Observation of $Z_c(3900)$ from $e^+e^- \to \pi^+\pi^- J/\psi$ at BESIII

USTC group seminar

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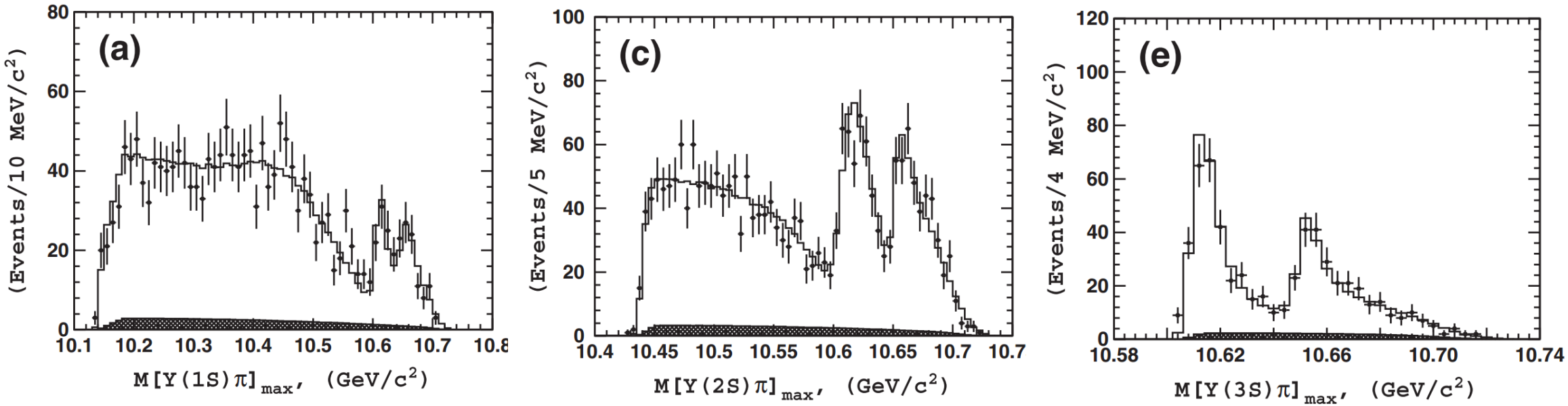
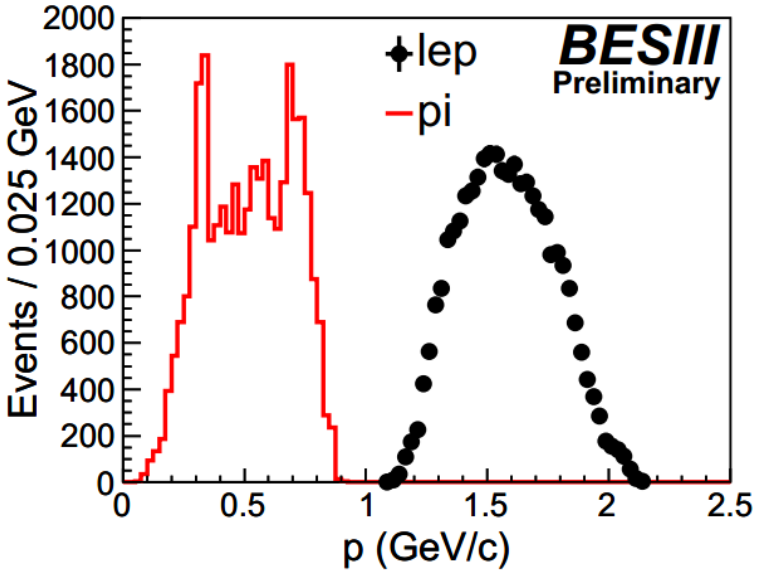
Motivation

