

Two Weak Bosons at the LHC

Tom Melia

DPhil Oxford
Theory

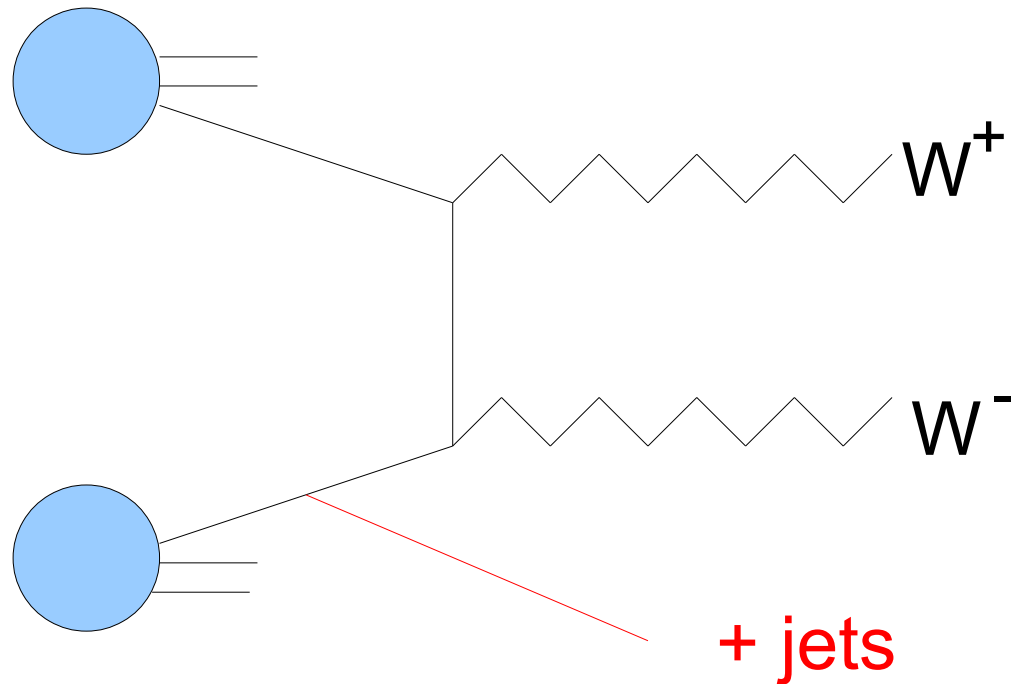


IPMU Japan
Short-term Fellowship



CERN
Fellowship

e.g.



Two Weak Bosons at the LHC

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QCD

NLO in QCD Amplitudes
using D-Dimensional
Unitarity

Higgs

Standard Model Background

BSM

Test $SU(2) \times U(1)$ EW gauge
Couplings
&
Background to Direct
Searches

NLO QCD

Important at the LHC – use perturbative QCD theory (factorisation and asymptotic freedom) → Jet Cross Sections

NLO QCD many particle processes ($N > 5$ particles) is difficult.

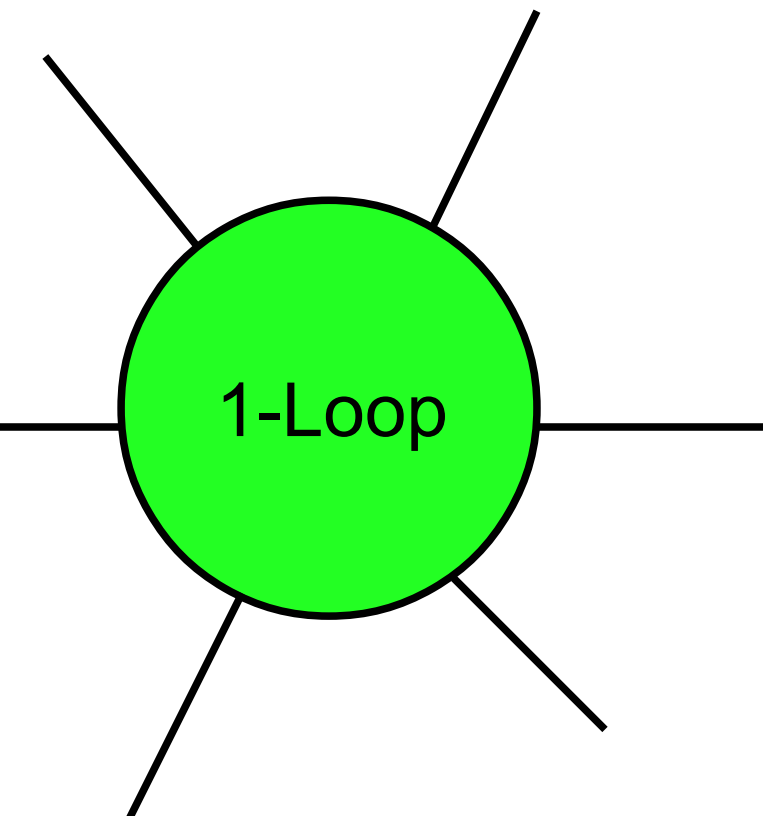
Number of virtual amplitude Feynman diagrams grows as $N!$.

