UE and MPI Tuning in ATLAS

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On behalf of the ATLAS Collaboration

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Overview

- Improvement of the min-bias tune for pileup overlay

- Test of new Pythia8 colour reconnection models against underlying event observables

- Tuning Madgraph+Pythia8 matched setups with ISR rapidity ordering off in Z-boson events

Minbias tune and Pileup

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- Pileup is modelled by overlaying minbias events in ATLAS, which requires a good tune which describes the minbias observables well.

- However, the disagreement in visible cross section results in reweighting <μ>, average number of collisions per bunch crossing.
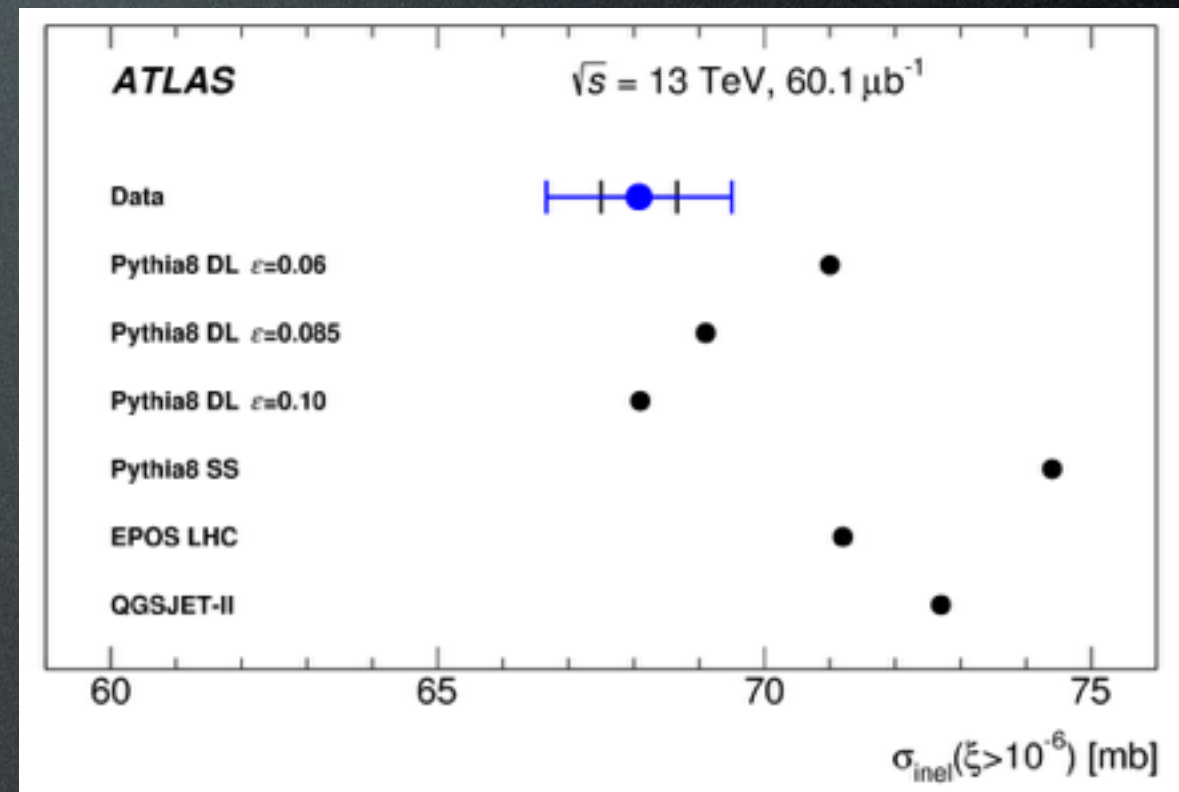
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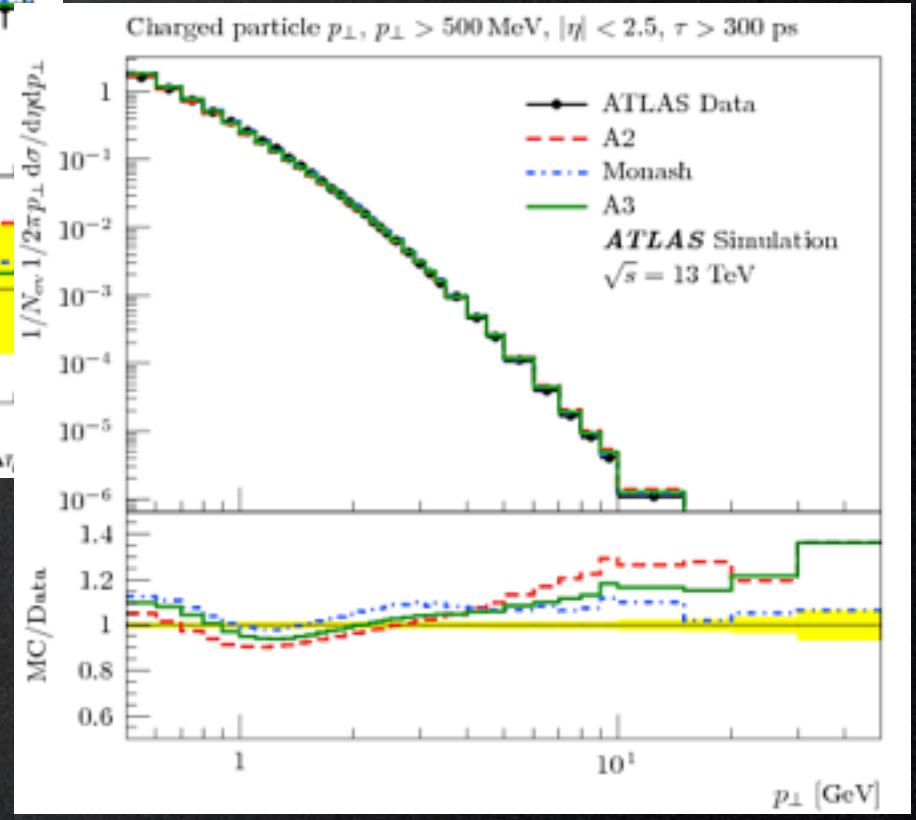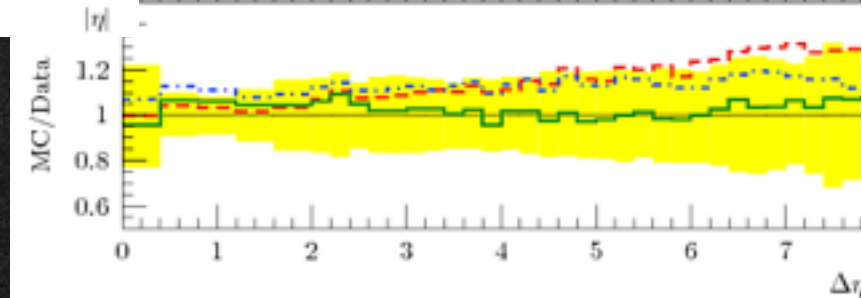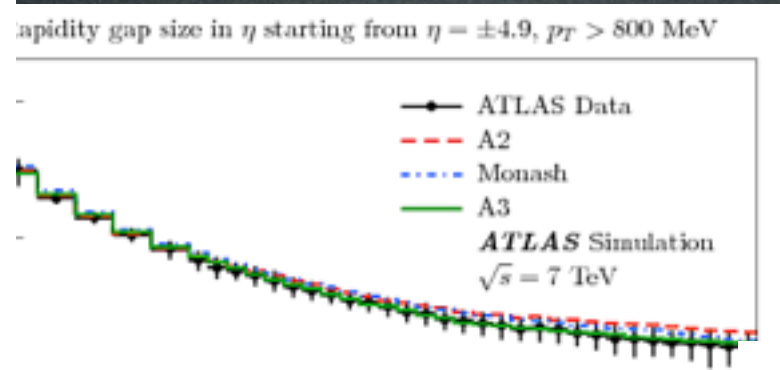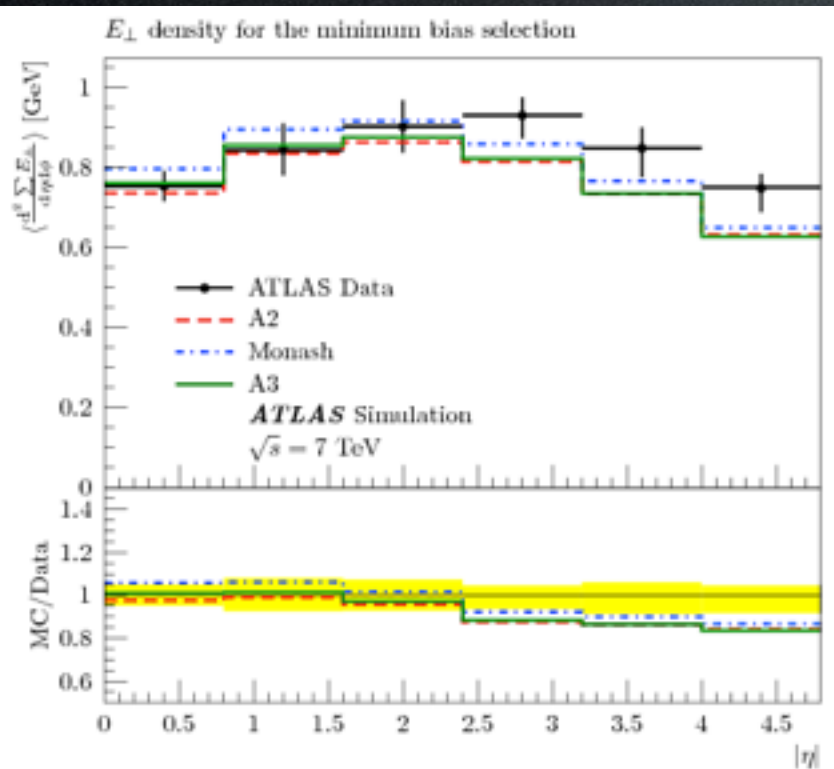# Pythia8 A3 Tune

