Overview of recent ATLAS results

Dominik Derendarz on behalf of the ATLAS collaboration

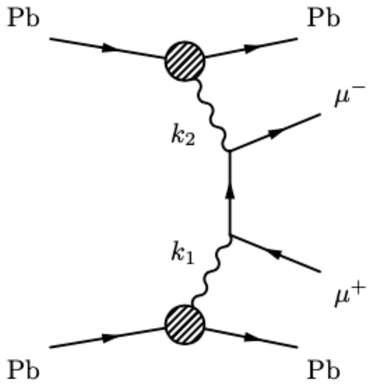
Hard Probes 2020

somewhere on the Zoom servers - 1/06/2020

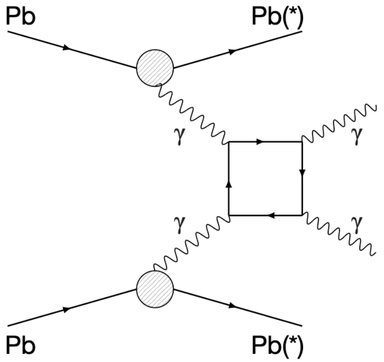
Ultra Peripheral Collisions (UPC)

- ➡ better understanding of QED
- ➡ better understanding of backgrounds in the peripheral heavy ion collisions
- ➡ sensitive to new physics

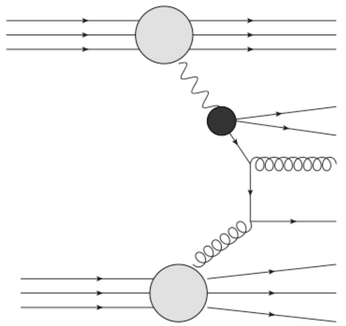
Di-lepton production



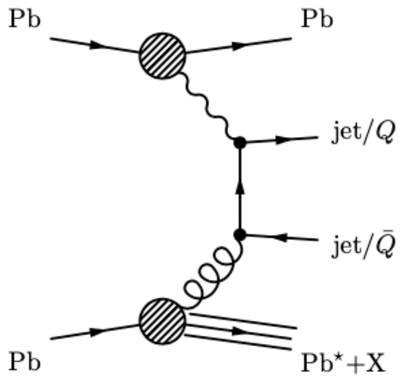
Light-by-light scattering



Photonuclear vector meson production



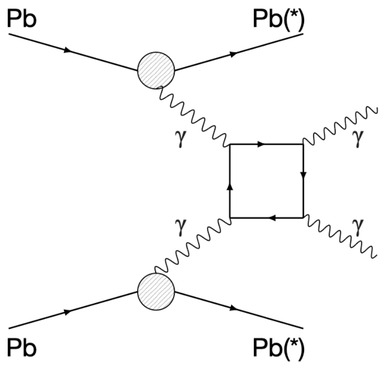
Photonuclear di-jets production



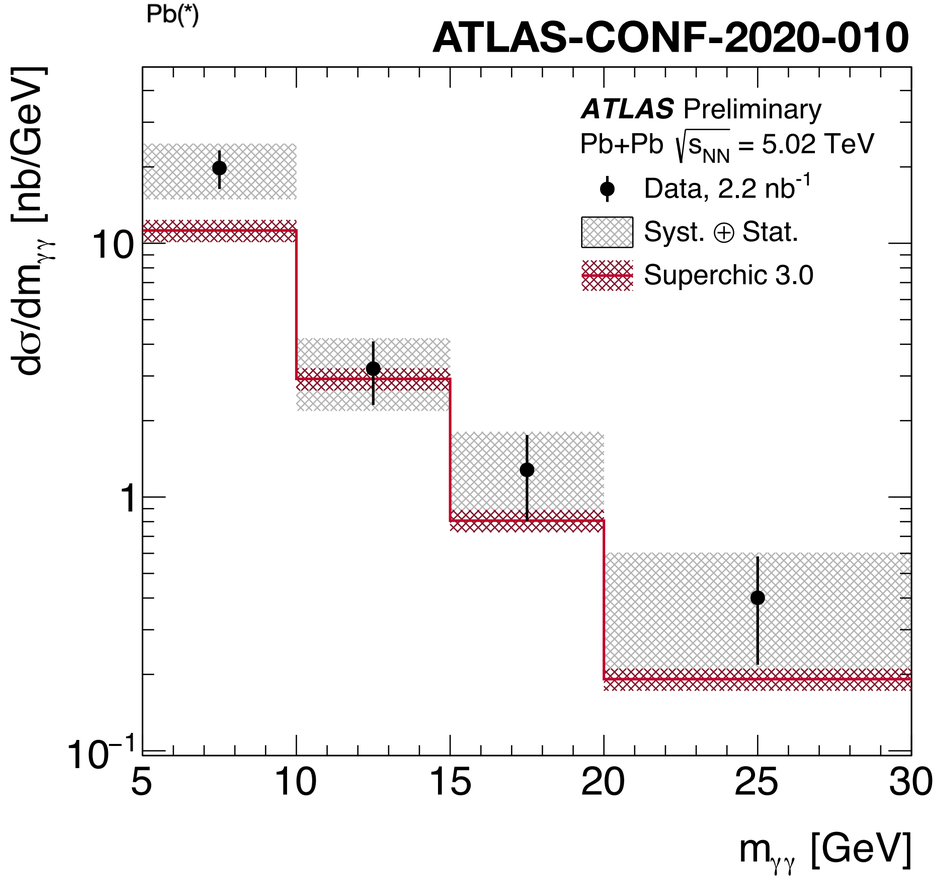
Light-by-Light scattering

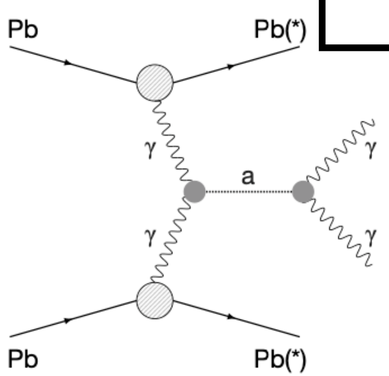
Iwona Grabowska Bold
Monday 11:00
(A2 - Electroweak Probes I)

Poster by Klaudia Burka

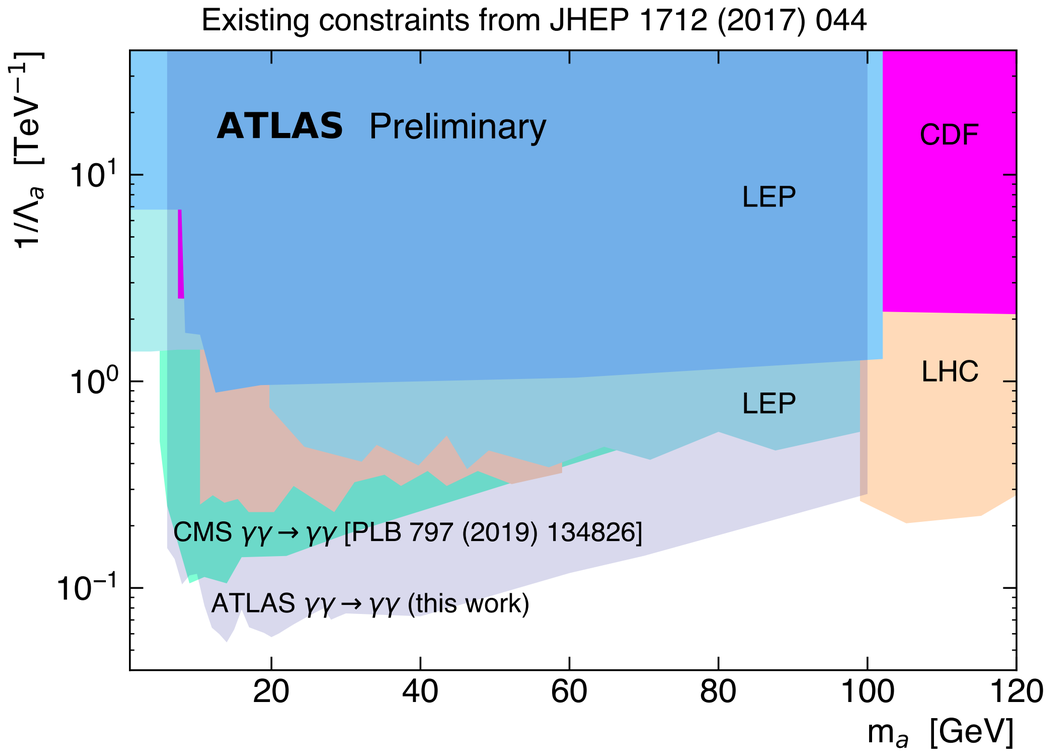


Full 5.02 TeV Pb+Pb dataset has been used to measure differential cross sections for $\gamma\gamma \to \gamma\gamma$





World best limit for axion like particles



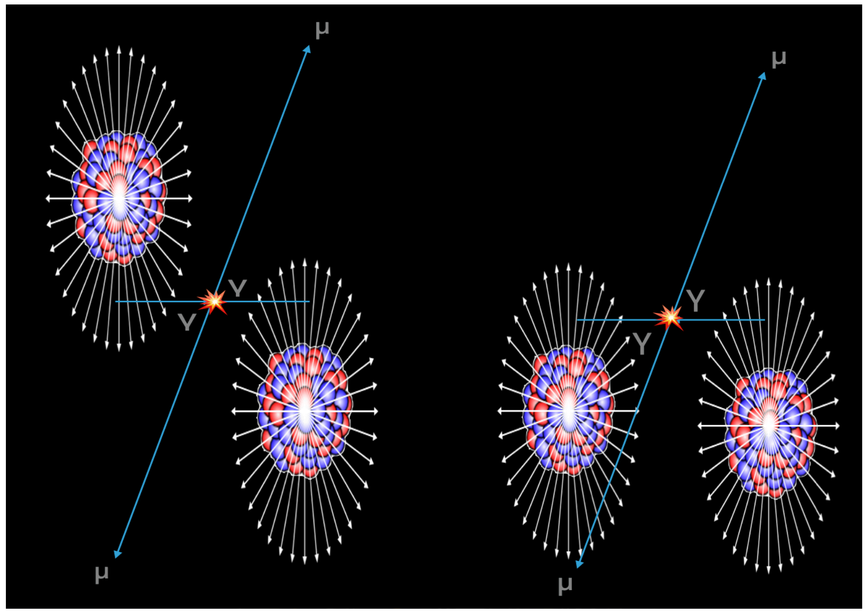
Non UPC di-muons

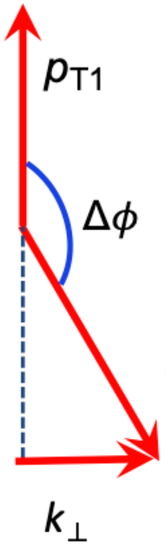
Soumya Mohapatra
Wednesday 10:30
(E2 - Electroweak Probes III)

Poster by Benjamin Gilbert

UPC di-muons may probe EM degrees of freedom of QGP if they are produced on top of the heavy ion collisions

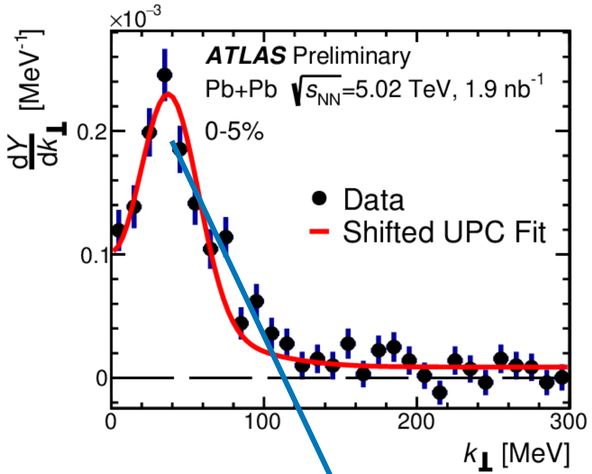
UPC non-UPC

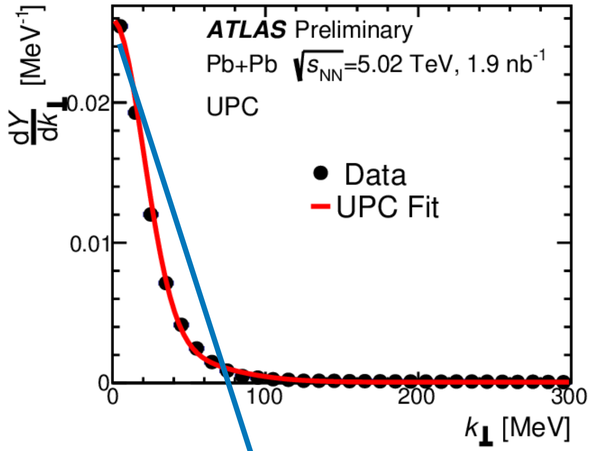


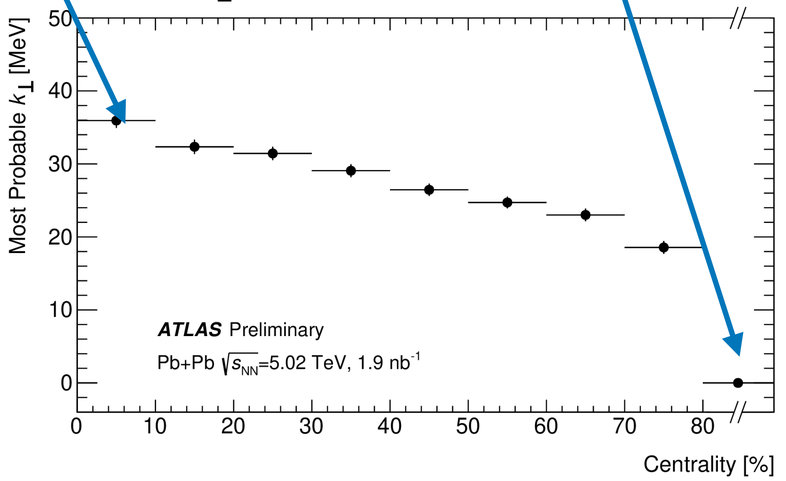


$$k_\perp = \frac{p_T^+ + p_T^-}{2}(\pi - |\phi^+ - \phi^-|)$$

ATLAS-CONF-2019-051





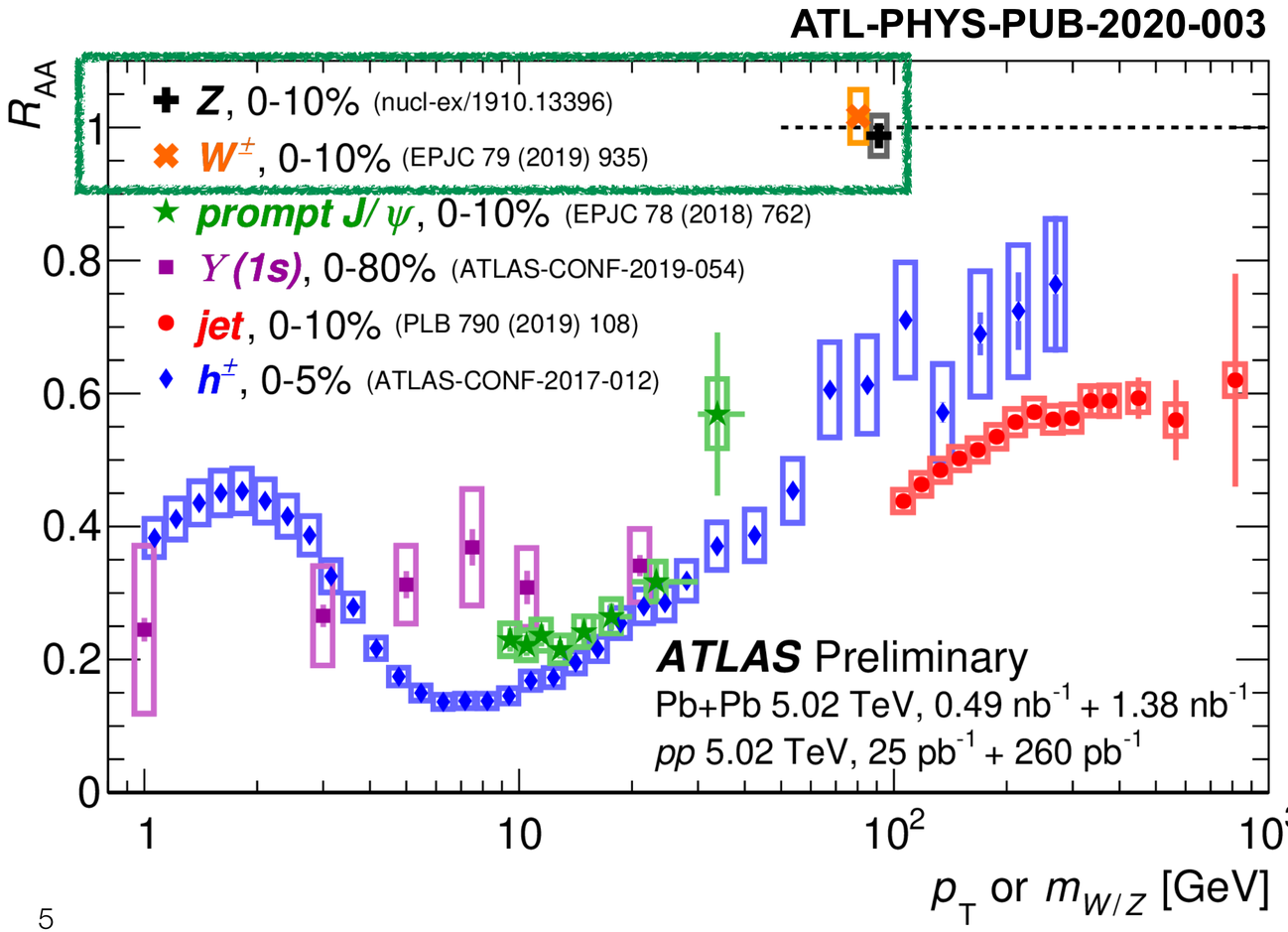


Centrality dependent, shift of the distribution going from UPC to peripheral to central events

Colorless probes - electroweak bosons (W/Z) in Pb+Pb

➡ how can we handle geometry of the collisions?

