Measurements of diboson production in lepton plus jets decays at the Tevatron

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On behalf of the CDF and D0 collaborations

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Physics goals

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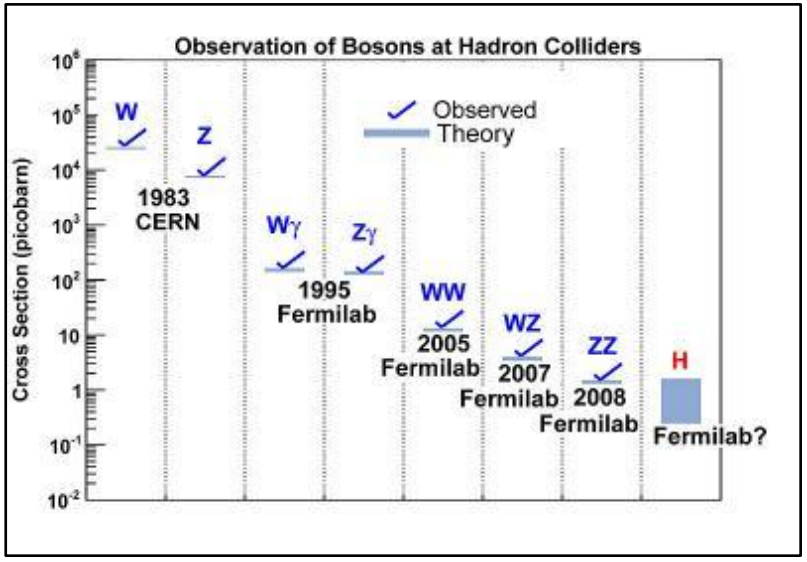


- Diboson physics at hadron colliders

➔ interesting by itself: precise cross-section predictions in the SM (NLO), new physics search via TGC enhancement,…

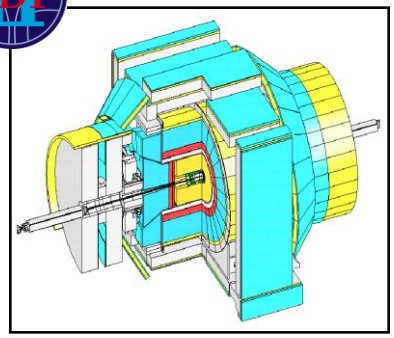
- *WW*, *WZ* and *ZZ* cross sections

➔ all measured in leptonic final states

- In the last years, interest turned to the lepton+jets decays

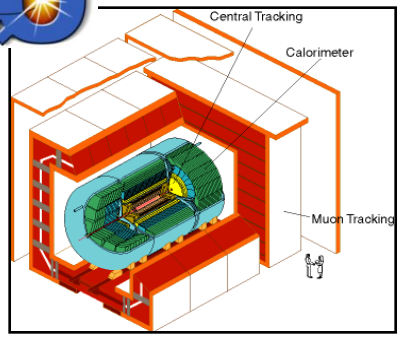
➔ **exact same topology as the Higgs boson associated production**

In this presentation: focus only on the leptons+jets decays



Tevatron: $p\bar{p}$ Collisions collider

- E(c.m.) = 1.96 TeV
- average luminosity : ~1-1.5 10^{32} $cm^{-2}.s^{-1}$
- dataset: ~8 fb^{-1} available for analysis (expect ~10 fb^{-1} by end of September 2011)



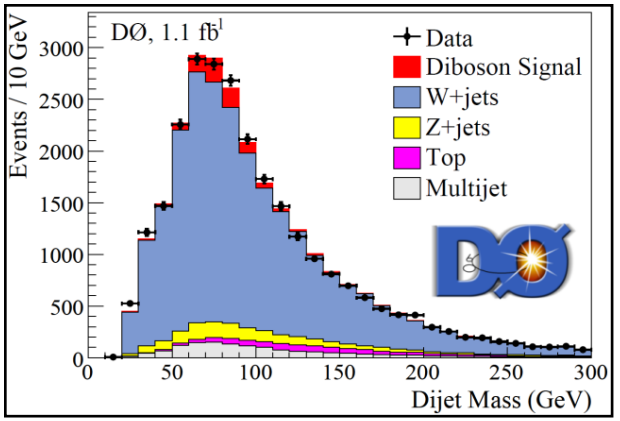
Past results

3 published results

- *Evidence of WW and WZ Production with lepton +jets Final States in $p\bar{p}$ Collisions at $\sqrt{s}$=1.96 TeV*

