TOP-25-003 — Simultaneous tγq+$t\bar{t}\gamma$ measurement

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https://cms-pub-talk.web.cern.ch/t/followup-pre-approval-comments-and-request-for-unblinding/39000/5

Change of prompt photon definition

Previous

```
promptmatch = true_photons.matched_gen.hasFlags(['isPrompt'])promptmatch = ( (promptmatch) |
                    (true_photons.matched_gen.hasFlags(['isPromptTauDecayProduct'])) |
                    (true_photons.matched_gen.hasFlags([“fromHardProcess"])))
```

New

```
mother_is_not_hadron = (abs(mother["pdgId"]) < 37)
while not ak.all(ak.is_none(mother, axis=1)):
        mother_is_not_hadron = (mother_is_not_hadron & ( (ak.fill_none(abs(mother["pdgId"]), 0) < 37) |
(ak.fill_none(abs(mother["pdgId"]), 0) == 2212) )) #mother is not hadron, except proton, proton is okay
        mother = mother.parent
promptmatch = mother_is_not_hadron
```

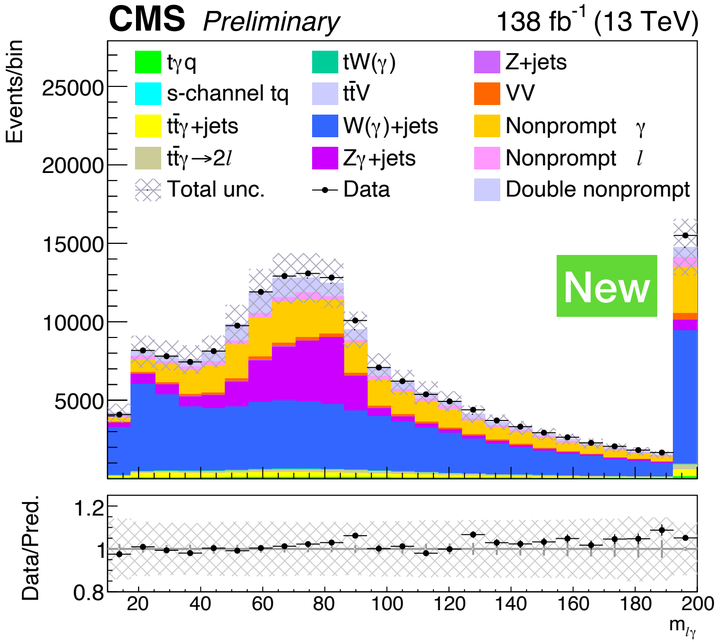
Change of prompt photon definition

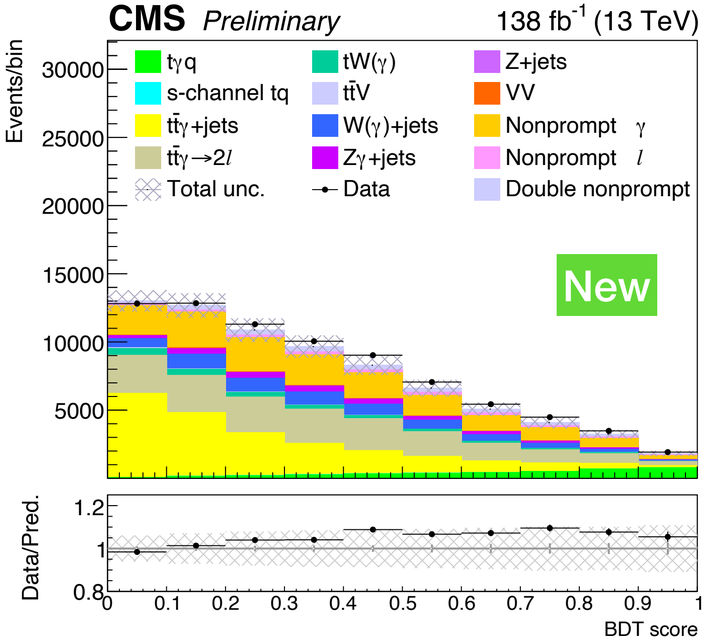
2018 Muon CR

Process	Prompt γ		E mis. γ	
	New	Old	New	Old
Zg	10813.7	10816.9	2.3	2.3
Zjets	0.0	181.0	109.4	109.4
Wg	34994.3	34994.3	0.7	0.7
VV	1393.0	1407.8	44.6	44.6
single_s	8.1	8.1	0.2	0.2
tWg	310.4	315.0	58.5	58.5
TTV	10.2	10.6	2.1	2.1
ttg2l	770.3	835.4	477.0	476.9
ttg	2122.7	2316.0	0.1	47.4
tgQ	506.5	551.9	0.0	4.5

