Run 15 pp J/ψ Multiplicity Analysis

PHENIX HI PWG Meeting

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Overview

Analysis Note for Preliminary Results:

- We have completed the systematic studies and produced analysis note v_0 for the preliminary results
- The analysis codes can be found at: https://github.com/MYOMAO/PHENIXJPsiAna
- The working version analysis note can be found at: https://www.overleaf.com/project/610b64a9f2882779db01a804

PHENIX

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Run15 J/ψ Multiplicity Dependence Analysis

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Abstract

This analysis note summarizes the technical details of the run15pp event multiplicity dependent relative J/ψ yield analysis. The event multiplicity is determined by the PHENIX silicon detectors, the FVTX and SVX, covering the pseudo rapidity range $1.2 < |\eta| < 2.4$ and $|\eta| < 1.0$, respectively. J/ψ are measured by the two muon arms in the rapidity range of $1.2 < |y| < 2.2$. Our results show the relative yield of J/ψ per p+p collision increases with the event multiplicity, indicating possible multi-parton interactions in p+p collisions.

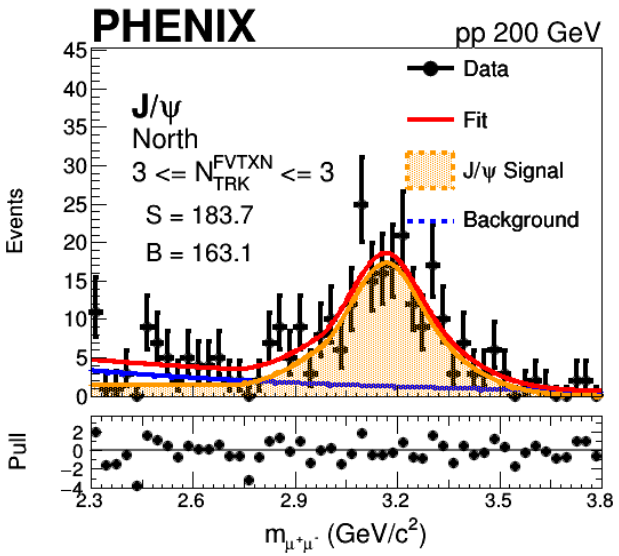
Sources Systematic Studies:

- J/ψ signal extraction
- Trigger bias
- Multiple collision
- J/ψ reconstruction

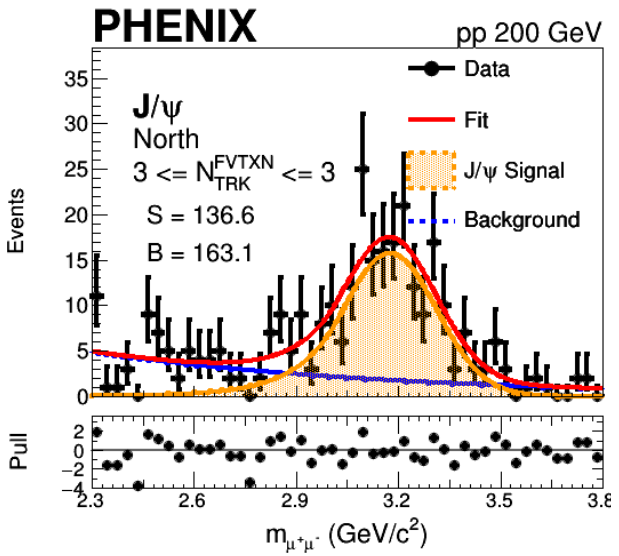
Fit Function Variation

- To evaluate the systematic uncertainties, we vary the signal and background model and compute the percent deviation from the nominal (double crystal ball + exponential decay) signal raw yield
- We add the signal and background variation into quadrature and quote the results as the systematic uncertainties:
- Signal variation: double crystal ball -> single crystal ball
- Background variation: exponential decay -> linear function

