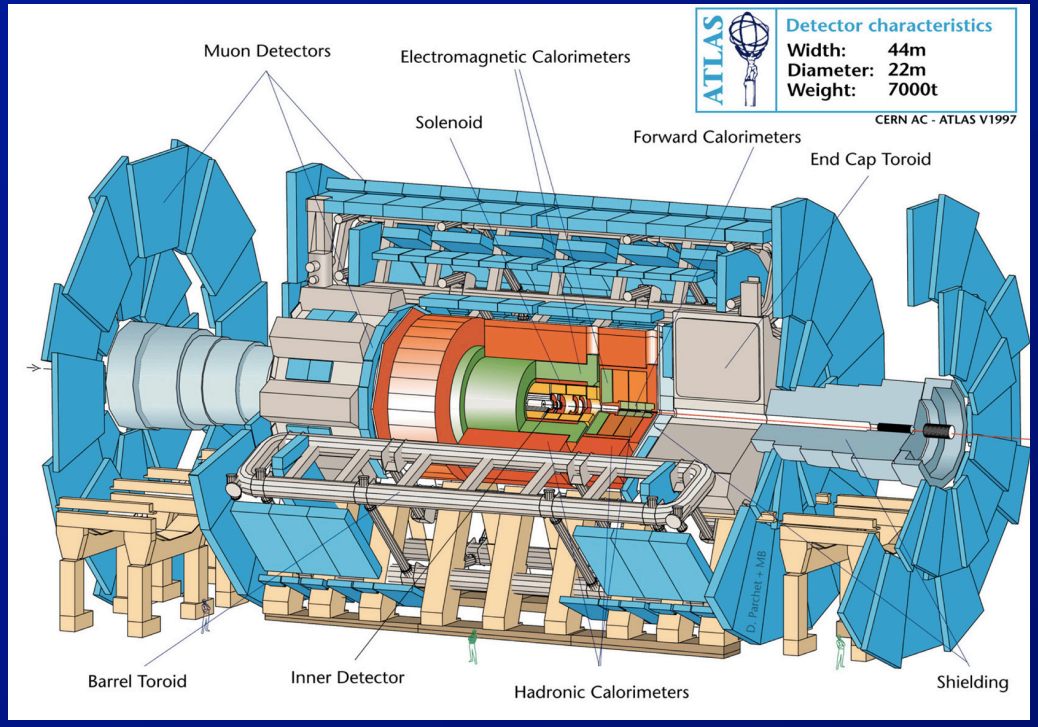
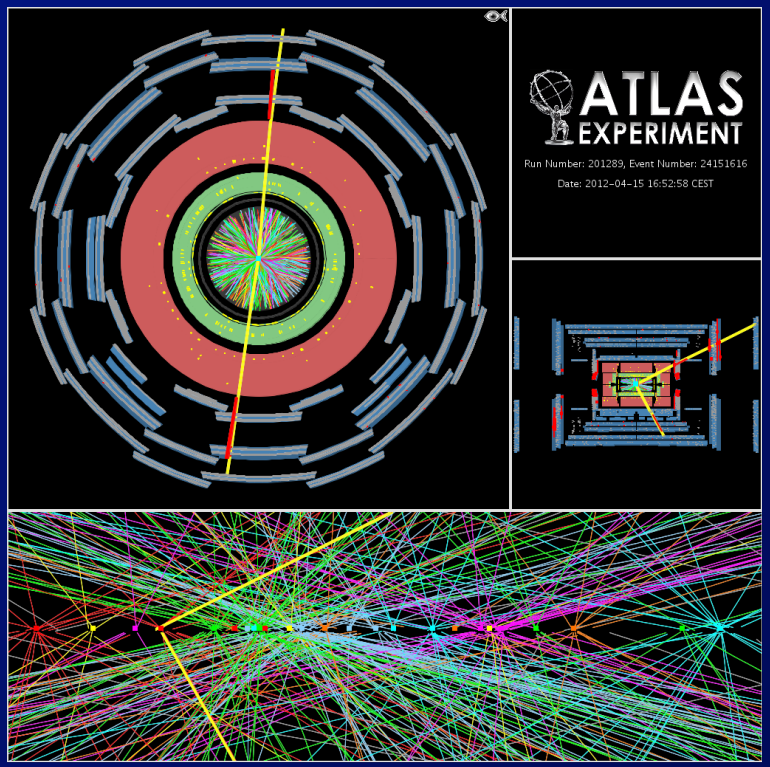
Measurement of long-range correlations in pp collisions characterized by presence of a Z boson with the ATLAS detector

