The 27th International Conference on Ultrarelativistic Nucleus-Nucleus Collisions

14–19 May | Palazzo del Cinema

Lido di Venezia, Italy

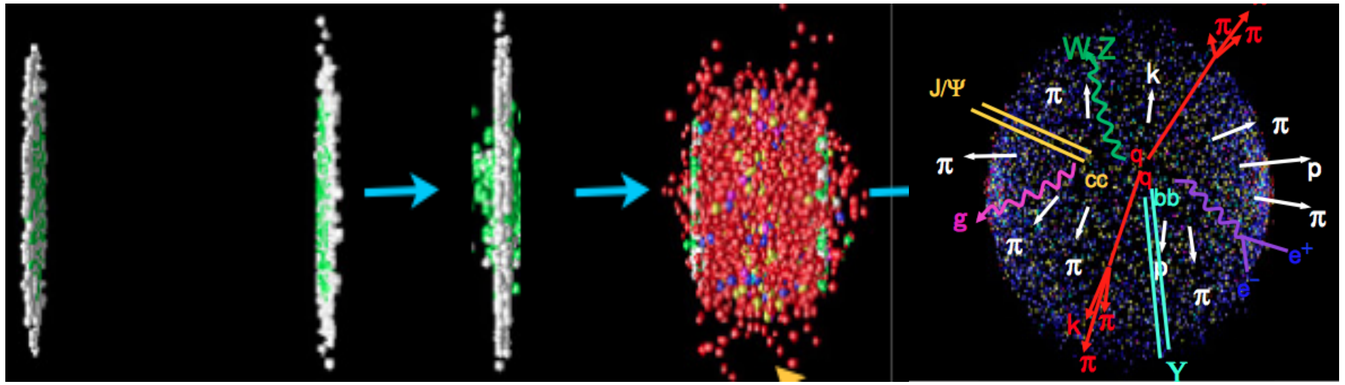
Highlights from the ATLAS experiment

Iwona Grabowska-Bold (AGH UST Kraków)
on behalf of the ATLAS Collaboration
Venice, May 14th, 2018

ATLAS EXPERIMENT

AGH

INTRODUCTION



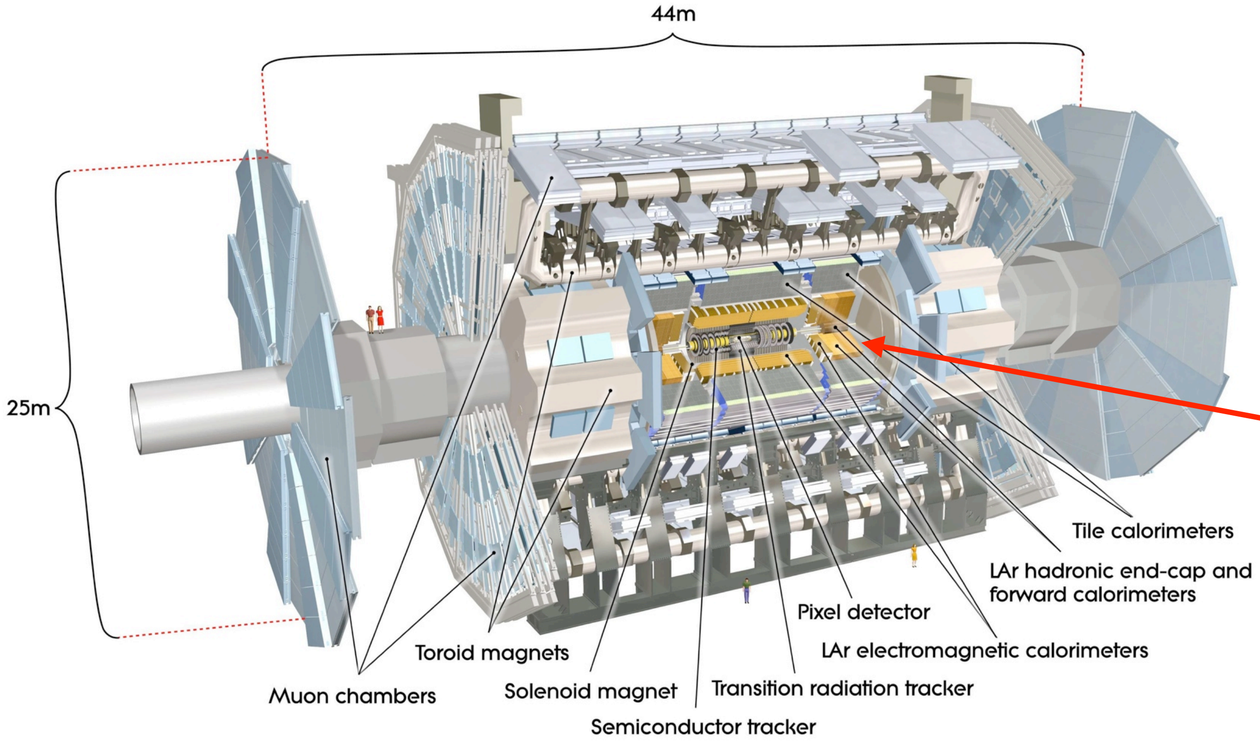
One of the main goals of heavy-ion physics is to study the QGP

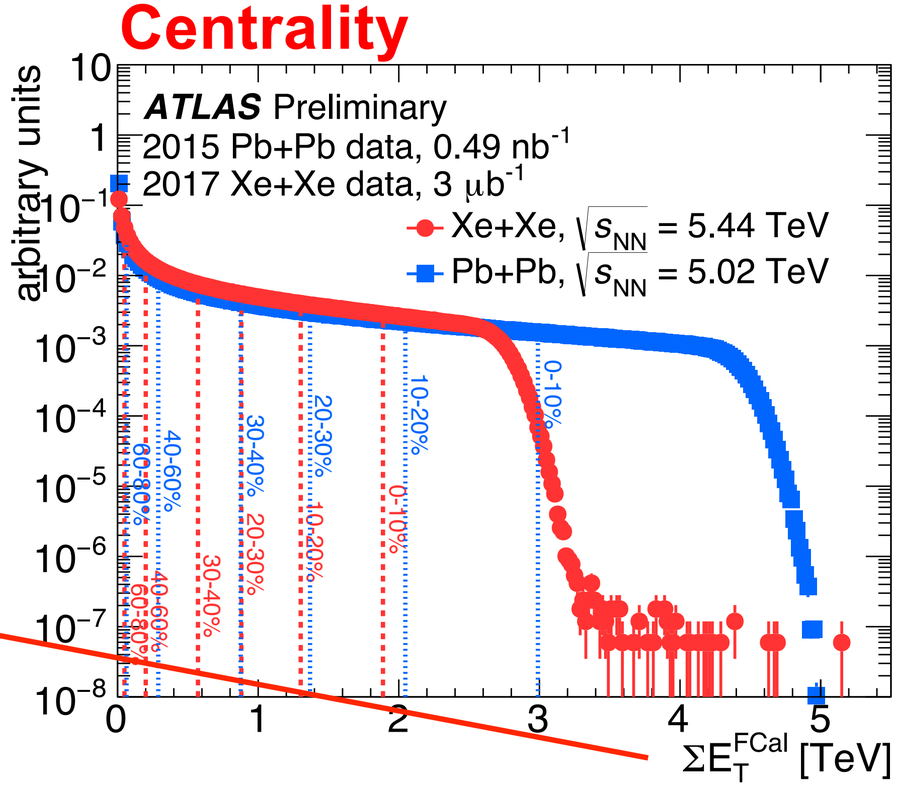
- Use a variety of final states to provide insight into various stages of heavy-ion (HI) collisions
  - Hard probes:
    - Colourless objects e.g. **electroweak bosons** – standard candles in the QGP, nPDFs
    - Colour objects e.g. **jets**, hadrons, **quarkonia** – partonic energy loss in the QGP
  - Bulk particle production:
    - Initial geometry, initial conditions, collective behaviour, ridge etc

- Use pp and p+Pb collisions
  - Disentangle initial- and final-state effects
- NEW: utilise **Xe collisions** to shed light on a role of geometry in HI collisions

ATLAS DETECTOR

Three main components: inner tracker, electromagnetic (EM) and hadronic (HAD) calorimeters, and muon system





Sub-detectors	|η| coverage
Inner Tracker	<2.5
Muon	< 2.7
EM Calorimeter	<3.2
HAD Calorimeter	<4.9
ZDC	>8.3

Full azimuthal acceptance

(I) Hard probes:

Electroweak bosons

Quarkonia & HF

Exclusive dimuon production

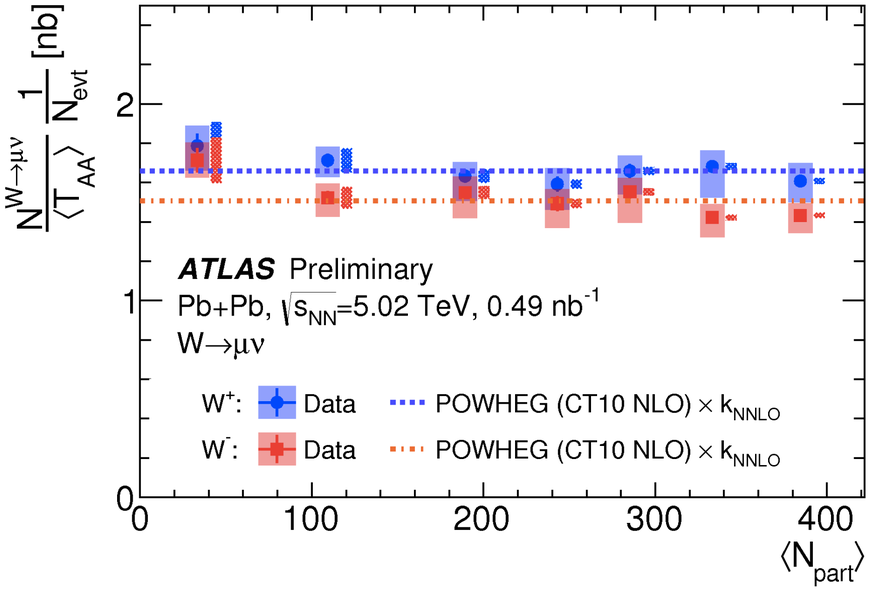
W BOSONS IN PB+PB

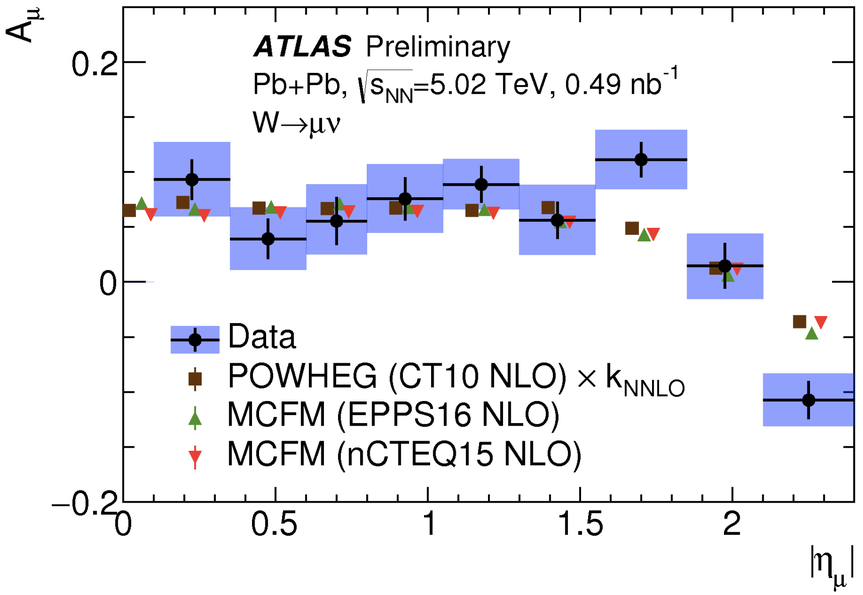
ATLAS-CONF-2017-067

- W boson yields in the muon channel in 5.02 TeV Pb+Pb data
  - Statistics by a factor of four wrt Run 1 improved
  - Yields/<T_{AA}> are approximately flat vs. N_{part}
    - **Scaling with the number of binary collisions holds**
  - W^+ yields by 10% larger comparing to W^-
    - Data consistent with POWHEG scaled to NNLO accuracy
  - **Lepton charge asymmetry consistent with theory** with some small deviations in the forward direction
  - Reference W/Z boson measurement is coming later this week

Talk by Z.Citron on Wed 10:00

Poster by M.Dumancic





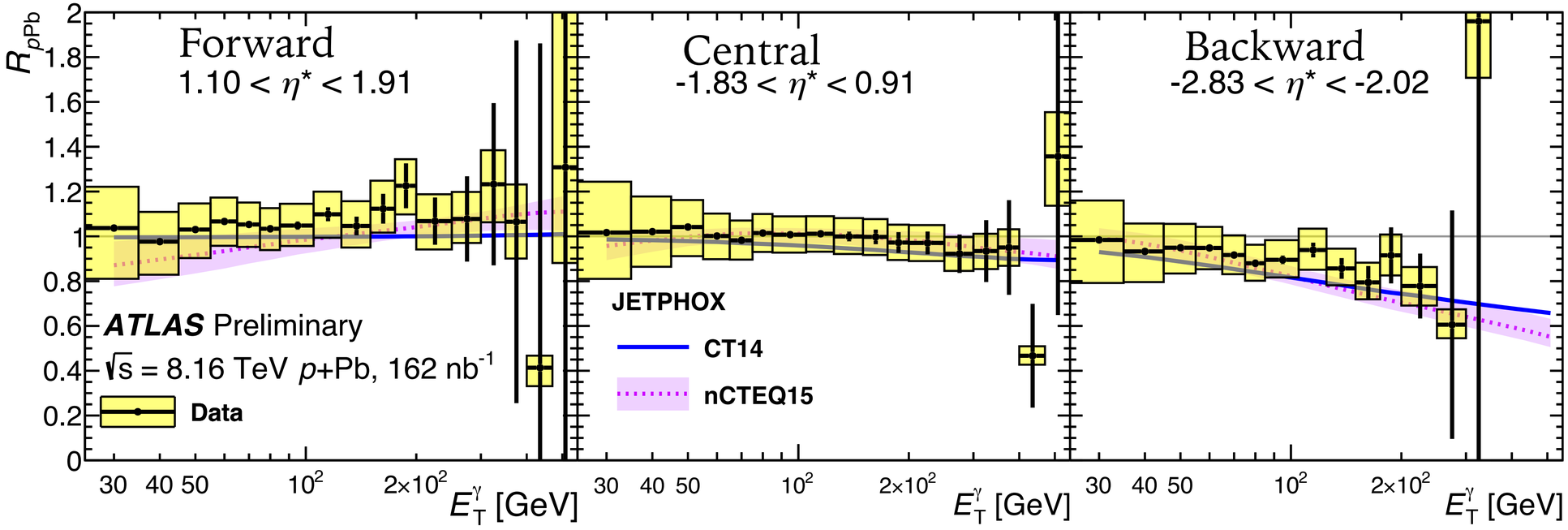
INCLUSIVE PHOTONS IN P+PB

ATLAS-CONF-2017-072

- Inclusive prompt photons in p+Pb collisions at 8.16 TeV
  - At forward and central rapidity, $\mathbf{R_{pPb}}$ consistent with **unity**
  - $\mathbf{R_{pPb}<1}$ for $\eta^*<-2$ due to **isospin effects**
- Comparison to JETPHOX with nPDF from EPPS16, nCTEQ15
  - **With the current uncertainties, the data is unable to constraint nPDF**
  - Ongoing work to reduce uncertainties

Talk by Z.Citron on Wed 10:00
Poster by K.Hill

$$R_{\mathrm{pPb}} = \frac{\frac{d\sigma^{\mathrm{pPb}}}{dE_{\mathrm{T}}^{\gamma}}}{A \times \frac{d\sigma^{pp}}{dE_{\mathrm{T}}^{\gamma}}}$$



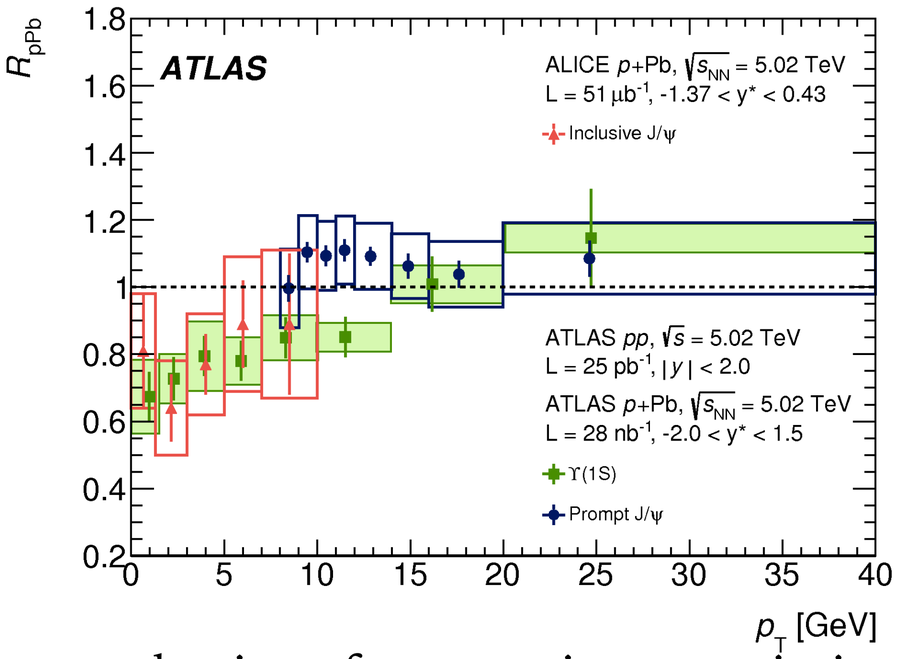
QUARKONIA PRODUCTION IN P+PB

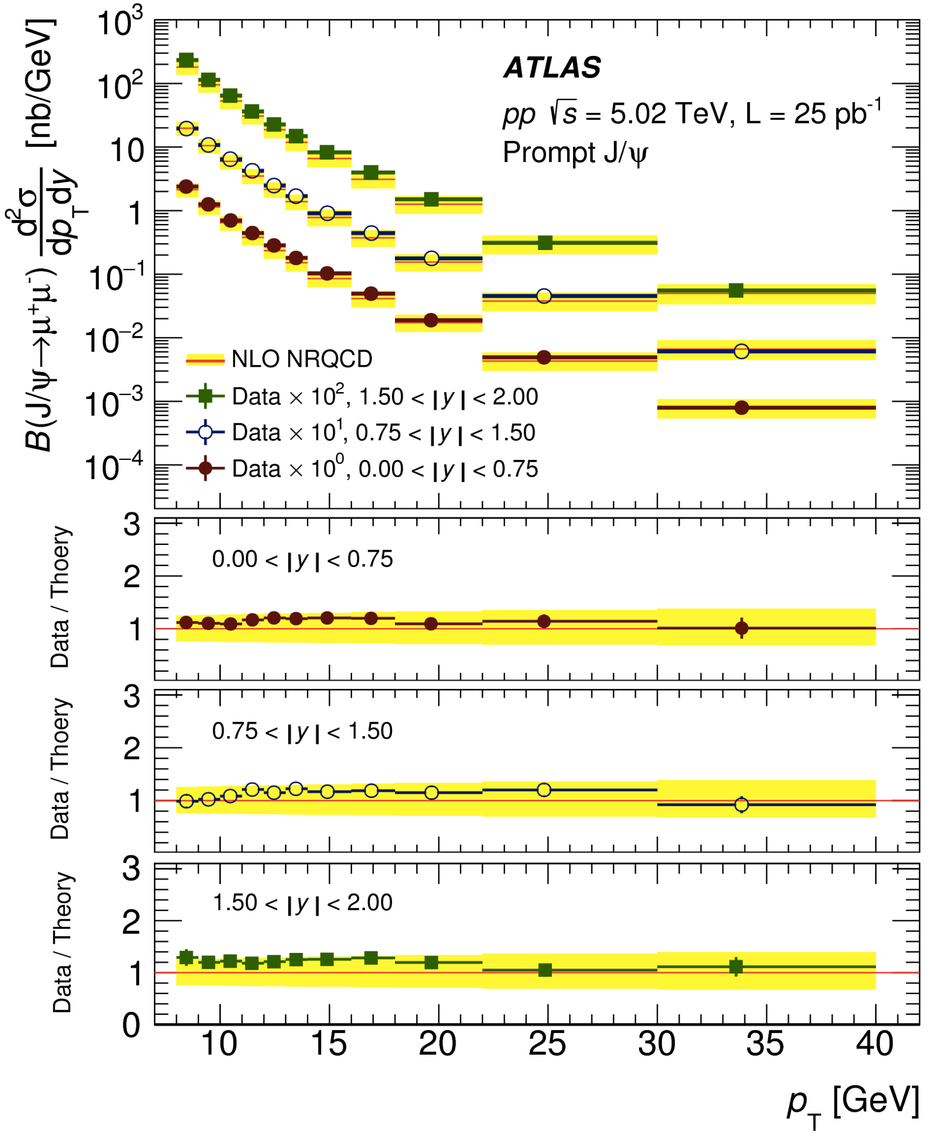
EPJC 78 (2018) 171

- Final measurement of quarkonia in p+Pb/pp collisions at 5.02 TeV

Talk by J.Lopez on Mon 16:50

  - Prompt and non-prompt cross sections of J/ψ, ψ(2S)
  - Inclusive yields of Υ(nS) (n = 1, 2, 3)





