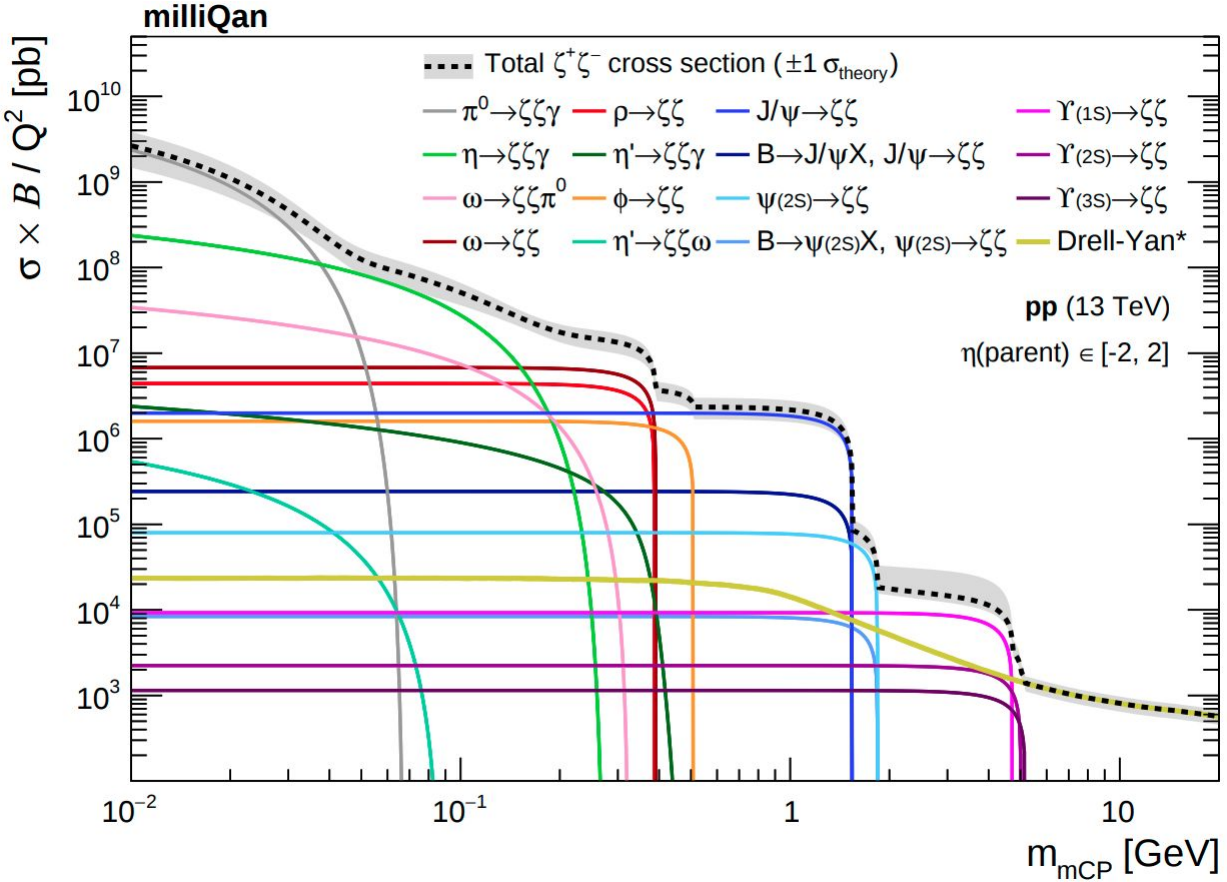
milliQan: mCP production cross sections and uncertainties

