SHERPA
Status and prospects

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MCnet

[1]for the Sherpas: J. Archibald, T. Gleisberg, S. Höche, H. Hoeth, F. Krauss, M. Schönherr, S. Schumann, F. Siegert, J. Winter, and K. Zapp

Outline

A brief introduction

- SHERPA has been under development since the late 1990's
  - In the beginning, borrowed and re-implemented physics from others: virtuality-ordered parton shower - APACIC++, underlying event like PYTHIA 6.2
  - Helicity amplitudes for matrix elements - AMEGIC++
  - Fragmentation/hadron decays through link to PYTHIA routines
- Constructed from scratch, in C++
  - Mainly done by diploma and PhD students
- Replaced physics modules one-by-one.
- Status in SHERPA 1.2: by now independent of other code
  - Virtuality-ordered shower replaced by dipole shower,
  - Berends-Giele matrix elements,
  - Own version of cluster fragmentation AHADIC++,
  - Huge own library of hadron and τ-decays,
  - QED radiation through YFS formalism,
  - Only UE modelling still along the line of Sjostyrand-van der Zijl, PYTHIA 6.2.
- A full-fledged independent event generator

High multiplicity matrix elements

Matrix element generation in SHERPA 1.2

- Provides three kinds of matrix elements:
  - Since 1.2.0: COMIX- mainly SM, can handle up to 8-10 final state particles

    (implementations for BSM-relevant methods have low priority in COMIX.)
  - AMEGIC++- SM & BSM generator, up to 6 final state particles

    (development stalled, will eventually move to COMIX.)
  - specific, hard-coded ME's
- Using COMIX makes SHERPA even easier to handle: no more libraries written out to be compiled in intermediate step.
- SHERPA/AMEGIC++ support FEYNRULES

  (a tool to generate Feynman rules directly from Lagrangians - a new standard to propagate BSM models?)
- No support for LHA - considered pointless by SHERPA.

SM matrix element generator COMIX

T.Gleisberg & S.Hoeche, JHEP **0812** (2008) 039

- Colour-dressed Berends-Giele amplitudes in the SM
- Fully recursive phase space generation
- Example results (cross sections):

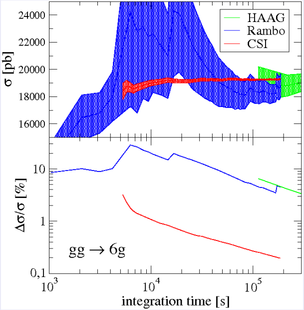
gg $\longrightarrow$ ng	Cross section [pb]				
n $\sqrt{s}$ [GeV]	8 1500	9 2000	10 2500	11 3500	12 5000
Comix	0.755(3)	0.305(2)	0.101(7)	0.057(5)	0.019(2)
Maltoni (2002)	0.70(4)	0.30(2)	0.097(6)		
Alpgen	0.719(19)				

σ [μb]	Number of jets						
$b\bar{b}$ + QCD jets	0	1	2	3	4	5	6
Comix	478(5)	8.83(2)	1.826(8)	0.459(2)	0.1500(8)	0.0544(6)	0.023(2)
ALPGEN	476(6)	8.83(1)	1.822(9)	0.459(2)	0.150(2)	0.053(1)	0.0215(8)
AMEGIC++	473(4)	8.84(2)	1.817(6)				

SM matrix element generator COMIX

T.Gleisberg & S.Hoeche, JHEP **0812** (2008) 039

- Colour-dressed Berends-Giele amplitudes in the SM
- Fully recursive phase space generation
- Example results (phase space performance):



BSM matrix element generator AMEGIC++

F.K., R.Kuhn, G.Soff, JHEP **0202** (2002) 044.

- Uses helicity/recursion methods;
- Helicity method supplemented with "factoring out" (taming the factorial growth)
- Phase space integration through multi-channeling (i.e. one phasespace mapping/Feynman diagram)
- Implemented & tested models: SM, SM+AGC, THDM, MSSM, ADD.
- Tested in >1000 SM & >500 MSSM channels.
- Recently: Automated dipole subtraction for NLO calculations (Fully supports the NLO-LHA)

Aside: Automated dipole subtraction

Implementation in SHERPA

T.Gleisberg & F.K., Eur.Phys.J.**C53** (2008) 501

- Implemented in AMEGIC++, including the $\alpha_{\rm cut}$ prescription
- First example for a generic interface, with BLACKHAT

(W+3jets, C.F.Berger et al., PRL **102** (2009) 222001, PRD **80** (2009) 074036)

(Z+3jets, C.F.Berger et al., arXiv:0912.4927)

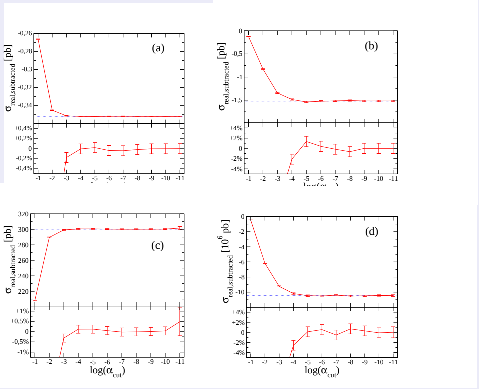
- Also interfaced to other calculations/codes

(ZZ+jet, T.Binoth et al., PLB **683** (2010) 154.)

- Conformal with the LH accord. Basic idea:
  - LO codes provide Born-level ME for given process;
  - LO code constructs and provides real corrections, their subtraction terms and the integrated subtracition terms;
  - LO code implements the phase space integration;
  - NLO code provides the loop MEs (i.e. virtual corrections only)

