UNIVERSITY OF TEXAS ARLINGTON

First LHC Results

What can they tell us about Standard Model

... and beyond

Fred Olness

SMU

Conspirators:
P. Nadolsky, K. Park, M. Guzzi, Z. Liang
I Schienbein, J.-Y. Yu, S. Berge, K.Kovarik
J. Owens, J. Morfin, C. Keppel, ...

Fourth ATLAS Physics
Workshop of the Americas
August 9 - 11, 2010.

The "Standard Model" Game … 40 Years & Counting

Fields

Symmetry

Lagrangian

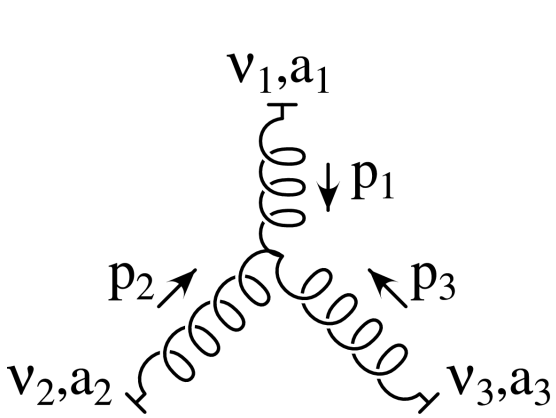
Perturbation Theory Rules

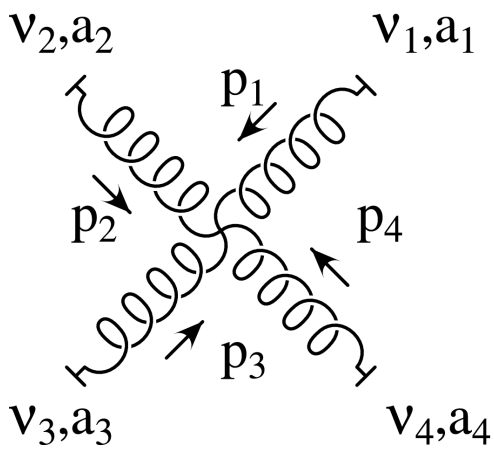
Greens Functions

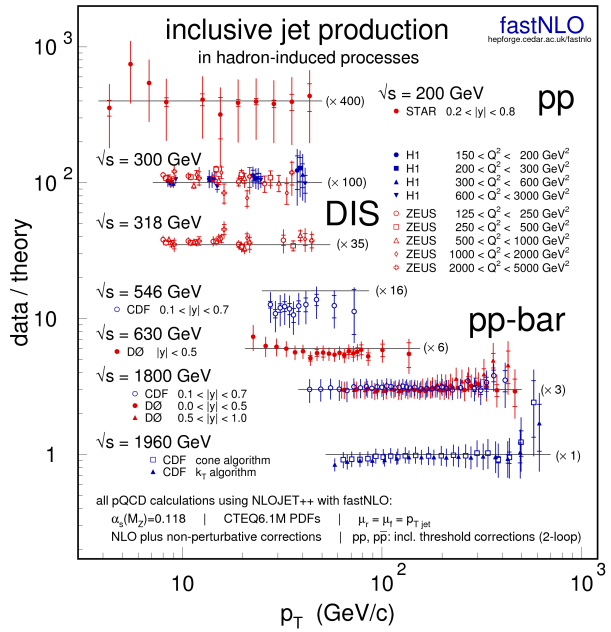
S-Matrix

Cross sections Observables

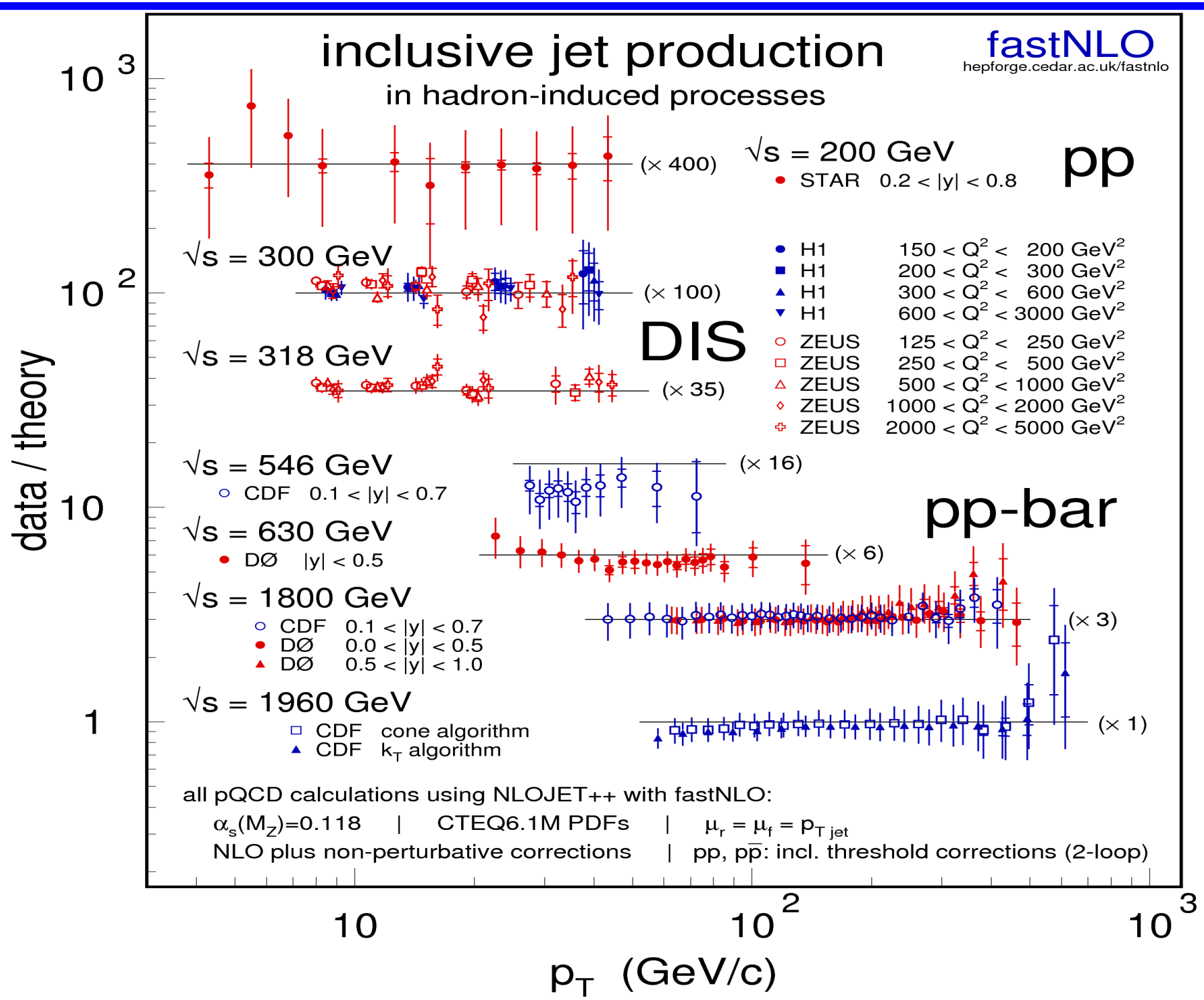
$$\mathcal{L}_{\mathrm{QCD}} = \bar{\psi}_i \left(i\gamma^\mu (D_\mu)_{ij} - m\,\delta_{ij}\right)\psi_j - \frac{1}{4} G^a_{\mu\nu} G^{\mu\nu}_a$$



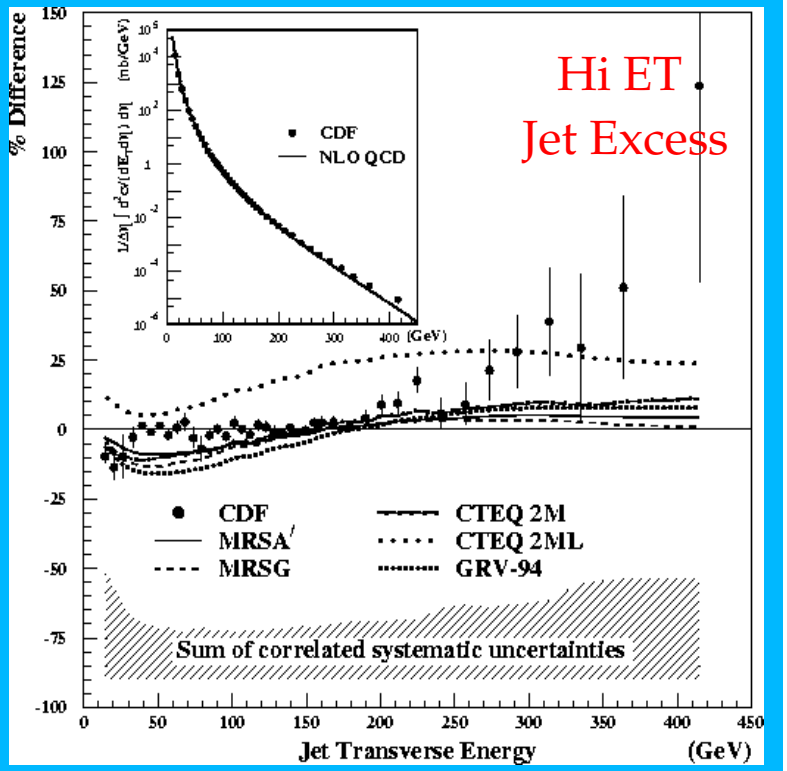




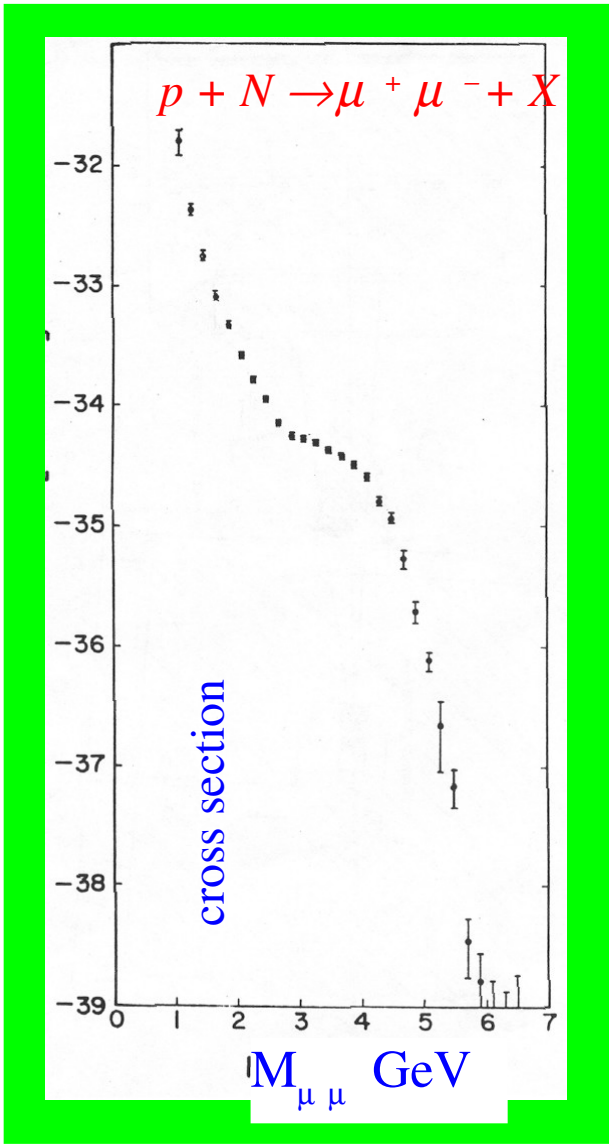
Standard Model does a remarkable job!!!