Bennett Marsh

December 12, 2019

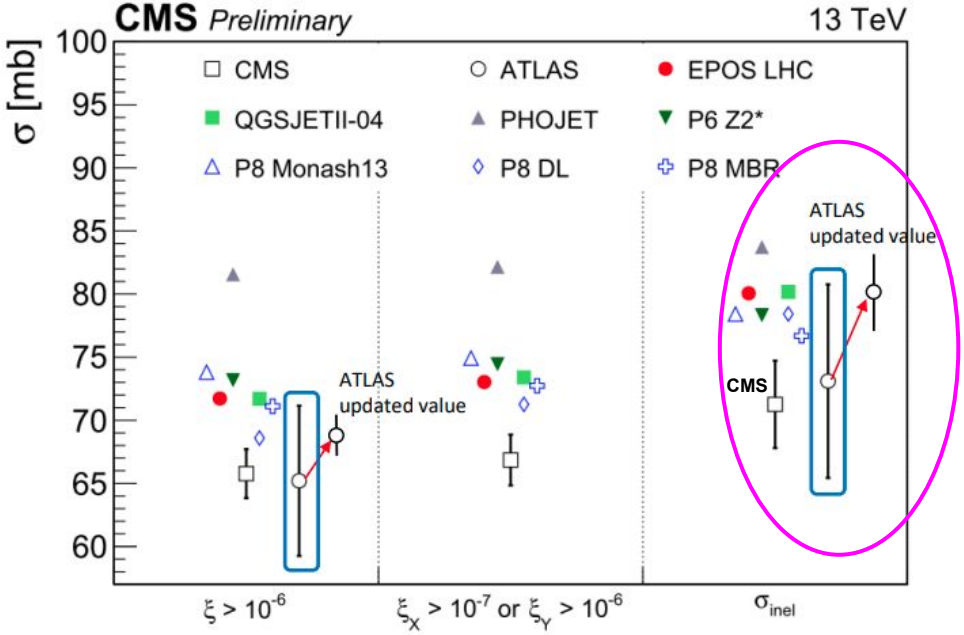
mCP production modes

- 16 distinct mCP production modes
- Need to decide on cross sections and assign an uncertainty to each



Light mesons

- For light mesons, we predict directly from pythia MinBias/QCD production
- Need to scale to the pp cross section (“total inelastic cross section”)
- Have been using the “CMS recommended value” (used for CMS PU reweighting) of 69.2 mb
- CMS value is lower than those measured by ATLAS and predicted by pythia/other models, which all give around 80 mb
- Just switch to using 80 mb, with some uncertainty?



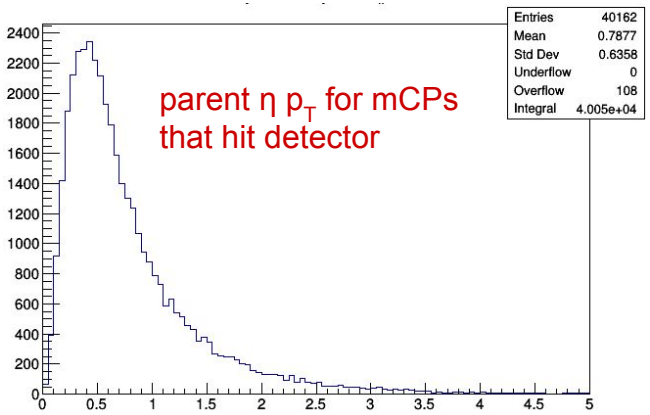
ATLAS: $\sigma_{\text{inel}} = 79.3 \pm 0.6\ (\text{exp.}) \pm 1.3\ (\text{lum.}) \pm 2.5\ (\text{extrap.})\ \text{mb}$

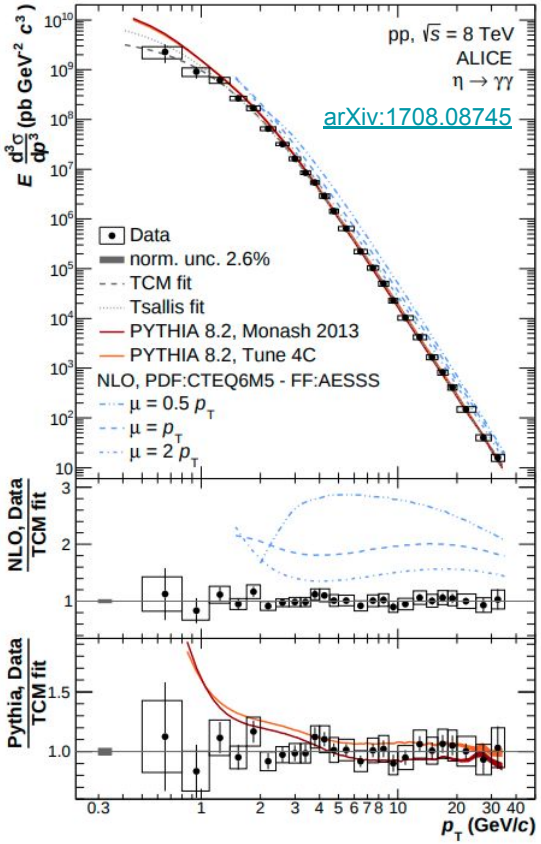
CMS: $\sigma_{\text{inel}} = 71.3 \pm 0.5\ (\text{exp.}) \pm 2.1\ (\text{lum.}) \pm 2.7\ (\text{ext.})\ \text{mb}$

https://indico.cern.ch/event/432527/contributions/1072410/attachments/1321213/1981420/xSections_ICHEP_2016_final_photosd.pdf

