REPORT

Lecce team

OUTLINE

- Some studies on pDNN
- Some expected limits
- Next steps

SOME STUDIES ON pDNN

- INPUT:
  - MC16a MC samples, CxAOD tag: 33-08, UFO-pFlow, BTagging201903
  - pDNN: version (see later)
  - No Data
  - Radion, ggF/DY, merged regime

- Studies:
  - Interpolation capability
  - From the light version to the configuration in ATL-COM-PHYS-2018-1549
  - Adding M_{llJ}
  - Stability with statistics

SOME STUDIES ON PDNN

- pDNN configuration: **light version**
  - Input variables:
    - Lepton 1, 2: m, pt, eta, phi
    - Leptonic Z: m, pt
    - Fatjet: m, d2, pt, eta, phi
    - Event: (Njet)
    - Special for pDNN: Signal Mass
  - Variable scaling: mean to 0; rms to 1
  - Training:
    - Background: Z+jet and Diboson, weighted to equalise stat. (No use of MC weights)
    - Signal: Sum (over masses) of all samples reweighed to match stat of sum of backgrounds
      - Mass (GeV): 500, 600, 700, 800, 1000, 1200, 1400, 1500, 1600, 1800, 2000, 2400, 2600, 3000, 3500, 4000, 4500, 5000, 6000
    - 20% dropout
    - 20% of the training set as validation sample (for the early stopping after 10 epochs without any decrease in the validation loss)

Layers	2
Nodes	32
Optimizer	RMSprop
Learning rate	0.001
Patience	10
Epochs	150

- Some results presented in https://indico.cern.ch/event/1037488/contributions/4356646/attachments/2242794/3803014/LecceActivities.pdf
-

SOME STUDIES ON PDNN

- pDNN configuration: light version

- Interpolation capability of the pDNN:
  - pDNN tested on a signal sample not used in the training