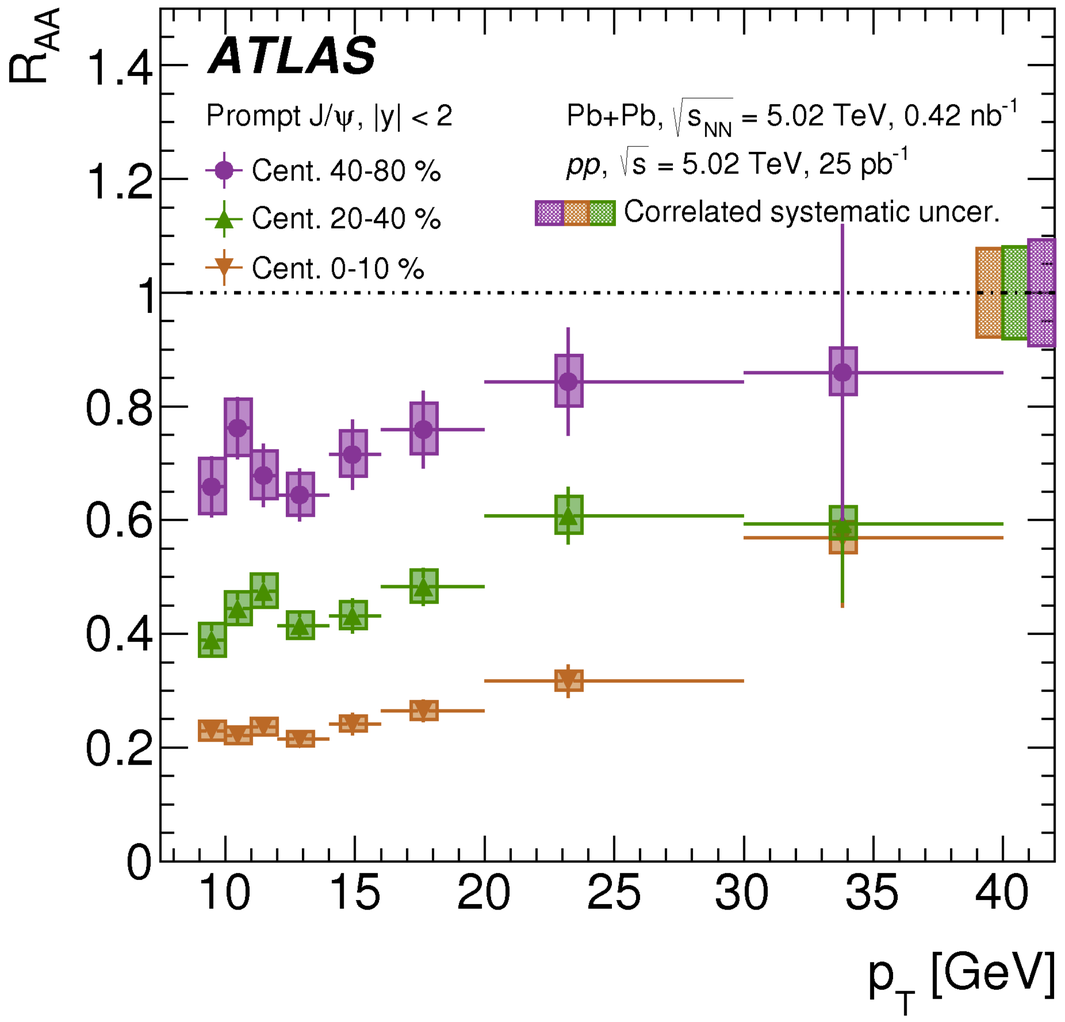
- Significant reduction of systematic uncertainties wrt the preliminary result [ATLAS-CONF-2015-023]
- J/ψ cross sections are in agreement with NRQCD (prompt) and FONLL (non-prompt) predictions
- **J/ψ R_{pPb} is consistent with unity for p_T between 8-40 GeV**
- **Υ(1S) R_{pPb} is found to be suppressed for p_T<15 GeV**

QUARKONIA PRODUCTION IN PB+PB (I)

arXiv:1805.04077

NEW

- Final measurement of prompt and non-prompt J/ψ and ψ(2S) in Pb+Pb and pp at 5.02 TeV
  - Sensitive to different production mechanisms
- Meson kinematics: $9<p_T<40$ GeV and $|y|<2$
- R_{AA} as a function of p_T, rapidity and centrality
- Comparison to models



- **Strong suppression is found for both J/ψ and ψ(2S) and increasing with centrality**
  - In 0-10%, $R_{AA}=\sim 0.25$
- **R_{AA} dependence of prompt and non-prompt J/ψ on centrality seems to be quite similar**

Talk by J.Lopez on Mon 16:50

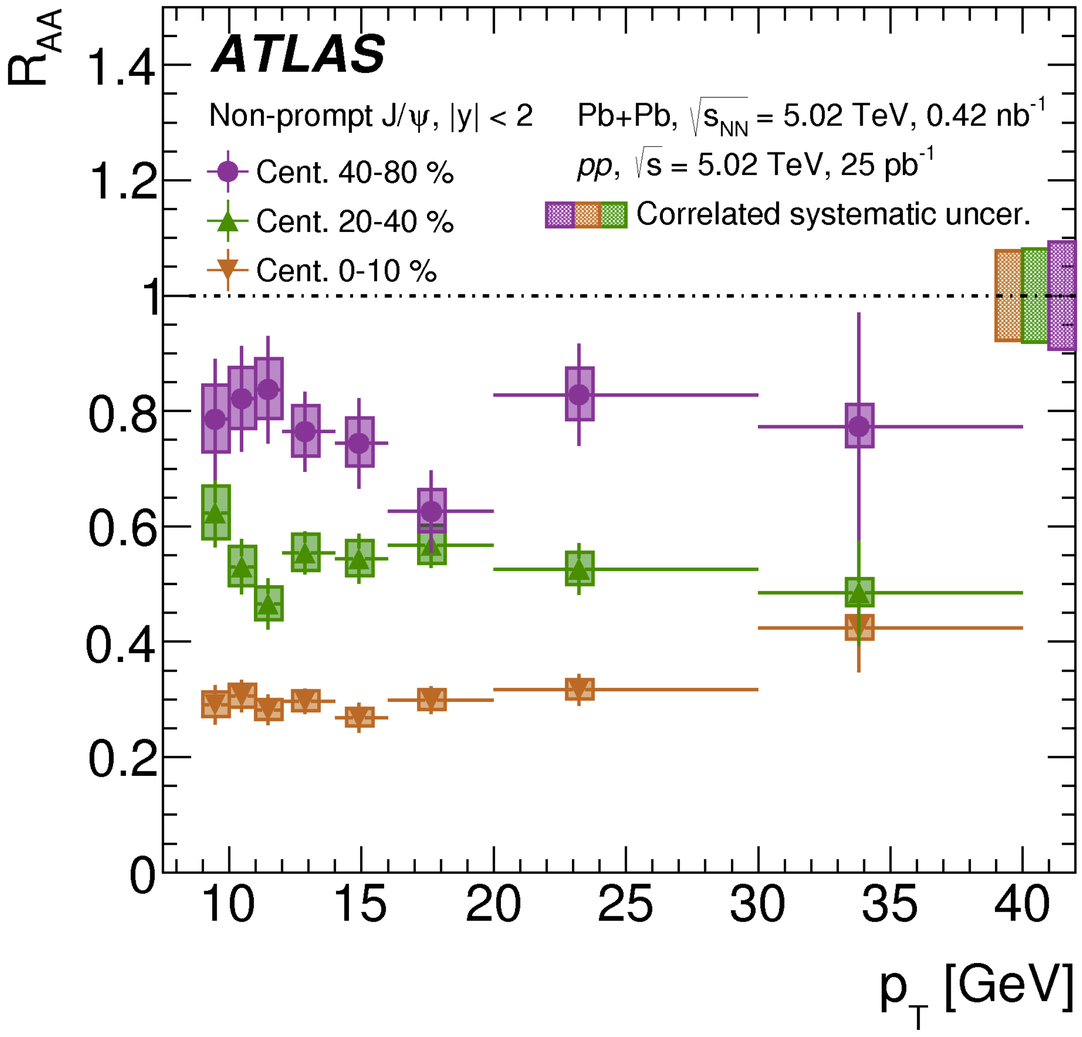
Poster by S.Tapia

QUARKONIA PRODUCTION IN PB+PB (II)

arXiv:1805.04077

NEW

- Final measurement of prompt and non-prompt J/ψ and ψ(2S) in Pb+Pb and pp at 5.02 TeV
  - Sensitive to different production mechanisms
- Meson kinematics: $9<p_T<40$ GeV and $|y|<2$
- R_{AA} as a function of p_T, rapidity and centrality
- Comparison to models



- **Strong suppression is found for both J/ψ and ψ(2S) and increasing with centrality**
- **R_{AA} dependence of prompt and non-prompt J/ψ on centrality seems to be quite similar**

Talk by J.Lopez on Mon 16:50

Poster by S.Tapia

QUARKONIA PRODUCTION IN PB+PB (III)

arXiv:1805.04077

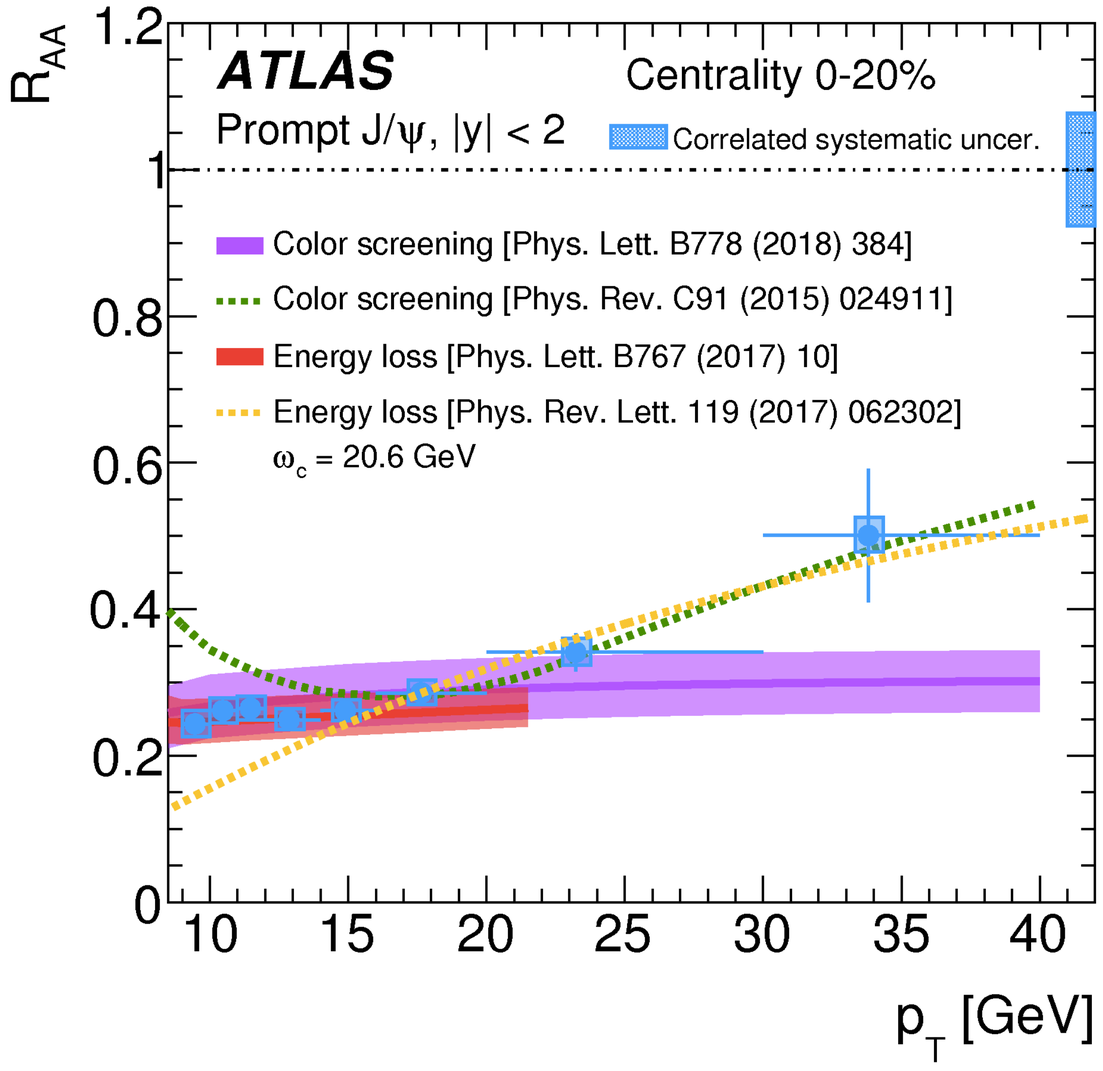
NEW

- Final measurement of prompt and non-prompt J/ψ and ψ(2S) in Pb+Pb and pp at 5.02 TeV
  - Sensitive to different production mechanisms
- Meson kinematics: $9<p_T<40$ GeV and $|y|<2$
- R_{AA} as a function of p_T, rapidity and centrality
- Comparison to models

- Result largely consistent with colour screening and colour transparency and parton energy-loss predictions

Talk by J.Lopez on Mon 16:50

Poster by S.Tapia



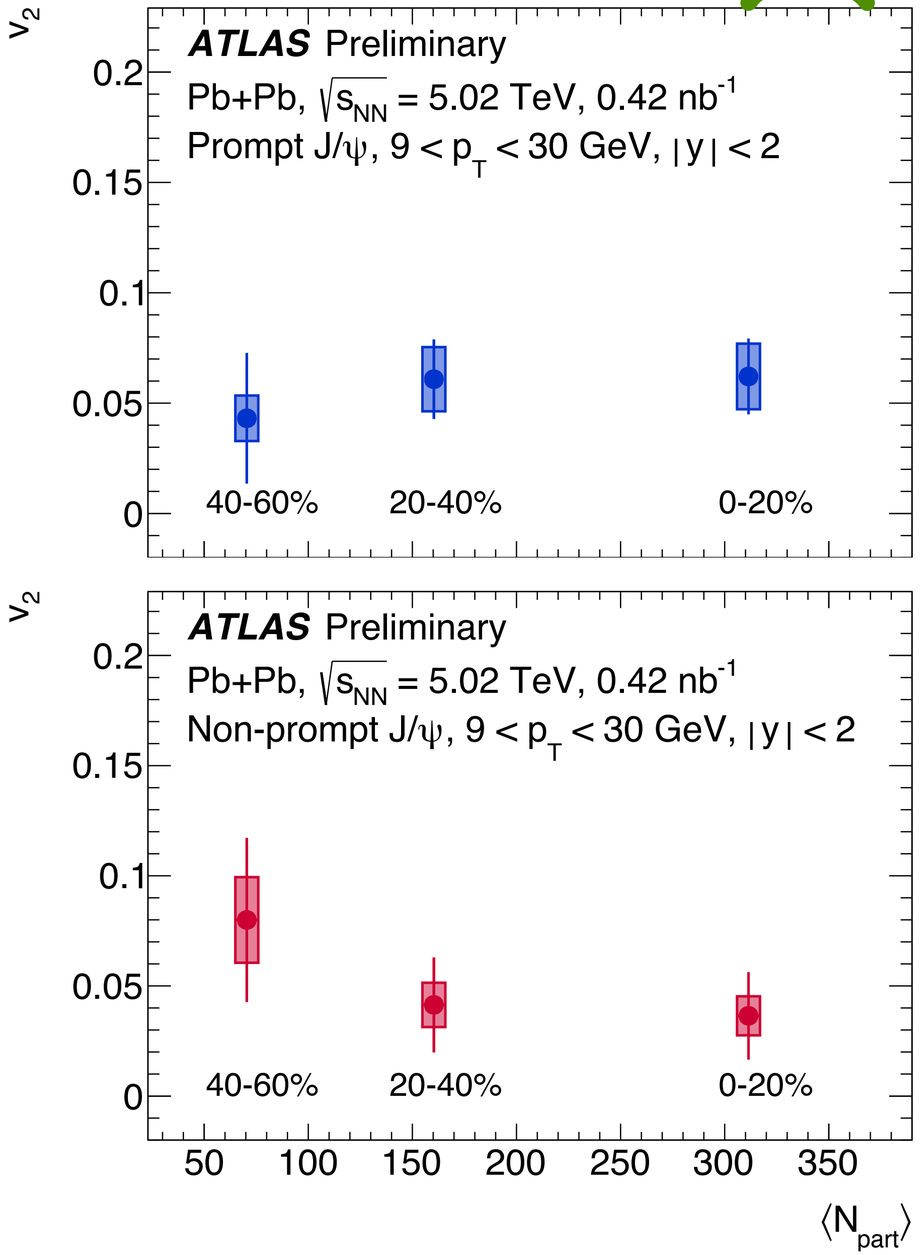
ELLIPTIC FLOW OF J/PSI IN PB+PB (I)

HION-2017-05

NEW

- Elliptic flow v_2 of prompt and non-prompt J/ψ in Pb+Pb at 5.02 TeV
- J/ψ mesons: $9<p_T<30$ GeV and 0-60% centralities
- v_2 evaluated as a function of p_T, rapidity and centrality

- Prompt and non-prompt J/ψ mesons have non-zero elliptic flow
- **No observed dependence on rapidity or centrality**



Talk by J.Lopez on Mon 16:50
Talk by Q.Hu on Wed 15:00
Poster by J.Lopez

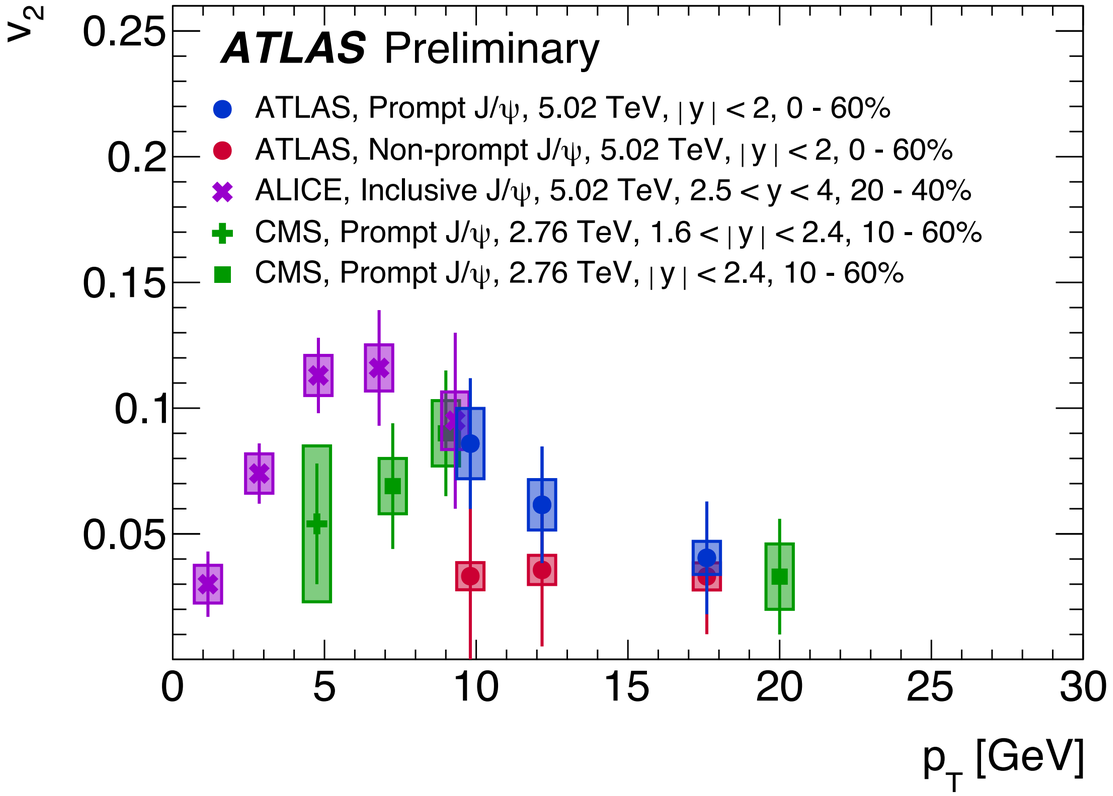
ELLIPTIC FLOW OF J/PSI IN PB+PB (II)

