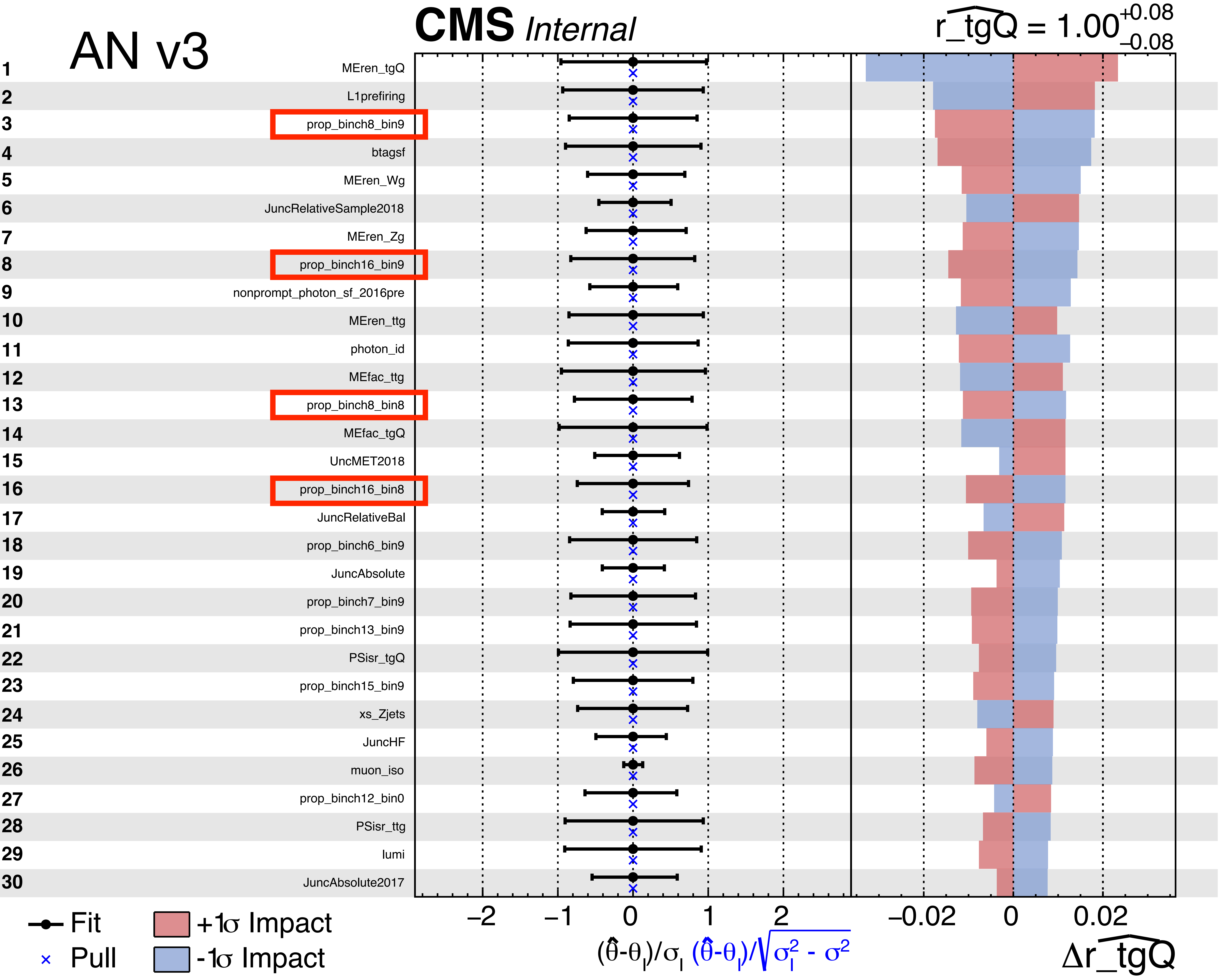
Comments for CADI talk

Check which samples drive MCstat uncertainty and request extensions where possible

Please show plots of binned data as it is given to the combine fit, e.g. with processes separated by years

