MadGraph and MadEvent

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Outline

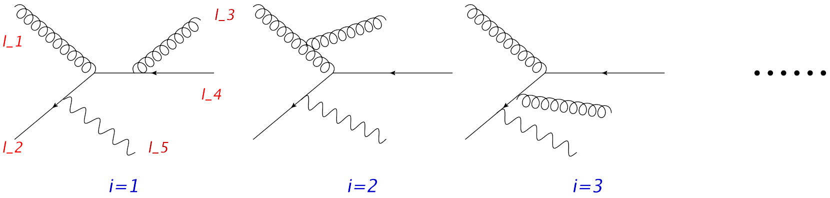
- Brief History Introdution:

  MG4-5, HELAS-ALOHA, UFO, Multi-Channel Integration.

- MG4
  - $e^+e^- \to \mu^+\mu^-$: cross section and distributions
  - $pp \to W^+$: w/o Parton Shower
  - W': 'usrmod'

- MG5
  - Tri-V anomalous coupling: FeynRules

Helicity Method and Multi-Channel Integration



gq–gqZ as an example

Topology generating → Insert particles and ineractions → Feynman Diagrams

$$d\sigma = \overline{|M|}^2 d\Phi$$

- $|M|^2$:
  - Trace method:
    $\sum_i |M_i|^2 + 2Re(\sum_{i,j} M_i M_j^*) \quad \mathcal{O}(N^2)$
  - Helicity method: $\sum_{(\lambda_1,...)} |\sum_i M_i(\lambda_1 ...)|^2 \quad \mathcal{O}(N)$
    Note another advantage is that Matrix Amplitude can be automatically got while generating the Feynman Diagrams.
- $d\Phi$

$$d\sigma = \sum_j \frac{|M_j|^2}{\sum_i |M_i|^2} \overline{|M|}^2 d\Phi_j$$

$d\Phi_j$ is optimized to capture the singularity of $\overline{|M_j|}^2$.

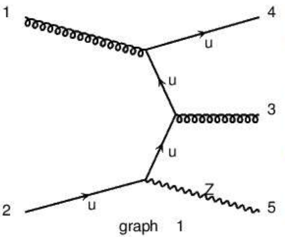
HELAS Subroutines

- HELAS (Helicity Amplitudes Subroutines) [MURAYAMA, WATANABE, HAGIWARA, 1992] is a set of Fortran77 subroutines which make it easy to compute the helicity amplitudes of an arbitrary tree-level Feynman diagram with a simple sequence of CALL SUBROUTINE statements.

- Calculating steps of Helicity amplitude:
  1. Getting the external particles' wave functions;
  2. Computing the off-shell lines;
  3. Calculating the helicity amplitude.
- **For new particles and new interactions with different Lorentz structure, additional HELAS subroutines need to be written by hand. time consuming and hard to debug!!!**

MG4 example

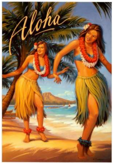
```
C BEGIN CODE
C ----------
      CALL VXXXXX(P(0,1   ),ZERO ,NHEL(1   ),-1*IC(1   ),W(1,1   ))
      CALL IXXXXX(P(0,2   ),ZERO ,NHEL(2   ),+1*IC(2   ),W(1,2   ))
      CALL VXXXXX(P(0,3   ),ZERO ,NHEL(3   ),+1*IC(3   ),W(1,3   ))
      CALL OXXXXX(P(0,4   ),ZERO ,NHEL(4   ),+1*IC(4   ),W(1,4   ))
      CALL VXXXXX(P(0,5   ),ZMASS ,NHEL(5   ),+1*IC(5   ),W(1,5   ))
      CALL FVOXXX(W(1,4   ),W(1,1   ),GG ,ZERO    ,ZERO    ,W(1,6   ))
      CALL FVIXXX(W(1,2   ),W(1,5   ),GZU ,ZERO    ,ZERO    ,W(1,7   ))
      CALL IOVXXX(W(1,7   ),W(1,6   ),W(1,3   ),GG ,AMP(1   ))
      CALL FVIXXX(W(1,2   ),W(1,3   ),GG ,ZERO    ,ZERO    ,W(1,8   ))
      CALL FVIXXX(                                       ,W(1,9   ))
      CALL IOVXXX(                                  2   ))
      CALL IOVXXX(                                  3   ))
      CALL JVVXXX(                                      ,W(1,10  ))
      CALL FVOXXX(                                       ,W(1,11  ))
      CALL IOVXXX(                                  4   ))
      CALL FVIXXX(                                       ,W(1,12  ))
      CALL IOVXXX(                                  5   ))
      CALL FVOXXX(                                       ,W(1,13  ))
      CALL IOVXXX(                                  6   ))
      CALL FVIXXX(                                       ,W(1,14  ))
      CALL FVIXXX(                                       ,W(1,15  ))
      CALL IOVXXX(                                  7   ))
      CALL IOVXXX(                                  8   ))
      JAMP(   1) =                                  4)+AMP(   5)
      JAMP(   2) =                                  7)+AMP(   8)
      MATRIX = 0.D0
      DO I = 1, NCOLOR
          ZTEMP = (0.D0,0.D0)
          DO J = 1, NCOLOR
              ZTEMP = ZTEMP + CF(J,I)*JAMP(J)
          ENDDO
```



