Systematic Uncertainties in SHERPA-1.2.2

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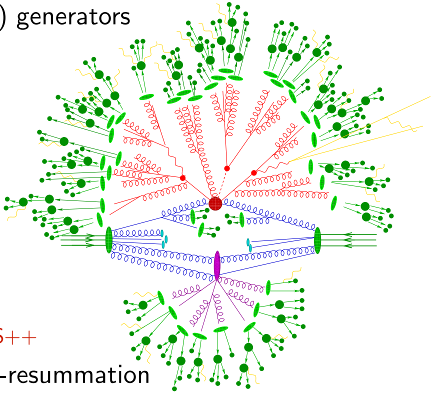
Contents

JHEP02(2009)007

The SHERPA event generation framework – v.1.2.2

- Two multi-purpose Matrix Element (ME) generators
  AMEGIC++ JHEP02(2002)044
  COMIX JHEP12(2008)039
- A Parton Shower (PS) generator
  CSSHOWER++ JHEP03(2008)038
- A multiple interaction simulation
  à la Pythia AMISIC++ hep-ph/0601012
- A cluster fragmentation module
  AHADIC++ EPJC36(2004)381
- A hadron and τ decay package HADRONS++
- A higher order QED generator using YFS-resummation
  PHOTONS++ JHEP12(2008)018

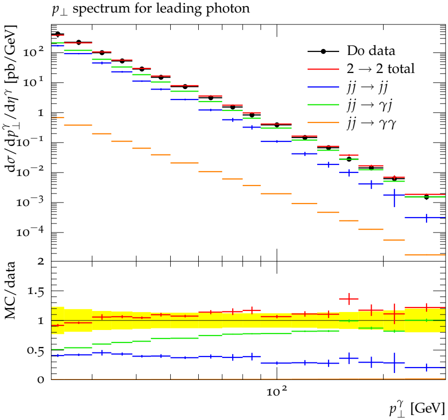


Sherpa's traditional strength is the perturbative part of the event

NLO real ME's are consistently combined with PS using CKKW JHEP05(2009)053

→ QCD-NLO calculations through automated CS-subtraction EPJC53(2008)501

SHERPA-1.2.2 – QCD⊗QED Merging



Inclusive photon $p_\perp$ at Tevatron

DØ : Phys. Lett. B639 (2006), 151-158

- $23\ \mathrm{GeV} < p_\perp^\gamma < 300\ \mathrm{GeV}$
- $E(\mathcal{R} = 0.4)/E_\gamma < 1.1$

$\Rightarrow$ Hard isolated photons

Contributions from subprocesses

Total single photon production

- $jj \to jj$ Dijets
- $jj \to \gamma j$ Photon + jet
- $jj \to \gamma\gamma$ Diphotons

$\Rightarrow$ Fragmentation component in dijets plays important role!

Systematic Uncertainties

in $pp \to Z/\gamma$+jets at $\sqrt{s} = 7$ TeV

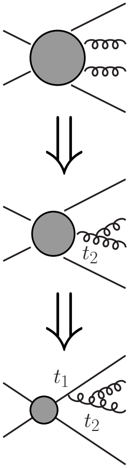
ME⊗PS Merging – CKKW

- divide real emission phase space in PS domain & ME domain

$$\begin{aligned}\langle O\rangle &= \int \mathrm{d}\Phi_B\, B(\Phi_B) \\ &\times \Big[\Delta(Q_0)\,O(\Phi_B) + \overbrace{\int_{Q_0}\mathrm{d}\Phi_{R|B}\,\mathcal{K}(\Phi_{R|B})\,\Delta(Q)\Theta(\mathbf{Q}_{\text{cut}}-Q)\,O(\Phi_R)}^{\text{PS domain}} \\ &\qquad + \underbrace{\int_{Q_0}\mathrm{d}\Phi_{R|B}\,\frac{R(\Phi_R)}{B(\Phi_B)}\,\Delta(Q)\Theta(Q-\mathbf{Q}_{\text{cut}})\,O(\Phi_R)}_{\text{ME domain}}\Big]\end{aligned}$$

