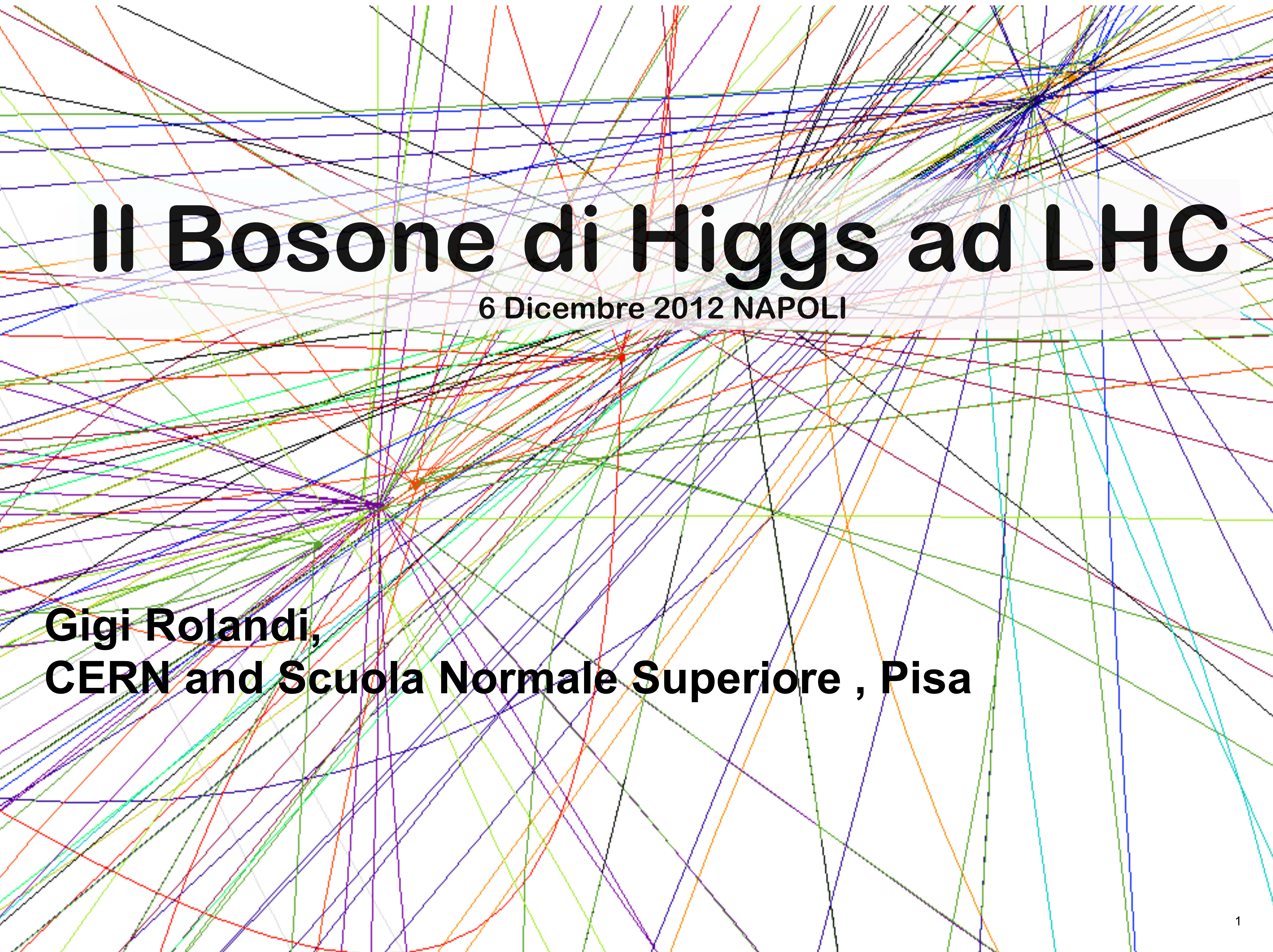


Il Bosone di Higgs ad LHC

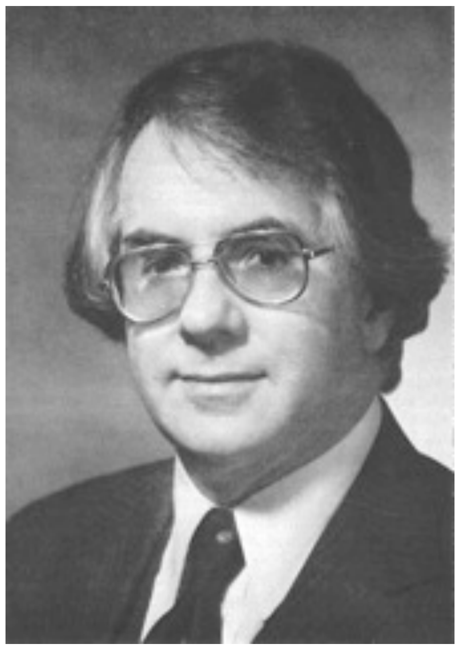
6 Dicembre 2012 NAPOLI

Gigi Rolandi,
CERN and Scuola Normale Superiore , Pisa

What is the Higgs Boson ?

Electro-Weak Interaction

Weak and Electromagnetic interactions are unified

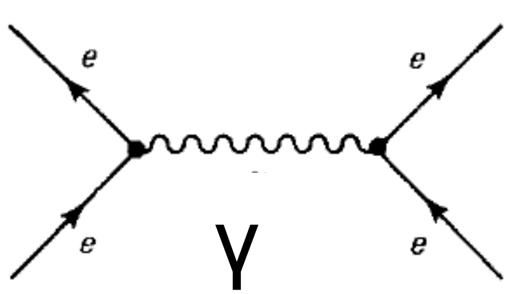


Sheldon L. Glashow

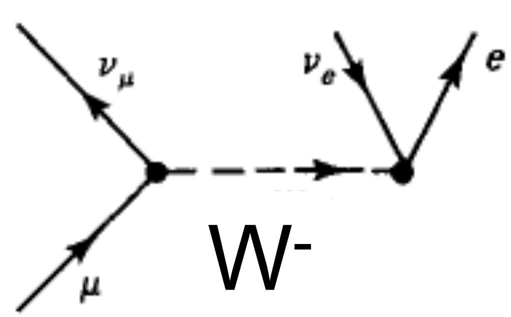
Steven Weinberg

Abdus Salam

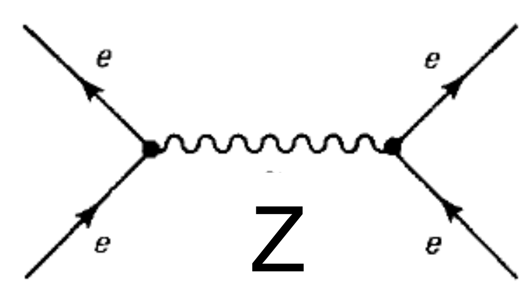
$SU(2)_L * U(1)_Y$



$m_\gamma=0$



$m_W=80$ GeV



$m_Z=91$ GeV

Symmetry Breaking

Why the photon is massless while the W^+ W^- and Z are massive ?

What breaks the symmetry among the carriers of the Electroweak interaction ?

Possible Explanation :

Symmetry Breaking

Why the photon is massless while the W^+ W^- and Z are massive ?

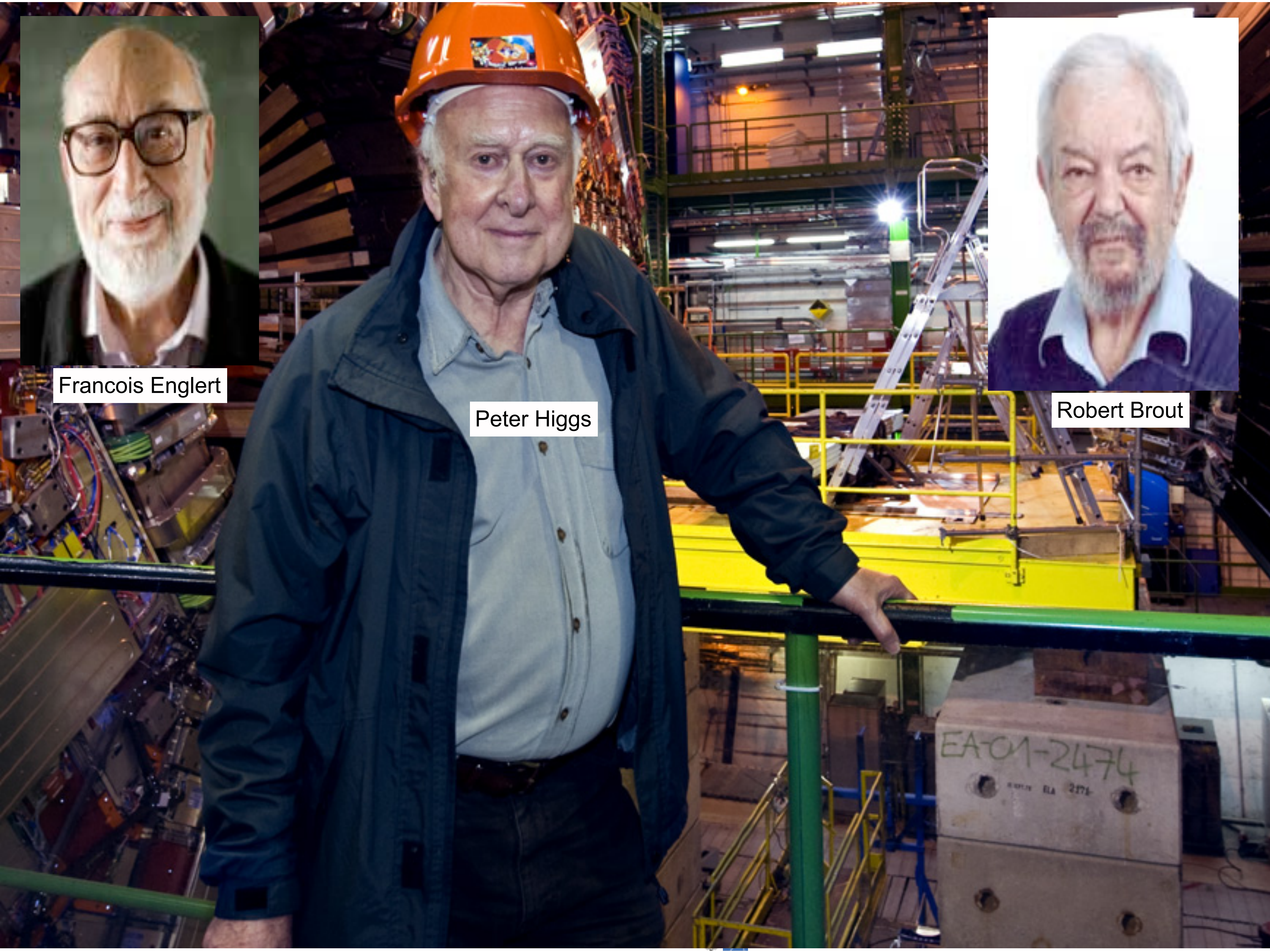
What breaks the symmetry among the carriers of the Electroweak interaction ?

Possible Explanation :

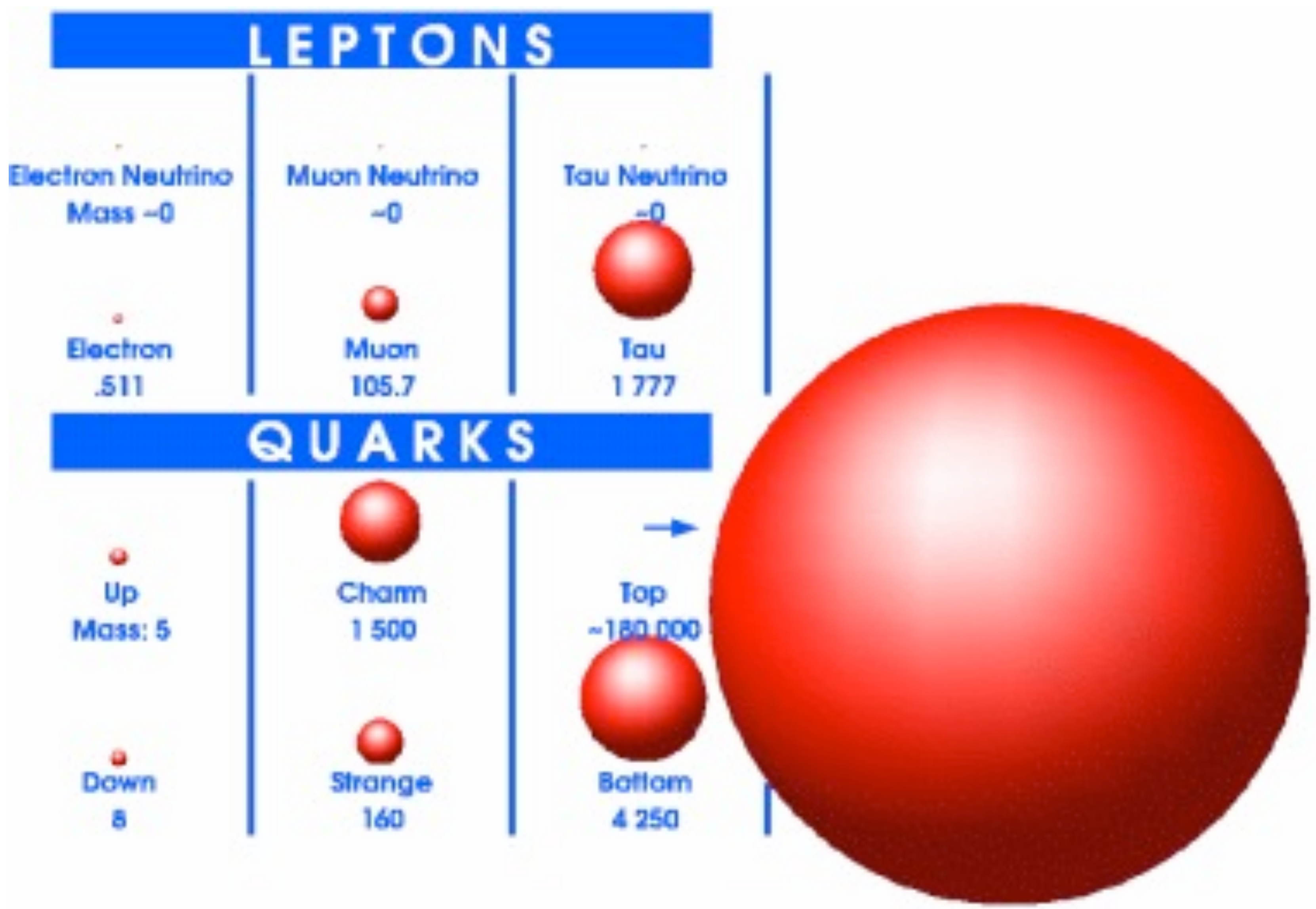
The Englert-Brout & Higgs Mechanism

F. Englert and R. Brout (1964). "Broken Symmetry and the Mass of Gauge Vector Mesons". *Physical Review Letters* **13** (9): 321–323

Peter W. Higgs (1964). "Broken Symmetries and the Masses of Gauge Bosons". *Physical Review Letters* **13** (16): 508–509.


Francois Englert
Peter Higgs
Robert Brout
EA-01-2474

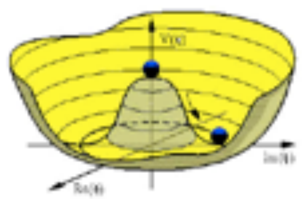
Mass of Fermions



The Higgs field can be used to give mass to the fermions in a way similar to the ElectroWeak symmetry breaking

The E.B.H. Mechanism

The Standard Model is extended by adding a complex scalar SU(2) doublet $\Phi = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix}$, whose potential has a "mexican hat shape"



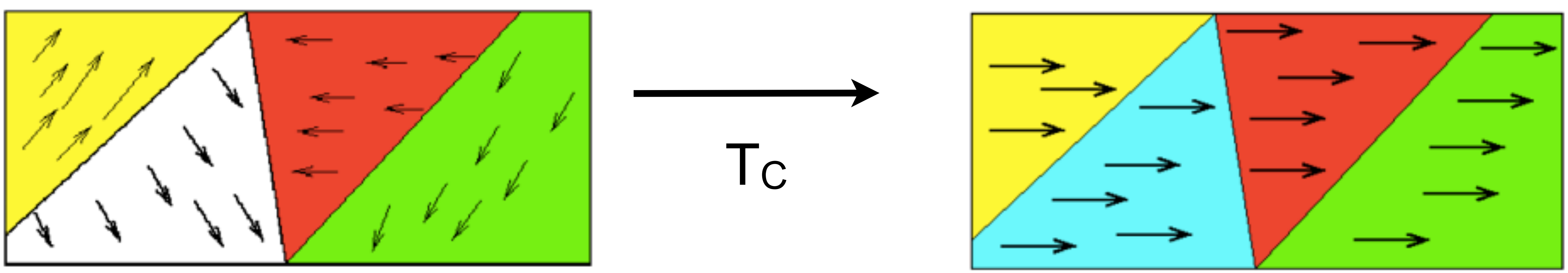
. with redundant minima and the minimum energy state is the Vacuum Expectation Value of the field VEV= <Φ> . The direction of Φ is arbitrary and breaks the symmetry

Before the spontaneous symmetry breaking in $SU(2)_L{}^*U(1)_Y$ we have 4 massless gauge bosons (8 d.o.f.) and 2 complex scalars (4 d.o.f.) 8+4=12

After spontaneous symmetry breaking we have 3 massive bosons ($W^\pm$, Z), the photon and the Higgs fields for a total of 3*3+2+1

Spontaneous Symmetry Breaking in classical physics

- Symmetry breaking is realized in nature when among many solutions that are “equipotential” only one is realized.
- Cooling a ferromagnet below the Curie temperature



- out all possible direction the magnetization will point in one particular direction breaking the symmetry

The Higgs Field permeate the Universe

Its vacuum expectation value v is linked to the mass of the W boson and the weak charge g

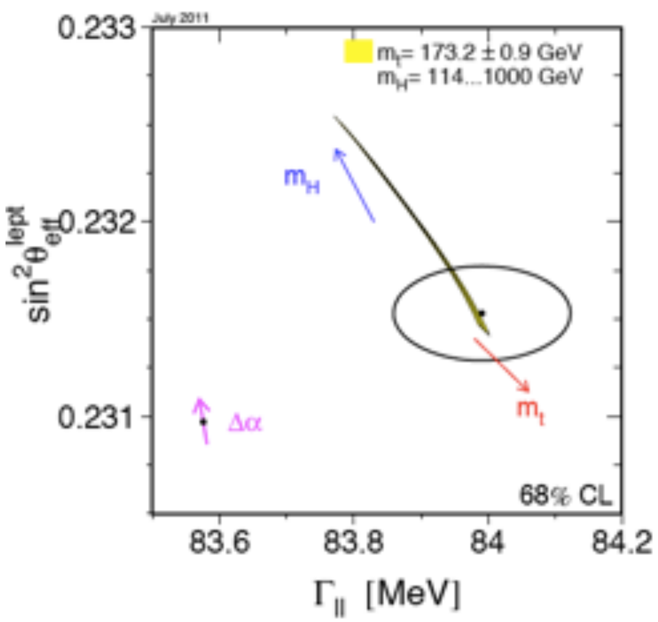
$$M_W^2 = \frac{1}{4} g^2 v^2$$

The mass of the Higgs boson is unknown

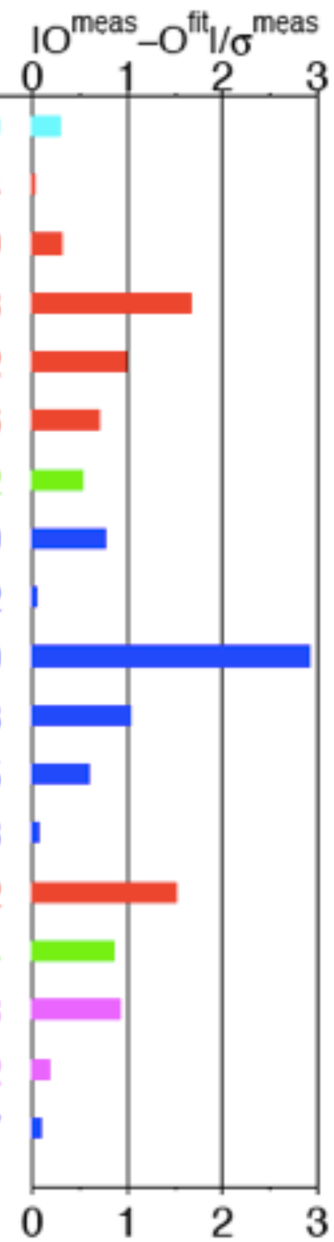
$$M_h^2 = 2v^2 \lambda.$$

Electroweak interaction tested at LEP/SLC

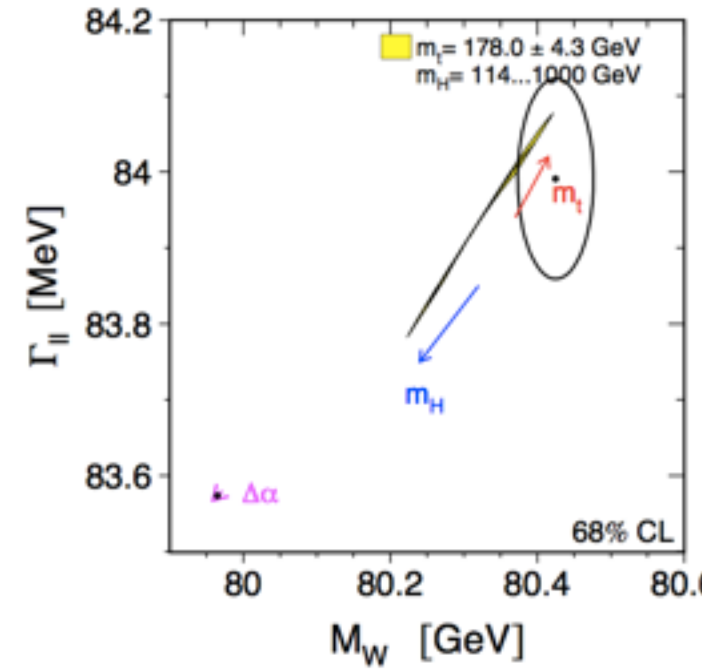
with great precision



	Measurement	Fit
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02750 ± 0.00033	0.02759
m_Z [GeV]	91.1875 ± 0.0021	91.1874
Γ_Z [GeV]	2.4952 ± 0.0023	2.4959
σ^0_{had} [nb]	41.540 ± 0.037	41.478
R_l	20.767 ± 0.025	20.742
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.01646
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1482
R_b	0.21629 ± 0.00066	0.21579
R_c	0.1721 ± 0.0030	0.1722
$A^{0,b}_{fb}$	0.0992 ± 0.0016	0.1039
$A^{0,c}_{fb}$	0.0707 ± 0.0035	0.0743
A_b	0.923 ± 0.020	0.935
A_c	0.670 ± 0.027	0.668
A_l(SLD)	0.1513 ± 0.0021	0.1482
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.2314
m_W [GeV]	80.399 ± 0.023	80.378
Γ_W [GeV]	2.085 ± 0.042	2.092
m_t [GeV]	173.20 ± 0.90	173.27

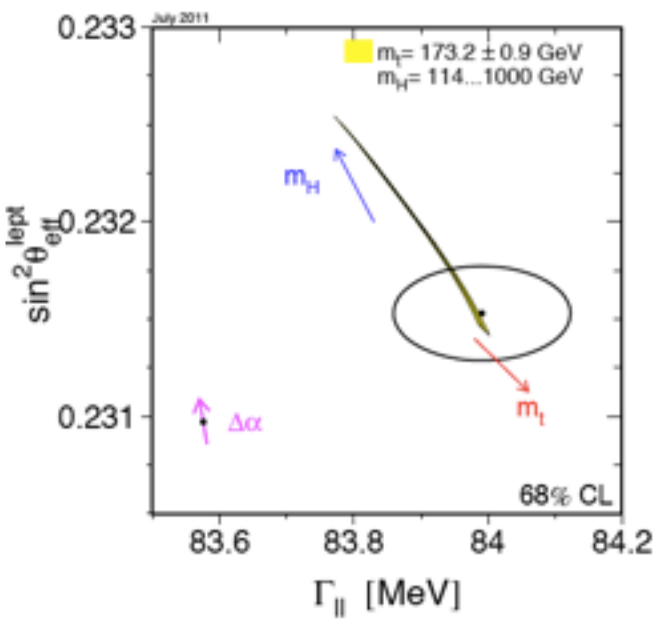


July 2011



Electroweak interaction tested at LEP/SLC

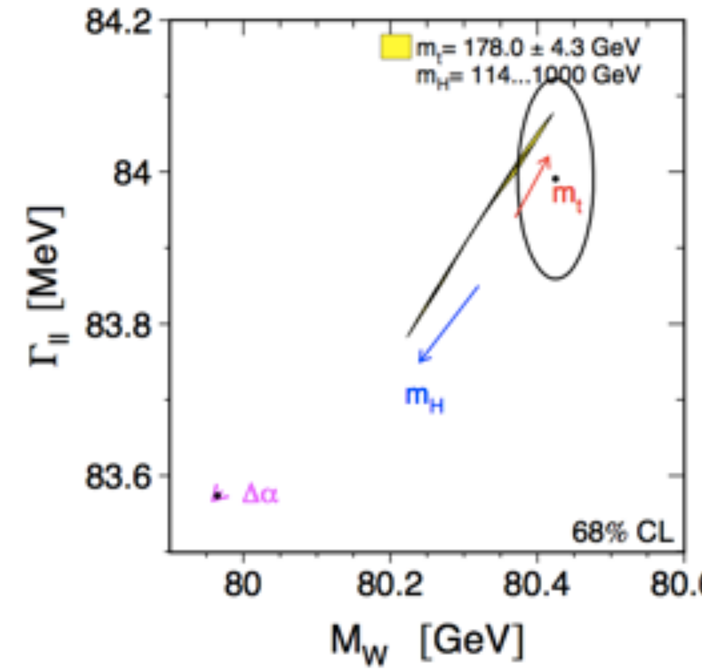
with great precision



	Measurement	Fit	$\lvert O^{meas}-O^{fit}\rvert/\sigma^{meas}$
$\Delta\alpha_{had}^{(5)}(m_Z)$	0.02750 ± 0.00033	0.02759	
m_Z [GeV]	91.1875 ± 0.0021	91.1874	
Γ_Z [GeV]	2.4952 ± 0.0023	2.4959	
σ_{had}^0 [nb]	41.540 ± 0.037	41.478	
R_l	20.767 ± 0.025	20.742	
$A_{fb}^{0,l}$	0.01714 ± 0.00095	0.01646	
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1482	
R_b	0.21629 ± 0.00066	0.21579	
[illegible]	[illegible]	[illegible]	
$A_{fb}^{0,c}$	0.0707 ± 0.0035	0.0743	
A_b	0.923 ± 0.020	0.935	
A_c	0.670 ± 0.027	0.668	
A_l(SLD)	0.1513 ± 0.0021	0.1482	
$\sin^2\theta_{eff}^{lept}(Q_{fb})$	0.2324 ± 0.0012	0.2314	
m_W [GeV]	80.399 ± 0.023	80.378	
Γ_W [GeV]	2.085 ± 0.042	2.092	
m_t [GeV]	173.20 ± 0.90	173.27	

0 1 2 3

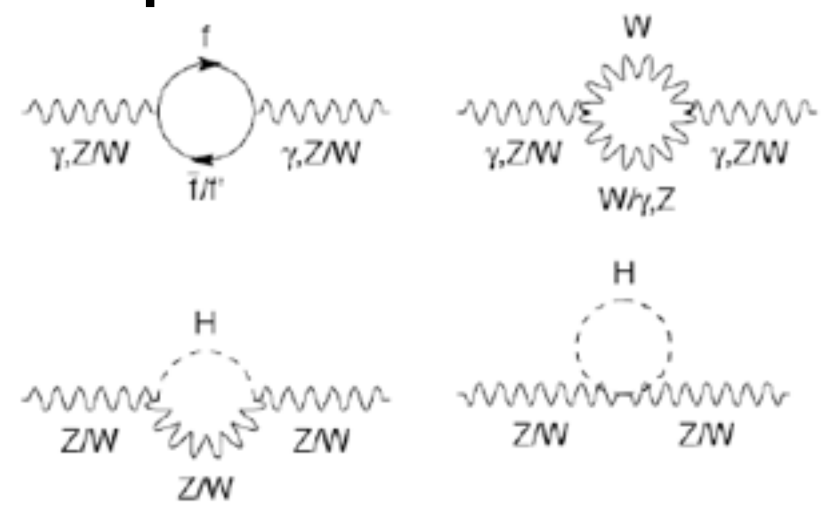
July 2011



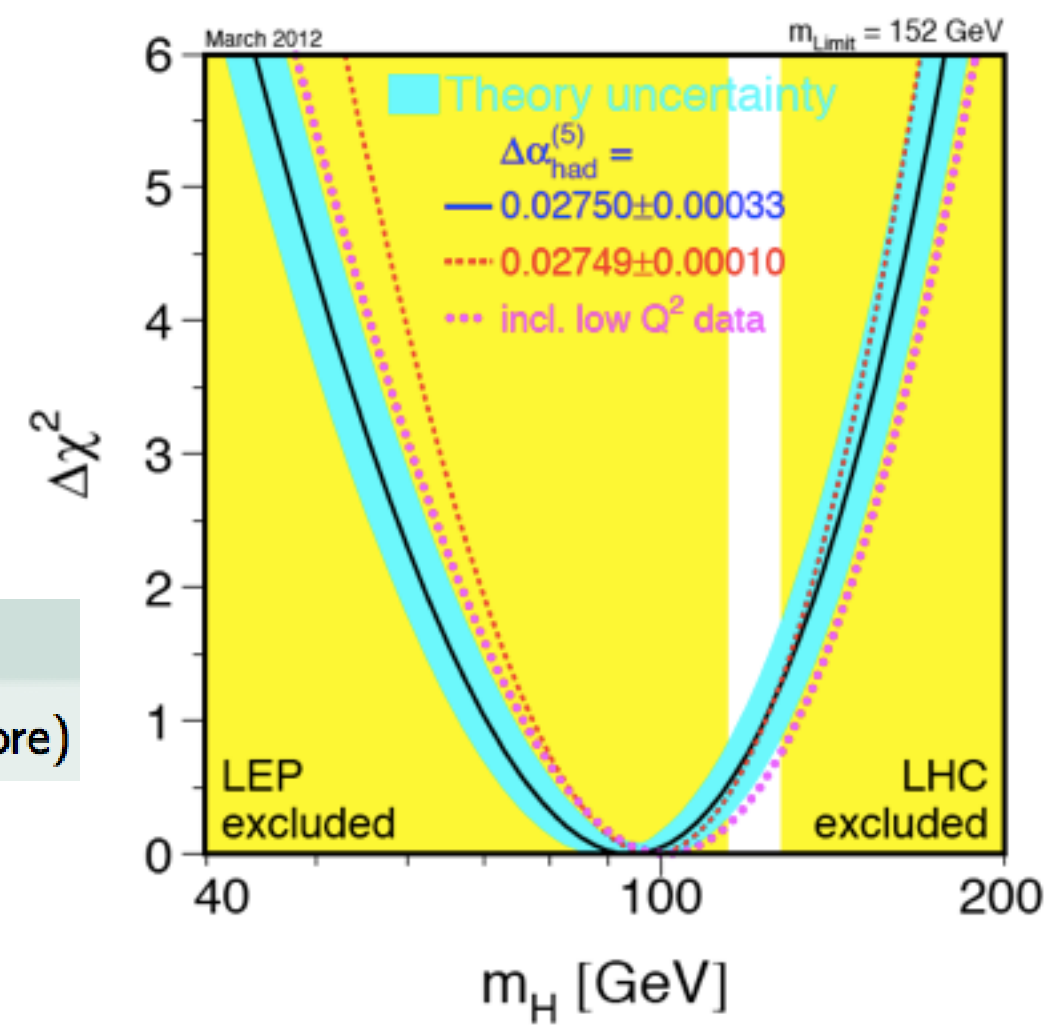
However : no direct proof of the EBH mechanism

Indirect limits on the Higgs boson mass in the Standard Model

The precision of the LEP/SLC experiments is such that radiative corrections are needed to compare calculations and measurements



These corrections involve the Higgs boson and its mass can be constrained performing a global Standard Model Fit to all precision measurements



New (preliminary) indirect Higgs mass determination

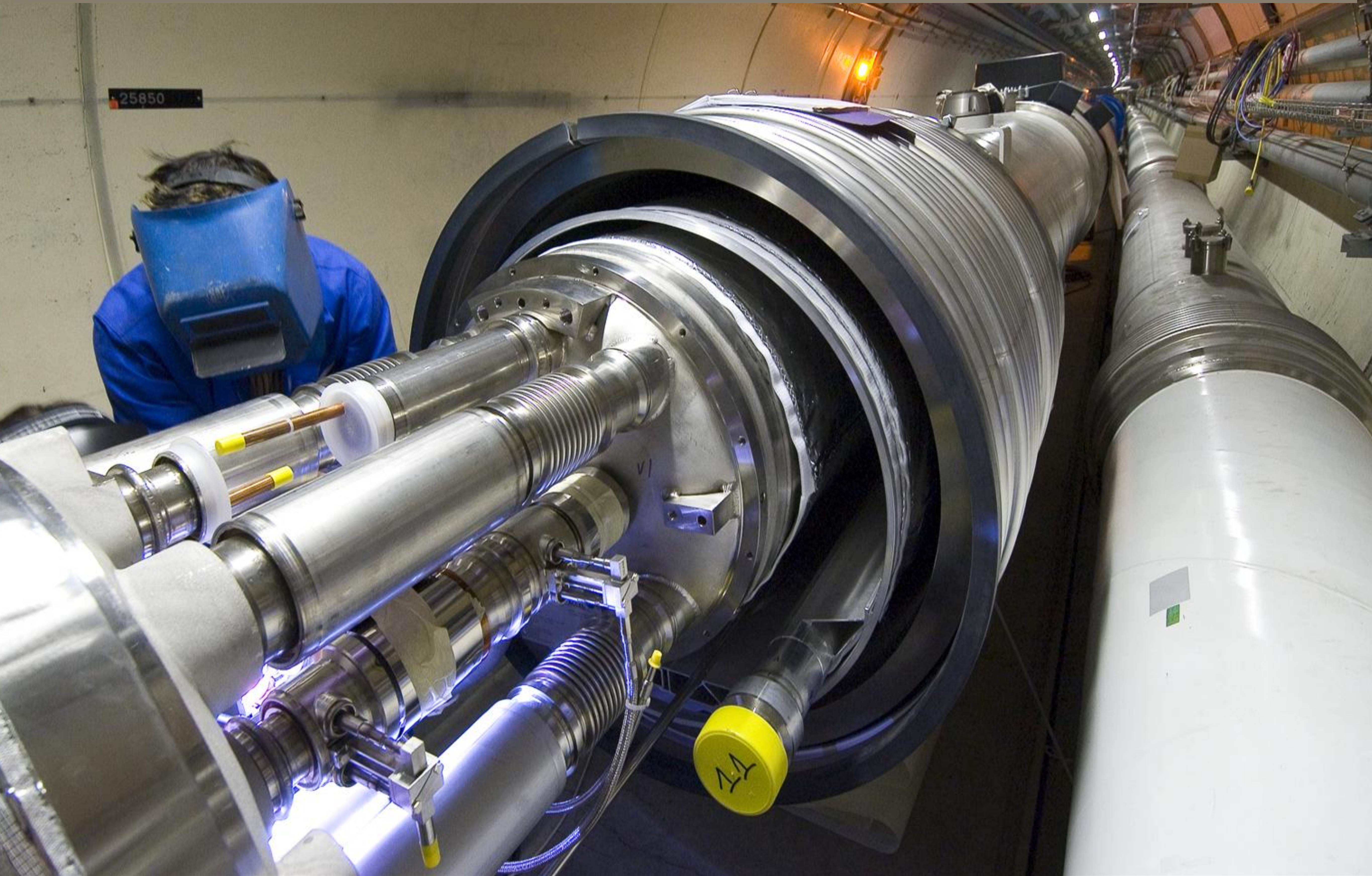
$M_H = 94^{+29}_{-24}\,GeV$ (was $M_H = 92^{+34}_{-26}\,GeV$ before)

However : these are only consistency checks. They are not a direct proof of the E.B.H. mechanism.

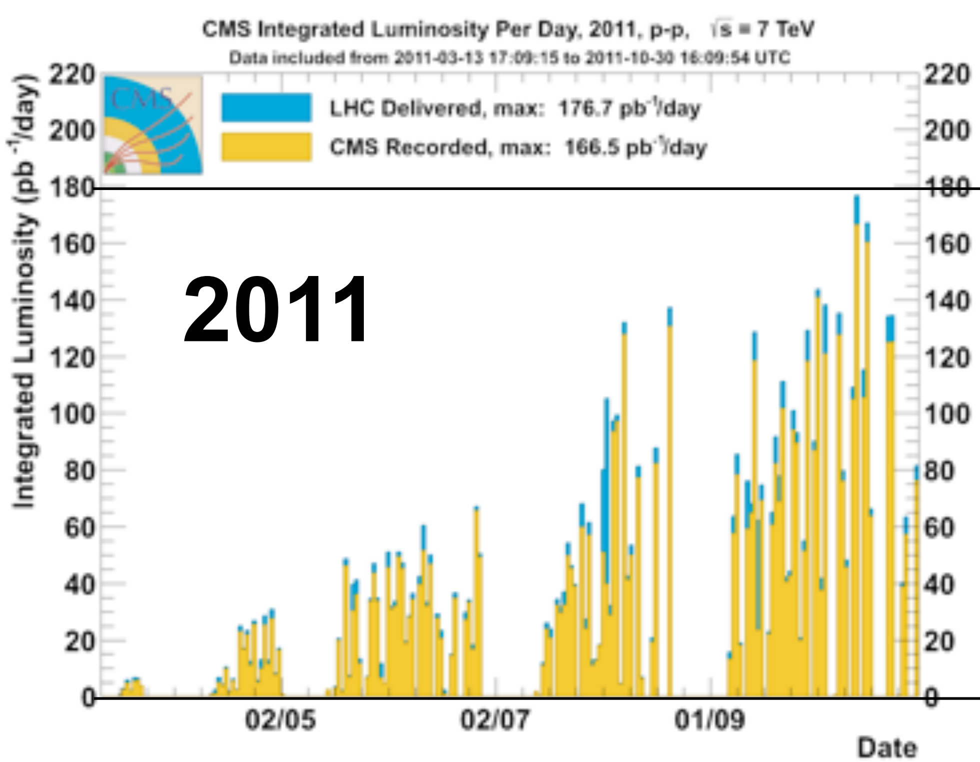
The direct proof is :

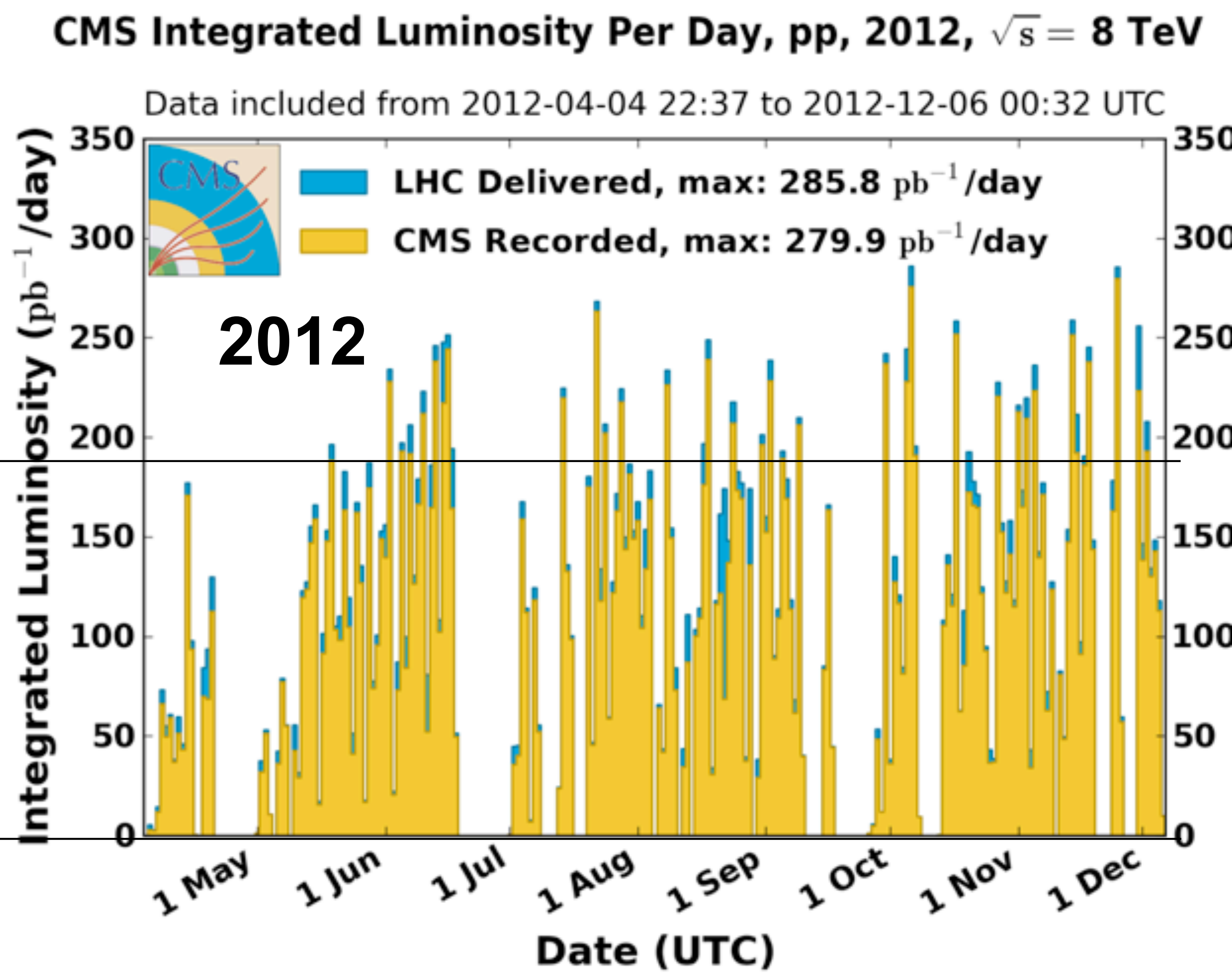
1) find the Higgs Boson
2) Measure its properties

The search for the Higgs Boson is one of the primary goals of the LHC program



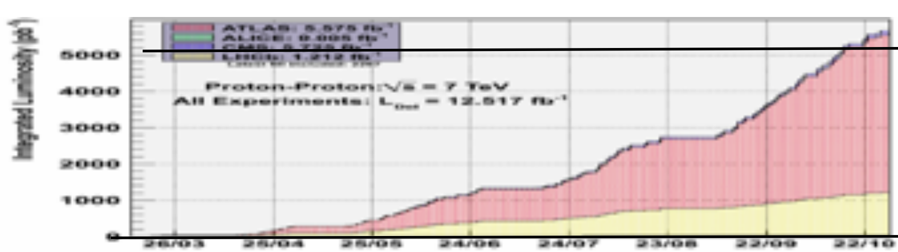
LHC has been [and is] working well above expectations