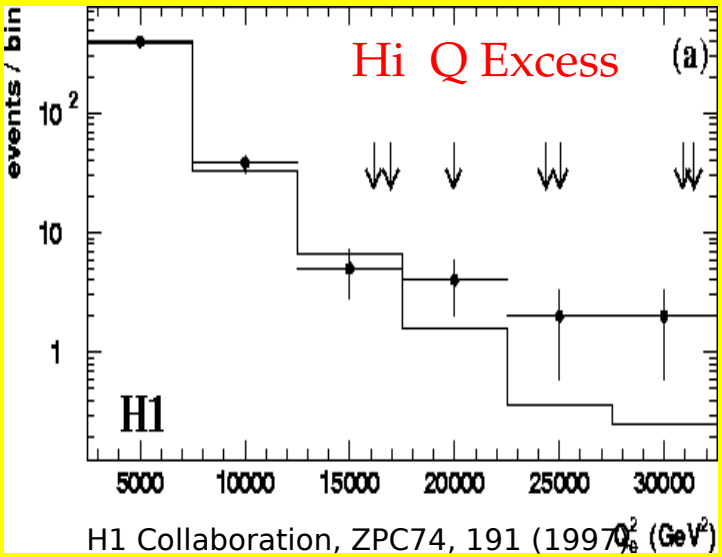


The LHC Game: Can you find the Nobel Prize???



CDF Collaboration, PRL 77, 438 (1996)



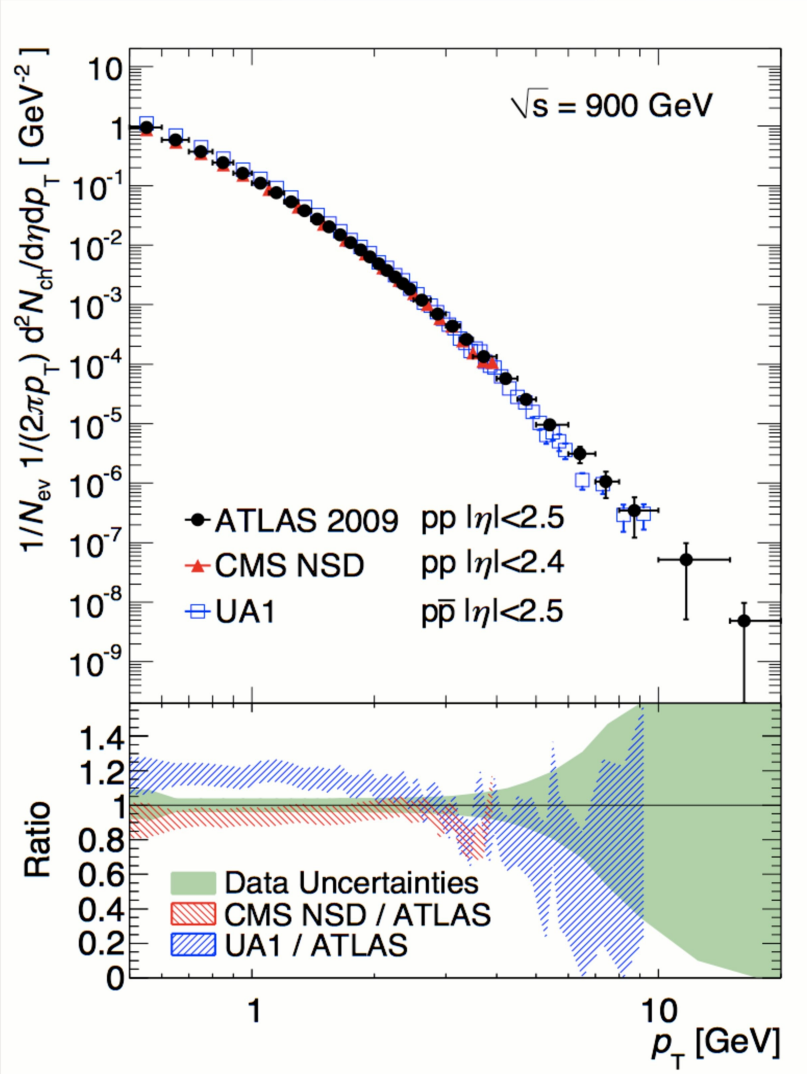


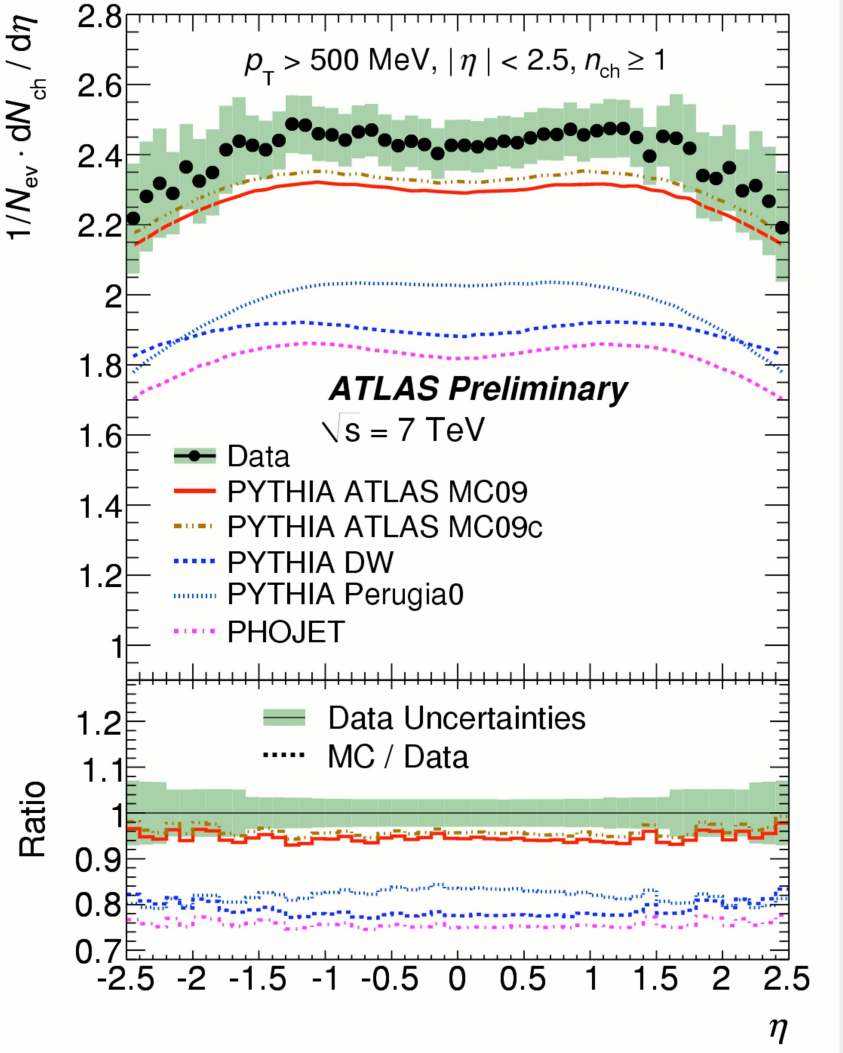
H1 Collaboration, ZPC74, 191 (1997)
ZEUS Collaboration, ZPC74, 207 (1997)

How accurately can we extrapolate to the LHC???

Is the Log[7 TeV/ 2 Tev] a big number???

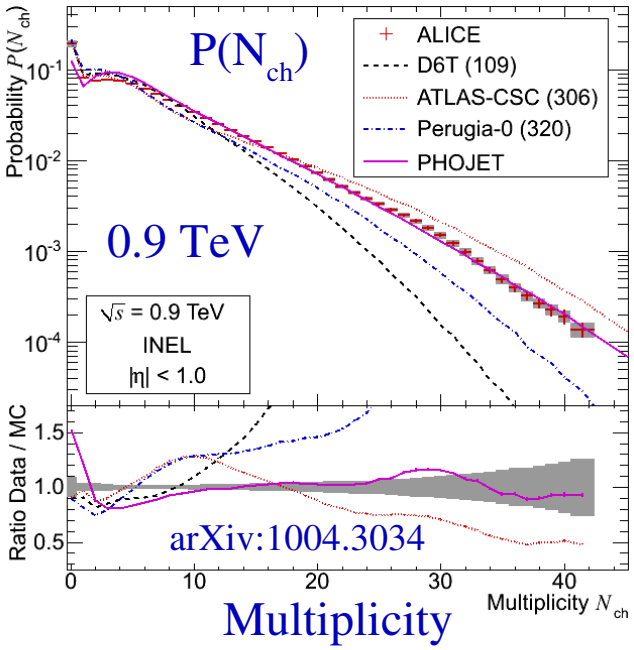
Charged Particle Multiplicities at √s=0.9, 7 TeV

