The Monash 2013 Tune of PYTHIA 8

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Current Default = **4C** (from 2010)

LEP tuning undocumented (from 2009)
LHC tuning only used very early data
based on CTEQ6L1

Aims for the Monash 2013 Tune

- Revise (and document) constraints from e^+e^- measurements
  - In particular in light of possible interplays with LHC measurements
- Test drive the new NNPDF 2.3 LO PDF set (with $\alpha_s(m_Z) = 0.13$) for pp & ppbar
  - Update min-bias and UE tuning + energy scaling → 2013
  - Follow "Perugia" tunes for PYTHIA 6: use same α_s for ISR and FSR
  - Use the PDF value of α_s for both hard processes and MPI

In Pythia 8.185
Tune:ee = 7; Tune:pp = 14
+ complete writeup (Apr 22 2014): arXiv:1404.5630

Monash University
Melbourne

Overview

- Current tunes:
  - ~ describe average UE properties
  - Reasonable agreement with LHC min-bias data on charged tracks in central region (except for tails)
- Discrepancies have been observed
  - In particular in forward region and for identified particles (strange particles and baryons)
    - Collective phenomena? Flow? CR?
- Not much of this has yet been put in the context of the constraints from LEP
  - E.g., how much room is there to adjust strangeness and baryon rates and spectra at LEP?

Definitions

Revised definition of chi2:

We include a blanket 5% "theory uncertainty" in the definition of the χ^2 value, as a baseline sanity limit for the achievable accuracy of the modelling

Also gives a basic protection against overfitting.

To avoid low statistics generating artificially low χ^2 values, we use the generated MC statistics to compute a ± uncertainty on the calculated χ^2 value:

$$\langle \chi^2_{5\%} \rangle = \frac{1}{N_{\mathrm{bins}}} \sum_{i=1}^{N_{\mathrm{bins}}} \frac{(\mathrm{MC}_i - \mathrm{Data}_i)^2}{\sigma^2_{\mathrm{Data},i} + (0.05\mathrm{MC}_i)^2}$$

with the corresponding MC uncertainty, $\sigma_{\mathrm{MC,i}}$, used to compute the statistical uncertainty on the χ^2

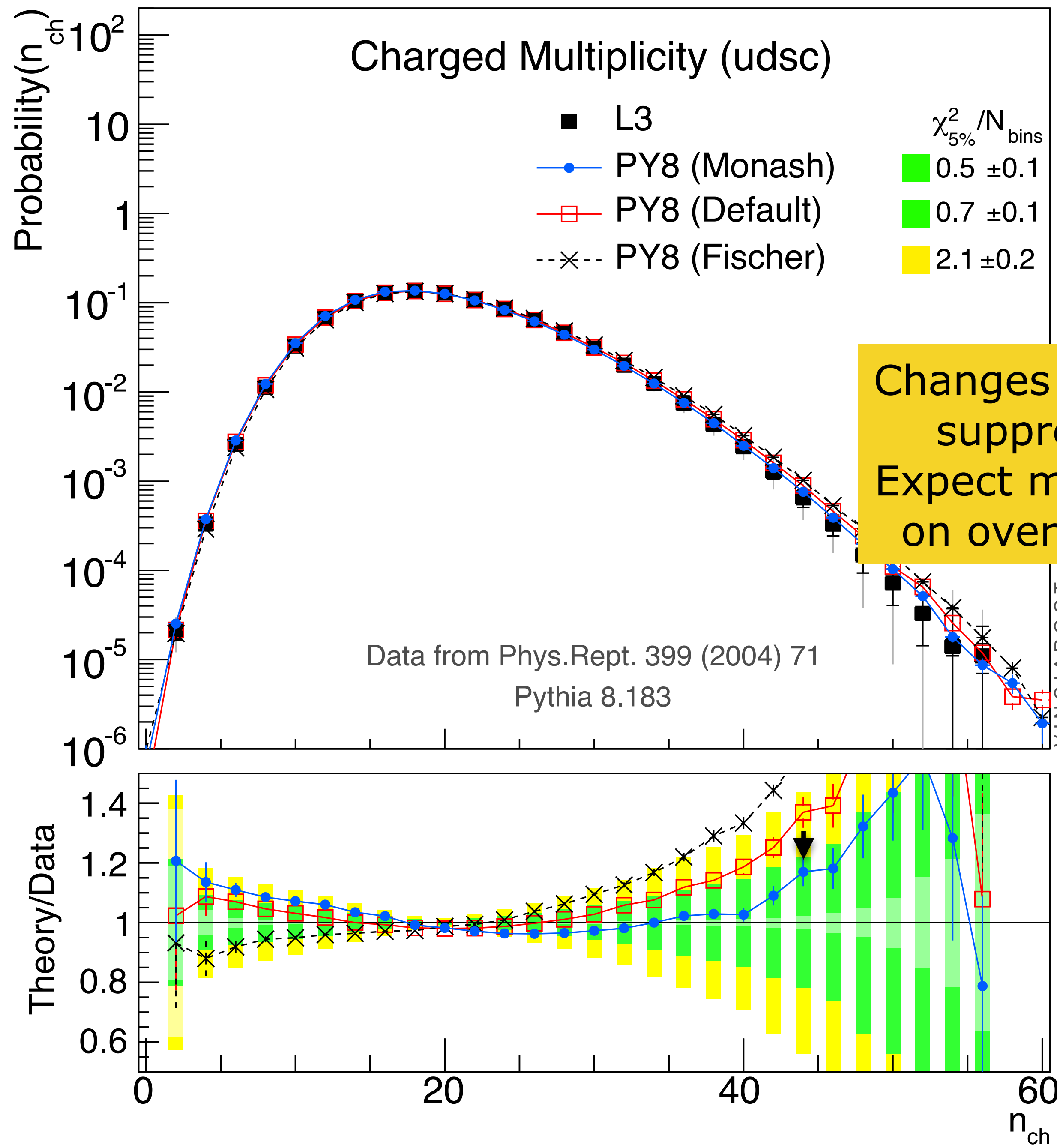
Example:

1-Thrust (udsc)

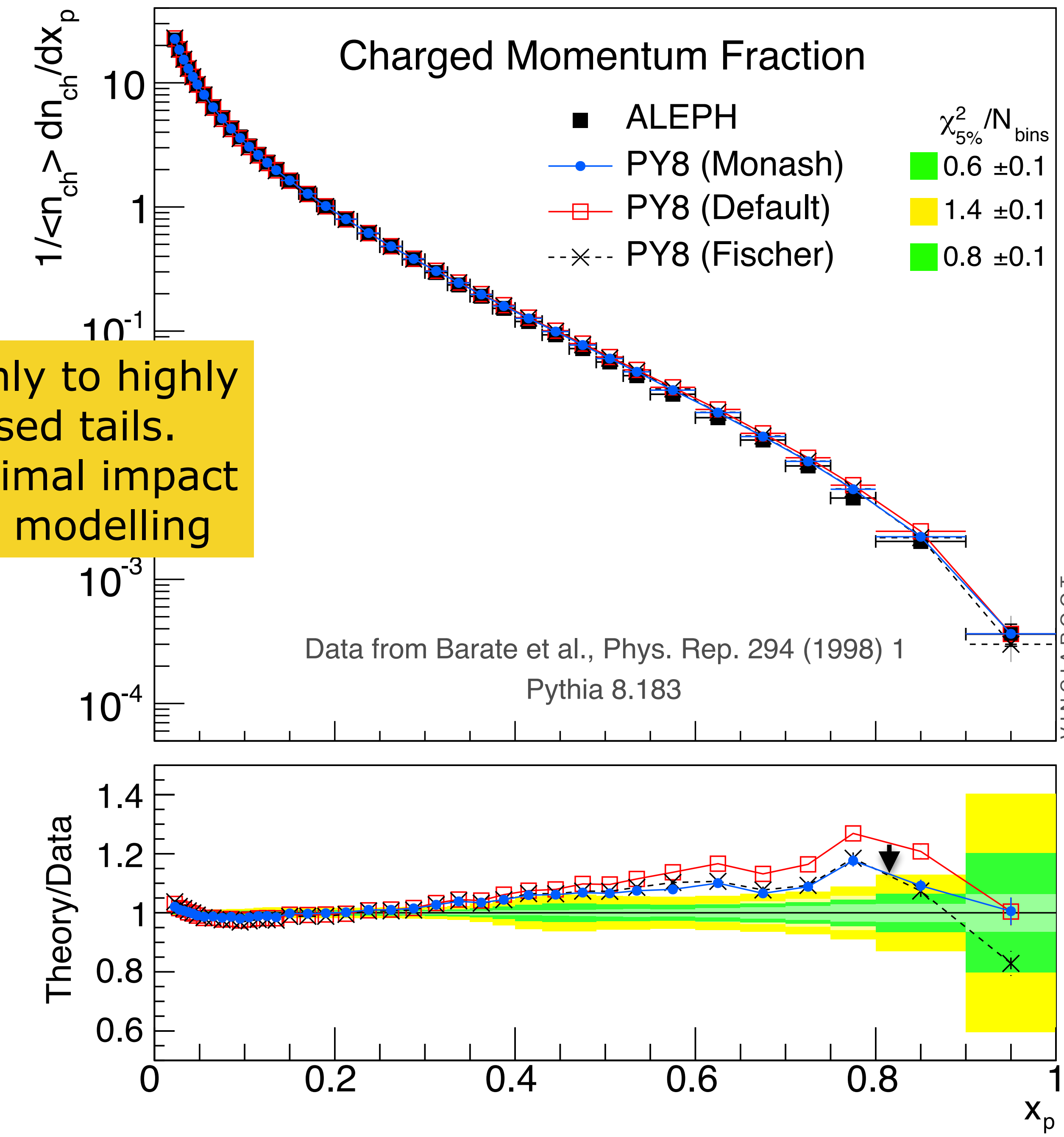
	$\chi^2_{5\%}/N_{\mathrm{bins}}$
L3	
PY8 (Monash)	0.3 ±0.1
PY8 (Default)	0.4 ±0.1
PY8 (Fischer)	0.5 ±0.2

LEP : Nch & $x_{p=2|p|/M_Z}$

Slightly lower large-N_{ch} tail



Slightly softer ultra-hard tail



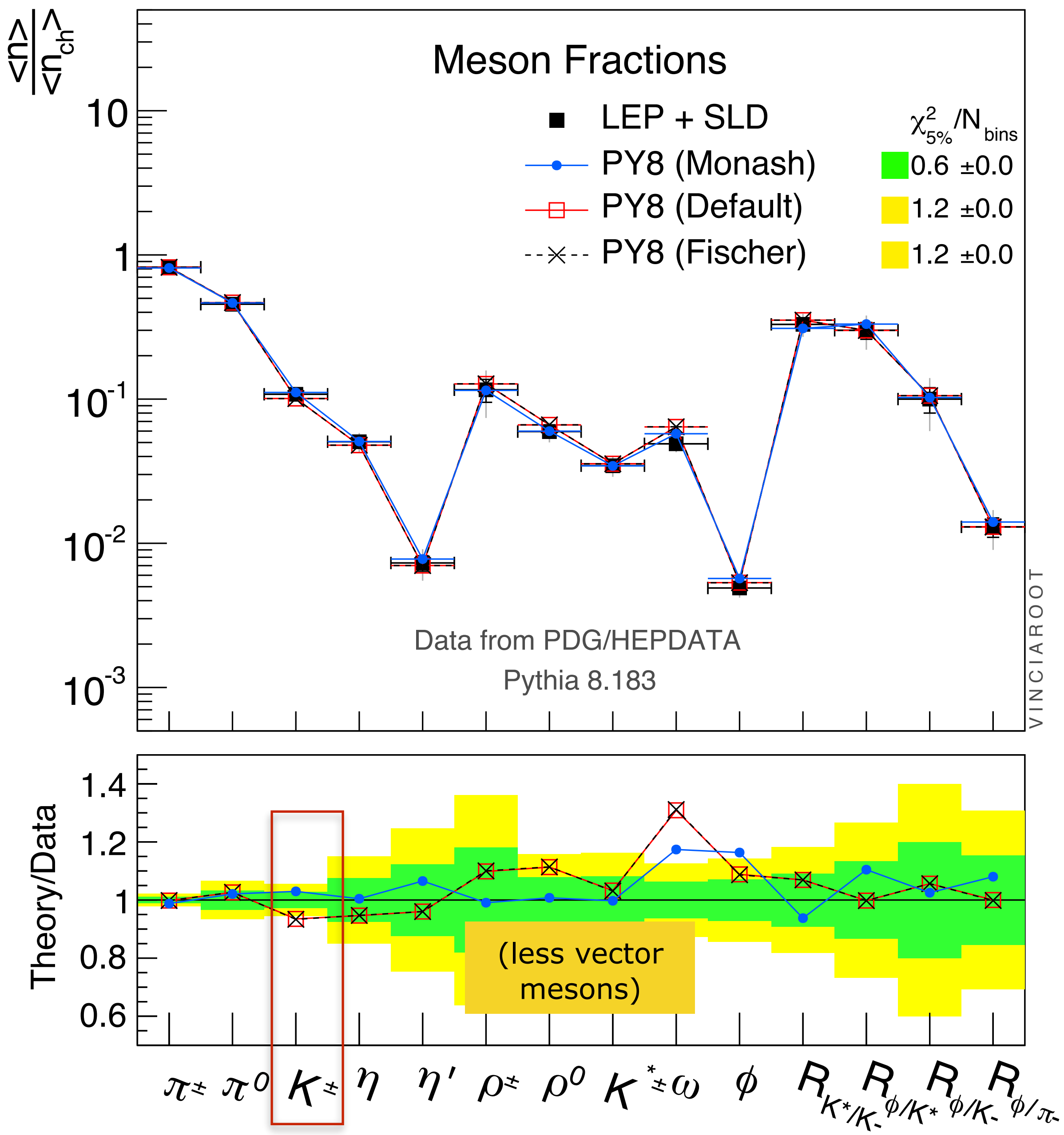
Changes only to highly suppressed tails. Expect minimal impact on overall modelling

