Experimental Summary Top 2012

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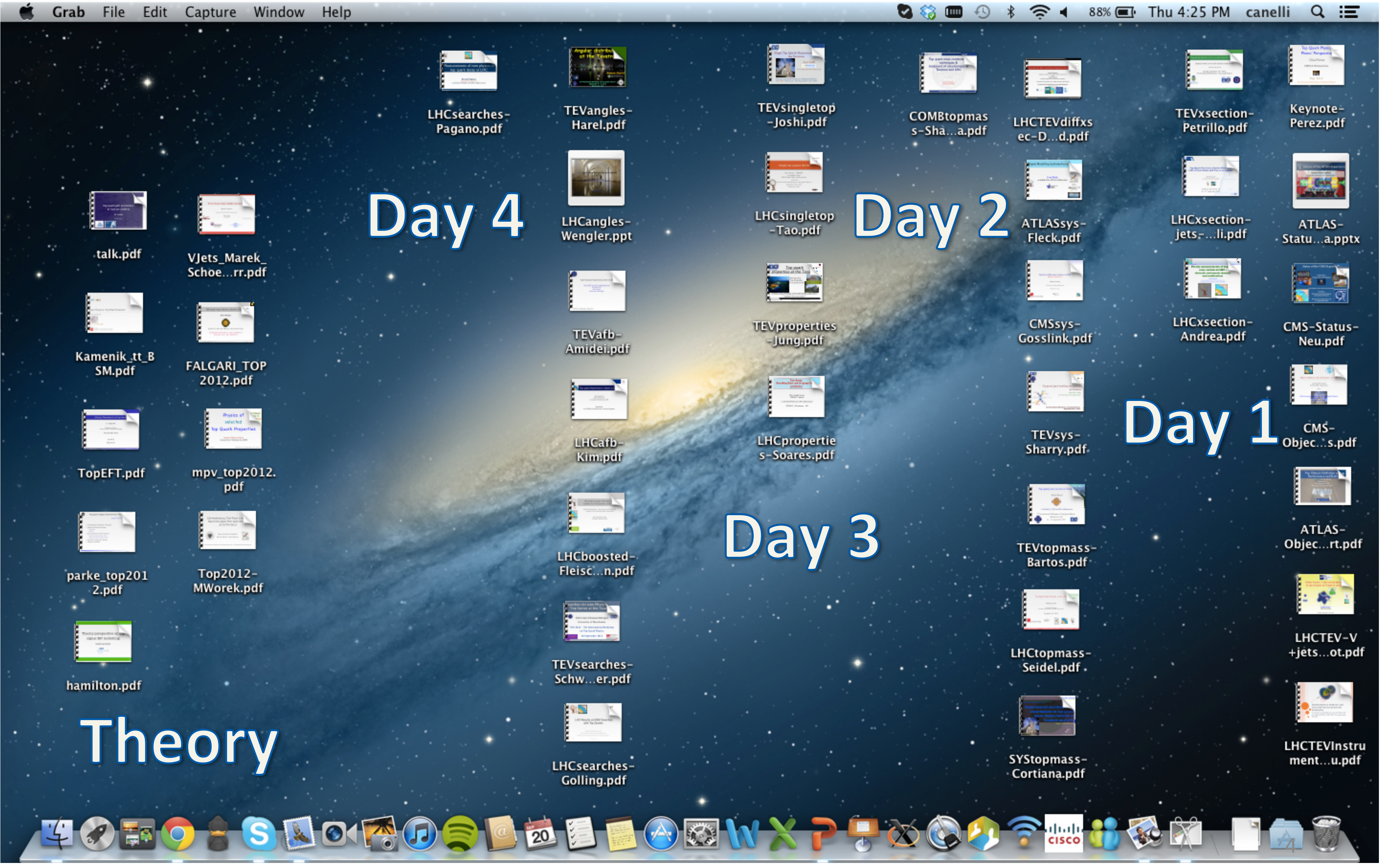
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Day 3
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Searches

Top properties

Cross sections (single top, ttX)

Top mass

Cross sections (ttbar)

Uncertainties

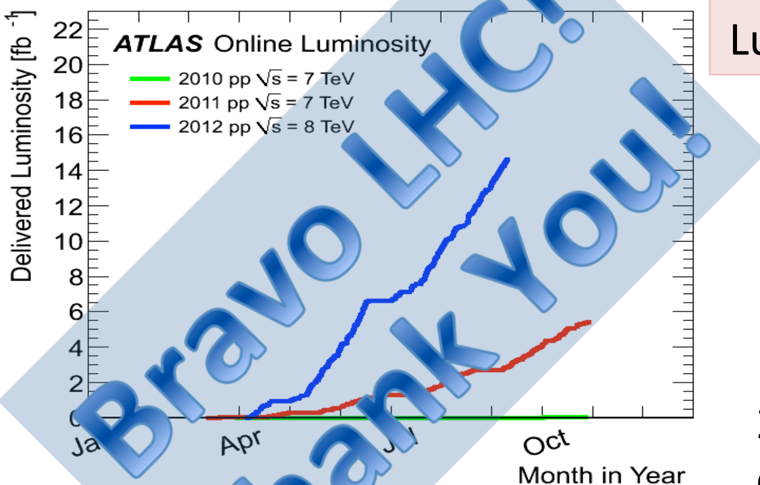
Backgrounds

Objects

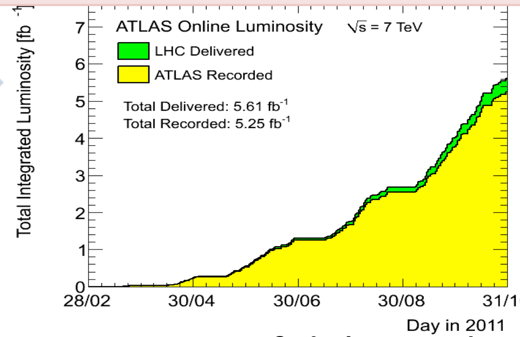
Detectors

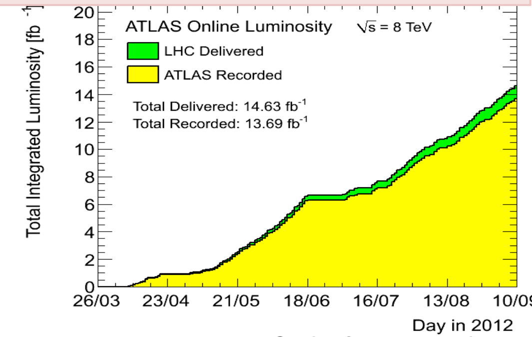
Accelerator

Luminosity, Data Taking + Quality



Luminosity uncertainty (prelim.): 2011: 1.8%, 2012: 3.6%





2011: 93.6% of delivered data are recorded ($5.25 fb^{-1}$)

2012: 93.6% of delivered data are recorded ($13.7 fb^{-1}$)

Peak luminosity: $7.73 \times 10^{33} cm^{-2}s^{-1}$

All good for physics

ATLAS 2011 p–p run

Inner Tracking			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.8	99.6	99.2	97.5	99.2	99.5	99.2	99.4	98.8	99.4	99.1	99.8	99.3

Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at √s=7 TeV between March 13th and October 30th (in %), after the summer 2011 reprocessing campaign

89.9% of recorded data

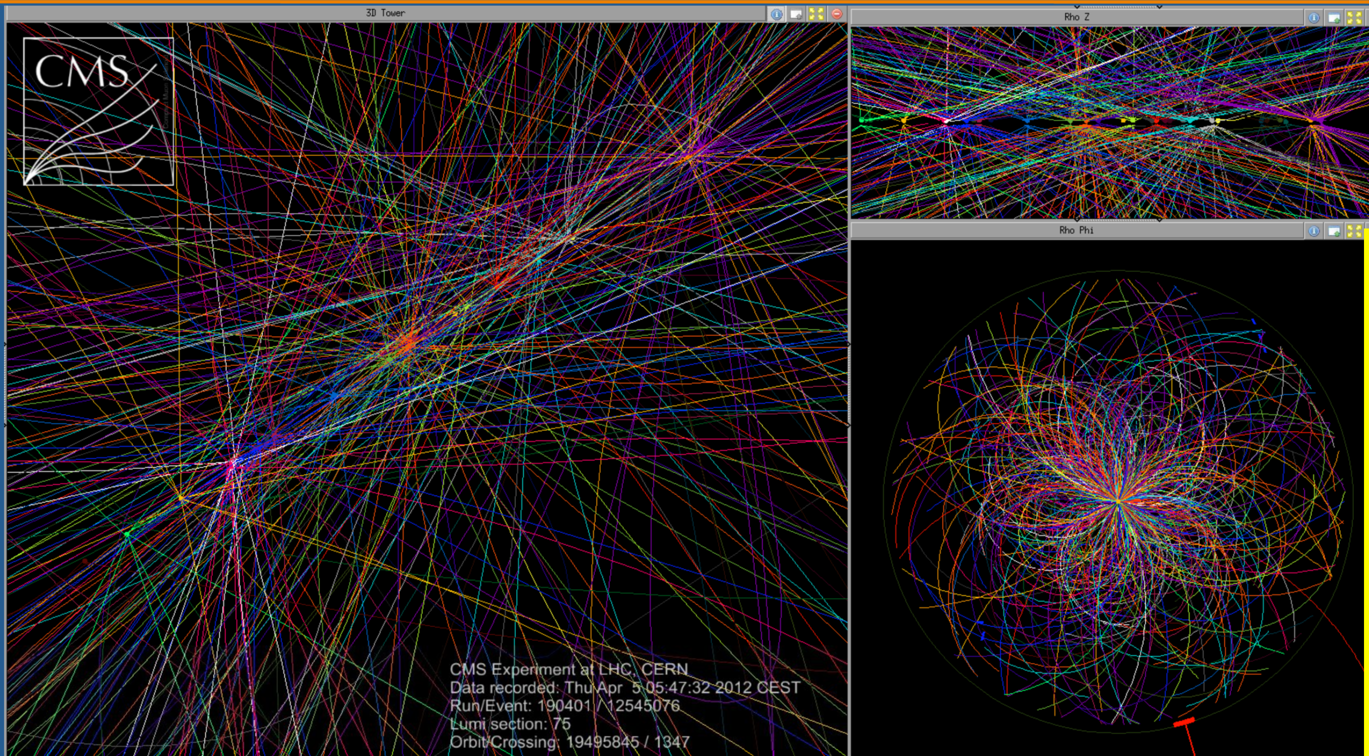
ATLAS p-p run: April-June 2012

Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
100	99.6	100	96.2	99.1	100	99.6	100	100	99.4	100

93.6% of recorded data (April – June 2012)

→ Close to 90% of the delivered luminosity in 2011 and 2012 is used for physics analysis!

LHC Performance Poses Challenges



- High instantaneous luminosity → increased pileup
- Example: ~16 primary vertices
  - Complicated environment – but actually quite common
  - Observed events with up to *78 reconstructed vertices*

Excellent performance of the LHC and detectors

Detector subsystems fully operational and better than design performance

Trigger coping with demands of high pileup

OBJECTS: Leptons, Jets, B-tagging, Missing Energy

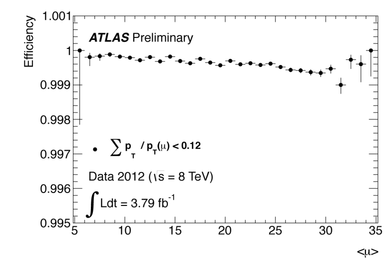
Summary

- Great performance of the object identification both at 7 and 8 TeV for precision measurement of top quark properties
- The agreement between data-simulation is remarkable
- CMS is performing well in this scenario, adapting to the increasing luminosity
  - PU dependent correction
  - customize isolation
- So far, top analyses show no significant dependence on the changing conditions.
- All CMS public results available from: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults

Conclusions

- ATLAS Top object definitions and calibrations have evolved a long way over the 2011 period
- Top members are at the forefront of ATLAS on those topics
- Combination of methods provides best performance
  - systematic uncertainty determination quite sophisticated
- PU has been a challenge but ATLAS has risen to it

Muon trigger isolation efficiency



V. Boisvert

Backgrounds: Instrumental

Affect objects measurements: jets, MET, b-tagging
True instrumental (cosmics, noise, beam gas) and fake instrumental (QCD)

METHODOLOGIES IN CMS AND ATLAS

Exper-iment	Channel	Goal	lumi fb^{-1}	Ref.	QCD Bkg Method
ATLAS	lepton+jets	$\sigma(t\bar{t})$	0.035	Phys. Lett. B711 (2012) 244-263	MM(μ), AE(e)
ATLAS	dilepton	$\sigma(t\bar{t})$	0.7	JHEP 1205 (2012) 059	MM
ATLAS	single top lepton+jets	σ(t), t-chan	1.04	arXiv:1205.313	JE
CMS	lepton+jets	$\sigma(t\bar{t})$	0.036	arXiv:1108.3773	AE
CMS	dilepton	$\sigma(t\bar{t})$	2.3	arXiv:1208.2671	MM
CMS	single top lepton+jets	σ(t), t-chan	0.036	Phys.Rev.Lett.107:091802,2011	AE

