ZH→llbb search using a Matrix Element technique

Full description in AN-12-476

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Scalar Search and Study in Belgium

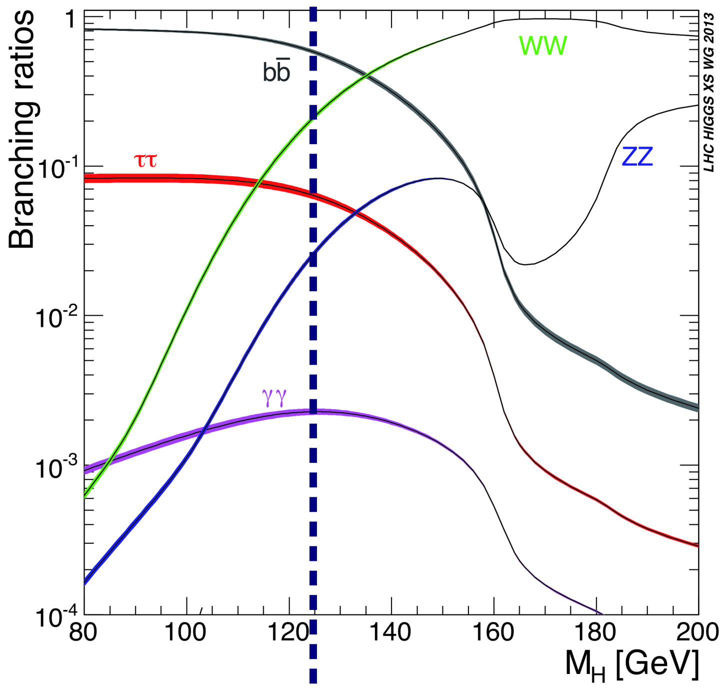
23-24 January 2014

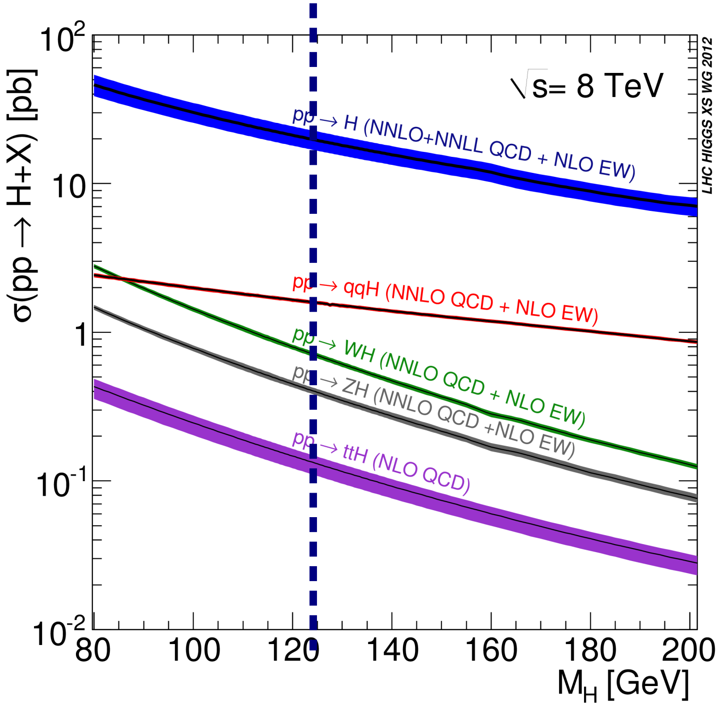
Motivations

- Important to probe SM in the fermionic sector
- H boson coupling to fermions harder to probe:
  - High background for H → bb due to QCD
    - Associate production (ZH)
  - Worse mass resolution

- At CP3:
  - llbb final state: Z+b(b) cross-section
  - ME automatized tool: MadWeight

- Search for Z(ll)H(bb)
- Use ME method to discriminate signal process from the background processes

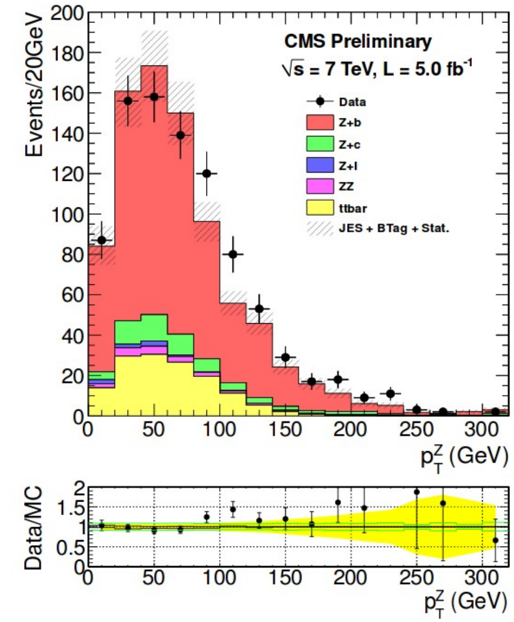




Selection

Basic selection

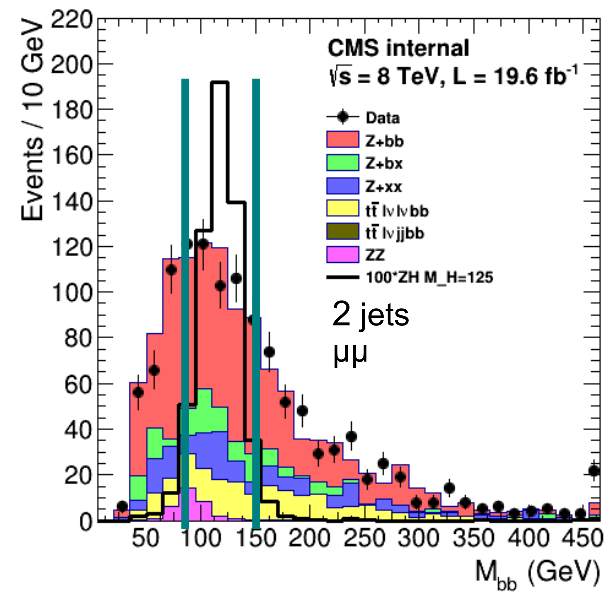
Object	Z(ll)H(bb) (2011+2012)
Trigger	DiMu + DiEl
Leptons (PF muons, electrons)	$p_T(l) > 20$ GeV $\lvert\eta(l)\rvert < 2.4, \lvert\eta(l)\rvert < 2.5$ isolation criteria
ll-pair	$76 < m(l^+l^-) < 106$ GeV $p_T(ll) > 20$ GeV
ak5 PF jets	$p_T(j_1) > 40, p_T(j_2) > 25$ GeV $\lvert\eta(j)\rvert < 2.4$
Jet-lepton separation	$\Delta R(l,j) > 0.5$
B-tagging	CSV-MM M: CSV > 0.679 (control: CSV-ML) (L: CSV > 0.244)
PF MET	MET significance < 10



Regions:

SR:	**Signal**	bb-pair	2 jets: $2j$: $80 < M(bb) < 150$ GeV >2 jets: $3j$: $50 < M(bb) < 150$ GeV
CR:	**Control**	bb-pair	$2j$: $M(bb) < 80 \mid\mid M(bb) > 150$ GeV $3j$: $M(bb) < 50 \mid\mid M(bb) > 150$ GeV
	Fit	ll-pair	**Control** + $61 < m(l^+l^-) < 121$ GeV

→ For background estimation



Matrix Element method

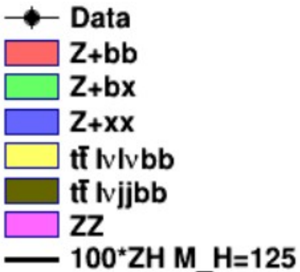
Matrix Element method* provide probability that an experimental event corresponds to a specific process (hypothesis).

$$P(x^{vis}|\alpha) = \frac{1}{\sigma_\alpha} \int dx_1 dx_2 f(x_1) f(x_2) \int d\Phi |M(p)_\alpha|^2 W(p^{vis}, p)$$

Where :

- p^{vis} : experimental event : {(Pt,eta,phi,E,B-tag,…)$_{jet1}$; (Pt,eta,phi,E,B-tag,…)$_{jet2}$; (Pt,eta,phi,E,charge,…)$_{lep1}$; (Pt,eta,phi,E,charge,…)$_{lep2}$; (Et,phi…)$_{met}$ }
- p : partonic state
- $f(x_1)$ $f(x_2)$: integration on pdf
- α : set of parameter defining the theoretical frame (α is fixed in this analysis).
- $|M(p)|^2$ Matrix element @ L.O.
- $W(p,p^{vis})$: transfer function. Conditional probability that an observed quantity (p^{vis}) is the evolution of a partonic level one (p).

