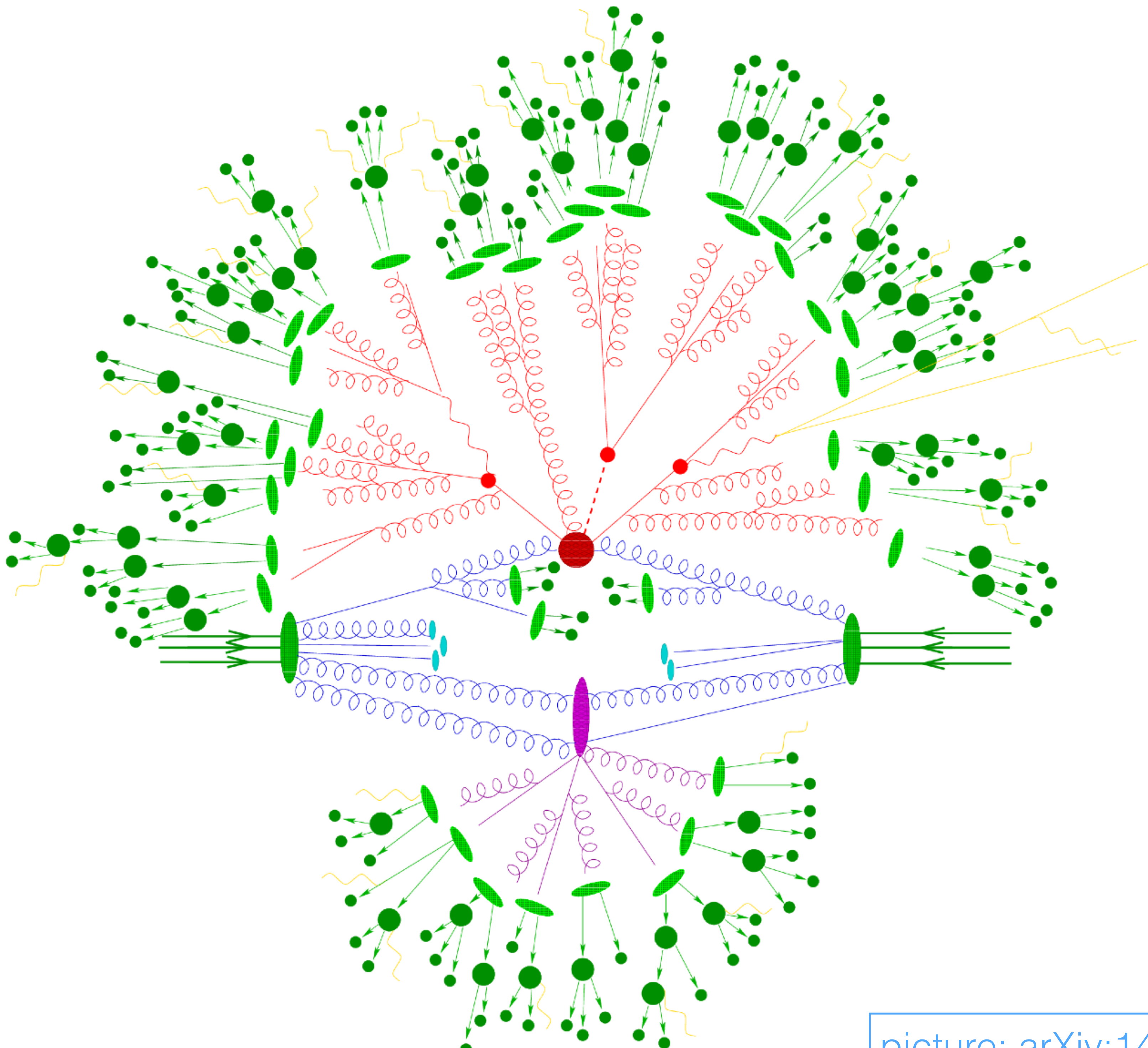
Colour Rearrangement for Dipole Showers

1. Short shower overview
2. Colour assignments
3. Colour Rearrangement
4. Results

Based on arXiv:1801.06113

J. Bellm (Lund U.), DIS18, KOBE, 17.4.2018

How we simulate events?



picture: arXiv:1411.4085

1->2 Showers

Use of 1–>2 splittings in Sudakov basis.

$$q_i = \alpha_i p + \beta_i n + q_{\perp i}$$

Keep track of virtualities.

Apply momentum conservation after shower by reshuffling.

Splitting functions:

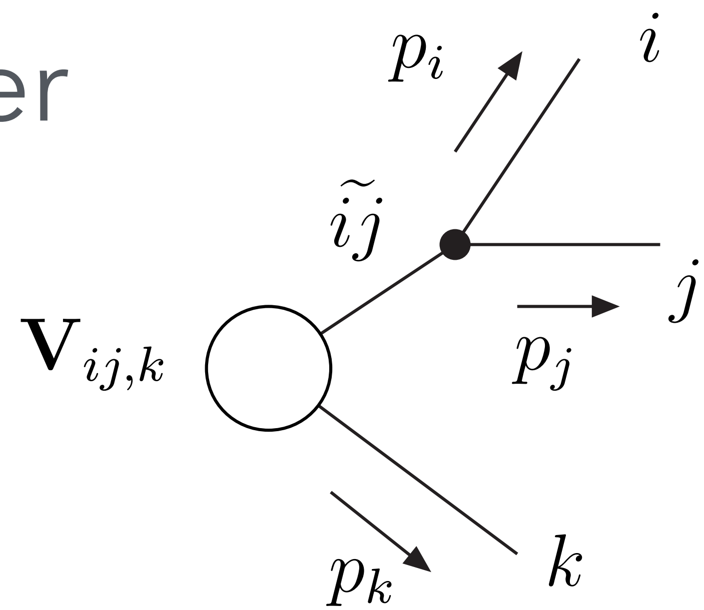
$$P_{q\to qg}(z) = C_F \left(\frac{1+z^2}{1-z}\right)$$

$$P_{g\to gg}(z) = C_A \left(\frac{z}{1-z} + \frac{1-z}{z} + z(1-z)\right)$$

Symmetry factor for final state gluons.

Angular ordering to include coherence effects and not to 'double count' soft pole.

(CS) Dipole Shower



Use 2–>3 to preserve momentum conservation between shower steps.

Each colour line defines partners in large colour limit. E.g. gluon has two colour partners.