HION-2017-05

NEW

- Elliptic flow v_2 of prompt and non-prompt J/ψ in Pb+Pb at 5.02 TeV
- J/ψ mesons: $9<p_T<30$ GeV and 0-60% centralities
- v_2 evaluated as a function of p_T, rapidity and centrality

- Prompt and non-prompt J/ψ mesons have **non-zero elliptic flow**
- **Prompt J/ψ v_2 decreases as a function of p_T**, while **non-prompt J/ψ v_2 is flat**



Talk by J.Lopez on Mon 16:50
Talk by Q.Hu on Wed 15:00
Poster by J.Lopez

HEAVY-FLAVOUR MUONS IN PB+PB

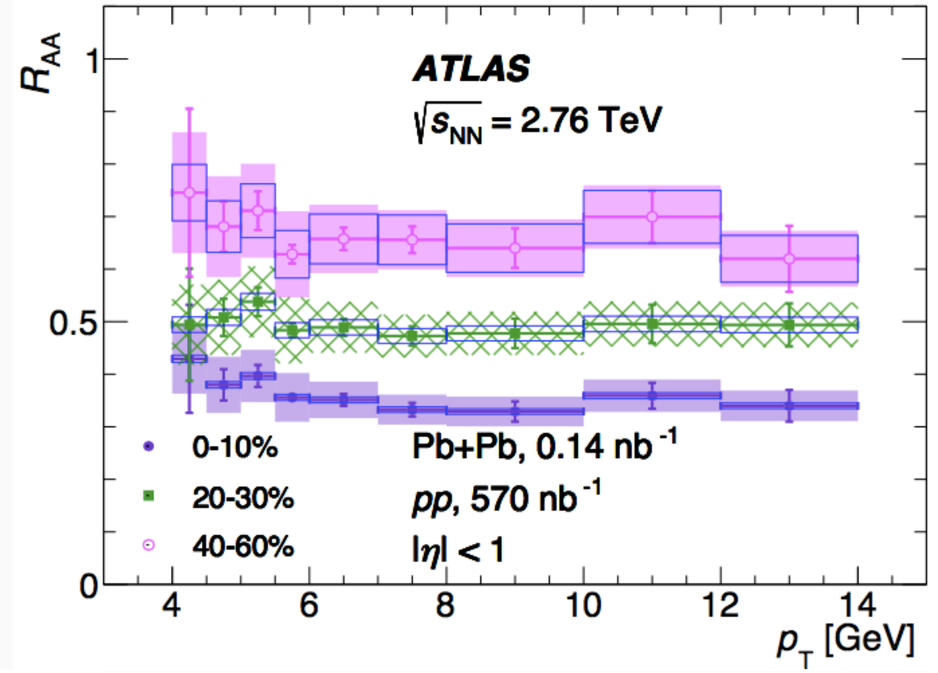
NEW

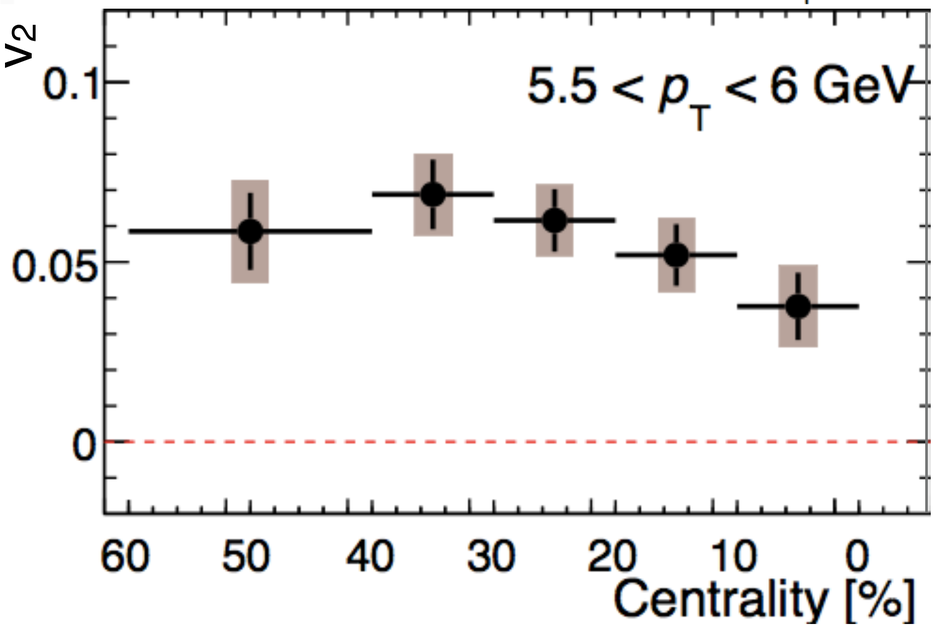
HION-2015-06

- Final measurement on muons from HF
- Production and flow harmonics v_2-v_4 of HF muons in Pb+Pb/pp at 2.76 TeV
- Muon cuts: $4<p_T<14$ GeV, $|\eta|<1$
- R_{AA} and v_n measured in p_T and centrality

- **R_{AA} is independent of p_T** and **decreases with centrality reaching about 0.35 in 0-10%**
- **v_2 is non-zero** and shows a systematic variation with centrality
- Also preliminary result on D meson production in p+Pb at 8.16 TeV [ATLAS-CONF-2017-073]

Talk by Q.Hu on Wed 15:00



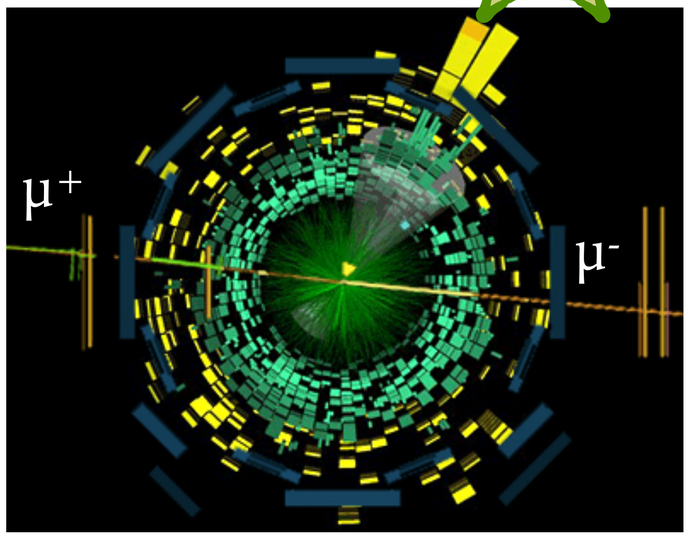


EXCLUSIVE DIMUONS IN NON-UPC PB+PB

HION-2018-11

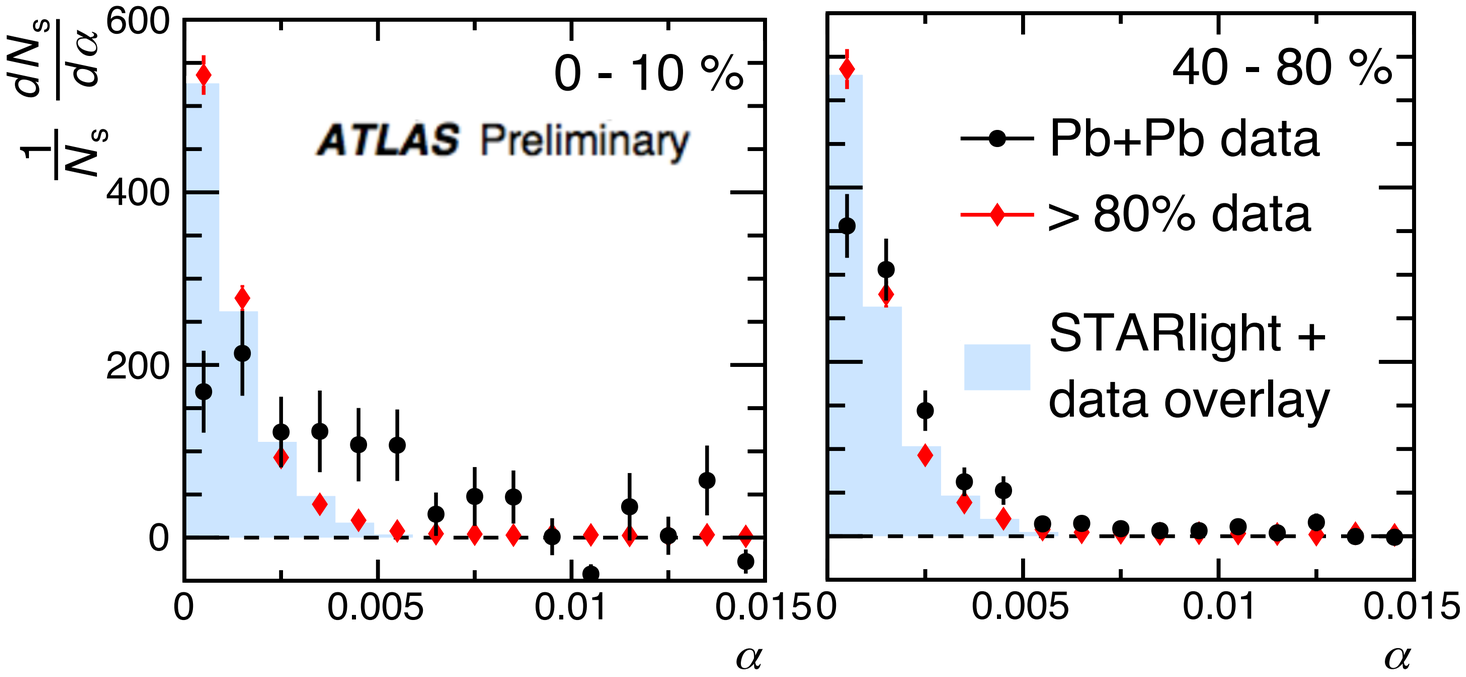
NEW

- Exclusive production of $\mu^+\mu^-$ pairs in non-Ultra-Peripheral Collisions (non-UPC) in Pb+Pb at 5.02 TeV
- Muons are back-to-back in azimuth [ATLAS-CONF-2016-025]
- What happens to acoplanarity in the QGP?



Acoplanarity: $\alpha = |1 - \frac{\phi_1 - \phi_2}{\pi}|$

- **Centrality-dependent broadening of α distribution**
- **Modification qualitatively consistent with re-scattering of muons in the QGP**
  - **70 MeV** per muon imparted
- MC model (signal from STARlight+MB event from data) does not describe the data
- **First observation of EM interactions with the QGP?**



Talk by P.Steinberg on Tue 11:50

Poster by A.Angerami

(II) Hard probes: Charged hadrons

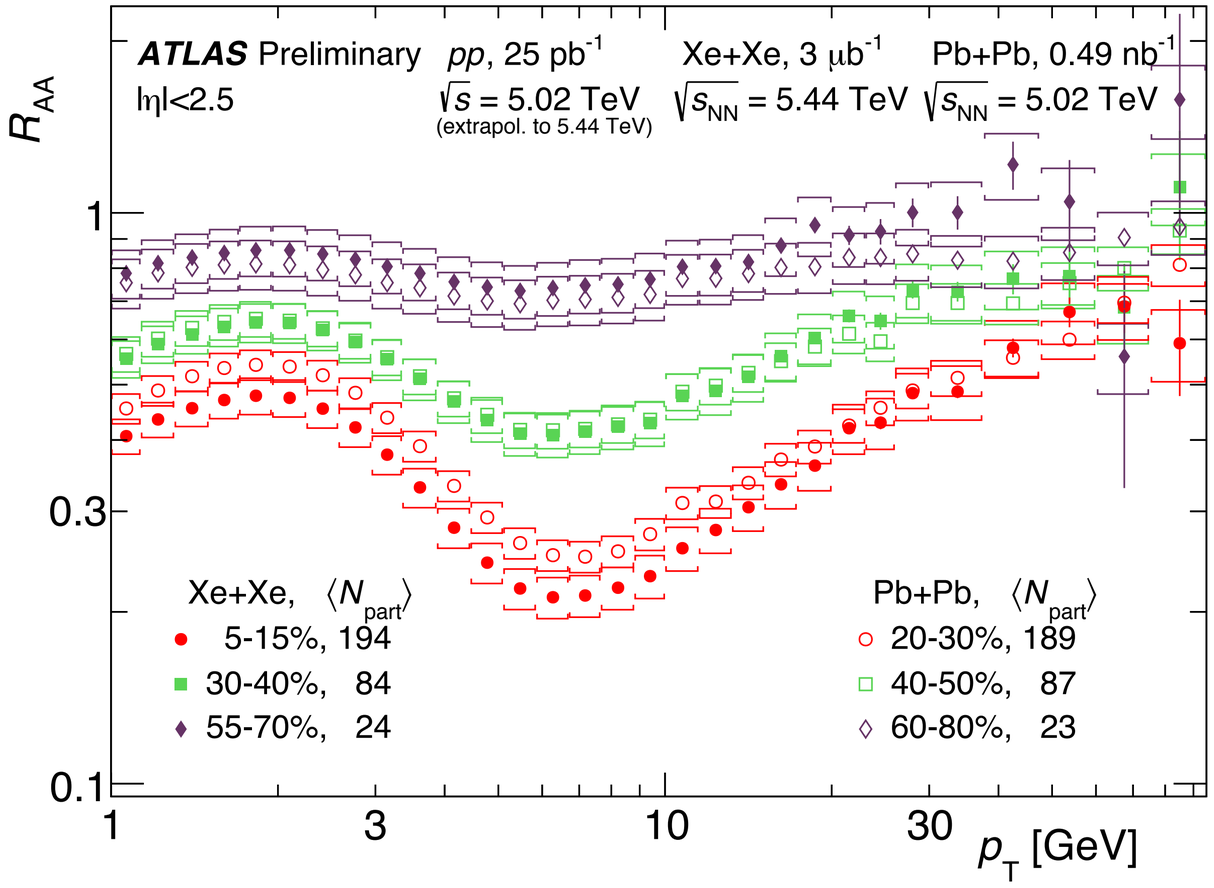
Jets

RAA FOR CHARGED HADRONS IN XE+XE

ATLAS-CONF-2018-007

NEW

- Measurement of charged-hadron spectra measured in Xe+Xe collisions at 5.44 TeV
  - Addresses a question about a role of geometry in HI collisions



- R_{AA} shows a centrality-dependent suppression with characteristics already observed in Pb+Pb
  - Increase to p_T=2 GeV (maximum), decrease to p_T~7 GeV (minimum), and again increase up to p_T~60 GeV
- R_{AA} in Xe compared to Pb in similar $<N_{part}>$ intervals
  - In **central events**, hadron yields in **Xe more suppressed** to those in Pb, while in **peripheral events**, **milder suppression in Xe** than Pb
  - Also shapes of R_{AA} seem to be systematically different in two collision systems

Talk by P.Balek on Tue 9:40

DIJET ASYMMETRY IN XE+XE

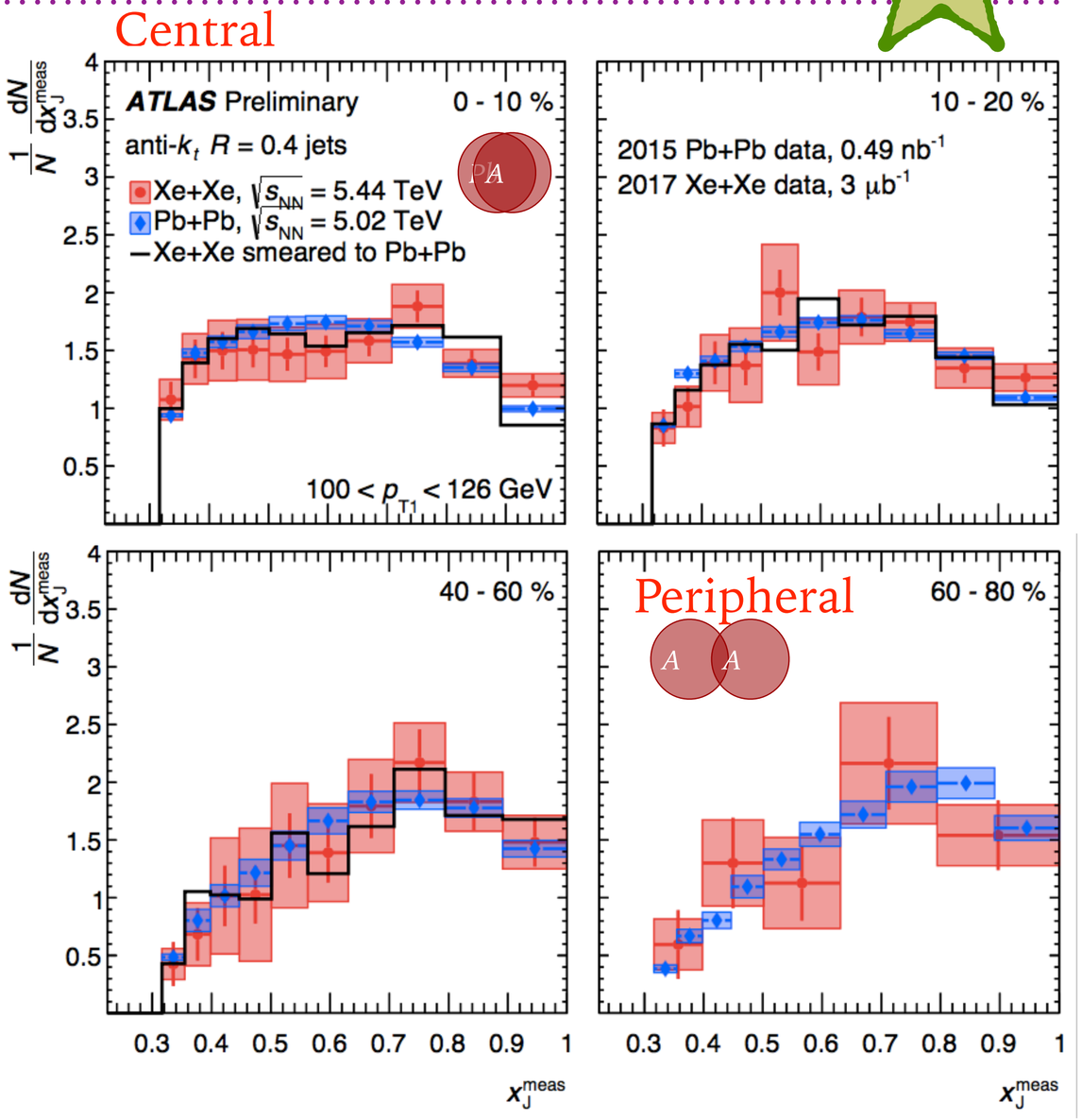
ATLAS-CONF-2018-007

NEW

- Dijet asymmetry, x_J, used in Run 1 to establish an observation of jet quenching
  - Question: what controls the dijet asymmetry?

$$x_{\mathrm{J}} = \frac{p_{\mathrm{T}}^{\mathrm{sublead}}}{p_{\mathrm{T}}^{\mathrm{lead}}}$$

- x_J measured in **Xe+Xe collisions** at 5.44 TeV as a function of centrality and jet p_T
  - x_J **is not unfolded** for detector effects
- x_J compared in Pb+Pb at 5.02 TeV to Xe+Xe at 5.44 TeV in **their own centrality** intervals
  - x_J distributions are **consistent** within uncertainties between **two systems** (Xe and Pb)



