Update on EM-Jet A_N in FMS and EEMC

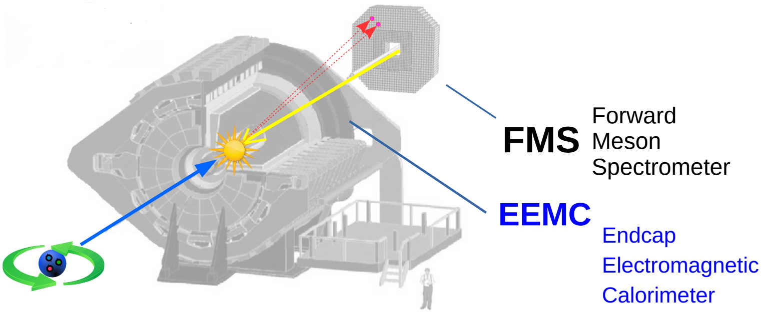
First Look at Run 17 Dataset
Preliminary Request for Run 15 Results

Latif Kabir

August 11, 2021

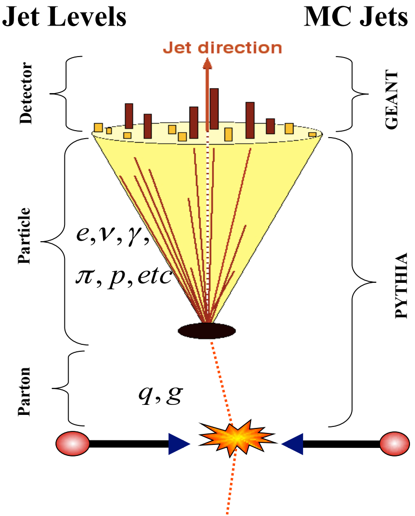
EM Jet A_N with FMS and EEMC

- $p^{\uparrow} + p \to$ EM-jet + X
- Extract A_N as a function of EM-jet p_T, energy and photon multiplicity.
- EM-jet in FMS and EEMC
- **Dataset:**
  - Run 15(200 GeV pp trans)
  - Run 17 (510 GeV pp trans)
- **Data-stream:**
  -FMS-stream (For FMS EM-jet)
  - Physics-stream (For EEMC EM-jet)
- **Triggers:**
  - Small BS, Large BS and FMS-JP Triggers (For FMS EM-jet)
  - EHT0, JP and MB triggers (For EEMC EM-jet)
  - Veto on LED and abort gap

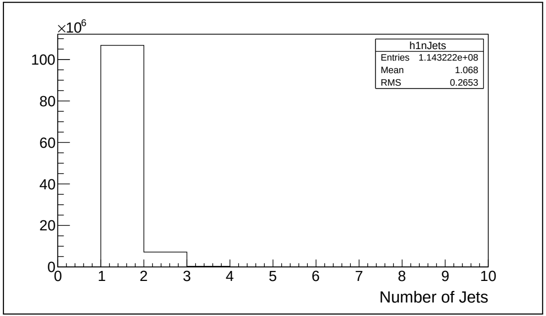


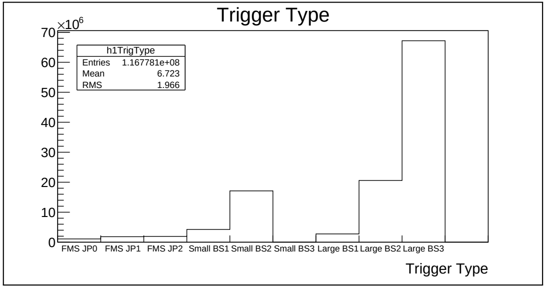
Jet Reconstruction

- $\sim$20% of total Run 17 dataset (Day 74 - Day 87)
- Initial calibration from Minghui
- FMS hot channel masking before reconstruction. $\rightarrow$ No additional masking
- Exclude highly bit-shifted FMS channels
- Vertex z priority: TPC, VPD, BBC
- FMS points as input for Anti-k_T
- Anti-k_T with R = 0.7
- $E_\gamma > 1.0$ GeV (For FMS EM-Jet)
- Jet p_T > 2.0 GeV/c
- -80 cm $< V_z <$ 80 cm

