Projections for measurements of Higgs boson cross sections, branching ratios and coupling parameters with the ATLAS detector.

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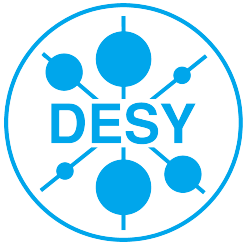
DESY

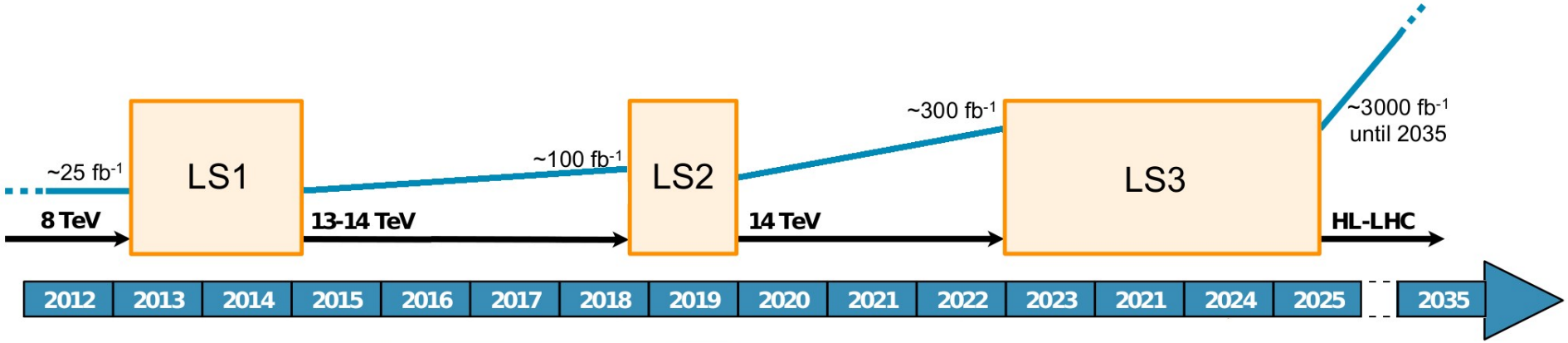


Hamburg workshop on Higgs physics

24th of October 2014

Introduction

- Refined analyses
  - new WH, ZH ($\rightarrow \gamma\gamma$) projections
  - new H $\rightarrow$ bb projections
  - new VBF H $\rightarrow \tau\tau$
  - ttH($\rightarrow \gamma\gamma$) and Zγ in talk by Y. Huang

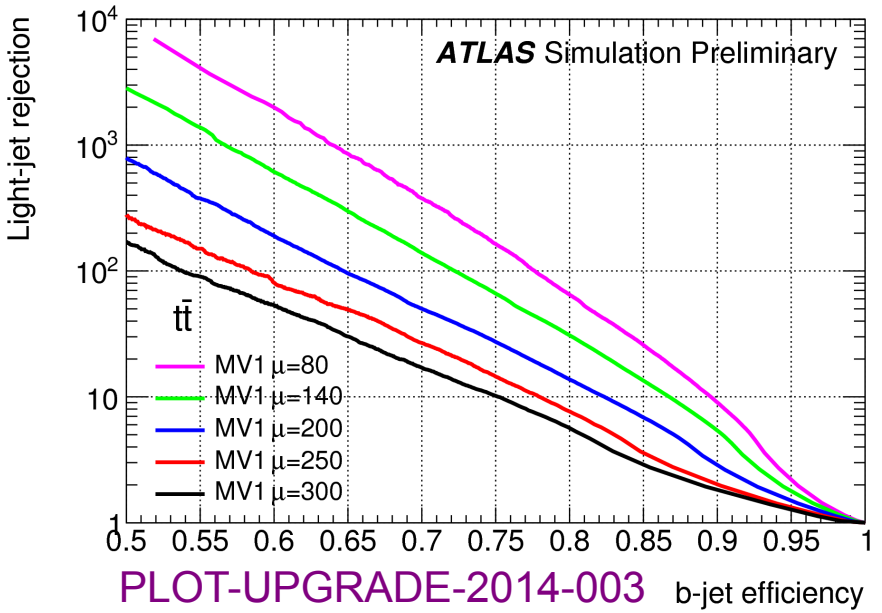


- New projections for coupling measurements
  - including needed theoretical uncertainties

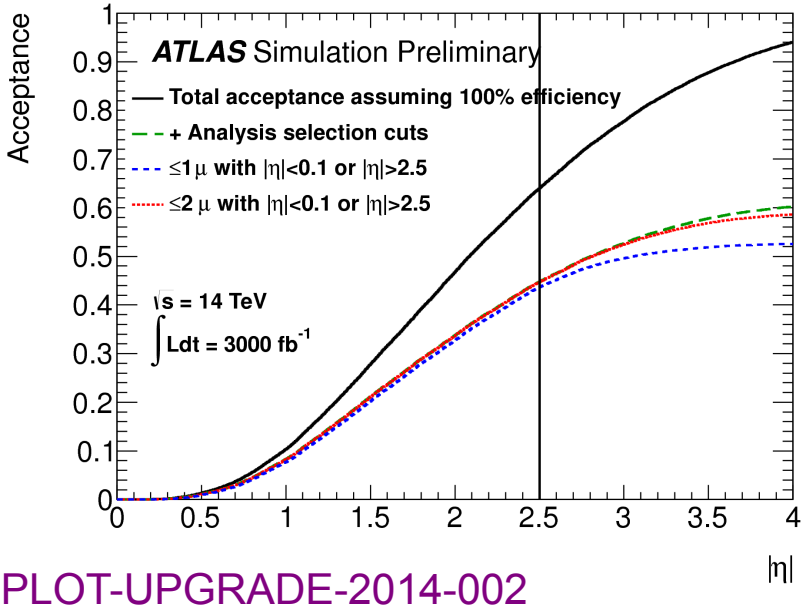
- New limits on BSM using couplings measurements

