

Other Top Quark Properties at ATLAS

1. Top Quark Charge Measurement (ATLAS-CONF-2011-141)
2. Inclusive Radiative Top-quark pair Cross-Section Measurement (ATLAS-CONF-2011-153)

Antonio Limosani

On behalf of the ATLAS Collaboration

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- Confirm SM nature of the top quark



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$$\begin{pmatrix} t \\ b \end{pmatrix}_L b_R t_R$$

Exotic Model

$$\begin{pmatrix} t \\ b \end{pmatrix}_L \begin{pmatrix} Q_1 \cos \Theta_b + b \sin \Theta_b \\ Q_4 \end{pmatrix}_R$$



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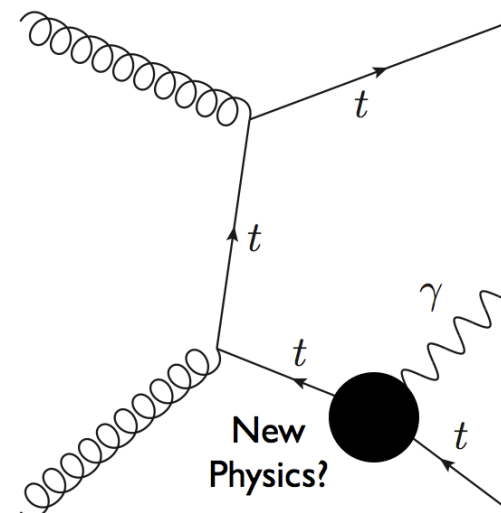
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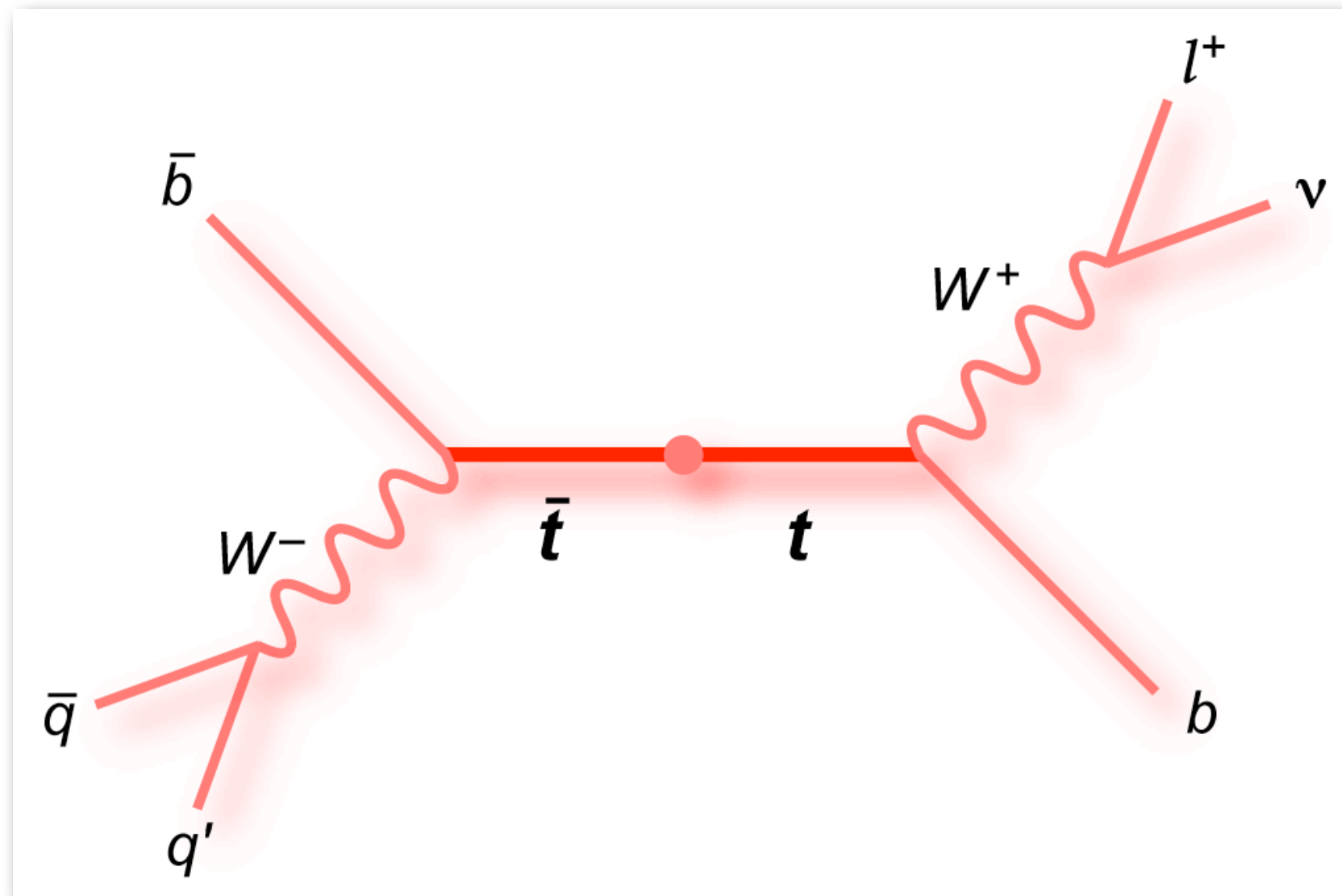
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- Confirm SM nature of coupling



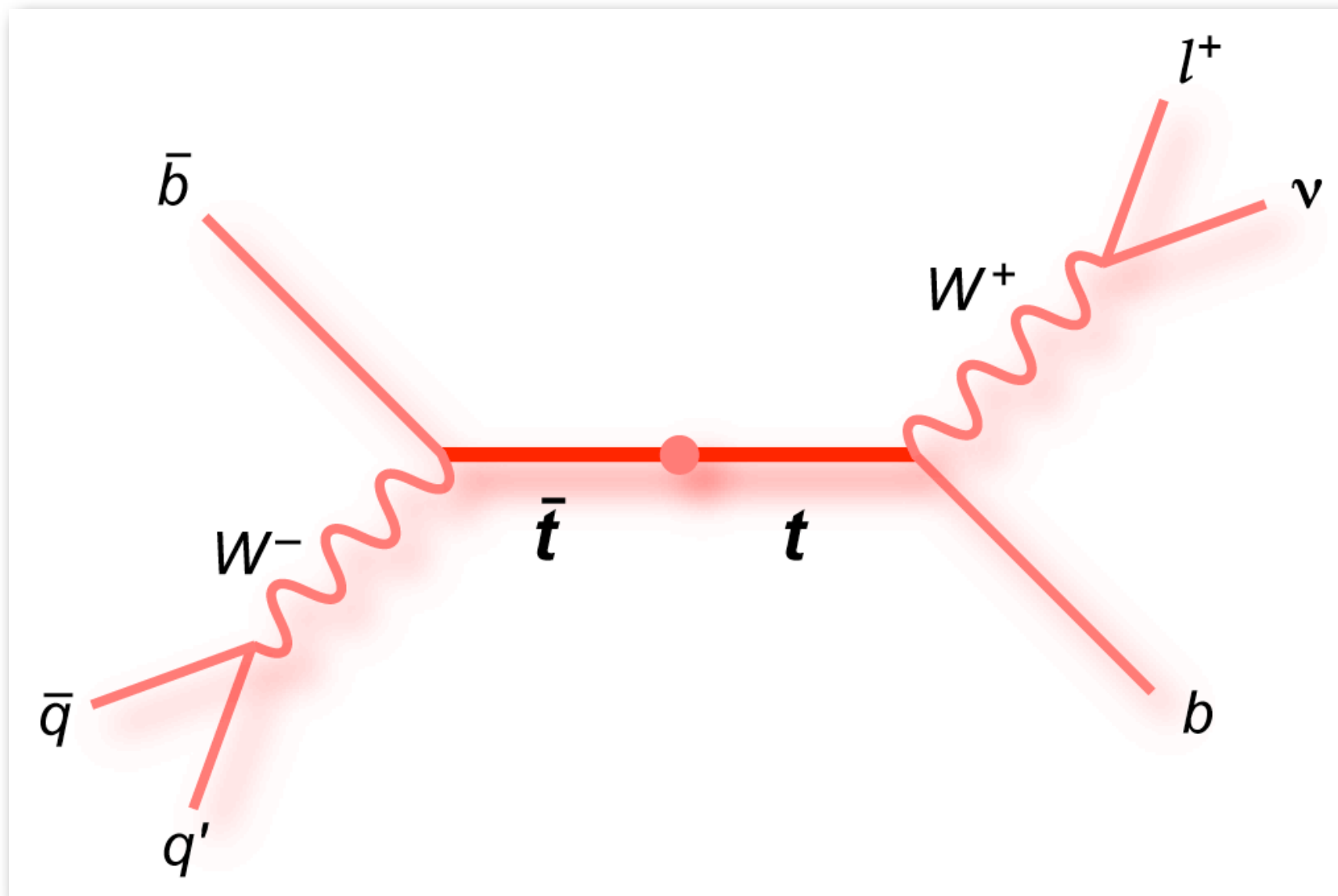
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- Single lepton trigger
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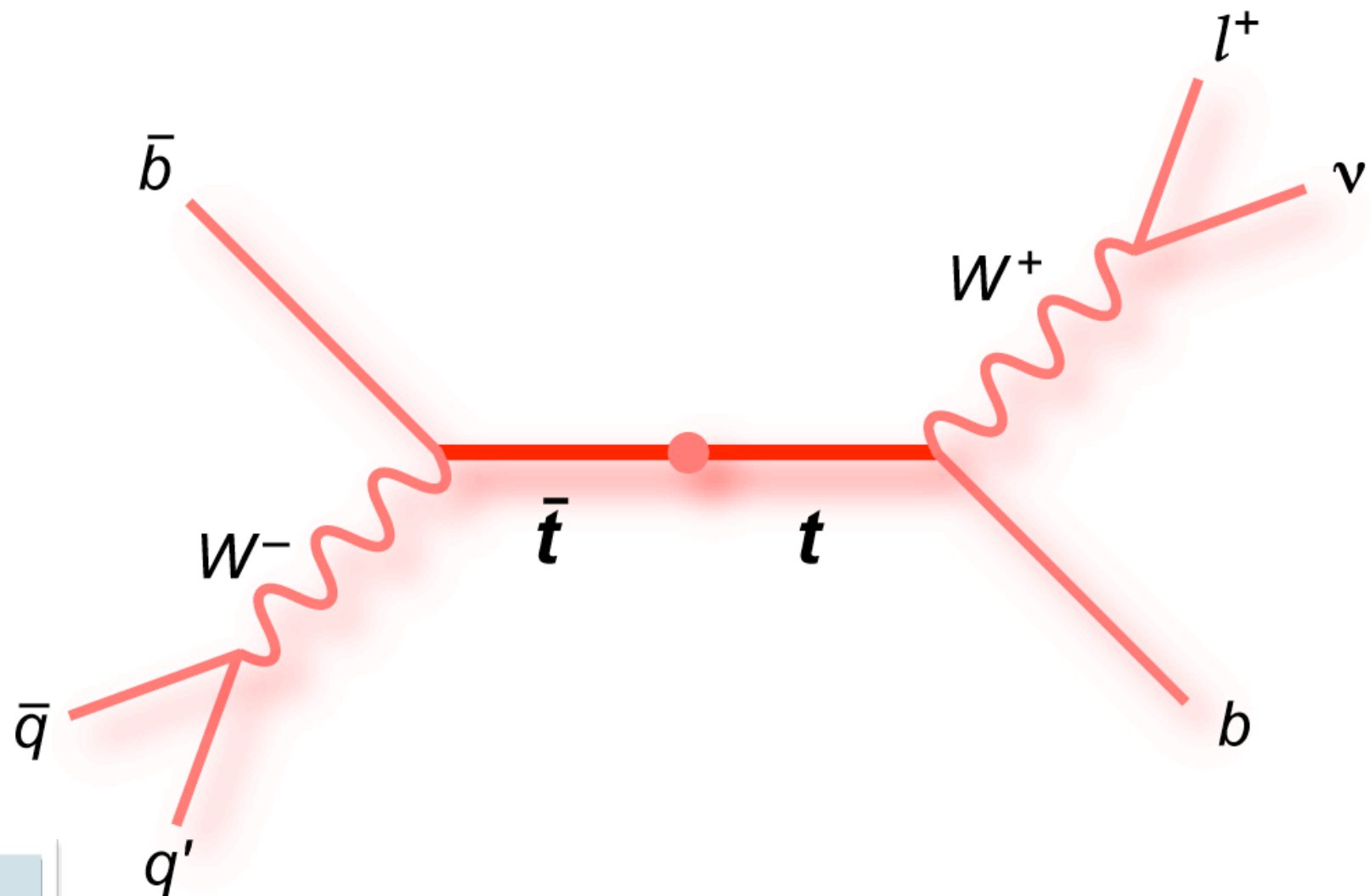
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- W + jets (data driven)
- QCD Multijet (data driven)
- Single Top, Z+jets, Diboson (MC)