η mesons

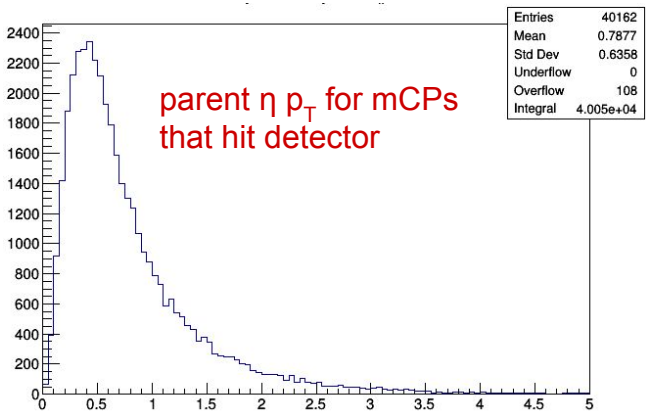
- ALICE 8 TeV paper compares η production to pythia8 Monash Tune
- Fairly good agreement until lower p_T, where pythia overpredicts
- Almost all production comes at p_T < 1 GeV
- Use Monash and scale down by a factor of ~2

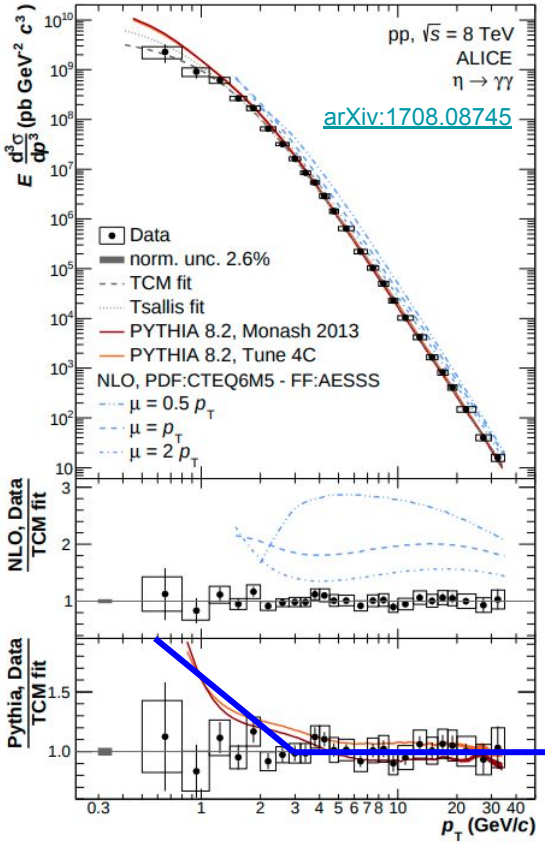




η mesons

- ALICE 8 TeV paper compares η production to pythia8 Monash Tune
- Fairly good agreement until lower p_T, where pythia overpredicts
- Almost all production comes at p_T < 1 GeV
- Use Monash and scale down by a factor of ~2

