Run 1 results on the scalar boson: mass and couplings

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for the ATLAS & CMS collaborations

Introduction

- The discovery of a Higgs-like boson in 2012 has set new goals for the LHC experiments:
  - measure precisely the mass of the boson (the last free parameter in the Standard Model)
  - test if the particle is indeed a scalar boson
    → *topic of next talk*
  - test if its couplings are compatible with SM predictions (several BSM theories can contain Higgs-like particles)
  - search for rare or more challenging production or decay modes → *see talks in monday's BEH session*

Mass measurement

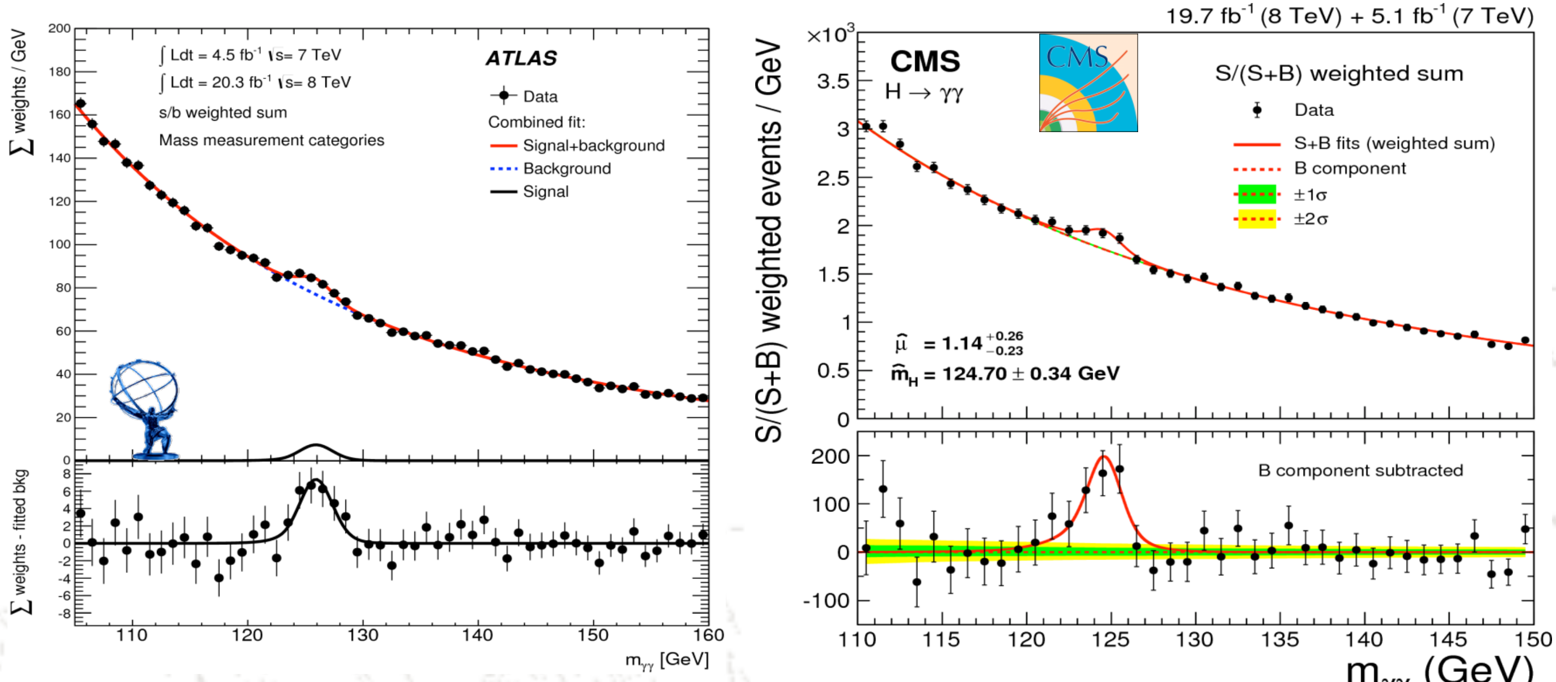
- The mass of the boson is directly accessible through the $H \to \gamma\gamma$ and $H \to 4\ell$ decays:
  - the kinematic of the decay is fully reconstructed
  - all final state objects can be precisely measured
  - theoretical issues negligible at the current precision
- Indeed, a mass measurement at 0.5% accuracy was available on the very day of the discovery!
- Improved analyses of the full Run 1 dataset have allowed gaining a factor 2 in precision

Analyses

- LHC experiments have released the final run 1 mass measurement papers in both final states:
  - ATLAS: 4ℓ + γγ combined paper [arXiv:1406.3827]
  - CMS: 4ℓ and γγ papers [arXiv: 1312.5353, 1407.0558], preliminary combination [HIG-14-009]
- Fundamental ingredient: excellent lepton and photon efficiency, resolution and energy scale calibration
  → see talks in monday's LHC Run 1 legacy session

H → γγ analysis strategy

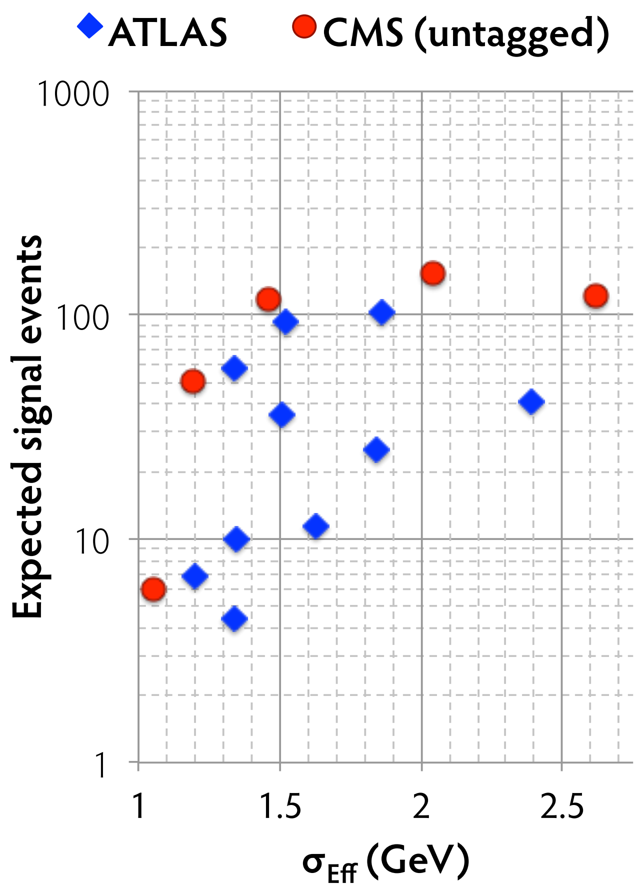
1. Fit narrow mass peak over smooth background
2. Enhance the sensitivity by categorizing events by purity and mass resolution.



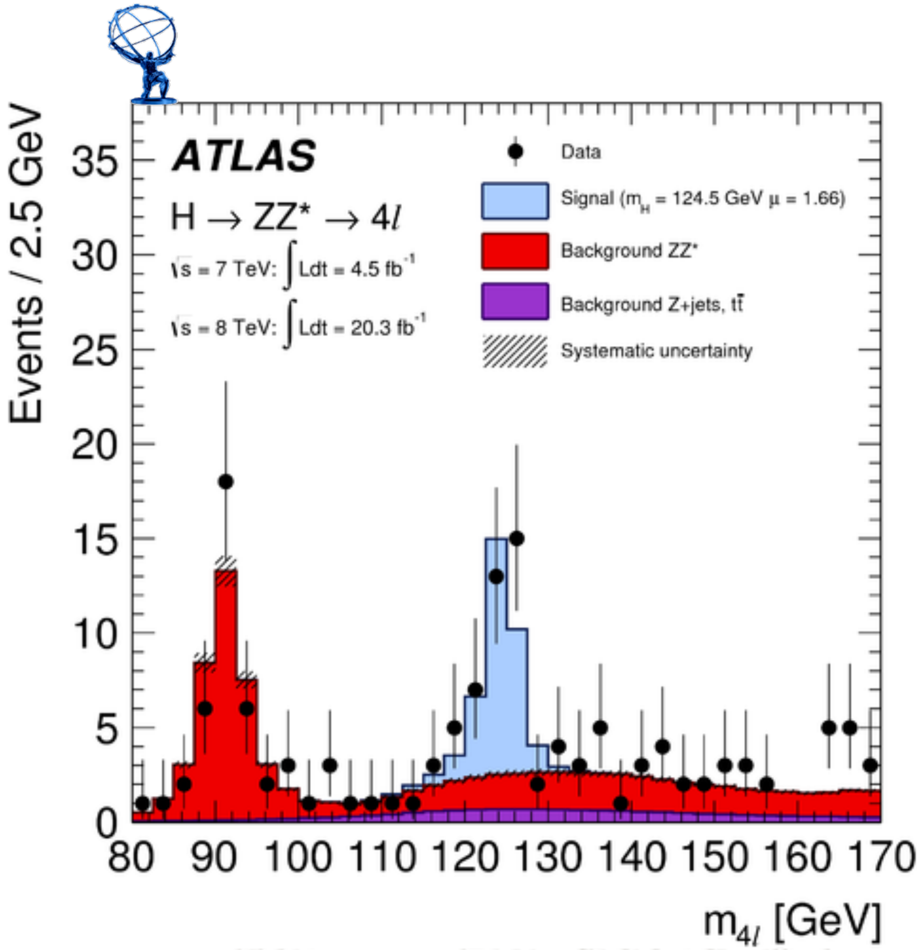
Categorization

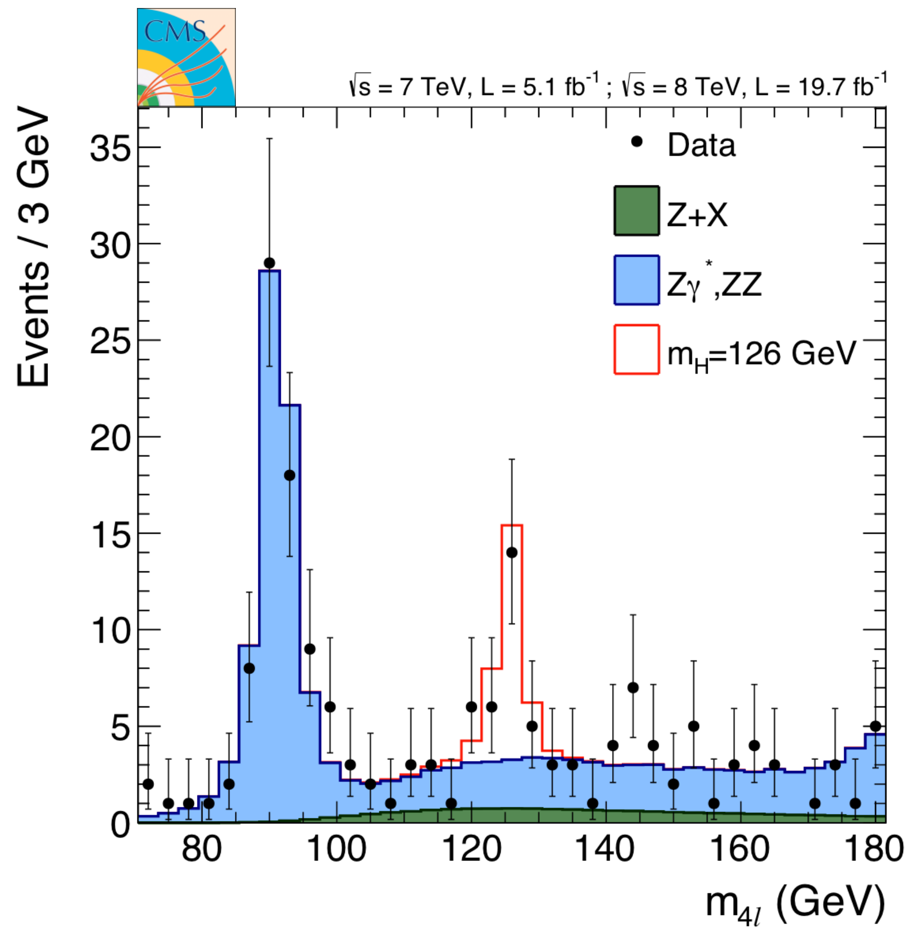
- ATLAS: dedicated event categorization for the mass measurement analysis:
  - Categorization by photon η and quality (unconverted vs converted), and by diphoton p_{Tt} (p_T rel. to trust axis)
- CMS: same analysis used for mass and couplings (and optimized for the latter)
  - Tagged categories for VBF, VH, ttH production modes: 7 topologies, based on jets, E_T^{miss}, leptons, b-tags
  - Untagged events categorized using a BDT classifier relying on photon p_T, η, purity, and m(γγ) resolution
- Larger variation of m(γγ) resolution in CMS categories compared to ATLAS ones

Comparison of γγ categories
√s = 8 TeV, m_H = 125 GeV



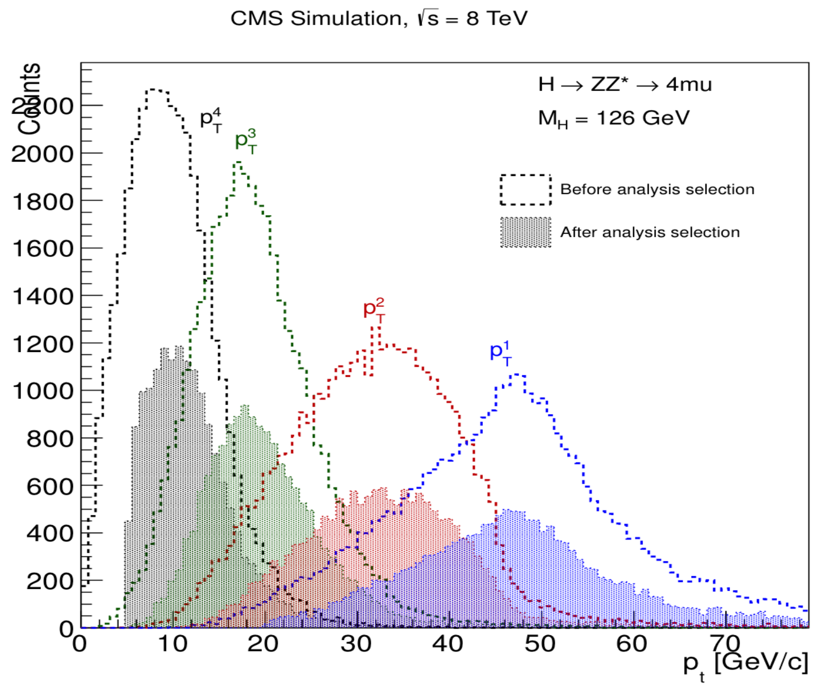
$H \to ZZ \to 4\ell$





$H \to ZZ \to 4\ell$ strategy

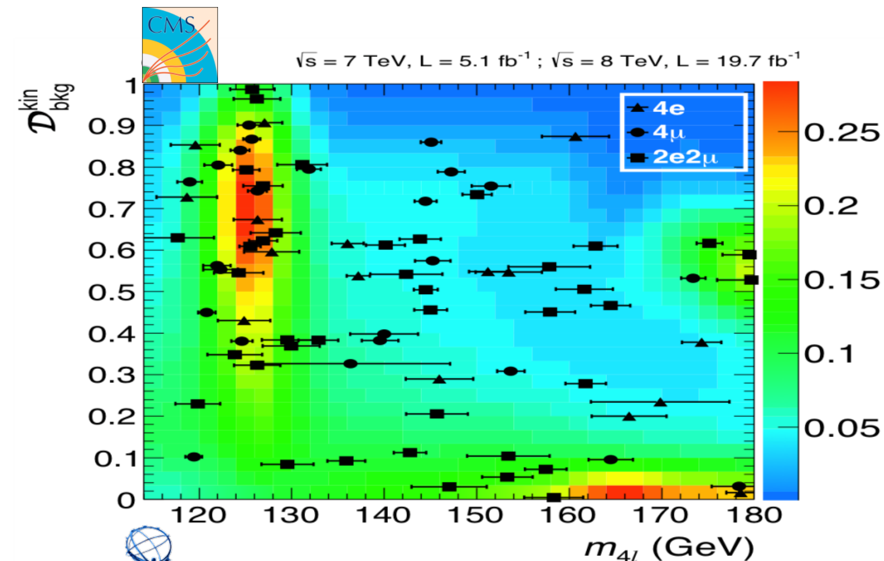
- Extremely clean signature, but challenging due to very low BR (10^{-4}) and soft lepton p_T spectrum

