Study of $\mathbf{D^0 \to \pi^+\pi^-\pi^+\pi^-}$ @ 3770

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Outline

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- Data Set
- Event Selection
- Background Study
- Summary and Next to do

Motivation

- Study of $\mathrm{D}^0 \to \pi^+\pi^-\pi^+\pi^-$ can provide important input for the determination of CKM unitarity triangle angle γ in $B^{\pm} \to DK^{\pm}$ process.
  - Global F_+ can be got from model-independent/dependent method.
  - Binning F_+ or c_i, s_i can be tried.

CLEO-c
Phys. Lett. B747 (2015)
JHEP05(2017)143

- CLEO-c and FOCUS have studied the resonance structure of $\mathrm{D}^0 \to \pi^+\pi^-\pi^+\pi^-$, more precise result can be got by using the large and clean D^0 sample in BESIII .

Data Set

- Boss Version: 6.6.4.p02
- Data: ψ(3770) data (2010 & 2011, $2.92 fb^{-1}$)
- Generic MC (round03 & round04):
  - 77M $e^+e^- \to \psi(3770) \to D^0\bar{D}^0$ (QCMC) 10.8X
  - 91M $e^+e^- \to \psi(3770) \to D^+D^-$ 10.8X
  - 15M $e^+e^- \to \psi(3770) \to \text{non}D\bar{D}$ 10.8X
  - 102M $e^+e^- \to \gamma_{ISR}\psi(2S)$ 10.8X
  - 33M $e^+e^- \to \gamma_{ISR}J/\psi$ 10.8X
  - 366M $e^+e^- \to q\bar{q}$ 7.3X
  - 90M $e^+e^- \to \tau^+\tau^-$ 10.8X

Event Selection

Three Flavor Tag modes: $\bar{D}^0 \to K^+\pi^-, K^+\pi^-\pi^0, K^+\pi^+\pi^-\pi^-$

- **Good charged tracks**:
  |Rz|≤10cm, |Rxy| ≤ 1cm, |cosθ| ≤0.93 ;

- **Good Photons:**
  - Barrel : $E_\gamma > 0.025$GeV, |cosθ |≤ 0.8
  - Endcap : $E_\gamma > 0.05$GeV, 0.84≤|cos θ |≤ 0.92
  - Time cut: 0≤ T≤ 14 (in unit of 50 ns);
  - |dang|> 20^o;

- **PID (SimplePID Package):**
  - Use dE/dx and TOF
  - Pion: prob(π) > prob(K);
  - Kaon: prob(K) > prob(π);

- **π^0 Candidates :**
  0.115<M(γγ)<0.150 GeV/c^2, X^2_{1c}<20;

- **Tag D Reconstruction:**
  - $\Delta E = E_D - E_{beam}$, $|\Delta E| < 0.1$ GeV
  - $M_{BC} = \sqrt{E^2_{beam} - \vec{P}^2_D}$, $M_{BC} > 1.83$ GeV/c^2
  - Minimum ΔE is used to select best candidate

- **Signal D Reconstruction:**
  - No extra good charged track except 4π
  - $|\Delta E| < 0.1$ GeV
  - $M_{BC} > 1.83$ GeV/c^2

