LHCphenOnet

in Poland

Members

- U. of Silesia **Katowice** and IFJ-PAN **Cracow**

Staff: K. Kołodziej, T. Jeliński, JG, S. Jadach, M. Skrzypek, A. van Hameren

- Phd students: M. Gunia, M. Ochman, R. Szafron, B.Dziewit, K. Bielas
- ESR: V. Yundin (Russia)

  R. Sevillano (Spain)
- ER: Ievgen Dubovyk (Ukraine), from October 2012

We are working within the following milestones

M1.4: On-shell NLO Amplitudes (WP1: Precision)

M2.3 and M2.4: BSM particles and decays (WP2: Discovery)

M3.4: Resummation vs. exact higher orders (WP3: Support to experiments)

M4.1: Multi-loop onshell recursions,

M4.2: Computer algebra (WP4: Technology innovations)

Cooperation within EU network

- DESY-Zeuthen (S.-O. Moch, T.Riemann)
- Saclay, Paris (D. Kosower)
- INB, Copenhagen (V.Yundin)
- Internal cooperation with Jagellonian U. - (W. Płaczek)
- Bielefeld U. (J. Fleischer)
- Humboldt U. Berlin (F. Jegerlehner)
- U. Wuppertal, RWTH Aachen (M.Czakon, M. Worek)

Talks

1. Kick-off meeting of the LHCPhenoNet InitialTraining Network":

BSM-GUT particles at LHC – J.G.,

One loop tensor reduction program PJFRY – V. Yundin
(also at Les Houches 2011: Physics at TeV Colliders)

2. Durham LHCPhenoNet annual meeting: R. Sevillano, R.Szafron

3. "Loops and Legs in Quantum Field Theory",
11th DESY Workshop on Elementary Particle Theory
Wernigerode, Germany, April 2012

"Computational tools for scattering amplitudes at LO and NLO QCD" – A. van Hameren
"NLO parton shower for LHC physics -- hard process and beyond" - S. Jadach
(also at Workshop: "Event Generators and Resummation" June 2012, DESY Hamburg)

Talks, Conferences

- ***Matter to the deepest*: Recent developments in physics of fundamental interactions**.
  33st International Conference of theoretical physics, Ustron, Poland, September 5-11, 2011
- Many participants from the LHCPhenoNet network

Ustroń 2011

- 3 sessions within the LHC mini Workshop

talks by:

M. Czakon, M. Worek, C. Sachrajda,
J. Kalinowski, D. Kosower, G.Ossola,
A. van Hameren, J. Fleischer,
B.Kayser, M. Skrzypek, S.-O. Moch,
J. Wudka, A. Kord

Guests

- Simon Badger (NBI, Copenhagen), 16-22 May 2011: lectures on “An Introduction To On-Shell Methods”
- Fred Jegerlehner (HU, Berlin), 20-26.2011: lectures on QCD
- J. Fleischer, T.Riemann, 6-9.6.2011, 10.2012

PhD training

- CAPP 2011 (Computer Algebra for Particle Physics": DESY-Zeuthen, March 2011, Ochman, Szafron,
- V. Yundin, visits at DESY: March, April 2011, visit at Saclay, February 2011
- R. Sevillano-Borkowski – his report (e.g. attended some of PhD courses in Katowice, LHCPhenoNet schools)
- Risc Gmbh interships: Ochman, Sevillano

Main publications

LPN11-89
HELAC-NLO
by G. Bevilacqua, M. Czakon, M.V. Garzelli, A. van Hameren, A. Kardos, C.G. Papadopoulos, R. Pittau, M. Worek, arxiv: 1110.1499

LPN12-044
Left-right symmetry at LHC and precise 1-loop low energy data
by J. Chakrabortty, J. Gluza, R. Sevillano (ESR), R. Szafron, arxiv: 1204.0736

LPN12-013
New developments in CARLOMAT, K. Kolodziej
arxiv: 1204.5099

LPN11-06
One-Loop Helicity Amplitudes for ttbar Production at Hadron Colliders
by S. Badger, R. Sattler, V. Yundin (ESR)
arxiv: 1101.5947

