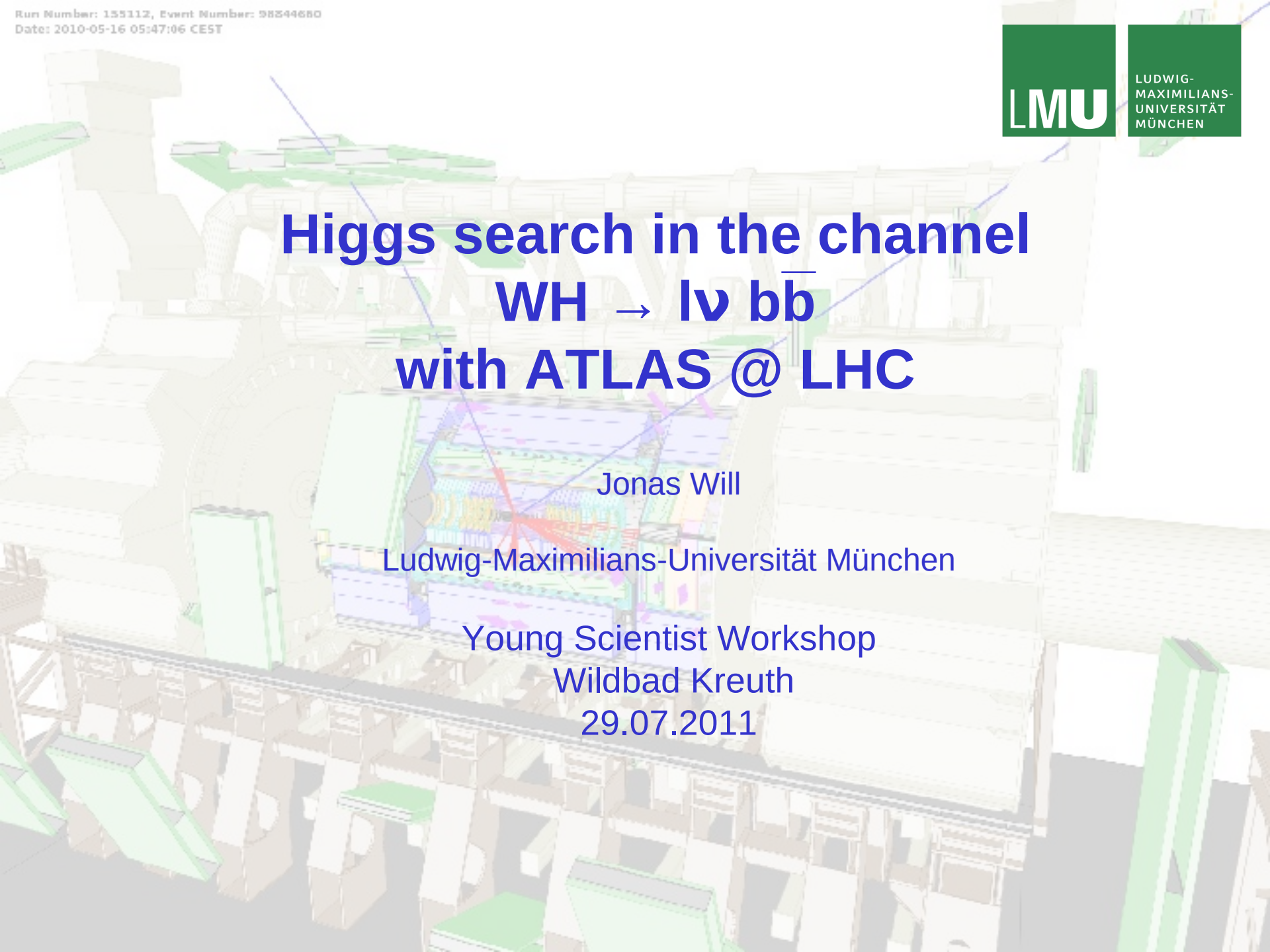


LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

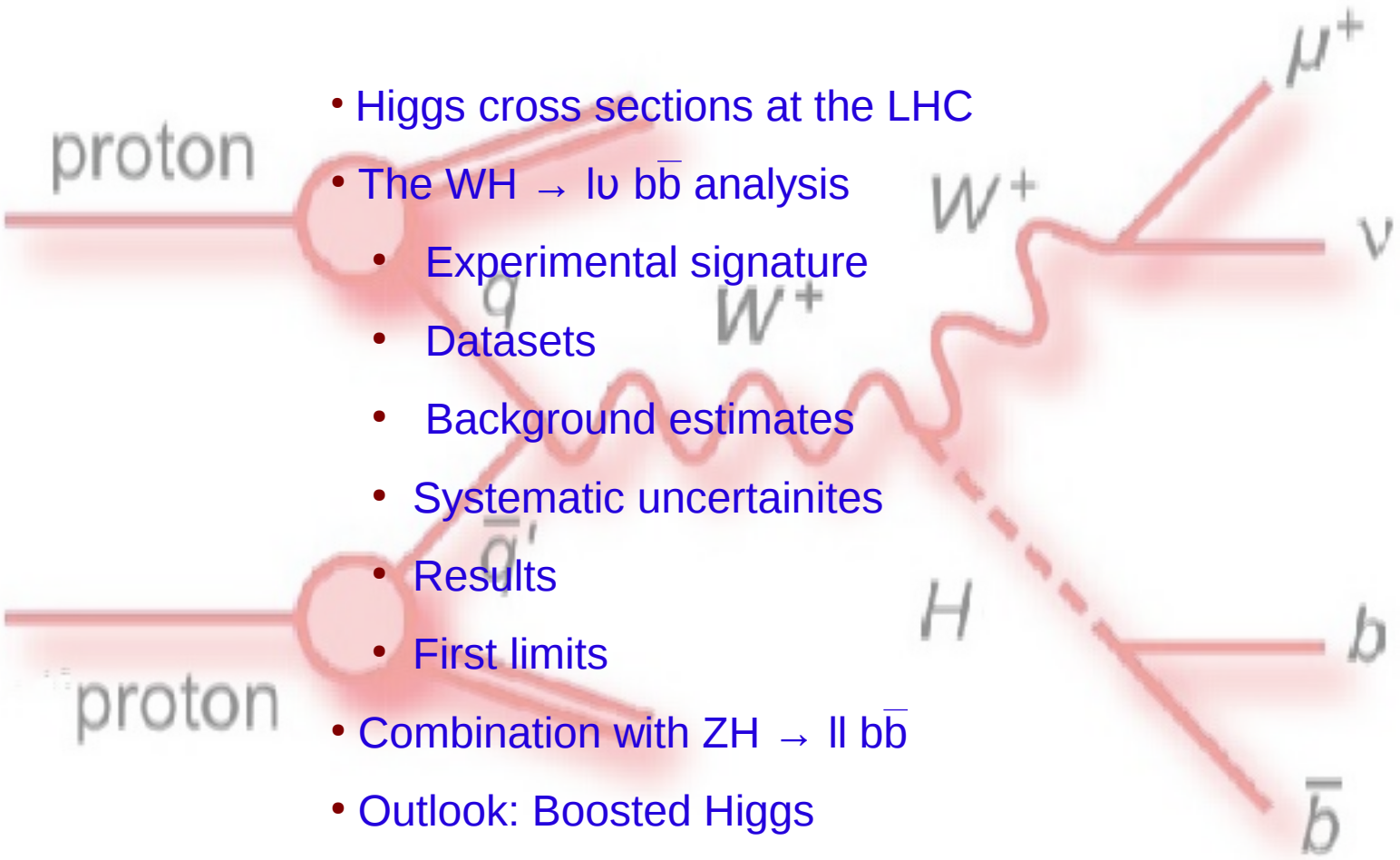
Higgs search in the channel $WH \rightarrow l\nu\, b\bar{b}$ with ATLAS @ LHC

Jonas Will

Ludwig-Maximilians-Universität München

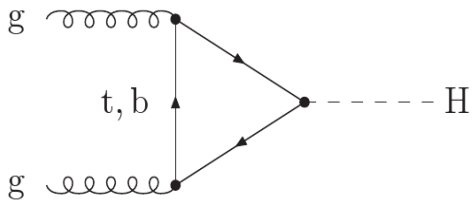
Young Scientist Workshop
Wildbad Kreuth
29.07.2011

Outline

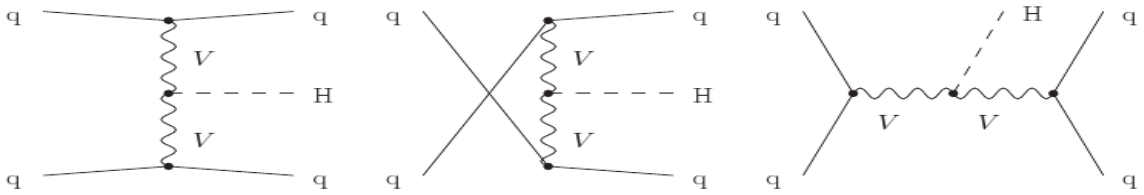


- Higgs cross sections at the LHC
- The WH → lυ $b\bar{b}$ analysis
  - Experimental signature
  - Datasets
  - Background estimates
  - Systematic uncertainites
  - Results
  - First limits
- Combination with ZH → ll $b\bar{b}$
- Outlook: Boosted Higgs
- ATLAS / CMS vs. Tevatron exclusion limits
- Things to remember

