Run 15 single diffractive process simulation and estimate the non-single diffractive fraction

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Aug. 14, 2024

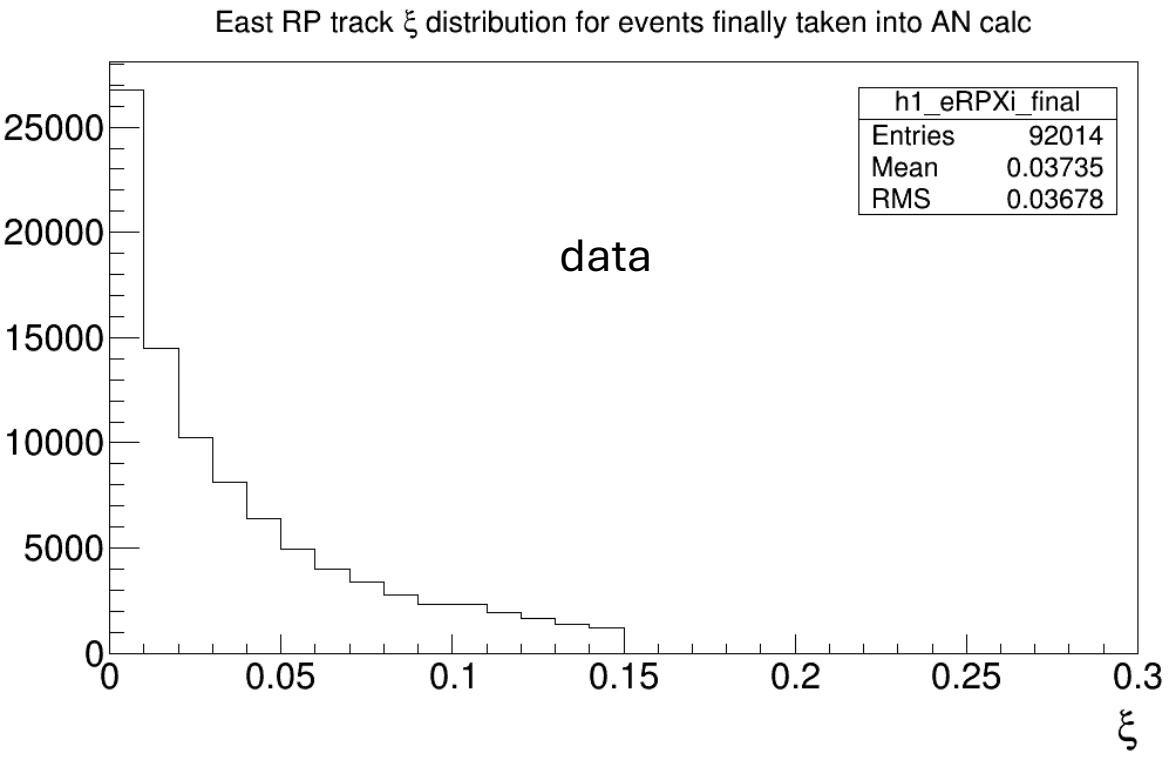
Simulation set up

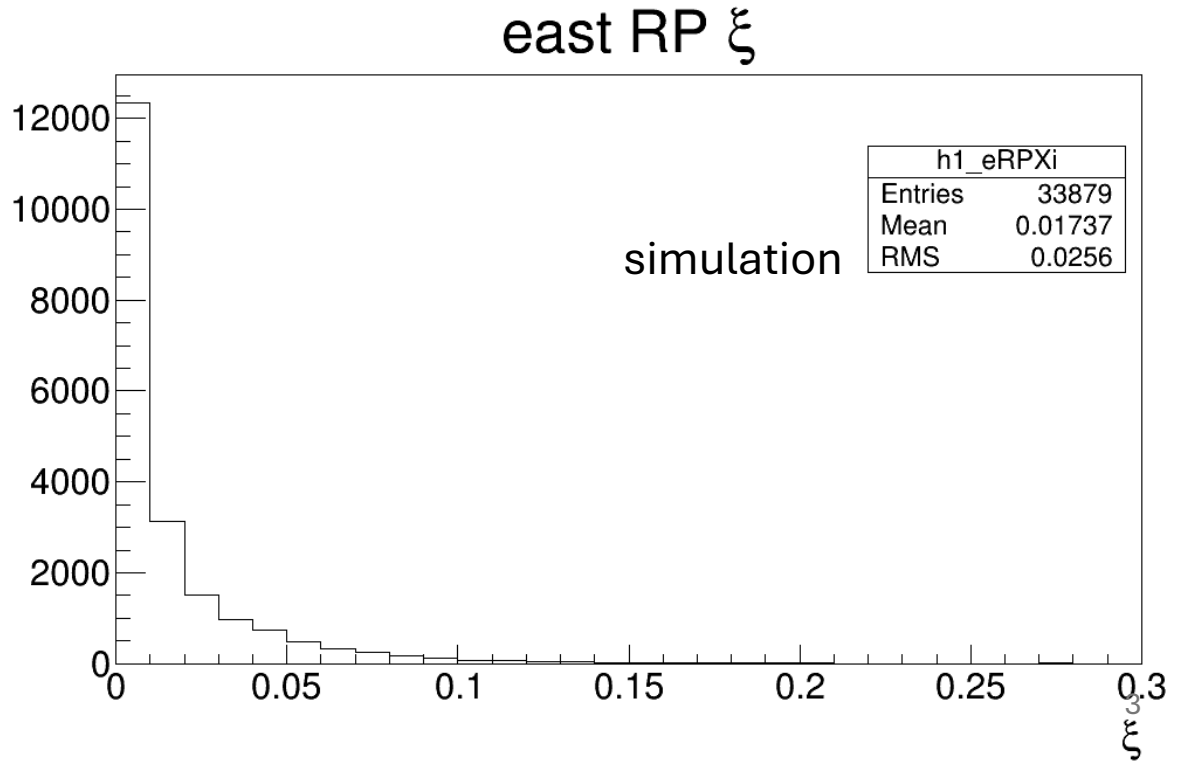
- Particle level simulation for single diffractive process:
  - Pythia 8 (version: 8.2.35)
  - Single diffractive events only (SoftQCD:singleDiffractive)
  - Totally 0.5 M events generated