Scientific Activity

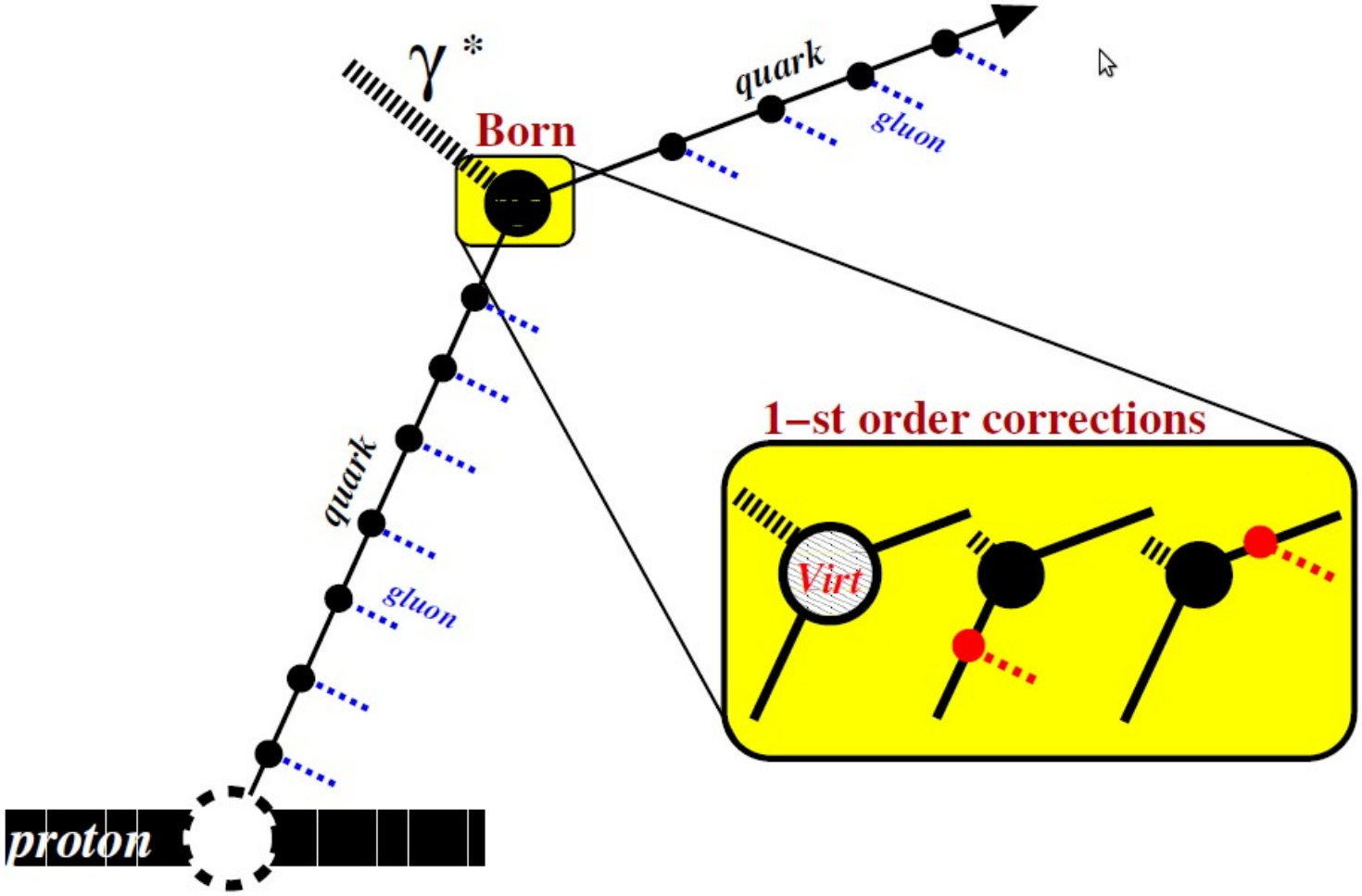
S.Jadach, M. Skrzypek, W. Płaczek,

A.Kusina, M.Sławińska

NLO MC activity in Krakow IFJPAN

- **R&D on the NLO MC parton shower** is pursued in Cracow since 2006. It features ladders of NLO kernels in the fully unintegrated/exclusive MC form. (arxiv.org/abs/1102.5083)
- **New method of NLO-correcting HARD process is part of the project (2011).** (arxiv.org/abs/1103.5015)
- **NLO-correcting LADDER parts advancing steadily – fresh progress reported here!**
- **Long term: NLO ladders + NNLO hard process:)**
- The whole project is still at the "feasibility study" stage:((

KRKMC method of NLO correcting HARD process



Summary on KRKMC project

- Parton shower MC implementing complete NLO in the hard process and in the ladders is shown to be feasible.
- Long term: NLO ladder + NNLO hard process, but (LO ladder + NLO hard proc. to be optimized first!!!)
- Most likely application: high quality QCD+EW+QED MC with hard process like $W/Z/H$ boson production.
- Potential gains from new QCD methods are:
  – reducing uncertainties due to distributions of partons in hadrons (PDFs, parton luminosities etc.)
  – easier implementation of NLO and NNLO corrections to hard process due to elimination of "trivial" (albeit numerically sizeable) soft gluon corrections
  – better environment for low x resummation (BFKL, CCFM) and heavy quark masses.

Andreas van Hameren

RWTH AACHEN UNIVERSITY

Institute of Nuclear Physics "Demokritos" | Bergische Universitat Wuppertal | Institute of Nuclear Physics PAN | RWTH Aachen University

HELAC-NLO & Associated Tools

Projects

HELAC-PHEGAS - A generator for all parton level processes in the Standard Model

HELAC-DIPOLES - Dipole formalism for the arbitrary helicity eigenstates of the external partons