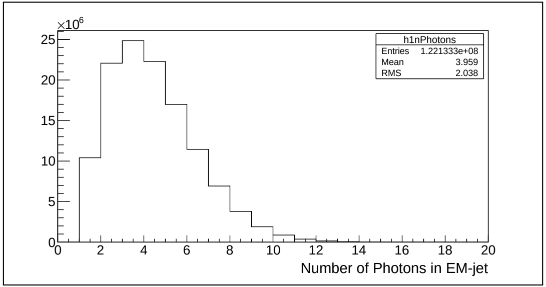


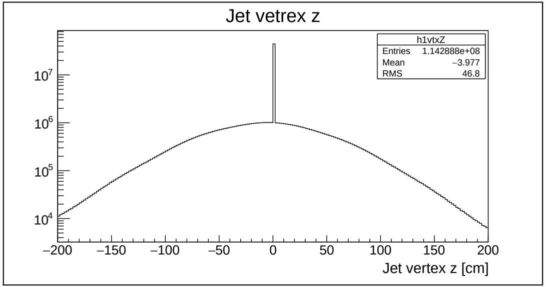
Run 17 EM-jet QA: EM-jets and Trigger Types



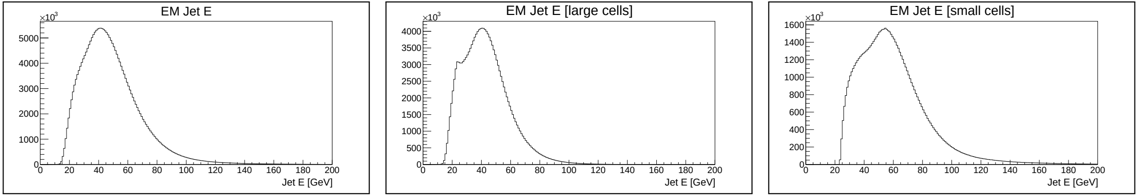


Run 17 EM-jet QA: Photons Multiplicity and Vertex

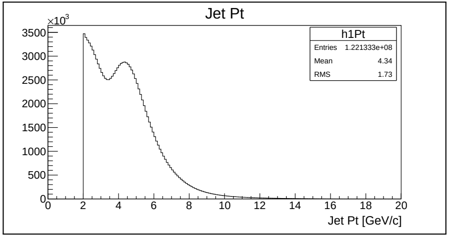


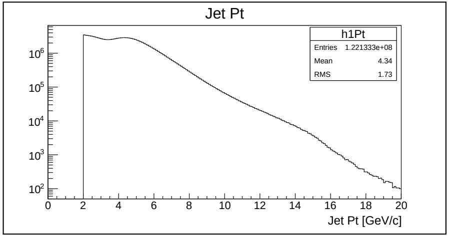


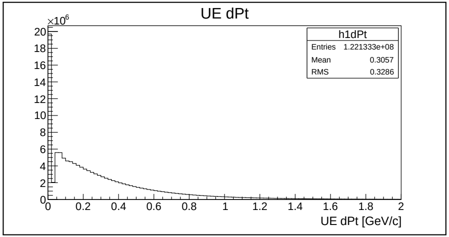
Run 17 EM-jet QA: Jet Energy

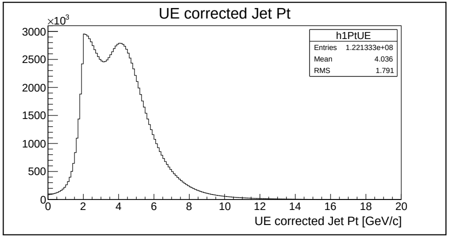


Run 17 EM-jet QA: Jet p_T

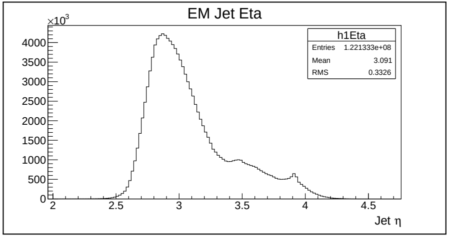


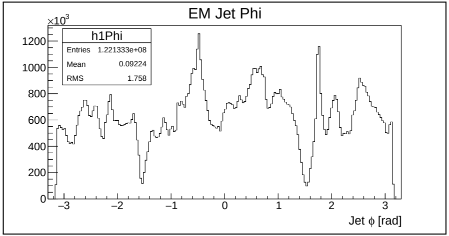


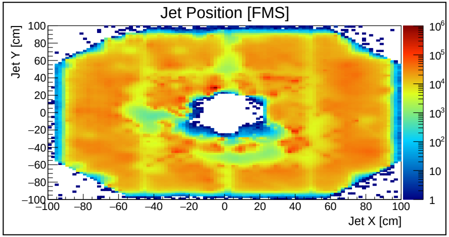


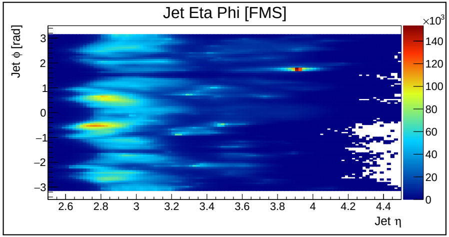


Run 17 EM-jet QA: Angular Distribution









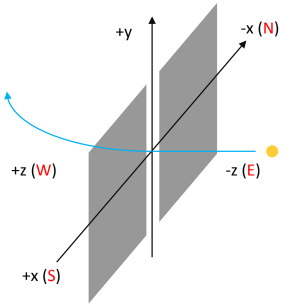
EM-Jet A_N Extraction

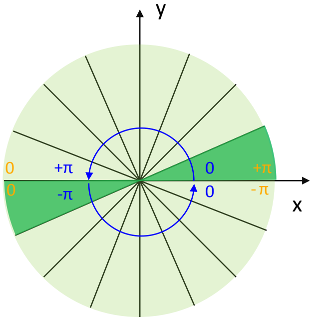
