Colour Reconnection - Models and Tests

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July 23, 2015
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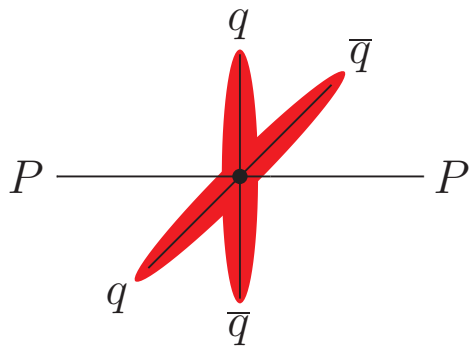
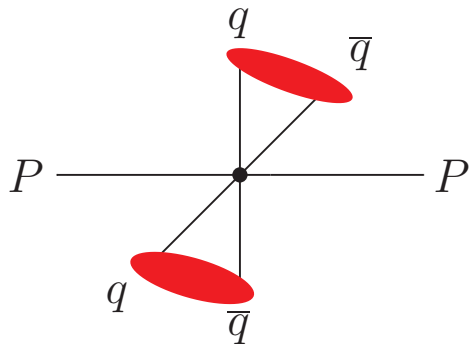
Introduction - What is Colour Reconnection?

CR address the question: between which partons do strings form?

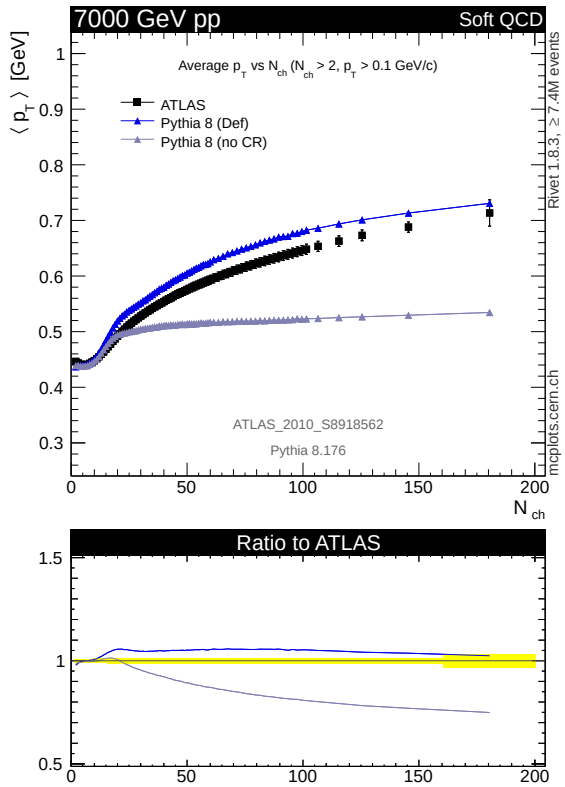
Before colour reconnection



After colour reconnection?

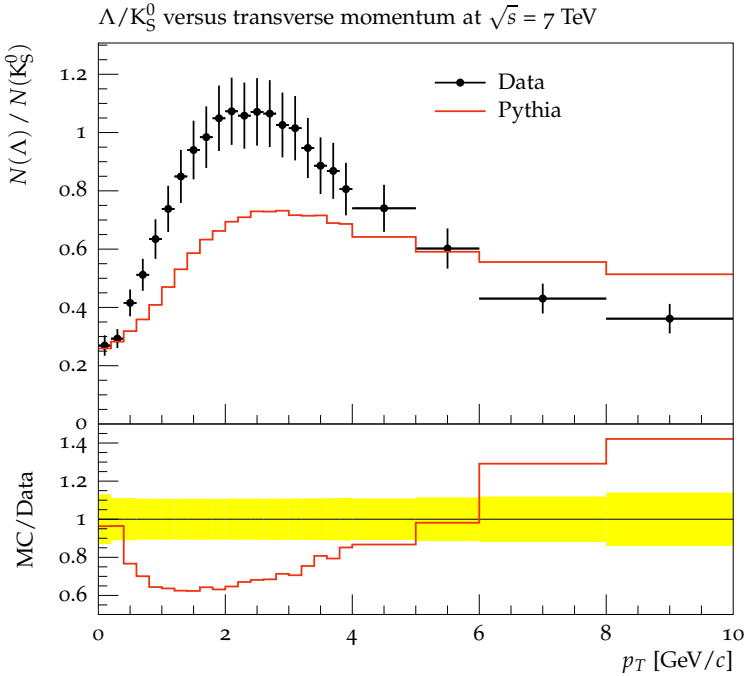


Experimentally needed to explain the rise of $\langle p_\perp \rangle$ with multiplicity



Introduction - Why now?