HELAC-1LOOP - A program for numerical evaluation of QCD virtual corrections to scattering amplitudes

ONELOOP - A program for the evaluation of one-loop scalar functions

CUTTOOLS - A program implementing the OPP reduction method to compute one-loop amplitudes

PARNI - A program for importance sampling and density estimation

KALEU - A general-purpose parton-level phase space generator

:: top ::

People

Helac–NLO

http://helac–phegas.web.cern.ch/helac–phegas/

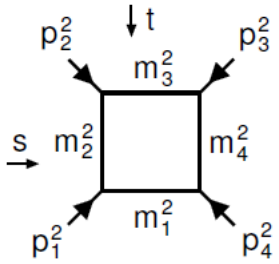
For the calculation of hard scattering processes at NLO QCD

$$\hat{\sigma}^{\rm NLO}_{a,b\to n} = \int d\Phi_n \, 2\Re\left(\mathcal{M}^{(0)}_{a,b\to n}\,\mathcal{M}^{(1)}_{a,b\to n}\right)\mathcal{O}^{\rm LO}_n + \int d\Phi_{n+1}\,\left|\mathcal{M}^{(0)}_{a,b\to n+1}\right|^2\mathcal{O}^{\rm NLO}_{n+1}$$

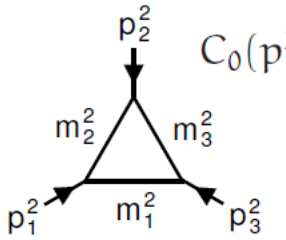
- based on automatic LO platform HELAC/PHEGAS Cafarella,Kanaki,Papadopoulos,Worek
- real-radiation with dipole-subtraction HELAC-DIPOLES Czakon,Papadopoulos,Worek
- OPP reduction with CUTTOOLS Ossola,Papadopoulos,Pittau
- scalar integrals with ONELOOP van Hameren
- rational contribution Draggiotis,Garzelli,Malamos,Papadopoulos,Pittau
- phase space integration with KALEU van Hameren
- so far, produced full differential distributions for
  - $pp \to t\bar{t}\,b\bar{b}$ Bevilacqua,Czakon,Papadopoulos,Pittau,Worek
  - $pp \to t\bar{t} + 2j$ Bevilacqua,Czakon,Papadopoulos,Worek
  - $pp \to W^+W^-b\bar{b} \to 4\ell\,b\bar{b}$ Bevilacqua,Czakon,van Hameren,Papadopoulos,Worek
  - $pp \to t\bar{t}\,t\bar{t}$ Bevilacqua,Worek
- used in combination with POWHEG BOX (Alioli,Nason,Oleari,Re) for $2 \to 3$ processes at NLO combined with parton shower
  - $pp \to t\bar{t} + j$ Kardos,Papadopoulos,Trocsanyi
  - $pp \to t\bar{t} + Z$ Kardos,Garzelli,Papadopoulos,Trocsanyi

