ZZ Cross−Section

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Question :

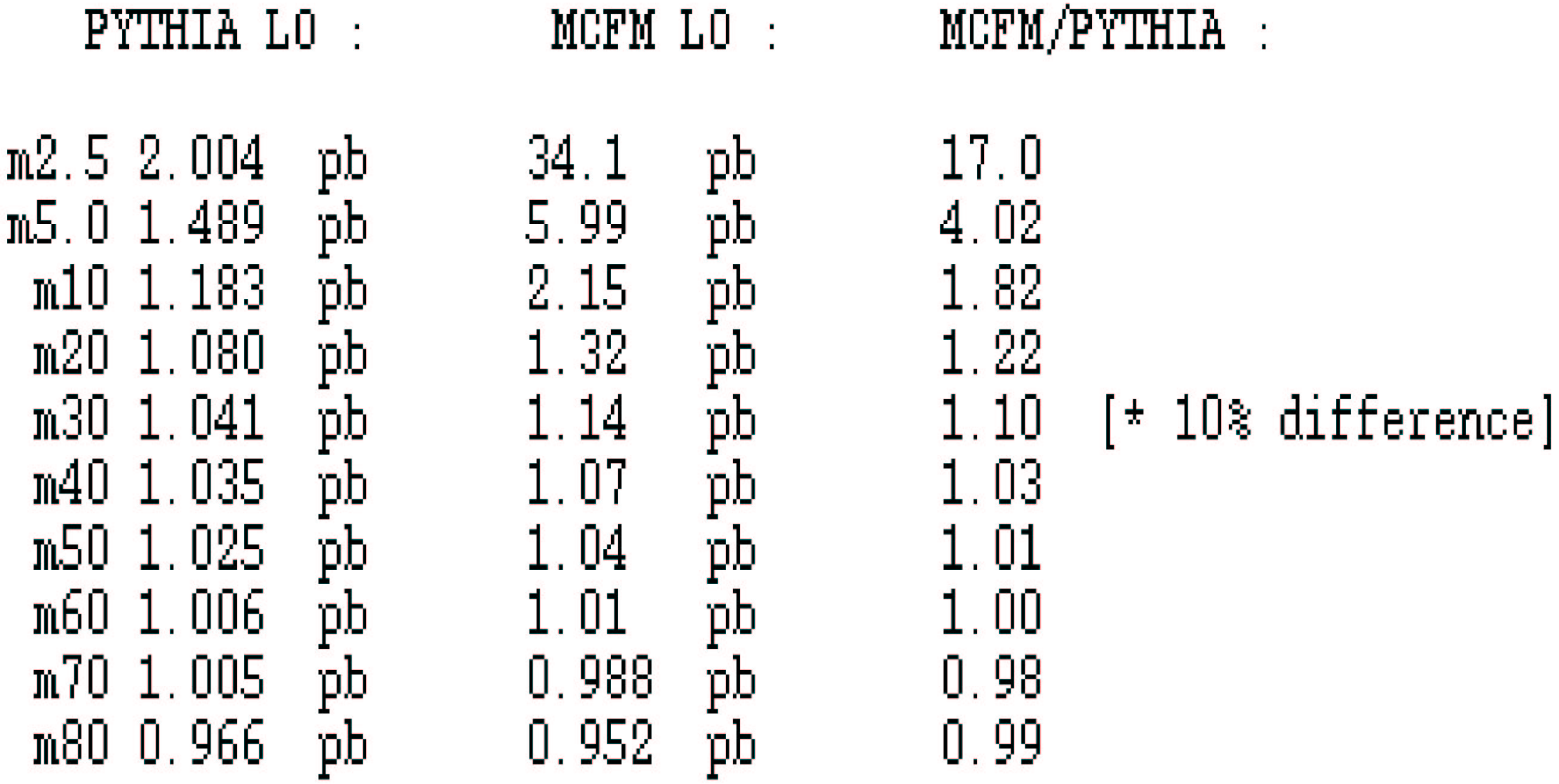
Have we been normalising our ZZ background sample correctly ?

- 1.43 pb taken from Campbell & Ellis 1999
- Pythia with certain kinematic cuts and settings used to generate the events.

Issues :

- Z and γ^* being correctly combined ?
- BR’s are a function of mass [$BR(Z \rightarrow ee)$] != [$BR(\gamma \rightarrow ee)$].
- Full−width versus zero−width ?
- Different renormalisation scales ?
- Best k−factors determination ?

Total ZZ cross−section comparison :



	PYTHIA LO :		MCFM LO :		MCFM/PYTHIA :	
m2.5	2.004	pb	34.1	pb	17.0	
m5.0	1.489	pb	5.99	pb	4.02	
m10	1.183	pb	2.15	pb	1.82	
m20	1.080	pb	1.32	pb	1.22	
m30	1.041	pb	1.14	pb	1.10	[* 10% difference]
m40	1.035	pb	1.07	pb	1.03	
m50	1.025	pb	1.04	pb	1.01	
m60	1.006	pb	1.01	pb	1.00	
m70	1.005	pb	0.988	pb	0.98	
m80	0.966	pb	0.952	pb	0.99	