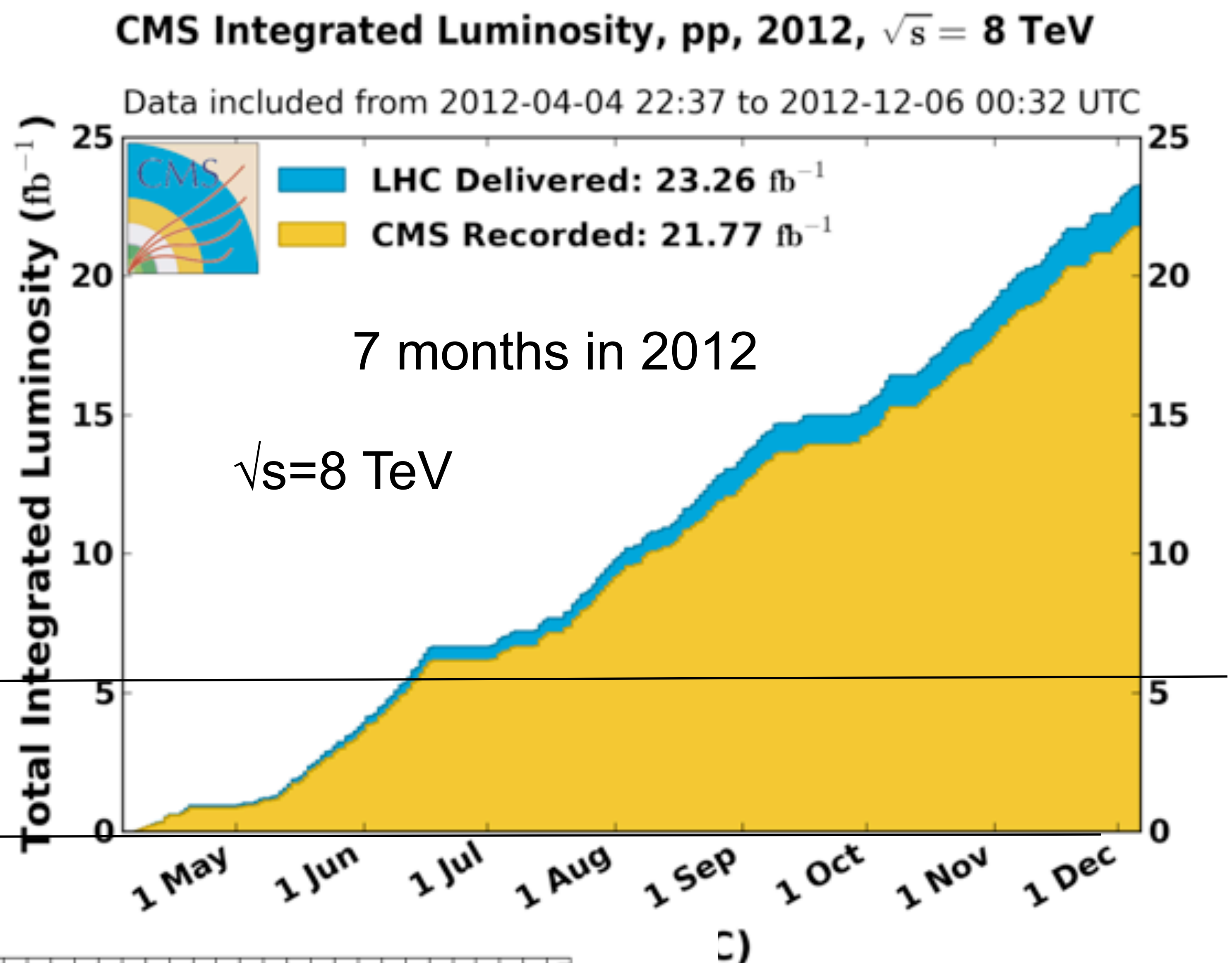
6 months in 2011

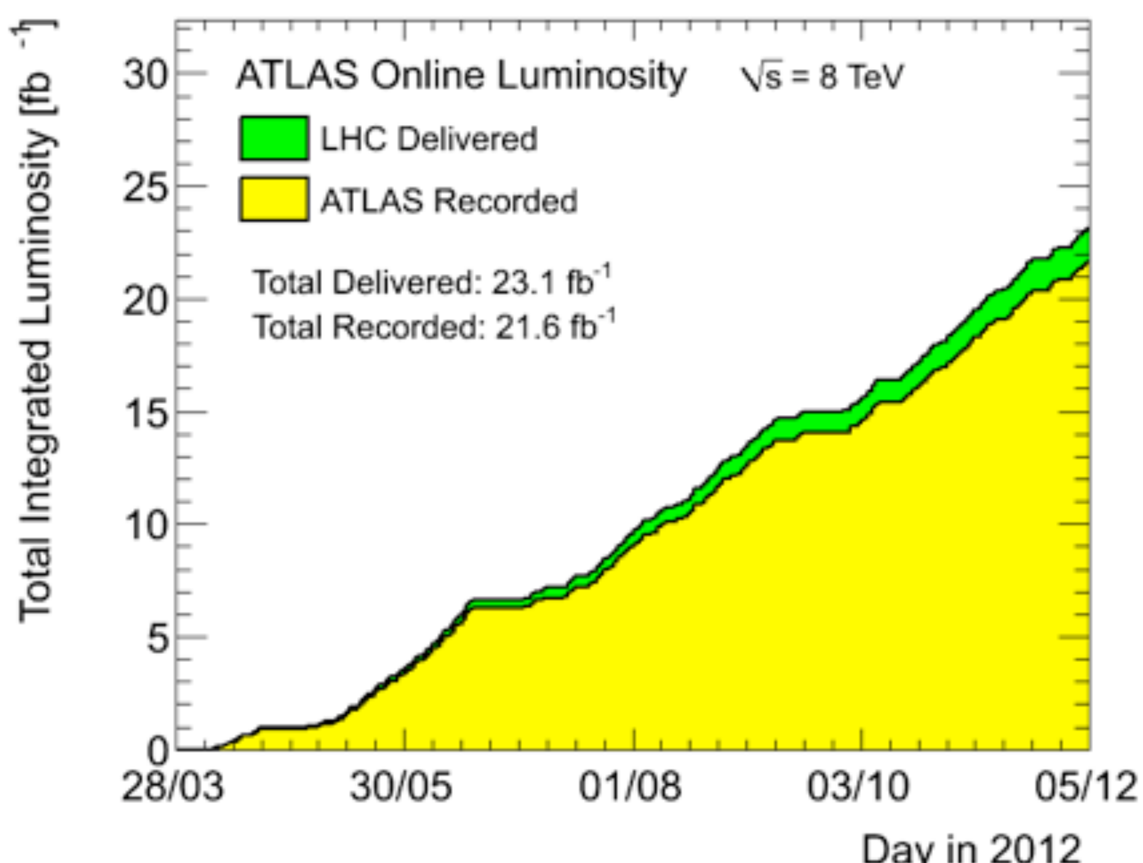
$\sqrt{s}$=7 TeV

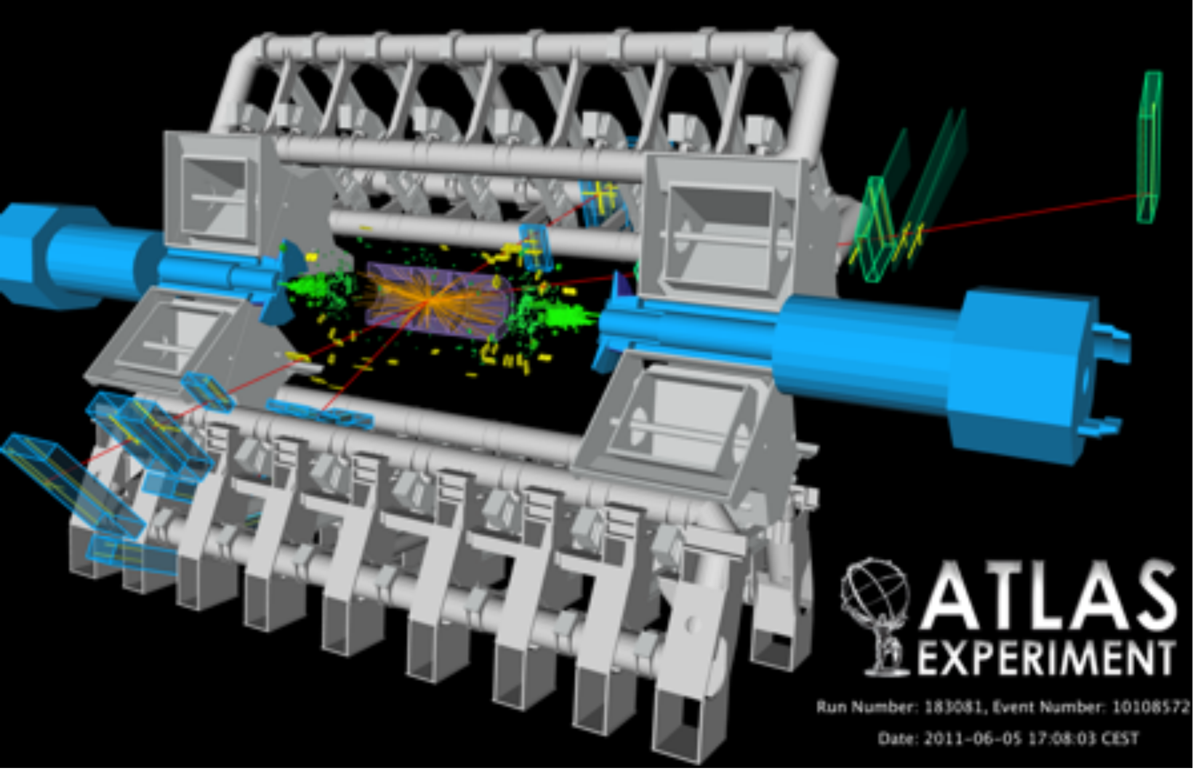


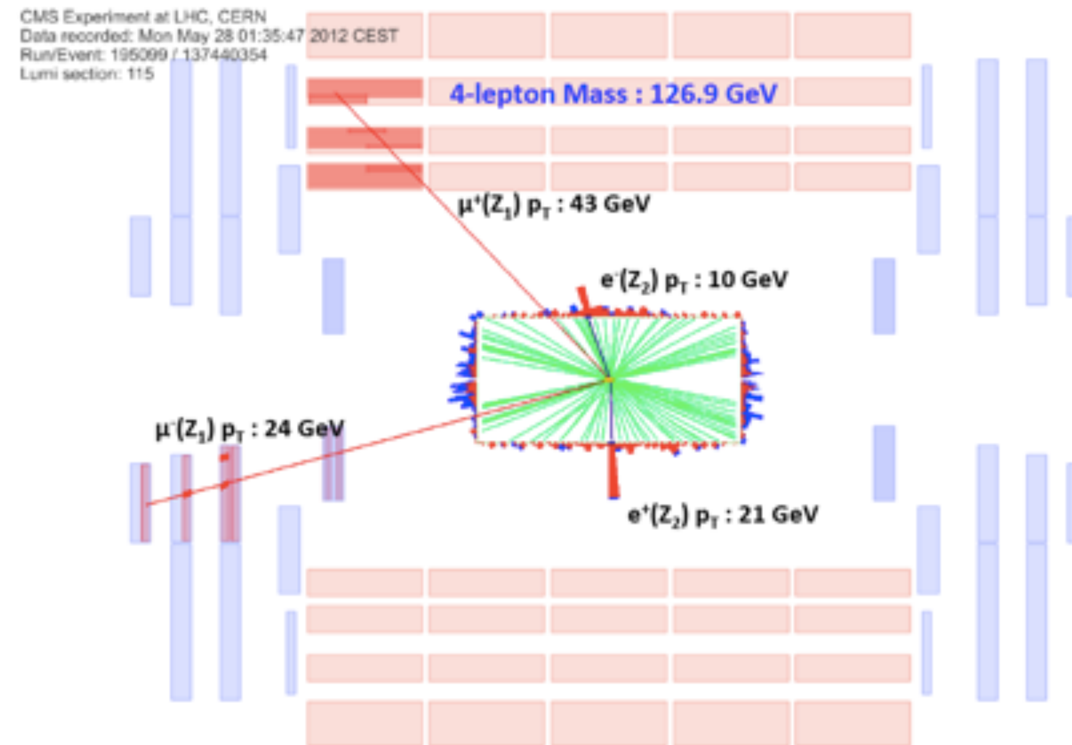
7 months in 2012

$\sqrt{s}$=8 TeV



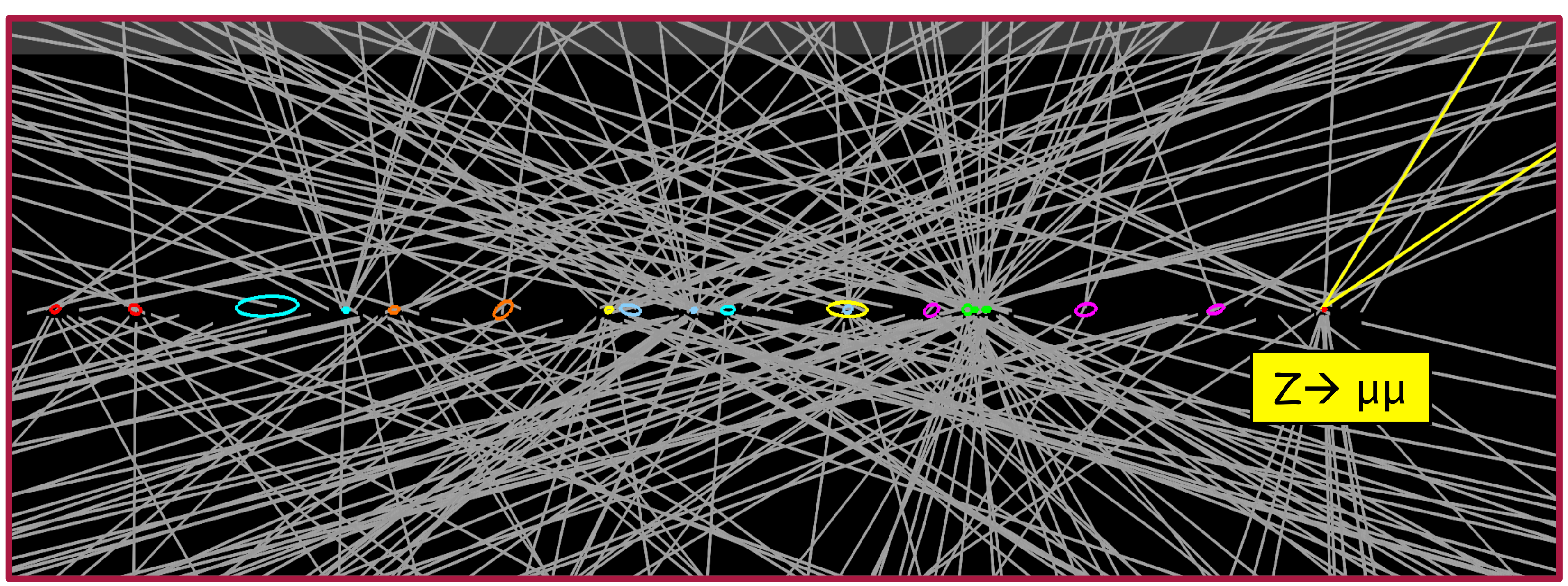




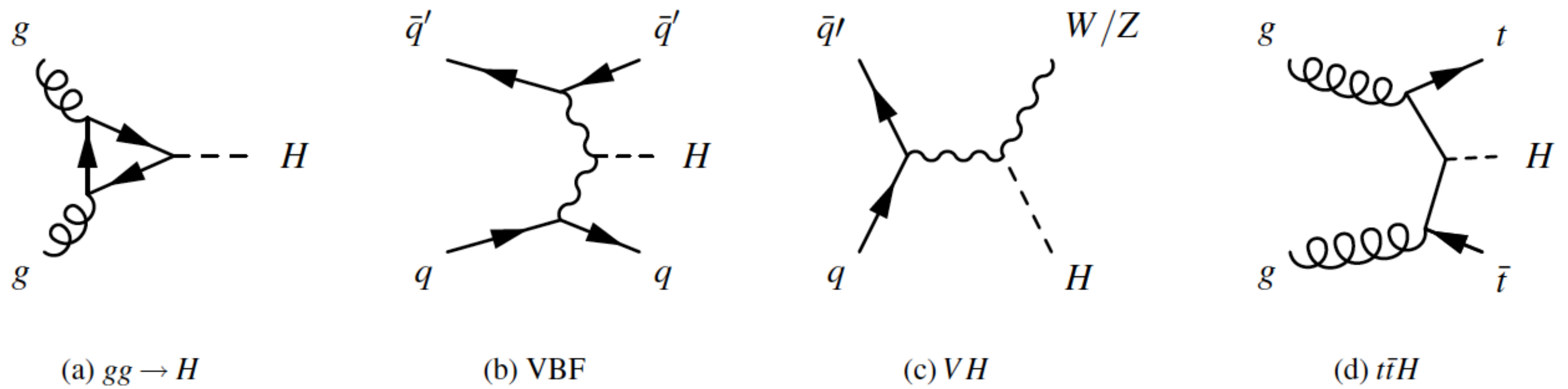


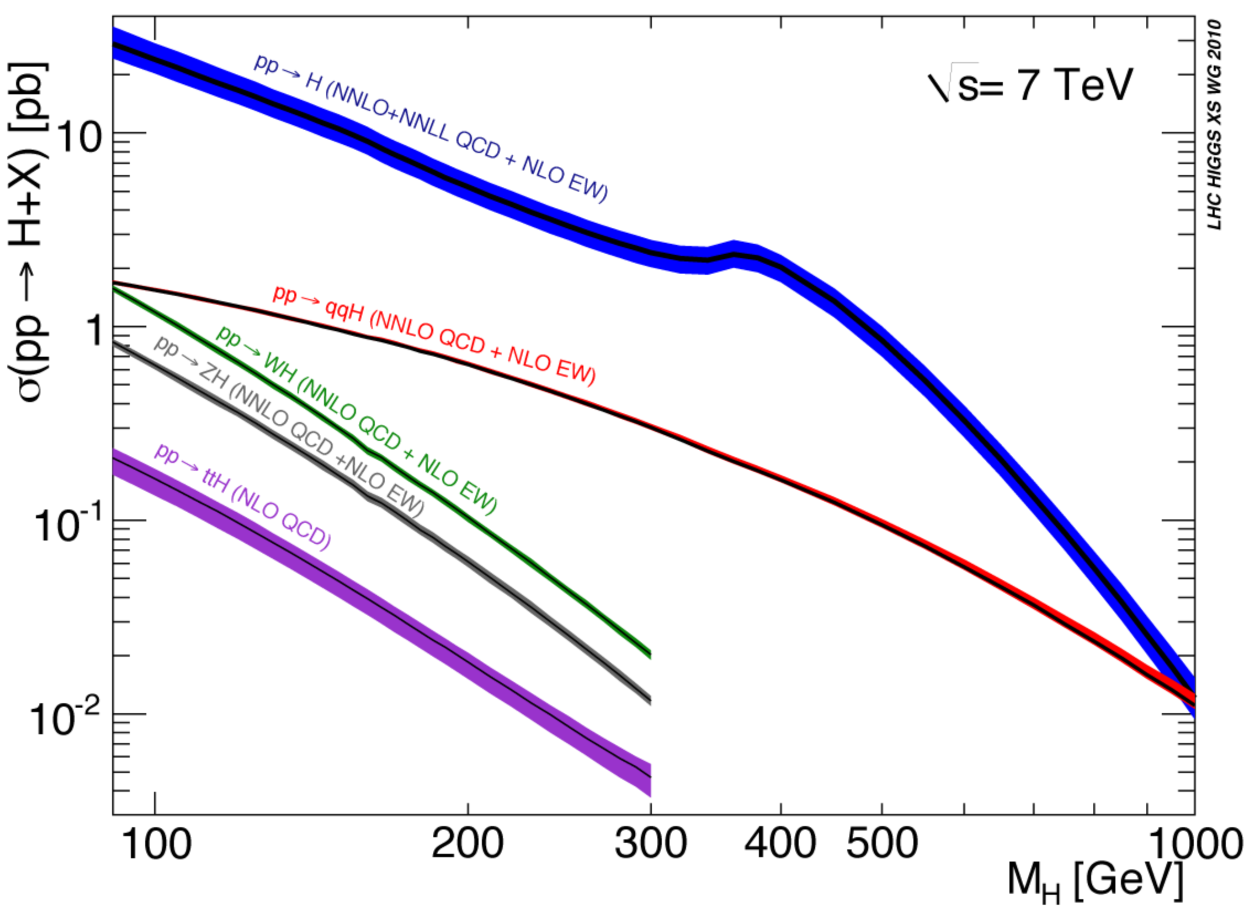
CMS EXPERIMENT AT LHC

ATLAS and CMS have excellent performance. They are capable to precisely measure leptons, photons, jets and Missing Transverse Energy also in the difficult conditions of the high pile-up environment



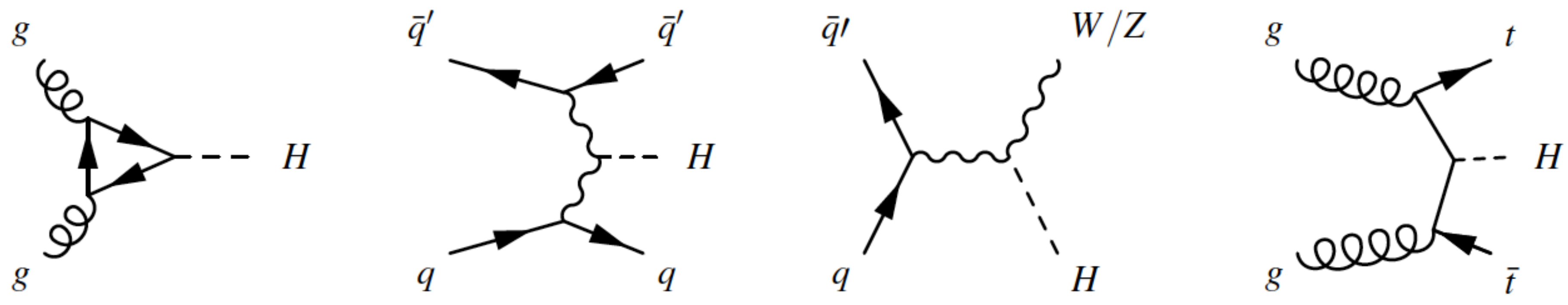
SM Higgs production pp@ 7-8 Tev



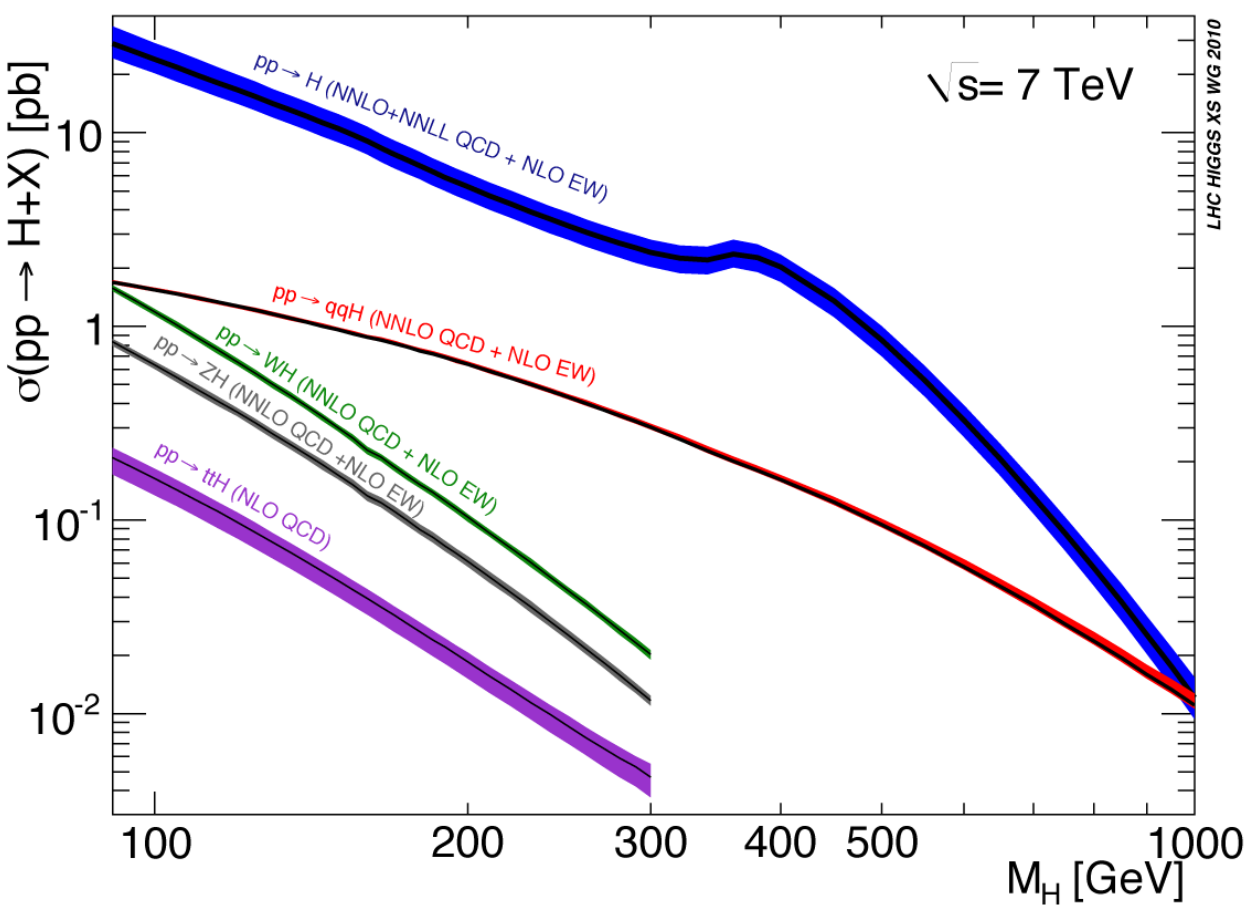


σ ~ 17 pb @ 7 TeV
σ ~ 22 pb @ 8 TeV

SM Higgs production pp@ 7-8 Tev



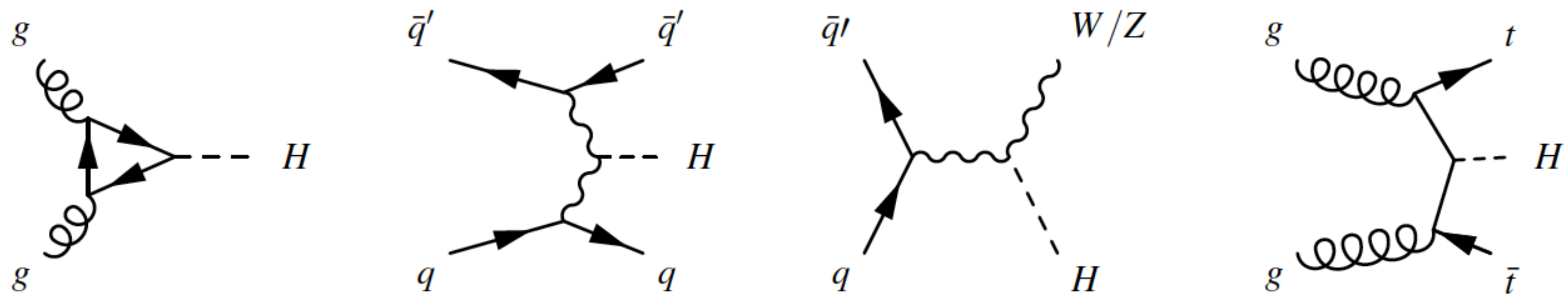
(a) $gg \to H$ (b) VBF (c) VH (d) $t\bar{t}H$



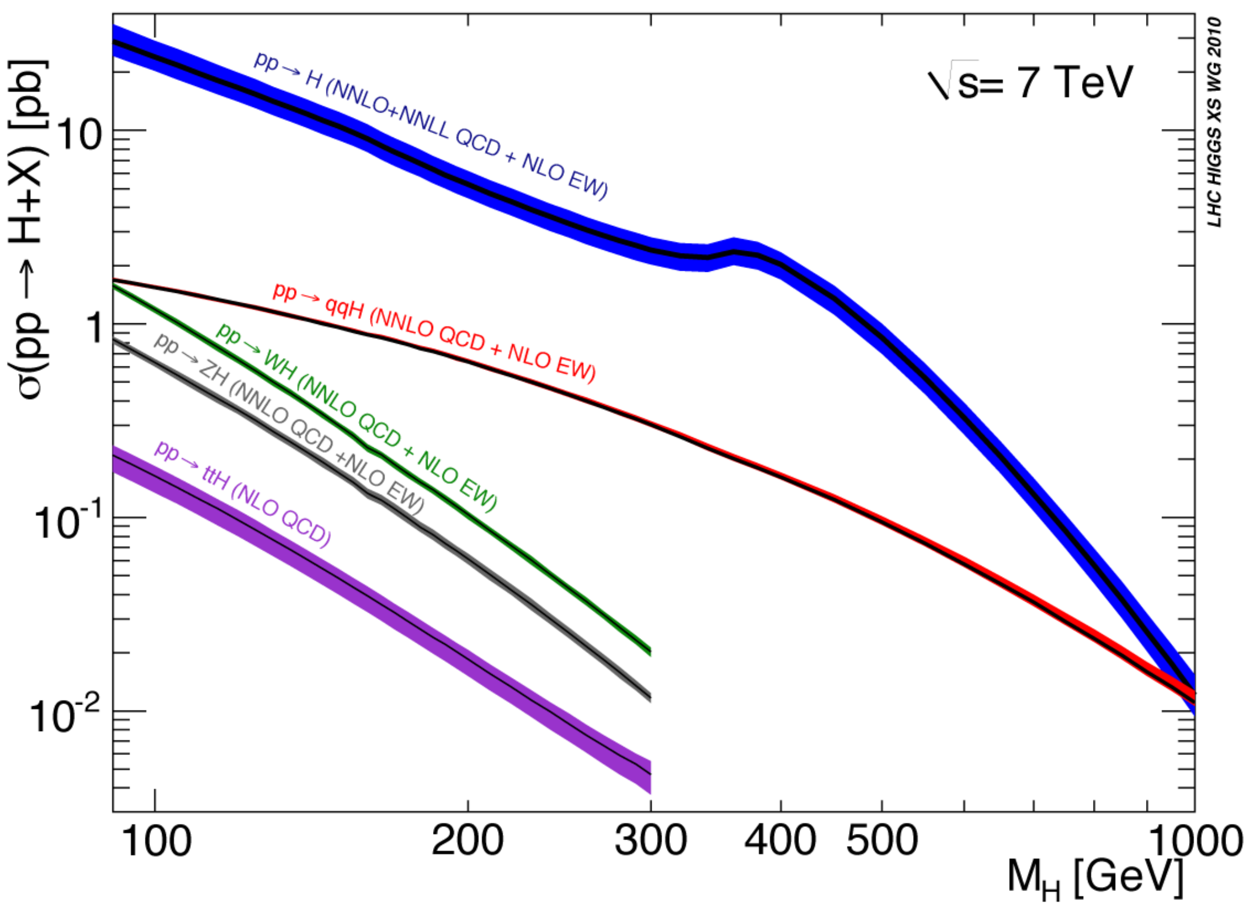
σ ~ 17 pb @ 7 TeV
σ ~ 22 pb @ 8 TeV

If m_H ~ 125 GeV
~ 200.000 Higgs Bosons produced in 10 fb-1 of pp collisions

SM Higgs production pp@ 7-8 Tev



(a) $gg \to H$ (b) VBF (c) VH (d) $t\bar{t}H$

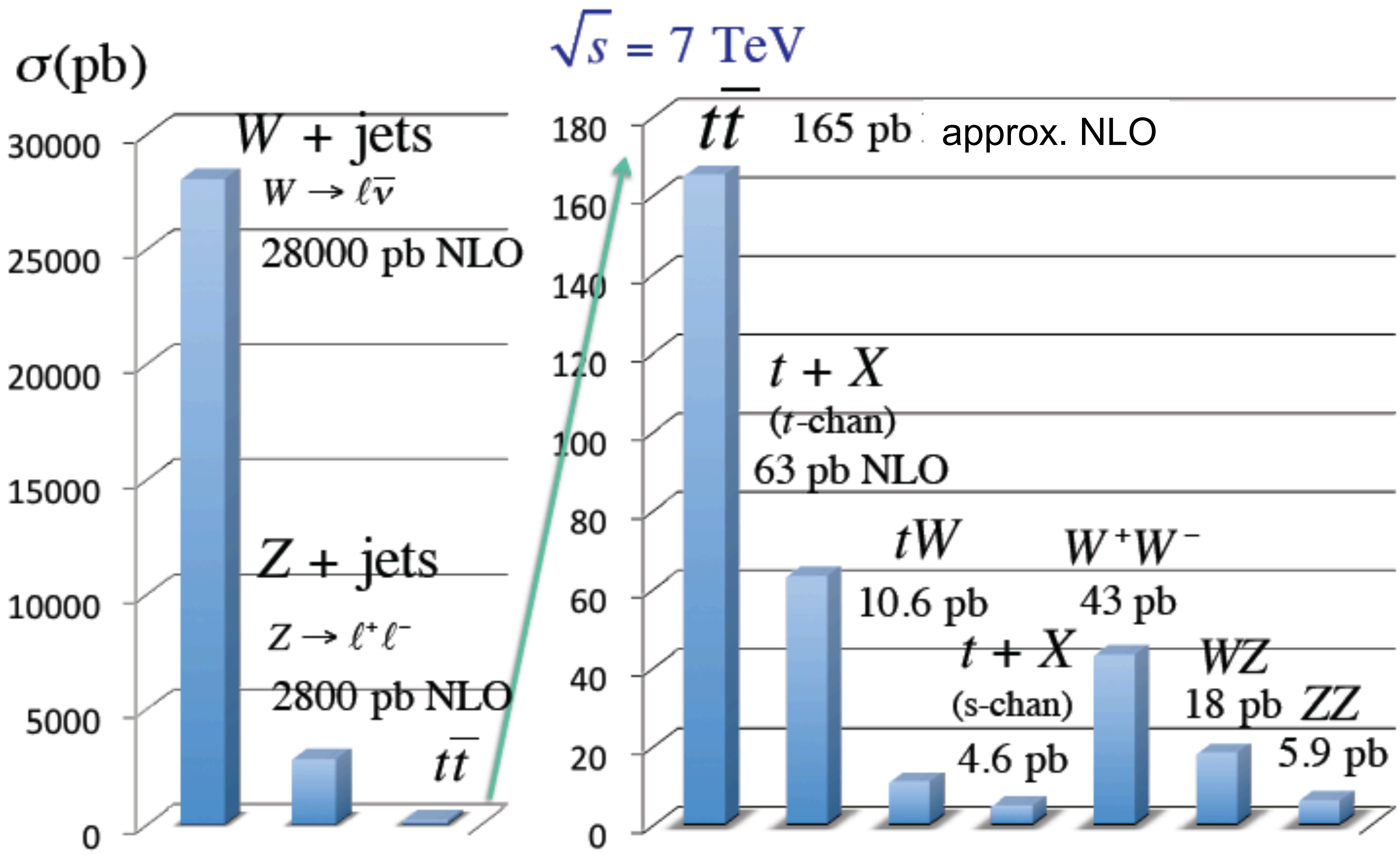


σ ~ 17 pb @ 7 TeV
σ ~ 22 pb @ 8 TeV

If m_H ~ 125 GeV
~ 200.000 Higgs Bosons produced in 10 fb-1 of pp collisions

However......

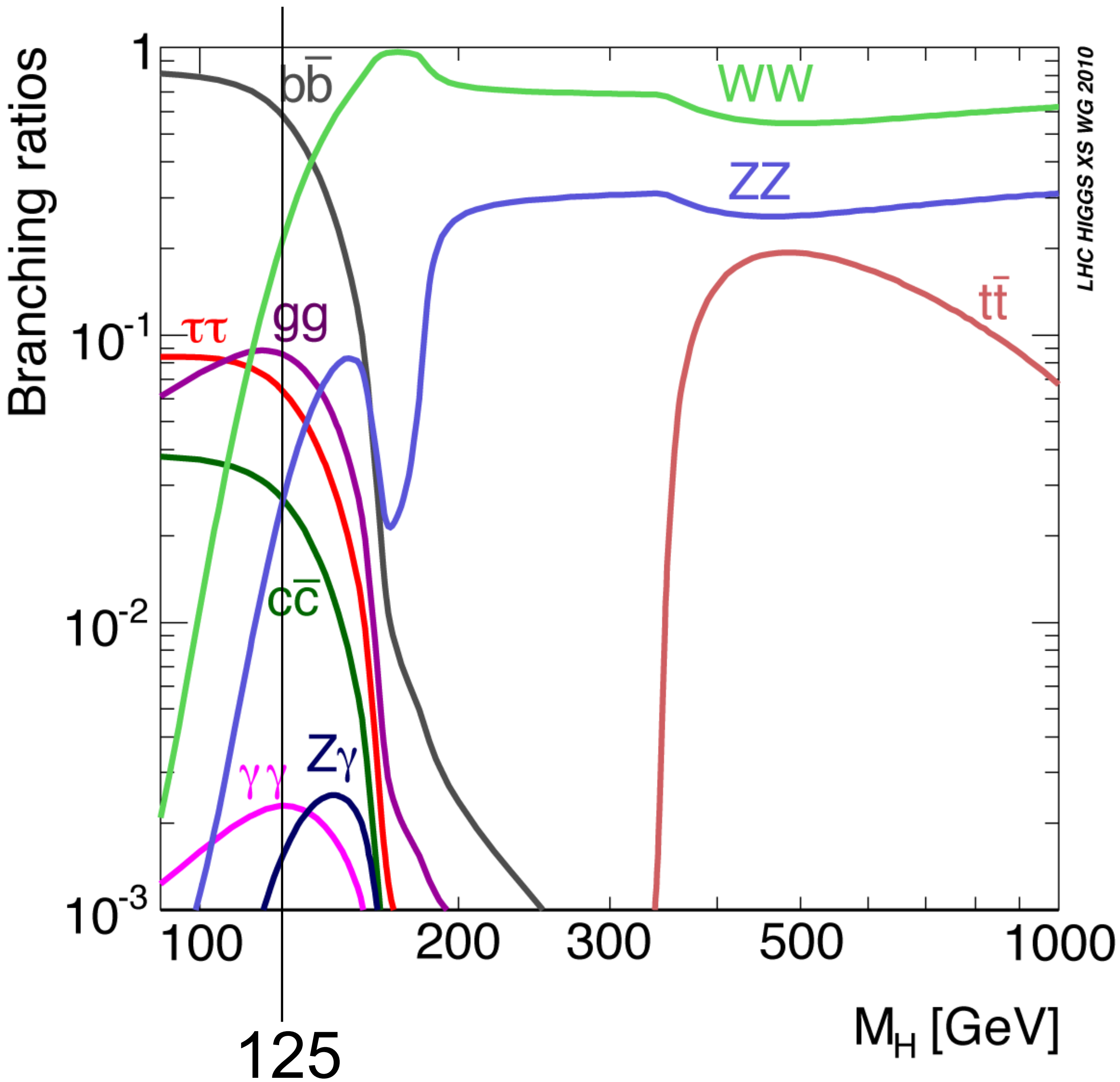
Key SM Background processes AT LHC



V. Sharma

in 10 fb^{-1} ~ 10^{15} min bias , ~ 10^{12} di-jets mjj>100 GeV, ~ $3 10^9$ W

Higgs Searches



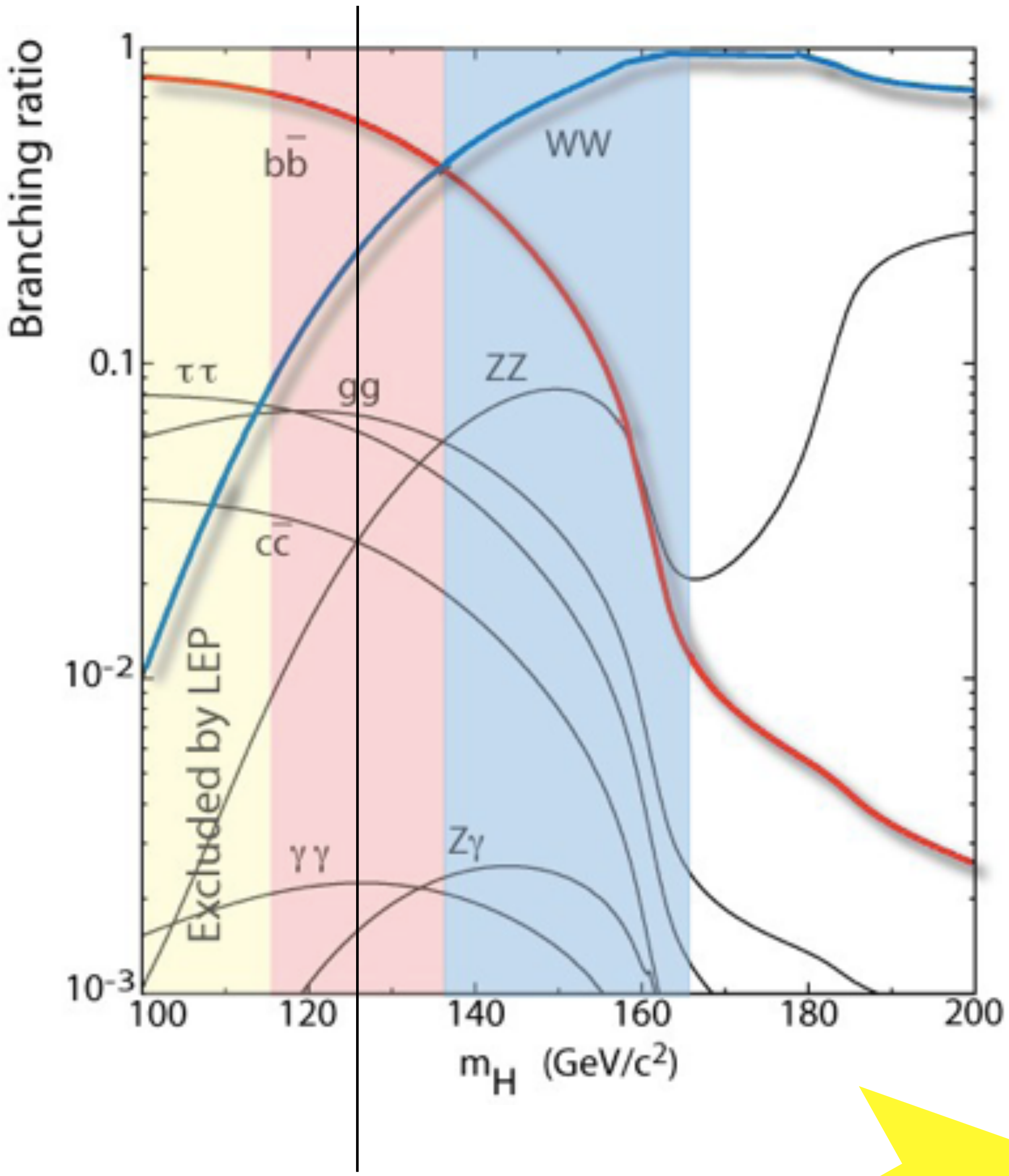
High mass : ZZ and WW

Low Mass: many channels

BR

4l	$1.2\ 10^{-4}$	(ZZ->4l)
γγ	$2.3\ 10^{-3}$	
2l2v	$1.0\ 10^{-2}$	(WW->2l2v)
ττ	$6.0\ 10^{-2}$	
bb	$5.8\ 10^{-1}$	

Higgs Searches



@ 125 GeV <σ> ~ 20 pb.

σ*BR*10 fb^{-1}

4l ~24 **Excellent mass resolution, small bkg. After selection 6 events and bkg of 1 event per ~ 1-2 GeV resolution**

γγ ~450 **Excellent mass resolution, large bkg. After selection 200 events and bkg of 2500 event per ~ 2 GeV resolution**

2l2ν ~2000 **Poor mass resolution, large bkg. After selection 60 events and bkg of 300 event**

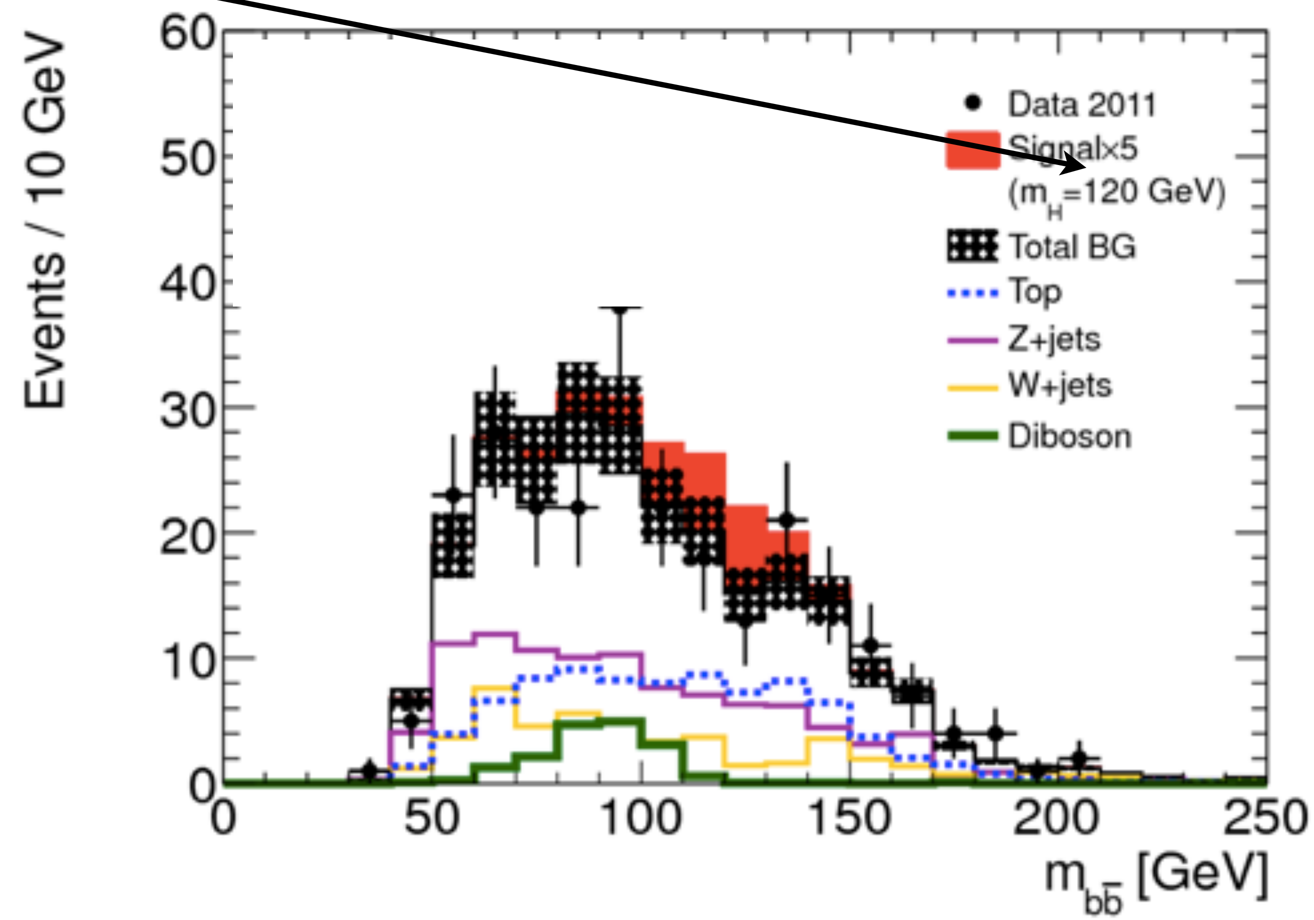
ττ ~12000 **15% mass resolution, large bkg. After selection 14 events and bkg of 140 event**

bb ~100000 **10% mass resolution, overwhelming bkg. After selection 8 events and bkg of 80 event**

Very rough figures, to guide the eye..... Analyses much more sophisticated

Typical analysis

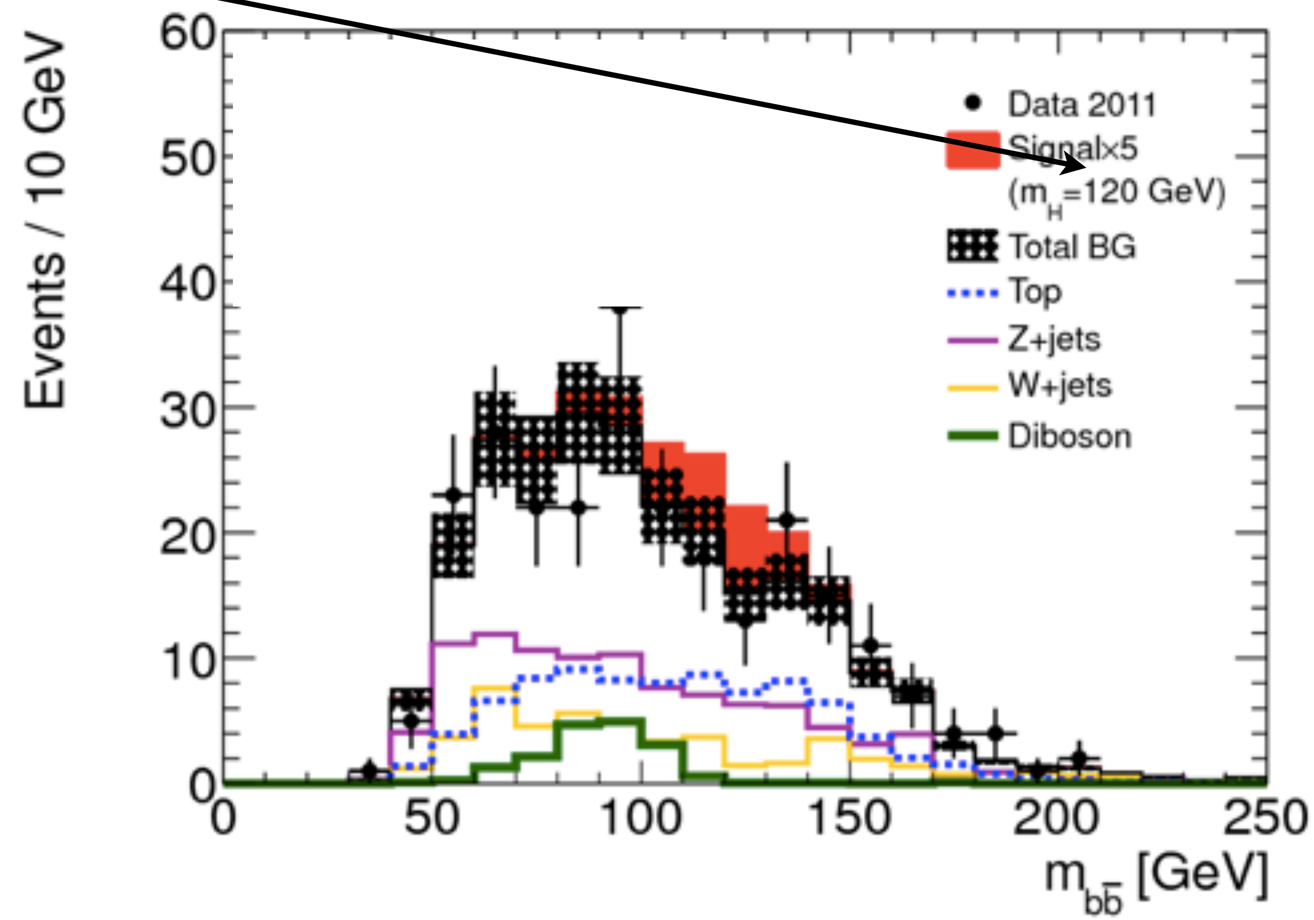
Design a selection at a given mass maximizing an estimator (eg s/√bkg)



Typical analysis

Design a selection at a given mass maximizing an estimator (eg s/√bkg)

Often cutting the phase-space in many regions

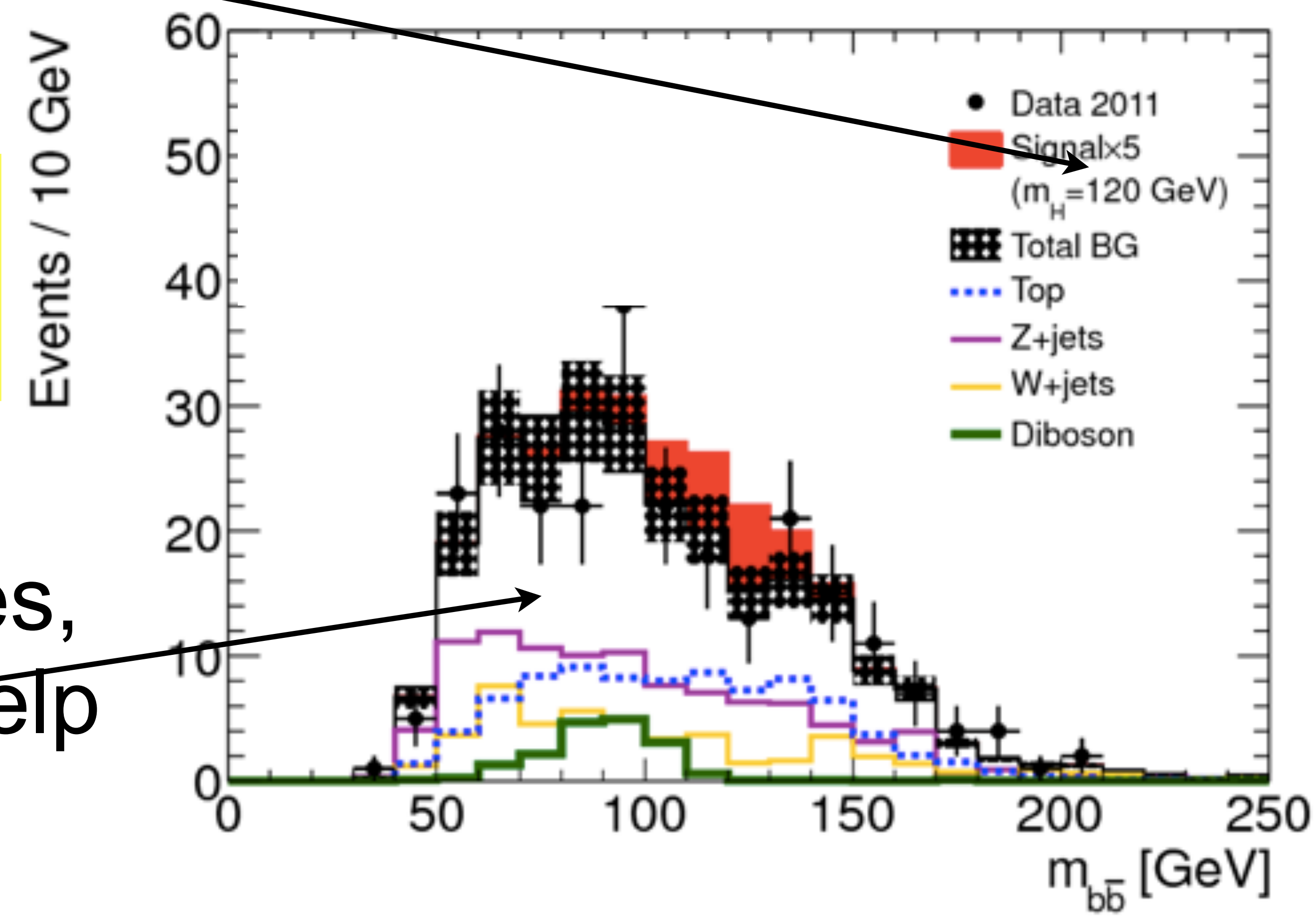


Typical analysis

Design a selection at a given mass maximizing an estimator (eg s/√bkg)

Often cutting the phase-space in many regions

Compute the expected SM background from control samples, side bands, etc.. also with the help from MC simulation (shapes). Assess the systematic error.