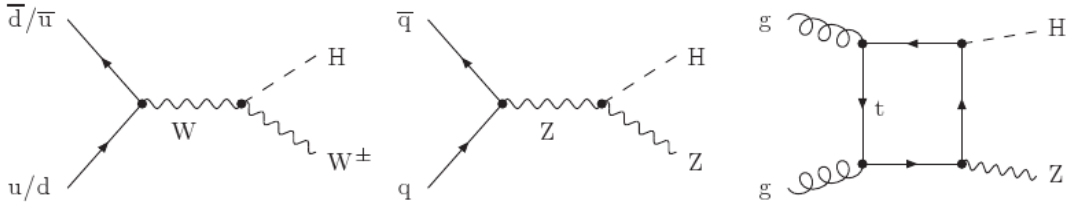
Overview over Higgs production processes



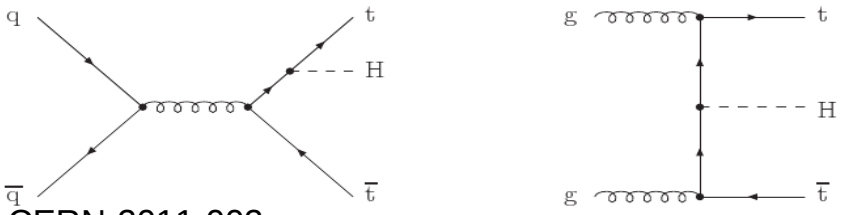
Gluon fusion (main process at the LHC)



Vector boson fusion



Associated production
“Higgs-Strahlung”



Associated production with $t\bar{t}$ pair

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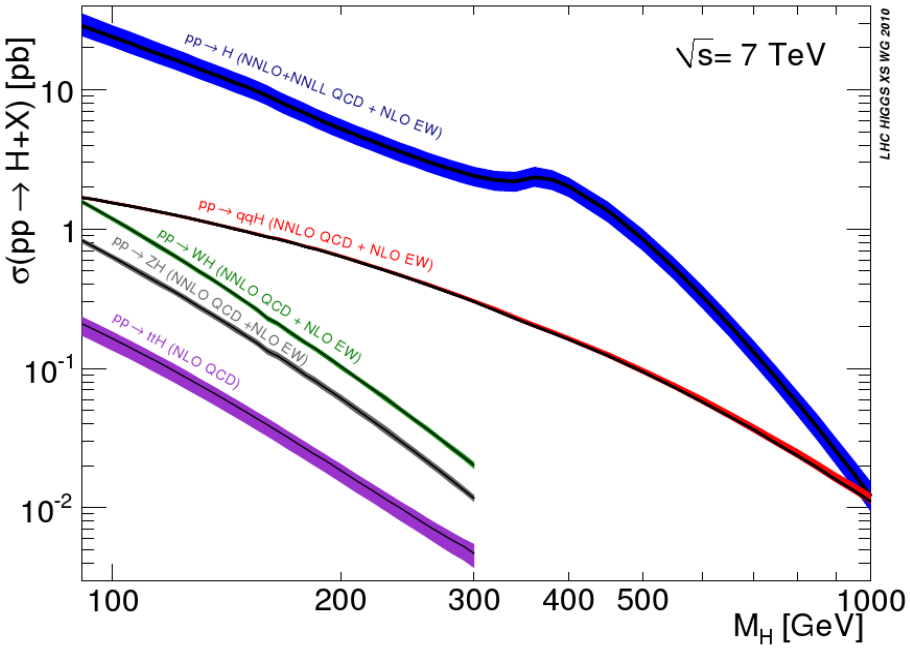
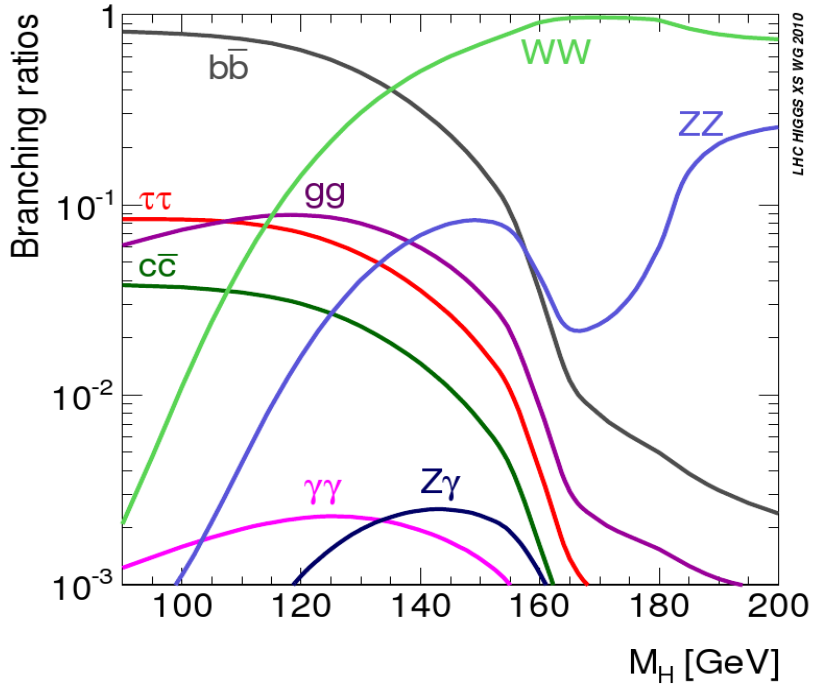
Production x-sec and branching ratios



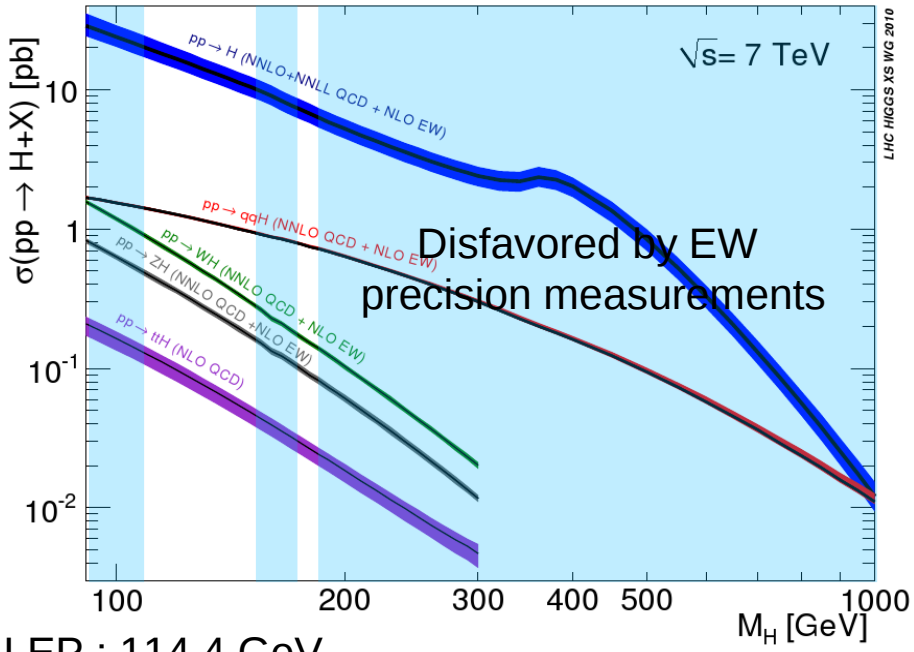
CERN-2011-002



CERN-2011-002

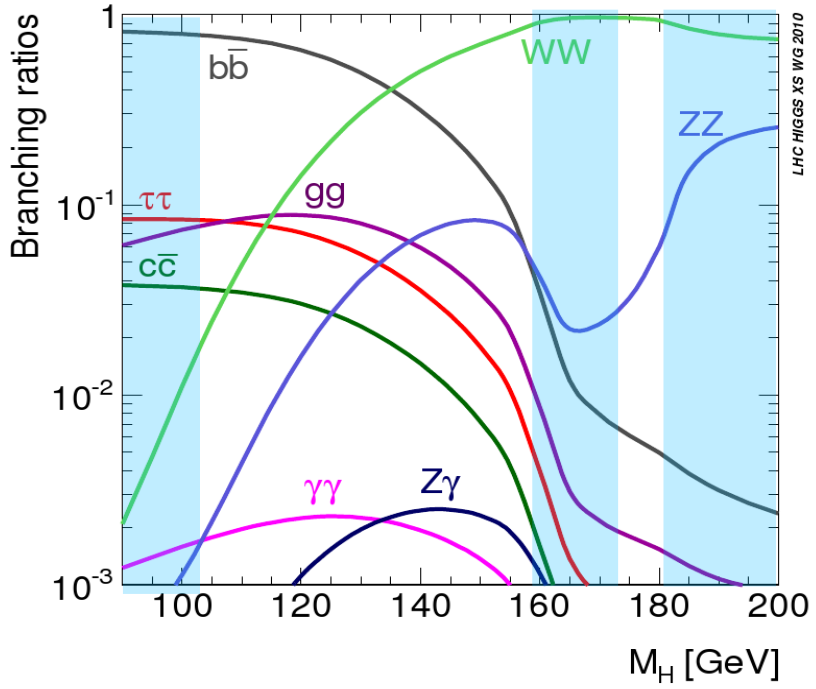
Production x-sec and branching ratios

Tevatron: 158 -173 GeV



LEP : 114.4 GeV

CERN-2011-002



CERN-2011-002

WH → l ν b$\bar{b}$ seems to be well motivated Higgs search channel

Different search strategies

H decay mode	ATLAS	CMS	Tevatron
ττ	--	Inclusive+VBF	H/VH/VBF
bb ATLAS-CONF-2011-103	lυH, llH	--	lυH, llH, υυH
γγ	Inclusive	Inclusive	Inclusive
WW → lνlν	0jet, 1 jet m<240	0jet, 1jet, VBF	0j / 1j / 2j / 1l
WW → lνqq	0jet, 1jet	--	0jet, 1jet
ZZ → llll	Inclusive	Inclusive	--
ZZ → llνν	Jet veto	b jet veto	--
ZZ → llbb	Inclusive	Inclusive	--