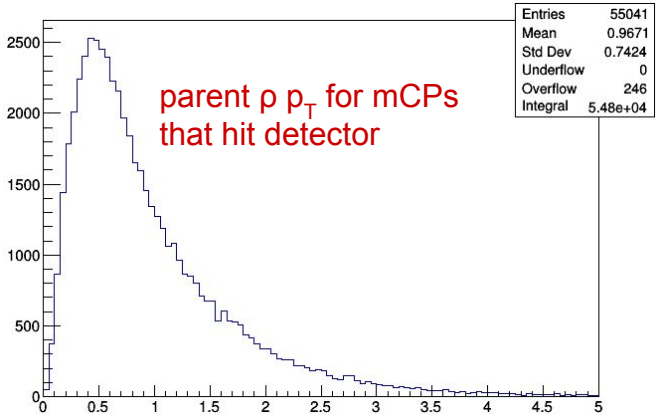


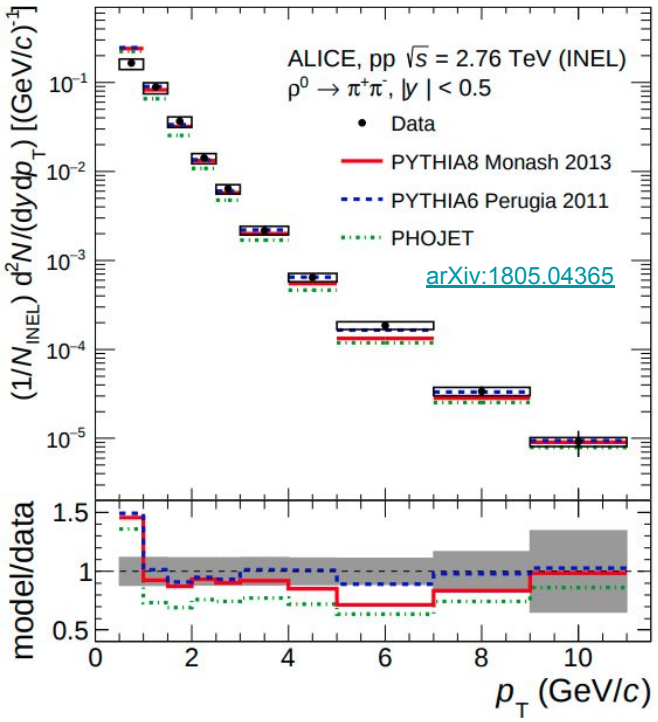


Scale down by this function

ρ mesons

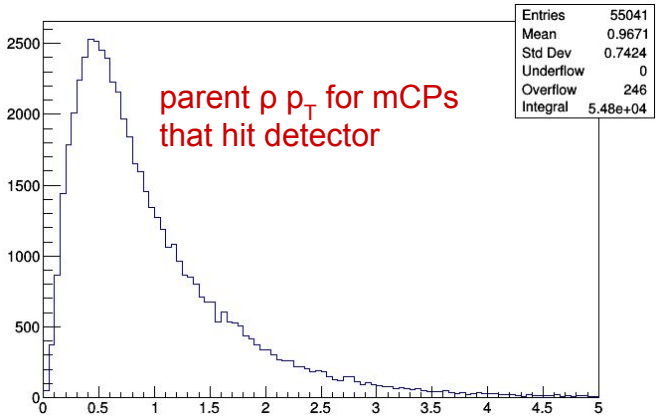
- ALICE 2.76 TeV paper compares ρ production to pythia8 Monash Tune
- Agreement to within 10-20%, except below 1 GeV where Monash is ~50% too high
- Most relevant production is below 2 GeV
- Use Monash and scale down by 30-40%?

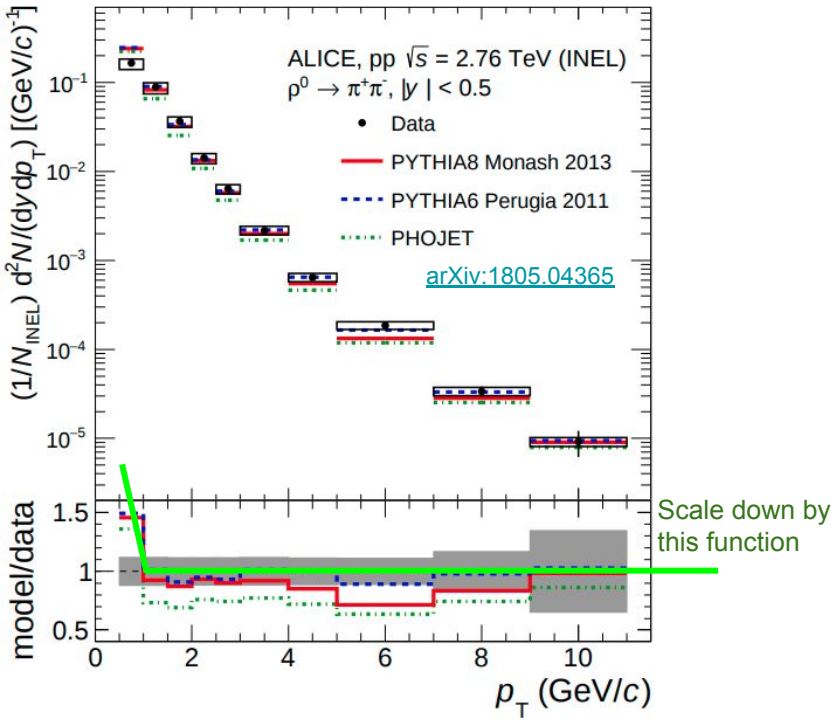




ρ mesons

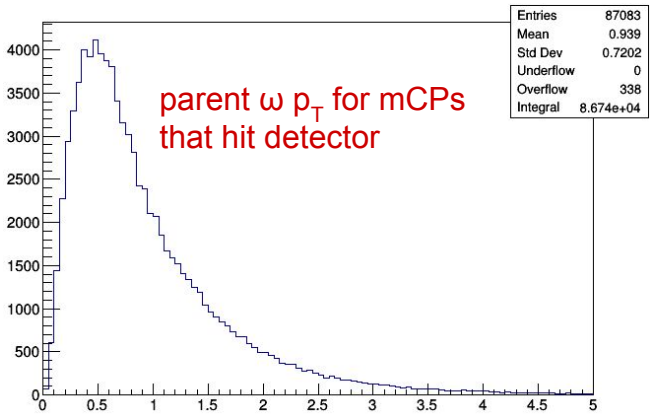
- ALICE 2.76 TeV paper compares ρ production to pythia8 Monash Tune
- Agreement to within 10-20%, except below 1 GeV where Monash is ~50% too high
- Most relevant production is below 2 GeV
- Use Monash and scale down by 30-40%?

