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Department of Physics

Energy Dependent Intrinsic kT tune Pythia & Herwig

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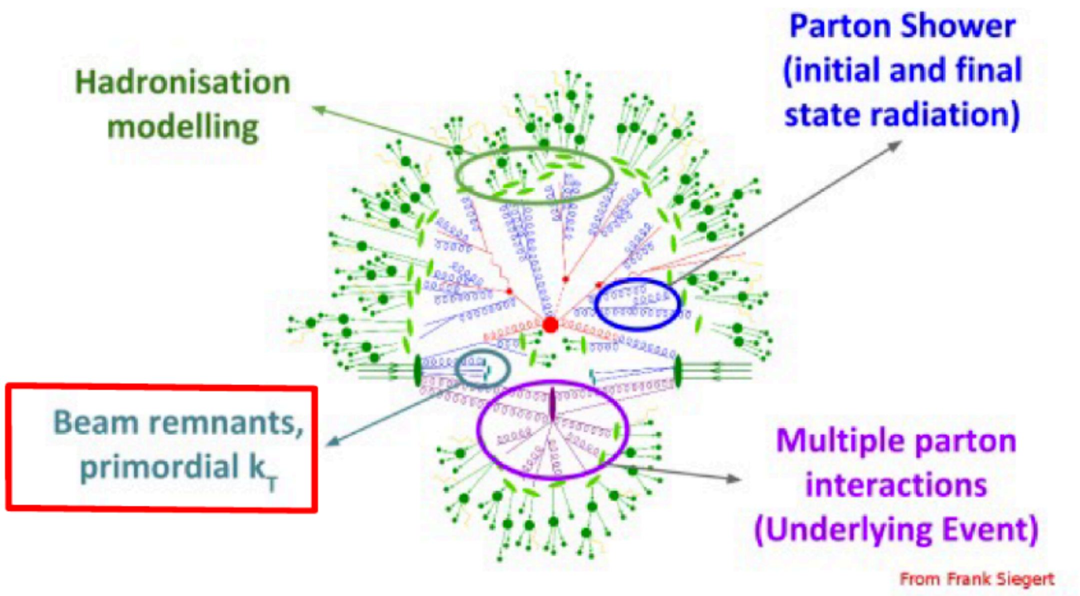
Intrinsic kT model



Intrinsic kT:

The transverse momenta of the partons in the incoming colliding hadrons

→ **Not calculable** in perturbative QCD

→ Described by phenomenological models

In PYTHIA & Herwig :

Gaussian distribution of primordial kT $e^{-k_T^2/\sigma^2}$

Relavant parameters:

In PYTHIA: **BeamRemnants:primordialKThard**

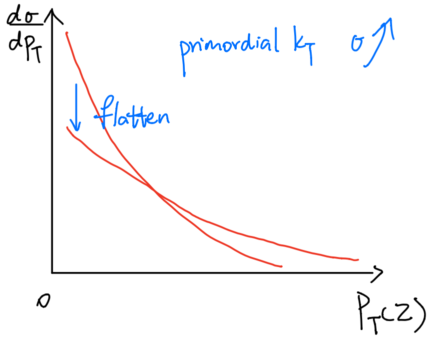
(width in the two transverse directions: σ_x , σ_y)

In Herwig: **ShowerHandler:IntrinsicPtGaussian**

(width in the transverse plane: σ)