[Phys. Rev. Lett. **102**, 161801 (2009)]

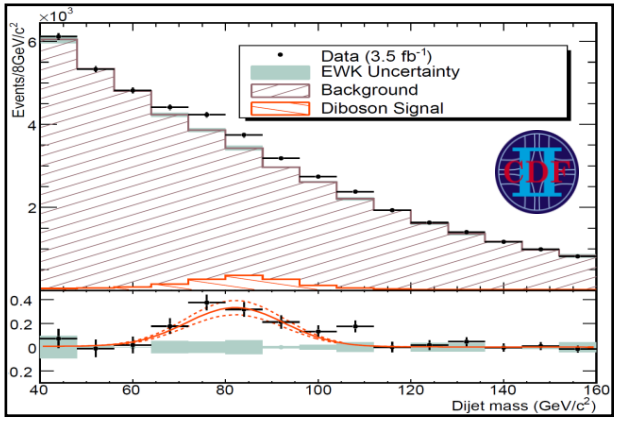
4.4 σ for *WW+WZ*



- *First Observation of Vector Boson Pairs in a Hadronic Final State at the Tevatron Collider*

[Phys. Rev. Lett. 103, 091803 (2009)]

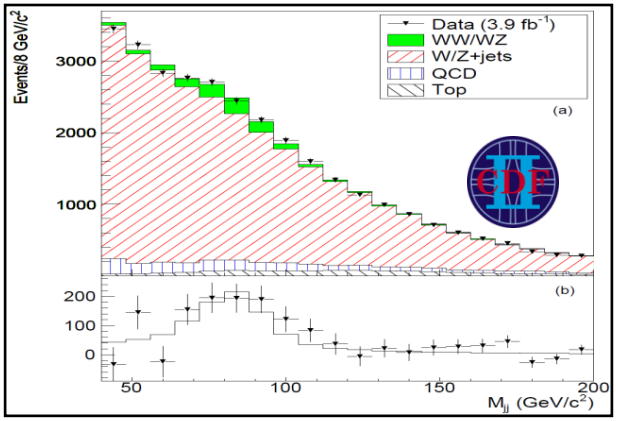
5.3 σ for *WW+WZ+ZZ*



- *Measurement of the WW+WZ Production Cross section using the Lepton+jets final state at CDF II*

[Phys.Rev.Lett. 104, 101801 (2010)]

5.3 σ for *WW+WZ*



The ultimate low mass Higgs benchmark at the Tevatron

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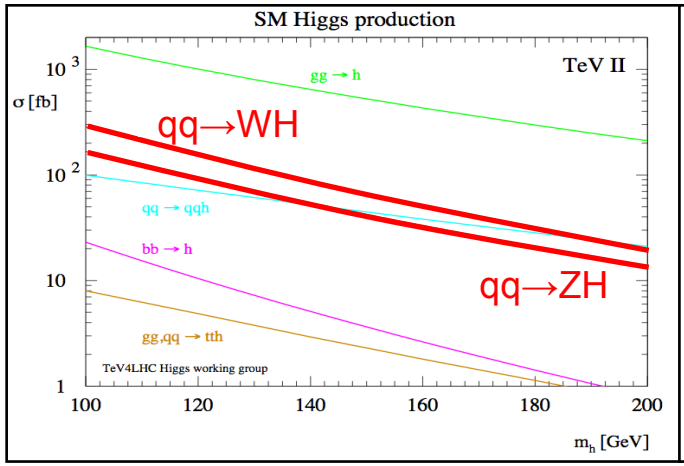