2018 Muon SR

Process	Prompt γ		E mis. γ	
	New	Old	New	Old
Zg	1192.9	1193.1	0.3	0.3
Zjets	0.0	36.2	11.3	11.3
Wg	2857.7	2857.7	0.0	0.0
VV	173.2	174.8	3.9	3.9
single_s	53.5	53.5	0.3	0.3
tWg	841.0	867.7	215.9	215.9
TTV	60.4	62.3	11.3	11.3
ttg2l	4736.3	5200.4	3484.1	3484.4
ttg	9303.3	10275.5	0.5	88.8
tgQ	1566.6	1718.8	0.1	7.0





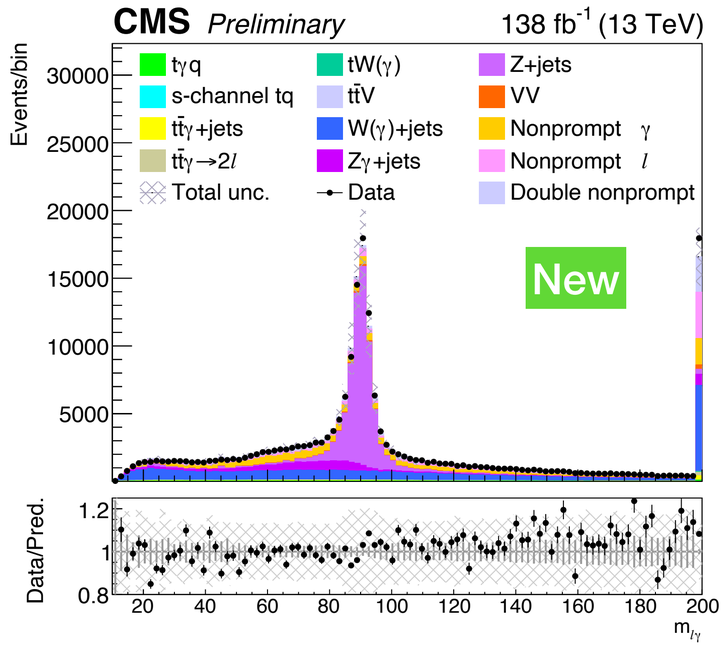
Change of prompt photon definition

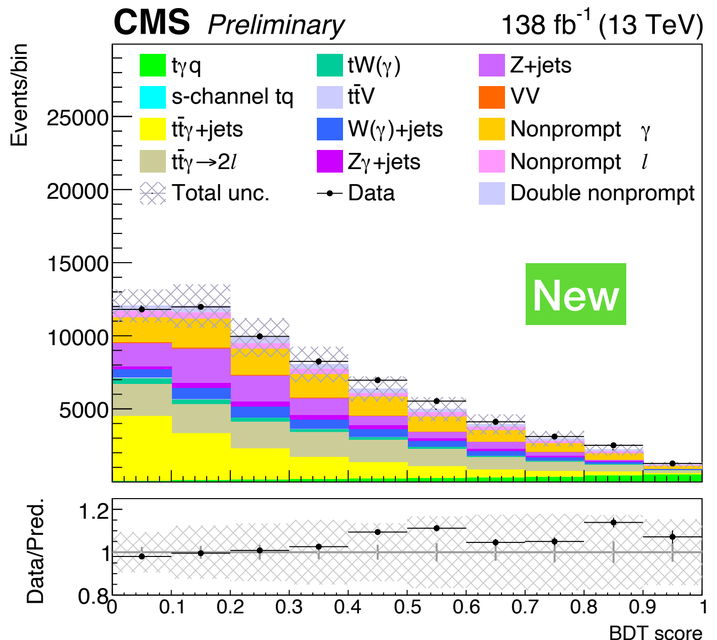
2018 Ele CR

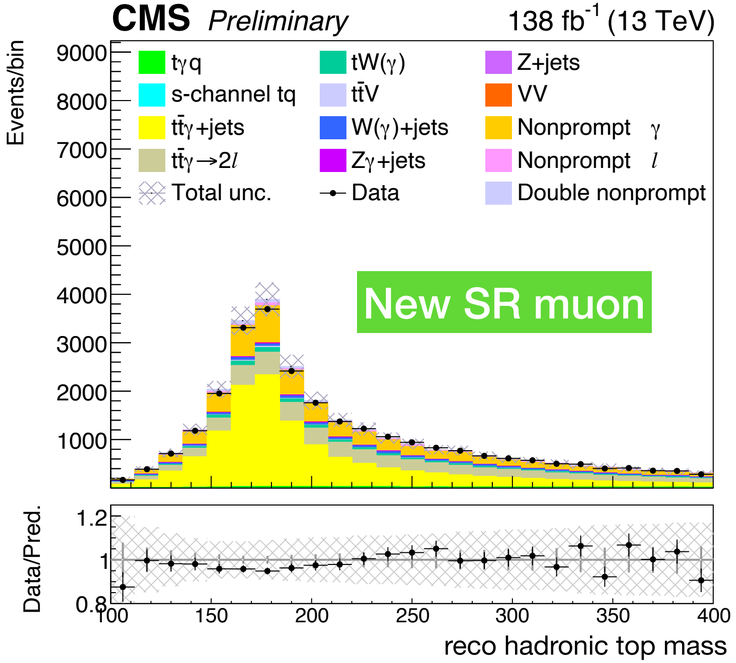
Process	Prompt γ		E mis. γ	
	New	Old	New	Old
Zg	8450.5	8452.8	323.9	323.9
Zjets	2.5	108.1	24848.7	24848.7