INTERPOLATION CAPABILITY

pDNN training

- UFO PFlow
- Merged ggF
- Signal: Radion
- Background: Z jets + DiBoson

```
Training set:
279445 signal (36%)
491558 background (64%)
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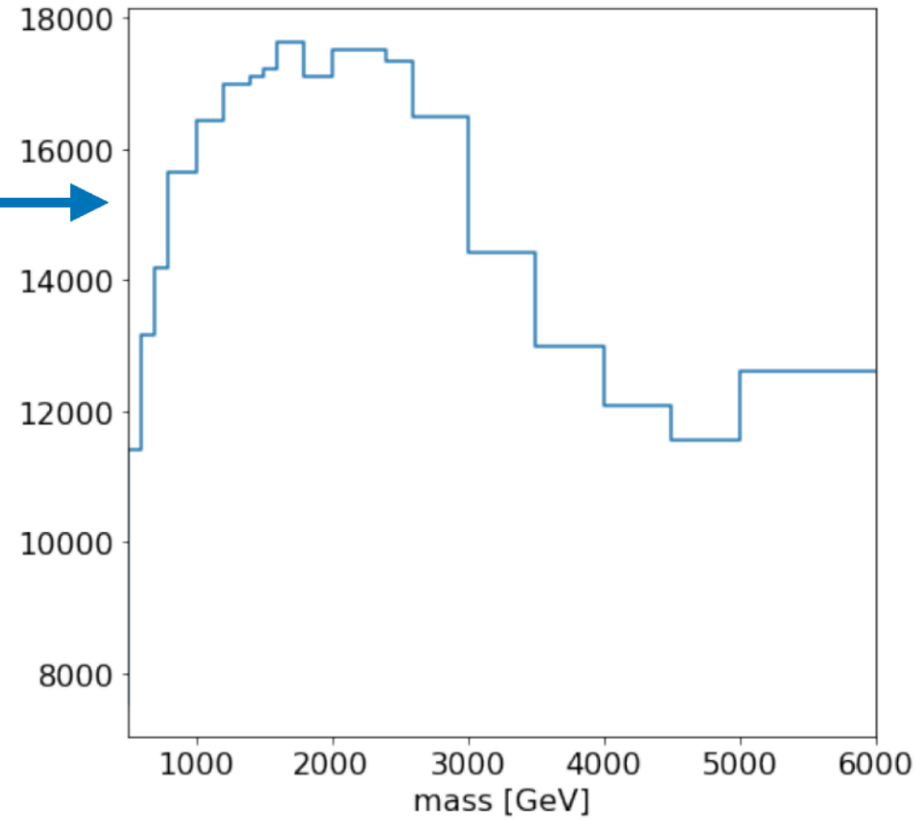
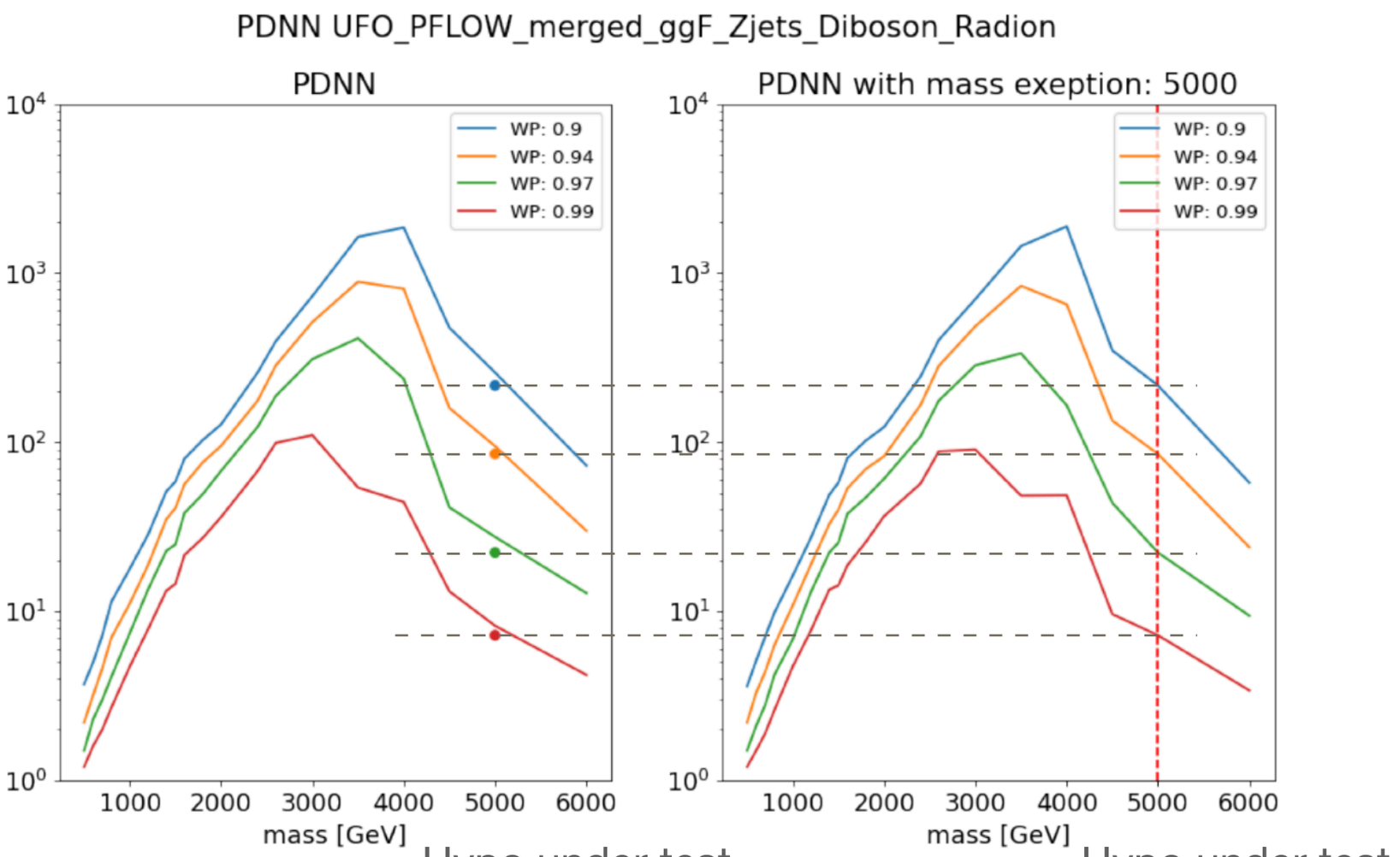
```
   Zjets    DiBoson
  439108    52450
    89%      11%
```



INTERPOLATION CAPABILITY

Mass = 5TeV NON in the training set

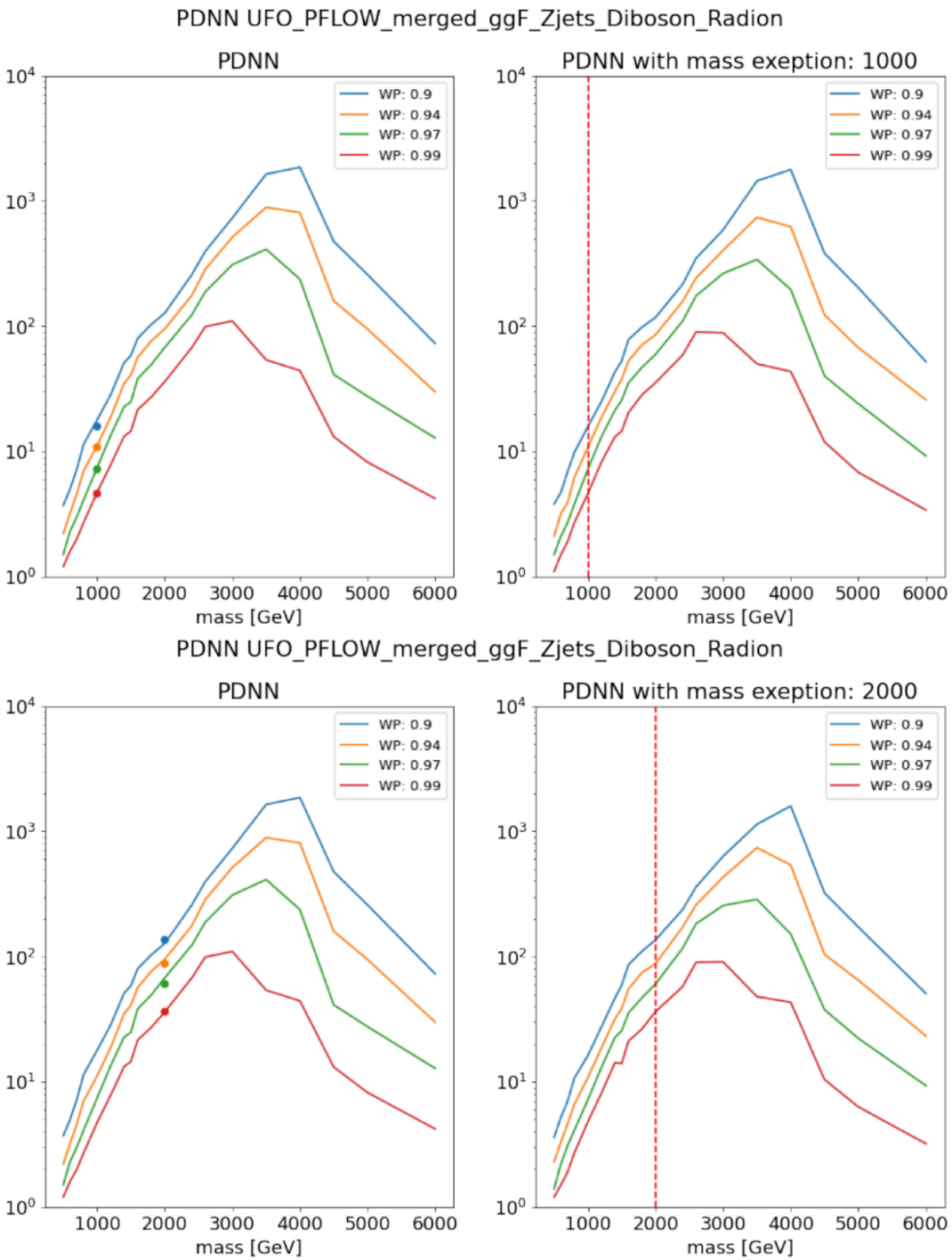
Mass = 5TeV IN the training set

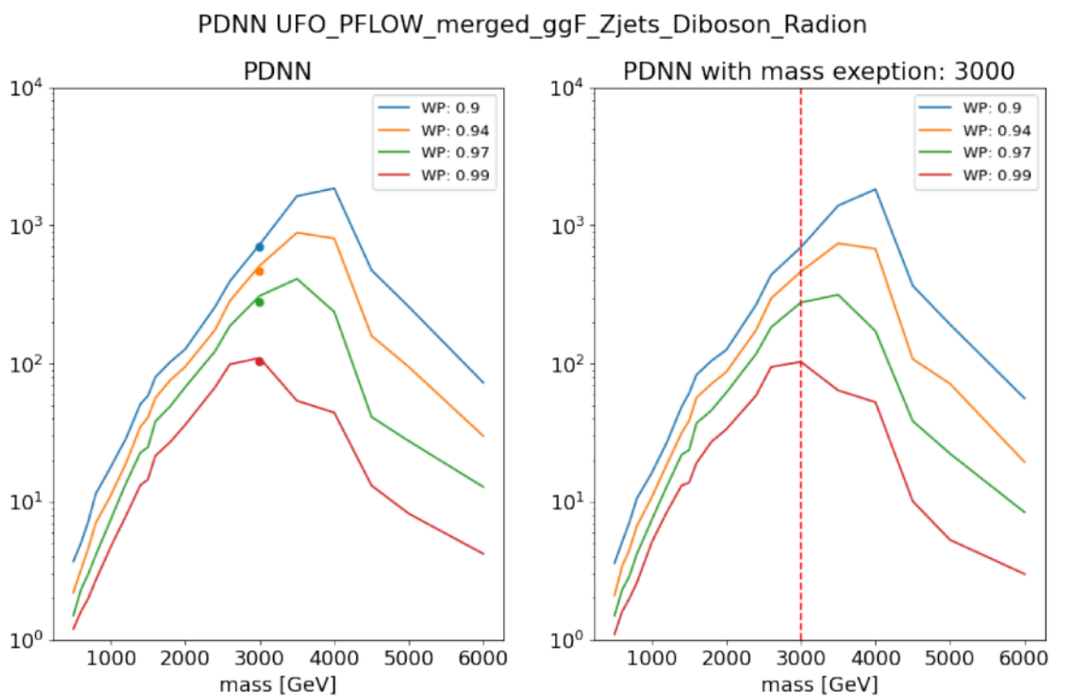


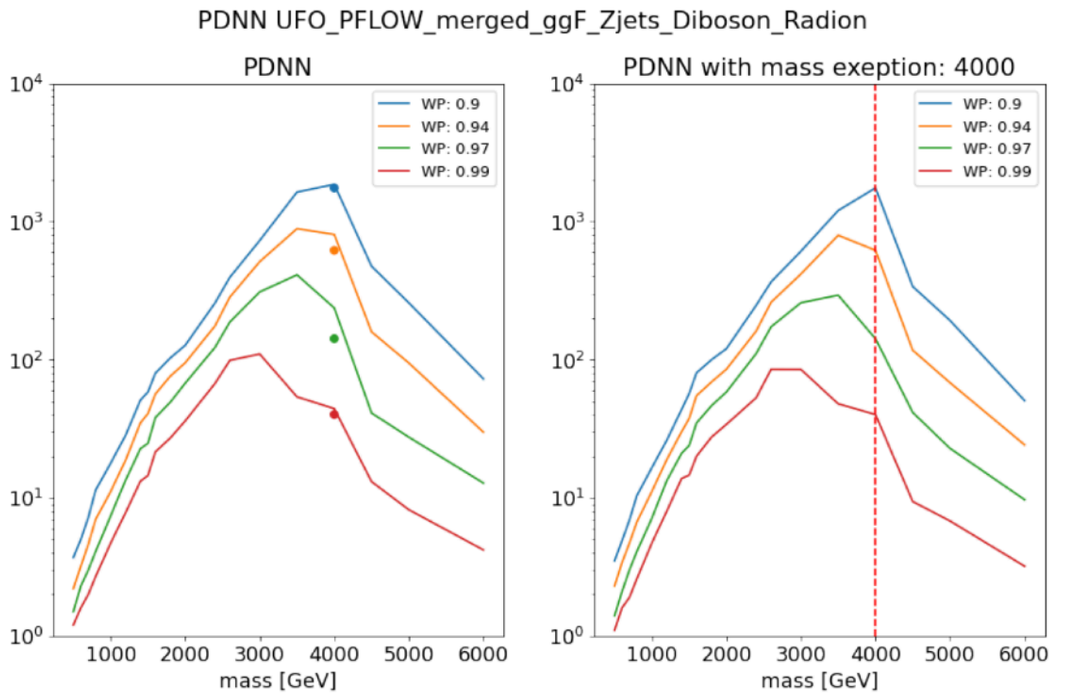
Hypo under test

Hypo under test

INTERPOLATION CAPABILITY







SOME STUDIES ON PDNN

- pDNN configuration: light version

- Comparing with pDNN documented in ATL-COM-PHYS-2018-1549 (internal note of Eur. Phys. J. C (2020) 80:1165)
  - Differences

	Our NN	paper
Layers	2	4
Nodes	32	128
Optimizer	RMSprop	Adam
Learning rate	0.001	0.0003
Patience	10	5
Epochs	150	200

SOME STUDIES ON pDNN

- Light vs ATL-COM-PHYS-2018-1549
  - CxAOD tag: 33-08, UFO-pFlow, BTagging201903

	Our NN	paper
Layers	2	4
Nodes	32	128
Optimizer	RMSprop	Adam
Learning rate	0.001	0.0003
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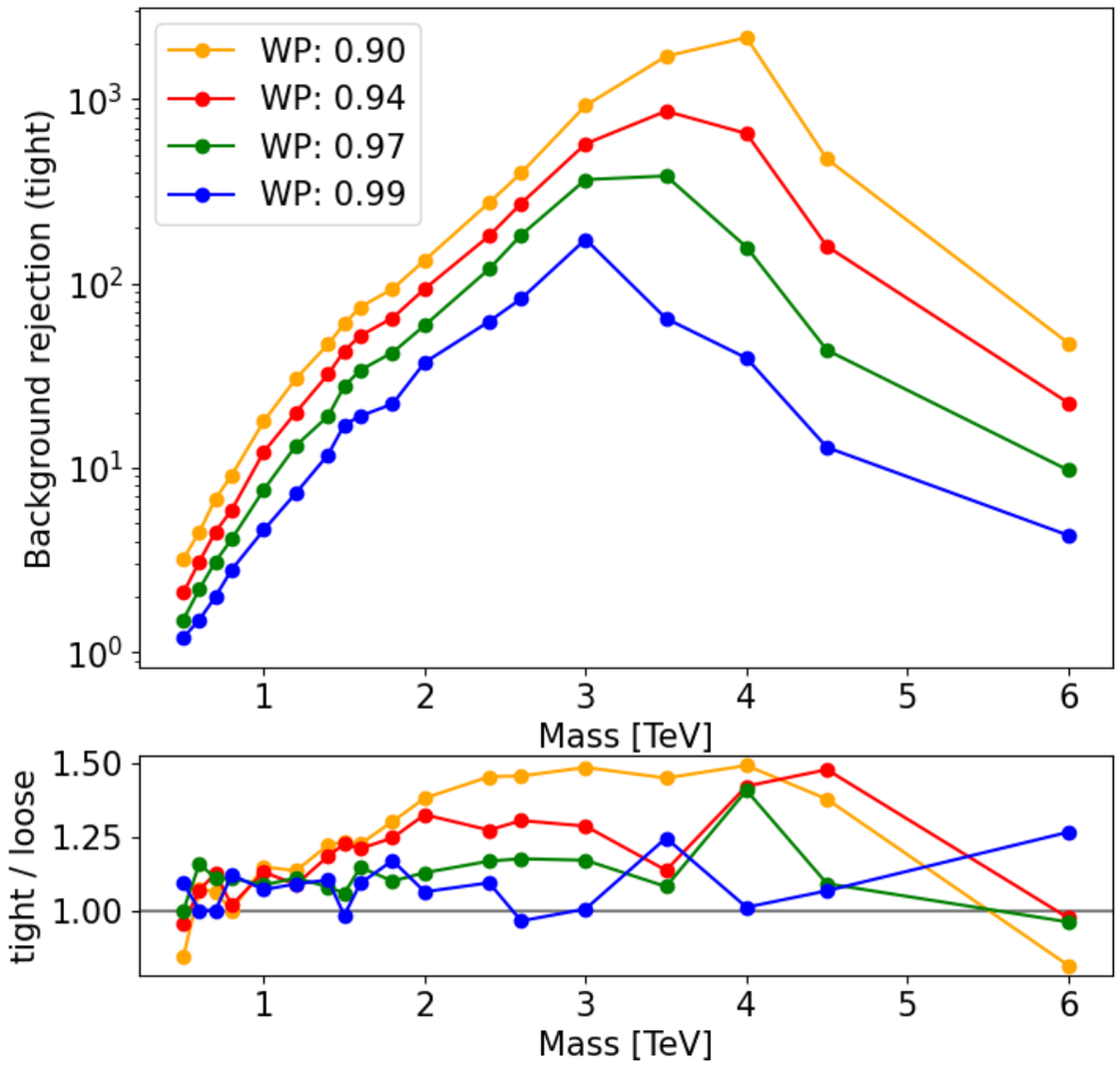
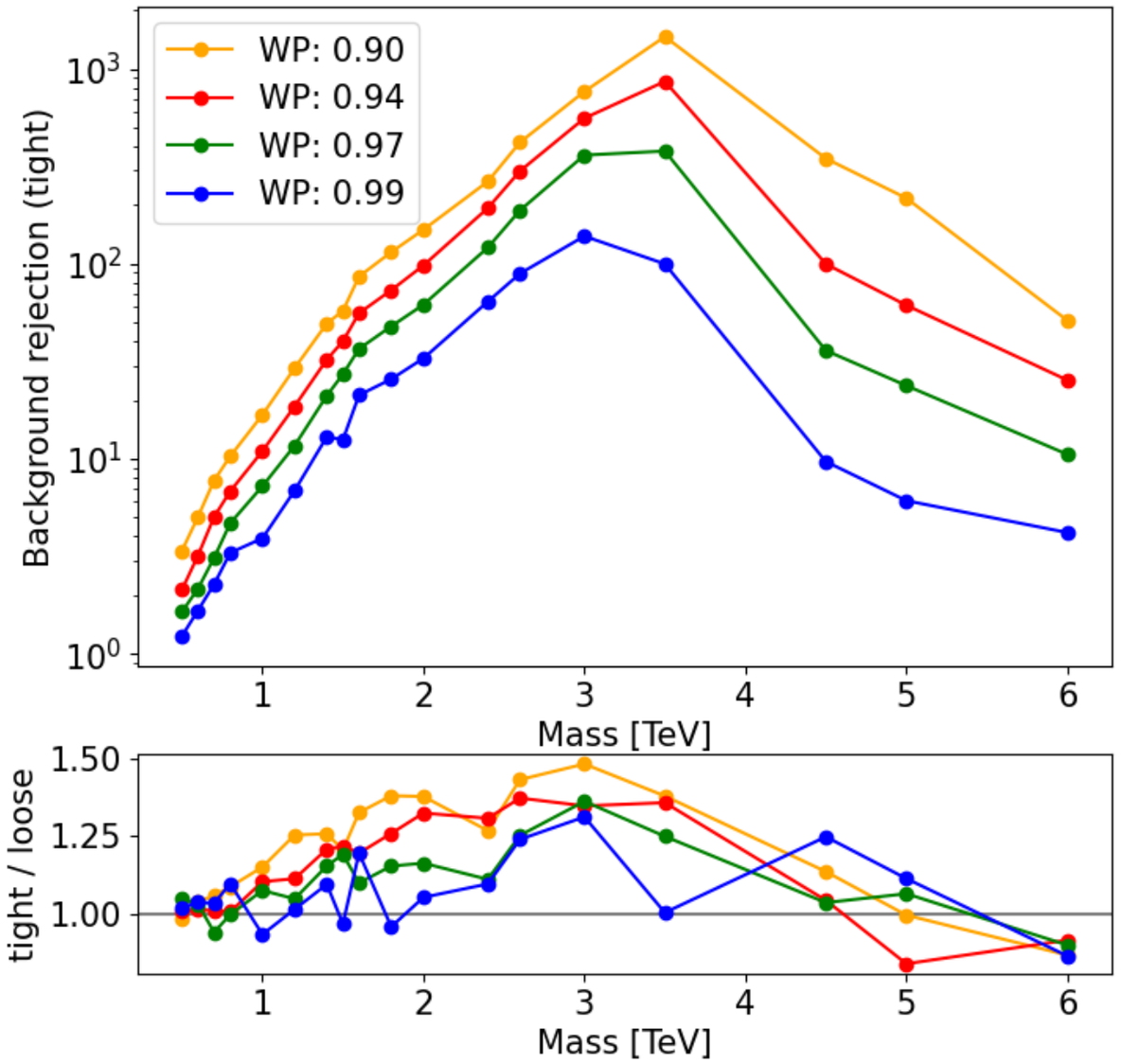


SOME STUDIES ON PDNN

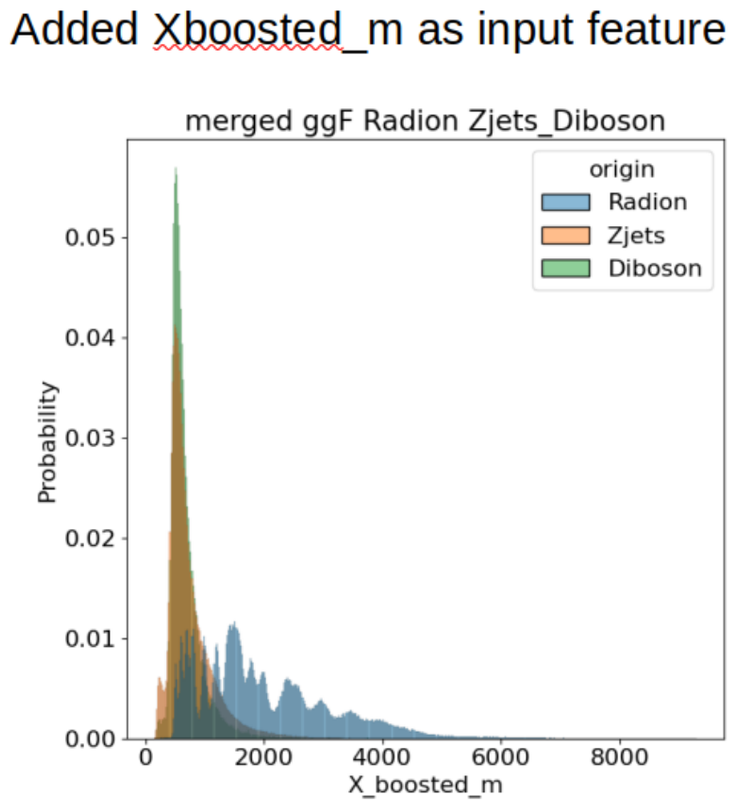
- Light vs ATL-COM-PHYS-2018-1549
  - CxAOD tag: 33-22, UFO-pFlow, BTagging201903

