Recent results on top quark physics with the CMS detector

Enrique Palencia Cortezón
(on behalf of the CMS collaboration)

Universidad de Oviedo

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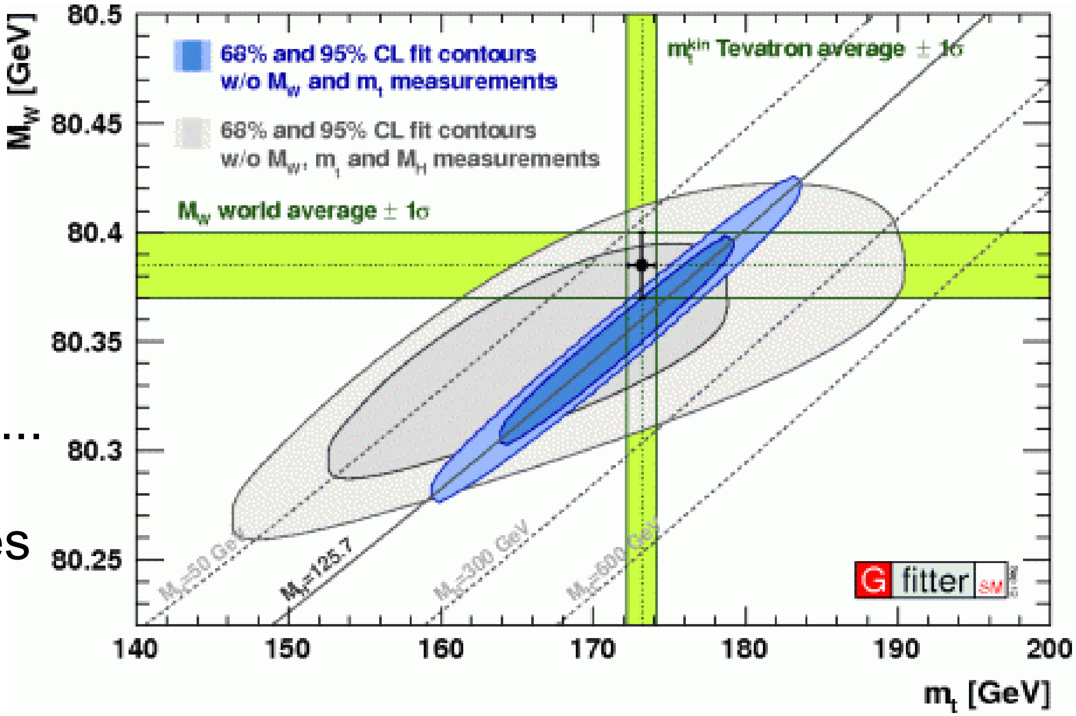
Why do we care about the Top Quark?

- Last quark to be discovered. It is only 20 years old!

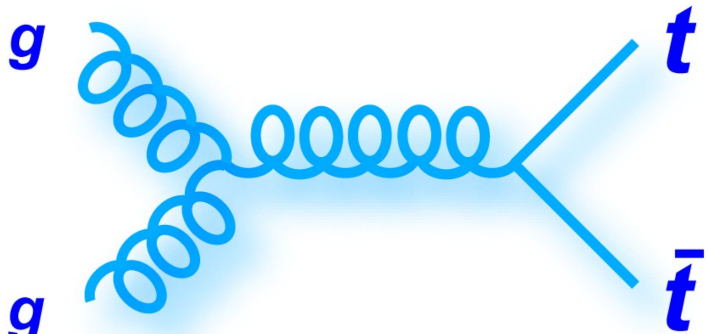
- It has many peculiarities!
  - **Heaviest** known elementary particle
  - Strong **coupling** to the **Higgs** boson (EWK loops, gg → H)
  - **Decays before hadronizing** → direct access to prop. (spin, charge, polarization)
- It allows for **precision measurements of SM** parameters: top quark mass, V_{tb}
- Useful as **probe for new Physics**!
  - In production: pp → X → tt
  - In association: pp → tt+X
  - In decay: H^+, FCNC....
  - Or indirectly: charge asymmetries, spin...
- Is one of the main bkgs to many searches



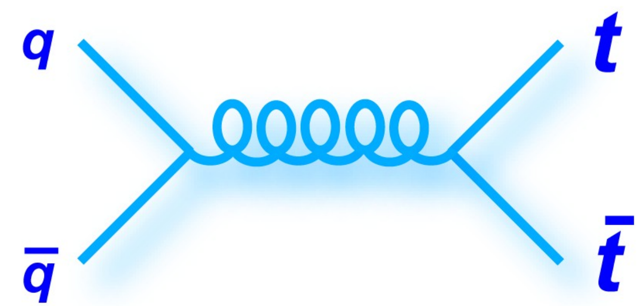
Top Quark Production @LHC

- Top quark pairs are produced via QCD production

CME	σ (pb)
7 TeV	177.3
8 TeV	252.9
13 TeV	831.7



Gluon fusion (85%)

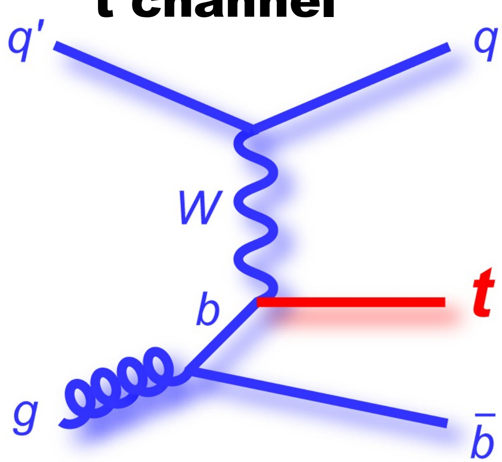


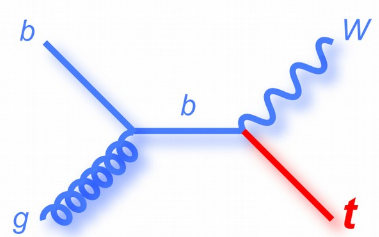
qq annihilation (15%)

- Single top quarks are produced via EWK interaction

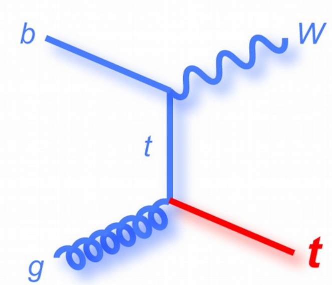
σ (pb)			
CME	**t-channel**	**tW**	**s-channel**
7 TeV	63.9	15.7	4.3
8 TeV	84.7	22.2	5.6
13 TeV	217.0	71.2	11.4

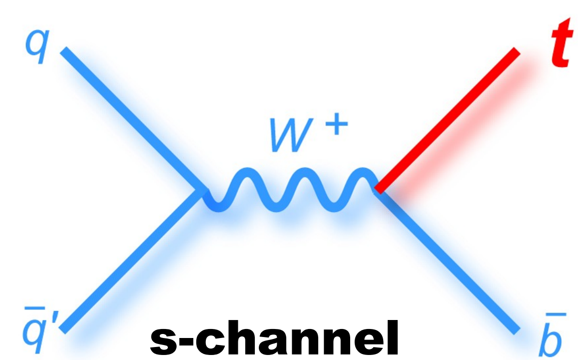
t channel





tW channel

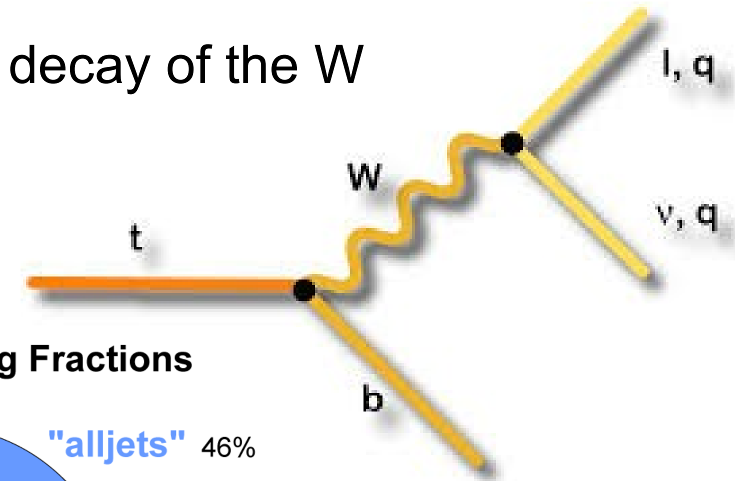




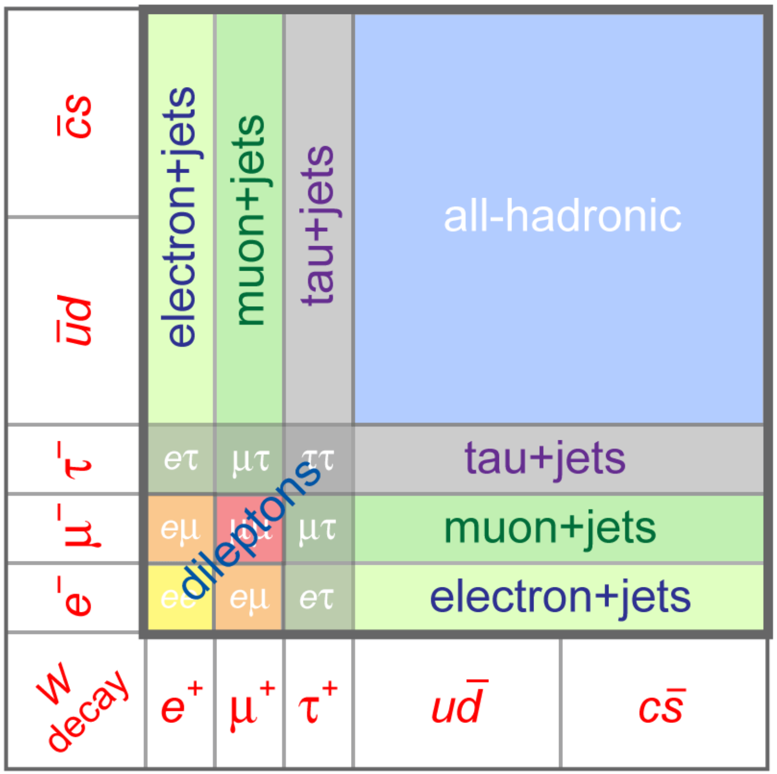
s-channel

Top Quark Decay

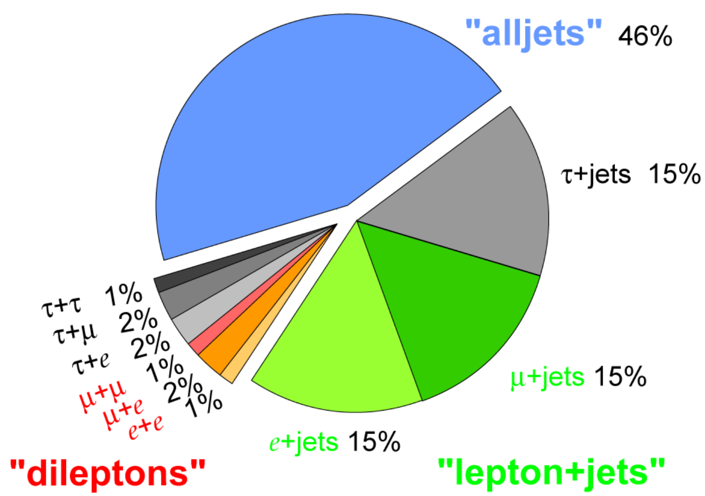
- BR(t → Wb) ≈1 ==> top quark decay is driven by the decay of the W

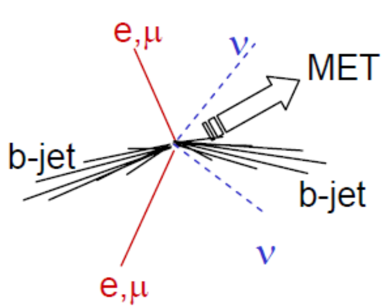


Top Pair Decay Channels

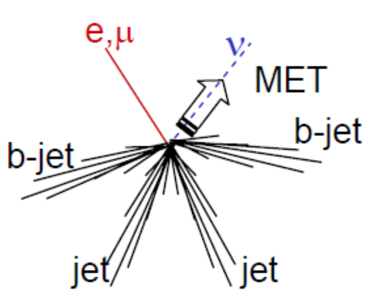


Top Pair Branching Fractions

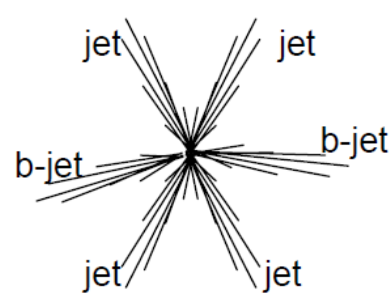




dileptons



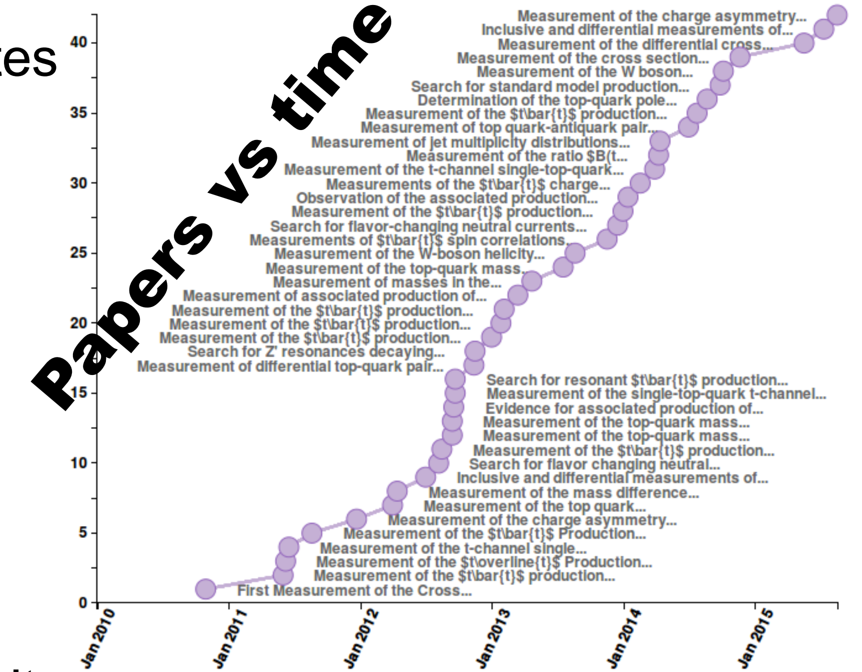
lepton + jets



all hadronic

Top Physics Program @CMS

- **Top physics is one of the main goals for CMS** since the start of the data taking
  - Probe all production modes in as many final states as possible
  - Also top properties (helicity, polarization, charge asymmetries..) are fully scrutinized
  - Leading to **42 publications**!!!
  - Several more papers (and preliminary results) are underway

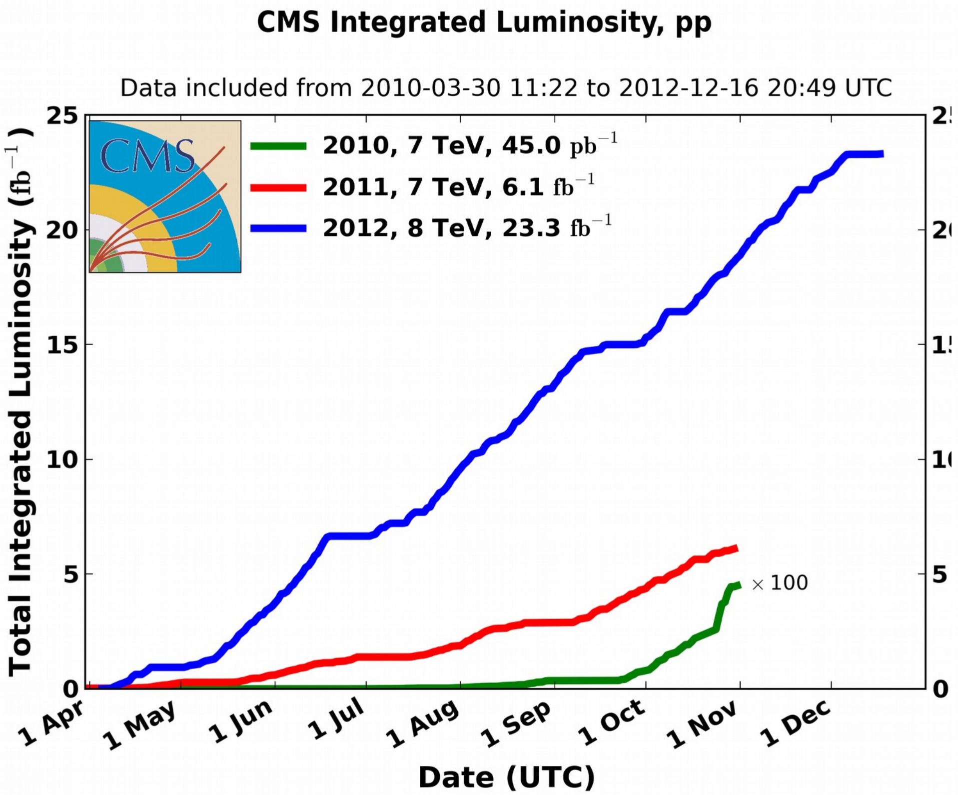


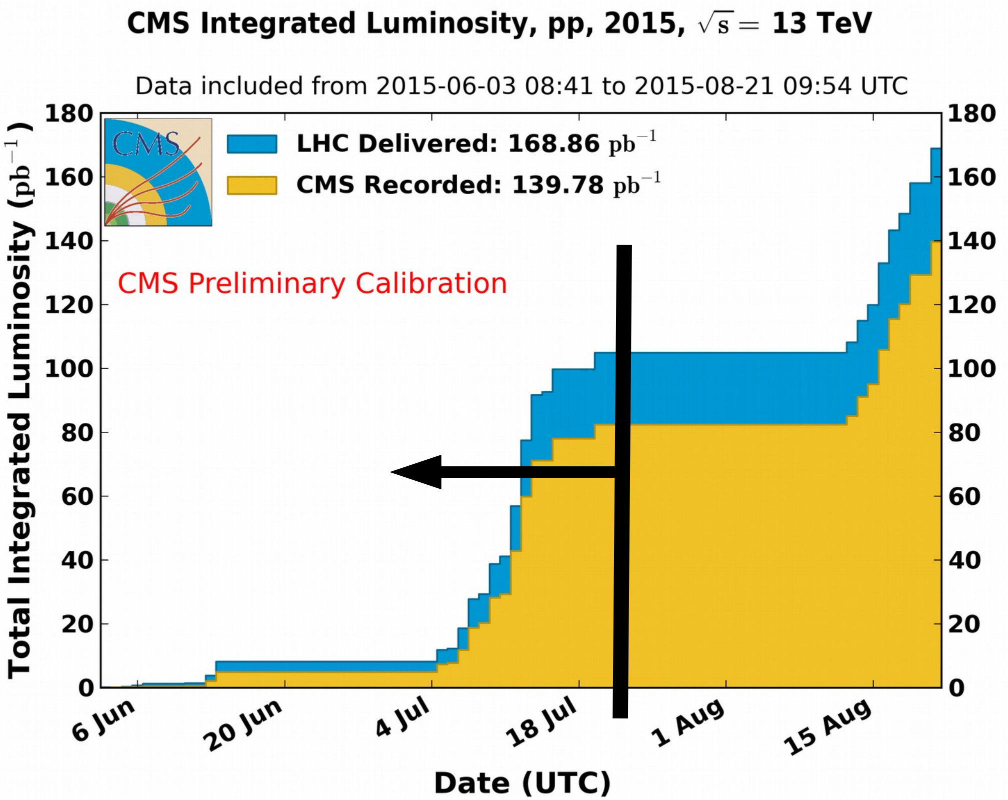
- **In this talk**, instead of covering the full set of results,

  I will will focus in the most recent ones. In particular:
  - **Top pair production cross section at 7, 8 and 13 TeV**
  - **Differential top pair production cross sections at 7 and 8 TeV**
  - **Boosted tops, ttbb and ttV production** (briefly)
  - All other results can be found in https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsTOP

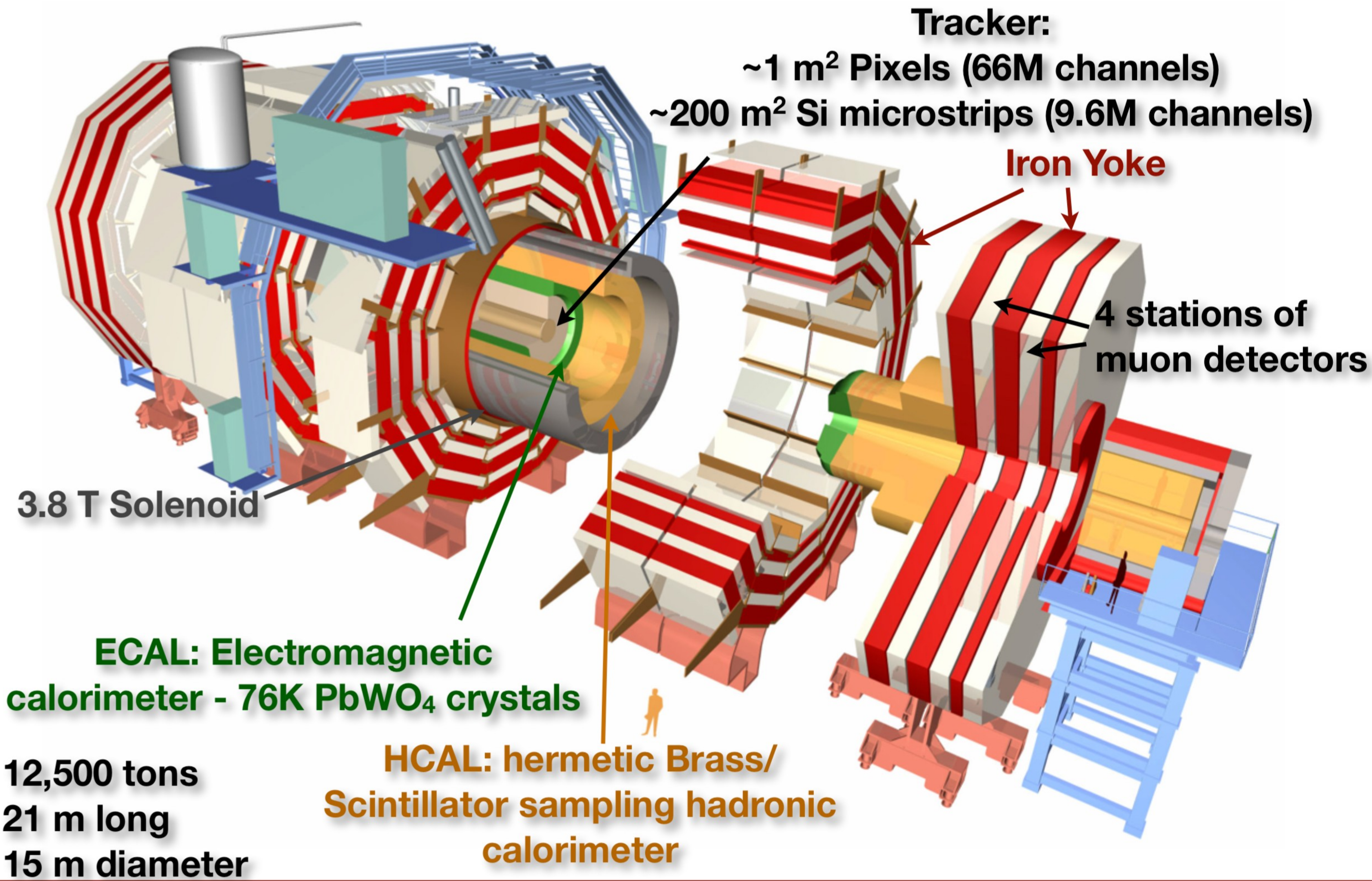
LHC Performance

- It is true that top quarks are produced abundantly at the LHC due to the large cross section
  - But without the **high luminosity and outstanding performance of the accelerator** chain, the results shown here would just not be possible

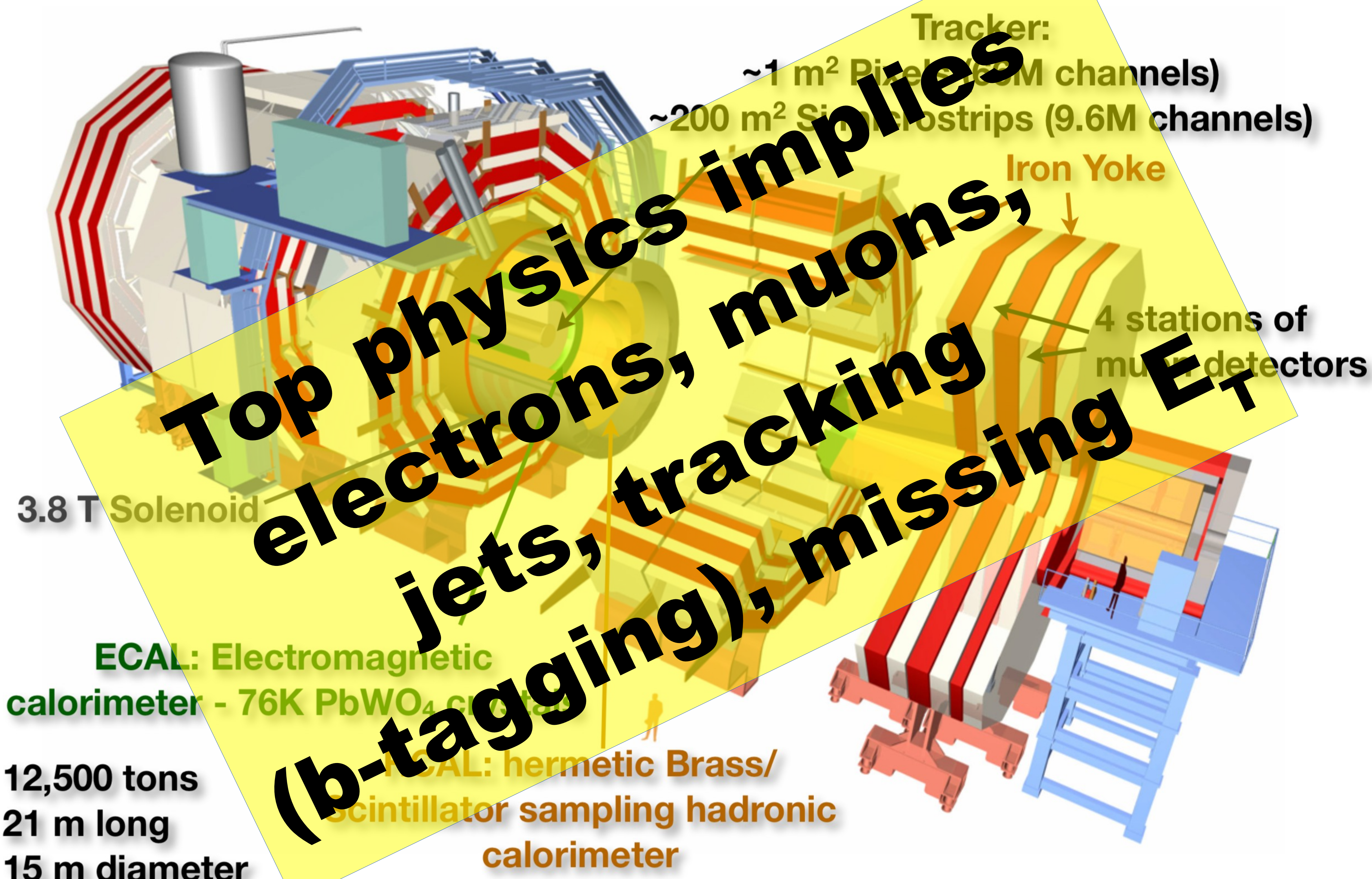




- **THANKS to the accelerator division!**



12,500 tons
21 m long
15 m diameter



Top physics implies electrons, muons, jets, tracking (b-tagging), missing E_T

CMS

For top physics, the full detector is used!!!!