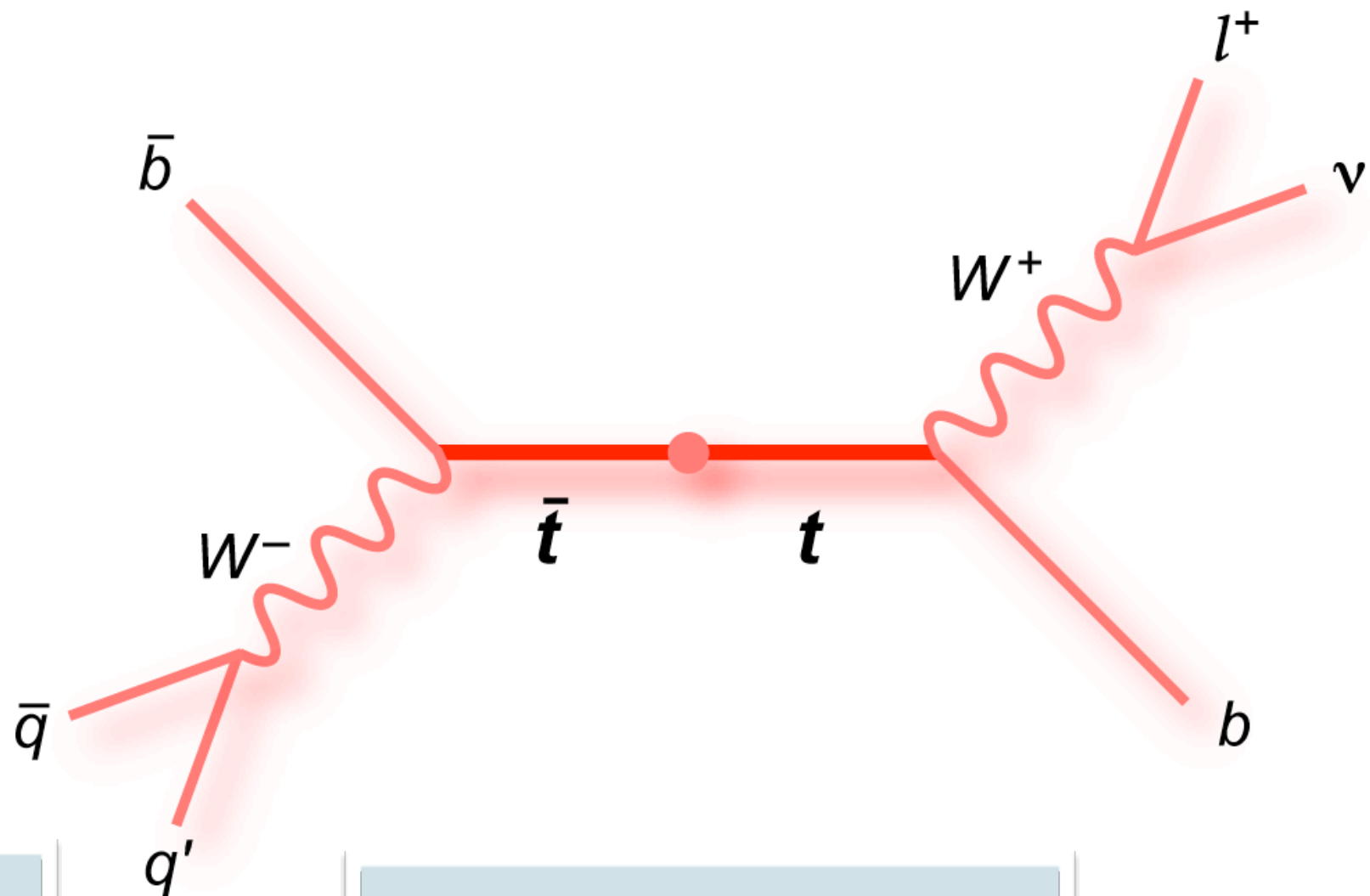




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Requirements for top charge measurement

- Measure b-jet charge
- Measure lepton charge
- Pair lepton and b-jet



b-jet Charge : Track Weighting Method

$$Q_{b\text{-jet}} = \frac{\sum_i q_i |\vec{j} \cdot \vec{p}_i|^{0.5}}{\sum_i |\vec{j} \cdot \vec{p}_i|^{0.5}}$$

q - charge

\vec{j} - jet axis

i over tracks within

cone $\Delta R < 0.25$

($i \leq 10$)