Wg	24096.6	24098.3	6.9	6.9
VV	951.5	957.7	257.1	257.1
single_s	5.3	5.3	0.1	0.1
tWg	206.1	209.9	35.8	35.8
TTV	8.3	8.4	1.4	1.4
ttg2l	545.5	589.7	345.9	345.9
ttg	1489.5	1629.5	0.2	33.6
tgQ	316.2	343.0	0.1	1.7

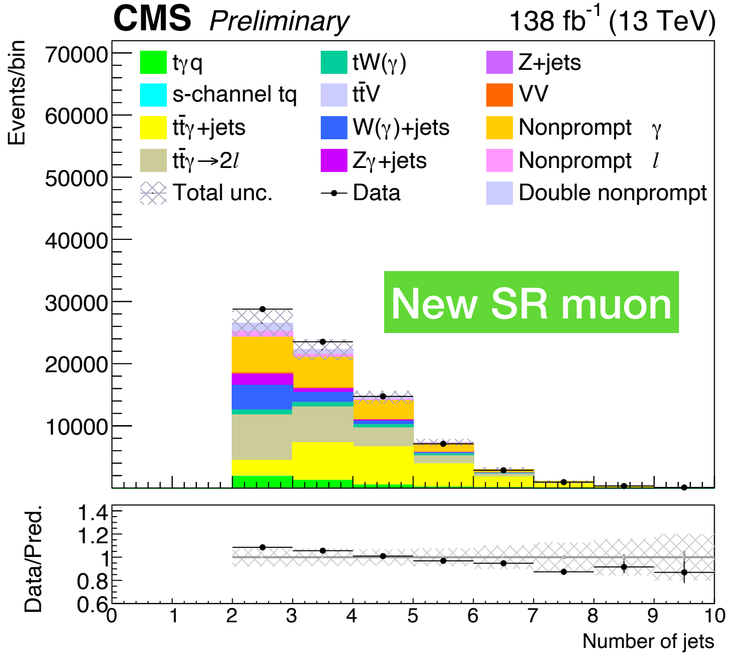
2018 Ele SR

Process	Prompt γ		E mis. γ	
	New	Old	New	Old
Zg	906.9	906.9	39.6	39.6
Zjets	0.0	8.0	2745.8	2745.8
Wg	1994.1	1994.1	-0.4	-0.4
VV	123.4	125.4	38.7	38.7
single_s	35.1	35.1	0.2	0.2
tWg	600.0	620.2	151.2	151.2
TTV	44.5	45.7	8.4	8.4
ttg2l	3302.2	3626.7	2477.9	2477.0
ttg	6428.5	7121.2	1.5	61.0
tgQ	978.0	1071.9	0.4	3.9