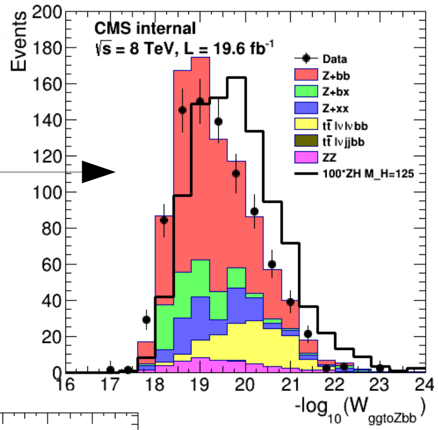
Weights are defined as : $W = \sigma \times P$

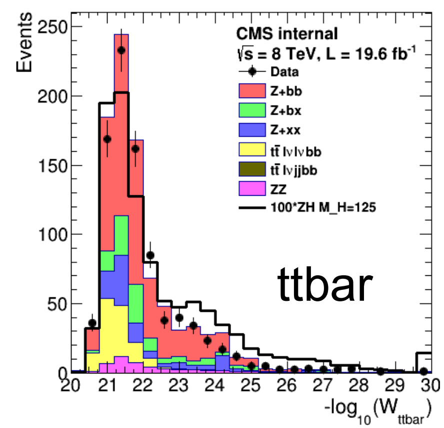


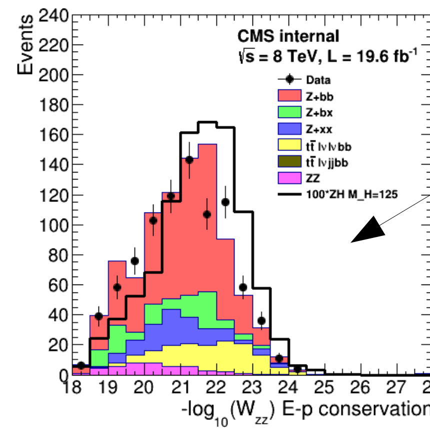
2012 data, 8 Tev
2 jets category
Signal Region
Bkg scaled to fit of the CR

ME observables

gg → Z+bb

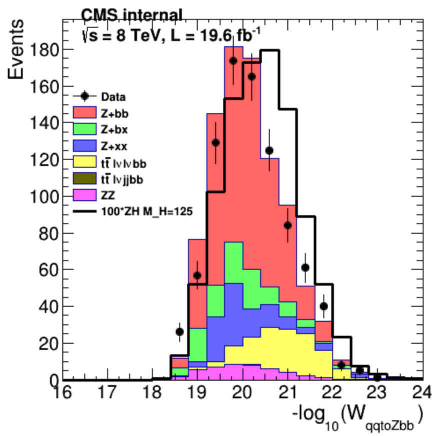




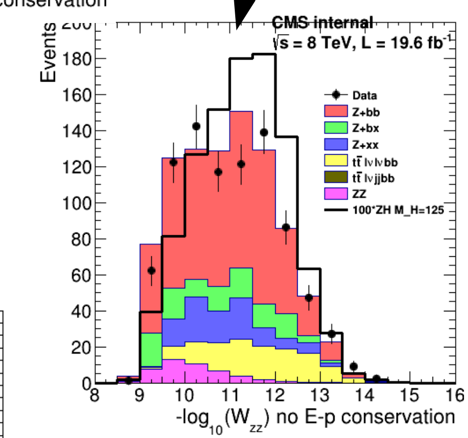


ZZ with E-p conservation

qq → Z+bb

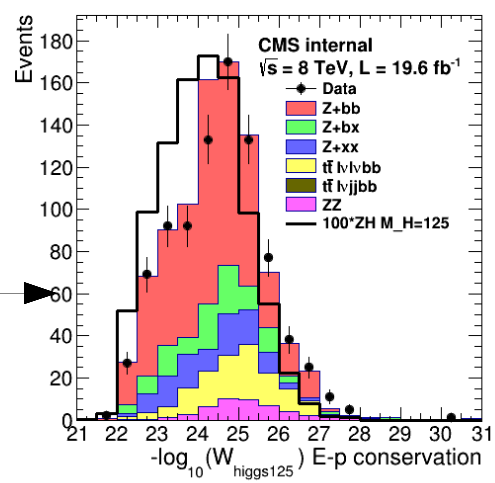


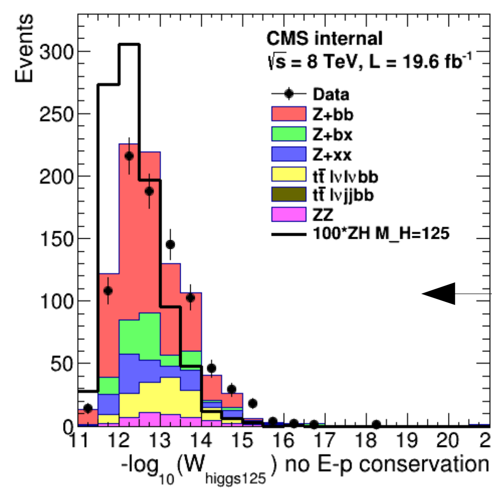
ZZ no E-p conservation



Good modelling of the ME weights

ZH(125) with E-p conservation

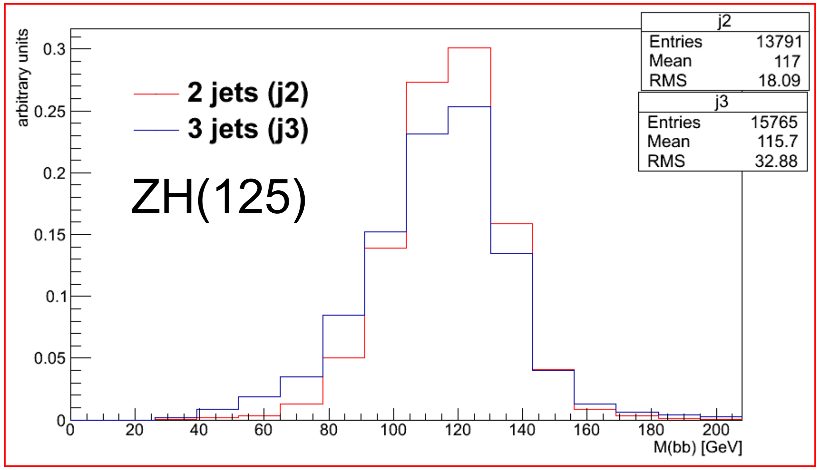




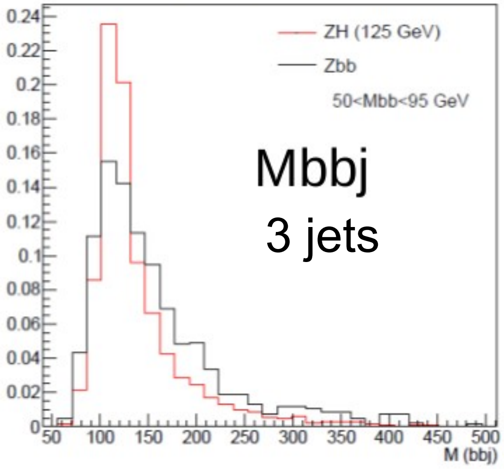
ZH(125) no E-p conservation

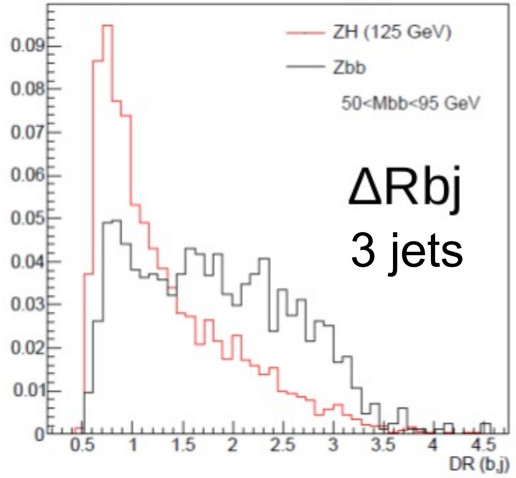
Choice of event categorization

- **Problem: events with >= 3 jets**
  - Bigger background
  - Worse dijet mass resolution



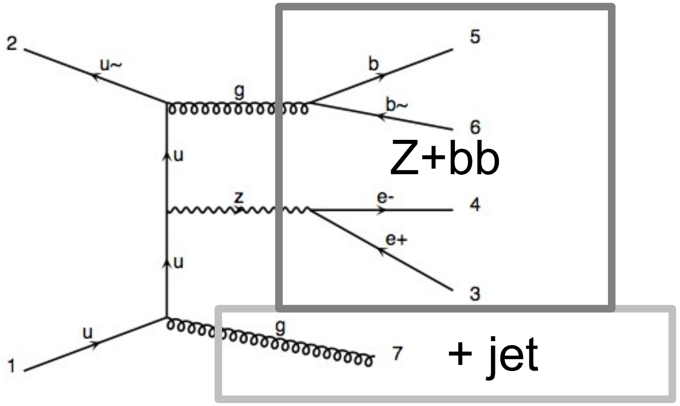
- **Solution: separate categories**
  - 2 categories based on the number of jets
    - p_T > 20 GeV: 2 or >= 3 jets categories
  - Improves sensitivity
  - Special treatment for events with extra jets
    - ISR: transverse boost to LO ME rest frame
    - FSR: use M(bbj) and ΔR(b,j)
  - Z pt spectrum found in agreement in each category