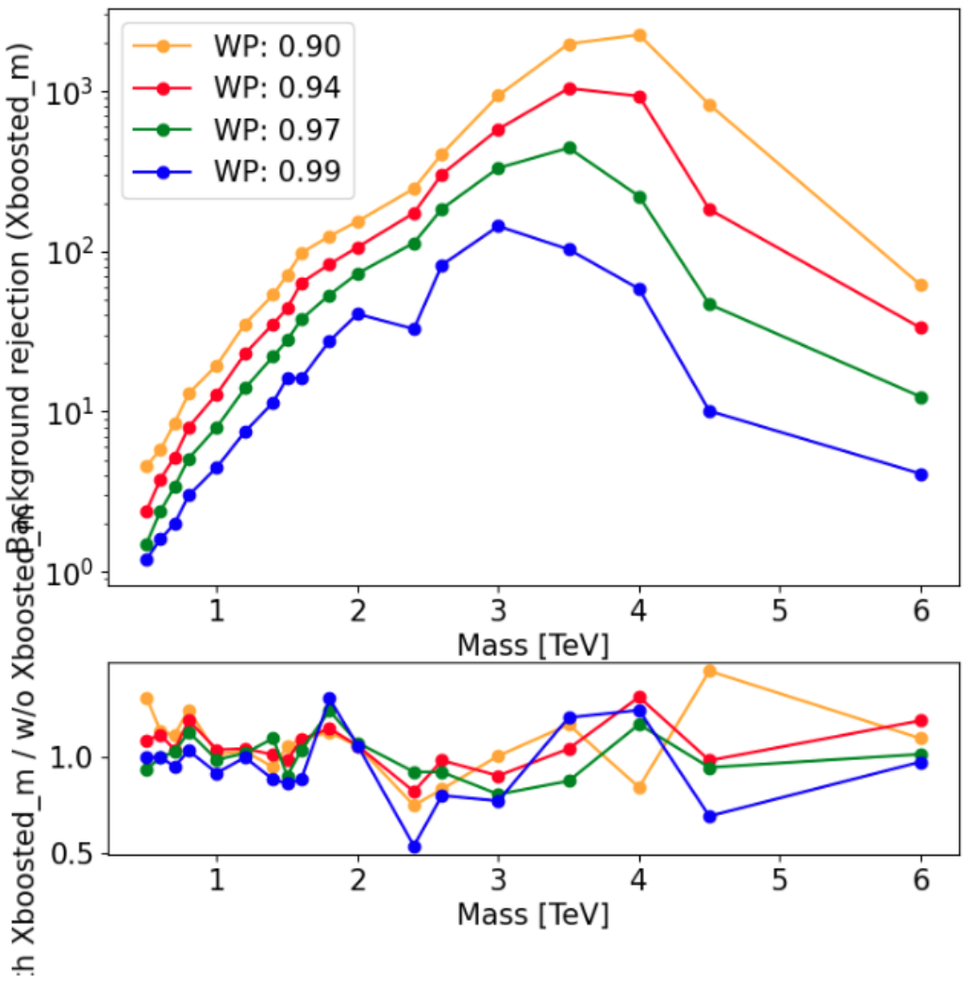
	Our NN	paper
Layers	2	4
Nodes	32	128
Optimizer	RMSprop	Adam
Learning rate	0.001	0.0003
Patience	10	5
Epochs	150	200



SOME STUDIES ON PDNN

- pDNN configuration: ATL-COM-PHYS-2018-1549
- Adding M_{llJ} as input variable





No apparent gain => input variables contain the information in M_{llJ}

SOME STUDIES ON PDNN

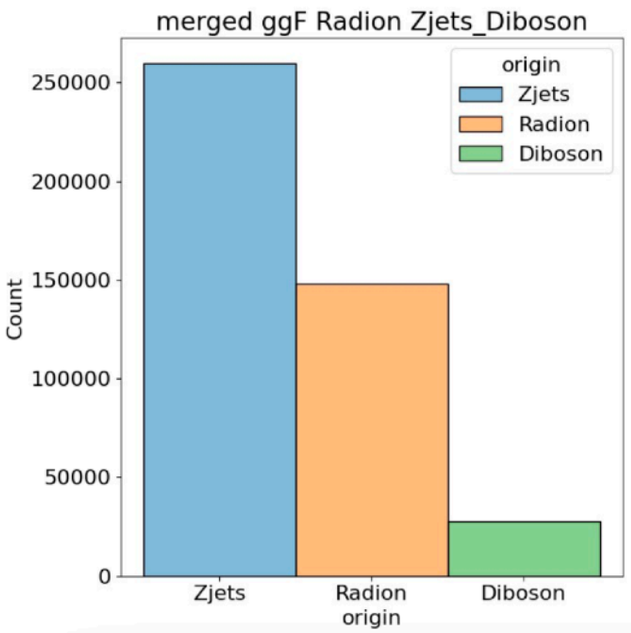
- pDNN configuration: ATL-COM-PHYS-2018-1549:

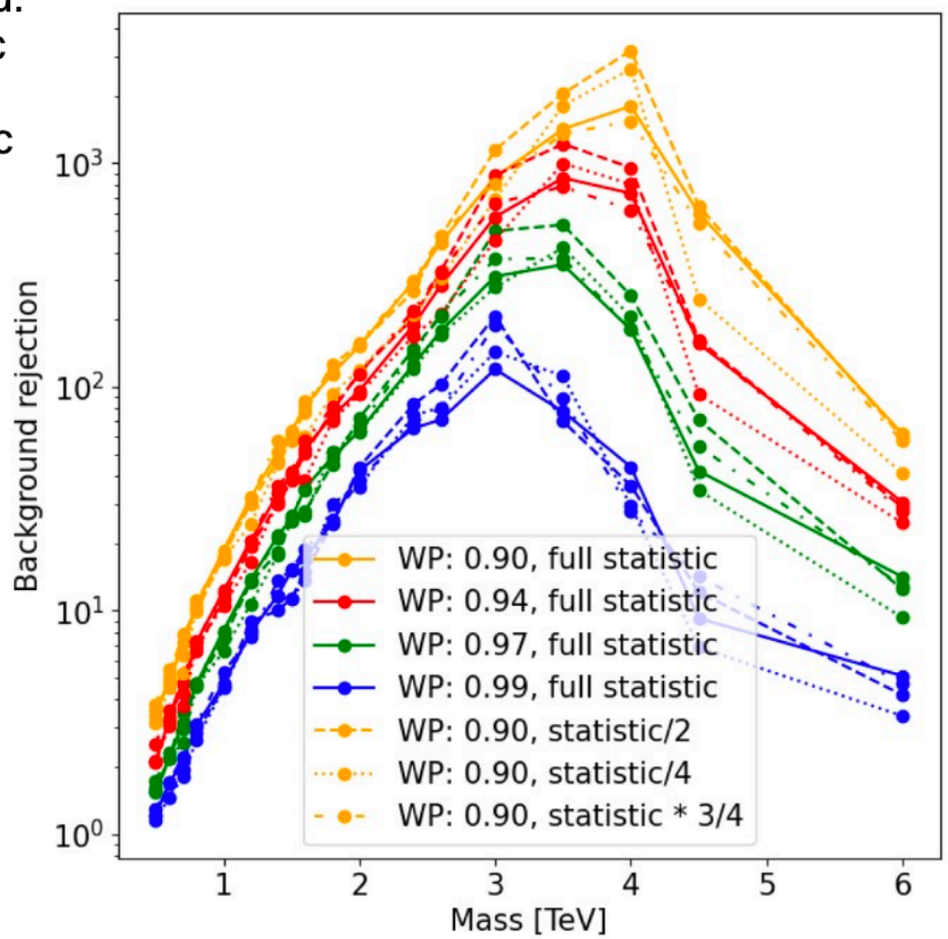
- Stability of the pDNN performance with statistics Full, 3/4, 1/2, 1/4

Cases studied:
- Full statistic
- ¾ statistic
- Half statistic
- ¼ statistic

Checking the origin histogram

Relative sample size with 1/2 stat





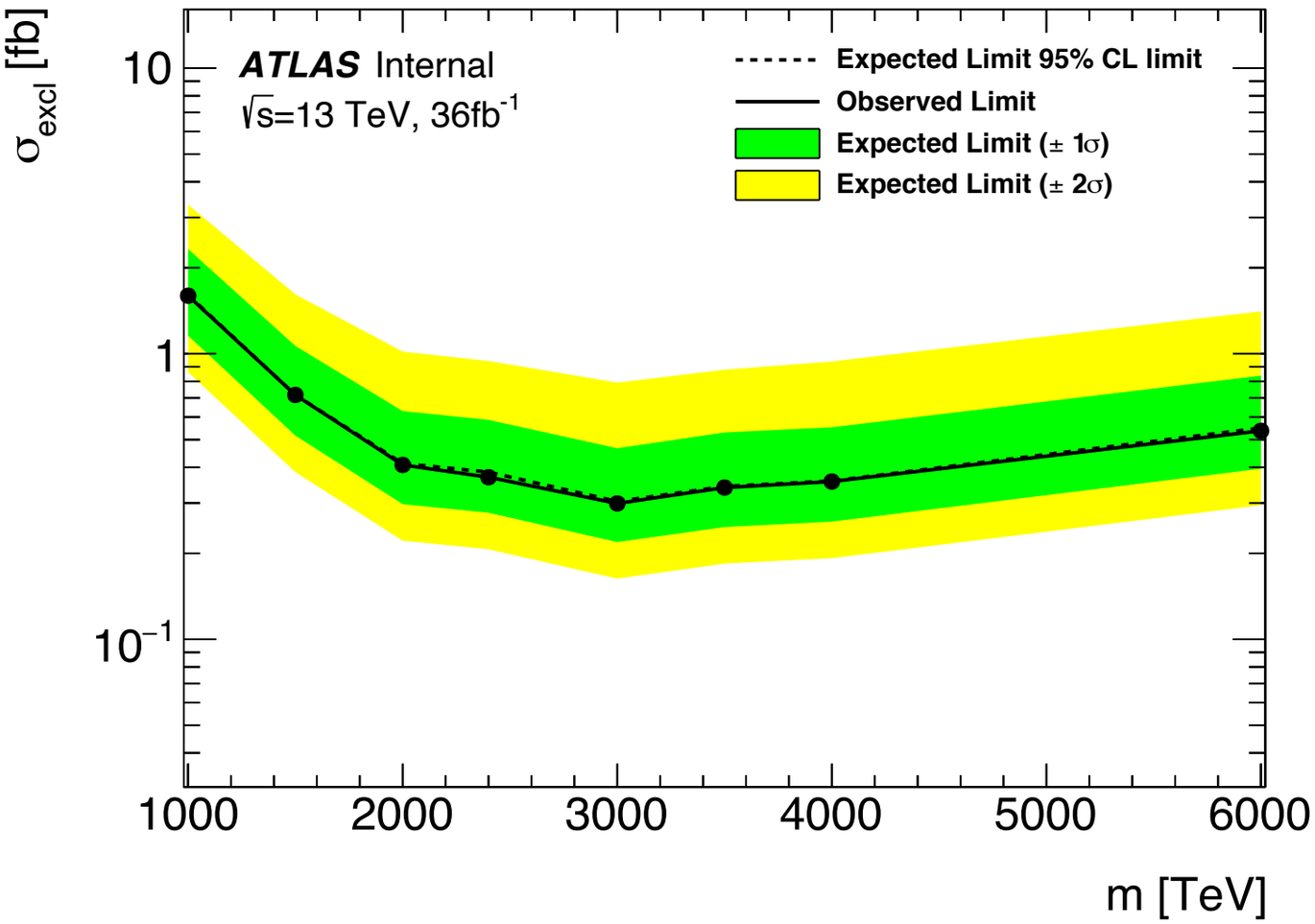
First comparison of limits from RF

- MC16a MC samples, CxAOD tag: 33-08, UFO-pFlow
- pDNN: **light version**
- Data = fake, no systematic variations

- Radion, ggF/DY, merged regime
  - 4 Signal Regions: MergedLP_Untag/Tag, MergedHP_Untag/Tag

First comparison of limits from RF

M_{lll}

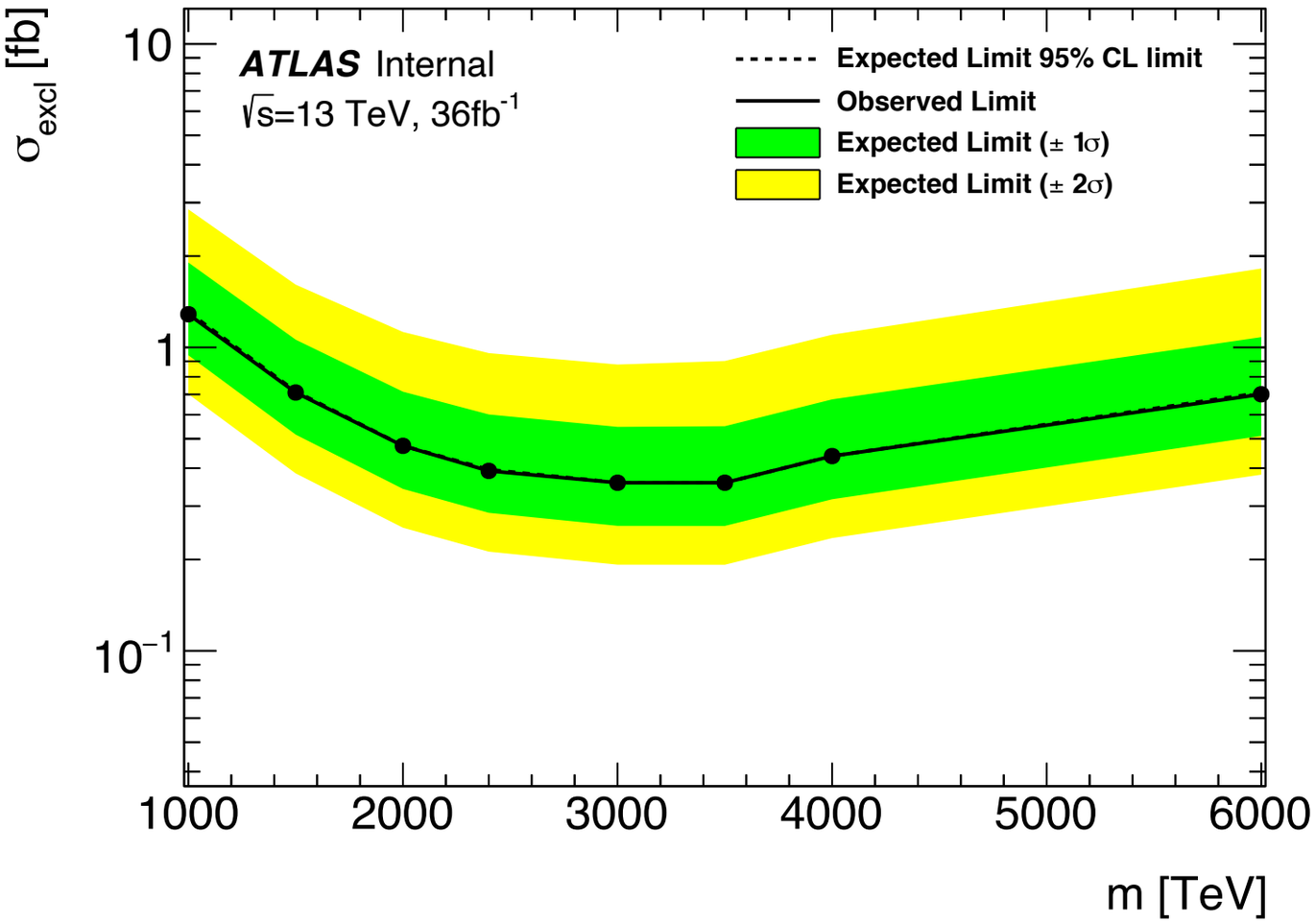


Cross Section Limit

mass=1000.000000, obs[fb]=1.595659, exp[fb]=1.605636
mass=1500.000000, obs[fb]=0.716886, exp[fb]=0.716932
mass=2000.000000, obs[fb]=0.407849, exp[fb]=0.412634
mass=2400.000000, obs[fb]=0.369438, exp[fb]=0.384979
mass=3000.000000, obs[fb]=0.299021, exp[fb]=0.303847
mass=3500.000000, obs[fb]=0.339803, exp[fb]=0.343007