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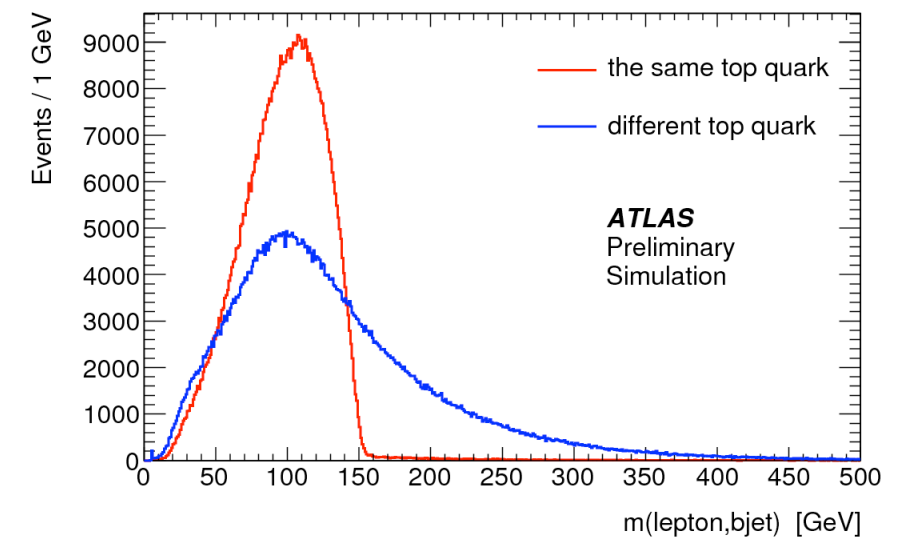
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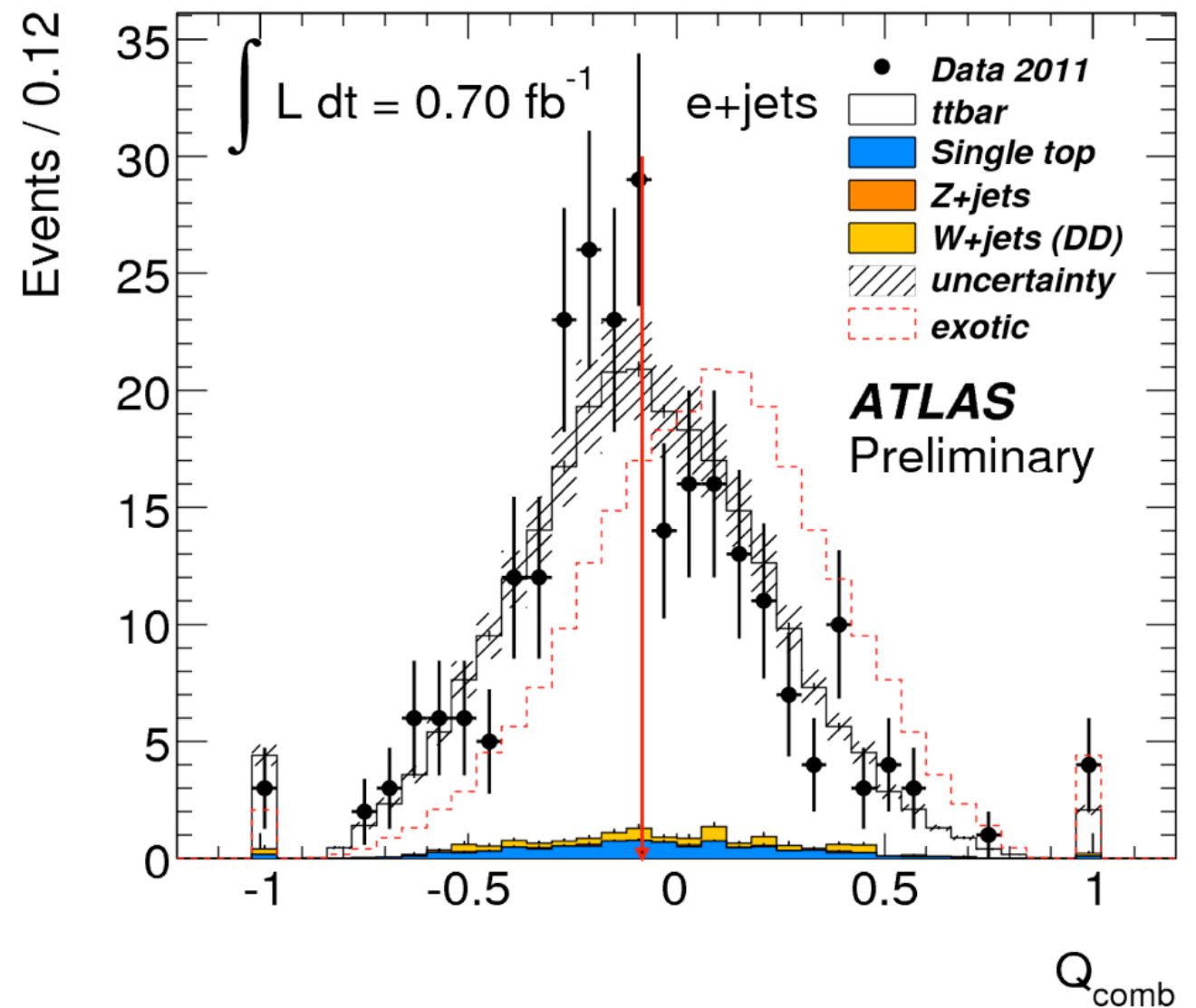
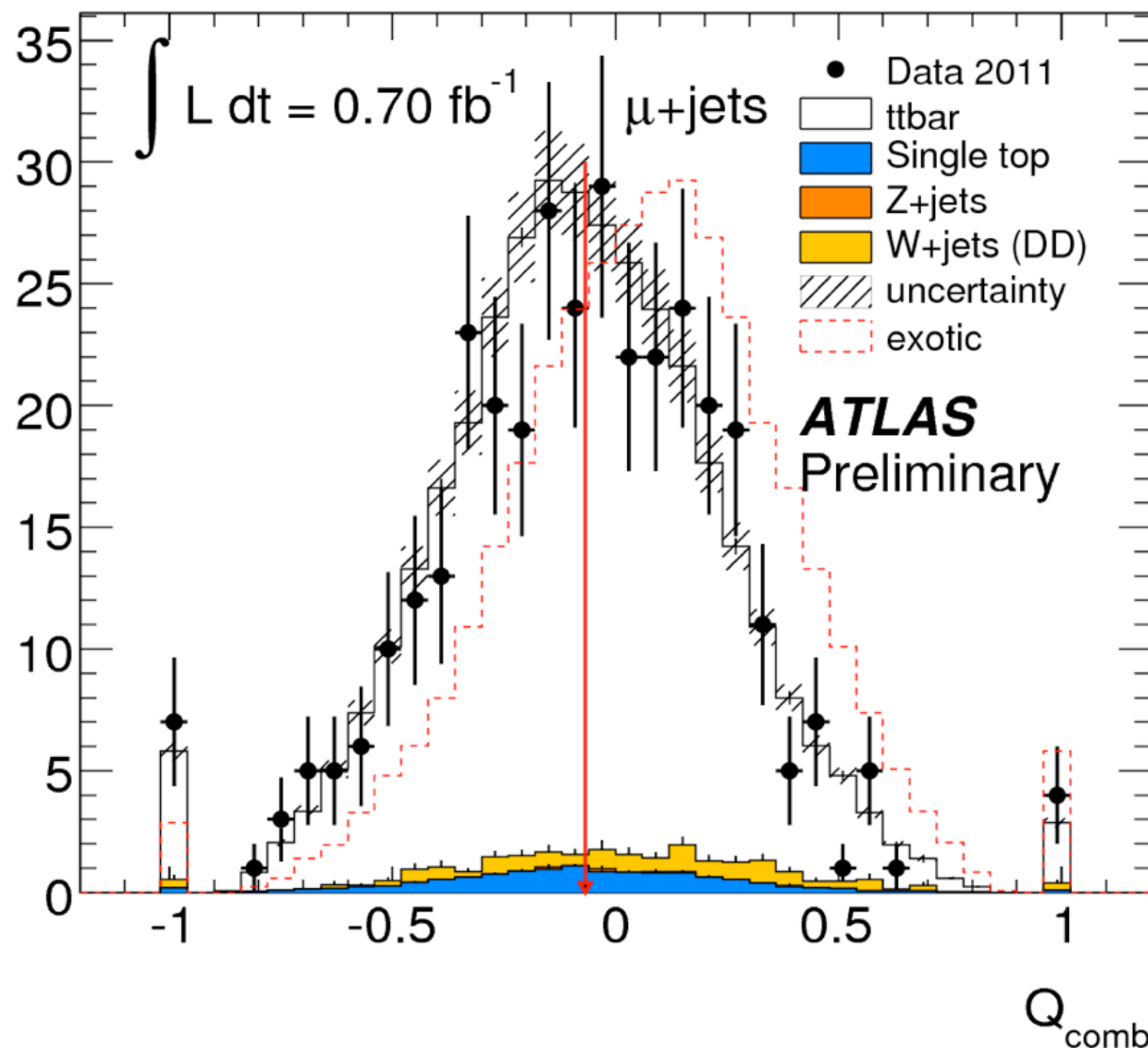
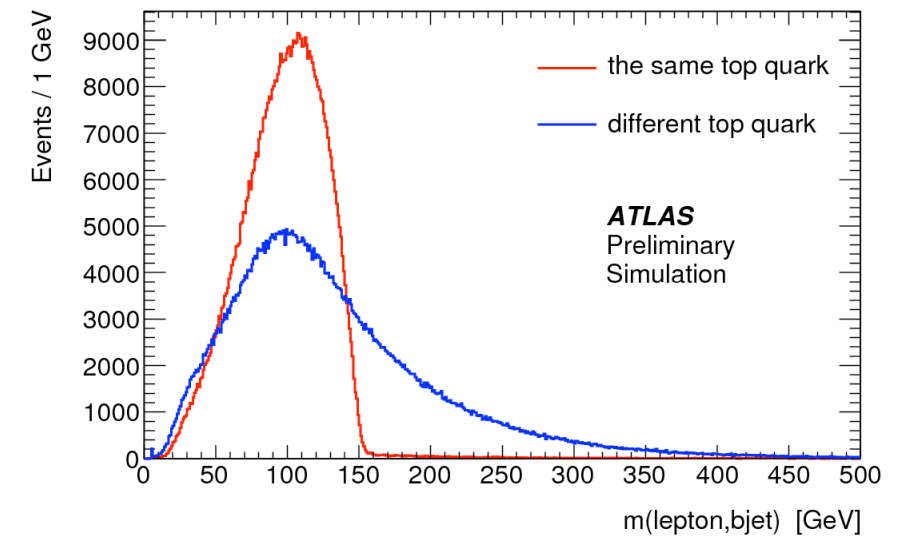
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$$Q_{\text{comb}} = Q_{b\text{-jet}} \cdot Q_l$$





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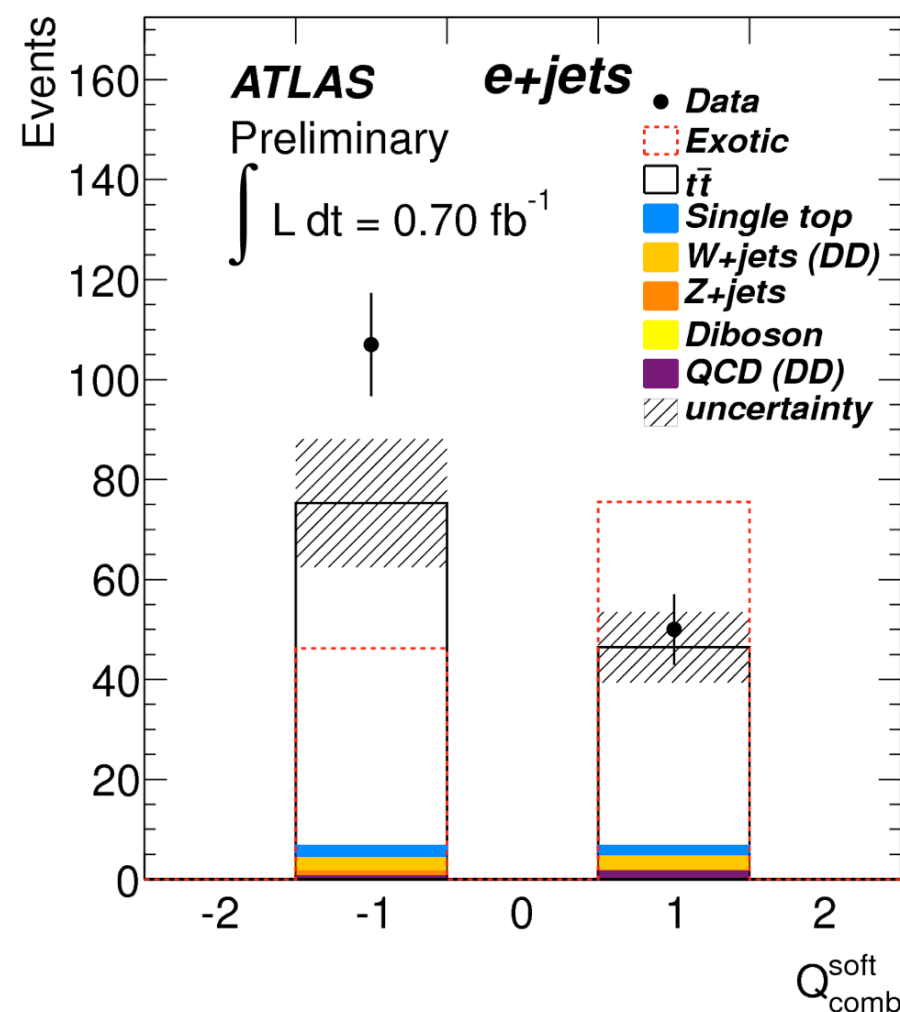
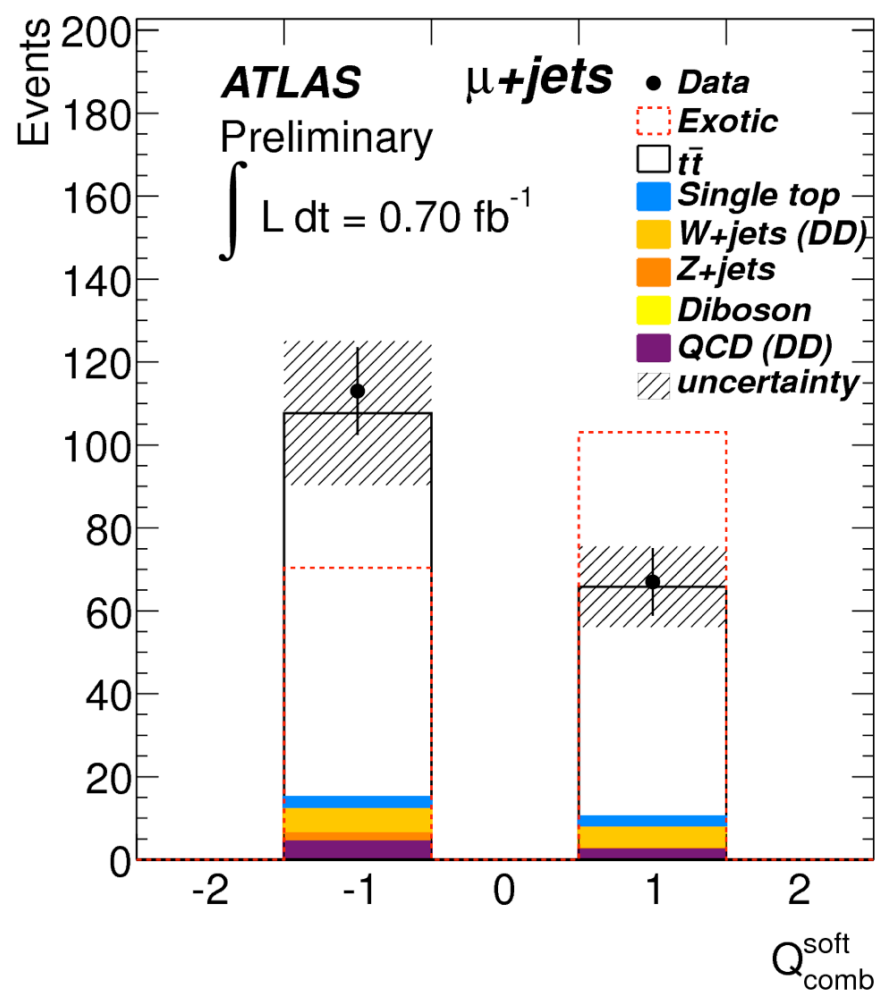
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$$Q_{\text{comb}}^{\text{soft}\mu} = Q_{\text{soft}\mu} \cdot Q_l$$





