

DESY tX analyses — tWZ and $t\gamma q + t\bar{t}\gamma$

CMS tX Roundtable Jan 08 2025

Ying AN on behalf of the DESY TOP group

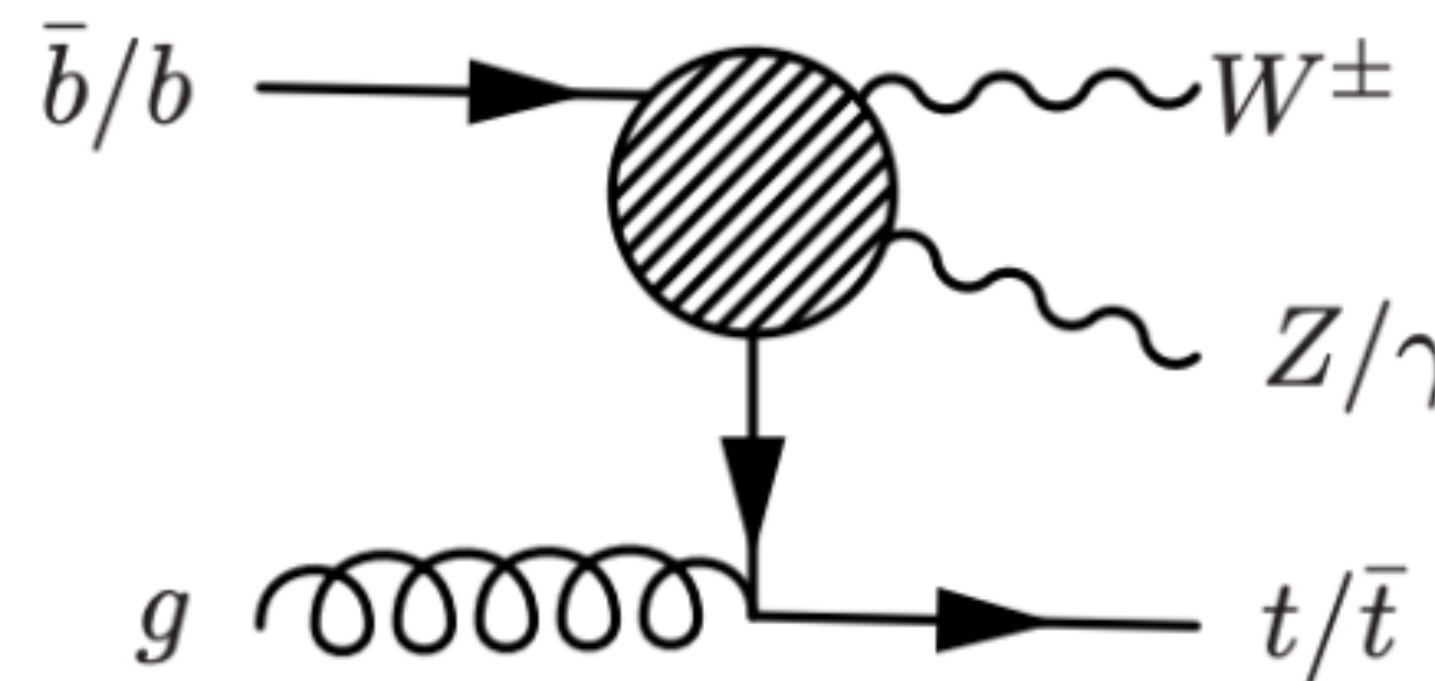


tWZ in multi-lepton final state analysis

Previous presentations: [1-2-CADI line talk](#)
CADI line: **TOP-24-009**

Motivation:

- tWZ has **never been observed**, only the evidence has been published (TOP-22-008).
- Its discovery would allow the analysis of SMEFT operators loosely constrained.
- New physics could arise from **bW** → **tZ** vertices.
- This would lead in **energy growth** for specific operators.



Dataset: Run2 + Run3

Status:

- Waiting for samples extension to retrain ML algorithm and approval of lepton SFs
- AN and paper draft submission before the end of the week to ask for pre-approval talk
- Target: Moriond conference

Person power:

- Alberto Belvedere (PhD student) and Roman Kogler (staff)

tWZ – analysis strategy

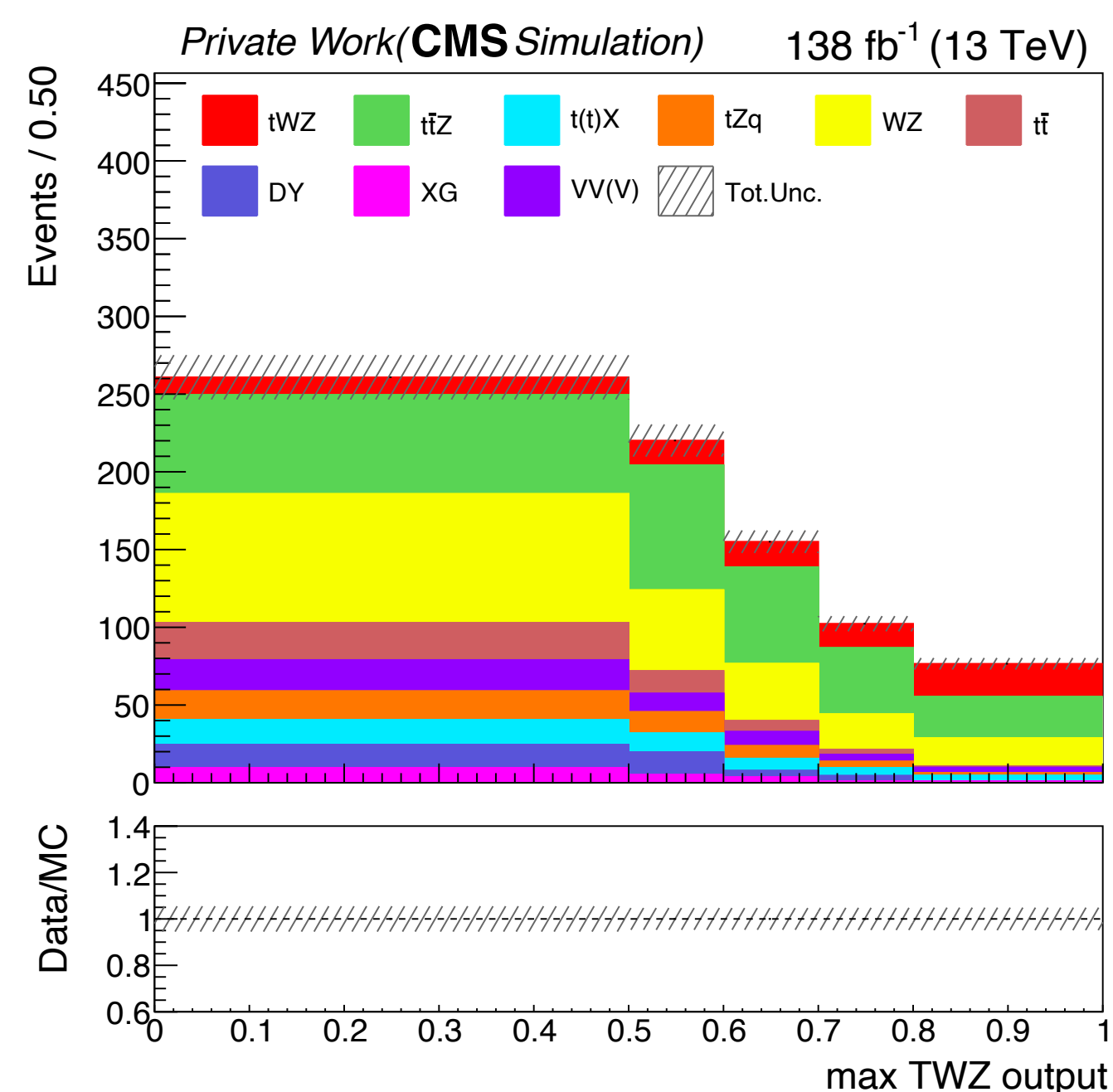
Events with 3 and 4 leptons in the final state split in **6 regions**:

- 3 and 4 leptons SRs
- WZ and ZZ CRs
- 3 leptons DY and TT CRs

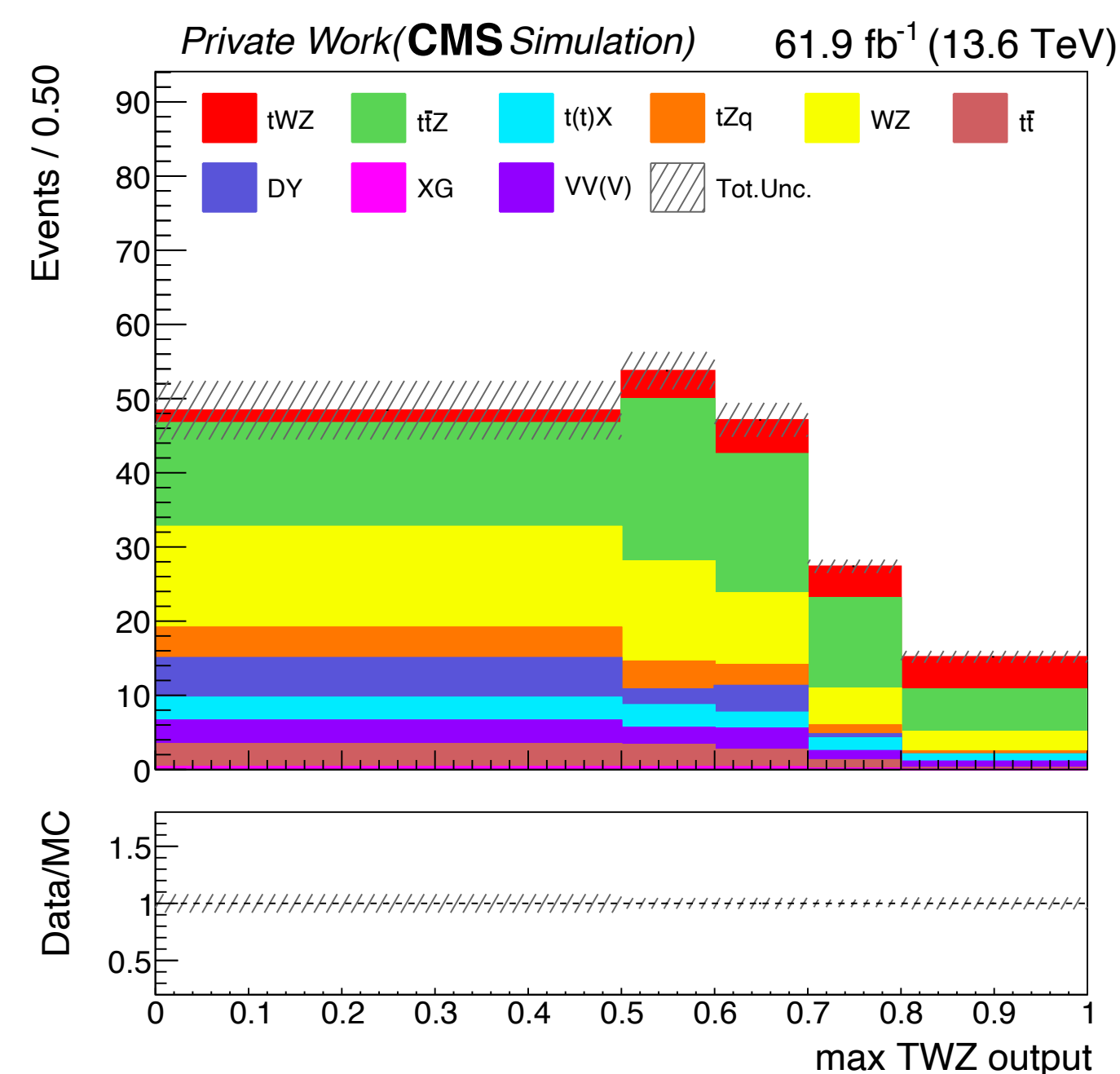
Non-prompt leptons estimated from data directly in the final fit.

ML algorithm to separate signal from background, mainly **TWZ vs TTZ**.