TOP-13-004 (to appear soon)

NEW!!!

Inclusive top pair production in the dilepton channel @7/8 TeV

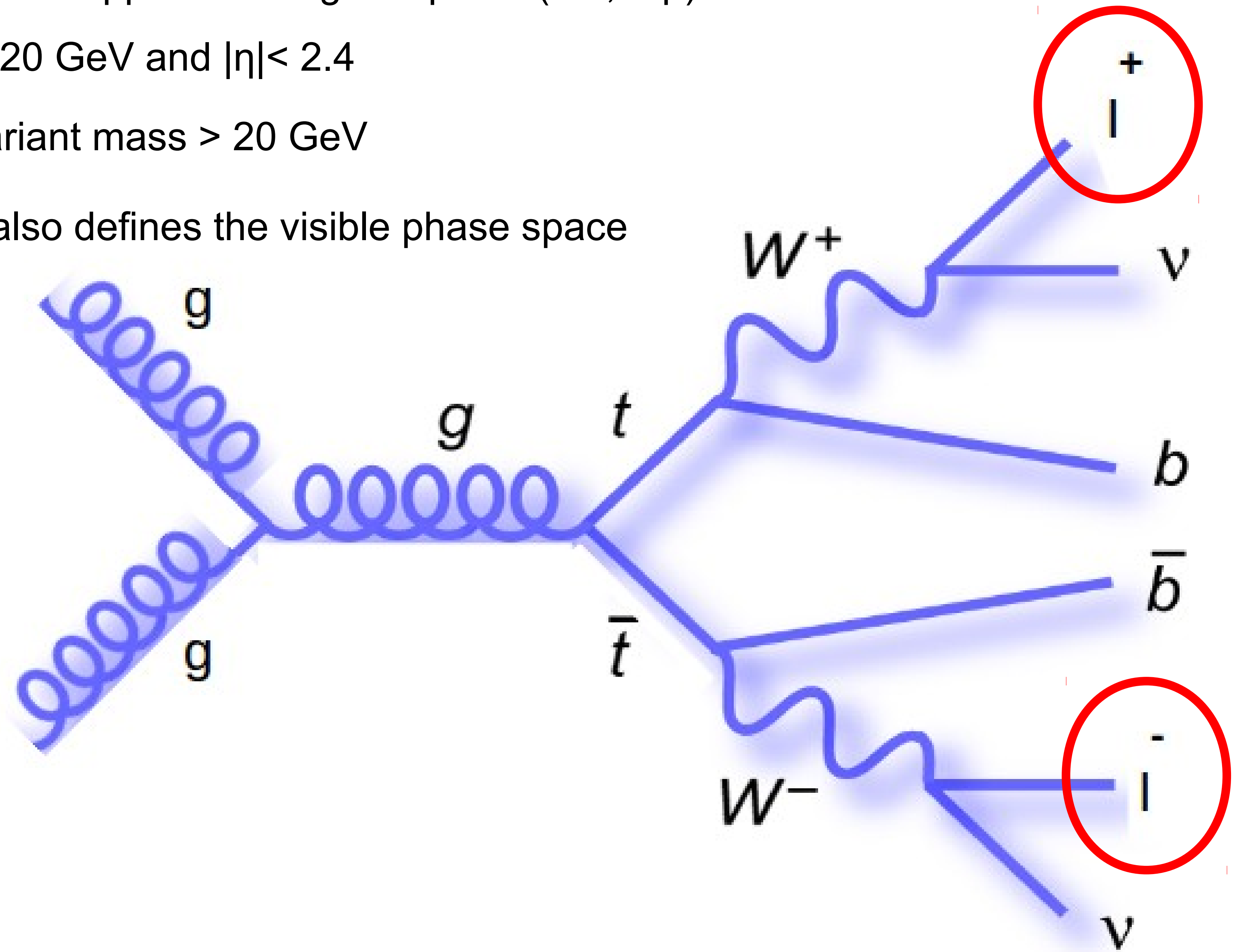
General Strategy

- **Measure the production cross sections first** at particle level in **a fiducial range**, defined within the kinematic acceptance of the ttbar decay particles that are directly visible in the detector
- The visible cross section is defined for events at particle level containing a true opposite charge electron-muon pair from the decay chain $t \rightarrow W \rightarrow l$ (including $W \rightarrow \tau \rightarrow l$) and with both leptons with $p_T > 20$ GeV and $|\eta| < 2.4$
- **Then, extrapolate** visible cross section **to obtain the cross section** for ttbar production at parton level **in the full phase space**

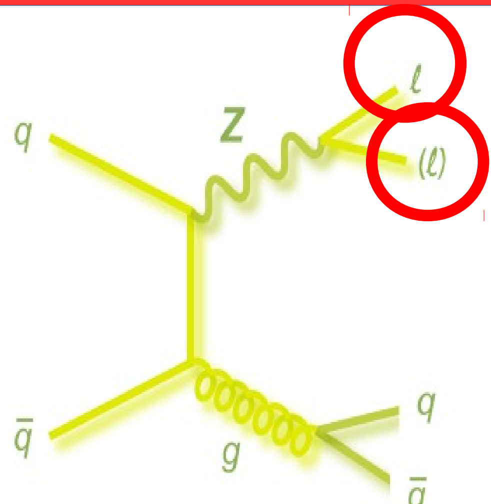
$$\sigma_{t\bar{t}} = \frac{\sigma_{t\bar{t}}^{vis}}{A_{e\mu}}$$

Event Selection

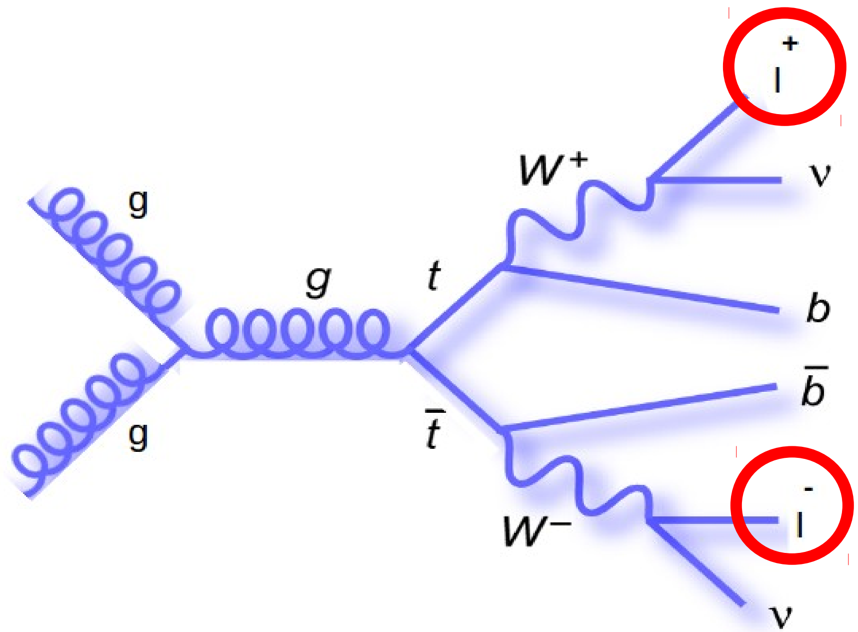
- At least 2 opposite charged leptons (1 e, 1 μ)
  - $p_T > 20$ GeV and $|\eta| < 2.4$
  - Invariant mass > 20 GeV
- This also defines the visible phase space



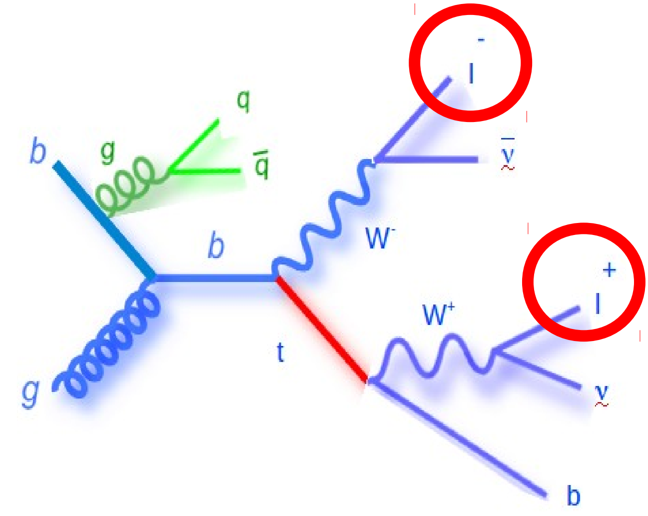
Signal and Background Modeling



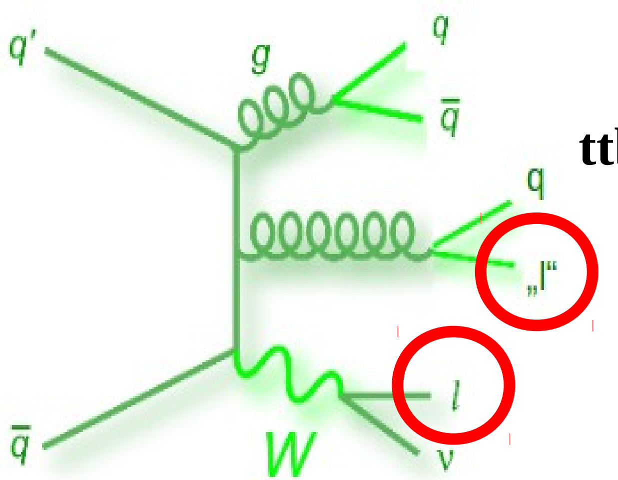
DY: *Madgraph +Pythia6*



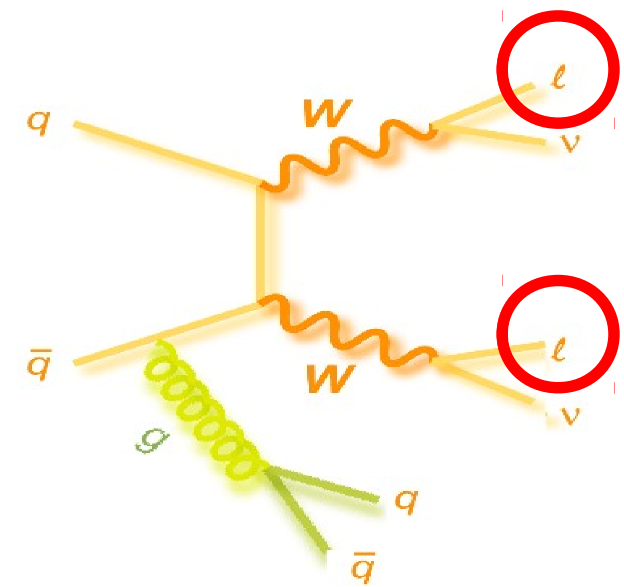
ttbar: *MadSpin+Pythia6 (LO)*



tW: *Powheg+Pythia6*



W+Jets: *Madgraph +Pythia6*

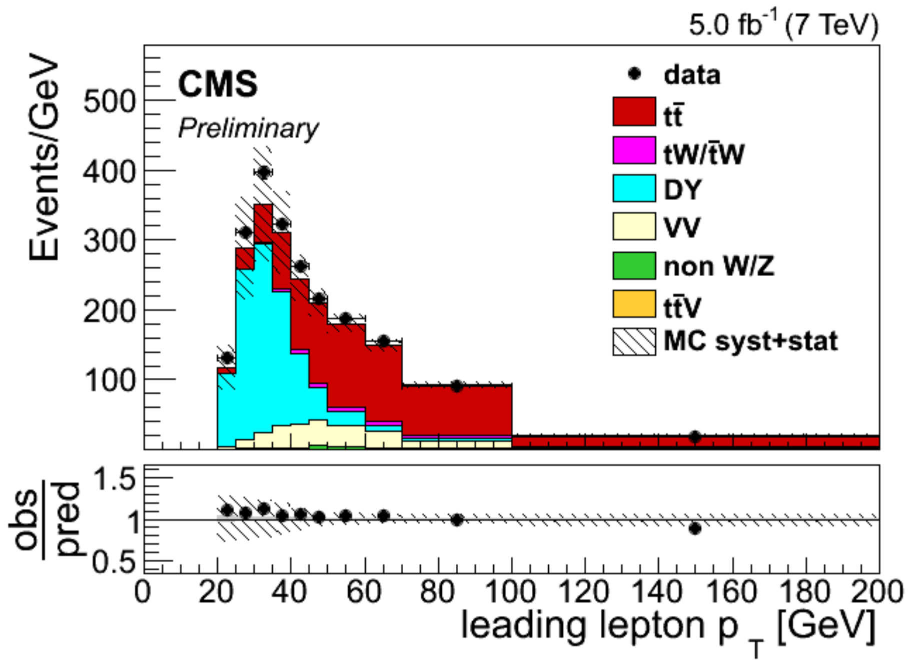


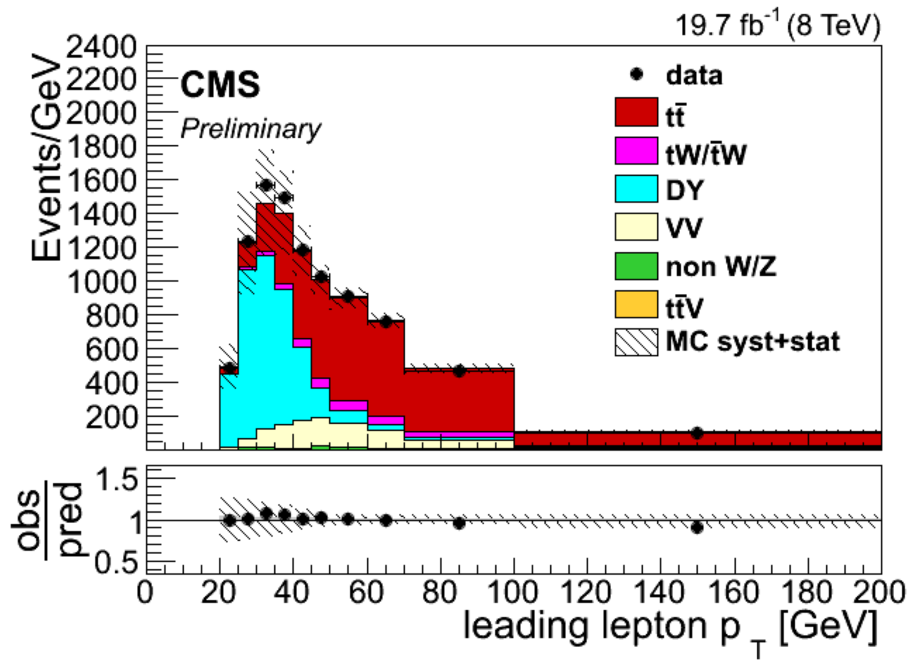
VV: Pythia6

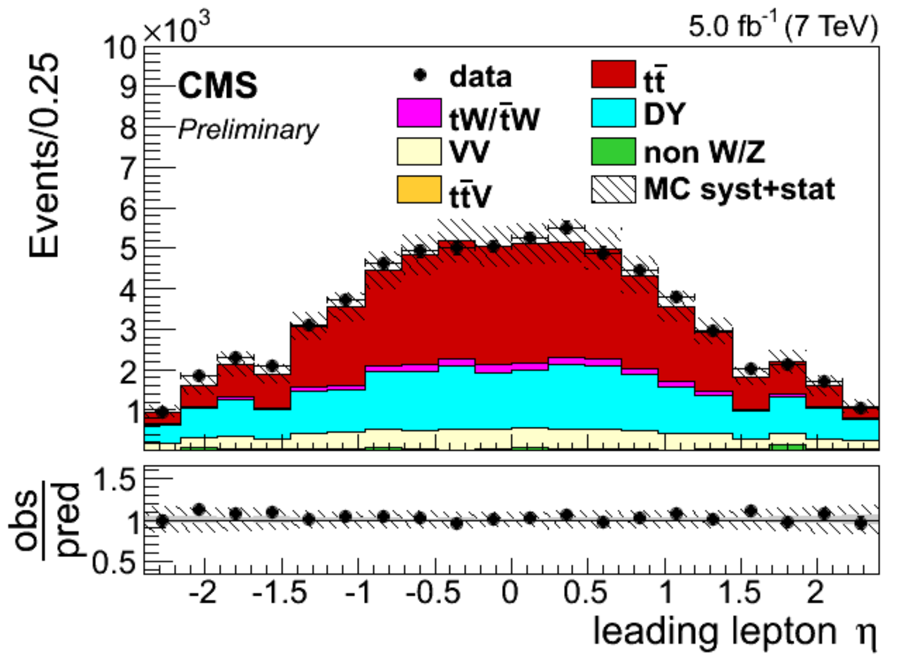
MC corrections

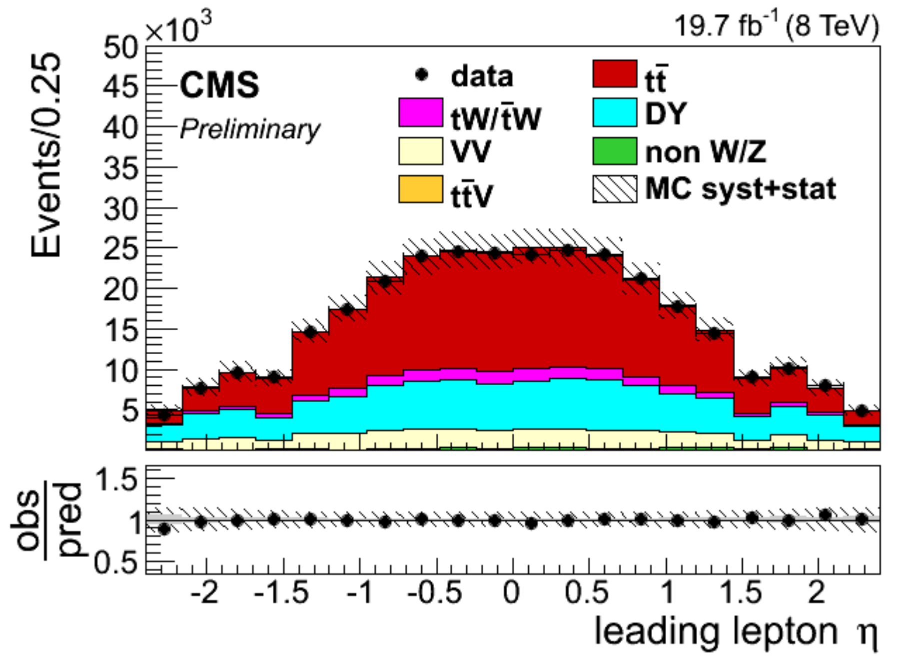
- Due to **not perfect modeling of the data**, simulation is corrected using data-driven measurements performed in control regions
- Trigger: efficiencies measured with **largely uncorrelated triggers** (MET-based), ~95% (variations of ~1.3%)
- Lepton Identification/Isolation: efficiencies measured using **Z candidates with a tag and probe method**, ~90 and ~80% for muons and electrons (variation of ~1%)
- B-tag/mistag: rates measured using **QCD multijets** (bbbar enriched), SF~95%
- In each case, **scale factors are applied** to re-weight the simulation

Leading Lepton Kinematics



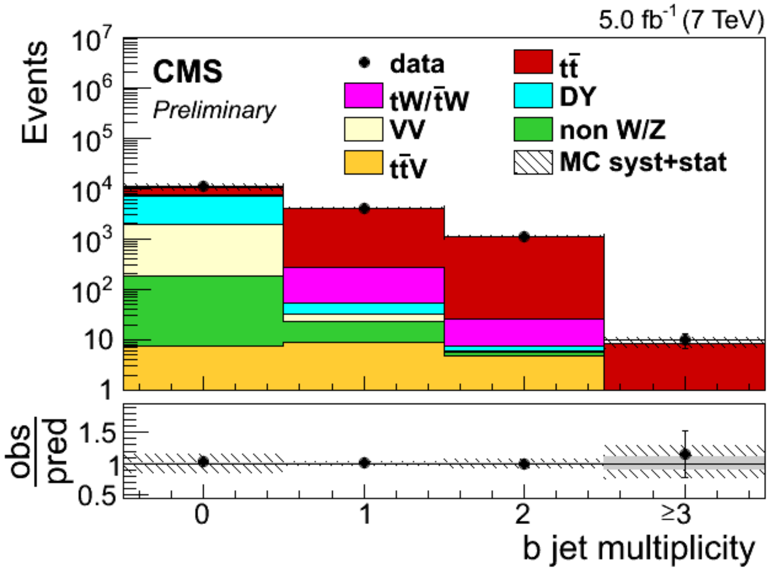






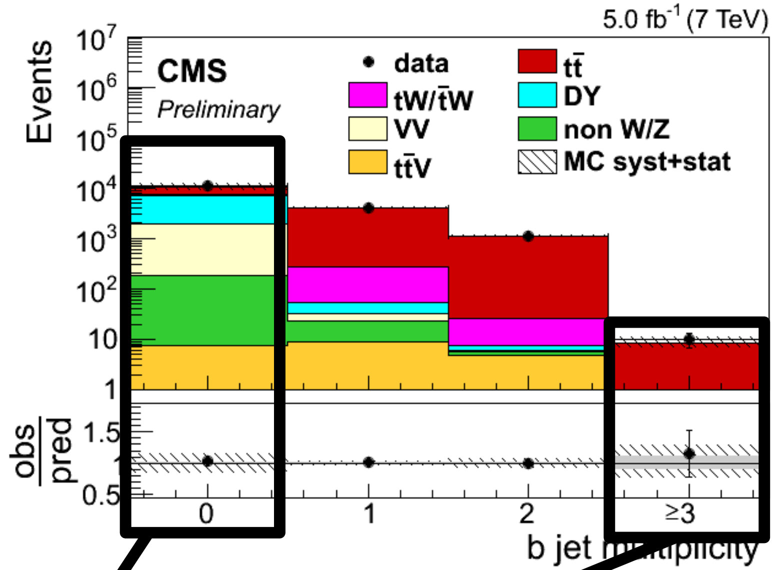
Variables used for templates

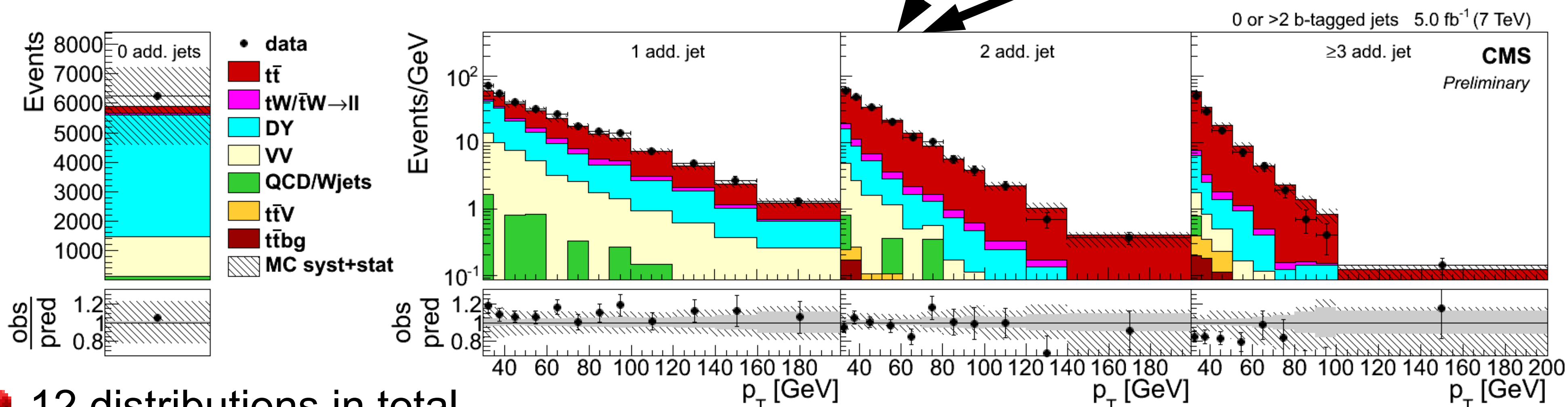
- Jet variables used in order to constrain uncertainty from b-tagging, JES
- First divide events into three bins by number of b-jets: N_b = 1, 2 and 0 or ≥3
- Then, we divide each category in 4 bins, as a function on the number of non b jets