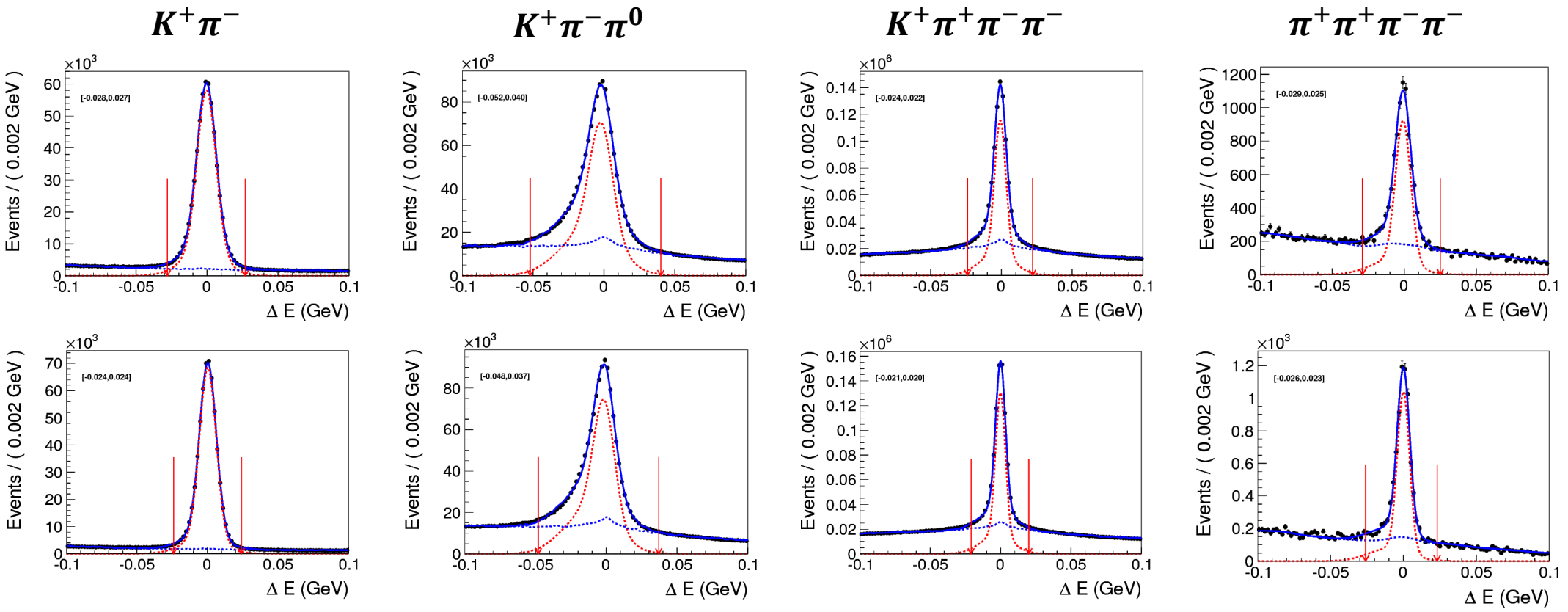
- **Kinematic Fit (5C):**
  4C for all track and 1C for signal D mass, χ^2_{5C}<200

- **K^0_S Veto for Signal Side and K3π tag side:**
  $|M(\pi^+\pi^-) - 0.4976| > 0.03$ GeV/c^2

Event Selection (ΔE cut optimization)