HL-LHC

- By the end of 2022
  - 300 fb^{-1} of 14 TeV data
  - pile-up: $<\mu_{PU}>$ = 50-60
- By the end of HL-LHC
  - 3000 fb^{-1} of 14 TeV data
  - pile-up: $<\mu_{PU}>$ = 140
- In the following conservative performance
  - E_T^{miss}, JES, etc
- Under discussion: extended tracker ($|\eta|$ = 4)
  - gain in acceptance for rare decays
  - pile-up jets rejection



PLOT-UPGRADE-2014-003

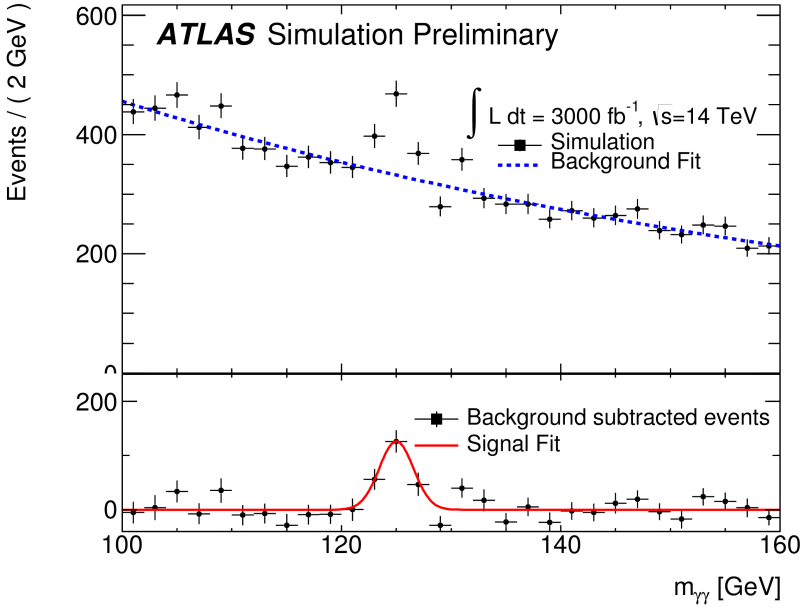


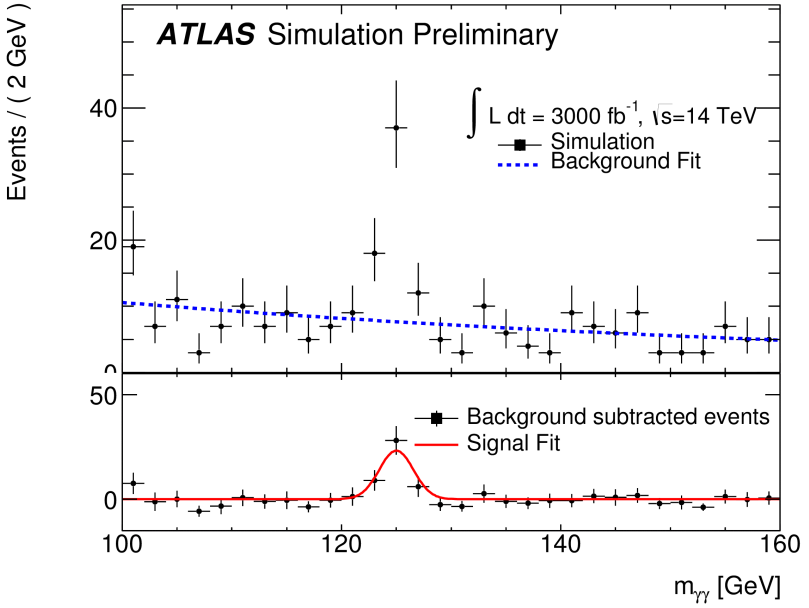
PLOT-UPGRADE-2014-002

VH (→ γγ)

- WH category
  - 1 lepton
  - Njets < 2
  - N_{WH}/N_{Higgs} = 72%
- ZH category
  - 2 leptons
  - $|m_{ll} - m_Z| < 15$ GeV
  - N_{ZH}/N_{Higgs} = 86%

	significance	μ	± stat	± syst	± theory
WH	4.2	1	+0.21	+0.13	+0.10
			-0.20	-0.12	-0.08
ZH	3.7	1	+0.32	+0.07	+0.12
			-0.29	-0.07	-0.08





- + 2 ttH categories (cf talk by Y. Huang)

