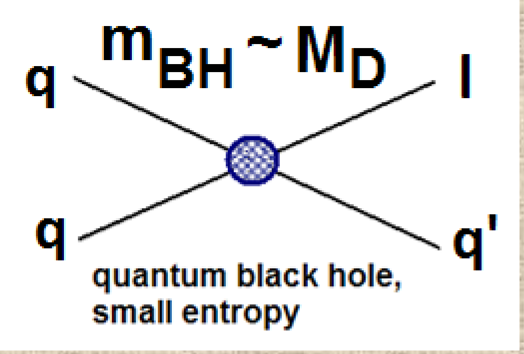
Search for Quantum Black Holes in 1 lepton + 1 jet channel at 13 TeV with the ATLAS

Sergey Karpov and Zoya Karpova

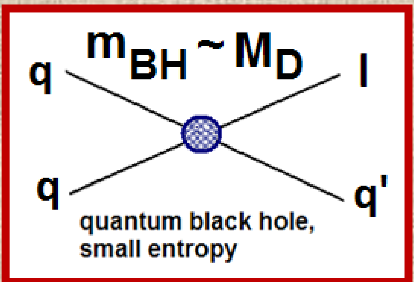
(Joint Inst. for Nuclear Research, Dubna, Russia)

On behalf of the ATLAS collaboration



25th anniversary of JINR in ATLAS, 24-29 April, 2017, Budva, Becici, Montenegro

Introduction



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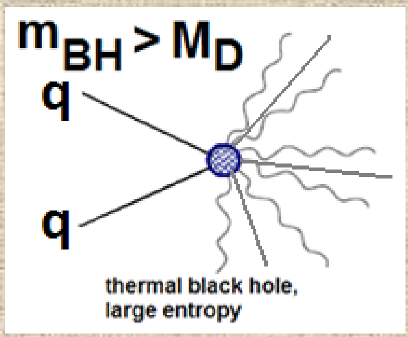


Quantum Black Holes (QBHs) are predicted in low-scale quantum gravity theories that offer solutions to the mass hierarchy problem of the Standard Model (SM) by lowering the scale of quantum gravity (M_D) from the Planck scale (~10^{16} TeV) to the TeV region. Here M_D is a multidimensional mass.

Features. The QBHs with masses near M_D have to decay to small number of particles (in upper panel). They have to conserve electric charge, color and total angular momentum. This quasi-particle behavior of QBHs (small entropy) differs from semi-classical Thermal Black Holes (TBH), which decay via Hawking radiation to a large number of objects (large entropy, bottom figure).

Signature. The QBH's decay mode in our analysis is assumed with 1 lepton (electron or muon) and 1 jet in final state. This mode has the best branching and signal to background ratio in ADD model.

Our intention is the search for QBH at 13 TeV with the same strategy, conditions and cuts as they were in previous analysis at 8 TeV.

The Large Extra Spatial Dimension Model was suggested by Arkani-Hamed, Dimopoulos and Dvali (ADD model) [1-3]:

[1] N. Arkani-Hamed, S. Dimopoulos, and G. R. Dvali, Phys. Lett. B 429, 263 (1998), arXiv:hep-ph/9803315.

[2] I. Antoniadis, N. Arkani-Hamed, S. Dimopoulos, and G. R. Dvali, Phys. Lett. B 436, 257 (1998), arXiv:hep-ph/9804398.

[3] N. Arkani-Hamed, S. Dimopoulos, and G. R. Dvali, Phys. Rev. D 59, 086004 (1999), arXiv:hep-ph/9807344.

Shortly about ADD-model

The Large Extra Spatial Dimension Model with n compact extra dimensions

The ADD model is founded on idea that low-scale quantum gravity relates to the large spatial extra dimensions. Only the gravitational field is allowed to penetrate into the extra dimensions, while all other physical fields of the Standard model are localized in the usual four-dimensional space-time.

The multi-dimensional mass scale is assumed approximately equal to the electroweak scale $M_D \approx M_{EWK}$ ~1 TeV for removing the hierarchy problem. The true Planck scale (4-dimentional) is equal $M_{Pl} \sim 10^{16}$ TeV. It is related to multi-dimensional mass M_D according to formula:

$$M_{Pl}^2 \sim M_D^{2+n} R^n$$

- where n – number of extra dimensions (n = 6 in our case). Extra spatial dimensions are large, i.e. the gravitation radius R could be about ~1 µm.
- According to the ADD scenario it is expected, that the microscopic black holes should form, when collisions energy will exceed a certain threshold mass M_{th}. It can be some above M_D, but far below M_{Pl}.
- Case of Quantum Black Hole. If QBH forms near threshold M_{th}, then thay can decay into the two-body final states. The production of QBH close to M_{th} dictates a quasi-resonant final state with an observable excess for a certain invariant mass. Therefore, we will search for a "bump" in spectrum of lepton-jet invariant mass M_{inv}.

About branching fractions

- The cross section of QBH production and branching of final state with lepton and jet depends on initial state.
- *For initial uu-quarks collision* and QBH objects with electric charge of +4/3 the branching fraction is BF=11%.
- *For initial ud-quarks* and objects with charge of +1/3 the branching fraction is BF=5.7%.
- *For initial dd-quarks* and objects with charge of −2/3 the branching fraction is BF=6.7%.
- Processes with initial states of anti-quarks and heavier sea-quarks are suppressed by a factor of ~100.

Event cleaning and object pre-selection

1. **Data quality and event cleaning:** GRL, problematic regions of the Lar and TileCal, incomplete events, check of primary vertex with ≥2 tracks.
2. **Trigger:** HLT_e26_lhtight_iloose, HLT_e26_lhtight_nod0_iloose, HLT_e60_lhmedium, HLT_e120_lhloose, HLT_mu26_imedium, HLT_mu26_ivarmedium, HLT_mu50
3. **Candidates of electrons ("Baseline"):** "LooseAndBLayerLLH" quality, $|\eta|\leq 2.47$ and p_T>10 GeV after calibration.
   "Baseline" muons: "Medium" quality, $|\eta|\leq 2.7$ and p_T>10 GeV.
   "Baseline" jets: "AntiKt4EMTopojets", JVT cut, $|\eta|\leq 2.8$ and p_T>20 GeV.
4. **Bad Jet Veto:** "LooseBad" condition in the JetCleaningTool package.
5. **Overlap Removal: a)** if ΔR(jet,lepton)<0.2 and jet is b-jet, then lepton is removed and jet is kept; if jet is no b-jet, then vice versa jet is removed;
   b) using only remaining jets if ΔR(jet,lepton)<0.4, we need to remove the lepton and keep the jet.
5. **Bad muon veto:** muon is "bad", if σ(q/p) / abs(q/p) >0.2.
6. **Cosmic muon veto:** muon is cosmic, if it has a track with $|z_0^{PV}|\geq 1$ mm and $|d_0^{PV}|\geq 0.2$ mm.
7. **Selection of "Final" objects:** isolated lepton with the "GradientLoose" condition, trigger matched and with p_T>30 GeV; good jets with p_T>20 GeV.
8. **Event pre-selection:** one or more "Final" lepton and one or more "Final" jet.

Selection of events with signal signature

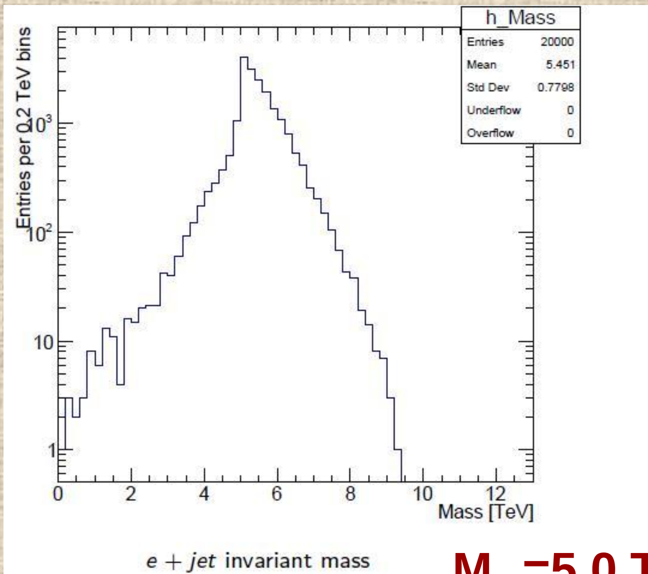
1. There is only **one hard lepton** with **p_T>130 GeV.** There is no one other "baseline" lepton with p_T>10 GeV (with exception of Z+jet control region only).
2. The most energetic **(leading) jet** has **p_T>130 GeV.**
3. All sub-leading **jets, photons and tau-jets** have **p_T<60 GeV** and **E_T^{miss}<60 GeV.** It is condition of hard two-body final state.

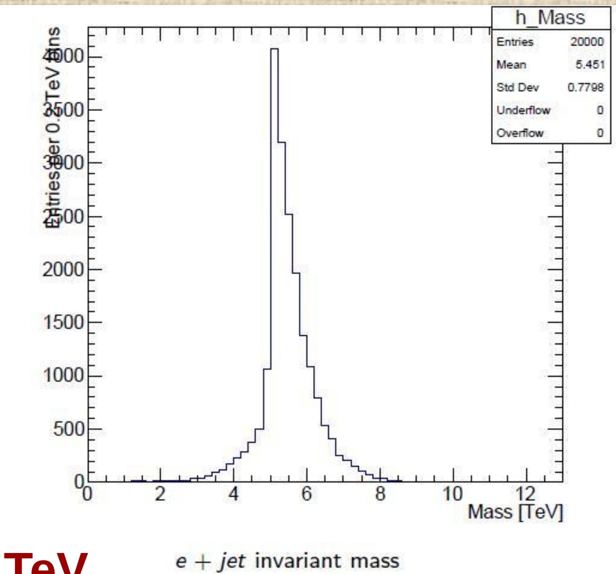
Control, signal and validation regions

The control, signal and validation regions are defined with using of **invariant mass M_{inv}** of lepton and leading jet. All these regions are like to that in analysis at 8 TeV.