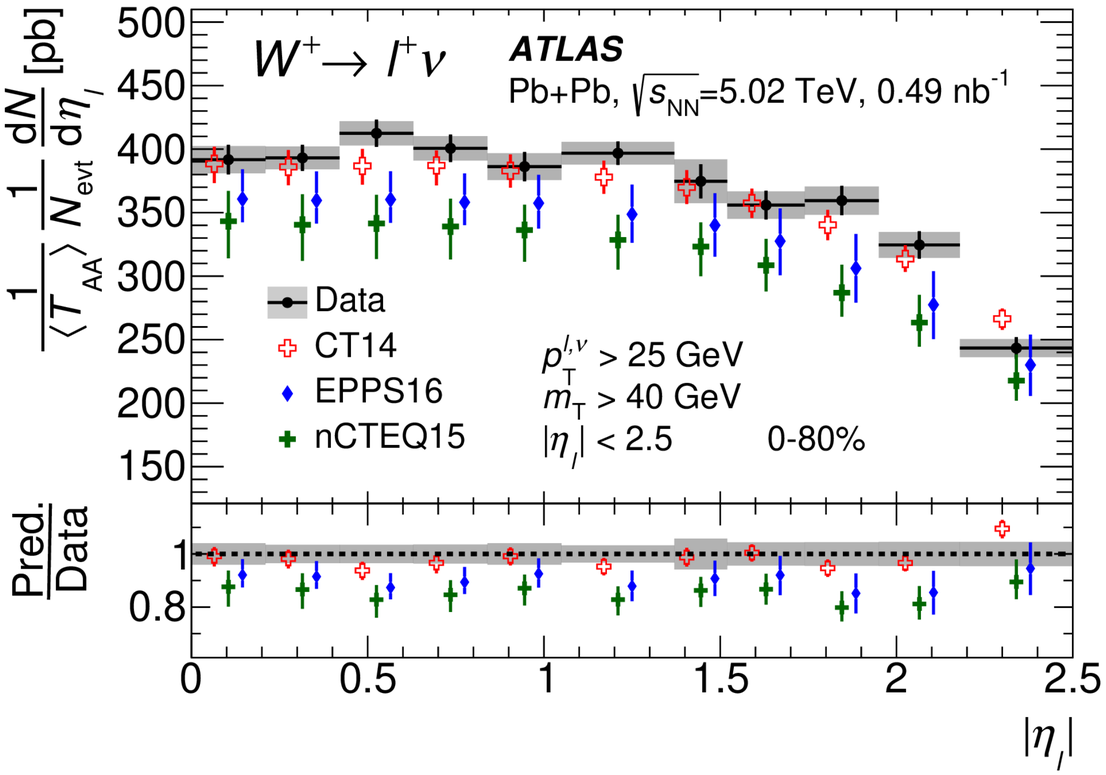
➡ what is the structure of the nucleon?



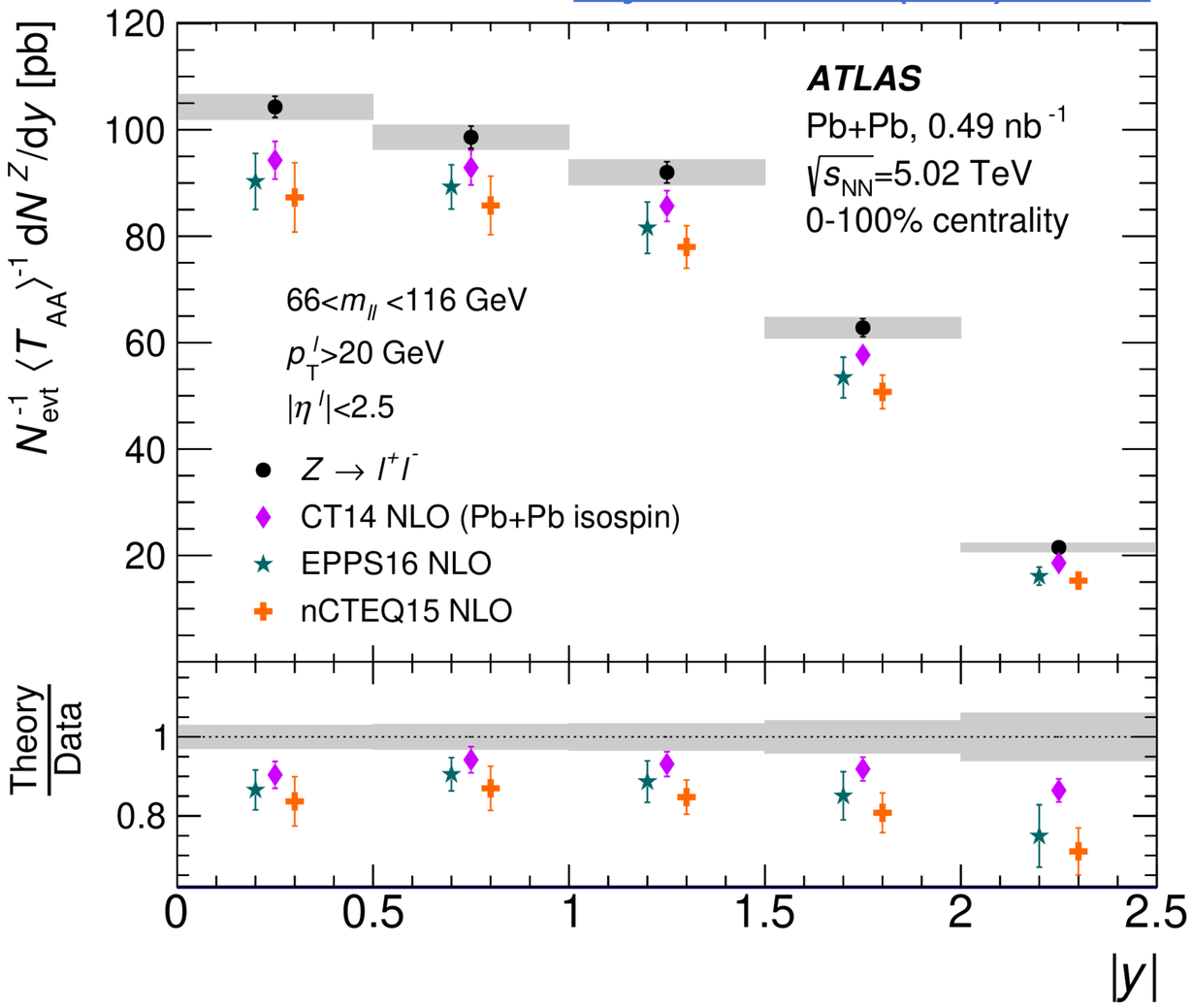
Electroweak bosons (W/Z) in Pb+Pb

Best agreement seen with free proton PDF including the isospin effect (CT14)

Eur. Phys. J. C 79 (2019) 935



Phys. Lett. B 802 (2020) 135262



Iwona Grabowska Bold
Monday 11:00
(A2 - Electroweak Probes I)

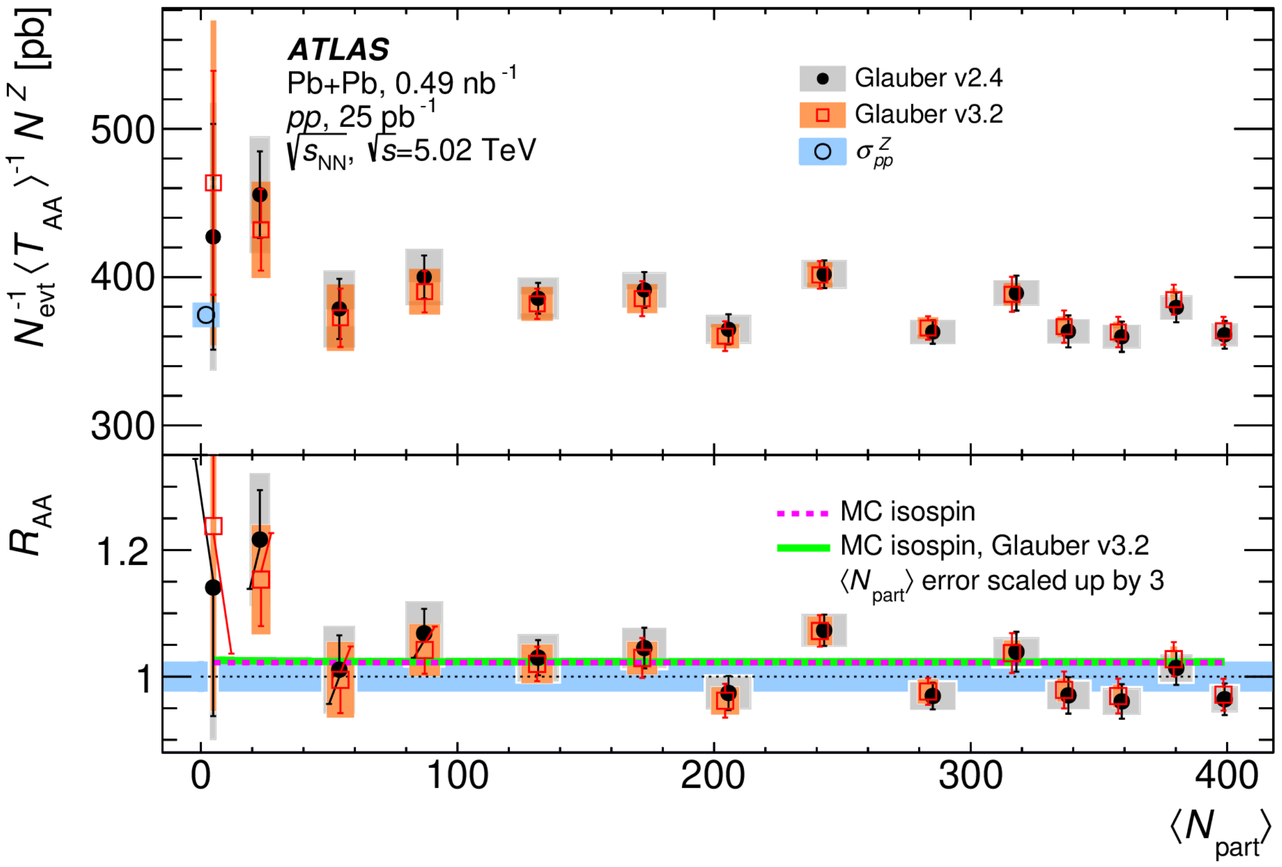
Electroweak bosons (W/Z) in Pb+Pb

Iwona Grabowska Bold
Monday 11:00
(A2 - Electroweak Probes I)

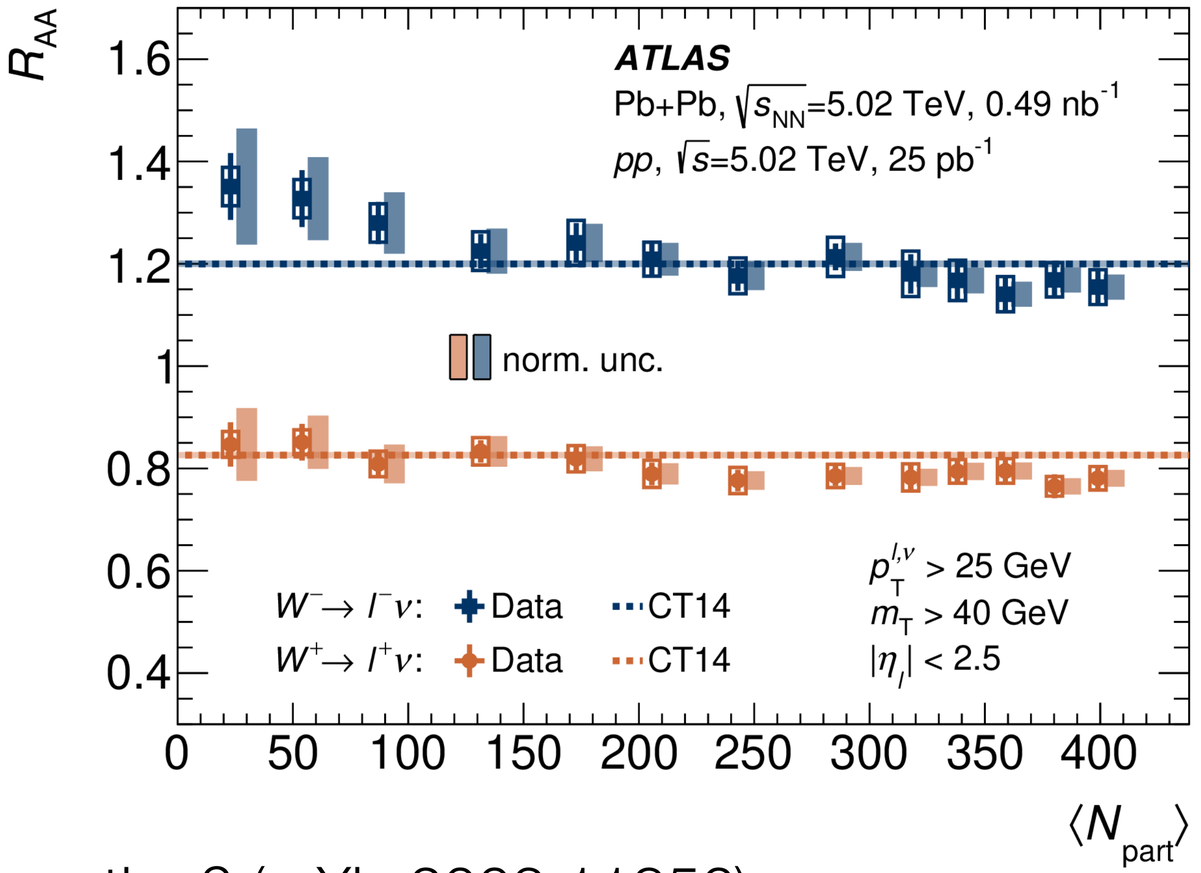
R_{AA} in centrality overall constant for *W* and *Z,* but ….

…. indication of excess in peripheral collisions

Phys. Lett. B 802 (2020) 135262



Eur. Phys. J. C 79 (2019) 935



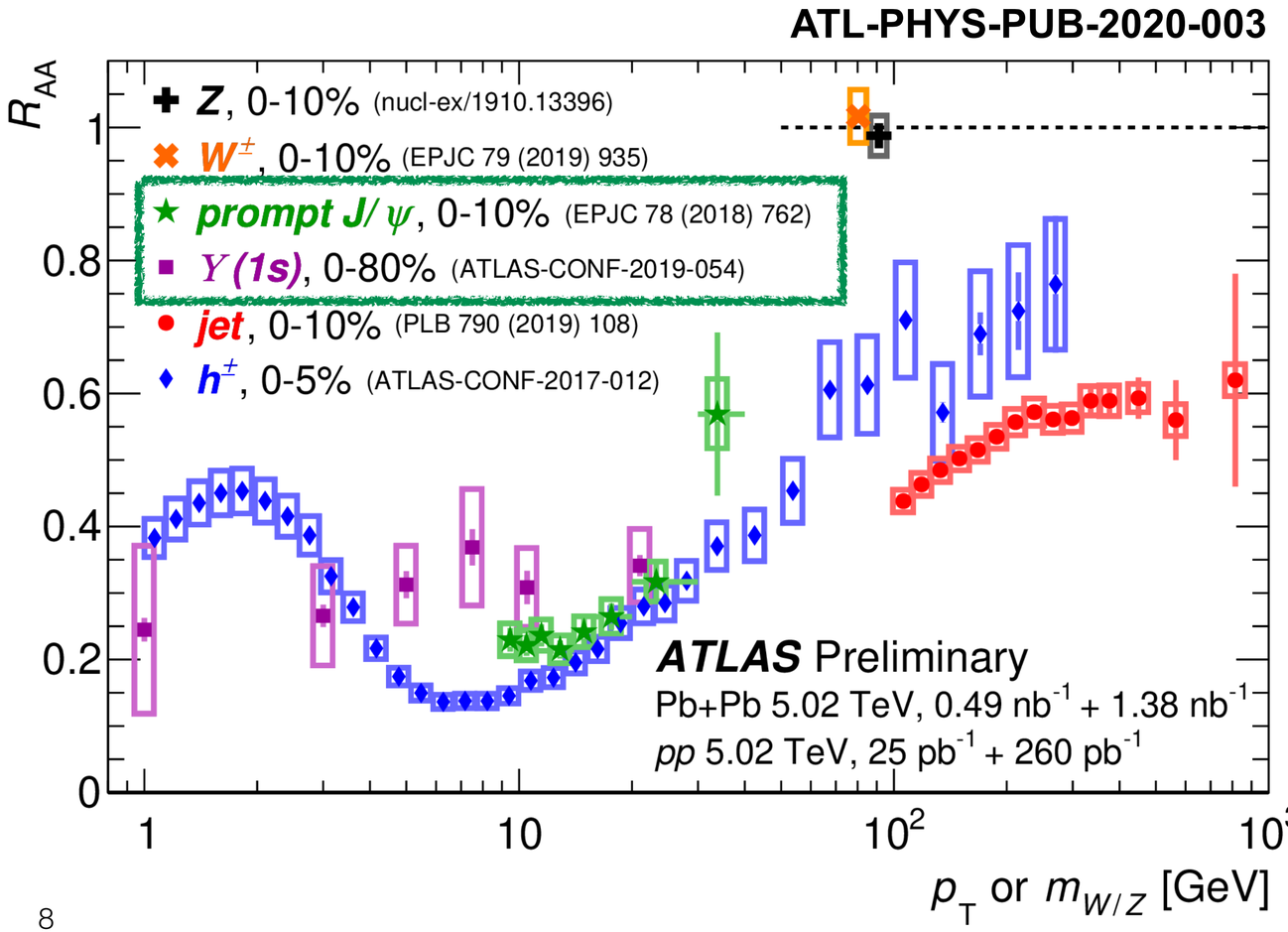
Shadowing in inelastic nucleon-nucleon cross section? (arXiv:2003.11856)

➡ analysis with those data suggest suppression of σ_{pp}^{inel}

Colored probes - heavy flavour

➡ how is QGP affecting quarkonia states formation?

➡ how is open heavy flavour interacting with the medium?