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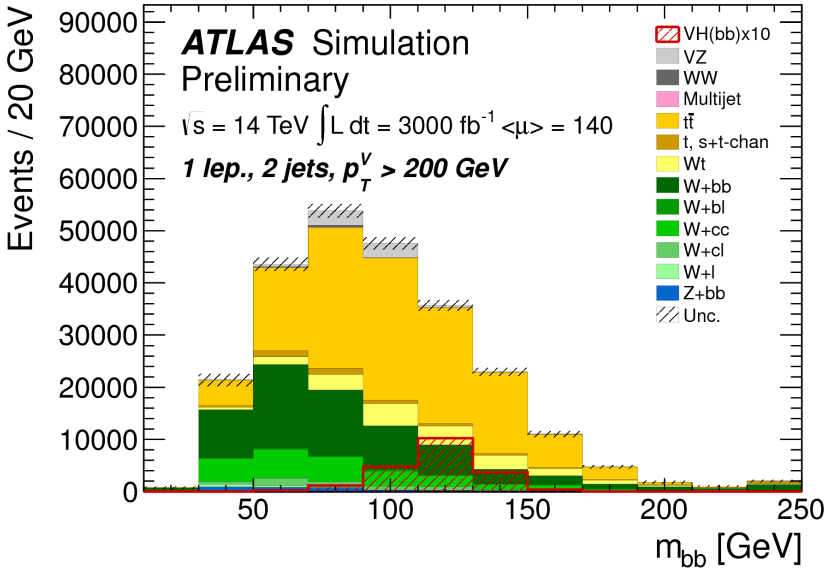
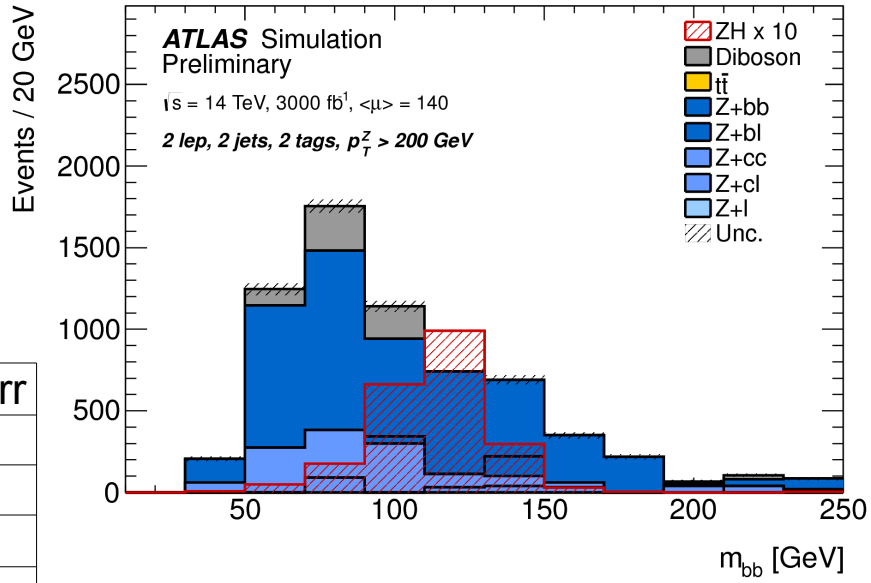
VH (→ bb)

- Same event selection strategy used for run 1 analysis
  - but no Z → νν here
  - 18 bins for signal region (2 b-jets + n leptons, n jets, p_T^V)
- Different scenarios for systematic uncertainties
  - JES (5% or 10%)
  - MVA selection, b-tagging, etc
- Example for a more performant analysis and JES = 10%:

	significance	μ	± w/ theory err	± /wo theory err
300 fb^{-1}	3.9σ	1	+0.27	+0.26
			-0.26	-0.26
3000 fb^{-1}	8.8σ	1	+0.14	+0.12
			-0.14	-0.12





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VBF H → ττ

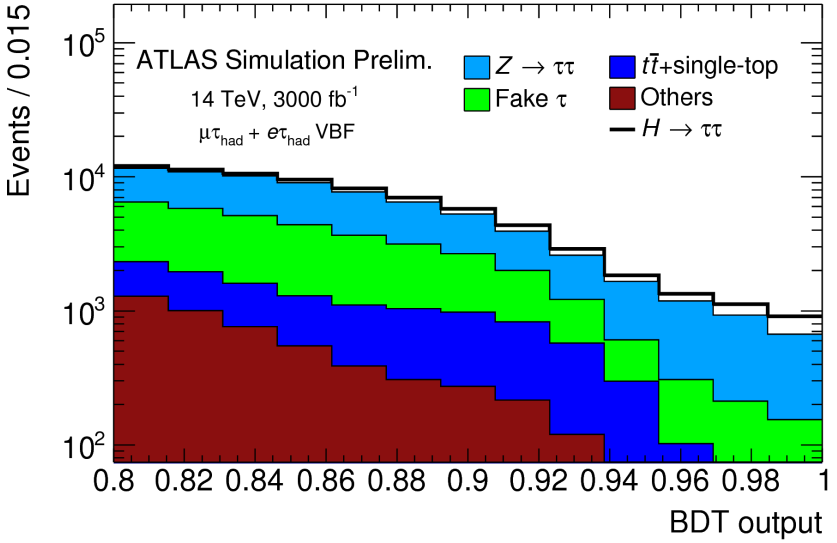
- VBF production + $\tau_l\tau_h$ decay
- Scenarios with extended tracker
- Error on μ with different syst uncertainties and theory uncertainties:

		current $\sigma_S^{\text{theo.}}$	no $\sigma_S^{\text{theo.}}$
$\sigma_B^{\text{syst.}}$	$\sigma_S^{\text{syst.}}$	$\Delta\mu$	$\Delta\mu$
10%	5%	0.25	0.24
5%	5%	0.16	0.13

- Error on μ with extended tracker coverage:

forward pile-up jet rejection	50%	75%	90%
forward tracker coverage		$\Delta\mu$	
Run-I tracking volume		0.24	
$\lvert\eta\rvert < 3.0$	0.18	0.15	0.14
$\lvert\eta\rvert < 3.5$	0.18	0.13	0.11
$\lvert\eta\rvert < 4.0$	0.16	0.12	0.08

