Efficiency studies for Higgs production mechanism in the channel H→ZZ→2l2q

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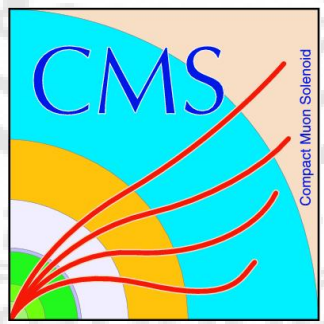
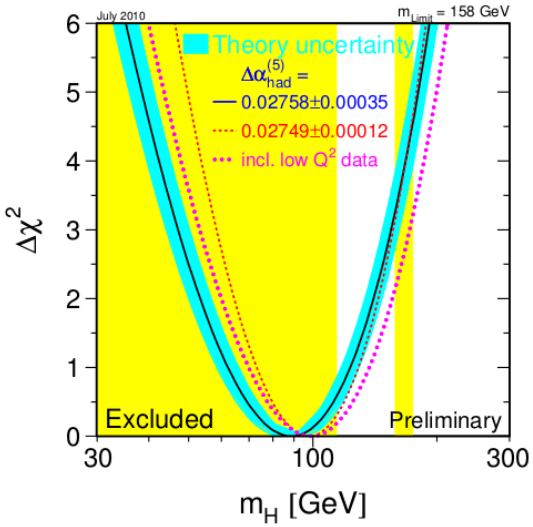