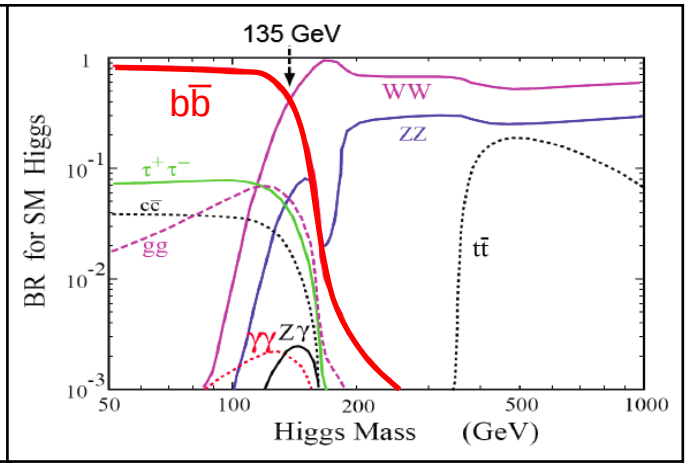

For m_H=115 GeV

WH→*lνbb*: σ = 26 fb

ZH→*ννbb*: σ = 15 fb

ZH→*llbb*: σ = 5 fb

Total VH: 46 fb

For *lν* and *ll*: *l* = *e*/*μ*

Let's replace the Higgs boson by our well-known *Z* boson

WZ→*lνbb*: σ = 105 fb

ZZ→*ννbb*: σ = 81 fb

ZZ→*llbb*: σ = 27 fb

Total VZ: 213 fb

σ(*VZ*→leptons+*bb*) ~ 5 σ(*VH[115]*→leptons+*bb*)

But more challenging *WW* background in the *Z* case
➔ dijet mass resolution too large to distinguish the hadronic decays of *W* and *Z*

The observation of this process is the last milestone to demonstrate the Tevatron capability to observe the Higgs in the *bb* channel

New results…towards this benchmark…

3 preliminary results

➔ all these new results consider *b*-tagged jets in the final state

- ***WZ+ZZ search in dilepton plus jets***

  Reference: CDF conference note 10601

6.6 fb^{-1}

- ***WW+WZ search in lepton-neutrino plus heavy-flavor jets***

  Reference: CDF conference note 10598

7.5 fb^{-1}

- ***WZ+ZZ search in missing transverse energy plus heavy-flavor jets***

  Reference: D0 conference note 6223

8.4 fb^{-1}

WZ+ZZ search in ll + jets

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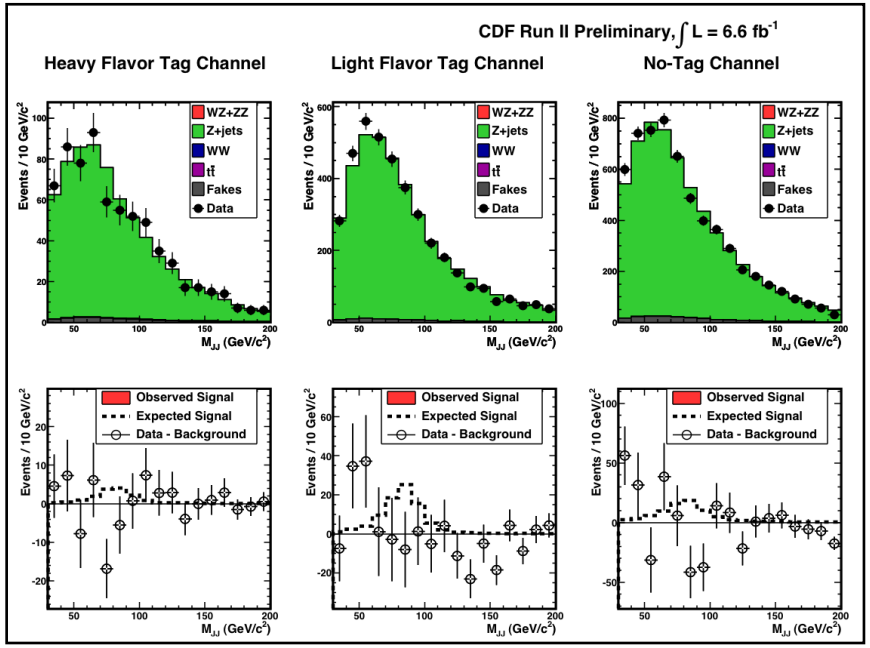
Selection: 2 leptons (electron/muon, 20 GeV), $76<M_{ll}<106$ GeV and at least 2 jets (20 GeV)

- Define three samples: a heavy-flavor tagged sample, a light-flavor tagged sample and an untagged sample
- *Z*+jets background shape adjusted using a modified jet energy scale for gluon jets (correction derived from the *Z*-jet p_T balance)

Yields	no-tag	LF-tag	HF-tag
Signal	80	87	16
Backg.	5690	3600	770
S/√B	1.1	1.5	0.6