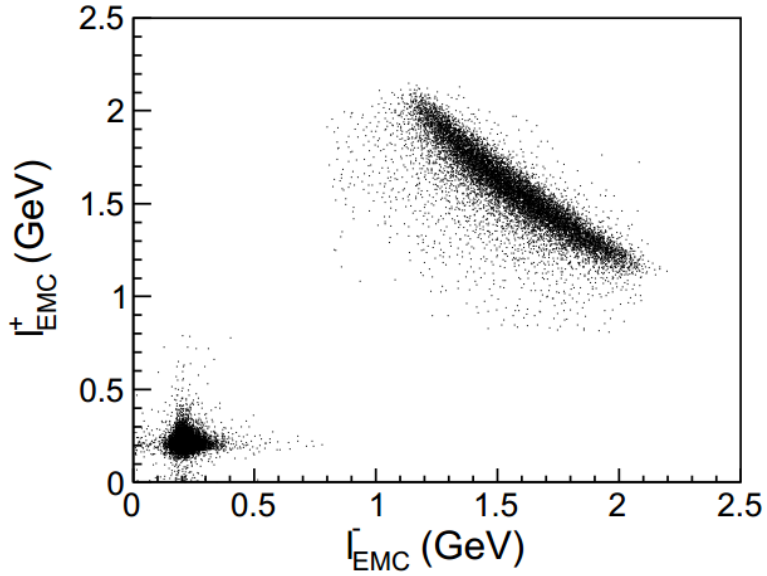
1. The unconventional properties of Y(4620)
2. The similar situation in bottomonium system, i.e. $\Upsilon(5S)$
3. New structures are observed in decays of $\Upsilon(5S) \to \pi^+\pi^-\Upsilon(nS)$



Background suppression

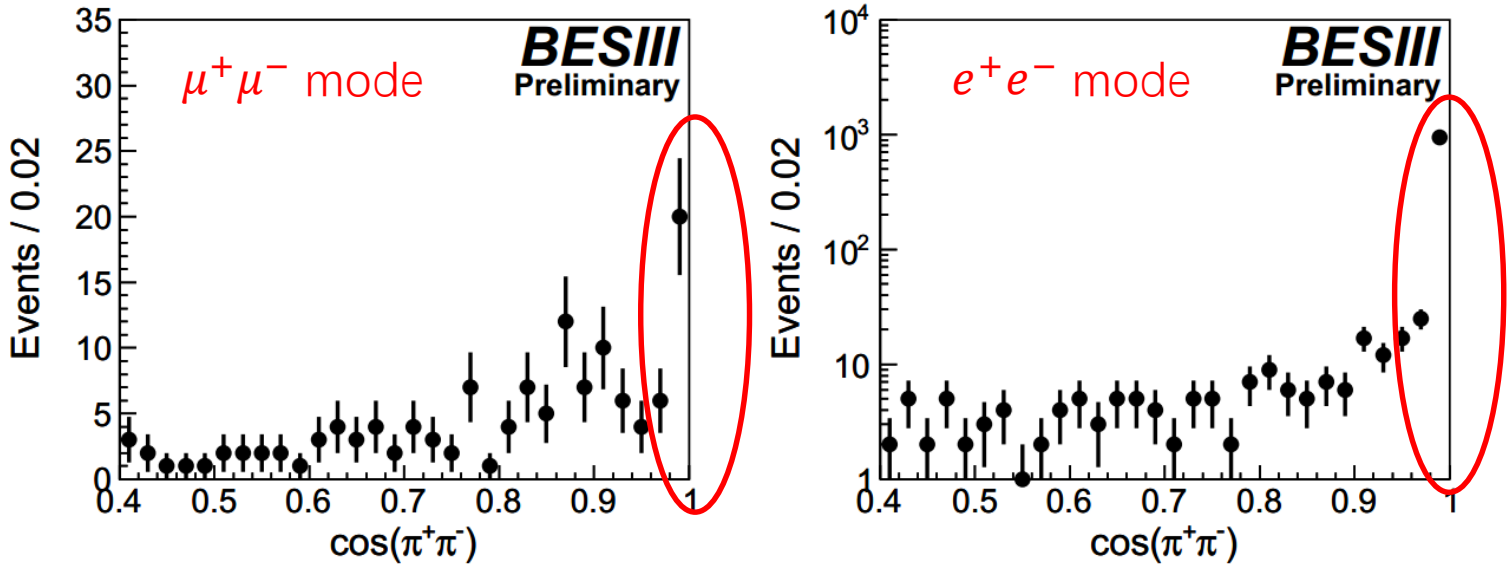
1. Common selection criteria for charged track at BESIII: $|V_z|$, $|V_r|$, $cos\theta$
2. Four good charged tracks with zero net charge
3. Two tracks with momentum less than 1.0 GeV and zero net charge are identified as $\pi^{\pm}$
4. Two tracks with momentum larger than 1.0 GeV and zero net charge are identified as $\ell^{\pm}$
5. Electron and muon pair are separated according to their deposited energies in EMC





