山东大学 SHANDONG UNIVERSITY

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Search for electroweakinos production in compressed region

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On behalf of IHEP SUSY group

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Outline

1. Introduction

2. Ntuple & Events construction

2.1 Ntuple setup

2.2 Events construction & trigger

3. SRs definition

3.1 HH channel

3.2 LH channel

4. Background estimation

4.1 HH channel

4.2 LH channel

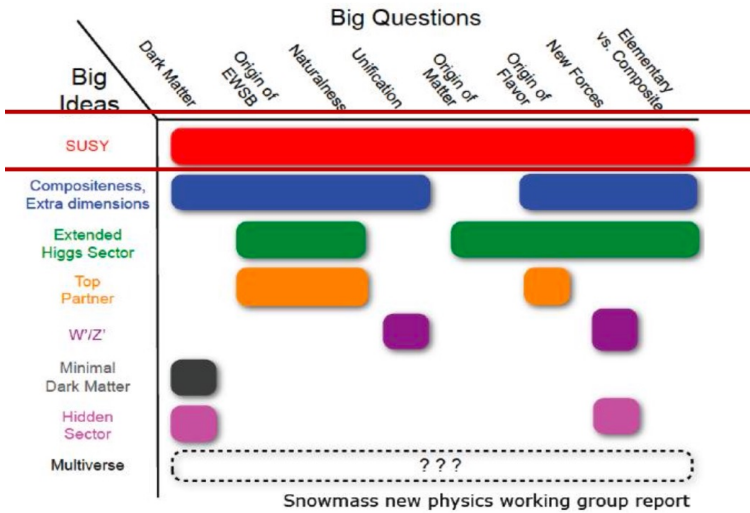
5. Sensitivity map

6. Summary and Outlook

Introduction

Why SUSY

- **Provide Dark matter candidate**
- **Unification of gauge coupling**
- **Solve the hierarchy problem**
- **……**

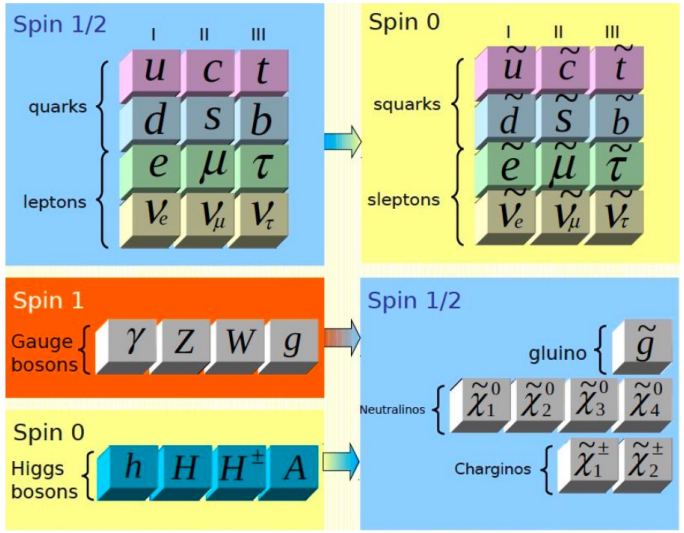


SUSY is a symmetry:

- **Extension of space and time: add fermionic coordinates**
- **Introduction of NEW particle: $boson \leftrightarrow fermion$**
- **Fundamental SUSY model**

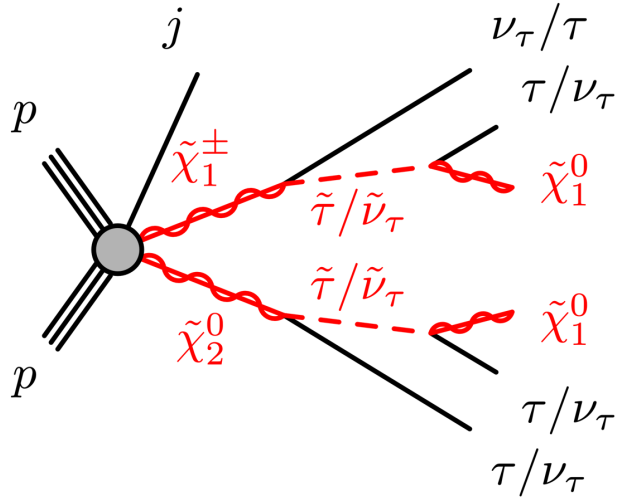
$$Q|\text{Boson}\rangle = |\text{Fermion}\rangle, \qquad Q|\text{Fermion}\rangle = |\text{Boson}\rangle.$$

$$\{Q, Q^\dagger\} = P^\mu,$$
$$\{Q, Q\} = \{Q^\dagger, Q^\dagger\} = 0,$$
$$[P^\mu, Q] = [P^\mu, Q^\dagger] = 0,$$



Motivation & Stragety

C1N2 via stau with $\geq 2\tau + E_T^{miss} + ISR$



Motivation:

Exclusion limit on C1/N2-N1 mass plane is derived. Still a gap in region with small Δm

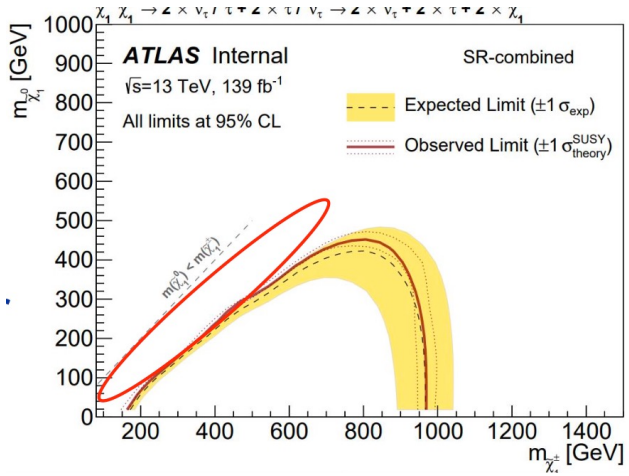
ISR can boost the SUSY system and improve the sensitivity in compressed region

Stragety:

BDT method to optimize SRs(HH and LH channel)

Fake taus with Fake Factor method

Real taus scaled with CRs and validate with VRs



Previous paper: JHEP 05 (2024) 150

Ntuple setup

- MelAnalysis framework
- Dataset: full run2 + partial run3
- DAOD PHYS
- ptag: signal p6244, bkg p6490/p6491, data p6479/p6269
- background list: mc20, mc23;

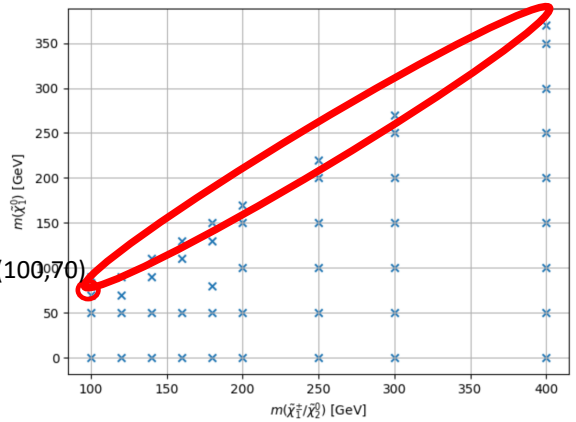
Type	dsid	sample
Higgs	346343	PhPy8EG_A14NNPDF23_NNPDF30ME_ttH125_allhad
	346344	PhPy8EG_A14NNPDF23_NNPDF30ME_ttH125_semilep
	346345	PhPy8EG_A14NNPDF23_NNPDF30ME_ttH125_dilep
	345097	PowhegPythia8EvtGen_NNLOPS_nnlo_30_ggH125_mumu
	345120	PowhegPy8EG_NNLOPS_nnlo_30_ggH125_tautaul13l7
	345121	PowhegPy8EG_NNLOPS_nnlo_30_ggH125_tautaulm15hp20
	345122	PowhegPy8EG_NNLOPS_nnlo_30_ggH125_tautaulp15hm20
	345123	PowhegPy8EG_NNLOPS_nnlo_30_ggH125_tautauh30h20
	345949	PowhegPythia8EvtGen_NNPDF30_AZNLOCTEQ6L1_VBFH125_bb
	346190	PowhegPy8EG_NNPDF30_AZNLOCTEQ6L1_VBFH125_tautaul13l7
	346191	PowhegPy8EG_NNPDF30_AZNLOCTEQ6L1_VBFH125_tautaulm15hp20
	346192	PowhegPy8EG_NNPDF30_AZNLOCTEQ6L1_VBFH125_tautaulp15hm20
	346193	PowhegPy8EG_NNPDF30_AZNLOCTEQ6L1_VBFH125_tautauh30h20
	345053	PowhegPythia8EvtGen_NNPDF3_AZNLO_WmH125J_MINLO_lvbb_VpT
	345054	PowhegPythia8EvtGen_NNPDF3_AZNLO_WpH125J_MINLO_lvbb_VpT
	345055	PowhegPythia8EvtGen_NNPDF3_AZNLO_ZH125J_MINLO_llbb_VpT
	345056	PowhegPythia8EvtGen_NNPDF3_AZNLO_ZH125J_MINLO_vvbb_VpT
	345057	PowhegPythia8EvtGen_NNPDF3_AZNLO_ggZH125_llbb
	345098	PowhegPythia8EvtGen_NNPDF3_AZNLO_ggZH125_Hmumu_Zinc
	345103	PowhegPythia8EvtGen_NNPDF30_AZNLO_ZH125J_Hmumu_Zincl_MINLO
	345104	PowhegPythia8EvtGen_NNPDF30_AZNLO_WpH125J_Hmumu_Wincl_MINLO
	345105	PowhegPythia8EvtGen_NNPDF30_AZNLO_WmH125J_Hmumu_Wincl_MINLO
	345109	PowhegPythia8EvtGen_NNPDF3_AZNLO_WmH125J_MINLO_lvcc_VpT
	345110	PowhegPythia8EvtGen_NNPDF3_AZNLO_WpH125J_MINLO_lvcc_VpT
	345111	PowhegPythia8EvtGen_NNPDF3_AZNLO_ZH125J_MINLO_llcc_VpT
	345112	PowhegPythia8EvtGen_NNPDF3_AZNLO_ZH125J_MINLO_vvcc_VpT
	345113	PowhegPythia8EvtGen_NNPDF3_AZNLO_ggZH125_llcc
	345211	PowhegPy8EG_NNPDF30_AZNLO_WmH125J_Winc_MINLO_tautau
	345212	PowhegPy8EG_NNPDF30_AZNLO_WpH125J_Winc_MINLO_tautau
	345217	PowhegPy8EG_NNPDF30_AZNLO_ZH125J_Zinc_MINLO_tautau
	346329	PowhegPy8EG_NNPDF30_AZNLO_ggZH125_lltautau_filt