Variables used for templates

- Jet variables used in order to constrain uncertainty from b-tagging, JES
- First divide events into three bins by number of b-jets: N_b = 1, 2 and 0 or ≥3
- Then, we divide each category in 4 bins, as a function on the number of non b jets
- For each of these, we take: Nevents, p_T^{lead}, $p_T^{sublead}$ and p_T^{lowest} for events with 0, 1, 2 or 3 non b jets, respectively

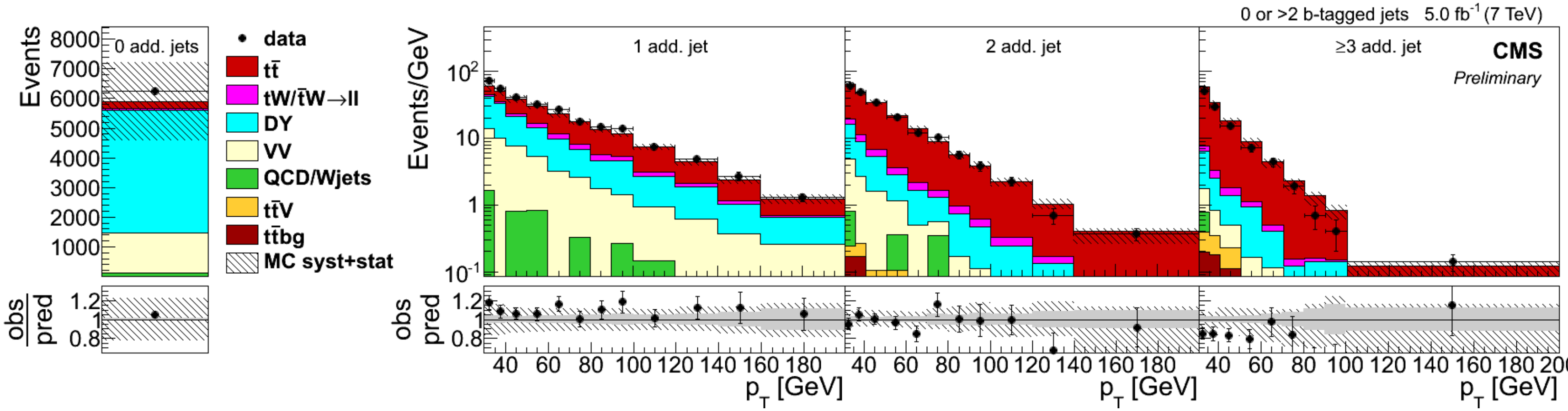




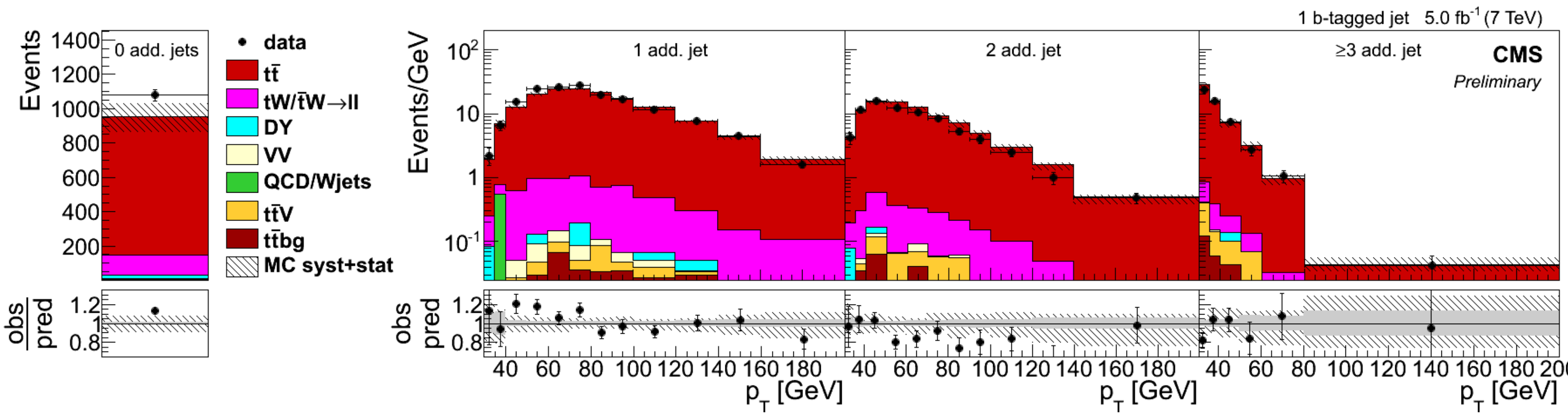
- 12 distributions in total

Pre-Fit Distributions (7 TeV)

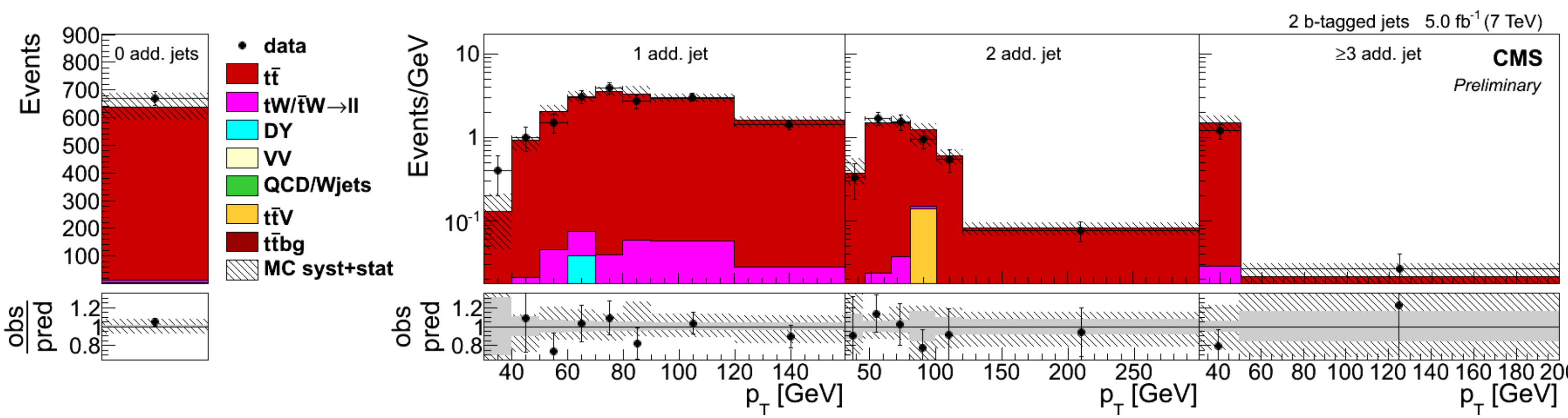
$N_b = 0$ or $N_b \geq 3$



$N_b = 1$



$N_b = 2$

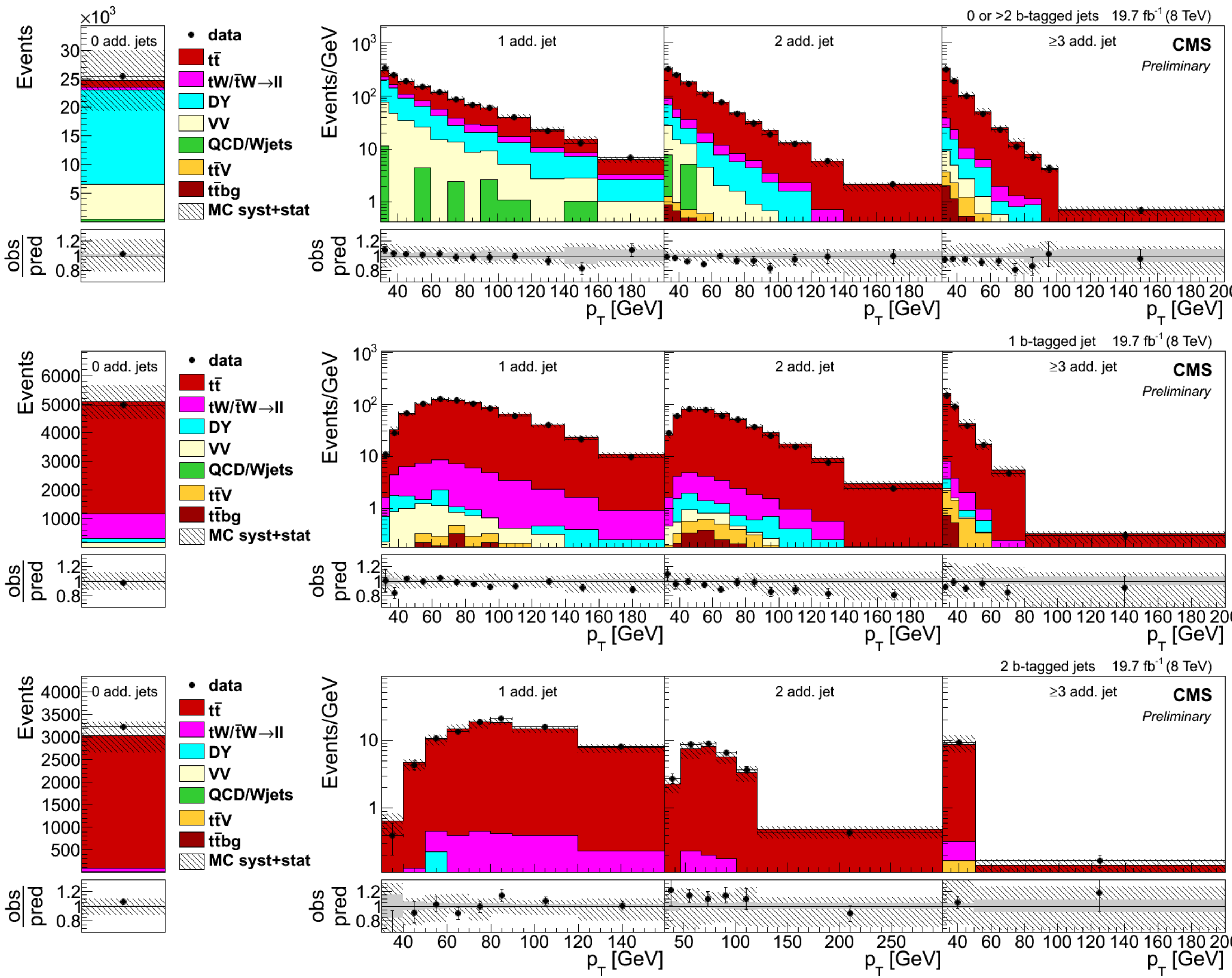


Pre-Fit Distributions (8 TeV)

$N_b = 0$ or $N_b \geq 3$

$N_b = 1$

$N_b = 2$



Method Review: Template Fit

- Template **fit to lowest light jet p_T** for each category (N events if there are no light jets)
  - Allows the extraction of the b-tagging efficiency and **constraining of syst. unc.**
- Signal and background templates taken from MC, fitted to data
  - Templates normalized to luminosity (depending on the cross section)
  - Templates depend on **systematic variations λ_i**
  - Binned Poisson Likelihood used for fitting

Constraints

- Constraints exploiting top-quark pair topology

$$N_1 = L\sigma_{t\bar{t}}\epsilon_{e\mu} \cdot 2\,\epsilon_b(1 - C_b\epsilon_b) + N_{bg1}$$

$$N_2 = L\sigma_{t\bar{t}}\epsilon_{e\mu} \cdot C_b\epsilon_b^2 + N_{bg2}$$

$$N_{0,3+} = L\sigma_{t\bar{t}}\epsilon_{e\mu} \cdot \left(1 - 2\epsilon_b(1 - C_b\epsilon_b) - C_b\epsilon_b^2\right) + \mathrm{N_{bg0,3+}}$$

$$N_b = L\sigma_{t\bar{t}}\beta_b + N_{bg}$$

$$C_b = \frac{4N_{e\mu}^{t\bar{t}}N_2^{t\bar{t}}}{(N_1^{t\bar{t}} + 2N_2^{t\bar{t}})^2}$$

Possible to derive the b-jet acceptance from data(Eur. Phys.J. C74 (2014) 3109)

- Implementation in the fit
  - Use above equations for signal contribution: $N_b^{sig} = L\sigma_{t\bar{t}}\epsilon_{e\mu} \cdot \beta_b$
  - Derive C_b, ε_b and $\varepsilon_{e\mu}$ parameters from MC
  - Parametrize them in terms of λ_i

Systematic Uncertainties

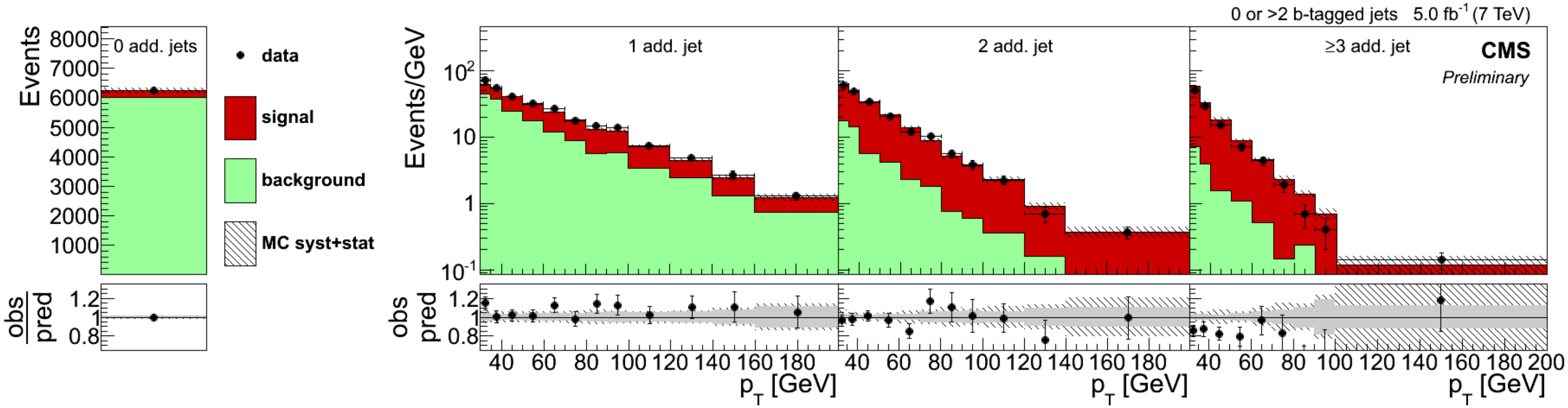
- **Each systematic source is treated individually** by suitable variations of the MC simulations or varying parameter values within their estimated uncertainties
- Each source is finally represented by a nuisance parameter which is fitted together with the visible cross section
- Need to describe expected probability distribution of systematics (prior assumptions)
  - Gaussian priors for detector uncertainties: preferred central value, smooth variation to 1 sigma
  - Box priors for modeling parameters: no preferred central value, free variation within 1 sigma
  - Backgrounds: 30% normalization uncertainty (DY allowed to shift)

Fit Simultaneously 7 and 8 TeV

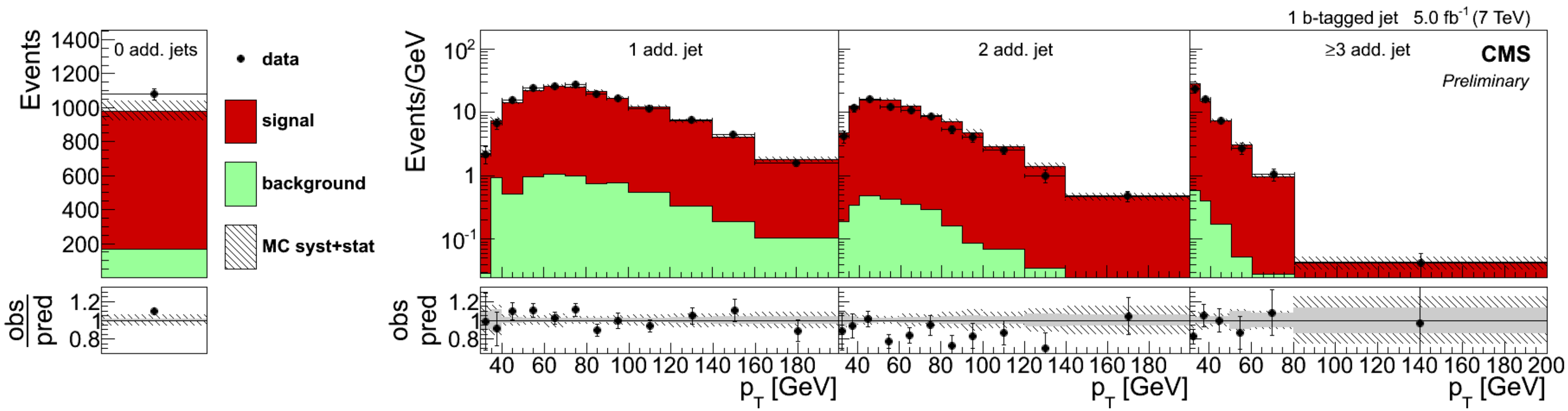
- Using as many constraints as possible, we can lower uncertainties
- Need to take into account correlations between sources at 7 and 8 TeV
  - Experimental sources, since the same procedures is used, are treated a priori as 100% correlated or close (a usually small uncorrelated component arises from statistical fluctuations in the used data or simulated samples)
  - Modeling uncertainties are assumed to be fully correlated
- For fully correlated sources, common nuisance parameters are used in the fit
- For partially correlated sources, three nuisance parameters are introduced, one for each data set for the uncorrelated part and one common for the correlated part
- Checks:
  - Variations of the correlations within reasonable ranges lead to negligible changes of the extracted cross sections
  - Independent measurements of 7 and 8 TeV datasets lead to very similar results

Fitted Distributions (7 TeV)

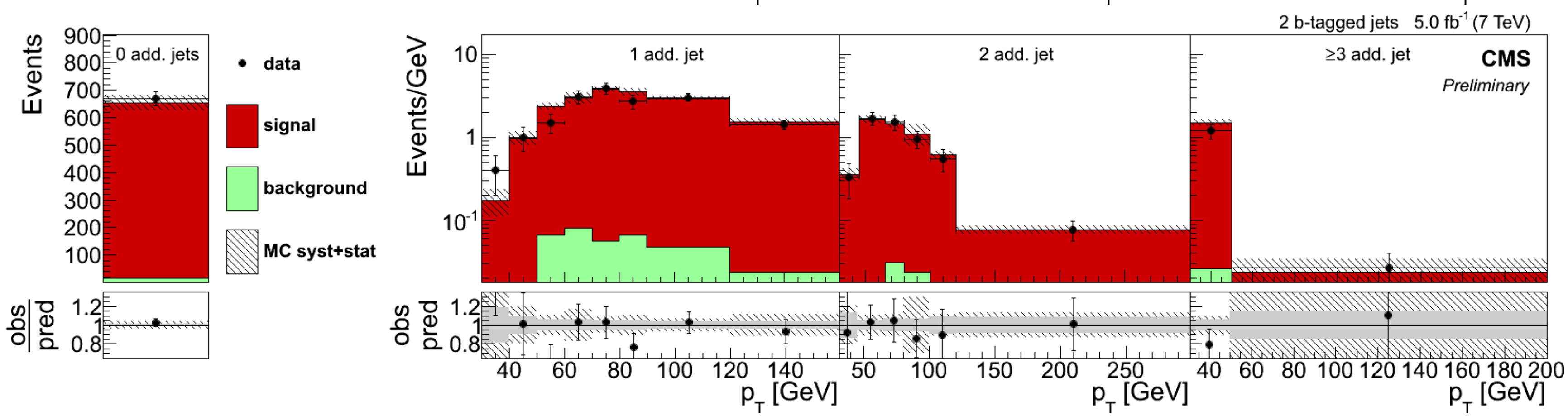
$N_b = 0$ or $N_b \geq 3$



$N_b = 1$

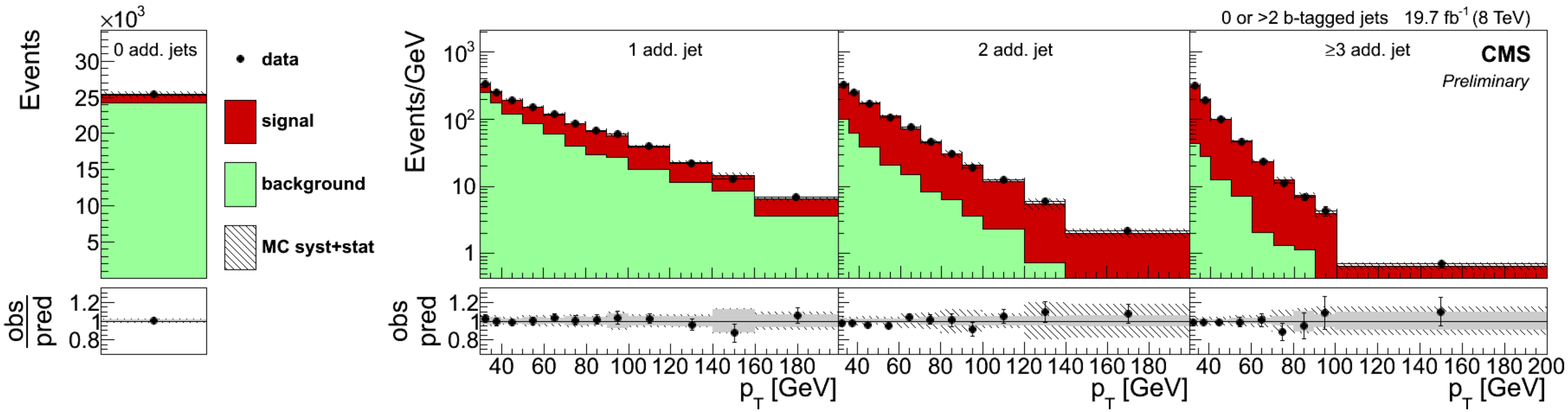


$N_b = 2$

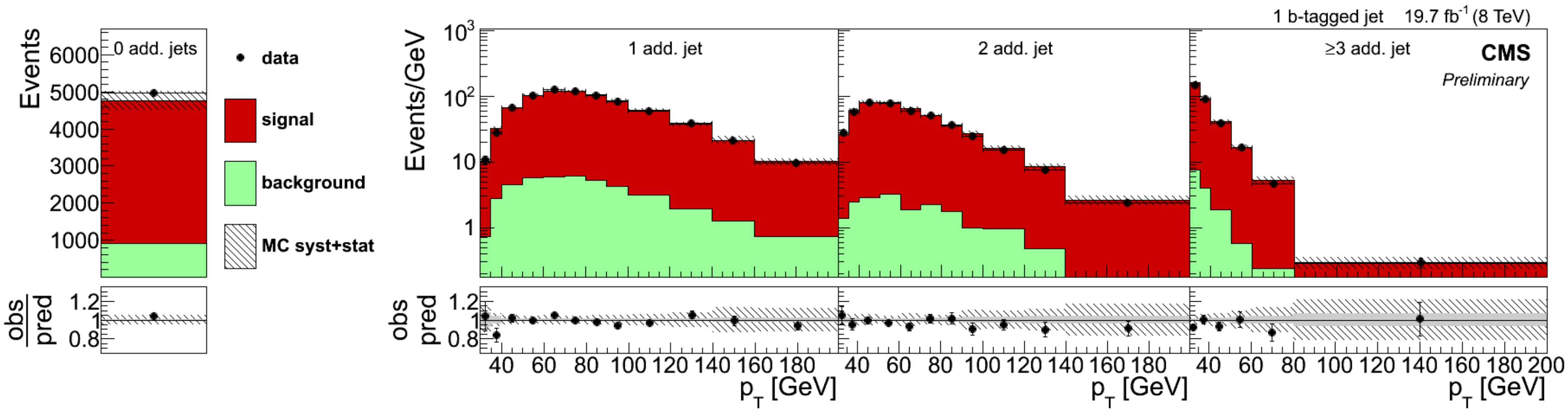


Fitted Distributions (8 TeV)