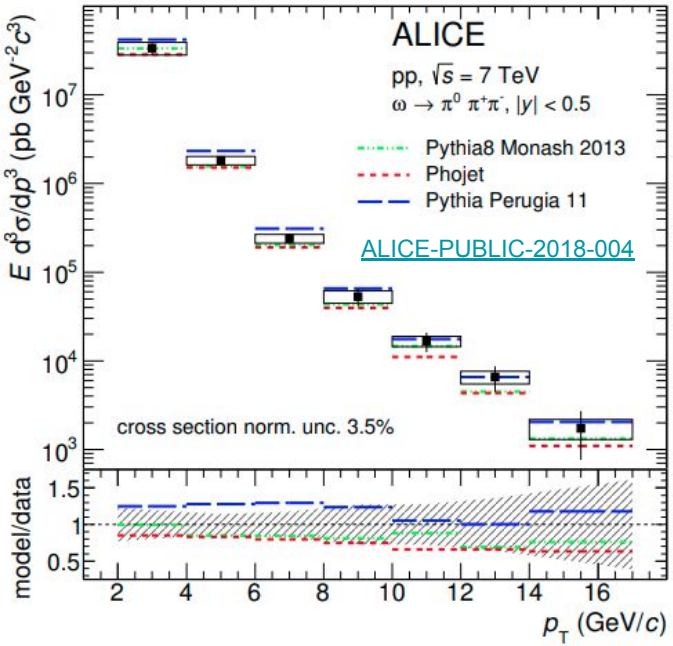




ω mesons

- ALICE 7 TeV paper compares ω production to pythia8 Monash Tune
- Agreement to within 10-20%, but only compare down to 2 GeV
- Almost all relevant production is below 2 GeV
- ω and ρ production probably similar, so I scale down based on previous slide

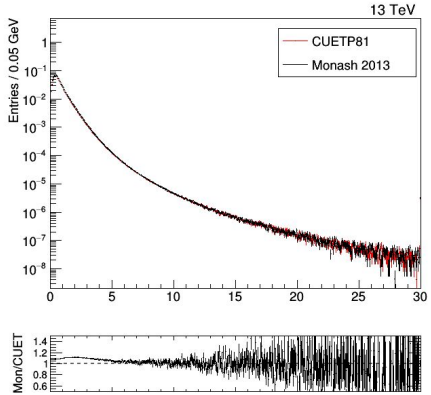


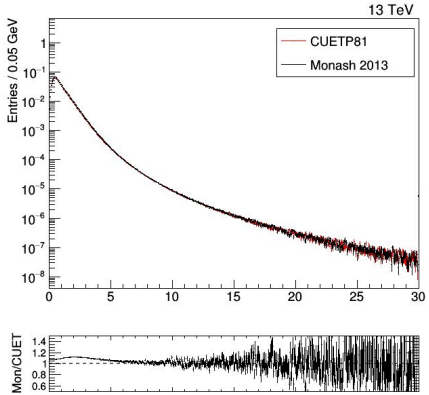


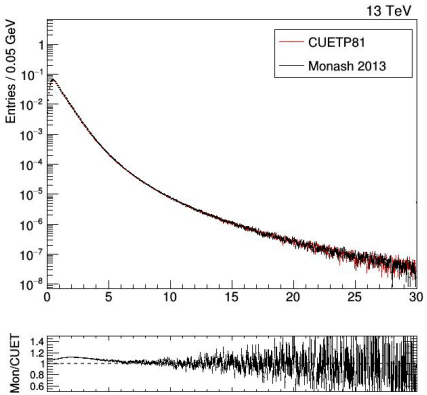
Monash2013/CUETP8M1 tune comparison

- Have been using the CUETP8M1 tune, which was used by CMS for 2016 MC. It is based on the Monash2013 tune, with slight modifications to a few parameters

- Comparing, the Monash2013 tune is ~10-15% higher in the relevant p_T ranges for η, ρ, ω