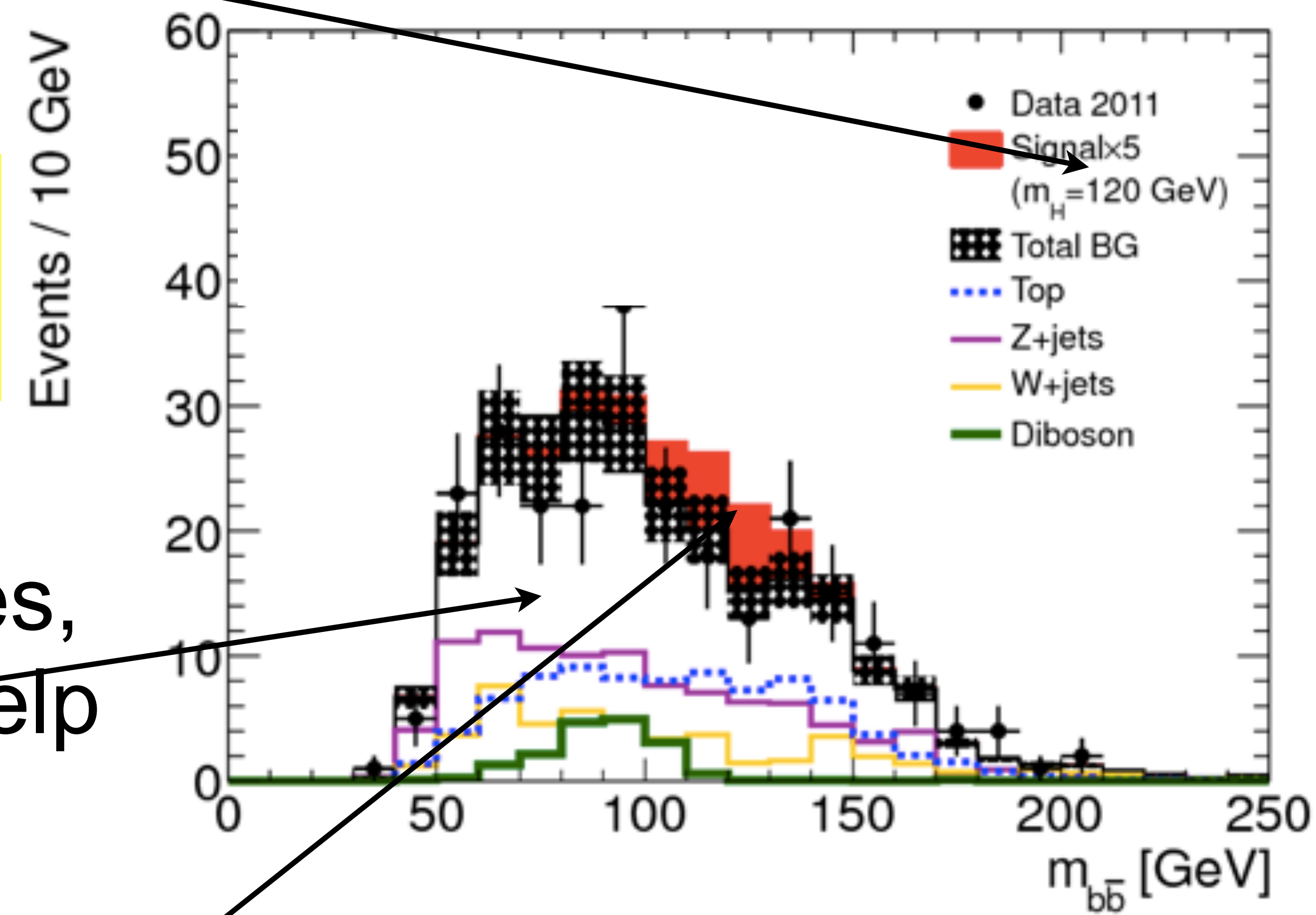
Typical analysis

Design a selection at a given mass maximizing an estimator (eg s/√bkg)

Often cutting the phase-space in many regions

Compute the expected SM background from control samples, side bands, etc.. also with the help from MC simulation (shapes). Assess the systematic error.

Evaluate the signal efficiency using SM Higgs MC simulation

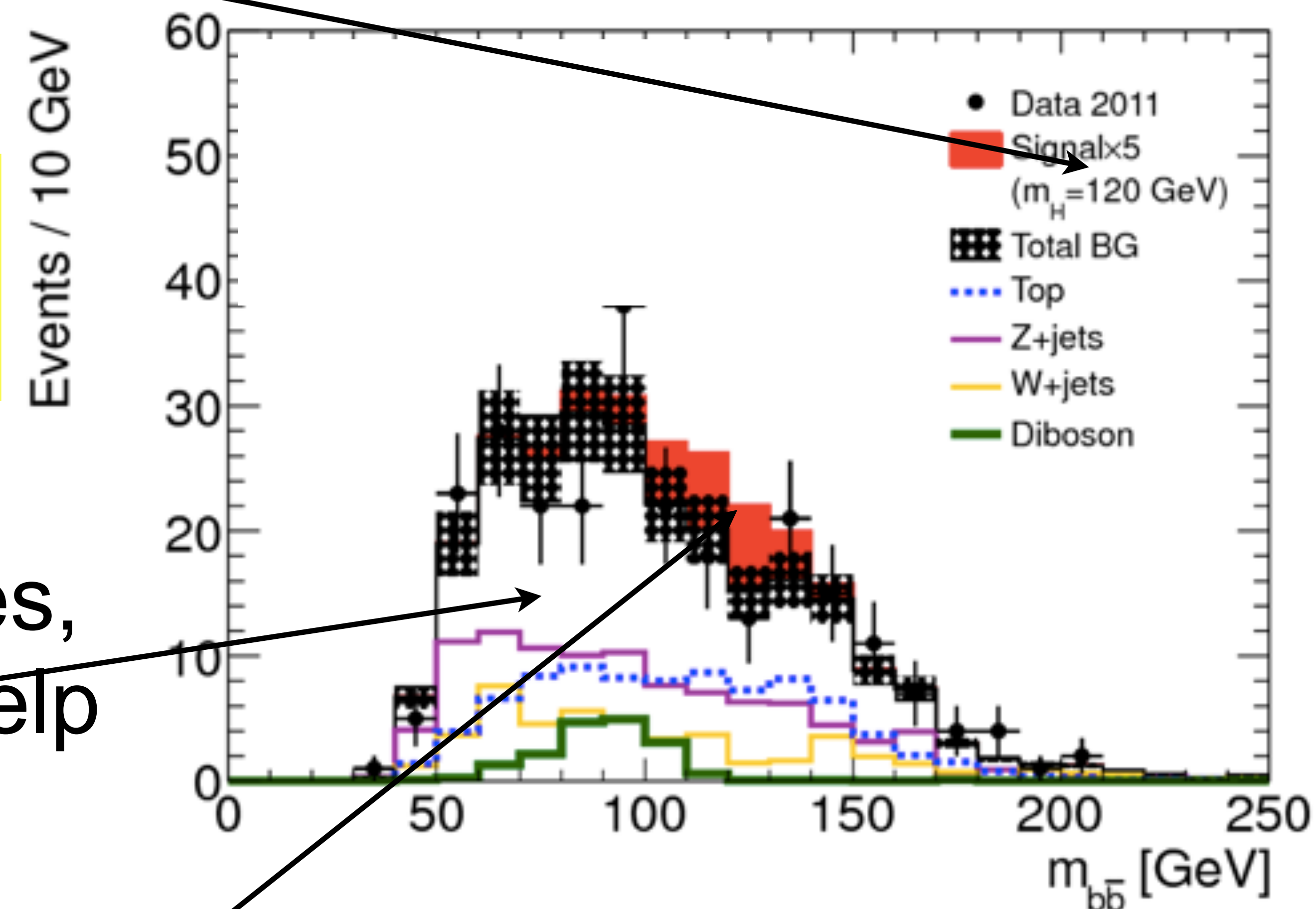


Typical analysis

Design a selection at a given mass maximizing an estimator (eg s/√bkg)

Often cutting the phase-space in many regions

Compute the expected SM background from control samples, side bands, etc.. also with the help from MC simulation (shapes). Assess the systematic error.

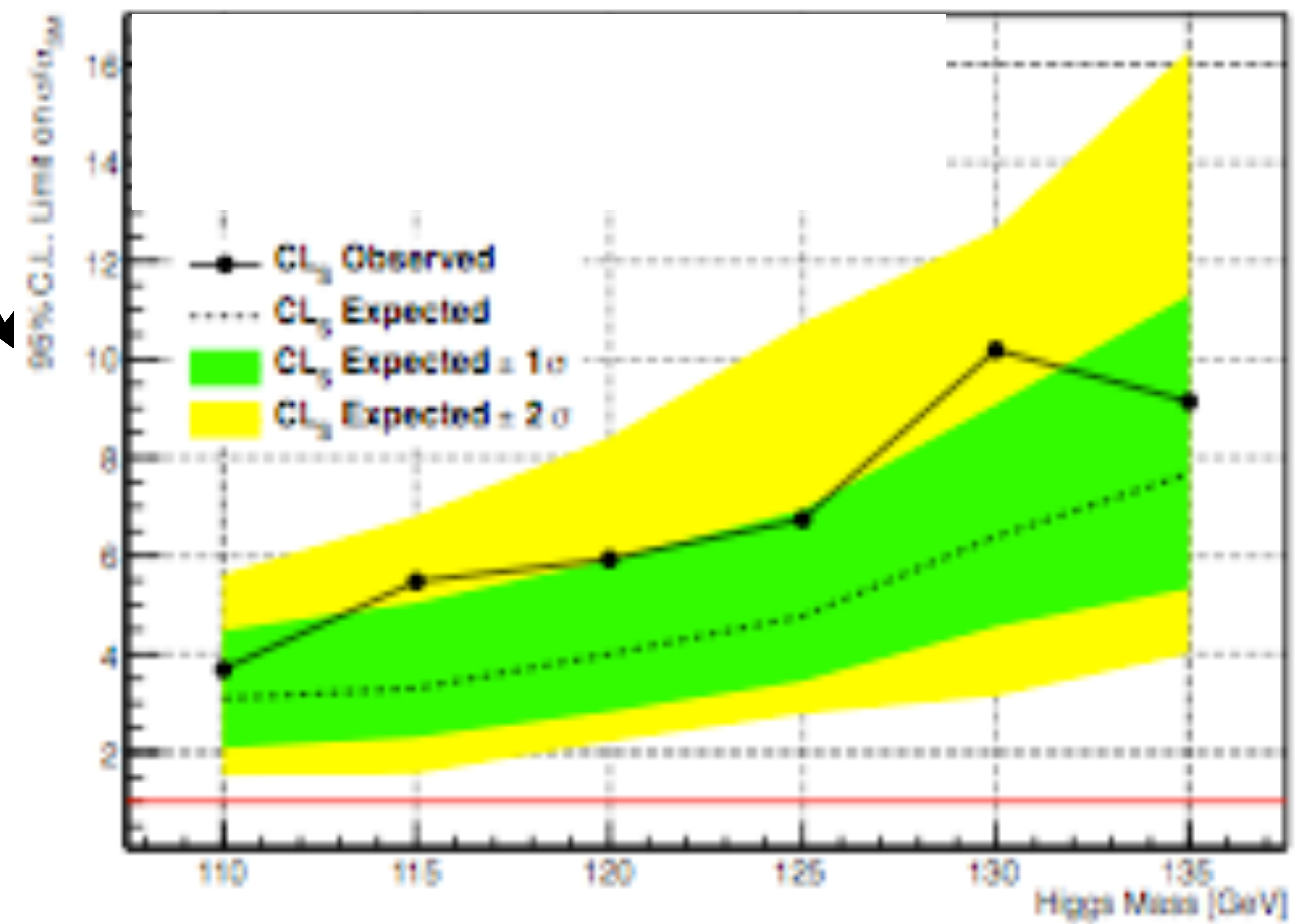


Evaluate the signal efficiency using SM Higgs MC simulation

Compute with statistical methods the largest signal cross section one can accommodate in the data.

The "typical plot"

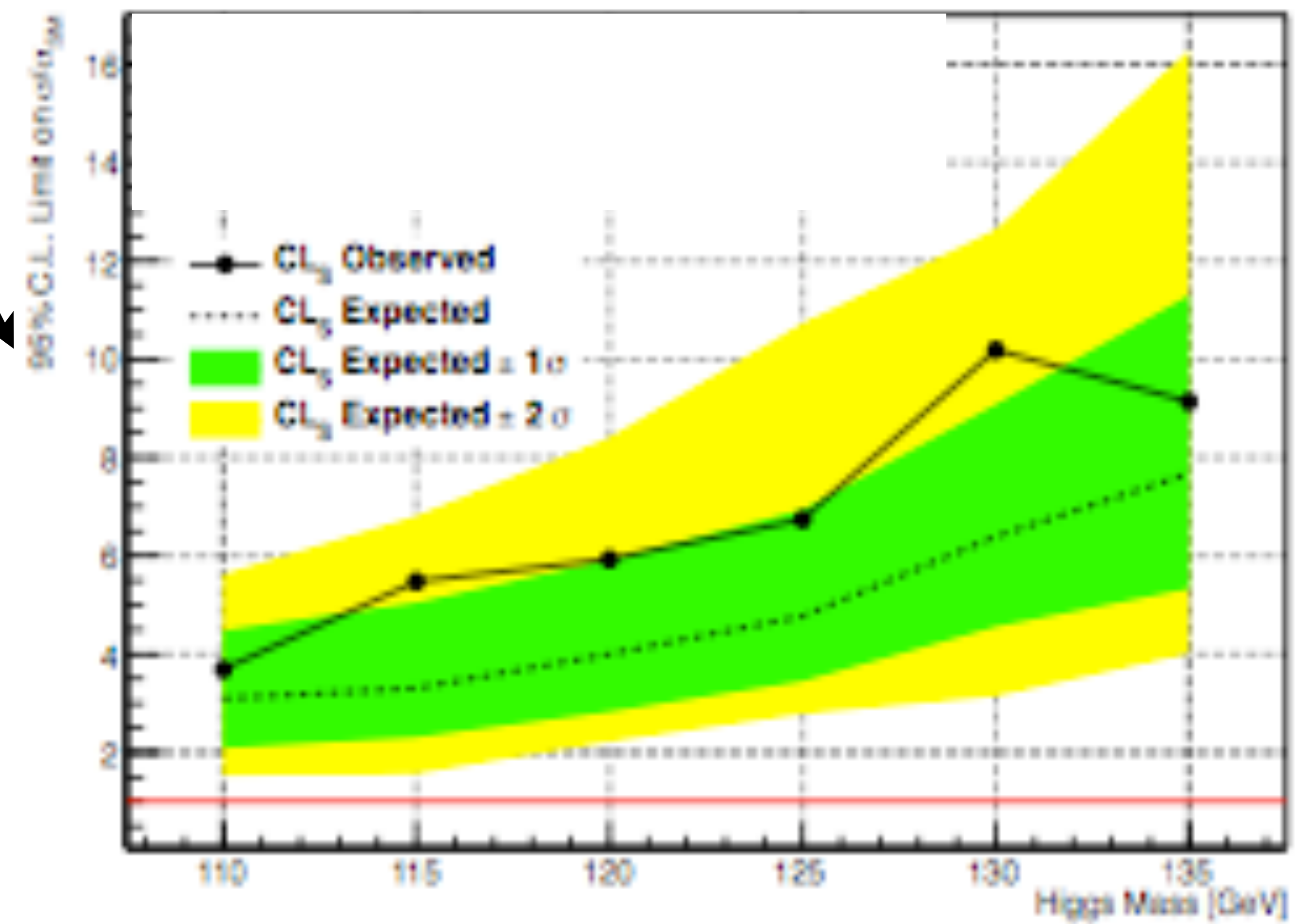
Analyses optimized for exclusion.
The result is expressed at a given mass as exclusion at 95% of a cross section.



The “typical plot”

Analyses optimized for exclusion.
The result is expressed at a given mass as exclusion at 95% of a cross section.

The excluded cross section is computed in unit of SM cross section (μ).

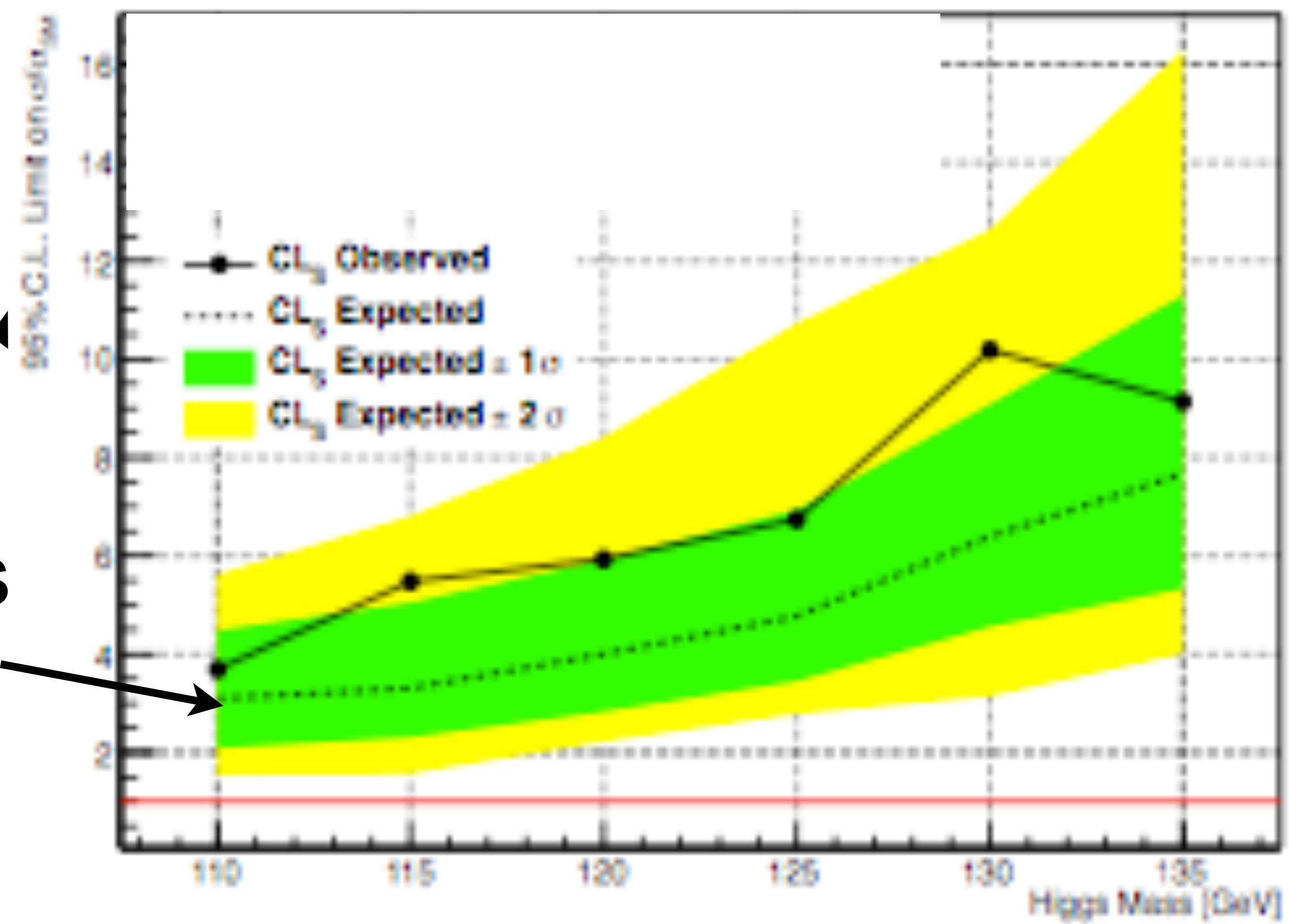


The “typical plot”

Analyses optimized for exclusion.
The result is expressed at a given mass as exclusion at 95% of a cross section.

The excluded cross section is computed in unit of SM cross section (μ).

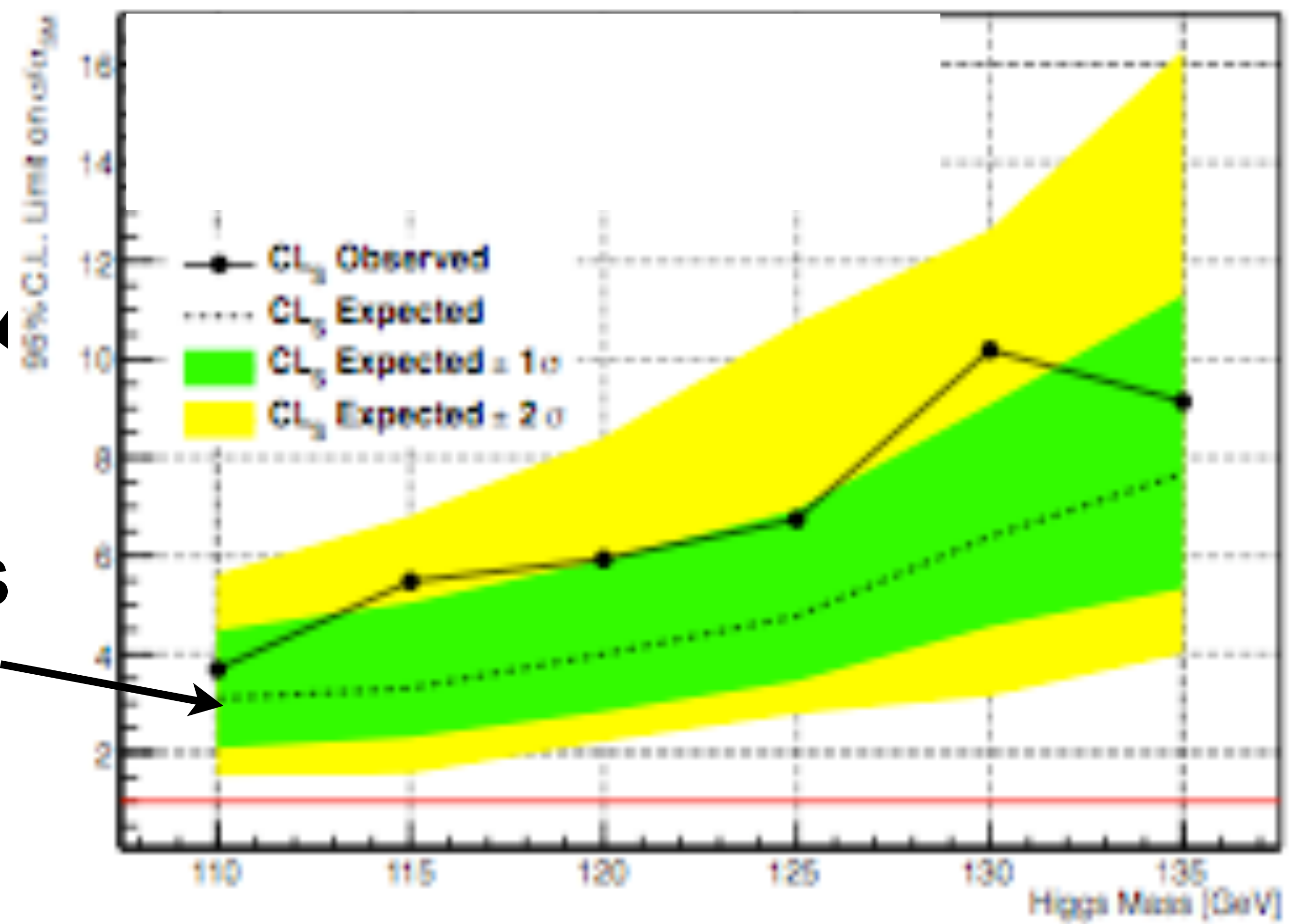
Expected sensitivity: measures how performing is the analysis



The “typical plot”

Analyses optimized for exclusion.
The result is expressed at a given mass as exclusion at 95% of a cross section.

The excluded cross section is computed in unit of SM cross section (μ).



Expected sensitivity: measures how performing is the analysis

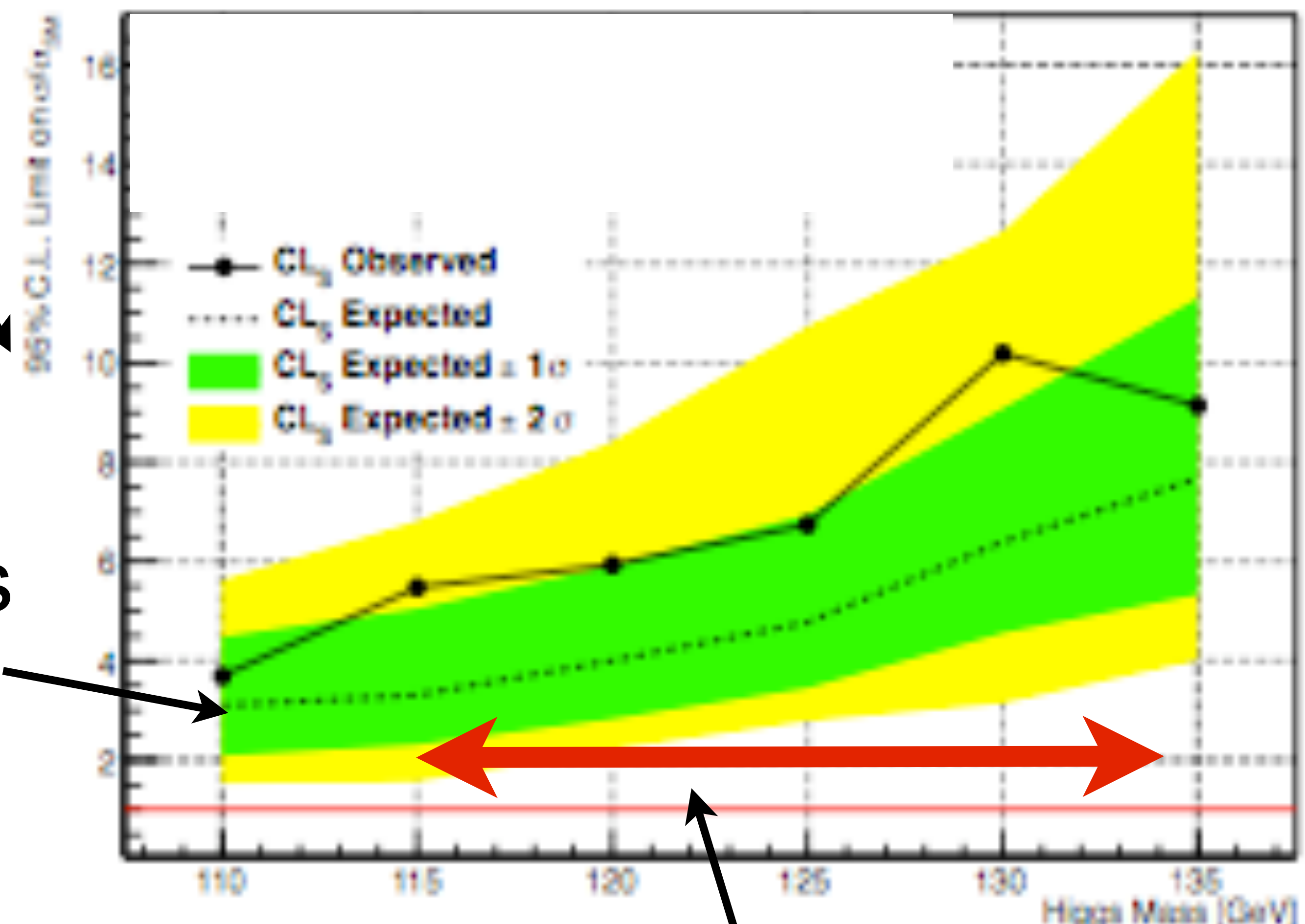
The colored bands give the expected statistical⊕systematic variation of the result wrt to the “expected”

The "typical plot"

Analyses optimized for exclusion.
The result is expressed at a given mass as exclusion at 95% of a cross section.

The excluded cross section is computed in unit of SM cross section (μ).

Expected sensitivity: measures how performing is the analysis

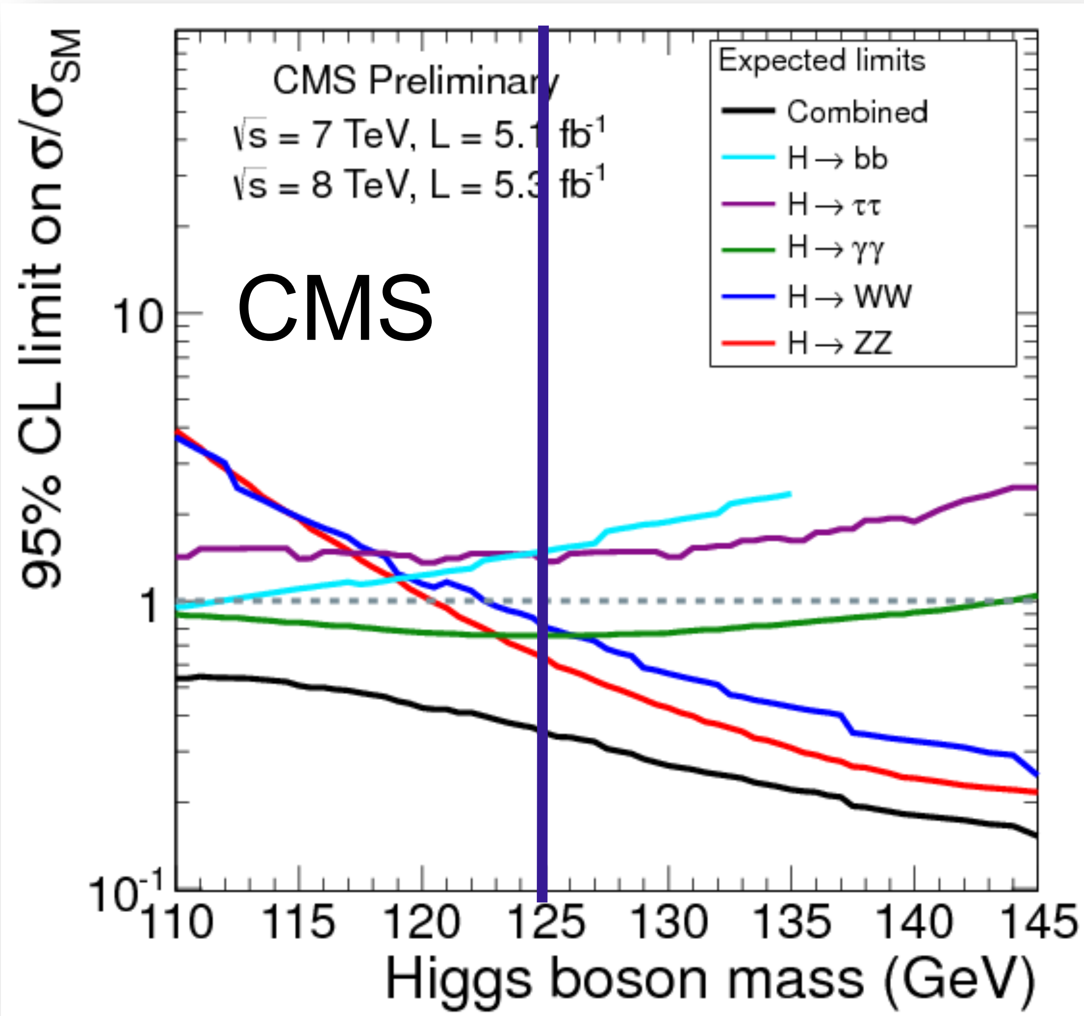


The colored bands give the expected statistical⊕systematic variation of the result wrt to the "expected"

Nearby points are correlated depending on the mass resolution

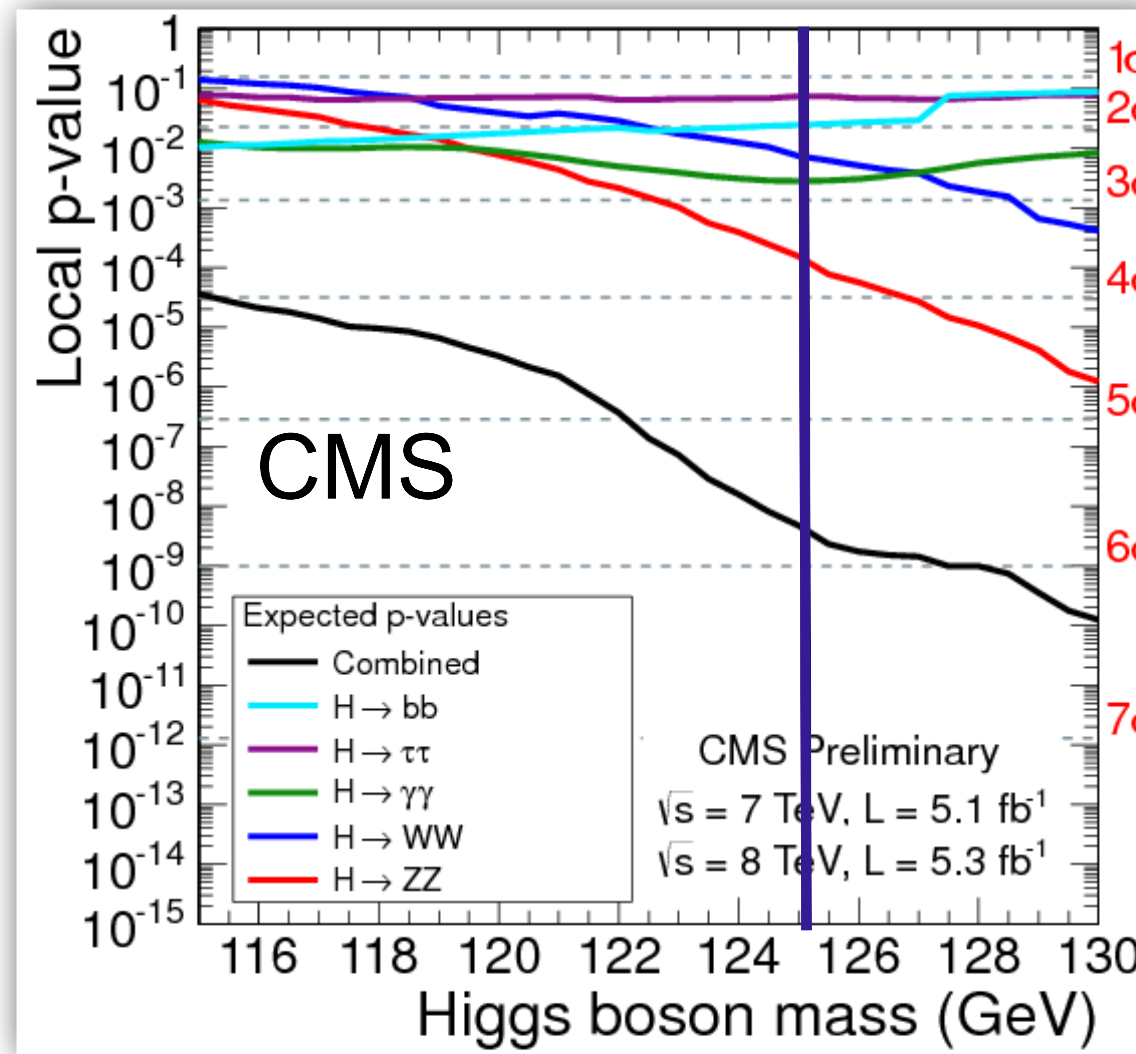
Expected sensitivity and p-value

Exclusion Potential



Measures which cross section can be excluded with the present statistics

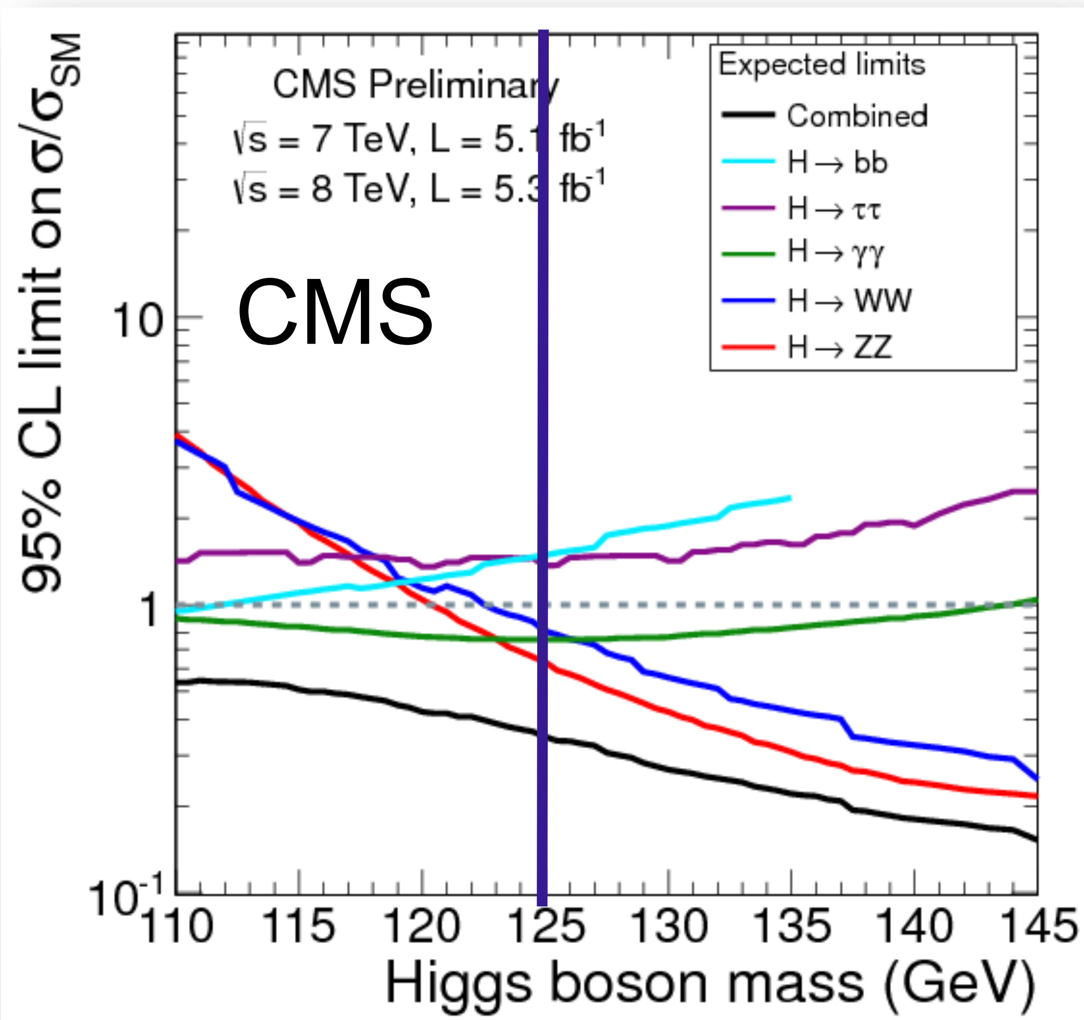
Discovery Potential



Measures which fluctuation of the bkg can mimic a signal of SM Higgs in the present statistics

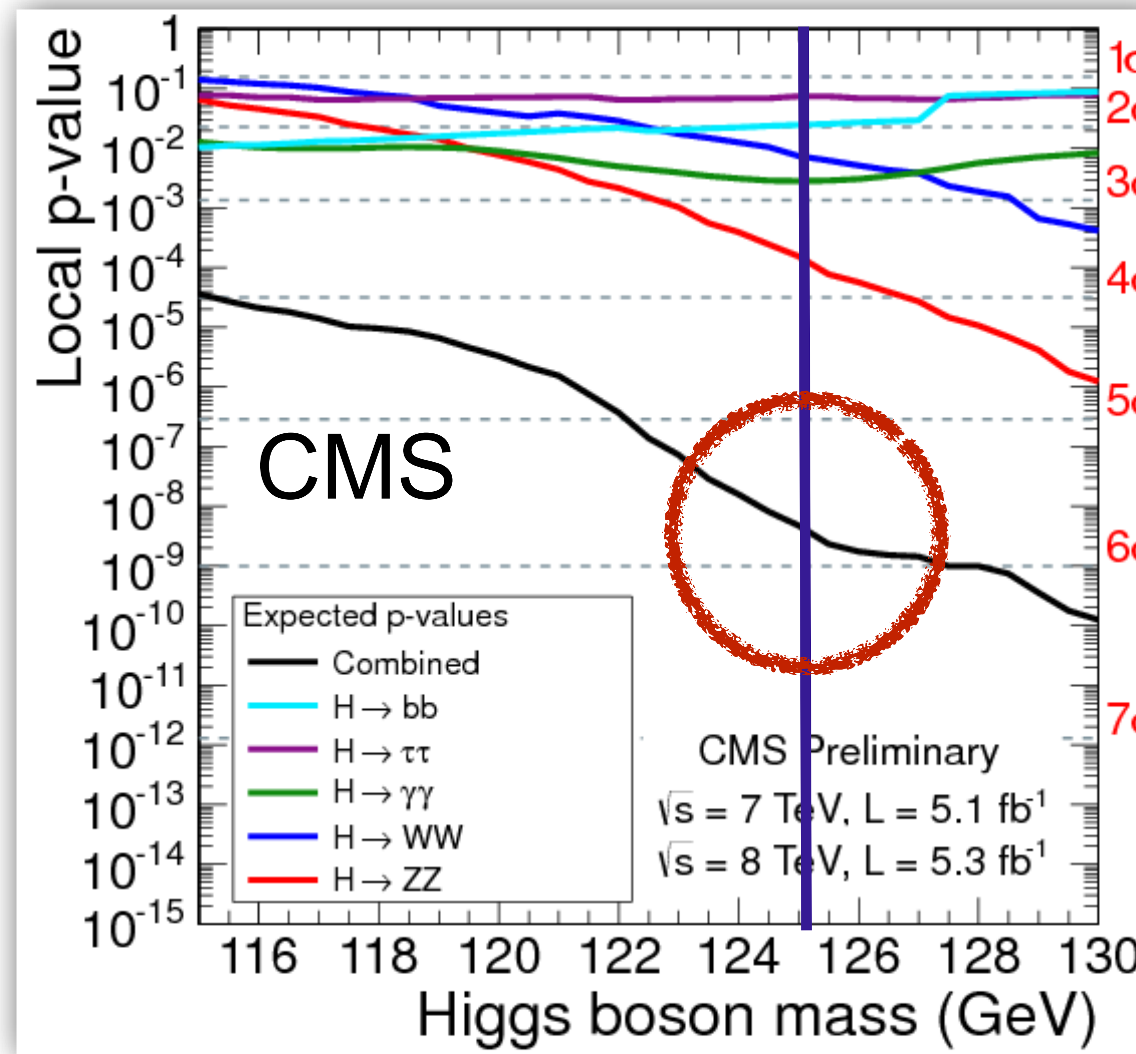
Expected sensitivity and p-value

Exclusion Potential



Measures which cross section can be excluded with the present statistics

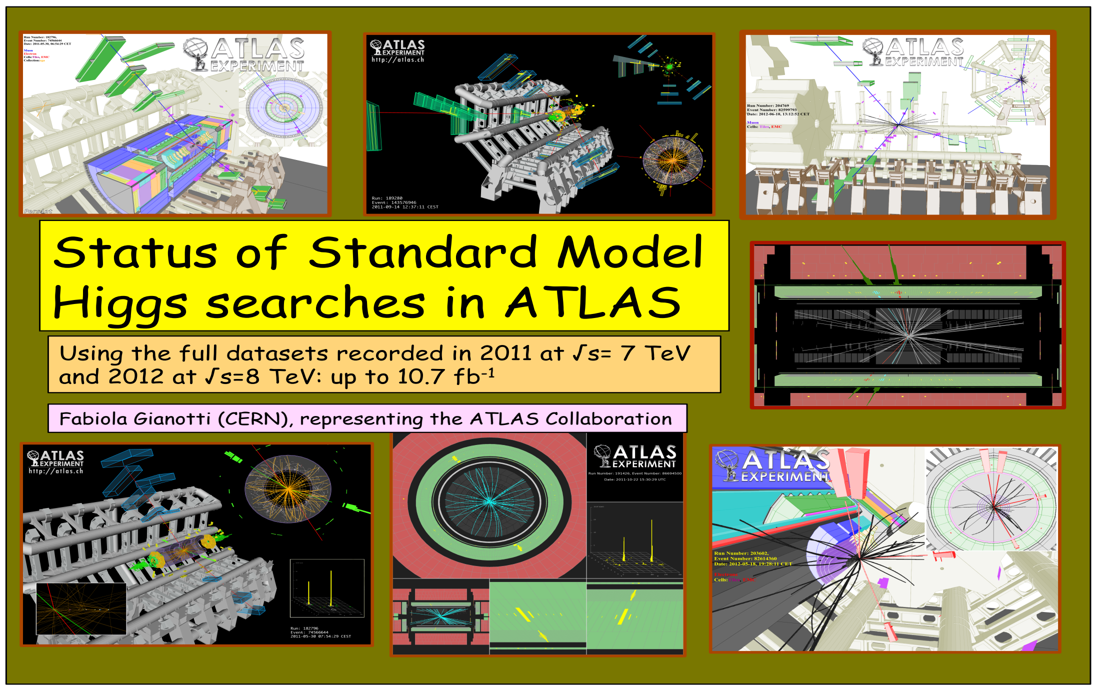
Discovery Potential

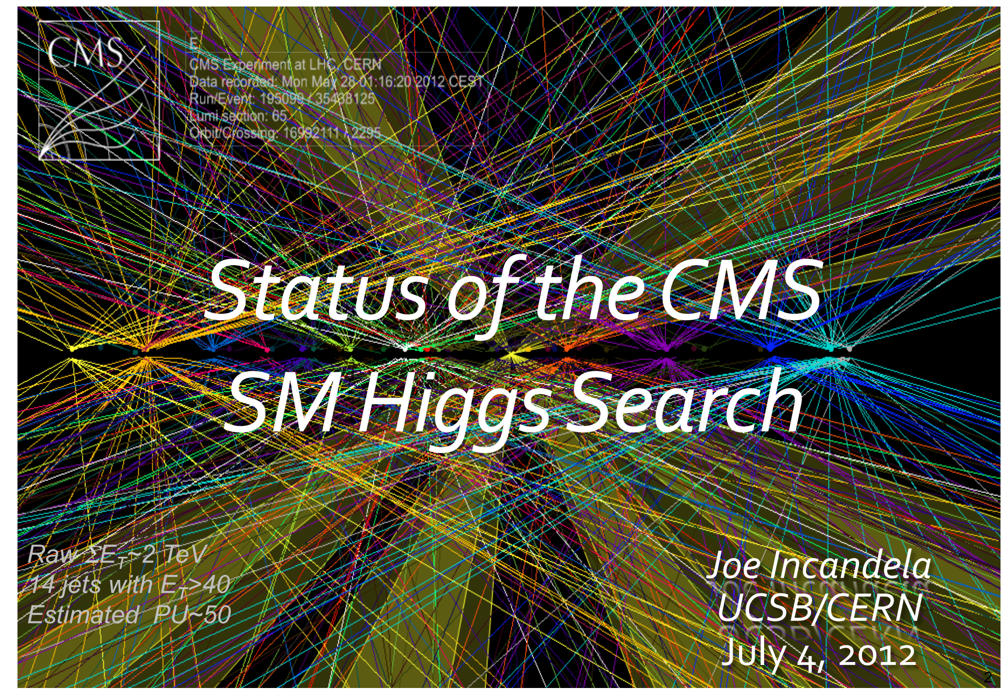


Measures which fluctuation of the bkg can mimic a signal of SM Higgs in the present statistics

