Strangeness issues

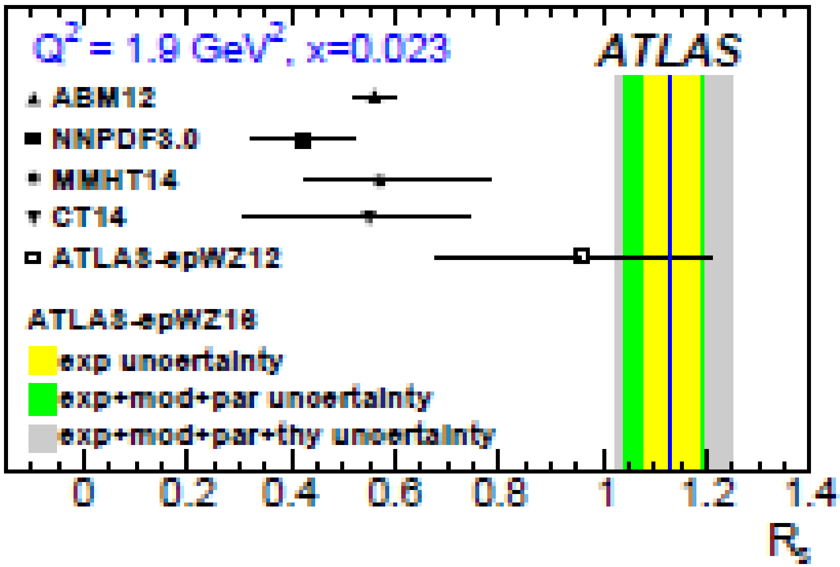
AM Cooper-Sarkar

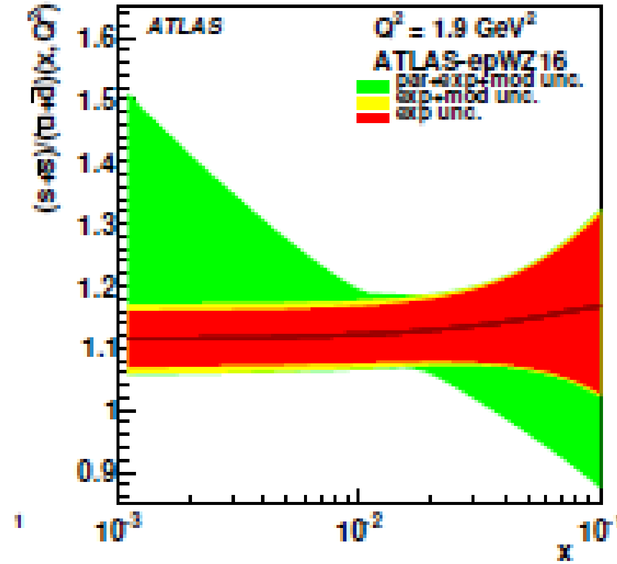
Nov 13th

Is there still an issue?

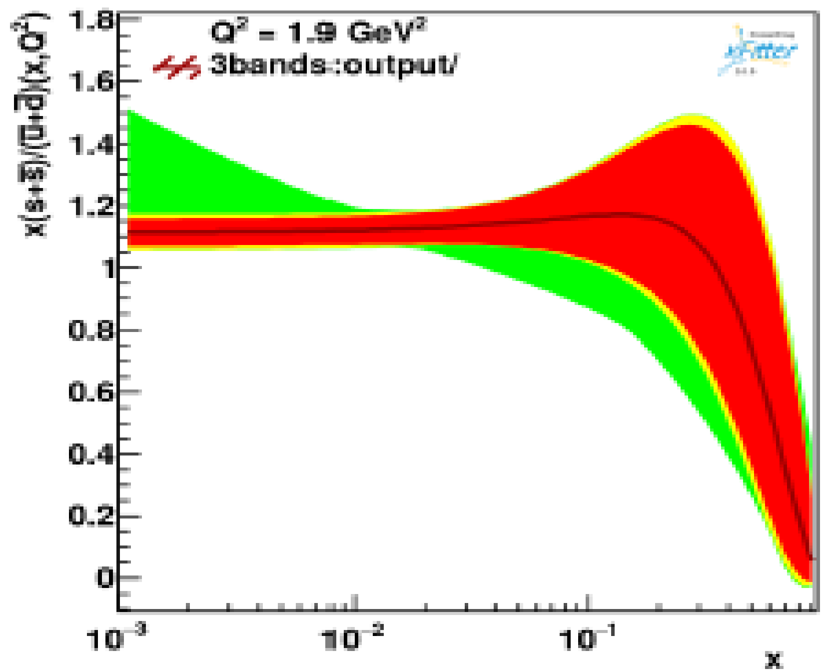
YES there is

We have seen that the ATLAS inclusive W,Z 2011 precision data arXIV:1612.03016
Imply unsuppressed strangeness





This figure is from the paper, but we can do better…..



