Search for WH associated production at Dø Tevatron

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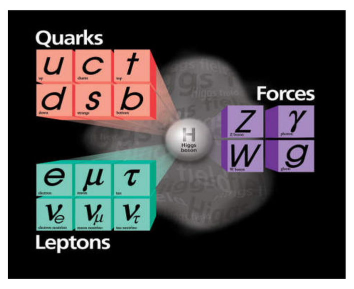
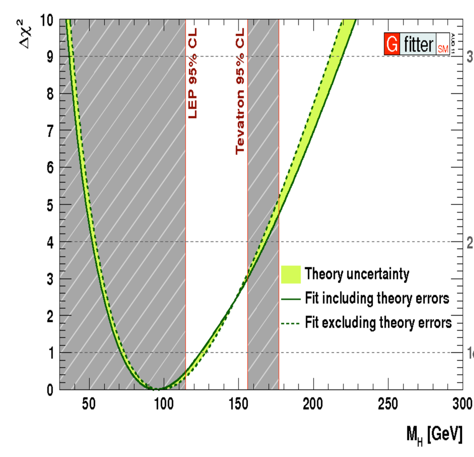
On behalf of the Dø collaboration

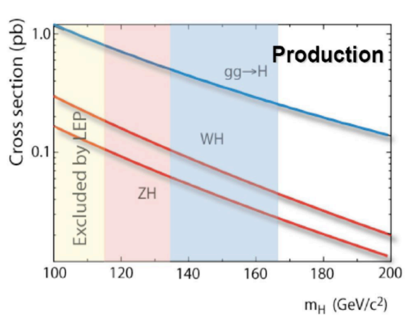
Low mass Higgs Search

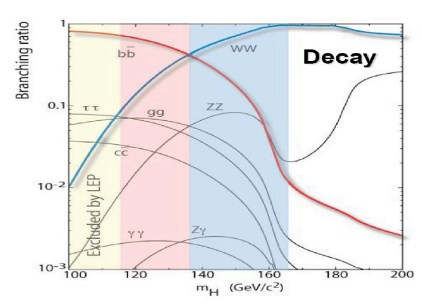


The Higgs boson is a key particle in the standard model, it is the source of the mass of every particle. Since its theoretical prediction in 1964, it has not been discovered by any experiment yet.



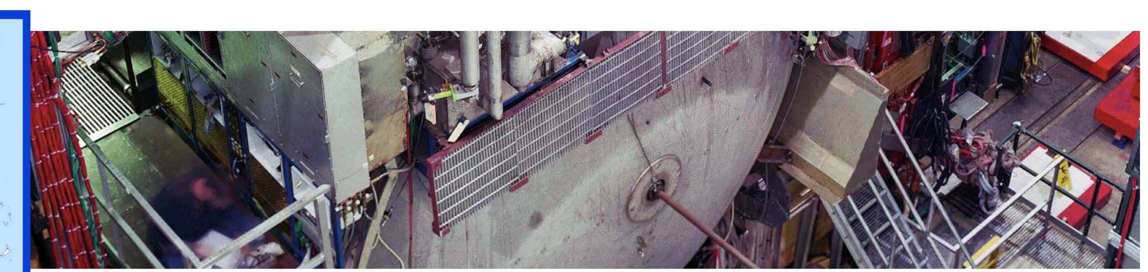
Nevertheless, direct searches at colliders, and measurements of electroweak observables show that the low mass region is a crucial area for the Higgs search.

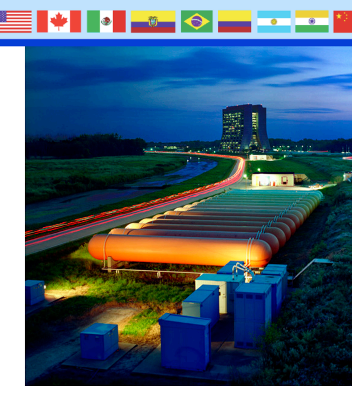




Gluon fusion has the greatest cross section over all the mass region. But at low mass, the Higgs boson decays in two b quarks, making it impractical to extract this signal within the overwhelming QCD background generated in a hadronic collider. Thus, the most sensitive channel is the WH associated production, the decay products of the W allowing to drastically reduce the hadronic background.