CERN Seminar on July 4th

Update most of the analyses to full statistics
~ 5 fb-1 @ 7 TeV (2011) + 5 fb-1 @ 8 TeV (2012)



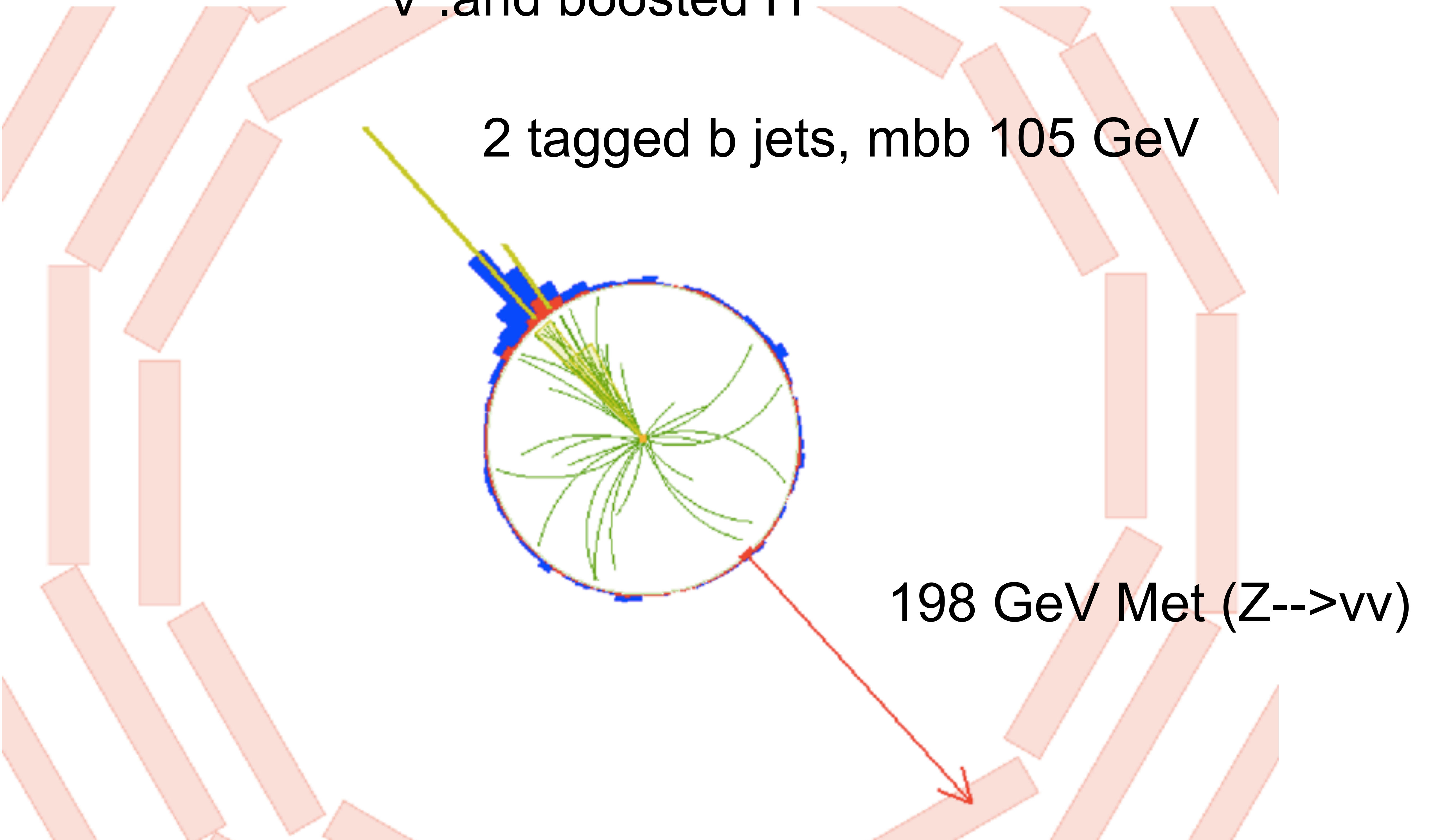


Updates for HCP November 2012

(5 + 13) fb^{-1}	(5 +5) fb^{-1}
bb ττ WW	γγ
4l in CMS	4l in ATLAS

VH --> Vbb

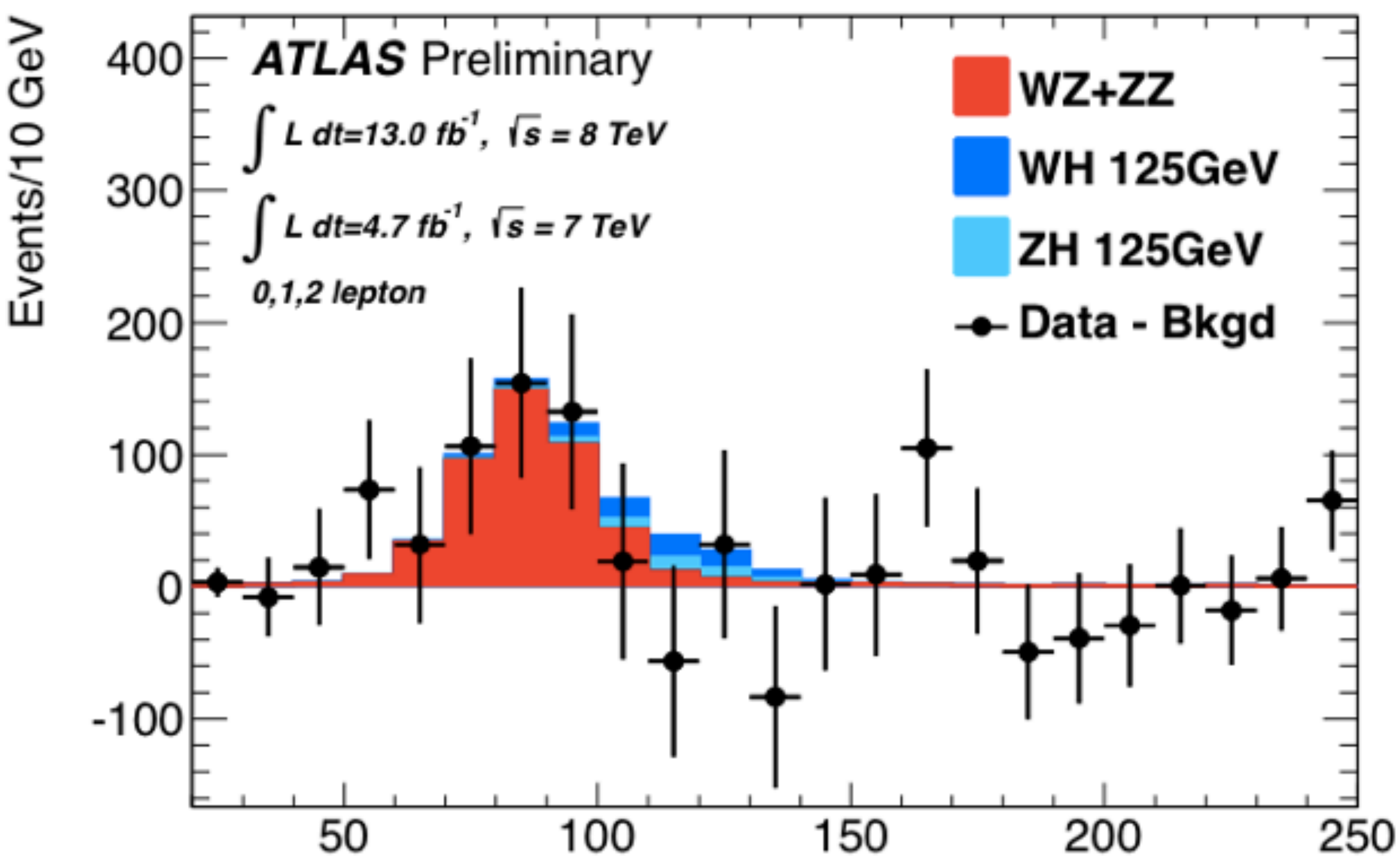
Overwhelming bkg from QCD. Reduced requiring associated production with V .and boosted H



VH-->Vbb

2 b-tagged jets
large MET (HZ,Z-->nunu)
1l + MET (HW,W-->lnu)
2l , no MET (HZ, Z-->ll)

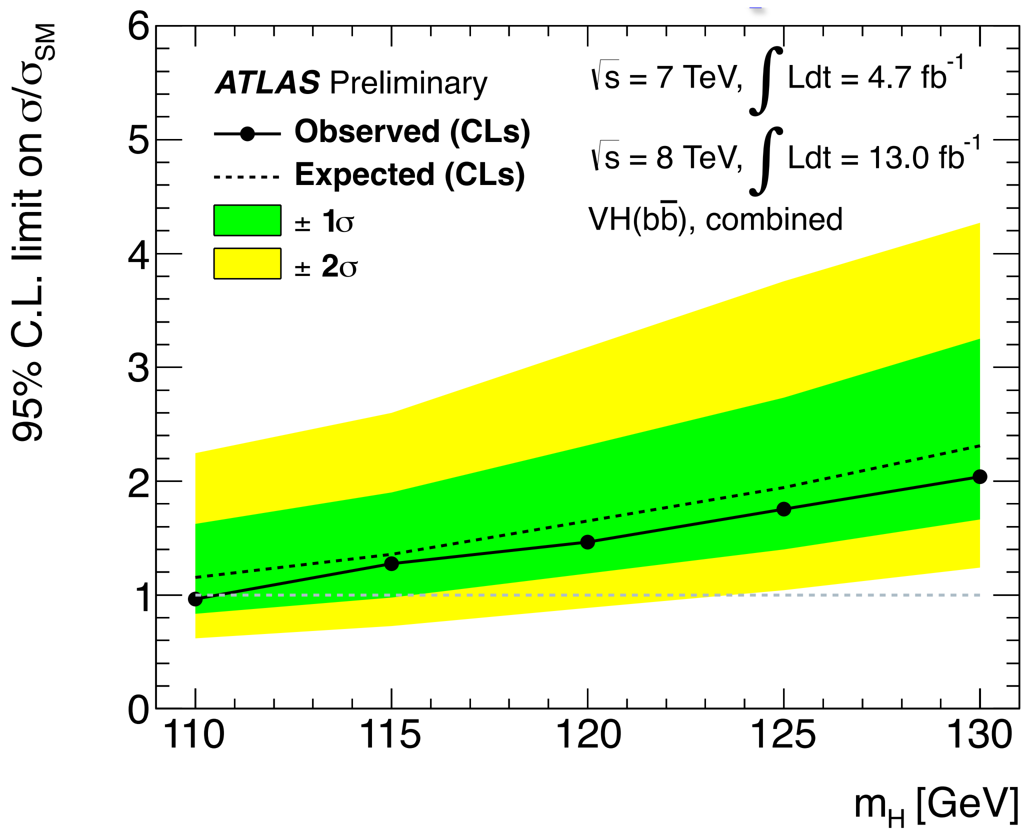
Same signature of WZ,ZZ with Z-->bb

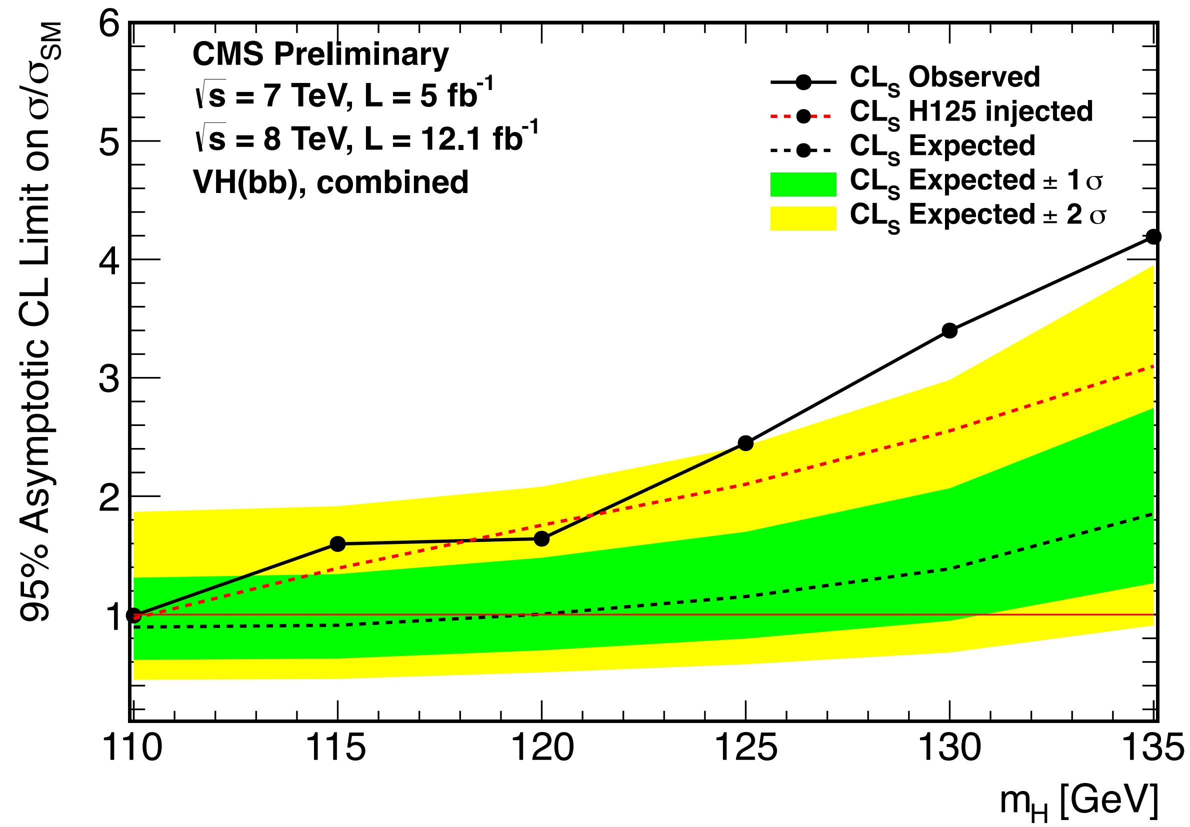


This is just a visual representation.

Analysis split into many channels to improve the sensitivity

VH-->Vbb

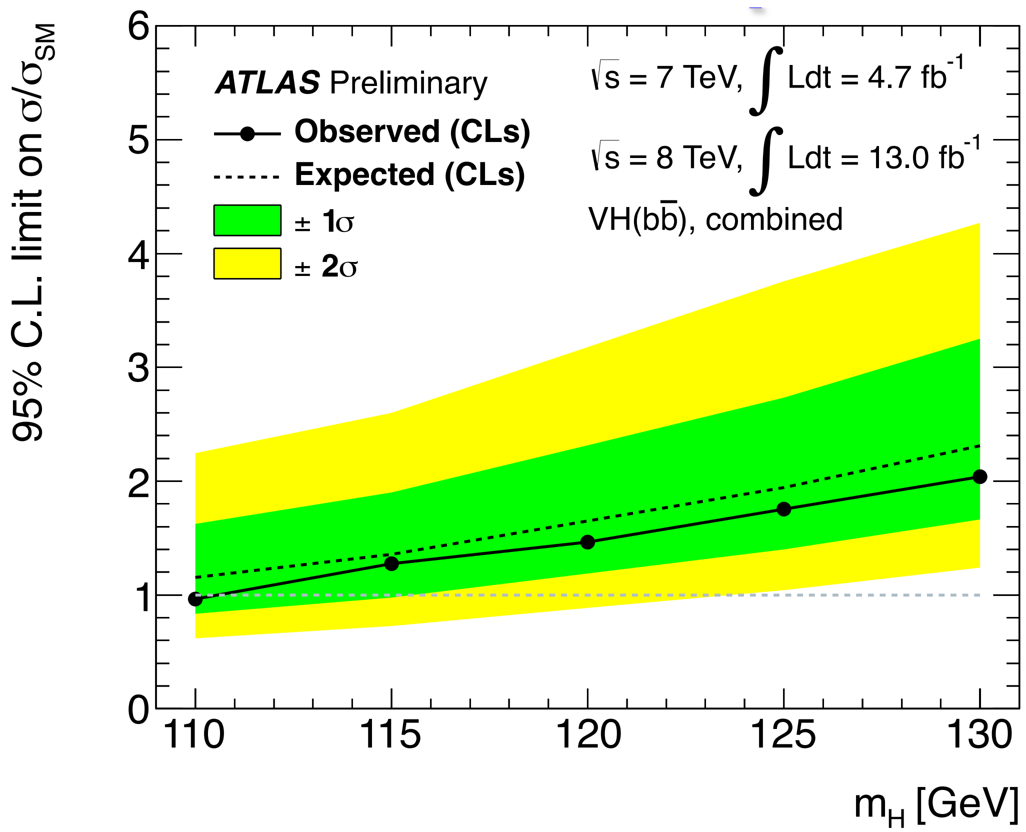


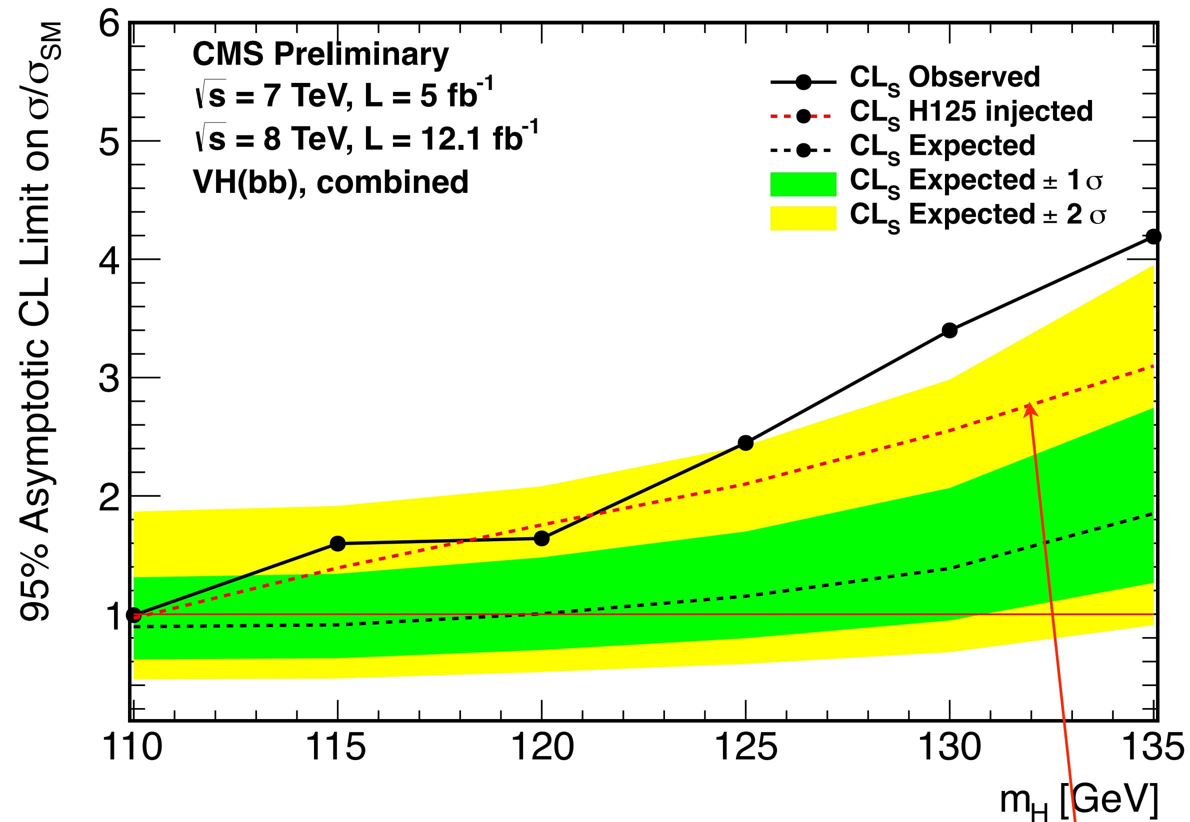


$\mu_{exp(125)}$=1.9

$\mu_{exp(125)}$=1.2

VH-->Vbb



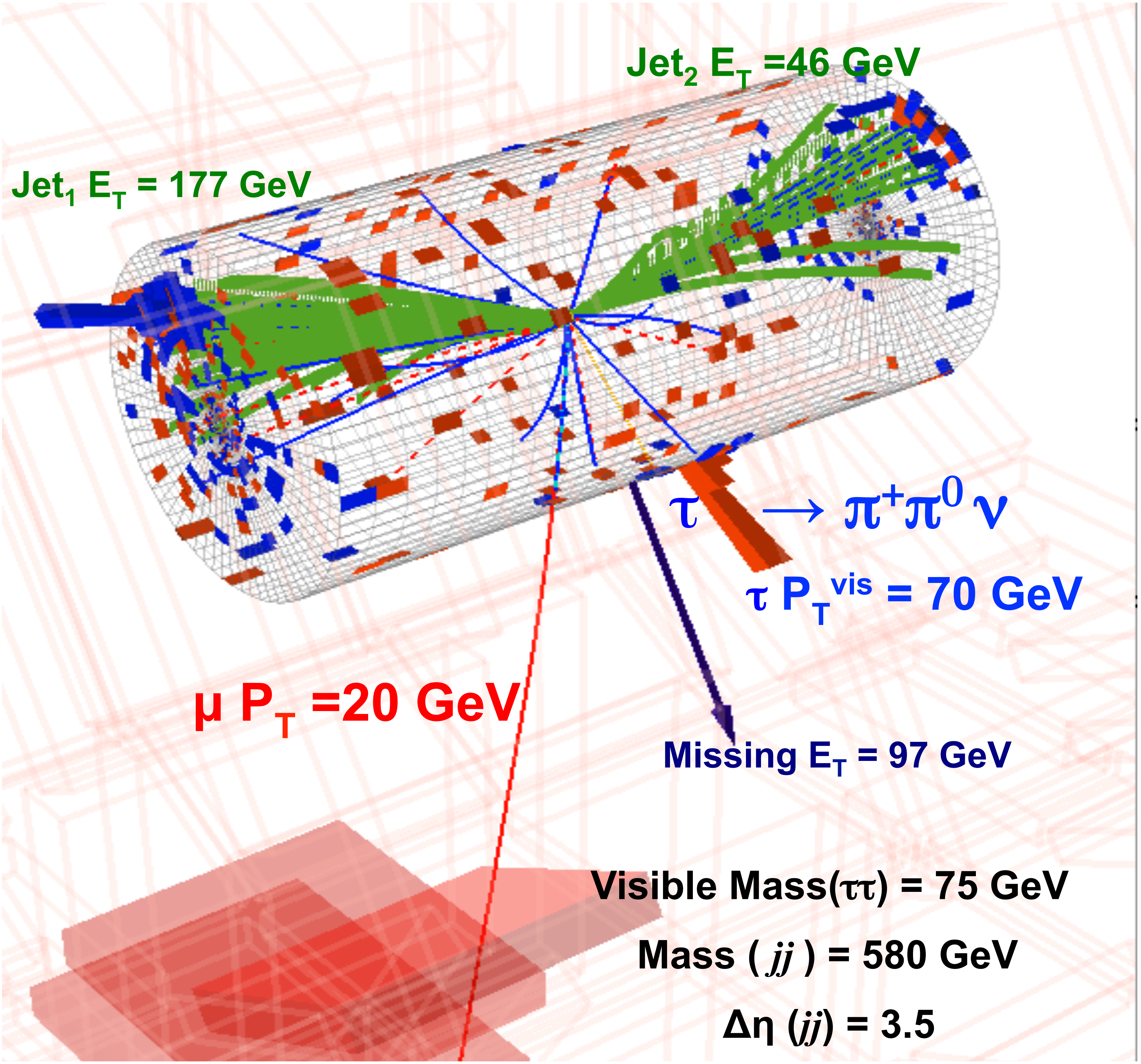


$\mu_{exp(125)}$=1.9

$\mu_{exp(125)}$=1.2

Expected for 125 GeV Higgs

H --> ττ



VBF cleanest most sensitive channel

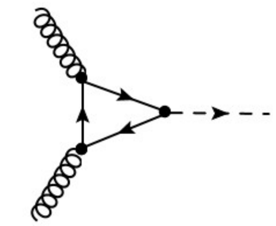
2l	4ν
1l τhad	3ν
2 τhad	2ν

Event categorization

0-Jet
In situ calbration of backgrounds

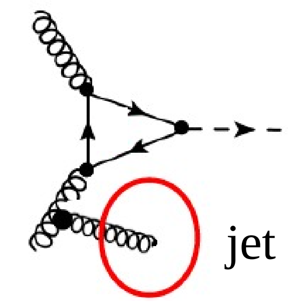
0-Jet, p_T(lep.)≤30 GeV	0-Jet, p_T(lep.)>30 GeV

No attempt to extract signal from these categories. NEW!



1-Jet
Suppression of backgr. from $Z\rightarrow\tau\tau$

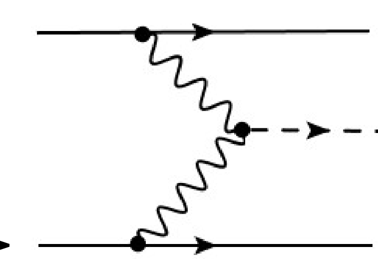
1-Jet, p_T(lep.)≤30 GeV • Large statistics.	1-Jet, p_T(lep.)>30 GeV • Improved resolution of $m_{\tau\tau}$. • Less background from $Z\rightarrow\tau\tau$.



2-Jet/VBF
Suppression of bkg from Z->ττ

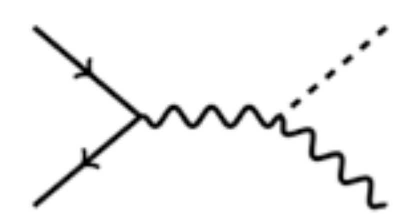
2-Jet, VBF
- Cut based: mjj>XXX, |Δη|>XXX, central jet veto. NEW!

Increasing $p_T(\tau/\mu)$



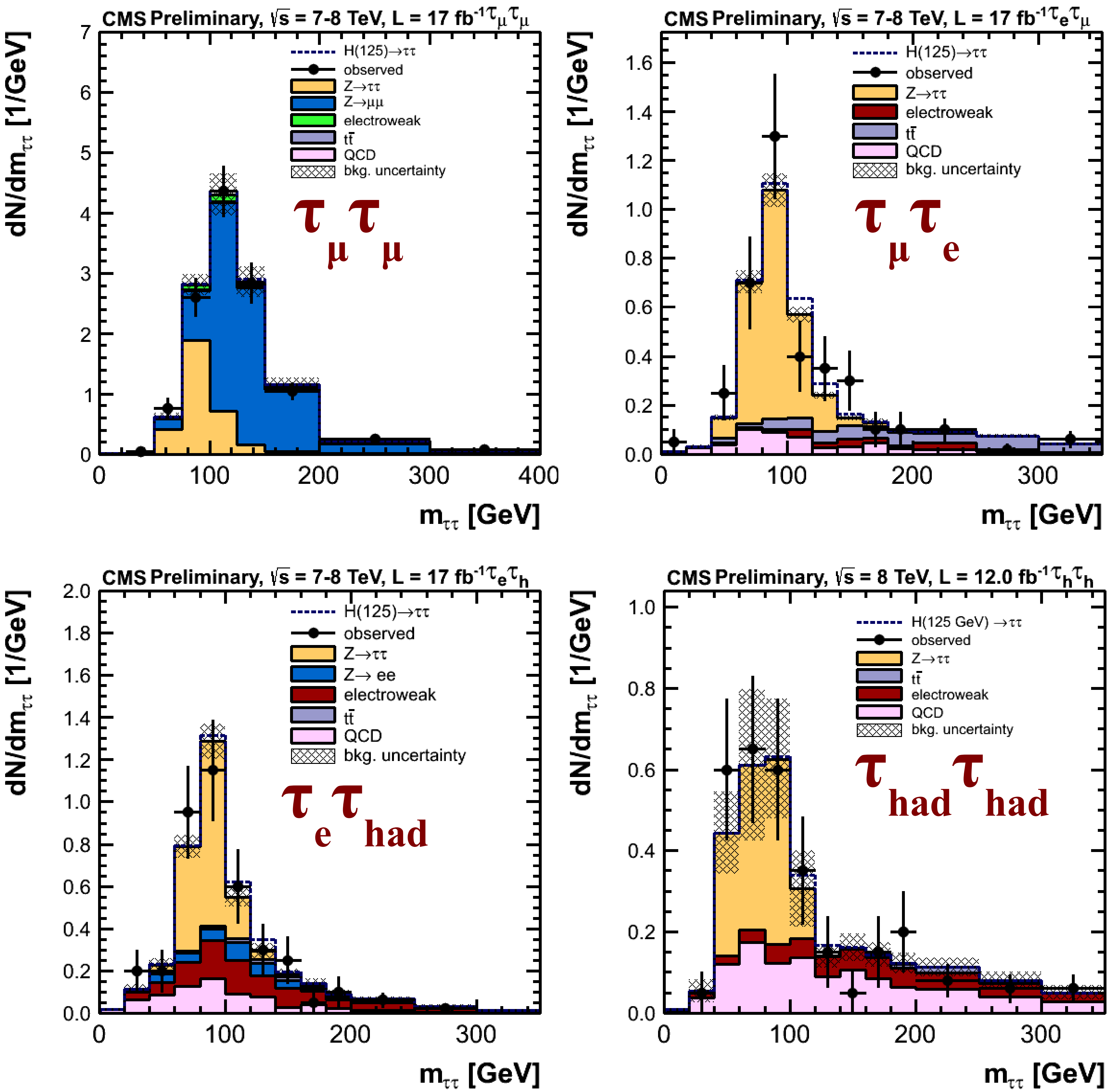
+ VH, H->ττ analysis
less sensitive with respect to 1 and 2jet due to low cross

additional leptons from V decay
- less bkg from Z->ττ
- main background from dibosons



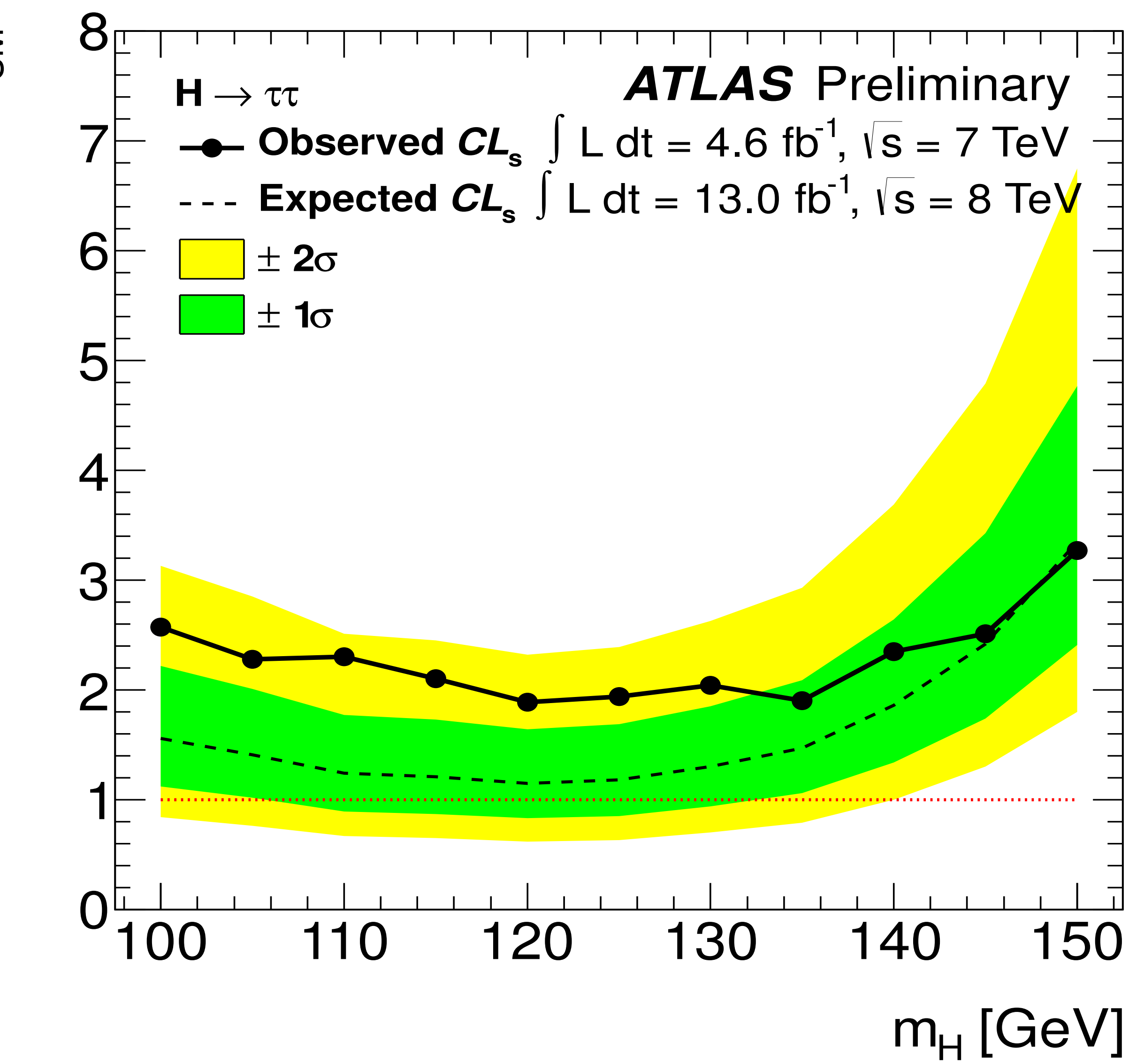
5.1 fb^{-1} @ 7 TeV (2011) + 12.2 fb^{-1} @ 8 TeV (2012): HIG-12-051

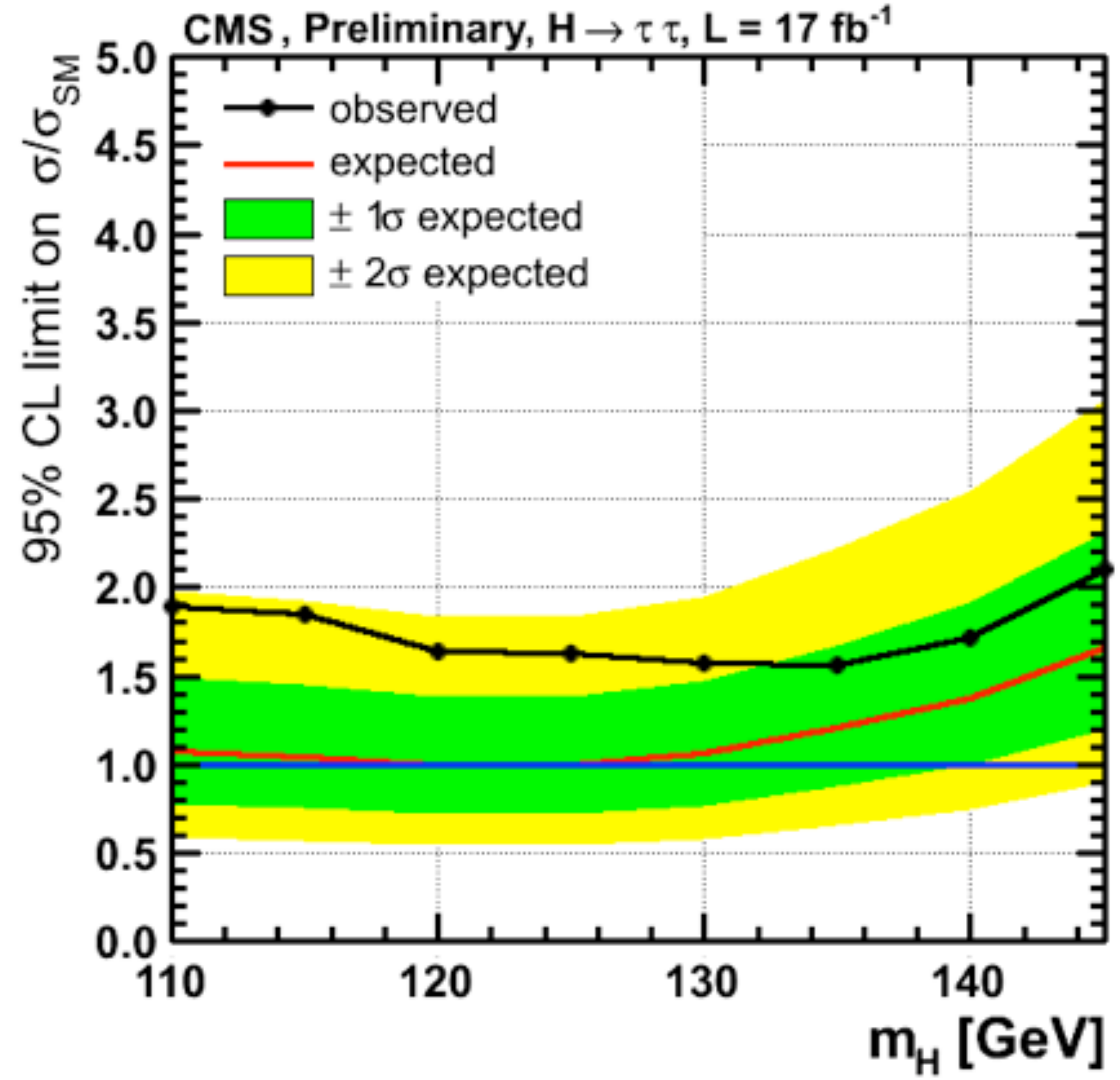
2jet VBF category



- After template fit has been applied (S+B hypothesis).
- Uncertainties after fit.

H --> ττ

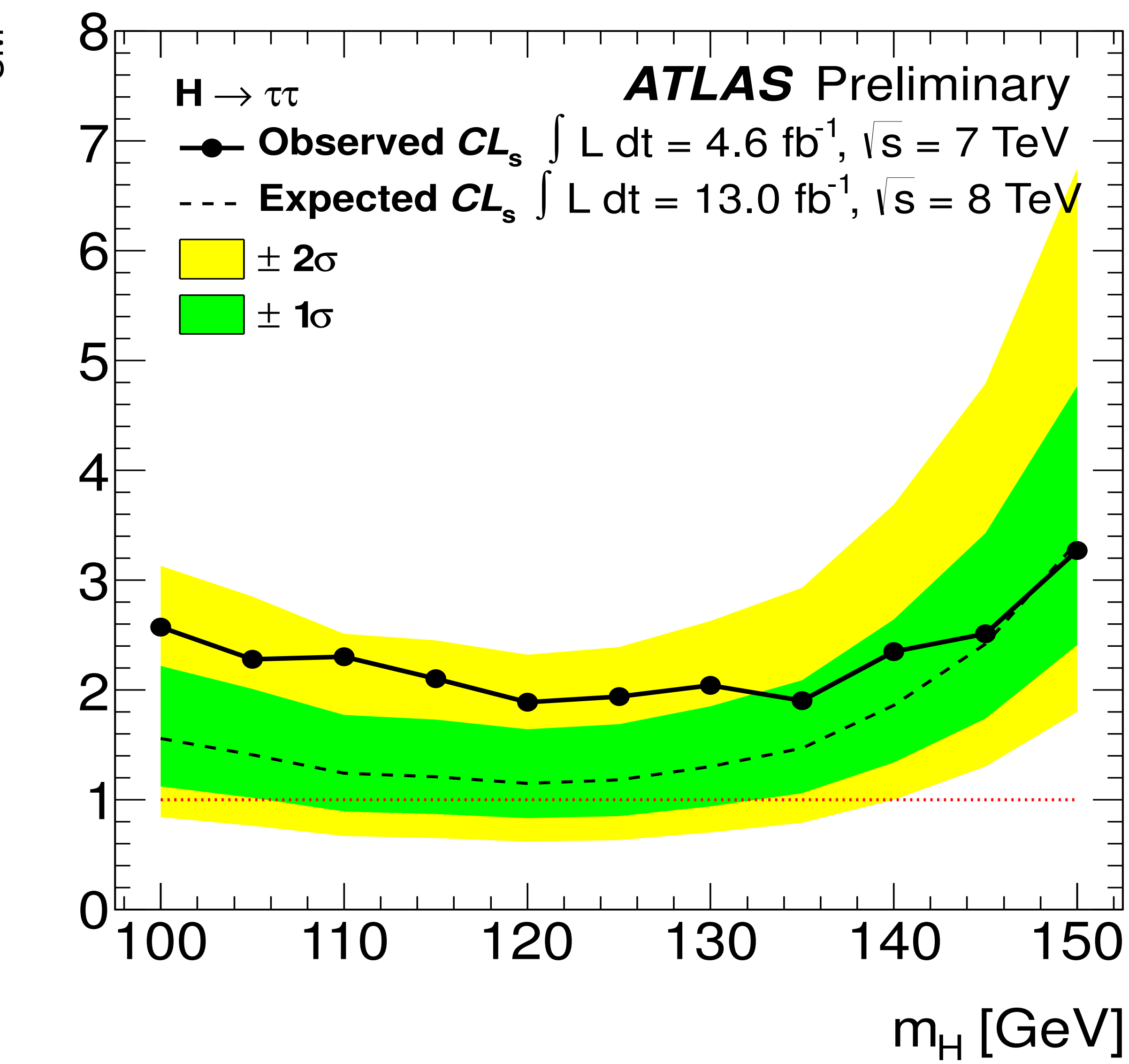


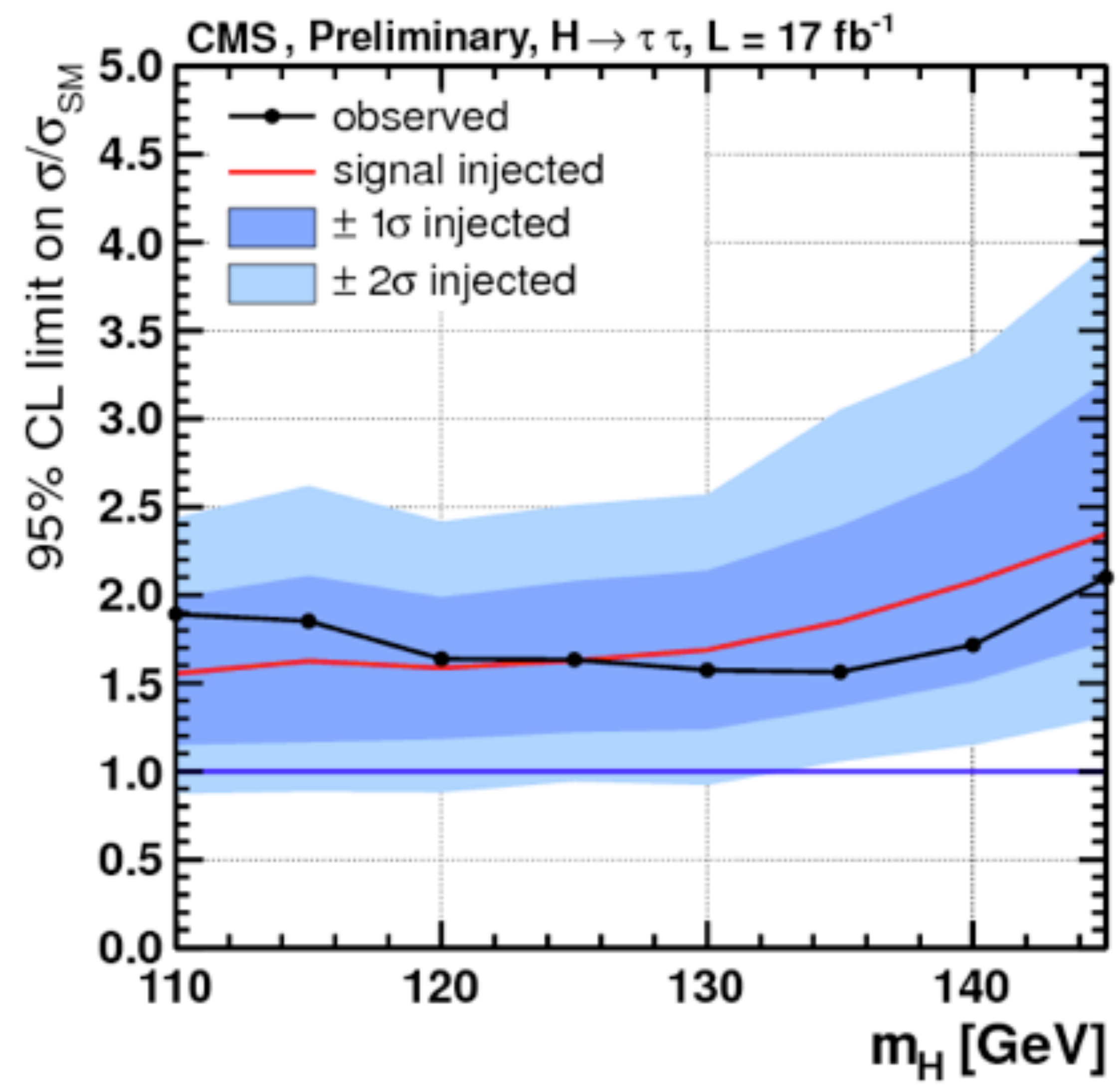


$\mu_{exp(125)}=1.2$

$\mu_{exp(125)}=1.0$

H --> ττ



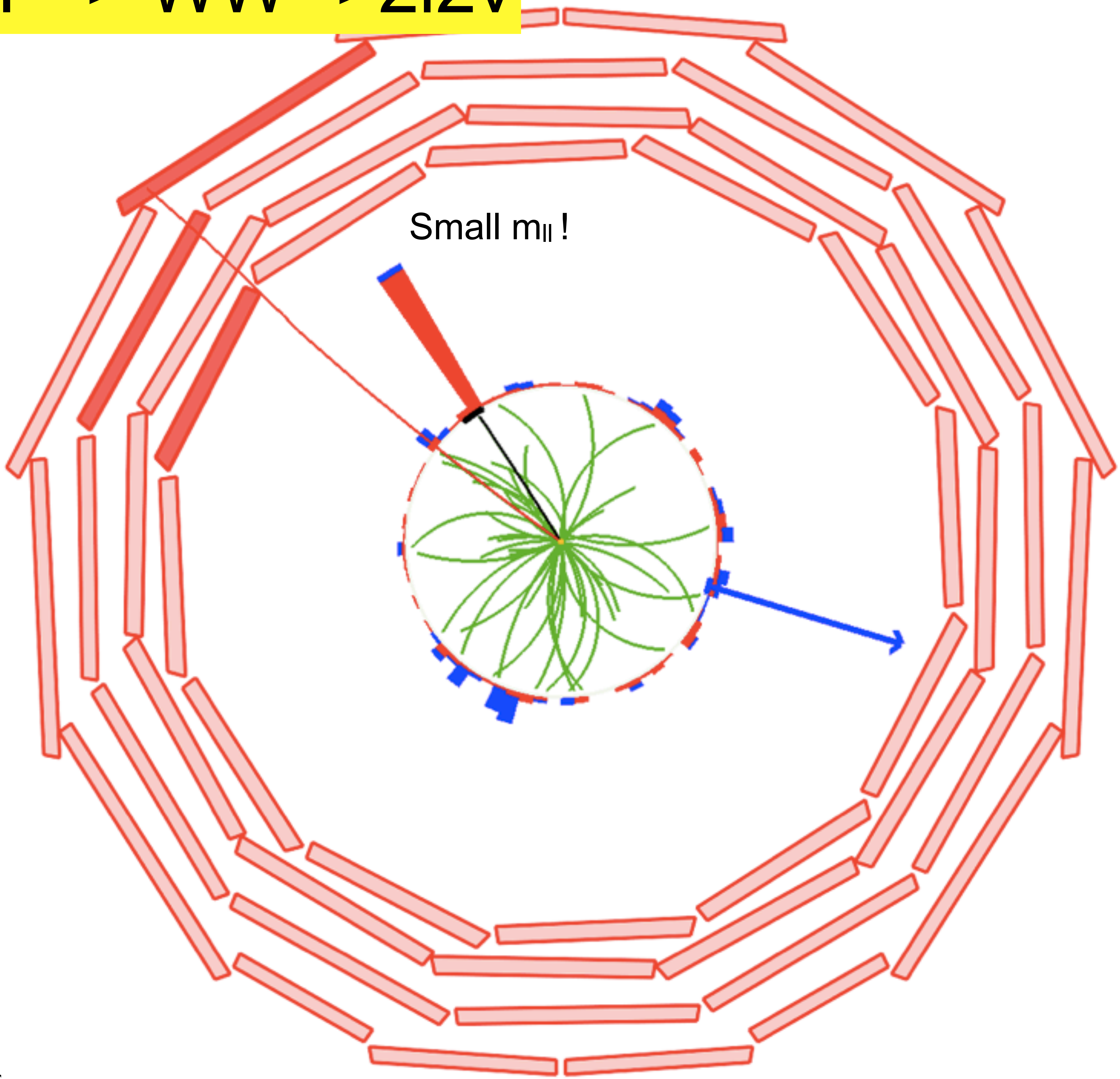


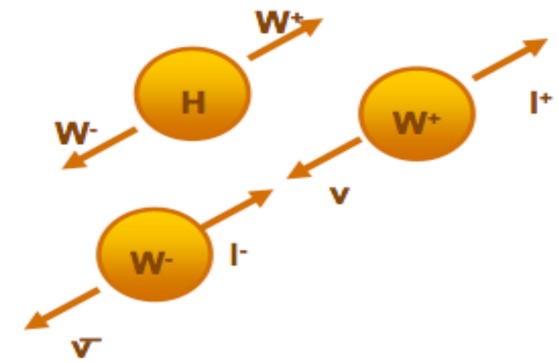
$\mu_{exp(125)}$=1.2

$\mu_{exp(125)}$=1.0

Slight excess is observed , compatible with H_{125} signal

H --> WW-->2l2v





Large sensitivity 125/180 GeV

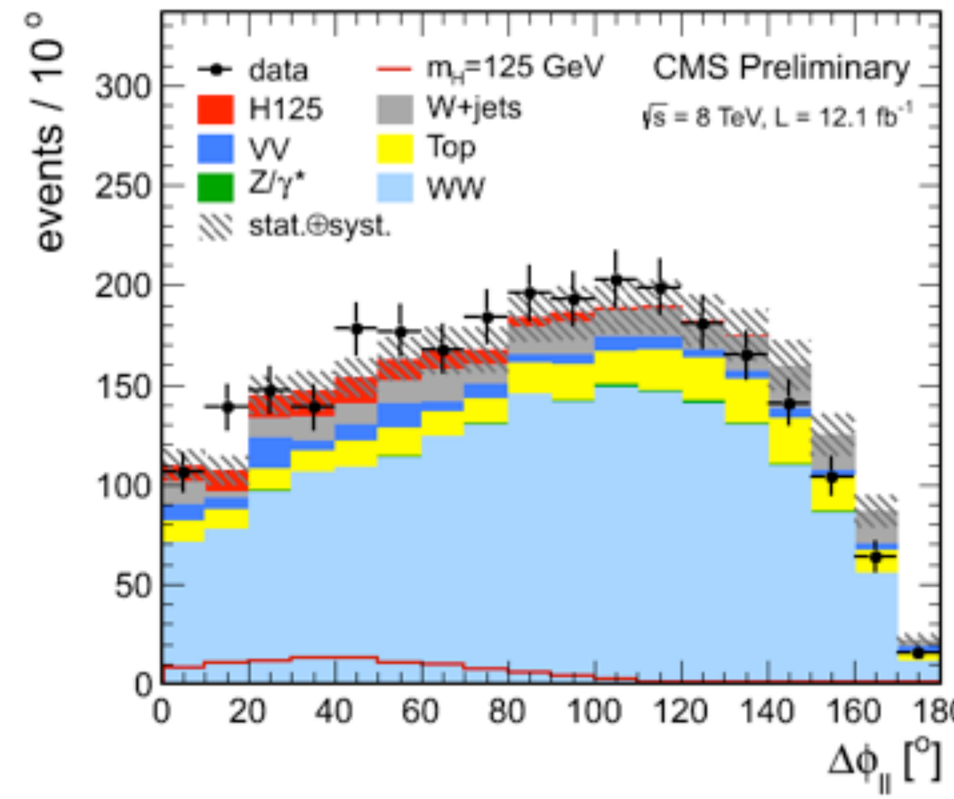
No mass peak !

