Pseudorapidity dependence of long-range two-particle correlations in pPb collision at CMS

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for the CMS Collaboration

Quark Matter conference, Darmstadt

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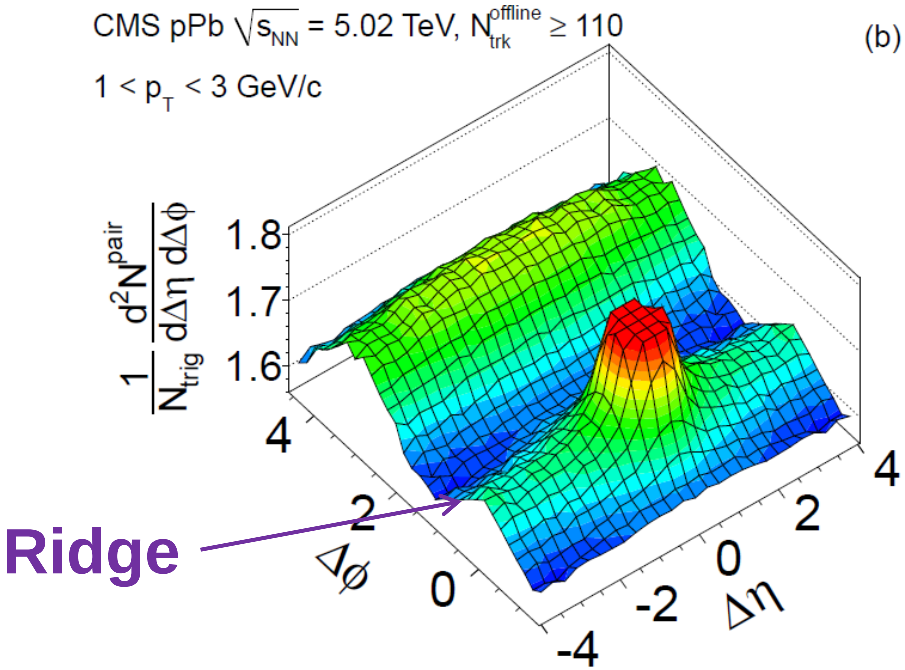
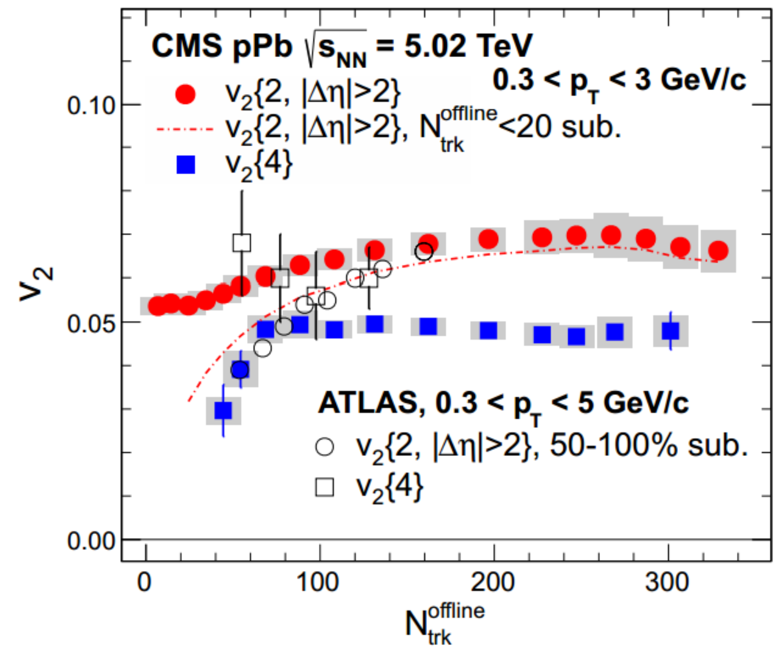
Outline

- Motivations
- Decompose η dependent near-side jet and ridge
- Extract η dependent v_n from dihadron correlations
- Conclusions

Motivation



Phys. Lett. B 718,795 (2013)



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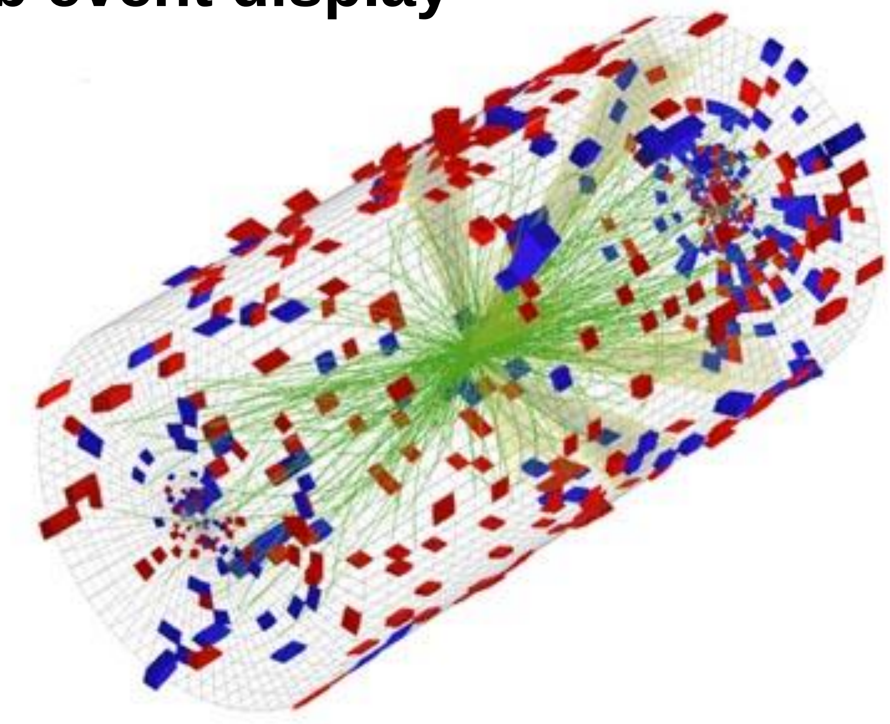
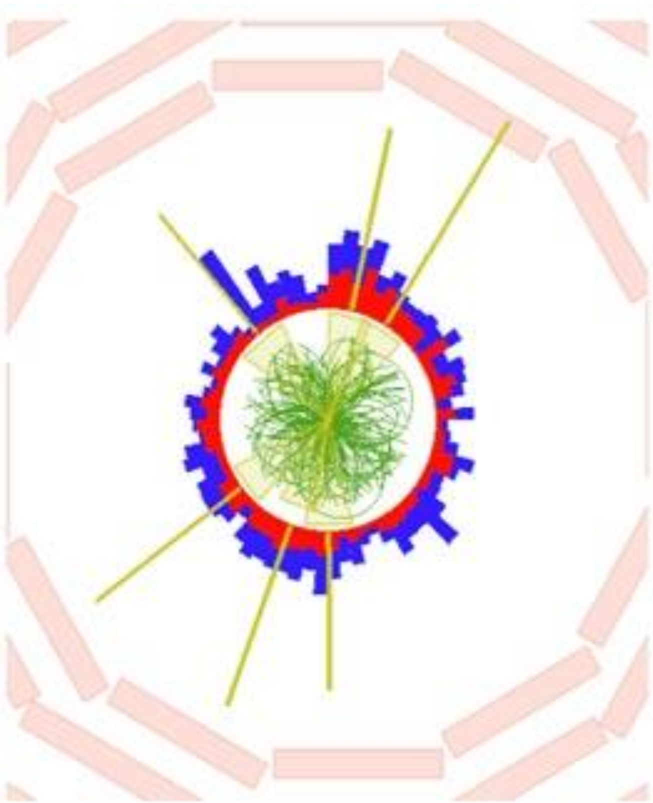
- Long range near-side ridge observed in pp and pPb
- Physics mechanisms under debate: hydro, CGC
- Study of $\Delta\eta$ dependence may reveal more insights

