Phi meson reconstruction in $p+p$ events using the pixel detector

Gergely Patay

June 22, 2006

1 Introduction

Phi mesons are reconstructed from the $\phi \to K^+K^-$ invariant mass spectrum.

2 Reconstruction method

Charged kaons are reconstructed in the pixel detector using the low-pT track finder algorithm. Reconstruction efficiency was investigated for different charged hadrons with single particle events in the 0–1.5 GeV/c^2 pT, $|\eta| < 1$ range. [fig:singletrack–effic]

Efficiency can be estimated for charged kaons with the following fitted function:

$$\epsilon_K(p_T) \approx 0.92 - 2.02 \exp(-8.55 p_T)$$

Fake rate was investigated with $p+p$ minimum bias events. In the kinematical range $p_T > 0.2$, $|\eta| < 1$ fake rate is about FIXME.

3 Track selection, acceptance

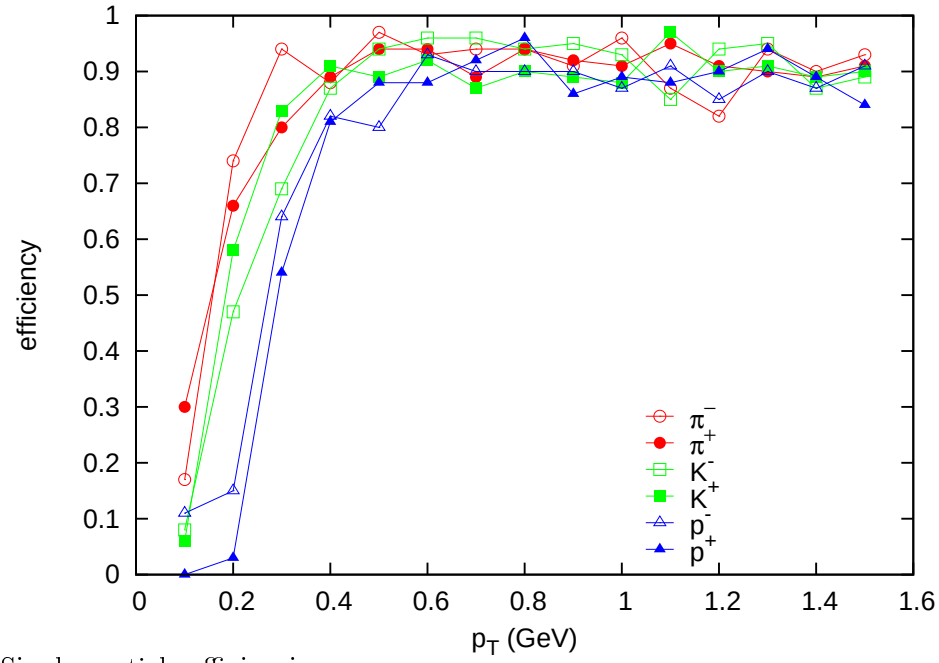
For reliable ϕ reconstruction daughter kaons with $p_T > 0.2$ GeV/c^2, $|\eta| < 1$ were selected. Acceptance was calculated for phi mesons in the p_T–η plane with a toy MC.

For the $|\eta| < 1$, $p_T = 0..2$ GeV range the averaged acceptance is 51%, for $p_T > 0.6$ it is cca. 70% (with kaon efficiency).

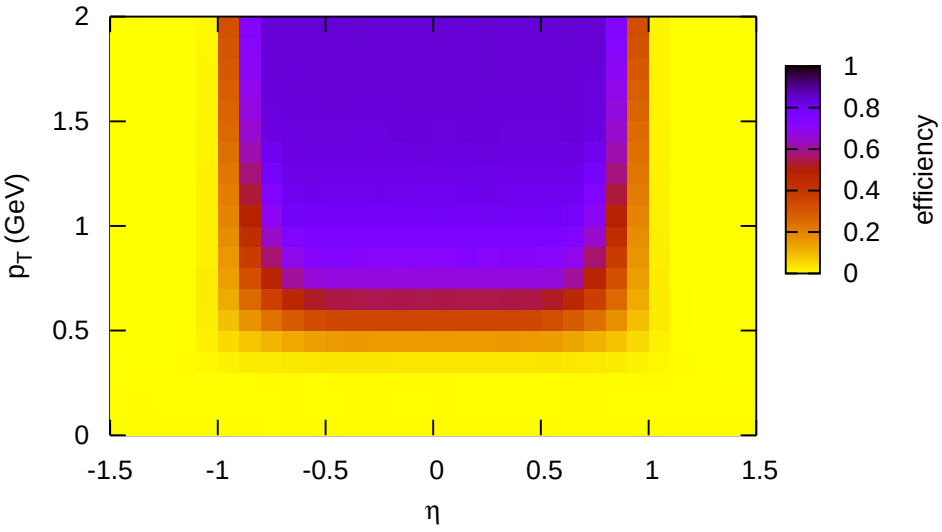
[fig:acceptance]