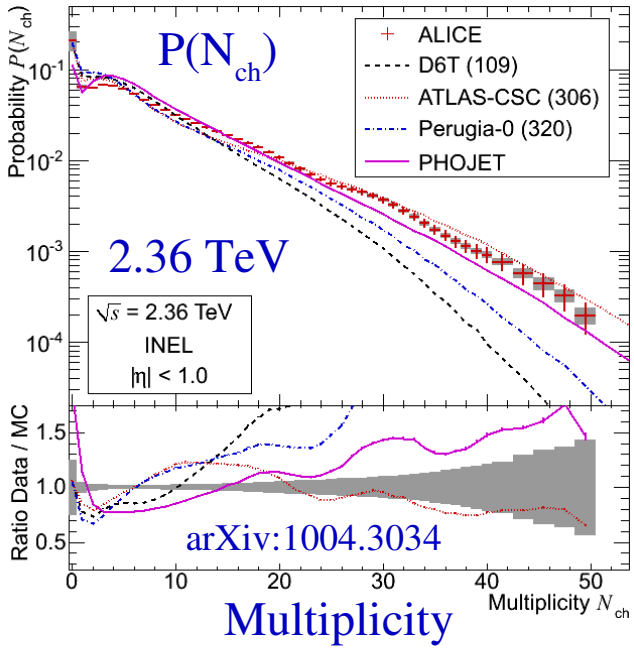


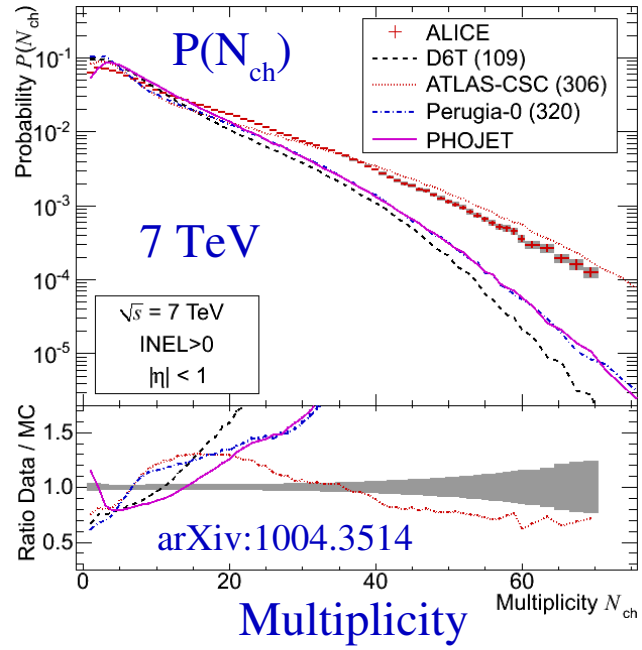


Monte Carlo underestimates the track multiplicity seen in ATLAS

$P(N_{ch})$ Comparison to Monte Carlo







Phojet

Provides a good description at 900 GeV
Fails at 2.36 and 7 TeV

Pythia Atlas CSC

Fails at 0.9 TeV

Reasonably close at 2.36 and 7 TeV but deviations around 10-20

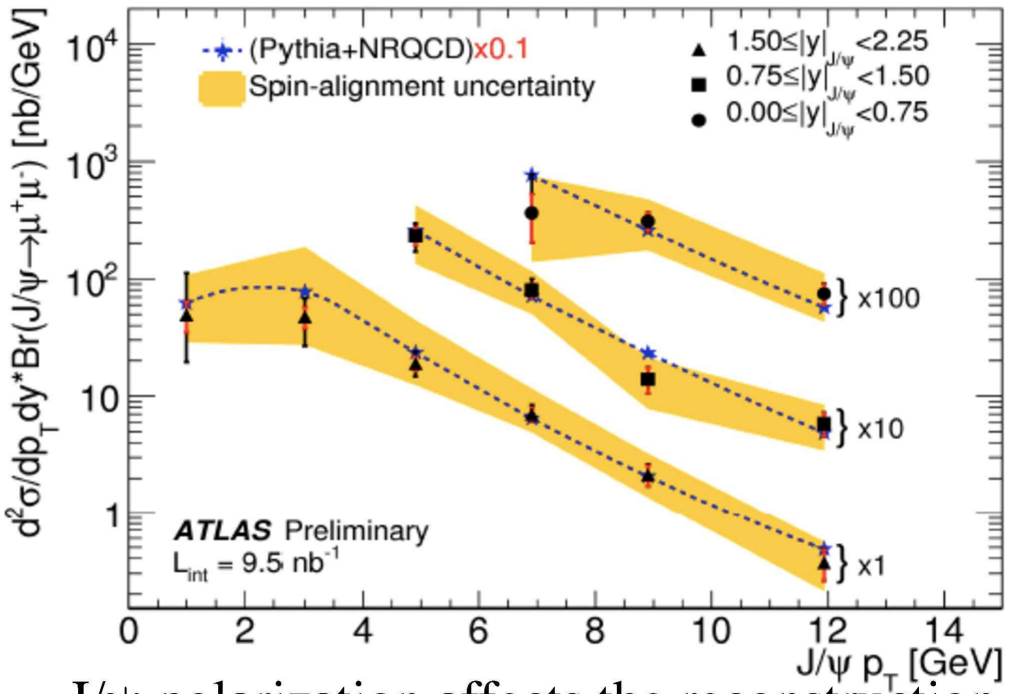
Pythia D6T & Perugia-0

far from the distribution at all energies

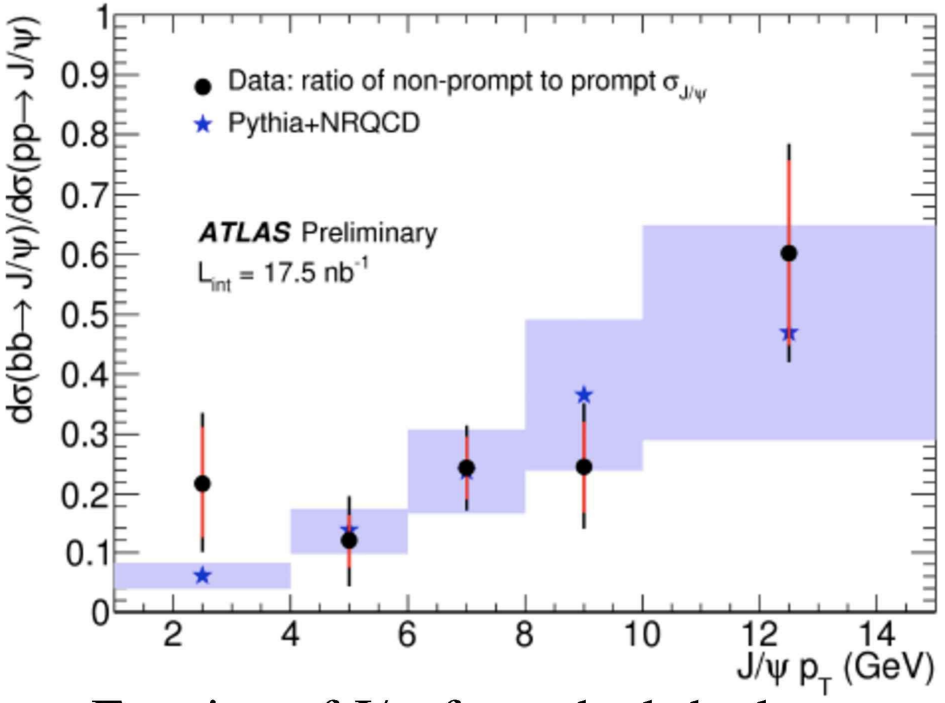
Production in pp interactions

LHC experiments have started to measure the b cross section at $\sqrt{s} = 7$ TeV

ATLAS J/ψ inclusive and from b-hadrons



J/ψ polarization affects the reconstruction efficiencies. Shape agree with a model but not the absolute value.



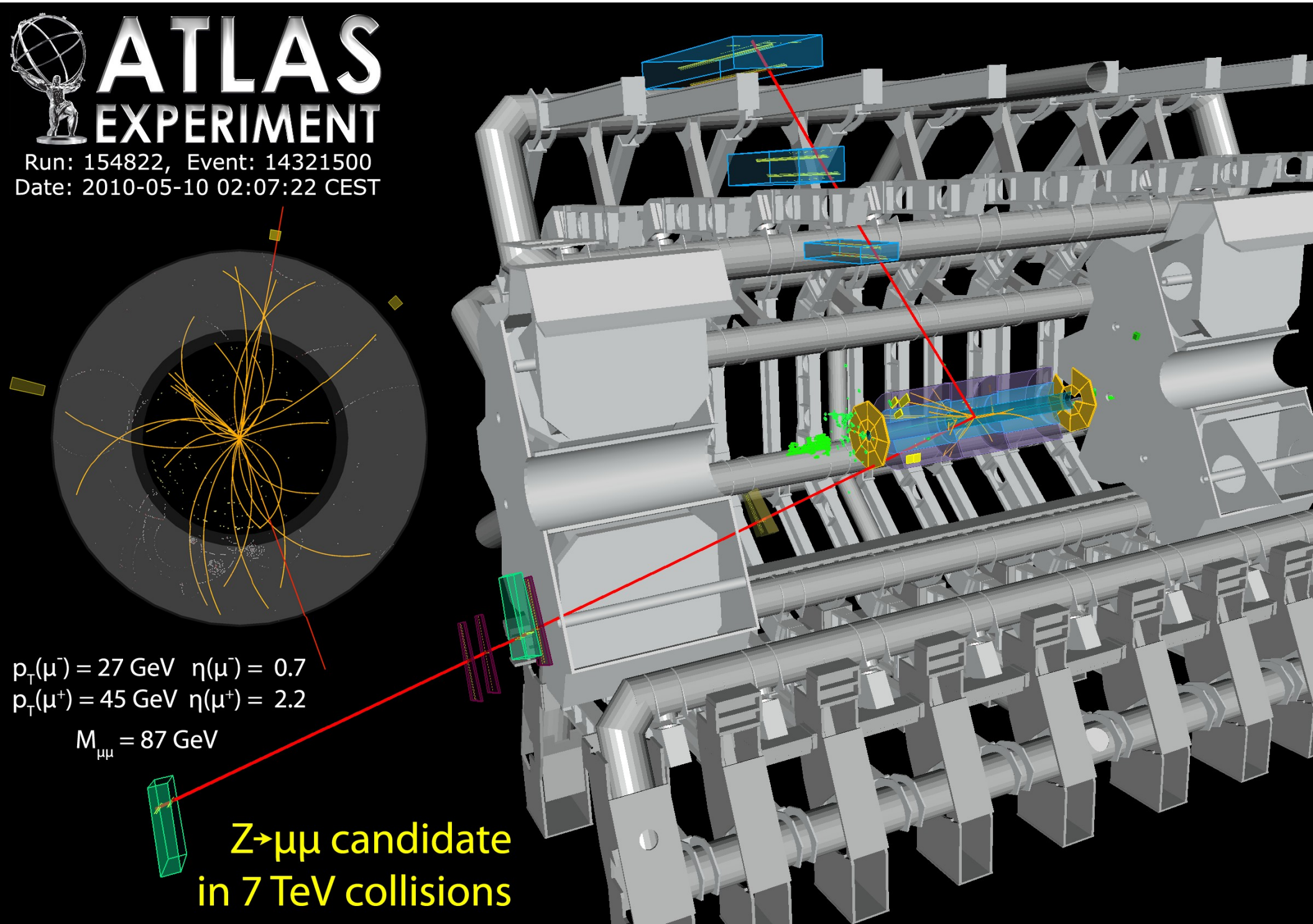
Fraction of J/ψ from the b-hadron. Agree with a model prediction.

