Thesis summary
Search for ZH → $e^+e^-bb_{bar}$

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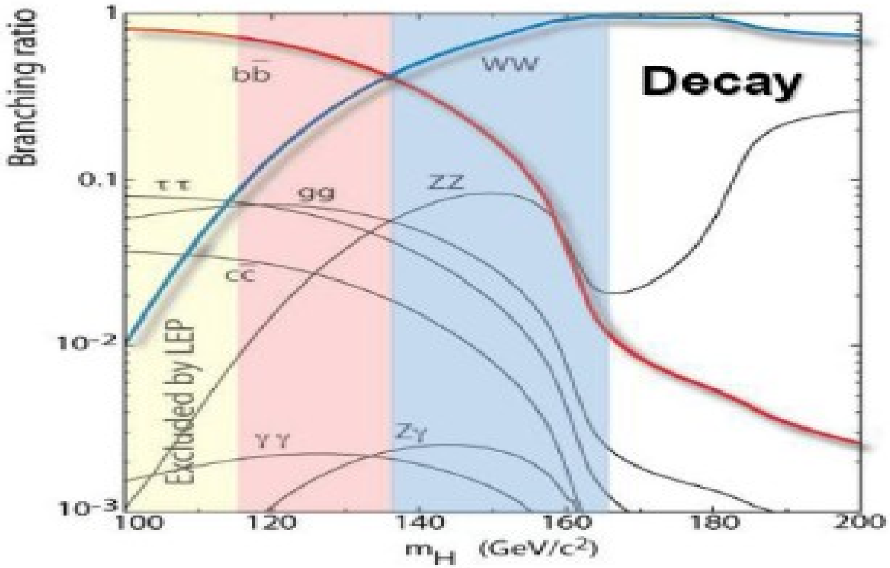
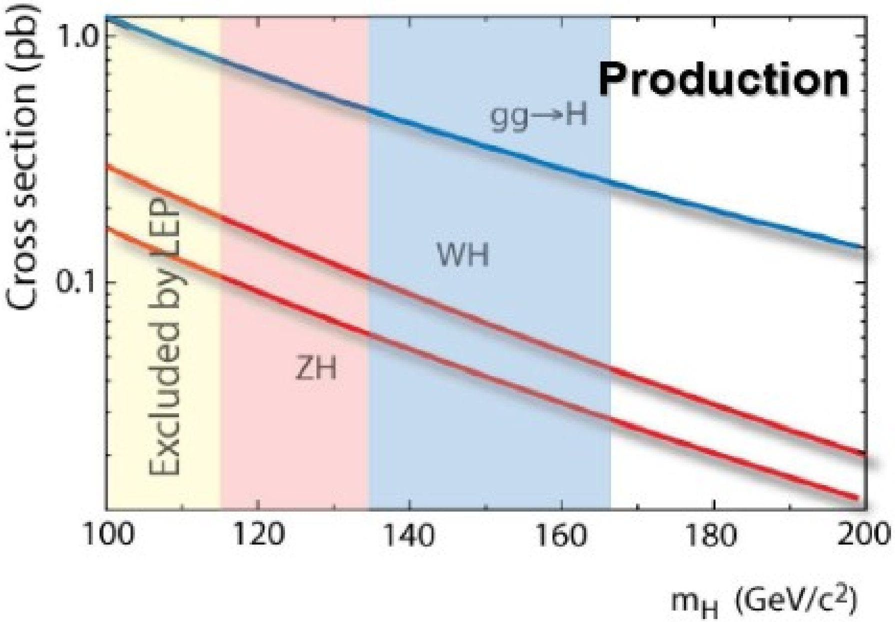
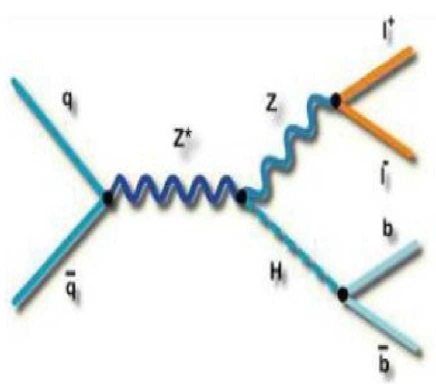
Outline

- Introduction
- Preselection
- Fit kinematic
- Multivariate analysis
- Combine limit
- Conclusion

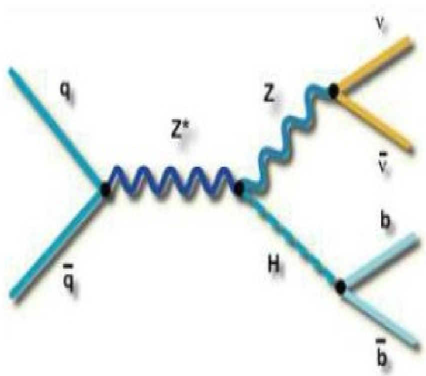
The main Higgs search channels at Tevatron at low masses



