Measurement of D^0 decays to $D^0 \to K_L^0 \pi^0$ and $D^0 \to K_S^0 \pi^0$

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In this presentation…

- Motivation for this analysis
- Selection procedure
- Recapitulation of previous studies
- Detailed Background study
- Priority issues and conclusion

This analysis intends to measure the asymmetry in $D^0 \to K_L^0 \pi^0$ and $D^0 \to K_S^0 \pi^0$.

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- comes from interference in CF and DCS modes of D0 decay, expected up to 5%.
- constrains the strong phase in $K^+\pi^-$, $K^-\pi^+$
- can be calibrated against $D0 \to (\bar{K}^0 \pi^-)_{K^*} \pi+$
- measured at belle, 0.06 ± 0.05 ± 0.05

hep-ex/0107078, July 2001

- measured at cleo 0.122 ± 0.024 ± 0.030

hep-ex/0607068, July 2006

Reconstruction and Event selection

- π^0 from mdst_pi0, $E_\gamma \geq 0.05$ GeV/c^2
- $\pi^\pm$, good charged
- K_S , good Kshort
- K_L , mdst_klong, $D^0 \rightarrow K_L \pi^0$ and $D^0 \rightarrow (K_L \pi^-)_{K^{*-}} \pi^+$ assumed
- $K^{*\pm}$ within 50 MeV of nominal mass
- D^0 within 100 MeV of nominal mass (for K_S modes only)
- $D^{*\pm}$ tags the signal, $M_{D^{*\pm}} \leq 2.03$ GeV
- δM = $D^{*\pm}$ and D^0 mass difference

  $\delta M + 1.8645 \leq 2.03$ GeV

  (for K_S modes only)

- A K_L with ECL cluster energy in 0.15 to 0.3 GeV range (corresponding to minimum ionization energy) rejected
- K^0 flight angle wrt D^0 boost (θ_{DK}), $-0.95 \leq \cos(\theta_{DK}) \leq 0.2$ for all modes
- Invariant mass of $(\pi^+\pi^-) \leq 0.7$ GeV
- Reconstructed scaled momentum of D^*, $0.6 \leq x_p \leq 1.0$

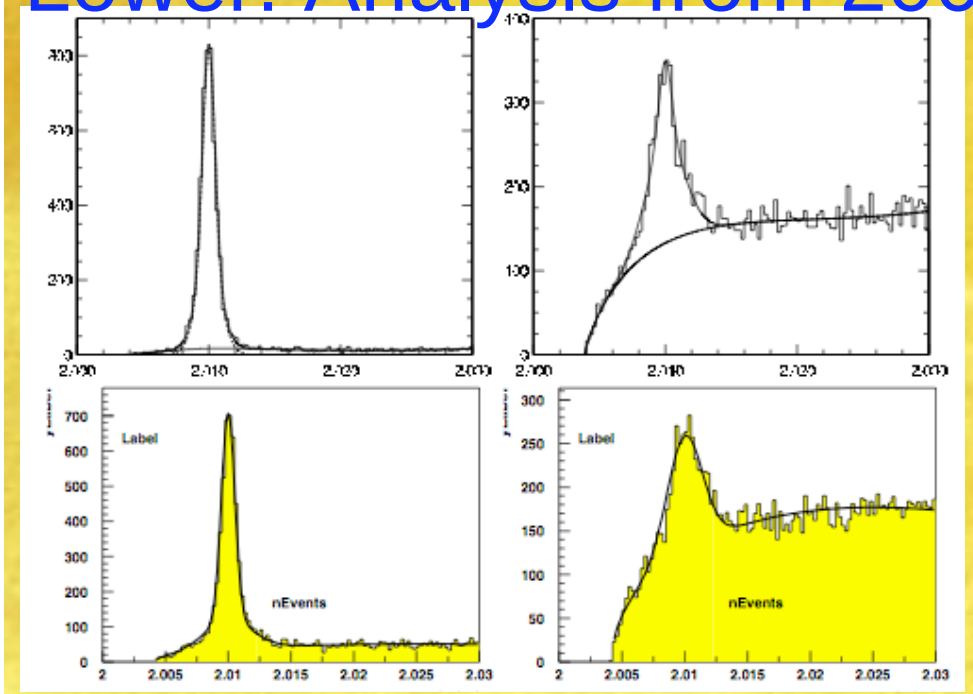
Comparison on same data

		This analysis	2001, Belle conf 0129
yield	$D^0 \to K_S \pi^0$	6739	4715 ± 91
	$D^0 \to K_L \pi^0$	3943	1839 ± 101
	$D^0 \to (K_S \pi^+) \pi^-$	3432	2524 ± 77
	$D^0 \to (K_L \pi^+) \pi^-$	2617	1119 ± 84
selection	K_S selection	Good kshort	Tighter vertex
	π^0 /$\pi^\pm$ selection	π^0 from mdst_pi0, $E_\gamma \geq 0.05$ GeV/c^2 $\pi^\pm$, good charged	Standard (?) procedure, 2001
fitting	Signal	Double Gaussian Mean of Gaussian fixed to D* nominal mass	Double Gaussian (KS modes), Single Gaussian (KL modes), means fixed
	Background	Threshold function	1st Poly x sqrt threshold