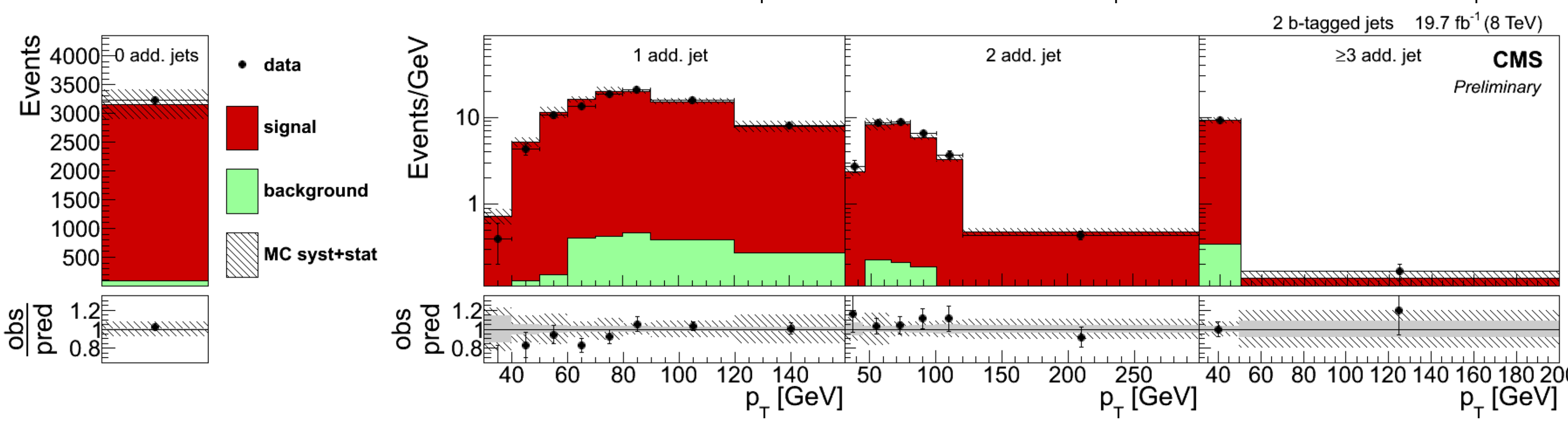
$N_b = 0$ or $N_b \geq 3$



$N_b = 1$



$N_b = 2$



Visible Cross Section

- Total uncertainty taken from parameter scan in nuisance parameter space in -2ln(L)=1
- Impacts of different sources on the total unc.estimated by removing groups of unc. one at a time and gauging the difference in quadrature on the total unc.
- Shifts of the fitted bkg (or other nuisance parameters) wrt their assumed uncertainty before the fit are in general small ==> consistent fit
- Luminosity, DY and lepton eff are the dominant effects

$\sigma_{vis}(7\ \text{TeV}) = 3.05^{+0.11}_{-0.10}$ pb (+3.5% -3.4%)

$\sigma_{vis}(8\ \text{TeV}) = 4.24^{+0.16}_{-0.14}$ pb (+3.7% -3.4%)

Source	Uncertainty [%]	
	7 TeV	8 TeV
Trigger	1.2	1.2
Lepton ID/isolation	1.4	1.5
Lepton energy scale	0.1	0.1
Jet energy scale	0.7	0.9
Jet energy resolution	0.1	0.1
Single top	0.9	0.6
DY	1.2	1.2
$t\bar{t}$ other	0.1	0.1
$t\bar{t}+V$	0.0	0.1
Diboson	0.2	0.6
W+jets	0.0	0.0
QCD	0.0	0.0
B-tag	0.5	0.5
Mistag	0.2	0.1
Pileup	0.3	0.3
Q^2 scale	0.3	0.3
ME/PS matching	0.2	0.1
MG+PY → PH+PY	0.2	0.4
Hadronization (JES)	0.6	0.8
Top p_T	0.3	0.3
Color reconnection	0.1	0.0
Underlying event	0.0	0.1
PDF	0.2	0.7
Luminosity	2.2	2.6
Statistical	1.2	0.6

Extrapolation to Full Phase Space

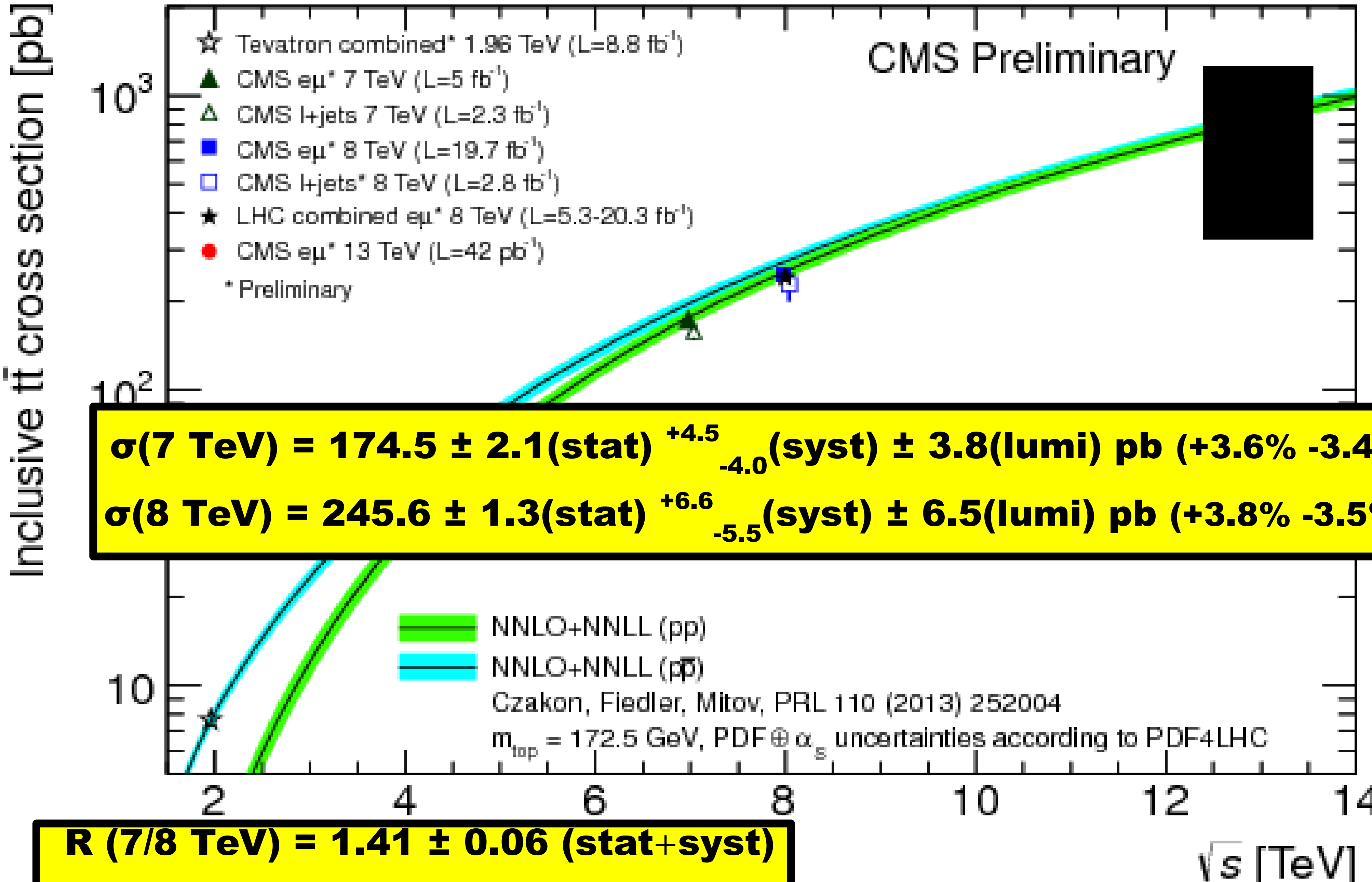
- Calculate acceptance from MC and extract the full phase space cross sections from

$$\sigma_{t\bar{t}} = \frac{\sigma_{t\bar{t}}^{vis}}{A_{e\mu}}$$

- Vary each modeling uncertainty by its ±1sigma in the acceptance
- Add difference in final cross section in quadrature to total uncertainty

Source	Uncertainty [%]	
	7 TeV	8 TeV
Total (vis)	$\pm^{3.5}_{3.4}$	$\pm^{3.7}_{3.4}$
Q^2 scale (extrapol.)	$\pm^{0.4}_{0.0}$	$\pm^{0.2}_{0.1}$
ME/PS matching (extrapol.)	$\mp^{0.1}_{0.1}$	$\pm^{0.3}_{0.3}$
Top p_T (extrapol.)	$\pm^{0.4}_{0.2}$	$\pm^{0.8}_{0.4}$
PDF (extrapol.)	$\mp^{0.2}_{0.1}$	$\mp^{0.1}_{0.2}$
Total	$\pm^{3.6}_{3.4}$	$\pm^{3.8}_{3.5}$

Inclusive Top Pair Cross Section vs √s



σ(7 TeV) = 174.5 ± 2.1(stat) $^{+4.5}_{-4.0}$(syst) ± 3.8(lumi) pb (+3.6% -3.4%)

σ(8 TeV) = 245.6 ± 1.3(stat) $^{+6.6}_{-5.5}$(syst) ± 6.5(lumi) pb (+3.8% -3.5%)

R (7/8 TeV) = 1.41 ± 0.06 (stat+syst)

R(7/8 TeV, NNLO) = 1.430

Cross check

- Cut and count method used to gain consistency and confidence in the main result
- On top of the dilepton selection we require:
  - ≥ 2 jets with with p_T> 30 GeV and $|\eta|$< 2.4
  - ≥ 1 of them b-tagged

$$\sigma(t\bar{t}) = \frac{N_{data} - N_{bkg}}{A \cdot \epsilon \cdot BR \int dt\, L}$$

Source	Number of $e^{\pm}\mu^{\mp}$ events	
	7 TeV	8 TeV
DY	$22.1 \pm 3.1 \pm 3.3$	$173.3 \pm 25.1 \pm 26.0$
Non-W/Z	$51.0 \pm 0.7 \pm 15.3$	$145.9 \pm 14.8 \pm 43.8$
Single top quark (tW)	$204.0 \pm 3.1 \pm 61.2$	$1033.6 \pm 2.9 \pm 313.8$
VV	$6.9 \pm 0.6 \pm 2.1$	$35.4 \pm 1.9 \pm 11.1$
Rare ($t\bar{t}$V)	$--$	$83.6 \pm 1.3 \pm 25.5$
Total background	$284.0 \pm 16.0 \pm 63.2$	$1471.7 \pm 46.7 \pm 319.1$
$t\bar{t}$ dilepton signal	$5008.2 \pm 15.4 \pm 188.0$	$24439.6 \pm 43.6 \pm 956.4$
Data	4970	25441

Cross check

- Cut and count method used to gain consistency and confidence in the main result
- On top of the dilepton selection we require:
  - ≥ 2 jets with with p_T> 30 GeV and |η|< 2.4
  - ≥ 1 of them b-tagged

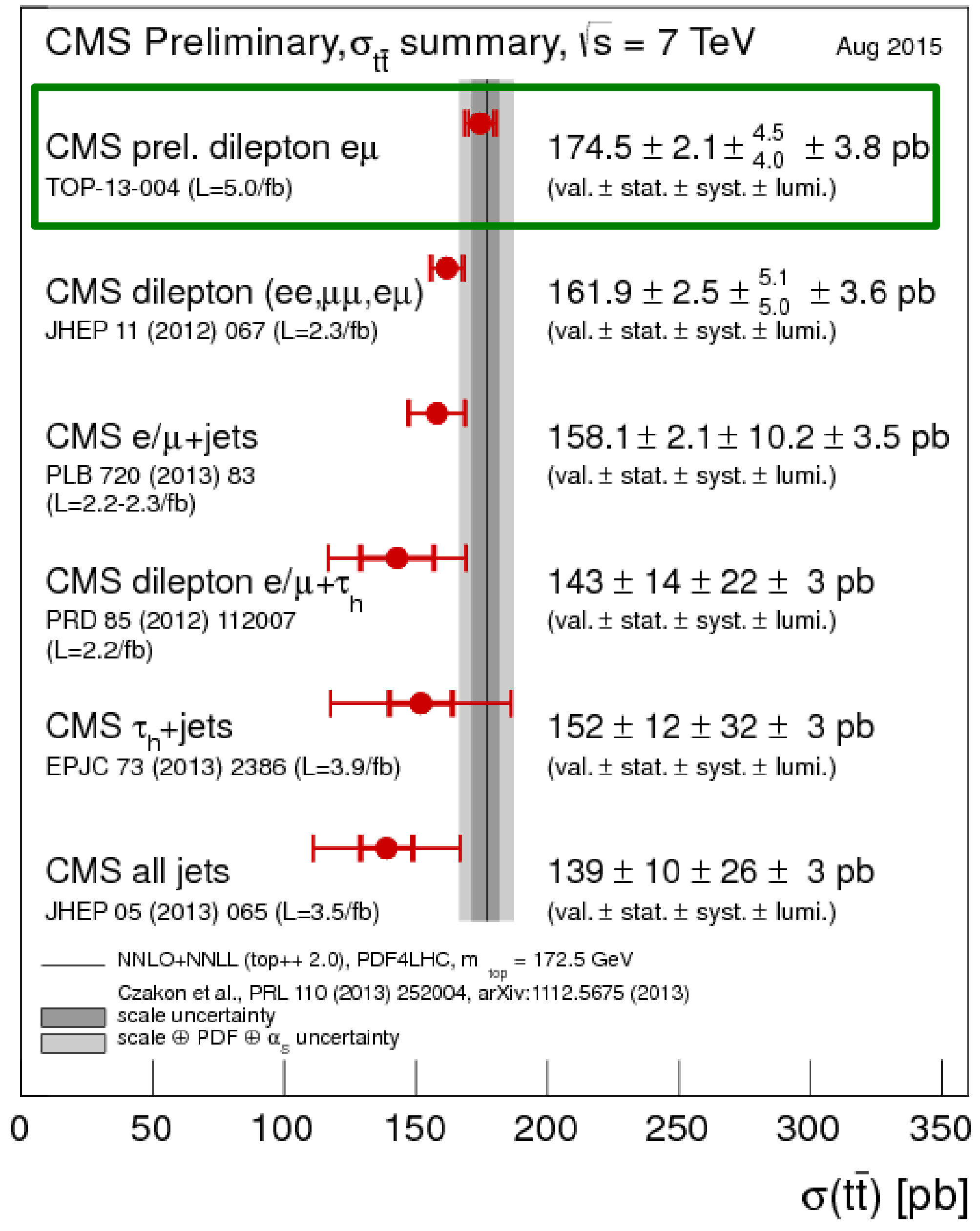
$$\sigma(t\bar{t}) = \frac{N_{data} - N_{bkg}}{A \cdot \epsilon \cdot BR \int dt\, L}$$

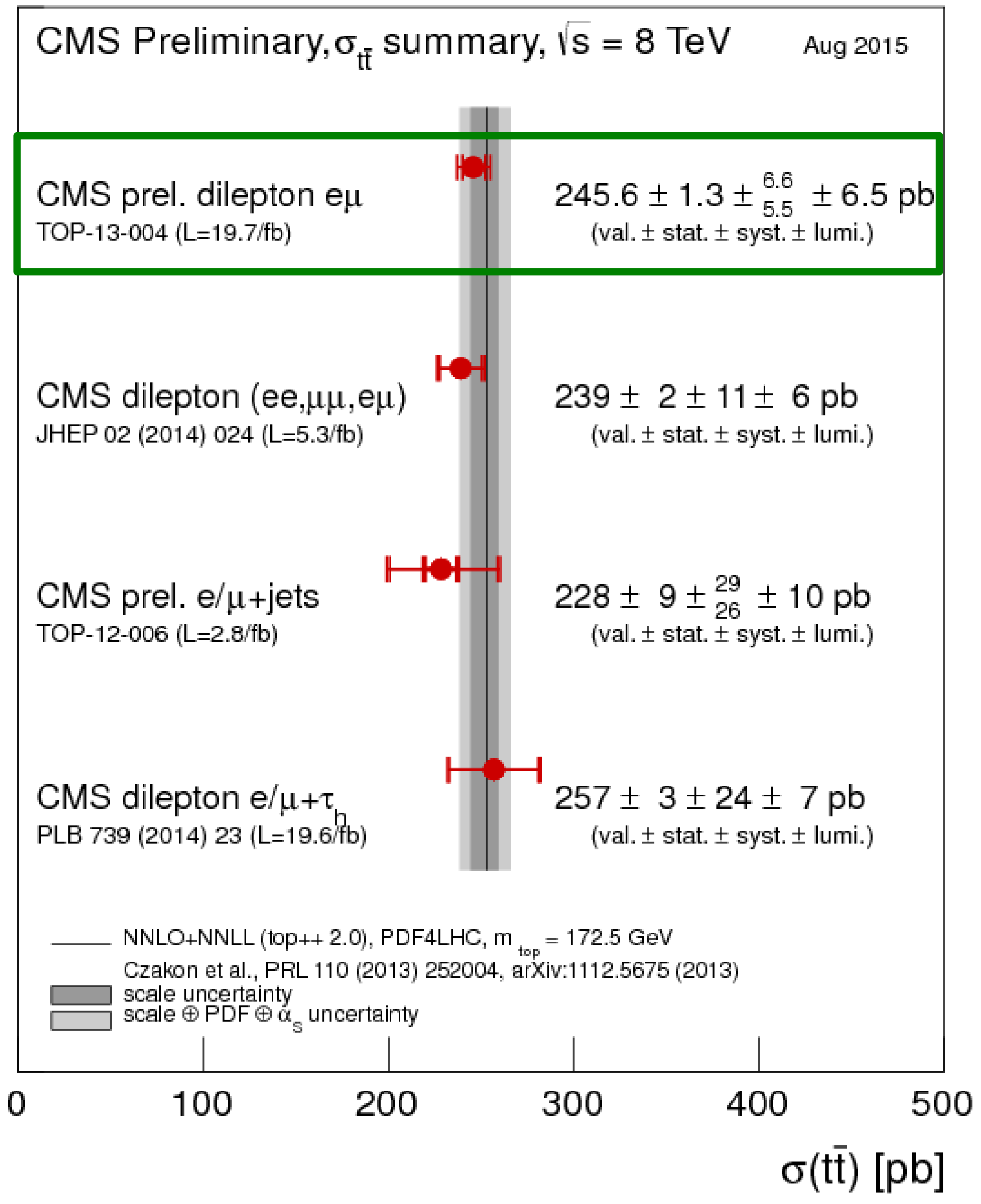
Source	Number of $e^{\pm}\mu^{\mp}$ events	
	7 TeV	8 TeV
DY	$22.1 \pm 3.1 \pm 3.3$	$173.3 \pm 25.1 \pm 26.0$
[illegible]	[illegible]	[illegible]
Rare ($t\bar{t}V$)	$--$	$83.6 \pm 1.3 \pm 25.5$
Total background	$284.0 \pm 16.0 \pm 63.2$	$1471.7 \pm 46.7 \pm 319.1$
$t\bar{t}$ dilepton signal	$5008.2 \pm 15.4 \pm 188.0$	$24439.6 \pm 43.6 \pm 956.4$
Data	4970	25441

σ(7 TeV) = 165.9 ± 2.5(stat) ± 6.2(syst) ± 3.6(lumi) pb (± 4.6%)

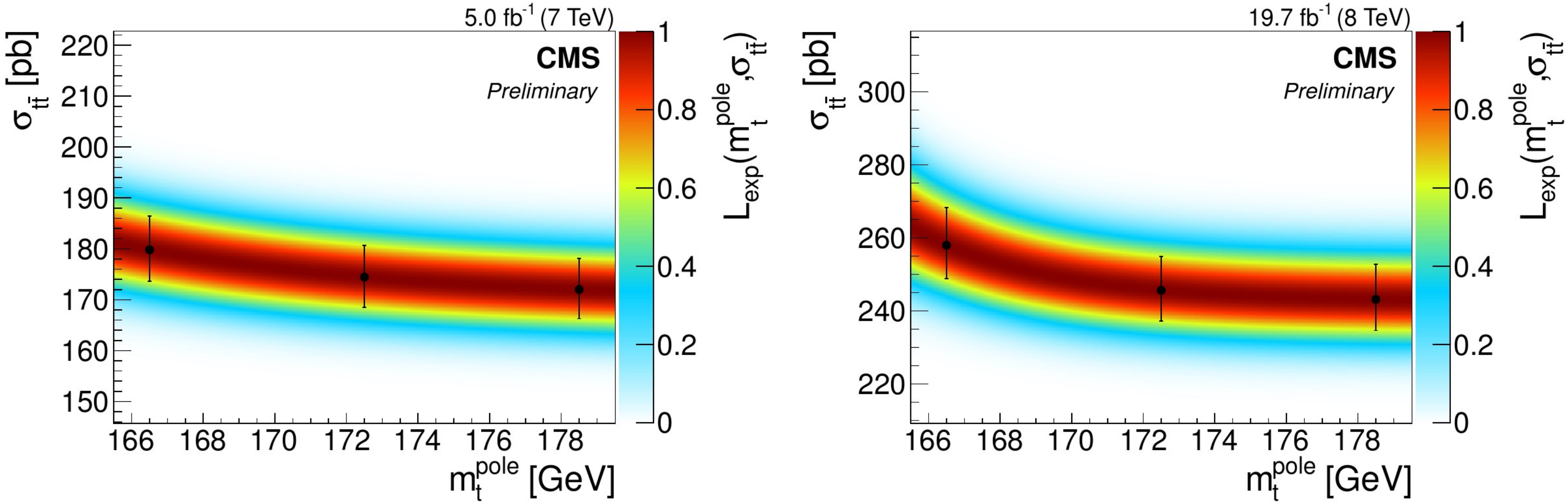
σ(8 TeV) = 241.1 ± 1.6(stat) ± 10.0(syst) ± 6.3(lumi) pb (± 5.0%)

Inclusive Top Pair Cross section: CMS summary

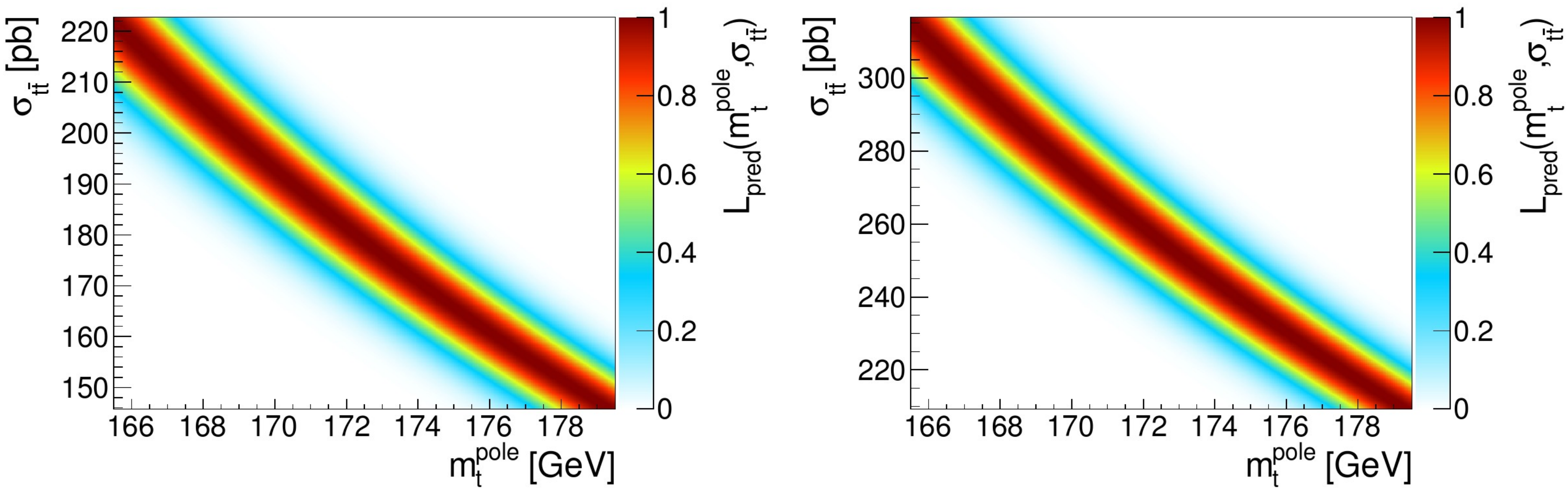




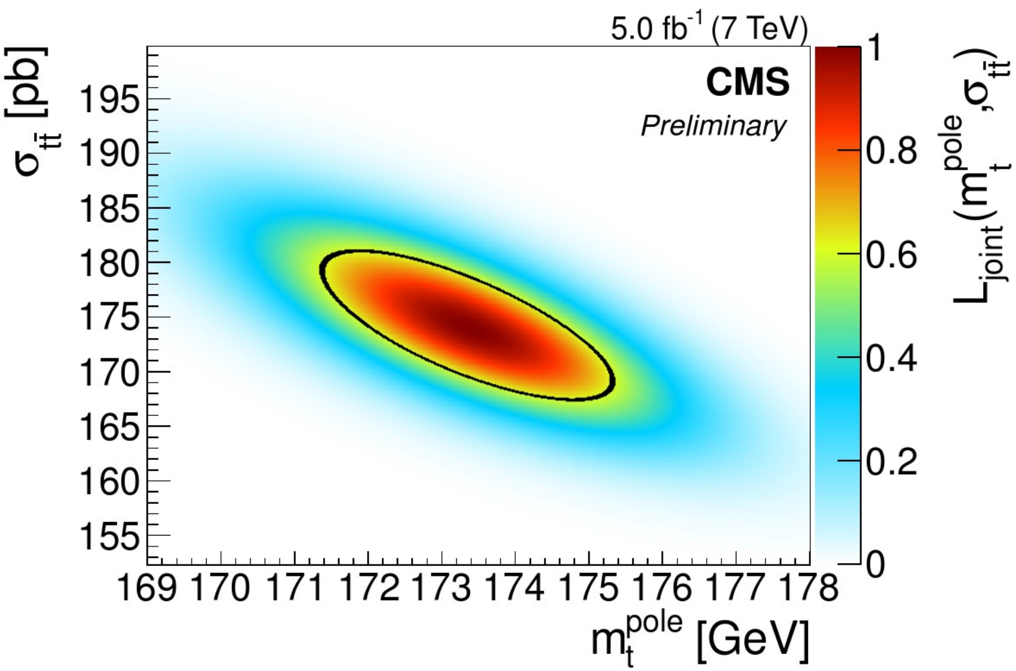
- Extract top cross section for different mass points (from different signal samples)
- Dependence described by an exponential