The final discriminant used is the dijet invariant mass: combination of three samples



- Distributions after a global fit of the background normalizations and of the systematic uncertainties
- Sensitivity not yet sufficient to observe the signal

➔ **expected limit: 2.6 σ_{SM}**

WW+WZ search in $l\nu$ + HF jets (1/2)

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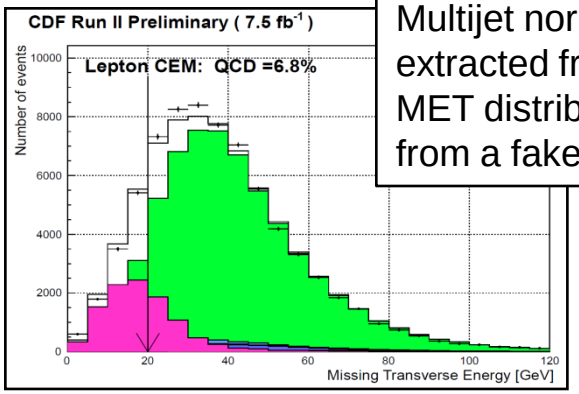
Selection: 1 lepton (electron/muon, 20 GeV), MET>20 GeV and exactly 2 jets (20 GeV)



Multijet normalization extracted from a fit to the MET distribution (template from a fake lepton sample)

Background models

- Rejection of the multijet background using a multivariate discriminant
  ➔ **R_B~90% / ε_S~95%**
- *W* + LF jets: normalization in the tagged samples from the pretag sample using mistag-rates derived from data
- Other backgrounds extracted directly from simulation

Yields	1-tag	2-tag
Signal	215	11
Backg.	5514	396
S/√B	2.9	0.6

In 1-tag: WW ~74% of the signal

In 2-tag: WZ ~88% of the signal

Most of the sensitivity of this search comes from the *W* decay into a charm-strange quark pair

WW+WZ search in $l\nu$ + HF jets (2/2)

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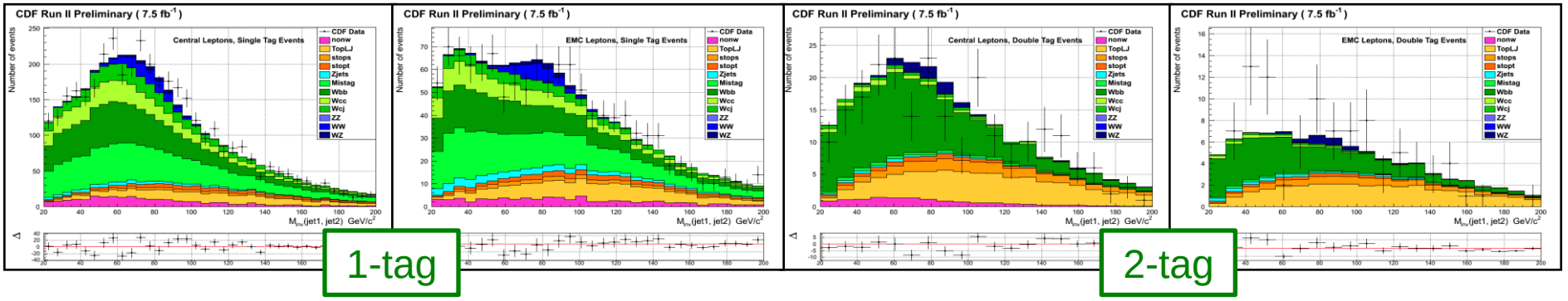
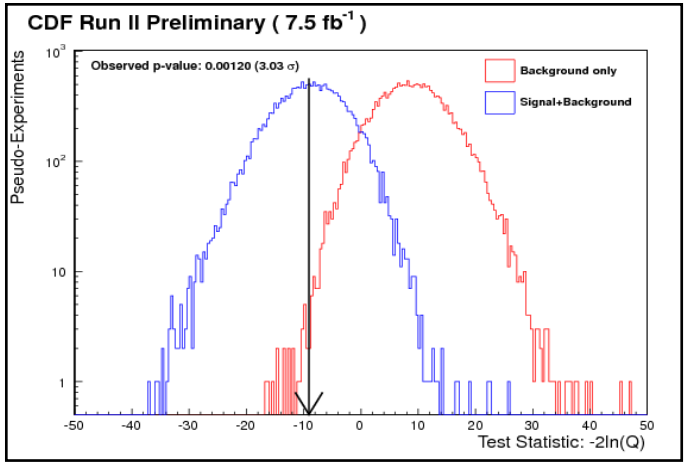
The final discriminant used is the dijet invariant mass