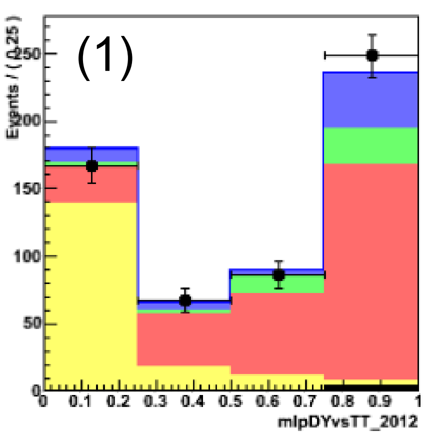
Background normalisation

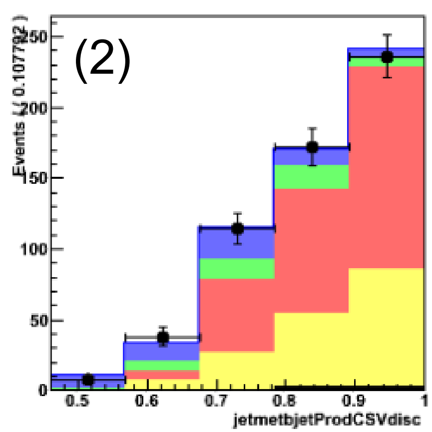
- 2D simultaneous fit in 4 cats:
  - ee & μμ
  - 2 jets & 3 jets
- 2 discriminating observables
  (1) MLP TTbar vs Zbb
    - ME weights: qqZbb, ggZbb, tt
  (2) CSV product
    - Product of CSV of the 2 b-tagged jets



SF	value 2011 MM	value 2012 MM
SF_Zbb	1.10 ± 0.09	1.12 ± 0.05
SF_Zbx	1.29 ± 0.11	1.27 ± 0.05
SF_Zxx	0.87 ± 0.18	1.08 ± 0.11
SF_tt	1.00 ± 0.10	0.94 ± 0.03

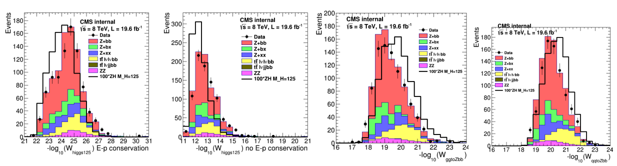
2 jets - μμ :

