Study of the Standard Model Higgs boson in $ZH \rightarrow l^+l^-bb$ at DØ

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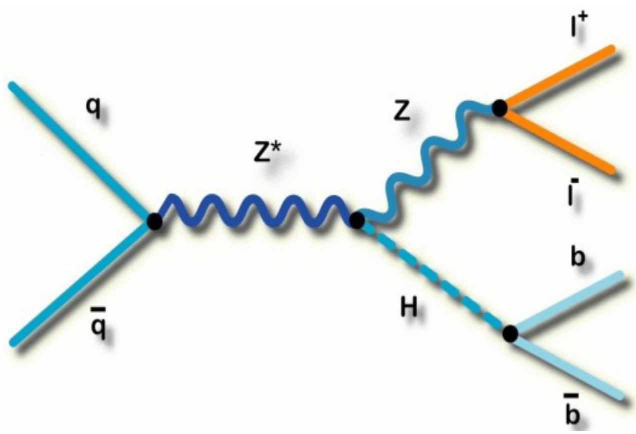
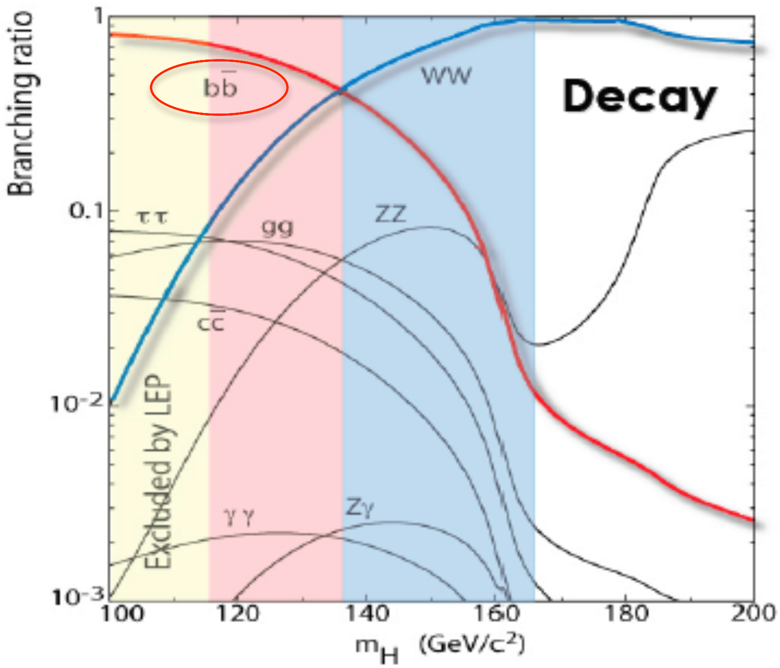
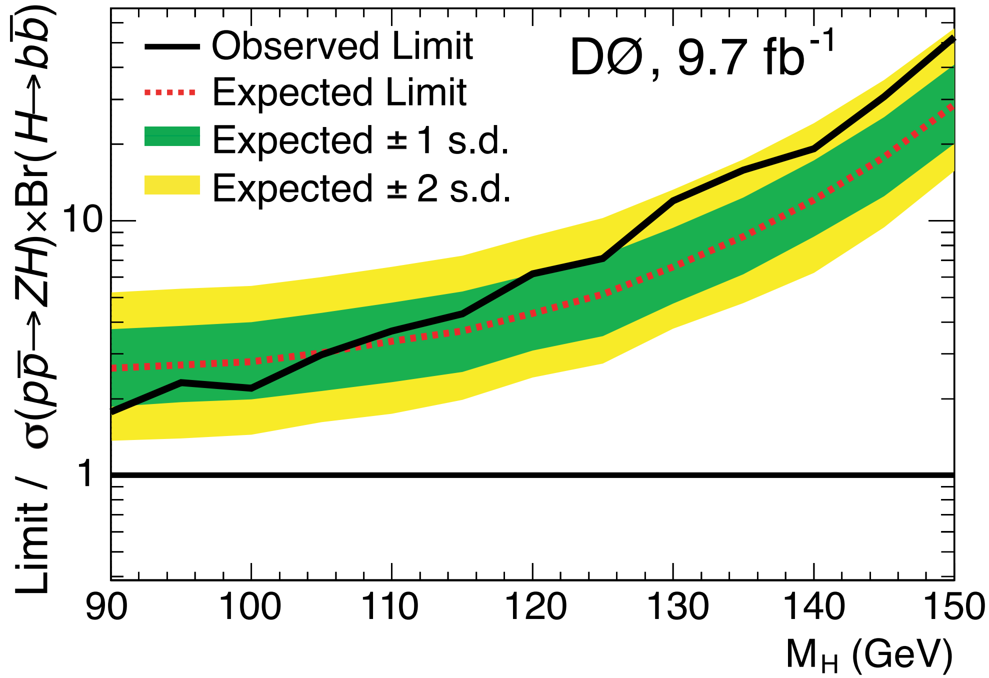
On behalf of the DØ collaboration

Higgs Hunting 2013, Orsay - France

Overview





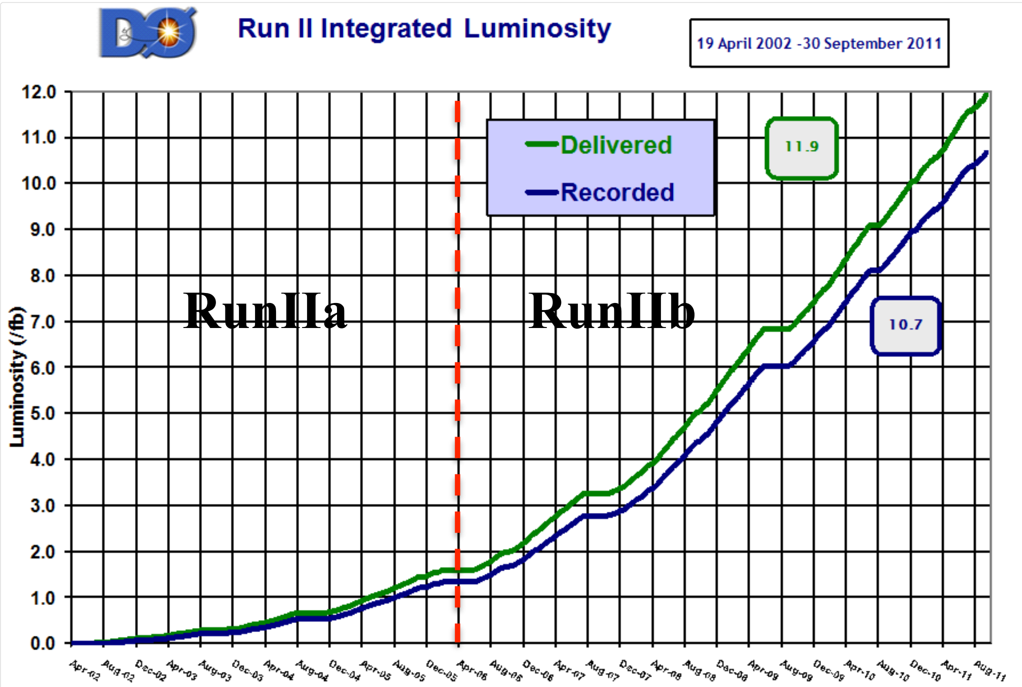


For m_H=125 GeV, the observed (expected) limit is **7.1 (5.1)** × SM cross section