CMS experiment

pPb event display



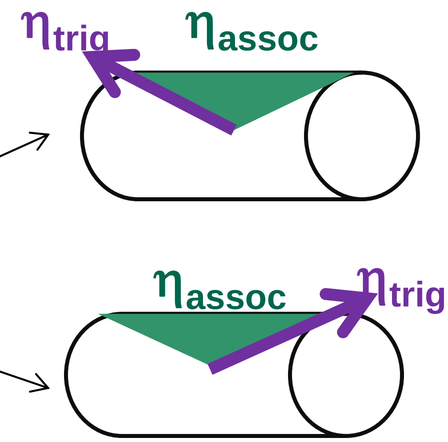


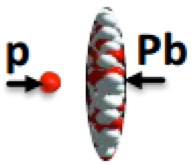
Large η acceptance
Tracker: |η|<2.5

Full ϕ coverage

Analysis procedure

- Previous analyses integrated over trigger and associate η. Possible $\Delta\eta$ dependence is averaged out.
- Use fixed narrow trigger η range:
  - ❑ $-2.4 < \eta_{trig} < -2.0$ (Pb-going side)
  - ❑ $2.0 < \eta_{trig} < 2.4$ (p-going side)



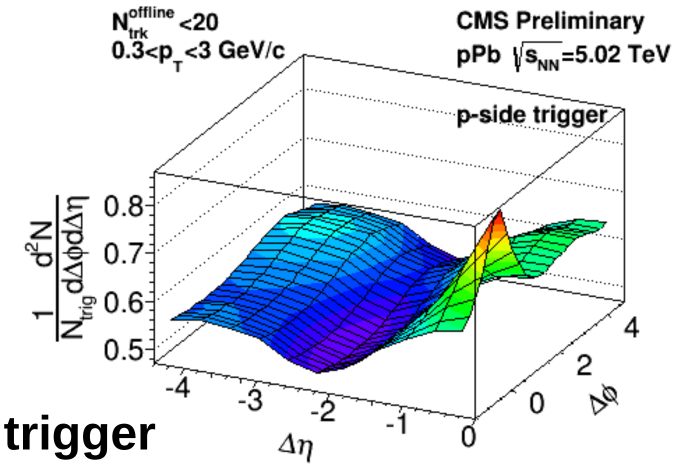


  - Two-particle acceptance is 100%; no need to divide by mixed-events.
  - Efficiency corrected for associated particles.
  - Correlation normalized per trigger particle.
  - p_T^{trig} = 0.3-3 GeV/c, p_T^{assoc} = 0.3-3 GeV/c
  - Low-multiplicity: $2 \leq N_{trk}^{offline} < 20$. High-multiplicity: $220 \leq N_{trk}^{offline} < 260$

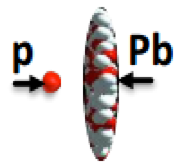
Dihadron per trigger pair density

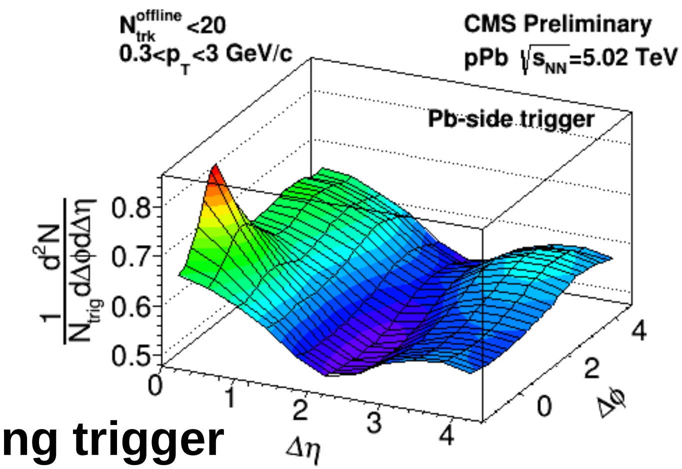
Dihadron techinique: $\Delta\phi = \phi_{assoc} - \phi_{trig}\,,\Delta\eta = \eta_{assoc} - \eta_{trig}$

Not divided by mixed events: $S(\Delta\eta,\Delta\phi)=\frac{1}{N_{trig}}\frac{d^2N^{same}}{d\Delta\eta\Delta\phi}$