Cross-Checks and Systematic Uncertainties

- Calibration of both methods using b-quark pair di-jets events
- lepton charge found to be uncorrelated to the absolute charge of the b-jet charge
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Main Systematics

Source	$\langle Q_{comb} \rangle (\%)$		$\langle Q_{comb}^{soft} \rangle (\%)$	
	e+jets	μ +jets	e+jets	μ +jets
ISR/FSR	14	11	15	24
Jet/ E_T^{miss}	7	8	5	8
$t\bar{t}$ Modelling	2	2	7	10
Total uncertainty	16	14	18	27



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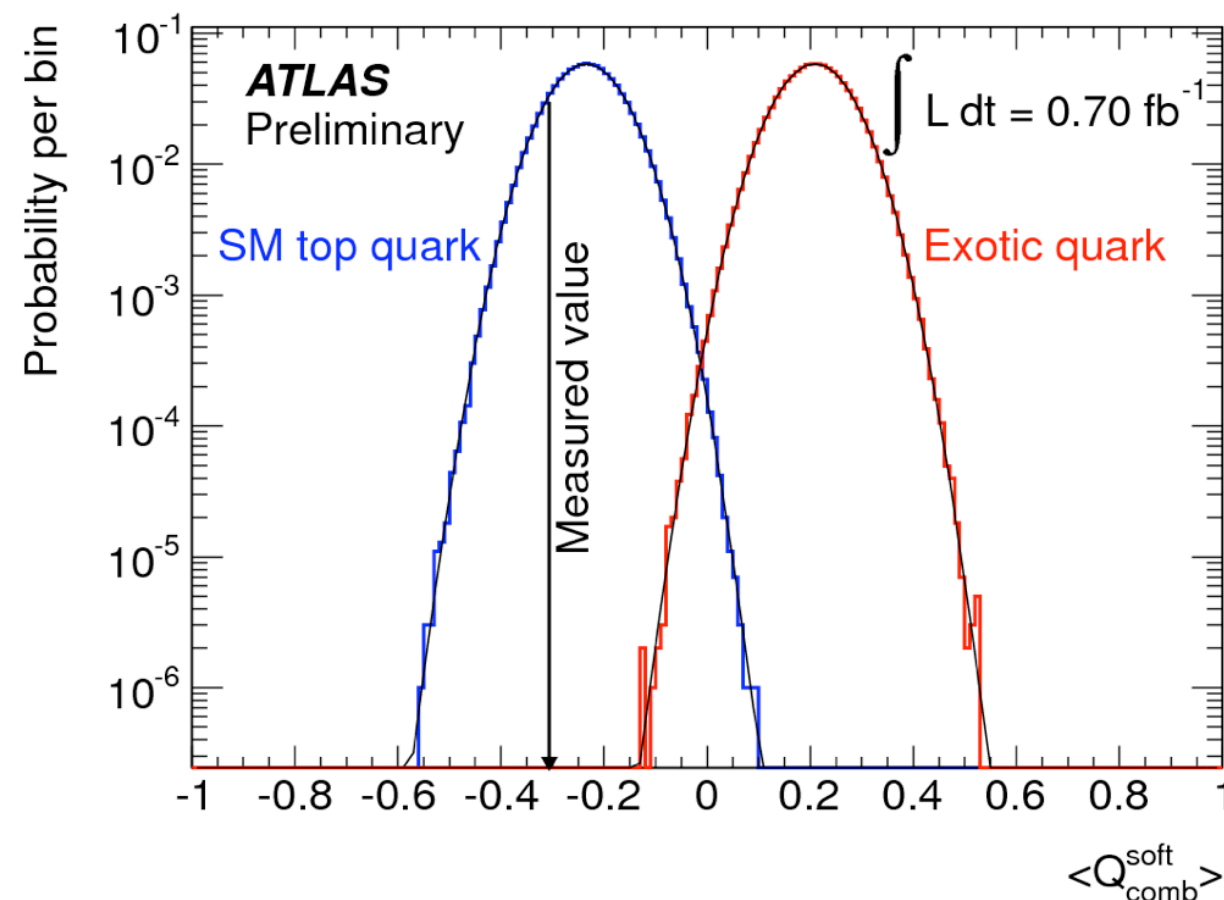
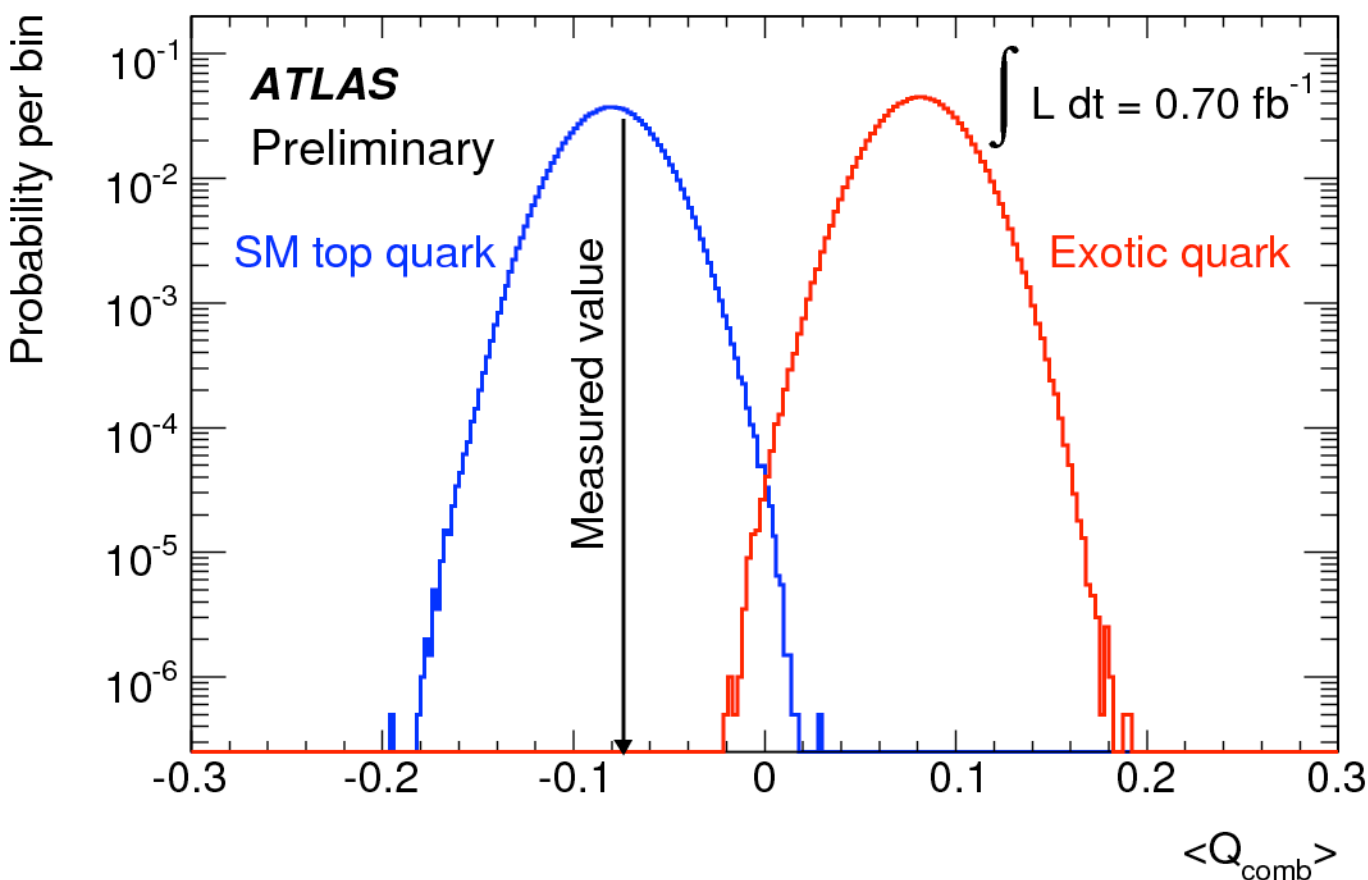
Model	$\langle Q_{\text{comb}} \rangle$	$\langle Q_{\text{comb}}^{\text{soft}} \rangle$
SM	-0.082 ± 0.020 (stat)	-0.234 ± 0.011 (stat)
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Measured	-0.082 ± 0.015	-0.31 ± 0.07