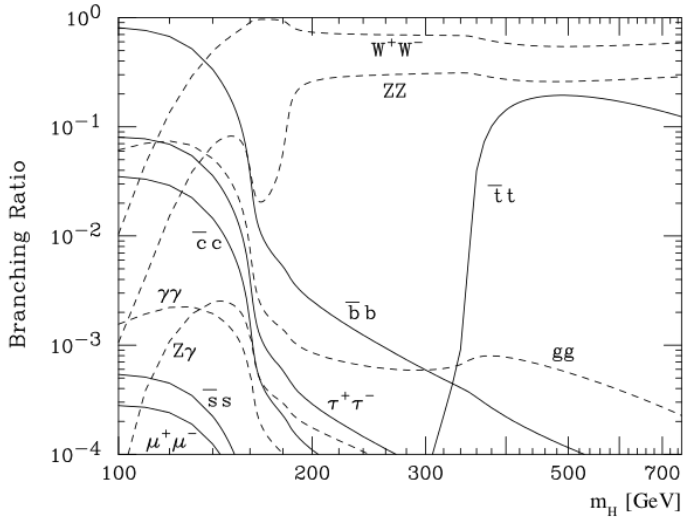
Why H → ZZ → 2l2q



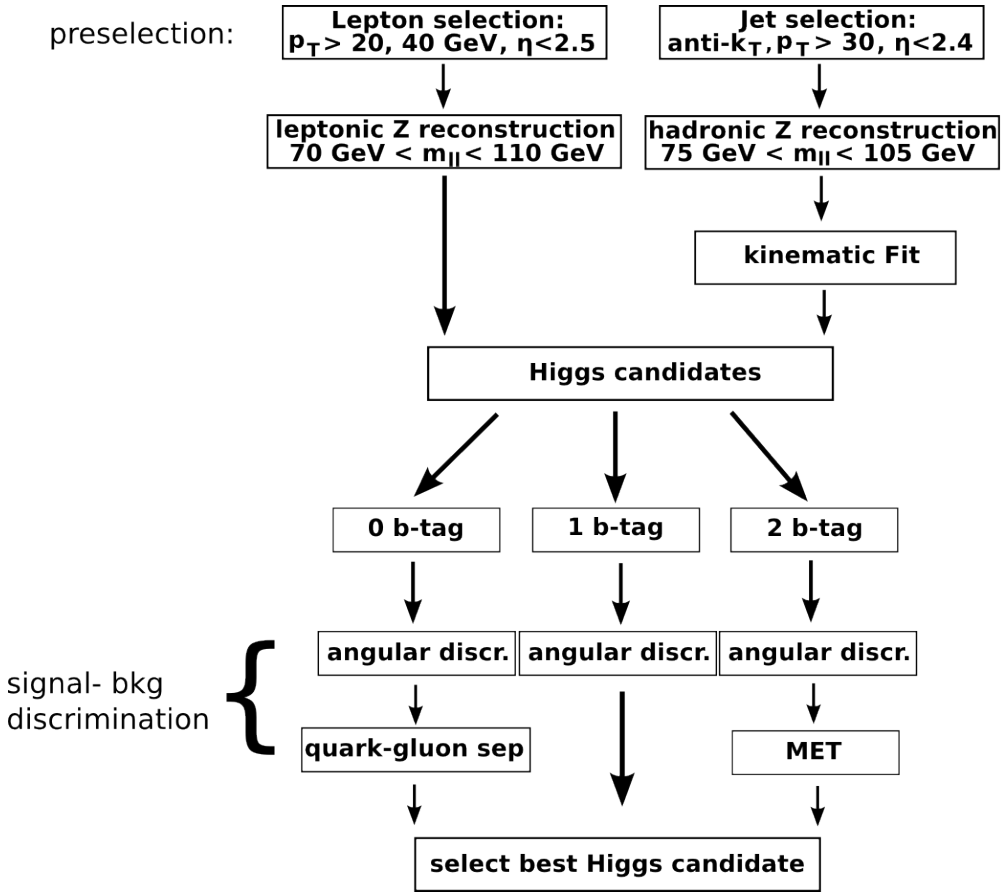
- electroweak precision measurements constrain Higgs mass to low masses
- **BUT:** constraints rely on theoretical assumptions

  $\Longrightarrow$ cover all mass ranges

- $m_H > 200$ GeV: $\mathrm{H} \to \mathrm{W^+W^-}, \mathrm{ZZ}$
- BR(H→ ZZ→ 2l2j) $\approx 20 \cdot \mathrm{BR}$(H→ ZZ→ 4l)
- decay fully reconstructable
- large Z + jets background



Analysis Chain



- up to 20 pile-up events
  $\rightarrow$ jet energy is raised
  $\rightarrow$ substraction
- several Higgs candidates because of hadronic Z
- split into b-tag categories
- choose Higgs with highest number of tags

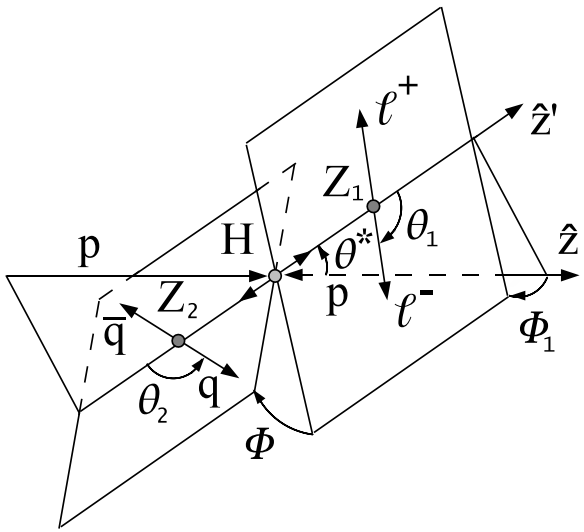
Signal - Background discrimination I

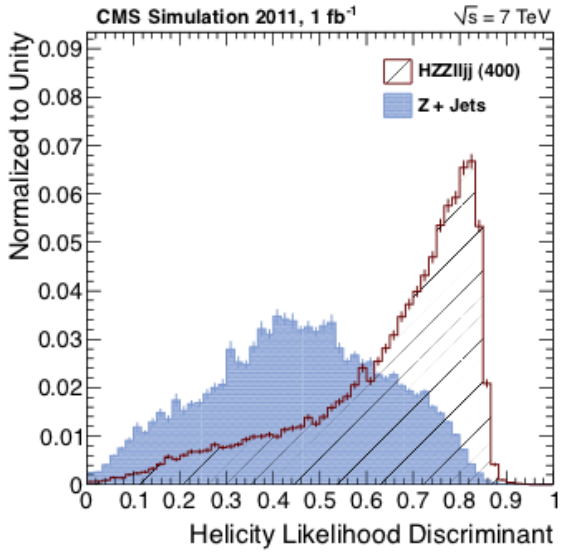
- cross section of Z + jets background $\approx 10^5$ times larger than signal $\Longrightarrow$ good separation between signal and bkg needed