Talk by M.Spousta on Wed 11:10

JET ASYMMETRY FOR GAMMA-JET IN PB+PB

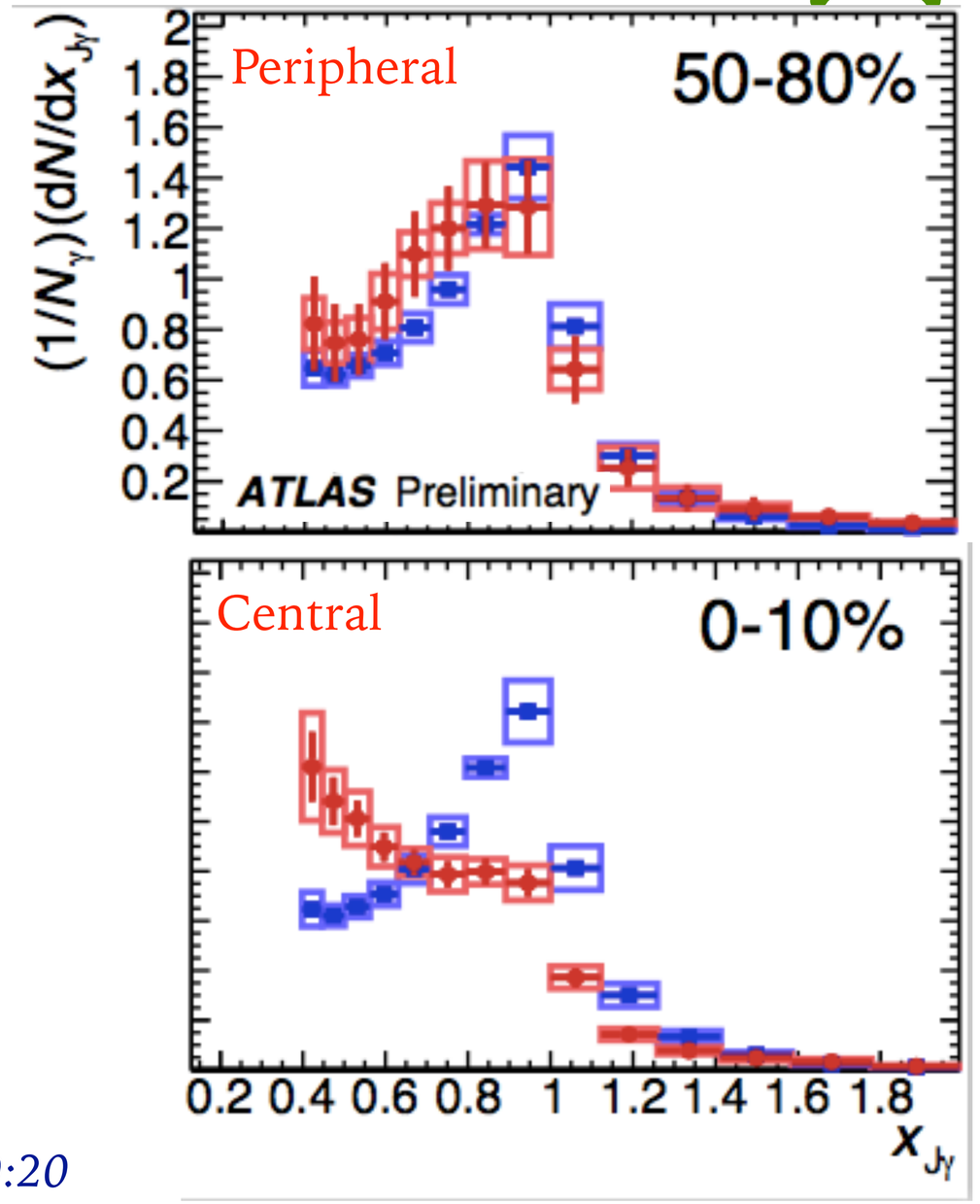
ATLAS-CONF-2018-009

NEW

- Photons act as calibration probes in HI collisions
- Measure $x_{J\gamma}$ in Pb+Pb/pp collisions at 5.02 TeV
  - $x_{J\gamma}$ **fully unfolded for detector effects**
- Centrality and photon p_T dependence measured

$$x_{J\gamma} = \frac{p_{\mathrm{T}}^{\mathrm{jet}}}{p_{\mathrm{T}}^{\gamma}}$$

- **$x_{J\gamma}$ evolves smoothly with centrality**
  - In 50-80%, comparable to pp
  - In 0-10%, no clear peak any more



Talk by D.Perepelitsa on Wed 9:20

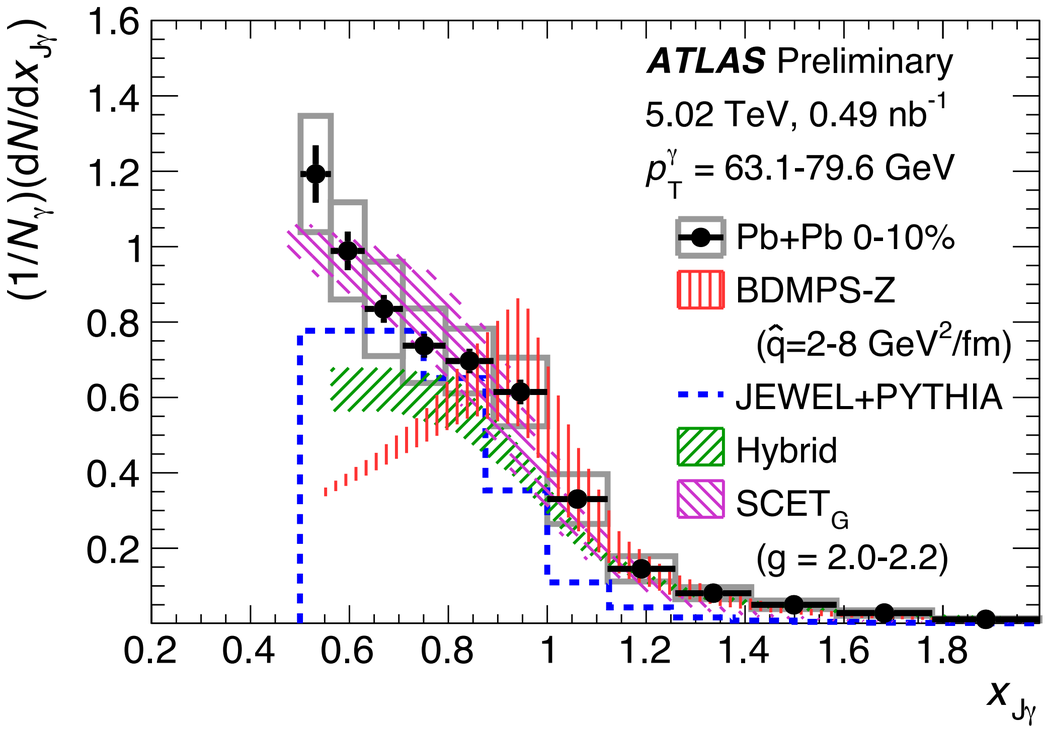
JET ASYMMETRY FOR GAMMA-JET IN PB+PB

ATLAS-CONF-2018-009

NEW

- Photons act as calibration probes in HI collisions
- Measure $x_{J\gamma}$ in Pb+Pb/pp collisions at 5.02 TeV
  - $x_{J\gamma}$ **fully unfolded for detector effects**
- Centrality and photon p_T dependence measured

$$x_{J\gamma} = \frac{p_{\mathrm{T}}^{\mathrm{jet}}}{p_{\mathrm{T}}^{\gamma}}$$



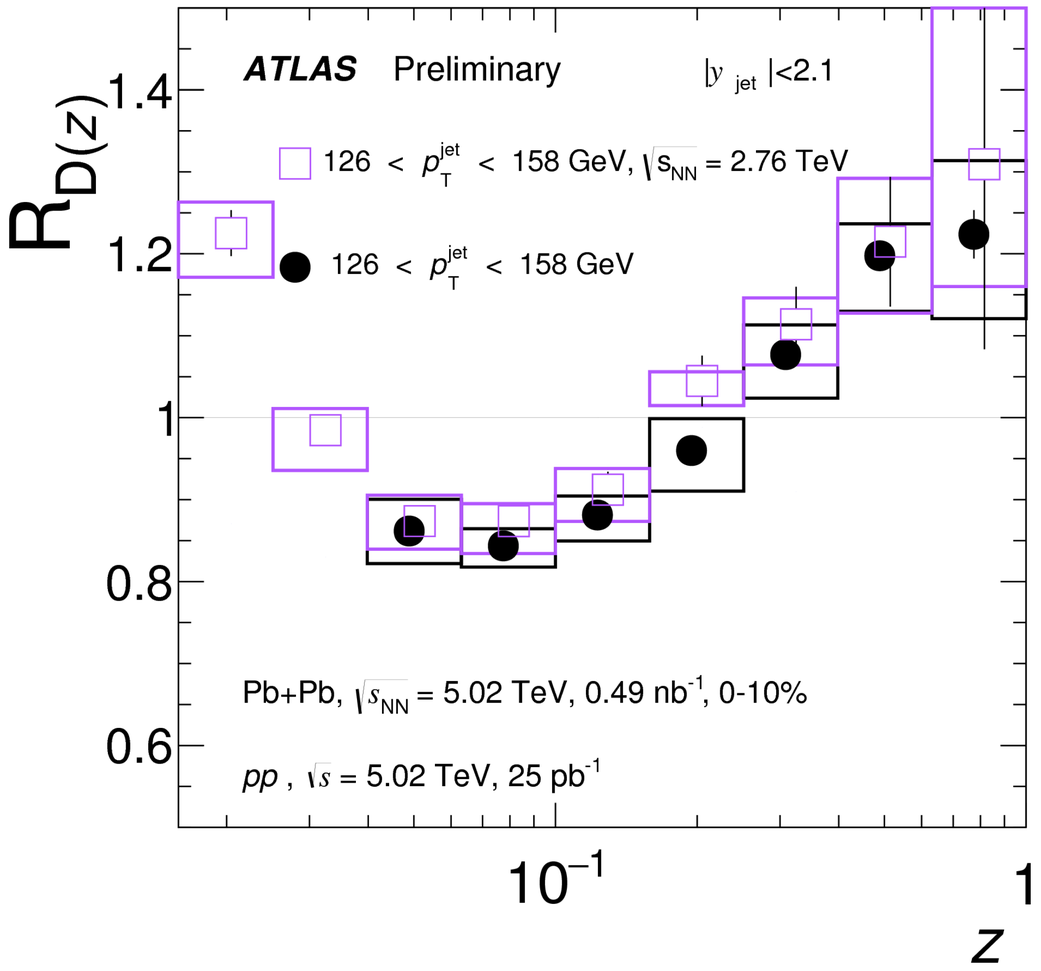
- Comparison to several theory predictions
- **Main features** of the data **described by models**

Talk by D.Perepelitsa on Wed 9:20

INCLUSIVE JET FF

ATLAS-CONF-2017-005

- ATLAS has a reach program of inclusive jet fragmentation function (FF) measurements
  - Final in p+Pb at 5.02 TeV [arXiv:1706.02859]
  - Final in Pb+Pb/pp systems at 2.76 TeV [EPJC (2017) 77: 379]
  - Preliminary in Pb+Pb at 5.02 TeV [ATLAS-CONF-2017-005]
    - In central Pb+Pb collisions (0-10%): **enhancement** at low a**, suppression** at intermediate z**, enhancement** at high z in all jet p_T bins
    - In peripheral Pb+Pb collisions (60-80%): **the magnitude of these modifications decreases**
    - Final 5.02 TeV result is also coming this week



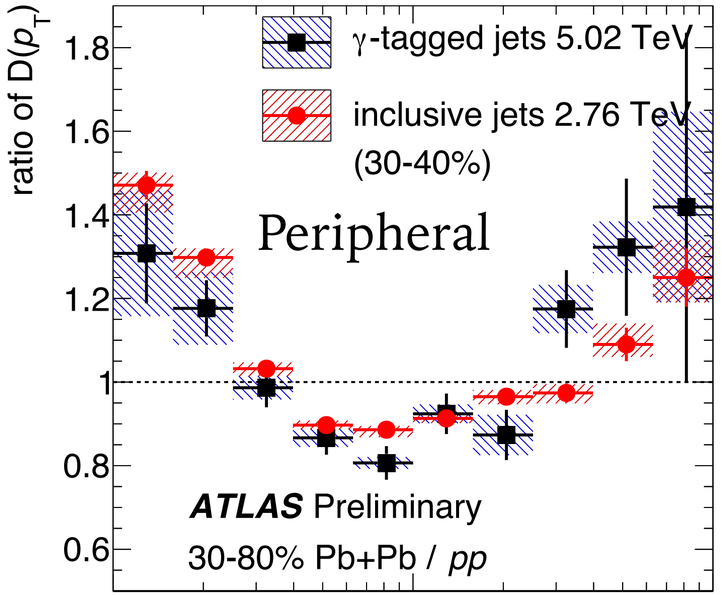
Talk by M.Rybar on Wed 12:30

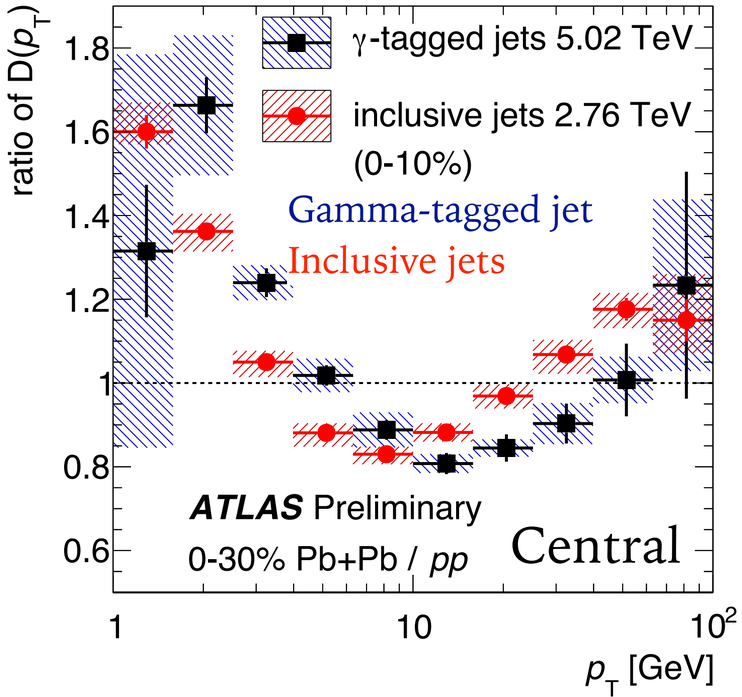
Poster A.Puri

PHOTON-TAGGED JET FF IN PB+PB

ATLAS-CONF-2017-074

- Photon-tagged jet FF with photons acting as unmodified probes in the QGP
- Photon-tagged jets are more likely to be initiated by quarks
- **Fully unfolded** ratios of jet FF for photon-tagged and inclusive in Pb+Pb/pp systems
  - Two centrality bins: 30-80% (peripheral) and 0-30% (central)





- In peripheral: **similar** behaviour for **photon-tagged and inclusive jets**
- In central: **differences** between **photon-tagged and inclusive jet FF - additional suppression** at high p_T and **enhancement** at low p_T

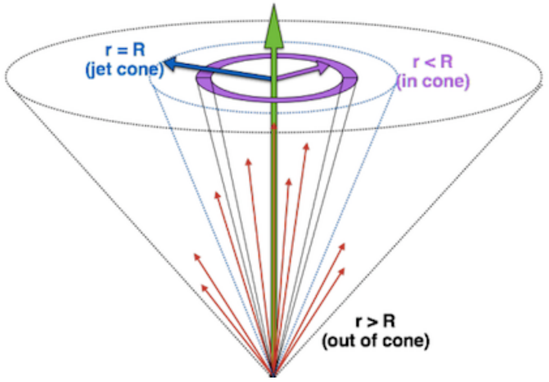
Talk by D.Perepelitsa on Wed 9:20

CHARGED PARTICLES VS. R IN PB+PB

ATLAS-CONF-2018-010

- More differential look at jet FF
  - Charged particles inside and around a jet (r<0.6) in Pb+Pb/pp at 5.02 TeV
- Dependence on centrality, jet- and charged-particle p_T
- Quantities $D(p_T, r)$ and $R_{D(pT,r)}$ **are fully unfolded**

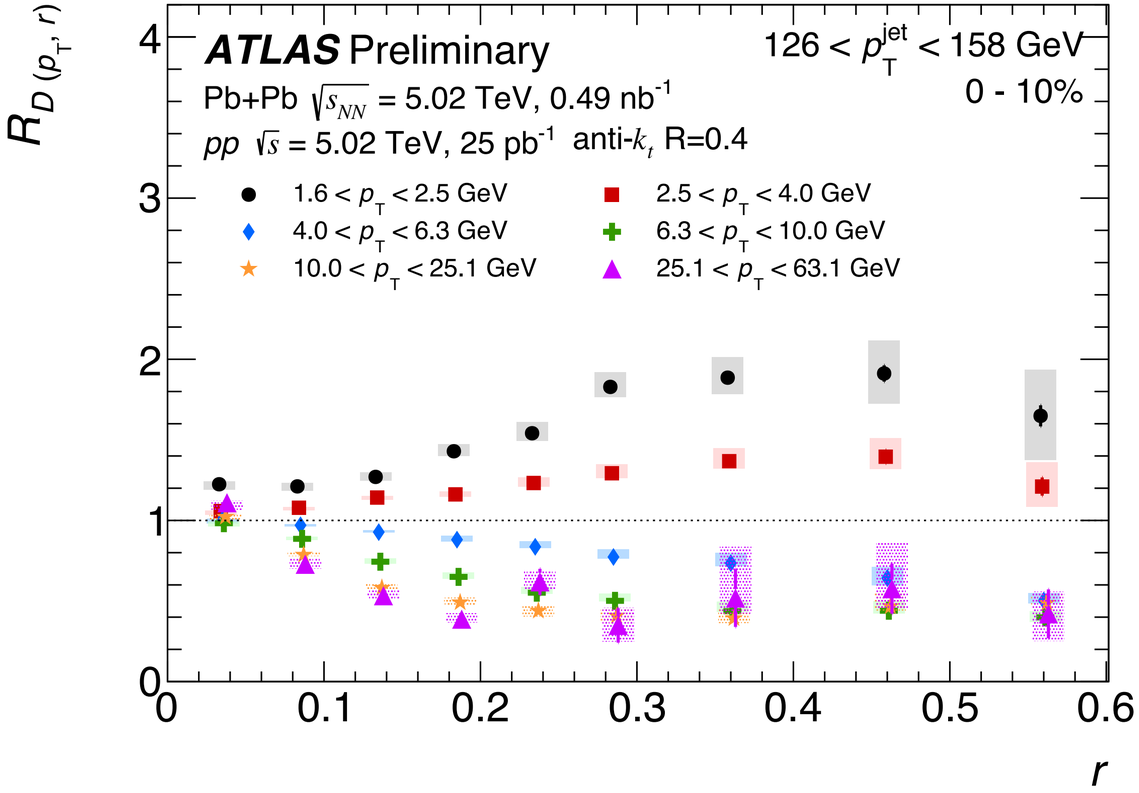
NEW



$$D(p_{\mathrm{T}}, r) = \frac{1}{N_{\mathrm{jet}}} \frac{1}{2\pi r} \frac{d^2 n_{\mathrm{ch}(r)}}{dr dp_{\mathrm{T}}}$$

$$R_{D(p_{\mathrm{T}},r)} = \frac{D(p_T, r)_{\mathrm{Pb+Pb}}}{D(p_T, r)_{pp}}$$

- In 0-10% centrality, $\mathbf{R_{D(pT,r)}}$ is:
  - **Above unity** (enhancement) for $1.6<p_T<4$ GeV
  - **Below unity** (suppression) for $p_T>4$ GeV
  - In agreement with inclusive jet FF for r<0.4
  - $R_{D(pT,r)}$ changes for r<0.3 and then saturates
- Energy lost is transferred to particles with $p_T < 4.0$ GeV with larger radial distances