Modified splitting functions to remove soft double counting

$$P_{q\to qg}(z) = \frac{\alpha_S}{2\pi} C_F \frac{1+z^2}{1-z}$$

$$\langle \mathbf{V}_{q_i g_j,k}(\tilde{z}_i, y_{ij,k})\rangle = C_{\mathrm{F}} \left\{ \frac{2}{1-\tilde{z}_i+\tilde{z}_i y_{ij,k}} - (1+\tilde{z}_i) \right\}$$

$$\langle \mathbf{V}_{g_i g_j,k}(\tilde{z}_i, y_{ij,k})\rangle = 2C_{\mathrm{A}} \left\{ \frac{1}{1-\tilde{z}_i+\tilde{z}_i y_{ij,k}} + \frac{1}{\tilde{z}_i + y_{ij,k} - \tilde{z}_i y_{ij,k}} - 2 + \tilde{z}_i(1-\tilde{z}_i) \right\}$$

Catani, Seymour arXiv:9605323 | Schumann, Krauss arXiv:0709.1027
Dinsdale, Ternick, Weinzierl arXiv:0709.1026 | Plätzer, Gieseke arXiv:0909.5593

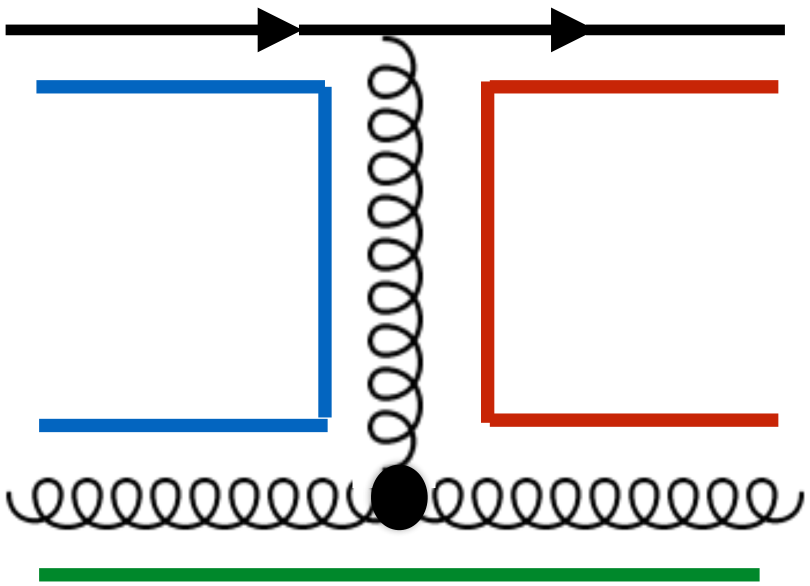
Colour assignment for hard process

Usually:
Assing Dipole chains according to Color-Flow amplitudes,

$$M = \sum_i C_i A_i(p)$$

in leading colour,

$$|C_i^{N_C \to \infty} A_i(p)|^2$$



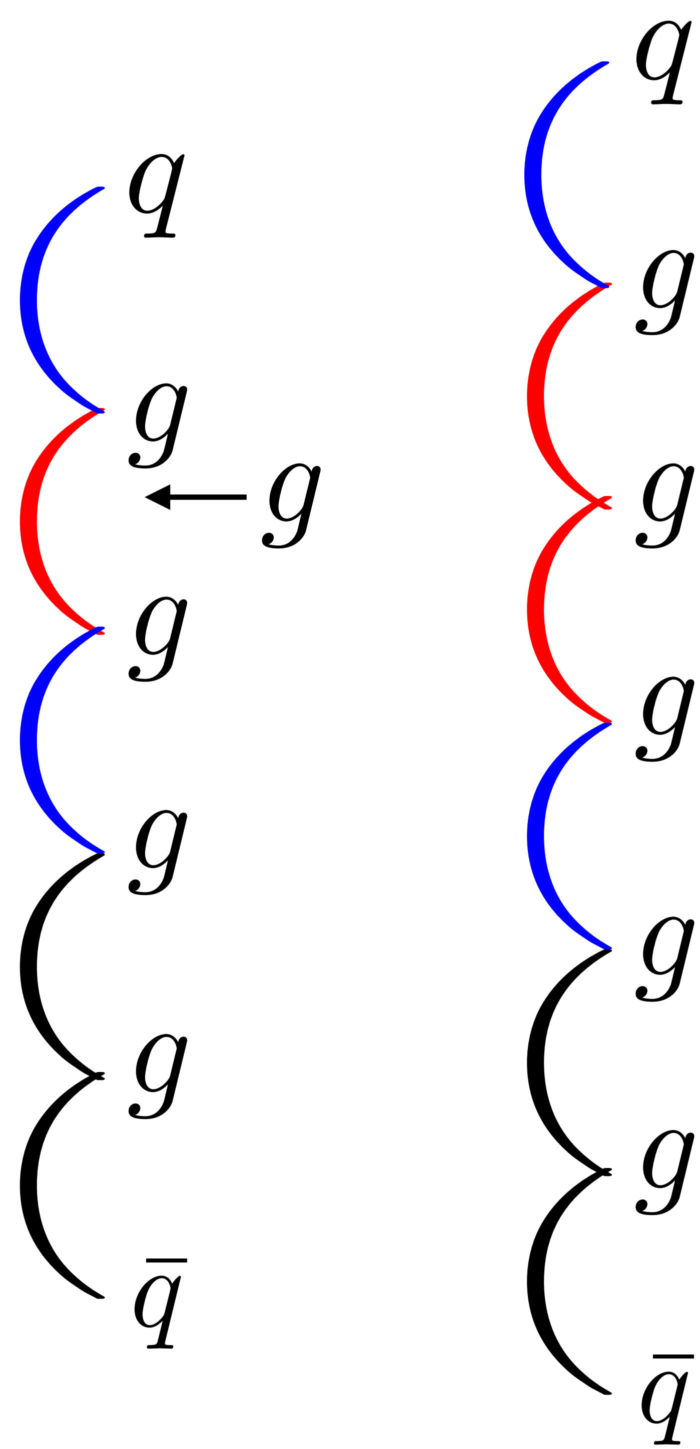
Maltoni et al. Phys.Rev. D67 (2003) 014026

Buckley et al. Phys.Rept. 504 (2011) 145-233

Concepts in dipole showers

Algorithm:

- Assign dipoles to hard process
- define $k_T^2 = 2\tilde{p}_{ij}\tilde{p}_k y z(1-z)$
- Competition algorithm
- (k_T, z, ϕ) defines emission
- After emission is produced, assign new color dipoles
- Allow emissions with $k_{T,n} > k_{T,n+1}$
- Include running coupling and CMW factors to include effects of higher orders

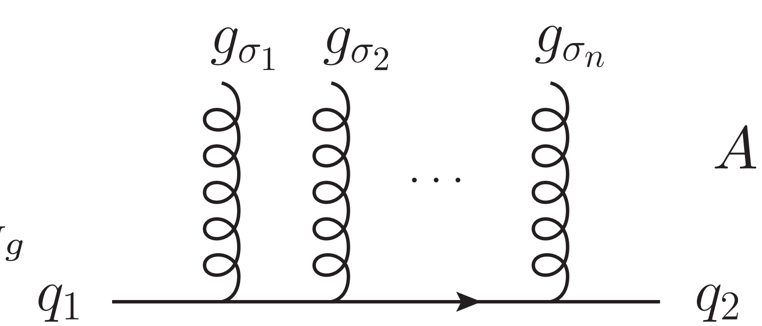


Goals of PS

Describe cross section close to matrix elements and include resummation effects.