- Observed Λ enhancement at LHC
  - Explained by introducing "junction" structures in CR
  - Other models also explain data, e.g. EPOS and DIPSY
- To understand $p_\perp$-spectra of identified hadrons (not addressed further in this talk)

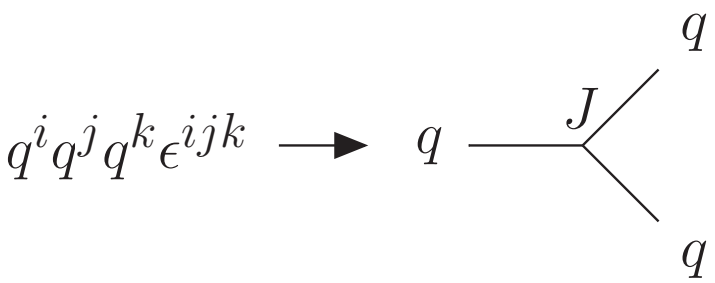


The new CR model

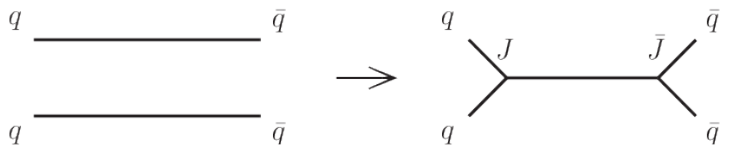
The new CR model reshuffles the colours just prior to hadronization based on three main principles:

- Use the SU(3) colour rules to determine if two strings are colour compatible
- Use a simplistic space-time picture to tell if the two strings coexist
- Minimize λ string-length measure to find which colour configurations Nature prefers

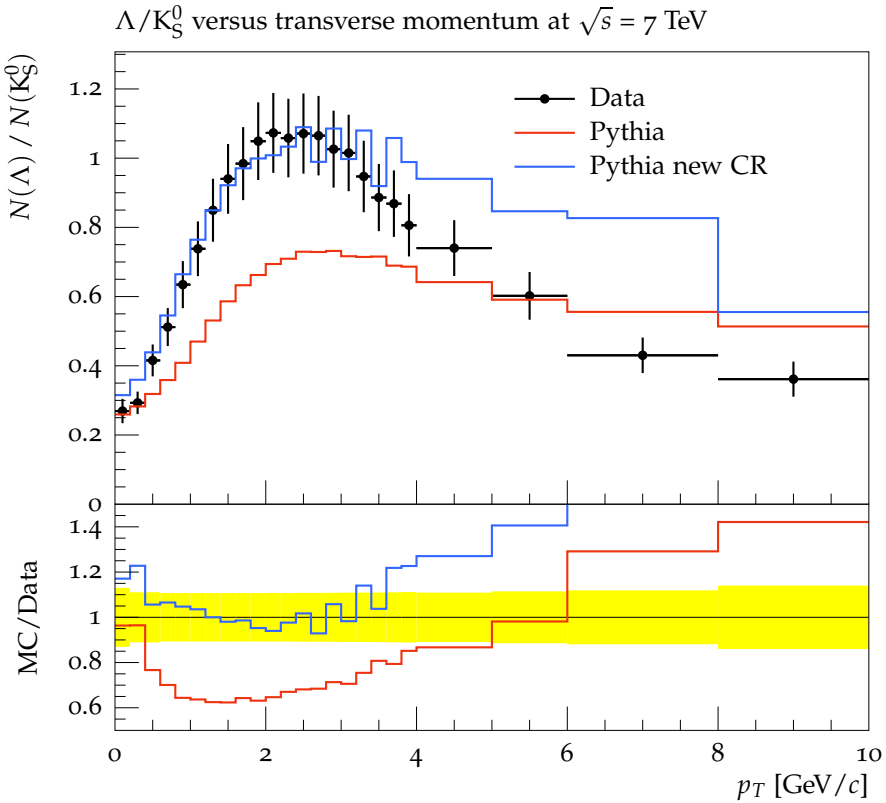
- Colour epsilon tensor corresponds to a junction structure

