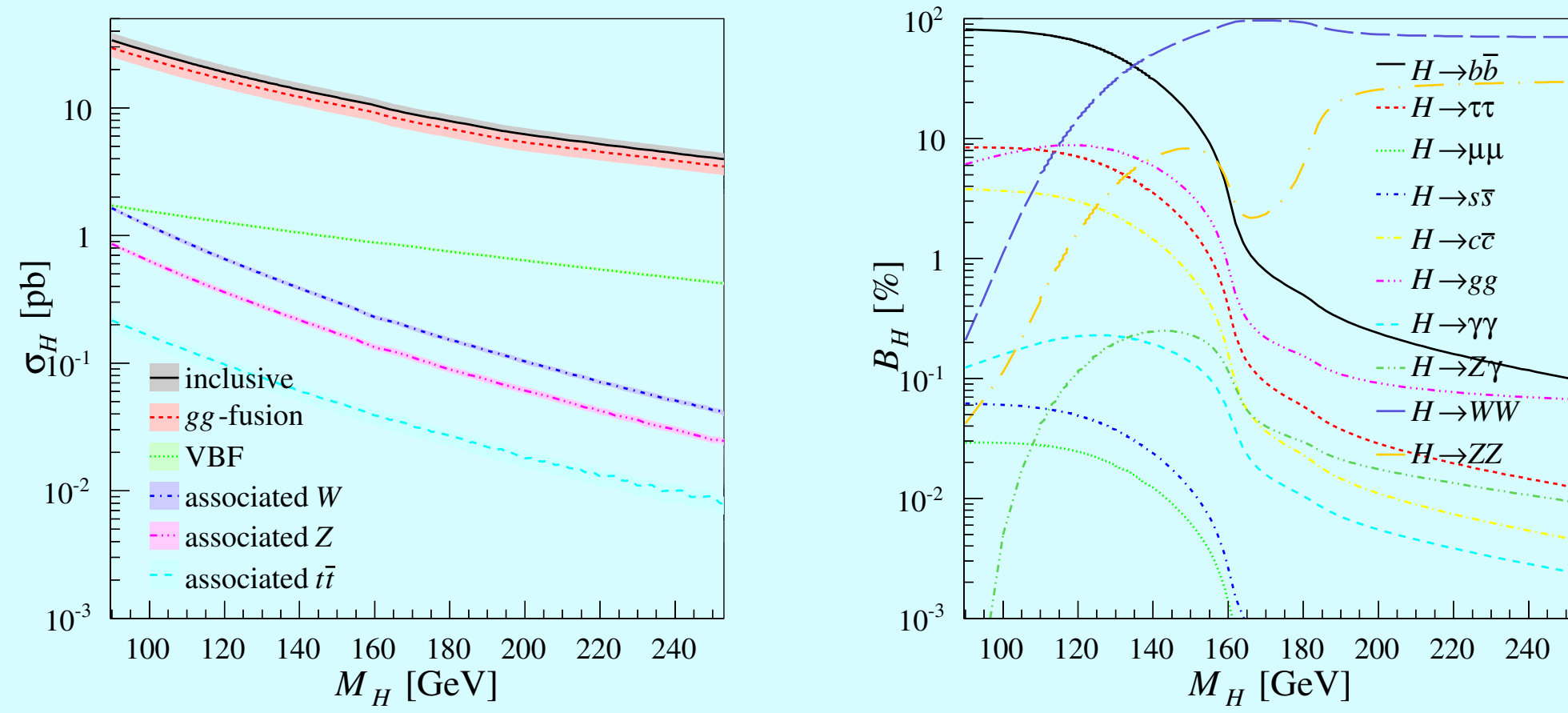


Introduction

LHCb is fully instrumented in the forward region, $2 \leq \eta \leq 5$, and provides complementary results to the central measurements of ATLAS and CMS. Preliminary limits are presented on neutral Higgs production using $\tau\tau$ final states in the forward region of LHCb.