EPS 2011 Grenoble W.Murray STFC/RAL

B. Murray, EPS

Experimental signature for WH → lν $b\bar{b}$ analysis

Simple robust cut based analysis for first LHC direct search

- Data quality requirements
- Single lepton trigger: e (p_T > 20 GeV) or mu (p_T>18 GeV)
- Exactly 1 'good' lepton (p_T > 25 GeV)
- MET > 25 GeV
- $M_T = \sqrt{2 p_T^{l} p_T^{\nu} (1 - \cos\Delta\Phi_{l\nu})} > 40$ GeV

W - selection

- Exactly 2 'good' jets (Anti-kT 0.4, p_T > 25 GeV, |η|<2.5)
- Exactly 2 'good' jets b-tagged (sophisticated likelihood tagger)

b - jets

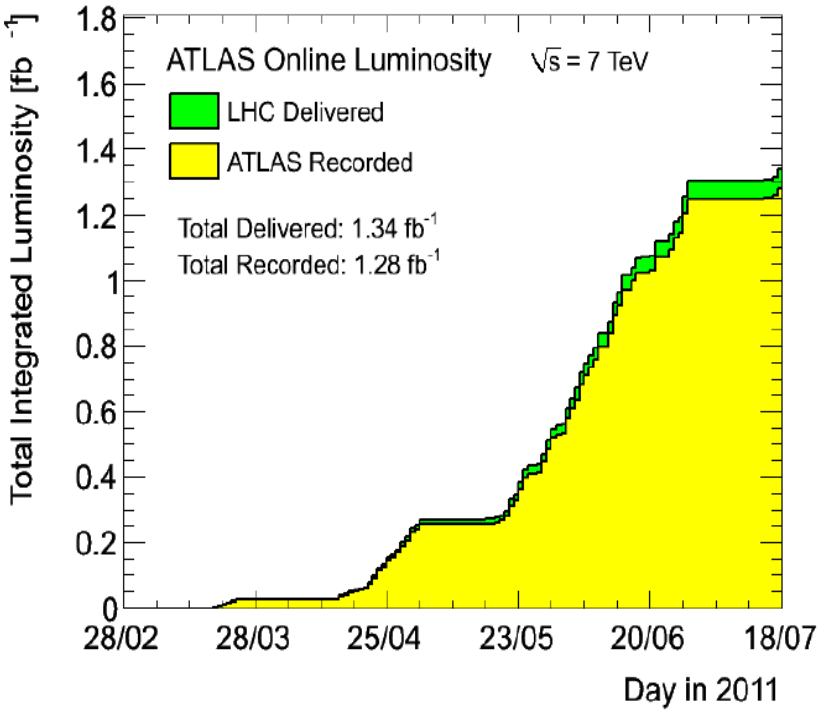
Considered data sets

MC

Process	Generator	σ ∗ BR
WH	Pythia	0.426 pb (120 GeV)
$W \rightarrow l \upsilon$	ALPGEN	10.46 nb
$Z \rightarrow l l$	ALPGEN	1.07 nb
WW	MC@NLO	46.23 pb
WZ	MC@NLO	18.0 pb
$t\bar{t}$	MC@NLO	164.6 pb
t-channel	MC@NLO	58.7 pb
s-channel	MC@NLO	3.94 pb
Wt-channel	MC@NLO	13.1 pb
$b\bar{b} \rightarrow \mu \mu$	Pythia	73.9 nb
$c\bar{c} \rightarrow \mu \mu$	Pythia	28.4 nb

Data

1.04 fb^{-1} used for WH analysis



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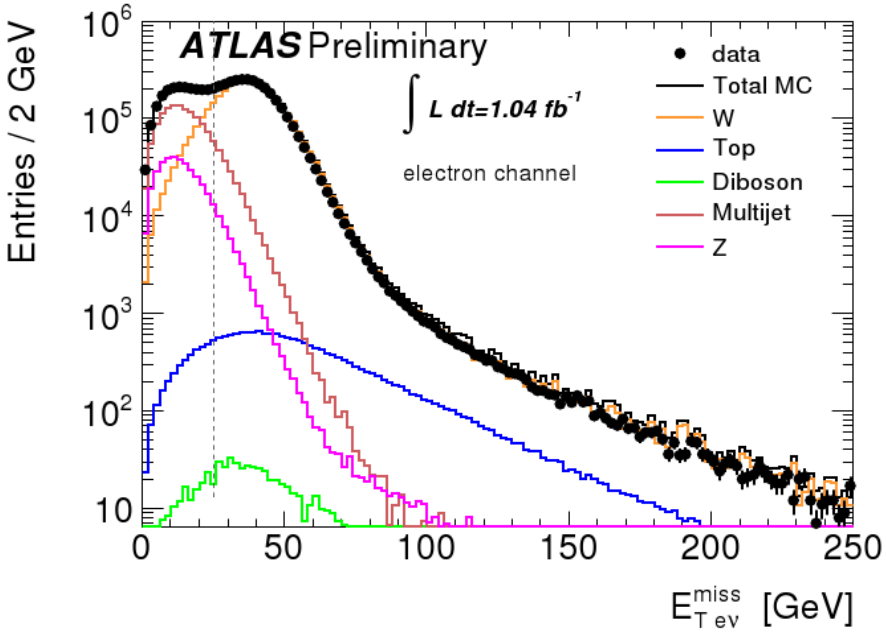
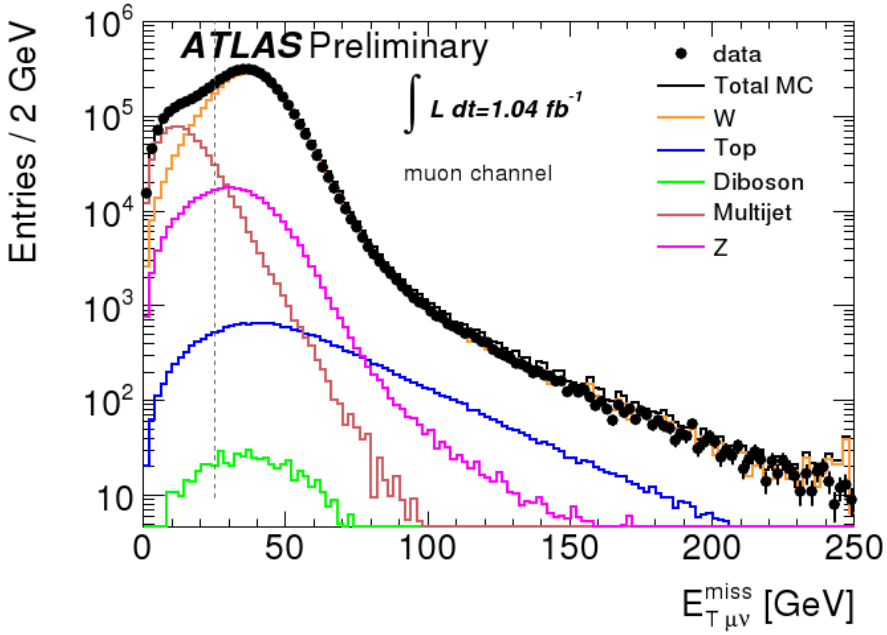
Data – MC comparison: MET





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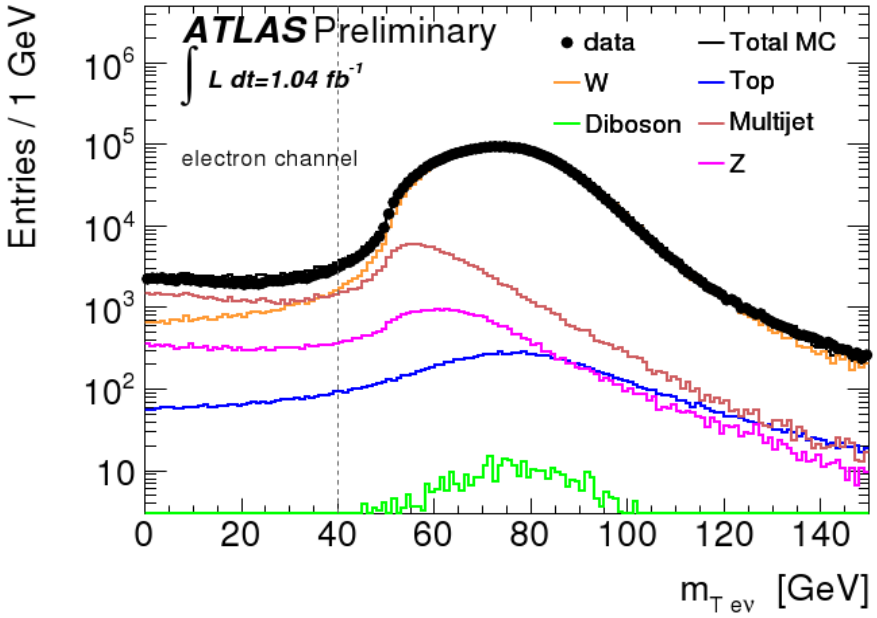
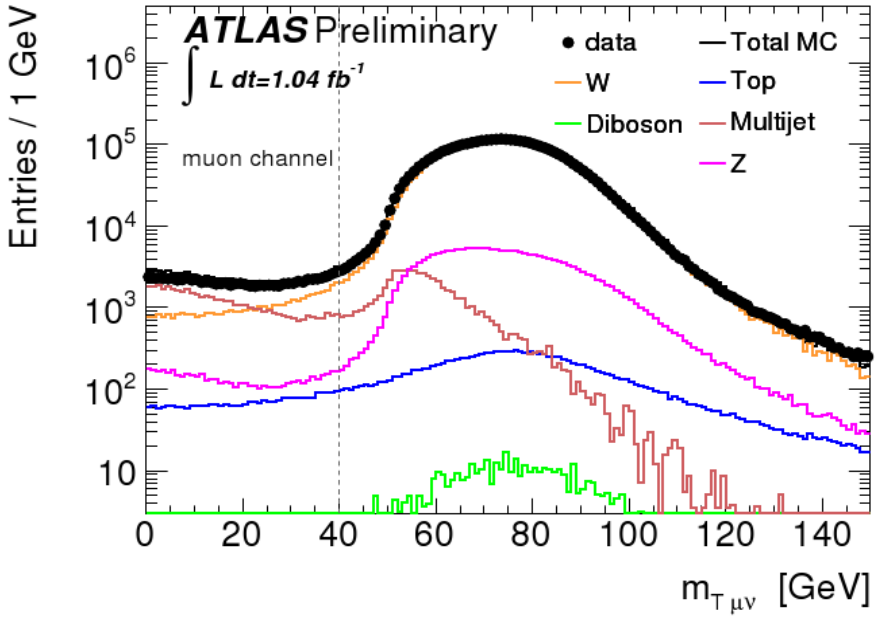
Data – MC comparison: M_T