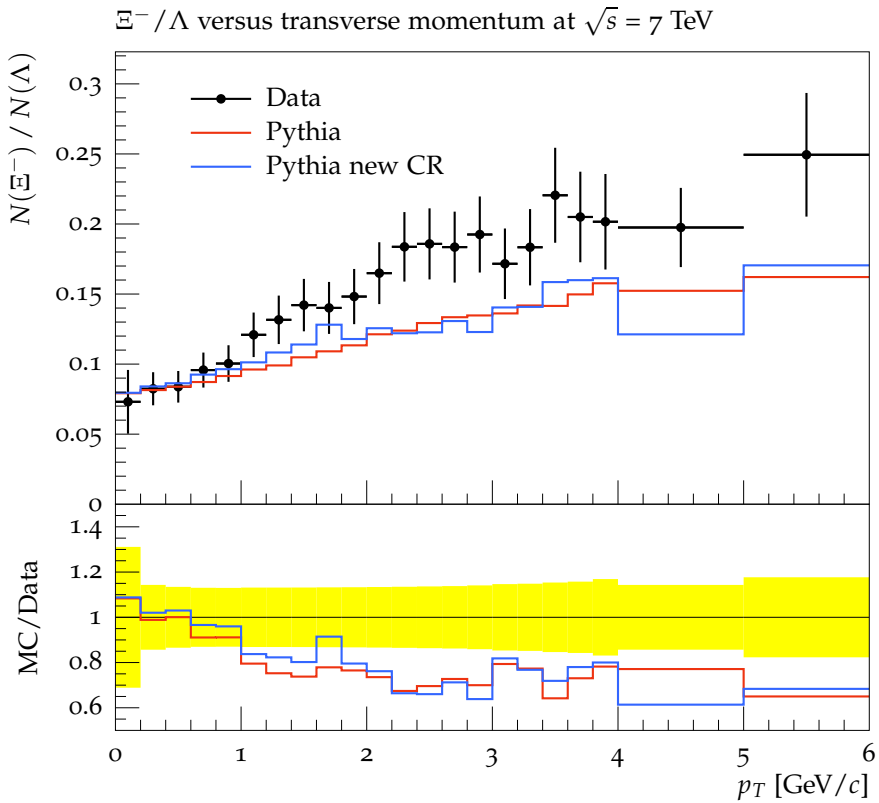


- New type of reconnection



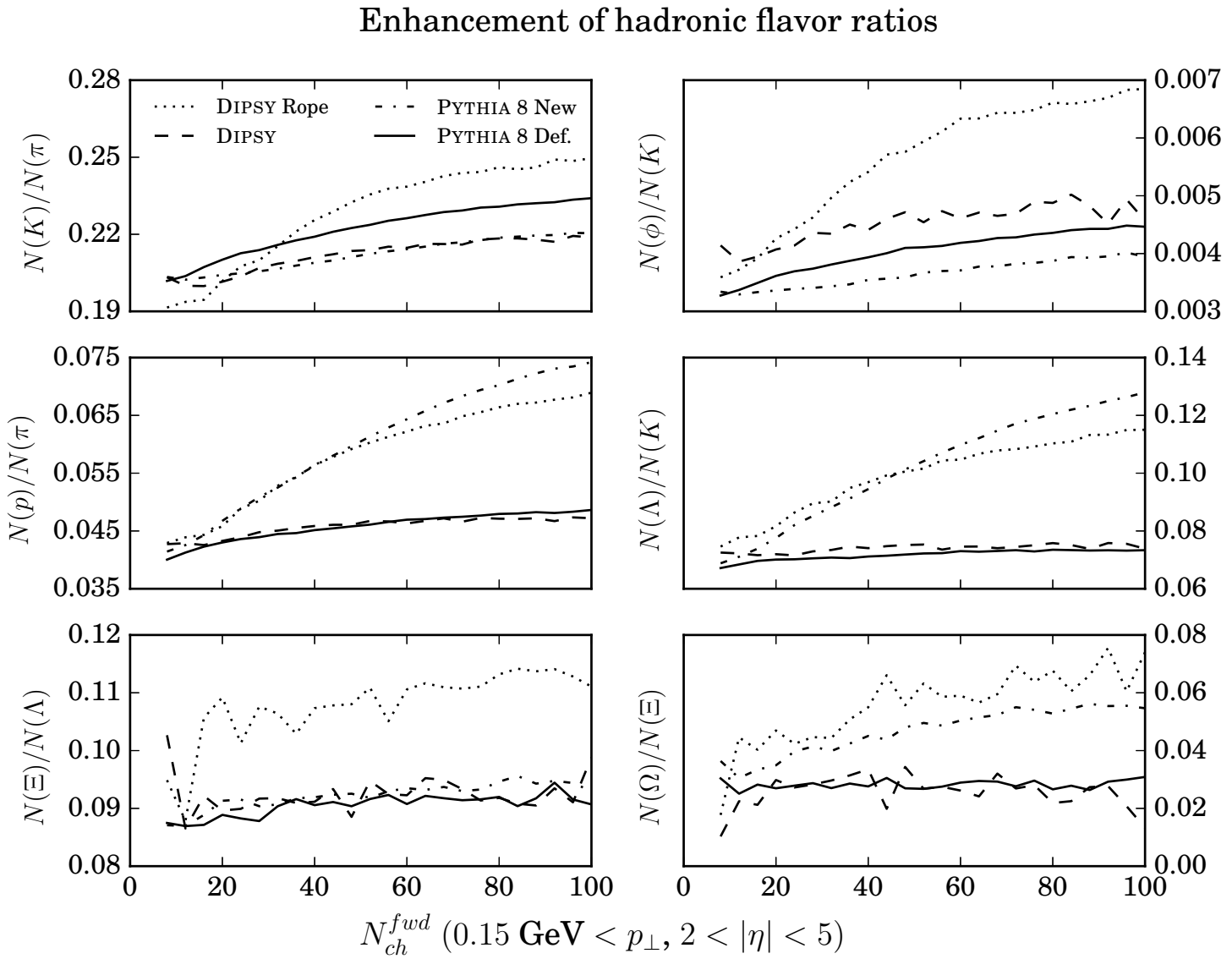
Tests - Λ/K_s and Ξ/Λ





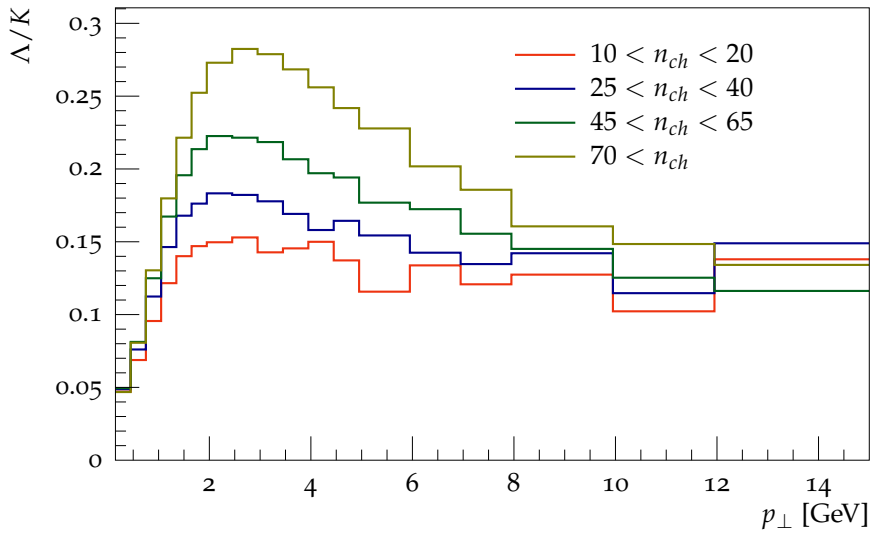
- Λ/K_S is better described by the model (overall yield is tuned)
- (No rate change in e^+e^-)
- Ξ/Λ is the same as old model - no strangeness enhancement