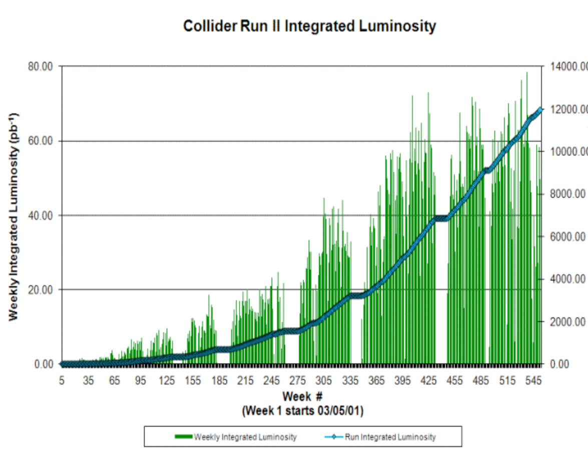
Experimental context





The Tevatron is the proton/antiproton collider of the american laboratory Fermilab. It can produce an energy of 1.96 TeV during the collisions. It allowed for example to discover the top quark in 1995. Dø is one the two Tevatron's multipurpose detector, designed to study high mass states and large Pt phenomena, design that suits very well the search of a standard Higgs boson.

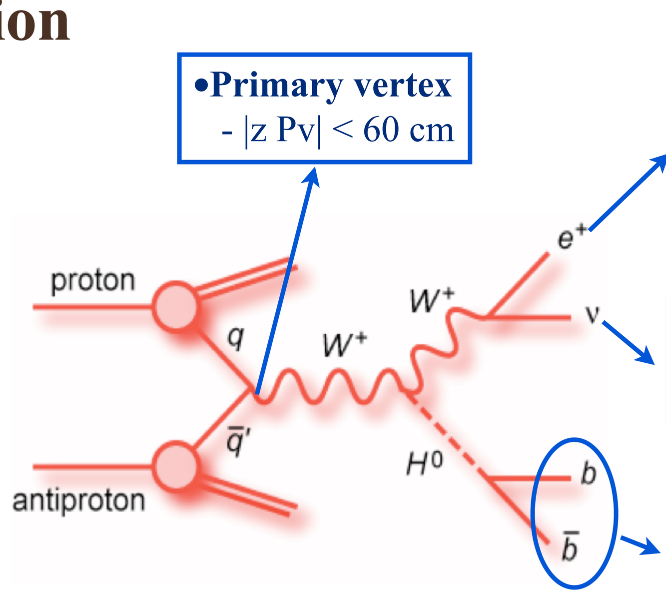
Tevatron's shutdown september the 30th 2011 leaves us about 12 fb^{-1} data to analyze, which gives us good chances to restrain the domain of existence of the Higgs boson, or even to discover it.



The WH analysis selection

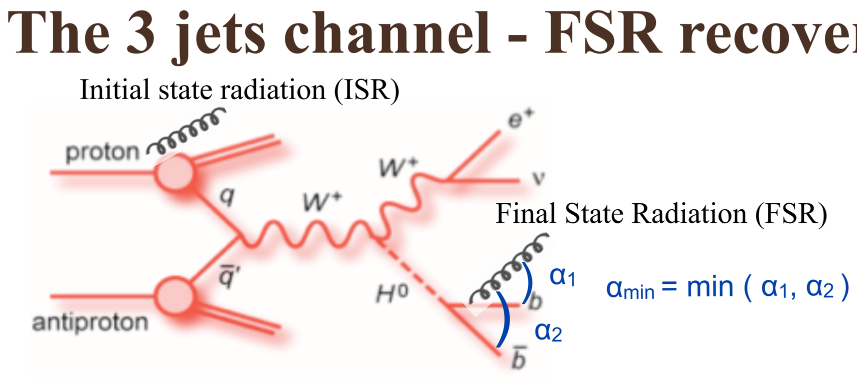
Higgs production is very rare, among the billions of collisions produced at Tevatron, only a fistful is likely to produce this particle. Thus, we have to develop powerful tools to reject every event that is unlikely to be interesting.

In order to reject the vast majority of the QCD background, we require several kinematical and topological characteristics on each events.