MM=matrix method,
JE =jet electron
AE =antielectron

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CONCLUSIONS

- Basic suppression of beam halo, calorimeter noise, cosmic rays are well established and reduce backgrounds to acceptable levels.
- Pileup is a continuing problem as the number of primary vertices has nearly reached its design value. ATLAS, CMS simulates this and has put in place algorithms to suppress the effect on physics analysis.
- QCD events containing fake leptons are a small background but irreducible. Matrix method, Jet Electron method, and anti-electron method obtain accurate estimates at the LHC and Tevatron for the precision top measurements now in progress.
- *Instrumental effects are largely under control thanks to the hard work of the performance groups.*

9/17/2012 Top2012/Boudreau

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Backgrounds : V+jets

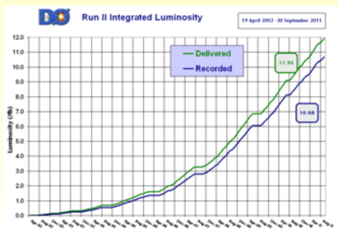
Cross section measurements
Background estimations: >4 different methods

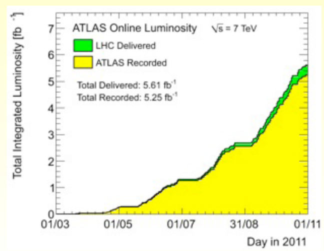
The bottom line

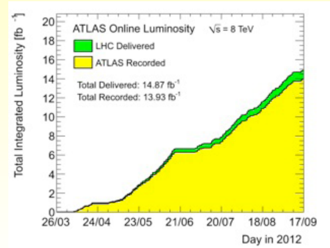
- V+light jets at the Tevatron and the LHC
  - ➔ measurements agree with predictions from NLO and multilegs generators (scaled to the NNLO inclusive prediction)
  - ➔ measurements would enable constraining MC predictions precision: W+3jets: ~ 20%, Z+2jets: ~ 15%
- V+c/b jets at the Tevatron and the LHC
  - ➔ in general, measurements agree with predictions from NLO and scaled multilegs ge
    some discrepancy in CDF measurement of W+b jets, LHC data agrees with predicti
  - ➔ measurement uncertainties are larger than the typical MC predictions precision: W+c jets: ~ 25%, W+b jets: ~ 20-30%, Z+b jets: ~ 15-30%
- more results than the ones that I presented here
- further measurements with higher statistics expected both from Tevatro
  + measurements @ 8 TeV

Conclusion

- a lot of V+jets results from 2 colliders and 4 experiments:
  - ➔ measurements agree with the NLO MC predictions
  - ➔ multilegs generators suitable to reproduce most of the V+jets kinematics
    W+b/bb measurements compared to predictions ?
  - ➔ still more results/checks to come
- various methods to measure the V+jets background in top analyses:
  - ➔ depending on the needed precisions:
    * use multilegs generator scaled to NLO predictions
    * data driven normalization (agrees with the MC predictions) or fit together with the top quark signal
  - ➔ because of the advanced developed background estimation technique usually the achieved uncertainty on the V+jets background is small







Frederic Deliot

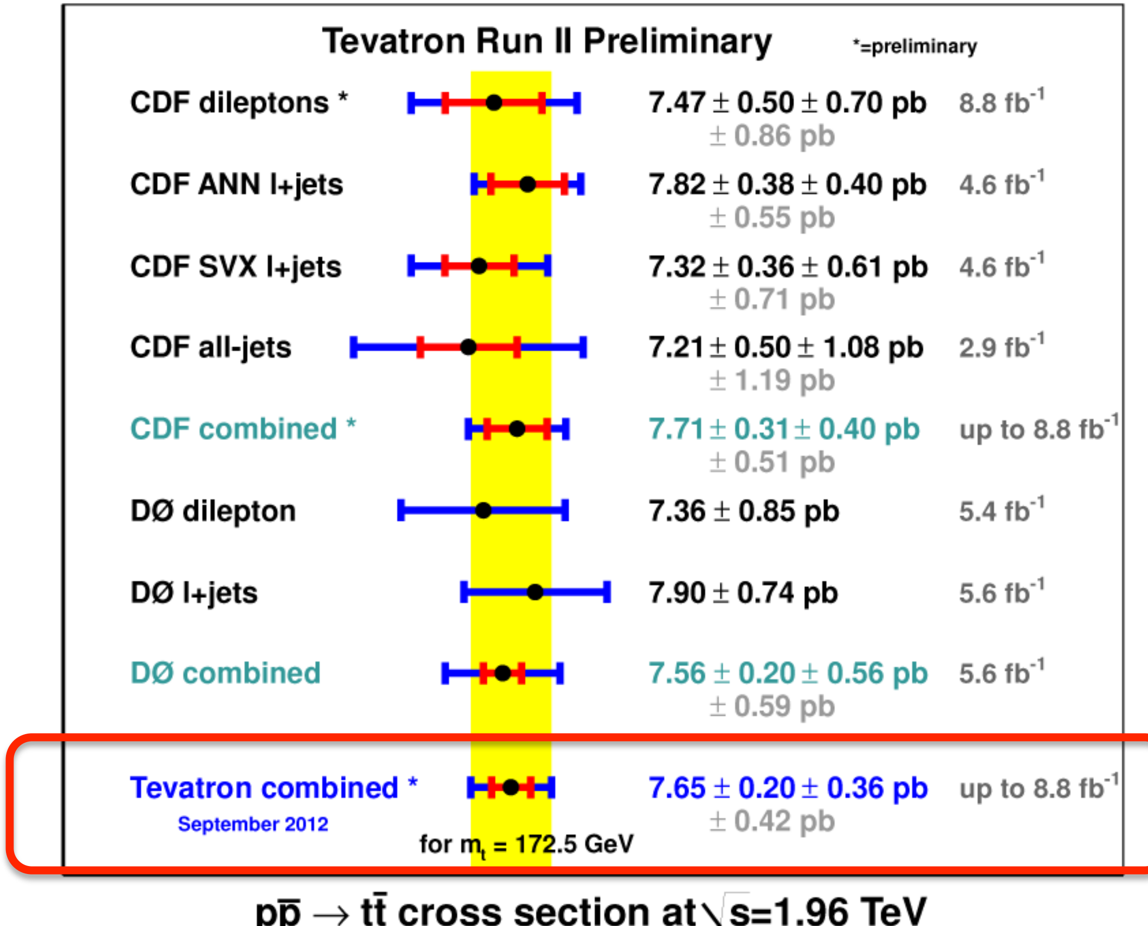
tt Cross Section: Tevatron

Tevatron results in TOP 2011 systematically limited

CDF added missing channels (taus) and
more data to stat. limited channels

New Tevatron combination (5.5% precise, theory 3.5%)

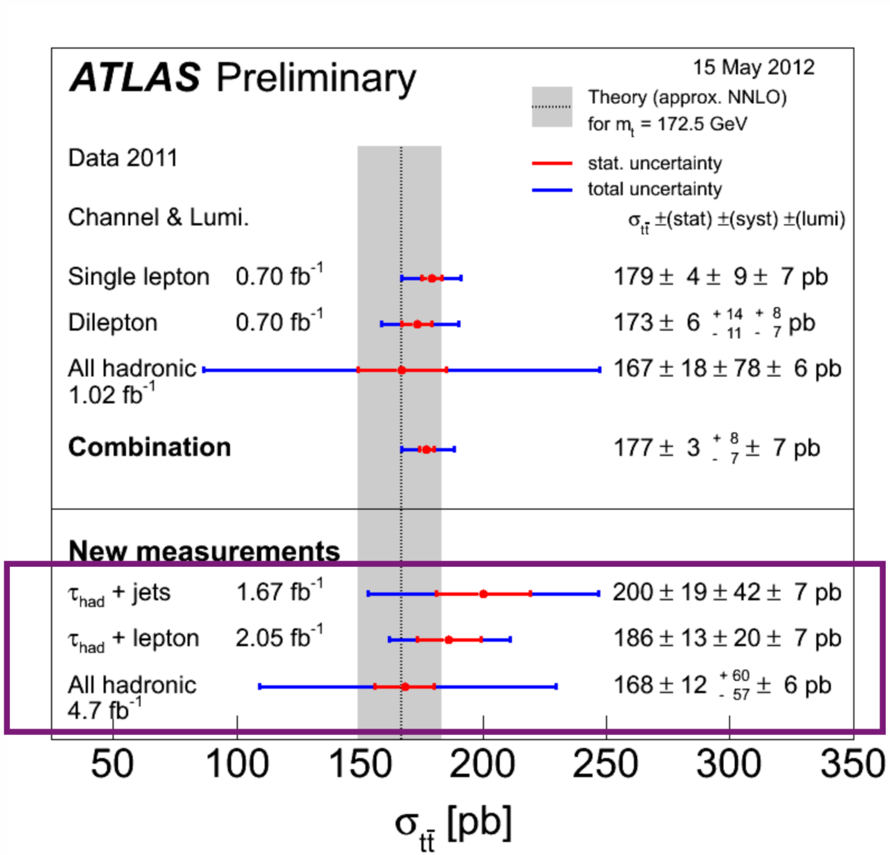
(Most precise single analysis 6.8%)

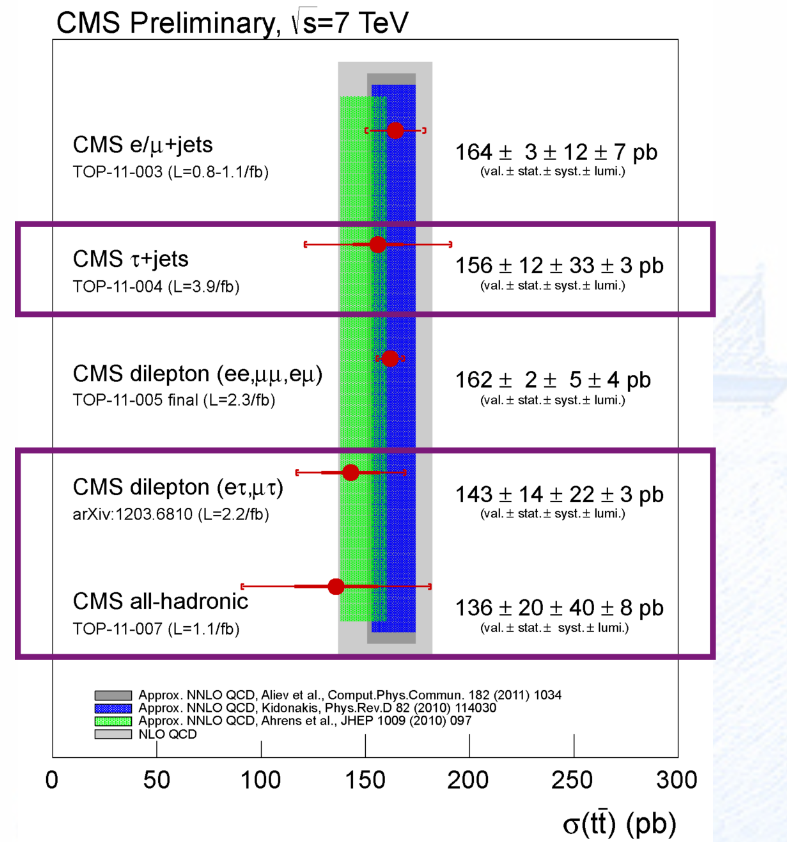


$t\bar{t}$ Cross Section: LHC (I)

Using taus or no leptons

Challenges: Trigger evolving, pile up, huge systematic uncertainties (all jet dominated)





tt Cross Section: LHC (II)

Using leptons: lepton+jets (b-tagging and semi leptonic b-tagging) and dilepton channels
LHC combination (7TeV, older results) produce a gain of 7%

$$\sigma_{t\bar{t}} = 179.0 \pm 3.9\,(\text{stat}) \pm 9.0\,(\text{syst}) \pm 6.6\,(\text{lumi})\ \text{pb}$$

ATLAS, 7 TeV, l+jets, 7%

$$\sigma_{t\bar{t}}^{e+jets} = 167 \pm 3(\text{stat.}) \pm 20(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb}$$
$$\sigma_{t\bar{t}}^{\mu+jets} = 164 \pm 2(\text{stat.}) \pm 17(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb}$$
$$\sigma_{t\bar{t}} = 165 \pm 2(\text{stat.}) \pm 17(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb}$$

ATLAS, 7 TeV, l+jets, semi leptonic b-tagging, 11%

Measured cross sections are :

μ+jets $\sigma_{t\bar{t}} = 163.2 \pm 3.4(\text{stat.}) \pm 12.7(\text{syst.}) \pm 7.3(\text{lum.})$ pb.

e+jets $\sigma_{t\bar{t}} = 163.0 \pm 4.4(\text{stat.}) \pm 12.7(\text{syst.}) \pm 7.3(\text{lum.})$ pb.

comb $\sigma_{t\bar{t}} = 164.4 \pm 2.8(\text{stat.}) \pm 11.9(\text{syst.}) \pm 7.4(\text{lum.})$ pb