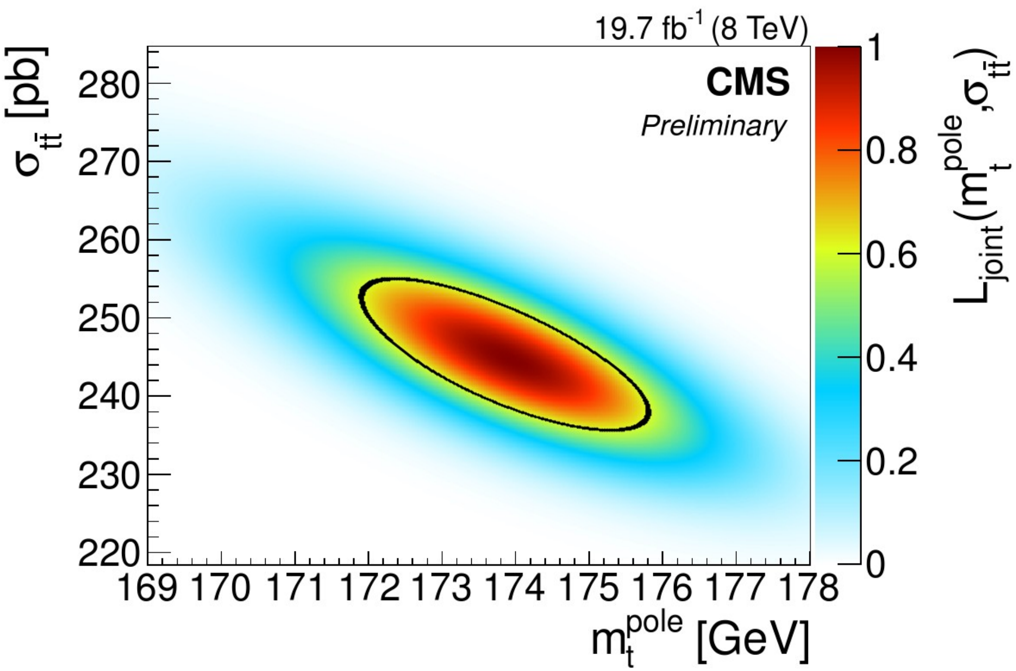


- Extract pole mass by comparing to predicted dependence (NNLO)



Top Pole Mass





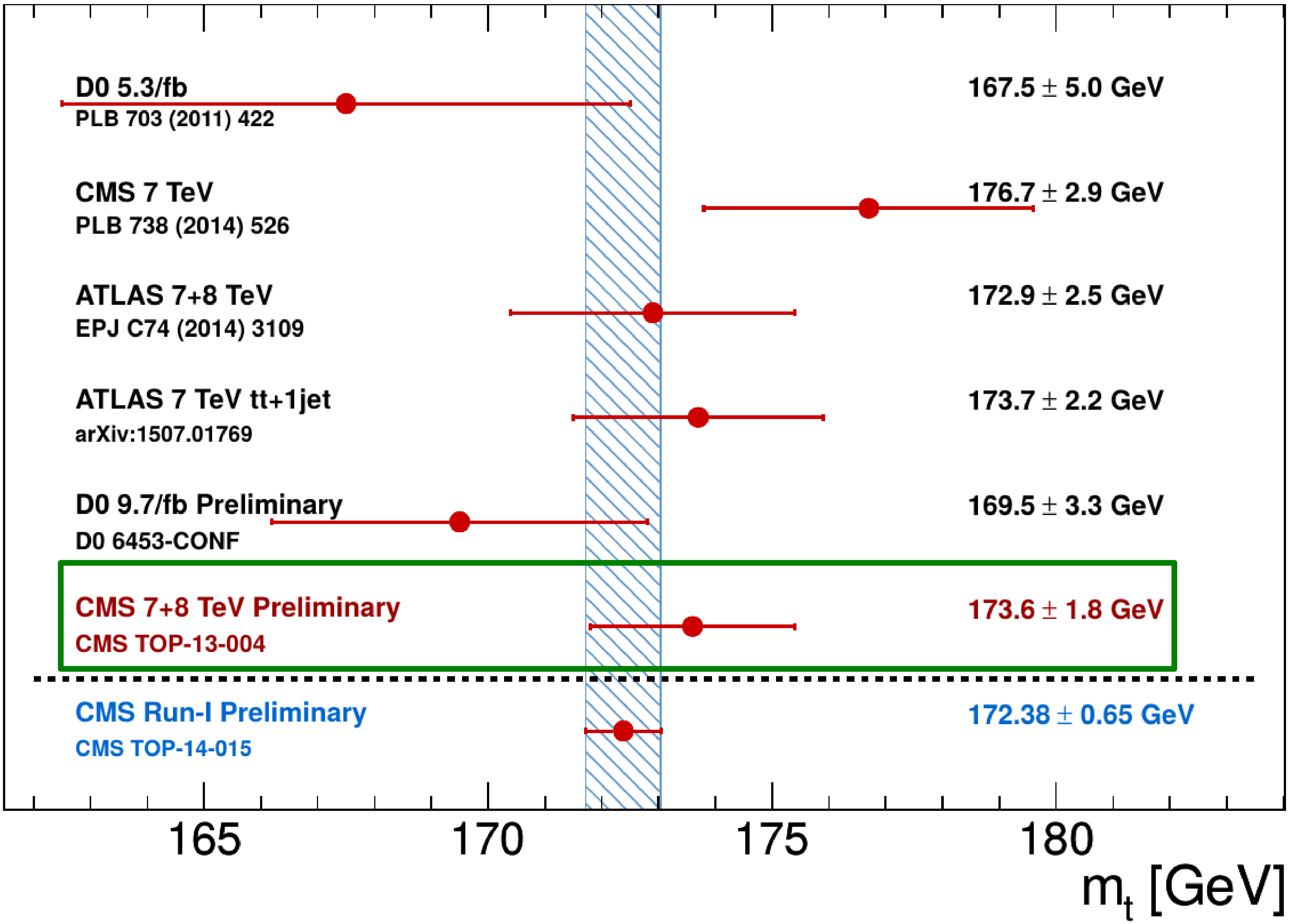
m_t = 173.4 ± 2.0 GeV

$m_t = 173.9^{+1.9}_{-2.0}$ GeV

$m_t = 173.6^{+1.7}_{-1.8}$ GeV

Consistent with previous CMS result Phys. Lett. B 738 (2014) 526

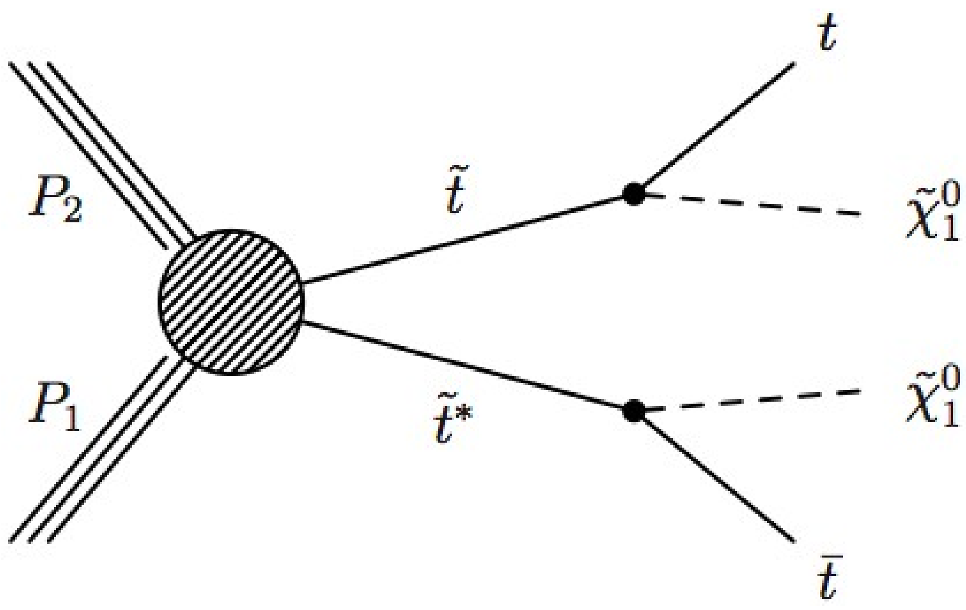
Top Pole Mass: Summary



SUSY Constraints from ttbar Cross Section

- We usually benefit from the precision measurements in top physics (differential cross sections or asymmetries) to constrain new physics

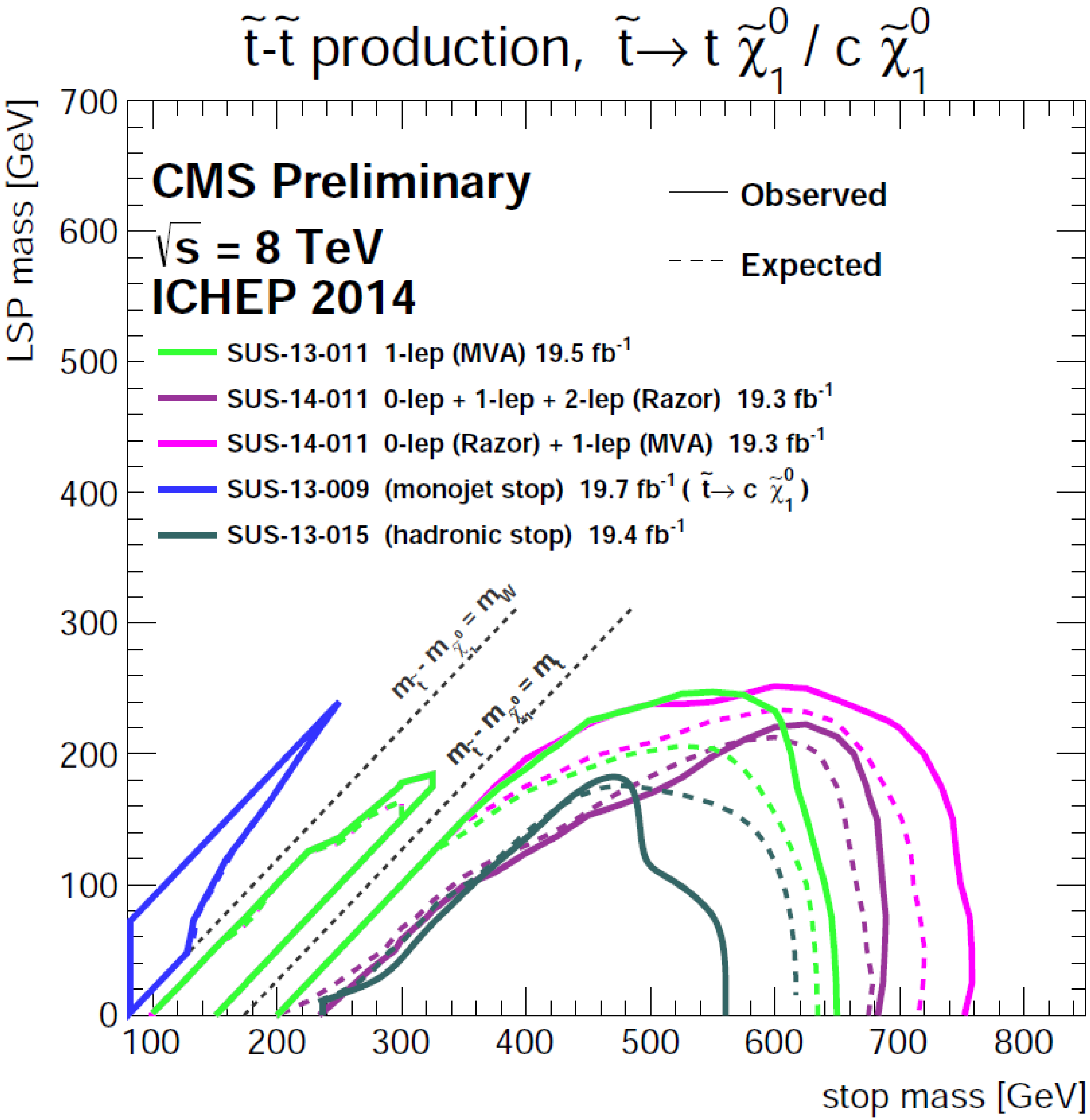
- What about inclusive cross-sections? Everything that produces ttbar could "in principle" be seen as an excess of ttbar events => differences between theoretical calculations and measurements



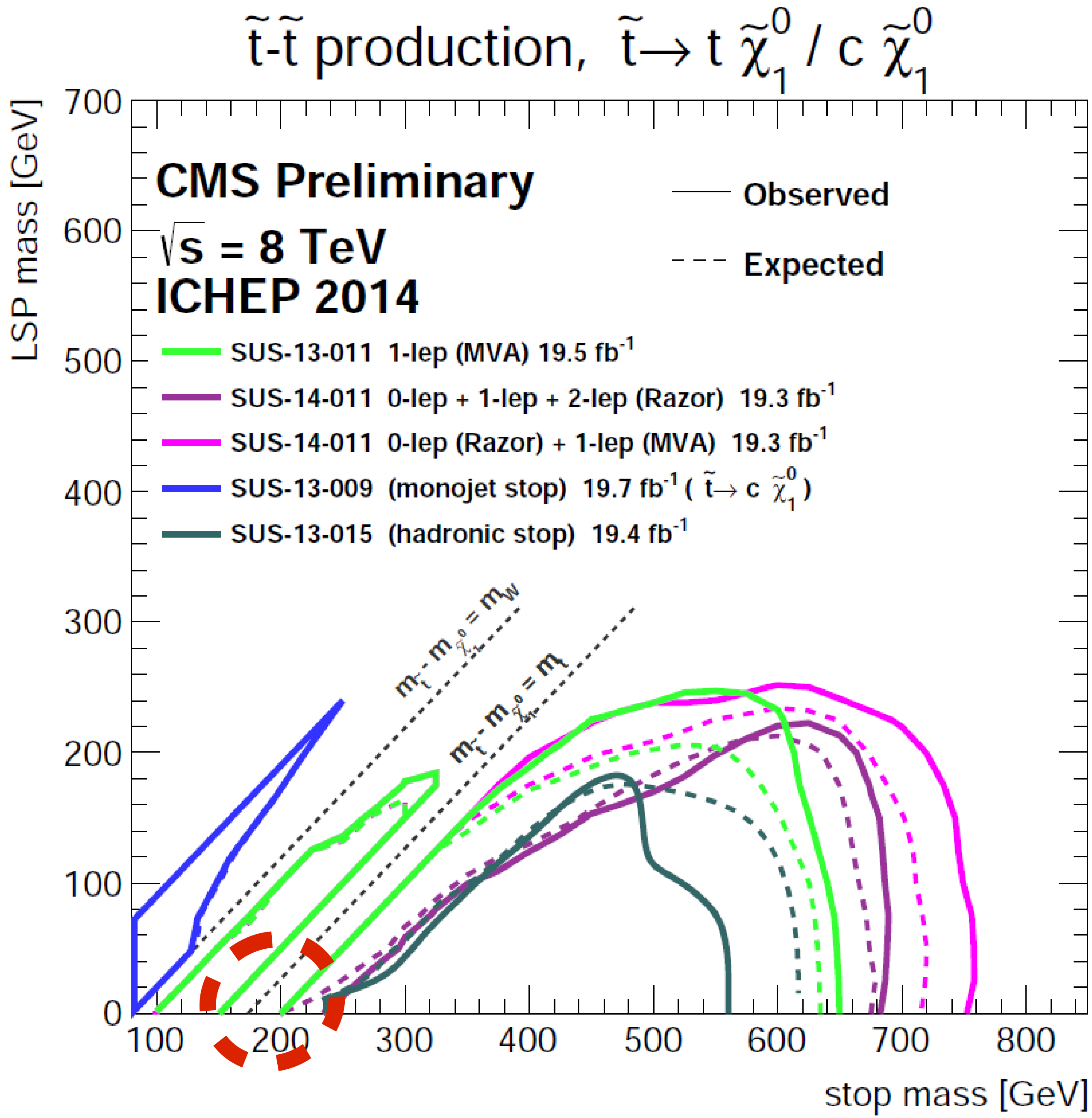
- Stop quark events would produce final states very much ttbar like

- We can set limits based on the ttbar expected yields and uncertainties

Current Status of Stop Quark direct Searches

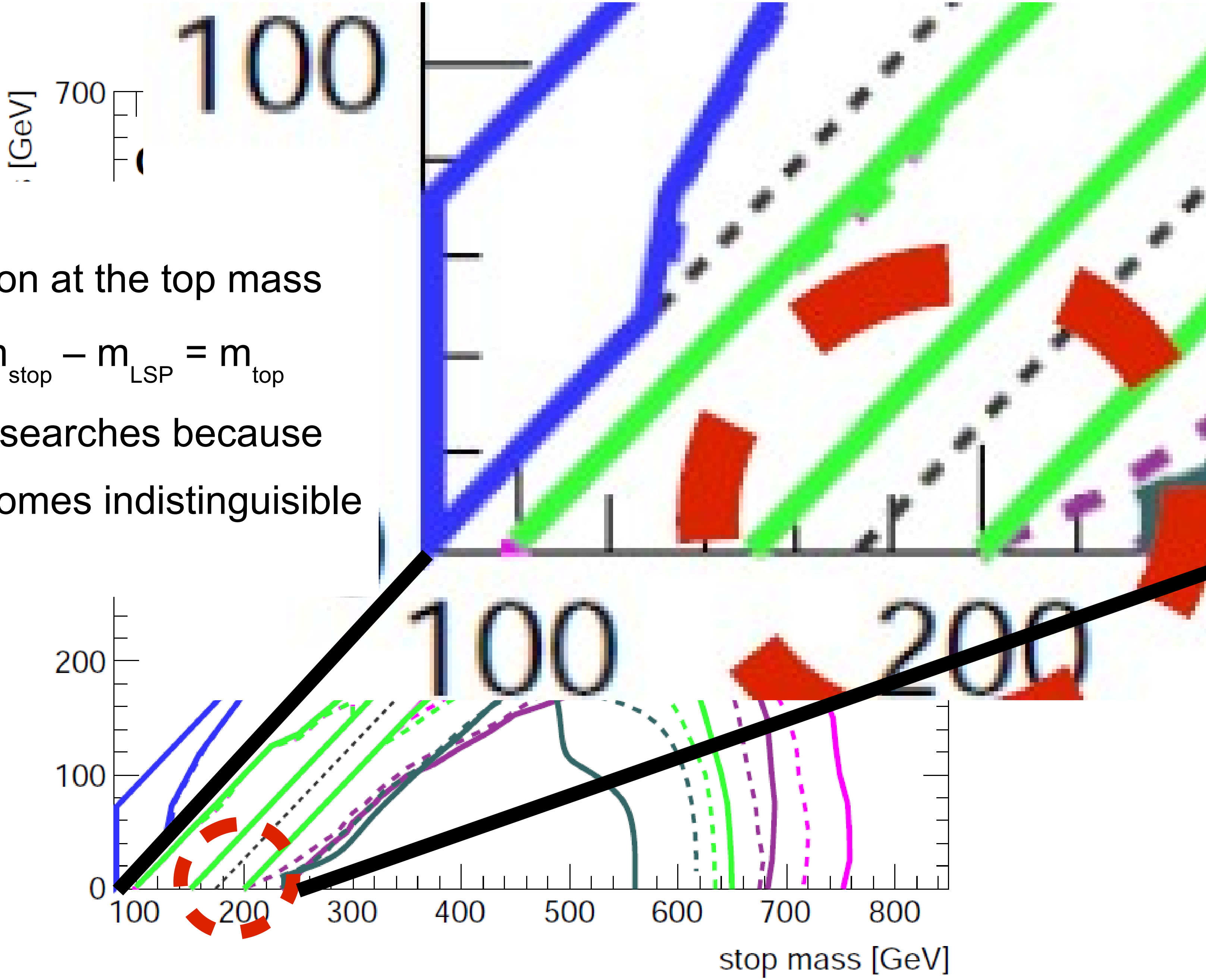


Current Status of Stop Quark direct Searches

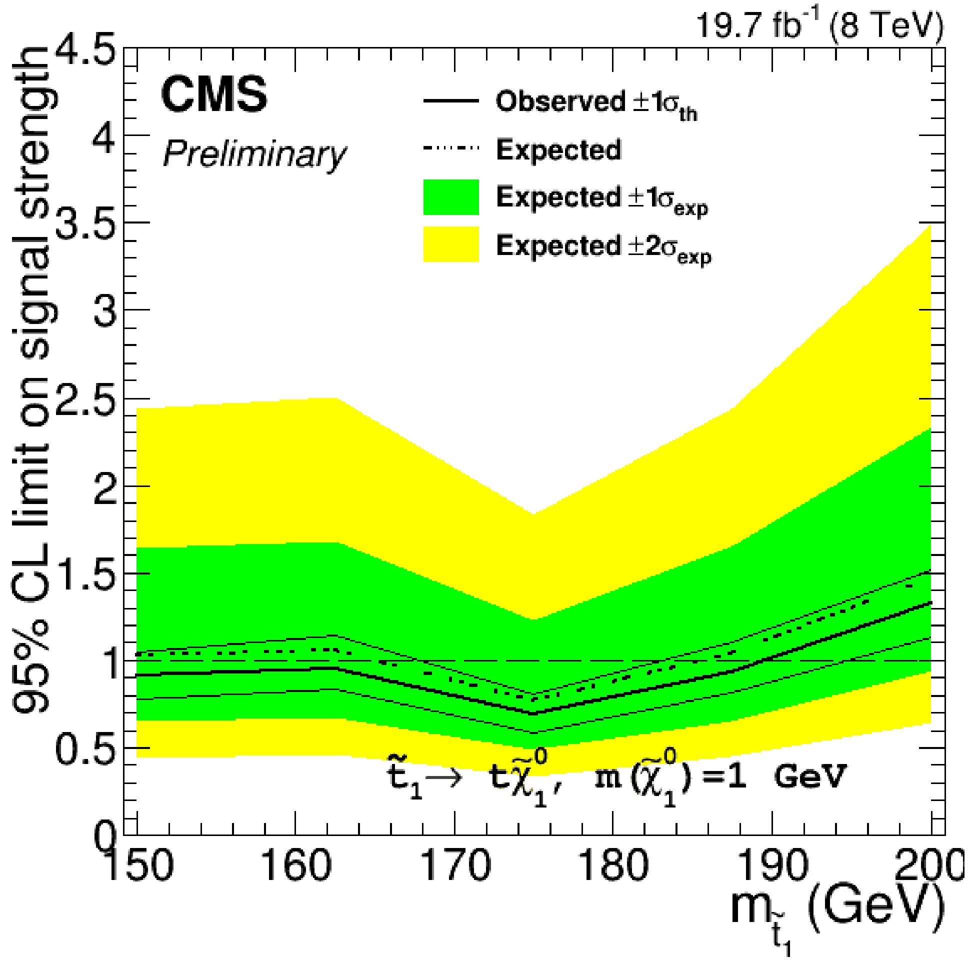


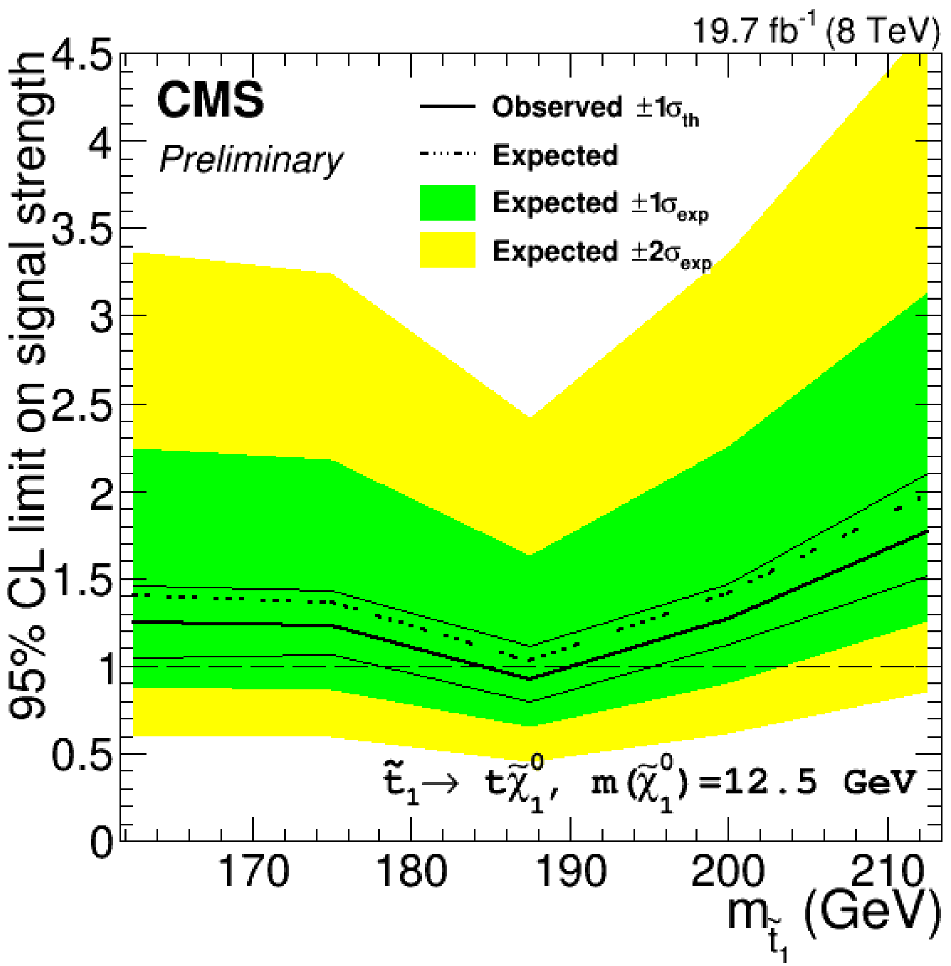
Current Status of Stop Quark direct Searches