mass=4000.000000, obs[fb]=0.356745, exp[fb]=0.358377
mass=6000.000000, obs[fb]=0.537053, exp[fb]=0.549133

First comparison of limits from RF

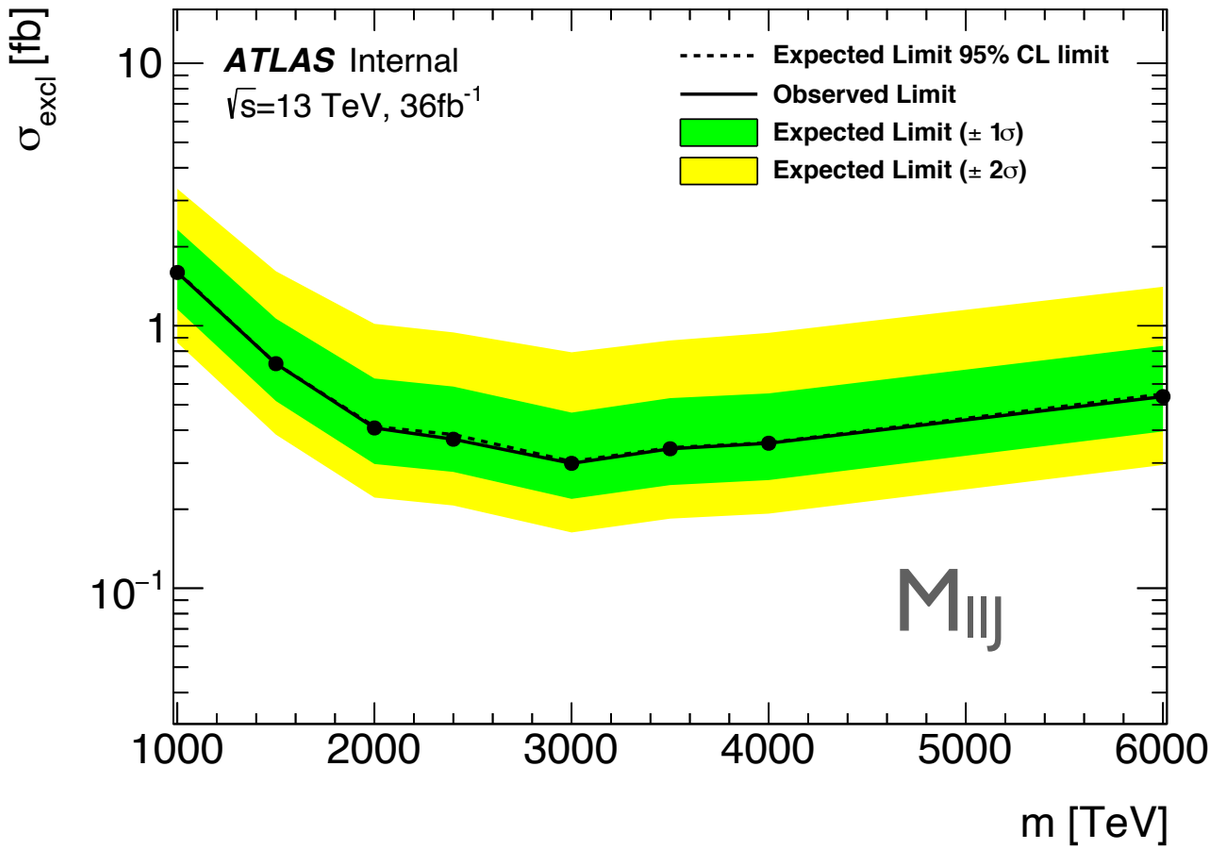
pDNN score
200 bin



Cross Section Limit

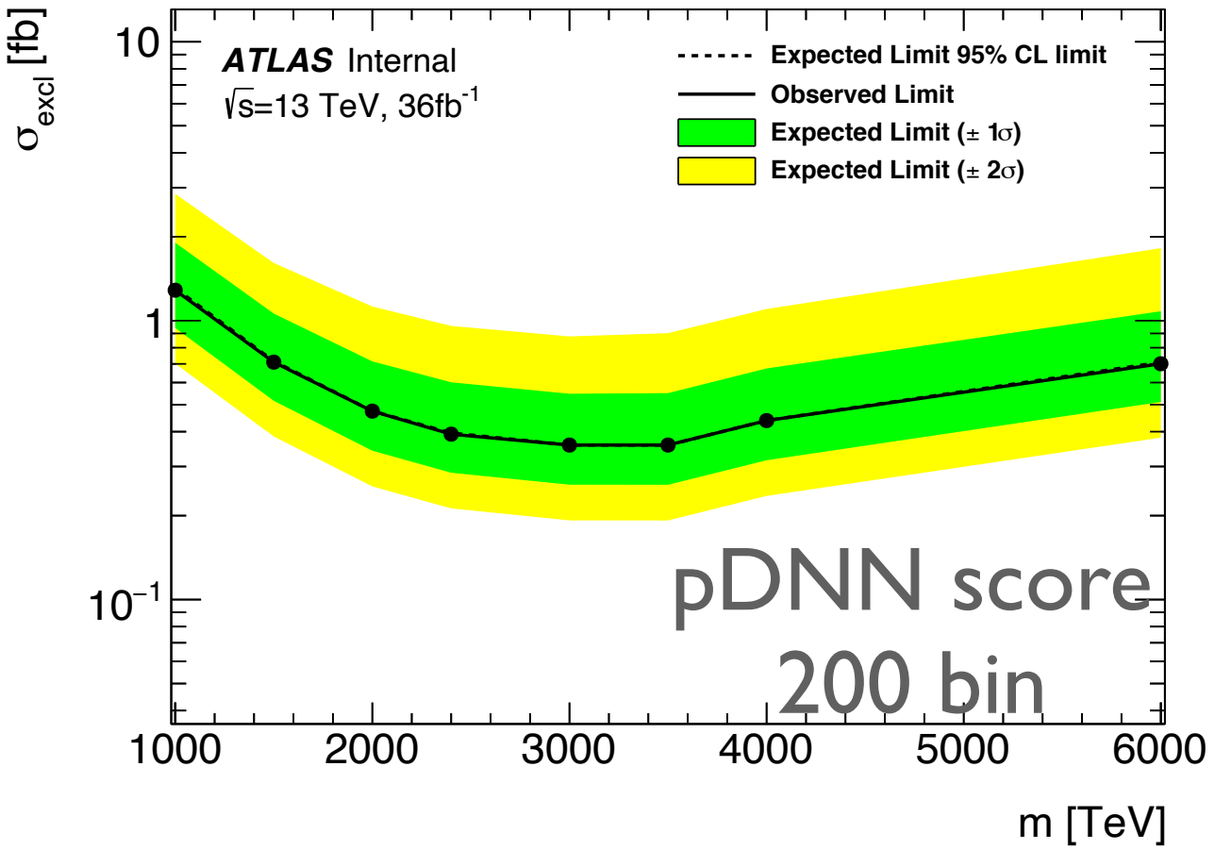
mass=1000.000000, obs[fb]=1.285975, exp[fb]=1.307315
mass=1500.000000, obs[fb]=0.710017, exp[fb]=0.716263
mass=2000.000000, obs[fb]=0.473827, exp[fb]=0.474285
mass=2400.000000, obs[fb]=0.391747, exp[fb]=0.395557
mass=3000.000000, obs[fb]=0.358052, exp[fb]=0.358318
mass=3500.000000, obs[fb]=0.358118, exp[fb]=0.358055
mass=4000.000000, obs[fb]=0.438339, exp[fb]=0.438441
mass=6000.000000, obs[fb]=0.700799, exp[fb]=0.709310

First comparison of limits from RF



Cross Section Limit

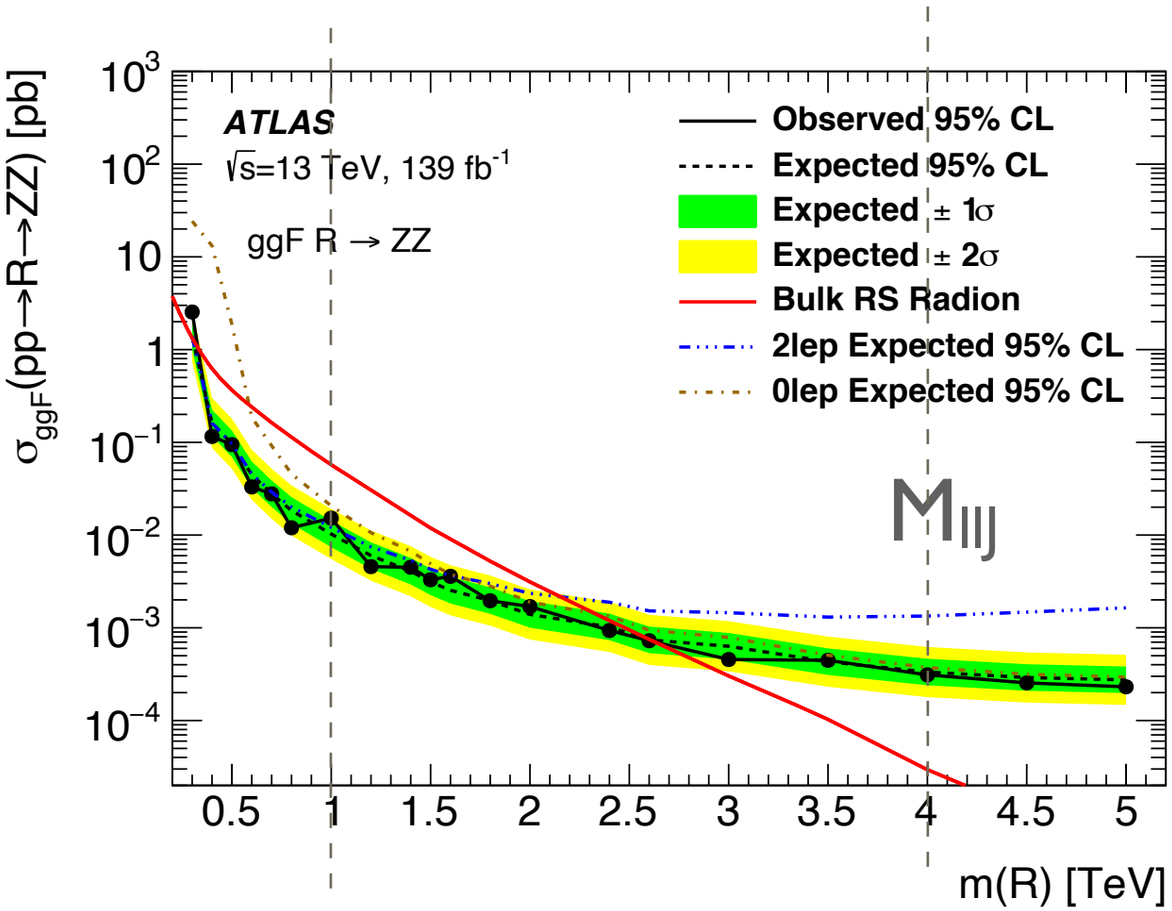
mass=1000.000000, exp[fb]=1.605636
mass=1500.000000, exp[fb]=0.716932
mass=2000.000000, exp[fb]=0.412634
mass=2400.000000, exp[fb]=0.384979
mass=3000.000000, exp[fb]=0.303847
mass=3500.000000, exp[fb]=0.343007
mass=4000.000000, exp[fb]=0.358377
mass=6000.000000, exp[fb]=0.549133



Cross Section Limit

mass=1000.000000, exp[fb]=1.307315
mass=1500.000000, exp[fb]=0.716263
mass=2000.000000, exp[fb]=0.474285
mass=2400.000000, exp[fb]=0.395557
mass=3000.000000, exp[fb]=0.358318
mass=3500.000000, exp[fb]=0.358055
mass=4000.000000, exp[fb]=0.438441
mass=6000.000000, exp[fb]=0.709310

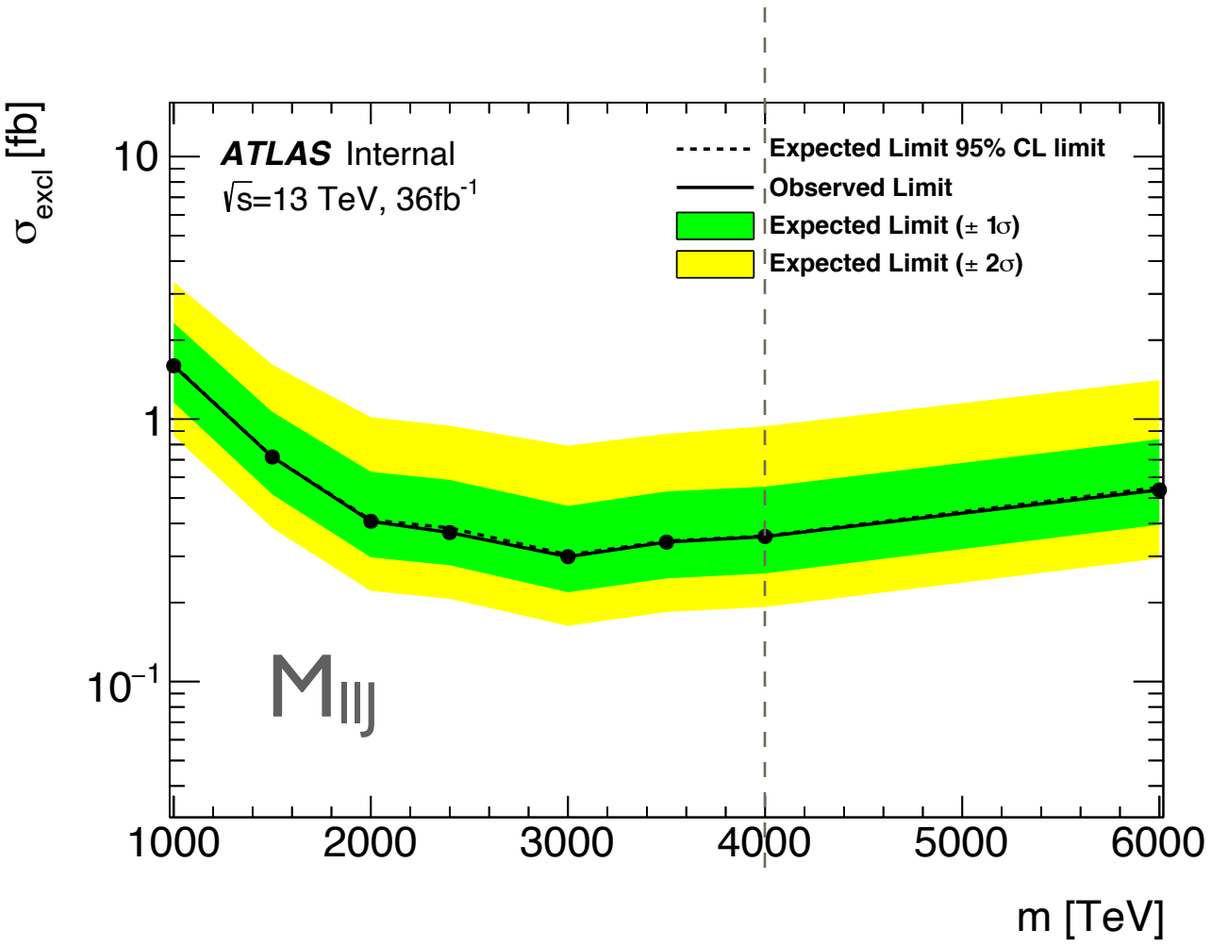
COMPARISON WITH PUBLISHED PAPER