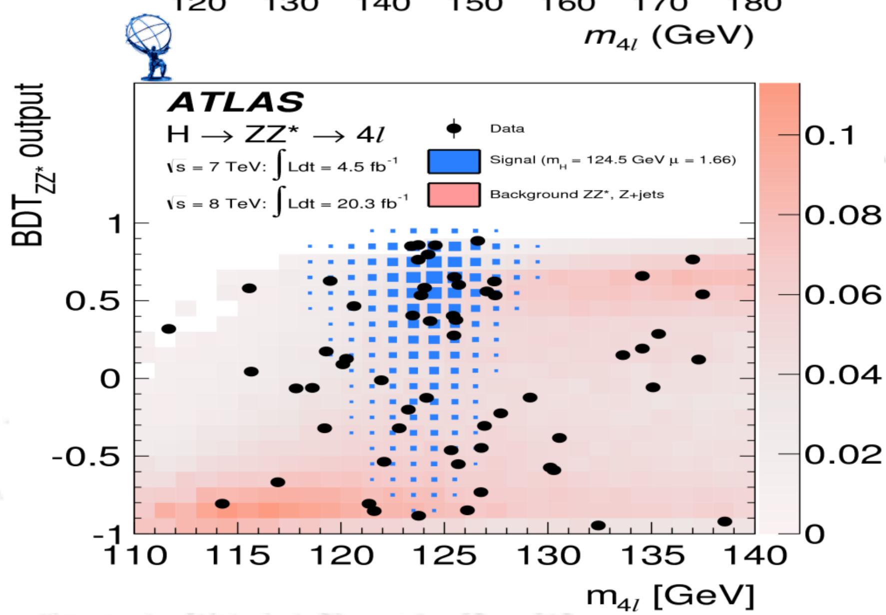


	ATLAS	CMS
μ	$p_T > 6$ GeV, $\lvert\eta\rvert < 2.7$	$p_T > 5$ GeV, $\lvert\eta\rvert < 2.4$
e	$p_T > 7$ GeV, $\lvert\eta\rvert < 2.5$	$p_T > 7$ GeV, $\lvert\eta\rvert < 2.5$

$H \to ZZ \to 4\ell$ strategy

- Extremely clean signature, but challenging due to very low BR (10^{-4}) and soft lepton p_T spectrum
- Fully reconstructed final state optimal for exploiting matrix element methods
  - Now included also in ATLAS analysis, combined in a BDT together with Higgs p_T and rapidity

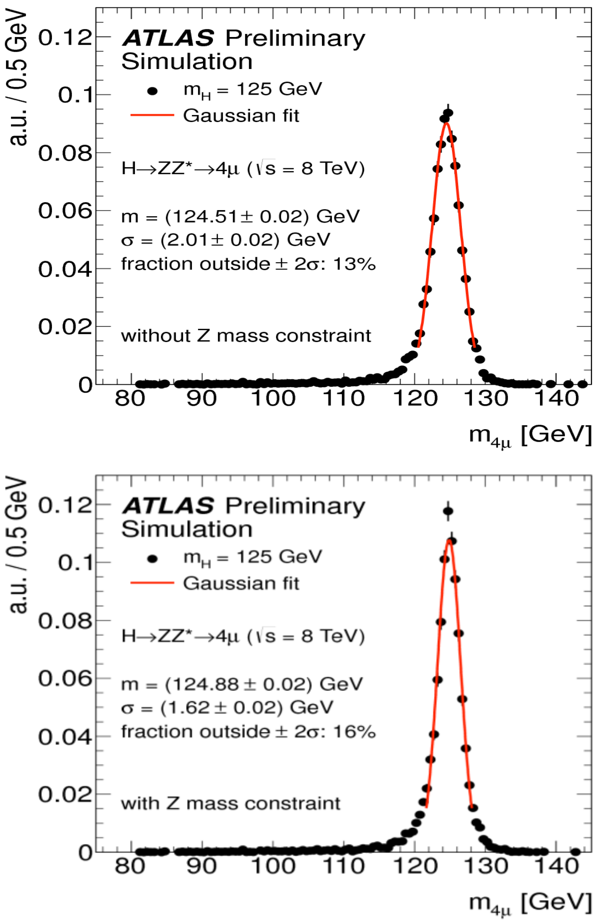




Improving further 4ℓ mass

- In ~75% of the H → ZZ → 4ℓ events, one Z boson is on mass shell:
  - a kinematic fit of the Z decay improves the m(4ℓ) resolution event by event, and reduces the energy scale systematic.
  - used by ATLAS only, ~15% gain on σ(m)

m(4μ) before and after Z → μμ refit



plot for illustration only, from ATLAS-CONF-2013-013

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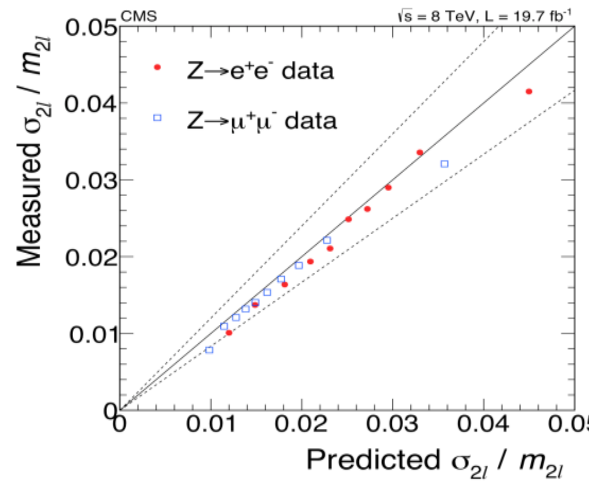
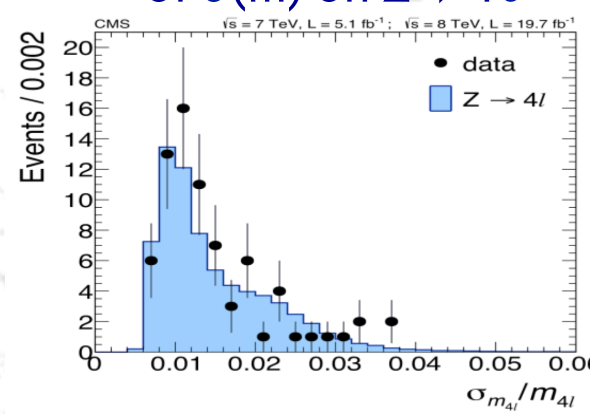
  - a kinematic fit of the Z decay improves the m(4ℓ) resolution event by event, and reduces the energy scale systematic.
  - used by ATLAS only, ~15% gain on σ(m)
- Lepton momentum resolution dependent on p_T, η, and quality (esp. for electrons)
  - m_H fit can be performed using the individual m(4ℓ) resolutions of each observed event
  - now used also by ATLAS (as cross-check)
- Identification of photons from final state radiation recovers signal tail at low m(4ℓ), and improves isolation efficiency
  - now implemented also in ATLAS analysis

validation of ev-by-ev mass errors on Z → ℓℓ

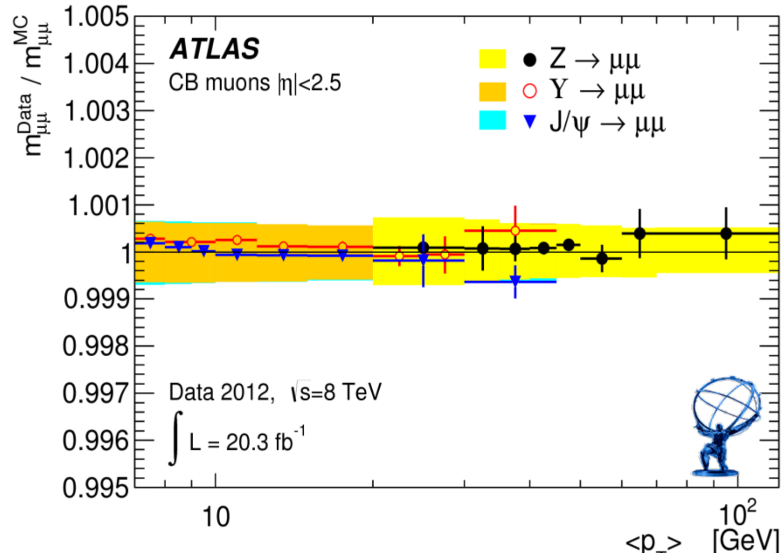


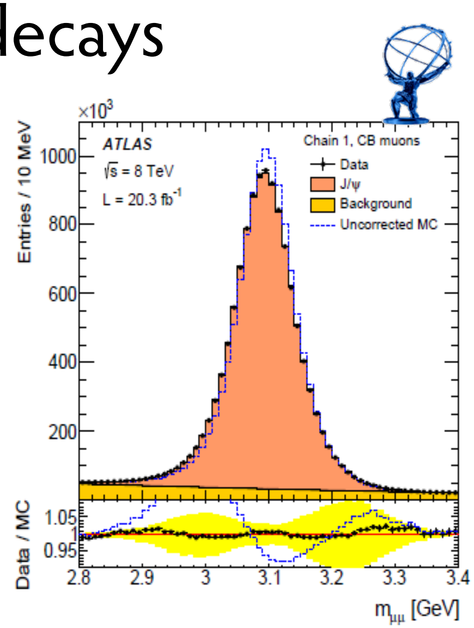
data/mc comparison of σ(m) on Z → 4ℓ

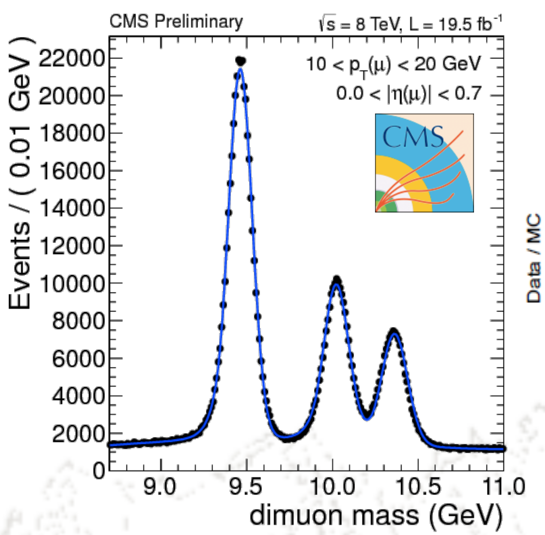


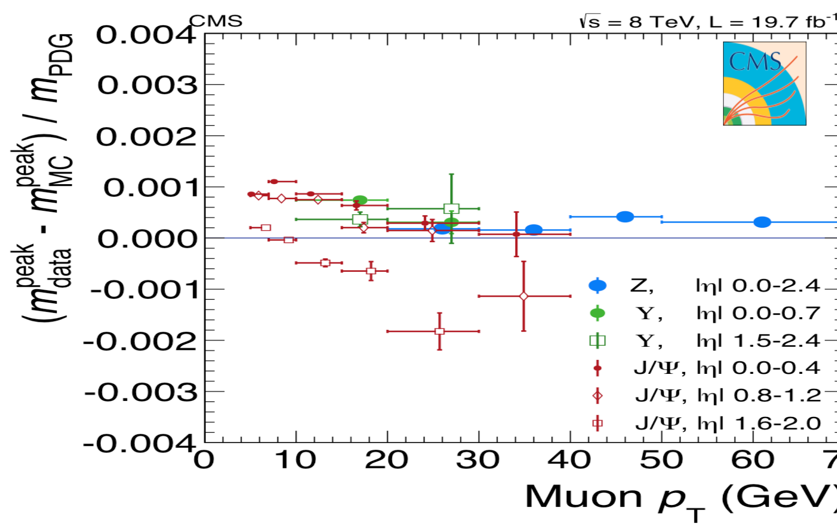
Systematics: muon momentum scale

- Muon momentum scale calibrated and validated on Z, J/ψ, Υ decays





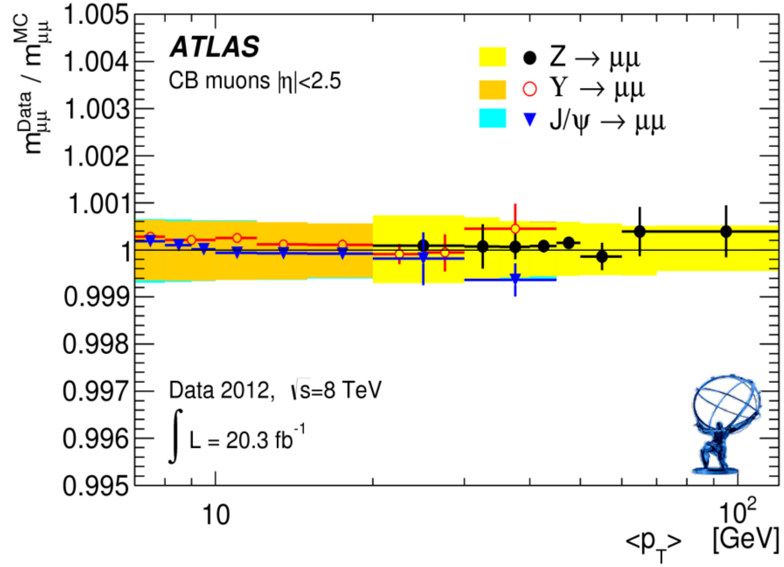


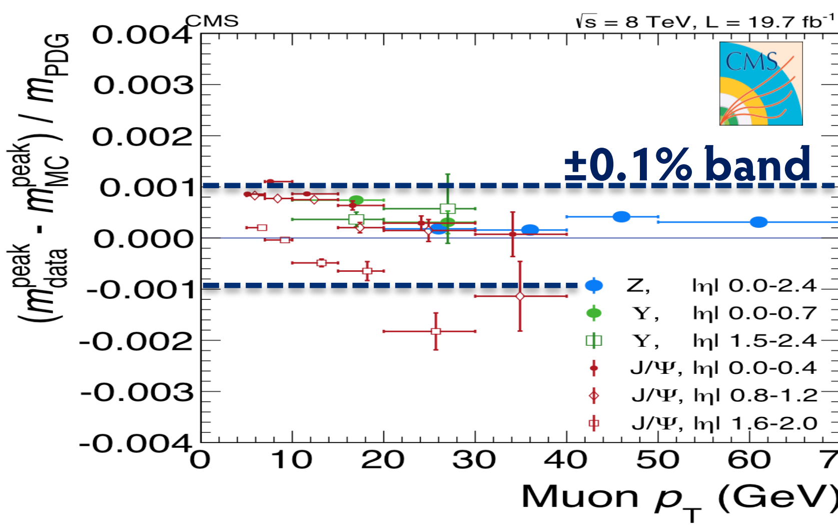


Systematics: muon momentum scale

- Muon momentum scale calibrated and validated on Z, J/ψ, Υ decays
- After calibration, the systematic uncertainty on m_H from the muon scale is negligible with respect to the statistical uncertainty:
  - ATLAS: 0.04%
  - CMS: 0.1% (conservative)

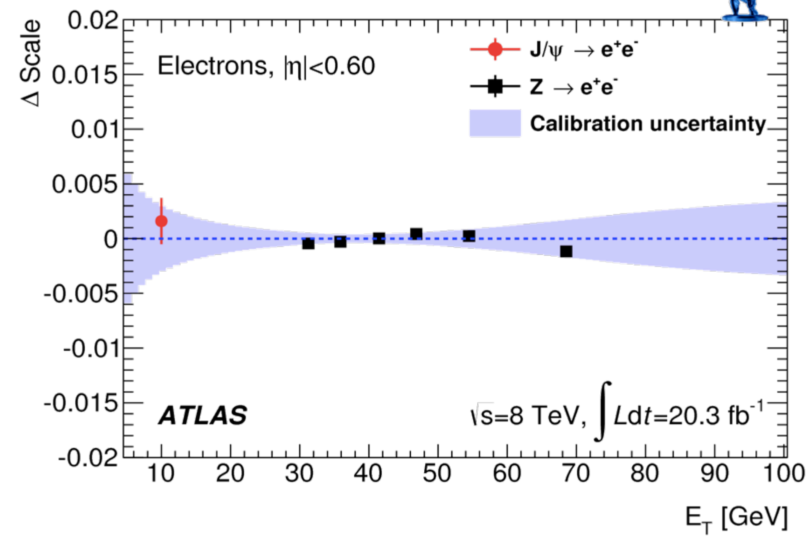
(stat. uncertainty: ~0.4%)