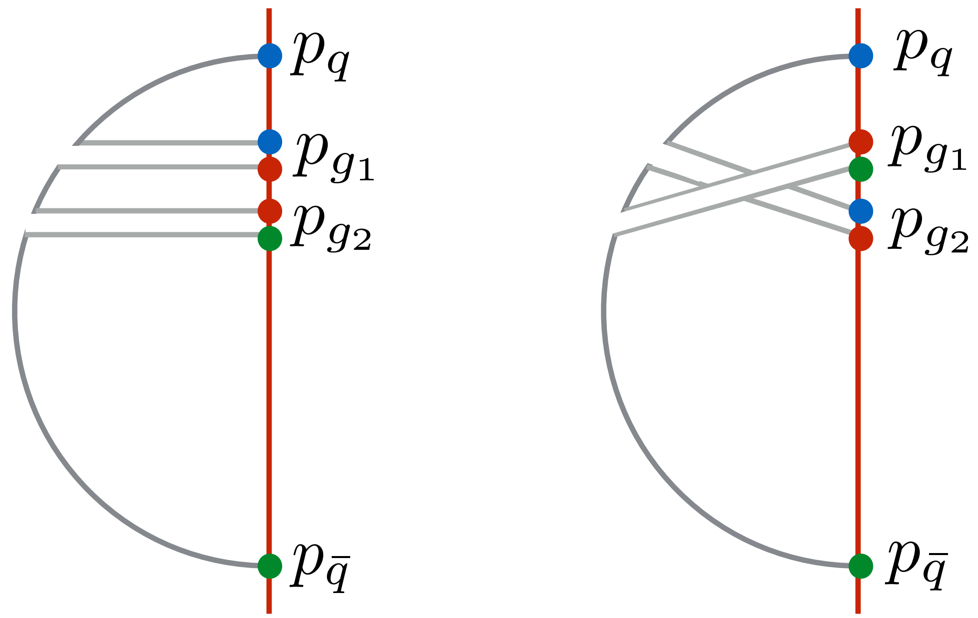
Process with qq+n g :

$$\mathcal{M}(q_1, g_3, \dots, g_n, \overline{q}_2) = \sum_{\sigma \in S_{N_g}} (t^{g_{\sigma_1}} t^{g_{\sigma_2}} \dots t^{g_{\sigma_n}})^{q_1}{}_{q_2} A(\sigma) = \sum_{\sigma \in S_{N_g}}$$



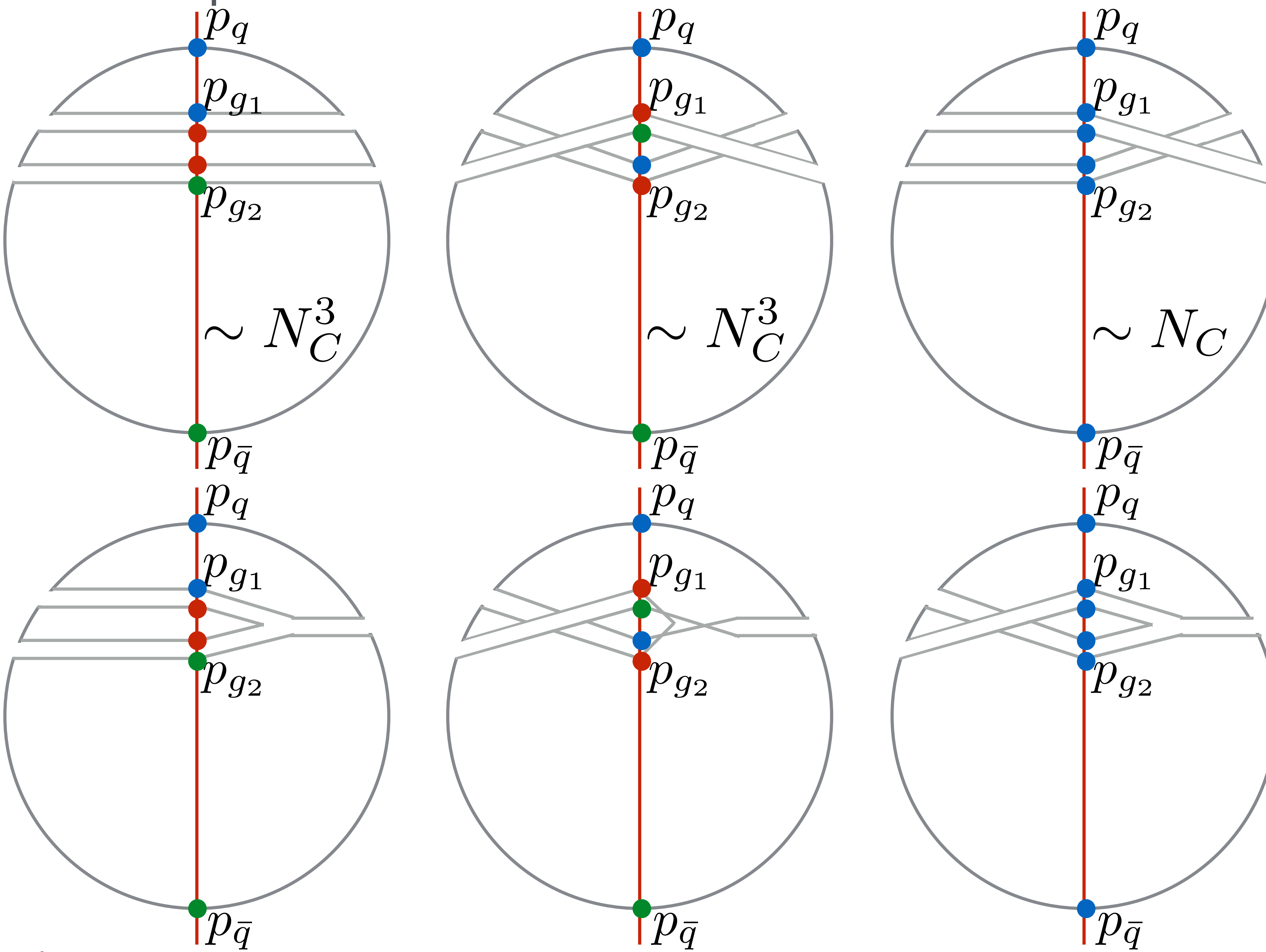
$$A(\sigma)$$

Basic Example:



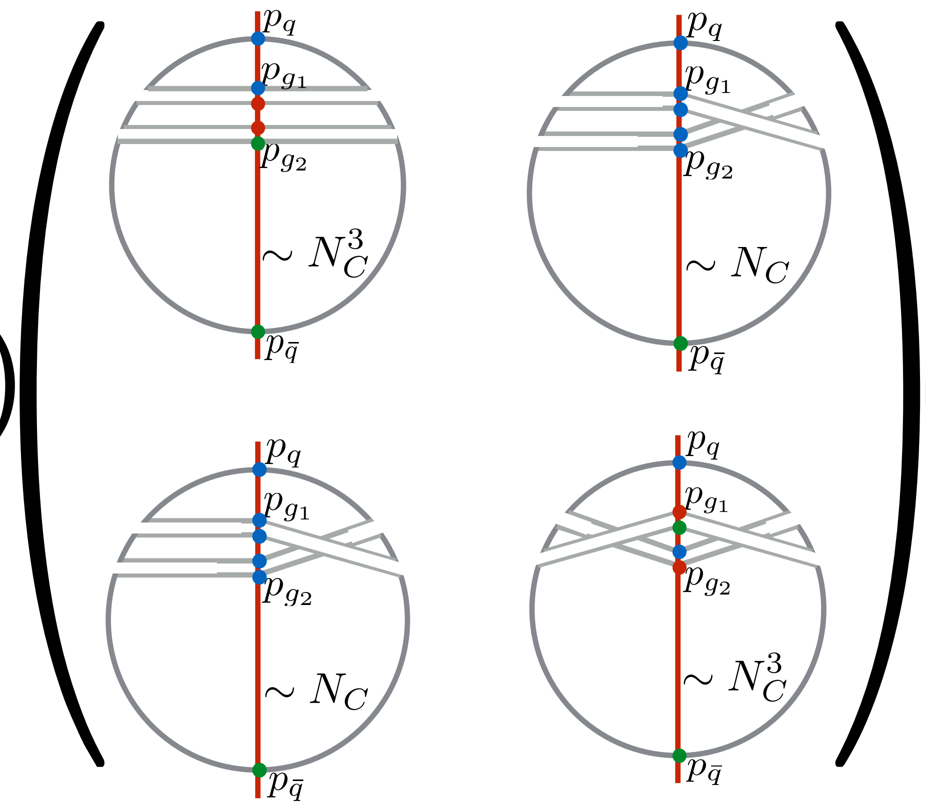
Equations from: M. Sjöldahl arXiv:1412.3967
similar equation in several sources

