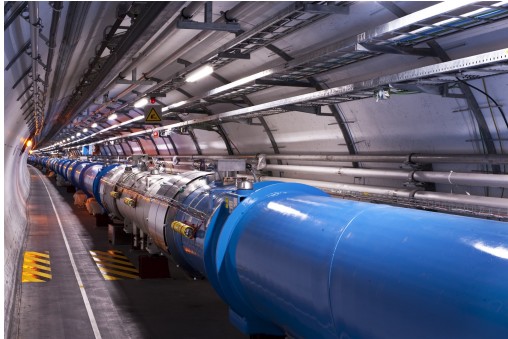


QCD Results from the LHC



Ringberg Castle, September 28, 2011

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Overview

Topics covered

- Inclusive jet production
- Exclusive jet production
- Rapidity gaps, BFKL signatures
- W/Z + n-jet production
- The $t\bar{t}$ cross-section
- The top-quark mass from the $t\bar{t}$ cross-section
- The charge asymmetry in $t\bar{t}$ production

Un-covered topics

- Underlying event structure, hadron production, jet shapes, track jets, jet fragmentation functions, W/Z+b-jet-production, direct photons, ...
- Total pp cross-section
- QCD properties of Pb-Pb collisions

Sorry, the title should really be – Selected QCD Results from ATLAS and CMS –

Theoretical predictions and Monte Carlo tunings

The classes of predictions

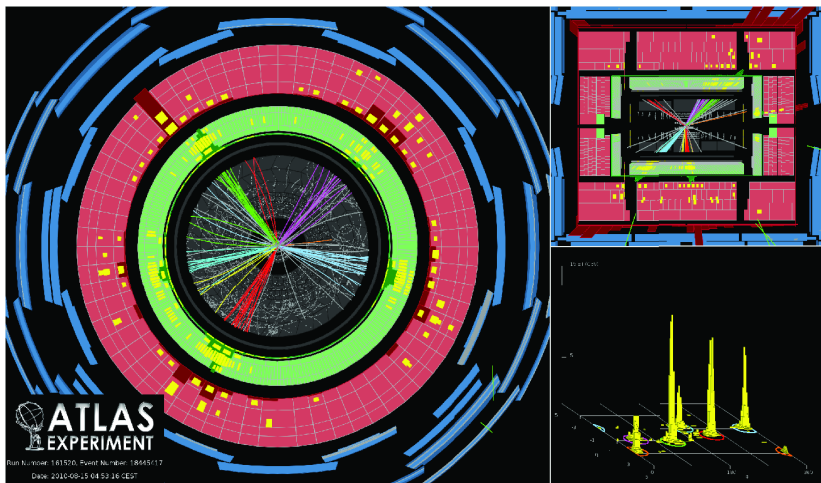
- Leading Order (LO) 2 \rightarrow 2 Matrix Elements (ME) plus Parton Shower (PS) and underlying event (UE): **Pythia**, **Herwig+Jimmy**.
- LO 2 \rightarrow n ME: **Sherpa**, **MadGraph**, **Alpgen** plus PS and UE via **Pythia** or **Herwig(PS)+Jimmy(UE)**.
- NLO calculations for up to n=3 partons: **MCFM** and **NLOJet++**.
- NLO calculations plus parton showers: **MC@NLO** (plus **Herwig+Jimmy**) and **Phoweg** (plus **Pythia** or **Herwig+Jimmy**).
- All order prediction of wide-angle emissions: **HEJ**.

The Monte Carlo tunings to data

- ATLAS: **Pythia** (AMBT, MC09'), **Herwig** (AUET1),
- CMS: **Pythia** (D6T, Z2, 2C) and **Herwig** (2.3).

This is a variety of predictions, the data have been compared to all of them.

A six-jet event at the LHC - ATLAS

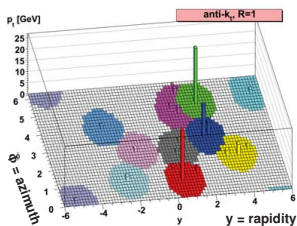


— A rich environment with many jets, underlying event and pile-up, $\langle \mu \rangle \approx 0.1 - 3$ in 2010.

A high performance jet algorithm is needed to get the physics out.

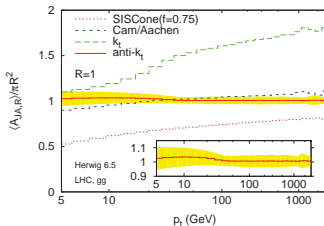
The anti- k_t algorithm - the present work horse

The jet shapes



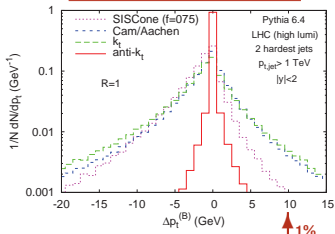
Herwig
parton level,
+ 10^4 soft
ghosts.

The average jet area as function of p_t



LHC $gg \rightarrow gg$,
stable particle,
di-jets, $R=1$

The back-reaction (BR)



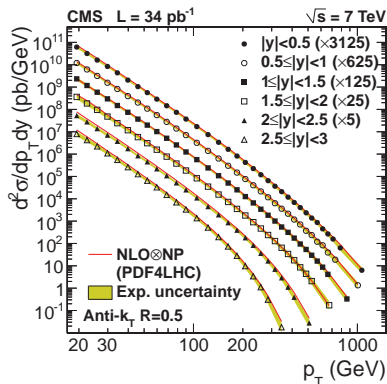
Some details on the algorithm

- $d_{ij} = \min(1/k_{t,i}^2, 1/k_{t,j}^2) \frac{\Delta_{ij}^2}{R^2}$, $d_{iB} = 1/k_{t,i}^2$.
- $\Delta_{ij}^2 = (y_i - y_j)^2 + (\Phi_i - \Phi_j)^2$, $R = 0.4 \dots 1.0$
- For $\Delta_{ij} > R$ the jet with Max k_t stays alone.
- The resulting jet shapes are round and rigid.
- The area is flat with $p_t \rightarrow$ stable pile-up contribution.
- BR = Change in p_t due to re-assignment of non-pileup particles when adding 25 pile-up events.