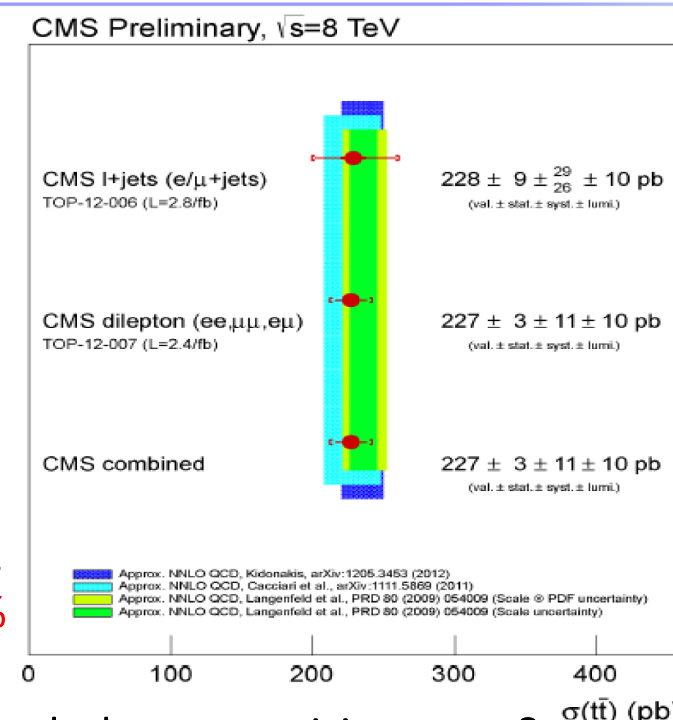
CMS, 7 TeV, l+jets, 9%

$$\sigma_{t\bar{t}} = 176 \pm 5(\text{stat.})^{+14}_{-11}(\text{syst.}) \pm 8(\text{lumi.})\ \text{pb.}$$

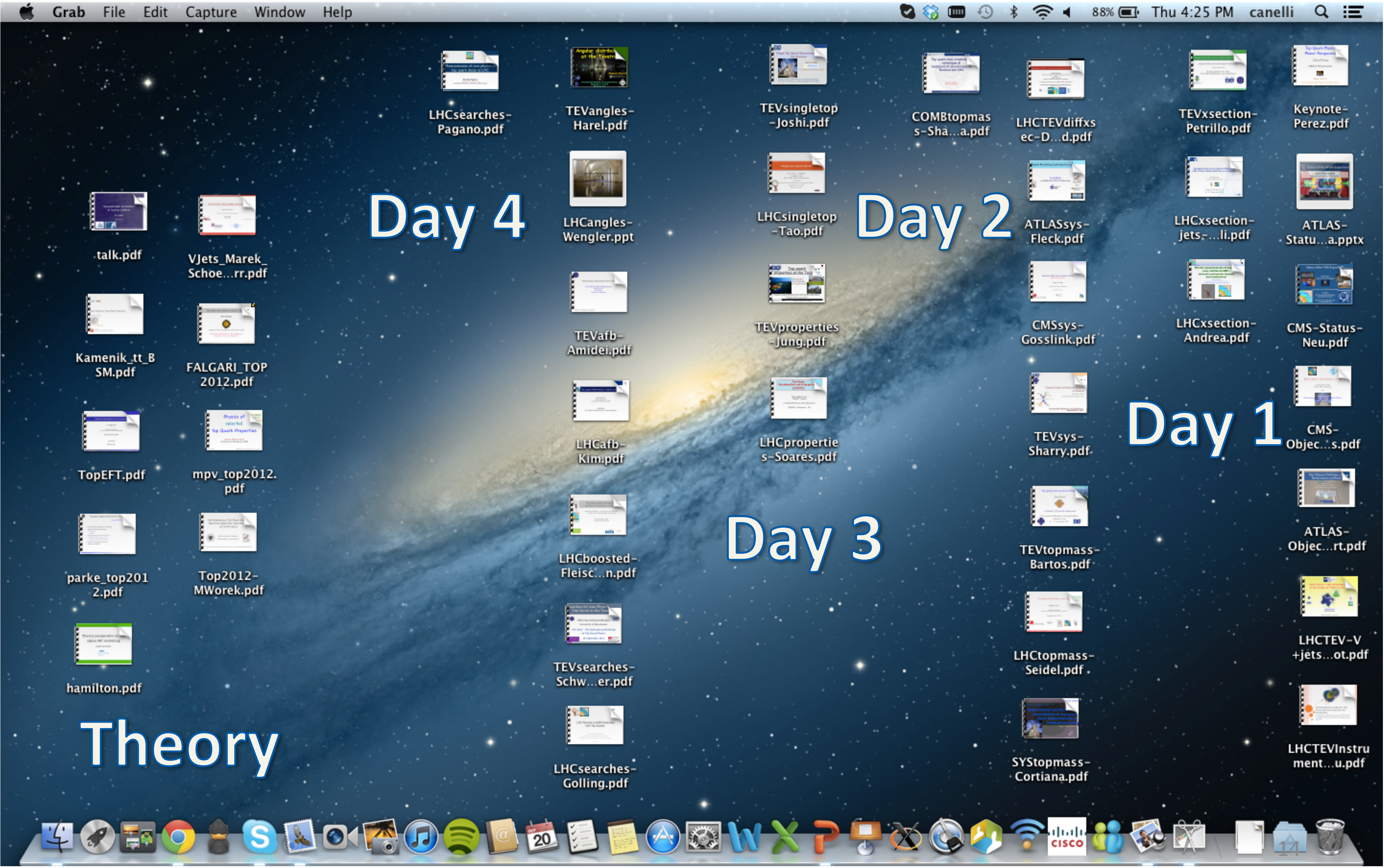
ATLAS, 7 TeV, dilepton, 10%

Combined $161.9 \pm 2.5^{+5.1}_{-5.0} \pm 3.6$

CMS, 7 TeV, dilepton, 5%



Reach theory precision soon ?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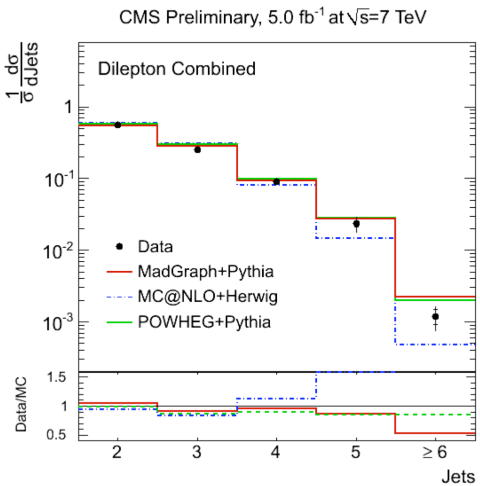
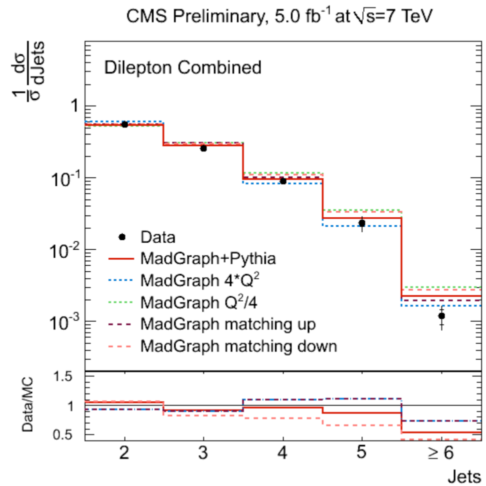
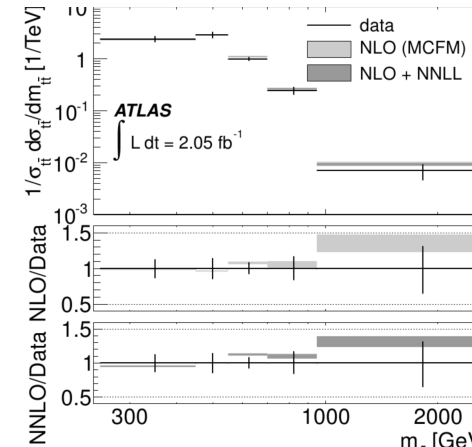
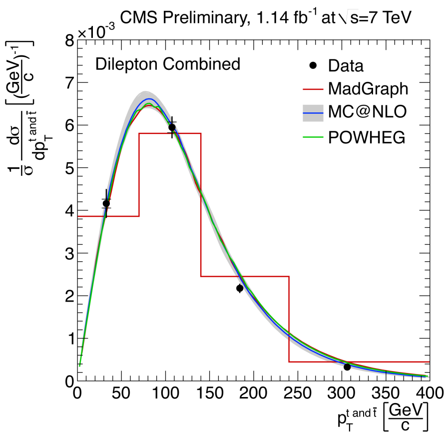
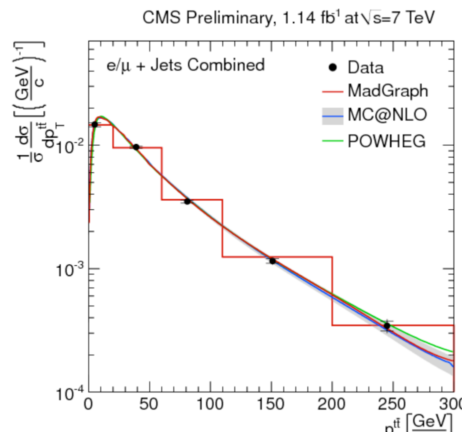
Differential Cross Section: TEV & LHC

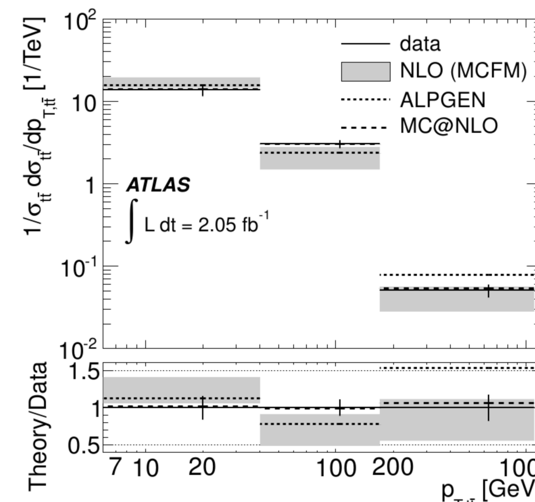






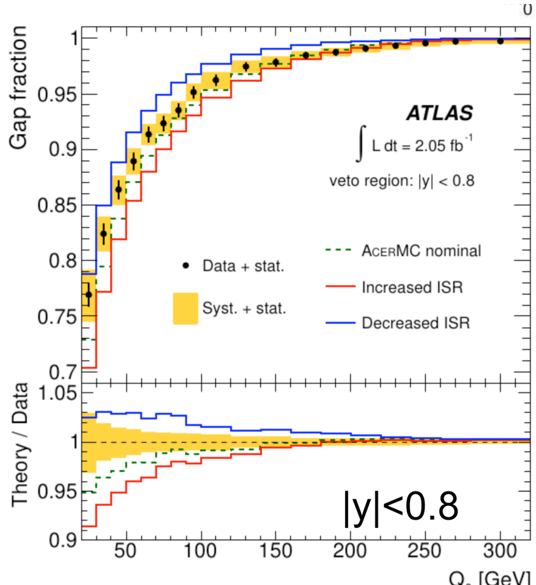


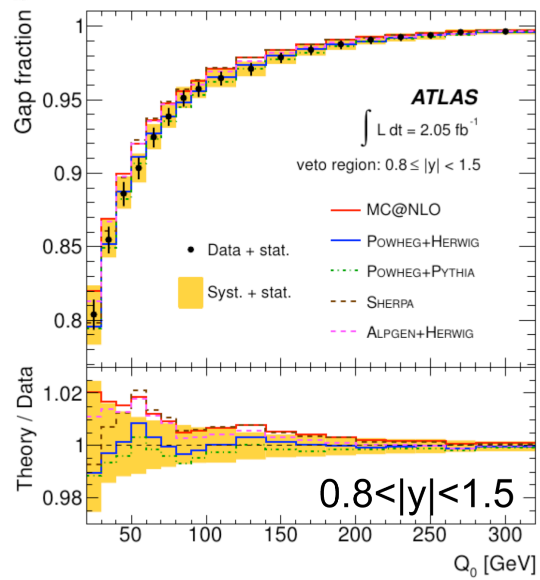


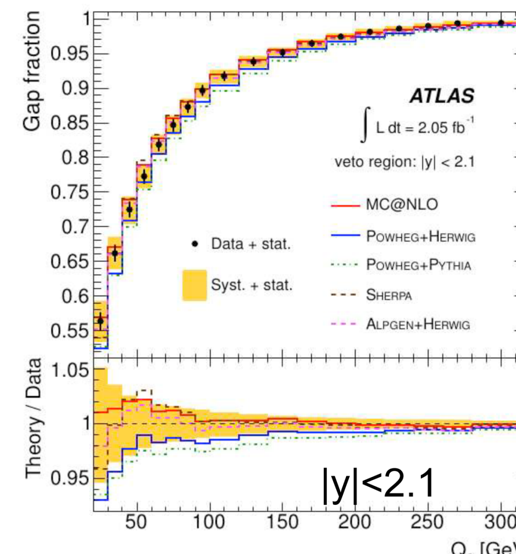


Tyler Dorland/Javier Brochero

Differential Cross Section: TEV & LHC

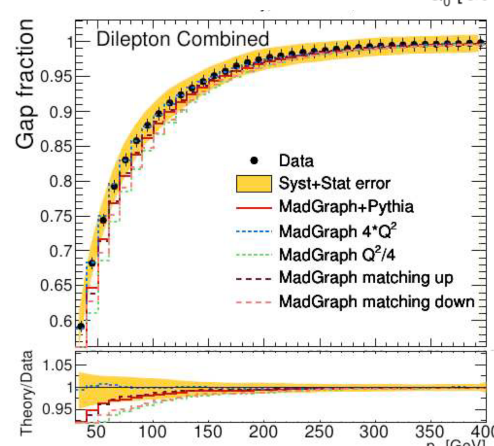


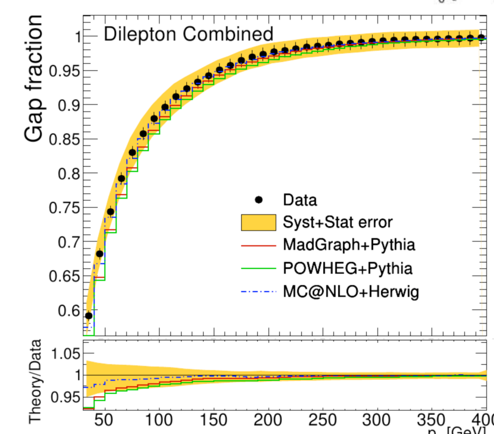




Use to tighten up model: initial model parameter, shower, higher order effects

Also shown measuremtents of ttj
And first fiducial measurements (ATLAS)