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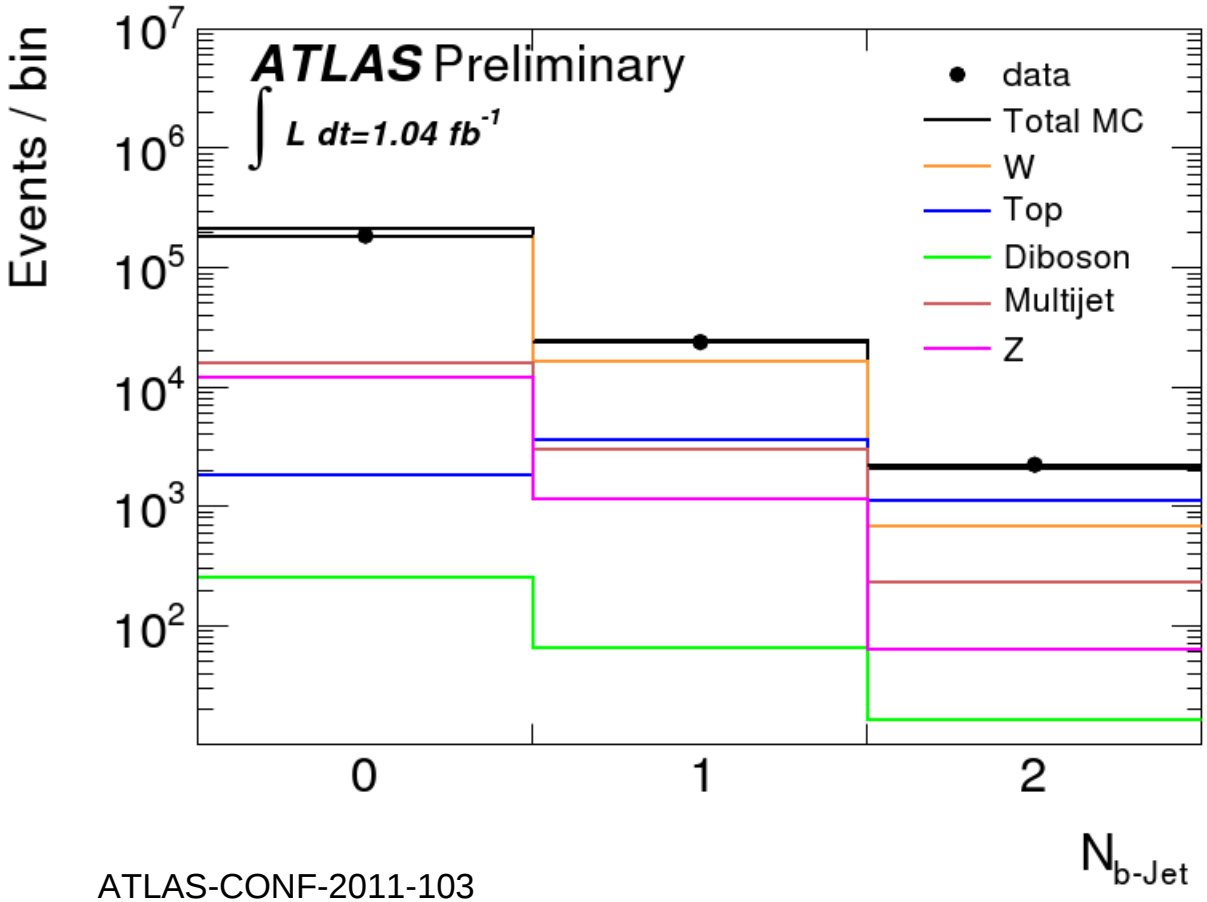
Data – MC comparison: $N_{b\text{–jets}}$



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Background estimates

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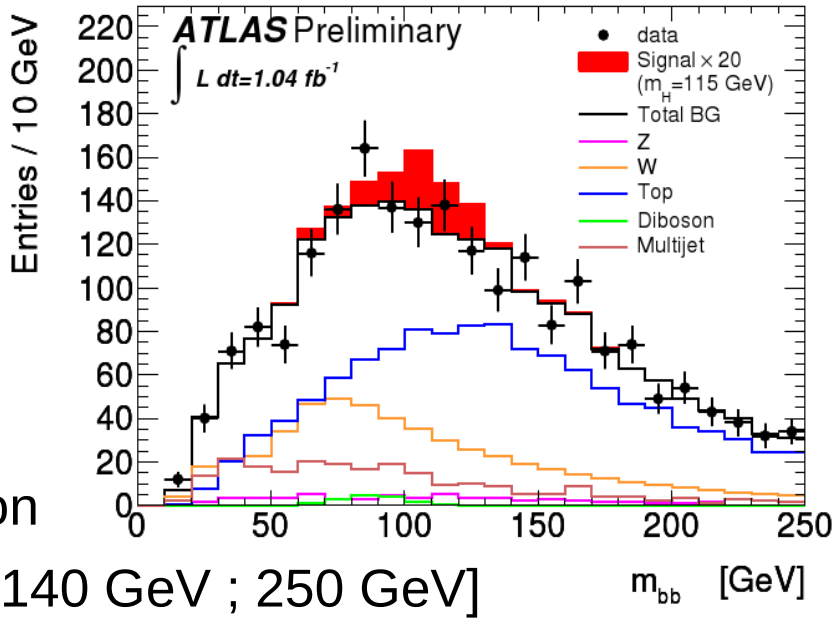

Top and W+jets dominant:

- W+jets important at low $m_{b\bar{b}}$
  - Use m_{jj} from data as template
- Top dominant at high $m_{b\bar{b}}$
  - Describe shape with MC

- Perform side-band fit in $m_{b\bar{b}}$ distribution

  In the range [40 GeV ; 80 GeV] and [140 GeV ; 250 GeV]

Multijet:

Get Multijet templates of MET distribution in QCD control region (anti-Isolation) → fit Multijet template and EW template to signal MET distribution

Diboson WW, WZ:

- from MC

Systematic uncertainties (Detector and Reconstruction)

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Source of Uncertainty	Treatment in analysis
Jet Energy Scale (JES)	$2-7\%$ as a function of p_{T} and η
Jet Pile-up Uncertainty	$2-7\%$ as a function of p_{T} and η
b-quark Energy Scale	2.5%
Jet Energy Resolution	$5-12\%$
Electron Selection Efficiency	$0.7-3\%$ as a function of p_{T}, $0.4-6\%$ as a function of η
Electron Trigger Efficiency	$0.4-1\%$ as a function of η
Electron Reconstruction Efficiency	$0.7-1.8\%$ as a function of η
Electron Energy Scale	$0.1-6\%$ as a function of η, pileup, material effects etc.
Electron Energy Resolution	Sampling term 20%, a small constant term has a large variation with η
Muon Selection Efficiency	$0.2-3\%$ as a function of p_{T}
Muon Trigger Efficiency	$< 1\%$
Muon Momentum Scale	$2-16\%$ η-dependent systematic on scale
Muon Momentum Resolution	p_{T} and η-dependent resolution smearing functions, systematic $\leq 1\%$
b-tagging Efficiency	$5-14\%$ as a function of p_{T}
b-tagging Mis-tag Fraction	$8-12\%$ as a function of p_{T} andη
Missing Transverse Energy	Add/subtract object uncertainties in $E_{\mathrm{T}}^{\mathrm{miss}}$

Systematic uncertainties (non-detector-related)

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Source of Uncertainty	WH
Luminosity	3.7 %
Higgs boson cross-section	5 %
Background norm. and shape:	
Top	6 %
Z+jets	9 %
W+jets	14 % plus shapes
ZZ	negligible
WZ	11 %
WW	11 %
QCD multijets	50 %

results in numbers

Source	expected events		(stat.)		(sys.)
Z+jets	54.4	±	3.9	±	12.3
W+jets	466.7	±	1.4	±	66.5
Top-quark	1141.8	±	8.8	±	78.0
Multijet	193.0	±	9.4	±	96.5
WZ	16.1	±	2.2	±	3.4
WW	4.8	±	1.1	±	1.4
Total background	1876.8	±	13.7	±	147.2
Data	1888				
Signal $m_H = 110$ GeV	6.72	±	0.31	±	1.20
Signal $m_H = 115$ GeV	5.25	±	0.30	±	0.97
Signal $m_H = 120$ GeV	4.54	±	0.25	±	0.83
Signal $m_H = 125$ GeV	4.08	±	0.21	±	0.77
Signal $m_H = 130$ GeV	3.28	±	0.17	±	0.62