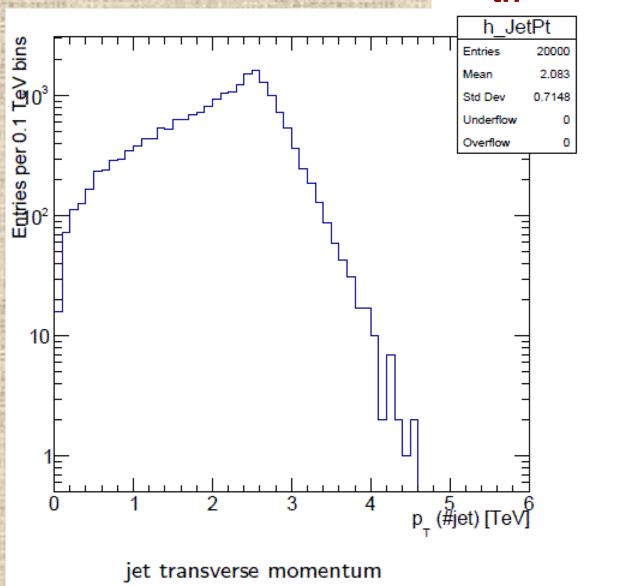
1. **Control region (CR)** is a **low invariant mass region** with **0.5<M_{inv} ≤1.5 TeV,** and has a negligible contamination of a potential signal (less than 0.3%) for the lowest threshold mass (M_{th} = 5.0 TeV).
2. **Signal region (SR)** is a **high invariant mass region** with **M_{inv}>2 TeV** for both electron and muon channel. Lesser invariant mass is used in comparison with the constraints (M_{th} ≥5.3 TeV) obtained with 8 TeV data, because no events were observed above 2.5 TeV in electron channel and only 1 event was observed above 3 TeV in muon channel.
3. **Validation region (VR)** is situated **between CR and SR** for both electron and muon channels. It is diapason of invariant masses from **1.5 TeV** up to **2 TeV.**

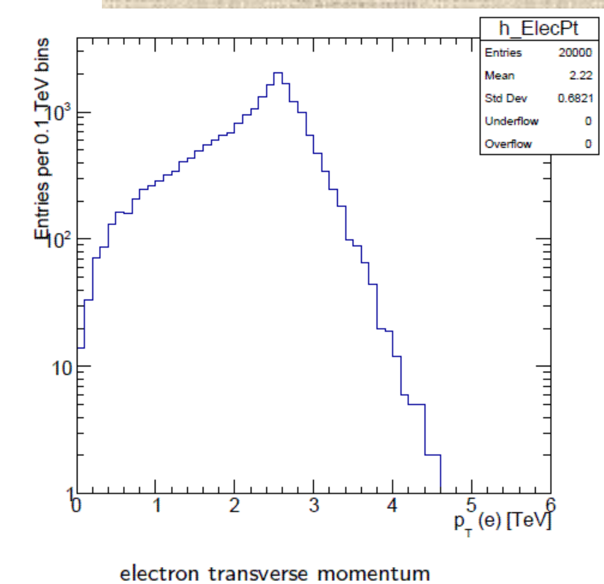
Generation of signal samples at 13 TeV





M_{th}=5.0 TeV





✓**The Signal samples** with threshold mass **M_{th}= 5.0–9.5 TeV** and with step of **0.5 TeV** were generated according to the ADD model with the **n=6** large extra dimensions for **e+jet** and **μ+jet** final states of QBH decay (10+10 samples).

✓**20000 events** per sample has been result of that.

✓The distributions of events over **invariant mass** at **M_{th}= 5.0 TeV** in electron+jet channel you can see in upper panels (in logarithmic and linear scales).

✓The distributions of **leading jets** and **electrons** over **transverse momentum** are shown in bottom panels.

Background for QBH

MC samples simulated with Sherpa 2.2.1: W+jets ($W^{\pm} \rightarrow e\nu, \mu\nu, \tau\nu$) sliced on max($H_T$, W_{pT}) (364156-364197), **Z+jets ($Z \rightarrow ee, \mu\mu, \tau\tau$)** sliced on max($H_T$, Z_{pT})(364100-364141), di-bosons **WW, WZ, ZZ → lνqq, llqq, lννν, llνν** (363356, 363358-363360, 363489, 363492, 363493).

MC simulated with Powheg+Pythia+EvtGen: ttbar non all hadronic (410000), **Wt** (410013, 410014), **single top** t-channel (410011, 410012) and s-channel (410025, 410026).

Fake leptons background from multi-jet events (QCD) was estimated for electron channel with data-driven matrix method by the **LPXMatrixMethod-00-00-02** package.

Some details of analysis

One's own code of analysis – **QBHLepOneJet** package based on **RootCore EventLoop** and **SUSYTools.** Software versions: **Root Core AnalysisBase-2.4.29 + SUSYTools-00-08-58 + Moriond 2017 recommendations.**

Baseline object selection, overlap removal, calibrations, systematics etc. are used by default as in SUSYTools. Results represented below were obtained with pile-up reweighting, trigger matching, scale factors for signal lepton and b-tagging. These results include systematics.

Data: D-J periods of 2015, L = 3.213 fb^{-1} and **A-L periods of 2016, L = 32.862 fb^{-1}** according to "PHYS_ StandardGRL_All_Good_25ns" Good Runs Lists. In total **L = 36.075 fb^{-1}.**

The **SUSY5 derivations** (1-lepton SUSY) is quite suitable for our analysis. The tags of **p2950** for data and **p2949** for the MC samples are the latest bulk production of SUSY5 derivations for Moriond 2017 and for summer conferences.

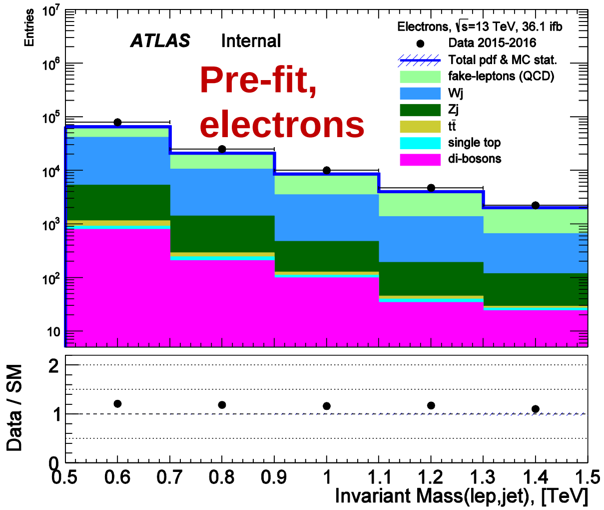
Some other features of analysis

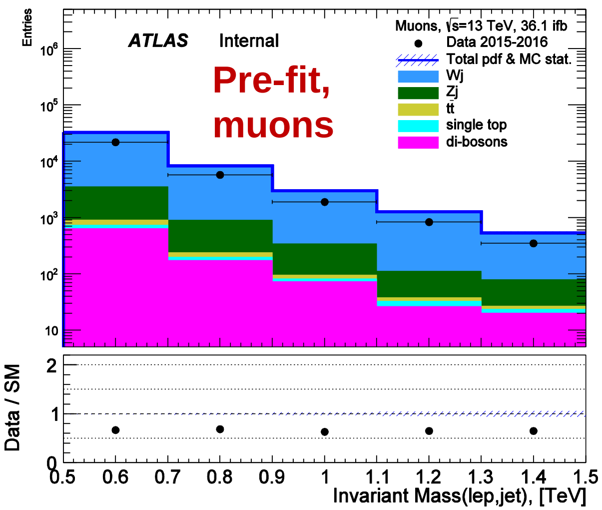
- **Statistical analysis is done with using of the HistFitter package v0.54.0.**
- We use the **W+jet, Z+jet** and **TTbar** control regions **(WCR, ZCR and TCR)** for both electron and muon channels. These samples are normalized and fitted in CRs and extrapolated to VR, because they are main three background modeled by MC.
- **Each control region** is fitted in **5 bins over M_{inv}** (from **0.5 to 1.5 TeV** with step of **0.2 TeV**), what allows us to use shape information of distributions.
- **Systematic uncertainties** are added as nuisance parameters. They are constrained also by the fit with taking into account of mutual correlations.
- **The background-only fit** is applied now: the control regions are used to constrain the fit parameters and to extrapolate distributions into validation region.
- **Small backgrounds** (W+t, single top and di-bosons) are not fitted and used as it is. Nevertheless, small variations within their systematic uncertainties are allowed for better performance of the fit.
- All MC events are weighted with following factors:
  totWeight = genWeight * mcEvtWeight * pileupWeight * lepSF * btagSF * jvtSF * tauSF,
  where **genWeight = (σ * L) / (∑mcEvtWeight)** and **lepSF= trigSF * idSF * recSF * isoSF.**
- **Background of fake leptons** is estimated with **data-driven matrix method.** It is not fitted. Special weights are calculated for events selected from the data by the LPXMatrixMethod package. Fake leptons bring a **second-large contribution** in total SM background in some regions in **electron channel.** However, this background can be **neglected for muons.**

The fit with HistFitter package of Electron and Muon channels

W+jet control region over M_{inv} before and after the fit with HistFitter

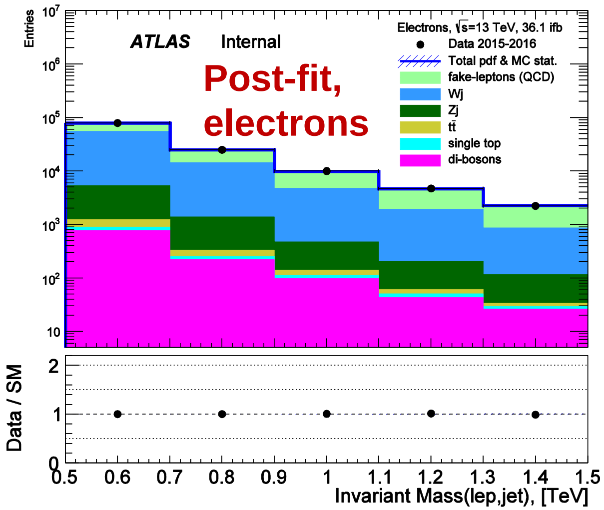
Definition of W+jet control region (WCR): 1 lepton with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + 0.5<M_{inv} ≤1.5 TeV + b-jet veto

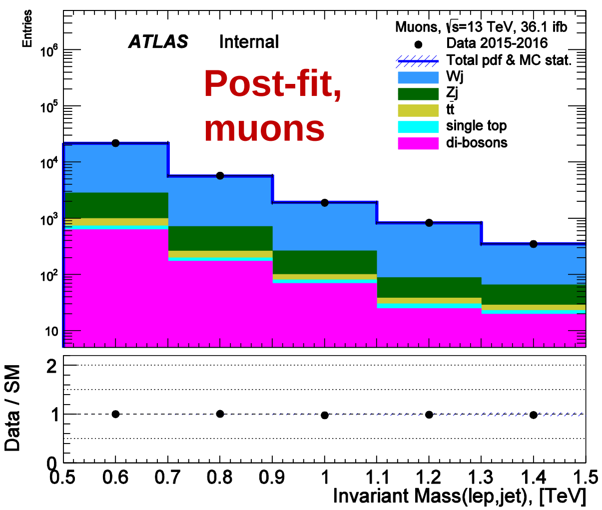




There is small disagreement of MC with data before the fit (upper panels). Some deficit of MC events is observed for electrons and some surplus for muons. But shape of MC and data distributions is very similar in both cases. Difference can be due to not quite correct weights, scale factors or some mis-modeling.

