VV→llqq - First steps towards MC/DATA comparison

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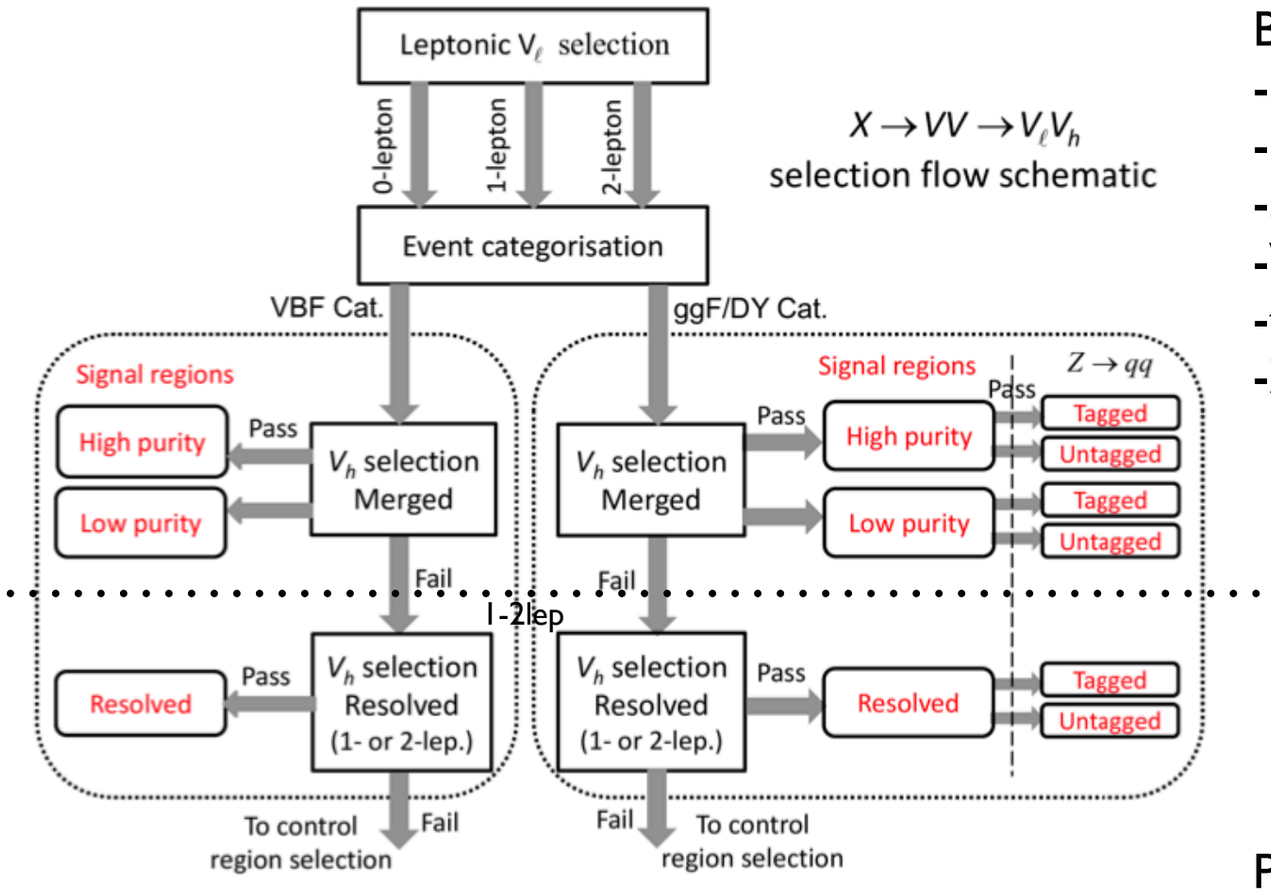
$V_l V_h$ analysis

SR:

$W_l W_h$ → 1Lep x (3+3) = 3VBF + 3ggF/DY = 6 SR

$Z_l Z_h$ → 0Lep x (2+4) +2Lep x (3+6) = 5VBF + 10ggF/DY =15 SR

$W_l Z_h + Z_l W_h$ → 1Lep x (3+6) +0Lep x (2+2) + 2Lep x (3+3) = 8VBF + 11ggF/DY =19 SR



$X \to VV \to V_\ell V_h$ selection flow schematic

BG:

-multijet: from DATA

-Diboson: Norm.+shape from MC,

-singletop: Norm.+shape from MC,

-Wjet: shape from MC and Norm. from 1Lep DATA CR, 15 CR

-ttbar: shape from MC but Norm. from 1Lep DATA CR, 15 CR

-Zjet : shape from MC but Norm. from 2Lep DATA CR, 15 CR

Paper arXiv:2004.14636

"Search for heavy diboson resonances in semileptonic final states in pp collisions at s = 13 TeV with the ATLAS detector"

ZV2Lep analysis

Merge Selection		SR		Z CR	
		HP	LP	HP	LP
$Z \to ll$	# loose leptons, p_T^l >30 GeV	2			
	Opposite charge μ, no requirement on electron charge				
	Z mass window cut				
$W/Z \to J$	# large-R jets	≥1			
	D_2 cut	Pass	Fail	Pass	Fail
	WZ mass window cut	Pass		Fail	
	# of associated VR track jets b-tagged	For Z→J:≤1(=2) or untagged (tagged) category			
Topology cut	$\min(p_{T,ll},p_{T,J})m_{WV}$	>0.35(0.25) for DY/ggF (VBF) category			
Top-quark veto	# of b-taggd jets outside of large R-jet	0			
Pass VBF selection		No (yes) for DY/ggF (VBF) category			

Resolved Selection		SR	Z CR
$Z \to ll$	# loose leptons, p_T^l >30 GeV	2	
	Opposite charge μ, no requirement on electron charge		
	Z mass window cut		
$W/Z \to jj$	# small-R jets	≥2	
	Leading jet p_T	>60 GeV	
	Sub-leading jet p_T	>30 GeV	
	$Z \to q\bar{q}$	$70 < m_{jj} < 105$ GeV	$50 < m_{jj} < 62$ GeV or
	$W \to q\bar{q}$	$62 < m_{jj} < 97$ GeV	$105 < m_{jj} < 150$ GeV
	# of b-tagged jets	For Z→jj:≤1(=2) or untagged (tagged) category	
Topology cuts	$\Delta\phi$(j,l)	>1.0	
	$\Delta\phi(j,E^T_{miss})$	>1.0	
	$\Delta\phi$(j,j)	>1.5	
	$\Delta\phi(l,E^T_{miss})$	>1.5	
	$\min(p_{T,ll},p_{T,jj})m_{WV}$	>0.35 for DY/ggF (VBF) category	
Top-quark veto	# of additional b-tagged jets	0	
Pass VBF selection		No (yes) for DY/ggF (VBF) category	

Run the Reader

Code:

1. Code check-out on lxplus following the instruction: https://gitlab.cern.ch/CxAODFramework/CxAODReader_VVSemileptonic/-/tree/master/CxAODReader_VVSemileptonic
2. Code in home: /afs/cern.ch/user/c/chiodini/VV
3. Code replica in: /afs/cern.ch/work/c/chiodini/public/VV
4. Run on full MC/data set on condor with option tomorrow from configuration file
5. Output in /afs/cern.ch/work/c/chiodini/VV
6. Move output in /eos/user/c/chiodini//eos/user/c/chiodini/CONDOR_output

Data:

1. Derived CxAOD's are stored in /eos/user/r/rles/CxAOD/r33-08/
2. Organised in 3 different pair of jet collections (large jets R=1)_(small jet R=0.4):
    1. LCTopo_EMTopo
    2. TCC_EMTopo
    3. UFO_PFlow
3. See https://cds.cern.ch/record/2724842/files/ATL-PHYS-SLIDE-2020-238.pdf
4. 3 CXAOD derivations: HIGG2D4 (0Lep filter), HIGG5D1 (1Lep filter), HIGG5D2 (2Lep filter)
5. Samples organised in directory according to sample logical names: Diboson Wjets Zjets data15 data16 stop ttbar
6. Running directory: run
7. Commands stored in run.sh script for reference

