New shower algorithms for the Sherpa Monte Carlo

[V+jets workshop @ LBNL]

Jan Winter [a]

– Fermilab –

- *Parton shower concept*
- *New parton shower based on Catani–Seymour dipole factorization*
- *New colour dipole model for hadronic collisions*

[a] Sherpa authors: T. Gleisberg, S. Höche, F. Krauss, M. Schönherr, F. Siegert, S. Schumann, J. W.

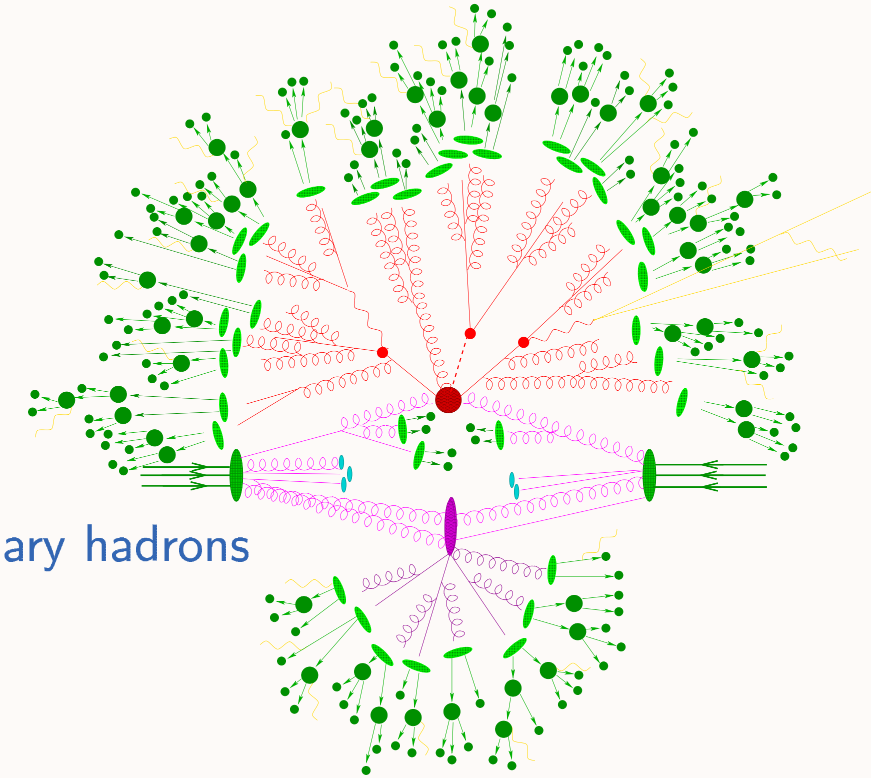
http://www.sherpa-mc.de/

Monte Carlo picture of jet evolution

Factorization approach: divide jet simulation into different phases

Perturbative Phases: *[parton jets]*

- ***Hard process/interaction (hard jet production)***
  exact matrix elements $|\mathcal{M}|^2$
- ***QCD bremsstrahlung (soft/coll multiple emissions)***
  initial- and final-state parton showering
- ***Multiple/Secondary interactions***
  modelling the underlying event



Non-perturbative Phases: *[jet confinement – particle jets]*

- ***Hadronization***
  phenomenological models to convert partons into primary hadrons
- ***Hadron decays***
  phase-space or effective models to decay unstable into stable hadrons as seen in the detectors

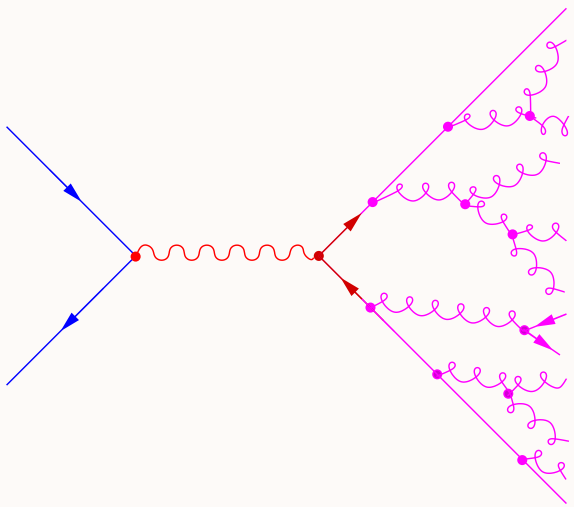
predictions at the hadron-level – comparable to experimental data corrected for detector effects

Parton shower concept

Traditional approach: describe additional jet activity by parton showers.

➜ ***QCD emissions preferably populate collinear and soft phase-space regions.***

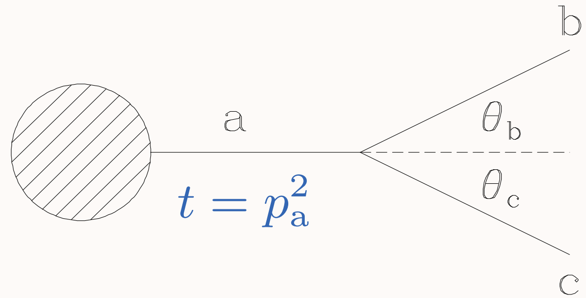
[Pythia, Herwig, Ariadne]



- QCD amplitudes factorize in the coll/soft limit.

➜ Recursive definition of multiple emissions:

$$d\sigma_{n+1} \;=\; d\sigma_n \, \frac{\alpha_s(t)}{2\pi} \frac{dt}{t} \, dz \, P_{a\to bc}(z) \qquad \text{(here, coll limit)}$$



- coll/soft parton emissions iteratively added to the initial/final states *[LL resummation]*
- good description of bulk of radiation and particle multiplicity growth
- partonic ensemble evolved down to hadronization scale *[ordering variable Q, ϑ, p_T]*

  ➜ provides suitable input for universal hadronization models *[$\mathcal{O}(1$ GeV$)$]*

Recent developments

Triggered by

- new physics challenges (LHC)
- rewrites of Pythia, Herwig and Ariadne codes
- enormous progress in the techniques of combining NLO/LO calculations with parton showers *[MC@NLO, POWHEG / MLM, CKKW]*

New efforts

- new shower in Herwig++: $1 \to 2$ splittings, improved treatment of massive partons
- new evolution variable in Pythia: p_T ordering, $1 \to 2$ splittings, $2 \to 3$ kinematics
- formulate parton shower in terms of NLO subtraction terms
  - dipole subtraction *[Nagy,Soper,2006; Dinsdale et al.,2007; Schumann,Krauss,2007]* $1 \to 2$ splittings, $2 \to 3$ kinematics
  - antenna subtraction *[Giele,Kosower,Skands,2007]* $2 \to 3$ splittings and kinematics

  ➔ should facilitate matching of NLO calculations with shower
- new approach to ISR in terms of emissions off colour dipoles *[W,Krauss,2007]* $2 \to 3$ splittings and kinematics

➔ Sherpa will be supplemented by two new shower algorithms : CS shower & dipole shower

Parton shower based on
Catani–Seymour dipole factorization.

PS based on Catani–Seymour dipole factorization

Catani–Seymour dipole subtraction CATANI,SEYMOUR,1997; CATANI ET AL.,2002

- universal framework for jet cross sections @ NLO
- factorization formulae for real emission process (phase space & matrix element)
- construct subtraction terms from Born process using universal dipole terms
- yields local approximation for the real-emission process, correct in soft & coll limits

Basic ideas for a new parton shower

- dipole terms can be used to describe splittings
- exponentiation in a Sudakov form factor (large-N_C limit, spin averaging)
- correct soft & collinear limits, local four-momentum conservation
- formalism well worked out for massive emitters ➔ shower will profit

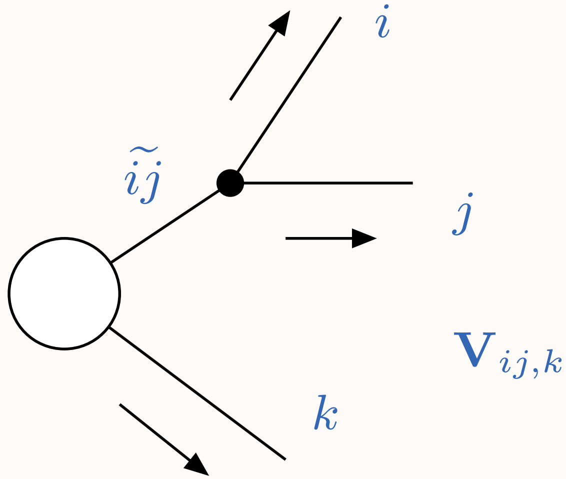
Example: final-state final-state dipoles

emitter+spectator: $\tilde{p}_{ij} + \tilde{p}_k \to p_i + p_j + p_k$

variables: $y_{ij,k} = \frac{p_i p_j}{p_i p_j + p_i p_k + p_j p_k}$, $z_i = \frac{p_i p_k}{p_i p_k + p_j p_k}$

splitting function, e.g. $\mathrm{q}_{ij} \to \mathrm{q}_i \mathrm{g}_j$ ➔

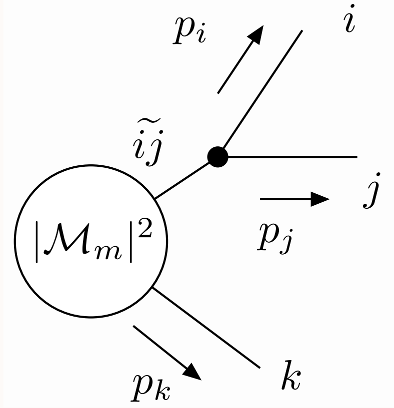
$$\langle V_{\mathrm{q}_i \mathrm{g}_j,k}(z_i, y_{ij,k})\rangle = C_F \left\{ \frac{2}{1 - z_i + z_i y_{ij,k}} - (1 + z_i) \right\}$$



PS based on Catani–Seymour dipole factorization

Catani–Seymour dipole subtraction

- dipole terms describe the limits $3 \to 2$ partons $\{i, j, k\} \to \{\widetilde{ij}, \tilde{k}\}$
- spectator k ensures momentum conservation and mass-shell conditions
  $p_i + p_j + p_k = p_{\widetilde{ij}} + p_{\tilde{k}}\,, \qquad p_l^2 = m_l^2 \quad \forall\, l \in \{l = \widetilde{ij}, \tilde{k}, i, j, k\}$
- $\widetilde{ij}$ and $\tilde{k}$ can be initial or final state partons: FF, FI, IF, II



Example: final-state emission with final-state spectator

$$|\mathcal{M}_{m+1}(p_1, \ldots, p_{m+1})|^2 \quad = \quad \sum_{i \neq j \neq k} -\frac{1}{2 p_i p_j}\, {}_m\langle 1, \ldots, \widetilde{ij}, \ldots, \tilde{k}, \ldots | \underset{\text{colour}}{\frac{\mathbf{T}_k \cdot \mathbf{T}_{ij}}{\mathbf{T}_{ij}^2}} \underset{\text{spin}}{\mathbf{V}_{ij,k}} | 1, \ldots, \widetilde{ij}, \ldots, \tilde{k}, \ldots \rangle_m$$

e.g. $\mathrm{q}_{ij} \to \mathrm{q}_i \mathrm{g}_j$

- $\langle s | \mathbf{V}_{\mathrm{q}_i \mathrm{g}_j, k} | s' \rangle = 8\pi \mu^{2\epsilon} \alpha_S C_{\mathrm{F}} \left[\frac{2}{1 - \tilde{z}_i (1 - y_{ij,k})} - (1 - \tilde{z}_i) - \epsilon (1 - \tilde{z}_i) \right] \delta_{ss'}$
- with $\tilde{z}_i = \frac{p_i p_k}{p_i p_k + p_j p_k}$ & $y_{ij,k} = \frac{p_i p_j}{p_i p_j + p_i p_k + p_j p_k}$

