Measurement of the branching fraction of $\eta_c \to 2(\pi^+\pi^-\pi^0)$

Ma Xuning [1] Wang Zhiyong[2] Yu Chunxu [1]

[1]Nankai Univ.

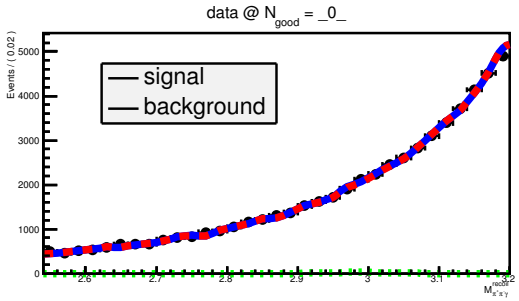
[2]IHEP

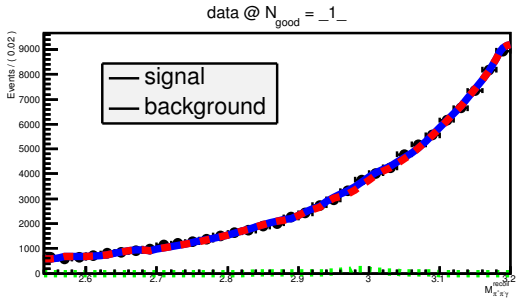
September 8, 2015

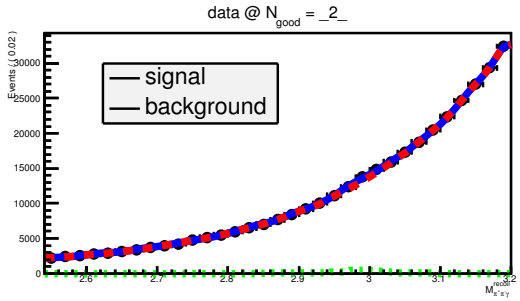
Overview

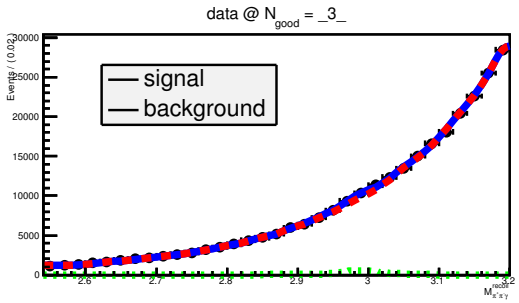
1. Measurement of multiplicity of the inclusive decays of η_c
   - Fitting
   - Multiplicity of N_{good} @ different energy points
2. Measurement of the Branching Fraction of $\eta_c \to \pi^+\pi^-\pi^0$
   - Motivation
   - Data Set
   - Event Selections
   - Optimized Selection