Event Selection

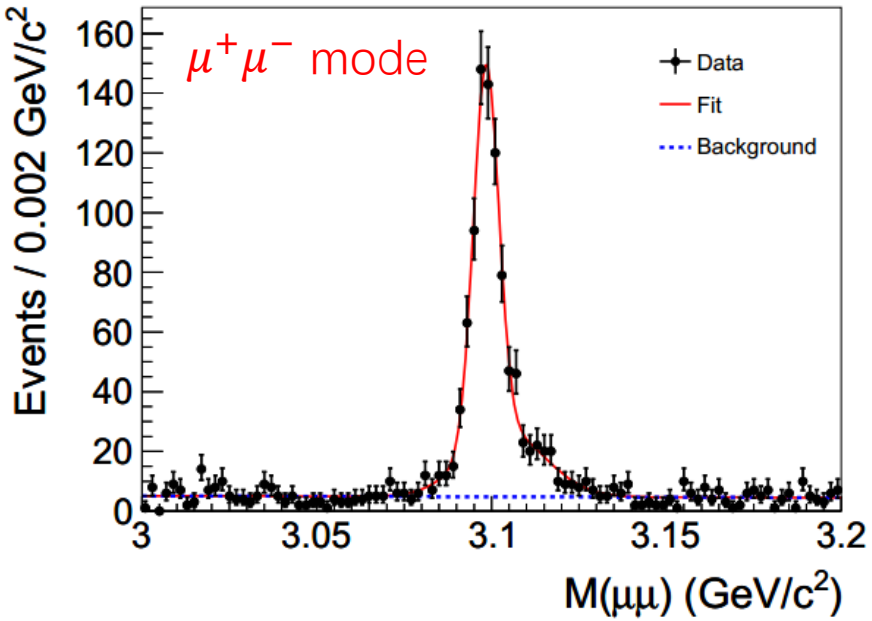
1. Radiative Bhabha and dimuon events are the main background due to gamma conversion and with the generated electron-positron are misidentified as pion. They are rejected by requiring $\cos(\pi^+\pi^-) < 0.98$ as well as $\cos(\pi^{\pm}e^{\mp}) < 0.98$ for e^+e^- mode
2. A 4C kinematic fit with $\chi^2 < 60$ is applied to improve the momentum resolution
3. The residual background is described by sideband of J/ψ mass sideband.