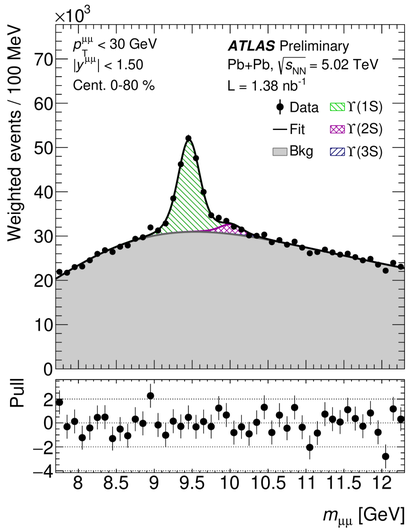


Suppression of ϒ(nS) states in Pb+Pb

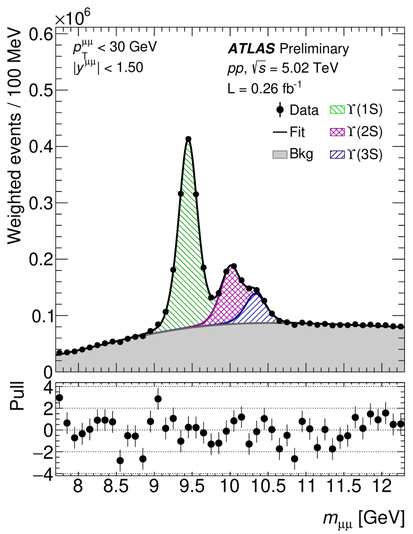
Songkyo Lee
Monday 13:15
(B2 - Heavy Flavor II)

Poster by Martin Krivos

Pb+Pb



p+p



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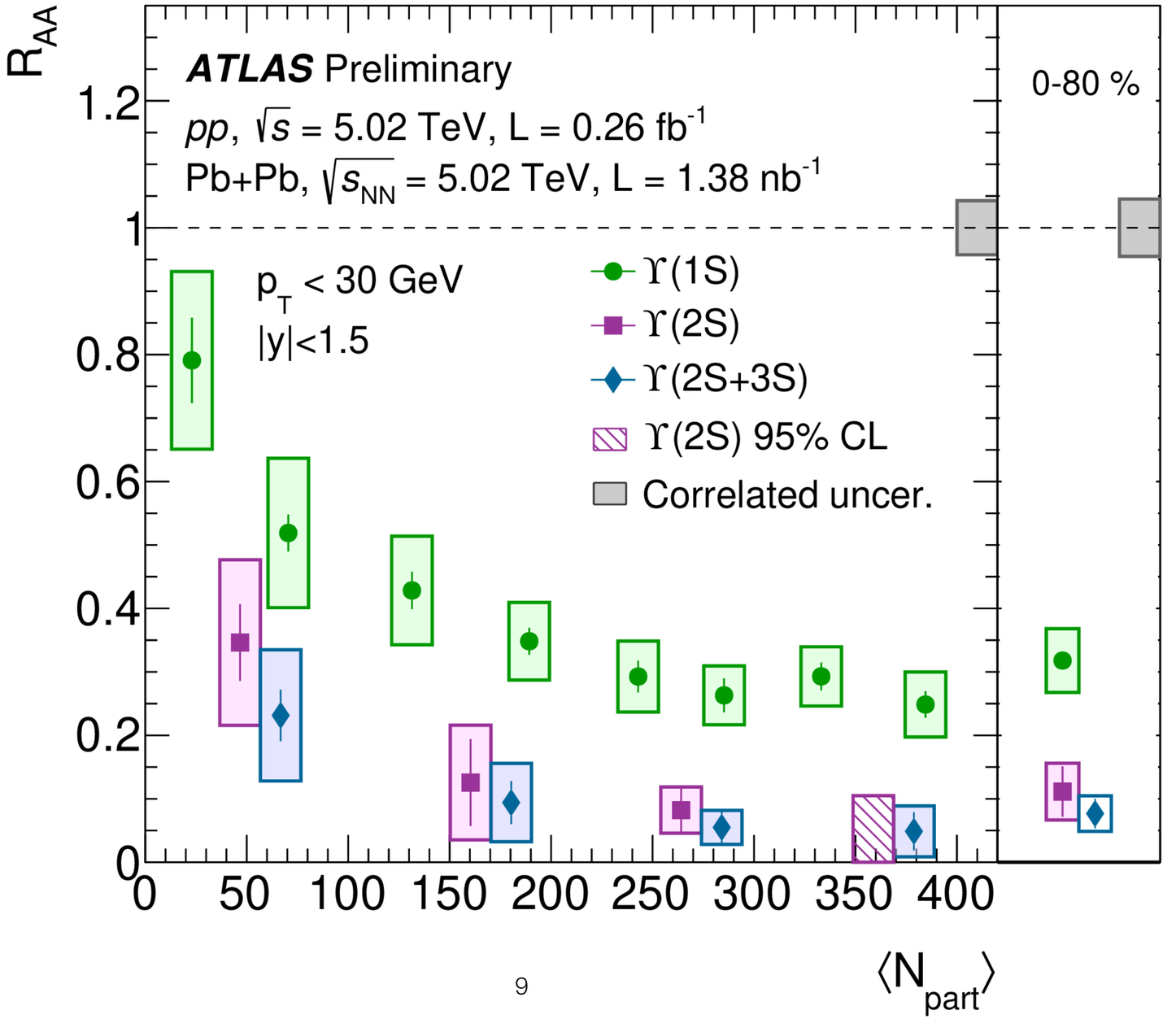


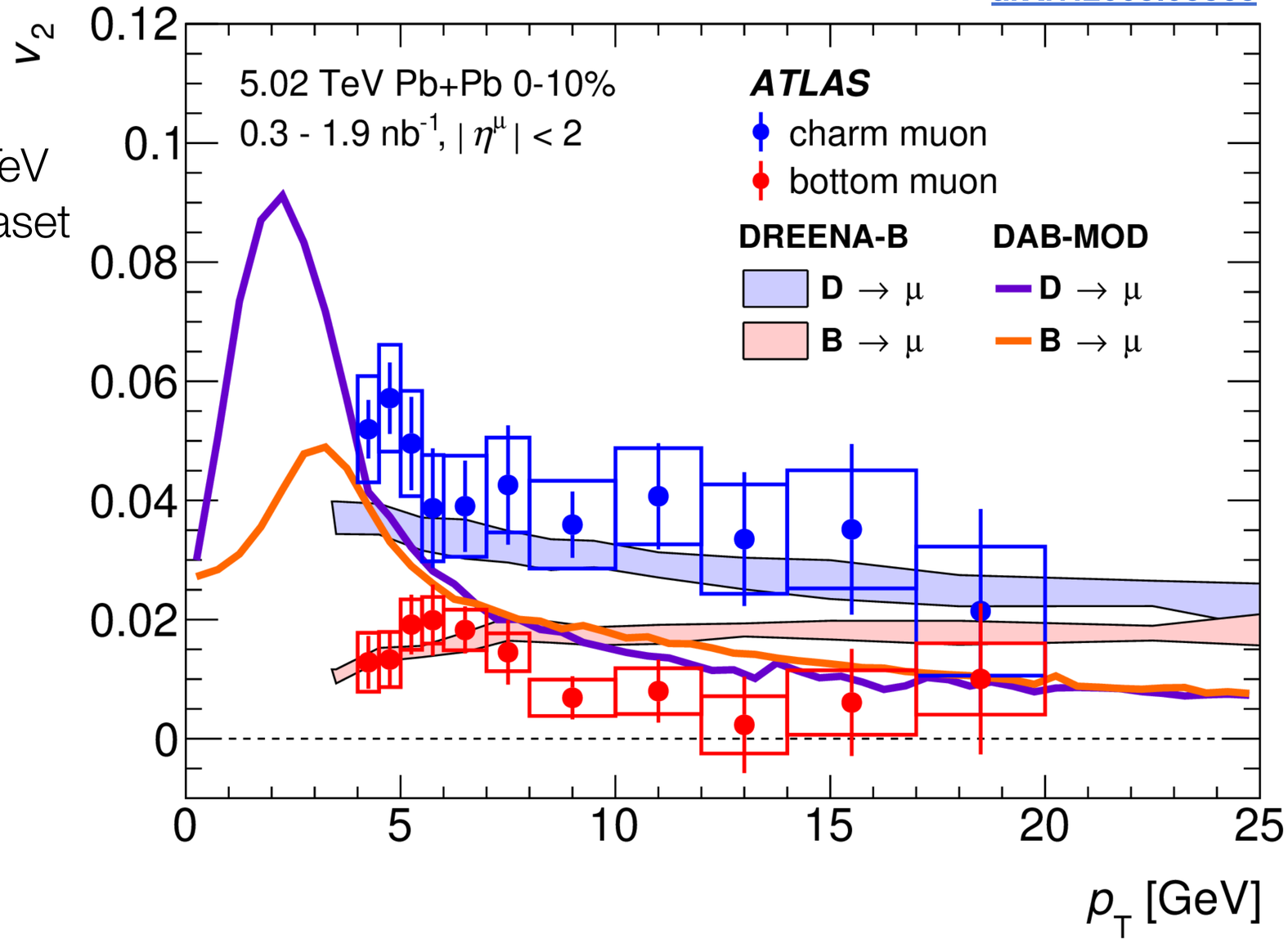
Clear signal of sequential melting of ϒ states

Heavy flavour flow in Pb+Pb

Qipeng Hu
Thursday 10:30
(G3 - Heavy Flavor IX)

Full 5.02 TeV Pb+Pb dataset

arXiv:2003.03565

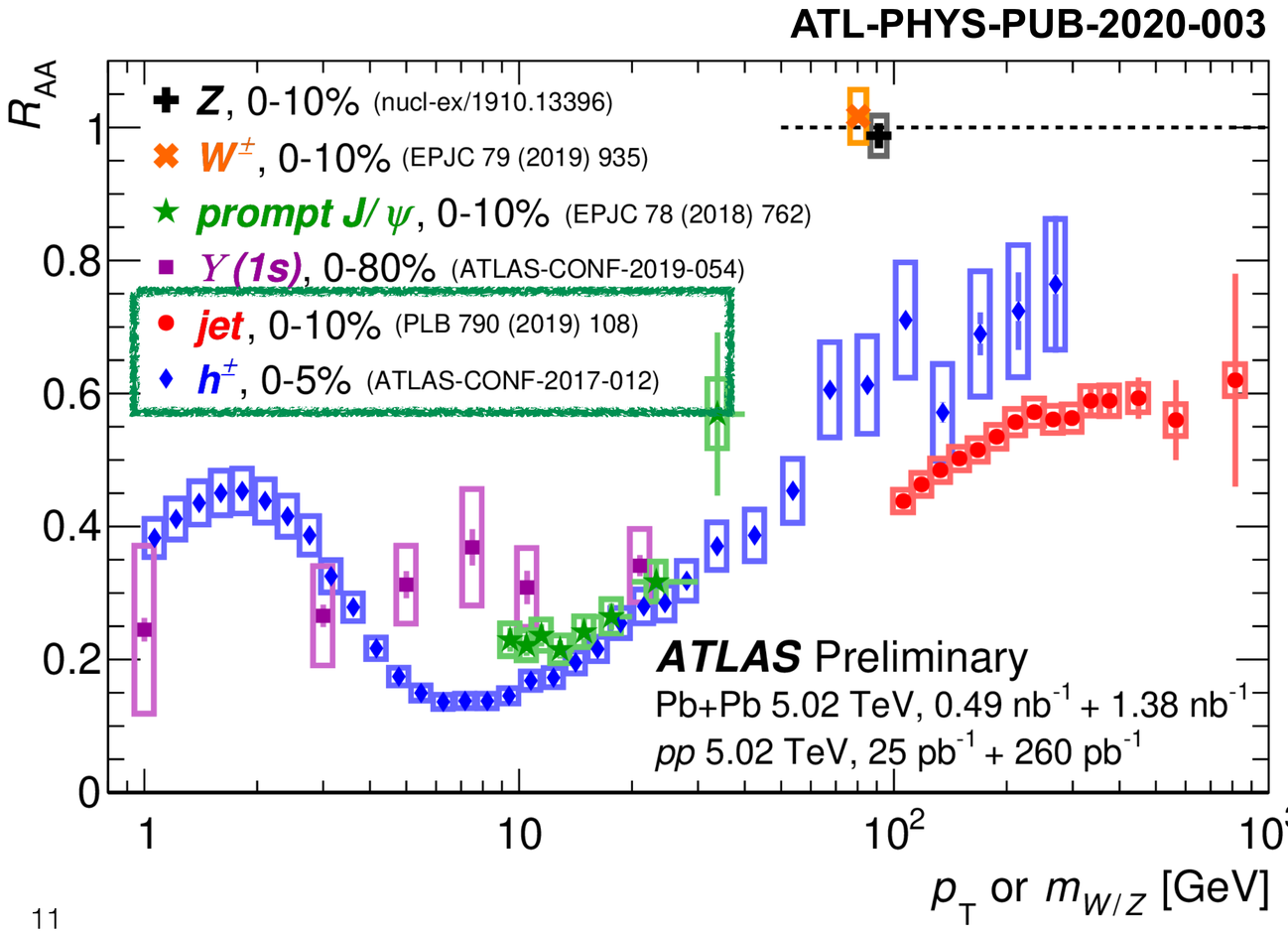


Non-zero v_2 of muons from **charm** and **beauty** decays

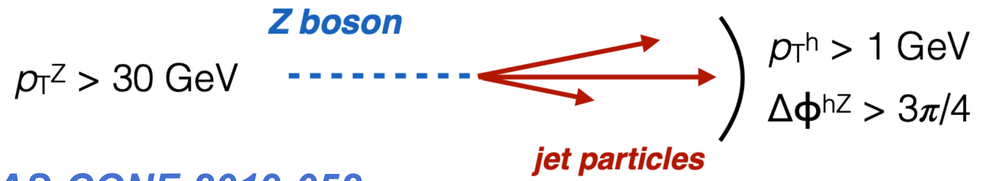
Model with energy loss (DREENA-B) better describe the data

Colored probes - jets

- ➡ precise measurement of jet quenching
- ➡ how does the jet suppression depend on jet structure?

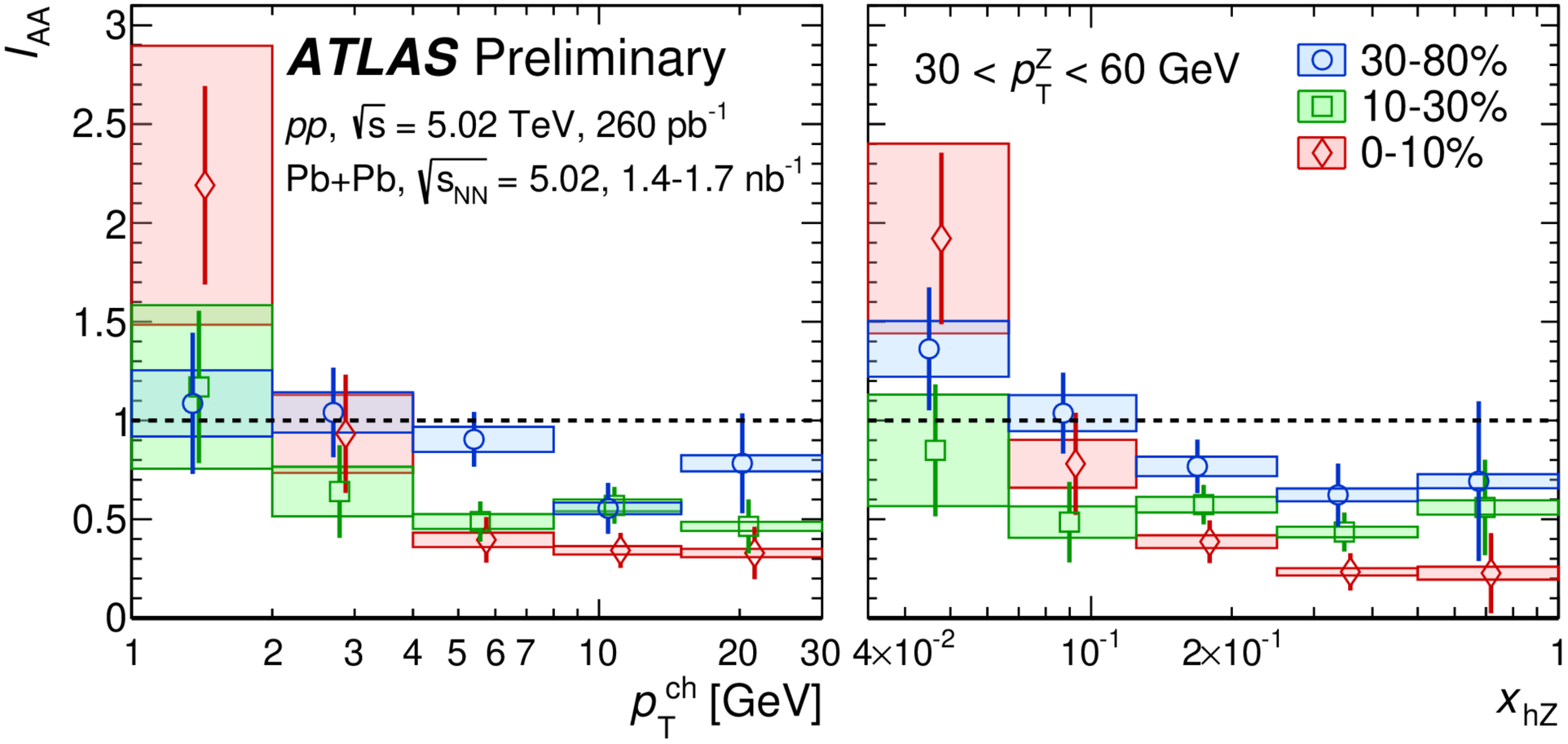


Fresh look a the fragmentation



I_{AA} = PbPb/pp of per-Z yields

ATLAS-CONF-2019-052



Jeff Ouellette
Thursday 13:30
(H1 - Jets and High-PT Hadrons XI)

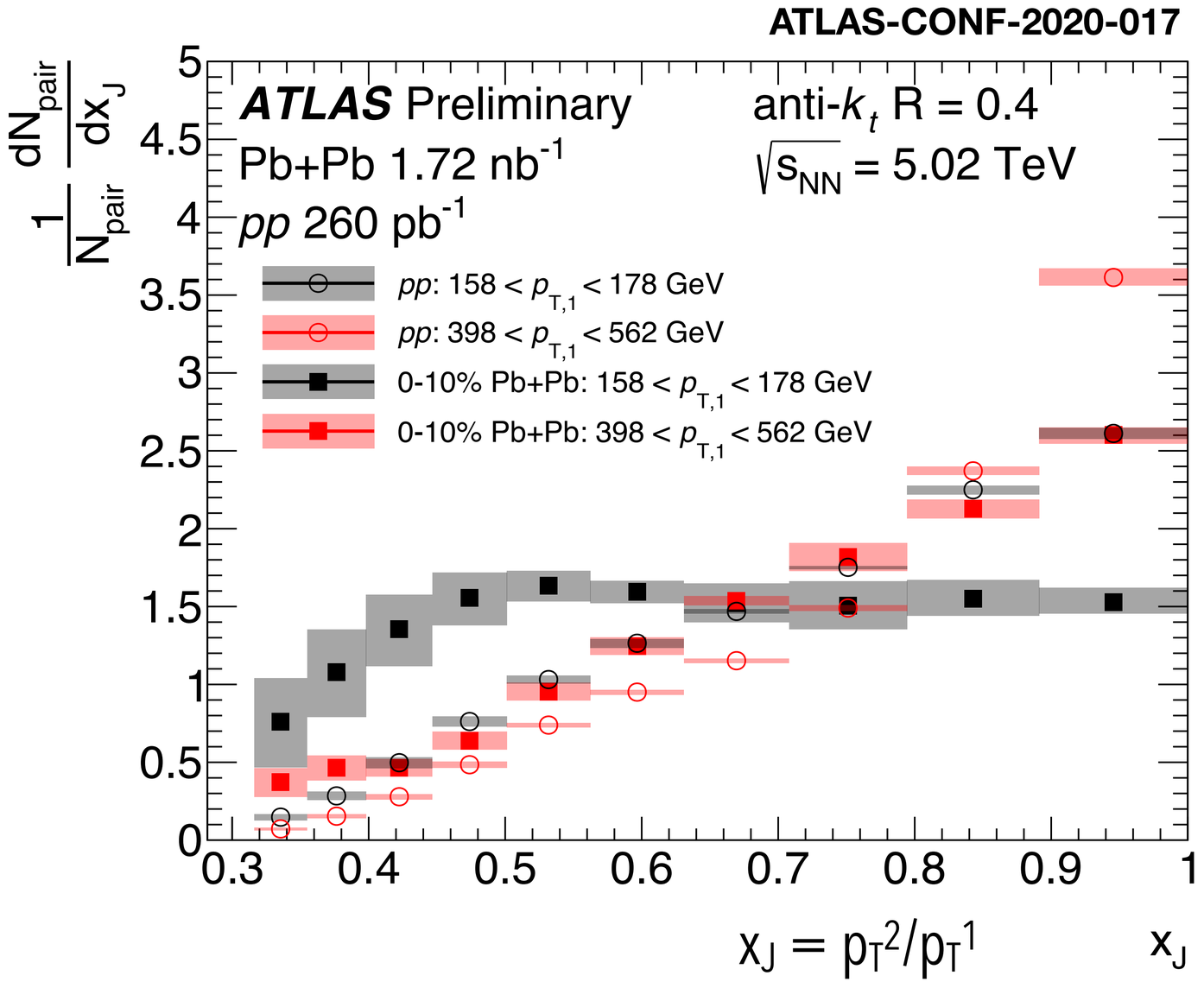
($x_{hZ} = p_T^h / p_T^Z$)