	ATLAS data (mb)	SS (mb)	A3 (mb)
At $\sqrt{s} = 13\,\mathrm{TeV}$	68.1 ± 1.4	74.4	69.9
At $\sqrt{s} = 7\,\mathrm{TeV}$	60.3 ± 2.1	66.1	62.3

Using Donnachie-Landshoff diffractive model and NNPDF2.3LO

Much improved total inelastic cross section prediction

ATL-PHYS-PUB-2016-017

Mostly similar level of agreement with minbias observables   4

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Parameter	A3 value	A2 value	Monash value
MultipartonInteractions:pT0Ref	2.45	1.90	2.28
MultipartonInteractions:ecmPow	0.21	0.30	0.215
MultipartonInteractions:coreRadius	0.55	-	-
MultipartonInteractions:coreFraction	0.90	-	-
MultipartonInteractions:a1	-	0.03	-
MultipartonInteractions:expPow	-	-	1.85
BeamRemnants:reconnectRange	1.8	2.28	1.8
Diffraction:PomFluxEpsilon	0.07 (0.085)	-	-
Diffraction:PomFluxAlphaPrime	0.25 (0.25)	-	-

Mostly similar level of agreement with minbias observables

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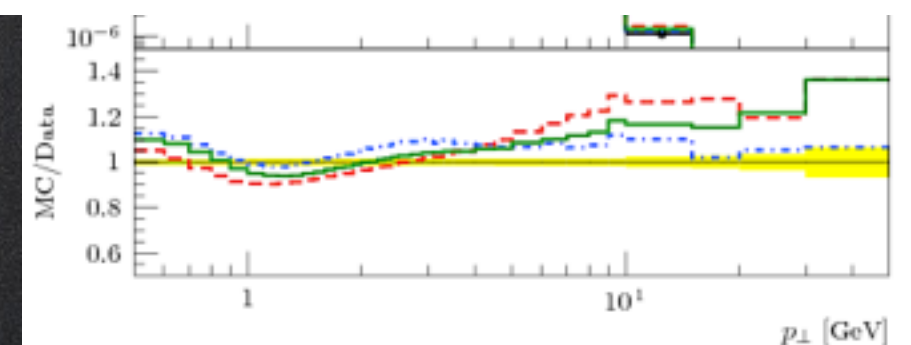
New Colour Reconnections Models in Pythia8

- CR0: Currently used MPI-based model.

- CR1: New QCD-based model, with more complete treatment of QCD multiplet structure, resulting in enhancement of baryon production.

- CR2: New gluon-move model, where only gluons are considered for reconnection.
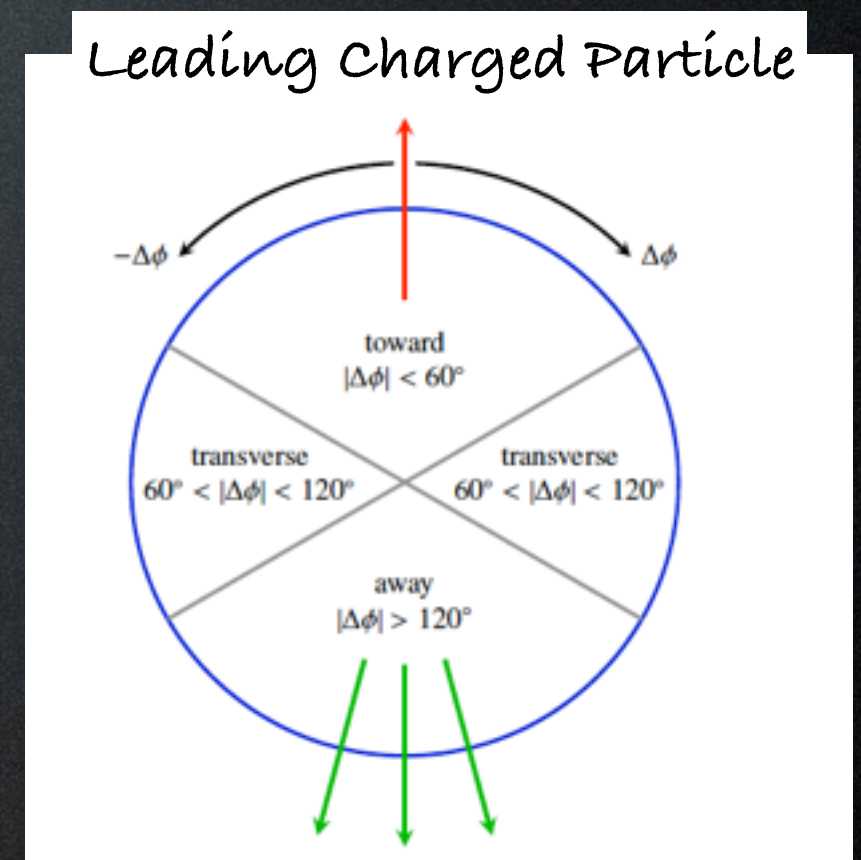
Question:

- Can the newer models describe our data reasonably well?