Other examples exist, including PDFs

Fallback on Standard Candles

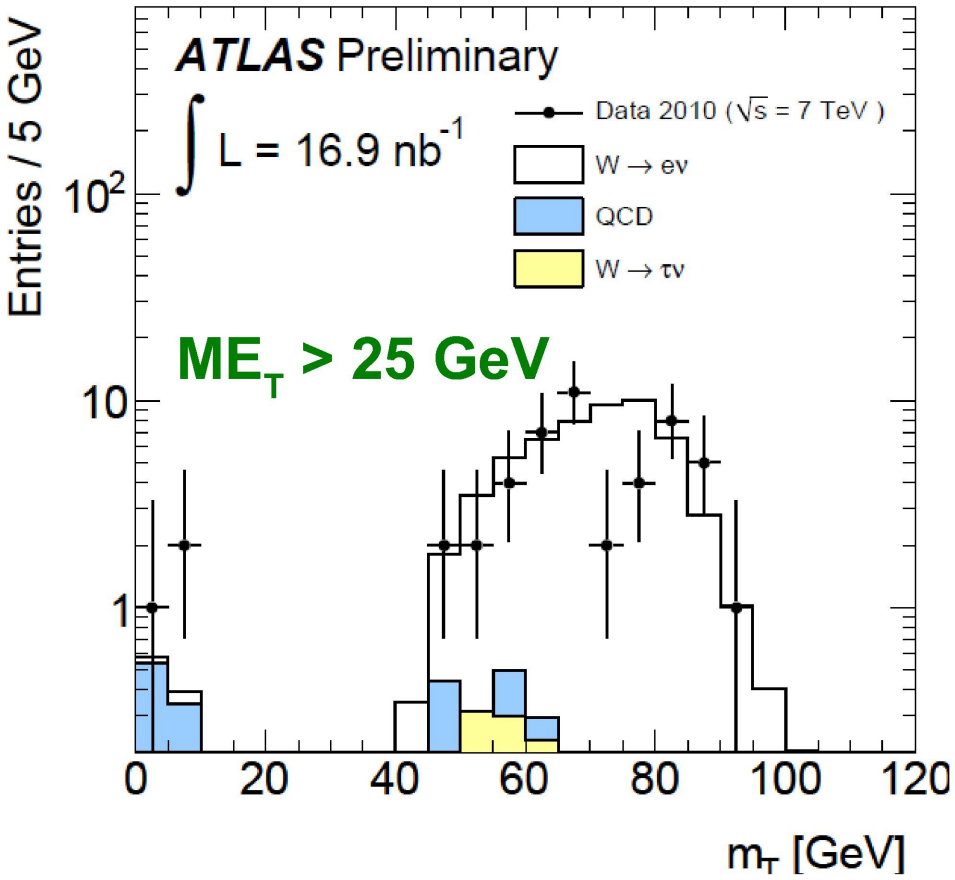
W & Z

Standard Candle --- W & Z Production at the LHC

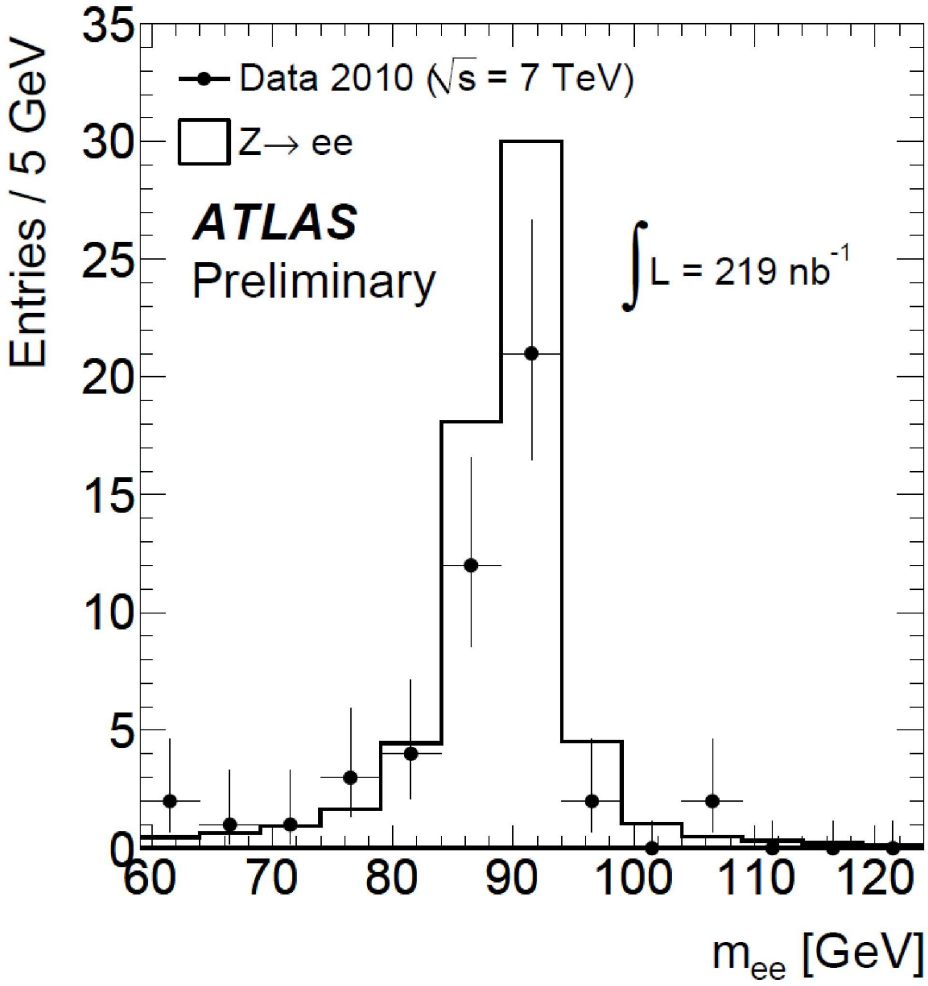


W & Z Production: Results from ICHEP

ATLAS: W → eν



ATLAS: Z → ee

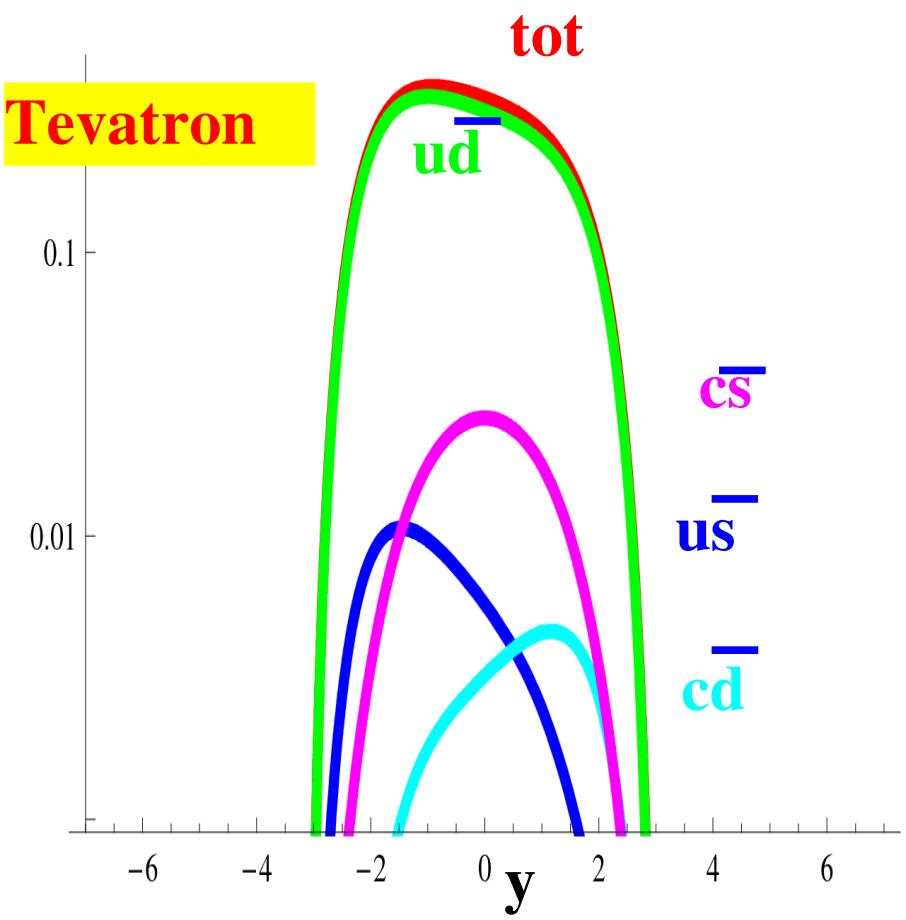


Congratulations on these results

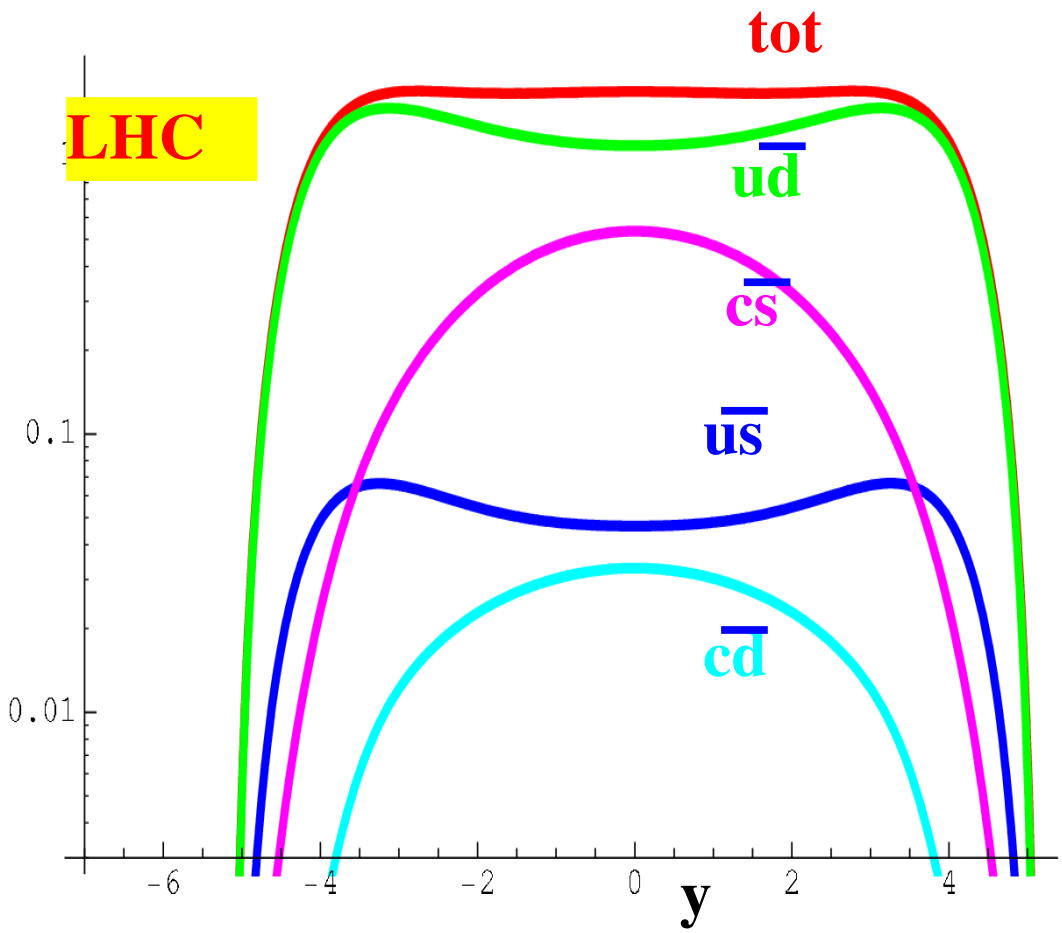
This is not your father's ~~Oldsmobile~~ W & Z

"Old" is "New" --- Re-discovering W & Z

LO W^+ Luminosities



LO W^+ Luminosities

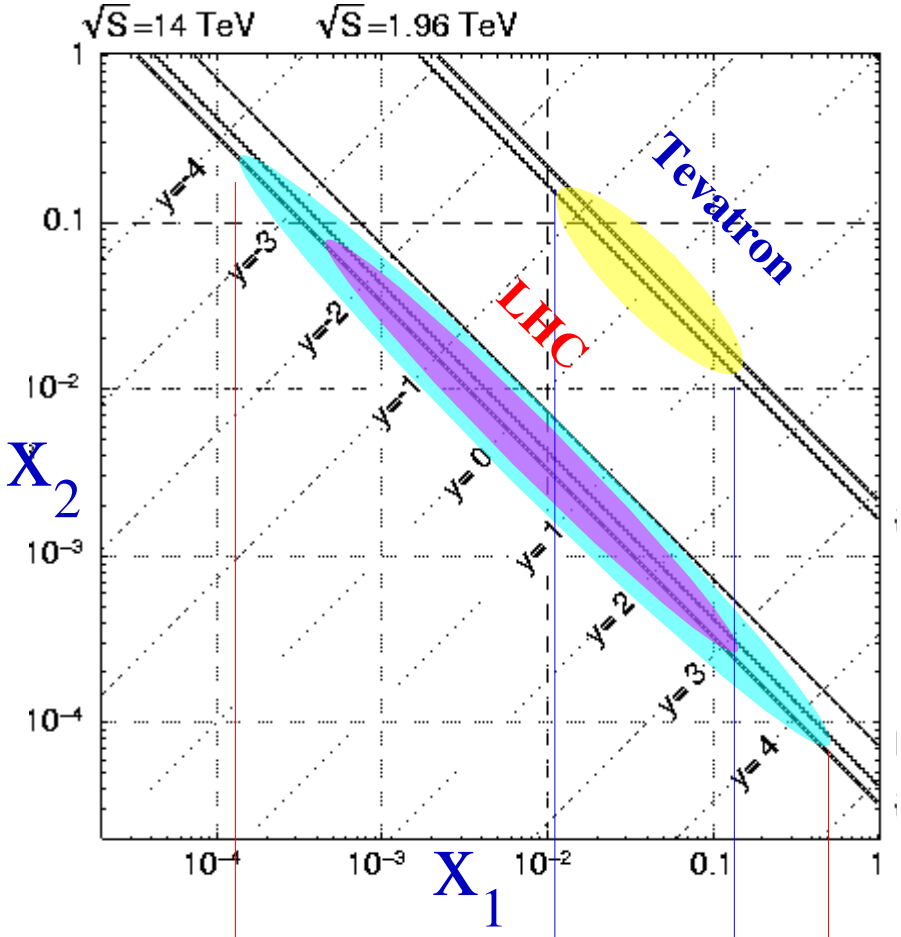


- Larger E ⇒ probes PDFs to small x
- Larger Rapidity ⇒ probes PDFs to ***really*** small x
- Larger fraction of heavy quarks