- Cross-ratio formula to calculate A_N

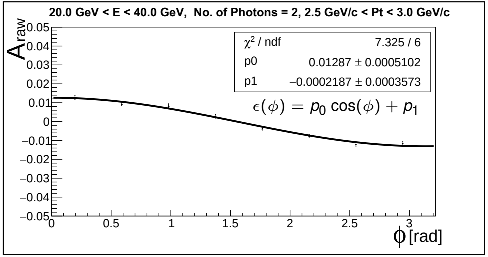
$$\epsilon = PA_N \cos(\phi)$$

$$\epsilon \approx \frac{\sqrt{N_\phi^\uparrow N_{\phi+\pi}^\downarrow} - \sqrt{N_{\phi+\pi}^\uparrow N_\phi^\downarrow}}{\sqrt{N_\phi^\uparrow N_{\phi+\pi}^\downarrow} + \sqrt{N_{\phi+\pi}^\uparrow N_\phi^\downarrow}}$$

- **Advantages:** Cancels systematics, such as luminosity and detector effects







EM-Jet A_N Extraction

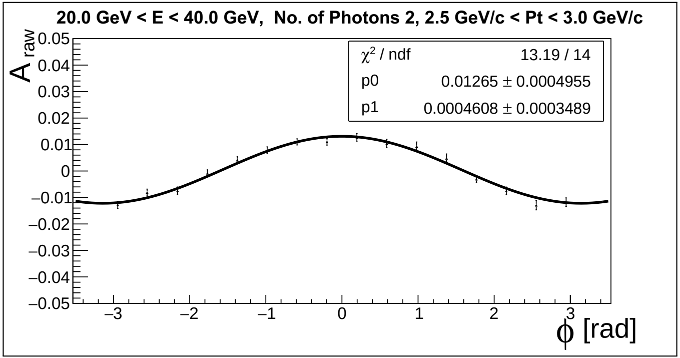
$$N^{\uparrow} = I_0^{\uparrow}\epsilon(1 + PA_N \cos\phi)$$
$$N^{\downarrow} = I_0^{\downarrow}\epsilon(1 - PA_N \cos\phi)$$

$$A(\phi) = \frac{N^{\uparrow} - N^{\downarrow}}{N^{\uparrow} + N^{\downarrow}}$$

$$A(\phi) \approx PA_N \cos\phi + \frac{I_0^{\uparrow} - I_0^{\downarrow}}{I_0^{\uparrow} + I_0^{\downarrow}}$$