TWZ output Run 2

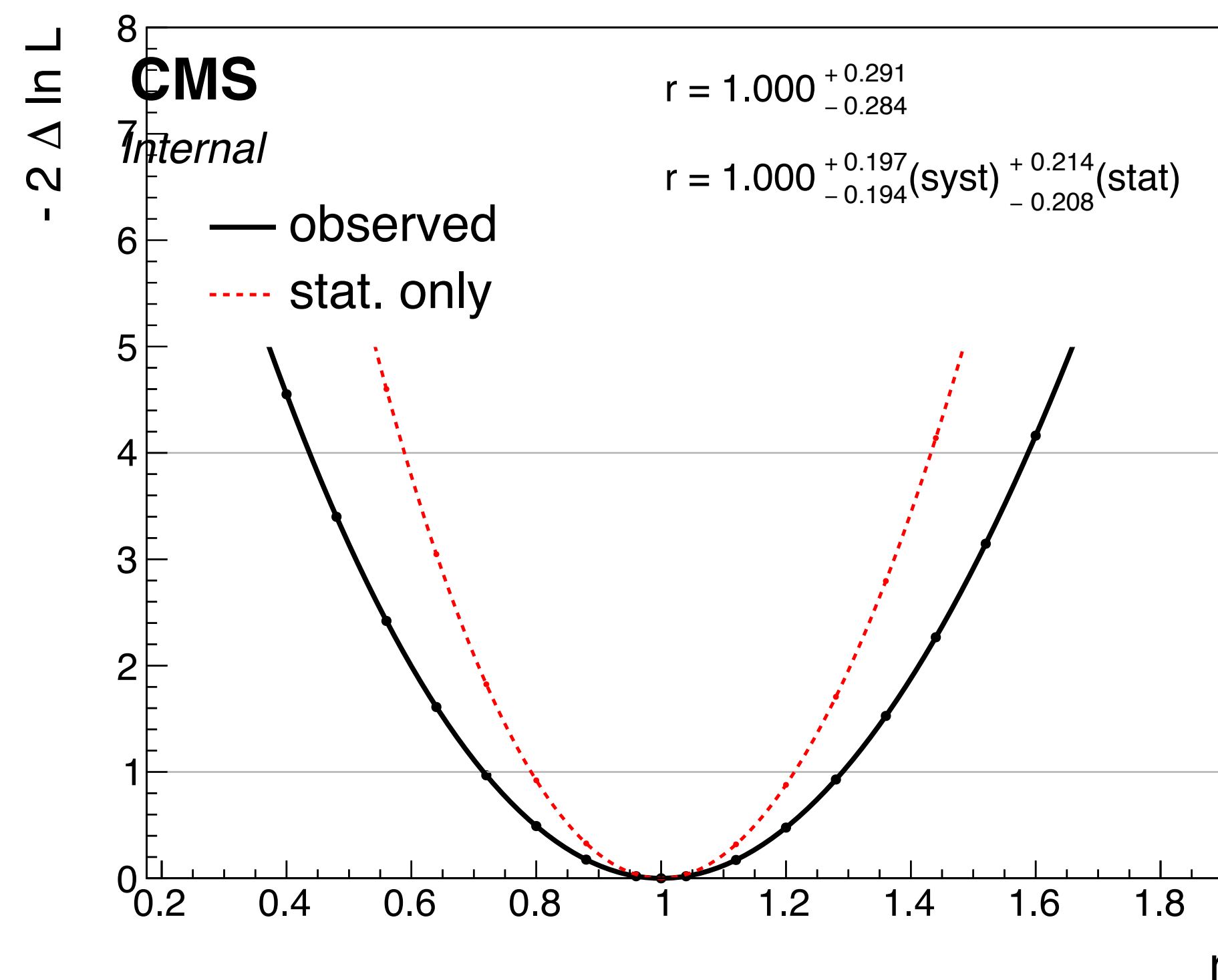


TWZ output Run 3

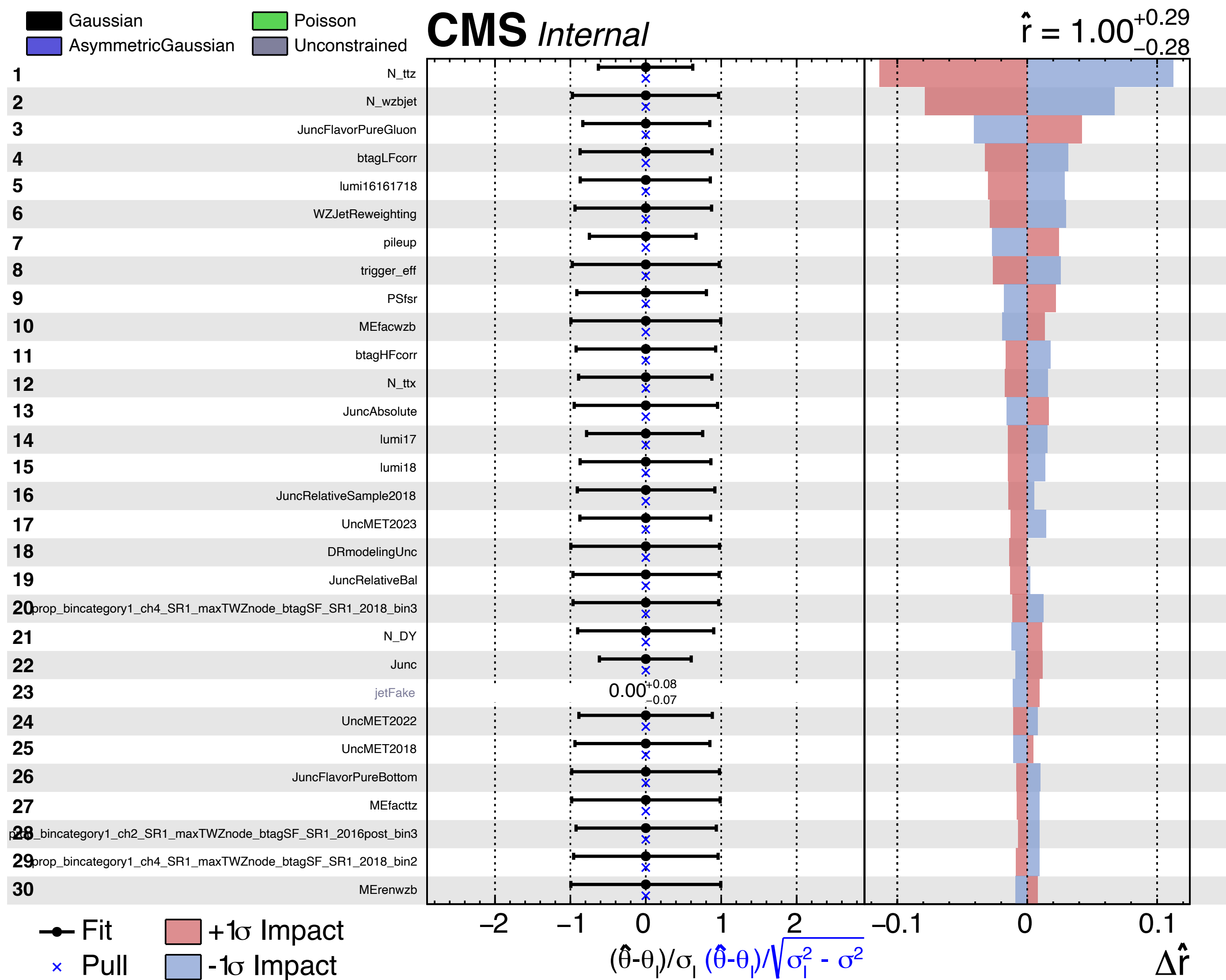


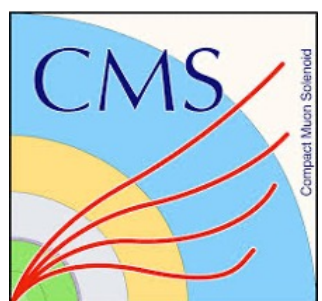


tWZ – Simultaneous fit on Run 2 and Run 3