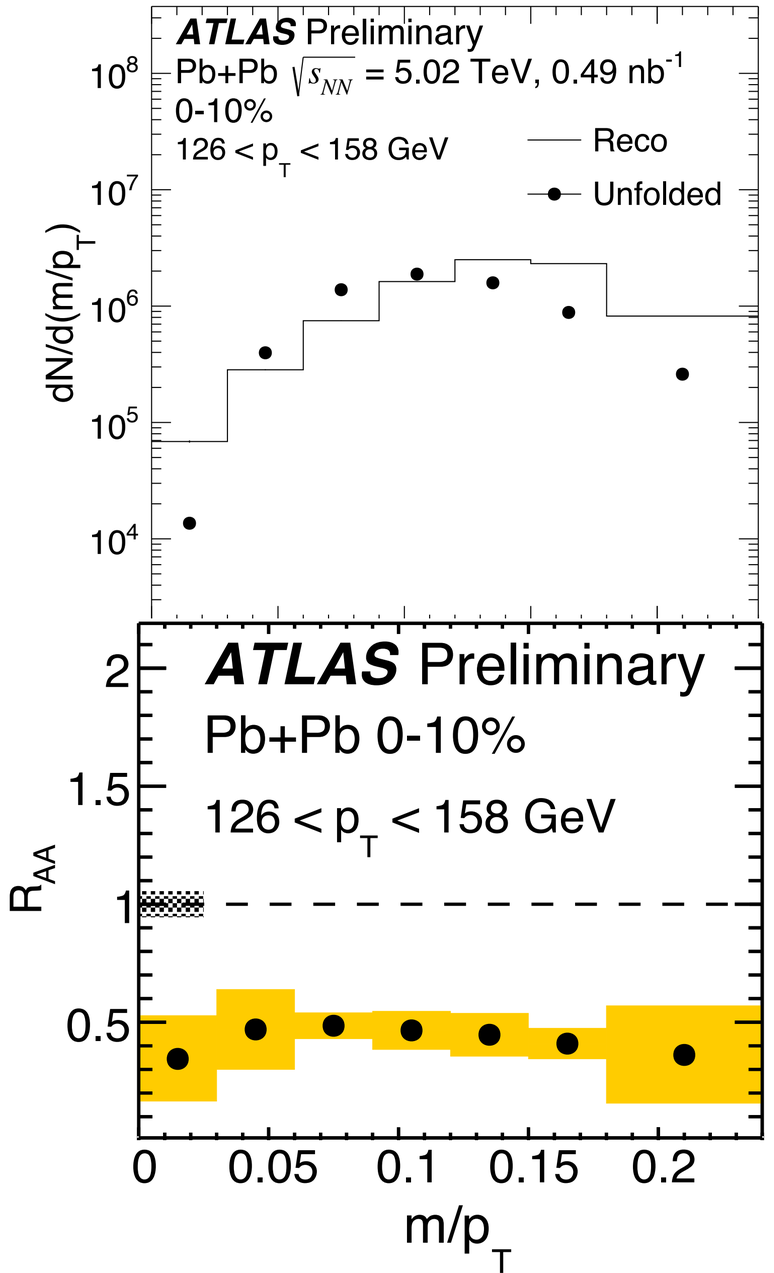


Talk by M.Rybar on Wed 12:30

JET MASS IN PB+PB

ATLAS-CONF-2018-014

NEW



- First **fully-unfolded measurement** of jet mass in Pb+Pb/pp collisions at 5.02 TeV by ATLAS
- Jets: $126<p_T<500$ GeV, $|y|<2.1$
- Distribution of $\mathbf{m/p_T}$ is measured, where **m** is the norm of jet four-momentum from calo towers

$$R_{AA}(m/p_T, p_T) = \frac{\frac{1}{N_{evt}} \frac{dN_{jet}^{Pb+Pb}}{d(m/p_T)}(p_T)\Big|_{cent}}{\langle T_{AA} \rangle \frac{d\sigma_{jet}^{pp}}{d(m/p_T)}(p_T)}$$

- R_{AA} has **no significant dependence on** $\mathbf{m/p_T}$
- R_{AA} values are **consistent with inclusive jet** $\mathbf{R_{AA}}$

Talk by M.Spousta on Wed 11:10

Poster by Y.Kim

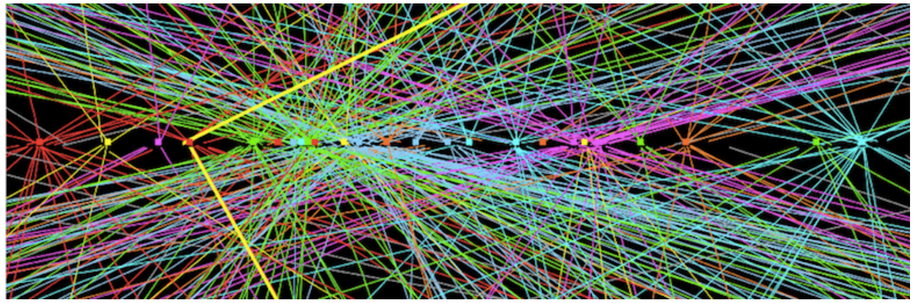
(III) Soft physics

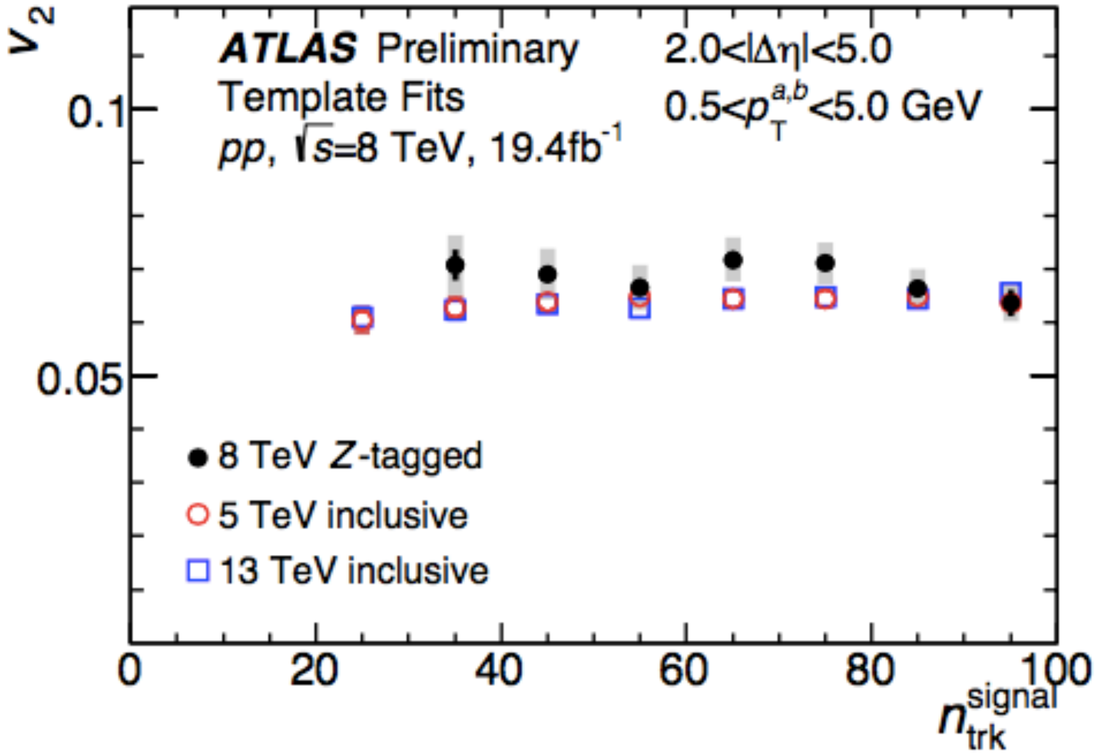
from small to large systems

RIDGE IN Z-TAGGED PP COLLISIONS

ATLAS-CONF-2017-068

- First attempt to control the impact parameter of pp by selecting a high-Q2 process
- 2PC for hadrons in events with Z bosons
- Analysis based on full 2012 pp data at 8 TeV with L=19.4 1/fb with 6.2M Z bosons
- Main challenge is high pileup: average μ is 20 (c.f. μ =1 in previous ATLAS ridge studies)
- **New technique** is **developed** to subtract the pileup contribution in 2PC (~20% correction)
- **v_2 is found to be 8±6% above that in the inclusive collisions at 13 TeV**





Talk by B.Cole on Tue 15:40

Poster by A.Milov

MIXED HARMONICS IN PP, P+PB AND PB+PB

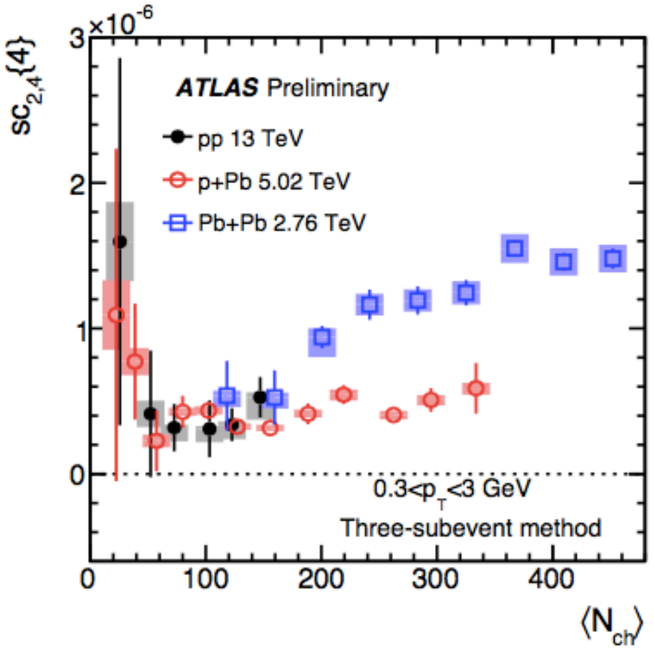
NEW

ATLAS-CONF-2018-012

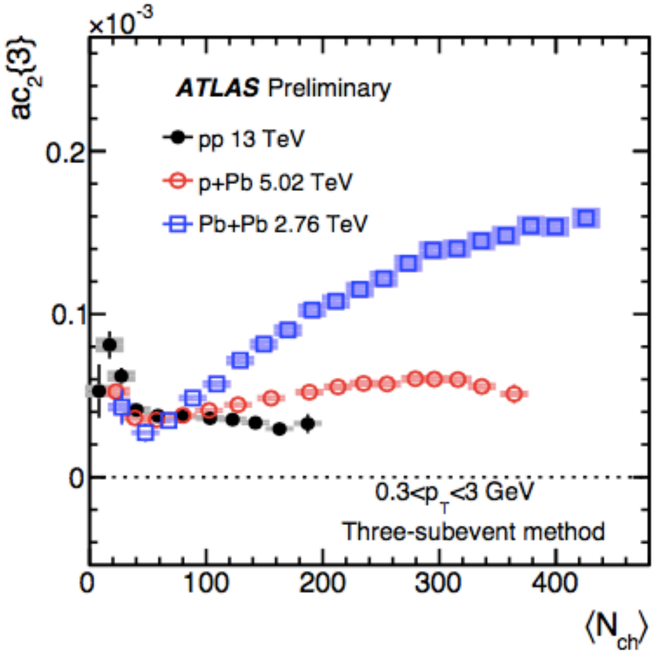
- Symmetric ($sc_{2,3}\{4\}$ and $sc_{2,4}\{4\}$) and asymmetric cumulants ($ac_2\{3\}$)
  - In pp, p+Pb and low-multiplicity Pb+Pb collisions as a function of N_{ch}
  - Addressing a question about a non-flow contribution and collectivity of small systems
- Non-flow subtracted using the **subevent method** [arXiv:1708.03559]
- Also normalised cumulants $nsc_{2,3}\{4\}$, $nsc_{2,4}\{4\}$ and $nac_2\{3\}$ scaled by $\langle v_n^2 \rangle$ are measured

$$sc_{n,m}\{4\} = \langle \nu_n^2 \nu_m^2 \rangle - \langle \nu_n^2 \rangle \langle \nu_m^2 \rangle$$

$$ac_n\{3\} = \langle \nu_n^2 \nu_{2n} \cos 2n(\Phi_n - \Phi_{2n}) \rangle$$



- Cumulants ($sc_{2,4}\{4\}$ and $ac_2\{3\}$):
  - Positive correlation between v_2 and v_4
  - First confirmation of such behaviour in small collisions systems
  - Similar at low N_{ch} in all systems, but diverge at higher N_{ch}

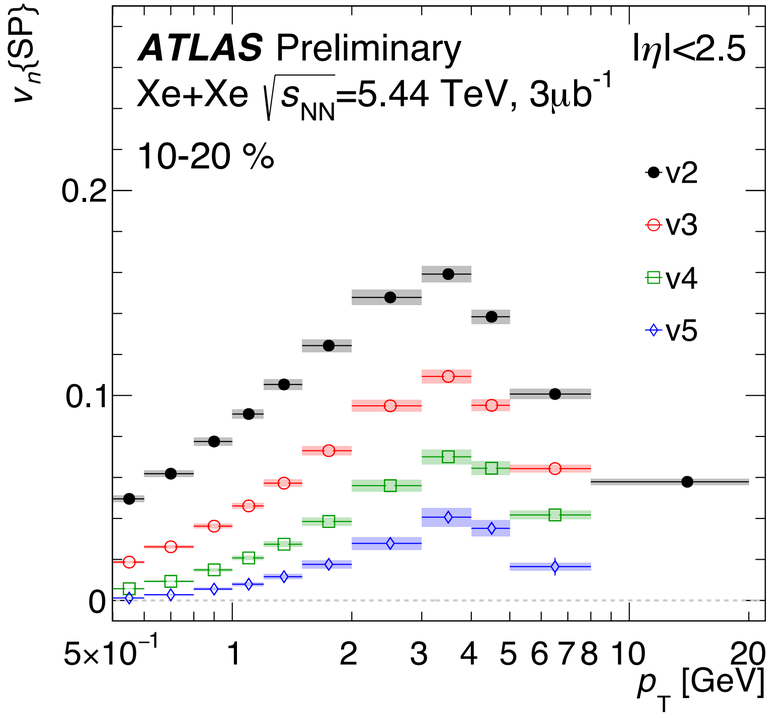


Talk by D.Derendarz on Tue 11:50

FLOW HARMONICS IN XE+XE

ATLAS-CONF-2018-011

- Centrality- and p_T-dependence of flow harmonics v_2-v_5 in Xe+Xe collisions at 5.44 TeV
  - Very precise measurement of multi-particle cumulants for 2, 4 and 6 particles and scalar-product (SP) method
- **Similar pattern** for flow harmonics as in Pb+Pb: rise up to p_T~3 GeV, then decrease with p_T, **magnitude** of flow harmonics **decreases with their order**



NEW

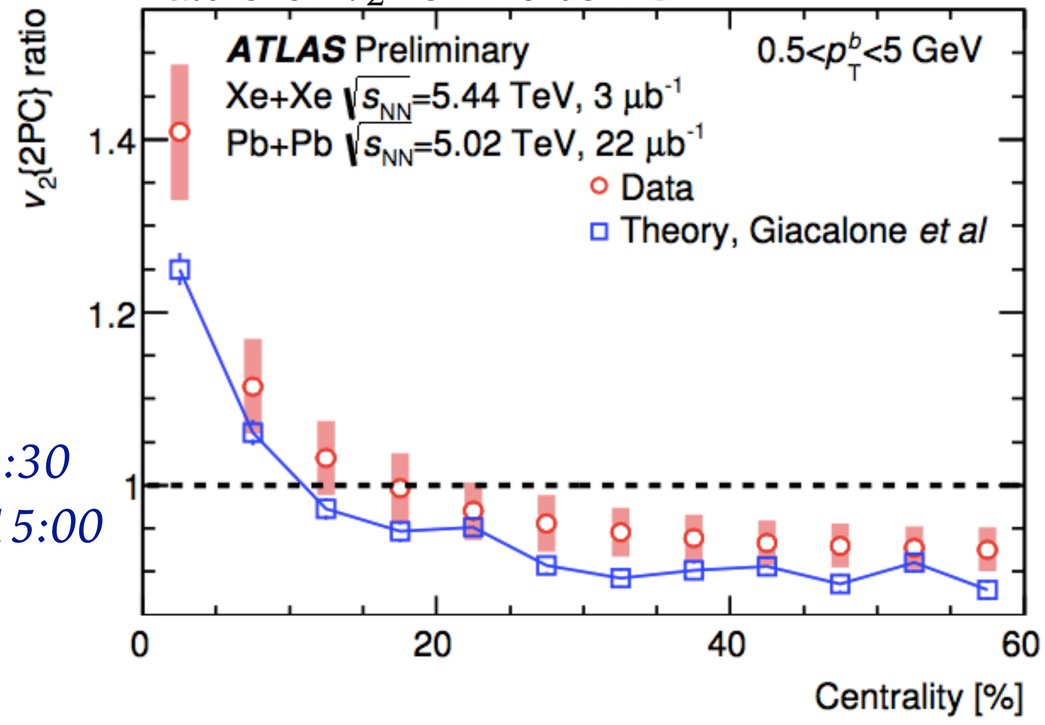
Talk by T.Bold on Tue 11:30

Talk by M.Zhou on Tue 15:00

Poster by K.Burka

- $\mathbf{v_n}$ are observed to be **larger in Xe than in Pb** for n=2,3,4 in most **central** events
- With decreasing centrality and increasing harmonic order, v_n in Xe become smaller comparing to Pb
- Predictions by Giacalone et al [arxiv:1711.08499] can describe basic features of the data

Ratio of v_2 for Xe to Pb

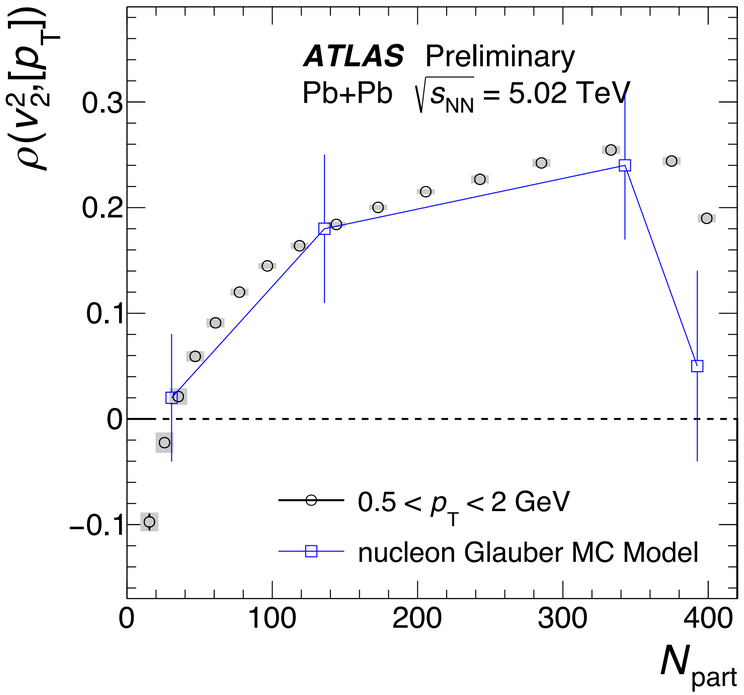


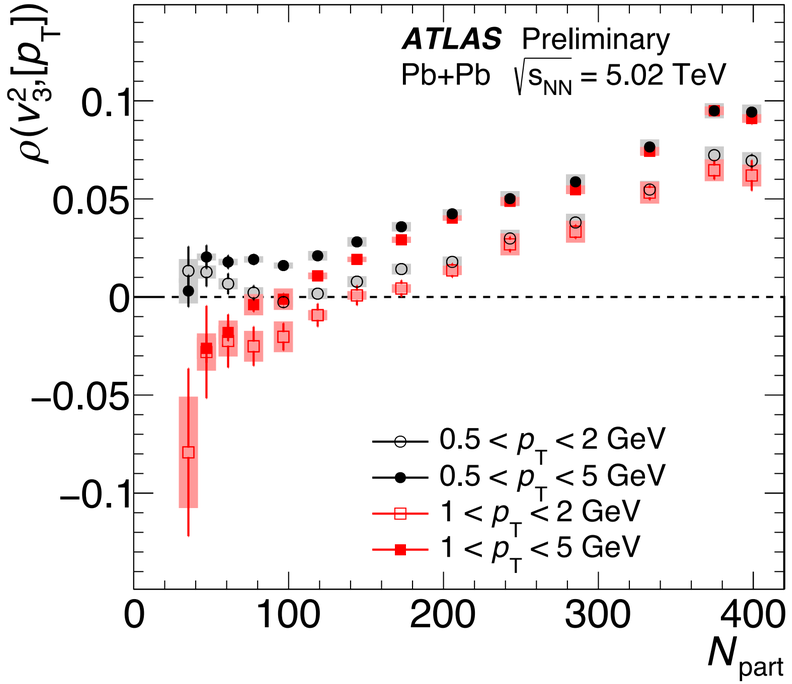
VN-PT CORRELATIONS IN PB+PB

NEW

ATLAS-CONF-2018-008

- New tool - **modified Pearson's correlation coefficient** ρ to quantify the correlation between mean p_T in the event and flow magnitude [Phys. Rev. C93 (2016) 044908]
- ρ for n=2-4 is measured in minimum-bias Pb+Pb collisions at 5.02 TeV
- Non-flow contribution suppressed using the subevent technique
- For **very small** N_{part} values, **$\rho(v_2^2,[p_T])$ is negative** and **rapidly raising** ($N_{part}<100$), then a **gentle increase up to** $N_{part}=350$, a **moderate drop in the most central**
- **$\rho(v_3^2,[p_T])$ is smaller** and has **weaker** N_{part} dependence
- **Prediction** based on nucleon Glauber MC model **describes data well** but its precision is limited [PRC94 (2016) 014902]





$$\rho = \frac{\mathrm{cov}(\nu_n\{2\}^2, [p_T])}{\sqrt{\mathrm{Var}(\nu_n\{2\}^2)_{\mathrm{dyn}}}\sqrt{c_k}}$$