$$A(\phi) = PA_N\cos(\phi) + p_1$$

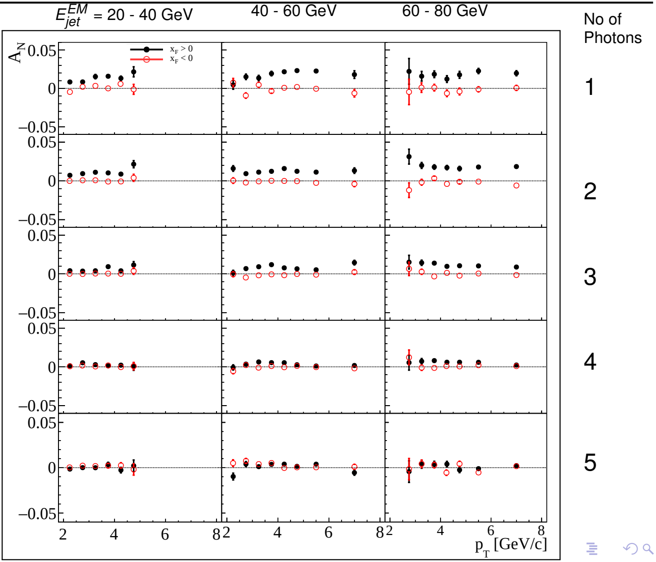
$$A(\phi) + A(\phi + \pi) \approx 2\frac{I_0^{\uparrow} - I_0^{\downarrow}}{I_0^{\uparrow} + I_0^{\downarrow}}$$



- Allows extraction of both physics asymmetry and beam asymmetry

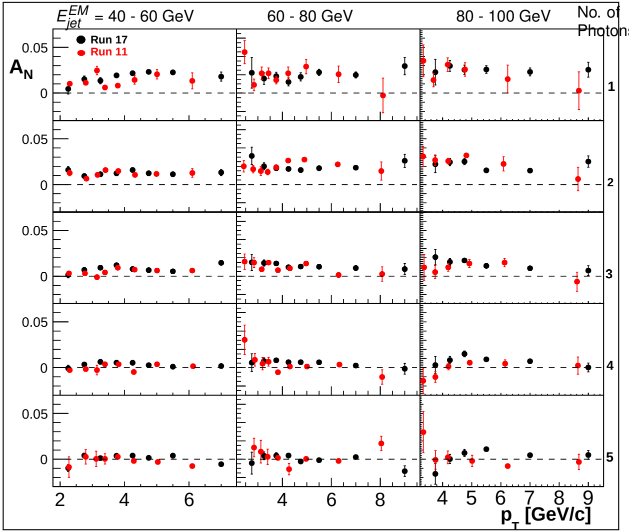
Run 17 FMS EM-Jet A_N

- About 20% of Run 17 data
- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- Error bars statistical only



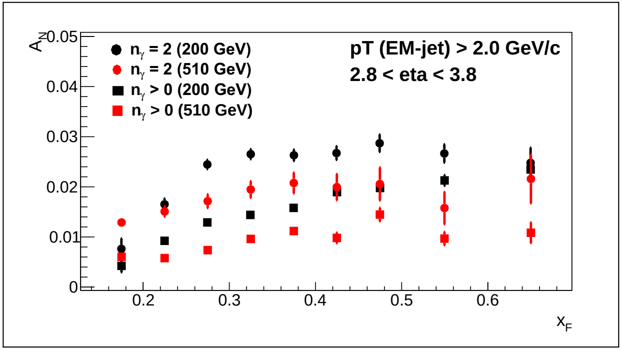
Comparing Run 17 FMS EM-Jet A_N With Run 11

- About 20% of Run 17 data
- Small BS, Large BS and FMS-JP Triggers
- Anti-k_T with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
- Error bars statistical only



Comparing Run 17 FMS EM-Jet A_N With Run 15

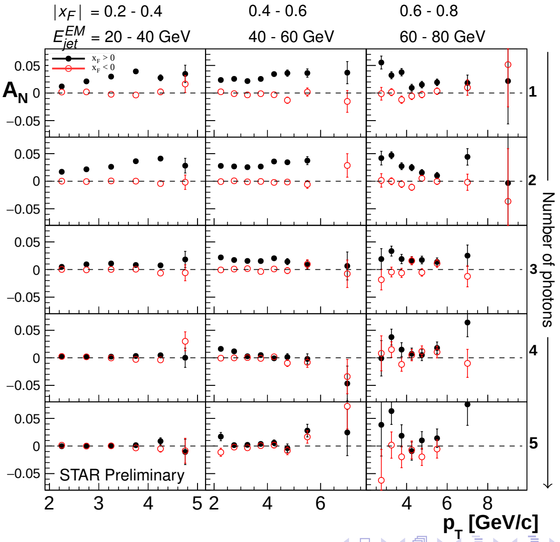
- About 20% of Run 17 data
- Small BS, Large BS and FMS-JP Triggers
- Anti-k_T with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
- Error bars statistical only



