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Recent Developments in Vincia

W. Giele, D.A. Kosower, P. Skands

A. Gehrmann-De Ridder, L. Hartgring, E. Laenen,
A. Larkoski, J.J. Lopez-Villarejo, MR

Overview

introduction

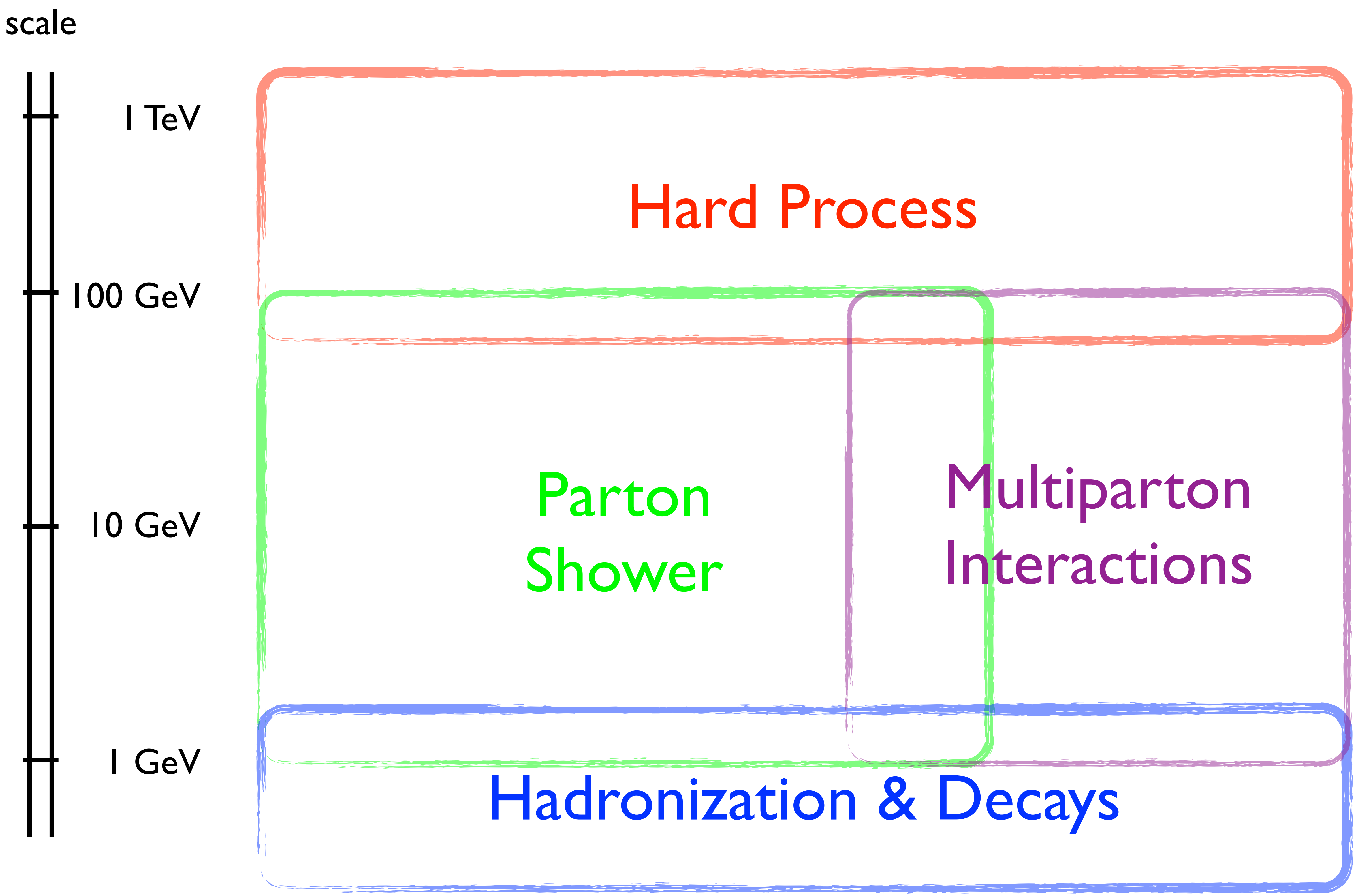
extension of Vincia to hadron collisions