- No exclusion at the top mass threshold $m_{stop} - m_{LSP} = m_{top}$ from direct searches because of stop becomes indistinguisible from ttbar

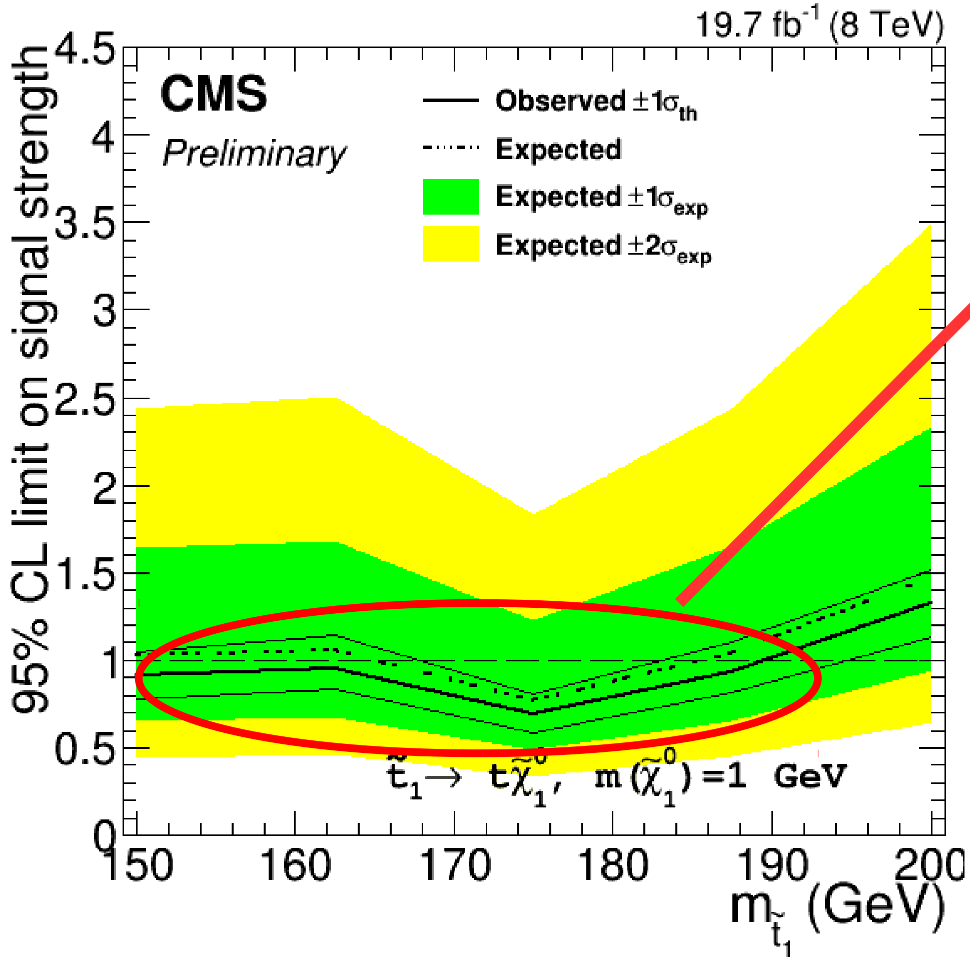


SUSY Constraints from ttbar Cross Section

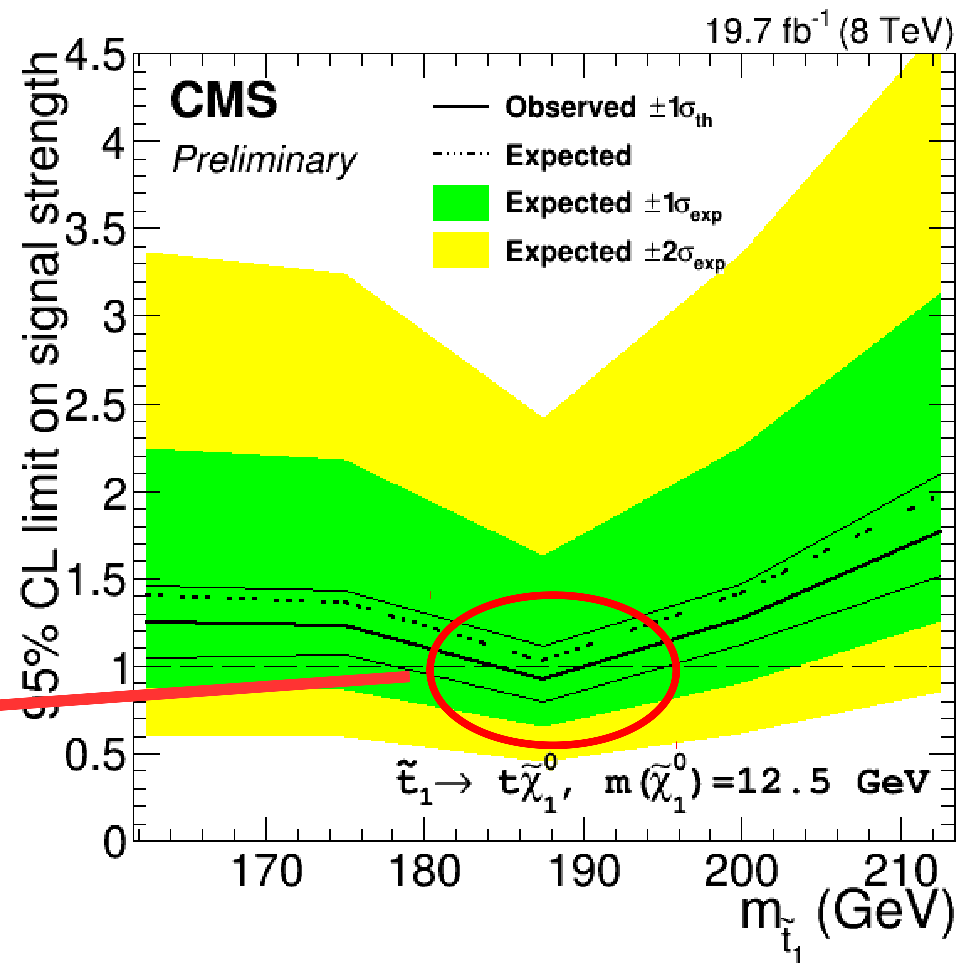




SUSY Constraints from ttbar Cross Section



- Stop quarks with masses below 189 GeV are excluded (for light neutralinos)



- For neutralinos with masses of 12.5 GeV, a very narrow range around 187 GeV is excluded

Differential top pair production measurements @7/8 TeV

Measure ttbar Differentially

- Why?
  - Extensive test of pQCD
  - Help to constrain PDF and some MC parameters
  - The huge amount of data collected in Run I allow us to do it!

- How?
  - Use a tight event selection to have a pure tt sample
  - Top quark kinematic reconstruction
  - Bkg subtraction
  - Apply corrections (detector acceptance, resolution) → unfolding techniques
  - Compare to theory predictions at parton or particle level

Normalized Differential Cross Section: Master Formula

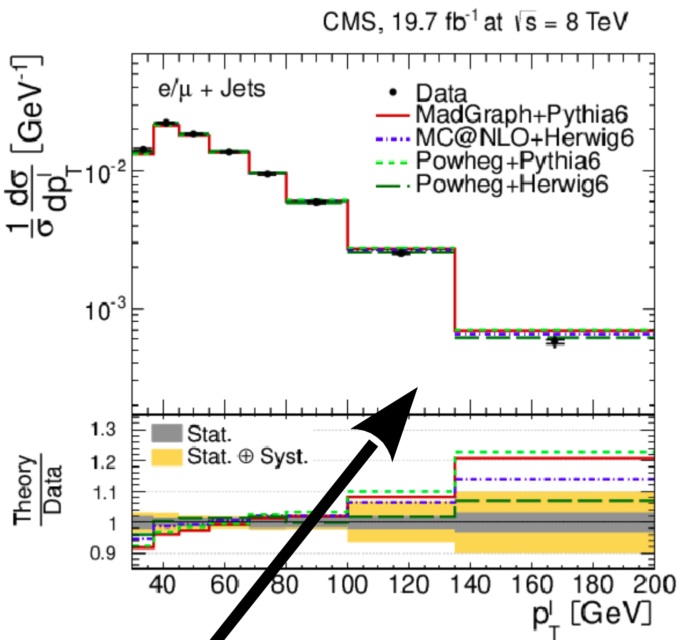
$$\frac{1}{\sigma}\frac{d\sigma_i}{dX} = \frac{1}{\sigma}\frac{\text{unfold}(s_i^X - b_i^X)}{\Delta_i^X \cdot \int \mathcal{L}\,dt}$$

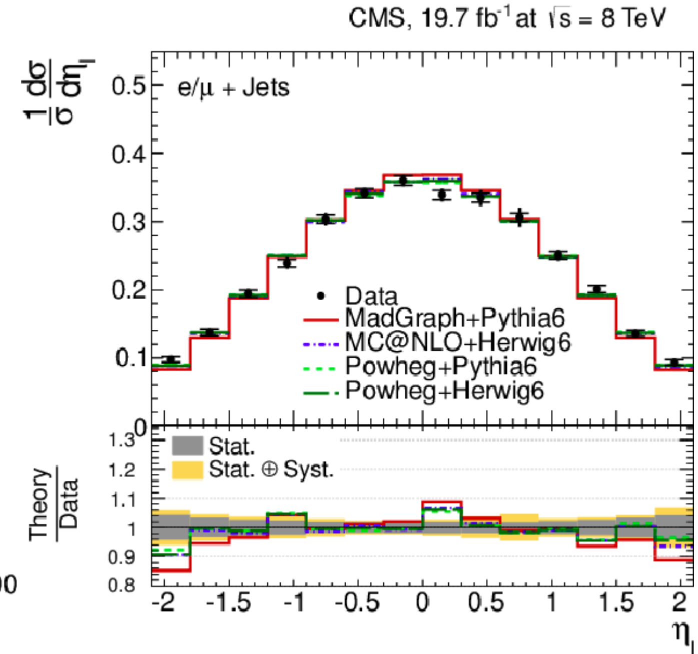
- CMS has a very comprehensive set of results: in dileptons and lepton + jets, at parton level (top quark distributions) and at particle level (lepton and b-jet distributions)

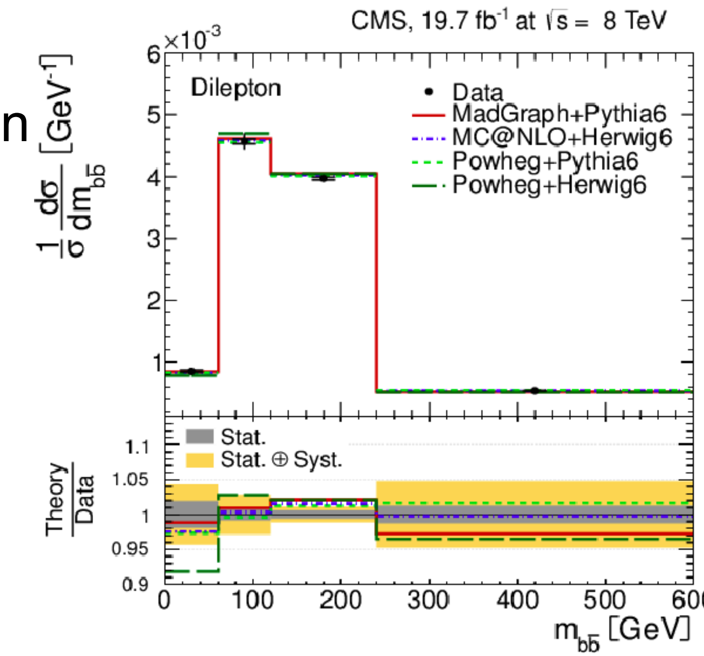
TOP-12-028
arXiv:1505.0448

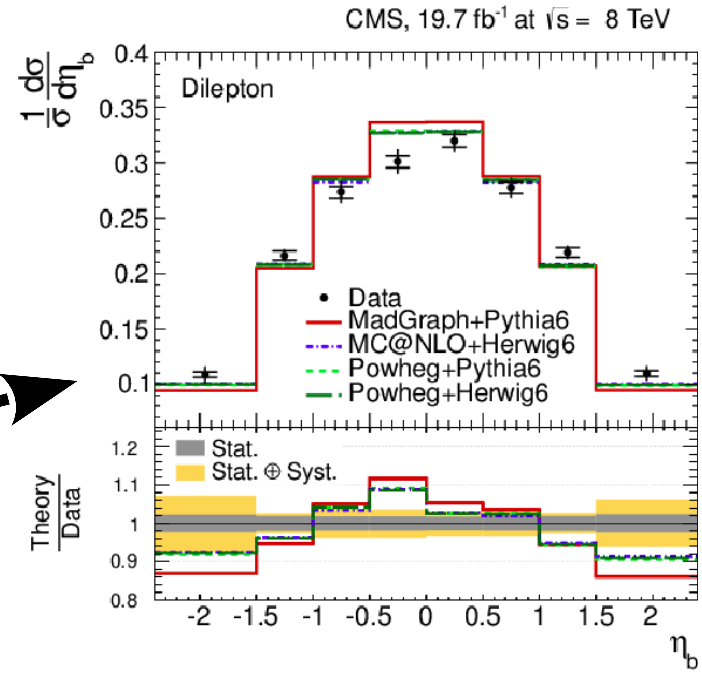
ttbar differential in visible phase space

- Differential cross section is measured as a function of kinematic prop. of leptons and b-jets in the fiducial region
- No significant deviations from SM predictions





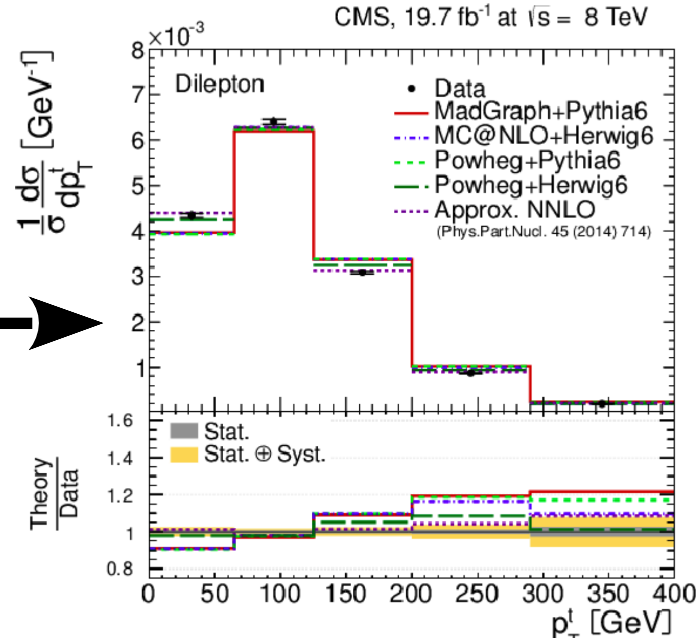


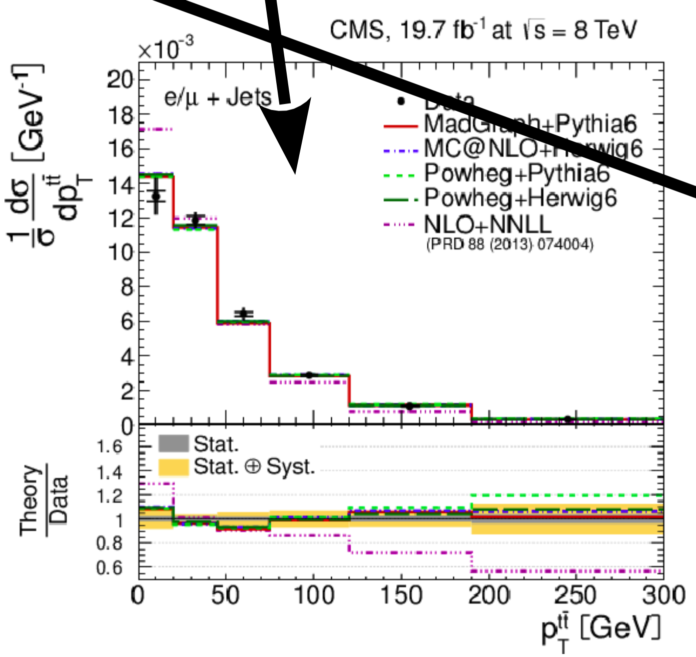


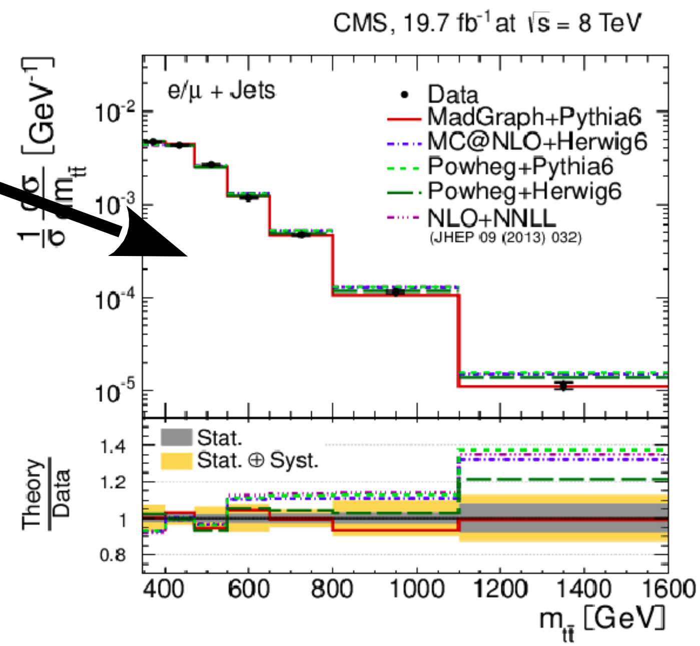
- p_T of leptons slightly softer in data
- η_b slightly less central in data

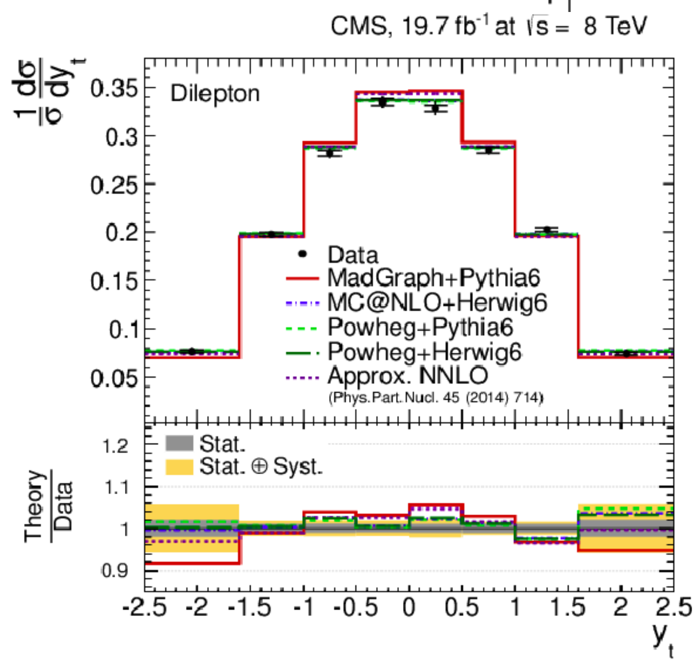
ttbar differential in full phase space

- Differential cross section is measured as a function of the top quarks and the ttbar system (at parton level) in full phase space
- Overall, good agreement with the SM predictions
- Observed top p_T softer than most MC predictions
- p_T(ttbar) generally well described
- m(ttbar) tails in data lower than predictions



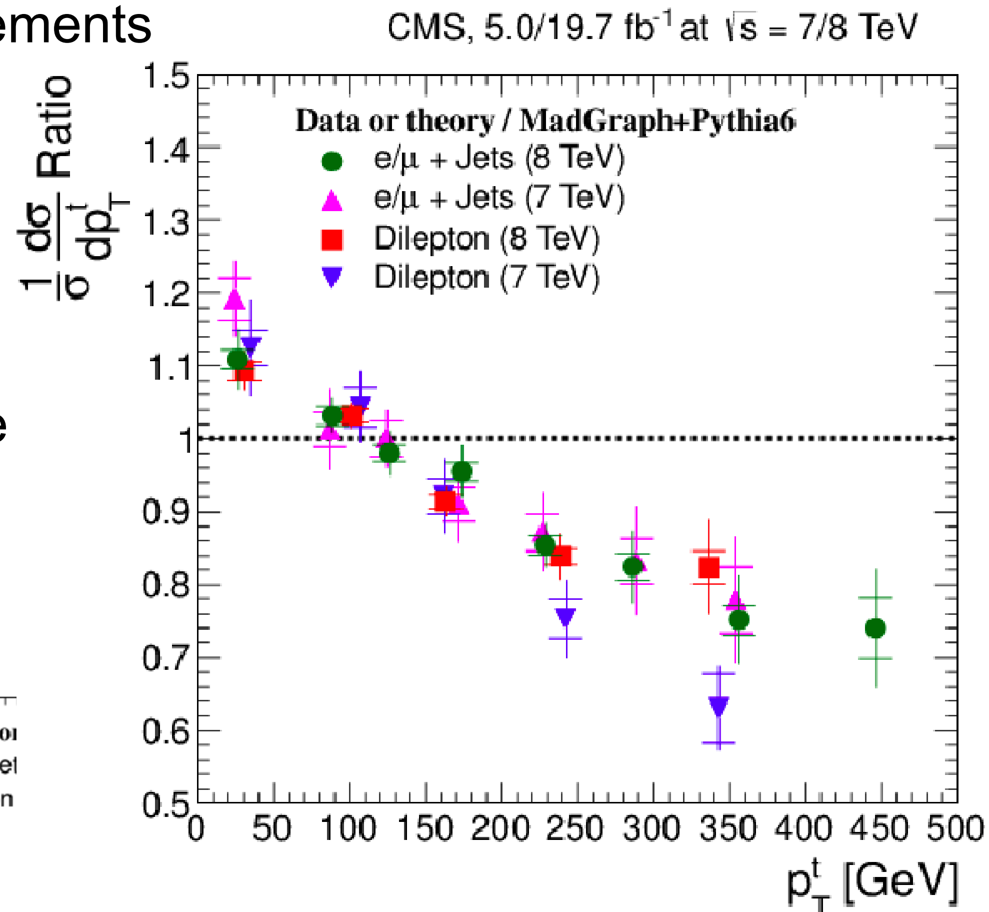


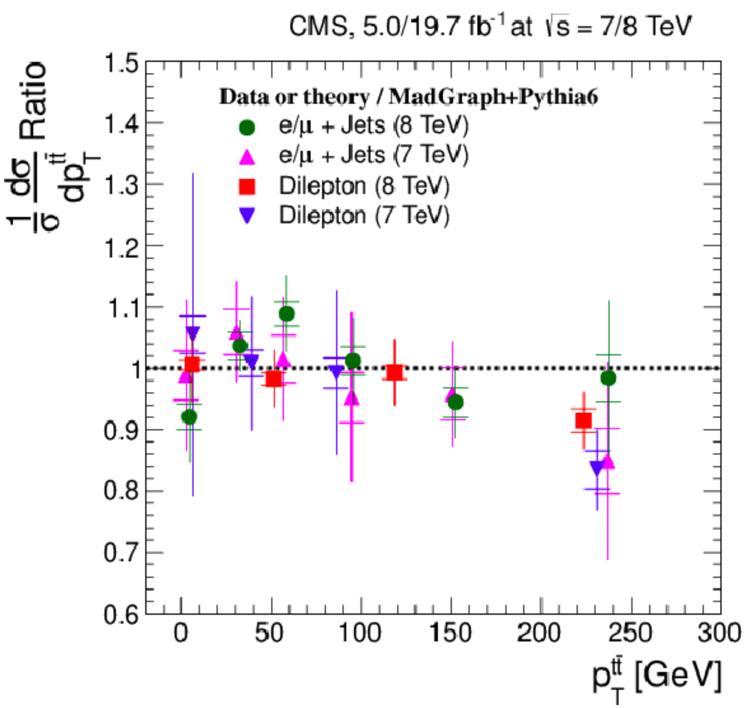


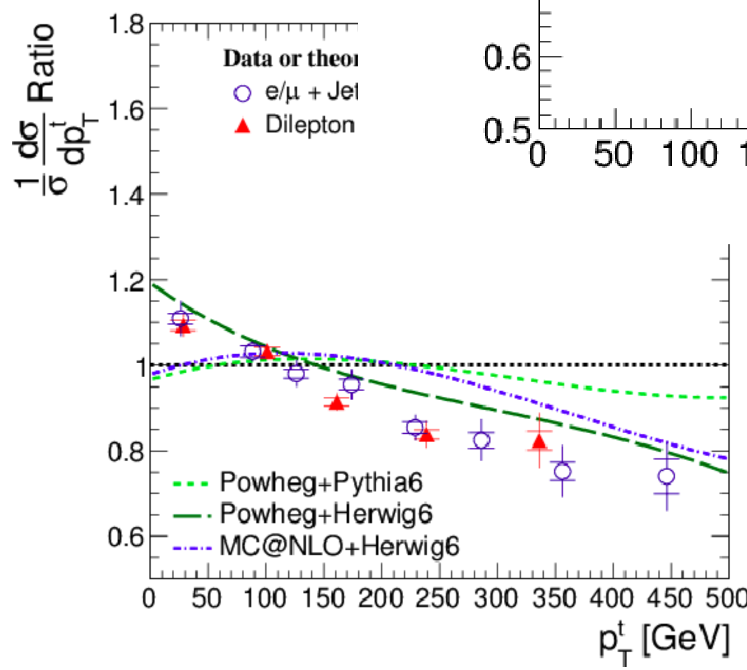


ttbar differential: Summary

- Results consistent among all CMS measurements
  - 7 vs 8 TeV
  - Dilepton vs l+jets
- General good agreement with ATLAS
  - Some differences in top p_T (hot topic in the LHCTOPWG)