Example checks & results: Independence of α_{cut}

T.Gleisberg & F.K., Eur.Phys.J.**C53** (2008) 501



(a) $e^+e^- \longrightarrow$ 2jets

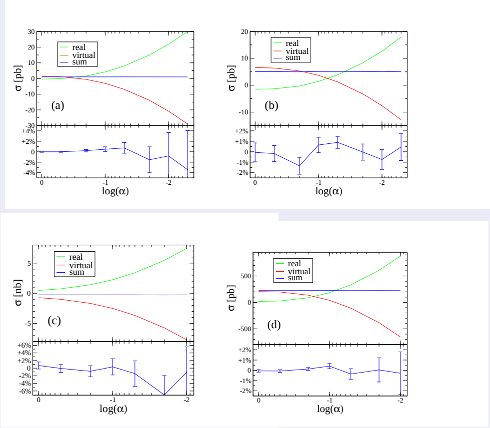
(b) $e^+e^- \longrightarrow$ 3jets

(c) $ep \longrightarrow e + $ 1jet

(d) $pp \longrightarrow$ 2jets

Example checks & results: Stability of total cross sections

T.Gleisberg & F.K., Eur.Phys.J.**C53** (2008) 501



(a) $e^+e^- \longrightarrow$ 2jets

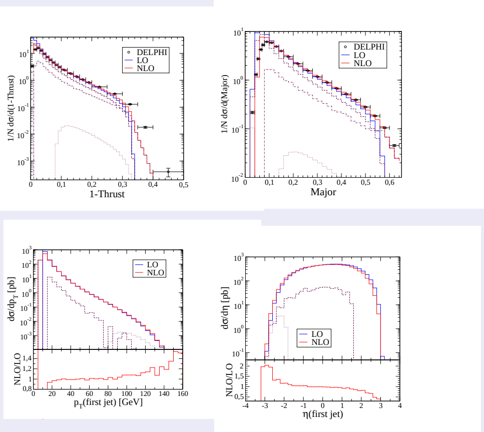
(b) $e^+e^- \longrightarrow$ 3jets

(c) $ep \longrightarrow e +$ 1jet

(d) $pp \longrightarrow W$

Example checks & results: Various cross sections

T.Gleisberg & F.K., Eur.Phys.J.**C53** (2008) 501



Parton showering

Motivation

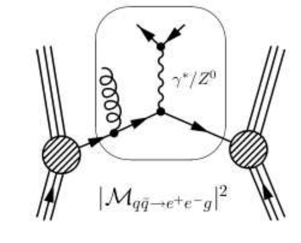
Matrix element calculations (collinear factorisation):

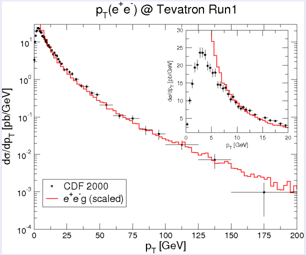
$$\sigma_{pp\to N}(Q^2) = \sum_{a,b} \int \mathrm{d}x_a \mathrm{d}x_b \; g_a(x_a, Q^2) g_b(x_b, Q^2) \; |\mathcal{M}_{ab\to N}|^2 \; \mathrm{d}\Phi_N$$

+ $|\mathcal{M}_{ab\to N}|^2$ encodes fundamental physics, interferences, off-shell effects
+ accounts for high-p_T, well separated partons
+ well-defined procedure to improve accuracy (perturbative expansion)
– poor for log-enhanced phase-space regions, few-parton final states only.
– link to hadronisation troublesome

Motivation (cont'd)

Example: $p_\perp^{(Z)}$ due to additional radiation in $pp \to e^+e^- + X$





- $|\mathcal{M}_{q\bar{q}\to e^+e^-g}|^2 \sim |\mathcal{M}_{q\bar{q}\to e^+e^-}|^2 \frac{\alpha_S(\mu_R^2)}{p_T^2} \rightsquigarrow \sigma_{pp\to e^+e^-g} \sim \sigma_{pp\to e^+e^-}\alpha_S(\mu_R^2) \log\frac{p_T^{\rm max}}{p_T^{\rm min}}$
- large logs need to be resummed
- $|\mathcal{M}|^2$ factorise in IR limit (universal) $\rightsquigarrow$ parton shower approach

Generating emissions from QCD evolution equations

(Also a warm-up exercise for new formalism for multijet merging in Sherpa 1.2)

Starting from $d\sigma$, generate radiation through QCD evolution

$$\frac{\partial g_a(z,t)}{\partial \log(t/\mu^2)} = \int_z^{\zeta_{\max}} \frac{d\zeta}{\zeta} \sum_{b=q,g} \mathcal{K}_{ba}(\zeta,t)\, g_b(\frac{z}{\zeta},t) - g_a(z,t) \int_{\xi_{\min}}^{\xi_{\max}} d\xi \sum_{b=q,g} \xi\, \mathcal{K}_{ab}(\xi,t)$$

- ζ, t - splitting, evolution variable

separate resolved from unresolved emissions

- $\mathcal{K}_{ba}(\zeta,t)$ - evolution kernels of the scheme:

$$\mathcal{K}_{ba}(\zeta,t) \stackrel{\mathrm{IR}}{\longleftrightarrow} \frac{1}{\sigma_a^{(N)}(\Phi_N)} \frac{d\sigma_b^{(N+1)}(\zeta,t;\Phi_N)}{d\log(t/\mu^2)\, d\zeta}$$

e.g. collinear factorization scheme $\alpha_s/2\pi\ P_{ba}(\zeta)$

The Sudakov form factor: No-emission probability

(Also a warm-up exercise for new formalism for multijet merging in Sherpa 1.2)

- Define Sudakov form factor:

$$\Delta_a(\mu^2,\, t) = \exp\left[-\int\limits_{\mu^2}^{t}\frac{\mathrm{d}t'}{t'}\int\limits_{z}^{\xi_{\max}}\mathrm{d}\xi\,\frac{1}{2}\sum_{b=q,g}\mathcal{K}_{ba}(\xi\,,t')\right]$$

- Rewrite equation above:

$$\frac{1}{\partial\log(t/\mu^2)}\,\frac{\partial g_a(z,t)}{\Delta_a(\mu^2,\,t)} = \frac{1}{\Delta_a(\mu^2,\,t)}\int\limits_{z}^{\zeta_{\max}}\frac{\mathrm{d}\zeta}{\zeta}\sum_{b=q,g}\mathcal{K}_{ba}(\zeta,t)\,g_b(\frac{z}{\zeta},t)$$

- Corresponding no-emission probability (from $\bar{t}$ to t):

$$\mathcal{P}^{\rm no}_a(z,\,t,\,\bar{t}) = \frac{\Delta_a(\mu^2,\,\bar{t})}{\Delta_a(\mu^2,\,t)}\,\frac{g_a(z,\,t)}{g_a(z,\,\bar{t})}$$
$$= \exp\left[-\int\limits_{t}^{\bar{t}}\frac{\mathrm{d}t'}{t'}\int\limits_{z}^{\zeta_{\max}}\frac{\mathrm{d}\zeta}{\zeta}\sum_{b=q,g}\mathcal{K}_{ba}(\xi\,,t')\,\frac{g_b(z/\zeta,\,t)}{g_a(z,\,\bar{t})}\right]$$

Parton showering in Sherpa 1.2

Parton shower based on Catani-Seymour splitting kernels

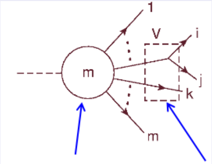
First discussed in: Z.Nagy and D.E.Soper, JHEP **0510** (2005) 024

Implemented by M.Dinsdale, M.Ternick, S.Weinzierl Phys.Rev.**D76** (2007) 094003

and S.Schumann& F.K., JHEP **0803** (2008) 038.