Talk by T.Bold on Tue 11:30

SUMMARY

- Many **new** results from **ATLAS**
  - Also including **first results** from **Xe+Xe run** at 5.44 TeV in October 2017
    - Role of geometry in HI collisions
    - Results of charged hadron R_{AA}, flow harmonics v_2-v_5, dijet asymmetry
- In addition, among highlights QM18 are:
  - Observation of **broadening of acoplanarity distribution for exclusive dimuons** in the QGP
  - **Fully unfolded p_T asymmetry** in gamma-jet events, **particle yields around a jet, jet mass**
  - **Photon-tagged** and inclusive jet selections utilised together to explore flavour dependence of energy loss and jet FF modification
  - **New tool** applied - so-called modified Pearson's coefficient - to quantify **flow-mean p_T correlations**
  - First measurement of **symmetric** and **asymmetric cumulants** in small systems w/ non-flow correlations removed
- More details in 12 parallel talks and in 11 posters by ATLAS members

ORAL CONTRIBUTIONS TO Quark Matter 2018 Venice FROM ATLAS

- Zvi Citron: Electroweak probes of small and large systems
- Qipeng Hu: Heavy flavor production and azimuthal anisotropy
- Jorge Lopez Lopez: Quarkonia production
- Dennis Perepelitsa: Photon-tagged measurements of jet quenching
- Martin Rybar: Jet fragmentation and the angular distributions of charged particles within and around jets
- Martin Spousta: Jet suppression, azimuthal dependence of jet yields, and jet substructure
- Petr Balek: Charged-particle suppression in Pb+Pb, Xe+Xe, and p+Pb collisions
- Tomasz Bold: Azimuthal anisotropy in Pb+Pb and Xe+Xe collisions
- Brian Cole: Long-range correlations in pp collisions characterized by presence of a Z boson
- Dominik Derendarz: Four-particle cumulants and symmetric cumulants in small systems
- Mingliang Zhou: Transverse and longitudinal event-by-event flow fluctuations of v_1 - v_4
- Peter Steinberg: EM-induced processes in heavy ion collisions

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HeavyIonsPublicResults

POSTER CONTRIBUTIONS TO Quark Matter 2018 Venice FROM ATLAS

- Mirta Dumancic: Z boson production in Pb+Pb and pp collisions
- Kurt Keys Hill: Prompt photon production in p+Pb collisions
- Qipeng Hu: D meson production and flow in 8.16 TeV p+Pb collisions
- Jorge Lopez Lopez: Prompt and non-prompt J/psi elliptic flow
- Sebastian Tapia Araya: Suppression of charmonia states in Pb+Pb collisions
- Yongsun Kim: Substructure of jets in pp and Pb+Pb collisions
- Akshat Puri: Jet fragmentation in pp, p+Pb and Pb+Pb collisions
- Alexander Milov: Underlying event in the presence of high pileup
- Klaudia Burka: Scalar product and event plane methods in Pb+Pb and Xe+Xe collisions
- Michael Ryan Clark: Femtoscopy with identified charged pions in p+Pb collisions
- Aaron Angerami: Non-UPC $\gamma\gamma \rightarrow \mu^+\mu^-$ with the ATLAS detector at the LHC

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HeavyIonsPublicResults

BACK-UP SLIDES

HEAVY-ION DATA SETS

- Run 1 (2010-2013) provided collisions of pp, p+Pb and Pb+Pb systems
  - In addition to the bulk of pp data at 0.9, 7 and 8 TeV at high luminosity
- In Run 2 (2015-present) CM energy almost doubled
  - Study **energy dependence** 2.76 vs 5.02 TeV
  - Factor of 3.5 **more integrated luminosity**
  - Test run with lighter **Xe ions** collected in 2017 to look at **different geometry**

	System	Year	sqrt(s_{NN}) [TeV]	L_{int}
Run 1	Pb+Pb	2011	2.76	0.14 nb^{-1}
	pp	2012	8	19.4 fb^{-1}
	pp	2013	2.76	4 pb^{-1}
	p+Pb	2013	5.02	29 nb^{-1}
Run 2	low-mu pp	2015-16	13	0.9 pb^{-1}
	pp	2015	5.02	28 pb^{-1}
	Pb+Pb	2015	5.02	0.49 nb^{-1}
	p+Pb	2016	5.02	0.5 nb^{-1}
	p+Pb	2016	8.16	0.16 pb^{-1}
	Xe+Xe	2017	5.44	3 μb^{-1}
	pp	2017	5.02	270 pb^{-1}

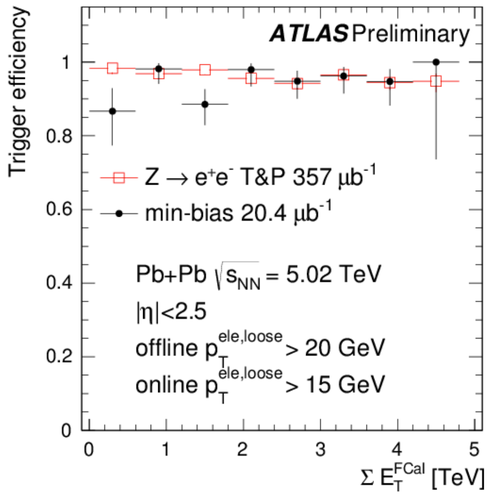
NEW

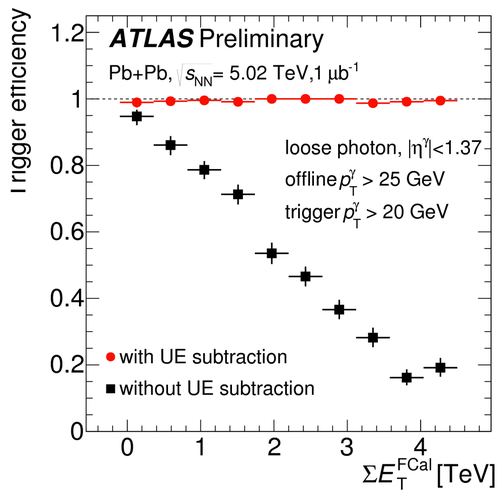
NEW

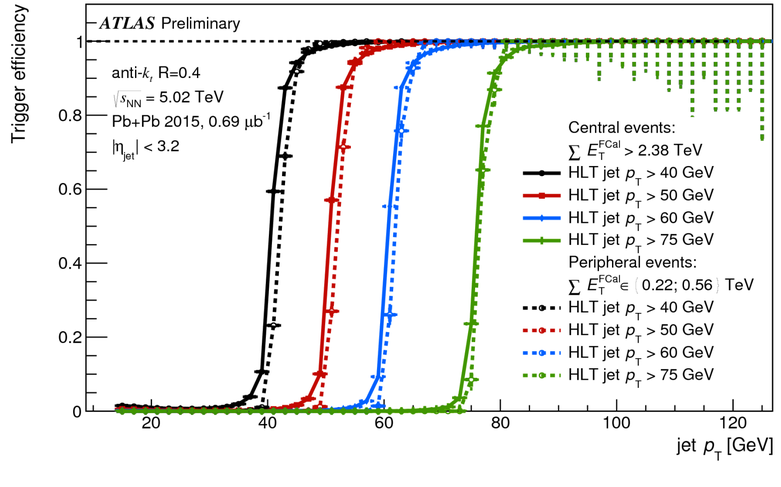
Results shown for the first time

PERFORMANCE IN PB+PB COLLISIONS IN RUN 2

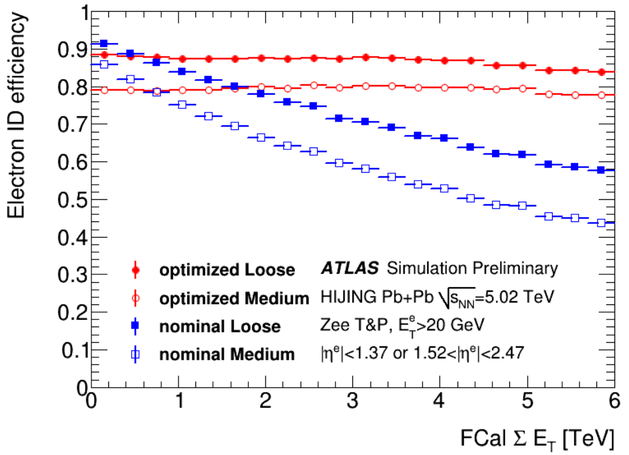
- Dedicated trigger strategies developed for HI collisions
  - Many effort put to preserve constant trigger efficiency w/ centrality

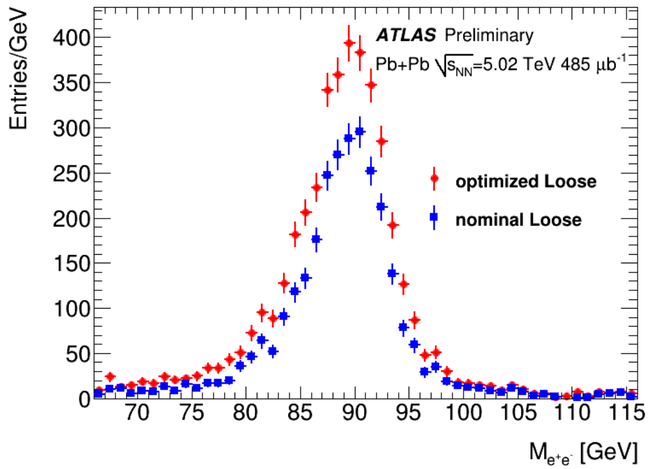






- *Also offline performance reoptimized for HI collisions*





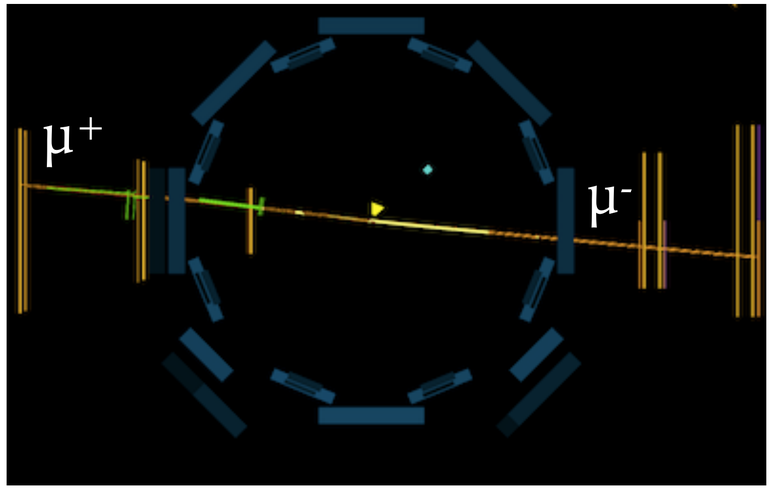
EXCLUSIVE DIMUONS IN PB+PB (I)

Talk by P.Steinberg on Tue 11:50

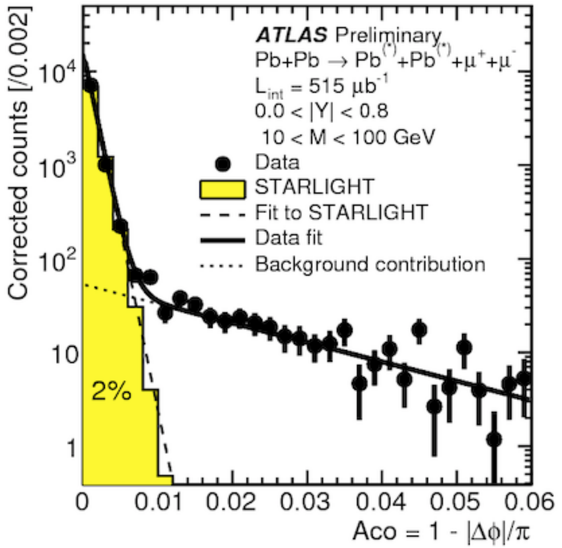
NEW

- Measurement of exclusive production of $\mu^+\mu^-$ pairs in non-Ultra-Peripheral Collisions (non-UPC) of Pb+Pb at 5.02 TeV
  - Inspired by the ATLAS measurements of exclusive dimuon pairs in UPC events [ATLAS-CONF-2016-025] and muons from heavy-flavour decays [Ref.]
  - In **UPC** (b>2R), the EM processes dominate, and have a very clean signature
  - In **non-UPC** (b<2R) collisions, EM processes are still present and are background to hadronic interactions
    - In this search, look for $\gamma\gamma \rightarrow \mu^+\mu^-$ production in MB events (non-UPC)
    - Very challenging due to various backgrounds

$\gamma\gamma \rightarrow \mu^+\mu^-$ event in UPC



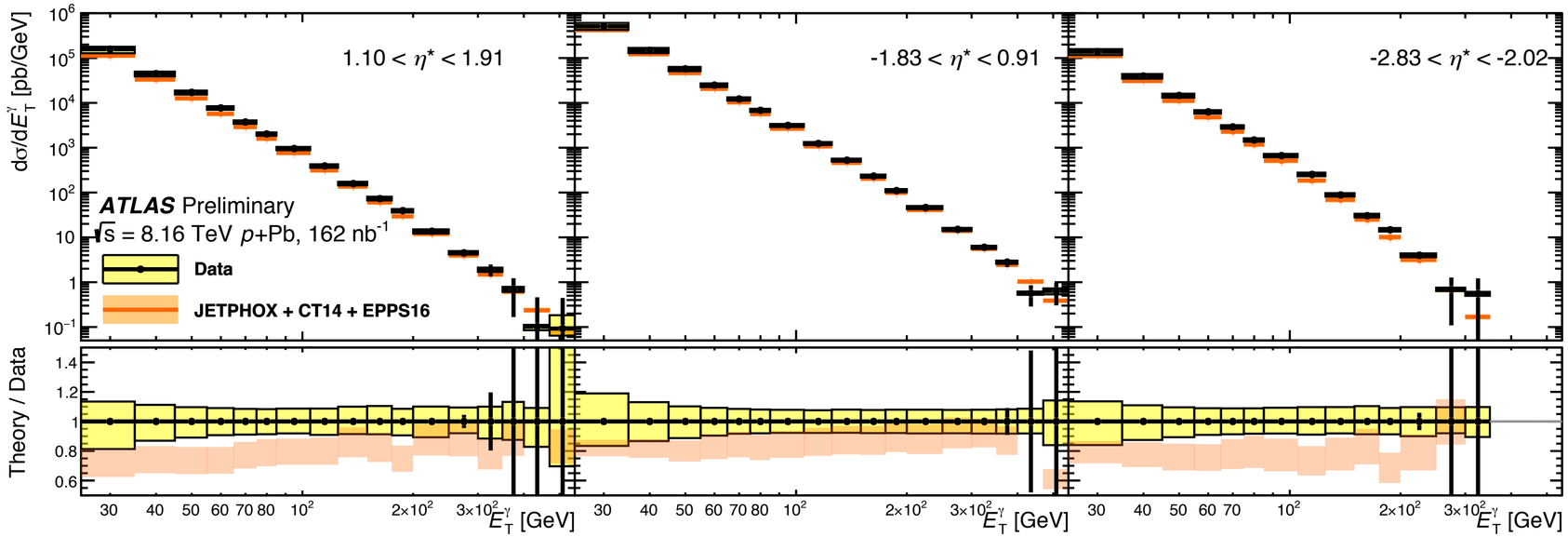
Main feature: $\mu^+\mu^-$ is back-to-back in azimuth, acoplanarity peaked at 0



INCLUSIVE PHOTONS: CNM EFFECTS

ATLAS-CONF-2017-072

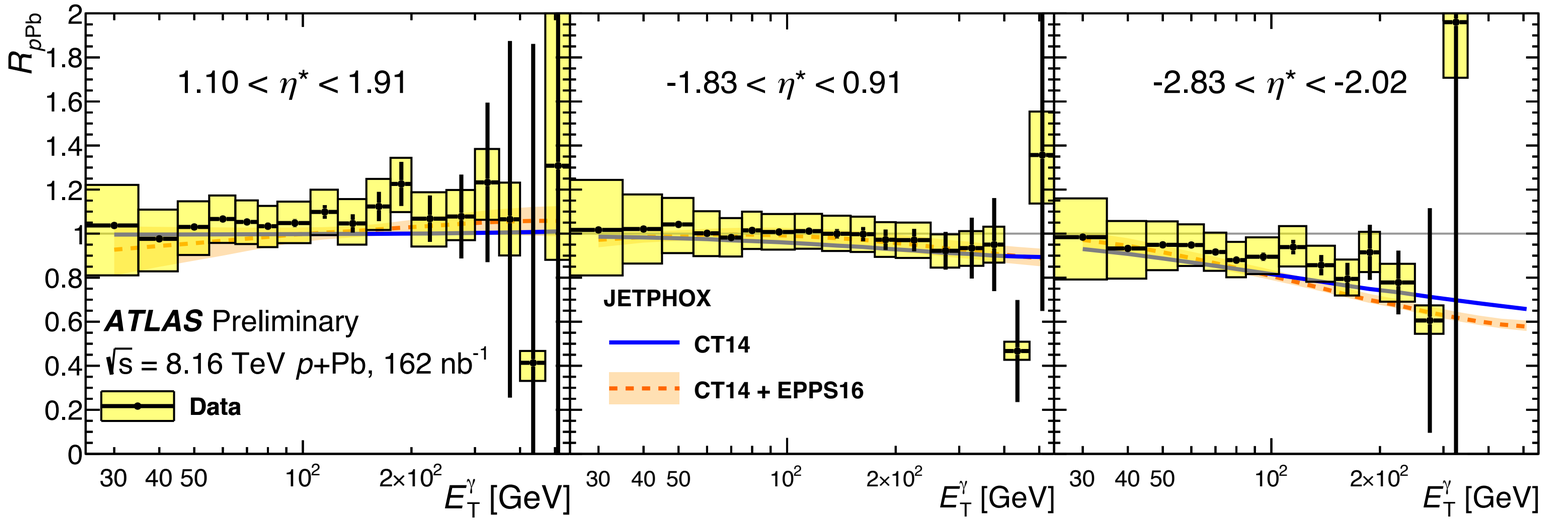
- Measurement of isolated prompt photons in p+Pb collisions at 8.16 TeV
  - Photon kinematics: E_T>25 GeV, $|\eta|$< 2.37 and three bins in η^*



- **ATLAS reaches photon E_T of 500 GeV at mid-rapidity and covers five orders of magnitude in cross sections**
- Dominant systematics: photon energy scale, photon PID (low photon E_T) and luminosity (6.2%)
- JETPHOX with CT14+EPPS16 underpredict the data by about 20%, consistent with JETPHOX results for pp [JHEP 08 (2016) 005]