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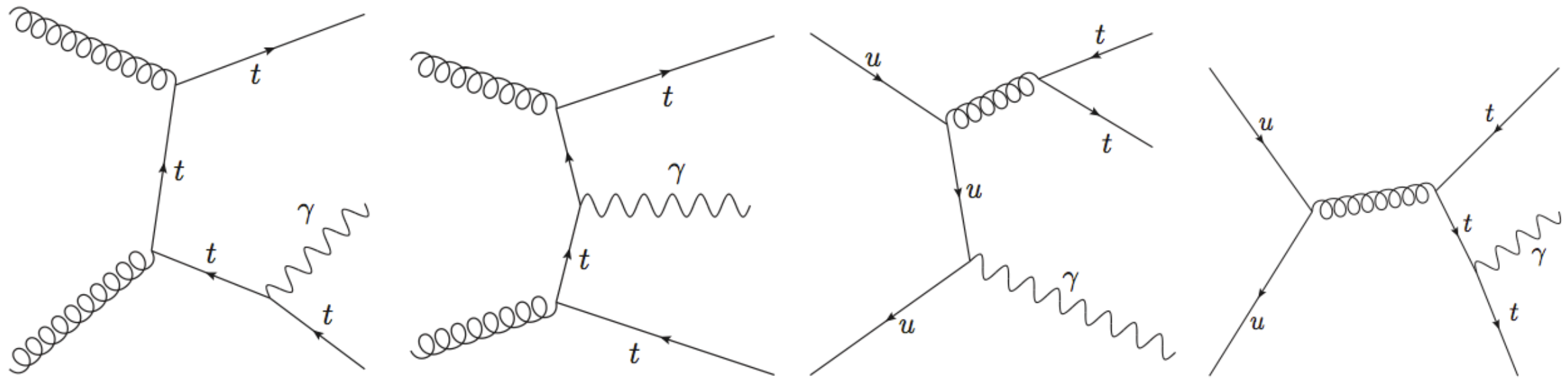
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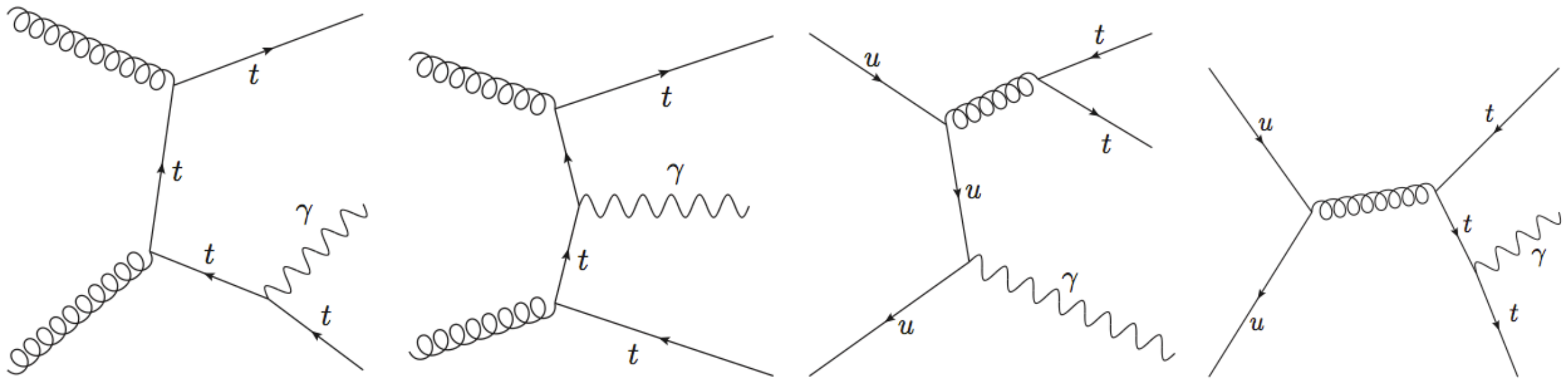
- Exotic top excluded at $>5\sigma$

Radiative Top Quark Pair Processes

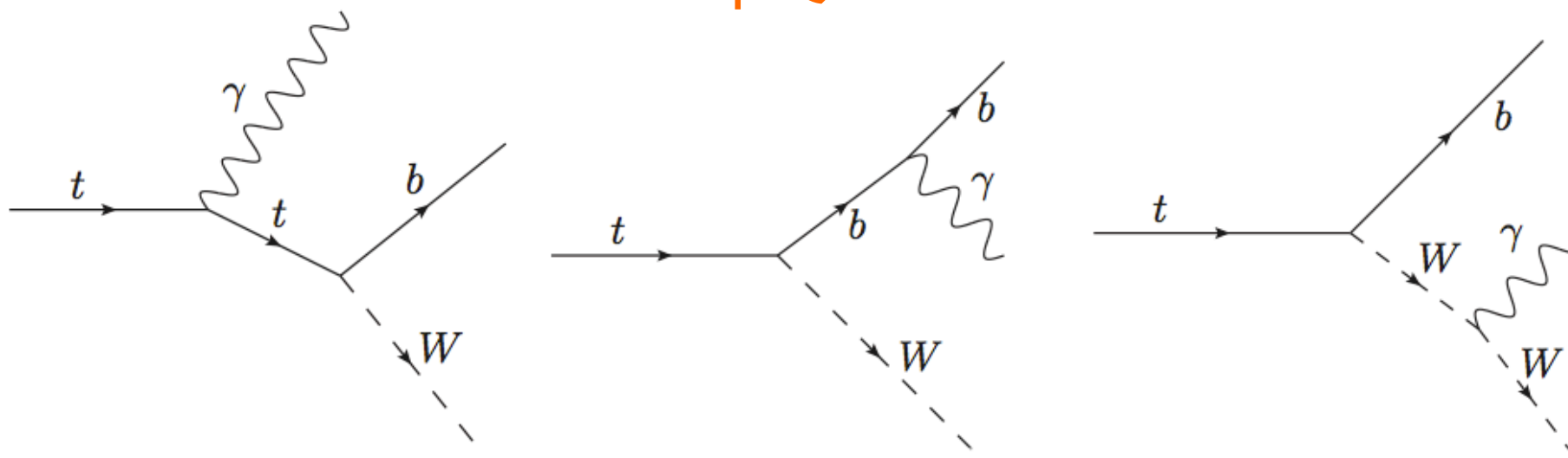


Radiative Top Quark Production

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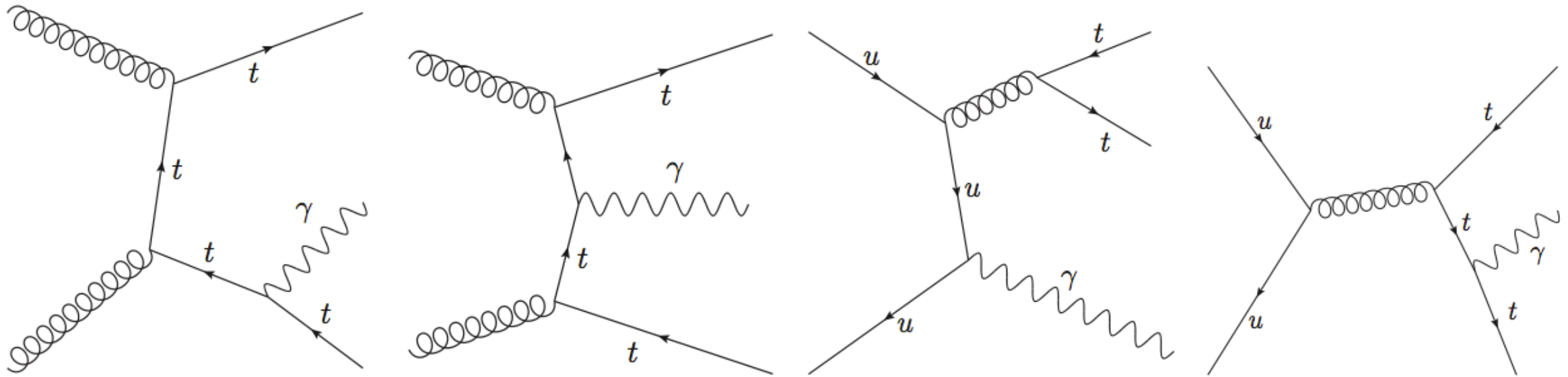


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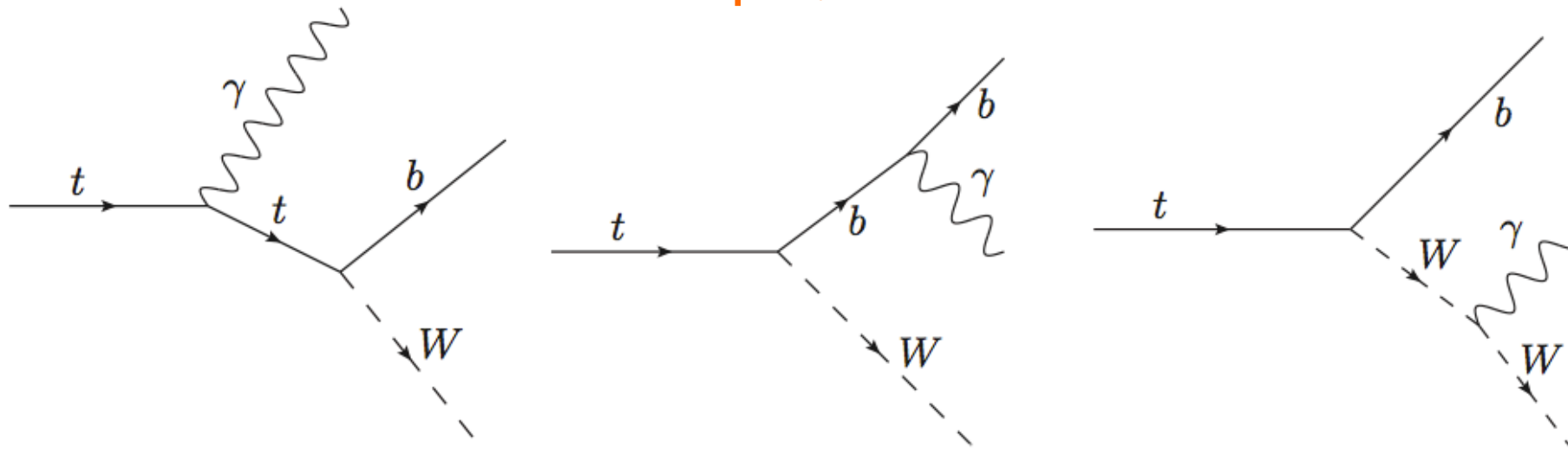