Counting experiment

H --> WW-->2l2v

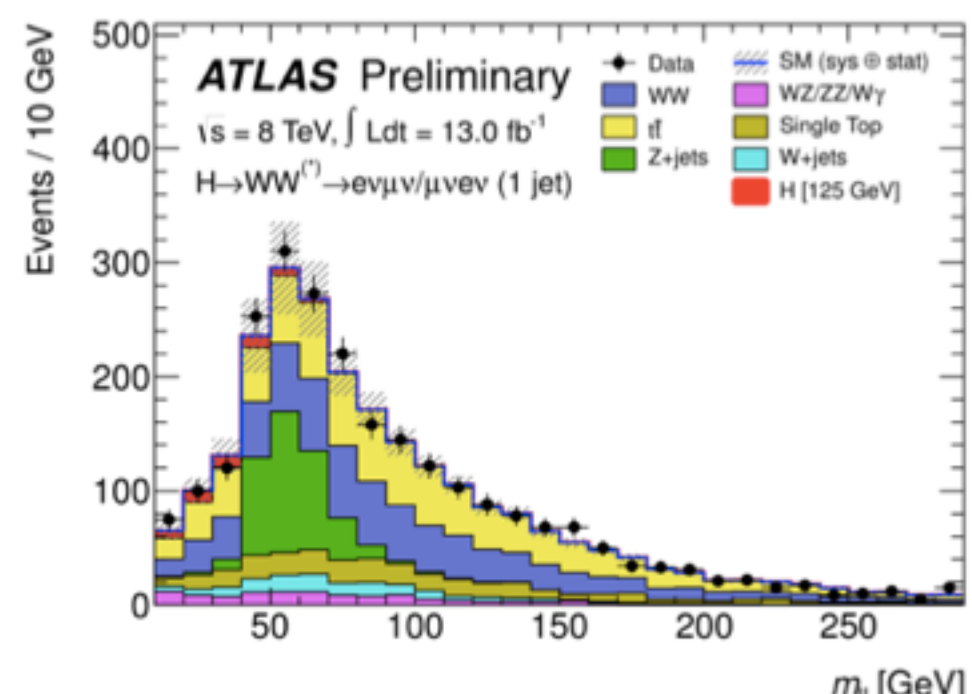
- Two opposite sign leptons + large MET
- BKG estimation crucial
  - WW: control sample (m_{ll}) - shape from simulation
  - top: control samples (N_jet, b tagging)
  - Z +jets: $|m - m_Z| < 15$ GeV, correcting for mis-modeling of MET tails.
  - W + jets: inverted lepton ID passing loose criteria.

OF - 0-jet - Preselection



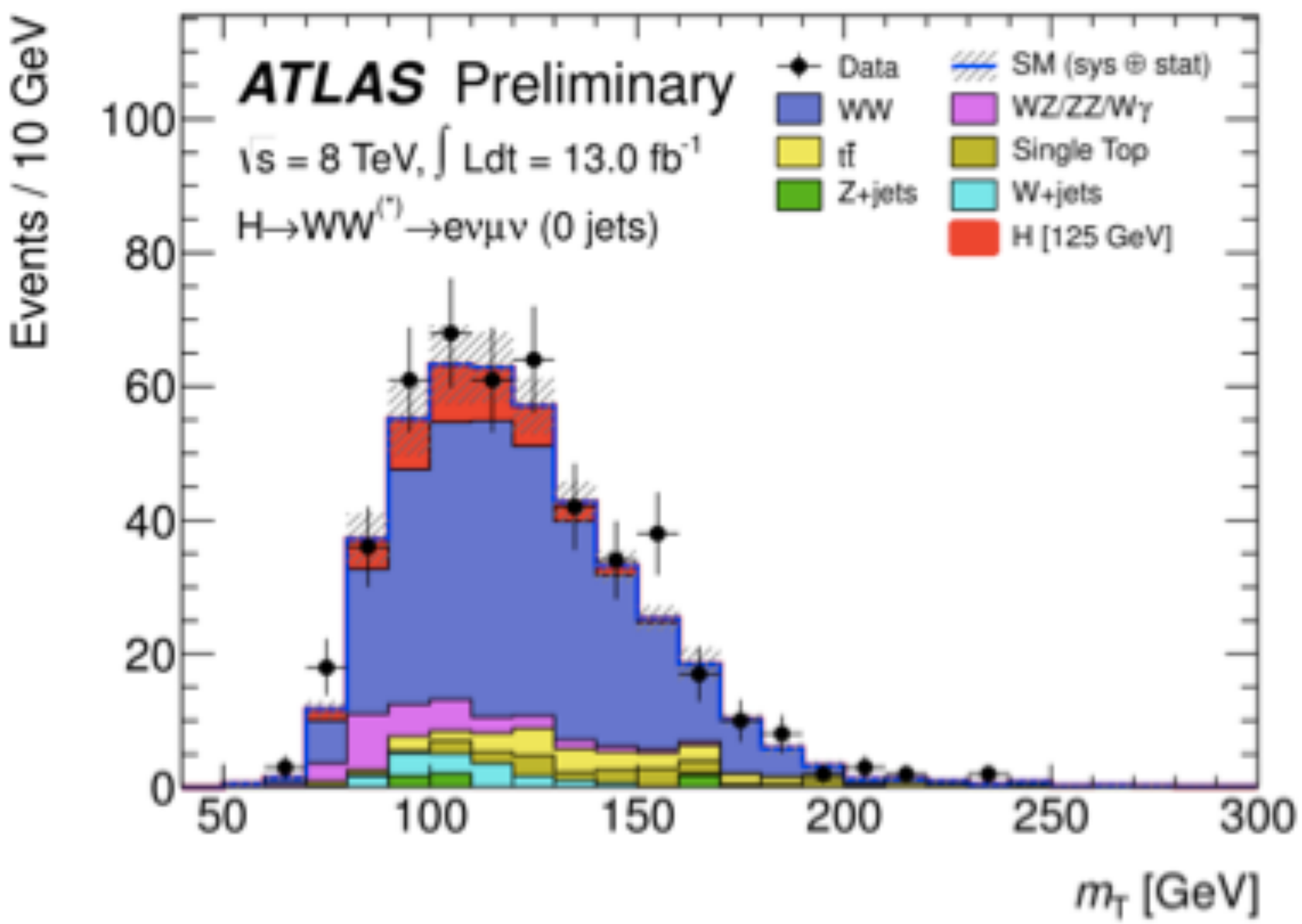
OF - 1-jet - Preselection

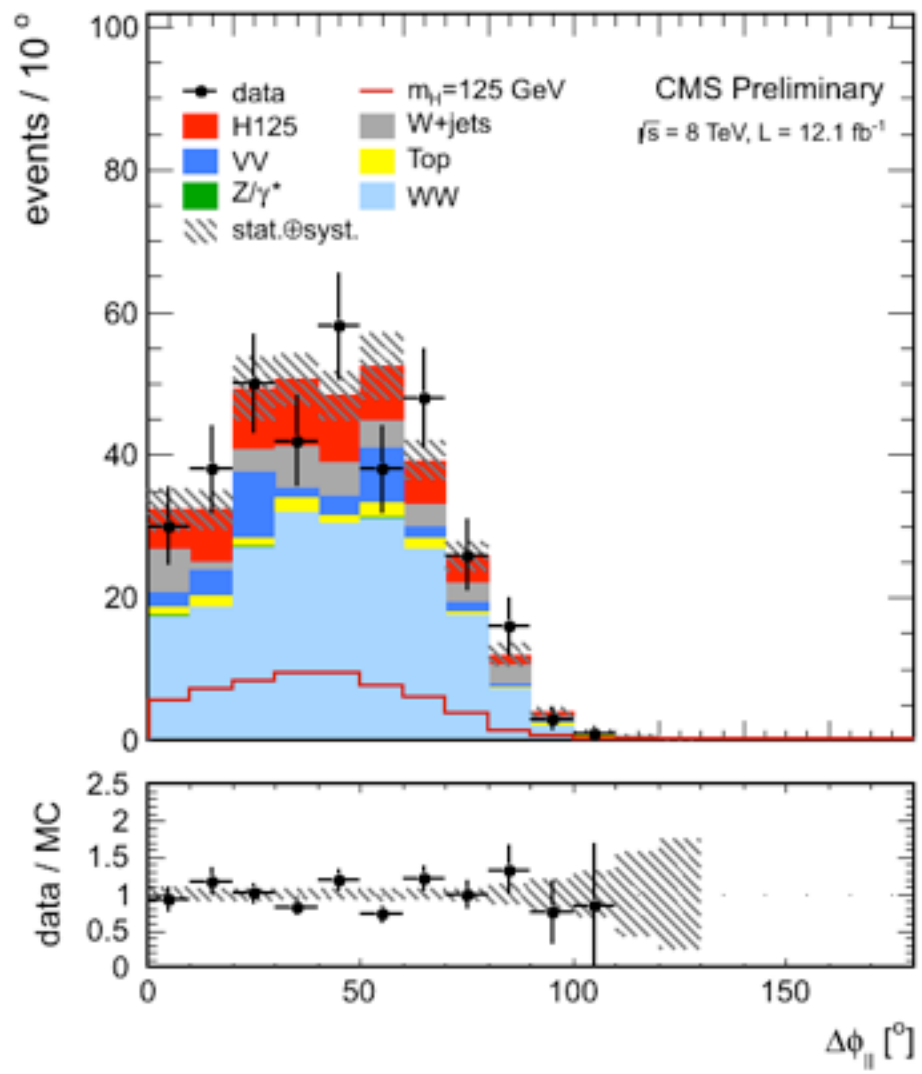
after b veto, Z → ττ veto



Signal to bkg ~ 15% in the final selection

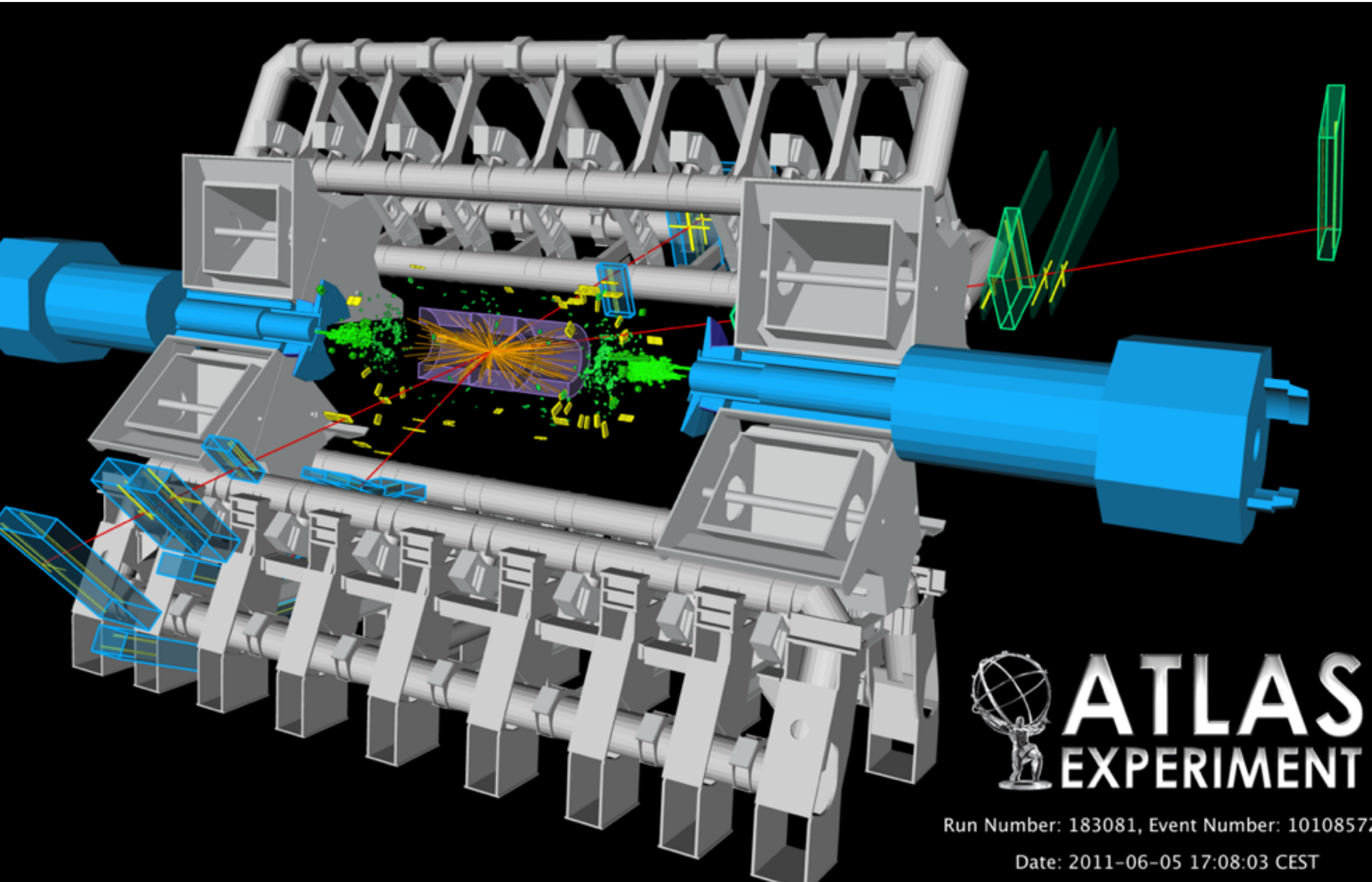
e has higher p_T



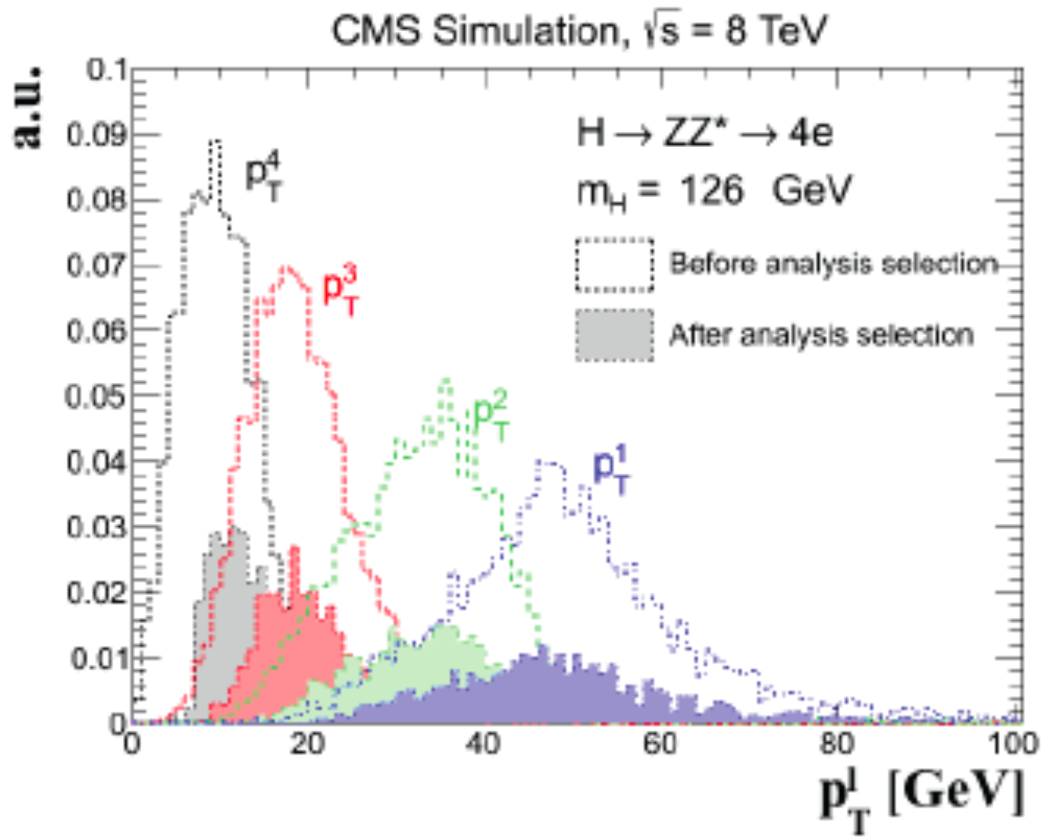


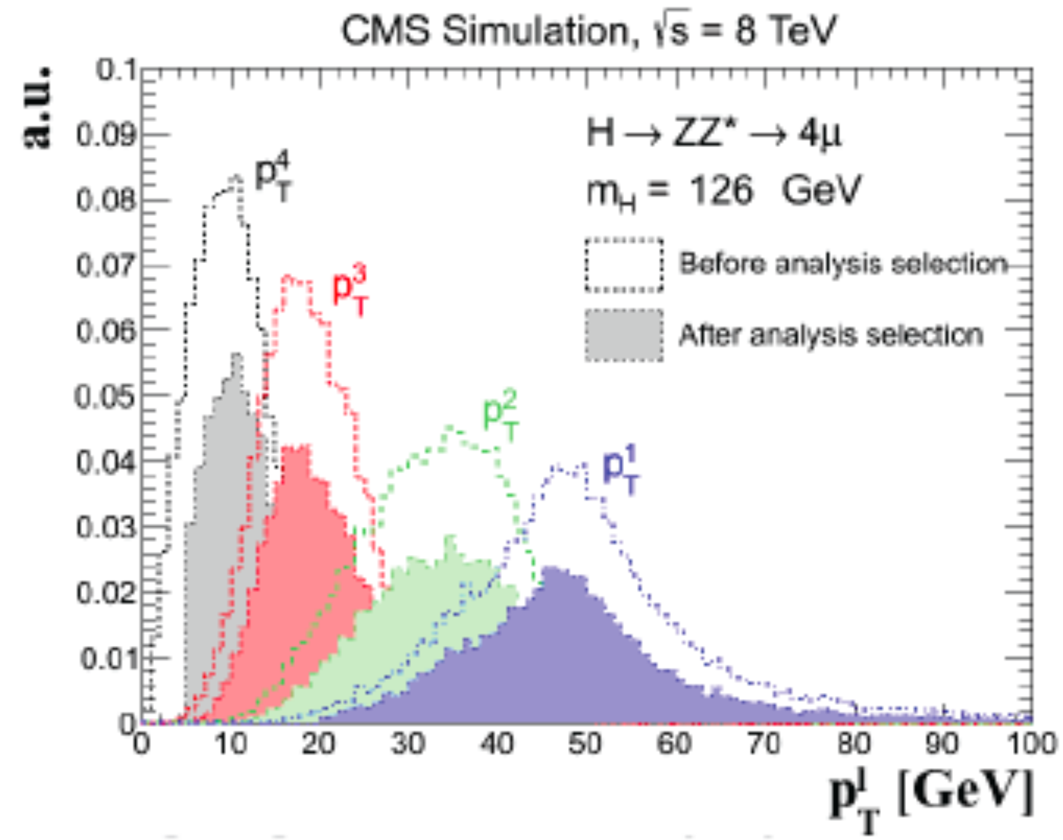
H --> ZZ-->4l

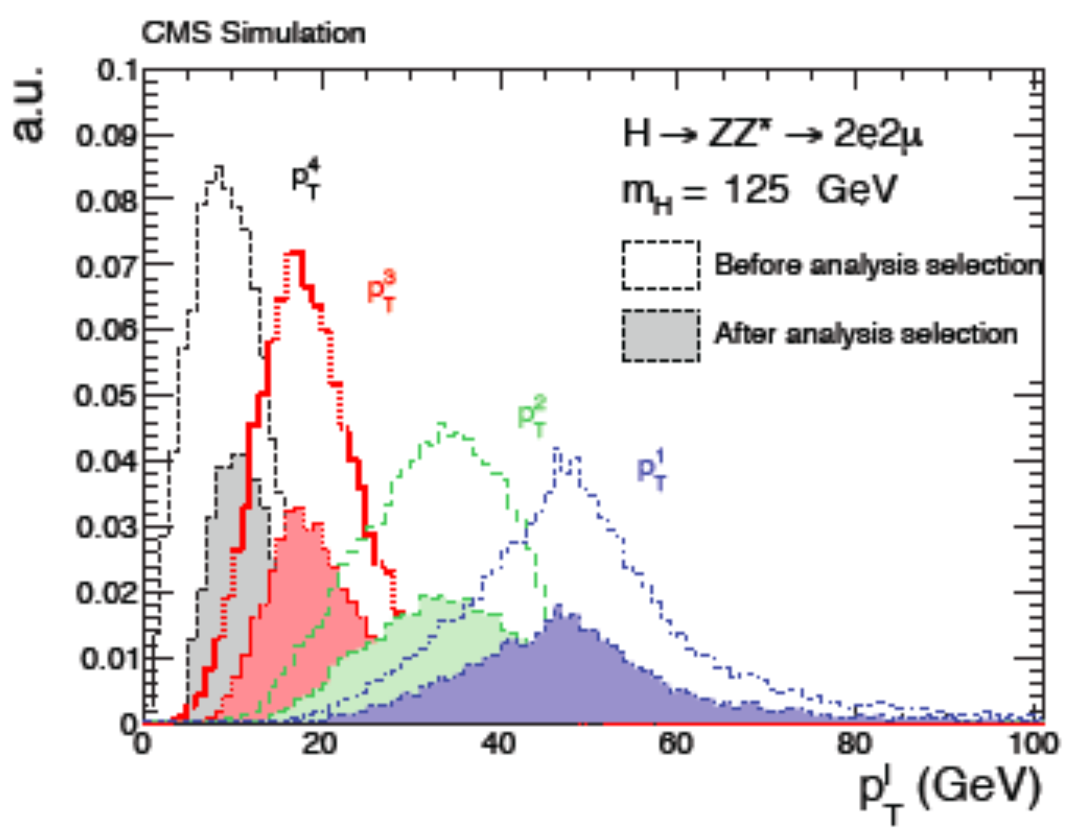
Best s/bkg, however very small statistics (at low mass)

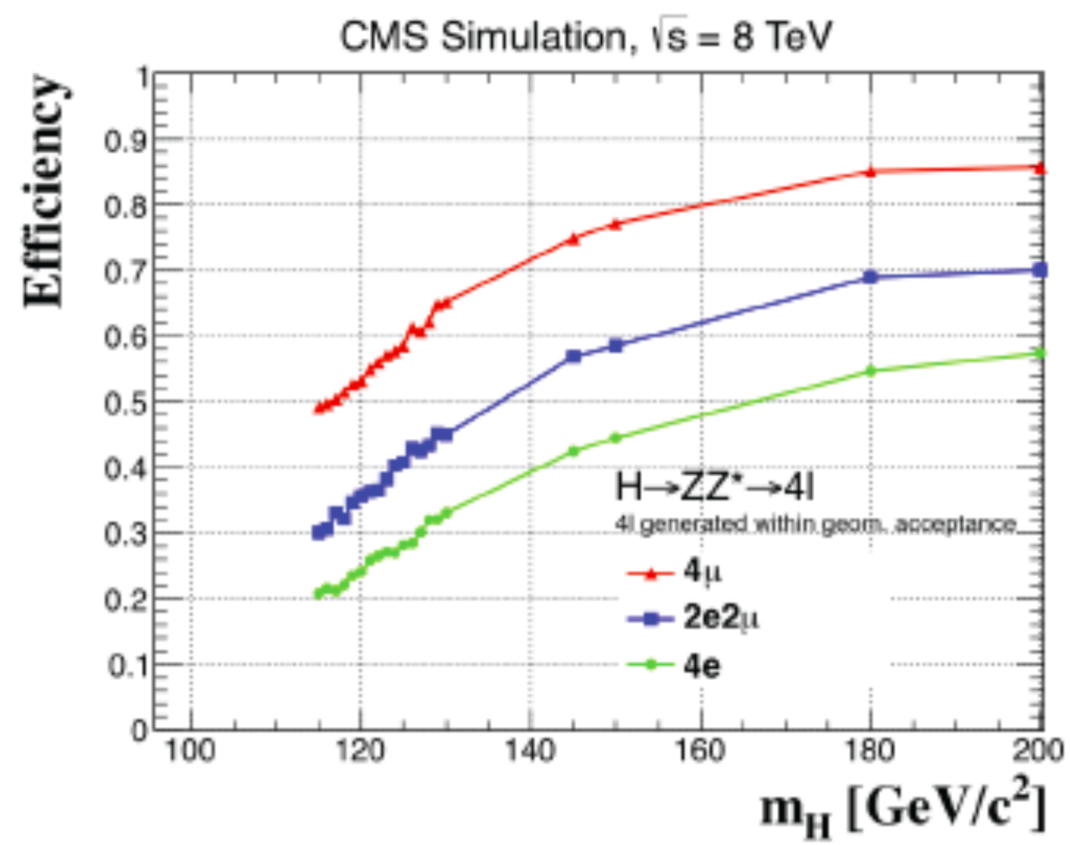


Low momentum acceptance is crucial



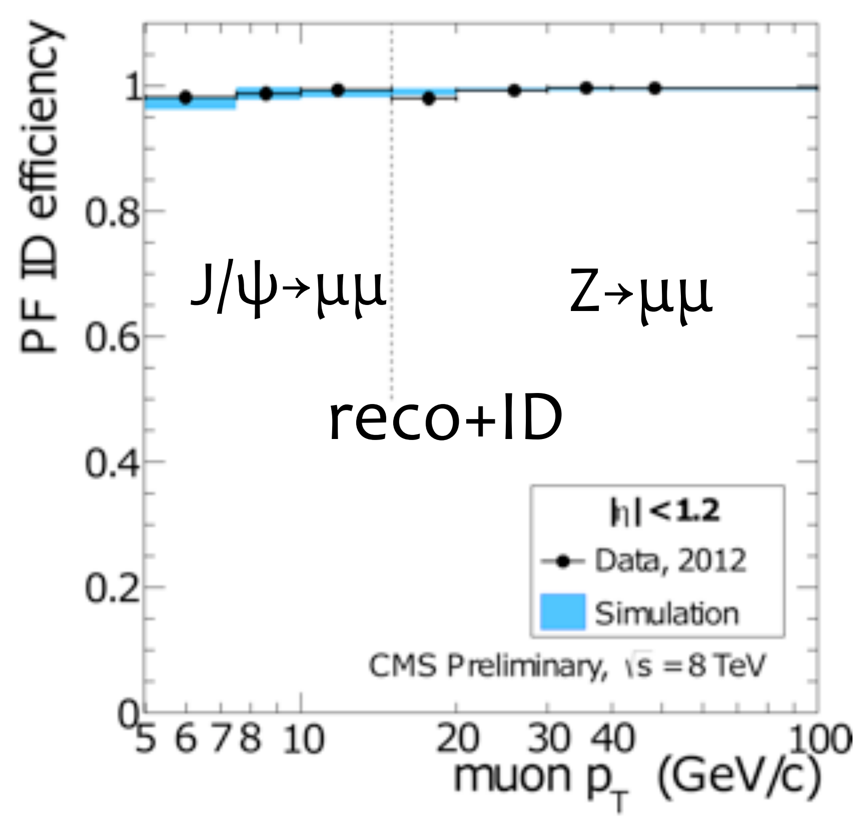


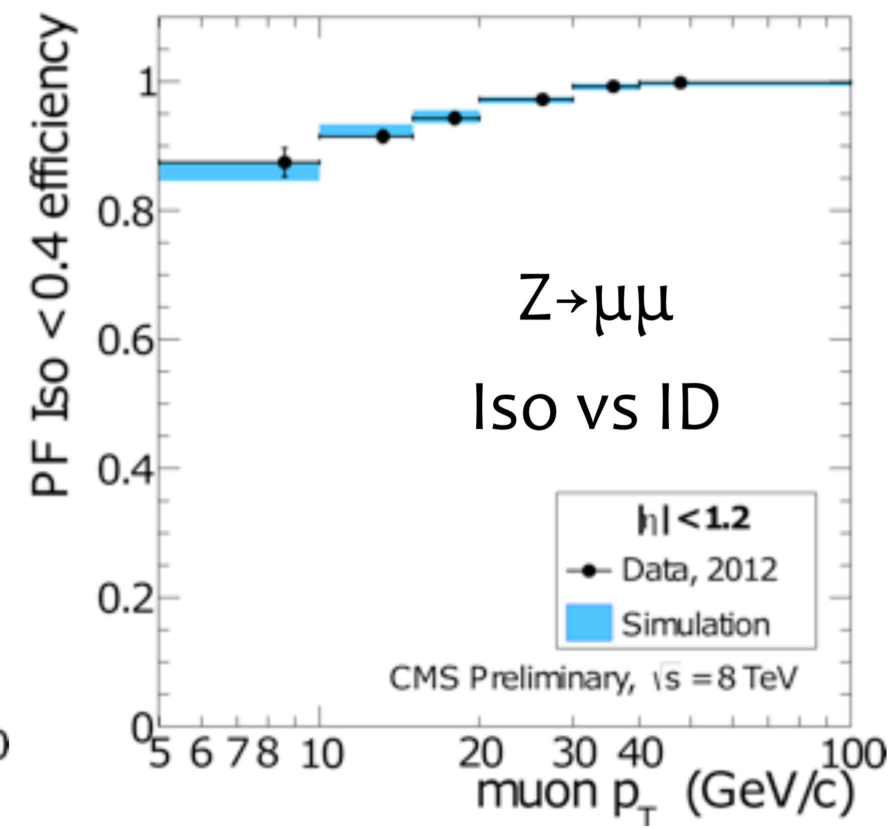




Leptons Identification

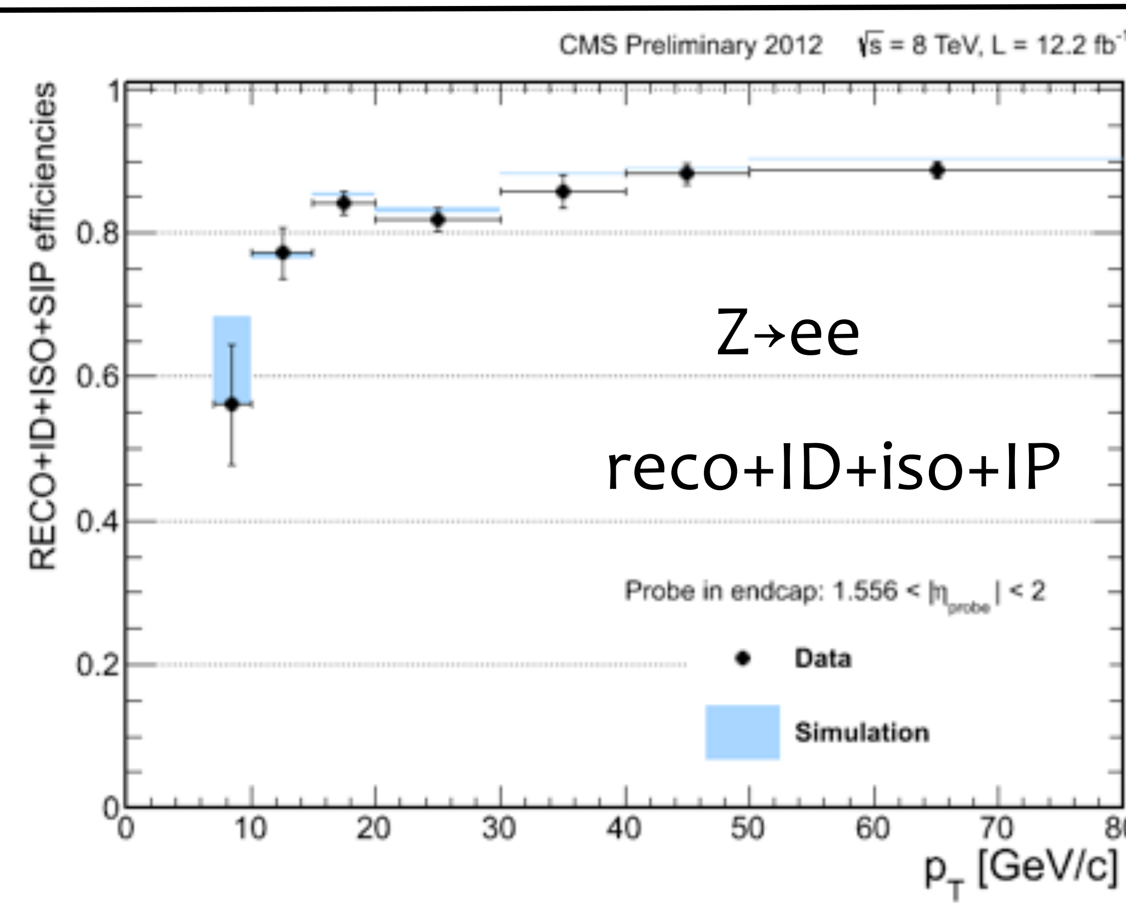
Efficiency to select prompt isolated leptons
- reconstruction
- identification
- isolation
- IP requirement





Muons

computed with TnP techniques

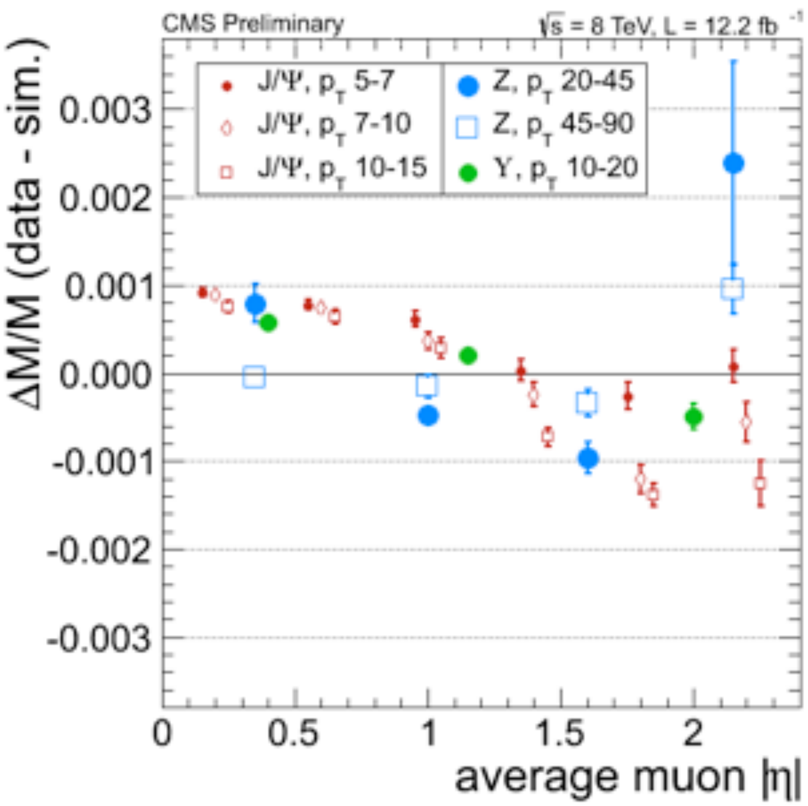


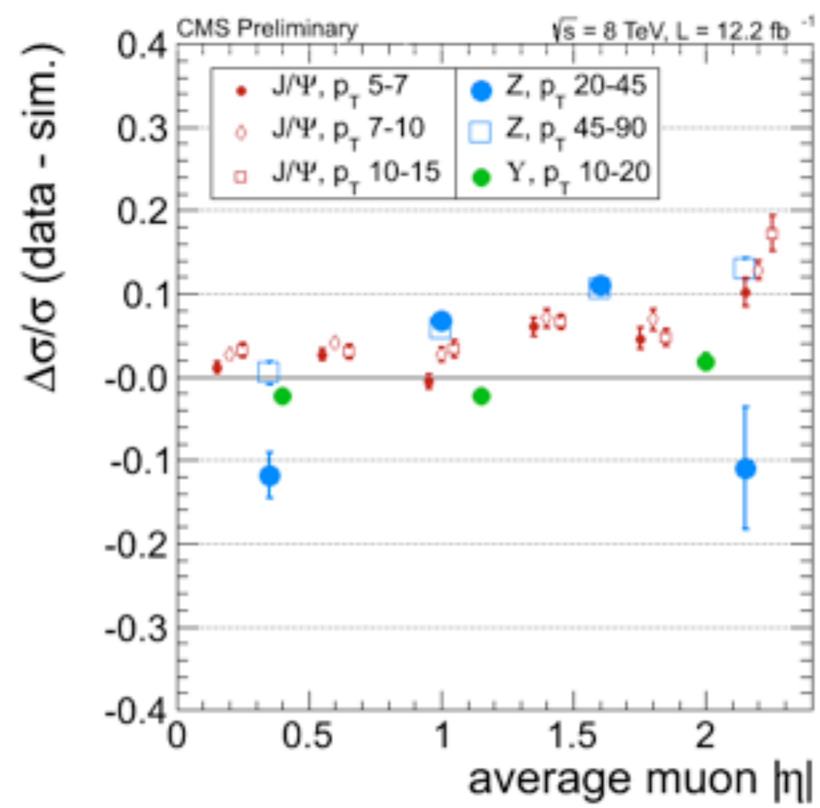
Electrons

efficiency correction factor
muons: 0.98 - 1.03
electrons: 0.84 - 1.01

Lepton Energy Scale and Resolution

Scale corrections on muon momentum obtained with a calibration procedure on Z->mm / J/psi -> mm events in data are applied
MC is **smeared** to match the resolution in data





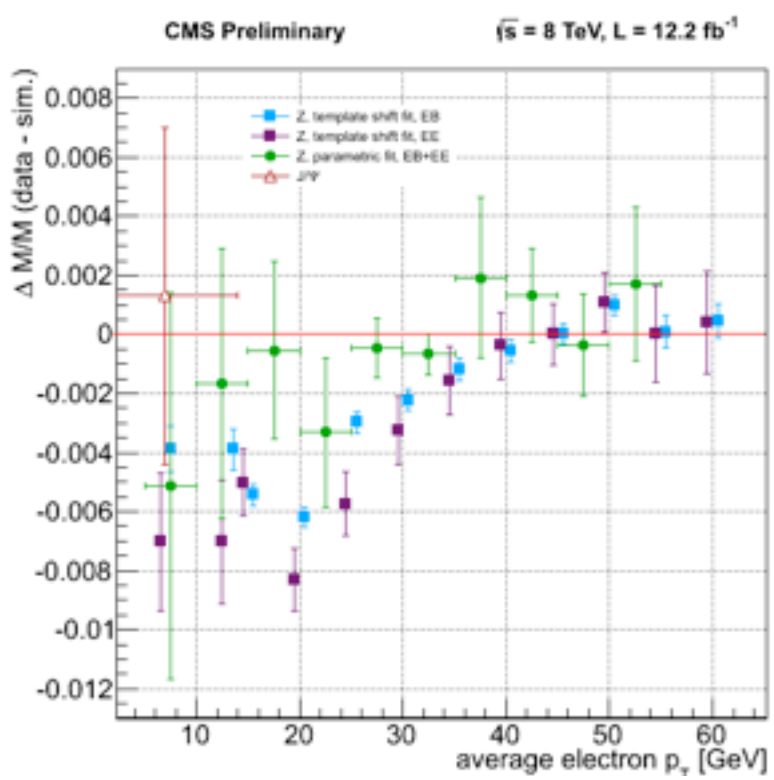
residual DATA/MC difference: ~ 0.1% in scale, 20% in resolution

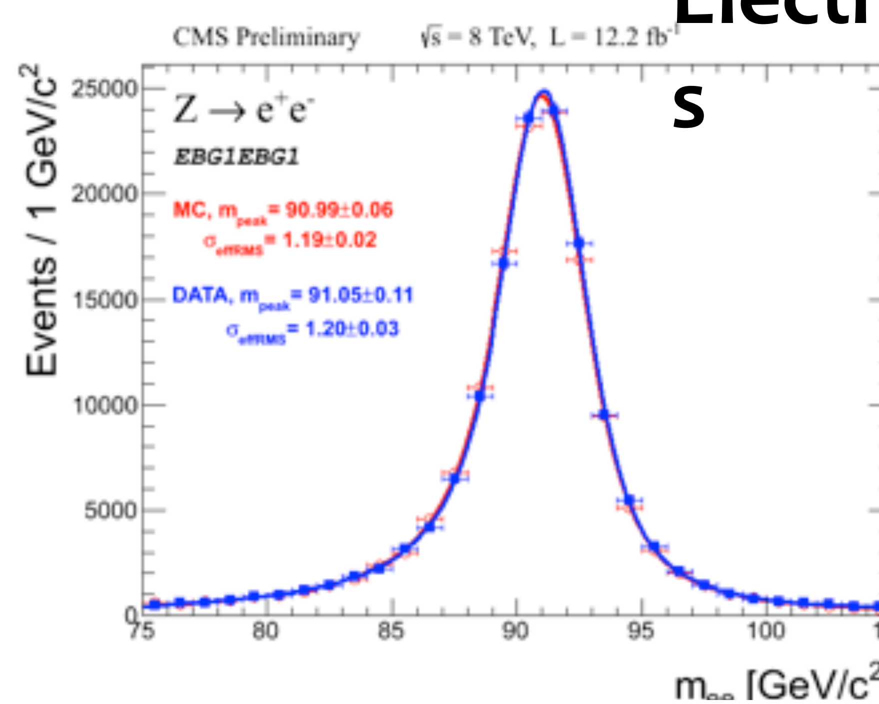
Muons

The ECAL contribution to the electron momentum and its uncert is from an MVA regression approach:

10-15% improvements on resolution

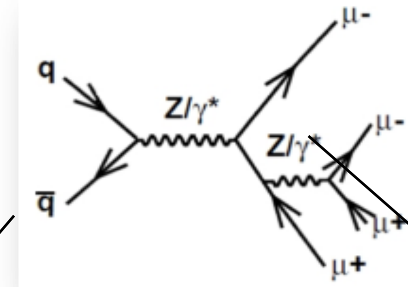
Energy scale and MC smearing obtained from calibration with Z->ee