Underlying Event Observables

- Measured at 900 GeV, 7 TeV and 13 TeV (new!) using leading charged particle.

- Tunes are derived for each CR model, and compared to A14 predictions (which uses CR0 model), and then with A14 with CR1 and CR2.
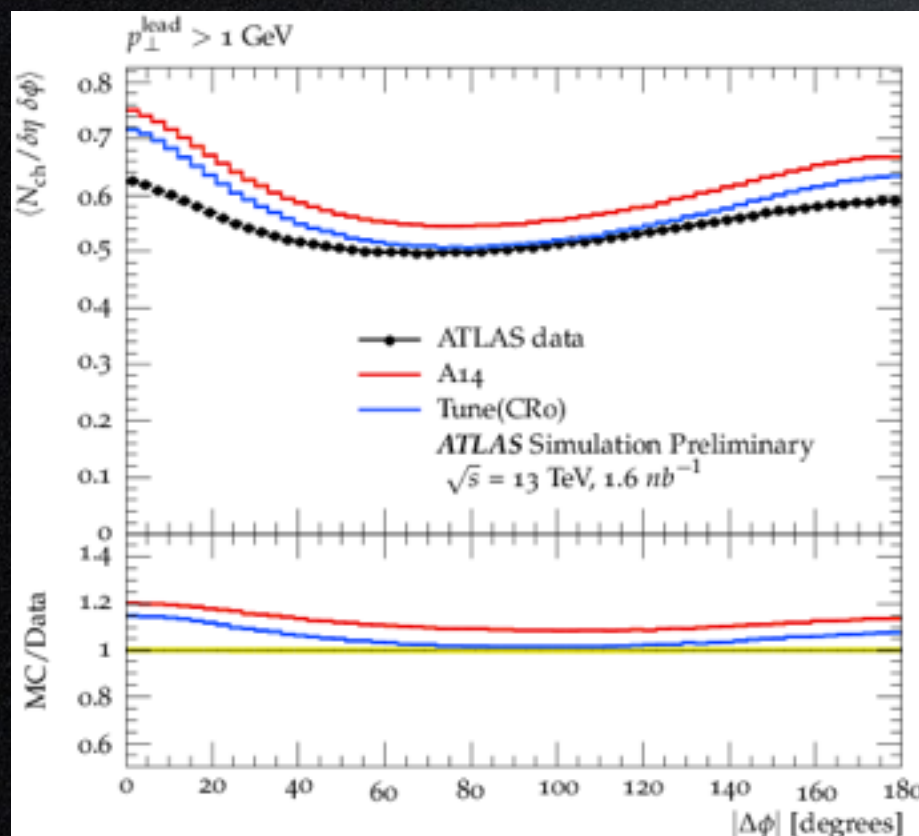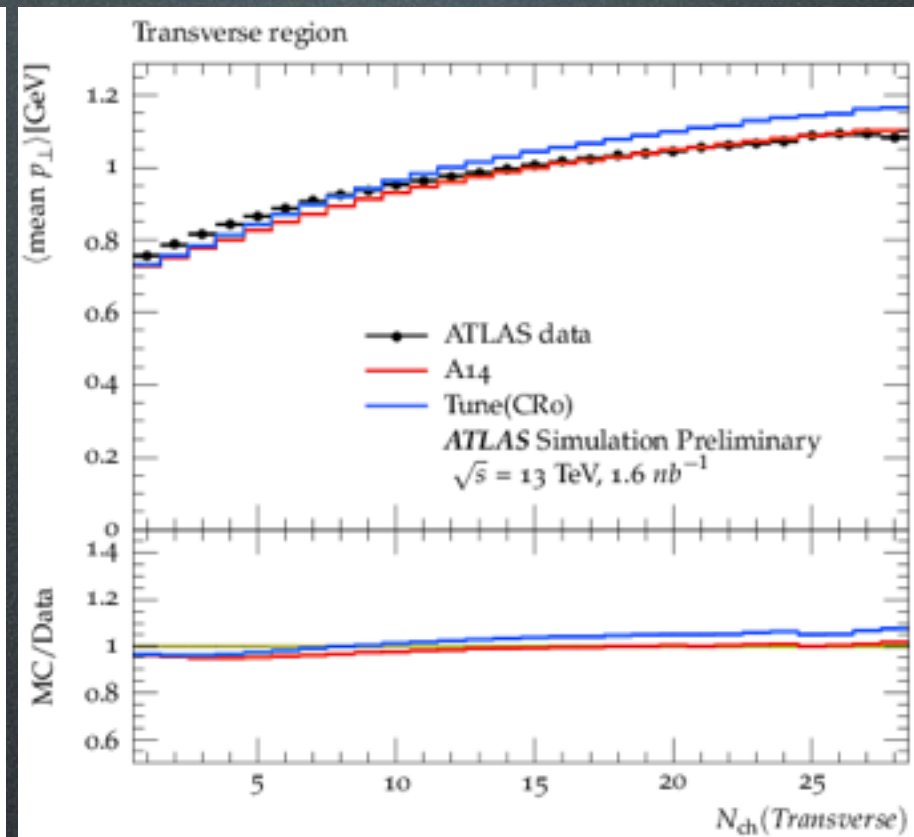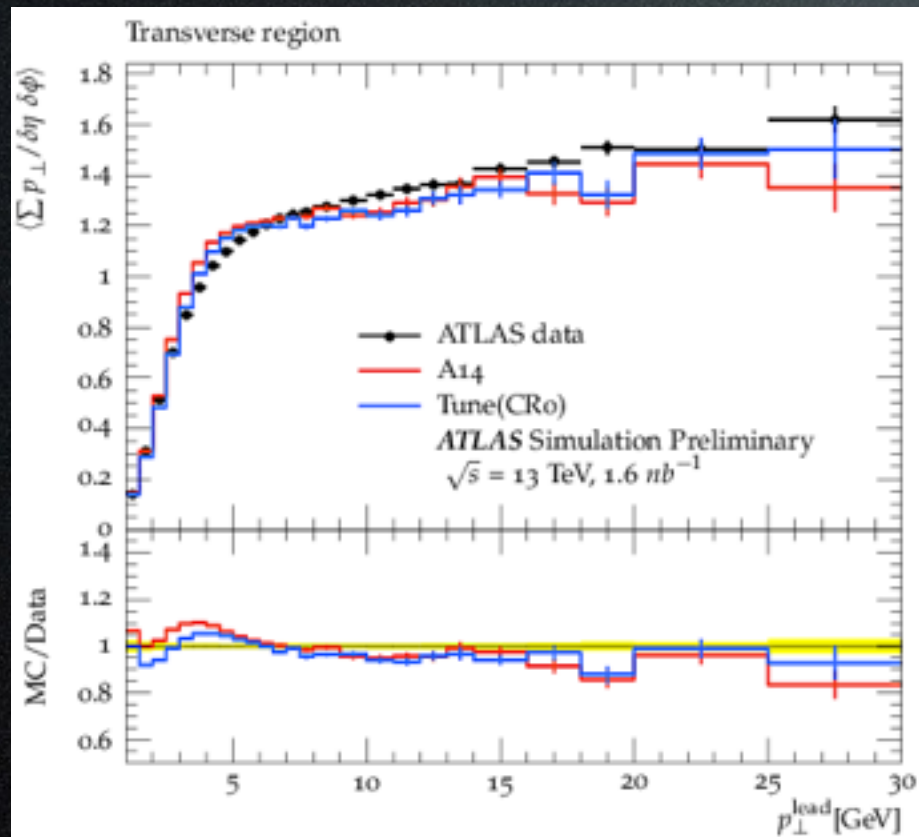