CMS Preliminary
138 fb-1 (13 TeV)
tγq
s-channel tq
tt̄γ+jets
tt̄γ→2l
Total unc.
tW(γ)
tt̄V
W(γ)+jets
Zγ+jets
Data
Z+jets
VV
Nonprompt γ
Nonprompt l
Double nonprompt
New SR muon
Events/bin
Data/Pred.
reco hadronic top mass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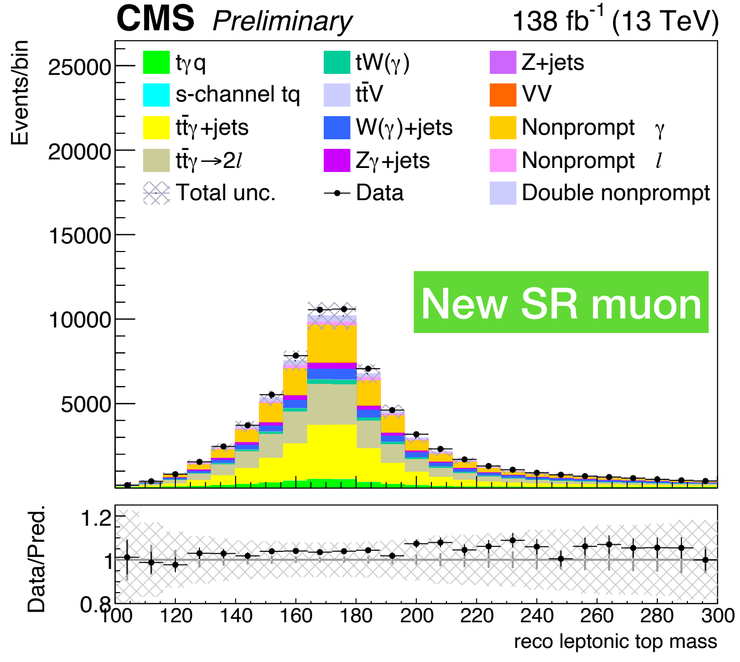
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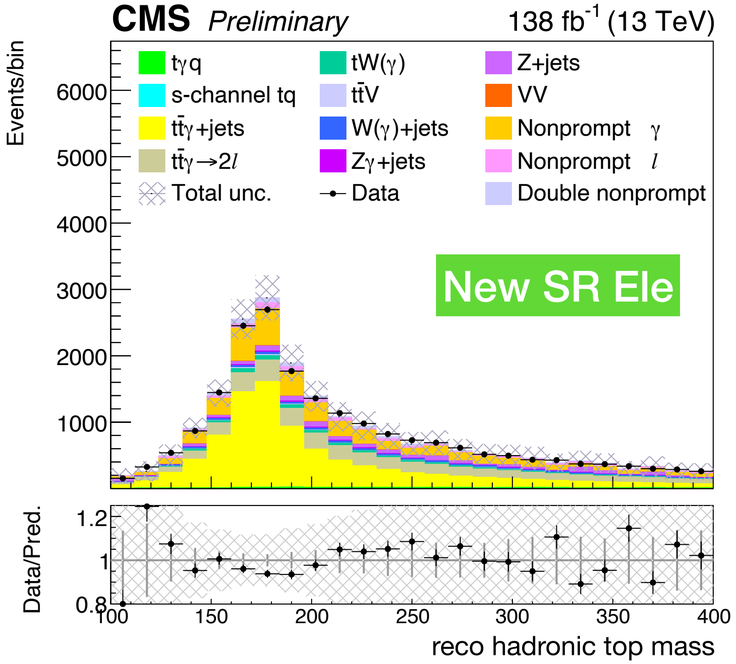