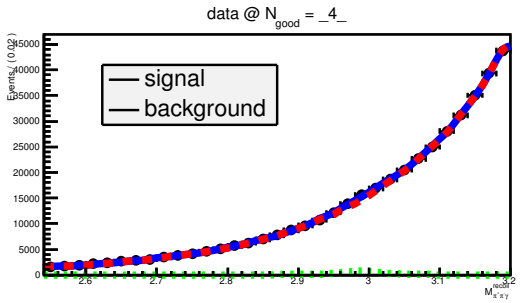
Fit data @ 4260 MeV simultaneously

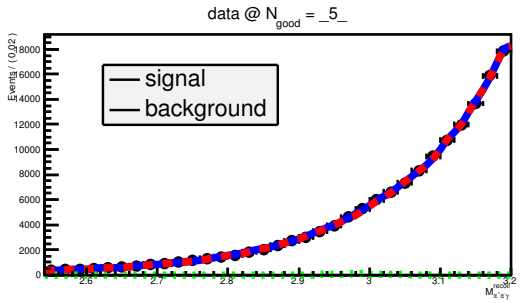


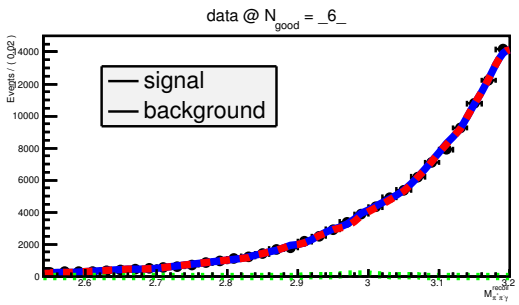


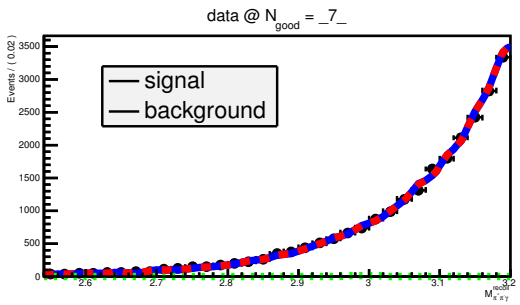


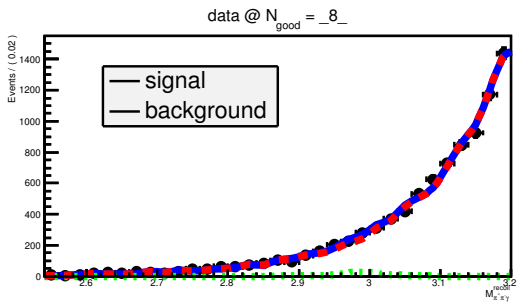




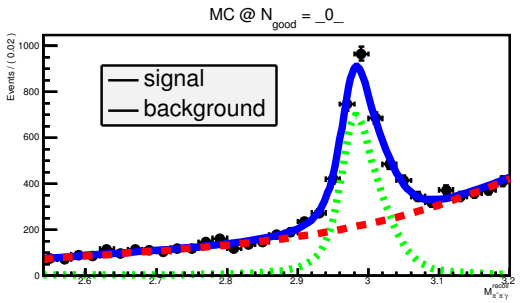


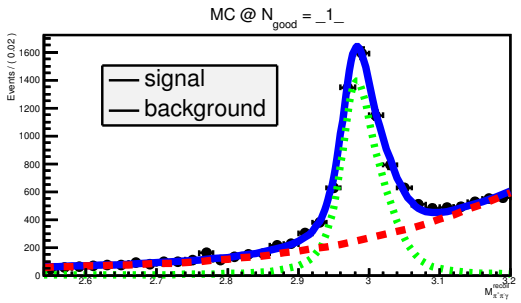


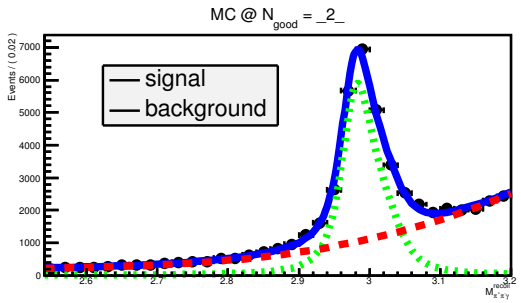


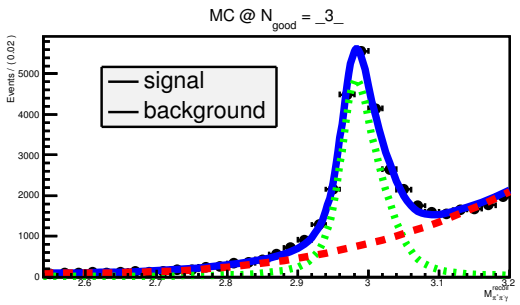


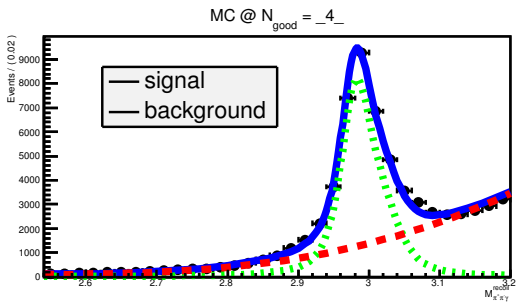
Fit MC @ 4260 MeV simultaneously

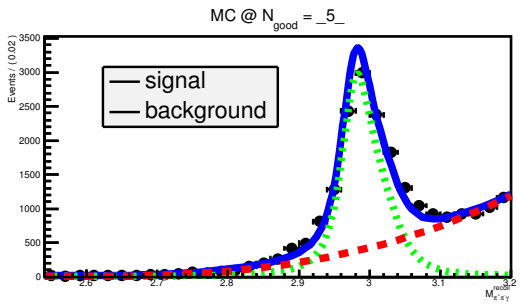


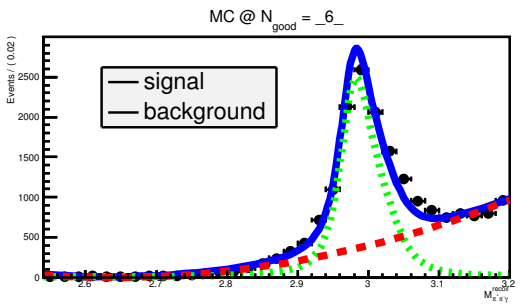


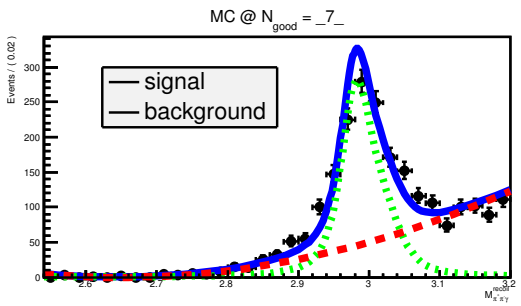


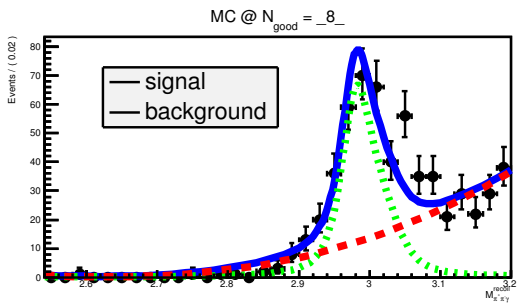




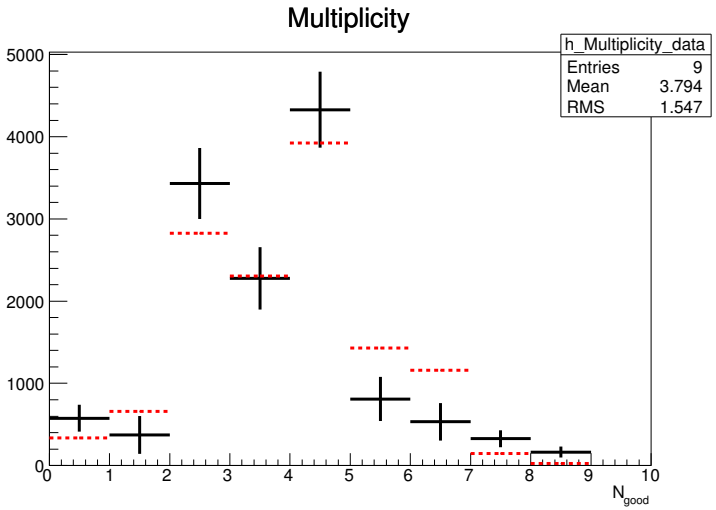


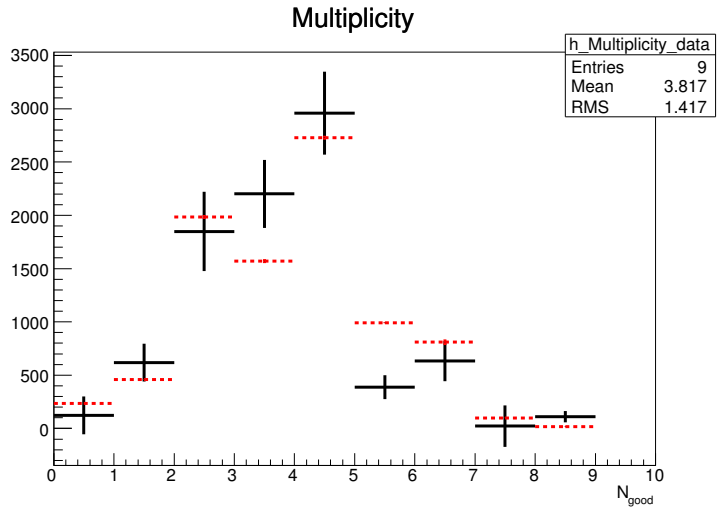


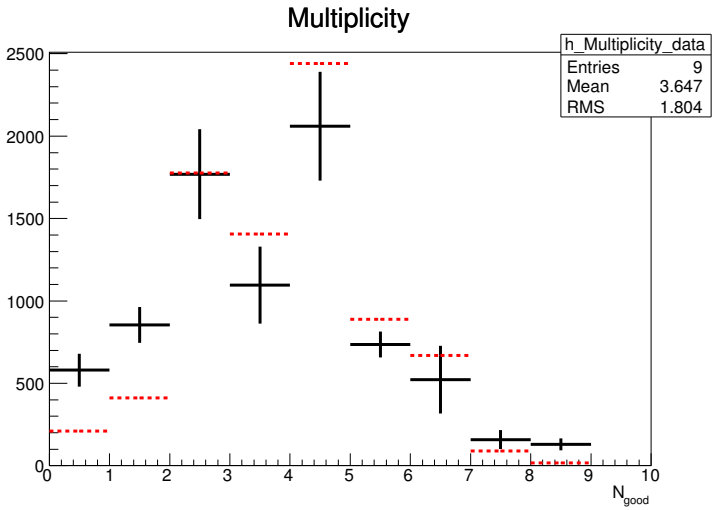


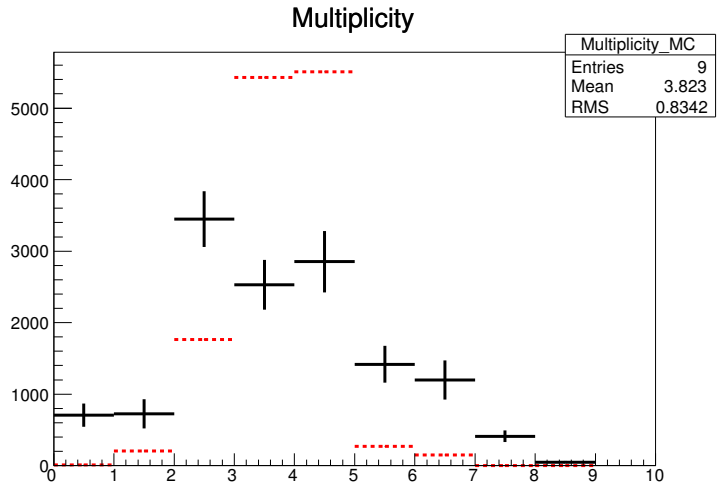


Multiplicity @ 4.23, 4.26, 4.36, 4.42 GeV









Motivation

- The systematic uncertainty of the efficiency of the inclusive decays is essential to measure the branching fraction of $\eta_c \to K_S^0 K^{\pm}\pi^{\mp}$;