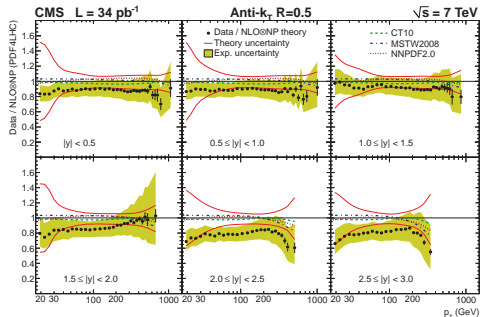
The anti- k_t algorithm has very good properties.

Inclusive jet cross-section - CMS

Double differential cross-section



Comparison to NLO in bins of rapidity



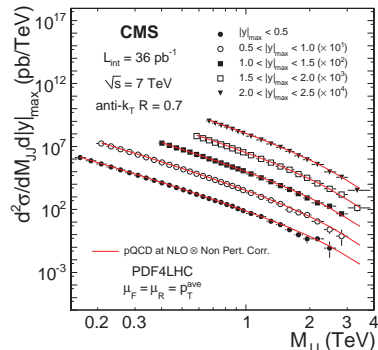
– CMS Particle Flow (l, γ, h^\pm, h^0) jets, $\Delta_{\text{JES}}=(3-4)\%$
 $\Delta \mathcal{L}_{\text{int}}=4\%$ and NP: Non.-Pert. Unc. = Pythia+Herwig.

- At high p_T the largest theoretical unc. is due to PDFs, i.e. the data start to constrain them.
- Experimental uncertainty mainly from Jet Energy Scale (JES), which will decrease.
- The NLOJet++ description of the data is fair, but generally slightly high, esp. at large $|y|$.

Agreement is found within 20%, however deteriorating for larger rapidities.

Inclusive di-jet cross-section - CMS

Double differential cross-section



$$p_{T,1} > 60 \text{ GeV}$$

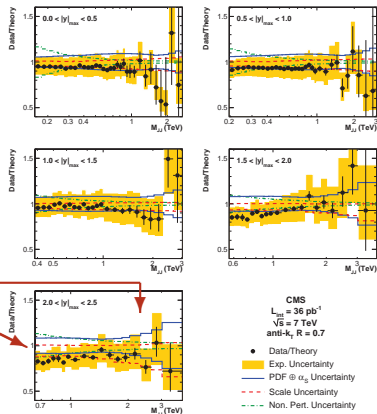
$$p_{T,2} > 30 \text{ GeV}$$

$$|y|_{\max} = \max(|y_1|, |y_2|)$$

PDF dominant

Non. Pert. dominant

Comparison to NLO in bins of $|y|_{\max}$



– $M_{12}^2 = x_1 x_2 s \Rightarrow$ probing $0.0008 < x_1 x_2 < 0.25$.

– Theo: $\Delta\sigma(\text{PDF}) \approx 5\%$ (30%) for 0.2 TeV (3 TeV)

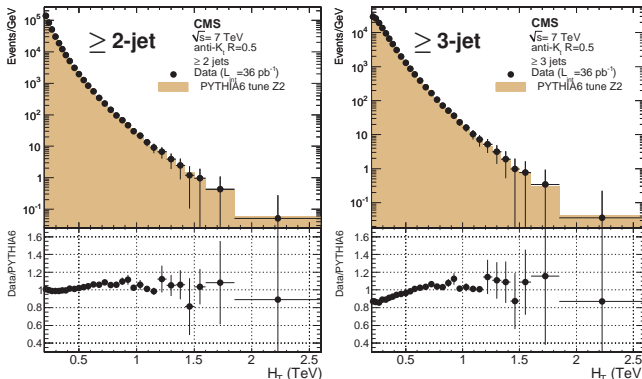
Exp: $\Delta\sigma(\text{JES}) \approx 15\%$ (60%) for 0.2 TeV (3 TeV), $\Delta M_{jj} \approx 7\%$ (3%) for 0.2 TeV (3 TeV).

– Sensitivity: $|y|_{\max}(\text{large}) \Rightarrow$ s-channel, $|y|_{\max}(\text{small}) \Rightarrow$ t-channel.

The di-jet cross-section is well described, but need smaller exp. unc. to constrain the PDFs.

The 3-jet to 2-jet ratio - CMS

The uncorrected H_T distribution for 2-jet and 3-jet inclusive



$$p_t > 50 \text{ GeV}$$

$$|y| < 2.5$$

$$H_T = \sum p_{t,i}$$

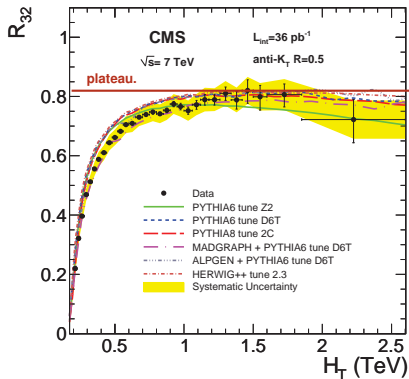
Monte Carlo
 normalized to
 $\sigma(\geq 2\text{-jet})$

- $\Delta p_t \approx 12\%$ (5%) for 50 GeV(1 TeV) and $\Delta H_T \approx 6\%$ (3.5%) for 50 GeV(1 TeV).
- The Pythia (MadGraph and Herwig) model describes the shapes to $\mathcal{O}(20\%)$.
- The Pythia corrections to the particle level amount to about 4%(2%) for $H_T < (>) 0.5$ TeV.

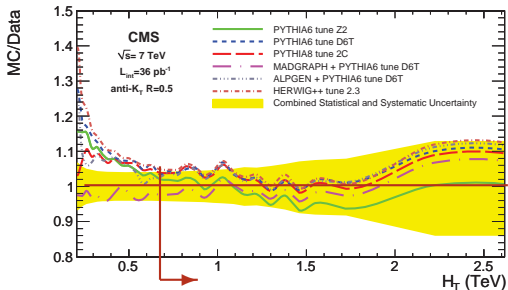
The corrected distributions will be compared to LO 2 \rightarrow n-parton predictions.