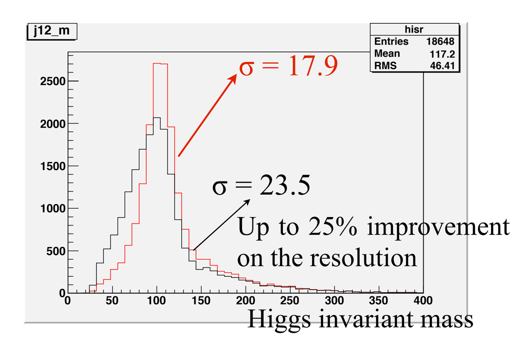


- •Primary vertex
  - |z Pv| < 60 cm
- •Electron "Tight"
  - EMID
  - $P_t > 15$ GeV
  - $0 \leq |\text{Detector } \eta| \leq 2.5$
  - second lepton veto
- •Missing transverse energy (MET)
  - MET ≥ 15 Gev
- •Jets
  - Number of jets ≥ 2
  - $P_t > 20$ GeV
  - $0 \leq |\text{Detector } \eta| \leq 2.5$
  - MVA QCD cut

The 3 jets channel - FSR recovery



$\alpha_{min} = \min(\alpha_1, \alpha_2)$

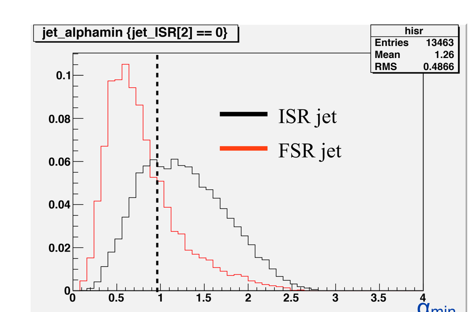


Usual Higgs invariant mass, reconstructed from the two leading jets.

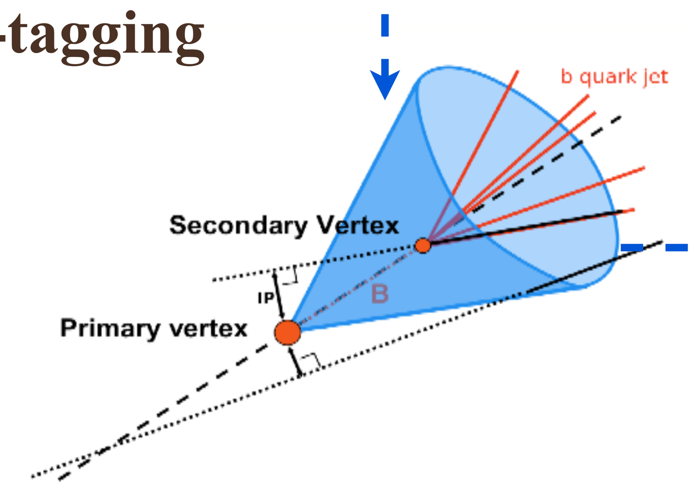
Higgs invariant mass, reconstructed from the two leading jets + the third jet when it is a FSR jet.

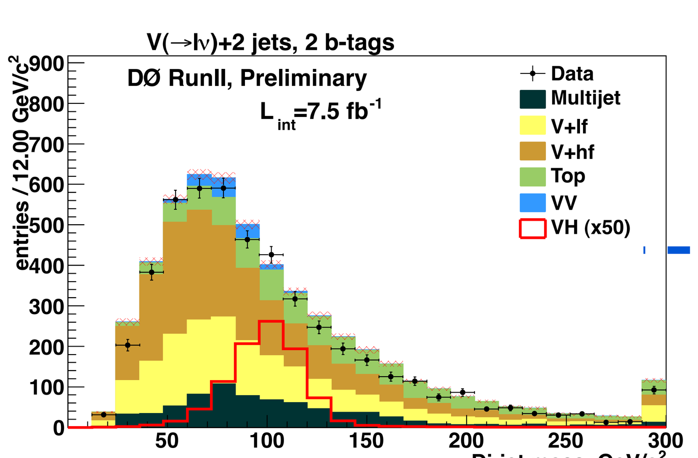
In a 3 jets selection case, the third jet is either an ISR jet or a FSR jet. To be able to reconstruct the Higgs invariant mass, we have to take into account the FSR jet and be sure not to take the ISR jet. This means that we have to be able to differentiate these two kinds of jet.

