Standard Model Physics with ATLAS

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Teresa Barillari on behalf of the ATLAS MPP Group

ATLAS MPP group:
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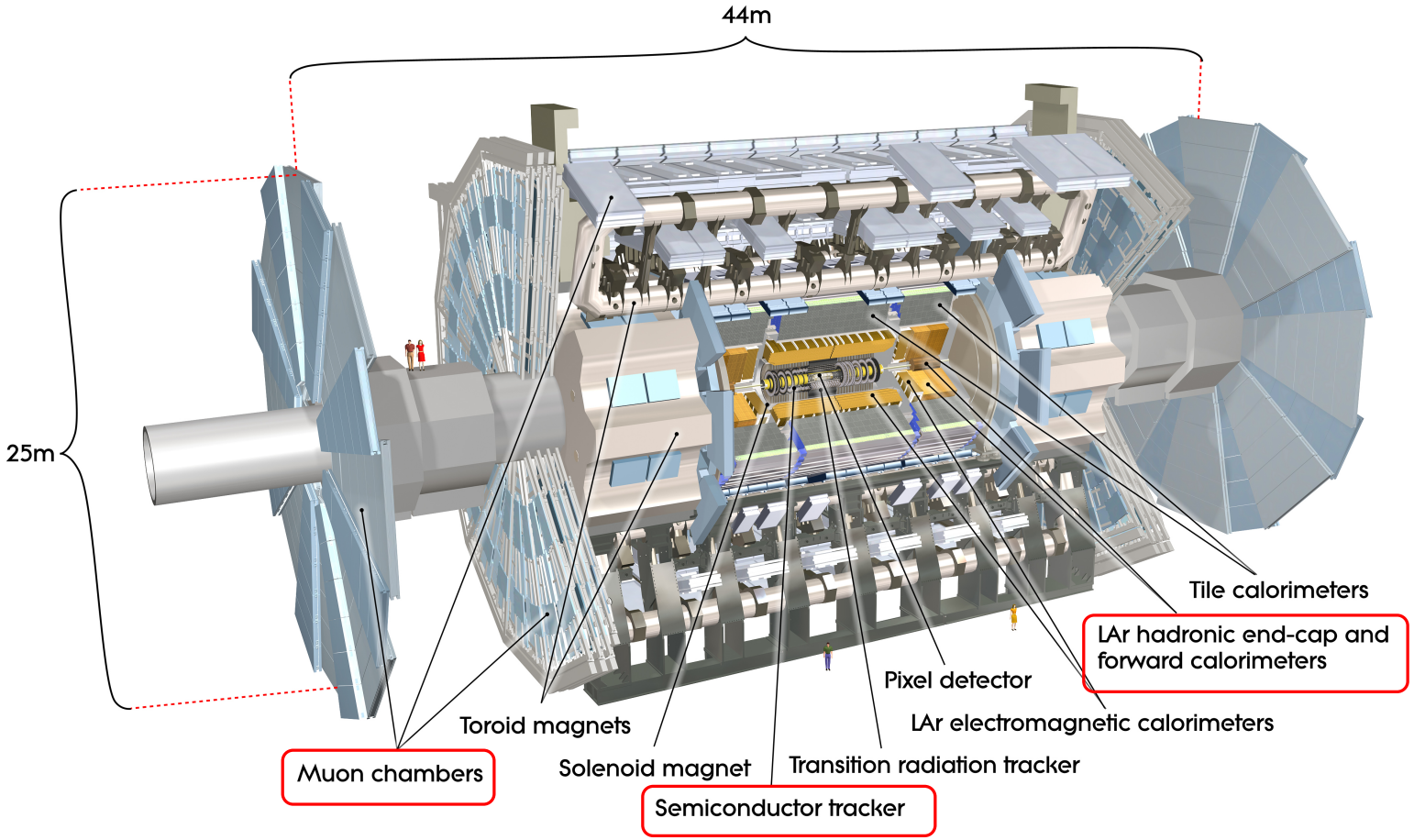
Introduction

- I will summarize the work done by the ATLAS MPP group in the following Standard Model (SM) analyses
  - Top-quark mass measurements in the lepton+jets, dileptons, and alljets channels
  - Precision top quark mass measurements and new NLO calculation
  - Boosted WW cross section measurements
  - Drell-Yan spectrum measurements in the ee and $\mu\mu$ channels
- The analyses have been done using the following ATLAS data:
  - Data taken in 2011 at the center-of-mass energy $\sqrt{s} = 7$ TeV and integrated luminosity of $\sim 4.7\,\text{fb}^{-1}$
  - Data taken in 2012 at $\sqrt{s} = 8$ TeV and integrated luminosity of $\sim 20\,\text{fb}^{-1}$
- MPP has lead the analyses yielding the latest and most precise measurements of the top quark mass measurements in ATLAS
- The ongoing ATLAS MPP Higgs physics and SUSY Searches analyses are presented in M. Goblirsch-Kolb's talk