On 23.6 fb^{-1} from Experiment 7, 9, 11, 13

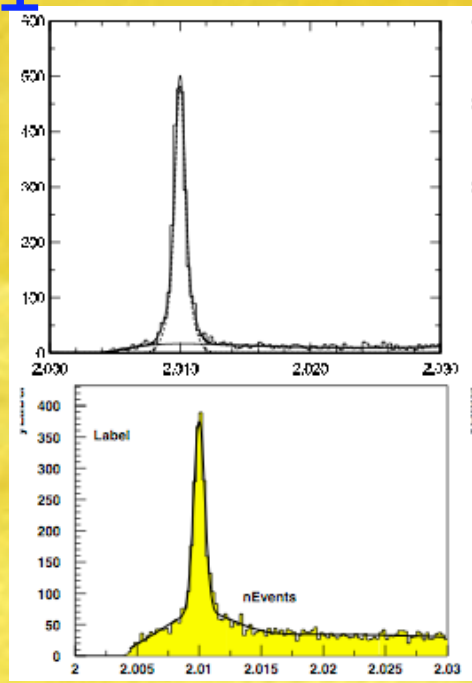
Upper: This Analysis,

Lower: Analysis from 2001

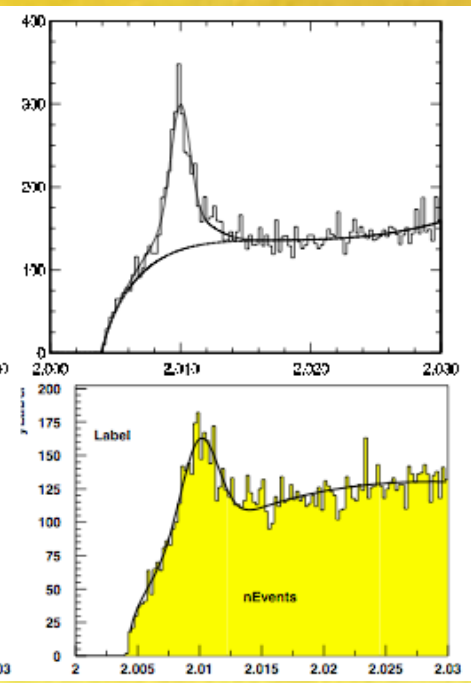


$D^0 \to K_S \pi^0$

$D^0 \to K_L \pi^0$



$D^0 \to K_S \pi^+ \pi^-$



$D^0 \to K_L \pi^+ \pi^-$

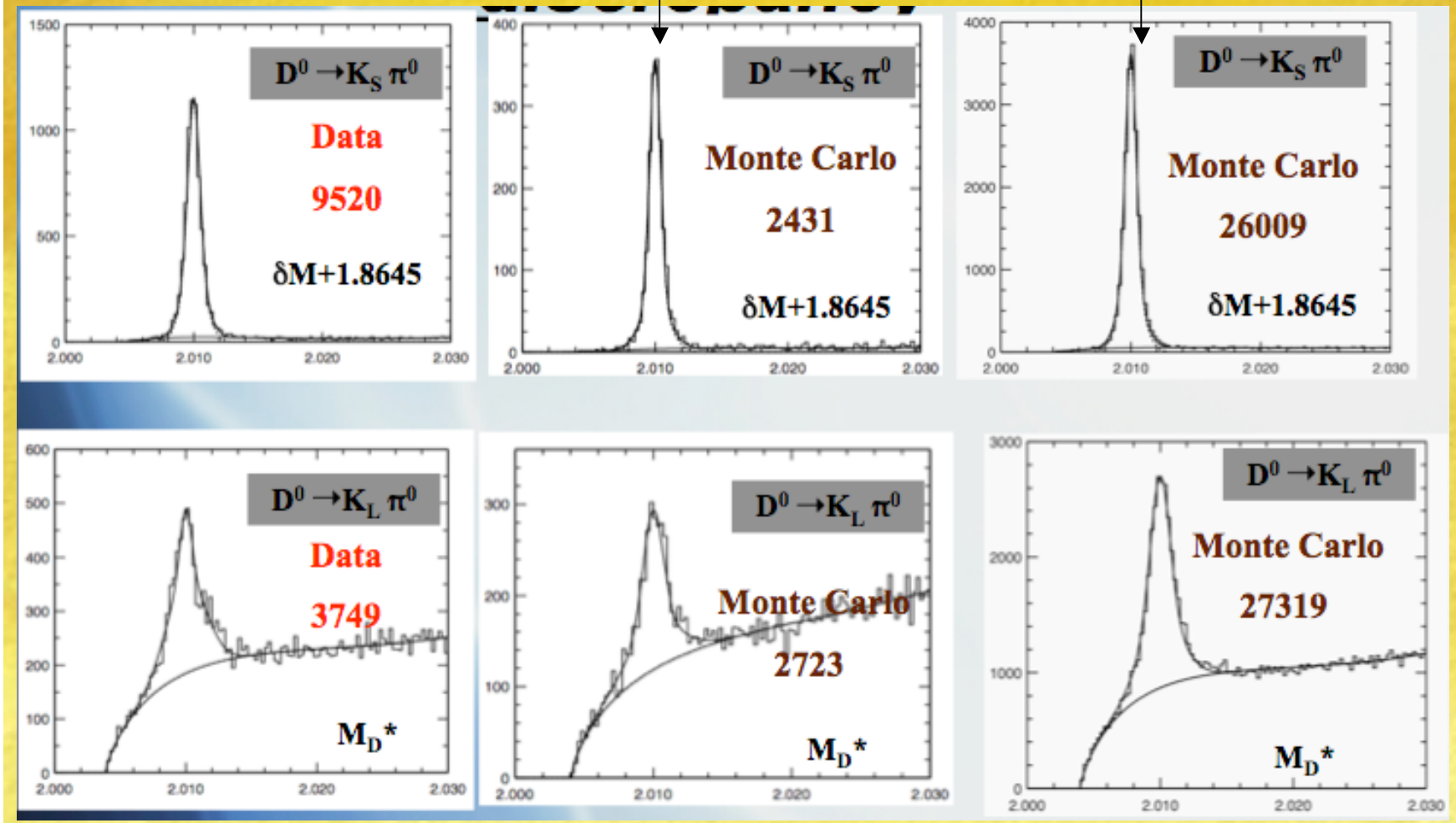
The data-MC discrepancy !!,

BAM Sept 2005

Data = 32.37 fb^{-1}