1. angular discriminant:

- final state can be fully described by five angles
- build likelihood from the five probability distributions:

$$\mathrm{LD} = \frac{P_{bkg}}{P_S + P_{bkg}}$$





Signal - Background discrimination II

2. jet flavor:

- jets in signal: democratically distributed over u, d, c, s, b
- jets in background: $\approx 45\%$ gluon jets and 0% b jets
- split into different b-tag categories
- gluons produce more particles during hadronization
  $\Longrightarrow$ quark-gluon discriminant:
  charged and neutral particle multiplicity and

$$p_T D = \frac{\sum p_T^2}{(\sum p_T)^2}$$

3. missing transverse energy:

- 2 b-tag category is dominated by semileptonic $t\bar{t}$ background
- cut on missing transverse energy: MET < 10 GeV

Higgs production

- two different production mechanism:

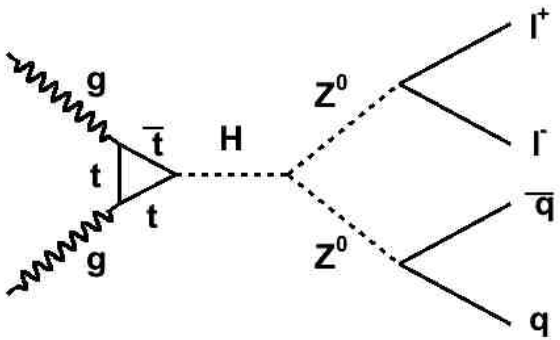


Figure: gluon-gluon fusion

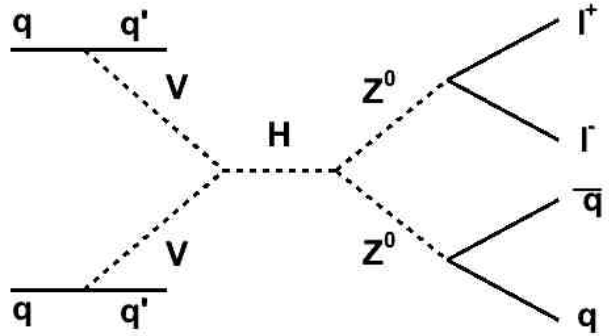


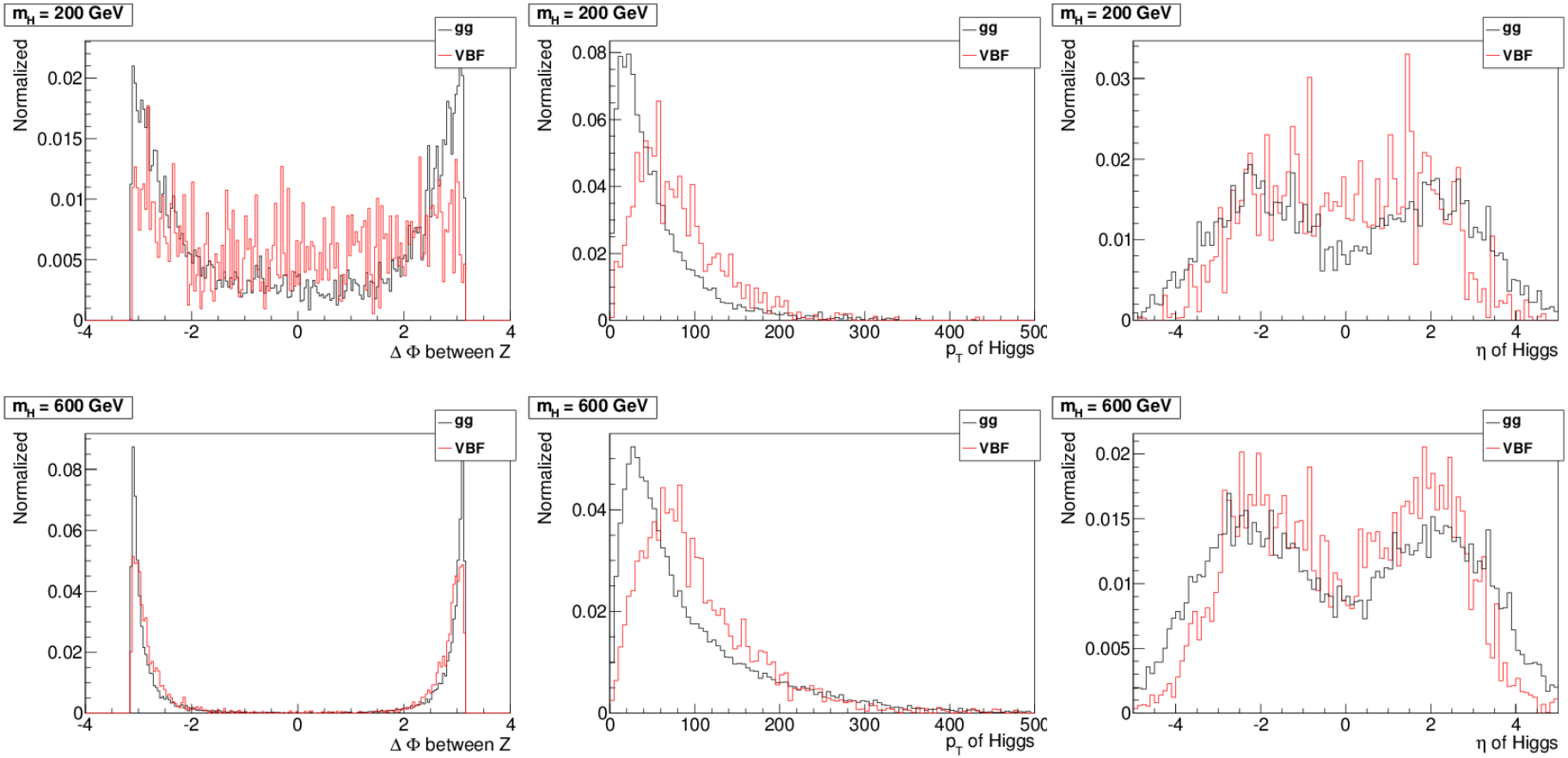
Figure: vector-boson fusion

- summer student project: focus on vector-boson fusion (VBF)

$\Downarrow$

1. compare kinematic variables in gg and VBF

Comparison between gg and VB fusion



Efficiencies

Efficiency

$$\epsilon = \frac{N_{\text{passed}}}{N_{\text{total}}}$$

- studies with MC simulations show that efficiency for gg-process is higher
- use extra jets in VBF to optimize efficiency
- loosen other selection criteria

Efficiencies after full selection

m_H [GeV]	300	400	500	600
gg	12.10%	16.43%	17.43%	15.87%
VBF	11.99%	15.81%	16.09%	14.16%

Efficiency checks

1. check if reconstructed jets match with generated jets
2. check efficiencies if only preselection is applied

m_H [GeV]	300	400	500	600
gg	17.67%	17.45%	24.06%	26.40%
VBF	17.66%	17.89%	22.44%	23.49%

3. choose no selection and check how often no Higgs appears

	no lept. Z	no hadr. Z
gg	56.07%	35.43%
VBF	59.46%	41.29%

Conclusion and Outlook

- vector boson fusion is less efficient than gluon gluon fusion
- the reconstruction of the leptonic Z causes more often the failure of a Higgs candidate
- overlap of missing leptonic and hadronic Z-candidate
- hadronic Z candidate seem to cause the lower efficiency of VBF
- next step: check why leptonic and hadronic Z are not reconstructed