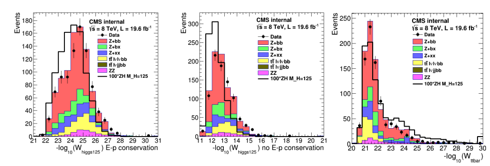


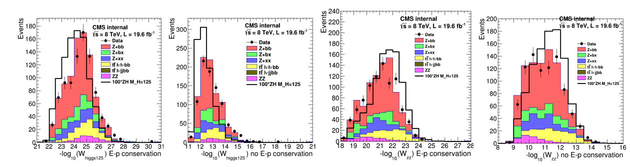


- **Considering Zbbx production**
- **All SFs consistent**
- **SF_Zbx > 1**

Construction of final discriminant







ZH and Zbb hypo. ME weights

ZH and ttbar hypo. ME weights

ZH and ZZ hypo. ME weights

MVA ZH vs DY

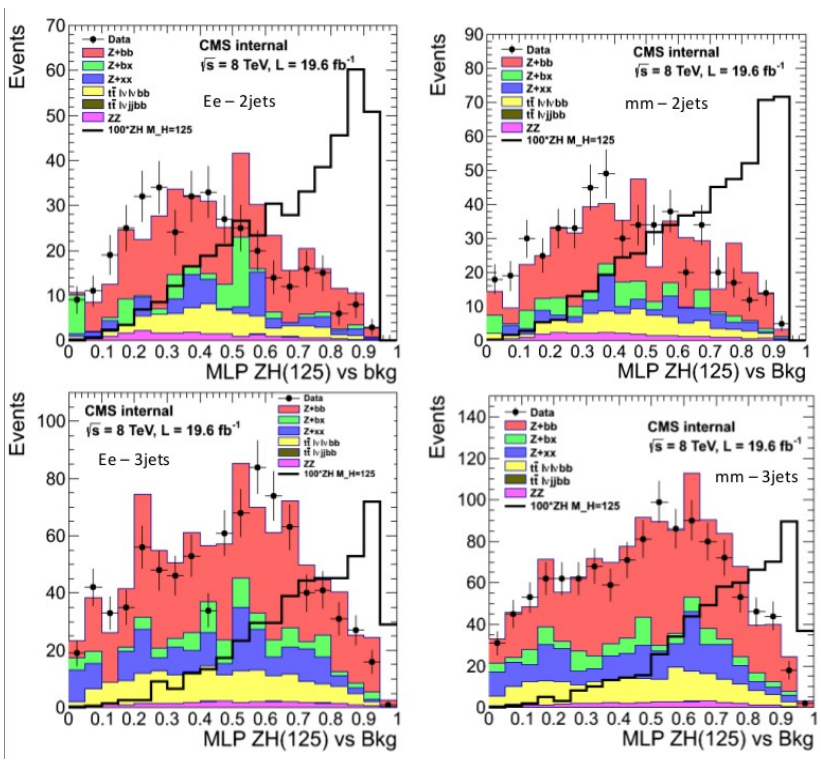
MVA ZH vs ttbar

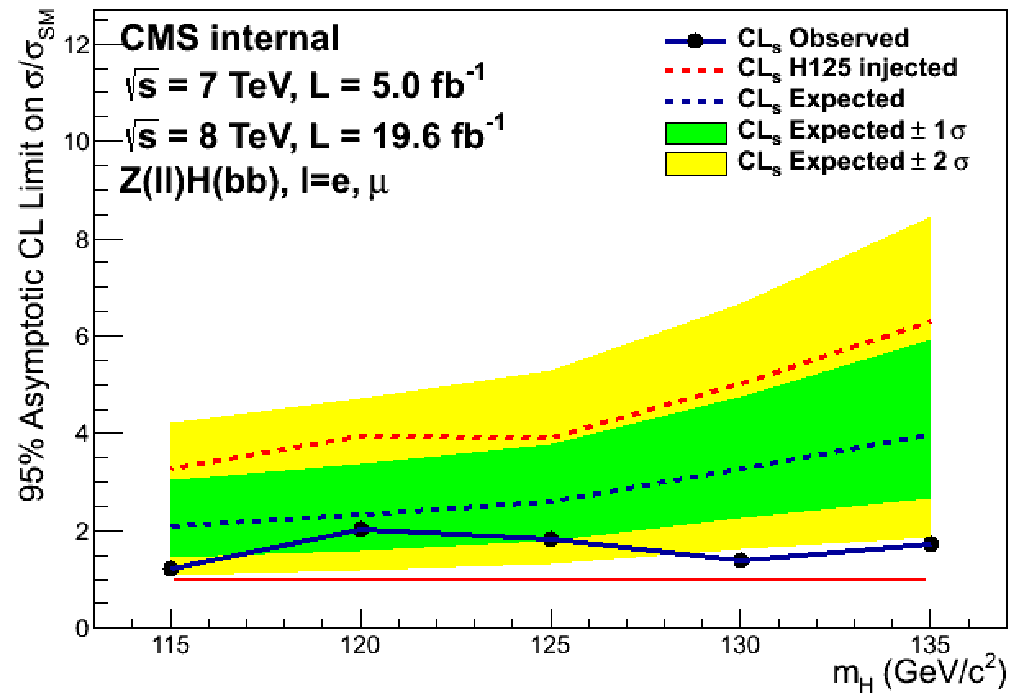
MVA ZH vs ZZ

MVA ZH vs Background

Unblinded ZH search
2011+2012

- Data/simulation of multivariate discriminant at 125 GeV
- Signal: 100*SM



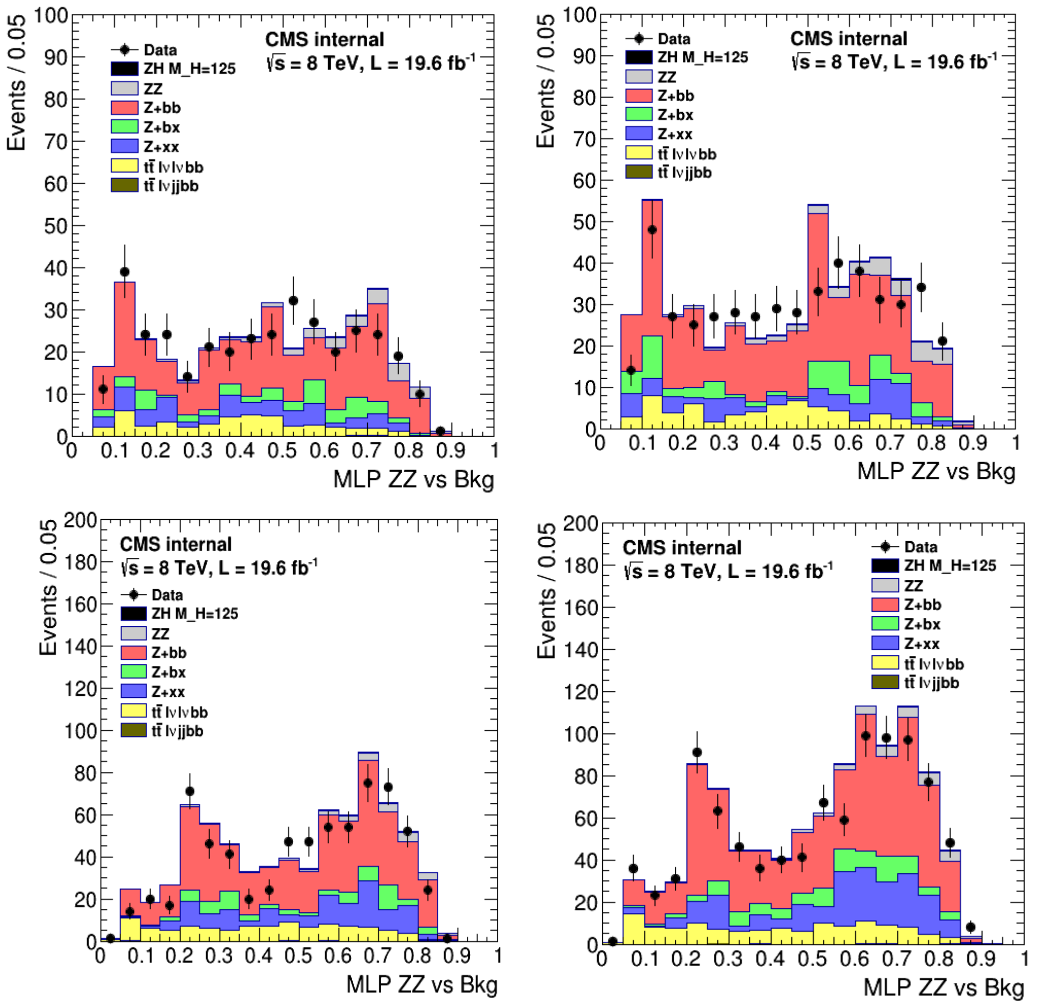


- Full unblinding of the analysis
  - Signal injection at 125: 3.9 x σ/σ_{SM}
  - Expected limit at 125: 2.6 x σ/σ_{SM}
  - Observed limit at 125: 1.8 x σ/σ_{SM}
- At 125 GeV
  - Compatible with background only within 1 s.d.
  - Compatible with a SM H boson within 2 s.d.

ZZ search cross-check

2011+2012

- **Limits**
  - Expected: 0.8 x $\sigma/\sigma_{\text{CMS Meas}}$
  - Observed: 1.4 x $\sigma/\sigma_{\text{CMS Meas.}}$
  - Signal injection: 1.8 $\sigma/\sigma_{\text{CMS Meas.}}$
- **Significance**
  - Expected: 2.4
  - Observed: 1.5
- **Signal strength:** $\mu=0.6\pm0.4$
- **Compatible with SM**



Summary

- **Matrix Element technique was used to perform a search of Z(ll)H(bb) process**
  - The MW weights are used in NN to discriminate signal and backgrounds
  - Extra jets are included with complementary info
- **Presented unblinded result for 2011+2012**
  - ZZ compatible with SM
  - ZH just unblinded and results compatible with SM H within 2 s.d.
- **Analysis competitive**
  - Many ways to improve it (CHS jets, jet energy regression...)
- **Outlook**
  - $H \rightarrow bb$ properties
  - Exotic searches in scalar sector with llbb final state

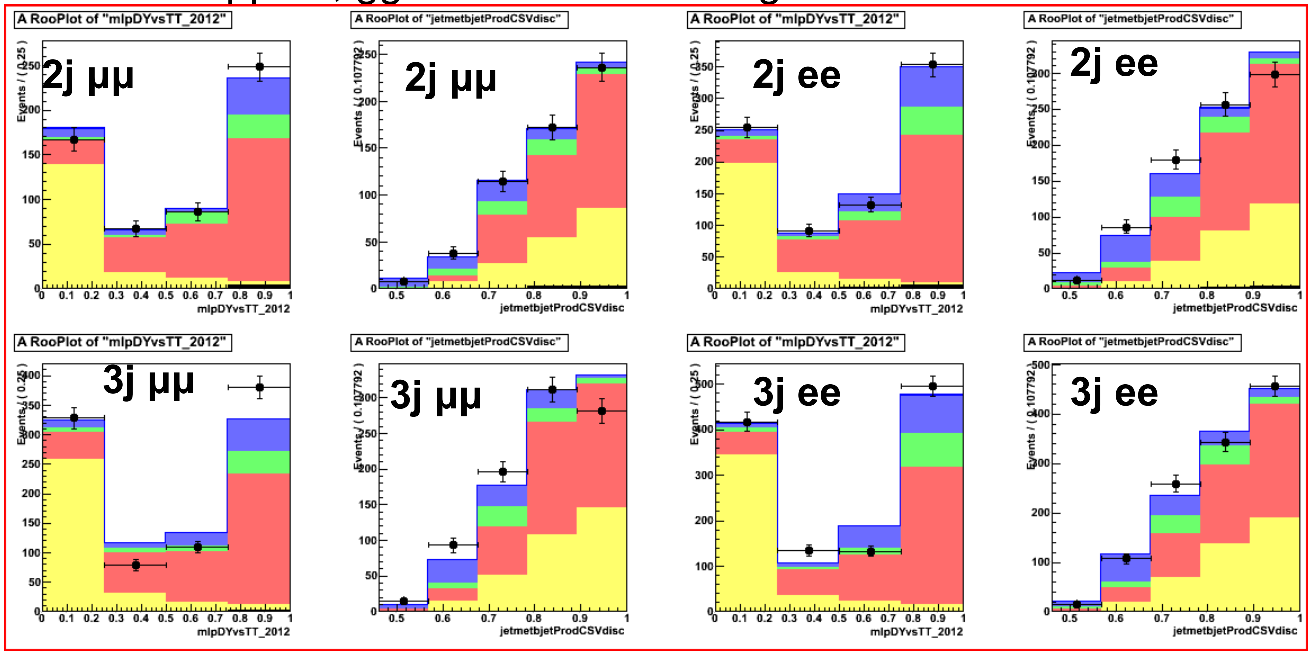
Backup

Documentation

- **Arnaud Pin thesis: Technique, validation and first 2011 results (link)**
- **AN-12-476**
  - To be updated with unblinded ZH results

Scale factors for the background estimation

- 2D simultaneous fit of the 4 channels ee – μμ in both jet categorization (2 jets and 3 jets)
- Variables used :
    - CSV product: product of the CSV value attached to the 2 b-tagged jets
    - MLP TTbar vs Zbb trained with 2011 or 2012 MC
        * inputs are the qqZbb, ggZbb and tt MW weights



Fit Region

Each channel:
- MLP: left
- CSVprod: right

SF_Zbb → Zbb in the 2 jets category → Zbb LO process
SF_Zbx → Zbb 3 jets category + Zbx → Zbb+j
SF_Zxx → same in both categories (DY+jets)
SF_tt → same in both categories
ZZ normalisation fixed to CMS measurements

Scale factors: results

Table 4: *The background scale factors as estimated from the 2D fits for 2011 and 2012 data.*

SF	value 2011 MM	value 2012 MM	value 2011 ML	value 2012 ML
SF_Zbb	1.10 ± 0.09	1.12 ± 0.05	1.05 ± 0.08	1.06 ± 0.05
SF_Zbx	1.29 ± 0.11	1.27 ± 0.05	1.20 ± 0.10	1.22 ± 0.04
SF_Zxx	0.87 ± 0.18	1.08 ± 0.11	0.88 ± 0.10	1.38 ± 0.04
SF_tt	1.00 ± 0.10	0.94 ± 0.03	0.96 ± 0.09	1.00 ± 0.03

Very good agreement between all four cases,
except for SF_Zxx, where the fake rate is affected by pileup in 2012

Strategy

Z(ll)H(bb) search (l= e/mu):

- Based on Z(ll)+bb cross-section measurement analysis (similar selection).
- b-tag: CSV discriminant at Medium-Medium working point.
- Categorization in jet multiplicity
  - 2 jets: events with Exactly 2 jets identified as b-jets
  - 3 jets: events with at least 3 jets with 2 identified as b-jets.

Considered Backgrounds:

- ttbar: Dileptonic decay channel (ee/mumu)
- DY + jets: Z+bb, Z+bx, Z+xx   x=light/c jets
- diboson: Z(ll)Z(bb)

Matrix Element Method:

- For each event we test signal and background hypothesis → 7 weights per event

Process	Hypothesis	ISR correction	E-P conservation
Higgs	$qq \to ZH \to l^- l + b\bar{b}$	without MeT	conserved
Higgs	$qq \to ZH \to l^- l + b\bar{b}$	without MeT	Not conserved
$t\bar{t}$	$pp \to t\bar{t} \to l^- l + \nu\bar{\nu}\ b\bar{b}$	with MeT	conserved
$Zb\bar{b}$	$gg \to l^- l + b\bar{b}$	without MeT	conserved
$Zb\bar{b}$	$qq \to l^- l + b\bar{b}$	without MeT	conserved
ZZ	$qq \to ZZ \to l^- l + b\bar{b}$	without MeT	conserved
ZZ	$qq \to ZZ \to l^- l + b\bar{b}$	without MeT	Not conserved

Multivariate analysis:

- MLP discriminants use as inputs the M.E. weights + other variables in the 3 jets category.
- Intermediate Discriminants: ZH-tt, ZH-Zbb, ZH-ZZ

→ ZH-BKG discriminant based on the three intermediate ones.