PS based on Catani–Seymour dipole subtraction

Construction of a shower model

- completely factorize $\mathrm{d}^{(4)}\sigma^A$ into $\mathrm{d}^{(4)}\sigma^B$ and $\mathrm{d}^{(4)}V_{\mathrm{dipole}}$
  - spin average kernels: $V_{\mathrm{dipole}} \to \langle V_{\mathrm{dipole}}\rangle$
  - take the leading term in $1/N_{\mathrm{c}}$ only: $-\frac{\mathbf{T}_k\cdot\mathbf{T}_{ij}}{\mathbf{T}_{ij}^2} \to 1(\frac{1}{2})$
- colour connected partons form the emitter–spectator pairs
- defines $2 \to 3$ splitting kernels $\mathrm{d}\langle V_{\mathrm{dipole}}\rangle$ and Sudakovs [FF,FI,IF,II]
- evolution variable is transverse momentum of splitting products $\mathbf{k}_\perp$

Example: FF Sudakov

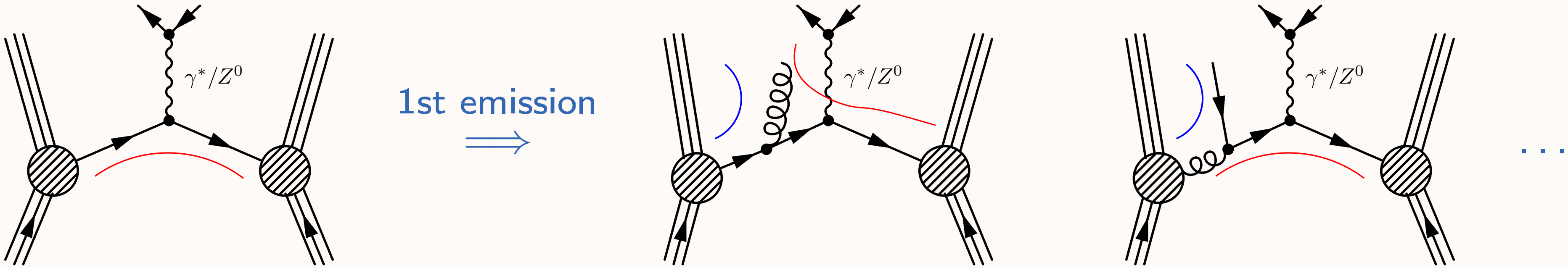
$$\mathrm{d}\hat{\sigma}_{m+1} = \mathrm{d}\hat{\sigma}_m \sum_{\mathrm{dipoles}} \mathrm{d}\langle V_{\mathrm{dipole}}\rangle = \mathrm{d}\hat{\sigma}_m \sum_{\widetilde{ij}} \sum_{\tilde{k}\neq\widetilde{ij}} \frac{1}{\mathcal{N}^{spec}_{\widetilde{ij}}} \frac{\mathrm{d}\mathbf{k}_\perp^2}{\mathbf{k}_\perp^2}\,\mathrm{d}\tilde{z}_i\,\frac{\alpha_{\mathrm{s}}}{2\pi}\,J(\mathbf{k}_\perp^2)\,\langle V_{\widetilde{ij},\tilde{k}}(\tilde{z}_i,\mathbf{k}_\perp^2)\rangle$$

$$\Rightarrow \Delta_{\mathrm{FF}}(\mathbf{k}^2_{\perp,\max},\mathbf{k}^2_{\perp,0})$$

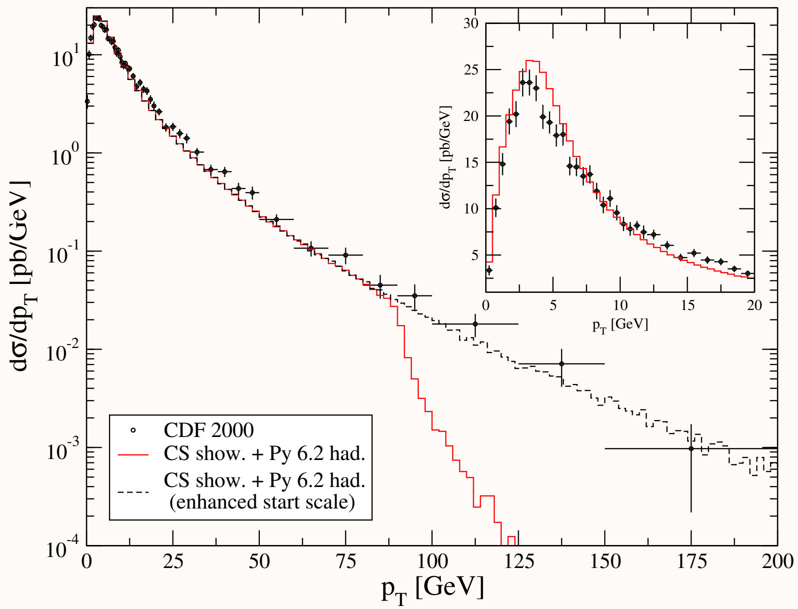
$$= \exp\left(-\sum_{\widetilde{ij}} \sum_{\tilde{k}\neq\widetilde{ij}} \frac{1}{\mathcal{N}^{spec}_{\widetilde{ij}}} \int_{\mathbf{k}^2_{\perp,0}}^{\mathbf{k}^2_{\perp,\max}} \frac{\mathrm{d}\mathbf{k}_\perp^2}{\mathbf{k}_\perp^2} \int_{z_-}^{z_+} \mathrm{d}\tilde{z}_i\,\frac{\alpha_{\mathrm{s}}(\mathbf{k}_\perp^2)}{2\pi}\,J(\mathbf{k}_\perp^2)\langle \mathbf{V}_{\widetilde{ij},\tilde{k}}(\tilde{z}_i,\mathbf{k}_\perp^2)\rangle\right)$$

Drell–Yan production

Consider $p\bar{p} \to \gamma^*/Z^0 \to e^+e^-$



- hard scale fixed by $M^2_{e^+e^-} \Rightarrow \mathbf{k}^2_{\perp,\max}$
- transverse momentum of lepton-pair determined by QCD emissions

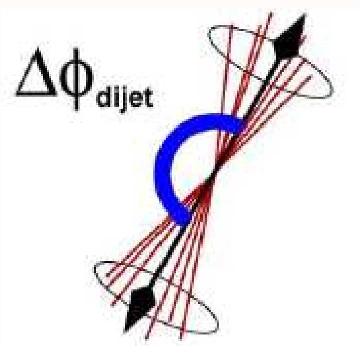


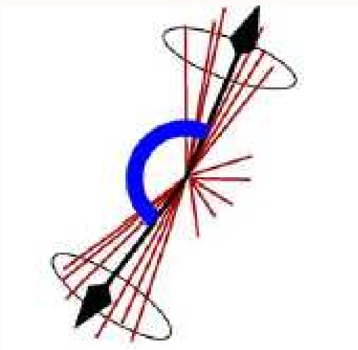
- Comparison with Tevatron CDF data
  - rate normalised to data
  - dominant contribution for $p_T^{e^+e^-}$
  - Sudakov damping for $p_T^{e^+e^-} \to 0$
  - hardest emission below $\mathbf{k}_{\perp,\max}$

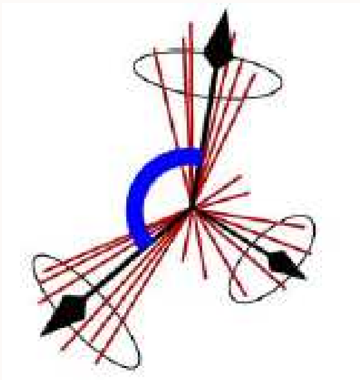
    $\hookrightarrow p_T^{e^+e^-} > \mathbf{k}_{\perp,\max}$ matrix element regime

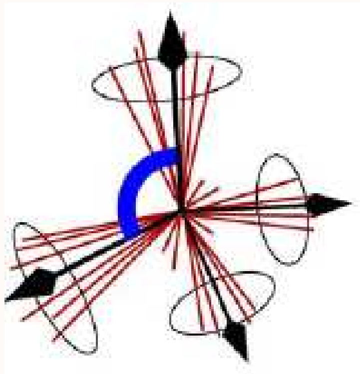
Inclusive jet production

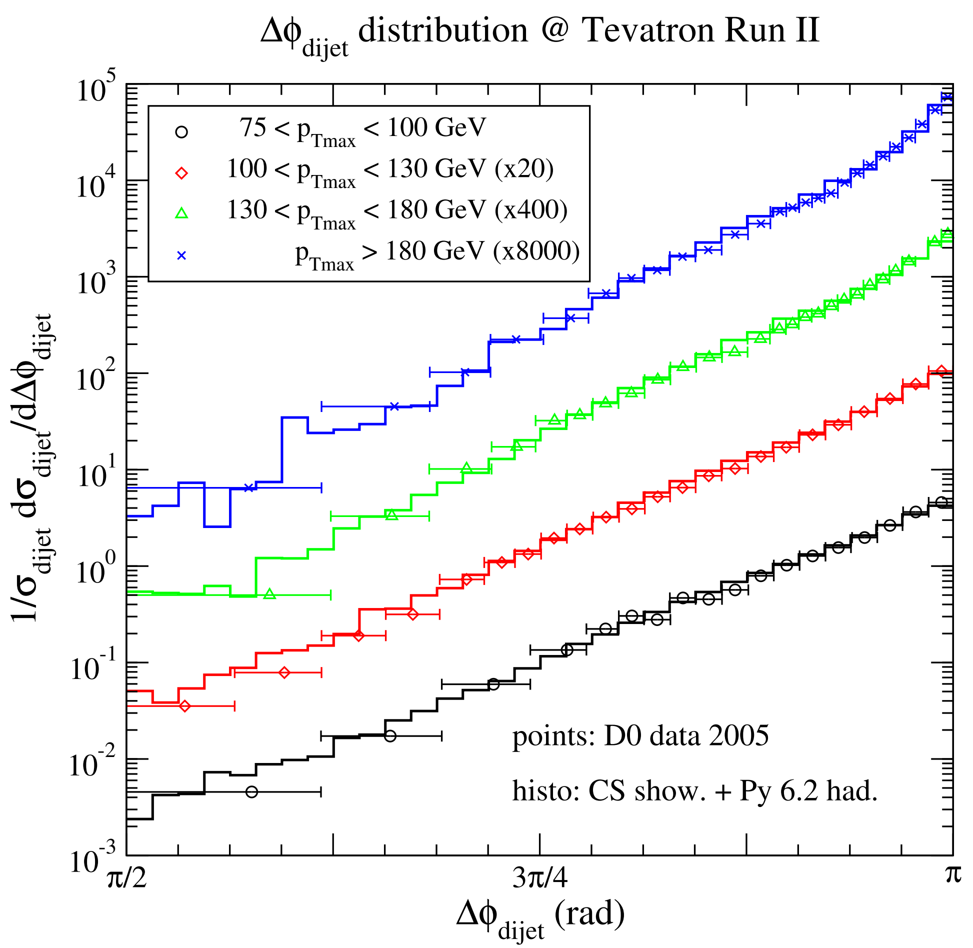
Dijet azimuthal decorrelation [data DØ 2005]