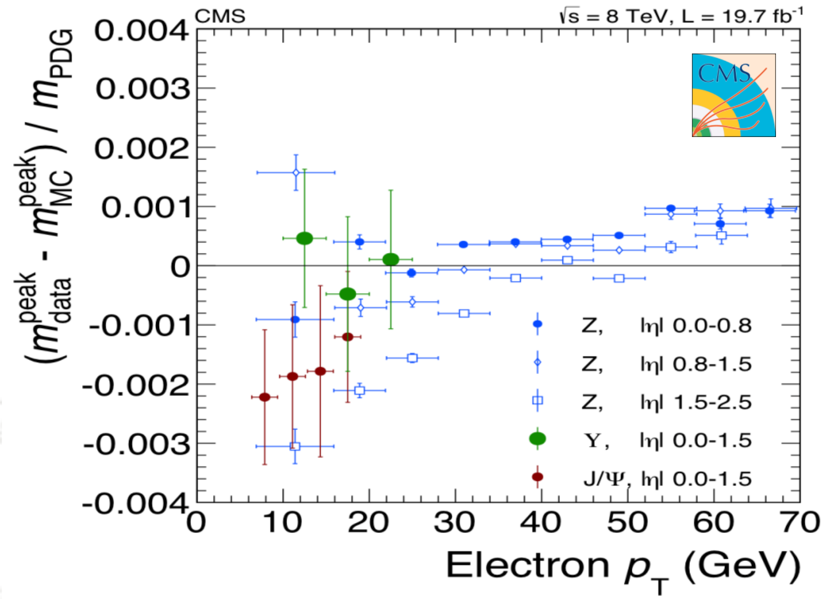




Systematics: electrons energy scale

- Similar approaches as for muons at Z peak, but more challenging at low p_T:
  - smaller calibration samples of J/ψ, Y (due to trigger)
  - relative weight of calo & tracker changes with p_T
- Scale uncertainty on m(4e): 0.3% (CMS), 0.04% (ATLAS)
- Impact on m_H reduced by the smaller weight of 4e and 2μ2e states wrt 4μ, 2e2μ in comb.
  - also by Z1 refit for ATLAS



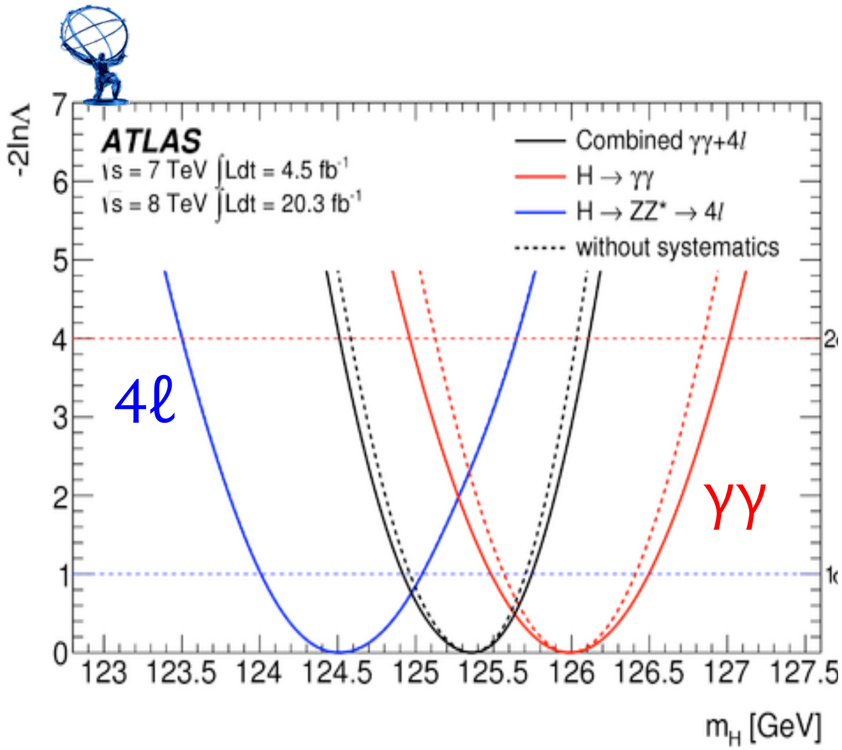


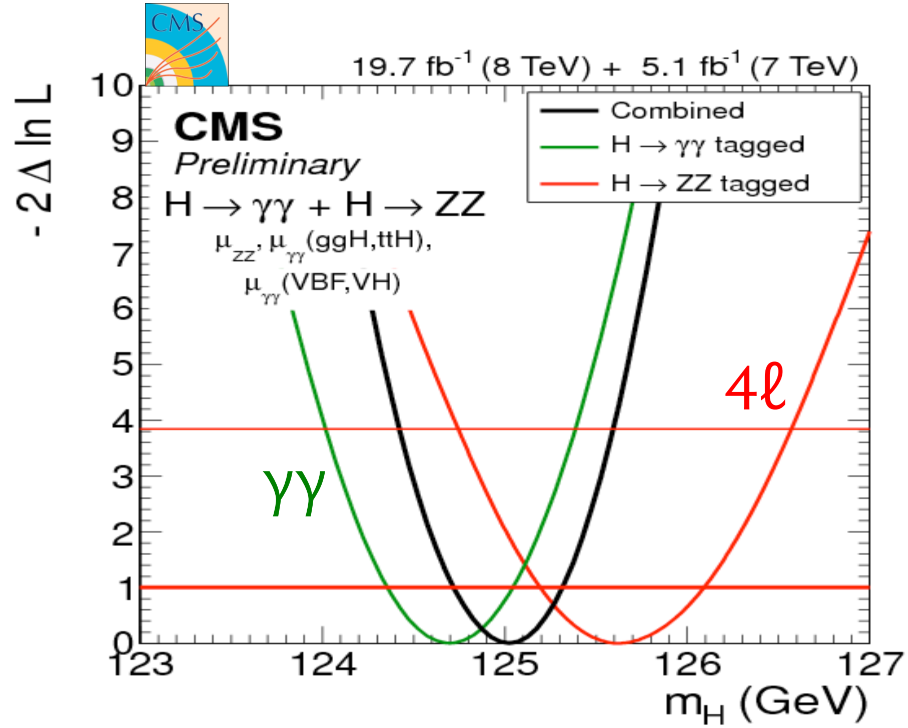
Systematics: photons

- Energy scale calibrated on $Z \rightarrow ee$ in data, then extrapolated to $H \rightarrow \gamma\gamma$ using MC. Main challenges:
  - Linearity: harder p_T spectrum in H(125) vs Z(91.2)
  - Photon to electron differences in data vs MC: from uncertainties in material description, longitudinal calibration, shower modelling.
- The scale uncertainty drives the systematic on the m_H measurement in $\gamma\gamma$ channel.
  - ATLAS vs CMS difference, due to more challenging response calibration for ATLAS detector (see backup)

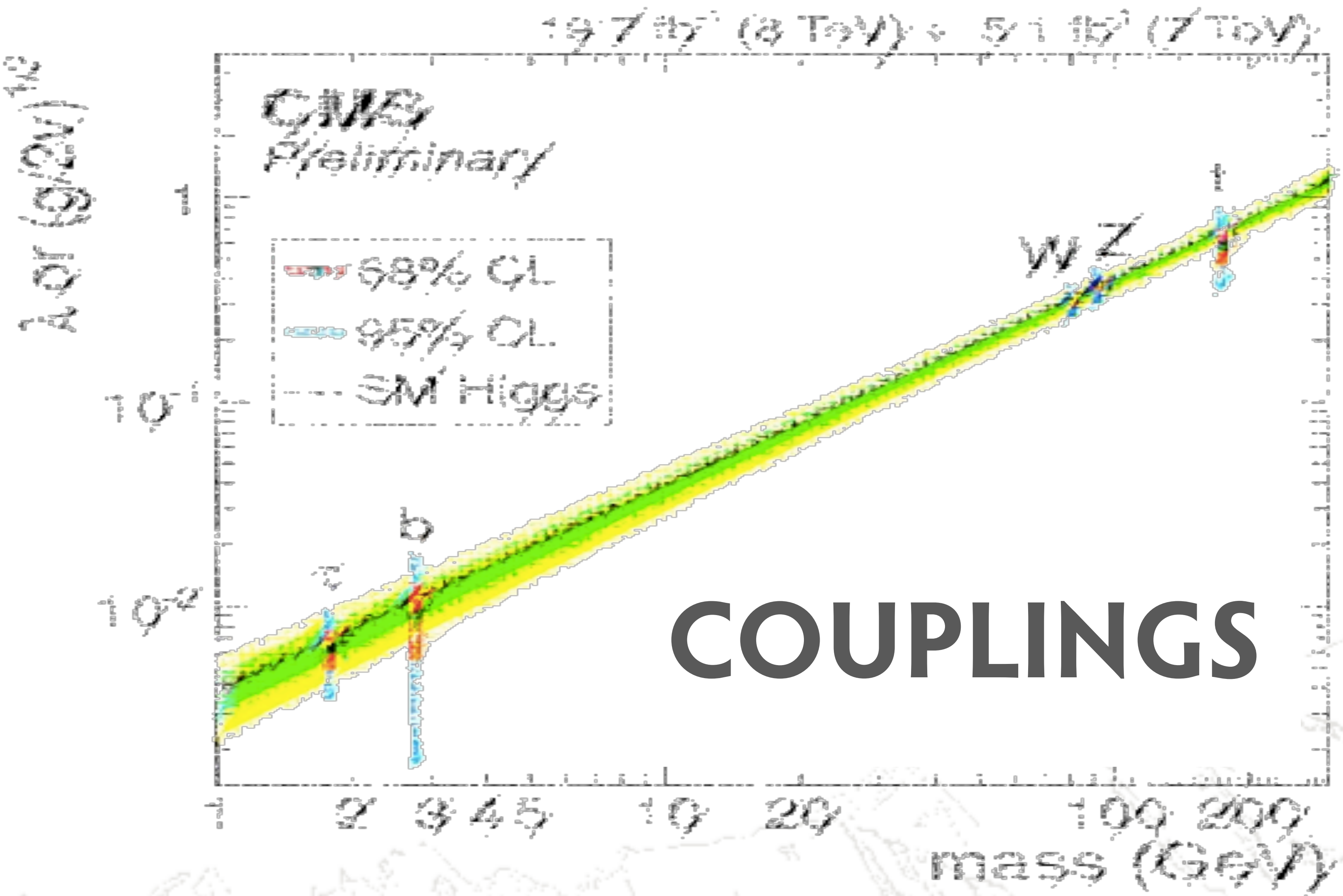
	stat.	syst.	comb.
ATLAS γγ	0.42 GeV	**0.28 GeV**	0.50 GeV
CMS γγ	0.31 GeV	**0.15 GeV**	0.35 GeV

Results





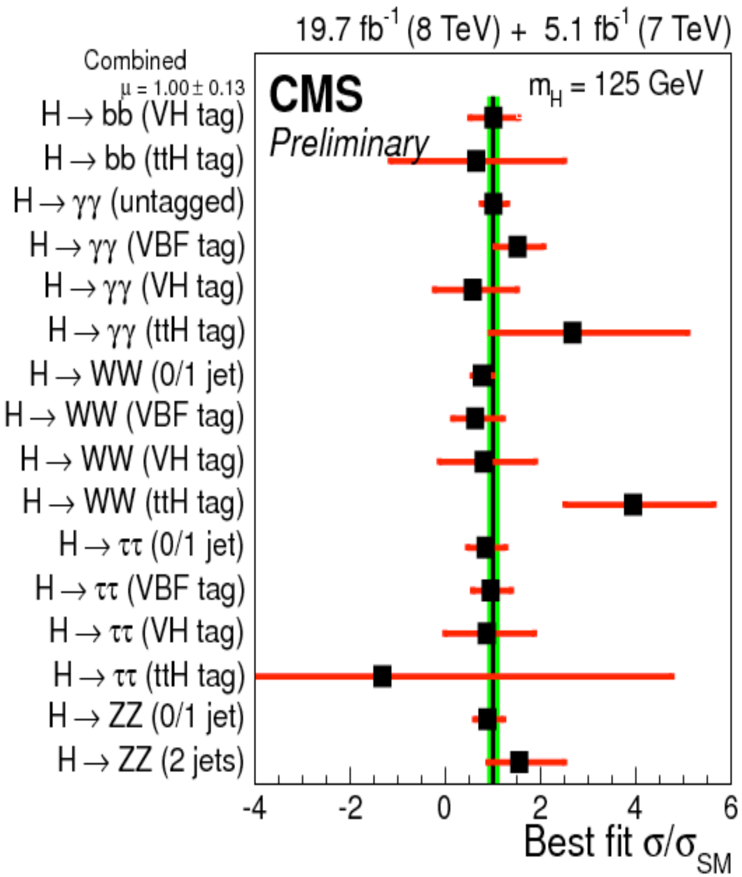
	ATLAS fit ± stat. ± syst	CMS fit ± stat. ± syst
γγ	125.98 ± 0.42 ± 0.28 GeV	124.70 ± 0.31± 0.15 GeV
4ℓ	124.51 ± 0.52 ± 0.06 GeV	125.8 ± 0.4 ± 0.2 GeV
comb	125.36 ± 0.37 ± 0.18 GeV	125.03 ± 0.26 ± 0.14 GeV


19.7 fb⁻¹ (8 TeV) + 5.1 fb⁻¹ (7 TeV)
CMS
Preliminary
68% CL
95% CL
SM Higgs
b
W Z
t
mass (GeV)

COUPLINGS

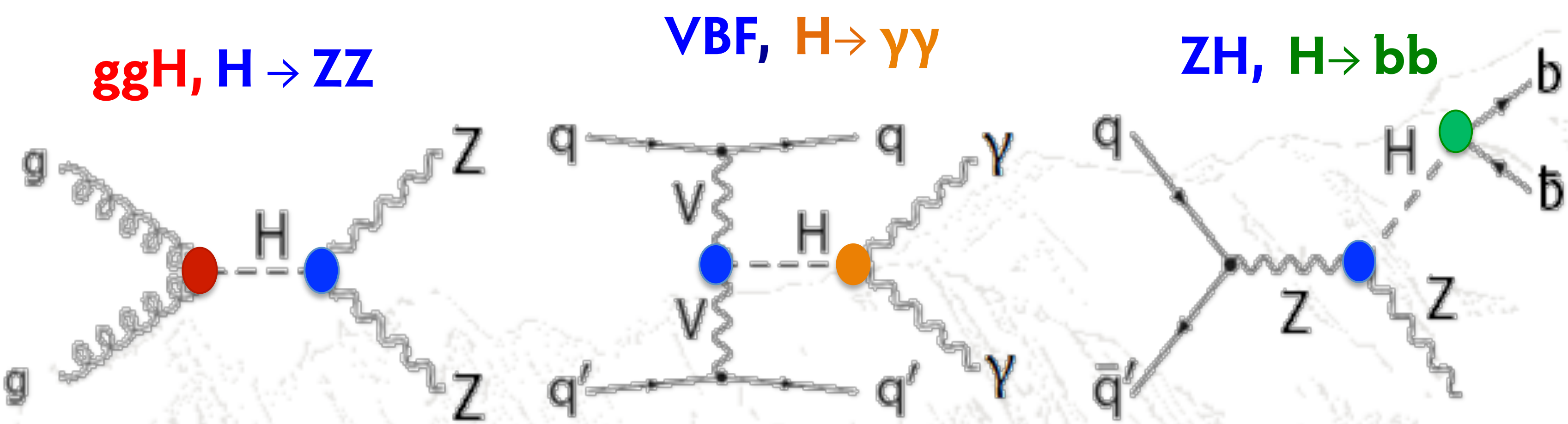
Testing compatibility with the SM

- Probing for the Higgs boson in many final states allows testing compatibility with the SM predictions, but:
  - sensitivity in many individual final states is limited
  - contributions from different production or decay modes hard to disentangle in some topologies (e.g. H+jets), making results harder to interpret in BSM models



Why couplings?

- Analyzing the combined data in terms of couplings helps overcoming these limitations:
  - harvests all information on the same coupling from both production and decay, in all experimental final states
  - allows direct comparison with BSM predictions without requiring theorists to simulate our experimental analyses



Input analyses

decay	production mode tags: incl.	VBF	VH	ttH
WW	CMS ATLAS	CMS ATLAS	CMS ATLAS	CMS
ZZ	CMS ATLAS	CMS ATLAS	CMS (*) ATLAS	CMS
γγ	CMS ATLAS	CMS ATLAS	CMS ATLAS	CMS ATLAS
bb		CMS	CMS ATLAS	CMS ATLAS
ττ	CMS ATLAS	CMS ATLAS	CMS ATLAS	CMS

CMS ATLAS = Included in comb. (full 8 TeV dataset)

CMS ATLAS = Full 8 TeV analyzed, but not yet in comb.