The ratio of strange to light quark densities was determined as roughly equal rather the suppressed, at the starting scale for Q^2 evolution and x=0.023-contrary to previous determinations.
But the analysis is much more than this 'sound bite'. It is a set of PDFs from which we can consider strangeness in ratio to the light quark PDFs as a function of x at any value of the scale.

This result has been criticised on two grounds
Relating to parametrisation

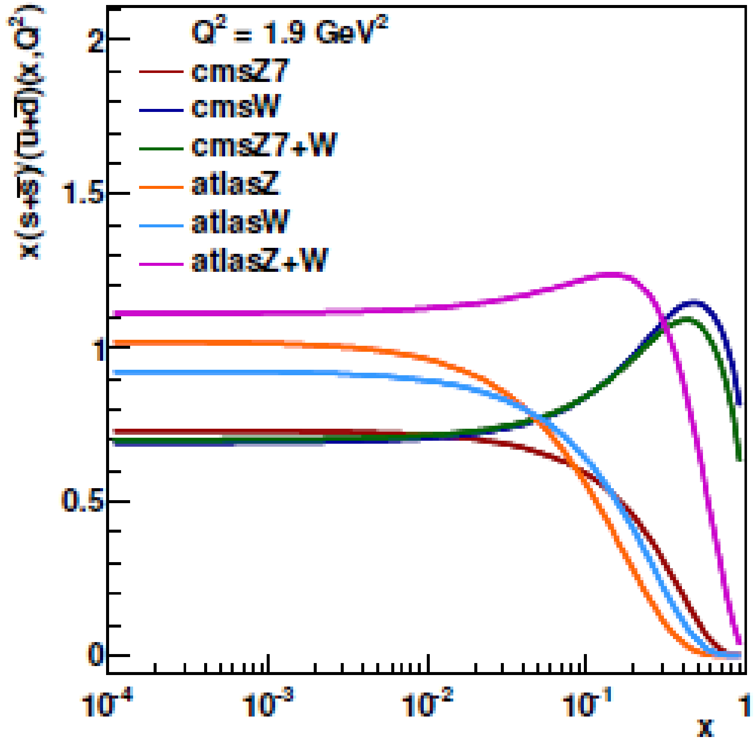
1) The PDF parametrisation is not flexible enough and thus produces a result close to unity –even without ATLAS data.

However, arXIV:1803.00968 considers inclusive W and Z data sets from ATLAS and CMS separately and together using the ATLAS form of the PDF parametrisation.

The figure shows the ratio of strangeness to light quarks at the starting scale as a function of x.

Clearly, the ATLAS parametrisation is flexible enough to produce suppressed strangeness IF the data want it.

BUT NOTE there are large uncertainty bands on some of these curves

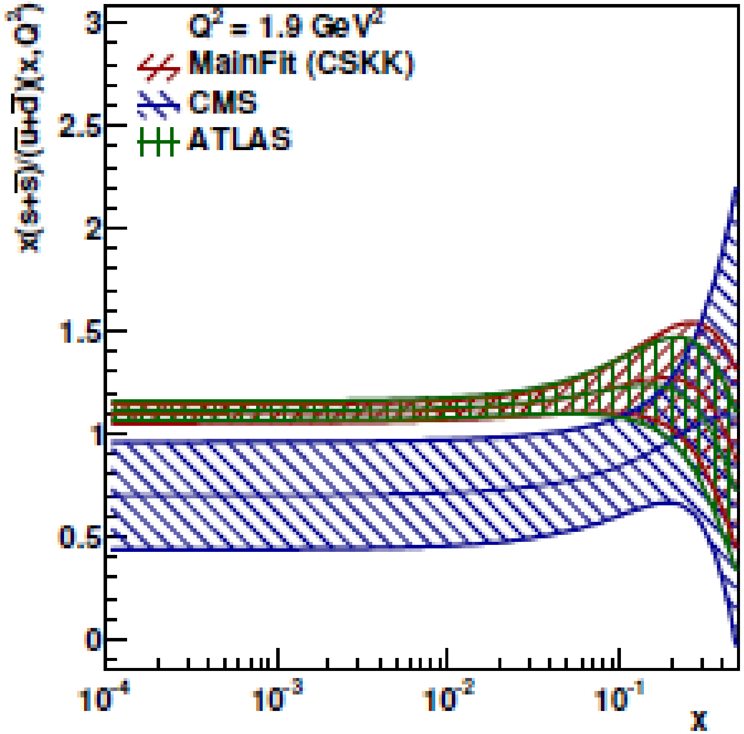


BUT DO the CMS inclusive data want Suppressed strangeness?