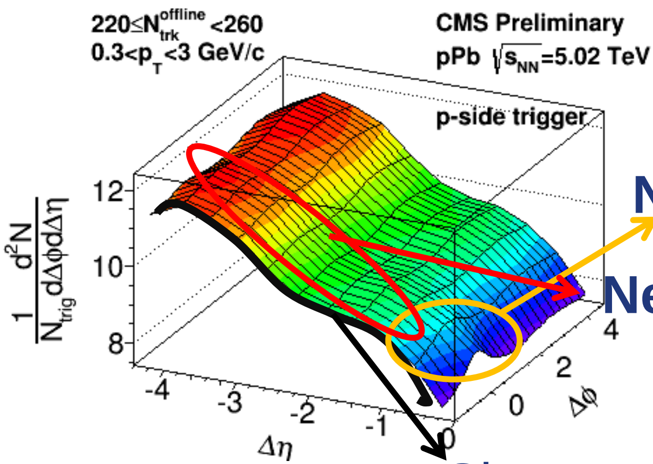


p-going trigger



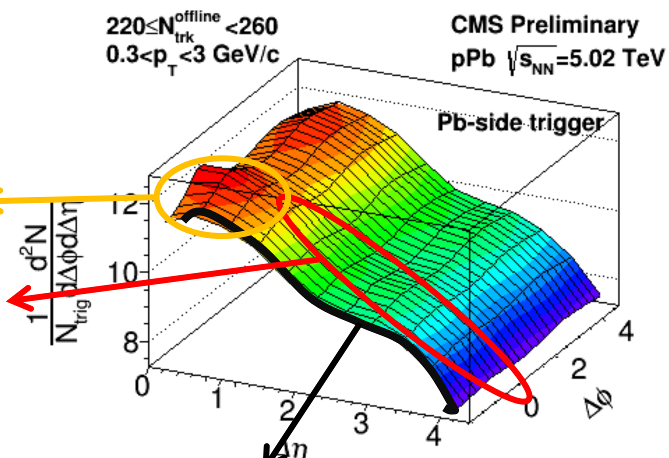


Pb-going trigger



Near-side jet

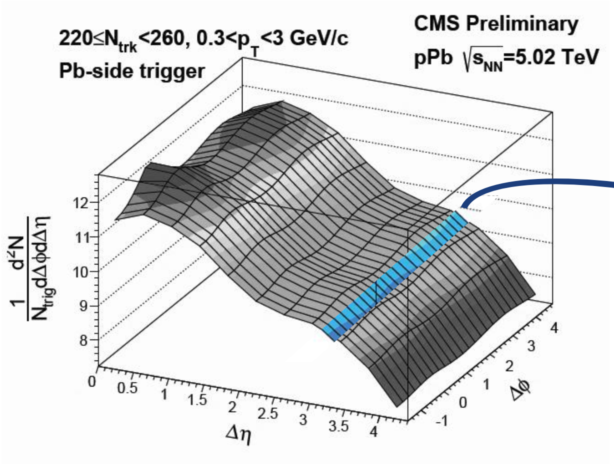
Near-side ridge

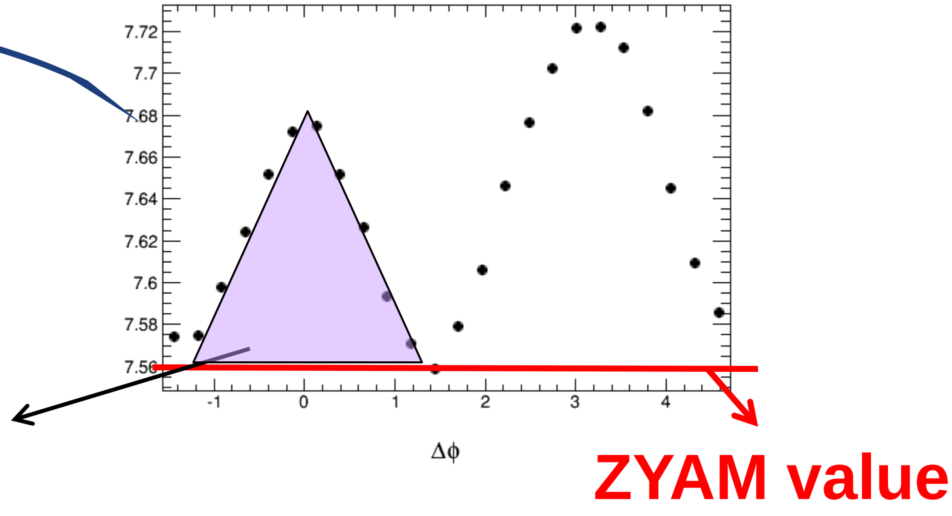


Shape reflects single particle dN/dη

ZYAM method

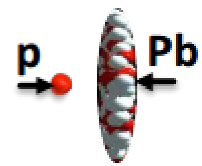
- For each $\Delta\eta$ slice, step through the $\Delta\phi$ range with $\Delta\phi$ width of 0.26 to find the minimum value.
- After ZYAM subtraction, near-side yield is calculated by integrating over $|\Delta\phi|<\pi/3$



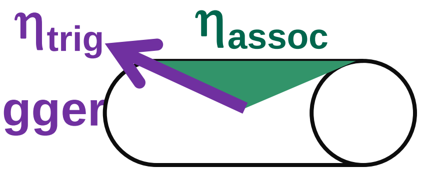


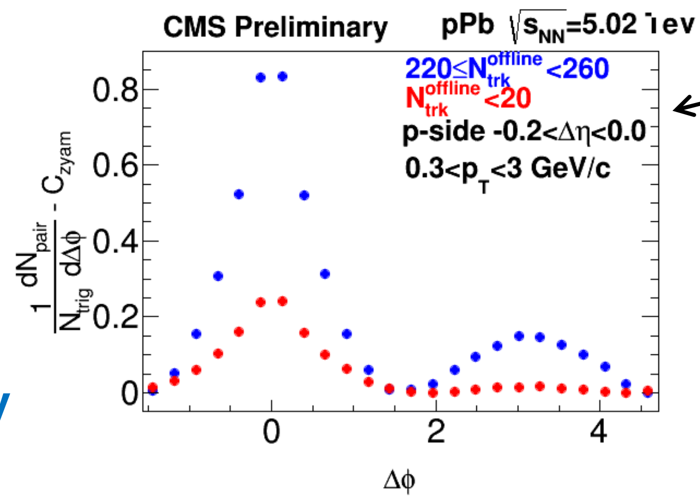
Δϕ distribution of correlated yield after ZYAM subtraction