Pictorial representation



Pictorial representation

$$\begin{pmatrix} A(q,1,2,\bar{q})^* & A(q,2,1,\bar{q})^* \end{pmatrix}$$



$$\begin{pmatrix} A(q,1,2,\bar{q}) \\ A(q,2,1,\bar{q}) \end{pmatrix}$$

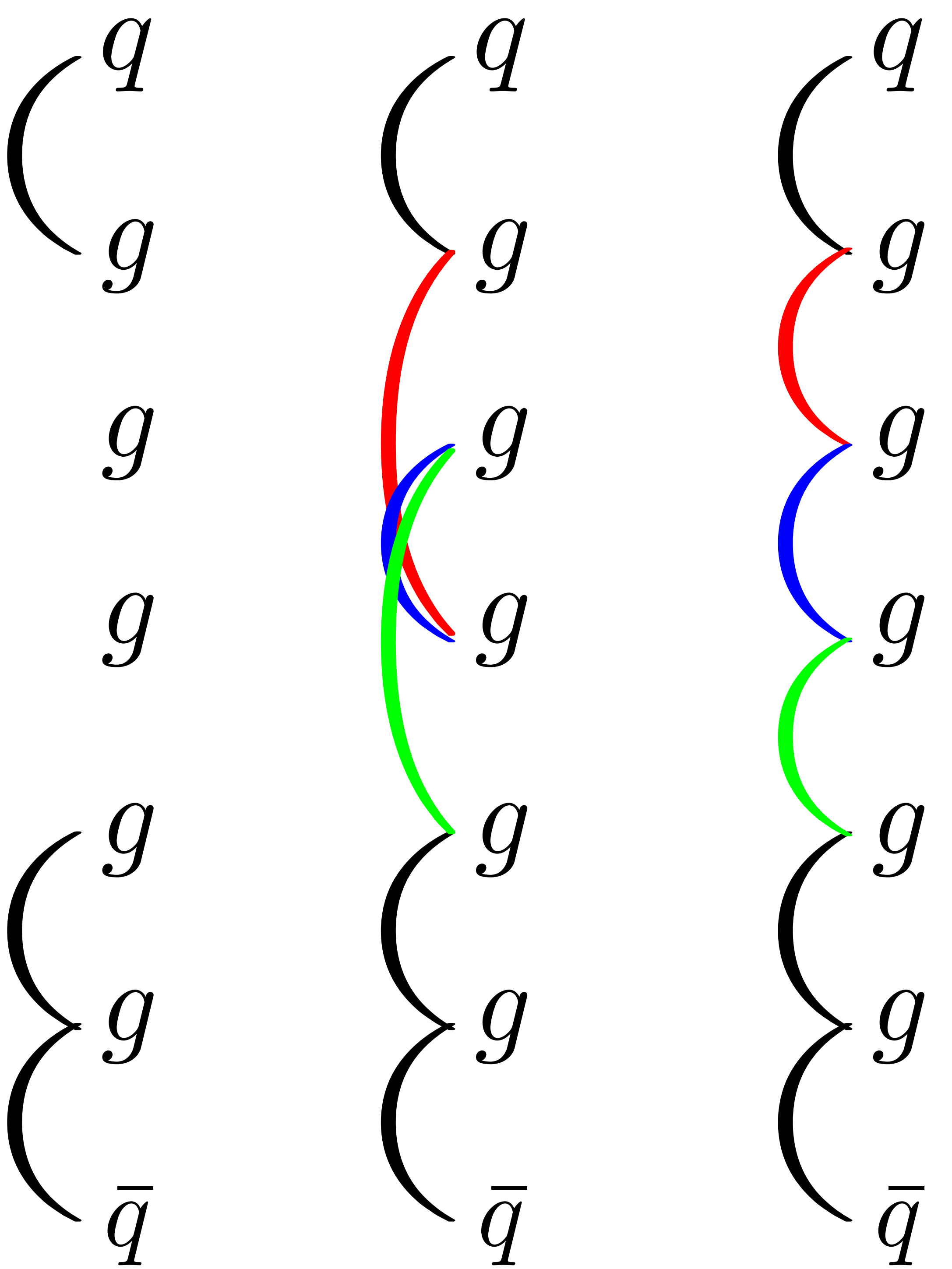
matrix elements

MADGRAPH 5

w1 = jamp2[0] = $A(q,1,2,\bar{q})\,A(q,1,2,\bar{q})^*$

w2 = jamp2[1] = $A(q,2,1,\bar{q})\,A(q,2,1,\bar{q})^*$

Rearranging the Colours



Recoils and angle choices can disorder the dipole chains.

1. Interpret gluons in LCA
2. For all triple dipoles:

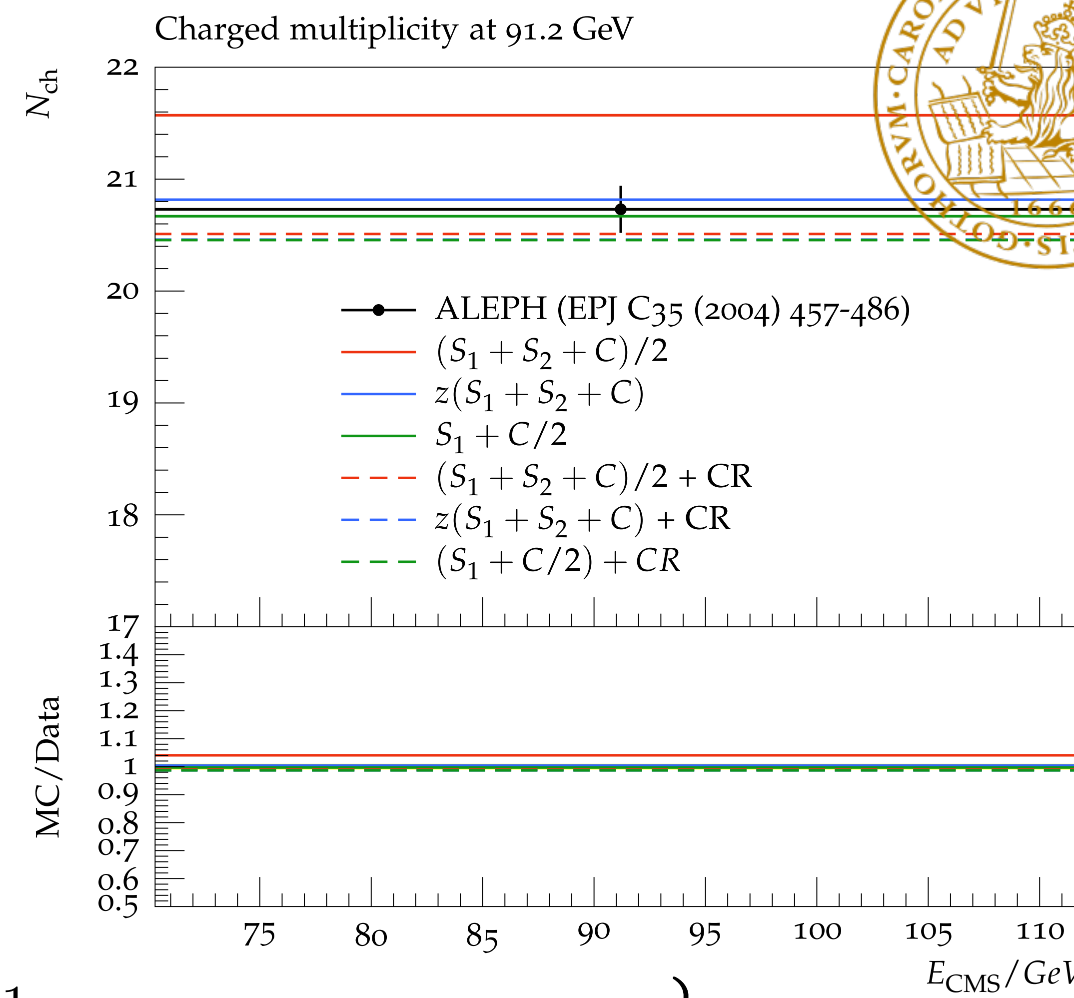
If $\quad \mathcal{R} < \dfrac{w_2}{w_1 + w_2}$