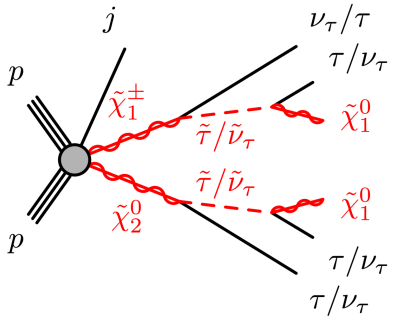
main background

Process	Generator	Computation order	Parton shower	PDF set	Set of tuned parameters
W+jets	SHERPA [2.2.11] [69]	NLO 0-2j + LO 3-5j	CSSHOWER [70]	NNPDF3.0NLO [71]	default
Ztt	SHERPA [2.2.14] [69]	NLO 0-2j + LO 3-5j	CSSHOWER [70]	NNPDF3.0NLO [71]	default
$t\bar{t}$	POWHEG-BOX [v2] [69]	NLO	PYTHIA [8.230] [77]	NNPDF3.0NLO [71]	A14

$\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$ mass degenerate and pure wino

$\tilde{\tau}/\tilde{\nu}$ mass degenerate and lie midway between $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}_2^0$





Filter set:

1. basic grids with 2TFilt
2. grids in compressed region with 1TFilt

Object Definition

- Full ST config: Run2, Run3
- Follow the CP recommendation

Decrease from 20GeV to 15GeV

Selection	Electron	Muon	Tau	Jet
Baseline	$p_T > 4.5$ GeV $\|\eta\| < 2.47$ $\|z_0 \cdot \sin\theta\| < 0.5$ mm ID: LooseAndBLayerLLH	$p_T > 5$ GeV $\|\eta\| < 2.5$ $\|z_0 \cdot \sin\theta\| < 0.5$ mm ID: Medium	$p_T > 15$ GeV $\|\eta\| < 1.37$ or $1.52 < \|\eta\| < 2.5$ $\|Q\| = 1$ 1 or 3 tracks Ele ID: RNN Loose Tau ID: VeryLoose	AntiKt4EMPFlow $p_T > 20$ GeV $\|\eta\| < 4.5$ JVT: FixedEffPt if $p_T < 60$ GeV bTag: GN2v01, 77% WP
Signal	ID: TightLLH Run2 ISO: Loose_VarRad, HighPtCaloOnly Run3 ISO: Tight_VarRad $\|d_0/\sigma_{d_0}\| < 5$	ISO: PflowLoose_VarRad $\|d_0/\sigma_{d_0}\| < 3$	Tau ID: Medium	

Overlap Removal

- ST default overlap removal
- Do Tau OLR

Reject	Against	Criteria
electron	electron	shared track, $p_{T1} < p_{T2}$
tau	electron	$\Delta R < 0.2$
tau	muon	$\Delta R < 0.2$
muon	electron	is calo-muon & shared ID track
electron	muon	shared ID track
jet	electron	$\Delta R < 0.2$
electron	jet	$\Delta R < \min\left(0.4,\ 0.04 + 10\ \mathrm{GeV}/p_T^{\mathrm{ele}}\right)$
jet	muon	NumTrack < 3 & (ghost-associated or $\Delta R < 0.2$)
muon	jet	$\Delta R < \min\left(0.4,\ 0.04 + 10\ \mathrm{GeV}/p_T^{\mu}\right)$
jet	tau	$\Delta R < 0.2$

Trigger Strategy

C1N2: MET trigger

Trigger	Trigger name	Year	HLT	Offline
MET trigger	HLT_xe70_mht	2015	70	200
	HLT_xe90_mht_L1XE50	2016	90	
	HLT_xe100_mht_L1XE50	2016	100	
	HLT_xe110_pufit_L1XE55	2017	110	
	HLT_xe110_pufit_L1XE50	2017	110	
	HLT_xe110_pufit_xe70_L1XE50	2018	70	
	HLT_xe110_pufit_xe65_L1XE50	2018	65	
	HLT_xe65_cell_xe90_pfopufit_L1XE50	2022,2023	90	

C1N2 ISR signal region optimization

- Preselection for HH and LH channel
- BDT method for signal region optimization
  - Figure of merit: AUC
  - 5-fold Cross-Validation

HH Pre-selection	LH Pre-selection
>= 2 medium taus	>= 1 medium taus
0 base lepton	>=1 base lepton, >=1 signal lepton
MET ≥ 200; pass MET trigger	MET ≥ 200; pass MET trigger
1≤nJet	1≤nJet
Opposite-sign hadronic-hadronic tau pair	Opposite-sign lepton-hadronic tau pair
bveto	bveto
jet pt>100 GeV	jet pt>100 GeV
$\mathbf{M_{\tau\tau}^{reco} < 40\ GeV\ or\ M_{\tau\tau}^{reco} > 130\ GeV}$	$\mathbf{M_{\tau\tau}^{reco} < 40\ GeV\ or\ M_{\tau\tau}^{reco} > 130\ GeV}$

Penalty function to balance the AUC and overfit

$$\mathcal{F} = AUC_{validation} - 0.3 \times AUC_{gap}$$

$$AUC_{gap} = |AUC_{train} - AUC_{validation}|$$

Grid Search for the best model

Hyperparameter	Scan Range
NTrees	200, 300, 400
MaxDepth	4, 6, 8
MinNode	1, 3, 5
Learning rate	0.01, 0.03, 0.05, 0.08, 0.1

C1N2 ISR signal region definition(HH)

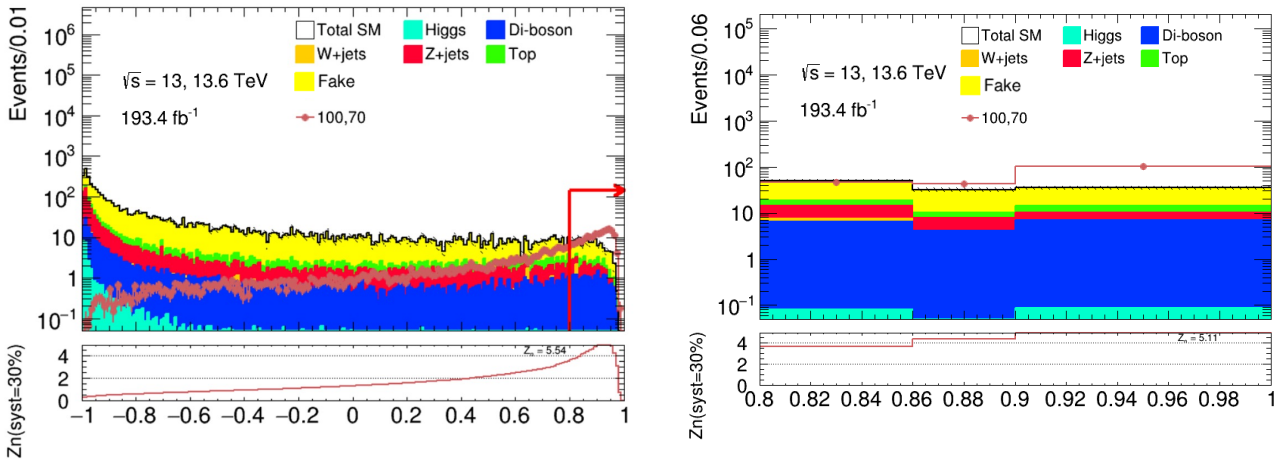
SR definition using BDT score(HH)

- Three bins
  [0.80, 0.86], [0.86, 0.90], [0.90, 1.00]

HH Pre-selection
>= 2 medium taus
0 base lepton
MET ≥ 150; pass MET trigger
1≤nJet
Opposite-sign hadronic-hadronic tau pair
bveto
jet pt>100 GeV
$\mathbf{M_{\tau\tau}^{reco} < 40\ GeV\ or\ M_{\tau\tau}^{reco} > 130\ GeV}$

SR
Pre-selection
BDT score > 0.8

Combined Zn 7.56



SM Process	[0.80, 0.86]	[0.86, 0.90]	[0.90, 1.00]
VV	6.508 ± 0.368	4.124 ± 0.341	6.855 ± 0.398
Top	4.719 ± 0.686	2.663 ± 0.546	4.331 ± 0.731
Fake	31.456 ± 3.898	21.525 ± 3.292	20.438 ± 2.976
Higgs	0.080 ± 0.023	0.045 ± 0.019	0.086 ± 0.031
Z+jets	6.659 ± 0.416	3.564 ± 0.286	3.207 ± 0.250
W+jets	0.978 ± 0.978	0.000 ± 0.000	0.000 ± 0.000
Total Bkg	50.402 ± 4.042	31.921 ± 3.354	34.917 ± 3.118
$m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0)$=(100,70)	46.569 ± 1.327	43.128 ± 1.283	101.059 ± 1.961
Z_n	3.65	4.37	5.11

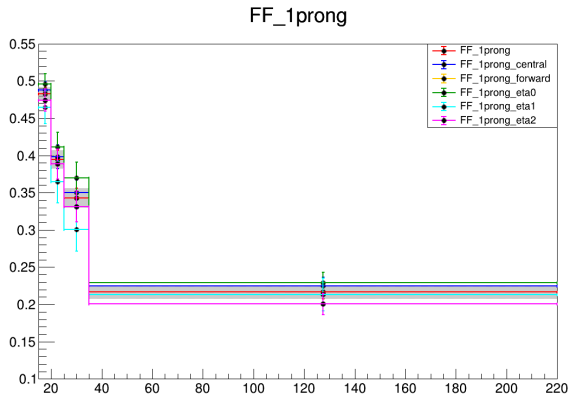
C1N2 ISR fake estimation(HH)

