Weekly report

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October 12, 2020

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ATLAS EXPERIMENT

INSTITUTE FOR COLLIDER PARTICLE PHYSICS
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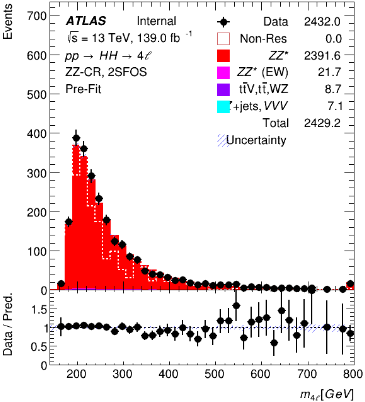
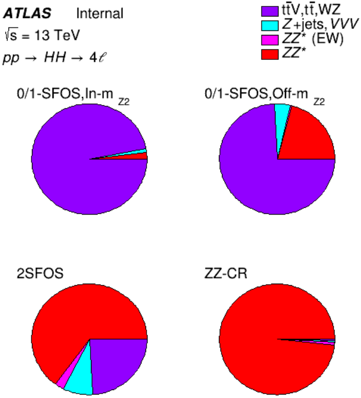
$HH \to 4\ell$ analysis

Data/MC agreement



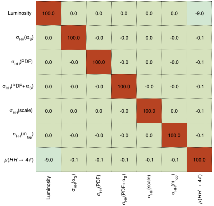


- We found that the ZZ^* backgrounds normalisation on the CR is 1.13.
- So the normalisation is fixed to this value during the fit.

LHCHXSWGHH

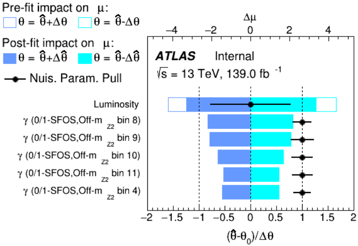
- ☐ Blind the signal region and use Asimov data on the fit.
- ☐ Adding 1.7% systematic uncertainty on the luminosity.
- ☐ And theoretical uncertainty on the signal cross section.

$\sqrt{s} = 13$ TeV	
$\sigma_{\text{NNLO FTapprox}}$ [fb]	31.05
Scale unc.	+2.2% -5.0%
PDF unc.	$\pm$2.1%
αS unc.	$\pm$2.1%
PDF+αS unc.	$\pm$3.0%
mtop unc.	$\pm$2.6%



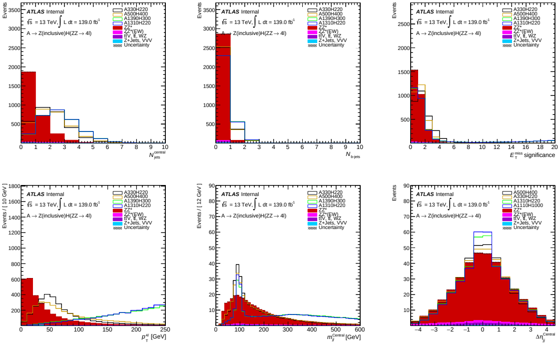
	-2σ	-1σ	Median	$+1\sigma$	$+2\sigma$	Significance
No systematic	44.95	60.34	83.74	119.00	168.60	0.0271
With systematic	46.34	62.21	86.34	153.70	210.7	0.0268

- The impact $\Delta\mu$ of NP θ on the POI μ is given by the shift in the POI between the nominal and another fit where the NP is fixed

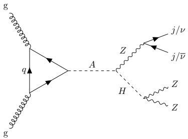


$4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ analysis

AZH signal optimisation: cut-based



- ☐ Keeping the categories from the RSH signal optimisation.
- ☐ At least 2 central jets inside the m_{jj} peak.
- ☐ Exactly one central jet with events outside m_{jj} peak.
- ☐ At least 1/2 b-jets.