ATLAS Detector at LHC

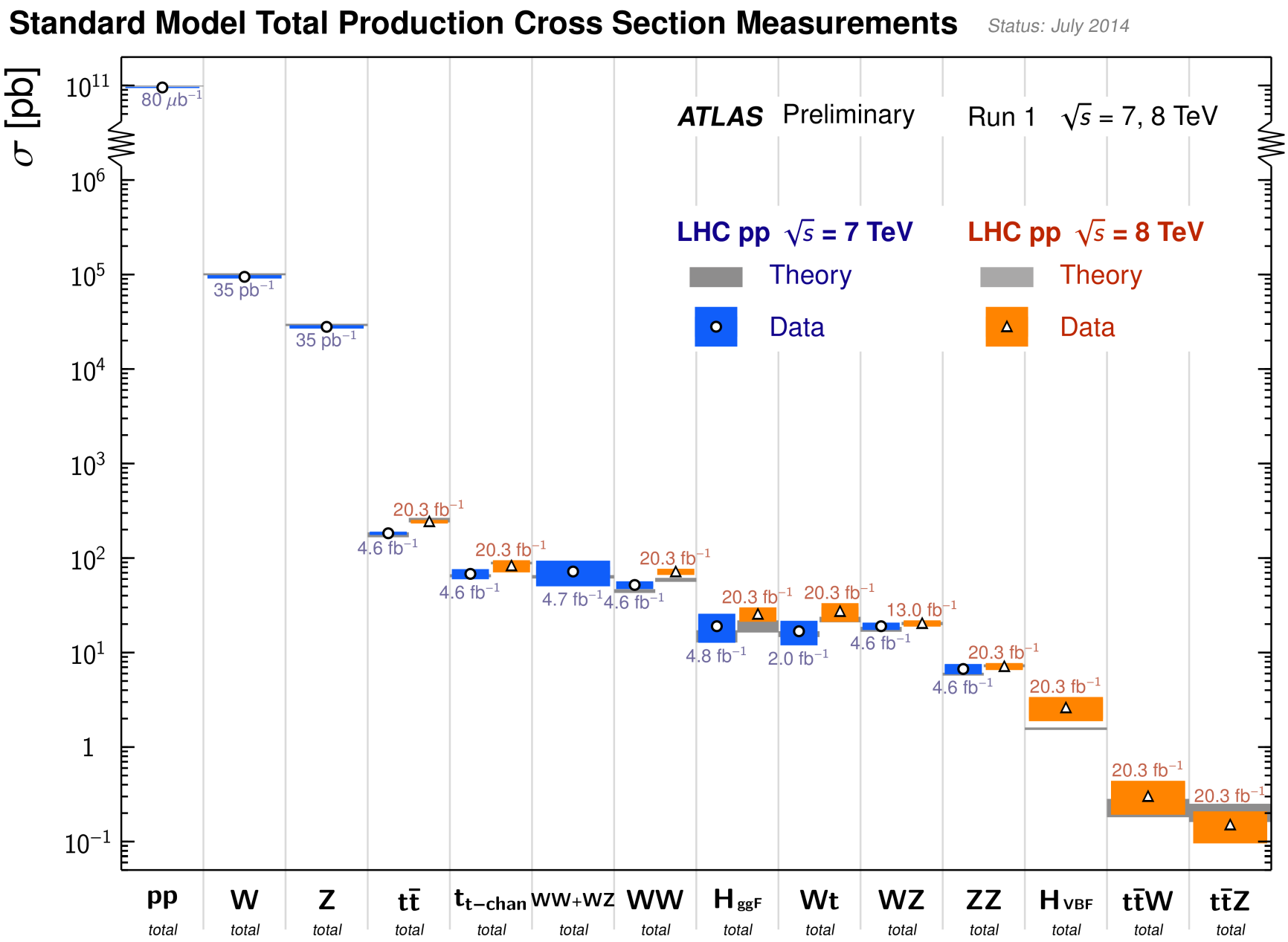
- **A T**oroidal **L**HC **A**pparatu**S** (**ATLAS**), at the **L**arge **H**adron **C**ollider (**LHC**): layout and detectors



- Overall weight 7000 Tons
- 40 Countries + CERN
- 185 Institutions
- ∼ 3000 Scientific authors total

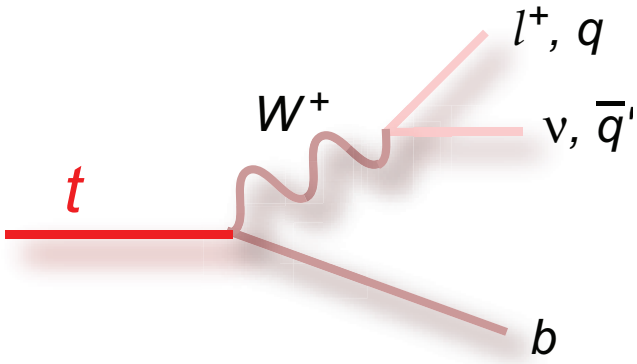
- ATLAS MPP group has leading contribution in: Semiconductor Tracker, Hadronic Endcap, Monitored Drift Tubes and Computing
- See T. Ince's talk on ATLAS MPP upgrade work

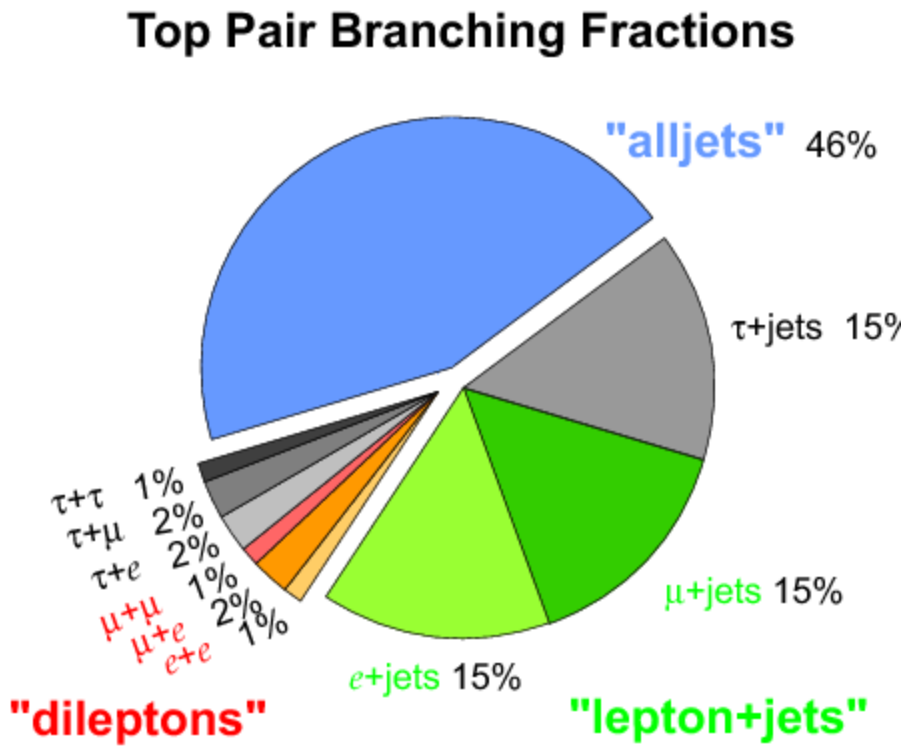
Large number of SM processes studied in ATLAS



