Higgs + Jet Production

at The LHC
Standard Model Higgs

Production mechanisms:

$gg \rightarrow H$ dominant over large range of $m_H$

LO:

NLO: Calculated $K \sim 1.7$

Useful limit: $m_t \gg m_H$

$$f_{\text{eff}} = \frac{1}{4} \left( \frac{\Lambda_S}{3\pi v} \right) \left( 1 + \frac{11x_s}{4\pi} + C(x_s^2) \right) H \sigma_C$$

Good approximation:

$$\sigma_{\text{NLO}} \sim K^{\text{large}-m_t} \cdot \sigma_{\text{LO}}$$

- Spira, Djouadi, Grandenz, Zerwas
- Dawson
From M. Spira

hep-ph/9705337
$g g \rightarrow H$

Graph showing the cross-section $\sigma$ (pb) versus $m_H$ (GeV) with two curves labeled "Exact LC" and "large-$M_t$".
Why $H + \text{jet}$?

For $m_H \leq 140 \text{ GeV}$,

use $H \rightarrow \gamma \gamma$ channel:

- Large Backgrounds

- Large Background uncertainty

⇒ Require Extra jet

- Can improve $S/B$

  (cut, angular cuts, ...)

  Abdullin, Dubinin, Il'gin, Kovalenko, Saurin, Stepanov

- More Reliable background calculation

  deFlorian, Kunszt

Or simply put $Q_1$ cut on $\gamma \gamma$ pair

Balazs, Nadolsky, CS, Yuan
$gg + X$ production

(smaller-$p_t$ resummed)
Higgs $P_{1}$ Spectra

1) Exact LO vs. large-$M_{t}$ limit
   - Good for $m_{H}, P_{1} < M_{t}$

   $m_{H} = 120, P_{1} \sim 100 \quad \Delta \sim 4\%$

   $m_{H} = 240, P_{1} \sim 100 \quad \Delta \sim 25\%$

2) QCD NLC in large-$M_{t}$ limit

   MC: de Florian, Grazzini, Kunszt

   Analytic: Glosser, CS

   (preliminary)
$m_H = 120 \text{ GeV}$
\eta_H = 2.40 \text{ GeV}
$m_H = 480$ GeV
$m_H = 100 \text{ GeV}$
from de Florian,
Grazzini, Kunst"}{\textit{et al.}}

\textit{hep-ph/9902483}
In small-\( p_t \) region

\[ \rightarrow \text{need resummation} \quad (L = \ln \frac{M_H^2}{p_t^2}) \]

\[
\frac{d\sigma}{dp_t^2 dy_H} \sim \frac{\sigma_0}{p_t^2} \frac{m_H^2}{S} \left[ \left( \frac{d\sigma}{2\pi} \right) \left( C, L + C_0 \right) \\
+ \left( \frac{d\sigma}{2\pi} \right) \left( C, L + C_2 L^2 + C_1 L \right) + \left( \frac{d\sigma}{2\pi} \right) \left( C_0, \left( \frac{d\sigma}{2\pi} \right) L^5 \right) \right]
\]

From analytic NLO calculation, extract "B\(_2\)" coefficient

\[ \rightarrow \text{Small-}\ p_t \text{ resummation at NLO} \]

with Glosser, Kauffman, Nadolsky, CS, Yuan
Small-$p_t$ resummed calculations

$pp \rightarrow HX, \text{ LHC, } \sqrt{s} = 14 \text{ TeV}$

$m_H = 150 \text{ GeV}, \text{ CTEQ4M}$

From Balazs & Yuan

hep-ph/0001103
$m_H = 100 \text{ GeV}$
Higgs + 2 Jets \quad \text{(in gg-fusion)}

Why?

- Background to WW fusion
- Use WW-fusion to measure HWW couplings.
- But must know backgrounds.

gg → Hgg \quad \text{(and related quark processes)}

- Amplitudes known in large-\text{m}_t \text{ limit}
  - Dawson, Kauffman
  - Kauffman, Desai, Risal
  - Exact (full-\text{m}_t \text{ dependence}) amps in progress
    (Kilgore, DelDuca, CS)

- Essentially done
- Substantial Progress
- The Big one!

- Phenomenology to be done.
Summary

1) H + 1 jet
   - can increase $S/B$
   - can improve reliability of background calculation
   - NLO in large-$m_t$ limit done
     use $\sigma_{NLO} = K^{m_t\to\infty}\cdot\sigma_{LO}$
   - NLO small-$p_t$ resummation in progress

2) H + 2 jet (gg fusion)
   - Background to WW-fusion
   - Large-$m_t$ LO Amps known
   - Exact LO Amps in progress