4ℓ+MET: Analysis update

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Status of the signal samples

- ☐ The total signal samples that generated for the RSH(AHZ) is 9+11+59 (72)
- ☐ The derivation request with p3980 is progressing, see RSH, RSH and AZH.
- ☐ Also, I'm going to submit derivation request for all signal samples with p4222.
- ☐ Minitrees production for the signal samples:
  - For RSH, we have 57 samples in the shared directory.
  - For AZH, all signal samples are ready.
- ☐ We'll use this sample for the optimisation of the AZH signal
- ☐ But the rest of the AZH samples will soon be available too.

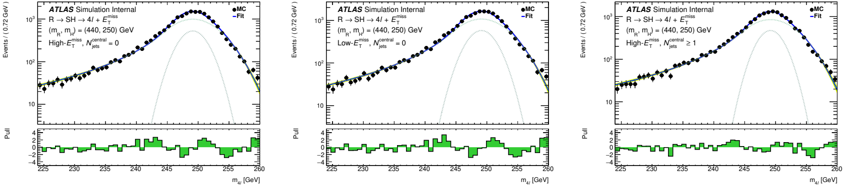
Signal modelling for the new samples

Mass point = (m_X, m_H) [GeV]	χ^2/ndof
1000, 800	1.85014
1010, 800	1.39401
1060, 400	1.35326
1160, 500	1.7892
1160, 800	1.9182
1180, 1000	1.88946
1190, 1000	1.44067
1200, 1000	1.96762
1210, 1000	1.84266
1260, 600	1.03395
1360, 1000	2.29052
1460, 300	1.59699
1560, 400	1.95268
1660, 500	1.96959
1760, 600	1.96896
1960, 800	1.91606
2160, 1000	1.84344
430, 250	1.20425
440, 250	2.227
460, 250	1.82697
470, 300	1.25585
480, 300	0.78615
490, 300	1.22549
500, 300	1.65248
510, 300	1.08176
560, 300	1.27141

Mass point = (m_X, m_H) [GeV]	χ^2/ndof
1000, 800	1.95861
1010, 800	1.4331
1060, 400	1.33143
1160, 500	1.81493
1160, 800	1.90257
1180, 1000	2.21897
1190, 1000	1.79124
1200, 1000	2.19962
1210, 1000	2.22952
1260, 600	1.01053
1360, 1000	2.3603
1460, 300	1.58613
1560, 400	1.94597
1660, 500	1.94704
1760, 600	1.97319
1960, 800	1.9331
2160, 1000	1.85017
430, 250	1.39613
440, 250	2.39374
460, 250	1.81402
470, 300	1.5037
480, 300	0.975977
490, 300	1.09163
500, 300	1.78116
510, 300	1.05868
560, 300	1.24675

Mass point = (m_X, m_H) [GeV]	χ^2/ndof
1000, 800	3.02924
1010, 800	1.65503
1060, 400	2.14735
1160, 500	3.58697
1160, 800	3.8316
1180, 1000	1.58653
1190, 1000	3.70556
1200, 1000	1.73328
1210, 1000	1.62238
1260, 600	3.13228
1360, 1000	4.06548
1460, 300	16.2813
1560, 400	36.6814
1660, 500	4.97472
1760, 600	4.61242
1960, 800	2.50776
2160, 1000	4.28975
430, 250	1.09142
440, 250	1.36827
460, 250	1.21041
470, 300	1.38476
480, 300	1.71727
490, 300	1.19766
500, 300	1.15194
510, 300	1.72806
560, 300	4.20236

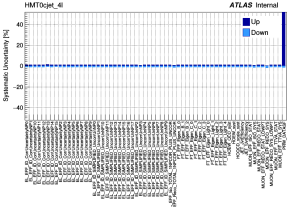
Mass point = (m_X, m_H) [GeV]	χ^2/ndof
1000, 800	inf
1010, 800	1.88674
1060, 400	2.16674
1160, 500	3.60057
1160, 800	3.81161
1180, 1000	2.77137
1190, 1000	2.73601
1200, 1000	2.82182
1210, 1000	2.04979
1260, 600	1866.55
1360, 1000	4.28811
1460, 300	7.02133
1560, 400	36.0858
1660, 500	4.97847
1760, 600	4.55971
1960, 800	2.5337
2160, 1000	4.28323
430, 250	1.57311
440, 250	127.647
460, 250	1.2663
470, 300	1.39411
480, 300	2.00516
490, 300	1.1077
500, 300	0.976088
510, 300	3.74319
560, 300	4.38394

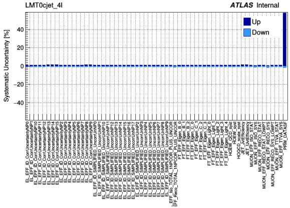


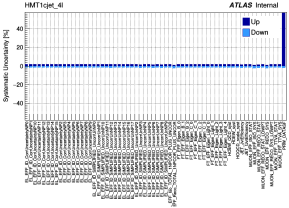
- The same effect that we observed earlier, the fit goes bad when move at least one central jet categories. So a bit of tuning there is needed. But for now this should be enough to get the expected upper limit.