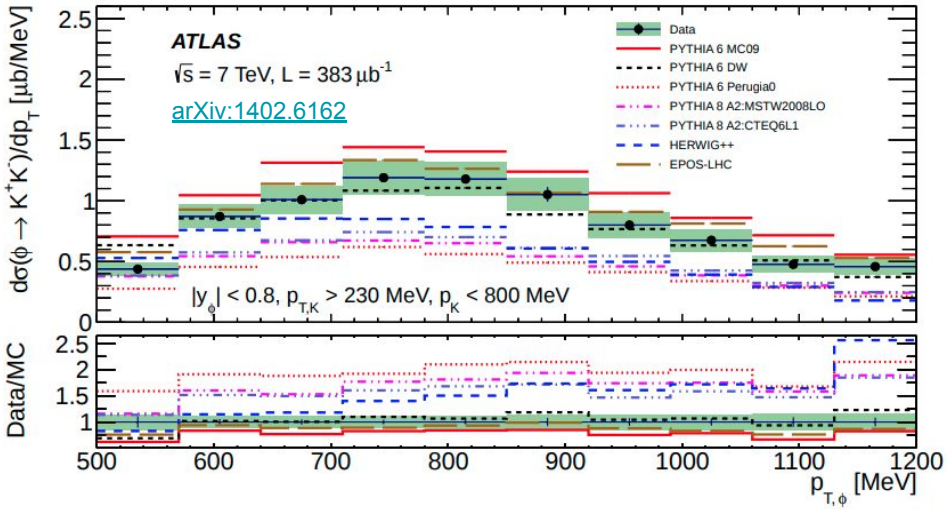


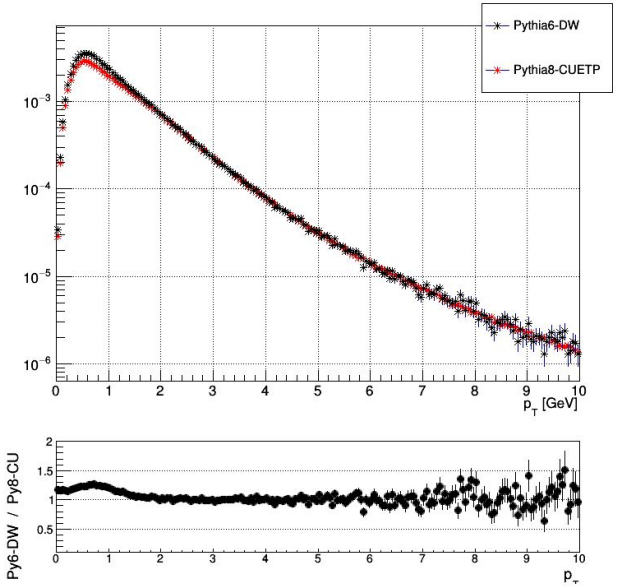




ϕ mesons

- ATLAS 7 TeV paper compares ϕ production to predictions from various pythia tunes
- Pythia6 DW is best, pythia8 tunes are too low
- Use pythia6-DW as the default here

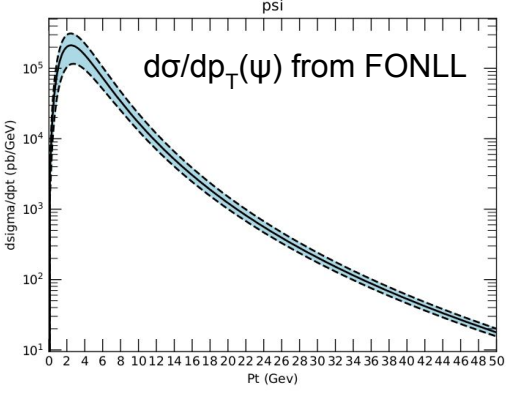


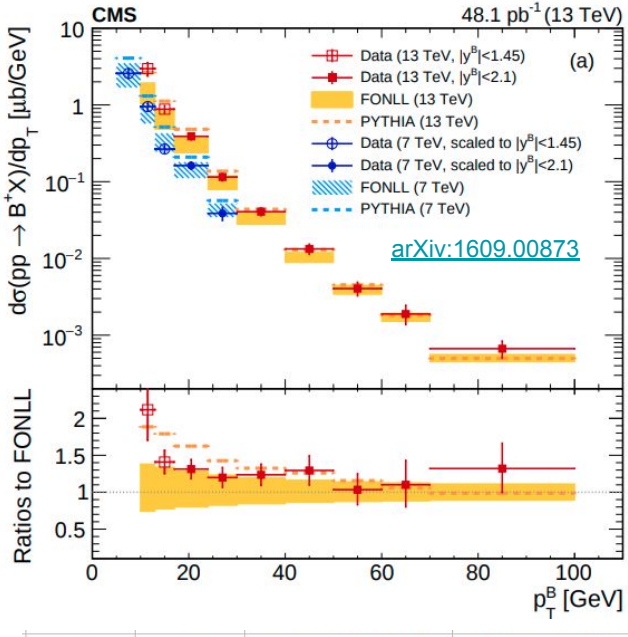


- Comparison of pythia6-DW (from Franny) to pythia8-CUETP8M1. The pythia6 is ~30% higher in the relevant region

