Run 15 pp J/ψ Multiplicity Analysis

PHENIX HI PWG Meeting

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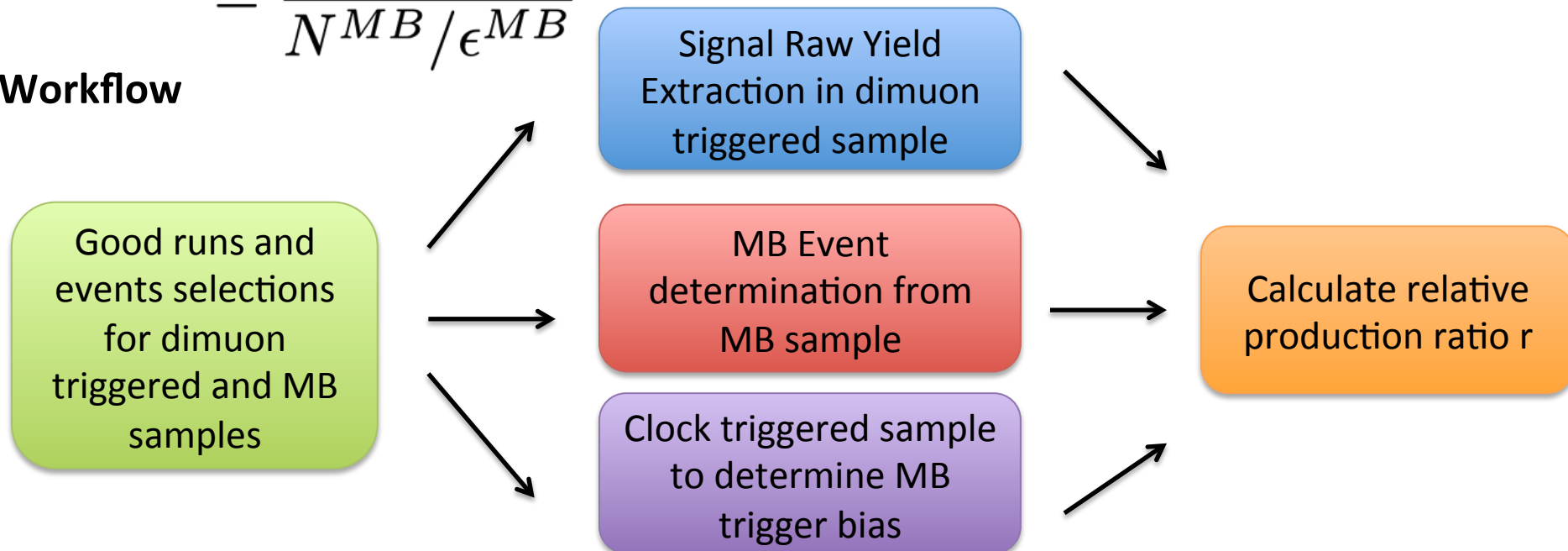
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Overview

Motivation

- Fully reconstruct J/ using the PHENIX north and south FVTX detectors
- Study J/ψ production in small systems from a quantity measurement

$$R(N^{ch}) = \frac{d\sigma^{J/\psi}(N^{ch})}{d\sigma^{MB}(N^{ch})}$$

$$= \frac{N^{J/\psi}/\epsilon^{J/\psi}}{N^{MB}/\epsilon^{MB}}$$

$$r = \frac{N^{J/\psi}/\epsilon^{J/\psi}/<\sigma^{J/\psi}>}{N^{MB}/\epsilon^{MB}/<\sigma^{MB}>}$$