p-going trigger

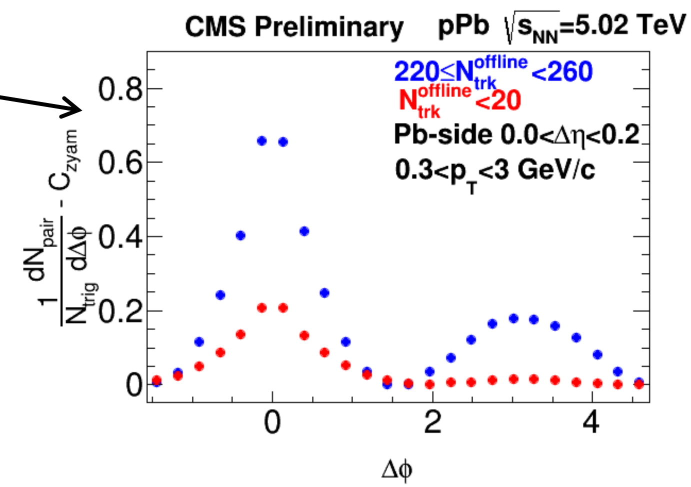


Pb-going trigger



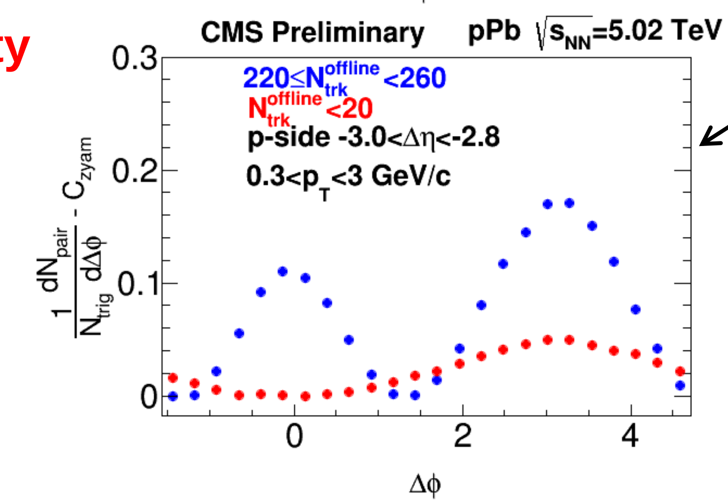


Jet region

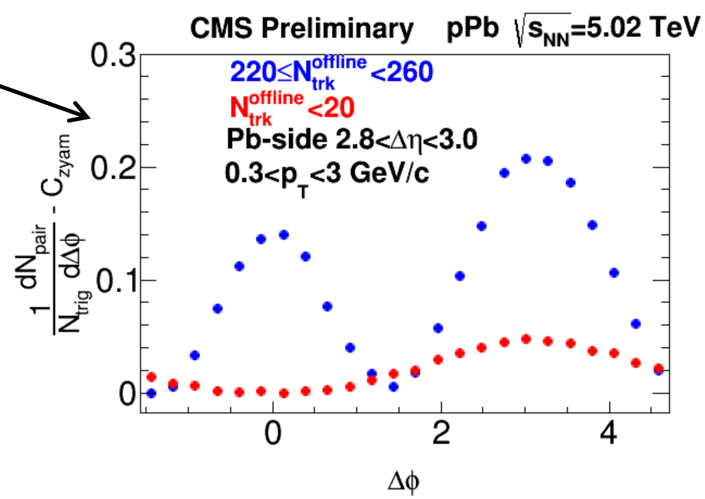


High multiplicity

Low multiplicity

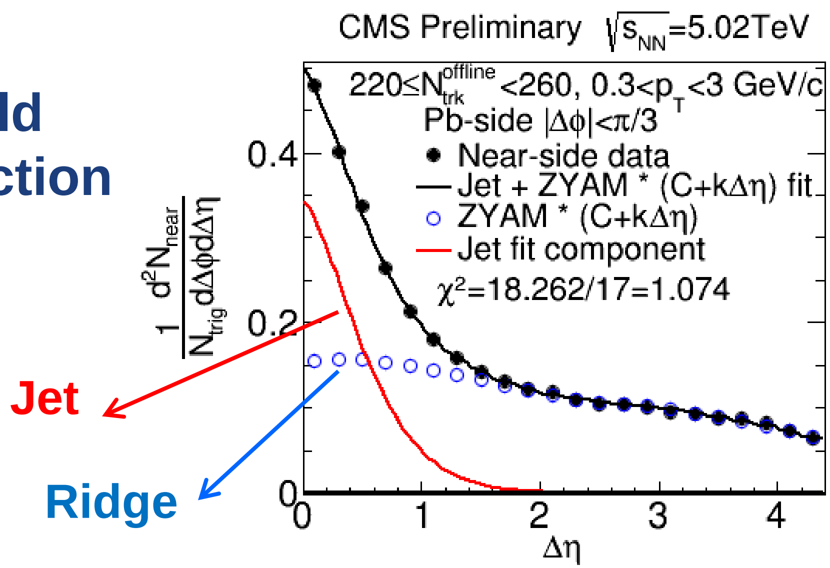


Ridge region



Near-side jet and ridge decomposition

$\Delta\eta$ distribution of correlated yield after ZYAM subtraction $|\Delta\phi|<\pi/3$



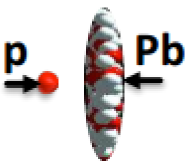
Pb-going trigger

Use a fit function representing jet + ridge structure:

$$\frac{1}{N_{trig}}\frac{dN_{near}(\Delta\eta)}{d\Delta\eta}=\boxed{\frac{Y\beta}{\sqrt{2}\sigma\Gamma(1/2\beta)}\exp[-(\frac{\Delta\eta^2}{2\sigma^2})^{\beta}]}+\boxed{(C+k\Delta\eta)\times ZYAM(\Delta\eta)}$$

- Jet yield ratio of $Y_{jet}(220\leq N_{trk}^{offline}<260)/Y_{jet}(N_{trk}^{offline}<20)$:
  3.13 ± 0.09 (Pb-side trigger) and 3.08 ± 0.11(p-side trigger)

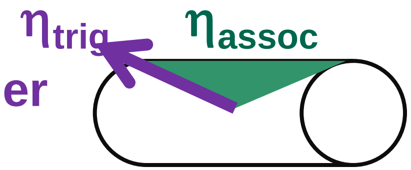
High-multiplicity near-side fit



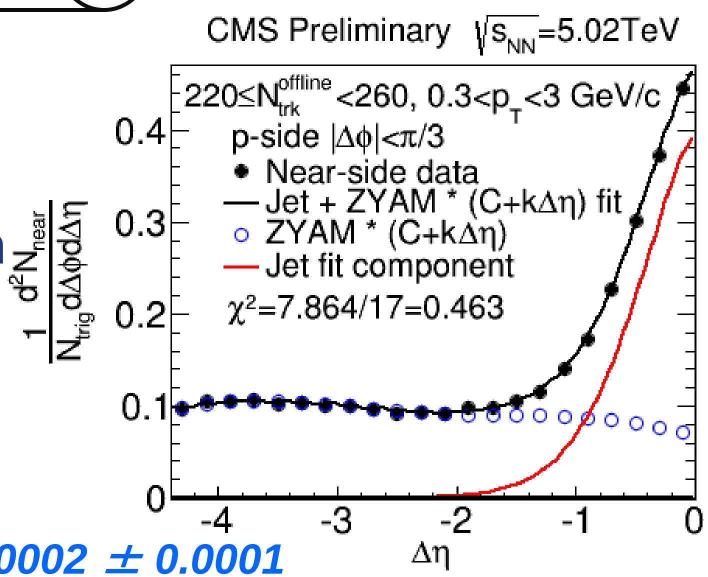
$$\frac{1}{N_{trig}}\frac{dN_{near}(\Delta\eta)}{d\Delta\eta} = \frac{N\beta}{\sqrt{2}\sigma\Gamma(1/2\beta)}\exp[-(\frac{\Delta\eta^2}{2\sigma^2})^{\beta}] + (C + k\Delta\eta)\times ZYAM(\Delta\eta)$$