Top quark production

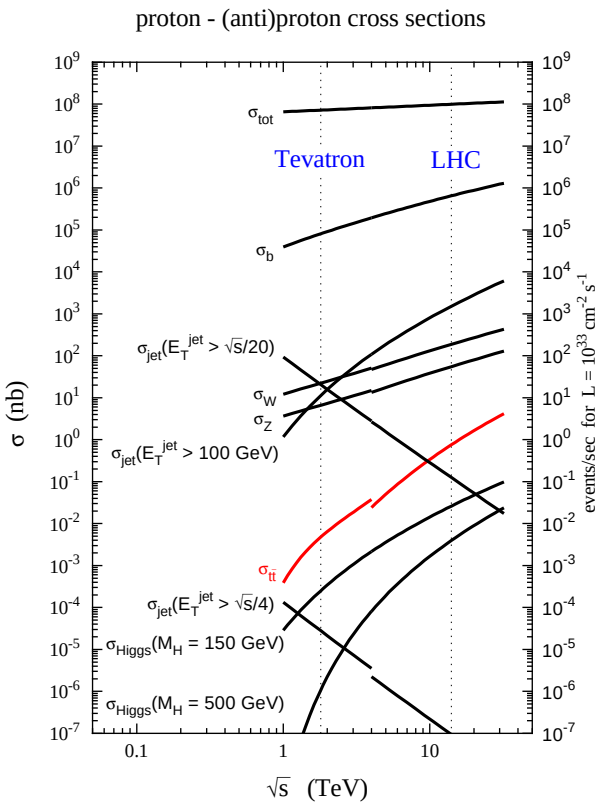
- The top quark is the heaviest known elementary particle whose mass is about 173 GeV
- The top-quark decays before hadronization (lifetime $\tau = \sim 5\text{x}10^{-25}$ s)
- Main top decay: $t \rightarrow Wb$ ($> 99.8\%$)
- The final states for the leading $t\bar{t}$-production process can be divided in three classes:
  - Alljets (46.2%):
    $t\bar{t} \rightarrow W^+bW^-\bar{b} \rightarrow q\bar{q}'bq''\bar{q}'''\bar{b}$
  - Lepton+jets (43.5%):
    $t\bar{t} \rightarrow W^+bW^-\bar{b} \rightarrow q\bar{q}'bl\bar{\nu}_l\bar{b} + \bar{l}\nu_l bq\bar{q}'\bar{b}$
  - Dilepton (10.3%):
    $t\bar{t} \rightarrow W^+bW^-\bar{b} \rightarrow \bar{l}\nu_l bl'\bar{\nu}_{l'}\bar{b}$

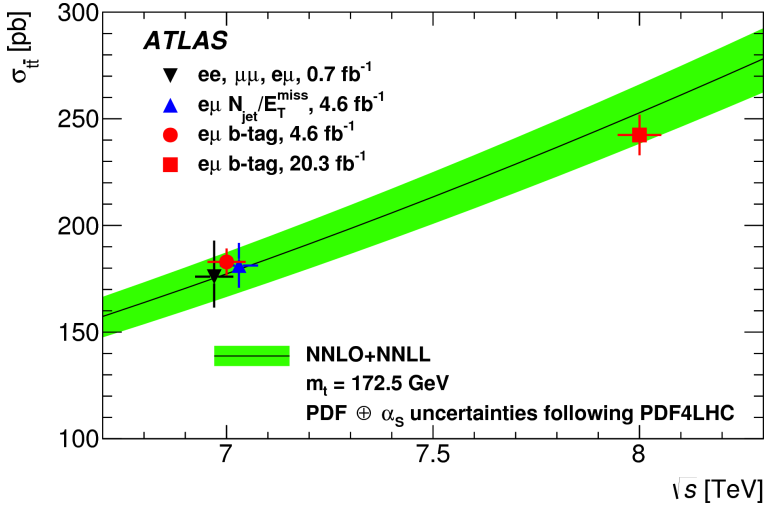




$t\bar{t}$ *production: total cross section*

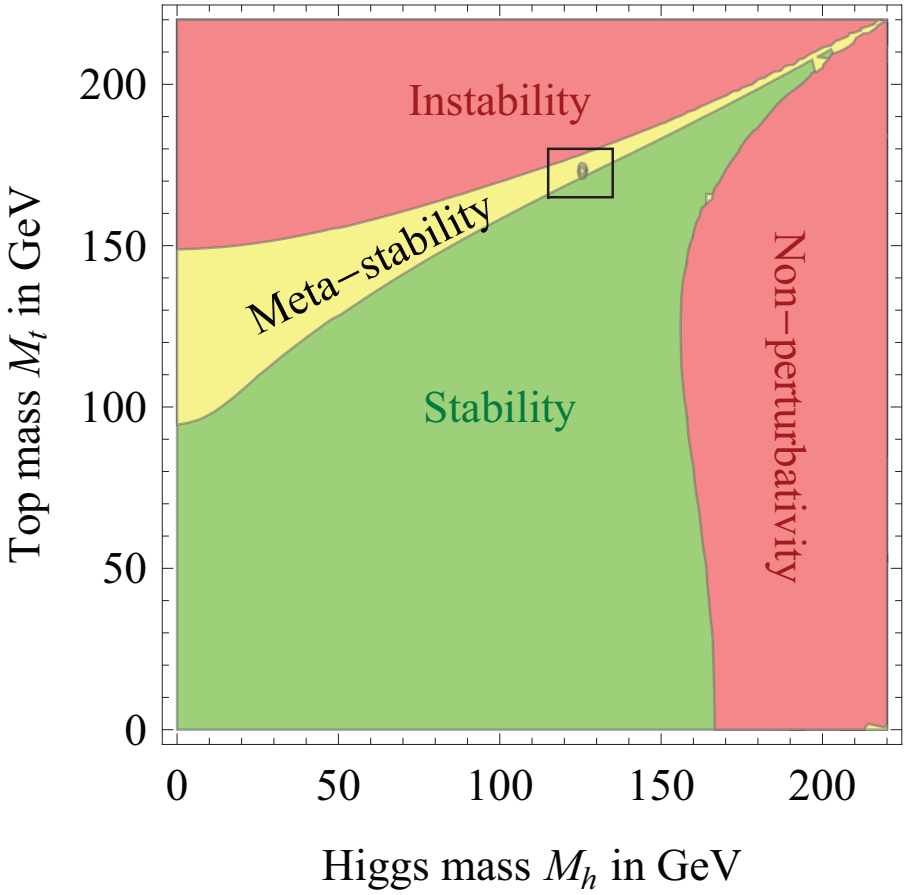
- LHC is a top quark factory
- Total cross section for $t\bar{t}$-production is about a factor of 100 larger at LHC than at Tevatron
- $\sigma_{t\bar{t}}(14.0\,\text{TeV}) = 800\,\text{pb}$
  - $2\,t\bar{t}$ events per second
- Perfect place for e.g. top quark mass (m_{top}) precision measurements
- m_{top} is an important SM parameter
- Precise measurements of m_{top} will allow precision tests of the SM predictions and they can also give an insight into new physics beyond the Standard Model (BSM)