Before 2009 no “2 to 4” processes were known

In the past four years new methods have simplified this virtual amplitude bottleneck enormously.

NLO QCD

D-Dimensional Unitarity (*Bern, Dixon, Kosower; Cachazo, Britto, Feng; OPP; Ellis, Kunszt, Giele, Melnikov and more*).

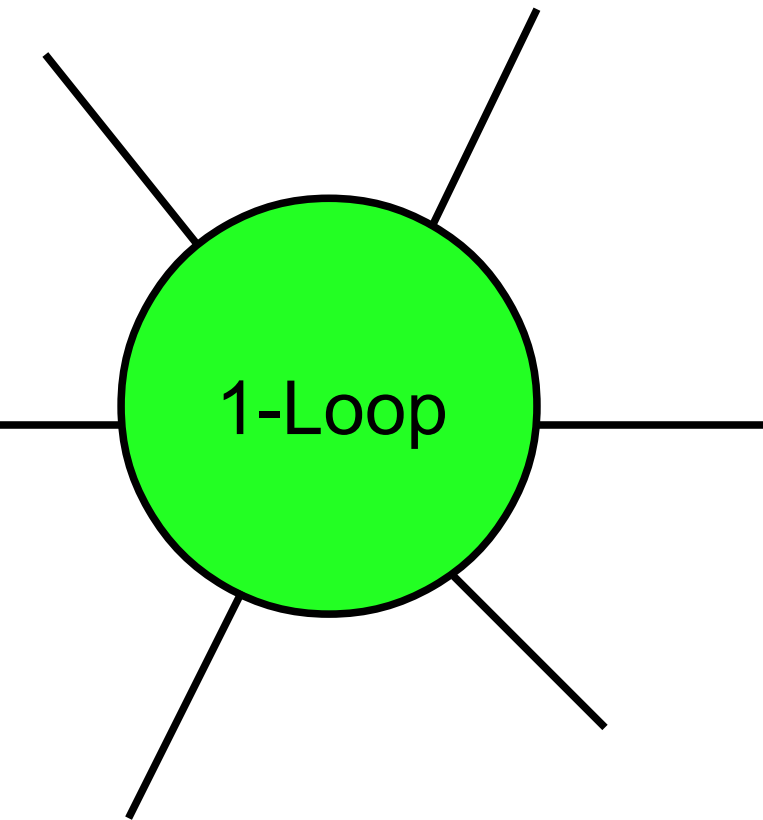


A diagram on the left shows a central green circle labeled "1-Loop". Five black lines radiate from the circle: one horizontal line to the left, one horizontal line to the right, and three diagonal lines (top-left, top-right, and bottom-left).

$$\begin{aligned} &= \sum_d (d \times \mathbf{I}_4) \\ &+ \sum_c (c \times \mathbf{I}_3) \\ &+ \sum_b (b \times \mathbf{I}_2) \\ &+ \sum_a (a \times \mathbf{I}_1) \\ &+ R \end{aligned}$$