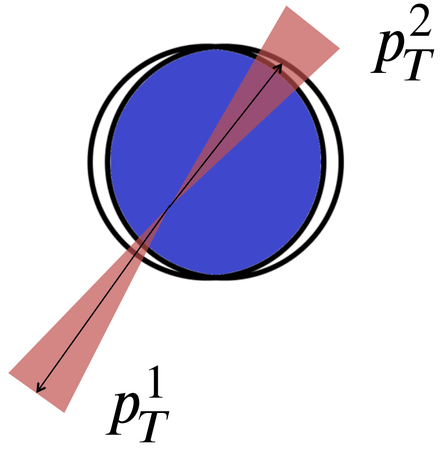
Complementary information to jet fragmentation measurements - no explicit jet requirement

Di-jet asymmetry - reaching new precision

Virginia Bailey
Monday 11:00
(A1 - Jets and High-PT Hadrons I)

Poster by Timothy Rinn

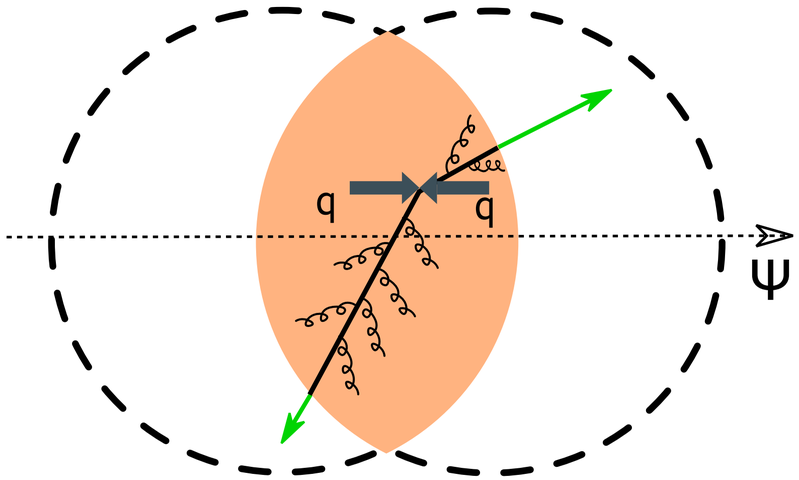


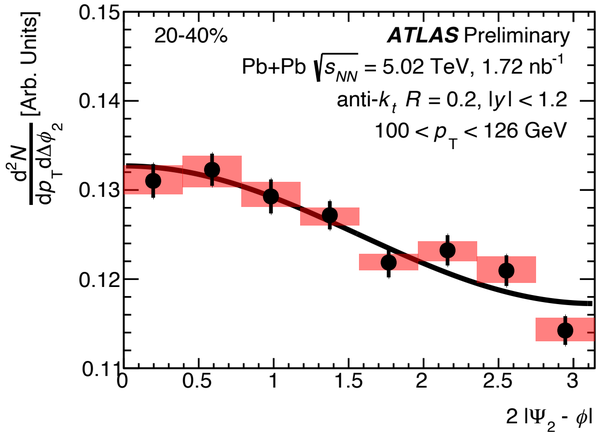


Significant modification of the momentum balance in central Pb+Pb with respect to pp

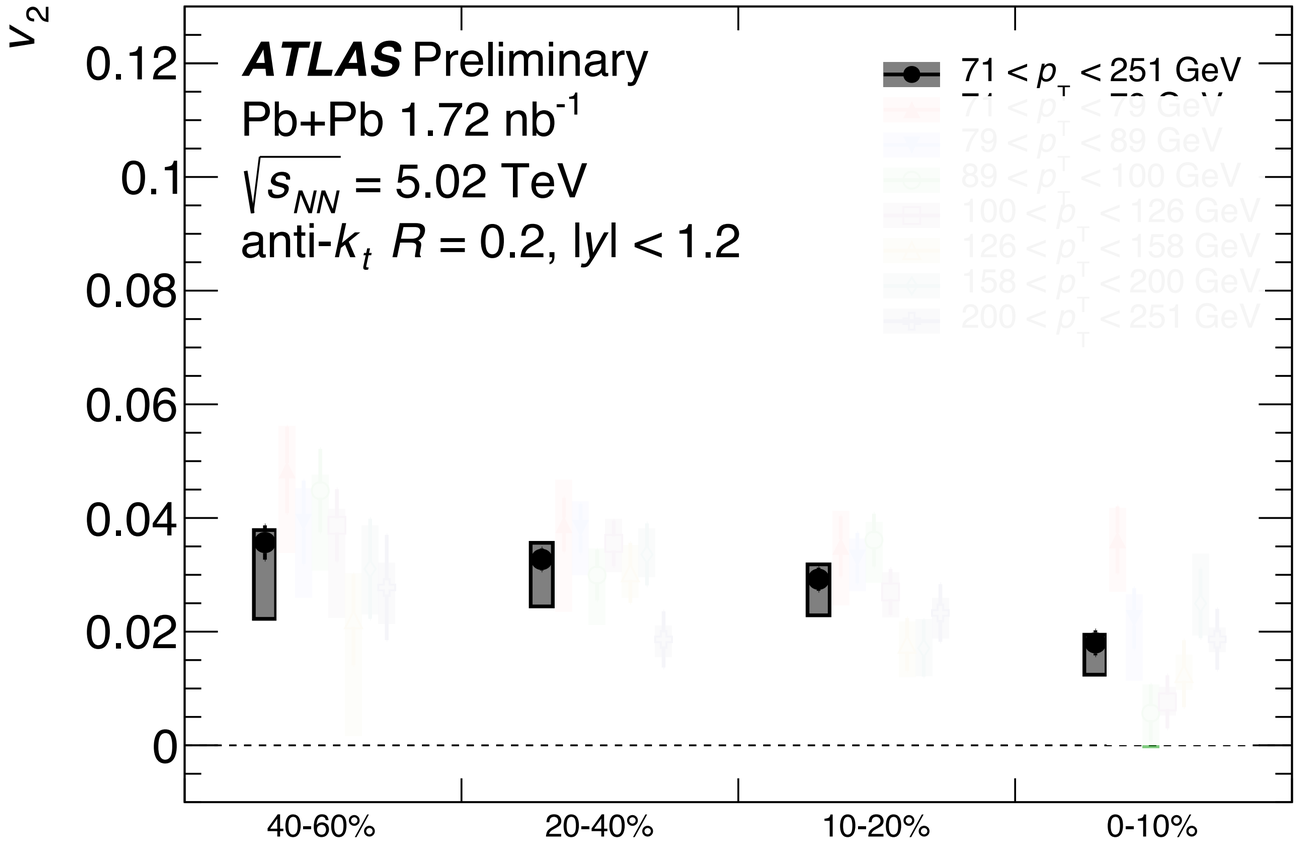
Jet v_n in Pb+Pb

Virginia Bailey
Monday 11:00
(A1 - Jets and High-PT Hadrons I)





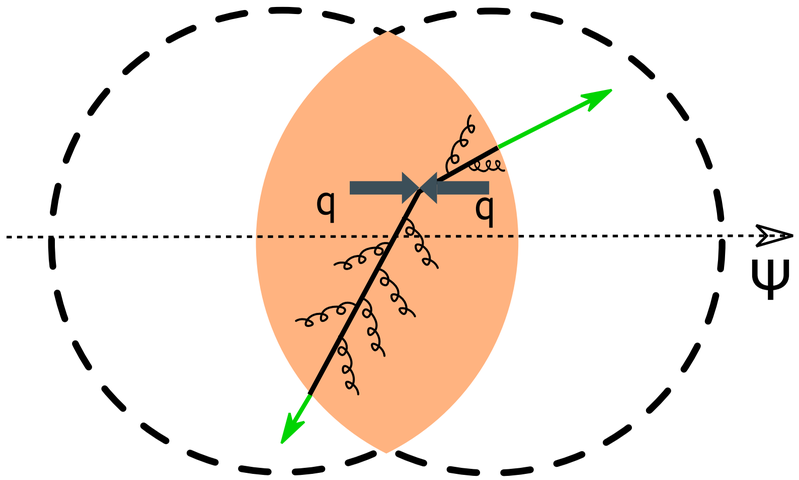
ATLAS-CONF-2020-019

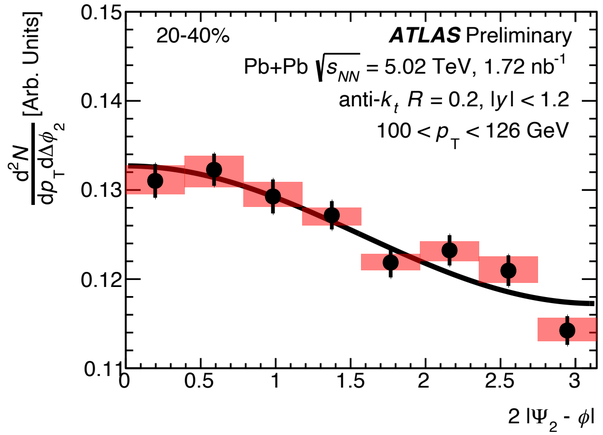


Clear signal of path length dependent energy loss

Jet v_n in Pb+Pb

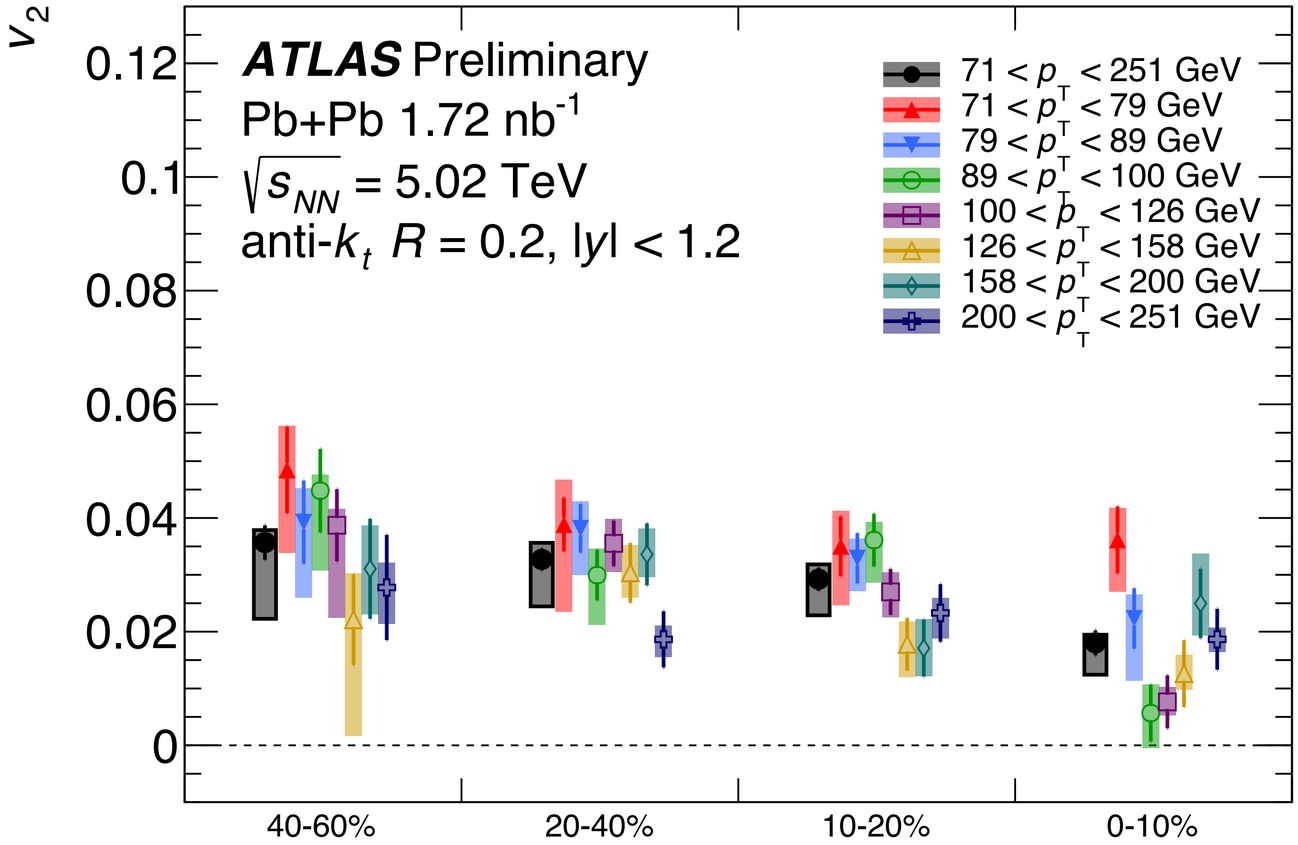
Virginia Bailey
Monday 11:00
(A1 - Jets and High-PT Hadrons I)





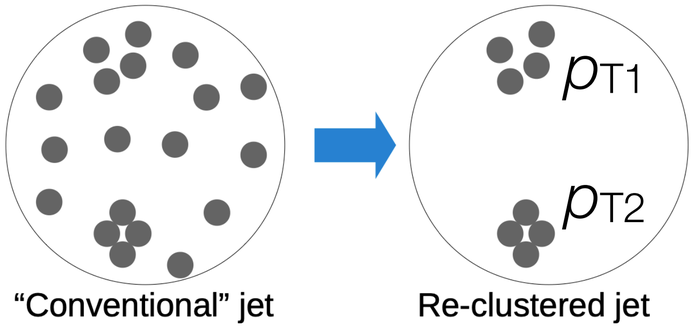
Clear signal of path length dependent energy loss

ATLAS-CONF-2020-019



Large R-jets - quenching and jet structure

Large R jets - ATLAS way



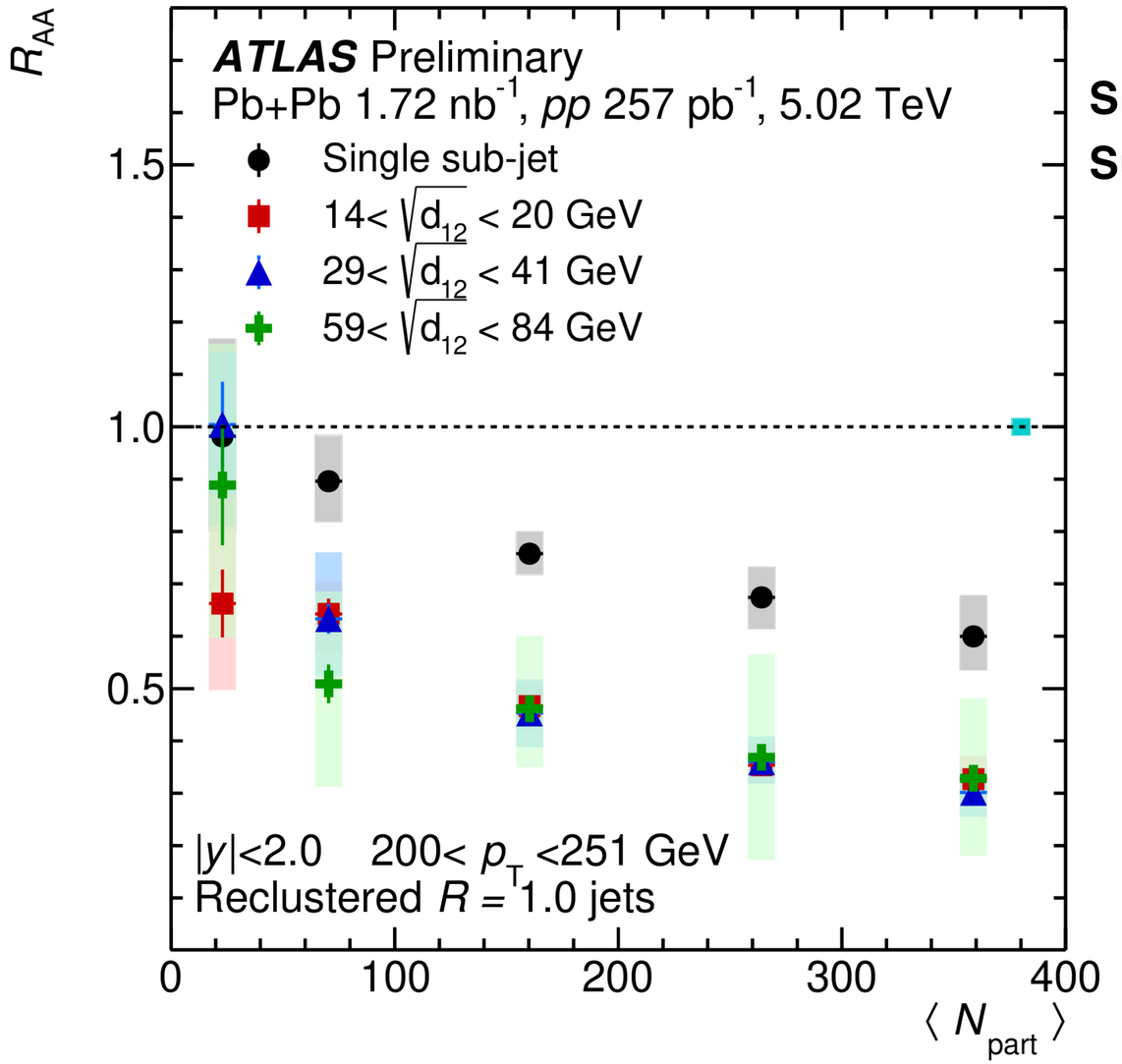
Splitting scale

$$\sqrt{d_{12}} = \min(p_{T1}, p_{T2}) \times \Delta R_{12}$$

Anne Sickles
Wednesday 10:30
(E1 - Jets and High-PT Hadrons V)

Poster by Wenkai Zou

ATLAS-CONF-2019-056



Single "isolated"
Sub-**J**et

SSJ jets less suppressed with respect to those with higher sub-jet multiplicity

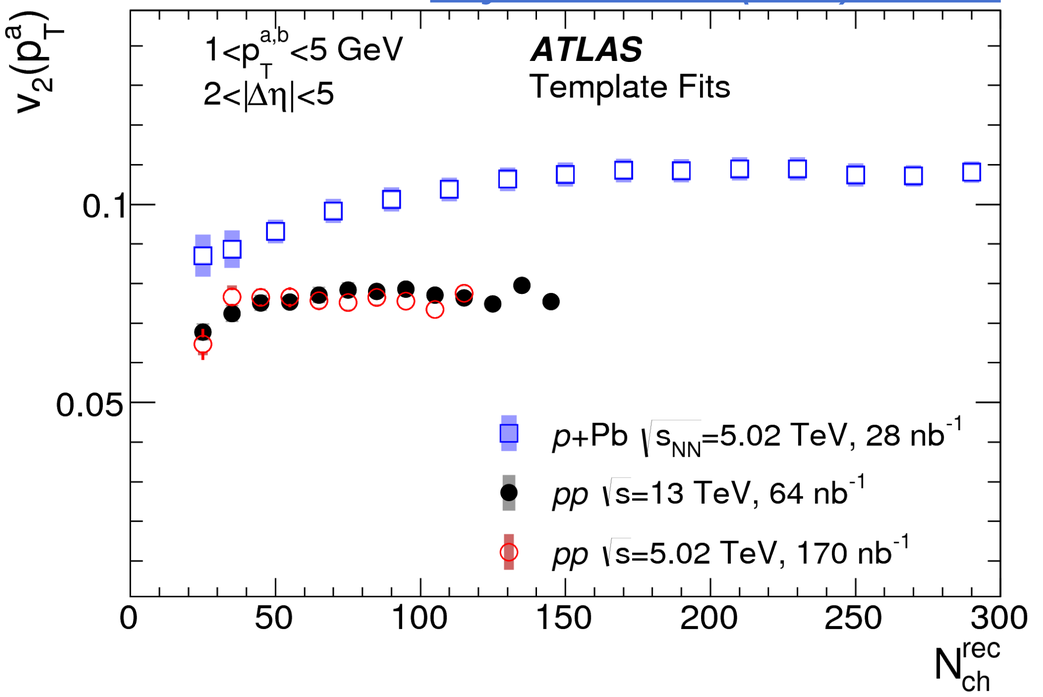
Flow in small systems

➡ is the azimuthal anisotropy at high pT consistent with energy loss?