Primordial kT in partons → pT(l+l-) in DY

Smear of primordial kT σ ↑ → low pT(l+l-) spectrum flattened



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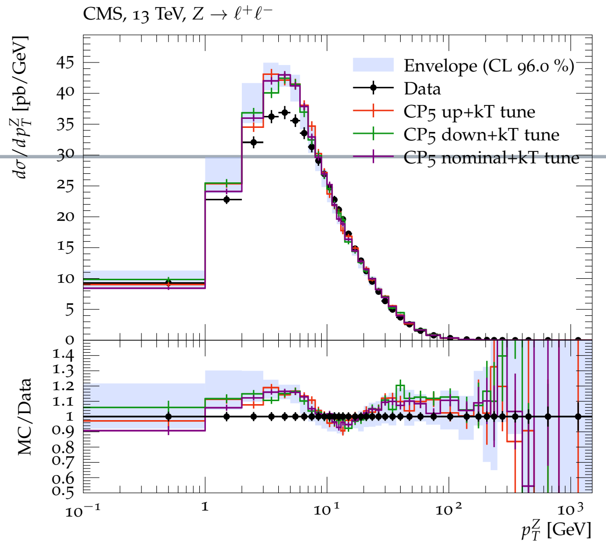
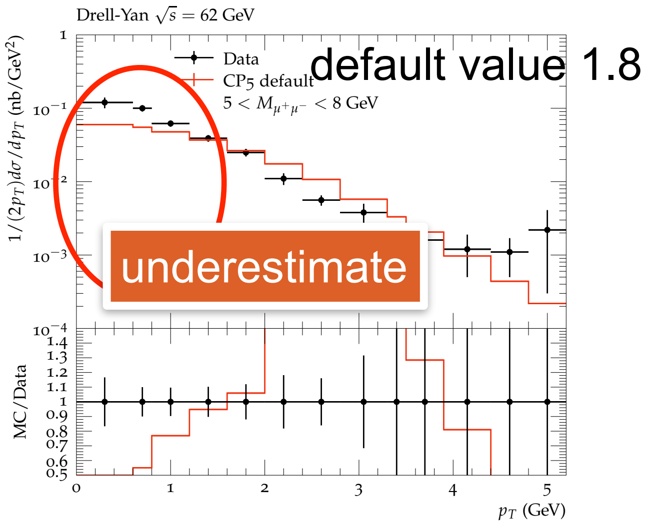
Tune Strategy



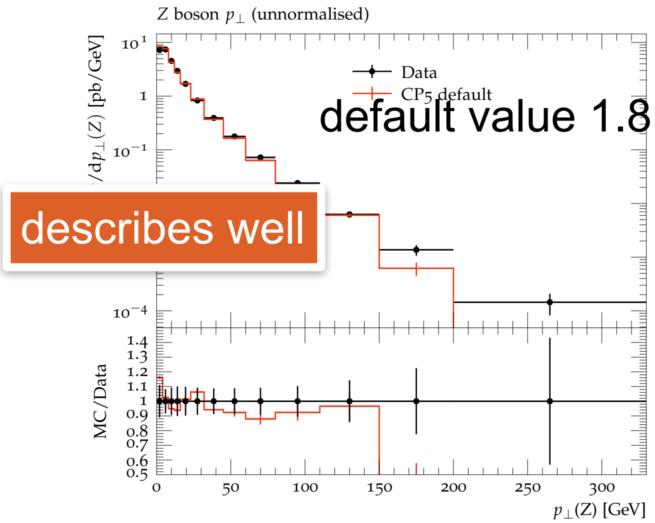
Underlying event (UE) parameters do not affect the pT(l+l-) spectrum much
-> **Fix the UE parameters** in the intrinsic kT tune

pT(Z) (after kT tune) variation when **changing UE parameters**

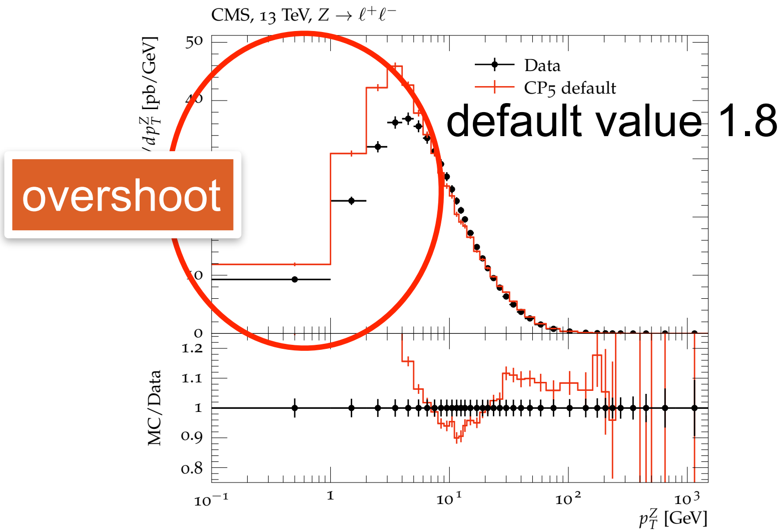
We cannot achieve universal intrinsic kT tune at different energies
-> Tune separately at different energies -> **energy-dependent** intrinsic kT parameters