Prof. Brian Cole
Columbia University
on behalf of ATLAS





The ridge in Z-tagged 8 TeV pp collisions

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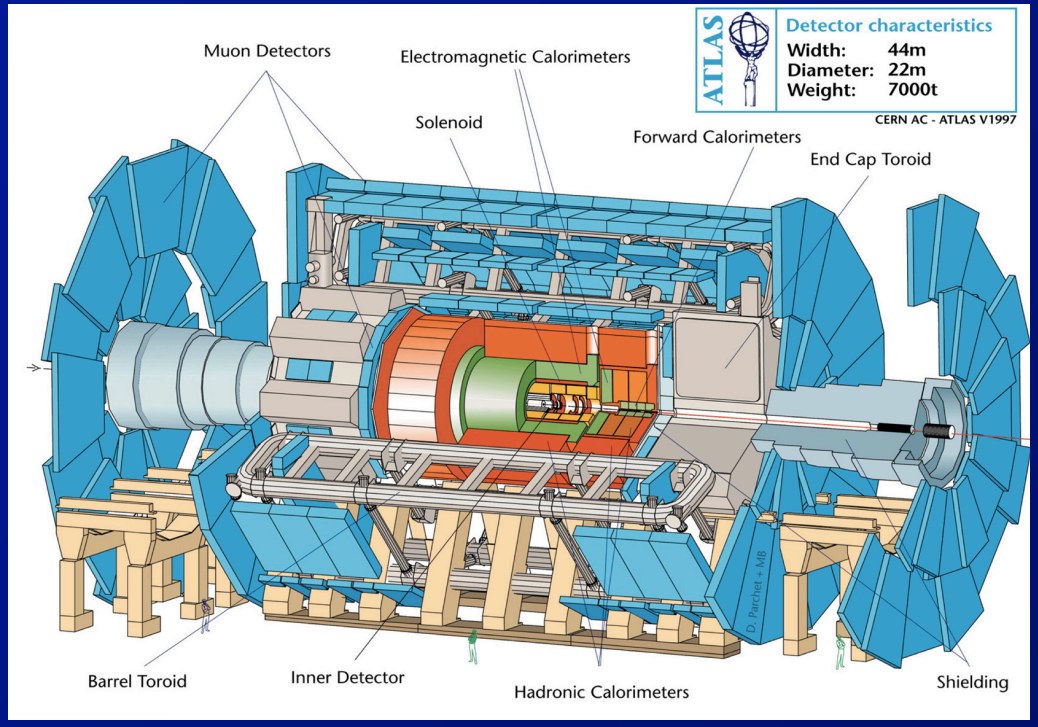
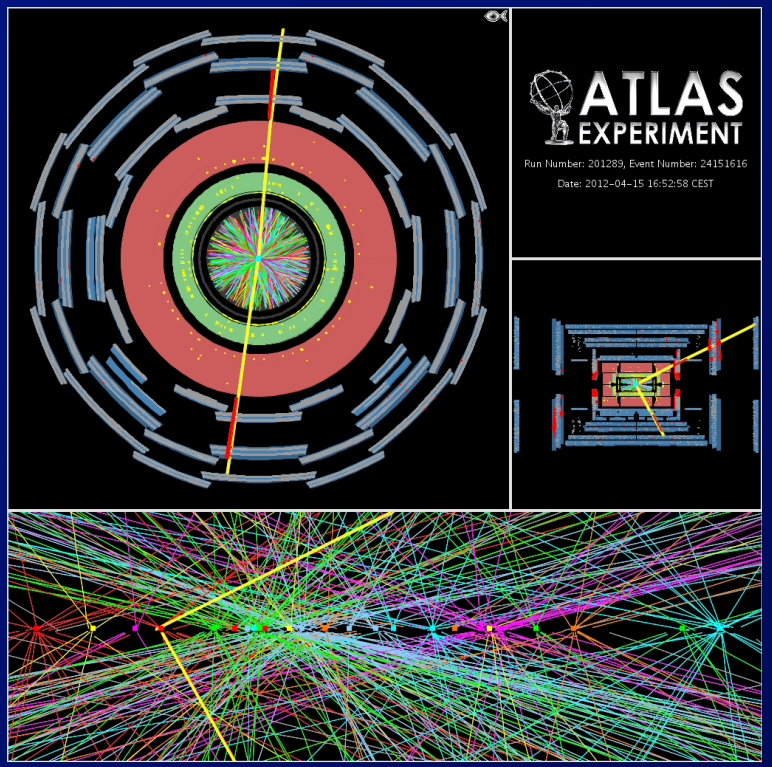
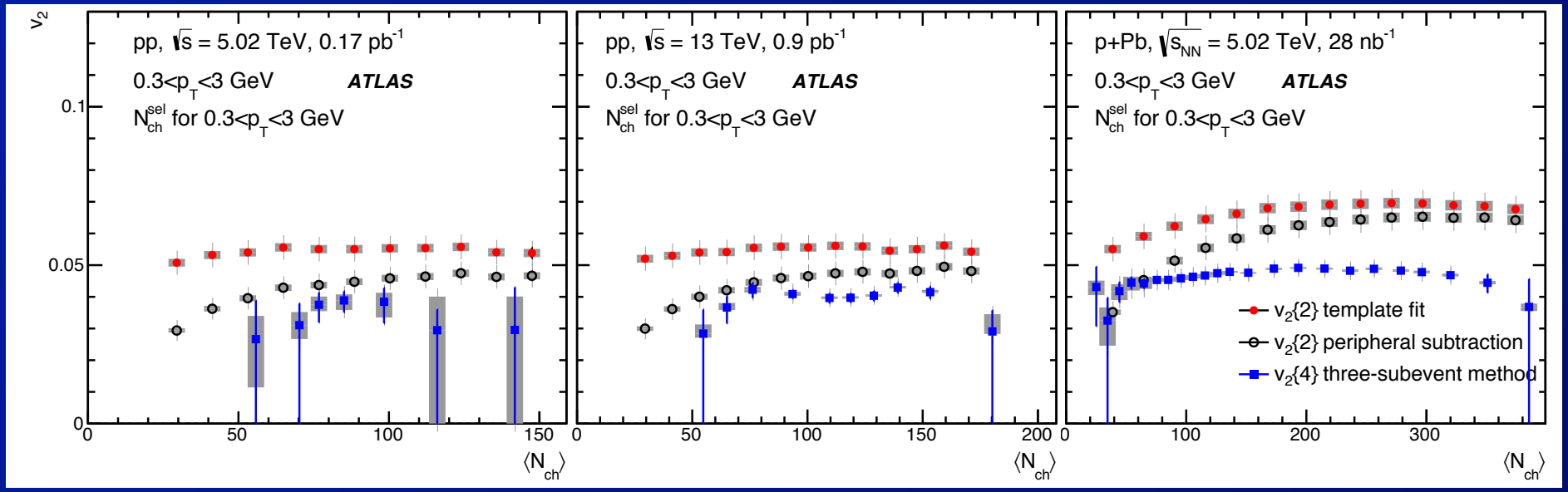
Many thanks to organizers for bringing us to this beautiful place