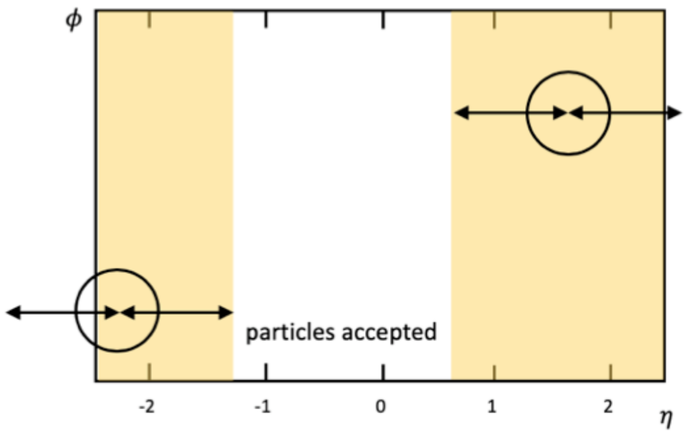
➡ how the flow in pp collision is affected by hard processes?

➡ can we constrain the geometry of the pp collision?

Phys. Rev. C 96 (2017) 024908



Flow of high pT hadrons in p+Pb



Associated charged particles close ($|\Delta\eta|<1$) to the jet (jet with $p_T > 15$ GeV) removed from the 2PC

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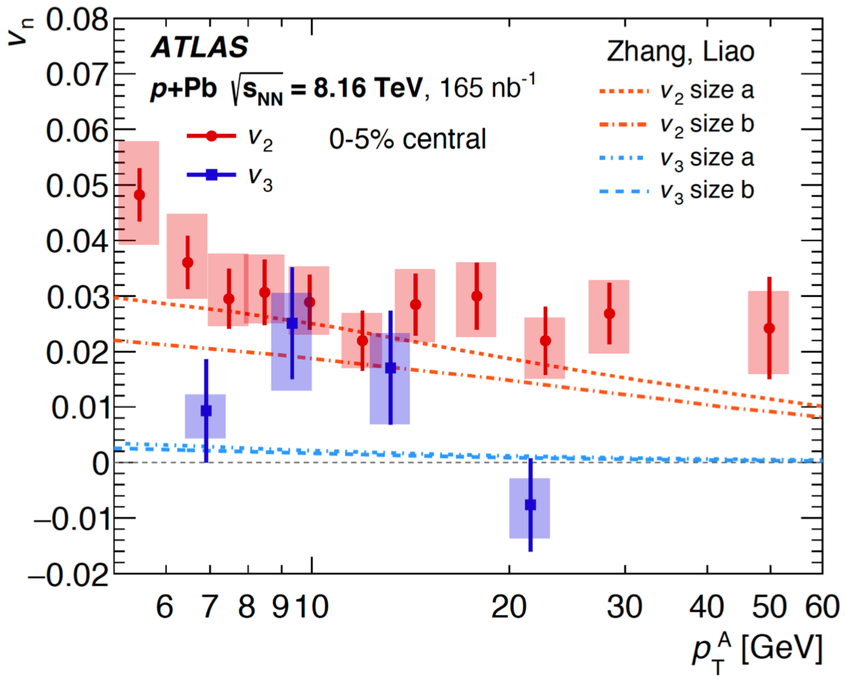


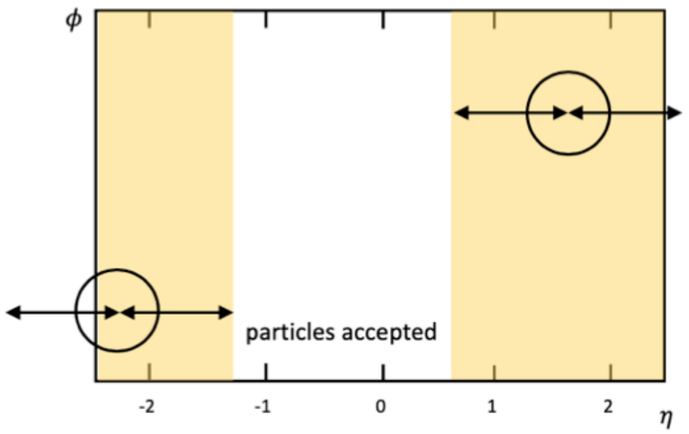
Tomasz Bold
Monday 12:20
(A4 - Initial State I)

Model able to reproduce the flow but …

Flow of high pT hadrons in p+Pb

Eur. Phys. J. C 80 (2020) 73

Tomasz Bold
Monday 12:20
(A4 - Initial State I)



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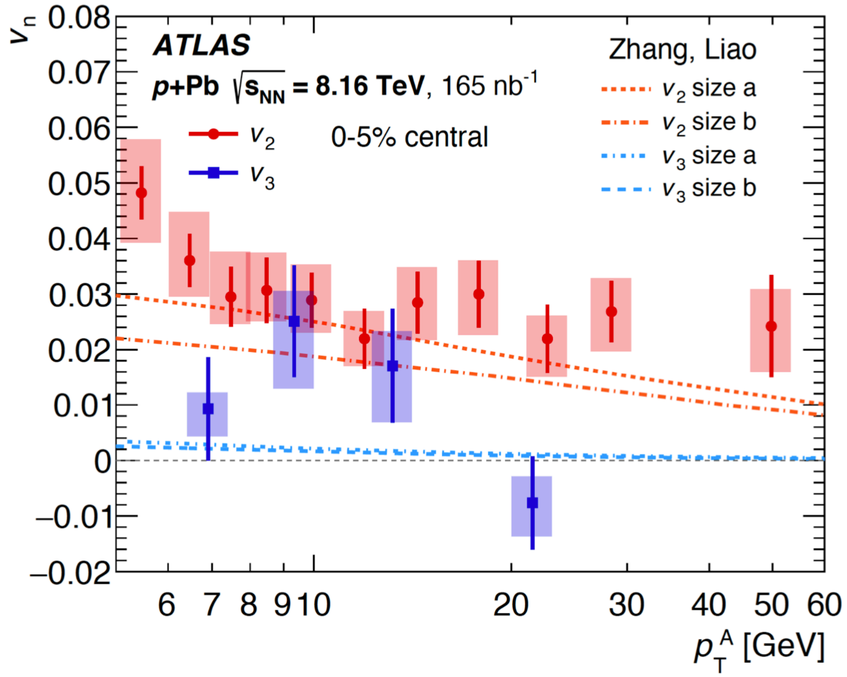
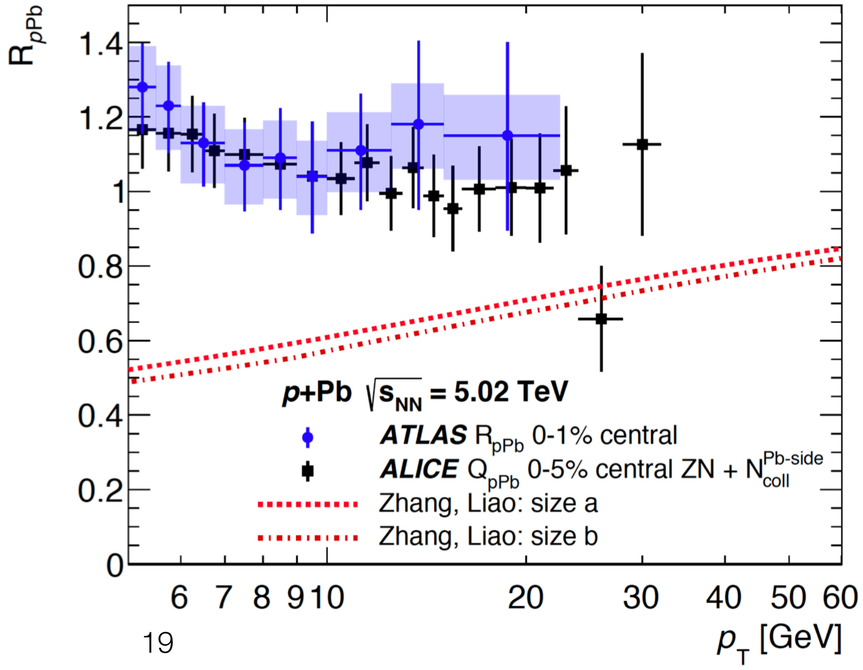
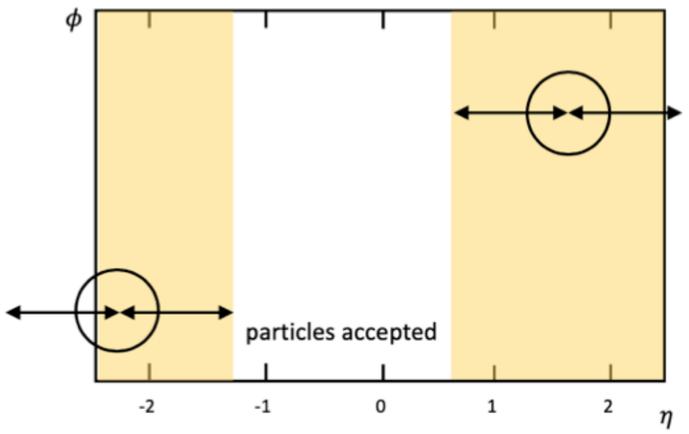




Model able to reproduce the flow but … requires significant modification of charged hadrons spectra

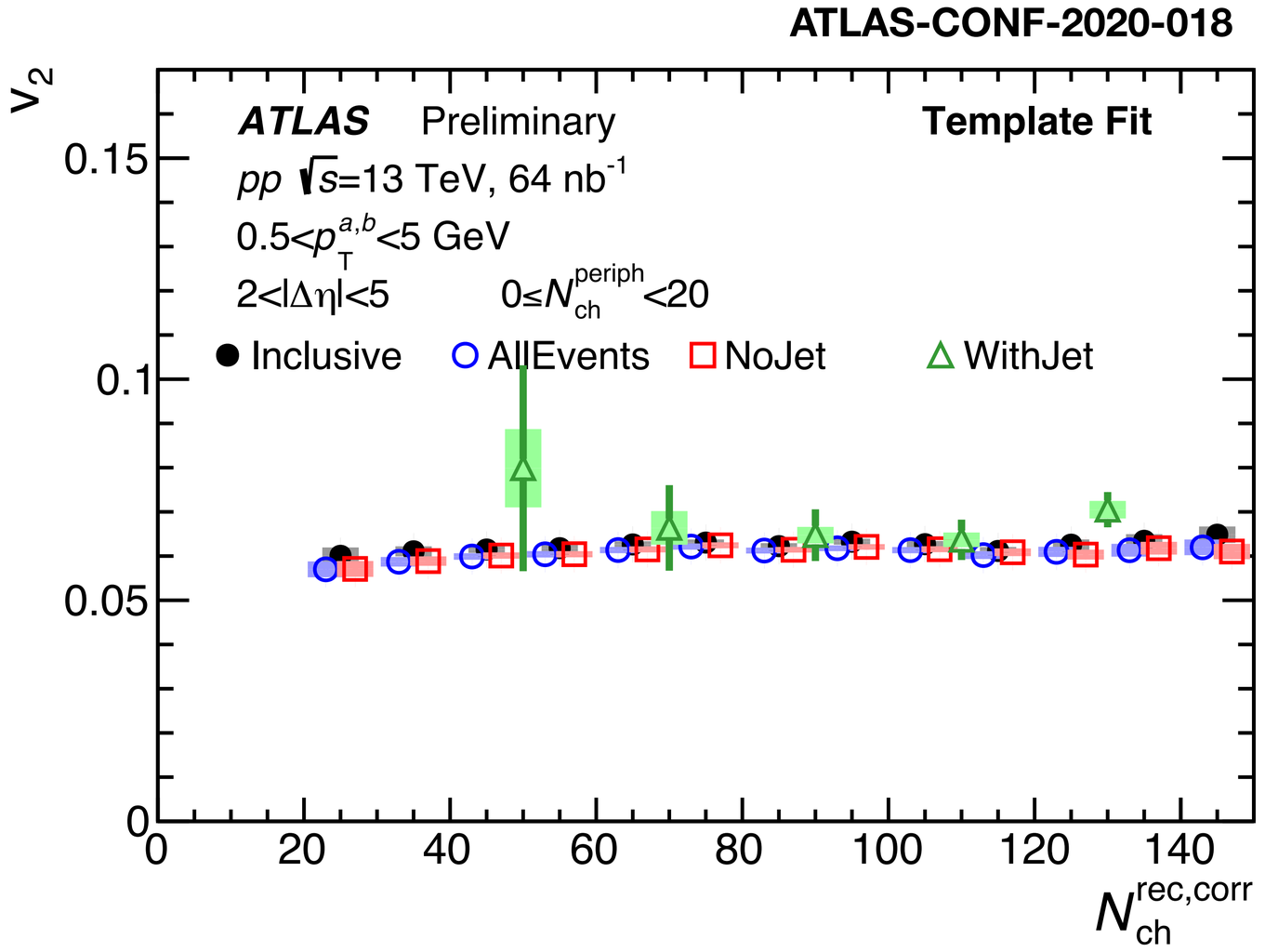
Flow in pp with jet particle rejection

Blair Seidlitz
Tuesday 12:00
(C4 - Initial State III)



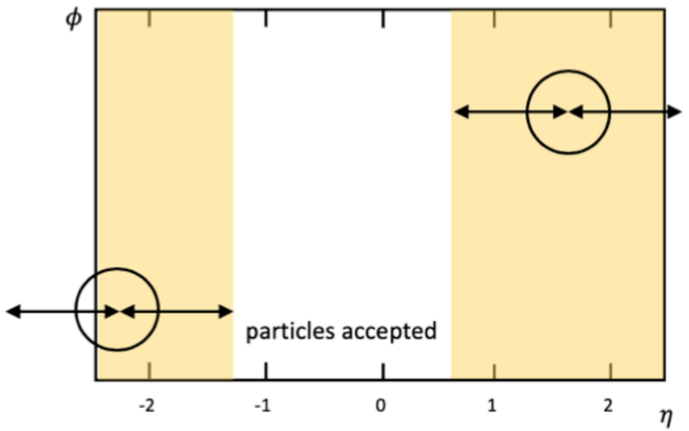
Charged particles close (|Δη|<1) to the jet (track jet with p_T > 10 GeV) removed from the 2PC (both trigger and associated)

The v_2 integrated over the 0.5–5 GeV p_T range decreases only marginally (2-5%) when applying jet particle rejection



Flow in pp with jet particle rejection

Blair Seidlitz
Tuesday 12:00
(C4 - Initial State III)



