Combination

BSM neutral Higgs

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and all the contributors working on A and H
01-09-2014
IHEP

Overview

- Combination on **higgs-pair production** with **HH->bbyy** and **HH->bbbb** final states for NON-resonant search:
  - bbyy released paper, mature [arXiv:1406.5053]
  - bbbb published previously with graviton signal [ATLAS-CONF-2014-005], has changed to higgs signal samples, being ongoing, not yet provided workspace
- Combination on **A->Zh production** with **lltautau (hadhad,lephad,leplep)** and **ll,vv bb** final states for A search
  - lltautau workspaces: hadhad/lephad updated with ATLAS convention; leplep updated but not yet with ATLAS convention (22Aug)
  - ll,vv bb workspaces: updated workspaces (27July)
  - Correlations on nuisance parameters: between hadhad and lephad, leplep can join once ATLAS convention is implemented; between llbb and vvbb
- This talk will focus on AZh combination

Nuisance parameters

- correlate LUMI between lltautau and xxbb: **169 + 58** nuis

	lltautau	xxbb
# nui parameters syst+stats	34+58	136+0
correlation	(only hadhad and lephad) alpha_ATLAS_BR_HTAUTAU, alpha_ATLAS_EL_EFF, alpha_ATLAS_EL_ES, alpha_ATLAS_JER_lltautau, alpha_ATLAS_JES_lltautau, alpha_ATLAS_MET_lltautau, alpha_ATLAS_MU_2012_TRIG, alpha_ATLAS_MU_EFF, alpha_ATLAS_MU_MS, alpha_ATLAS_PILEUP, alpha_ATLAS_TAU_2012_ID, alpha_ATLAS_TES_2012, alpha_QCDscale_VH, alpha_QCDscale_ggVV, alpha_QCDscale_qqVV, alpha_pdf_qq	(between llbb and vvbb) 40 SysBtag* 25 SysJet* SysJVF 3 SysMET ATLAS_norm_Zbb, ATLAS_norm_Zcl, ATLAS_norm_Zl, ATLAS_norm_ttbar, etc.

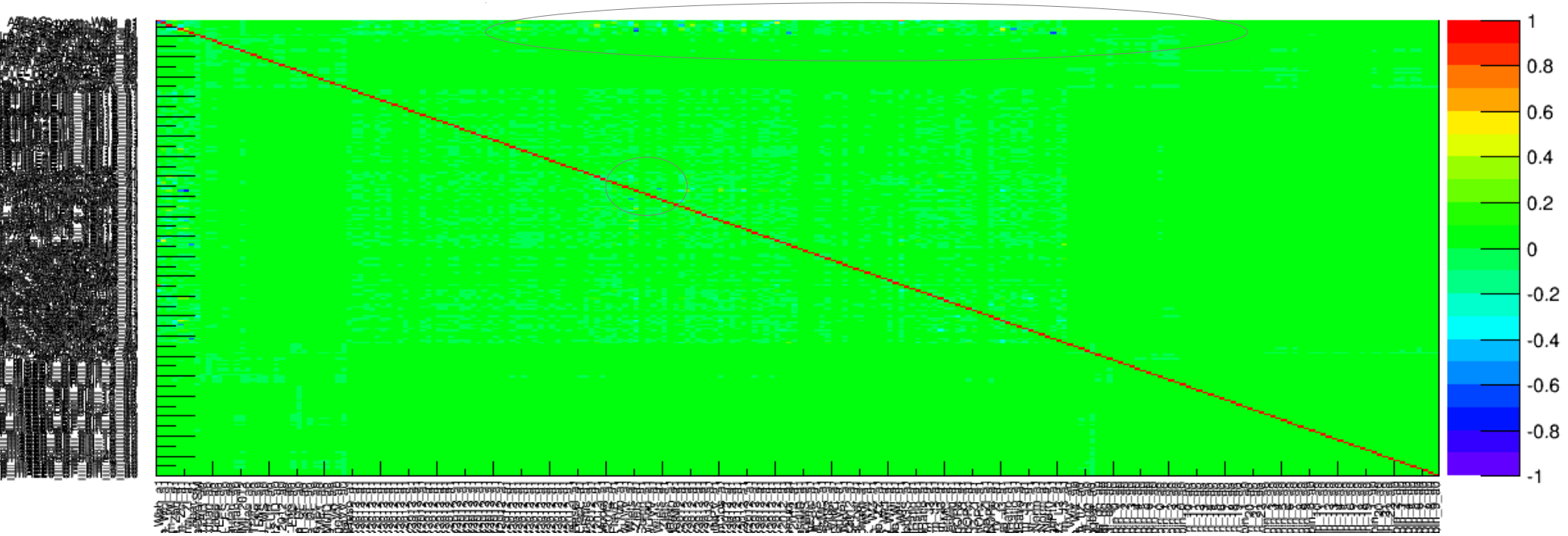
AZh – correlation (asimov mu=0)

mA=220GeV

ATLAS_norm_XXX

SysJet

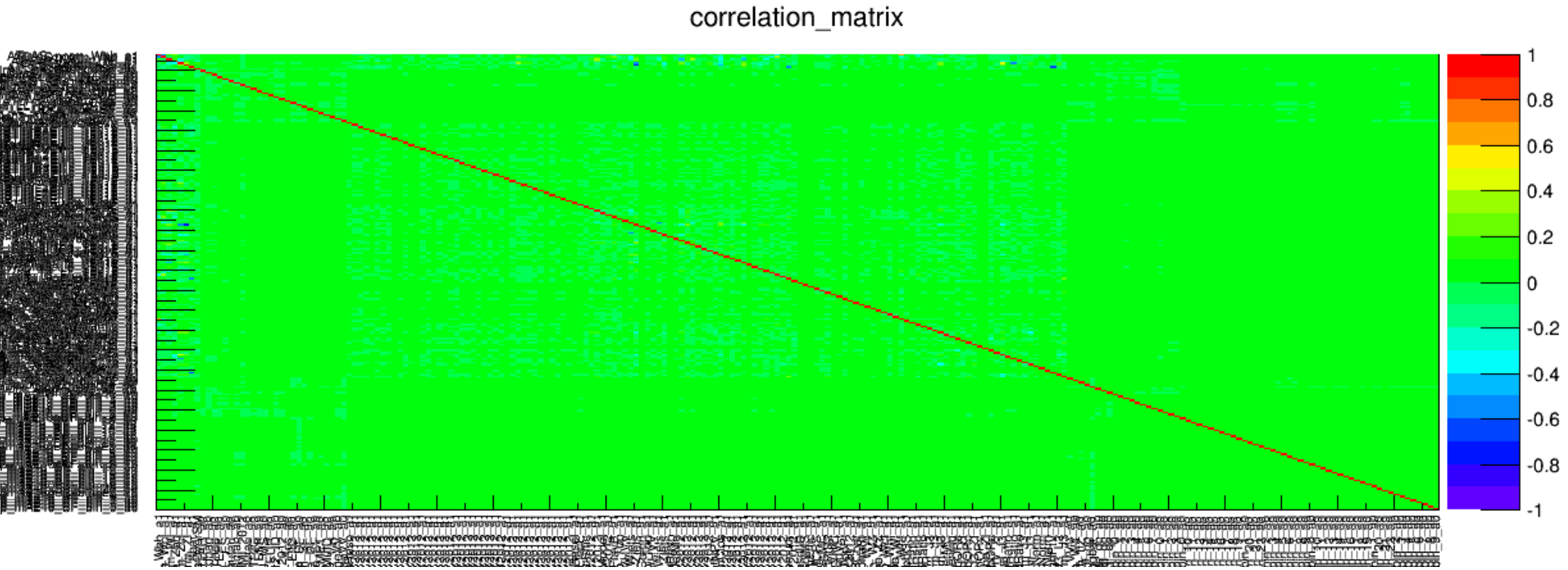
SysZbbNorm_J3
SysZblZbbRatio
SysttbarHighPtV



close to diagonal: SysJetFlavComp_Wjets vs SysJetFlavResp_Wjets

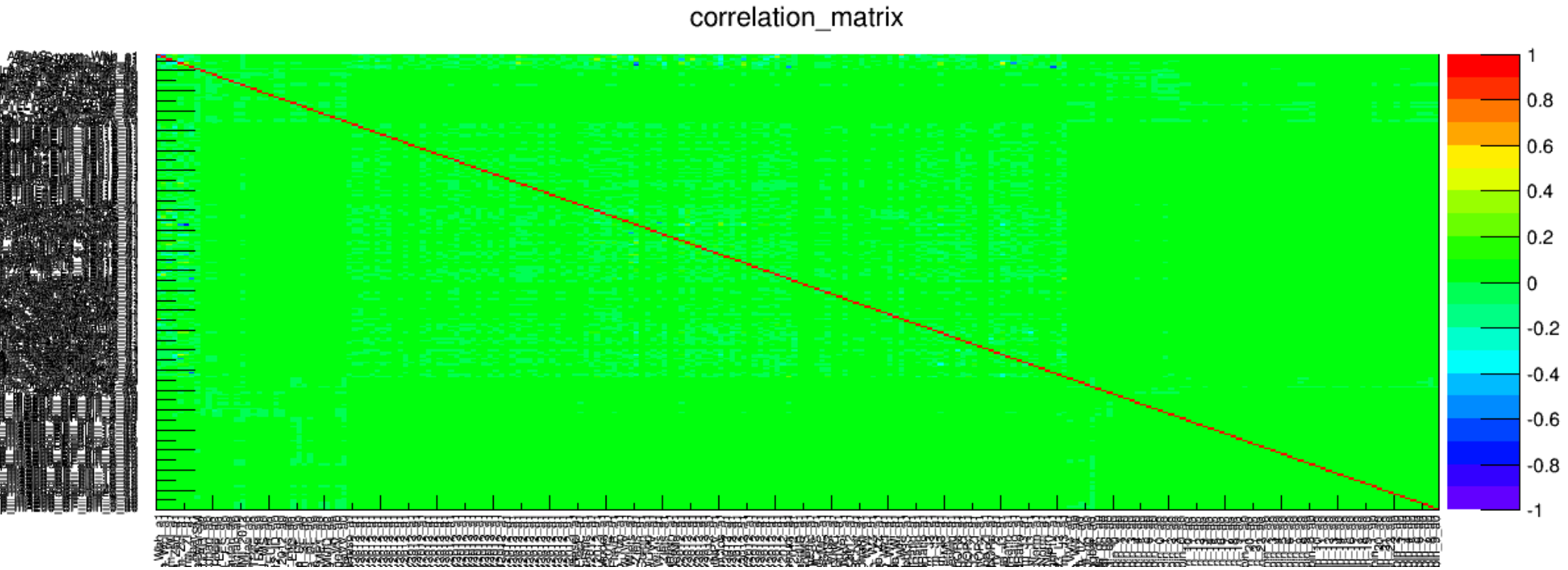
AZh – correlation (asimov mu=0)

mA=240GeV



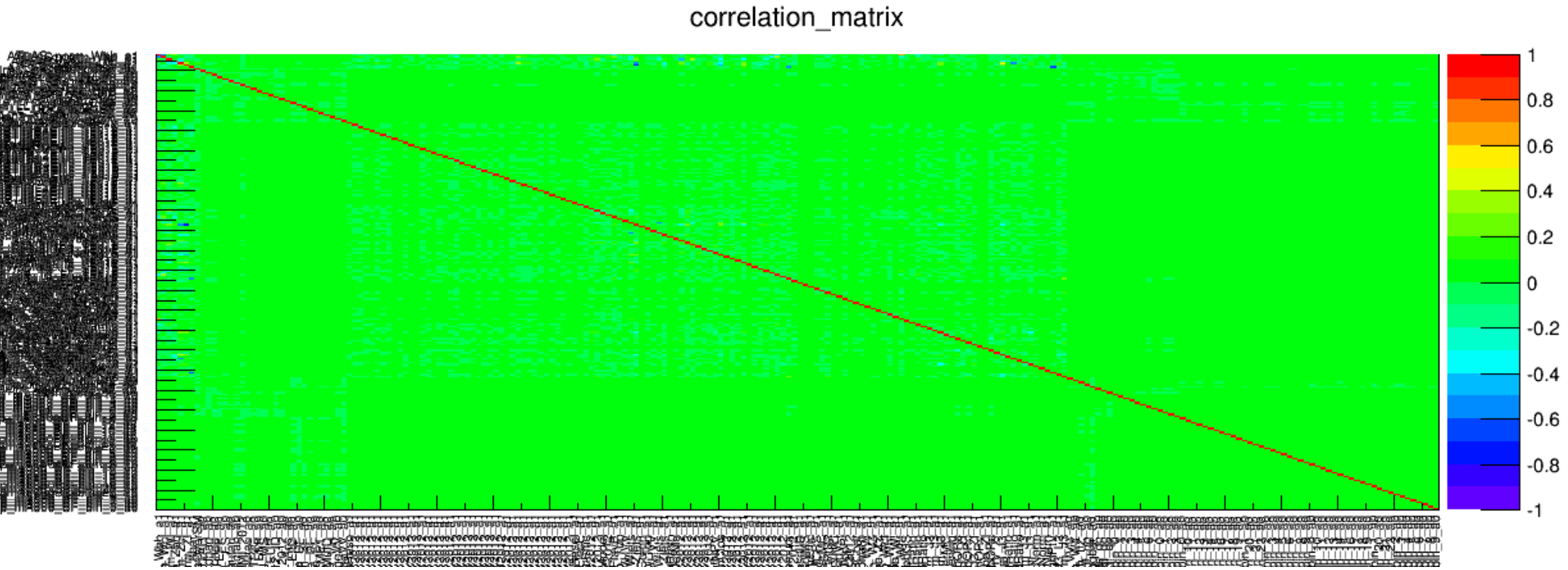
AZh – correlation (asimov mu=0)

mA=260GeV



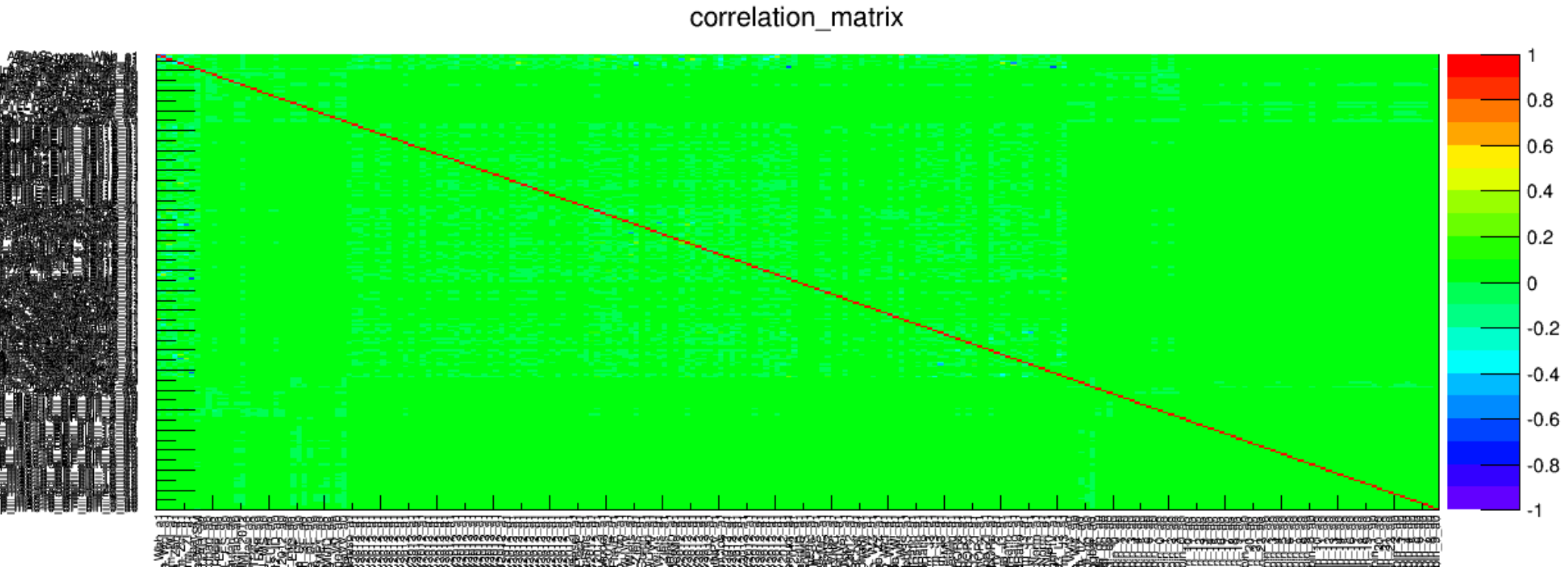
AZh – correlation (asimov mu=0)