swap gluon momenta.

Independent of input:

$$\left(1 - \frac{w_2}{w_1 + w_2}\right) \cdot a + \left(\frac{w_1}{w_1 + w_2}\right) \cdot (1-a) = \frac{w_1}{w_1 + w_2}$$

Gluon Splitting



In descriptions and in the Herwig dipole shower:

$$\langle \mathbf{V}_{g_i g_j,k}(\tilde{z}_i, y_{ij,k})\rangle = 2C_{\mathrm{A}}\left\{\frac{1}{1-\tilde{z}_i+\tilde{z}_i y_{ij,k}} + \frac{1}{\tilde{z}_i + y_{ij,k} - \tilde{z}_i y_{ij,k}} - 2 + \tilde{z}_i\,(1-\tilde{z}_i)\right\}$$

$$\frac{1}{q_i\cdot q_j}\,\frac{z}{1-z}\bigg|_{n=p_k} = \frac{q_i\cdot p_k}{q_i\cdot q_j\;q_j\cdot p_k} \qquad \frac{1}{q_i\cdot q_j}\,\frac{1-z}{z}\bigg|_{n=p_k} = \frac{q_j\cdot p_k}{q_j\cdot q_i\;q_i\cdot p_k}$$

Symmetric emission and emitter in kinematics and kernel.
Can be and is changed by multiplying the kernel by z or use only (1-z) pole.

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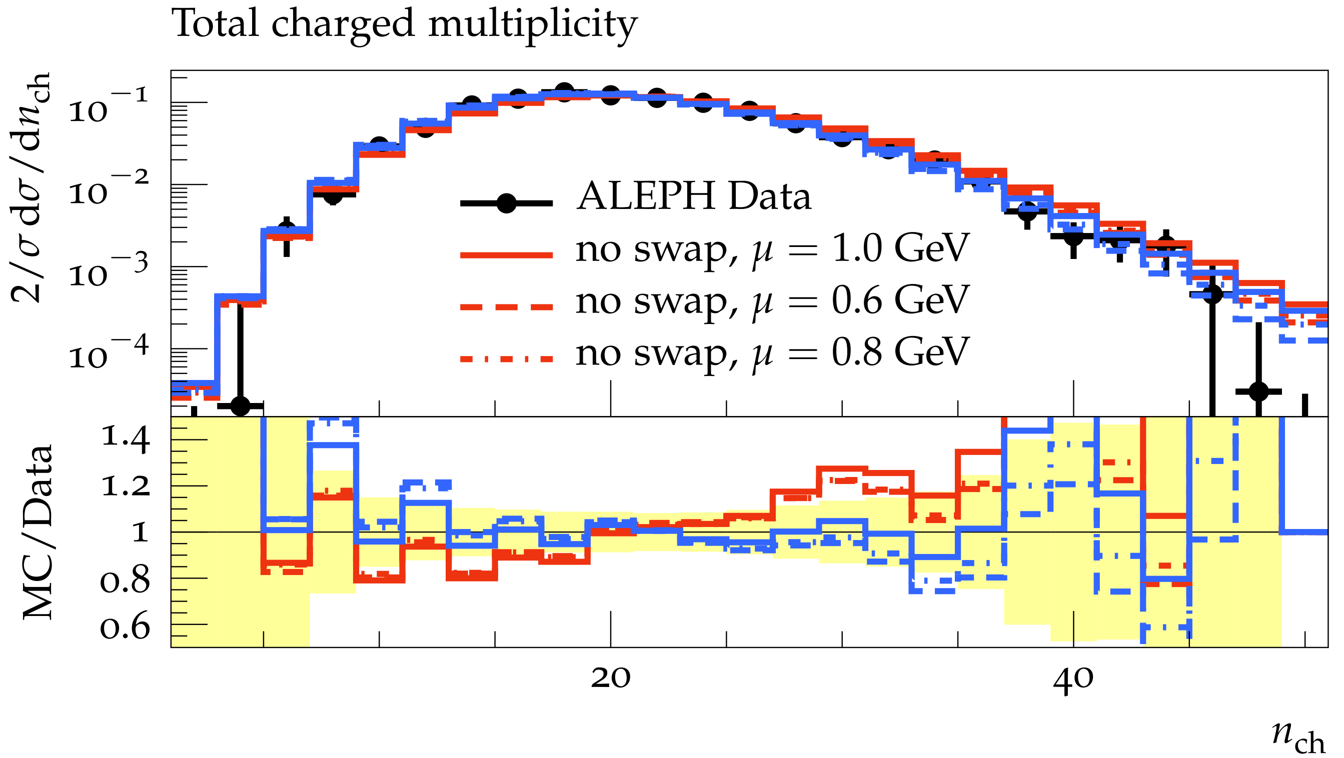
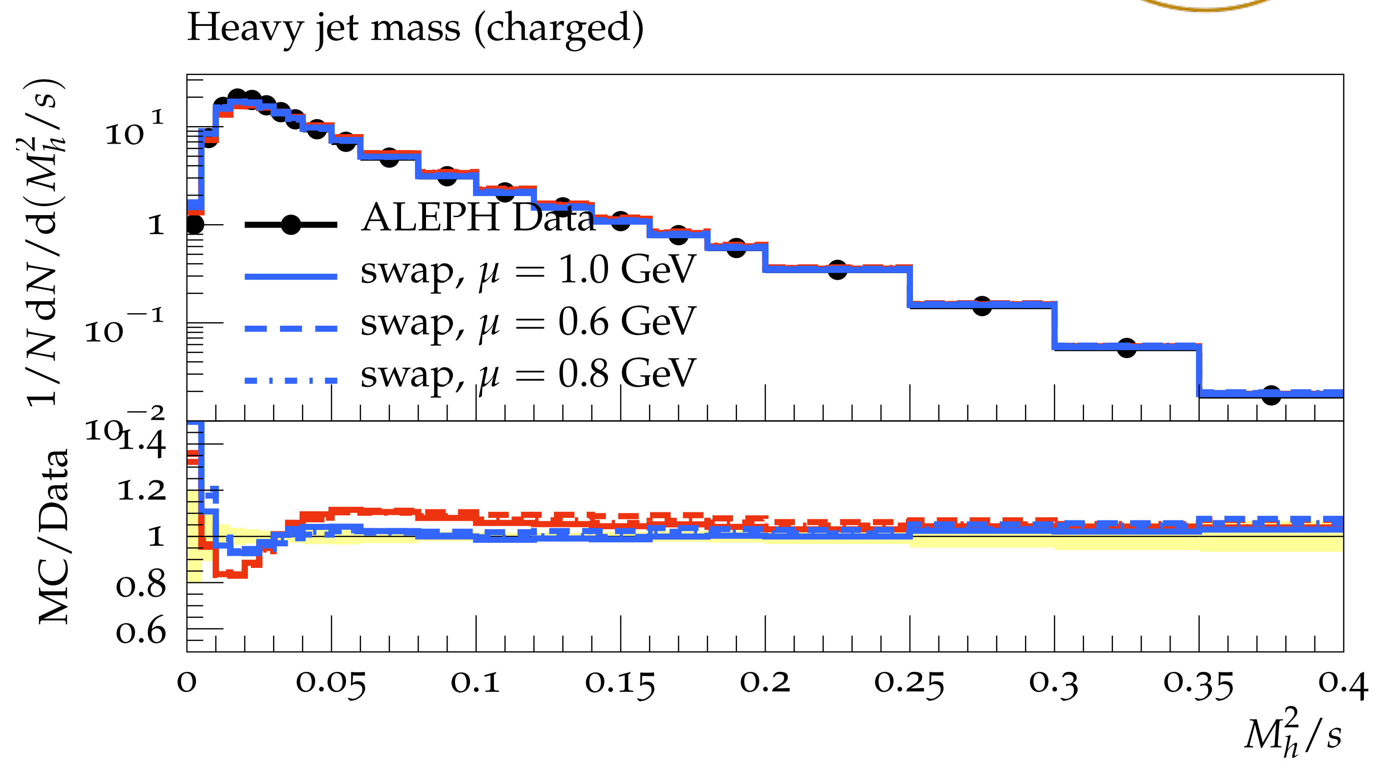
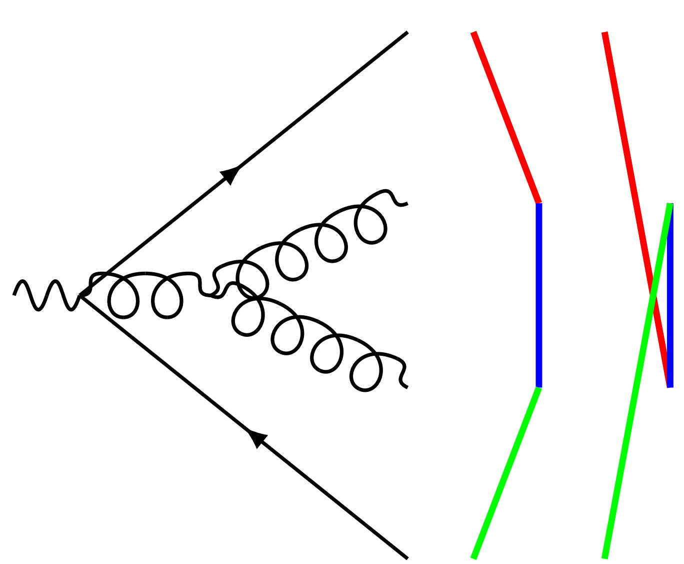