Two papers with 9.7fb^{-1} data :

- Phys. Rev. Lett. 109, 121803 (2012), arXiv:1207.5819
- Accepted 04/22/13: Phys. Rev. D, arXiv:1303.3276

DØ reprocessed data



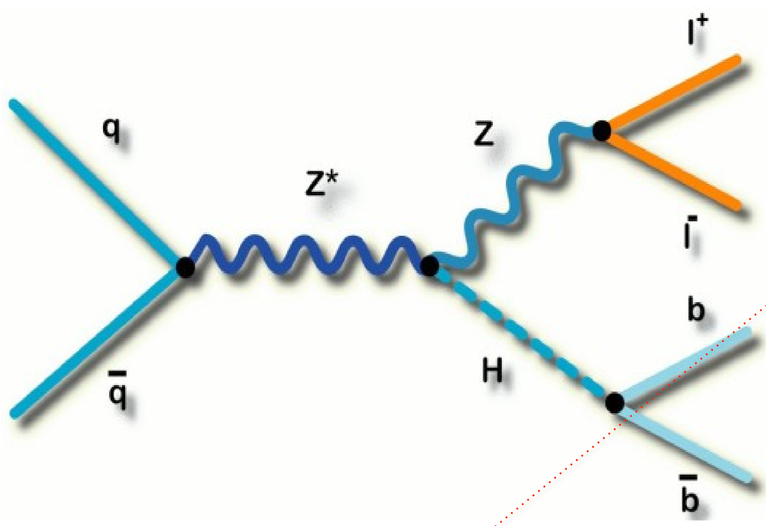
DØ Reprocessed dataset

- **8.6fb^{-1}** (RunIIb) after data quality requirements
- Improvements : lepton tracking, vertex algorithm
- New b-jet tagging tools

Analysis goals with reprocessed data:

- Perform the analysis with new version of dataset and MC samples; optimize the analysis strategy
- Higgs production cross section measurement

Event Selection



- $Z \rightarrow \mu^+\mu^-$ or $Z \rightarrow e^+e^-$ with $70 < m_{ll} < 110$ GeV
- at least two jets with $p_T > 20$ GeV and $|\eta| < 2.5$
- The primary vertex has at least three associated tracks

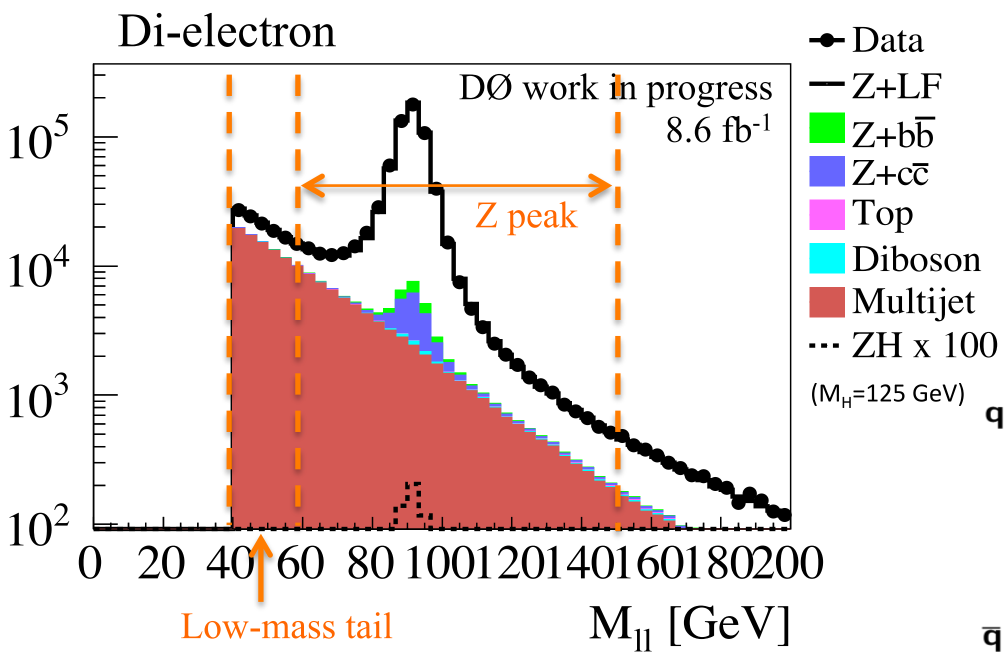
$\mu^+\mu^-$:

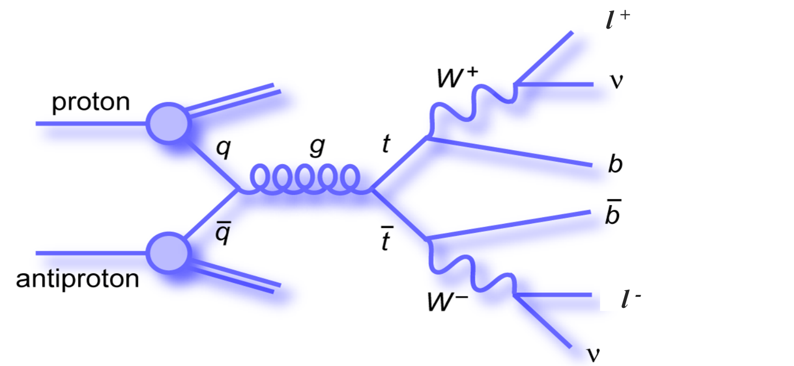
- at least one isolated muon with $p_T > 15$ GeV and $|\eta| < 1.5$
- at least one more isolated muon with $p_T > 10$ GeV, $|\eta| < 2.0$