Preliminary Request for Run 15 Results

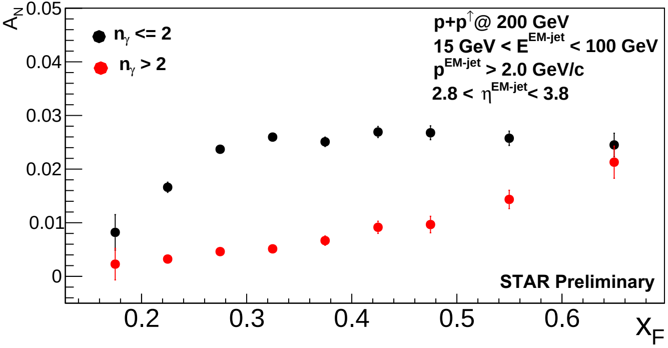
Run 15 FMS EM-jet A_N Results

- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
- Statistical and systematic error bars
- 3.46% polarization scale uncertainty not shown



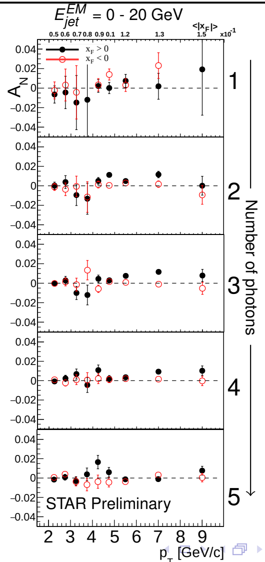
Run 15 FMS EM-jet A_N Results

- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
- Error bars statistical only
- 3.46% polarization scale uncertainty not shown



Run 15 EEMC EM-jet A_N Results

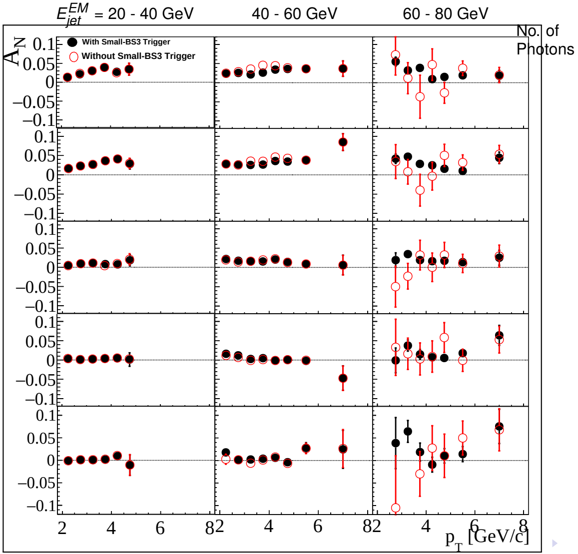
- EHT0, JP and MB triggers
- Anti-k$_T$ with R = 0.7
- Photon multiplicity based on EEMC tower counts
- Tower $E_T > 0.2$ GeV
- Jet p_T > 2.0 GeV/c
- 1.0 < η^{EM-jet} < 2.0
- Statistical and systematic error bars
- 3.46% polarization scale uncertainty not shown



Other Consistency Check

Run 15 FMS EM-jet A_N Results: With vs Without Small-BS3 Trigger

- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
- Error bars statistical only
- 3.46% polarization scale uncertainty not shown



t-Test

- Following is the t-test output from the program R comparing asymmetries from Latif and Zhanwen for $n_\gamma > 0$ case:

```
> latif <- c(0.00045, 0.0047, 0.0066, 0.0087, 0.0112, 0.0134, 0.0171, 0.0219)
> zhanwen <- c(0.00439442, 0.00409551, 0.00554648, 0.00717851, 0.00818287, 0.00990652, 0.0130281, 0.018355)
> t.test(latif, zhanwen, paired = TRUE)

        Paired t-test

data:  latif and zhanwen
t = 1.8139, df = 7, p-value = 0.1126
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0005070875  0.0038477350
sample estimates:
mean of the differences
            0.001670324

>
```

Materials for Preliminary Results

- Brief analysis note for the preliminary results
- Drupal page with the preliminary results