INCLUSIVE PHOTONS: CNM EFFECTS

ATLAS-CONF-2017-072

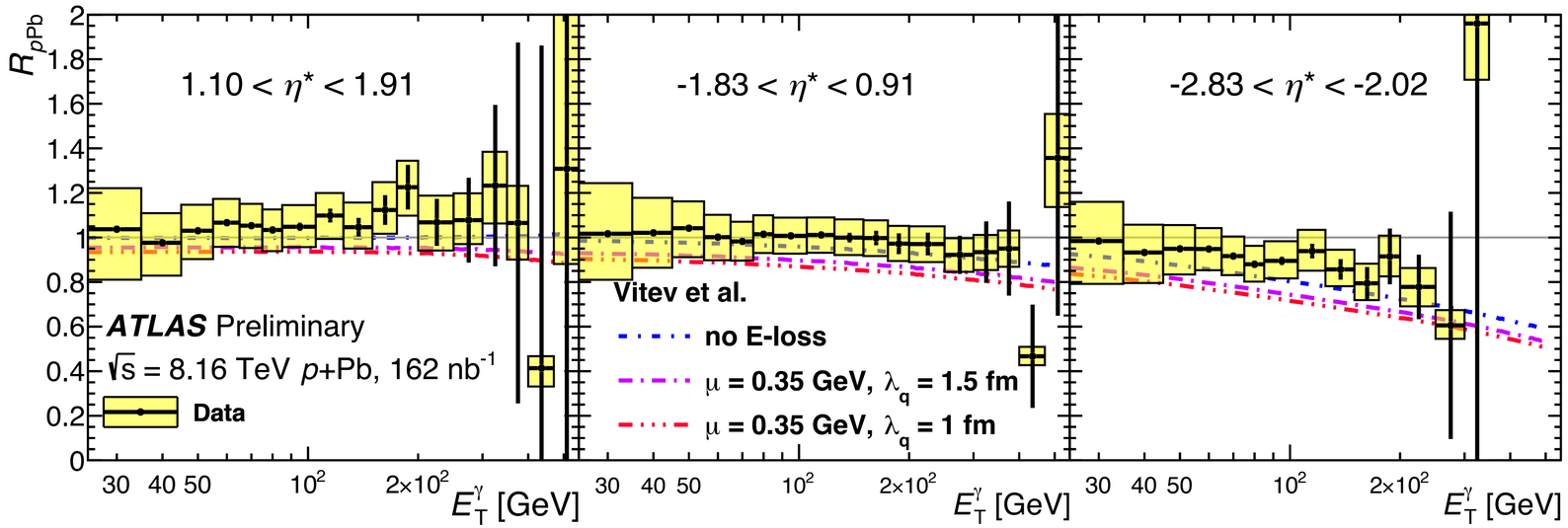


$$R_{\mathrm{pPb}} = \frac{\frac{d\sigma^{\mathrm{pPb}}}{dE_{\mathrm{T}}^{\gamma}}}{A \times \frac{d\sigma^{pp}}{dE_{\mathrm{T}}^{\gamma}}}$$

- R_{pPb} measured and compared to JETPHOX with nPDF from EPPS16, nCTEQ15, as well as with parton energy-loss models by medium-induced gluon bremsstrahlung [I.Vitev et al., PRD 93, 074030 (2016)]
  - R_{pPb} cancels out the 20% scale problem, no dependence on Glauber modelling, 8 TeV pp data is extrapolated to 8.16 TeV for reference, requiring sizeable correction above100 GeV
  - **At forward rapidity and for low/intermediate photon E_T, R_{pPb} is consistent with unity**
  - **At high photon E_T, in the backward rapidity R_{pPb} is significantly below unity which is due to a change in up/down quark mixture wrt pp system**
  - **With the current uncertainties, the data can not distinguish between free PDF and nPDF**

INCLUSIVE PHOTONS: CNM EFFECTS

ATLAS-CONF-2017-072



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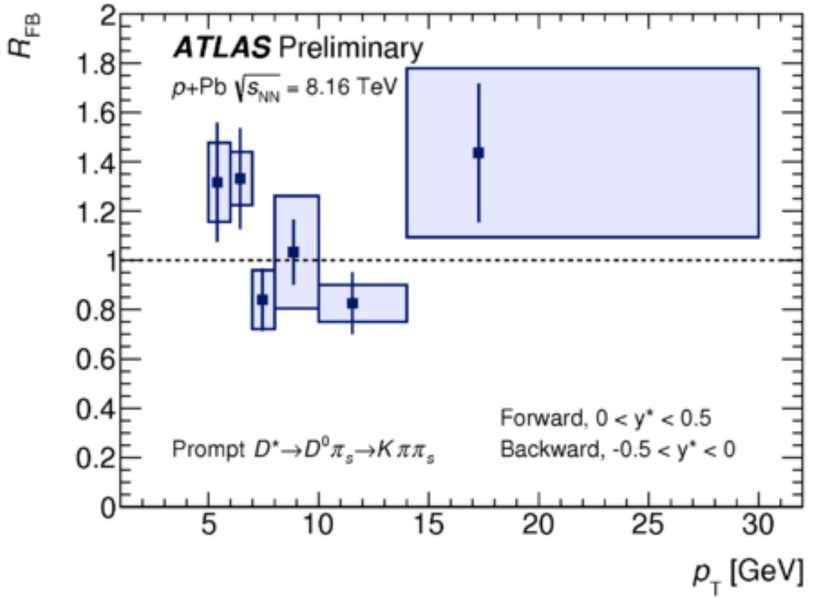
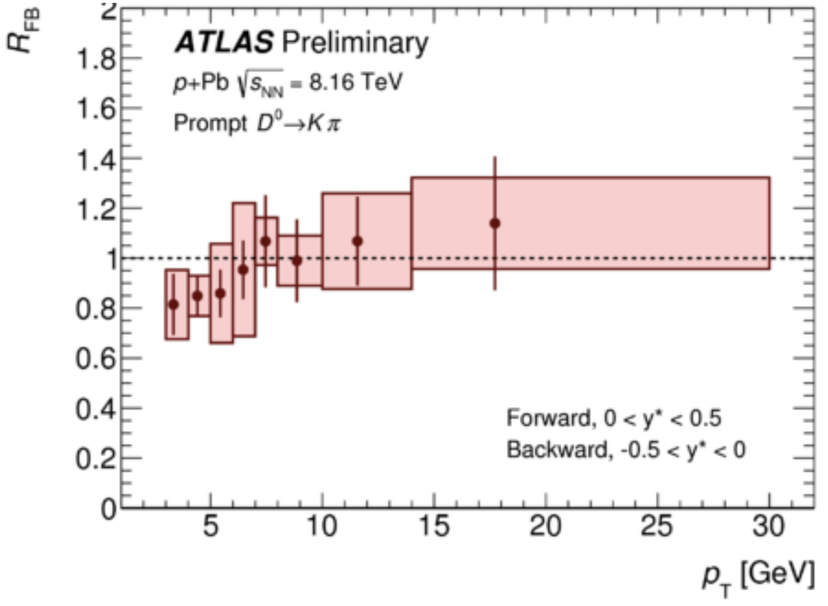
  - **At high photon E_T, in the backward rapidity R_{pPb} is significantly below unity which is due to a change in up/down quark mixture wrt pp system**
  - With the current uncertainties, the data can not distinguish between free PDF and nPDF
  - **Data are unable to discern a substantial energy loss in the initial state**

HEAVY FLAVOUR: D MESONS

ATLAS-CONF-2017-073

- First ATLAS measurement of D meson production
  - Prompt D^0 and D^* production in p+Pb at 8.16 TeV
    - $D^0 \rightarrow K\pi$: $3 < p_T < 30$ GeV
    - $D^* \rightarrow K\pi\pi$: $5 < p_T < 30$ GeV
    - Rapidity: $-1.5 < y^* < 0.5$
  - Cross-sections in p_T and y^* compared to FONLL predictions with scale and PDF uncertainties in good agreement with the data
  - **Forward-backward R_{FB} ratios show no significant deviation from unity**

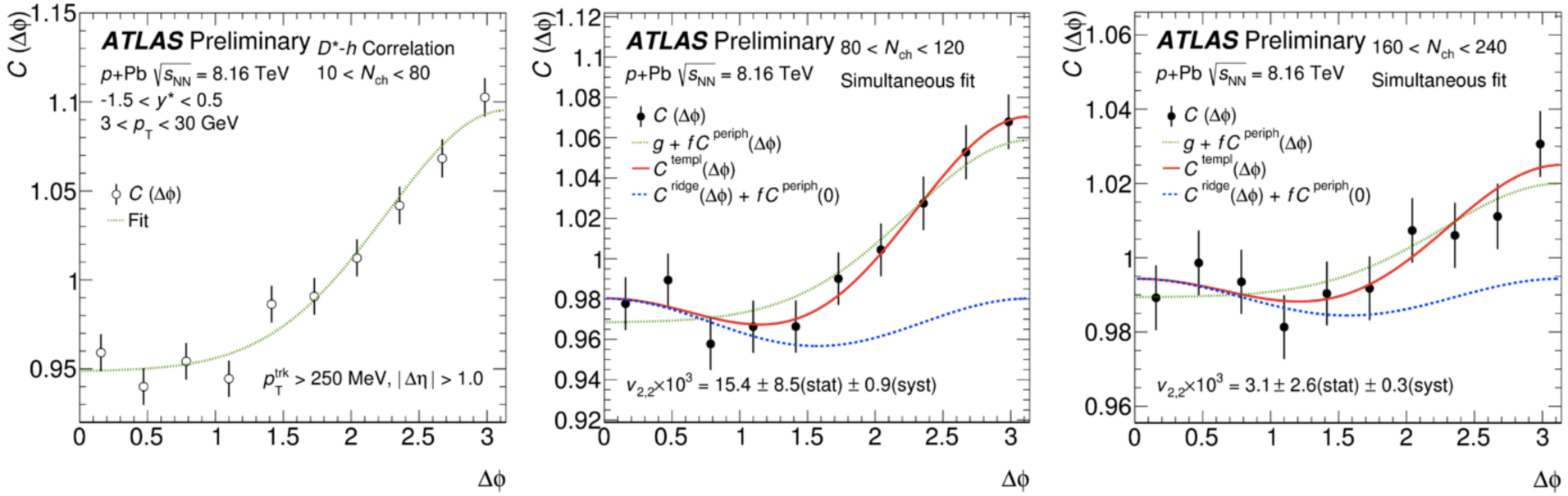




Talk by Q.Hu on Wed 15:00

D–HADRON CORRELATIONS

ATLAS-CONF-2017-073

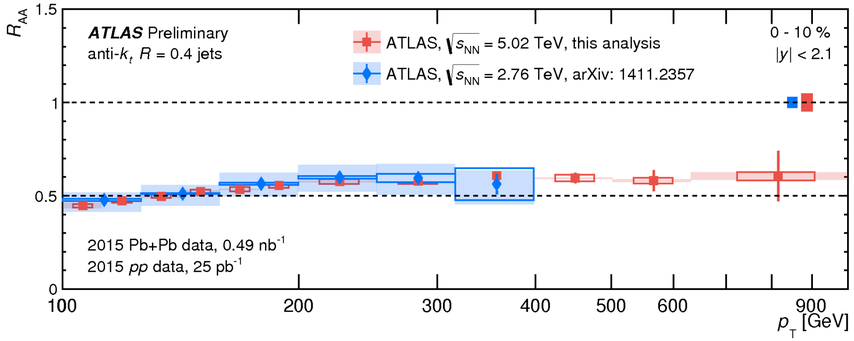


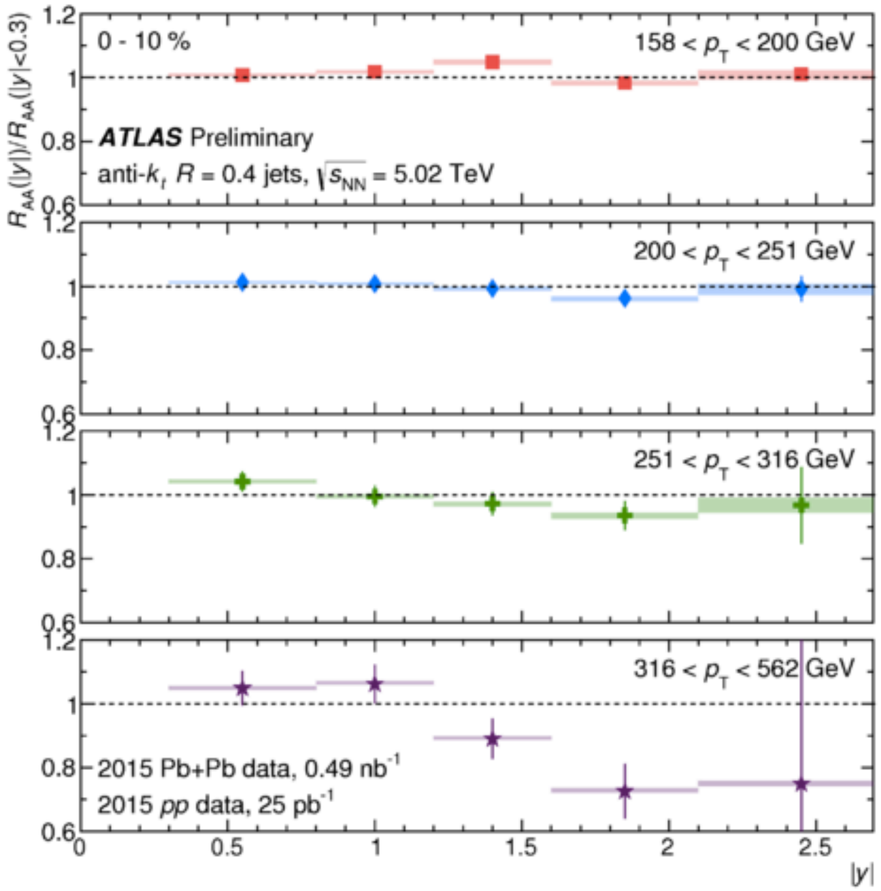
- 2PC correlations for D*-h
- Coefficients of cos(2Δφ) modulation in the inclusive $D^{*\pm}$ mesons and charged particles azimuthal angle correlation are measured with the template fits
- $D^{*\pm}$–hadron correlation is broadly consistent with what one would expect from the observed muon–hadron correlations

INCLUSIVE JETS: QUENCHING IN THE QGP

ATLAS-CONF-2017-09

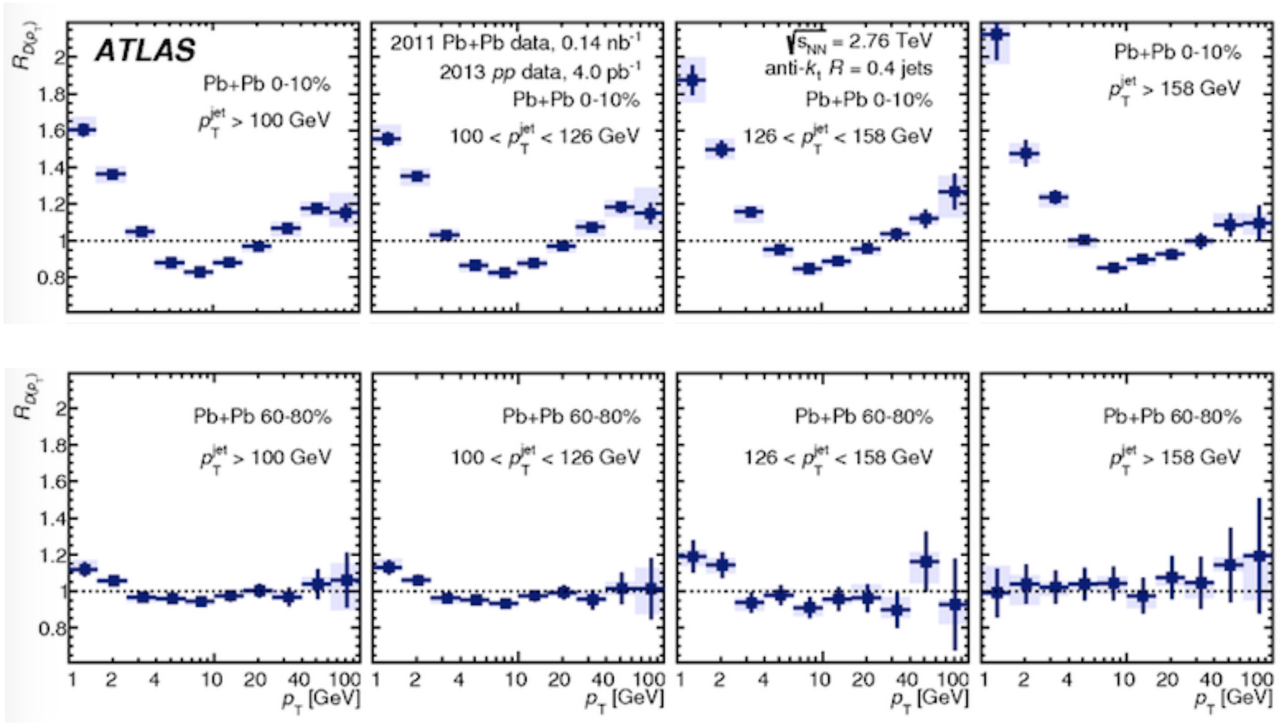
- Substantial advance with the increased Run-2 statistics:
  - More **precise** measurements with better control over the underlying event subtraction and **unfolded** so they can be directly compared to theory
  - **Reduction** of **systematic uncertainties**
  - Addressing questions such as what is the flavour dependence of jet quenching, do jets stop being affected by the plasma if they are high enough energy, what happens in boson+jet systems, etc.
- R_{AA} vs jet p_T
  - Access to jets at TeV scale in Pb+Pb at 5TeV
  - **R_{AA} is still about 0.5 in 0-10% centrality**
  - **R_{AA} rises with jet p_T until ~300 GeV where it begins to flatten**
  - R_{AA} is independent of $\sqrt{s_{NN}}$ when comparing 2.76 and 5.02 TeV results
- Ratio of R_{AA} vs rapidity
  - Large cancelation of systematics in the ratio
  - **R_{AA} is flat with rapidity below 316 GeV**
  - **R_{AA} decreases with rapidity at higher p_T**
    - Change in the spectra steepness and in the flavour composition

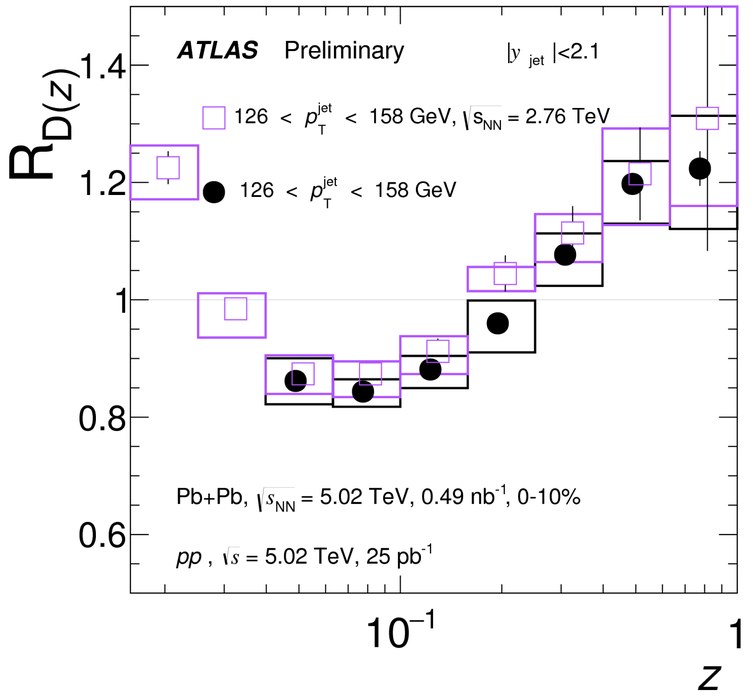




JET FF: MODIFICATIONS IN THE QGP

EPJC (2017) 77: 379
ATLAS-CONF-2017-005





- Measure $R_{D(pT)}$ and $R_{D(z)}$ in the Pb+Pb system wrt pp at 2.76 TeV
  - As a function of jet p_T and centrality
  - **In central collisions (0-10%): enhancement at low p_T, suppression at intermediate p_T, enhancement at high p_T in all jet p_T bins**
  - **In peripheral collisions (60-80%): the magnitude of these modifications decreases**
  - No jet p_T dependence
  - **No CM energy dependence: jet FF comparable between 2.76 and 5.02 TeV**