- This study not used in the coupling fits (yet)



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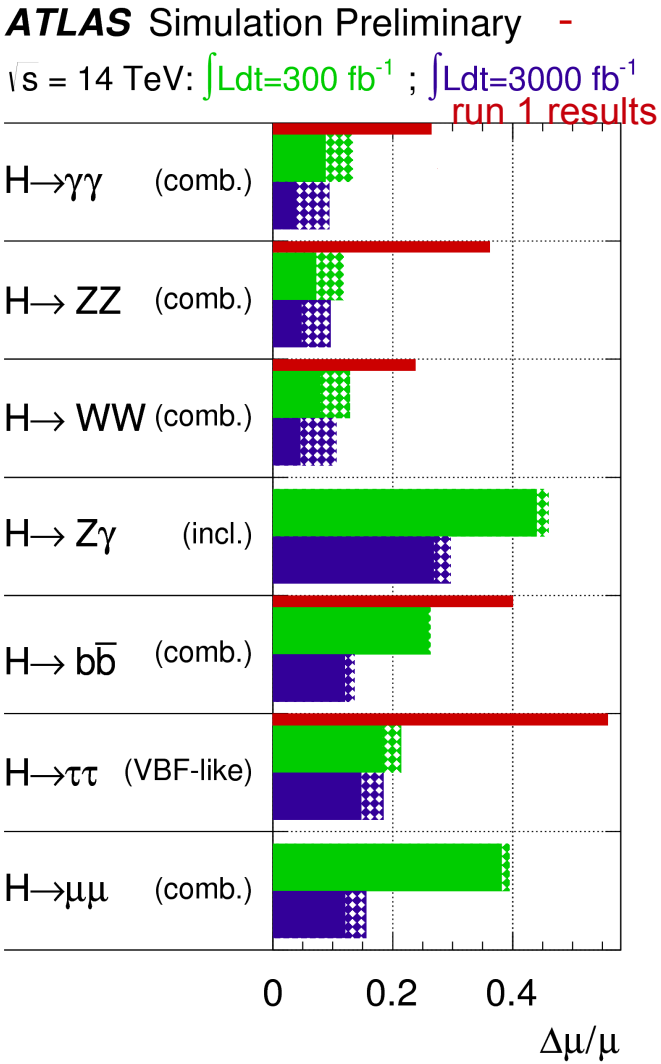
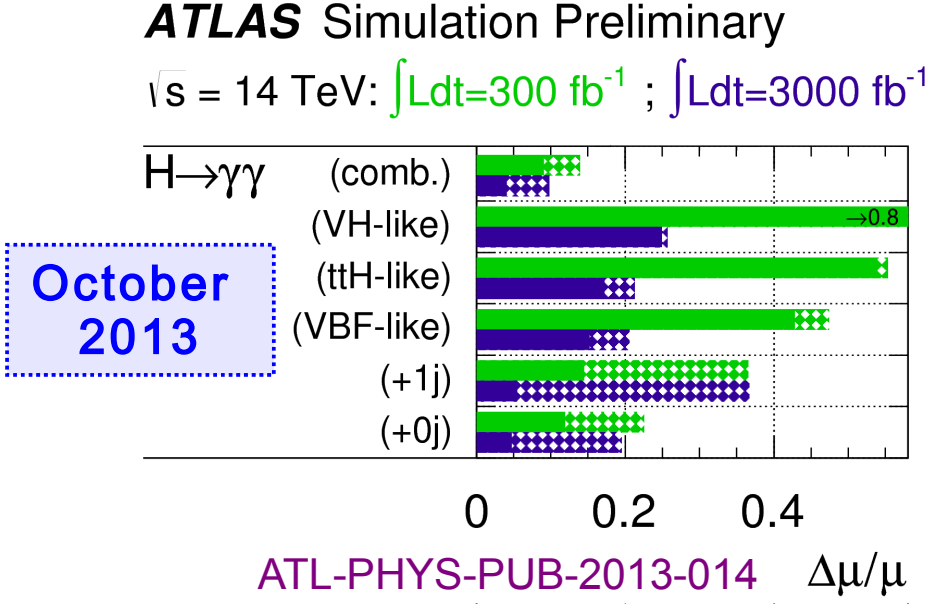
Expected signal strengths

- for 300 fb-1 and 3000 fb-1





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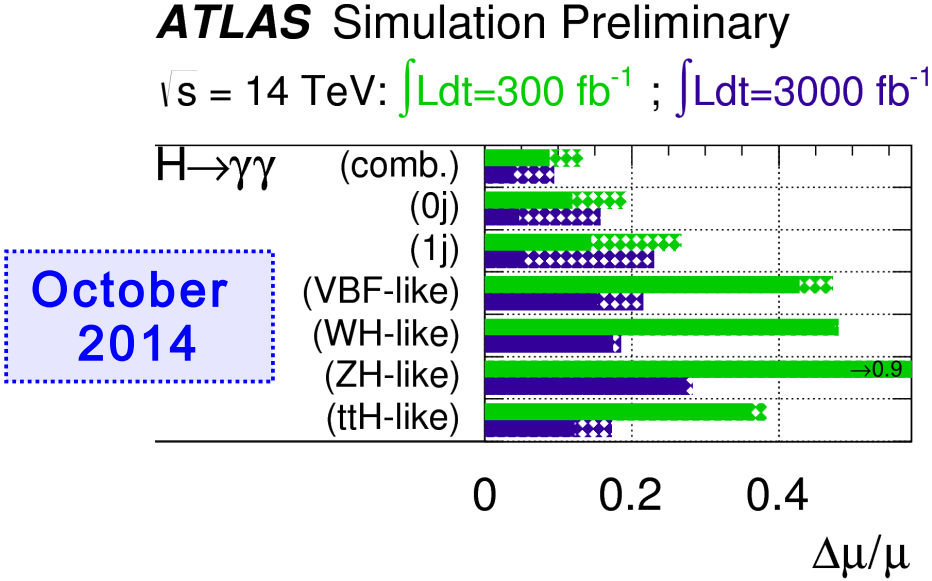

