Search for Z’→ττ at 13TeV

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The CMS Collaboration

On behalf of the EXO-16-008 team

Overview

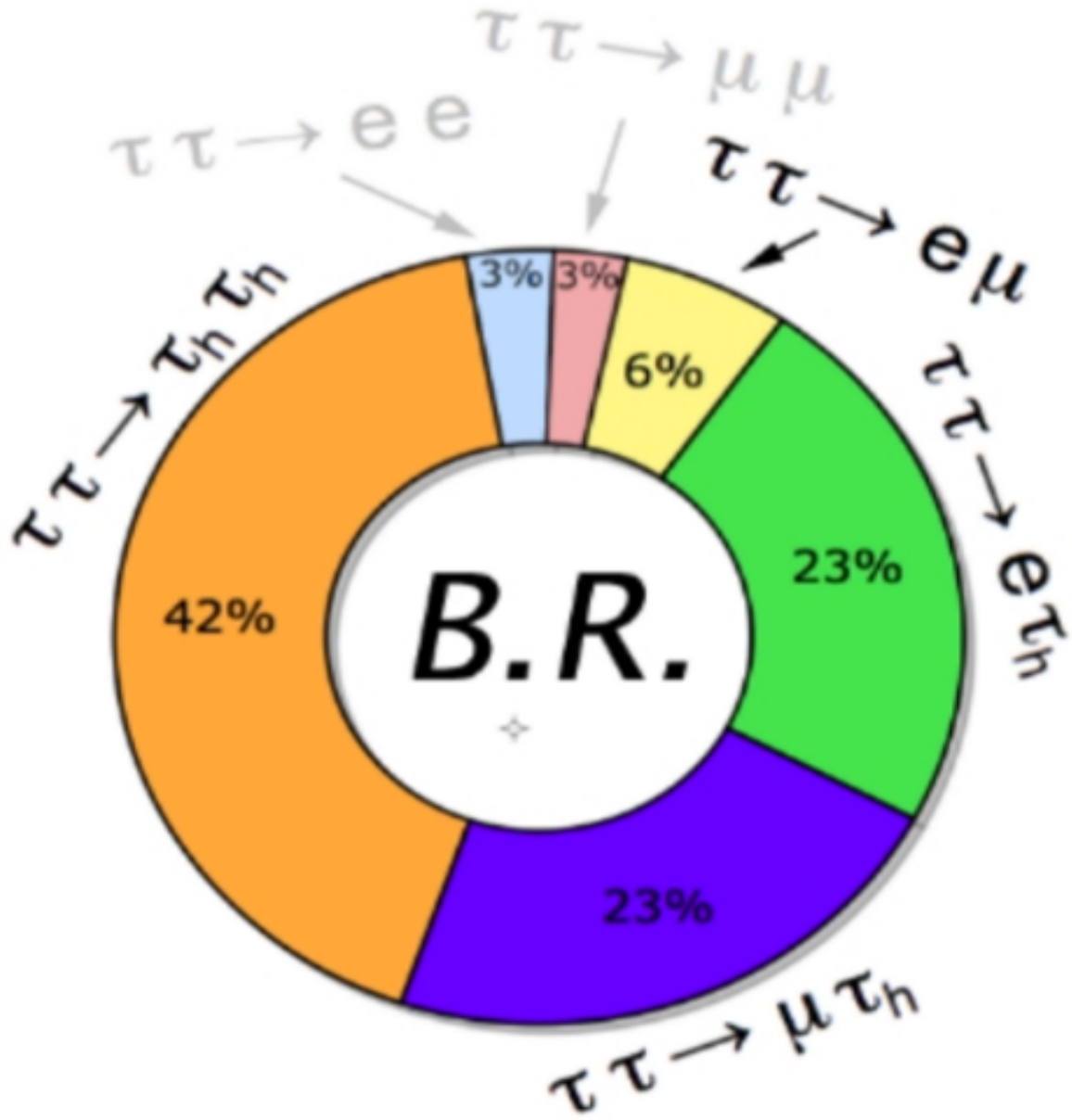
- Physics motivation
- Tau selection
- Background estimation
- Results and limits
- Summary