  - About half of the entire events (~250 k) are with east proton
- Detector level simulation:
  - Roman Pot simulation for run 15 pp200

East RP track ξ

$$\xi = \frac{p_{beam} - p_{RP}}{p_{beam}}$$

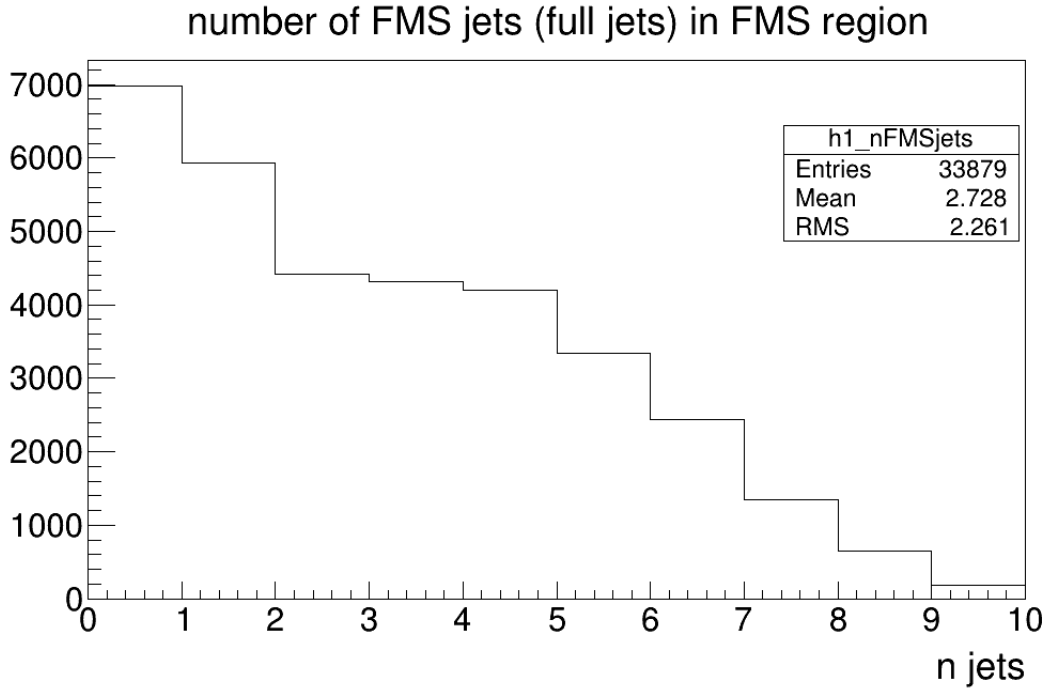
- These events are events with only 1 east RP track, and the track hit at least 7 planes.
- More than 99% of the events are with East RP track $\xi < 0.15$
  - Note: the data have already applied East RP track $\xi < 0.15$ cut