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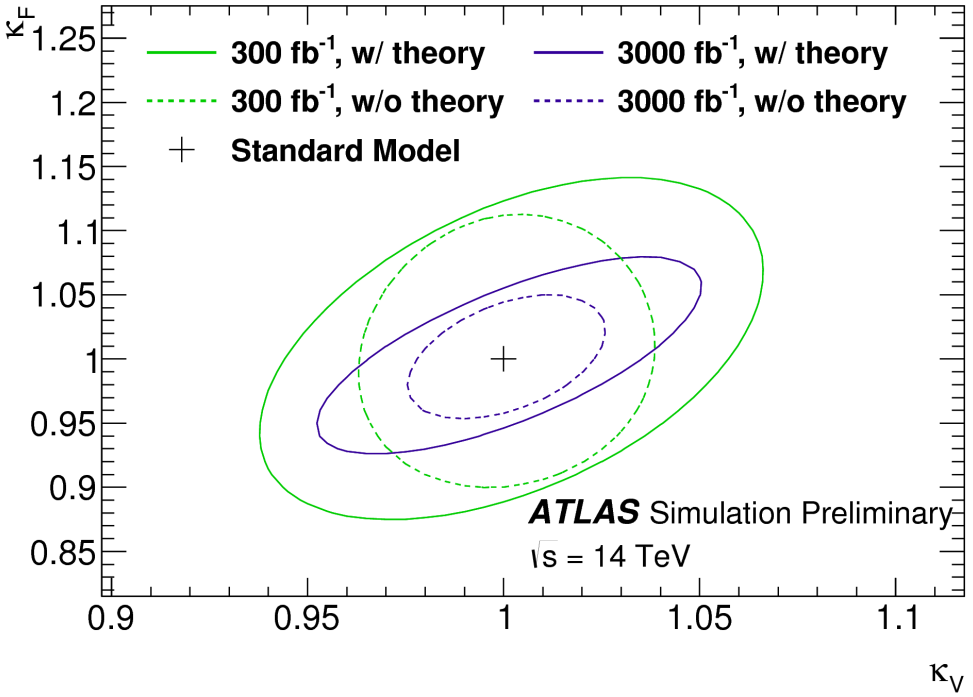
Couplings parameters (1)

- Assumptions
  - single resonance with m = 125 GeV
  - narrow width
  - only modifications to coupling strengths considered
  - CP-even scalar



- Example: Minimal couplings fit:
  - $\kappa_V = \kappa_W = \kappa_Z$
  - $\kappa_F = \kappa_t = \kappa_b = \kappa_\tau = \kappa_\mu$
  - precision on Higgs couplings scale factors:

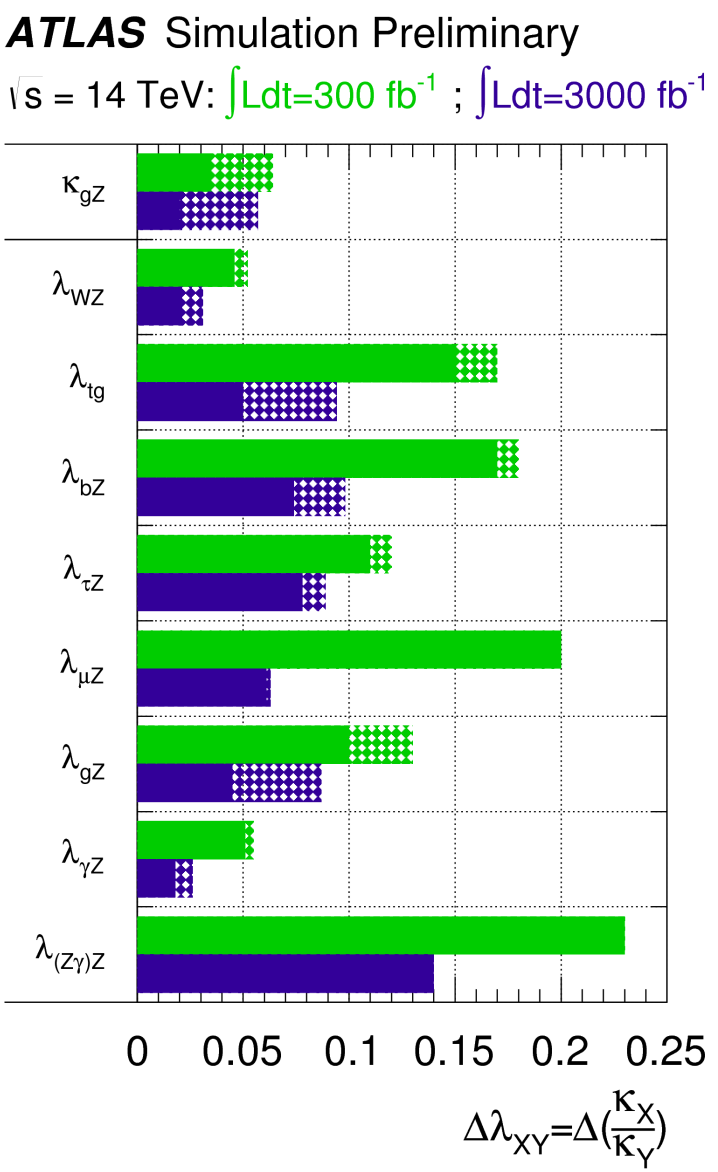
		w/ theory err	/wo theory err
κ_V	run 1	8%	
	300 fb^{-1}	4.3%	2.5%
	3000 fb^{-1}	3.3%	1.7%
κ_F	run 1	17%	
	300 fb^{-1}	8.8%	7.1%
	3000 fb^{-1}	5.1%	3.2%