Configuration files used

run.sh:

```
#WV1Lep
#ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/WV1Lep_LCTopo_EMTopo.cfg -o /afs/cern.ch/work/c/chiodini/VV/WV1Lep_LCTopo_EMTopo
#ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/WV1Lep_TCC_EMTopo.cfg -o /afs/cern.ch/work/c/chiodini/VV/WV1Lep_TCC_EMTopo
#ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/WV1Lep_UFO_PFlow.cfg -o /afs/cern.ch/work/c/chiodini/VV/WV1Lep_UFO_PFlow
#ZV2Lep
ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/ZV2Lep_LCTopo_EMTopo.cfg -o /afs/cern.ch/work/c/chiodini/VV/ZV2Lep_LCTopo_EMTopo
ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/ZV2Lep_TCC_EMTopo.cfg -o /afs/cern.ch/work/c/chiodini/VV/ZV2Lep_TCC_EMTopo
ReadCxAODVVAnalysis -c data/CxAODReader_VVSemileptonic/ZV2Lep_UFO_PFlow.cfg -o /afs/cern.ch/work/c/chiodini/VV/ZV2Lep_UFO_PFlow
```

Changes in config file:

1. Select the right Derived CxAOD and pair of jet collections
2. string xSectionFileVV = data/CxAODReader_VVSemileptonic/XSections_13TeV.txt
3. Select the right analysis: ZV0Lep, W1Lep, ZV2Lep
4. Select the right btagging tool
5. Select the right jets and MET containers
6. Select the input samples
7. Select the number of events
8. Select direct run or batch run (I use condor with option tomorrow)
9. Set max output from histograms (like tree):
   int doHistStrategy = 3 #0=none, 1=MVVonly, 2=more, 3=all

B-tagging tool

```
## B-tagging configuration
## ----------------------
vector<string> bTagToolConfigs = MV2c10 85 AntiKt4EMTopoJets FixedCut # or FlatBEff
vector<string> bTagToolConfigsVR = MV2c10 85 AntiKtVR30Rmax4Rmin02TrackJets FixedCut
#string btaggingCDIfilename = 2017-21-13TeV-MC16-CDI-2018-10-19_v1 # October 2018
reccomendation
#string btaggingCDIfilename = /eos/atlas/atlascerngroupdisk/phys-higgs/HSG5/Run2/
BoostedVHbb2019/Custom_CDI/boosted-CDI-14-03-2019.root
string btaggingCDIfilename = /eos/atlas/atlascerngroupdisk/asg-calib/
xAODBTaggingEfficiency/13TeV/2017-21-13TeV-MC16-CDI-2019-07-30_v1.root
```

In order to avoid code error for “obsolete Btagging tool” I replaced with:

```
# B-tagging configuration
# ----------------------
#vector<string> bTagToolConfigs = MV2c10 85 AntiKt4EMTopoJets FixedCut # or FlatBEff
#vector<string> bTagToolConfigsVR = MV2c10 85 AntiKtVR30Rmax4Rmin02TrackJets FixedCut
vector<string> bTagToolConfigs =
SMALLR:MV2c10;85;AntiKt4EMTopoJets_BTagging201810;FixedCutBEff;D;AllSignalJets;BTAGMEDI
UM LARGER:MV2c10;85;AntiKtVR30Rmax4Rmin02TrackJet
s_BTagging201810;FixedCutBEff;D;AllSignalJets;BTAGMEDIUM
string btaggingCDIfilename = 2020-21-13TeV-MC16-CDI-2020-03-11_Sh228_v3
```