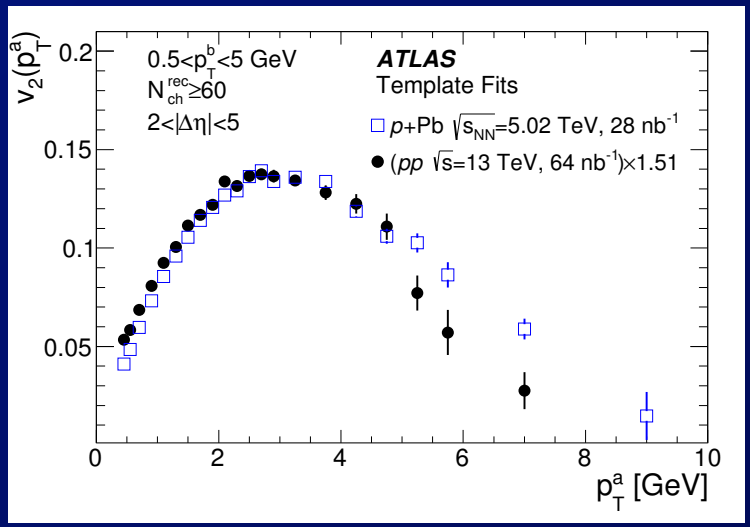


Motivation



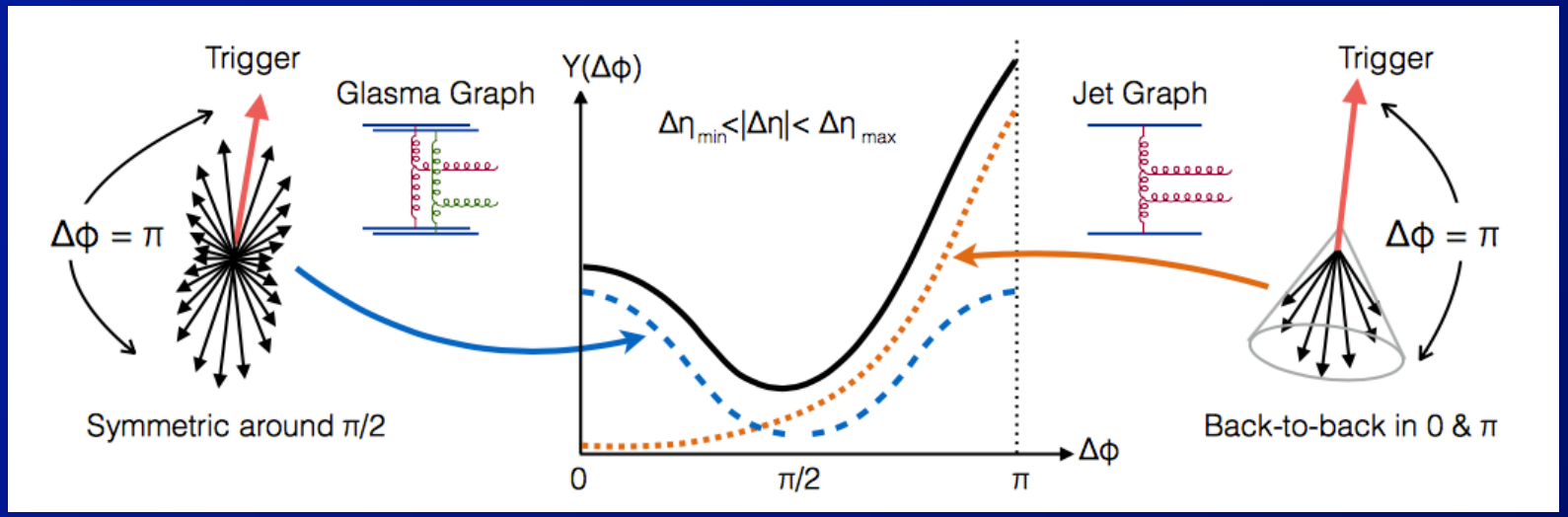
- **We now have ample evidence of multi-particle azimuthal correlations in pp collisions over a wide range of multiplicities.**
  - **Comparisons with p+Pb data, mass dependence, … strongly suggestive of collectivity**

⇒But we must thoroughly test this interpretation.



Motivation (2)

- **But, what about alternatives:**
  - glasma, CGC/BEC, MPI+string interactions, …



- **More generally, can ask the question:**
  - Is there any "coupling" between ridge phenomenon and hard or semi-hard processes

  ⇒ Study using pp events with Z production

  ⇒ Large-Q^2 process, but without back-to-back jets
  - Even if ridge reflects collectivity, does requiring a hard process change the geometry of the initial state?

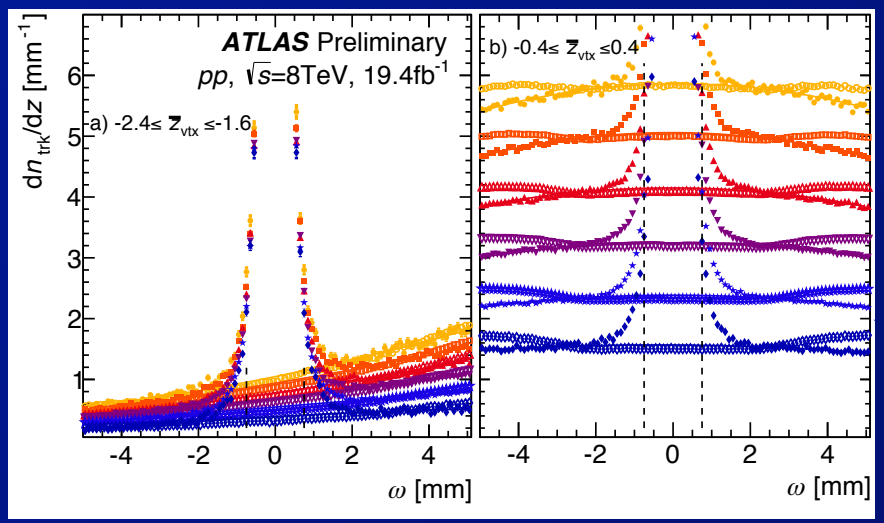
The measurement

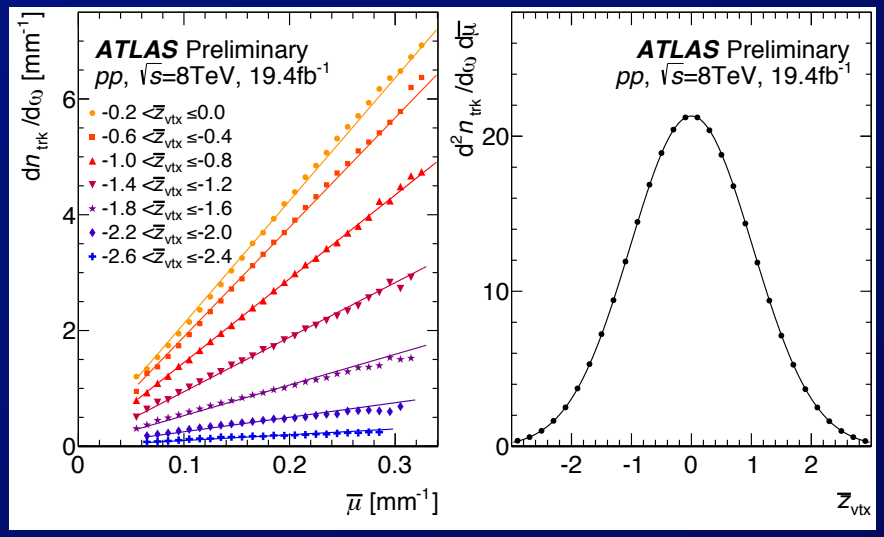
- Measure two-particle azimuthal correlations in 8 TeV pp collisions that contain Z boson
  - $L_{int} = 19.4\ fb^{-1}$ from Run 1 (2014)
  - $Z \rightarrow \mu^+\mu^-$ with $80 < M_{\mu\mu} < 100$, $p_T^{\mu} > 20$ GeV, $|\eta_\mu| < 2.4$