mA=300GeV



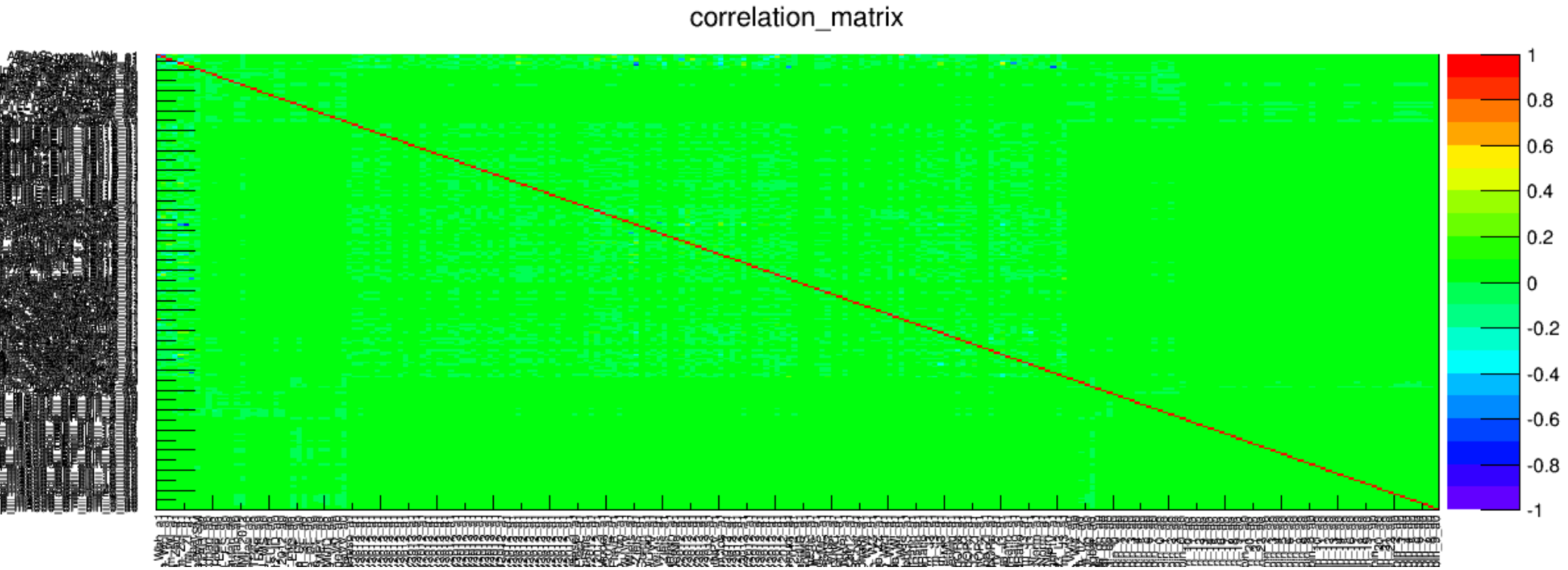
AZh – correlation (asimov mu=0)

mA=340GeV



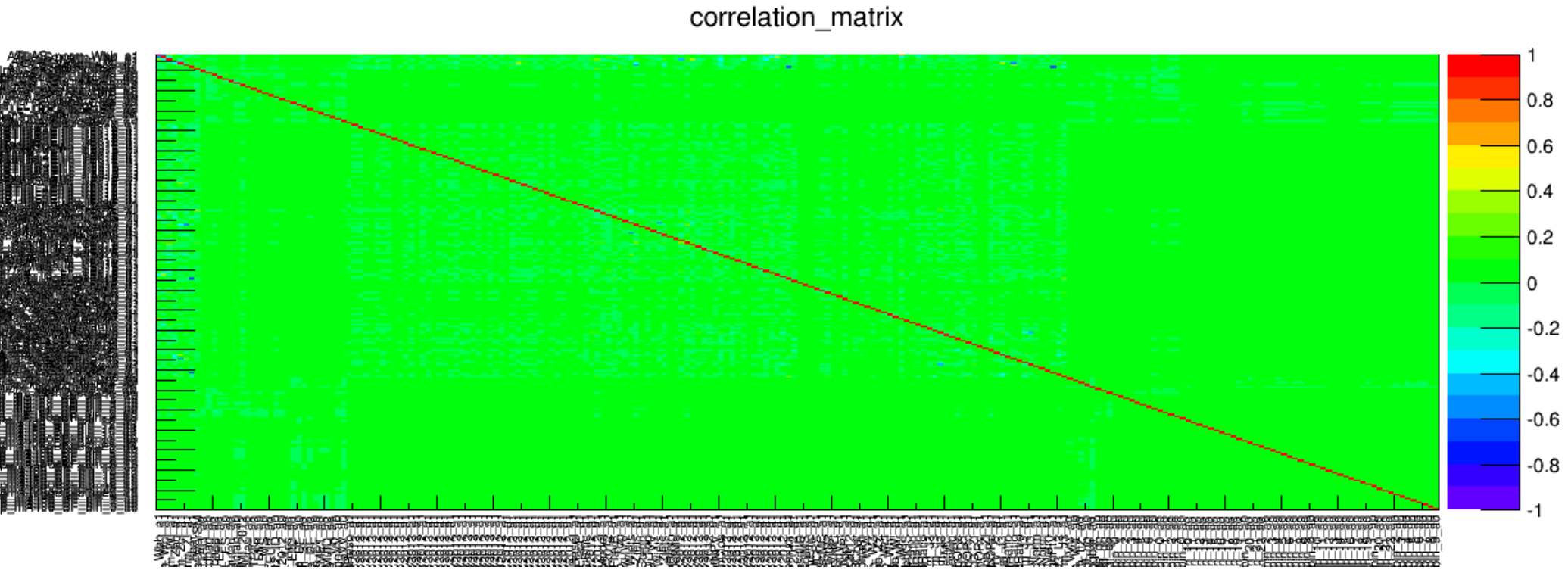
AZh – correlation (asimov mu=0)

mA=350GeV



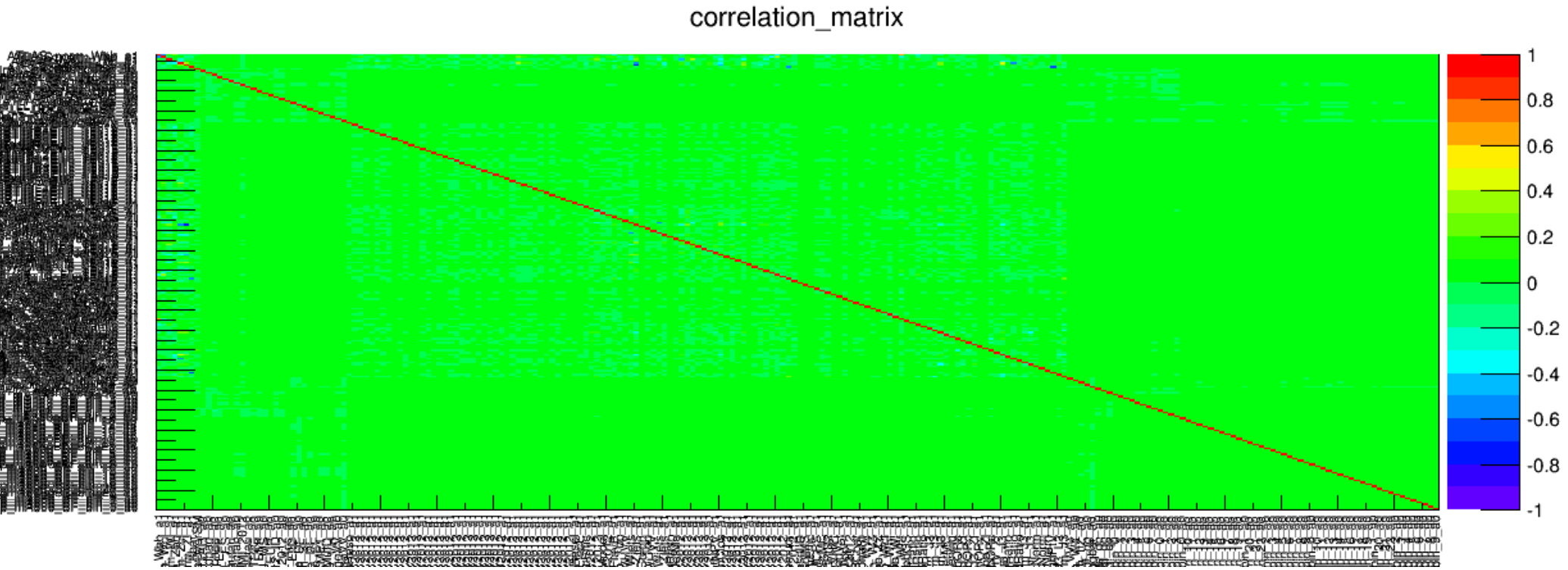
AZh – correlation (asimov mu=0)

mA=400GeV



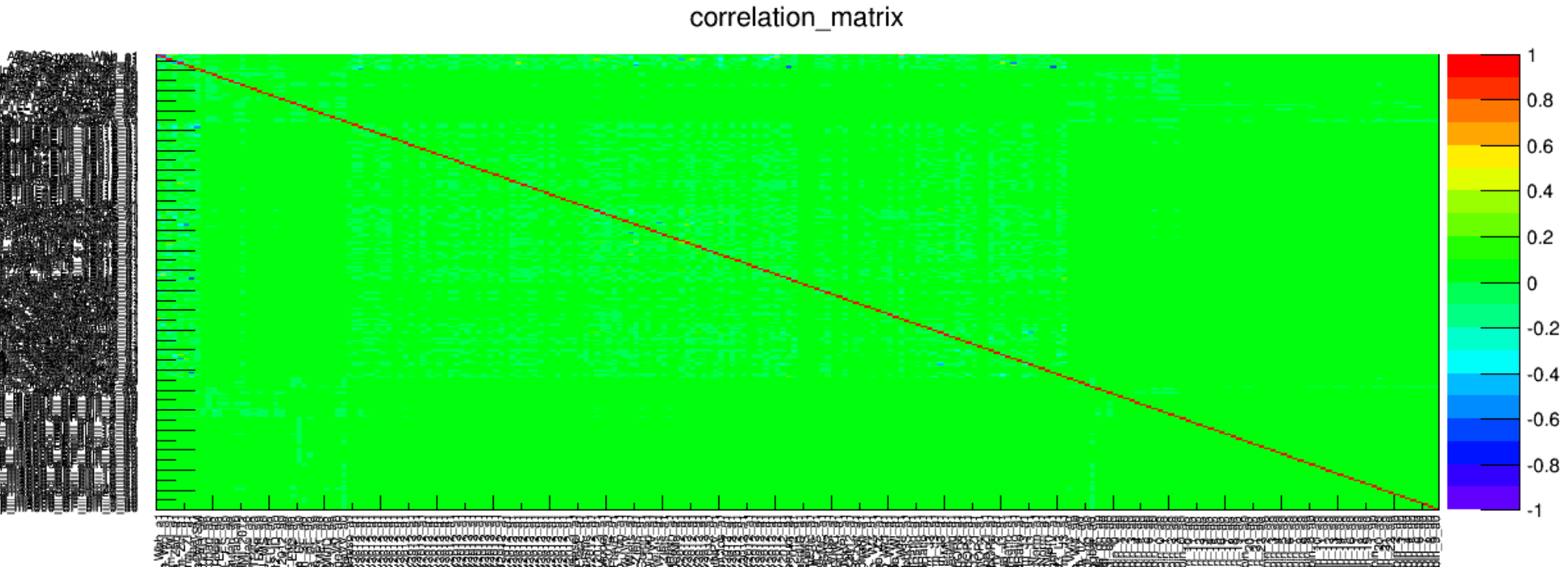
AZh – correlation (asimov mu=0)

mA=500GeV



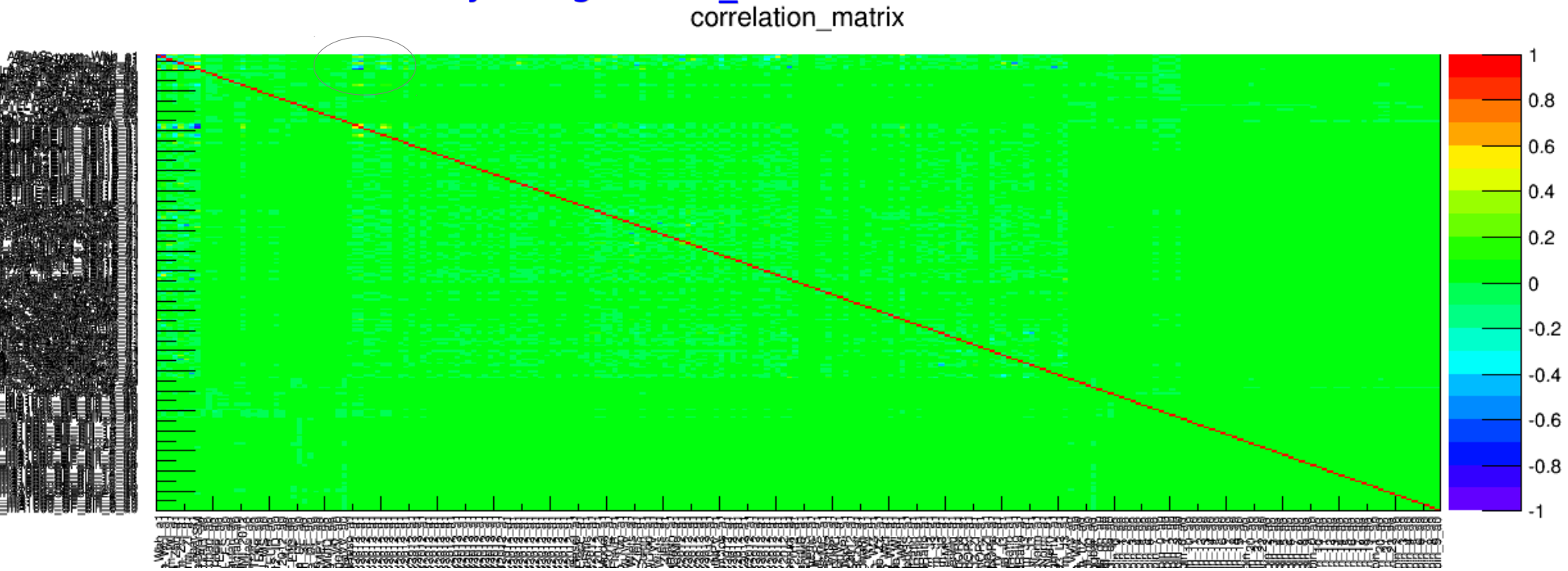
AZh – correlation (asimov mu=0)