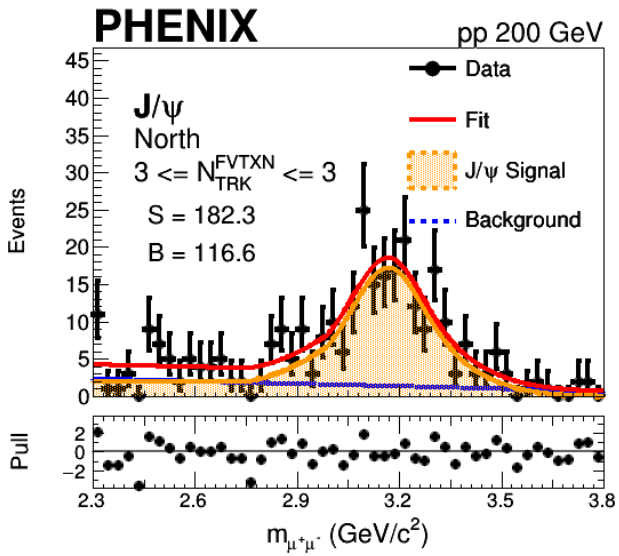
Nominal



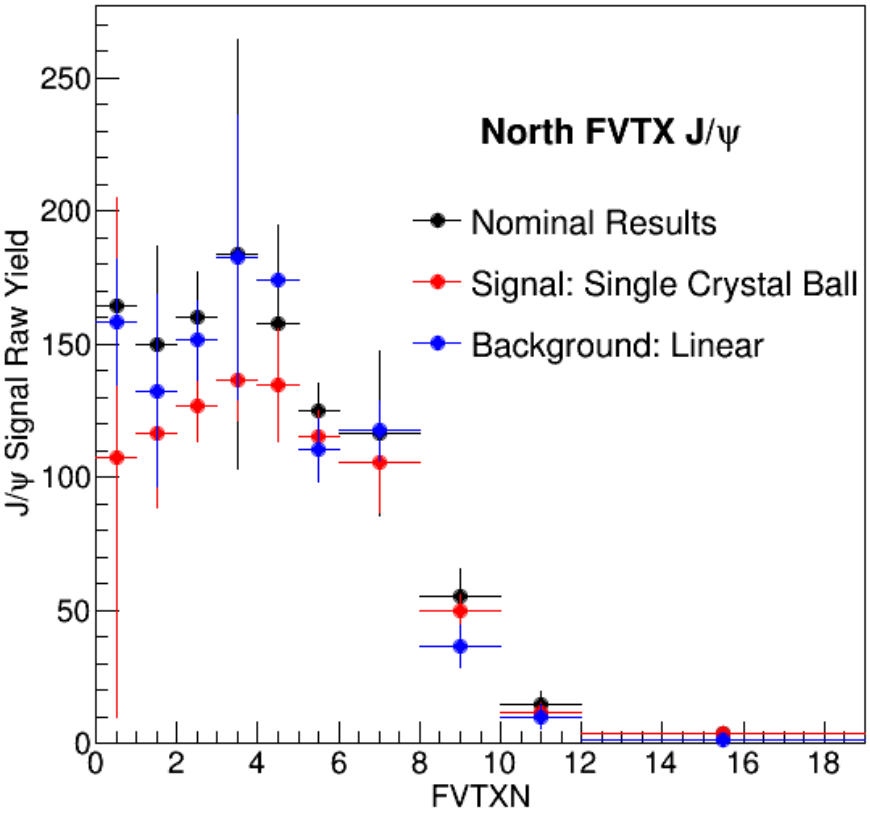
Single Crystal Ball Signal

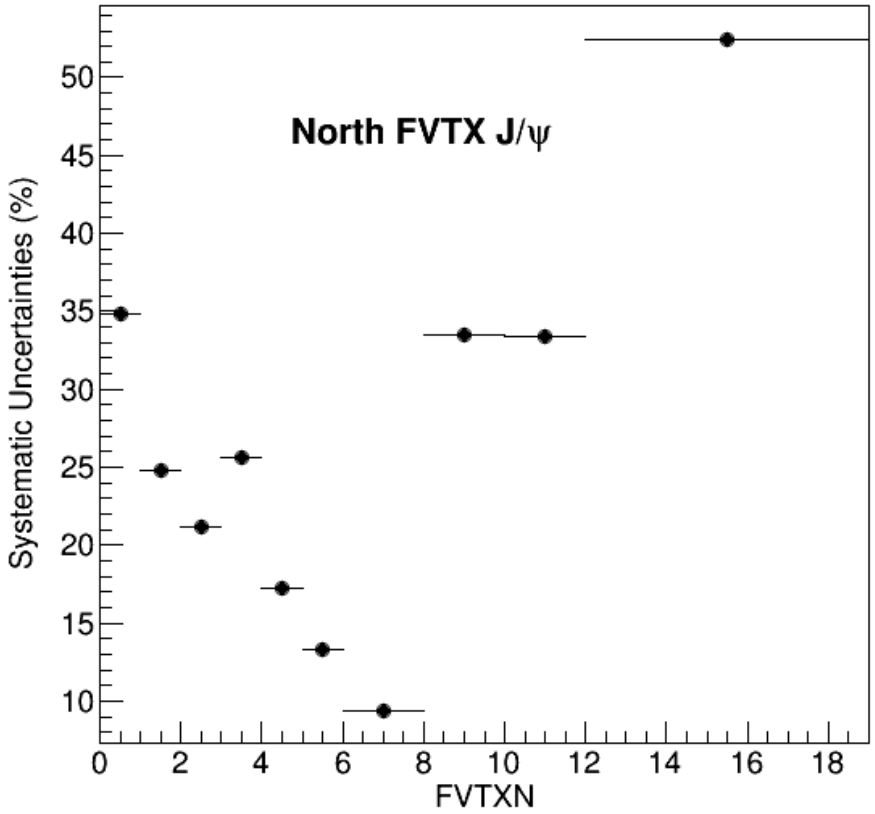


Linear Background



Fit Variation Results

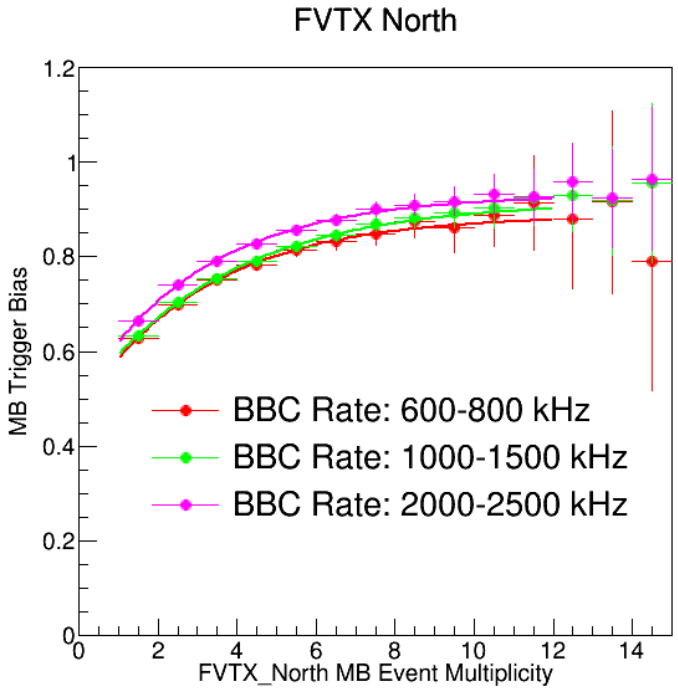


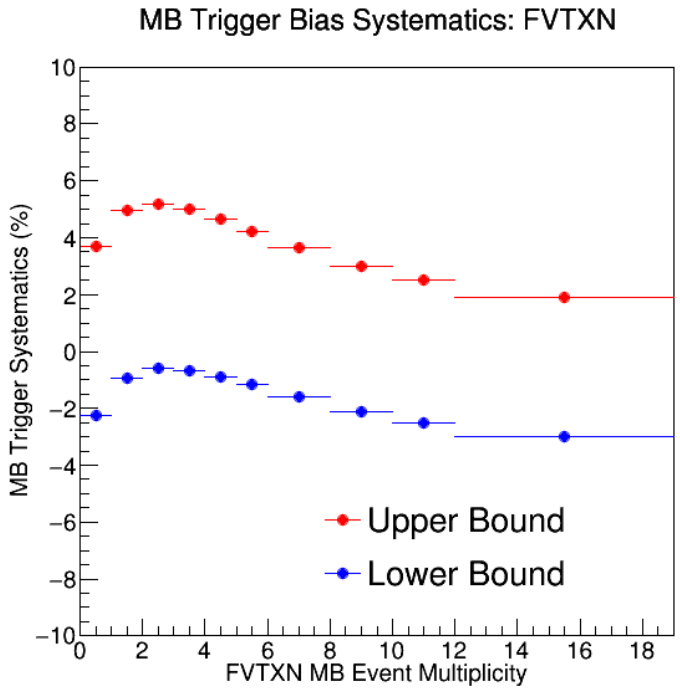


- The systematic uncertainties generally fluctuate between about 20 – 30%
