Gluon initiated vector boson fusion

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in collaboration with
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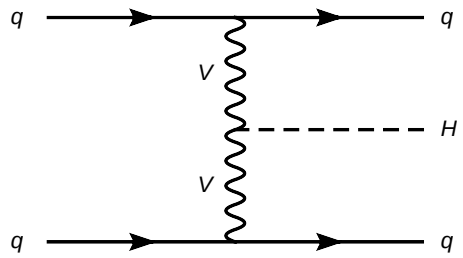
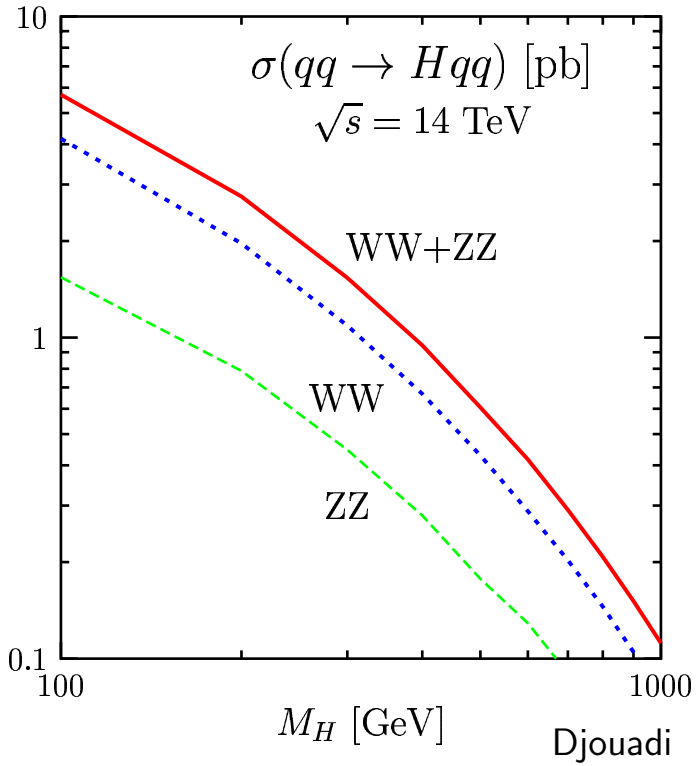
vector boson fusion: introduction





- important discovery mode at LHC
- measurement of HVV couplings

characteristics

- 2 jets at high rapidities
- no color exchange

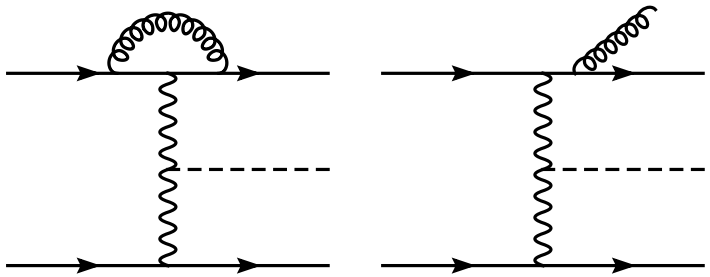
  no central hadronic activity
- H decay products at low rapidities

$\longrightarrow$ can be exploited to separate VBF from background

vector boson fusion at NLO

QCD corrections

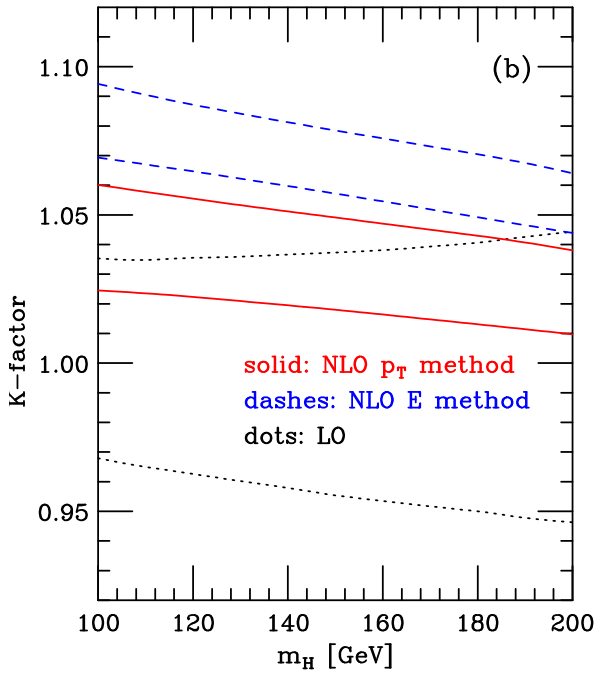
- total rates [Han, Valencia, Willenbrock '92] [Djouadi, Spira '00]
- distributions [Figy, Oleari, Zeppenfeld '03] [Barger, Campbell '04]