The 3-jet to 2-jet ratio - CMS

The corrected 3-jet to 2-jet ratio



Comparison to various predictions



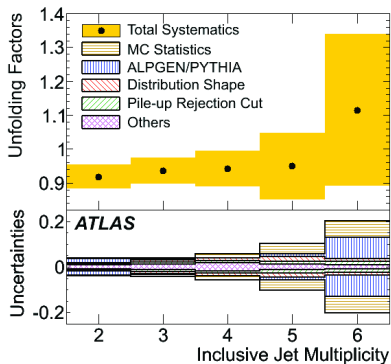
- Alpgen: MLM matching $p_t = 20 \text{ GeV}$, $R=0.7$.
- MadGraph: parton matching $p_t = 30 \text{ GeV}$.

- Experimental unc. (4-10)% dominated by the knowledge of the p_t dependence in the MC.
- Good description at large H_T . Predictions overestimate data at low- H_T , but for MadGraph.

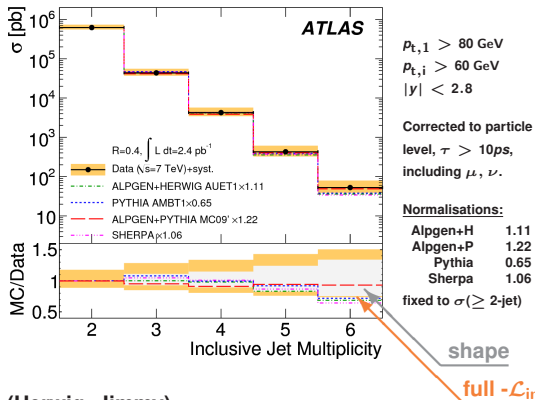
The low- H_T region needs further attention.

Inclusive multi-jet production - ATLAS

The corrections but for the JES



The inclusive jet cross-section



- The corrections are based on Alpgen+(Herwig+Jimmy).
- $\Delta\sigma(JES) \approx +5\%(+2.5\%)$ for 60 GeV(1 TeV), and 'larger' -3% everywhere.
- Compare to LO for $R=0.4$ (less UE dependent) and to NLO for $R=0.6$ (less scale dep.).

The inclusive jet multiplicity is well described by the predictions.

Di-jet production with jet veto - ATLAS

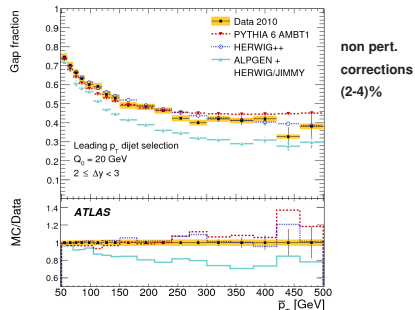
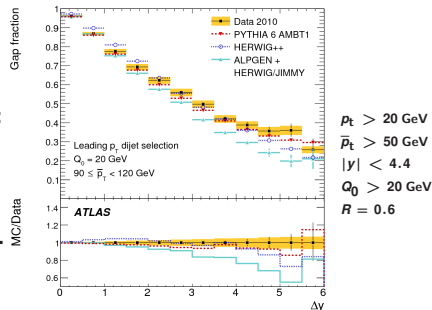
The strategy

- Study jet activity in gap between pair of jets with:
 - highest $p_t \Rightarrow p_{t,1}, p_{t,2}$ similar
 - largest $|\Delta y| \Rightarrow M_{12} > \bar{p}_t$.
- Study two observables within gap:
 - Fraction of events f with no jet above $p_t = Q_0$.
 - Average jet multiplicity $\langle N(p_t > Q_0 \gg \Lambda) \rangle$.
- This probes: wide angle soft gluon radiation for $Q_0 \ll \bar{p}_t$, BFKL dynamics for large $|\Delta y|_{\max}$, and color singlet exchange if both are fulfilled.
- The distributions are corrected to particle level.
- $\Delta(JES)$ (2-5)% in barrel and 13 % for $|\eta| > 3.2$.
- $\Rightarrow \Delta \approx 3\%(7\%), 3\%(6\%), 5\%$, for $f, \Delta y$ and $\langle N \rangle$.

The findings

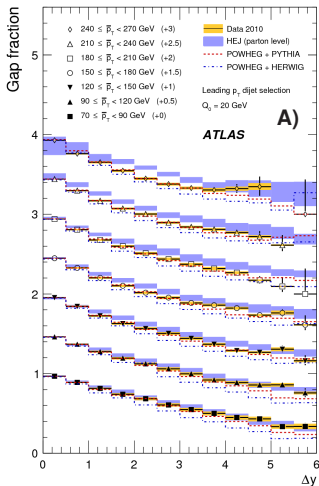
- Herwig and Pythia are ok, except for large Δy .
- Alpgen has too many jets, except for low scales.

Complicated interplay of various scales.

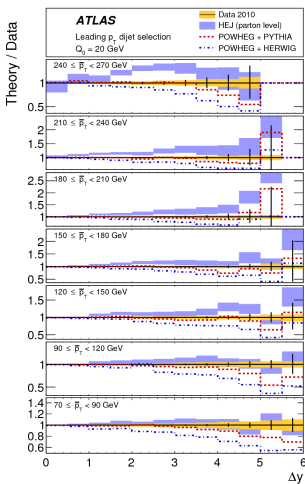


Di-jet production with jet veto - ATLAS

Gap-fraction $f(\Delta y)$



Ratios to predictions



The predictions

- HEJ = all order wide-angle.
- From Powheg = NLO di-jet, the Pythia-Herwig difference is smaller than the HEJ fact. scale, PDF, α_s uncertainties \Rightarrow keep HEJ at parton level.