Leading Charged Particle

toward $|\Delta\phi| < 60°$

transverse $60° < |\Delta\phi| < 120°$

transverse $60° < |\Delta\phi| < 120°$

away $|\Delta\phi| > 120°$

$-\Delta\phi$ $\Delta\phi$

Only 13 TeV results shown: the trend is similar at lower collision energies, but somewhat worse agreement at 900 GeV

UE Activity: CRO

Similar level of agreement.

This data was not used in A14.
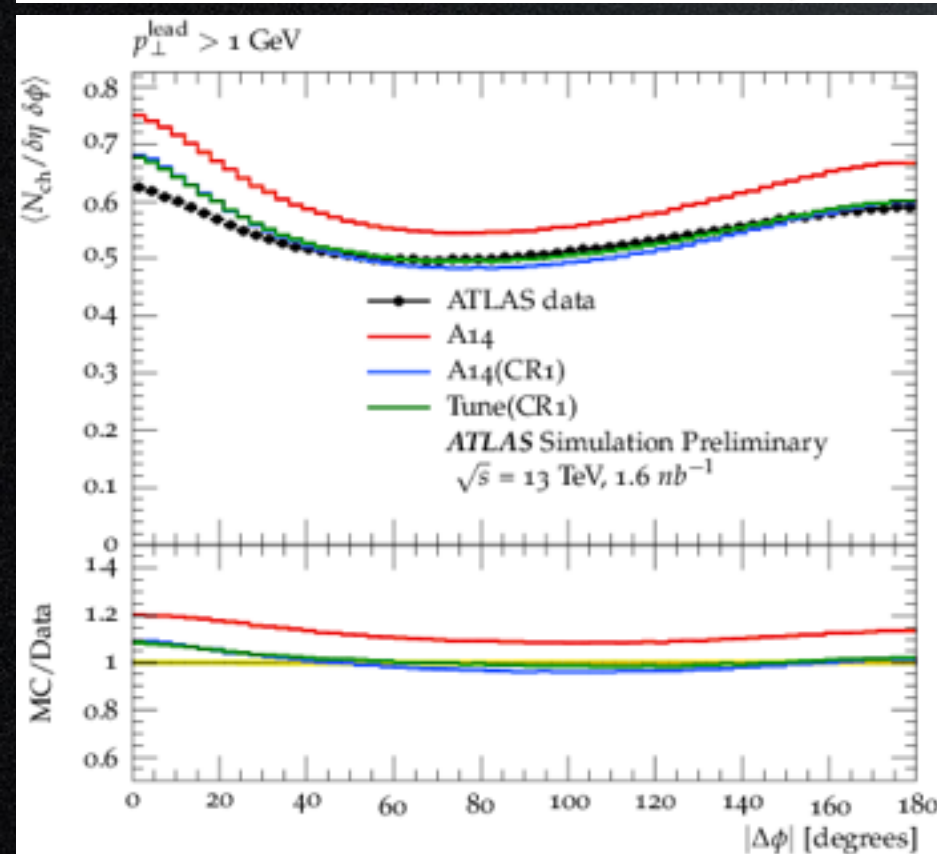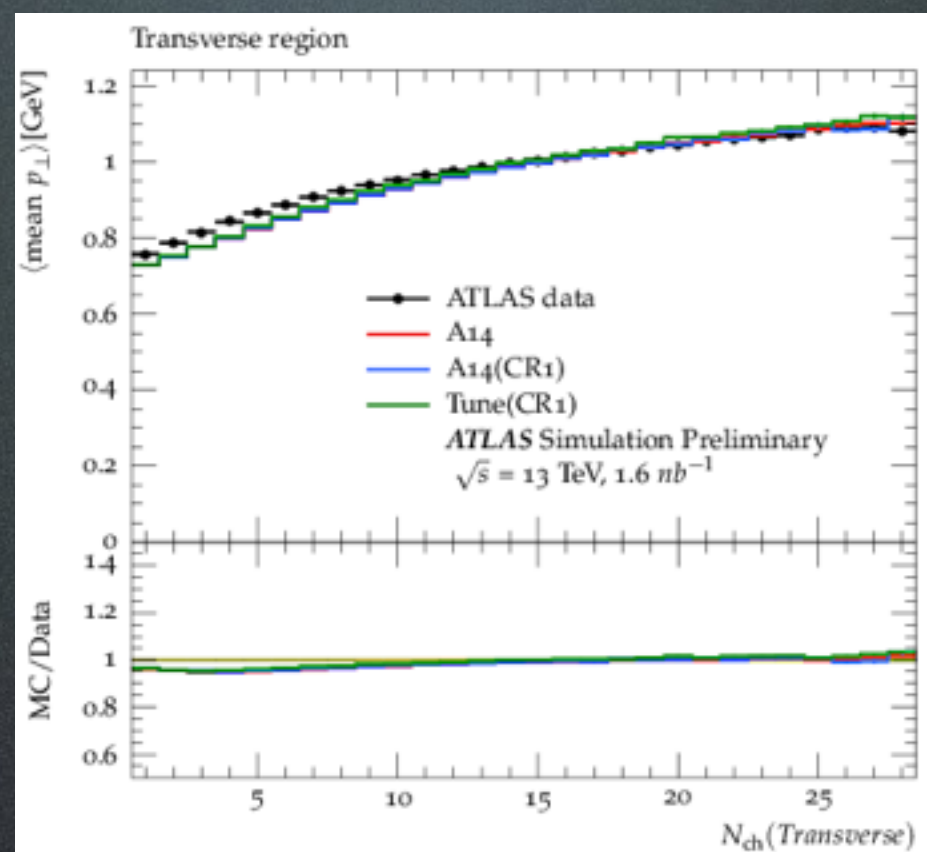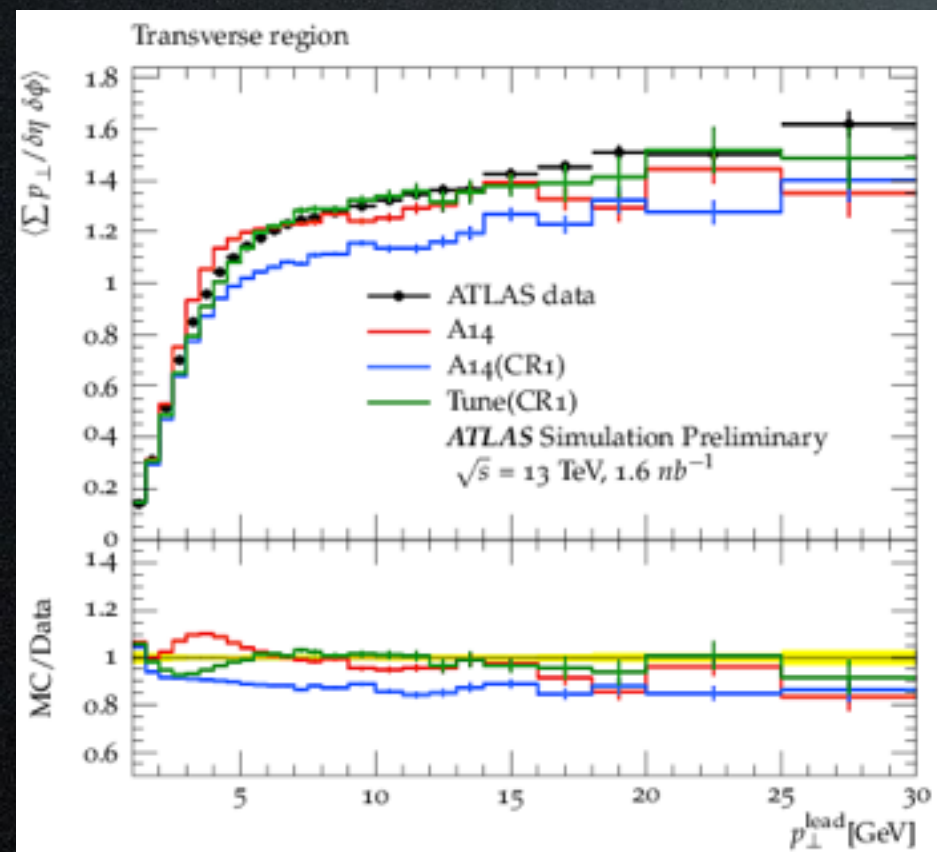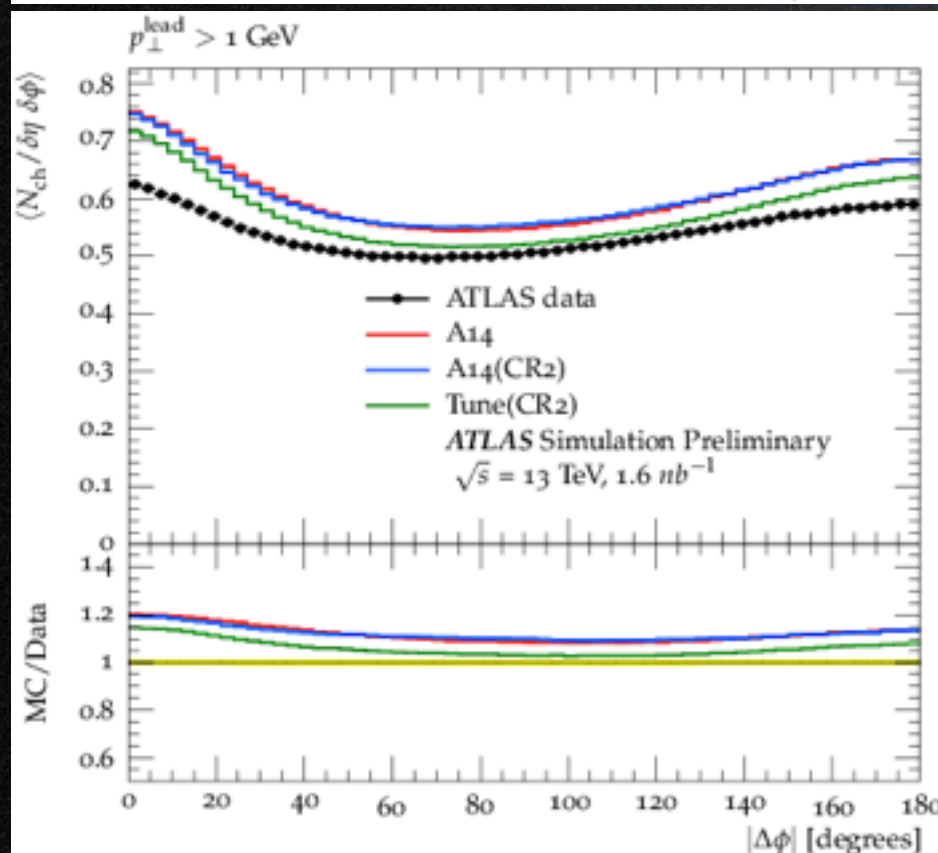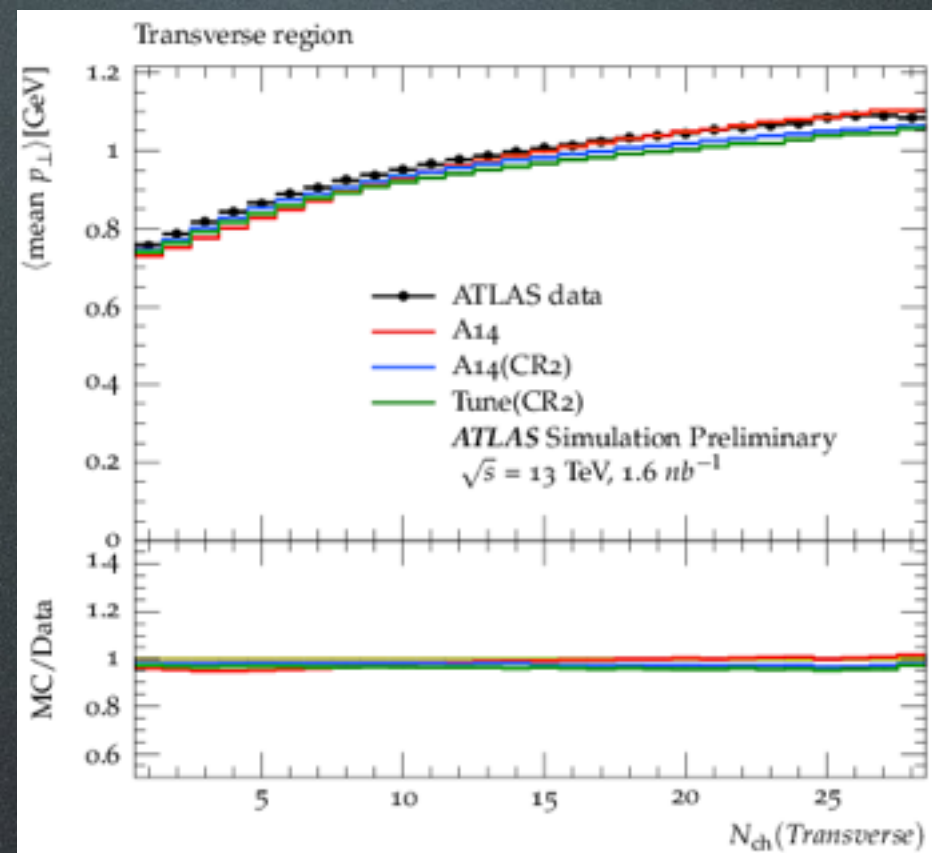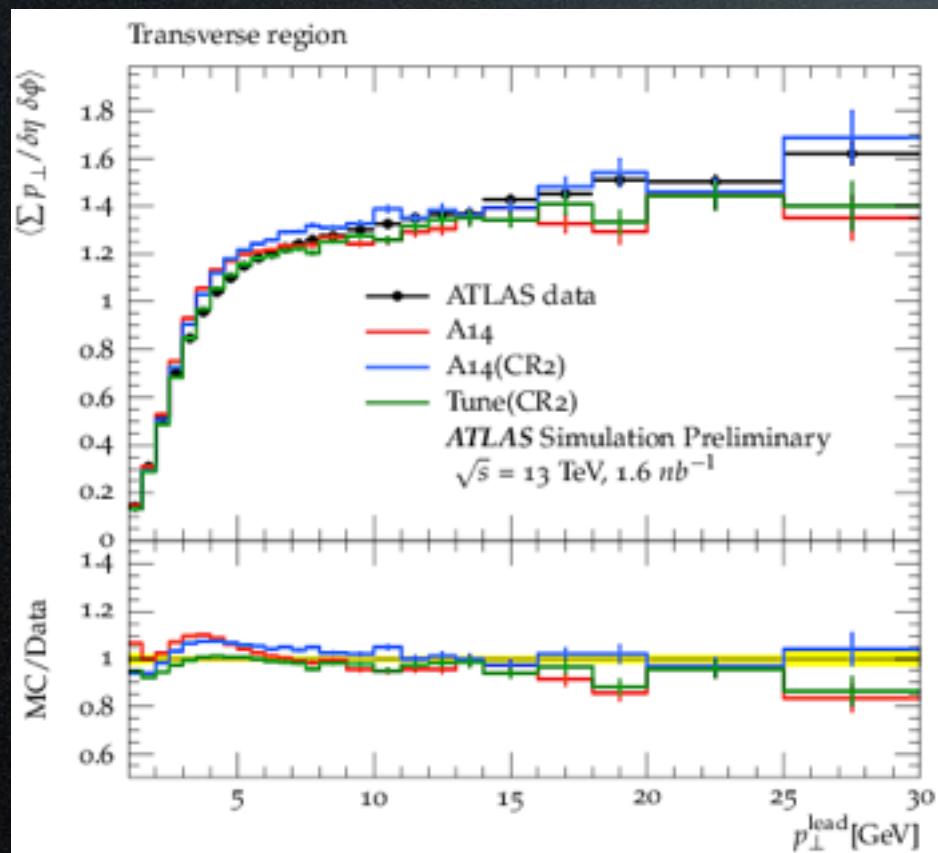
Mean p_T vs multiplicity can be modelled well.