- no color exchange

  $\longrightarrow$ only corrections to structure functions

  same as in DIS
- size: $+5 \ldots 10\%$
- scale uncertainty $\sim 2\%$



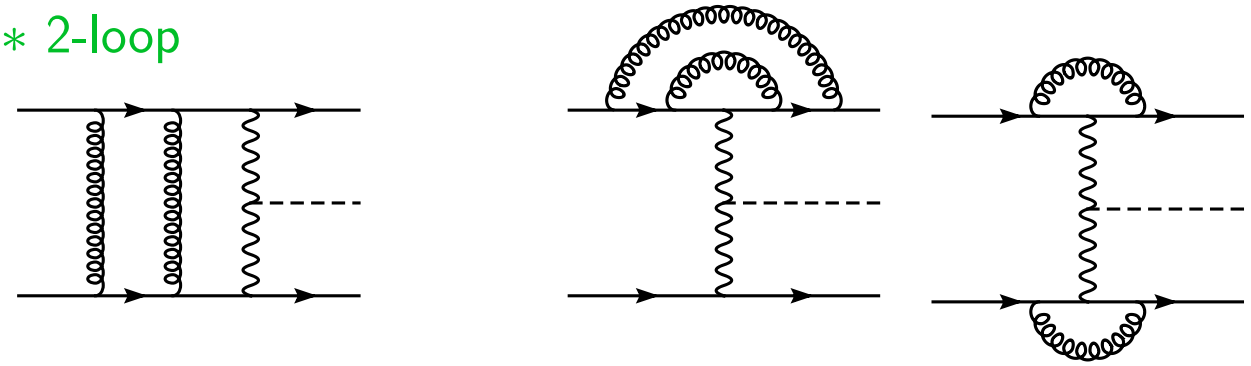
Figy,Oleari, Zeppenfeld

vector boson fusion at NNLO

2-loop QCD corrections unknown

virtual corrections

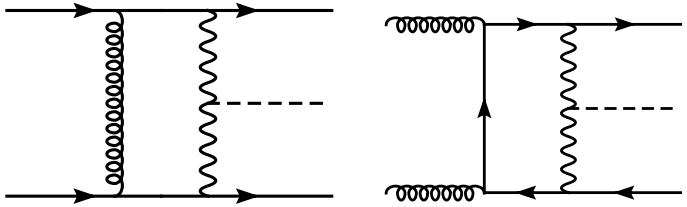
- tree $*$ 2-loop



DIS like

$\longrightarrow$ no color exchange

- (1-loop)^2



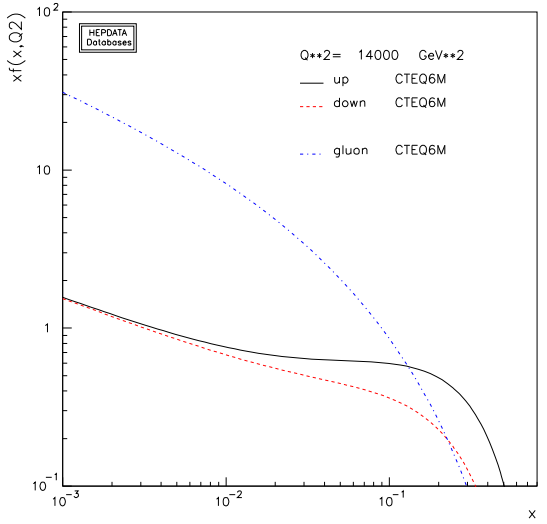
$\longrightarrow$ color exchange

- gluon initiated process: $gg \longrightarrow q\bar{q}H$

  finite, gauge invariant

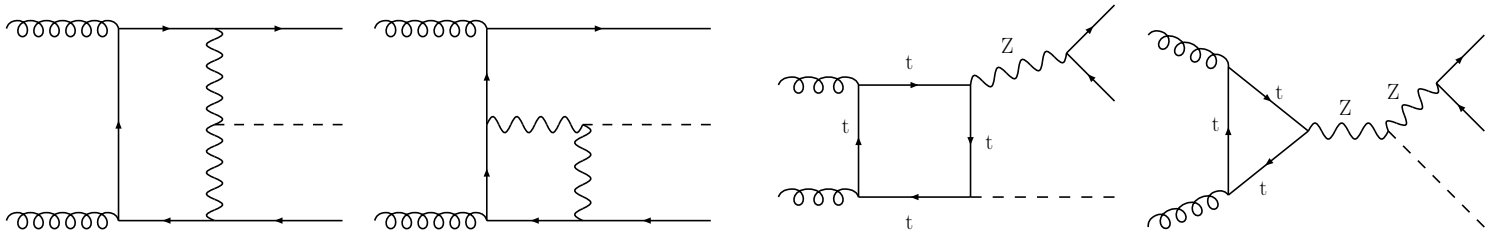
  gluon luminosity large at LHC

  $\longrightarrow$ this talk



$gg \to q\bar{q}H$

sample diagrams



non-resonant resonant Z

decomposition of diagrams:

- resonant and nonresonant diagram sets separately gauge invariant
- resonant diagrams: $gg \to HZ^* \to Hq\bar{q} \to$ Higgsstrahlung
  $\to$ exclude, use only non-resonant diagrams

- external quarks: sum over 5 light flavours, taken as massless

- amplitude diverges for soft or collinear final state quarks
  $\to$ require 2 non-collinear well separated hard jets using cuts
  $\to$ finite cross section

$gg \to q\bar{q}H$: calculation

- 't Hooft-Feynman gauge
- generation by FeynArts
- evaluation using Mathematica / FormCalc
  $\to$ standard matrix elements and coefficients containing tensor loop integrals
  $\to$ translation to C++ code for numerical evaluation
- tensor loop integrals
  3/4 point integrals: Passarino-Veltman reduction
  5 point integrals:
  numerical instabilities from inverse Gram determinants in tensor reduction
  $\to$ alternative reduction avoiding leading inverse Gram determinants
  [Denner, Dittmaier '02]
- phase space integration: VEGAS
  distributions possible

total cross section

minimal cuts

$$p_T > 20\,\text{GeV}, \quad |\eta_j| < 5, \quad R > 0.6$$

$$R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

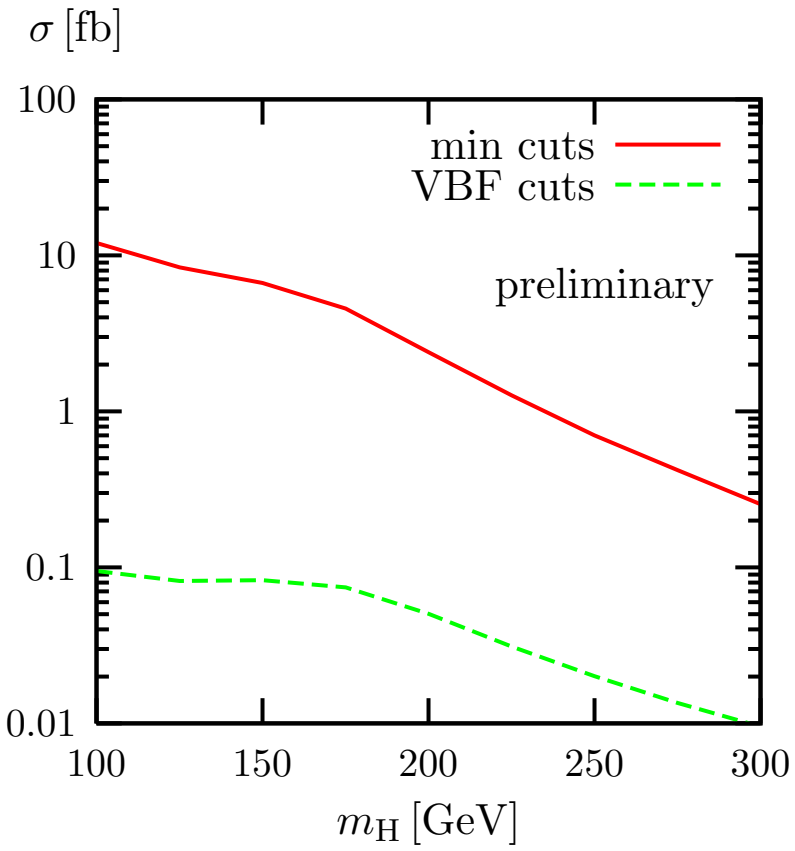
$\longrightarrow$ 2 well separated hard jets