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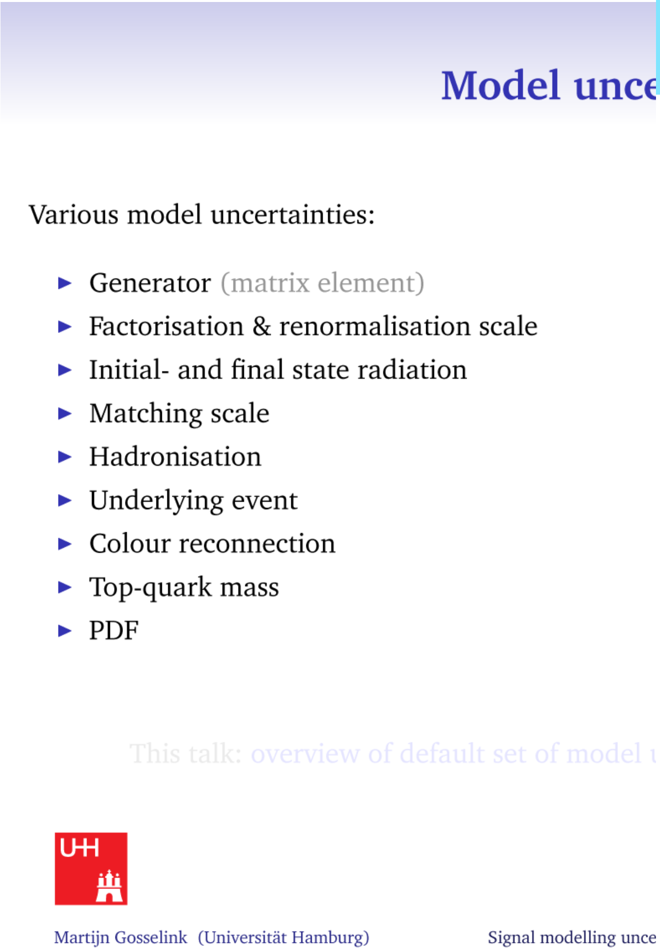
Signal Modeling: LHC

Very different classification of the same effects. Small uncertainties in agreement.



Modelling Parameters

- event generators: MC@NLO vs. POWHEG vs. ALPGEN

- parton shower: POWHEG with two different parton showers models, HERWIG and PYTHIA

- PDF: envelope of PDF sets from different collaborations according to PDF4LHC recommendation

- ISR/FSR: ACERMC interfaced with PYTHIA with different settings

- top quark mass: MC@NLO with different top quark masses

- colour reconnection: ACERMC Perugia2011 with and without colour reconnection (with new PS/MI Pythia model) and Tevatron tune A-Pro and ACR-Pro (with old PS/MI Pythia model)

Signal Modeling: LHC

Example: Top mass measurement in all-hadronic channel

Systematic uncertainty	Δm_{top} [GeV]
Method	0.4
Template statistics	0.9
MC generator	0.5
ISR/FSR	1.7
PDF	0.6
Background modeling	1.9
Jet energy scale	2.1
b-jet energy scale	1.4
b-tag efficiency scale factors	0.3
Jet energy resolution	0.3
Jet reconstruction efficiency	0.2
Total	**3.8**

Systematic uncertainty	Δm_{top} [GeV]
Calibration	0.13
b-JES	0.49
Jet energy scale	0.97
Jet energy resolution	0.15
b-tagging	0.06
Trigger	0.24
Pileup	0.06
PDF	0.06
Q^2 scale	0.22
ME-PS matching threshold	0.24
Underlying event	0.32
Color reconnections	0.15
Non-$t\bar{t}$ background	0.20
Total	**1.25**

Signal Modeling: Tevatron

Classification good enough for statistics

CDF/D0 extensive comparisons after long discussions

In conclusion: improving systematic uncertainties estimation (personal thoughts)

- Hadronization uncertainties:
  - Update jet shape studies. Use top quark events directly for the jet shapes?
- NLO generators:
  - How to estimate higher order effects?
  - Factorization and renormalization scale variation, but overlap with ISR/FSR uncertainties.
  - $t\bar{t}$ differential cross section measurement.
- ISR/FSR and p_T spectra:
  - New tune using full Tevatron statistics?
  - Constrain using experimental distribution?
- Color reconnection: estimation using the new Pythia tunes.
- Reducing double counting between systematics:
  - Higher order effect estimation may overlap with ISR/FSR uncertainty estimation and hadronisation.
  - ISR/FSR may overlap with out-of-cone energy correction in JES.

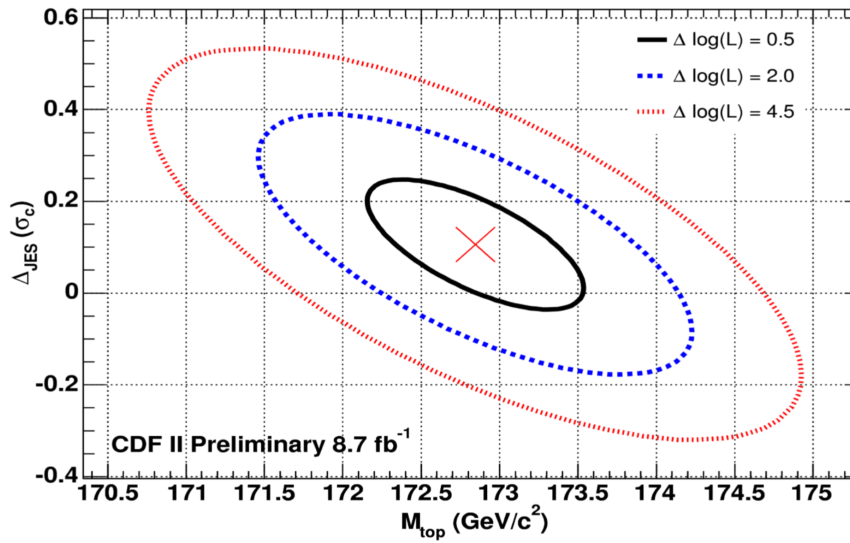
Top Quark Mass: Tevatron

Uses full dataset 8.7 fb^{-1}

Tevatron combination:

$$m_t = 173.2 \pm 0.6\,(\text{stat}) \pm 0.8\,(\text{syst})$$
$$= 173.2 \pm 0.9\ \text{GeV}/c^2$$

Uncertainty below 1 GeV/c^2!



Also showed updates on less sensitive channels

ΔM_{top} = -1.95 ± 1.11 (stat.) ± 0.59 (syst.) GeV/c^2

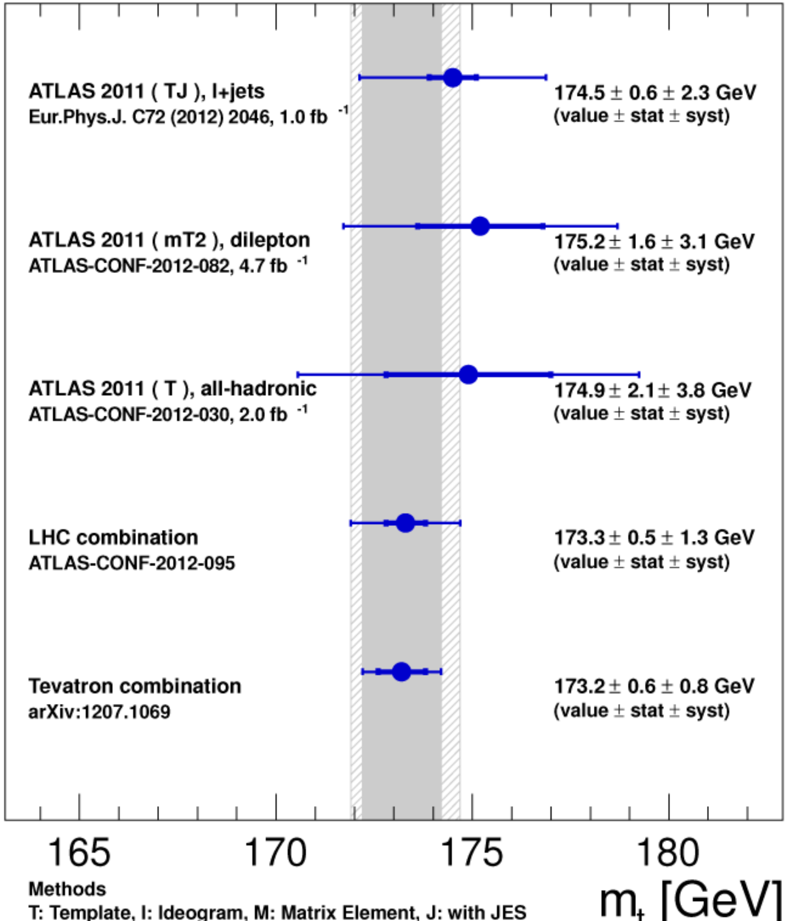
ΔM_{top} = -1.95 ± 1.26 GeV/c^2

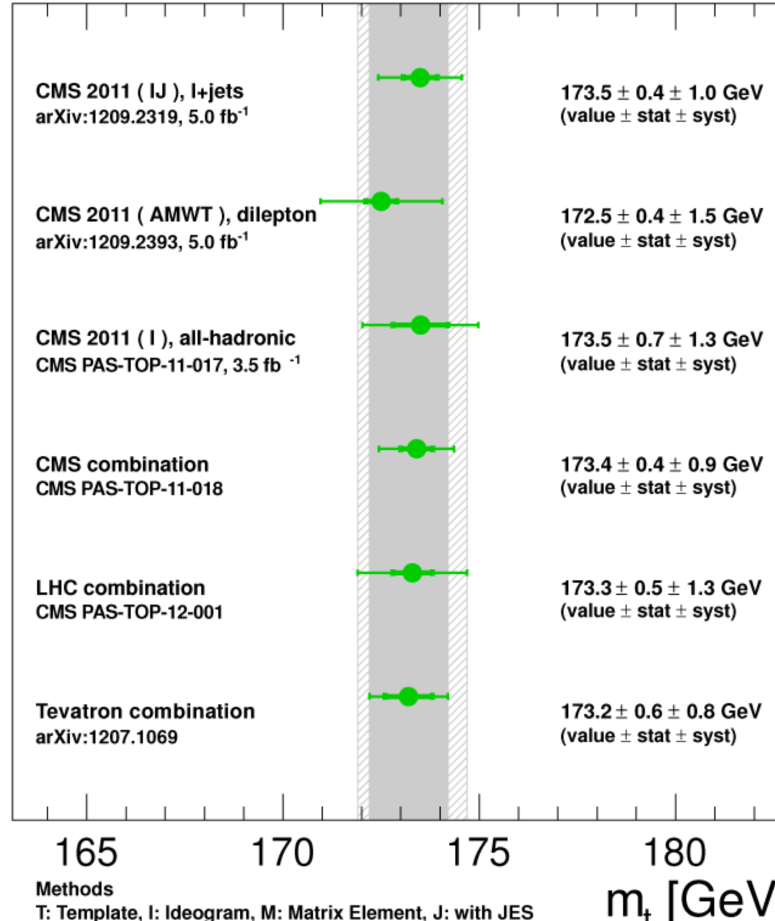
m_t = 172.85 ± 0.71 (stat.) ± 0.84 (syst.)