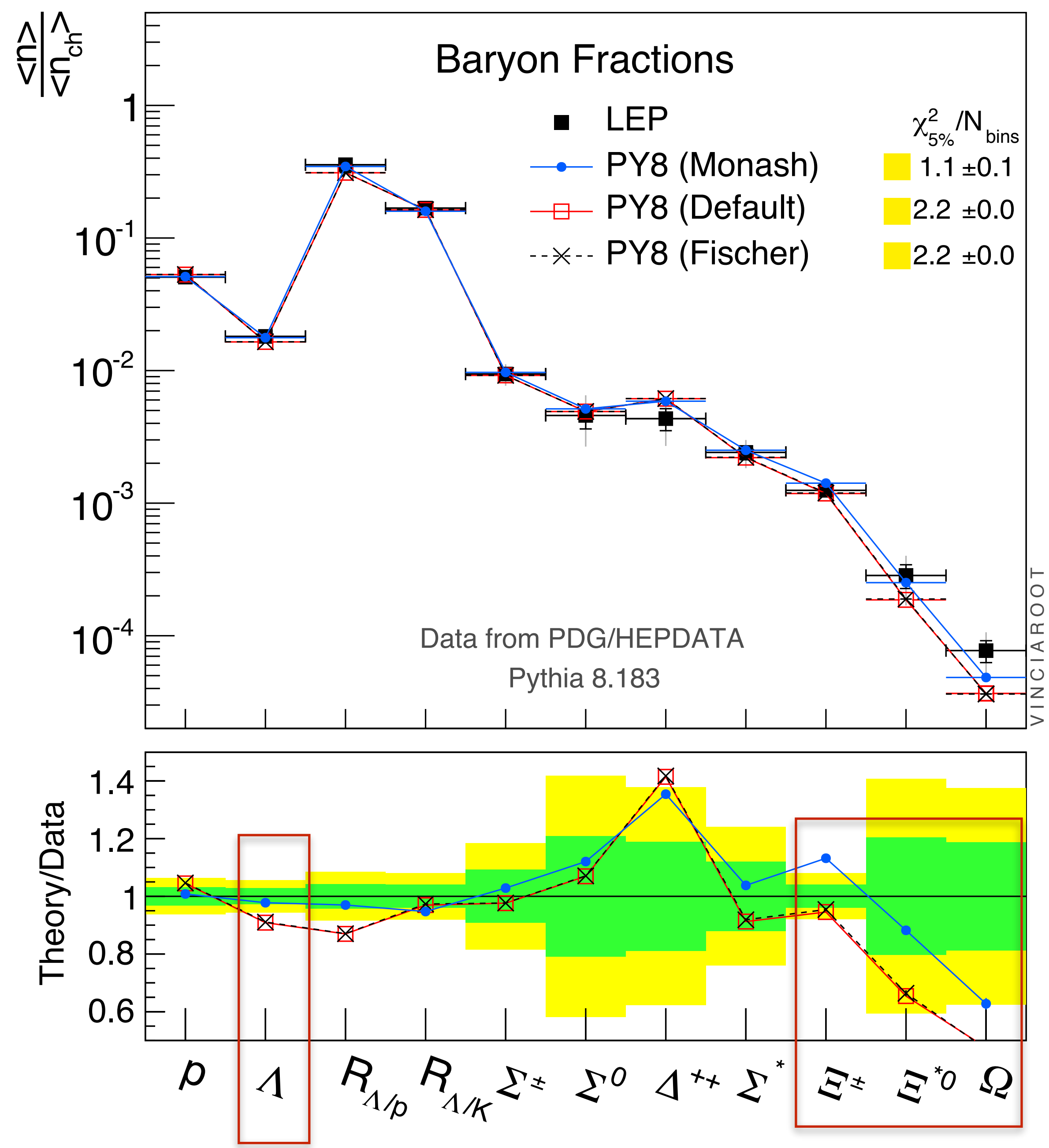
Note: these fragmentation parameters go directly into the modelling of diffraction

Strangeness

10% More Strangeness

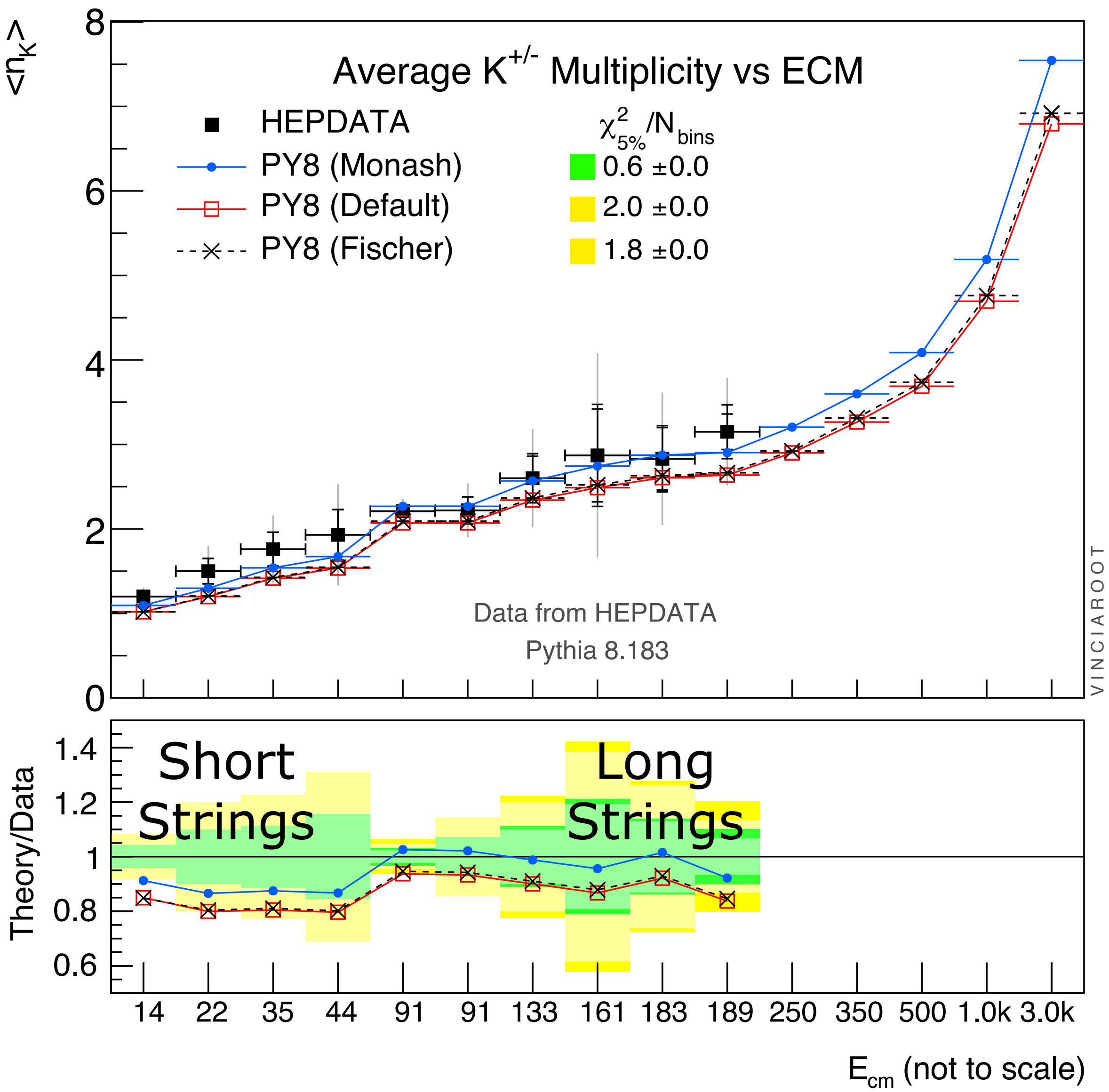
StringFlav:ProbStoUD = 0.217 **M13** = 0.19 **4C**

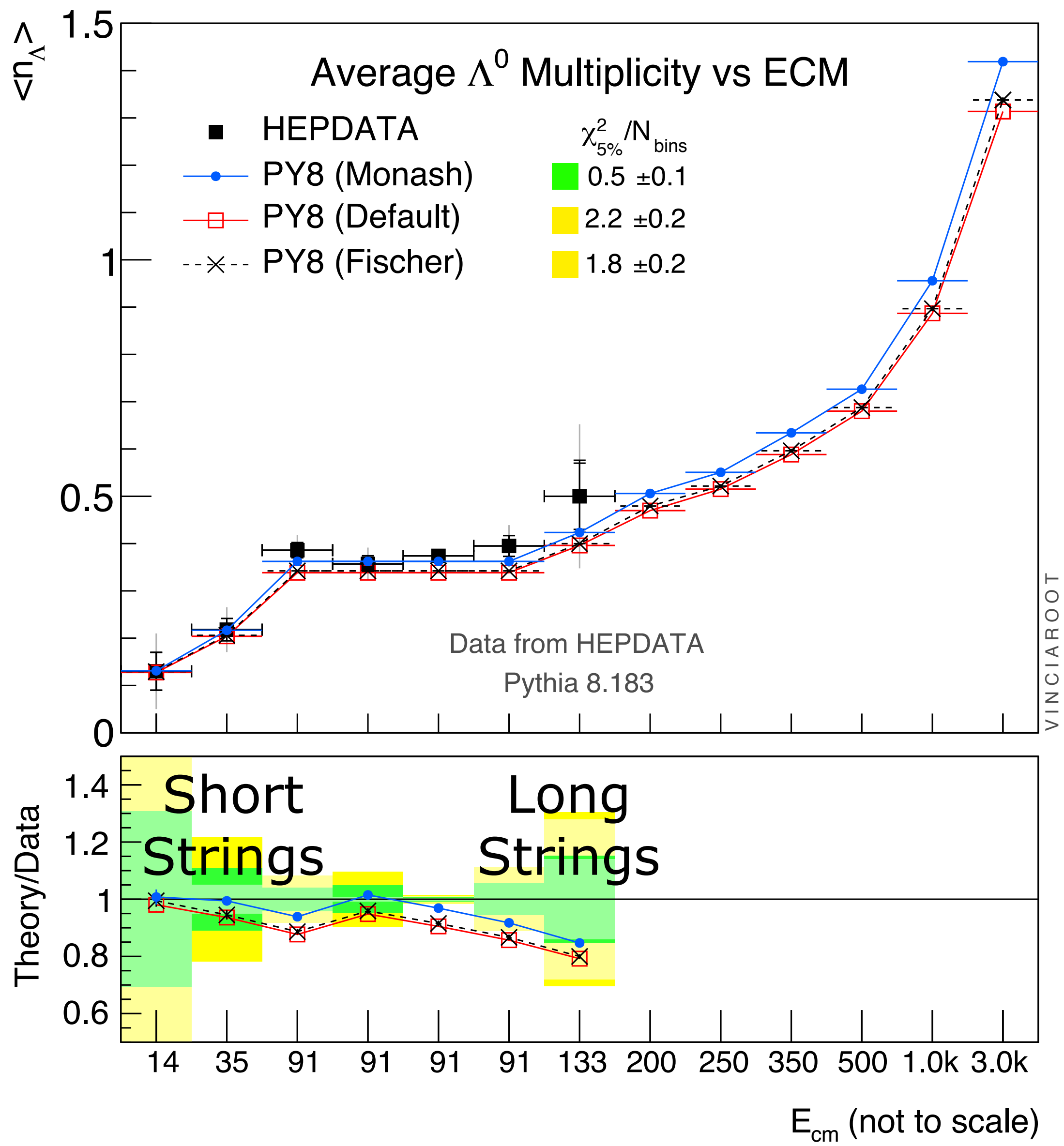




Consistency: Rates of D_s and B_s also improve. Kaon fraction at LHC also improves