- The 10 – 12 and 12 – 19 results are way too large and invalid due to the little statistics of the high multiplicity
- For preliminary results, we quote a uniform 20% systematics for fit variation

MB Trigger Bias Variation

- Select 3 BBC rates: 600 – 800 kHz (low), 1000 – 1500 kHz (central), and 2000 – 2500 kHz (high)
- Plot the MB trigger biased for all 3 of the BBC rates
- Fit the BBC rate with polynominal functions
- Evaluate the deviation of low and high to central and quote them as upper bound and lower bound of the MB trigger bias systematic uncertainties





- For preliminary results, we quote a uniform 5% systematics for trigger bias variation

Multiple Collision Systematics Summary

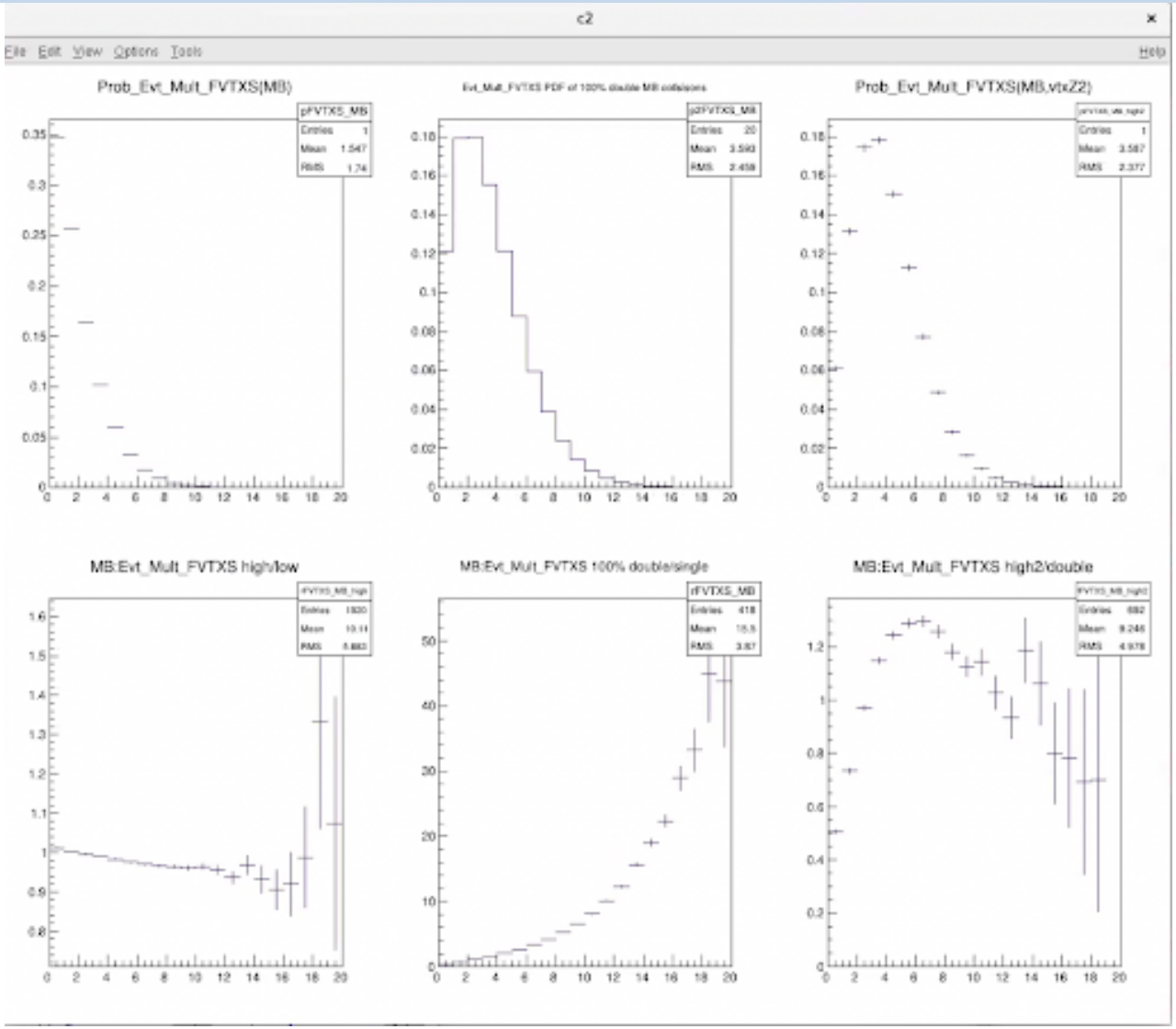
- We model the event multiplicity distribution with 2% of double collision multiplicity calculated from theory according to the BBC rate of about 1000 kHz