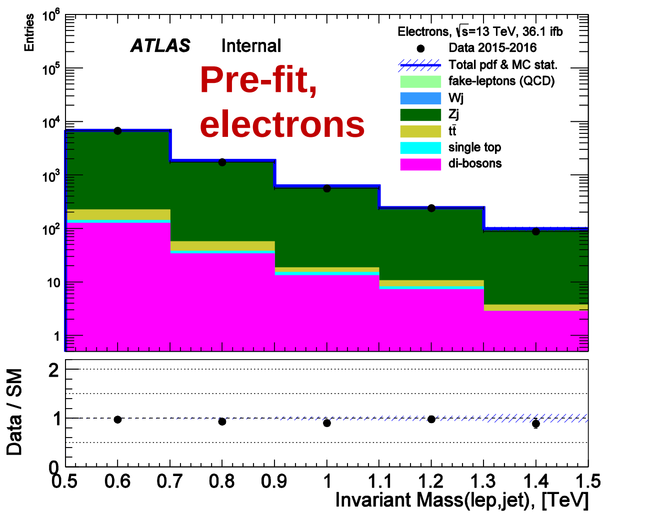
The fit (bottom panels) gives a good agreement within errors and systematic uncertainties in both electron and muon channels.

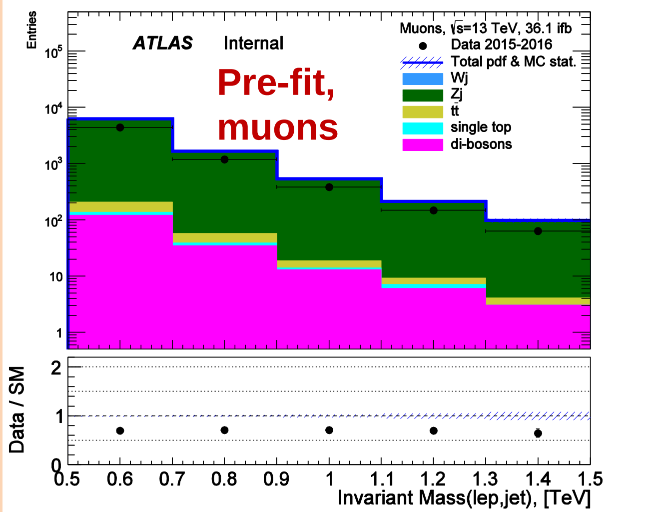




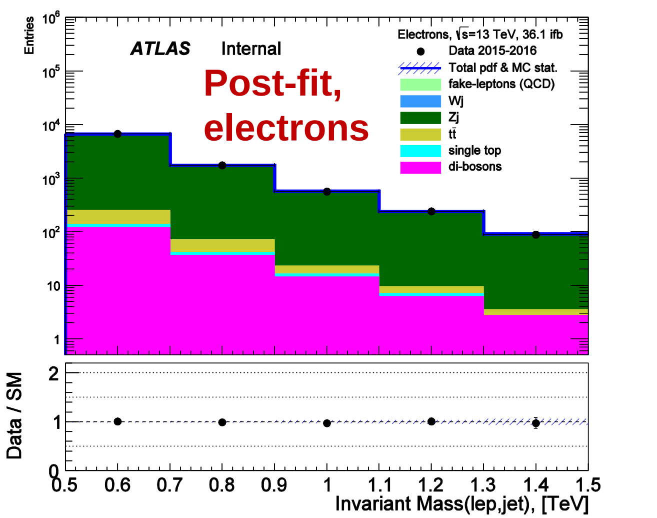
Z+jet control region over M_{inv} before and after the fit with HistFitter

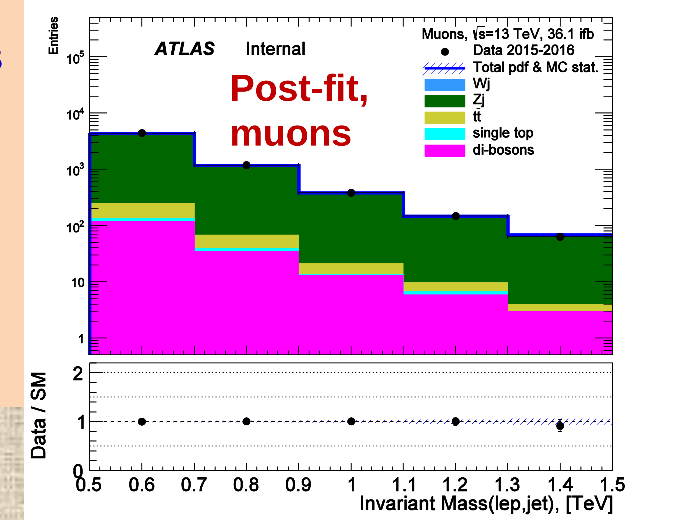
Definition of Z+jet control region (ZCR): 1 lepton with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV+0.5<M_{inv}≤1.5 TeV+second OS and SF lepton





The Z+jet events give main part of background as it is expected in this control region.
The agreement of MC with data for electrons is good even before the fit. But for muons there is some excess of MC above data in whole region of M_{inv}. Shape of distributions is very similar (upper panels).

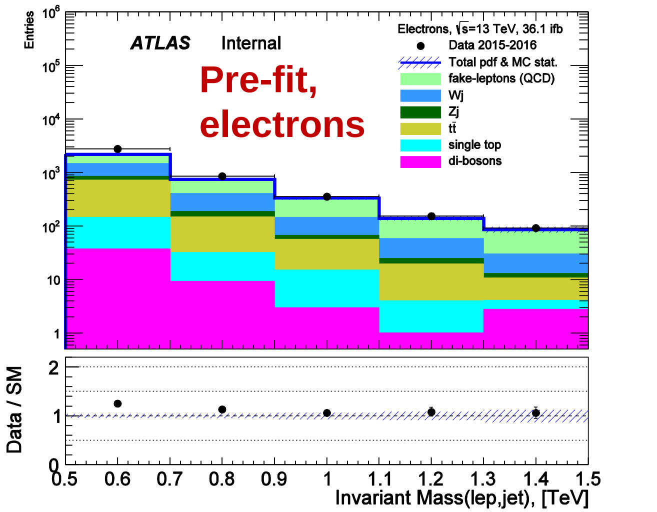




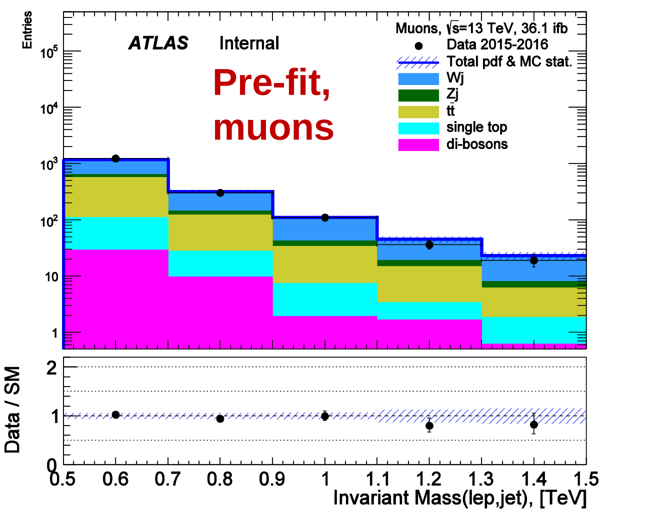
The fit (bottom panels) changes electron distributions slightly and makes accordance a little bit better. Very good agreement of MC with data for muons is obtained also after the fit.

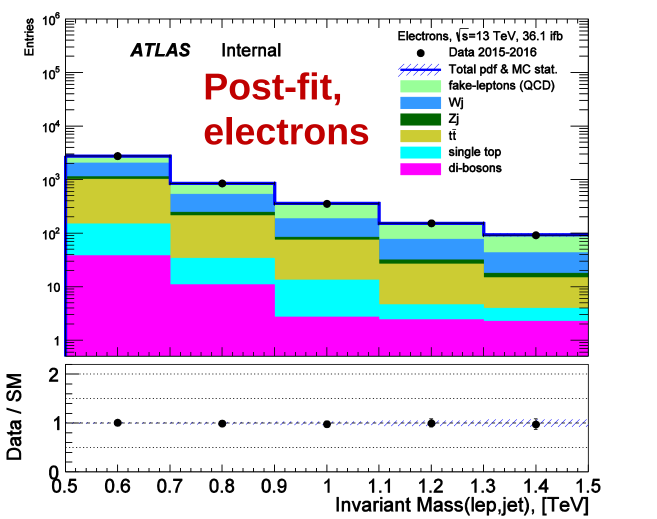
TTbar control region over M_{inv} before and after the fit with HistFitter

Definition of TTbar control region (TCR): 1 lepton with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + 0.5<M_{inv}≤1.5 TeV + ≥4 final jets + ≥1 b-jet

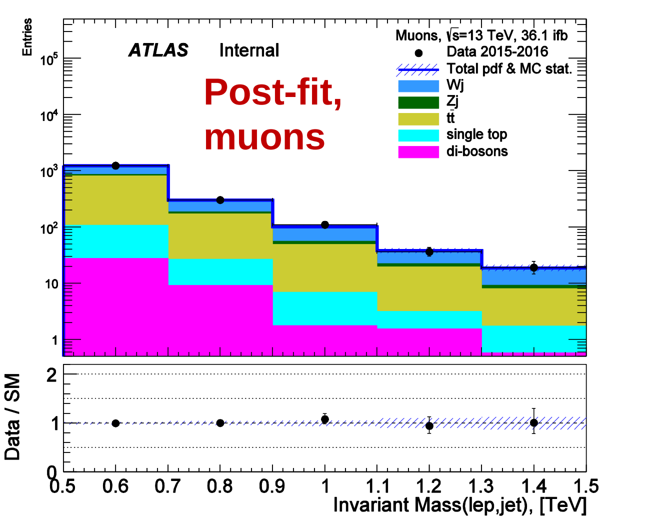


There is some deficit of MC and some disagreement in shape of MC and data distributions before the fit for electrons. One can see a drift up of MC relatively of data with increase of M_{inv}. But for muons the agreement of MC with data is good even before the fit (upper panels).