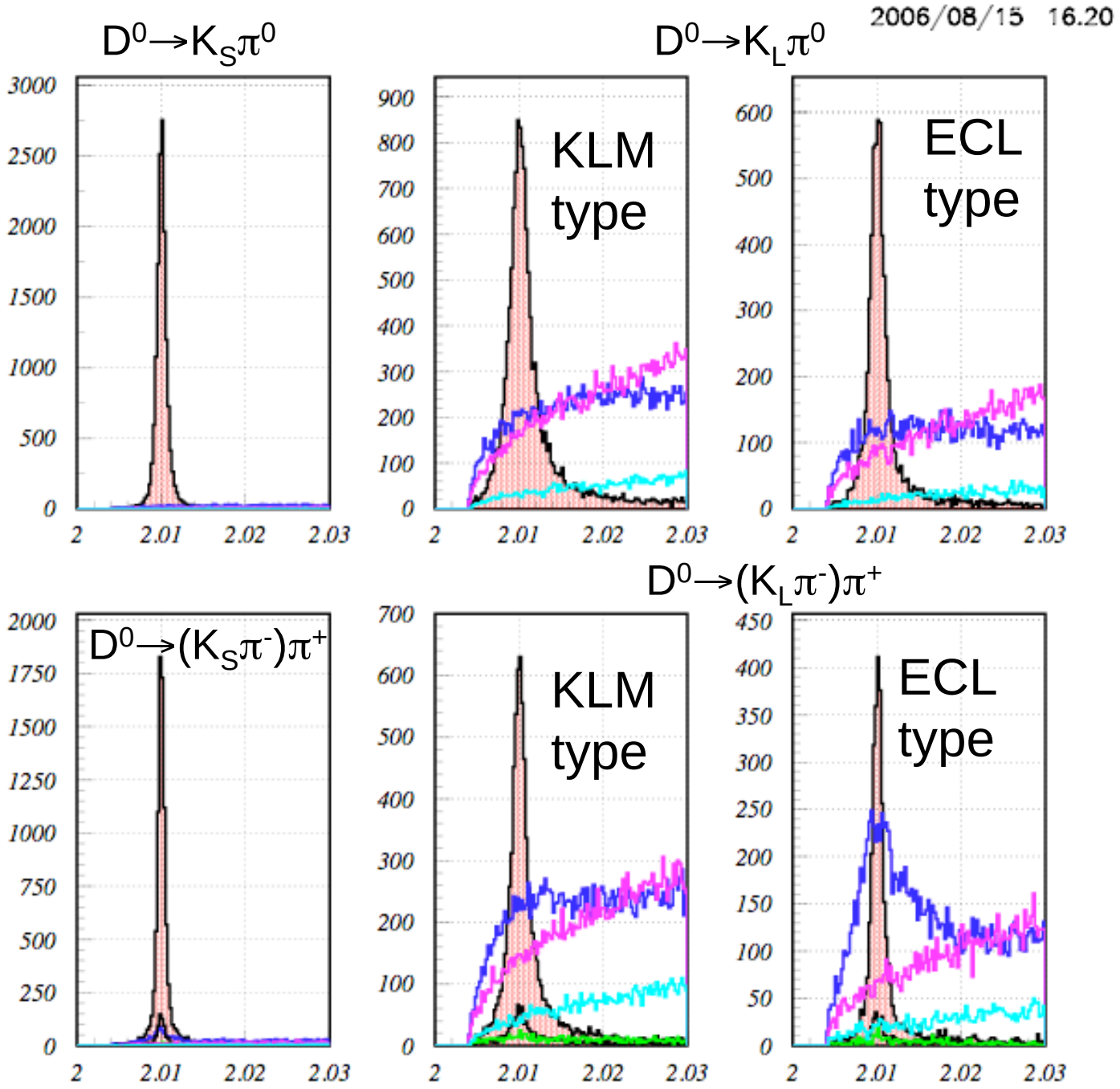
MC = ~2.7 x Data

Missing cont. data | **Correct**



Detailed background study follows…

- MC truth study has been done by tagging specific decay modes at the generated level in the analysis code and vetoing or allowing them at the n-tuple level.
- Overall event composition study is shown in next page followed by detailed breakdown of background modes in the later slides.