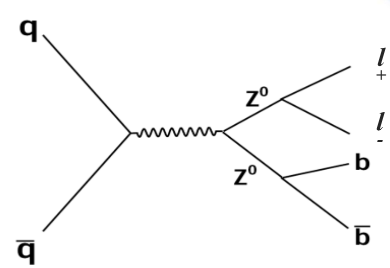
e^+e^- :

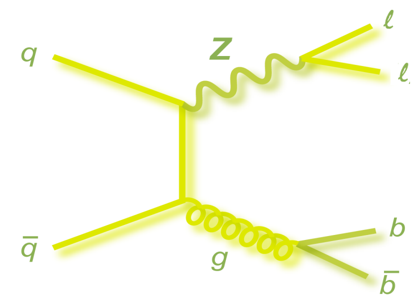
- at least one isolated electron with $p_T > 10$ GeV and $|\eta| < 1.1$
- at least one more isolated electron with $p_T > 15$ GeV, $|\eta| < 1.1$ or $1.5 < |\eta| < 2.5$

SM background



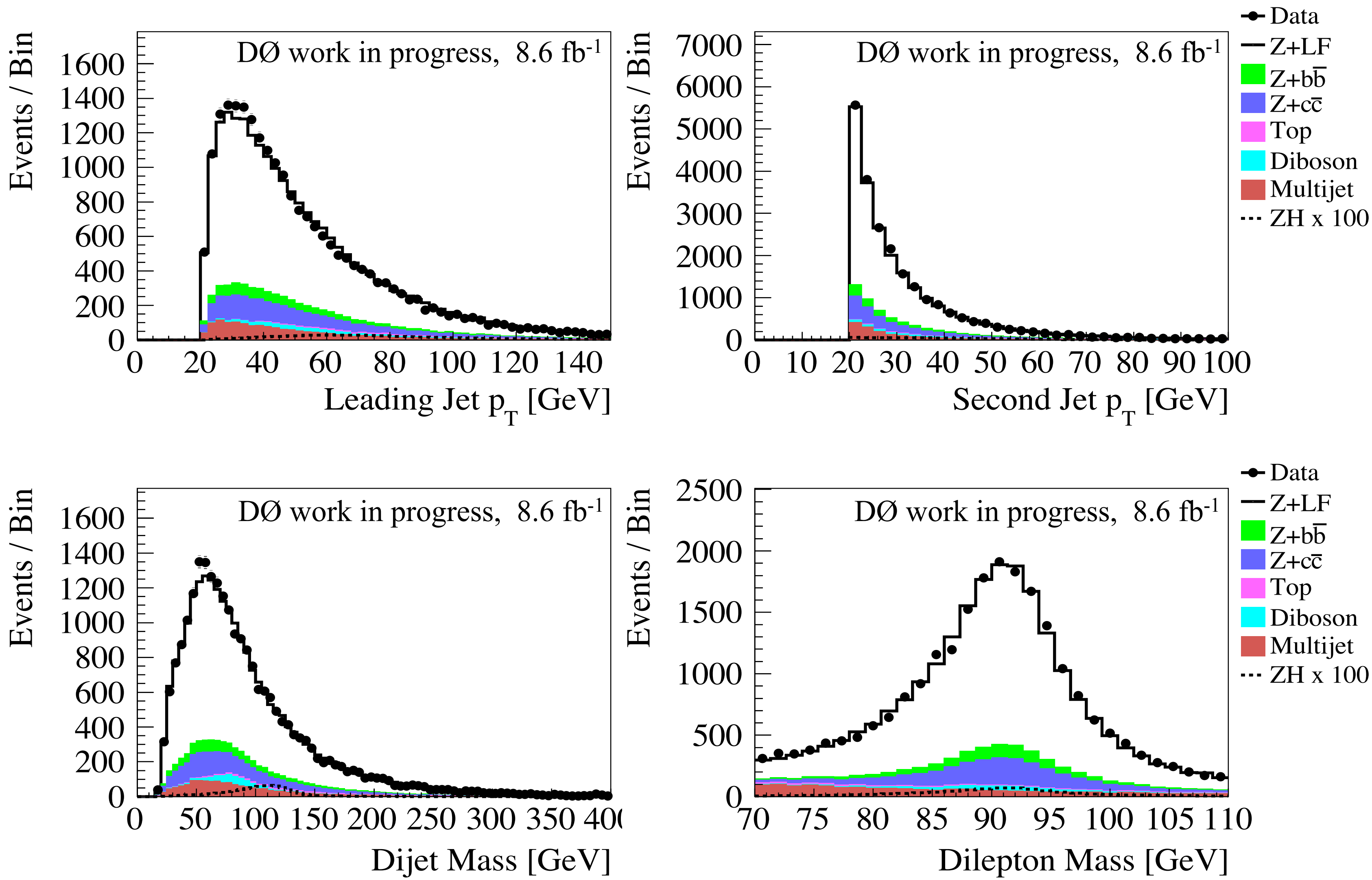






- ❑ Multijet backgrounds are estimated from control samples in data :
  - Di-muon : events with same-sign charge muons
  - Di-electron : inverting the electron isolation and shower shape requirements
- ❑ Normalization – global fit to the m_{ll} distribution :
  - Multijet samples normalized in the low-mass tail of the m_{ll} distribution
  - MC backgrounds normalized in the Z peak

Pre-btag selection

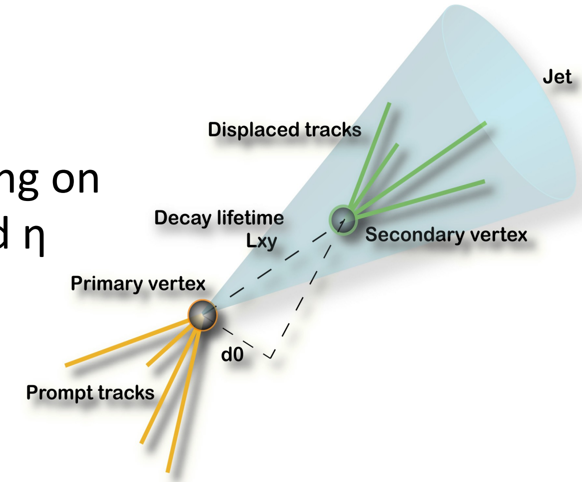


b-jet tagger

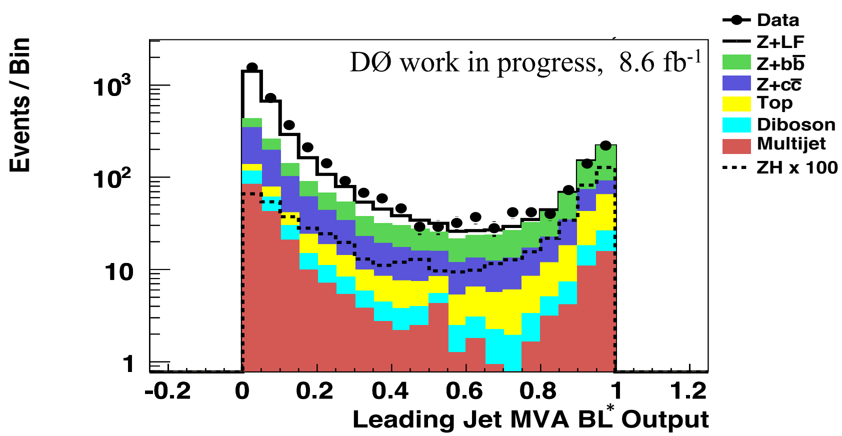
- Improved MVA technique based b-tagging algorithm [12 Operating Points(OPs)]