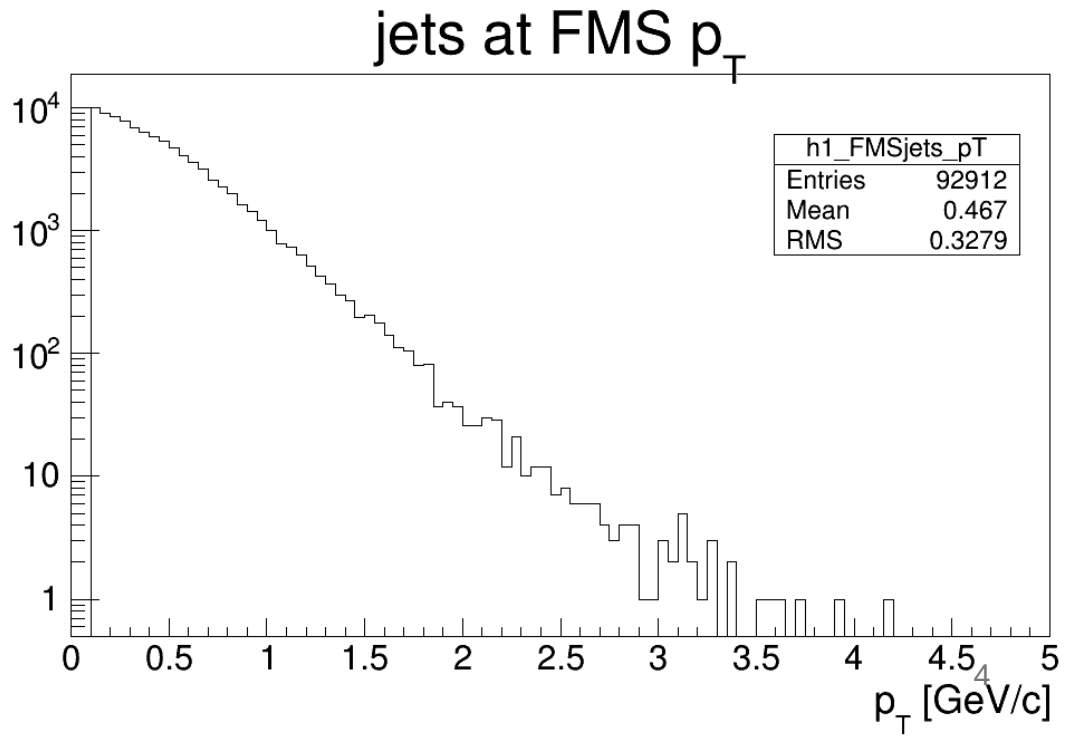




Jets at FMS region

- Apply the fastjet Anti-kT algorithm (R = 0.7) for reconstructing the jets within the FMS region.
  - We consider all the final state particle , not only the photons
  - FMS region: 2.4 < eta < 4.2 (sightly larger than the real FMS region)
  - At this stage, minimum pT: 0.1 GeV/c. But we see pretty small amount of jets for pT> 2.0 GeV/c





Determine the east BBC veto

- We determine the events should be veto by east BBC in simulation by considering two conditions:
  1. There are charged particles in the east BBC region ($-5 < \eta < -2.1$)
  2. There are some photons convert to electron and leave MIP on east BBC.