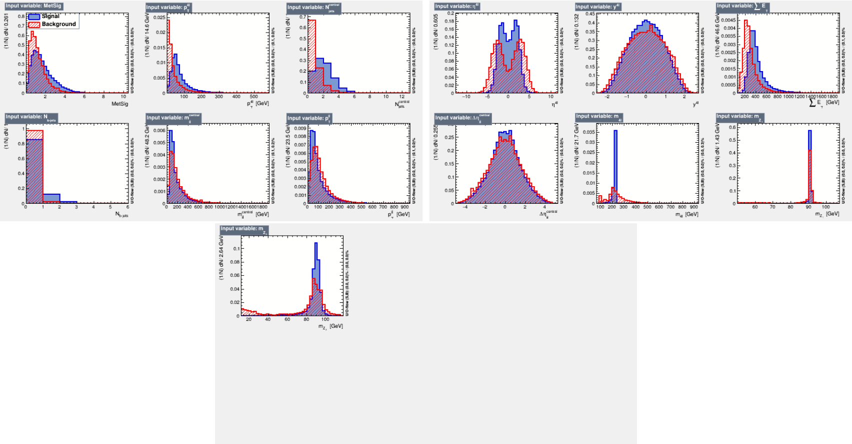


	$(m_A, m_H) = (330, 220)$	$(m_A, m_H) = (500, 400)$	$(m_A, m_H) = (1390, 300)$	$(m_A, m_H) = (1310, 220)$	$qqZZ^*$	$qqZZ^*$ (EW)	$ggZZ^*$	$t\bar{t}V$	$Z + jets$	$t\bar{t}$	VVV	WZ	$s/\sqrt{k \cdot b}$	$s/\sqrt{k \cdot b}$	$s/\sqrt{k \cdot b}$	$s/\sqrt{k \cdot b}$
4ℓ	60.35±0.13	72.29±0.14	85.04±0.15	79.38±0.15	2516.52±4.50	348.96±0.71	32.85±0.28	10.35±8.28	19.04±0.11	8.60±0.05	5.12±0.34	2.68±0.20	2.47	6.66	4.35	3.25
High-E_{T}^{miss} & $N_{\mathrm{jets}}^{\mathrm{Central}} = 0$	5.61±0.04	3.51±0.03	5.03±0.04	4.86±0.04	82.73±0.94	21.12±0.18	0.51±0.03	0.32±0.32	7.22±0.07	0.33±0.01	1.69±0.19	0.53±0.07	1.16	1.64	1.30	1.01
Low-E_{T}^{miss} & $N_{\mathrm{jets}}^{\mathrm{Central}} = 0$	2.22±0.02	2.81±0.03	0.30±0.01	0.27±0.01	175.31±1.47	37.18±0.23	0.48±0.03	1.51±1.51	0.96±0.02	0.04±0.00	0.44±0.10	0.12±0.03	0.33	0.96	0.06	0.04
High-E_{T}^{miss} & $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$	2.88±0.03	1.33±0.02	14.69±0.06	13.40±0.06	10.46±0.23	2.25±0.06	0.30±0.02	0.01±0.01	4.68±0.06	0.93±0.02	0.76±0.13	0.63±0.11	1.43	1.48	9.11	6.65
Low-E_{T}^{miss} & $N_{\mathrm{jets}}^{\mathrm{Central}} \geq 1$	4.50±0.03	4.00±0.03	2.45±0.03	2.13±0.02	41.09±0.62	8.40±0.11	1.04±0.04	0.00±0.00	1.50±0.03	0.32±0.01	0.32±0.08	0.12±0.03	1.37	2.75	0.94	0.65
$N_{\mathrm{b-jets}} \geq 1$	8.94±0.05	10.21±0.05	18.87±0.07	17.52±0.07	65.07±0.54	7.32±0.11	2.19±0.07	0.00±0.00	0.56±0.02	6.45±0.04	0.16±0.06	0.92±0.13	2.18	5.61	5.76	4.28
$N_{\mathrm{jets}}^{\mathrm{Central}} \geq 2$& $\lvert m_{\mathrm{jj}}^{\mathrm{Central}} - m_Z \rvert < 60$	10.86±0.05	13.58±0.06	6.18±0.04	6.43±0.04	113.57±0.53	18.48±0.16	3.65±0.08	0.25±0.21	0.50±0.02	0.11±0.01	0.14±0.05	0.03±0.01	2.06	5.81	1.47	1.22
$N_{\mathrm{jets}}^{\mathrm{Central}} = 1$ & $\lvert m_{\mathrm{jj}}^{\mathrm{Central}} - m_Z \rvert > 60$	12.31±0.06	16.46±0.07	10.07±0.05	9.40±0.05	526.17±2.00	80.78±0.34	8.83±0.14	0.34±0.28	1.58±0.03	0.19±0.01	0.68±0.12	0.16±0.05	1.10	3.31	1.12	0.84
Rest	13.04±0.06	20.40±0.07	27.45±0.09	25.36±0.08	1502.12±3.49	173.43±0.50	15.85±0.21	7.93±8.13	2.04±0.03	0.22±0.01	0.94±0.16	0.17±0.04	0.70	2.47	1.85	1.36