Signal in Red

Peaking background from $\bar{K}^0/K^0\,\rho^0$

Background from other broad resonances

Unknown peaking +

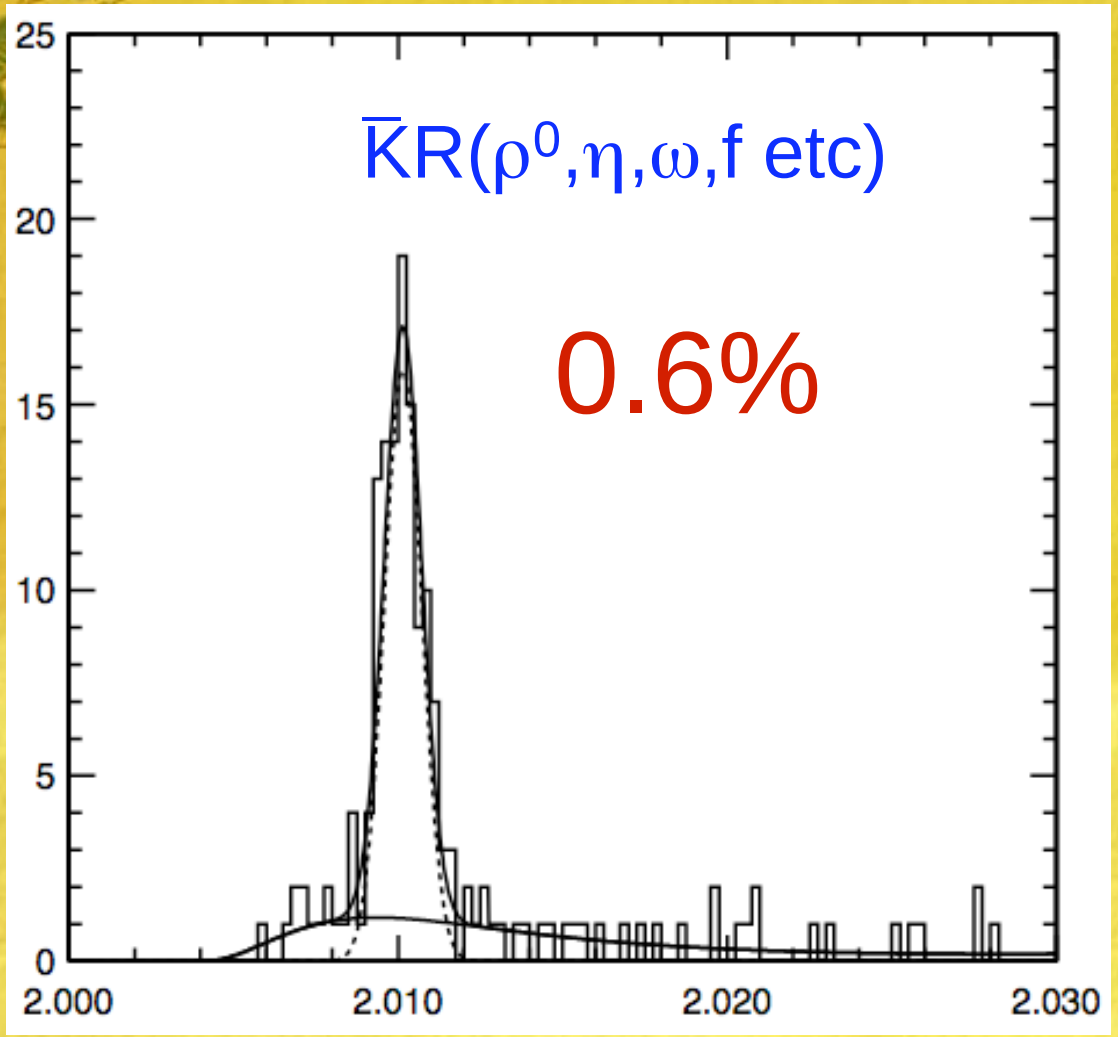
rest of c cbar background

uds background

mixed + charged background

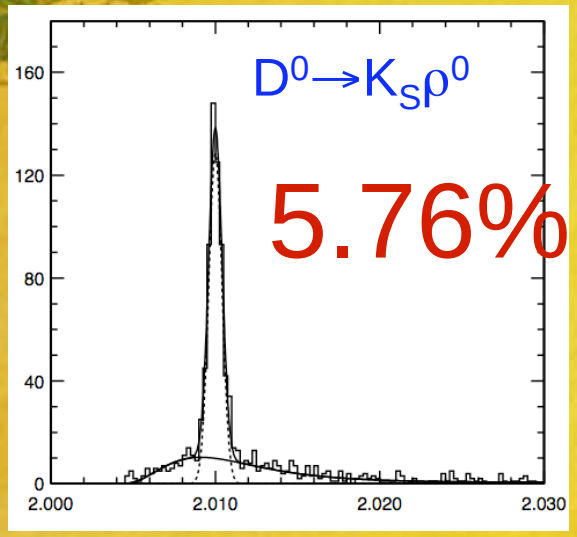
	yield	$\bar{K}R$, $R=\rho^0$, η,ω,f etc	$K^-\pi^+$	$K^{*-}K^+$	$K^{*+}K^-$
$D^0\to K_S\pi^0$	13959. +/- 133.06	91.49 +/- 11.07 (~0.6%)	---	---	---
$D^0\to K_L\pi^0$ KLM type	8957.6 +/- 302.57	---	---	---	---
$D^0\to K_L\pi^0$ ECL type	5313.6 +/- 320.34	---	---	---	---

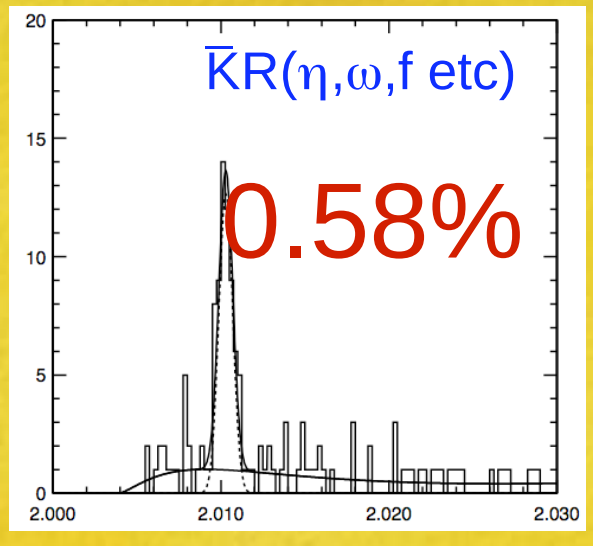
	yield	$\bar{K}R$, R= ρ^0	$\bar{K}R$, R= η,ω,f etc	$K^-\pi^+$	$K^{*-}K^+$	$K^{*+}K^-$	Still not known
PDG 2006 BF In %		0.75+0.6-0.8		3.8± 0.07	0.2±0.11	0.37± 0.08	
$D^0\to(K_S\pi^-)\pi^+$	7937.6 +/- 101.70	521.96 +/- 26.49 (5.76%)	52.59 +/- 8.23 (0.58%)	39.19 +/- 7.48 (0.43%)	86.11 +/- 9.56 (0.83%)	78.54 +/-8.91 (0.87%)	334.57 +/- 56.56 (3.70%)
$D^0\to(K_L\pi^-)\pi^+$ KLM type	4665.5 +/- 121.76	354.22 +/- 37.89 (6.98%)	55.88 +/- 19.94 (1.10%)	---	---	---	---
$D^0\to(K_S\pi^-)\pi^+$ ECL type	2334.3 +/- 62.81	155.43 +/- 16.05 (3.58%)	35.15 +/- 8.08 (0.81%)	115.49 +/- 26.22 (2.66%)	30.12 +/- 46.03 (0.69%)	72.00 +/- 21.56 (1.66%)	1595.8 +/- 307.71 (36.78%)