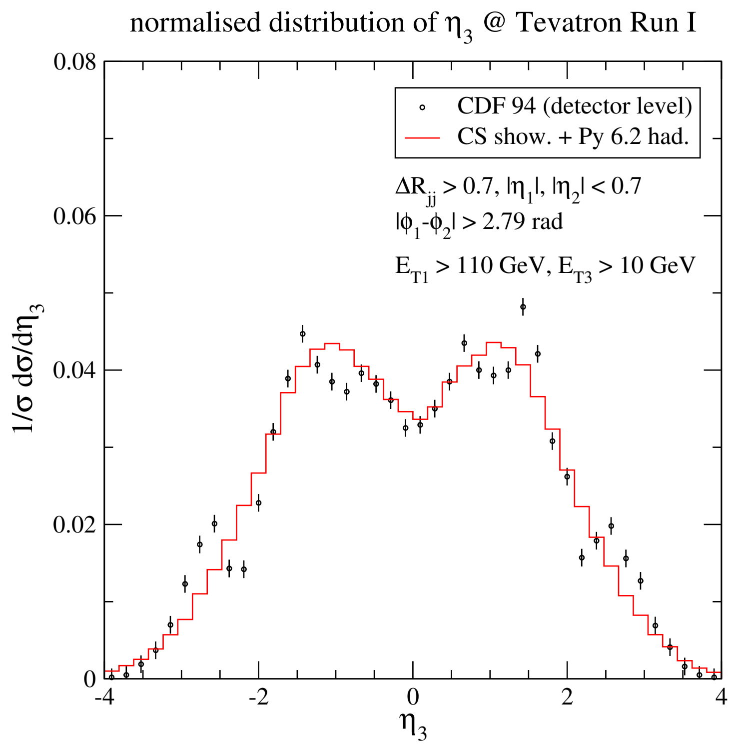


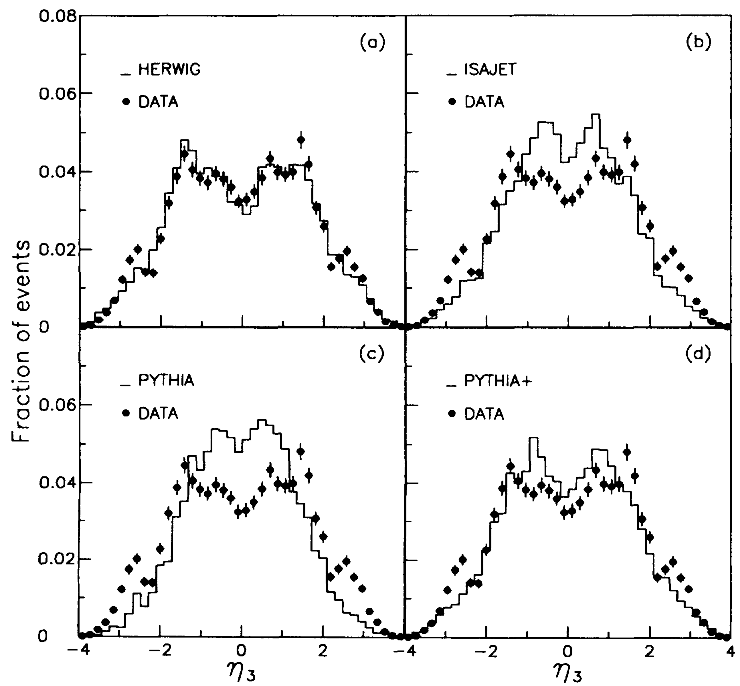


- only the two leading jets need to be reconstructed
- strong test of the initial- and final-state radiation pattern

Inclusive jet production

Coherence effects in three-jet production [data CDF 1994]





- soft color coherence included through $\mathbf{k}_\perp$-evolution of "dipoles"

  [angular ordering in Herwig, only approx. in Pythia (pre 6.3) and standard Sherpa]

- important for the LHC due to larger phase space

New colour dipole model
for hadronic collisions.

Lund colour dipole model

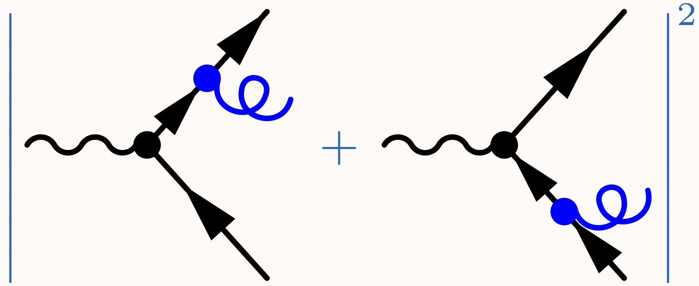
AZIMOV, DOKSHITZER, KHOZE, TROYAN / GUSTAFSON, PETTERSSON, ANDERSSON, LÖNNBLAD

Interesting alternative to conventional parton showers.

Recursive principle applied in limit of soft gluon emissions
- soft gluons intrinsically correct
- colour coherent radiation pattern

- QCD $q\bar{q}$ antenna (x_i energy fractions)

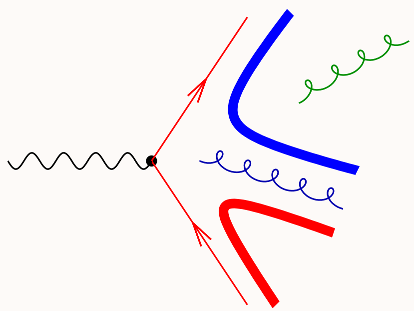
$$d\sigma = d\sigma_0 \frac{2\,\alpha_s}{3\,\pi} \frac{(x_1^2 + x_3^2)\; dx_1 dx_3}{(1 - x_1)(1 - x_3)} \sim d\sigma_0 \frac{d\omega_g}{\omega_g}\, dy_g$$

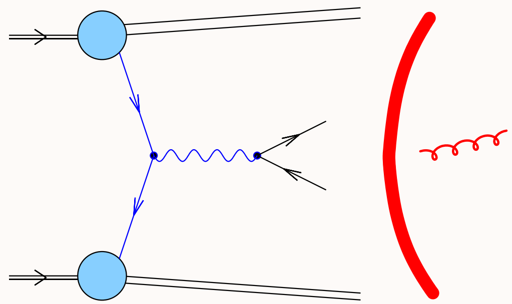


Even correct for hard gluons!
Gluon emission is $2 \to 3$ process.

- Semi-classical picture of a dipole cascade

  $q\bar{q}$ emits g, in turn $q'g\bar{q}'$ emits softer g',
  $q'\bar{q}'$ contribution is neglected ($1/N_C^2$).





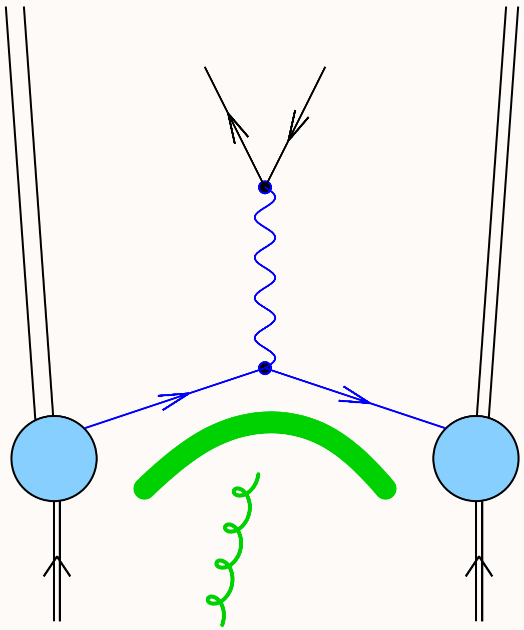
- Local 4-momentum conservation, partons on mass shell! g splitting included: $\hat{q}g \to \hat{q}\bar{q}q$.
- ISR mapped onto FSR, parametrize suppression of high-p_T emissions for dipoles containing hadron remnants

Idea implemented in Ariadne ... very good performance in describing LEP/HERA data

Colour dipole shower for hadronic collissions

W, Krauss, arXiv:0712.3913

- Formulate IS emission completely perturbatively through colour dipoles (partly) spanned by incoming parton lines.
- Radiation that is associated to ***initial***, ***initial-final*** and ***final*** colour lines.
- Keep beam remnants outside evolution as long as hadronization has not set in.



Construction principles of perturbative CDM:

- new dipole types: $\bar{q}_{\rm i}q_{\rm i}$, $g_{\rm i}q_{\rm i}$, $g_{\rm i}g_{\rm i}$ and $q_{\rm f}q_{\rm i}$, $q_{\rm f}g_{\rm i}$, $g_{\rm f}g_{\rm i}$.
- radiation pattern in terms of $2 \to 3$ splittings.
- generalization of the kinematics setup to the new cases
  - *dipole phase-space factorization and invariant evolution variables*.
- *dipole ME factorization* → re-calculate or use crossing symmetry of FF dipole MEs or use antenna functions.
- probabilistic interpretation of Sudakov form factor based on dipole splitting cross sections.
- large $N_{\rm C}$ limit, onshell kinematics, for all ISR apply backward evolution.

Gluon emission from colour dipoles

➡ *Instead of redefining ISR in terms of FSR,*

$$\tilde{k}\,\tilde{\ell} \;\to\; \begin{cases} \tilde{k}\,g_{\rm f}\,\tilde{\ell} & : \quad \text{gluon emission}\,, \\ q\,g_{\rm i}\,\tilde{\ell} & : \quad \text{quark emission},\ \text{provided that}\ \ \tilde{k} = \bar{q}_{\rm i}\,, \\ \tilde{k}\,g_{\rm i}\,\bar{q} & : \quad \text{antiquark emission},\ \text{provided that}\ \ \tilde{\ell} = q_{\rm i}\,. \end{cases}$$

Basic idea: find generalized (and recursive) form for ...

➡ *differential cross section for a $\tilde{k}\tilde{\ell} \to kg\ell$ dipole splitting:*

$$d\sigma_{0\to kg\ell} \;=\; d\sigma_{0\to\tilde{k}\tilde{\ell}}\,\frac{\alpha_s(\mu_{\rm R})}{2\pi}\;D_{\tilde{k}\tilde{\ell}\to kg\ell}(p_\perp, y)\;\frac{dp_\perp^2}{p_\perp^2}dy$$

➡ *expressed through dipole splitting functions D and Lorentz invariant evolution variables:*

transverse momentum: $p_\perp^2 \;=\; \left|\dfrac{s_{kg}\,s_{g\ell}}{s_{kg\ell}}\right|$, rapidity: $y \;=\; \dfrac{1}{2}\,\ln\left|\dfrac{s_{g\ell}}{s_{kg}}\right|$;

- $s_{mn} \;=\; (\varsigma_m\,p_m + \varsigma_n\,p_n)^2\,, \quad s_{mnr} \;=\; (\varsigma_m\,p_m + \varsigma_n\,p_n + \varsigma_r\,p_r)^2$
- $\varsigma_m = \pm 1$ ($+$ outgoing, $-$ incoming)

Gluon emission from colour dipoles

- ***Similarly apply to II dipoles:***

$$d\sigma_{\bar{\imath}' i(gi)\to 0g(0q)} \simeq d\sigma_{\bar{\imath}' i(\bar{q}i)\to 0} \left(\frac{dy_{\rm cm}}{d\tilde{y}_{\rm cm}}\right) \frac{f_{\bar{\imath}'(g)}(x_\pm,\mu_{\rm F})\, f_i(x_\mp,\mu_{\rm F})}{f_{\bar{\imath}'(\bar{q})}(\tilde{x}_\pm,\tilde{\mu}_{\rm F})\, f_i(\tilde{x}_\mp,\tilde{\mu}_{\rm F})} \frac{M^4}{s^2_{\bar{\imath}' i(g_{\rm i} i)}(p_\perp,y)}$$

$$\times \frac{\xi\, C\alpha_s}{2\pi} \hat{D}_{\bar{\imath}' i(\bar{q}_{\rm i} i)\to \bar{\imath}' gi(qg_{\rm i} i)}(p_\perp,y)\, dp_\perp^2\, dy$$