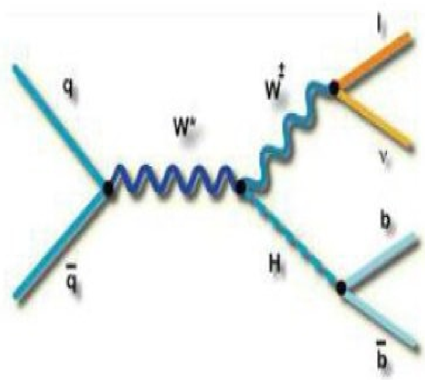




(a) $ZH \to \ell^+\ell^- b\bar{b}$



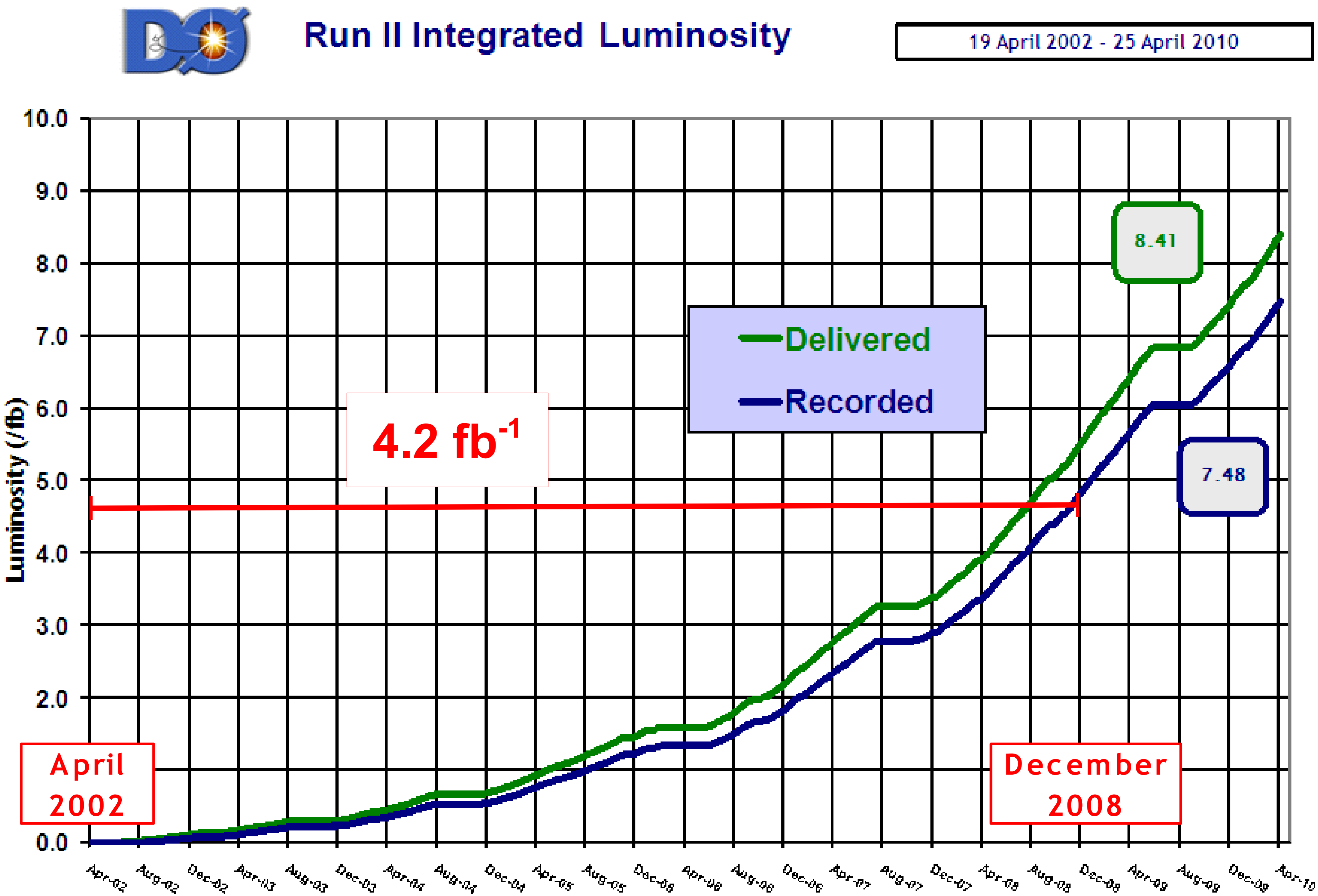
(b) $ZH \to \nu\nu b\bar{b}$



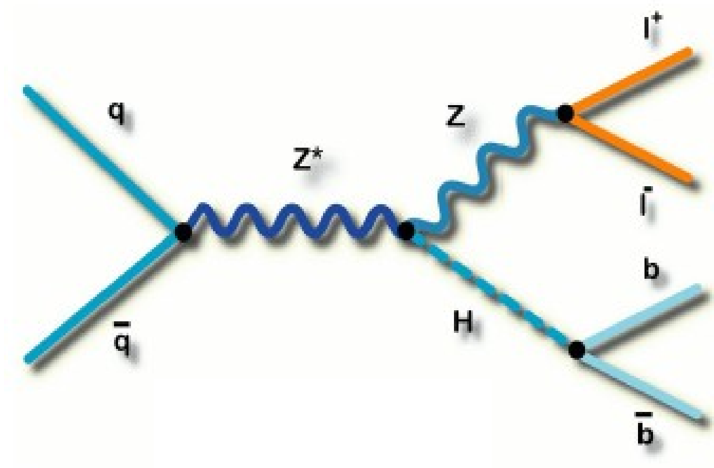
(c) $WH \to \ell\nu b\bar{b}$

Low mass m_H < 135 GeV
W/Z associate production

The analysis presented today with 4.2 fb^{-1} collected between April 2002 and December 2008



Event selection (I)



Signal selection

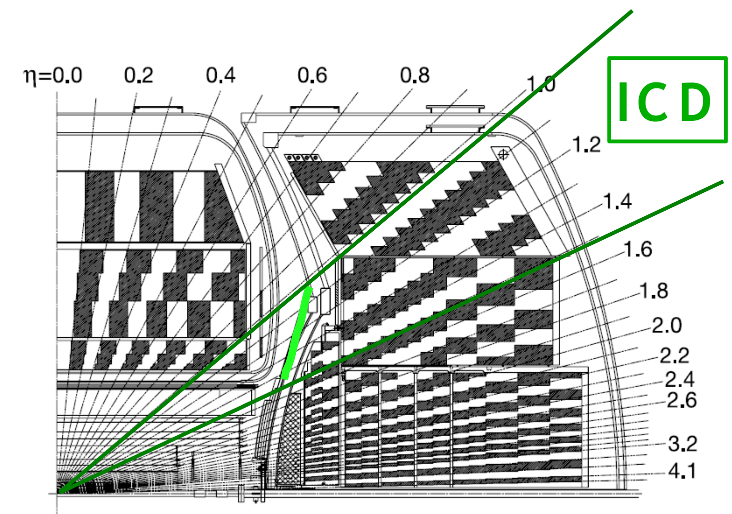
Events are selected with 2 charged leptons

e^+e^- (in the calorimeter), or $\mu^+\mu^-$ (in the muon system).

To increase signal efficiency

The dimuon selection is extended to include events with one muon in the muon system plus an isolated track in the central tracker system (μ^{trk}).

The dielectron selection is extended to include events with one electron in the calorimeter plus an electron reconstructed in the inter-cryostat region (e^{icr}).



Z boson selection

The reconstructed invariant mass of the Z boson for the 4 channels should be in the mass range [60 – 150] GeV.

Event selection (II)

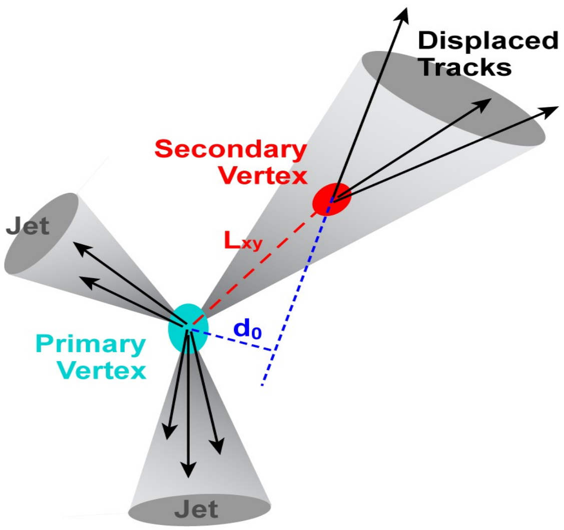
Jets selection: Events are selected by requiring at least 2 jets.

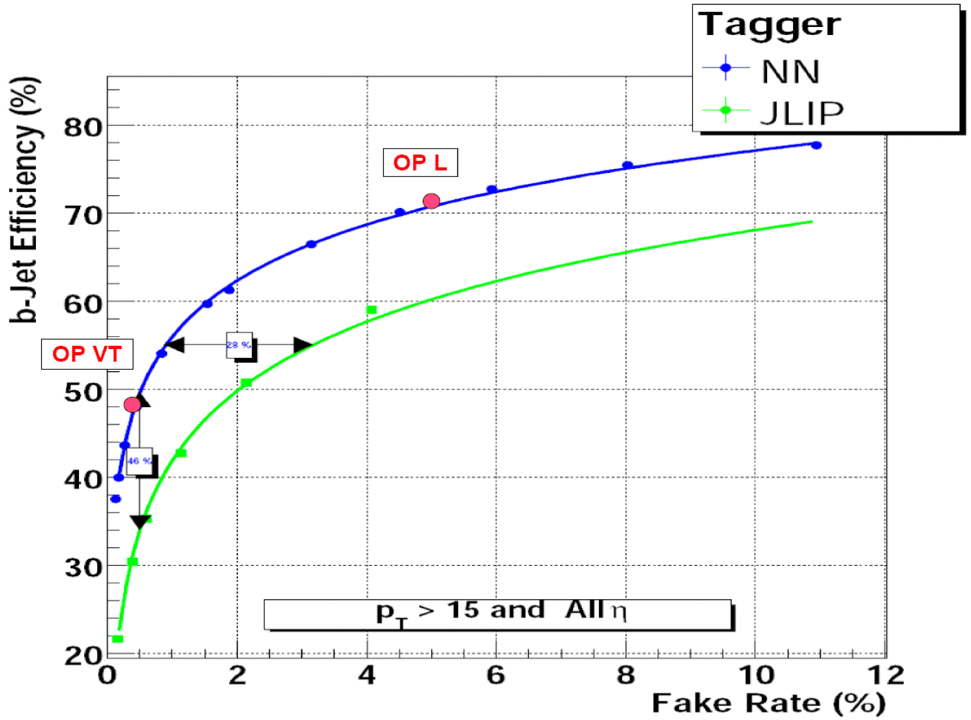
b jet identification: At least one of the jets is required to be tagged as b quark, using the fact that b quarks has long life time:

- search for Secondary Vertex

- calculate jet lifetime probability from the impact parameters (d_0)

- Combine these information in a Neural Network.