AN v3



prop_binch8(16, 6, 7,13,15)_bin9

prop_binch8(16)_bin8

ch6: incl_muon_SR16pre

ch7: incl_muon_SR17

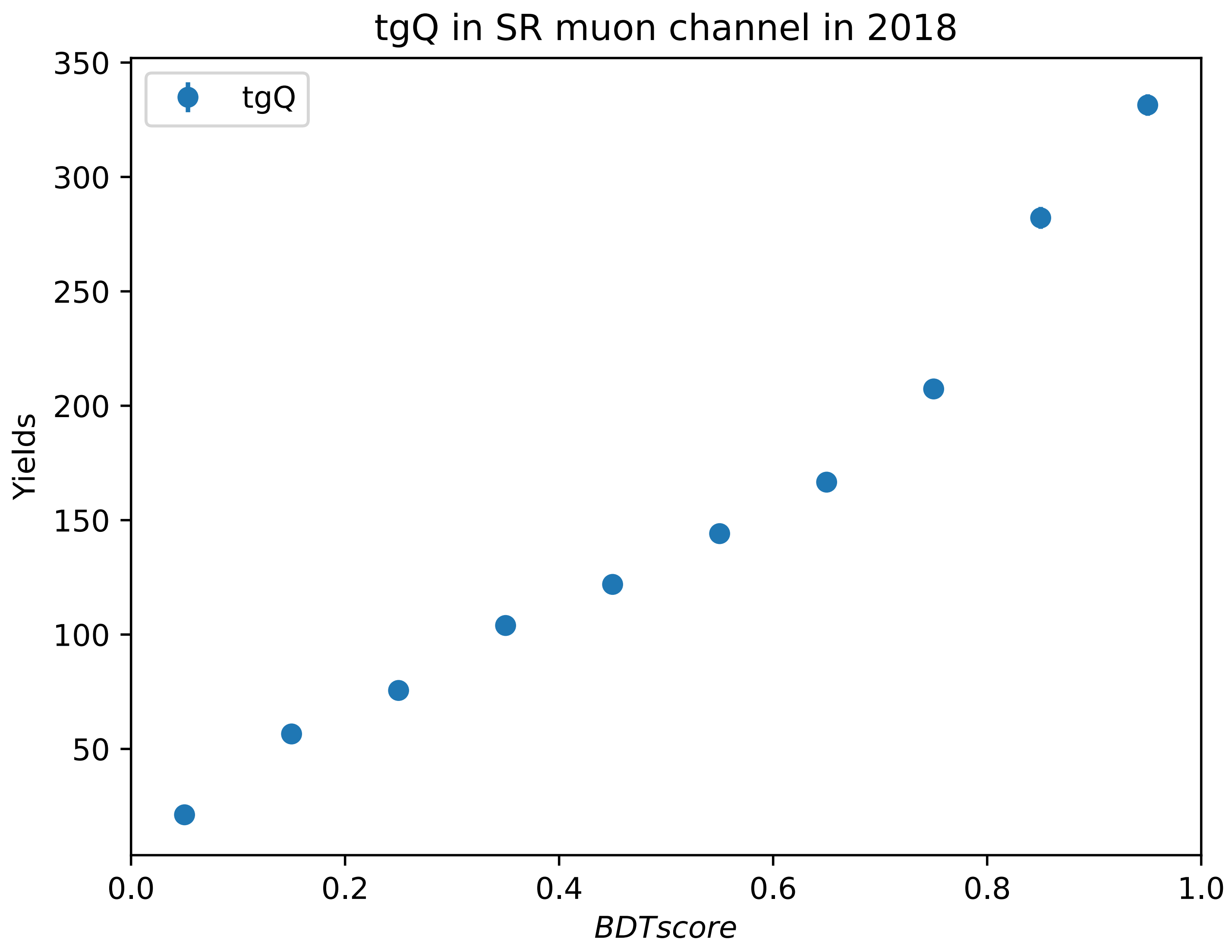
ch8: incl_muon_SR18

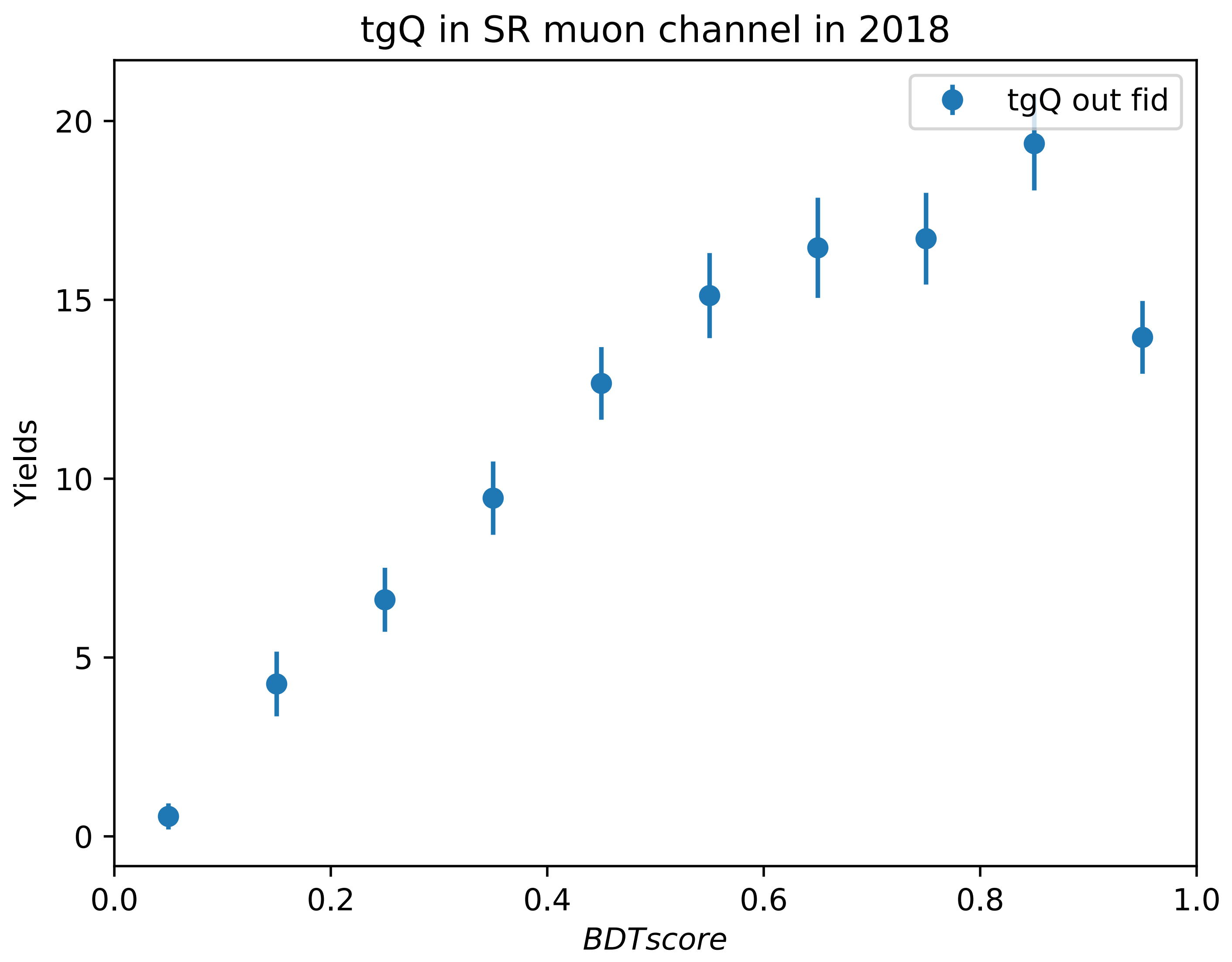
ch13: incl_ele_SR16post

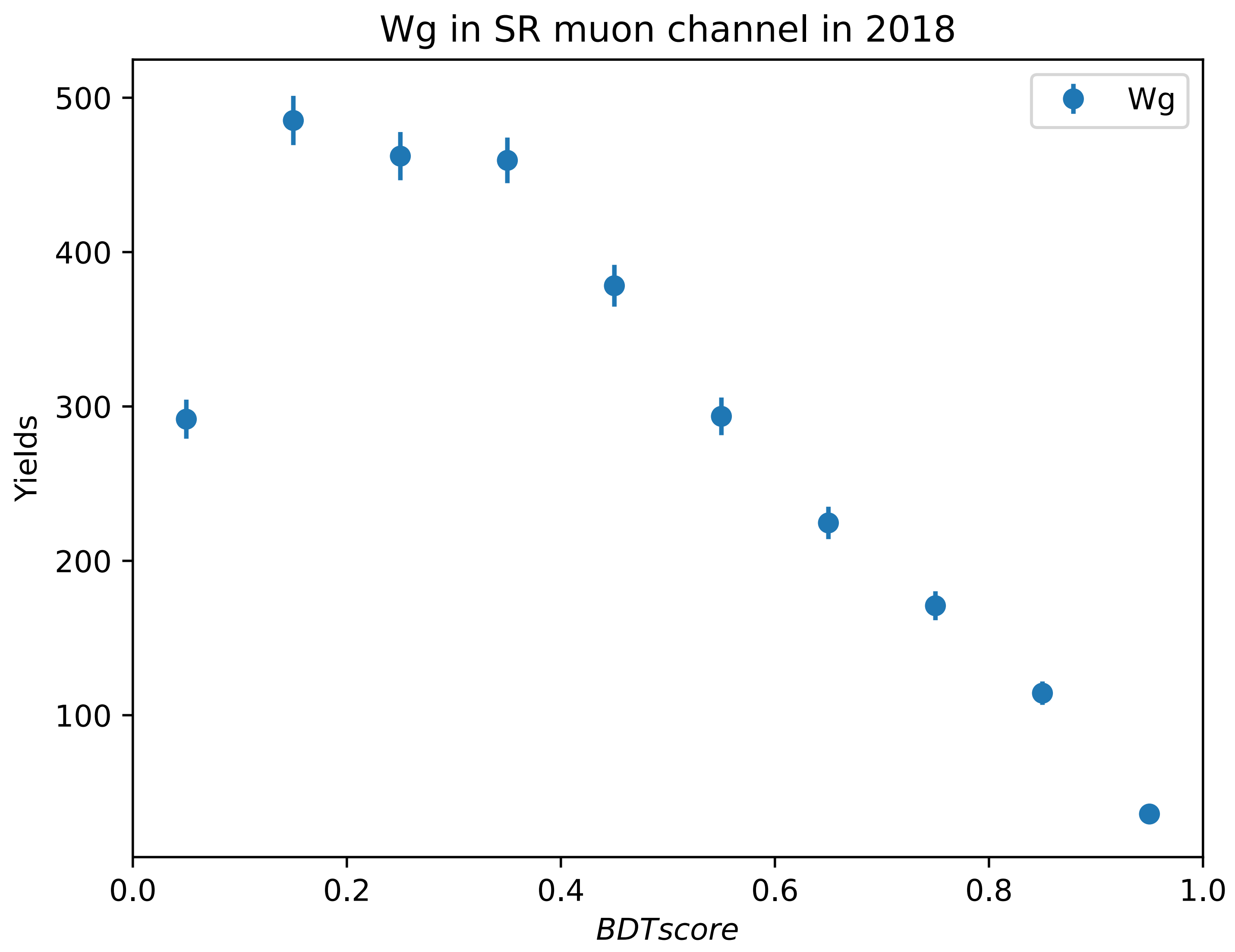
ch15: incl_ele_SR17

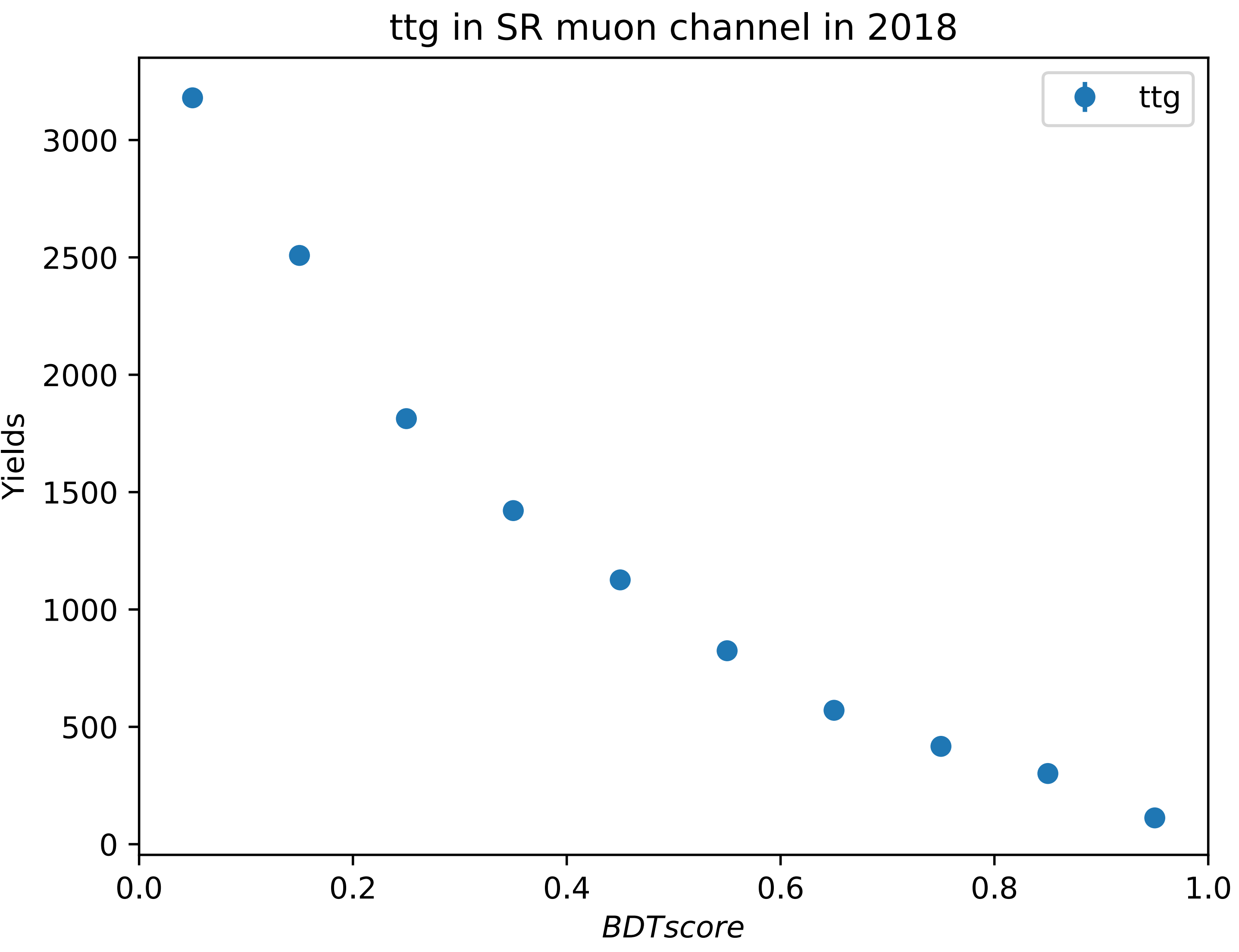
ch16: incl_ele_SR18

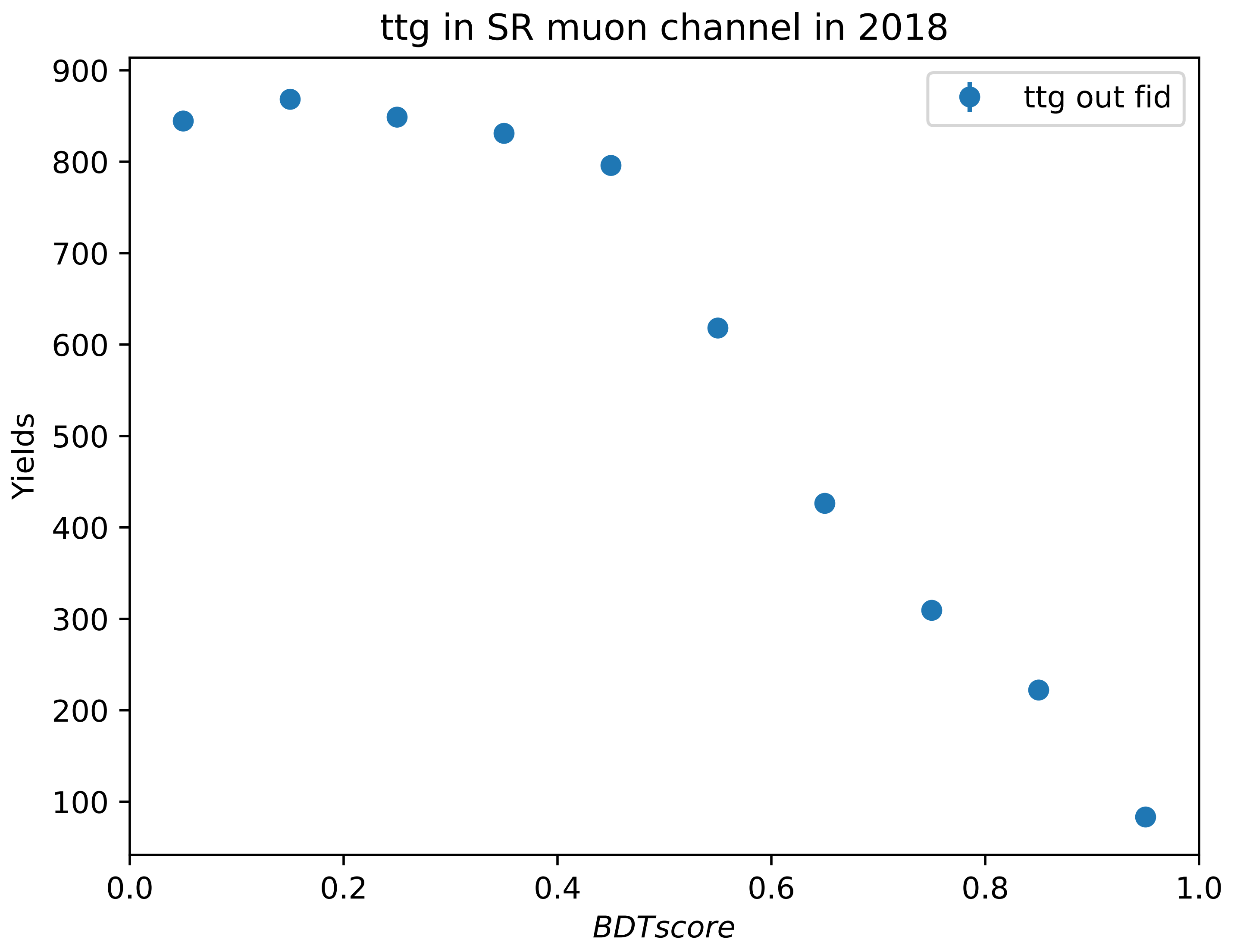
Input histograms for 2018 muon channel

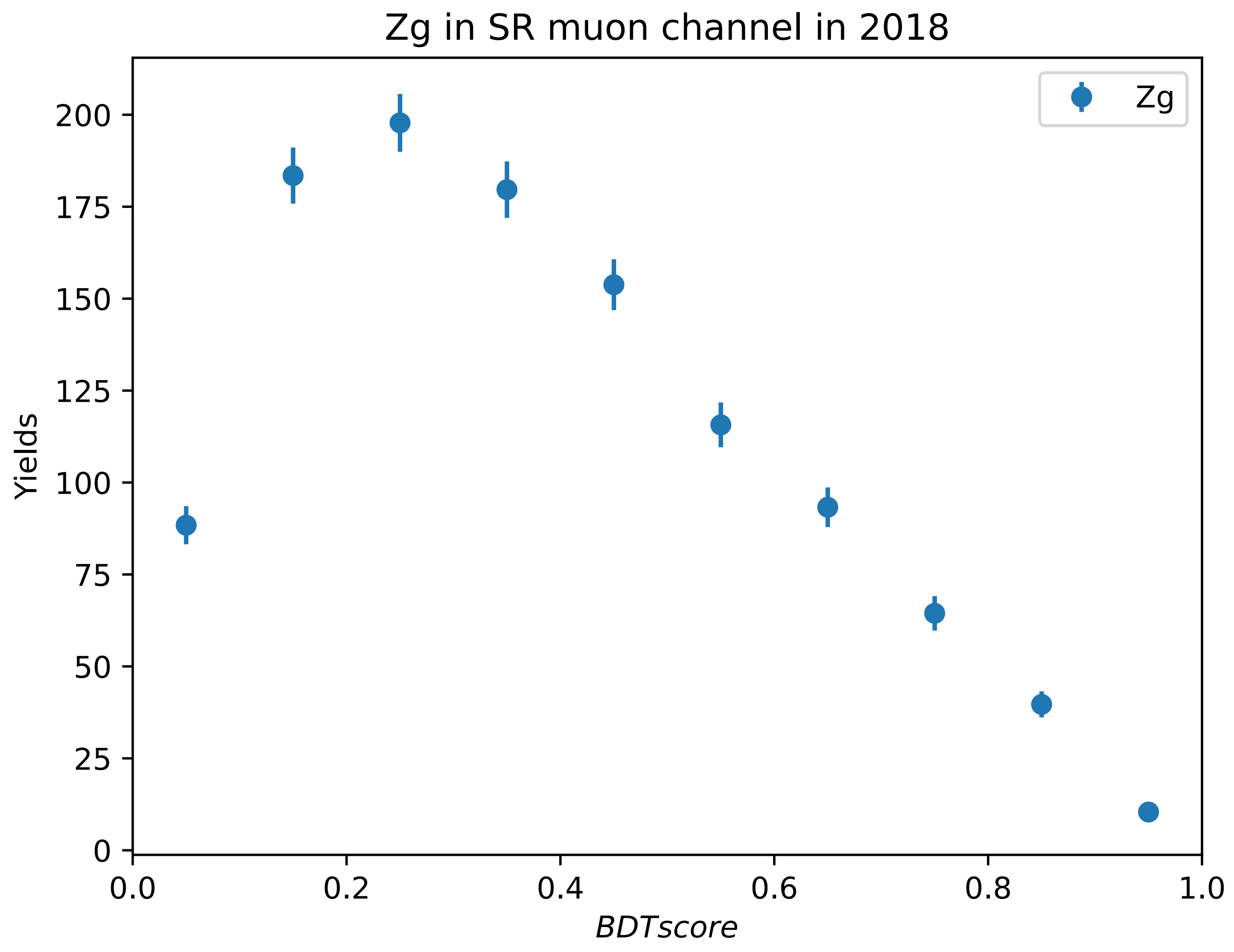




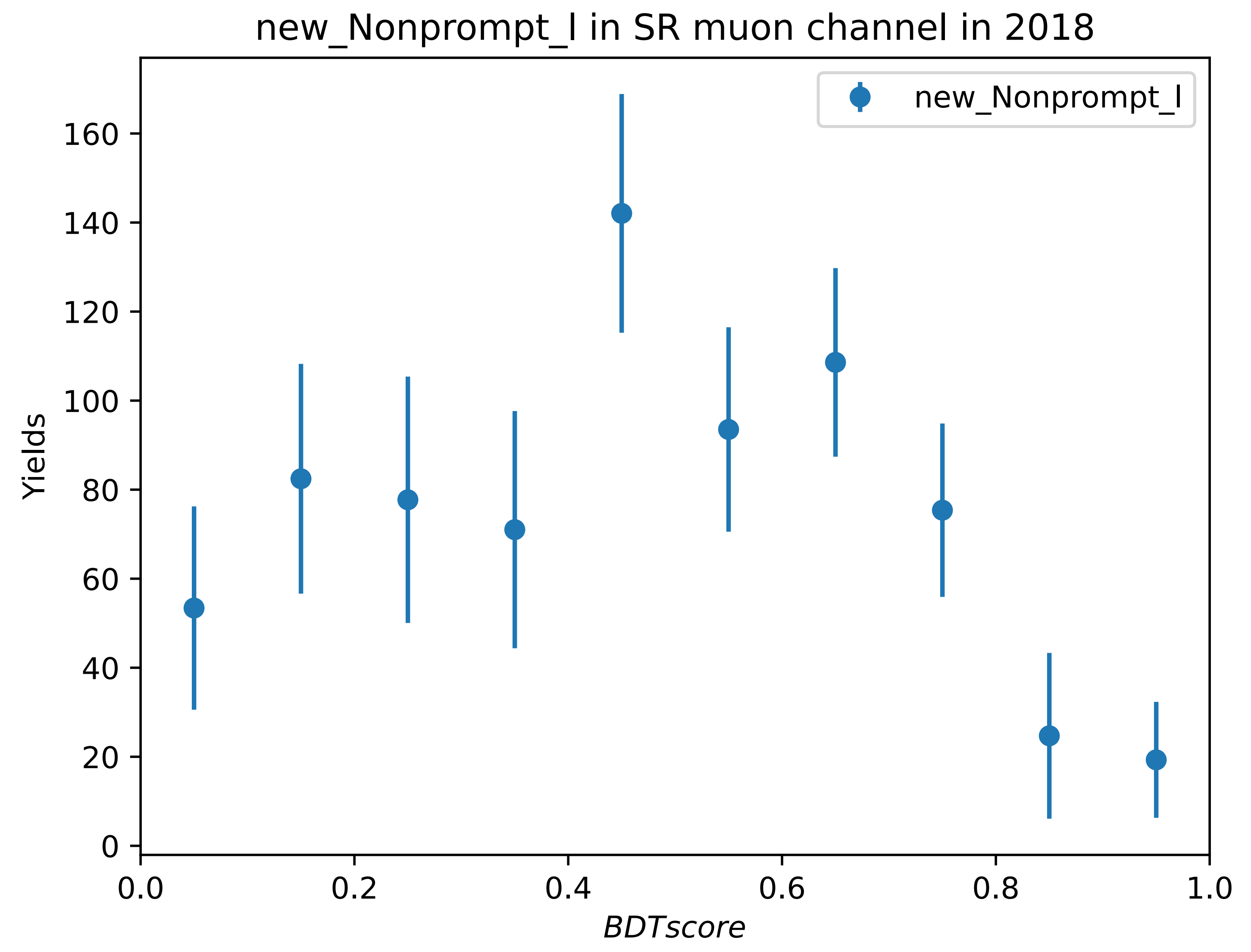