mA=800GeV



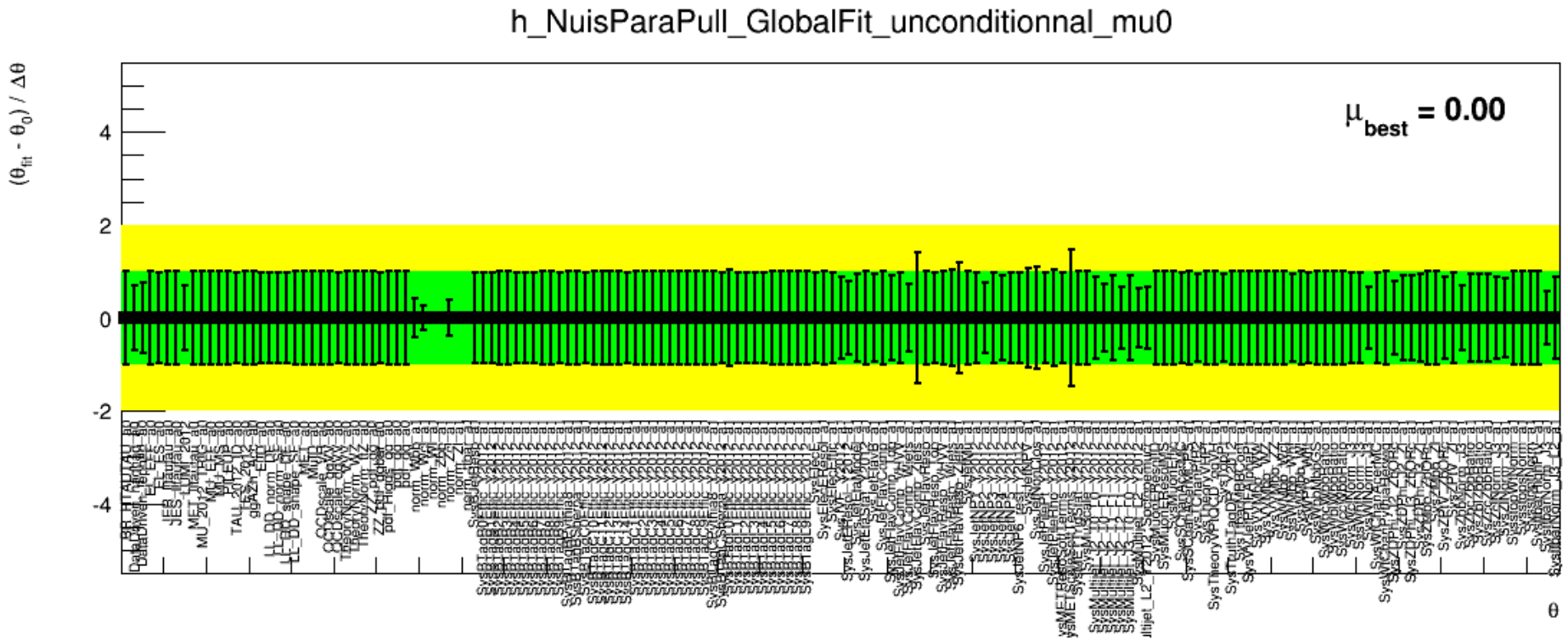
AZh – correlation (asimov mu=0) mA=1TeV

ATLAS_norm_XXX SysBTagB0Effic_Y2012
POI SysBTagB1Effic_Y2012



AZh – pull check (asimov mu=0)

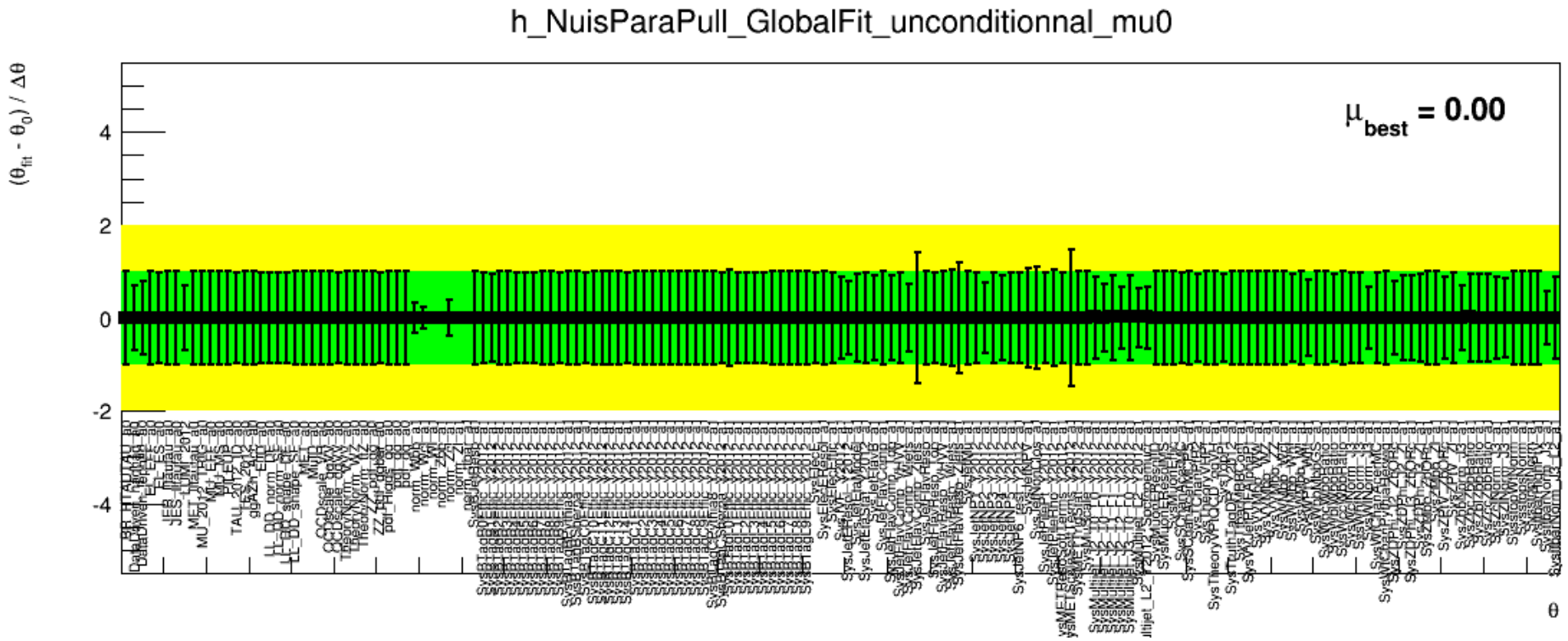
mA=220GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

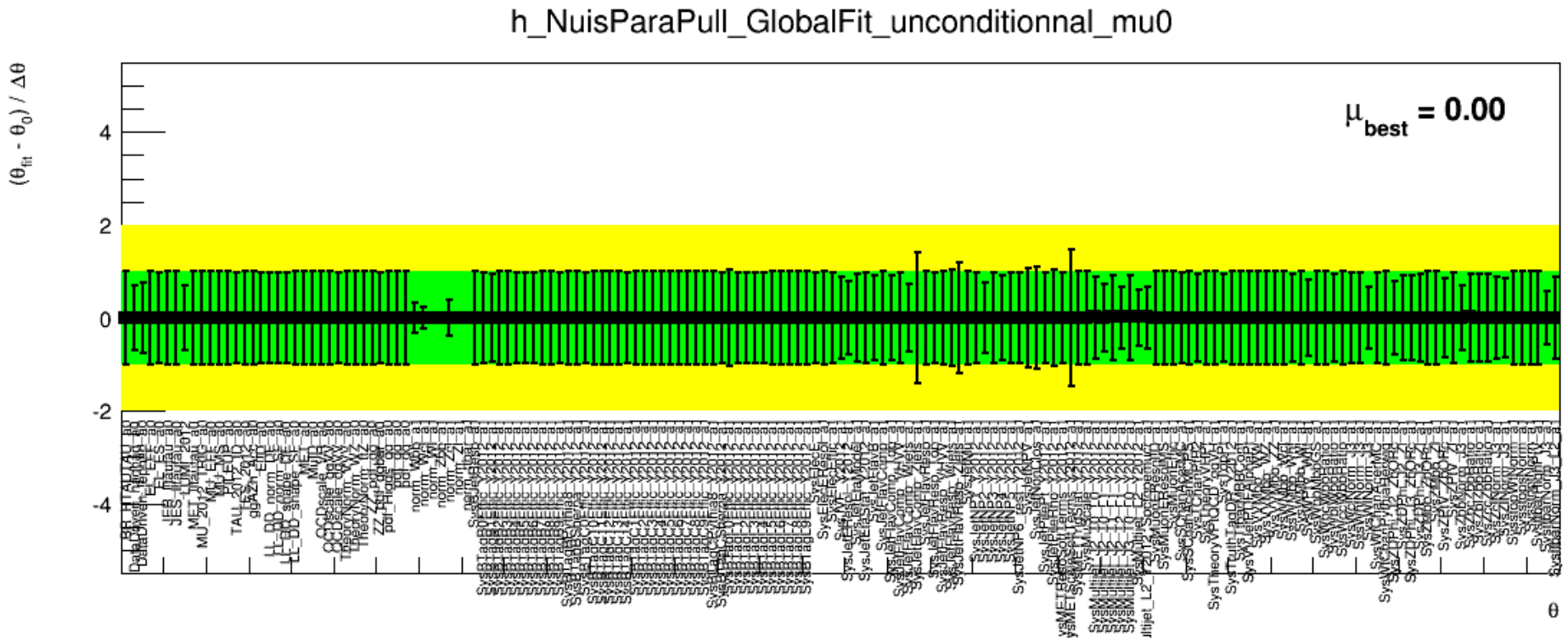
mA=240GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

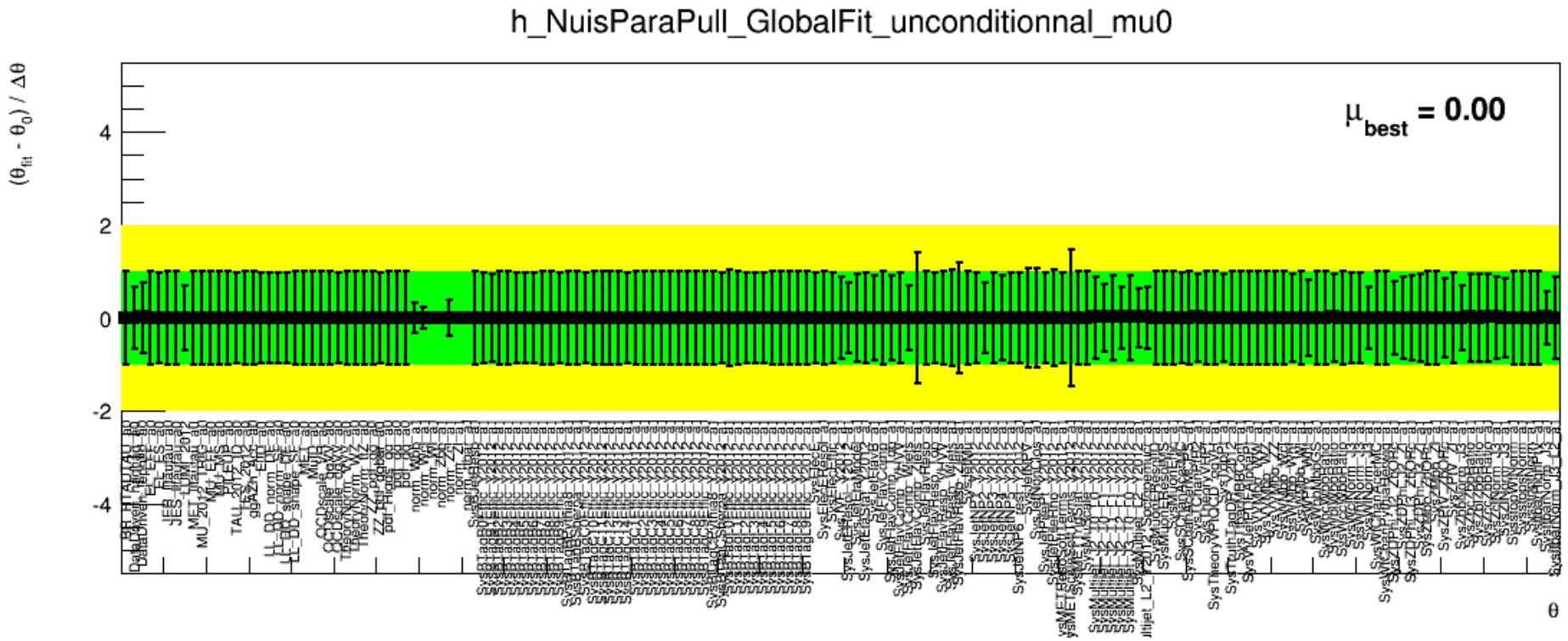
mA=260GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

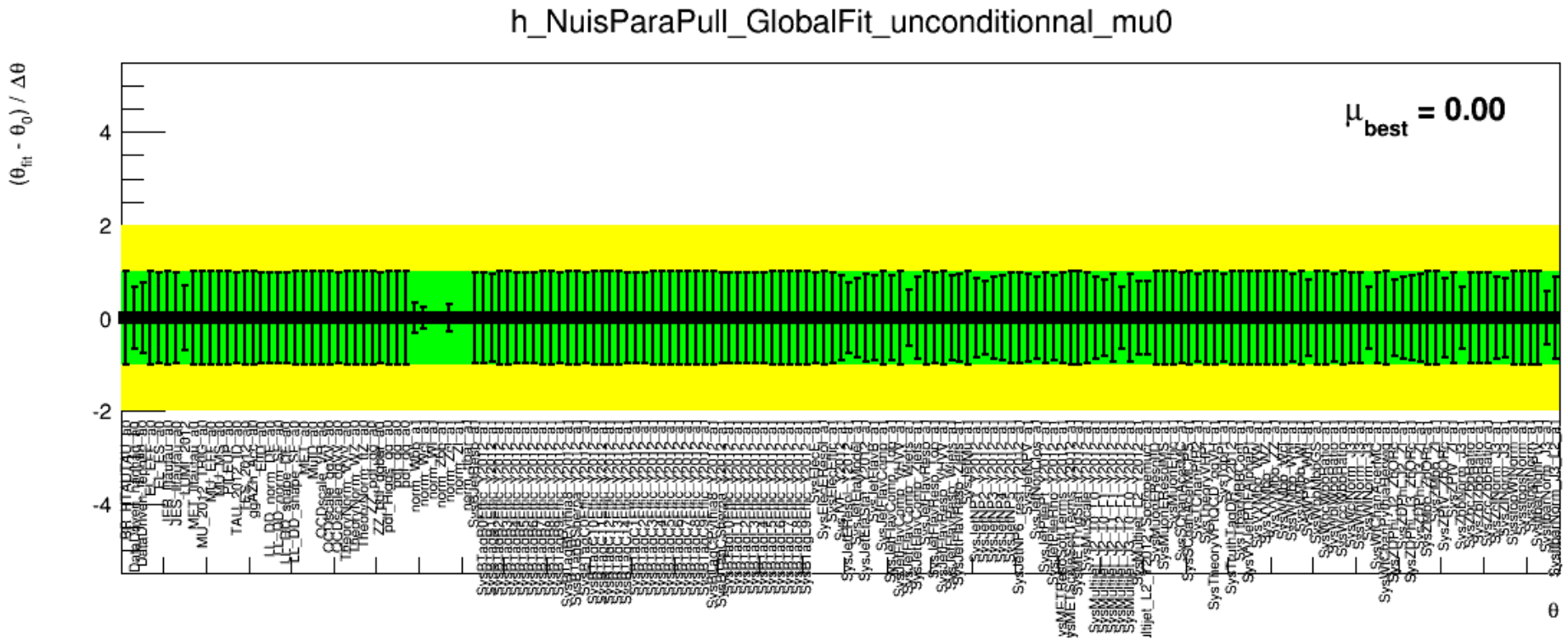
mA=300GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