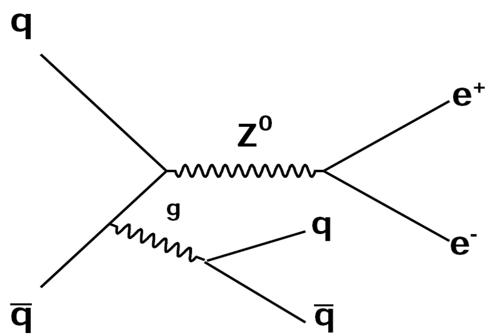


2 orthogonal b jets data set:
with 2 operating point (OP) 1VT and 2L

Background (I)

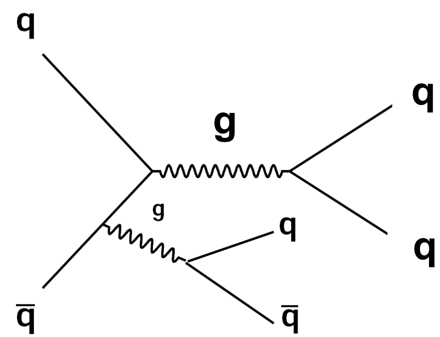
Electroweak (from simulation)

- Z + jets coming from light and heavy flavor quarks (Alpgen+Pythia)
- Dibosons: WW, WZ or ZZ (Pythia)
- $t\bar{t}$ (Alpgen+Pythia)



Multijet (from data)

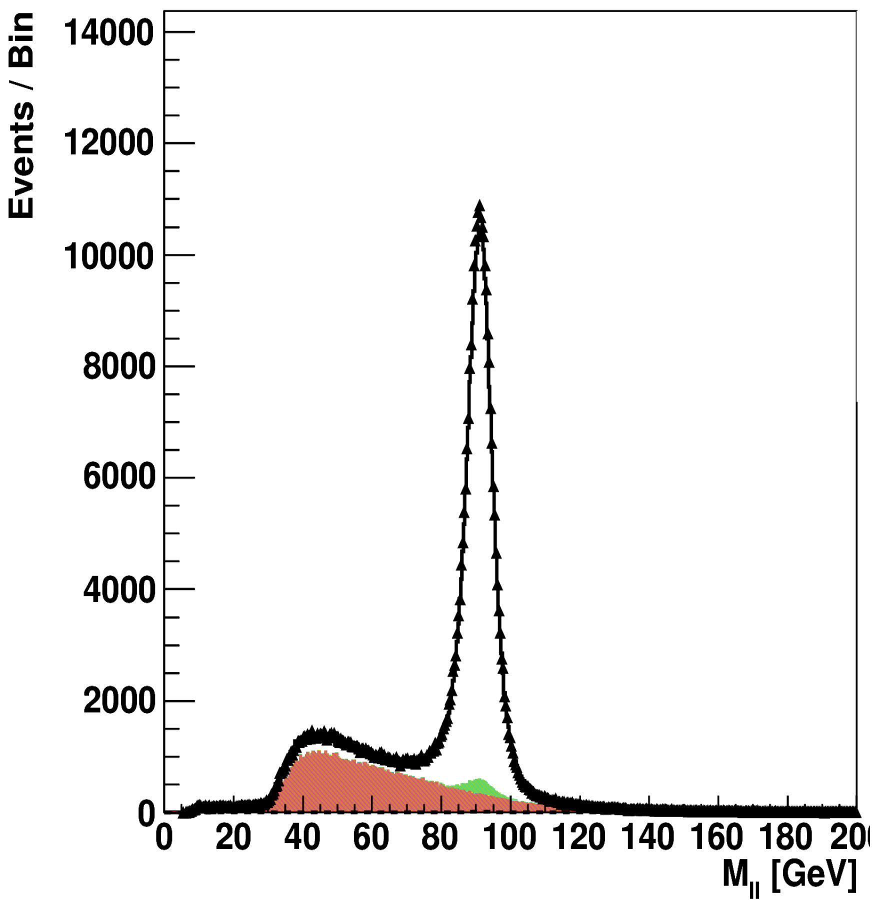
- Di-electron channel : jets misidentified as leptons
- Di-muon channel : non isolated muon



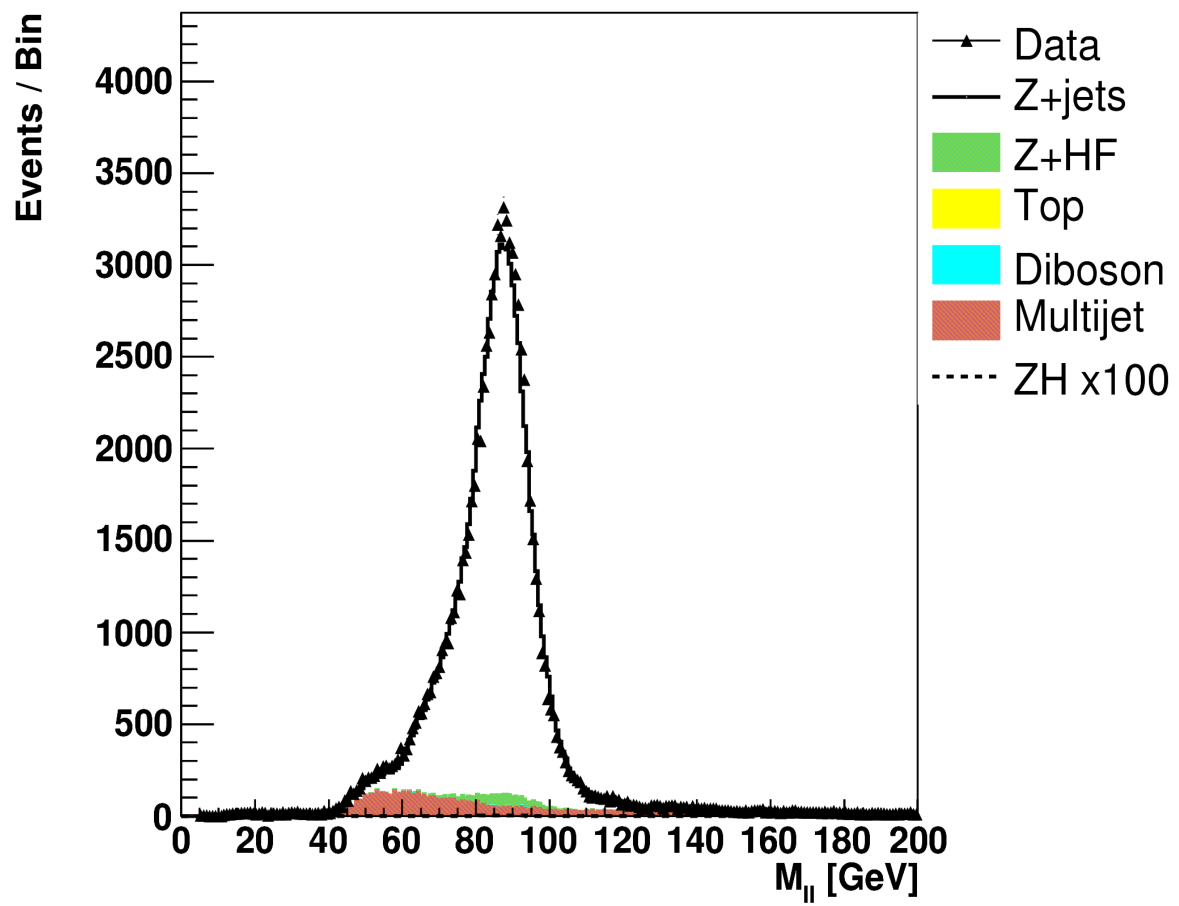
- The multijet sample has been selected by inverting jet shape selection cuts like Hmx for ee or NNh for ee^{icr}
- In case of ee, the sample was corrected for trigger bias, in pT and eta distributions
- The number of multijet events has been determined with a fit performed on data and simulation on the M_{ll} distribution.