1. Use tune for default shower.
2. CMW scheme
3. Cutoff variation.



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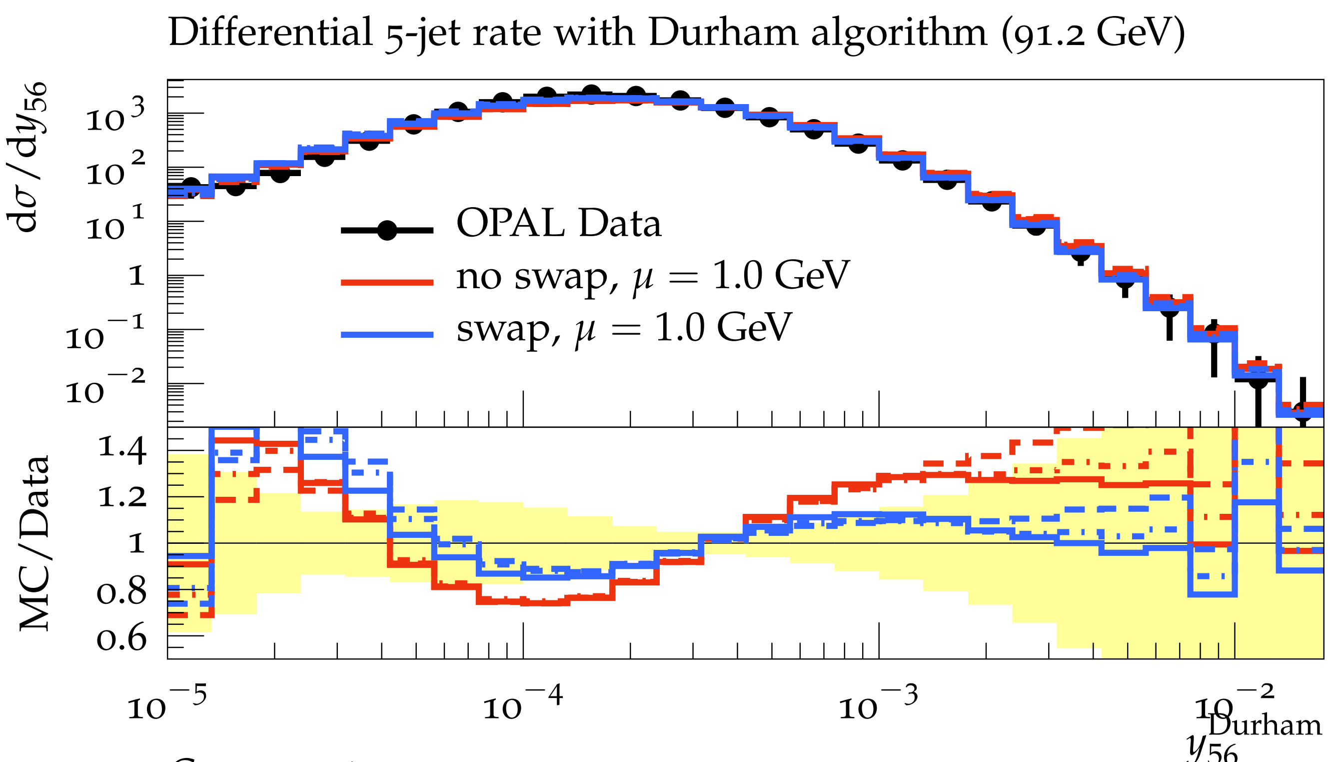
