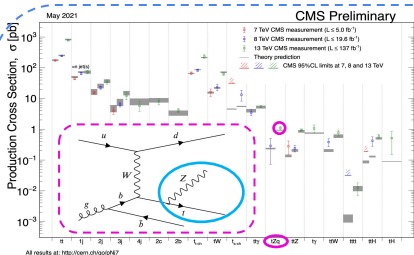
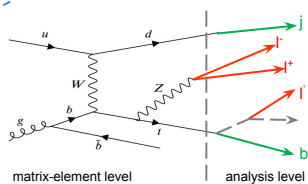


the tZq process



- tZq = t-channel single top production with additional Z boson.
- cross-section measured with 14-15% precision by CMS and ATLAS.
- sensitive to tZ and tW couplings, proton PDF, and many new physics scenarios (e.g. FCNC).

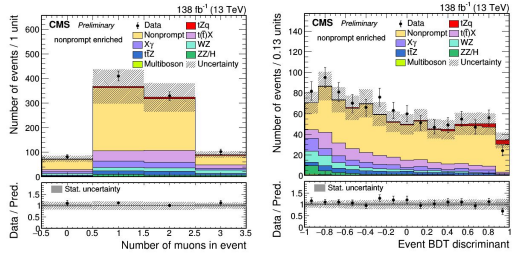


- Event selection:
- 3 leptons (electrons or muons) (selection based on **new lepton MVA!**).
 - 1 OSSF pair compatible with Z boson mass within 15 GeV.
 - ≥ 2 jets ($p_T > 25$ GeV, $|\eta| < 5$).
 - ≥ 1 b-jet (medium **deepFlavor** working point, central).

- Event reconstruction:
- Z boson candidate: OSSF lepton pair with $|m_{2\ell} - m_Z| < 15$ GeV.
 - top quark candidate: reconstructed analytically using mass constraints.

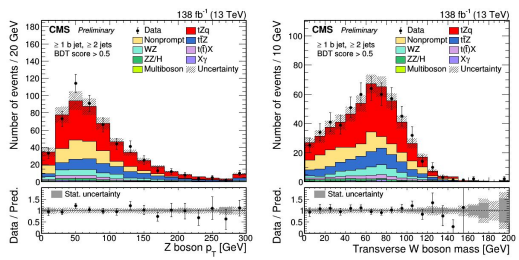
Highlights of the analysis

- Data-driven nonprompt background estimation with **fake-rate method**:
- based on two lepton selection definitions: 'tight' and 'loose'.
 - goal: measure the fake rate, i.e. $P(\text{lepton is tight} | \text{lepton is loose and nonprompt})$
 - measurement in QCD multijet data using a fit of QCD and several electroweak templates from MC simulation.
 - application in **sideband to signal region** (same selection as signal region but with at least one lepton non-tight).
 - check of the method in **control region** (same selection as signal region but with veto on OSSF pair or Z mass).

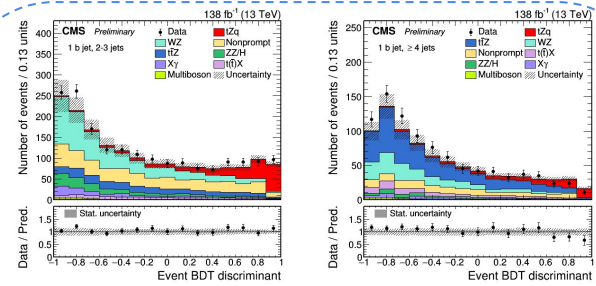


New MVA to discriminate nonprompt from prompt leptons

- BDT using **TMVA** toolkit to discriminate tZq from all backgrounds
- after BDT cut, obtain relatively pure tZq enriched region
 - shows feasibility of differential measurement (see related poster)



Results

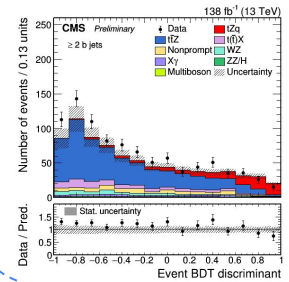


- binned maximum likelihood fit on all signal regions and control regions simultaneously:

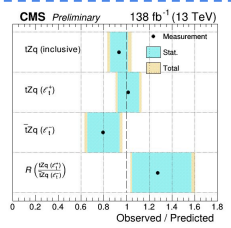
$$\sigma_{tZq} = 87.9_{-7.3}^{+7.5} (\text{stat.})_{-6.0}^{+7.3} (\text{syst.}) \text{ fb}$$

→ total uncertainty of $\pm 11\%$

- improvement of about 30% w.r.t. earlier measurements [1-3], due to
 - larger data set
 - larger measurement region
 - improved prompt lepton MVA
 - better control over nonprompt background.



- can measure tZq cross section **separately for top quarks and antiquarks**, as well as their ratio.
- sensitive to **proton PDF**
- similar measurements performed for **single top production**, here extend to rare associated process.
- statistically limited for now, but promising for when more data arrives!



further reading: [link](#)

references:
 [1]: *Phys. Lett. B* **779** (2018) 358, [doi](#)
 [2]: *Phys. Rev. Lett.* **122** (2019) 132003, [doi](#)
 [3]: *JHEP* **07** (2020) 124, [doi](#)