➔ combination of four samples: central leptons/non-central muon, 1-tag/2-tag



LLR for the B-only and S+B hypotheses

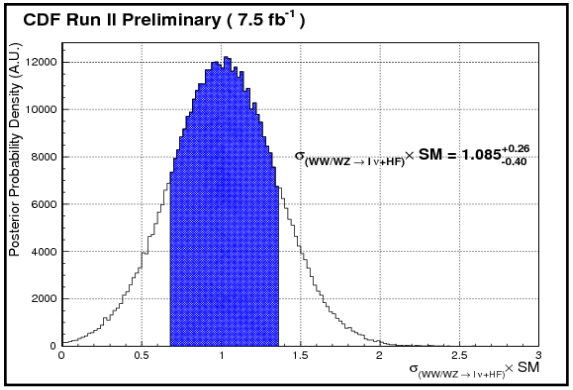


WW+WZ→$l\nu$+HF jets observed with a significance of 3.0 S.D. from the B-only hypothesis

Cross-section measurement:

$$\sigma(\mathrm{WW}+\mathrm{WZ}) = 1.1^{+0.3}_{-0.4} \cdot \sigma_{SM}$$

Bayesian posterior



WZ+ZZ search in MET + HF jets (1/3)

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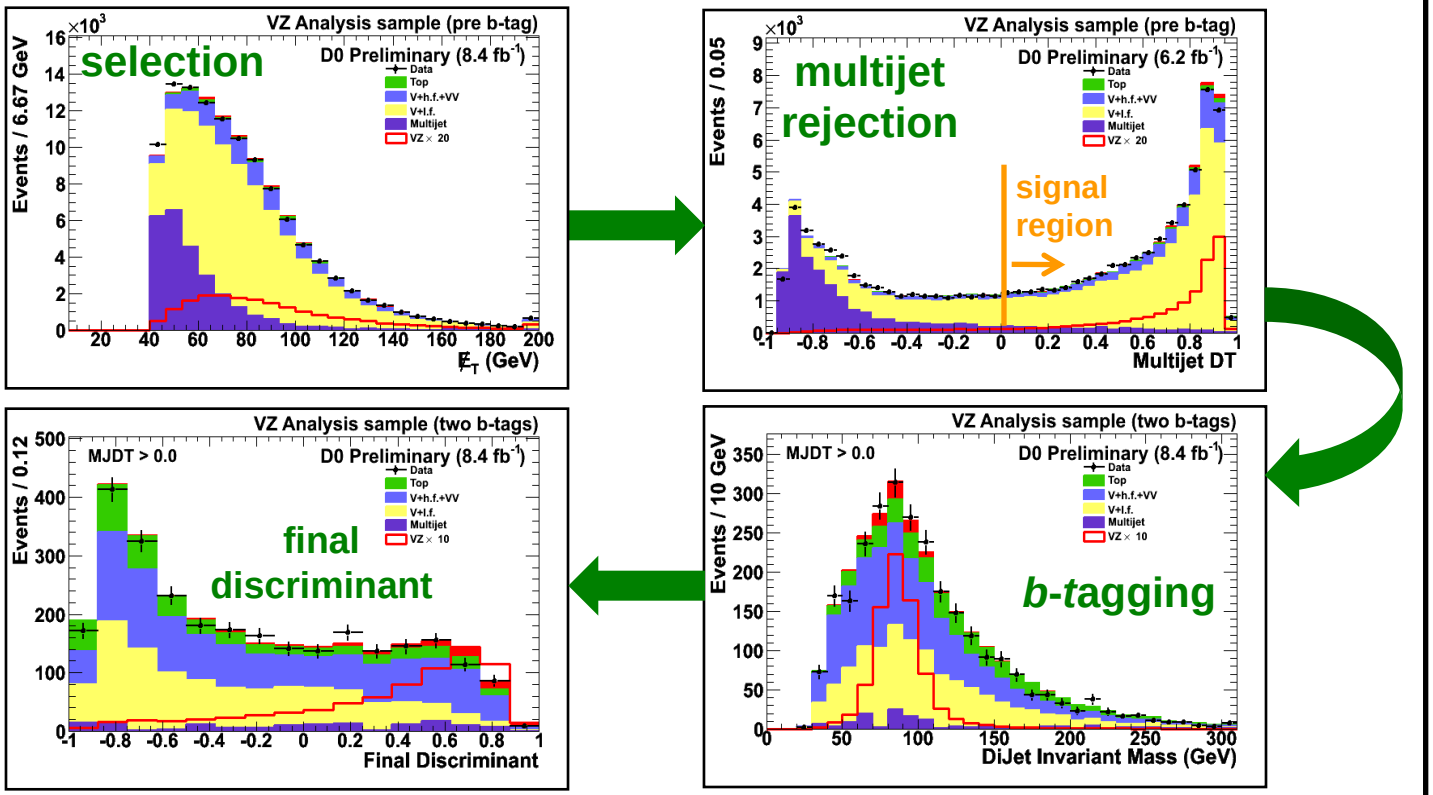
Selection: high missing transverse energy (40 GeV) and exactly 2 jets acoplanar (20 GeV)