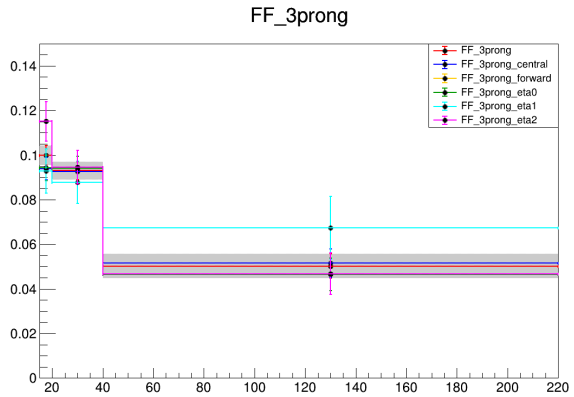
- CRs (fake factor computation)
  - METtrig
  - MET>=200
  - bveto
  - at least 1 signal lepton
  - $\Delta\phi(\tau, MET) > 2$
  - **ID: >= 1 medium tau**
  - **antiID: >= 1 VeryLoose tau, 0 medium tau**
- SRs
  - preselection
  - 2ID: >= 2 medium tau
  - 1ID1antiID: >= **2 VeryLoose tau** , 1 medium tau
  - 2antiID: >= **2 VeryLoose tau** , 0 medium tau

FF determination Data	FF determination Data
CR Pass ID	SR Pass ID
	SR but **1 tau Fail ID**
CR Fail ID	SR but **2 tau Fail ID**

$$FF = \frac{N^{\text{data}}_{\text{ID CR}} - N^{\text{real}}_{\text{ID CR}}}{N^{\text{data}}_{\text{antiID CR}} - N^{\text{real}}_{\text{antiID CR}}}$$

- **Binned in prongness, tau eta, tau pT**
  - Eta bins
    - 2 bins: central [0,1.37], forward [1.52,2.5]
    - 3 bins: eta0,1,2 for [0,1), [1, 1.37], [1.52,2.5]
- **Auto binning:**
  - > 10% of events in nominator and denominator
  - Add bins to bin i until it is not consistent anymore with bin i - 1
    - Relative stat uncertainty on ratio smaller than 50%
    - >10% events in nominator and denominator

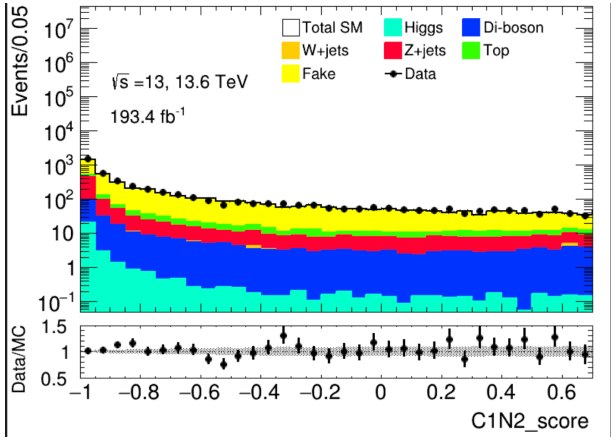




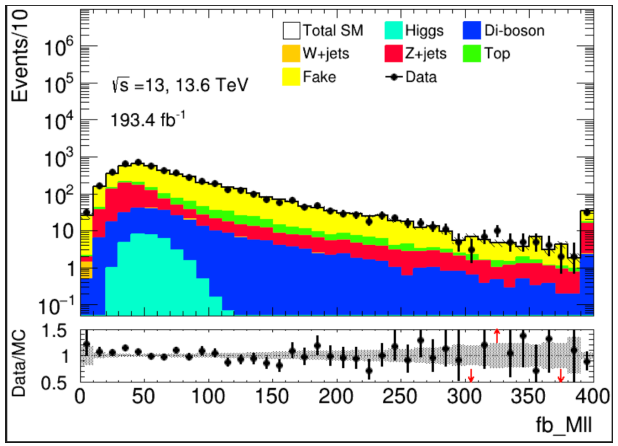
C1N2 ISR fake estimation validation(HH)

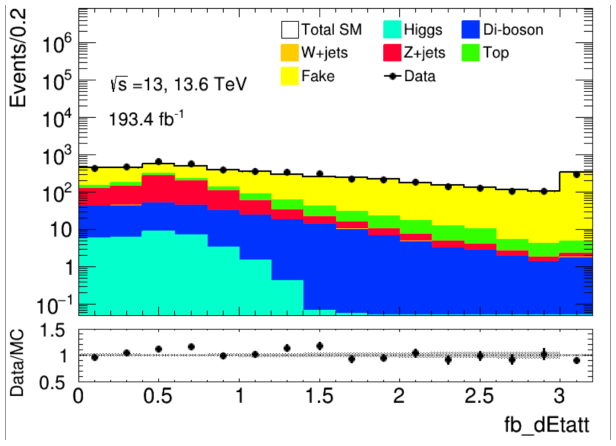
- Data-driven fakes in preselection region
- More data/MC please check in backup

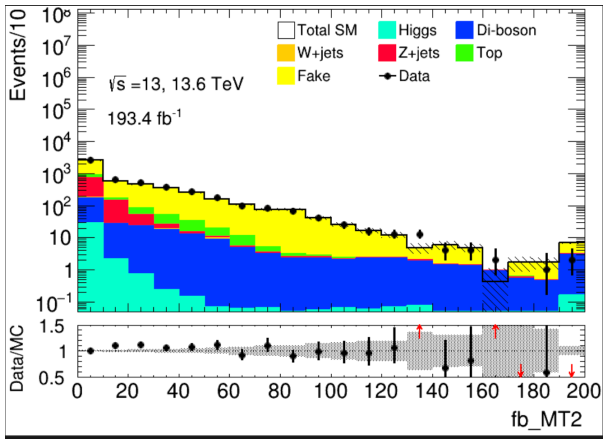
Score distribution (Pre-selection)

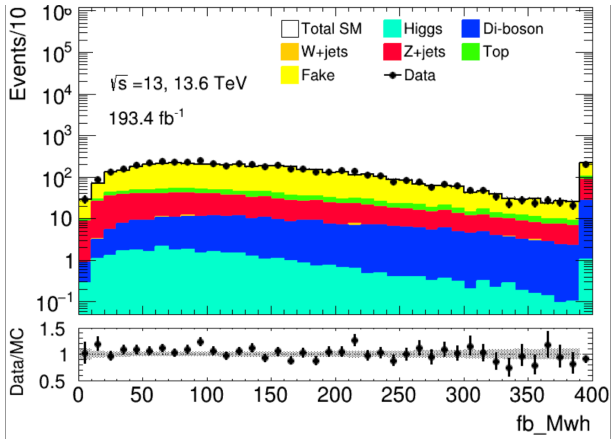


Kinematic distribution



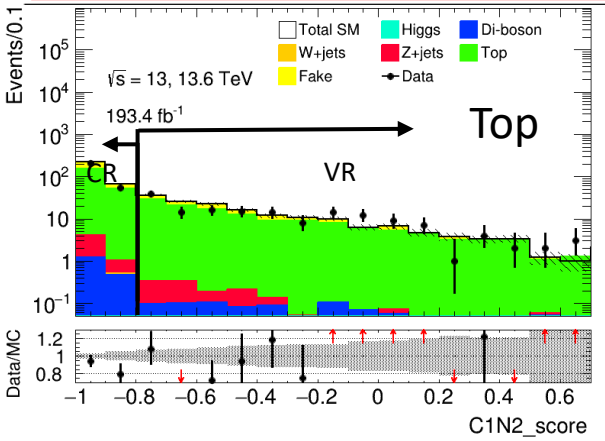


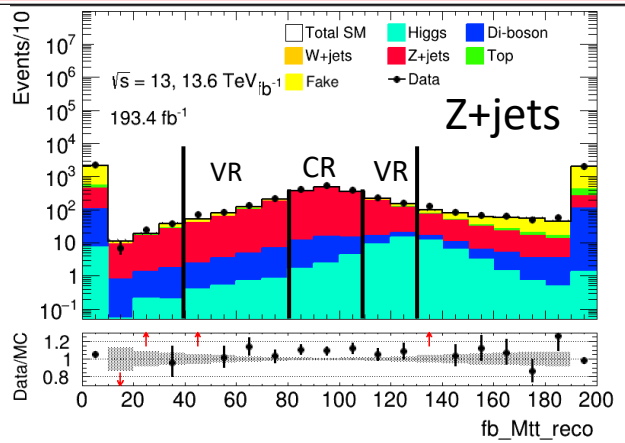


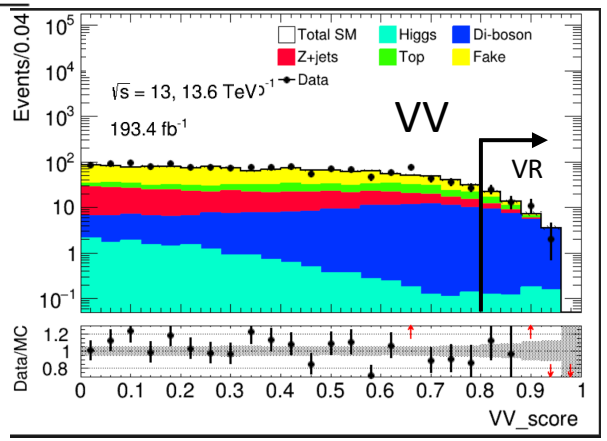


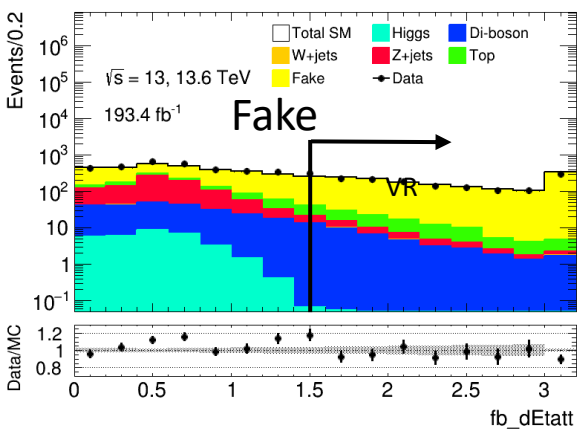
C1N2 ISR background estimation(HH)