Physics Motivation

- Standard Model (SM) of particle physics is incomplete
  - No gravity, no dark matter candidate, hierarchy problem…
- Some Beyond-Standard Model (BSM) theories add an extra gauge group to SM
- Expect to see an extra neutral resonance, Z', as a result
- Some theories predict enhanced Z' coupling to 3G
- CMS excluded Z'->ττ to 1.4 TeV during 8 TeV run, using only $\tau_e\tau_\mu$ channel, to 1.4 TeV (all channels) during 7 TeV run

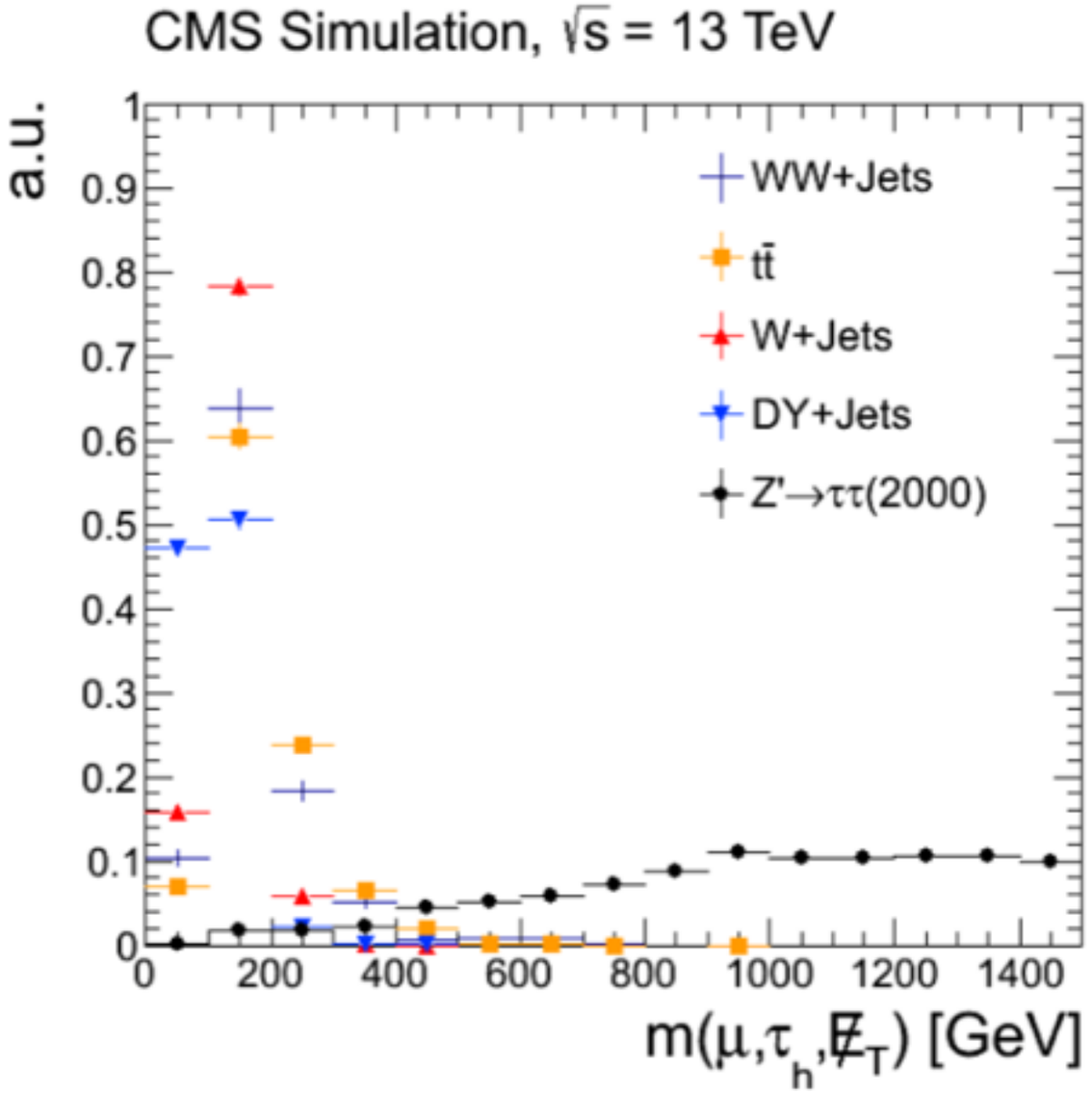
τ Physics

- Four channels considered in Z'->ττ analysis
  - $\tau_e\tau_\mu$, $\tau_e\tau_h$, $\tau_\mu\tau_h$, $\tau_h\tau_h$
    - 2-4 missing neutrinos in each channel
- "τ_h" denotes hadronic decay
- ee, μμ channels not explored due to large background from Z->ee/μμ decay
- Efficiency for eμ highest