(*) Not a dedicated category, but the di-jet discriminant can separate VH(V→jj) from ggH+jets and VBF

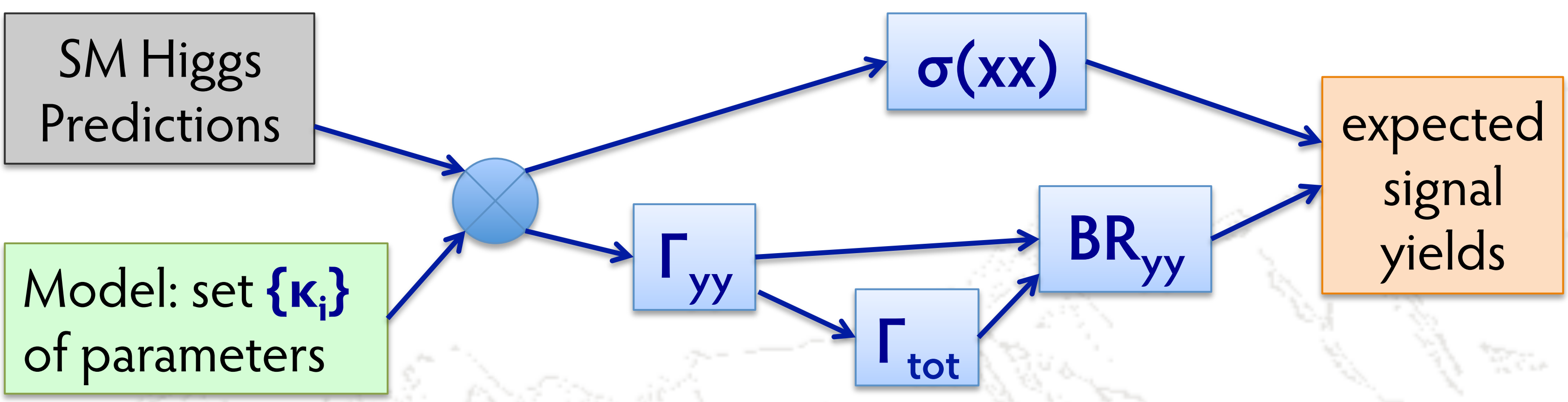
- CMS: preliminary combination [HIG-14-009], but all included inputs are now submitted as final run 1 papers
- ATLAS: preliminary combination [ATLAS-CONF-2014-009] of *in itinere* papers on WW, ZZ, γγ and preliminary bb, ττ
- Direct H→invis, Zγ, μμ searches exist but are not included

Testing couplings

- Framework set within LHC Higgs XS WG [CERN YR3].
- Assume a single, narrow width, scalar boson:

$$\sigma(xx \to H \to yy) = \sigma(xx) \times \Gamma_{yy} / \Gamma_{tot}$$

- Parameterize deviations of σ and Γ from their SM values in terms of coupling modifiers κ_i (or ratios $\lambda_{ij} := \kappa_i/\kappa_j$).



Approximations and assumptions

- We account for deviations only in expected yields, not in the kinematics of individual processes

→ limitation of experimental analyses and of used theory inputs

- We don't have higher order corrections in theory predictions except for the SM case ($\kappa = 1$)

→ limitation of theoretical predictions

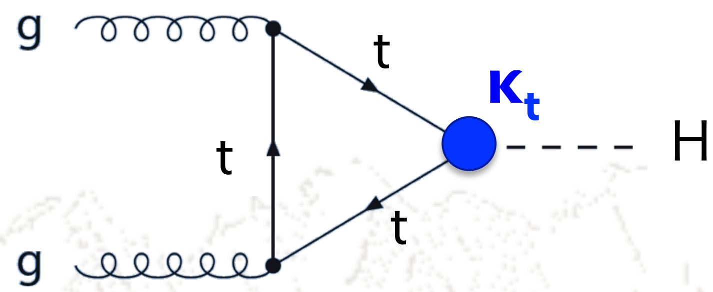
- Assumptions are needed on unmeasured couplings, (e.g. same relative deviations for charm and top)

→ limitation of the hadron collider environment

- We assume no beyond SM Higgs production modes, and that backgrounds are only from SM

General fits

- Full Run 1 dataset allows testing fairly general models, which can be constructed as following:
  1. Start introduce modifiers for tree-level couplings to W, Z, t, b, τ: κ_W, κ_Z, κ_t, κ_b, κ_τ (or use a common κ_V)
  2. Two choices for loop-level contributions (e.g. σ_{ggH}, $\Gamma_{\gamma\gamma}$):
     A. Assume only SM particles in the loop: contribution can be computed in terms of κ_W, κ_Z, κ_t, κ_b, κ_τ



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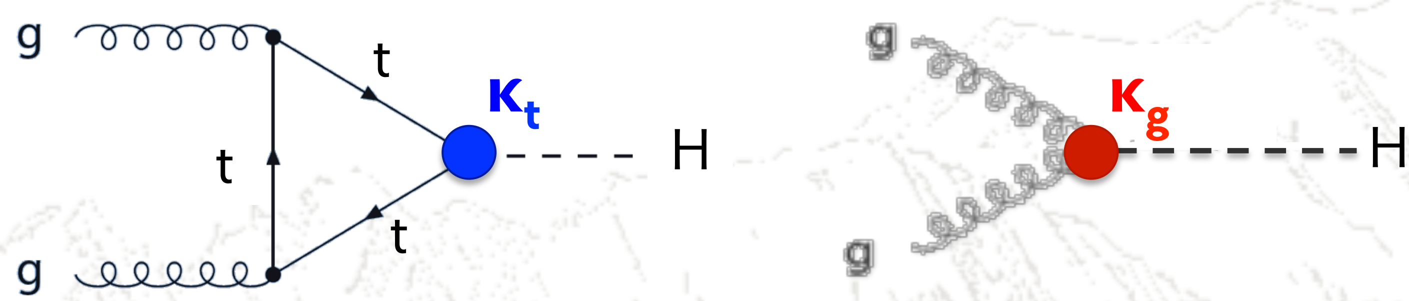
     B. Be agnostic: introduce effective κ_g, κ_γ parameters



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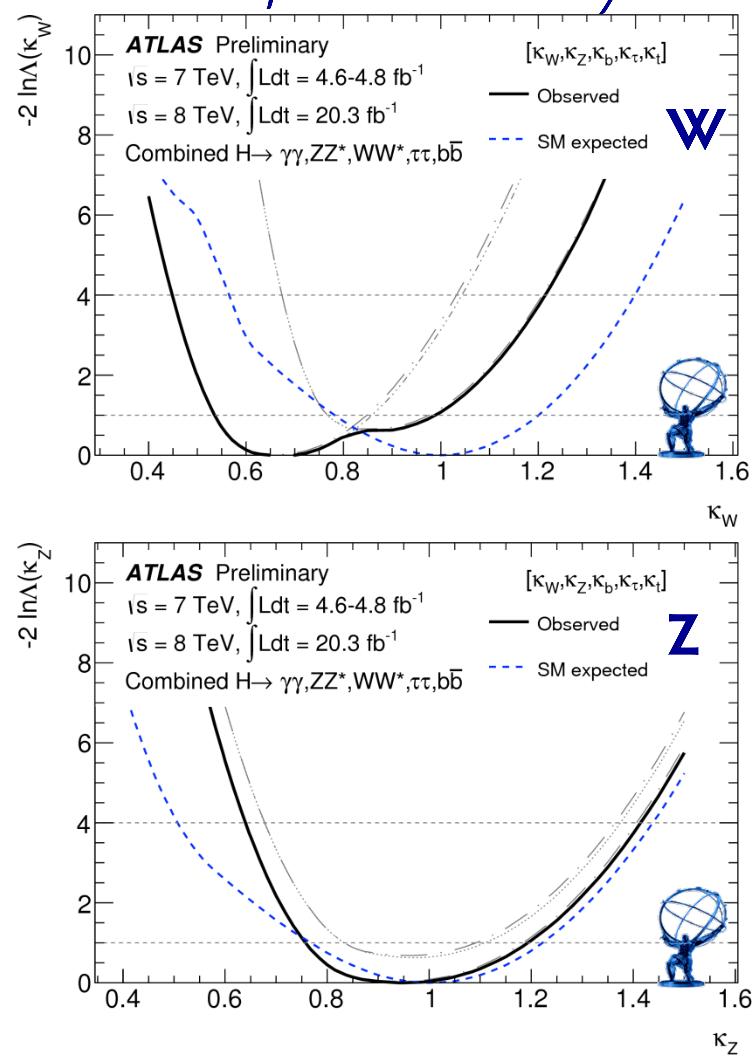
     - B. Be agnostic: introduce effective κ_g, κ_γ parameters
- An alternative paradigm is instead to parameterize everything in terms of coupling ratios λ_{XY}, except for one reference process setting the overall scale (by convention taken to be ggH, $H \to ZZ$)

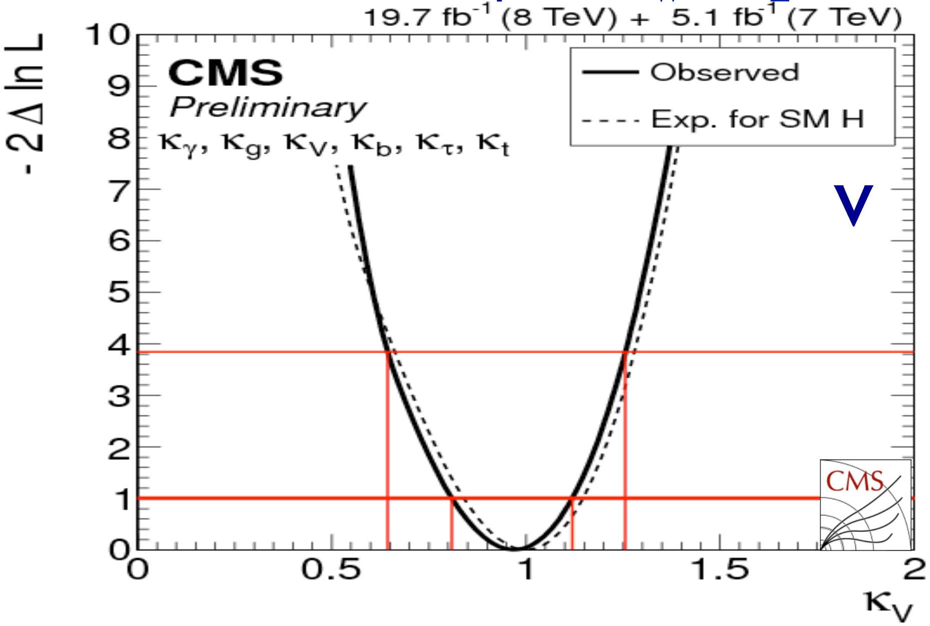
Vector bosons

- W and Z couplings tested at the 15-20% level.
- Good compatibility with SM predictions

ATLAS, tree-level only κ's



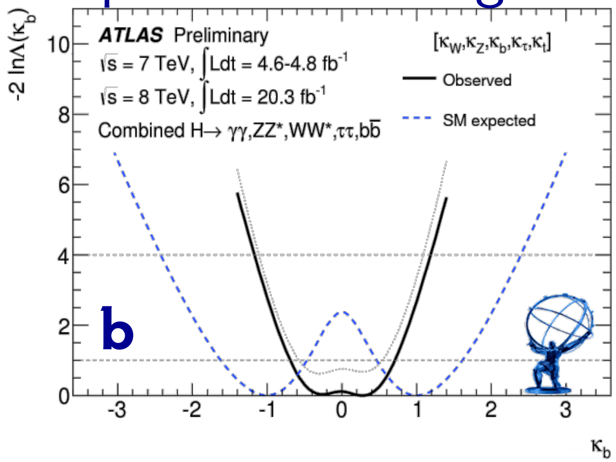
CMS, tree & loop κ's, $\kappa_W = \kappa_Z$

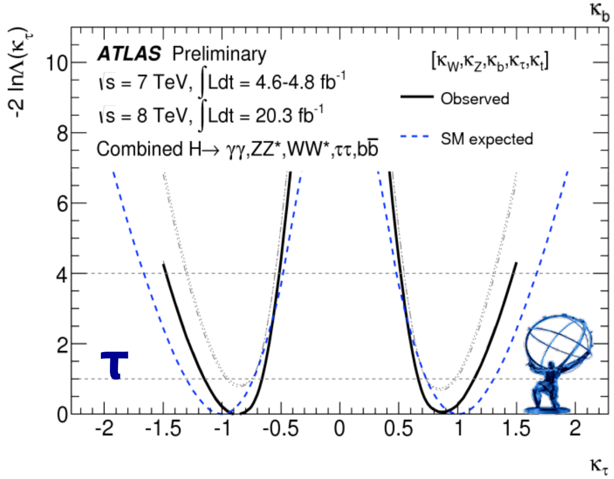


Bottom, Tau

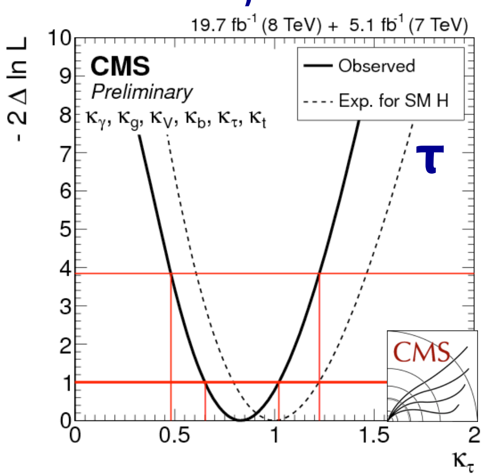
- Coupling probed at the 30-40% level
  - Agreement with SM, with some preference for smaller κ values
- Deviations on b couplings also affect strongly the yields in other modes through Γ_{bb} in Γ_{tot} at denominator
  - and cancellation Γ_{bb} / Γ_{tot} in makes VH→bb yield not so sensitive to κ_b

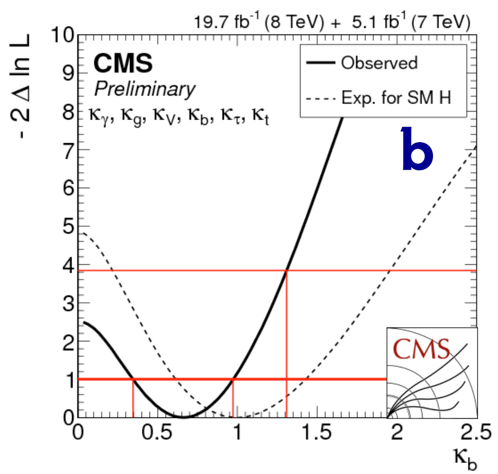
ATLAS, tree-level only κ's: interference in γγ and gg loops sensitive to sign of κ





CMS, tree & loop κ's: assume κ > 0

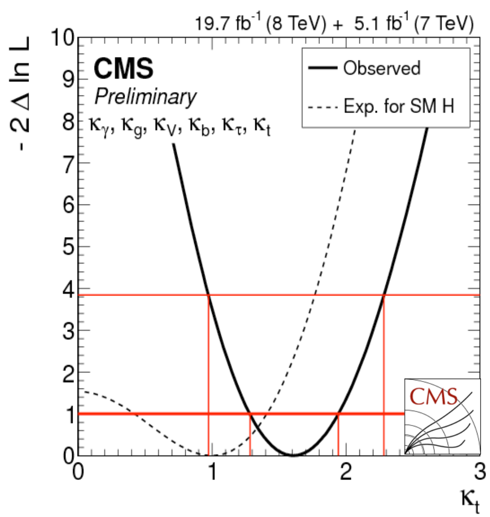




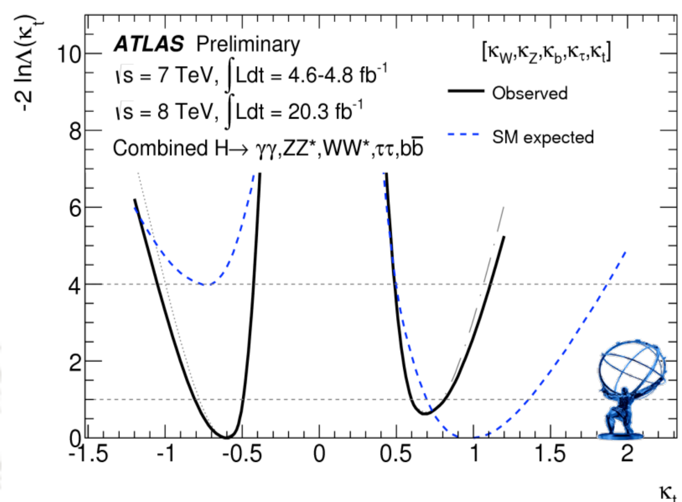
Top

- Can be probed directly via ttH production:
  → dedicated talk on ttH in monday's BEH session
- Also probed indirectly via loops in gluon fusion production and H → γγ partial decay width:
  - Requires the assumption of no BSM particles in loop

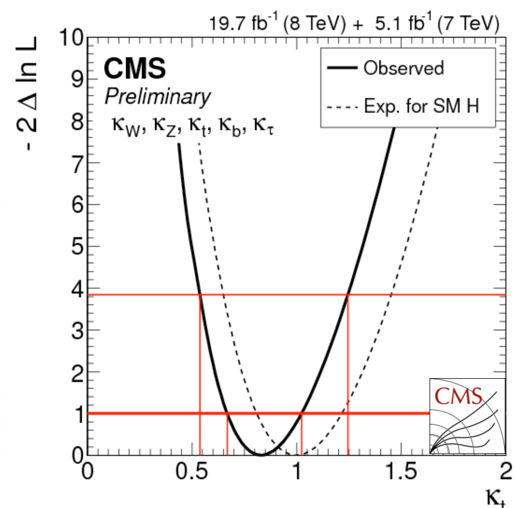
CMS, ttH only: Δκ/κ ~ 40-50%



ALAS, loop only: Δκ/κ ~ 30% (ttH not in this combination)