- Explicit use of factorization formulae for real emission process $\longleftrightarrow$ NLO dipole subtraction
- Full phase space coverage (invertible).
- Typically good approximation to ME.
- Project onto leading $1/N_c$ & employ spin-averaged dipole kernels.
- four types of splittings: FF, IF, FI, II.
- Recently: improved kinematics mappings to account for exponentiation properties

(Work in progress.)



m-parton state splitting operator

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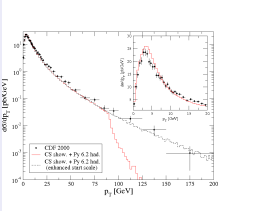

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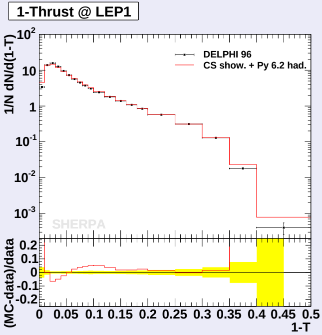
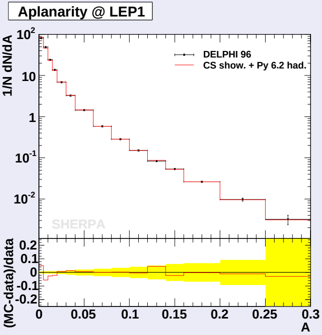
Results in e^+e^- collisions at LEP1

S.Schumann& F.K., JHEP **0803** (2008) 038.





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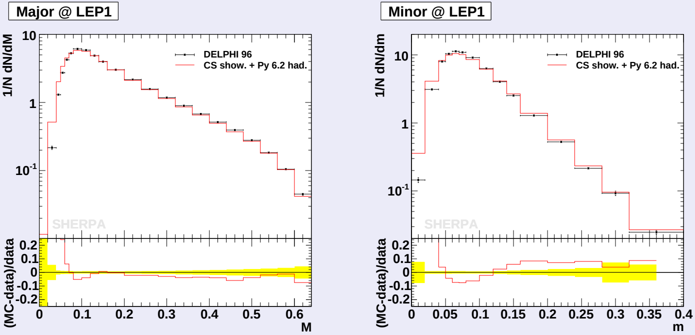

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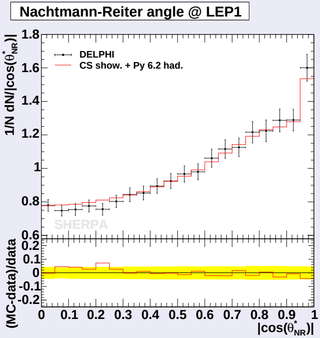
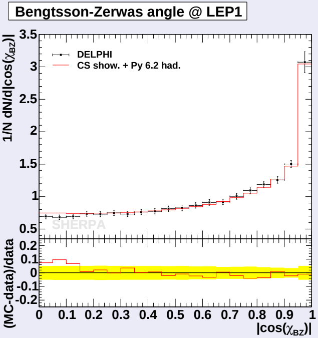
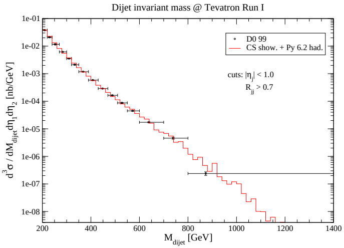
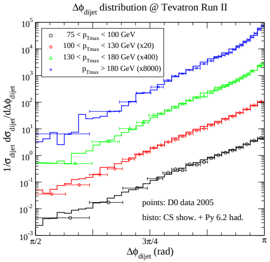




CS-Shower: Results in $p\bar{p}$ collisions

S.Schumann& F.K., JHEP **0803** (2008) 038.





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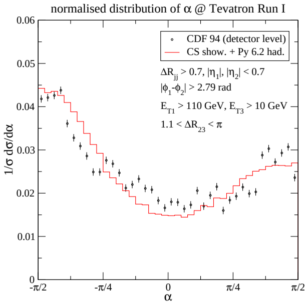
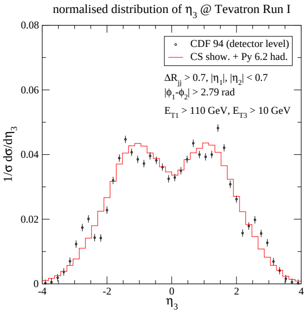




Multijet merging

From partons to hadrons

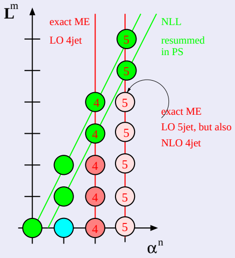
- Experimental definition of jets based on hadrons.
- But: Hadronization through phenomenological models

(need to be tuned to data).

ME vs. PS

- MEs: hard, large-angle emissions; interferences.
- PS: soft, collinear emissions; resumation of large logarithms.
- Combine both, avoid double-counting.

α_s vs. Log



Constructing the algorithm

- Want the best of both - what else?
  - Proper description of soft/collinear and hard emissions
  - Combine QCD matrix elements of different parton multiplicity with showers
- General outline of algorithm:
  - Use LO (tree-level) matrix elements for jet production
    - Could use parton shower kernel $K_{ba}^{ME} \propto |\mathcal{M}_{n+1}|^2/|\mathcal{M}_n|^2$
    - Idea effectively used in traditional reweighting
    - Also in generation of hardest emission in POWHEG
  - Preserve original parton shower evolution equation

    (N.B.: this guarantees preservation of log accuracy provided by shower)
  - Avoid double-counting (positive or negative)
    Must slice the phase space: Jet production vs. jet evolution
    $\Longrightarrow$ adds a parameter - the jet resolution criterion $Q_{\rm cut}$

    (but results should better not depend too strongly on this parameter)

Slicing the phase space

- Write
  $K_{ba}(z, t) = K_{ba}(z, t)\Theta[Q_{\rm cut} - Q_{ba}(z, t)] + K_{ba}(z, t)\Theta[Q_{ba}(z, t) - Q_{\rm cut}]$.
- In hard region, call $K_{ba}\Theta[Q_{ba}(z, t) - Q_{\rm cut}] \to K_{ba}^{ME}$,
- Call $K_{ba}\Theta[Q_{\rm cut} - Q_{ba}(z, t)] \to K_{ba}^{PS}$ in soft region.
- Sudakov form factor factorises (exponential):

  $$\Delta_a(\mu^2, t) = \Delta_a^{PS}(\mu^2, t)\Delta_a^{ME}(\mu^2, t)$$

  Also, no emission probability can be rewritten:

  $$\mathcal{P}_a^{\rm no}(z, t, \bar{t}) = \frac{\Delta_a^{PS}(\mu^2, \bar{t})}{\Delta_a^{PS}(\mu^2, t)} \frac{\Delta_a^{ME}(\mu^2, \bar{t})}{\Delta_a^{ME}(\mu^2, t)} \frac{g_a(z, t)}{g_a(z, \bar{t})}$$
- In shower, need to veto emissions with $Q_{ba} > Q_{\rm cut}$.
  But possibly at Q larger than those in ME
  "mismatch" of shower and jet measure $\longrightarrow$ truncated showers