NLO QCD

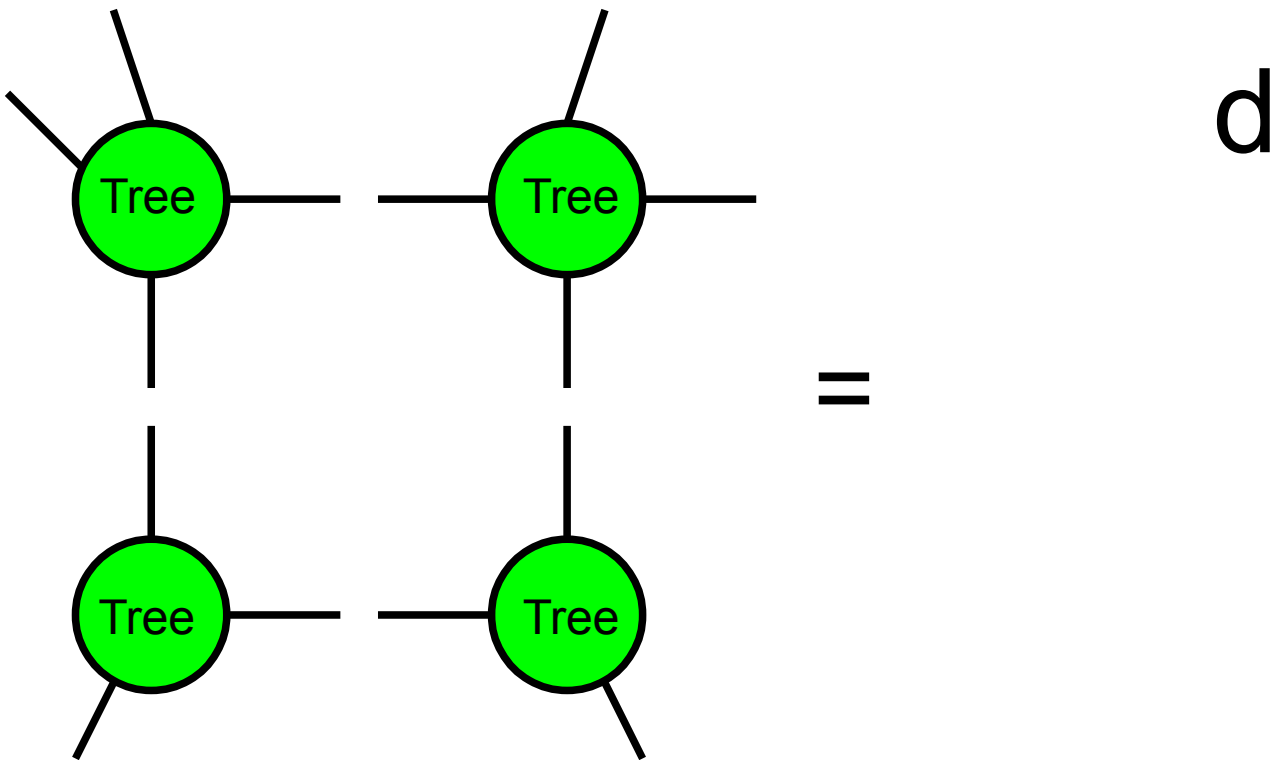
$$\int d^d l \frac{1}{(l^2 - m^2)(l+p_1)^2 - m^2)(l+p_2)^2 - m^2)(l+p_3)^2 - m^2)}$$



$$= \sum_d (d \times \mathbf{I}_4) + \sum_c (c \times \mathbf{I}_3) + \sum_b (b \times \mathbf{I}_2) + \sum_a (a \times \mathbf{I}_1) + R$$

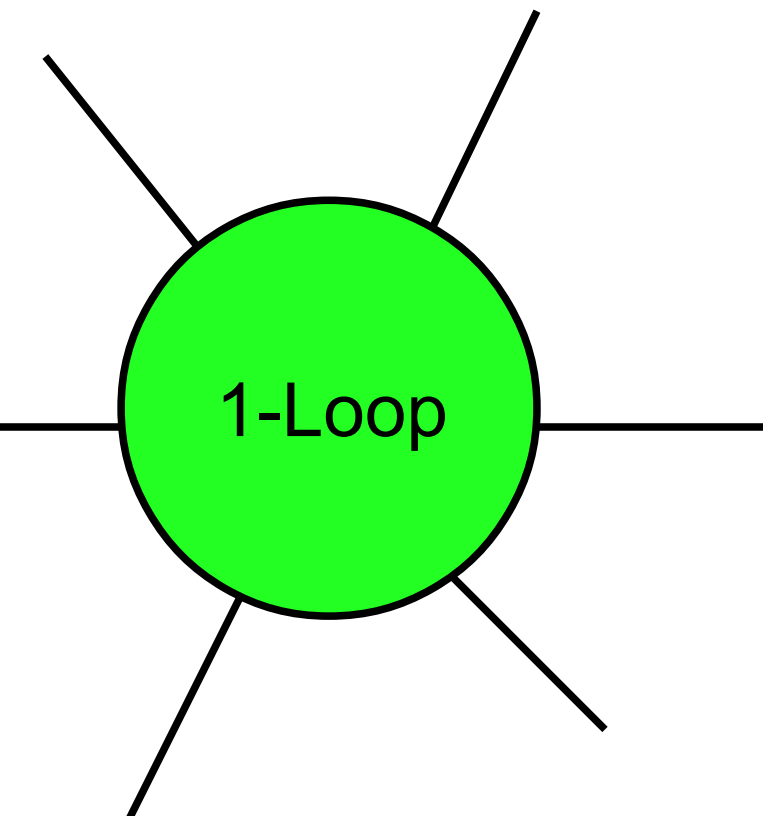
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NLO QCD