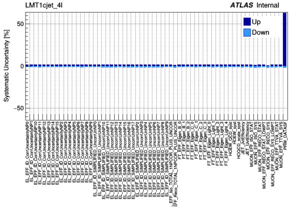
Experimental systematic uncertainties

Normalisation systematic





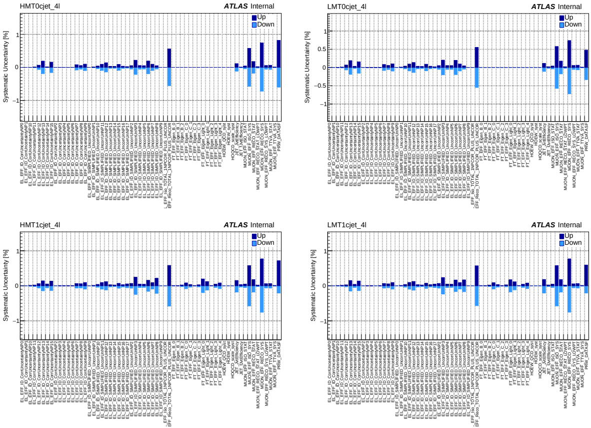




- ☐ Systematic variation in the normalisation of the $m_{4\ell}$ for the $(390, 220)$ signal.
- ☐ We had visualization problem for the nuisance parameters but now is fixed.
- ☐ However, still see a problem on the PRW_DATASF parameter.

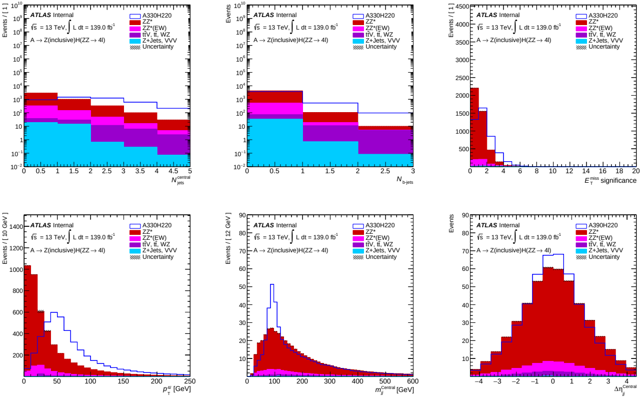
Experimental systematic uncertainties

Normalisation systematic



- After fixing the problem with the PRW_DATASF parameter, now we can see that the systematic variation in the normalisation of the $m_{4\ell}$ is roughly less than 1%.

AZH signal optimisation



- ☐ Keeping the categories from the RSH signal optimisation (4 categories).
- ☐ At least 2 central jets inside the m_Z peak.
- ☐ Exactly one central jet together with events outside m_Z peak.
- ☐ At least 1/2 b-jets.

AZH signal optimisation

	$(m_A, m_H) = (330, 220)$	$qqZZ^*$	$qqZZ^*$ (EW)	$ggZZ^*$	$t\bar{t}V$	$Z + jets$	$t\bar{t}$	VVV	WZ	$s/\sqrt{20.3\% \cdot b}$
4ℓ	65.21±0.13	3825.72±5.50	454.60±0.81	56.51±0.35	18.79±0.07	32.71±15.81	1.55±0.25	12.16±0.51	22.85±0.13	2.17587
High-E_T^{miss} & $N_{jets}^{Central} = 0$	5.99±0.04	139.23±1.20	29.67±0.21	1.62±0.06	0.67±0.01	0.32±0.32	0.08±0.05	4.10±0.30	8.84±0.08	0.97829
Low-E_T^{miss} & $N_{jets}^{Central} = 0$	2.50±0.03	298.53±1.84	52.52±0.28	1.31±0.05	0.09±0.00	8.01±7.94	0.00±0.00	1.20±0.16	1.24±0.03	0.29119
High-E_T^{miss} & $N_{jets}^{Central} \geq 1$	3.05±0.03	19.24±0.34	3.27±0.07	0.81±0.04	2.08±0.02	0.01±0.01	0.51±0.15	2.10±0.21	5.56±0.07	1.16727
Low-E_T^{miss} & $N_{jets}^{Central} \geq 1$	4.83±0.04	67.41±0.74	11.13±0.13	2.39±0.06	0.66±0.01	1.93±1.52	0.08±0.05	1.04±0.15	1.76±0.04	1.15302
$N_{jets}^{Central} \geq 2$& $\lvert m_{jj}^{Central} - m_Z \rvert < 60$	15.07±0.06	168.88±0.65	23.75±0.18	7.44±0.12	4.42±0.03	0.25±0.21	0.23±0.10	0.37±0.08	0.72±0.02	2.33051
$N_{jets}^{Central} = 1$ & $\lvert m_{jj}^{Central} - m_Z \rvert > 60$	16.02±0.07	773.63±2.48	103.21±0.39	17.70±0.19	2.97±0.02	11.60±10.55	0.36±0.12	1.64±0.18	2.03±0.04	1.17657
$N_{b-jets} \geq 1$	3.24±0.03	25.75±0.22	2.25±0.06	1.93±0.06	7.46±0.05	0.00±0.00	0.29±0.11	0.02±0.02	0.30±0.02	1.16829