Data

MC

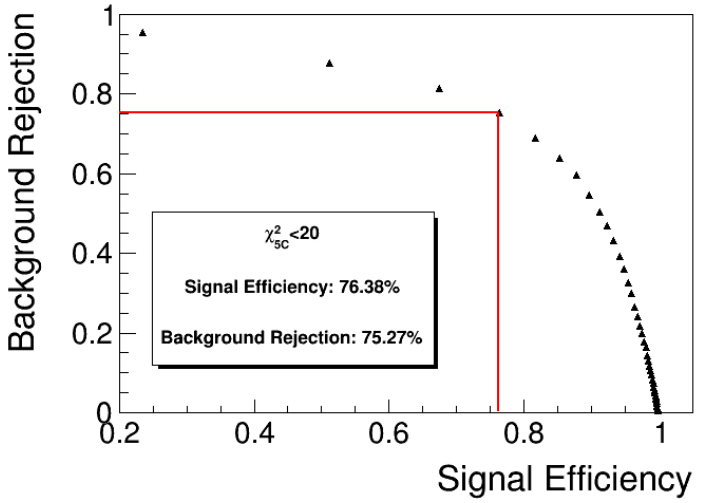


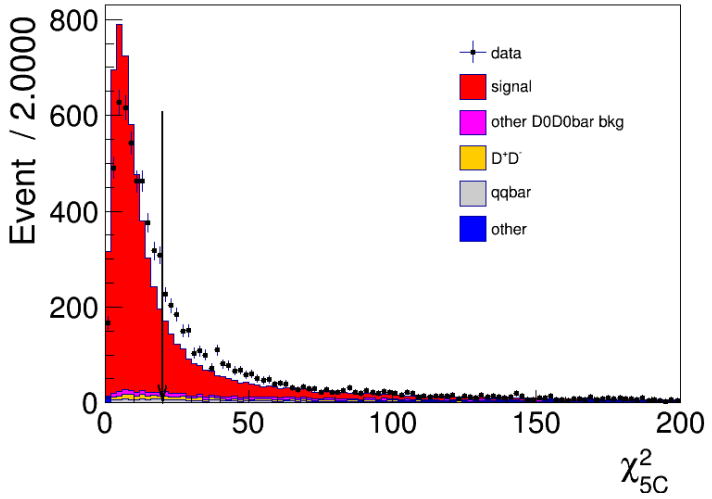
Signal is fitted by double-Gaussian
ΔE cut set to be 3σ of double-Gaussian

ΔE cut (GeV)	$K^+\pi^-$	$K^+\pi^-\pi^0$	$K^+\pi^+\pi^-\pi^-$	$\pi^+\pi^+\pi^-\pi^-$
data	[-0.028,0.027]	[-0.052,0.040]	[-0.024,0.022]	[-0.029,0.025]
MC	[-0.024,0.024]	[-0.048,0.037]	[-0.021,0.020]	[-0.026,0.023]

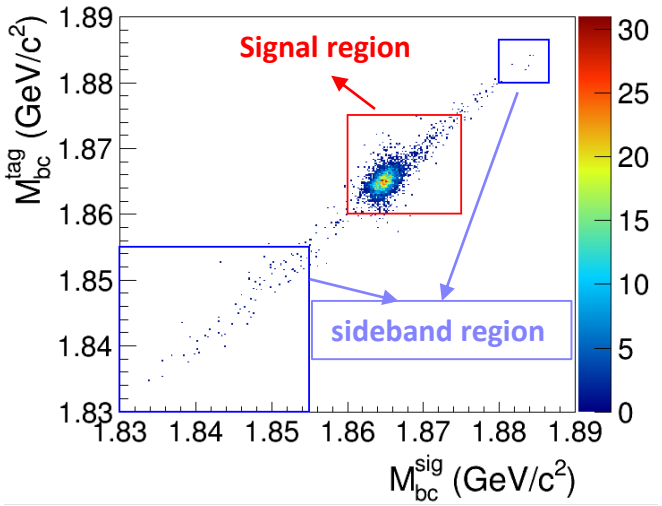
Event Selection (χ^2_{5C} cut optimization)

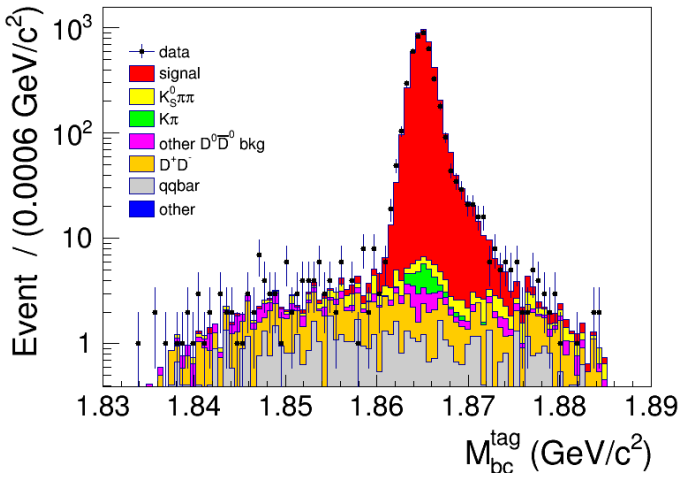
- χ^2_{5C} cut is determined by ROC of MC
  - signal region:
    $1.86 < \mathrm{M}^{\mathrm{tag}}_{\mathrm{BC}} < 1.875, 1.86 < \mathrm{M}^{\mathrm{sig}}_{\mathrm{BC}} < 1.875\ \mathrm{GeV/c^2}$
  - Signal: tag and signal is true
    (contain wrong side of tag mode)
  - Background: tag or signal or both is wrong
- Require χ^2_{5C}<20
- Purity in MC ~97.00% after cut
- Signal efficiency: ~76.38%
- Background rejection: ~75.27%