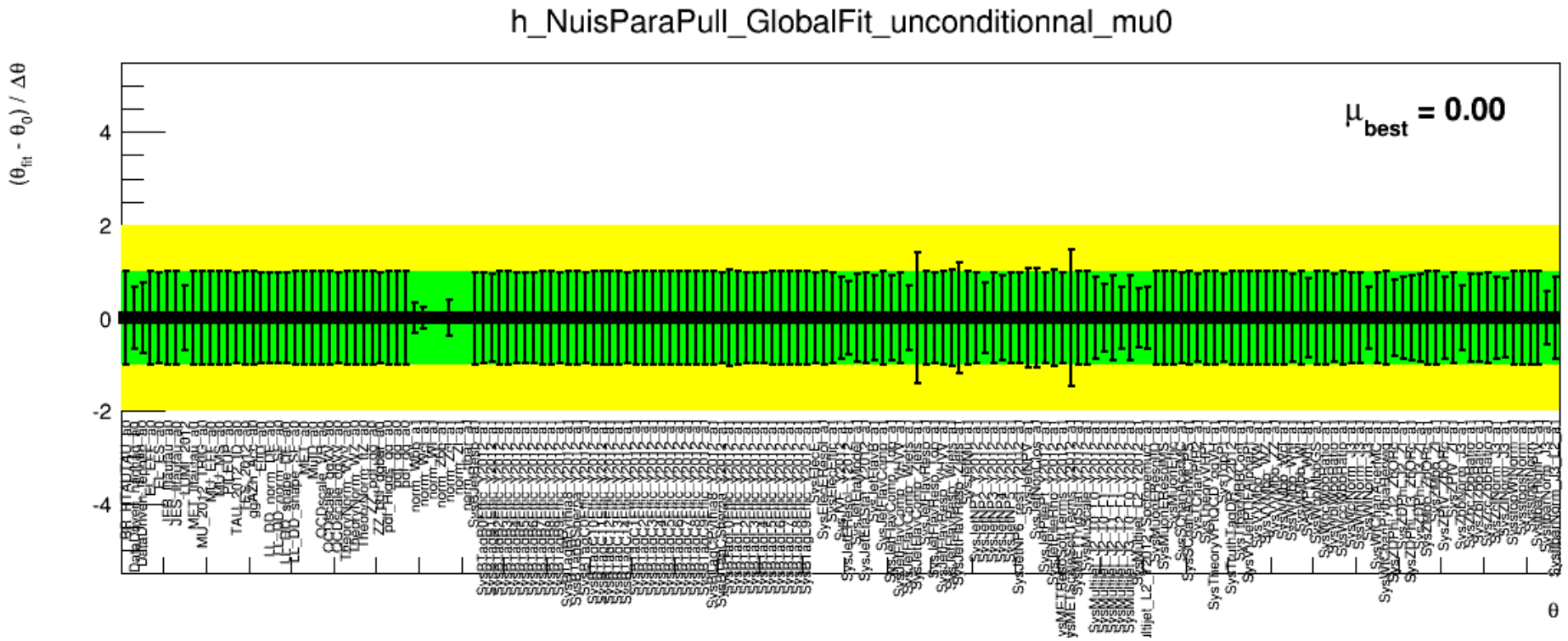
mA=340GeV



Underconstrained

AZh – pull check (asimov mu=0)

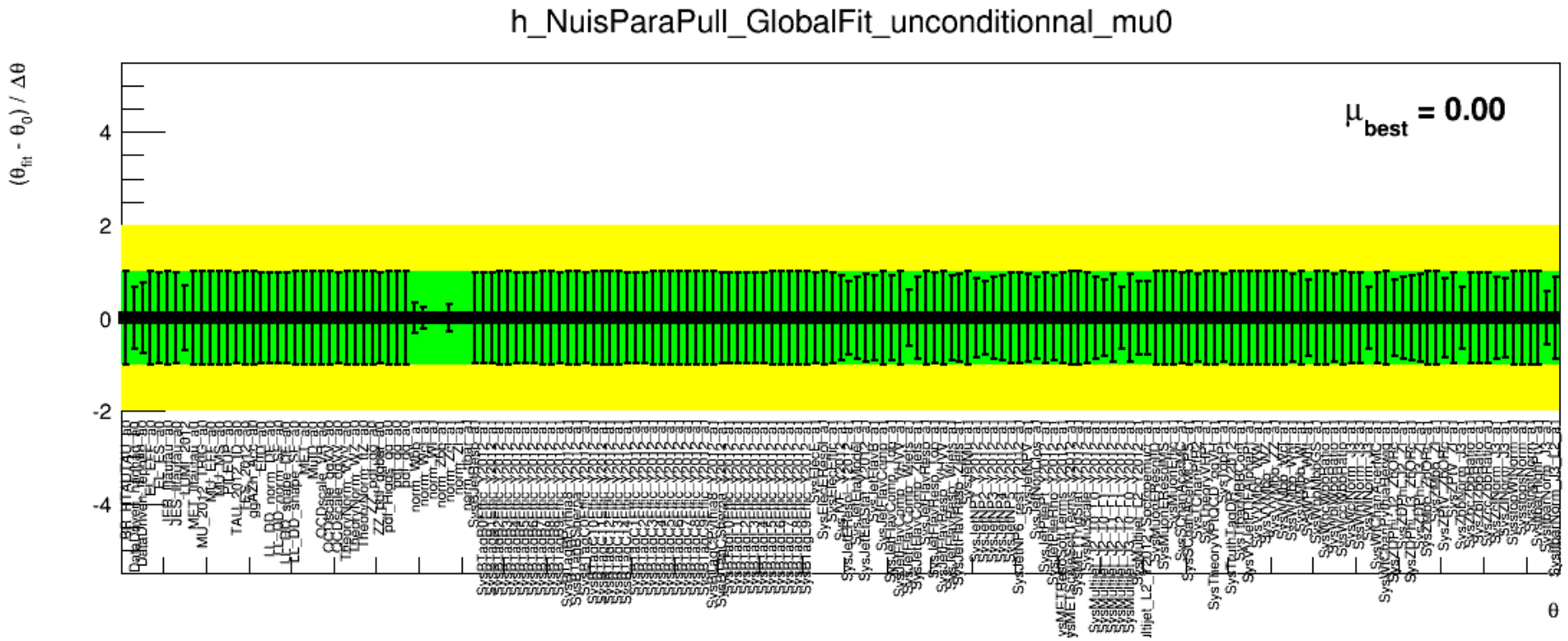
mA=350GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

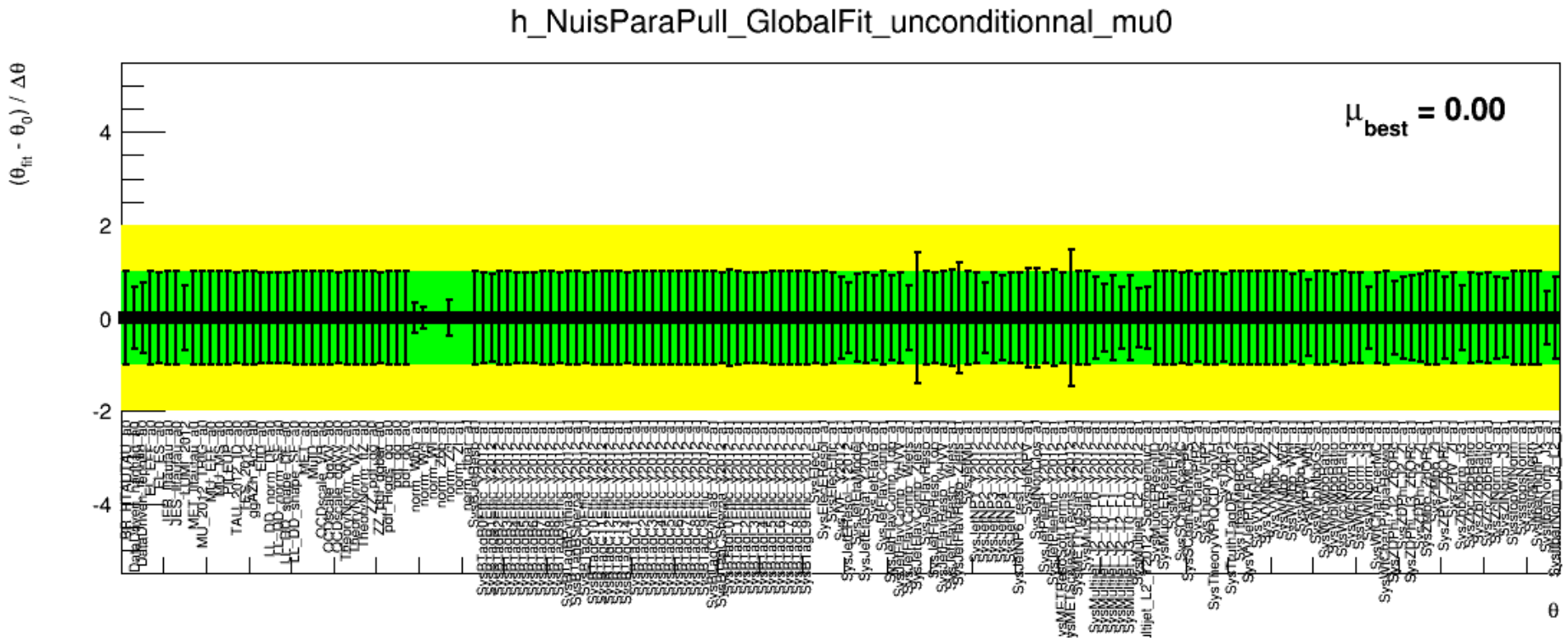
mA=400GeV



Underconstrained

AZh – pull check (asimov mu=0)

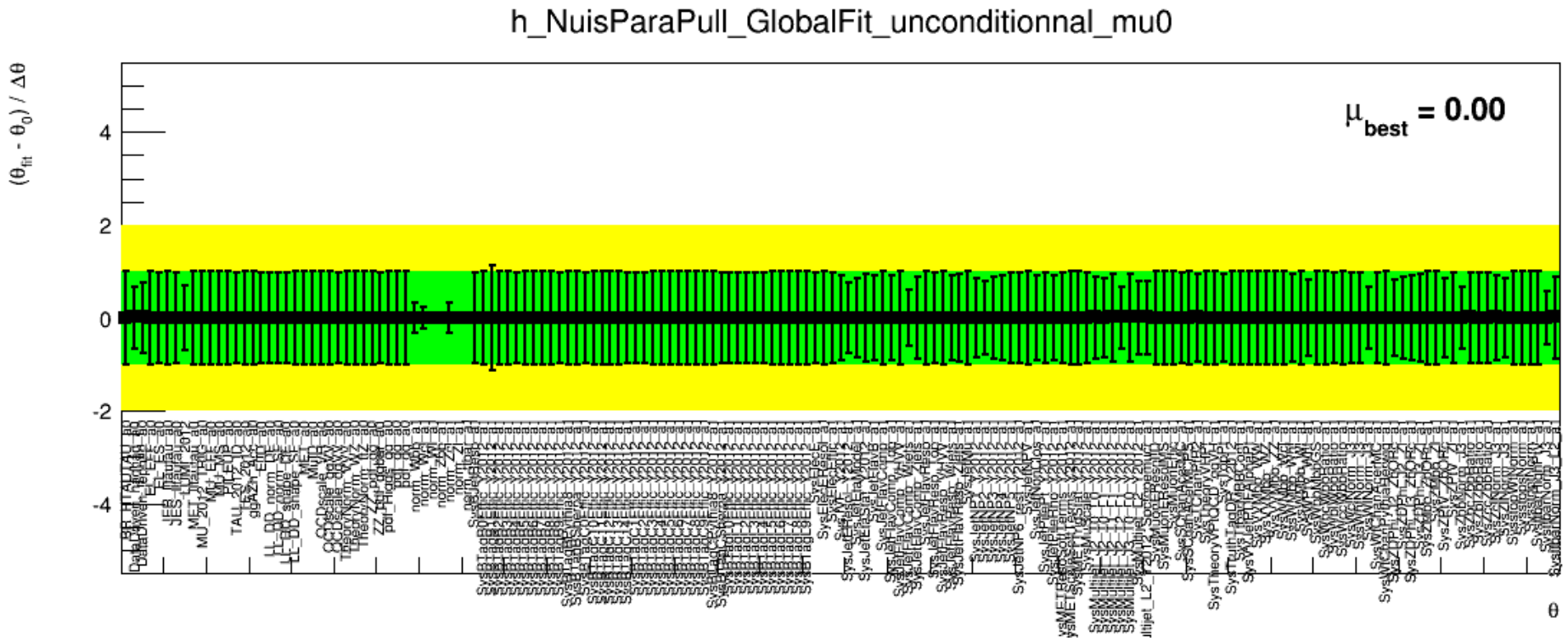
mA=500GeV



Underconstrained
SysJetFlavorComp_Zjets
SysJetFlavorResp_Zjets
SysMETScaleSoftTerms_Y2012

AZh – pull check (asimov mu=0)

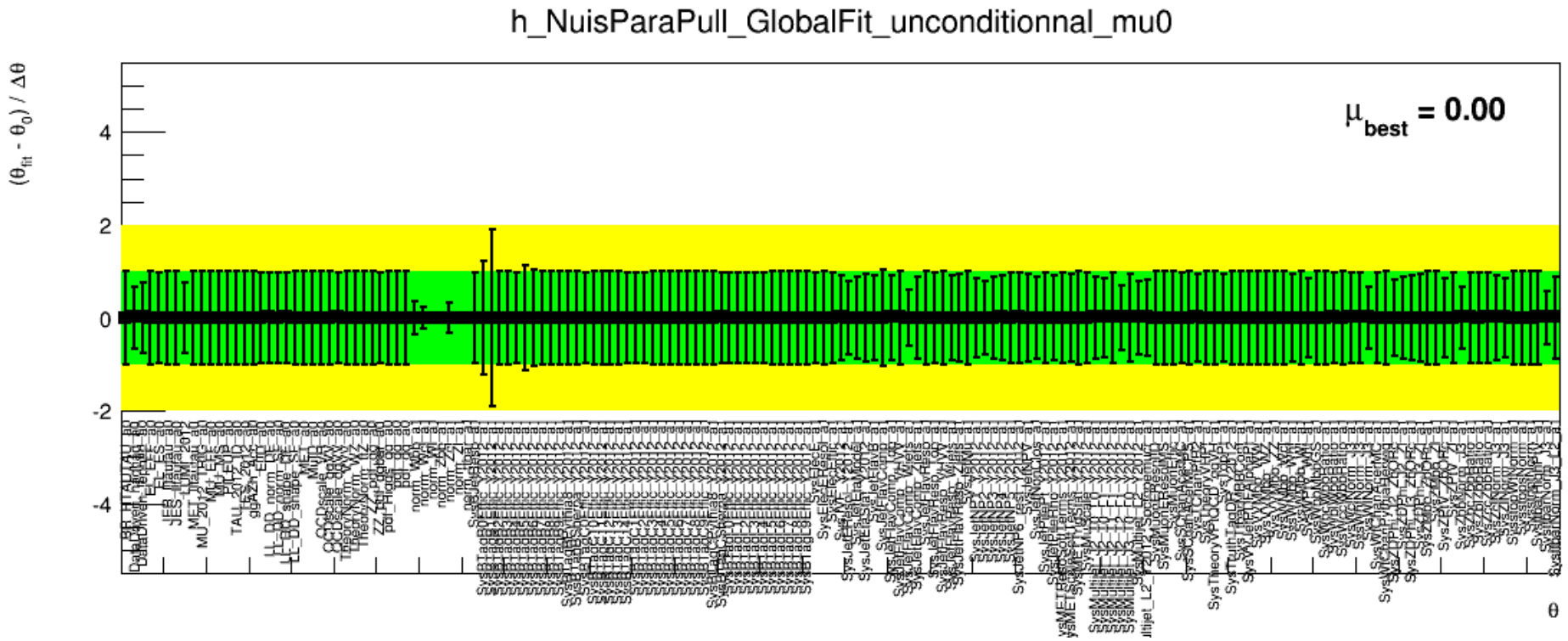
mA=800GeV



Underconstrained

AZh – pull check (asimov mu=0)