Operating Point	L6	Old Loose	Very Tight
Cut value	0.45	0.75	0.88
Efficiency to tag b-jet	~82%	~68%	~58%
Chance to tag light jet	~10%	~2%	~0.8%

depending on p_T and η



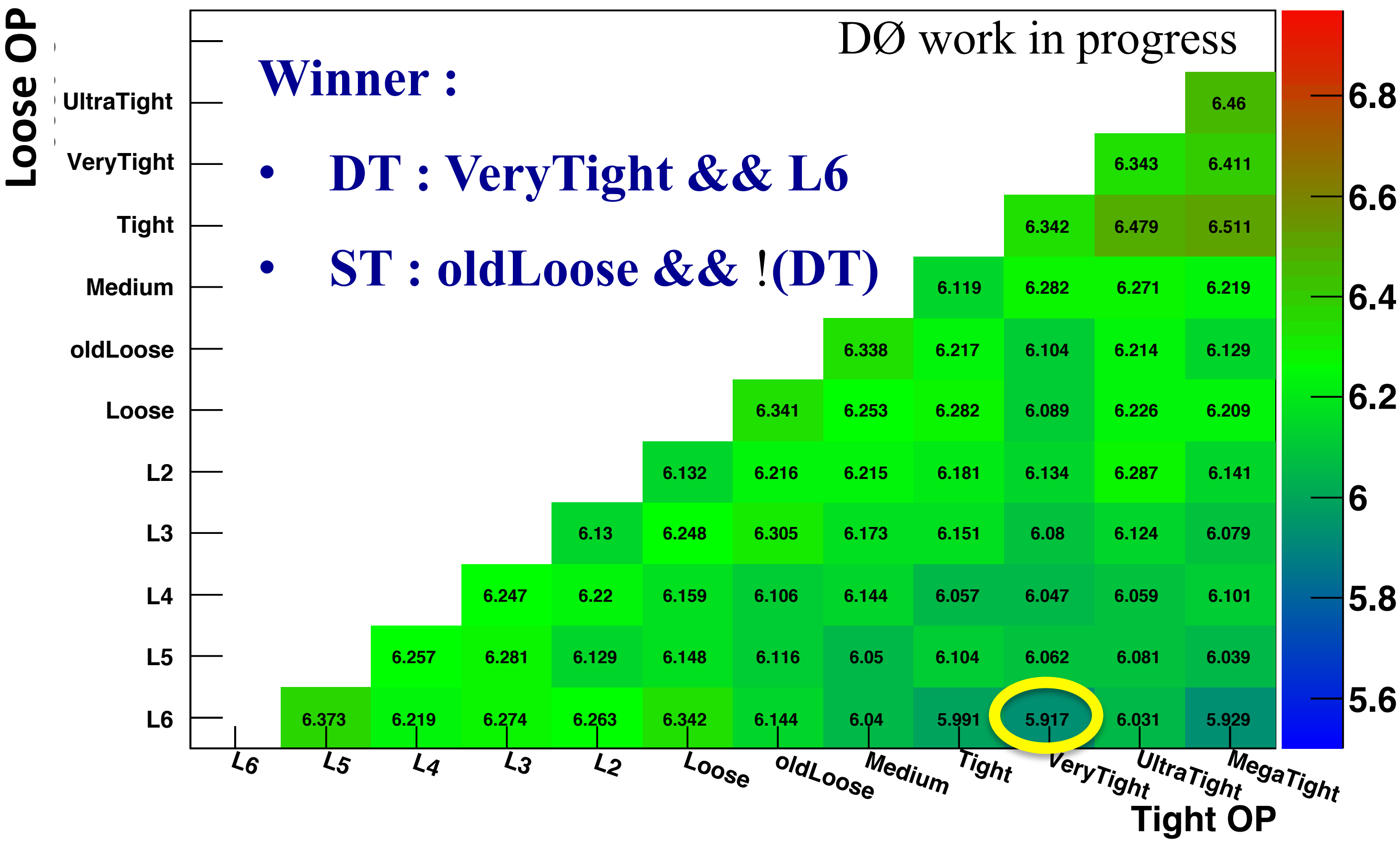
- Two b-tagging categories selection :
  - Double Tag (DT) : TightOP && LooseOP
  - Single Tag (ST) : SingleTightOP && !(DT)



- In DT, if more than 2 b-tagged jets, form a Higgs candidate with highest p_T tagged jets
- In ST, use the tagged jet and the highest p_T untagged jet

Optimize b-tag category

Expected limits M_H=125 GeV



	Pre-btag	ST	DT
Signal/Background	~1/2800	~1/360	~1/130

Kinematic fit

A kinematic fit is adopted to improve the resolution of the dijet invariant mass :