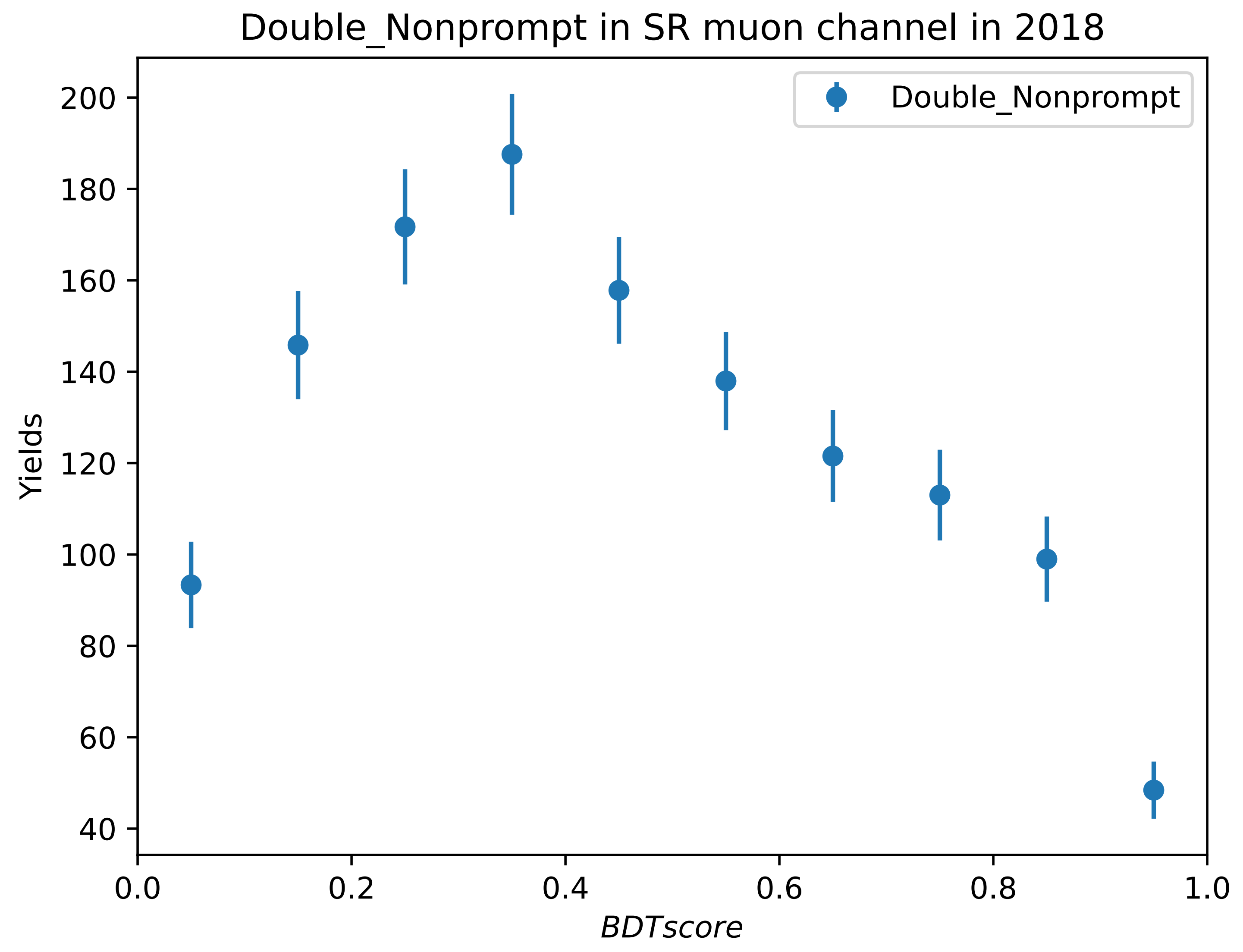


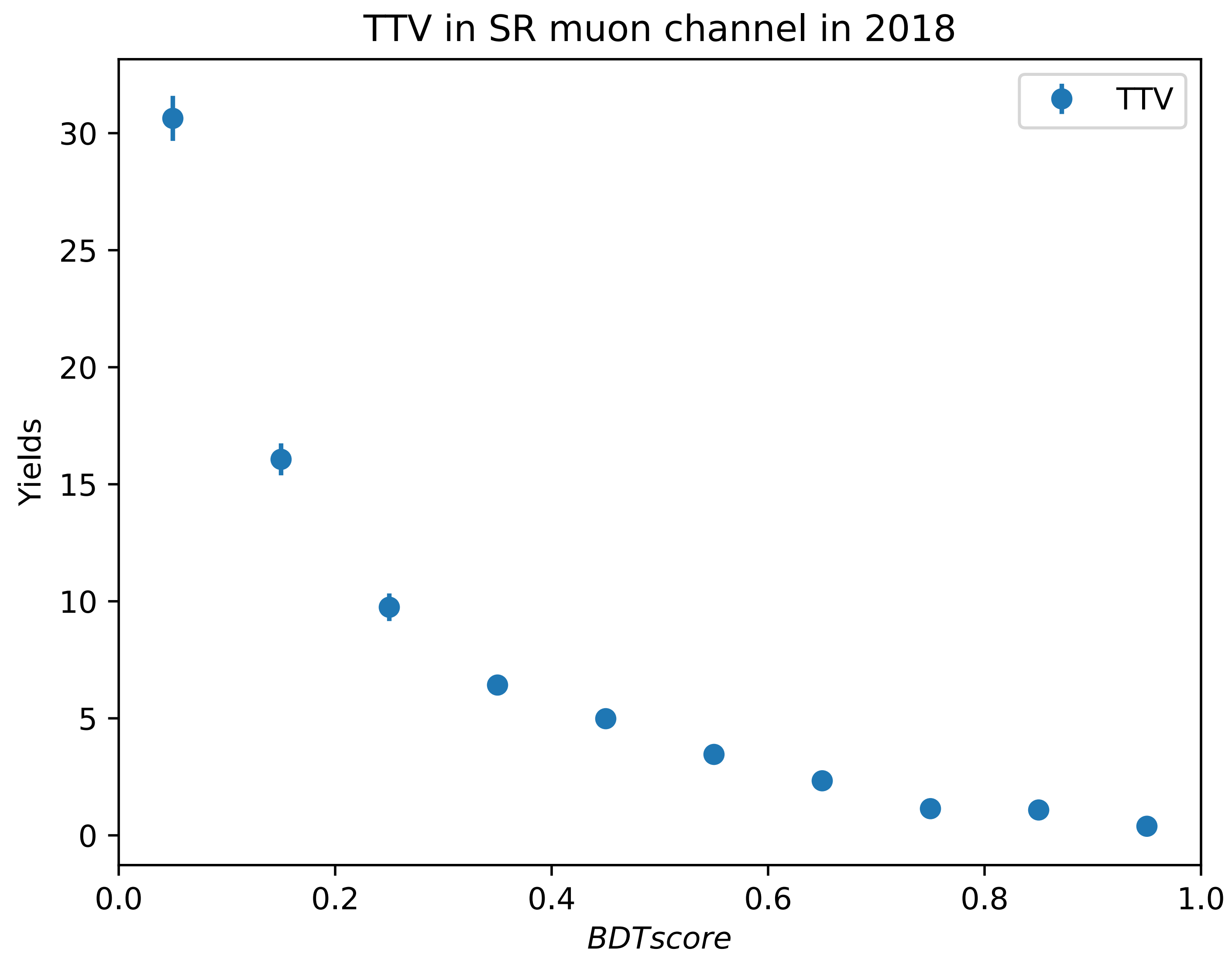


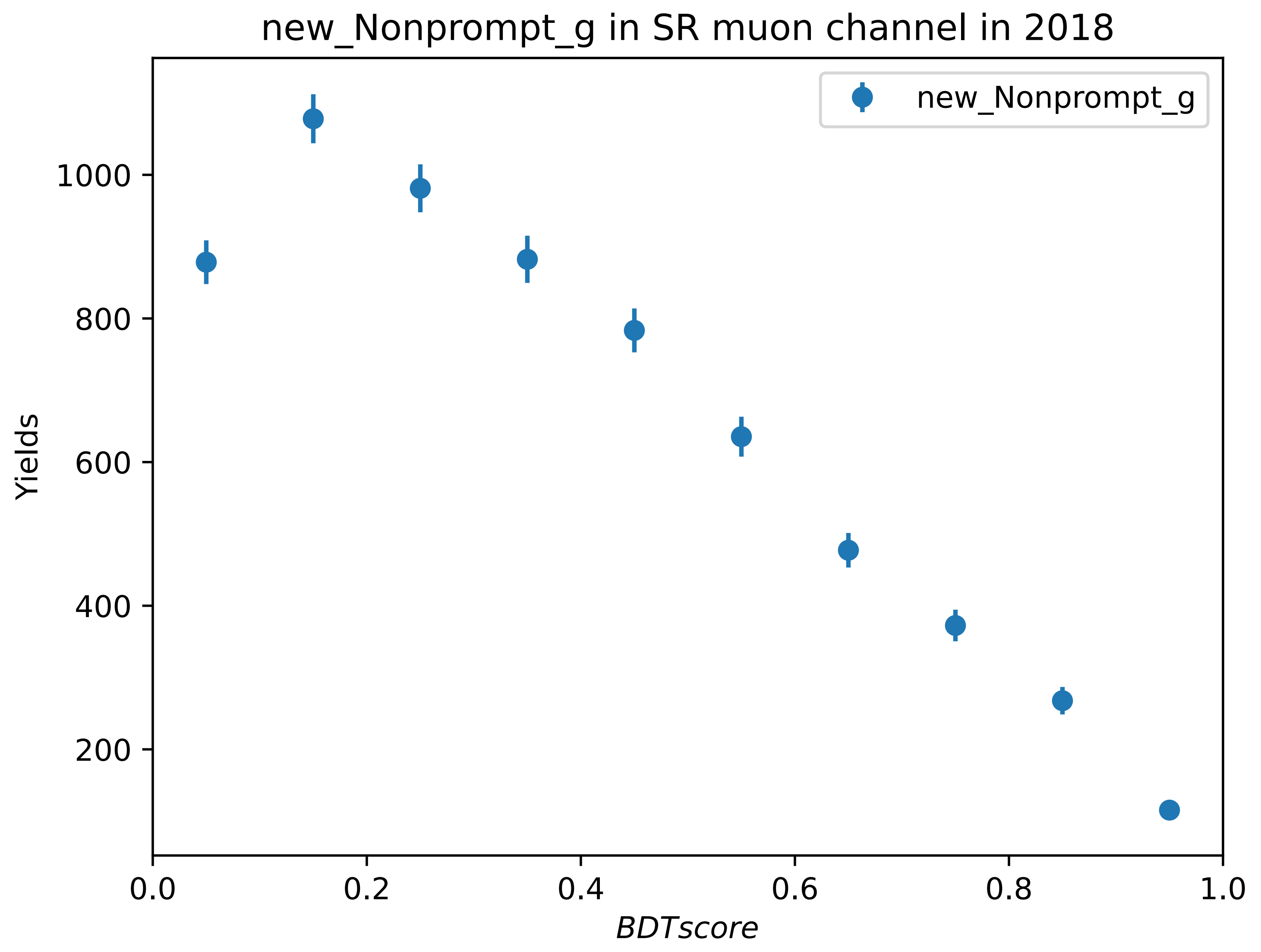


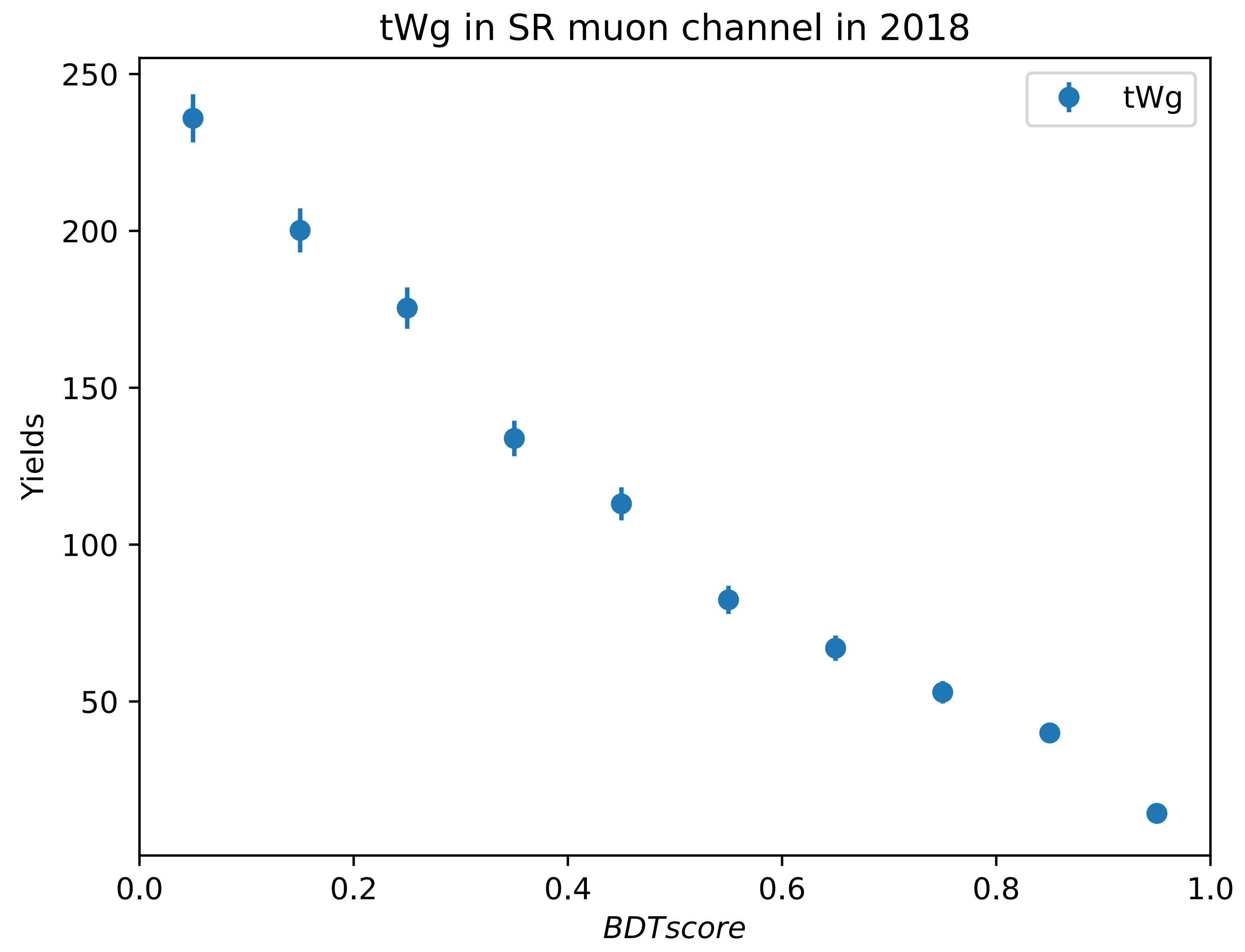
Input histograms for 2018 muon channel

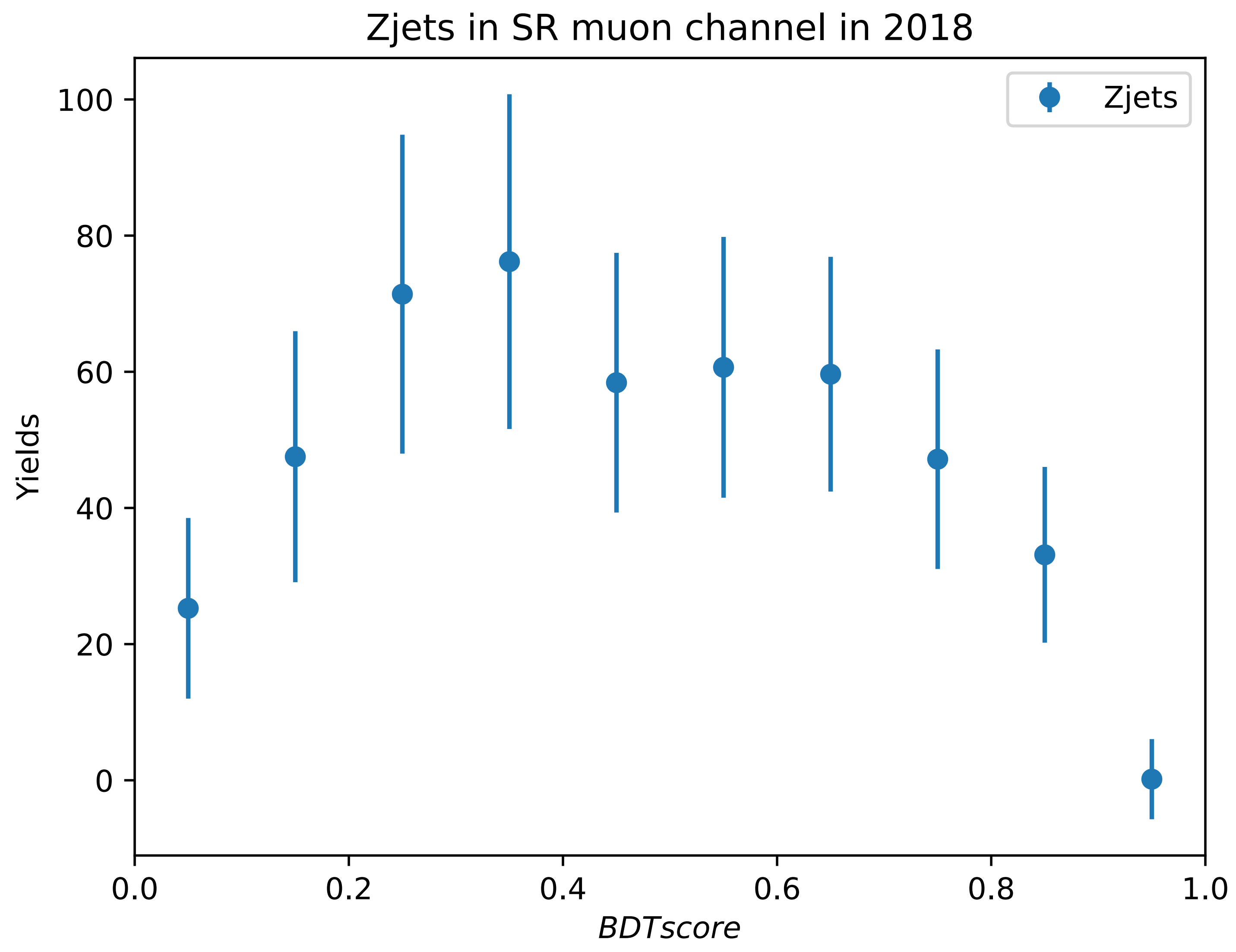




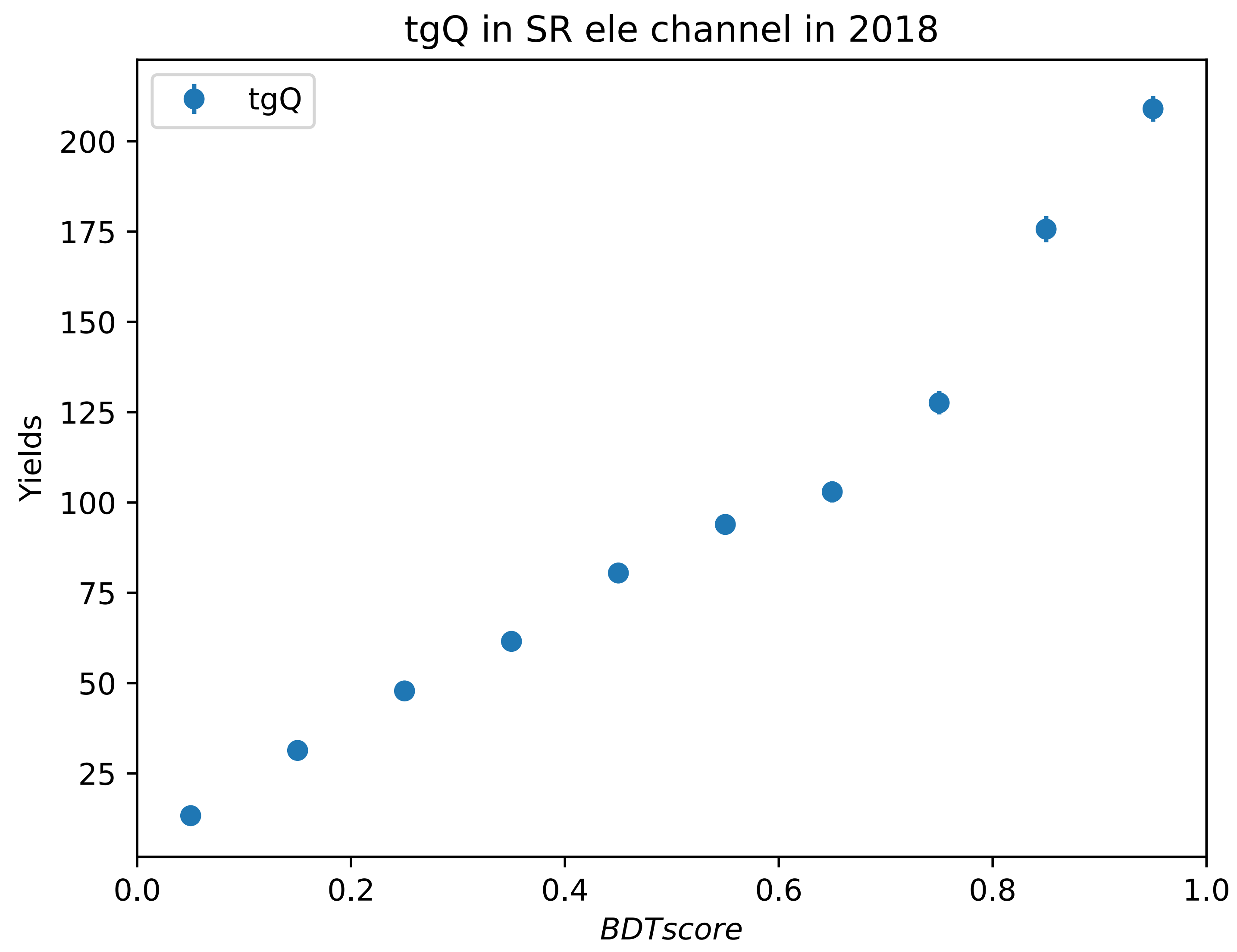


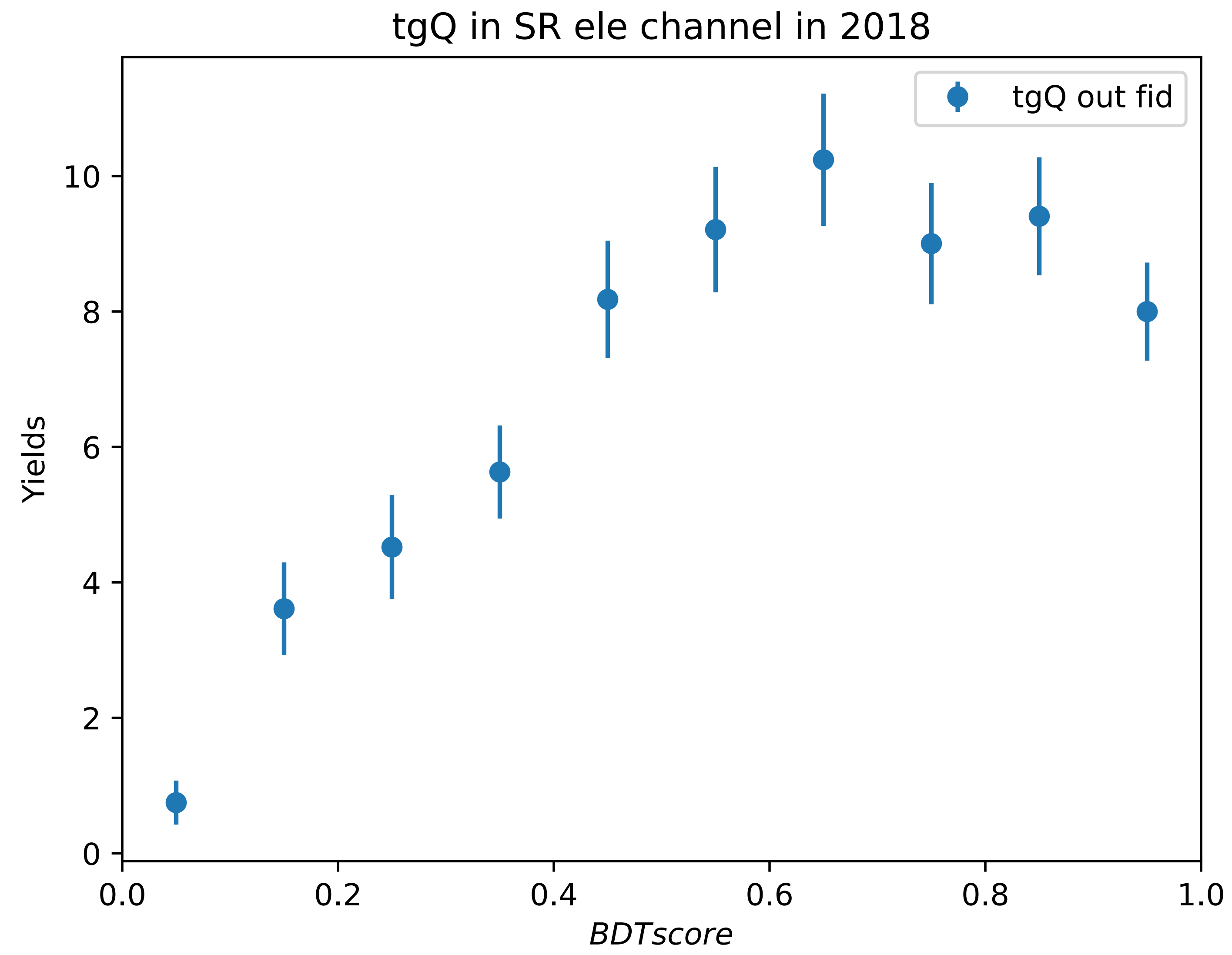


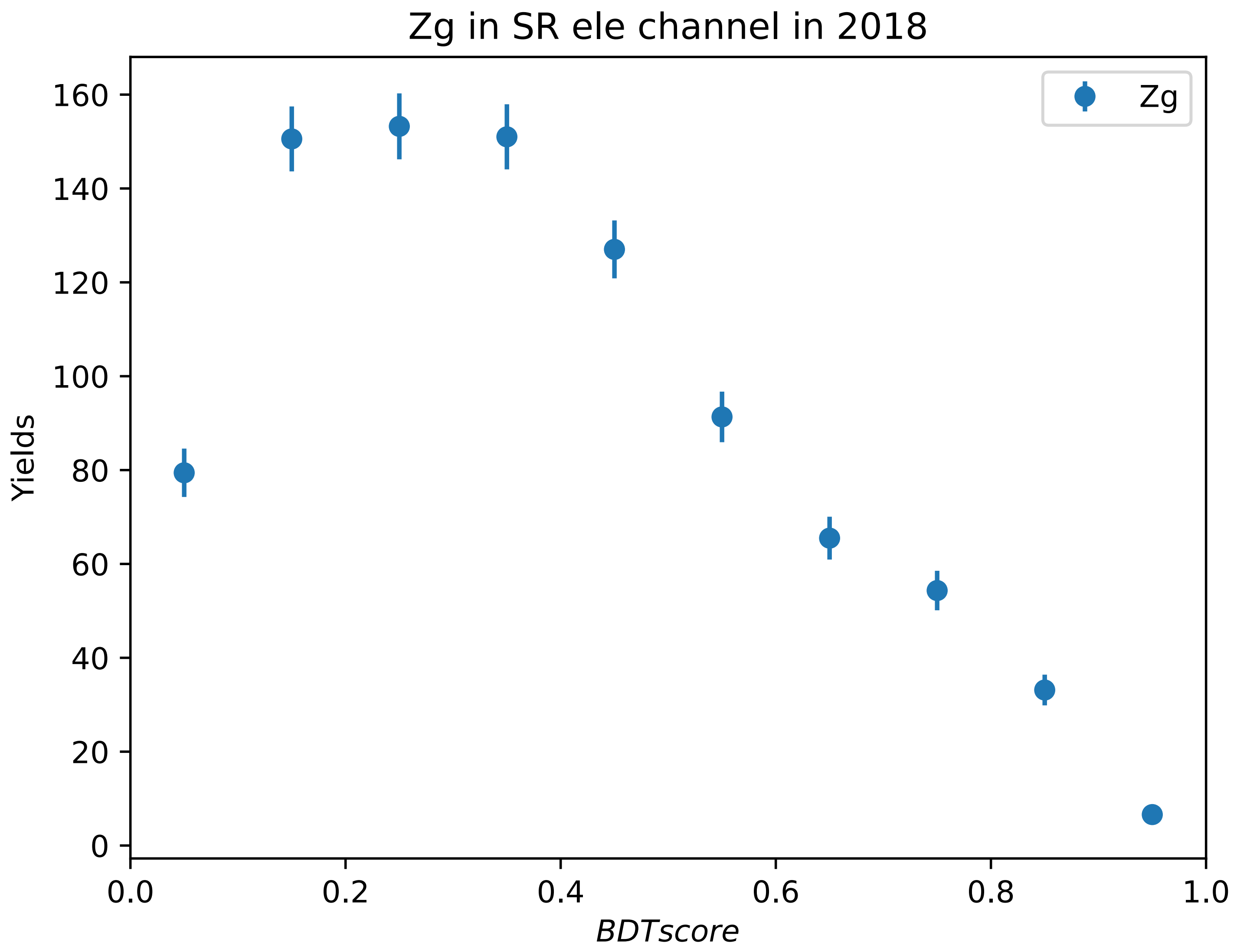


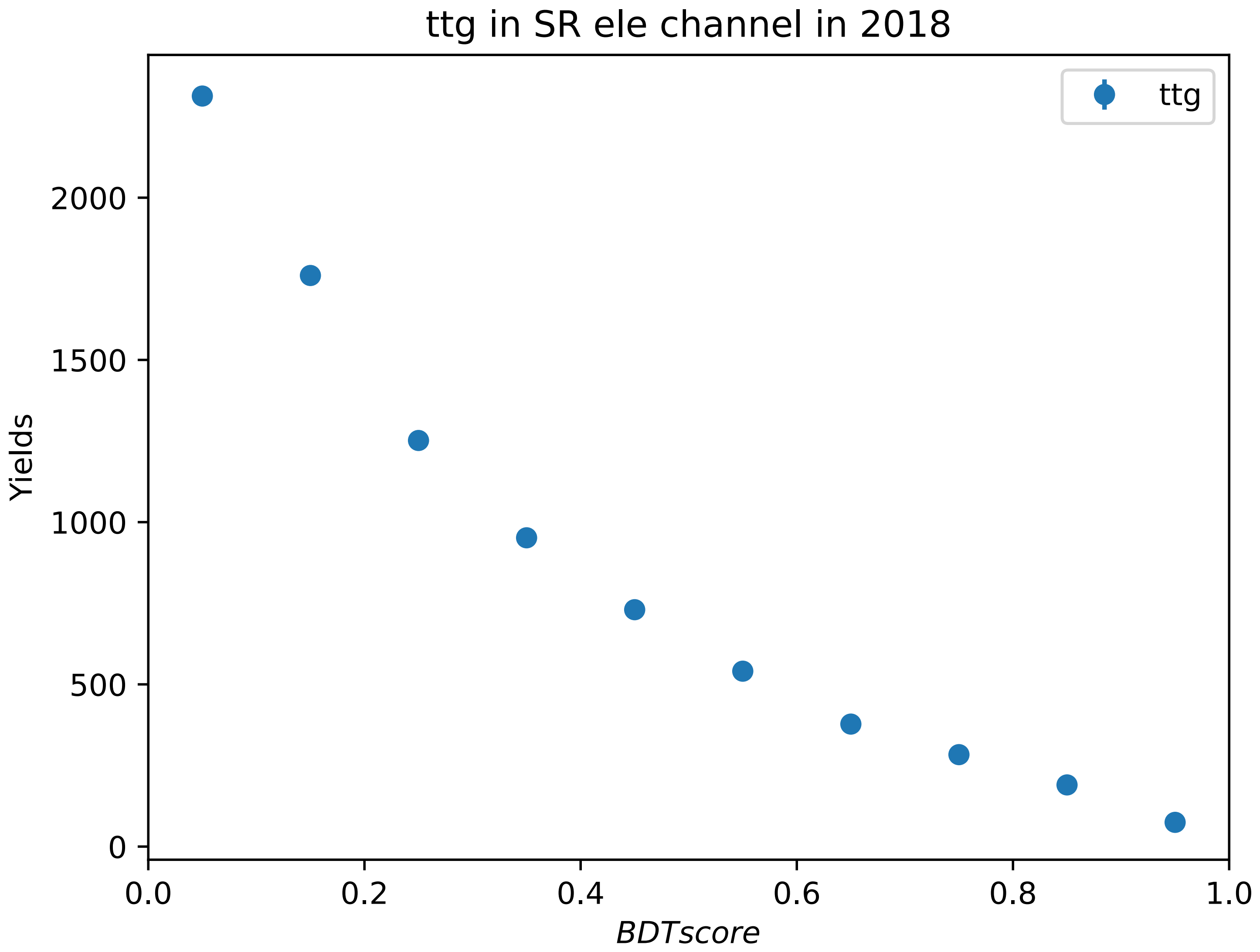


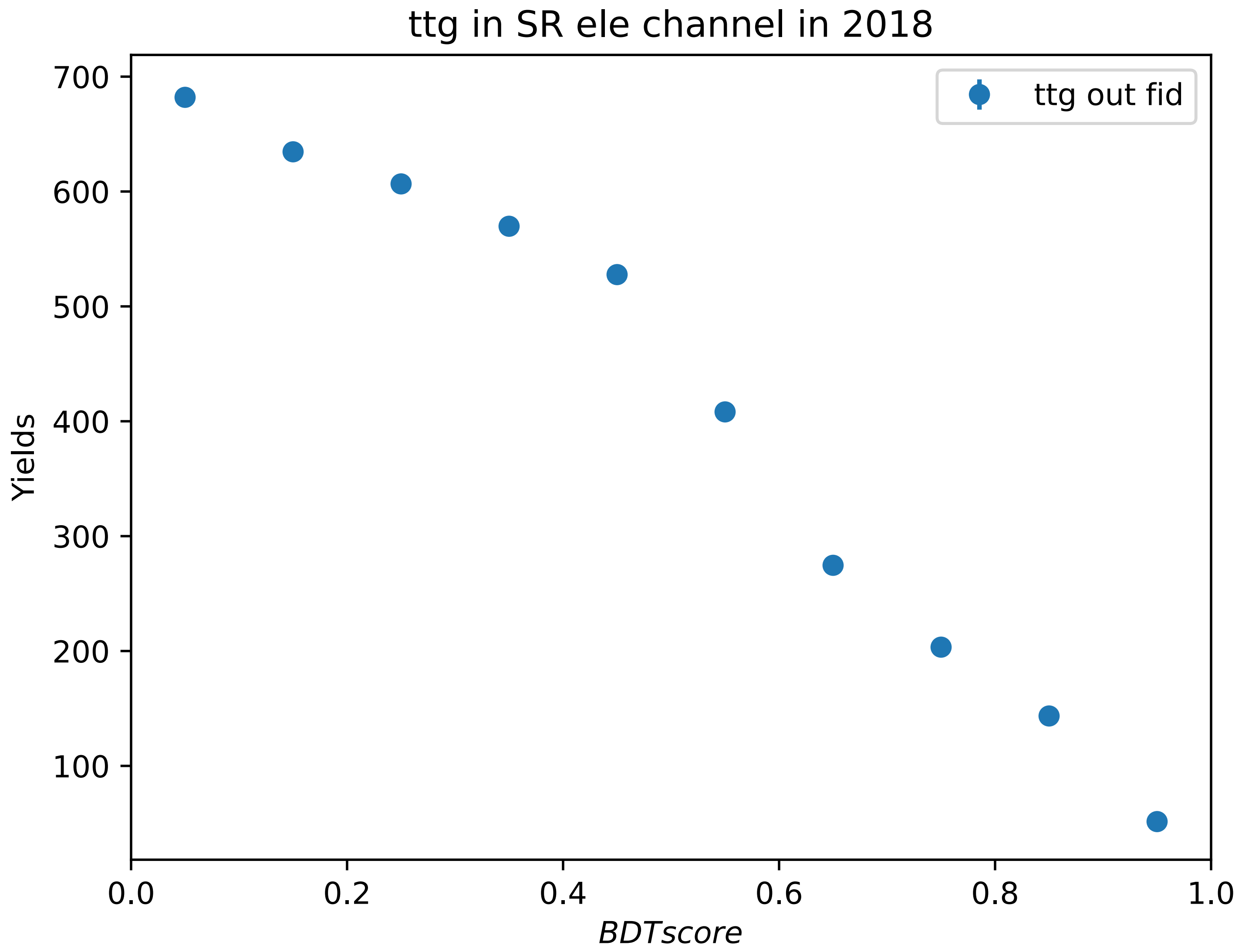
Input histograms for 2018 ele channel

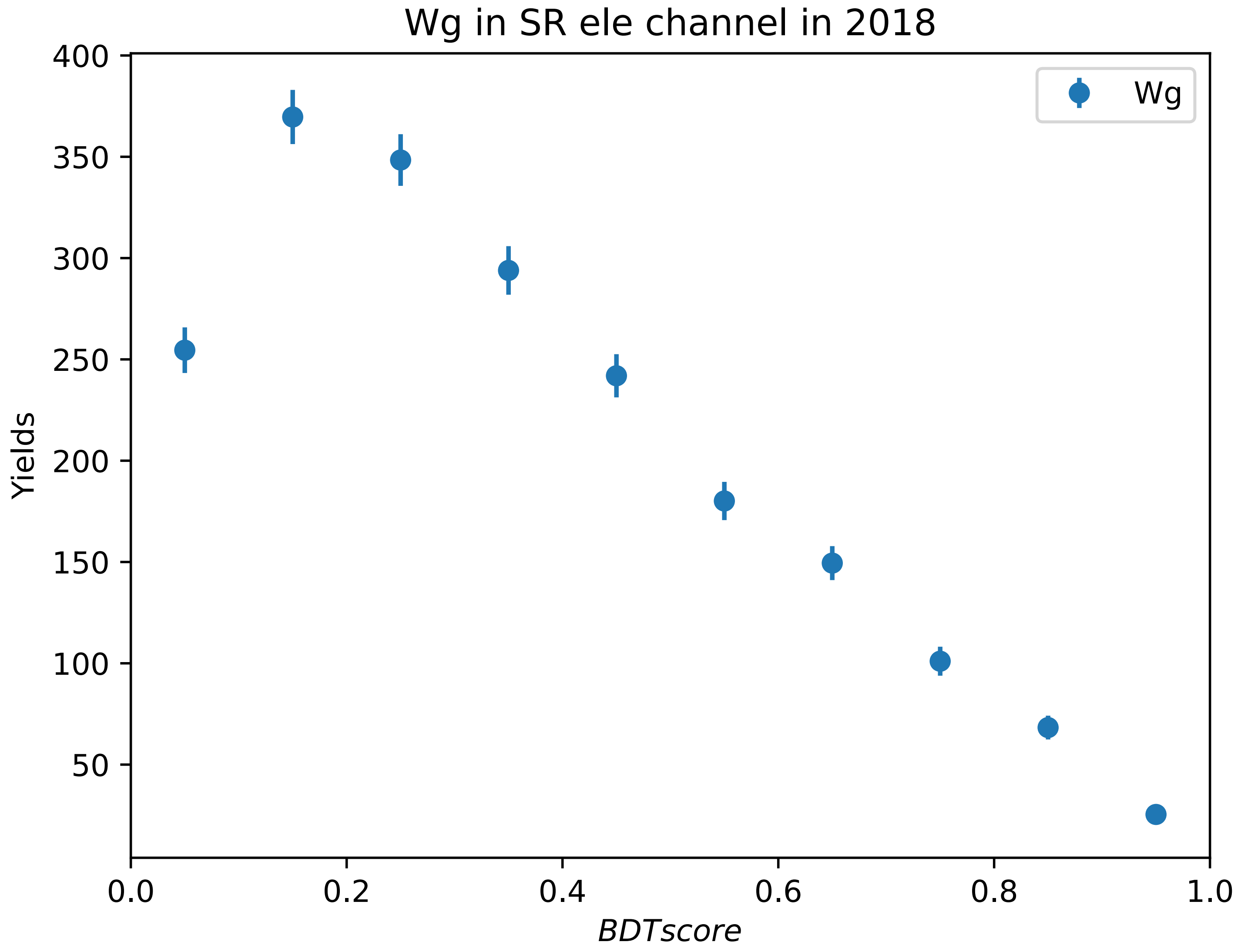