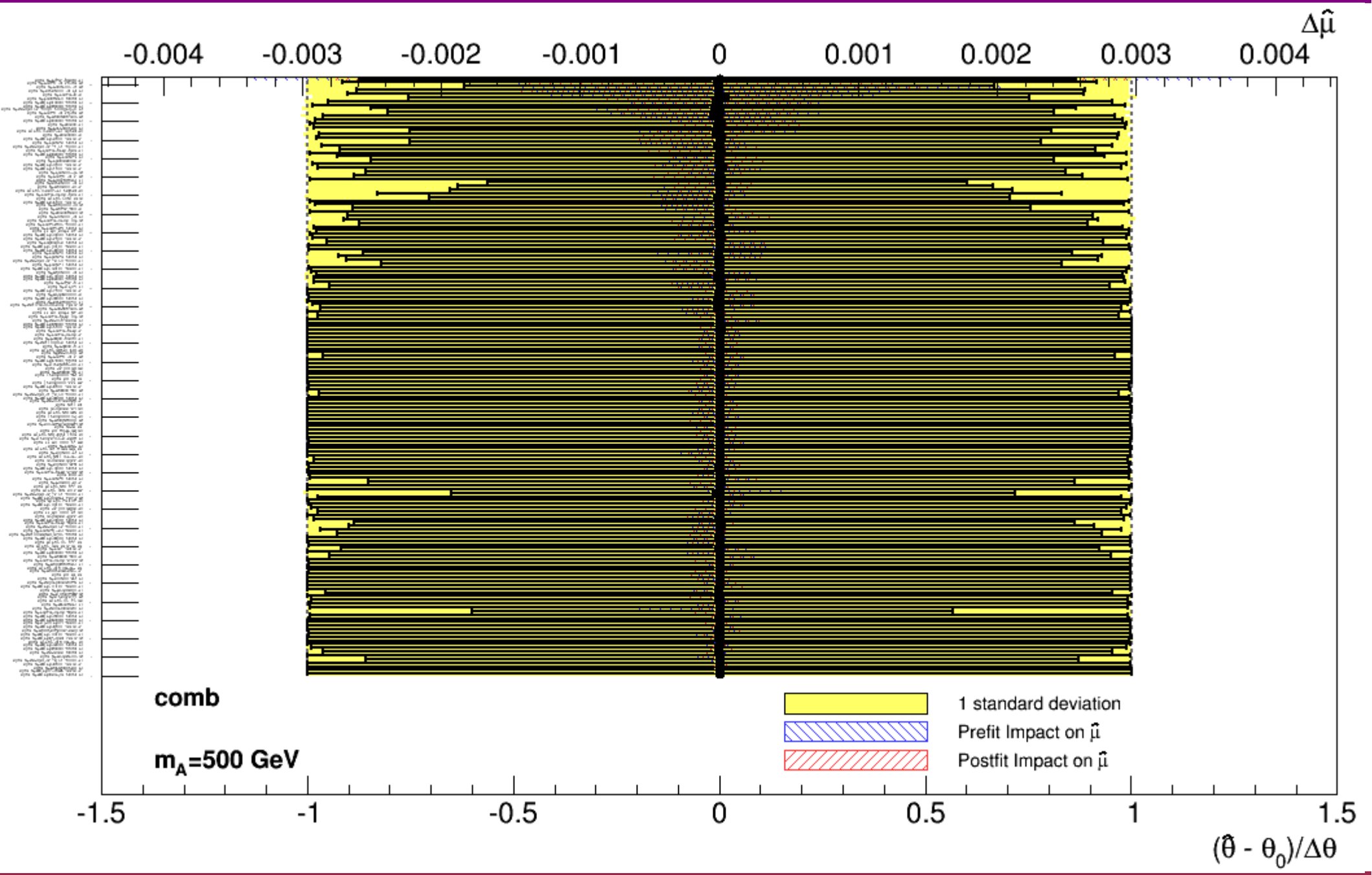
mA=1TeV



Underconstrained
SysBTagB1Effic_Y2012

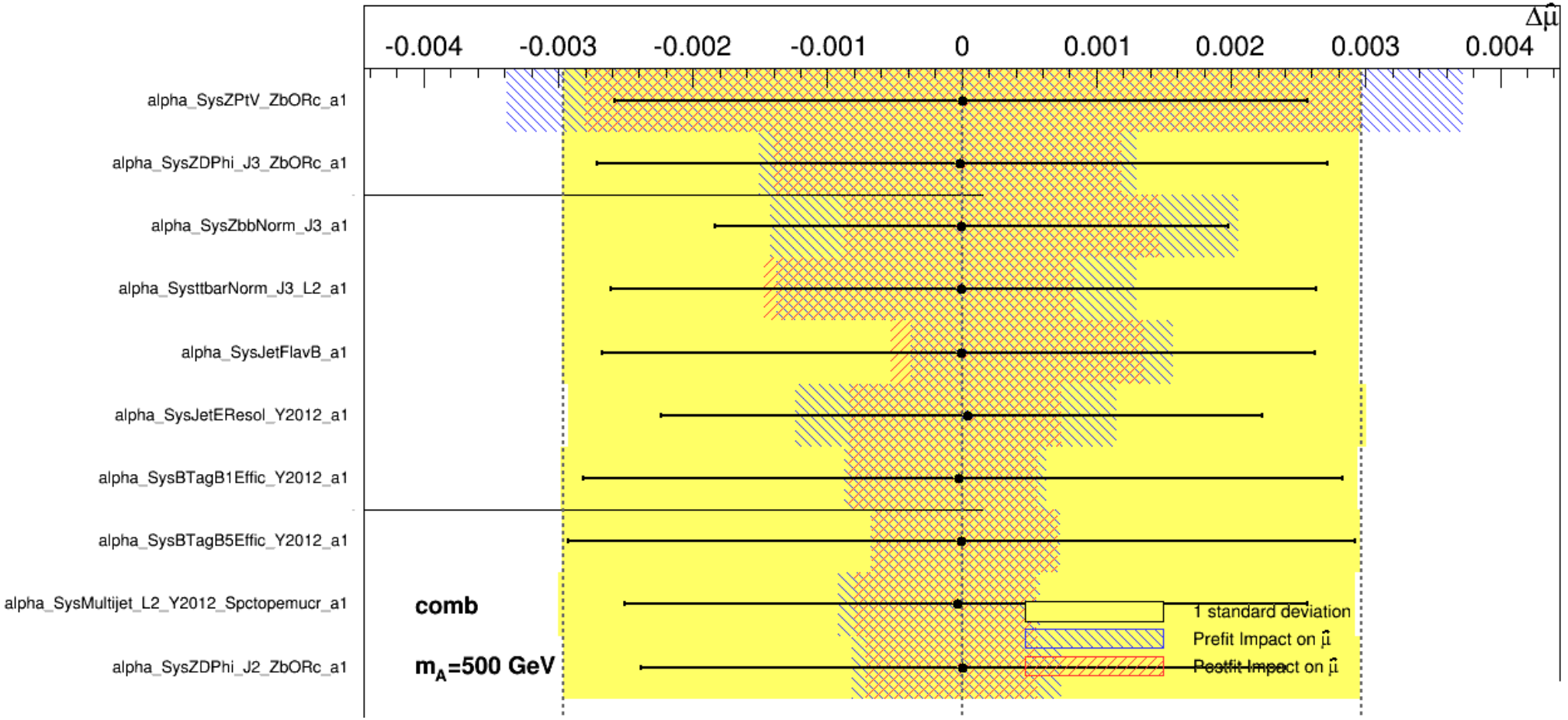
AZh – significance check

mA=500GeV



AZh – significance check

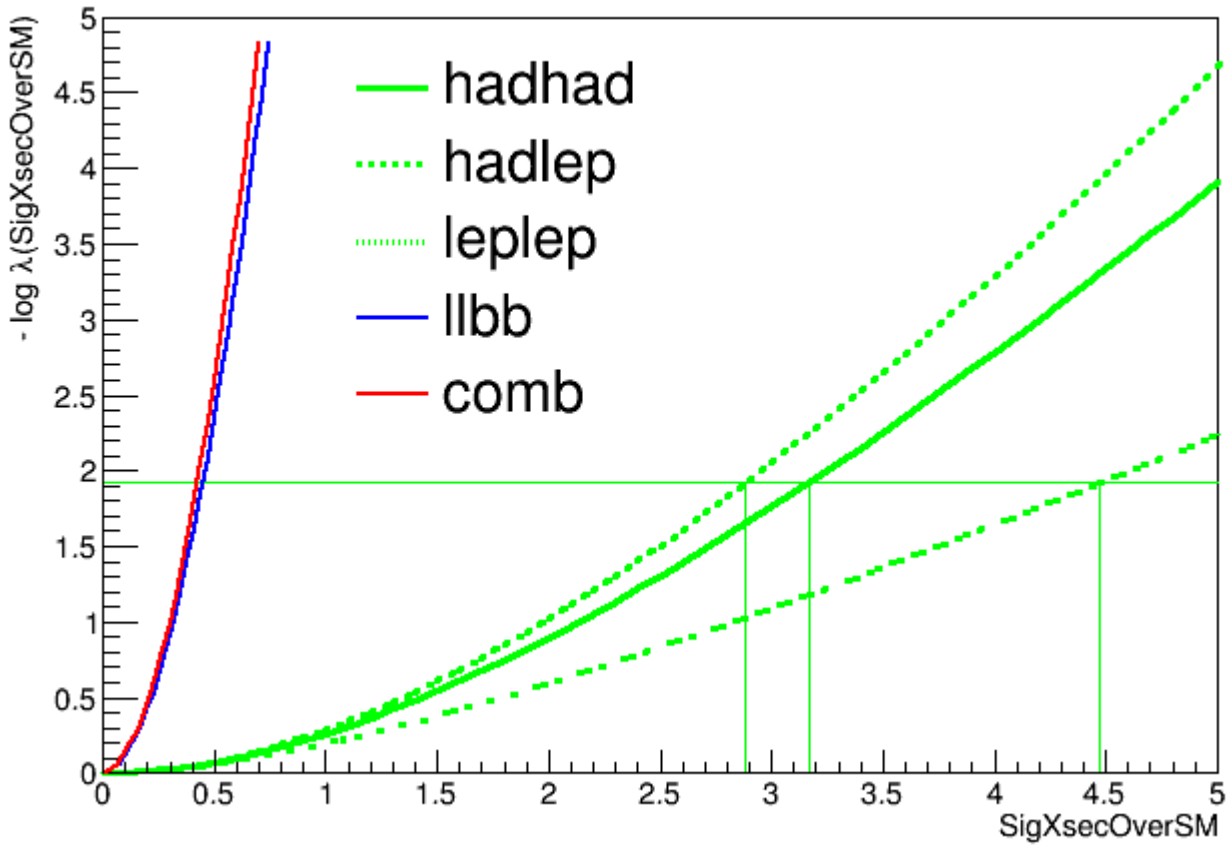
mA=500GeV



Top 10 ranked nuisance parameters

AZh – PLR curves (asimov mu=0) mA=220GeV

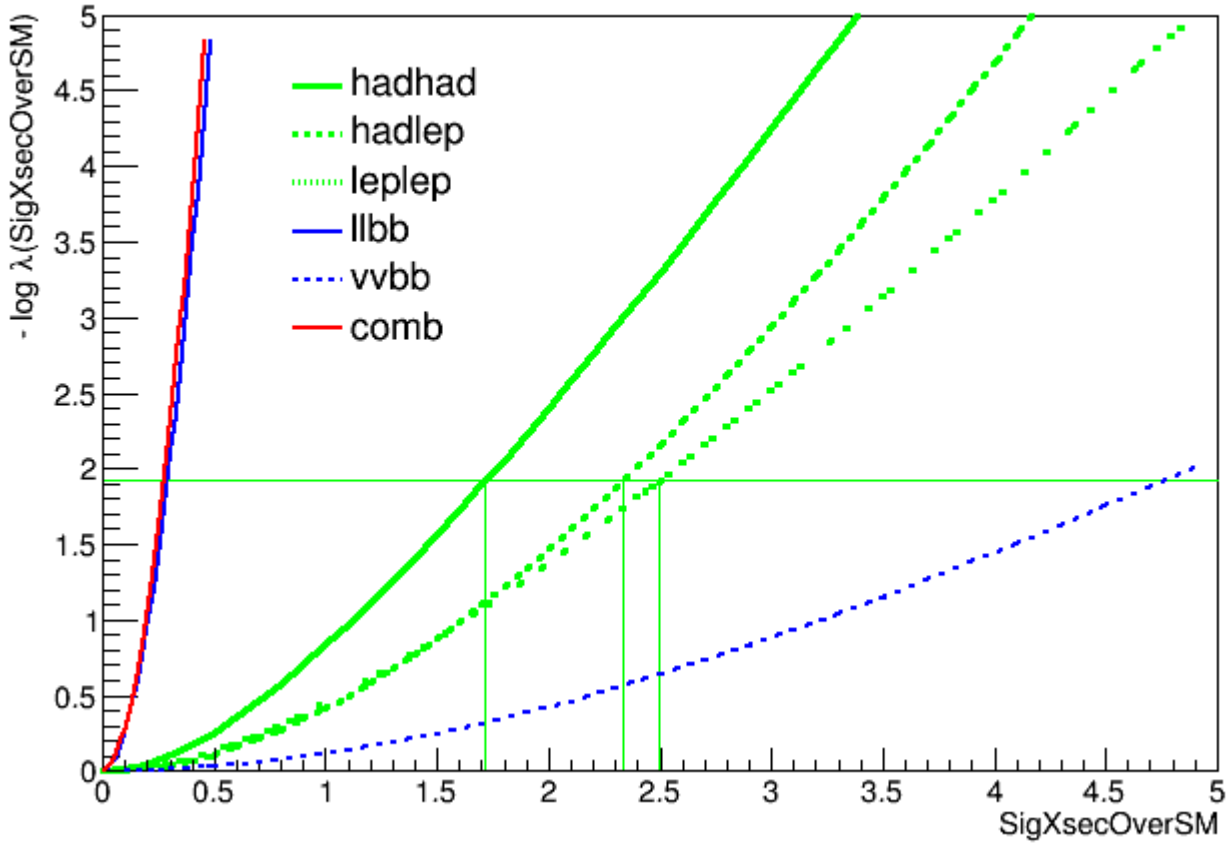
- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



No vvbb enters

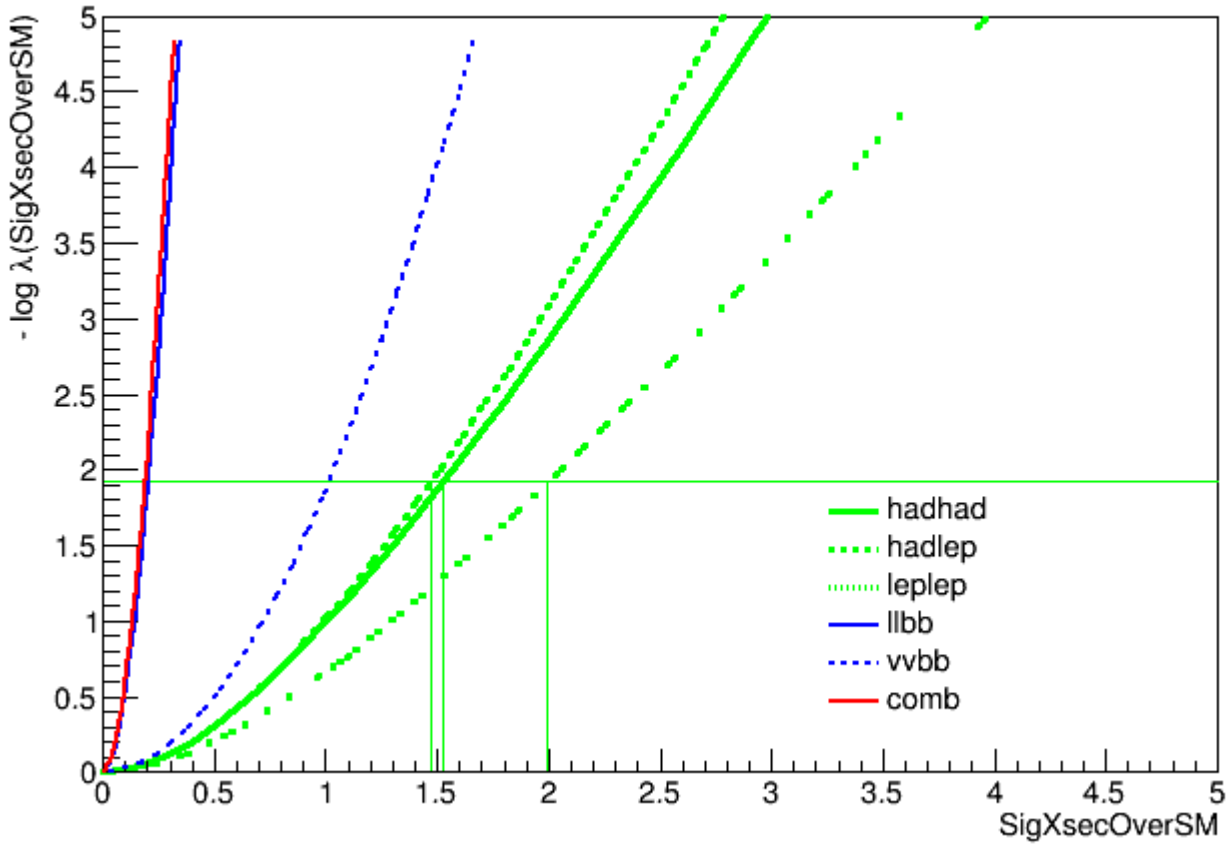
AZh – PLR curves (asimov mu=0) mA=300GeV

- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



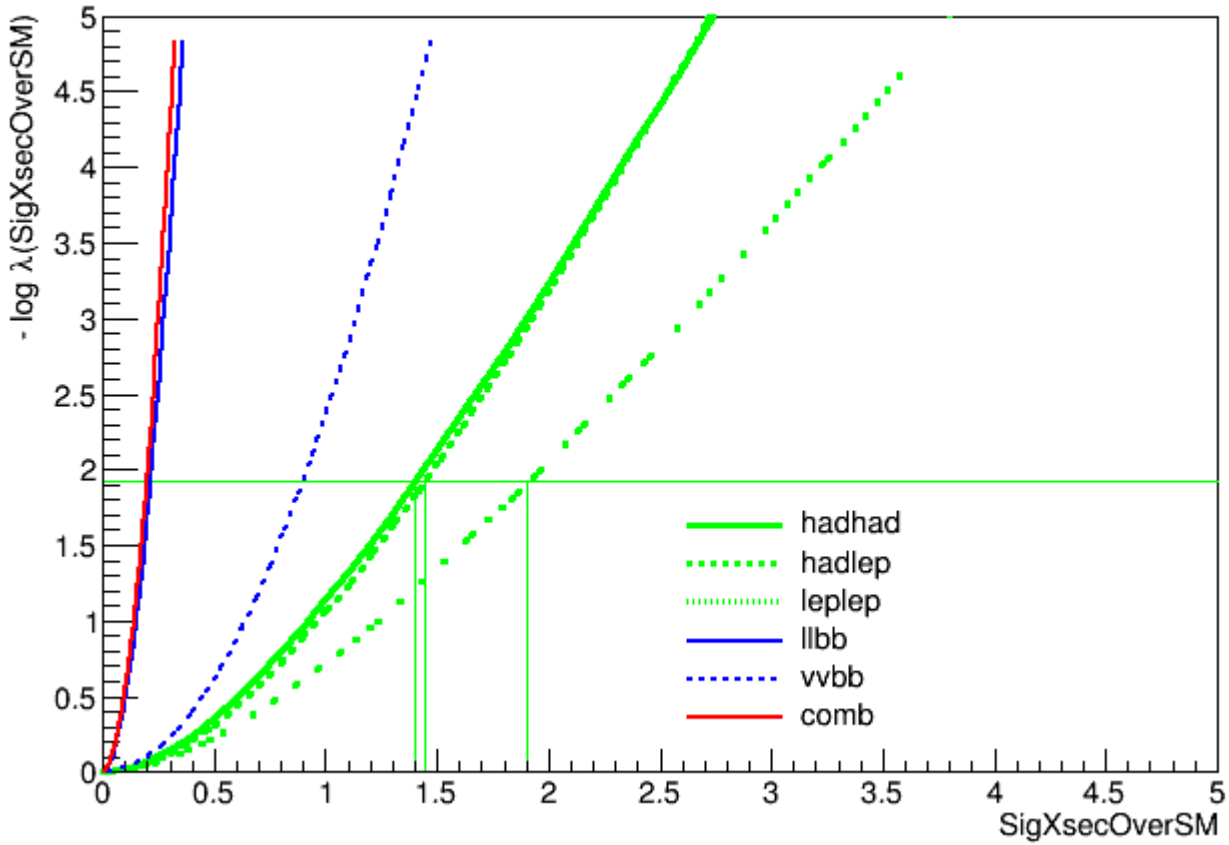
AZh – PLR curves (asimov mu=0) mA=340GeV

- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



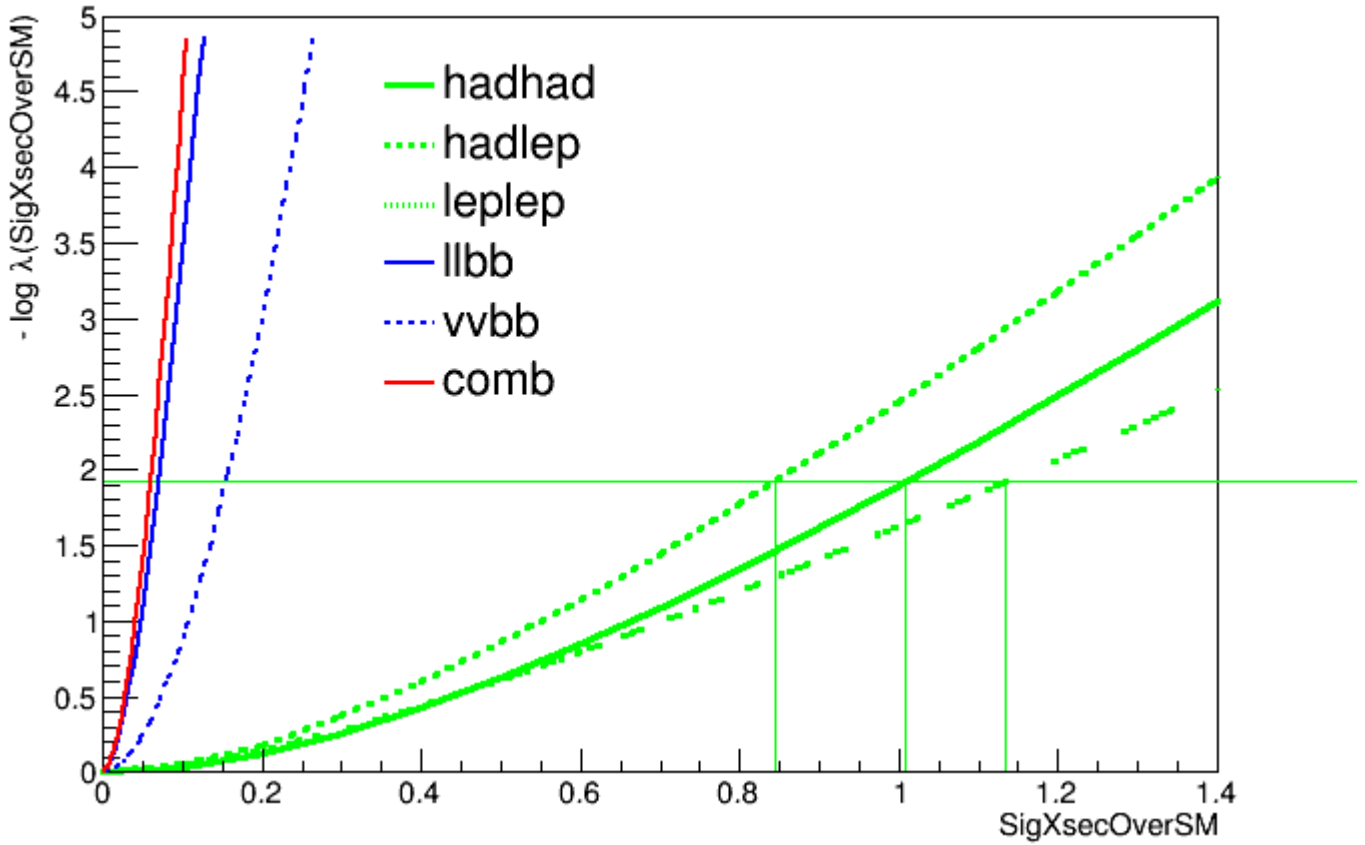
AZh – PLR curves (asimov mu=0) mA=400GeV

- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



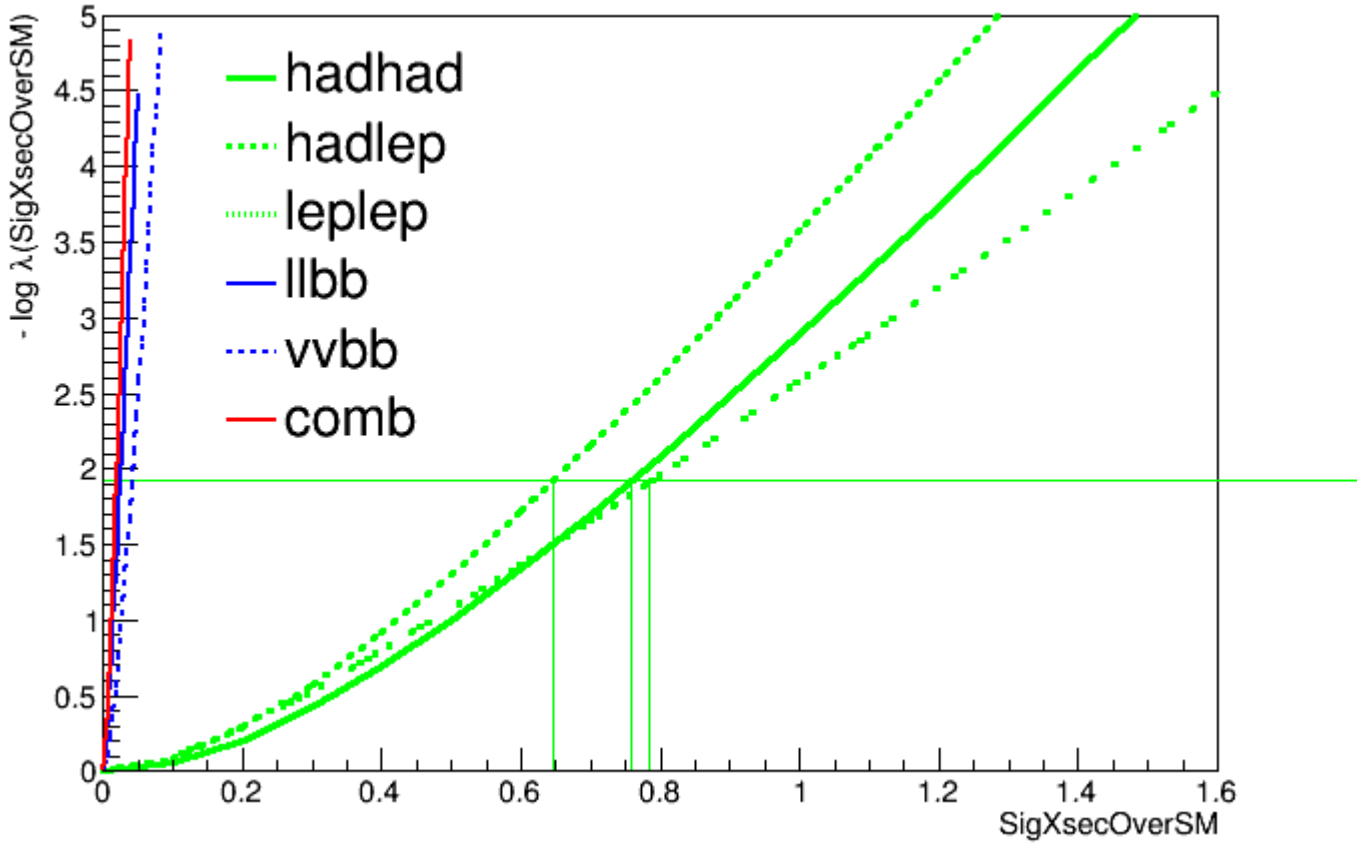
AZh – PLR curves (asimov mu=0) mA=500GeV

- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



AZh – PLR curves (asimov mu=0) mA=800GeV

- PLR curves are calculated for each sub-channel and the combined to have a basic idea of sensitivities and cross check with asymptotic upper limit setting
- PLR is calculated with asimovData in which signal strength is set to 0, so one-sided curves are shown as below (min_mu=0)



AZh combination (previous version)

- Trying different scripts for upper limit setting (only asymptotics):
  - Standard script from StatForum (Kyle): >2days, endless
  - Aaron script: 1~2 days
  - Modified Aaron script from HSG5: comb/xxbb/vvbb >3 days not finished yet, llbb is done < 1 days

mA 300GeV

+++ Aaron script +++

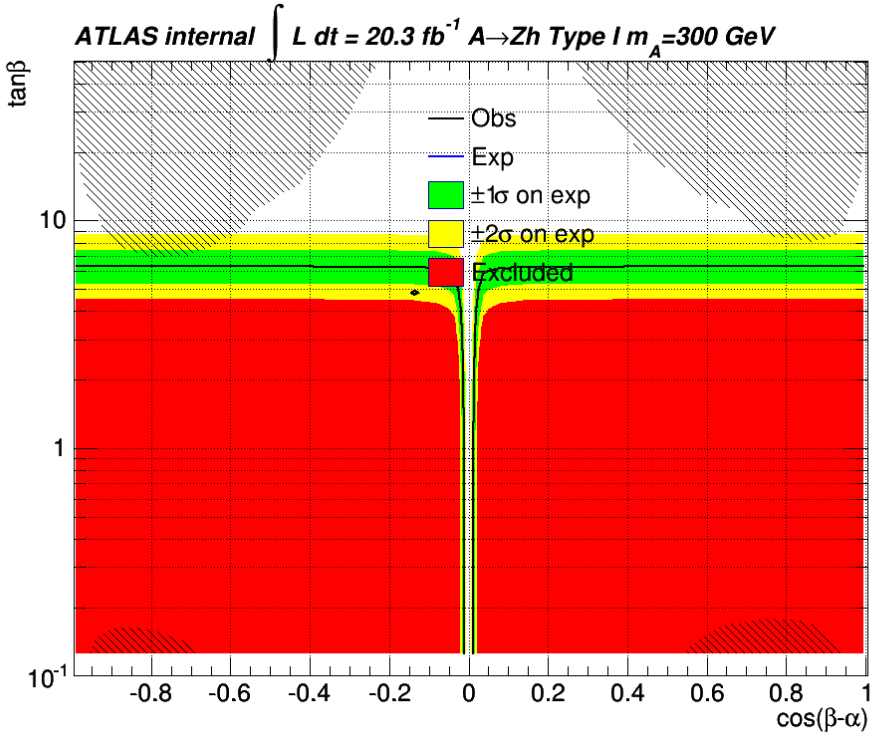
	Observed	Median	+2sig	+1sig	-1sig	-2sig
combined	0.2798	**0.2798**	0.5432	0.3946	0.2016	0.1502
xxbb	0.2918	0.2918	0.5704	0.4122	0.2103	0.1566
llbb	0.2945	**0.2945**	0.5778	0.4171	0.2122	0.1580
vvbb	4.7677	4.7677	10.7129	7.0971	3.4354	2.5589
hadhad	1.8711	1.8711	4.0766	2.7397	1.3482	1.0043
lephad	2.3156	2.3156	4.7806	3.3400	1.6685	1.2429
leplep	2.4921	2.4921	5.5921	3.7159	1.7957	1.3376