62 GeV pp collisions



1.96 TeV p+p- collisions



13 TeV pp collisions

Setup

pT(l+l-) XS measurements from hadron collisions

38.8 GeV pp (NUSEA), **62 GeV** pp (R209), **200 GeV** pp (PHENIX), **1.8 TeV** ppbar (CDF, D0),
1.96 TeV ppar (CDF), **2.76 TeV** pPb (CMS), **8 TeV** pp (ATLAS), **8.16 TeV** pPb (CMS), **13 TeV** pp (CMS)

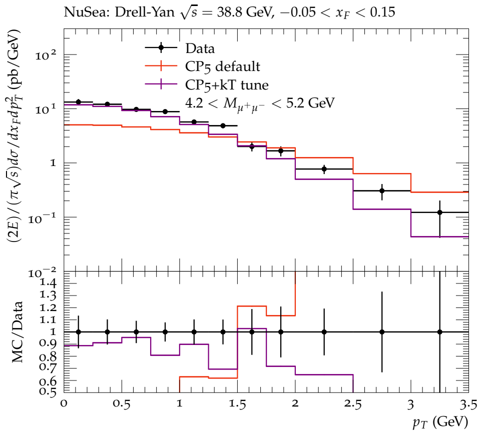
Tune range: pT(l+l-) under 10 GeV

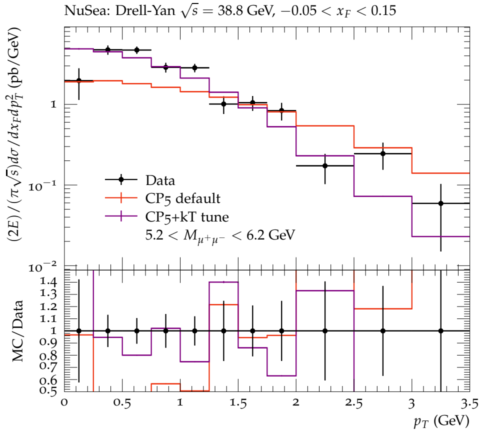
Procedure:

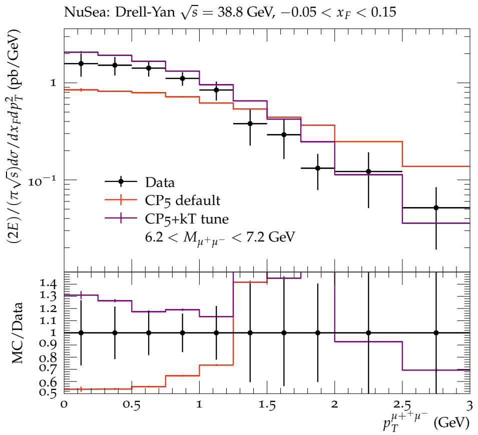
1. Generate MC with different intrinsic kT parameters
2. Interpolate the pT(l+l-) bins as polynomials of the intrinsic kT parameters
3. Calculate the goodness of fit (GOF) v.s. intrinsic kT
4. Minimize the GOF -> tuned intrinsic kT parameters

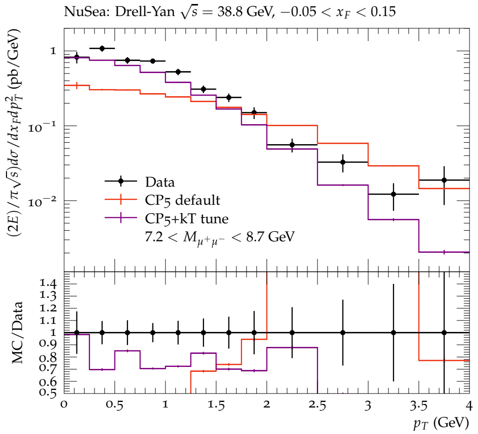
Tuning results (Examples)