The figure shows fits to inclusive W + Z data for ATLAS and CMS separately and together- now with the uncertainty bands. arXIV:1803.00968

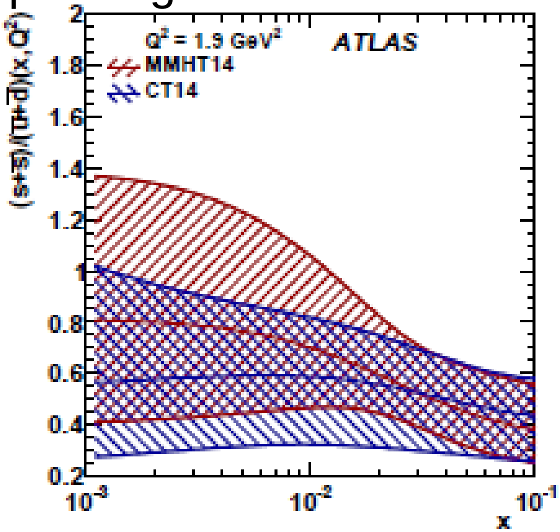
When ATLAS and CMS data are fitted together the accuracy of the ATLAS data dominates the fit.

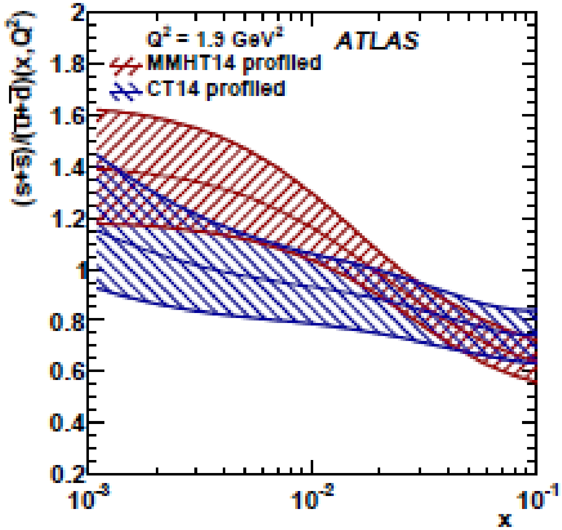
There is NO significant tension with CMS inclusive data

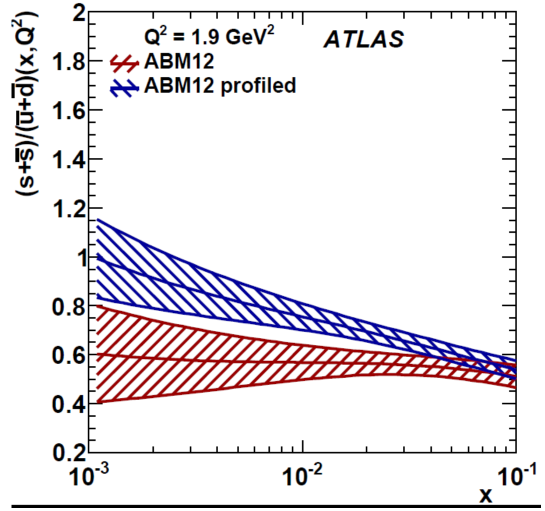


Further remarks on the dependence of the ATLAS strangeness result on parametrisation.

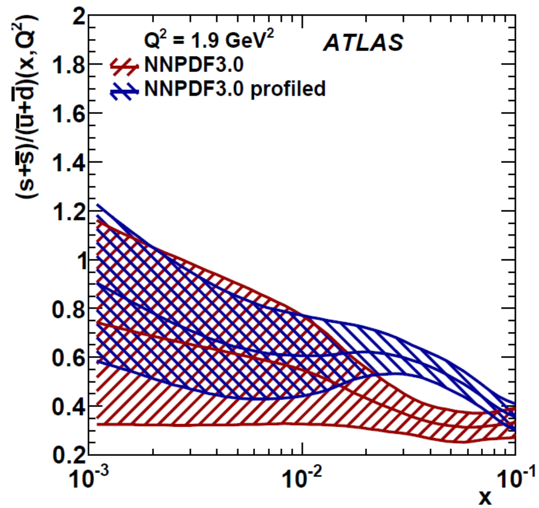
ATLAS also considered the impact of their W,Z 2011 precision data on strangeness in a way that is **completely independent of parametrisation-** namely PDF profiling.







All PDF sets profiled show enhanced low-x strangeness after profiling. The results when MMHT and NNPDF use these data themselves in fits also see enhancement– see back-up

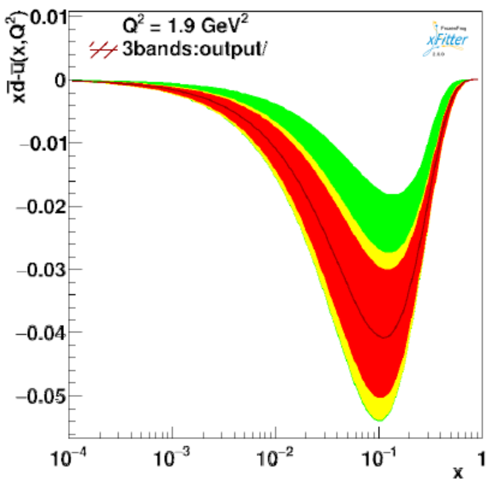


$$\chi^2(\boldsymbol{b}_{\mathrm{exp}}, \boldsymbol{b}_{\mathrm{th}}) = \sum_{i=1}^{N_{\mathrm{data}}} \frac{\left(\sigma_i^{\mathrm{exp}} + \sum_\alpha \Gamma_{i\alpha}^{\mathrm{exp}} b_{\alpha,\mathrm{exp}} - \sigma_i^{\mathrm{th}} - \sum_\beta \Gamma_{i\beta}^{\mathrm{th}} b_{\beta,\mathrm{th}}\right)^2}{\Delta_i^2} + \sum_\alpha b_{\alpha,\mathrm{exp}}^2 + \sum_\beta b_{\beta,\mathrm{th}}^2 .$$