Strangeness: scaling

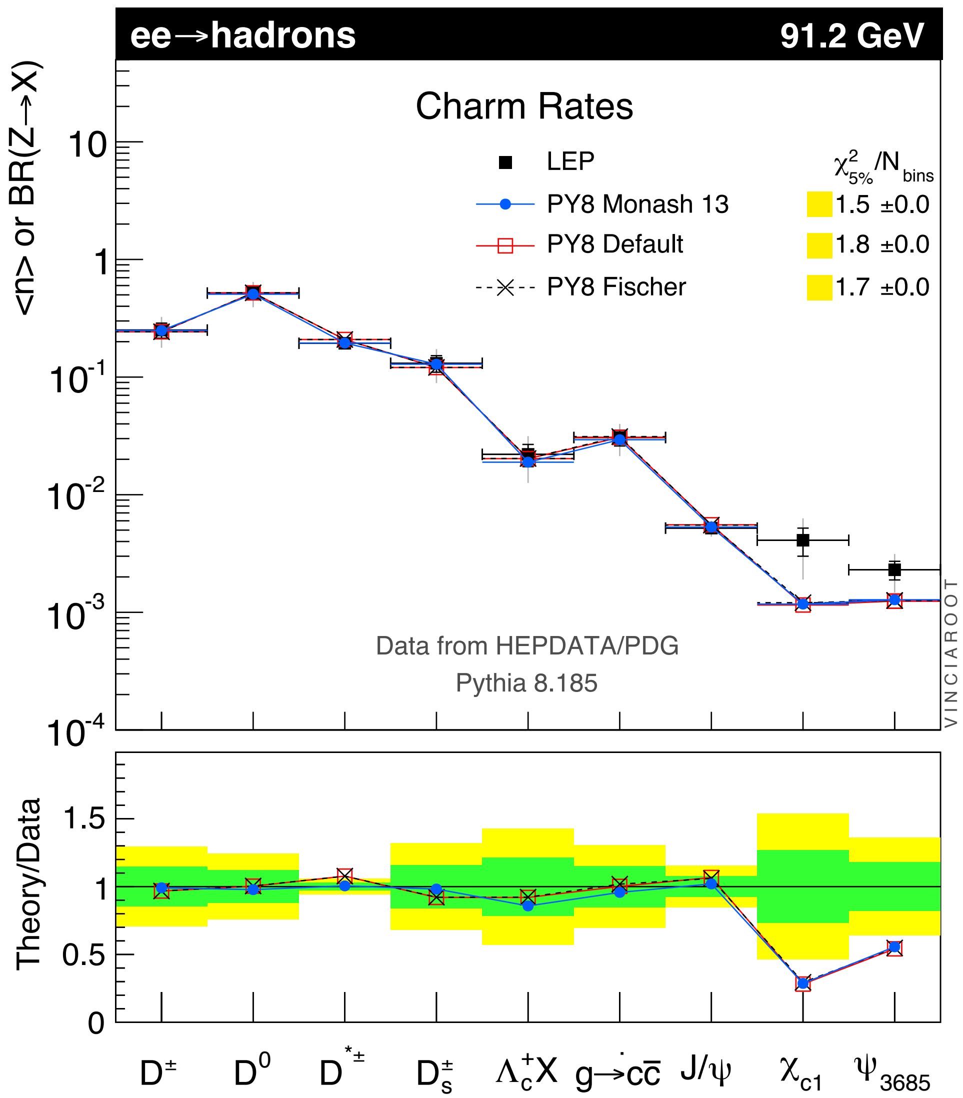




Consistency: improvements repeated across all ee energies

Charm

Rates ~ unchanged

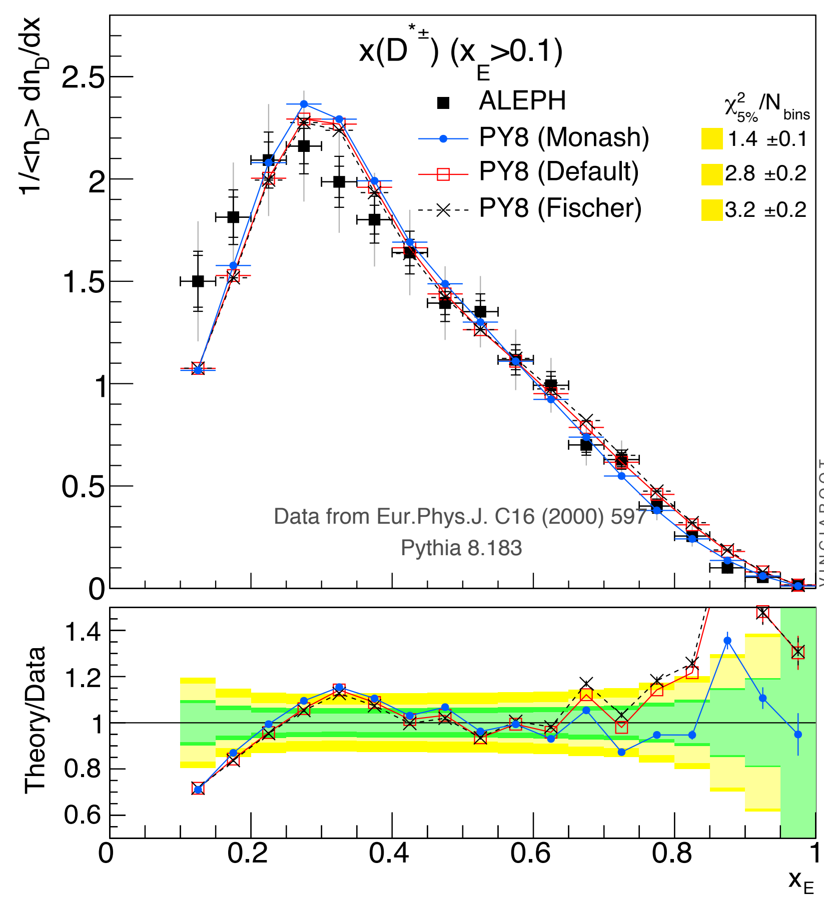


Slightly less D*

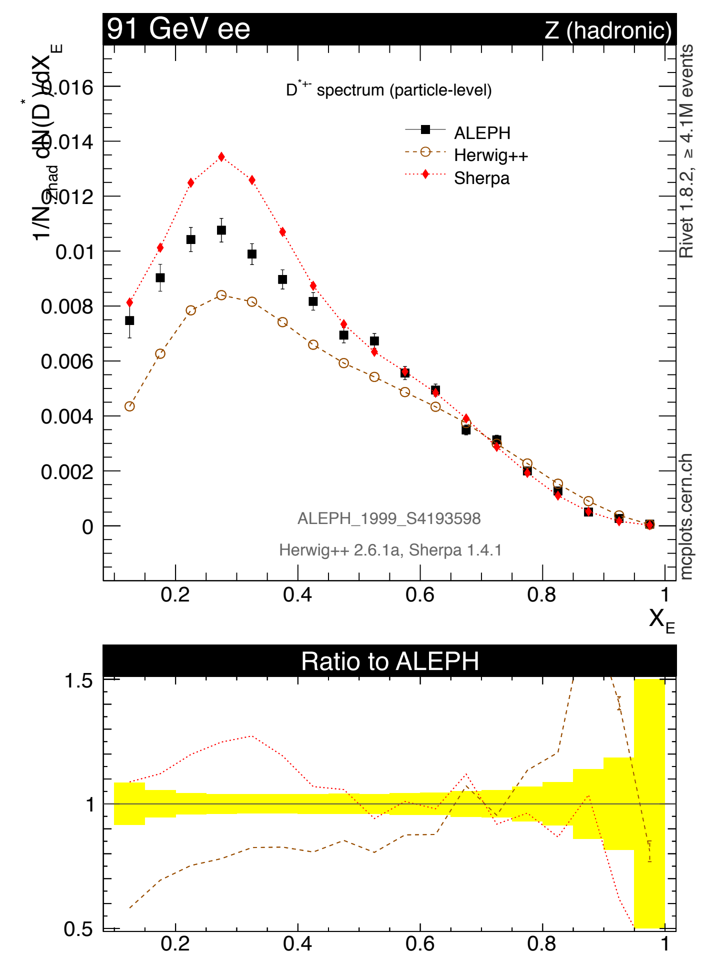
StringFlav:mesonCvector **M13** = 0.88 **4C** = 1.06

Slightly more D_s

Softer spectra



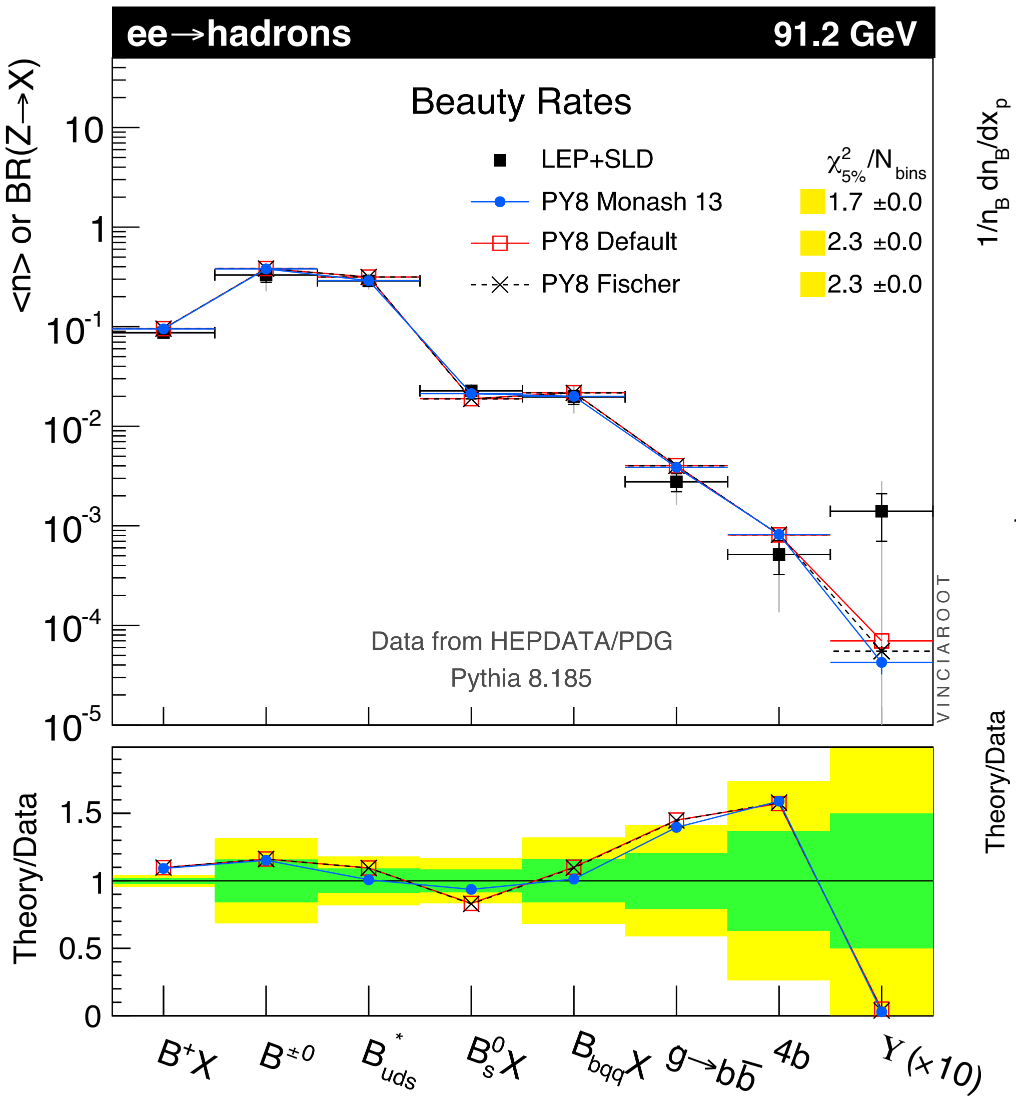
Comparison to Herwig++ and Sherpa



Interesting to compare at LHC!!!
(and at future FCC-ee)