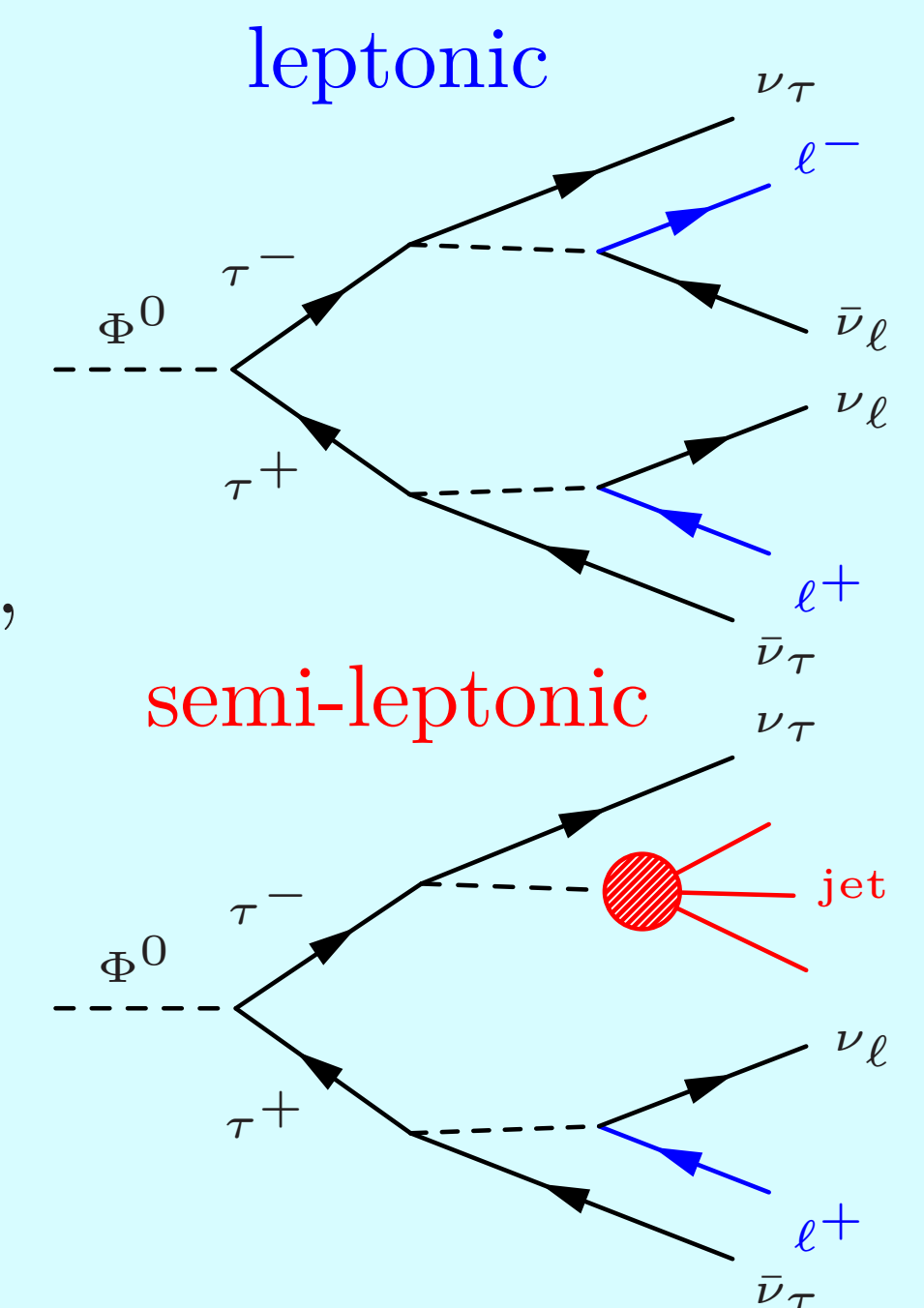


Signals

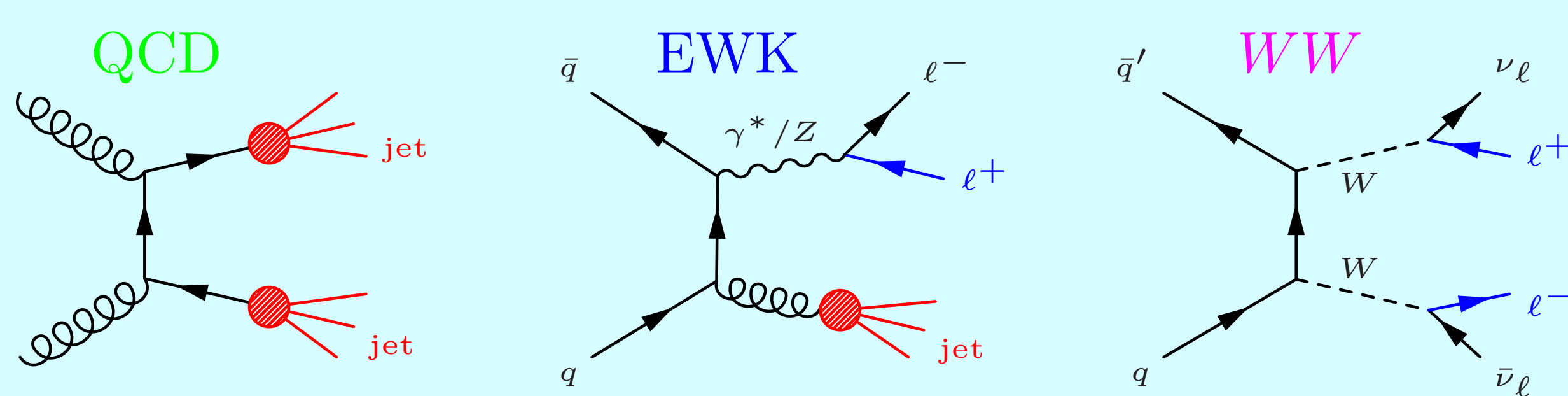
Both **leptonic** and **semi-leptonic** final states are considered: muon-muon, muon-electron, muon-hadron, and electron-hadron. The signal is normalised by:

$$\mathcal{L} \cdot \sigma \cdot \mathcal{B} \cdot \mathcal{A} \cdot \varepsilon$$

- \mathcal{L} is the integrated luminosity of $1028 \pm 36 \text{ pb}^{-1}$
- σ is the signal cross-section evaluated using HIGLU, DFG, BBH@NNLO, and GGH@NNLO
- \mathcal{B} is the $\tau\tau$ branching fraction calculated with FEYNHIGGS
- \mathcal{A} is the acceptance from PYTHIA simulation
- ε is the momentum dependent efficiency from data



Backgrounds



QCD, semi-leptonic hadron decays or mis-identified hadrons

EWK, single lepton from W or Z and underlying event

$Z \rightarrow \tau\tau$, dominant and irreducible background

$t\bar{t}$ and WW , leptonic or hadronic decays

- fit QCD and EWK templates to the same-sign distribution of the p_T difference between the two decay candidates
- evaluated from simulation with the same normalisation procedure as for the signal

$Z \rightarrow \ell\ell$, $\mu\mu$ or ee events with a possibly mis-identified lepton