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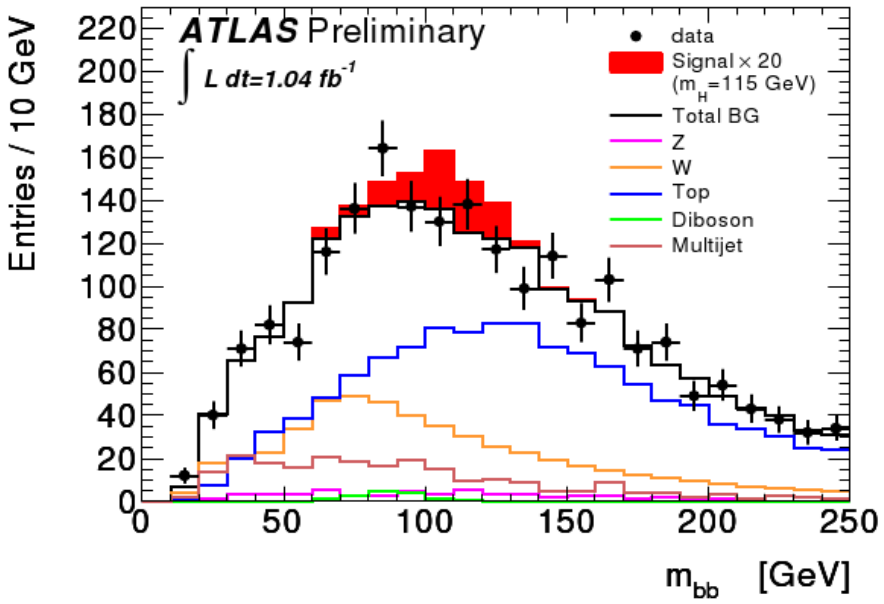
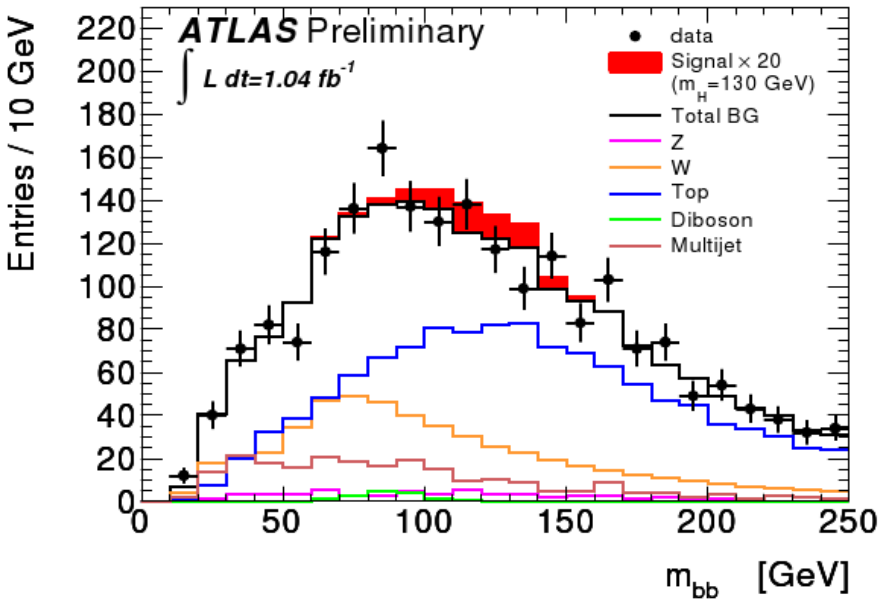
$m_{b\bar{b}}$ for two different Higgs masses





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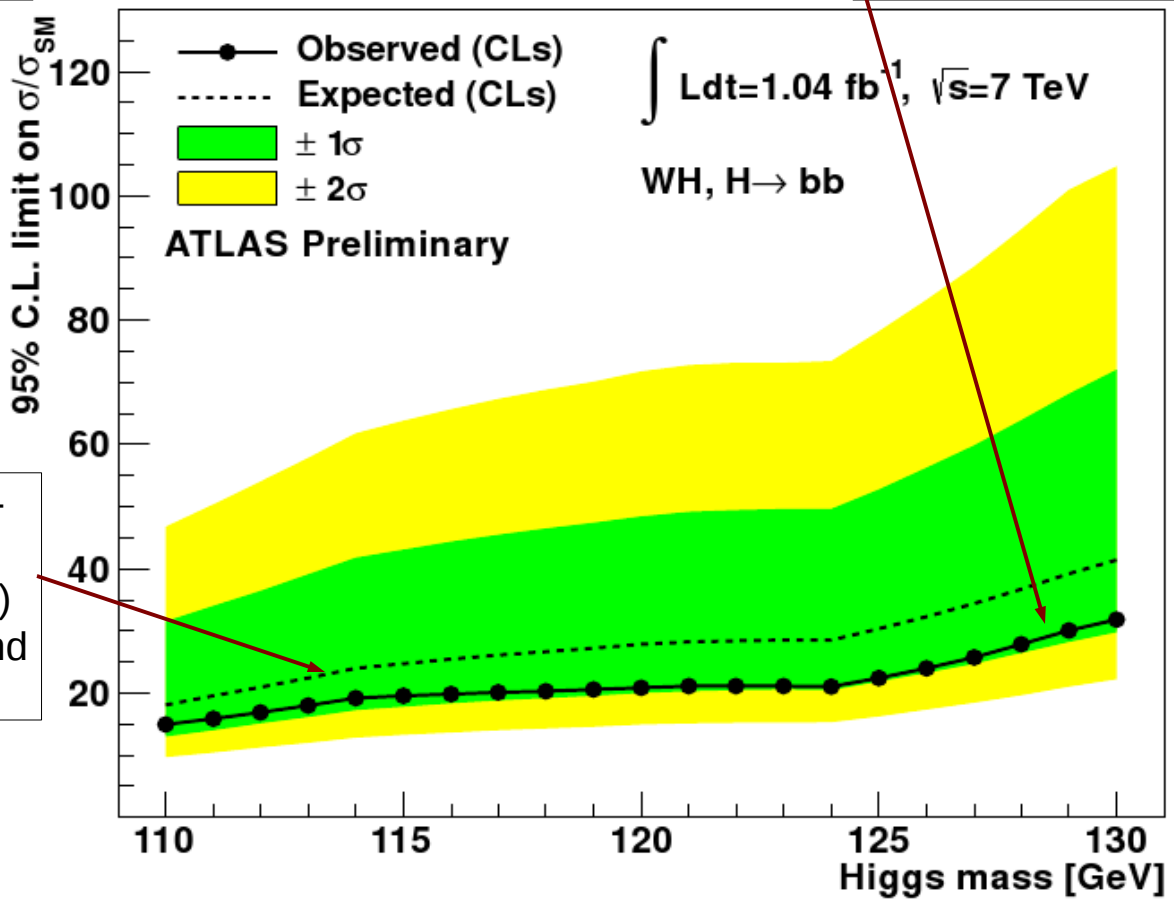
first limits

Upper cross section limit for Higgs production relative to SM prediction

Observed limit (solid line) from data



Median expected limit (dot-dashed line) and predicted 1σ/2σ (green/yellow bands) excursions from background only pseudo-experiments

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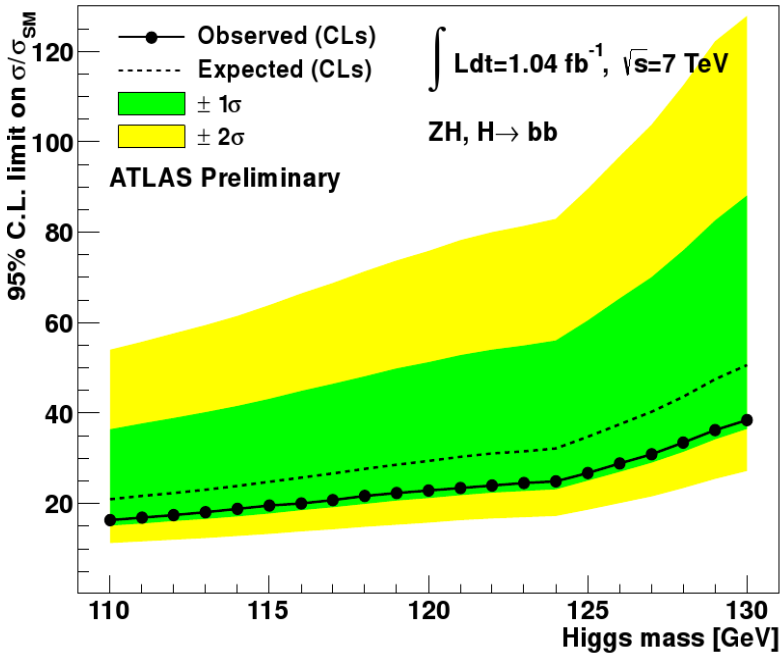
. . . combine with ZH → ll $b\bar{b}$