Phase space measure

- Motivated by parton shower/dipole kinematics:

$$Q_{ij}^2 = 2\,p_i p_j \min_{k\neq i,j} \frac{2}{C_{i,j}^k + C_{j,i}^k}\;;\; C_{i,j}^k = \begin{cases} \dfrac{p_i p_k}{(p_i+p_k)p_j} - \dfrac{m_i^2}{2\,p_i p_j} & \text{if } j=g \\ 1 & \text{else} \end{cases}$$

- IR limits:
  - soft limit: $p_j = \lambda q,\ \lambda \to 0$

$$\frac{1}{Q_{ij}^2} \to \frac{1}{2\,\lambda^2}\,\frac{1}{2\,p_i\,q}\,\max_{k\neq i,j}\left[\frac{p_i p_k}{(p_i+p_k)\,q} - \frac{m_i^2}{2\,p_i q}\right]$$

  - quasi-collinear limit: $k_\perp \to \lambda k_\perp,\ m \to \lambda m$

$$\frac{1}{Q_{ij}^2} \to \frac{1}{2\,\lambda^2}\,\frac{\widetilde{C}_{i,j}+\widetilde{C}_{j,i}}{p_{ij}^2 - m_i^2 - m_j^2}\ \widetilde{C}_{i,j} = \begin{cases} \dfrac{z}{1-z} - \dfrac{m_i^2}{2\,p_i p_j} & \text{if } j=g \\ 1 & \text{else} \end{cases}$$

- measure correctly identifies enhanced phase-space regions

Defining PS histories

- Identify most likely splitting acc. to PS branching probability
- Combine partons into mother parton acc. to inverse PS kinematics
- Continue until $2 \to 2$ core process

$\rightsquigarrow$ shower specific cluster algorithm

$\rightsquigarrow$ predetermined shower emissions

PS starts at core process

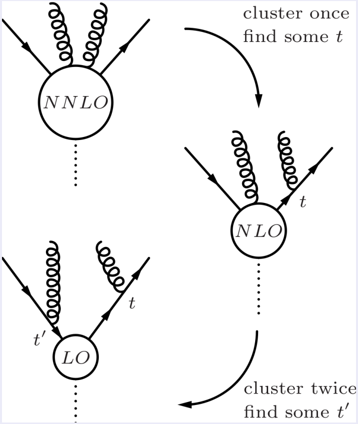
can radiate "between" ME emissions

ME branchings must be respected

evolution-, splitting- & angular variable preserved

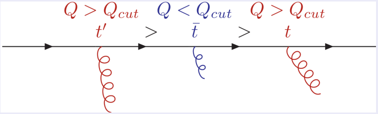
$\rightsquigarrow$ truncated shower

Example branching history



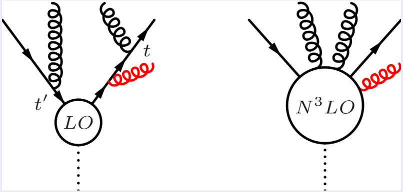
Truncated shower

Shower emission below $Q_{\rm cut}$:



- $\rightsquigarrow$ emission accepted
- $\rightsquigarrow$ large-angle soft emissions
- $\rightsquigarrow$ soft color coherence
- $\rightsquigarrow$ approx. in CKKW only

Shower emission above $Q_{\rm cut}$:



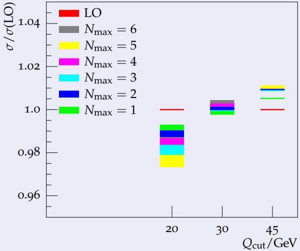
- $\rightsquigarrow$ entire event is rejected
- $\rightsquigarrow$ Sudakov suppression $\mathcal{P}^{\rm ME}_{{\rm no},\,a}(t,t')$
- $\rightsquigarrow$ to be described by ME instead
- $\rightsquigarrow$ $\sigma_{\rm tot}$ preserved at LO

Z^0+jets at Tevatron: Total cross sections

Q_{cut} and/or N_{max} variation should affect σ_{tot} only beyond (N)LL

- Example: DY-pair production $\sigma_{\rm tot}$ @ Tevatron

		$N_{\rm max}$						
		0	1	2	3	4	5	6
$Q_{\rm cut}$	20 GeV	192.6(1)	191.0(3)	190.5(4)	189.0(5)	189.4(7)	188.2(8)	189.9(10)
	30 GeV		192.3(2)	192.7(2)	192.6(3)	192.9(3)	192.7(3)	193.2(3)
	45 GeV		193.6(1)	194.4(1)	194.3(1)	194.4(1)	194.6(2)	194.4(1)



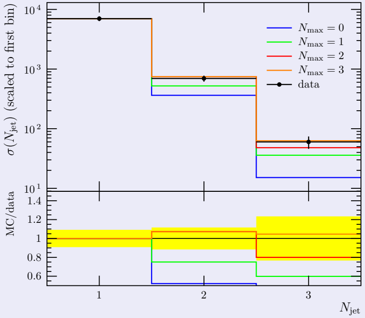
- improved “merging systematics” of $\boldsymbol{\sigma_{\rm tot} < \pm 3\%}$

Z^0+jets at Tevatron: jet multiplicities

Jet rates and -spectra improved compared to pure PS simulation

- Example: DY-pair production $\sigma_{\mathrm{e^+e^-+N_{jet}}}$

CDF Data: PRL **100** (2008) 102001



$Q_{\mathrm{cut}} = 30$ GeV

Z^0+jets at Tevatron: jet spectra

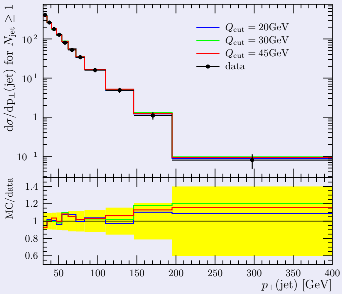
Variation of Q_{cut} should affect distributions only beyond (N)LL

But Q_{cut} must be in range where PS approximation is valid!