Beauty

Rates ~ unchanged

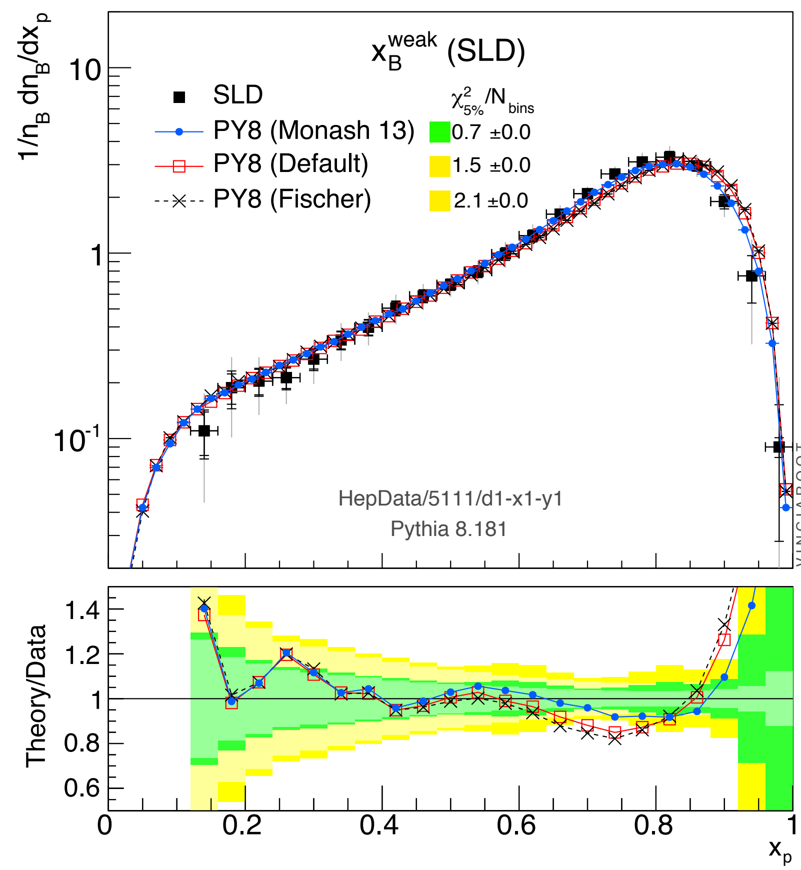


Slightly less B* — StringFlav:mesonBvector: **M13** = 2.2, **4C** = 3.0

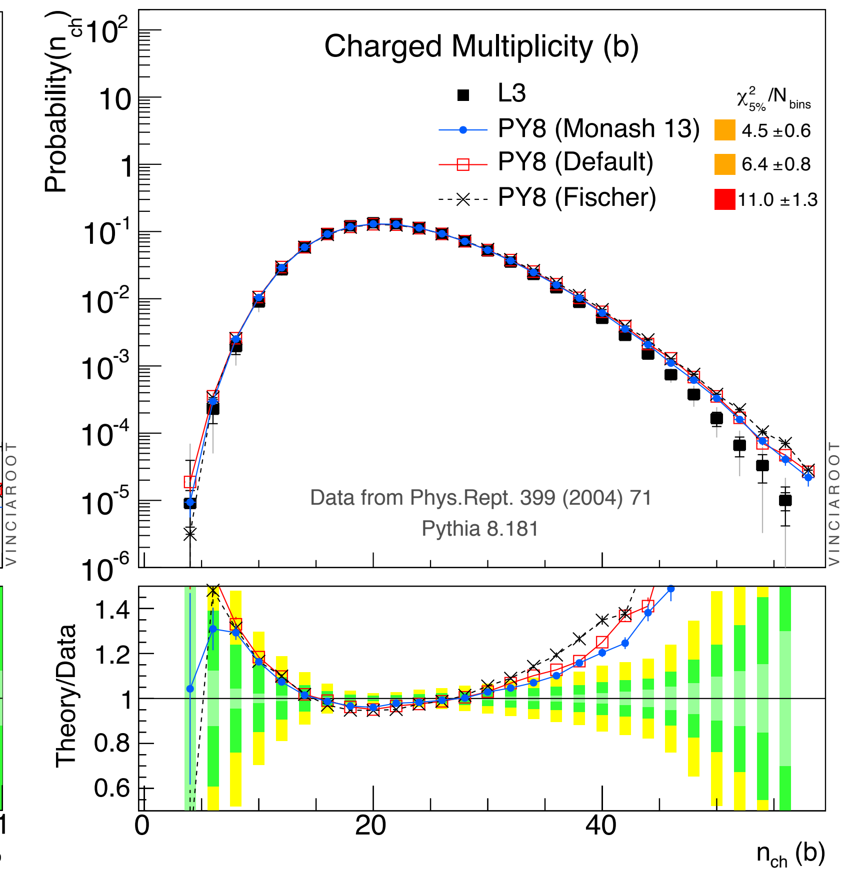
Slightly more B_s

Still too many g→bb

Softer spectra



N_{ch} in b events



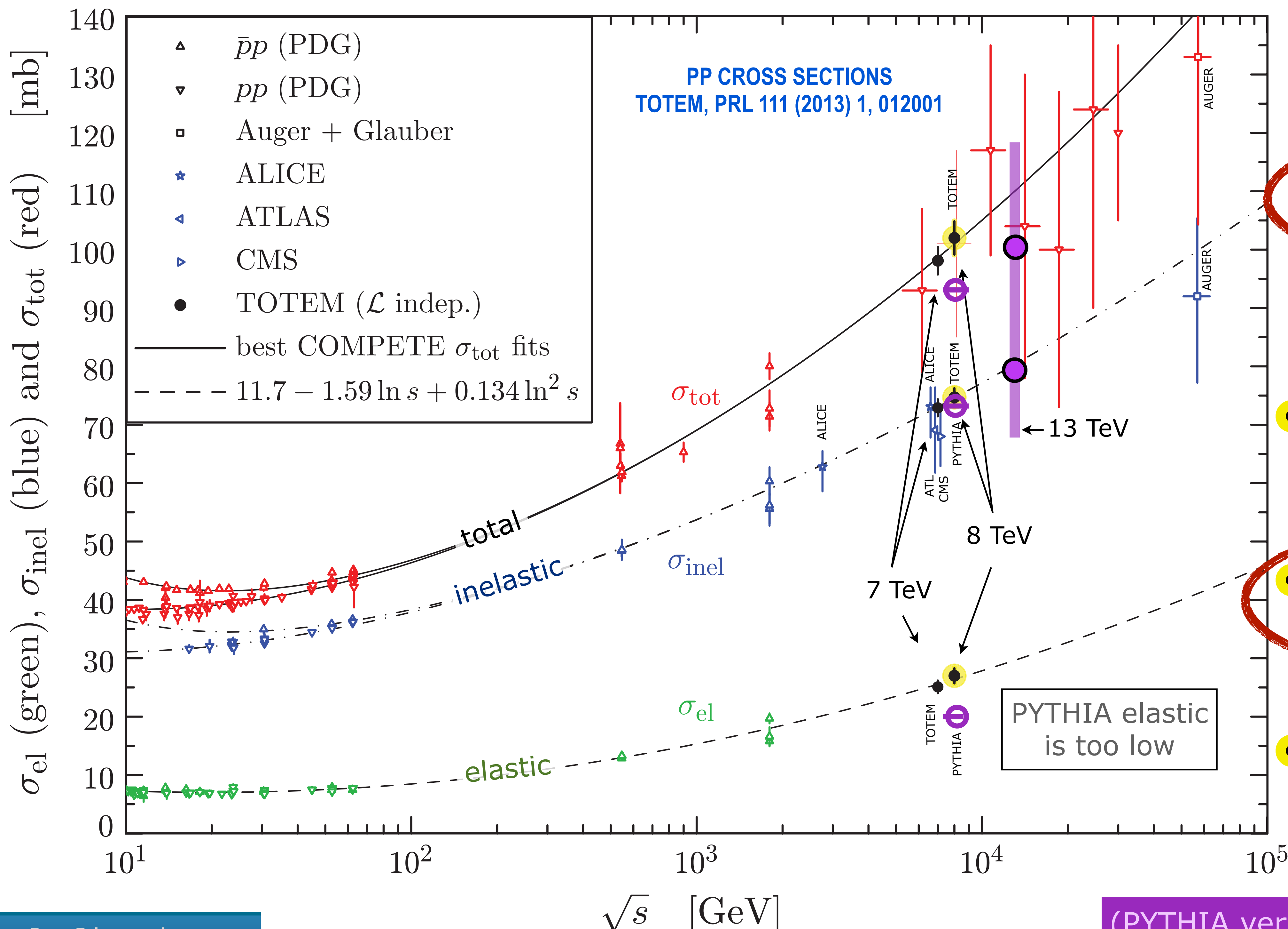
High-multiplicity tail still problematic ?

Interesting to compare at LHC!!!
(and at future FCC-ee)

PP: the Total Cross Section

$$\text{Pileup rate} \propto \sigma_{\rm tot}(s) = \sigma_{\rm el}(s) + \sigma_{\rm inel}(s) \propto s^{0.08} \text{ or } \ln^2(s)\ ?$$

Donnachie-Landshoff (0.096?) Froissart-Martin Bound



$\sigma_{\rm tot}(13\ \text{TeV}) \sim 110 \pm 6$ mb

PYTHIA: 100 mb

$\sigma_{\rm inel}(13\ \text{TeV}) \sim 80 \pm 3.5$ mb

PYTHIA: 78 mb

(2.9%)

$\sigma_{\rm tot}(8\ \text{TeV}) = 101 \pm 2.9$ mb

PYTHIA: 93 mb

(2.3%)

$\sigma_{\rm inel}(8\ \text{TeV}) = 74.7 \pm 1.7$ mb

PYTHIA: 73 mb

(5.1%)