A lepton veto is applied to keep orthogonality with the similar search in the *lvbb* channel but important *WZ* contribution from events with a non-identified lepton

This analysis is a copy of the analogous low mass Higgs search in the same final state: the only difference is the signal used for the training of the final discriminant, *VZ* instead of *VH*

Analysis strategy



WZ+ZZ search in MET + HF jets (2/3)

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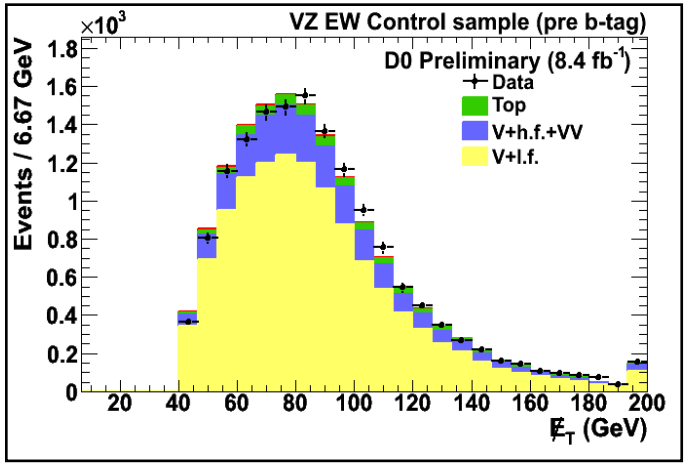
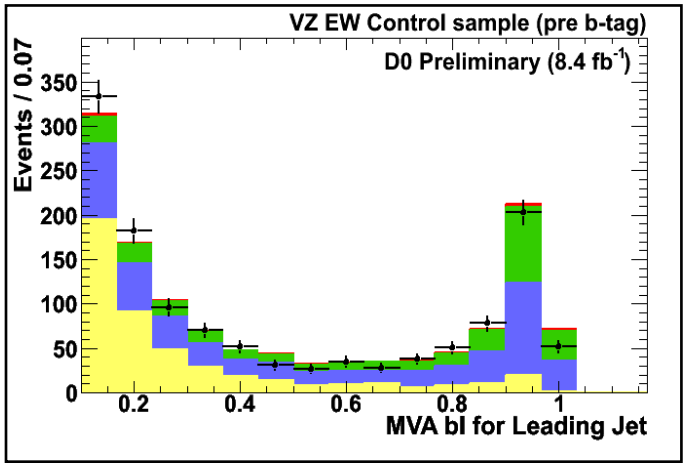
Control samples are used to validate and improve the background modeling:

- multijet control sample (loosening of the MET cut)
- electroweak control sample (inversion of the isolated muon veto)

Example: validation of the **trigger simulation** and of the ***b*-tagging algorithms** in the **electroweak control sample**





Relatively loose tagging requirements to define the 1-tag/2-tag samples but full *b*-tag output injected in the final discriminant

WZ+ZZ search in MET + HF jets (3/3)