JET FRAGMENTATION FUNCTIONS IN P+PB

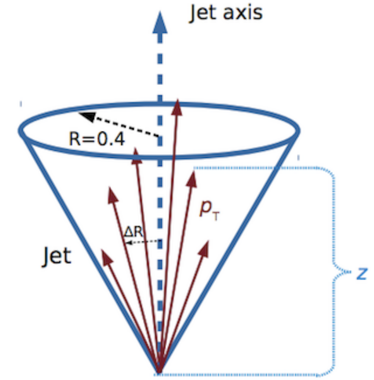
arXiv:1706.02859

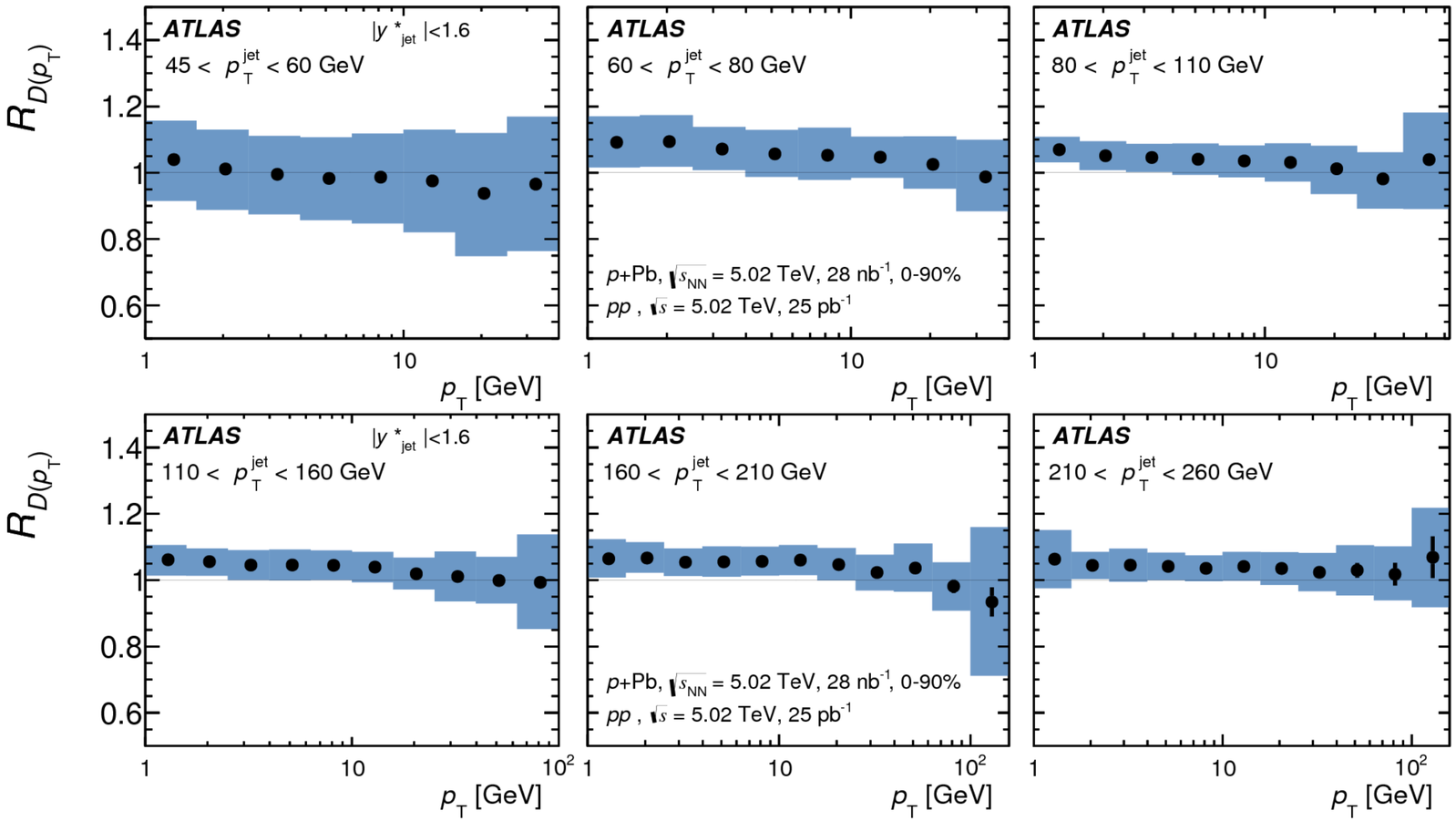
- Fragmentation functions (FF) are a measure how particles are distributed in the jet
  - R=0.4 jets with charged tracks starting at 1 GeV for Pb+Pb and p+Pb
  - N_{ch} is the particle multiplicity associated with a jet
  - Jet FF are background subtracted, corrected for tracking efficiency, and **fully unfolded** in 2D jet p_T and z

$$D(z) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dz}$$

$$z = \frac{p_T \cos \Delta R}{p_T^{jet}}$$

$$D(p_T) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dp_T}$$





- $R_{D(pT)}$ is a ratio of jet FF in p+Pb and pp systems at 5.02 TeV presented in bins of jet p_T
  - **No modification of jet structure within experimental precision in the p+Pb system**
  - Result consistent with unmodified hadron R_{pPb} measured with the 5.02 TeV pp reference data [ATLAS-CONF-2016-108]

Talk by M.Rybar on Wed 12:30

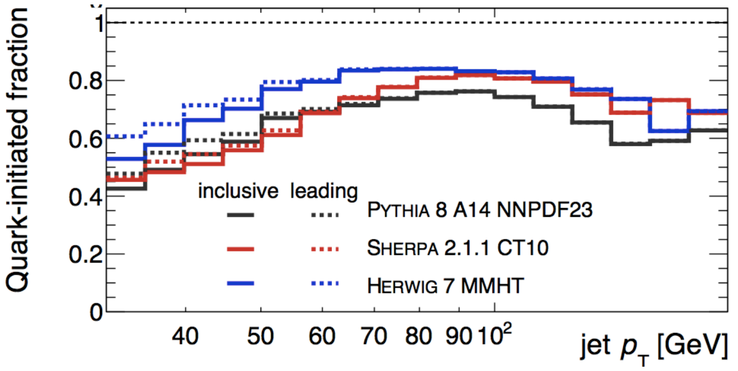
Poster A.Puri

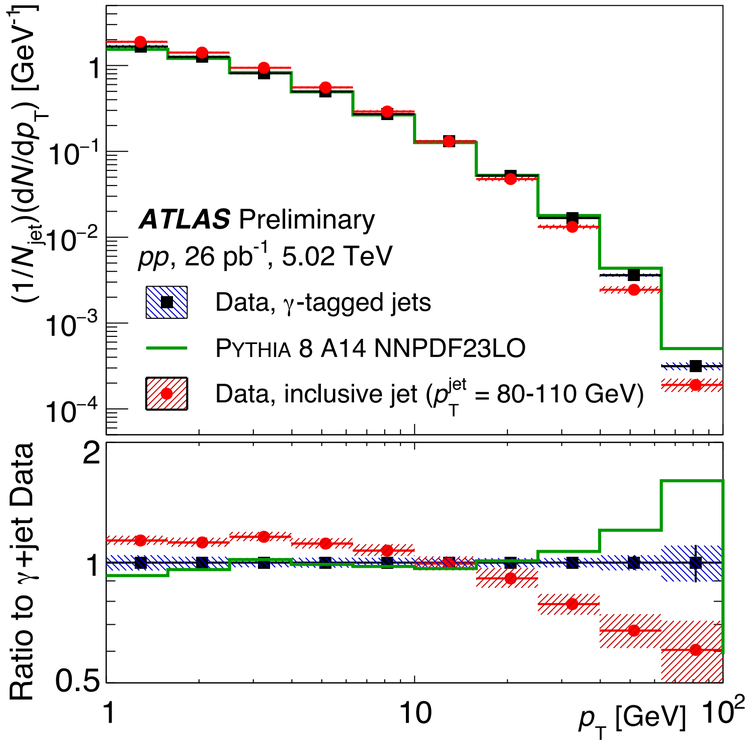
PHOTON-TAGGED JET FF: FLAVOUR DEPENDENCE

- Investigate flavour dependence in jet FF
  - Photon-tagged jets are more likely to be initiated by quarks
  - Measurement done systematically in pp and Pb+Pb systems
    - Kinematic requirements:
      - photon E_T: 79.6-126 GeV
      - jet p_T: 63.1-144 GeV
      - Difference in azimuthal angle between jet and photon $>7\pi/8$

- Differences between photon-tagged and inclusive jet FF seen already in pp
  - Different flavour composition in photon-tagged vs inclusive jet FF
  - **FF is systematically harder for photon-tagged jets**
  - PYTHIA8 reproduces data well for low and intermediate p_T values, while for higher p_T overpredicts the data

ATLAS-CONF-2017-074

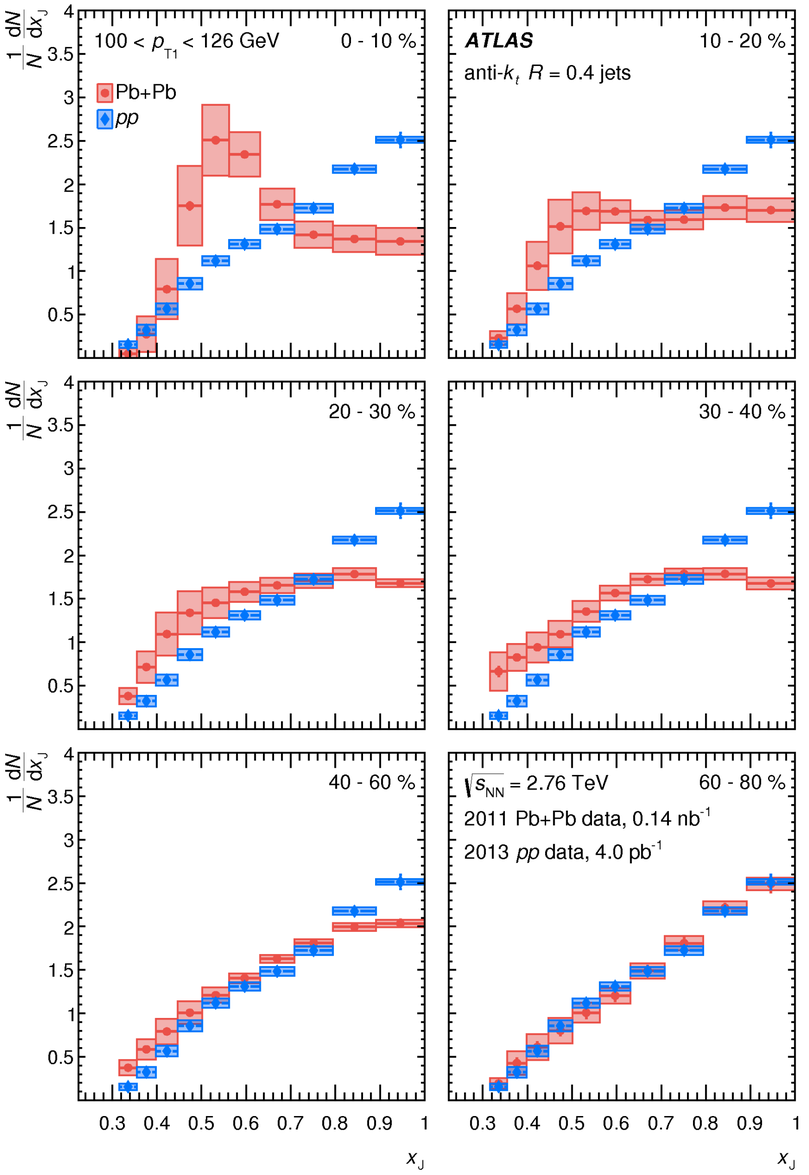




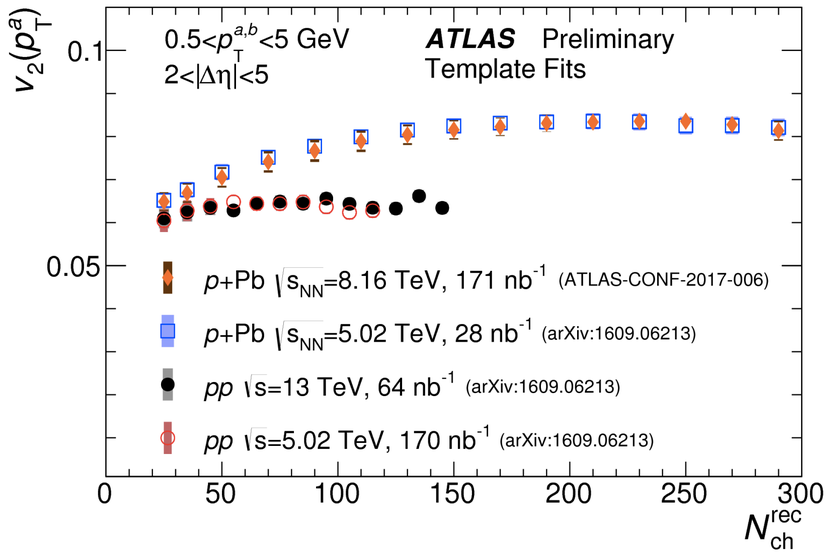
DIJET ASYMMETRY

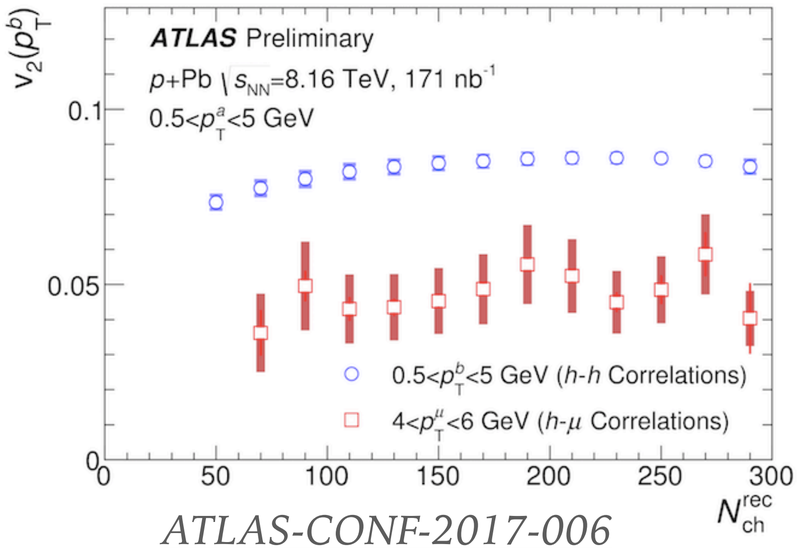
arXiv:1706.09363

- First attempts to measure jet quenching were through the dijet asymmetry
  - Dijets are the most probable configuration for jets in pp (and Pb+Pb) collisions
  - Sensitive to energy loss differences due to anti-correlation in path length and jet-by-jet fluctuations
- Use **dijet momentum fraction** - ratio of the sub-leading (2) jet p_T to the leading (1) jet p_T: $\mathbf{x_J = p_{T2}/p_{T1}}$
  - x_J has been unfolded
  - **In pp: most probable configuration is $x_J \sim 1$**
  - **In Pb+Pb: more asymmetric in more central collisions**
    - In 0-10%: $x_J \sim 0.5$
    - As Pb+Pb becomes more peripheral the distribution is like pp
  - Consistent results between R=0.4 and 0.3 jets
- Final result submitted for publication



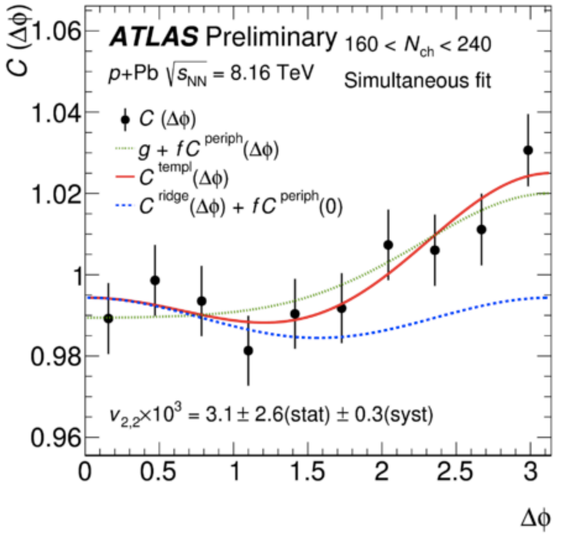
RIDGE IN SMALL SYSTEMS: EVIDENCE FOR COLLECTIVITY?





ATLAS-CONF-2017-006

- One of hallmarks for collective behaviour in Pb+Pb collision are two-particle correlations (2PC) in Δη–Δφ so-called "ridge"
- Surprisingly same behaviour found in pp (2010) and p+Pb (2012) collisions
  - Open questions: Can the pp ridge be attributed to collective flow effects? Can the bulk of the matter created in high-multiplicity collisions be described in terms of hydrodynamics? How can thermalisation happen in such small systems?
- What have we learnt about the ridge so far?
  - Large contribution from non-flow background in small systems —> Dedicated techniques developed to evaluate and subtract it (e.g. ATLAS template-fit method)
  - **Ridge is a feature of all N_{ch} values: v_2 flat with N_{ch} in pp, while grows and then saturates in p+Pb**
  - **Has no CM energy dependence**
  - **Ridge is observed to persist for heavy flavour, a hint of non-zero flow signal in D*–hadron correlations in p+Pb as well**



ATLAS-CONF-2017-073

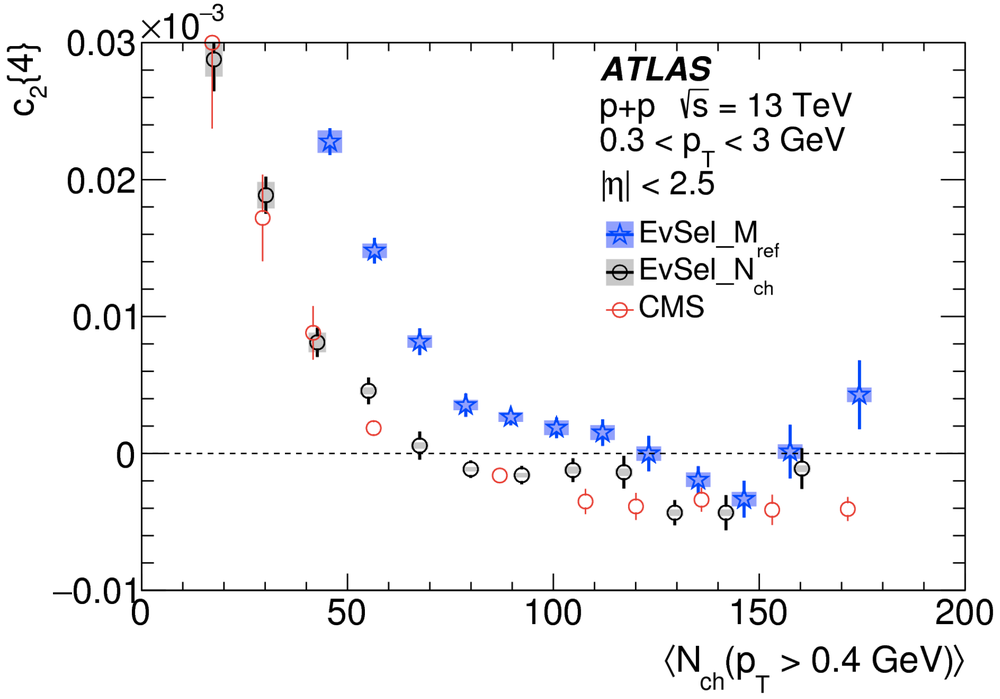
MULTI-PARTICLE CUMULANTS IN SMALL SYSTEMS

EPJC 77 (2017) 428

- Multi-particle cumulants are another tool to explore collective nature of the system
  - Using well-established Q-cumulant method
  - Expressed in terms of $c_2\{4\}$ which relates directly to elliptic flow $v_2\{4\}$

$$v_2\{4\} = \sqrt[4]{-c_2\{4\}}$$

  - Very detailed studies of pp (5.02 and 13 TeV), p+Pb (5.02 TeV) and low-multiplicity Pb+Pb (2.76 TeV) collisions



- **Non-collective sources from dijet dominate the statistical properties of two- or multi-particle correlations**
- Standard multi-particle cumulants have strong sensitivity to multiplicity class definition and multiplicity bin-width
  - **$c_2\{4\}$ values change dramatically as the event-class definition is varied**

MULTI-PARTICLE CUMULANTS IN PB+PB

ATLAS-CONF-2017-066

- Cumulants capture event-by-event flow fluctuations
  - Three-subevent cumulant method also applied to check residual non-flow
- Studies based on full 2015 Pb+Pb data set
  - Measure centrality and p_T dependence of $c_n\{4\}$, n=1,2,3,4
  - **Observation of $c_2\{4\} > 0$ in ultra-central collisions: strong indication of non-Gaussian flow fluctuations**
  - First measurement of non-zero $c_1\{4\}$ in high p_T with standard and three-subevent method: non-Gaussian nature of dipolar eccentricity fluctuation in the initial-stage geometry
  - Sign change of $c_4\{4\}$ with better precision: consistent with a nonlinear contribution to v_4 from v_2