A cut on the energy loss of charged particles was imposed: only track candidates with $dE/dx > 3500 * (m_K^2/p^2 + 1)$ (unit) were selected. This cut lowers drastically the combinatorical background coming from low pT pions while keeping most of the kaons. [see: fig:spectra w|w/o dE/dx]

Estimation of loss due to dE/dx cut...



Single particle efficiencies



Acceptance of ϕ mesons in the p_T–η plane. Kinematical cuts on kaon momentum and reconstruction efficiency were applied.

4 Detector resolution

The detector bias of phi mass resolution was determined with special events. 5000 single $\phi \to K^+K^-$ decays were generated, fully simulated and reconstructed. ϕ mass was fixed at the m = PDG value with no linewidth. ϕ's were generated with flat p_T and η distribution (p_T = 0..2 GeV, $|\eta| < 1$). These events went through the same analysis as the 'real' events. Mass peak was fitted by both gaussian and BW-type function. The result of the fit is the following:

	m_0 (MeV)	$FWHM$ (MeV)	peak area
like sign bg			
Gaussian	1017.4	12.0	2429
Lorentz	1017.5	9.2	3067
mixed event bg			
Gaussian	1017.4	11.8	2372
Lorentz	1017.5	8.9	2972
simple count of the total histogram			2661
total simulated ϕ's in the kinematical range			3756

The efficiency of ϕ reconstruction for $\phi \to K^+K^-$-only events is cca. 70%. Note the small shift of the reconstructed ϕ mass wrt. the PDG value!

5 Background subtraction

Combinatorical background is subtracted with two different methods.

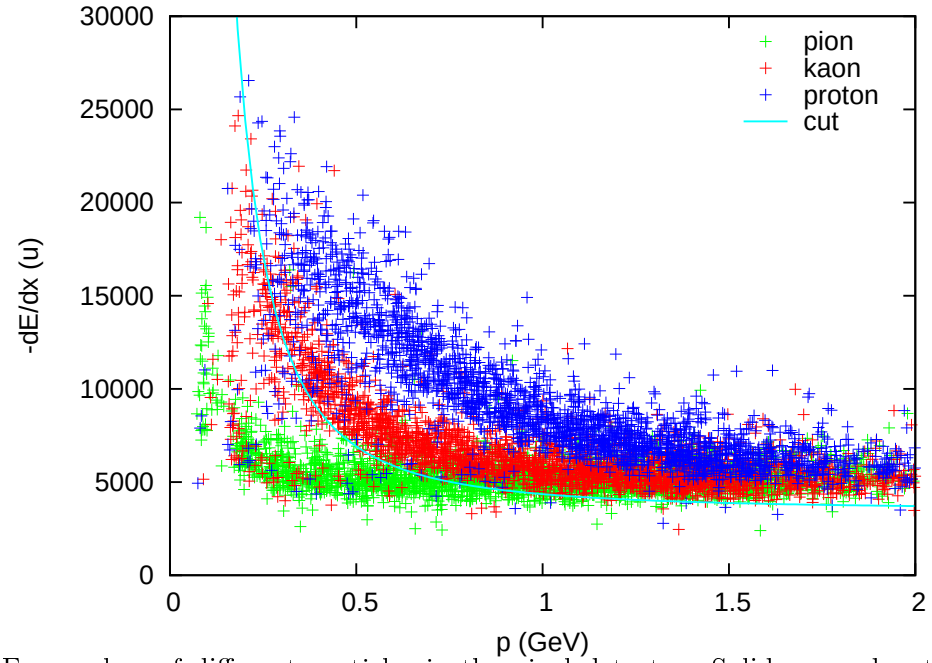
- Like particle background: invariant mass histograms are calculated for each event using like charged particle pairs.