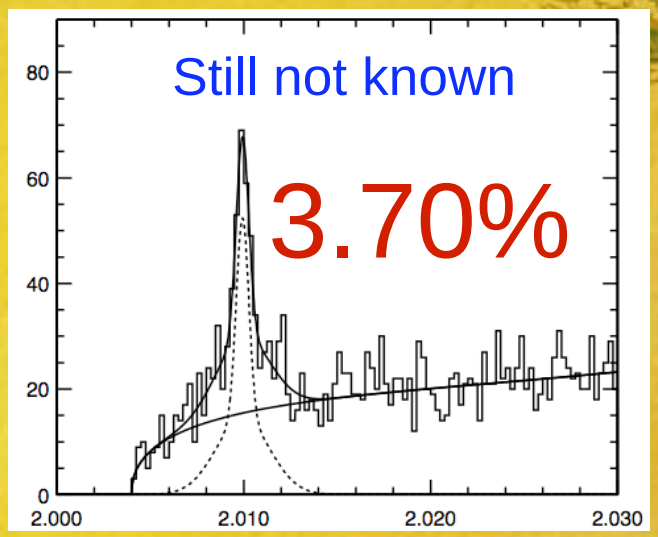


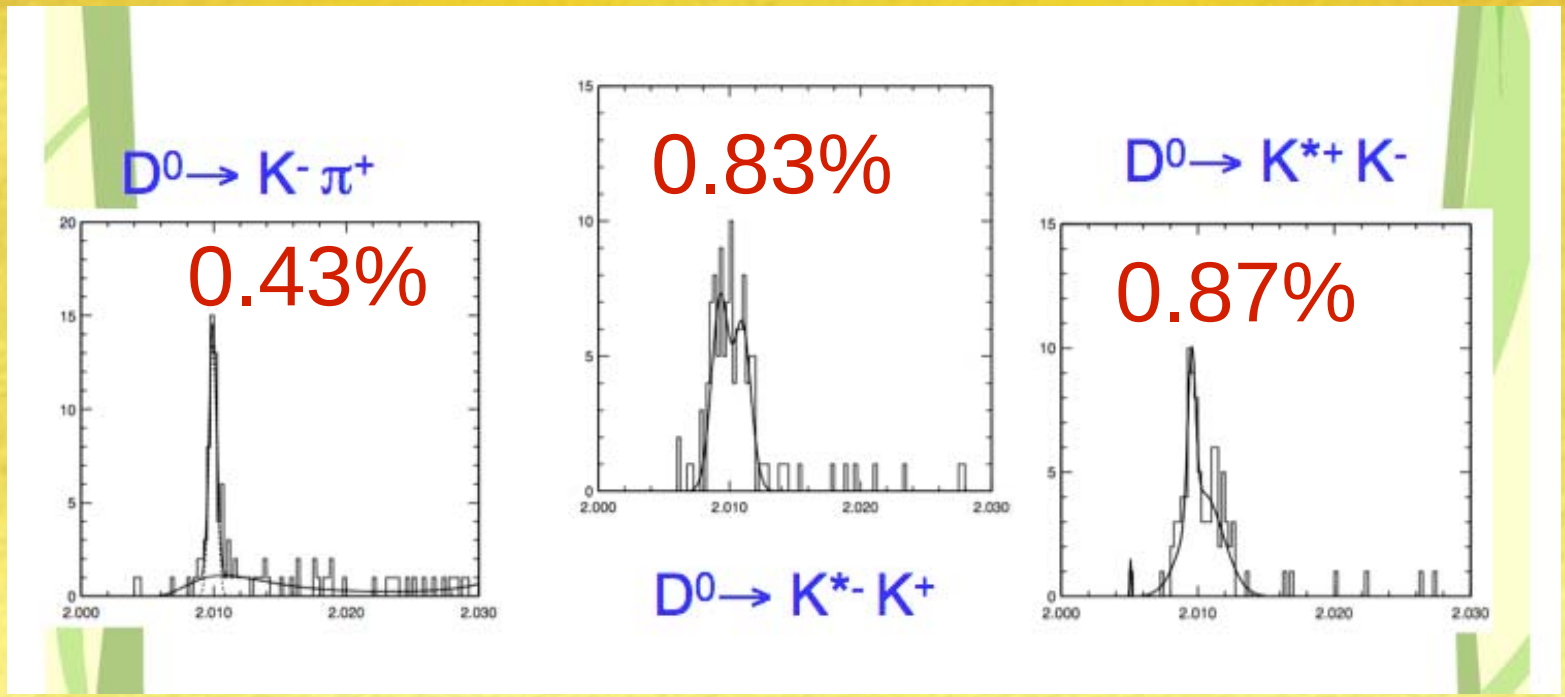
The only peaking background in Signal Mode appears in $D^0 \to K_S\pi^0$ mode with negligible yield.