Jets and MET containers

LCTopo_EMTopo

```
string eventInfoContainer     = EventInfo
string muonContainer          = Muons
string electronContainer      = Electrons
string tauContainer           = TauJets
string photonContainer        = Photons
string jetContainer           = AntiKt4EMTopoJets_BTagging201810 #LCTopo_EMTopo #TCC_EMTopo
string fatJetContainer        = AntiKt10LCTopoTrimmedPtFrac5SmallR20Jets #LCTopo_EMTopo
string trackJetContainer      = AntiKtVR30Rmax4Rmin02TrackJets_BTagging201810 #LCTopo_EMTopo #TCC_EMTopo
string METContainer           = MET_Reference_AntiKt4EMTopo #LCTopo_EMTopo  #TCC_EMTopo
string MPTContainer           = MET_Track
string truthParticleContainer = TruthParticles
string truthVertexContainer   = TruthVertices
```

TCC_EMTopo

```
…
string fatJetContainer        = AntiKt10TrackCaloClusterTrimmedPtFrac5SmallR20Jets #TCC_EMTopo
…
```

UFO_PFlow

```
…
string jetContainer           = AntiKt4EMPFlowJets_BTagging201810 #UFO_PFlow
string fatJetContainer        = AntiKt10UFOCSSKSoftDropBeta100Zcut10Jets #UFO_Flow
string trackJetContainer      = AntiKt2PV0TrackJets_BTagging201810 #UFO_PFlow
string METContainer           = MET_Reference_AntiKt4EMPFlow #UFO_PFlow
…
```

Modified code

In order to study jets variable after preselection but before V_h tagging and mass, and D2 cuts

AnalysisReaderWZ1Lep.cxx

```
//Do W/Z-tagging
bool pass_isWJet = Props::passWMassCut.get(fatjet) && Props::passWSubstructure.get(fatjet);
bool pass_isZJet = Props::passZMassCut.get(fatjet) && Props::passZSubstructure.get(fatjet);
pass_isWJet = true;
bool pass_isWJetLP = Props::passWMassCut.get(fatjet) && !Props::passWSubstructure.get(fatjet);
bool pass_isZJetLP = Props::passZMassCut.get(fatjet) && !Props::passZSubstructure.get(fatjet);
bool pass_isWZJet = pass_isWJet || pass_isZJet;
bool pass_isWZJetLP = pass_isWJetLP || pass_isZJetLP;
```