ME TF

Z(ll)Hbb search based on matrix element method.

Transfer function

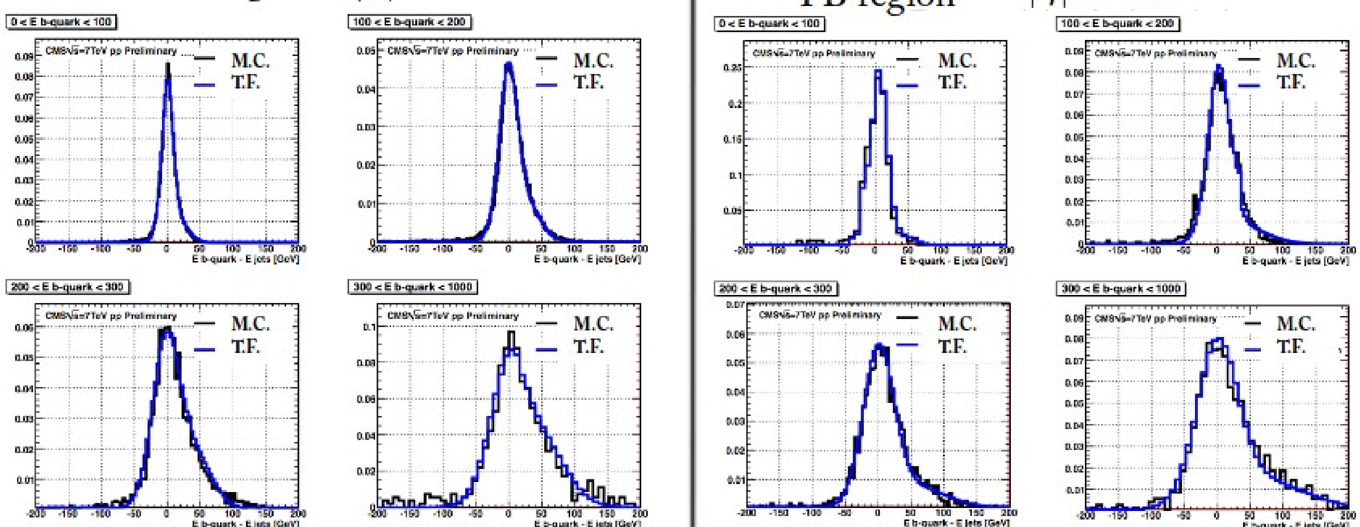
Factorisation : $W(x,y) = \prod_{i=1}^{n} W_i(x^i,y^i) = \prod_{i=1}^{n} \left[W_i^E(x^i,y^i).W_i^\eta(x^i,y^i).W_i^\phi(x^i,y^i) \right]$

Hypothesis on TF: δ function assumed for angular variables.

Jets Energy (b-jets ; √s=7 TeV) : Double gaussian parametrisation

Central region $|\eta| < 1.6$

FB region $|\eta| > 1.6$



•Blue curve represent the sum, over b-quark energy (Ep), of the transfer function W(Ep,Ejet) weighted according to Ep distribution.
•Black curve represent the M.C. expectation.

21/09/12 Arnaud Pin 9

ME ISR

Z(ll)Hbb search based on matrix element method.

I.S.R. correction

Matrix Element evaluated at leading order.
Effect of I.S.R are taken into account by looking at the Pt of boosted topology.
Pt is defined:

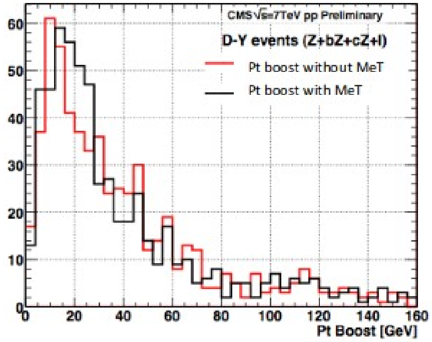
- Process with a not fully observabe leading order final state (with neutrino) e.g. ttbar dileptonic

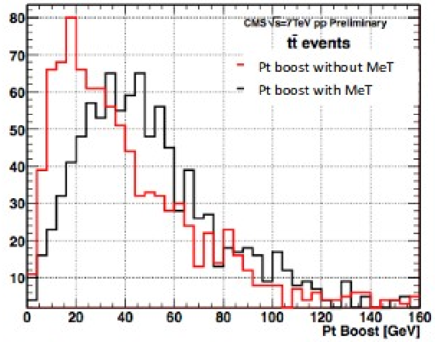
$$\vec{P}t_{boost} = \sum_{L.O.finalstate} \vec{P}t + M\vec{e}T = -\sum_{radiation} \vec{P}t \quad \text{Type 1}$$

- Process with a fully observabe leading order final state (no neutrino) e.g. Z(ll)bb process

$$\vec{P}t_{boost} = \sum_{L.O.finalstate} \vec{P}t = -\sum_{radiation} \vec{P}t \quad \text{Type 2}$$

- Choice driven by the processs NOT by the event topology.





21/09/12 Arnaud Pin 10

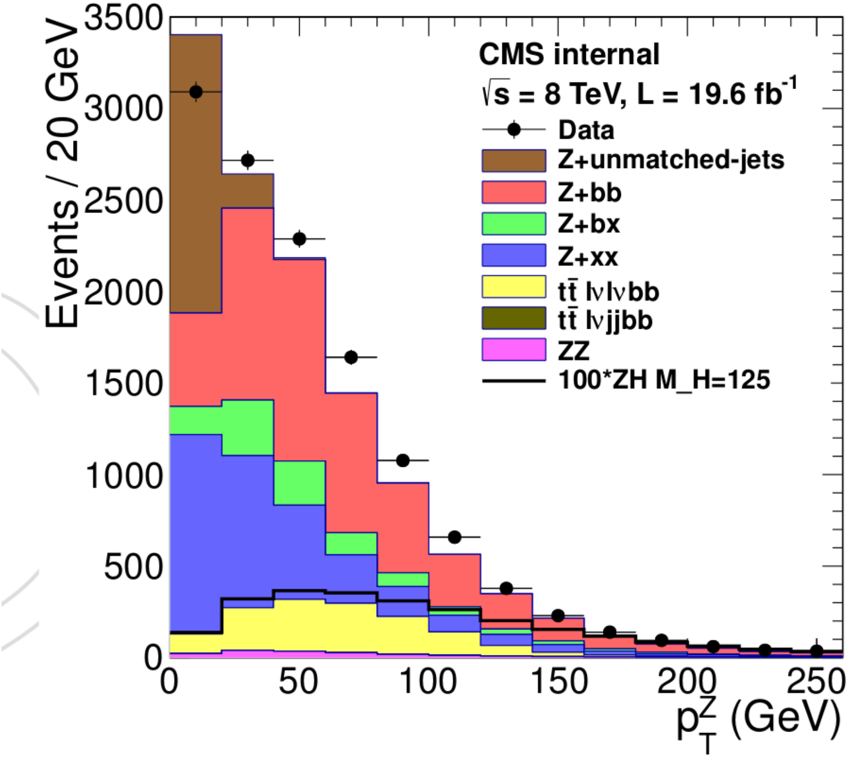
Datasets

Table 2: *Data and MC samples used in this analysis.* `MASS` *means all masses between 110 and 135 by step of 5 GeV/c2. * is* `Fall11-PU_S6` *for 7 TeV MC and* `Summer12_DR53X-PU_S10` *for 8 TeV MC. Samples with a*† *are not used in the MVA training. All samples are taken from* `AOD` *(Data) and* `AODSIM` *(MC) files.*