uncertainties

matching

summary and outlook

Event Generators - Cartoon



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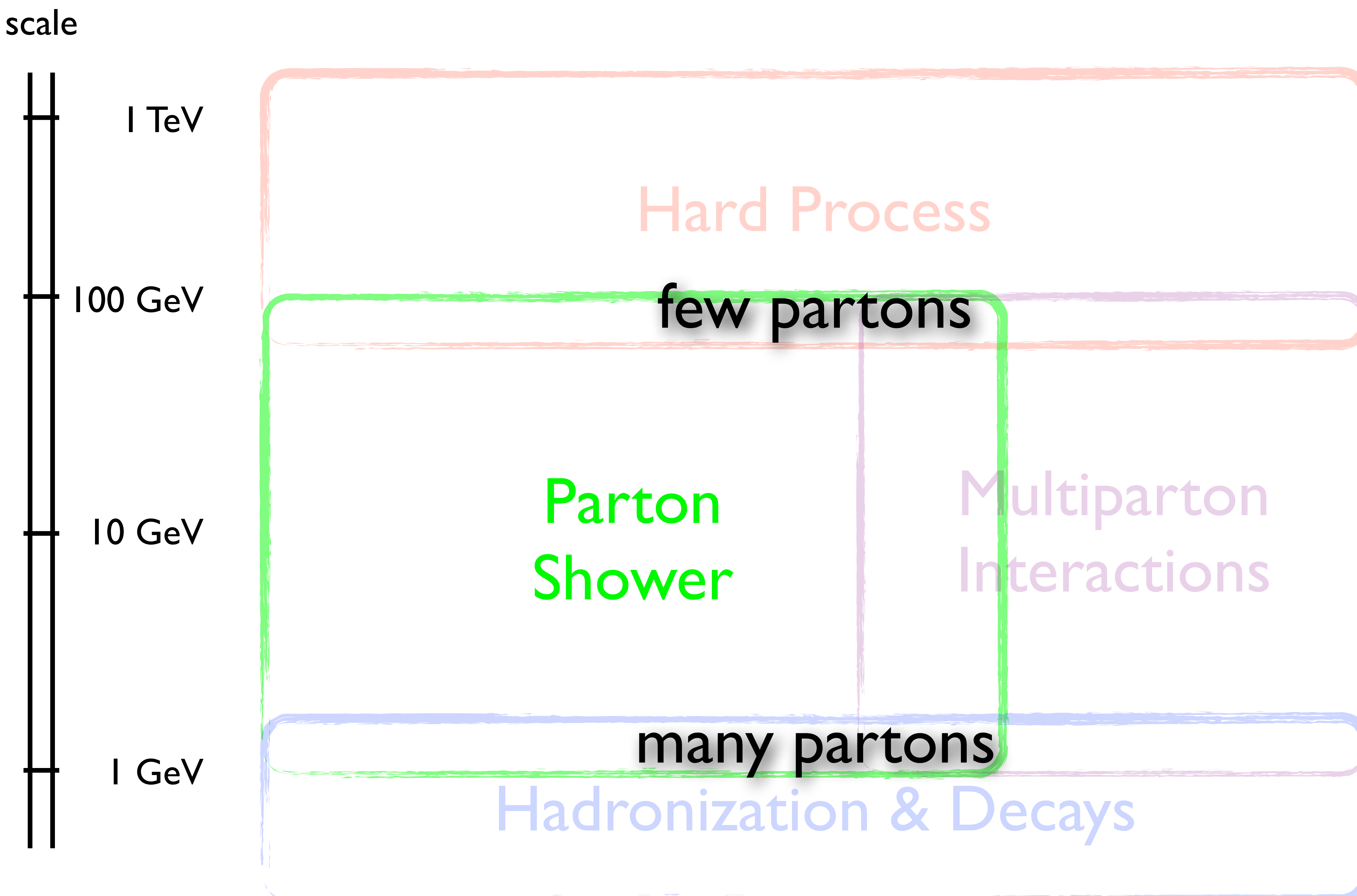