Couplings parameters (2)

- If assumption on total width removed, only ratios of coupling scale factors: $\lambda_{XY} = \kappa_X \kappa_Y$

- Generic parametrisation
  - no assumptions on new particles
  - $\lambda_{Z\gamma}$: important to look for charged particles in $H \rightarrow \gamma\gamma$ loop
  - λ_{tg} : important for new coloured particles contributing to gluon fusion loop

		w/ theory err	/wo theory err
$\lambda_{Z\gamma}$	300 fb^{-1}	5.5%	5.1%
	3000 fb^{-1}	2.6%	1.8%
λ_{tg}	300 fb^{-1}	17%	15%
	3000 fb^{-1}	9.4%	5.0%



Couplings parameters (3)

- Try to compute which theoretical uncertainty is needed so that the total uncertainty is increased by less than 10%

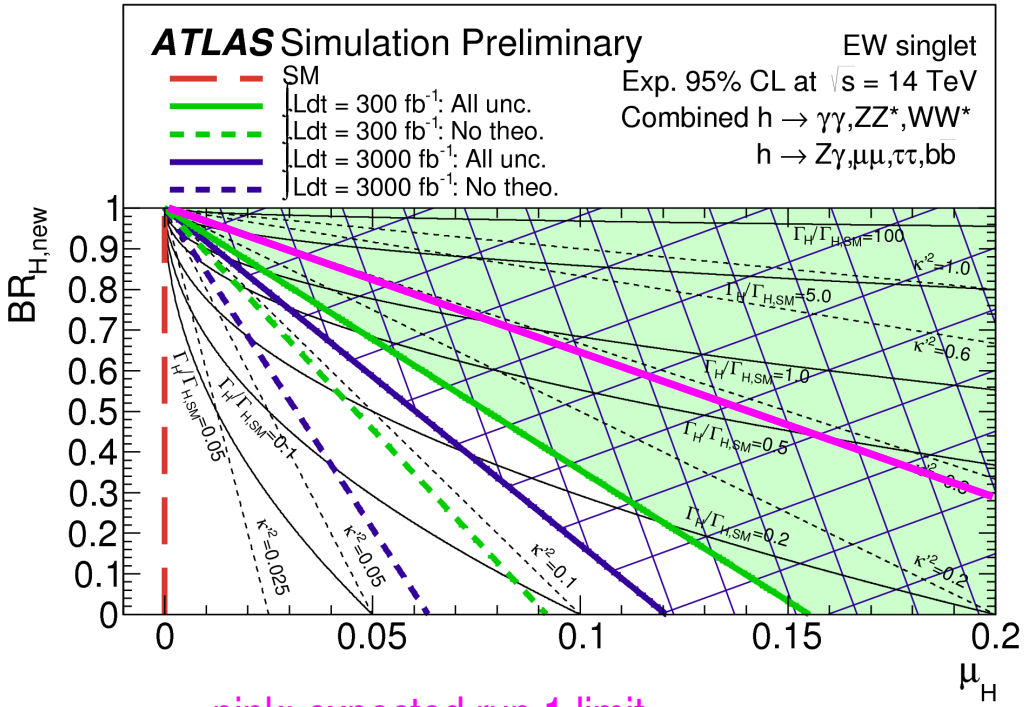
Scenario	Status 2014	Deduced size of uncertainty to increase total uncertainty by $\lesssim$10% for 300 fb^{-1}			by $\lesssim$10% for 3000 fb^{-1}				
Theory uncertainty (%)	[10–12]	κ_{gZ}	λ_{gZ}	$\lambda_{\gamma Z}$	κ_{gZ}	$\lambda_{\gamma Z}$	λ_{gZ}	$\lambda_{\tau Z}$	λ_{tg}
$gg \to H$									
PDF	8	2	-	-	1.3	-	-	-	-
incl. QCD scale (MHOU)	7	2	-	-	1.1	-	-	-	-
p_T shape and 0j $\to$ 1j mig.	10–20	-	3.5–7	-	-	1.5–3	-	-	-
1j $\to$ 2j mig.	13–28	-	-	6.5–14	-	3.3–7	-	-	-
1j $\to$ VBF 2j mig.	18–58	-	-	-	-	-	6–19	-	-
VBF 2j $\to$ VBF 3j mig.	12–38	-	-	-	-	-	-	6–19	-
VBF									
PDF	3.3	-	-	-	-	-	2.8	-	-
$t\bar{t}H$									
PDF	9	-	-	-	-	-	-	-	3
incl. QCD scale (MHOU)	8	-	-	-	-	-	-	-	2

Indirect constraints on BSM physics (1)

- Additional electroweak singlet
  - h and H: couple to fermions and vector bosons as SM Higgs boson
  - each with strength reduced by common scale factor: κ for h, κ' for H
  - independent from mass and $BR_{H,new}$