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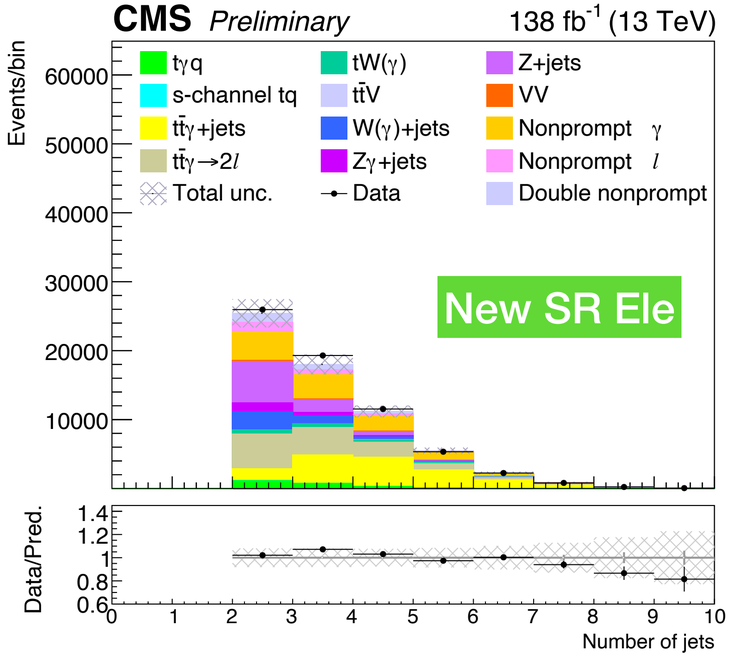
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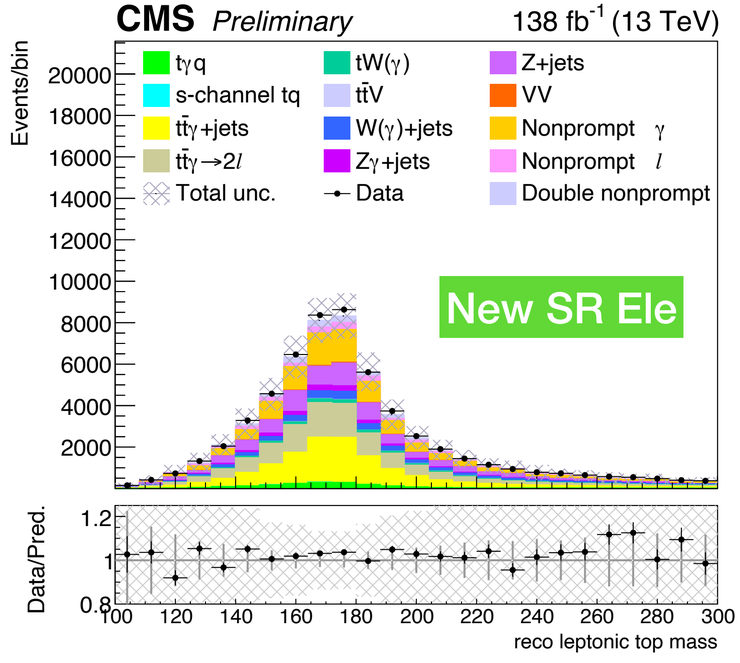
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Data
Z+jets
VV
Nonprompt γ
Nonprompt l
Double nonprompt
New SR Ele
Events/bin
Data/Pred.
reco leptonic top mass