Radiative Top Quark Decay

Radiative Top Quark Pair Processes



Radiative Top Quark Production



Radiative Top Quark Decay

- WHIZARD MC generator : $l\nu_l q\bar{q}' b\bar{b}\gamma$ and $l\nu_l l'\nu_{l'} b\bar{b}\gamma$ at leading order ($p_T^{\text{GEN}}(\gamma) > 8 \text{ GeV}$)
- Prediction LO $\sigma \cdot \text{BR}(s = \sqrt{7} \text{ TeV}) = 0.84 \text{ pb}$, with k-factor of 2.55, NLO prediction $\sigma \cdot \text{BR}(s = \sqrt{7} \text{ TeV}) = 2.1 \pm 0.4 \text{ pb}$



Analysis Strategy

- Photon $E_T > 15$ GeV, $|\eta| < 2.47$, Veto $1.37 < |\eta| < 1.52$
- At least one b-tagged jet
- Veto event if $\Delta R < 0.5$ between jet and the photon
- e+jets: $m_{e\gamma} < 86$ GeV and $m_{e\gamma} > 96$ GeV

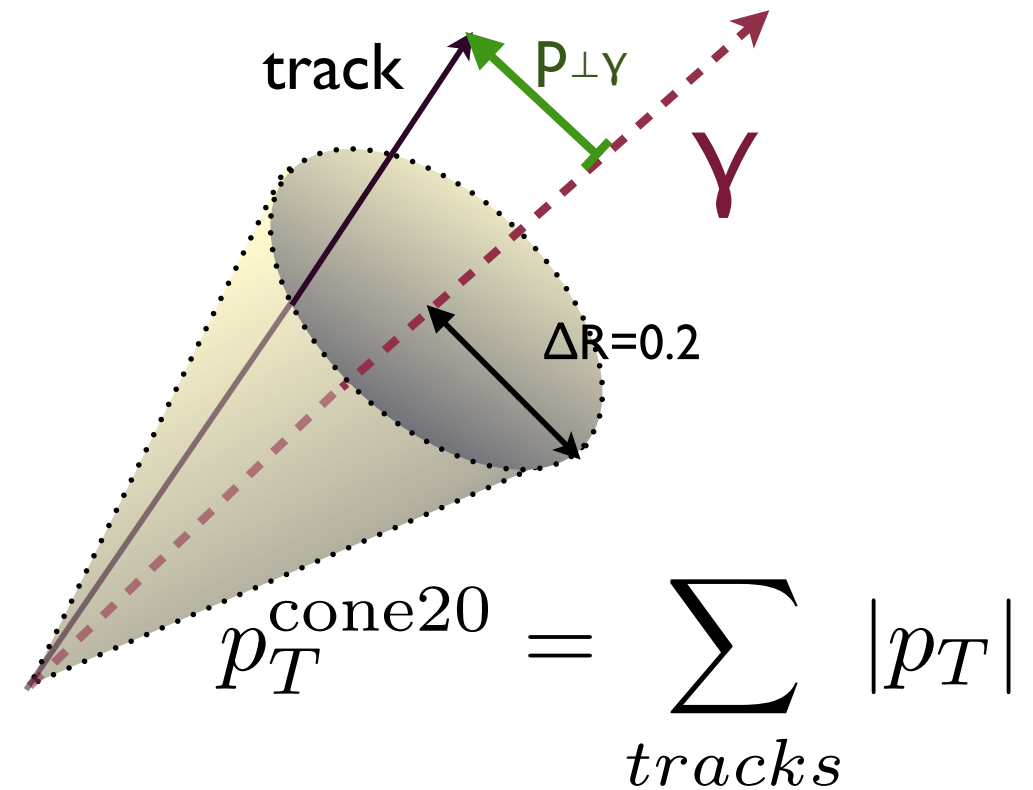


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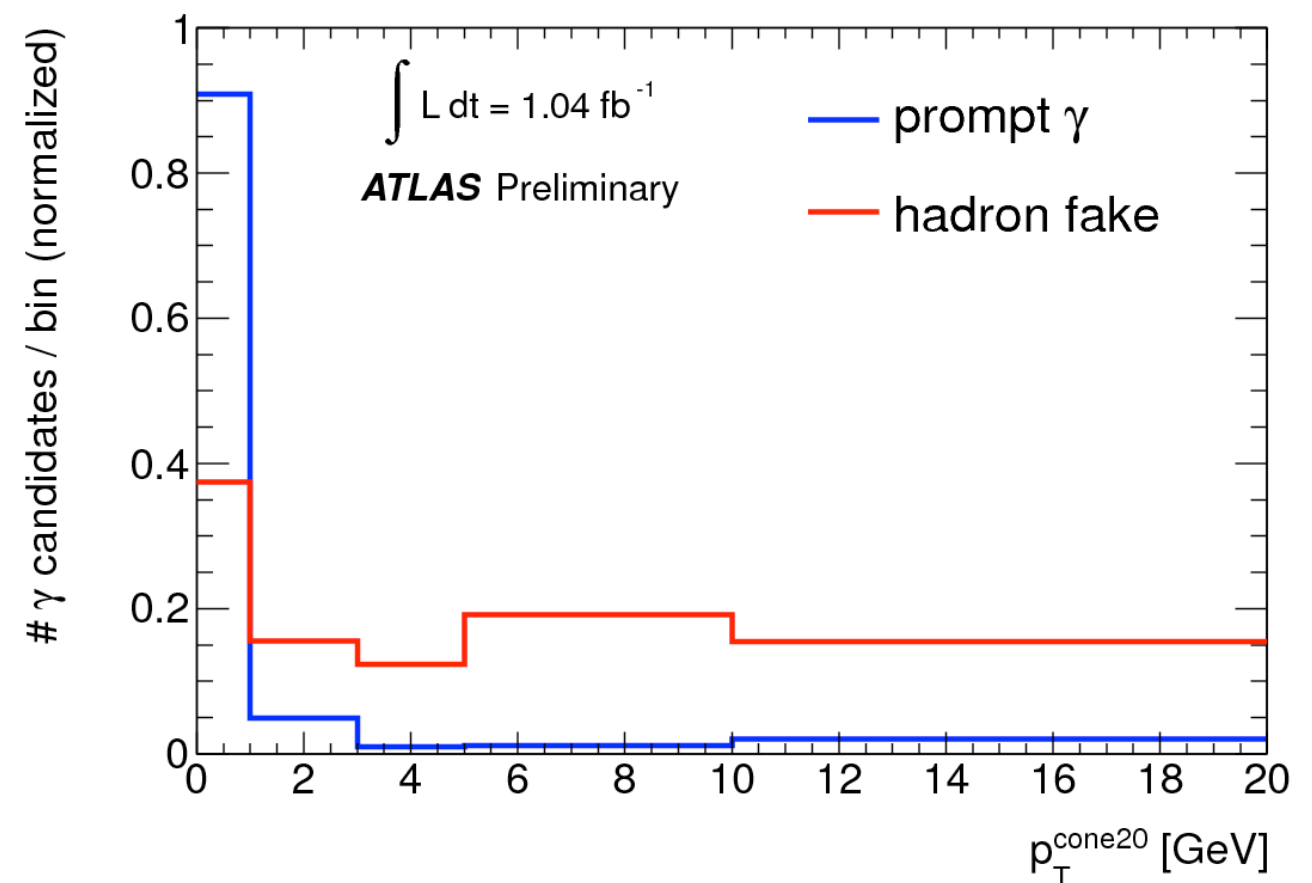
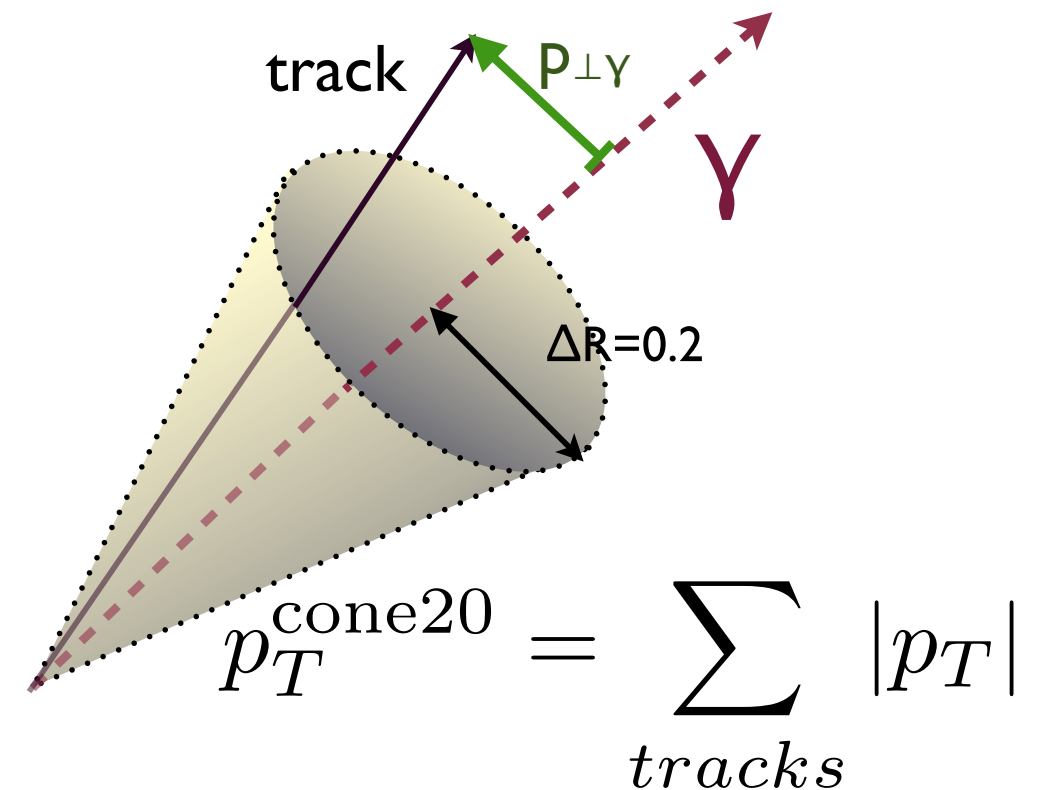
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 - $Z \rightarrow ee$ data (signal)
 - Jet-triggers (hadron fake)