139 ifb

https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/HDBS-2018-10/figaux_07a.pdf

~10 fb @ 1TeV
~1 fb @ 4TeV



36 ifb
No systematic errors

~2 fb @ 1TeV
~0.4 fb @ 4TeV

NEXT STEPS

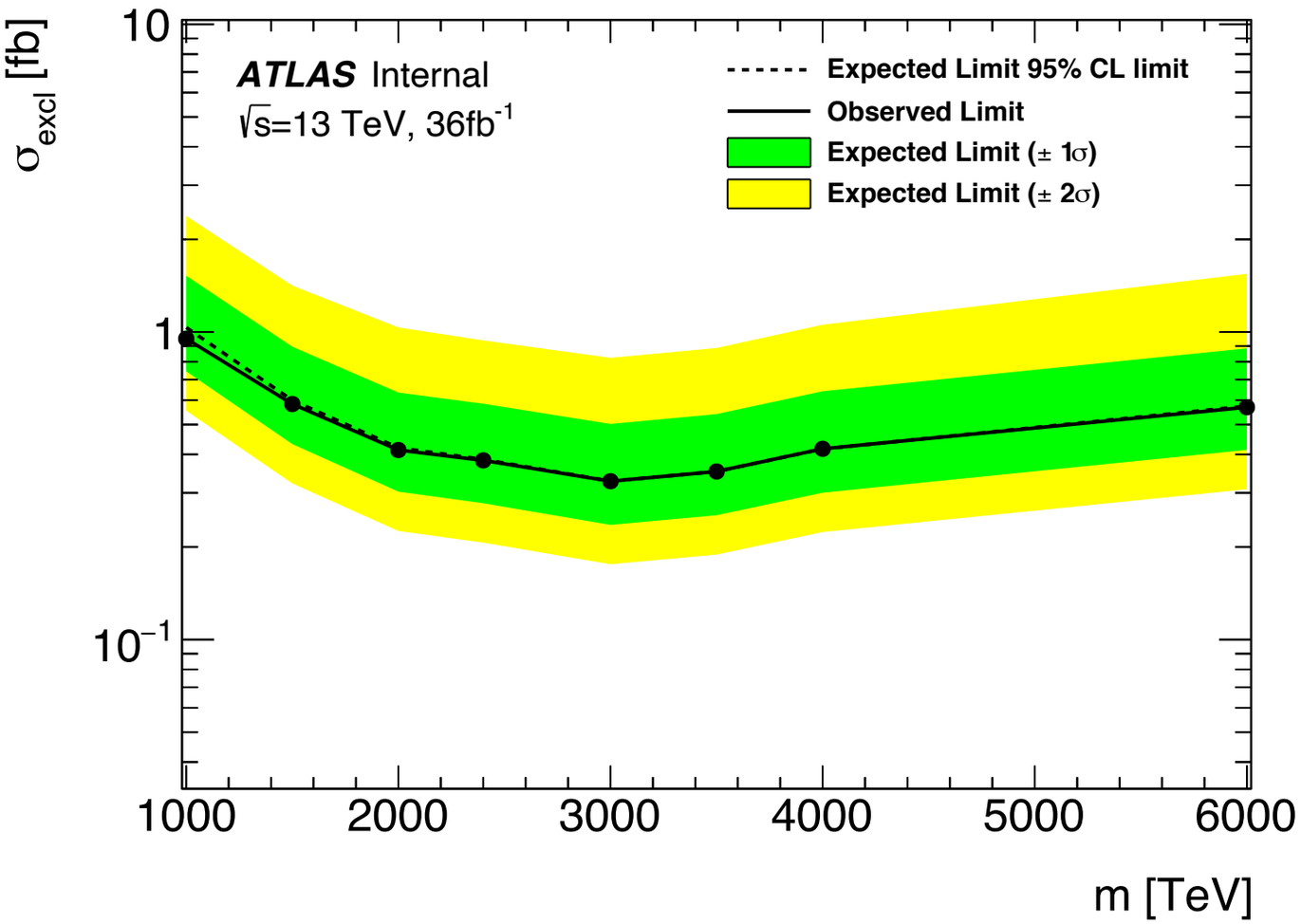
- Ready to move to r33-22

- Moving to pDNN optimisation
  - Trying to follow ATL-COM-PHYS-2020-766, HH -> bbττ
    - TO DO:
      - Training set preparation:
        - Equalize (by reweighting) the stat. of signal samples;
        - Equalize (by reweighting) the stat. of total signal sample to total background
        - Consider all physics backgrounds processes (with their MC weights)
        - Scale input variables (median to zero, interquartile range to 1) taking into account the training weights
      - Technical optimisations:
        - Hyperparameter optimization on random realizations
        - k-fold cross validation splitting events in even/odd → remove high variance realizations
      - Reconsider input variables

Backup

FIRST COMPARISON OF LIMITS FROM RF

pDNN score
1000 bins



Cross Section Limit

mass=1000.000000, obs[fb]=0.950482, exp[fb]=1.033647
mass=1500.000000, obs[fb]=0.583156, exp[fb]=0.599691
mass=2000.000000, obs[fb]=0.413288, exp[fb]=0.420130
mass=2400.000000, obs[fb]=0.382443, exp[fb]=0.385068
mass=3000.000000, obs[fb]=0.327206, exp[fb]=0.327483
mass=3500.000000, obs[fb]=0.351858, exp[fb]=0.352043
mass=4000.000000, obs[fb]=0.417012, exp[fb]=0.416731