There is a further more detailed criticism of the parametrisation:

2) It produces dbar-ubar negative at high-x, when E866 fixed target Drell-Yan data measure it as positive.

This is true and COULD affect the strangeness -since more strangeness implies less dbar in a PDF analysis where HERA data, which are sensitive to Dbar=sbar+dbar, is a significant input. However the unsuppressed sbar of ATLAS is best determined at x~0.02 for the starting scale, whereas the enhanced dbar required by E866 is best determined at x~0.1, for a similar low scale. Since the sbar and dbar have freedom to have different x dependence we could satisfy both requirements.

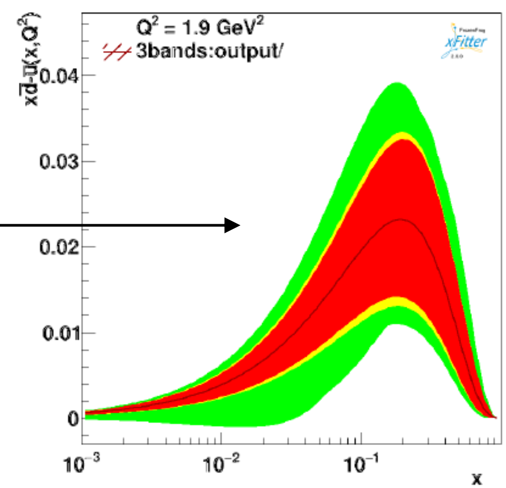


(b) ATLASepWZ16

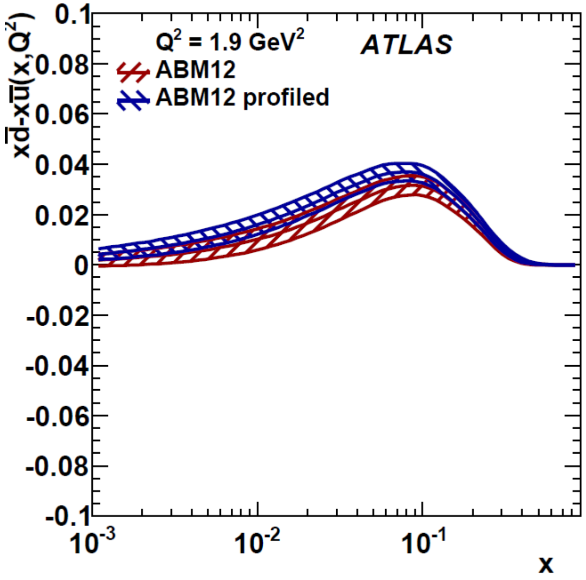
So in arXIV:1803.00968 we forced the fit to ATLAS and CMS W and Z data to take the dbar-ubar shape implied by E866

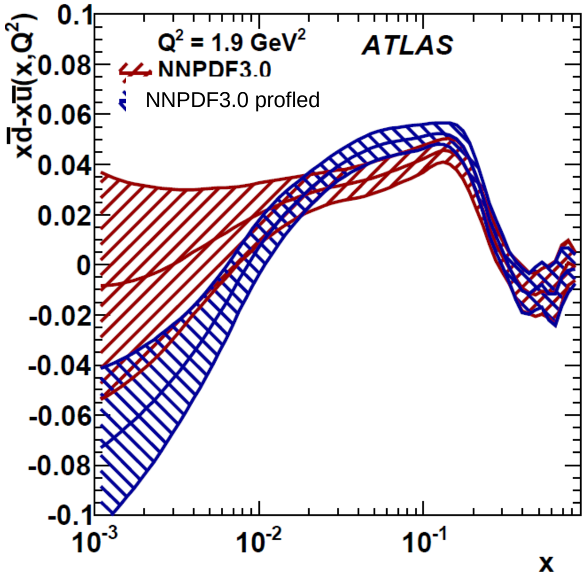
Then the value of Rs =0.95 ±0.07 as opposed to 1.13 ± 0.12 (at x=0.023, Q2=1.9)