Dilepton invariant mass

Di-electron

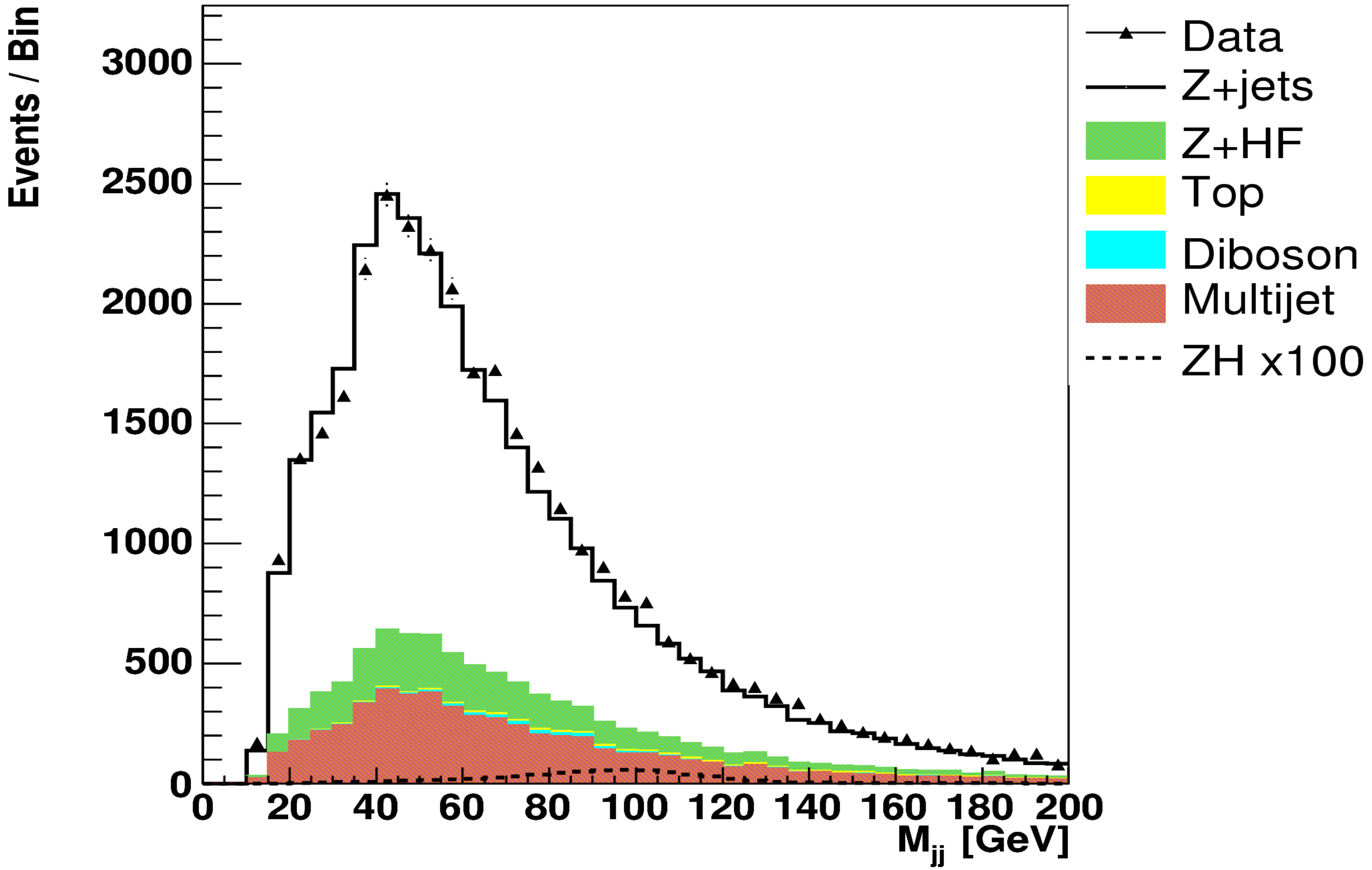


Electron+ electron ICR



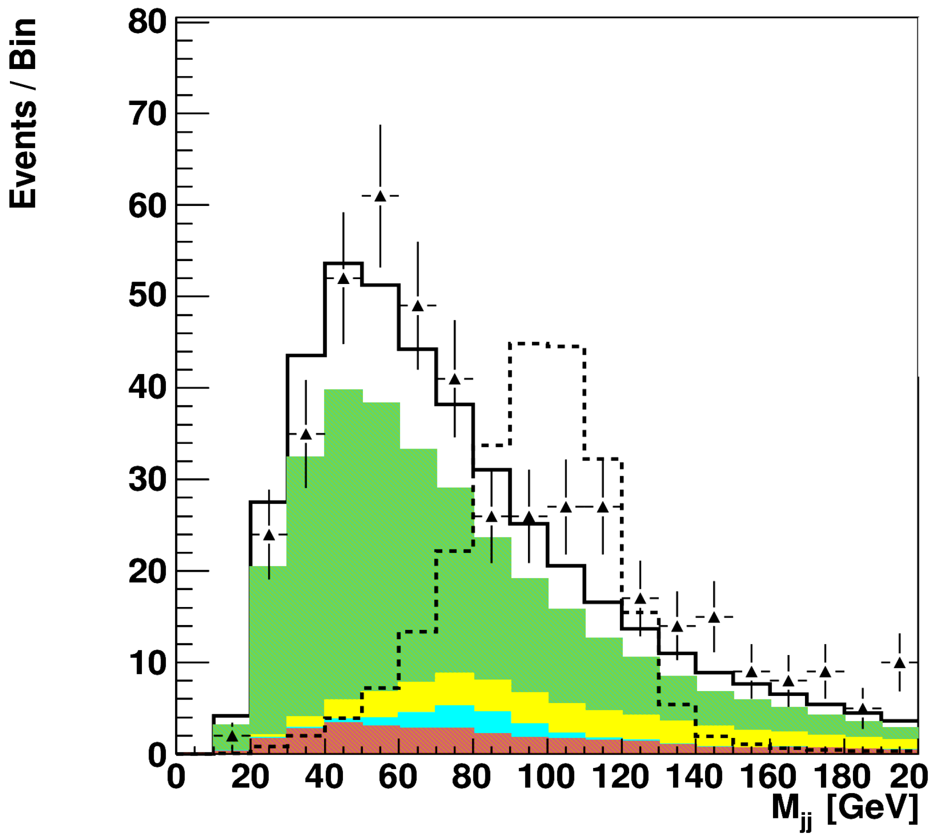
Di-jet mass before b-tagging

Combined 4 channels

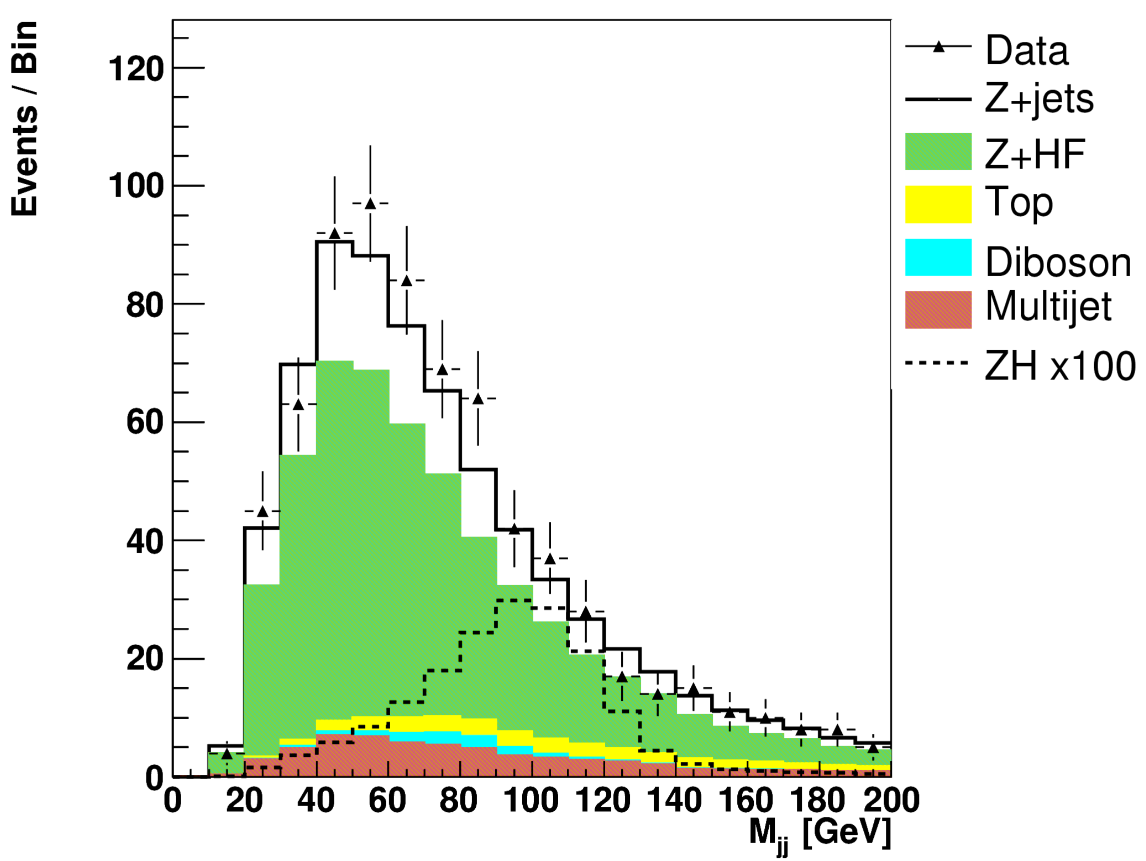


Di-jet mass after b-tagging

Combined 4 channels 2L