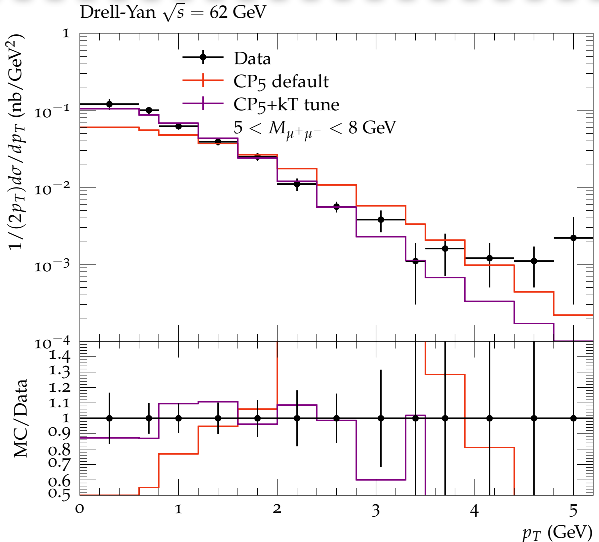
38.8 GeV pT(Z->ll) in various dilepton mass ranges











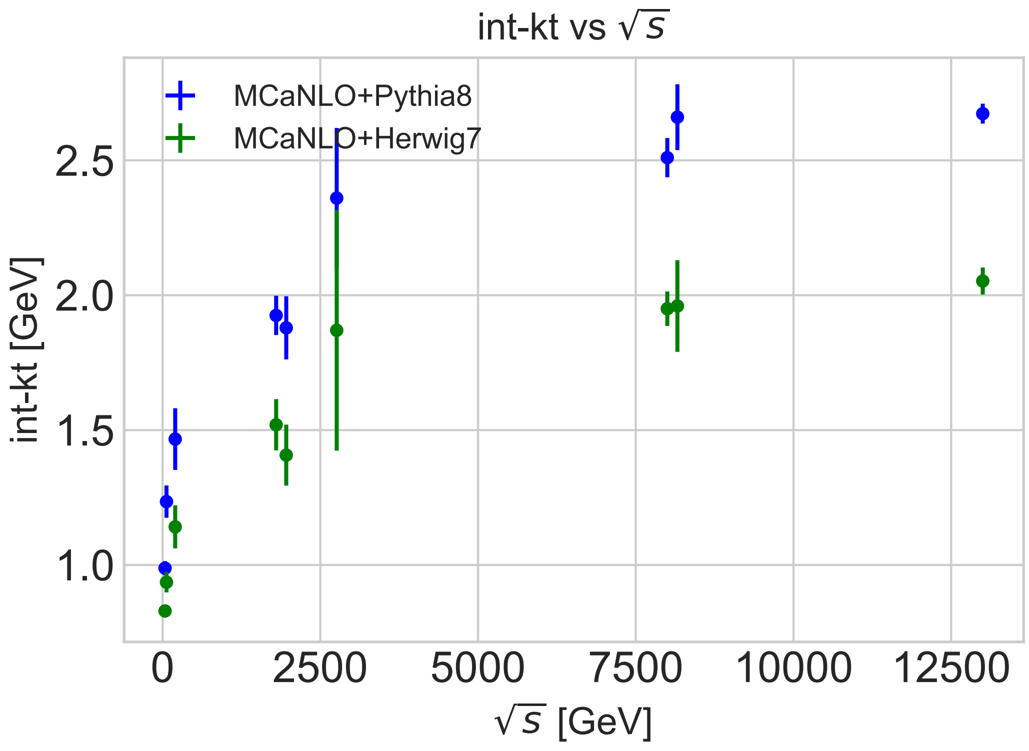
62 GeV pT(Z->μμ) in M(μ⁺μ⁻) 5-8 GeV

CP5+default primordial kT

CP5 + tuned primordial kT

Tuning results

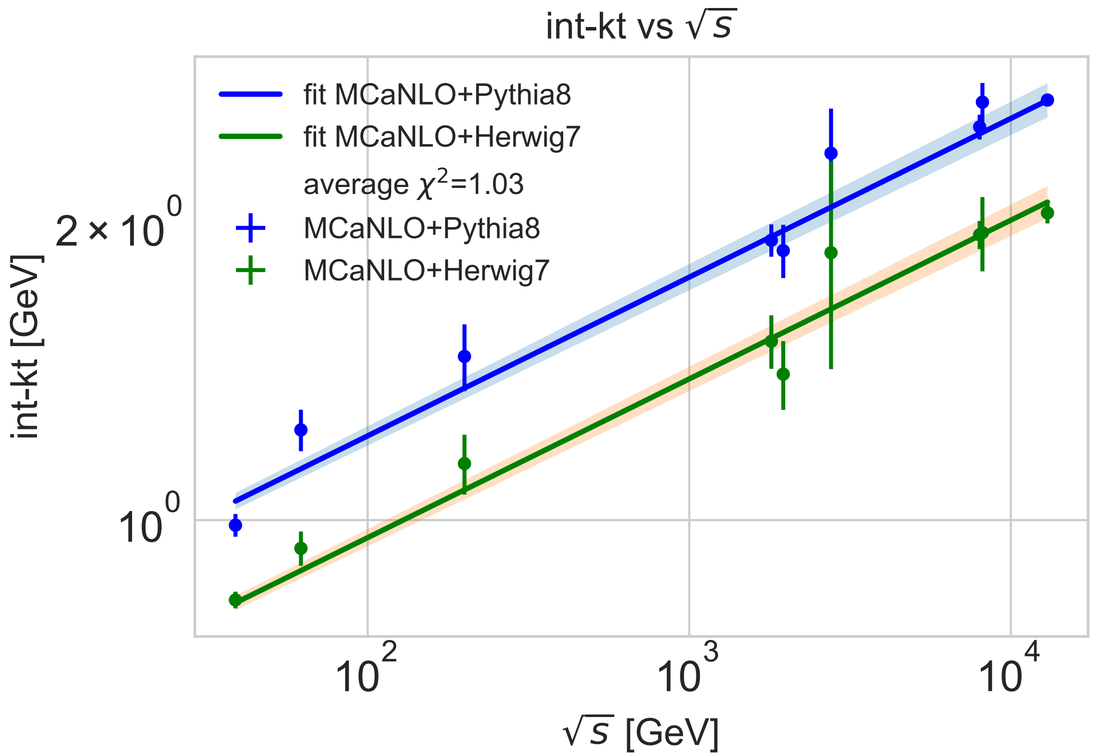
Energy scaling behavior of intrinsic kT



Intrinsic kT width increase with energy
Similar tendency for both generators

Hypothesis:

linear relation between **log(int-kT)** and **log(√s)**
same slope for both generators



Fitting results agree with the tuned parameters

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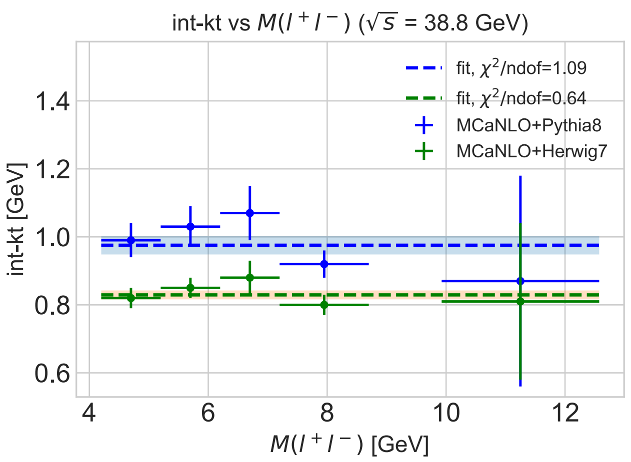
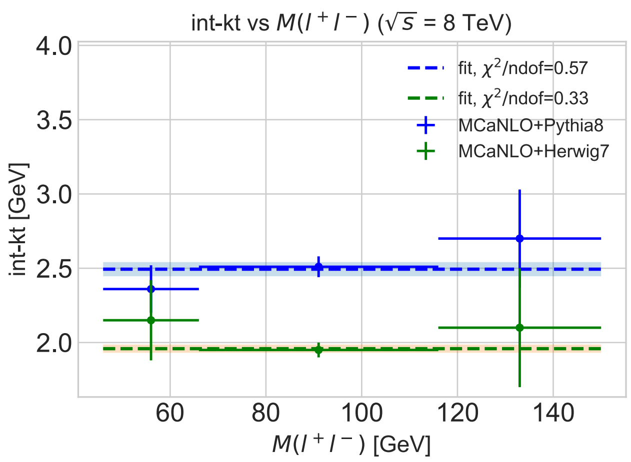
Tuning results

At the **same √s**, tune the MC to data in **various M(l+l-) ranges** separately
-> **Intrinsic kT** dependence on **dilepton mass**