Followup pre-approval comments

Contribution of photon from electron mis-identification is split out as a single background with corresponding normalization floating as rateParam in the fit

Current input processes are

tgQ_reco_and_gen tgQ_OutGen
ttg_reco_and_gen ttg_OutGen
ttg2L
ttg2L_mis
Zg
Zjets
Wg
tWg
Others
Others_mis
Nonprompt_g
Nonprompt_l
Double_Nonprompt

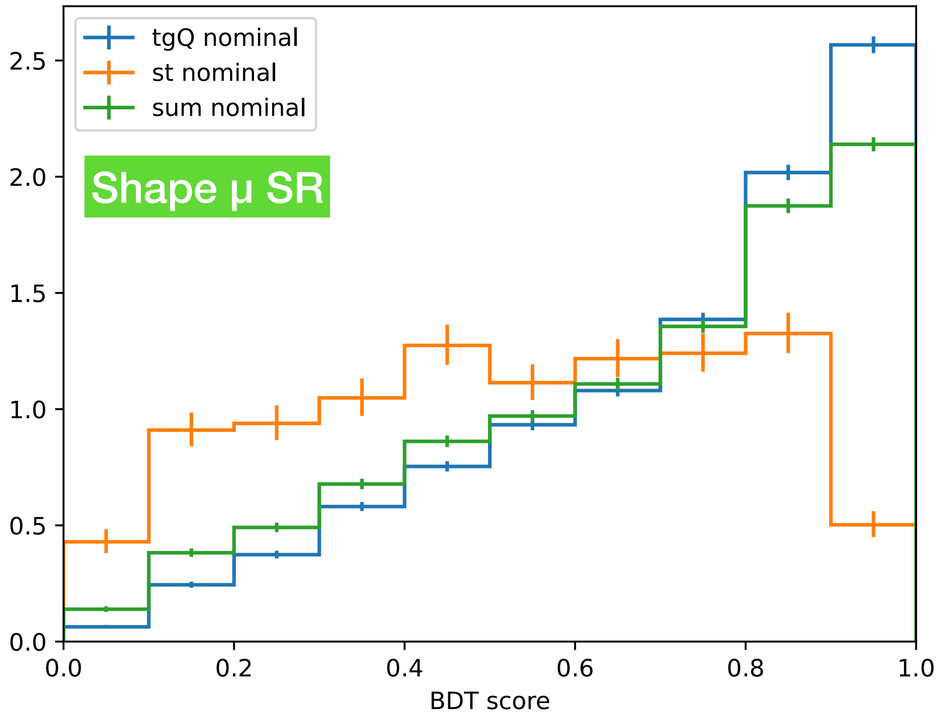
Previous input processes are

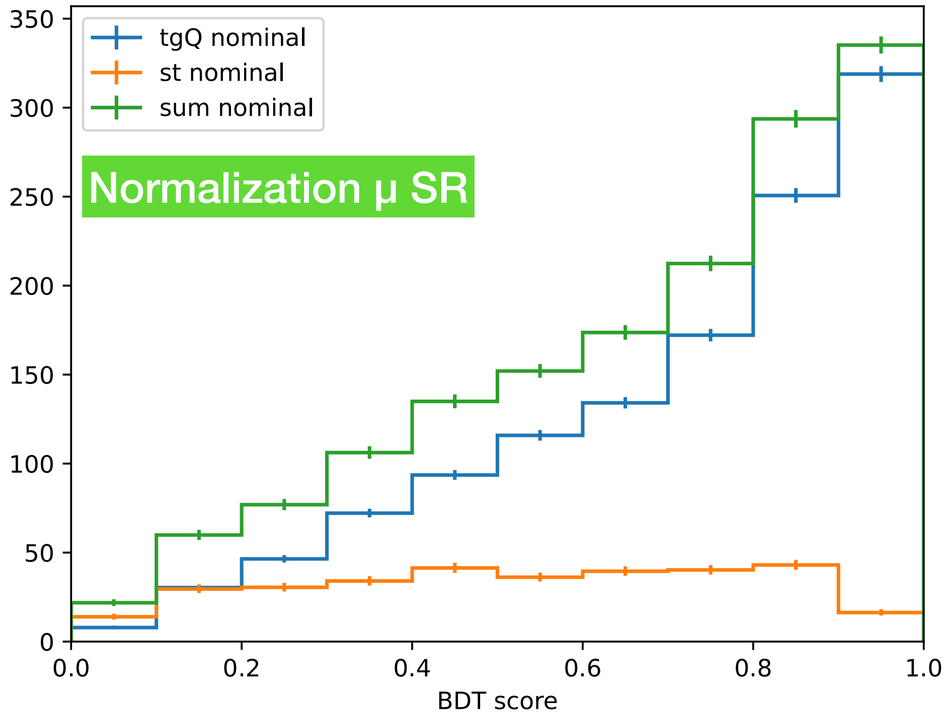
tgQ_reco_and_gen tgQ_OutGen
ttg_reco_and_gen ttg_OutGen
ttg2L
Zg
Zjets
Wg
tWg
Others
Nonprompt_g
Nonprompt_l
Double_Nonprompt

Referring to TOP-18-010, float the normalisation for misID contributions and consider the uncertainty correlated for different processes and uncorrelated for different years

Followup pre-approval comments

Regarding the uncertainty on the fraction of tgammaq production vs decay fraction, we are a bit surprised this makes a big difference, so we would like to follow up on this topic as well. **Could you show us the BDT distributions normalized and not normalized of both t-gamma-q production and decay separately**? It is difficult to ascertain much about t-gamma-q from decay with what you have shown.