$$N^{ii} = N^{ii}_{+-} - 2\sqrt{N^{ii}_{++} \times N^{ii}_{--}}$$

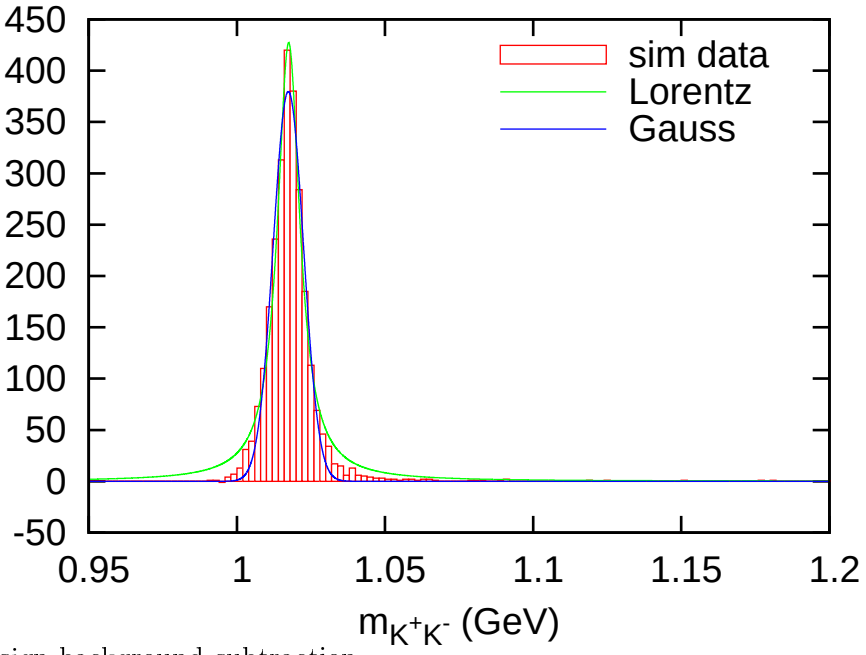
- Event mixing: every event is mixed with n others; choosing the positive particle from the ith, the negative from the jth event and vice versa ($j = i{+}1...i{+}n$). Background histogram is normalised to have the same area as the original one. (Although this is not the most sophisticated normalisation.)

$$N^i = N^{ii}_{+-} - r \times \sum_{j=i+1}^{i+n} (N^{ij}_{+-} + N^{ij}_{-+})$$

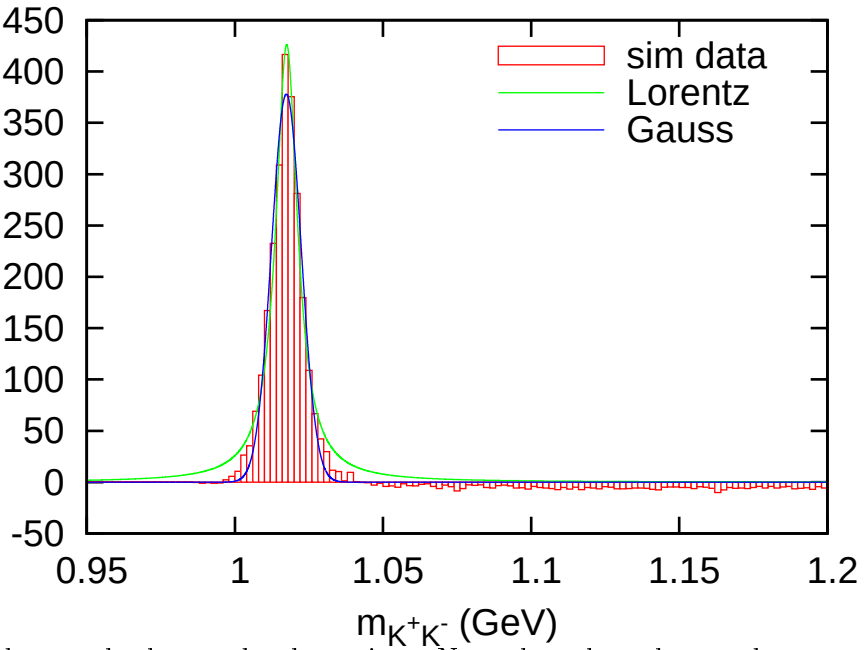
On the figures (XY) one can see the effect of different background subtraction.