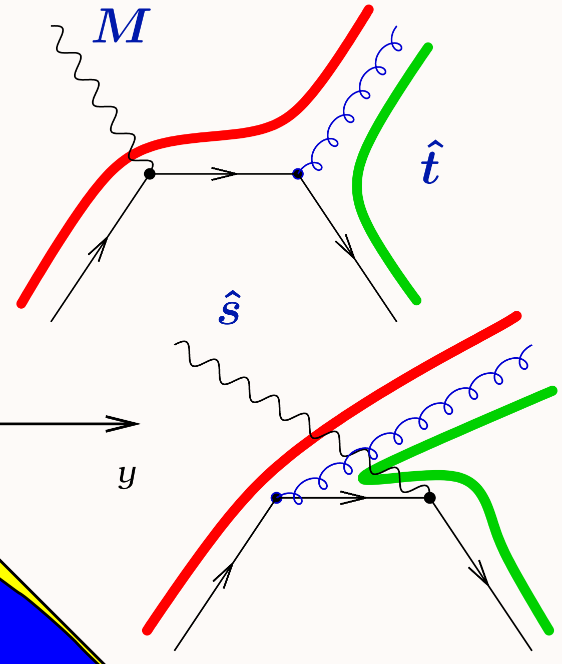
- $y_{\rm cm} = \ln(x_+/x_-)/2, \qquad \tilde{y}_{\rm cm} = \ln(\tilde{x}_+/\tilde{x}_-)/2$

- ***And to FI dipoles as well:***

$$d\sigma_{0i(0g)\to fg(f\bar{q})} \simeq d\sigma_{0i(0q)\to f} \frac{f_{i(g)}(x_\pm,\mu_{\rm F})}{f_{i(q)}(\tilde{x}_\pm,\tilde{\mu}_{\rm F})} \frac{Q^4}{\left[s_{fg(f\bar{q})}(p_\perp,y)+Q^2\right]^2}$$

$$\times \frac{\xi\, C\alpha_s}{2\pi} \hat{D}_{fi(fq_{\rm i})\to fgi(fg_{\rm i}\bar{q})}(p_\perp,y)\, dp_\perp^2\, dy$$

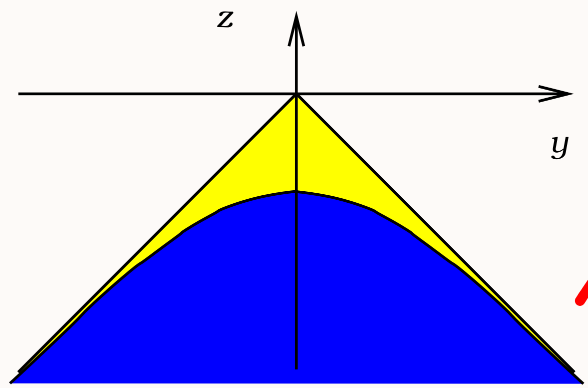
Initial-state dipole evolution at a glance: $\bar{\imath}' i \to \bar{\imath}' g i$



- Invariant transverse momentum and rapidity

$$p_\perp^2 \;=\; \left|\frac{s_{\bar{\imath}' g}\, s_{gi}}{s_{\bar{\imath}' gi}}\right| \;=\; \frac{\hat{t}\,\hat{u}}{M^2}\,, \qquad y \;=\; \frac{1}{2}\ln\left|\frac{s_{gi}}{s_{\bar{\imath}' g}}\right| \;=\; \frac{1}{2}\ln\frac{\hat{u}}{\hat{t}}$$

- Phase space, $\quad a = \hat{s}_{\max}/M^2 \leq S/M^2$



$$|y| \;\leq\; \operatorname{arcosh}\frac{(a-1)M}{2p_\perp} \;\leq\; \ln\frac{(a-1)M}{p_\perp} = \ln\frac{1}{z}$$

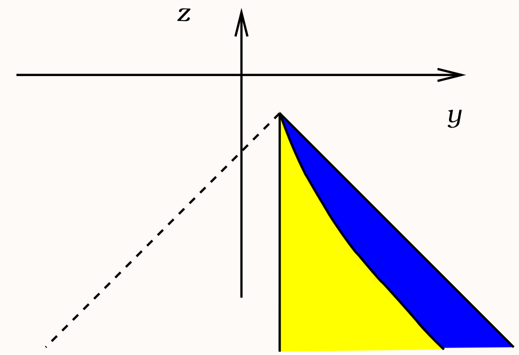
- Dipole splitting function for ***gluon emission*** off II dipoles, $\qquad x_{\bar{\imath}',i} \;=\; 1 + \frac{p_\perp}{M}\, e^{\pm y}$

$$D_{\bar{\imath}' i \to \bar{\imath}' g i}(p_\perp, y) \;=\; \frac{f_{\bar{\imath}'}(x_\pm, \mu_{\rm F})\, f_i(x_\mp, \mu_{\rm F})}{f_{\bar{\imath}'}(\tilde{x}_\pm, \tilde{\mu}_{\rm F})\, f_i(\tilde{x}_\mp, \tilde{\mu}_{\rm F})}\; \xi_{\left\{ {F \atop A} \right\}} C_{\left\{ {F \atop A} \right\}}\; \frac{x_{\bar{\imath}'}^{n_{\bar{\imath}'}}(p_\perp, y) + x_i^{n_i}(p_\perp, y)}{[x_{\bar{\imath}'}(p_\perp, y) + x_i(p_\perp, y) - 1]^2}$$

$$\leq\; \mathcal{N}_{\rm PDF}\; \xi_{\left\{ {F \atop A} \right\}} C_{\left\{ {F \atop A} \right\}} \left\{ \begin{matrix} 2 \\ a+1 \end{matrix} \right\} \;\equiv\; D^{\rm approx}_{\bar{\imath}' i \to \bar{\imath}' g i}(p_\perp, y)$$

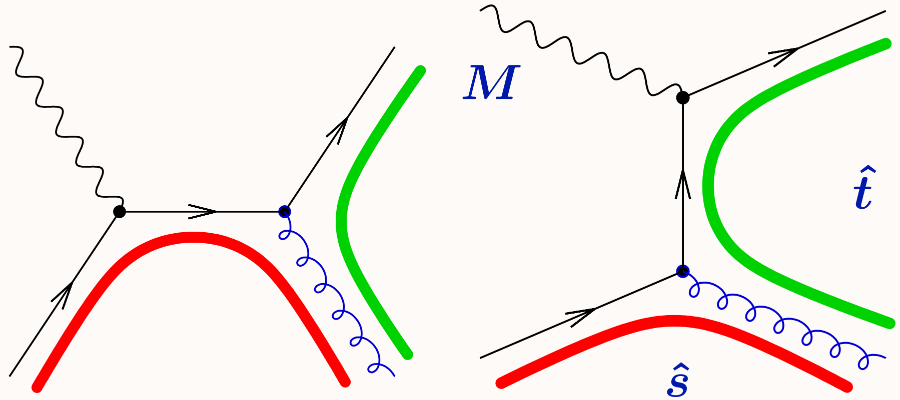
$$n_{q,g} = 2, 3; \qquad \left\{ \begin{matrix} \ldots & \text{for quark dipoles} \\ \ldots & \text{else} \end{matrix} \right\}$$

Initial-state dipole evolution at a glance: $\bar{q}_{\rm i} i \longrightarrow q g_{\rm i} i$



- Invariant transverse momentum and rapidity

$$p_\perp^2 \;=\; \left|\frac{s_{qg_{\rm i}}\,s_{g_{\rm i}i}}{s_{qg_{\rm i}i}}\right| \;=\; -\frac{\hat{t}\,\hat{s}}{M^2}\,, \qquad y \;=\; \frac{1}{2}\,\ln\left|\frac{s_{g_{\rm i}i}}{s_{qg_{\rm i}}}\right| \;=\; \frac{1}{2}\,\ln\frac{\hat{s}}{-\hat{t}}$$



- Phase space, $a = \hat{s}_{\rm max}/M^2 \le S/M^2$

$$\operatorname{arsinh}\frac{M}{2\,p_\perp} \;\le\; y \;\le\; \ln\frac{a\,M}{p_\perp} = \ln\frac{1}{z}$$

- Dipole splitting function for ***quark emission*** off II dipoles, $x_{q,i} \;=\; \mp 1 + \frac{p_\perp}{M}\,e^{\pm y}$

$$D_{\bar{q}_{\rm i}i\to qg_{\rm i}i}(p_\perp,y) \;=\; \frac{f_g(x_\pm,\mu_{\rm F})\,f_i(x_\mp,\mu_{\rm F})}{f_{\bar{q}}(\tilde{x}_\pm,\tilde{\mu}_{\rm F})\,f_i(\tilde{x}_\mp,\tilde{\mu}_{\rm F})}\;T_R\;\frac{x_q^2(p_\perp,y)+x_i^{n_i}(p_\perp,y)}{[1+x_q(p_\perp,y)]^2}$$

$$\le\; \mathcal{N}_{\rm PDF}\;T_R\;\left\{\begin{array}{c}2\\ a+1\end{array}\right\} \;\equiv\; D^{\rm approx}_{\bar{q}_{\rm i}i\to qg_{\rm i}i}(p_\perp,y)$$

$$n_{q,g} = 2,3;\qquad \left\{\begin{array}{ll}\ldots & \text{for quark dipoles}\\ \ldots & \text{else}\end{array}\right\}$$

Sudakov exponentiation, kinematics and showering

- Rule of thumb: no-branching probability exponentiates

$$\Delta(p^2_{\perp,\mathrm{stt}}, p^2_\perp) \;=\; \exp\left\{ -\int_{p^2_\perp}^{p^2_{\perp,\mathrm{stt}}} \frac{dk^2_\perp}{k^2_\perp}\, \mathcal{I}(k^2_\perp) \right\},$$

$$\mathcal{I}(k^2_\perp) \;=\; \frac{\alpha_s[\mu_\mathrm{R}(k_\perp)]}{2\pi} \sum_{\{\tilde{k}\tilde{\ell}\to kg\ell\}} \int_{y_-(k_\perp,\,a)}^{y_+(k_\perp,\,a)} dy\; D_{\tilde{k}\tilde{\ell}\to kg\ell}(k_\perp, y)$$

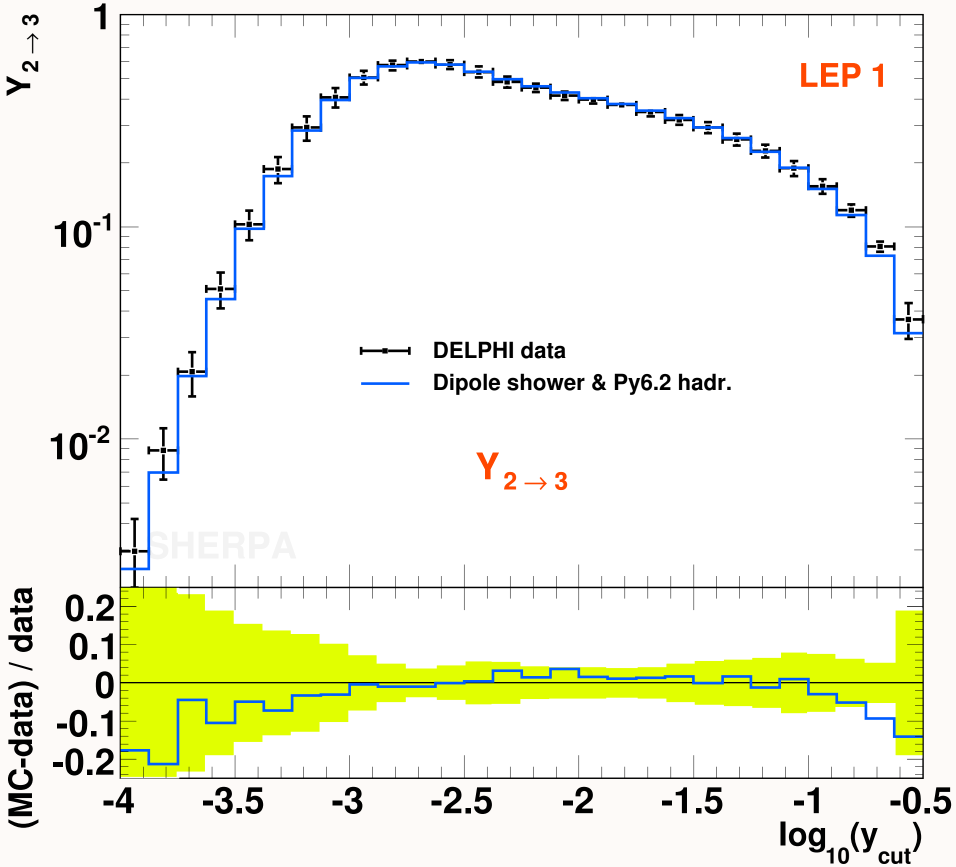
- Differential probability that branching occurs at $p^2_\perp$