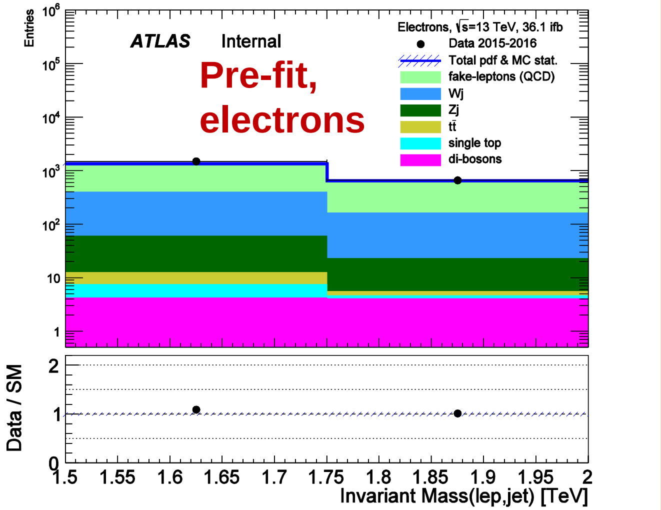


The fit (bottom panels) gives a good agreement for electrons and makes accordance a little bit better for muons too.



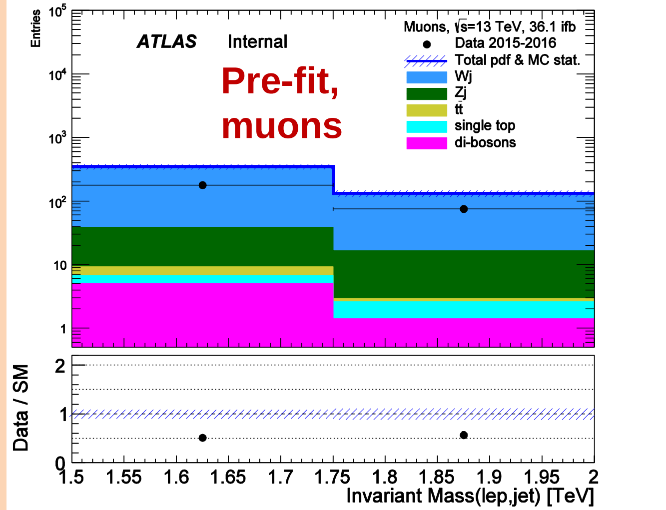
Validation region over M_{inv} before and after the fit with HistFitter

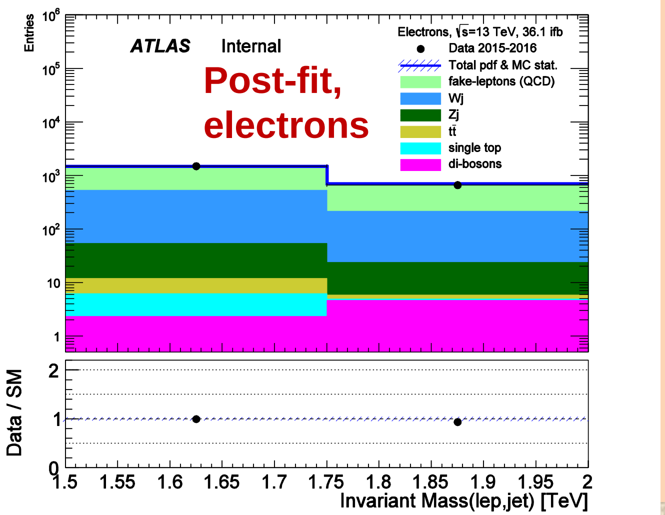
Definition of validation region (VR): 1 lepton with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + 1.5<M_{inv}≤2.0 TeV.



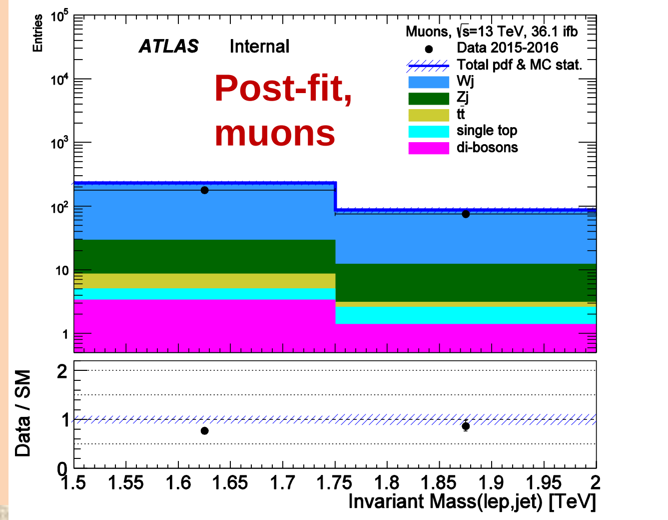
The VR does not fitted directly. It is changed only due to the fit in control regions.

There is good enough agreement of MC with data before the fit for electrons. But for muons there is a visible deficit of data in comparison with MC events before the fit (upper panels).





The fit (bottom panels) changes distributions of electrons slightly. The residual difference is within statistical errors and systematic uncertainties. For muons the fit gives agreement of MC with data significantly better. Nevertheless, small deficit of data events is observed after the fit.



The fitted and MC expected yields for Control and Validation regions of electron channel.

Yield of channel	WCR	ZCR	TCR	VR
Observed events	120580	9308	4188	2141
Fitted bkg events	120530.05 ± 346.85	9308.23 ± 97.54	4198.04 ± 64.83	2188.85 ± 73.14
Fitted dd events	43479.12 ± 409.42	$26.66^{+43.25}_{-26.66}$	1300.24 ± 59.40	1440.57 ± 61.00
Fitted Wj events	69551.01 ± 562.70	6.91 ± 1.03	1371.99 ± 75.64	670.51 ± 27.03
Fitted Zj events	5674.55 ± 116.05	8910.44 ± 107.90	174.97 ± 9.06	59.80 ± 3.96
Fitted Tt events	474.84 ± 104.04	157.05 ± 24.91	1144.46 ± 120.41	6.70 ± 3.00
Fitted sT events	181.41 ± 17.45	25.06 ± 1.65	149.47 ± 13.85	4.27 ± 0.58
Fitted DB events	1169.13 ± 66.79	182.12 ± 10.81	56.91 ± 5.25	7.00 ± 1.23
MC exp. SM events	100869.23 ± 653.84	9723.70 ± 101.51	3495.55 ± 139.21	2006.14 ± 70.82
MC exp. dd events	43062.10 ± 480.55	$39.39^{+54.82}_{-39.39}$	1357.47 ± 82.13	1440.57 ± 61.00
MC exp. Wj events	50241.66 ± 249.78	5.07 ± 0.74	989.05 ± 54.62	482.49 ± 24.56
MC exp. Zj events	5913.81 ± 47.40	9365.38 ± 79.25	187.59 ± 8.81	64.79 ± 3.82
MC exp. Tt events	313.06 ± 35.64	106.22 ± 7.96	759.41 ± 38.11	6.08 ± 1.45
MC exp. sT events	176.70 ± 17.57	24.29 ± 1.61	148.08 ± 16.88	3.82 ± 0.48
MC exp. DB events	1161.91 ± 77.92	183.35 ± 10.64	53.94 ± 7.32	8.38 ± 1.26

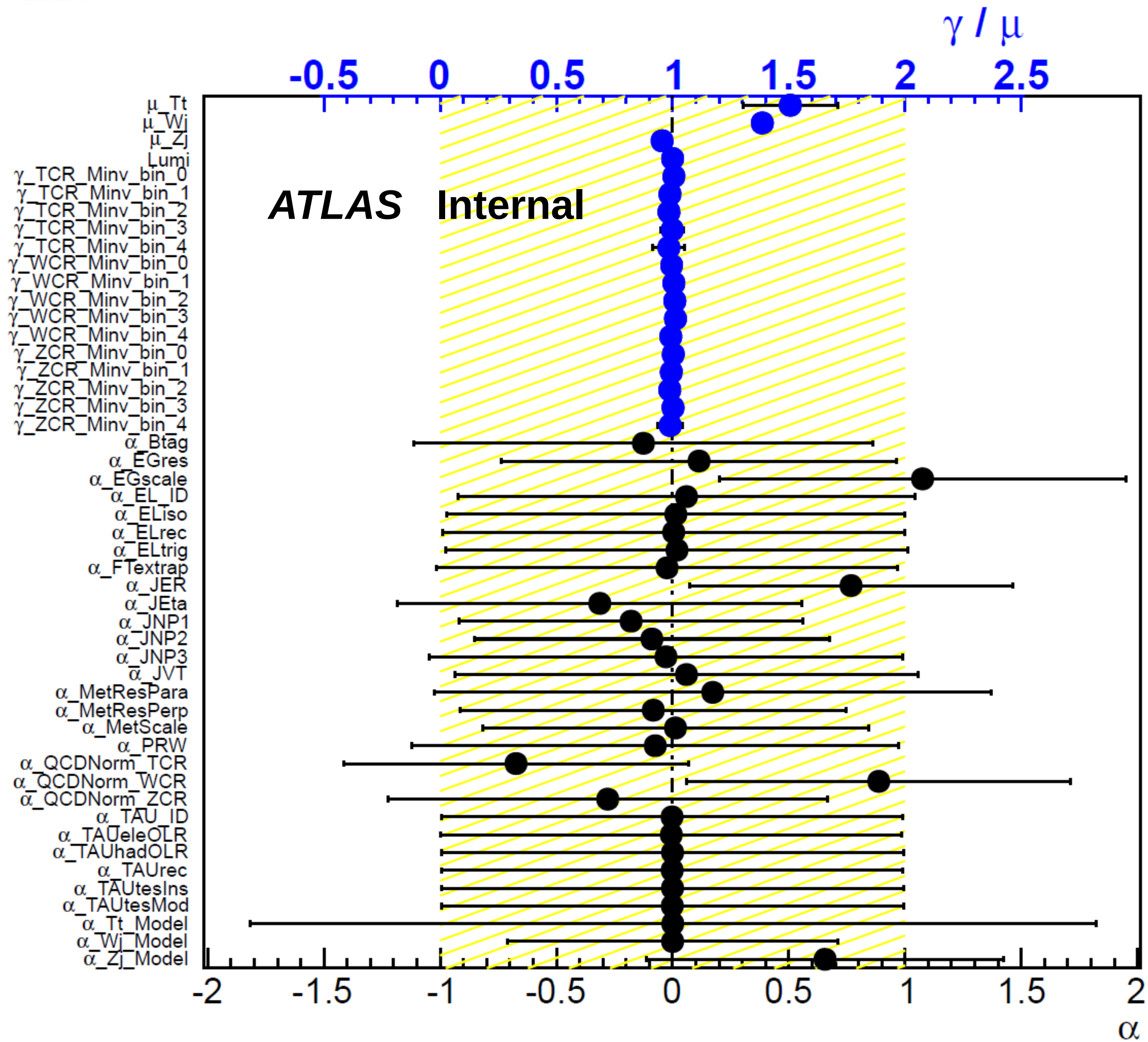
There is very good agreement between MC and data in all control regions (WCR, ZCR, TCR) after the fit. A very good accordance of data and fitted MC background is also in validation region (VR) after the fit. Residual difference is not more 0.5 σ (statistic + systematic).