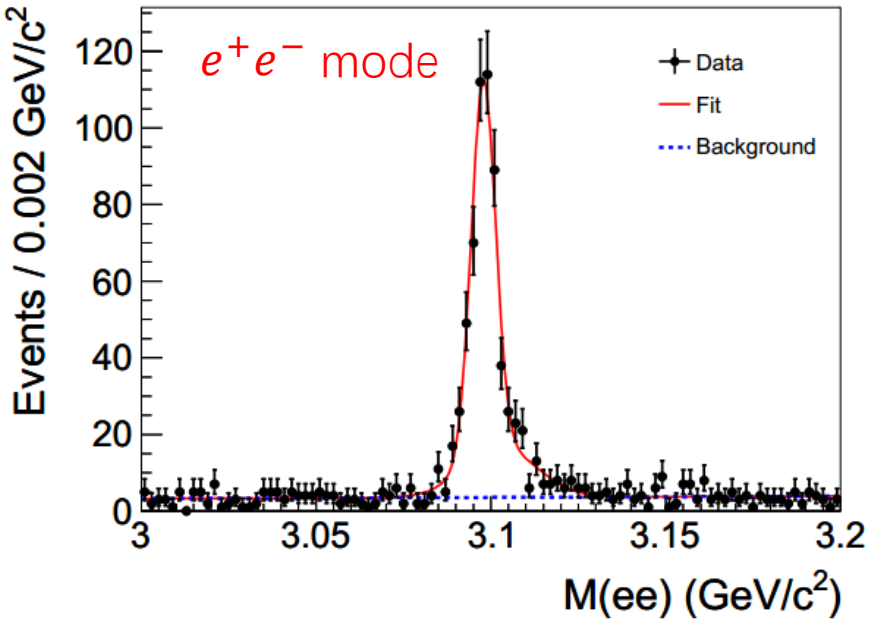


Extract yields of $e^+e^- \to \pi^+\pi^- J/\psi$

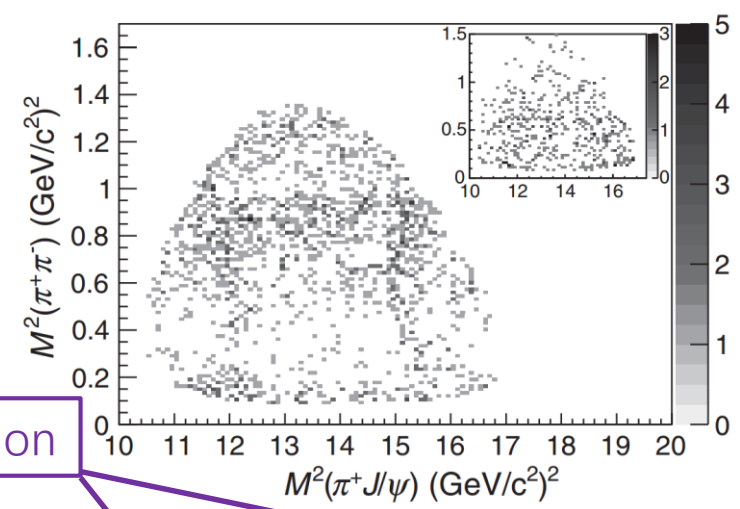
The J/ψ signal is reconstructed by $e^+e^-$and $\mu^+\mu^-$ mode respectively

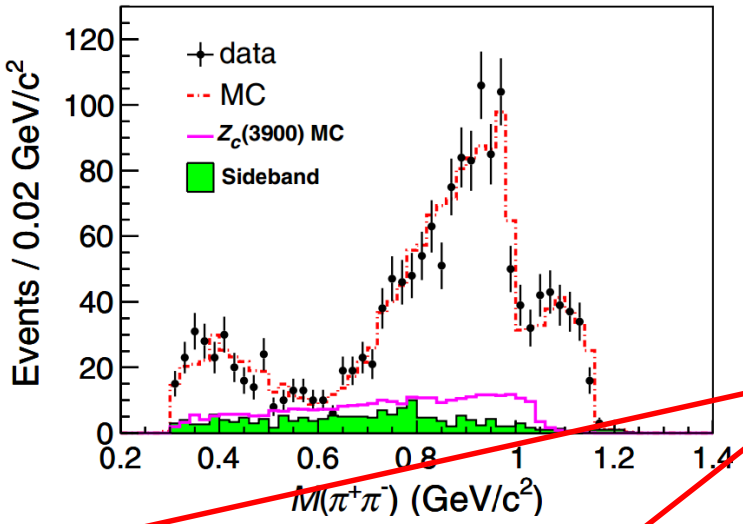
Signal is described by two Gaussian function and background is depicted by linear function