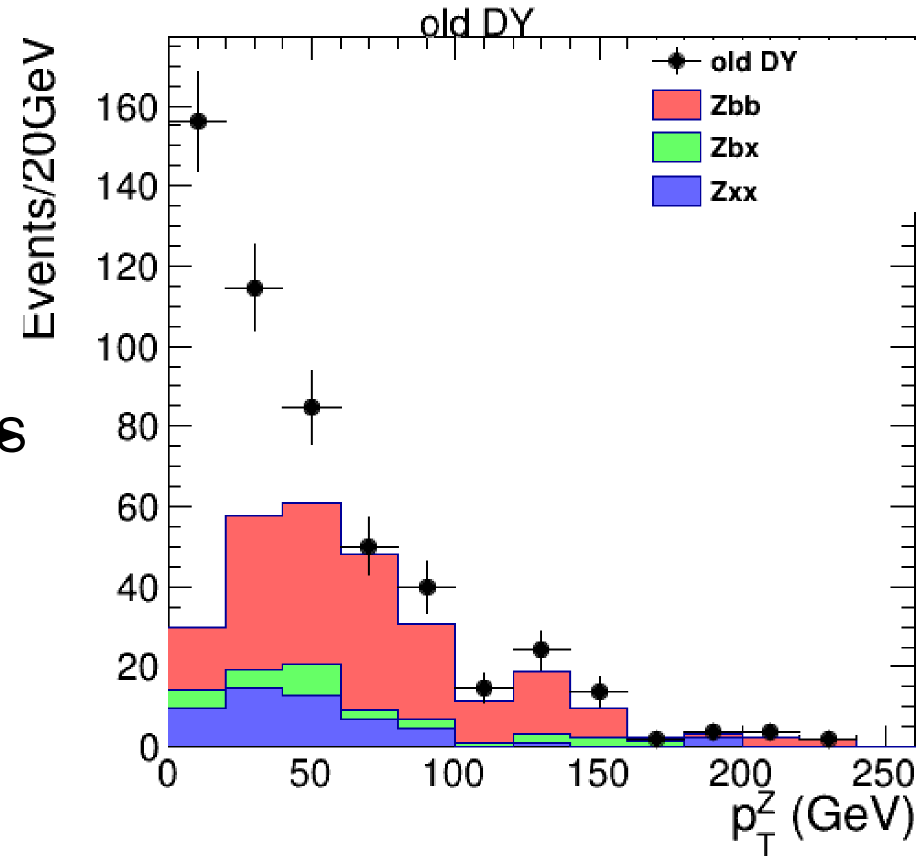
2011		
Data	ElA	/DoubleElectron/Run2011A-08Nov2011-v1/
	ElB	/DoubleElectron/Run2011B-19Nov2011-v1/
	MuA	/DoubleMu/Run2011A-08Nov2011-v1/
	MuB	/DoubleMu/Run2011B-19Nov2011-v1/
MC	DY	/DYJetsToLL_TuneZ2_M-50_7TeV-madgraph-tauola/*-START44_V5-v1/
	DY $p_T(Z) > 100$	/DYJetsToLL_PtZ-100_TuneZ2_7TeV-madgraph-tauola/
	TT	/TTJets_TuneZ2_7TeV-madgraph-tauola/*-START44_V5-v1/
	ZZ	/ZZ_TuneZ2_7TeV_pythia6_tauola/*-START44_V5-v1/
	ZH	/ZH_ZToLL_HToBB_M-*MASS*_7TeV-powheg-herwigpp/
Training	Zbb	/Zbb_4F_7TeV_madgraph/*_START44_V9B-v1/
2012		
Data	ElA	/DoubleElectron/Run2012A-13Jul2012-v1/
	ElB	/DoubleElectron/Run2012B-13Jul2012-v1/
	ElA 06aug	/DoubleElectron/Run2012A-recover-06Aug2012-v1/
	ElC-v1	/DoubleElectron/Run2012C-24Aug2012-v1/
	ElC-v2	/DoubleElectron/Run2012C-PromptReco-v2/
	ElD	/DoubleElectron/Run2012D-PromptReco-v1/
	MuA	/DoubleMu/Run2012A-13Jul2012-v1/
	MuB	/DoubleMu/Run2012B-13Jul2012-v4/
	MuA 06aug	/DoubleMu/Run2012A-recover-06Aug2012-v1/
	MuC-v1	/DoubleMu/Run2012C-24Aug2012-v1/
	MuC-v2	/DoubleMu/Run2012C-PromptReco-v2/
	MuD	/DoubleMu/Run2012D-PromptReco-v1/
MC	DY inclusive	/DYJetsToLL_M-50_TuneZ2Star_8TeV-madgraph-tarball/*_START53_V7A-v1/
	DY $p_T(Z)$ $[50-70]^\dagger$	/DYJetsToLL_PtZ-50To70_TuneZ2star_8TeV-madgraph-tarball/*_START53_V7A-v1/
	DY $p_T(Z)$ $[70-100]^\dagger$	/DYJetsToLL_PtZ-70To100_TuneZ2star_8TeV-madgraph-tarball/*_START53_V7A-v2/
	DY $p_T(Z) > 100^\dagger$	/DYJetsToLL_PtZ-100_TuneZ2star_8TeV-madgraph/*_START53_V7A-v2/
	DY $p_T(Z) > 180^\dagger$	/DYJetsToLL_PtZ-180_TuneZ2star_8TeV-madgraph-tarball/*_START53_V7C-v1/
	TT Fully Leptonic	/TTJets_FullLeptMGDecays_8TeV-madgraph/*_START53_V7A-v2/
	TT Semi-Leptonic†	/TTJets_SemiLeptMGDecays_8TeV-madgraph/*_START53_V7A_ext-v1/
	ZZ	/ZZ_TuneZ2star_8TeV_pythia6_tauola/*_START53_V7A-v1/
	ZH	/ZH_ZToLL_HToBB_M-*MASS*_8TeV-powheg-herwigpp/*_START53_V7A-v1/
Training	Zbb	/ZbbToLL_massive_M-50_TuneZ2star_8TeV-madgraph-pythia6_tauola/*_START53_V7A-v1/
	TT inclusive	/TTJets_MassiveBinDECAY_TuneZ2star_8TeV-madgraph-tauola/*_START53_V7A-v1/

PU discussion

No CHS on the jets



CHS



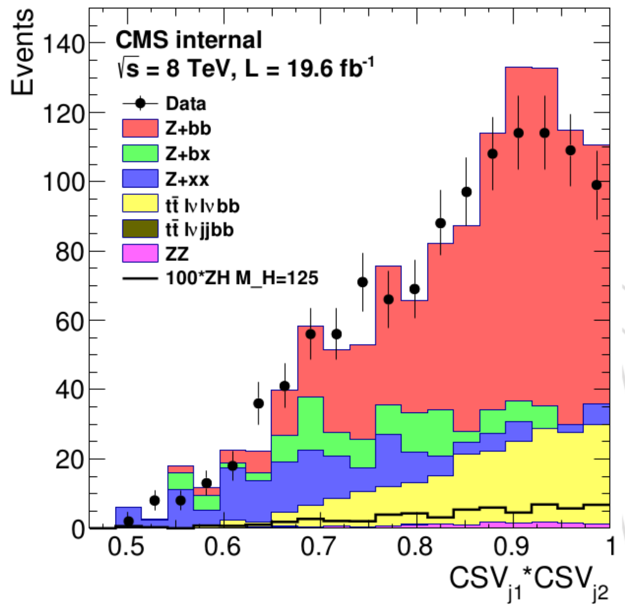
- Brown is purely PU events contribution:
  - Both b-tagged jets are unmatched with a gen-jet
- Cut on jets lower: pt>20 and no cut on pt Z

- Same cuts, comparing same DY vs DY events. (~12% of whole sample)
- Raw number of selected events
- Old DY is part of the DY on the right,
- Zbb, Zbx and Zxx used CHS jets