In other words strangeness is still unsuppressed at low x

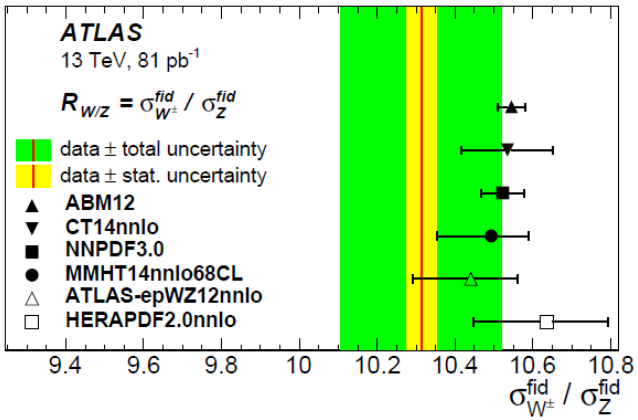


And as an aside--- profiling PDF sets with the ATLAS W,Z 2011 data does not affect their dbar-ubar distributions



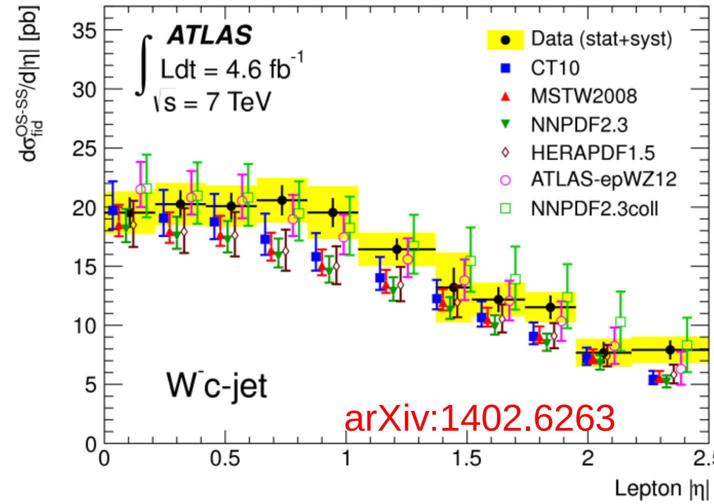


Do we see any evidence for enhanced strangeness in other data sets?

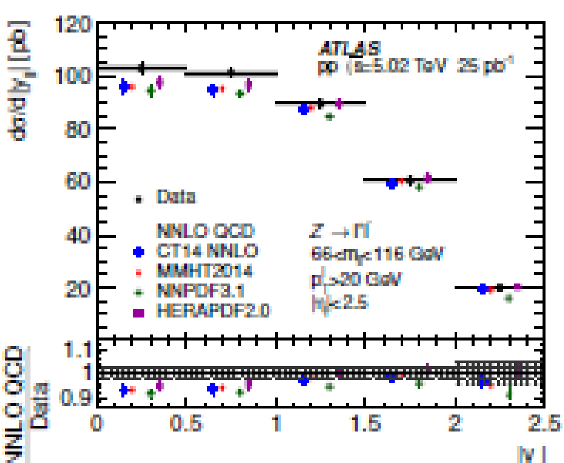


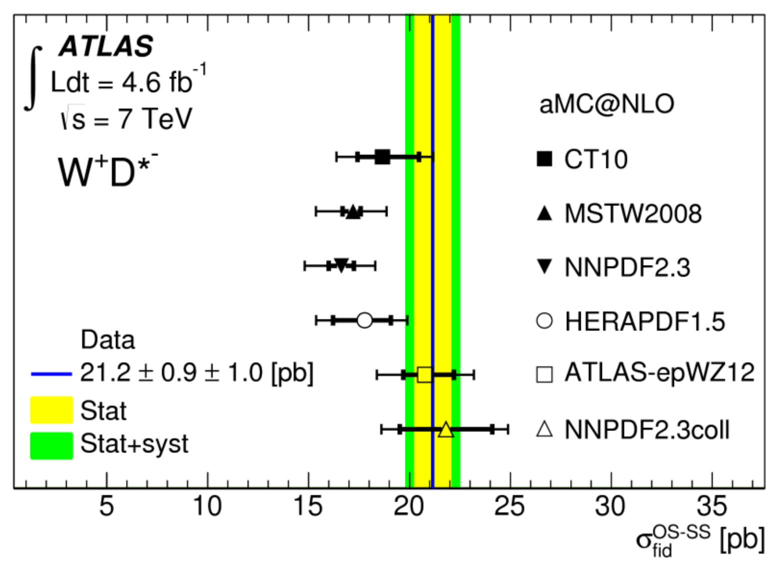
We also see it in 13Tev supressed W/Z ratio (more strangeness gives more Z)

And in the 5TeV data ..