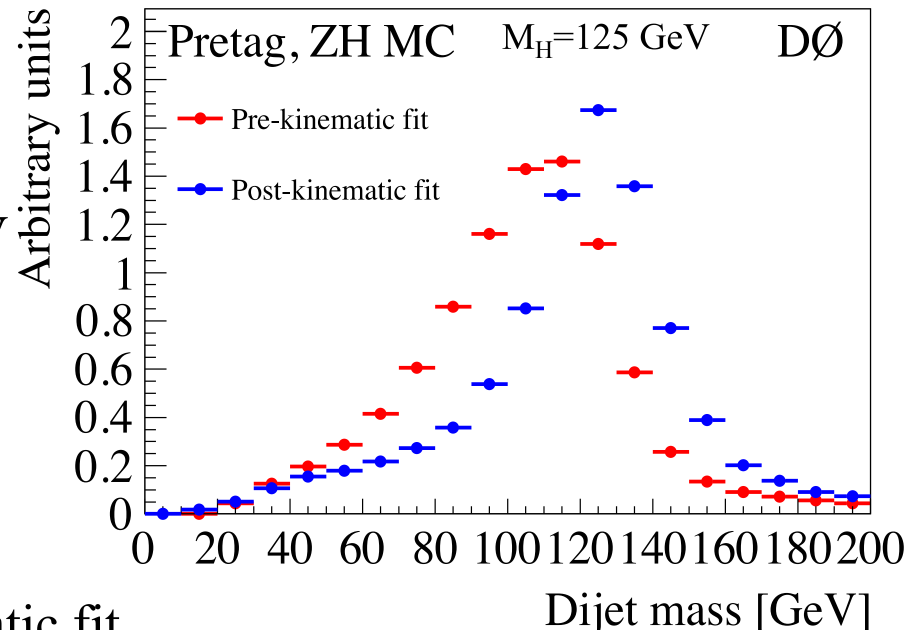
- Lepton energies are measured more precisely than jet energies
- The p_T boost of the ZH system is moderate, and no neutrinos in the final state
- Three constrains :

$\Sigma_{lep,jets}\ p_x = 0$, with Gaus width of 7 GeV

$\Sigma_{lep,jets}\ p_y = 0$, with Gaus width of 7 GeV

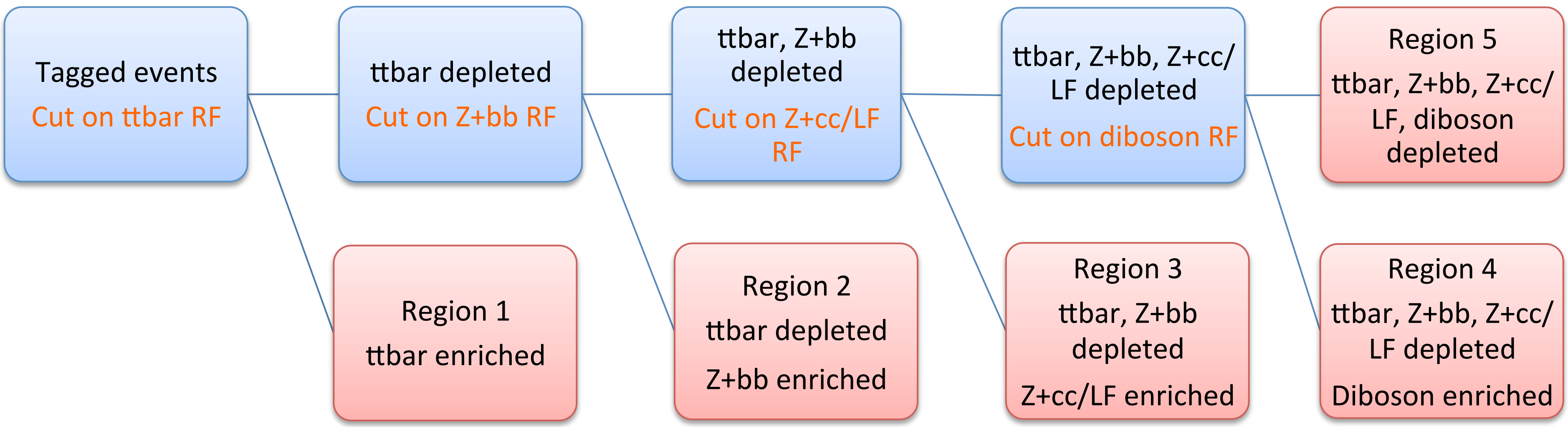
$M_{ll} = M_Z$, with Breit-Wigner Γ_Z=2.49 GeV

- Improving the dijet mass resolution by 10~15% depending on M_H
- the resolution for M_H=125 GeV is approximately 15 GeV after the kinematic fit



Multivariate analysis

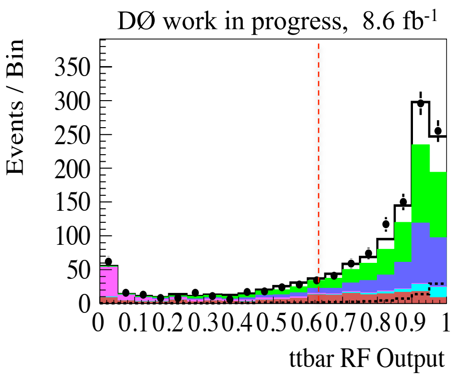
- A multivariate analysis strategy based on Random Forest discriminants (RF) is used to improve the separation of the signal from the background



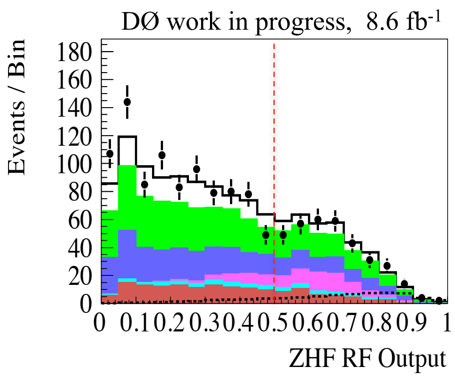
- Four intermediate RFs (trained with all tagged events) :
  ttbar vs. ZH, Z+bb vs. ZH, Z+cc/LF vs. ZH, diboson vs. ZH
- Cuts used to define the enriched/depleted region is optimized
- In each final region, a global RF(all Bkg vs. ZH) is trained independently
- 5 regions × 2 post b-tagging bins =10 final discriminants in each sub-channel