    ⇒muon inner detector tracks excluded from 2PC
  - high-luminosity data, $\mu \sim 20$

    ⇒need to correct for background due to pileup

    ⇒evaluated using event mixing



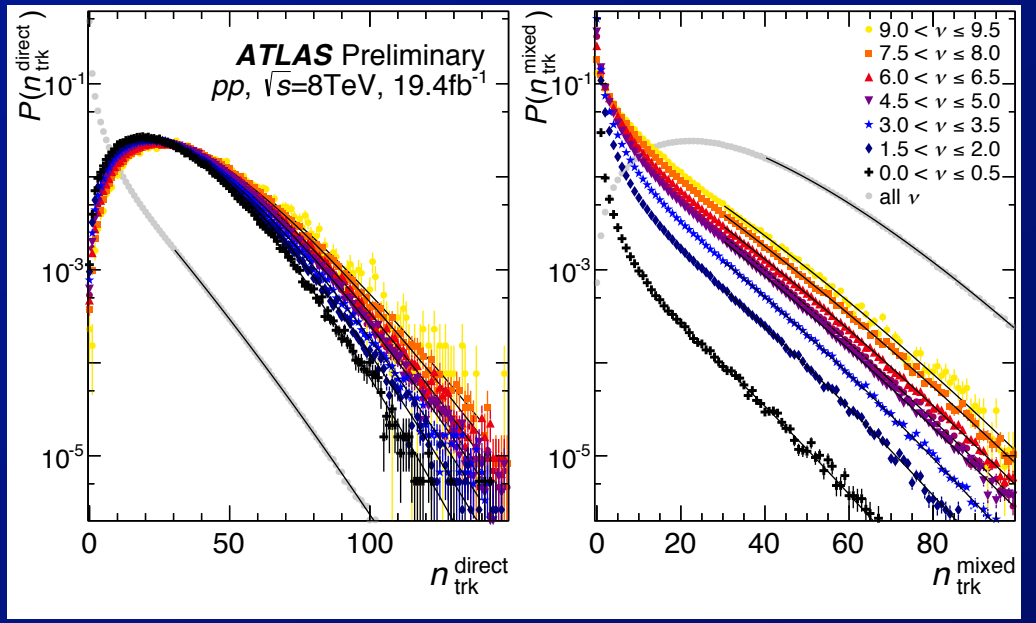


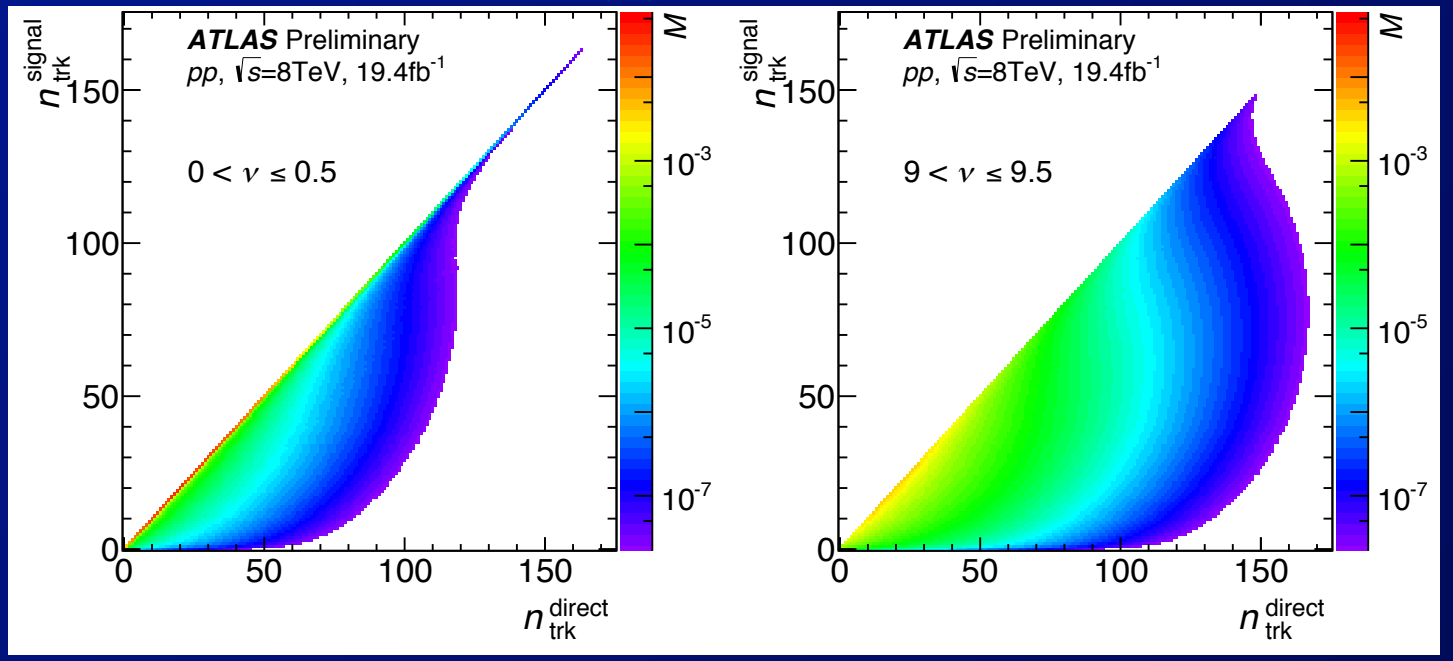
$\omega = (z - z_{\mathrm{vtx}}) \sin\theta \qquad \bar{\mu} = \mu / \sqrt{2\pi} z_{\mathrm{vtx}}^{\mathrm{RMS}} \qquad \bar{z}_{\mathrm{vtx}} = (z - z_{\mathrm{vtx}}) / z_{\mathrm{vtx}}^{\mathrm{RMS}}$