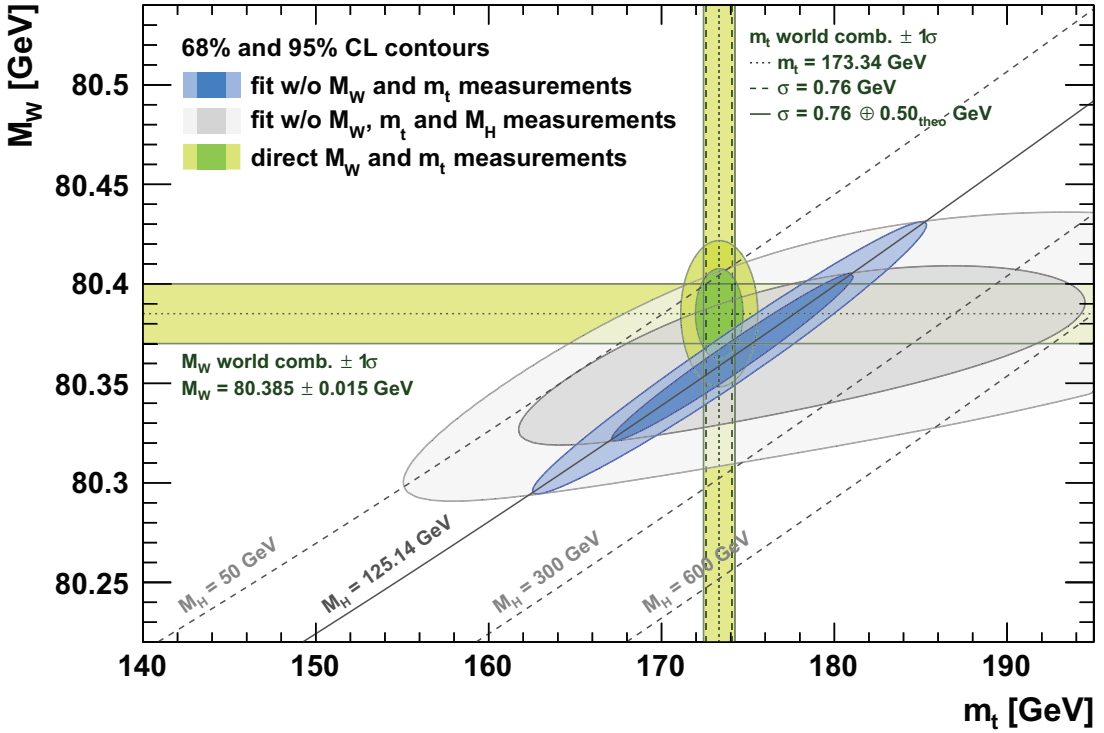




Precision measurements motivations

- Precise determinations of the SM parameters (m_{top}, m_W, m_H, ...) allow to challenge consistency tests of the SM and to look for signs of new physics BSM. Look e.g. vacuum stability (left plot)