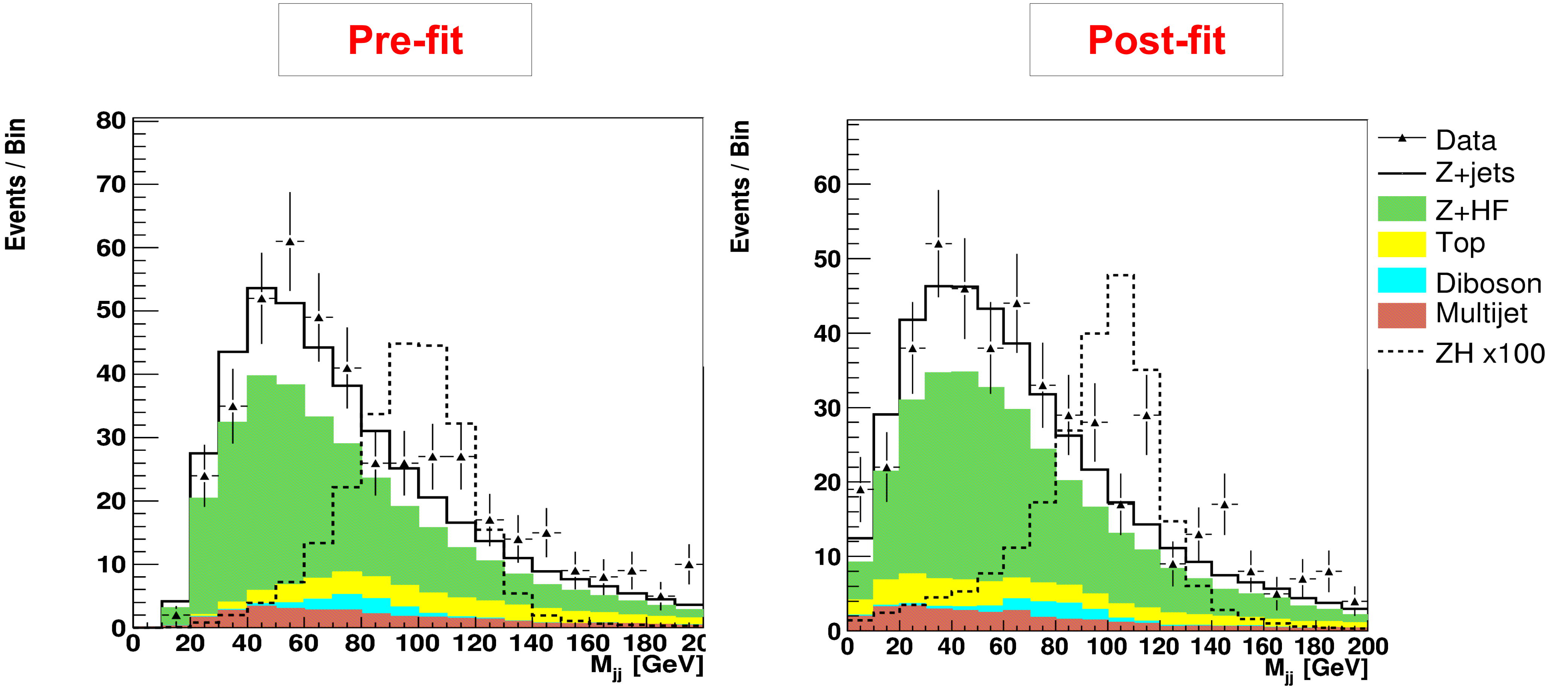
Combined 4 channels 1T



Kinematical Fit

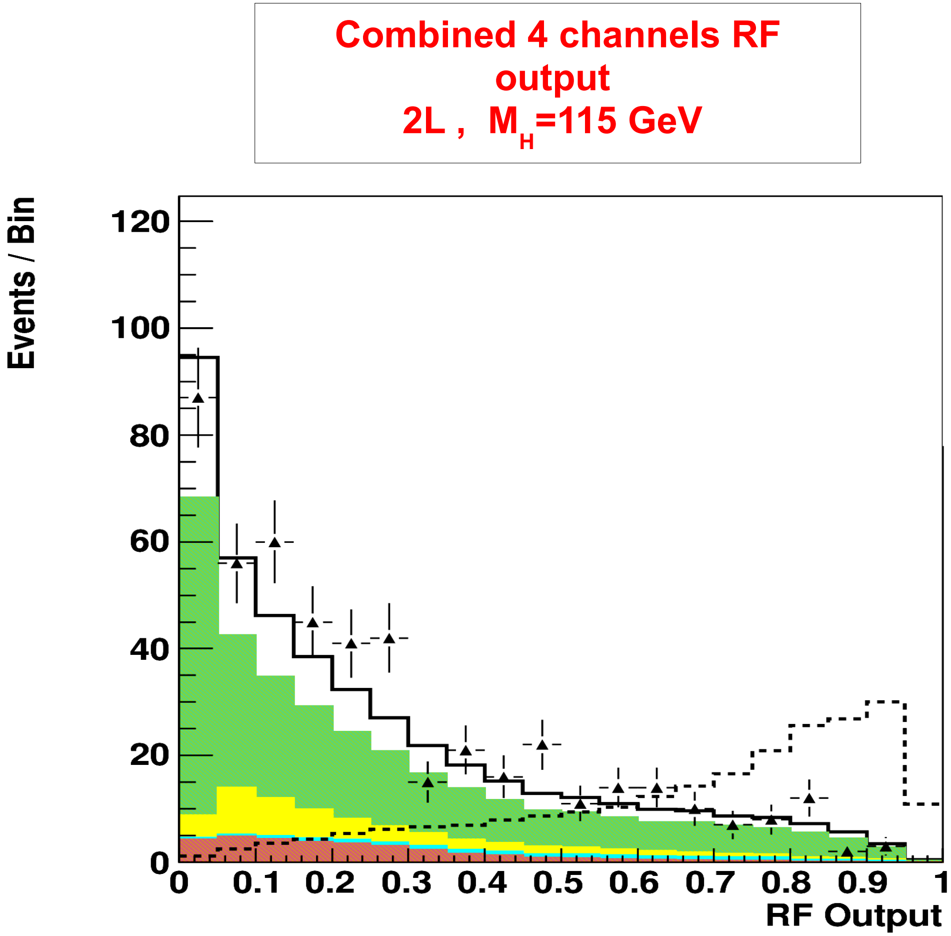
To have the best kinematical information, the energies and angles of the 2 leptons and 2 jets are fit within their resolutions, to new values which minimize a χ^2 under the constraints:

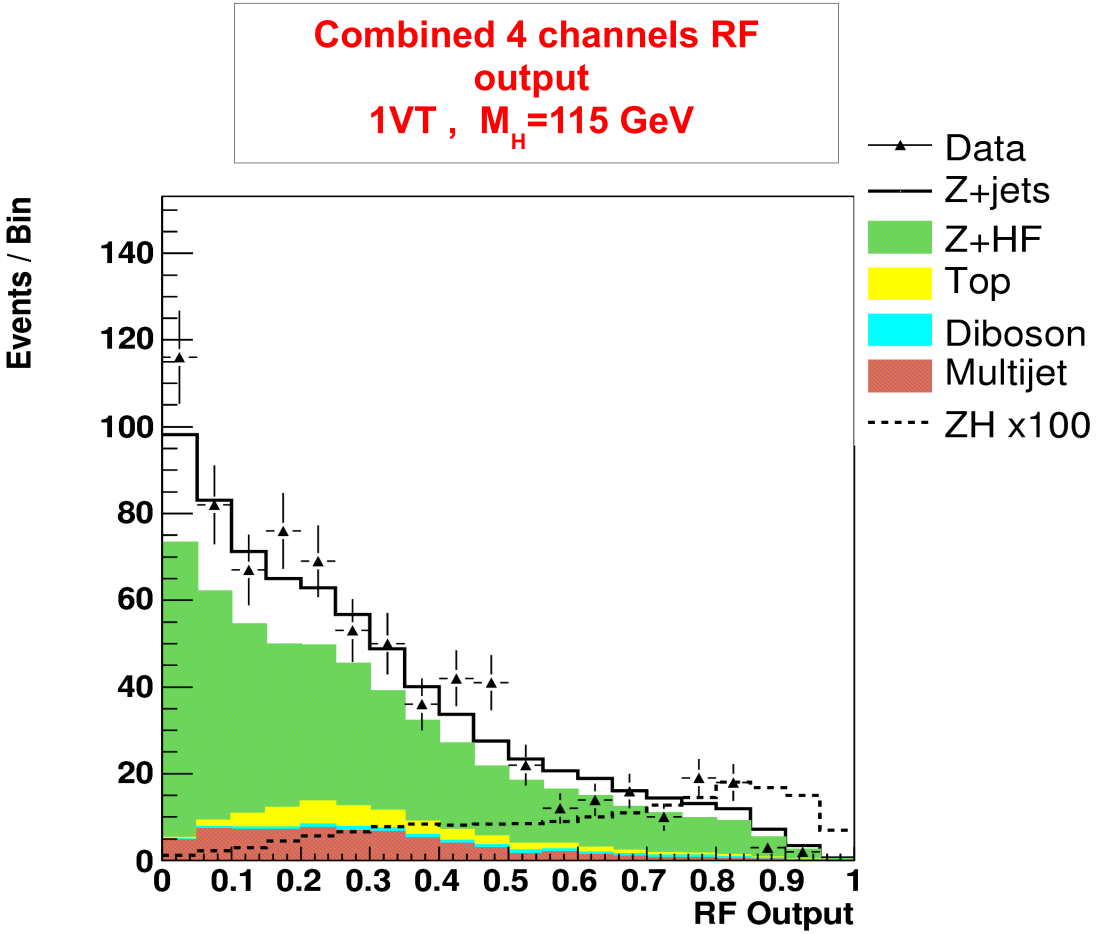
$$M_{ll} = M_Z \pm 2.5 \text{ GeV} , \Sigma p_{x(y)}(ZH) = 0 \pm 7 \text{ GeV}$$



Final discriminant

To further separate signal and background, a multivariate discriminant analysis tool called "Random Forest of boosted decision trees (RF)", is used with several input variables. The output of the RF is used for the limit setting.





Systematic errors

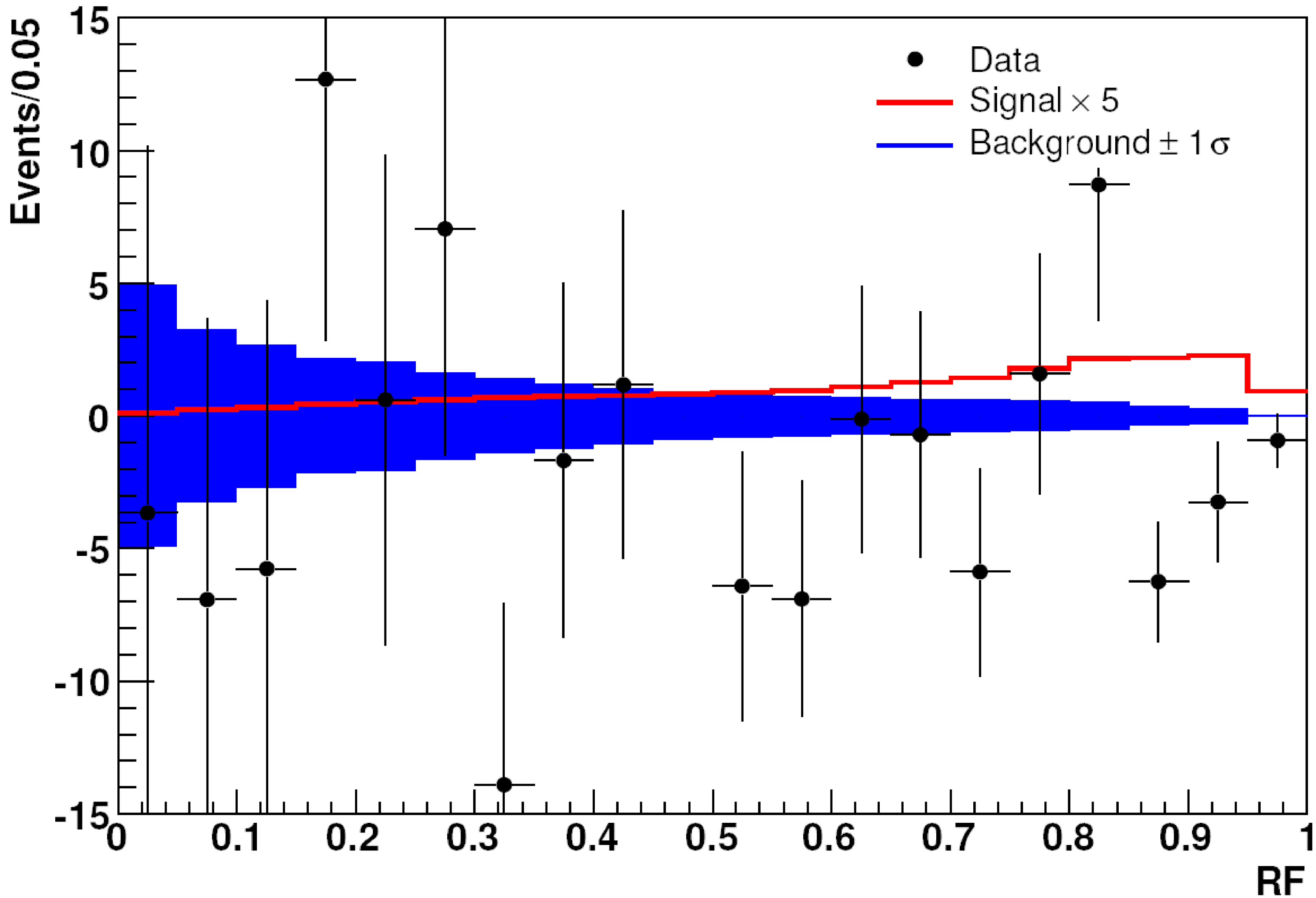
- Flat systematics:

do not change the form of the RF distribution like luminosity, cross section or efficiency factors