	$(m_A, m_H) = (1310, 220)$	$qqZZ^*$	$qqZZ^*$ (EW)	$ggZZ^*$	$t\bar{t}V$	$Z + jets$	$t\bar{t}$	VVV	WZ	$s/\sqrt{20.3\% \cdot b}$
4ℓ	81.64±0.15	3825.72±5.50	454.60±0.81	56.51±0.35	18.79±0.07	32.71±15.81	1.55±0.25	12.16±0.51	22.85±0.13	2.72405
High-E_T^{miss} & $N_{jets}^{Central} = 0$	5.00±0.04	139.23±1.20	29.67±0.21	1.62±0.06	0.67±0.01	0.32±0.32	0.08±0.05	4.10±0.30	8.84±0.08	0.81687
Low-E_T^{miss} & $N_{jets}^{Central} = 0$	0.28±0.01	298.53±1.84	52.52±0.28	1.31±0.05	0.09±0.00	8.01±7.94	0.00±0.00	1.20±0.16	1.24±0.03	0.03241
High-E_T^{miss} & $N_{jets}^{Central} \geq 1$	13.88±0.06	19.24±0.34	3.27±0.07	0.81±0.04	2.08±0.02	0.01±0.01	0.51±0.15	2.10±0.21	5.56±0.07	5.31504
Low-E_T^{miss} & $N_{jets}^{Central} \geq 1$	2.24±0.02	67.41±0.74	11.13±0.13	2.39±0.06	0.66±0.01	1.93±1.52	0.08±0.05	1.04±0.15	1.76±0.04	0.53456
$N_{jets}^{Central} \geq 2$& $\lvert m_{jj}^{Central} - m_Z \rvert < 60$	9.30±0.05	168.88±0.65	23.75±0.18	7.44±0.12	4.42±0.03	0.25±0.21	0.23±0.10	0.37±0.08	0.72±0.02	1.43810
$N_{jets}^{Central} = 1$ & $\lvert m_{jj}^{Central} - m_Z \rvert > 60$	12.80±0.06	773.63±2.48	103.21±0.39	17.70±0.19	2.97±0.02	11.60±10.55	0.36±0.12	1.64±0.18	2.03±0.04	0.94021
$N_{b-jets} \geq 1$	12.13±0.06	25.75±0.22	2.25±0.06	1.93±0.06	7.46±0.05	0.00±0.00	0.29±0.11	0.02±0.02	0.30±0.02	4.36708

- $s/\sqrt{kb}$ is used as a sensitivity to judge the optimisation.
- It's only calculated for background events under the signal peak.
- $k = m_{4\ell}(> 210- > 230)/m_{4\ell}(> 200) = 20.3\%$
- The combined significance is 3.85 for the 7 categories.
- 2.27 combined significance for the E_T^{miss} categories, and 3.10 for the jet ones.

Summary

- ☐ The generation of all signal samples for RSH and AZH is completed.
- ☐ Now we're on the process of getting the DAOD's, the request was made for p3980. Soon we'll request DAOD's with p4222 p-tag.
- ☐ A preliminary signal fit is made for the new samples to carry on with the upper limit calculation.
- ☐ The problem we had with visualizing the experimental systematic is fixed.
- ☐ And it turns out that the normalisation systematic is less than 1%.
- ☐ The AZH signal optimisation is divided into 7 categories; 3 jet categories in addition to the 4 categories from the RSH optimisation.

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	

Additional slides

AZH kinematic distributions