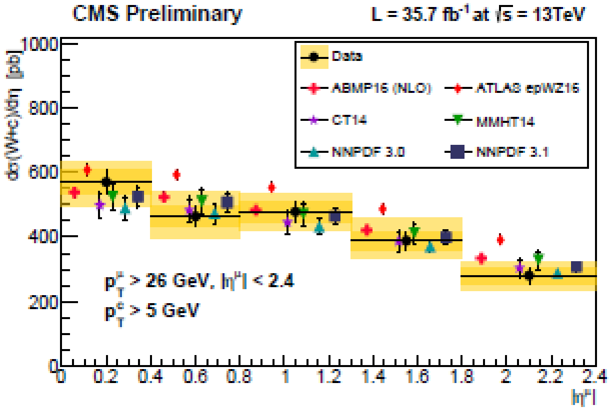
And we see it in the ATLAS 7 TeV W+charm data sets



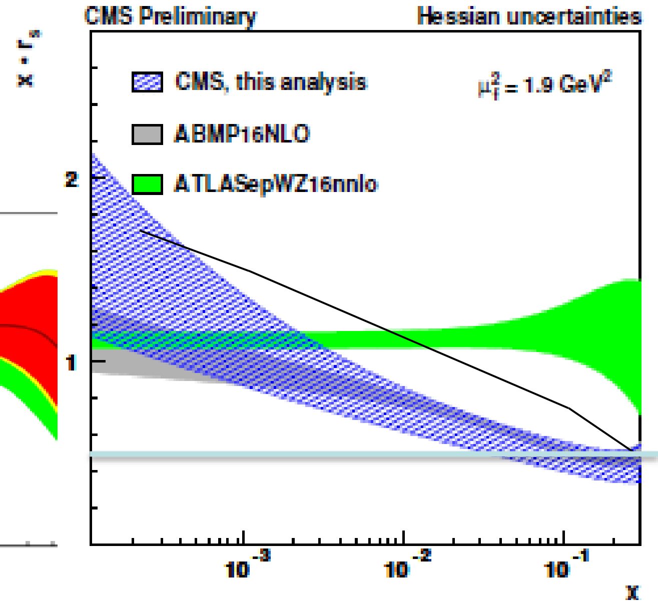


However, CMS does not see it in their new 13TeV analysis CMS-PAS-SMP-17-014

.

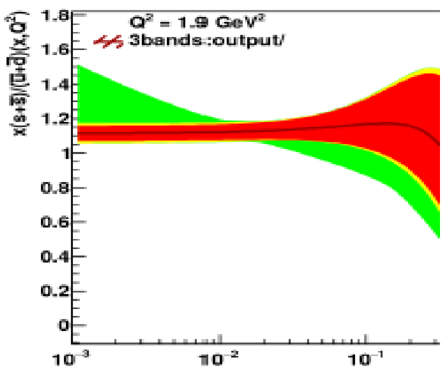


AND a PDF analysis of these data gives a strangeness /light quark ratio which appears in disagreement with ATLAS

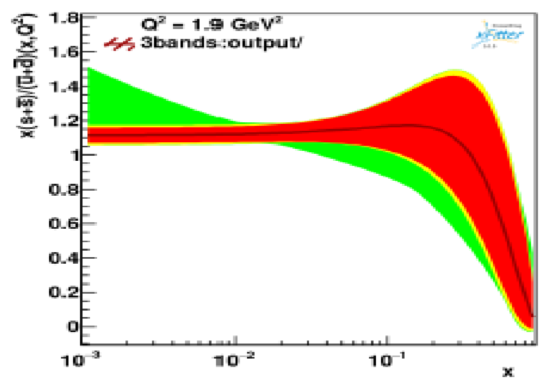


BUT

- If the full error band of the ATLAS inclusive analysis is laid on the CMS plot the discrepancy is not so eye-catching

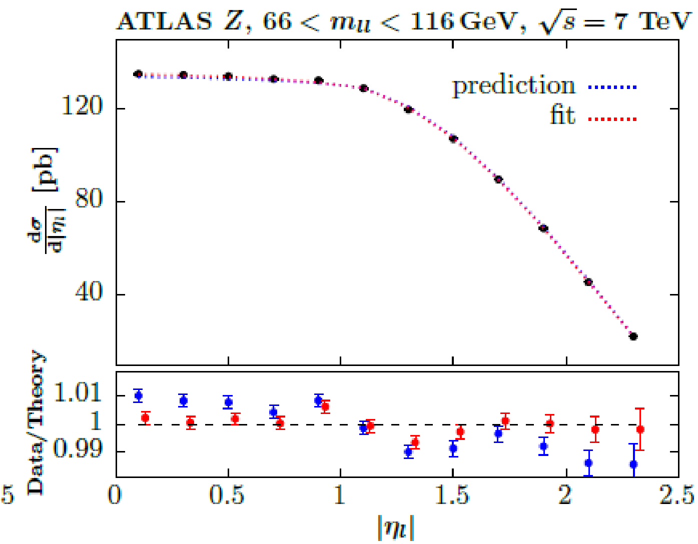


- CMS (and ABMP) still implies larger strangeness than the conventional 0.5 suppression at low –x, x< 0.005
- **Disagreement is most significant at x ~0.02— when evolved to $Q^2 \sim M_W^2$ this is x~0.01**