- Take the ratio to pure single collision calculation and fit the ratio with a function to evaluate the multiple collision factor

- We compare the shapes of double collision calculation to PHENIX data with exactly 2 vertex within $|Pv_z| < 10$ cm for FVTXS and SVX and take the ratio between them

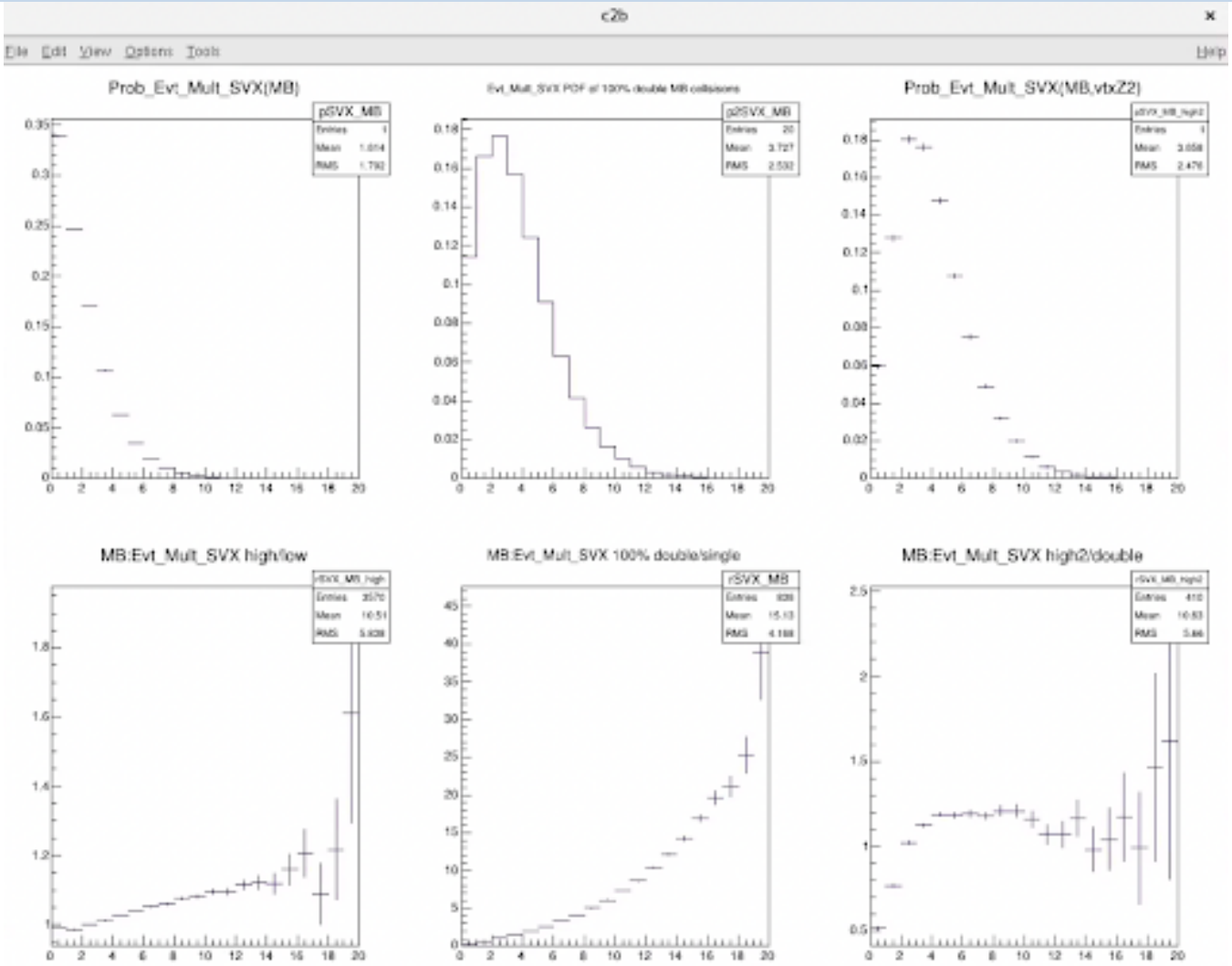
- We quote the deviation from unity as systematic uncertainties due to the imperfect modeling of theoretical calculated double/single collision ratio