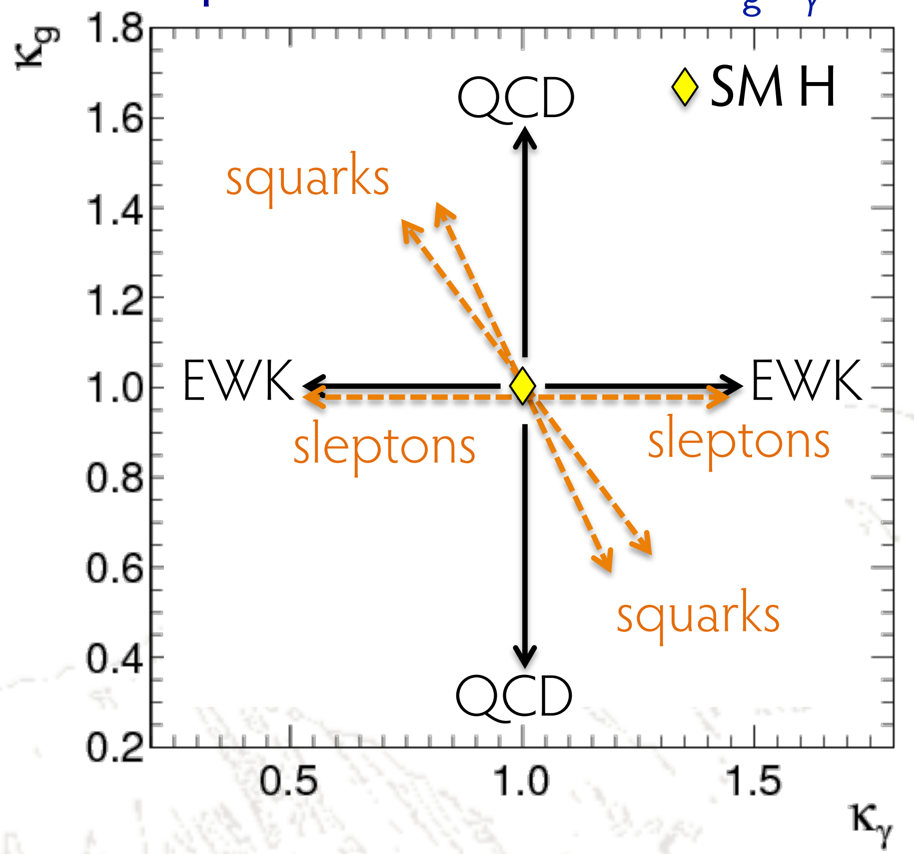
CMS, loops & ttH: Δκ/κ ~ 25%



Loop-induced couplings

- Effective couplings to gluons and photons are good probes for new physics beyond the SM:
  - Extra coloured particles can affect gluon fusion
  - Extra charged particles can affect $H \to \gamma\gamma$ decay
- BSM extensions like top partners give correlated deviations in the two

A qualitative sketch of possible deviations in κ_g κ_γ



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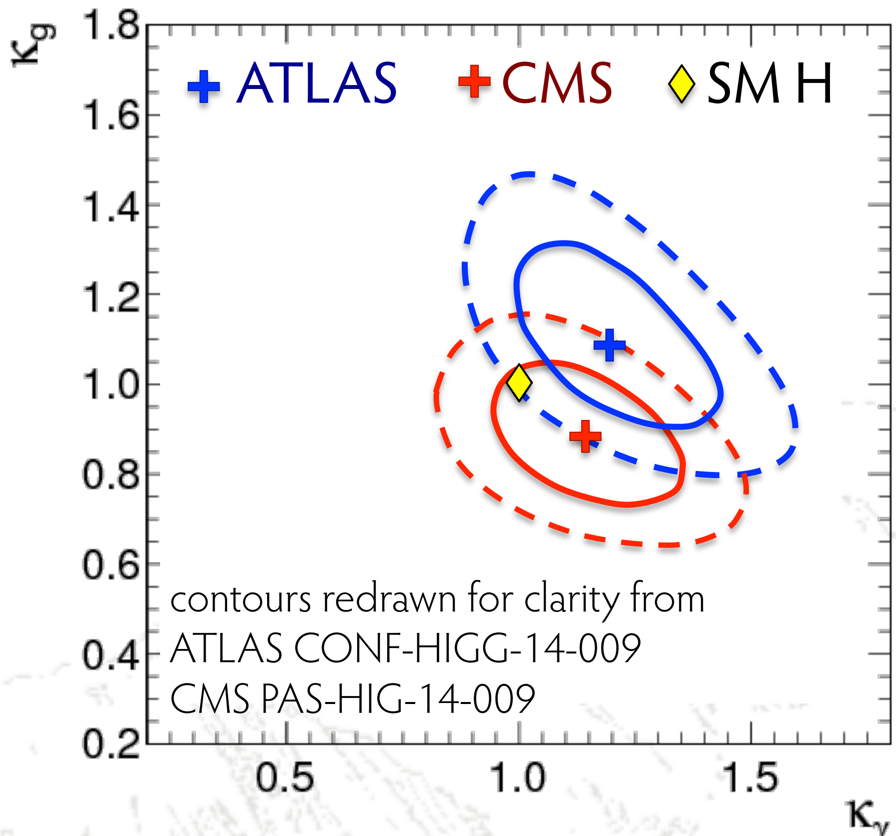
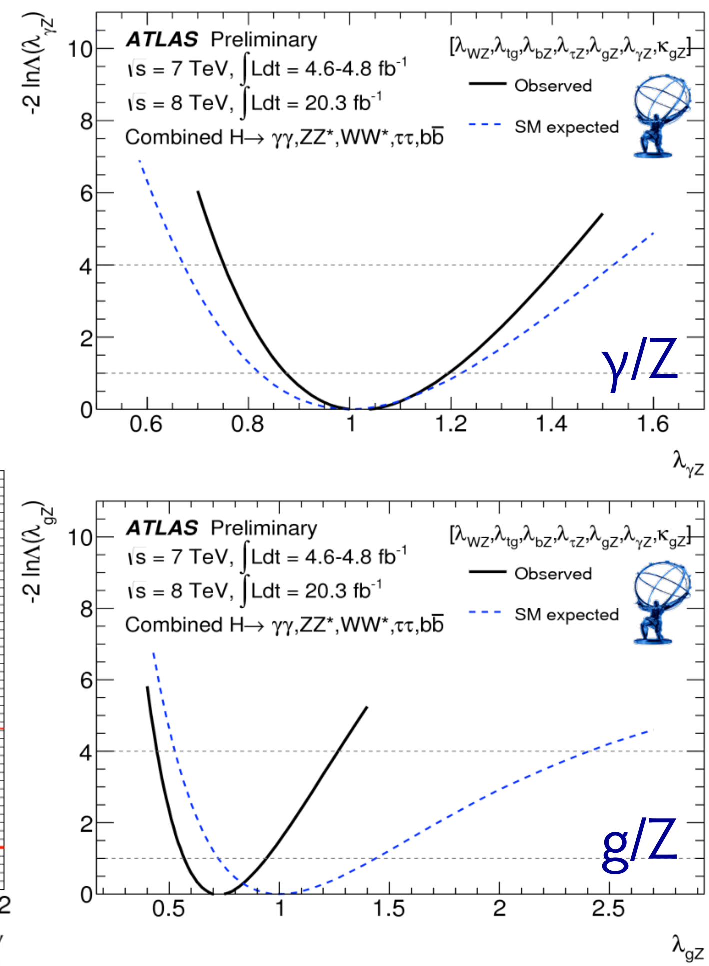
ATLAS & CMS: simplified model with only loop couplings floating



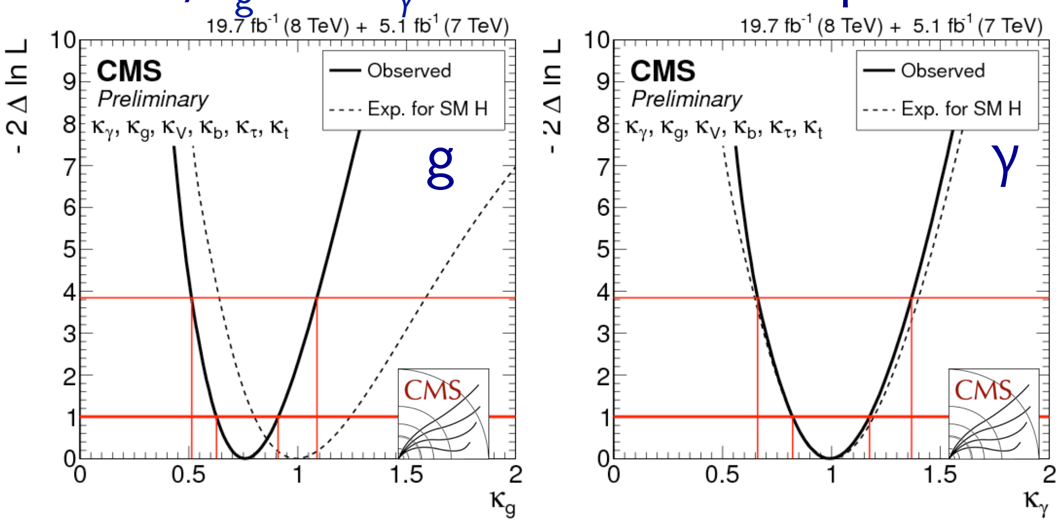
Loop-induced couplings

- In more general fits, deviations in couplings to photons tested at 15-20%, gluons at 20–30%
- Hard to constrain correlated shift in $\sigma(ggH)$ and Γ_{tot} (e.g. from κ_b):
  - cancellation in ggH → VV, γγ yields

ATLAS, g/Z and γ/Z from full coupling ratio model



CMS, κ_g and κ_γ from full tree+loop model



Probing BSM decays

- New physics can introduce new Higgs decay modes not detected at LHC.
  $$\Gamma_{tot} = \Gamma_{SM}(\kappa_i) + \Gamma_{BSM}$$
- A larger Γ_{tot} can be resolved from a deviation in the κ's if we have some assumption.

$$\sigma(xx) \sim \kappa_x^{\,2}$$

$$\Gamma_{yy} \sim \kappa_y^{\,2}$$

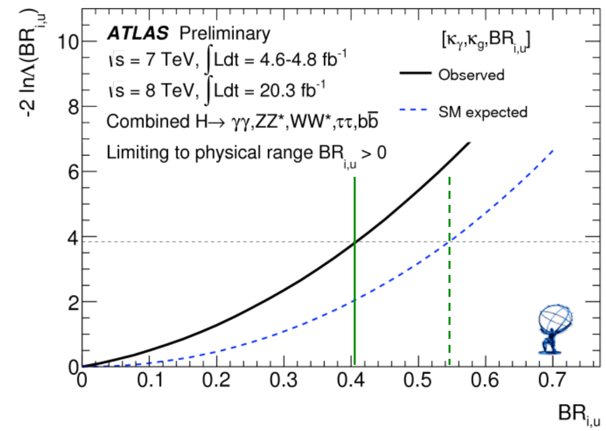
$$\Gamma_{tot} = \kappa^2\,\Gamma_{SM} + \Gamma_{BSM}$$

$$\sigma \cdot BR \sim \frac{\kappa^2 \cdot \kappa^2}{\kappa^2\,\Gamma_{SM} + \Gamma_{BSM}}$$

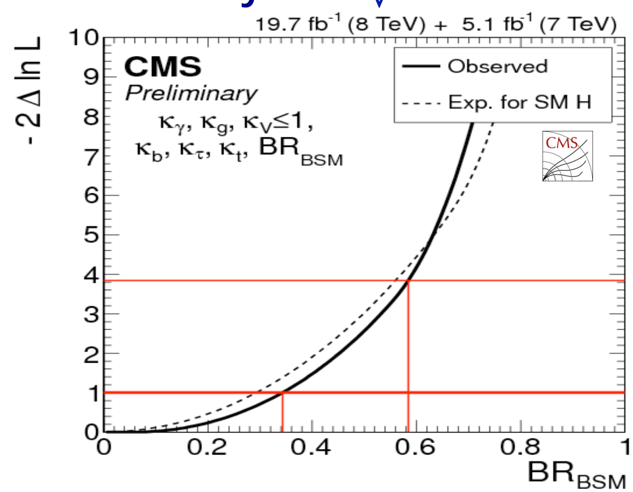
Probing BSM decays

- New physics can introduce new Higgs decay modes not detected at LHC.
  $\Gamma_{tot} = \Gamma_{SM}(\kappa_i) + \Gamma_{BSM}$
- A larger Γ_{tot} can be resolved from a deviation in the κ's if we have some assumption.
- Two scenarios considered:
  1. tree level couplings as in SM (assume new physics entering only in loops and decays)
  2. $\kappa_V \leq 1$ (EWSB motivated)

all tree-level κ's = 1

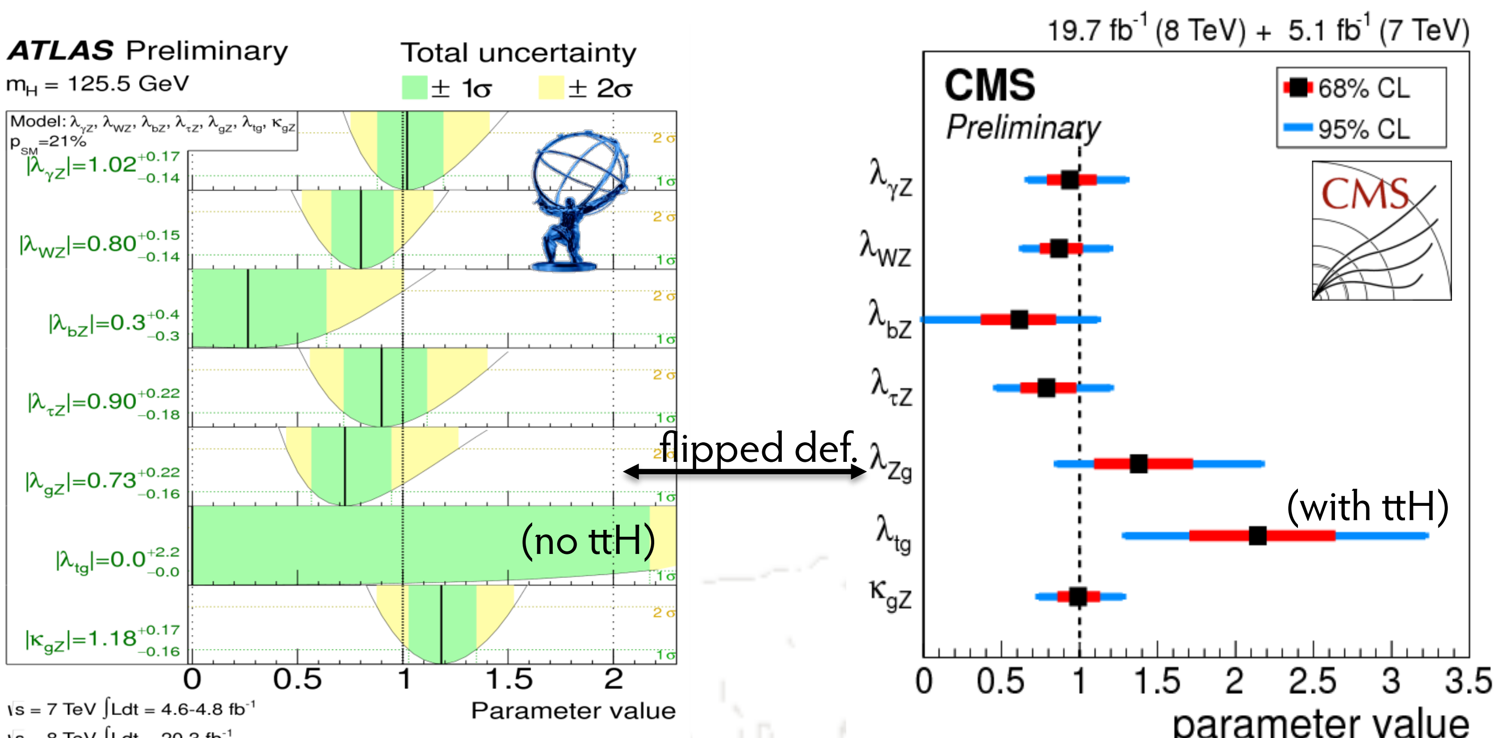


just $\kappa_V \leq 1$



Overall picture

- Couplings to vector bosons and 3rd generation fermions probed at ATLAS & CMS with 15-50% precision
  - Fair compatibility with SM predictions overall