- From the above results of multiplicity of N_{good}, we can see that there exists difference between Monto Carlo sample and data;
- The difference between data and Monto Carlo sample leads systematic uncertainty to the efficiency;
- To determine the uncertainty of the efficiency, we measured another decay mode of η_c, which is $\eta_c \to \pi^+\pi^-\pi^0$ which has the largest branching fraction.

Methods

Methods to measure the branching fraction

- We measure the branching fraction of $\eta_c \to 2(\pi^+\pi^-\pi^0)$ via the decays
  - $e^+e^- \to \pi^+\pi^- h_c, h_c \to \gamma\eta_c, \eta_c \to 2(\pi^+\pi^-\pi^0)$(exclusive mode)
  - $e^+e^- \to \pi^+\pi^- h_c, h_c \to \gamma\eta_c, \eta_c \to X$(inclusive mode)
- The Branching fraction is

$$Br(\eta_c \to 2(\pi^+\pi^-\pi^0)) = \frac{N_{signal}^{exclusive}}{N_{signal}^{inclusive}} \bullet \frac{\epsilon^{inclusive}}{\epsilon^{exclusive}} \bullet \frac{1}{Br(\pi^0 \to \gamma\gamma) * Br(\pi^0 \to \gamma\gamma)}.$$

- And via this method we can also cancel parts of the system errors.
- However it is a little bit hard to determine the efficiency of inclusive process. So far we have not known all η_c decays well.

Data Sets and Monto Carlo Samples

BOSS version

6.6.4.p01

Data Sets

We currently used the XYZ data at the energy points of

$$4.23GeV,\ 4.26GeV,\ 4.36GeV,\ 4.42GeV$$

Monto Carlo Samples

$200K$ Monto Carlo Samples are generated at each of the four energy points of $4.23GeV$, $4.26GeV$, $4.36GeV$ and $4.42GeV$.

Event Selections

Good Charged tracks selections

- $V_{xy} < 1cm$, $|V_z| < 10cm$ (except for the two tracks from K_S^0)
- $|\cos\theta < 0.93|$
- $N_{good} \geq 6$

Good photon selections($1 \leq N_\gamma \leq 20$)

- $E_\gamma > 25MeV$ for $|\cos\theta| < 0.8$
- $E_\gamma > 50MeV$ for $0.86 < |\cos\theta| < 0.92$
- $0 \leq TDC \leq 14$(in unit of $50ns$)

Event Selections

π^0 Reconstruction($N_{\pi^0} \geq 2$)