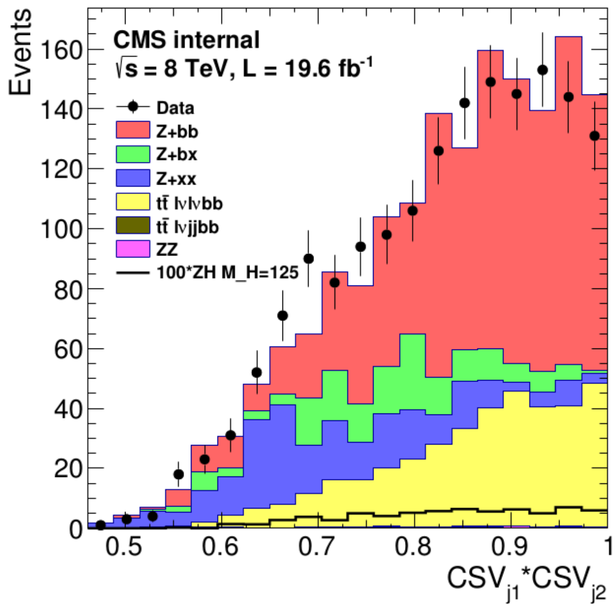
ee+μμ

CR: Variables used to perform the SFs fit

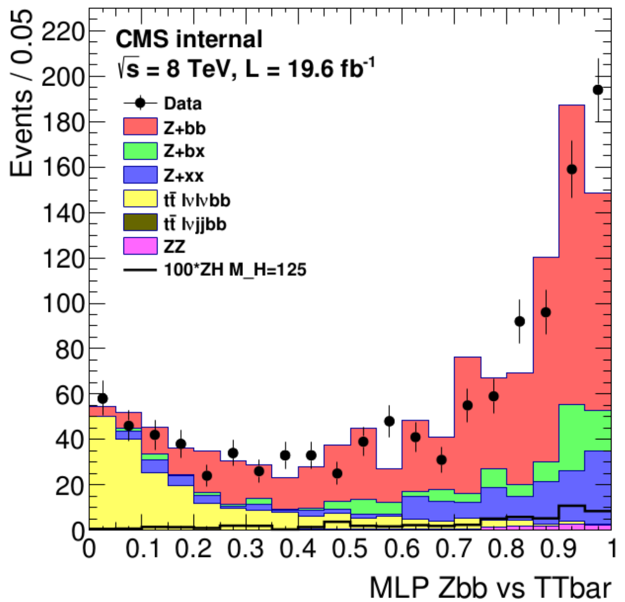
2 jet: CSV product



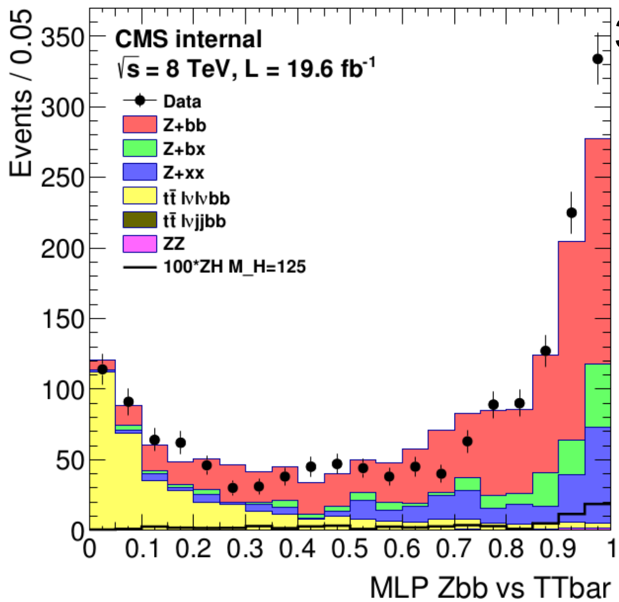
3 jet: CSV product



2 jet: MLP tt vs Zbb



3 jet: MLP tt vs Zbb



Systematics

- **Luminosity unc.:**
  - 2.2% (4.4%) on signal normalisation at 7 TeV (8 TeV)
- **Theoretical unc. on signal cross-section:**
  - 4% on signal normalisation
- **Lepton Reconstruction and Trigger Efficiency:**
  - 4% on the signal normalisation
- **ZZ cross-section measurement unc.:**
  - 40% (15%) at 7 TeV (8 TeV)
- **Background normalisation unc.:**
  - Uncorrelated unc. from the fit unc.
- **JER unc.:**
  - 2-6% normalisation on the signal normalisation
- **B-tag unc.:**
  - shape unc., b, c SFs unc. and light SFs unc. are taken uncorrelated
- **JES unc.:**
  - shape unc. (MW weights recomputed)
- **MC statistics unc.: shape unc.**
  - Allow a bin by bin fluctuation of the MC normalisation according the statistical uncertainties in the 10 most sensitive bins.

Systematics: Background fit correlations

- Diagonalization of covariance Matrix → we obtain transformation Matrix T such as T^{-1} Cov T = Diag.

- Error matrix=

Correlated Uncert.	bg1	bg2	bg3
e1	a	0	0
e2	0	b	0
e3	0	0	c

input in data card: unity matrix + Modif_error

- e1, e2, e3 correlated

- ModifiedError=T-[1]Error=

Not correlated	bg1	bg2	bg3
Eprime1	x11	x12	x13
Eprime2	x23	x33	x23
Eprime3	x13	x23	x33

- ePrime1, ePrime2, ePrime3 not correlated

Systematics breakdown

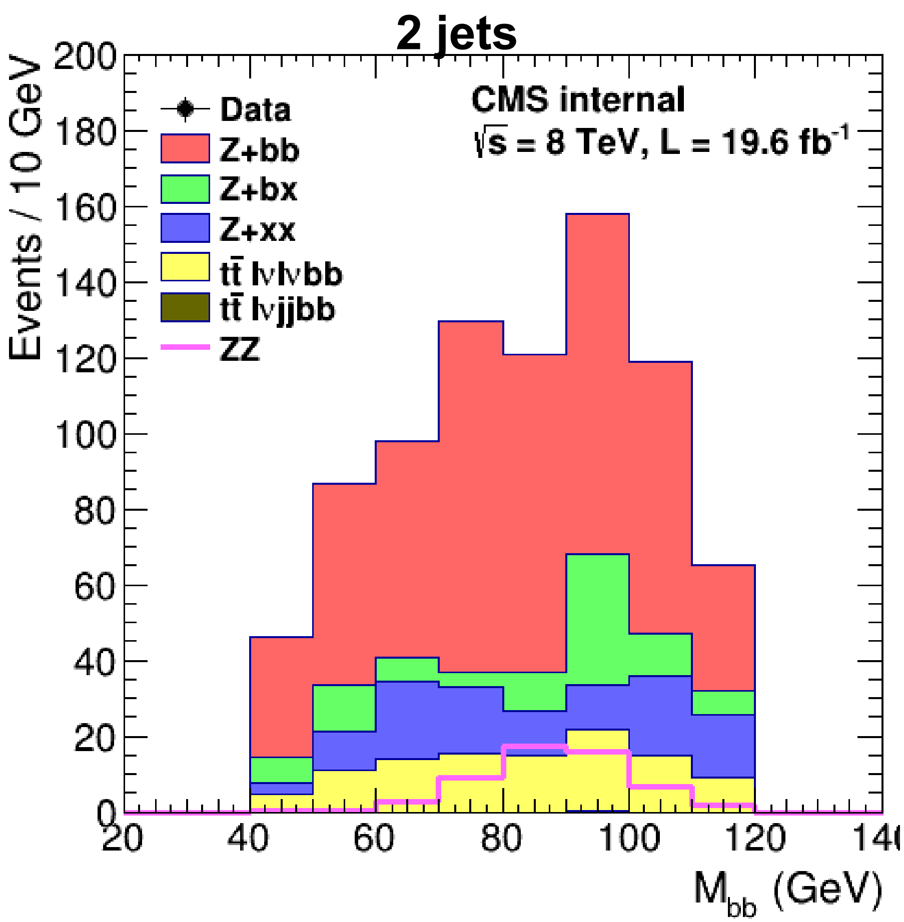
Systematics	limit	degradation (%)
No	2.07	
All	2.43	
-MC statistical unc.	2.26	7.5
-Zbb	2.30	5.7
-Zxx	2.40	1.3
-Zbx	2.41	0.8
-tt	2.41	0.8
-ZZ	2.42	0.4
-ZH	2.42	0.4
-Background norm.	2.32	4.7
-JER	2.41	0.8
-JES	2.41	0.8
-ZH cross-section	2.41	0.8
-Luminosity	2.41	0.8
-Lepton SFs	2.41	0.8
-Btag b, c-jets SFs	2.41	0.8
-Btag light-jets SFs	2.43	0

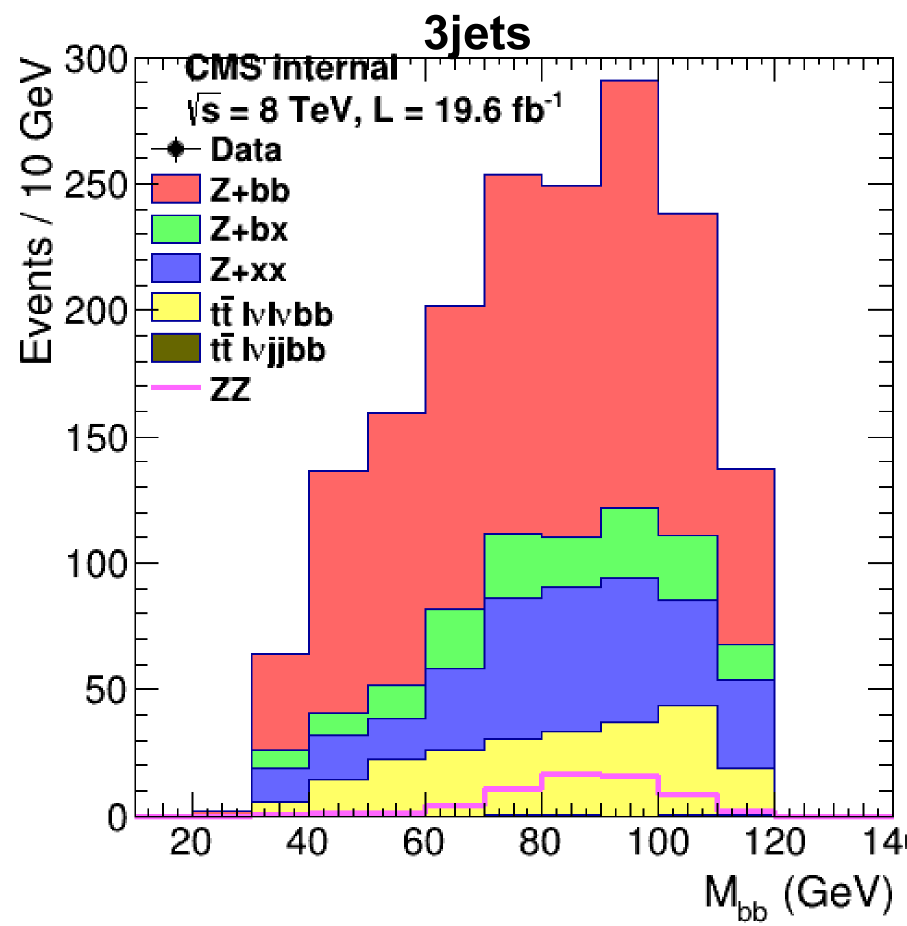
- Breakdown of systematics
  - Show the effect of removing ONE source of systematic each time
  - Most important effect from MC stat. uncertainty and from Bkg Normalization SFs