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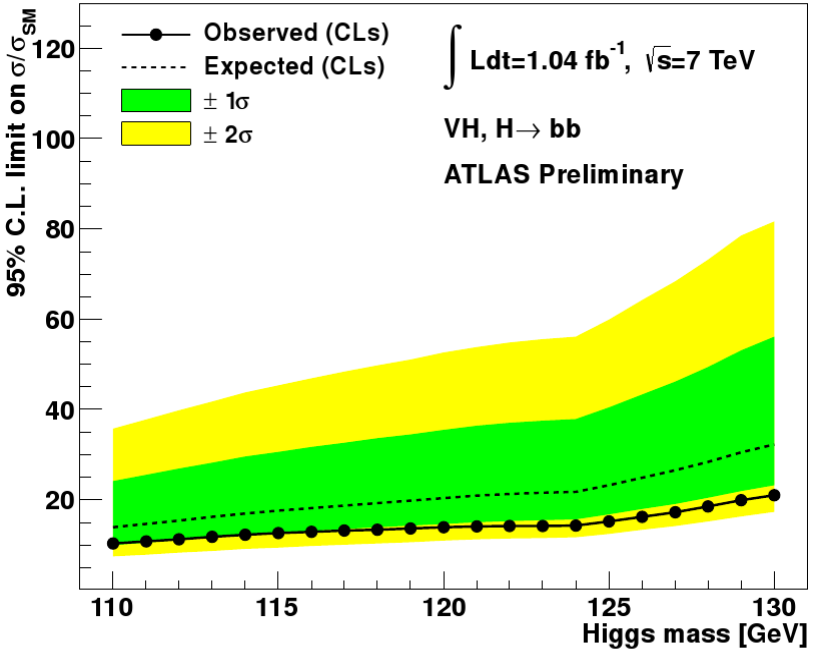

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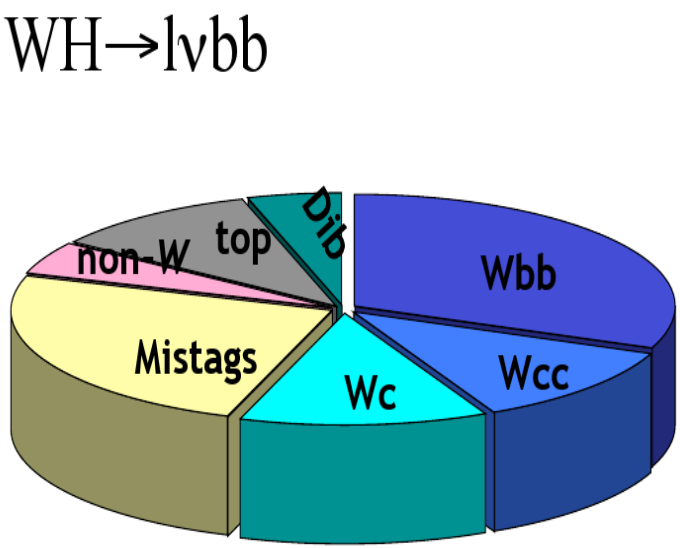
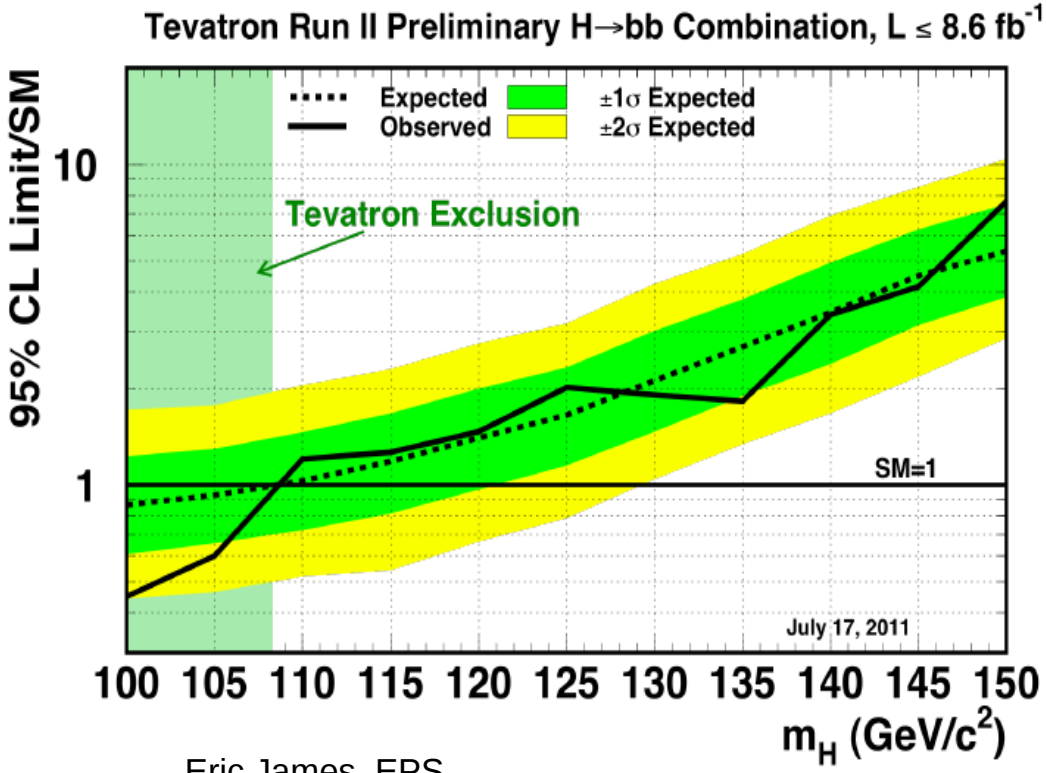
. . . H → bbbar at the Tevatron



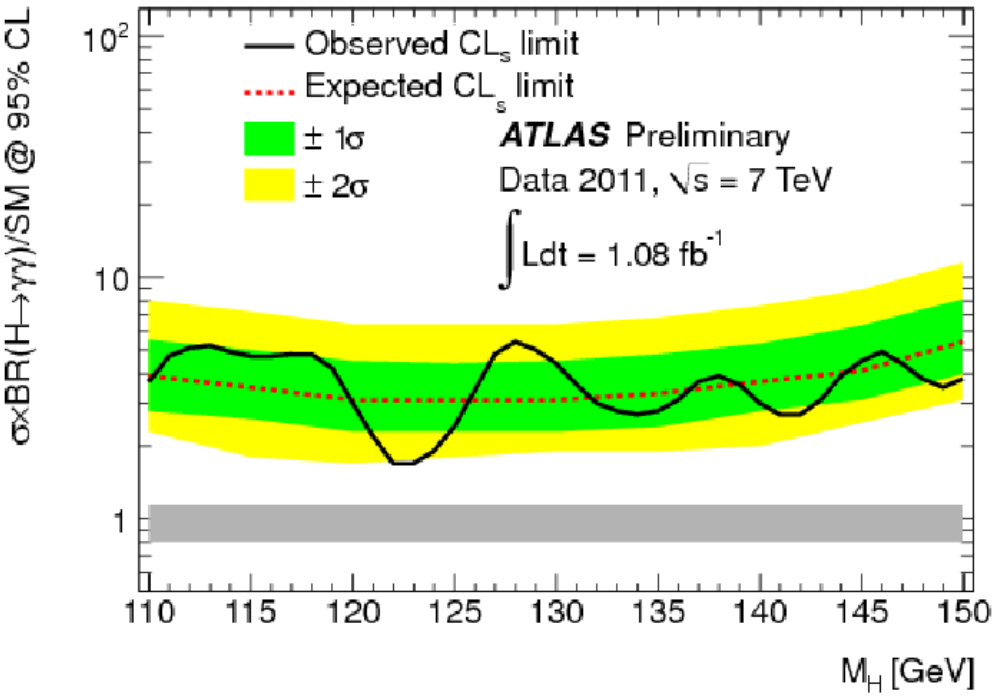
Eric James, EPS



Eric James, EPS

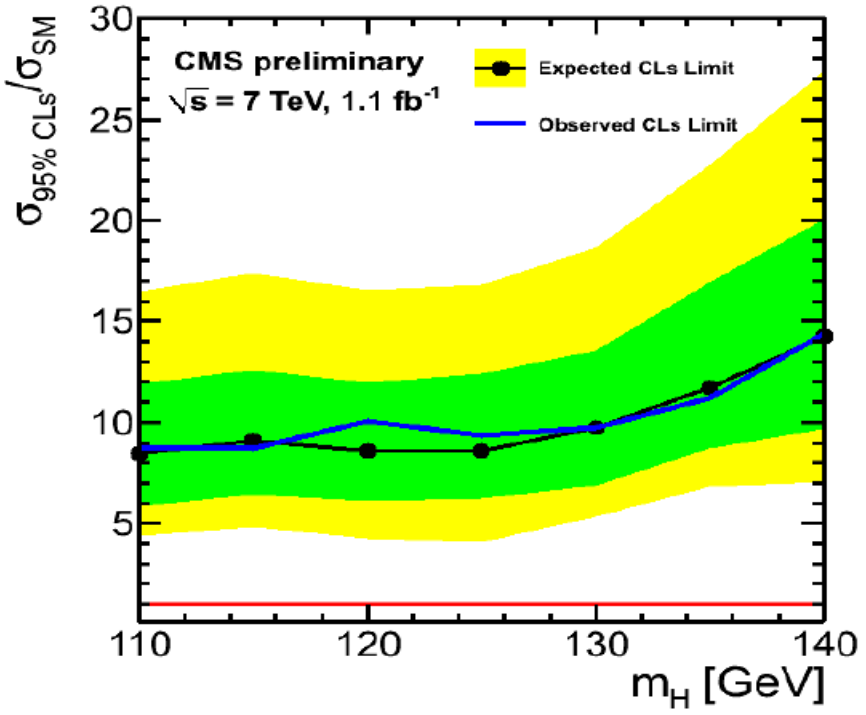
How about the other low mass channels at the LHC ?