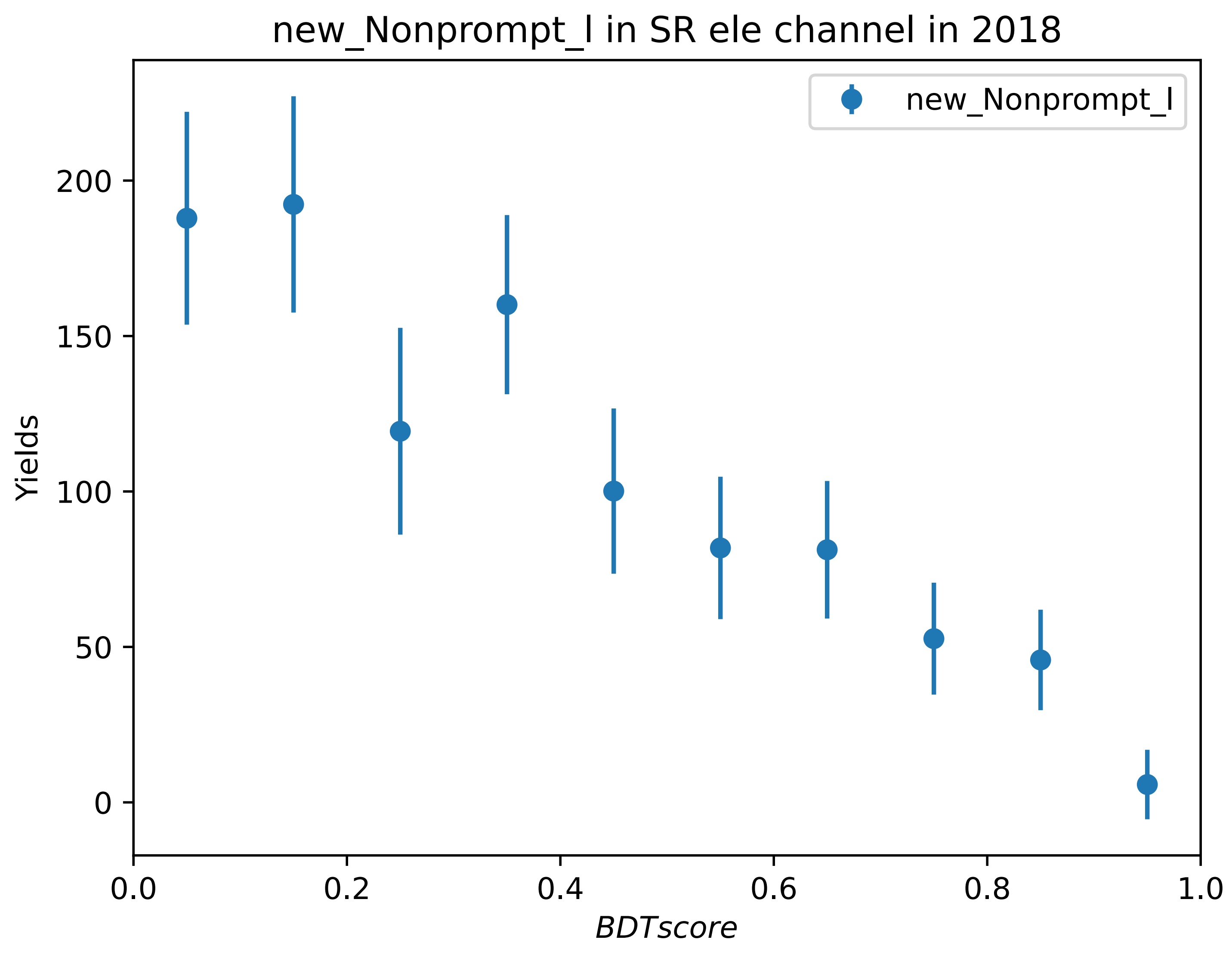


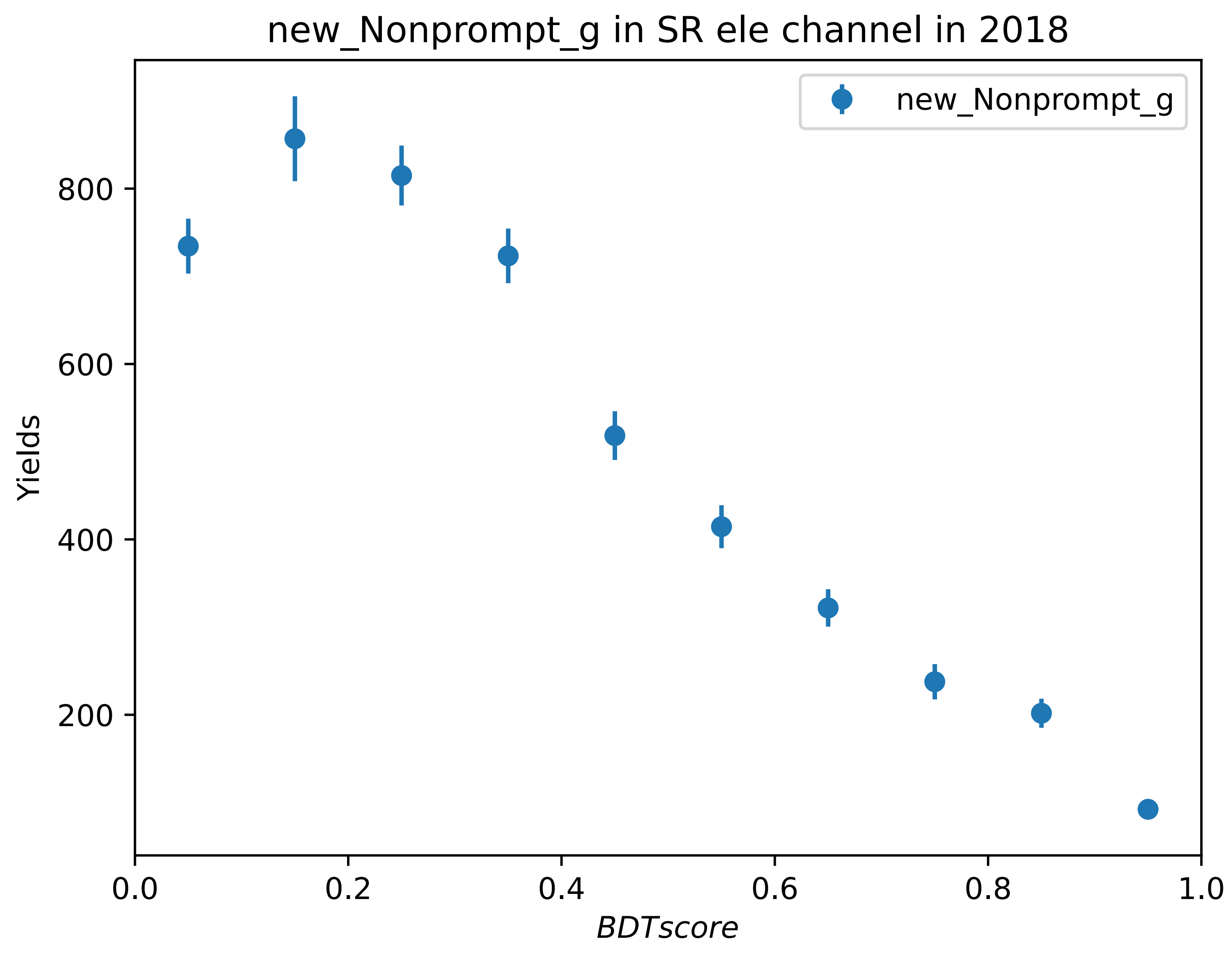


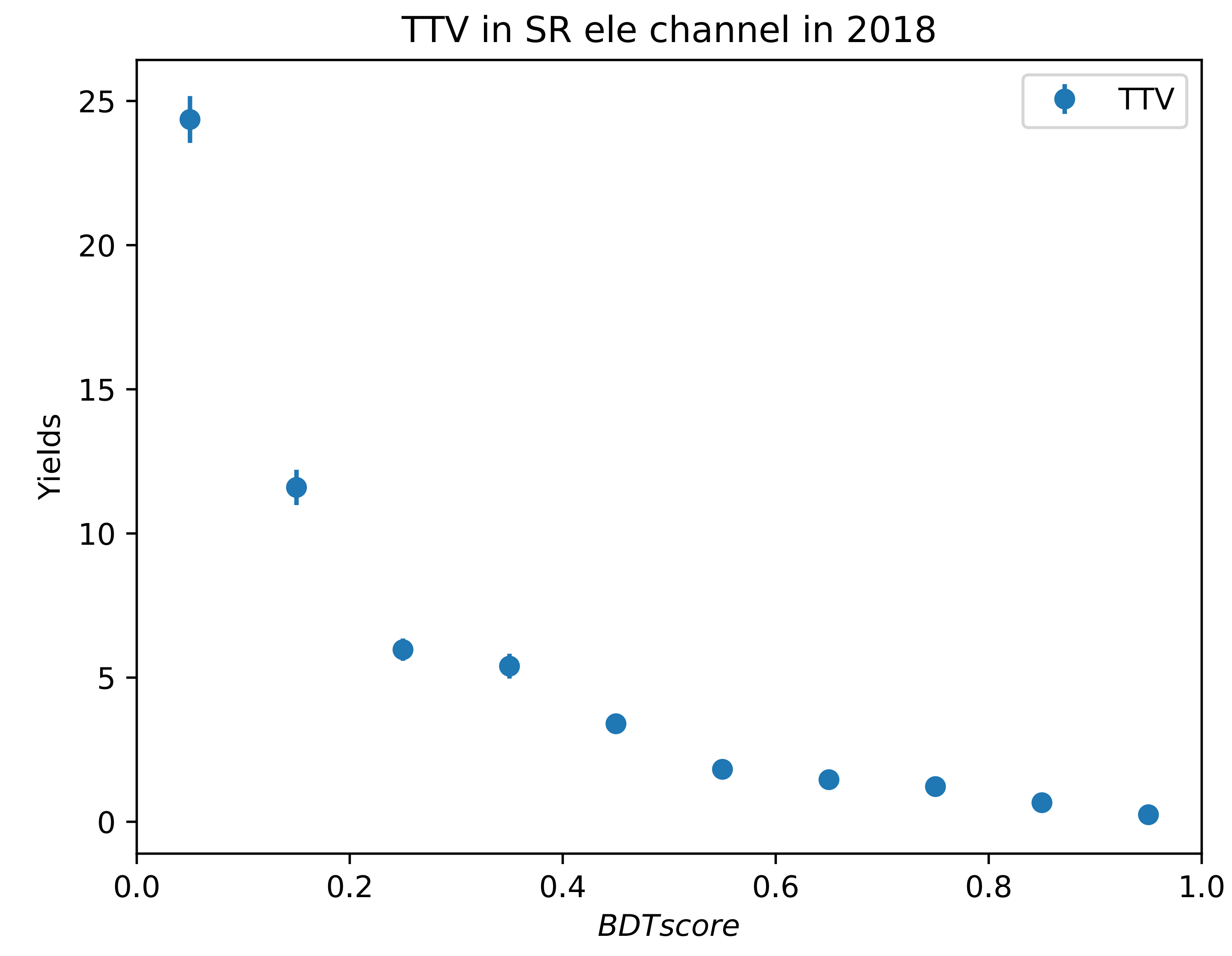


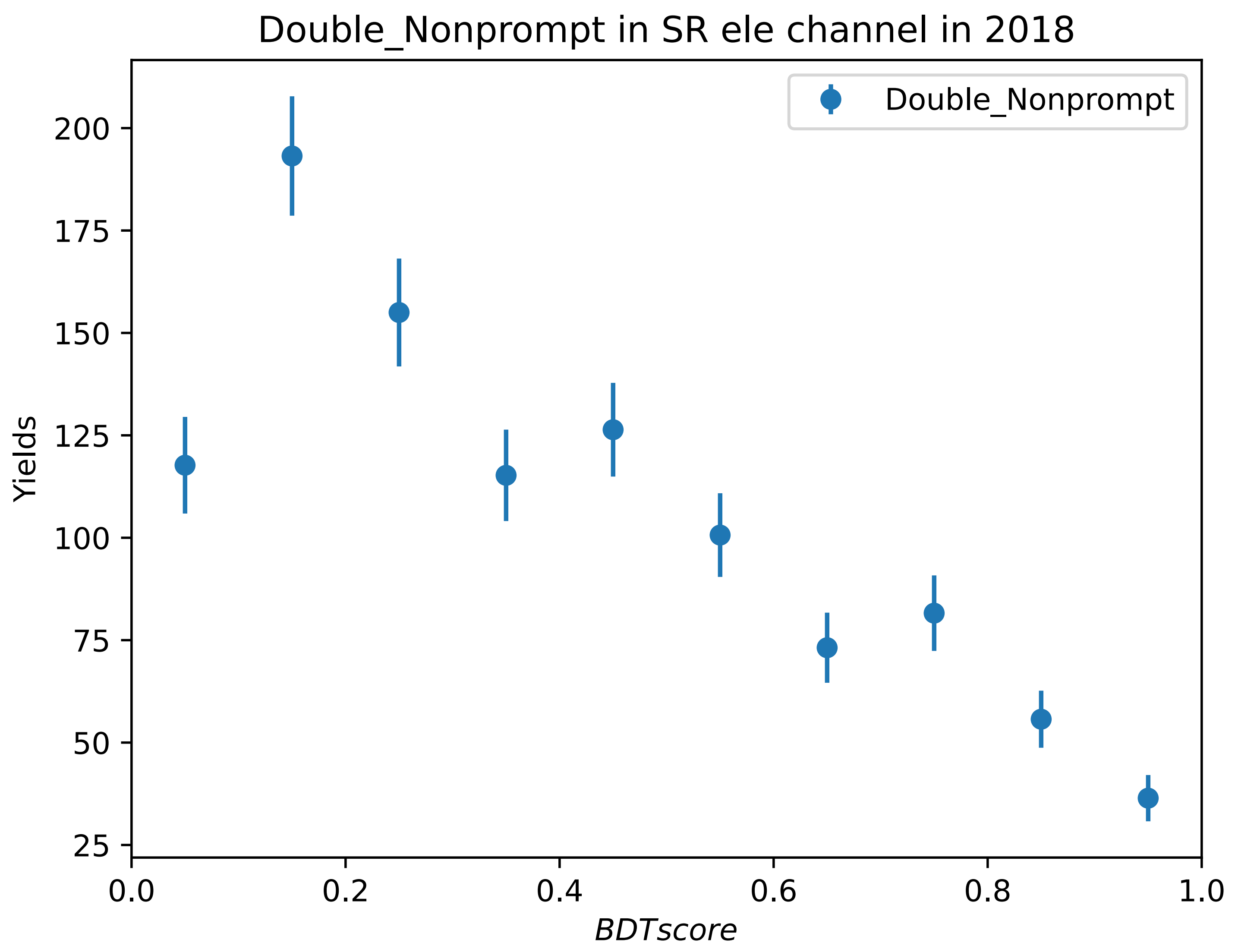


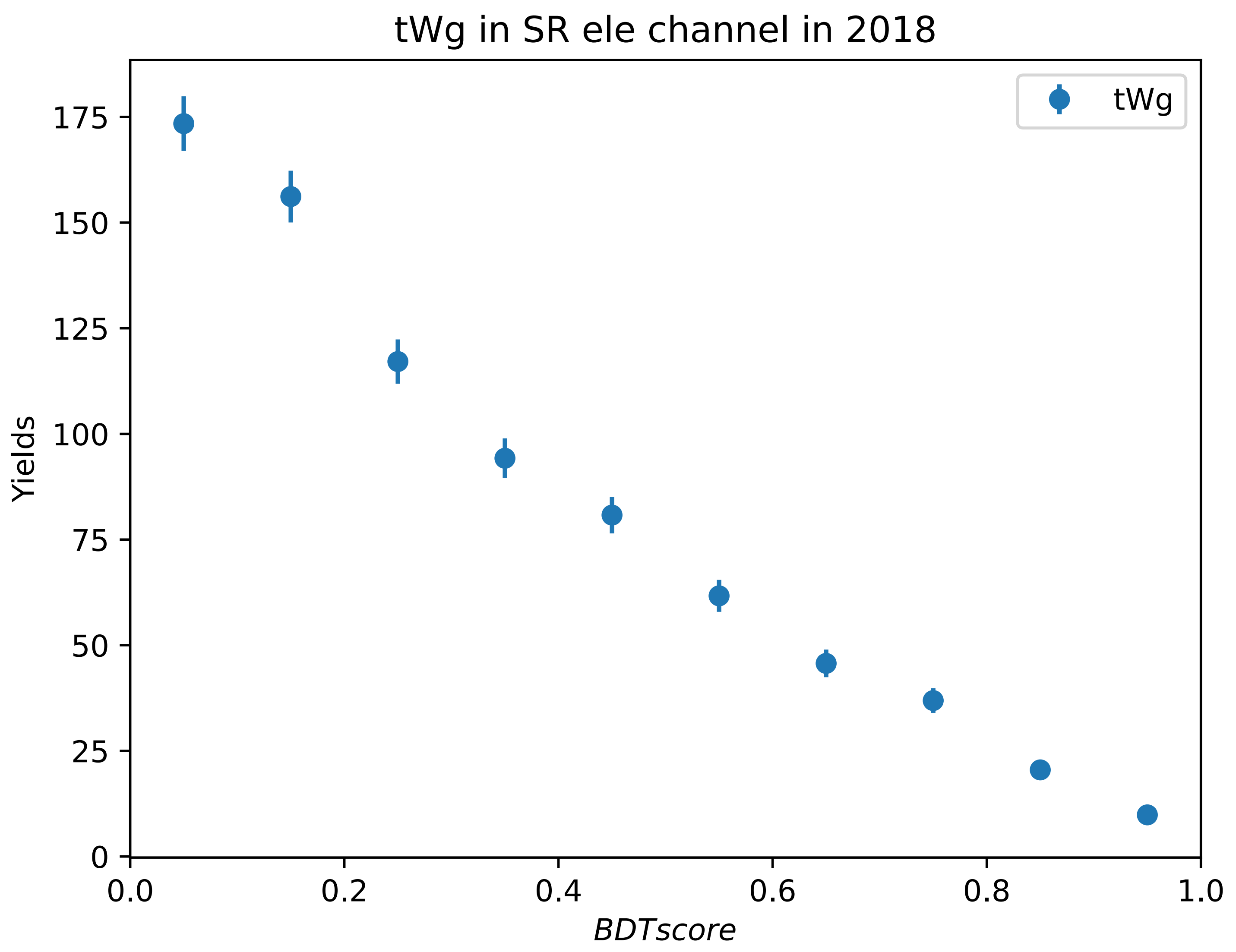
Input histograms for 2018 ele channel

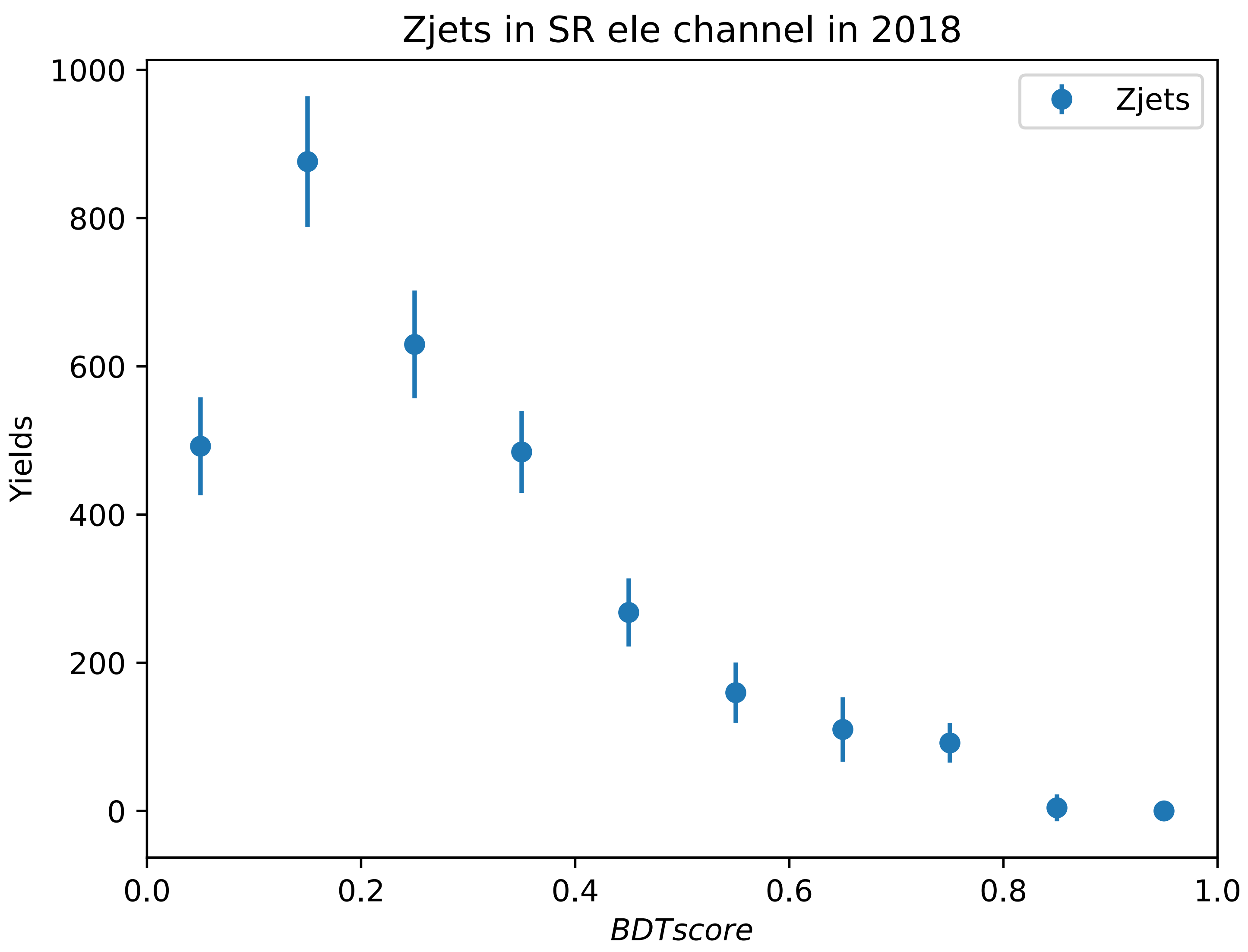












Check which samples drive MCstat uncertainty and request extensions where possible

Please show plots of binned data as it is given to the combine fit, e.g. with processes separated by years

autoMCStats [threshold] [include-signal = 0] [hist-mode = 1]