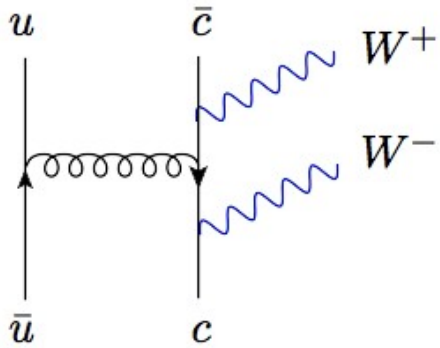
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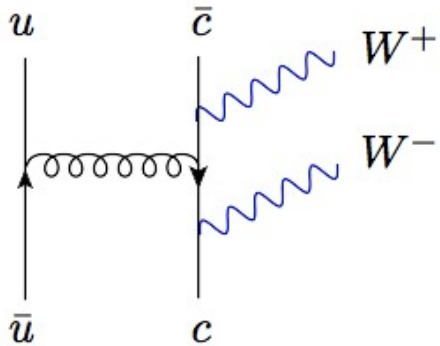
Higgs



NLO QCD corrections to
 $pp \rightarrow W^+ W^- j j$

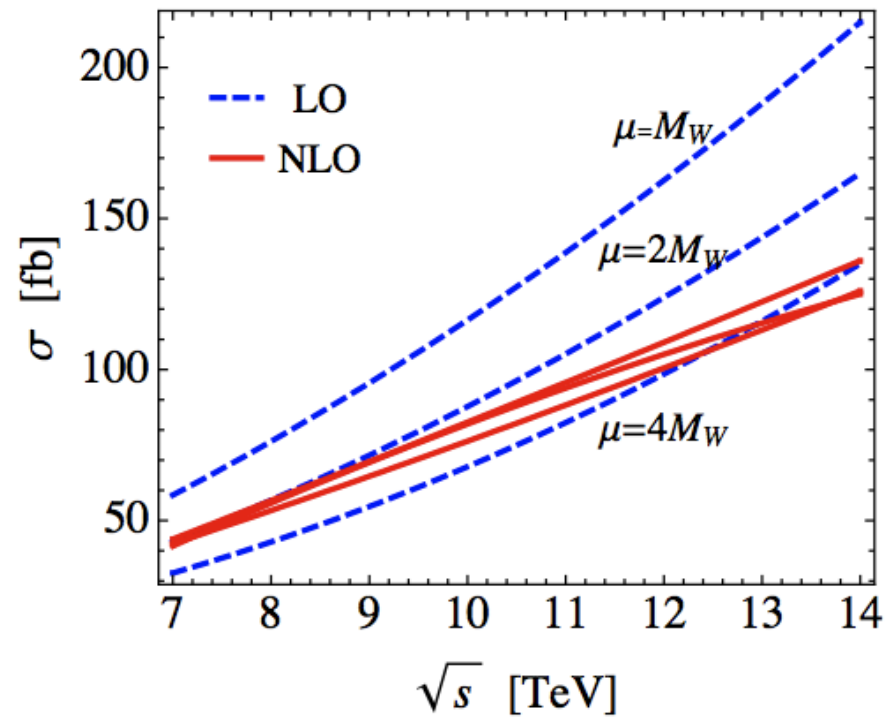
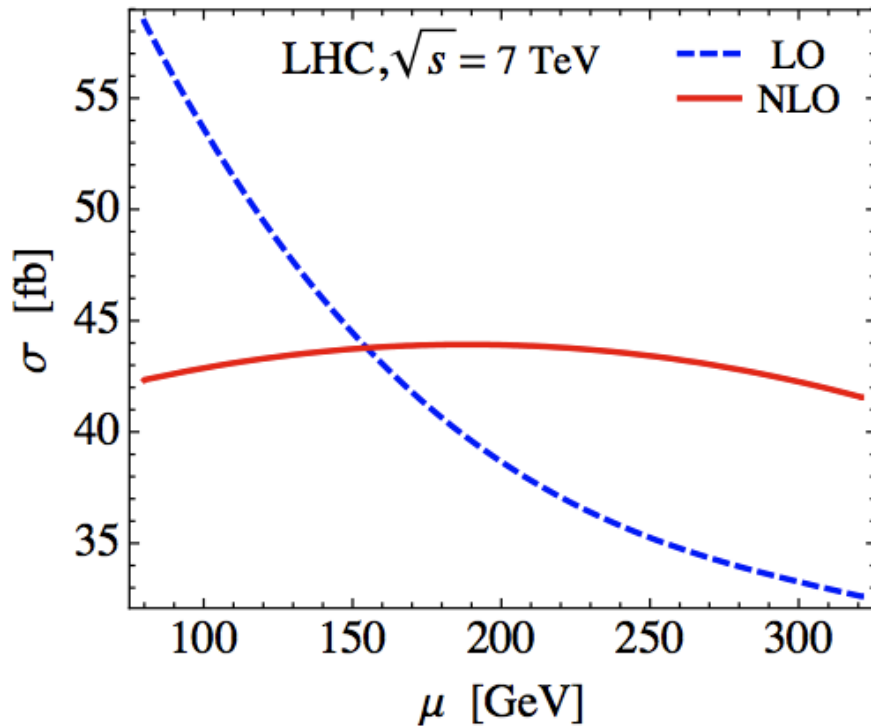
Melia, Rontsch, Melnikov, Zanderighi (Phy Rev D 2011)