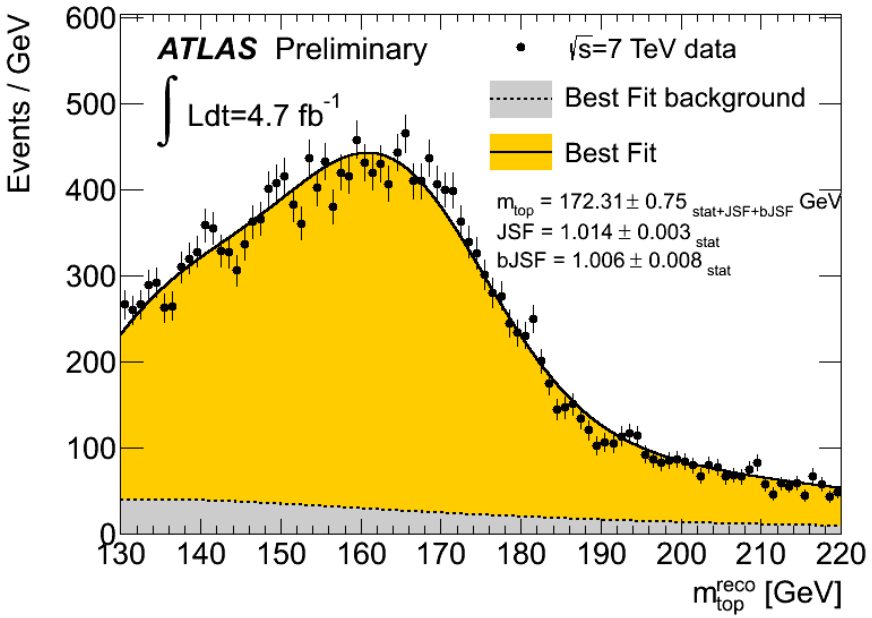
arXiv:1205.6497v2 arXiv:1407.3792v1

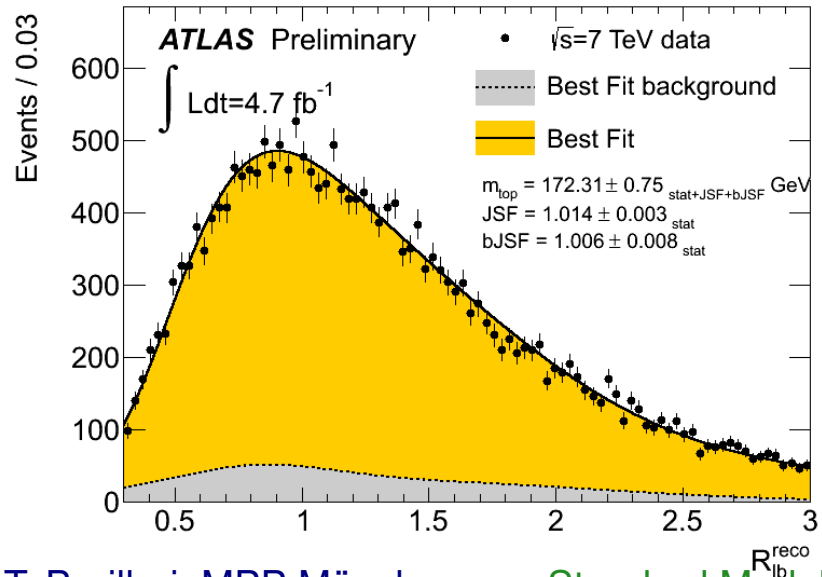
m_{top} in lepton+jets channel

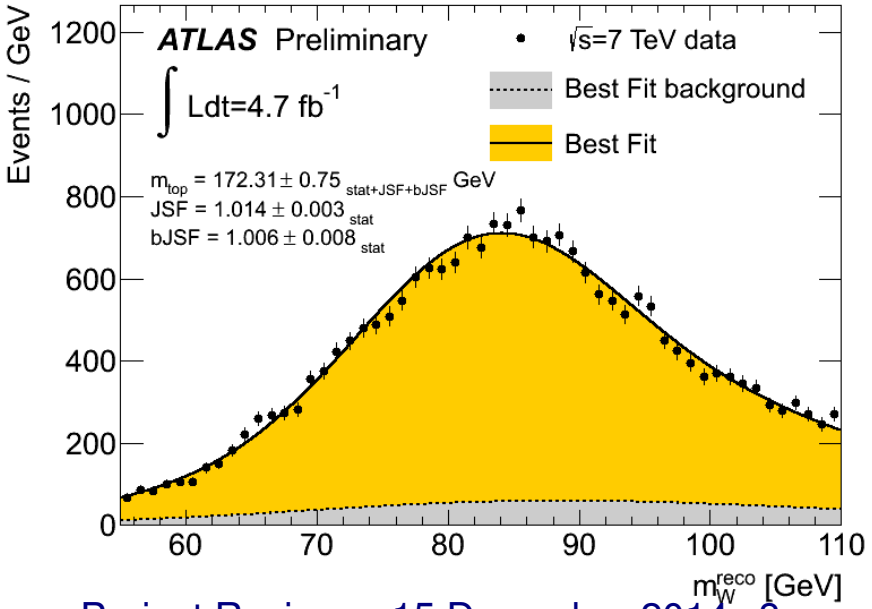
G. Compostella, G. Cortiana, A. Maier, R. Nisius

ATLAS-CONF-2013-046

- m_{top} measured via three-dimensional template method, together with global jet energy scale factors (JSF and bJSF) to reduce the impact on the jet energy uncertainties
- $m_{top} = 172.31 \pm 1.55$GeV
  - $m_{top} = 172.31 \pm 0.75$ (stat + JSF + bJSF) ± 1.35 (sys) GeV
  - JSF $= 1.014 \pm 0.003$ (stat) ± 0.021 (sys)
  - bJSF $= 1.006 \pm 0.008$ (stat) ± 0.020 (sys)