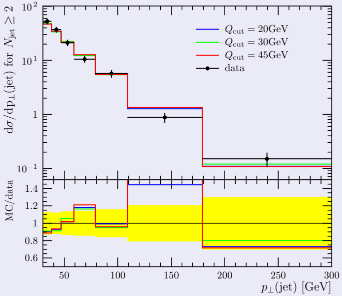
- Example: All-jets p_T's in DY-pair production

CDF Data: PRL **100** (2008) 102001

p_T(jet) for $N_{\rm jet} \geq 1$



p_T(jet) for $N_{\rm jet} \geq 2$



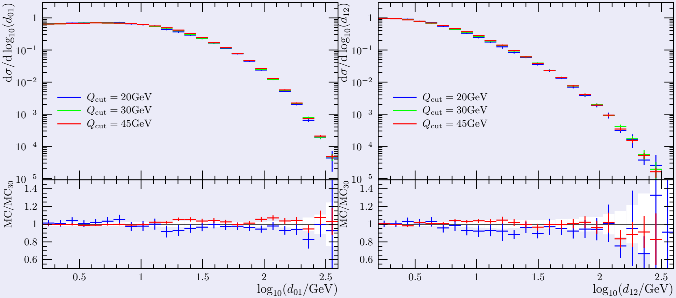
Z^0+jets at Tevatron: jet spectra

Variation of Q_{cut} should affect distributions only beyond (N)LL

But Q_{cut} must be in range where PS approximation is valid!

- Example: Differential $\mathbf{k_T}$ jet rates

$1 \longrightarrow 0$ $2 \longrightarrow 1$



- $\mathbf{Q_{cut}}$ variations within $\mathbf{\pm 10\%}$

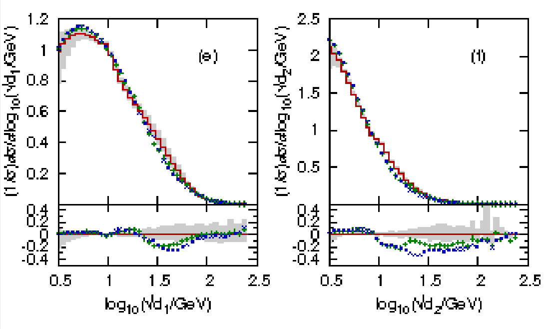
Z^0+jets at Tevatron: jet spectra

Variation of Q_{cut} should affect distributions only beyond (N)LL

But Q_{cut} must be in range where PS approximation is valid!

- Example: Differential $\mathbf{k_T}$ jet rates
  Compare: standard CKKW for W+jets (Sherpa 1.1)

Alwall et. al Eur. Phys. J. C **53** (2008) 473

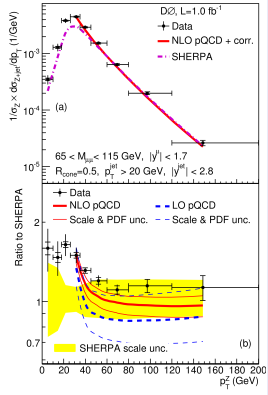


Z^0+jets at Tevatron: Z/γ^* transverse momentum

DØ data: Phys. Lett. B **669** (2008) 278

Comparison with Sherpa's CKKW implementation in v1.1.3

SHERPA v1.1.3

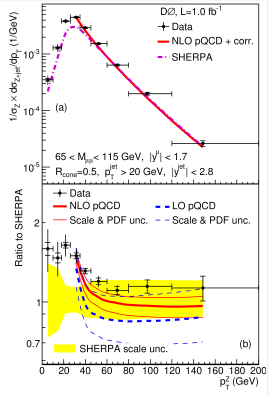


Z^0+jets at Tevatron: Z/γ^* transverse momentum

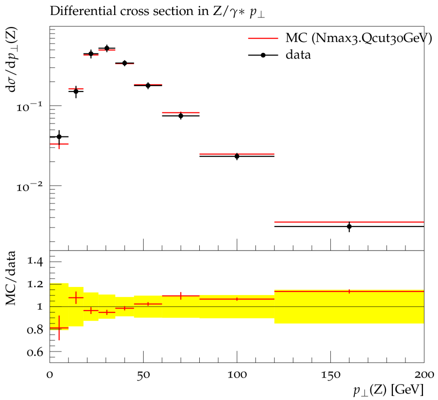
DØ data: Phys. Lett. B **669** (2008) 278

Comparison with Sherpa's CKKW implementation in v1.1.3

SHERPA v1.1.3



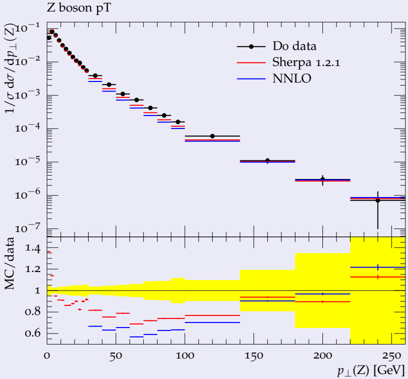
SHERPA v1.2



Z^0+jets at Tevatron: Z/γ^* transverse momentum

DØ data: Phys. Lett. B **669** (2008) 278

Comparison between SHERPA 1.2.1 and NNLO Z production

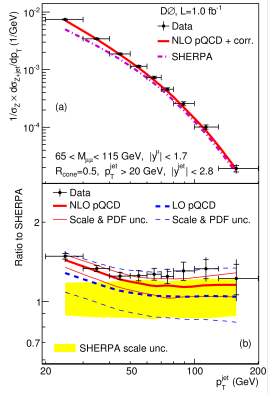


Z^0+jets at Tevatron: jet spectra

DØ data: Phys. Lett. B **669** (2008) 278

Comparison with Sherpa's CKKW implementation in v1.1.3

SHERPA v1.1.3

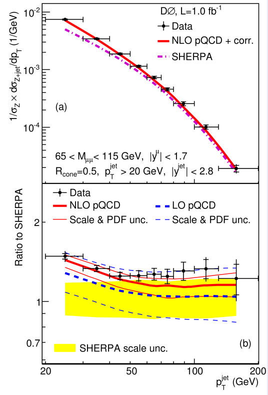


Z^0+jets at Tevatron: jet spectra

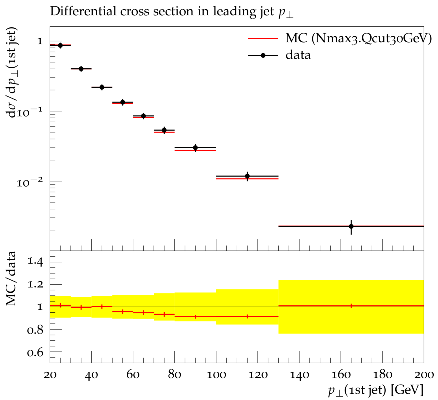
DØ data: Phys. Lett. B **669** (2008) 278