Multiplicity dependent particle ratios



CR and Flow-like effects

- Flow-like effects observed in pp is potentially connected with CR
- Repeat typical HI observable: Λ/K as function of $p_\perp$ separated into different multiplicity intervals (or centrality)
- Qualitative similar effect seen in the model as in HI collisions



CR in $e^+e^- \to W^+W^-$

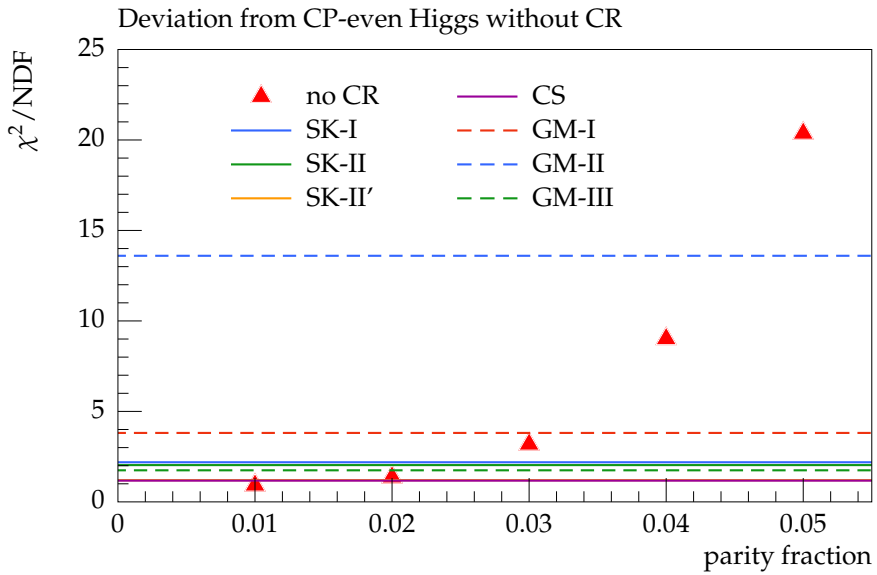
- Clean environment to test CR effects
- CR established at 2.8 σ
- Turn table around and use precision studies to constrain CR (e.g. W mass measurement, see table)
- Dedicated angular studies in fully hadronic WW
- Multiplicity comparisons between semi-leptonic and fully hadronic WW

Model	$\langle \delta \overline{m}_{\mathrm{W}} \rangle$ (MeV)		
	170 GeV	240 GeV	350 GeV
SK-I	+18	+95	+72
SK-II	-14	+29	+18
SK-II'	-6	+25	+16
GM-I	-41	-74	-50
GM-II	+49	+400	+369
GM-III	+2	+104	+60
CS	+7	+9	+4

Table : Systematic W mass shifts at three different center-of-mass energies.

CR in $H \to W^+W^-$

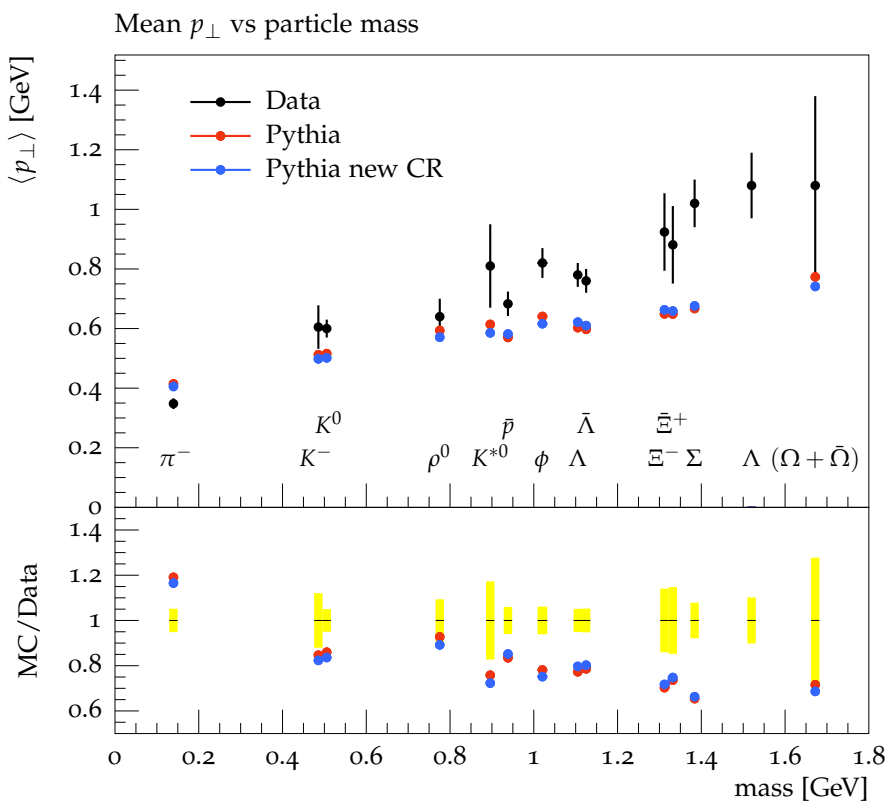
- Need to include CR as an uncertainty
- Example: Higgs Parity measurement in $\mathrm{WW} \to \mathrm{q\bar{q}q\bar{q}}$
  - Select events with four jets
  - Compare interjet angles using a simple χ^2 test
  - Compare between different CR models and different amount of CP-oddness in the Higgs
  - The analysis contains room for improvements