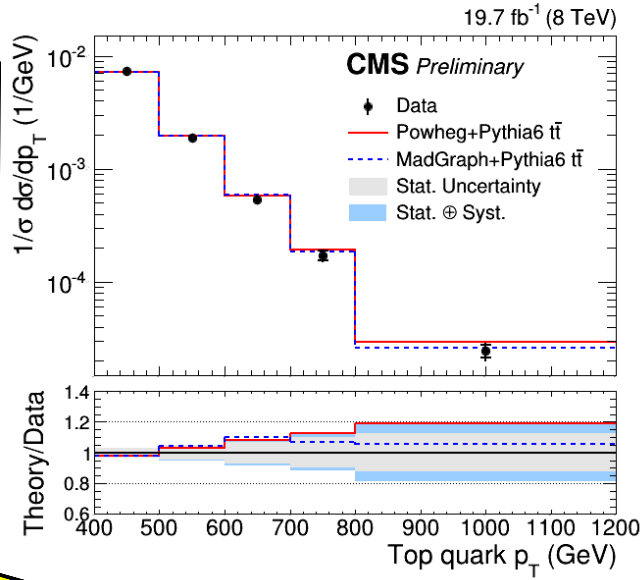
Other top pair production measurements @7/8 TeV

Boosted tops, ttbb, ttV

- Boosted tops, p_T>400 (l+jets)

σ(particle) = 1.28 ± 0.09 (stat + syst) ± 0.10 (PDF) ± 0.09 (Q^2) ± 0.03 (lumi) pb
σ(parton) =1.44 ± 0.10 (stat + syst) ± 0.13 (PDF) ± 0.15 (Q^2) ± 0.04 (lumi) pb
Powheg: 1.49 (particle), 1.67 (parton) pb

TOP-14-012



- Associated production with at least two additional jets:

Measure of ratio (ttbb)/(ttjj) to cancel uncertainties

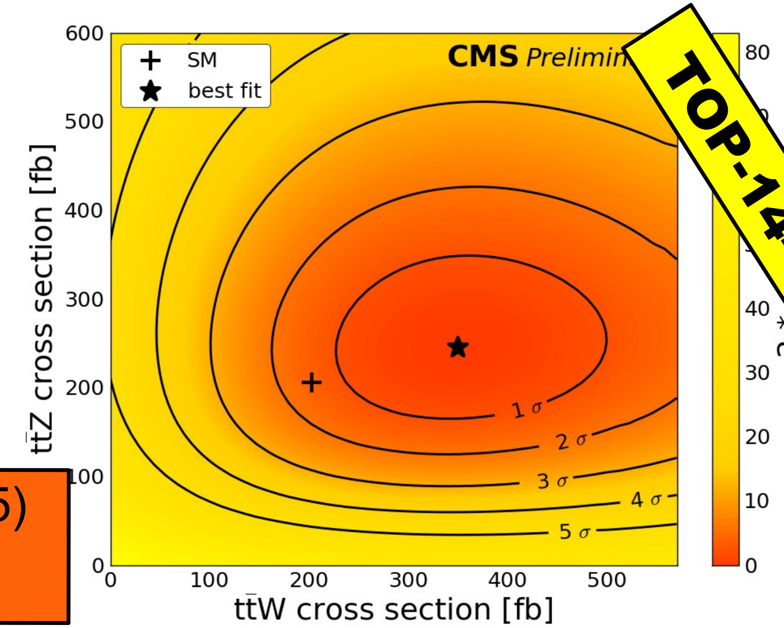
R (parton) = (1.17 ± 0.40(stat) ± 0.03(syst)) %
R (particle) = (1.51 ± 0.49(stat) ± 0.04(syst)) %
Theory: R=1.09%

TOP-13-016

- Associated production with a W or Z boson is relatively unexplored

σ(ttW) = 382 ± +117 (stat) ± -102 (syst) fb
σ(ttZ) = 242 ± +65 (stat) ± -55 (syst) fb

observed (expected) significance of 4.8 (3.5)
observed (expected) significance of 6.4 (5.7)



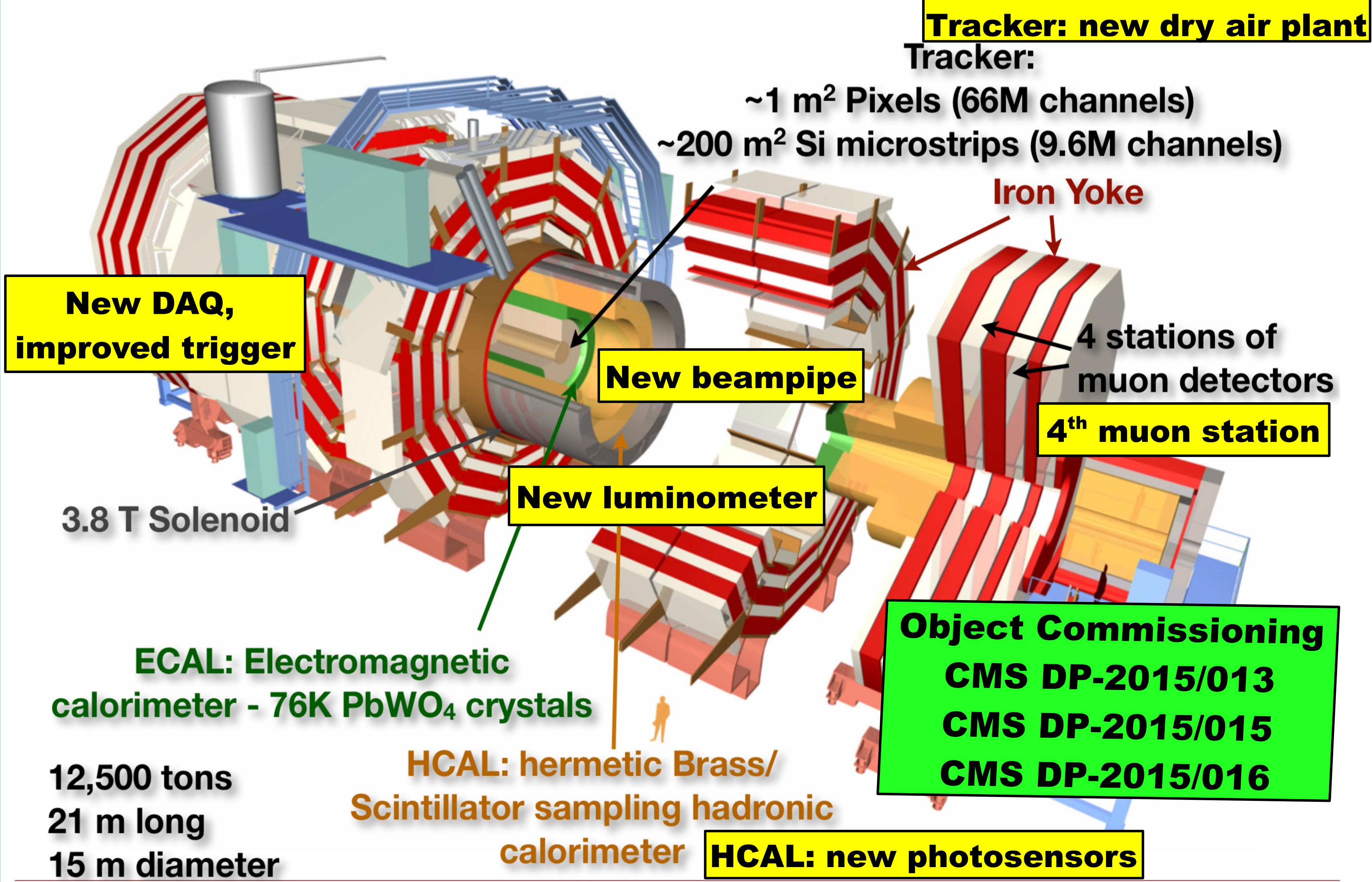
TOP-14-021

Run II

Run II is already here!

And we have more data to look at!!!

Upgrades in CMS

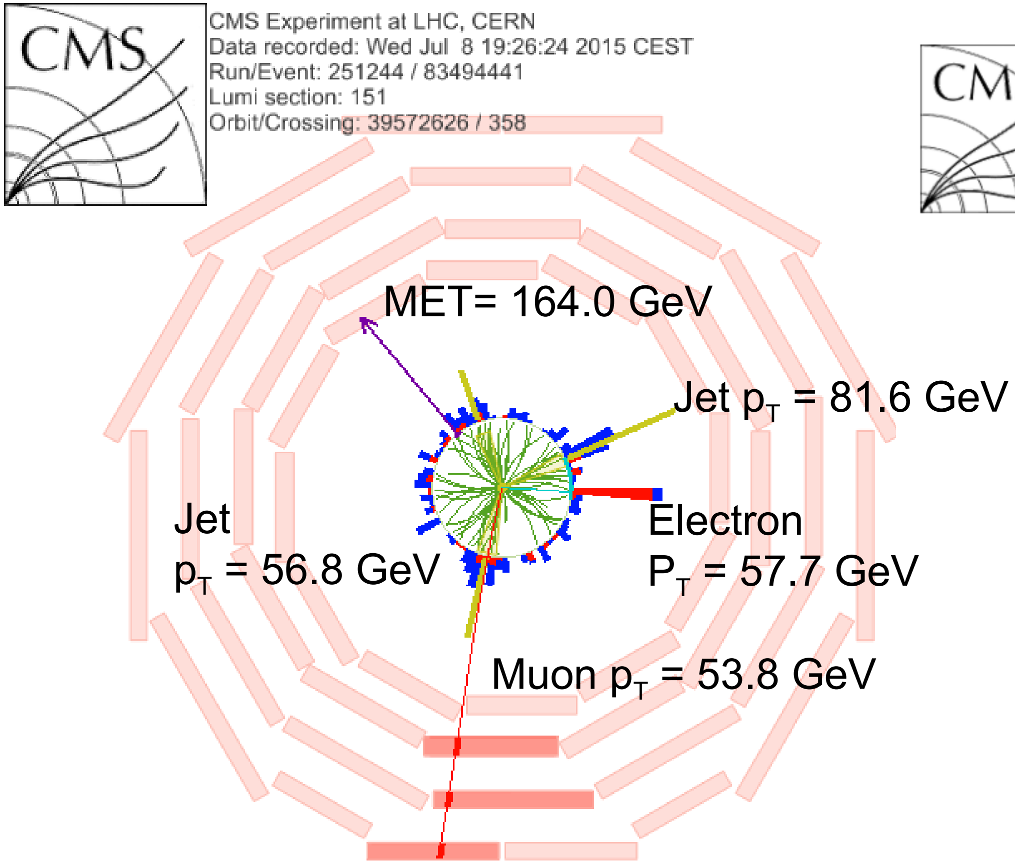


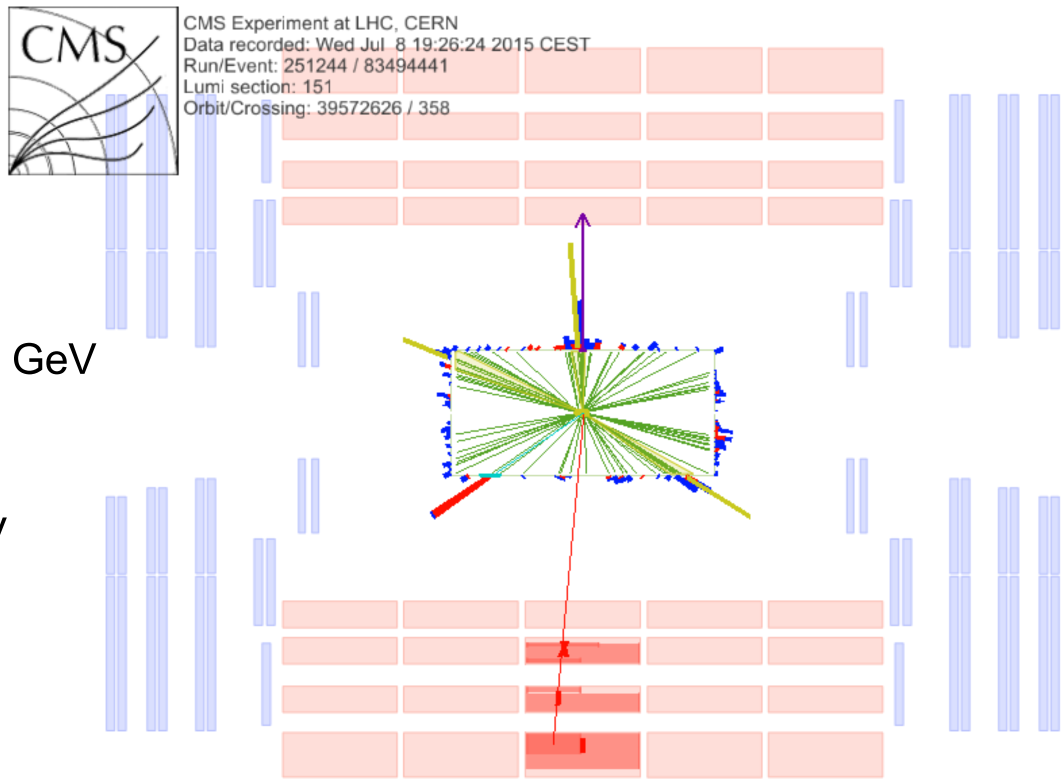
TOP-15-003

NEW!!!

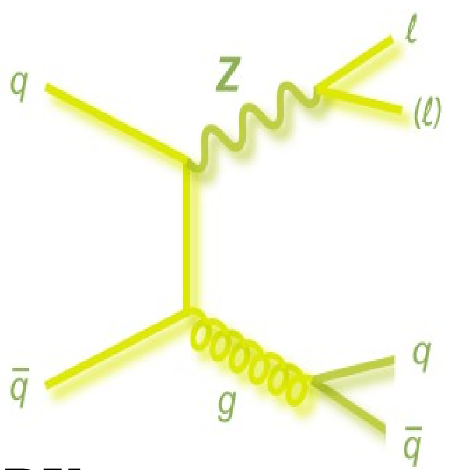
Inclusive top pair production in the dilepton channel @13 TeV

Event Display: Top pair candidate, e-μ+ 2 jets

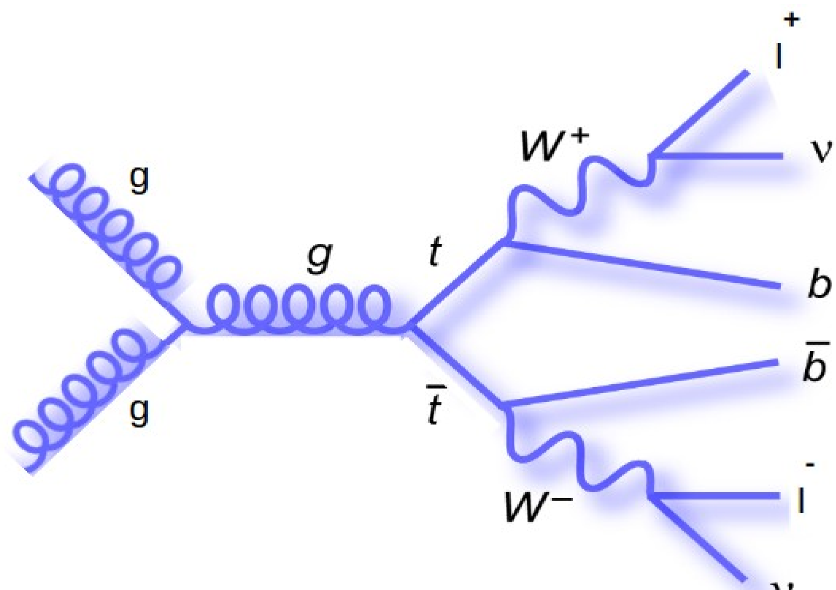




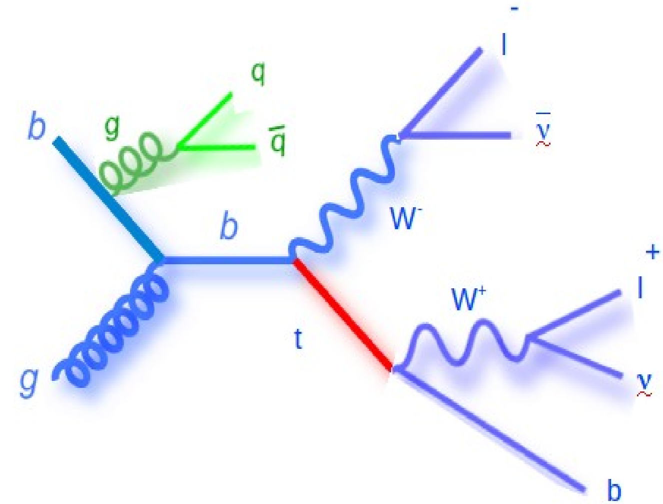
Signal and Background Modeling



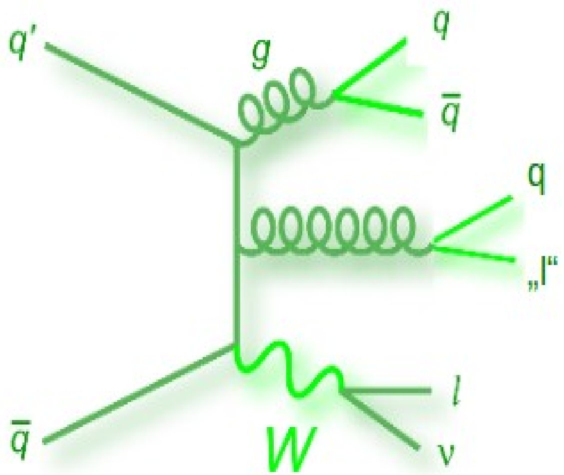
DY: *MG5_aMC@NLO +Pythia8*



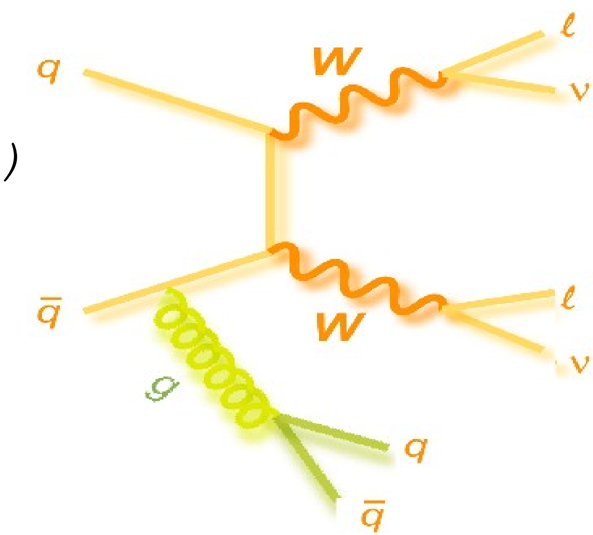
ttbar: *PowhegV2+Pythia8 (NLO)*
For systematics:
- PowhegV2+Herwig++
*- MG5_aMCNLO*Pythia8*



tW: *Powheg+Pythia8*



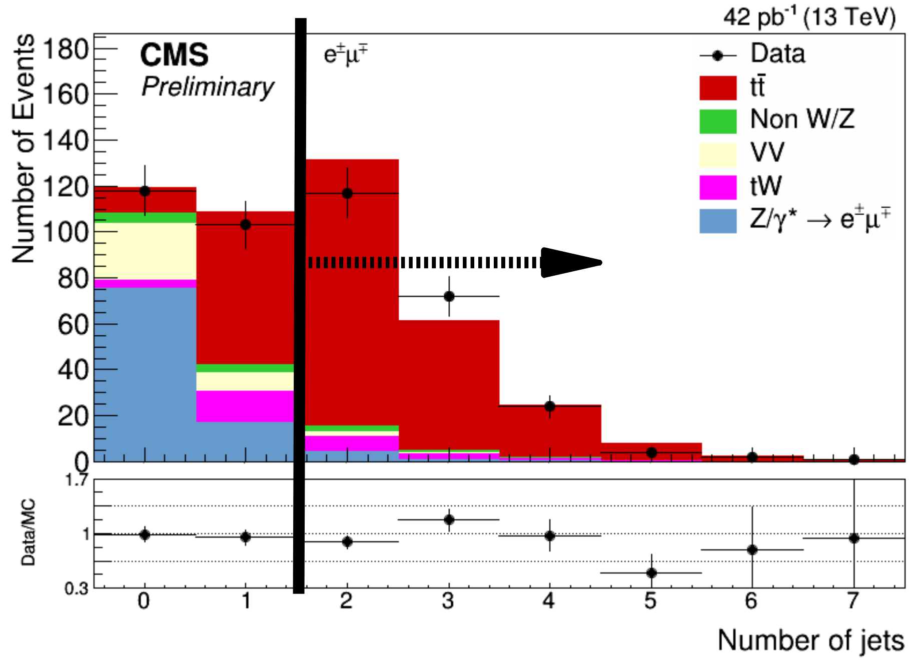
W+Jets: *MG5_aMC@NLO +Pythia8*



VV: Pythia8

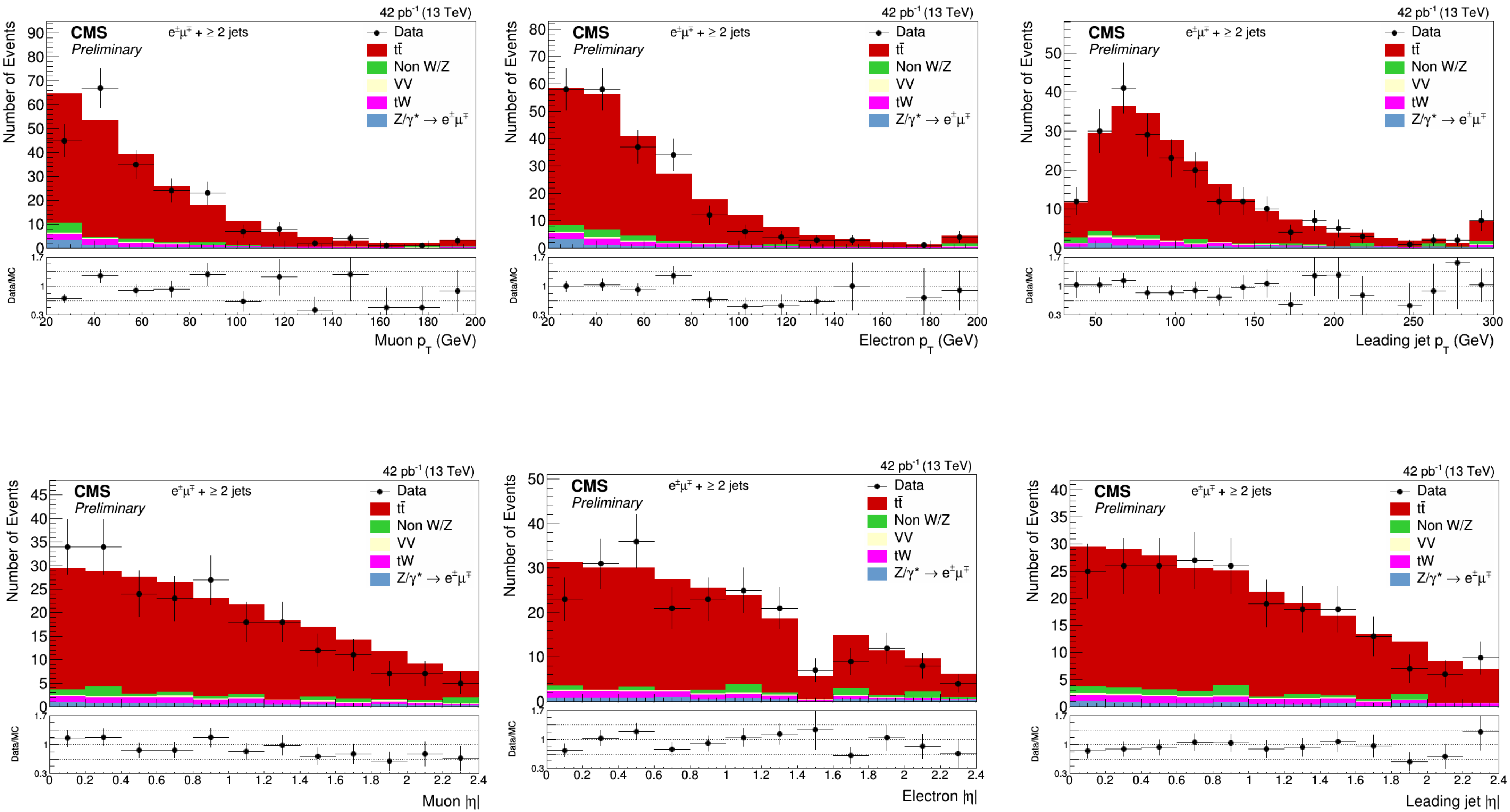
Top Pair Production Cross Section

- Same Cut and Count technique as in Run I (TOP-11-005, TOP-12-007, TOP-13-004) is used for the measurement
- Luminosity: 42 pb^{-1}
- Event selection
  - ≥ 2 (OS) leptons (1 e, 1 μ), p_T> 20 GeV and |η|< 2.4, and invariant mass > 20 GeV
  - ≥ 2 jets with p_T> 30 GeV and |η|< 2.4
- Background estimation
  - Drell Yan normalized to MC prediction by a data/MC SF (from Z peak in data)
  - Non W/Z: fully data driven technique
  - Single top (tW) and diboson are taken from MC