MG5 (2011): FeynRules UFO and ALOHA

The biggest advances

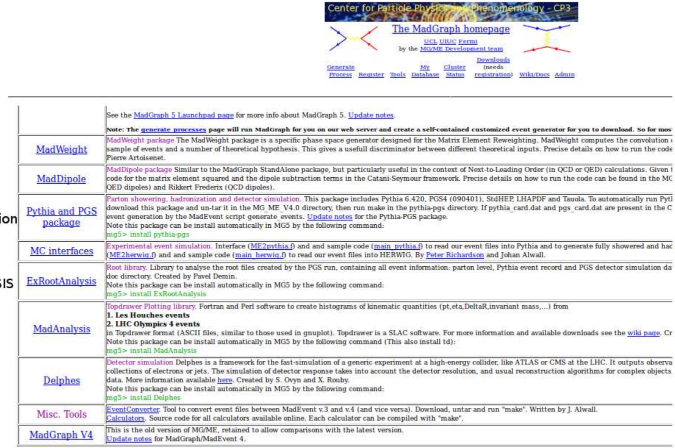
- Universal FeynRules Output (UFO)
  - Includes color and Lorentz structure
  - Allows for complete specification of effective/non-renormalizable vertices
  - Allows for automatic output of model parameter calculations for any model and language
- Automatic Language-independent Output of Helicity Amplitudes (ALOHA)
  - Automatic generation the necessary helicity amplitude code for any new model (including effective theories, multi-fermion vertices,...) in Fortran/C++/Python/...



See talk by Olivier

Detector Simulation

ROOT ANALYSIS



Center for Particle Physics and Phenomenology - CP3

The MadGraph homepage

UCL UIUC Fermi

by the MG/ME Development team

Generate Process | Register | Tools | My Database | Cluster Status | Downloads (needs registration) | Wiki/Docs | Admin

	See the MadGraph 5 Launchpad page for more info about MadGraph 5. Update notes. **Note: The generate processes page will run MadGraph for you on our web server and create a self-contained customized event generator for you to download. So for mos**
MadWeight	MadWeight package The MadWeight package is a specific phase space generator designed for the Matrix Element Reweighting. MadWeight computes the convolution sample of events and a number of theoretical hypothesis. This gives a usefull discriminator between different theoretical inputs. Precise details on how to run the code Pierre Artoisenet.
MadDipole	MadDipole package Similar to the MadGraph StandAlone package, but particularly useful in the context of Next-to-Leading Order (in QCD or QED) calculations. Given code for the matrix element squared and the dipole subtraction terms in the Catani-Seymour framework. Precise details on how to run the code can be found in the MC QED dipoles) and Rikkert Frederix (QCD dipoles).
Pythia and PGS package	Parton showering, hadronization and detector simulation. This package includes Pythia 6.420, PGS4 (090401), StdHEP, LHAPDF and Tauola. To automatically run Pytl download this package and un-tar it in the MG_ME_V4.0 directory, then run make in the pythia-pgs directory. If pythia_card.dat and pgs_card.dat are present in the C event generation by the MadEvent script generate_events. Update notes for the Pythia-PGS package. Note this package can be install automatically in MG5 by the following command: mg5> install pythia-pgs
MC interfaces	Experimental event simulation. Interface (ME2pythia.f) and and sample code (main_pythia.f) to read our event files into Pythia and to generate fully showered and had (ME2herwig.f) and and sample code (main_herwig.f) to read our event files into HERWIG. By Peter Richardson and Johan Alwall.
ExRootAnalysis	Root library. Library to analyse the root files created by the PGS run, containing all event information: parton level, Pythia event record and PGS detector simulation da doc directory. Created by Pavel Demin. Note this package can be install automatically in MG5 by the following command: mg5> install ExRootAnalysis
MadAnalysis	Topdrawer Plotting library. Fortran and Perl software to create histograms of kinematic quantities (pt,eta,DeltaR,invariant mass,...) from **1. Les Houches events** **2. LHC Olympics 4 events** in Topdrawer format (ASCII files, similar to those used in gnuplot). Topdrawer is a SLAC software. For more information and available downloads see the wiki page. Cr Note this package can be install automatically in MG5 by the following command (This also install td): mg5> install MadAnalysis
Delphes	Detector simulation Delphes is a framework for the fast-simulation of a generic experiment at a high-energy collider, like ATLAS or CMS at the LHC. It outputs observa collections of electrons or jets. The simulation of detector response takes into account the detector resolution, and usual reconstruction algorithms for complex objects data. More information available here. Created by S. Ovyn and X. Rouby. Note this package can be install automatically in MG5 by the following command: mg5> install Delphes
Misc. Tools	EventConverter. Tool to convert event files between MadEvent v.3 and v.4 (and vice versa). Download, untar and run "make". Written by J. Alwall. Calculators. Source code for all calculators available online. Each calculator can be compiled with "make".
MadGraph V4	This is the old version of MG/ME, retained to allow comparisons with the latest version. Update notes for MadGraph/MadEvent 4.