UE Activity: CR1

Only changing to CR1 degrades performance.

Retuning helps.

UE Activity: CR2

Not a significant improvement
by retuning, more study needed.

Tuned Values

Parameter	A14/ Default (range)	Tune		
		CR0	CR1	CR2
MultipartonInteractions:pT0Ref	2.09	2.15	1.89	2.21
MultipartonInteractions:expPow	1.85	1.81	2.10	1.63
ColourReconnection:range	1.71	2.92	–	–
ColourReconnection:m0	0.3 (0.1 - 5)	–	2.17	–
ColourReconnection:junctionCorrection	1.20 (0.01 - 10)	–	9.33	–
ColourReconnection:m2Lambda	1.0 (0.25-16)	–	–	6.73
ColourReconnection:fracGluon	1.0 (0-1)	–	–	0.93
ColourReconnection:dLambdaCut	0 (0-10)	–	–	*0.0*
χ^2, Ndof		17706, 2929	18597, 2928	113814, 2928
$\chi^2/Ndof$		6.1	6.4	38.9

Worst fit for CR2 tune, but overall reasonable level of agreement can be achieved with all models.

Z-boson observables in matched setup with Madgraph

- The A14 tune has ISR rapidity ordering on.

- When showering events generated with Madgraph (upto three extra jets, CKKW-L), it introduces non-negligible dependance on merging scale.

- So efforts have been ongoing in ATLAS to retune A14 with ISR rapidity ordering off (RO) for this setup.

- Two approaches tried: tuning only Pythia8 (PS only) and tuning the matched setup.