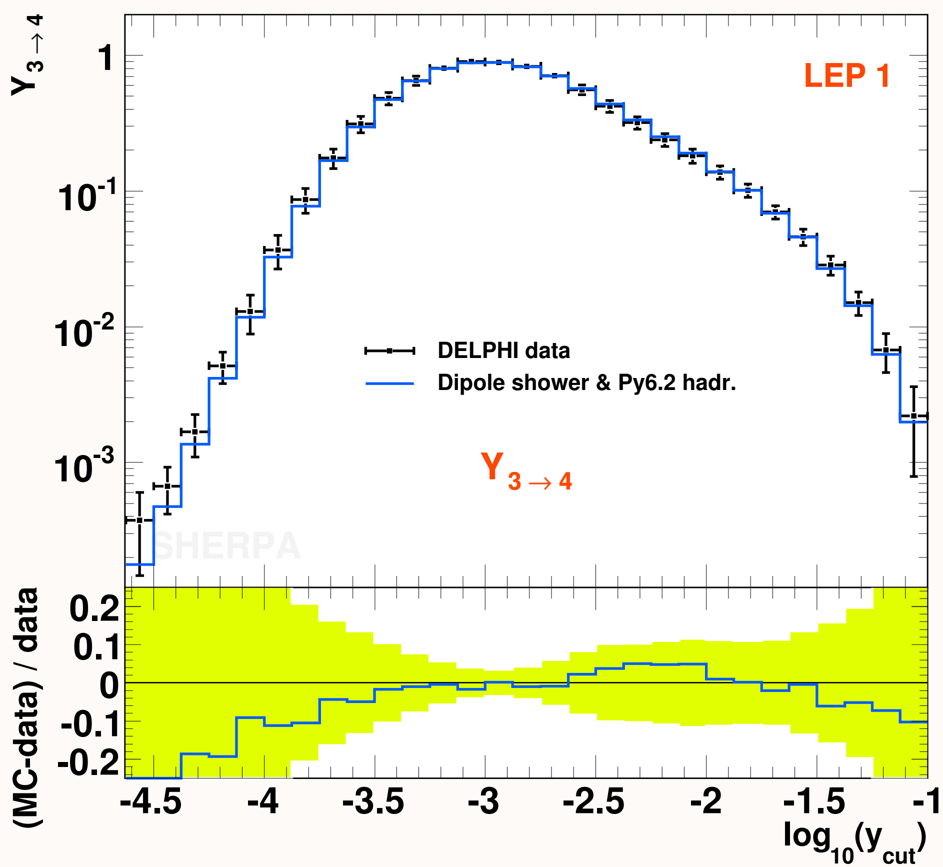
$$\frac{dP}{dp^2_\perp} \;=\; \frac{d\Delta(p^2_{\perp,\mathrm{stt}}, p^2_\perp)}{dp^2_\perp} \;=\; \frac{\mathcal{I}(p^2_\perp)}{p^2_\perp}\Delta(p^2_{\perp,\mathrm{stt}}, p^2_\perp)$$

- Monte Carlo method (Veto Algorithm) yields values for evolution variables.
- Set up kinematics: use light-cone variables and recoil strategies.
- Shower algorithm fully defined by fixing:
  - *renormalization and factorization scale choices.*
  - *the initializing scale in dependence on the hard process.*
  - *the maximal phase space of a single emission globally.*
  - *the iteration procedure to generate the cascade and the cut-off(s).*

Results for pure final-state cascading

➡ *Testbed: hadron production in electron–positron annihilations @ LEP1*

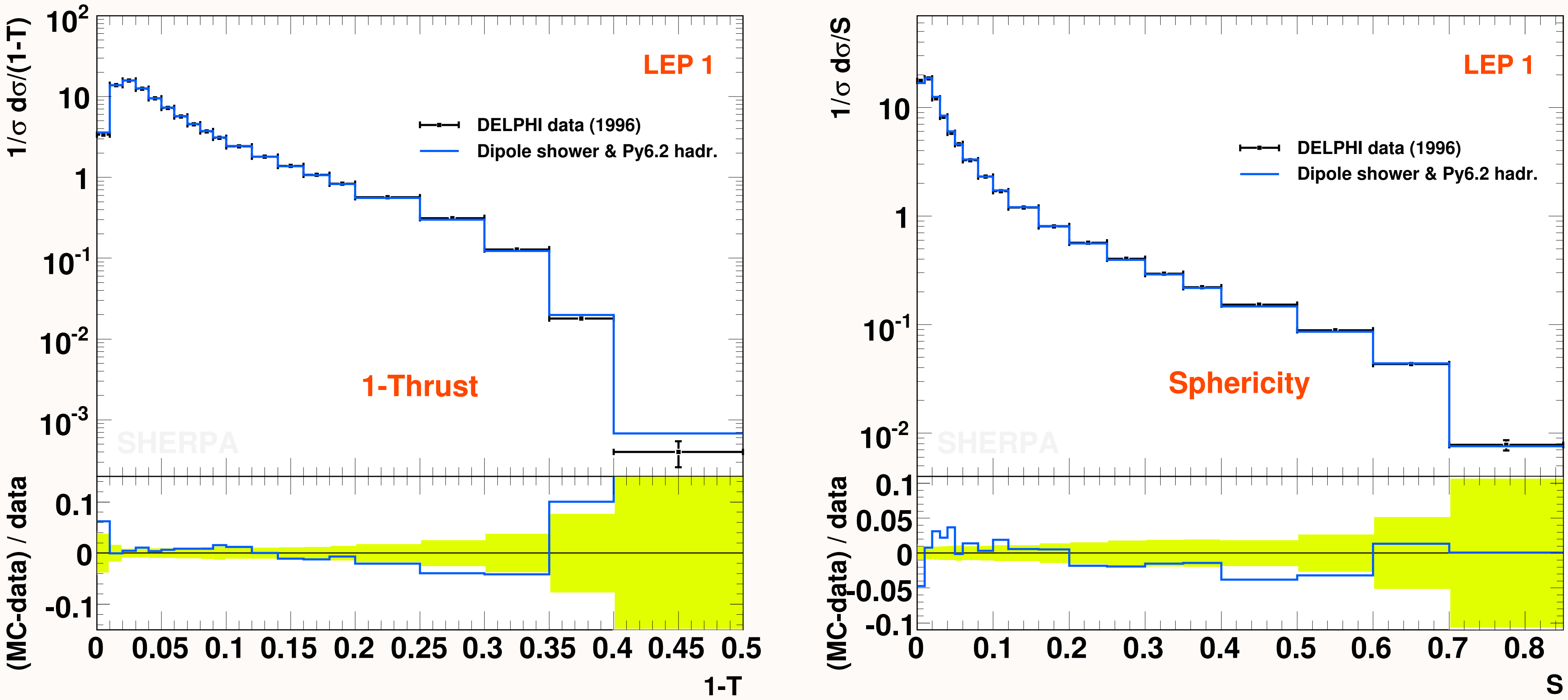




- Durham differential jet rates as a function of the jet-resolution parameter $y_{\rm cut}$.
- Data: H. Hoeth, diploma thesis, Bergische Universität Wuppertal.

Results for pure final-state cascading

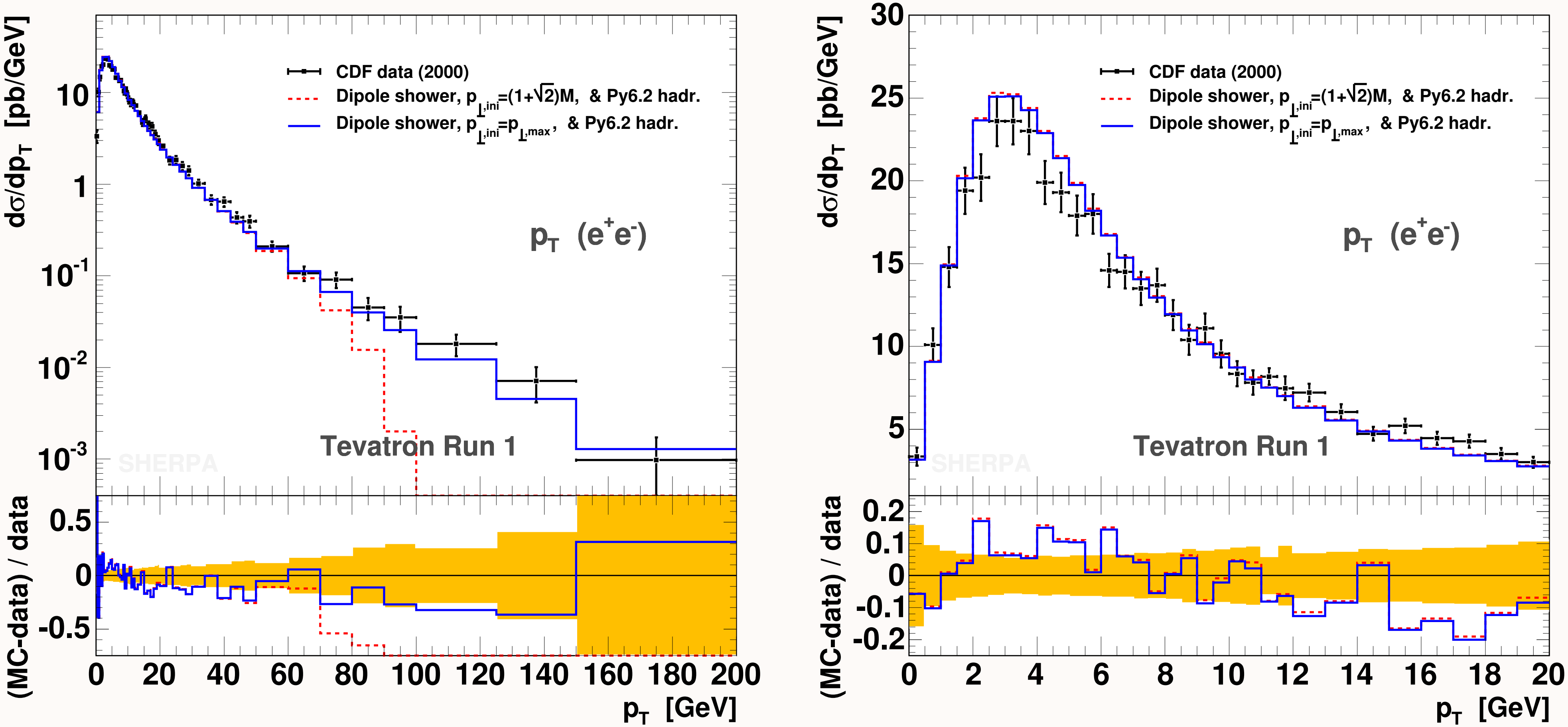
→ *Testbed: hadron production in electron–positron annihilations @ LEP1*



- Examples of event-shape observables: 1-thrust (left panel) and sphericity.
- Data: P. Abreu et. al. Z. Phys. **C73** (1996) 11.