ψ's from B's

- For J/ψ and ψ' from B decay, we take differential cross sections from theorists' FONLL tool
- CMS B measurement (right plot/table) show that FONLL is consistently low
- For muons, relevant B p_T range is 20-40 GeV, so we scale by 1.25±0.25 based on table to right
- For ψ's, relevant B p_T range is much lower, with no data. Should we still scale by something? Direct production is ~order of magnitude higher, so probably doesn't matter much either way

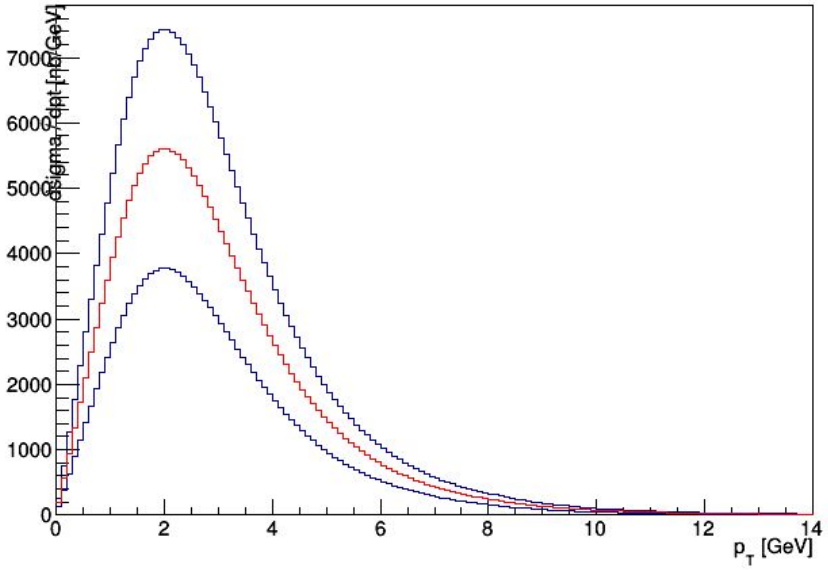




eta	pT	Data/FONLL	Pythia/FONLL
<1.45	10-13	2.14 +- 0.86	1.86
	13-17	1.42 +- 0.50	1.81
<2.1	17-24	1.30 +- 0.37	1.60
	24-30	1.20 +- 0.28	1.40
	30-40	1.24 +- 0.26	1.33

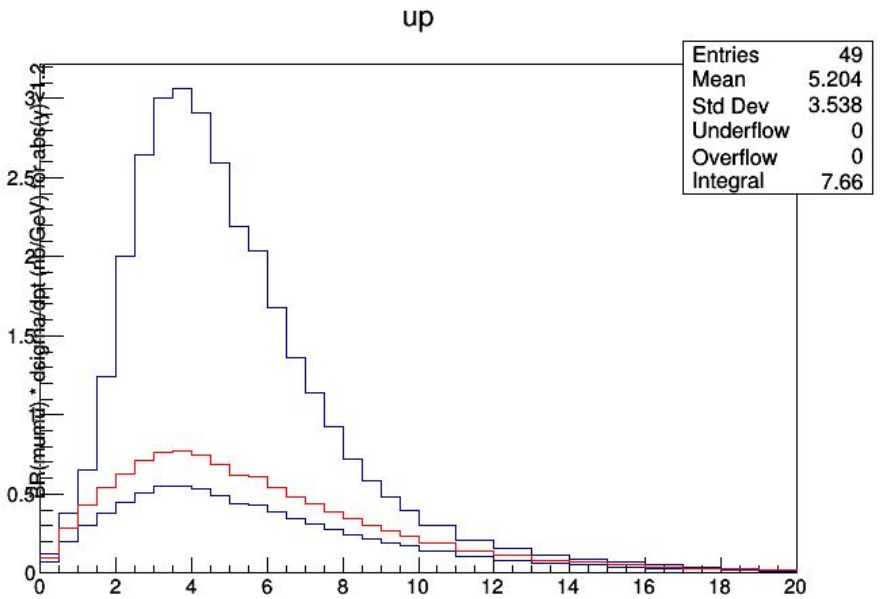
Direct ψ's

- For direct J/ψ and ψ', take differential cross sections directly from theory.
- ~33% uncertainty in total cross section



Y's

- For upsilons use CMS 13 TeV data at high p_T (>20 GeV), and rescaled ATLAS 7 TeV data at low p_T.
- Uncertainties are very asymmetric (200% up, 30% down)