The Vincia Parton Shower

W. Giele, D.A. Kosower, P. Skands
0707.3652, 1102.2126

estimates its uncertainty

facilitates matching to fixed-order

integrates into Pythia 8[1] as a plugin

[1] T. Sjöstrand, S. Mrenna, P. Skands
0710.3820

Formalism

use approximate factorization of matrix element

$$|M_n| \approx \sum_{(ijk)} a(i,j,k) \left|M_{n-1}(\ldots, I, K, \ldots)\right|^2$$

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and exact factorization of phase space

$$\mathrm{d}\Phi_n = \mathrm{d}\Phi_{\mathrm{ant}}\,(i,j,k)\,\mathrm{d}\Phi_{n-1}\,(\ldots,I,K,\ldots)$$

to approximate σ_n from σ_{n-1}

Extension to Hadron Collisions

D.A. Kosower, P. Skands, MR
1210.6345

the **convolution** factorizes, not the phase space

$$\int \frac{\mathrm{d}x_a}{x_a}\frac{\mathrm{d}x_b}{x_b} f_a\left(x_a\right) f_b\left(x_b\right) \mathrm{d}\Phi_{2\to n} =$$

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ratios of parton distribution functions enter the branching probabilities

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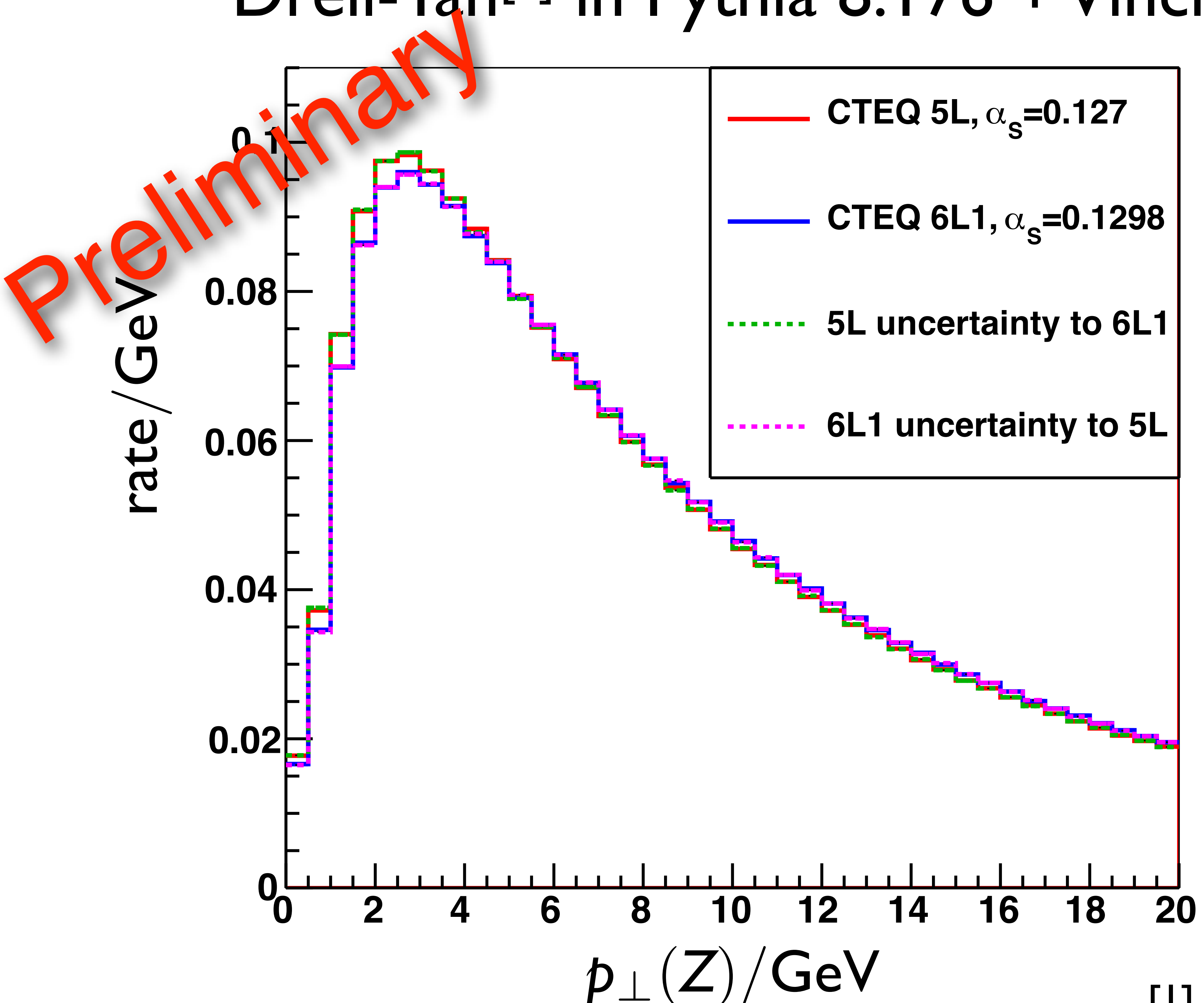
$\Rightarrow$Vincia can generate uncertainty bands

