Fiducial differential comparisons (and combinations) of ATLAS and CMS results

Example: recent $ZZ \to \ell^+\ell^-\ell'^+\ell'^-$ measurements

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The idea

We want:

minimum model dependence → no extrapolation

competition and complementarity: each experiment's strengths → no pre-agreed common fiducial definition

→ So "intrapolate" instead to the intersection of the experiments' fiducial phase spaces!

Intrapolation matrices

Intrapolation matrix I relating the histogram c in the intersecting phase space to that in the experiment's phase space, e

$$c_i = I_{ij} e_j \tag{1}$$

$$I_{ij} = M_{ij}\, \varepsilon_j\, \phi_i \tag{2}$$

M_{ij} describes the *bin migrations*:

$$M_{ij} = \frac{P(\text{in intersection bin } i \;\cap\; \text{in experiment bin } j)}{\sum_{i'} P(\text{in intersection bin } i' \;\cap\; \text{in experiment bin } j)} \tag{3}$$

ε_j is like an *efficiency*:

$$\begin{aligned} \varepsilon_j &= \frac{\sum_{i'} P(\text{in intersection bin } i' \;\cap\; \text{in experiment bin } j)}{P(\text{in experiment bin } j)} \\ &= P(\text{in any intersection bin} \mid \text{in experiment bin } j) \leq 1 \end{aligned} \tag{4}$$

ϕ_i corrects for events falling in the "intersection", but not the experiment's phase space (only possible if it's not truly the intersection!):

$$\phi_i = \frac{P(\text{in intersection bin } i)}{\sum_j P(\text{in intersection bin } i \;\cap\; \text{in experiment bin } j)} \geq 1 \tag{5}$$

Example: $ZZ \to \ell^+\ell^-\ell'^+\ell'^-$ @ 13 TeV

Input:

ATLAS measurement [1709.07703]

CMS measurement [1709.08601]

Ideally joint phase space = ATLAS ∩ CMS,
but this is not always practical

Here: CMS pairing algorithm is used, which does not select a subset of events of those selected by the ATLAS pairing algorithm

But almost!

Comparing the four-lepton $p_\perp$

Binnings in GeV:

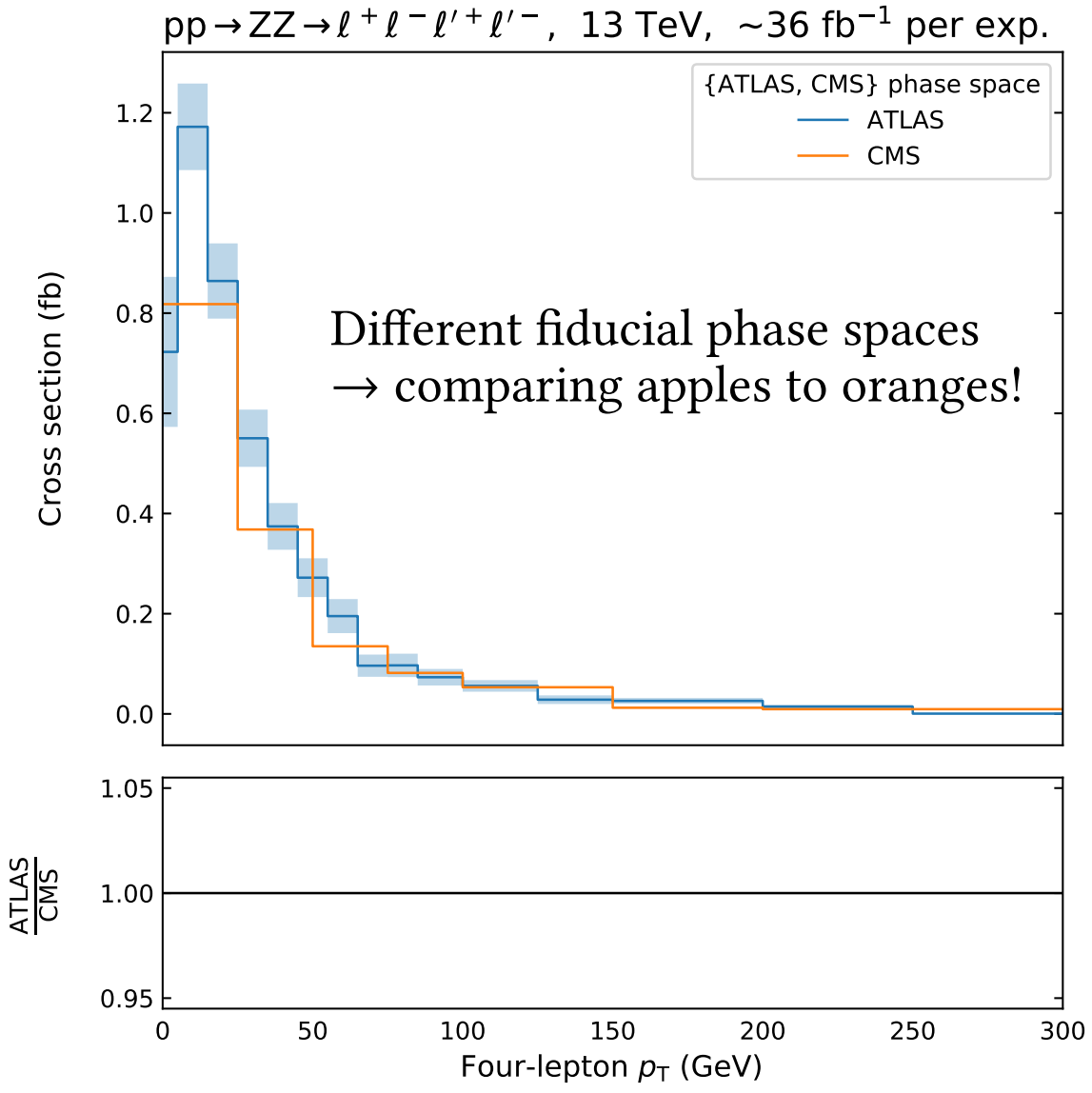
ATLAS	0, 5, 15, 25, 35, 45, 55, 65, 75, 85, 100, 125, 150, 200, 250, 1500
CMS	0, 25, 50, 75, 100, 150, 200, 300
Combined	0, 25, 50, 75, 100, 150, 200, 300