The fitted and MC expected yields for Control and Validation regions of muon channel.

Yield of channel	WCR	ZCR	TCR	VR
Observed events	30600	6182	1691	254
Fitted bkg events	30602.50 ± 175.28	6181.82 ± 78.77	1689.26 ± 41.27	318.89 ± 19.40
Fitted Wj events	26631.17 ± 210.56	0.34 ± 0.03	545.26 ± 26.54	277.10 ± 17.08
Fitted Zj events	2541.31 ± 64.19	5825.81 ± 80.80	79.26 ± 4.83	29.96 ± 2.46
Fitted Tt events	359.42 ± 70.32	156.98 ± 15.93	918.18 ± 58.09	4.15 ± 0.76
Fitted sT events	149.30 ± 13.50	22.48 ± 1.78	105.85 ± 9.60	2.86 ± 0.36
Fitted DB events	921.30 ± 44.17	176.20 ± 8.89	40.71 ± 5.92	4.81 ± 2.36
MC exp. SM events	45950.81 ± 377.33	8826.28 ± 95.72	1691.86 ± 88.36	480.58 ± 30.33
MC exp. Wj events	40944.01 ± 328.22	0.55 ± 0.07	829.45 ± 46.33	424.92 ± 27.05
MC exp. Zj events	3694.33 ± 63.45	8526.67 ± 91.64	113.27 ± 7.16	43.39 ± 3.13
MC exp. Tt events	232.55 ± 28.23	98.37 ± 7.02	597.31 ± 31.03	2.77 ± 0.76
MC exp. sT events	146.83 ± 14.36	21.88 ± 1.99	108.61 ± 12.63	3.00 ± 0.40
MC exp. DB events	933.09 ± 51.92	178.81 ± 9.46	43.22 ± 8.84	6.50 ± 3.54

There is very good agreement between MC and data in all control regions (WCR, ZCR, TCR) after the fit. Some deficit of data in comparison with MC is remained in validation region (VR) after the fit. Nevertheless, we can say that there is a good enough agreement between data and fitted MC background.

The fit parameters of electron channel



mu_ (μ) is the normalization factor of fitted MC sample, unconstrained in the fit;

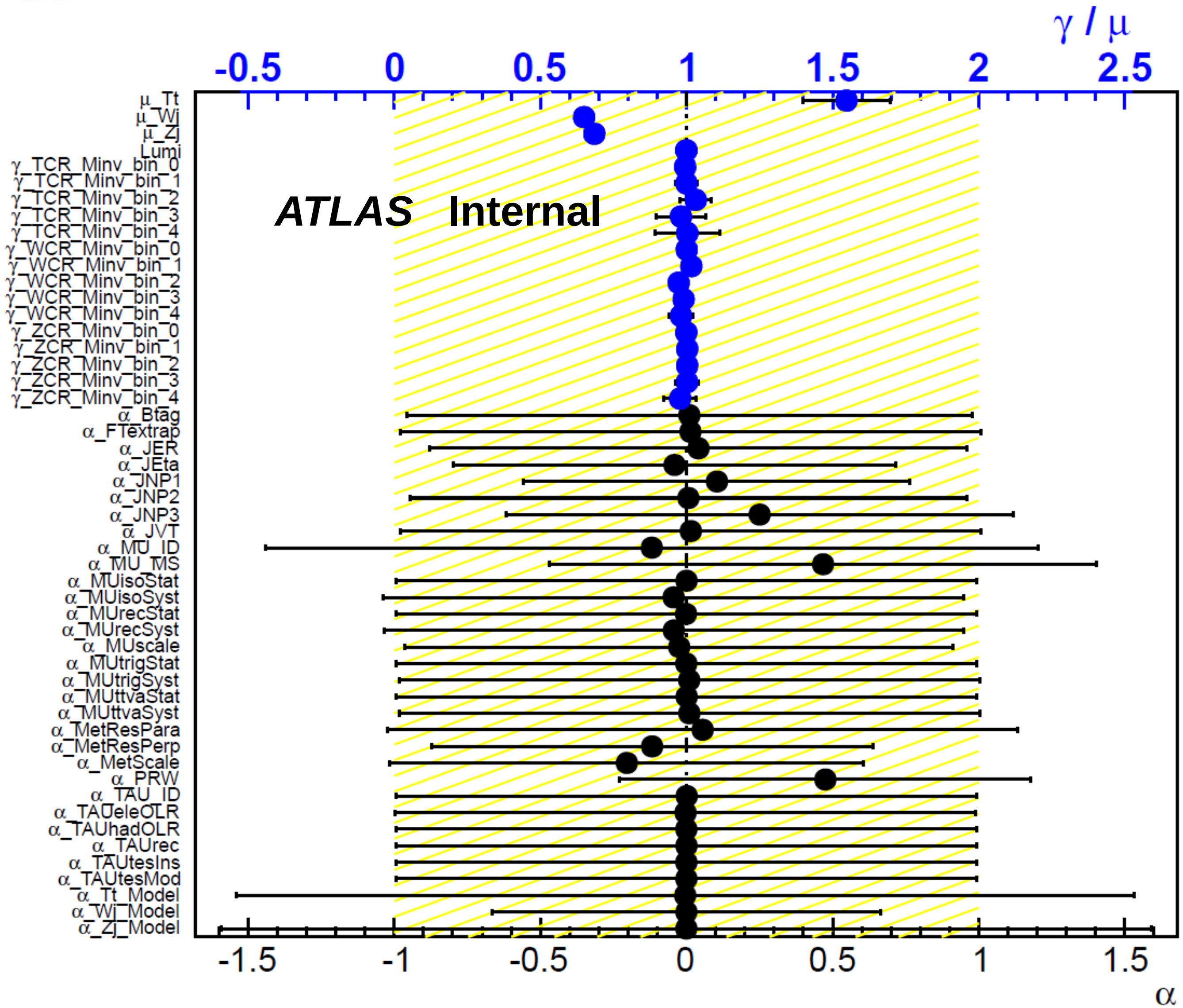
gamma_stat_ (γ) is bin-by-bin uncertainty from the MC statistics; constrained parameter (Poisson); it is used mainly for propagating errors, not to constrain information in bin;

- value of **γ** represents width of Poisson;
- error of **γ** represents error on width;

alpha_ (α) is constrained parameter on systematic uncertainty;

- value of **α** represents preferred mean value of Gaussian;
- error of **α** represents preferred gamma value of Gaussian in units of input sigma;

The fit parameters of muon channel



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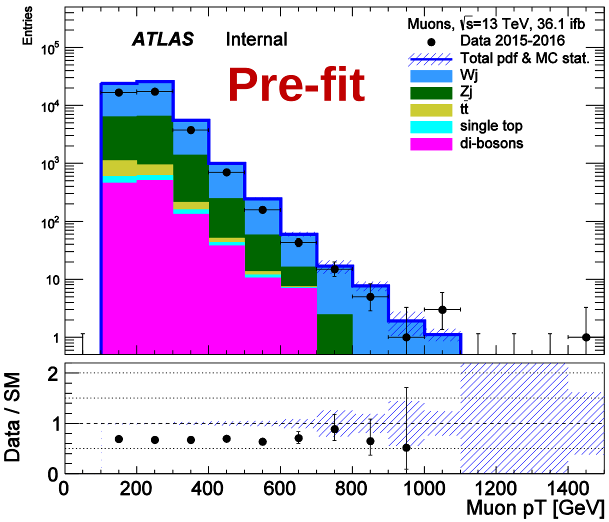
- value of γ represents width of Poisson;
- error of γ represents error on width;

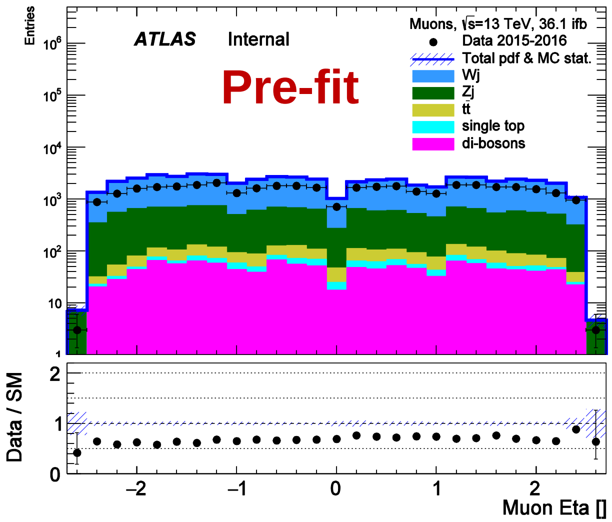
alpha_ (α) is constrained parameter on systematic uncertainty;

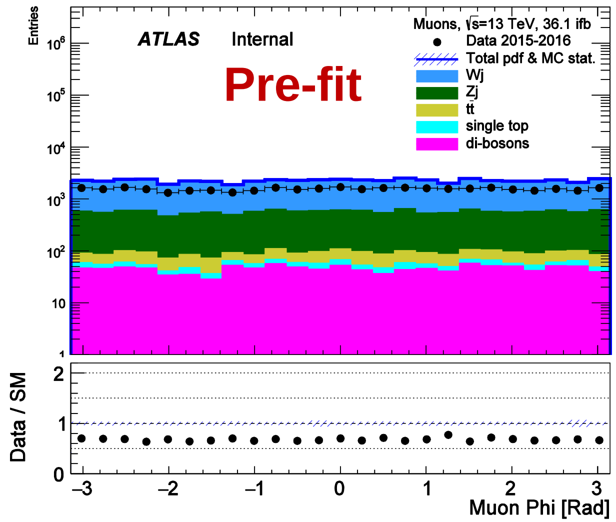
- value of α represents preferred mean value of Gaussian;
- error of α represents preferred gamma value of Gaussian in units of input sigma;

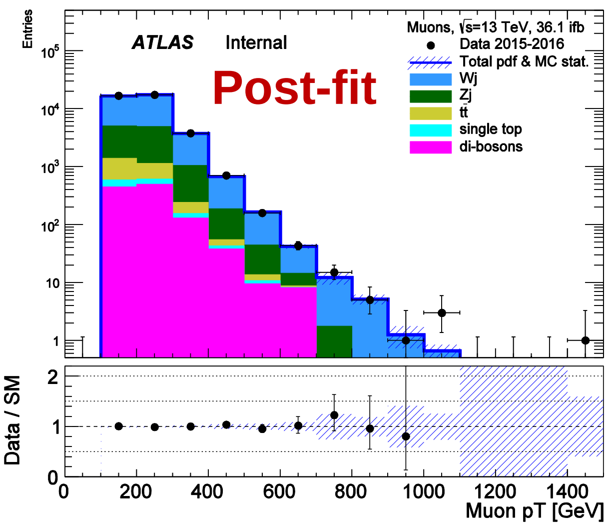
Kinematic distributions (p_T, η, φ) of muons before and after the fit with HistFitter