Workflow

Good runs and events selections for dimuon triggered and MB samples

Signal Raw Yield Extraction in dimuon triggered sample

MB Event determination from MB sample

Clock triggered sample to determine MB trigger bias

Calculate relative production ratio r

# Update on the Analysis

Change of binning

- Switch the binning of 5 bins from [0,2,5,8,12,19] to 10 bins [0,1,2,3,4,5,6,8,10,12,19]
- More focus on the low multiplicity bins, which has more statistics
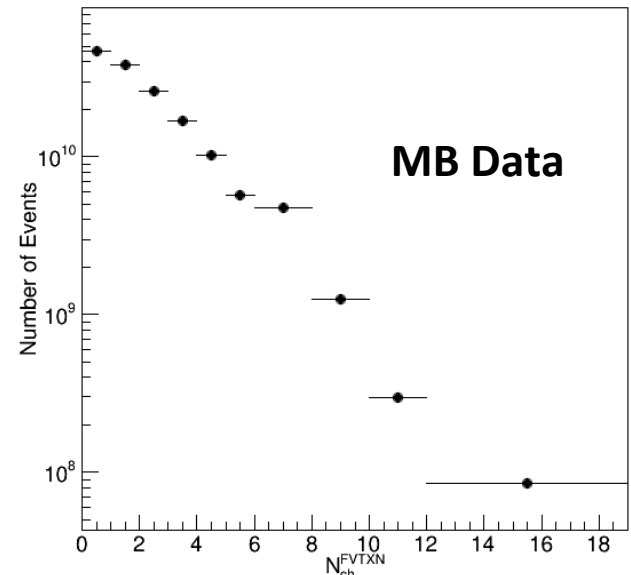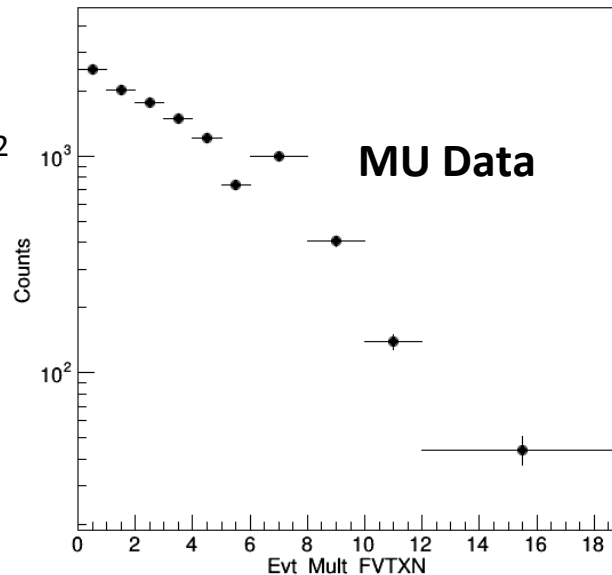
Change of Mass Window for J/ψ Signal

- Switch the invariant mass window to be 200 MeV/c^2 near the PDG mass of J/ψ

Include multiple collision correction in the final results

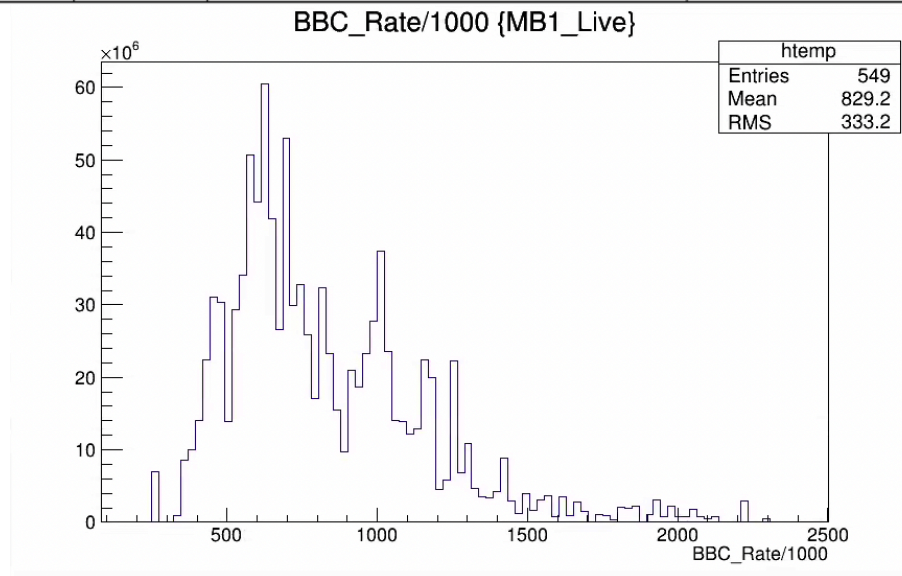- More details will be shown in the following slides
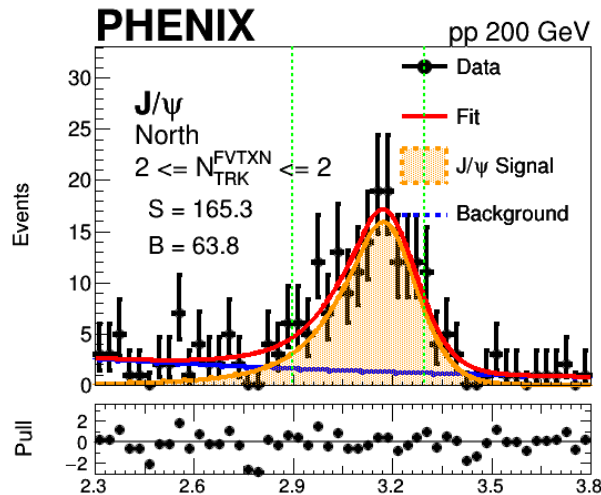
Multiple Collision Effect