Challenges:

ATLAS published $\frac{\mathrm{d}\sigma}{\mathrm{d}x}$, CMS published $\frac{1}{\sigma}\frac{\mathrm{d}\sigma}{\mathrm{d}x}$

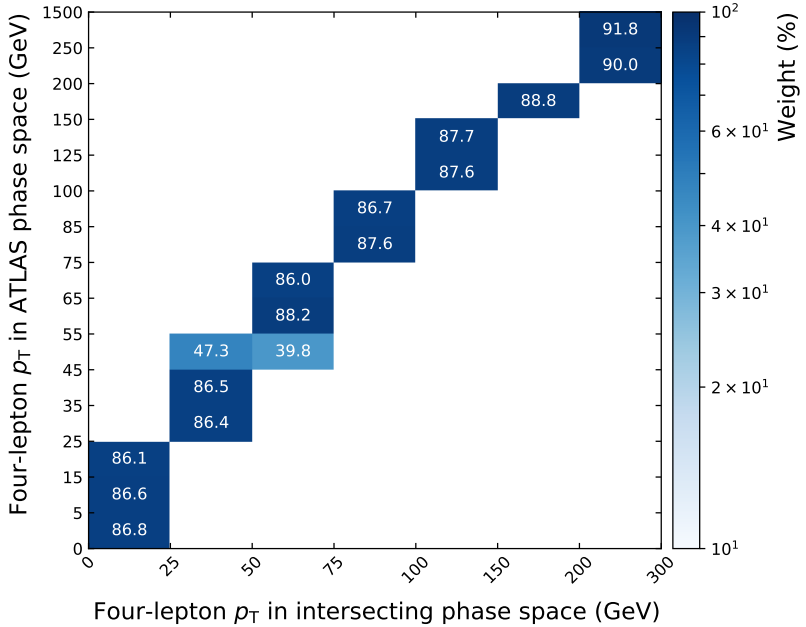
I quickly read CMS data off plots with exponential y-axes — very inaccurate *(apologies!)*