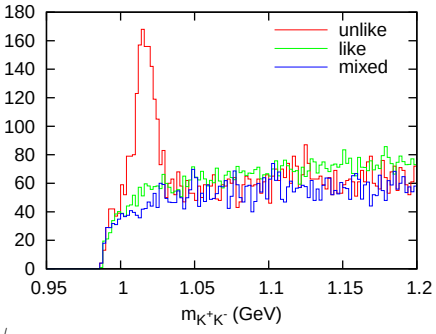
Energy loss of different particles in the pixel detector. Solid curve denotes the applied cut.



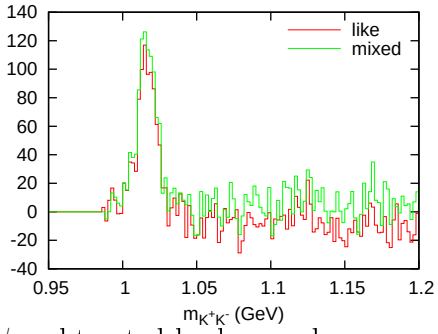
Like sign background subtraction



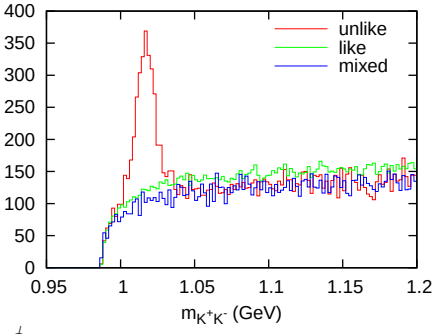
Mixed event background subtraction. Note that the subtracted spectrum goes under 0 because of area normalisation. This is a feature, since this signal-only mixed event histogram can be subtracted from real spectra.



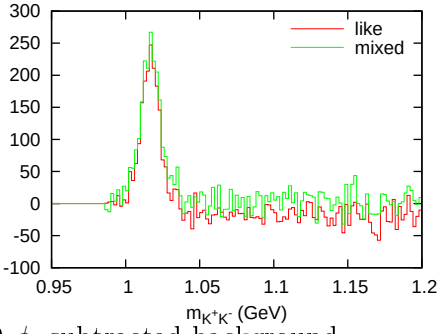
5 ϕ



5 ϕ, subtracted background



10 ϕ



10 ϕ, subtracted background

6 Events

Special event samples were used for the analysis. At CMKIN level for each minbias event 5 (10) $\phi \to K^+K^-$ decays were added. The 1000+1000 modified events were then fully simulated with OSCAR and digitised/reconstructed with ORCA. Embedded ϕ's have flat $|\eta| < 1$, isotropic azimuthal angle and p_T drawn from a $p_T \exp(-p_T/T)$, $T = 300$ MeV [1] distribution, daughter kaons are isotropic in the ϕ's cms.