- Expected 95% CL upper limit on κ'^2:

	w/ theory err	/wo theory err
run 1	0.29	
300 fb^{-1}	0.17	0.1
3000 fb^{-1}	0.13	0.06



pink: expected run 1 limit

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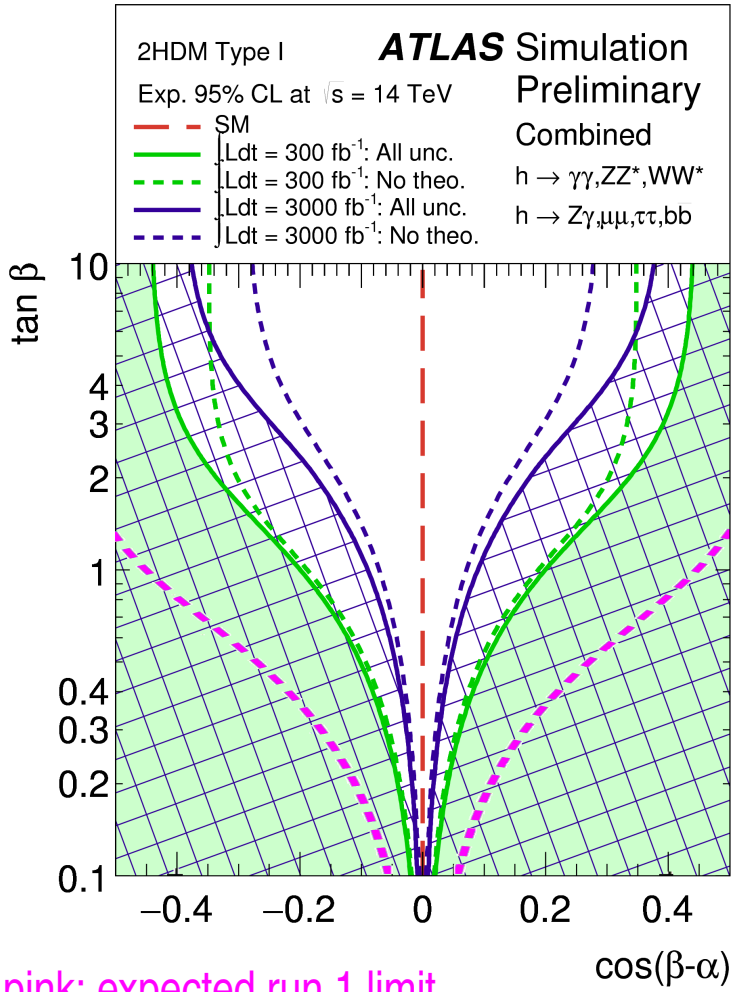
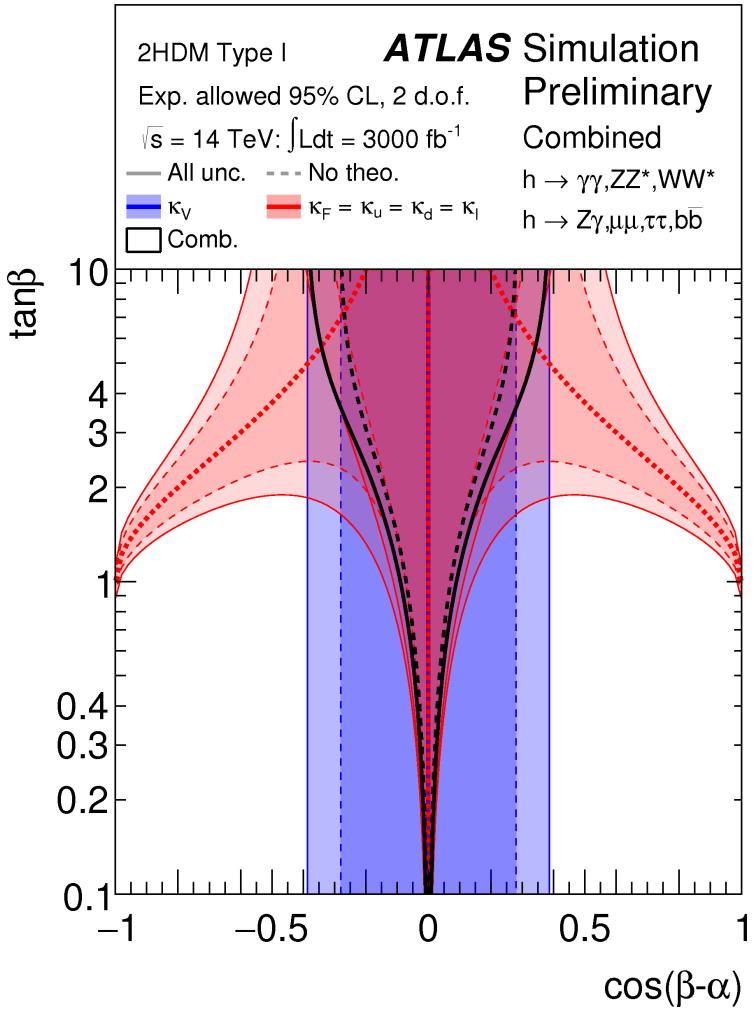
Indirect constraints on BSM physics (2)

- 2HDM, type I
  - one Higgs doublet couples to vector bosons, the other one to fermions
  - assume that small h found at 125 GeV