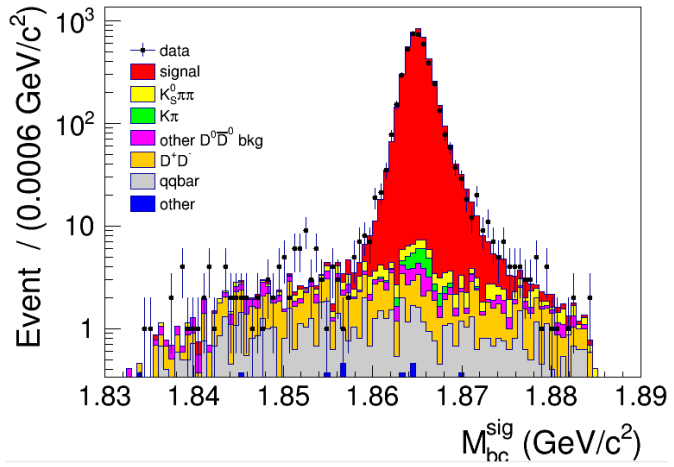


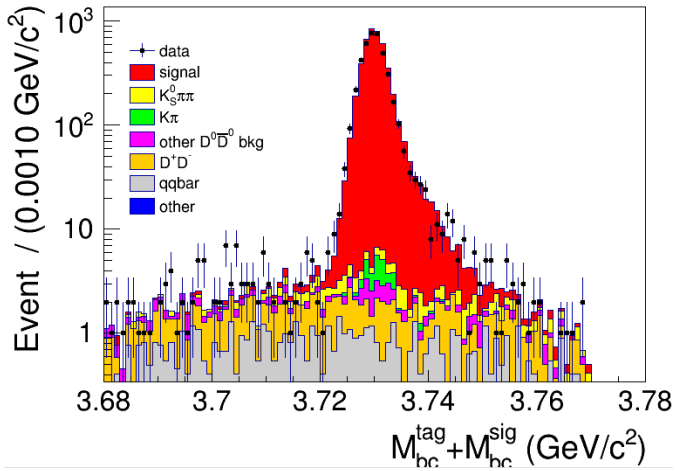


Background Study





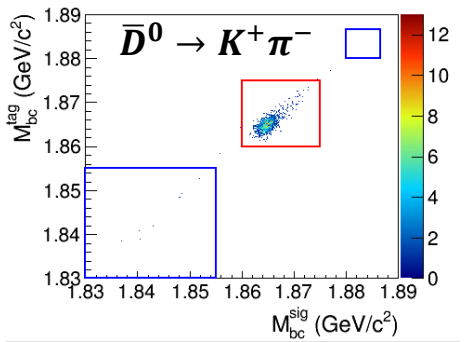


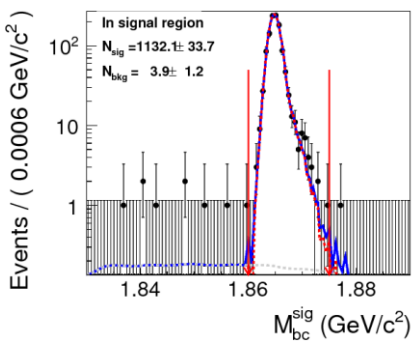


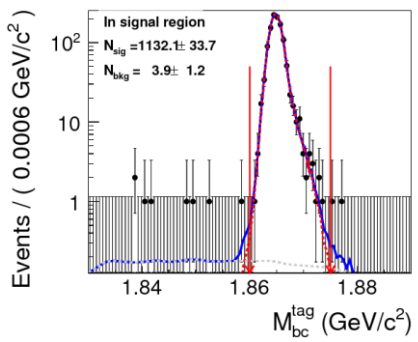
- Peaking background in MC
  - $D^0 \to K_S^0\pi^+\pi^-$ ~0.76%
  - $D^0 \to K^-\pi^+$ ~0.19%
  - Which can be estimated by MC
- Non-peaking background in MC
  - ~2% which can be estimated by using event in sideband region