Test of Uncertainty Variations

Drell-Yan[1] in Pythia 8.176 + Vincia



[1] pure parton shower

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Vincia uses a veto algorithm, generating trial branchings according to simple trial antennae

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what the shower would do without matching

Matching

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note: events still unweighted, $P_{\mathrm{ME}} \xrightarrow{\text{unresolved}} 1$

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[1] J.J. Lopez-Villarejo, P. Skands
1109.3608

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sector shower[1]: only one term in denominator

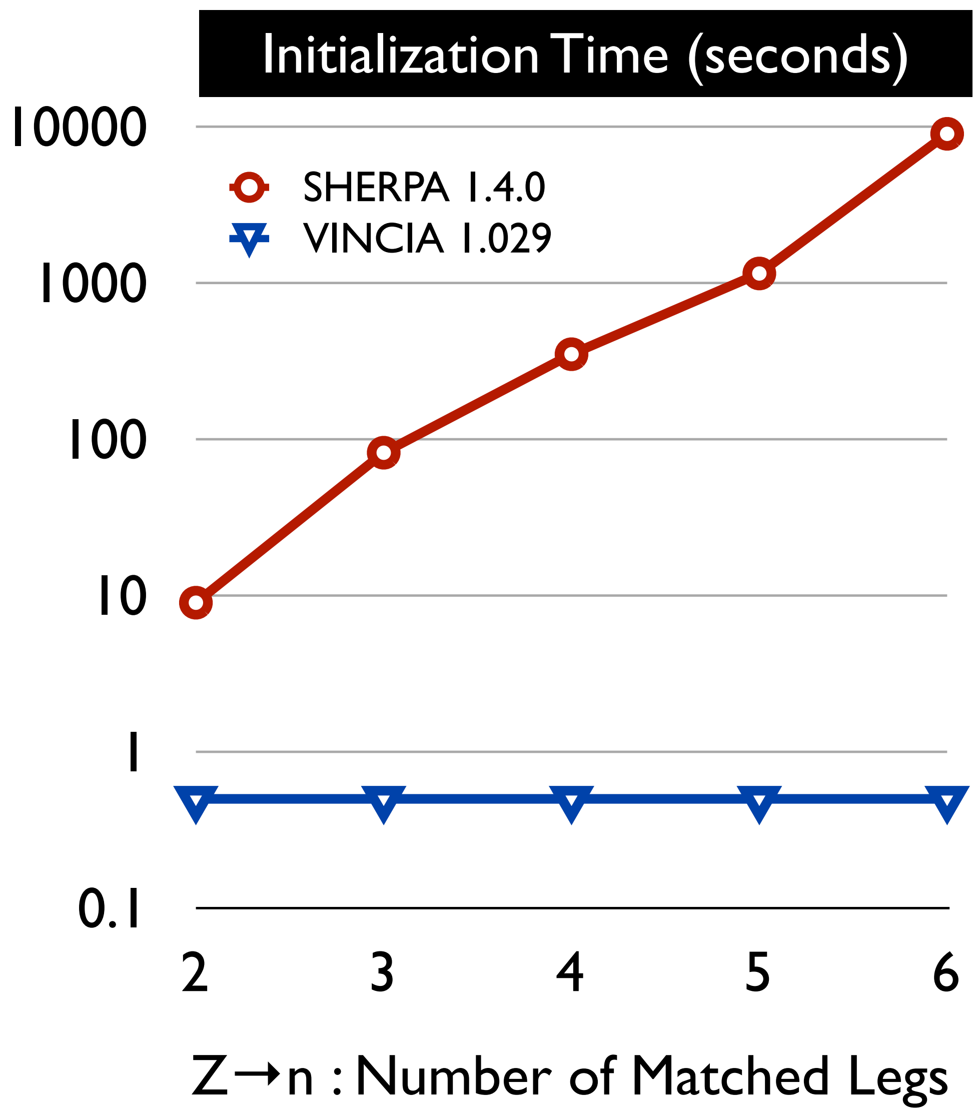
helicity-identified shower[2]: M much cheaper

