Theory Summary of the SM and NLO Multi-leg WG

Roberto Pittau

Departamento de Física Teórica y del Cosmos
Universidad de Granada

Les Houches June 17th 2009

Theory Summary of the SM and NLO Multi-leg WG

Roberto Pittau

Departamento de Física Teórica y del Cosmos
Universidad de Granada

Les Houches June 17th 2009

- Theorists talking to Experimentalists

Theory Summary of the SM and NLO Multi-leg WG

Roberto Pittau

Departamento de Física Teórica y del Cosmos
Universidad de Granada

Les Houches June 17th 2009

- Theorists talking to Experimentalists
- Theorists talking to Theorists

Theory Summary of the SM and NLO Multi-leg WG

Roberto Pittau

Departamento de Física Teórica y del Cosmos
Universidad de Granada

Les Houches June 17th 2009

- Theorists talking to Experimentalists
- Theorists talking to Theorists
- Standardization

The Subgroups

- Observables
- Higgs phenomenology
- New HO ((N)NLO) calculations/wish list
- NLO techniques/Standardization/automation
- NLO+parton shower *(jointly with the MC group)*

Theoretical Calculations (N)NLO

- $W/Zb\bar{b}$ (Laura Reina)
- $VBFNLO$ (Dieter Zeppenfeld)
- ZZj (Nikolas Kauer)
- $t\bar{t}H$, ttj, Wj (NLO+EW) $\cdots$ (Stefan Dittmaier)
- $W + 3j$, BlackHat+Sherpa (Darren Forde)
- $W + 3j$, MCFM+ROCKET (Giulia Zanderighi)
- $t\bar{t}b\bar{b}$ (Stefano Pozzorini)
- $gg \to H$ QCD-EW (Radja Boughezal)
- $H \to WW/ZZ \to 4f$ $\mathcal{O}(\alpha)$ and $\mathcal{O}(\alpha_s)$ (Marcus Weber)
- $H \to WW \to ll\nu\nu$ at NNLO (Guenther Dissertori)
- $X + n\,j$ matching BFKL with exact results (Jeppe Andersen)

Some issues that have been discussed

- Jet veto reduces the K factor $\Rightarrow$ it is important to perform detailed studies with NLO codes (e.g. $Wb\bar{b}$ in the WH region, $Ht\bar{t}$ and $t\bar{t}b\bar{b}$)
- The "right" scale of the process can only be confirmed after the actual NLO calculation has been performed (e.g $t\bar{t}b\bar{b}$).
- Can the $Ht\bar{t}$ channel be used to determine the Higgs Yukawa couplings?
- Mixed QCD-EW corrections $gg \rightarrow H$ relevant to settle the Tevatron exclusion limits $160GeV < M_H < 170GeV$
- Need of codes with complete NLO QCD and EW corrections for final states with photons (e.g. $W\gamma$)
- Comparisons of BlackHat+Sherpa and MCFM+ROCKET on a common set of Observables/Distributions would be useful

The NNLO (Sub)Subgroup

- Methods for NNLO Calculations, *antenna subtraction and sector decomposition* (Gudrun Heinrich)
- $e^+e^- \to 3jets$ (Stefan Weinzierl)
- α_s from nnlo/nnla matching (Guenther Dissertori)
- Towards $pp \to WW$ at NNLO (Grigorios Chachamis)
- EW corrections to $gg \to H$, $H \to \gamma\gamma$ (Giampiero Passarino)
- First attempts to extend the one-loop duality method to two loops (Isabella Bierenbaum)

Some issues that have been discussed

- Catani-Seymour versus Antenna subtraction
- Why α_s was systematically higher in some LEP measurements
- Is the 2 loop technology ready for a complete $2 \to 2$ EW calculation?
- Complex pole to study external particles in a gauge invariant way?

Updating the 2007 Les Houches wish list

Question: Do we need a new wish list?

Updating the 2007 Les Houches wish list

Question: Do we need a new wish list?

Answer: We wish a need list!

Updating the 2007 Les Houches wish list

Question: Do we need a new wish list?

Answer: We wish a need list!

Outcome:

- Add a column in the 2007 Les Houches wish list, with the precision needed by the experimentalists
  Theorists will then decide whether, for example, EW corrections should be included as well
- Joey Huston's proposal for a *gentlemen's agreement* to properly include decays (including spin correlations) in the processes listed in the 2007 wish list
- A limited numbers of new processes to be computed at NLO could be added, such as
  - $tttt$
  - $Wbbj$ (massive b)
  - $Z + 3j$
  - $W + 4j$

NLO technique and Automation

Feynmanians versus Unitarians $\cdots$ *(J. Huston)*

- Techniques with Feynman diagrams, $t\bar{t}b\bar{b}$ (Stefano Pozzorini)
- GOLEM (Thomas Reiter)
- OPP and Rational terms (Maria Vittoria Garzelli)
- BlackHat + Sherpa (Daniel Maitre)

Unitarity methods

- Soft singularities at all orders (Lorenzo Magnea)