7 Results

7.1 Total yield

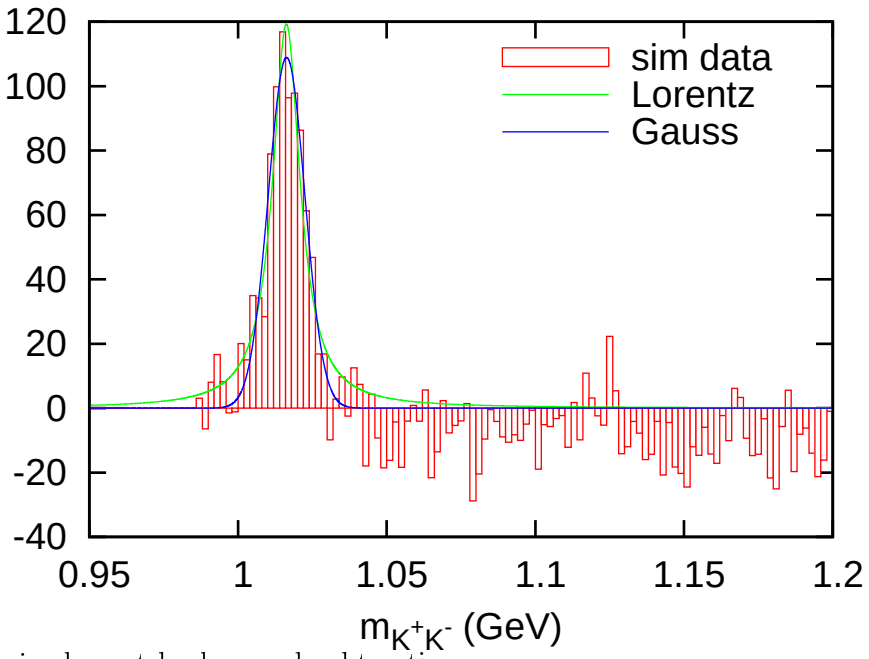
Mass peak was fitted by either a Breit–Wigner or a Gaussian function (the theoretical peak shape should be a Voigt function, ie. BW*Gauss). Peak area was calculated from the fitted parameters. The difference between the two methods shows a cca. 20% systematic error.

5 ϕ / event			
	m_0 (MeV)	$FWHM$ (MeV)	peak area
like sign bg			
Gaussian	1016.3	15.2	985
Lorentz	1016.2	12.4	1287
mixed event bg			
Gaussian		14.5	842
Lorentz		11.2	1052
total simulated ϕ's in the kinematical range			2278
10 ϕ / event			
	m_0 (MeV)	$FWHM$ (MeV)	peak area
like sign bg			
Gaussian	1016.8	16.1	2048
Lorentz	1016.9	12.7	2625
mixed event bg			
Gaussian	1016.7	14.1	1746
Lorentz	1016.8	10.6	2143
total simulated ϕ's in the kinematical range			4574

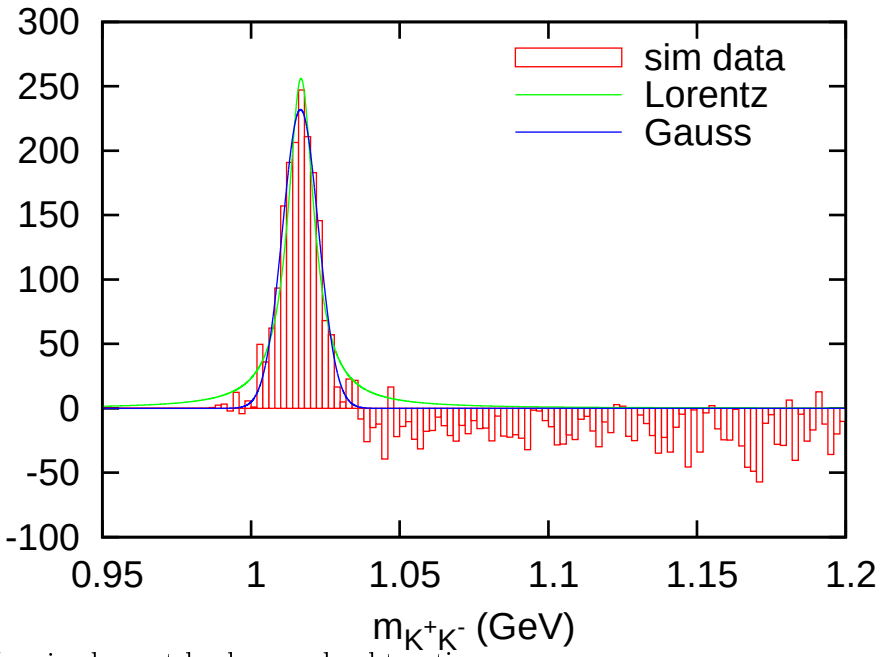
In both samples total phi efficiency is cca. 46% in good agreement with the 51% predicted by toy-MC acceptance study.

Fitted peaks are depicted on the figures (XY) for the different background subtraction schemes.