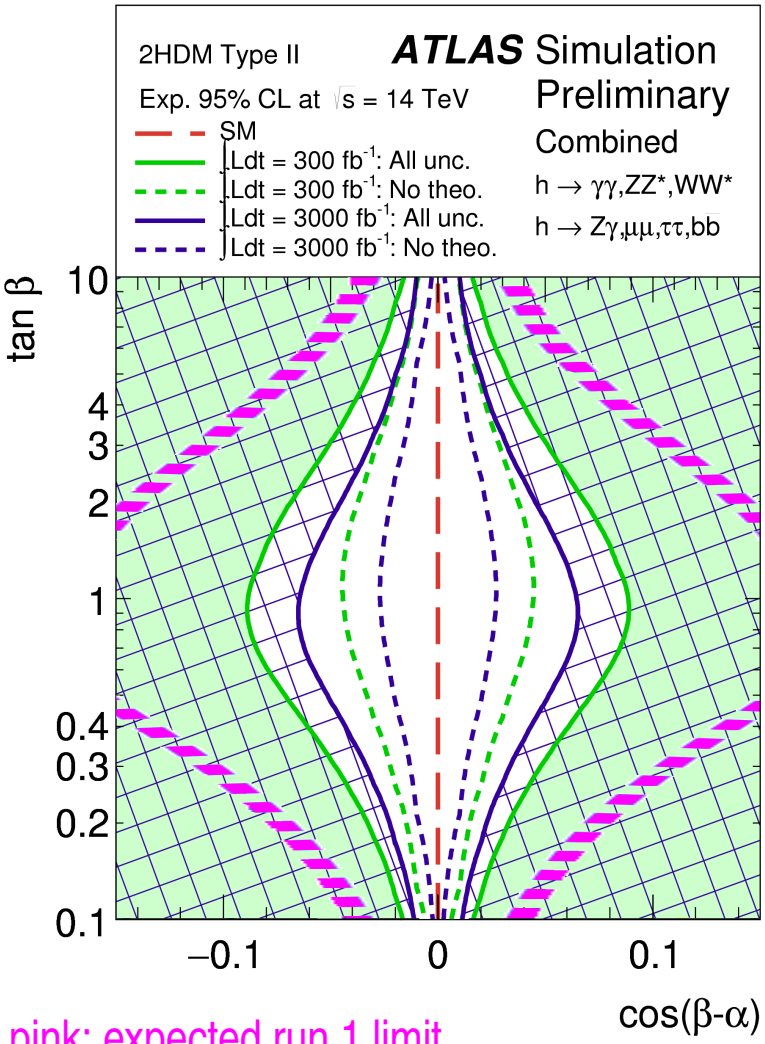


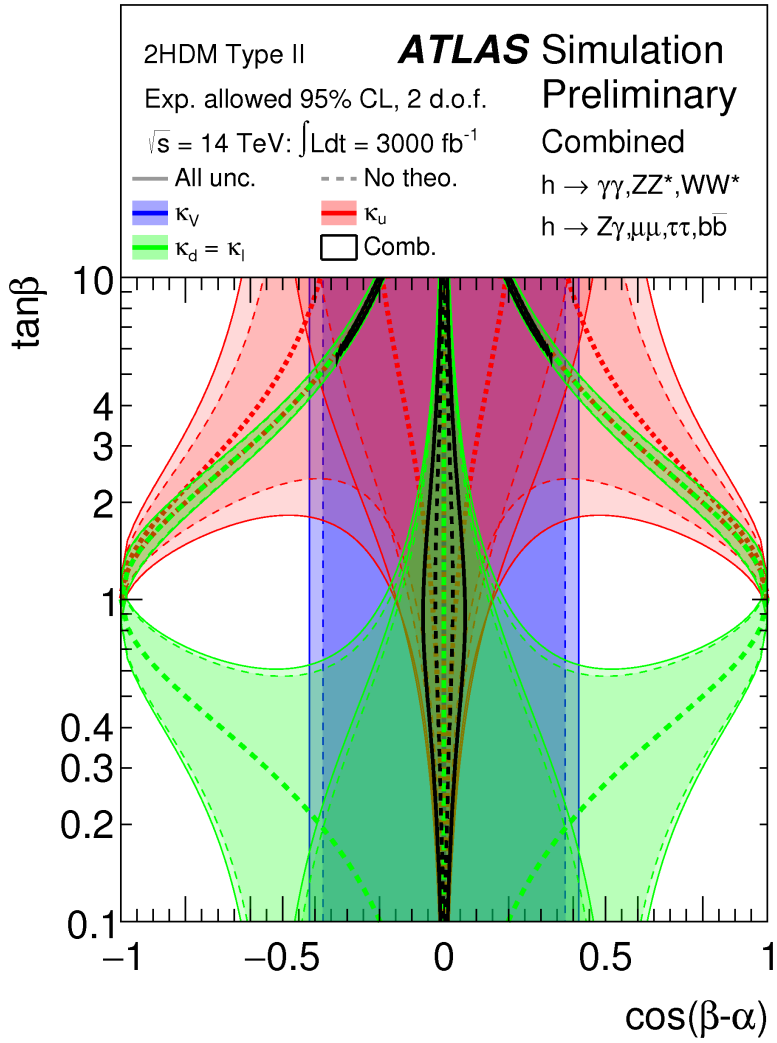
pink: expected run 1 limit



Indirect constraints on BSM physics (3)

- 2HDM, type II
  - one Higgs doublet couples to u-type quarks, the other one to d-type quarks and charged leptons
  - assume that small h found at 125 GeV





pink: expected run 1 limit

Conclusion

- Updates projections for different decay channels
  - still conservative approach on object reconstruction and systematics
- Couplings parameters can be measured with few percent uncertainty
- Theoretical uncertainty will limit the precision
  - projections on necessary theoretical uncertainty
- Precise couplings measurements will also improve limits on BSM models

Back-up