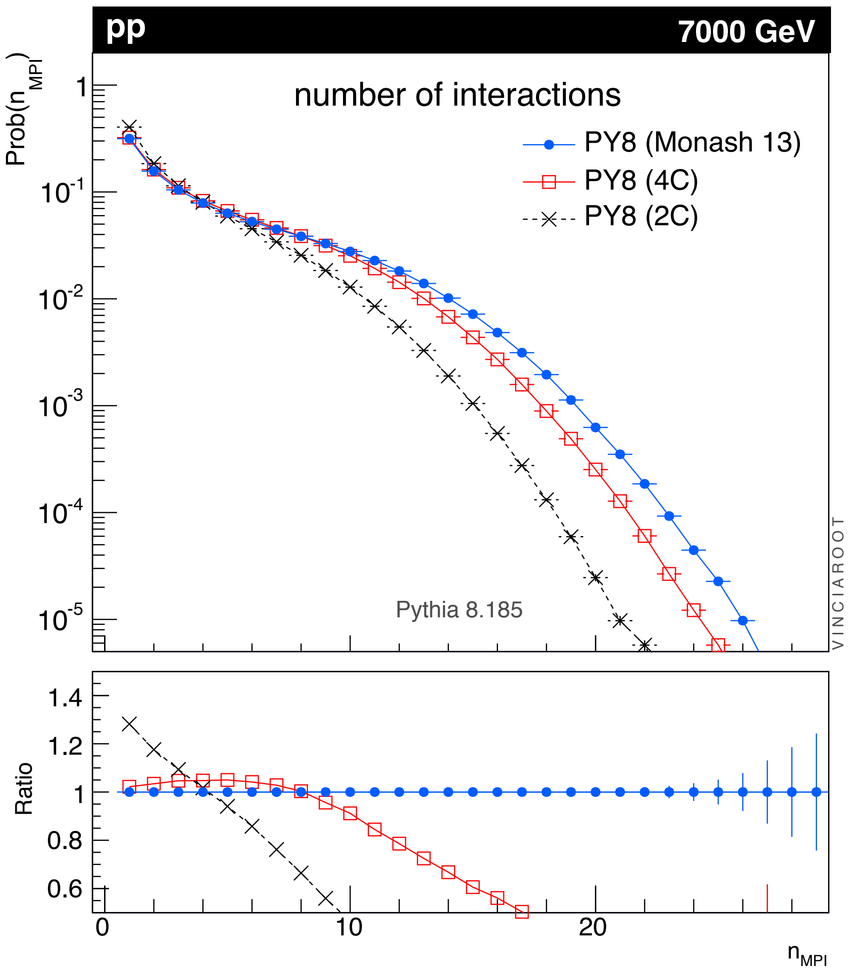
$\sigma_{\rm el}(8\ \text{TeV}) = 27.1 \pm 1.4$ mb

PYTHIA: 20 mb

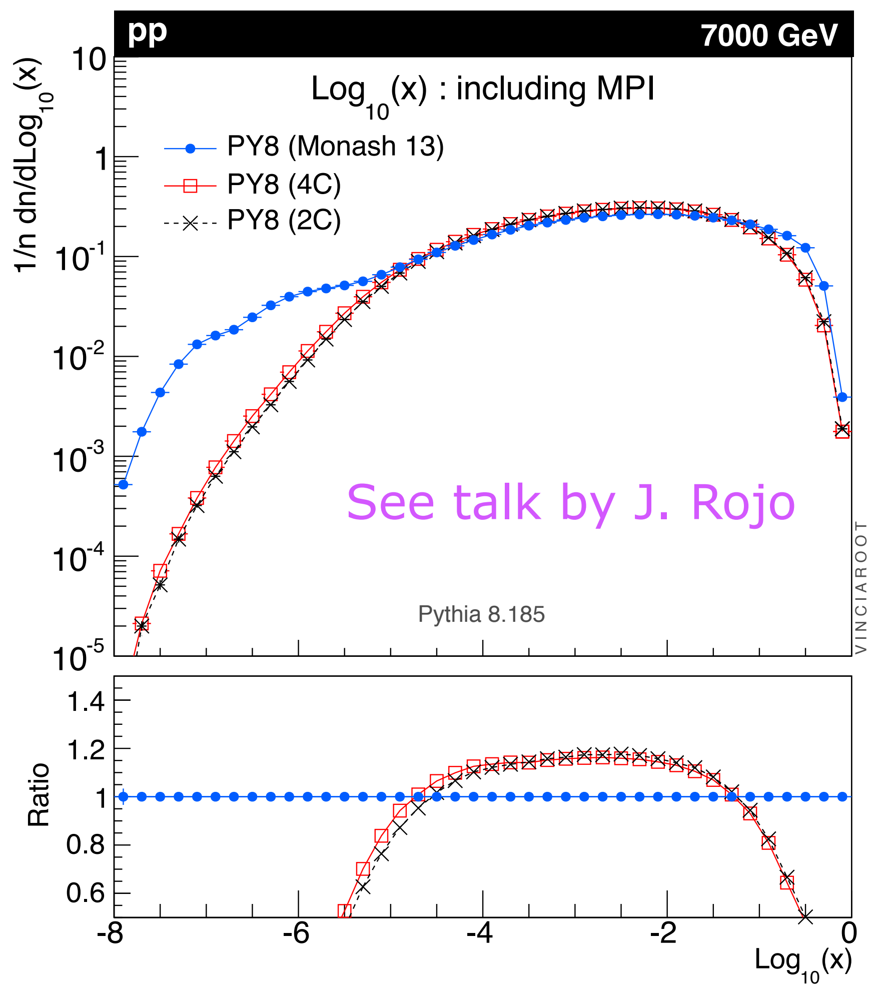
(PYTHIA versions: 6.4.28 & 8.1.80)

MPI Theory Level Distributions

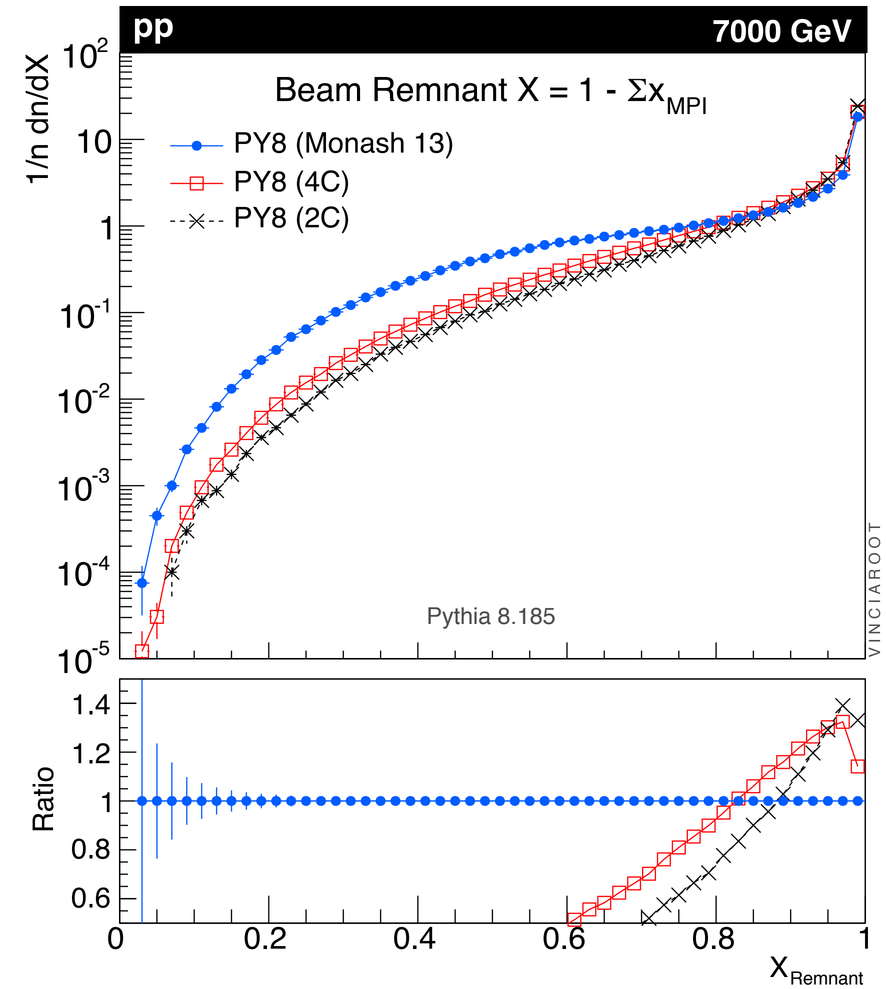
of MPI



Which x values?