OneLOop

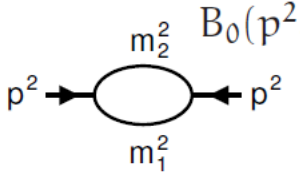
A. van Hameren



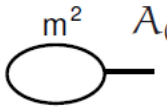
$$D_0(p_1^2, p_2^2, p_3^2, p_4^2, s, t, m_1^2, m_2^2, m_3^2, m_4^2; \mu, \varepsilon)$$



$$C_0(p_1^2, p_2^2, p_3^2, m_1^2, m_2^2, m_3^2; \mu, \varepsilon)$$



$$B_0(p^2, m_1^2, m_2^2; \mu, \varepsilon)$$



$$A_0(m^2; \mu, \varepsilon)$$

$$f(\varepsilon) = \frac{f^{(2)}}{\varepsilon^2} + \frac{f^{(1)}}{\varepsilon} + f^{(0)} + \mathcal{O}(\varepsilon)$$

- all IR and UV divergent cases within dimensional regularization
- all kinematical configurations relevant for collider physics
- any internal squared masses with positive real and negative imaginary part
- also supplies the Passarino-Veltman functions B_1, B_{00} and B_{11}
- any intrinsic precision supplied by compiler
- arbitrary precision with any of `mpfun90`, `arprec`, `dd`, `qd`

Scattering amplitudes for high–energy factorization

A. van Hameren
in collaboration with
P. Kotko and K. Kutak

High-energy, or k_T, factorization [Gribov, Levin, Ryskin 1983, Catani, Ciafaloni, Hautmann 1991] involves k_T-dependent pdfs, and requires scattering amplitudes with off-shell initial-state partons, *eg.*

$$\sigma_{h_1,h_2\to QQ} = \int d^2k_{1\perp}\,\frac{dx_1}{x_1}\,\mathcal{F}(x_1,k_{1\perp})\,d^2k_{2\perp}\,\frac{dx_2}{x_2}\,\mathcal{F}(x_2,k_{1\perp})\,\hat{\sigma}_{gg}\left(\frac{m^2}{x_1x_2s},\frac{k_{1\perp}}{m},\frac{k_{2\perp}}{m}\right)$$

- *unintegrated pdf* $\mathcal{F}$ may satisfy BFKL-eqn, CCFM-eqn, BK-eqn...
- typically associated with small-x physics
- relevant for forward physics, saturation physics, heavy-ion physics...
- $k_\perp$ gives a handle on the size of the proton
- it is known how to construct the necessary gauge invariant matrix elements with off-shell gluons Lipatov 1995, Antonov, Lipatov, Kuraev,Cherednikov 2005

An alternative approach to calculate amplitudes for $g^*\,g \to n\,g$ has been formulated van Hameren, Kotko, Kutak 2012.
General approach for $g^*\,g^* \to$ anything, including a Monte Carlo program, is under development.

Karol Kołodziej

carlomat

New developments in carlomat, a multipurpose program dedicated in particular for automatic computation of the lowest order cross sections of multiparticle reactions, with the maximum number of 12 particles.

- Generation of the phase space integration routines has been improved.
- Some extensions of the SM have been implemented.
- Many other improvements, as e.g., size reduction of the colour matrix, have been done.
- Some minor bugs have been corrected.