Analysis Strategy

- Look for events with two τ candidates
  - High pT (momentum)
  - Decay products passing ID criteria (“clean”)
  - back-to-back
    - Opposite sign
    - Lots of missing energy (MET)
- Blind signal region (SR) until we understand background distributions
- Estimate BG contributions via data-driven analysis
- Unblind and study visible+MET distributions
- Look for excesses/set limits



Signal shape broad, peaked at high mass

Background Estimation

Expected events in full mass range

smaller yields in $\tau_h\tau_h$ due to higher pT threshold

Process	$\tau_h\tau_h$	$\mu\tau_h$	$e\tau_h$	$e\mu$
Drell-Yan	8 ± 3	882 ± 127	375 ± 40	321 ± 37
W+jets	0.1 ± 0.1	916 ± 96	456 ± 35	19 ± 6
Diboson	0.5 ± 0.5	29 ± 7	18 ± 4	108 ± 11
$t\bar{t}$	–	26 ± 7	26 ± 6	223 ± 20
(QCD) Multijet	49 ± 13	122 ± 84	250 ± 50	36 ± 16
Total	58 ± 13	1976 ± 180	1125 ± 73	707 ± 47
Observed	55	1807	1113	728

Mix of MC & data-driven estimates

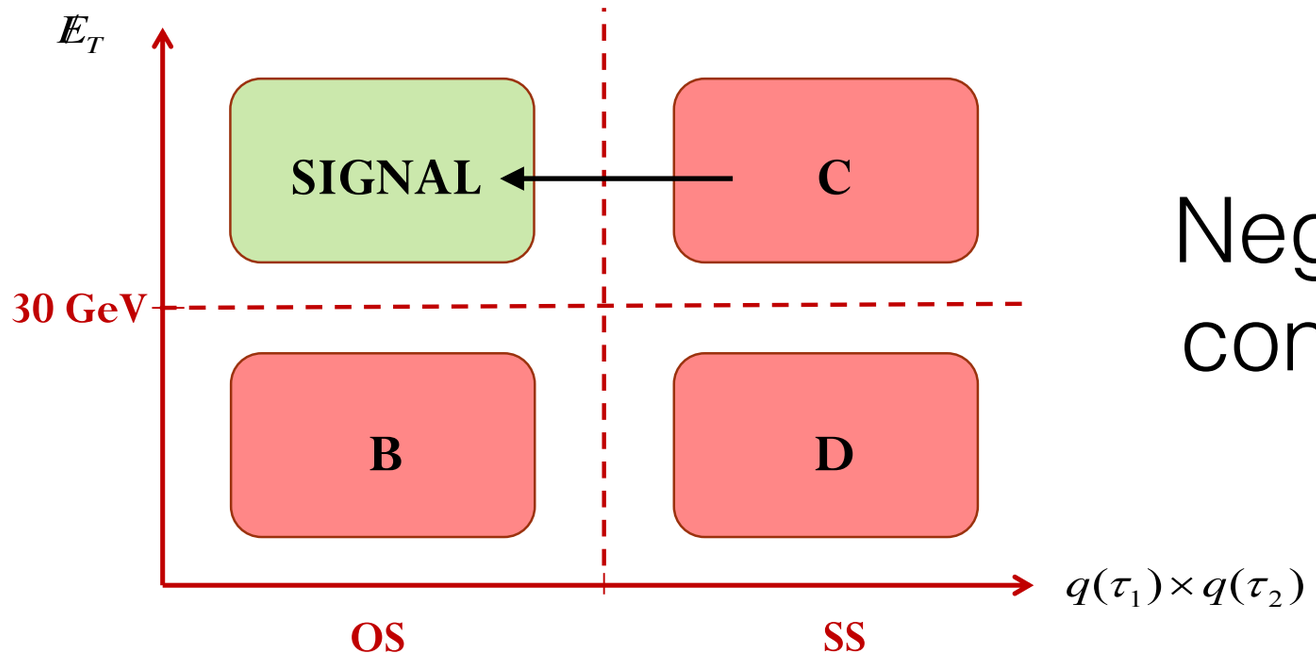
Expected events at high mass ($m(\tau_1,\tau_2,MET) > 300$ GeV)