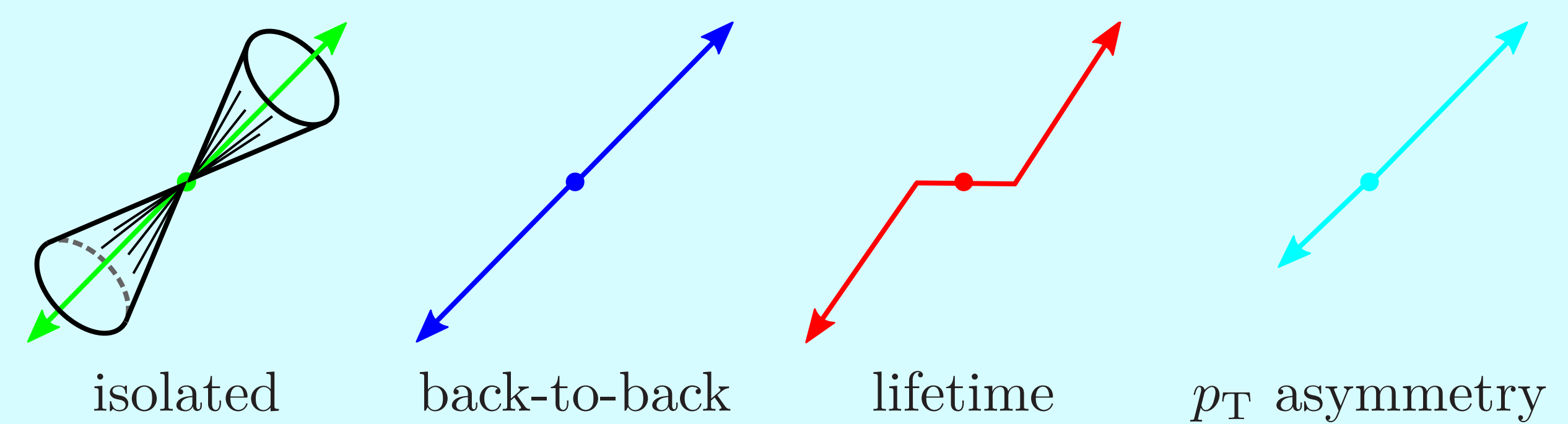
- template from prompt sideband, normalisation to Z peak or with mis-id rates

Event Selection

The event selection of Ref. [1] is used which is broken into five streams: $\tau_\mu\tau_\mu$, $\tau_\mu\tau_e$, $\tau_e\tau_\mu$, $\tau_\mu\tau_h$, and $\tau_e\tau_h$.

- the first τ decay product must have $p_T > 20$ GeV and the second $p_T > 5$ GeV (for $\tau_e\tau_\mu$ the second must also have $p_T < 20$ GeV)
- both decay products must have a pseudorapidity of $2.0 \leq \eta \leq 4.5$
- the events are triggered on single leptons

To separate signal from background, the following selection is applied.



Statistical Methods

Limits are set with the q_μ test statistic of Ref. [2] assuming the asymptotic limit for $\hat{\mu}$. The test statistic is calculated using an extended likelihood of the mass distribution with normal nuisance parameters.