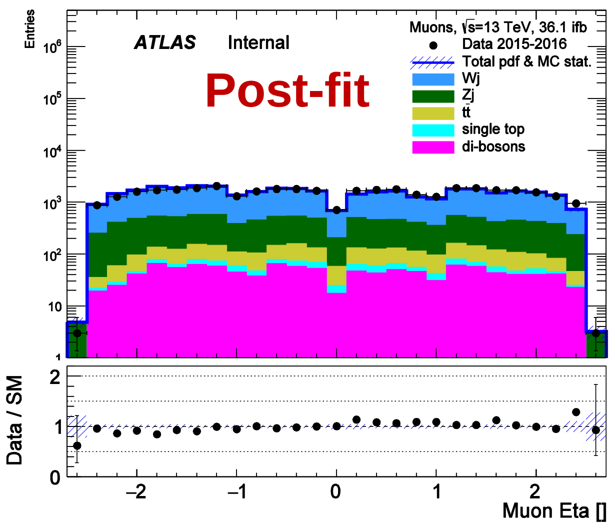
All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 muon with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV

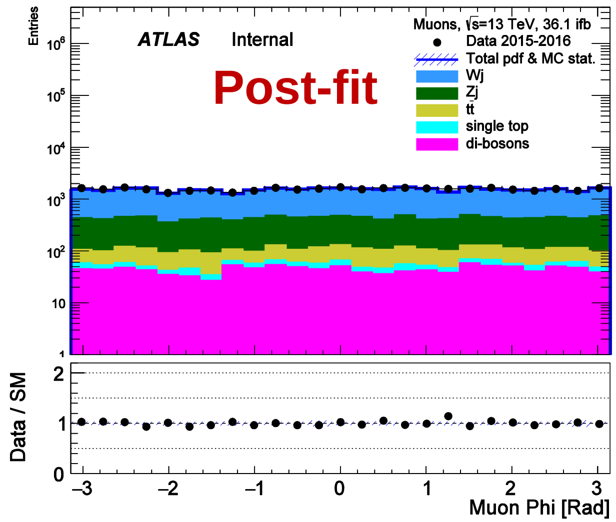






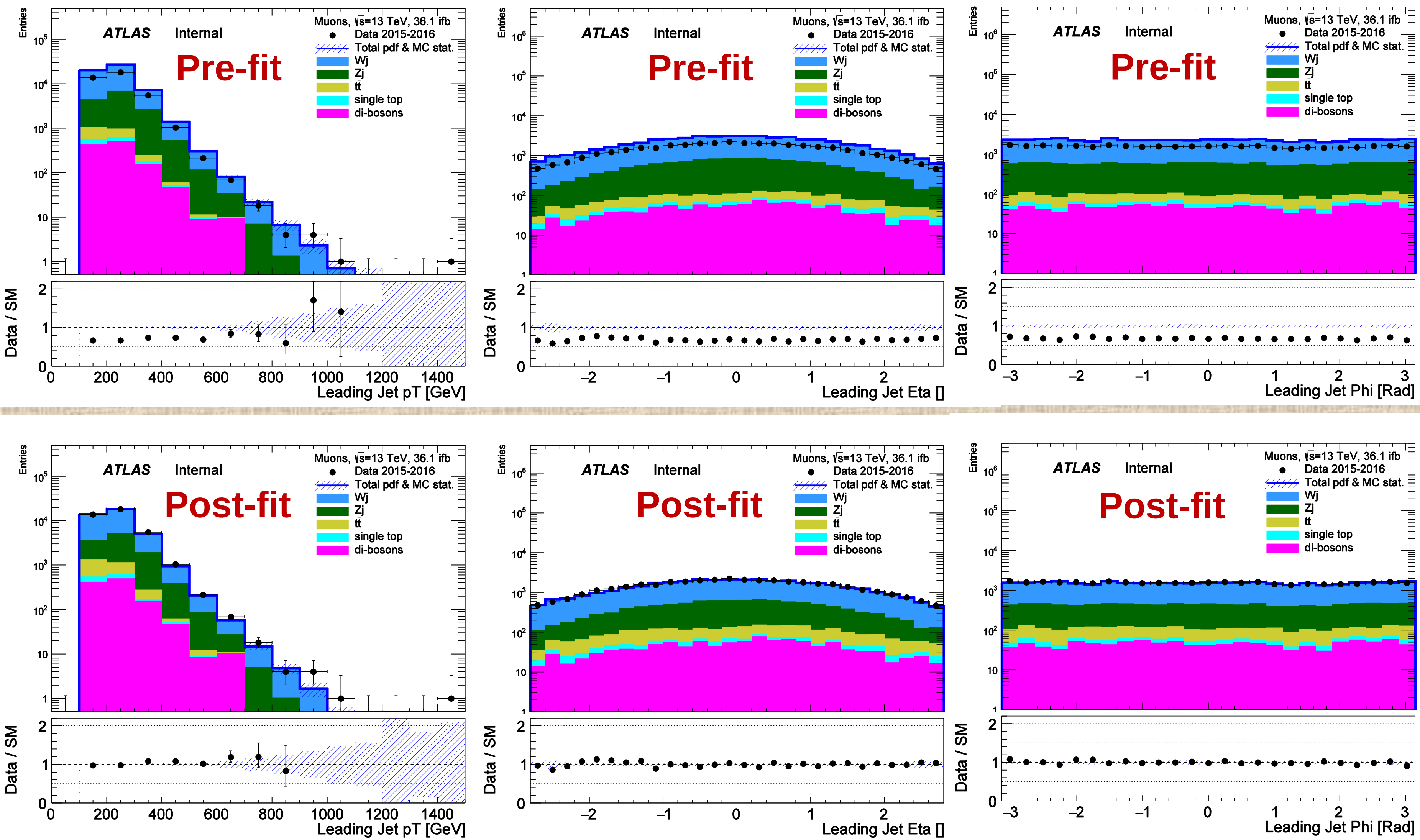






Kinematic distributions (p_T, η, φ) of leading jets in muon channel before and after the fit with HistFitter

All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 muon with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV



Summary

1. SM background modeled by MC was fitted with HistFitter package in three control regions and was extrapolated to validation region. Fake leptons background from multi-jet events (QCD) was estimated for electron channel with data-driven matrix method by the LPXMatrixMethod package. Last background can be neglected for muon channel.
2. Some deficit of MC events in comparison with data is observed in the control and validation regions before the fit with HistFitter tools in electron channel. On the contrary, the surplus of MC events above data is observed in muon channel before the fit. The fit practically eliminates these both disagreements. Conformity of MC with data after the fit is very good in all control regions.
3. Very good accordance of data and fitted MC background is observed also in validation region (VR) of electron channel after the fit. Some deficit of data in comparison with MC is remained in validation region of muon channel after the fit.
4. All additional kinematic distributions (lepton p_T, leading jet p_T, η, φ, H_T, N_{jet}, $N_{b\text{-}jet}$) have small enough residual discrepancy between MC and data after the fit. Differences are within statistical errors and systematic uncertainties in the majority of distributions.
5. Updated draft of Supporting Note at $\sqrt{s}$=13 TeV and 36.1 fb^{-1} is in CDS:

   ATL-COM-PHYS-2016-1762 (old version was at 14.8 fb^{-1}).
6. We don't have unblinding now. Therefore, we can not show signal region. Our work is in progress.

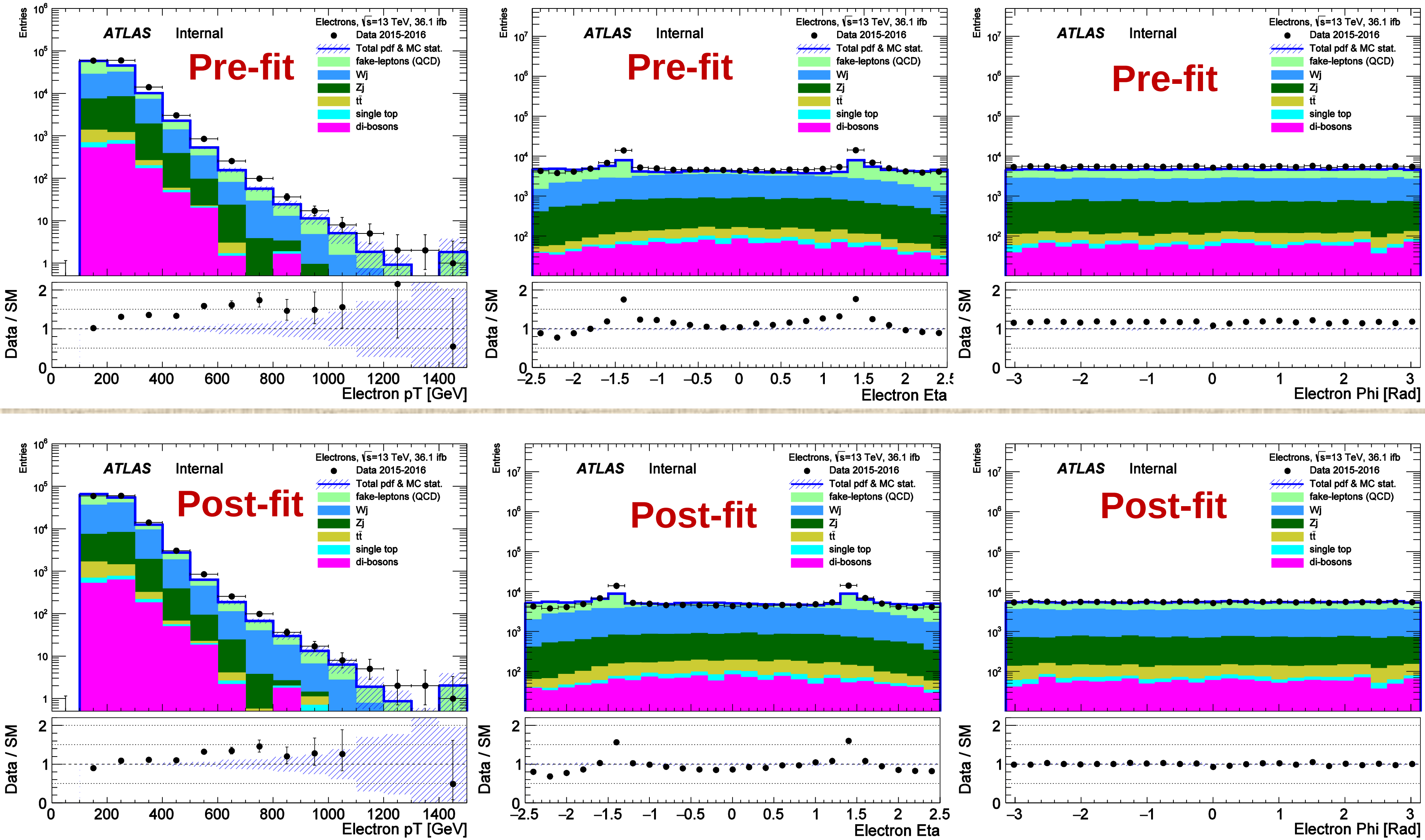
Thank you!