Peaking backgrounds in $D^0 \to (K_S \pi^-)\pi^+$

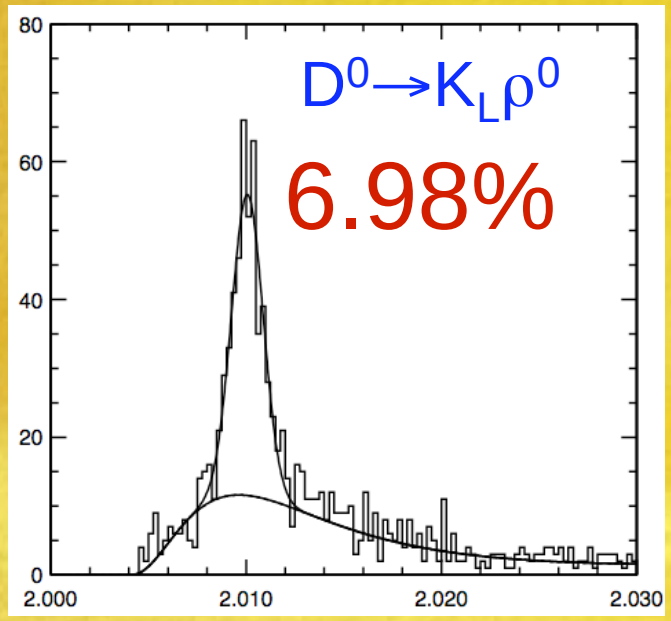


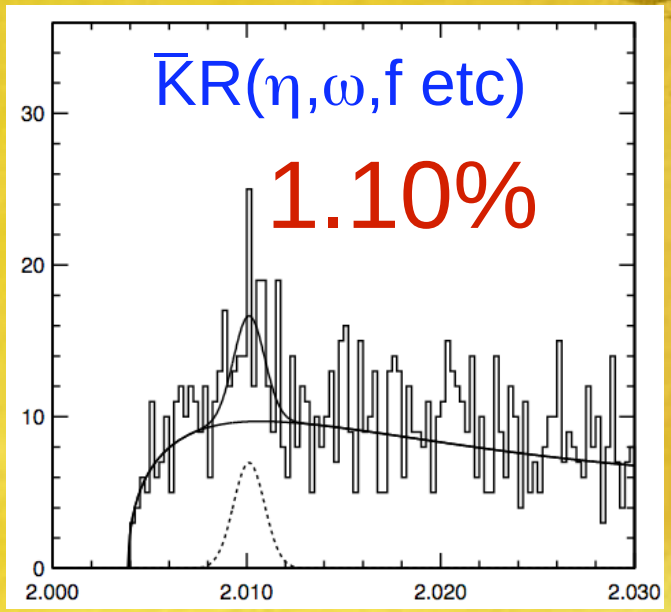


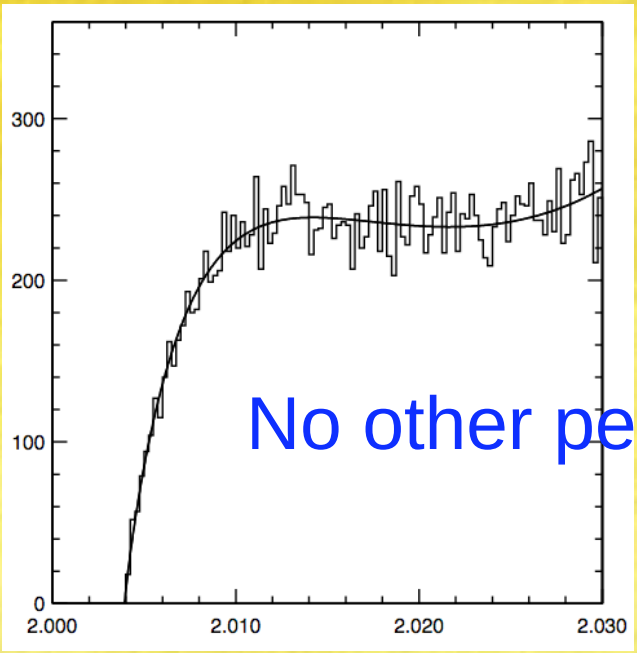




Peaking backgrounds in $D^0 \to (K_L \pi^-)\pi^+$, KLM type

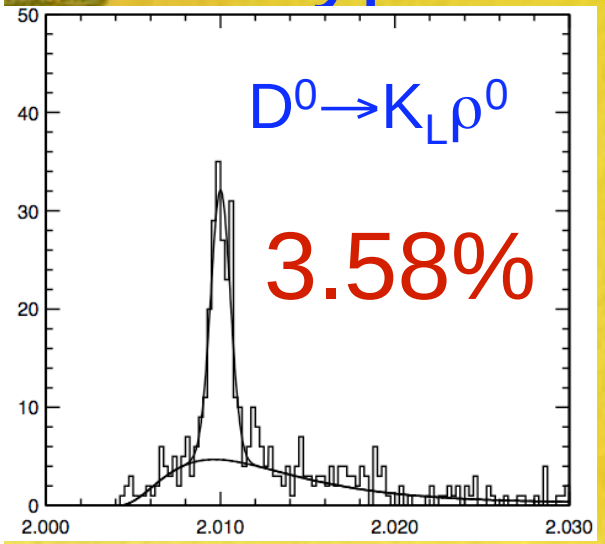


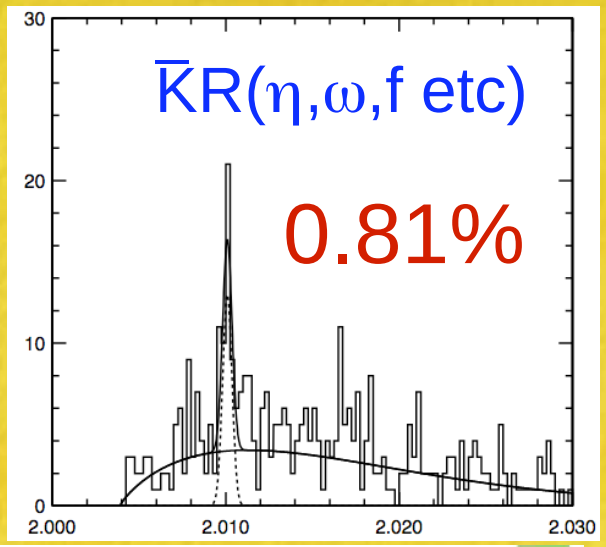


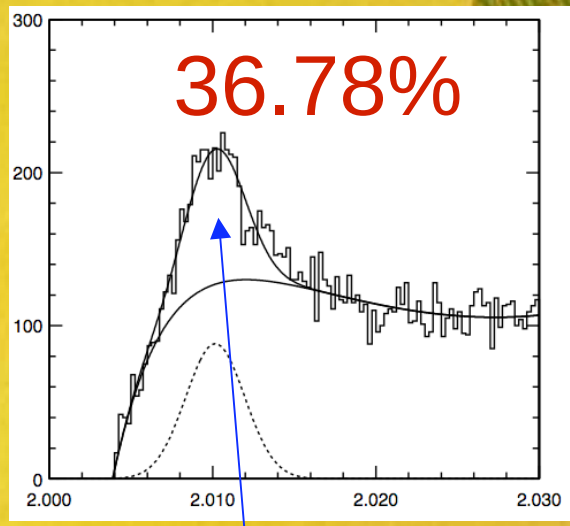


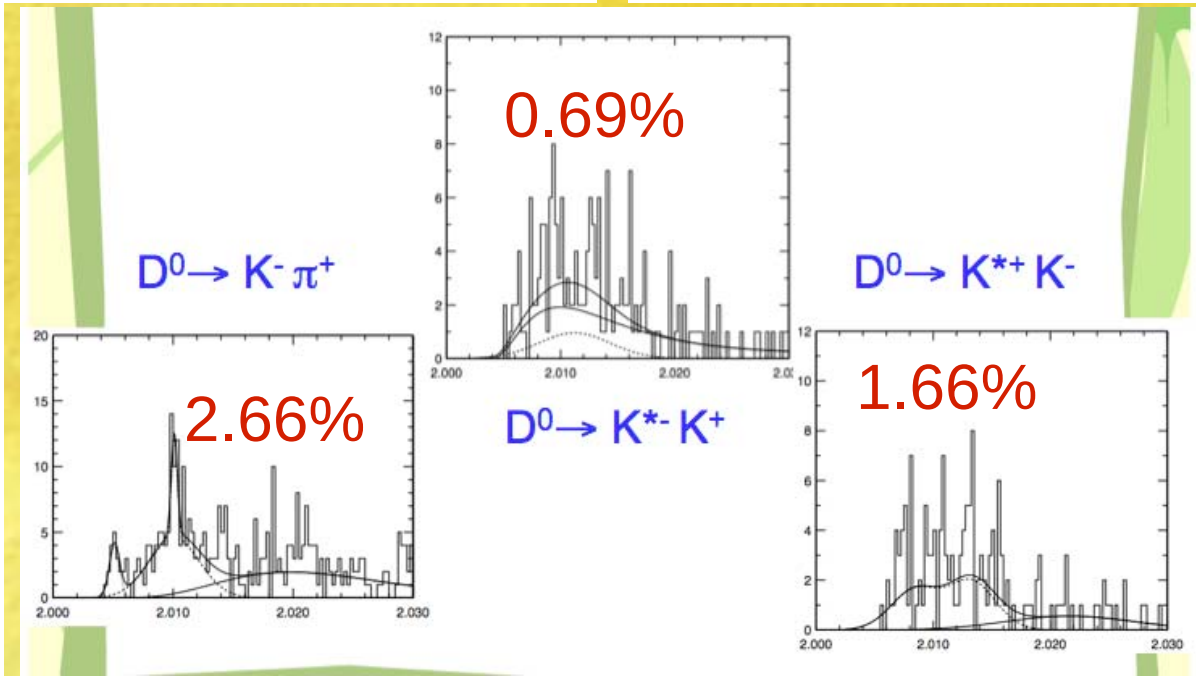
No other peak in $c\bar{c}$

Peaking backgrounds in $D^0 \to (K_L \pi^-)\pi^+$, ECL type