BBC Rate (kHz)	μ	Prob. of 2+ collisions	Prob. of 3+ collisions
250	0.05	0.12%	2.0×10^{-5}
500	0.10	0.47%	1.5×10^{-4}
1,000	0.20	1.8%	1.1×10^{-3}
1,500	0.31	3.9%	3.9×10^{-3}
2,000	0.43	6.9%	9.6×10^{-3}
2,500	0.55	10%	1.8×10^{-2}

BBC_Rate/1000 {MB1_Live}

| htemp	
Entries	549
Mean	829.2
RMS	333.2

- The number of collisions can be modeled by Poisson distribution
- Correct the multiple collision effect, particular occurring at high multiplicity events
- The BBC rate is about ~ 1000 kHz -> correspond to ~ 2% of multiple collision in pp

Double Collision to Single Collision Ratio
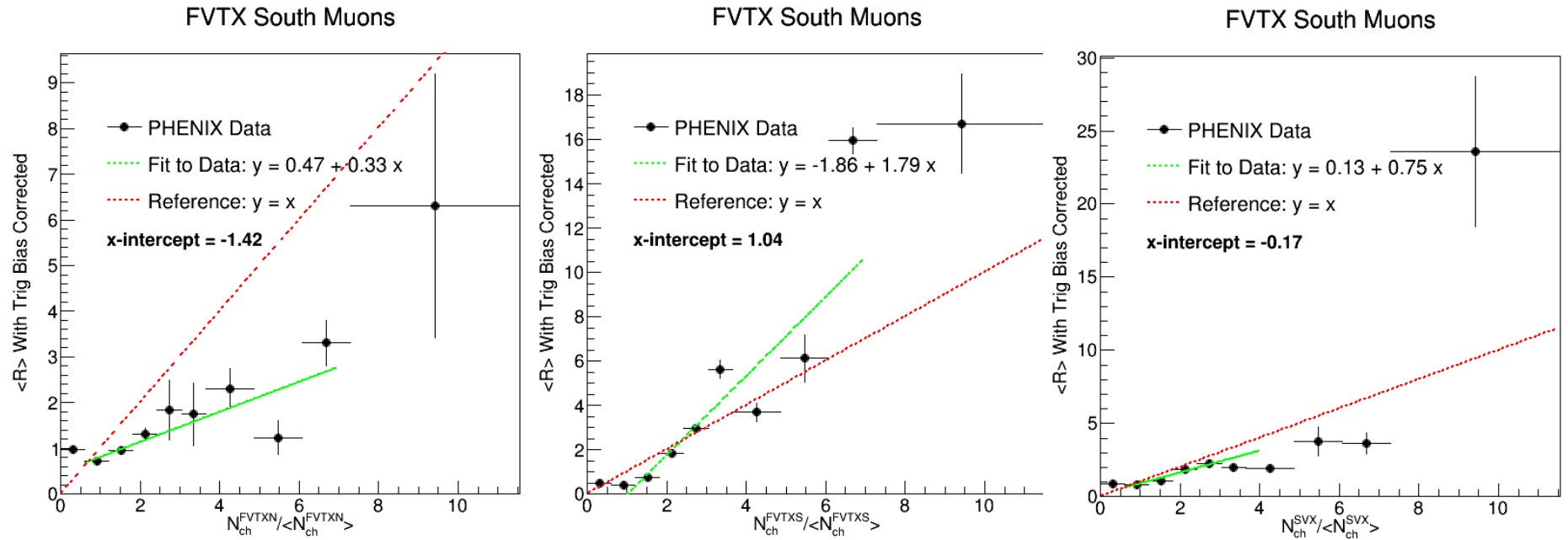
MB: Evt_Mult_FVTXS 2% double/single
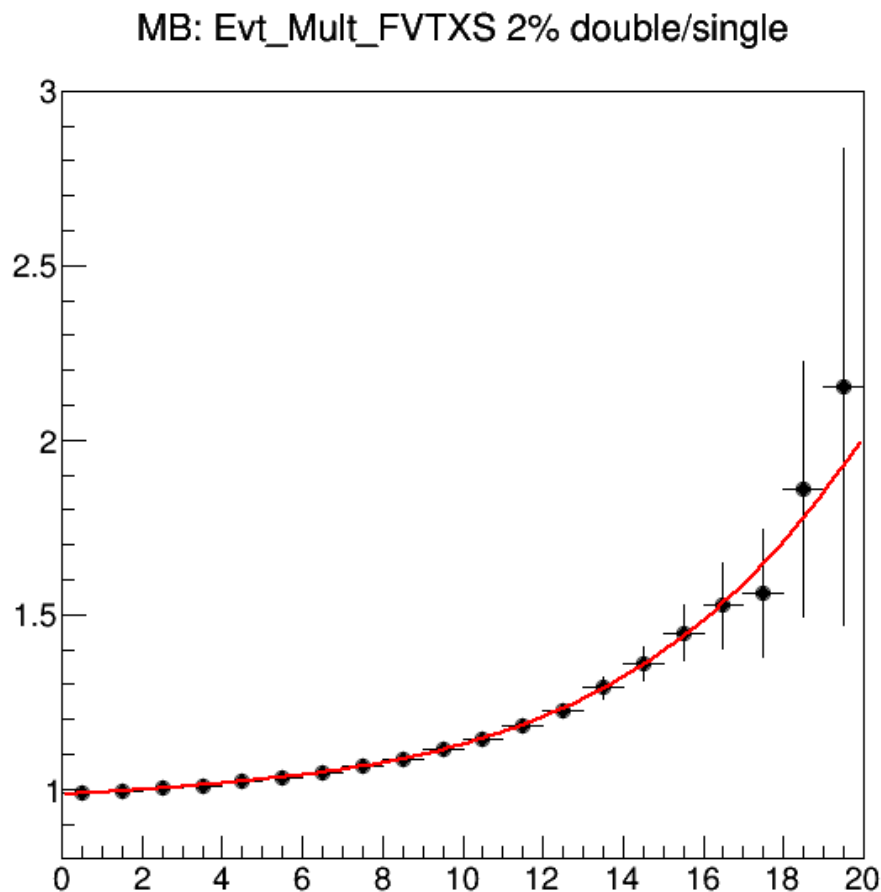
- The correction factor range from 1.0 – 1.5 for our analysis
- Fitting function: $y = 0.984 + 0.00645x + 0.000302x^2 + 0.00000483x^4$, which fits the data well
- Evaluate the fit function at the bin center to obtain the correction
- Multiply the correction factor to the ratio r to obtain the final results