Results for hadronic collisions

➡ *Testbed: inclusive production of Drell–Yan lepton pairs @ Tevatron Run I*

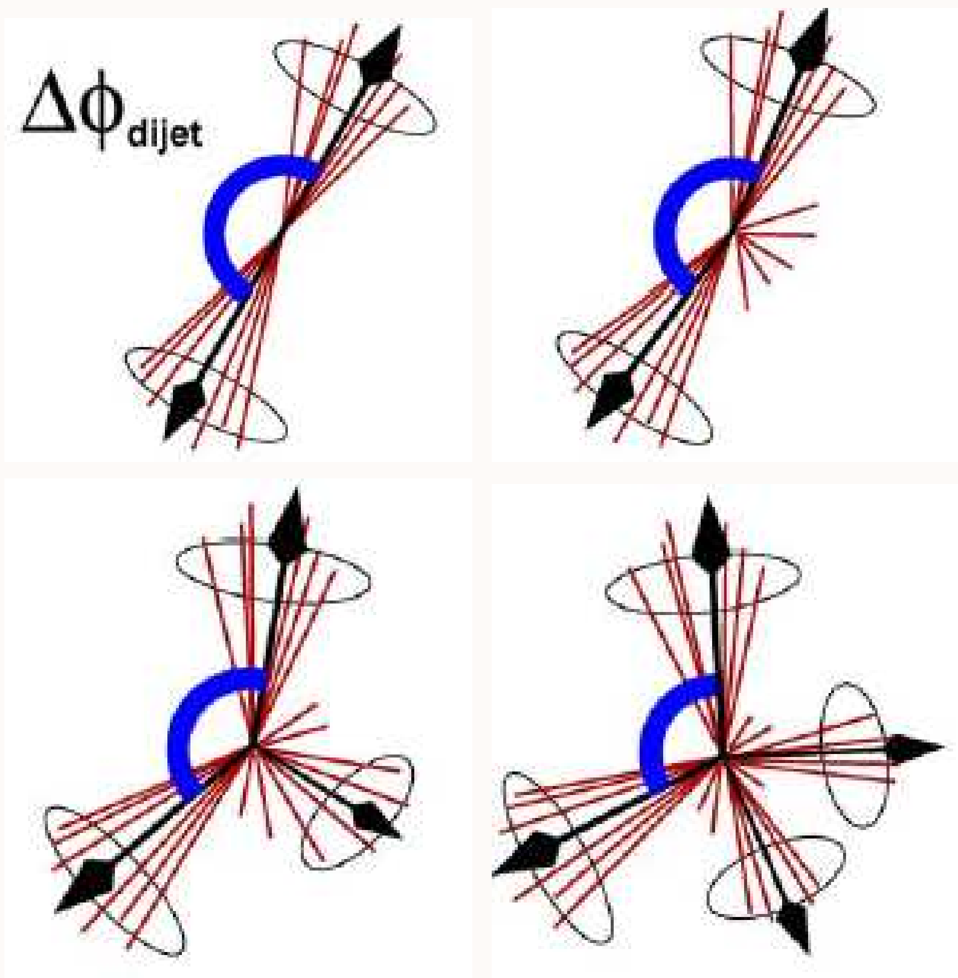


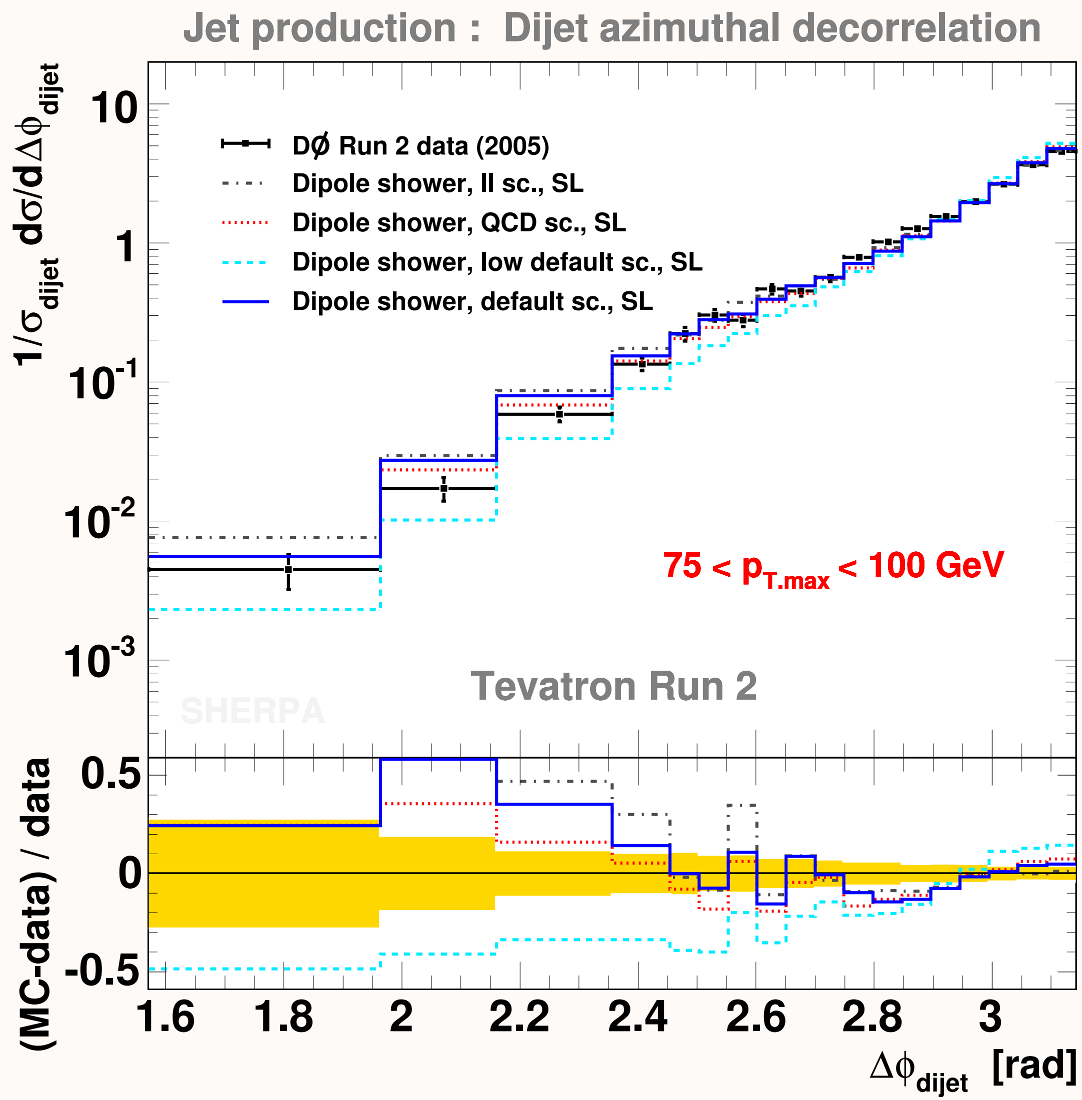
- Boson transverse-momentum distribution and its peak region in $e^+e^- + X$.
- The 1st emission in the dipole shower is ME corrected per construction.
- Data: A. A. Affolder et. al. Phys. Rev. Lett. **84** (2000) 845.

Correlations ... inclusive jet production @ Tevatron

V.M. Abazov et al., Phys. Rev. Lett. ***94*** (2005) 221801

- Dijet azimuthal decorrelation measured by DØ at Run II.
- Idea: test QCD radiation pattern.