The unknown bump.
If we discard all ECL KL then loss in signal efficiency: 37.23% in signal mode.

33.34% in calibration mode.

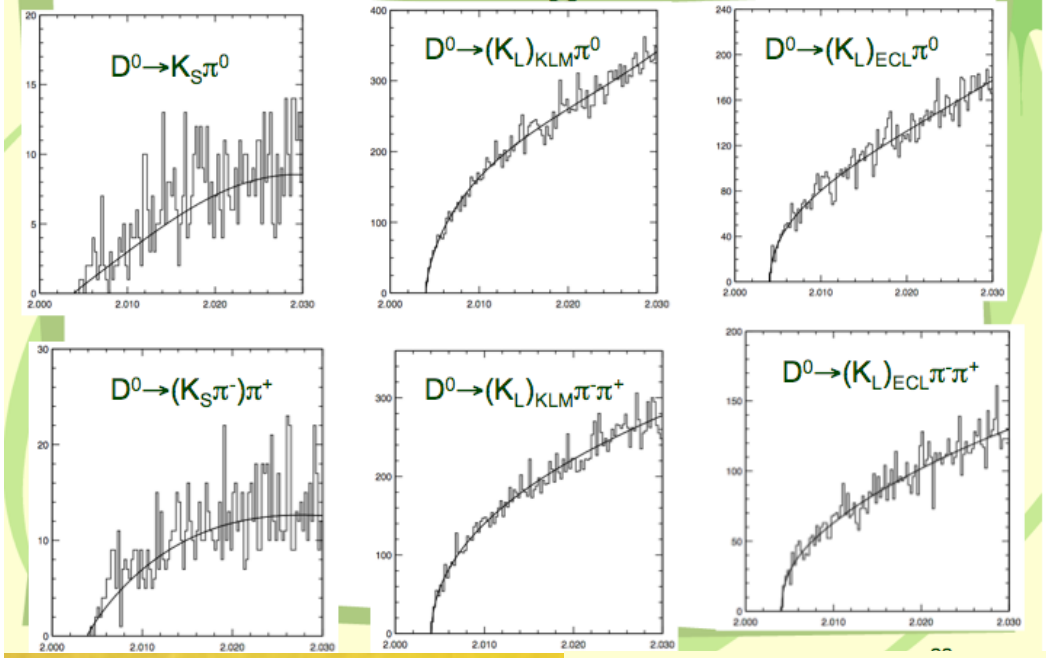
Investigation for the unknown bump…

- Scanned ECL variables in calibration mode. Didn't find any strange behavior.
- Checked $\pi^+ \pi^- \pi^0$ and $\pi^+ \pi^- K_L$. No peaking background from these sources.
- $K^-\pi^+$,$K^{*-}K^+$, $K^{*+}K^-$ don't account much for the bump.