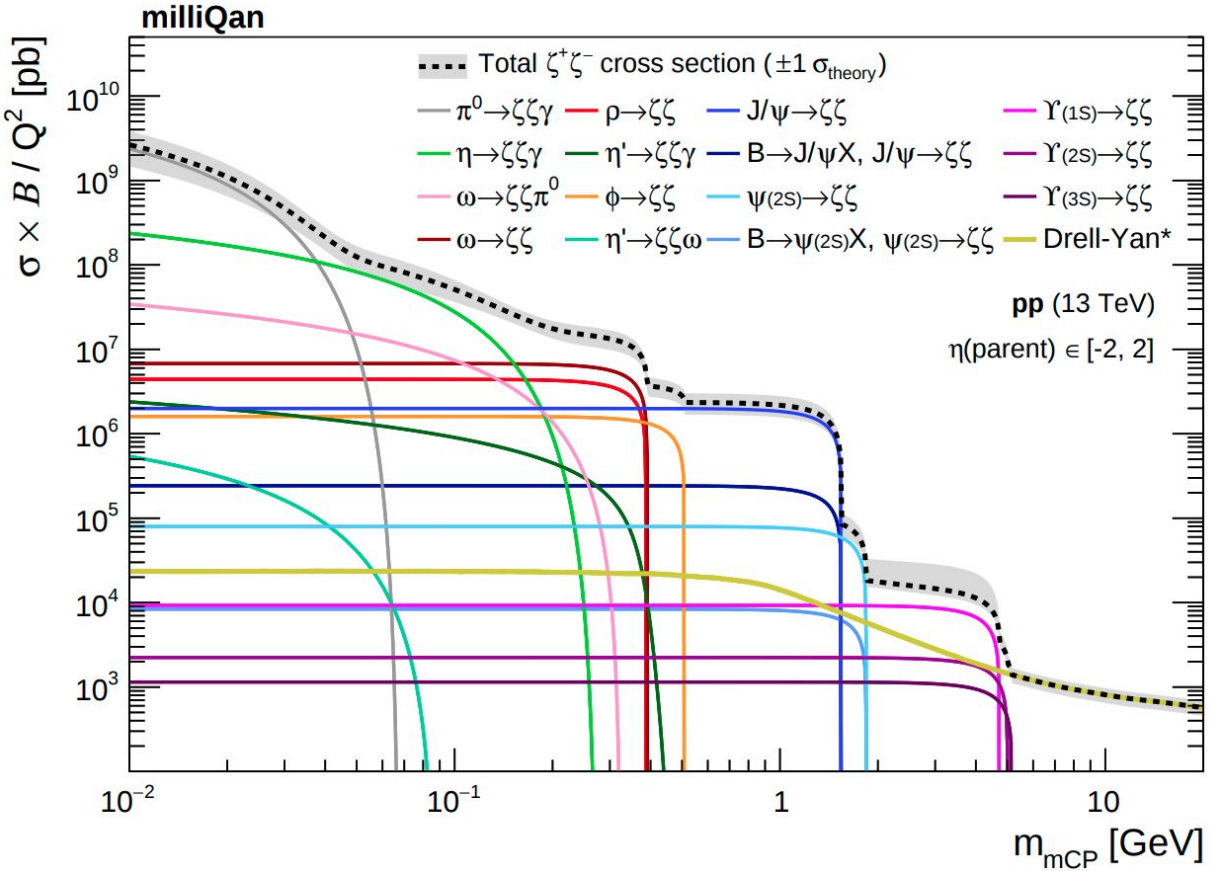


Summary

- Switch to 80 mb for central pp cross section value (±10 mb?)
- For η, ρ, ω, use the Pythia8 Monash2013 tune as default. Scale down η's by a factor of ~2, and ρ's/ω's by a factor of ~1.3. Apply O(30%) uncertainty on this?
- For ϕ's, use Pythia6 DW tune as default. Again O(30%) uncertainty to cover data disagreement and tune variation?
- For ψ's from B's, take central values and uncertainties directly from FONLL. Evidence that FONLL is too low, but data doesn't go down to low enough p_T to make a comparison, so we'd just be guessing at any kind of scale factor
- For direct ψ's, take central value/uncertainties directly from theory
- For Y's, use merged ATLAS/CMS data. Uncertainties are highly asymmetric for low-p_T upsilons; not sure if this will cause problems

Summary

- Comparison of old/new cross sections after changes on summary slide
- This is with OLD cross sections
- (flip back and forth with next slide)



Summary

- Comparison of old/new cross sections after changes on summary slide
- This is with NEW cross sections
- (flip back and forth with previous slide)
- etas go down, rhos/omegas don't change much, phis go up slightly