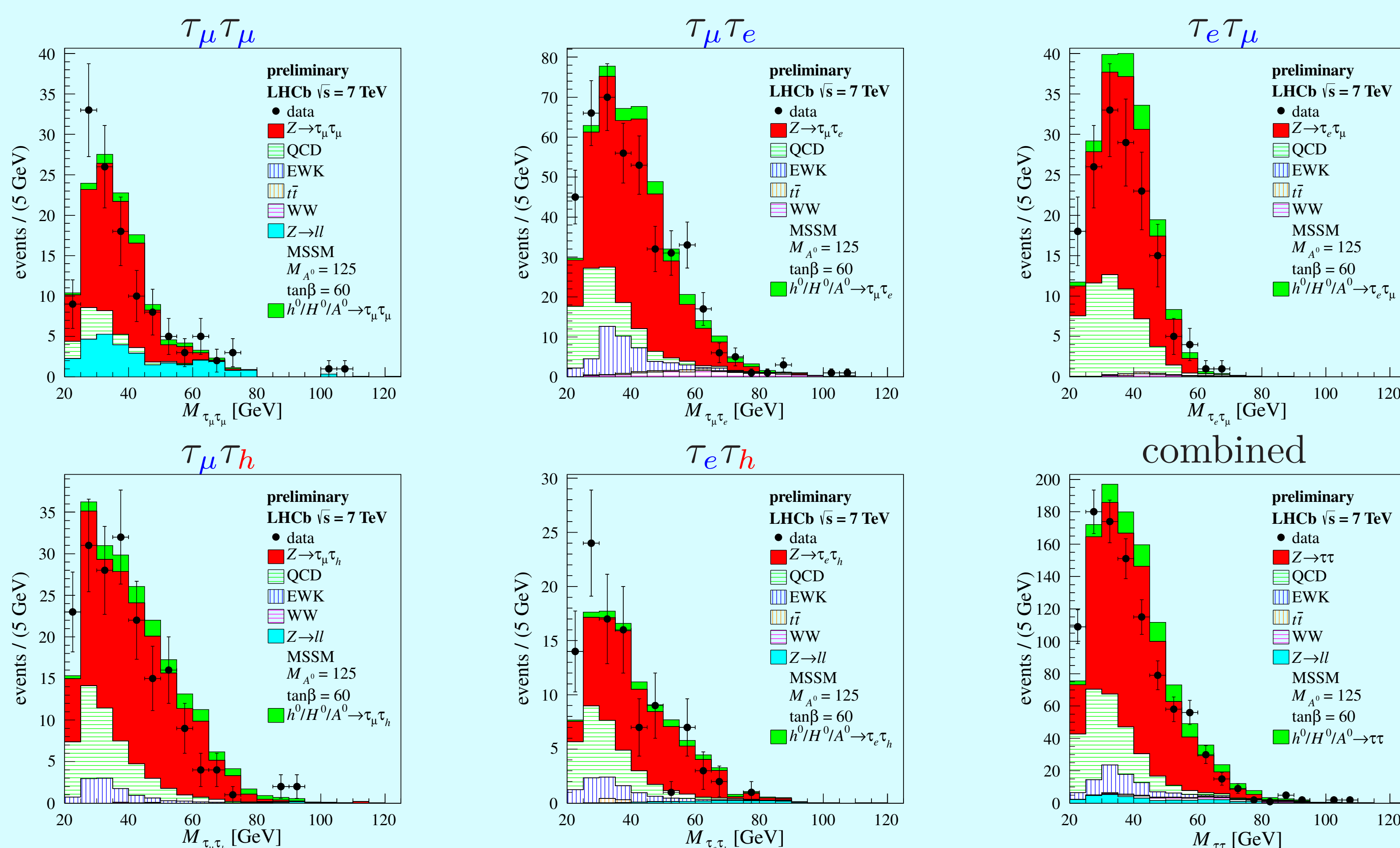
$$L(\vec{x}|\mu, \vec{\theta}) = e^{-(N_b + \mu N_s)} \prod_{i=1}^{N_{\text{obs}}} F(\vec{x}_i|\mu, \vec{\theta}) \prod_{j=1}^{N_\theta} \phi(\theta_j)$$

- \vec{x} , observables
- μ , signal strength
- $\vec{\theta}$, nuisance parameters
- N_b expected background
- N_s expected signal
- F , unnormalised expected distribution
- ϕ , normal PDF