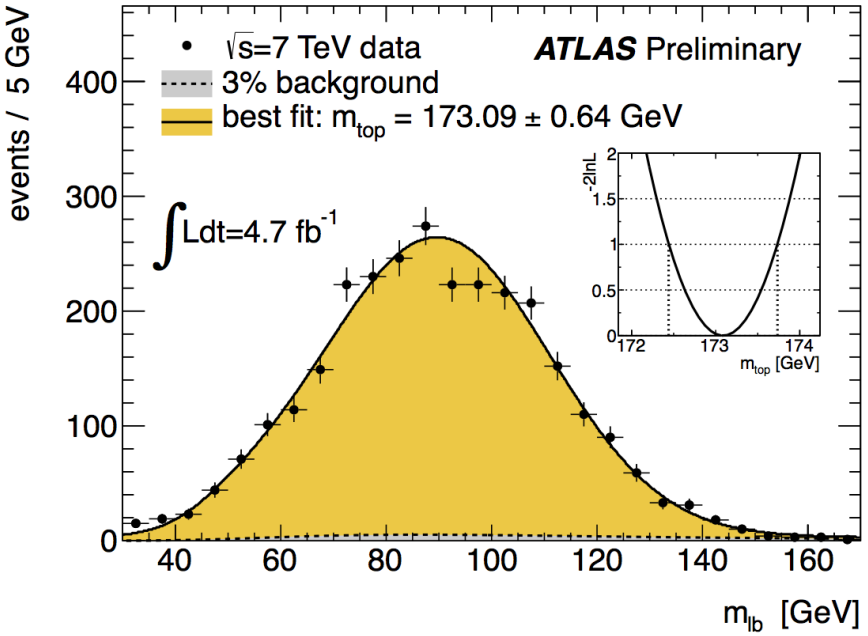


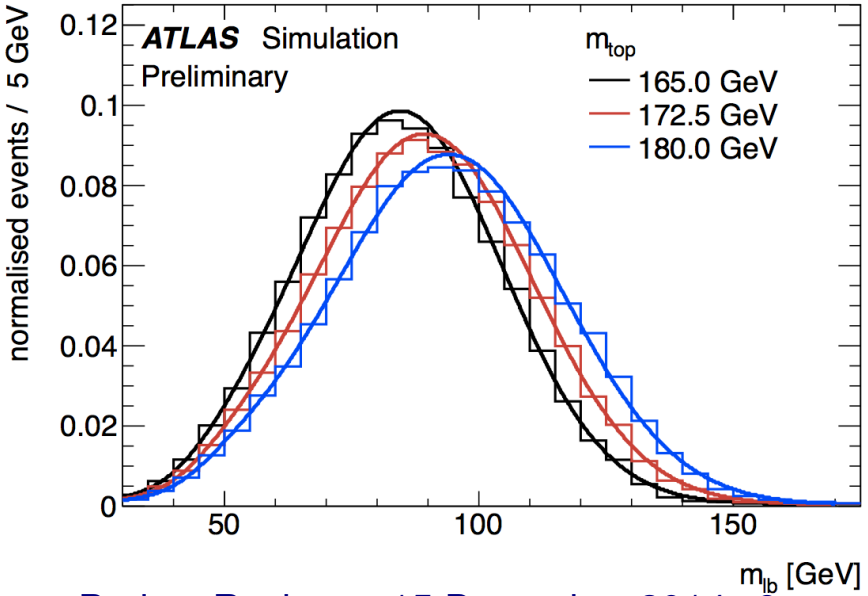


m_{top} in dileptons channel

G. Compostella, G. Cortiana, A. Maier, R. Nisius

- In the dileptons channel m_{top} is measured via one-dimensional template method, based on lepton and b-quark jet information (m_{lb})
- Select events with 2 charged leptons (e, μ), E_T^{miss} and 2 b quark tagged jets
- Almost background free sample (background $< 3\,\%$)
- $m_{top} = 173.09 \pm 1.63$GeV
  - $m_{top} = 173.09 \pm 0.64$ (stat) ± 1.50(sys) GeV
- See ATLAS-CONF-2013-077





First m_{top} world combination

G. Cortiana, R. Nisius

- For the first time, m_{top} results from the Tevatron and the LHC colliders have been combined
- 5 input measurements from LHC (CMS + ATLAS 7 TeV analyses)
- 6 input mesurements from Tevatron (D0 + CDF RunII analyses)

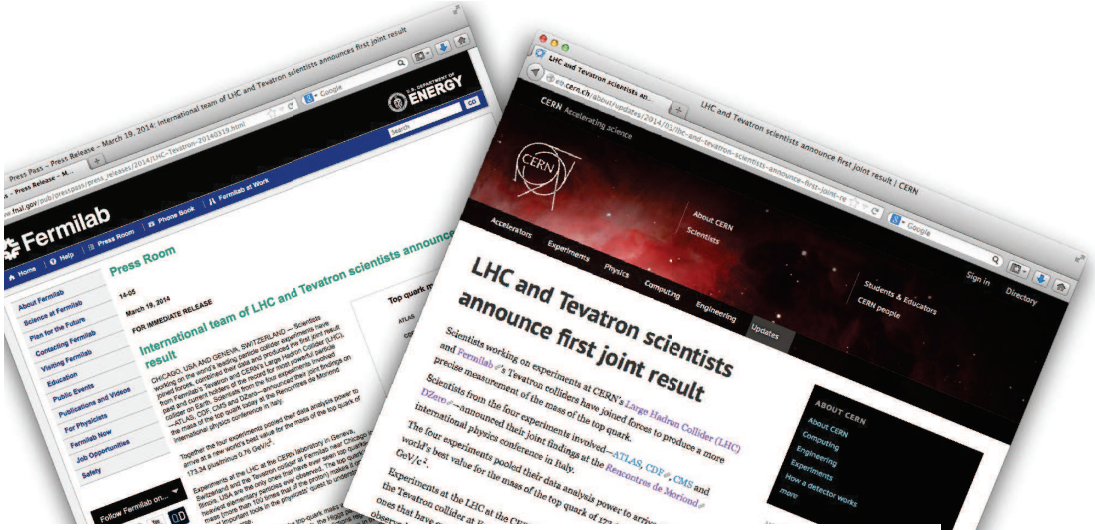
Experiment	$t\bar{t}$ final state	$\mathcal{L}$ fb^{-1}	m_{top} (stat) + (sys) GeV	Tot. uncertantiey on m_{top} (GeV)
CDF	l+jets	8.7	$172.85 \pm 0.52 \pm 0.99$	1.12 (0.65)
	dileptons	5.6	$170.28 \pm 1.95 \pm 3.13$	3.69 (2.17)
	all jets	5.8	$173.93 \pm 1.26 \pm 1.36$	1.85 (1.07)
	E_T^{miss}+ jets	8.7	$172.47 \pm 1.43 \pm 1.41$	2.10 (1.16)
D0	l+jets	3.6	$174.94 \pm 0.83 \pm 1.25$	1.50 (0.86)
	dileptons	5.3	$174.00 \pm 2.36 \pm 1.49$	2.79 (1.60)
ATLAS	l+jets	4.7	$172.31 \pm 0.23 \pm 1.53$	1.55 (0.90)
	dileptons	4.7	$173.09 \pm 0.64 \pm 1.50$	1.63 (0.94)
CMS	l+jets	4.9	$173.49 \pm 0.27 \pm 1.03$	1.06 (0.61)
	dilepton	4.9	$172.50 \pm 0.43 \pm 1.46$	1.52 (0.88)
	all jets	3.5	$173.49 \pm 0.69 \pm 1.23$	1.41 (0.81)