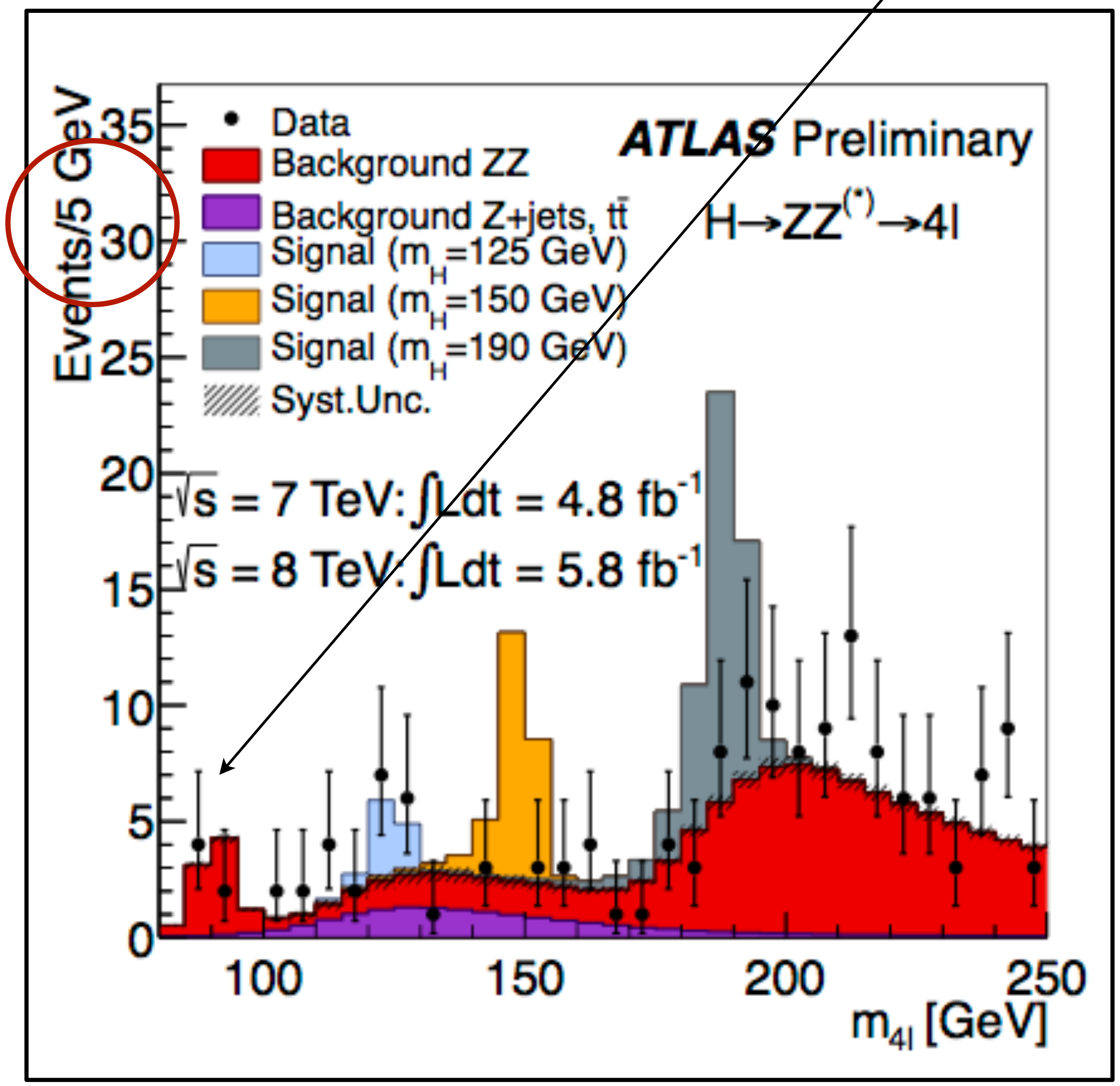


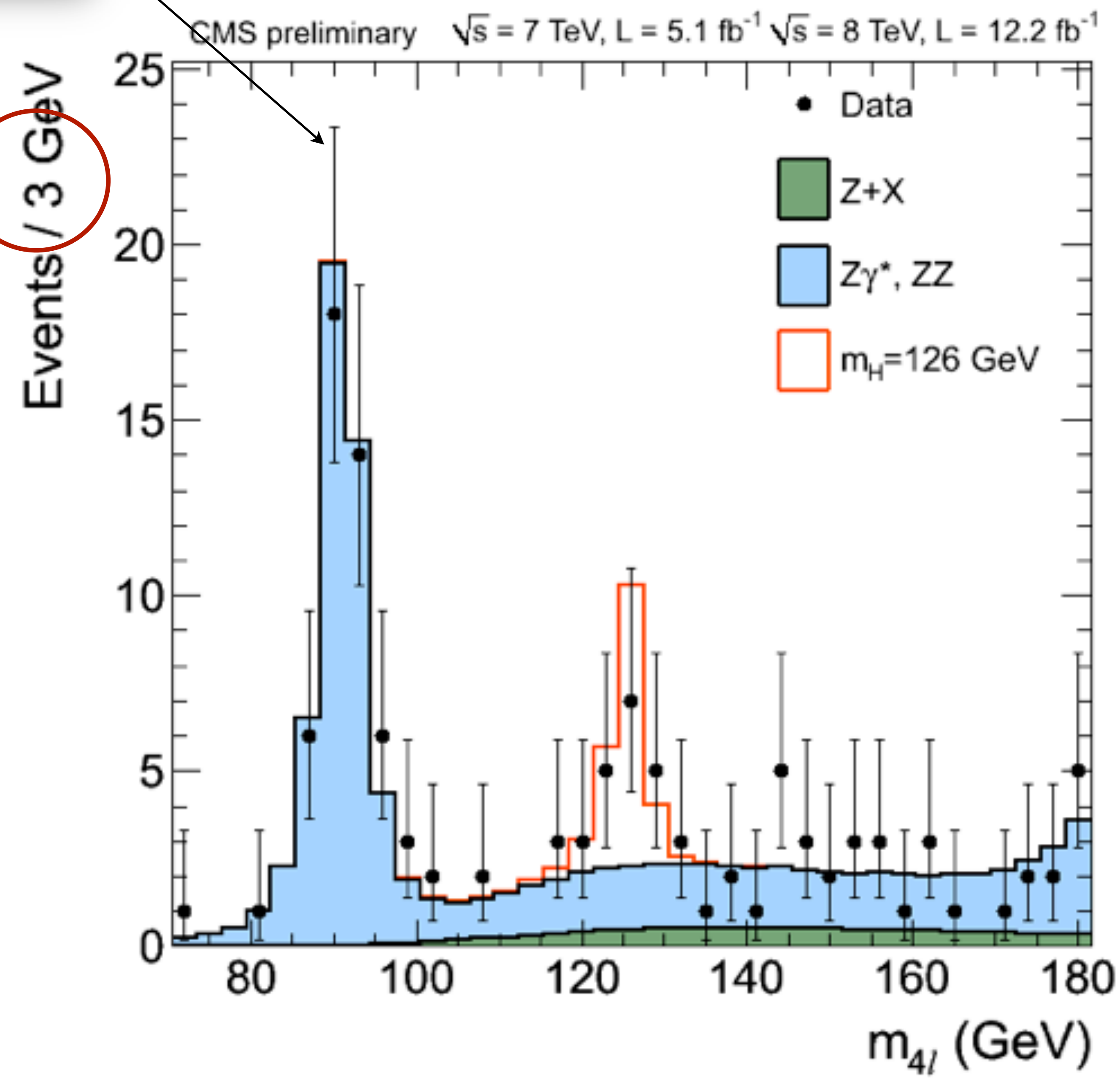


Electrons

residual DATA/MC difference: ~ 0.4% in scale, 20% in resolution [conservative]







In the region 125 ± 5 GeV

Dataset	2011	2012	2011+2012
Expected B only	2±0.3	3±0.4	5.1±0.8
Expected S m_H=125 GeV	2±0.3	3±0.5	5.3±0.8
Observed in the data	4	9	13

2011+ 2012	4μ	2e2μ	4e
Data	6	5	2
Expected S/B	1.6	1	0.5
Reducible/total background	5%	45%	55%

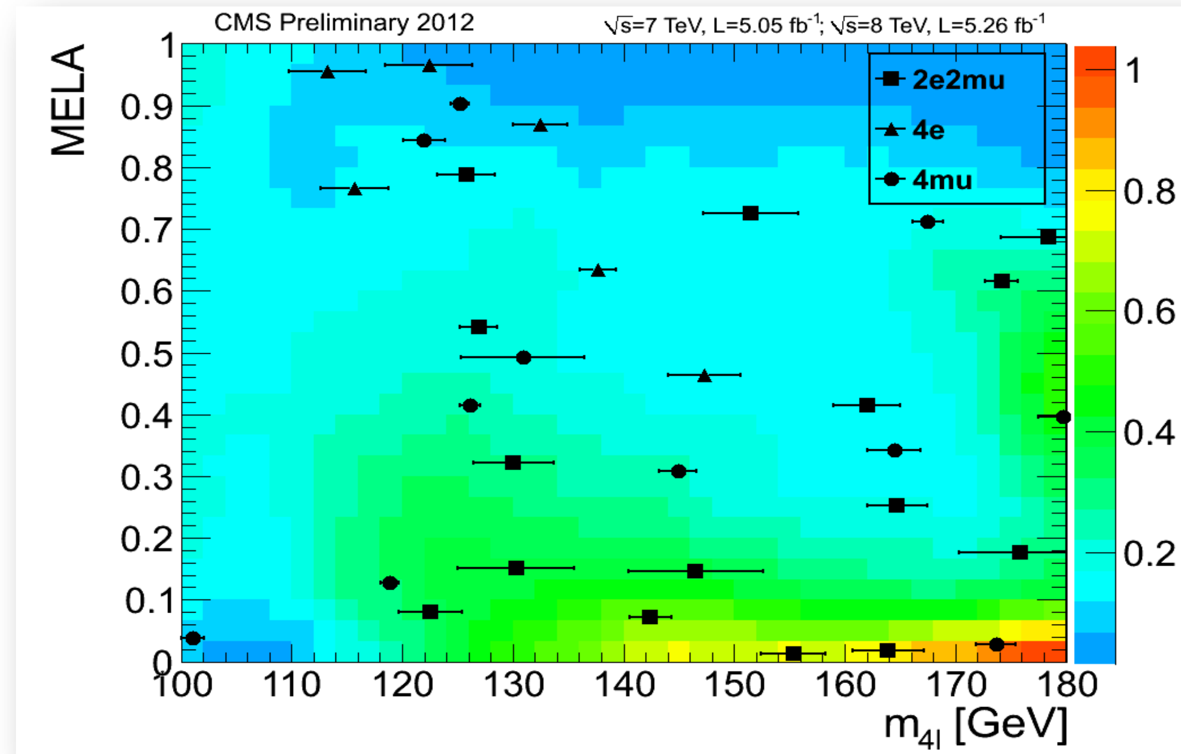
CMS expects in the same range
SM Higgs (125) 13 ± 1 events
B only 6 ± 1 events
Observed in data 17 events

CMS Matrix ELement Analysis (MELA)

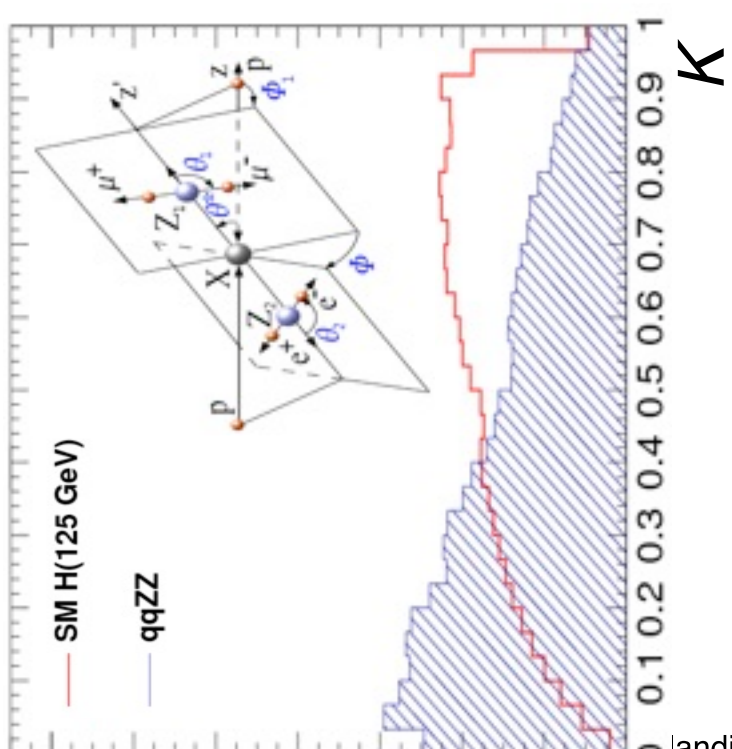
Perform 2D fit

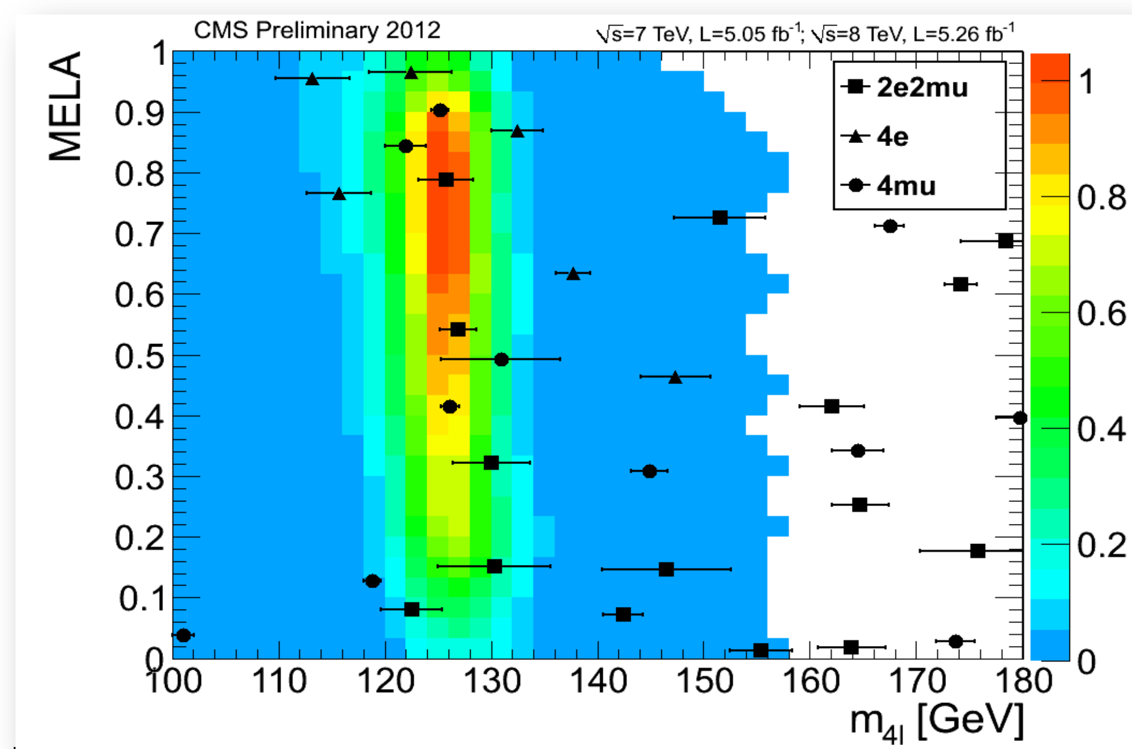
- MELA discriminant versus m_{4l}
  - Data points shown with per-event mass uncertainties

Data vs Bkg Expectation



Data vs Signal Expectation



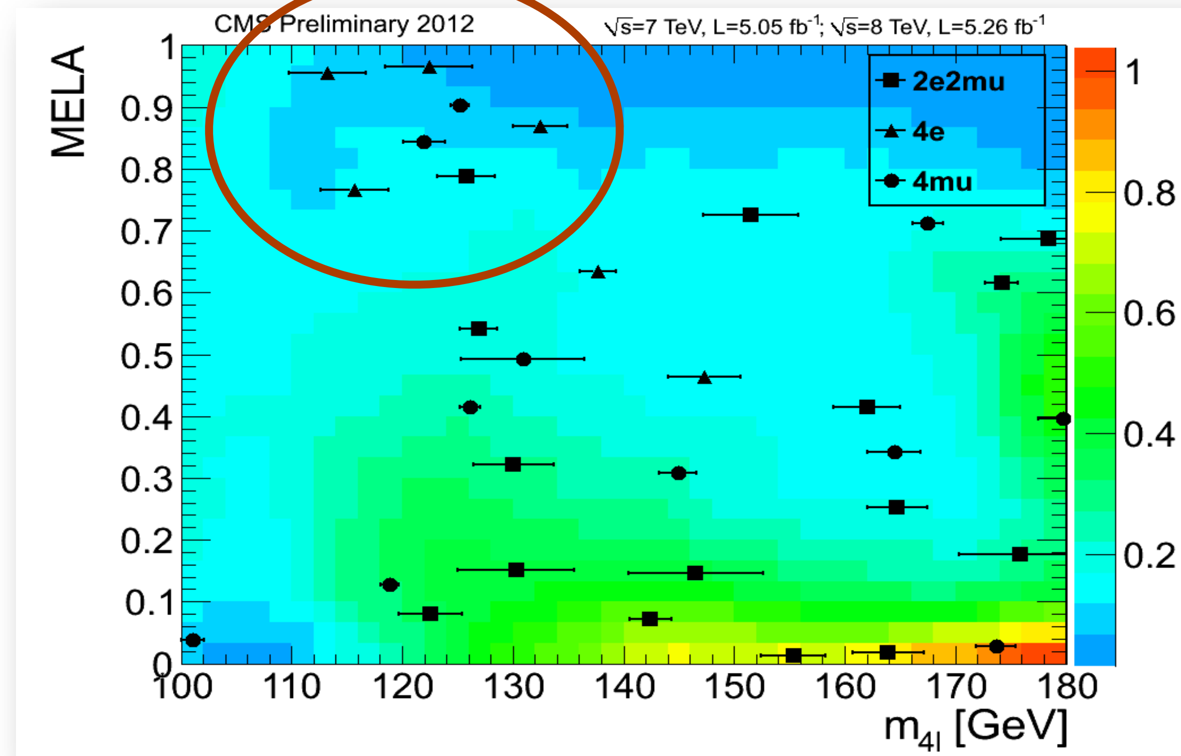


CMS Matrix ELement Analysis (MELA)

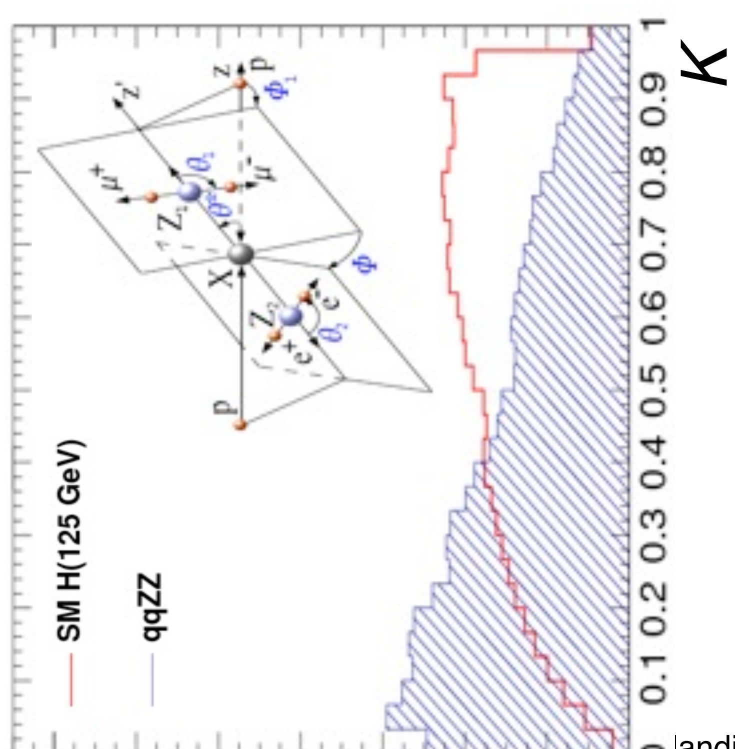
Perform 2D fit

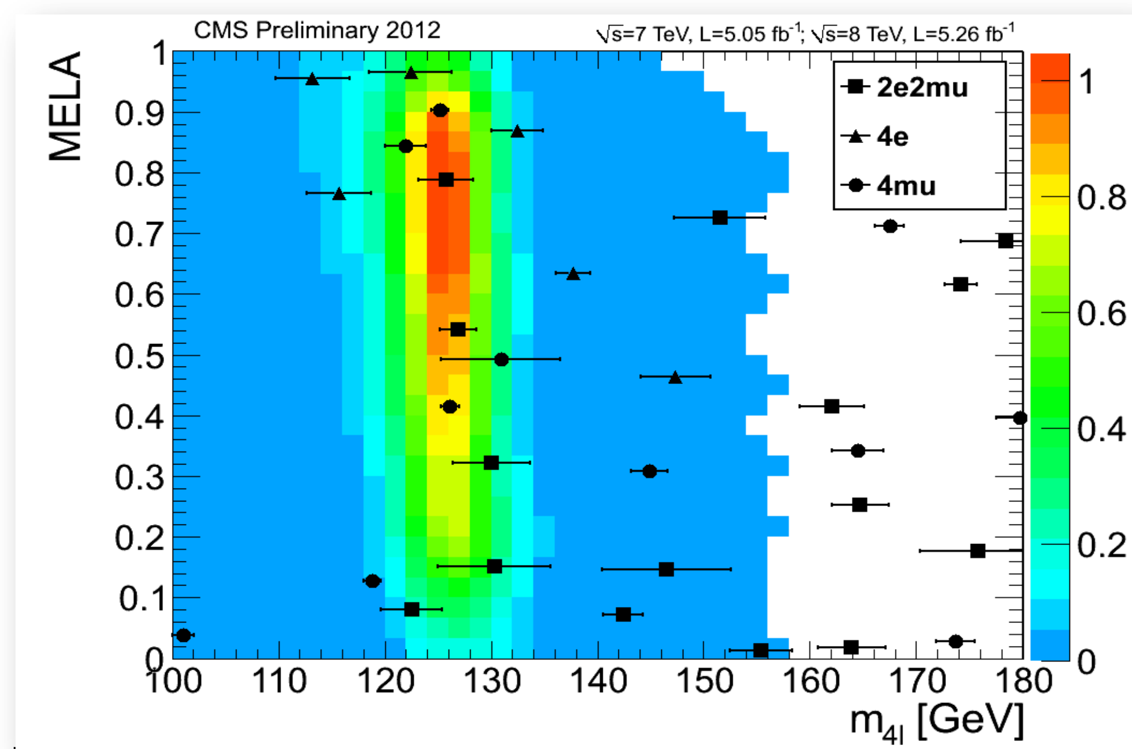
- MELA discriminant versus m_{4l}
  - Data points shown with per-event mass uncertainties

Data vs Bkg Expectation

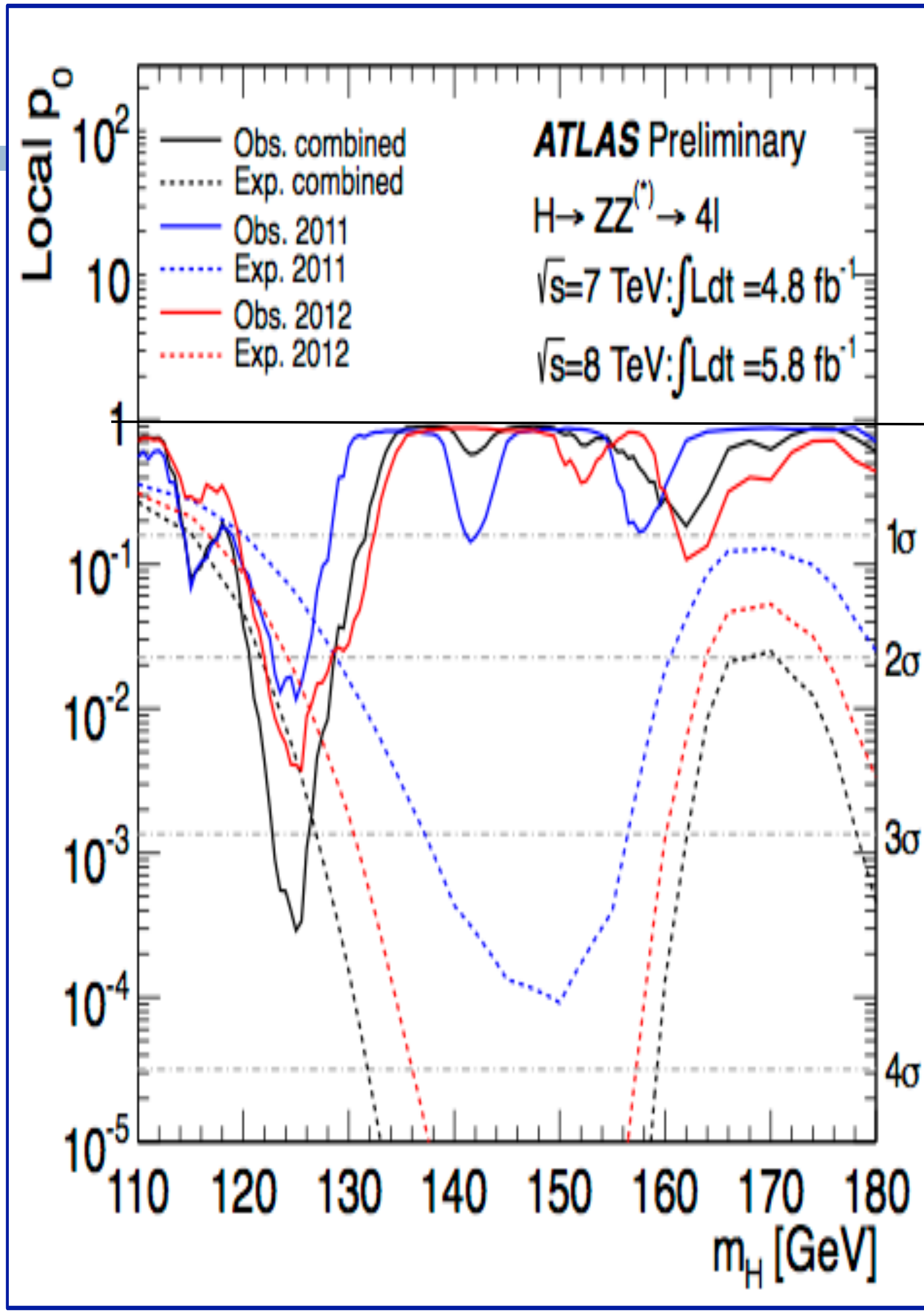


Data vs Signal Expectation

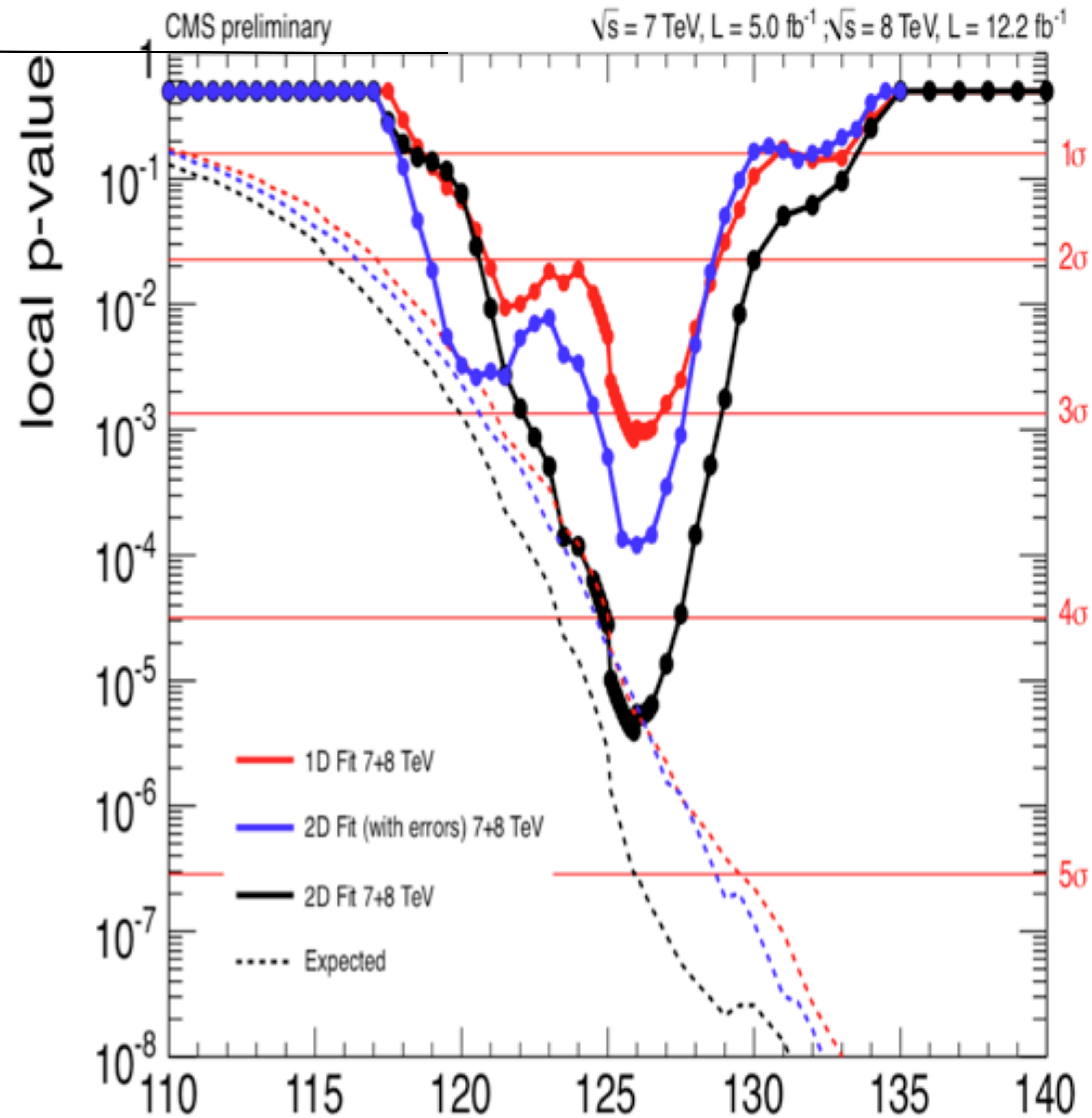




4 - Leptons P value

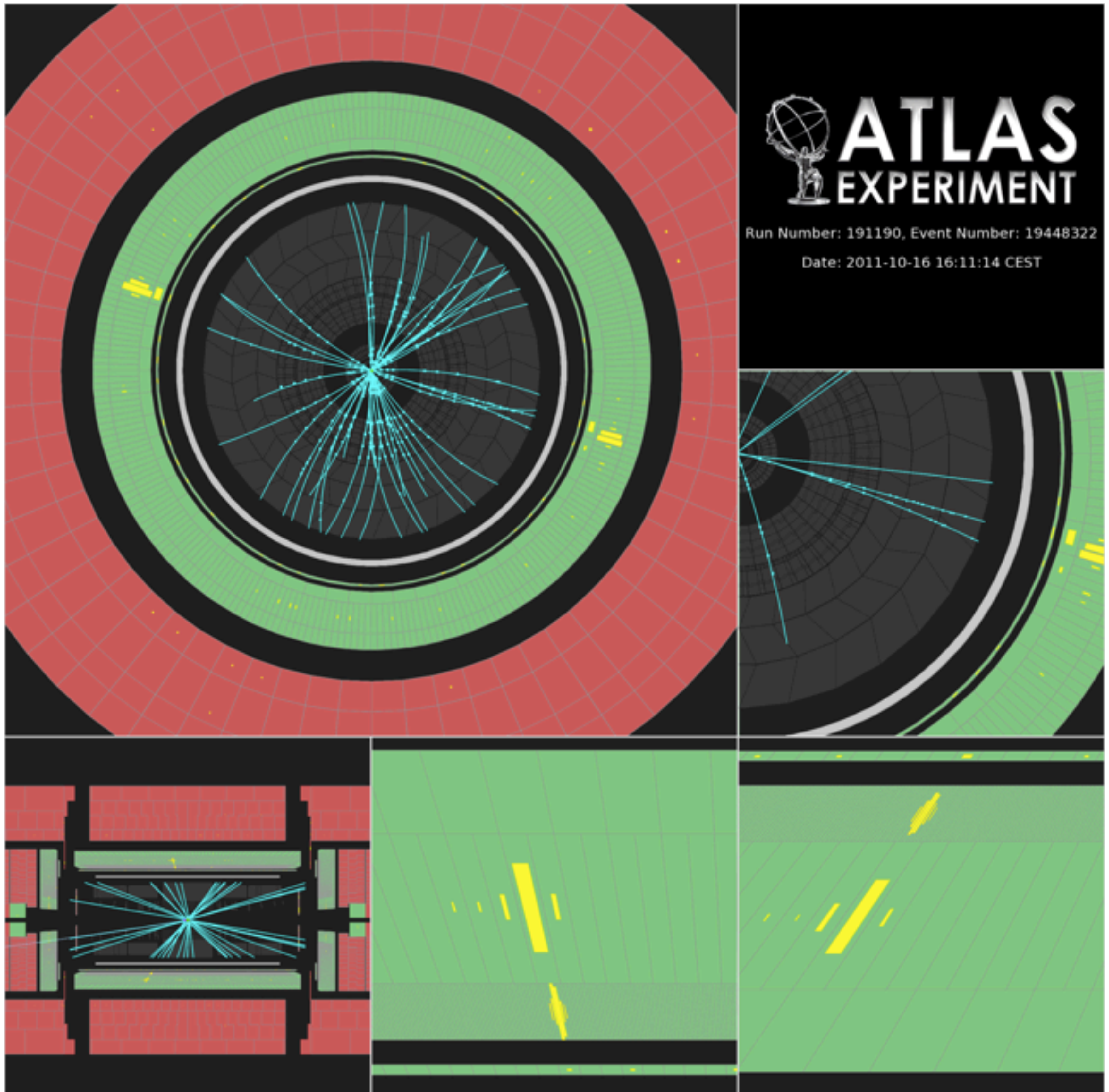


Expected significance 2.6 σ
Observed significance 3.4 σ



Expected significance 5.0 σ m_H [GeV]
Observed significance 4.5 σ

H --> γγ



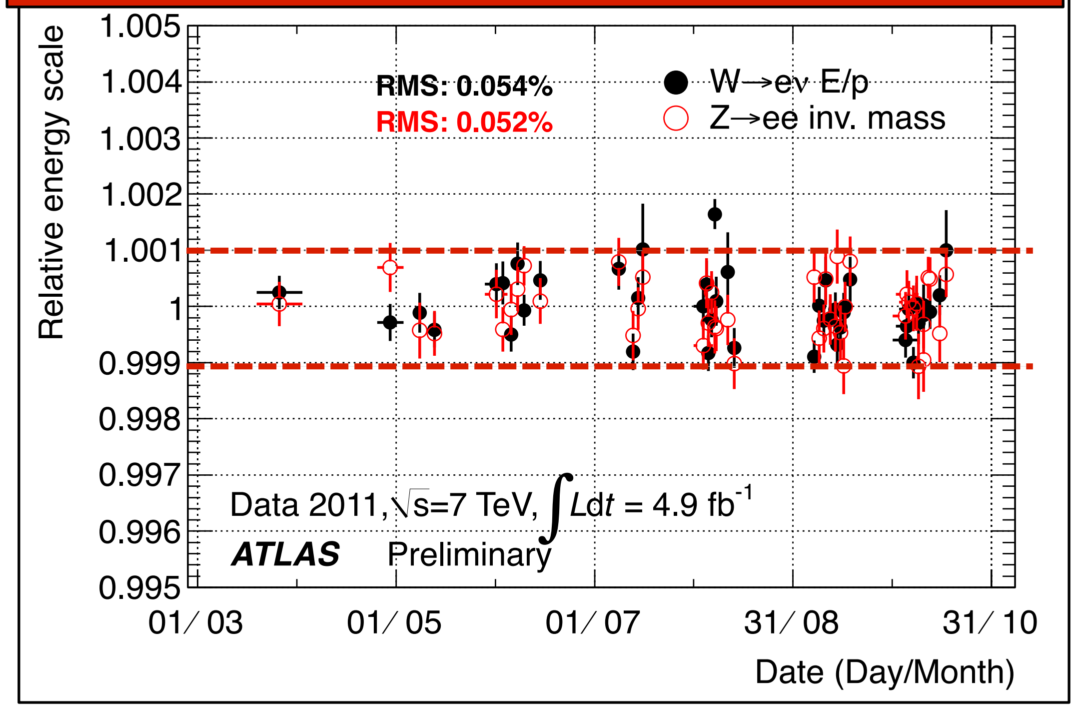
Main backgrounds:
* ırreducible (30 pb);
* reducible j (200 nb);
* reducible jj (500 μb).

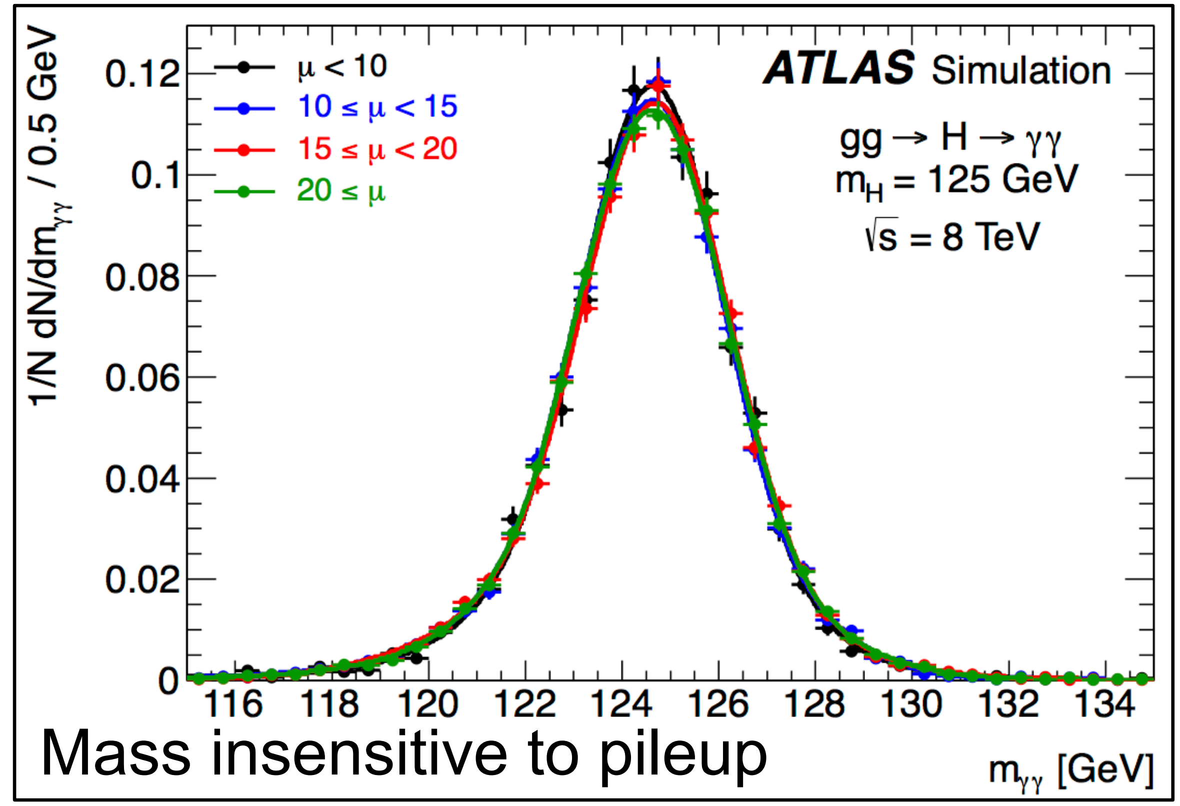
Powerful /jet separation is crucial.

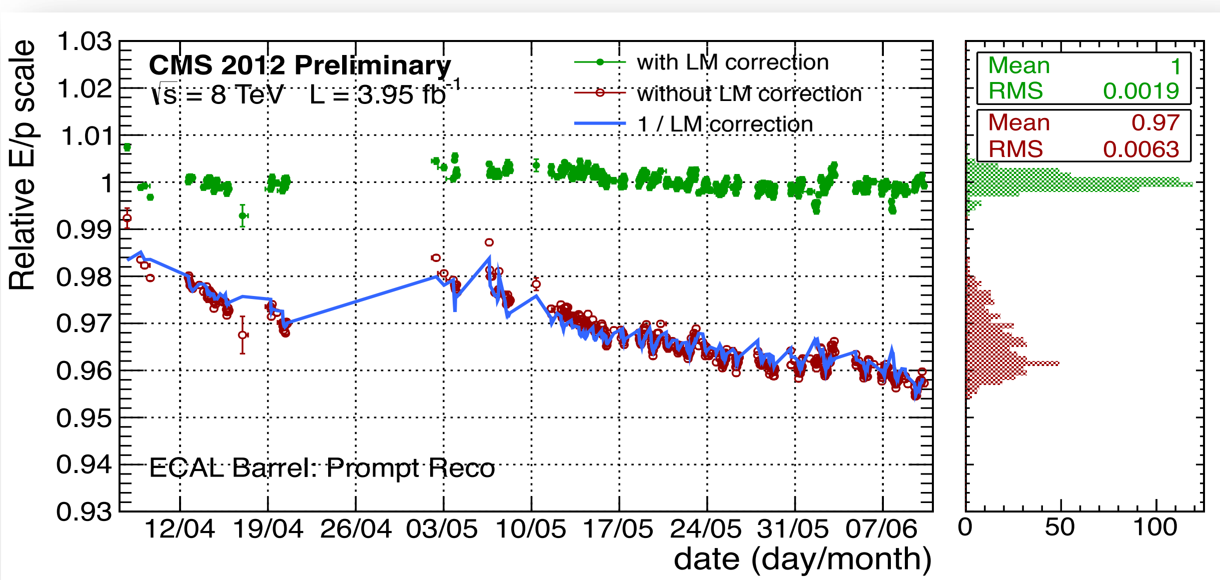
Need an excellent mass resolution.

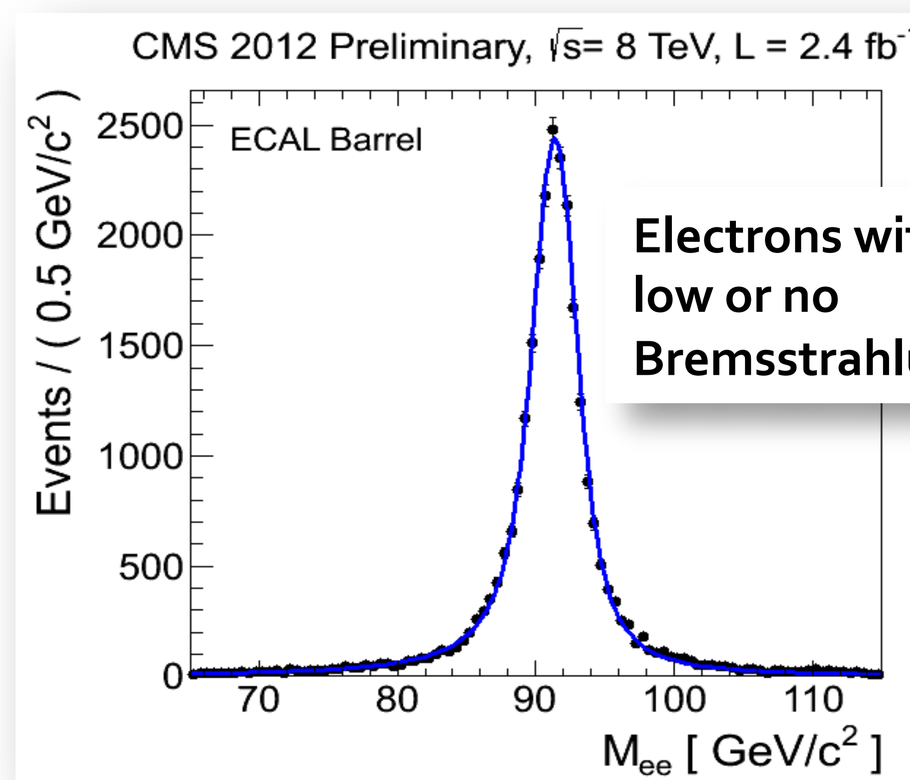
The importance of Energy Calibration

Stability of EM calorimeter response vs time (and pile-up) during full 2011 run better than 0.1%