Process	$\tau_h\tau_h$	$\mu\tau_h$	$e\tau_h$	$e\mu$
Drell-Yan	5 ± 2	16 ± 4	9 ± 4	4 ± 3
W+jets	0.004 ± 0.004	23 ± 9	7 ± 5	0.2 ± 0.5
Diboson	0.02 ± 0.02	6 ± 3	3 ± 2	23 ± 5
$t\bar{t}$	–	4 ± 2	5 ± 3	65 ± 12
(QCD) Multijet	18 ± 6	4 ± 3	9 ± 3	0.8 ± 1.0
Total	23 ± 6	51 ± 11	33 ± 8	93 ± 13
Observed	20	42	40	96

QCD Estimation in $\tau_h\tau_h$

Data driven estimation using "ABCD" method

Take shape from SS region (**C**)



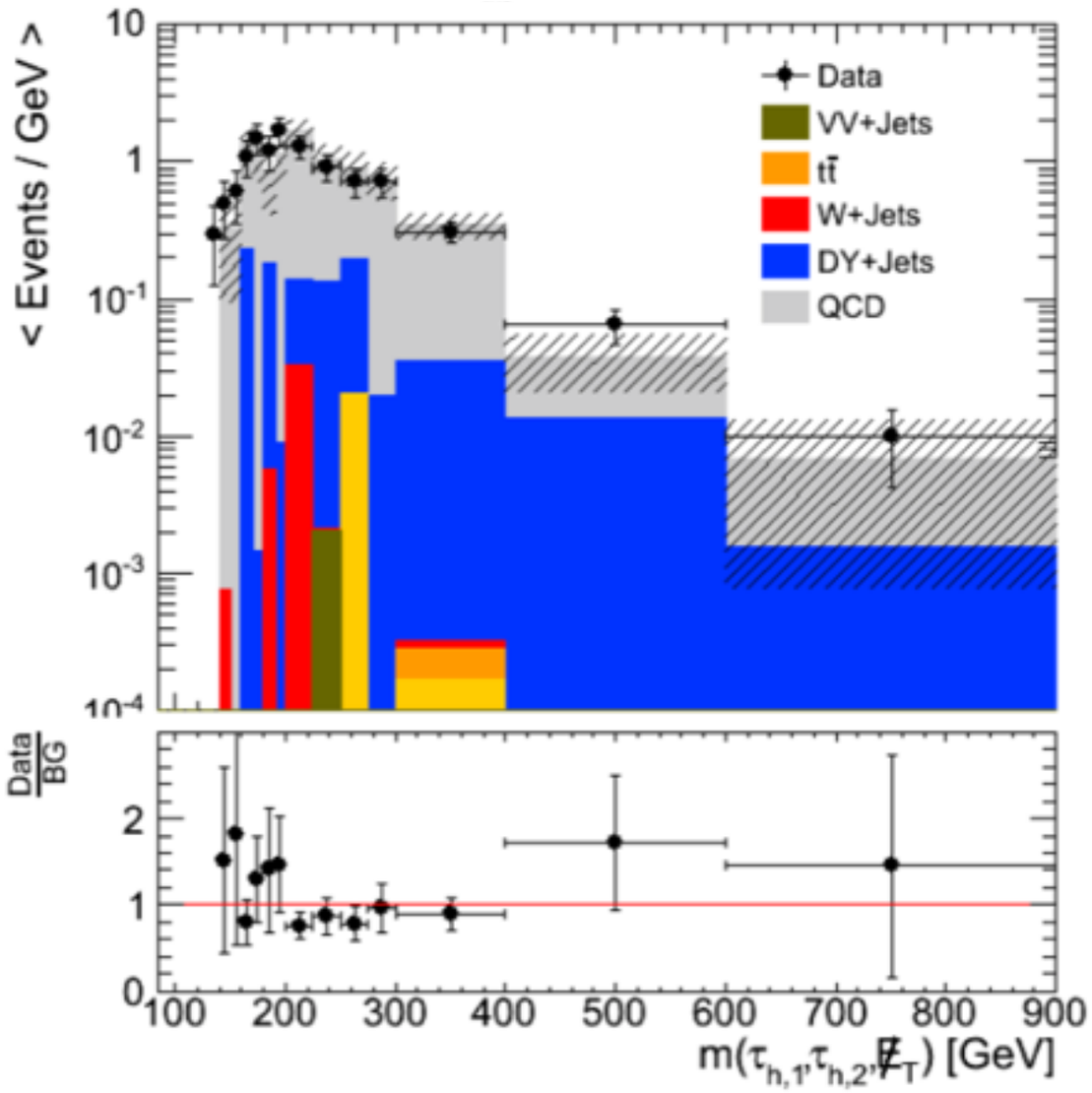
Negligible signal contamination in CRs