Multiple Collision Systematics Studies: FVTXS



- Here we could see reasonably good agreement between the calculation and the data

Multiple Collision Systematics Studies: SVX

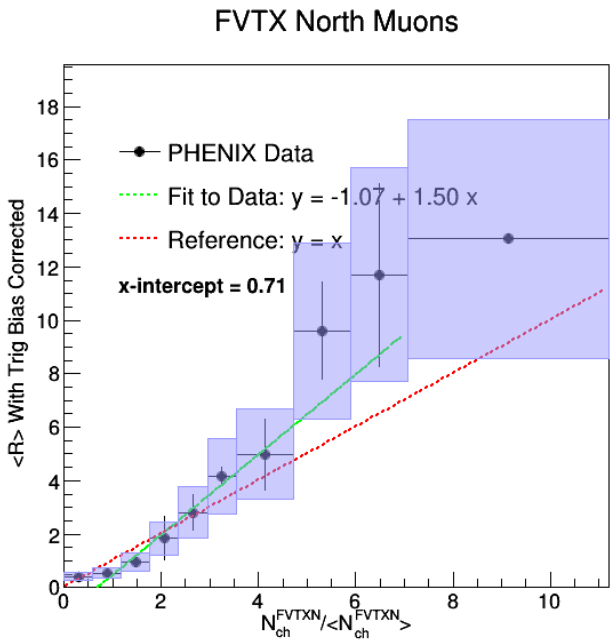


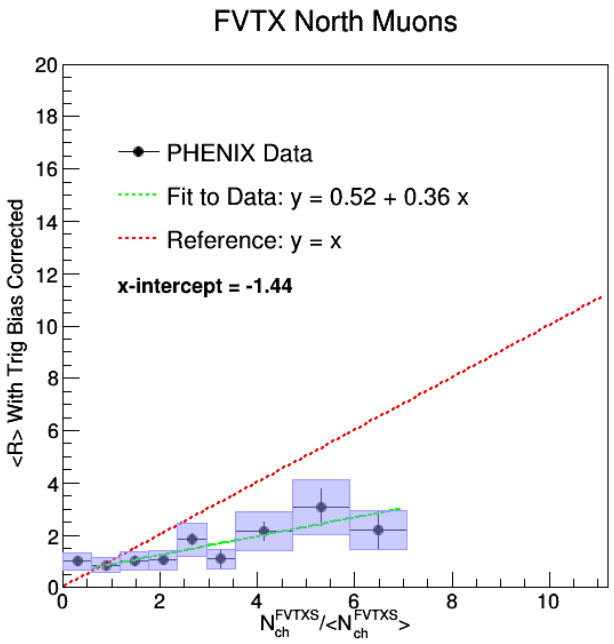
- Here we could see reasonably good agreement between the calculation and the data
- For preliminary results, we quote a systematic uncertainty of 20% for our correction