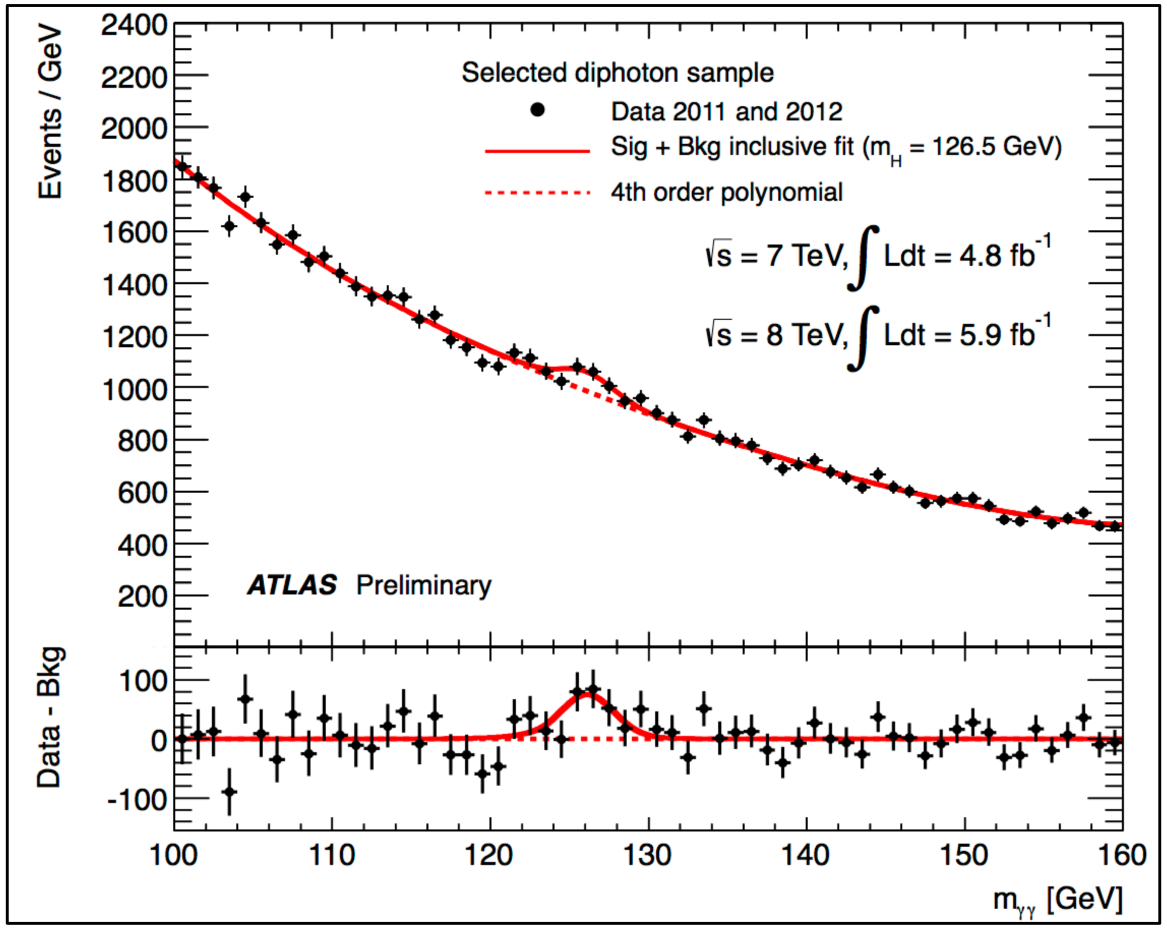


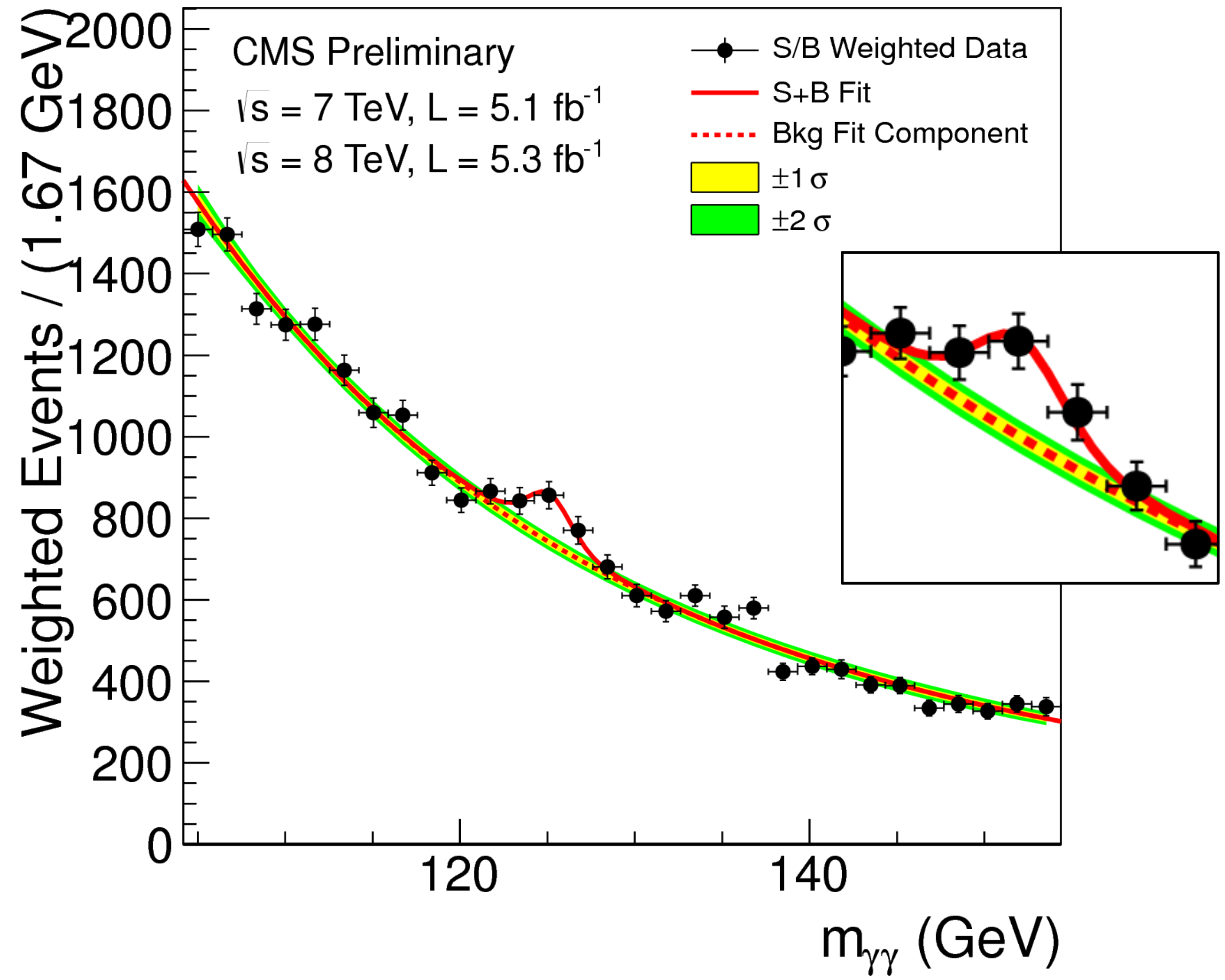




Electrons with low or no Bremsstrahlung

γγ mass Distribution

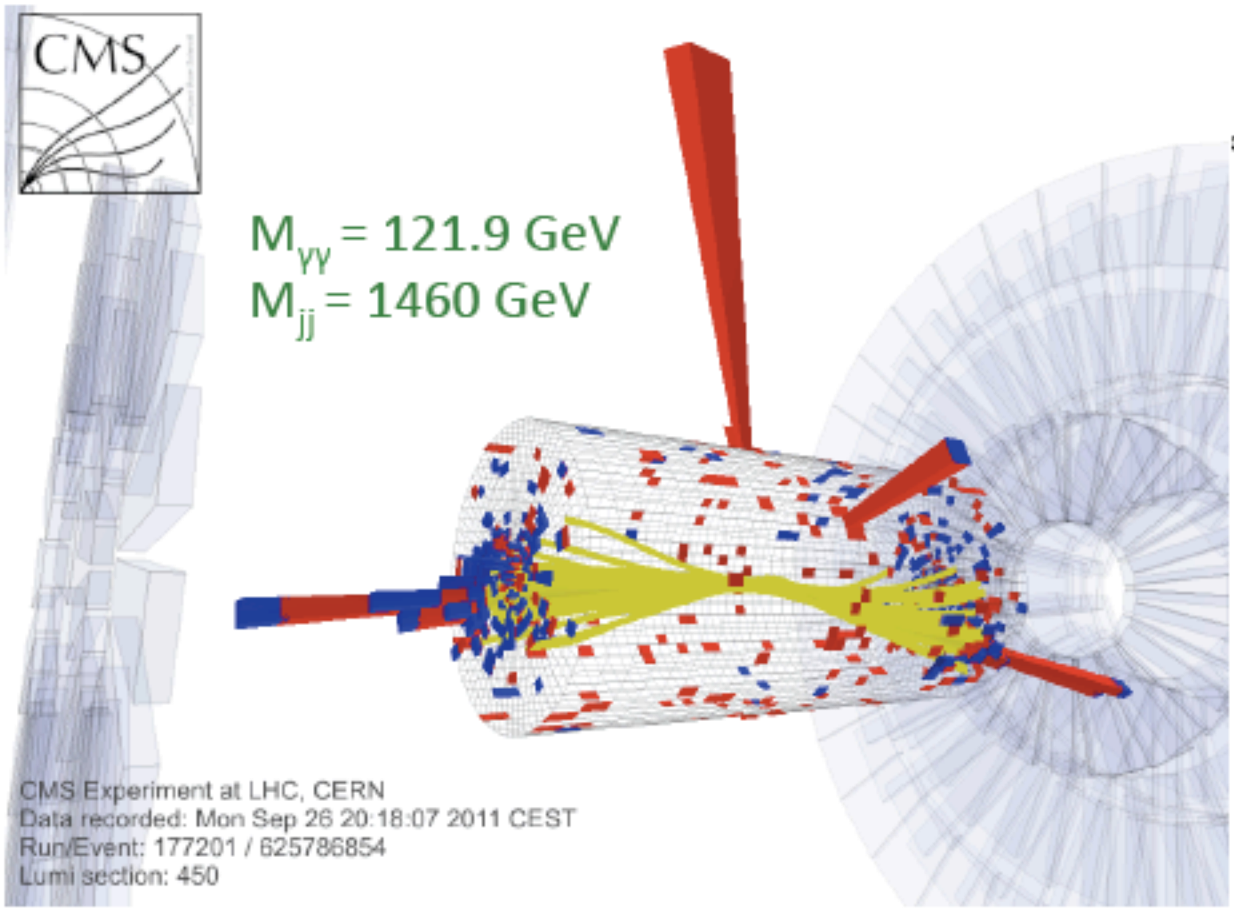


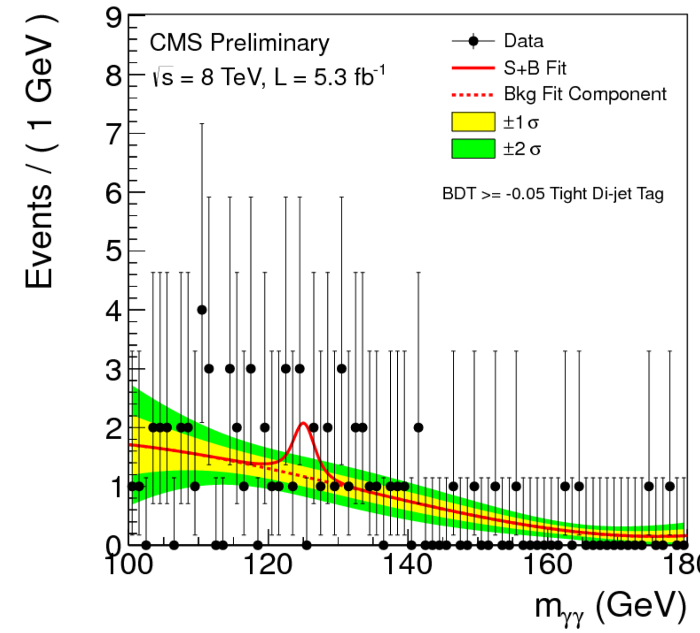


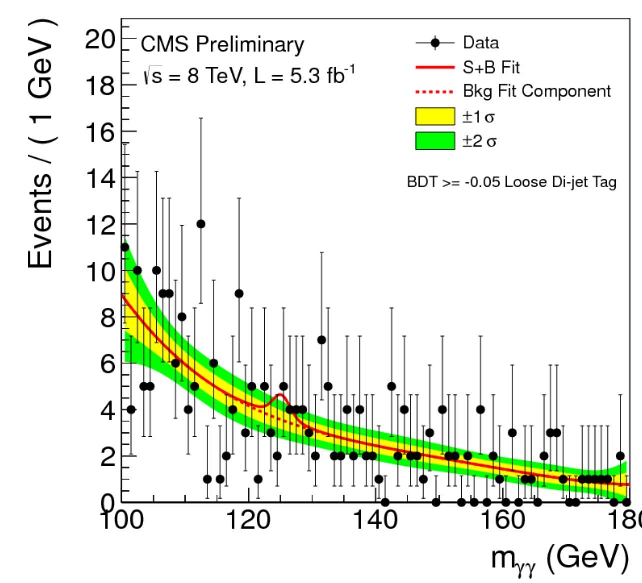
Sum of mass distributions for each event class, weighted by S/B

B is integral of background model over a constant signal fraction interval

H --> γγ



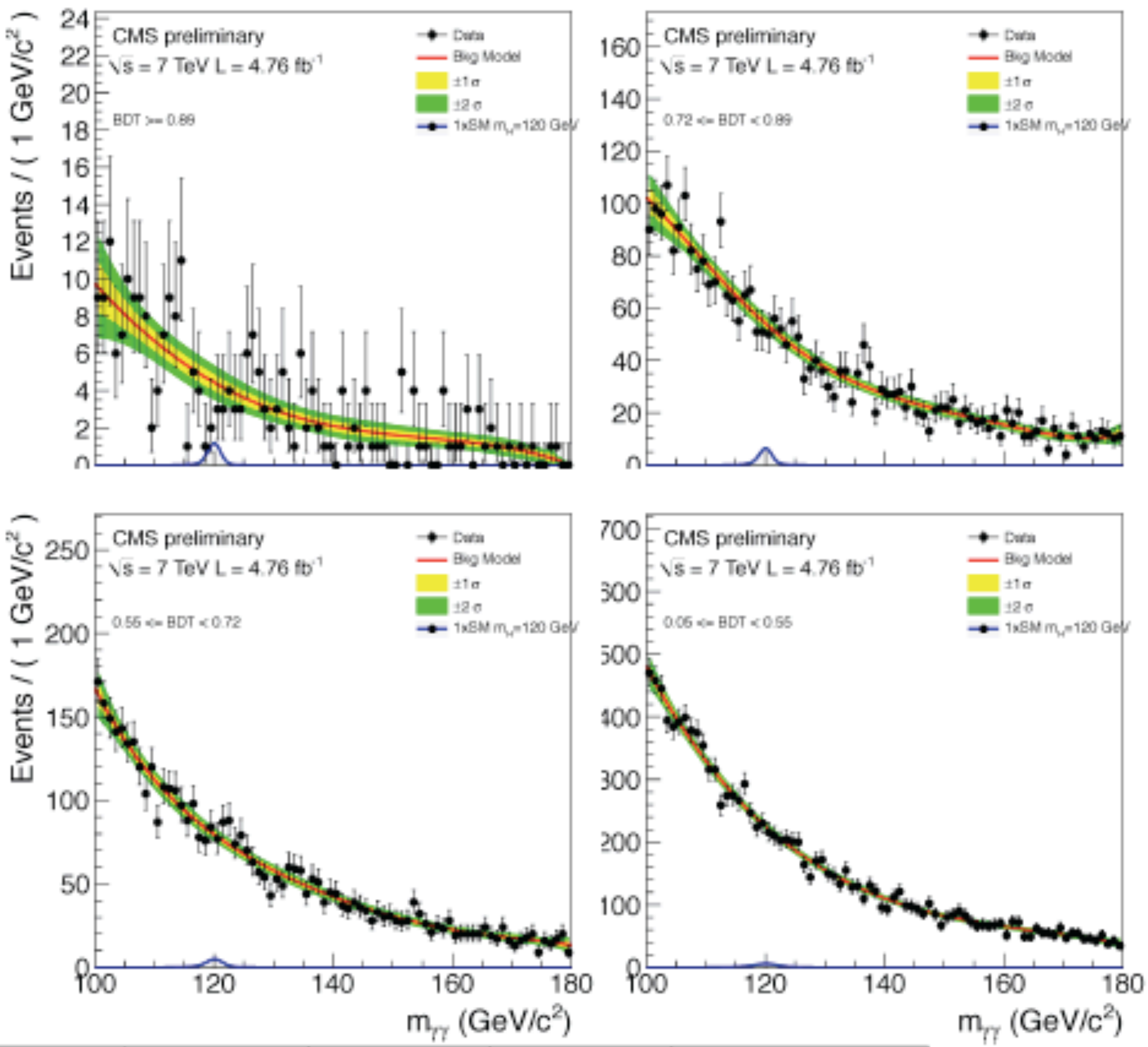




Events with two jets (VBF motivated selection) are separated from the rest [in MC the sample is 70% VBF and 30 % gluon gluon]

H --> γγ

Events passing VBF selection removed

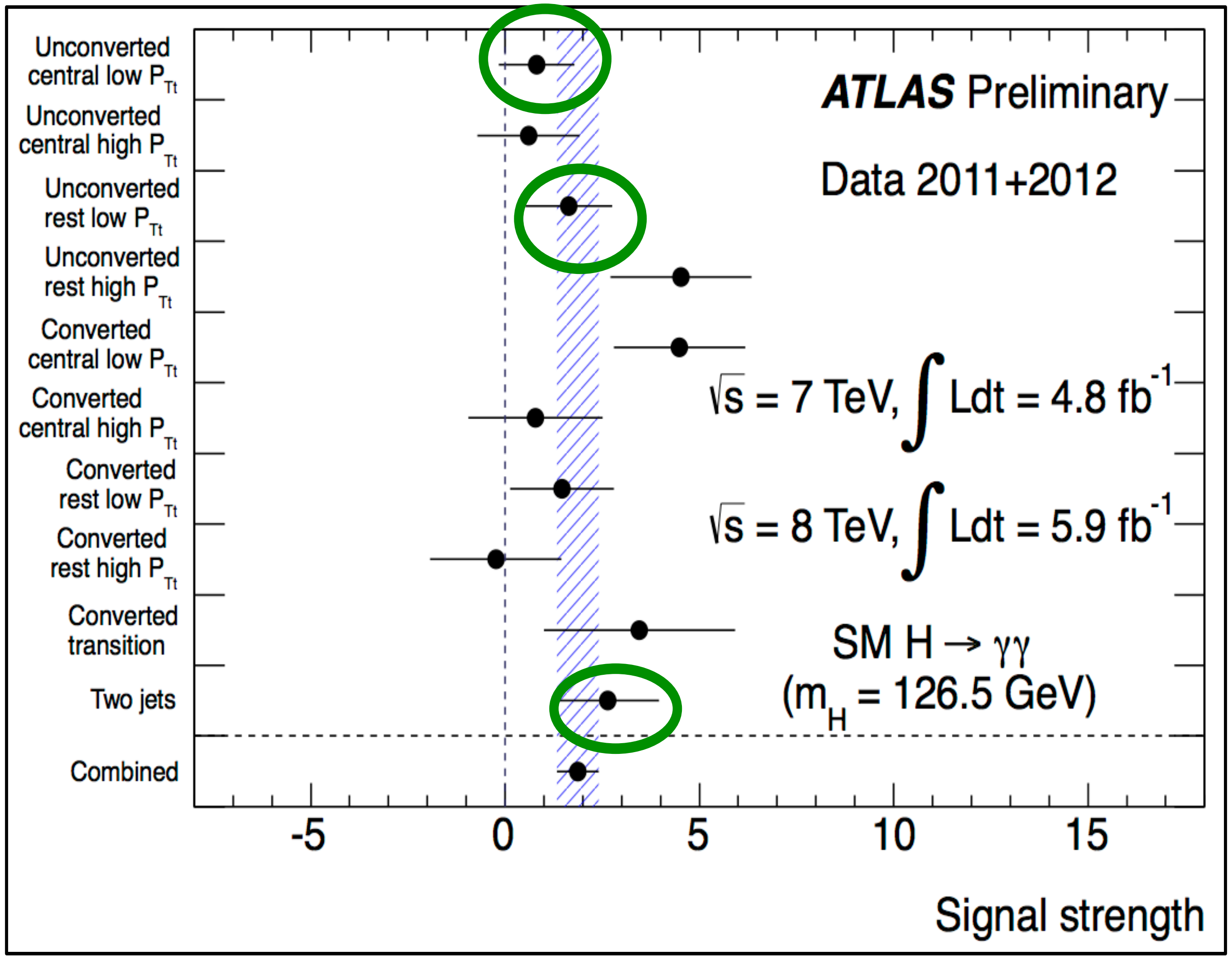


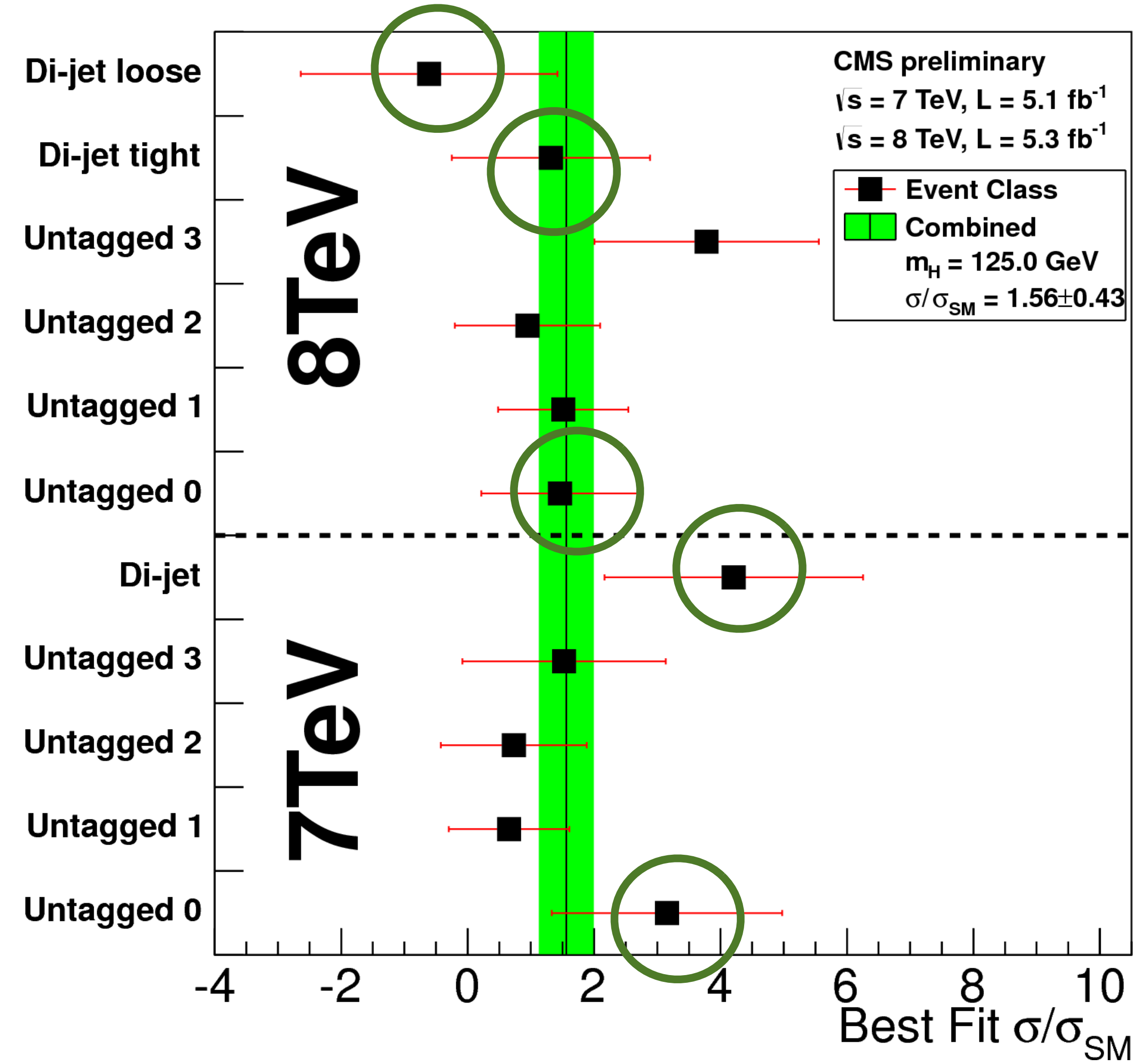
Remaining events are split in 4 categories depending on photon id / resolution / mass resolution with an MVA method

Combined μ ~ 1.7±0.33

μ=1.9±0.5

μ=1.56±0.43

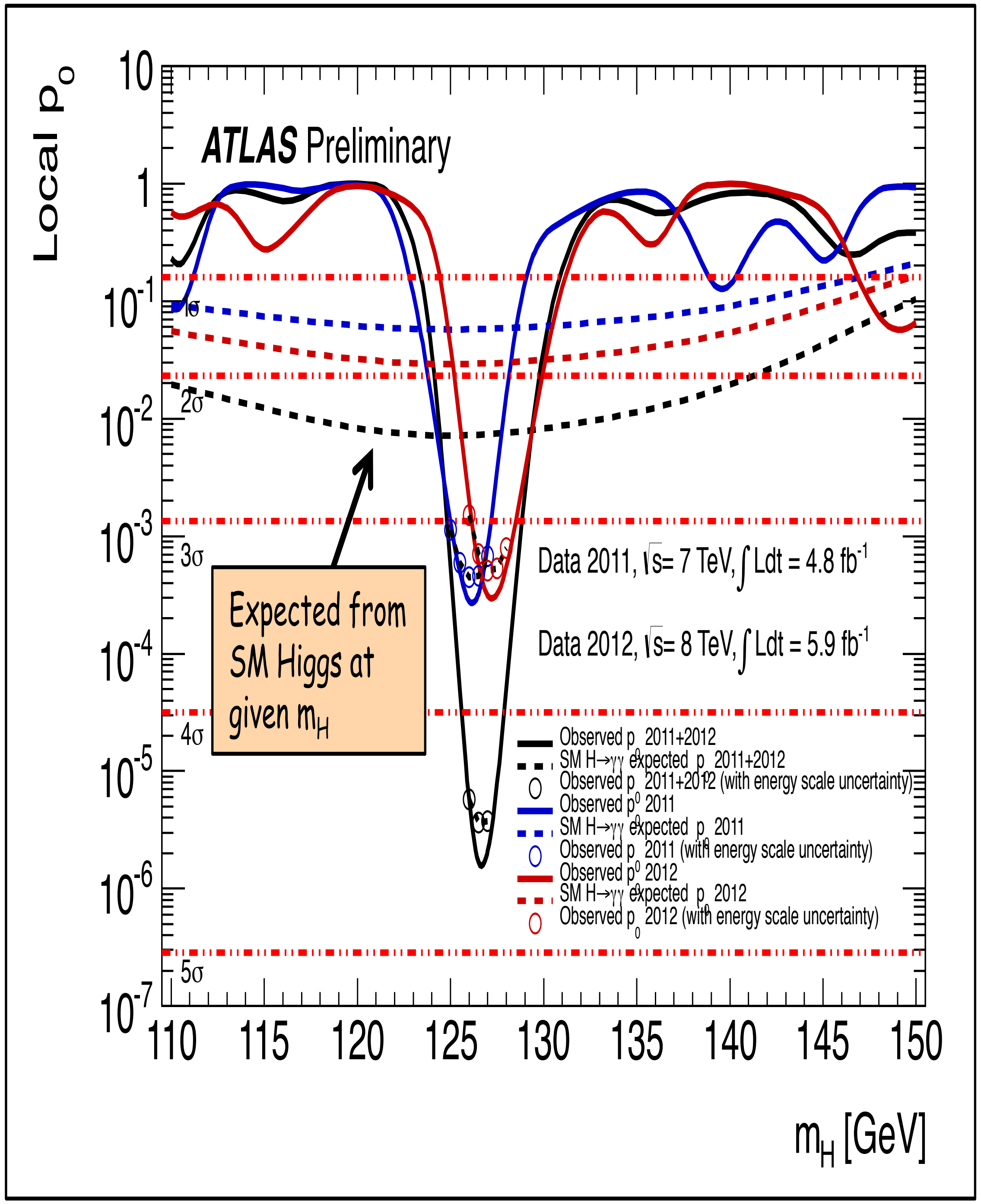


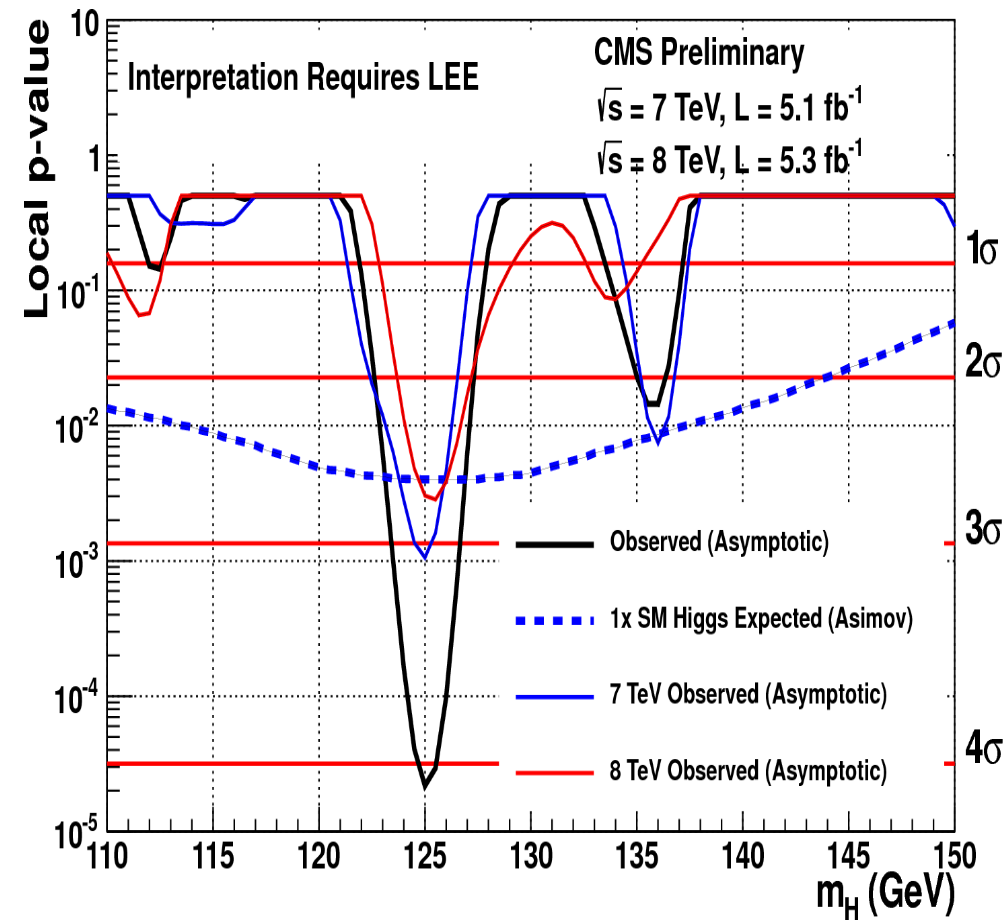


Most sensitive categories

Warning: in this channel with small S/B it is more likely to see a positive fluctuation of the signal

γγ p-value

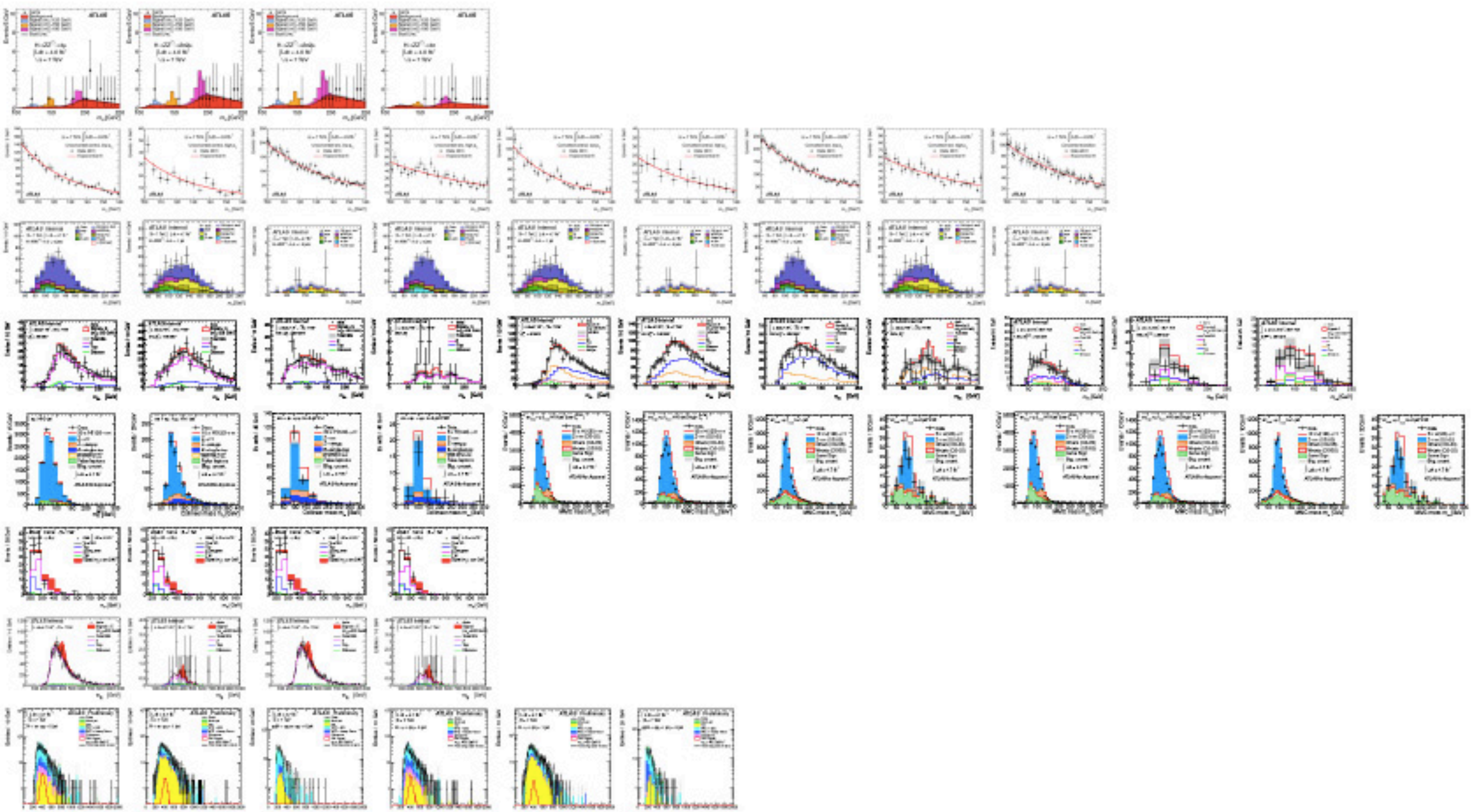




Expected significance 2.4 σ
Observed significance 4.5 σ

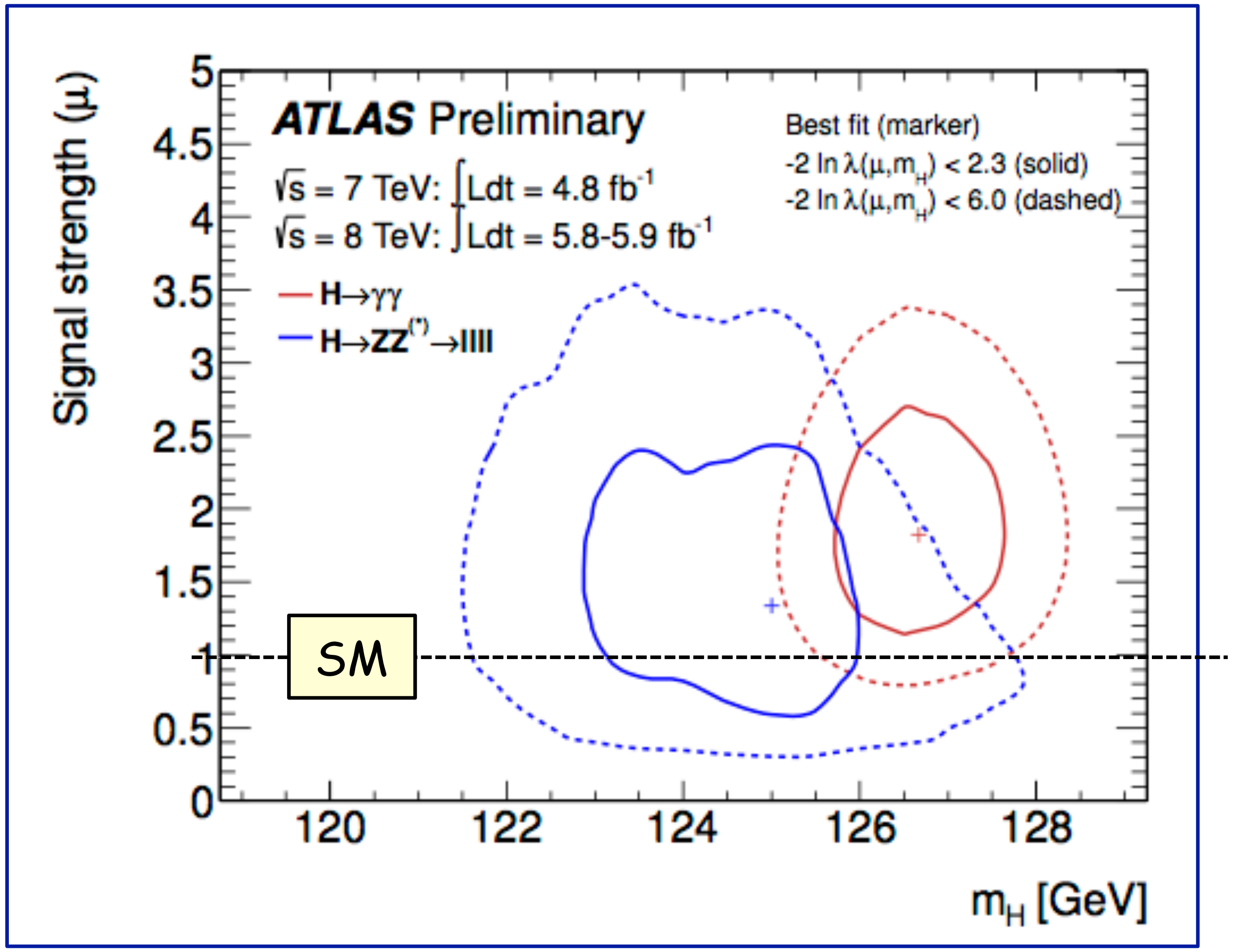
Expected significance 2.8 σ
Observed significance 4.1 σ

COMBINATION

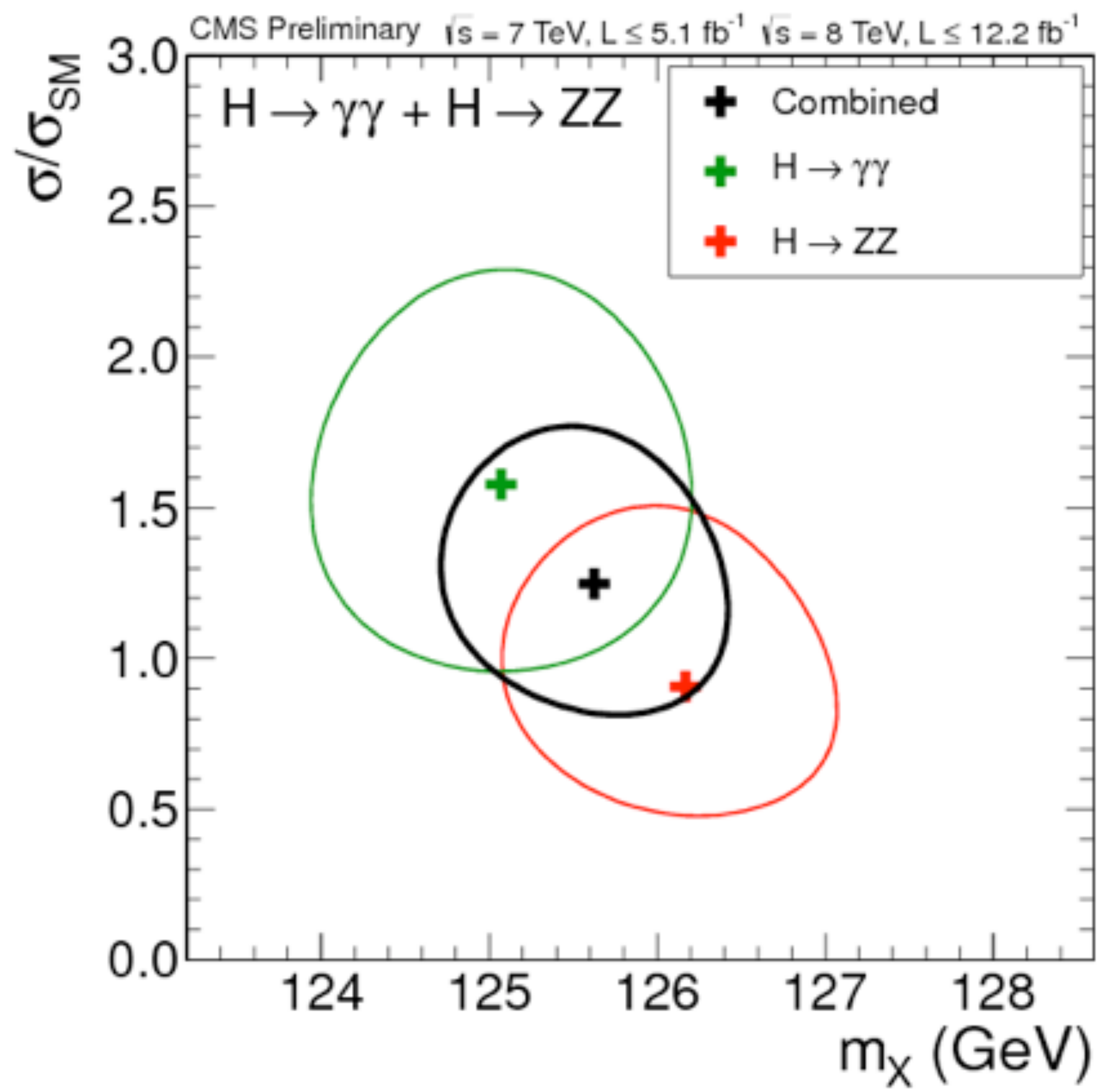


Sandra Kortner

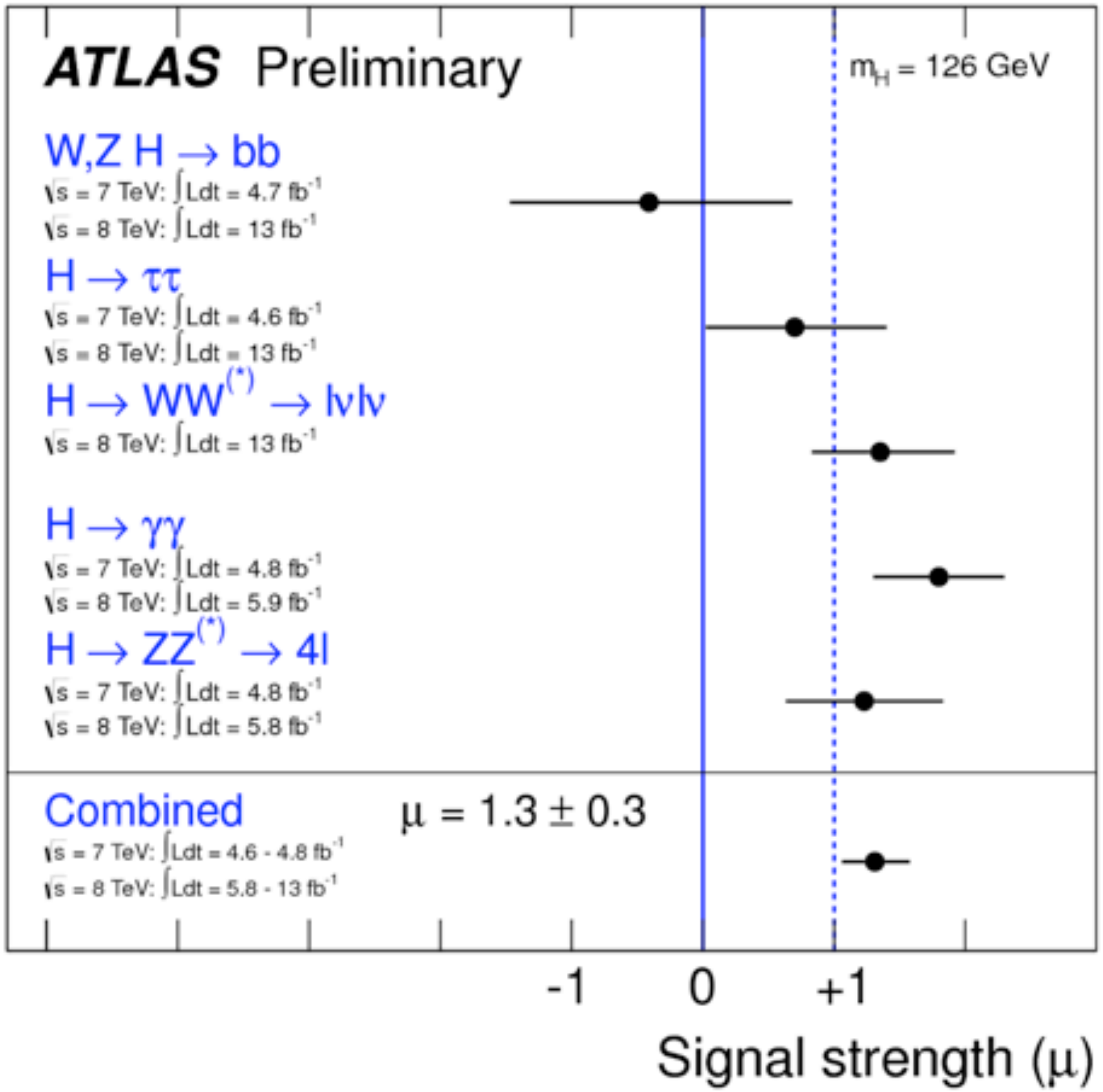
Mass

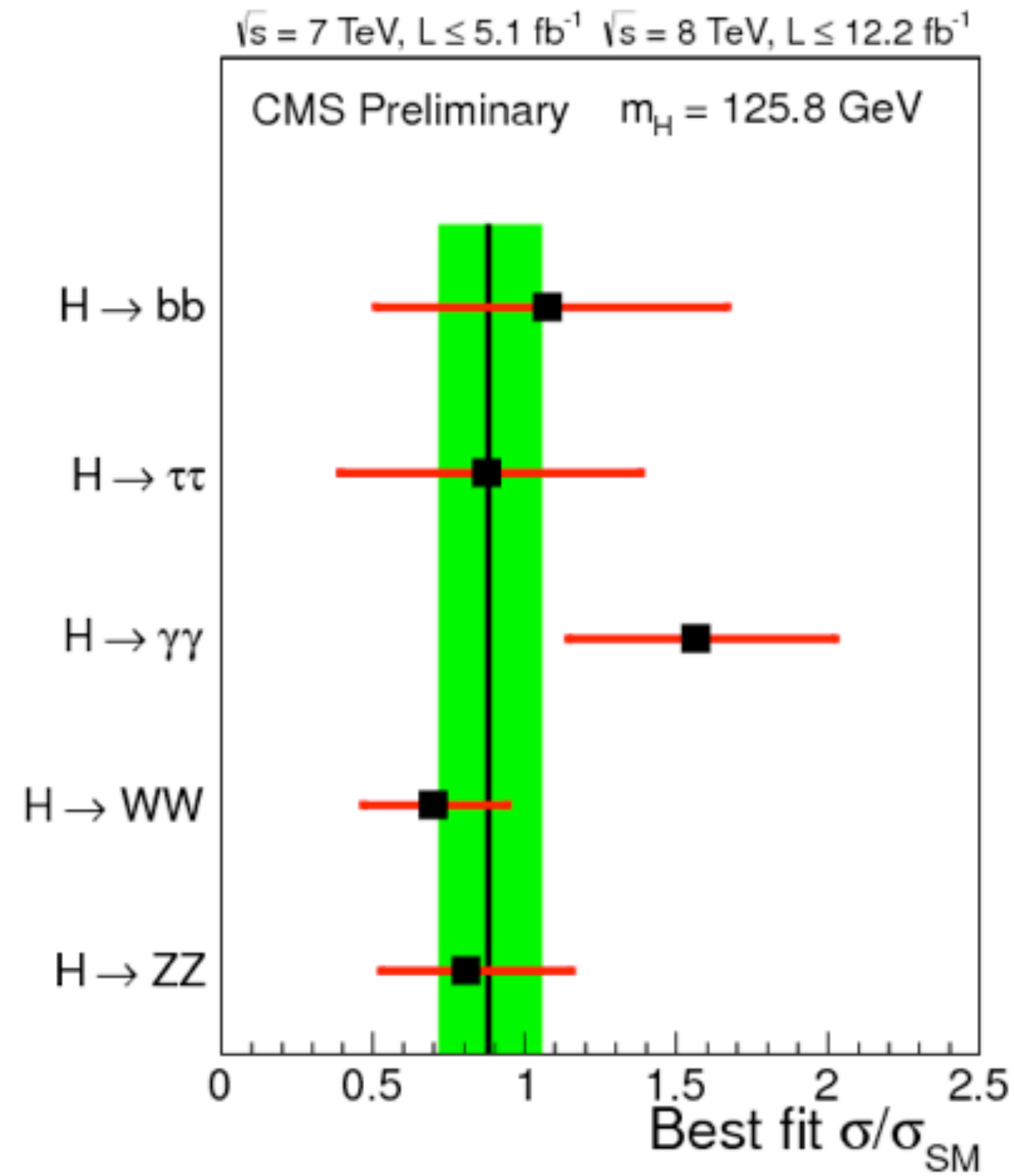


126.0 ± 0.6 GeV



125.8 ± 0.5 GeV



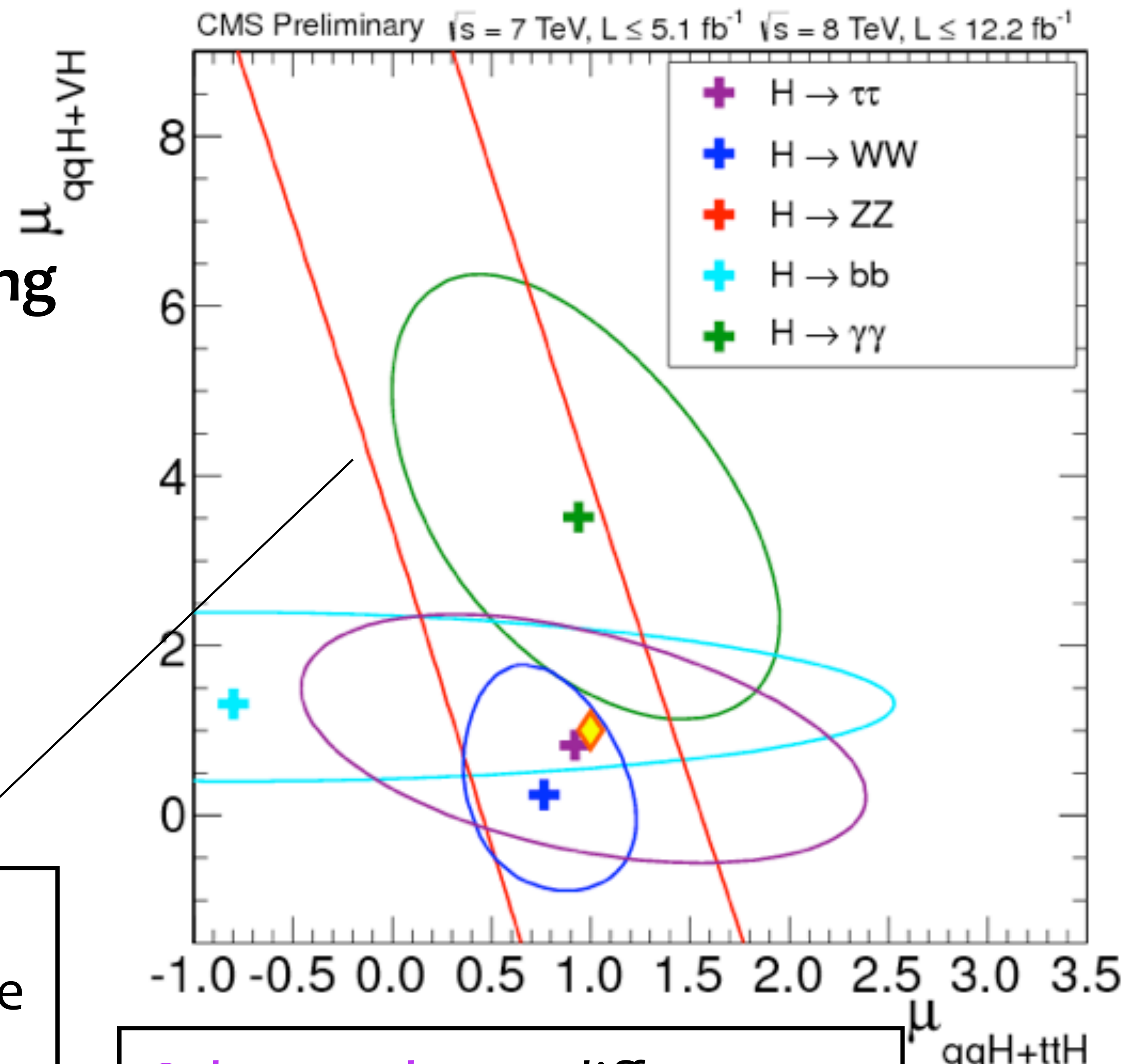


Combined 1.3 ± 0.3

Combined 0.88 ± 0.21

Signal Strenght at m_H=125.8 GeV

A combination of channels associated with a particular decay mode and explicitly targeting different production mechanisms can be used to test the relative strengths of the couplings to the vector bosons [μ_{qqH+VH}] and top quarks [$\mu_{ggH+ttH}$]