Pileup background

- Use mixed events to obtain distribution of # background tracks
  - as a function of Z-event (direct) N_{trk}
  - and $\nu \equiv \langle N_{trk}^{bkgd} \rangle$

  $\Rightarrow N_{trk}$ response matrices





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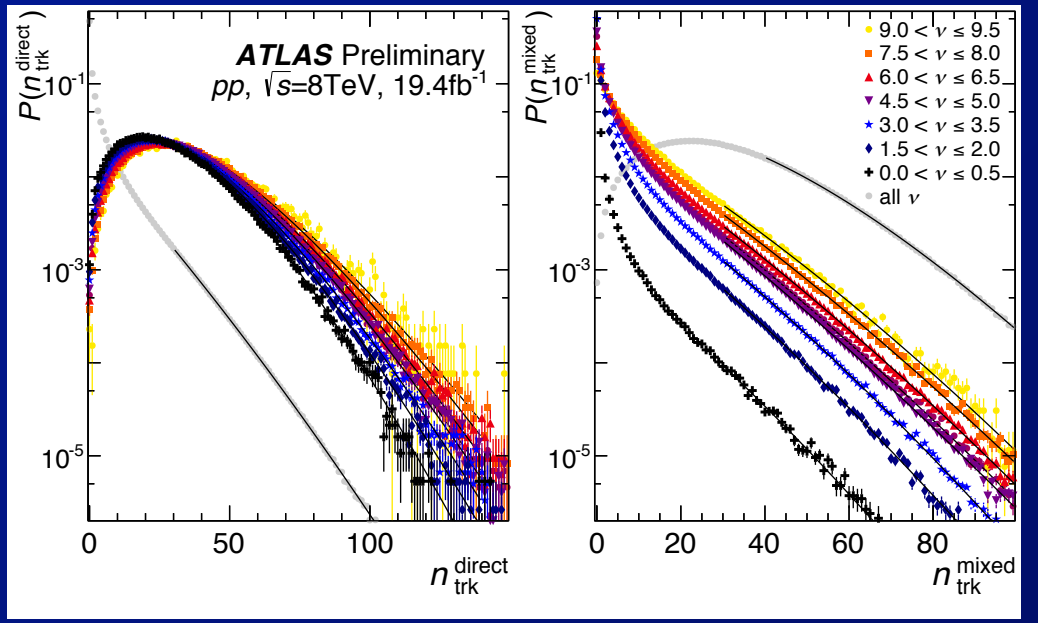
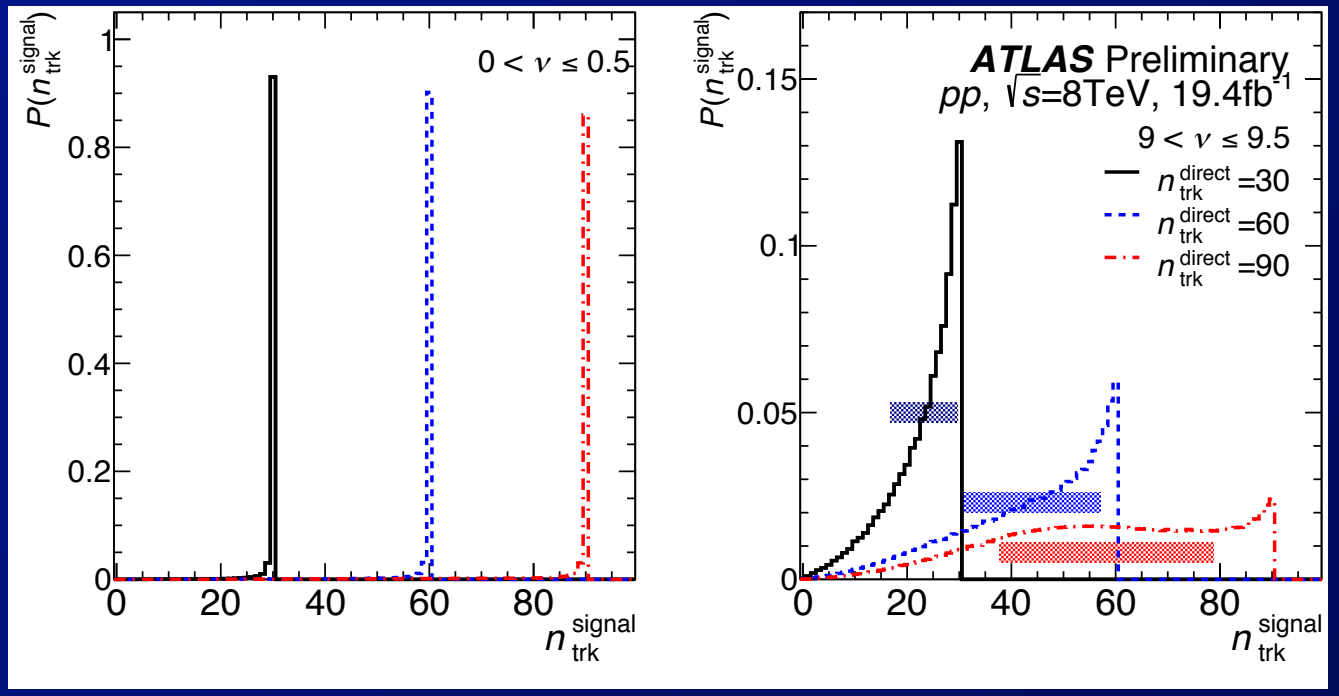
  ⇒Unfold N_{trk} distributions