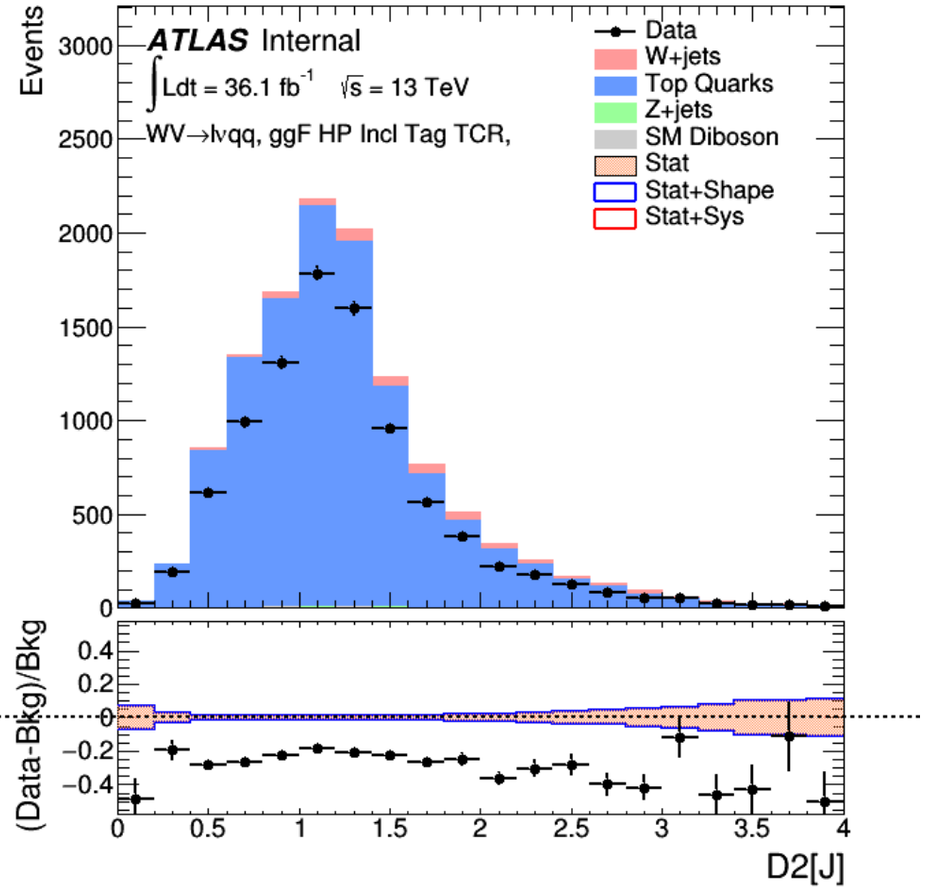
AnalysisReaderZV2Lep.cxx

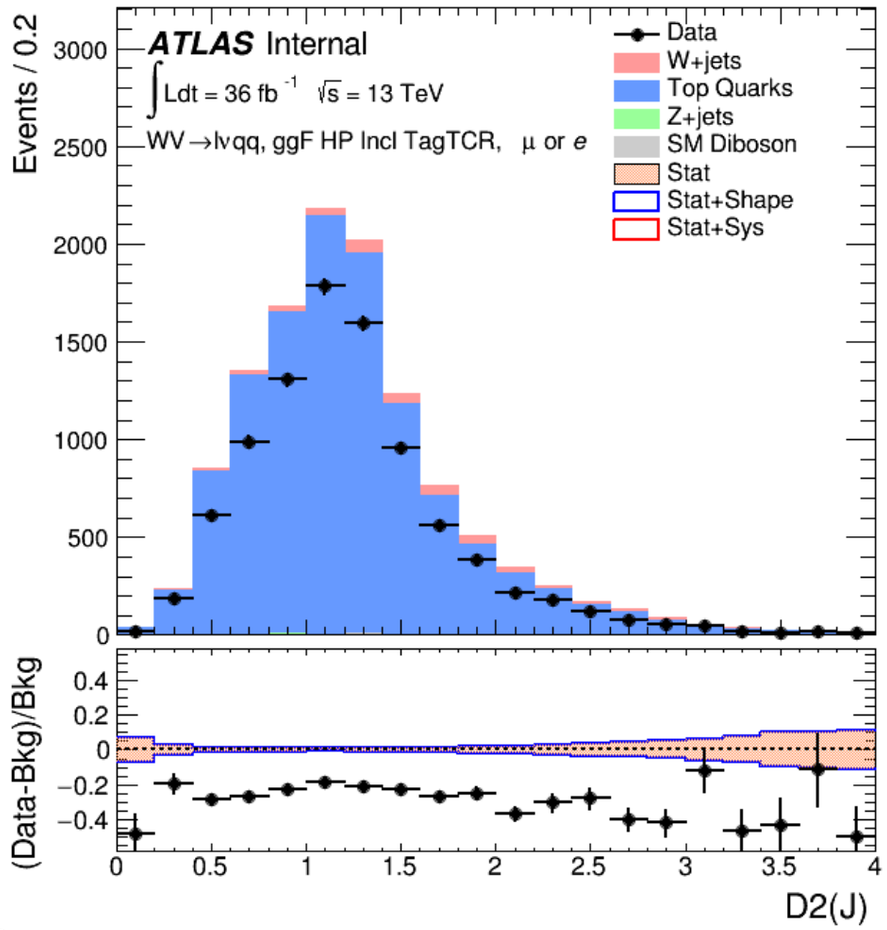
```
//Do W/Z-tagging
bool pass_isWJet = Props::passWMassCut.get(fatjet) && Props::passWSubstructure.get(fatjet);
pass_isWJet = true;
bool pass_isZJet = Props::passZMassCut.get(fatjet) && Props::passZSubstructure.get(fatjet);
pass_isZJet = true;
bool pass_isWJetLP = Props::passWMassCut.get(fatjet) && !Props::passWSubstructure.get(fatjet);
bool pass_isZJetLP = Props::passZMassCut.get(fatjet) && !Props::passZSubstructure.get(fatjet);
bool pass_isWZJet = pass_isWJet || pass_isZJet;
bool pass_isWZJetLP = pass_isWJetLP || pass_isZJetLP;
```