p-going trigger

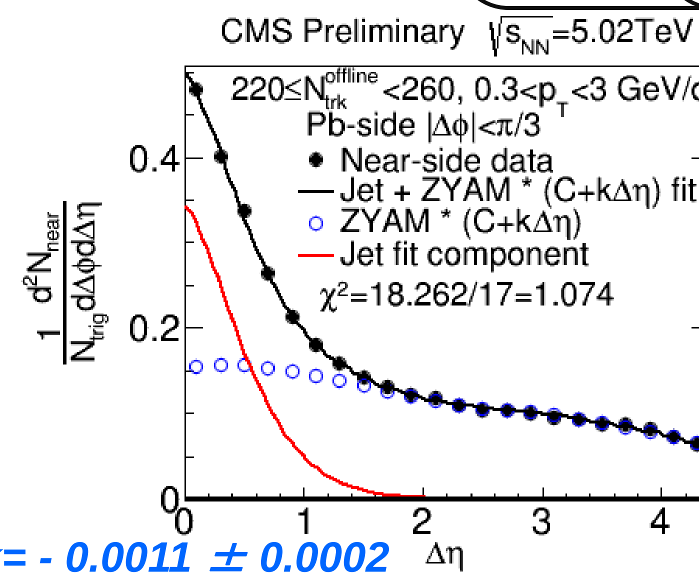
Pb-going trigger



After ZYAM subtraction



k=0.0002 ± 0.0001

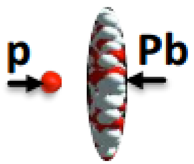


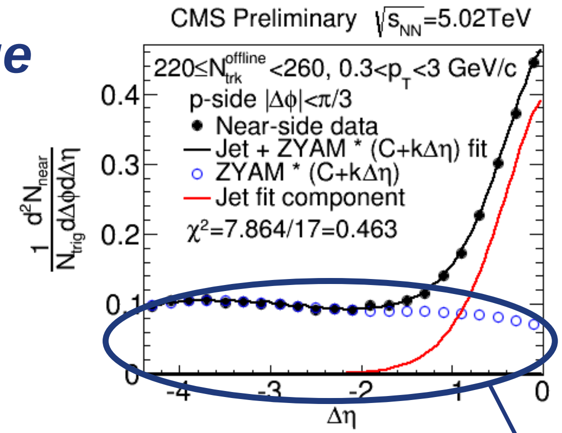
k= - 0.0011 ± 0.0002

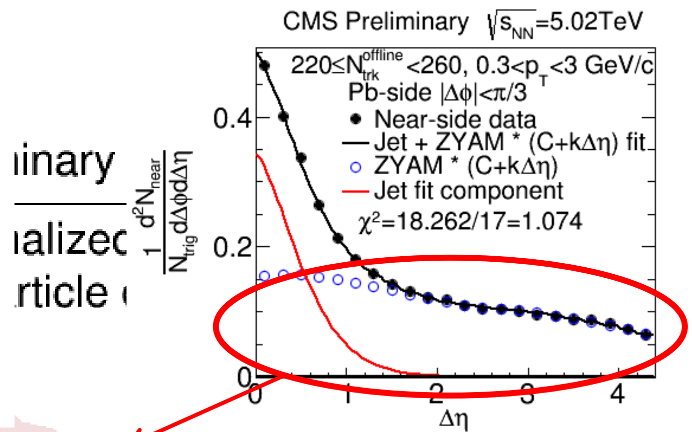
- Ridge favors linear Δη–dependence; $(C + k\Delta\eta)\times ZYAM(\Delta\eta)$
- Other functional forms used for systematic study.
- **Subtract the fitted jet to obtain the near-side ridge**

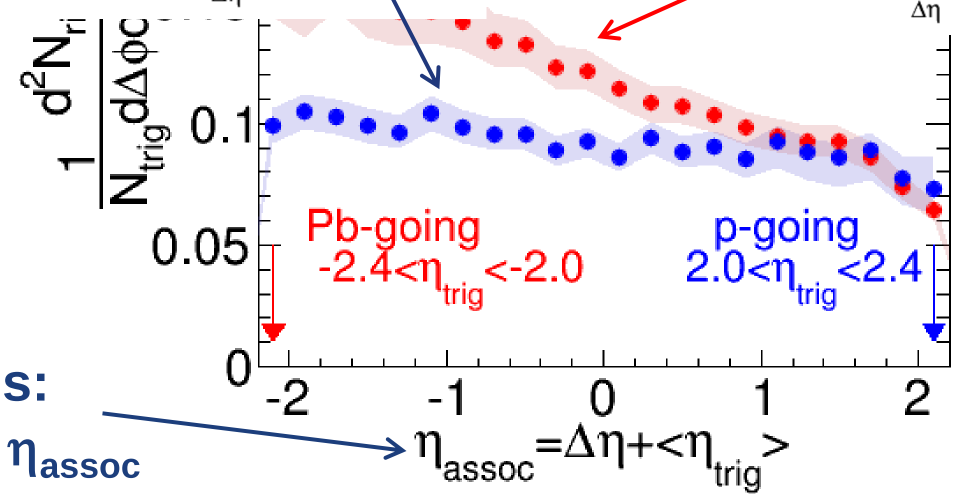
Ridge yield vs η_{assoc}

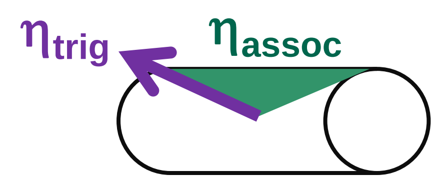
Near-side ridge after jet subtraction











Shifted axis:

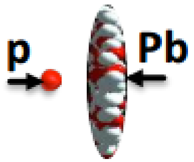
Single particle η_{assoc}

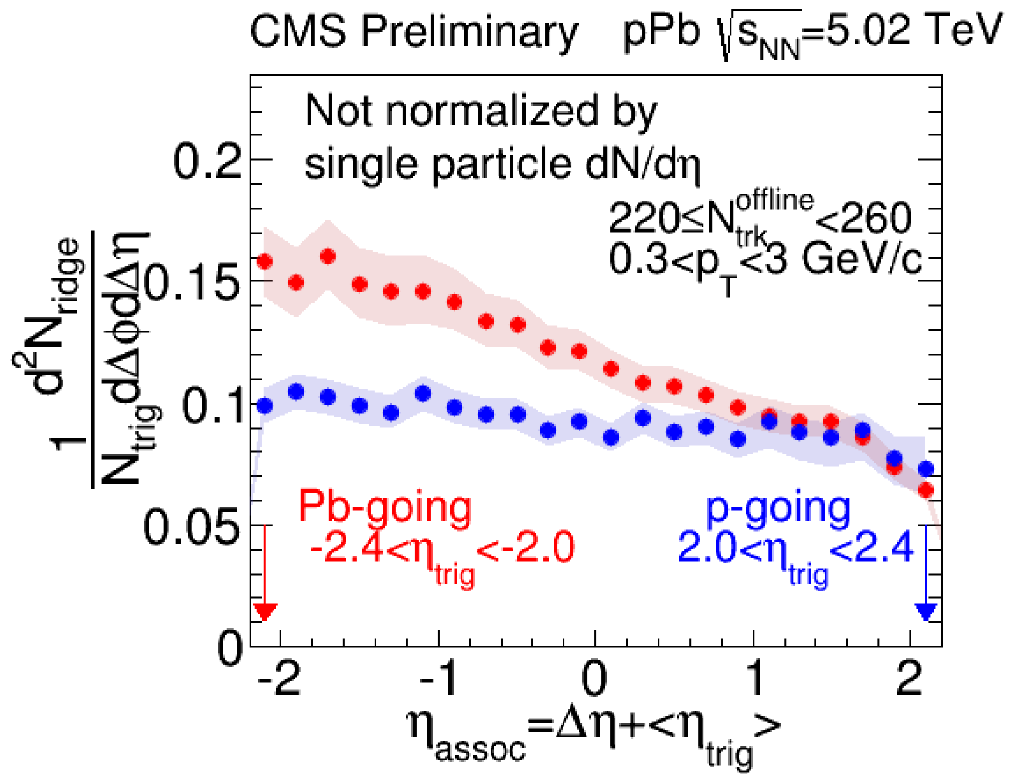
Compare** **Pb-going trigger** **and** **p-going trigger