Conclusions

- Final LHC Run 1 mass measurements available:
  - already in the realm of precision measurements: discussing sub-per-mille systematics in calibrations
  - work ongoing on ATLAS+CMS mass combination
- For couplings, the books are still quite open:
  - Current constraints at 10-50%: still room for almost-but-not-quite-SM-like Higgs bosons
  - Expect some further improvement already on Run 1 data, e.g. from final ATLAS analyses
  - Improving these constraints will be one of the main goals for Run 2 and beyond (incl. future machines)

BACKUP

Systematics: photon differences

- Some reasons for the difference in systematics:
  - Larger uncertainty from non-linearity in ATLAS (0.1% vs 0.08%): LAr gain switch at energies between Z and H
  - ATLAS has ~0.1% extra systematics from the material in between the inner detector and the calorimeter
  - CMS homogeneous crystal calorimeter reduces impact of longitudinal calibration systematic (0.02% vs 0.1%)
  - CMS synchronous categorization of photons and electrons by shower compactness mitigates the effects of the uncertainty on the material budget:
    - calibrate unconverted photons with golden electrons
    - calibrate converted photons with showering electrons

Theoretical systematics

- For overall μ and for μ_{ggH} experimental uncertainties are comparable to theoretical uncertainties.

$$\textbf{CMS}\ \mu = 1.00\,^{+0.09}_{-0.09}\,(\text{stat})\,^{+0.08}_{-0.07}\,(\text{theo})\,^{+0.07}_{-0.07}\,(\text{exp})$$

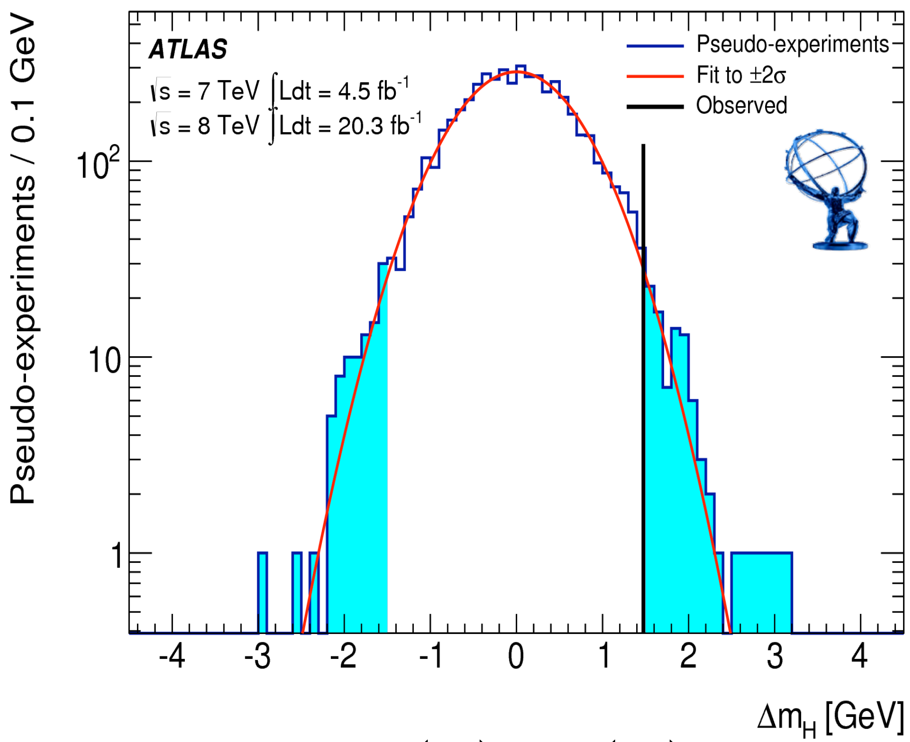
$$\mu_{ggH} = 0.85\,^{+0.11}_{-0.09}\,(\text{stat})\,^{+0.11}_{-0.08}\,(\text{theo})\,^{+0.10}_{-0.09}\,(\text{exp})$$

$$\textbf{ATLAS}\ \mu = 1.30\,^{+0.12}_{-0.12}\,(\text{stat})\,^{+0.10}_{-0.08}\,(\text{theo})\,^{+0.10}_{-0.08}\,(\text{exp})$$

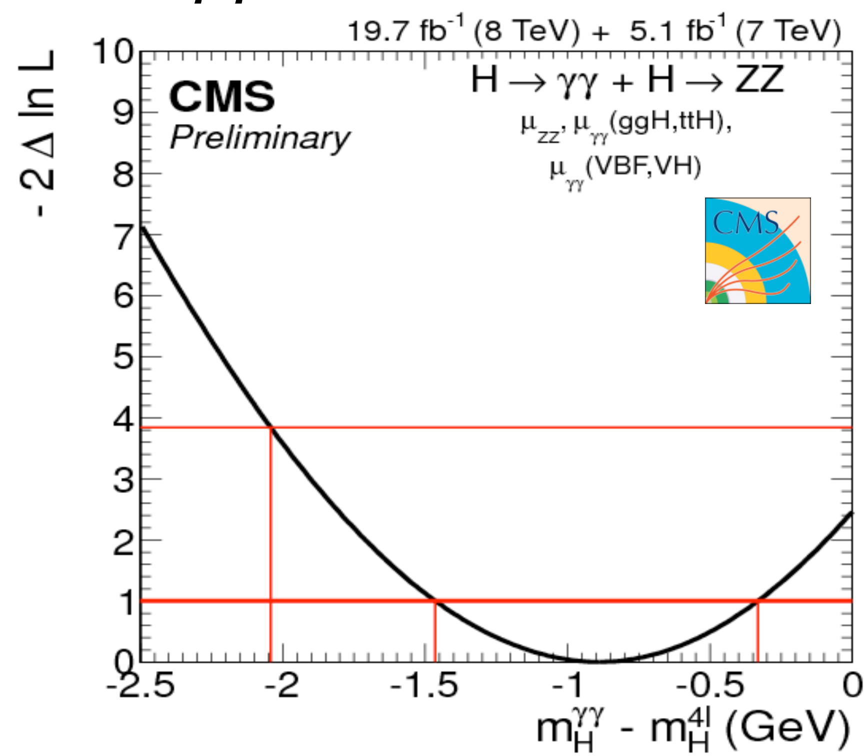
- For the tests of couplings, experimental uncertainties are still expected to be dominant.
- Their evaluation and treatment, also for backgrounds and differential distributions, will be very important for analysis of Run 2 and beyond

Compatibility of 4ℓ, γγ

Statistical compatibility two mass measurements evaluated by looking at $\Delta m = m(\gamma\gamma) - m(4\ell)$



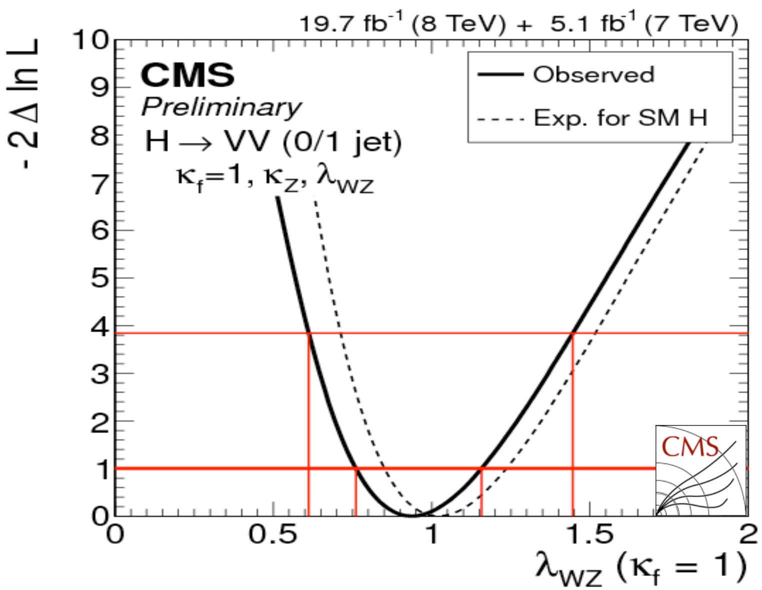
$\Delta m = +1.5 \pm 0.7^{(stat)} \pm 0.3^{(syst)}$ GeV (1.6σ)

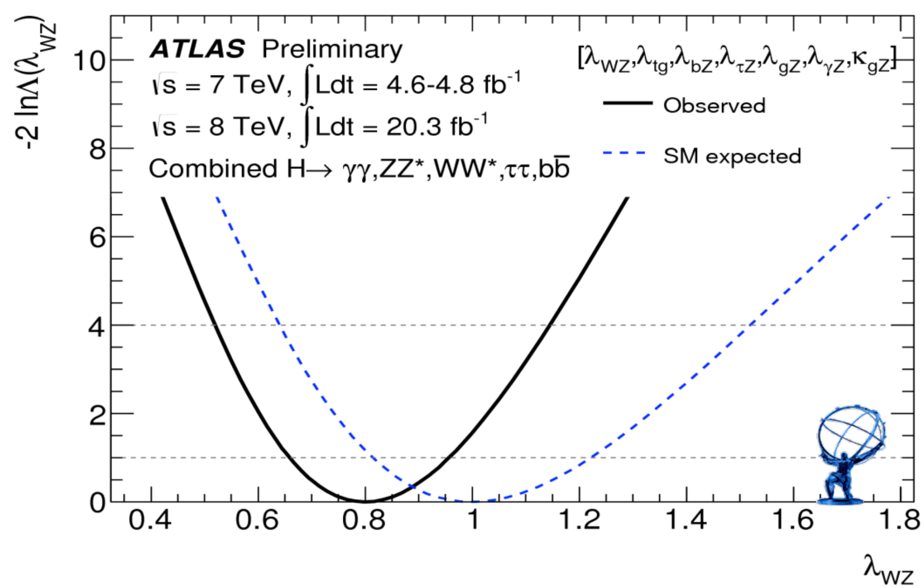


$\Delta m = -0.9 \pm 0.6$ GeV (1.6σ)

Probing custodial symmetry

- Couplings to W & Z closely related in SM and most BSM alternatives with a doublet field.
- Tested in many different ways, two examples here:
  - CMS: from H → VV alone, in ggH-dominated final states
  - ATLAS: from most general coupling fit





m_H combination & model independency

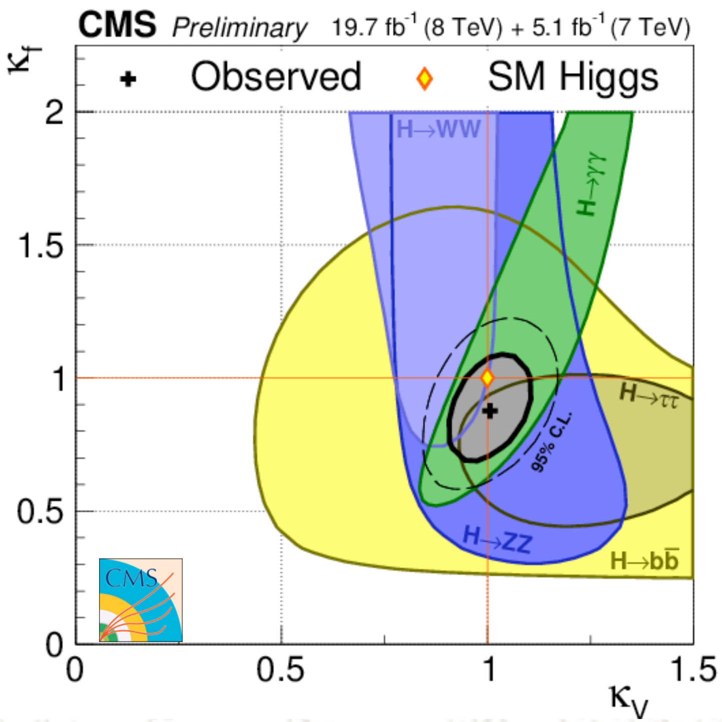
- An effort is made to make the mass measurement more model independent.
- In designing the analysis:
  - ATLAS: don't use tagged categories for mass measurement, both in $H \to \gamma\gamma$ and $H \to 4\ell$
  - CMS $H \to ZZ$: don't use dijet category and $p_T(H)$
- In parametrizing the signal in the combination:
  - Separately floating signal strengths for $H \to 4\ell$, $H \to \gamma\gamma$
  - CMS $H \to \gamma\gamma$: float separately μ(VBF,VH) vs μ(ggH,ttH)
  - Both experiments checked independency of result on assumptions made on signal strengths.

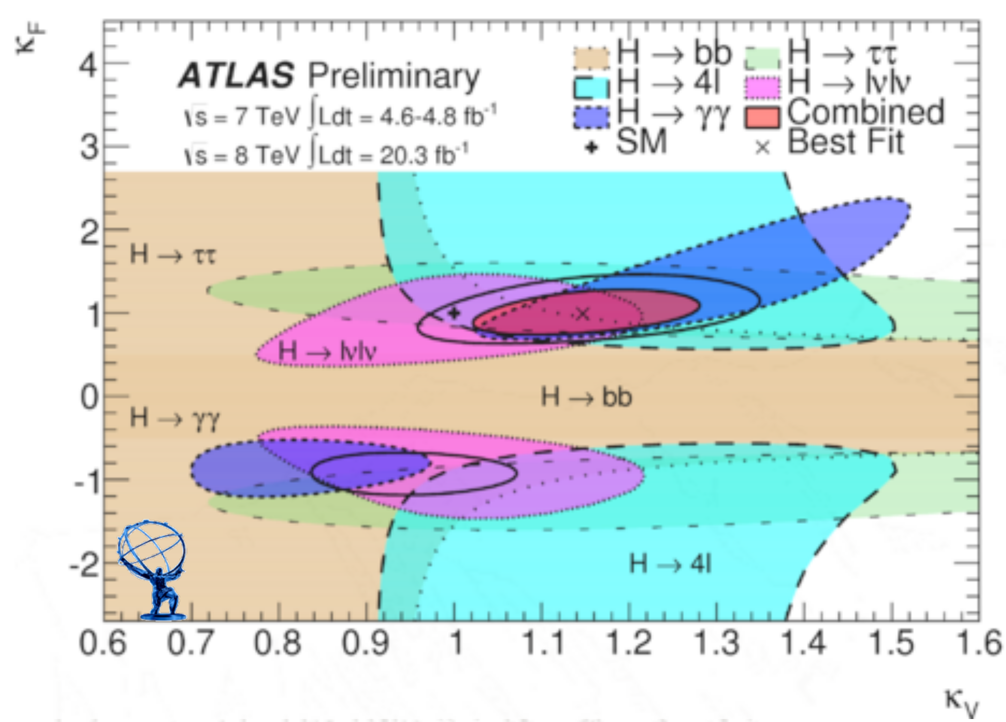
Signal and background modelling

- Both experiments rely on a parametric modelling for the Higgs boson signal shape:
  - Parameters determined from fitting MC samples, after applying all data/mc corrections & smearings
- Backgrounds modelled with arbitrary smooth functions: polynomials, exponentials, power laws
  - Studies to determine the biases from assumed bkg parameterization done with toy MC or fast sim.
  - ATLAS: include bias as extra systematic on signal yield
  - CMS: profile likelihood over the choice of bkg shape

Minimal benchmark model

- Assume universal deviations in couplings to fermions (κ_f) and to vector boson (κ_V)
- Shows consistency across the 5 decay channels





Untagged γγ categories, 8 TeV

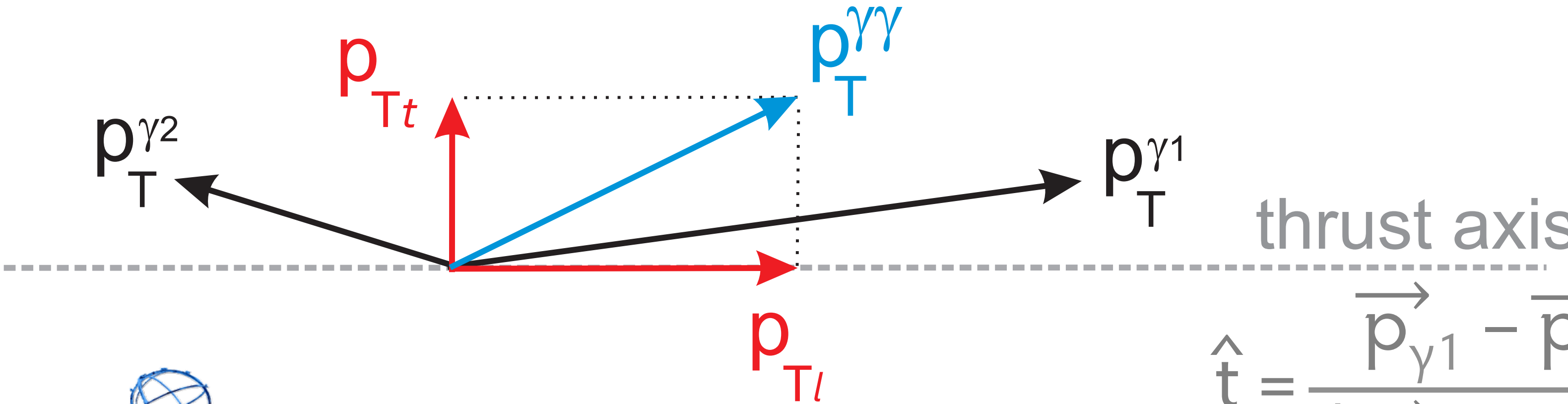
ATLAS Category	n_{Sig}	σ_{eff} (GeV)
unconv central high p_T	7.1	1.21
unconv central low p_T	59.3	1.35
unconv rest high p_T	10.4	1.36
unconv rest low p_T	96.2	1.53
conv central high p_T	4.5	1.35
conv central low p_T	37.2	1.52
conv rest high p_T	11.9	1.64
conv rest low p_T	107	1.88
unconv transition	26.0	1.86
conv transition	42.1	2.41