Compare WV1Lep with Yassine

Plots produced with: root -l CxAODReader_VVSemileptonic/macros/runCxAODPlots_Syst.cxx
after changing runCxAODPlots_Syst.cxx (I/O), makePlots2Lepton_Syst.cxx (loop on plot names) and PlottingTool//core/Config.cxx (initial state -> final state)

(sample)_0ptag1pfat0pjet_0ptv_MergHP_GGF_Inclusive_Tag_TCR_fatjet_D2->Draw();





LCTopo_EMTopo

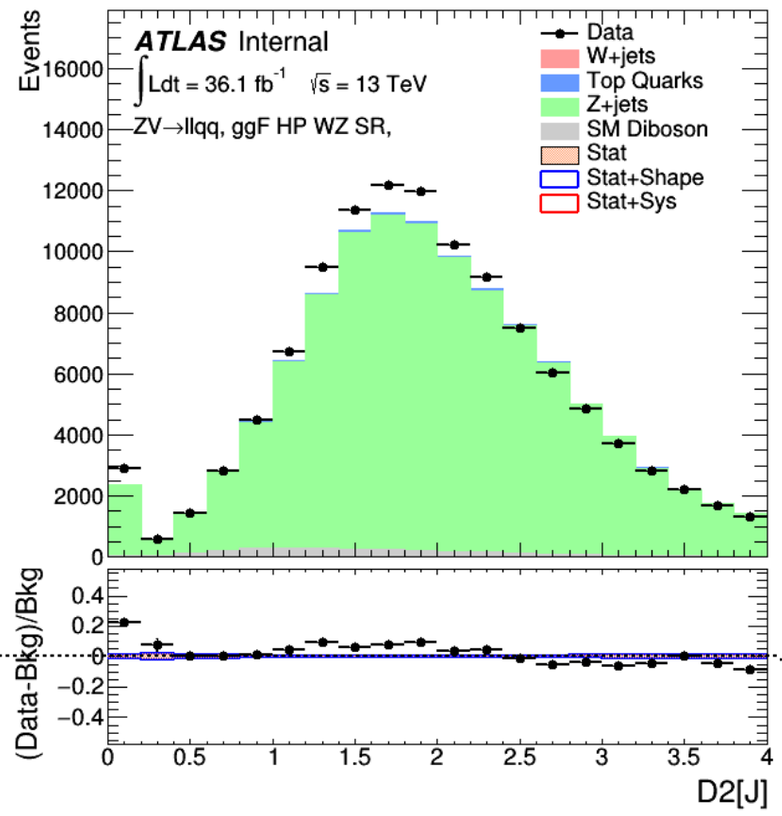
From my WV1Lep_LCTopo_EMTopo.cfg

From Yassine:

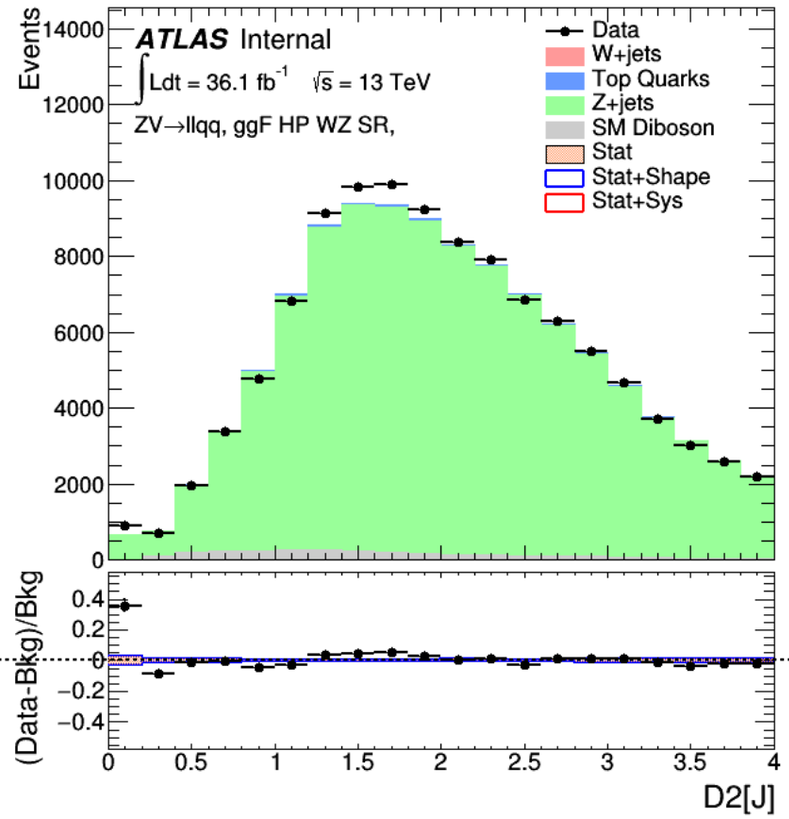
ZV2Lep first comparison

```
(sample)_0ptag1pfat0pjet_0ptv_MergHP_GGF_WZ_SR_fatjet_D2->Draw();
```

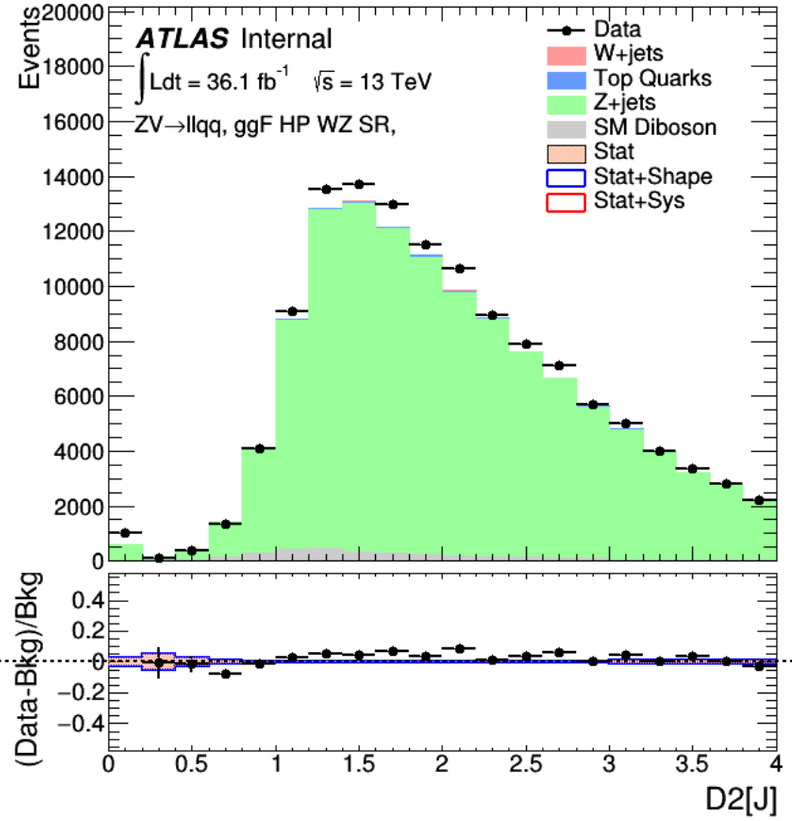
LCTopo_EMTopo



TCC_EMTopo



UFO_PFlow



What next

1. Go head comparing more SR and CR plots and variables.This requires more understanding of the analysis flow and add more histograms

2. Understand the difference with the analysis presented on paper

3. Try to address the difference between DATA/MC

4. Other suggestions?