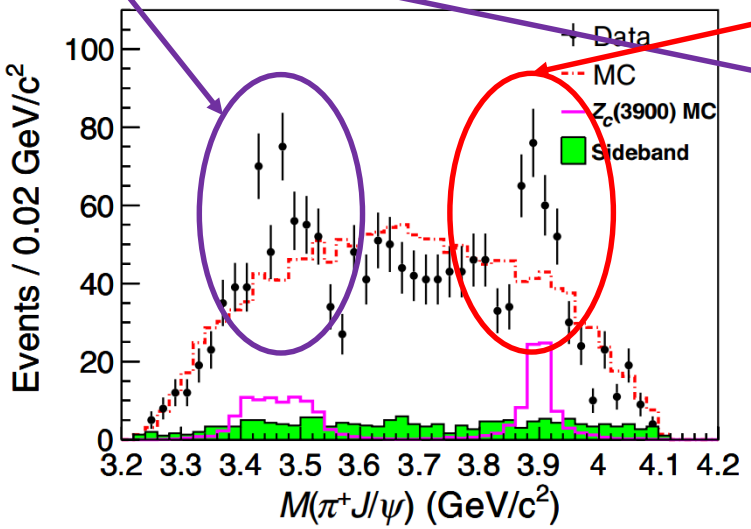
Intermediate states $Z_c(3900)$

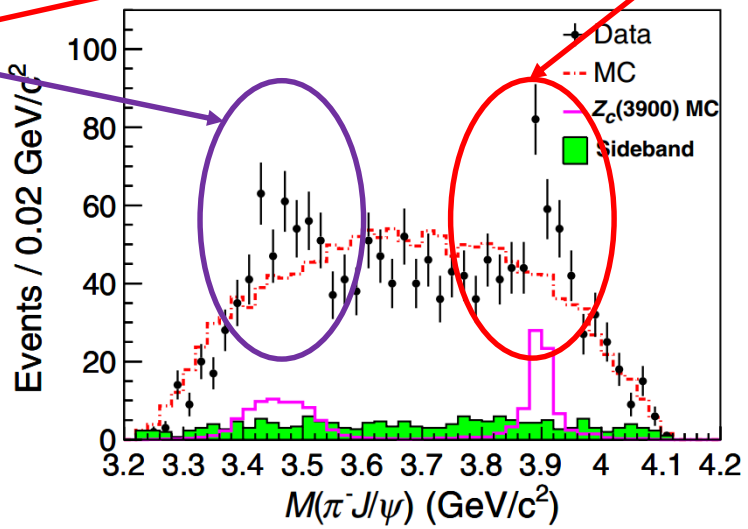




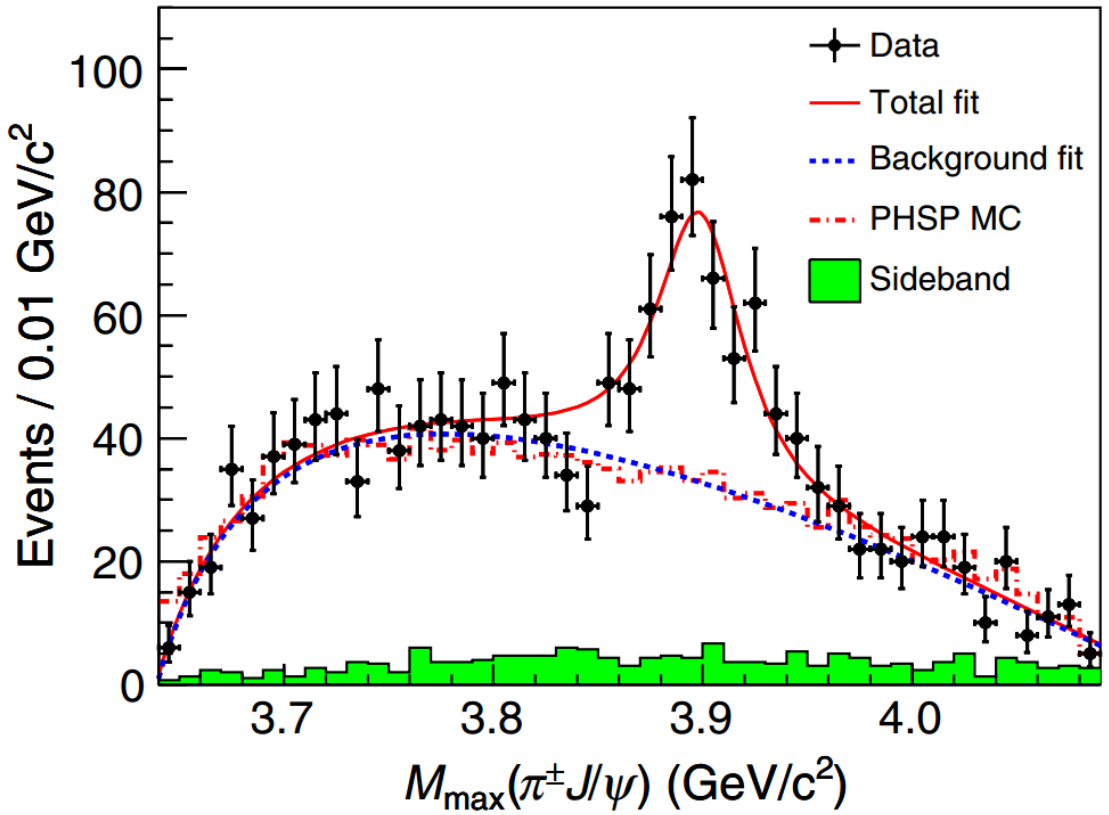
$Z_c(3900)$ Reflection

$Z_c(3900)$ signal





Establishment of $Z_c(3900)$



1. Remove the reflection of $Z_c(3900)$ by choosing the maximum value between $M(\pi^+J/\psi)$ and $M(\pi^-J/\psi)$
2. Using S-wave Breit-Wigner function convoluted with a Gaussian to describe the $Z_c(3900)$ signal after considering the phase-space factor in corresponding partial width
3. The background is depicted by a dedicated phenomenological function
4. Efficiency curve is considered but the interference between signal and background is neglected

Summary and outlook

1. The establishment of charged charmonium-like state $Z_c(3900)$ is reviewed.
2. This state is consisted of at least four quarks $u\bar{d}c\bar{c}$
3. It can be expected that there are similar states in process $e^+e^- \to \pi^+\pi^-\psi(2S)$, $\pi^+\pi^-\chi_{c1}$