Resummation probed by Parton Showers in Drell-Yan + Jets

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Introduction

 $\sigma_{\rm pp} = \sum_{\bar{z}} \int dx_1 dx_2 f_q(x_1, \mu_{\rm F}^2) f_{\bar{q}}(x_2, \mu_{\rm F}^2) \,\hat{\sigma}_{q\bar{q}\to l^+l^-} \,_{\rm p} \equiv$



 $\widehat{\sigma}$

Motivation

DY dilepton pair transverse momentum distribution

▷Small p_T : resummed higher-order contributions dominate ▷Large p_T : perturbative QCD corrections at fixed-order



3

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Drell-Yan Measurement

- Two opposite charged muons $|\eta_{\mu}^{lead, sublead}| < 2.1 \quad p_T^{lead} > 20 \ GeV$, $p_T^{sublead} > 10 \ GeV$
- **O** Jets are defined by the anti- k_{T} algorithm (R=0.5)
- **O** Jet $p_T > 30 \text{GeV}$ and $| \gamma | < 4.5$

Transverse Momentun Distribution

 $d^2\sigma/dm^{\mu\mu}dp_T^{\mu\mu}$

Jet Multiplicity

• Measurement is performed in bins of the dimuon invariant mass (30-1500GeV)

• Investigate transverse momentum spectra as a function the Drell-Yan lepton pair mass to change the scale

$$\alpha_{\rm S}^n \ln^{2n-1} \frac{M^2}{p_{\rm T}^2}$$

Cross Section Measurement



- **O** Double differential cross section in p_{T} and mass
- **O** Five bins in invariant mass
- **O** Inclusive Drell-Yan production

O Drell-Yan production in association with at least one jet

O Drell-Yan production in association with at least two jets



Inclusive

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Monte Carlo Comparison







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11

DY+2jets



Jet Multiplicity



▷ Average Number of Jets in Δy of DY and the leading jet

▷ Forward Drell-Yan production $| \eta | > 2.5$



Jet Multiplicity





▷ Increasing jet multiplicity with increasing Δy

 \triangleright Calculations to higher order O(α _s) show good description

▶ Lowest and first order calculations predict too low jet multiplicity

DY+1jet

Summary

▶ Double differential cross section in mass and transverse momentum of the dimuon pair (2011 Data, 4.9fb⁻¹)

$$d^2\sigma/dm^{\mu\mu}dp_T^{\mu\mu}$$

 \triangleright Jet multiplicity as a function of \varDelta y



• Increased sensitivity to soft gluon resummation by using DY + jets

• Parton Showers describe the region of soft gluon resummation (inclusive DY)

• Merged parton showers and fixed order calculation provides best agreement

O Higher order calculation is needed to describe the low p_{T} region

Backup

Introduction

Differential transverse momentum distribution

▶ Resummed leading logarithms to all orders

$$\frac{1}{\sigma} \frac{\mathrm{d}\sigma}{\mathrm{d}p_{\mathrm{T}}^{2}} \sim \frac{\mathrm{d}}{\mathrm{d}p_{\mathrm{T}}^{2}} \exp\left(-\frac{\alpha_{\mathrm{S}}}{2\pi} C_{F} \ln^{2}\left(\frac{M^{2}}{p_{\mathrm{T}}^{2}}\right)\right)$$

Different approach to test Resummation ▶ Parton Showers

$$\Delta(t) = \exp\left(-\int_{t_0}^t \frac{\mathrm{d}t'}{t'} \int \frac{\mathrm{d}z}{z} \frac{\alpha_{\mathrm{S}}}{2\pi} P(z) \frac{f(x/z,t)}{f(x,t)}\right)$$

Sudakov form factor of initial state parton radiation arises from the resummation of the soft and collinear gluon emissions

Drell-Yan Measurement

- Measurement is performed in bins of the dimuon invariant mass (30-1500GeV)
- Investigate transverse momentum spectra as a function the Drell-Yan lepton pair mass to change the scale
- Relevant background contributions: ttbar, QCD, $Z \rightarrow \tau \tau$, W+jets, diboson
- Background is subtracted from data events
- **O** Data is corrected to stable particle level
- Systematic uncertainties: Unfolding, JEC, pileup reweighting, efficiency correction, background estimation
- Cross sections are normalized by cross section in the Z Peak region (60-120GeV) to reduce systematics

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DY+1jet

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• Forward Drell-Yan production $|\eta| > 2.5$

$$\boldsymbol{\eta}^{\text{DY}} = \boldsymbol{\eta}^{(\mu)} (\boldsymbol{\mu}_{1}) + \boldsymbol{\eta}^{(\mu)} (\boldsymbol{\mu}_{2})$$

• Drell-Yan production in association with at least one jet and at least two jets

 $|\Delta y(\mu\mu, j_1)|$



22