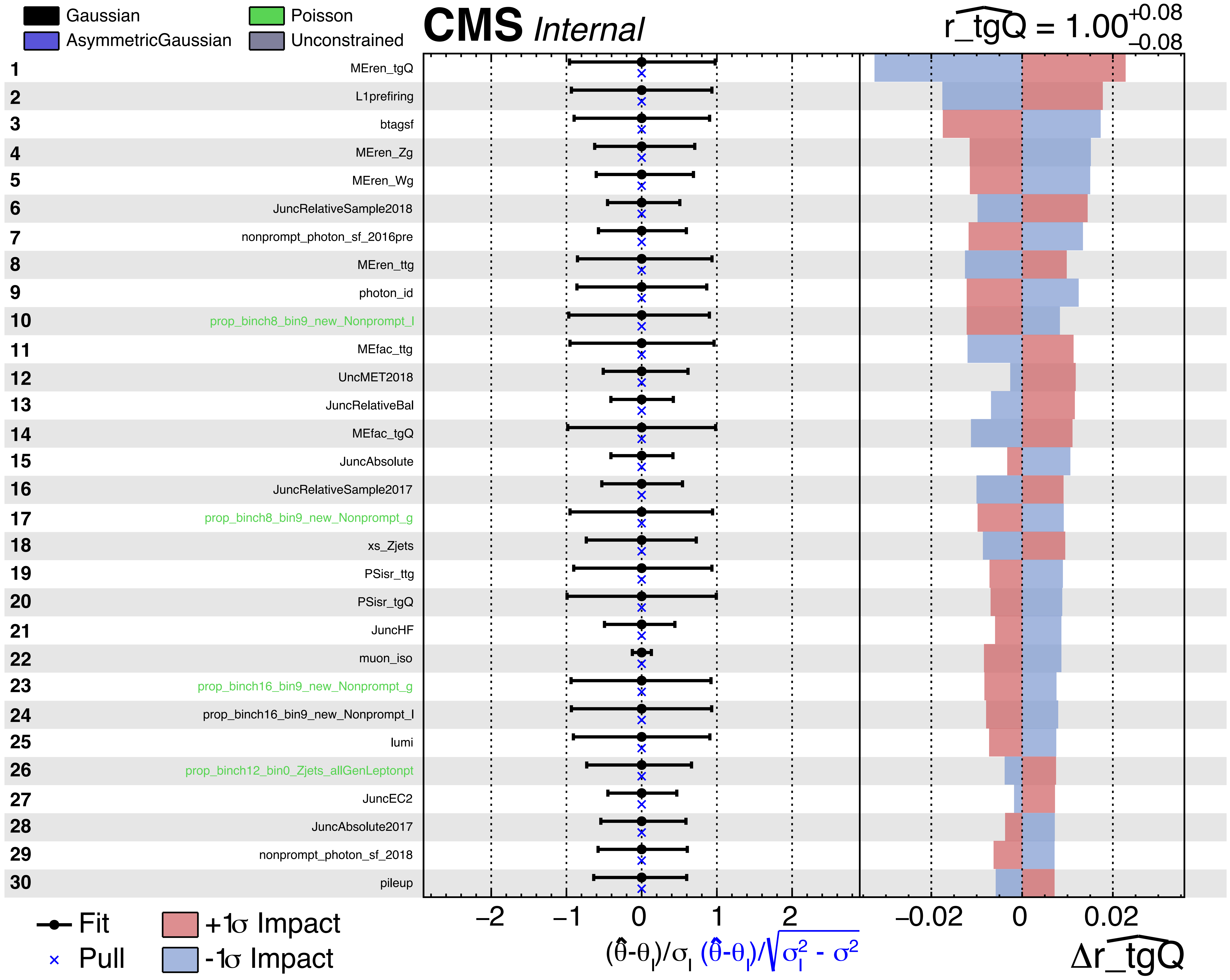
- The effective number of unweighted events are above threshold, the uncertainty will be modeled with the Barlow-Beeston-lite approach described above. Below the threshold an individual uncertainty per-process will be created
- We use autoMCStats 10 0 1 for results in CADI talk

```
-----------------------------------------------------------
8         1450.307685     33.249160       total sum
8         1903.000000     43.623388       Unweighted events, alpha=0.762116
  => Total parameter prop_binch8_bin8[0.00,-7.00,7.00] to be Gaussian constrained
-----------------------------------------------------------
9         786.197056      21.606461       total sum
9         1324.000000     36.386811       Unweighted events, alpha=0.593804
  => Total parameter prop_binch8_bin9[0.00,-7.00,7.00] to be Gaussian constrained
```

- To create an individual uncertainty per-process, we change it to ***autoMCStats 1904 1 1***
- More NPs increase the fit complexity, *--cminDefaultMinimizerStrategy 0* need to make the fit successful