For additional information mail to: Sergey.Karpov@cern.ch

Backup

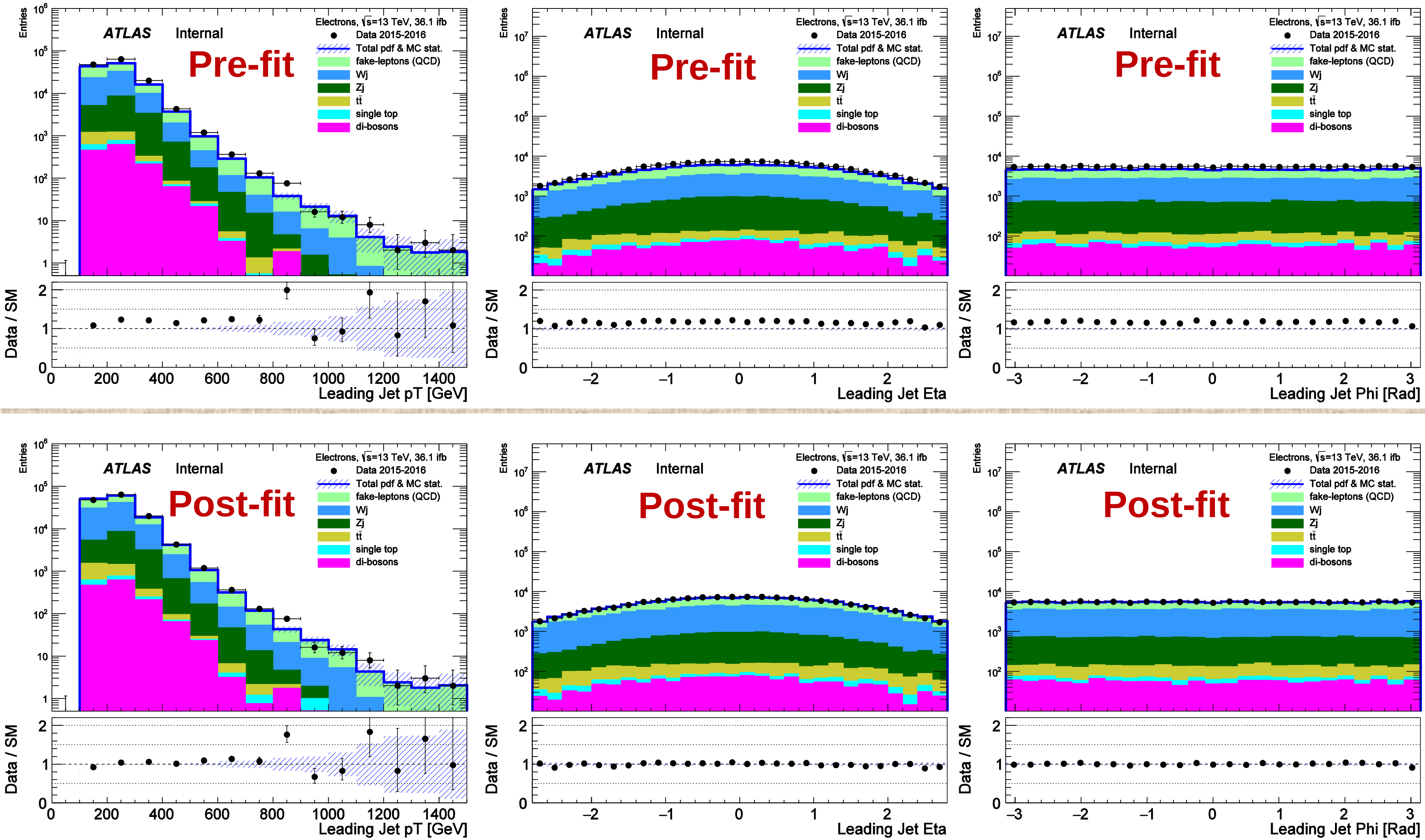
Kinematic distributions (p_T, η, φ) of electrons before and after the fit with HistFitter

All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 electron with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV



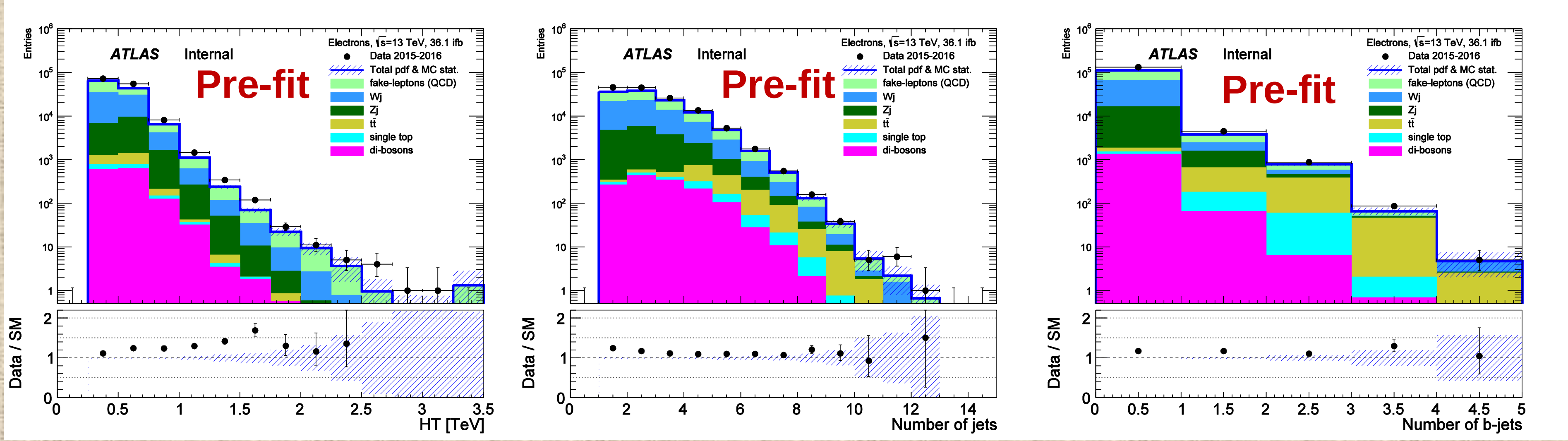
Kinematic distributions (p_T, η, φ) of leading jets in electron channel before and after the fit with HistFitter

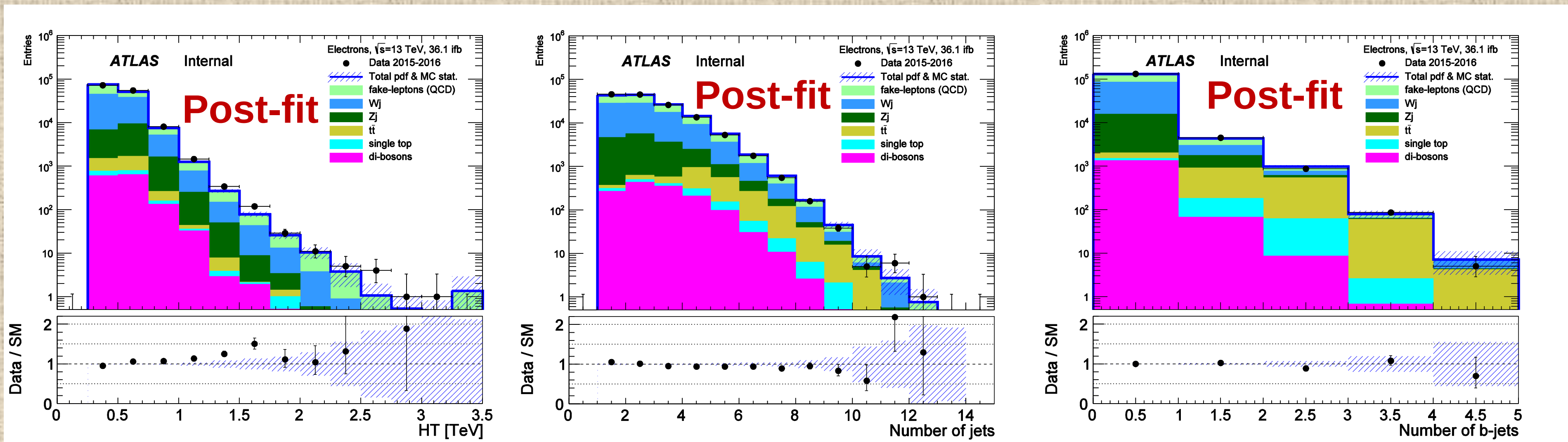
All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 electron with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV



Distribution of events over H_T, N_{jets} and $N_{b\text{-}jets}$ in electron channel before and after the fit with HistFitter

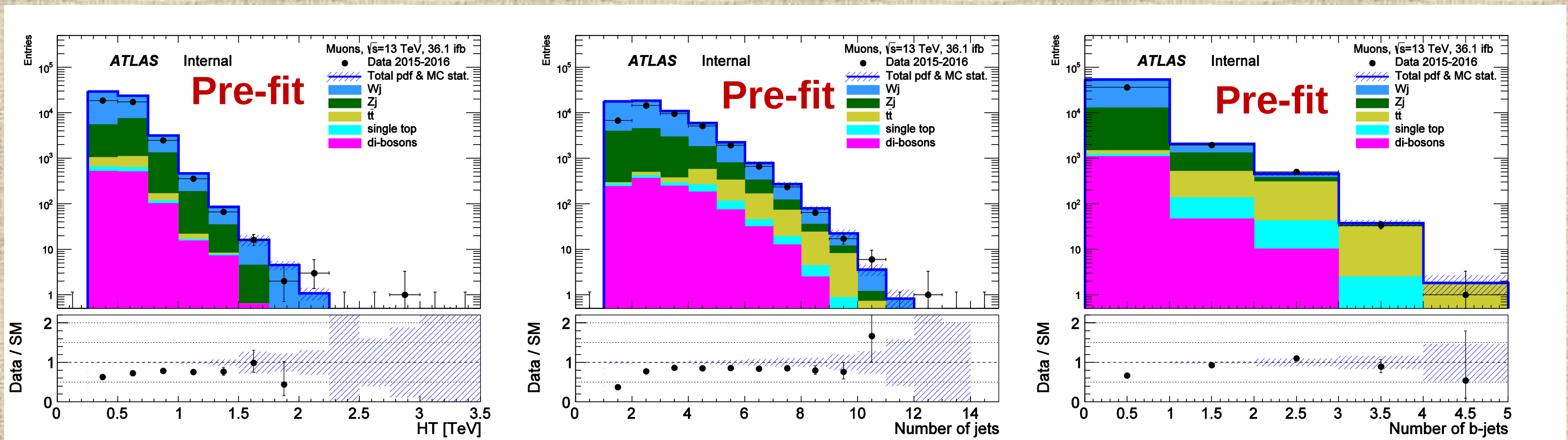
All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 electron with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV

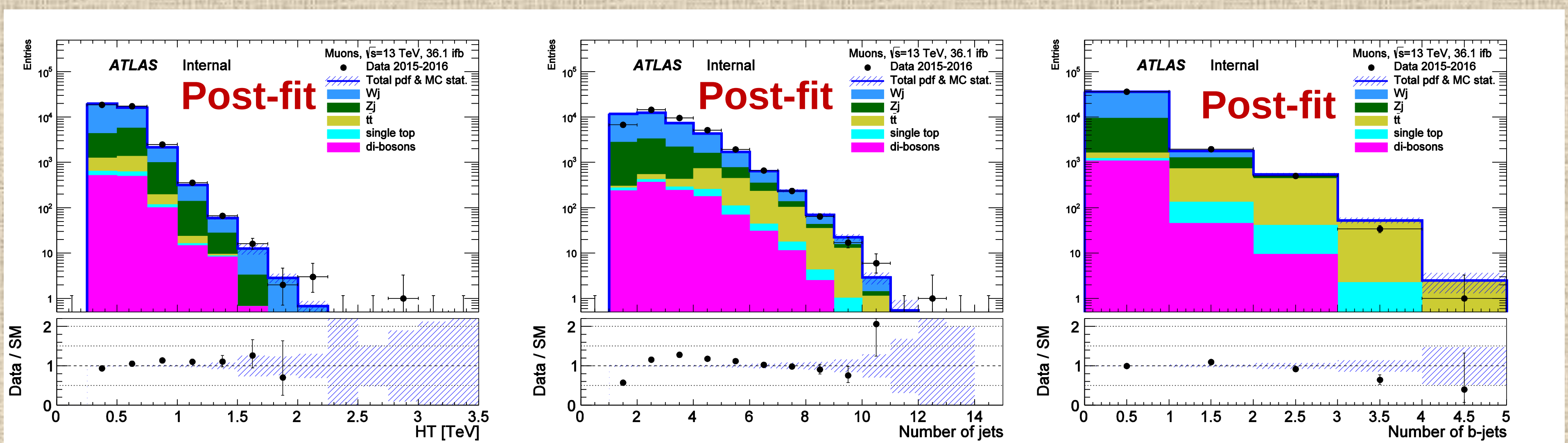




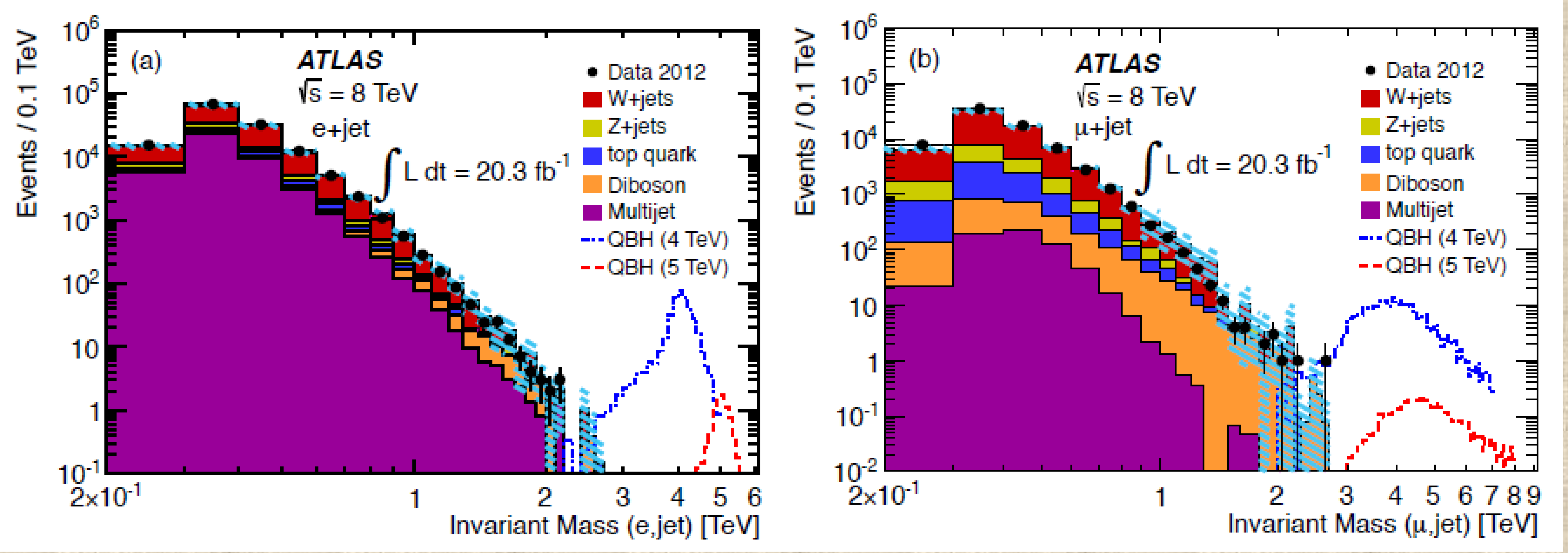
Distribution of events over H_T, N_{jets} and $N_{b\text{-}jets}$ in muon channel before and after fit with HistFitter

All events with signal signature (WCR+ZCR+TCR+VR+SR): 1 muon with p_T>130 GeV + 1 jet with p_T>130 GeV + other jets, photons, taus p_T<60 GeV + MET<60 GeV + M_{inv}>0.5 TeV





Results of search for QBH at √s = 8 TeV



e + jet channel

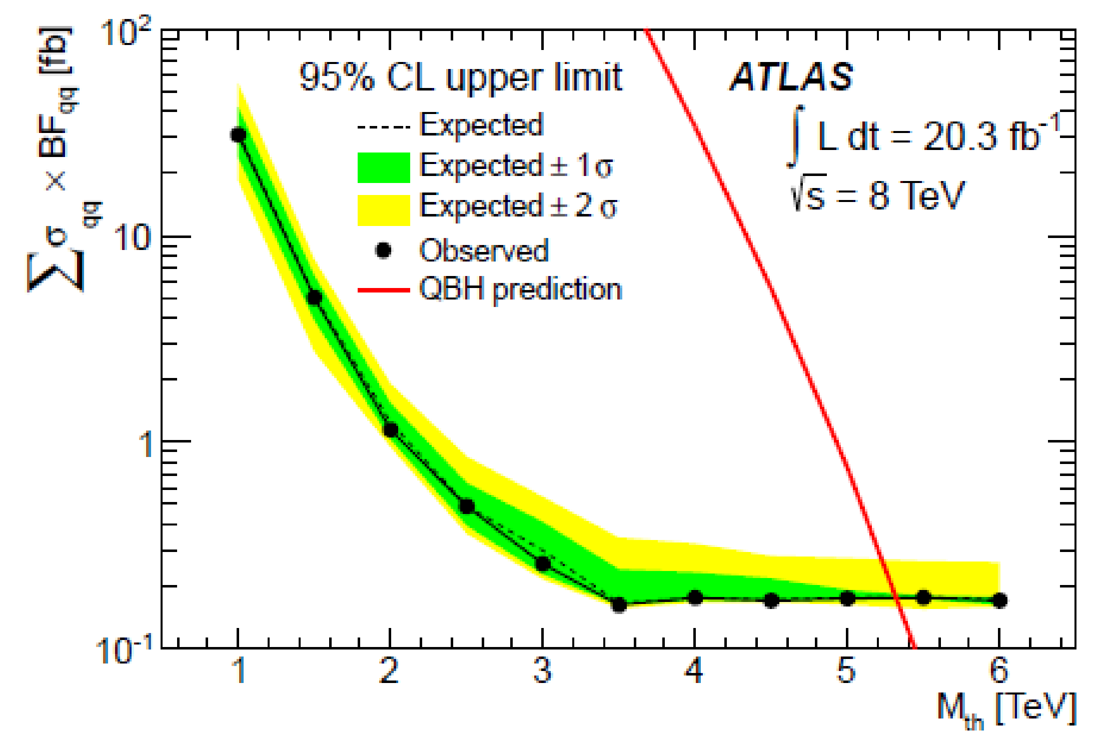
Distributions over the ***Invariant Mass*** of the electron and highest-p_T for data (this are points with error bars) and for SM backgrounds (they are solid histograms).

m + jet channel

Distributions over the ***Invariant Mass*** of the muon and highest-p_T jet for data (this are points with error bars) and for SM backgrounds (they are solid histograms).

[4] The ATLAS Collaboration, Search for Quantum Black Hole Production in High-Invariant-Mass Lepton+Jet Final States Using pp Collisions at √s = 8 TeV and the ATLAS Detector, Phys.Rev.Lett. 112 (2014) 091804 (2014-03-05), DOI: 10.1103/PhysRevLett.112.091804 CERN-PH-EP-2013-193, e-Print: arXiv:1311.2006v2 [hep-ex].

Results of search for QBH at √s = 8 TeV



- **The combined 95% CL upper limits** on $\Sigma\sigma_{qq} \times BF_{qq}$ for QBHs decaying to a lepton and jet, as a function of M_{th}, assuming $M_D = M_{th}$ and n=6 of ADD extra dimensions.

- **The lower limit** on M_{th} is 5.3 TeV. In other words **$M_{th} \leq$ 5.3 TeV** was excluded by the QBH searches.

[4] The ATLAS Collaboration, Search for Quantum Black Hole Production in High-Invariant-Mass Lepton+Jet Final States Using pp Collisions at √s = 8TeV and the ATLAS Detector, Phys.Rev.Lett. 112 (2014) 091804 (2014-03-05), DOI: 10.1103/PhysRevLett.112.091804 CERN-PH-EP-2013-193, e-Print: arXiv:1311.2006v2 [hep-ex].