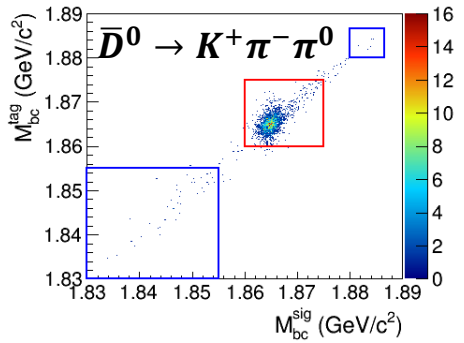
(Fraction of background is got from MC)

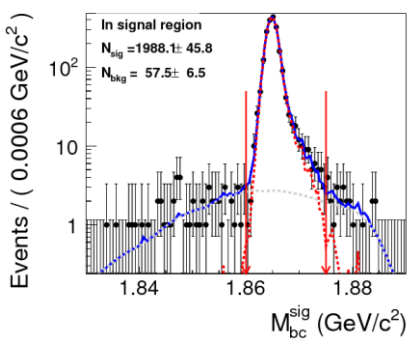
Background Study (fit to data)

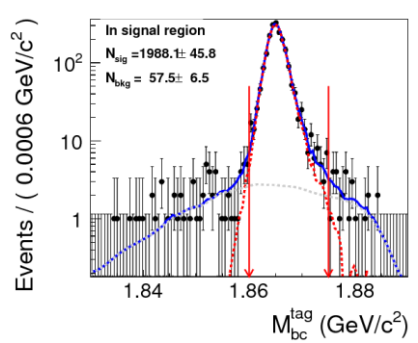


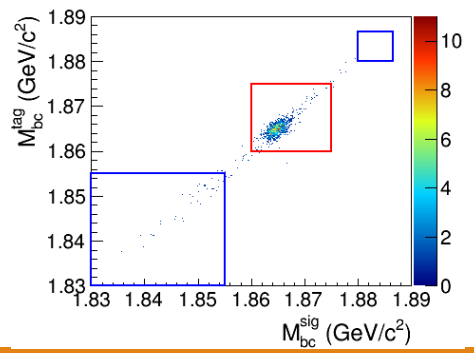


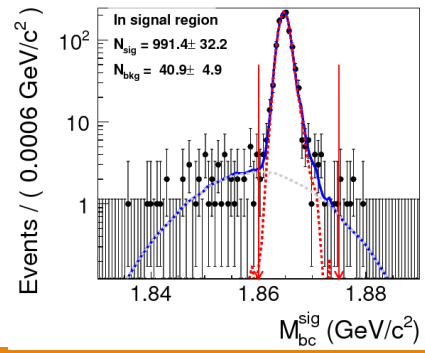


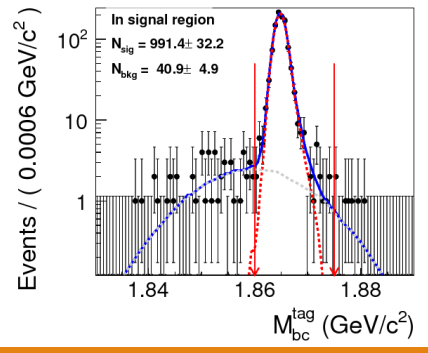












2D Fit to M_{BC}

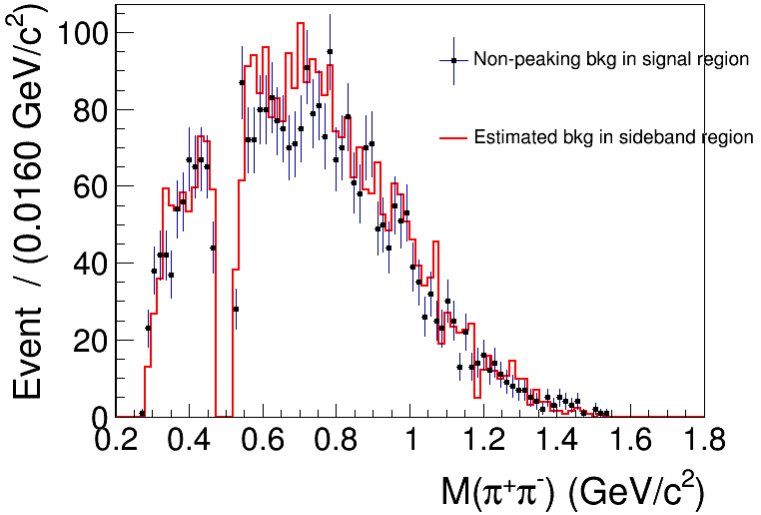
- Signal Pdf:
  - $a(x,y) \otimes g(x;\mu_x,\sigma_x) \otimes g(y;\mu_y,\sigma_y)$
  - $a(x,y)$ is 2D signal MC shape (HistPdf)
  - g(x),g(y) are Gaussian function, the parameters are determined from 1D fit