Final Results for FVTX North Muon
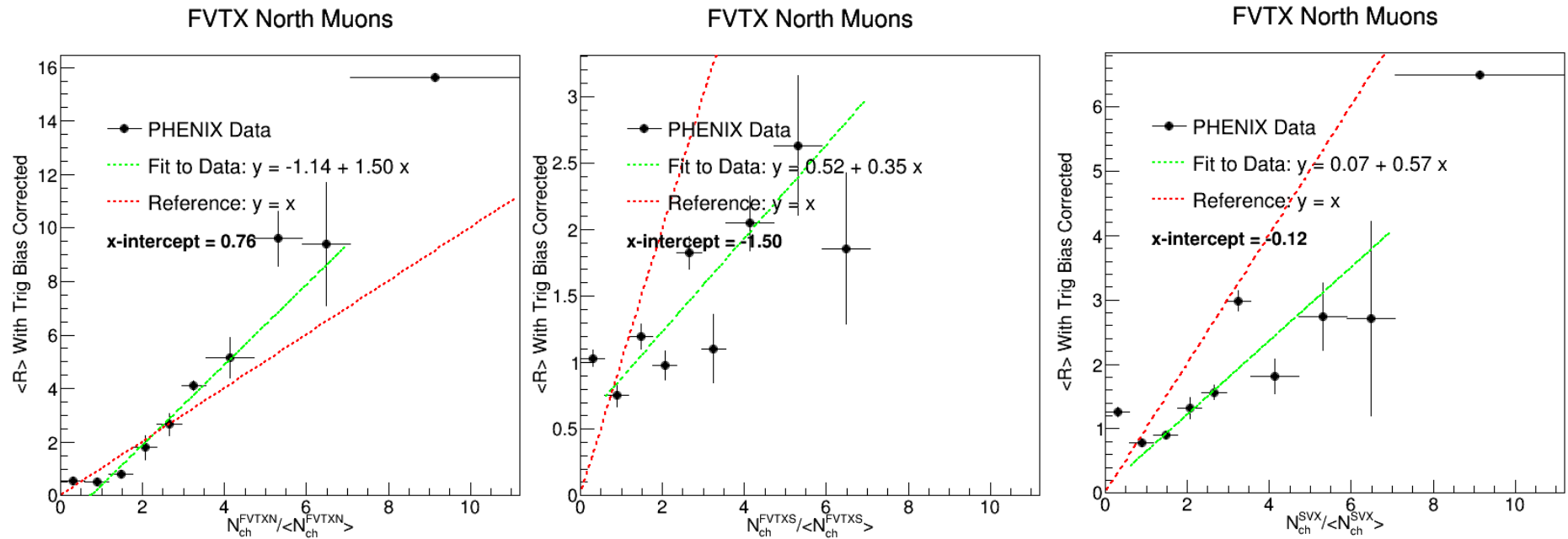
- Fit the results with y = ax + b linear function (green) and compare it to y = x (red)
- Possibly adding non-linear components to model the modification of J/ψ production at higher multiplicity
- a < 0 and b > 1 for the same multiplicity counting in the same arm. which could be explain the missing tracklets from the reconstruction
- a > 0 and b < 1 for the opposite arm, which can be explained by the fact that there are some activities in the other side of the detector
- For SVX, a is near 0 while b < 1.

Final Results for FVTX South Muons

FVTX South Muons — PHENIX Data; Fit to Data: $y = 0.47 + 0.33x$; Reference: $y = x$; x-intercept = -1.42

FVTX South Muons — PHENIX Data; Fit to Data: $y = -1.86 + 1.79x$; Reference: $y = x$; x-intercept = 1.04

FVTX South Muons — PHENIX Data; Fit to Data: $y = 0.13 + 0.75x$; Reference: $y = x$; x-intercept = -0.17

- Fit the results with $y = ax + b$ linear function
- Possibly adding non-linear components to model the modification of J/ψ production at higher multiplicity
- $a < 0$ and $b > 1$ for the same multiplicity counting in the same arm. which could be explain the missing tracklets from the reconstruction
- $a > 0$ and $b < 1$ for the opposite arm, which can be explained by the fact that there are some activities in the other side of the detector
- For SVX, a is near 0 while $b < 1$.