Process	Top		Z+jets		Multi-bosons	Fake
	TCR	TVR	ZCR	ZVR	MBVR	FakeVR
Charge combination	OS					
Trigger	MET trigger, $E_T^{miss} \geq 200GeV$					
N medium τ	≥ 2					
N lep	=0					
$nBaseJet$	≥ 1					
$Jet \quad p_T$[GeV]	≥ 100					
N b-jets	≥ 1			$= 0$		
$m(\tau_1, \tau_2)$ [GeV]	≤ 40 or ≥ 130		[80,110]	[40,80] or [110,130]	≤ 40 or ≥ 130	
$M_T(\tau_1, E_T^{\text{miss}})$	≥ 200		–	–	–	–
$d\eta(\tau_1, \tau_2)$	–	–	–	Orthorgonal with SR	–	≥ 1.5
C1N2 score	[-1, -0.8]	[-0.8, 0.7]		< 0.7		
VV score	–	–	–	–	≥ 0.80	–
Total bkg	290+-7	162+-5	1420+-10	1286+-11	46+-2	2000+-28
Dominant Bkg	206+-4	131+-3	1221+-5	993+-4	24+-1	1851+-28
Purity	0.71	0.80	0.86	0.77	0.52	0.93
Data	264	161	1559	1427	51	1950
Data/MC	0.91	0.99	1.09	1.10	1.10	0.98









C1N2 ISR signal region definition(LH)

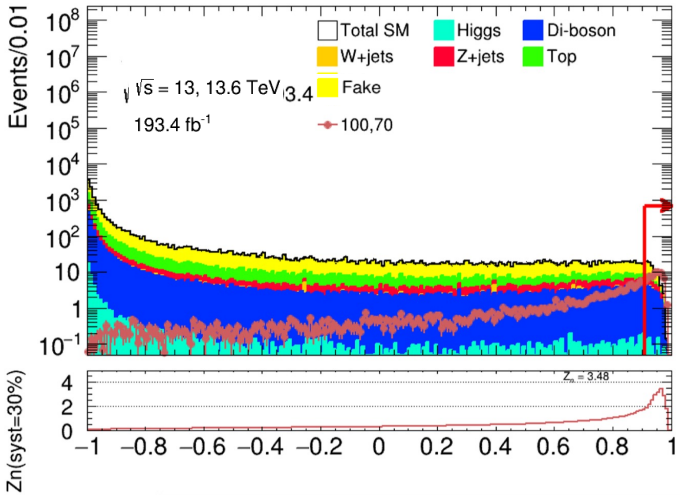
Combined Zn 4.934

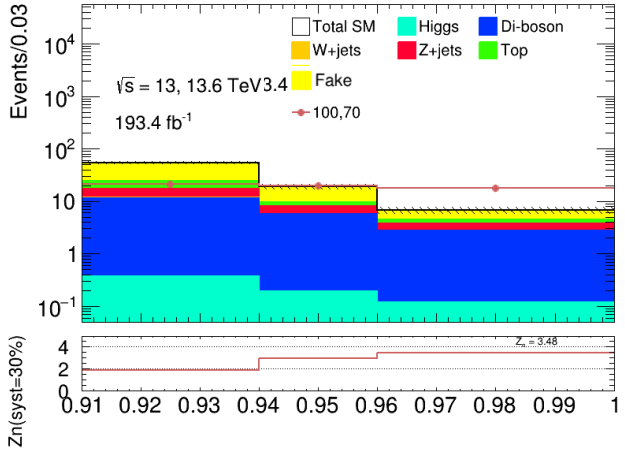
SR definition using BDT score(LH)

- Three bins
  [0.91, 0.94], [0.94, 0.96], [0.96, 1.00]

LH Pre-selection
>= 1 medium taus
>=1 base lepton, >=1 signal lepton
MET ≥ 200; pass MET trigger
1≤nJet
Opposite-sign lepton-hadronic tau pair
bveto
jet pt>100 GeV
$\mathbf{M_{\tau\tau}^{reco} < 40\ GeV\ or\ M_{\tau\tau}^{reco} > 130\ GeV}$

SR
Pre-selection
BDT score > 0.91



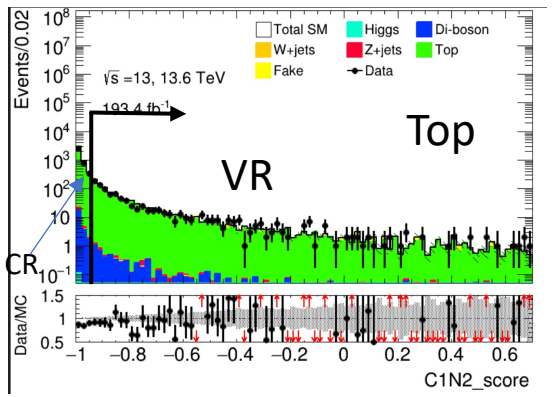


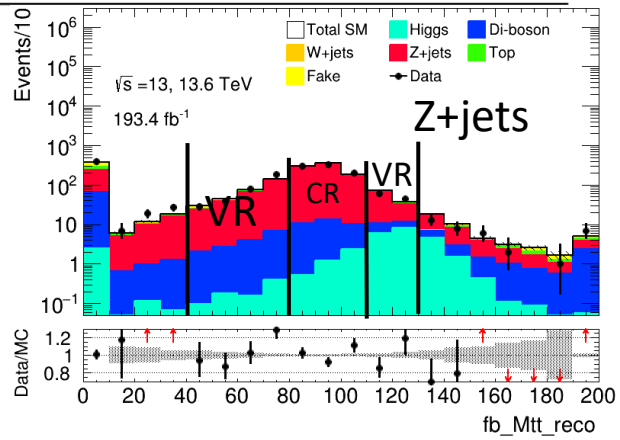
Process	[0.91, 0.94]	[0.94, 0.96]	[0.96, 1.00]
VV	11.105 ± 0.565	5.550 ± 0.367	2.666 ± 0.263
Top	7.432 ± 0.956	1.524 ± 0.441	0.578 ± 0.237
Fake	28.625 ± 3.295	9.404 ± 1.929	2.400 ± 1.009
Higgs	0.376 ± 0.057	0.189 ± 0.052	0.118 ± 0.040
Z+jets	5.515 ± 0.357	2.251 ± 0.222	1.026 ± 0.118
W+jets	0.173 ± 0.142	0.000 ± 0.000	0.000 ± 0.000
Total Bkg	53.226 ± 3.497	18.918 ± 2.018	6.788 ± 1.067
C1N2 (100,70)	21.447 ± 0.901	19.678 ± 0.874	17.543 ± 0.820
Z_n	1.90	2.94	3.47

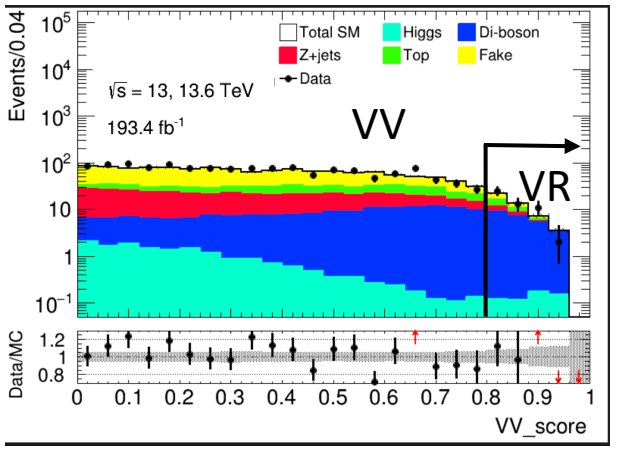
C1N2 ISR background estimation(LH)

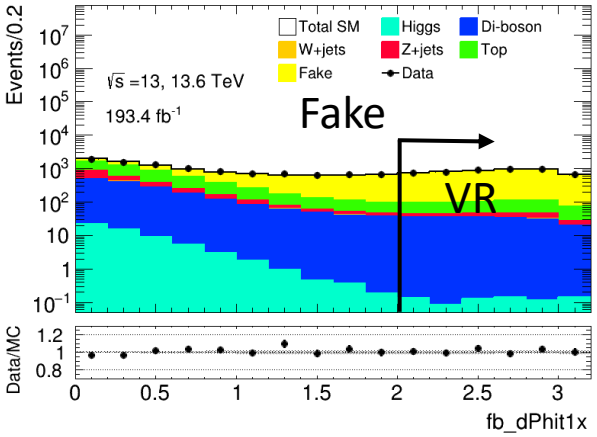
Selection for control region and validation region

Process	Top		Z+jets		Multi-bosons	Fake
	TCR	TVR	ZCR	ZVR	MBVR	FakeVR
Charge combination			OS			
Trigger			MET trigger, $E_T^{miss} \geq 200GeV$			
N medium τ			≥ 1			
N lep			≥ 1			
$nBaseJet$			≥ 1			
Jet p_T[GeV]			≥ 100			
N b-jets	≥ 1			$= 0$		
$m(\tau_1, l)$ [GeV]	≤ 40 or ≥ 130		[80,110]	[40,80] or [110,130]	≤ 40 or ≥ 130	
$M_{inv}(l, MET)$	≥ 300		–	–	–	–
$\Delta\phi(MET, \tau_1)$	–	–	–	–	–	≥ 2
$dR(\tau, l)$	–	–		< 0.6	–	–
C1N2 score	[-1, -0.95]	[-0.95, 0.7]		< 0.7		
VV score	–	–	–	–	≥ 0.80	–
Total bkg	4151+-11	1212+-13	917+-6	823+-4	78+-2	4983+-40
Dominant Bkg	3781+-20	1102+-11	823+-4	606+-3	53+-1	4390+-40
Purity	0.91	0.90	0.90	0.84	0.68	0.88
Data	3626	1119	908	745	72	5043
Data/MC	0.87	0.91	0.99	1.03	0.92	1.01