Directly comparing fiducial results

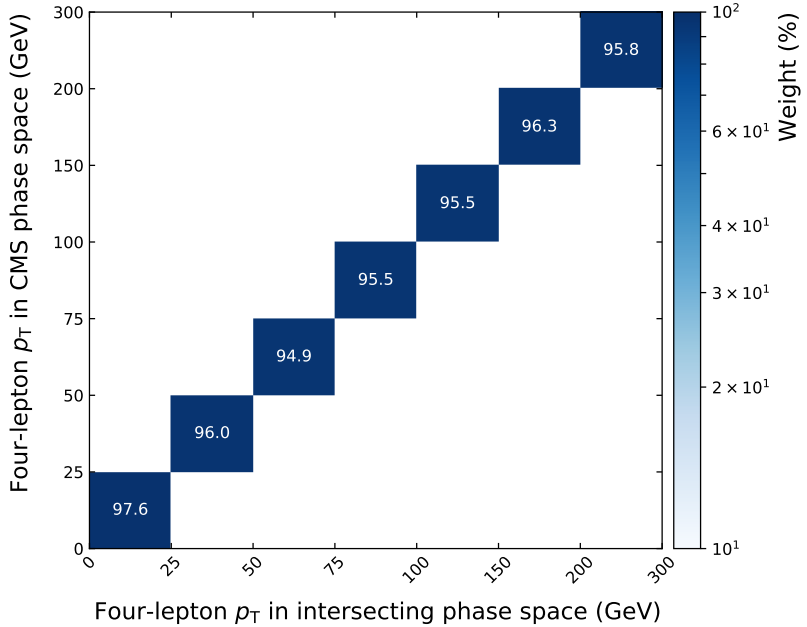


Intrapolation matrices

ATLAS → intersection

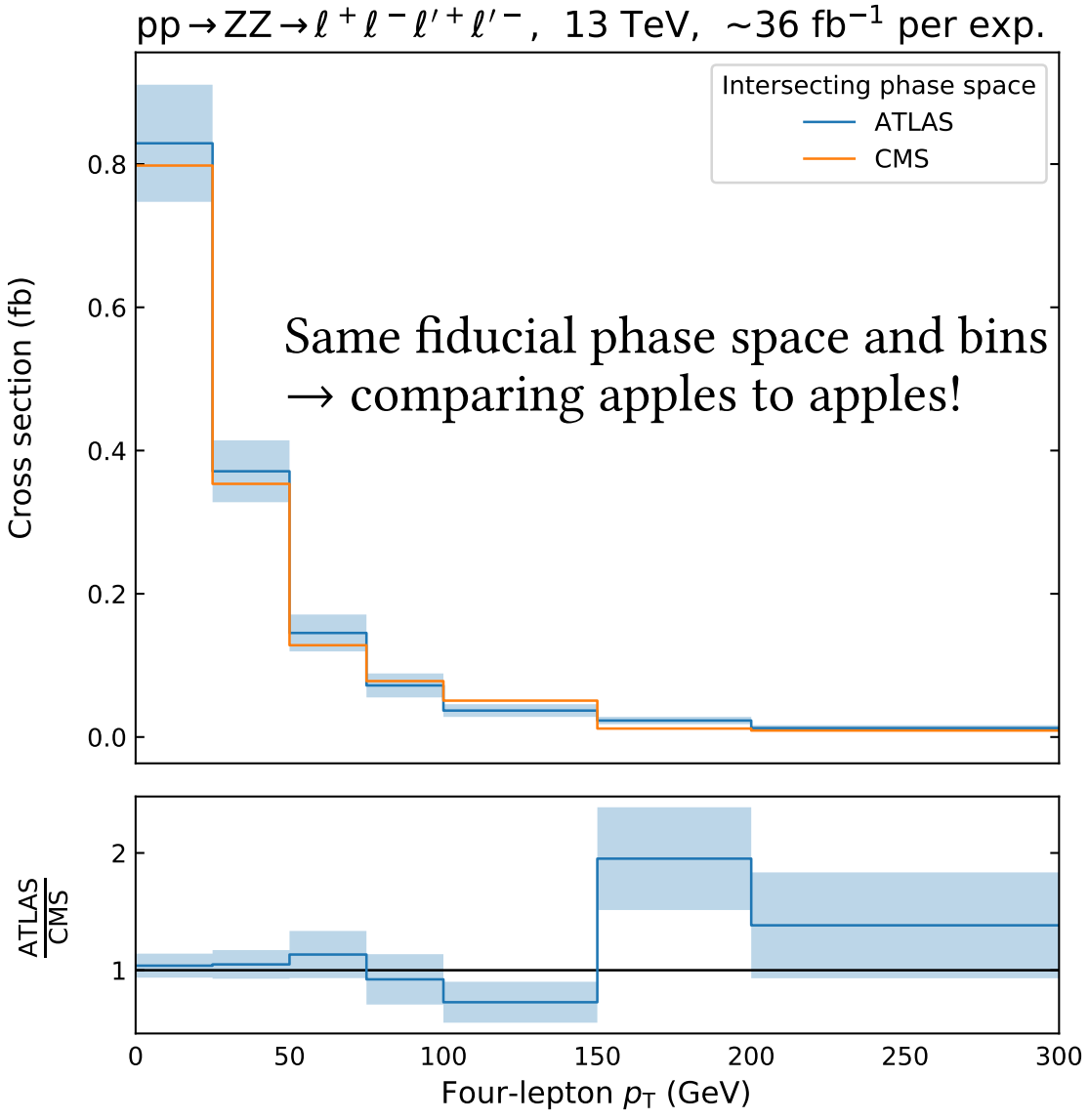


CMS → intersection

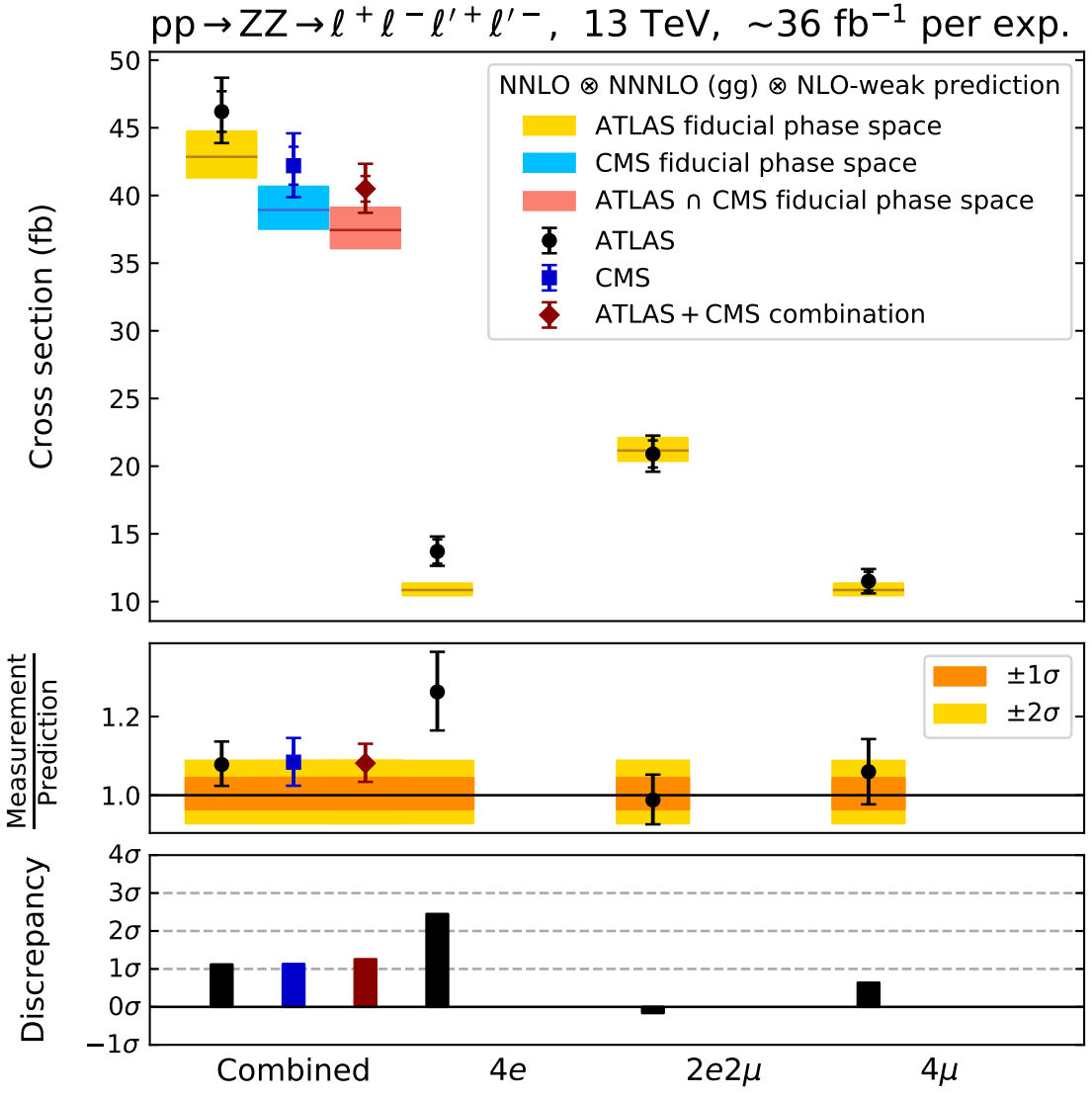


Using SHERPA pp $\to \ell^+\ell^-\ell'^+\ell'^-$ + {0, 1} jets @ NLO + {2, 3} jets @ LO

Properly comparing fiducial results



Simpler: integrated cross sections



Project repository

Full details in my thesis

Much room for improvement

Get CMS data from HepData (or similar) ;)

Combine ATLAS ⊕ CMS: fit to intrapolated curves

Careful treatment of uncertainties:
- Correlations between bins
- Correlations between experiments

Intrapolate the different channels (4e, 2e2μ, 4μ) separately, then sum (neither experiment published channels separately)

Use best theory predictions to calculate the intrapolation matrices

Agree on *some* common bin edges beforehand (could have alternative binning for auxiliary materials & HepData)

The EWWG can help with many of the above!