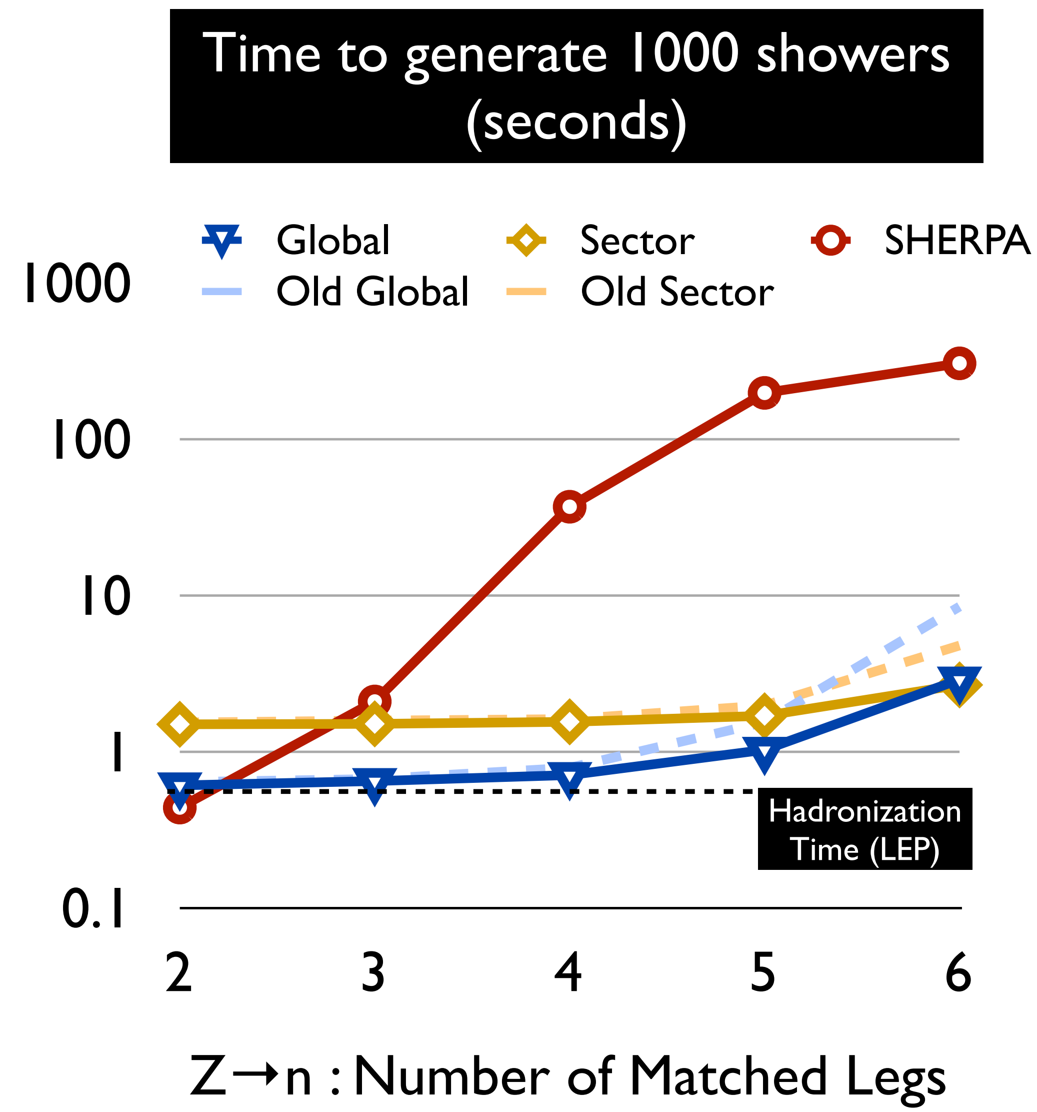
[1] J.J. Lopez-Villarejo, P. Skands
1109.3608