Source	Number of events $e^{\pm}\mu^{\mp}$
Drell–Yan	6.4 ± 1.2
Non-W/Z leptons	8.5 ± 4.3
Single top quark	10.6 ± 3.4
VV (V = W or Z)	2.6 ± 0.9
Total background	28.1 ± 5.7
$t\bar{t}$ dilepton signal	207 ± 16
Data	220

Kinematic Distributions (norm. to NNLO+NNLL)

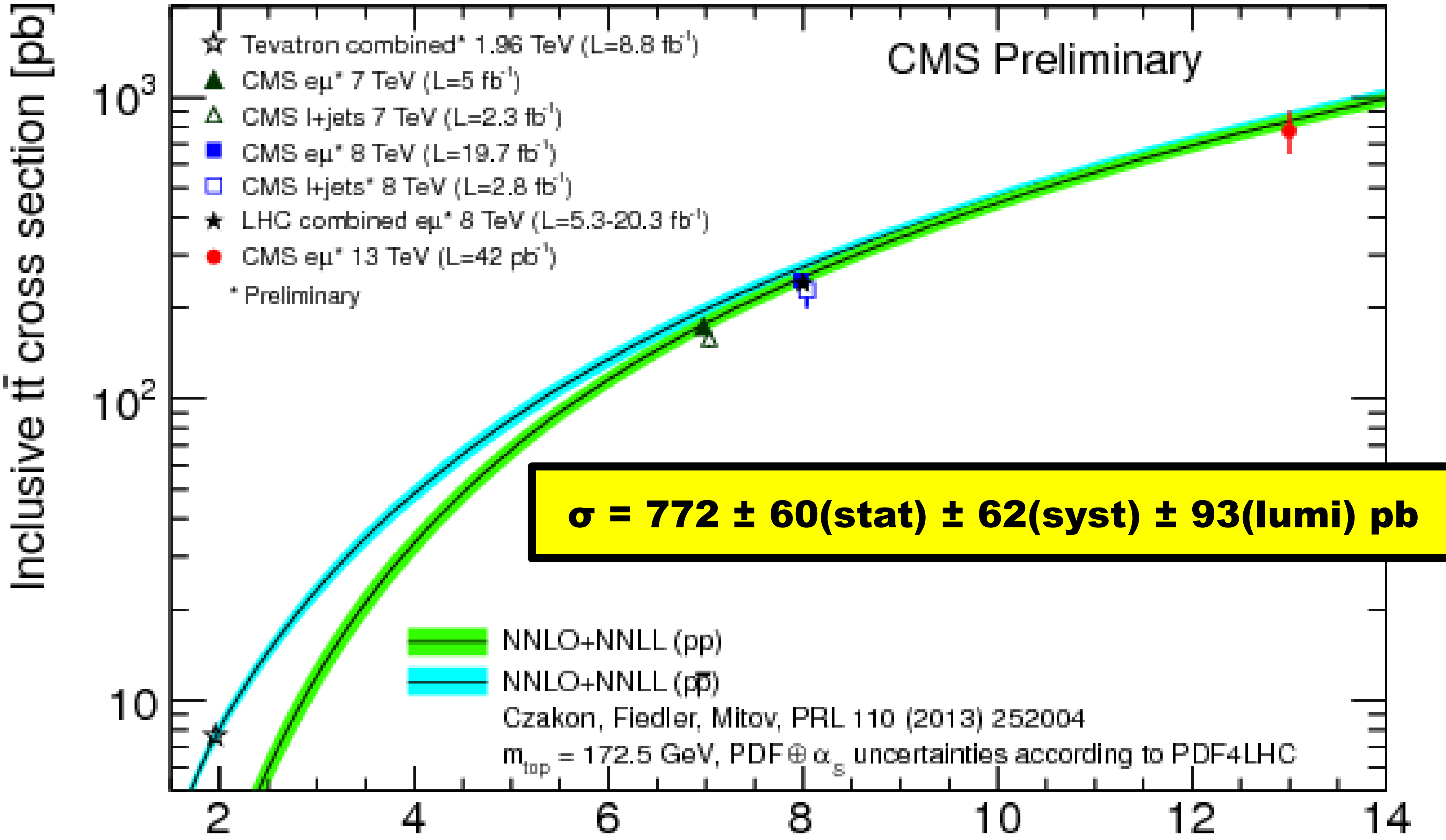


Systematic Uncertainties

- Luminosity dominant uncertainty
  - preliminary calibration obtained from “mini” VdM scans, not optimized for precision measurement
  - **Expected to go down substantially** after a full VdM scan
- Lepton Id/Iso
- Trigger
  - low statistics in the monitoring trigger paths
- Jet energy scale
  - Derived from 4% flat unc.
- All current main effects are expected to go down

Source	$\Delta\sigma_{t\bar{t}}$ (pb)	$\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ (%)
Data statistics	60	7.7
Trigger efficiencies	39	5.0
Lepton efficiencies	33	4.3
Lepton energy scale	< 1	≤ 0.1
Jet energy scale	20	2.6
Jet energy resolution	< 1	≤ 0.1
Pileup	2.8	0.4
Scale (μ_F and μ_R)	1.5	0.2
$t\bar{t}$ NLO generator	15	1.9
$t\bar{t}$ hadronization	14	1.8
PDF	12	1.5
Single top quark	14	1.8
VV (V = W or Z)	3.5	0.5
Drell–Yan	3.9	0.5
Non-W/Z leptons	8	1.0
Total systematic (no integrated luminosity)	62	8.0
Integrated luminosity	93	12
Total	126	16.4

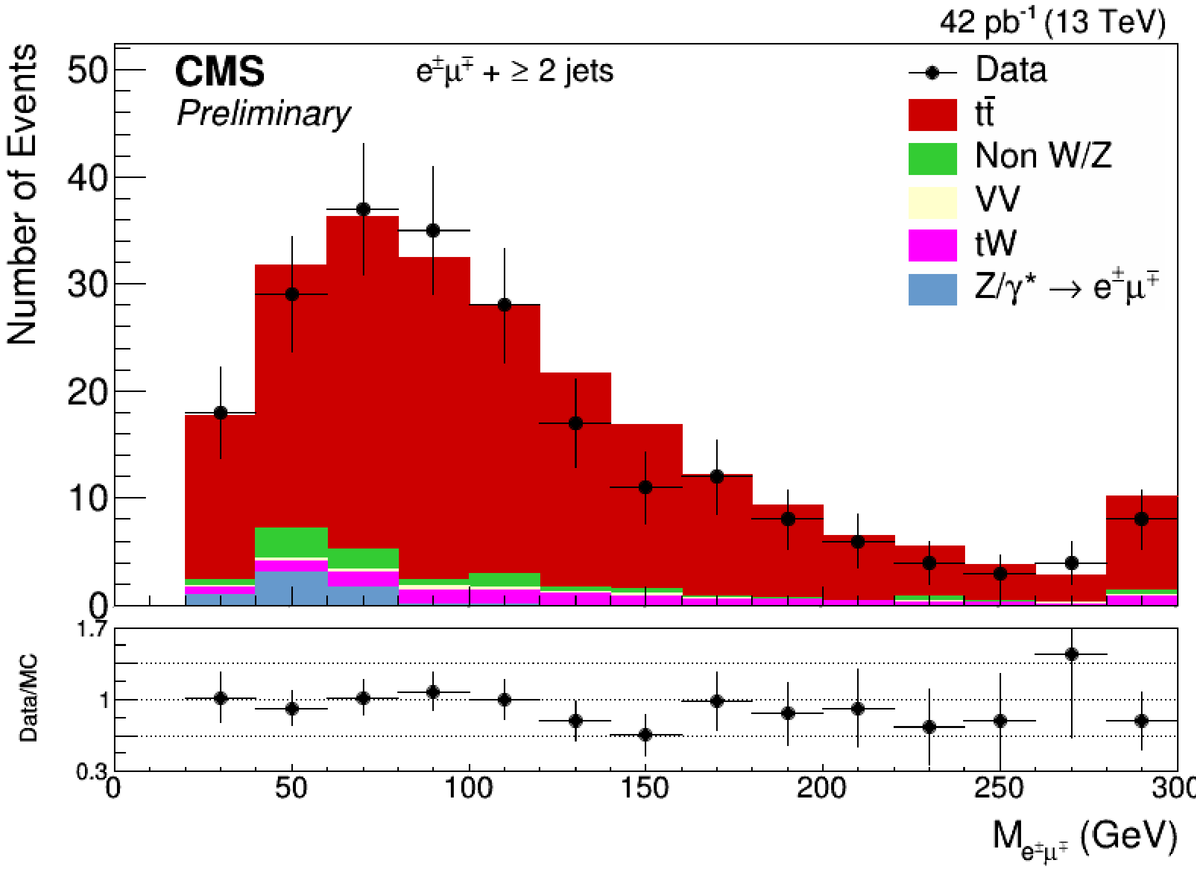
Top pair production cross section: results

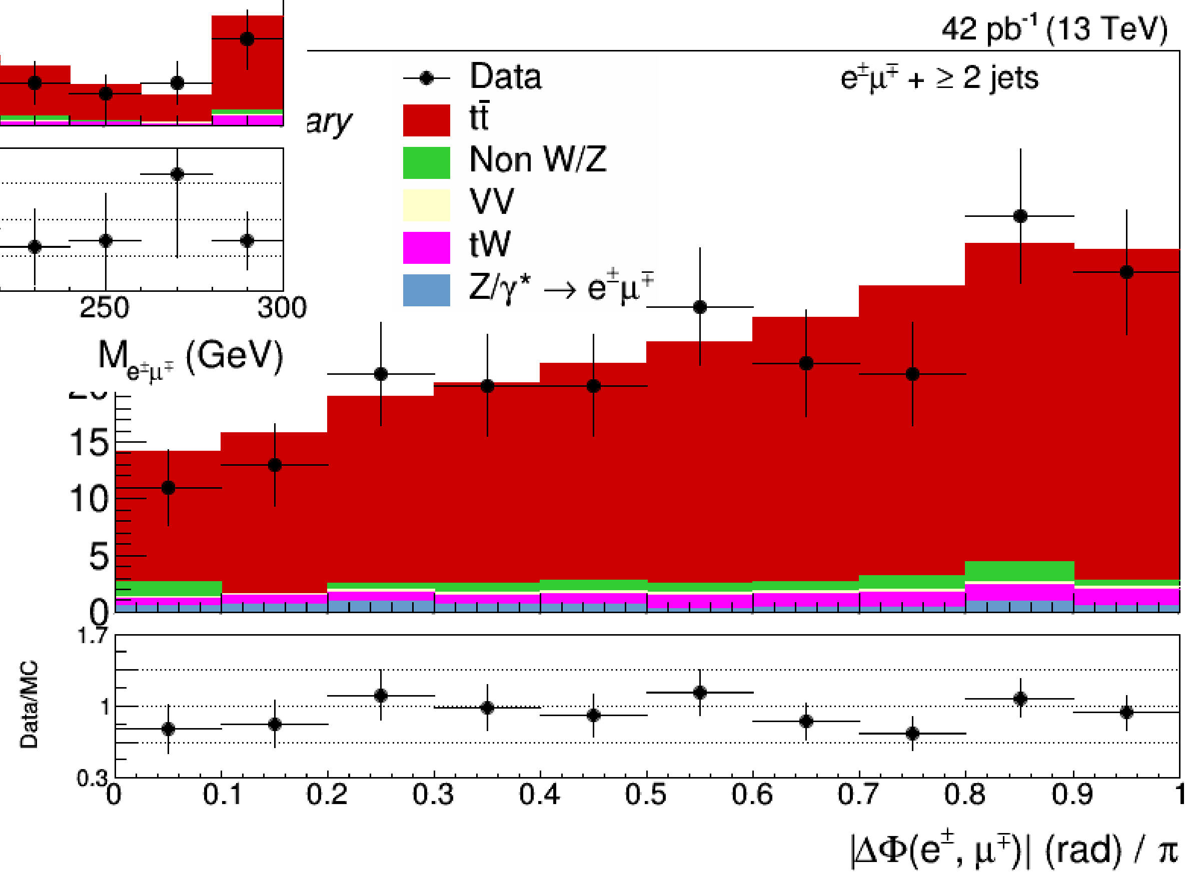


σ = 772 ± 60(stat) ± 62(syst) ± 93(lumi) pb

σ_{vis} = 12.9 ± 1.0(stat) ± 1.1(syst) ± 1.5(lumi) pb

Any sign of New Physics?





- Unfortunately, no (yet)

Comparison with ATLAS and theory

- Good agreement in central values
- Similar global systematic uncertainties
  - But dominant effects are different
  - To be studied and compared in more detail

		σ(pb)		Stat (%)	Syst (%)	Lumi (%)
		NNLO	Meas.			
7 TeV	~~CMS~~	177.3	~~174.5~~	~~1.2~~	~~2.5~~	~~2.2~~
	ATLAS[1]		182.9	1.7	2.3	2.0
8 TeV	~~CMS~~	252.9	~~245.6~~	~~0.5~~	~~2.4~~	~~2.6~~
	ATLAS[1]		242.4	0.7	2.3	3.1
13 TeV	~~CMS~~	831.7	~~772~~	~~7.7~~	~~8.0~~	~~12~~
	ATLAS[2]		825	5.9	7.2	10

[1] Eur.Phys.J. C74 (2014) 3109

[2] ATLAS-CONF-2015-033

Summary

- Top physics program at CMS is very rich
- Right now, we are focusing on
  - Finalizing precise measurements with Run I data
  - Start looking at the 13 TeV data
- Most of the results shown today have been released very recently
- New top pair production cross section measurements
  - **Very precise and competitive** with Run I data
  - **Robust** measurement with Run II, will focus now on precision
  - In both cases, in **agreement with** the **theory** and with **ATLAS** results
- Very precise measurement of the top pole mass
- Exclusion limits on stop production from ttbar cross section
- More results are just around the corner. **Stay tuned!!!**

Thank you

for your

attention!

Back-up

Slides

Magnet Cryogenics

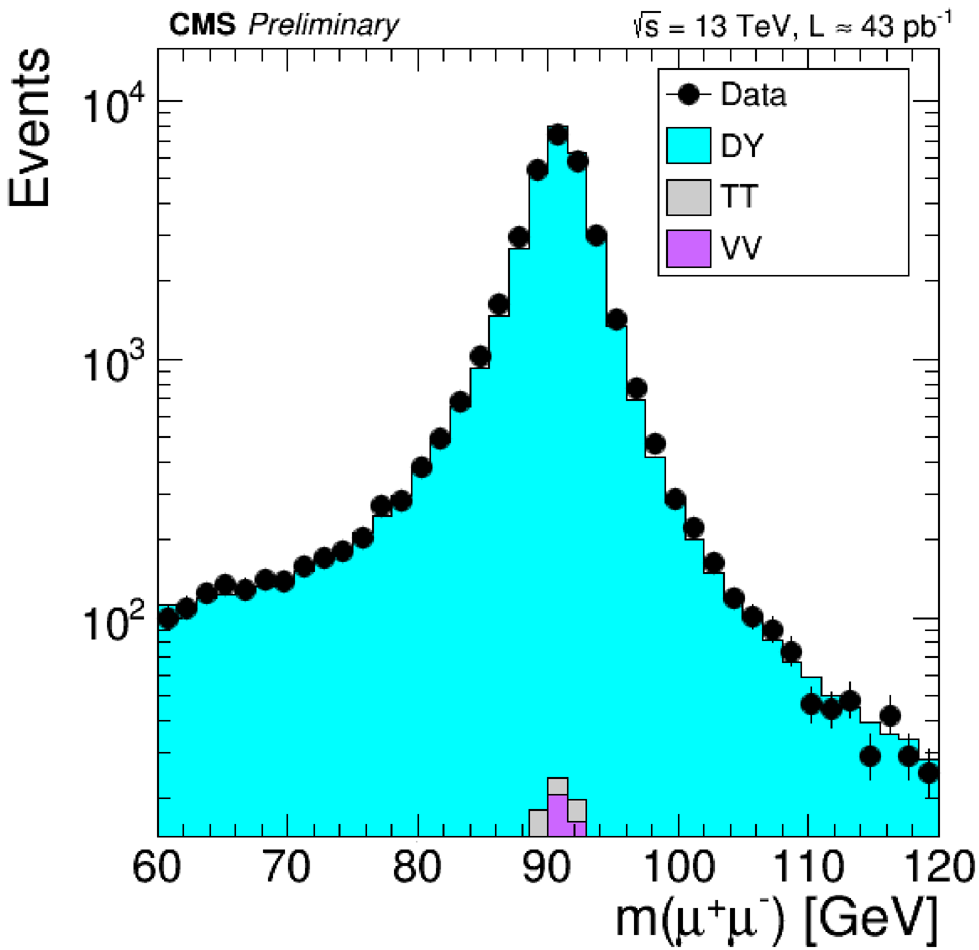
- The restart of the CMS magnet after LS1 was more complicated than anticipated due to problems with the cryogenic system in providing liquid Helium.
- Inefficiencies of the oil separation system of the compressors for the warm Helium required several interventions and delayed the start of routine operation of the cryogenic system
- The data delivered during the first two weeks of LHC recommissioning with beams at low luminosity have been collected with B=0
- Currently the magnet can be operated, but the continuous up-time is still limited by the performance of the cryogenic system requiring more frequent maintenance than usual.
- A comprehensive program to re-establish its nominal performance is underway. These recovery activities for the cryogenic system will be synchronized with the accelerator schedule in order to run for adequately long periods
- A consolidation and repair program is being organized for the next short technical stops and the long TS at the end of the year.

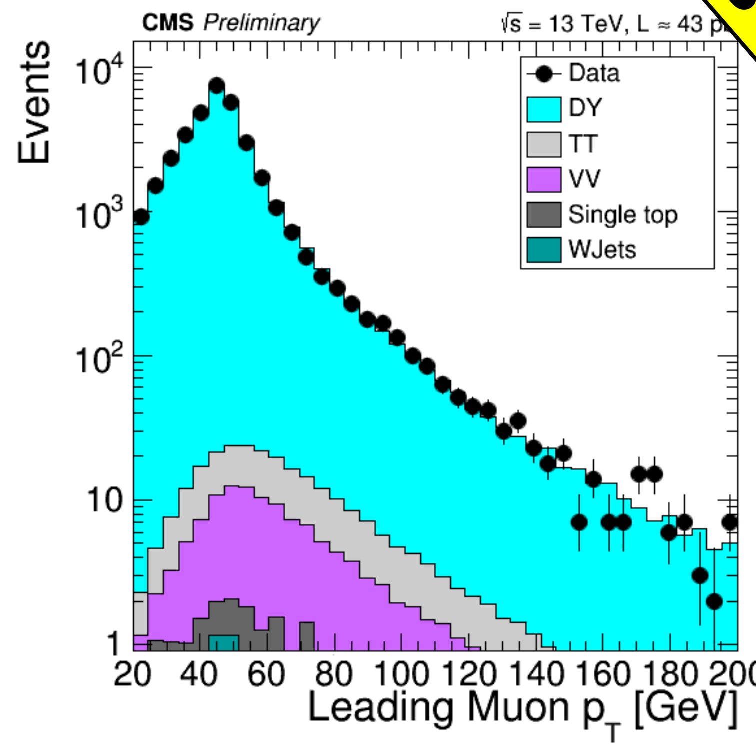
Modeling Systematic 7/8 TeV

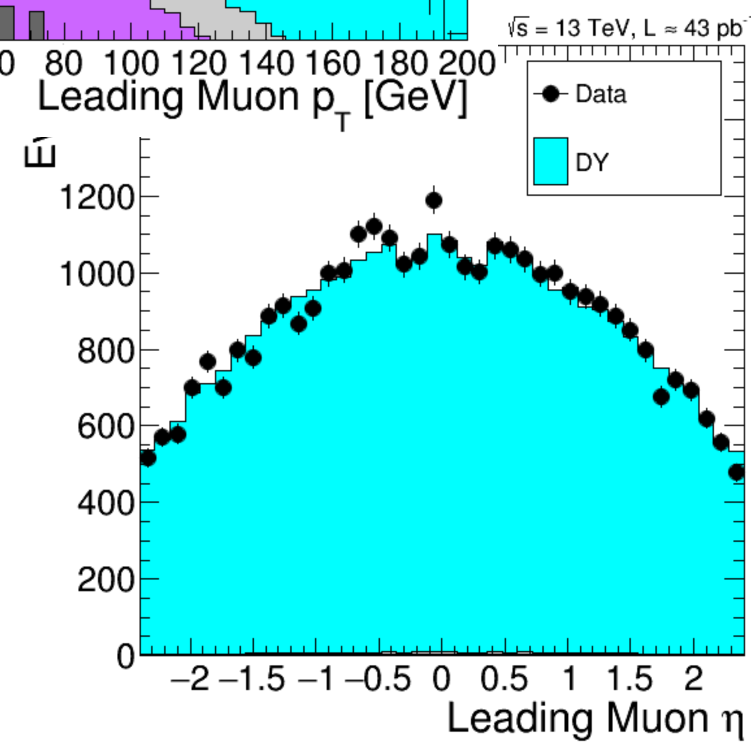
- Modeling of the hard-production process ("Q2 scale") is assessed through changes in the renormalization and factorization scales in the MADGRAPH sample by factors of two and 0.5 relative to their common nominal value
- Choice of the scale that separates the description of jet production through matrix elements or parton shower ("ME/PS matching") in MADGRAPH is studied by changing its reference value of 20 GeV to 40 GeV and to 10 GeV
- The differences in results between using POWHEG for the tt simulation instead of MADGRAPH is taken as an additional modeling uncertainty ("MG+PY --> PH+PY")
- Hadronization comes from differences in the energy response for different jet flavors. It is estimated by the differences between using simulations with the Lund fragmentation model (PYTHIA) and the cluster fragmentation (HERWIG++)
- Color reconnection effects are estimated by comparing simulations of an underlying event tune (Perugia2011) including color reconnection to a tune without it
- Underlying event is evaluated by comparing two different P11 PYTHIA tunes, namely mpHi and TeV, to the standard P11 tune.

CMS DP-2015/015

- Dimuon trigger (17-8) events vs DY MC
  - ≥ 2 OS muons, loose Id and Isolation
  - p_T > 20 and 10 GeV, $|\eta|$ < 2.4
  - 60 < M(μμ) 120 GeV







Commisioning: electrons

- Variables part of the electron Id validated
- Uncalibrated electron energy scale (from run1) already quite good