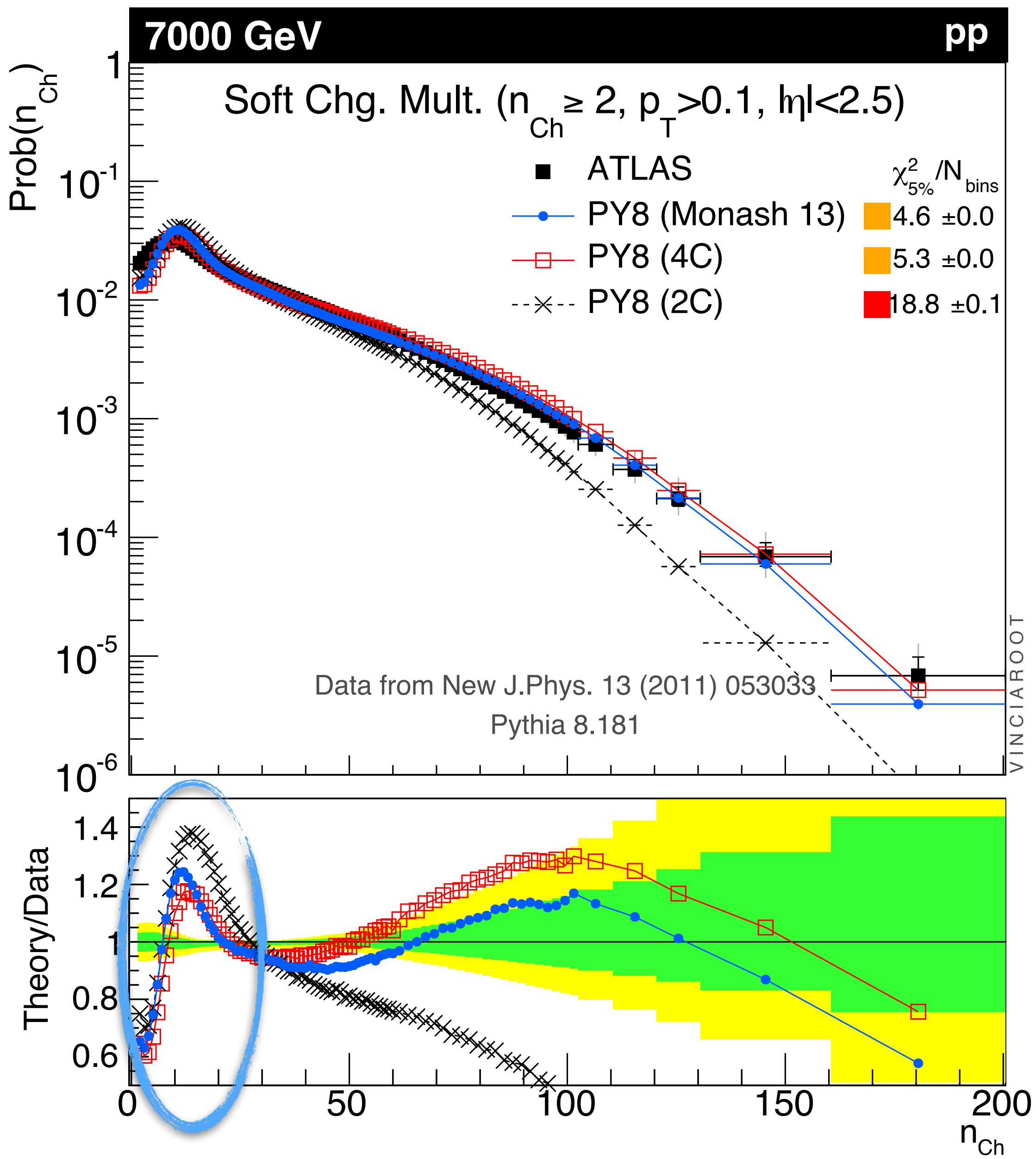


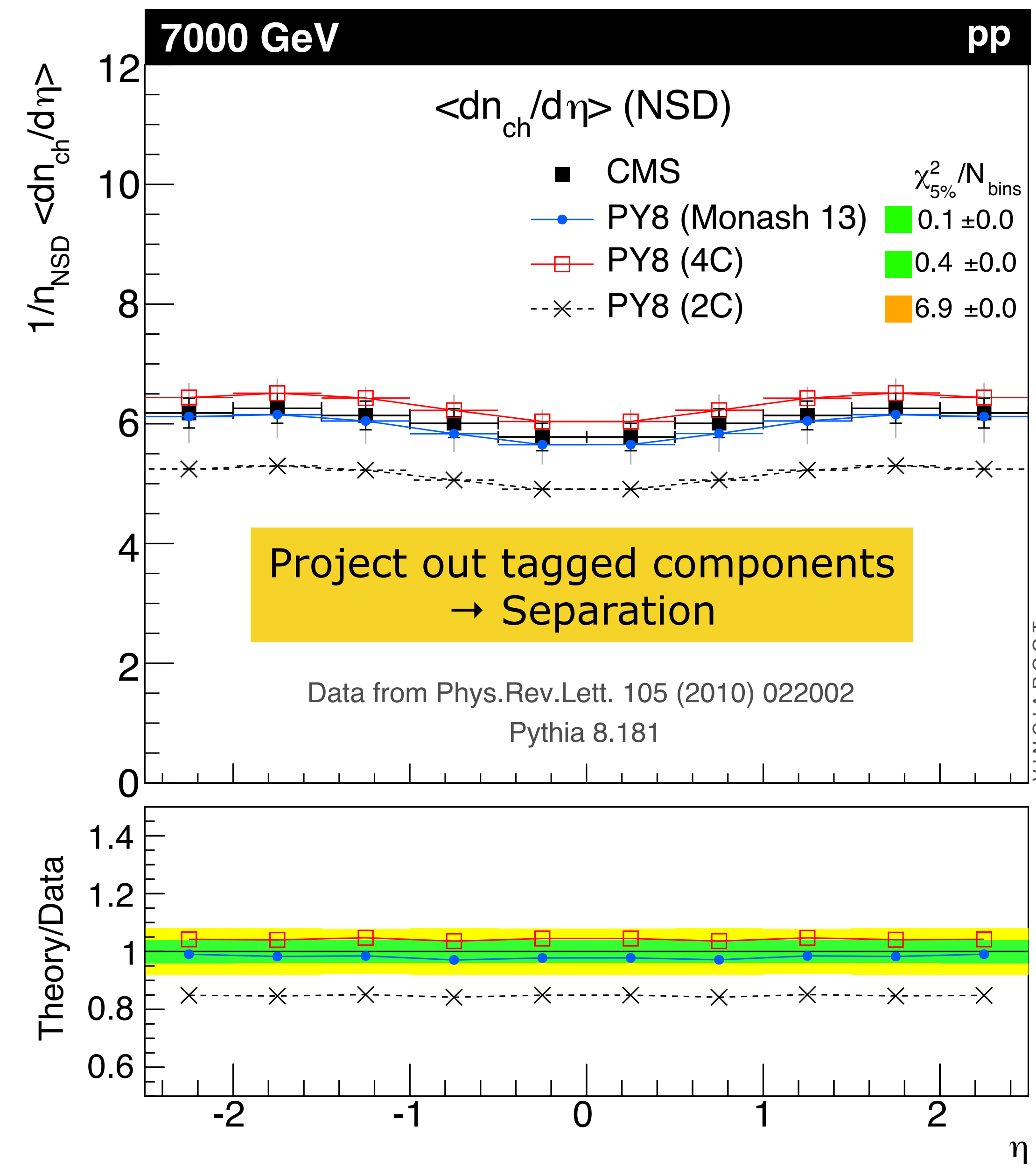
How much x in Remnant?



More events with "**catastrophic energy loss**"
(< 10% remaining in remnant)
Possible to observe "**total inelastic scattering**"?
(<10% in BOTH remnants; 10 - 1000 pb?)

Charged-Particle Multiplicities

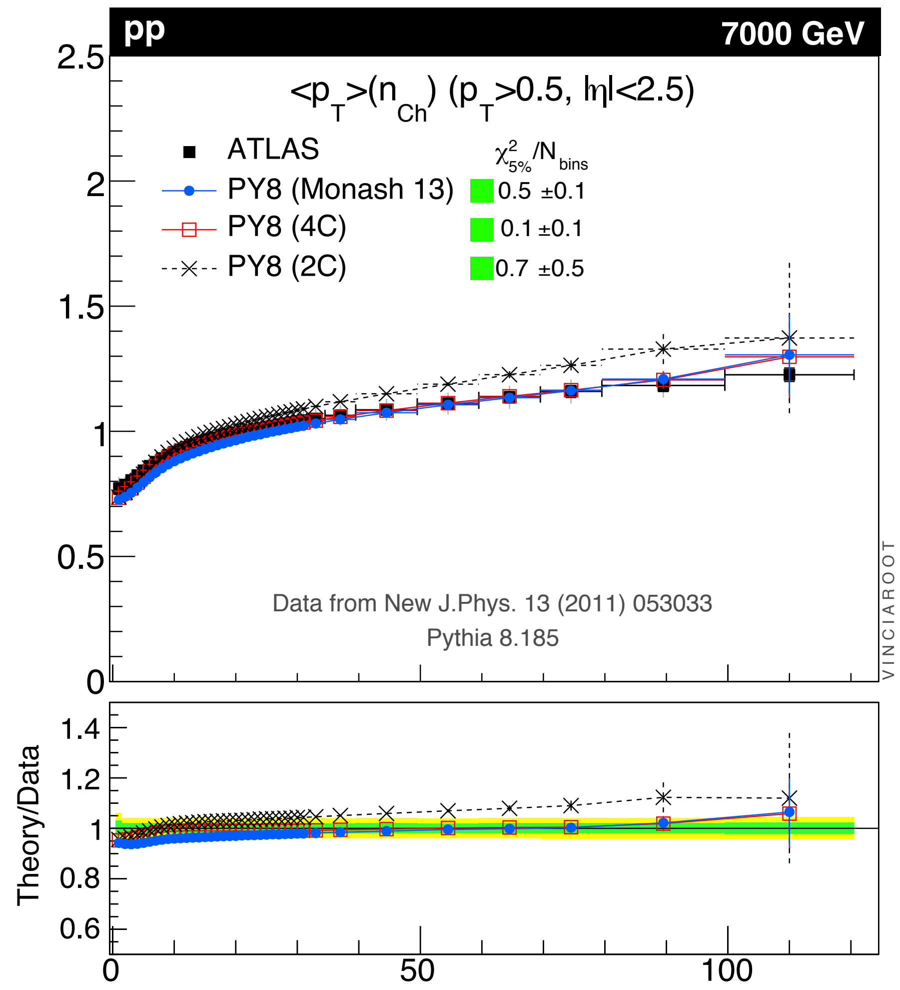


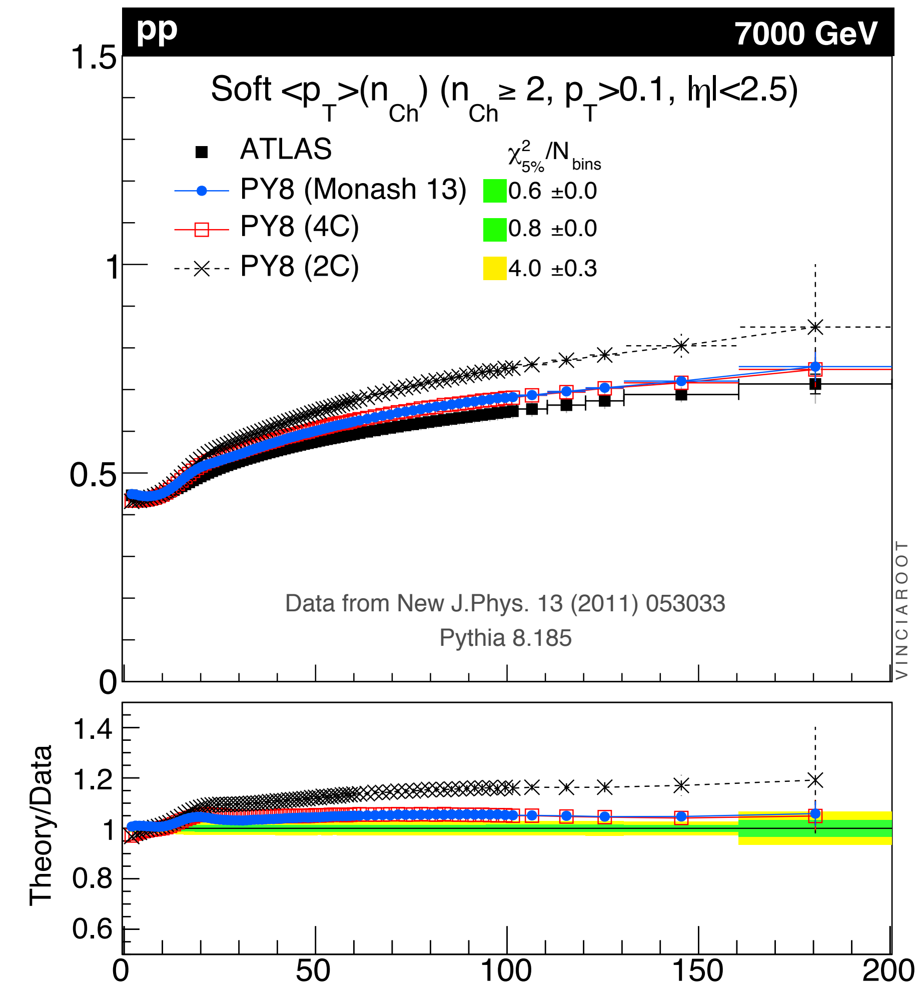


Note: would be interesting to see with/without forward proton tag
to isolate diffractive contributions

<pT> vs Nch

No big changes





NB: now developing new CR model;
Expect significant changes for identified-particle components!

IDENTIFIED PARTICLES

10% more **kaons** (as expected)
Now agrees with CMS

But shape of pT distribution still not understood
Collective effects?
New CR model?