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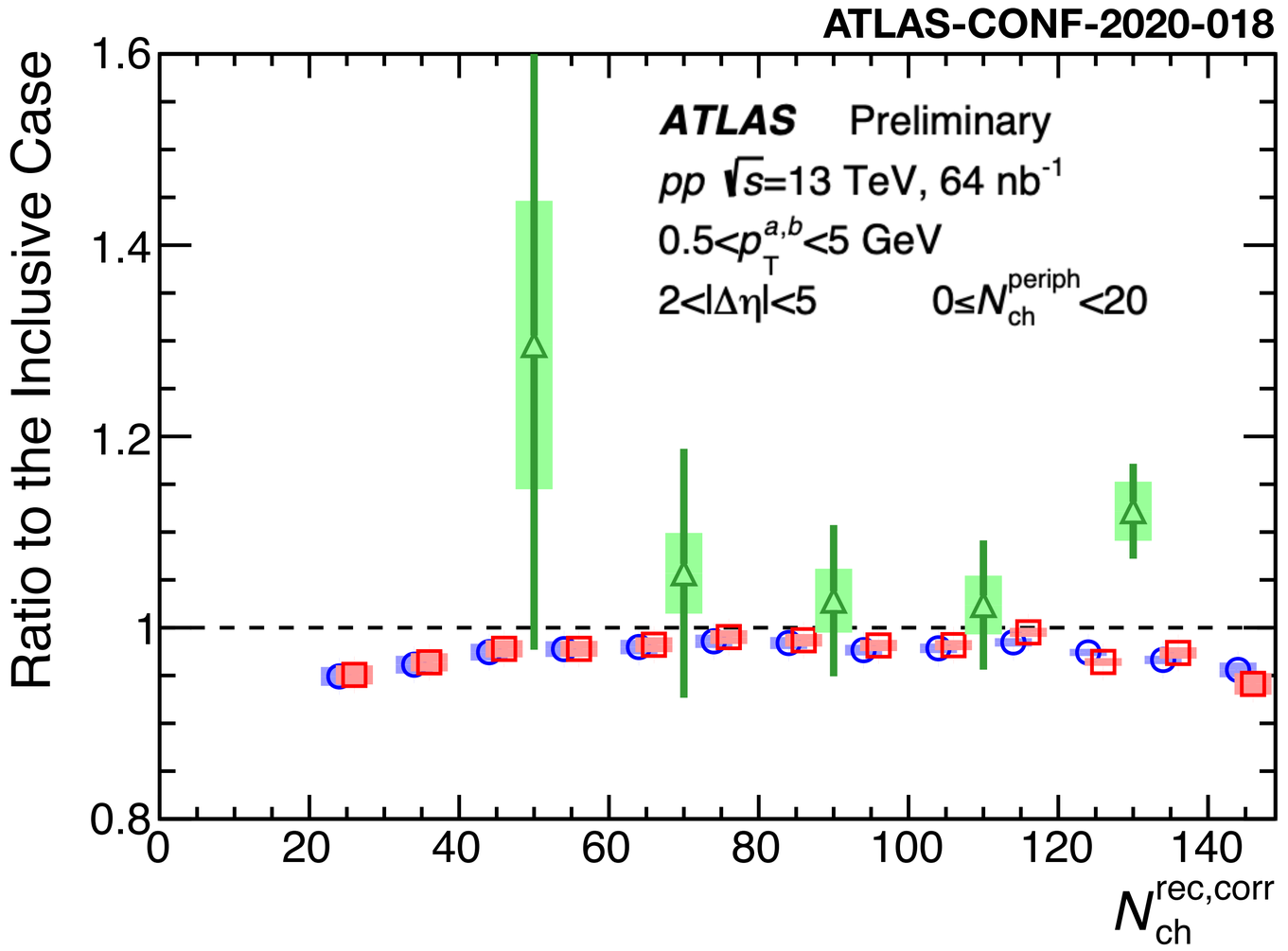
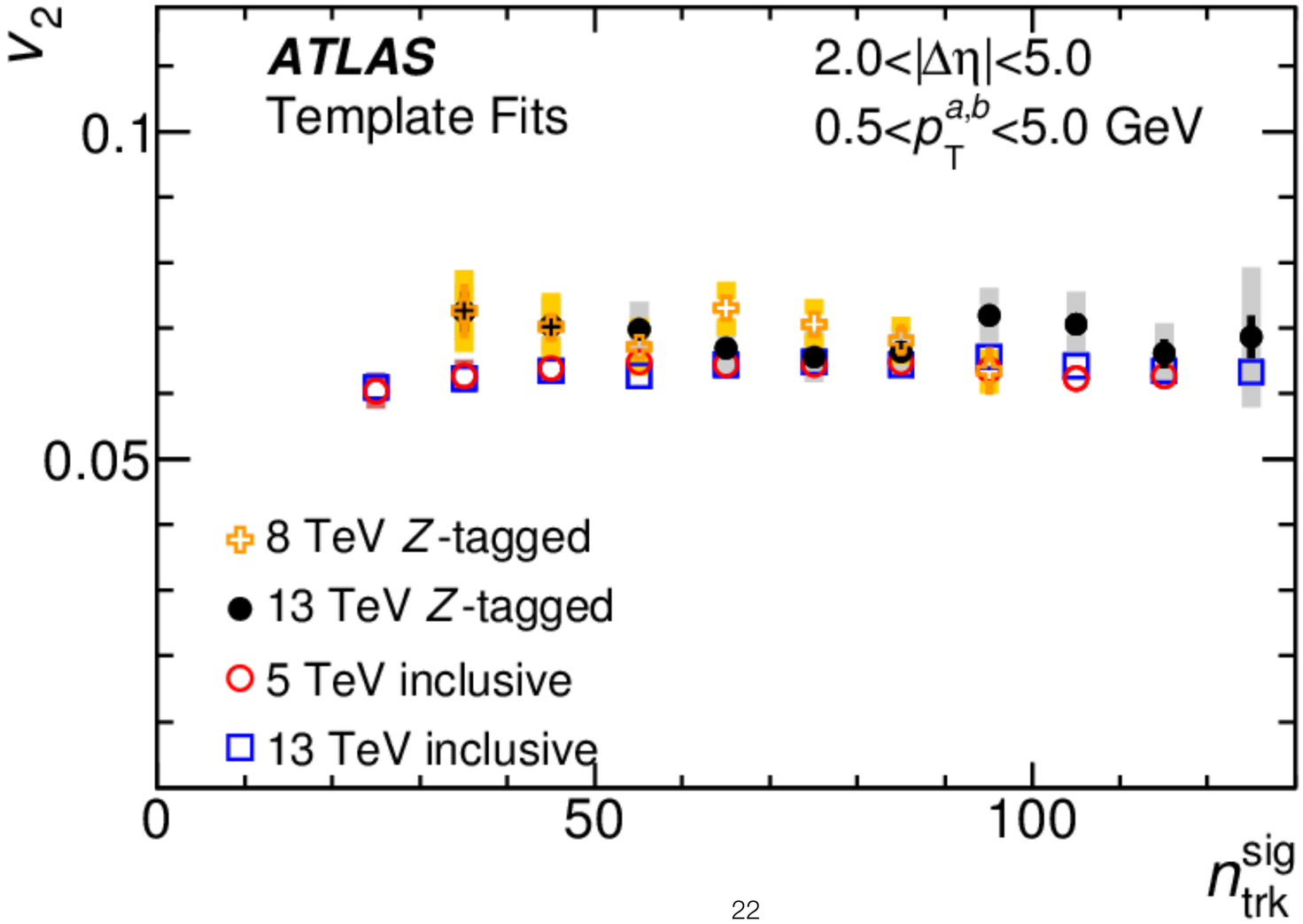


Flow in Z tagged pp collisions

Blair Seidlitz
Tuesday 12:00
(C4 - Initial State III)

Eur. Phys. J. C 80 (2020) 64



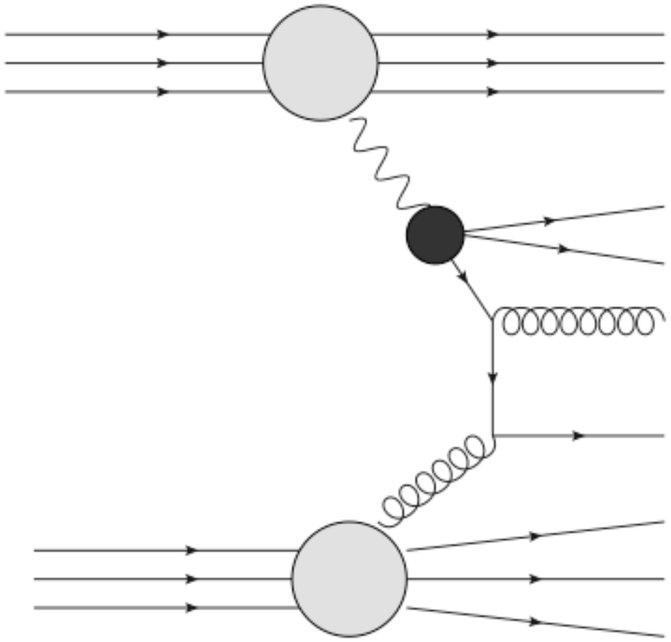
Large Q^2-process (Z) select pp events with smaller impact parameter

v_2 in Z-tagged events shows only a slight increase if any

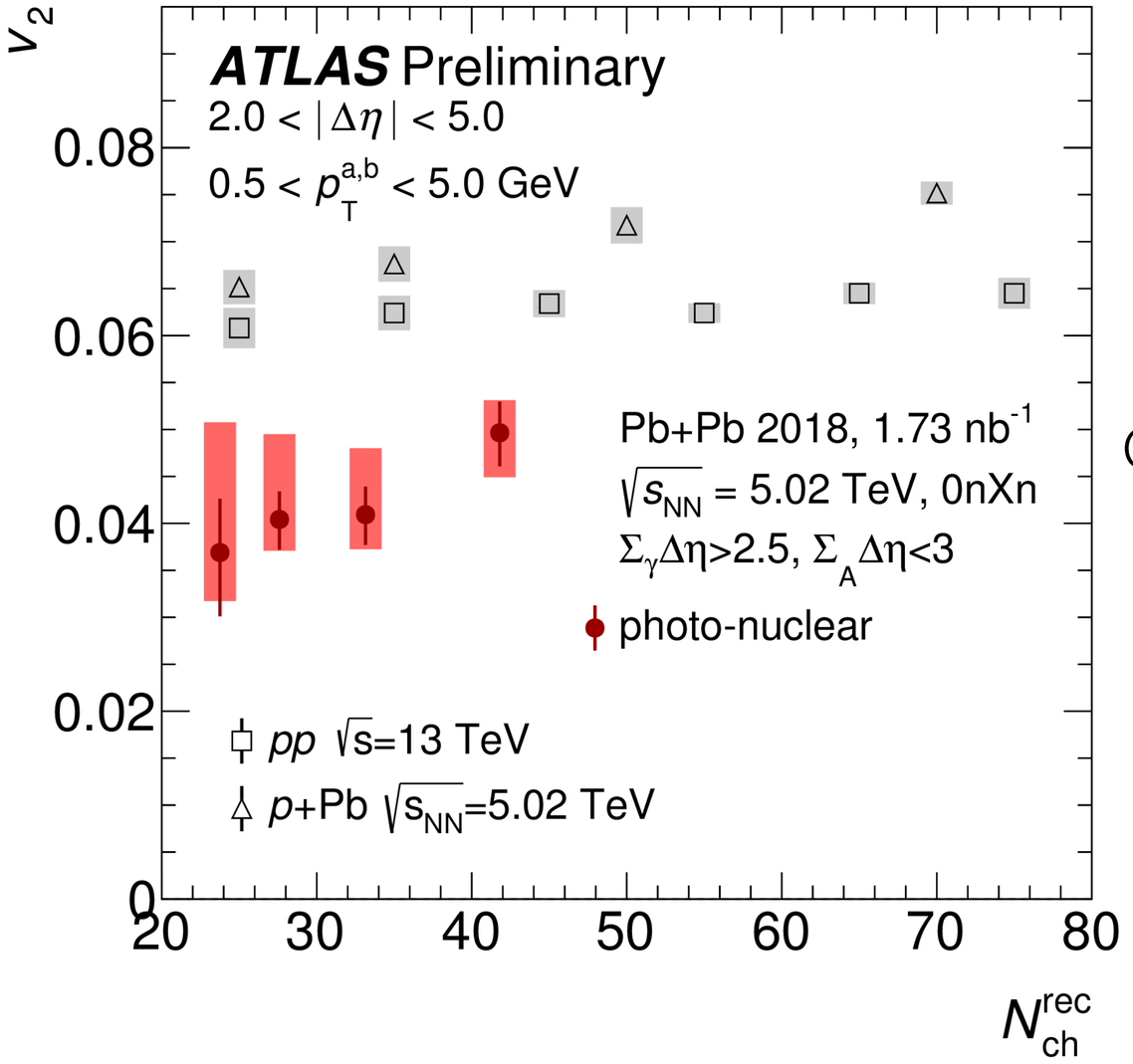
Flow in UPC

Blair Seidlitz
Tuesday 12:00
(C4 - Initial State III)

UPC γ+Pb (p+Pb)



ATLAS-CONF-2019-022

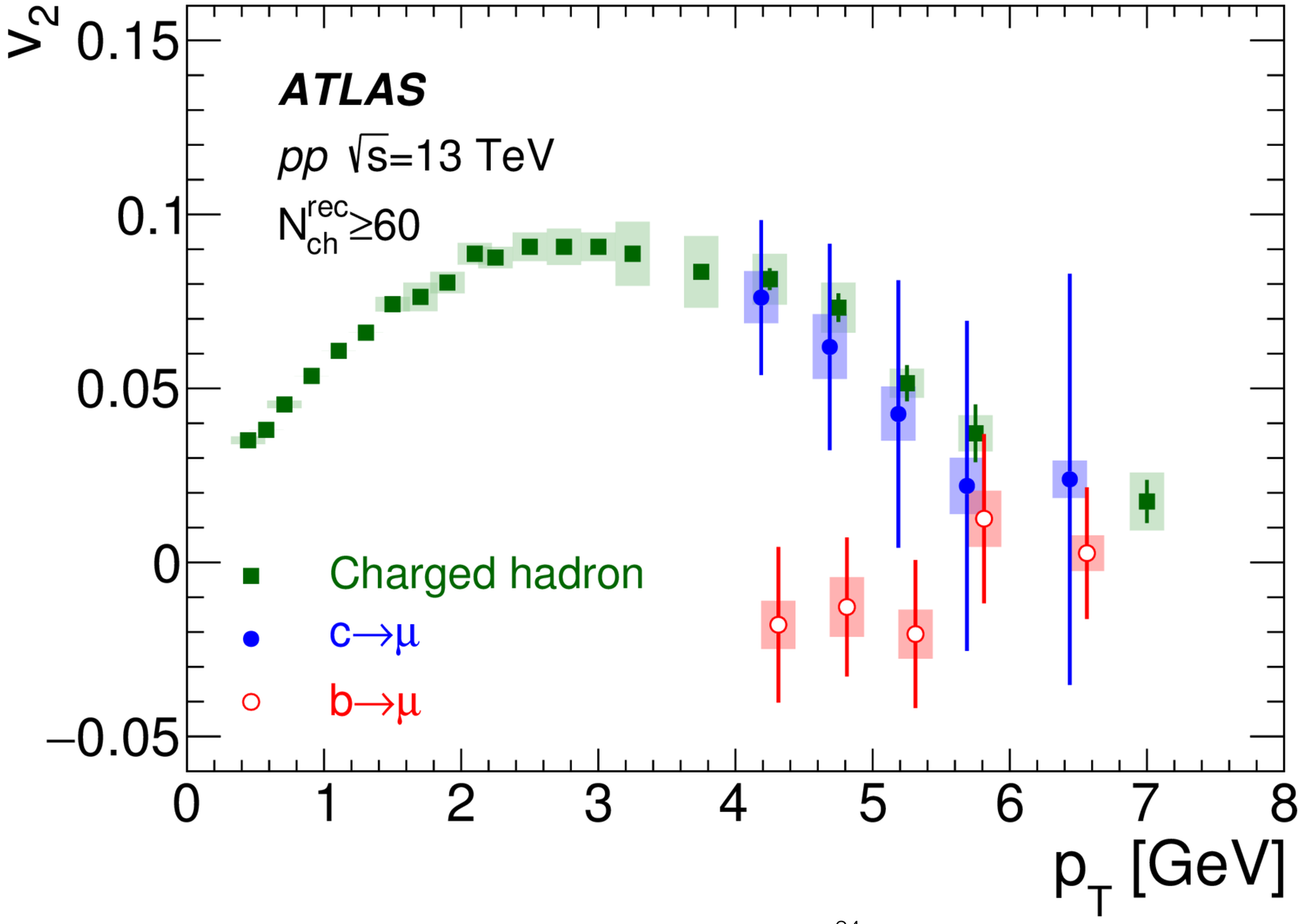


Observed significant v_2, but smaller than p+Pb and pp

Heavy flavour flow in pp

Qipeng Hu
Thursday 10:30
(G3 - Heavy Flavor IX)

Phys. Rev. Lett. 124 (2020) 082301



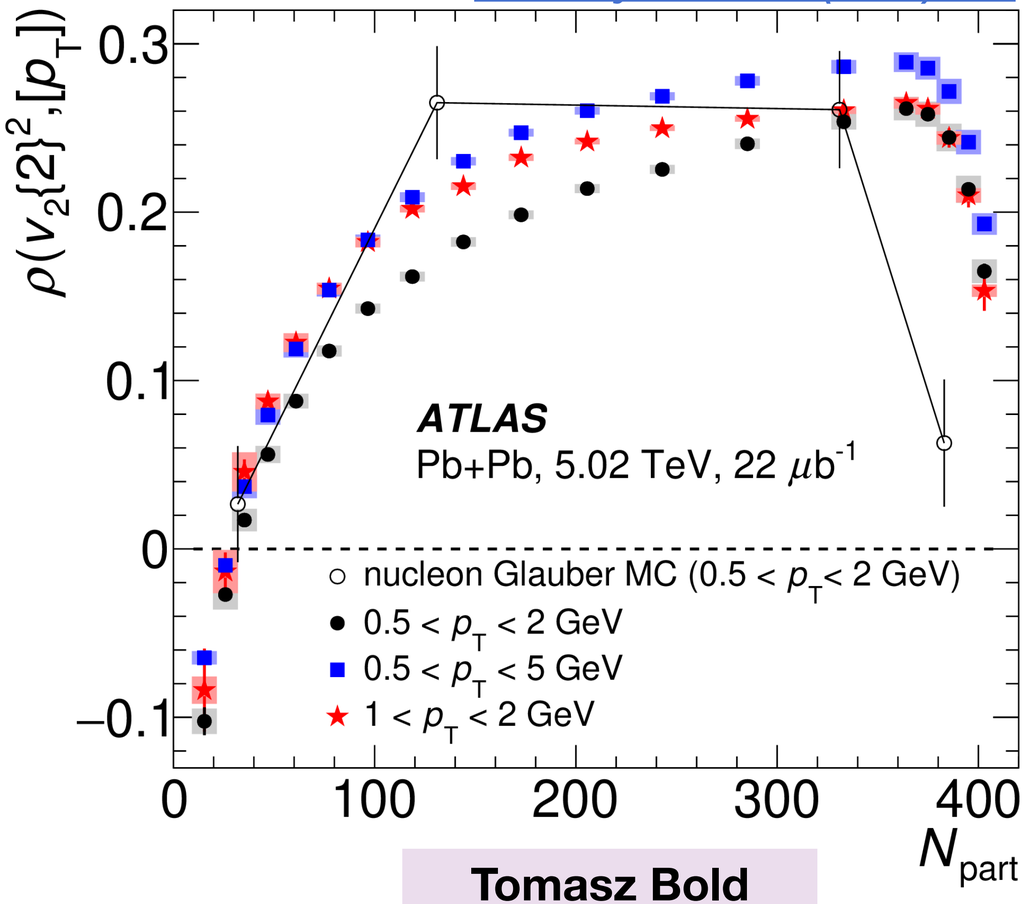
v_2 of muons from **charm** decays consistent with light hadrons flow

v_2 of muons from **beauty** decays consistent with 0

Role of the initial state

vn - [pT] correlation

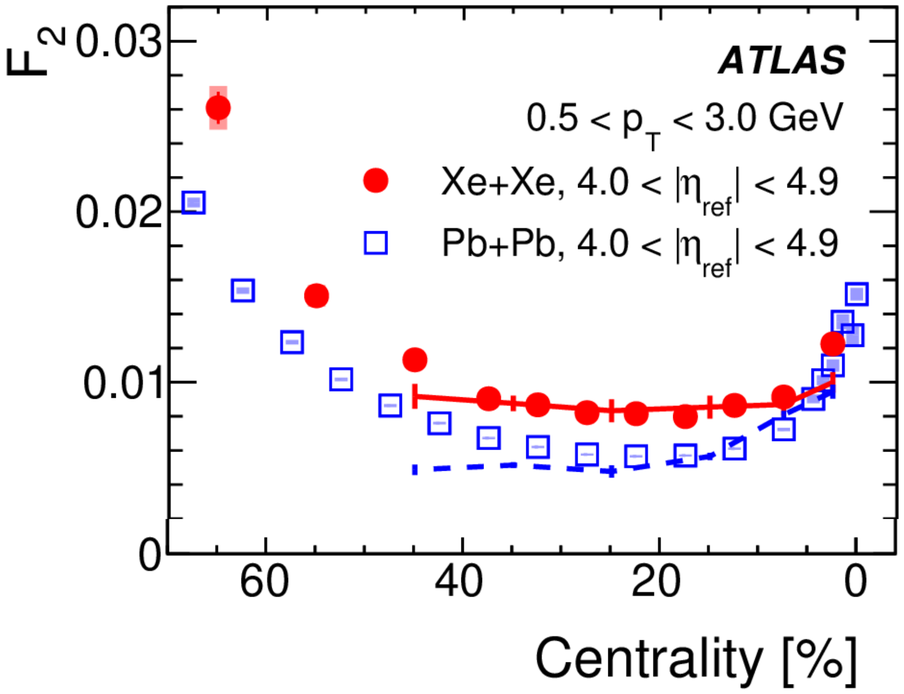
Eur. Phys. J. C 79 (2019) 985



Tomasz Bold
Monday 12:20
(A4 - Initial State I)