W & Z at the LHC is a whole new game

Large Shifts in Benchmark W & Z Cross Sections

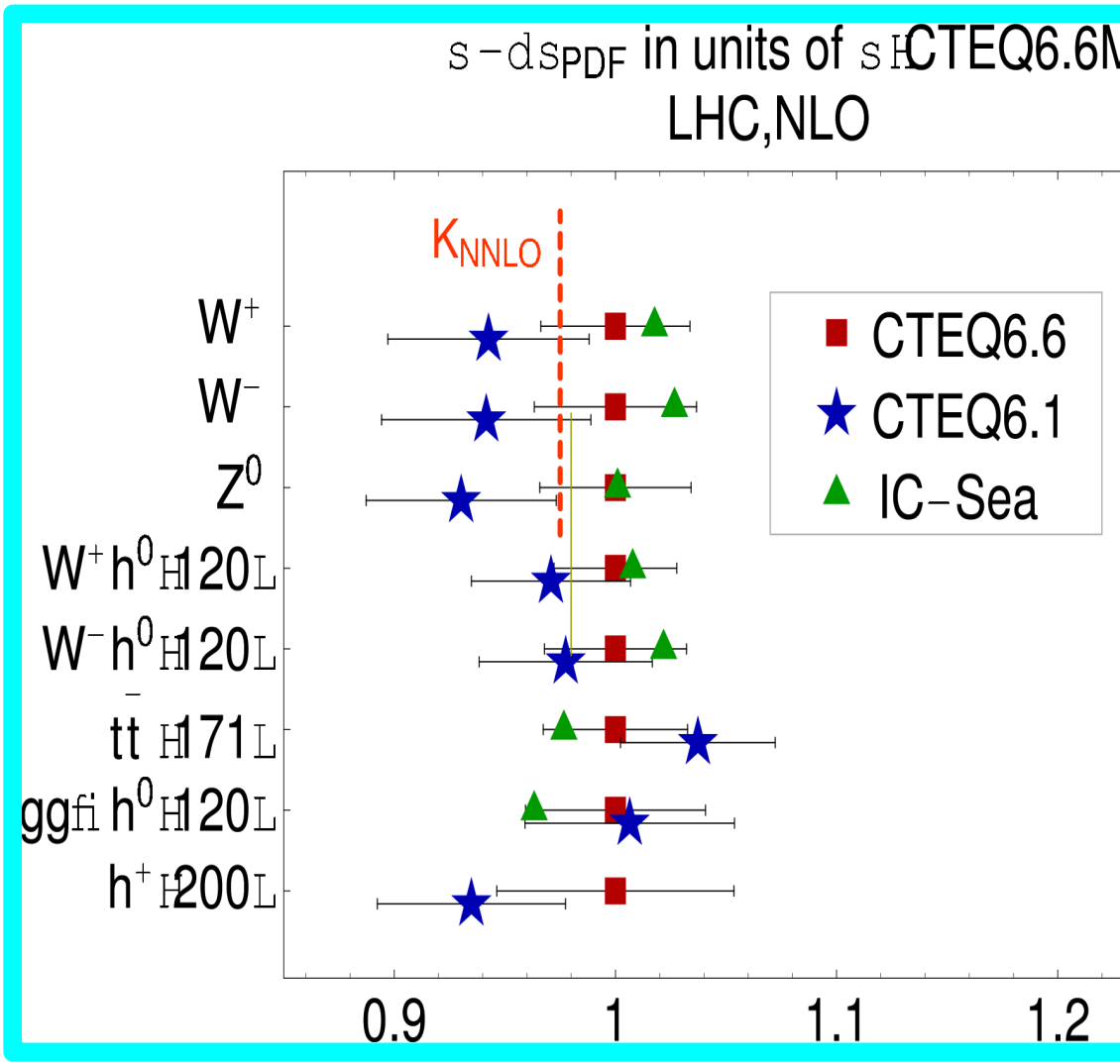
$$\sigma_{W,Z} = f(x_1) \otimes \hat{\sigma} \otimes f(x_2)$$



H
Z
W

x range for LHC

x range for Tevatron



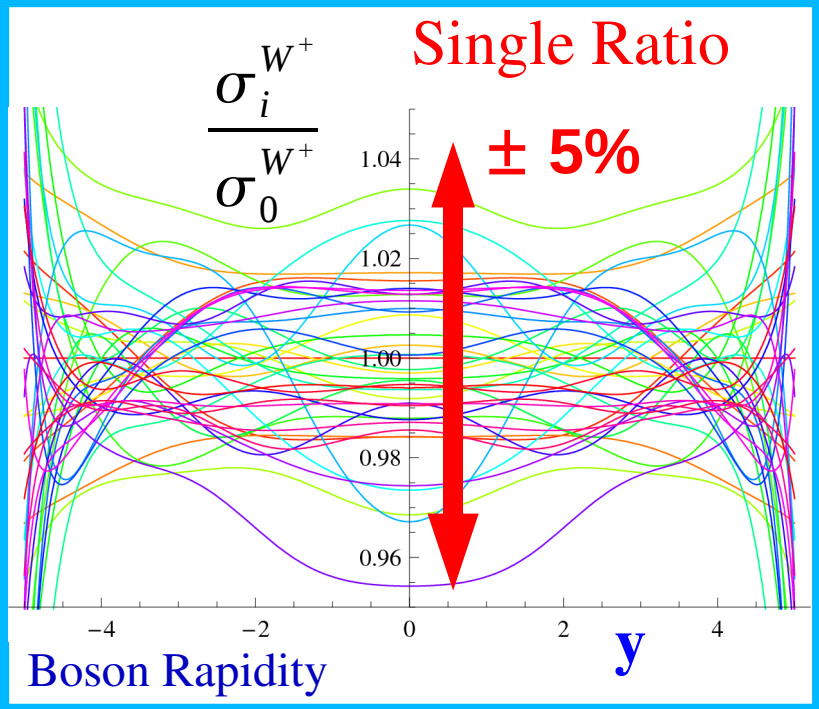
W/Z Production highly sensitive to small-x effects & heavy flavors

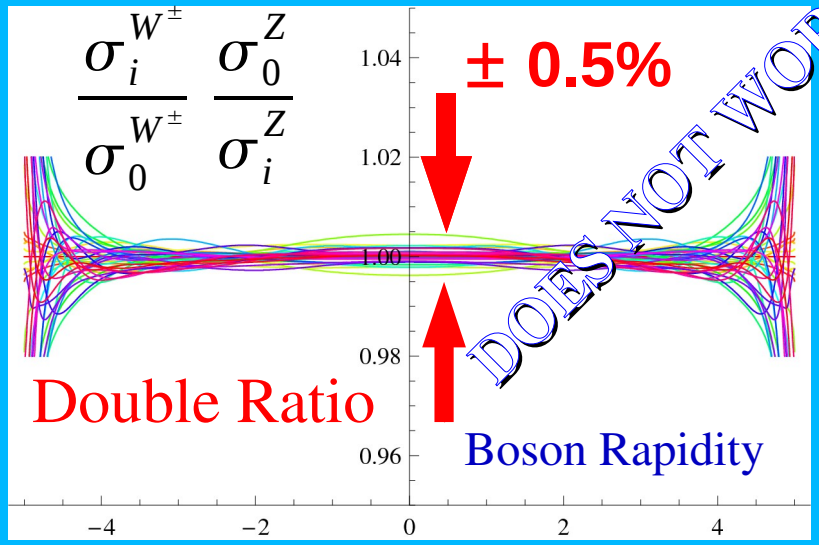
What can go wrong

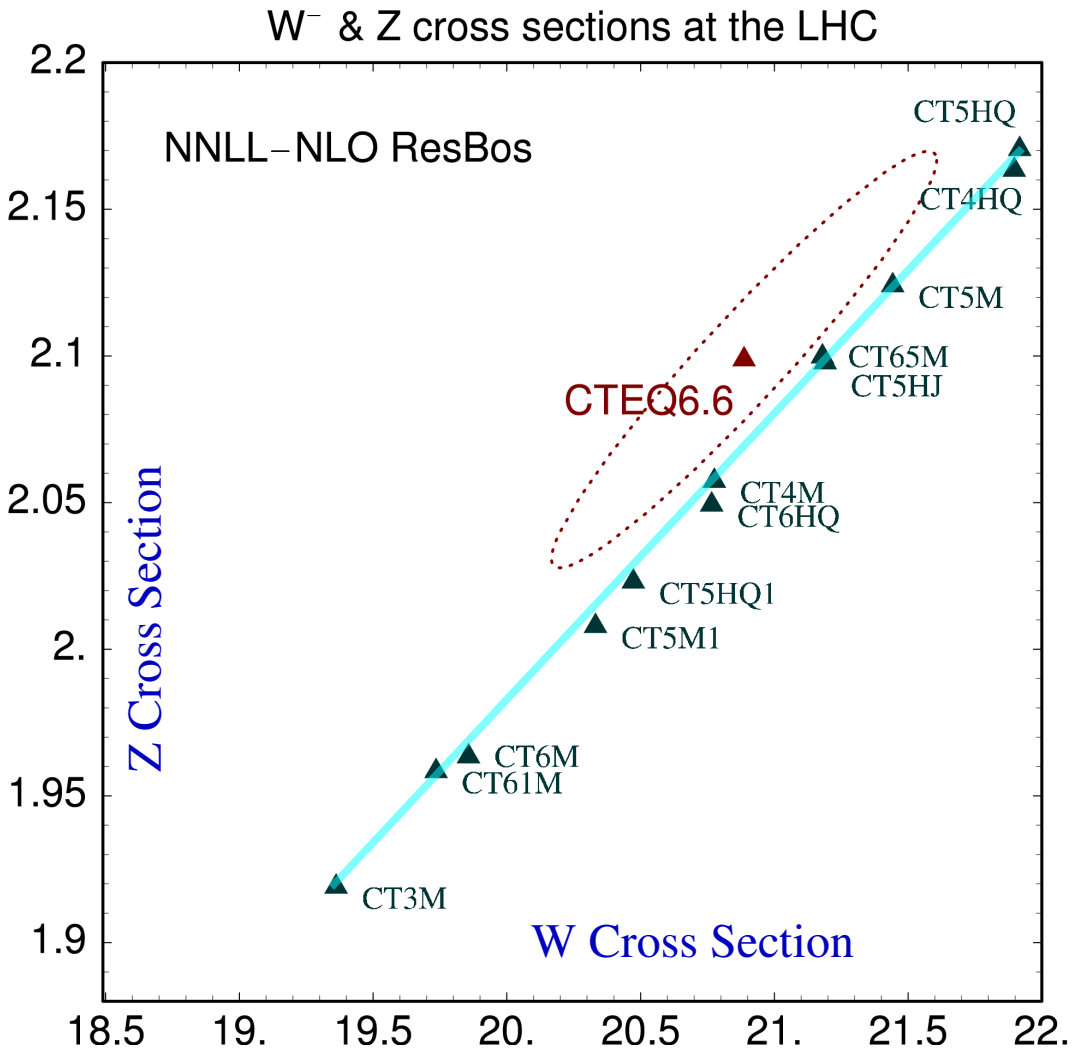
Murphy's Law & Corollaries

1. If anything can go wrong, it will.
2. Nothing is ever as simple as it seems.
3. Everything takes longer than you expect.
4. Nature always sides with the hidden flaw.
5. It is impossible to make anything foolproof, because fools are so ingenious.

Can We Predict W & Z Correlation???