= 172.85 ± 1.10 GeV/c^2

Pavel Bartos

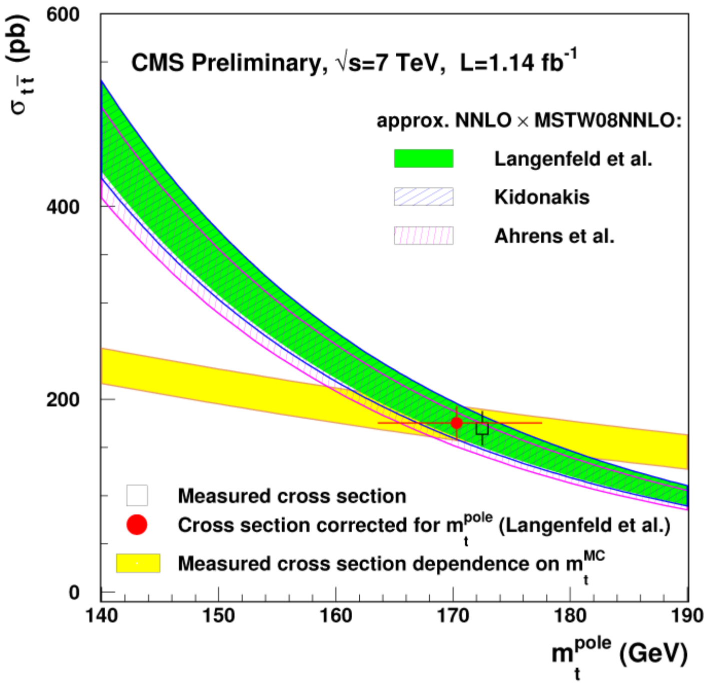
Top Quark Mass: LHC

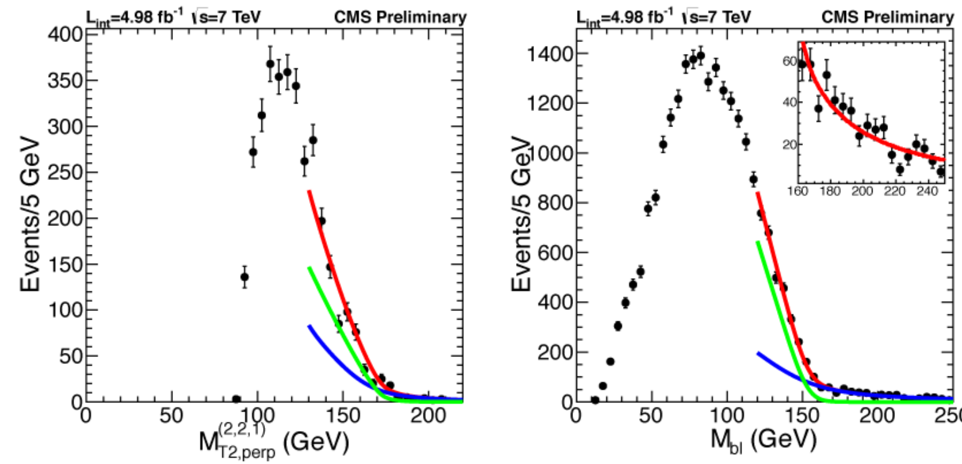




How more precise can we get ? Definition !

Top Quark Mass: LHC





$$m_t = 173.9 \pm 0.9\ (\text{stat})^{+1.2}_{-1.8}\ (\text{syst})\ \text{GeV}$$

Top mass difference (CMS, 4.96 fb^{-1}, 7 TeV)

$$\Delta m_t = -0.44 \pm 0.46\ (\text{stat}) \pm 0.27\ (\text{syst})\ \text{GeV}$$

Top Quark Mass Uncertainties

Talk roadmap

Systematic uncertainties on top-quark mass measurements

Good starting point for combining and improving the systematics in top quark mass:

- Minimize double counting in each measurement
- Minimize correlations among experiments

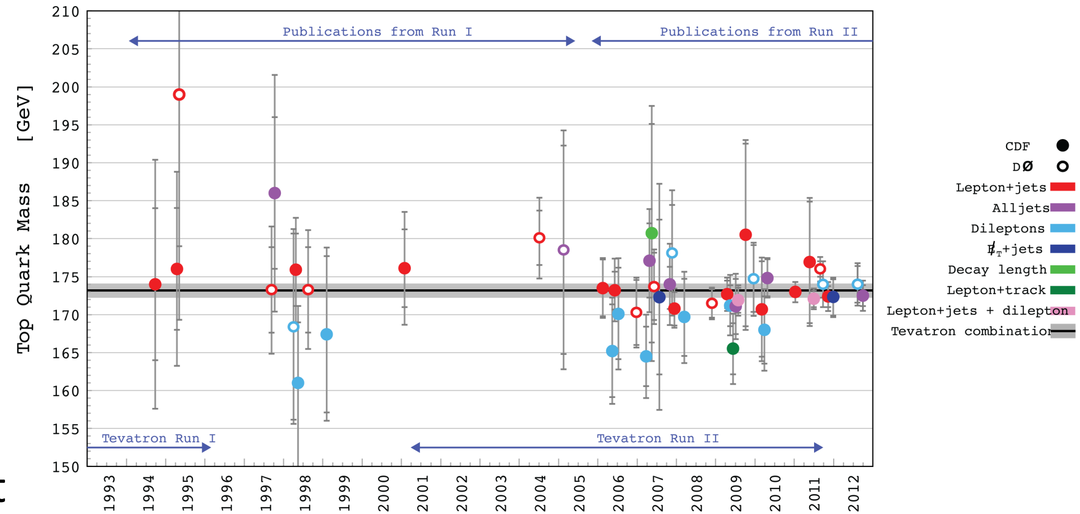
- Theory uncertainties:
  - Signal simulation
  - Event modelling and environment
- Experimental uncertainties
  - Physics objects and detector modelling
    - identification, reconstruction, and calibration
  - Energy scales
    - (in particular for jets)

- How the systematics uncertainties are evaluated by different experiments
- What are the techniques adopted and/or prospects to reduce the uncertainties

I will discuss the uncertainties on direct m_{top} determination. m_{top} extraction from x-section will have in addition theoretical uncertainties related to the x-sec calculation (PDF, scales)

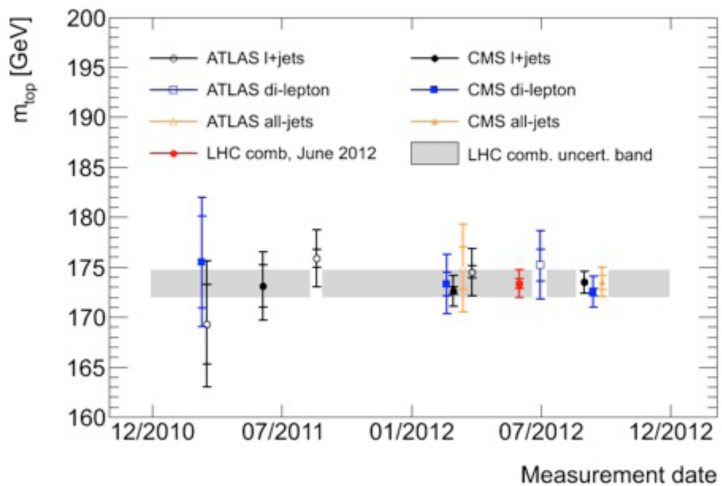
Top Quark Mass Combination

Methodology for Tevatron and LHC combinations



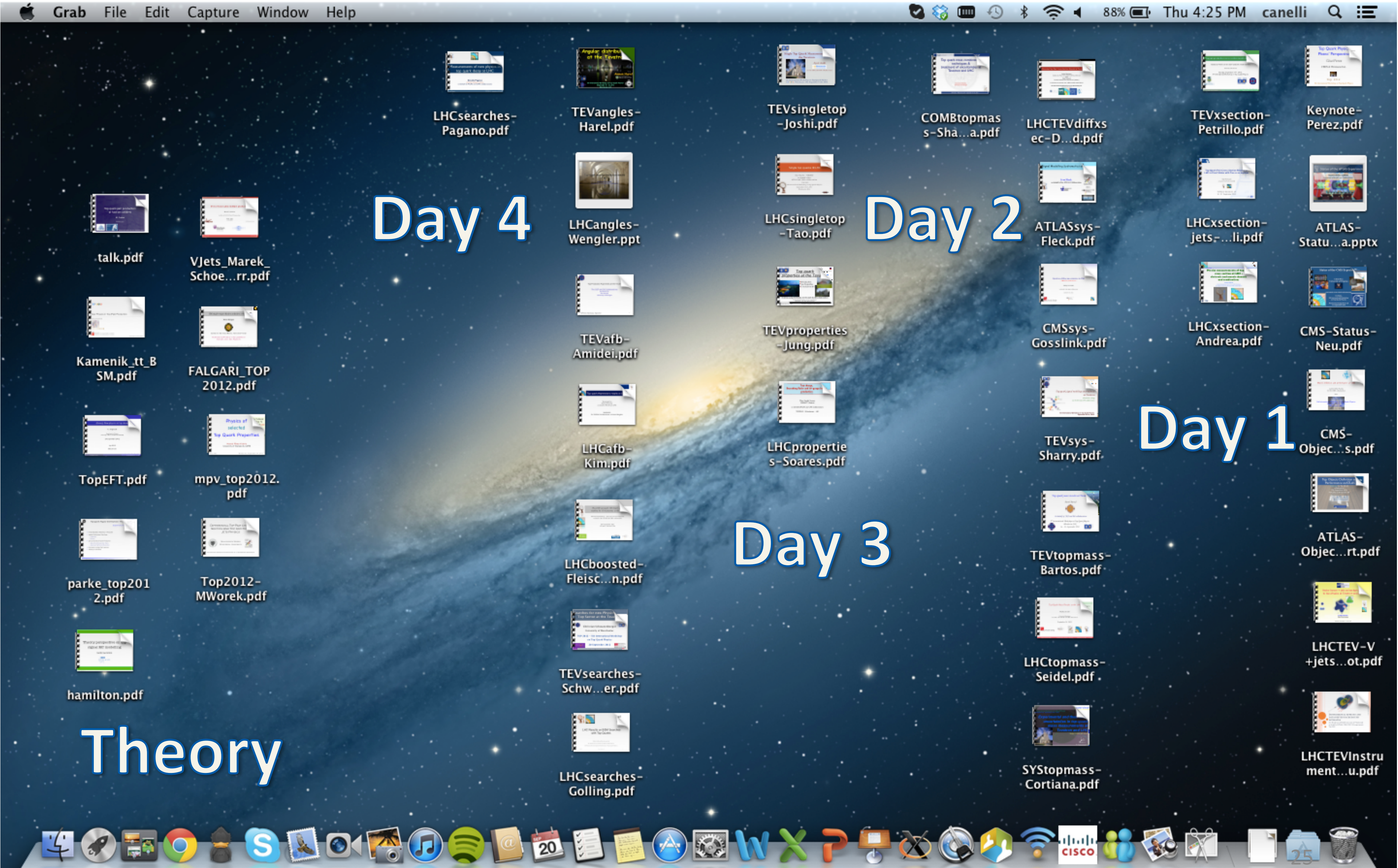
Tevatron improved 25% wrt best result

LHC 9%



World combination in Top 2013 ?

Lisa Shabalina



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Day 3
Theory
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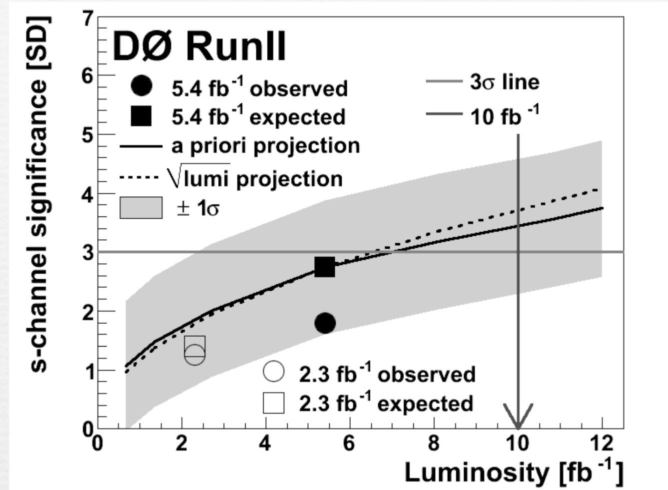
Single Top: Tevatron

Perspectives

- Legacy with full dataset: s-channel
  - Only 4X higher production rate at LHC with even more background



- Till Now ::
  - DØ : **3.0σ** of expected sensitivity with 5.4 fb^{-1} of data.
  - CDF : sensitivity not calculated but about **3.0σ** with 7.5 fb^{-1} of data.

- With full dataset ::
  - Evidence per experiment possible
  - Observation with **DØ + CDF combination**

	tb [pb]	tqb [pb]	tW [pb]
Tevatron (1.96 TeV)	1.04 ↓x4.4	2.26 ↓x28	0.3 ↓x26
LHC (7 TeV)	4.59	64.2	7.8

Single Top: LHC

$\sigma = 67 \pm 4(\text{stat.}) \pm 3(\text{syst.}) \pm 4(\text{theo.}) \pm 2(\text{lumi.})$ **pb**

$V_{tb} = 1.02 \pm 0.05 \pm 0.02$ (theo.)