Multivariate analysis

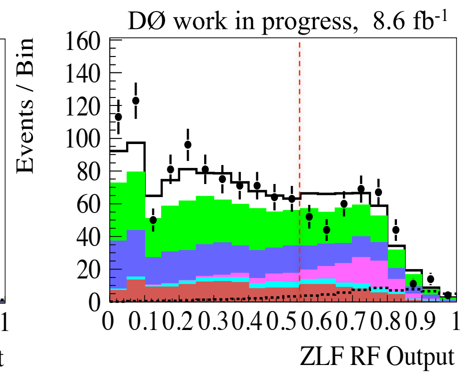
Intermediate RF : ST



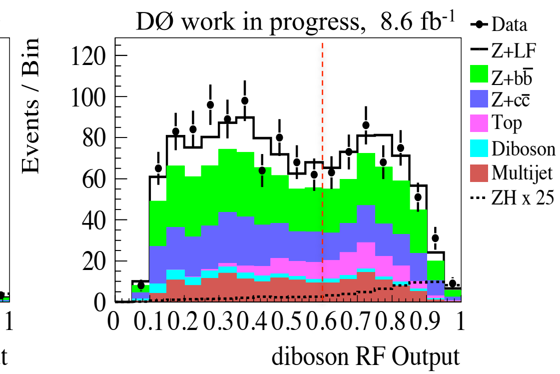
Cut @ 0.633



Cut @ 0.504

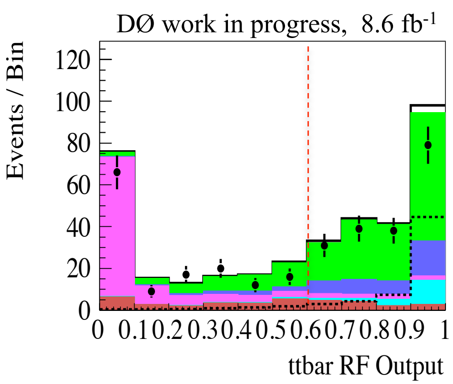


Cut @ 0.544

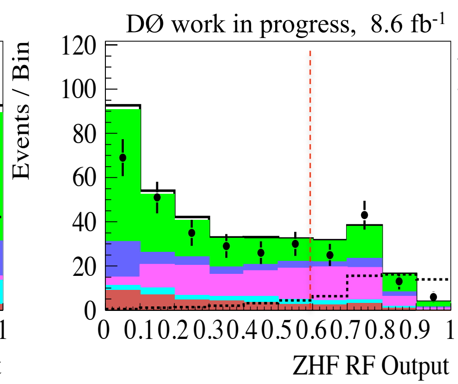


Cut @ 0.599

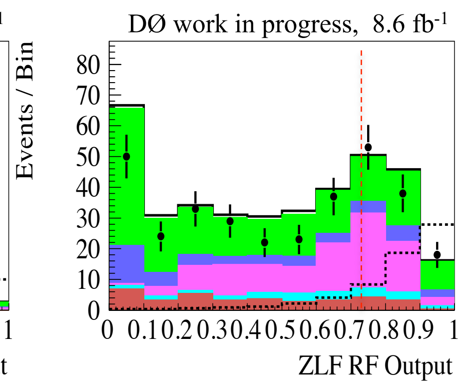
Intermediate RF : DT



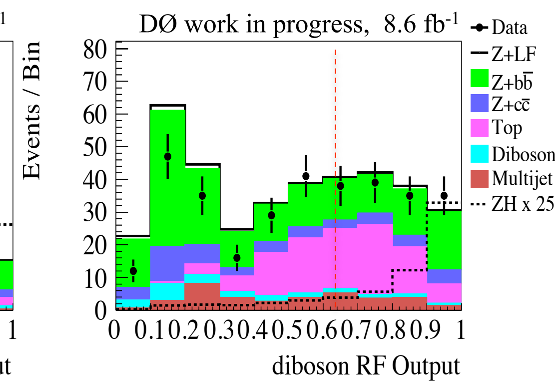
Cut @ 0.602



Cut @ 0.594



Cut @ 0.733

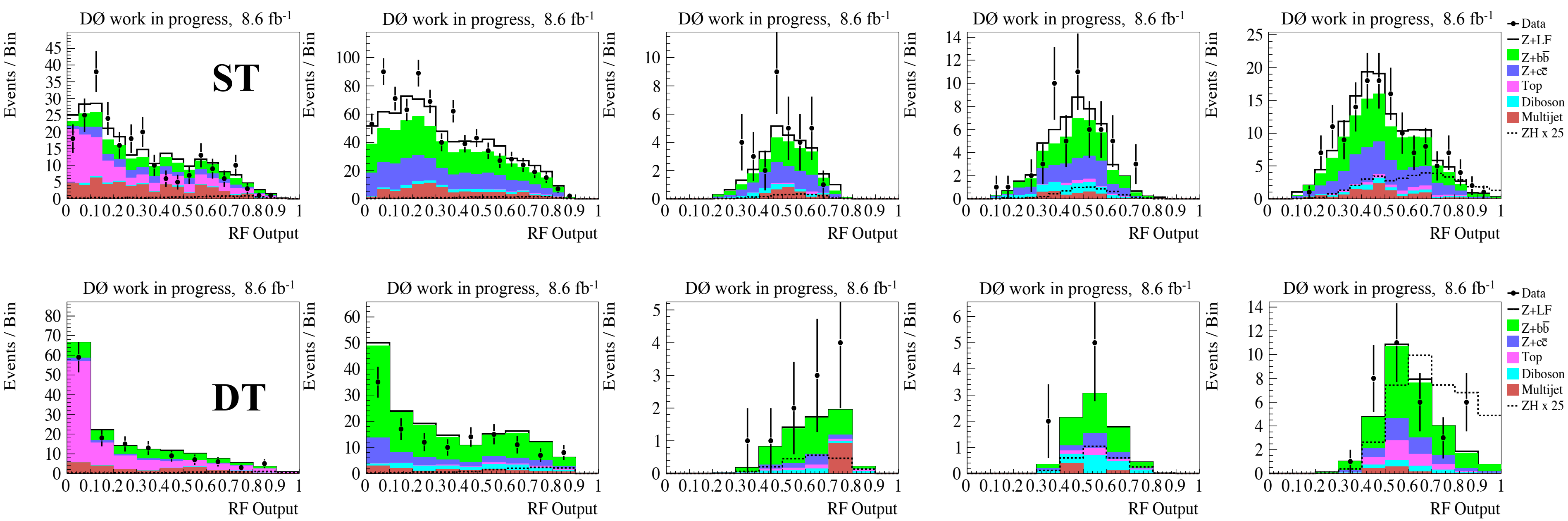


Cut @ 0.638

Preliminary analysis results

Final discriminant

Region 1	Region 2	Region 3	Region 4	Region 5
ttbar enriched	ttbar depleted Z+bb enriched	ttbar, Z+bb depleted Z+cc/LF enriched	ttbar, Z+bb, Z+cc/LF depleted Diboson enriched	ttbar, Z+bb, Z+cc/LF, diboson depleted



95% C.L.