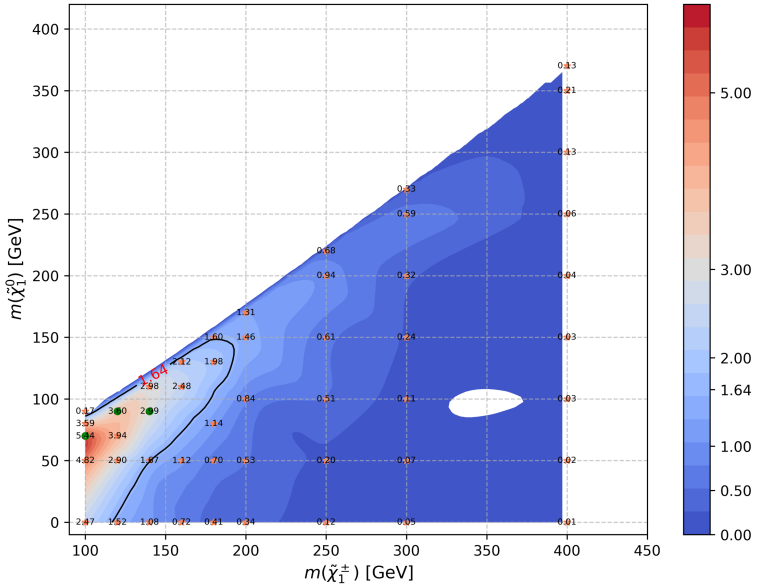




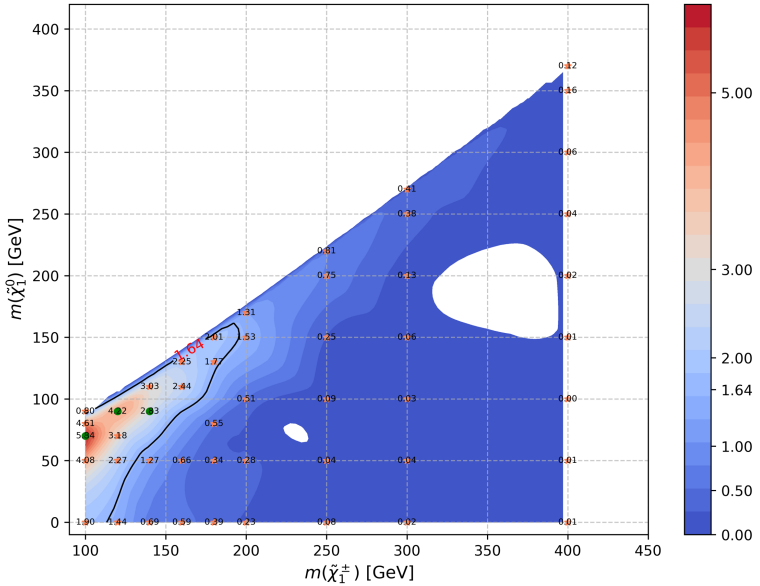
C1N2 ISR sensitivity map

- Expected sensitivity
  - 30% flat systematic uncertainty
  - gap caused by interpolation algorithm
  - Result only for full run2 sample, will update to full run2 + partial run3 sample later

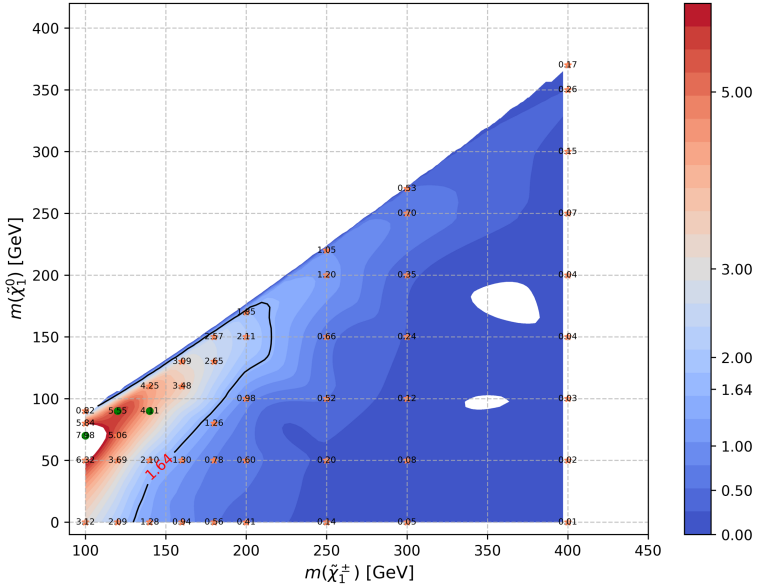
HH channel



LH channel



Combined channel



Summary and Outlook

Contribution Note

- Full analysis include SRs optimization, sensitivity map, background estimation, Internal note
- Invited to give an approval talk

Summary

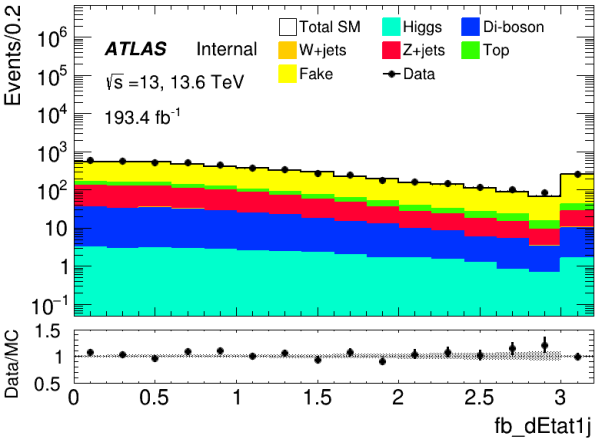
- Initial result show good sensitivity to compressed region

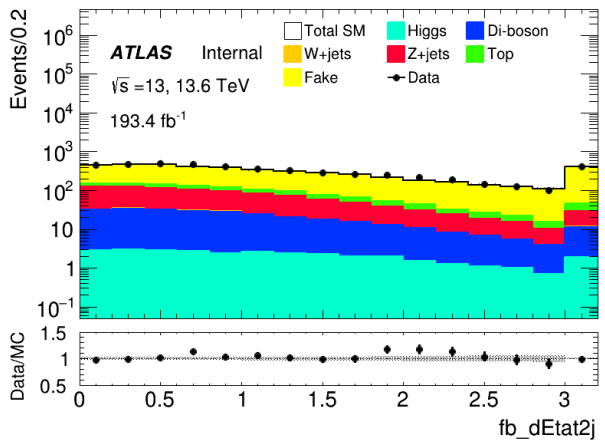
TODO

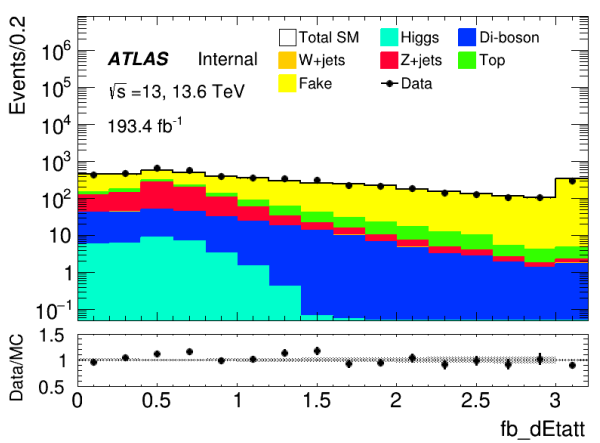
- Include more signal points the ML to expand exclusion limit
- Systematics studies
- Expected limit with uncertainty

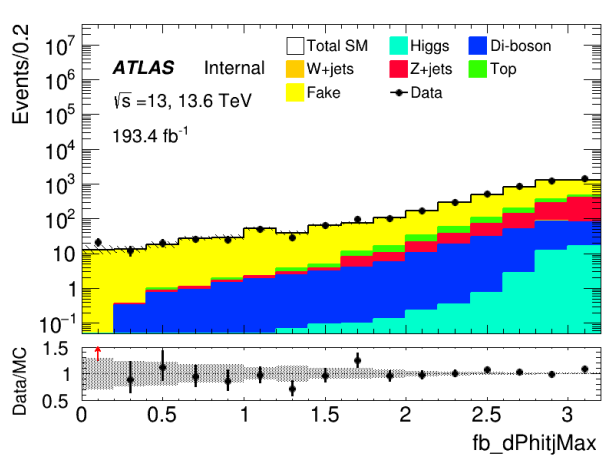
Backup

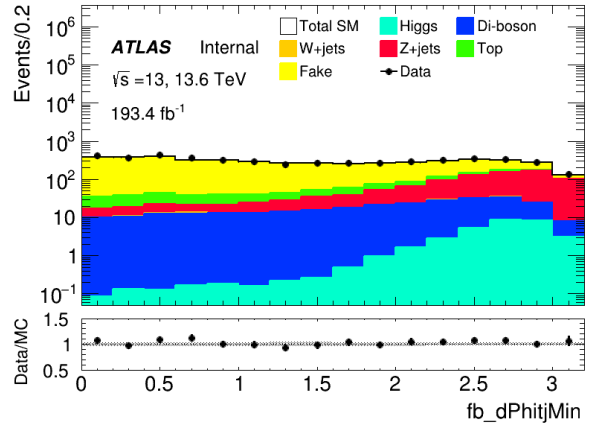
C1N2 ISR MC Modeling(HH)