CMS Category	n_{Sig}	σ_{eff} (GeV)
Untag 0	6.0	1.05
Untag 1	50.8	1.19
Untag 2	117	1.46
Untag 3	153	2.04
Untag 4	121	2.62

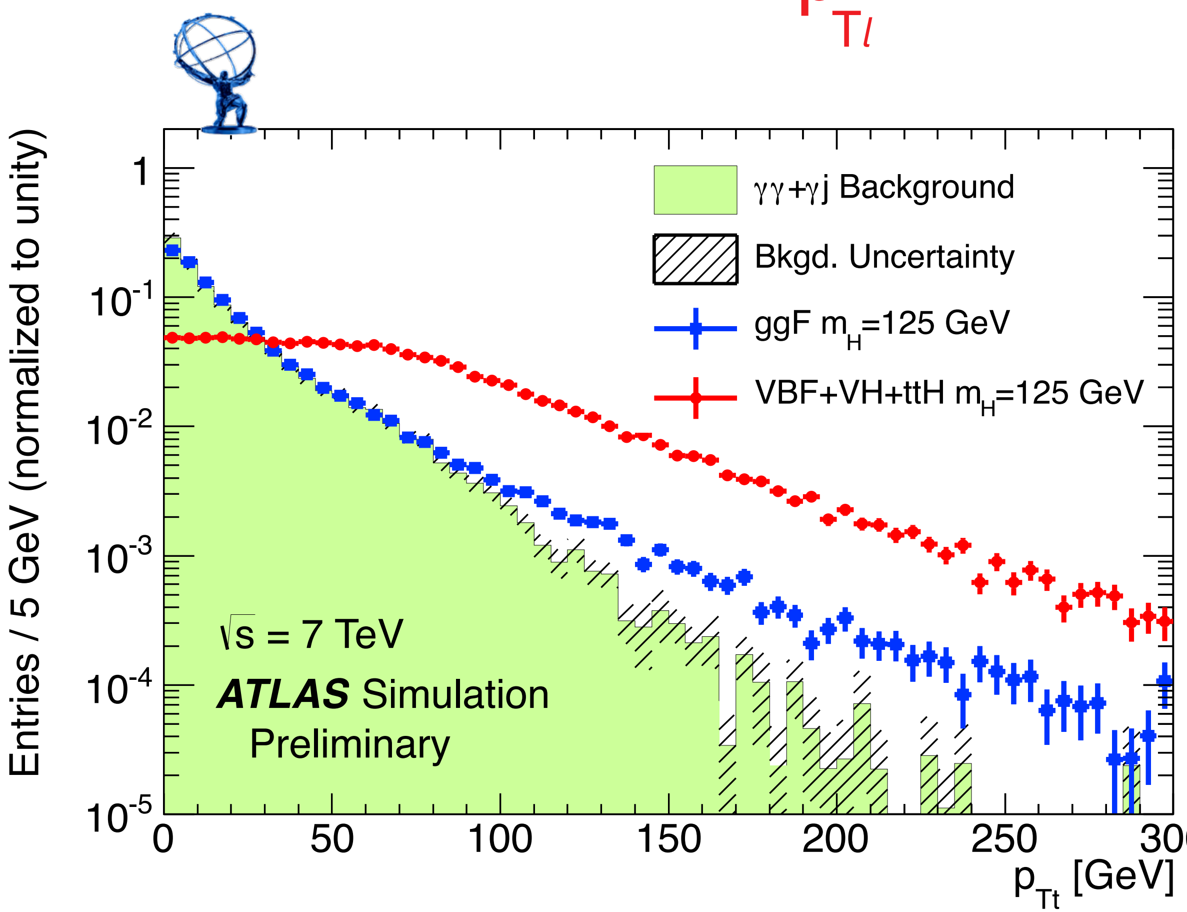
Notes:

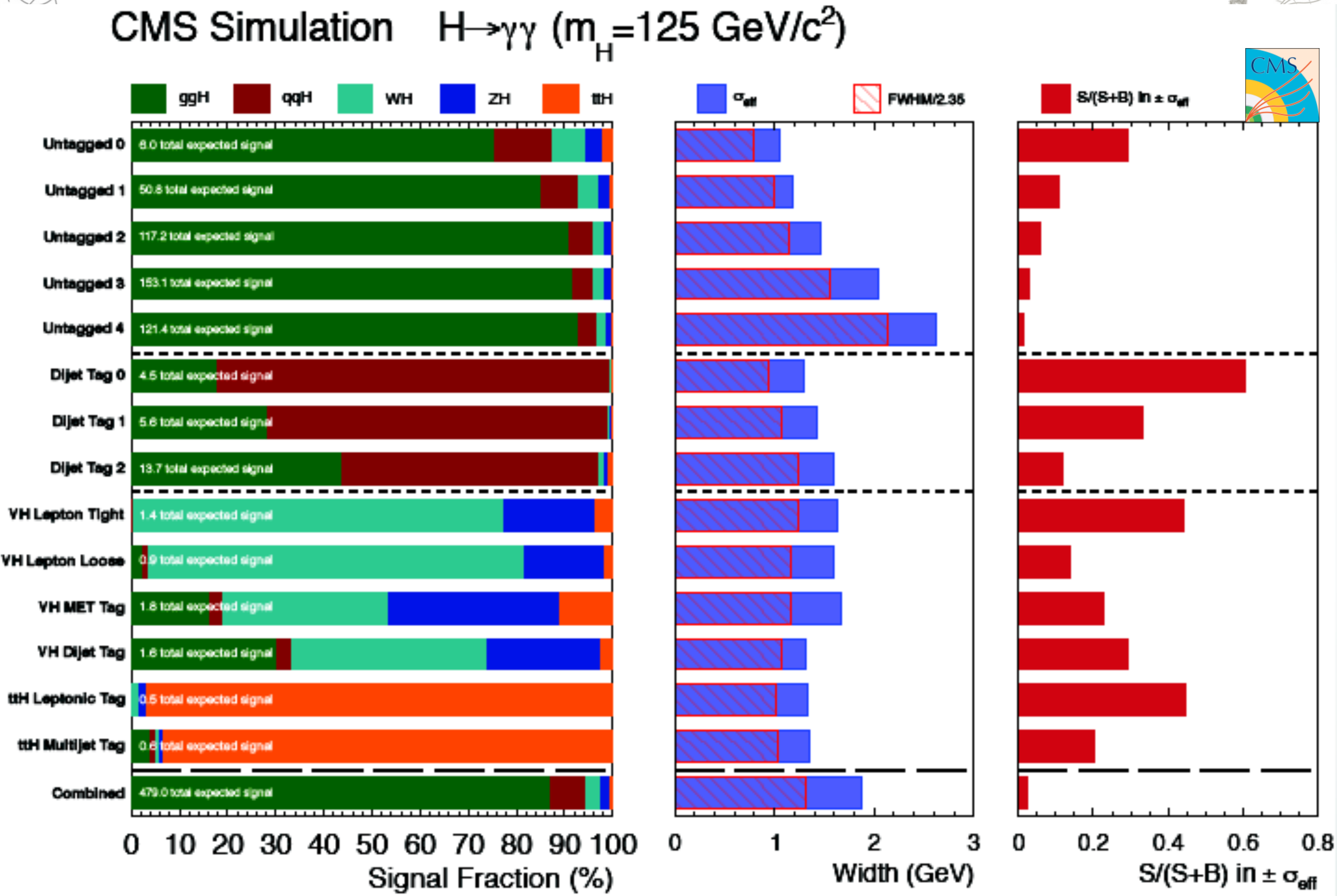
- CMS numbers for m_H = 125 GeV, ATLAS ones for m_H= 126 GeV.
- ATLAS σ_{eff} 5-10% better at 7 TeV; CMS instead ~5% worse at 7 TeV

The p_{Tt} variable



$$\hat{t} = \frac{\overrightarrow{p_{\gamma 1}} - \overrightarrow{p_{\gamma 2}}}{|\overrightarrow{p_{\gamma 1}} - \overrightarrow{p_{\gamma 2}}|}$$

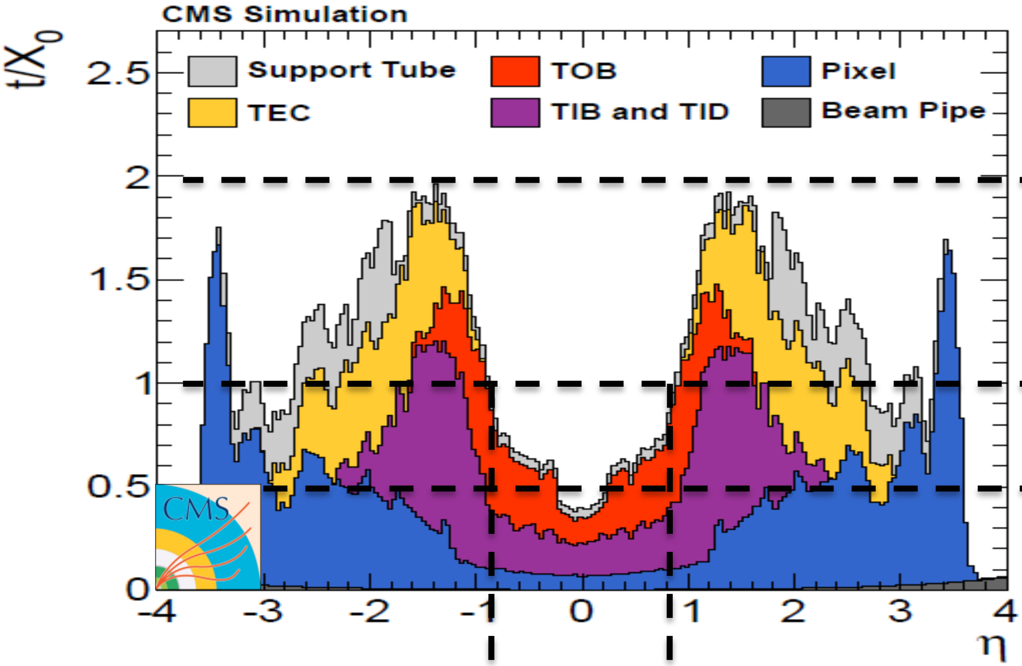



CMS Simulation H→γγ (m_H=125 GeV/c²)
ggH
qqH
WH
ZH
ttH
σ_eff
FWHM/2.35
S/(S+B) in ± σ_eff
Untagged 0
Untagged 1
Untagged 2
Untagged 3
Untagged 4
Dijet Tag 0
Dijet Tag 1
Dijet Tag 2
VH Lepton Tight
VH Lepton Loose
VH MET Tag
VH Dijet Tag
ttH Leptonic Tag
ttH Multijet Tag
Combined
6.0 total expected signal
50.8 total expected signal
117.2 total expected signal
153.1 total expected signal
121.4 total expected signal
4.5 total expected signal
5.6 total expected signal
13.7 total expected signal
1.4 total expected signal
0.9 total expected signal
1.8 total expected signal
1.6 total expected signal
0.5 total expected signal
0.6 total expected signal
479.0 total expected signal
Signal Fraction (%)
Width (GeV)
S/(S+B) in ± σ_eff

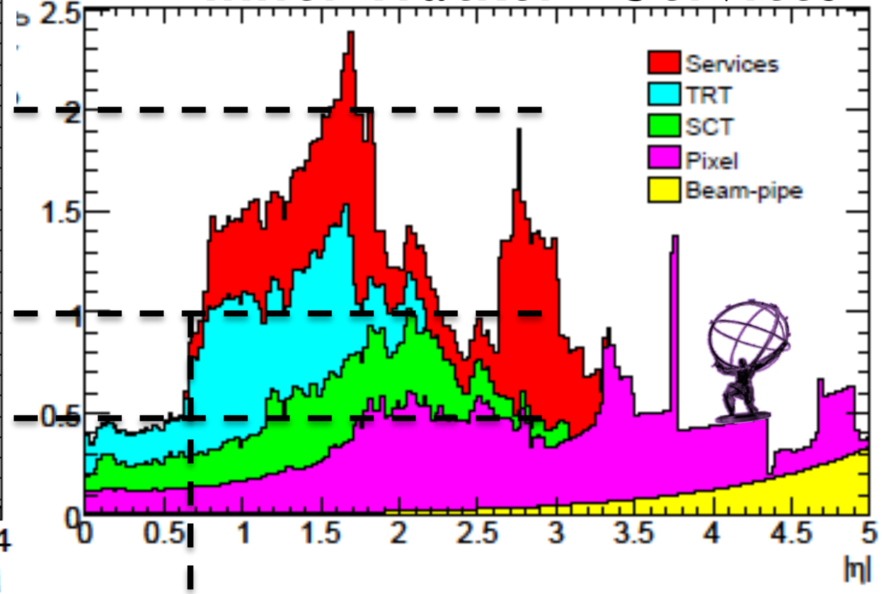
Systematics on ATLAS m_H

Systematic	Uncertainty on m_H [MeV]
LAr syst on material before presampler (barrel)	70
LAr syst on material after presampler (barrel)	20
LAr cell non-linearity (layer 2)	60
LAr cell non-linearity (layer 1)	30
LAr layer calibration (barrel)	50
Lateral shower shape (conv)	50
Lateral shower shape (unconv)	40
Presampler energy scale (barrel)	20
ID material model ($\lvert\eta\rvert < 1.1$)	50
$H \to \gamma\gamma$ background model (unconv rest low p_{Tt})	40
$Z \to ee$ calibration	50
Primary vertex effect on mass scale	20
Muon momentum scale	10
Remaining systematic uncertainties	70
Total	180

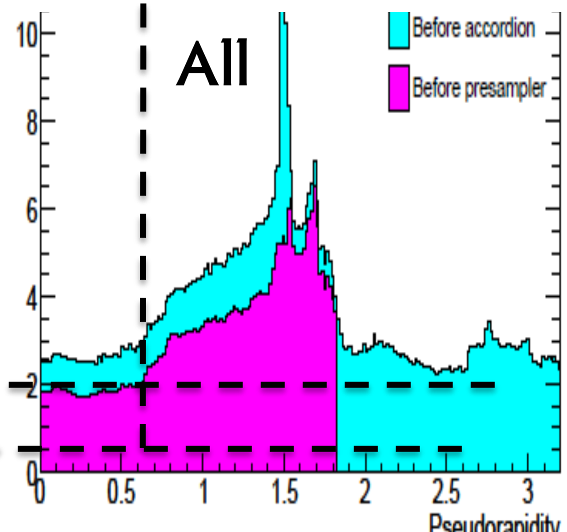
Material before ECAL

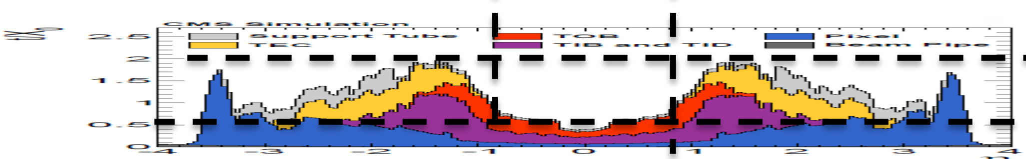


Inner Tracker + Services



All





Comparison of systematics on $m_{\gamma\gamma}$

Source	Name	ATLAS	CMS
In situ calib	$Z \rightarrow ee$ calibration	0.04%	0.04%
e/γ diff	Material tracker	0.07% (5% ID unc)	0.06% (10-20% ID unc)
	Other material	0.1%	-
	Longitudinal calib	0.1%	0.02%
	Lateral shower sha[illegible]	0.06%	0.0[illegible]
Linearity		0.12% (MG/HG full effect)	0.08% (a[illegible]orr)
Conversion classification		0.02%	-
Analysis	Background	0.04%	$< 0.01\%$
	Vertex	0.03%	-
Total		0.22%	0.12%