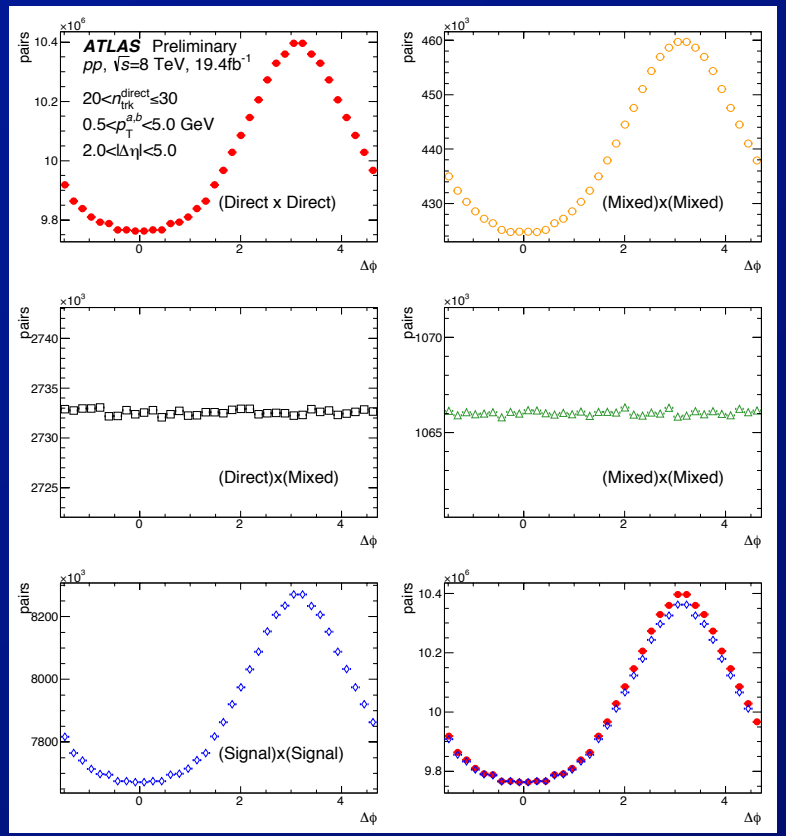


Two-particle correlation analysis

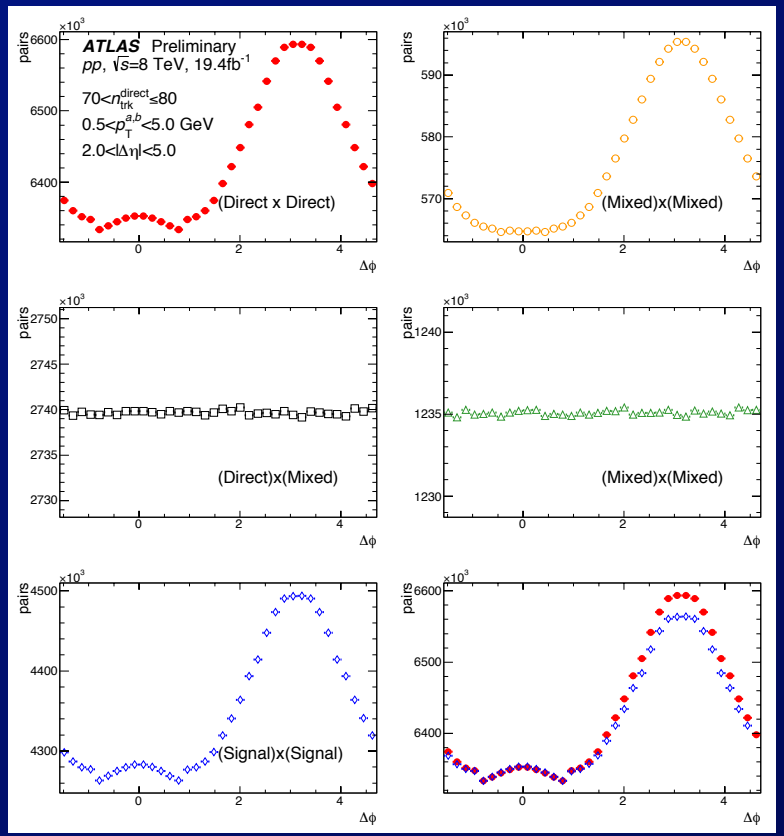
- Pileup can add multiple tracks from same collision
  - background not flat in $\Delta\varphi$
- Pileup has different η distribution than Z events
  - due to ν-dependent effect of $\Delta z \sin\theta$ cut applied to tracks

⇒ Need to measure two-particle correlations for both correlated and uncorrelated pileup & subtract

N_{trk}^{dir} 20-30



N_{trk}^{dir} 70-80



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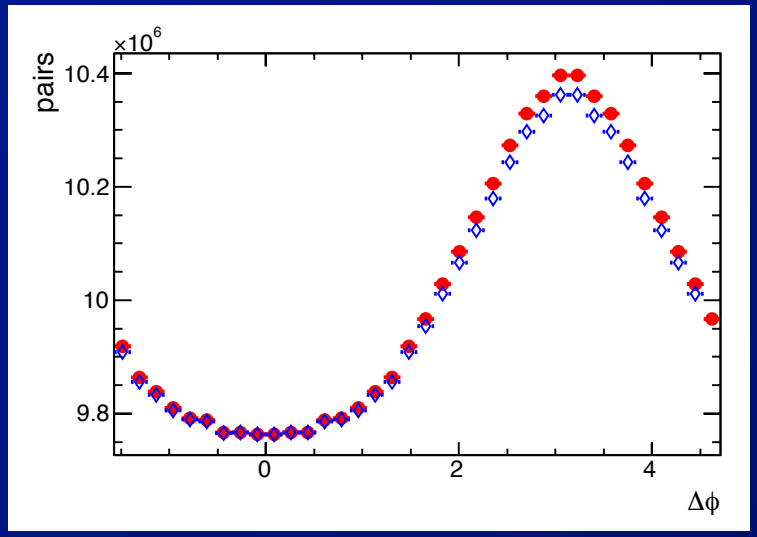