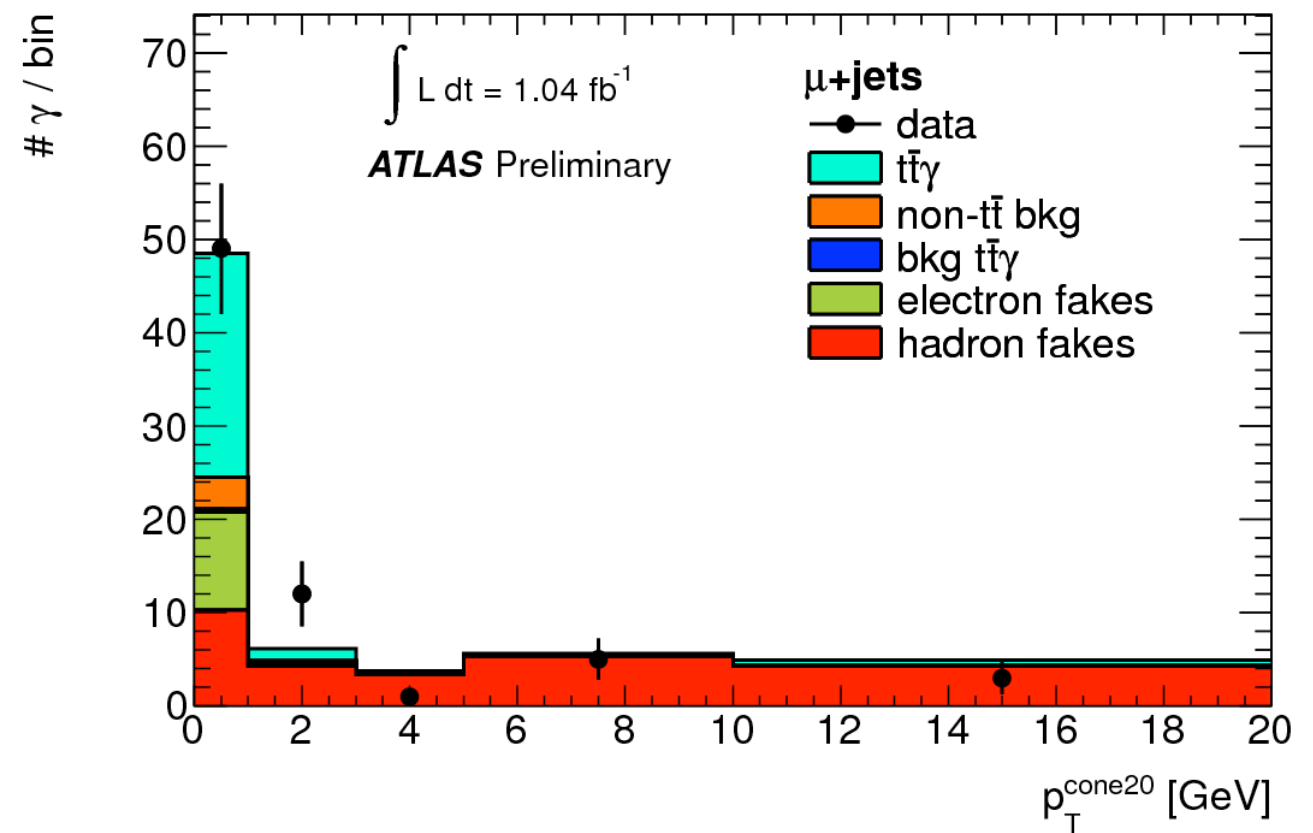
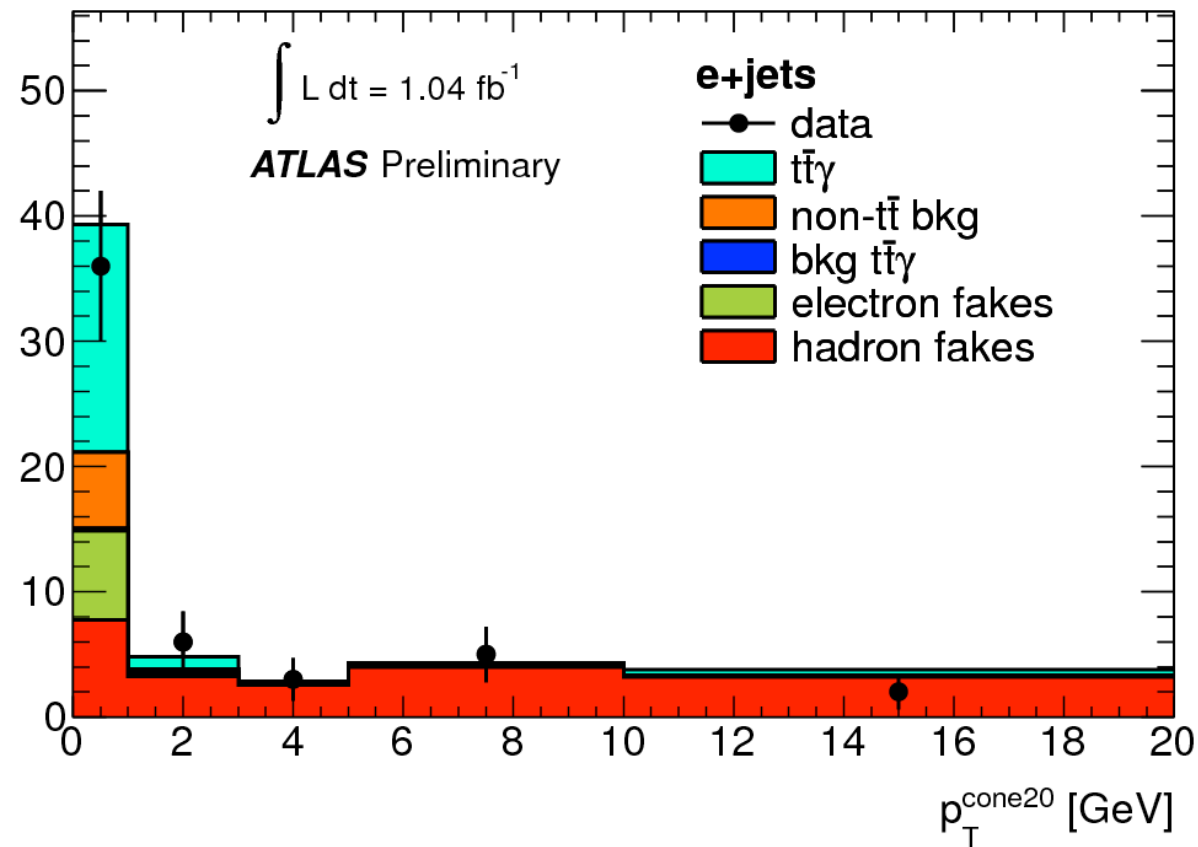
Yields from fit to data

- Templates fit to e +jets and μ +jets data simultaneously
- Signal and hadron fakes floated in the fit

fit parameter	fit value with statistical uncertainty		
hadron fakes in the e +jets channel	21	± 6	events
hadron fakes in the μ +jets channel	28	± 8	events
electrons faking photons from $t\bar{t}$ in the e +jets channel	7.4	± 1.7	events
electrons faking photons from $t\bar{t}$ in the μ +jets channel	10.9	± 2.2	events
$t\bar{t}\gamma$ background in the e +jets channel	0.2		events
$t\bar{t}\gamma$ background in the μ +jets channel	0.4		events
non- $t\bar{t}$ background in the e +jets channel	6.7		events
non- $t\bar{t}$ background in the μ +jets channel	3.8		events
total number of background events	78	± 14	events
total number of signal events	46	± 12	events
$t\bar{t}\gamma$ signal (before selection and acceptance cuts)	2100	± 500	events

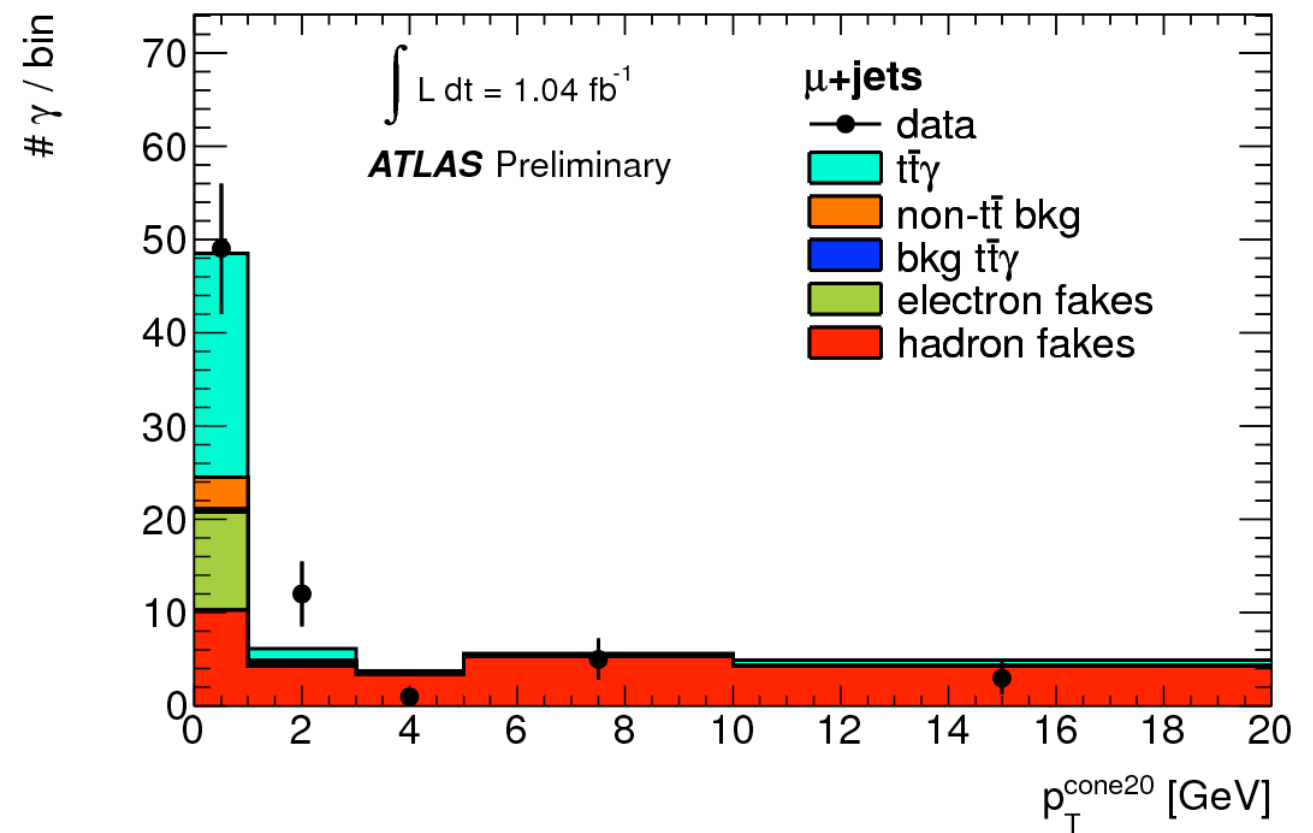
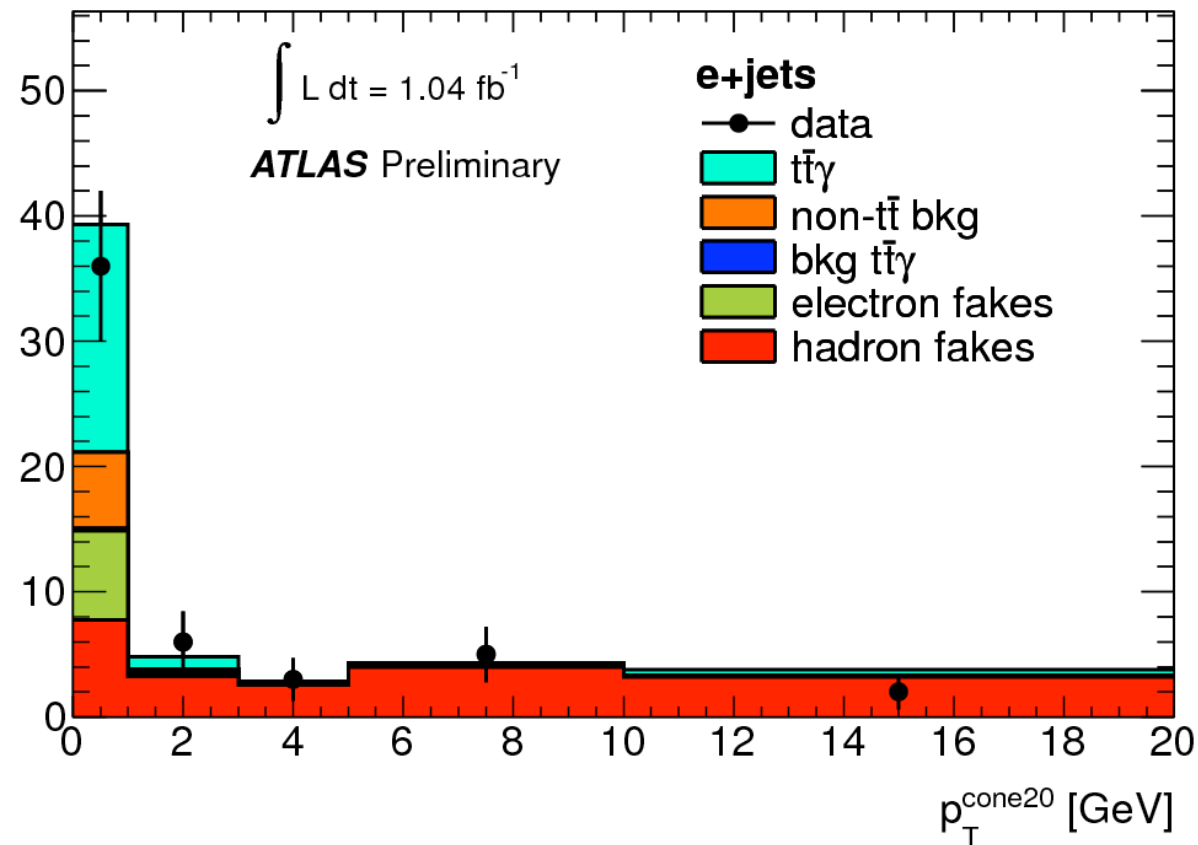