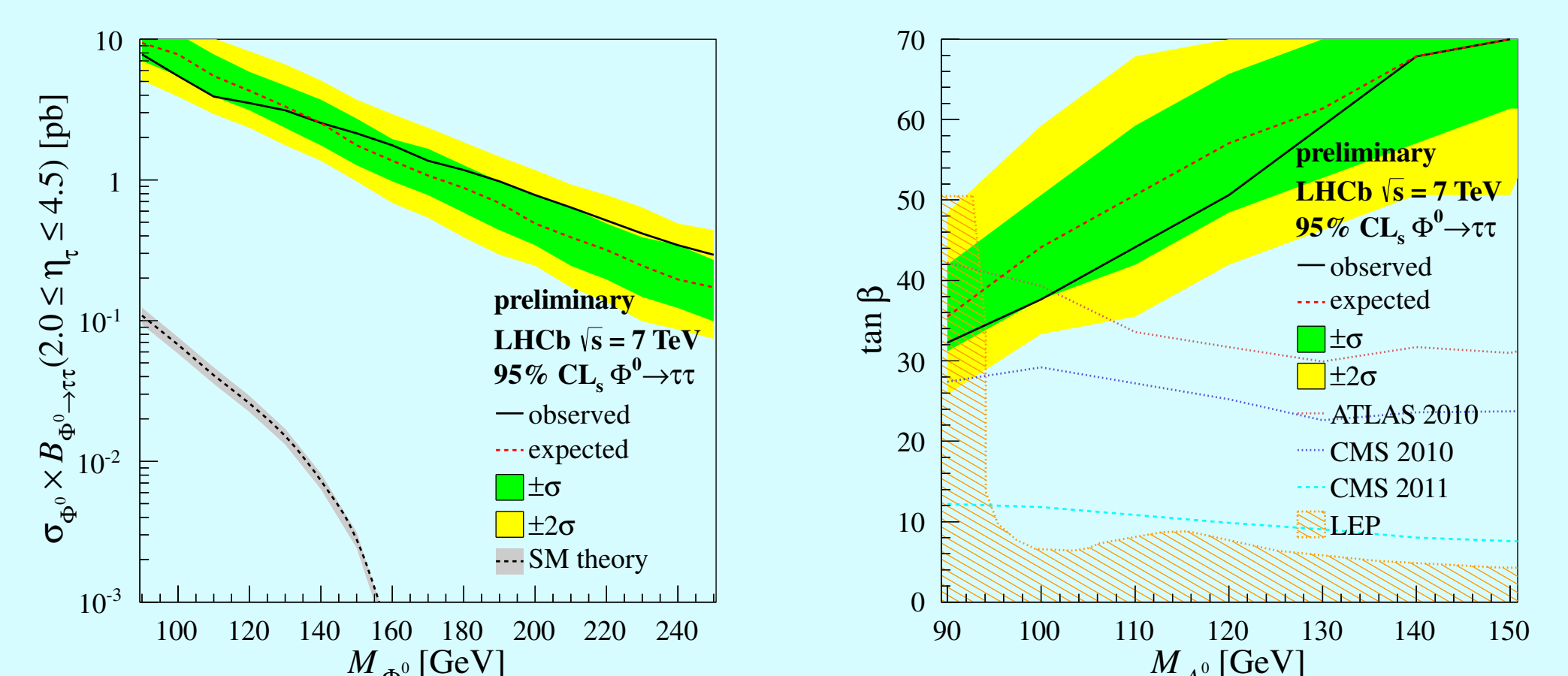
Observed Event Yields

	$\tau_\mu\tau_\mu$	$\tau_\mu\tau_e$	$\tau_e\tau_\mu$	$\tau_\mu\tau_h$	$\tau_e\tau_h$
QCD	11.7 ± 3.4	72.4 ± 2.2	54.0 ± 3.0	41.9 ± 0.5	24.5 ± 0.6
EWK	0.0 ± 3.5	40.3 ± 4.4	0.0 ± 1.3	10.8 ± 0.5	9.3 ± 0.5
$t\bar{t}$	$< 0.1 \pm 0.1$	3.7 ± 0.2	1.0 ± 0.1	0.2 ± 0.1	0.7 ± 0.4
WW	$< 0.1 \pm 0.1$	13.4 ± 0.4	1.6 ± 0.1	$< 0.1 \pm 0.1$	0.1 ± 0.1
$Z \rightarrow \ell\ell$	29.8 ± 7.0	—	—	0.4 ± 0.1	2.0 ± 0.2
$Z \rightarrow \tau\tau$	79.8 ± 5.6	288.2 ± 26.2	115.8 ± 12.7	146.1 ± 9.7	62.1 ± 8.0
Total	121.4 ± 10.2	417.9 ± 26.6	172.4 ± 13.1	199.3 ± 9.7	98.7 ± 8.0
Observed	124	421	155	189	101

Observed Mass Distributions



Results



Model independent limits (left) and MSSM $m_{h^0}^{\text{max}}$ limits (right) in the forward region of LHCb are given.

References

- [1] LHCb Collab., JHEP **1301** (2013) 111, arXiv:1210.6289.
- [2] G. Cowan, K. Cranmer, E. Gross, and O. Vitells, Eur. Phys. J. **C71** (2011) 1554, arXiv:1007.1727.