Near-side ridge yield

Ridge yield vs η_{assoc}

Near-side ridge after jet subtraction



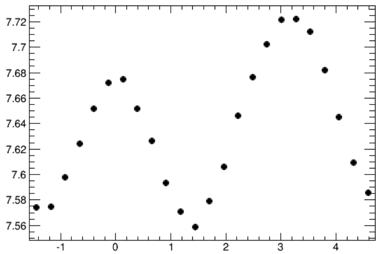


- Near-side ridge yield: different η dependences observed for Pb-going trigger and p-going trigger

Fourier coefficients V_n from dihadron correlation

- Fourier decomposition

$$\frac{1}{N_{trig}}\frac{dN^{pair}}{d\Delta\phi} = \frac{N_{assoc}}{2\pi}\left\{1+\sum_n 2V_n \cos(n\,\Delta\phi)\right\}$$



  – Calculate Fourier coefficient $V_n = \langle\cos(n\,\Delta\phi)\rangle$ as a function of $\Delta\eta$.

- Low-multiplicity subtraction to minimize jet contributions

$$V_n^{sub} = V_n - V_n(N_{trk}^{offline} < 20) \times \frac{N_{assoc}(N_{trk}^{offline} < 20)}{N_{assoc}} \times \frac{Y_{jet}}{Y_{jet}(N_{trk}^{offline} < 20)}$$

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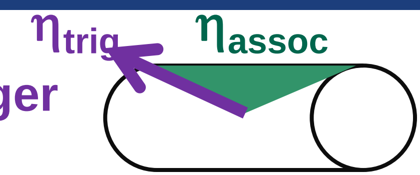
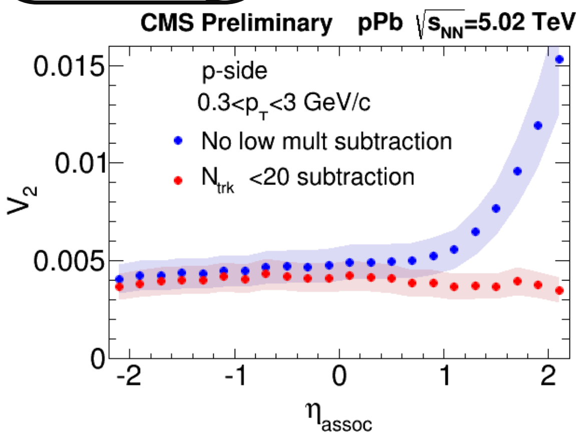
Fourier coefficients V_n from dihadron correlation

p-going trigger

Pb-going trigger

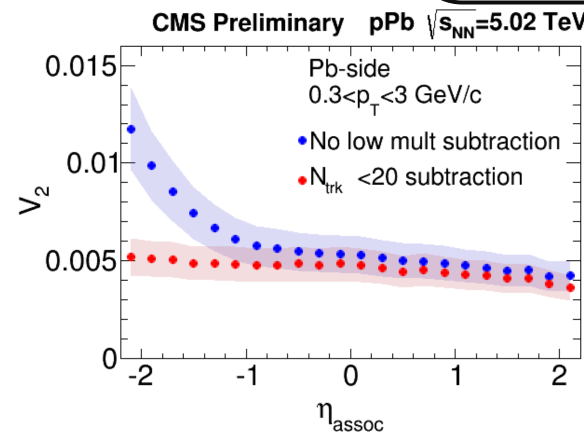


V_2

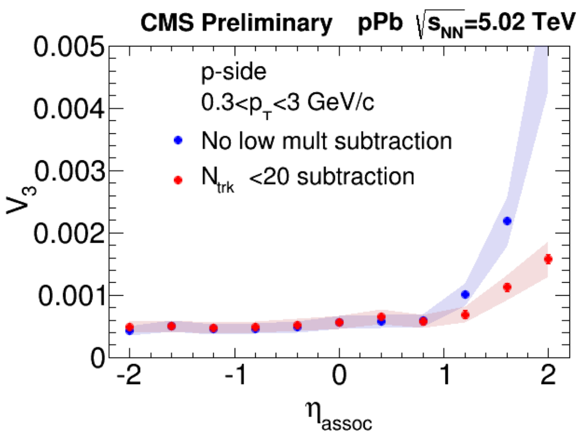


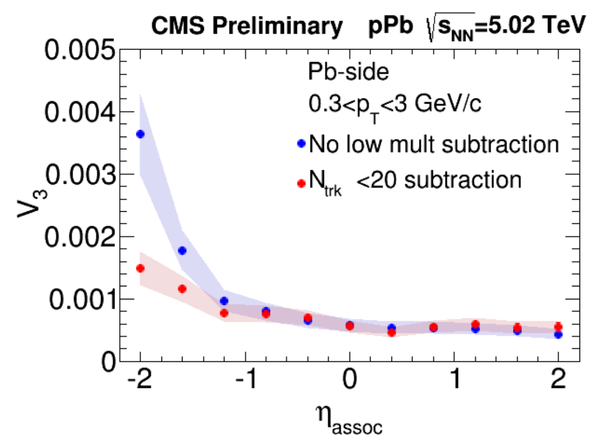
Blue: no jet Subtraction

Red: with jet subtraction



V_3





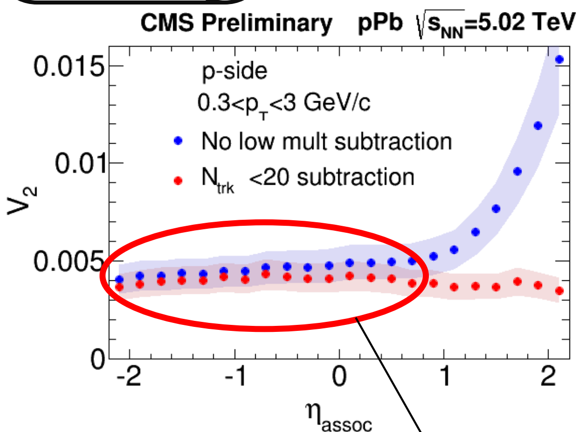
- Jet contribution mostly removed at short range.
- Small difference at long range: away jet contribution is small