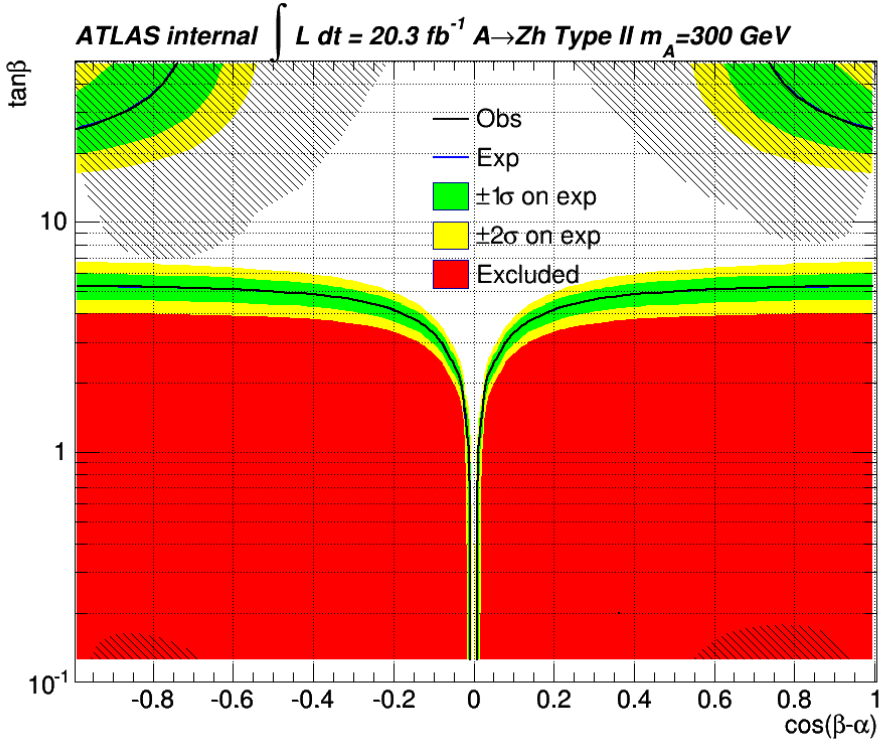
+++ Aaron script modified in HSG5 +++

llbb	0.294514	0.294514	0.563147	0.39158	0.212214	0.158073

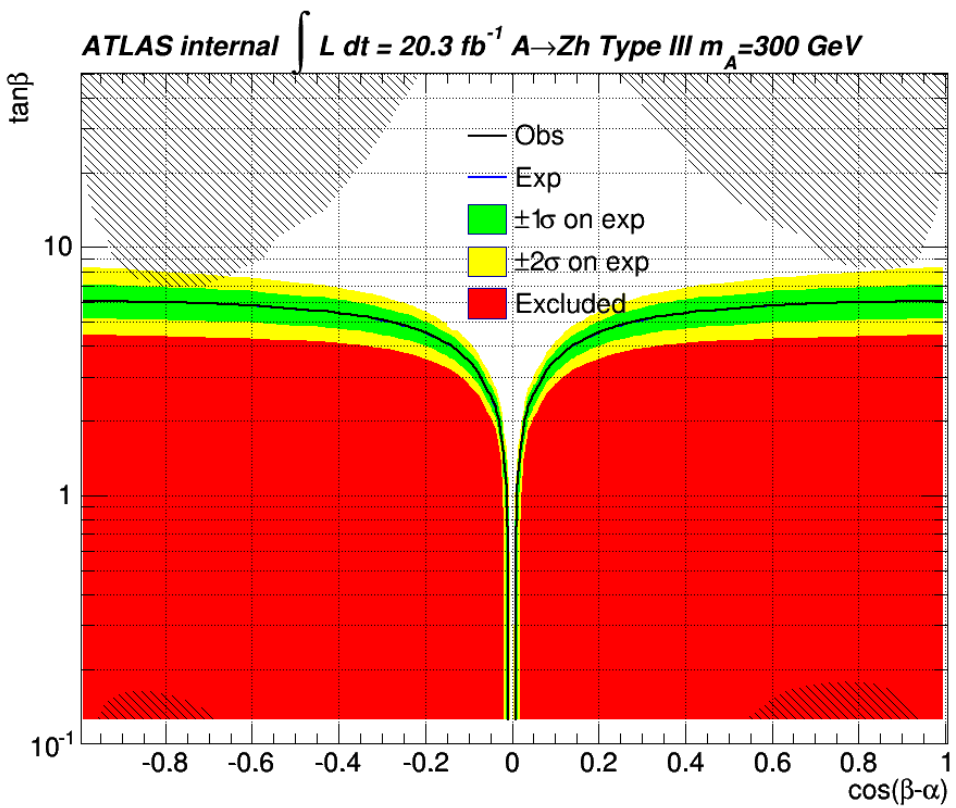
2HDM interpretation

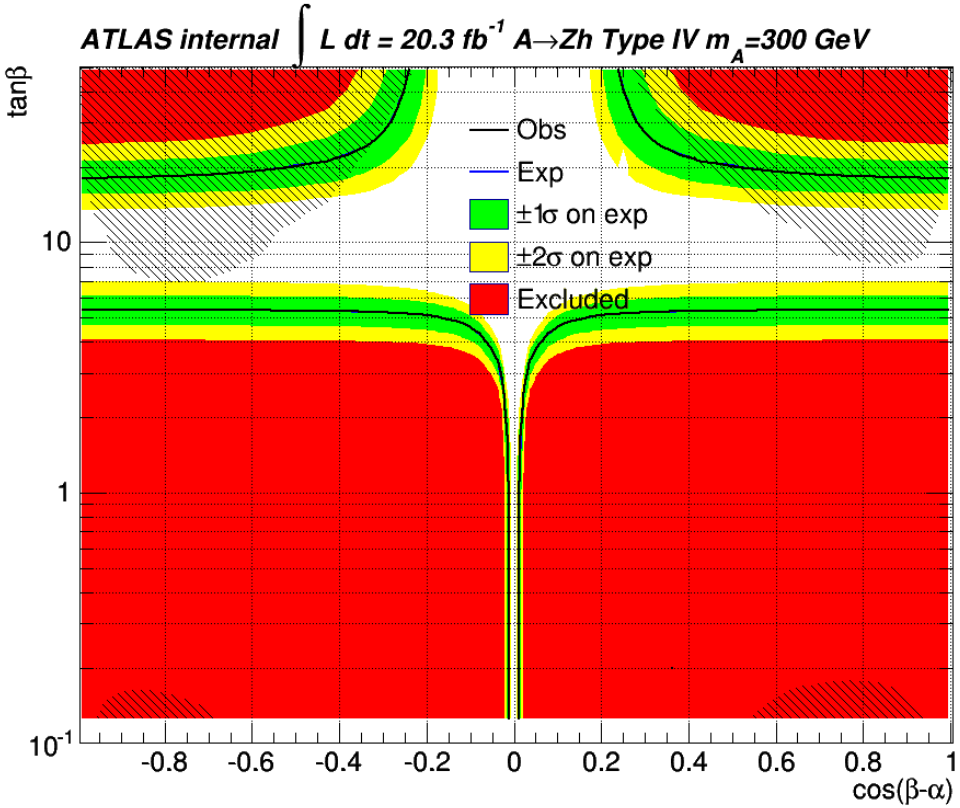
- https://twiki.cern.ch/twiki/bin/view/AtlasProtected/HiggsBSM2HDMPlotting
- Using A -> Zh limits from all channel combined
- Shadowed area where width/mass>20% [NEW]





2HDM interpretation





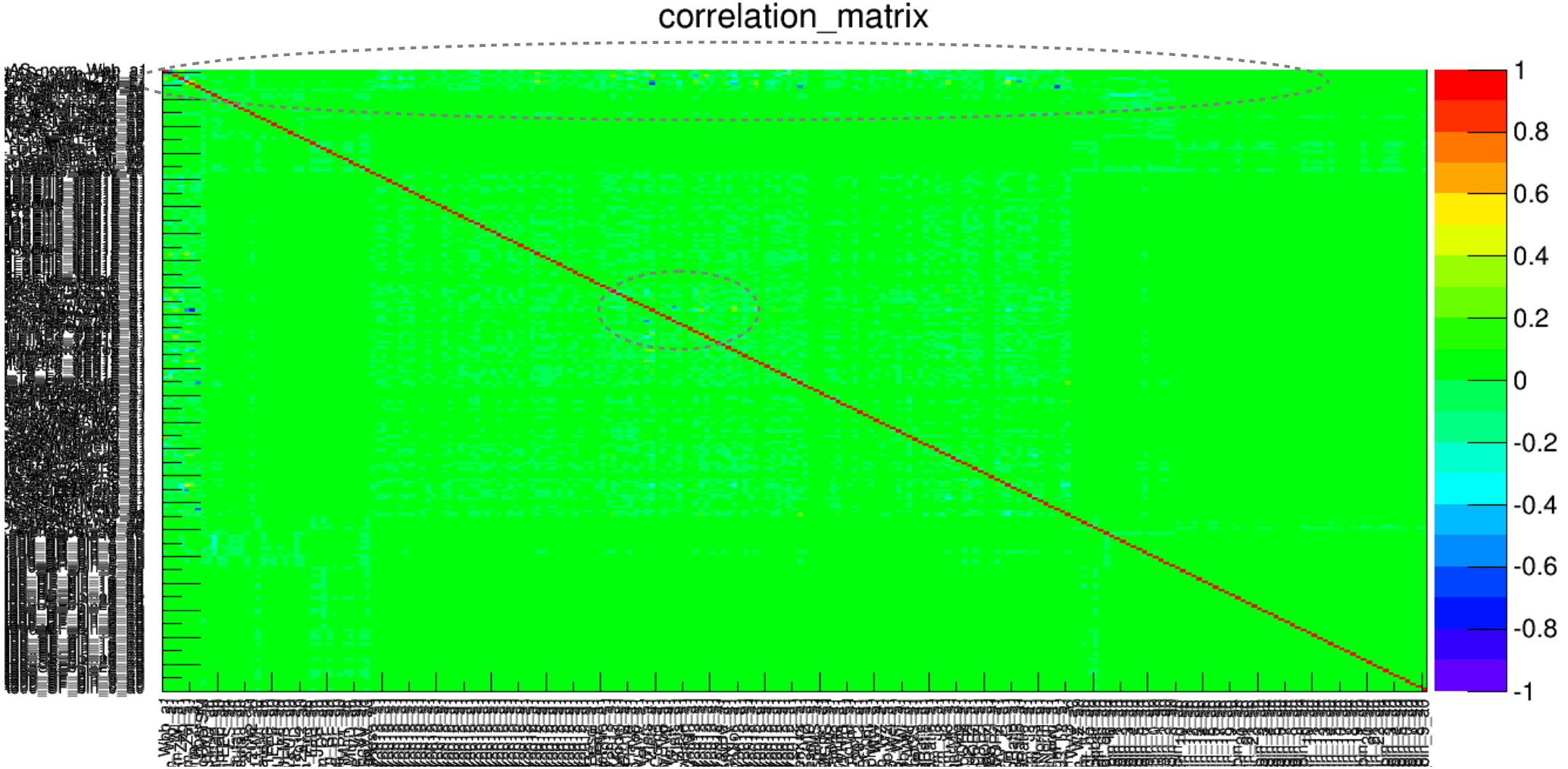
Summary

- Mature workspaces are provided from each subchannel
- Combination framework, nuisance parameter check on pull, limit setting are ready and running smoothly, although 8 hours~2days are needed for each single test (NuiSig for each nuis); upper limit setting may take even longer
- Correlations: within both side, lltautau and xxbb are correlated in their subchannels; across lltautau and xxbb, lumi is correlated
- The upper limits setting are still running for this version
- Will run with latest workspaces if there is any recent updates :)
- Will start documentation recently, at least on AZh side
- Extending 2HDMPlottingTool to support exclusion planes on tanb vs mA/mH, cos(b-a) va mA/mH, still under development
- WWyy analysis, estimating uncertainties on resonant search

Backup

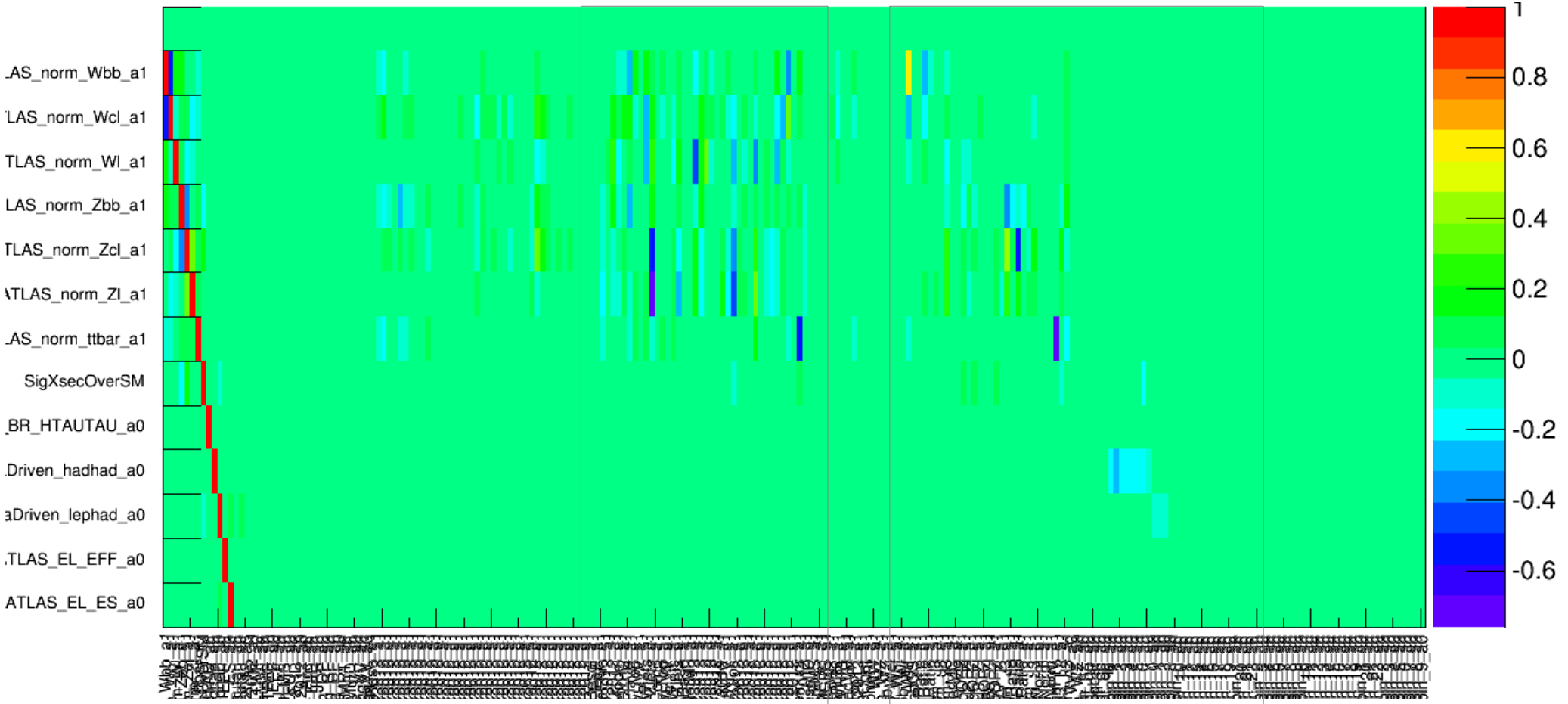
Correlation matrix (previous version)