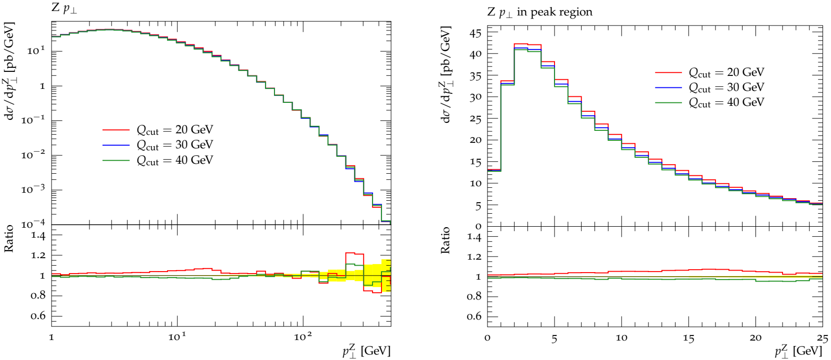
- Scales are determined by backwards clustering the ME using the PS
  $\rightarrow \mu_0 = \min(s,t,u),\ t_1,\ t_2,\ \ldots$
  $\alpha_s^{k+n}(\mu_{\text{eff}}) = \alpha_s^k(\mu_0)\,\alpha_s(t_1)\ldots\alpha_s(t_n)$

Scales:



Merging Cut Variations

- $Q_{\text{cut}} = 20, 30, 40$ GeV, $N_{\text{max}} = 4$, CTEQ6.6

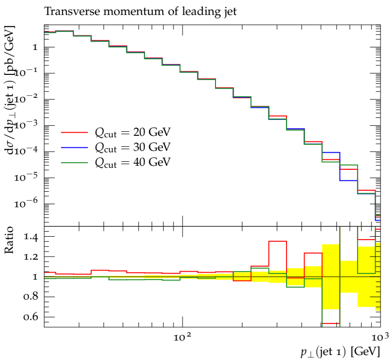


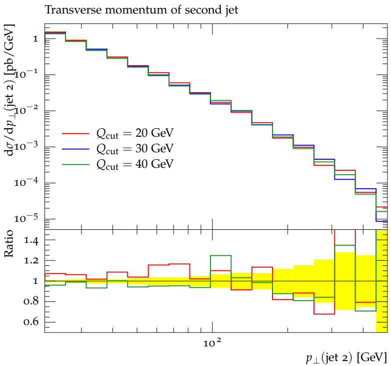
→ variations $\sim 5\%$

→ due to inclusion of non-logarithmic terms in ME domain down to Q_{cut}

Merging Cut Variations

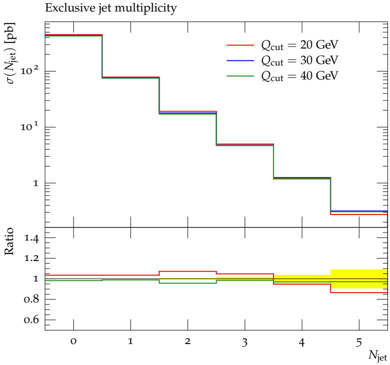
- Analysis: $k_\perp$-jets with $D = 0.7$ and $p_\perp > 20$ GeV

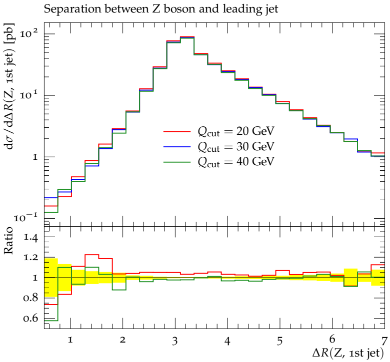




$\rightarrow$ variations $\sim 5\%$ for first jet, larger for second
$\rightarrow$ due to inclusion of non-logarithmic terms in ME domain down to Q_{cut}