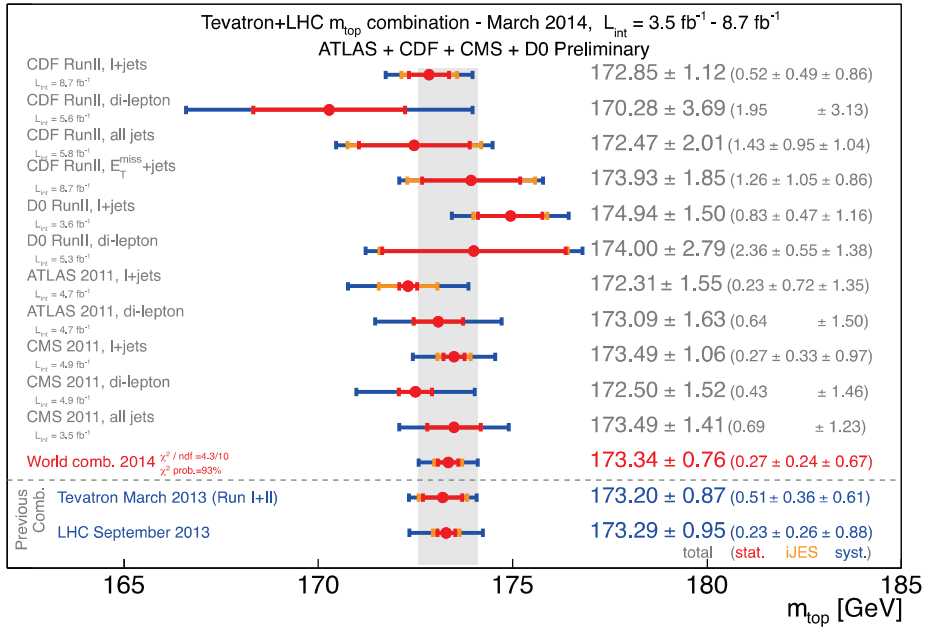
arXiv:1403.4427

First m_{top} world combination results

G. Cortiana, R. Nisius

- Combination results accompanied by two simultaneous press releases from Fermilab and CERN
- Combined results:
  $m_{top} = 173.34 \pm 0.76\text{GeV}$
  - $\sim 13\,\%$ ($\sim 20\,\%$) more precise than the previous Tevatron (LHC) combination





m_{top} in all jets channel

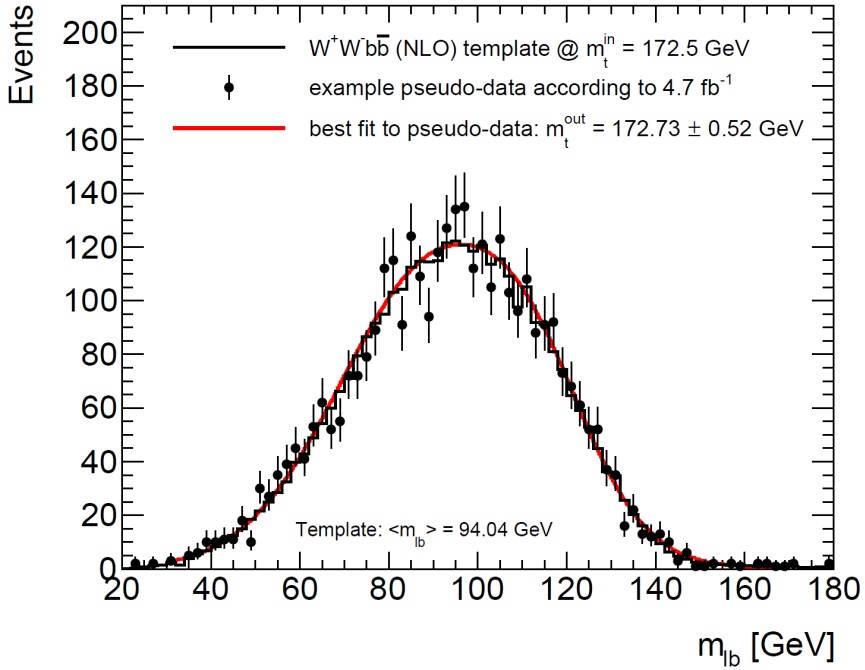
T. Barillari, T. McCarthy, S. Menke, D. Salihagic, A. Wildauer

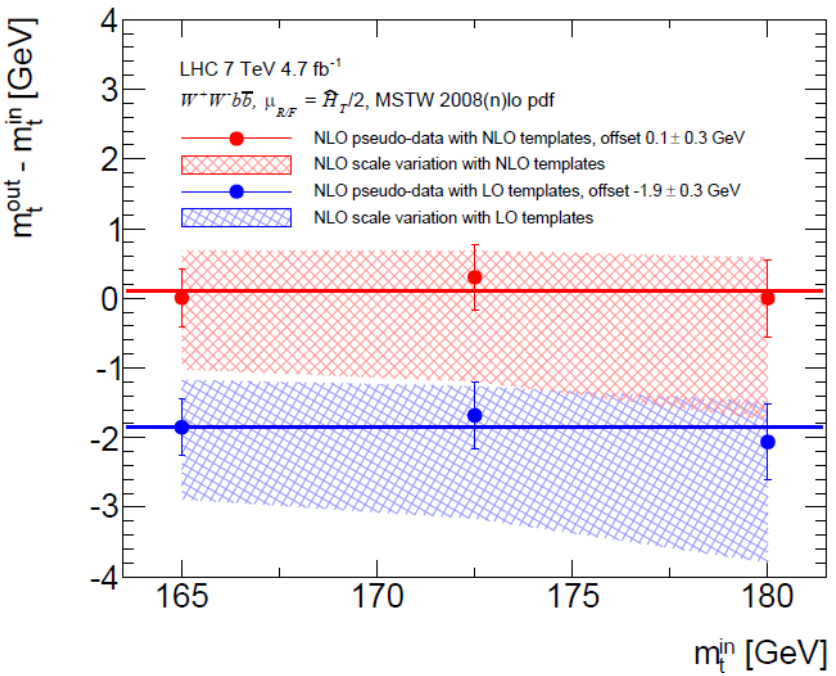
- The top quark mass measurement in the all jets production is challenging because of the high QCD multi-jet background rate
- $t\bar{t}$ events here decay into 6 jets 2 of which are b quark jets
- Latest ATLAS results based on $4.6\,\text{fb}^{-1}$ data with $\sqrt{s} = 7\text{TeV}$
  - $m_{top} = 175.1 \pm 1.4$ (stat.) ± 1.2 (sys.) (arXiv:1409.0832v1)
- Work on new m_{top} measurements using $\sim 20\,\text{fb}^{-1}$ data at $\sqrt{s} = 8\,\text{TeV}$ is ongoing
  - The analysis is based on the full reconstruction of the final state
  - It uses a 1 dimensional template method and the two χ^2 minimization
  - One χ^2 minimization is used to reconstruct the top and the anti-top quarks in $t\bar{t}$ events
  - The second χ^2 minimization is used for the m_{top} measurement itself
- The analysis is at advanced point. We are aiming for a publication next year