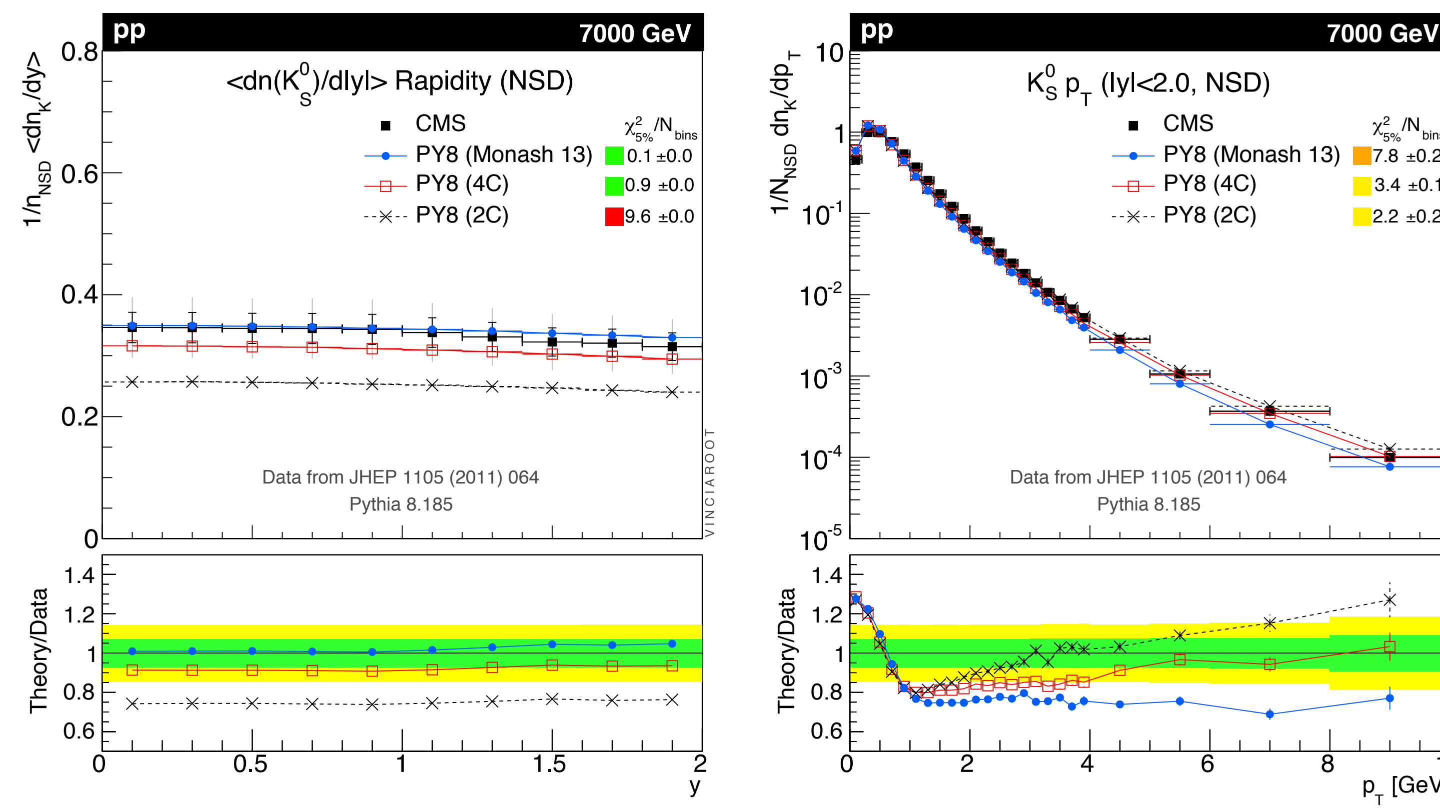
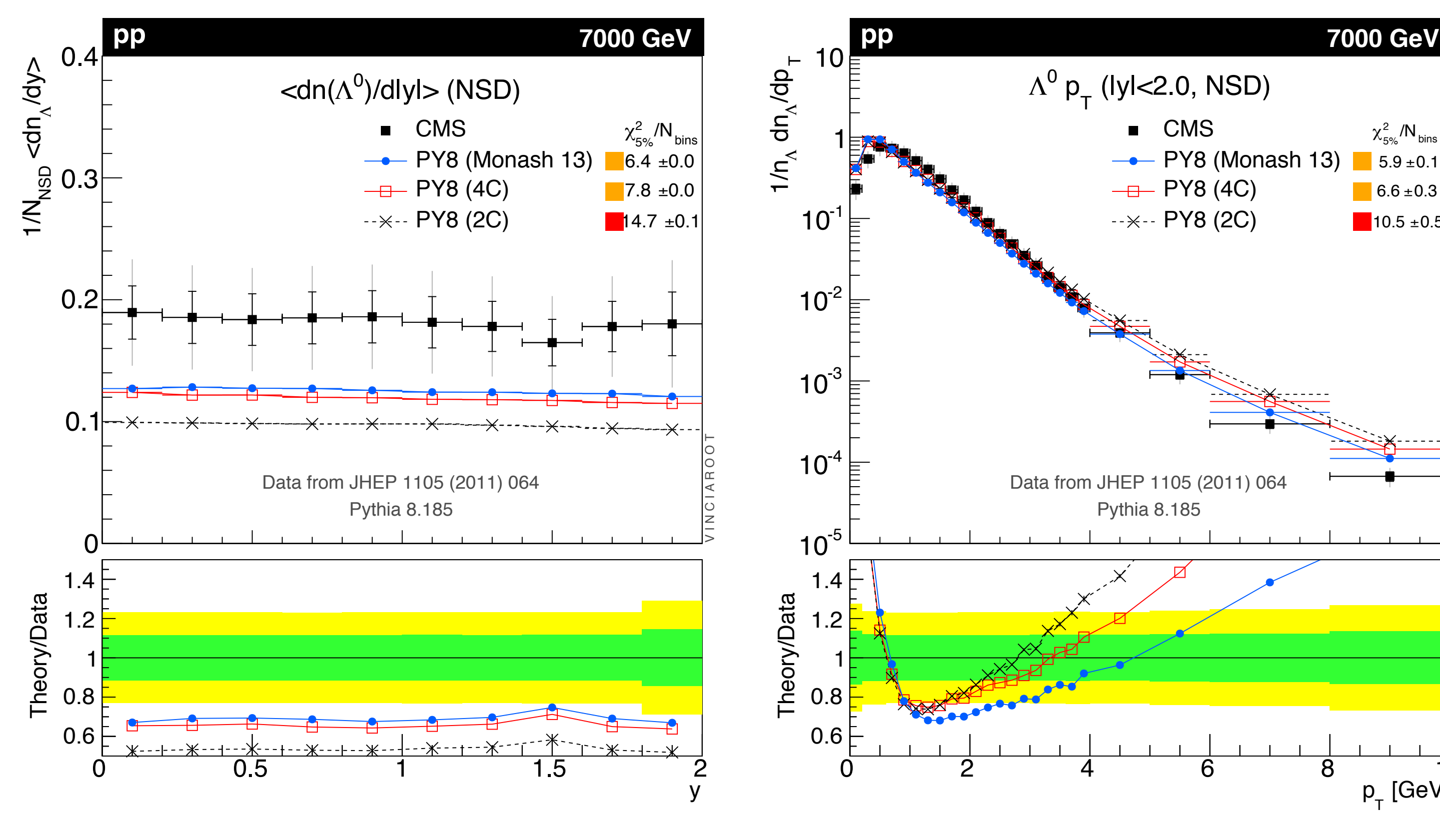


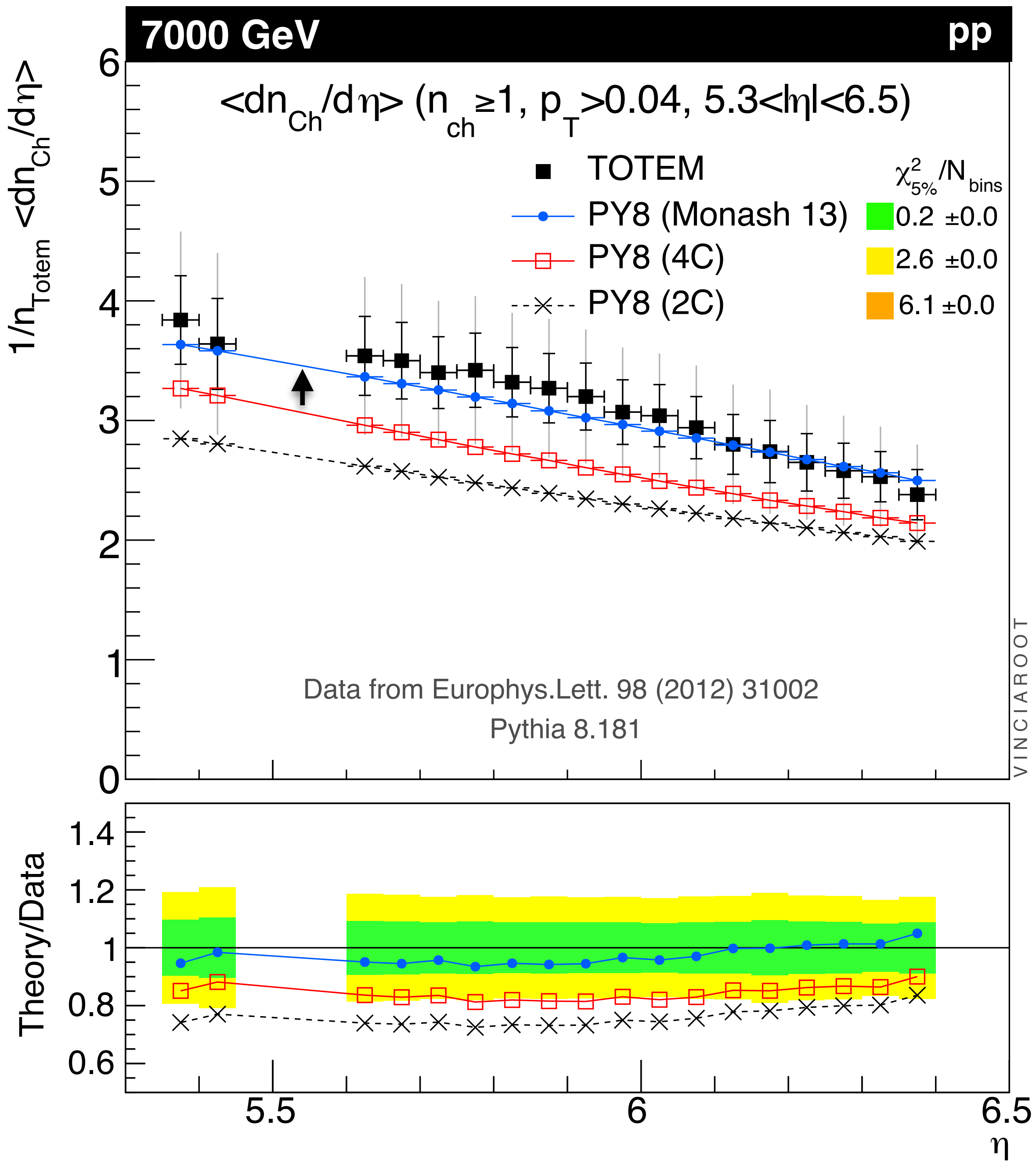
Figure 23: pp collisions at 7 TeV. K_S^0 rapidity and $p_\perp$ spectrum, compared with CMS data [99].

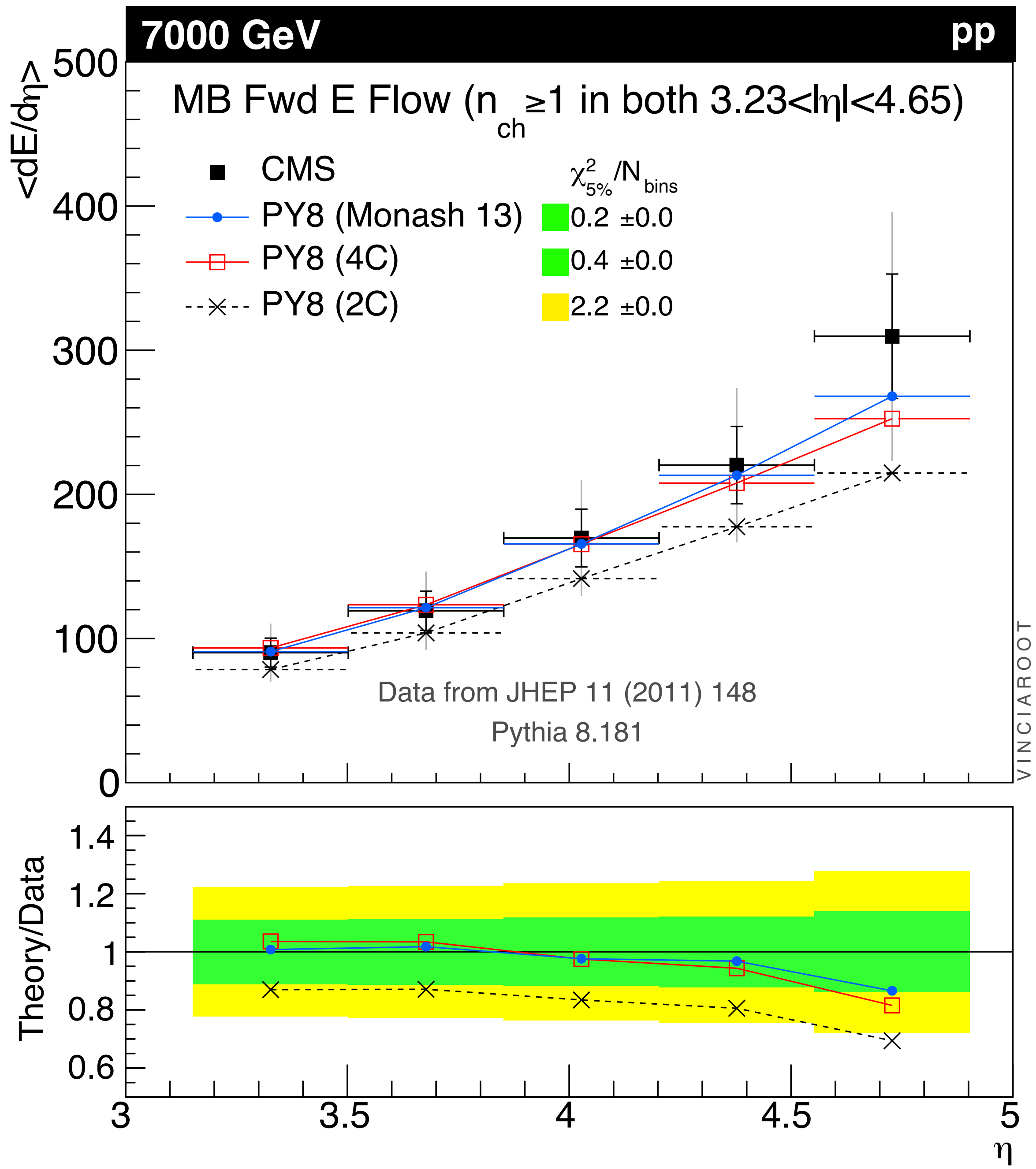
Still not enough **baryons** and shape of pT distributions not understood
New CR model?