Derive OS/SS SF using low-MET CRs (**B**/**D**)

$$N_{QCD}^{Signal}(m_{\tau\tau\not{E}_T}) = N_{QCD}^{C}(m_{\tau\tau\not{E}_T}) \times \frac{N_{QCD}^{B}}{N_{QCD}^{D}} = N_{QCD}^{C}(m_{\tau\tau\not{E}_T}) \times R_{OS/SS}$$

QCD Shape Validation

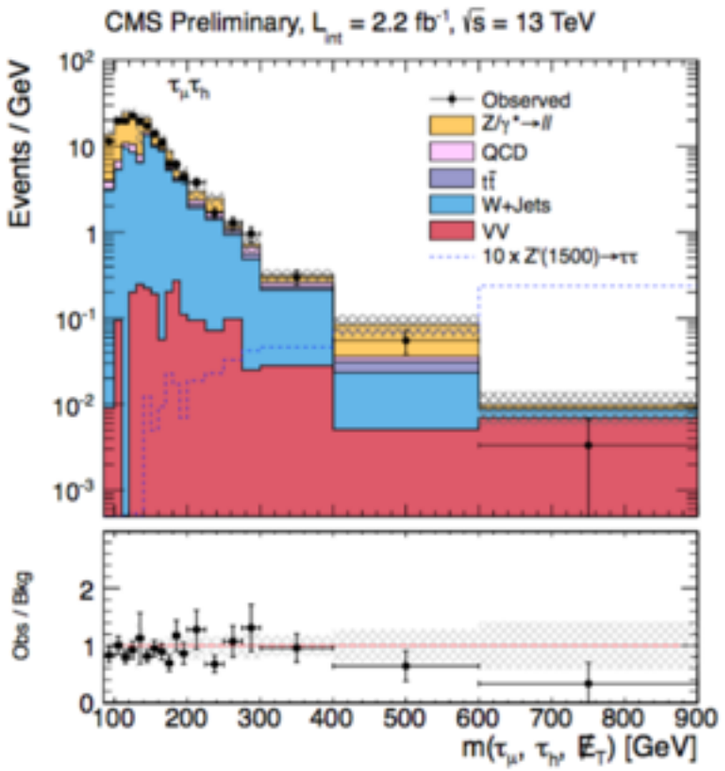
- Shape taken from SS sideband, normalized to OS yield
- Check data/estimation in low-MET sideband
- Good agreement between data and estimation
- Shapes provide robust estimation