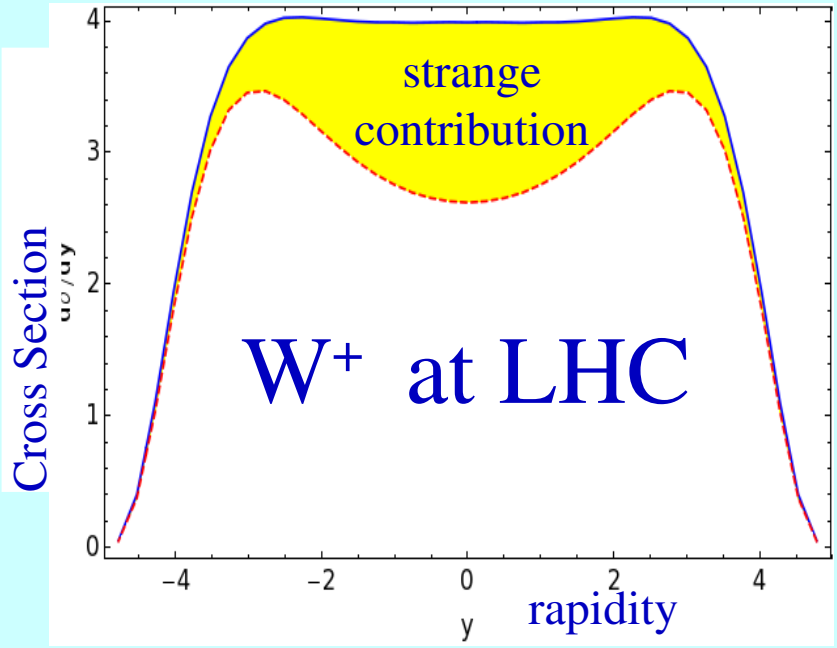
$\frac{\sigma_W}{\sigma_Z}$ Strong Correlations
Precise QCD Test

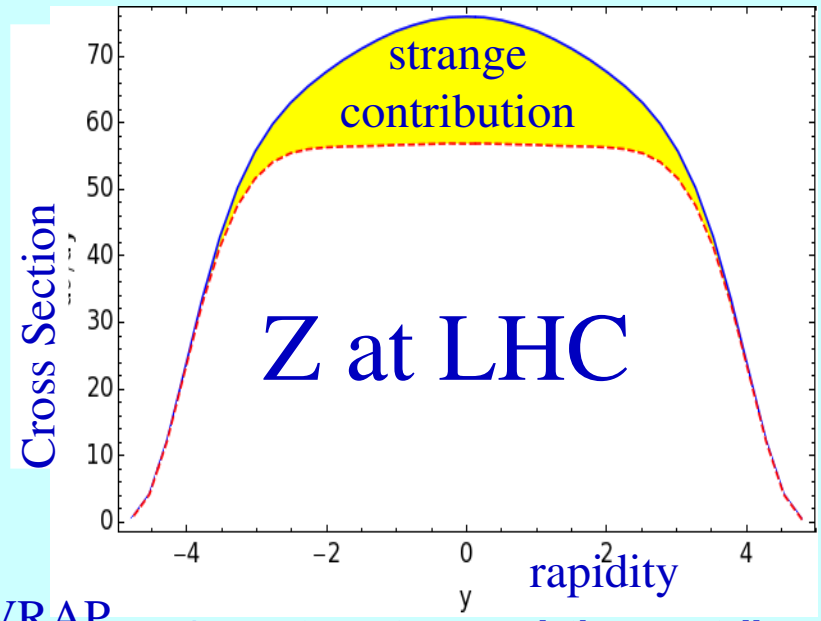
Key ingredient for M_W

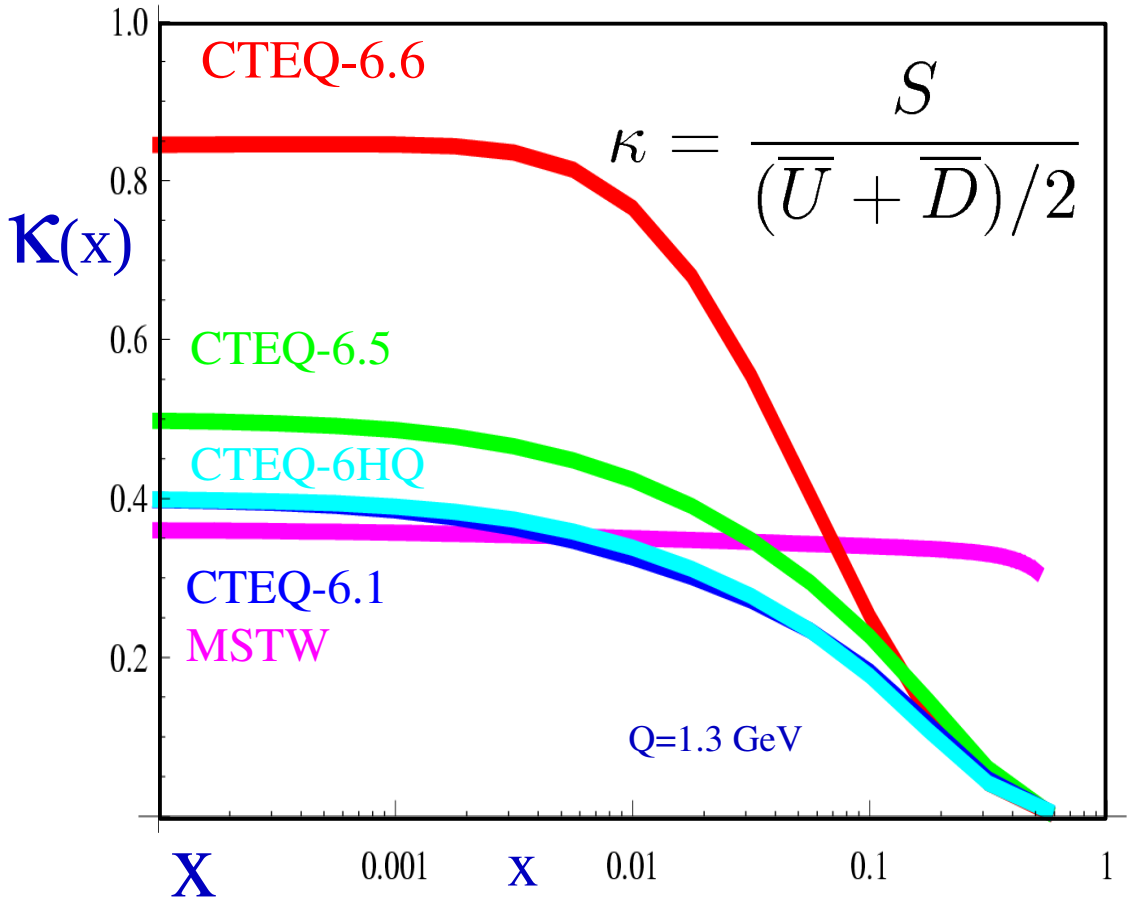
That's Strange

Exactly!

PDF Uncertainties ⇒ S(x) PDF ⇒ W/Z at LHC







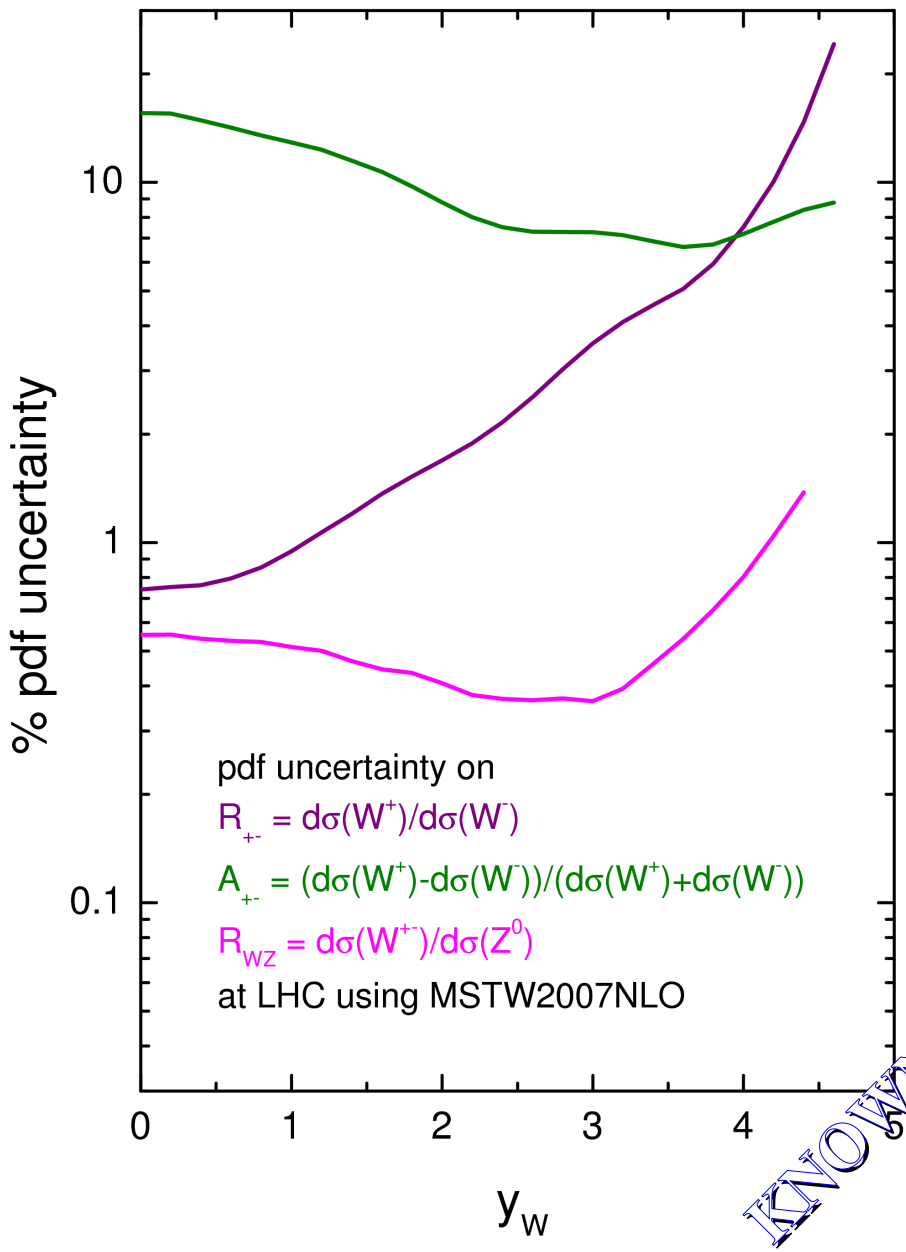
PDF Uncertainties will feed into LHC "Benchmark" processes

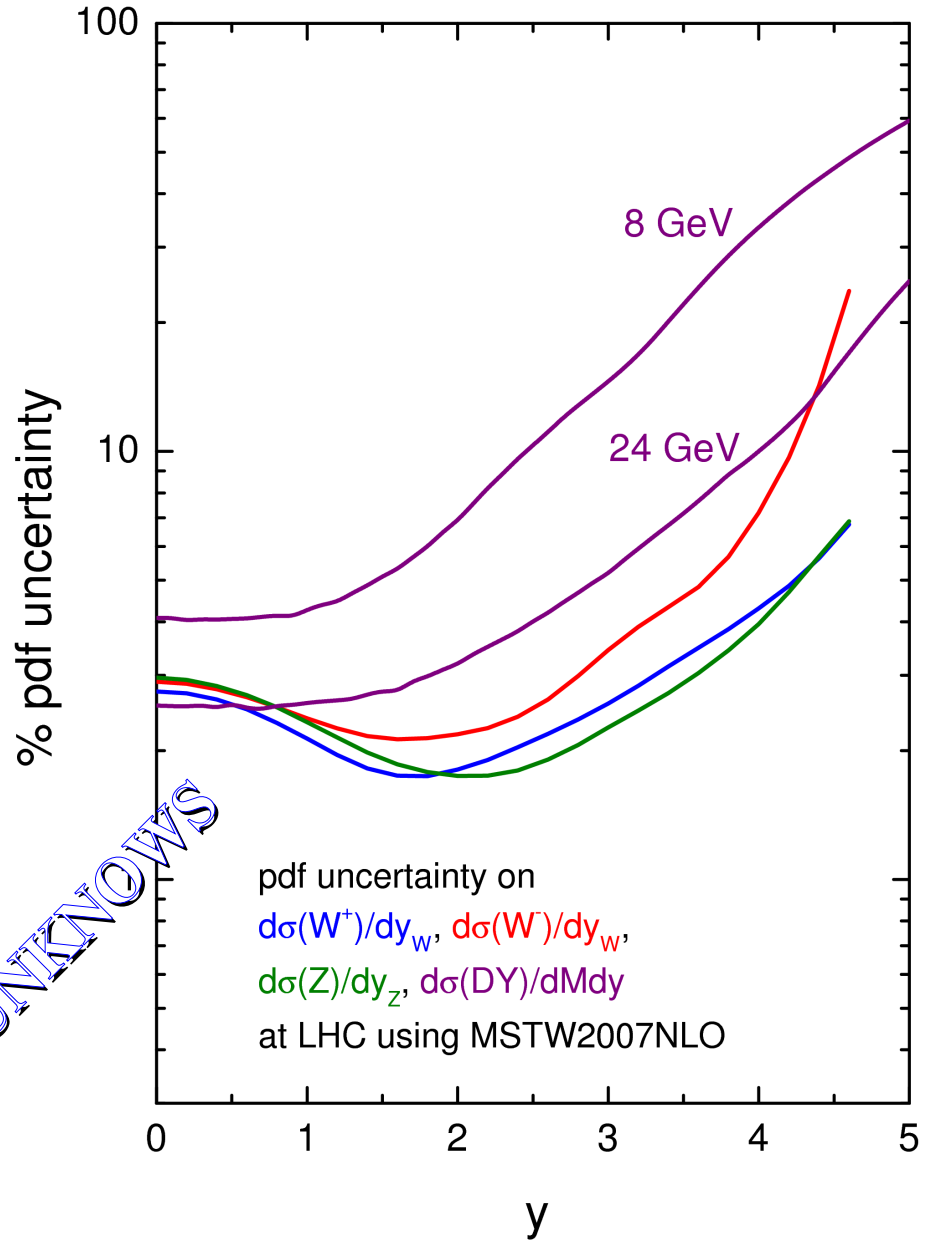
VRAP Code

Anastasiou, Dixon, Melnikov, Petriello, Phys.Rev.D69:094008,2004.