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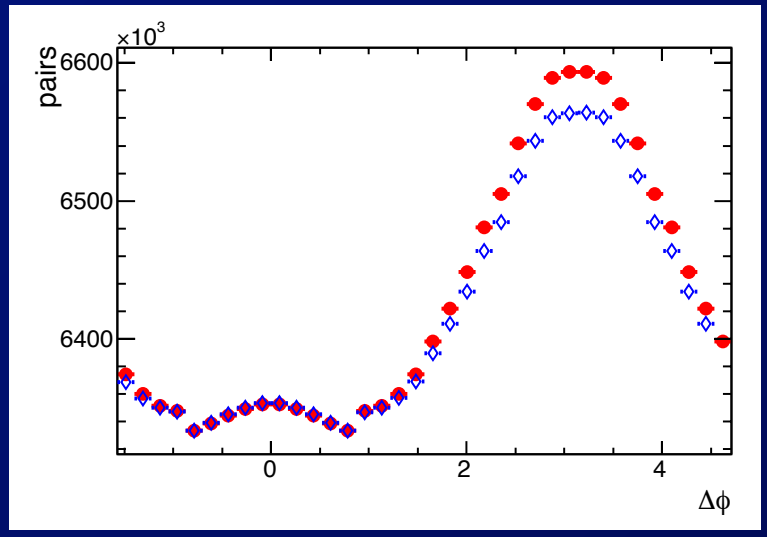

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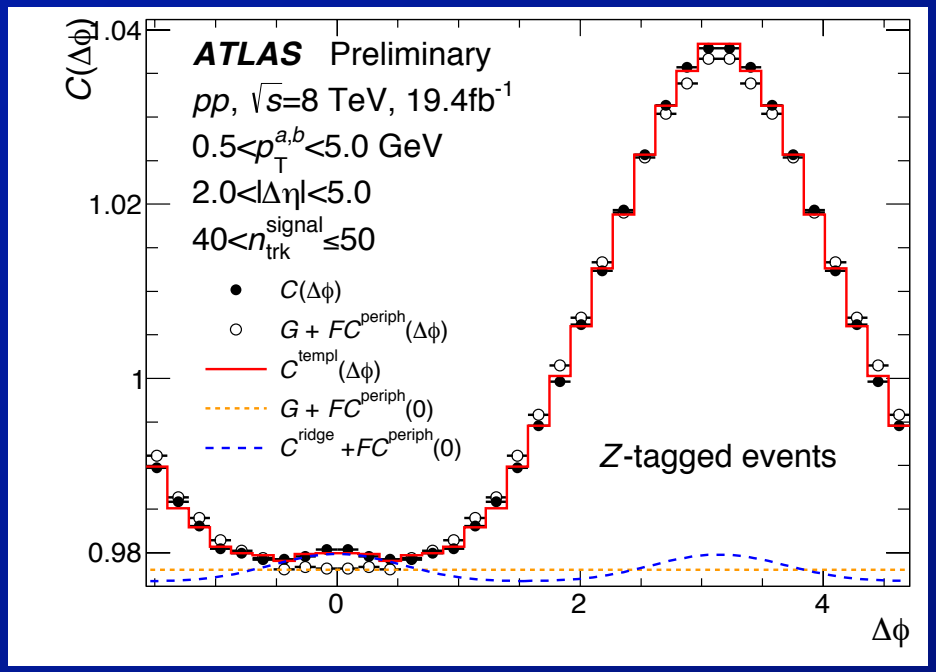
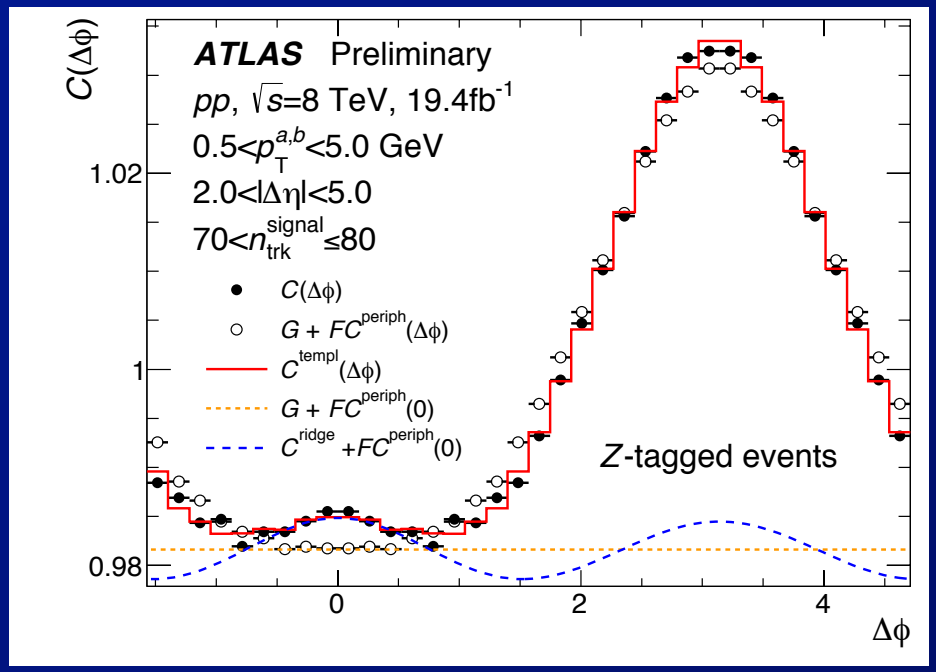


