ALOHA

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PURPOSE OF ALOHA

• ALOHA = Automatic Language-independent Output of Helicity Amplitude.

• Idea: made BSM model implementation 100% automatic from FeynRules to detector simulation.

• Color: reason for the new color module of MG5

• HELAS: Need an automation
Idea: Evaluate $m$ from impulsions and helicity of external particles.
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• 1: Evaluate Wavefunctions of external particles
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1: Evaluate Wavefunctions of external particles

2: Evaluate Wavefunctions of internal particles
STANDARD HELAS

• **Idea:** Evaluate $m$ from impulsions and helicity of external particles.

• **1:** Evaluate Wavefunctions of external particles

• **2:** Evaluate Wavefunctions of internal particles

• **3:** Evaluate the Amplitude
if ( gc(2).ne.cZero ) then
   c0 =  gc(1)*( fo(3)*fi(1)+fo(4)*fi(2))
   & +gc(2)* ( fo(1)*fi(3)+fo(2)*fi(4))
   c1 =  -gc(1)* ( fo(3)*fi(2)+fo(4)*fi(1))
   & +gc(2)* ( fo(1)*fi(4)+fo(2)*fi(3))
   c2 =  gc(1)* (fo(3)*fi(2)-fo(4)*fi(1))
   & +gc(2)* (-fo(1)*fi(4)+fo(2)*fi(3))*cImag
   c3 =  gc(1)*(-fo(3)*fi(1)+fo(4)*fi(2))
   & +gc(2)* (-fo(1)*fi(3)-fo(2)*fi(4))
else
   d = d*gc(1)
   c0 =  fo(3)*fi(1)+fo(4)*fi(2)
   c1 =  -fo(3)*fi(2)-fo(4)*fi(1)
   c2 =  ( fo(3)*fi(2)-fo(4)*fi(1))*cImag
   c3 =  -fo(3)*fi(1)+fo(4)*fi(2)
end if

Fabio's implementation of the fixed width
   cm2=dcmplx( vm2, -vmass*width )

   cs = (q(0)*c0-q(1)*c1-q(2)*c2-q(3)*c3)/vm2
   cs = (q(0)*c0-q(1)*c1-q(2)*c2-q(3)*c3)/cm2
   jio(1) = (c0-cs*q(0))*d
   jio(2) = (c1-cs*q(1))*d
   jio(3) = (c2-cs*q(2))*d
   jio(4) = (c3-cs*q(3))*d
else
   d = dcmplx( r0ne/q2, rZero )
PHYSICAL CONTENT

• Lorentz structure associated to “e+ e- A” vertex is $\gamma^\mu$

• So the Associate Amplitude (IOV) will be:

$$-i W_f(e^-) \gamma^\mu W_f(e^+) A_\mu$$

• And the computation of the vector wavefunctions (JOV) is

$$W_f(e^-) \gamma^\mu W_f(e^+) \frac{-i \eta_{\mu\nu}}{p_A^2}$$

• From the Lorentz structure it’s easy to compute automatically the HELAS routine
UFO

Vertices.py

```
V_15 = Vertex(name = 'V_15',
    particles = [ P.s__tilde__, P.s, P.A ],
    color = [ 'Identity(1,2)' ],
    lorentz = [ L.FFV1 ],
    couplings = {{(0,0):C.GC_1}}

V_16 = Vertex(name = 'V_16',
    particles = [ P.b__tilde__, P.b, P.A ],
    color = [ 'Identity(1,2)' ],
    lorentz = [ L.FFV1 ],
    couplings = {{(0,0):C.GC_1}}

V_17 = Vertex(name = 'V_17',
    particles = [ P.e__plus__, P.e__minus__, P.A ],
    color = [ '1' ],
    lorentz = [ L.FFV1 ],
    couplings = {{(0,0):C.GC_3}}
```

Lorentz.py

```
SSS1 = Lorentz(name = 'SSS1',
    spins = [ 1, 1, 1 ],
    structure = '1')

FFS1 = Lorentz(name = 'FFS1',
    spins = [ 2, 2, 1 ],
    structure = 'Identity(1,2)')

FFV1 = Lorentz(name = 'FFV1',
    spins = [ 2, 2, 3 ],
    structure = 'Gamma(3,2,1)')

ν^μ
```
**ALOHA**

- **Idea:** Evaluate $m$ from impulsions and helicity of external particles.
- **1:** Evaluate Wavefunctions of external particles

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**Diagram 1**

\[ u_{\sim}^{1} \rightarrow t_{\sim}^{2} QED=0 \]
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**STANDARD HELAS**

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**Diagrams made by MadGraph5**

![Diagram 1](image_url)
STANDARD HELAS

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STANDARD HELAS

- **Idea:** Evaluate $m$ from impulsions and helicity of external particles.
- **1:** Evaluate Wavefunctions of external particles
- **2:** Evaluate Wavefunctions of internal particles
- **3:** Evaluate the Amplitude
ONE ALOHA ROUTINE

This File is Automatically generated by ALOHA
The process calculated in this file is:
Gamma(3,2,1)

```
SUBROUTINE FFV1_0(F1,F2,V3,C,VERTEX)

IMPLICIT NONE
DOUBLE COMPLEX F1(6)
DOUBLE COMPLEX F2(6)
DOUBLE COMPLEX V3(6)
DOUBLE COMPLEX C
DOUBLE COMPLEX VERTEX

VERTEX = C*( F2(1)*( F1(3)*( (0, -1)*V3(1)+(0, 1)*V3(4)) )
$ + (F1(4)*((0, 1)*V3(2)+V3(3))))+( F2(2)*(( F1(3)*((0, 1)
$ *V3(2)-V3(3)))+( F1(4)*((0, -1)*V3(1)+(0, -1)*V3(4))))
$ +( F2(1)*(( F1(1)*((0, -1)*V3(1)+(0, -1)*V3(4))))+( F1(2)
$ *( (0, -1)*V3(2)-V3(3))))+( F2(4)*(( F1(1)*((0, -1)*V3(2)
$ +V3(3)))+( F1(2)*((0, -1)*V3(1)+(0, 1)*V3(4)))))))
```

END
ALOHA FEATURE

• ALOHA IS PURE PYTHON

• ALOHA IS FAST

  • SM in 3s and MSSM in 5s

• Possible to ask a subset of routine (Done in MG5)

• Output in Python / Fortran / C

• Particles spin implemented Scalar Fermion Vector

• Spin2 in progress (This week)
PERSPECTIVE

• Spin 2
• Spin 3/2
• 4 Fermion Interactions (and more)
• GPU

vendredi 8 octobre 2010
CONCLUSION

• The Helas routine for BSM without the pain to write it.

• Fully interfaced with MG5.