$V_{tb} > 0.92$ @95%CL for V_{tb} in [0,1]

CMS, 7 TeV

$\sigma = 95 \pm 2(\text{stat.}) \pm 18(\text{syst.})$ **pb**

$V_{tb} = 1.04 \pm 0.11$

$V_{tb} > 0.80$ @95%CL for V_{tb} in [0,1]

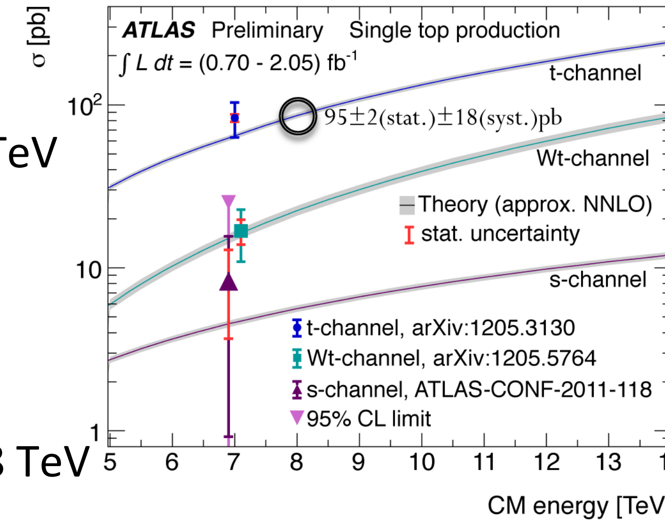
ATLAS, 8 TeV

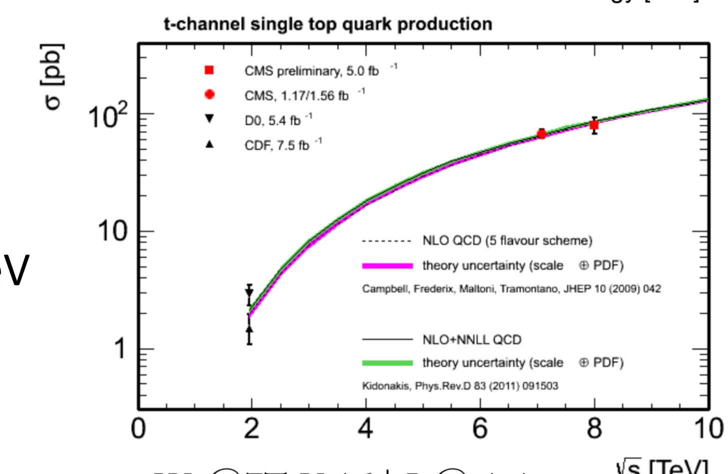
$\sigma = 80 \pm 6(\text{stat.}) \pm 11(\text{syst.}) \pm 4(\text{lumi.})$ **pb**

$V_{tb} = 0.96 \pm 0.08 \pm 0.02$ (theo.)

$V_{tb} > 0.81$ @95%CL in [0,1]

CMS, 8 TeV





Wt@7TeV 16±5 @ 4.4σ

Duc Bao Tao

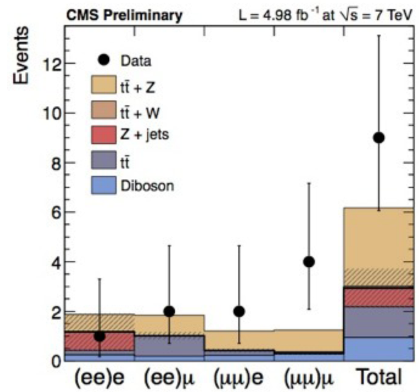
(some) Top Properties: LHC

Top charge -4/3e excluded

R>0.85 @ 95% CL

ttV, ttgamma first cross sections measurements

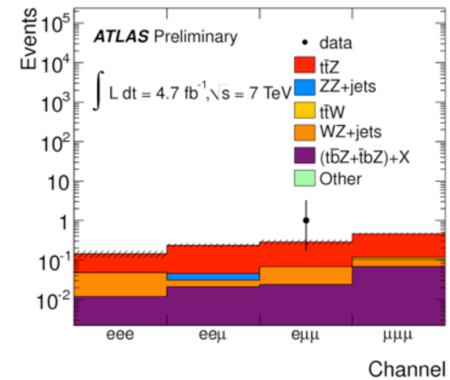
- 9 events (2.9±0.8 expected bkg)



$\sigma_{ttZ} = 0.30^{+0.14}_{-0.11}(\text{stat})^{+0.04}_{-0.02}(\text{syst})$ pb

significance: 3.66 σ
(p-value 0.0001)
(NLO pred: 0.1387 pb)

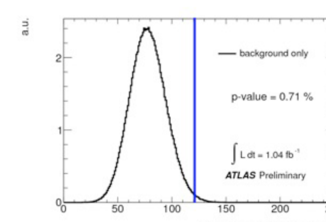
- 1 event (exp. 1.13±0.06 SM, $0^{+1.16}$ fakes)



σ_{ttZ} <0.71 pb
at 95% CL

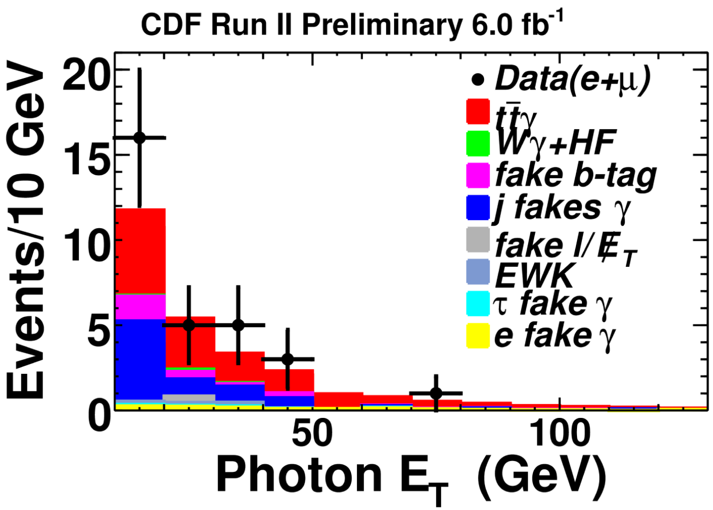
σ . BR = 2±0.5(st)±0.7(sys)±0.08(lumi) pb, for $p_T(\gamma)$>8 GeV
NLO prediction: 2.1±0.5 pb

Observed vs expected:
background-only
hypothesis significance 2.7 σ



Mara Senghi Soares

(some) Top Properties: Tevatron



- Presented recent measurements of top properties at the Tevatron:

$R = \frac{\mathcal{B}(t\to Wb)}{\mathcal{B}(t\to Wq)}$	Value (stat+syst)
$\sigma_{p\bar{p}\to t\bar{t}}$ (pb)	7.5 ± 1.0
R	0.94 ± 0.09
$\lvert V_{tb}\rvert$	0.97 ± 0.05

$$\Gamma_t = 2.00 \pm^{0.47}_{0.42}\ \text{GeV}$$

$$\tau_t = 3.29 \pm^{0.90}_{0.63} \cdot 10^{-25}\ \text{s}$$

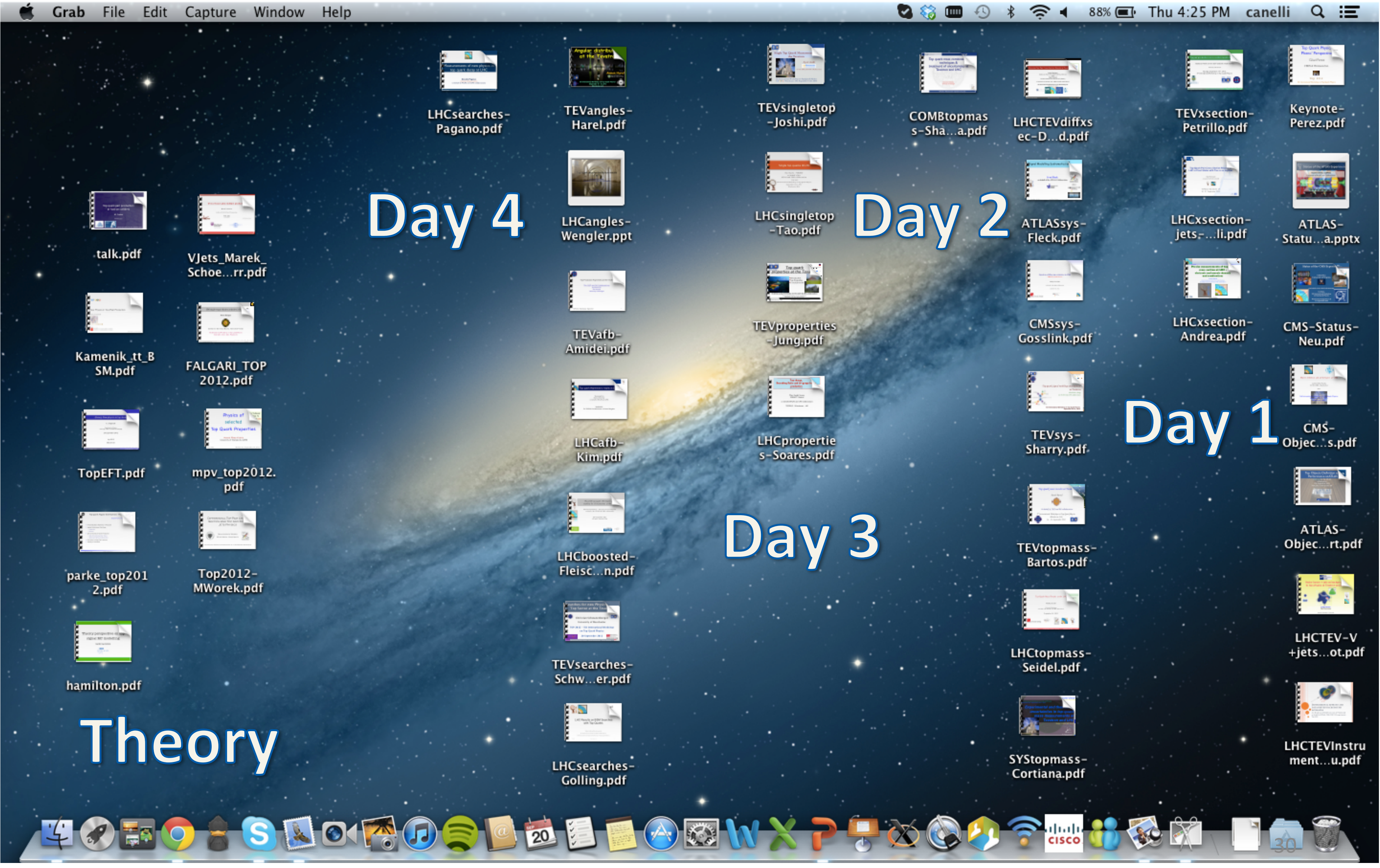
$$BR(t \to \tau\nu b) = 0.120 \pm 0.030(stat.)^{+0.022}_{-0.019}(syst.) \pm 0.007(lum.)$$

$$\sigma(p\bar{p} \to t\bar{t}\gamma) = 0.18 \pm 0.07(\text{stat.}) \pm 0.04(\text{sys.}) \pm 0.01(\text{lum.})\ \text{pb}$$

No indication for Lorentz Invariance Violation

Outlook:

- More precise results in the near future, *but:*
  - Concentrate on results which are **competitive or complimentary** to LHC



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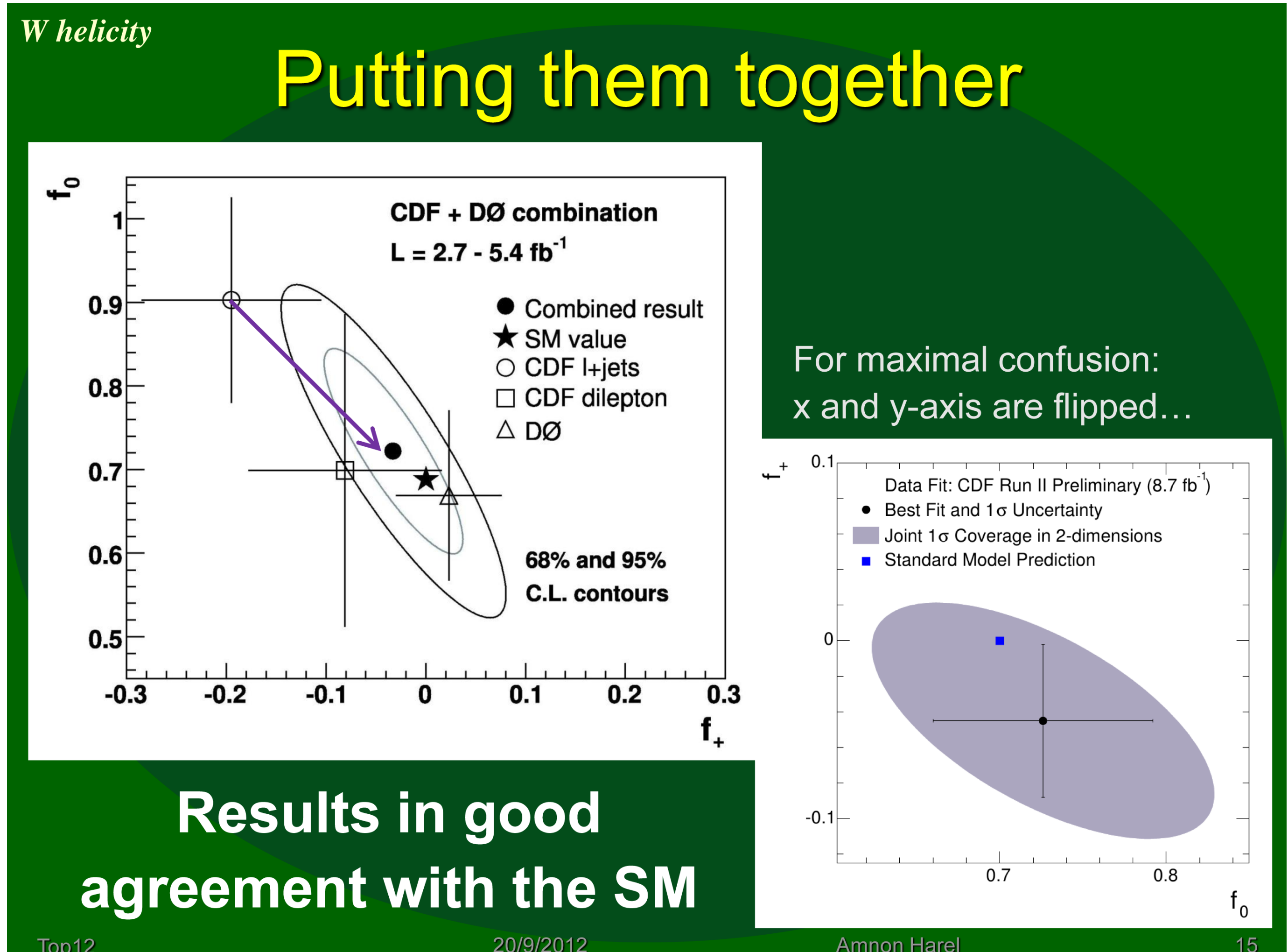
Top Properties (angles): Tevatron