Final Results Combined
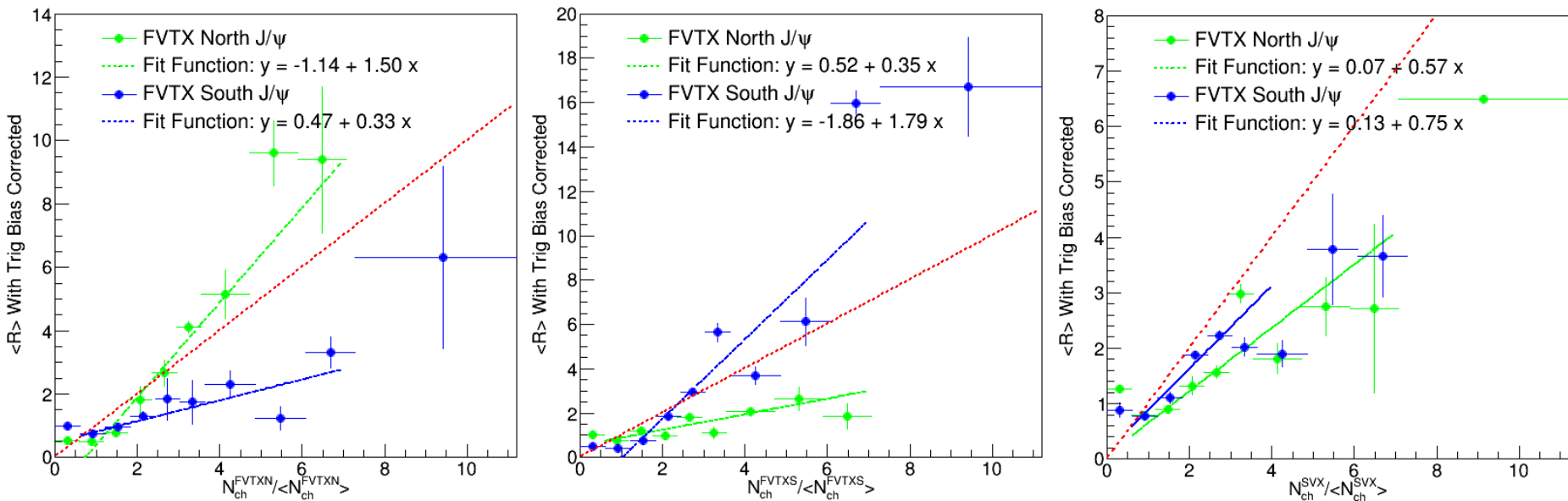
- FVTX North and South muons as a function of SVX are overall consistent with each other due to symmetry of the system
- Systematic uncertainties estimation is currently on-going and will be included soon
- May compare with theoretical predictions to study J/ψ production mechanism in small systems

Source of Systematic Uncertainties

Variation of fitting model
- Variation of the signal model
- Variation of the background model
- Addition of the percent deviation in quadrature as systematic uncertainties for J/ψ signal extraction
- Estimated order magnitude ~5%

Variation of MB trigger bias
- Obtain different fit functions with different BBC rates
- Quote the deviation as the systematic uncertainties
- Estimated order magnitude ~10%

J/ψ reconstruction efficiency uncertainties
- Quote a 15% uncertainty for the pp dataset

Summary and To Do List

- We have quickly updated the preliminary results of J/ψ production ratio as a function of event multiplicity with the new binning, mass window, and multiple collision corrections

- We compare our results for North and South J/ψ with different event multiplicity definition: FVTXN, FVTXS, and SVX

- We compare our results with y = x and fit it with a linear function and cross check the N_{coll} - like scaling for J/ψ in pp collision in the point of view of partons and found that the enhancement for same direction and suppression for opposite directions

- Finish the systematic uncertainties studies for pp and try to finalize results within this week

- Complete the analysis notes and aim at presenting the pp results in QM 2022