The shapes are really different, and the sum is dominated by the ME photon from tγq MG5 sample

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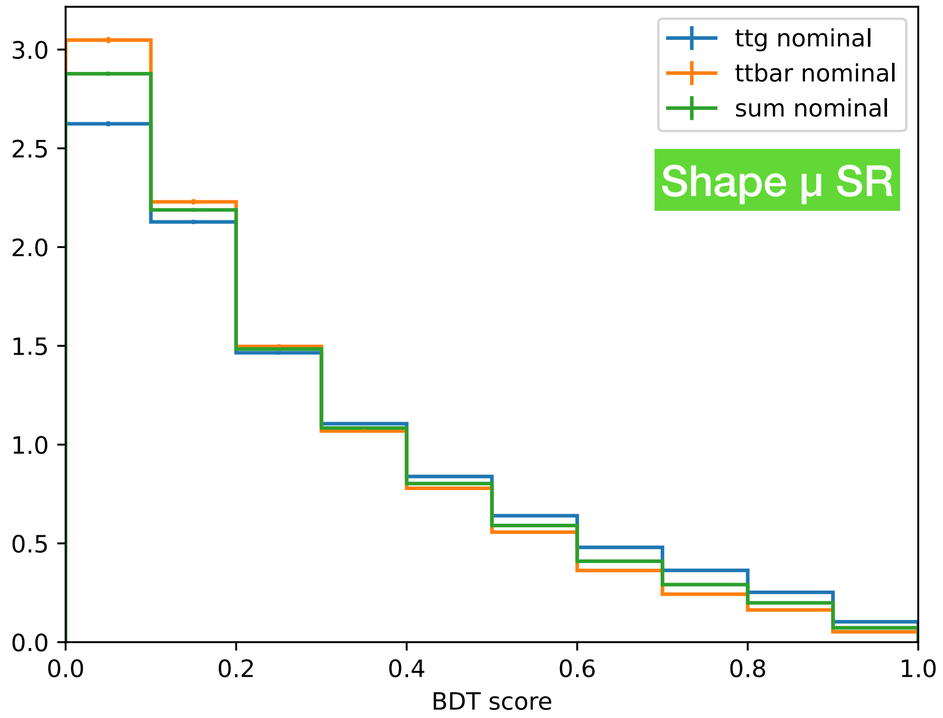