Backup Slides

Run 15 FMS EM-jet A_N Results

- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
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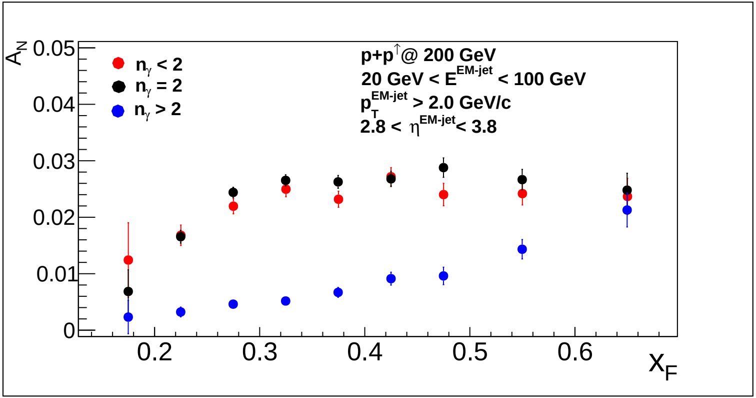

Run 15 FMS EM-jet A_N Results

- Small BS, Large BS and FMS-JP Triggers
- Anti-k$_T$ with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- 2.8 < η^{EM-jet} < 3.8
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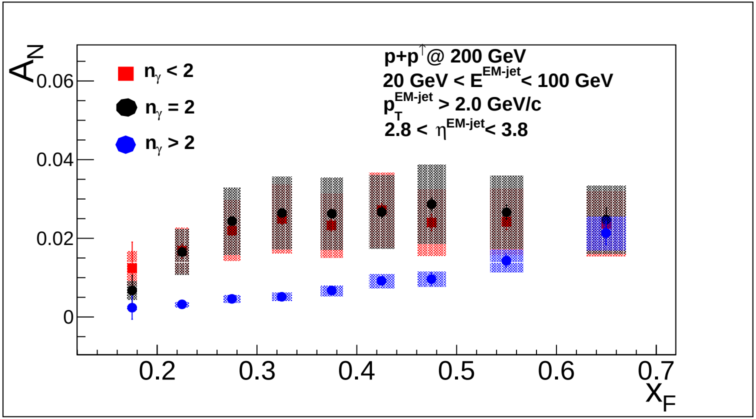


Analysis Details and List of Cuts

	Status / Value
1. Trigger:	
1.1. FMS Data	FMS BS and JP
1.2. EEMC Data	EHT0, JP and MB
2. Jet Reconstruction:	
2.1. FMS hot channel masking before reconstruction	Yes
2.2. Exclude highly bit-shifted channel	Yes
2.3. Fill-by-fill hot/bad channel masking	Yes
2.4(a). FMS Calibration	UCR (Chong)
2.4(b). FMS points as input for Anti-k_T	Yes
2.4(c). FMS Point: Try 1 photon fit (default is yes)	Yes
2.4(d). FMS point: Scale shower shape to 0.8 for large and 0.6 for small cells (default)	Yes
2.4(e). FMS point: Merge Small to large (default)	Yes
2.4(f). FMS point: Choose cluster categorization algorithm (default)	Yes
2.5. R for Anti-k_T	0.7
2.6. Photon energy cut	E_γ > 1.0 GeV
2.7. Jet p_T	Jet p_T > 2.0 GeV/c
2.8. Vertex z priority according to TPC, VPD, BBC	Yes
2.9. BBC slewing correction	Yes
2.10. Jet Finder Class	`StJetMaker2015`

Analysis Details and List of Cuts

	Status / Value
3. Event Selection Cuts:	
3.1(a). Veto on LED	Yes
3.1(b). Veto on abort gap	Yes
3.2(a). Eta (η) range covered (FMS)	2.8 - 3.8
3.2(b). Eta (η) range covered (EEMC)	1.0 - 2.0
3.3. Vertex z cut	-80 cm < V_z < 80 cm
3.4. Trigger dependept p_T cut	Yes
3.5. Exclude bad spin status	Yes
3.6. Ring of fire cut: BBC and TOF	No
3.7. Ring of fire cut: Exclude Sm-bs3 trigger	Yes
3.8. Exclude fills with wrong spin pattern	Yes
3.9. Exclude events with x_F > 1 or E_{jet} > 100 GeV	Yes

	Status / Value
4. Corrections:	
4.1. Photon energy correction	No
4.2. Jet energy correction	Yes
4.3. Jet Pt correction	Yes
4.4. Underlying event correction	Yes
4.5. Time dependent correction	No
5. A_N Extraction:	
5.1. Extraction method	Cross-Ratio Formula
5.2. Phi binning	16

