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Hi everyone. Today, I will present an update for the J/ψ-J/ψ final state in the 2μ2e channel.

here is my outline, first i will give a brief recap for our last meeting. then i will present our progress and show the fitting package development.

To recap, last meeting Yilin Zhou delivered the opening report for this analysis. Since then, we have made progress. A new version (v3) of the analysis note was released. Following this update, we received the green light to unblind all the Run III data.

For the preliminary event selections, updates based on suggestions are highlighted in purple. First, we set the single muon's η to be less than 2.4 and and a new cut: single-electron pT larger 2 GeV, which in previous one is larger than 1GeV. The detailed optimization of these cuts will be presented later. For the Run III data trigger strategy, we adopted an "OR" logic between two triggers.

Regarding the optimization of the single-electron pT cut, we did 2-dimensional fit using a Double Crystal Ball function for the resonant part and second-order Chebyshev polynomial for the non-resonant, by varying p_T (e) from 1 to 2.5 GeV, and Calculate FOM by s over square s plus b. The results indicate that the maximum FOM is achieved at 2 GeV. To ensure the stability of the chosen electron ID working point, we performed a second round of optimization. The results confirm that the FOM remains maximized at Electron ID ≥1, demonstrating that this working point is stable for our analysis.

Moving on to the ψ-pair yields for Run III: we modeled the data with four components: J/ψ-J/ψ, J/ψ e+e-, μ+μ- J/ψ, and μ+μ- e+e-. The resonant part of the data was fitted using a Double Crystal Ball function, while non-resonant parts used a first-order Chebyshev polynomial. here is our fit result, mention that due to calibration effects, the mean value of ee mass spectrum is shifted from J/ψ mass.

To investigate the mass resolution and efficiency curves, we generated Monte Carlo samples using JHUGen with different mass points and a width of 1 MeV. Here are the results so far. As you can see, Mass resolution improved visible between the cases with and without mass difference, and the mean value shift back to the original setting.

We fitted each mass point individually. For each signal MC sample, a Breit-Wigner convoluted with a double Gaussian is used to fit the m(J/ψJ/ψ) distribution, where the width of Breit-Wigner is fixed to 1 MeV.The double Gaussian function means a sum of two Gaussian functions with a shared mean value while distinct σ. The fractions of the narrow Gaussian and wide Gaussian in the sum are f and 1 - f , respectively. The mass resolution and efficiency curves will be used in the systematic study.

The fitting package in this analysis used to fit the unblinded data basically continues the experience of the published PRL paper. Reviewing the default model in Run II 4mu analysis, there are a total of NRSPS, DPS, combinatorial background, feed-down, and TH1(BW0), BW1, BW2, and BW3. N with subscript is the number of corresponding components; f (m) with subscript is the PDF of corresponding components.
The first sum term is for the contribution from BW0 resonance which is not involved in interference. The second sum term is for the contributions from three resonances involved in interference. the others are the main background sources.

In the default fitting model, there are three signal resonances, BW1(X6600), BW2(X6900), and BW3(X7100), described by the relativistic Breit-Wigner. where q is the magnitude of the momentum of a daughter in the resonance rest frame, L is the orbital angular momentum number between the two daughters. Note that $L = 0$ is used for default fit, but we tried other L values in the systematic investigation. We will also change the value of d or let it be free in further studies of the systematic uncertainty.

In this analysis, the main background sources include NRSPS, DPS, feed-down, and combinatorial background. Specifically, the NRSPS and Feed-down shape is analyzed using MC samples. the DPS shape is analyzed using an artificial dataset from event mixing. The combinatorial background is determined from data after candidate selection but without mass window cuts using the Nine-tile method. we unified these functions into a new generic formula to parameterize the shapes of background components. The shapes of these background are all parameterized by ”Uni” function which reads this equation, where the parameter $p0$ is specifically fixed to be 1.

We used the Nine-tile method to extract the J/ψJ/ψ mass distribution of the combinatorial background. When using the Nine-tile method, we assumed that the mass distributions of these three components are linear, which means if their numbers in the sideband region are known, we can extrapolate their contributions in the signal region. Therefore we define three regions for both the mumu mass and ee mass axis ,and get nine tiles shown in this figure. Under the linear distribution assumption for these background components, we can estimate their contributions in the signal region (Tile 5) with their respective weights. the fitting result parameterized with the UNI function are shown here. We will fix the shape obtained via the Nine-tile and constrain the yield of the combinatorial background using a Gaussian constraint in our final fitting package.

In DPS contribution, the two J/ψ are produced from different parton collisions. Starting from this feature, we can simulate DPS events by applying the event mixing method to a random part of real data. In the event mixing method, we select one J/ψ candidate and the other J/ψ candidate from two different events to form a new $J/\psi J/\psi$ event, and we can obtain the $m(J/\psi J/\psi)$ of this new event. Applying the same procedure to part of the $J/\psi J/\psi$ candidates, we can get an artificial $J/\psi J/\psi$ dataset, in which the two J/ψ candidates are completely independent. Therefore we use this mixed dataset to estimate the shape of Run III DPS background. While the fit was initially poor near the threshold, zooming in on the region showed an improved fit. the fitting result parameterized are shown here.

For the NRSPS and feed-down shapes, the MC samples are still being generated. Although the SPS yield is currently limited, we found that the shape is consistent with the 4μ SPS MC. so we validated our fit package by using the 4μ NRSPS and feed-down parameterizations before all things are ready.

so here is our fitting package, The current fitting package is complete for DPS, combinatorial background, and signal components (BW0, BW1-3 with interference). Parameterization of NRSPS and feed-down is ongoing. But, we can try to build fitting package use parameterization **from 4muon channel** temporarily. Based on this initial package, we just have a try to fit to the dataset and here is what we get for package validation.

To summarize, we have completed the DPS and combinatorial background parameterization, while NRSPS, feed-down, and signal MC generation are still in progress. Our next steps will focus on updating the NRSPS and feed-down parameterizations and finishing the signal MC samples.

Thank you.