mass=6000.000000, obs[fb]=0.569377, exp[fb]=0.574183

RS_ZZ_GGF_MERGED

Atlas link with auxiliary plots HDBS-2018-10

Eur. Phys. J. C (2020) 80:1165

Channel	$V \to qq$ recon.	Signal regions	Background estimates												Data
			W+jets		Z+jets		$t\bar{t}$		Diboson		Single-t		Multijet	Total	
2-lepton (ZZ)		HP Tag	0.0135 ±	0.0043	85 ±	6	0.283 ±	0.035	21.1 ±	2.3	0.34 ±	0.05	-	107 ± 7	94
10149 MC	Merged	HP Untag	0.772 ±	0.010	3300 ±	40	4.27 ±	0.08	361 ±	32	0.58 ±	0.11	-	3670 ± 50	3671
		LP Tag	0.0135 ±	0.0043	138 ±	8	0.313 ±	0.034	12.8 ±	1.4	0.30 ±	0.04	-	152 ± 8	141
		LP Untag	2.341 ±	0.017	5920 ±	50	10.16 ±	0.16	278 ±	26	2.03 ±	0.29	-	6220 ± 60	6095
	Resolved	Tag	-		1323 ±	26	110 ±	10	159 ±	12	4.7 ±	0.8	-	1600 ± 30	1583
		Untag	4.681 ±	0.026	42 750 ±	160	110.6 ±	1.5	1800 ±	100	13.4 ±	2.0	-	44 650 ± 190	44 604

Total 14+26+769+2716 = 3524 = 1.34 * expected according to Eur. Phys. J. C (2020) 80:1165

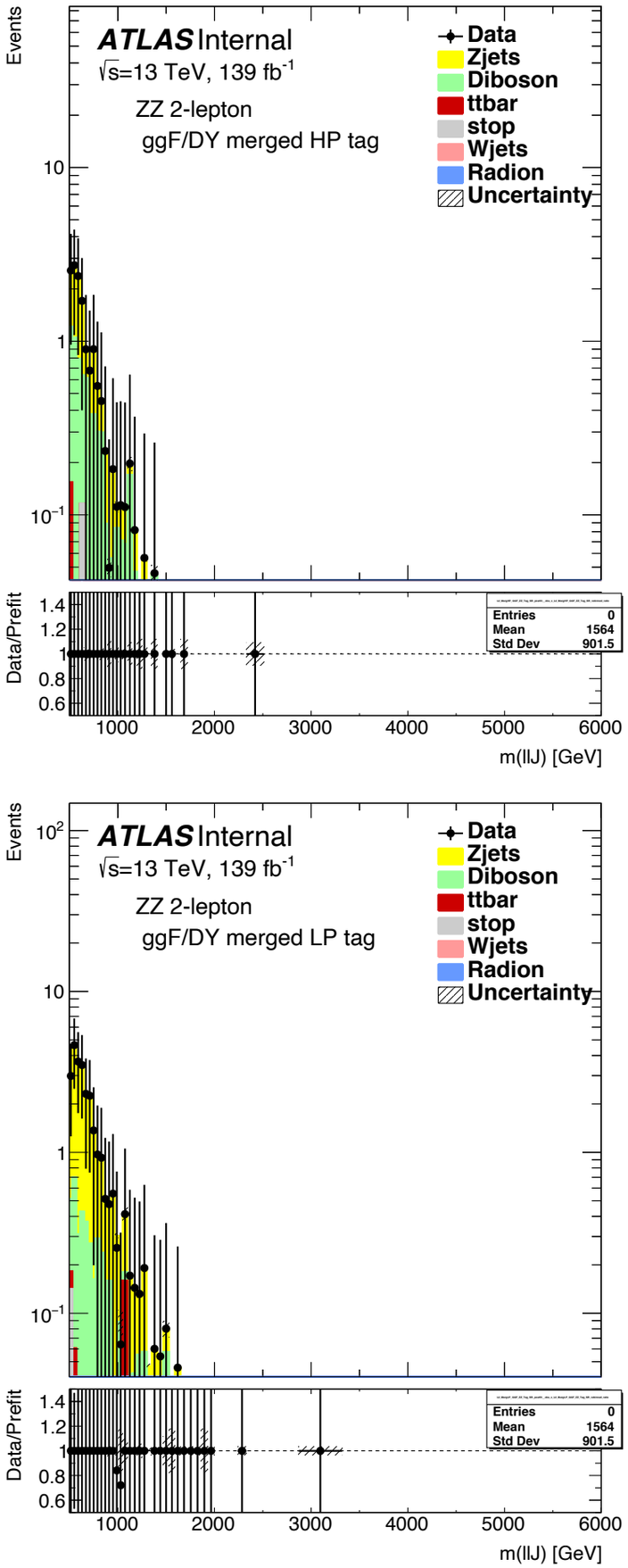
Region: ***L2_MergHP_GGF_ZZ_Tag_SR***
Diboson Integral=5.941466 +/- 0.370521
Radion Integral=0.000000 +/- 0.000000
Wjets Integral=0.000040 +/- 0.000008
Zjets Integral=7.874548 +/- 1.580589
stop Integral=0.116039 +/- 0.023291
ttbar Integral=0.187731 +/- 0.037682
SumMC Integral=14.119825
Postfit Integral=14.119824 + 0.319207 - 0.319214
Data Integral=14.119779
Prefit integral=14.119824 0.51

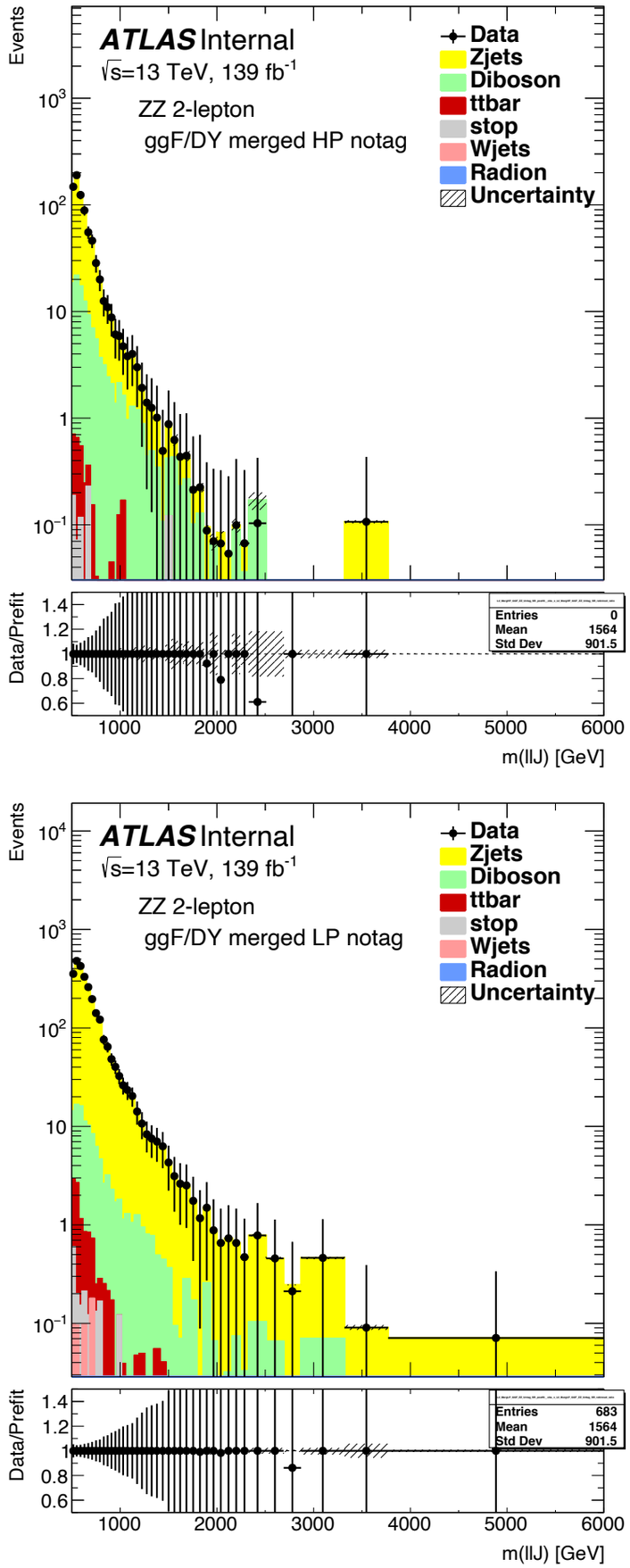
Region: ***L2_MergLP_GGF_ZZ_Tag_SR***