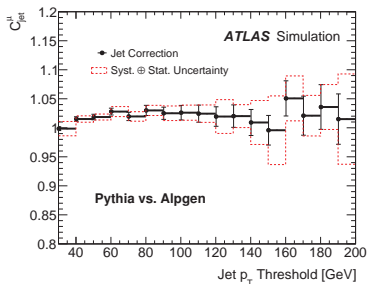
The findings

- The NLO prediction has too much jet activity.
- Phoweg + Pythia is closer to data than with Herwig.
- HEJ has too few jets, especially for large Δy and at large \bar{p}_t/Q_0 for all Δy .

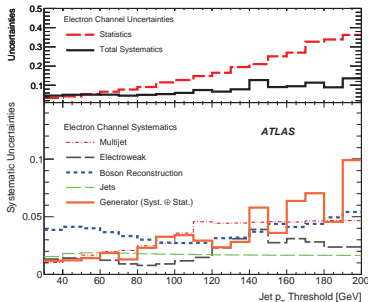
The largest deviations are seen at large \bar{p}_t/Q_0 and/or large Δy .

W/Z + 1-jet production - ATLAS

The remaining jet-level corrections



Breakdown of systematics



$\mathcal{L}_{int} = 33/\text{pb}$
 now 3.6/fb on tape

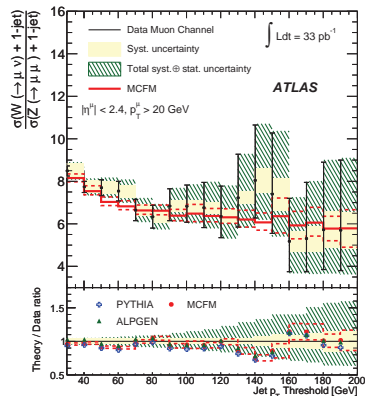
syst. $\mathcal{O}(5 - 10)\%$
 large stat component

- Determining the ratio $\frac{W(\rightarrow \ell\nu) + 1\text{-jet}}{Z(\rightarrow \ell^+\ell^-) + 1\text{-jet}} (p_t > p_t^0)$ constitutes a precision test of QCD.
- Use $p_t > 30 \text{ GeV}$, $|\eta| < 2.8$, veto events with additional jets with $p_t > 30 \text{ GeV}$.
- All EW background estimated from MC, QCD background is taken from data side-bands.
- Bgd in % for W(Z): EW: 3.4(1) e, 5(1) μ QCD: 19(0.3) e, 3.2(0.3) μ .
- Data corrected to particle level. Most uncertainties cancel in the ratio.

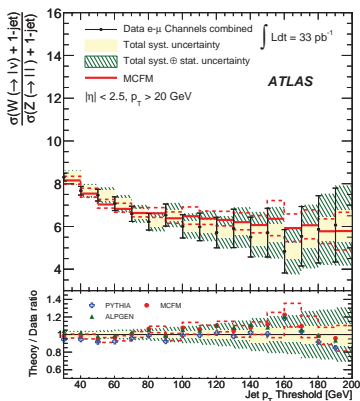
First analysis of a potentially very precise challenge for QCD.

W/Z + 1-jet production - ATLAS

The muon channel result



The combined result



Pythia: LO 2 → 2
 Alpgen: LO 2 → n
 MCFM: NLO 2 → 2
 corrected with Pythia

MCFM uncertainties
 PDF + scales

Muon: $8.49 \pm 0.23 \pm 0.33$

Combined: $8.29 \pm 0.18 \pm 0.28$, corrected to a common

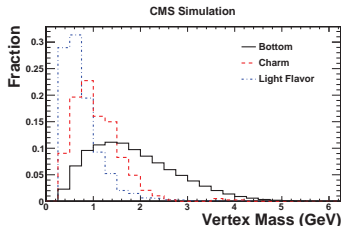
Electron: $8.73 \pm 0.30 \pm 0.40$

phase space, (e and μ have slightly different acceptances).

Good agreement at low p_t , at large p_t the data is statistically limited.

The $t\bar{t}$ cross-section - CMS

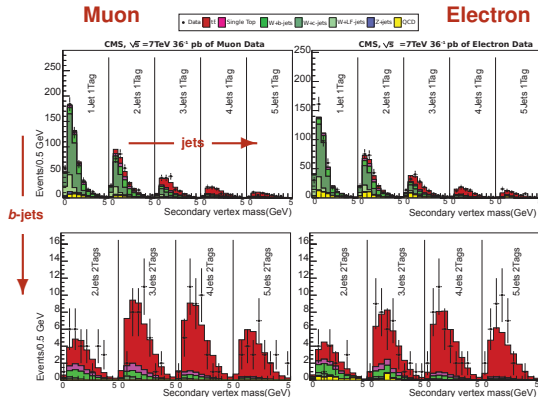
The sensitive distribution



Some analysis details

- Use one discriminative variable.
- Combine lepton channels.
- Exploit a number of statistically independent sub-sets of data with different signal to background compositions.
- The analysis is already systematics limited for the 2010 data with $\mathcal{L}_{\text{int}} = 36\text{pb}^{-1}$.
- Use profile likelihood, i.e. allow systematics to cancel each other, within bounds.

The combined fit

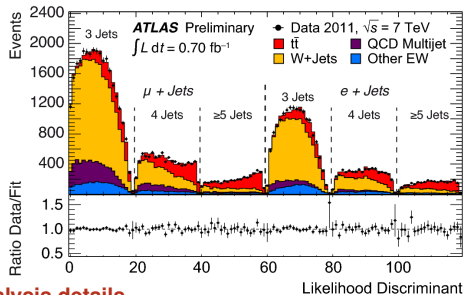
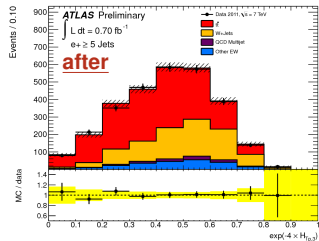
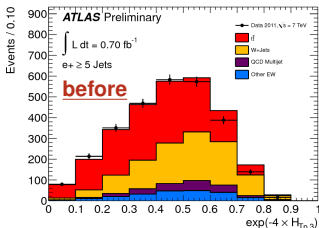


The analyses explores one observable for different jet and b -jet multiplicities.