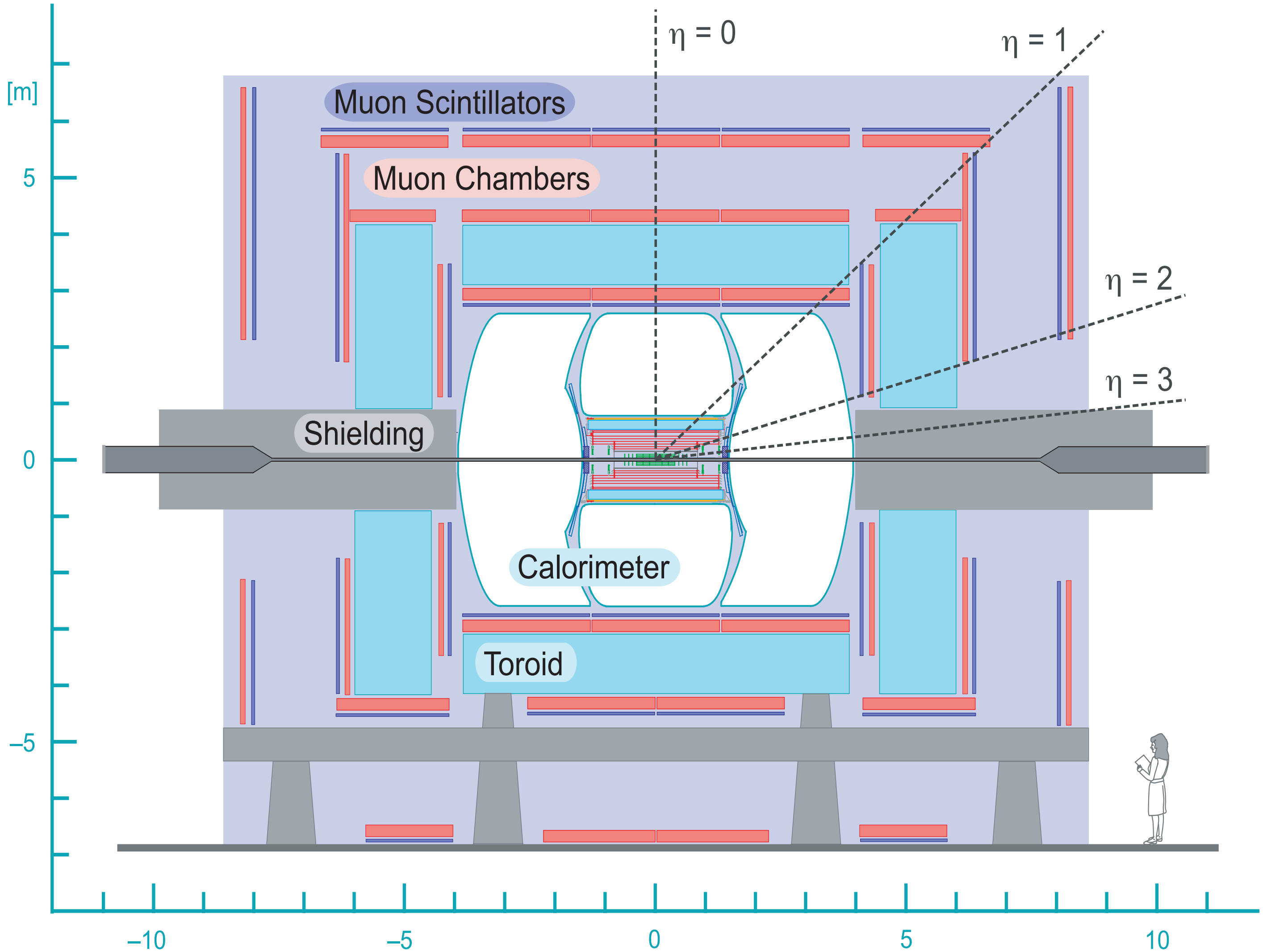
@ m_H = 125GeV	Non-reprocessed	Reprocessed
Expected limit (8.6fb^{-1})	5.9	5.8

Summary and future plan

- The analysis with $8.6 fb^{-1}$ reprocessed data is validated
  - The analysis is performed in di-muon and di-electron sub-channels
  - All the improvements in the reprocessed data are adopted
  - b-tag category is optimized
  - A MVA strategy with four intermediate RFs is well studied
- Future plan
  - Higgs boson production cross section measurement

Back up

DØ Detector

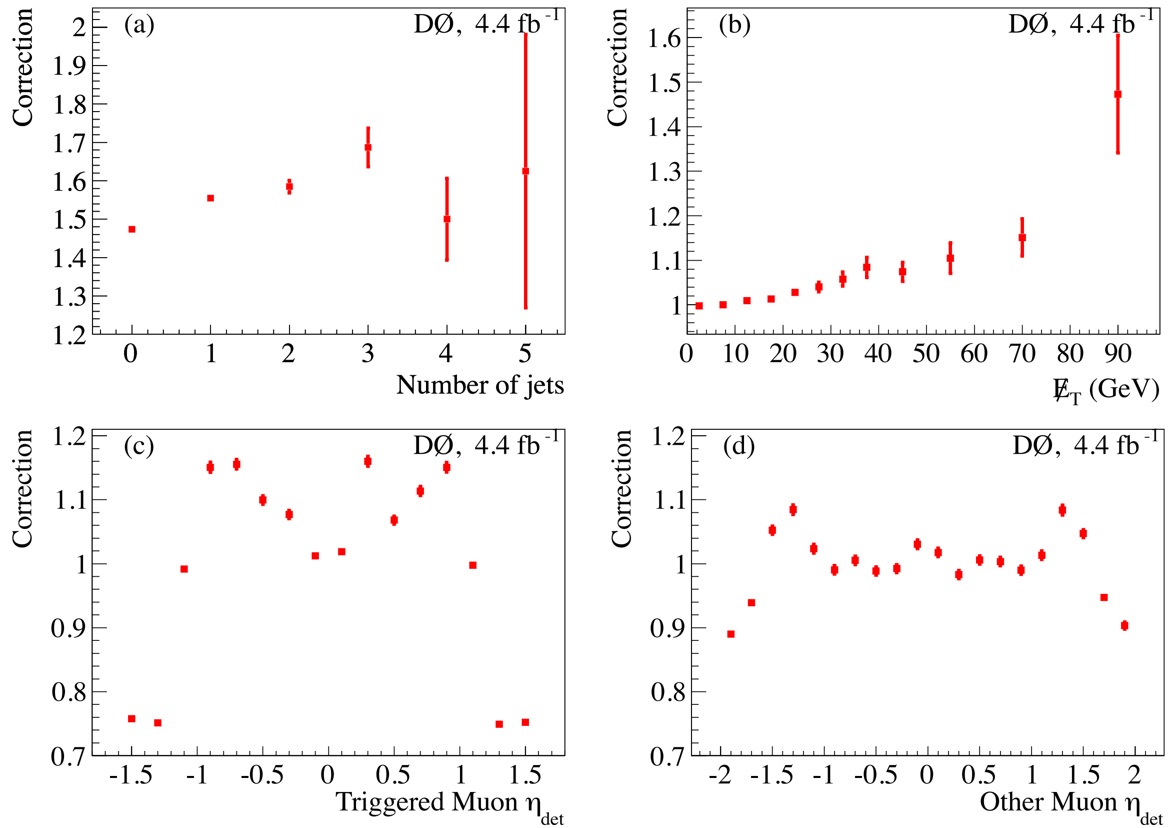


[m]
5
0
–5
–10
–5
0
5
10
η = 0
η = 1
η = 2
η = 3
Muon Scintillators
Muon Chambers
Shielding
Calorimeter
Toroid