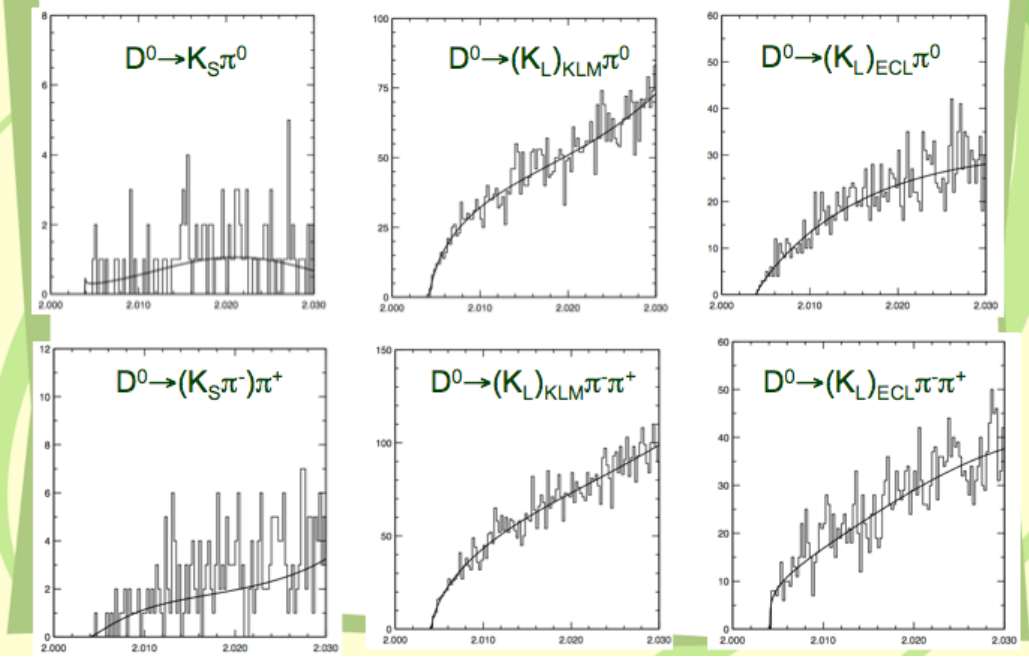
Conclusion.

- The peaking background yields will be estimated from MC. Uncertainty of PDG BF will introduce systematic error into asymmetry.
- The ECL in Calibration is suffering from most of the peaking backgrounds. It also has a strange huge bump with unknown source so far. We propose to discard the ECL solution for our estimation of asymmetry.

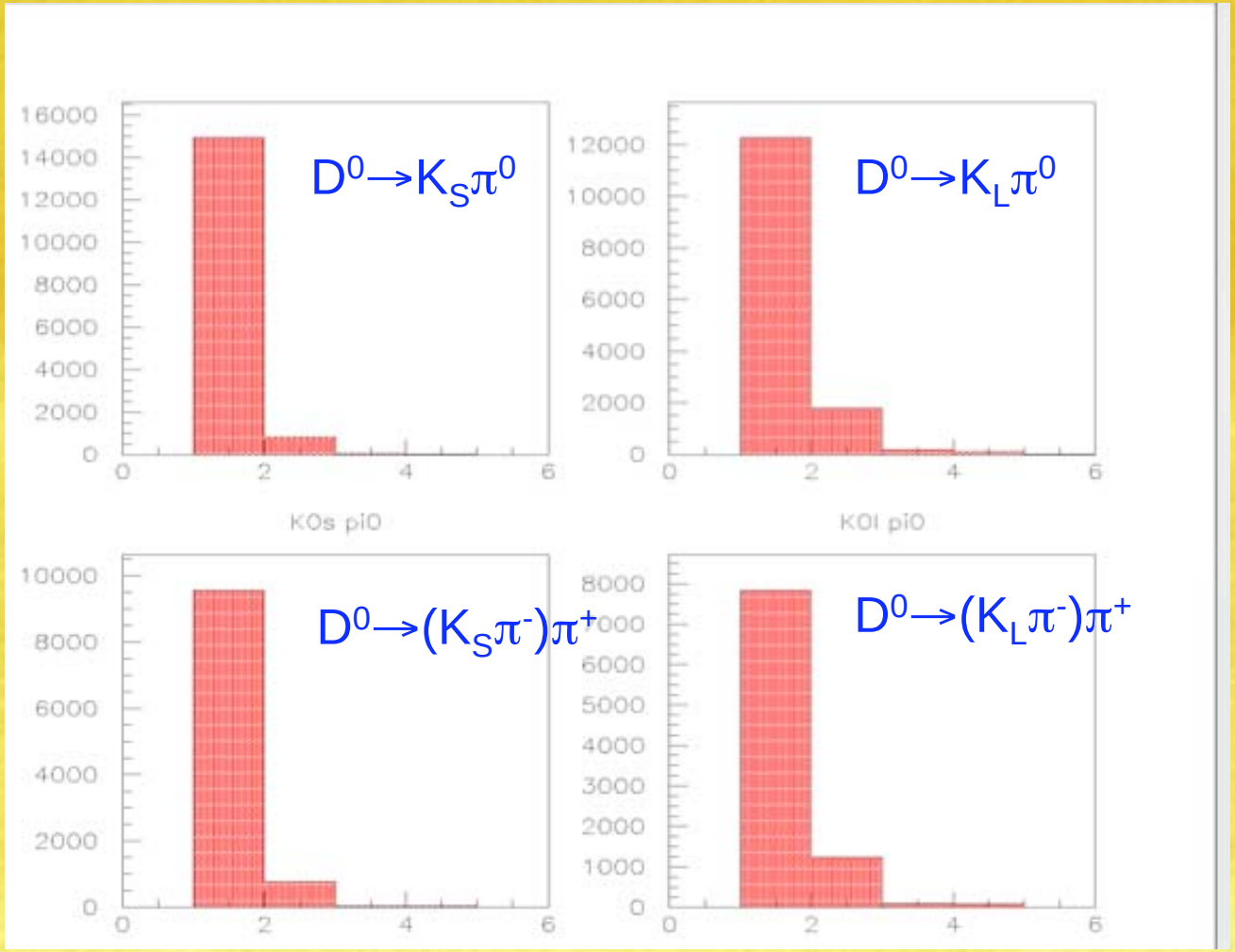
uds background



b bar background



Multiple candidates



Issues to be dealt on a priority basis.

- More MC statistics. Extend MC to exp 23. (~100/fb) Skim finished $c\bar{c}$ MC. Extend the analysis to Exp 23 in MC.
- Belle Note started, will finish in 1 week.
- Bias and fit method systematics study from MC true # and fit yield.
- Asymmetry in data by smearing Pseudo KL direction to match KL direction resolution.
- No best candidate selection. Estimate error of this in asymmetry.
- Update to full data.
- Abstract submitted for DPF/JPS.