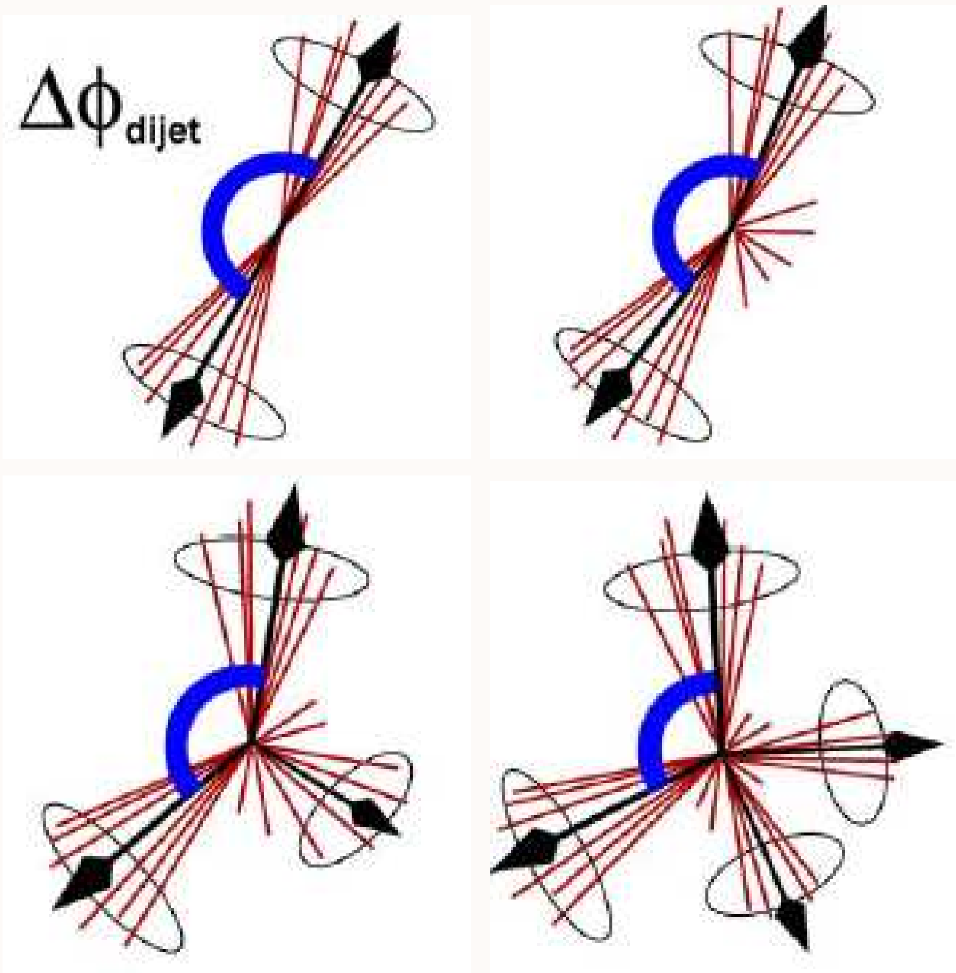


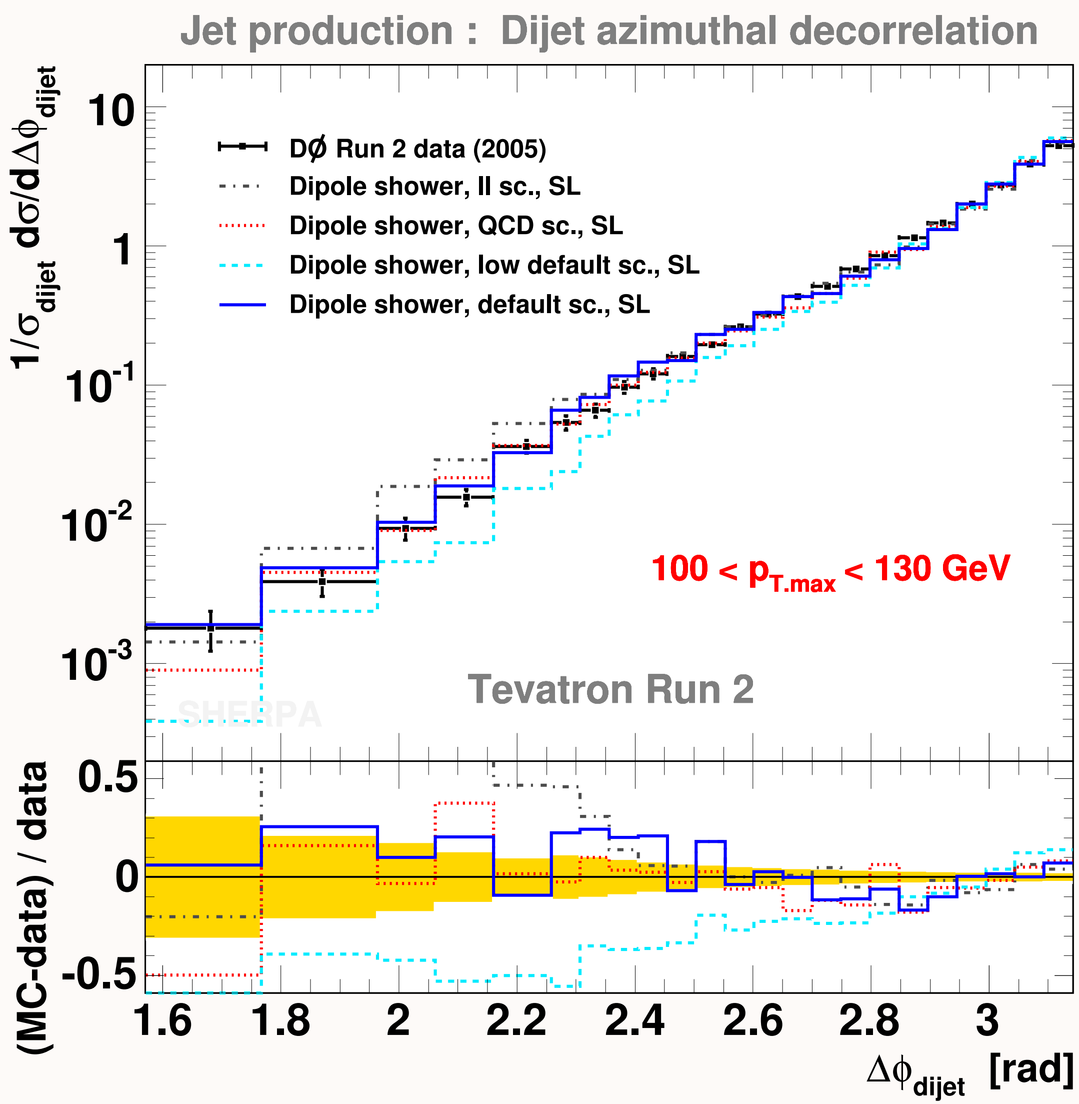


Correlations ... inclusive jet production @ Tevatron

V.M. Abazov et al., Phys. Rev. Lett. ***94*** (2005) 221801

- Dijet azimuthal decorrelation measured by DØ at Run II.
- Idea: test QCD radiation pattern.

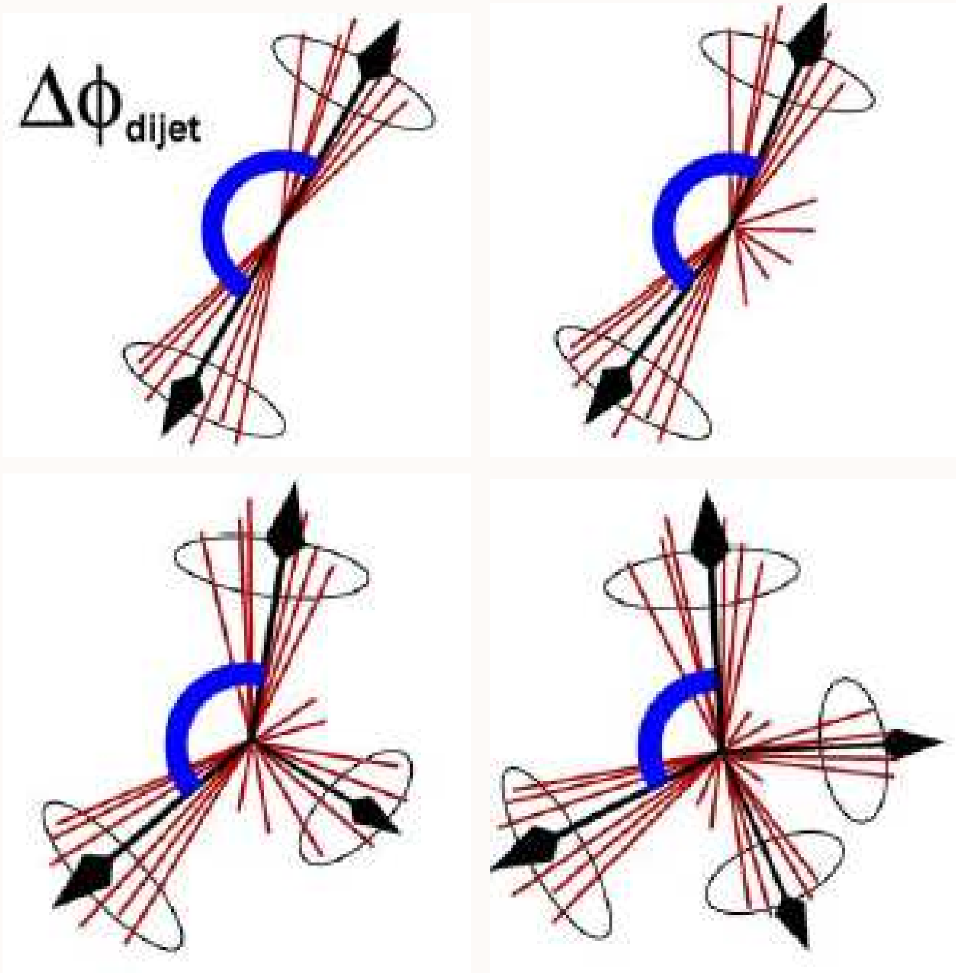


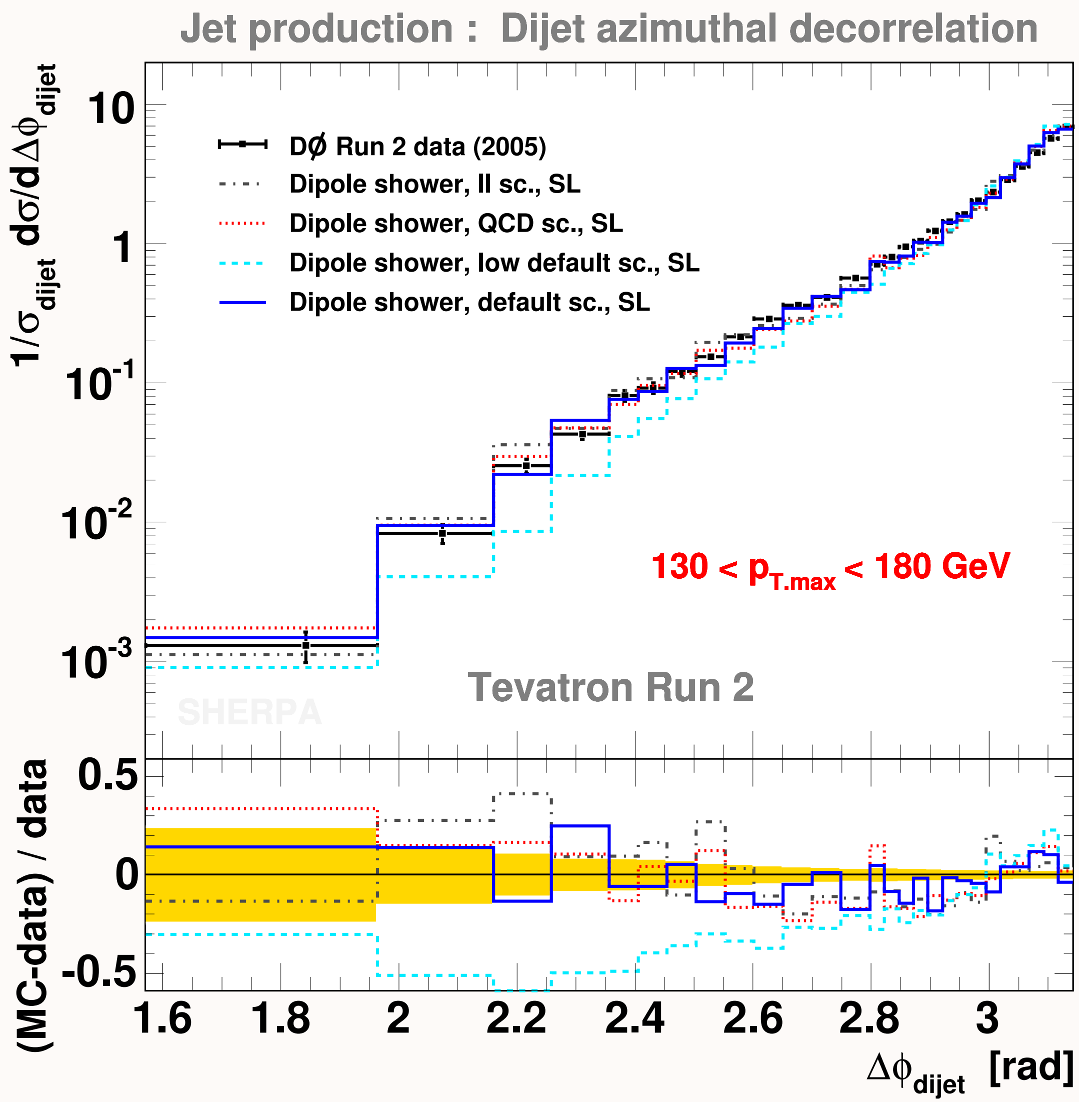


Correlations ... inclusive jet production @ Tevatron

V.M. Abazov et al., Phys. Rev. Lett. ***94*** (2005) 221801

- Dijet azimuthal decorrelation measured by DØ at Run II.
- Idea: test QCD radiation pattern.