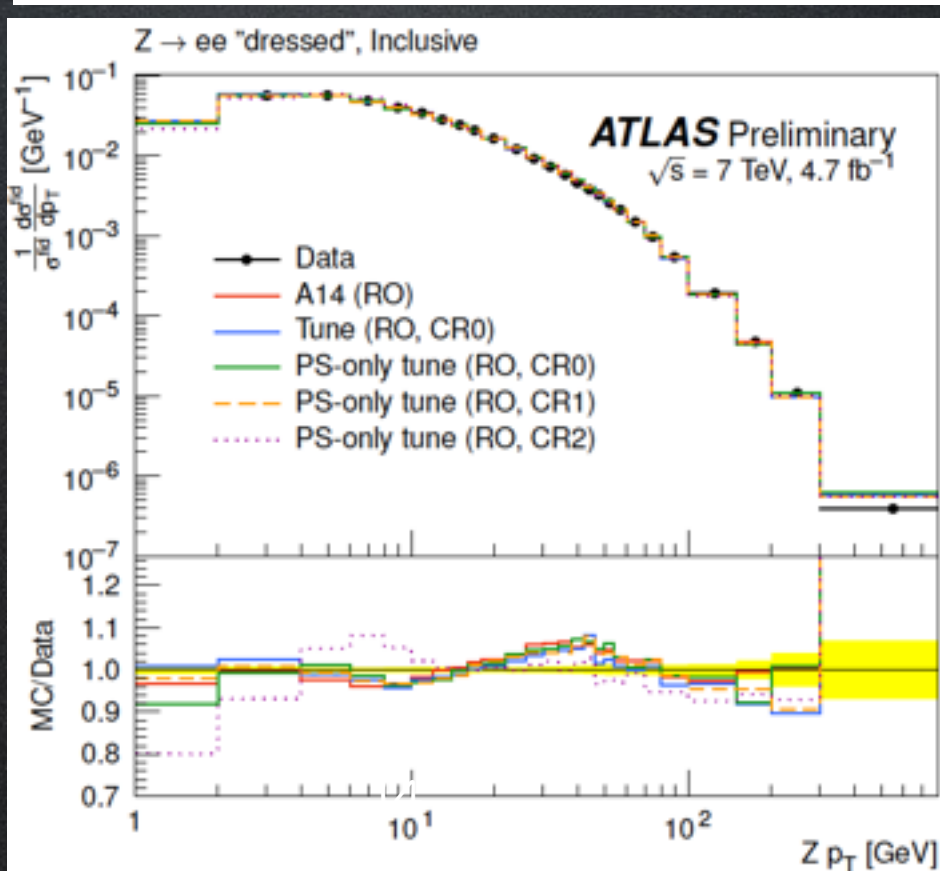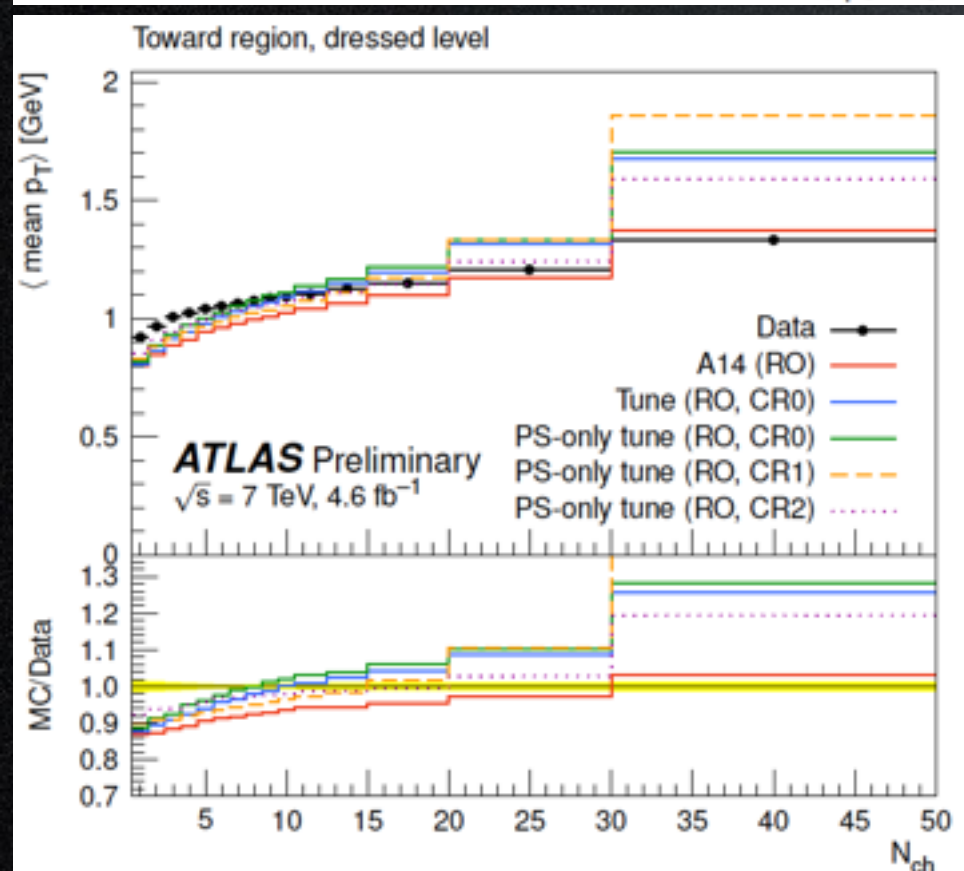- **Bonus:** also looked at new CR models.

Results
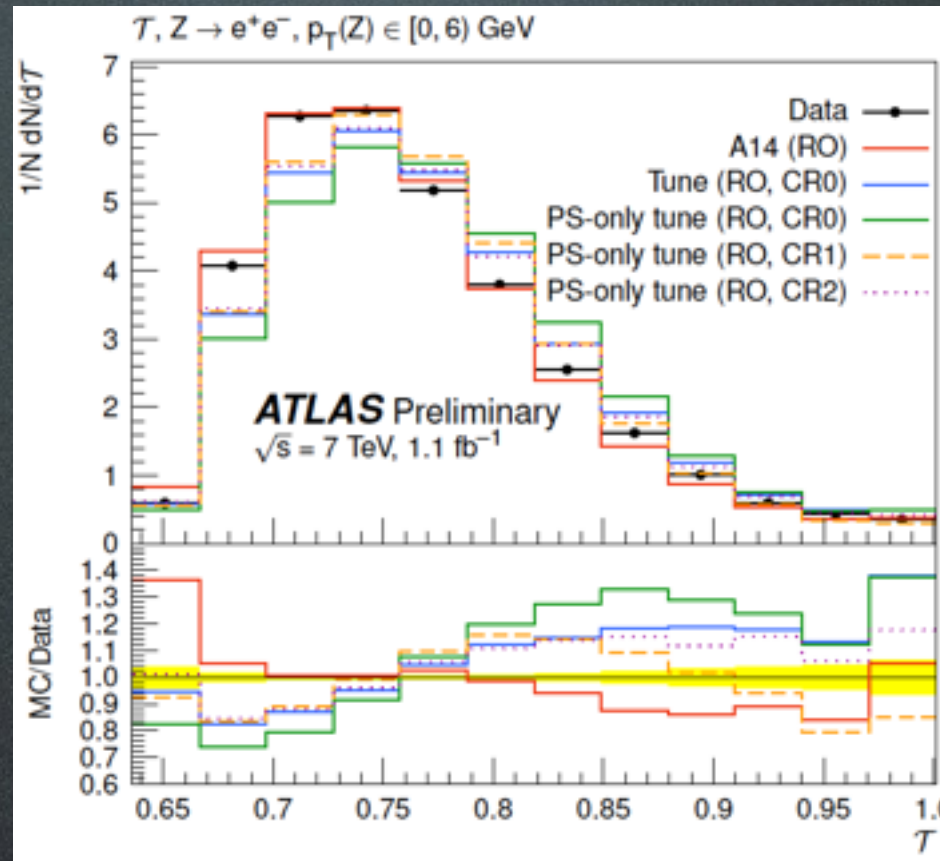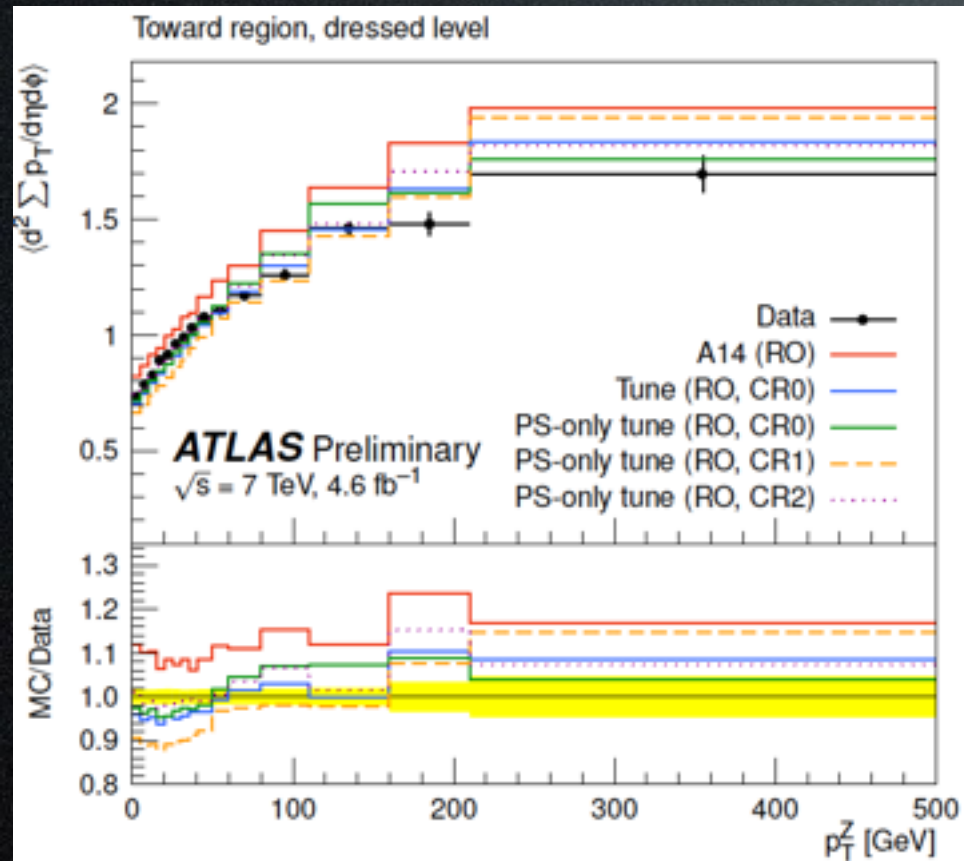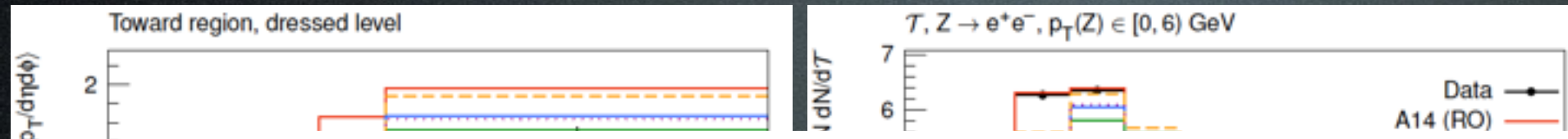
Tunes by two approaches are similar