The $t\bar{t}$ cross-section - ATLAS

The combined fit

A discriminating distribution



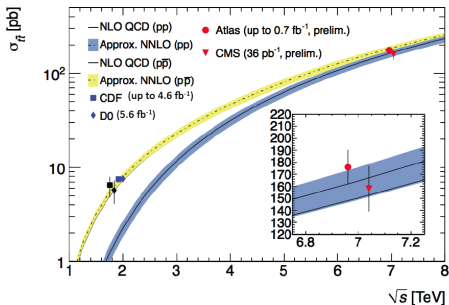
Some analysis details

- Very similar to CMS, however, uses four distributions and no b -tagging (was largest syst. for ATLAS).
- QCD and W+jets (normalization) from data, other from MC.
- Example: $H_{T,p,3} = \frac{p_t(3) + p_t(4)}{p_t(1...4) + p_t(\ell) + p_t(\nu)}$, η^ℓ , $p_{t,max}$, aplanarity.
- Likelihood fit gives fractions and nuisance parameters.
- The fit improves on the data description.

The analyses explores various observables for different jet multiplicities.

The $t\bar{t}$ cross-section - Results

Latest LHC combined figure

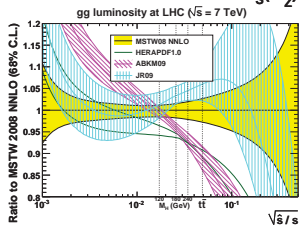
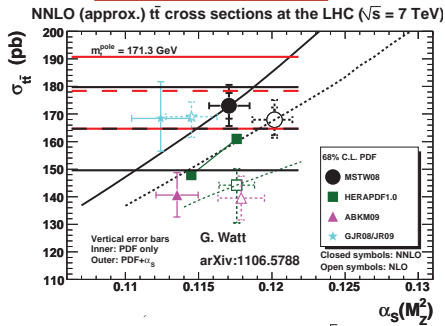


Latest prel. LHC measurements ($\sigma_{t\bar{t}}$ in pb)

Exp(Lumi)	Value	stat.+sys.	lumi
CMS (0.8-1.1/fb)	164.4	12.2	7.4
ATLAS (0.7/fb)	179.0	9.8	6.6

The experimental precision challenges the predictions.

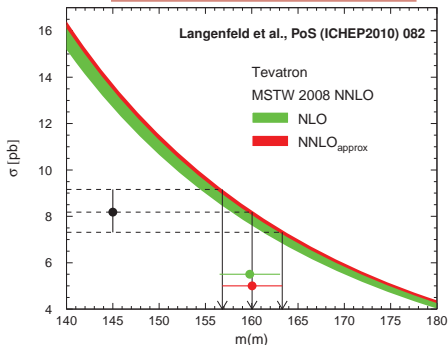
Theoretical predictions



R.S.Thorne, G. Watt arXiv:1106.5789

Measure m_t from the $\sigma_{t\bar{t}}$ - general considerations

The cross-section $\sigma_{t\bar{t}}(m_t(\overline{MS}))$



Theory predictions

- Use m_t (pole): Treat quark as free and long lived, or $m_t(\overline{MS})$: Treat mass as a coupling.
- Relate $m_t(\overline{MS})$ and m_t (pole), i.e. $m_t(\text{pole}) = 172 \text{ GeV} \Rightarrow m_t(\overline{MS}) = 162 \text{ GeV}$.
- The difference of m_t (MC), m_t (pole) is expected to be $\mathcal{O}(1 \text{ GeV})$ so: **Where to put the data?**

The dependence on the mass definition is significant.

The strategy

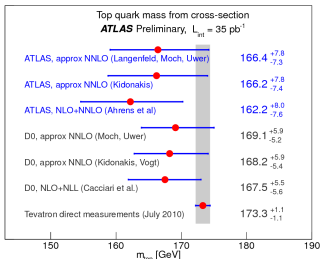
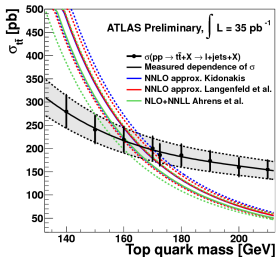
- $\sigma_{t\bar{t}}(m_t)$ is known at NLO, NLO+(N)NLL or approx. NNLO.
- Measure $\sigma_{t\bar{t}}(m_t)$, profit from $\frac{\Delta m_t}{m_t} \approx \frac{1}{5} \frac{\Delta \sigma_{t\bar{t}}}{\sigma_{t\bar{t}}}$.
- So: $\sigma_{t\bar{t}}(m_t) = (8.2 \pm 0.8) \text{ pb}$ (10%)
 $\Rightarrow m_t = (163 \pm 3) \text{ GeV}$ (2%).

The caveat

- This is only true if the measurement of $\sigma_{t\bar{t}}$ does not depend on m_t itself.
- However, the **acceptance is not flat**, but **a function of the m_t (MC) parameter used** in the LO (NLO) Monte Carlo.

Measure m_t from the $\sigma_{t\bar{t}}$ - results

The ATLAS measurement



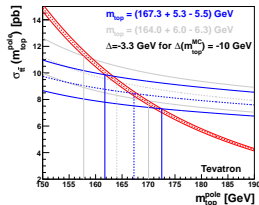
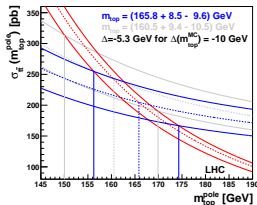
Interpret the result

– $\Delta \sigma_{t\bar{t}}(\text{exp}) = 13\% \Rightarrow \Delta m_t(\text{exp}) = 3\%$,

But: $\frac{\sigma_{t\bar{t}}(160) - \sigma_{t\bar{t}}(172.5)}{\sigma_{t\bar{t}}(172.5)} = 18\%$

\Rightarrow Need to find an m_t independent !? selection.

$$m_t(\text{direct}) = (173.18 \pm 0.56 \pm 0.76) \text{ GeV} \\ < 1 \text{ GeV (0.6\%)}$$



Comparison to D0 measurement

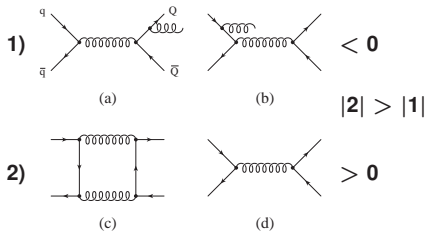
– $\sigma_{t\bar{t}}(\text{exp}) = 8.13^{+1.02}_{-0.90} \text{ pb}$ yields $\Delta m_t = \mathcal{O}(5) \text{ GeV}$.