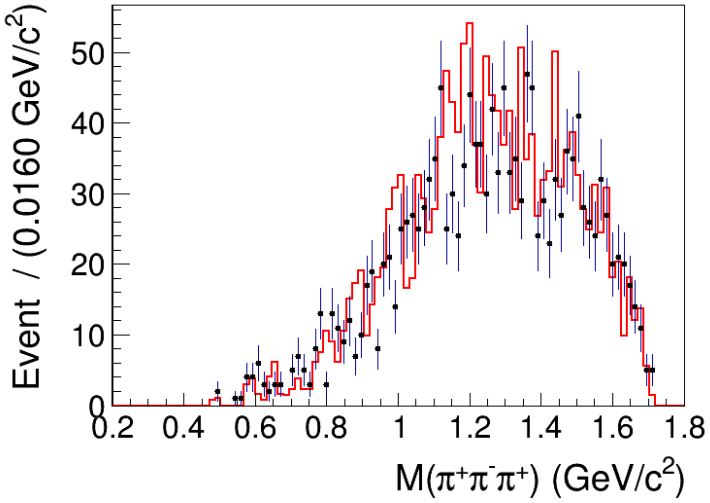
- Background Pdf:
  - $g(x-y;\mu_0,\sigma_0) * (f * c(x+y;m_0,\xi,\rho) + (1-f) * g(x+y;\mu_1,\sigma_1))$
  - g(x-y) is Gaussian function, the parameters are determined from 1D fit
  - c(x+y) is argus function with m_0=1.8865*2, $\rho = 0.5$.
  - f is a fraction [0,1]
  - For tag mode $\bar{D}^0 \to K^+\pi^-$, f=1

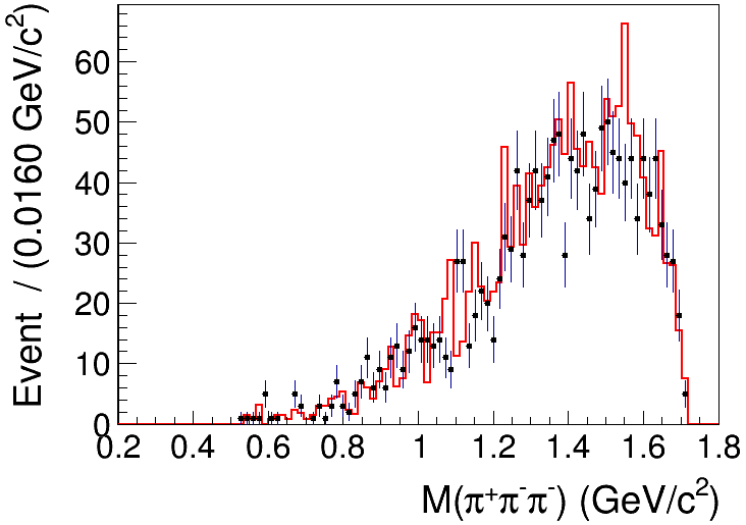
Fit signal event: 4111+-66
Fit non-peaking background: 103+-8