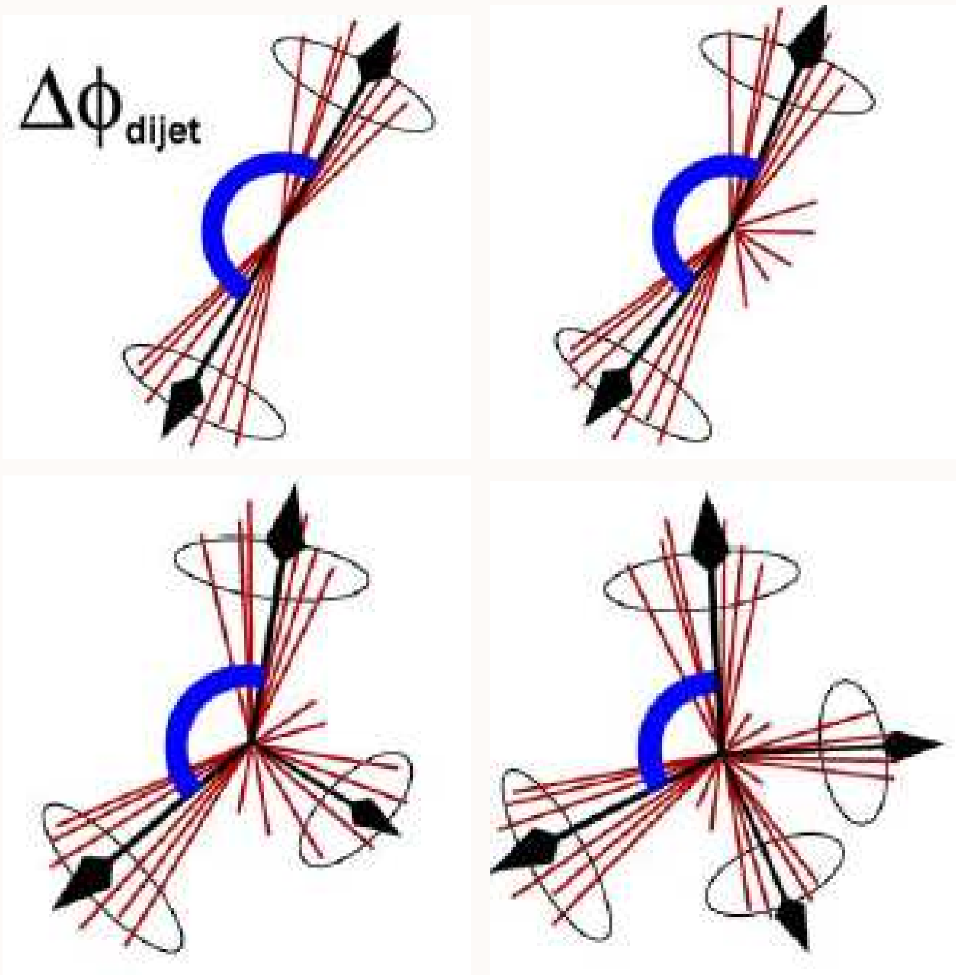


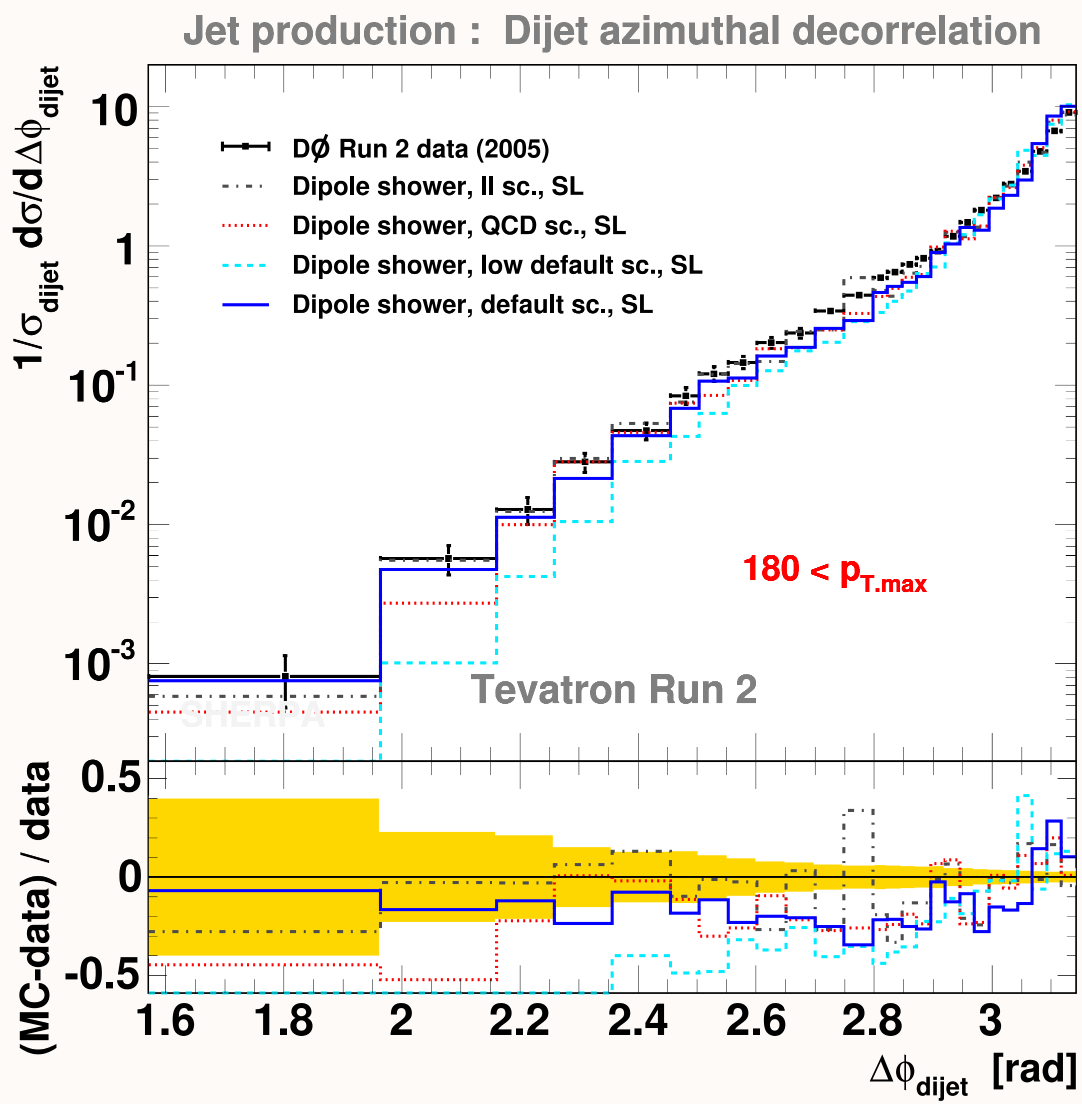


Correlations ... inclusive jet production @ Tevatron

V.M. Abazov et al., Phys. Rev. Lett. ***94*** (2005) 221801

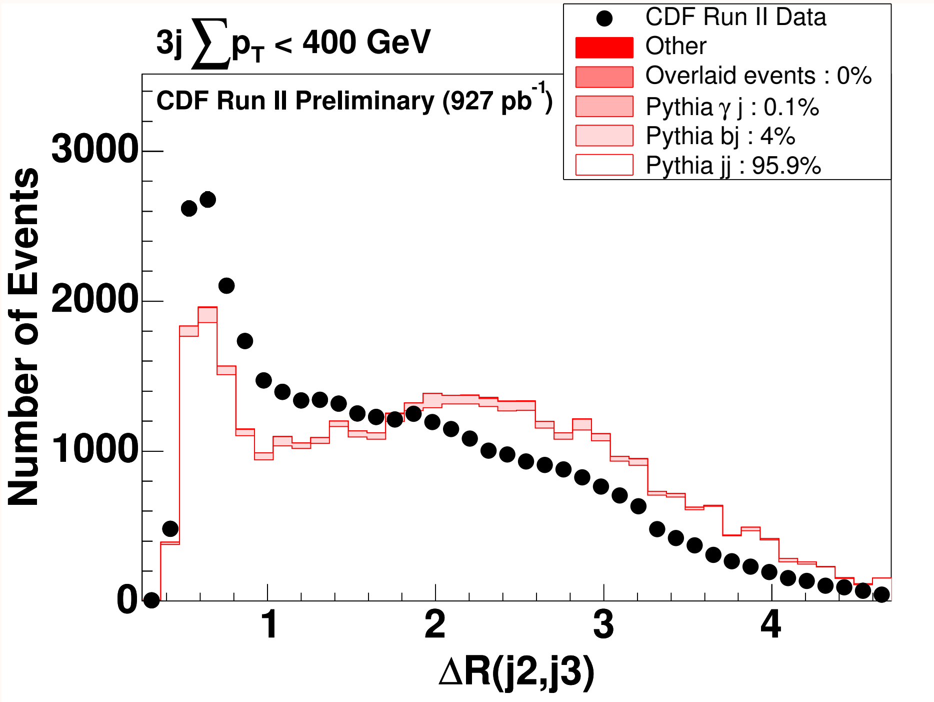
- Dijet azimuthal decorrelation measured by DØ at Run II.
- Idea: test QCD radiation pattern.

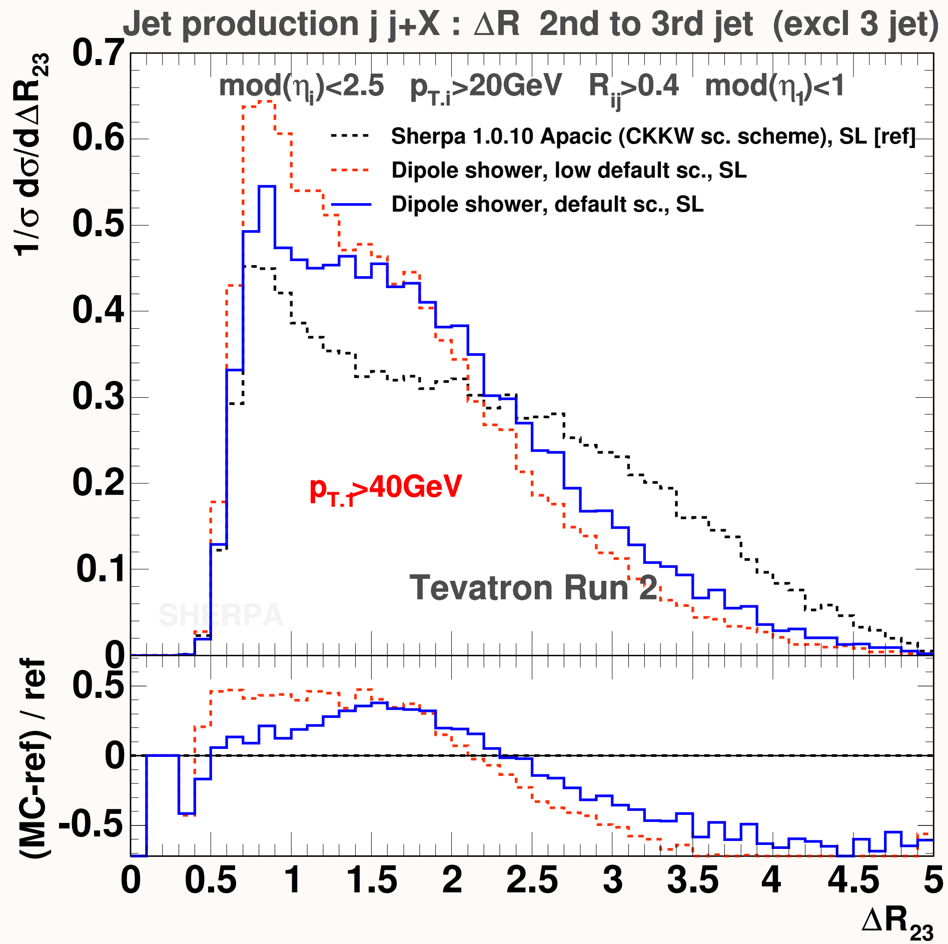




Results for hadronic collisions

➡ *Testbed: inclusive jet production @ Tevatron Run II*





- Discrepancy between MC and CDF data: ARXIV:0710.2372
- Was interested what the new dipole shower would predict

Summary/Outlook

New parton-shower formalisms:

- Parton shower based on Catani–Seymour dipole subtraction
  - splitting kernels corresponding to subtraction terms
  - exact phase-space mapping & on-shell momenta
  - finite-mass effects and SUSY splittings included
- Dipole shower for hadronic collisions
  - $2 \to 3$ splitting kernels & $2 \to 3$ onshell kinematics
  - dipole phase-space & ME factorization
  - mass effects need to be included

Next steps

- merging with tree-level matrix elements
- matching with 1-loop calculations