- $s/\sqrt{kb}$ is used as a sensitivity to judge the optimisation.
- It's only calculated for background events under the signal peak.
- Remove the Low-$E_{\mathrm{T}}^{\mathrm{miss}}$ bin of $N_{\mathrm{jets}}^{\mathrm{Central}} = 0$ and the Rest categories.
- The combined significance for the 6 categories is 3.93.
- The optimisation depends on the signal mass point.
- So for different signal samples the sensitivity is quite different.

$4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ analysis

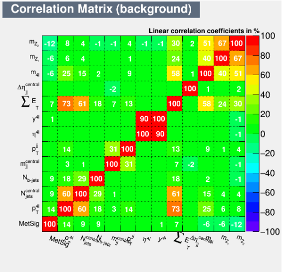
AZH signal optimisation: TMVA

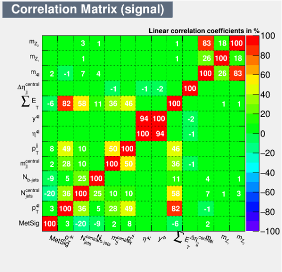


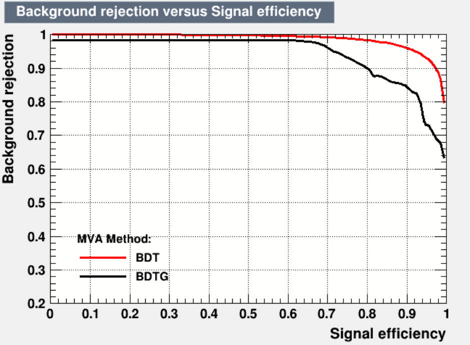
- ☐ 13 input variables to the TMVA.

$4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ analysis

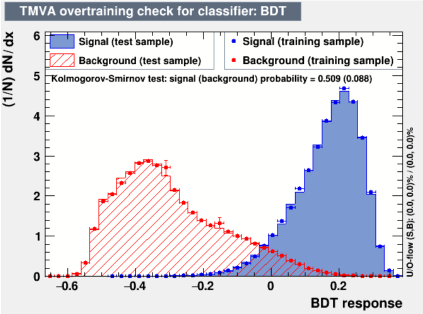
AZH signal optimisation: TMVA

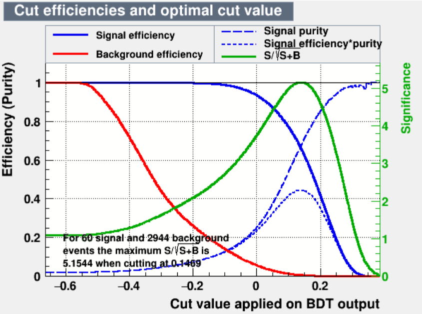






$4\ell + E_{\mathrm{T}}^{\mathrm{miss}}$ analysis
AZH signal optimisation: TMVA





Summary

- A preliminary result of the upper limit and significance for the $H \to 4l$ are shown.
- AZH signal optimisation is done using cut-based analysis and TMVA.

