Some Instructions if you want to get your own imaginary parts of scattering amplitudes for a given helicity state of the gluons

1) Clone the repository and read the README.md to set up the necessary libraries.
https://gitlab.msu.edu/reyesriv/hj-scattering-amplitudes/-/tree/master/

2) Use scripts/make_feynamps.nb

   a) You should run the first 3 blocks to define all the topologies/diagrams for the process. Then on the 4th block you will see the function to choose an specific subset of diagrams and an example on how to use it. On this example (see below) diagrams 1 and 2 are chosen from the group of insB (all box diagrams). This will create the scattering amplitude of those diagrams. The file should be created and saved to the directory /feynamps.

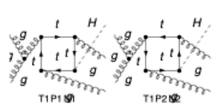
```
(* Give this function a list of the diagrams you want to use *)
(* You have to first run the block after this one to define insT,insB (TOPOLOGIES)*)

SaveDiagramSubGroup[list_, outfilename_] := {
  Clear[Amp];
  Amps = CalcFeynAmp[CreateFeynAmp[list], SortDen → True];
  Amps = Amps //. Abbr[] //. Subexpr[] //. Abbr[];
  Export[outfilename, Amps[[1]]];
 }

(* Example of using it *)
SubGroupIwant = DiagramExtract[insB, {1, 2}]; (* use insT instead of insB for triangle diagrams *)
Paint[SubGroupIwant]; (* Use Paint[] to see the diagrams you chose are actually the ones you want *)
SaveDiagramSubGroup[SubGroupIwant, "test"];
(* Scattering amplitude will be saved at feynamps/test.m *)
```

```
> Top. 1 afbf/cgdhei/fjghgihjij.m, 2 diagrams
```

g g → H g g



3) Use scripts/translate2X.nb to translate PV coefficients to the Package X format. Run the first 2 blocks. Here you can see that the function is very easy to use. Just provide the infilename and outfilename. Make sure the infilename is in the directory /feynamps.

```
SetDirectory[NotebookDirectory[]];
SetDirectory[StringJoin[ParentDirectory[], "/feynamps"]];


(* Function that Translates from FormCalc notation to Package X notation *)
Translate2X[infilename_, outfilename_] := {
  Amplitude = Import[infilename];
  Amplitude = Amplitude //. MATColor //. SubDen;
  AmpX = Collect[ReleaseHold[((HoldForm[Evaluate[Amplitude]]) //. RIntList)], Mat[__]];
  Export[outfilename, AmpX];
 }

(* Example *)
Translate2X["test.m", "test_PVX.m"];
(* Takes the file feynamps/test.m and saves the translation to feynamps/test_PVX.m *)
```

4) Use sub_analyticPVcoeff.nb. This one substitute the PV coefficients with their analytical expansions. Run the first 2 blocks. Just provide the infilename and outfilename to use function. It uses definitions that are saved in the directory /pvcoefficients/2jets. Also the outfile will be saved to /feynamps.

```
(* Function that substitutes PV coefficients for their analytical expansions *)
subAnalyticalPVCoeff[infilename_, outfilename_] := {
  Amps = Import[infilename] /. rl1;
  Amps = Amps //. {repTPVB};
  Amps = Amps //. {repTPVC};
  Amps = Amps //. {repBPVC};
  Amps = Amps //. {repBPVD};
  Export[outfilename, Amps];
 }

(* Example *)
subAnalyticalPVCoeff["test_PVX.m", "test_FeynAmp.m"];
(* Takes test_PVX.m and substitutes any PVC,PVD to its analytical expansion,
which then is saved to test_FeynAmp.m *)
```

5) Run the first 3 blocks. This one substitutes the 4 vectors, kinematic conditions and sets the polarization of the vectors. Notice that you have run poldef2jets[±,±,±,±] to able to substitute the 4 vectors and therefore to use the function.

```
(* Function to sub some Mandelstam variables, 4-vectors *)
(* NOTE: First you have to call the function poldef2jets[p1,p2,p4,p5] to define the polarization vectors,
here pn is the polarization of the gluons which could be 1 or -1. *)

Sub4VecsAndMandelstam[infilename_, outfilename_] := {
  Amps = Import[infilename];
  Amps = Amps /. SubFourVecs;
  Amps = Amps /. k4Cond /. ml3;
  Export[outfilename, Amps];
 }

(* Example *)
(**)
SetDirectory[NotebookDirectory[]];
SetDirectory[StringJoin[ParentDirectory[], "/feynamps"]];
poldef2jets[1, 1, 1, 1]; (* First we define the polarization states:  + + -> + +   *)
Sub4VecsAndMandelstam["test_FeynAmp.m", "test_FinalAmp.m"];
```

6) At the end you will have amplitudes in terms of S, k3 (magnitude of the momentum of the Higgs), Phi3,Phi4, theta3 and theta4 and col1,col2,col3,col4,col5,col6 (color factors). Box diagrams tend to be larger and therefore take more time to run. Relationship between the color factors:

```
colList = {col1*col2 -> 2/3, col2*col5 -> -1/3, col2*col3 -> -1/3,
  col2*col6 -> -1/3, col2*col4 -> -1/3, col2^2 -> 19/6,
  col1*col6 -> -1/3, col5*col6 -> 2/3, col3*col6 -> -1/3,
  col6^2 -> 19/6, col4*col6 -> -1/3, col1*col5 -> -1/3,
  col5^2 -> 19/6, col3*col5 -> -1/3, col4*col5 -> -1/3,
  col1^2 -> 19/6, col1*col3 -> -1/3, col1*col4 -> -1/3,
  col3*col4 -> 2/3, col4^2 -> 19/6, col3^2 -> 19/6};
```