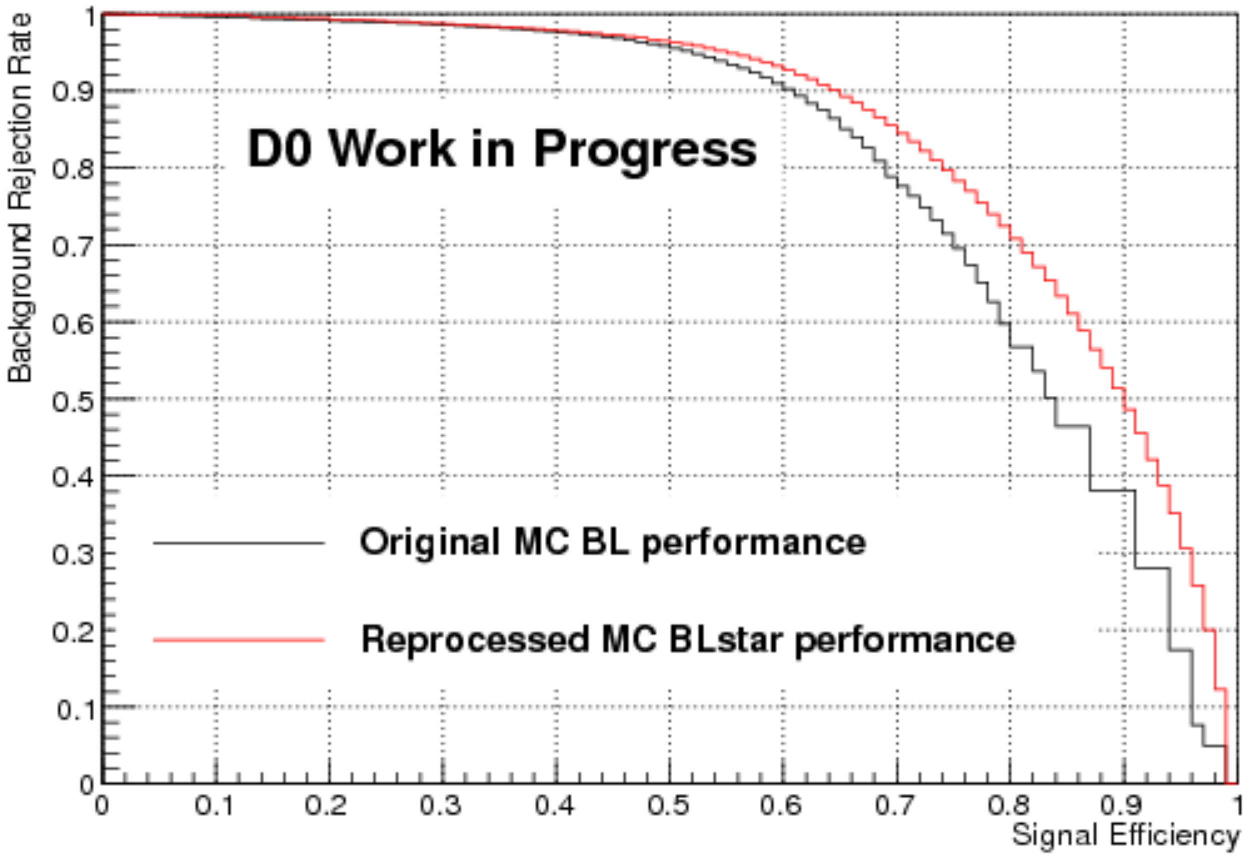
Triggers

- Di-electron : inclusive, efficiency consistent with 100%
- Di-muon : inclusive

For di-muon sub-channel : a trigger efficiency correction is derived from the ratio of the inclusive data to SingleMu_OR trigger data(parameterized in four variables), then applied to the MC samples



MVA BL* tagger



Additional primary vertex information in the MVA training

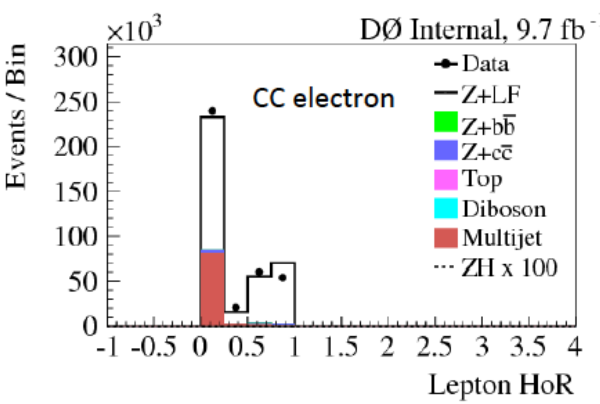
New electron scenario

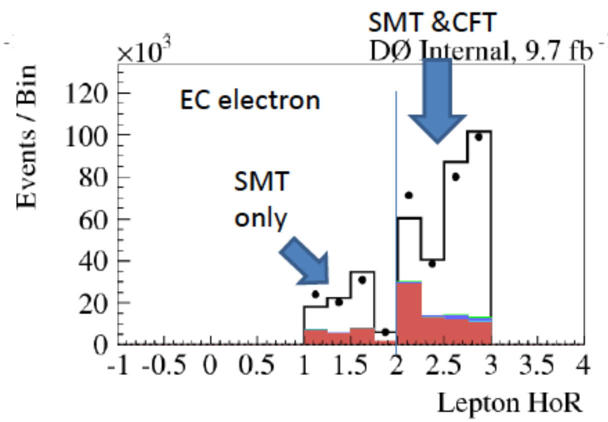
Electron selection in di-electron sub-channel

old: CC electron Point0 p_T>15GeV **+** (CC electron Point0 p_T>15GeV **or** EC electron Point05 p_T>15GeV)

new: CC electron Point0 p_T>10GeV **+** (CC electron Point0 p_T>15GeV **or** EC electron Point0 + HoR p_T>15GeV)

CCEC events:





- Cut on HoR for EC :
  - ≥1.2 for SMT only
  - ≥2.2 for SMT&&CFT
- No cut on HoR for CC