BACKUP

Work of other groups: MMHT



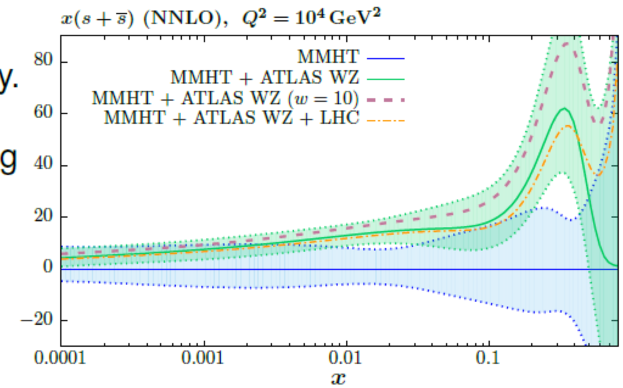
Significant change in shape required for Z production, Higher at low $|\eta|$ and lower at high $|\eta|$

MMHT see significant increase in strange using ATLAS data even though their fit includes:

1. neutrino dimuon data- which gave the conventional suppression- and
2. E866 data which requires more dbar than ubar at x~0.1

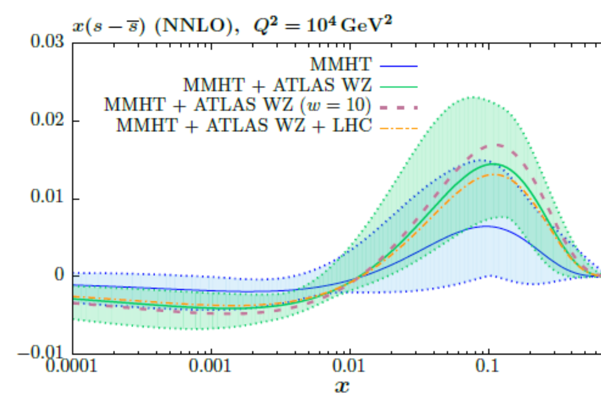
Effect on PDFs

Large increase in $s + \bar{s}$ and decrease in uncertainty. Correlation with fit to dimuon data (lower branching ratio) leads to increase at high x. (Note negative NNLO correction Phys. Rev. Lett. 116 (2016), Berger *et al.*.)

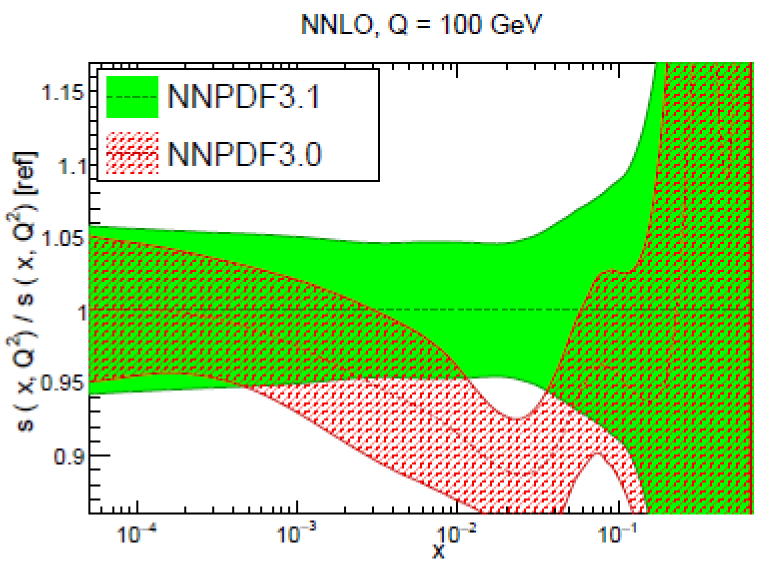


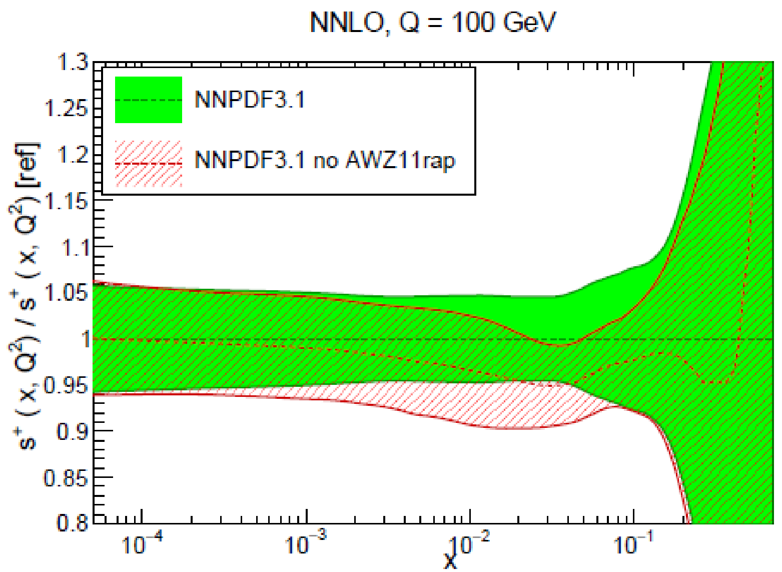
Larger for $x > 0.1$ due to significant down quark contribution in this region despite Cabibbo suppression.