additional VBF cuts

$$|\Delta\eta| > 4.2, \quad \eta_1 \cdot \eta_2 < 0$$

$$m_{jj} > 600\,\text{GeV}$$

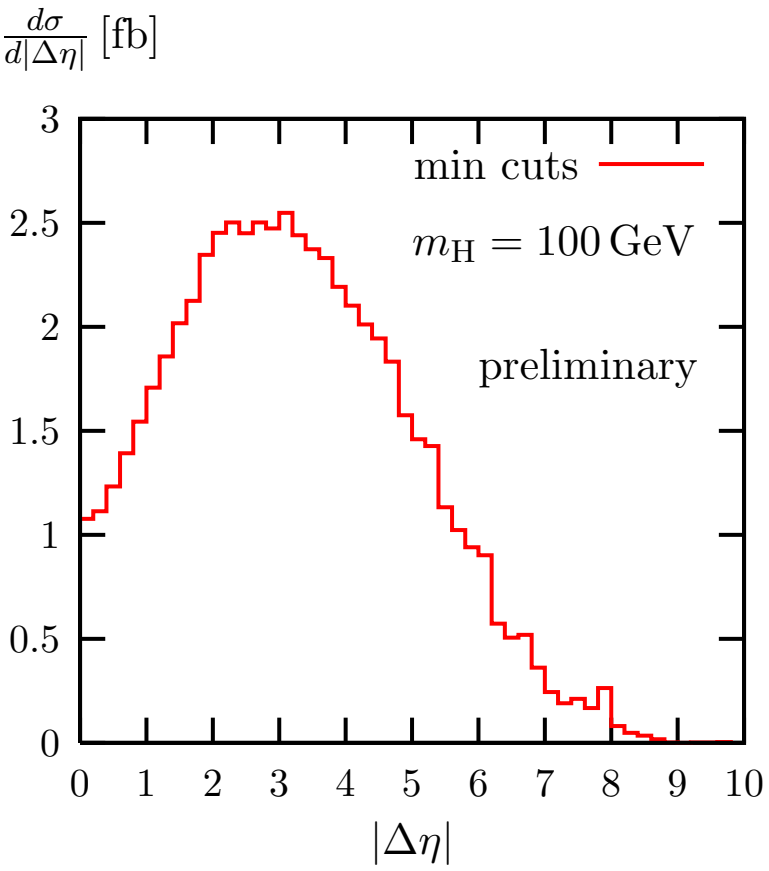
$\longrightarrow$ separation of VBF process from background

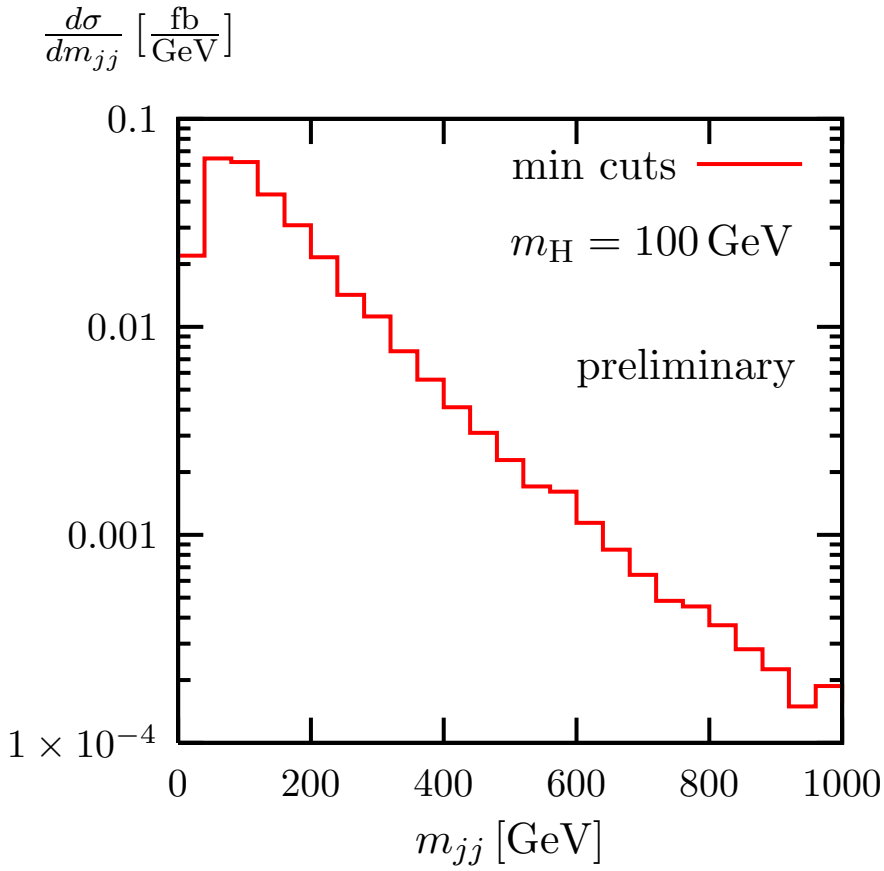


- minimal cuts: $\sigma(gg \to q\bar{q}H) \sim 0.3\%$ of $q\bar{q} \to q\bar{q}H$
- VBF cuts: strong suppression

distributions

$m_H = 100\,\text{GeV}$, **minimal cuts**





- rapdity gap: smaller than vector boson fusion (LO)
- dijet invariant mass: rapid falloff

conclusions

- vector boson fusion important Higgs production channel at LHC
- no color exchange at LO and NLO
  color exchange contributions only at NNLO
- $gg \to q\bar{q}H$: finite, gauge invariant subset of NNLO corrections
  with color exchange
- $\sigma \sim 10\,\text{fb}$ for 100 GeV Higgs with minimal cuts
  strong suppression by additional VBF cuts