Fit Projections and Measurement





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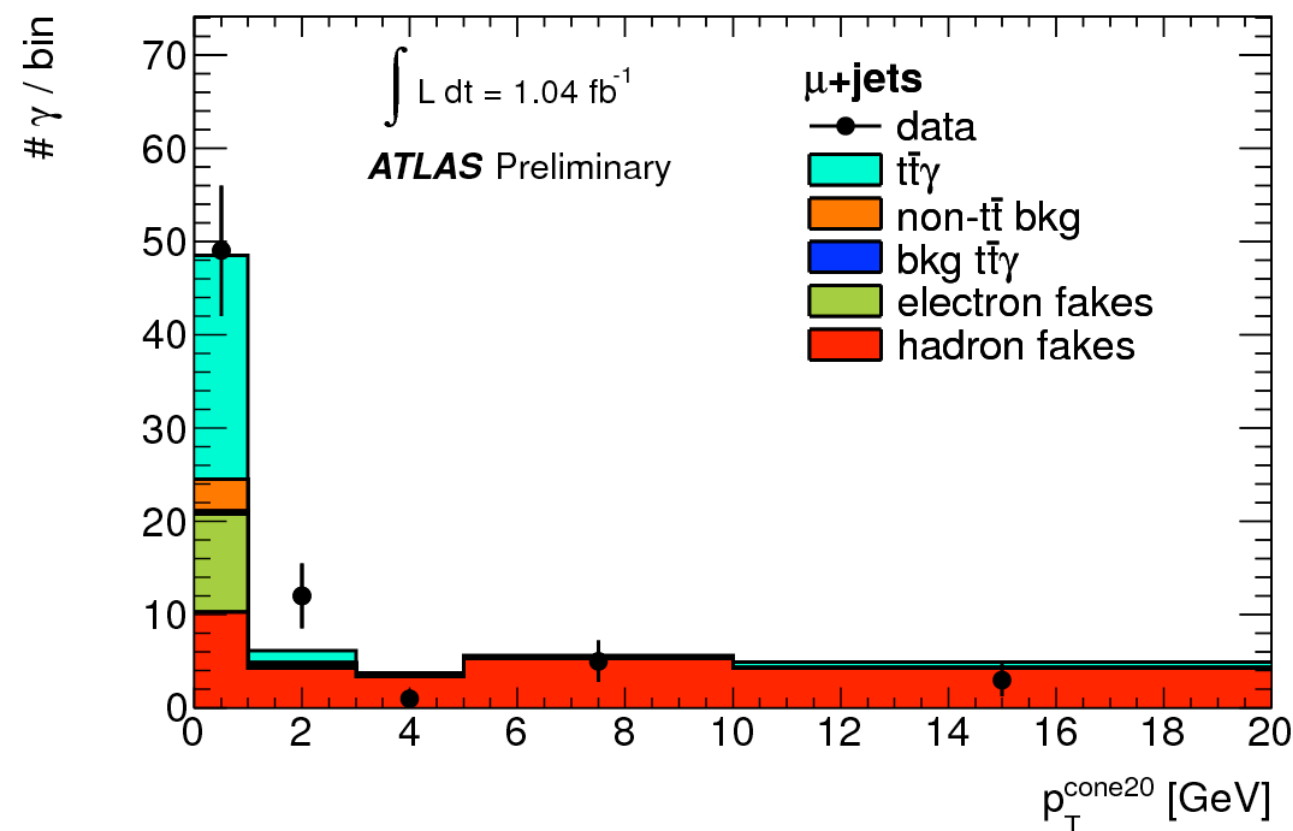
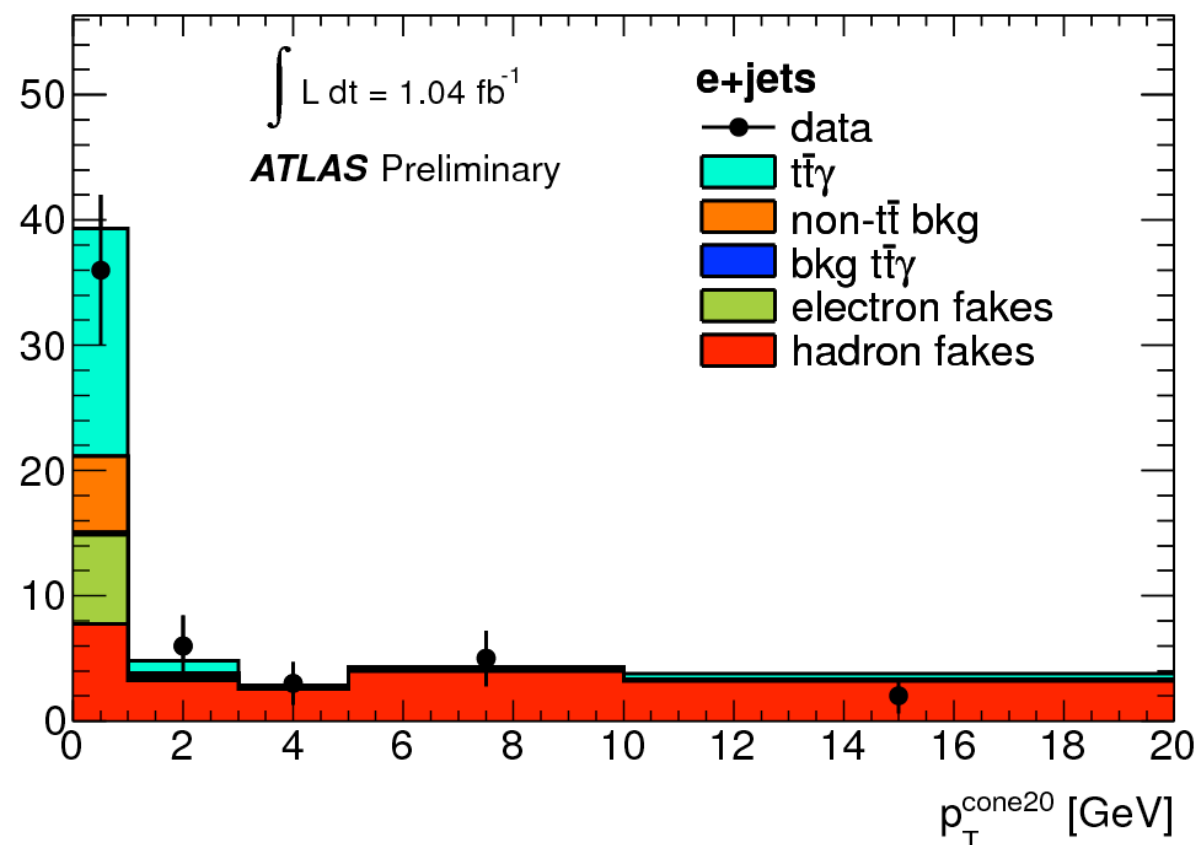


$$\sigma_{t\bar{t}\gamma} \cdot \mathcal{B}(p_T^{\text{GEN}}(\gamma) > 8 \text{ GeV}) = 2.0 \pm 0.5_{\text{stat.}} \pm 0.7_{\text{syst.}} \pm 0.08_{\text{lum.}} \text{ pb}$$

- Null hypothesis p-value = 0.71% (2.7σ)



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Systematics Source	Uncertainty on the cross-section [pb]
Photon identification scale	± 0.33
Initial and Final State Radiation	± 0.31
Jet Energy Scale (pile-up uncertainty)	± 0.28
Jet Energy Scale	± 0.28
Electron to Photon extrapolation	± 0.22
Overall Total	± 0.70



Summary

- Top quark charge $+2e/3$. Unequivocally exclude the exotic charge $-4e/3$ scenario at $>5\sigma$
- $pp \rightarrow t\bar{t}\gamma$ measurement a first at the LHC (2.7σ significance). On the road to testing SM predictions for the electroweak couplings