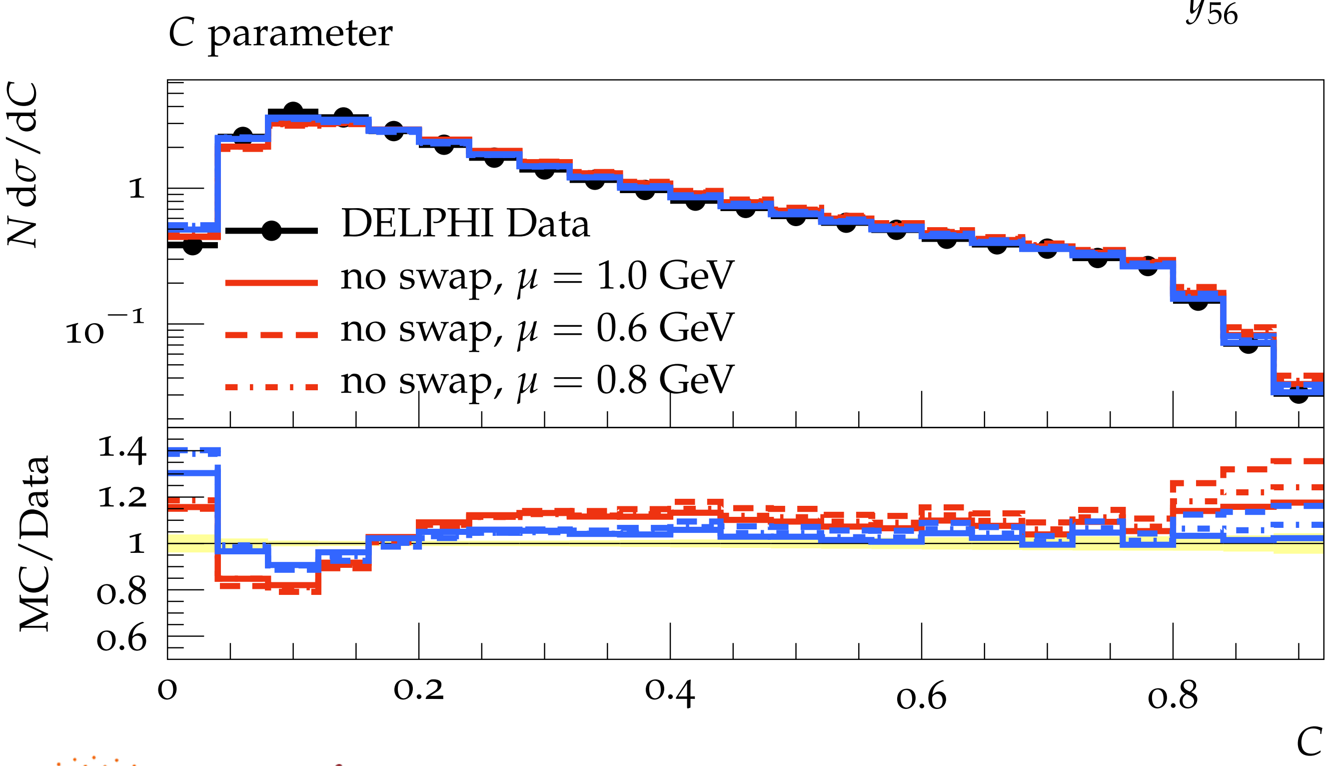
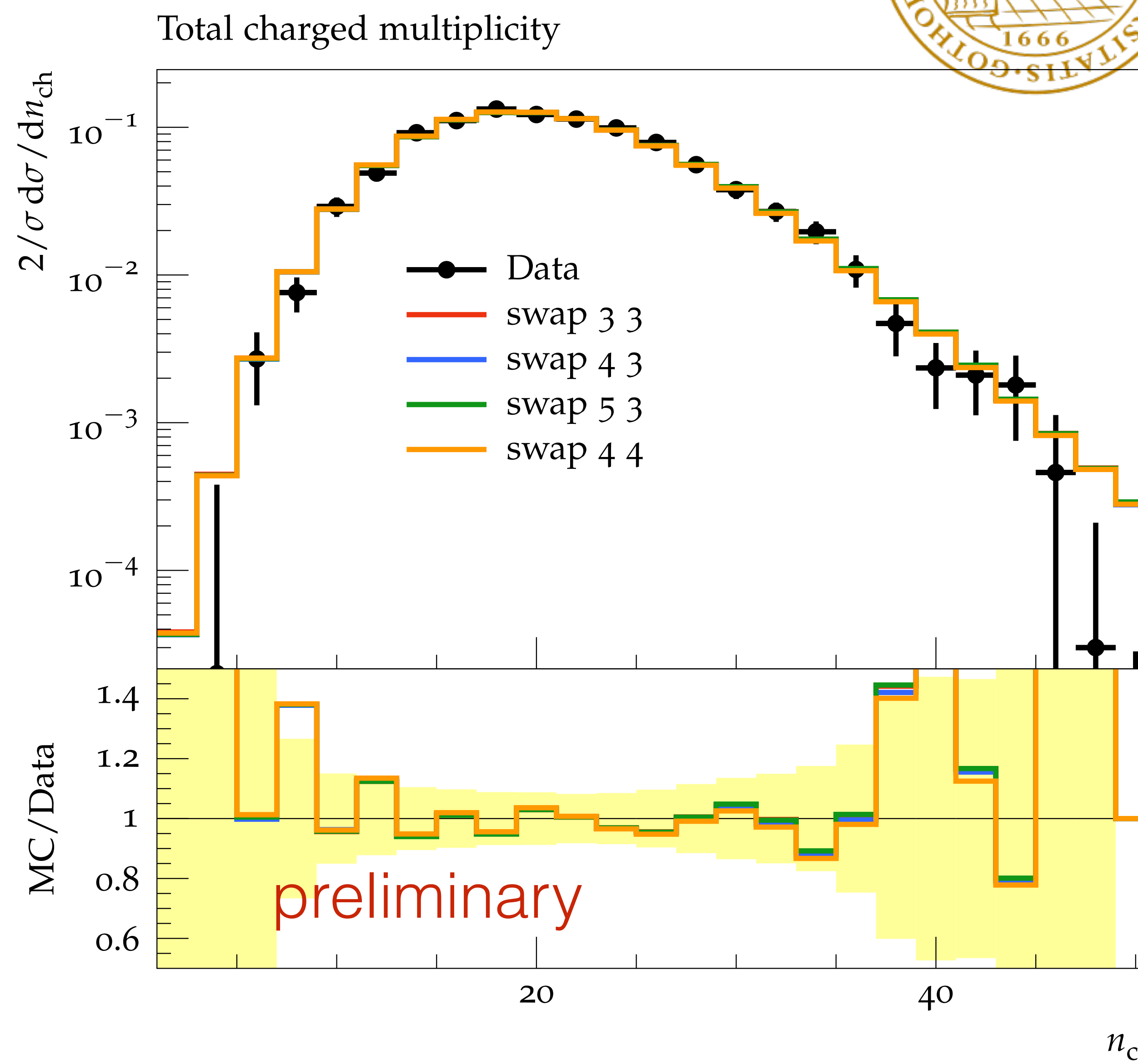
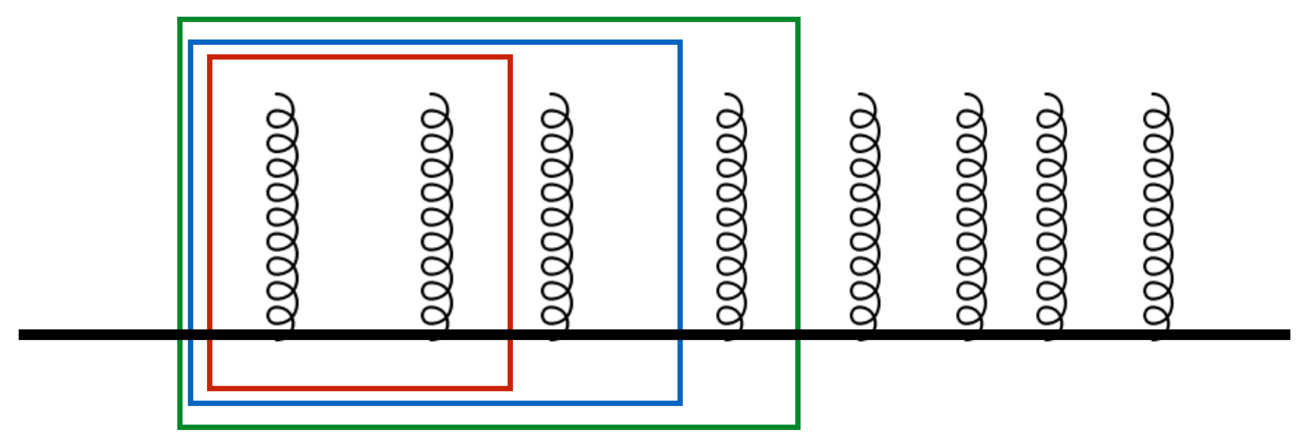