Note: EPOS has striking success describing these spectra, but uses hydro!
How to discriminate?
Correlations?

Going Forward

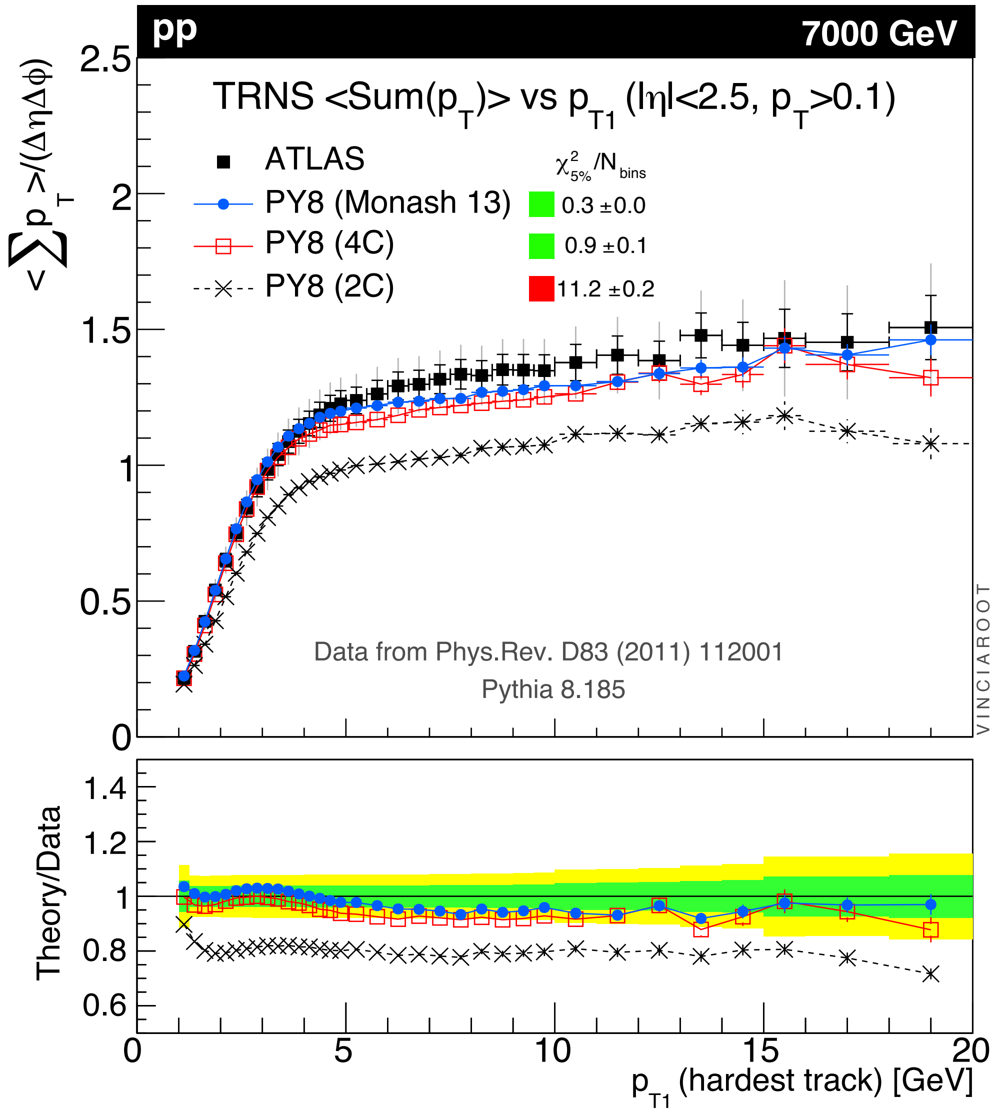


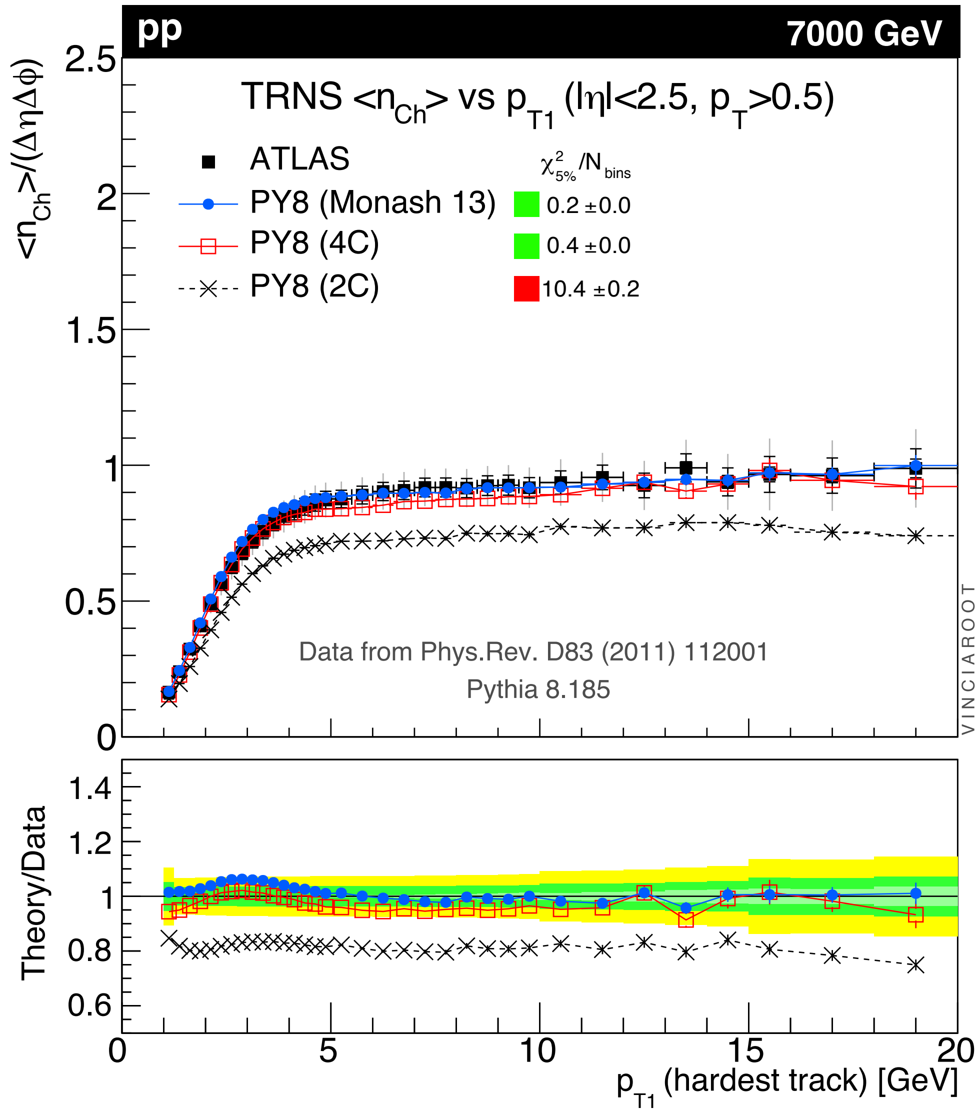


Increased $\langle N_{ch} \rangle$ in TOTEM acceptance. Slightly steeper CMS FWD E flow.

Underlying Event

Slight increase in UE with respect to 4C

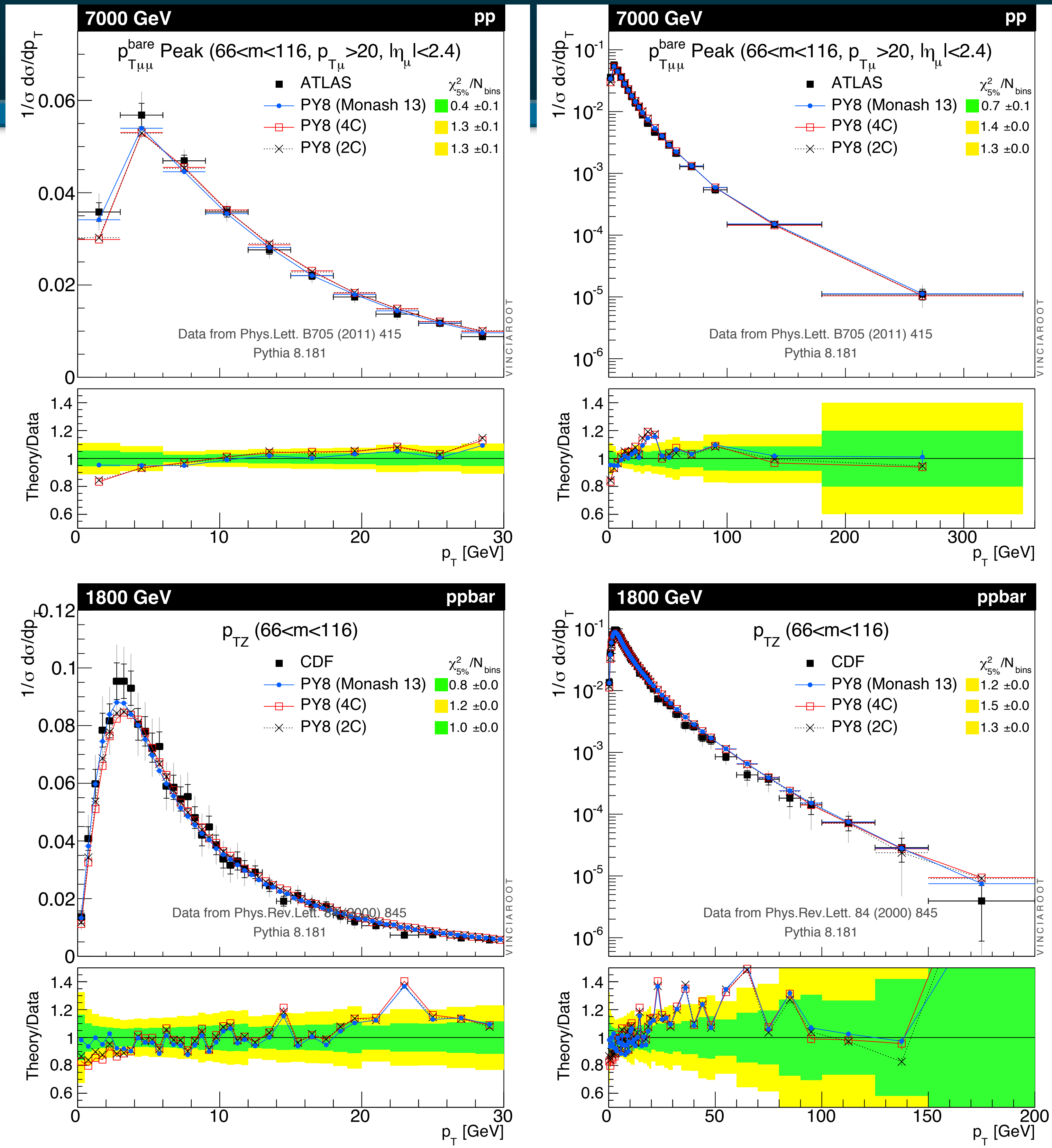




pT(Z)

Slightly softer spectrum

	M13	4C
SpaceShower:alphaSvalue	= 0.1365	= 0.137
BeamRemnants:primordialKTsoft	= 0.9	= 0.5
BeamRemnants:primordialKThard	= 1.8	= 2.0
BeamRemnants:halfScaleForKT	= 1.5	= 1.0
BeamRemnants:halfMassForKT	= 1.0	= 1.0



Note: peak very sensitive to soft effects, IR regularization, etc.

Lesson: do not assume this stays exactly the same when doing matching

Summary

Complete writeup : arXiv:1404.5630

Apologies: did not do dedicated study of diffraction

- E.g., gap-size distributions not included, though interesting

Revised ee fragmentation parameters and pp tune using new NNPDF2.3 LO PDF set

- Increased strangeness and more forward activity
- Low-multiplicity region and strangeness spectra still challenging

Pythia 8.185 Monash 2013

Tune:ee=7; Tune:pp = 14;

Work underway:

- Improved colour-reconnection model (PS + J.R. Christiansen)
- Inclusion of diffractive Z (T. Sjostrand + C. Rasmussen)
- Improved model for $g \to QQ$ (T. Sjostrand + student)