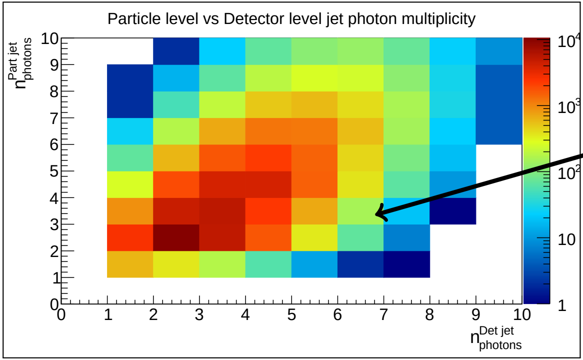
Unfolding for Event Misidentification

$$A_N^{1'} = p_{11}A_N^1 + p_{12}A_N^2 + \cdots\cdots + p_{15}A_N^5$$
$$A_N^{2'} = p_{21}A_N^1 + p_{22}A_N^2 + \cdots\cdots + p_{25}A_N^5$$
$$\vdots$$
$$A_N^{5'} = p_{51}A_N^1 + p_{52}A_N^2 + \cdots\cdots + p_{55}A_N^5$$

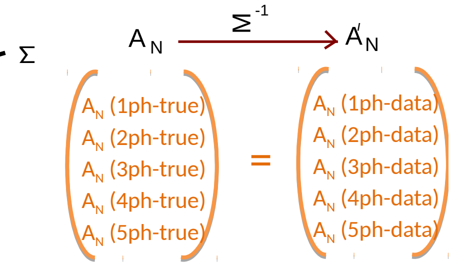
$$\boxed{A_N' = \Sigma A_N \Rightarrow A_N = \Sigma^{-1} A_N'}$$

$$\Sigma = \begin{bmatrix} p_{11} & \cdots & p_{15} \\ \vdots & \ddots & \vdots \\ p_{51} & \cdots & p_{55} \end{bmatrix}$$

Unfolding for Event Misidentification



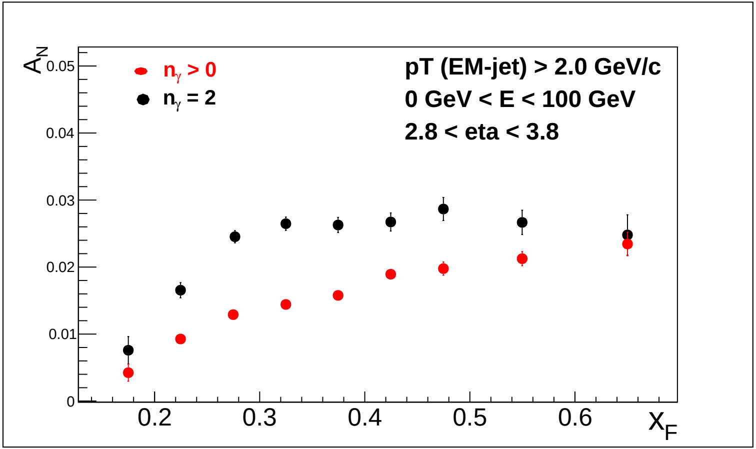
- The leading contributions come from A_N for EM-jets with photon multiplicity n < 6



- Solve a set of five linear equations with five variables for each energy and p_T bin
- Decompose A_N as a linear composition of A^i_N corresponding to n_i photons
- Use SVD for the unfolding procedure (e.g. TSVDUnfolding class)

Run 15 FMS EM-jet A_N Results

- Small BS, Large BS and FMS-JP Triggers
- Anti-k_T with R = 0.7
- $E_\gamma > 1.0$ GeV
- Jet p_T > 2.0 GeV/c
- Statistical and systematic error bars



Comparing With Zhanwen's Results

Summary of Comparison After Matching Most Conditions:

- $n_\gamma = 2$ (Two photon multiplicity) case compares well for both of us
- $n_\gamma > 2$ case compares well for both of us
- For $n_\gamma > 0$ case, my asymmetries are over estimated for few points compared to Zhanwen.
- The source of the difference is attributed to:
  Differences in -
  - FMS gain correction
  - FMS photon and jet reconstruction
  - Analysis approaches
- The details of the comparison can found in this drupal post (Link).