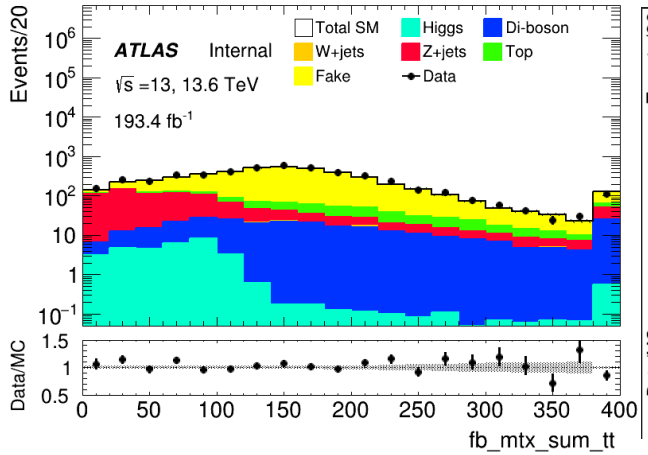


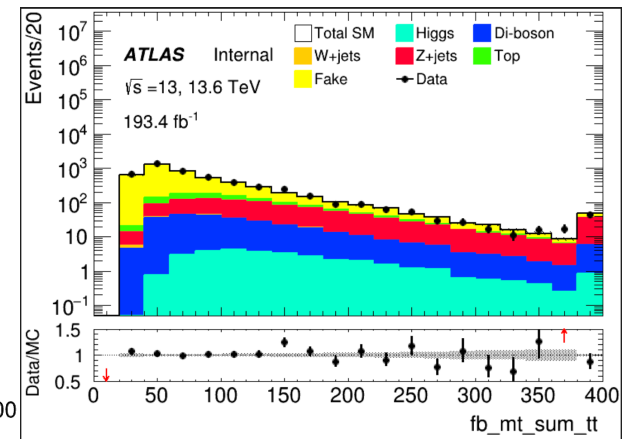


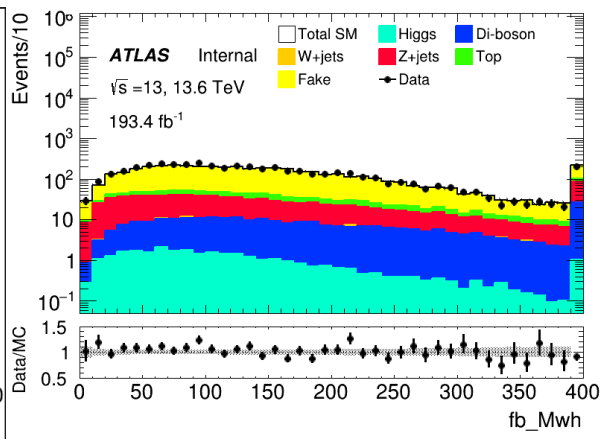






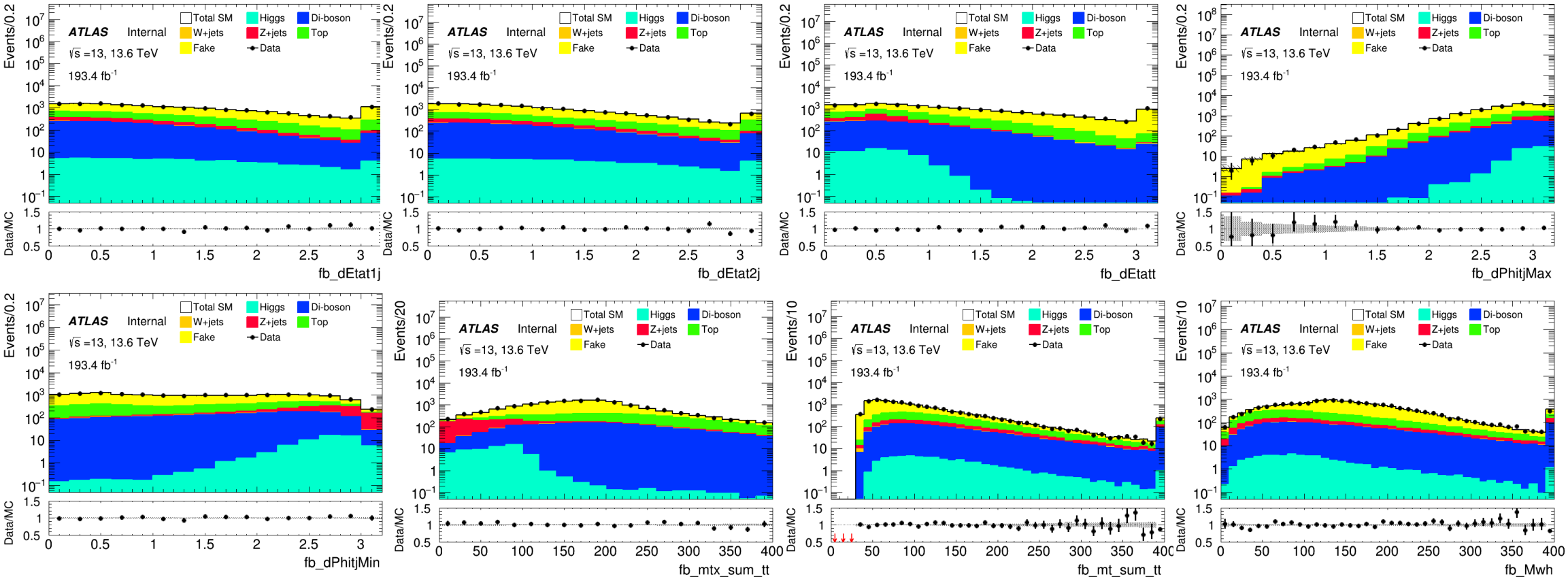






Full run2 + partial run3 after data-driven

C1N2 ISR MC Modeling(LH)



Full run2 + partial run3 after data-driven

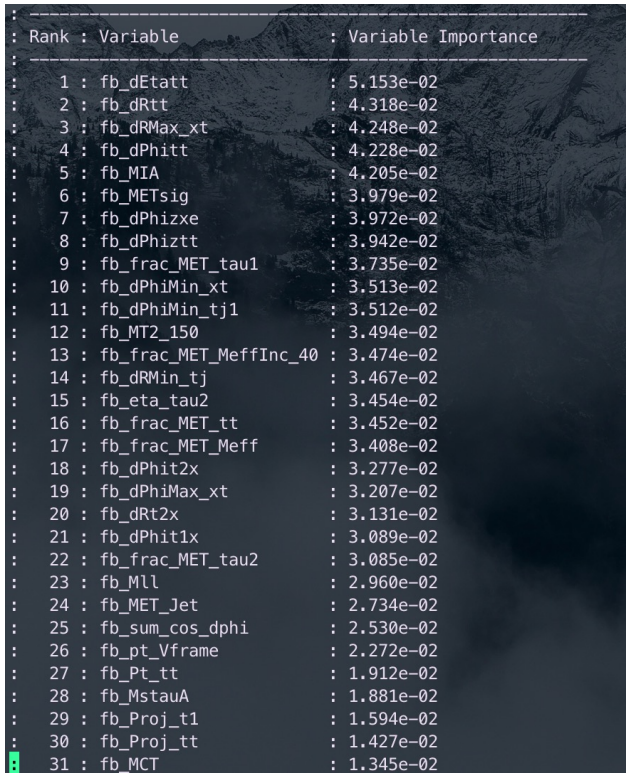
C1N2 ISR signal region optimization(HH)

Hyperparameters: Ntrees = 200, MaxDepth = 6, MinNodeSize = 2%, Learning rate = 0.03(initial setting)

Feature engineering:

Select a simple model and put all features into model, choose Top 30 vars based on importance list, drop high correlated vars

Final feature list:



Rank	Variable	Variable Importance
1	fb_dEtatt	5.153e-02
2	fb_dRtt	4.318e-02
3	fb_dRMax_xt	4.248e-02
4	fb_dPhitt	4.228e-02
5	fb_MIA	4.205e-02
6	fb_METsig	3.979e-02
7	fb_dPhizxe	3.972e-02
8	fb_dPhiztt	3.942e-02
9	fb_frac_MET_tau1	3.735e-02
10	fb_dPhiMin_xt	3.513e-02
11	fb_dPhiMin_tj1	3.512e-02
12	fb_MT2_150	3.494e-02
13	fb_frac_MET_MeffInc_40	3.474e-02
14	fb_dRMin_tj	3.467e-02
15	fb_eta_tau2	3.454e-02
16	fb_frac_MET_tt	3.452e-02
17	fb_frac_MET_Meff	3.408e-02
18	fb_dPhit2x	3.277e-02
19	fb_dPhiMax_xt	3.207e-02
20	fb_dRt2x	3.131e-02
21	fb_dPhit1x	3.089e-02
22	fb_frac_MET_tau2	3.085e-02
23	fb_Mll	2.960e-02
24	fb_MET_Jet	2.734e-02
25	fb_sum_cos_dphi	2.530e-02
26	fb_pt_Vframe	2.272e-02
27	fb_Pt_tt	1.912e-02
28	fb_MstauA	1.881e-02
29	fb_Proj_t1	1.594e-02
30	fb_Proj_tt	1.427e-02
31	fb_MCT	1.345e-02

Weight choose: no weight, abs(weight)

No weight have better performance
but abs(weight) fit our anaysis requirment

Split strategy: Separate entries by using mod 5, for Fake bkg, if separate follow sequence, all weighted entry will split into first fold

C1N2 ISR signal region optimization(HH)

Class: C1N2, bkg
Test_auc = \sum{Test_auc_class}
Train_auc = \sum{Train_auc_class}

Hyperparameter tune:
use optuna to auto-optimze

constraint:

average of AUC need to >= 0.6
penalty function: score = test_auc – 0.3*auc_gap (auc_gap = abs(train_auc- test_auc))
maximum(score)

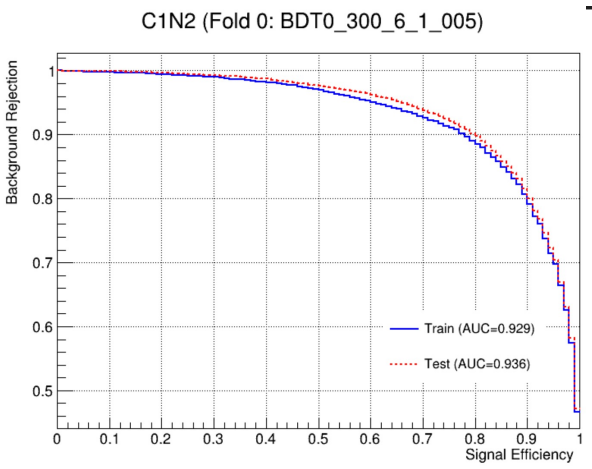
Grid Search
Ntrees: [200, 300, 400]
MaxDepth: [4, 6, 8, 10]
MinNode: [1, 3, 5, 7]
Learning rate: [0.001, 0.005, 0.01, 0.05, 0.1]

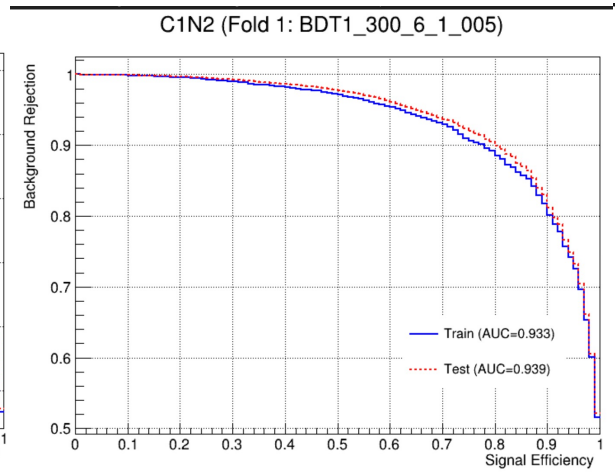
Best one: Ntree=300, MaxDepth=6, MinNode=1%, Learning Rate=0.05