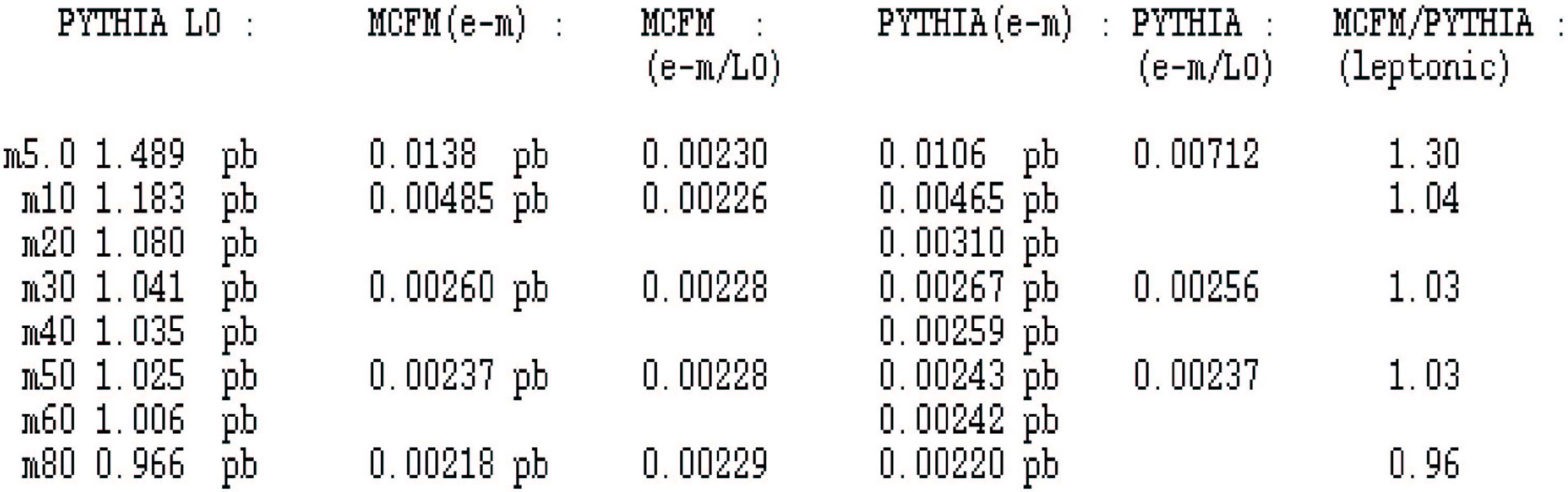
MCFM >> Pythia for small mass cuts

Leptonic ZZ cross−section comparison :

- Run MCFM and Pythia in ZZ→ eeμμ mode :

constant BR

varying BR



	PYTHIA LO :	MCFM(e-m) :	MCFM : (e-m/LO)	PYTHIA(e-m) :	PYTHIA : (e-m/LO)	MCFM/PYTHIA : (leptonic)
m5.0	1.489 pb	0.0138 pb	0.00230	0.0106 pb	0.00712	1.30
m10	1.183 pb	0.00485 pb	0.00226	0.00465 pb		1.04
m20	1.080 pb			0.00310 pb		
m30	1.041 pb	0.00260 pb	0.00228	0.00267 pb	0.00256	1.03
m40	1.035 pb			0.00259 pb		
m50	1.025 pb	0.00237 pb	0.00228	0.00243 pb	0.00237	1.03
m60	1.006 pb			0.00242 pb		
m80	0.966 pb	0.00218 pb	0.00229	0.00220 pb		0.96

ratio of leptonic cross sections in much better agreement down to 5 GeV or so

Conclusions :

- Only Pythia has mass dependence of BR’s.
- MCFM looks like an overestimate due to Z−only BR’s being used.
- Prefer to use Pythia to drive cross−section estimate.
- Confirmed with analysis of ZZ→ eeνν

effective BR from Pythia for M_{Z/γ^*}>30 GeV

↑

$$\sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{MCFM} \;=\; \frac{\sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{PYTHIA}}{\sigma\,(ZZ\to ee\,\mu\,\mu\,;Q^2=\hat{s}\,)^{LO}_{PYTHIA}}$$

$\sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{PYTHIA} \longrightarrow$ **0.94 pb**

$\sigma\,(ZZ\to ee\,\mu\,\mu\,;Q^2=\hat{s}\,)^{LO}_{PYTHIA} \longrightarrow$ **2.459 fb**

$$\times \quad \sigma\,(ZZ\to ee\,\mu\,\mu\,;Q^2=4M_Z^2\,)^{LO}_{MCFM} \longrightarrow \textbf{2.60 fb}$$

$$\times \quad \frac{\sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{MCFM}}{\sigma\,(ZZ\,;Q^2=4M_Z^2\,)^{LO}_{MCFM}} \longrightarrow \textbf{1.10/1.14 (JMC)}$$

↓

adjustment for different QCD scales

$$\left.\begin{array}{l} \sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{MCFM} \;=\; 0.96\ \ \text{pb} \\ \sigma\,(ZZ\,;Q^2=\hat{s}\,)^{LO}_{PYTHIA} \;=\; 0.94\ \ \text{pb} \end{array}\right\}$$

- ★ for M_{Z/γ^*}>30 GeV
- ★ agreement to within 2%

k−factors :

Use MCFM with 30 GeV cut ; CTEQ5L/M ; $Q^2 = 4M_Z^2$:

Full−width :

NLO/LO = 1.585/1.143 = 1.386

Zero−width :

NLO/LO = 1.389/0.989 = 1.404

- 1.3% difference

Best estimate of ZZ cross−section to normalise Pythia background sample :

$$\boxed{\sigma\,(ZZ\,;Q^2\!=\!\hat{s})^{LO}_{PYTHIA} \;\times\; 1.386 \;=\; 1.30 \;\; \text{pb}}$$

To do :

- Need to pass this by John Campbell/Keith Ellis
- John will provide code for using Q2 = shat in MCFM for easier comparison with Pythia
- Need to look again at WZ :
  - Pythia description of this process does not include γ^* component.
  - Uli Baur’s concern that nearly on−shell γ^* component could produce a large background.