- $0.12 GeV < M_{\gamma\gamma} < 0.15 GeV$;
- 1-C Kinematic Fit

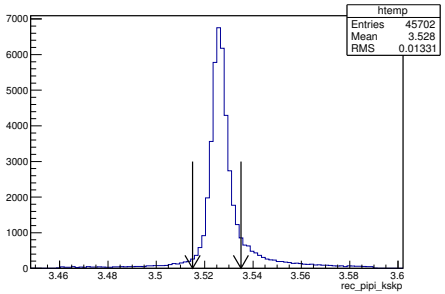
preliminary $\gamma\pi^+\pi^-$ list

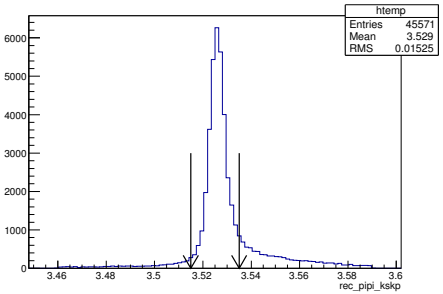
- $3.46 < m^{recoil}_{\pi^+\pi^-} < 3.59 GeV$ (h_c mass region)
- $2.5 < m^{recoil}_{\pi^+\pi^-\gamma} < 3.4 GeV$ (η_c mass region)

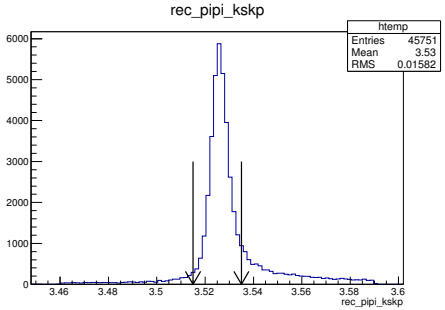
$3\pi^+$, $3\pi^-$, at least $1\gamma\pi^+\pi^-$ list and at least $2\pi^0$ are required.
Combination with the minimum $\chi^2 = \chi^2_{4C} + \sum_{i=1}^{N} \chi^2_{PID}(i) + \sum_{i=1}^{2} \chi^2_{\pi^0}(i)$ is kept

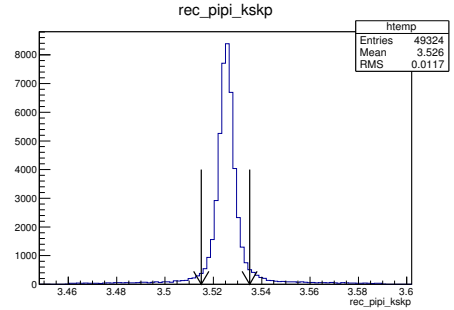
Optimized Selections

- $3.515 < M^{recoil}_{\pi^+\pi^-} < 3.535$ ($M_{h_c} \pm 3\sigma$)

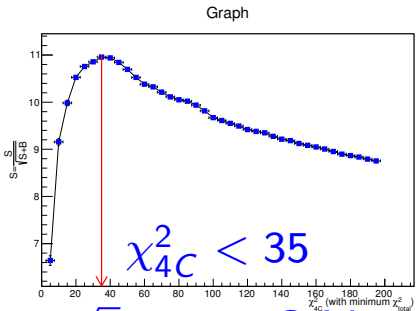




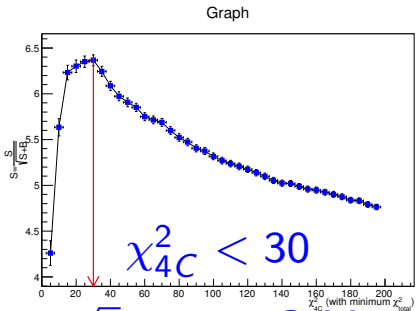




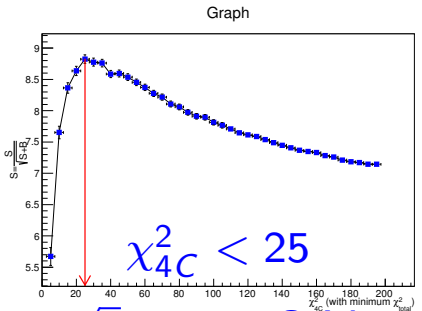
- The χ^2_{4C} cut is optimized with the figure of merit(FOM) $\frac{S}{\sqrt{S+B}}$



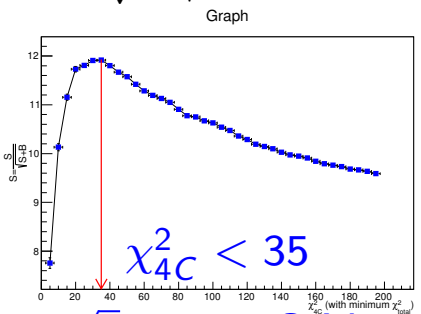
$\sqrt{s} = 4.23 GeV$



$\sqrt{s} = 4.26 GeV$



$\sqrt{s} = 4.36 GeV$



$\sqrt{s} = 4.42 GeV$

Results after optimized selections