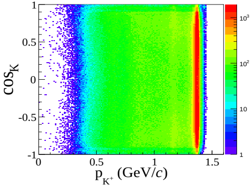
- The signal MC is the DIYMC and the background is got by the inclusive MC. The total event of MC is scaled to data. And the background MC is scaled by the statistics of data.
- The combined MC can described the data well.

Comparison between MC and data (reconstructed)

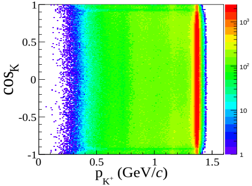


- Situation is similar to the missing.
- The events near the end cap loose a lot.

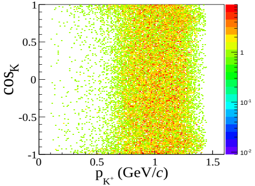
2D distribution



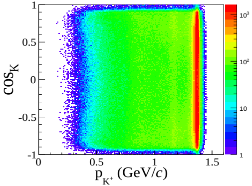
data,missing



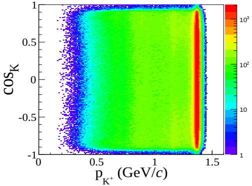
signal,missing



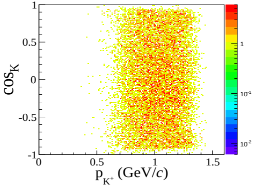
background,missing



data,reconstructed

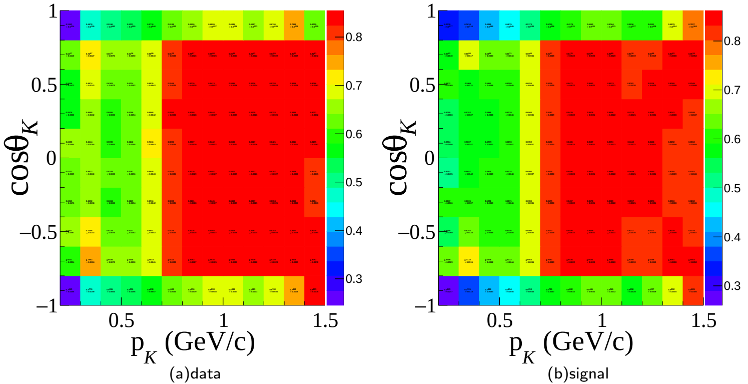


signal,reconstructed



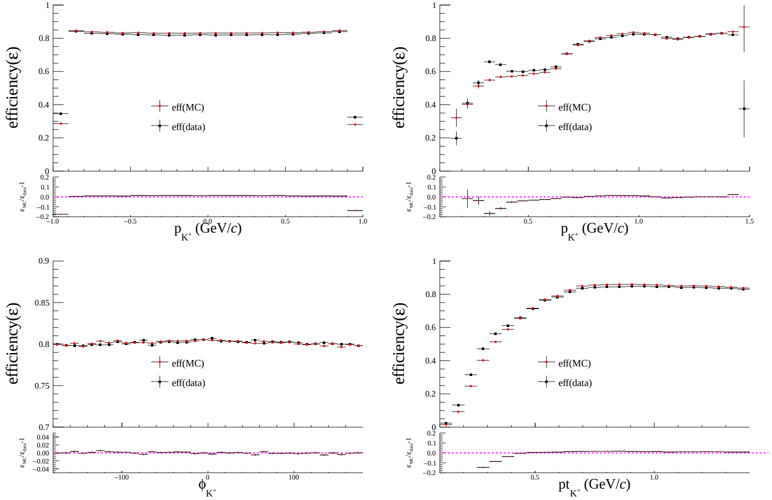
background,reconstructed

2D efficiency



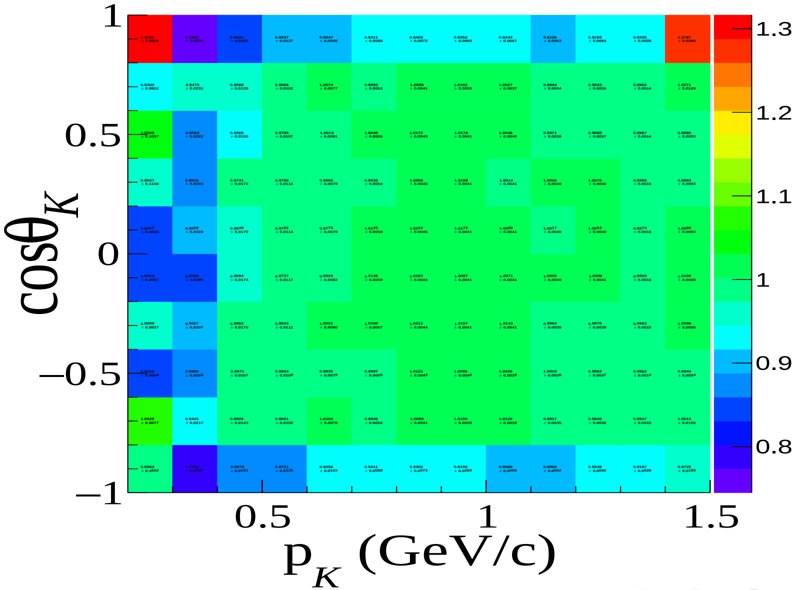
- To get the 2-dimensional efficiency, the 2D histogram of background is firstly scale to the statistics of data. Then it will be subtracted from that of data. Finally we get the efficiency by getting the ratio of the 2 histogram before and after tagging the Kaon.

1D efficiency

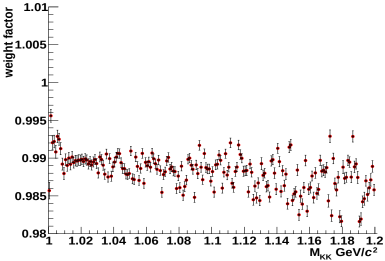


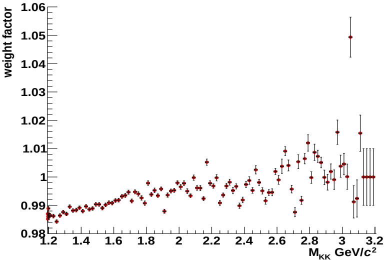
- Great agreement between data and MC near 1 GeV.
- The background has been subtracted from data .

weight factor (2D)



weight factor varies with M_{KK}

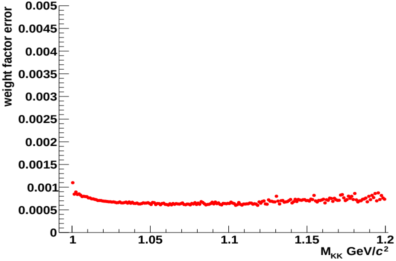




How to get the weight factor varying with M_{KK}:

- Get the $cos\theta_{K^+}$ and p_{K^+} 2D distribution of different M_{KK} bins.
- Then calculate the ratio of each 2D bin to the total event number of the M_{KK} bin and get the corresponding weight factor.
- Sum over the product of the weight factor and the ratio, then we can get the weight factor of the MKK bin. The error of it is calculated as: $err = \sqrt{\sum(ratio * err_{weight})^2}$

Systematic uncertainties of tracking efficiency



- For now, we take the error of the weight factor as the systematic uncertainties. Below the 1.2 GeV/c^2 the systematic uncertainty is taken as 0.1%. From 1.2 to 2.6 GeV/c^2, the systematic uncertainty is taken as 0.2%. Above 2.6 GeV/c^2, the systematic uncertainty is taken as 1%