Comparison with Sherpa's CKKW implementation in v1.1.3

SHERPA v1.1.3



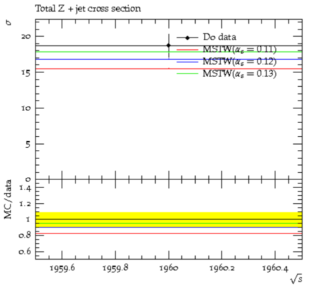
SHERPA v1.2

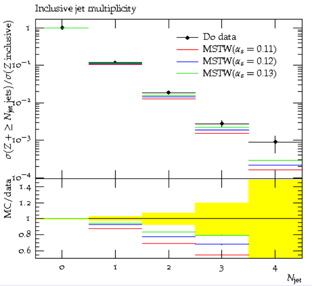


Z^0+jets at Tevatron: cross sections

CDF data from PRL 100 (2008) 102001 and D0/, arXiv:0808:1296

Impact of α_S - global in SHERPA

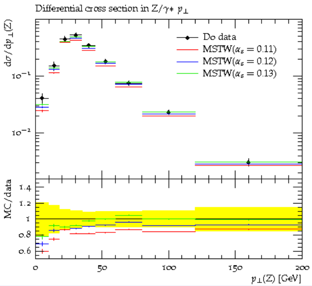


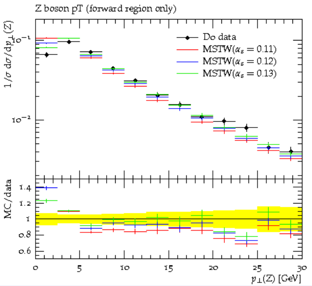


Z^0+jets at Tevatron: Z/γ^* transverse momentum

DØ data: PRL 100 (2008) 102002

Impact of α_S - global in SHERPA



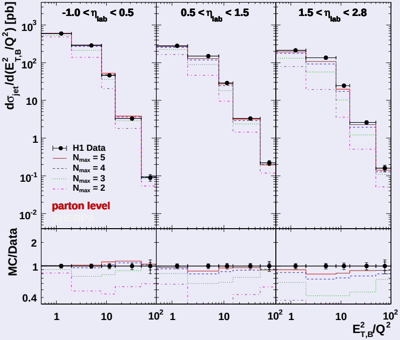


Generalisation of merging algorithm to DIS

ME & PS results: Inclusive jets in DIS

S.Hoeche et al., arXiv:0912.3715, data from PL **B542** (2002) 193

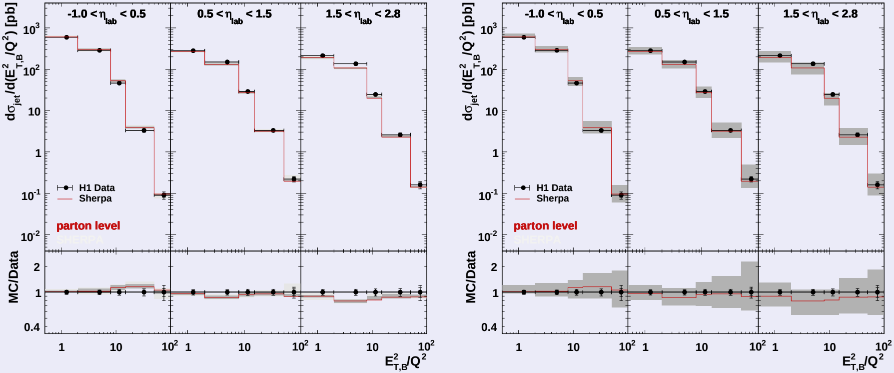
Variation of maximum matrix-element multiplicity, $N_{\max}$



ME & PS results: Inclusive jets in DIS

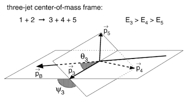
S.Hoeche et al., arXiv:0912.3715, data from PL**B542** (2002) 193

Variation of merging parameters and factorisation/renormalisation scales

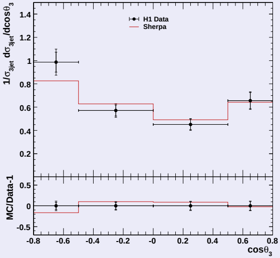


ME & PS results: Inclusive trijets in DIS

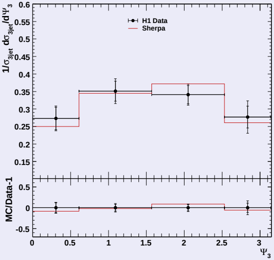
S.Hoeche et al., arXiv:0912.3715, data from PL **B515** (2001) 17



$\cos\theta_3$ $Q^2 > 150$ GeV^2

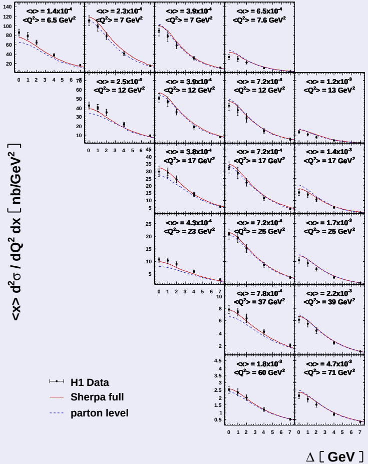


Ψ_3 $Q^2 > 150$ GeV^2



ME & PS results: Low-x dijets in DIS

S.Hoeche et al., arXiv:0912.3715, data from EPJ **C33** (2004) 477

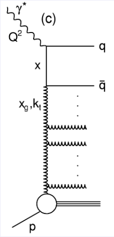


Δ in bins of $\langle x\rangle$ and $\langle Q^2\rangle$

Δ defined as $E^*_{T,\max} > E^*_{T\,\mathrm{cut}} + \Delta$

$E^*_{T\,\mathrm{cut}} \longrightarrow$ minimum jet transverse energy

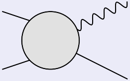
$E^*_{T\,\max} \longrightarrow$ transverse energy of hardest jet



Merging for Prompt-Photon Production

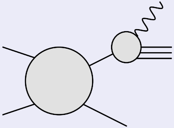
The perturbative QCD approach

Direct production



- fixed-order calculations
  - γ+jet @ NLO (JetPhox) [Catani et. al]
  - $\gamma\gamma$ @ NLO (DiPhox) [Binoth et. al]
  - $\gamma\gamma$+jet @ NLO [Del Duca et. al]
  - $gg \to \gamma\gamma g$ [de Florian et. al]

Fragmentation component



- QED $\gamma - q$ collinear singularity
- resummation to all orders α_s
- fragmentation function $D^{\gamma}_{q,g}$

- Apporach bases on IR safe xsec definition (photon isolation) [cone, smooth isolation, democratic approach]
- Assumption: non-prompt component, e.g. $\pi^0 \to \gamma\gamma$, $\eta \to \gamma\gamma$, experimentally separable

A new Monte Carlo approach for Prompt-Photon Production

(S.Höche, S.Schumann, F.Siegert PRD **81** (2010) 034026)