Diboson Integral=3.666073 +/- 0.228623 0.91
Radion Integral=0.000000 +/- 0.000000
Wjets Integral=0.000040 +/- 0.000008
Zjets Integral=21.808302 +/- 4.377388 0.62
stop Integral=0.141827 +/- 0.028468
ttbar Integral=0.368419 +/- 0.073949
SumMC Integral=25.984659
Postfit Integral=25.984661 + 0.359983 - 0.359983
Data Integral=25.864803
Prefit integral=25.984661 0.63

Region: ***L2_MergHP_GGF_ZZ_Untag_SR***
Diboson Integral=112.358536 +/- 7.006886
Radion Integral=0.000000 +/- 0.000000
Wjets Integral=0.000040 +/- 0.000008
Zjets Integral=653.897095 +/- 131.251007
stop Integral=0.723407 +/- 0.145203
ttbar Integral=2.416062 +/- 0.484955
SumMC Integral=769.395142
Postfit Integral=769.395142 + 5.543274 - 5.543335
Data Integral=769.291199
Prefit integral=769.395142 0.81

Region: ***L2_MergLP_GGF_ZZ_Untag_SR***
Diboson Integral=98.287056 +/- 6.129363 1.4
Radion Integral=0.000000 +/- 0.000000
Wjets Integral=0.563510 +/- 0.113108
Zjets Integral=2606.893555 +/- 523.258789 1.7
stop Integral=1.392521 +/- 0.279508
ttbar Integral=8.703288 +/- 1.746934 3.3
SumMC Integral=2715.840088
Postfit Integral=2715.839844 + 3.307373 - 3.307617
Data Integral=2715.784424
Prefit integral=2715.839844 1.7

RS_ZZ_GGF_MERGED

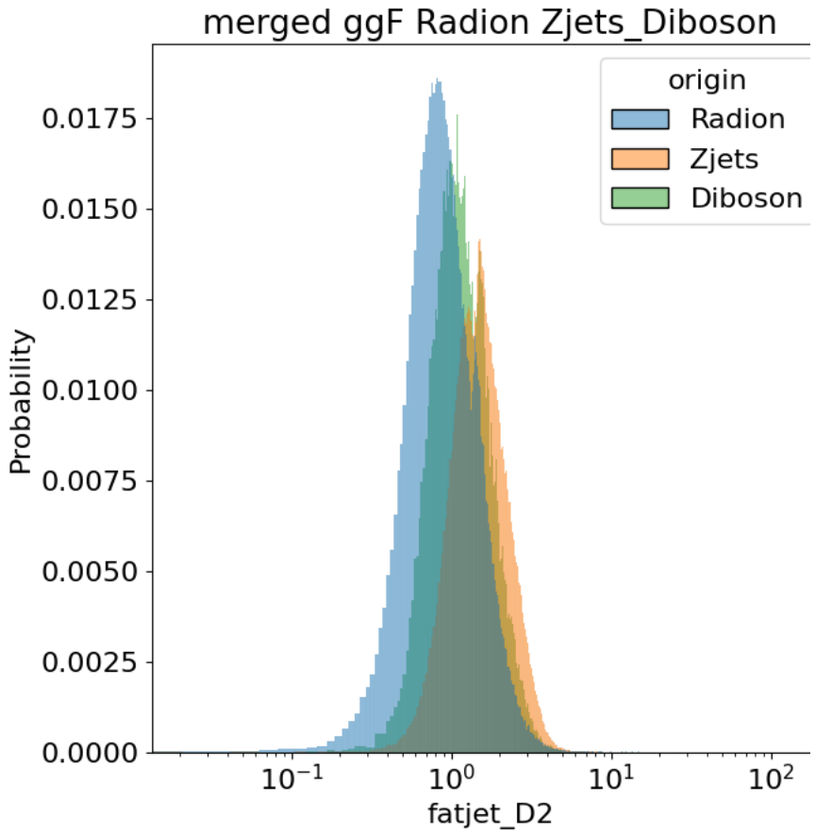


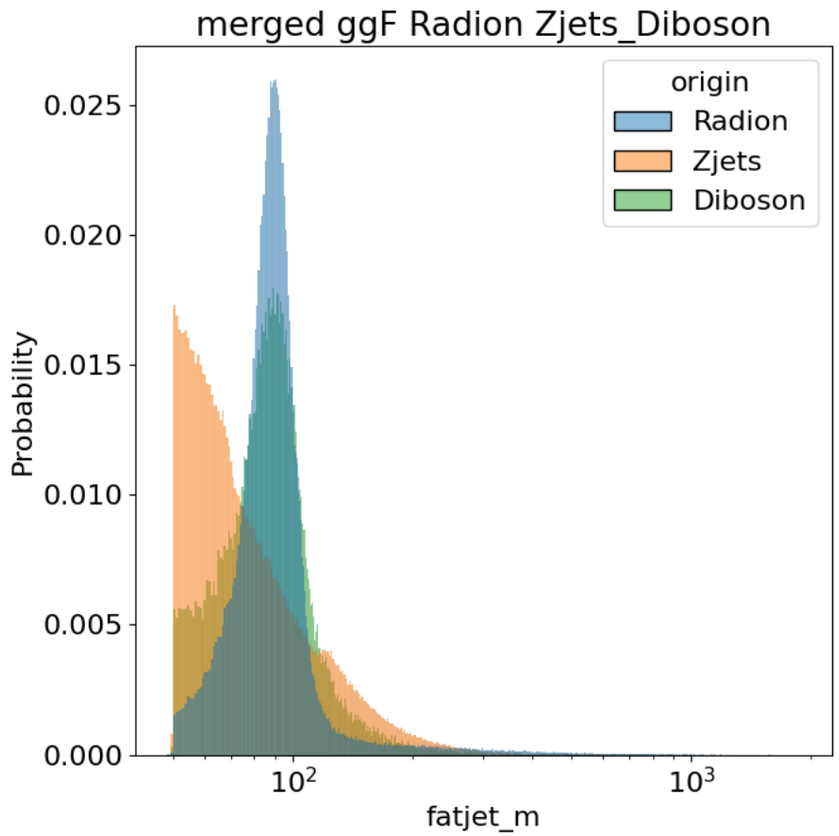


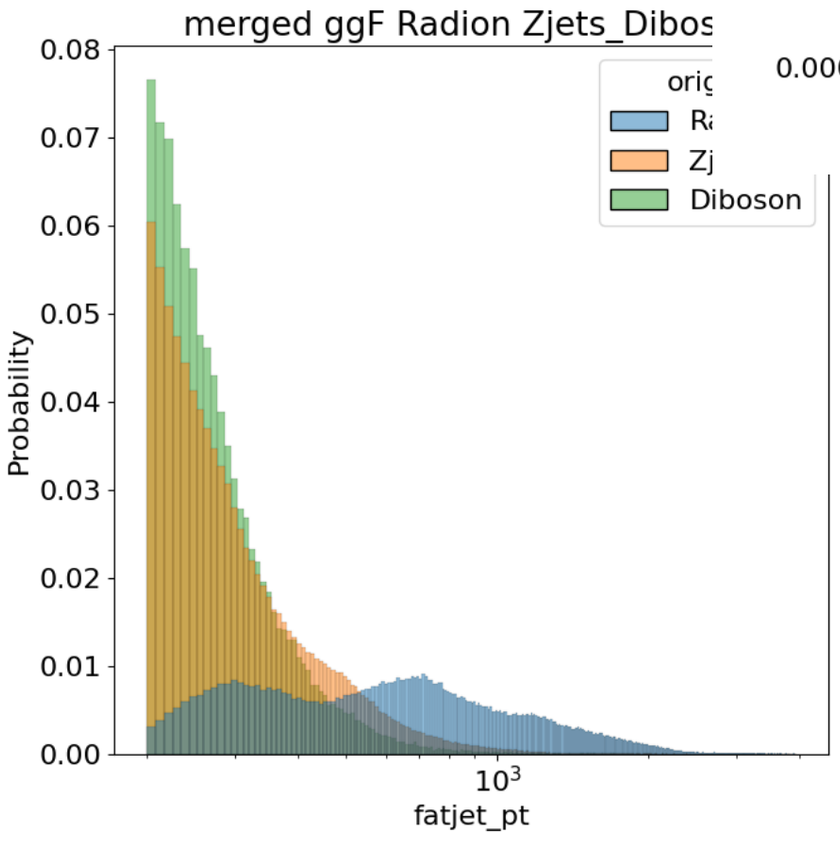
- python RS_ZZ_GGF_Merged_HP_Tag.py 2MergSR 1000 Radion
  - basedirectory="/nfs/kloe/einstein4/HDBS/PDNNTestAGS/ntuples" # as before but from Lecce