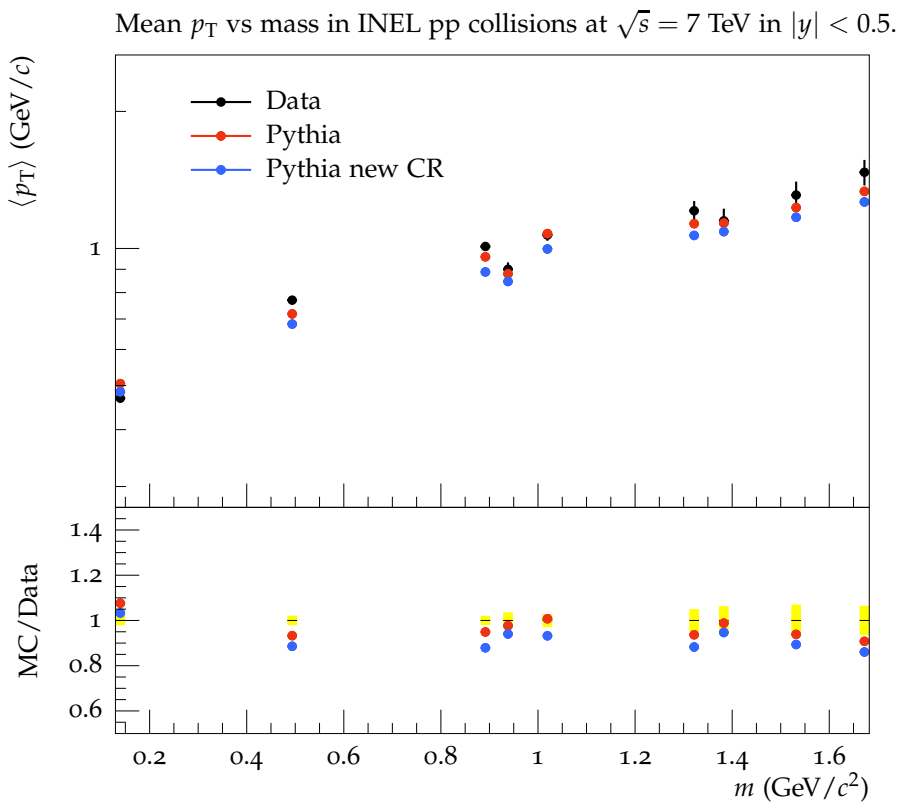


Conclusion

- I presented a new CR model able to describe the Λ/K_s ratio
- Identified particle ratios as a function of multiplicity is an excellent probe to test CR models
- Similarity between CR and flow-like effects in pp was presented, more studies still needed
- CR in e^+e^- collisions both provides constraints and needs to be included as an uncertainty
- All the CR models are publicly available in PYTHIA 8.210
- For more details see: arXiv:1507.02091, arXiv:1506.09085, arXiv:1505.01681

Tests - $p_\perp$ boosts





- Expected larger boosts for heavier particles - no effects for new model
- Discrepancy largest at low CM energies