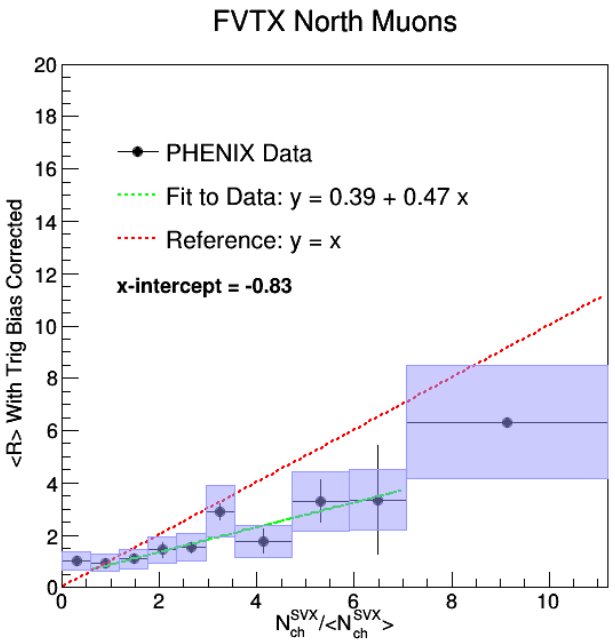
J/ψ Trigger Efficiency Systematics

- According to other previous PHENIX analyses, generally, J/ψ has a trigger efficiency of about 79 ± 2 %
- We expect variation of J/ψ trigger efficiency in different multiplicity
- For preliminary results, we quote a uniform 15% systematics to cover the multiplicity dependence of J/ψ reconstruction
- We can then add all sources of identified systematic uncertainties into quadrature to obtain the total systematic uncertainties
- Hence, currently, for preliminary results, we quote a uniform systematic uncertainty of $20\% \oplus 5\% \oplus 20\% \oplus 15\% = 32.4\%$