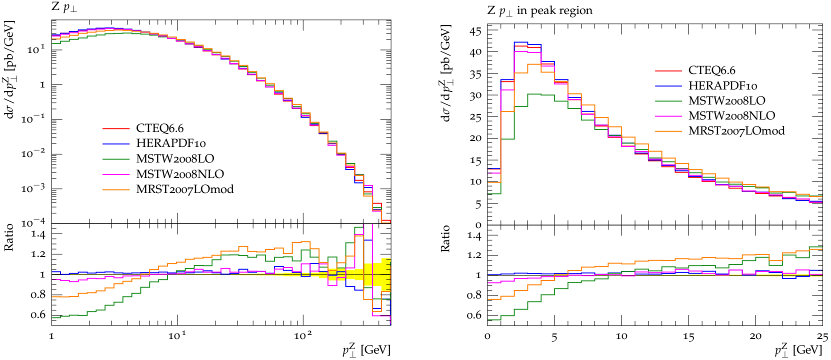
Merging Cut Variations





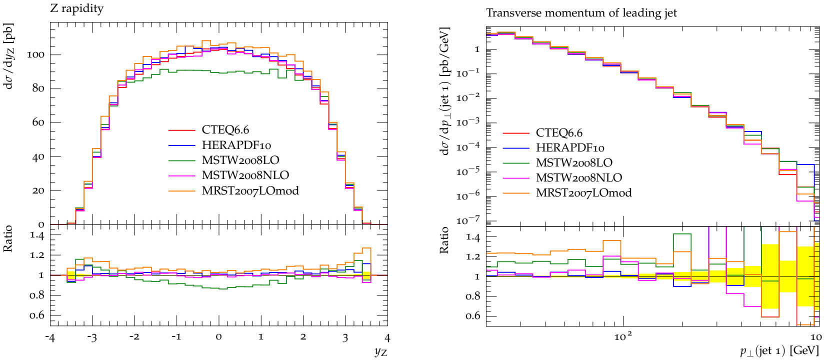
PDF Variations

- $Q_{\text{cut}} = 30$ GeV, $N_{\text{max}} = 4$
- CTEQ6.6, HERAPDF10, MSTW2008LO/NLO, MRST2007LOmod



→ good agreement between NLO pdfs (SHERPA default is CTEQ6.6)
→ major differences to LO pdfs, LOmod inbetween

PDF Variations

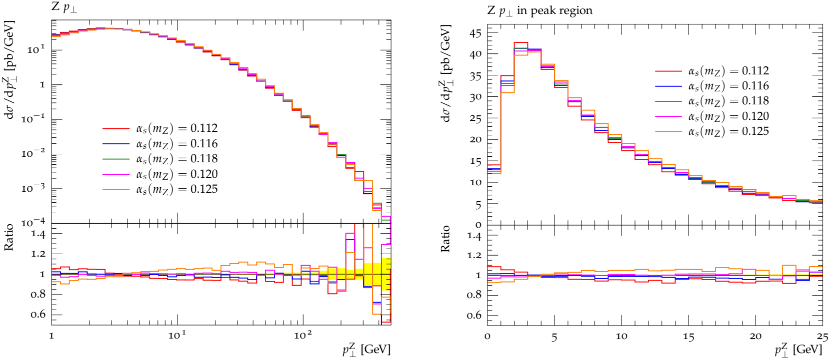


→ jet rates raised for LO PDFs, even more for LOmod

→ y_Z with LOmod resembles those with NLO PDFs in central region

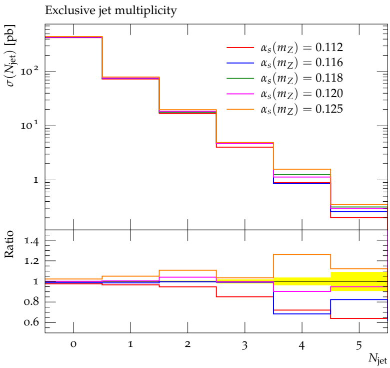
$\alpha_s(m_Z)$ Variations

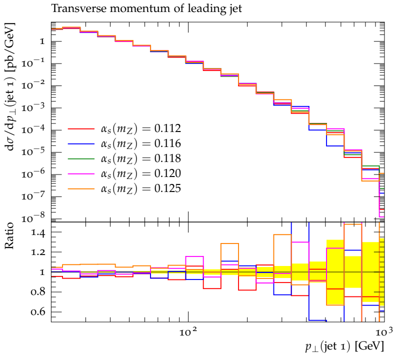
- $Q_{\text{cut}} = 30$ GeV, $N_{\text{max}} = 4$, CTEQ6.6 α_s variation sets
- $\alpha_s(m_Z) = 0.112, 0.116, 0.118, 0.120, 0.125$