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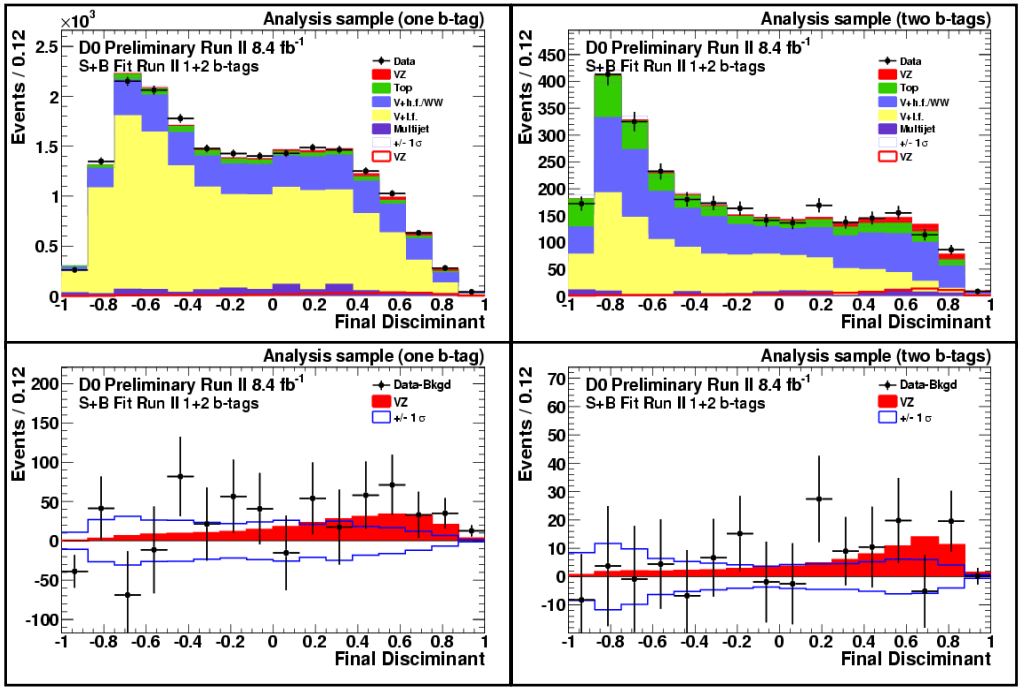
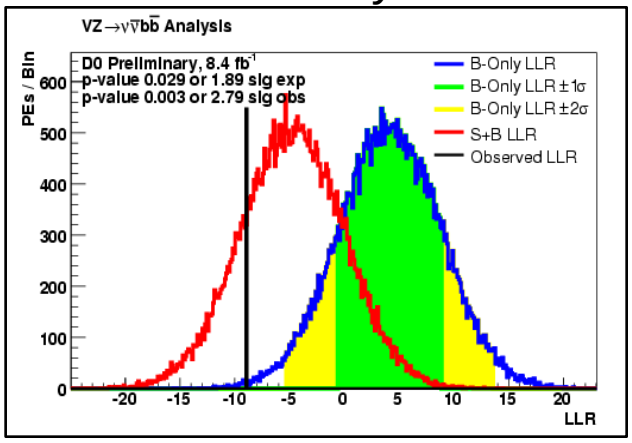
Yields	1-tag	2-tag
Signal	252	77
Backg.	18883	2725
S/√B	1.8	1.5

Final discriminants in the 1-tag and 2-tag samples after a global fit to the data in the S+B hypothesis with marginalization of the systematic uncertainties



LLR for the B-only and S+B hypotheses



WZ+ZZ→MET+HF jets observed with a significance of 2.8 S.D. from the B-only hypothesis (1.9 S.D. expected)

Cross-section measurement:

$\sigma(WZ+ZZ)_{mes} = 6.9 \pm 2.2$ pb

$\sigma(WZ+ZZ)_{th} = 4.6$ pb

Summary and prospects

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3 preliminary results presented

- ***WZ+ZZ*** *search in dilepton plus jets*
  - ➔ **expected limit: 2.6 σ_{SM}**

- ***WW+WZ*** *search in lepton-neutrino plus heavy-flavor jets*
  - ➔ **production observed with a significance of 3.0 S.D. from the B-only hypothesis**

- ***WZ+ZZ*** *search in missing transverse energy plus heavy-flavor jets*
  - ➔ **production observed with a significance of 2.8 S.D. from the B-only hypothesis**

In preparation: a Tevatron combination for the *WZ+ZZ search in lepton plus heavy-flavor jets*