– Use $\sigma_{t\bar{t}}(m_t^{\text{pole}})$ and $\sigma_{t\bar{t}}(\overline{\text{MS}})$ while assuming $m_t^{\text{MC}} = m_t^{\text{pole}}$ or $m_t^{\text{MC}} = m_t^{\overline{\text{MS}}} \Rightarrow \Delta m_t = \mathcal{O}(3) \text{ GeV}$.

The measurement is hampered by its interpretation.

The charge (forward-backward) asymmetry

The two sources of the asymmetry



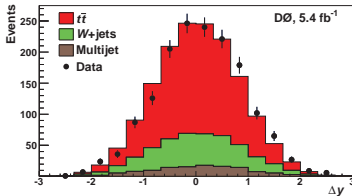
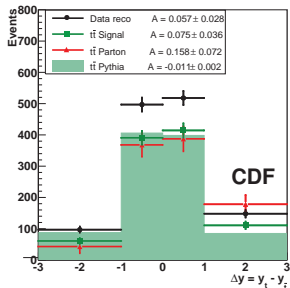
The formulas

- Rapidity: $y = \frac{1}{2} \ln \frac{E+p_z}{E-p_z}$.
- Single Asymmetry: $A^{P\bar{P}} = \frac{N_t(y \geq 0) - N_t(y < 0)}{N_t(y \geq 0) + N_t(y < 0)}$.
- Difference: $\Delta y = y_t - y_{\bar{t}} = q_\ell (y_\ell - y_{\text{had}})$.
- Pair Asymmetry: $A^{t\bar{t}} = \frac{N(\Delta y > 0) - N(\Delta y < 0)}{N(\Delta y \geq 0) + N(\Delta y \leq 0)}$.
- $A^{t\bar{t}}/A^{P\bar{P}}(\text{QCD, \%}) = 8/5 (\approx 1)$ TeV (LHC).
- CP-Invariance: $CP | N_t(y) \rangle = | N_t(-y) \rangle$.
- Charge \leftrightarrow forward-backward, if defined.

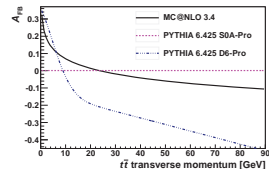
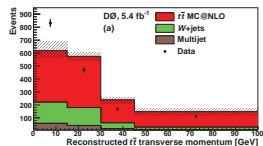
- Only caused by quark initiated processes, i.e. gluon initiated processes dilute A^{ff} .
 $\Rightarrow A^{\text{ff}}(\text{Tevatron}) > A^{\text{ff}}(\text{LHC})$ because $q\bar{q}/gg \approx 90/10$ (15/85) for Tevatron (LHC).
- $A^{\text{ff}} > 0$, however selecting 1) or 2) could help to look for consistency.
- The asymmetry is NLO in $\sigma_{t\bar{t}}$, i.e. it is only known at LO! A^{ff} depends on $p_t(t\bar{t})$, Δy , $M_{t\bar{t}}$, ...
- $A^{t\bar{t}} > A^{P\bar{P}}$ because all pairs contribute, i.e. $A^{t\bar{t}}$ is theoretically preferred.
- The channel $t\bar{t} \rightarrow \text{lepton} + \text{jets}$ is used. $A^{P\bar{P}}$ only needs $y_{\text{had}} = y(qqb)$. In contrast, $A^{t\bar{t}}$ also needs $y_\ell = y(b\ell\nu)$ which has a worse angular resolution, i.e. experimentally $A^{P\bar{P}}$ is easier.

The asymmetry values measured at Tevatron created some excitement.

The charge asymmetry - Tevatron results



Beware!



Results on $A^{\bar{t}t}$ in (%)

both high!

Exp/Theo	all	$A^{\bar{t}t}(\Delta y < 1)$	$A^{\bar{t}t}(\Delta y > 1)$
CDF	15.8 ± 7.4	$2.6 \pm 10.4 \pm 5.6$	$61.1 \pm 21.0 \pm 14.7$
MCFM	5.8 ± 0.9	3.9 ± 0.6	12.3 ± 1.8
DØ	19.6 ± 6.5	6.1 ± 4.1	21.3 ± 9.7
MC@NLO	5.0 ± 0.1	1.4 ± 0.6	6.3 ± 1.6

rise
not sign.

– $A^{\bar{t}t}$ \nearrow by $\mathcal{O}(20\%)$ relative with EW corrections.

	$A^{\bar{t}t}(M_{\bar{t}t} < 450 \text{ GeV})$	$A^{\bar{t}t}(M_{\bar{t}t} > 450 \text{ GeV})$
CDF	$-11.6 \pm 14.6 \pm 4.7$	$47.5 \pm 10.1 \pm 4.9$
MCFM	4.0 ± 0.6	8.8 ± 1.3
DØ	7.8 ± 4.8	11.5 ± 6.0
MC@NLO	1.3 ± 0.6	4.3 ± 1.3

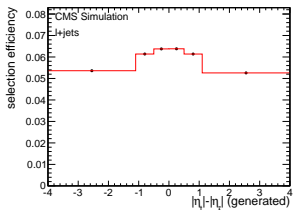
rise
not sign.

– The NLO corrections to $A^{\bar{t}t}$ are not fully known. \Rightarrow need to wait.

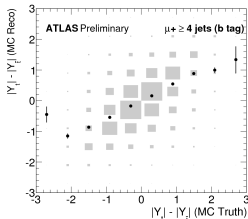
The asymmetries are all larger than expected - lets see what LHC finds.