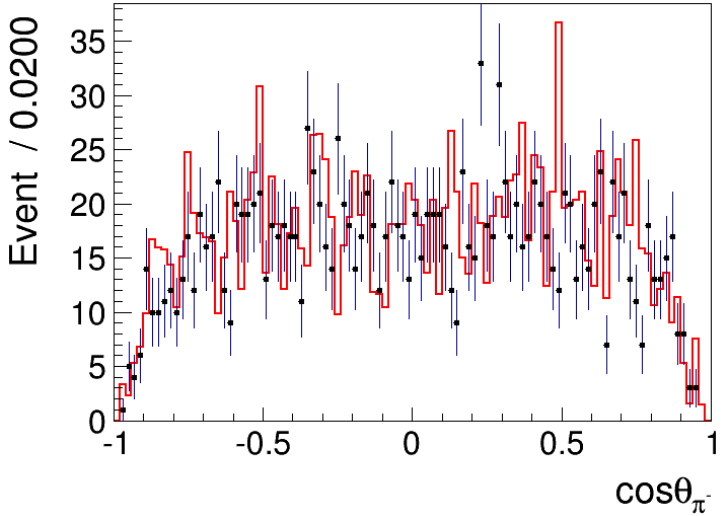
Background Study (MC test)

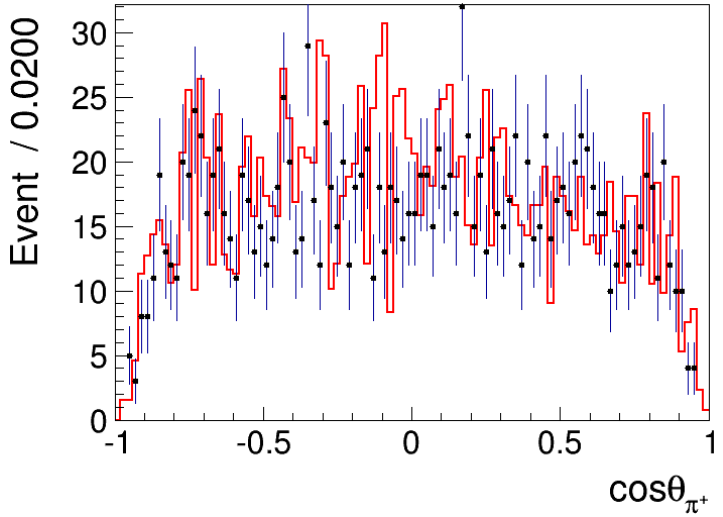
- Same fit is performed to MC and use sideband to estimate non-peaking background
- Event fix to non-peaking bkg fit value
- non-peaking background can be described well by using the event in sideband region