- treat photons and QCD partons fully democratically

(Glover, Morgan Z. Phys. C **62** (1994) 311)

- combine matrix elements of different parton/photon multiplicity with
- QCD$\oplus$QED evolution and hadronization $\rightsquigarrow$ models $D^{\gamma}_{q,g}(z,Q^2)$

Generalized merging formalism

- Emission probabilities factorise trivially as before

$$\Delta_a(Q_0^2,Q^2) = \Delta_a^{(\mathrm{QCD})}(Q_0^2,Q^2)\Delta_a^{(\mathrm{QED})}(Q_0^2,Q^2)$$

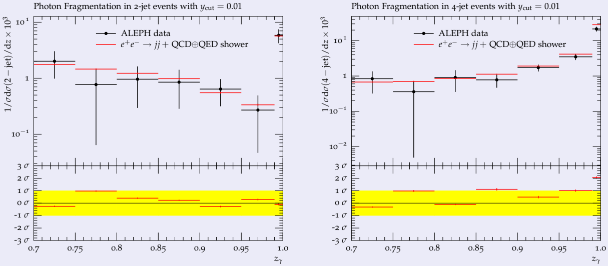
- Implemented by adding splitting functions $q \to q\gamma$
- Different then large-N_C QCD: spectators *all* particles with opposite charge
- Neglect (negative) interference with same-sign charges

(S.Dittmaier, Nucl. Phys. B **565** (2000) 69)

Results: photon fragmentation function in $e^+e^- \to$ Hadrons

(Aleph data from Z. Phys. C **69** (1996) 365)

- Validation of the shower/hadronization component
- Perform jet finding including final-state photons
- Study photon-energy fraction wrt its containing jet: $z_\gamma \equiv E_\gamma/E_{\rm jet}$



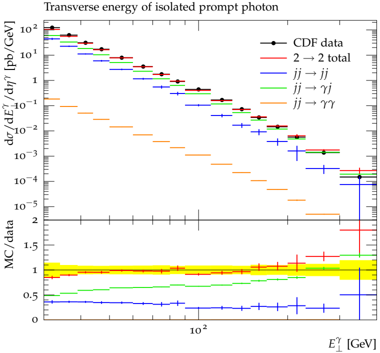
Isolated prompt-photon production at Tevatron

(Data from CDF, Phys. Rev. D **80** (2009) 111106)

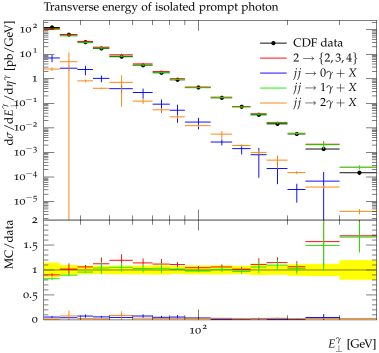
cuts: $30 < E_T^\gamma < 400$ GeV, $|\eta^\gamma| < 1$, isolation: $E_T^{R=0.4} - E_T^\gamma < 2$ GeV

- Sherpa: pure shower vs. ME$\oplus$TS

E_T^γ – pure shower



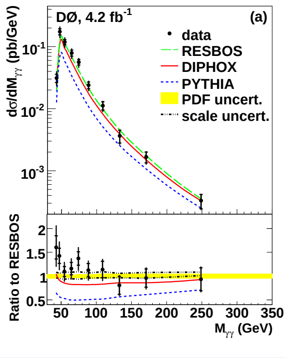
E_T^γ – ME$\oplus$TS

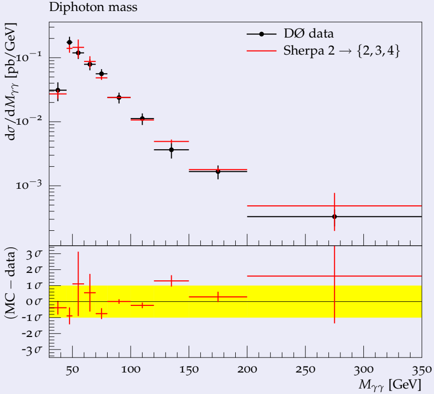


Di-Photon production at Tevatron: Invariant mass

(D0/ data, arXiv:1002.4917)

- Compare with other codes: DiPhox, ResBos, Pythia
- Sherpa: merged $2 \to \{2,3,4\}$ plus $gg \to \gamma\gamma$ box

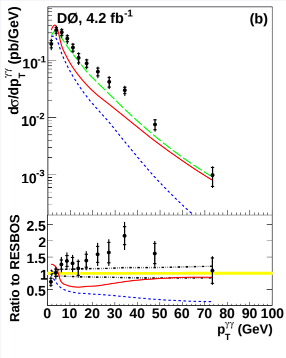


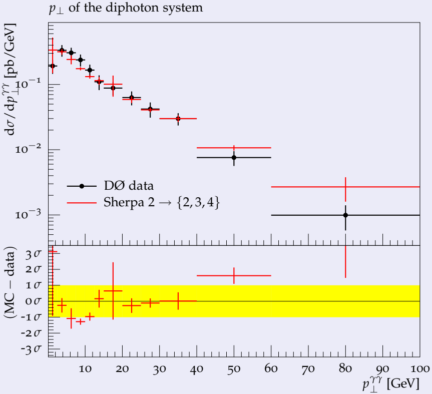


Di-Photon production at Tevatron: Transverse momentum of pair

(D0/ data, arXiv:1002.4917)

- Compare with other codes: DiPhox, ResBos, Pythia
- Sherpa: merged $2 \to \{2,3,4\}$ plus $gg \to \gamma\gamma$ box

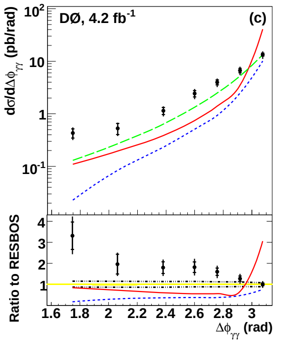


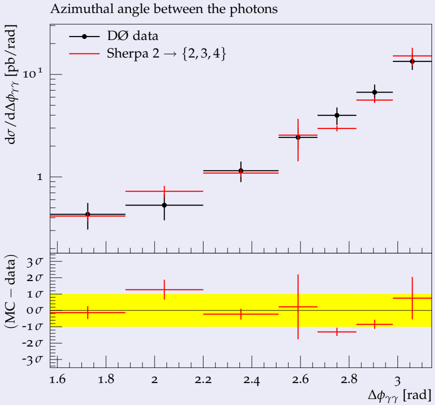


Di-Photon production at Tevatron: Azimuthal decorrelation

(D0/ data, arXiv:1002.4917)