We use an angular distribution (α_{min}), which correspond to the minimal angle between the third and first or second jet, to select events where the third jet is more likely to be a FSR jet.



b-tagging

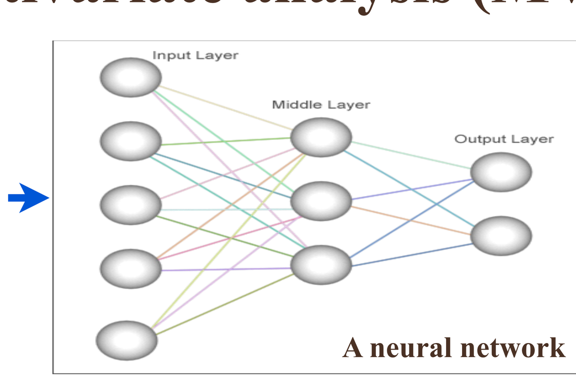




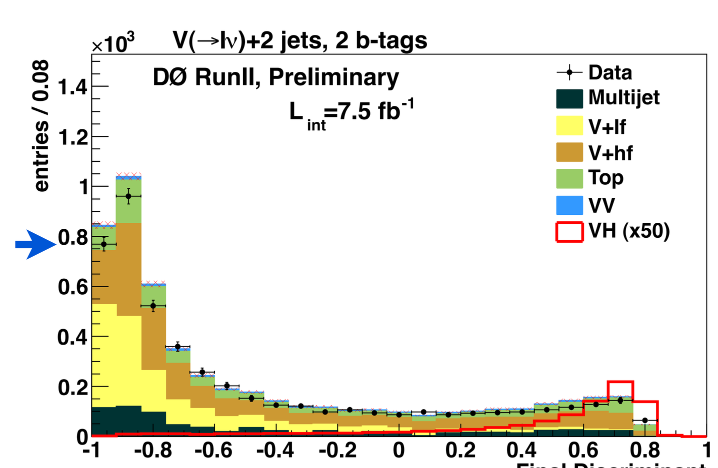
Unfortunately many standard model processes pass the analysis selection. Then, we use a crucial tool for low mass Higgs search : the b-tagging. An event in which we can identify a b jet is more likely to be a Higgs event. This algorithm is based on the characteristics of the b quarks (high mass) and B meson (long life time) which lead to :

- A secondary vertex (about 3 mm apart from the primary vertex).
- High impact parameter tracks (noted IP on the figure).
- A higher secondary vertex mass and a different jet angular opening.
- The possible presence of a muon in the jet reconstruction cone.

Multivariate analysis (MVA)