- Shape systematics:

do change the shape of the RF distribution like JES, Jet ID, ZpT reweighting …

Background subtracted RF output distribution of the data at 115 GeV

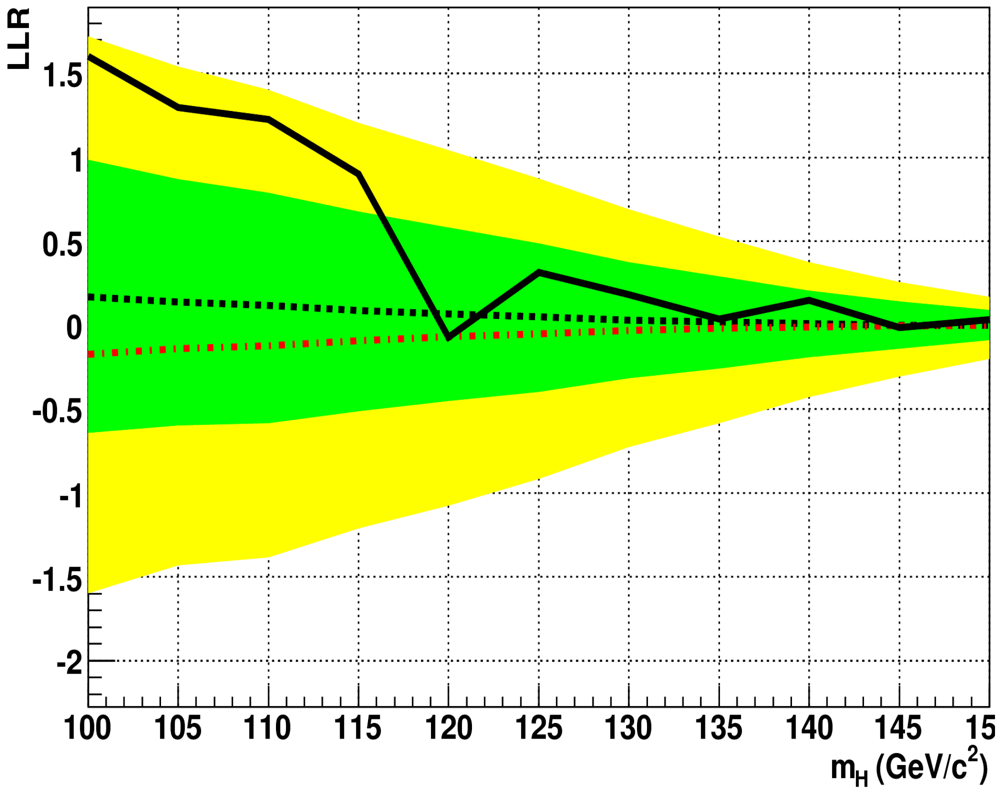


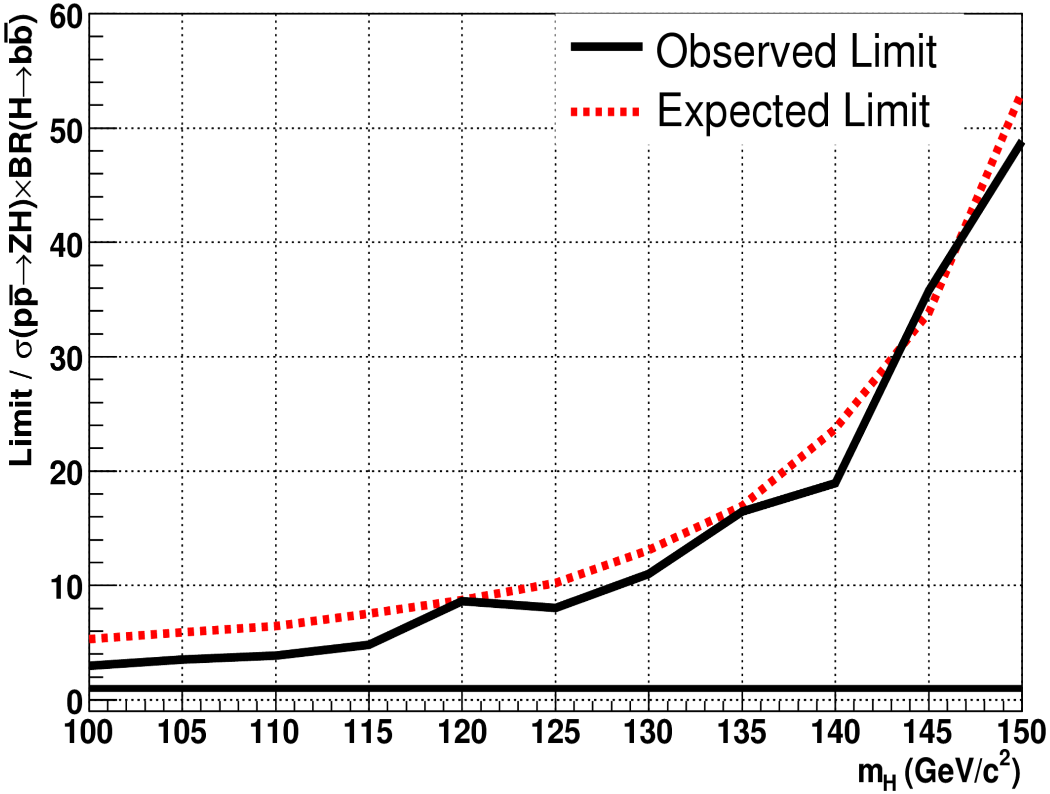
Combined limit

The upper limit on the Higgs production cross section ZH times branching ratio for $H \to b\bar{b}$ was set at 95% CL, with the modified frequentist CLs approach with a Poisson log-likelihood ratio test statistic.

Limit exp (obs) at 115 GeV: ee^{icr}=35.5 (27.2), ee =12.6 (10.1), all elec =11.5 (8.2), all leptons=7.52 (4.83)

The inclusion of the ee^{icr} events improves the limit by 9% wrt that obtained with only the di-em events.





Summary

- Result of the $ZH \rightarrow l^+l^-bb_{bar}$ search with 4.2 fb^{-1} has been presented.

- No Higgs signal has been observed.

- 95% CL limits on the ZH cross-section x $BR(H \rightarrow bb)$ for different Higgs masses were set.

- The ee^{icr} improuves the ee chanel expected limit by 9%.

- Results currently in EB for publication.

Back up slides

Event selection (I)

Dielectron Selection (ee)

2 electrons in CC $|\eta_{det}| < 1.1$ or EC $1.5 < |\eta_{det}| < 2.5$

$p_T > 15$ GeV

Isolation < 0.1

Emfraction > 0.95

Hmx7(8) < 35 (20) in CC (EC),

IsoHC4 < 3 (2) in CC (EC)

NNout7(3) > 0.2 (0.4) in CC (EC)

track in CC

Dimuon Selection (μμ)

At least 2 Loose muons ID

in the region $|\eta_{det}| < 2.0$

$p_T > 10$ GeV

A central track

dca < 0.02 (0.2) cm for track w. (w/o) SMT hit ???

- at least 1 muon with $p_T > 10$ GeV in $|\eta_{det}| < 1.5$

To increase signal efficiency

Electron plus ICR Selection (ee^{icr})

1 electron in the calorimeter plus 1 electron in the ICR (e^{icr}) which should pass the cuts:

To be in $1.1 < |\eta_{det}| < 1.5$,

At least 1 SMT hit

$p_T > 20$ GeV

$NN_{\tau} > 0.7$

LHood > 0.15

- the calo. e should have $p_T > 20$ GeV

Muon-plus-Track Selection ($\mu\mu^{trk}$)

1 muon plus 1 track muon (μ^{trk}) wich should pass the cuts:

To be in $|\eta_{det}| < 2.0$

At least 1 SMT hit

$p_T > 20$ GeV

dca < 0.02 cm

$\Delta R(\mu^{trk}, \mu) > 0.1$, and $\Delta R(\mu^{trk}, jet) > 0.5$

Scaled Isolation $I(\mu_{trk}) < 0.3$

Z selection

$60 < M_{ee} < 150$ GeV , $|PV_Z| < 40$ cm

Background selection (II)

Dielectron QCD Selection (ee)

Isolation < 0.2

Emfraction > 0.9

Hmx7(8) > 35 (20) in CC (EC),

no requierement on NNout7(3) CC (EC) variable

no more then 1 Loose EM object

Biais du to reverse Hmx cut has been corrected in pT and Eta

Electron plus ICR QCD Selection (ee^{icr})

Fake eicr has been select in QCD region with:

$0.2 < NN_{\tau} < 0.4$

$NN_{e} < 0.3$

Dimuon QCD Selection (μμ)

The 2 muons should fail the product scaled isolation cut:

$I(\mu^1).I(\mu^2) > 0.03$

Muon-plus-Track QCD Selection ($\mu\mu^{trk}$)

μ^{trk} and μ should have same sign charge

The QCD have been normalise to data and simulation on the M_Z distribution.