Extensions of SM implemented in `carlomat`

- Scalar electrodynamics $\Rightarrow$ description of the low energy processes involving $\pi^{\pm}$.
- Anomalous Wtb coupling $\Rightarrow$ description of the new physics effects in the top quark interactions.

The anomalous Wtb coupling does not explain the forward-backward asymmetry in the top quark pair production observed at the Tevatron.

New version of the program will be released, hopefully soon.

- Mbtools
- http://projects.hepforge.org/mbtools/

Improvements under way with ER: Ievgen Dubovyk

- Home
- Downloads
- Mailing list
- Tracker
- Wiki

MB Tools

This project is a collection of tools devoted to the evaluation of Mellin-Barnes integrals.

The project has been started by Michael Czakon; currently the web-page is also being updated by Alexander Smirnov.

The project is at the development stage, so expect more codes to appear here.

Currently the following codes can be downloaded:

- **MB.m** : version 1.2 of MB (last updated January 2nd, 2009) by Michal Czakon,
  the main collection of routines for the resolution of singularities and the numerical evaluation of Mellin-Barnes integrals;
  for details see hep-ph/0511200;
  the current version is documented in the **Manual** ;
  the distribution contains two example notebooks, MBexamples1.nb and MBexamples2.nb;
- **MBasymptotics.m** : a routine which expands Mellin-Barnes integrals in a small parameter by Michal Czakon;
  example usage is illustrated in MBasymptotics.nb;
- **MBresolve.m** : a tool by Alexander Smirnov and Vladimir Smirnov realizing another strategy of resolving singularities of Mellin-Barnes integrals. This code should be loaded together with **MB.m** since it uses some of its routines. For details see arXiv:0901.0386
- **AMBRE.m** : a tool by Janusz Gluza, Krzysztof Kajda and Tord Riemann for constructing Mellin-Barnes representations. It works both for planar multiloop scalar and one-loop tensor Feynman integrals. This is version 1.2, for previous versions and detailed description of the package with examples see the **home page** . The program is described in arXiv:0704.2423 and Computer Physics Communications 177 (2007) 879.
- **barnesroutines.m** : a tool by David Kosower for automatic application of the first and second Barnes lemmas on lists of multiple Mellin-Barnes integrals. An example notebook is included.

ESR: Radomir Sevillano

Left-right symmetry at LHC and precise 1-loop low energy data
J. Chakrabortty, J. Gluza, R. Sevillano, R. Szafron, JHEP 2012

Muon decay restricts space of LR parameters (e.g. Heavy Higgs scalar masses > 15 TeV):
large influence on LHC discovery signals

(positive signals still not excluded, heavy gauge bosons and heavy neutrinos at a few TeV region)

Remark:

"Delta F = 2 observables and B -> Xq gamma decays in the Left-Right Model: Higgs particles striking back"

Monika Blanke, Andrzej J. Buras, Katrin Gemmler, Tillmann Heidsieck
JHEP 1203 (2012) 024

NLO tensor reductions

contracts.cc, a new package for the tensor reduction of one-loop 5-point, 6-point and 7-point tensor integrals - continuation of the work made by V.Yundin (PJFRY)

- Based on improvements by J.Fleischer and Tord Riemann (co-supervisor of R.Sevillano)

ESR: Valery Yundin

During his stay in Katowice

1. he started collaboration with S.Badger and made a publication in PRD: “One-Loop Helicity Amplitudes for ttbar Production at Hadron Colliders”

2. prepared his package PJFRY for NLO calculations

3. Finished PhD thesis.

Still in contact, two common projects underway.

Next year

September 2013 in Poland:

1. LHCPhenoNet school

2. ***Matter to the deepest: Recent developments in physics of fundamental interactions***.

Summary

Our local groups are stimulated through the LHCPhenoNet network activities (PhD traininigs, workshops, conferences, collaborations)

We hope for further close and fruitful cooperation with EU scientists and commercial partners within the LHCPhenoNet network.