Theoretical predictions for four jet production at next-to-leading order accuracy in QCD

Motivation

Leading-order calculations in perturbative QCD suffer from large scale uncertainties, for reliable predictions at least next-to-leading order (NLO) results required

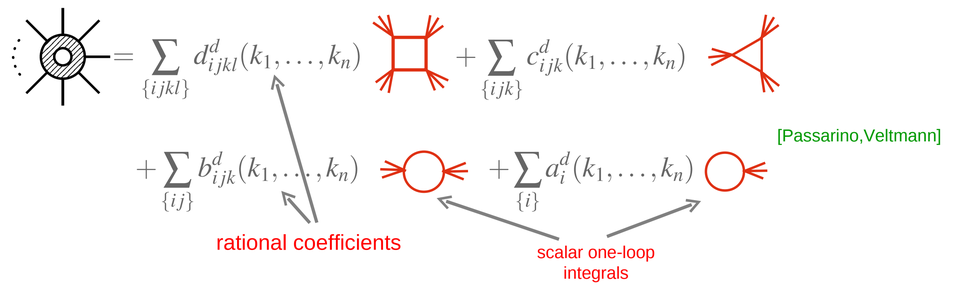
Four jet production in hadronic collisions important:

- Important test ground for perturbative QCD
- Important input for α_s and PDF measurements
- Background for many signal reactions
- Important for New Physics searches with high p_t jets

Methods

Feynman diagramatic approach problematic due to large number of diagrams (O(1000))

Alternative: Use unitarity method recently developed [Badger, Bern, Ellis, Dixon, Giele, Kosower, Kunszt, Melnikov, Ossola, Papadopoulos, Pittau, Zanderighi]



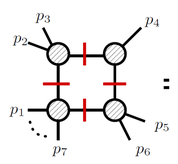
Important Observation:

- All scalar one-loop integrals known
- Coefficents can be reconstructed using tree-level amplitudes

Some Details

- Rational coefficients are calculated studying multiple cuts, e.g.:

$$d^4_{ijkl} \leftrightarrow$$

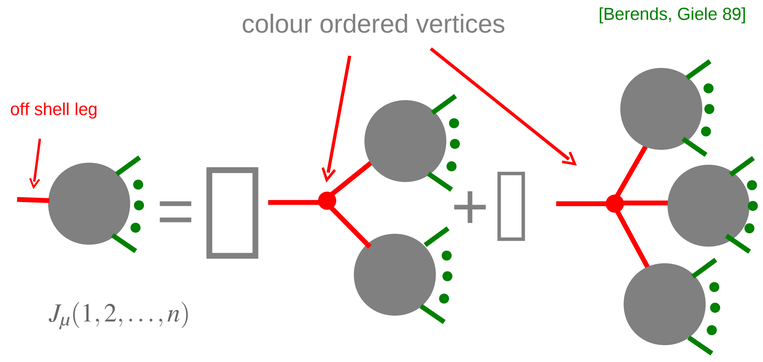


$$= A_{\text{tree}}(-\ell_1, p_2, p_3, \ell_2) \times A_{\text{tree}}(-\ell_2, p_4, \ell_3)$$
$$\times A_{\text{tree}}(-\ell_3, p_5, p_6, \ell_4) \times A_{\text{tree}}(-\ell_4, p_7, \ldots, p_1, \ell_1)$$

➡ One-loop amplitudes are computed from tree-level amplitudes

Efficient evaluation of Born amplitudes using recursions:

[Berends, Giele 89]



$$A(k_1,\varepsilon_1,\ldots,k_{n+1},\varepsilon_{n+1}) = A(1,2,\ldots,n+1) = \varepsilon^\mu(k_{n+1}) J_\mu(1,\ldots,n)$$

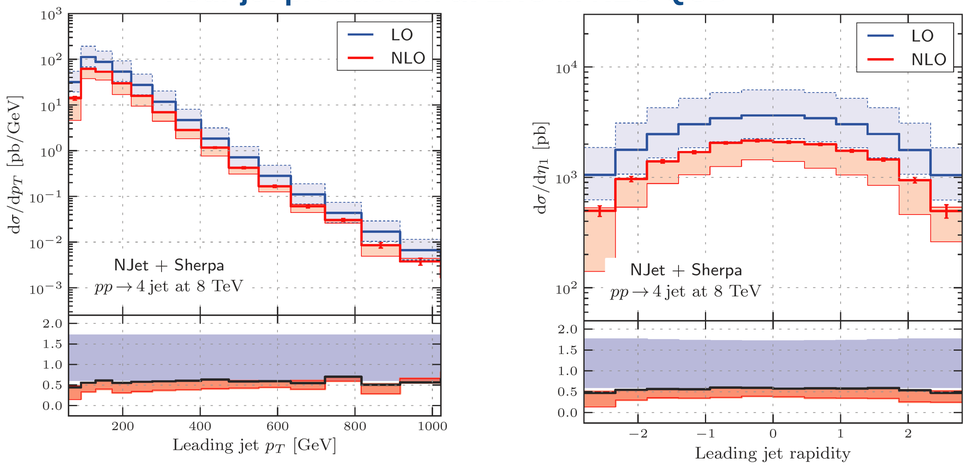
Achieved milestones:

- Automatic evaluation of Born amplitudes
- One-loop (colour ordered) amplitudes in pure gauge theory [1]
- Extension to massless quarks [2,4,5]
- First phenomenological application to LHC physics [6]

Parton multiplicity only restricted through numerical accuracy and computing time

Recent Results

Four jet production at LHC in NLO QCD



- Large (~50%) negative corrections
- Improved scale dependence
- Dynamical scale $\mu = H_t$ leads to almost const. K-factor

Important findings:

- Full agreement with existing results for 7TeV
- Detailed study of differential distributions at 8TeV
- Origin of large negative corrections well understood → recipe to model NLO results using predictions in Born approximation
- Important contributions due to gq channel
- Rapidity ratios perturbatively very stable → useful observable to validate experimental analysis
- Developed tools are made publicly available, can be used in experimental analysis and for further theoretical studies

Outlook:

- Everything available for the evaluation of five jet production at NLO accuracy
- Extend approach to include also massive quarks and weak gauge bosons
- Detailed study of leading colour approximation vs full colour
- Additional phenomenological applications
- Further improvements of numerical performance

Publications

[1] "NGluon: *A Package to Calculate One-loop Multi-gluon Amplitudes*", S. Badger, B. Biedermann, P. Uwer, Comput.Phys.Commun. 182 (2011) 1674-1692

[2] "*Numerical Evaluation of One-Loop QCD Amplitudes*", S. Badger, B. Biedermann, P. Uwer, J.Phys.Conf.Ser. 368 (2012) 012055,

[3] "*Comparing efficient computation methods for massless QCD tree amplitudes: Closed Analytic Formulae versus Berends-Giele Recursion*", S. Badger, B. Biedermann, L. Hackl, J. Plefka, T. Schuster, P. Uwer, arXiv:1206.2381, submitted to PRD

[4] "*One-Loop Amplitudes for Multi-Jet Production at Hadron Colliders*", S. Badger, B. Biedermann, P. Uwer, arXiv:1201.1187

[5] "*Numerical evaluation of virtual corrections to multi-jet production in massless QCD*", S.Badger, B. Biedermann, P. Uwer, V.Yundin, arXiv:1209.0100, submitted to CPC

[6] "*NLO QCD corrections to multi-jet production at the LHC with a centre-of-mass energy of sqr(s)=8 TeV*", S. Badger, B. Biedermann, P. Uwer, V. Yundin, arXiv:1209.0000, to appear in PLB

- Bitte beim Ausschneiden von Grafiken aus PDF's Files auf ausreichende Auflösung achten (600 dpi, kann im acroreader eingestellt werden
- Die Punke Selected Talks, Collaborations, Profit from the Gk dienen nur als Anregung
- Weitere denkbare Punkte könnten sein
  - Engagement in the GK
  - Further scientific Activities
- Das Poster soll als Diskussiongrundlage dienen, es muß also nicht selbst erklärend sein

Selected Talks

- "*Numerical evaluation of one-loop QCD ar*
  Workshop on Advanced Computing and A
  2011, Sept. 2011, London
- "Numerical evaluation of massless QCD s
  loop order", Max Planck Institut, Munich, J
- "*Numerical evaluation of one-loop QCD ar*
  workshop,2011
- "*One-loop amplitudes with generalised un*
  , 2011
- "*One-loop amplitudes with generalised unitarity*", LHCPhenonet kick off meeting, Valencia, February 2011

group, HU Berlin)
ut, Copenhagen)

school
d international schools
Contact to experimental colleagues within the GK

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PhD Advisors: Prof. Peter Uwer (HU) / Prof. Jan Plefka (HU)

WWW: http://www.physik.hu-berlin/pep/tools/njet
https://bitbucket.org/njet/njet

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