$\rightarrow \sim 10\%$ variations for extreme values of α_s

$\alpha_s(m_Z)$ Variations



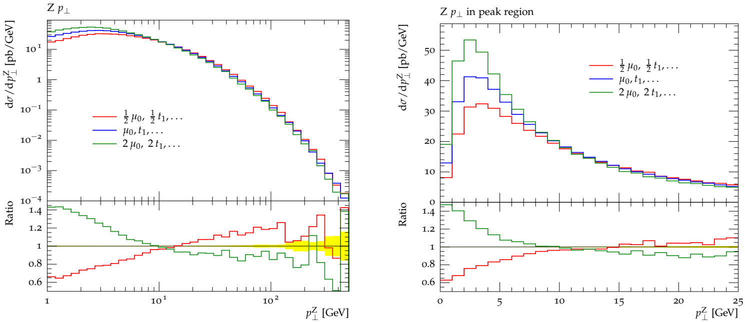


→ larger effects on jet rates

→ larger the corrections for observables looking at higher order jets

Scale Variations – μ_F and μ_R

- $Q_{\text{cut}} = 30$ GeV, $N_{\text{max}} = 4$, CTEQ6.6
- ME and PS scales cannot be varied independently
  $\rightarrow$ naïvly vary all scales $\mu_0, t_1, \ldots$ by factor 2 ($\neq$ varying μ_{eff} by factor 2)
  $\rightarrow$ maximal change

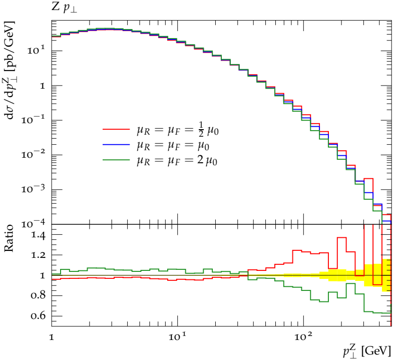


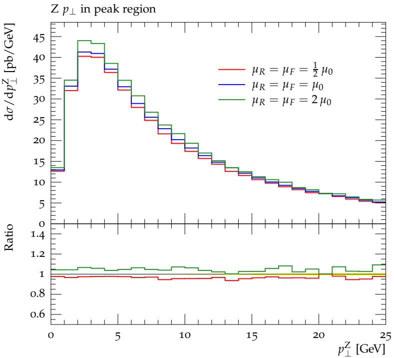
$\rightarrow$ huge variations

$\rightarrow$ violates logarithmic accuracy of shower since $t \not\rightarrow p_\perp$ in IR region

Scale Variations – μ_F and μ_R

- $Q_{\text{cut}} = 30$ GeV, $N_{\text{max}} = 4$, CTEQ6.6
- core scale μ_0 can be varied independently $\rightarrow$ enters PS starting scale
- $\mu_F = \mu_R = \frac{1}{2}\,\mu_0, \mu_0, 2\,\mu_0$, ($\mu_0 = \min(s,t,u)$ after backwards clustering)

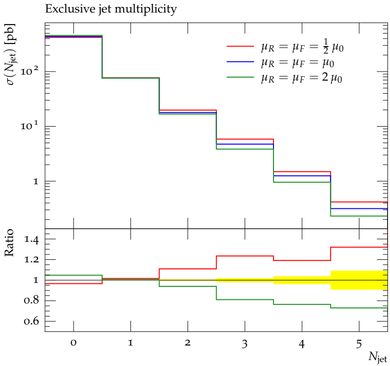


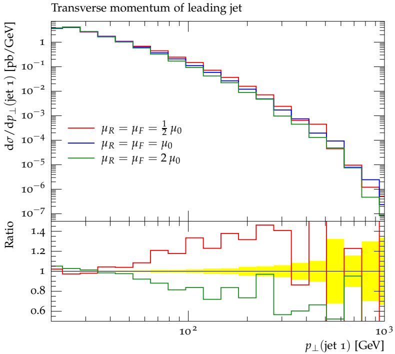


$\rightarrow$ small variations in region of $jj \rightarrow \ell\ell$ core

$\rightarrow$ larger variations in region of $jj \rightarrow jZ$, $jj \rightarrow jj$ core

Scale Variations – μ_F and μ_R





$\rightarrow$ LO observables with LO scale dependence

Current Developments – Not Released Yet

- New MB & UE model based upon Khoze-Martin-Ryskin model
- Automisation of POWHEG-approach arXiv:1008.5339
  $\rightarrow$ consistent combination of NLO ME and PS
  $\rightarrow$ only virtual MEs needed $\rightarrow$ Binoth-LesHouches interface
  $\rightarrow$ see Emanuele's talk
- Automisation of MENLOPS-approach arXiv:1009.1127
  $\rightarrow$ consistent combination of POWHEG and ME$\otimes$PS merging
  $\rightarrow$ see Keith's talk
- Electroweak dipole subtraction