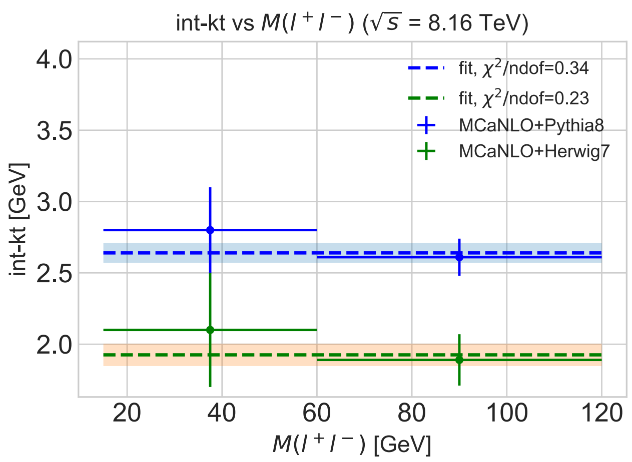
√s = 38.8 GeV



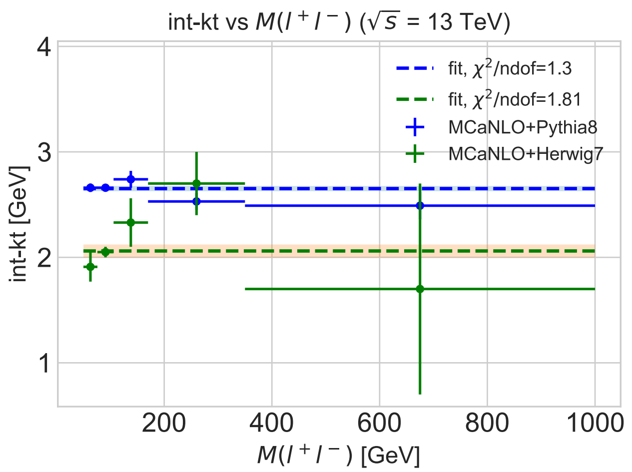
√s = 8 TeV



√s = 8.16 TeV



√s = 13 TeV



weak / no dependence of intrinsic kT on dilepton mass

Summary

Intrinsic kT tune at various collision energies

Similar energy scaling behavior for **Pythia** and **Herwig**

Regardless of their different showering models

The fit cannot exclude the hypothesis of **linear dependence** of **log(int-kT)** on **log(√s)** with the **same slope**

Intrinsic kT versus M(l+l-)

The fit indicates weak/no dependence

-> different from the behavior in CASCADE

Next to do:

Look at the intrinsic kT tune under other UE tunes (e.g. CP1-4 in Pythia, default is CP5)

Ongoing investigation on **Sherpa intrinsic kT tune**

Slightly different intrinsic kT model (both mean and width of the int-kT distribution are tunable)

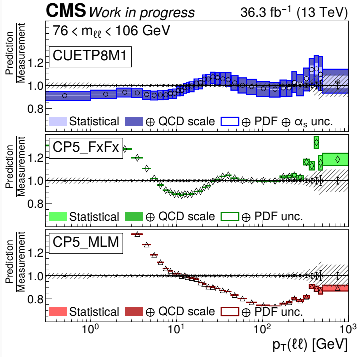
Will it show a similar energy scaling behavior?

Information about tunes

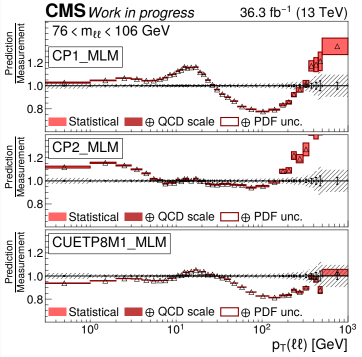
Table 1: Information about tunes

Pythia parameters	Tunes			
	CUETP8M1	CP1	CP2	CP5
PDF	NNPDF2.3(LO)	NNPDF3.1(LO)	NNPDF3.1(LO)	NNPDF3.1 (NNLO)
α_s - MPI	0.13	0.13	0.13	0.118
α_s - hard scattering	0.13?	0.13	0.13	0.118
α_s - FSR	0.1365	0.1365	0.13	0.118
α_s - ISR	0.1365	0.136	0.13	0.118
order	LO	LO	LO	NLO

xs (pt) in 5 mass bins



(a) CUETP_FxFx, CP5_FxFx, CP5_MLM



(b) CP1_MLM, CP2_MLM, CUETP8M1_MLM

Figure 2: xs (pt) for mass bin: 76-106 GeV