Higgs

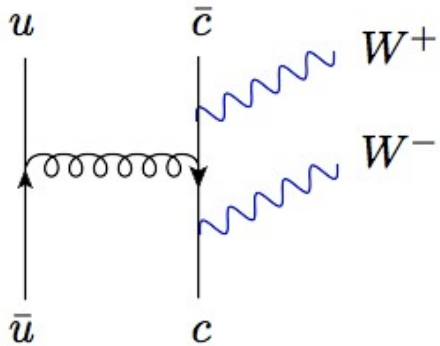


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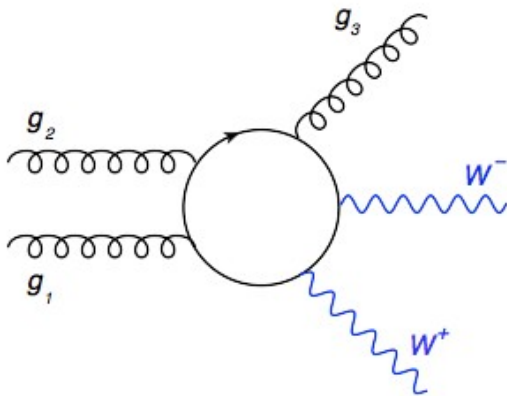


Higgs



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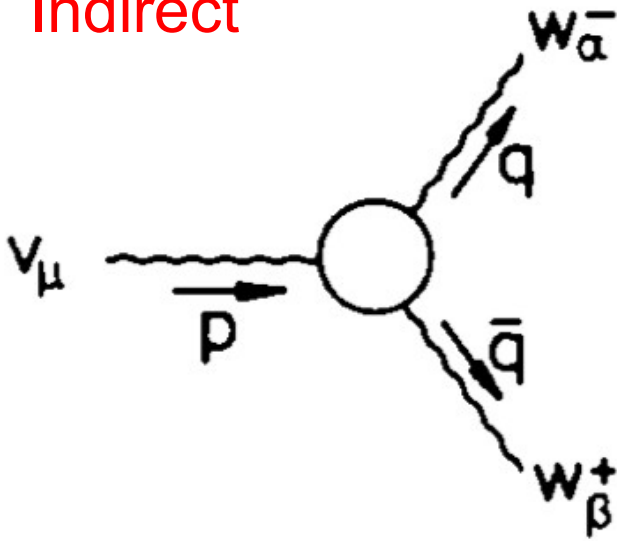


gluon-fusion contribution to
 $pp \rightarrow W^+ W^- j$

Melia, Rontsch, Melnikov, Schulze, Zanderighi (arXiv 2012)