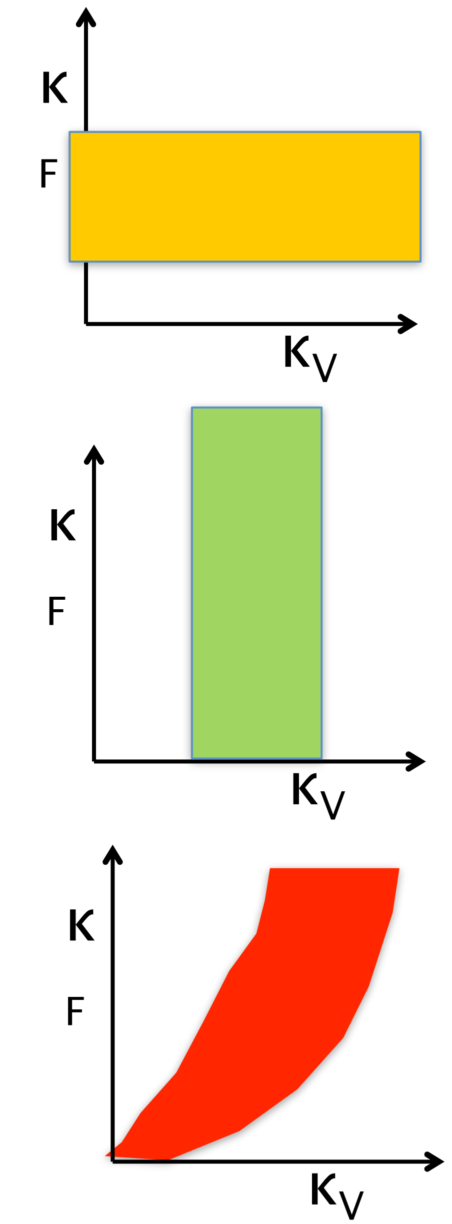


ZZ analysis: the different production mechanisms are not yet explicitely separated [diagonal band corresponding to same values of total cross section]

Other analyses: different production mechanisms are explicitely exploited [elliptical allowed regions]

Universal vector and fermion

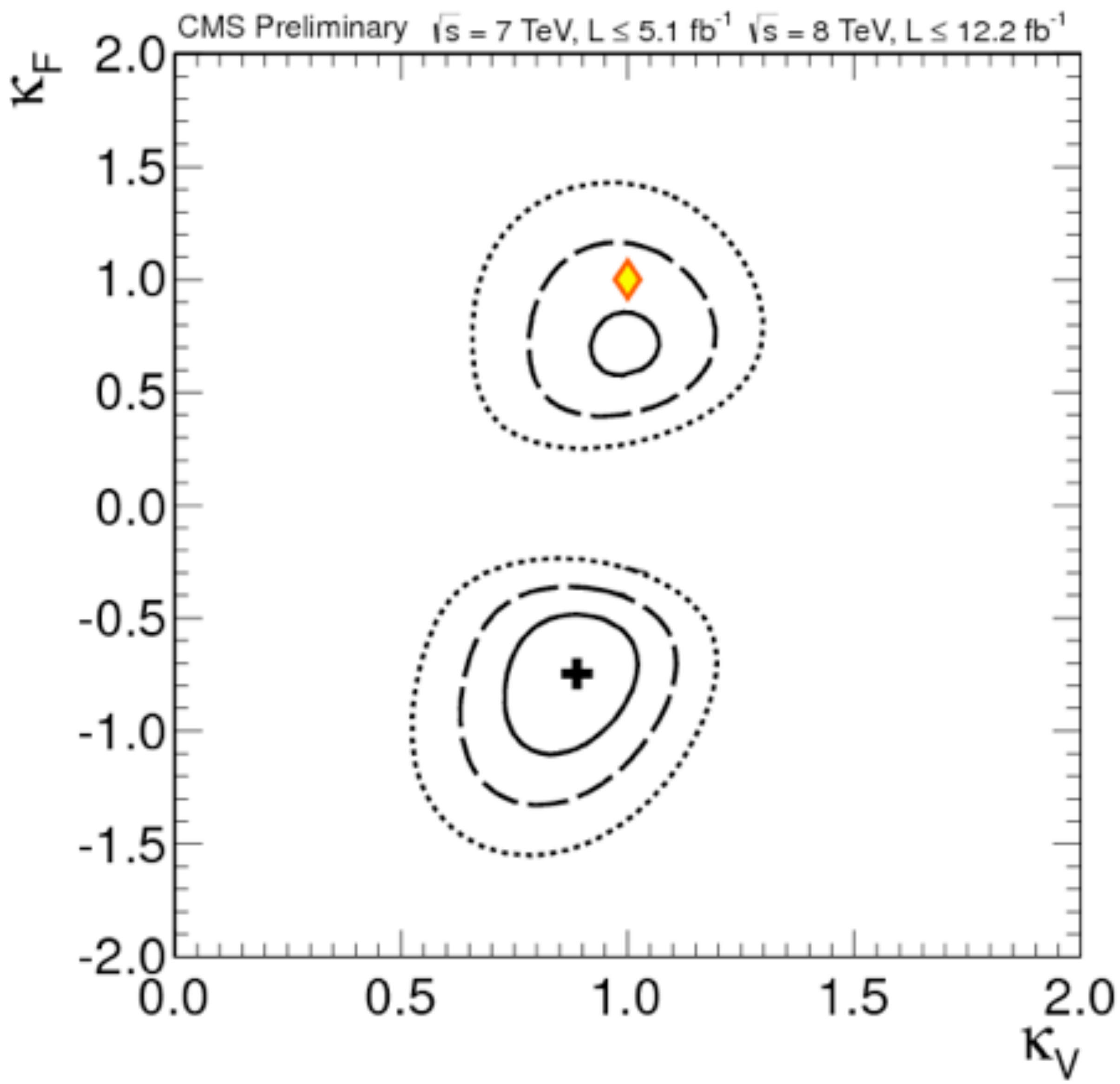
Prod.	Decay	Signal yield scale	Approx
VH	bb	$\kappa_V^2\ \kappa_F^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	κ_V^2
ttH	bb	$\kappa_F^2\ \kappa_F^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	κ_F^2
VBF	ττ	$\kappa_V^2\ \kappa_F^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	κ_V^2
ggH	ττ	$\kappa_F^2\ \kappa_F^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	κ_F^2
ggH	WW, ZZ	$\kappa_F^2\ \kappa_V^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	κ_V^2
VBF	WW	$\kappa_V^2\ \kappa_V^2\ /\ [\frac{3}{4}\ \kappa_F^2 + \frac{1}{4}\ \kappa_V^2]$	$\kappa_V^4\ /\ \kappa_F^2$
ggH	γγ	$\kappa_F^2\ \lvert\kappa_V - 0.21\ \kappa_F\rvert^2\ /\ [...]$	κ_V^2
VBF	γγ	$\kappa_V^2\ \lvert\kappa_V - 0.21\ \kappa_F\rvert^2\ /\ [...]$	$\kappa_V^4\ /\ \kappa_F^2$



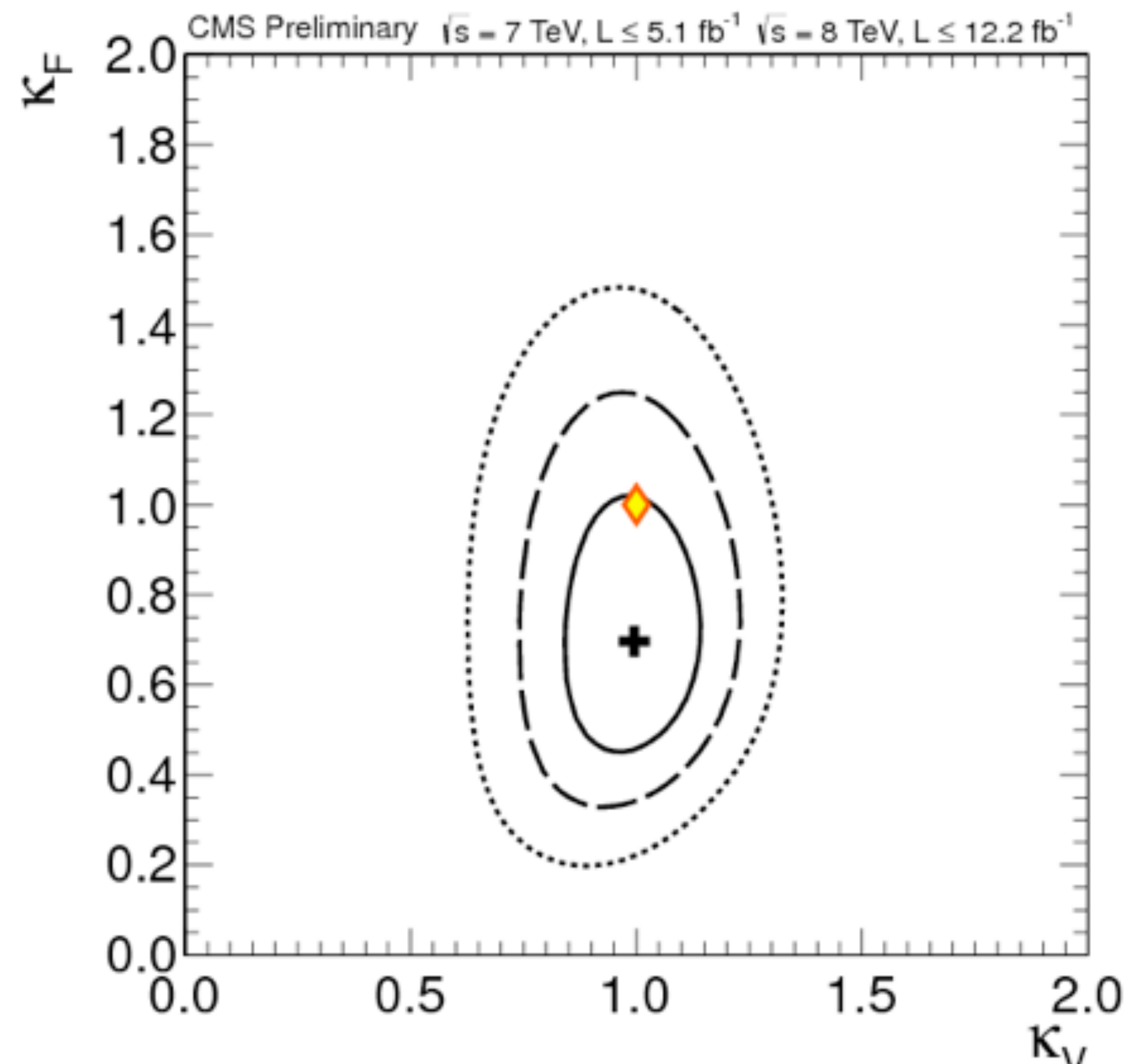
gigi.rolandi@cern.ch

Universal vector and fermion couplings

2D likelihood scan of the test statistic $q(k_v, k_f)$ vs the (k_v, k_f) parameters



Likelihood scan in two quadrants (++), (+-)



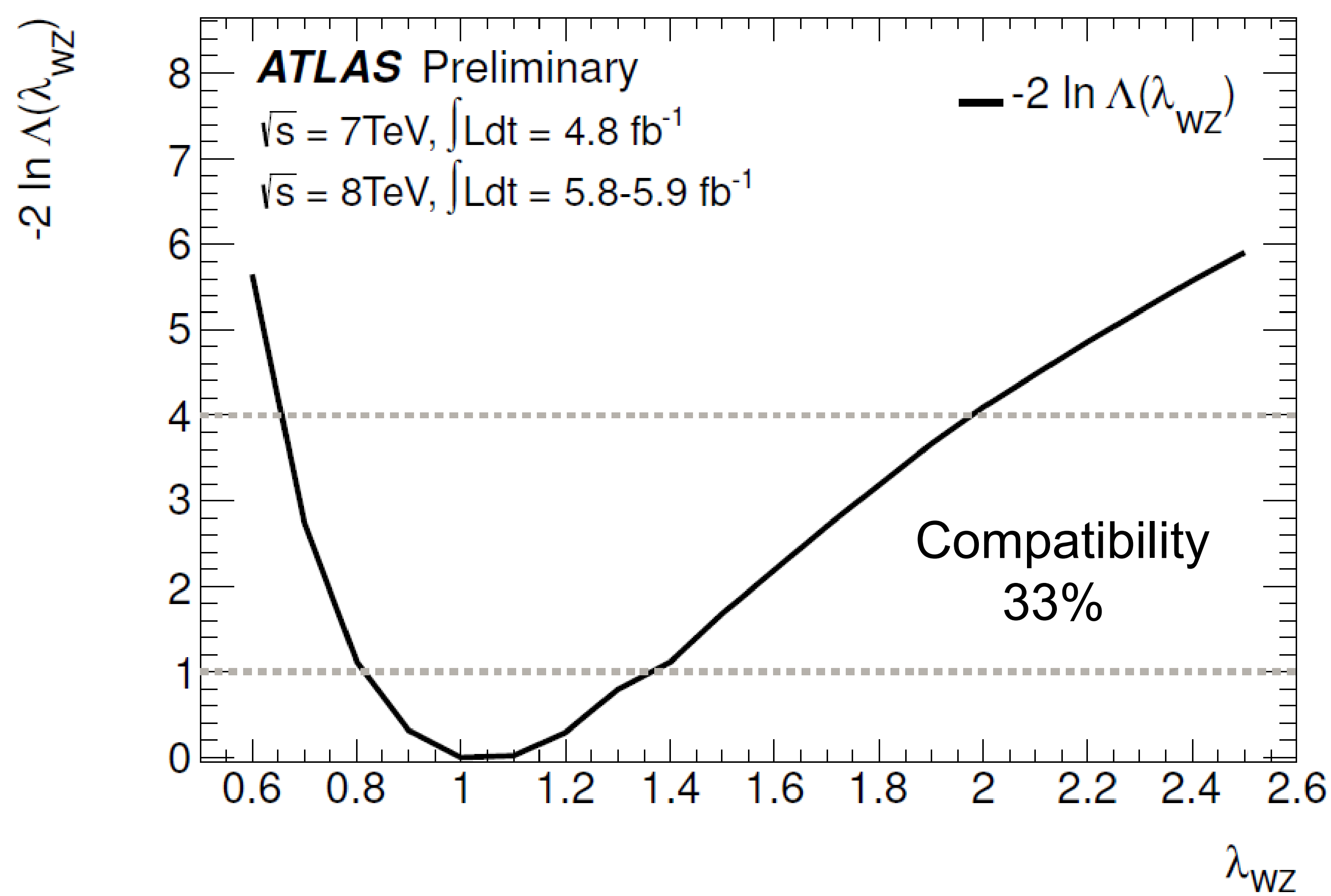
Likelihood scan constrained to the (++) quadrant

Solid, dotted, dashed contours show the 68%, 95%, 99.7% CL ranges
Yellow diamond shows the SM point (kv, kf) = (1,1)

Probing the custodial symmetry

- Similar to previous benchmark model, but $\kappa_V \rightarrow \kappa_W$ and κ_Z, so there are three free parameters κ_W , κ_Z and κ_F. Identical couplings scale factors for the W and Z are required within tight bounds by SU(2) custodial symmetry and ρ parameter.
- The VBF process is parametrized with κ_W and κ_Z according to the Standard Model.

$$\lambda_{WZ} = \frac{\kappa_W}{\kappa_Z} = 1.07^{+0.35}_{-0.27}$$



BSM Physics in loops

Processes induced by loop diagrams ($H \to \gamma\gamma$, $gg \to H$) can be particularly susceptible to the presence of new particles

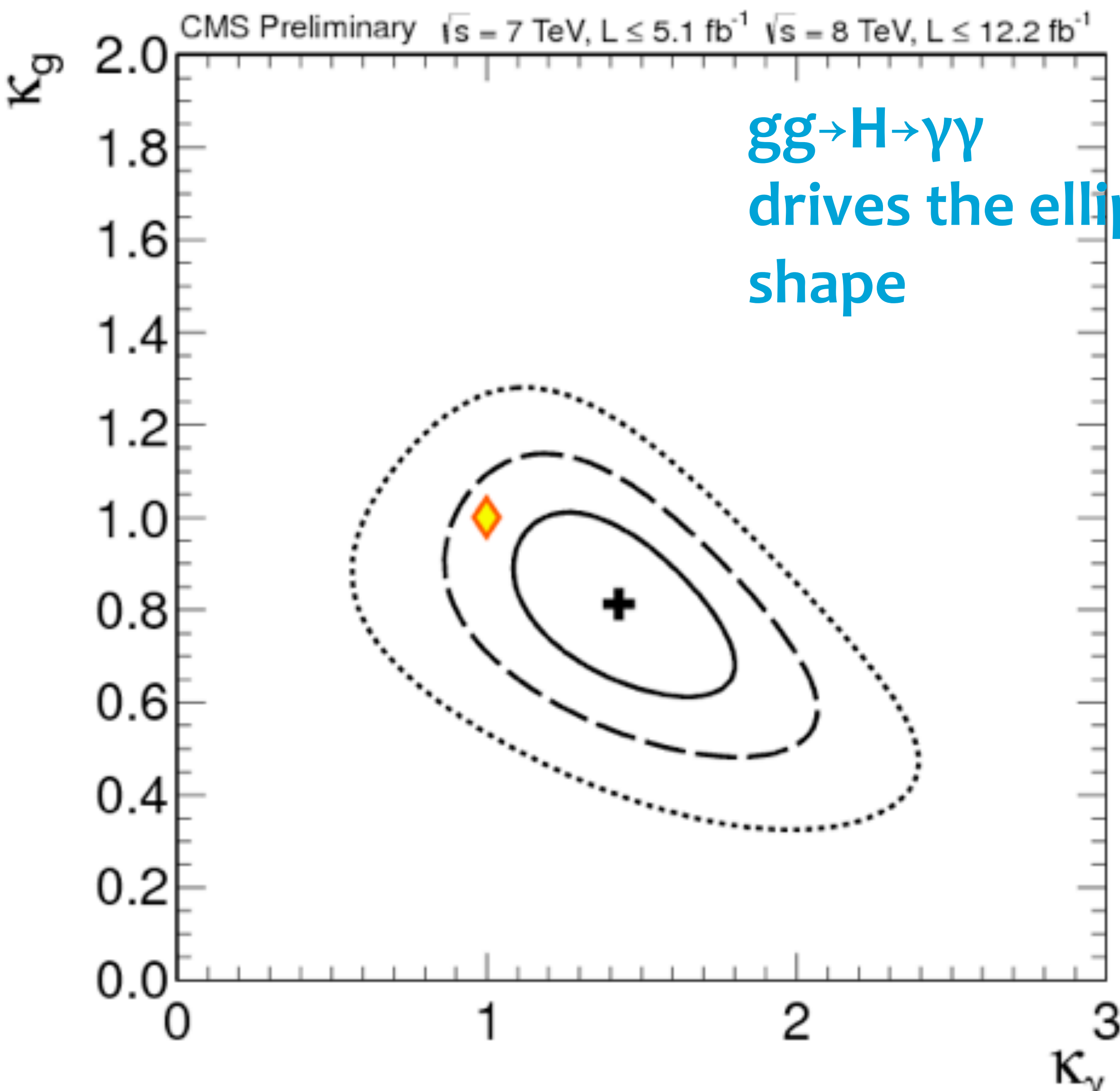
Combine and fit data for scaling factors k_γ and k_g for these two processes

$$\sigma_{ggH} \sim \kappa_g^2 \quad \Gamma_{gg} \sim \kappa_g^2 \quad \Gamma_{\gamma\gamma} \sim \kappa_\gamma^2$$

(assume the tree-level couplings between Higgs and the other particles as they are in the SM)

BSM Physics in loops

2D likelihood scan of the test statistic $q(k_\gamma, k_g)$ vs the (k_γ, k_g) parameters: interplay of different decay modes



gg→H→γγ drives the elliptical shape

The best fit value is (k_γ, k_g) = (1.43, 0.81),
while the 95% CL intervals for these coupling separately are:
k_γ [0.98 - 1.92] k_g [0.55 - 1.07]

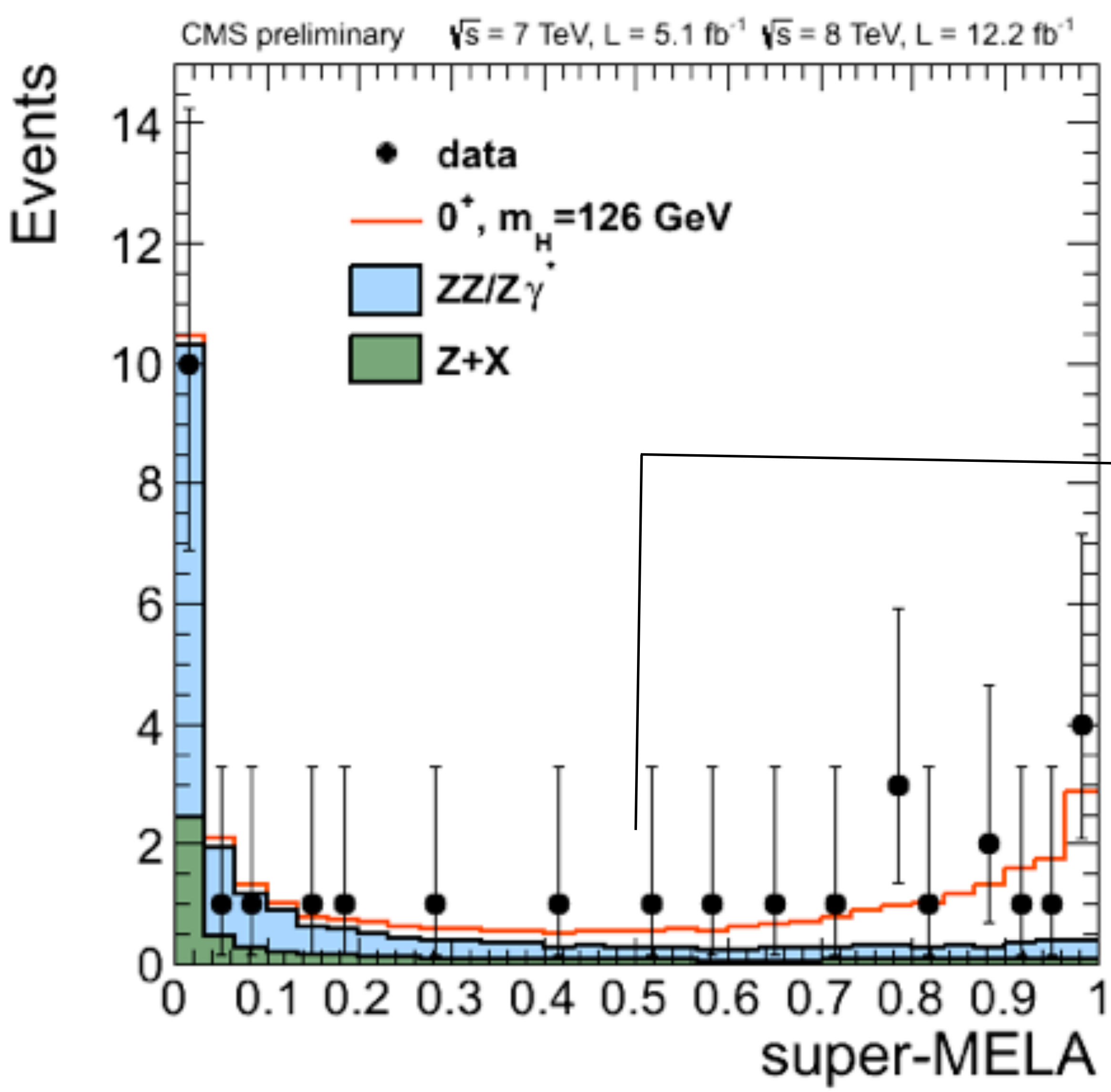
The data agree with the SM expectations

Solid, dotted, dashed contours show the 68%, 95%, 99.7% CL ranges
Yellow diamond shows the SM point (k_γ, k_g) = (1,1)

Spin and Parity

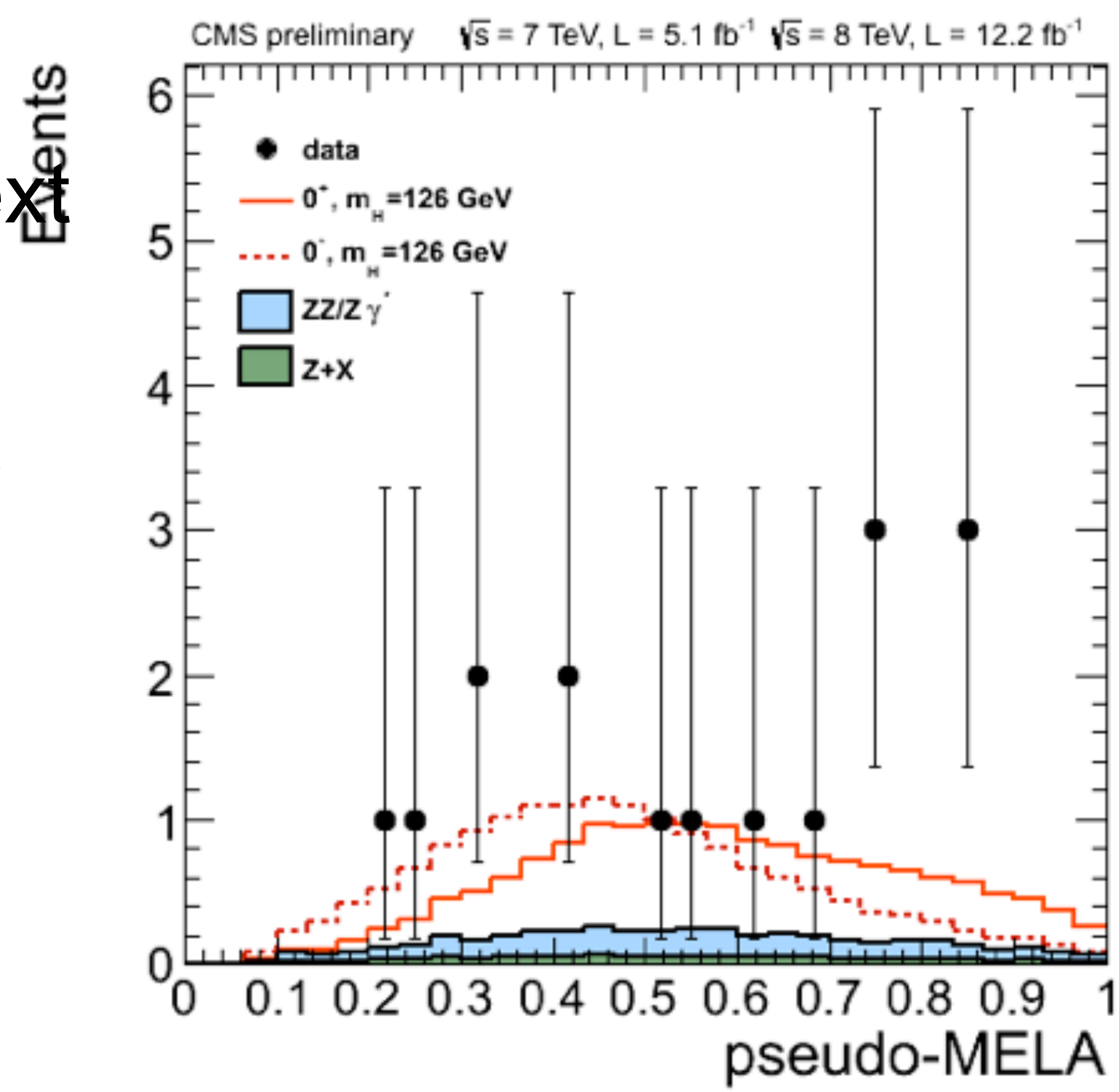
The new state decays in **γγ -> SPIN 1 Hypothesis ruled out**
The **H->ZZ->4l** channel can exploit the angular information using the "MELA" methodology to test the hypothesis **$J^P = 0^+$ vs $J^P = 0^-$**

Signal BKG separation



Text

0^+ 0^- separation

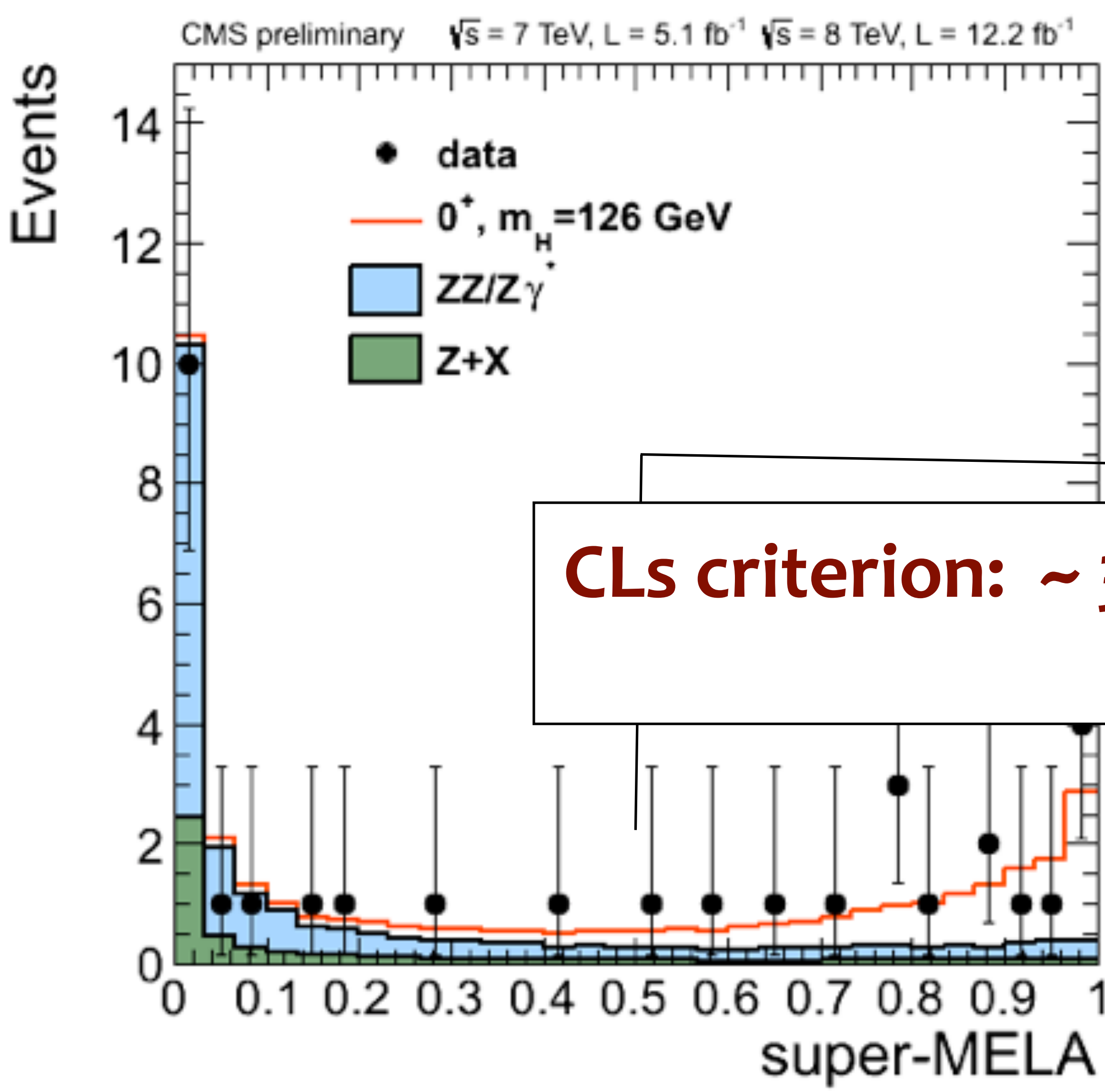


Spin and Parity

The new state decays in **γγ -> SPIN 1 Hypothesis ruled out**

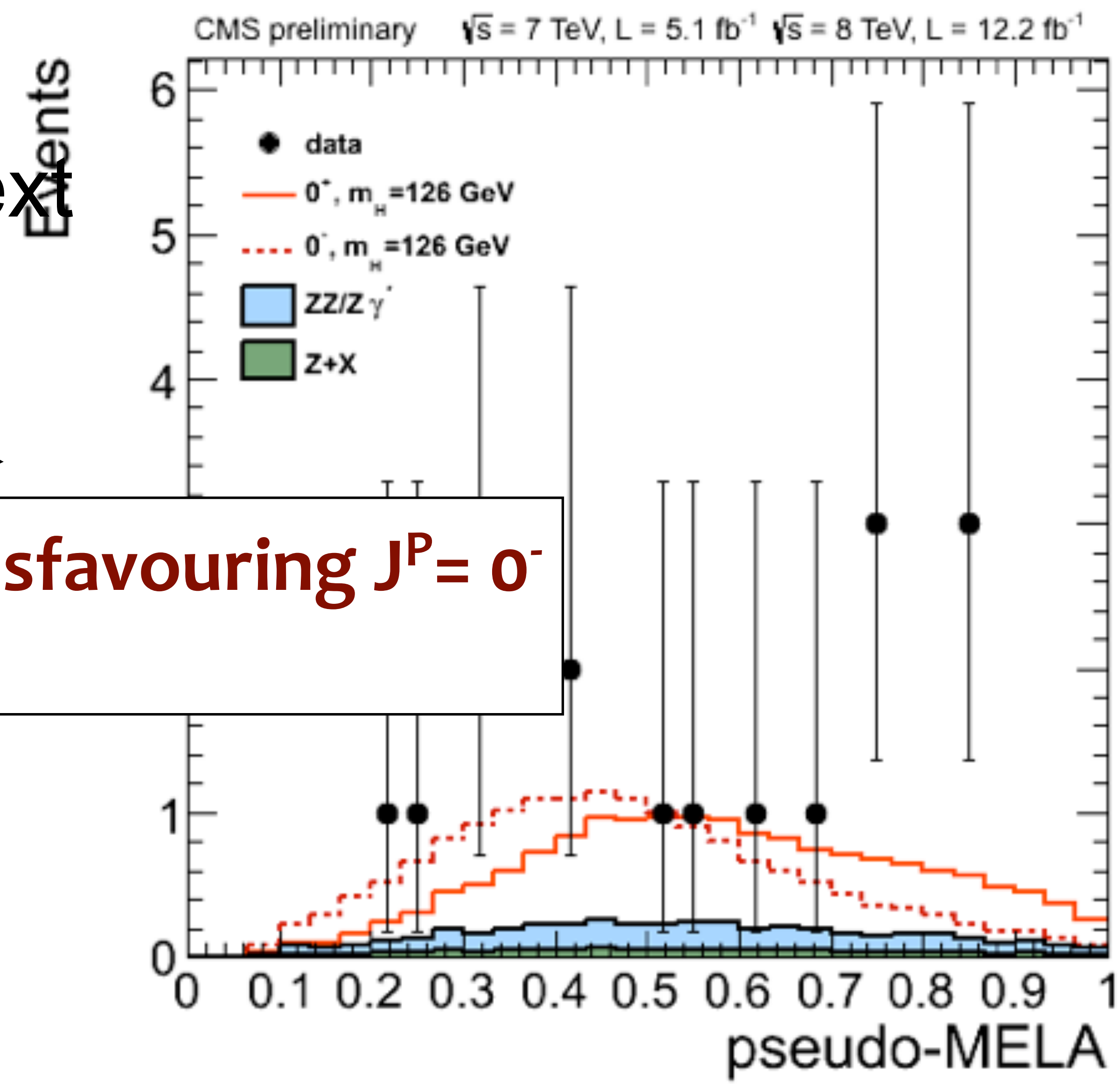
The **H->ZZ->4l** channel can exploit the angular information using the "MELA" methodology to test the hypothesis **$J^P = 0^+$ vs $J^P = 0^-$**

Signal BKG separation



0^+ 0^- separation

Text



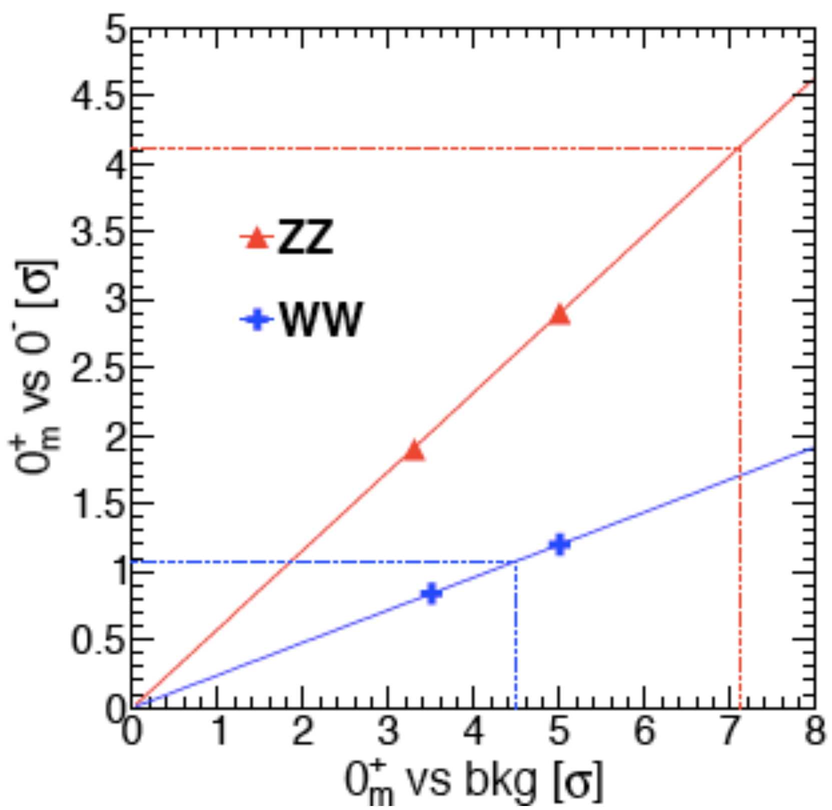
CLs criterion: ~ 3% disfavouring $J^P = 0^-$

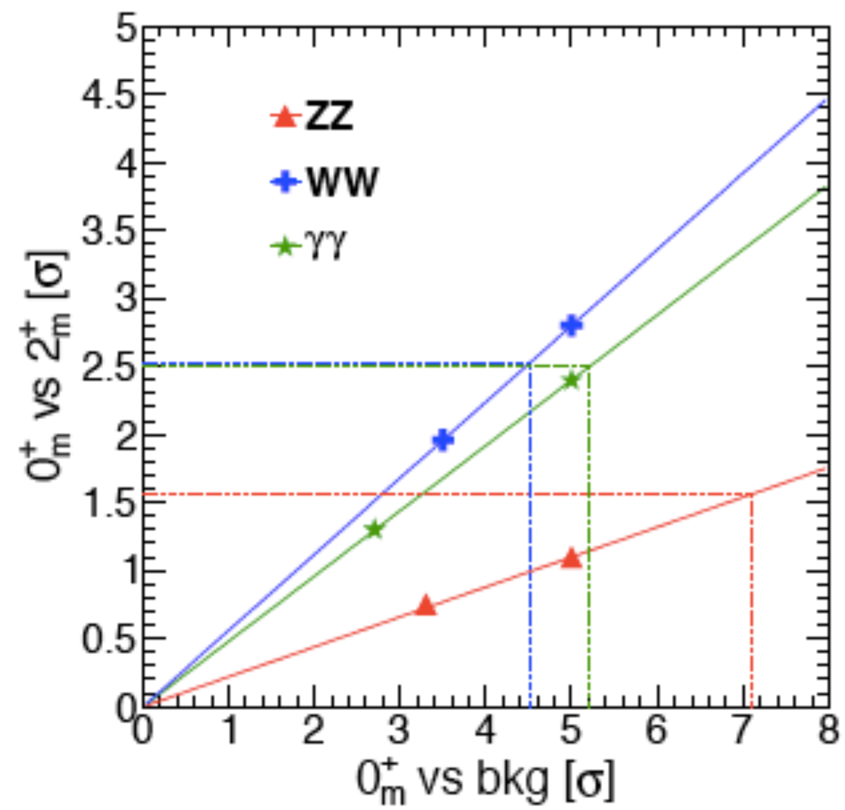
2012 run prospects : J^P

http://arxiv.org/abs/1208.4018

35 fb^{-1} 1 experiment

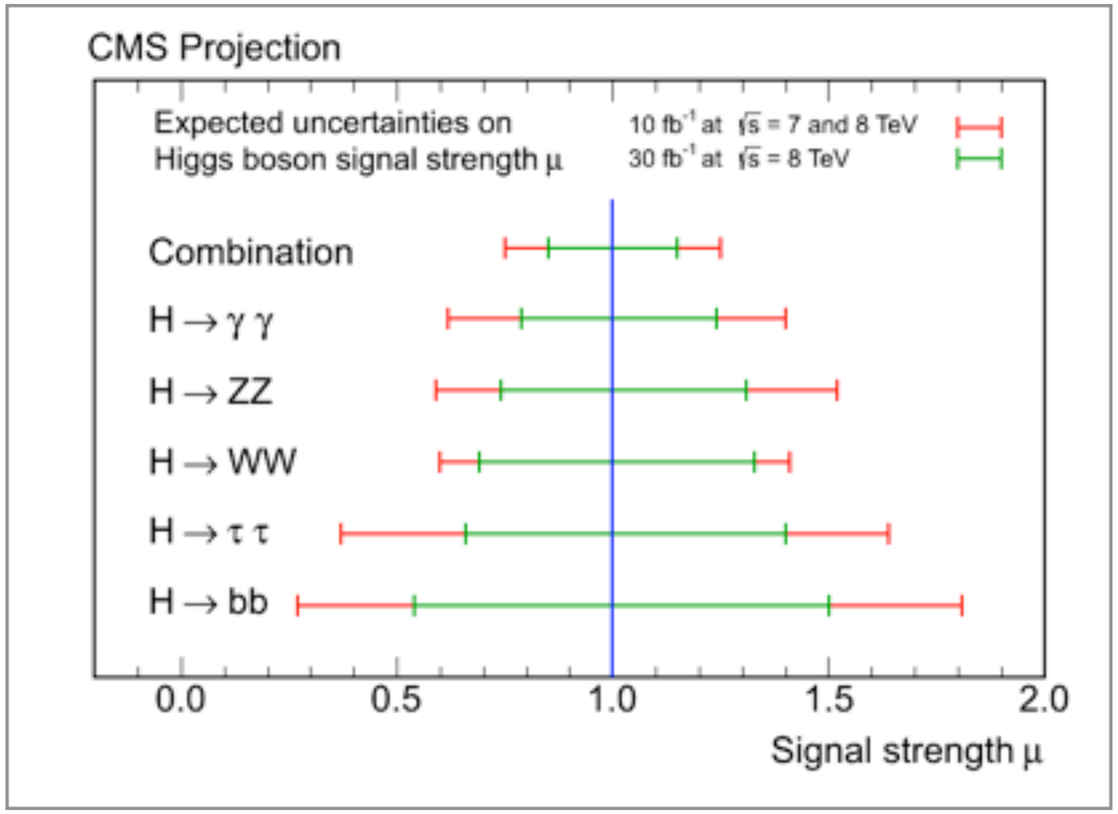
Angular analysis of final state H--> ZZ, WW, γγ

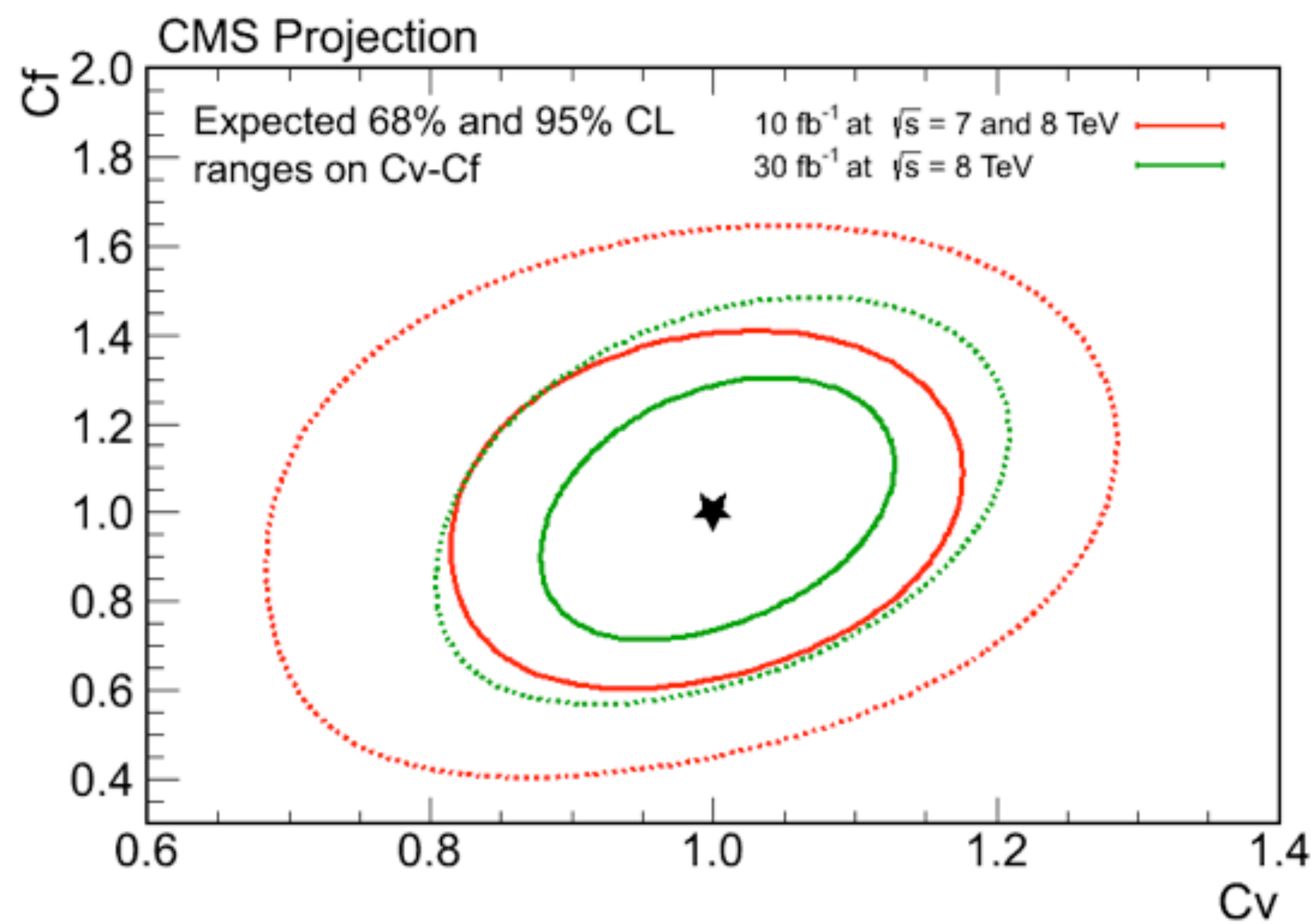




scenario	$X \to ZZ$	$X \to WW$	$X \to \gamma\gamma$	combined
0^+_m vs background	7.1	4.5	5.2	9.9
0^+_m vs 0^-	4.1	1.1	0.0	4.2
0^+_m vs 2^+_m	1.6	2.5	2.5	3.9

2012 run prospects: couplings





Conclusions 1

A narrow resonance has been observed by ATLAS and CMS at a mass near 125 GeV . The observation is consistent in both experiment and in both 2011 and 2012 data sets. It is a robust observation. The probability that this excess is a background fluctuations is smaller than 10^{-6} in each experiment becoming less than 10^{-5} when including the LEE effect.

gigi.rolandi@cern.ch

Conclusions 1

A narrow resonance has been observed by ATLAS and CMS at a mass near 125 GeV . The observation is consistent in both experiment and in both 2011 and 2012 data sets. It is a robust observation. The probability that this excess is a background fluctuations is smaller than 10^{-6} in each experiment becoming less than 10^{-5} when including the LEE effect.

It is compatible with the Standard Model Higgs.

There are however tantalizing 2 sigma effects that, if confirmed by the larger statistics to be collected in 2012, would be the first observation beyond the Standard Model.

Conclusions 2

The LHC experiments have given extensive proof of being able to deliver at high quality and over short time scales

We are just at the beginning of a long journey: with the 14 TeV run LHC will go in a new territory

gigi.rolandi@cern.ch

Conclusions 2

The LHC experiments have given extensive proof of being able to deliver at high quality and over short time scales

We are just at the beginning of a long journey: with the 14 TeV run LHC will go in a new territory