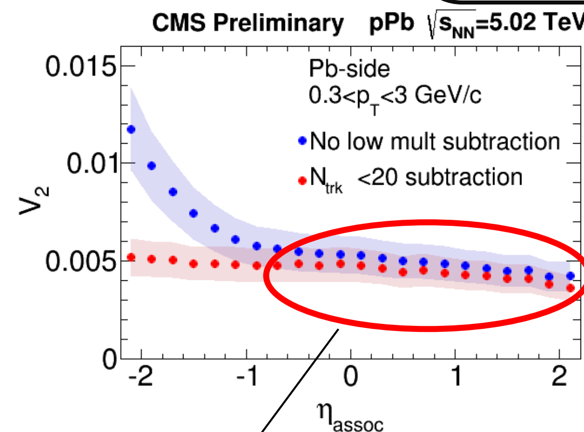
Extract $v_n(\eta)/ v_n(0)$ from Fourier coefficient

p-going trigger

Pb-going trigger

V_2





Long range used for single $v_n(\eta_{assoc})/ v_n(0)$

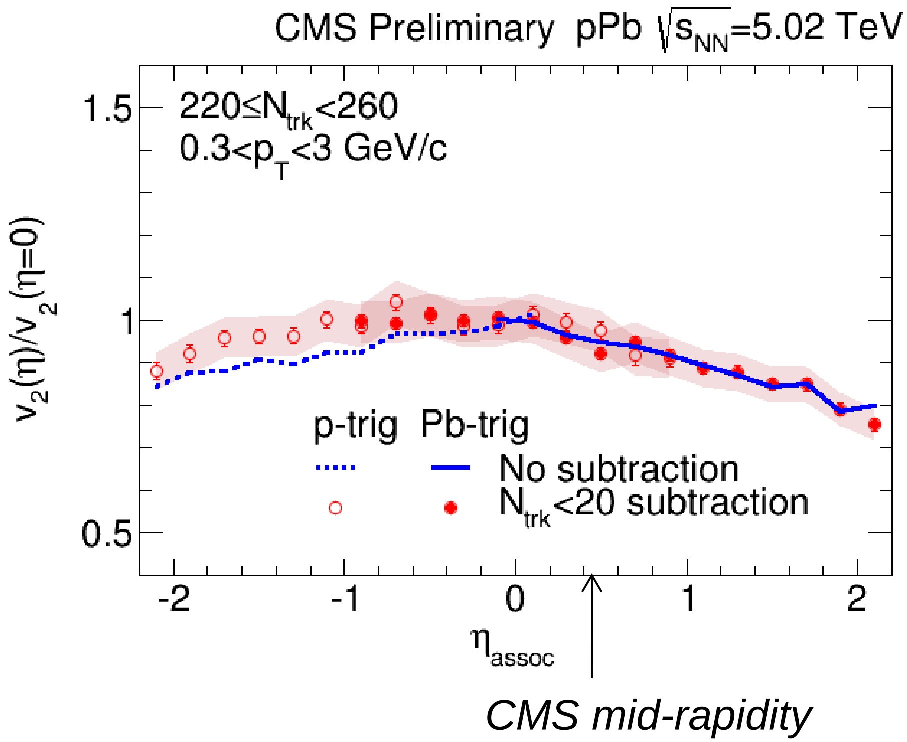
Assuming factorization, $V_n(\eta_{trig},\eta_{assoc})=v_n(\eta_{trig})\, v_n(\eta_{assoc})$

calculate self-normalized single particle $v_n(\eta_{assoc})/ v_n(0)$:

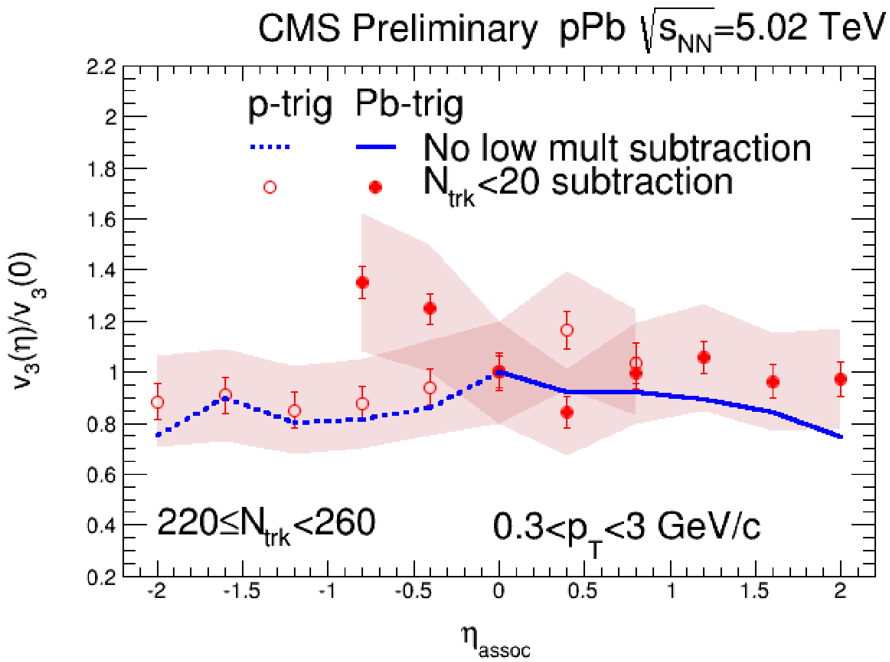
$$v_n(\eta_{assoc})/ v_n(0)= V_n(\eta_{trig},\eta_{assoc})/ V_n(\eta_{trig},0)$$

Extract $v_n(\eta)/ v_n(0)$ from Fourier coefficient

$v_2(\eta)/ v_2(0)$:



$v_3(\eta)/ v_3(0)$:



- v_2 shape is η dependent !
- v_2 from low-mult. subtraction: asymmetric about mid-rapidity
- With large errors, cannot draw conclusion for v_3

Conclusions

- Two-particle correlations studied in pPb, with trigger particles restricted to fixed, narrow windows, for

  Pb-going side ($-2.4 < \eta_{trig} < -2.0$) and

  p-going side ($2.0 < \eta_{trig} < 2.4$)

- Near-side jet and ridge decomposed:

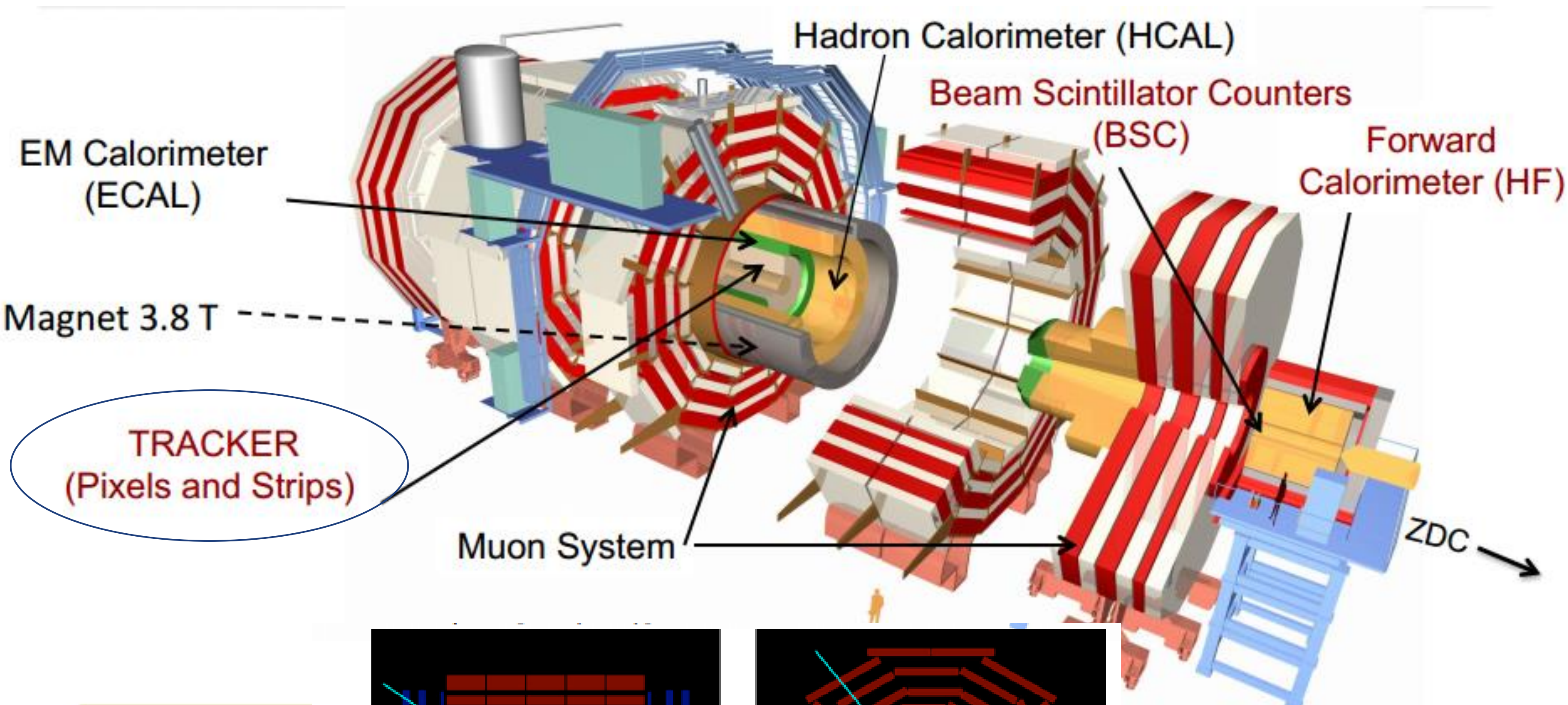
  Ridge yield depends on η, and different for Pb-going and p-going triggers.

- Fourier coefficients and self-normalized single-particle harmonics extracted:

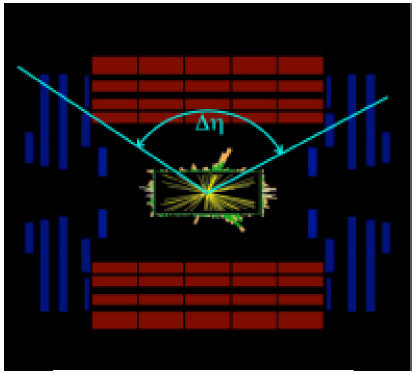
  Significant η dependence observed for v_2.

Backups

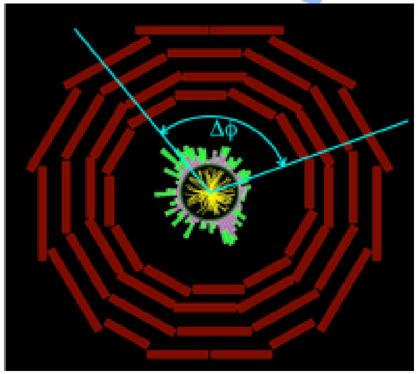
CMS experiment



Large η acceptance $|\eta|<2.5$



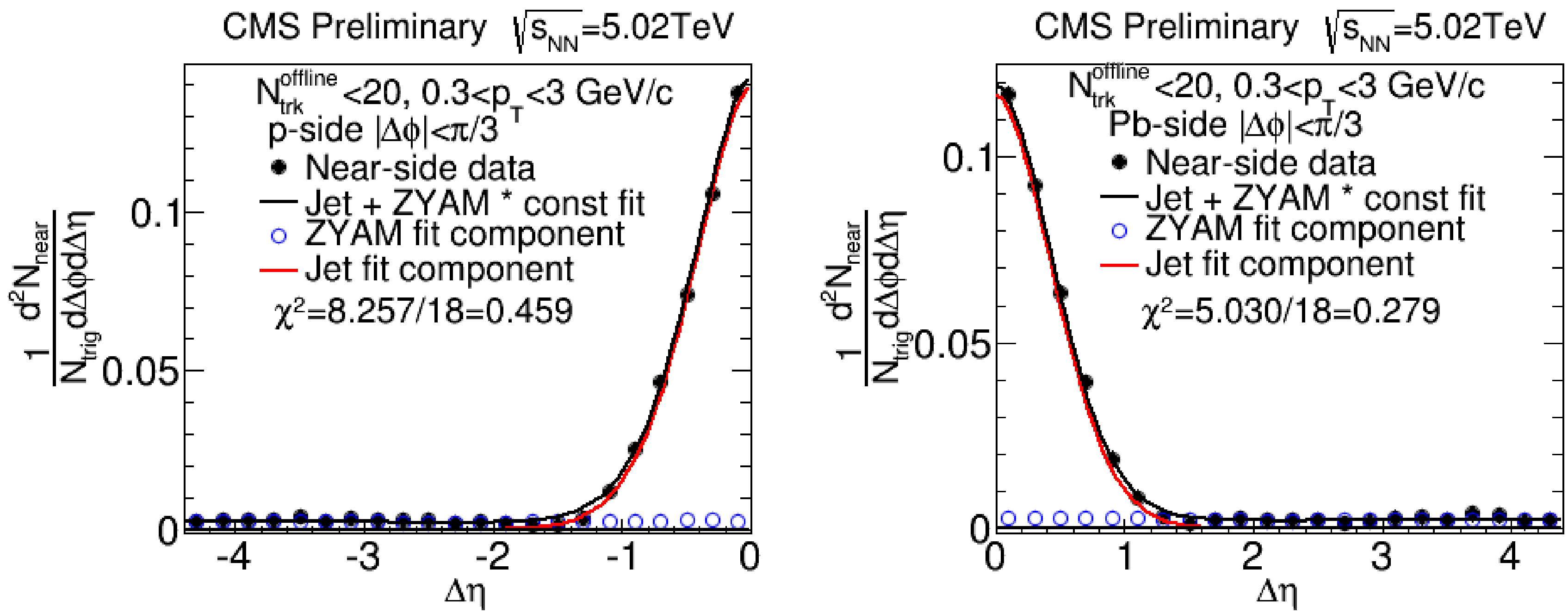
$\eta=-\ln[\tan(\theta/2)]$



Full φ coverage

Low multiplicity near-side fit result

$$\frac{1}{N_{trig}}\frac{dN_{near}(\Delta\eta)}{d\Delta\eta} = \frac{N\beta}{\sqrt{2}\sigma\Gamma(1/2\beta)}\exp[-(\frac{\Delta\eta^2}{2\sigma^2})^{\beta}] + C\times ZYAM(\Delta\eta)$$



- Jet yield ratio $Y_{jet}/ Y_{jet}(N_{trk}<20)$ will be used for jet subtraction in v2 study
- No ridge