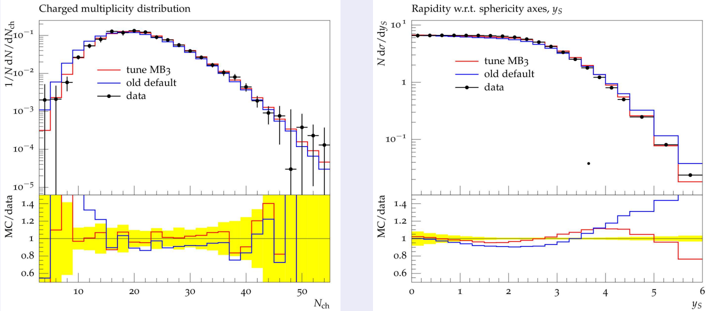
- Compare with other codes: DiPhox, ResBos, Pythia
- Sherpa: merged $2 \to \{2,3,4\}$ plus $gg \to \gamma\gamma$ box



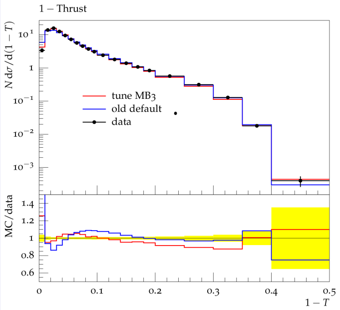


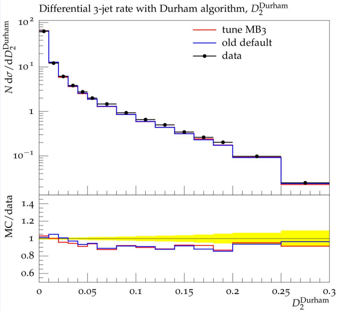
Sherpa's hadronisation

Recent results in $e^+e^- \to$ hadrons

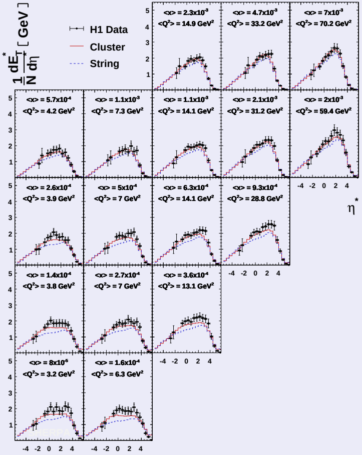


Recent results in $e^+e^- \longrightarrow$ hadrons





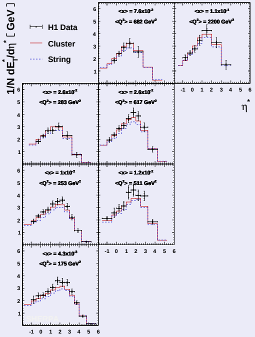
Hadronisation in DIS: Energy flow analysis



EPJ **C12** (2000) 595

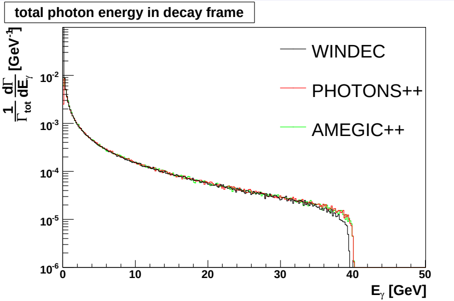
Transverse energy flow

SHERPA cluster fragmentation
vs. Lund string fragmentation

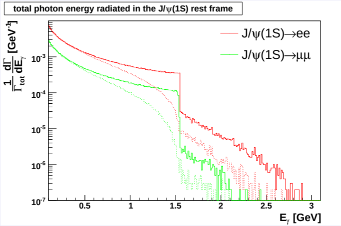


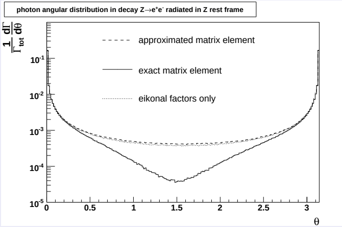
QED radiation in Sherpa

Example: Photon radiation in $W \longrightarrow \ell\nu$



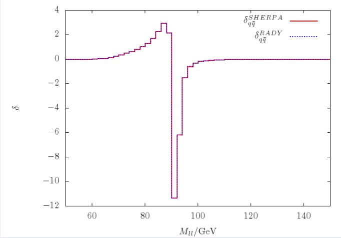
Example: Photon radiation in $J/\psi \to \ell\bar{\ell}$

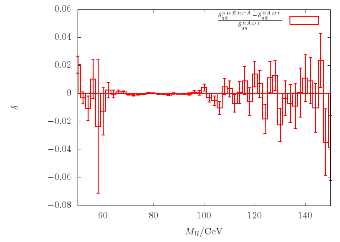




Dipole subtraction for EW corrections

- LH accord for EW corrections more involved:
  defintions of schemes, complex masses for unstable particles, etc..
- Implemented and tested in QED corrections to DY.



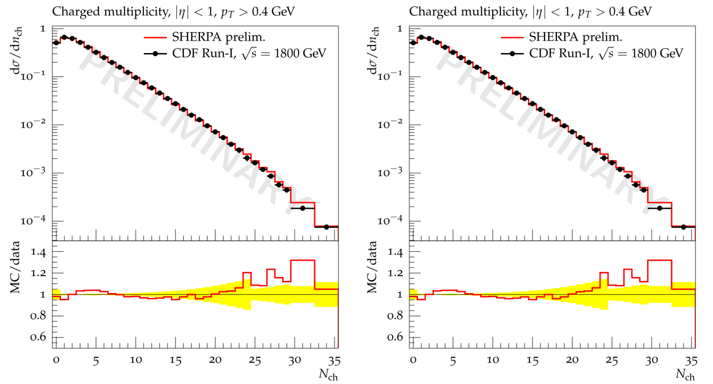


A new model for Minimum Bias (and the underlying event)

Underlying ideas

- Multi-channel eikonal approach
  allows for natural description of low-mass diffraction
- Rooted in unitarisation by exponentiating eikonals
- BFKL-inspired interpretation: exchange of "ladders" (cut pomerons) between hadrons
- Naturally incorporates diffraction/diffractive parts in ladder dynamics

Some appetisers



Conclusions

SHERPA v1.2 and beyond

- SHERPA v1.2 added enhanced physics and usability:
  higher multis, no more libraries, merging completely automatic
- New merging algorithm with improved features:
  - less merging scale uncertainty (below 10% in most cases), smooth transitions
  - has been extended to DIS ($\rightarrow$ VBF) and prompt photon production
- Added dipole subtraction for NLO calculations (LH accord)
- Will include new Minimum Bias model by summer
- First steps towards NLO precision under way.