  - *"Radion_1000":451147 instead of 309993 (from original Rob macro)*
- *./runPreFit.py ../runSS/output/ZZSignalRegionsGGF/ws/ExampleVV_Radion_1000_test.root*

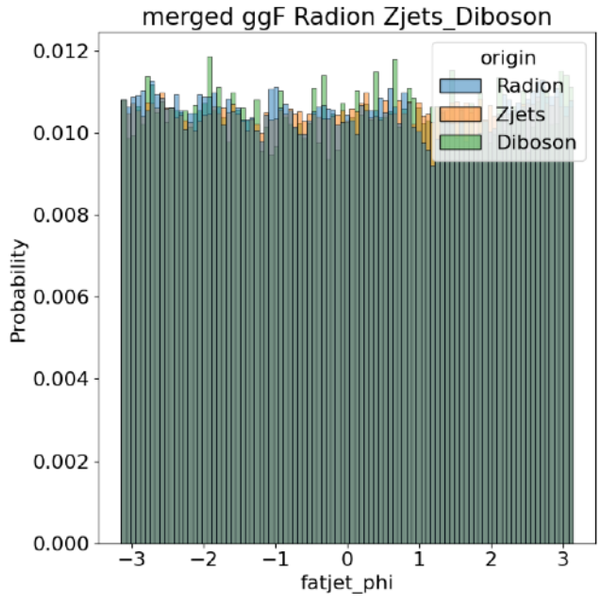
VARIABILI ATTUALMENTE UTILIZZATE

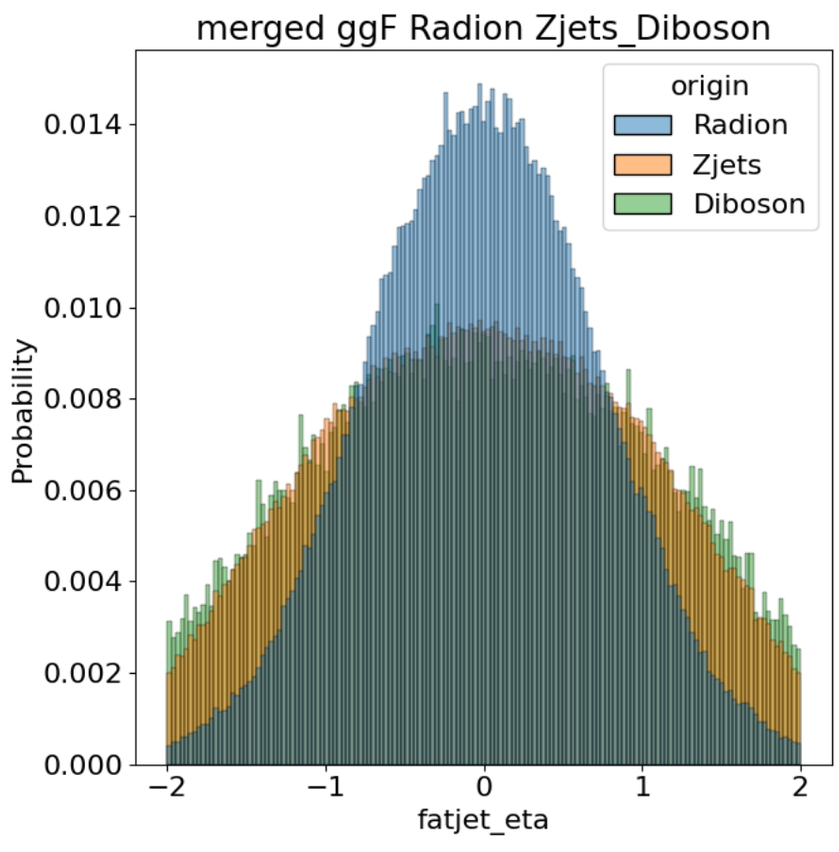
- Fatjet: m, d2, pt, eta, phi





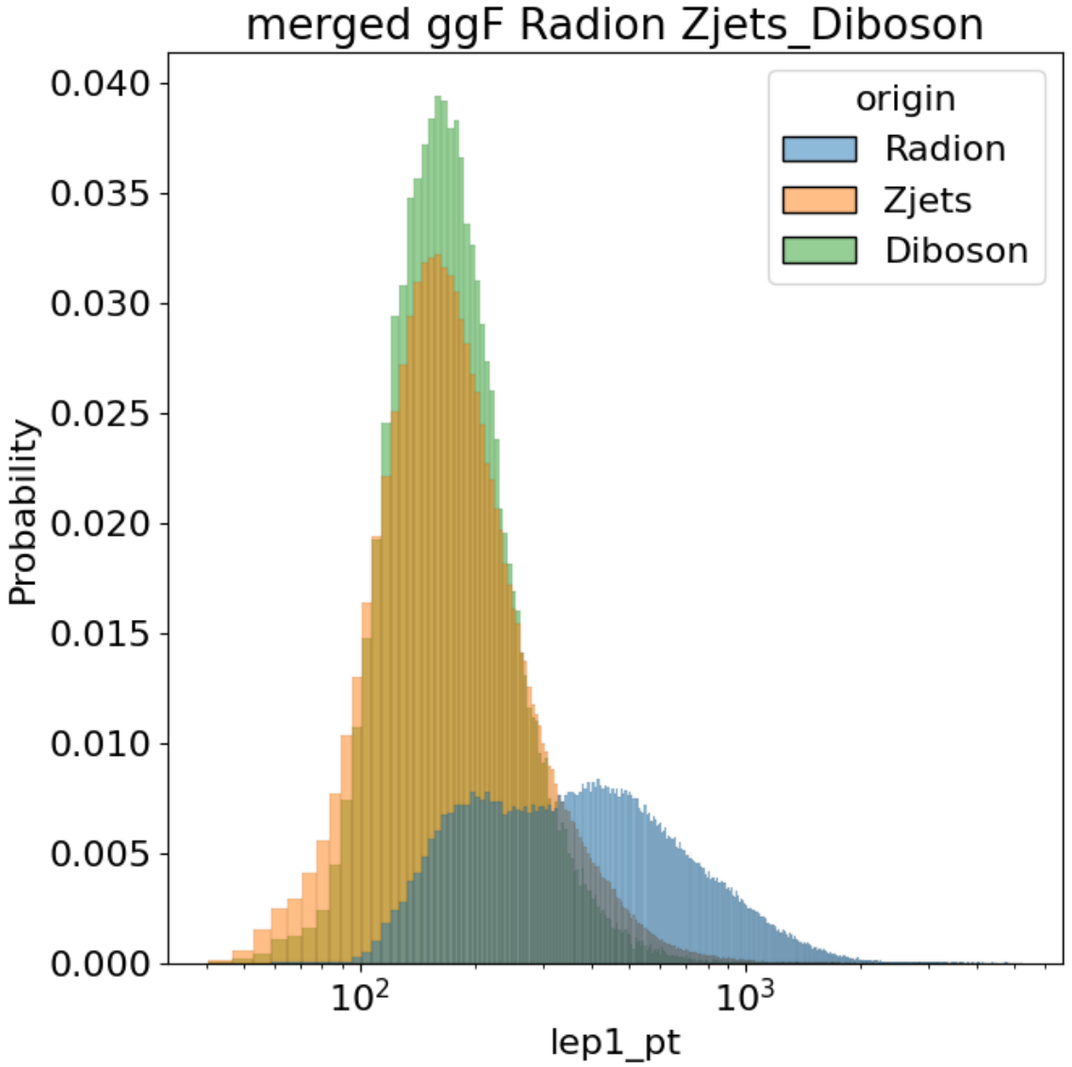


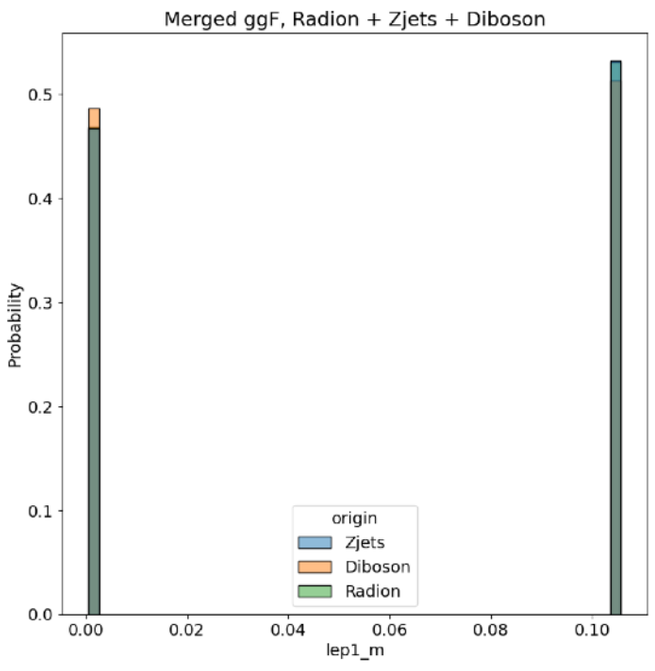


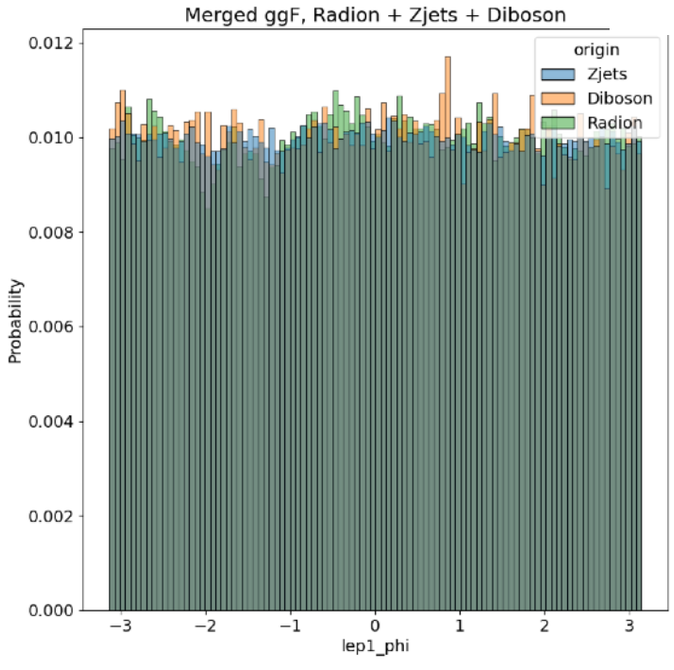


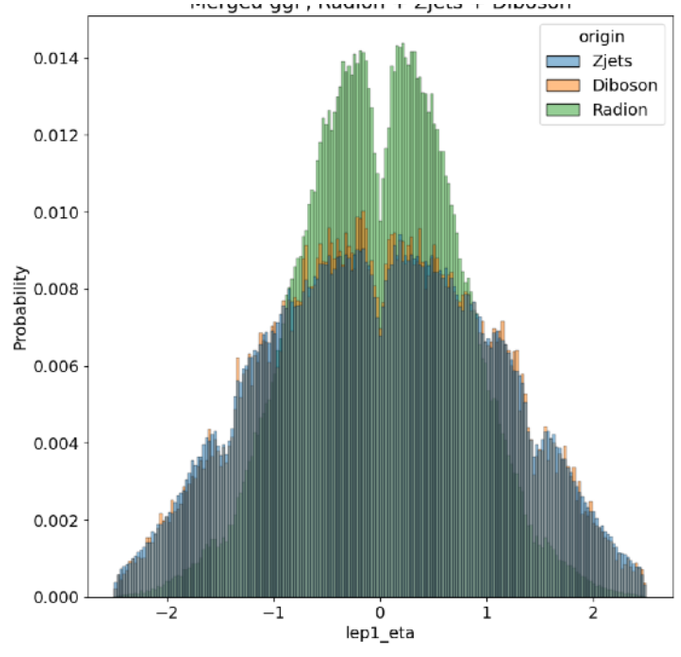
VARIABILI ATTUALMENTE UTILIZZATE

- Lepton 1: m, pt, eta, phi



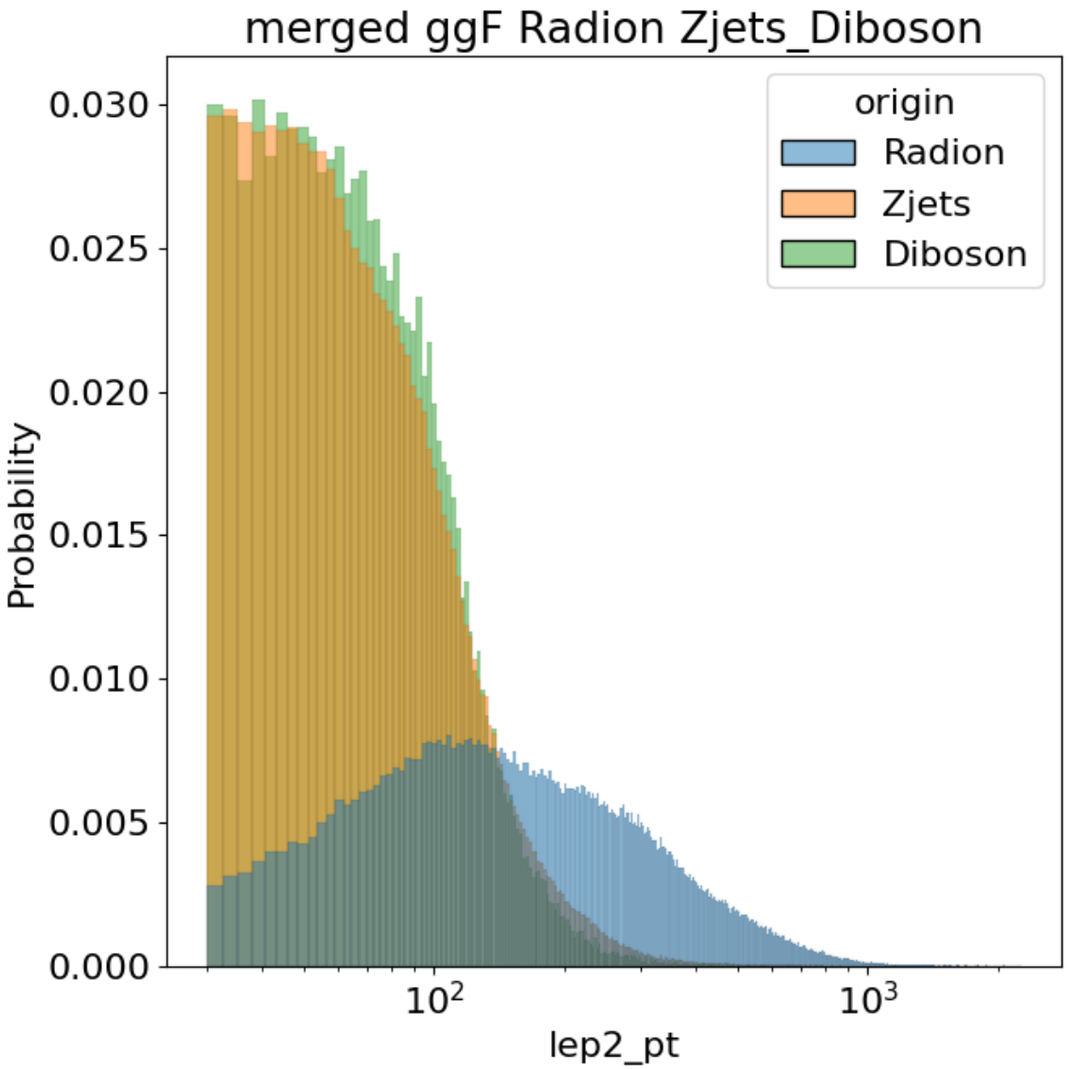


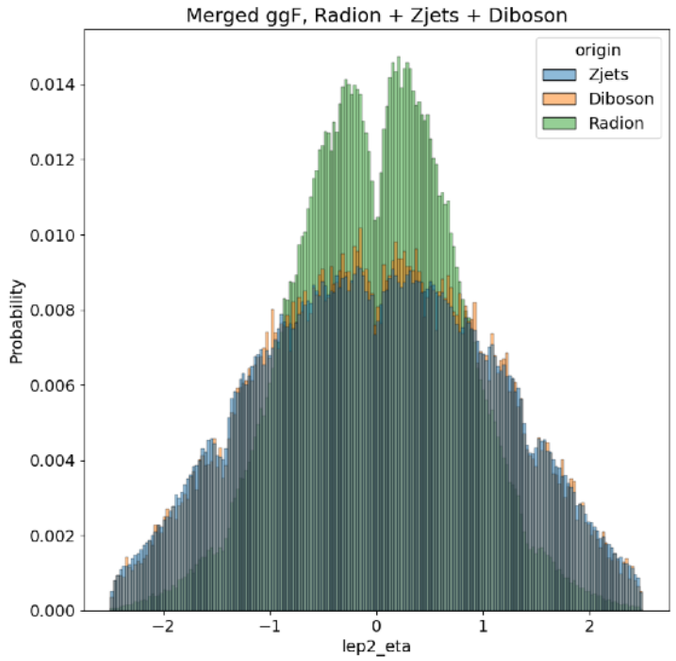


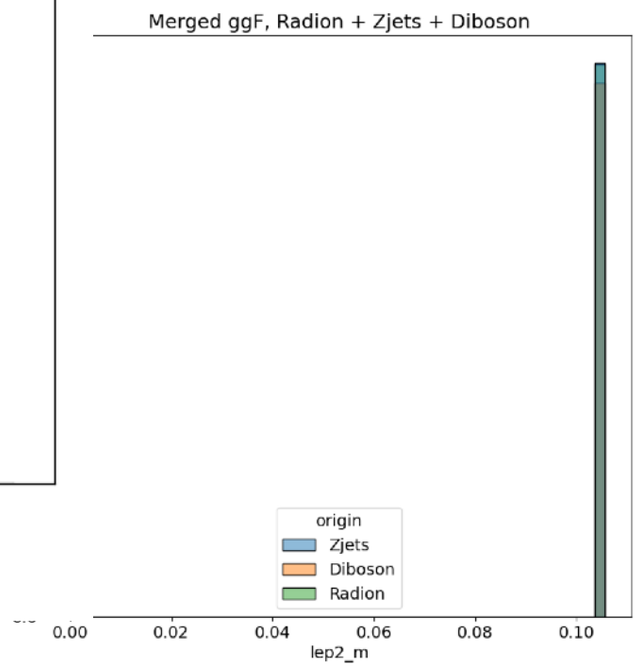


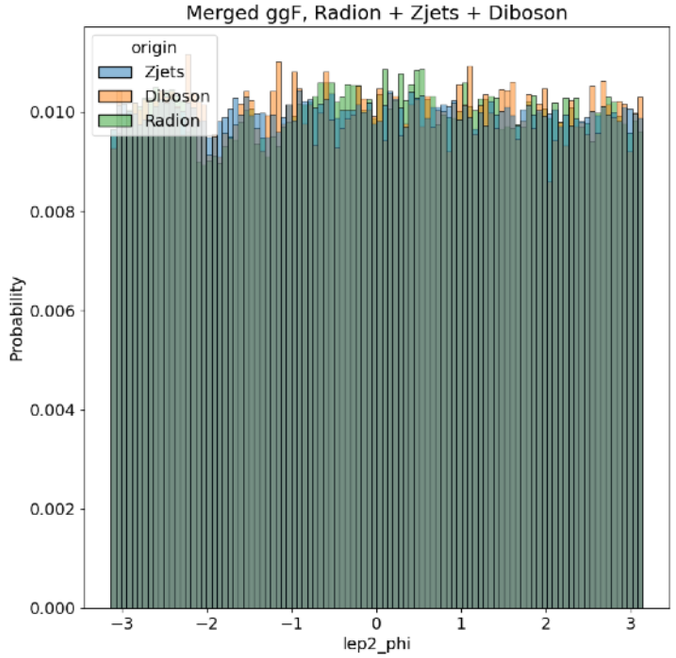
VARIABILI ATTUALMENTE UTILIZZATE

- Lepton 2: m, pt, eta, phi



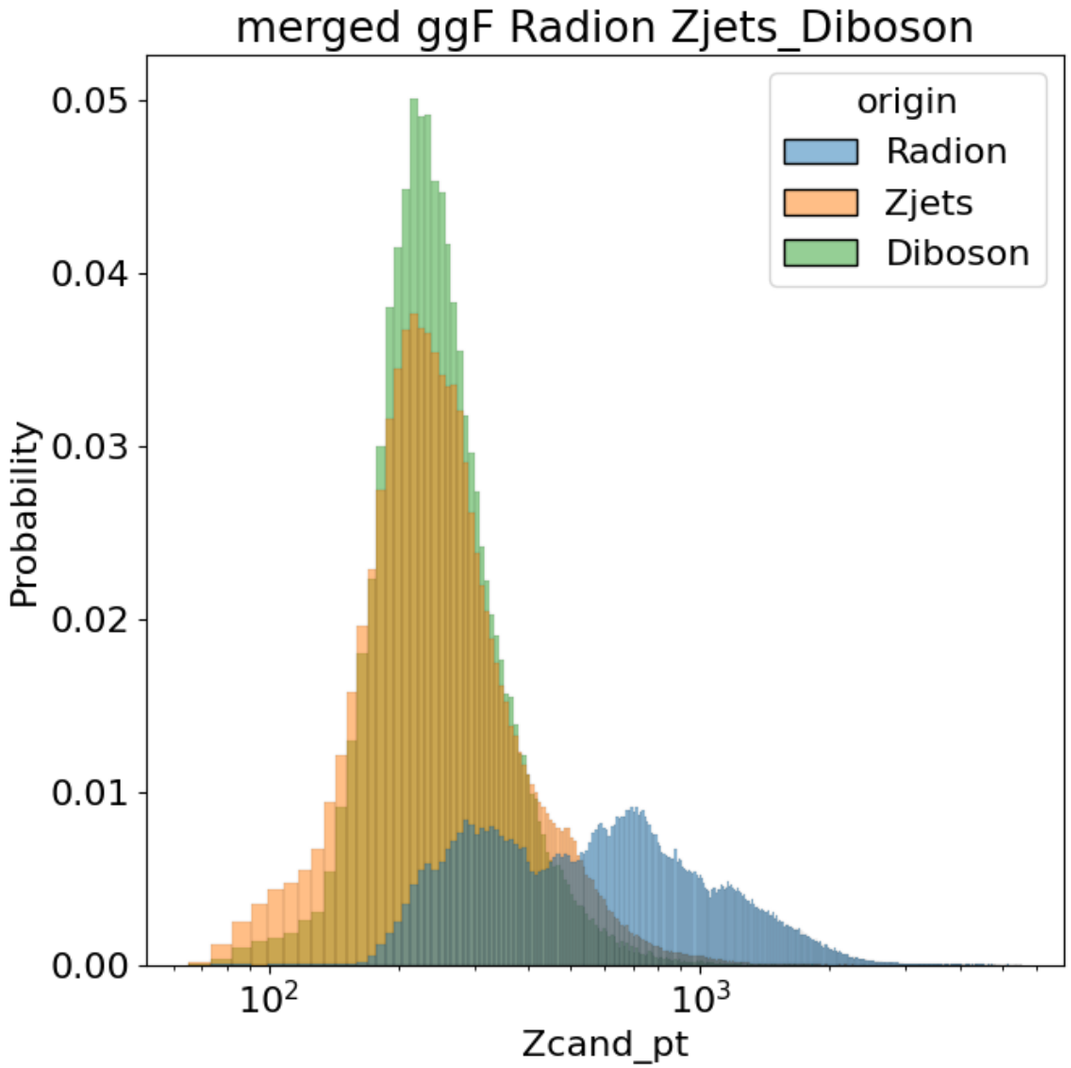


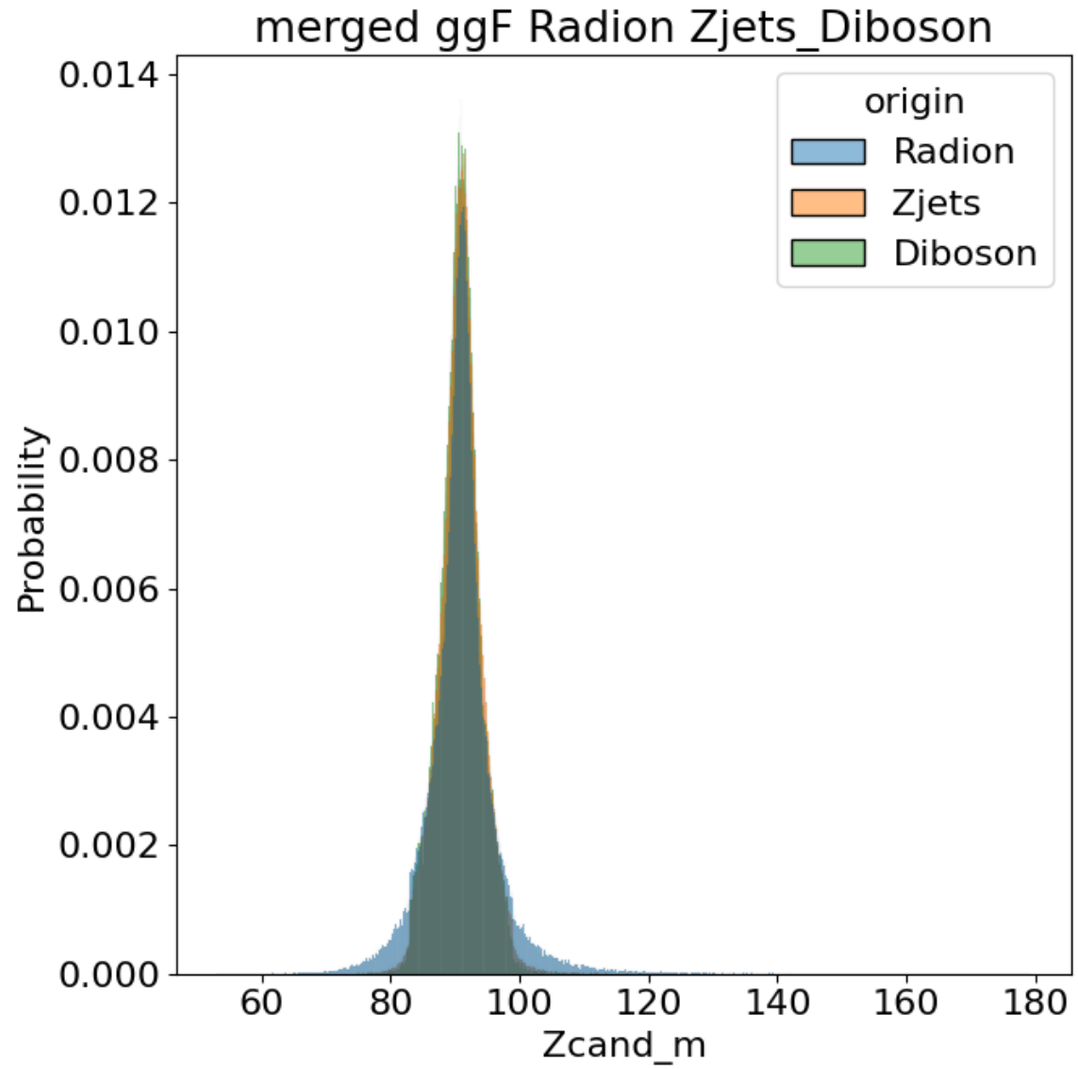




Variabili attualmente utilizzate

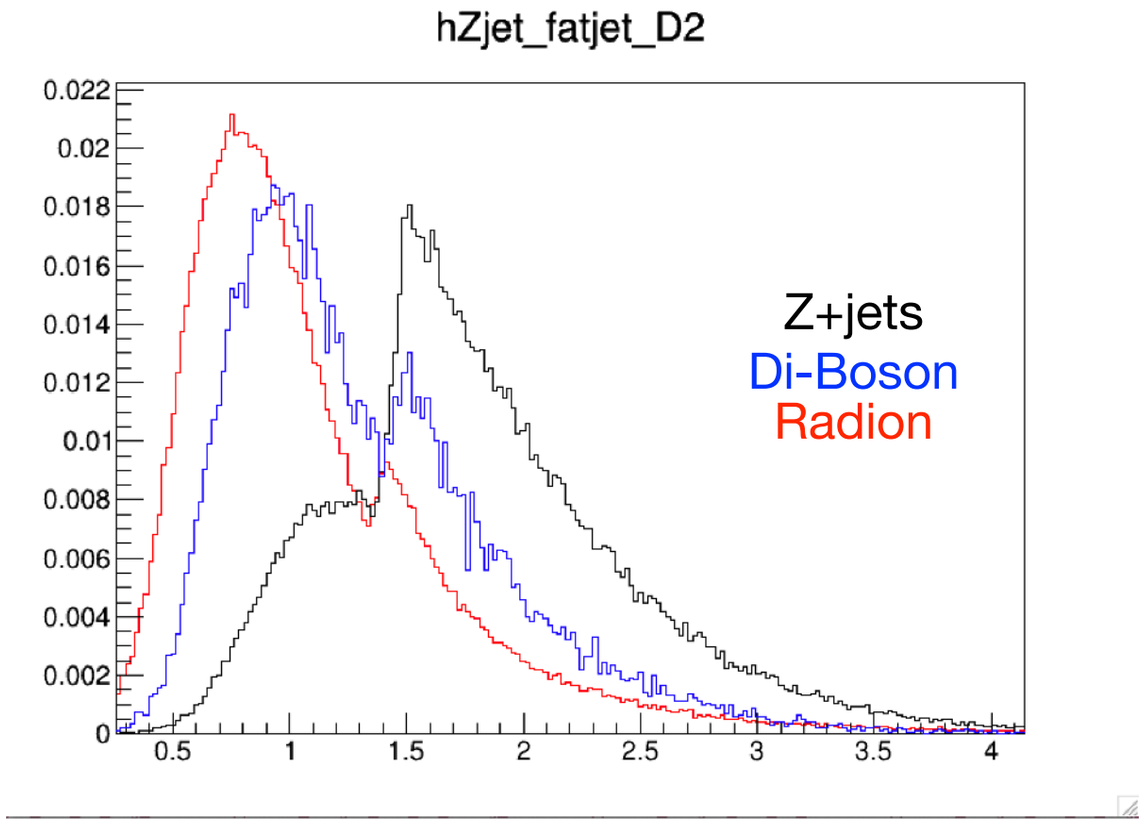
- Leptonic Z: m, pt





- Pass_MergHP_GGF_ZZ_Tag_SR == 1 || Pass_MergHP_GGF_ZZ_Untag_SR == 1 || Pass_MergHP_GGF_WZ_SR == 1 || Pass_MergLP_GGF_ZZ_Tag_SR == 1 || Pass_MergLP_GGF_ZZ_Untag_SR == 1 || Pass_MergHP_GGF_ZZ_Tag_ZCR == 1 || Pass_MergHP_GGF_WZ_ZCR == 1 || Pass_MergHP_GGF_ZZ_Untag_ZCR == 1 || Pass_MergLP_GGF_ZZ_Tag_ZCR == 1 || Pass_MergLP_GGF_ZZ_Untag_ZCR == 1 || Pass_MergLP_GGF_WZ_SR == 1 || Pass_MergLP_GGF_WZ_ZCR == 1

Signal Regions only



Signal+Control Regions