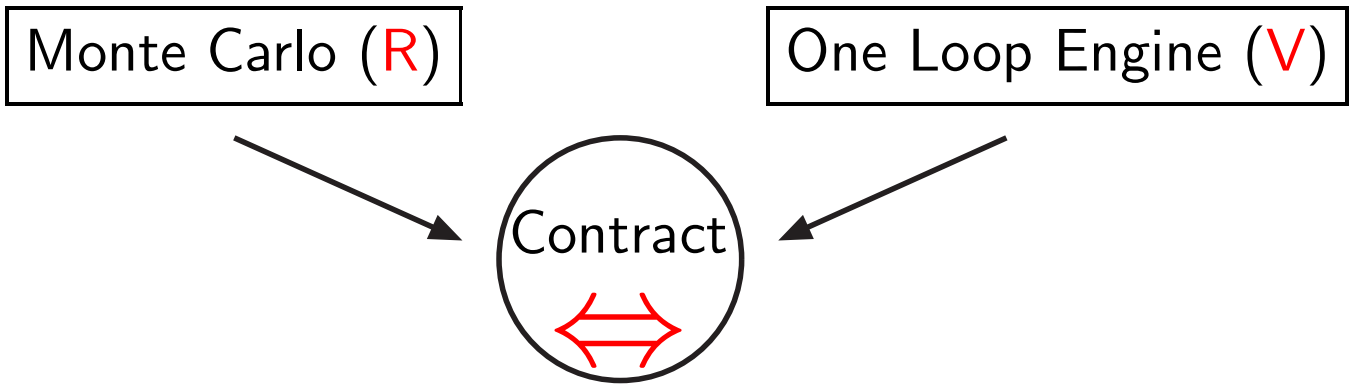
- Generalized Unitarity and masses, analytic approach (Simon Badger)
- Automating d-Dimensional Unitarity, numerical approach (Achilleas Lazopoulos)
- Numerical calculation of 1-loop amplitudes (Jan Winter)
- Generalized Unitarity and $W + 3jets$ (Giulia Zanderighi)
- Progress in analytic results (Ruth Britto)
- Double-Cut, Stokes' Theorem and Berry's Phase (Pierpaolo Mastrolia)

Some issues that have been discussed

- Analytic approach versus Numerical approach
- The numerical stability of the Unitarity Methods
- The problem of the Gram determinants
- What is the most time consuming part of the calculation?
- Efficiency in getting the Rational Part of the Amplitude

Towards a Les Houches Accord to merge Real (R) and Virtual (V) Corrections

Contributions from T. Binoth, S. Dittmaier, G. Heinrich, N. Kauer, D. Kosower, D. Maitre, F. Maltoni, T. Reiter, G. Passarino, P. Skands $\cdots$



A draft of the proposal for $\Leftrightarrow$ can be found in

http://www.lpthe.jussieu.fr/LesHouches09Wiki/index.php/Draft

NLO/PS Matching

- The POWHEG Method (Carlo Oleari)
- Proposal of Leif Lonnblad for matching NLO and Parton Shower by consistently subtracting terms $\mathcal{O}(\alpha_s)$ from the sudakov and by adding σ_{NLO}

Some issues that have been discussed

- Modifying the LHEF v2.0 to allow the merging of NLO results with the parton shower
- Adding information such as max weight and cuts
- Grouping the events in eventgroups

more details in

http://www.lpthe.jussieu.fr/LesHouches09Wiki/index.php/LHEF_for_Matching

More Standards?

Automation of Dipole Subtraction

- MadDipole as a building block (Nicolas Greiner)

Standard output of NLO programs

- Common ROOT tree output for NLO programs in C++ (Joanna Weng)
- Using ROOT/ntuples as a standard output of NLO programs (Joey Huston)

Conclusions

- In the last 2 years, a tremendous progress in our capability of computing *NLO Multi-Leg* processes took place

Conclusions

- In the last 2 years, a tremendous progress in our capability of computing *NLO Multi-Leg* processes took place
- Our final task is developing a set of NLO tools to be able to analyze the *whole* set of the LHC data *at least* at at the NLO accuracy, including a correct matching with Parton Shower

Conclusions

- In the last 2 years, a tremendous progress in our capability of computing *NLO Multi-Leg* processes took place
- Our final task is developing a set of NLO tools to be able to analyze the *whole* set of the LHC data *at least* at at the NLO accuracy, including a correct matching with Parton Shower
- To this end, a coherent effort is needed, to standardize and modularize all *building blocks* of the complete calculation, in such a way different parts can be attacked by different groups, making a matching effort to avoid double or multiple counting

Conclusions

- In the last 2 years, a tremendous progress in our capability of computing *NLO Multi-Leg* processes took place
- Our final task is developing a set of NLO tools to be able to analyze the *whole* set of the LHC data *at least* at at the NLO accuracy, including a correct matching with Parton Shower
- To this end, a coherent effort is needed, to standardize and modularize all *building blocks* of the complete calculation, in such a way different parts can be attacked by different groups, making a matching effort to avoid double or multiple counting
- A general consensus for a *standard* interface between MCs and OLEs seems to be at reach

Conclusions

- In the last 2 years, a tremendous progress in our capability of computing *NLO Multi-Leg* processes took place
- Our final task is developing a set of NLO tools to be able to analyze the *whole* set of the LHC data *at least* at at the NLO accuracy, including a correct matching with Parton Shower
- To this end, a coherent effort is needed, to standardize and modularize all *building blocks* of the complete calculation, in such a way different parts can be attacked by different groups, making a matching effort to avoid double or multiple counting
- A general consensus for a *standard* interface between MCs and OLEs seems to be at reach
- It is time to end the religious war between Feynmanians and Unitarians. We must now start signing *Contracts* to produce accurate predictions for LHC Physics