The charge asymmetry - LHC analyses

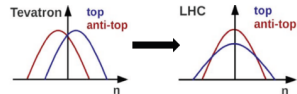
The efficiency



The transfer matrix

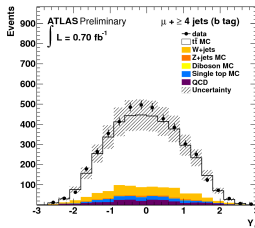
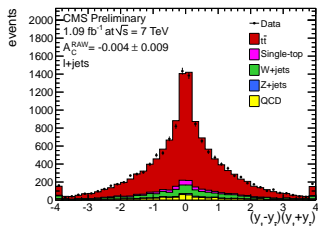


Tevatron vs. LHC



- The LHC is FB-symmetric, and valence quarks have larger x ,
- \Rightarrow forward regions counts most.

The raw distributions



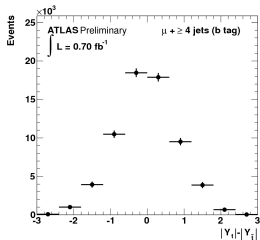
Some analyses details

- The efficiencies are symmetric.
- The transfer matrix calls for unfolding of the data distributions.
- Good description of the data by combination of MC models and data driven estimates.

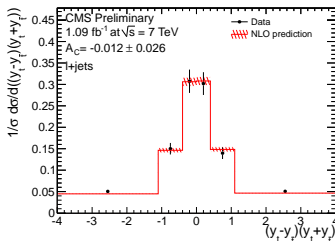
Controlling all effects that may be asymmetric is essential.

The charge asymmetry - LHC results

Unfolded results on $A^{\text{t}\bar{\text{t}}}$

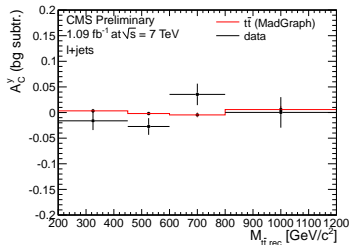


$\mathcal{L}_{\text{int}} = 0.70 \text{ fb}^{-1}$



$\mathcal{L}_{\text{int}} = 1.09 \text{ fb}^{-1}$

The raw $M_{\text{t}\bar{\text{t}}}$ dependence



The preliminary results

ATLAS: $A^{\text{t}\bar{\text{t}}}(|y_t| - |y_{\bar{t}}|) = (-2.4 \pm 1.6 \pm 2.3)\%$.

CMS: $A^{\text{t}\bar{\text{t}}}(y_t^2 - y_{\bar{t}}^2) = (-1.3 \pm 2.6 \pm 2.6)_{-2.1}^{\%}$.

The predictions

0.6% (MC@NLO).

(1.1 ± 0.1)% (Rodriguez).

– In addition, CMS does not find any significant dependence on $M_{\text{t}\bar{\text{t}}}$.

At LHC the asymmetry is found to be independent of $M_{\text{t}\bar{\text{t}}}$, and the SM describes the data.

Conclusions and Outlook

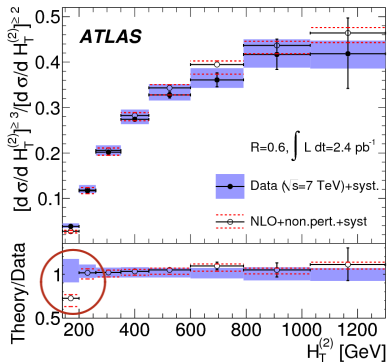
- The LHC is a QCD machine and it performs beautifully $\mathcal{L} = 3.3 \cdot 10^{33}/\text{cm}^2/\text{s}$, $\mathcal{L}_{\text{int}} = 3.6\text{fb}$. However, the ever increasing number of pile-up events is a continuous challenge.
- Statistics is plentiful, and the key to success is reducing the systematics, either by an even better detector understanding, or by optimizing observables.
- Jet physics is a very rich field with many predictions up to NLO. Here, reducing the jet energy scale uncertainty is the key to precision.
- The W/Z + jets processes offer some precision NLO QCD tests.
- Also top-quark physics offers many QCD observables and challenges to theory. Some interesting features of the Tevatron data could not be confirmed.
- As always, the close collaboration and interplay between theorists and experimentalists pays off in designing the analyses.
- Finally, my apologies to those interested in UE, soft QCD, track jets, *b*-jets,

There is lot more to come in the next years, stay tuned.

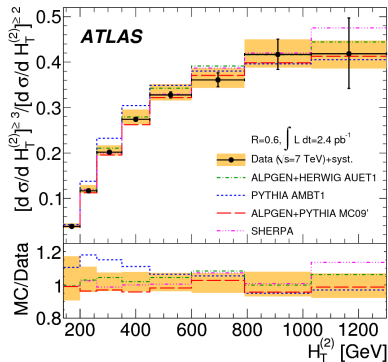
Backup - Transparencies

Inclusive multi-jet production - ATLAS

Comparison to NLO + Non.-Pert.



Comparison to LO Monte Carlo

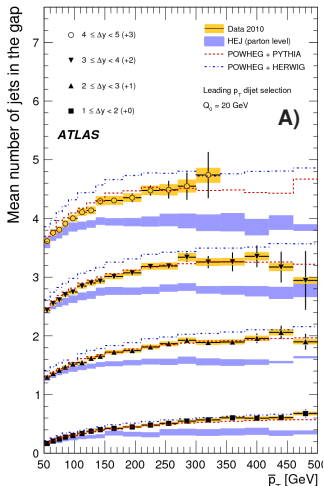


- $H_T^{(2)} = p_{t,1} + p_{t,2}$ has smallest scale uncertainty and mainly probes PDF and α_S .
- Non.-Pert. effects taken from Pythia (LO ME \leftrightarrow LO ME+PS+UE) are about 5%.
- NLOJet++ prediction shows an overall good description, **but for low $H_T^{(2)}$** .