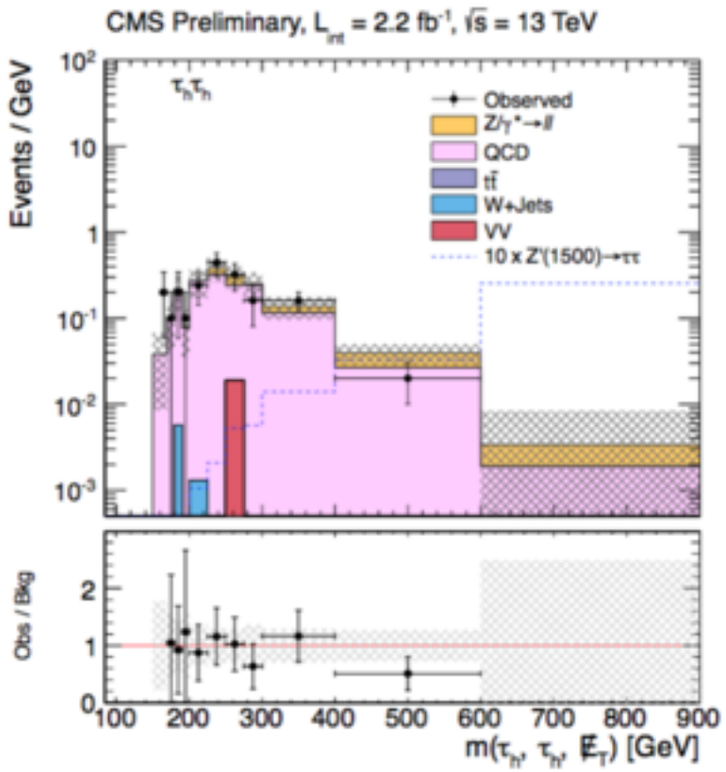


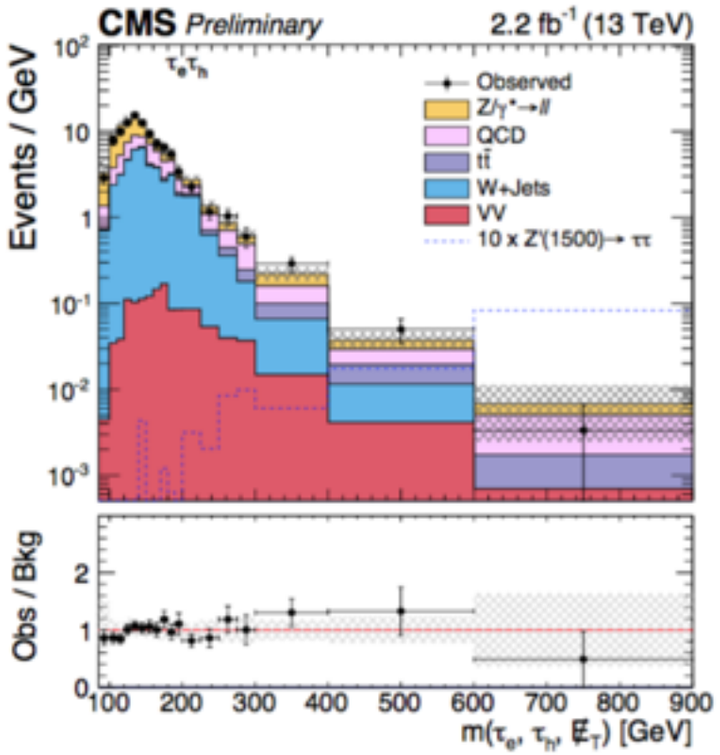
Shape in **D** normalized to yield in **B**

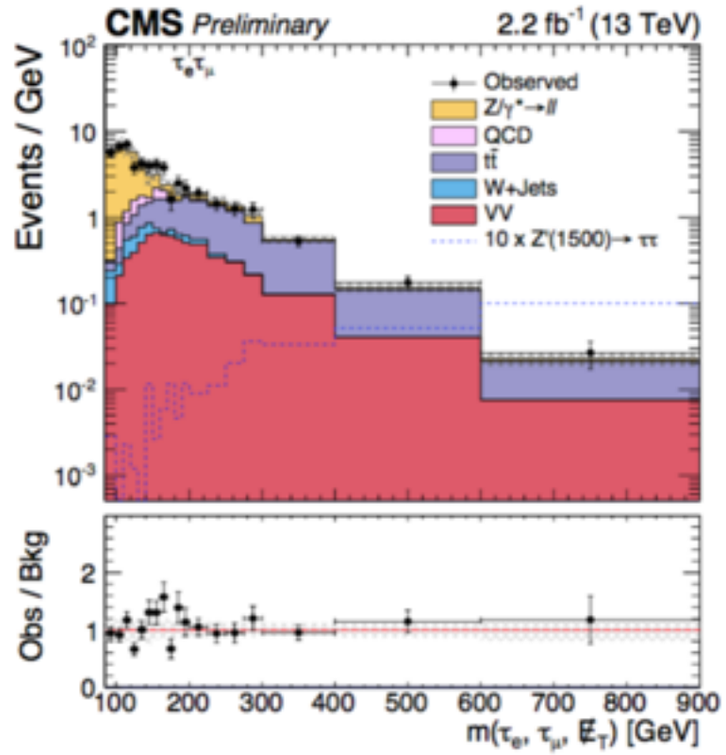
Good agreement!