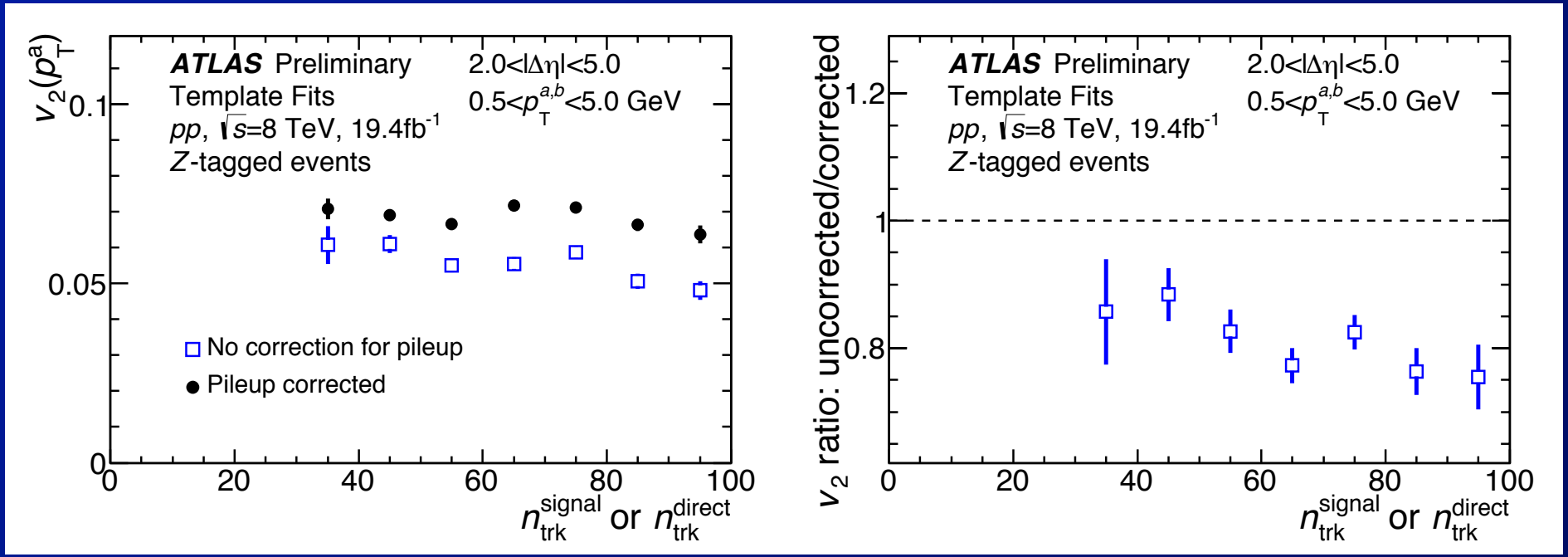


- **Apply template fit method using $20 < N_{trk} < 30$ (after correction) as peripheral reference**
  - **only v_2 term included in the ridge contribution**

  ⇒as in inclusive pp collisions @ 5 and 13 TeV, the two-particle correlation function well described by scaled peripheral + cos(2φ) term

Two-particle correlation analysis

- Comparison of v_2 obtained from template analysis before and after pileup correction



- Corrected: versus corrected multiplicity
- Uncorrected: versus direct multiplicity

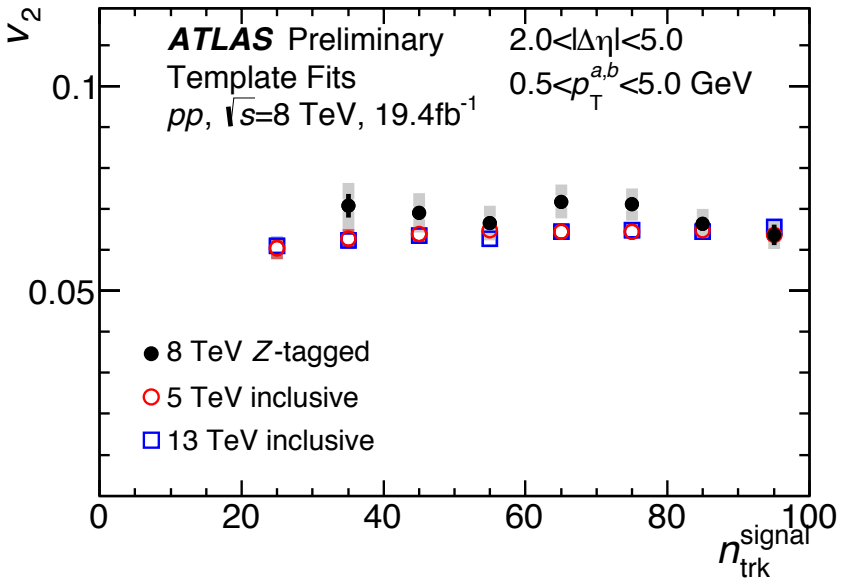
⇒ essentially no multiplicity dependence to either

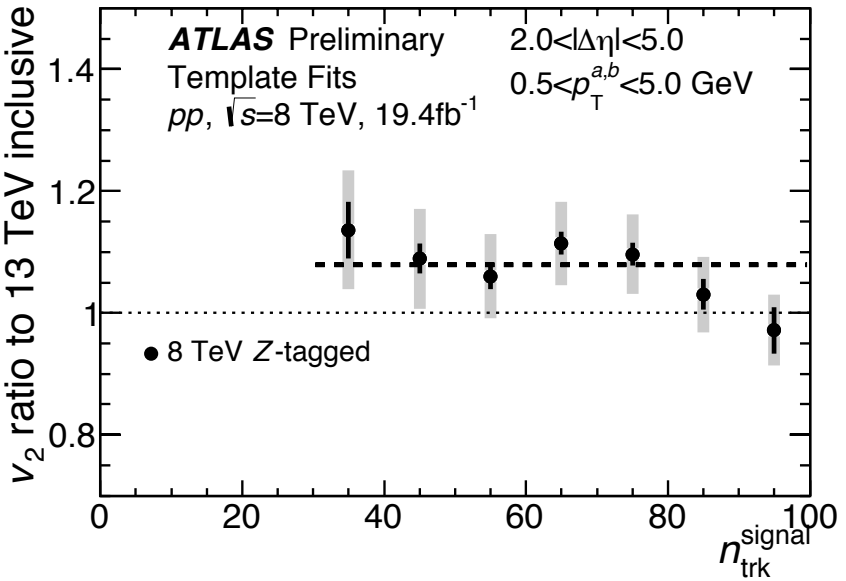
⇒ subtraction reduces v_2 by 20%

Two-particle correlation results

- **Main physics result:**
  - v_2 versus corrected N_{trk} compared to previous minimum-bias pp results @ 5 and 13 TeV

⇒reminder: no $\sqrt{s}$ dependence observed





⇒ Z-tagged p_T-integrated v_2 8±6% higher than in minimum-bias pp collisions

⇒No multiplicity dependence seen

Summary, conclusions

- ATLAS has carried out a measurement of long-range two-particle azimuthal correlations in Z-tagged pp collisions @ 8 TeV
  - L_{int} = 19.4 fb^{-1} from Run 1 (2014), $Z \rightarrow \mu^+\mu^-$
- Goal of the measurement:
  - test our understanding of the origin of ridge
  - ⇒is it associated with/affected by hard or semi-hard processes *a la* Glasma ?
  - ⇒does requiring hard-scattering process change initial geometry, MPI, … so as to effect 2PC?
    - » no predictions prior to measurement
- Observe that Z-tagged collisions have 8±6% larger p_T-integrated v_2 than minimum-bias pp
  - similar to minimum-bias, no variation with N_{trk}