BSM

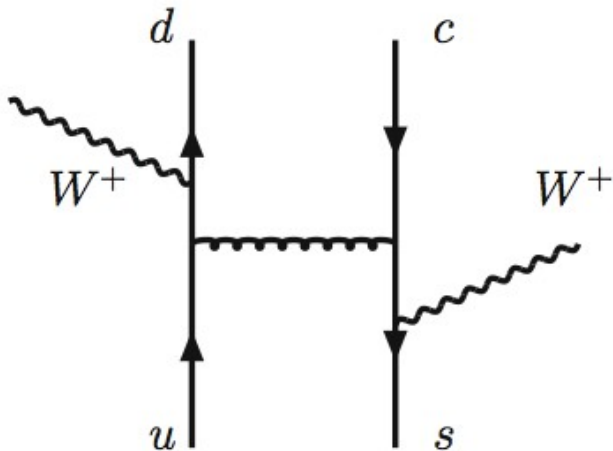
Indirect



Anomalous tri-linear vector boson couplings in WW production: NLO + Parton Shower for WW, WZ, ZZ production (POWHEG)

Melia, Rontsch, Nason, Zanderighi (JHEP 2011)

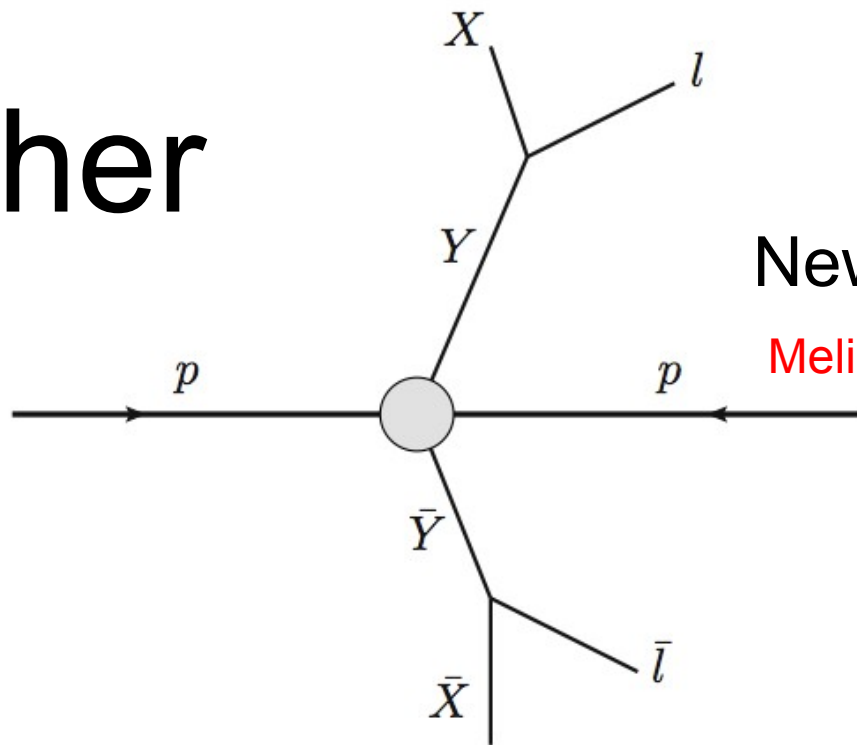
Background to Direct



NLO QCD corrections to $pp \rightarrow W^+ W^+ j j$

Melia, Rontsch, Melnikov, Zanderighi (JHEP 2010)

Other



New particle spin determination

Melia (JHEP 2011)

+ future interests

- New SM calculations (QCD + EW NLO).
- Learning more about effective field theories (general Lagrangians based on symmetry) – NLO calculations, more ATGs.
- Spin correlations, spin determination, mass determination.
- Structure of amplitudes. Ideas from N=4 SYM, different types of recursion relations (BCFW, CSW). n-Photon scattering.