Systematic uncertainties (I) Flat uncertainties

Systematic	Uncertainty (%)	bkg (%)
σ_ϵ^{COR}	6	0.7
k_Z^2 (Run IIa)	1.1	0.9
k_Z^2 (Run IIb)	0.9	0.7
k_Z^2 (CC-EC)	1.8	
r(A/B)	7	0.8
r(EC)	13	
$Z + HF$ xsec	20	10.9
$t\bar{t}$ xsec	10	0.9
Diboson xsec	7%	0.2%
ZH xsec	6	

TAB. 8.1 – Erreurs systématiques en pourcentage, sur la normalisation et les sections efficaces, communes pour tous les canaux.

Run IIa

i	ee (bkg) (%)	ee^{icr} (bkg) (%)	$\mu\mu$ (bkg) (%)	$\mu\mu^{trace}$ (bkg) (%)
$\sigma_\epsilon^{i,IND}$	2 (1.8)	4 (3.6)	2 (2.0)	3 (2.4)
Multijet	20 (2.5)	60 (6.1)	50 (1.1)	50 (10)

Runs IIb

i	ee (bkg) (%)	ee^{icr} (bkg) (%)	$\mu\mu$ (bkg) (%)	$\mu\mu^{trace}$ (bkg) (%)
$\sigma_\epsilon^{i,IND}$	2 (1.6)	4 (1.9)	2 (1.9)	3 (1.9)
Multijet	20 (4.2)	20 (11)	30 (0.9)	20 (7.0)

TAB. 8.2 – Erreurs systématiques en pourcentage, sur la normalisation pour chaque canaux, et pour les Runs IIa (en haut) et IIb (en bas).

	Multijet	$Z + LP$	$Z + HF$	Diboson	$t\bar{t}$	ZH	Run IIa/IIb
Multijet	X						Independent
k_Z^2		X	X				Independent
$\sigma_\epsilon^{i,IND}$		X	X	X	X	X	Independent
σ_ϵ^{COR}				X	X	X	Correlated
r(A/B)				X	X	X	Independent
r(EC)				X	X	X	Independent
$Z + HF$ xsec			X				Correlated
Diboson xsec				X			Correlated
$t\bar{t}$ xsec					X		Correlated
ZH xsec						X	Correlated

TAB. 8.3 – Applicabilité des erreurs systématiques sur la normalisation et les sections efficaces pour chaque échantillon, et en fonction de la corrélation entre les Runs IIa et IIb.

Systematic uncertainties (II) Shape uncertainties

1VT

Run IIa

	ZH (115) (%)	$Z+LP$ (%)	$Z+b\bar{b}$ (%)	$Z+c\bar{c}$ (%)	Diboson	$t\bar{t}$	Multijet
JES	2.4	1.0	3.5	1.7	3.5	4.0	
RES	3.3	3.9	8.9	7.8	5.4	5.5	
Jet ID	1.0	0.6	0.5	0.4	0.6	0.7	
ZpT		2.2	2.3	2.1			
PDF	0.9	0.6	1.7	0.9	0.2	0.7	
TRF HF	1.0		2.3	4.0		0.4	
TRF LF		16			3.8		1.6
taggability	2.4	2.2	2.5	2.5	2.4	2.5	
Vjet RW		0.9	0.9	0.9			
$\mu\mu$ Trig	1.9	1.9	2.0	2.1	2.2	1.9	
$\mu\mu^{trace}$ Trig	4.8	4.6	4.8	4.9	3.8	5.4	
MLM		0.1					
Alpgen Scale		0.04	0.1	0.04			
Alpgen UE		0.1	0.1	0.07			

Runs IIb

	ZH (115) (%)	$Z+LP$ (%)	$Z+bb$ (%)	$Z+c\bar{c}$ (%)	Diboson	$t\bar{t}$	Multijet
JES	1.9	0.9	2.4	2.8	3.1	3.8	
RES	1.3	2.2	4.9	3.3	1.5	2.4	
Jet ID	2.9	0.2	1.2	0.2	5.5	3.5	
ZpT		2.4	2.6	2.3			
PDF	1.0	0.7	1.6	1.0	0.2	0.3	
TRF HF	0.03		2.3	3.6		0.4	
TRF LF		19			4.0		4.2
taggability	0.6	0.4	0.4	0.5	0.7	0.7	
Vjet RW		0.9	0.9	0.9			
$\mu\mu$ Trigger	1.8	1.7	1.8	1.8	1.8	1.7	
$\mu\mu^{trace}$ Trigger	3.6	3.6	3.3	3.6	3.3	3.4	
MLM		0.03					
Alpgen Scale		0.01	0.07	0.04			
Alpgen UE		0.08	0.1	0.07			

2L

Run IIa

	ZH (115) (%)	$Z+LP$ (%)	$Z+b\bar{b}$ (%)	$Z+c\bar{c}$ (%)	Diboson	$t\bar{t}$	Multijet
JES	3.1	1.0	3.0	3.2	3.7	3.4	
RES	3.5	4.9	12	10	3.8	3.9	
Jet ID	1.1	0.7	0.7	0.8	0.6	0.8	
ZpT		2.2	2.1	1.9			
PDF	0.7	0.6	1.5	0.6	0.3	0.7	
TRF HF	5.6		4.6	5.3		6.5	
TRF LF		4.9			4.5		0.4
taggability	4.9	3.9	4.6	4.1	4.5	5.5	
Vjet RW		0.8	0.9	0.9			
$\mu\mu$ Trig	2.0	2.1	2.1	2.1	2.2	2.0	
$\mu\mu^{trace}$ Trig	3.8	5.0	4.9	4.7	4.4	6.4	
MLM		0.2					
Alpgen Scale		0.1	0.01	0.06			
Alpgen UE		0.1	0.1	0.3			

Runs IIb

	ZH (115) (%)	$Z+LP$ (%)	$Z+bb$ (%)	$Z+c\bar{c}$ (%)	Diboson	$t\bar{t}$	Multijet
JES	2.7	0.4	2.5	3.0	5.1	3.1	
RES	2.0	1.3	7.9	3.7	4.2	0.9	
Jet ID	3.6	0.2	0.5	0.7	2.8	4.4	
ZpT		2.5	2.3	2.1			
PDF	0.7	0.7	1.5	1.3	0.1	0.4	
TRF HF	5.0		4.1	4.5		6.7	
TRF LF		4.8			4.4		1.0
taggability	0.9	0.8	0.9	0.8	1.0	1.2	
Vjet RW		0.9	1.0	0.9			
$\mu\mu$ Trig	1.8	2.1	1.9	1.8	2.2	1.8	
$\mu\mu^{trace}$ Trig	3.5	4.4	3.8	3.0	3.7	3.7	
MLM		0.1					
Alpgen Scale		0.06	0.02	0.02			
Alpgen UE		0.01	0.1	0.2			

Systematic uncertainties for parameters used in the lepton combination for p17 and p20, and 1T and 2L samples. The table lists the percentage change in the predicted number of events for each background sample and each shape dependent systematic.

Limit

	ee^{icr}		ee		ee^{icr}, ee		$ee^{icr}, ee, \mu\mu, \mu\mu^{trace}$	
M_H GeV	Exp/SM	Obs/SM	Exp/SM	Obs/SM	Exp/SM	Obs/SM	Exp/SM	Obs/SM
100	22.75	21.11	9.18	6.87	8.17	6.05	5.30	2.99
105	26.52	24.82	10.07	8.58	9.09	7.36	5.92	3.52
110	29.55	21 51	10.89	9.08	9.85	7.36	6.44	3.87
115	35.47	27.17	12.54	10.08	11.50	8.22	7.52	4.83
120	39.87	28.02	14.97	17.07	13.30	12.66	8.71	8.65
125	49.06	33.95	17.10	14.39	15.60	11.34	10.24	8.03
130	61.84	49.50	22.62	20.35	20.50	15.58	13.08	11.03
135	86.27	58.47	28.21	24.16	25.87	18.28	16.98	16.44
140	114.47	79.22	40.93	26.23	36.32	20.27	23.70	18.94
145	161.16	151.29	58.52	41.81	53.07	37.73	33.86	35.78
150	270.84	257.79	88.90	69.75	81.65	59.88	53.21	48.86