Full dataset used in W helicity measurement (~10%)

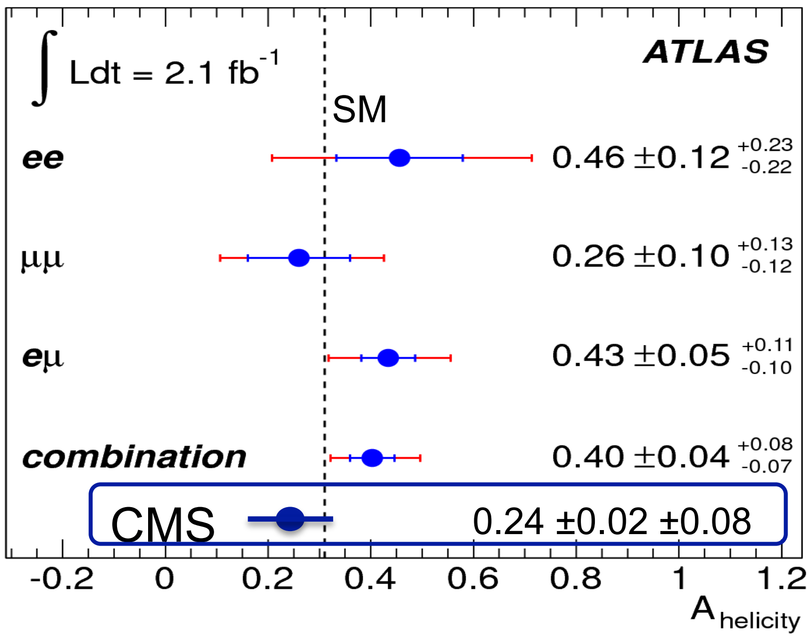
Evidence for spin Correlations

Indications that tops are not 100% polarized

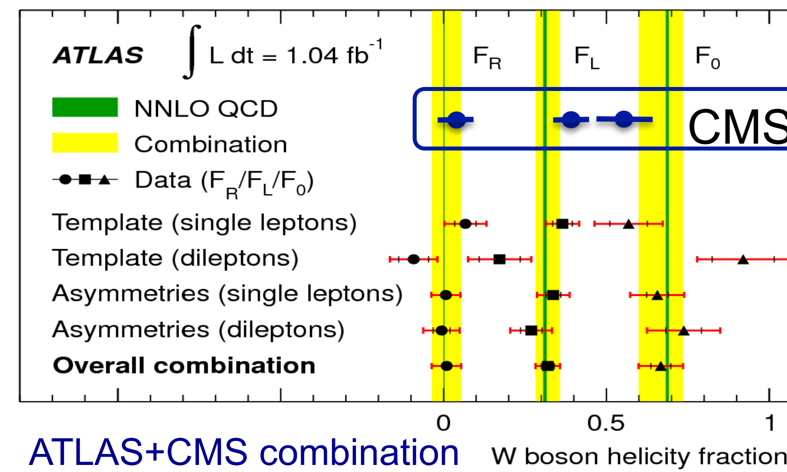


Top Properties (angles): Tevatron

$t\bar{t}$ spin correlations

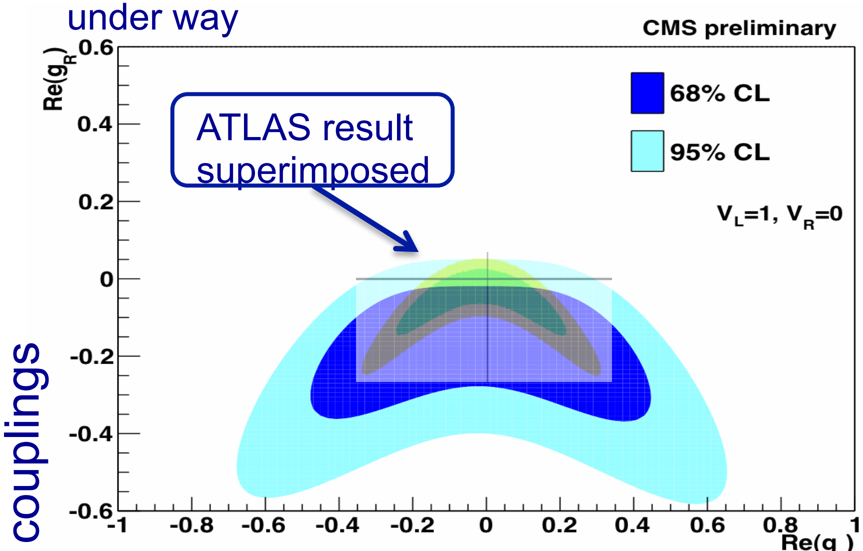


W helicity fractions



ATLAS+CMS combination under way

Limits on anomalous couplings



top polarization

CMS: $P_n = -0.009 \pm 0.029 \pm 0.041$

SM: P=0

ATLAS: $\alpha_\ell p = -0.060 \pm 0.018(\text{stat})^{+0.046}_{-0.064}(\text{syst})$

Top Production Asymmetry: Tevatron

summary

in l+jets

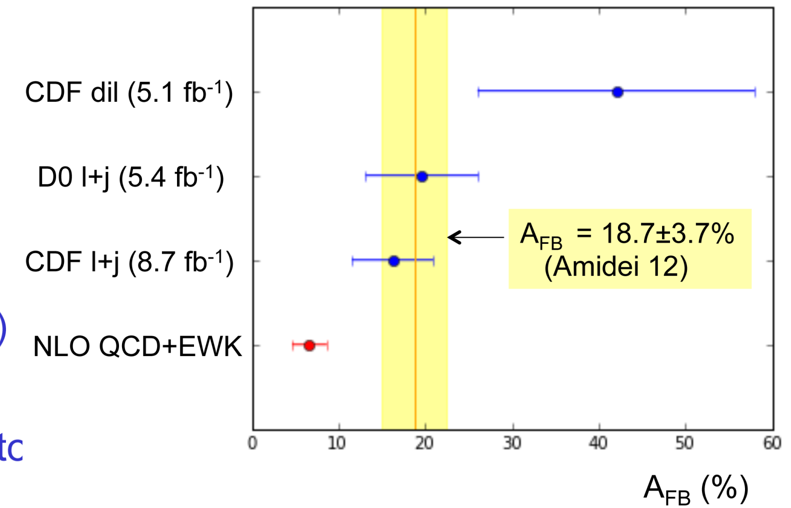
- inclusive asymmetry in agreement CDF+D0
  - informal combo A^{tt}_{FB} ~ (19 ± 4)%
  - eventual combined δA_{FB} ~ 3.0%
- linear M_{tt} and Δy dependence of A_{fb} in tt system (CDF)
  - slopes 3σ from zero and 2σ larger than NLO prediction
- measured $2\text{-}3\sigma$ asymmetry in the lepton alone (D0 partc
- p_t(tt) dependence agrees with Poweg/Pythia + offset

in dileptons

- no significant A_{FB} in any lepton variable (D0)
  - tension in A^{l}_{FB}? but combined A^{l}_{FB} agrees with expected R
- significant A_{FB} in reco tt Δy (CDF)
  - tension w D0 dil leptons?

something is there ?

- picture still incomplete, much work still to do



Top Production Asymmetry: LHC

Result summary

- ATLAS

top A_C (combined)= 0.029±0.018(stat.)±0.014(syst.)
lepton A_C (dilepton) = 0.023±0.012(stat.)±0.008(syst.)

- CMS

top A_C (lepton+jets) = 0.004±0.010(stat.)±0.012(syst.)

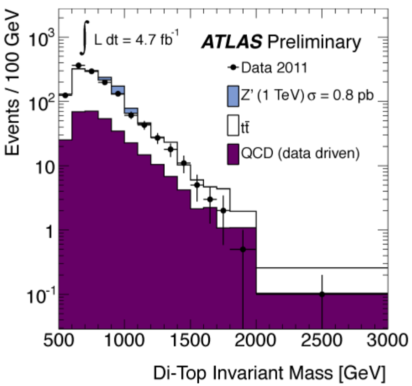
A_C in SM ≈ 0.01

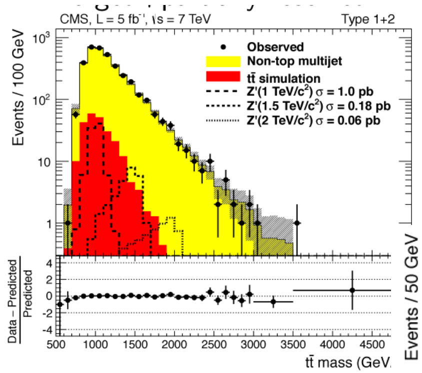
(J.H. Kühn and G. Rodrigo)

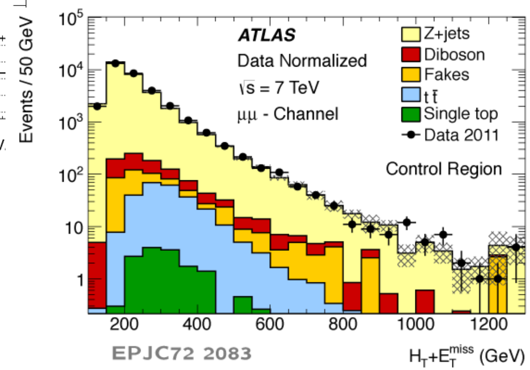
Needs more data
AND reducing
systematic uncertainties

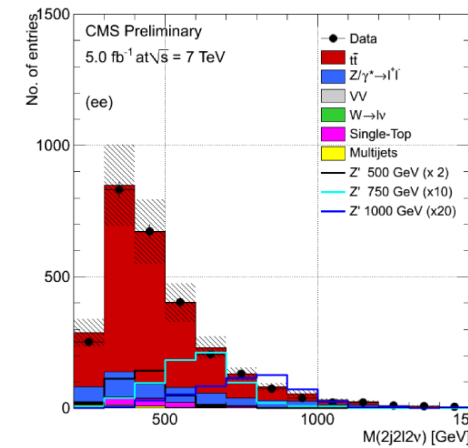
- Results correspond to 5 fb^{-1}
- All are in agreement with the SM expectations within uncertainties.