PDF UNCERTAINTIES

PDF Uncertainty at LHC





KNOWN UNKNOWS

Thorne, Martin, Stirling, Watt
arXiv:0808.1847 [hep-ph]

A NEW

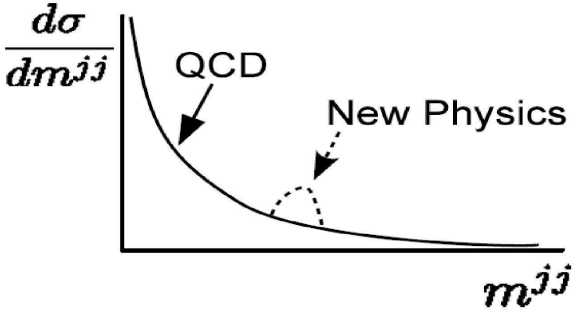
PARADIGM

The "Standard Model" Landscape is changing!!!

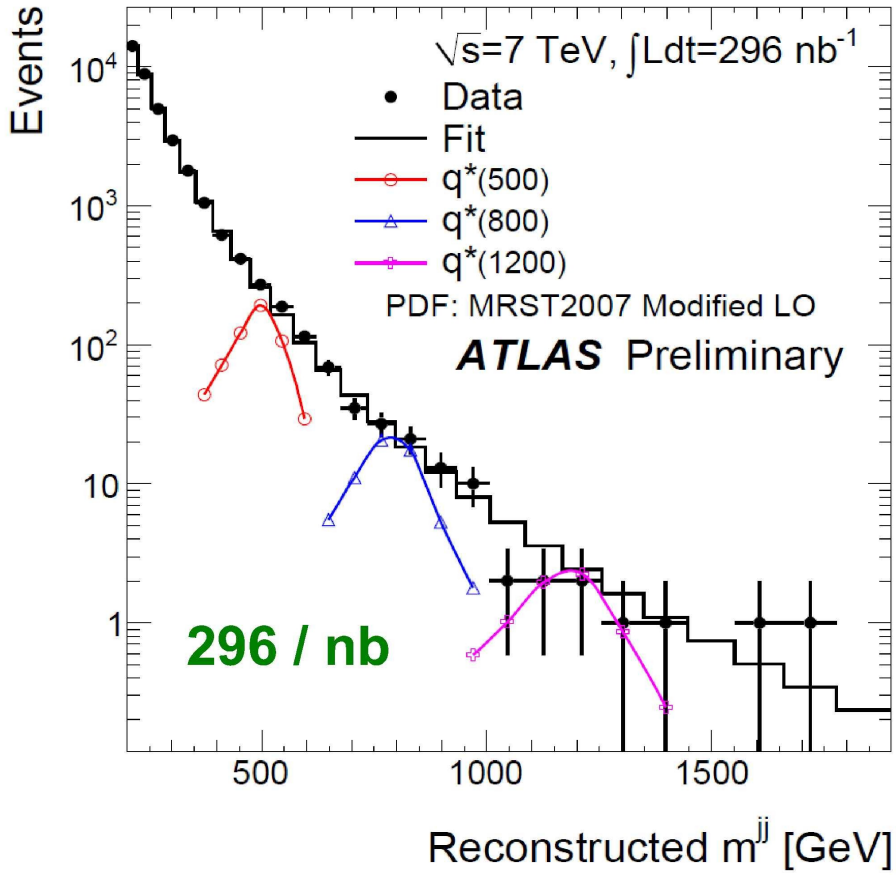
Many of us have never known anything except the Standard Model

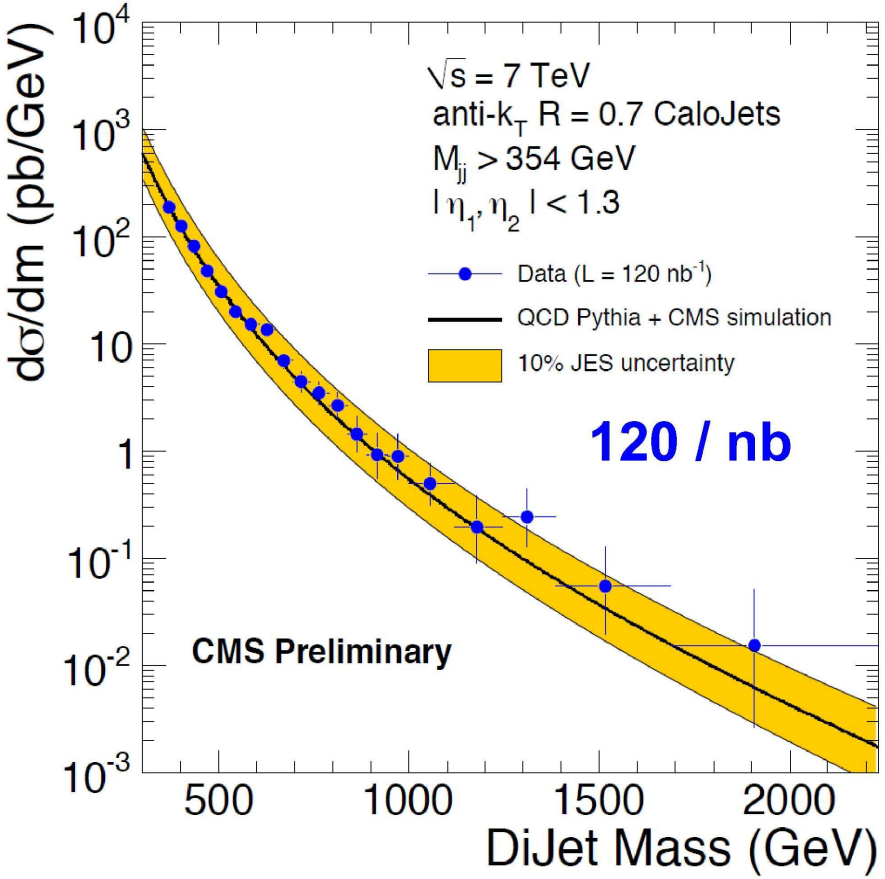
STEP 1: SM DEVIATIONS

Dijet Mass Bump Hunt



No bumps **found so far!**



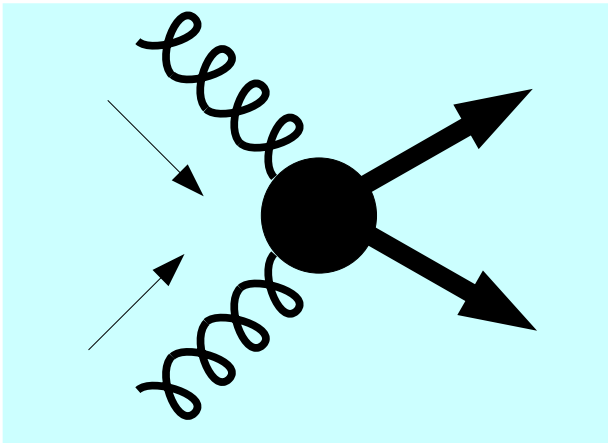


Include SUSY in PDF Evolution

STEP 2:

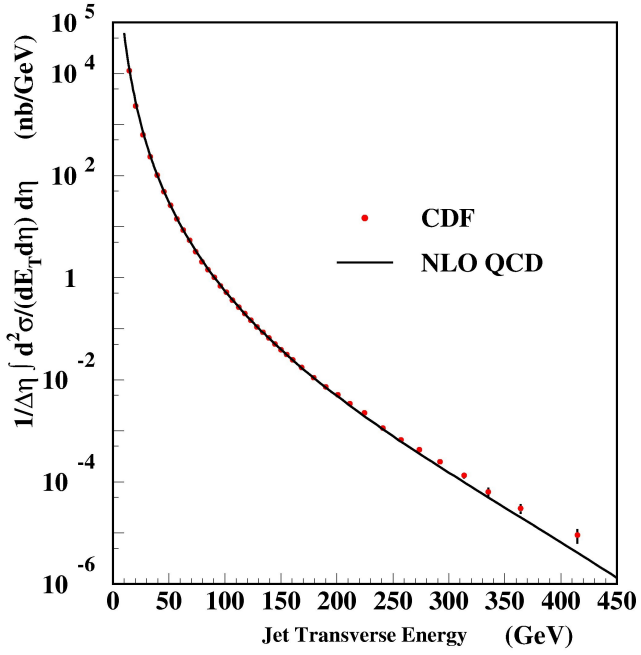
Need to re-compute $d\sigma$ including SUSY