ee+μμ

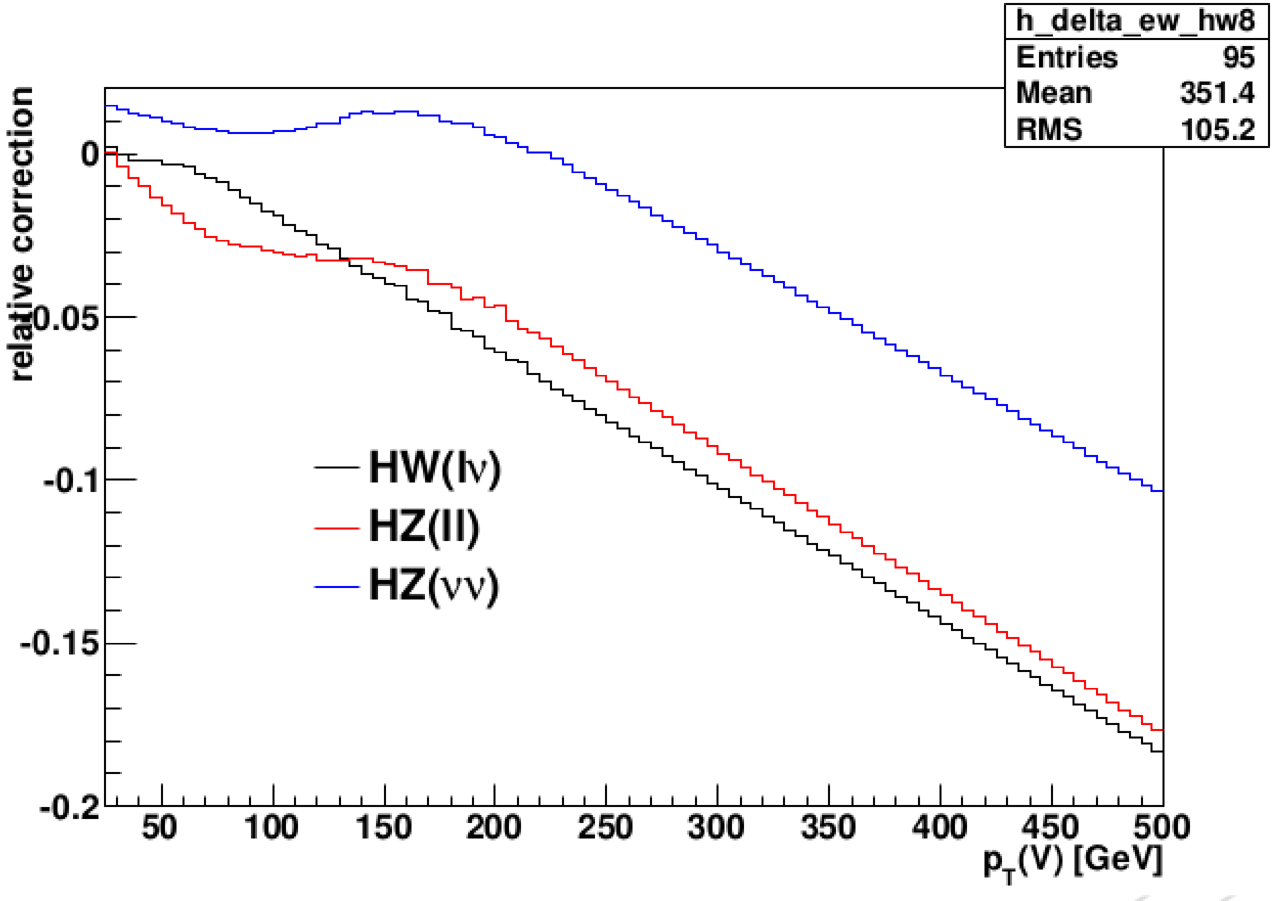
ZZ search: strategy

- **Signal region defined as M(bb) in [45,115] in the 2 jets category and M(bb) in [15,115] in the 3 jets category.**
- **Same strategy but only 2 intermediate NNs trained against DY and TTbar**
- **Difficult training as the background peak around the Z mass**





Signal EWK NLO $p_T(Z)$ reweigting



- We use the official values to reweight our signal samples to higher order corrections.
- Signal yields decrease by ~3-4%

Nuisance parameters fit

Comparison of nuisances

nuisance	background fit $\Delta x/\sigma_{in}, \sigma_{out}/\sigma_{in}$	signal fit $\Delta x/\sigma_{in}, \sigma_{out}/\sigma_{in}$	$\rho(\mu, \theta)$
JER	+0.00, 0.99	+0.00, 0.97	-0.00
JER2012	-0.12, 0.99	-0.09, 0.97	+0.00
JES 2011	+0.00, 0.99	+0.01, 0.97	-0.01
ZHunc	+0.00, 0.99	-0.01, 0.97	+0.04
ZHuncEWK	+0.00, 0.99	-0.01, 0.97	+0.05
ZHuncQCD	+0.00, 0.99	-0.00, 0.97	+0.02
ZZunc	+0.04, 0.98	+0.09, 0.96	-0.06
_EEChannelCut1TT-FullLeptstat_bin11	-0.07, 0.98	-0.07, 0.92	-0.01
_EEChannelCut1TT-FullLeptstat_bin12	-0.18, 0.97	-0.18, 0.91	+0.00
_EEChannelCut1TT-FullLeptstat_bin13	-0.12, 0.97	-0.11, 0.91	-0.00
_EEChannelCut1TT-FullLeptstat_bin14	-0.07, 0.98	-0.06, 0.91	-0.01
_EEChannelCut1TT-FullLeptstat_bin15	-0.09, 0.97	-0.08, 0.91	-0.00
_EEChannelCut1TT-FullLeptstat_bin16	-0.04, 0.98	-0.04, 0.92	-0.01
_EEChannelCut1TT-FullLeptstat_bin17	-0.13, 0.95	-0.13, 0.89	-0.01
_EEChannelCut1TT-FullLeptstat_bin18	-0.04, 0.97	-0.03, 0.92	-0.02
_EEChannelCut1TT-FullLeptstat_bin19	+0.03, 1.02	+0.12, 0.98	-0.08
_EEChannelCut1TT-FullLeptstat_bin20	-0.00, 0.99	-0.00, 0.44	+0.00
_EEChannelCut1TT-SemiLeptstat_bin11	-0.01, 0.97	-0.00, 0.91	-0.00
_EEChannelCut1TT-SemiLeptstat_bin12	-0.04, 0.97	-0.04, 0.91	+0.00
_EEChannelCut1TT-SemiLeptstat_bin13	-0.01, 0.95	-0.01, 0.89	-0.00

_JES 2012	+0.43, 0.08	+0.44, 0.08	-0.17

Nuisance parameters fit

_MuMuChannelCutlZbxstat_bin19	+0.09, 1.07	+0.14, 1.01	-0.06
_MuMuChannelCutlZbxstat_bin20	-0.00, 0.09	-0.00, 0.01	-0.00
_MuMuChannelCutlZxxstat_bin11	+0.51, 0.94	+0.51, 0.88	-0.01
_MuMuChannelCutlZxxstat_bin12	+0.28, 0.87	+0.29, 0.81	-0.01
_MuMuChannelCutlZxxstat_bin13	-0.45, 0.73	-0.45, 0.70	-0.01
_MuMuChannelCutlZxxstat_bin14	+0.25, 0.93	+0.26, 0.86	-0.01
_MuMuChannelCutlZxxstat_bin15	+0.09, 0.95	+0.11, 0.88	-0.02
_MuMuChannelCutlZxxstat_bin16	-0.17, 0.91	-0.17, 0.87	-0.01
_MuMuChannelCutlZxxstat_bin17	-0.45, 0.83	-0.44, 0.78	-0.00
_MuMuChannelCutlZxxstat_bin18	+0.01, 1.01	+0.01, 0.95	-0.00
_MuMuChannelCutlZxxstat_bin19	+0.18, 1.11	+0.30, 1.02	-0.14
_MuMuChannelCutlZxxstat_bin20	-0.00, 0.08	-0.00, 6.05	-0.05
bgnorm1	-0.22, 0.93	-0.20, 0.91	-0.02
bgnorm2	-0.52, 0.96	-0.51, 0.94	-0.02
bgnorm3	+0.34, 0.74	+0.32, 0.73	+0.03
bgnorm4	+2.14, 0.69	+2.08, 0.68	+0.11
bgnorm5	-0.19, 0.94	-0.17, 0.92	-0.01
boostEWK	+0.00, 0.99	+0.00, 0.97	-0.00
boostQCD	+0.00, 0.99	+0.01, 0.97	-0.00
elecSF	+0.00, 0.99	+0.00, 0.97	+0.00
lepunc_ee	+0.00, 0.99	+0.02, 0.97	-0.01
lepunc_mm	+0.00, 0.99	-0.03, 0.97	+0.05
lumi	+0.01, 0.99	+0.02, 0.97	+0.02
lumi2011	+0.00, 0.99	+0.00, 0.97	-0.00
muonSF	+0.00, 0.99	+0.00, 0.97	-0.00
sftt_MM	-0.22, 0.89	-0.20, 0.88	-0.03
sfzbb_MM	-0.19, 0.84	-0.31, 0.84	+0.17
sfzbx_MM	+1.37, 0.86	+1.36, 0.84	+0.02
sfzxx_MM	-1.49, 0.78	-1.40, 0.77	-0.13
signorm	+0.00, 0.99	+0.01, 0.97	-0.00

Limitation and room for improvement

- basing the analysis on the re-reco dataset for 2011 and 2012.
- implementing the Charge Hadron Substraction.
    - Better treatment of PU jets in the event.
- Improving the M_{bb} resolution applying the M_{bb} regression.
- Re-evaluating the M.E. weights with optimized transfer functions.
- Using single Muon trigger.

Timescale: during 2014 (for all of them)