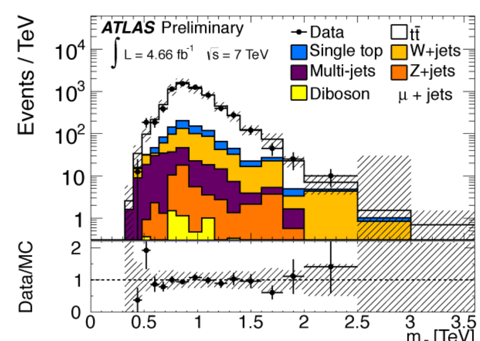
Boosted Top Techniques in m_{tt} Searches

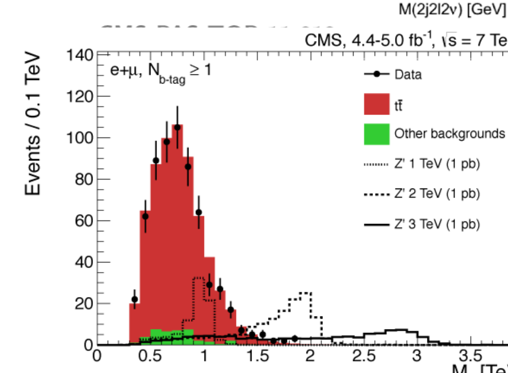












Techniques in good shape

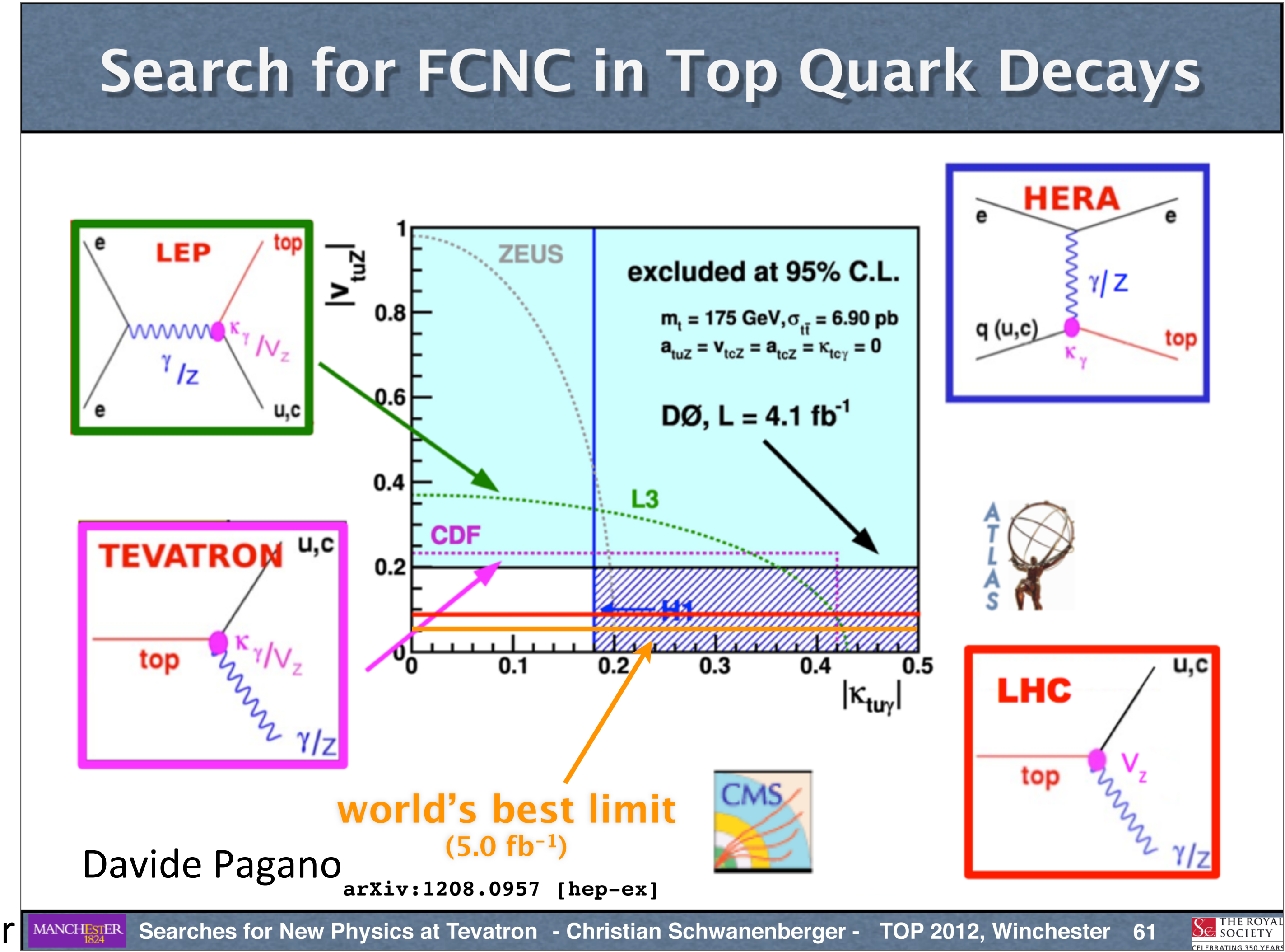
Searches in all possible channels

Benchmark scenarios excluded to about ~ 2TeV

Sebastian Fleischmann

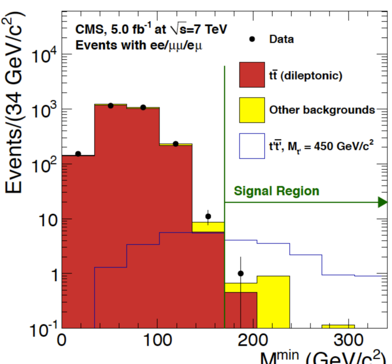
Searches in the Top Sector: Tevatron

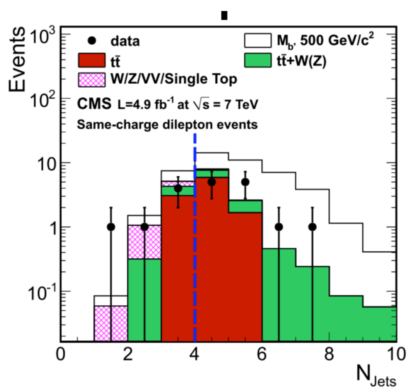
Searches presented: tt resonances, chromophilic Z', tj resonance, stop pair production, dark matter in top pair production, monotopic dark matter, FCNC in top decays

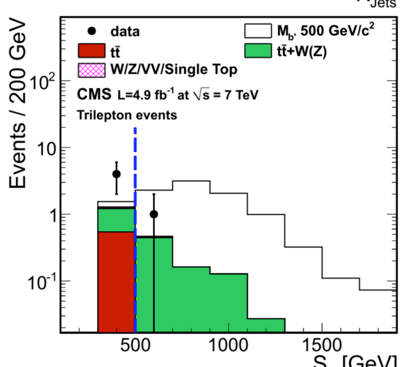


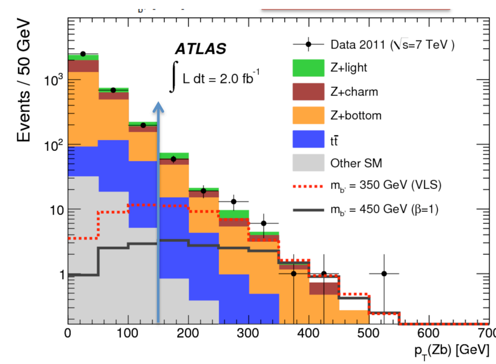
Searches in the Top Sector: LHC

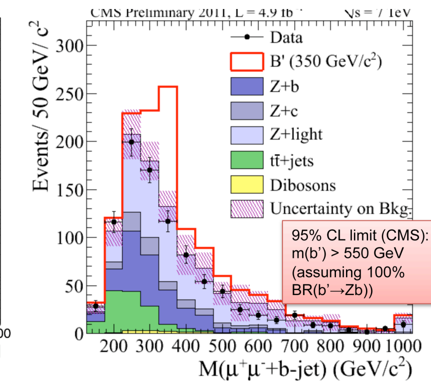
Searches presented: 4th generation and Vector-Like Quarks, same-sign (SS) top (tt), T5/3, 4-top, Other top partners (tt+ETmiss), Top+jet resonance in tt+jet events, W'→tb, FCNC in single top-quark production

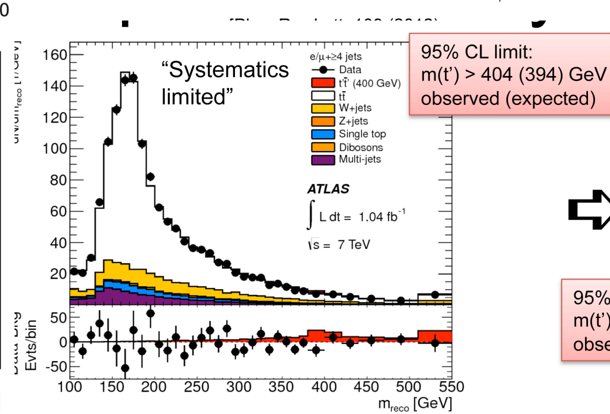


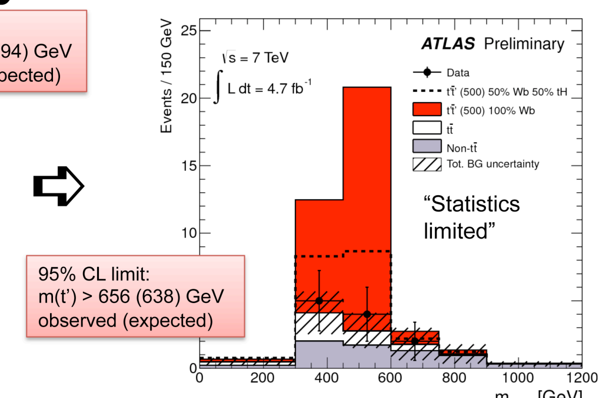












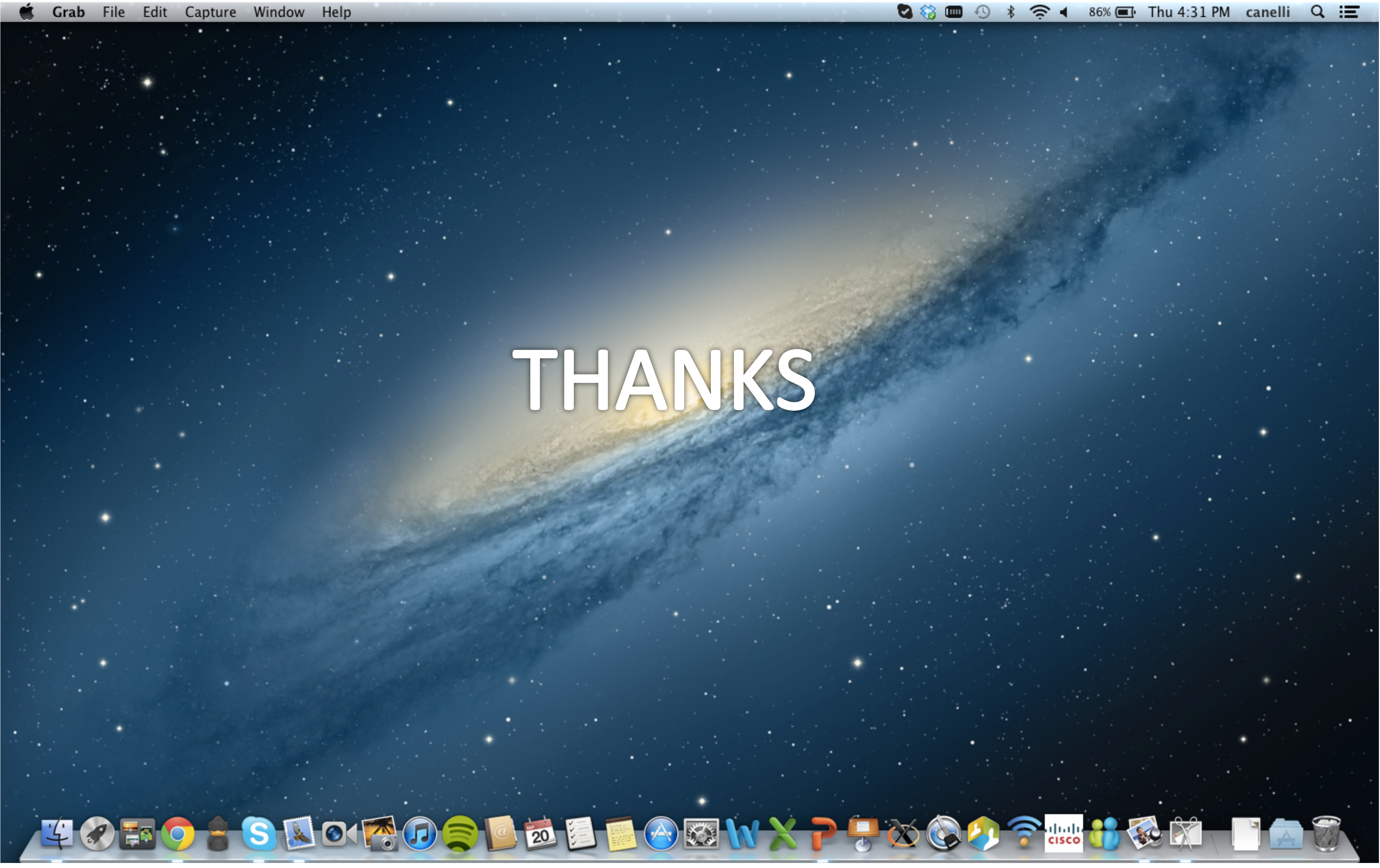
Summary

- Impressive results !
  - LHC 7 and 8 TeV and Tevatron full dataset
- The SM top quark
  - Top mass measurements from LHC comparable to Tevatron - precision ~1 GeV
  - Cross sections
    - ttbar more precise (dilepton 5%), almost compable to theory
    - Single top 10%
  - Differential cross section: keep them coming
    - Already being used in improving signal modeling uncertainties
  - Many measurements of other properties are now systematically limited: W helicity, top polarization, spin correlations
- Systematic uncertainties: lots to do
- Many stringent direct searches for new physics

Top 2013 wishlist

- Top quark mass
  - Definition (different measurement technique)
  - All channels in each experiment
  - World combination (<1 GeV?)
- Cross section ttbar and single top
  - All measurements in each channel
  - Theory uncertainty (~3%)
- Differential cross sections
- Top properties
  - Include single top samples
- More searches

This relies on improving our systematic uncertainties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