CMS

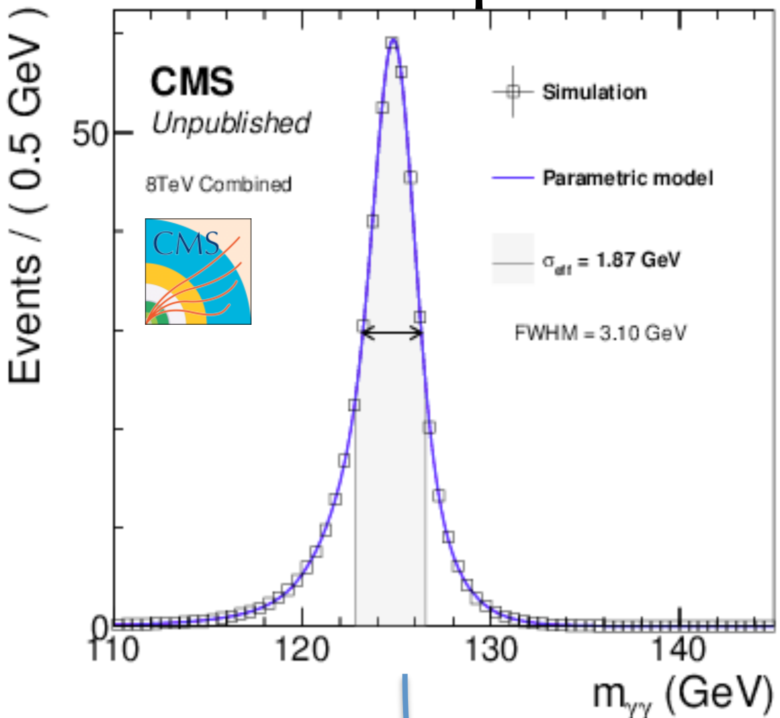
Source of uncertainty	Uncertainty in $\hat{m}_{H}$ (GeV)
Imperfect simulation of electron-photon differences	0.10
Linearity of the energy scale	0.10
Energy scale calibration and resolution	0.05
Other	0.04
All systematic uncertainties in the signal model	0.15
Statistical	0.31
Total	0.35

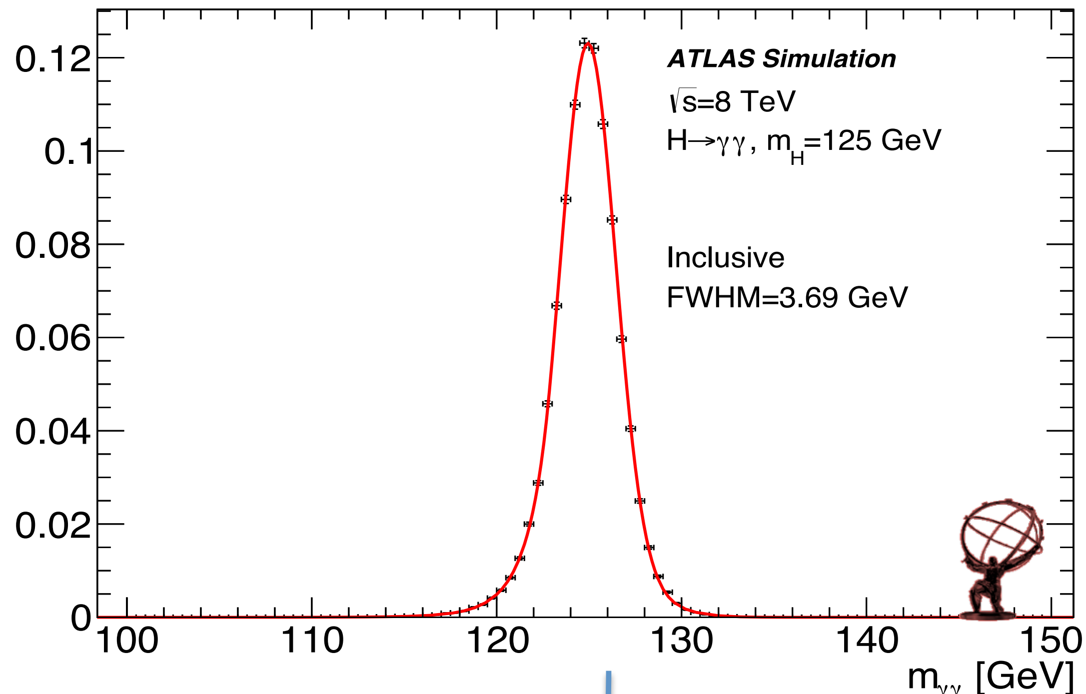
ATLAS

Class	Unconverted					Converted				
	Central		Rest		Trans.	Central		Rest		Trans.
	low p_{Tt}	high p_{Tt}	low p_{Tt}	high p_{Tt}		low p_{Tt}	high p_{Tt}	low p_{Tt}	high p_{Tt}	
$Z \to e^{+}e^{-}$ calibration	0.02	0.03	0.04	0.04	0.11	0.02	0.02	0.05	0.05	0.11
LAr cell non-linearity	0.12	0.19	0.09	0.16	0.39	0.09	0.19	0.06	0.14	0.29
Layer calibration	0.13	0.16	0.11	0.13	0.13	0.07	0.10	0.05	0.07	0.07
ID material	0.06	0.06	0.08	0.08	0.10	0.05	0.05	0.06	0.06	0.06
Other material	0.07	0.08	0.14	0.15	0.35	0.04	0.04	0.07	0.08	0.20
Conversion reconstruction	0.02	0.02	0.03	0.03	0.05	0.03	0.02	0.05	0.04	0.06
Lateral shower shape	0.04	0.04	0.07	0.07	0.06	0.09	0.09	0.18	0.19	0.16
Background modeling	0.10	0.06	0.05	0.11	0.16	0.13	0.06	0.14	0.18	0.20
Vertex measurement	0.03									
Total	0.23	0.28	0.24	0.30	0.59	0.21	0.25	0.27	0.33	0.47

H → γγ signal models (inclusive)

- The CMS signal model has narrower core, larger tails compared to ATLAS one





same X axis scale in the two plots

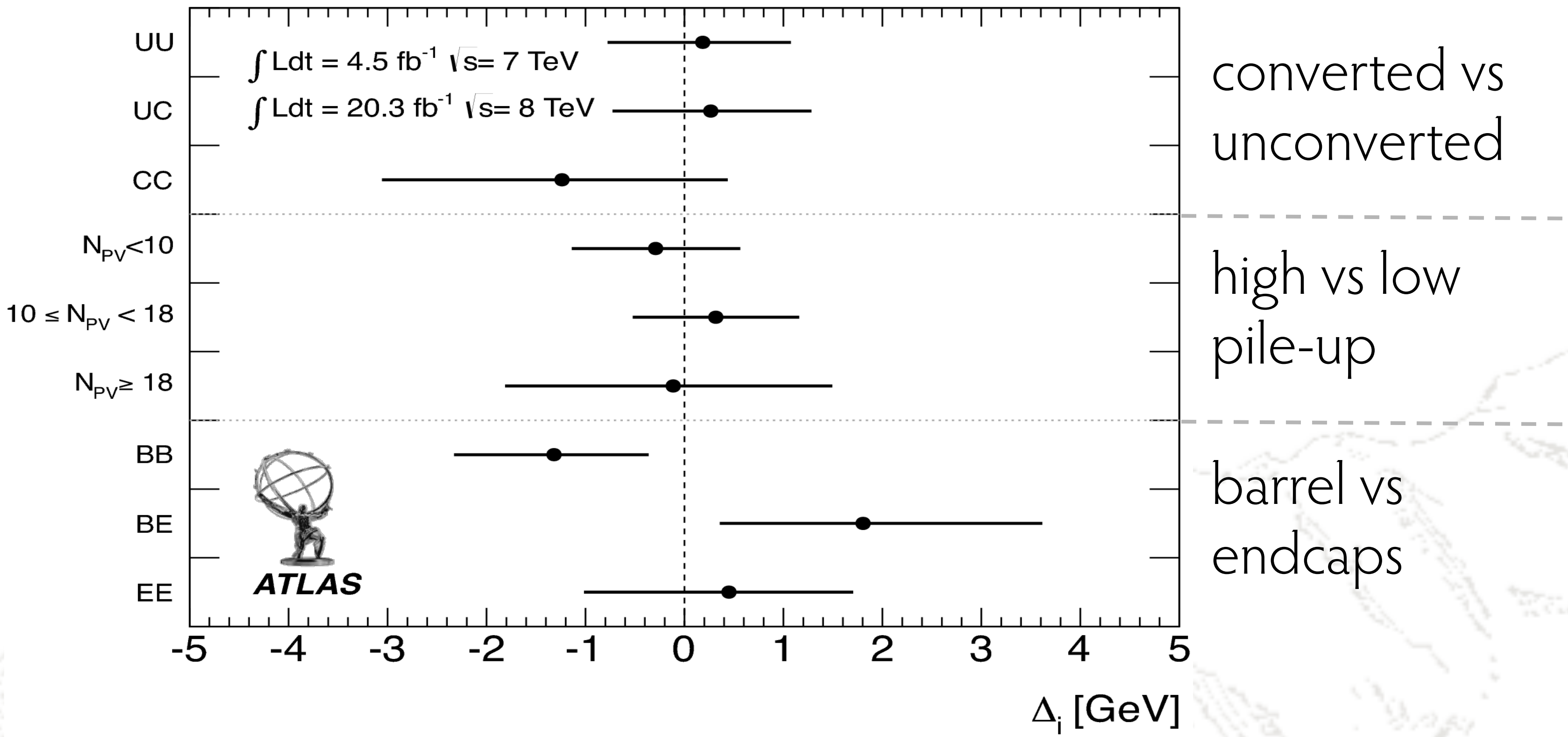
CMS mγγ: cross-checks

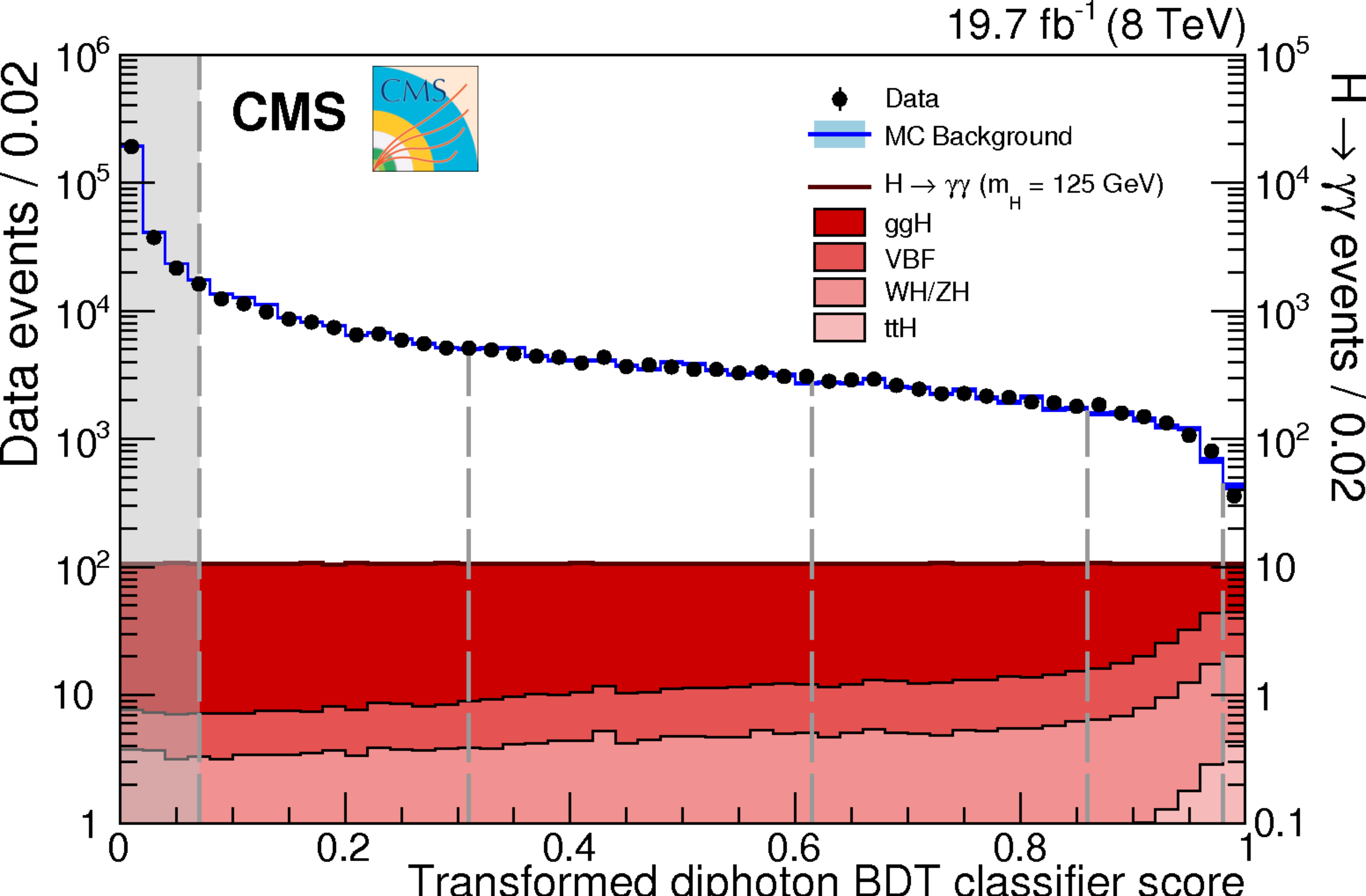
	$\hat{\mu}$	$\hat{m}_{\mathrm{H}}$ (GeV)
7 TeV	$2.22^{+0.62}_{-0.55}$	124.2
8 TeV	$0.90^{+0.26}_{-0.23}$	124.9
Combined	$1.14^{+0.26}_{-0.23}$	124.7

	Expected	Observed	***m(H)***
Main analysis	$1.00^{+0.24}_{-0.22}$	$1.14^{+0.26}_{-0.23}$	*124.7*
Cut-based analysis	$1.00^{+0.26}_{-0.24}$	$1.29^{+0.29}_{-0.26}$	*124.6*
Sideband bkg. model analysis	$1.00^{+0.25}_{-0.22}$	$1.06^{+0.26}_{-0.23}$	*124.7*

ATLAS H → γγ cross-checks

- Mass re-measured splitting datasets in categories to test for possible biases




19.7 fb^{-1} (8 TeV)
CMS
Data
MC Background
H → γγ (m_H = 125 GeV)
ggH
VBF
WH/ZH
ttH
Data events / 0.02
H → γγ events / 0.02
Transformed diphoton BDT classifier score

ATLAS simulation

Category	n_{sig}	FWHM [GeV]	σ_{eff} [GeV]	b in $\pm\sigma_{\text{eff90}}$	s/b [%]	$s/\sqrt{b}$
			$\sqrt{s}$=8 TeV			
Inclusive	402.	3.69	1.67	10670	3.39	3.50
Unconv. central low p_{Tt}	59.3	3.13	1.35	801	6.66	1.88
Unconv. central high p_{Tt}	7.1	2.81	1.21	26.0	24.6	1.26
Unconv. rest low p_{Tt}	96.2	3.49	1.53	2624	3.30	1.69
Unconv. rest high p_{Tt}	10.4	3.11	1.36	93.9	9.95	0.96
Unconv. transition	26.0	4.24	1.86	910	2.57	0.78
Conv. central low p_{Tt}	37.2	3.47	1.52	589	5.69	1.38
Conv. central high p_{Tt}	4.5	3.07	1.35	20.9	19.4	0.88
Conv. rest low p_{Tt}	107.2	4.23	1.88	3834	2.52	1.56
Conv. rest high p_{Tt}	11.9	3.71	1.64	144.2	7.44	0.89
Conv. transition	42.1	5.31	2.41	1977	1.92	0.85
			$\sqrt{s}$=7 TeV			
Inclusive	73.9	3.38	1.54	1752	3.80	1.59
Unconv. central low p_{Tt}	10.8	2.89	1.24	128	7.55	0.85
Unconv. central high p_{Tt}	1.2	2.59	1.11	3.7	30.0	0.58
Unconv. rest low p_{Tt}	16.5	3.09	1.35	363	4.08	0.78
Unconv. rest high p_{Tt}	1.8	2.78	1.21	13.6	11.6	0.43
Unconv. transition	4.5	3.65	1.61	125	3.21	0.36
Conv. central low p_{Tt}	7.1	3.28	1.44	105	6.06	0.62
Conv. central high p_{Tt}	0.8	2.87	1.25	3.5	21.6	0.40
Conv. rest low p_{Tt}	21.0	3.93	1.75	695	2.72	0.72
Conv. rest high p_{Tt}	2.2	3.43	1.51	24.7	7.98	0.40
Conv. transition	8.1	4.81	2.23	365	2.00	0.38

ATLAS Calibration scheme