Check which samples drive MCstat uncertainty and request extensions where possible

Please show plots of binned data as it is given to the combine fit, e.g. with processes separated by years



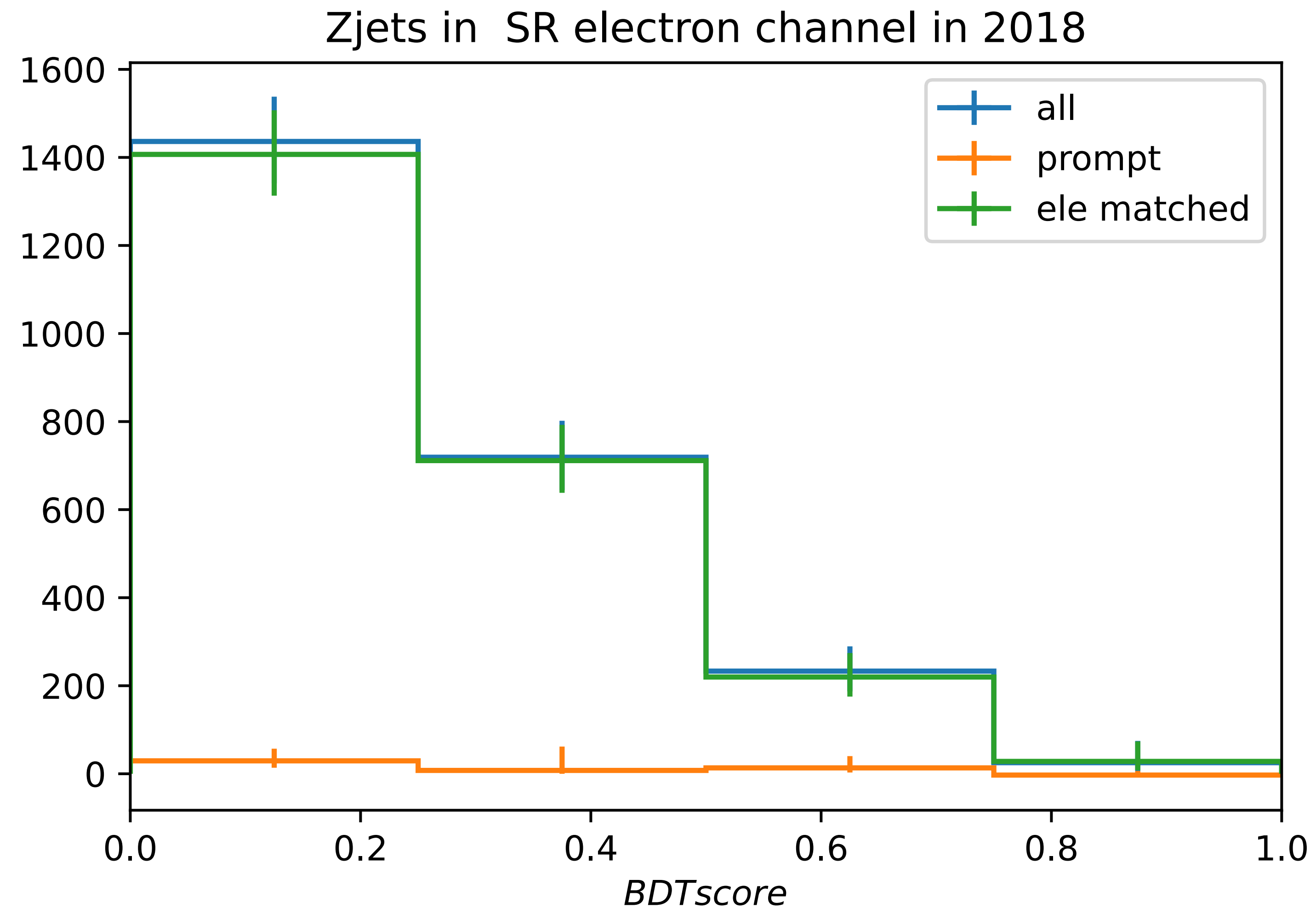
The final results don't change, the ranking of NPs impact change a little bit

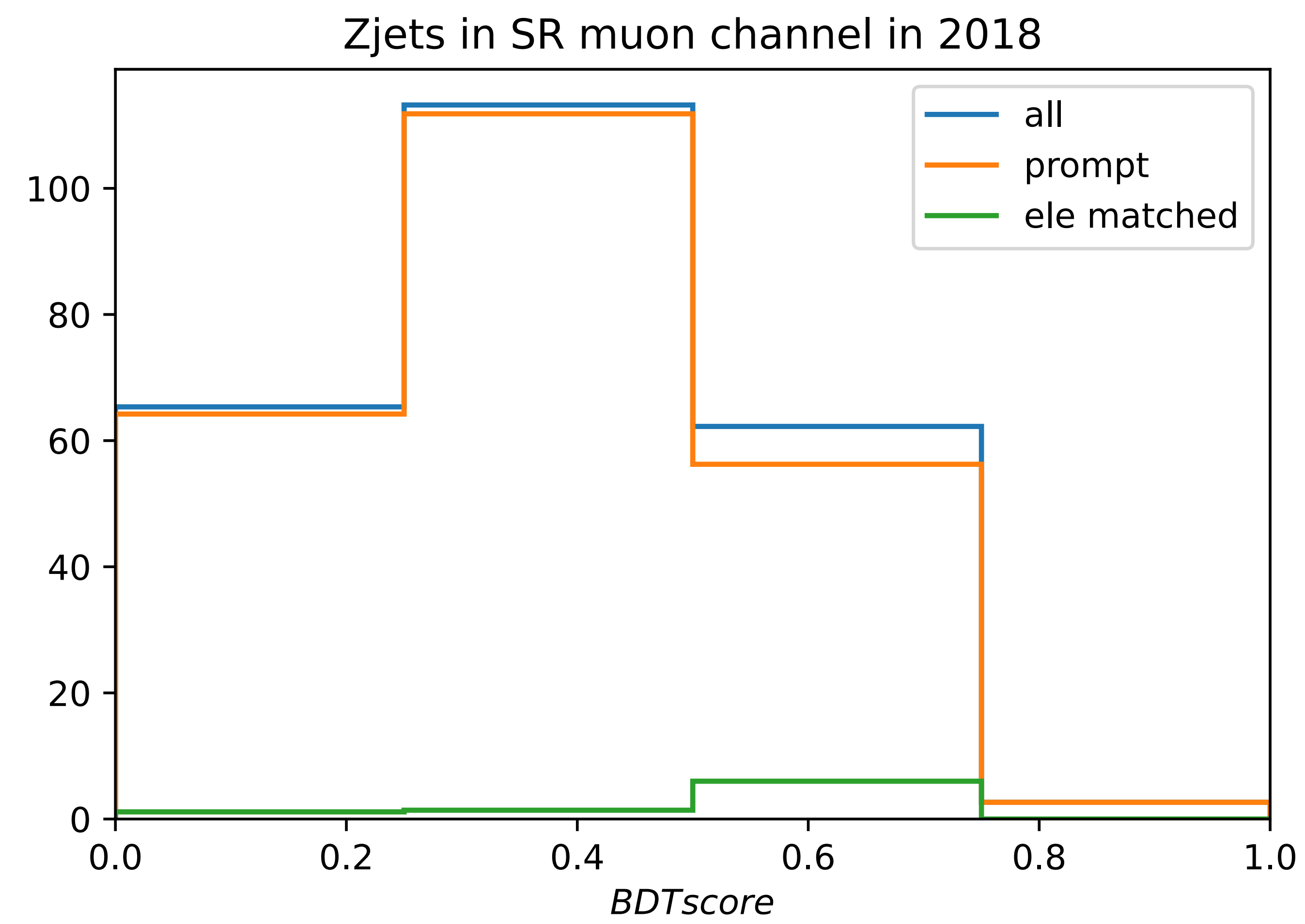
The two leading MC statistical NPs are from nonprompt lepton and photon in ch8 (2018 muon channel)

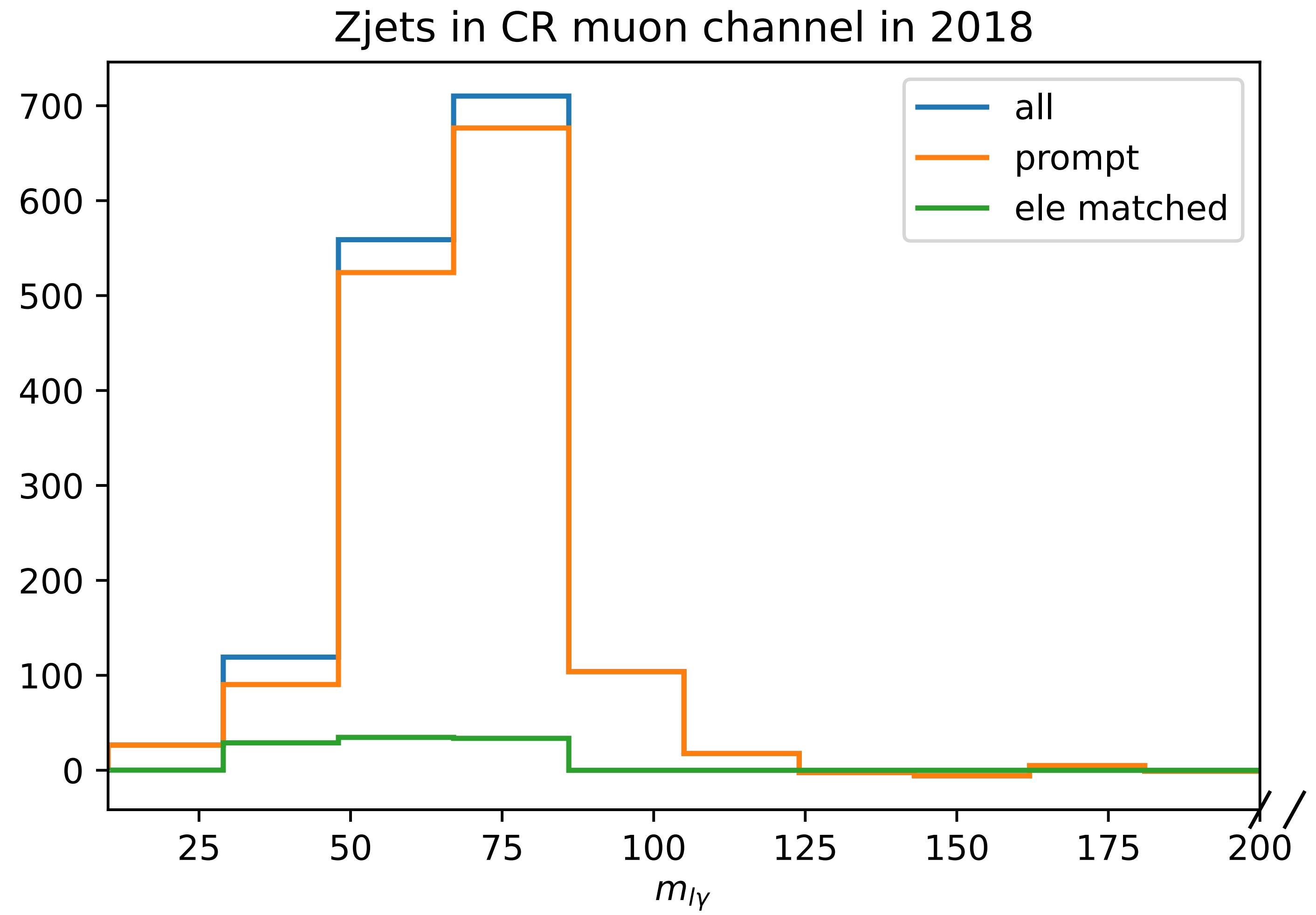
Try decorrelating the Z+jets, W+jets normalizations with and without b-jets present. A gaussian variable could be introduced to modify the ratio of the heavy flavor / light flavor normalization factors, with the light normalization left floating, for example.

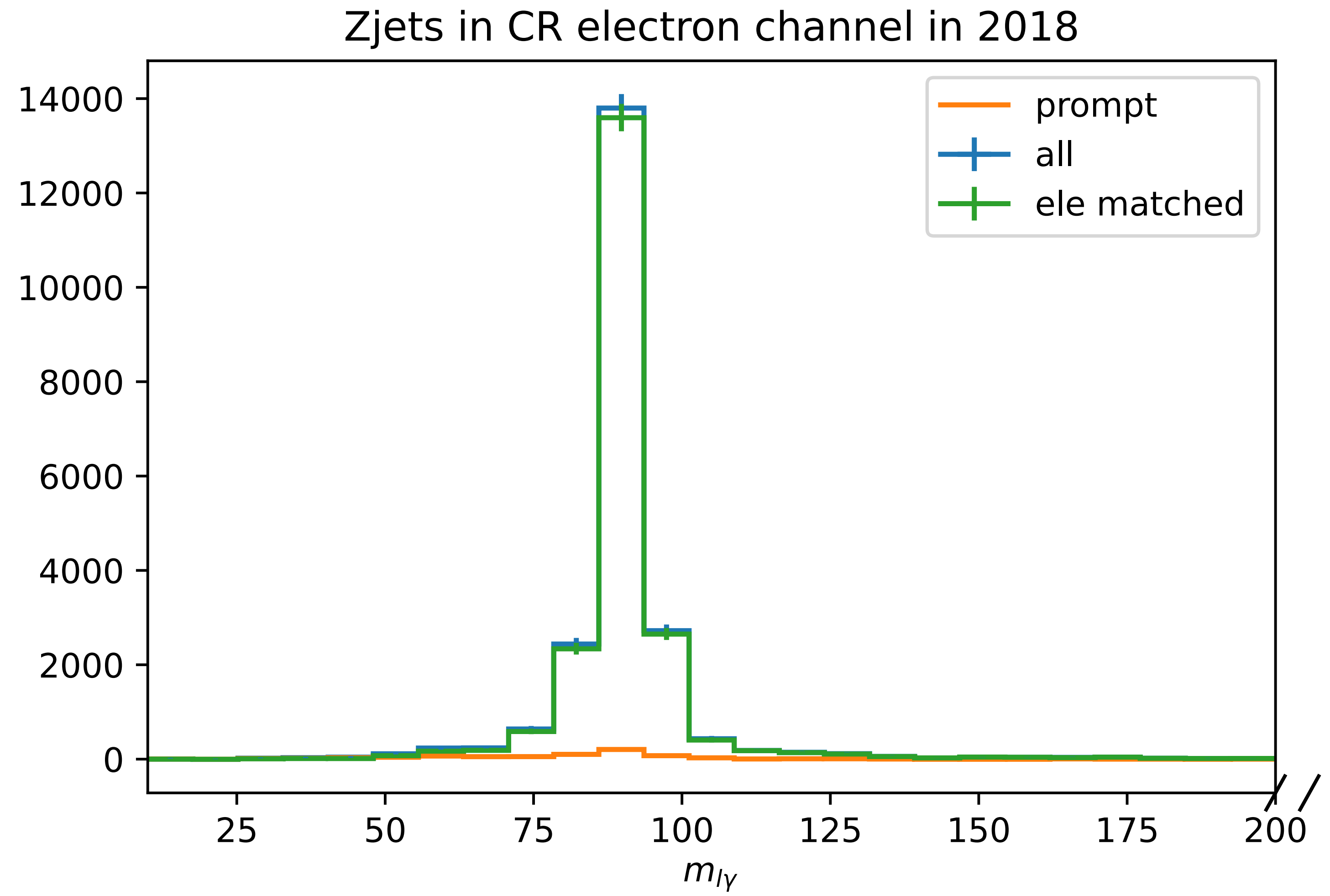
Find an alternative to decorrelating the Z+jets normalization between years. If there is really an effect due to the 2017 tracker upgrade, this can surely be handled without decorrelating all 4 data-taking periods arbitrarily, which is unphysical

- As a summary, we consider
  1. xs_wg_lightCR, xs_wg_bSR for both μ and e channel as lnN NPs
  2. xs_zjets_lightCR, xs_zjets_bSR for both μ and e channel as lnN NPs
  3. norm_zjets_lightCR16, norm_zjets_lightCR1718 for e channel as rateParam NPs
  4. norm_zjets_bSR16, norm_zjets_bSR1718 for e channel as rateParam NPs
- The Zjets contribution is not split to prompt or ele mis. γ, because it's almost pure prompt in μ channel and pure ele mis. γ in e channel as the following plots show.









Related to the above, it would be good to motivate why a dedicated treatment of the electron → photon fakes is not needed anymore.