System size dependence of flow harmonics decorrelation

arXiv:2001.04201



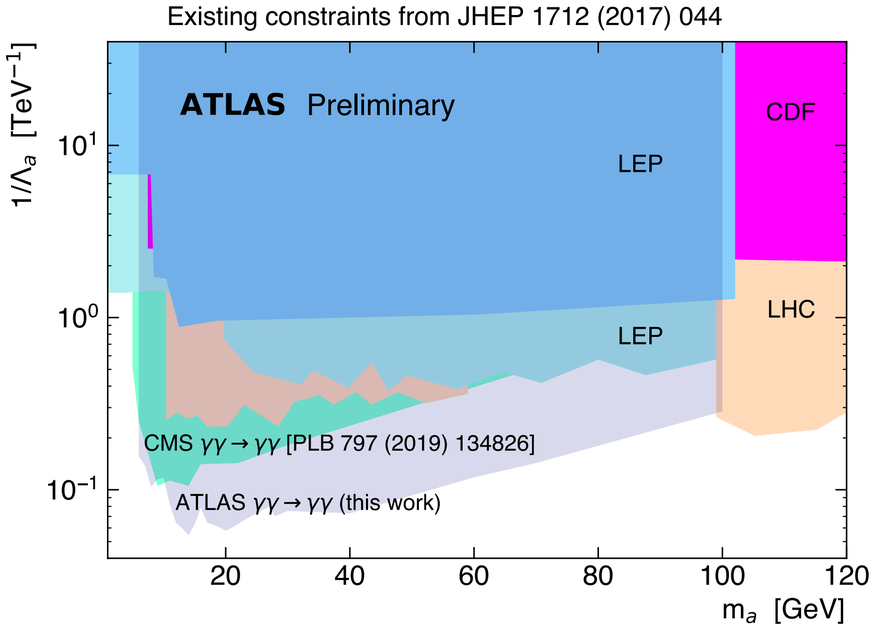
Arabinda Behera
Wednesday 10:30
(E4 - Initial State V)

Poster by Arabinda Behera

What have we learned

Ultra Peripheral Collisions (UPC)

➡ **limit for axion like particles production**



ATLAS-CONF-2020-010

W/Z bosons in Pb+Pb

➡ better description of data without nuclear PDFs

Heavy flavour probes

➡ observed sequential suppression of ϒ(nS) states

➡ interplay of hydro expansion and energy loss in open heavy flavour

Jet quenching

➡ new high precision measurement give better constrain on energy loss

➡ single isolated jets experience less energy loss than jets with more complicated structure

Flow in small systems

➡ no sing of impact parameter dependence of flow in pp

➡ flow in pp decreases only by few percent (2–5%) if jet particles rejection is applied

What have we learned

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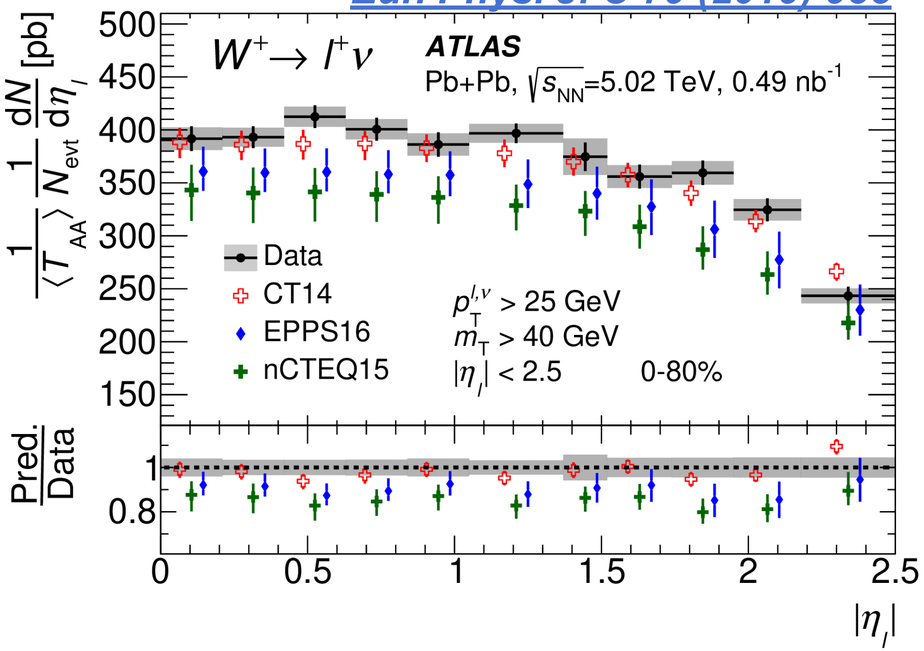

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W/Z bosons in Pb+Pb

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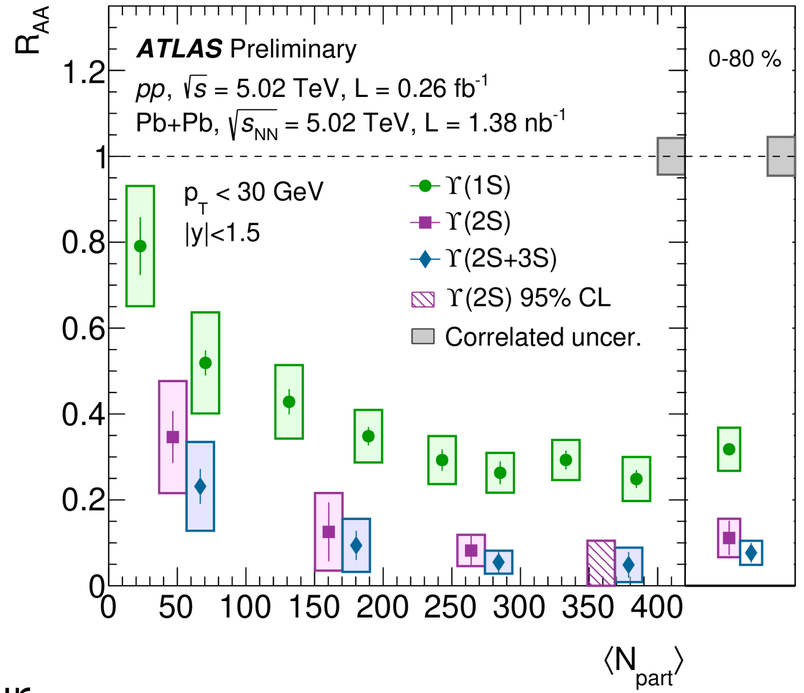
➡ **observed sequential suppression of Υ(nS) states**

➡ interplay of hydro expansion and energy loss in open heavy flavour



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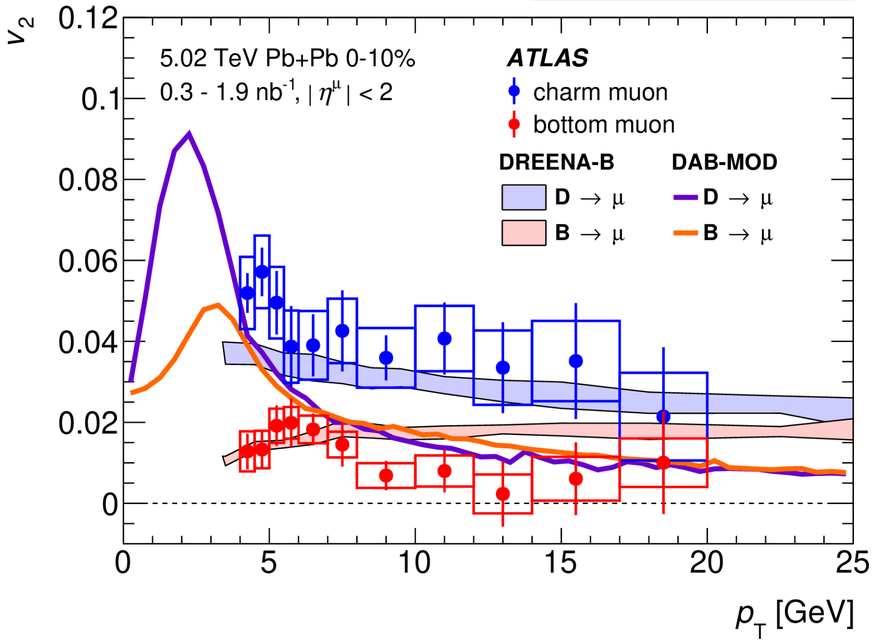
What have we learned

arXiv:2003.03565



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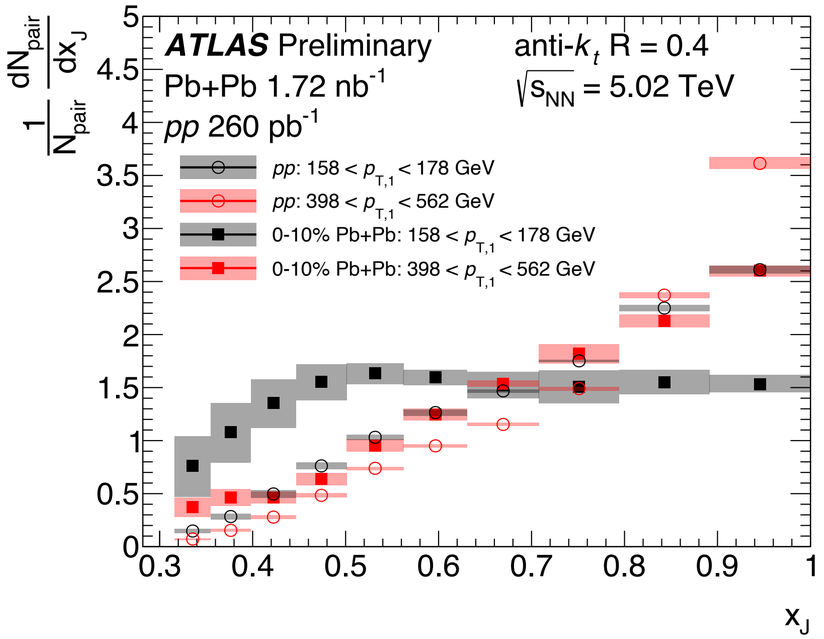
What have we learned

ATLAS-CONF-2020-017



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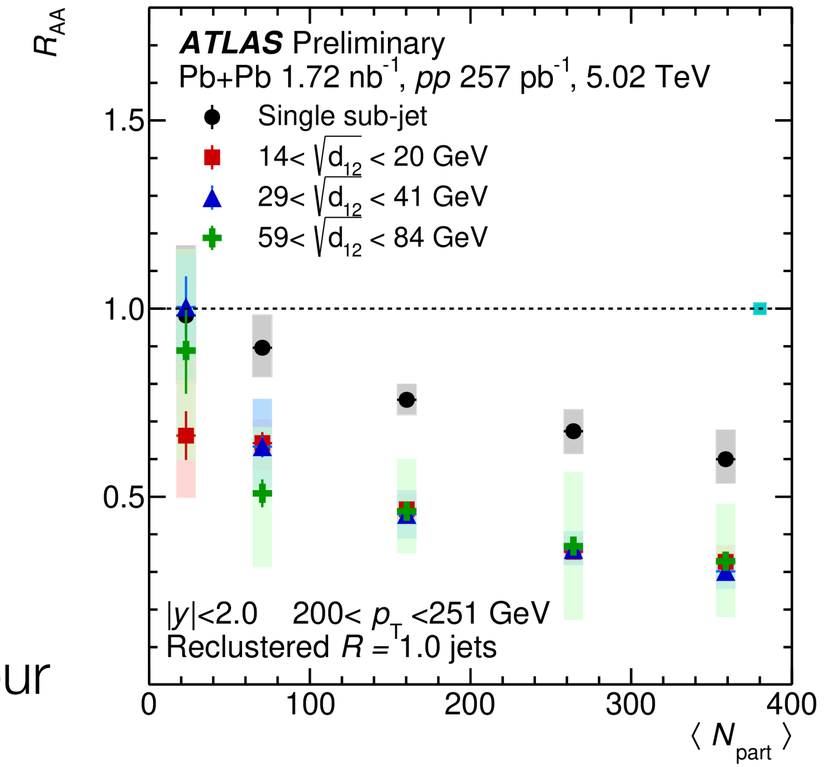
What have we learned

ATLAS-CONF-2019-056



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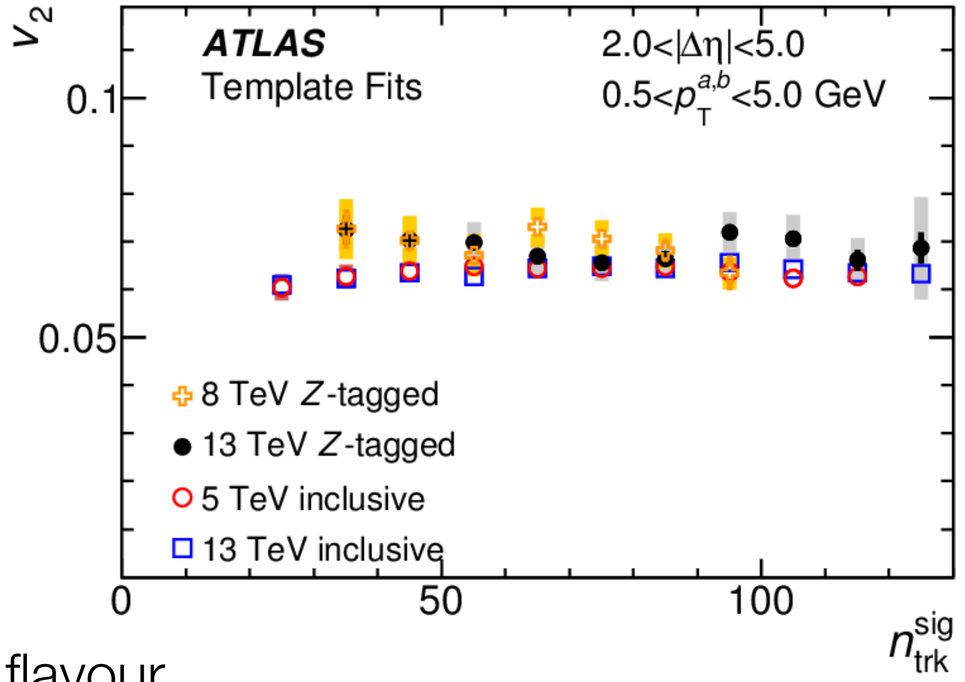
What have we learned

Eur. Phys. J. C 80 (2020) 64



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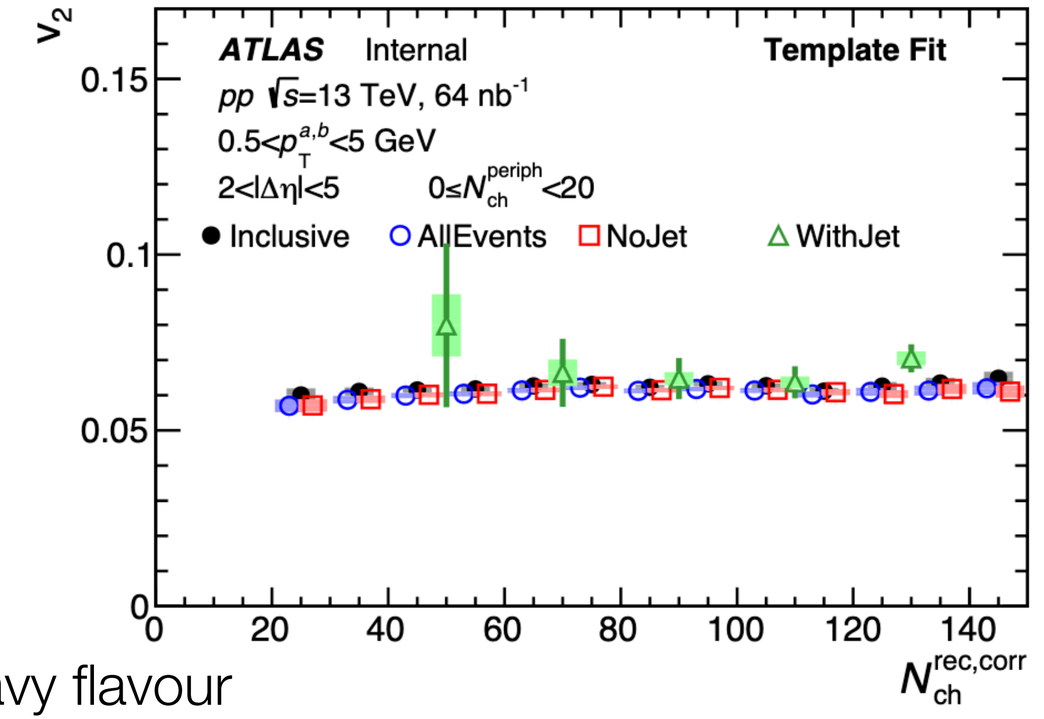
What have we learned

ATLAS-CONF-2020-019



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ATLAS talks

Monday 11:00	*Single jet and dijet measurements of jet quenching with the ATLAS detector*
Monday 11:00	*Electroweak probes in heavy-ion collisions with ATLAS*
Monday 12:20	*Measurements of v_n at high-p_T and correlation between v_n and mean-p_T in p+Pb collisions with the ATLAS detector*
Monday 13:15	*Quarkonium production in Pb+Pb collisions with ATLAS*
Tuesday 12:00	*ATLAS measurement of azimuthal anisotropies in Z-boson tagged pp collisions at 8 and 13 TeV and in ultra-peripheral Pb+Pb collisions at 5.02 TeV*
Wednesday 10:30	*Non-UPC production of di-muons from two-photon scattering in Pb+Pb collisions with the ATLAS detector*
Wednesday 10:30	*Measurement of jet structure and substructure in heavy ion collisions with ATLAS*
Wednesday 10:30	*ATLAS measurements of transverse and longitudinal flow decorrelations in Xe+Xe, Pb+Pb, and p+Pb collisions*
Thursday 10:35	*Production and azimuthal anisotropy of muons from heavy flavor decays in small and large systems with ATLAS*
Thursday 13:30	*Measurements of photon- and Z-tagged jet quenching by ATLAS*

ATLAS posters

Timothy Rinn	*Exploring jet quenching through the measurement of di-jet momentum balance with ATLAS*
Klaudia Burka	*Light-by-light scattering in ultra-peripheral Pb+Pb collisions in the ATLAS experiment*
Martin Krivos	*Suppression of charmonia states in Pb+Pb collisions at 5.02 TeV with the ATLAS detector*
Arabinda Behera	*Longitudinal flow decorrelation in Xe+Xe and p+Pb collisions with the ATLAS detector*
Wenkai Zou	*Measurement of suppression of large-radius jets and its dependence on substructure in Pb+Pb with ATLAS*
Benjamin Gilbert	*Measurement of $\gamma\gamma \rightarrow \mu\mu$ pairs in non-ultra peripheral Pb+Pb collisions with the ATLAS detector*