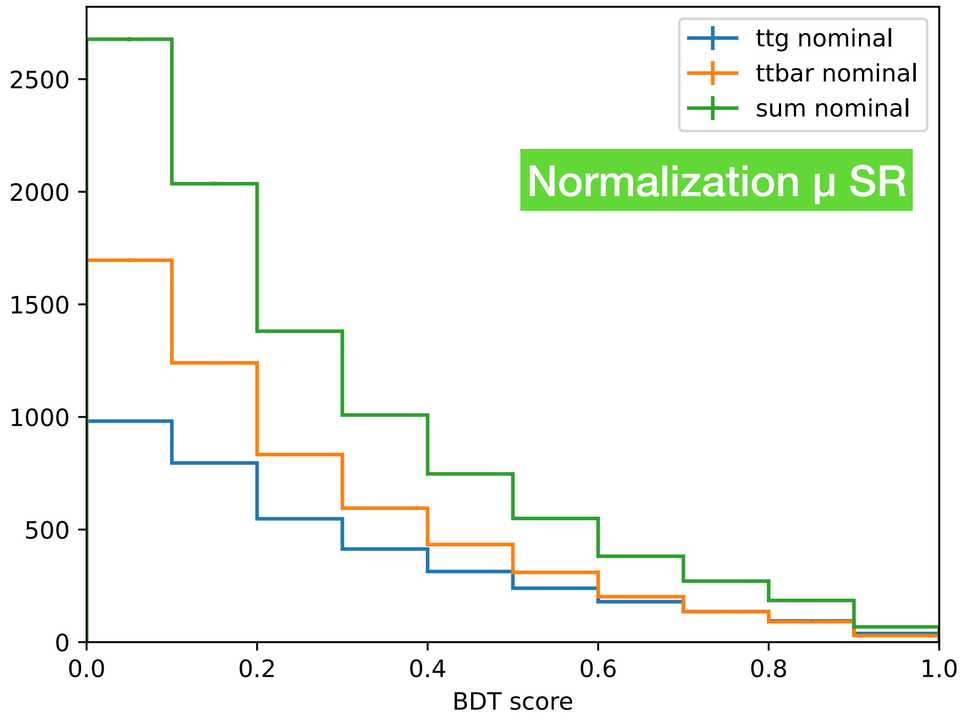

The shapes are really similar, contributions of ME photon from tγq MG5 sample and PS photon from ttbar Powheg sample are comparable

Followup pre-approval comments

If this is a genuine effect (and we do not see any study suggesting it isn't) we do not find the suggestion to arbitrarily make the uncertainty smaller convincing: we would need a physics motivated prescription to assess this uncertainty. Along those lines, **we believe that one could use the scale uncertainties on either the production or decay, or both, to assign such an uncertainty. Please also check with Beatriz on how different the shapes for photons from ME and PS in the decay for ttgamma are**. We need to understand if that is an additional uncertainty that we should consider for tgammaq where this is always taken from the PS.

- With updates mentioned in previous slides
- **Uncorrelated theoretical uncertainties** for both production and decay
- **Don't use uncertainty on fraction**

r_tgQ : +1.000 -0.079/+0.083 (68%)
r_ttg : +1.000 -0.052/+0.055(68%)

- With updates mentioned in previous slides
- **Correlated theoretical uncertainties**
- **Use uncertainty on fraction**

r_tgQ : +1.000 -0.100/+0.110 (68%)
r_ttg : +1.000 -0.050/+0.052 (68%)

- With updates mentioned in previous slides
- **Only production events as signal**
- **Don't use uncertainty on fraction**

r_tgQ : +1.000 -0.083/+0.084 (68%)
r_ttg : +1.000 -0.050/+0.051 (68%)

- Results in pre-approval presentation

$$r_{t\gamma q} = 1.0^{+0.081}_{-0.078} = 1.0^{+0.073}_{-0.070}(\text{syst})\,^{+0.036}_{-0.036}(\text{stat})$$

$$r_{t\bar{t}\gamma} = 1.0^{+0.043}_{-0.042} = 1.0^{+0.042}_{-0.041}(\text{syst})\,^{+0.01}_{-0.01}(\text{stat})$$

Followup pre-approval comments

We also would like authors to consider exploring different ways for mitigating this dependence, which is not straightforward to assess. This includes:

1. Considering fitting dR(lepton,photon) together with the BDT, to have an additional handle to constrain the t-gamma-q decay component, to see if the impact of this uncertainty is reduced
2. Alternatively, consider training a multiclass (background, t-gamma-q production, t-gamma-q decay) with the same purpose
3. Provide, as an alternative, a fit where the t-gamma-q decay is considered as part of the background, with its own uncertainties

Conclusion

Followup pre-approval comments

Please also provide feedback on these points that we asked here:

“Also Table 3 is different, e.g. please clarify and check the NLO ttgamma cross section from FxFx. Beatriz quotes (corrected for BR) a value of 3.7 pb. Which cross section did you use for tW. Make sure it is the same for top and antitop and ideally the same as Beatriz (35.9 pb). What are the efficiencies for photon emission in the tq sample from Powheg? How do you use the cross section of 136 resp. 80.95 pb you quote in the table?”

Followup pre-approval comments

Finally let us ask a few follow-ups on the presentation in tX (https://indico.cern.ch/event/1551310/contributions/6535662/attachments/3076707/5444773/tgQ_ttg_preapproval_comments_v1.pdf):

p9: Please provide the corresponding impact plot! Which uncertainties are pulled to accommodate the step in the prefit plots?

p11: Why are the uncertainties in the electron channel between 50% and 100% larger than in the muon channel?

p14: Why were the njet uncertainties for Wγ and Zγ and Zjets uncorrelated between SR and CR? What exactly do you use as uncertainty per jet bin? Please quantify the size per bin and process.