High or low CR strength for CR0?

Shape of mean p_T vs multiplicity distributions are poorly modelled, specially compared to the earlier result.

Results

Parameter	A14/ Default (range)	PS-only tune			Tune
		CR0	CR1	CR2	
MultipartonInteractions:pT0Ref	2.09	2.05	1.89	1.97	2.20
MultipartonInteractions:expPow	1.85	1.94	2.97	2.47	NT
MultipartonInteractions:alphaSvalue	0.126	NT	NT	NT	0.125
BeamRemnants:primordialKThard	1.88	2.24	1.86	2.73	NT
ColourReconnection:range	1.71	3.35	NA	NA	6.5
ColourReconnection:m0	0.3 (0.1 - 5)	NA	3.23	NA	NA
ColourReconnection:junctionCorrection	1.20 (0.01 - 10)	NA	3.31	NA	NA
ColourReconnection:m2Lambda	1.0 (0.25-16)	NA	NA	8.87	NA
ColourReconnection:fracGluon	1.0 (0-1)	NA	NA	0.93	NA
ColourReconnection:dLambdaCut	0 (0-10)	NA	NA	0.90	NA
SpaceShower:alphaSvalue	0.125	0.127	0.125	0.121	0.125
SpaceShower:pT0Ref	1.30	2.35	1.40	1.58	NT
SpaceShower:pTdampFudge	1.21	0.80	0.92	1.09	NT
TimeShower:alphaSvalue	0.126	0.132	0.142	0.118	0.125
TimeShower:pTmin	0.50	1.45	1.51	1.52	NT
TimeShower:pTdampFudge	1.0	0.81	1.18	1.34	NT
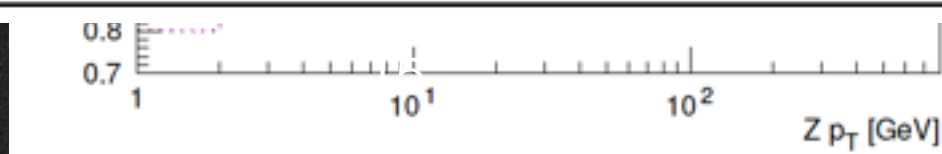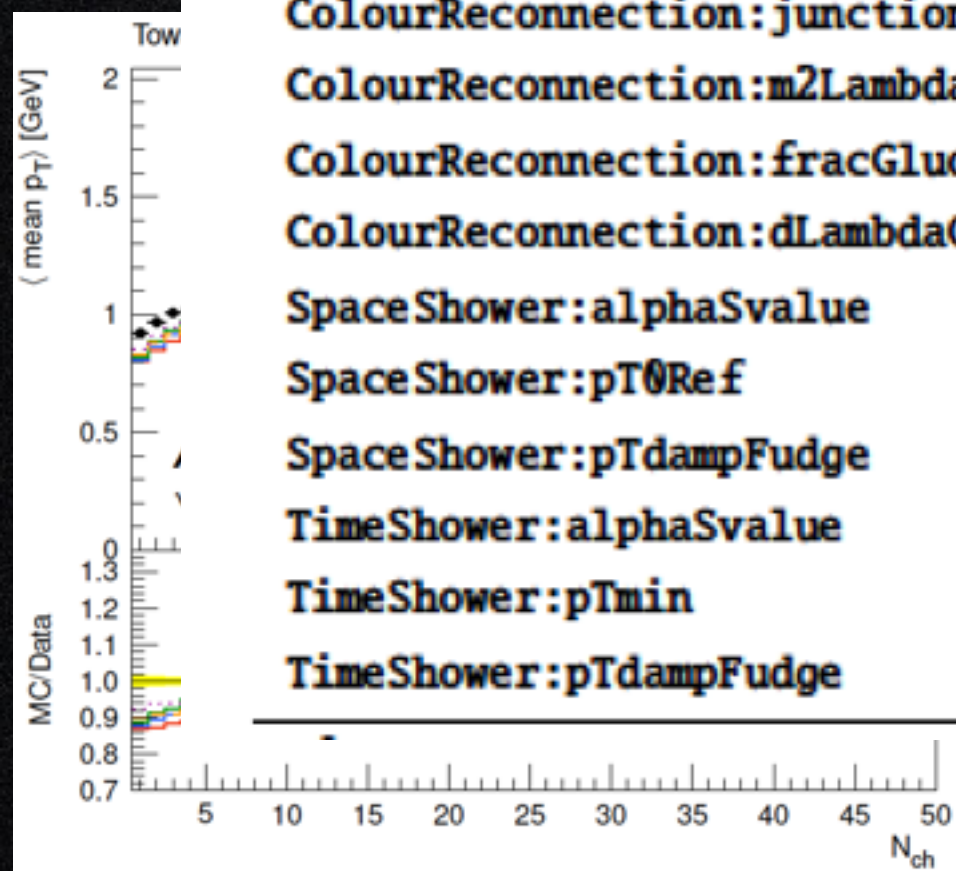
Summary

- New minbias A3 tune with improved visible cross-section description developed and to be used in ATLAS simulation.

- Underlying event distributions at three c.m energies can be described reasonably well by newer CR models.

- Retune with ISR rapidity ordering off for matched setup with Madgraph in Z-boson events is in progress.

Summary

Tuning uncertainties?

Tunes relevant for very specific phase spaces?

Better constraining gluon splitting

Is pure PS tuning dead?

And finally

Happy Birthday Josh!