H → γγ



B. Murray, EPS

H → ττ



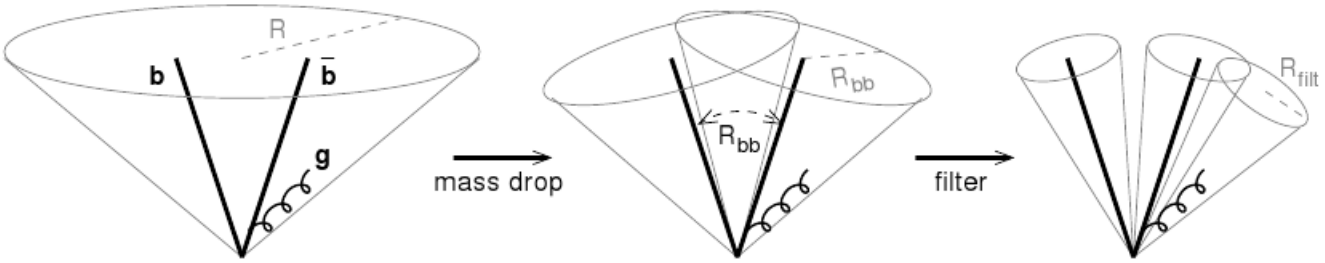
B. Murray, EPS

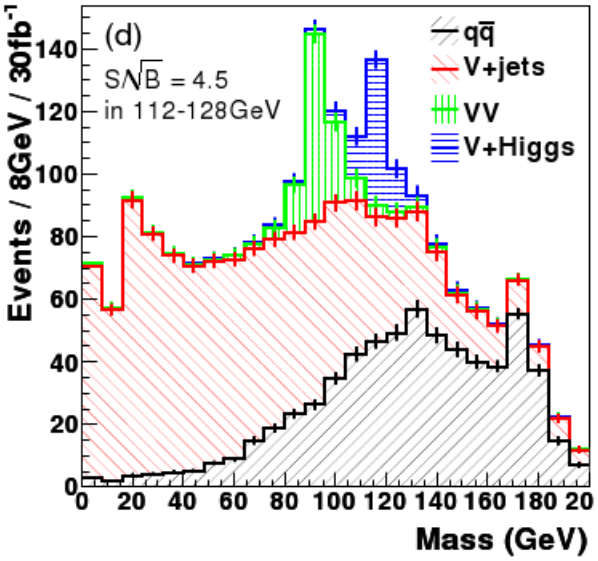
(how) can we do better ?

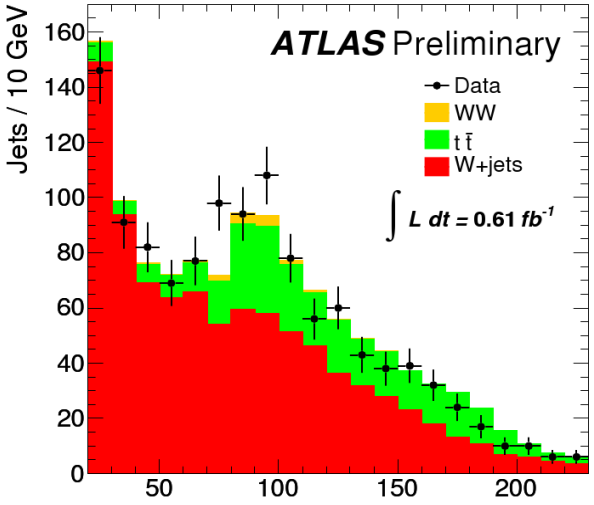
a) Multivariate analysis techniques

b) boosted Higgs regime

Butterworth, Davison, Rubin, Salam Phys. Rev. Lett. 100 (2008) 242001







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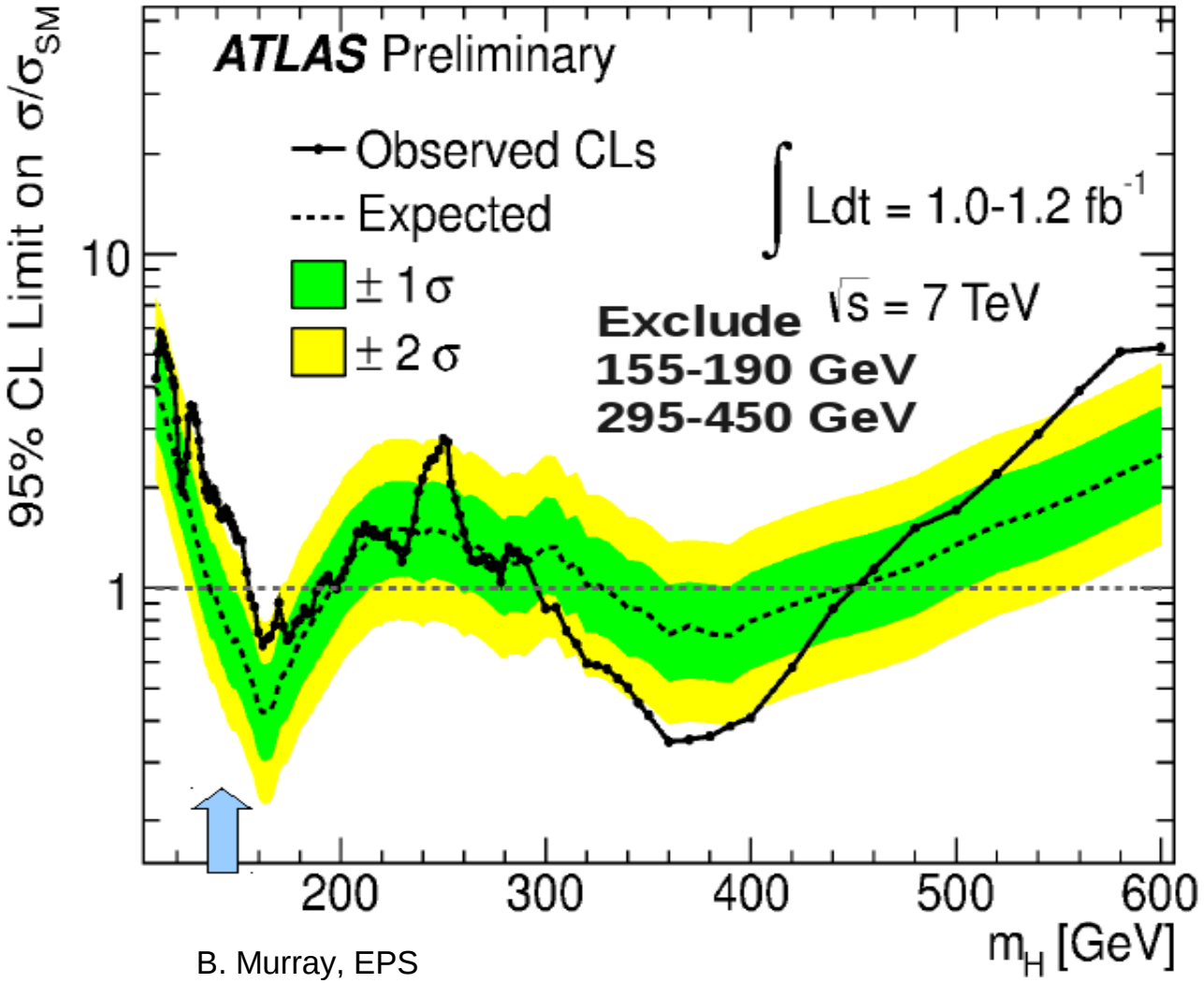
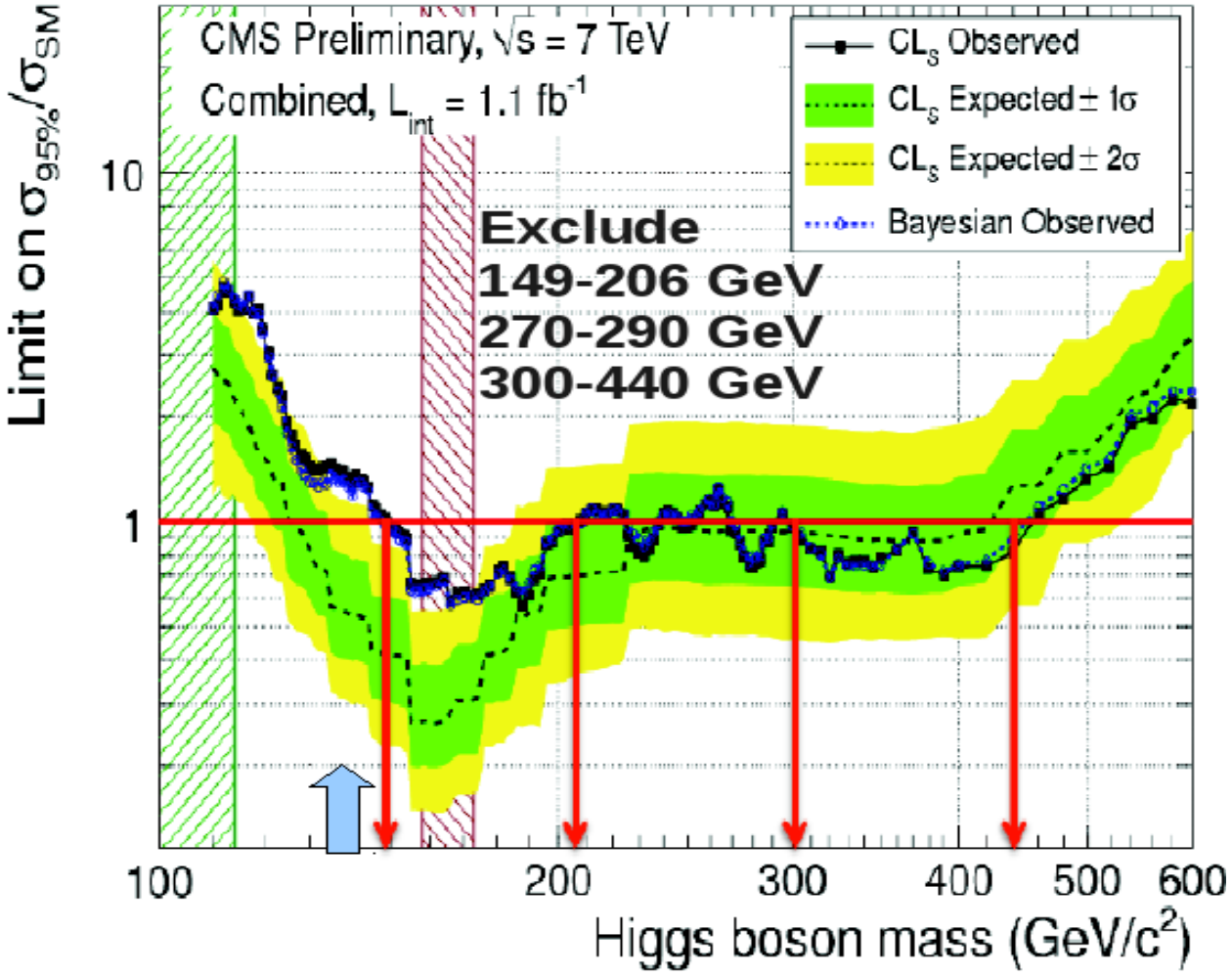
ATLAS limits