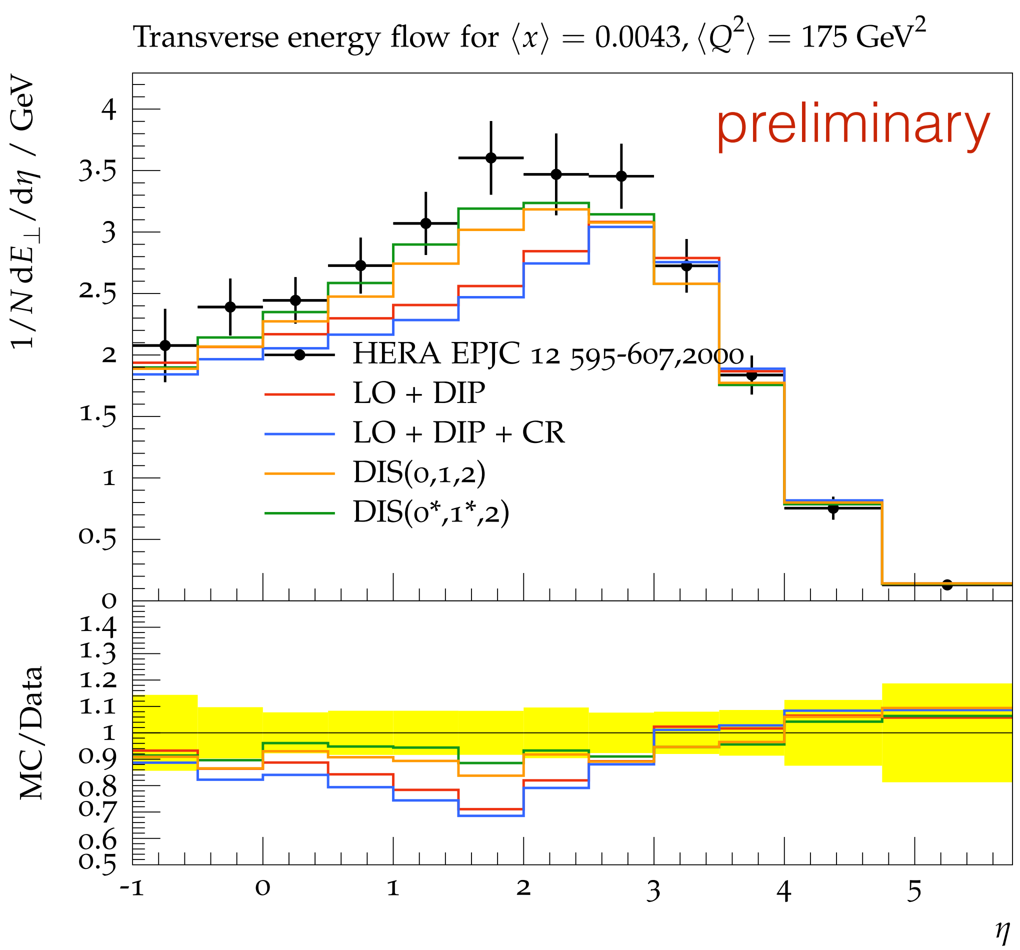


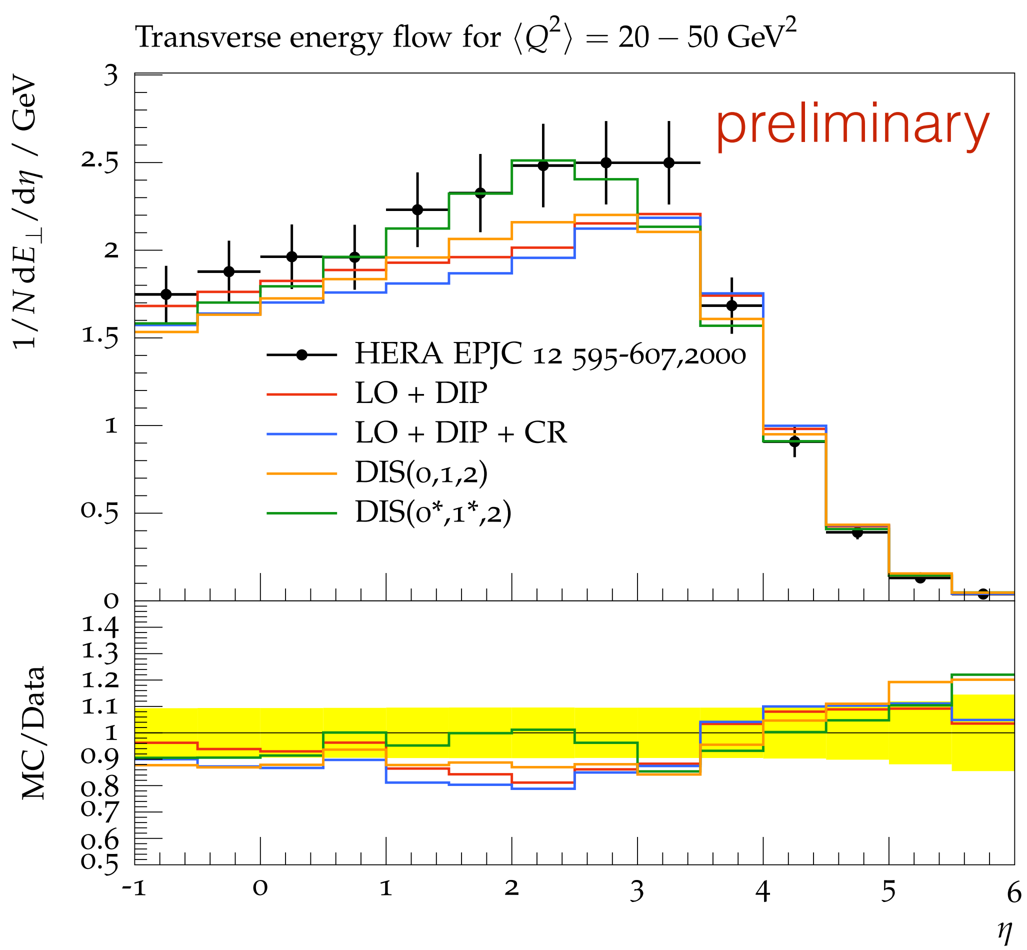




DIS data

Extending the method to process with QCD in initial state is under investigation, but here at least LO or even NLO merging is needed to describe data.





Conclusion

Method to allow rearranging the color chains in dipole showers.

Main effect produced by symmetric emitter emission treatment.

For now only modify color assignment.
One can also ask for rate modifications.

The End

Thank you!