- mA=300GeV



Correlation matrix – zoom in

- high correlations are mainly related to **ATLAS_norm_XXX**

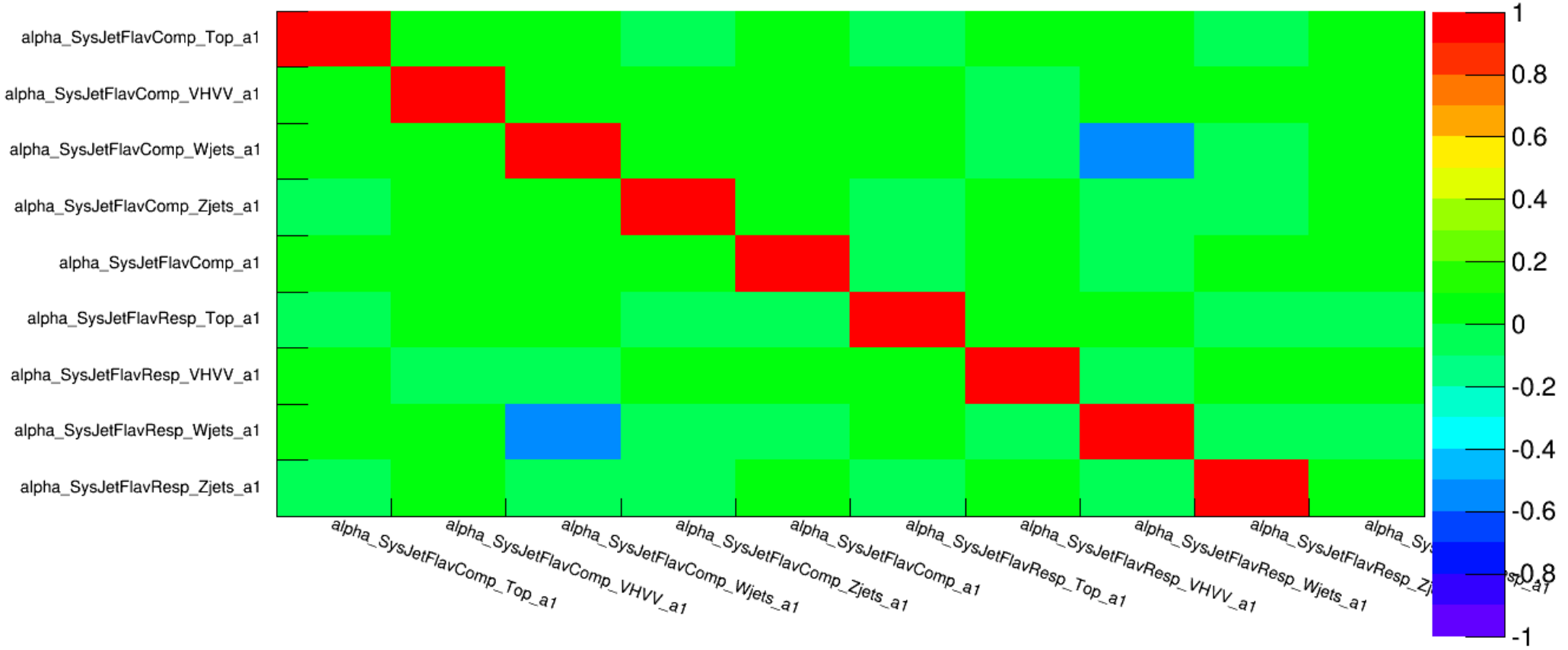


SysJet

SysZbbNorm_J3
SysZblZbbRatio
SysttbarHighPtV

Correlation matrix – zoom in

- SysJetFlavComp_Wjets correlated with SysJetFlavResp_Wjets



All nuisance parameters

lltautau (syst)
alpha_ATLAS_BR_HTAUTAU_a0,
alpha_ATLAS_DataDriven_hadhad_a0,
alpha_ATLAS_DataDriven_lephad_a0,
alpha_ATLAS_EL_EFF_a0,
alpha_ATLAS_EL_ES_a0,
alpha_ATLAS_JER_lltautau_a0,
alpha_ATLAS_JES_lltautau_a0,
alpha_ATLAS_LUMI_a0,
alpha_ATLAS_LUMI_2012_a0,
alpha_ATLAS_MET_lltautau_a0,
alpha_ATLAS_MU_2012_TRIG_a0,
alpha_ATLAS_MU_EFF_a0,
alpha_ATLAS_MU_Eff_a0,
alpha_ATLAS_MU_MS_a0,
alpha_ATLAS_PILEUP_a0,
alpha_ATLAS_TAU_2012_ID_a0,
alpha_ATLAS_TES_2012_a0,
alpha_ATLAS_ggAZh_Acc_a0,
alpha_ElID_a0,
alpha_JES_a0,
alpha_LL_DD_norm_DF_a0,
alpha_LL_DD_norm_SF_a0,
alpha_LL_DD_shape_DF_a0,
alpha_LL_DD_shape_SF_a0,
alpha_MET_a0,
alpha_MuID_a0,
alpha_QCDscale_VH_a0,
alpha_QCDscale_ggVV_a0,
alpha_QCDscale_qqVV_a0,
alpha_TheoryNorm_VVV_a0,
alpha_TheoryNorm_WZ_a0,
alpha_TheoryNorm_ttZ_a0,
alpha_ZZ_pdf_gg_a0,
alpha_ZZ_pdf_qqbar_a0,
alpha_pdf_gg_a0,
alpha_pdf_qq_a0,

All nuisance

xxbb (syst)
ATLAS_norm_Wbb_a1,
ATLAS_norm_Wcl_a1,
ATLAS_norm_Wl_a1,
ATLAS_norm_Zbb_a1,
ATLAS_norm_Zcl_a1,
ATLAS_norm_Zl_a1,
ATLAS_norm_ttbar_a1,
alpha_ATLAS_LUMI_2012_a1,
alpha_SysBJetReso_a1,
alpha_SysBTagB0Effic_Y2012_a1,
alpha_SysBTagB1Effic_Y2012_a1,
alpha_SysBTagB2Effic_Y2012_a1,
alpha_SysBTagB3Effic_Y2012_a1,
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alpha_SysBTagC10Effic_Y2012_a1,
alpha_SysBTagC11Effic_Y2012_a1,
alpha_SysBTagC12Effic_Y2012_a1,
alpha_SysBTagC13Effic_Y2012_a1,
alpha_SysBTagC14Effic_Y2012_a1,
alpha_SysBTagC1Effic_Y2012_a1,
alpha_SysBTagC2Effic_Y2012_a1,
alpha_SysBTagC3Effic_Y2012_a1,
alpha_SysBTagC4Effic_Y2012_a1,
alpha_SysBTagC5Effic_Y2012_a1,
alpha_SysBTagC6Effic_Y2012_a1,
alpha_SysBTagC7Effic_Y2012_a1,
alpha_SysBTagC8Effic_Y2012_a1,
alpha_SysBTagC9Effic_Y2012_a1,
alpha_SysBTagCPythia8_Y2012_a1,
alpha_SysBTagCSherpa_Y2012_a1,
alpha_SysBTagL0Effic_Y2012_a1,
alpha_SysBTagL1Effic_Y2012_a1,
alpha_SysBTagL2Effic_Y2012_a1,
alpha_SysBTagL3Effic_Y2012_a1,
alpha_SysBTagL4Effic_Y2012_a1,
alpha_SysBTagL5Effic_Y2012_a1,
alpha_SysBTagL6Effic_Y2012_a1,
alpha_SysBTagL7Effic_Y2012_a1,
alpha_SysBTagL8Effic_Y2012_a1,
alpha_SysBTagL9Effic_Y2012_a1,

All nuisance parameters

xxbb (syst)
alpha_SysElecE_a1,
alpha_SysElecEResol_a1,
alpha_SysElecEffic_a1,
alpha_SysJVF_Y2012_a1,
alpha_SysJetEResol_Y2012_a1,
alpha_SysJetEtaModel_a1,
alpha_SysJetEtaStat_Y2012_a1,
alpha_SysJetFlavB_a1,
alpha_SysJetFlavComp_a1,
alpha_SysJetFlavComp_Top_a1,
alpha_SysJetFlavComp_VHVV_a1,
alpha_SysJetFlavComp_Wjets_a1,
alpha_SysJetFlavComp_Zjets_a1,
alpha_SysJetFlavResp_a1,
alpha_SysJetFlavResp_Top_a1,
alpha_SysJetFlavResp_VHVV_a1,
alpha_SysJetFlavResp_Wjets_a1,
alpha_SysJetFlavResp_Zjets_a1,

alpha_SysJetMu_a1,
alpha_SysJetNP1_Y2012_a1,
alpha_SysJetNP2_Y2012_a1,
alpha_SysJetNP3_Y2012_a1,
alpha_SysJetNP4_Y2012_a1,
alpha_SysJetNP5_Y2012_a1,
alpha_SysJetNP6_rest_Y2012_a1,
alpha_SysJetNPV_a1,
alpha_SysJetNonClos_a1,
alpha_SysJetPilePt_Y2012_a1,
alpha_SysJetPileRho_Y2012_a1,

alpha_SysMETResoSoftTerms_Y2012_a1,
alpha_SysMETScaleSoftTerms_Y2012_a1,
alpha_SysMETTrigStat_Y2012_a1,
alpha_SysMuScale_Y2012_a1,
alpha_SysMultijet_J2_T0_L0_Y2012_a1,
alpha_SysMultijet_J2_T0_L1_Y2012_a1,
alpha_SysMultijet_J2_T1_L1_Y2012_a1,
alpha_SysMultijet_J2_T2_L1_Y2012_a1,
alpha_SysMultijet_J3_T0_L0_Y2012_a1,
alpha_SysMultijet_L2_Y2012_a1,
alpha_SysMultijet_L2_Y2012_Spctopemucr_a1,

All nuisance parameters

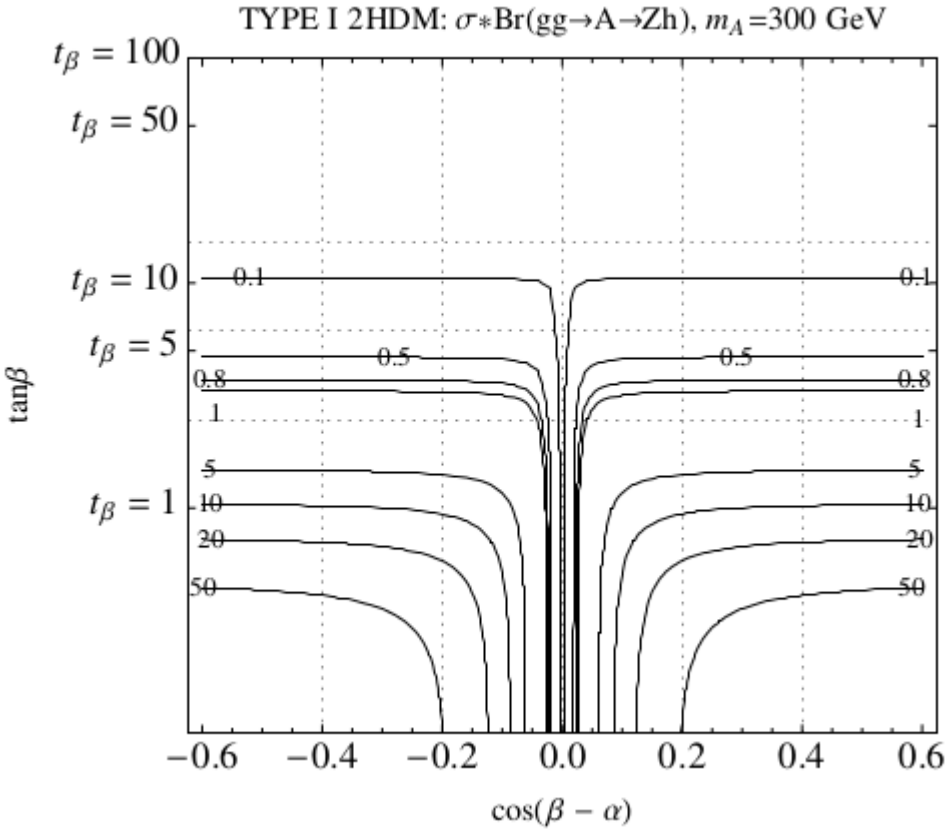
xxbb (syst)
alpha_SysMuonEResolID_a1,
alpha_SysMuonEResolMS_a1,
alpha_SysMuonEffic_a1,
alpha_SysSChanAcerMC_a1,
alpha_SysSChanAcerMCPS_a1,
alpha_SysTChanPtB2_a1,
alpha_SysTheoryVHPt_a1,
alpha_SysTheoryVPtQCD_qqVH_a1,
alpha_SysTopPt_a1,
alpha_SysTruthTagDR_Y2012_a1,
alpha_SysTtbarMBBCont_a1,
alpha_SysVVJetPDFAlphaPt_a1,
alpha_SysVVMbb_WW_a1,
alpha_SysVVMbb_WZ_a1,
alpha_SysVVMbb_ZZ_a1,
alpha_SysWMbb_Wcl_a1,
alpha_SysWMbb_Whf_a1,
alpha_SysWMbb_Wl_a1,
alpha_SysWPtV_Whf_a1,
alpha_SysWbbMbbGS_a1,
alpha_SysWbcWbbRatio_a1,
alpha_SysWblWbbRatio_a1,
alpha_SysWccWbbRatio_a1,
alpha_SysWclNorm_J3_a1,
alpha_SysWhfNorm_J3_a1,
alpha_SysWlNorm_J3_a1,
alpha_SysWtChanAcerMC_a1,
alpha_SysWtChanPythiaHerwig_a1,

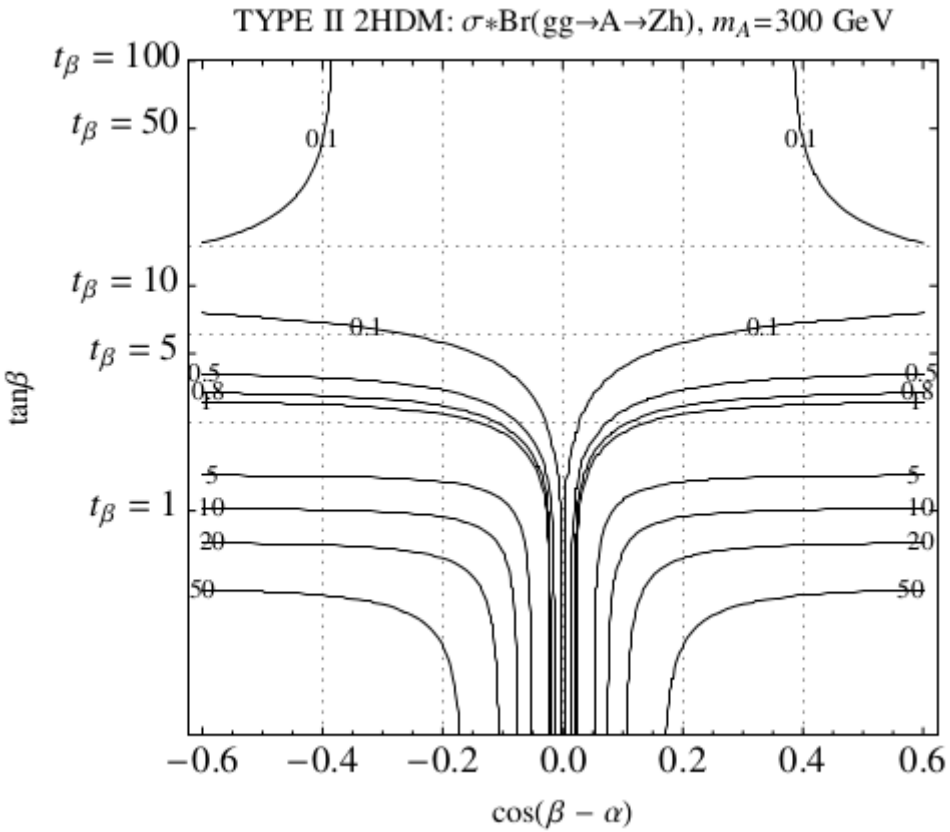
All nuisance parameters

xxbb (syst)
alpha_SysZDPhi_J2_ZbORc_a1,
alpha_SysZDPhi_J2_Zl_a1,
alpha_SysZDPhi_J3_ZbORc_a1,
alpha_SysZDPhi_J3_Zl_a1,
alpha_SysZMbb_ZbORc_a1,
alpha_SysZMbb_Zl_a1,
alpha_SysZPtV_ZbORc_a1,
alpha_SysZPtV_Zl_a1,
alpha_SysZbbNorm_J3_a1,
alpha_SysZbcZbbRatio_a1,
alpha_SysZblZbbRatio_a1,
alpha_SysZccZbbRatio_a1,
alpha_SysZclNorm_J3_a1,
alpha_SysZlNorm_J3_a1,

alpha_SysstopWtNorm_a1,
alpha_SysstopsNorm_a1,
alpha_SysstoptNorm_a1,
alpha_SysttbarHighPtV_a1,
alpha_SysttbarNorm_J3_a1,
alpha_SysttbarNorm_J3_L2_a1

2HDM xsec contour





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