Unblinded Results



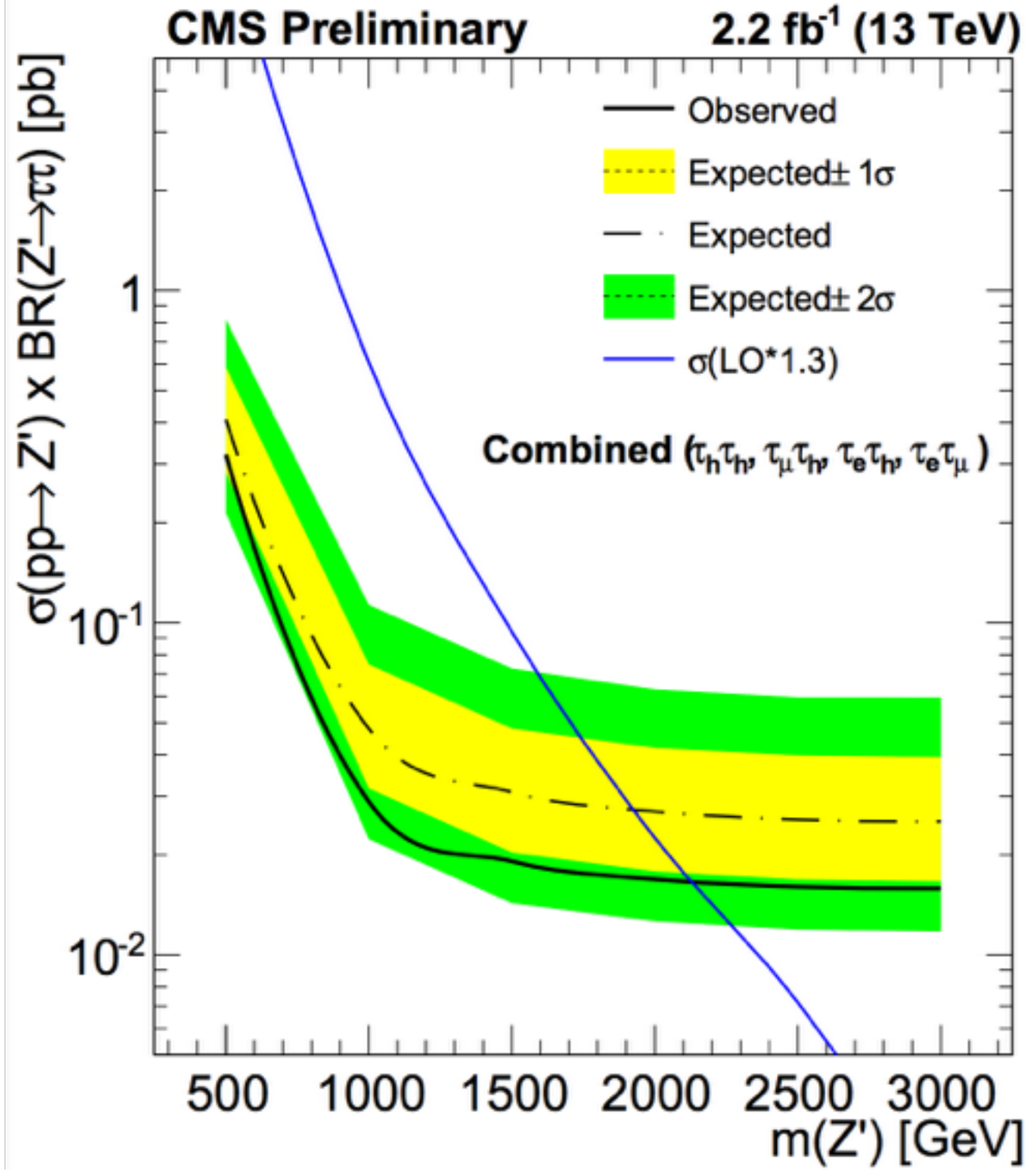






Fair agreement between observation and SM expectation in all channels

Combined Limit



Exclude m(Z') < 2.12 TeV
(1.9 TeV expected)

New record limit!!

Current CMS limit
for Z'->ee/μμ is
m(Z') < 2.96 TeV

Summary

- Search for high τ-τ+MET mass performed in pp collisions at sqrt(s) = 13TeV
- Backgrounds estimated using primarily data-driven methods
- All channels show agreement with SM
- We exclude a Z’ decaying to τ-τ below 2.12 TeV