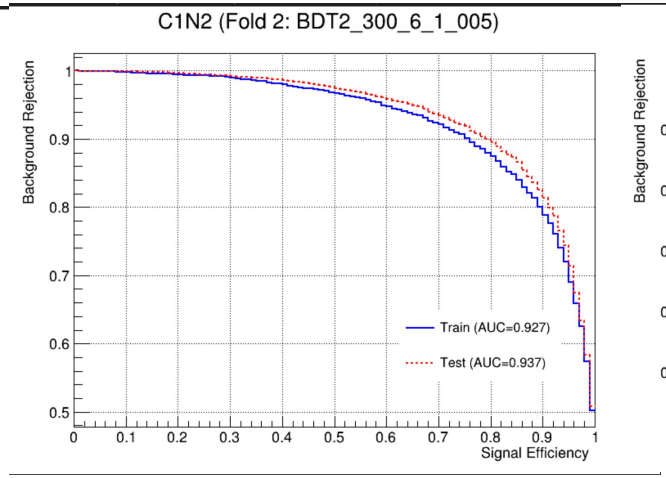
There still have rooms to optimize for lr

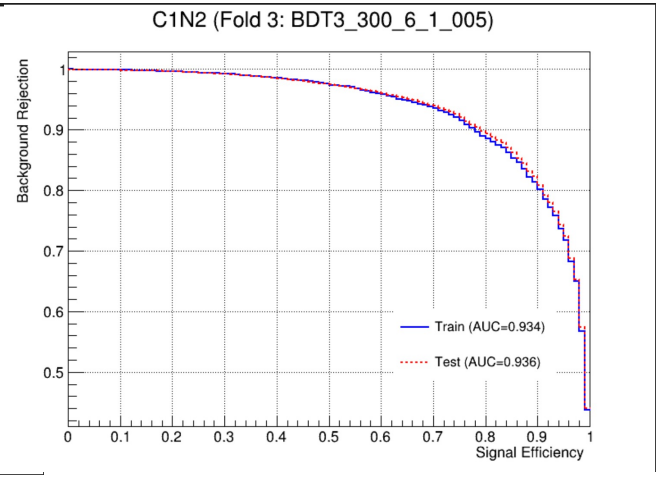
C1N2 ISR signal region optimization(HH)

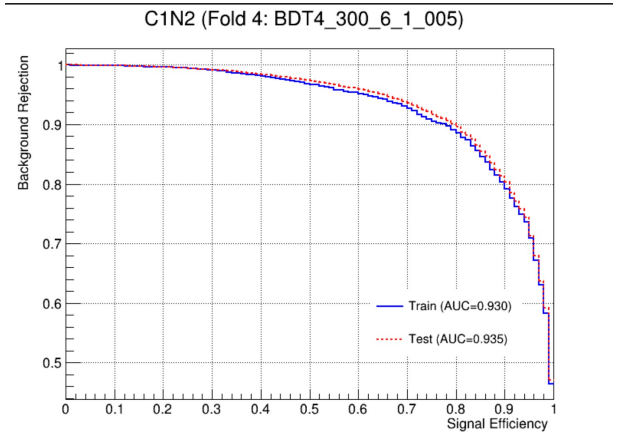
Overfit Check





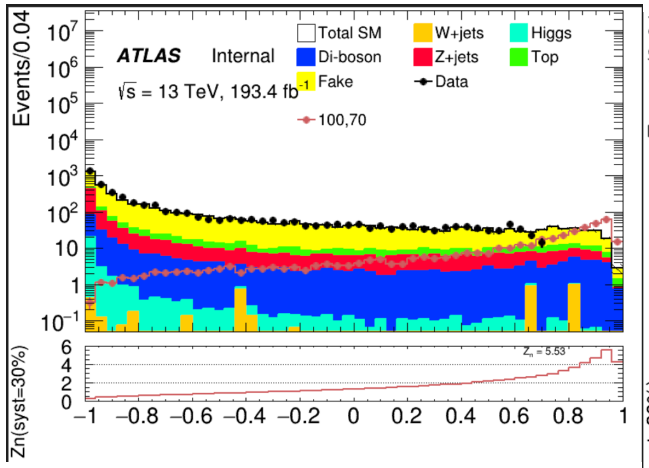




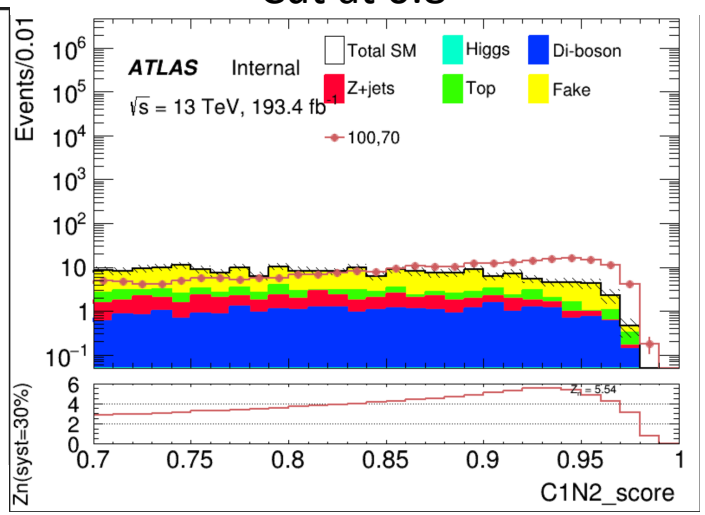


C1N2 ISR signal region optimization(HH)

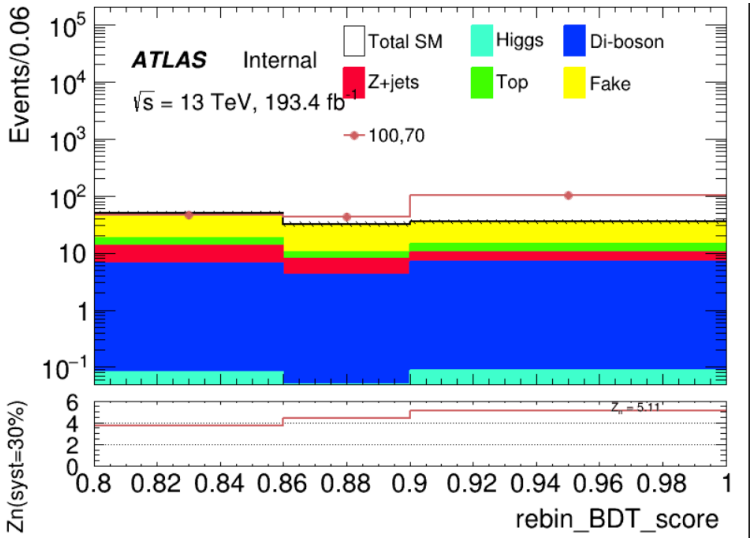
50 bins



Cut at 0.8



rebin



Sum Zn = 7.65

Bin Range	Zn	C1N2 (100_70) Yield ± Error	VV Yield ± Error	Top Yield ± Error	Fake Yield ± Error	Higgs Yield ± Error	Zjets Yield ± Error	Wjets Yield ± Error	Total Bkg Yield ± Error
[0.80,0.85]	3.65	46.569 ± 1.327	6.508 ± 0.368	4.719 ± 0.686	31.458 ± 3.898	0.080 ± 0.023	6.659 ± 0.416	0.978 ± 0.978	**50.402 ± 4.042**
[0.85,0.90]	4.37	43.128 ± 1.283	4.124 ± 0.341	2.663 ± 0.546	21.525 ± 3.292	0.045 ± 0.019	3.564 ± 0.286	0.000 ± 0.000	**31.921 ± 3.354**
[0.90,1.00]	5.11	101.059 ± 1.961	6.855 ± 0.398	4.331 ± 0.731	20.438 ± 2.976	0.086 ± 0.031	3.207 ± 0.250	0.000 ± 0.000	**34.917 ± 3.118**

C1N2 ISR signal region optimization(LH)

Hyperparameters: Ntrees = 200, MaxDepth = 6, MinNodeSize = 2%, Learning rate = 0.03(initial setting)

Feature engineering:

Select a simple model and put all features into model, choose Top 30 vars based on importance list, drop high correlated vars

Final feature list:

Rank	Variable	Variable Importance
1	fb_frac_MET_tau2	8.270e-02
2	fb_dRtt	6.684e-02
3	fb_dPhitt	6.226e-02
4	fb_frac_MET_tt	5.197e-02
5	fb_frac_jet_tau2	5.179e-02
6	fb_MT2_50	5.077e-02
7	fb_dPhiMax_tj	4.779e-02
8	fb_dPhiMin_xj	4.343e-02
9	fb_mt_taumin	3.547e-02
10	fb_Mll	3.511e-02
11	fb_mtx_tau1	3.408e-02
12	fb_nBaseJet	3.146e-02
13	fb_frac_jet_tt	3.110e-02
14	fb_mtx_tau2	2.941e-02
15	fb_frac_MET_tau1	2.898e-02
16	fb_METsig	2.824e-02
17	fb_pt_Vframe	2.726e-02
18	fb_Mwh	2.684e-02
19	fb_Proj_j	2.678e-02
20	fb_frac_MET_sqrtHT_40	2.560e-02
21	fb_frac_jet_tau1	2.518e-02
22	fb_MCT	2.254e-02
23	fb_Mwl	2.185e-02
24	fb_mt_quad_sum	2.165e-02
25	fb_Proj_tt	2.038e-02
26	fb_ht_tau	1.992e-02
27	fb_e_tau2	1.819e-02
28	fb_mt_sum_ttj	1.624e-02
29	fb_mt_tau2	1.618e-02

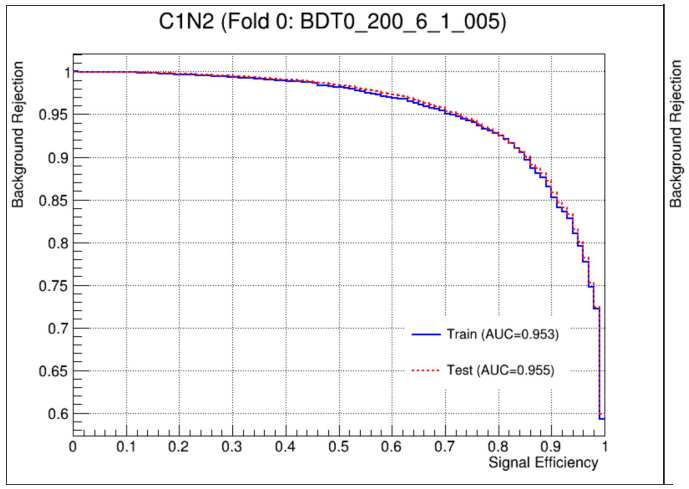
Weight choose: no weight, abs(weight)