Implications of new NLO calculations

A. Maier

- A new NLO calculation of WWbb production and decay has been performed
- Based on this, estimator distributions can be constructed and the effect of theoretical uncertainties on the m_{top} determination can be studied at parton level
- Potentially important for all ongoing efforts towards a precise m_{top} measurement
- Result of an in-house collaboration of ATLAS MPP group and G. Heinrich's MPP phenomenology group
- Published in JHEP06(2014)158

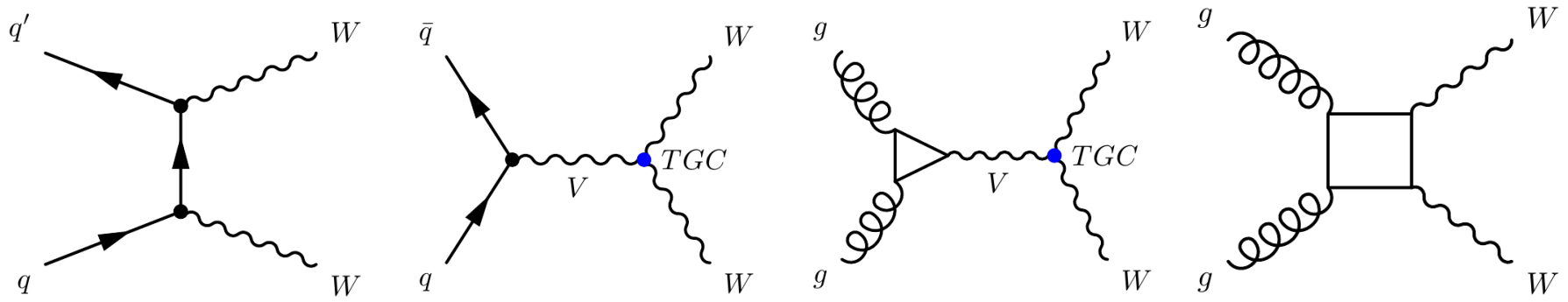




Boosted WW cross section measurement

F. Spettel

- WW production is sensitive to anomalous triple gauge boson couplings



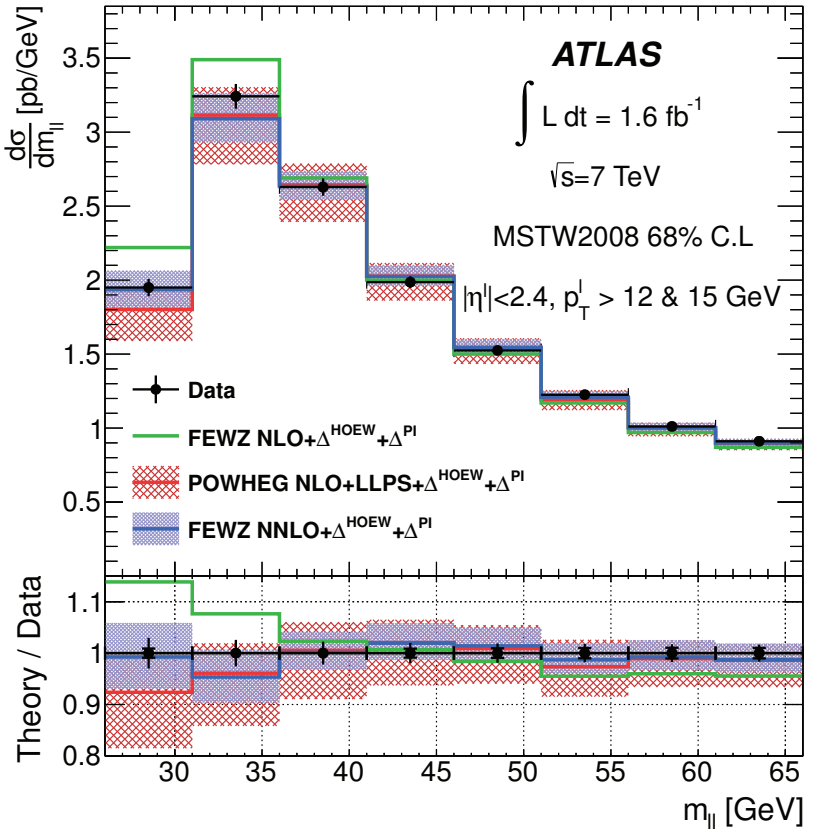
- It is also the dominant background for $H \rightarrow WW^*$
- Latest ATLAS results based on $4.6\,fb^{-1}$ data with $\sqrt{s} = 7TeV$, see arXiv:1410.7238v1
- Analysis is ongoing to study the semileptonic decay channel, where the hadronic W is boosted and produces one "fat jet"
- The analysis uses $\sim 20\,fb^{-1}$ ATLAS data at $\sqrt{s} = 8\,TeV$
- The "fat jet" is further analysed using recently developed jet substructure methods (e.g. mass drop tagging and filtering). These methods help to discriminate signal from the huge background
- To further enhance the signal to background ratio, a multivariate method, like a boosted decision tree or an artificial neural network is employed

Measurements of low-mass Drell-Yan cross-section

T. Ince

- The Drell-Yan process of dilepton production at LHC provides important information on the partonic structure of hadrons which is distinct from that obtained in deep inelastic scattering measurements

- The differential cross section for the process $Z/\gamma^* \rightarrow ll$ ($l = e, \mu$) as a function of dilepton invariant mass (m_{ll}) is measured in ATLAS at at $\sqrt{s} = 7$TeV
- Lepton pair masses ranging from 26 GeV to 66 GeV have been considered in the analysis
- Results show that NNLO predictions provide a good description of the measurement, while NLO predictions yield very large χ^2 values, unless matched to a parton shower calculation
- See JHEP06(2014)112



Conclusions

- The ATLAS MPP group plays a leading role in several Standard Model analysis as e.g. in the top quark domain
  - Precision measurements of the top quark mass studied in all decay channels: **lepton+jets**, **dileptons**, **all jets**
  - First m_{top} world combination
  - Studies on implications of new NLO calculations, with a collaboration of the ATLAS MPP group with the MPP phenomenology group
  - Ongoing analysis on boosted WW cross-section measurement and already performed low-mass Drell-Yan cross-section measurement
- All the analyses presented here have been using Run I ATLAS data
- More interesting results will come with the new Run 2 data starting at LHC next year