Final Results – FVTX North Muons

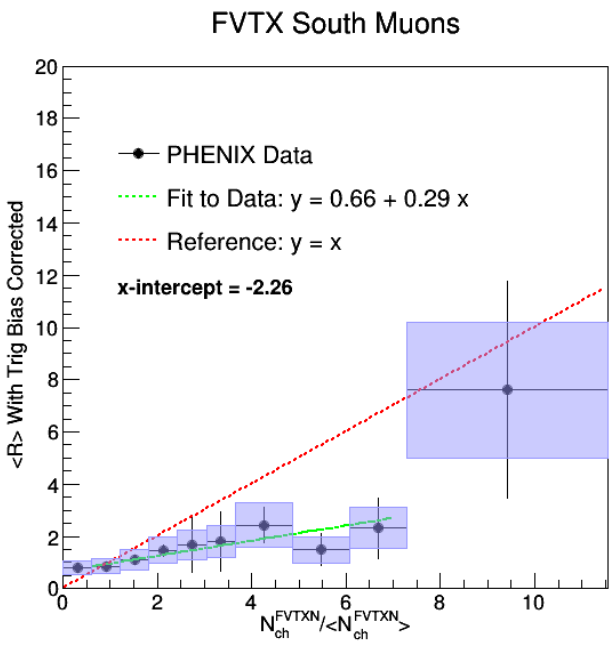


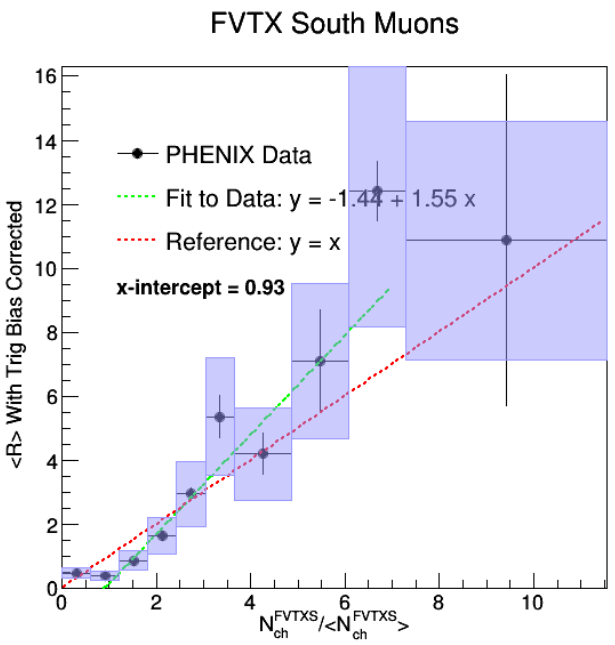


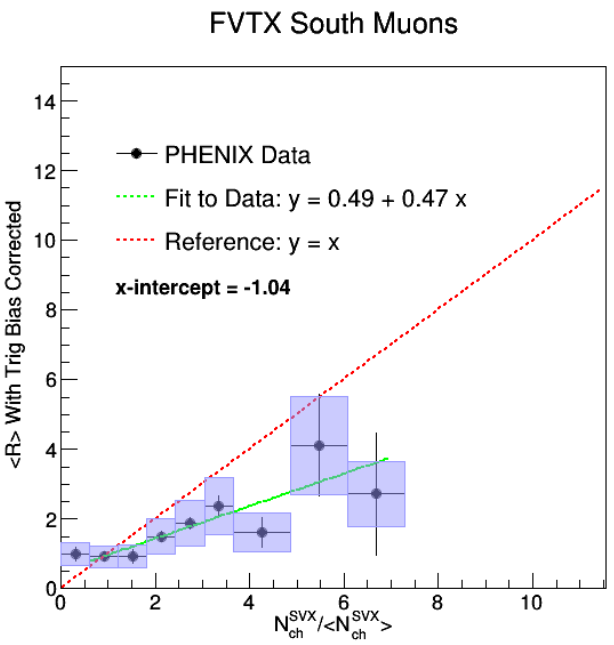


- Systematic uncertainties are 32.4% in half-transparent blue boxes for each bin

Final Results – FVTX South Muons







- Systematic uncertainties are 32.4% in half-transparent blue boxes for each bin

Summary

- We have completed systematic uncertainties evaluation to the fit, trigger bias, multiple collision, and J/ψ reconstruction
- We have also obtain the preliminary results for the trigger bias and multiple collision corrected North and South J/ψ normalized yield as normalized FVTXN, FTVXS, and SVX track multiplicity
- We have produced a first version of the analysis note and document our preliminary results to the analysis note
- We would like to the convener to review our analysis and give us green light to present these preliminary results to present in Quark Matter 2022

To Do List

- Meanwhile, more refinement to improve the J/ψ signal raw yield fits as well as the all other corrections will be ongoing during the review period
- Improve the 15% systematic uncertainty used for the J/ψ trigger efficiency with clock triggered data to achieve 5% level
- Explore data driven method to improve double collision systematics, and apply the corrections based on the BBC rate run by run
- Improve crystal ball unbinned fit. Check how well other PHENIX J/ψ analysis control the fit systematics and make sure our systematics are at least as good as them
- Check the consistency of final results: eg: same arm North J/ψ vs FVTXN with South J/ψ vs FVTXS and opposite arm: North J/ψ vs FVTXS with South J/ψ vs FVTXN
- Add more results without overlapping muons, for instance, North + South J/ψ vs FVTXN + FVTXS + SVX and North J/ψ vs FVTXS + SVX, and South J/ψ vs FVTXN + SVX,
- Include PHENIX analysis notes and published paper in our analysis notes and further proofread the analysis notes