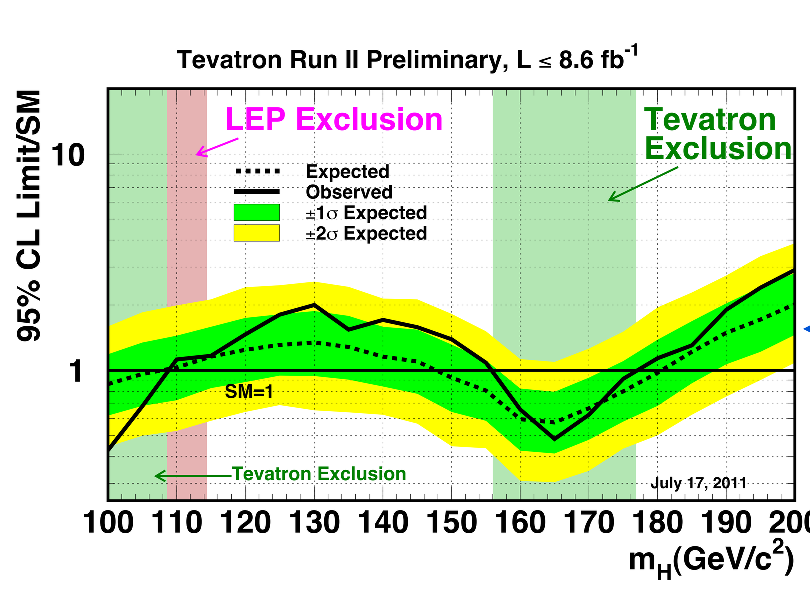


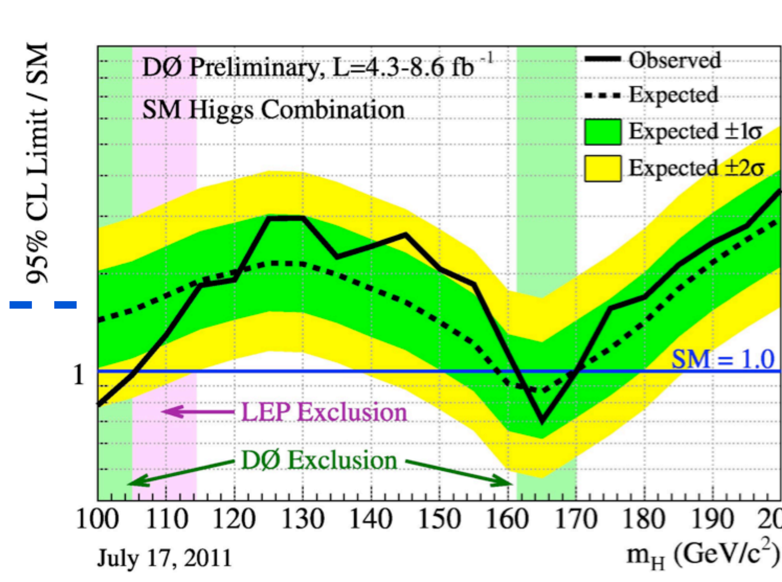
A neural network

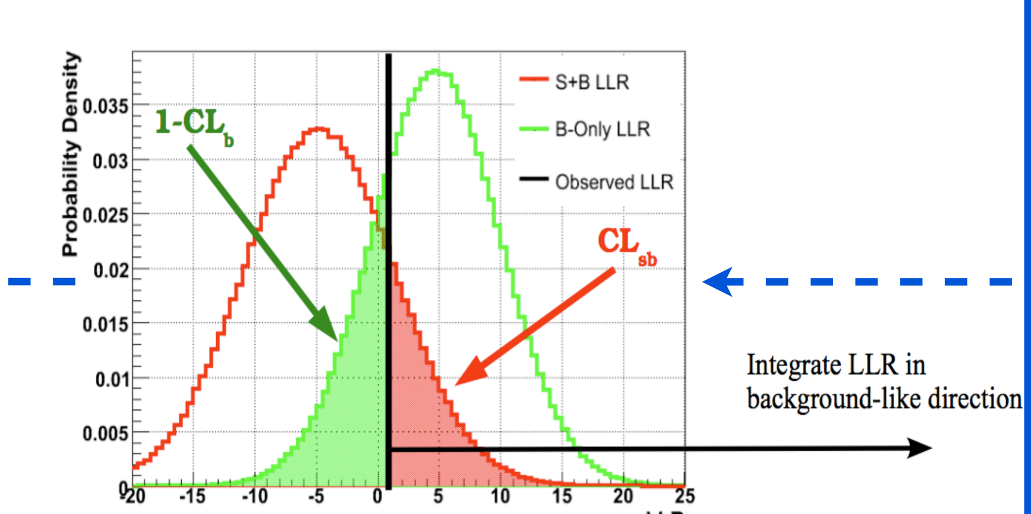


The di-jet mass reconstruction is an important step in the analysis, this variable being the most important. But still, the signal is too weak to be able to observe it directly on top of this distribution. We have to combine several informations discriminating between signal and background with multivariate analysis techniques (neural network, decision tree etc.) to improve the discrimination. Multivariate analysis have been successfully used in high energy physics for over a decade, it allows to optimize discrimination using multiple distributions as well as using the correlations between input variables. In the WH analysis, we use a MVA discriminant based on boosted decision trees from the TMVA package.

Extracting the limit







In the end, a statistical approach allows us to set an upper limit on the ratio between the observed (resp. expected) Higgs production cross section and its theoretical cross section for each Higgs mass considered. The latest result obtained in the WH channel using 7.5 fb^{-1} at Dø is 4.6 (resp. 3.5) for a 115 GeV/c^2 Higgs boson. Results at Tevatron combination level are very promising since the observed limit is below twice the standard model on the all low mass range. We also looked at WZ and ZZ events as signal to study our sensitivity to WZ + ZZ production. We measured a cross section of 7.20 ± 2.03(stat.) ± 2.74(syst.) pb, with a significance of 2.2 standard deviations.