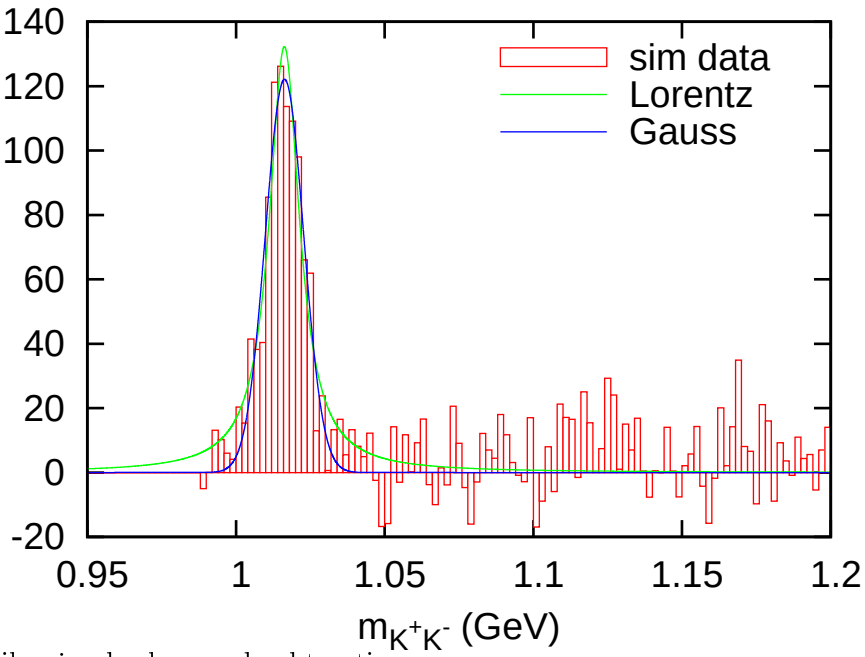
[1] SPS and RHIC data suggest $T \sim 400$ MeV, but for the moment $T = 300$ is perfect



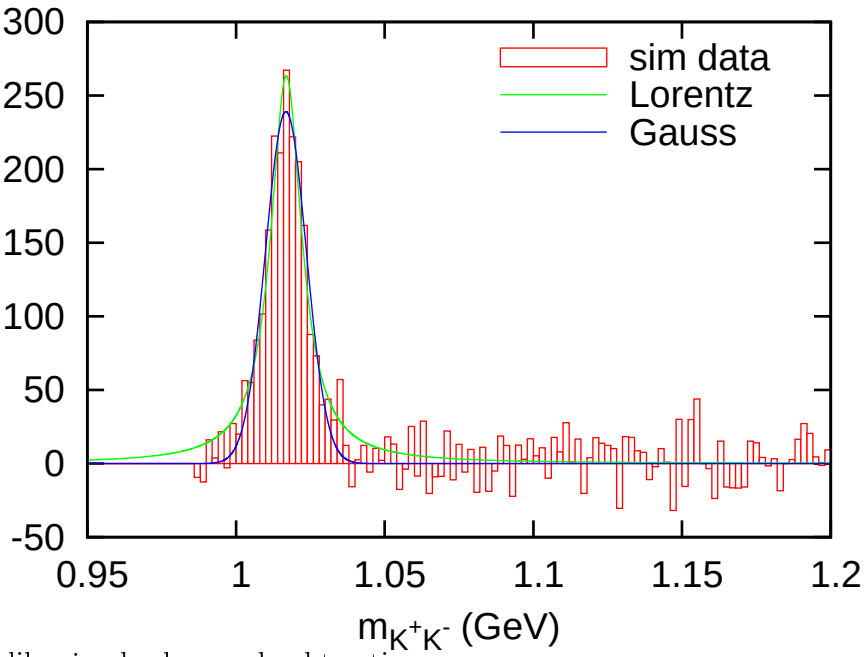
5 ϕ, mixed event background subtraction



10 ϕ, mixed event background subtraction



5 ϕ, like sign background subtraction



10 ϕ, like sign background subtraction

7.2 p_T spectra

The available statistics is not enough to make clear p_T spectra. Generating more events to achieve higher statistics is is progress.