- We still consider the electron → photon fakes and through our check in our Vγ validation region, we found that the electron → photon fakes don't show a shape trend, so it's good way to get its normalisation from fit.

We suggest producing a detailed comparison with TOP-18-010 to understand where the increased sensitivity comes from.

Selection

	TOP-18-010	TOP-25-003
2nd μ veto	PF candidate global or tracker muon	Cut-based loose ID
2nd γ veto	Cut-based medium ID w/o cuts on $\sigma_{i\eta i\eta}$ and chg.Iso pixelSeed veto	X
Photon η	Barrel	Barrel and endcaps
Jet	$\|\eta\|<2.4$ for all jets deepCSV for btagging $\Delta R(j,\gamma) > 0.1$	$\|\eta\|< 2.5$ (2.4) for btagged jets $\|\eta\|<4.7$ for non-bagged jets deepJet for btagging $\Delta R(j,\gamma) > 0.4$
Nj	$N_j \geq 3$, $N_b \geq 2$	$N_j \geq 2$, $N_b \geq 1$

For the background estimation:

- The main difference is on the Nonprompt ℓ estimation
- The nonprompt γ and ele mis. γ are almost the same

  Nonprompt γ → ABCD method

  ele mis. γ → free floating from fit

Shouldn’t we consider tWgamma as part of your signal? The story is similar to https://arxiv.org/pdf/2410.23475.

The tWγ samples are only available for dilepton channel, we use tW inclusive sample which should be fine.

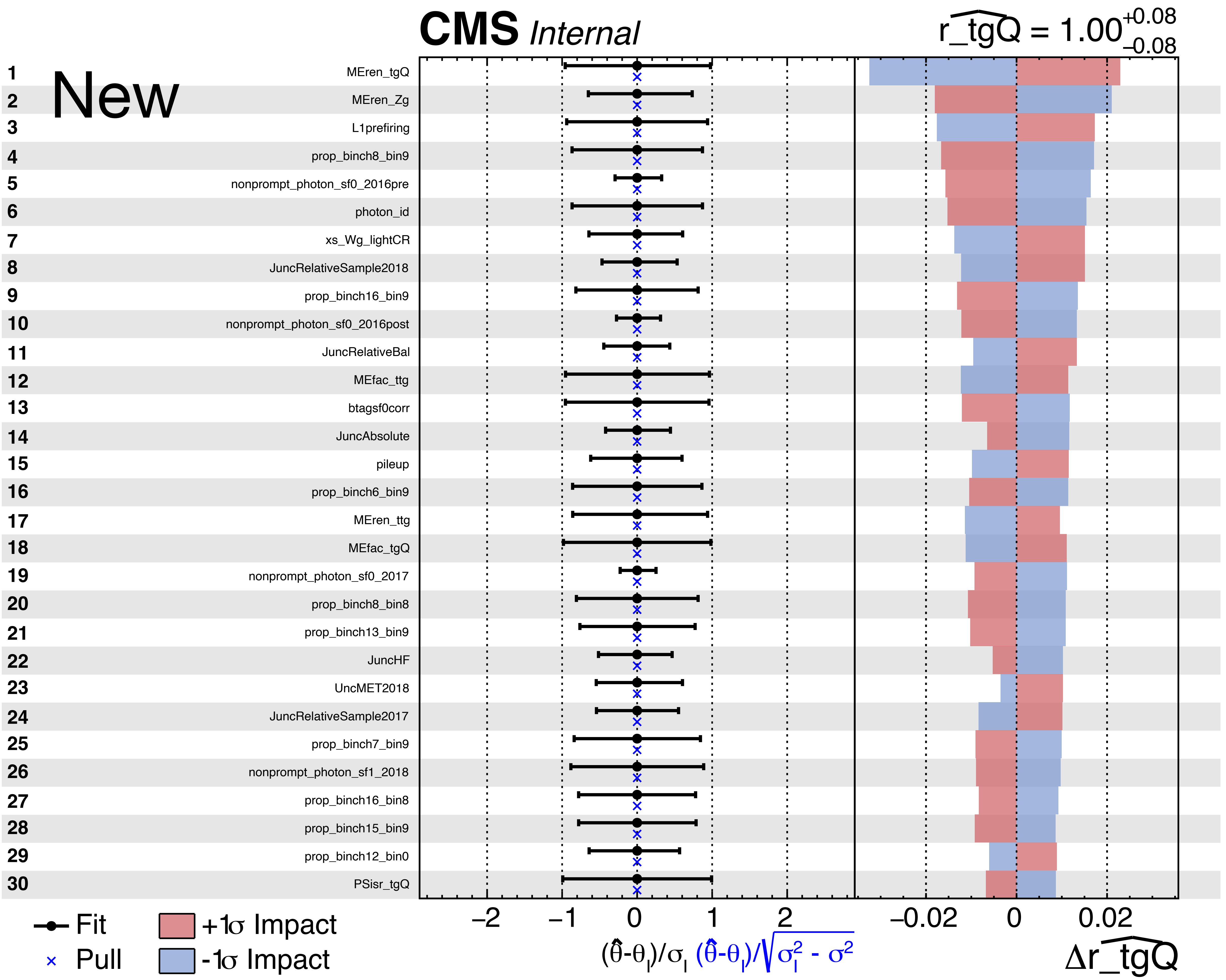
Is photon pT really flat in the closure test? Although we don't know for sure that this is not a mismodeling in the MC, it might be useful to check the impact on the final result and if relevant consider this as an additional uncertainty on the fakes.

Nonprompt gamma shape uncertainty: decompose this into two separate shape templates with different nuisance parameters, so that the shape variations have meaning, rather than summing in quadrature

The shape uncertainty is included now, new impact and uncertainty templates are provided seen next slide

Jet energy correction uncertainties: Try to keep these consistent between samples in a way that preserves correlations. For example, having a “flat” uncertainty on smaller samples that is constructed as a shape template with the same nuisance as other samples, so as to preserve the correct up or down behavior in the normalization. Or consider combining small samples, if that is sufficient. But avoid splitting one JEC uncertainty source into two parameters in the combine datacards.

Fixed, new results are procured and provided



New tγq for photon pT

r_1	:	1.000	-0.154/+0.159
r_2	:	1.000	-0.122/+0.126
r_3	:	1.000	-0.105/+0.109
r_4	:	1.000	-0.090/+0.092

Variables	Bin [GeV]	$\mu \pm \Delta\mu$
p_T^γ	20–27	$+1.0^{+0.154}_{-0.152}$
	27–38	$+1.0^{+0.126}_{-0.125}$
	38–60	$+1.0^{+0.110}_{-0.107}$
	60–200	$+1.0^{+0.092}_{-0.091}$

AN v3

Both inclusive and differential fits have negligible change.

Try summing up differential results across the different bins and taking the correlations into account in order to get an alternate and more compatible estimate of the inclusive cross section. Is the theory uncertainty reduced in this way?

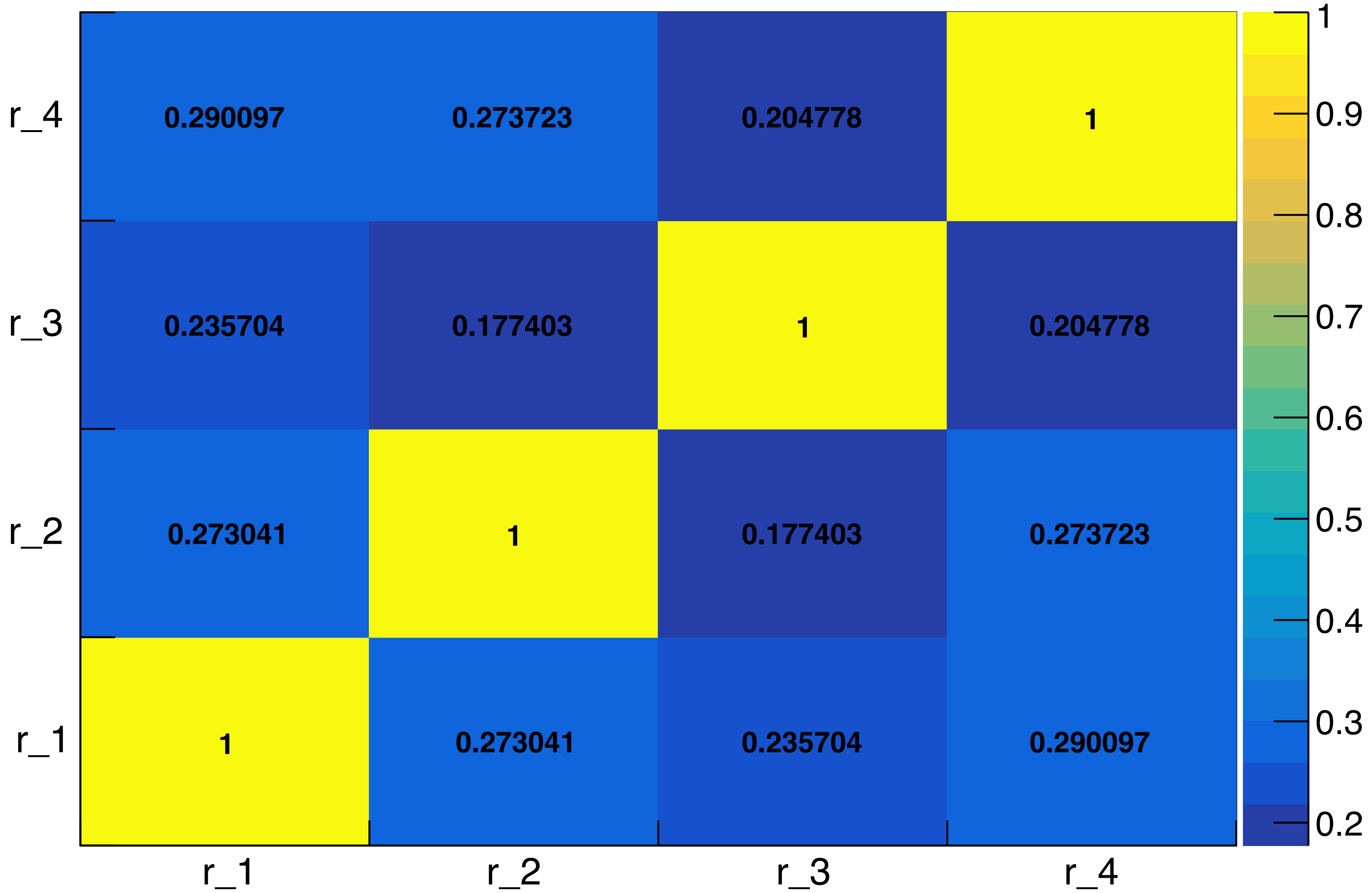
$$r_{\text{tot}} \cdot N = \sum_i r_i \cdot n_i \qquad cov(r_{\text{tot}}, r_{\text{tot}}) = cov(\sum_i r_i \frac{n_i}{N}, \sum_j r_j \frac{n_j}{N})$$

$$r_{\text{tot}} = \sum_i r_i \frac{n_i}{N} \qquad cov(r_{\text{tot}}, r_{\text{tot}}) = \sum_{ij} \frac{n_i}{N}\frac{n_j}{N} cov(r_i, r_j)$$

New tγq for photon pT

r_1	:	1.000	-0.154/+0.159
r_2	:	1.000	-0.122/+0.126
r_3	:	1.000	-0.105/+0.109
r_4	:	1.000	-0.090/+0.092

Correlation Matrix tγq



By equation of $\text{cov}(r_i, r_j) = \rho_{ij}\sigma_i\sigma_j$ and the results from differential photon p_T fit, we have covariance of signal strengths of different reconstructed bins:

[0.024 0.005 0.005 0.004]
[0.005 0.015 0.004 0.004]
[0.005 0.004 0.011 0.004]
[0.004 0.004 0.004 0.008]
[0.289 0.253 0.241 0.216]

Variance of r_{tot} = 0.007
Std dev of r_{tot} = **0.085**

Compatible with the inclusive fit result 1 ± 0.08

In the gen level definition in the AN it is specified that the lepton/photon should not have a meson mother, but I think it should not originate from hadrons. Was this a typo or why are you only rejecting meson mothers? For the dressed lepton it is also specified to require "No meson mother", how is this done using the GenDressedLepton collection in NanoAOD? For the gen photon a custom isolation is used. Was this used in other analyses before? And how does it compare to the Frixione isolation criteria that is often used instead?

- We reject both meson and hadron mothers.
- The *GenDresseLepton* already requires that mothers not from mesons and hadrons
- It was used in TOP-18-010. The default *Frixione* value used in *GenIsolatedPhoton* is 0.4, so we're using a loose requirement with more events passing.

In your presentation the benefit of removing the b jet requirement on gen level was mentioned. I am wondering if also the jet requirement can/should be removed. This could have a similar improvement and also simplify the gen level definition. Since you only unfold to lepton photon related variables I don't see that it is needed. Unless you plan to also unfold to some jet related variables of course. Or does the jet requirement reduce theory uncertainties in the fiducial phase space (see next question)?

In the inclusive fit, do you normalize the theory uncertainties in the fiducial phase space or do you take them as they are? Similar for the unfolding, how do you treat the theory uncertainties in particular w.r.t. how they change the normalization of the generator level bins? Do you do any normalization of these variations or are they the same as used in the inclusive fit?

- I refer to the single top differential cross section measurements to define our fiducial region with an extra photon included. We don't study the effect of jet requirement on the theory uncertainty, but it should have a negligible effect
- The theory uncertainties are first normalized to the nominal cross section without any selection applied. If it's signal, they're then normalised to the fiducial phase space for the inclusive fit and to each bin for the differential fits. Furthermore, the normalisation part of the theory uncertainty template for signal is removed by scaling the uncertainty template to the nominal integral.

The data driven estimation gives reasonable results, it is very sophisticated and interesting in particular w.r.t. the double nonprompt contribution. Was this developed for this analysis or was this used before somewhere else? Which events contain these a, b, c regions? Are those the "application regions", i.e. the regions where the fakerate factors are applied? If this is the case, do the fakerate factors themself not also depend on the double nonprompt? There are some approximations in this method "a.3 ≈ c.3, b.3 ≈ c.4, a.4 ≈ b.4 ≈ c.1" how did you conclude to these approximations and what are the assumptions?

- It was also used in analysis SMP-19-002 (inclusive Wγ XS measurement) and SMP-21-011 (VBS Wγ)
- Yes. The a, b, and c regions are different application regions.
- The fake rate for nonprompt lepton and photon are calculated in corresponding enriched region. The double nonprompt is due to the usage of more than one data-driven samples.
- The assumption is based on the weights nonprompt CR lepton (photon) equals to the nonprompt SR (lepton) photon. I provide some closure test results shown in next slide.

Use ttbar simulation to calculate nonprompt lepton and photon fake rate and perform the closure test


CMS Preliminary 138 fb^{-1} (13 TeV)
double fake in SR
double fake est. in double CR → c.1
double fake in γ CR → a.4
double fake in l CR → b.4
μ channel
e channel
P γ_{CR} + NP l_{SR} in γ CR with w_γ → a.3
P γ_{CR} + NP l_{CR} in double CR with $w_\gamma w_l$ → c.3
NP γ_{SR} + P l_{CR} in l CR with w_l → b.3
NP γ_{CR} + P l_{CR} in double CR with $w_\gamma w_l$ → c.4
Events/bin
Est./SR
Photon η


CMS Preliminary
138 fb^{-1} (13 TeV)
double fake in SR
double fake est. in double CR → c.1
double fake in γ CR → a.4
double fake in l CR → b.4
μ channel
e channel
P γ_{CR} + NP l_{SR} in γ CR with w_γ → a.3
P γ_{CR} + NP l_{CR} in double CR with $w_\gamma w_l$ → c.3
NP γ_{SR} + P l_{CR} in l CR with w_l → b.3
NP γ_{CR} + P l_{CR} in double CR with $w_\gamma w_l$ → c.4
Events/bin
Est./SR
$m_{l\gamma}$

Main changes summary

- Merge single top s-channel, ttbarV, and VV into one histogram
- Add shape uncertainty for nonprompt lepton and photon
- Split btag uncertainties to corr. and uncorr.
- Add correlated part of lumi between 2017 and 2018
- Split muon uncertainty into systematical and statistical parts and remove muon reconstruction uncertainty
- Add log-normal uncertainty for Wγ and Zjets as suggested
- Change the correlation of rateParam of Zjets normalisation for ele mis. γ
- Optimising the binning for differential fits of the lepton p_T and $m_{\ell\gamma}$
- Add differential results for ΔR(top,γ) in Parton level