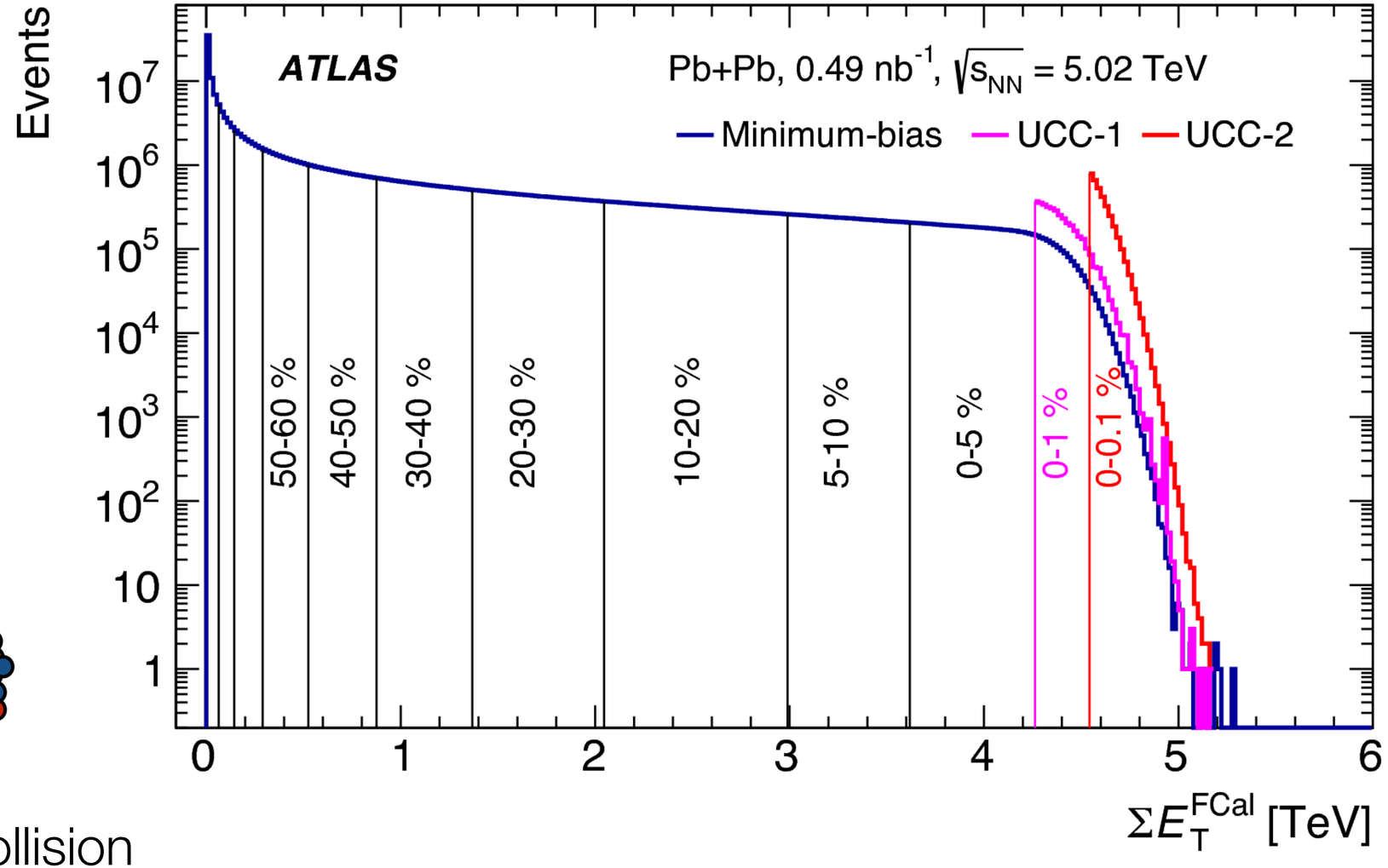
Thank you for attention!

All HI ATLAS public results: https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HeavyIonsPublicResults

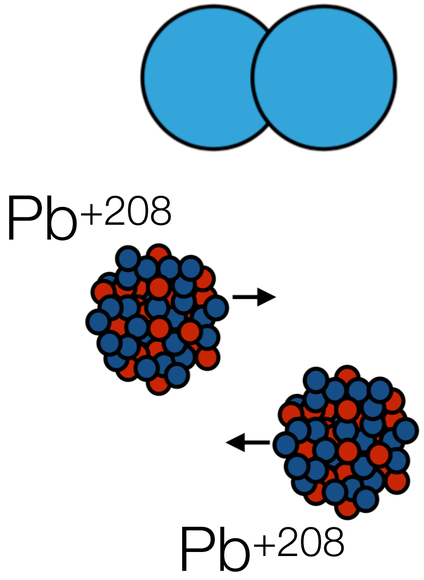
Backup

Centrality in Heavy Ion collisions

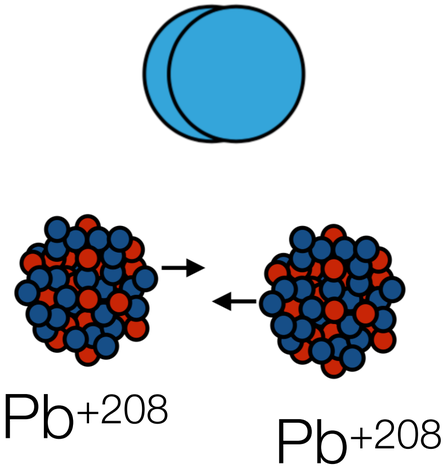
2015 Pb+Pb data



Negligible pile-up!



Peripheral collision



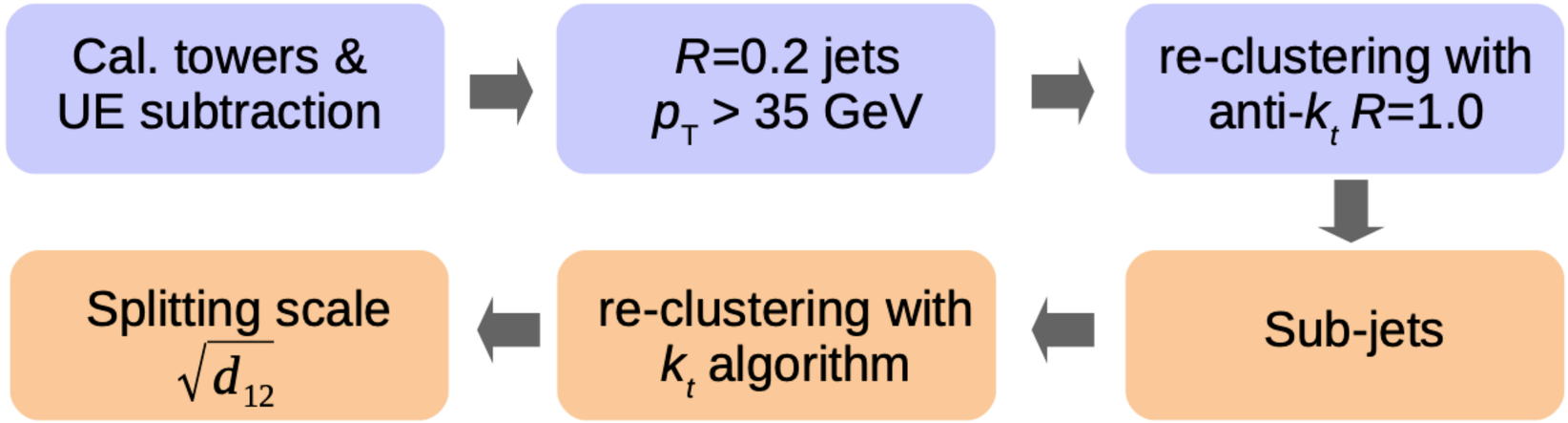
Central collision

Centrality is parametrized using the energy deposited in the Forward calorimeter (|η|>3.2)

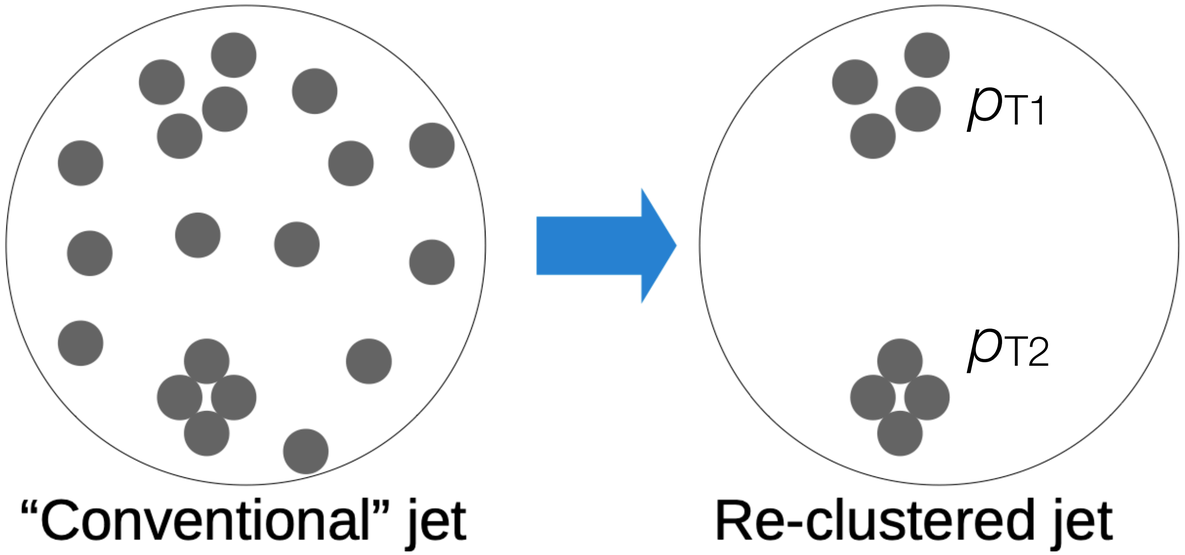
Centrality intervals and their corresponding geometric quantities

Centrality [%]	$\langle N_{\mathrm{part}} \rangle$	$\langle T_{\mathrm{AA}} \rangle$ [mb^{-1}]	Centrality [%]	$\langle N_{\mathrm{part}} \rangle$	$\langle T_{\mathrm{AA}} \rangle$ [mb^{-1}]
0–2%	399.0 ± 1.6	28.30 ± 0.25	20–25%	205.6 ± 2.9	9.77 ± 0.18
2–4%	380.2 ± 2.0	25.47 ± 0.21	25–30%	172.8 ± 2.8	7.50 ± 0.17
4–6%	358.9 ± 2.4	23.07 ± 0.21	30–40%	131.4 ± 2.6	4.95 ± 0.15
6–8%	338.1 ± 2.7	20.93 ± 0.20	40–50%	87.0 ± 2.4	2.63 ± 0.11
8–10%	317.8 ± 2.9	18.99 ± 0.19	50–60%	53.9 ± 2.0	1.28 ± 0.07
10–15%	285.2 ± 2.9	16.08 ± 0.18	60–80%	23.0 ± 1.3	0.39 ± 0.03
15–20%	242.9 ± 2.9	12.59 ± 0.17	80–100%	4.80 ± 0.36	0.052 ± 0.006
			0–100%	114.0 ± 1.1	5.61 ± 0.06

Large R jets - ATLAS way



$$\sqrt{d_{12}} = \min(p_{T1}, p_{T2}) \times \Delta R_{12}$$



Different jets than the conventional

R=1.0

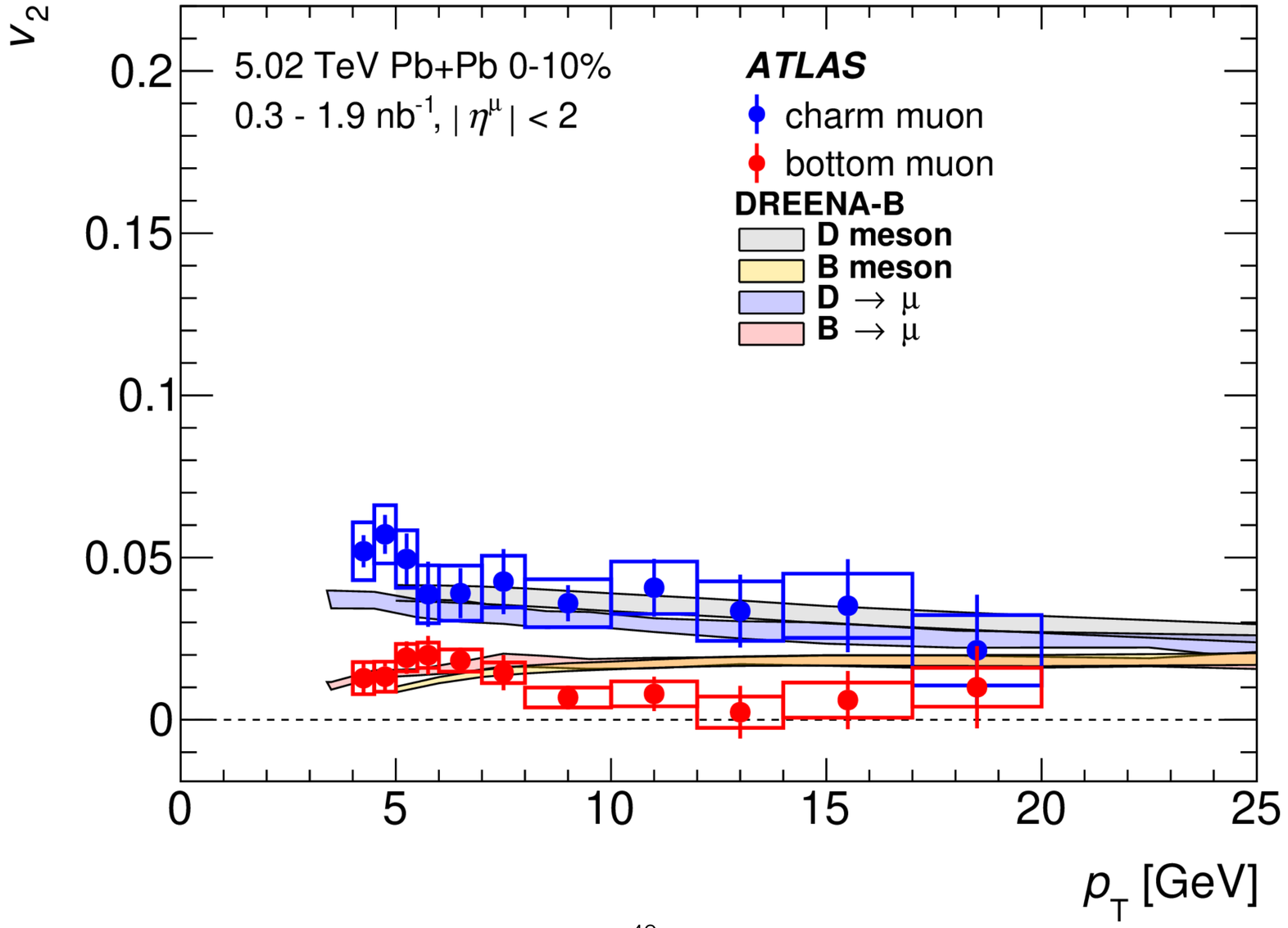
Trimming & 35 GeV threshold remove all the soft component

Heavy ion datasets

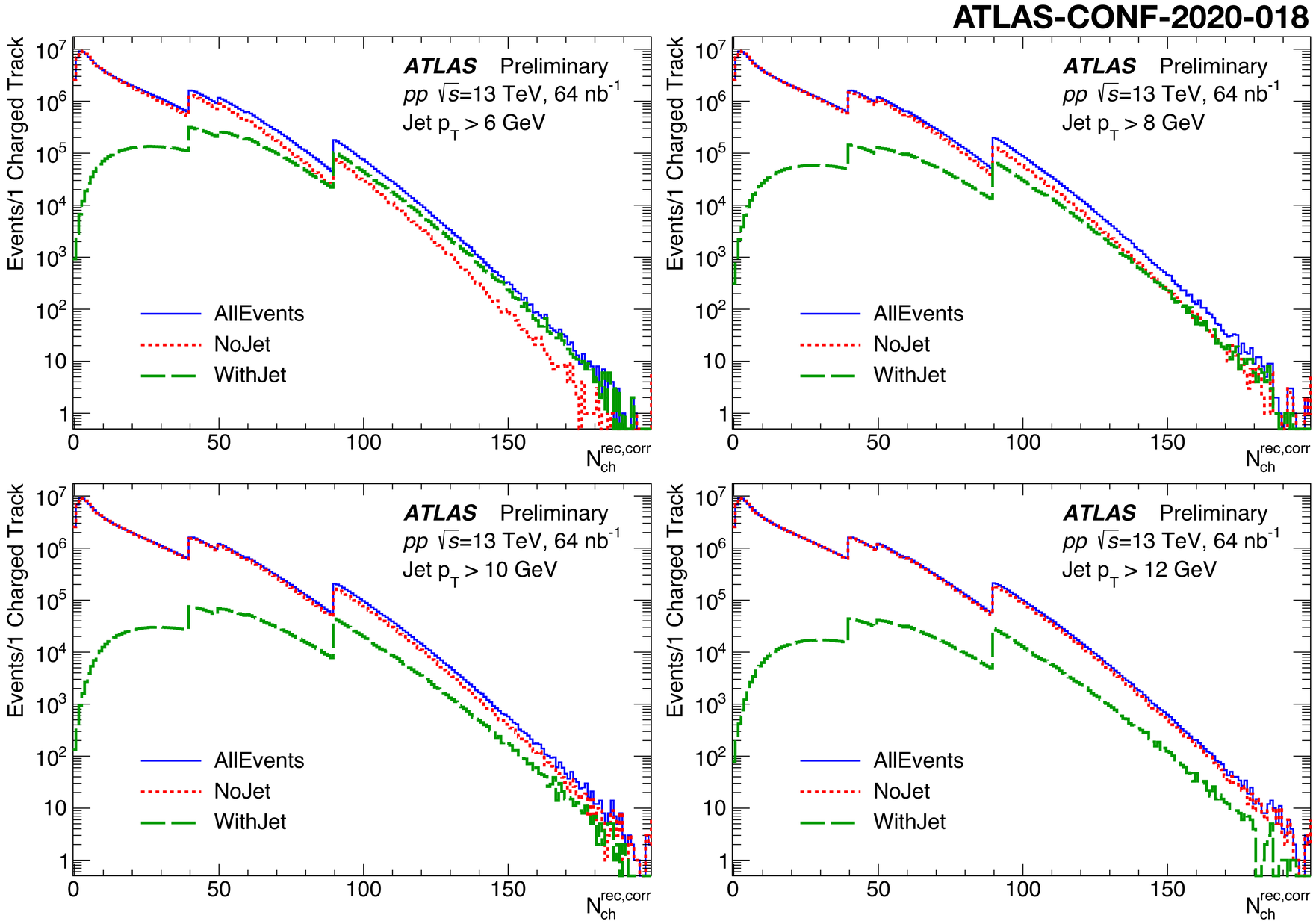
	System	Year	sqrt(s_{NN}) [TeV]	L_{int}
Run 1	**Pb+Pb**	2010	2.76	7 μb^{-1}
	Pb+Pb	2011	2.76	0.14 nb^{-1}
	pp	2012	8	19.4 fb^{-1}
	pp	2013	2.76	4 pb^{-1}
	p+Pb	2013	5.02	29 nb^{-1}
Run 2	**low <μ> pp**	2015-16	13	0.9 pb^{-1}
	pp	2015	5.02	28 pb^{-1}
	Pb+Pb	2015	5.02	0.49 nb^{-1}
	p+Pb	2016	5.02	0.5 nb^{-1}
	p+Pb	2016	8.16	0.16 pb^{-1}
	Xe+Xe	2017	5.44	3 μb^{-1}
	pp	2017	5.02	270 pb^{-1}
	Pb+Pb	2018	5.02	1.76 nb^{-1}

Heavy flavor muon versus heavy flavor meson flow

arXiv:2003.03565



Events with and without track jet of certain threshold in pp



Flow in pp with jet particle rejection - p_T dependence