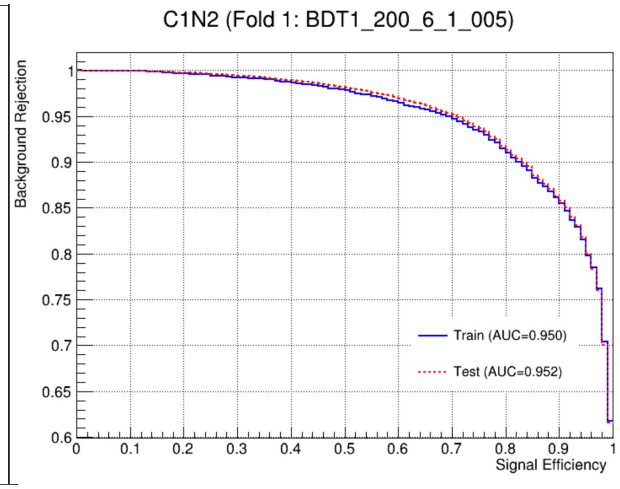
No weight have better performance
but abs(weight) fit our anaysis requirment

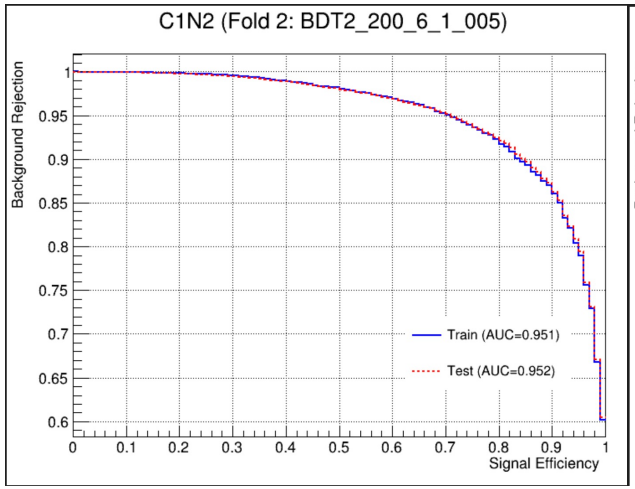
Split strategy: Separate entries by using mod 5, for Fake bkg, if separate follow sequence, all weighted entry will split into first fold

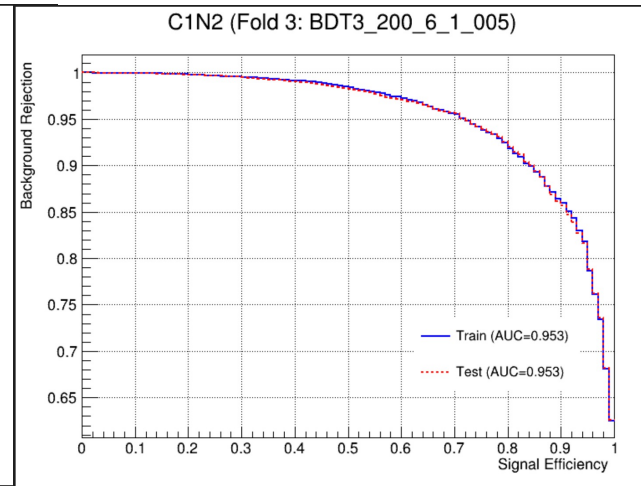
C1N2 ISR signal region optimization(LH)

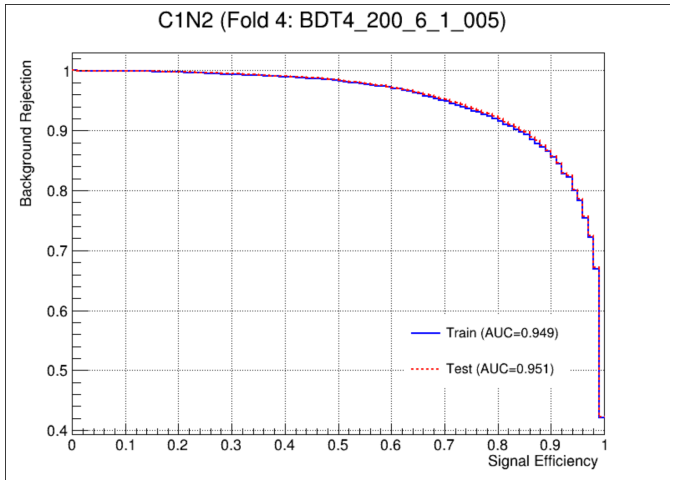
Overfit Check





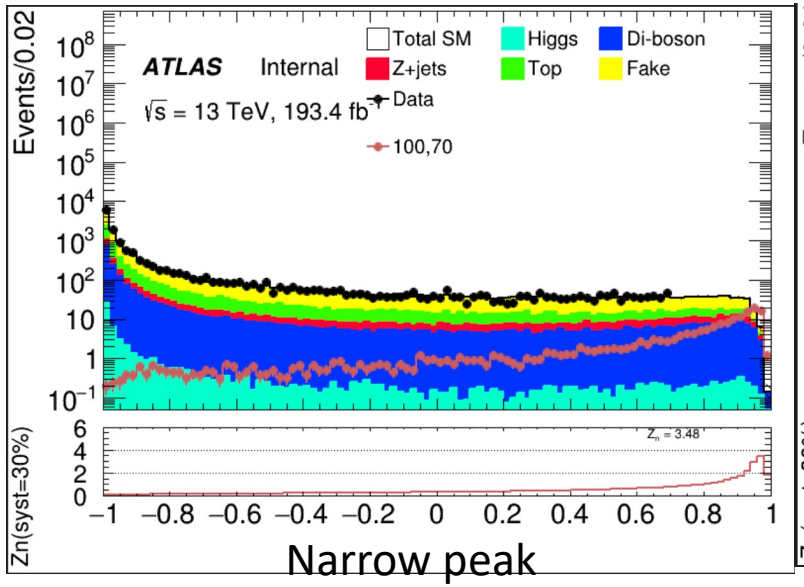






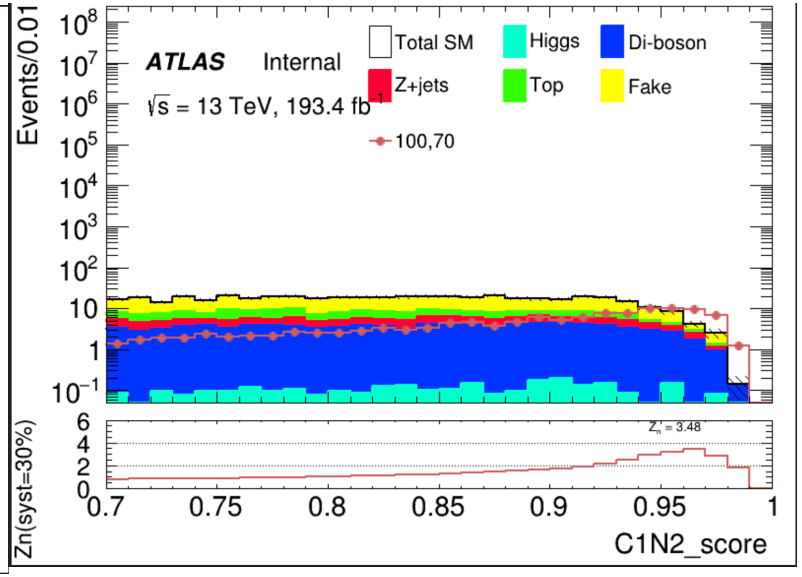
C1N2 ISR signal region optimization(LH)

100 bins

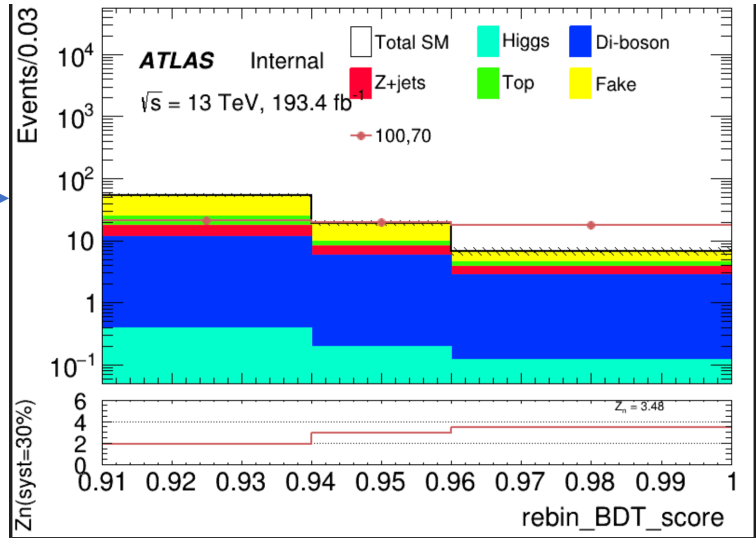


Narrow peak

Cut at 0.91



rebin



Sum Zn = 4.934

Bin Range	Zn	C1N2 (100_70) Yield ± Error	VV Yield ± Error	Top Yield ± Error	Fake Yield ± Error	Higgs Yield ± Error	Zjets Yield ± Error	Wjets Yield ± Error	Total Bkg Yield ± Error
[0.91,0.94]	1.90	21.447 ± 0.901	11.105 ± 0.565	7.432 ± 0.956	28.625 ± 3.295	0.376 ± 0.057	5.515 ± 0.357	0.173 ± 0.142	**53.226 ± 3.497**
[0.94,0.96]	2.94	19.678 ± 0.874	5.550 ± 0.367	1.524 ± 0.441	9.404 ± 1.929	0.189 ± 0.052	2.251 ± 0.222	0.000 ± 0.000	**18.918 ± 2.018**
[0.96,1.00]	3.47	17.543 ± 0.820	2.666 ± 0.263	0.578 ± 0.237	2.400 ± 1.009	0.118 ± 0.040	1.026 ± 0.118	0.000 ± 0.000	**6.788 ± 1.067**