Thank you!

Additional slides
Event selection

Event Selection	
Quadruplet Selection	- Require at least one quadruplet of leptons consisting of two pairs of same-flavour opposite-charge leptons fulfilling the following requirements: - p_T thresholds for three leading leptons in the quadruplet: 20, 15 and 10 GeV - Maximum one calo-tagged or stand-alone muon or silicon-associated forward per quadruplet - Leading di-lepton mass requirement: $50 < m_{12} < 106$ GeV - Sub-leading di-lepton mass requirement: $m_{\text{threshold}} < m_{34} < 115$ GeV - $\Delta R(\ell, \ell') > 0.10$ for all leptons in the quadruplet - Remove quadruplet if alternative same-flavour opposite-charge di-lepton gives $m_{\ell\ell} < 5$ GeV - Keep all quadruplets passing the above selection
Isolation	- Contribution from the other leptons of the quadruplet is subtracted - FixedCutPFlowLoose WP for all leptons
Impact Parameter Significance	- Apply impact parameter significance cut to all leptons of the quadruplet - For electrons: $d_0/\sigma_{d_0} < 5$ - For muons: $d_0/\sigma_{d_0} < 3$
Best Quadruplet	- If more than one quadruplet has been selected, choose the quadruplet with highest Higgs decay ME according to channel: 4μ, $2e2\mu$, $2\mu2e$ and $4e$
Vertex Selection	- Require a common vertex for the leptons: - χ^2/ndof < 5 for 4μ and < 9 for others decay channels

Additional slides

Nuisance parameters

Normalisation	Shape
Electrons	
EL_EFF_ID_CorrUncertaintyNP[0-15] EL_EFF_ID_SIMPLIFIED_UncorrUncertaintyNP[0-17] EL_EFF_Iso_TOTAL_1NPCOR_PLUS_UNCOR EL_EFF_Reco_TOTAL_1NPCOR_PLUS_UNCOR	EG_RESOLUTION_ALL EG_SCALE_ALLCORR EG_SCALE_E4SCINTILLATOR EG_SCALE_LARCALIB_EXTRA2015PRE EG_SCALE_LARTEMPERATURE_EXTRA2015PRE EG_SCALE_LARTEMPERATURE_EXTRA2016PRE
Muons	
MUON_EFF_ISO_STAT MUON_EFF_ISO_SYS MUON_EFF_RECO_STAT MUON_EFF_RECO_STAT_LOWPT MUON_EFF_RECO_SYS MUON_EFF_RECO_SYS_LOWPT MUON_EFF_TTVA_STAT MUON_EFF_TTVA_SYS	MUON_ID MUON_MS MUON_SAGITTA_RESBIAS MUON_SAGITTA_RHO MUON_SCALE
Jets	
	JET_BJES_Response JET_EffectiveNP_[1-7] JET_EffectiveNP_8restTerm JET_EtaIntercalibration_Modelling JET_EtaIntercalibration_NonClosure_highE JET_EtaIntercalibration_NonClosure_negEta JET_EtaIntercalibration_NonClosure_posEta JET_EtaIntercalibration_TotalStat JET_Flavor_Composition JET_Flavor_Response JET_JER_DataVsMC JET_JER_EffectiveNP_[1-6] JET_JER_EffectiveNP_7restTerm JET_Pileup_OffsetMu JET_Pileup_OffsetNPV JET_Pileup_PtTerm JET_Pileup_RhoTopology JET_PunchThrough_MC16 JET_SingleParticle_HighPt
Missing transverse energy	
	MET_SoftTrk_ResoPara MET_SoftTrk_ResoPerp MET_SoftTrk_Scale
Other	
HOEW_QCD_syst HOEW_syst HOQCD_scale_syst PRW_DATASF	