- Totally about 40k events of the single diffractive process are the events with charged particles in the east BBC region, which will not pass the east BBC veto cut in data

BBC east veto from electron

- The photons could have the pair production to produce electron pair, which might leave MIPs on the BBC east. In such situation, it will not pass the east BBC veto cut as well.
- We calculate the radiation length for beam pipe by each η bin ($-5 < \eta < -2$). The beam pipe consist of Aluminum (Al) and Beryllium (Be) , depending on z, so we consider that case by case.
  - If the $\eta > \sim -3.7$, we assume it passes through Be section, otherwise we assume it passes through Al section.
- The BBC scintillator material represents ~2.5% of a radiation length. Both effects on beam pipe and BBC will consider into conversion probability calculation for photon.
- We calculate the survival probability for each events with the photon in east BBC region $P(sur, event) = \prod P(sur, photon)$, the conversion probability $\mathrm{P}(\mathrm{conv}, \mathrm{event}) = 1 - P(sur, event)$
- Number of events with BBC east veto from electron $= \sum \mathrm{P}(\mathrm{conv}, \mathrm{event})$

Events for SD and RG

- Count the number of the events satisfying the rapidity gap (RG) events or single diffractive (SD) events for the simulation and data
  - For the simulation, SD events are the events satisfying BBCE veto and one good east RP track and at least one jet in FMS region; RG events are the events satisfying BBCE veto only and at least one jet in FMS region

Without excluding BBC east veto from electron	RG	SD	SD / RG
Simulation (SD)	166,796	26,896	16.13%

Subtracting BBC east veto from electron	RG	SD	SD / RG
Simulation	165,940	26,761	16.13%
Data	417,993	46,294	11.08%

Estimate the non single diffraction fraction in RG events

- We estimate the non single diffraction (NSD) fraction in RG events using the fraction of the SD events to the RG events from data and simulation.
  - Note: The simulation fraction have already subtracted BBC east veto from electron
- For the RG events in data, they contain the real SD (RSD) events and NSD events:
  - Frac(SD/RG in data)= $\frac{SD}{RSD+NSD}$ =11.08%
  - Frac(SD/RG in sim) = $\frac{SD}{RSD}$ =16.13%
  - Assuming $\frac{SD}{RSD}$ is same between data and simulation
- Therefore, NSD in RG events in data = $\frac{NSD}{RSD+NSD} = 31.3\%$

Are these NSD events in RG events in data from the non diffractive events?

- To understand this question, we also do the non diffractive simulation
  - SoftQCD:nonDiffractive
- RG event fraction in non-diffractive simulation: $\frac{N_{RG}}{N_{all}} = \mathbf{0.4\%}$
  - RG event: BBC East veto + jets at FMS region (particle level only)
- Fraction of RG events to inclusive events ($\frac{RG}{Inc}$): 1.37%
- Therefore, NSD in RG events in data to inclusive events $\frac{NSD}{RG} \times \frac{RG}{Inc} = \mathbf{0.43\%}$
  - Note: The RG events in data used are with response in RP detector
  - NSD in RG events in data = $\frac{NSD}{RG} = 31.3\%$
- They are close to each other! → The NSD events in RG events in data are non diffractive events

Conclusion

- Based on the single diffractive process simulation, we estimate the non single diffractive fraction in rapidity gap events in data: 31.3%
- The non single diffractive events in RG events in data are non diffractive events