[2] A. Larkoski, J.J. Lopez-Villarejo, P. Skands
1301.0933

Matching

speed of tree-level matching in Z decay





A. Larkoski, J.J. Lopez-Villarejo, P. Skands
1301.0933

One-loop matching

L. Hartgring, E. Laenen, P. Skands
1303.4974

multiplicative matching like at tree-level

events remain unweighted

tree-level matching at higher multiplicities stays

tuning of shower matched to $Z \to 3$ at one loop to event shapes (two-loop running & CMW scheme):

$$\alpha_s^{\mathrm{NLO}}(m_Z) \approx 0.122 \text{ compared to } \alpha_s^{\mathrm{LO}}(m_Z) \approx 0.139$$

Summary and Outlook

Vincia has been extended to hadron collisions

unitary and efficient matching at tree- and one-loop level has been demonstrated for e+ e- collisions

next: matching for hadron collisions

Thanks for your attention

Backup

One-loop matching

L. Hartgring, E. Laenen, P. Skands
1303.4974

analogous to tree-level matching:

$$\text{matched} = (1 + V_3)\,(\text{shower approximation})$$

rate for exactly three resolved partons at Q_{had}:

$$\text{matched} = \left|M_3^0\right|^2 + 2\Re\left(M_3^0 M_3^{1*}\right) + \int_0^{Q^2_{\text{had}}} \frac{d\Phi_4}{d\Phi_3}\left|M_4^0\right|^2$$

$$(\text{s. approx.}) = (1 + V_2)\left|M_3^0\right|^2 \Delta_2\left(m_Z^2, Q_3^2\right)\Delta_3\left(Q_3^2, Q^2_{\text{had}}\right)$$

One-loop matching

L. Hartgring, E. Laenen, P. Skands
1303.4974

$$V_3 = -V_2 + \frac{2\Re\left(M_3^0 M_3^{1*}\right)}{\left|M_3^0\right|^2}$$

$$+ \int_{Q_3^2}^{m_2^2} \mathrm{d}\Phi_{\mathrm{ant}} a\left(2 \to 3\right) + \sum_{3\to4} \int_0^{m_3^2} \mathrm{d}\Phi_{\mathrm{ant}} a\left(3 \to 4\right)$$

$$+ \int_0^{Q_{\mathrm{had}}^2} \frac{\mathrm{d}\Phi_4}{\mathrm{d}\Phi_3} \frac{\left|M_4^0\right|^2}{\left|M_3^0\right|^2} - \sum_{3\to4} \int_0^{Q_{\mathrm{had}}^2} \mathrm{d}\Phi_{\mathrm{ant}} a\left(3 \to 4\right)$$

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shower is matched at tree-level

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integral over 3→4 antennae has two pieces:

$$\sum_{3\to 4} \int_0^{m_3^2} \mathrm{d}\Phi_{\text{ant}} \left[a^{\text{std}}\left(3 \to 4\right) + \delta a\left(3 \to 4\right)\right]$$

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universal, divergent, integrated analytically

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process-dependent, finite, integrated numerically