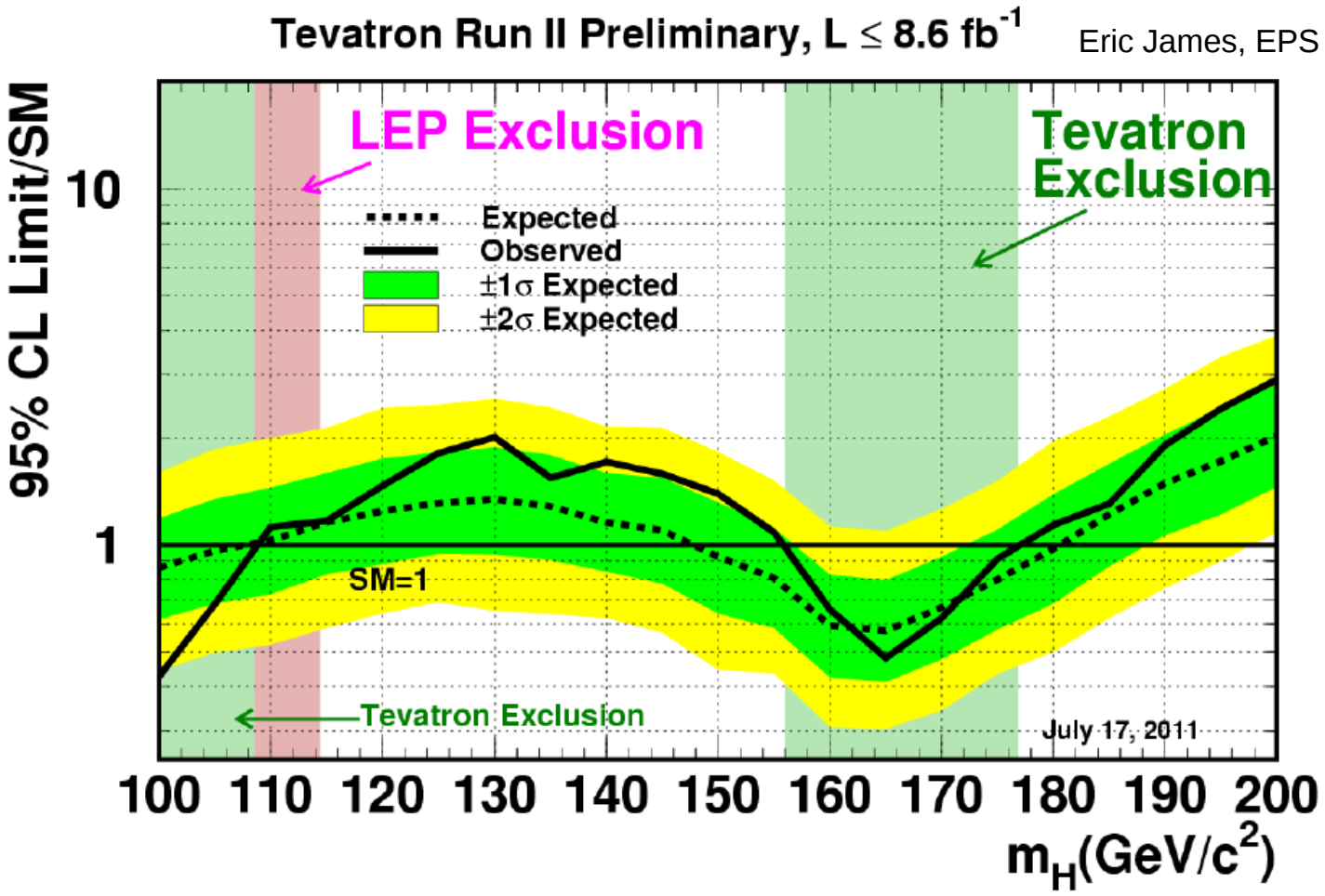
B. Murray, EPS

CMS limits



B. Murray, EPS

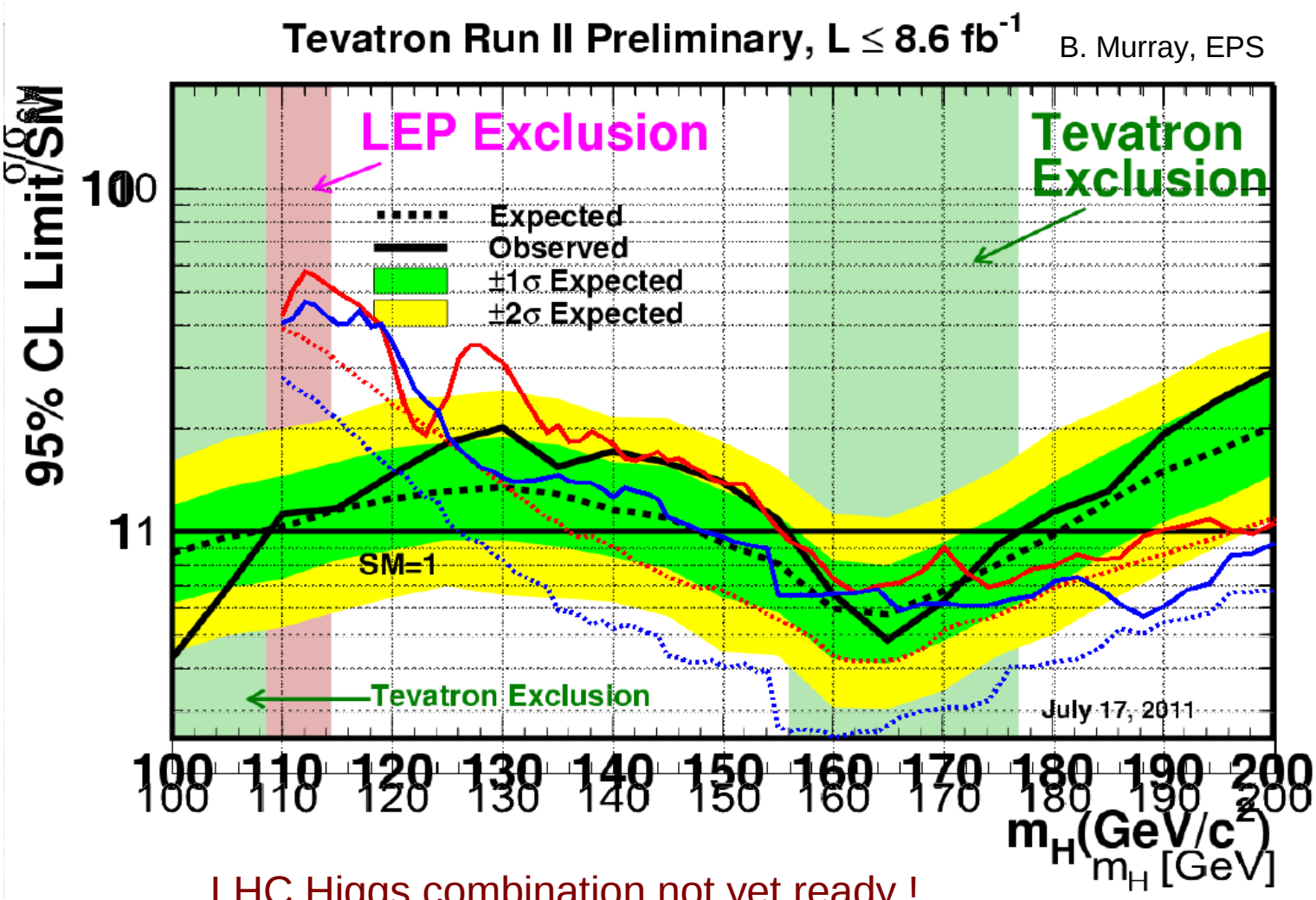
new Tevatron limits



Observed Exclusion : 100-109 and 156-177 GeV/c2

Expected Exclusion : 100-108 and 148-181 GeV/c2

“All in one”



LHC Higgs combination not yet ready !

Things to remember

- First direct search for the SM Higgs in the channel $WH \rightarrow l\nu\, b\bar{b}$ gives exclusion of ~ 15* SM σ.
- Analysis suffers from huge SM background, especially top.
- Possible improvements: multivariate analysis and boosted Higgs
- LHC dominates now the SM Higgs search but Tevatron claims exclusion sensitivity over the range [100 GeV ; 185 GeV] by next spring
- LHC combined limits not yet ready for current statistics

Thank you !

Thanks for the the internet access, Martin !