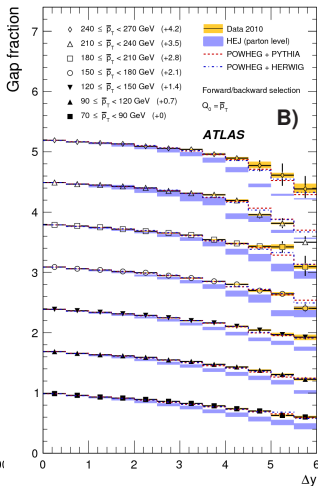
Overall good description by NLO, but for low $H_T^{(2)}$. LO predictions are further away.

Di-jet production with jet veto - ATLAS

$\langle N(p_t > Q_0) \rangle$ as function of \bar{p}_t



$f(\Delta y)$ for $Q_0 = \bar{p}_t$



The findings for $\langle N \rangle$

- Deviations are enhanced when using $\langle N \rangle$.
- Phoweg + Pythia describes the data well.
- Phoweg + Herwig is far off especially at large Δy .
- HEJ has too little activity especially for large \bar{p}_t/Q_0

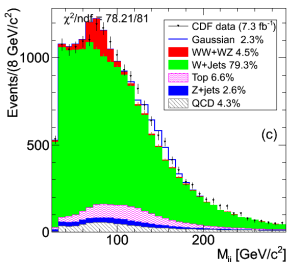
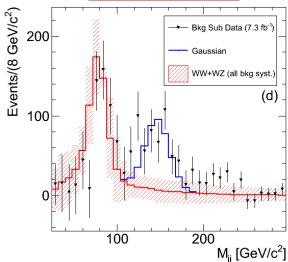
The findings for $f(\Delta y)$ f

- Case B) $|\Delta y|_{\max} (M_{ij} > \bar{p}_t)$, and $Q_0 = \bar{p}_t$ not fixed.
- Phoweg describes the data well with Pythia and Herwig.
- HEJ describes the data at low Δy , but has too many jets for large Δy .

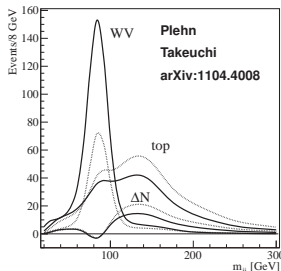
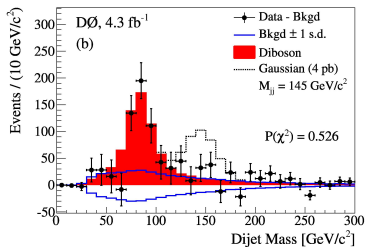
Largest deviations at large \bar{p}_t/Q_0 and/or large Δy .

The production of a W-Boson + 2-jets - Tevatron

The CDF result



The D0 result



The experimental facts

- Can not describe shoulder in M_{jj} distribution.
- Use additional Gauss to describe the difference.
- Subtract all background.
- Not confirmed by D0, set limit $\sigma(145 \text{ GeV}) < 1.9\text{pb}$ with 95% C.L.

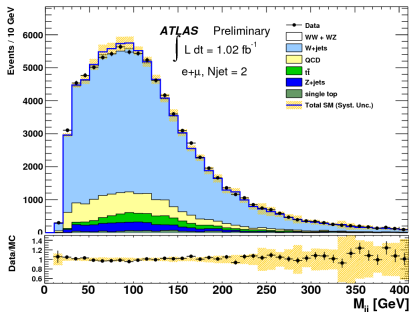
Possible explanation

- Mis-reconstructed top-quarks peak at $\sqrt{m_t^2 - m_W^2}$!
- Shift in single top + $t\bar{t}$ background wrt. WV can solve this.
- CDF sees too many single top events, but D0 does not!

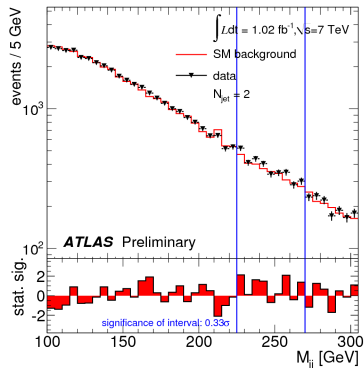
An inconclusive situation.

The production of a W-Boson + 2-jets - ATLAS

The invariant mass distribution



In search for a bump

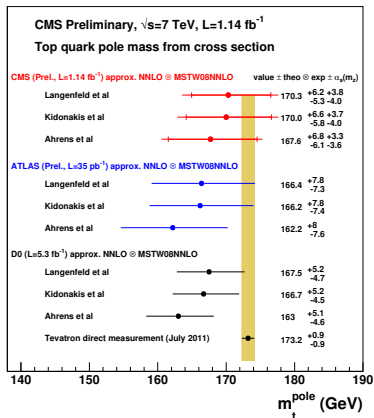


- Try to mimic the CDF analysis, but: $\frac{WW}{W+n>2-jets}$ decreases by factor 5, i.e. $\frac{3.7}{22} \rightarrow \frac{15.3}{440}$.
- Jet selection: $p_t > 30$ GeV, $|\eta| < 2.8$, $|\Delta\eta| < 2.5$, $M_{jj} > 40$ GeV, $\Delta\Phi_{jet, E_{miss}} > 0.4$.
- Estimate background for QCD and the W+jets (normalization) from data.

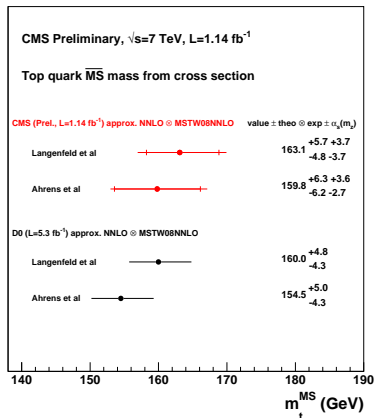
There is no sign of an excess, the CDF result can not be confirmed.

The measured m_t from the $\sigma_{t\bar{t}}$ - CMS

The m_t^{pole} mass



The $m_t^{\overline{\text{MS}}}$ mass



Brand new - Write-up not yet available.