- Simultaneous fit on Run 2 and Run 3.
- Expected σ : 3.60

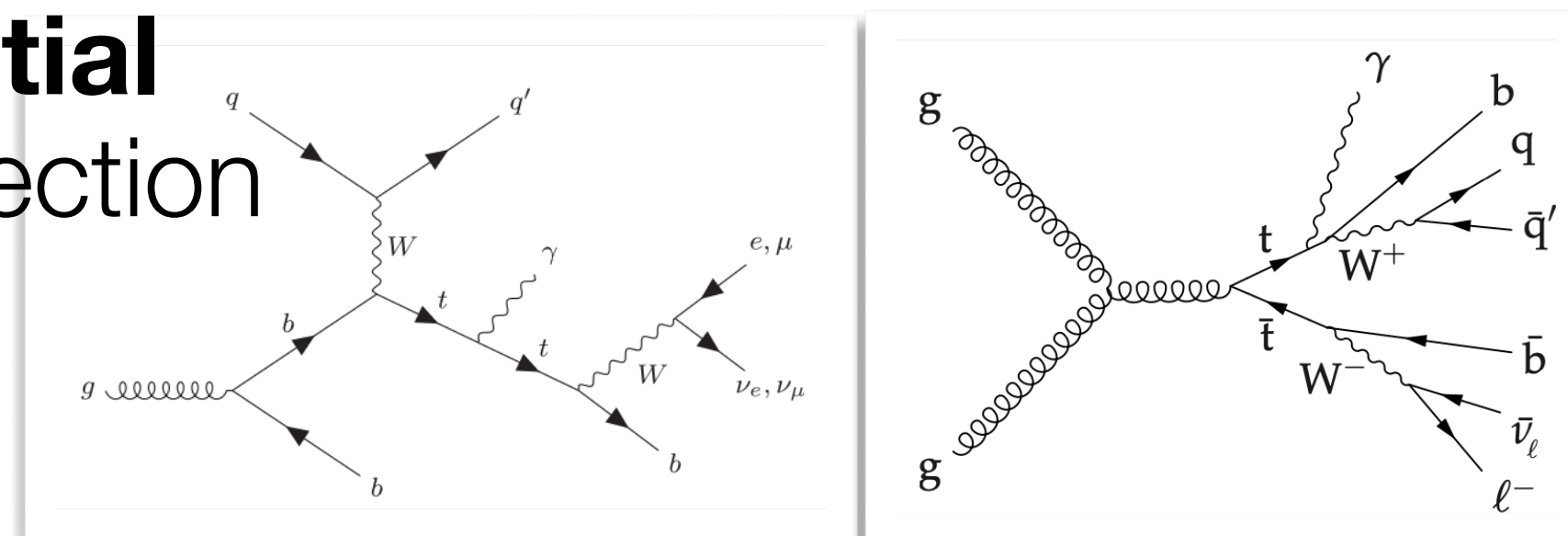




Simultaneous $t\gamma q + t\bar{t}\gamma$ measurement

Motivation:

- CMS so far only has evidence for $t\gamma q$, **first-ever $t\gamma q$ differential** cross sections and **simultaneous $t\gamma q + t\bar{t}\gamma$ inclusive** cross section
- Full set of correlations between the two processes
- Compatible precision $t\bar{t}\gamma$ (1ℓ) results in TOP-18-010
- Possible for a more straightforward EFT interpretation



exactly 1 lepton, ≥ 1 photon, ≥ 2 jets, of which ≥ 1 is b-jet

Dataset: Run2

Status:

- Awaiting 2nd round of comments to AN, expect to schedule CAD I talk soon after
- Target: Moriond conference

Bottlenecks: Lack LO $t\gamma q$ with proper FSR γ simulation

Person power:

- Ying AN (postdoc), Hugo A. Becerril Gonzalez (postdoc), Maria Aldaya (staff), Andreas Meyer (staff), Abideh Jafari (staff)

$t\gamma q + t\bar{t}\gamma$ – Analysis strategy

Background estimation ($t\bar{t}\gamma$ as signal):

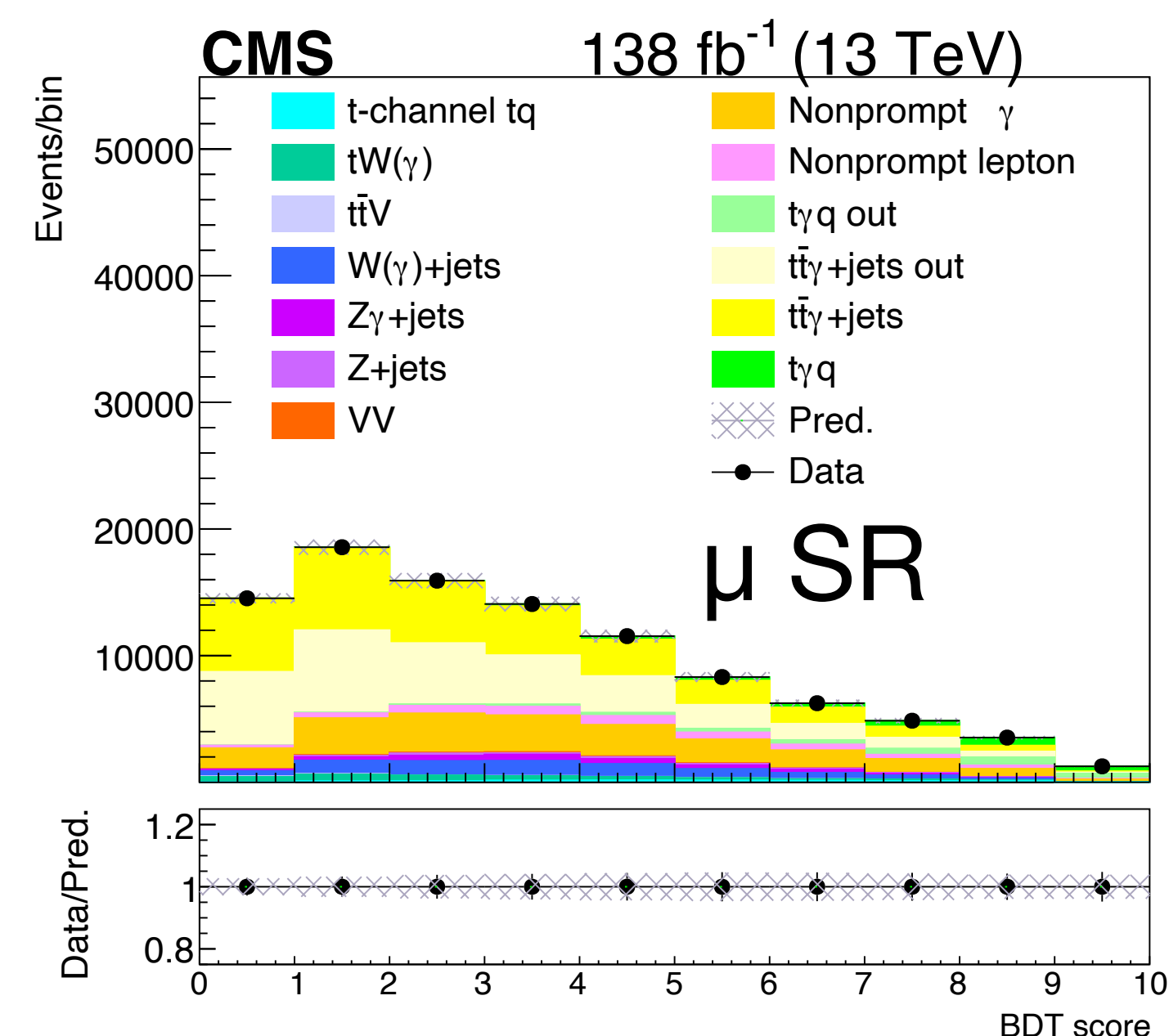
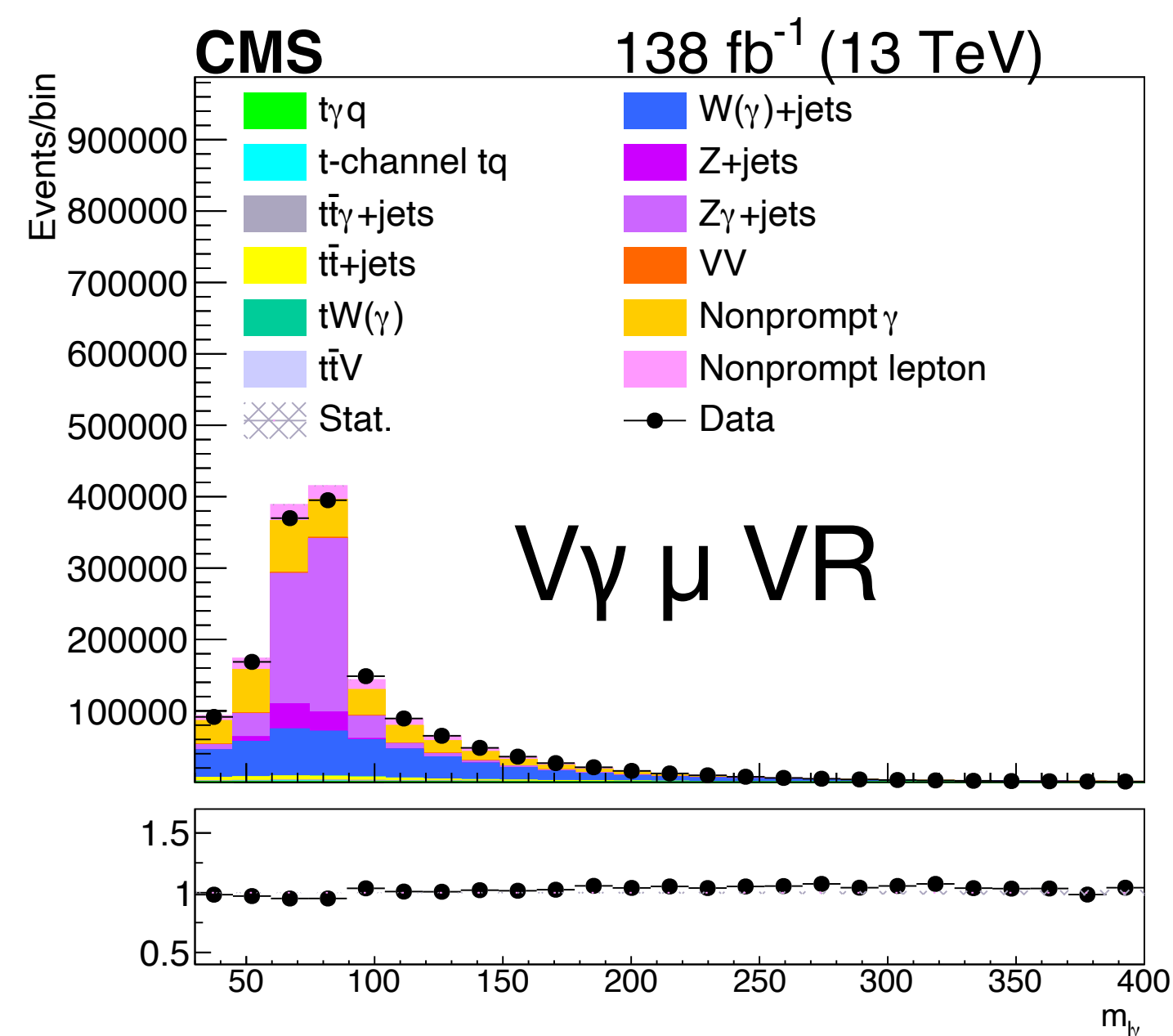
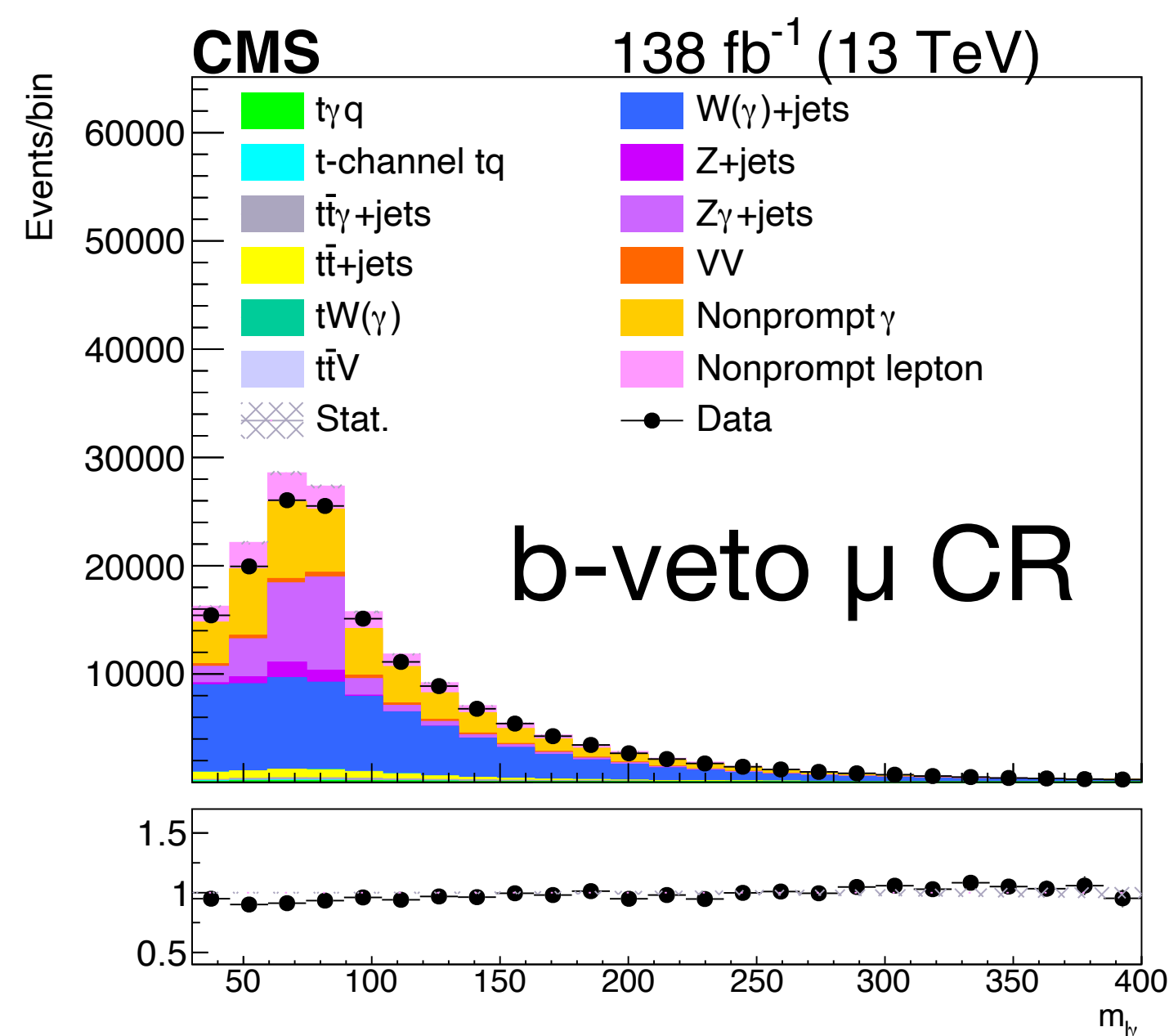
- Simulation: $t\bar{t}$, V +Jets/ $V\gamma$ +Jets, tW / $tW\gamma$, TTV , VV
- Data-Driven backgrounds:
 - $j \rightarrow \gamma$ (nonprompt γ), $j \rightarrow \ell$ (nonprompt ℓ), $e \rightarrow \gamma$ (mainly in e channel)

Separate signal and background

- Train **BDT** to separate $t\gamma q$, $t\bar{t}\gamma$ and others

Signal and control regions definition

- Signal regions in e or μ channel
- b -veto control region in e or μ channel
- $V\gamma$ validation region in e or μ channel



$t\gamma q + t\bar{t}\gamma$ — Preliminary fit results

- Perform a simultaneous fit for events in the **signal** and **b-veto control regions**
 - The signal region uses the BDT distribution
 - The control region uses the $m_{\ell\gamma}$ distribution
- Float Z+jets ($e \rightarrow \gamma$) normalisation in electron channels
- Differential fits are as functions of photon p_T , lepton p_T , and $m_{\ell\gamma}$ in particle level
 - Top related variables will be added in parton level