There is impact on $s - \bar{s}$ uncertainty, from the change in branching ratio.



Work of other groups: NNPDF

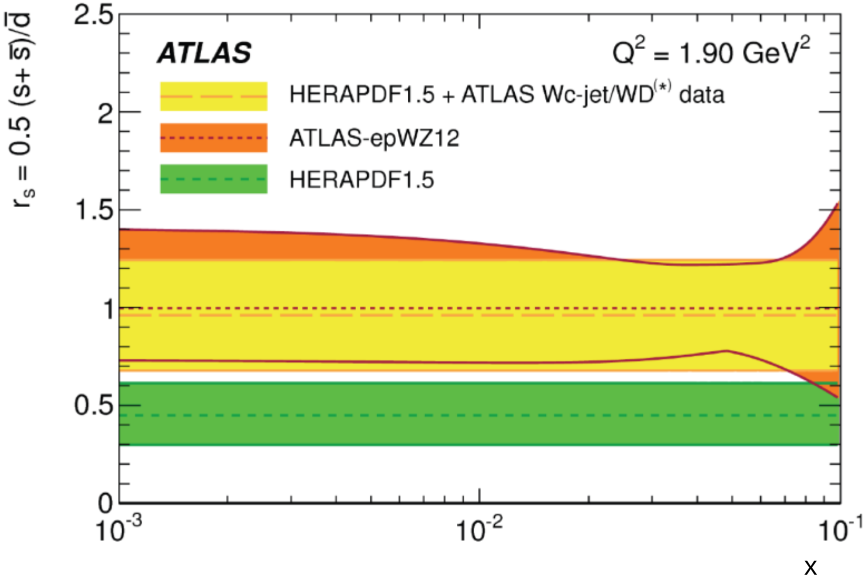




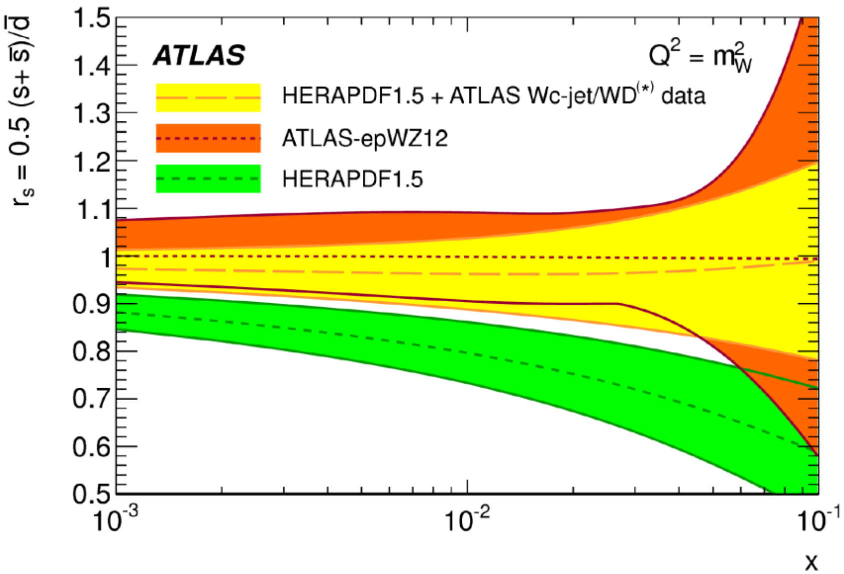
NNPDF see significant increase in strange between NNPDF3.1 wrt to NNPDF3.0- this is dominated by the ATLAS data (NNPDF also include dimuon and E866 data)

PDF set	$R_s(0.023, 1.38\ \text{GeV})$	$R_s(0.023, M_Z)$
NNPDF3.0	0.45±0.09	0.71±0.04
NNPDF3.1	0.59±0.12	0.77±0.05
NNPDF3.1 collider-only	0.82±0.18	0.92±0.09
NNPDF3.1 HERA + ATLAS W, Z	1.03±0.38	1.05±0.240
xFitter HERA + ATLAS W, Z (Ref. [73])	$1.13^{+0.11}_{-0.11}$	1.05 ± 0.04

NNPDF extract Rs using only HERA and ATLAS data obtaining 1.03 with their much more flexible parametrisation.
When they use CMS and Tevatron data they get 0.82



Since PDF fitting starts with assumptions as to the PDF parameters- and the fraction of strangeness- at low scale
And since the neutrino data which originally suggested suppressed strangeness was also taken at low scale
We also show the comparison of strangeness fraction at Q^2 =1.9 GeV^2 where HERAPDF has an assumption that the strangess fraction is x indepedent
$0.44^{+0.17}_{-0.14}$



After QCD evolution to $Q^2 \sim M_W^2$
This is no longer x independent since quarks with higher x split to quark-gluon of lower-x and then the gluon splits to q-qbar flavour independent at even lower x such that flavour symmetry is recovered at low x and high scale even starting from a very suppressed value.