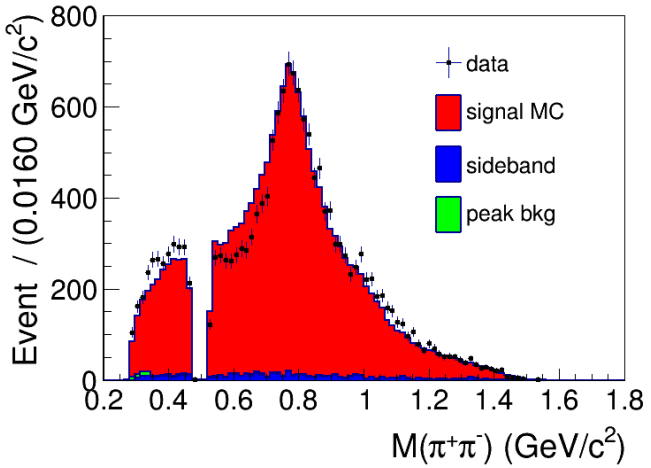


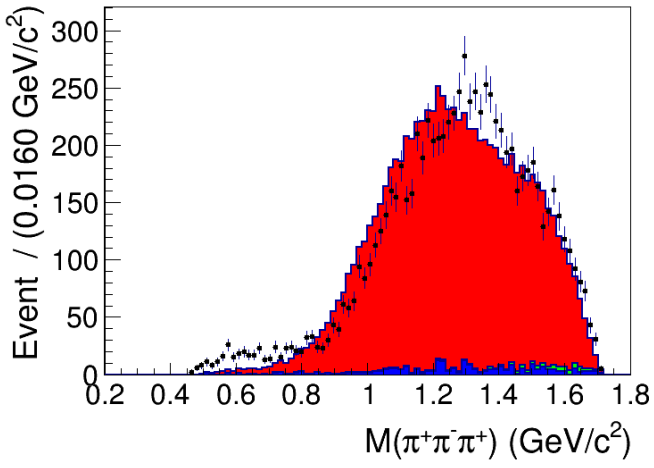


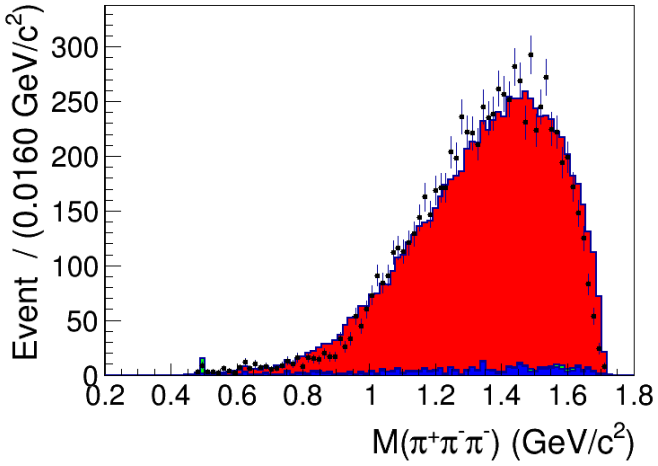
Background Study

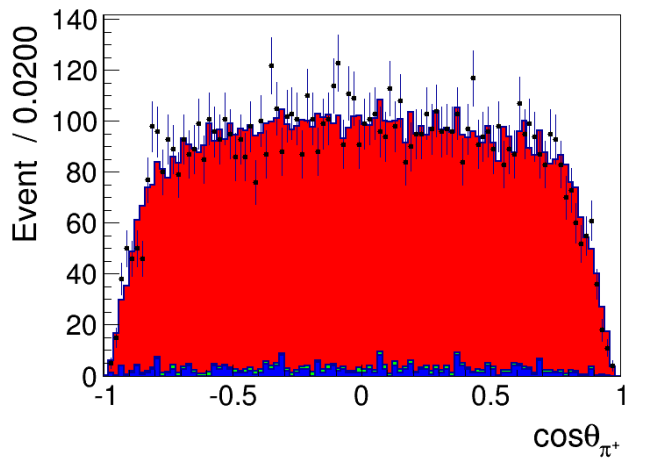
Compare MC and data

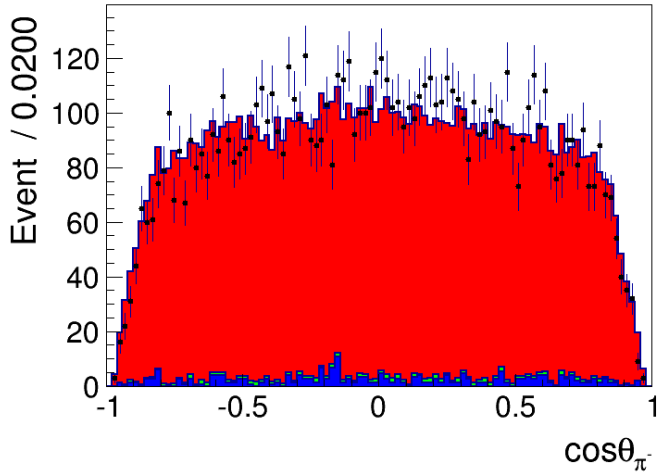
	Event	Estimation
Signal	4068+-66	-
Peaking bkg	43+-2	MC
Non-peaking	103+-8	Sideband











Summary and next to do

Summary:

- DT method with three flavor tag has been use to select $\mathrm{D}^0 \to \pi^+\pi^-\pi^+\pi^-$, ~4000 events with ~96.5% purity
- The non-peaking background is ~2% which can be estimated by the sideband of 2D M_{BC}
- The peaking background is ~1% and come from well-know decay channel $D^0 \to K_S^0\pi^+\pi^-$ and $D^0 \to K^+\pi^-$, which can be estimated by MC

Next to do:

- The flavor tag event may be increased by using $D^{*+} \to \pi^+ D^0$ process @ 4180 and 4260, we will try it next
- PWA will be performed later
- CP tag in 3770 will be used to determining F+

Thank you!