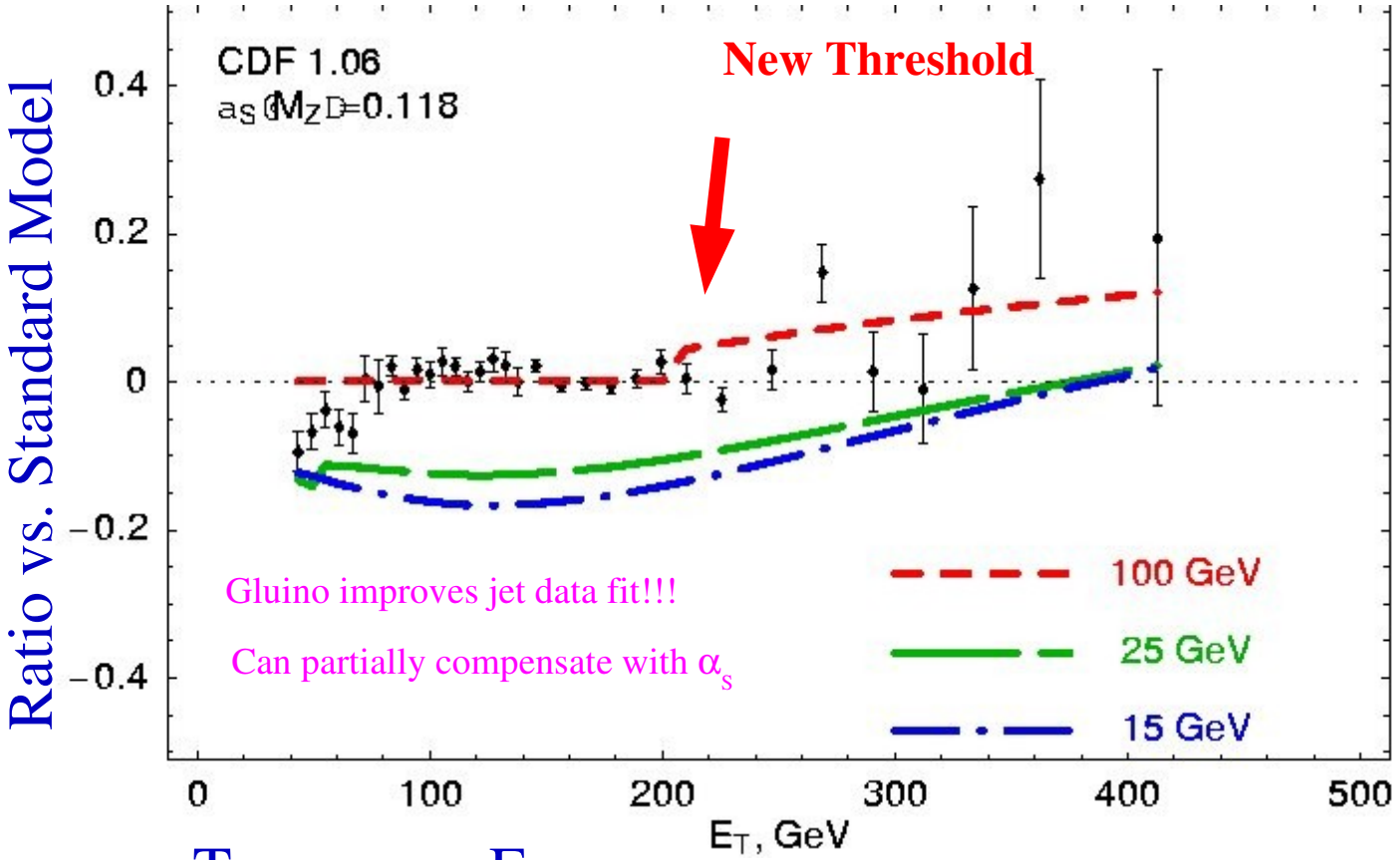
And re-compute α_s



$$g\,g \rightarrow \tilde{q}\,\tilde{q}$$

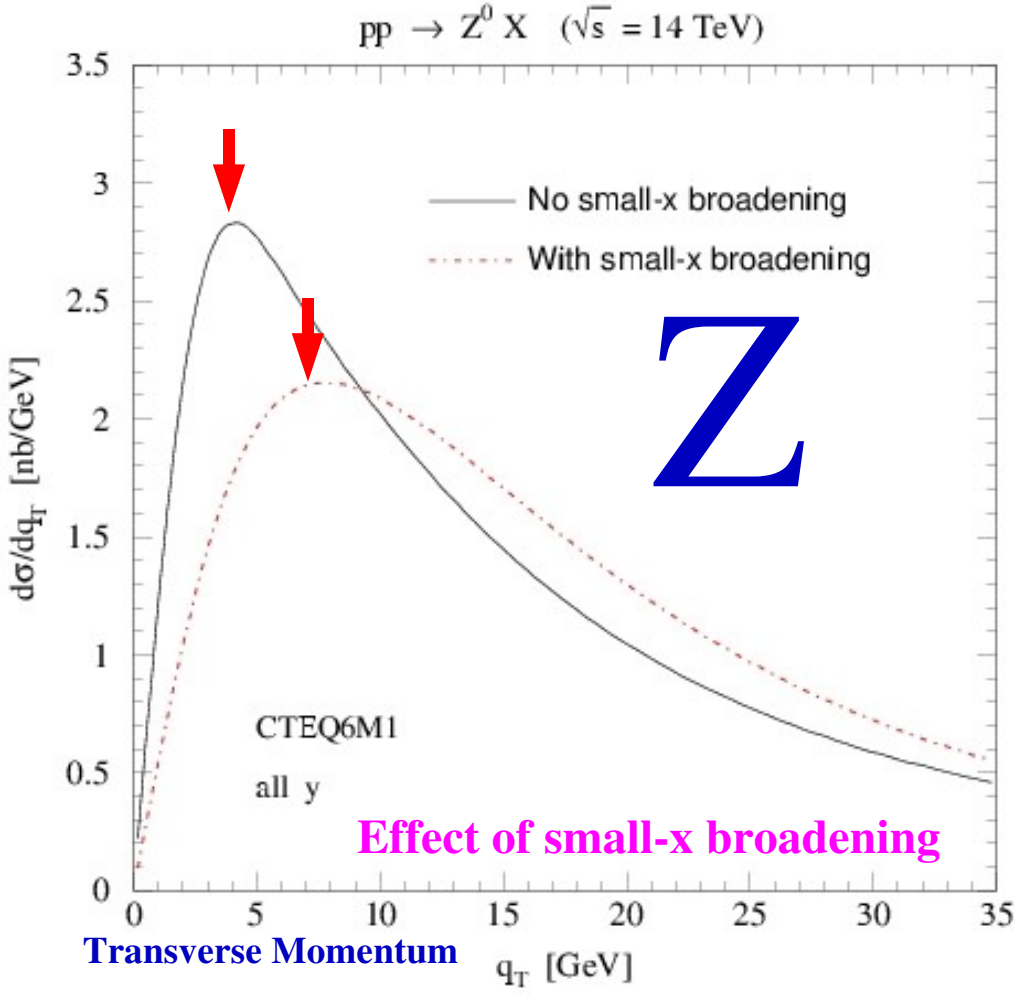
$$g\,g \rightarrow \tilde{g}\,\tilde{g}$$



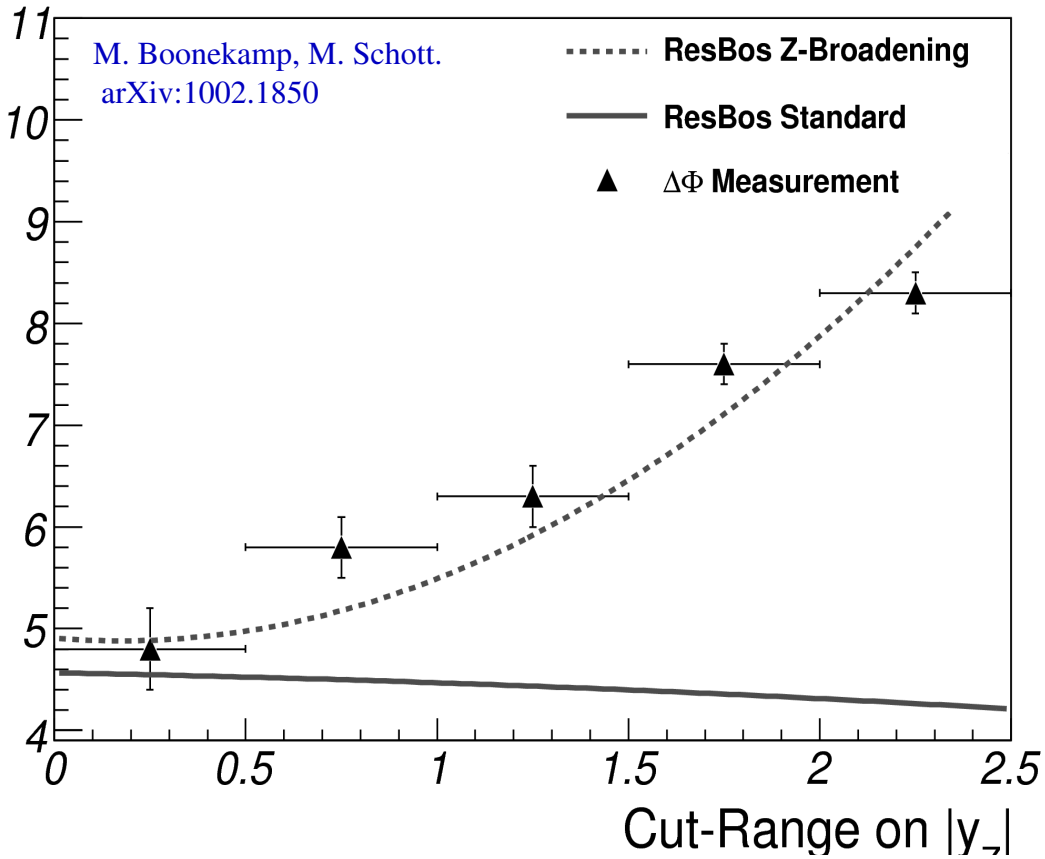


Need to re-evaluate α_s

Small-x uncertainties (broadening) can have large impact at LHC



Shift of PT-Max (GeV)



These uncertainties are not acceptable for "benchmark" processes

LHC can nail this in the first run!!!

Berge, Nadolsky, Olness, Yuan, Phys.Rev.D72:033015,2005
Berge, Nadolsky, Olness, Phys.Rev.D73:013002,2006.

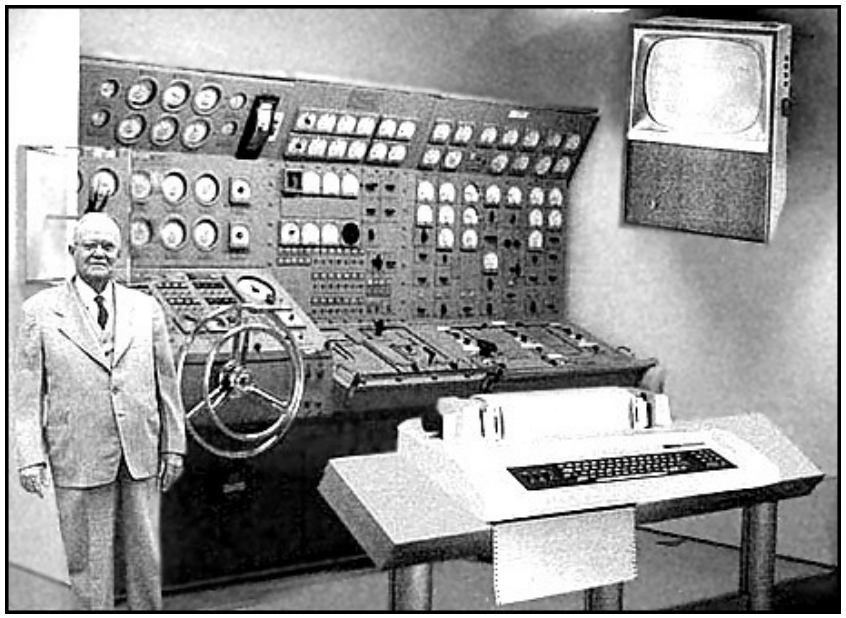
Did not Tevatron rule this out???

DATA PRESERVATION

Things can change a bit over the years

Mobile Phone Circa 1960's

Vintage TV



A (hoaxed) photo portraying a 1950's computer

Mobile Phone Circa 2007

IMac

Modern Laptop

Global PDF Analysis uses a broad range of data sets

Data Preservation and Long Term Analysis in High Energy Physics

ICFA Study Group on Data Preservation and Long Term Analysis in High Energy Physics

High Energy Physics experiments initiate with this Study Group a common reflection on data persistency & long term analysis in order to get a common vision on these issues and create a multi-experiment dynamics for further reference.

https://www.dphep.org/

An Example: Rivet Analysis of Tevatron Data in VirtualBox

Applications Places System — 77 °F Wed Aug 4, 6:15 PM

MCnet [Running] - Oracle VM VirtualBox

Machine Devices Help

plots - D0_2008_S7863608 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

file:///home/mcnet/day2/herwig/ME/plots/D0_2008_S7863608/index.html

Most Visited Getting Started Latest Headlines

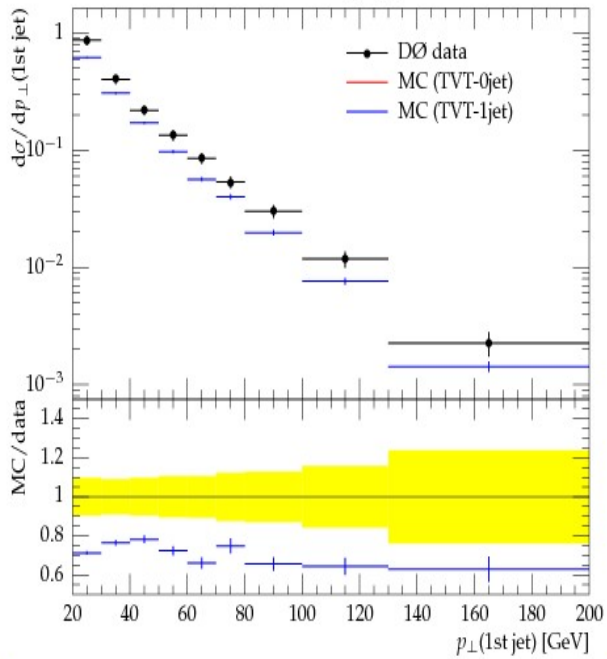
D0_2008_S7863608

Back to index

Measurement of differential Z/γ^* + jet + X cross sections (D0_2008_S7863608)

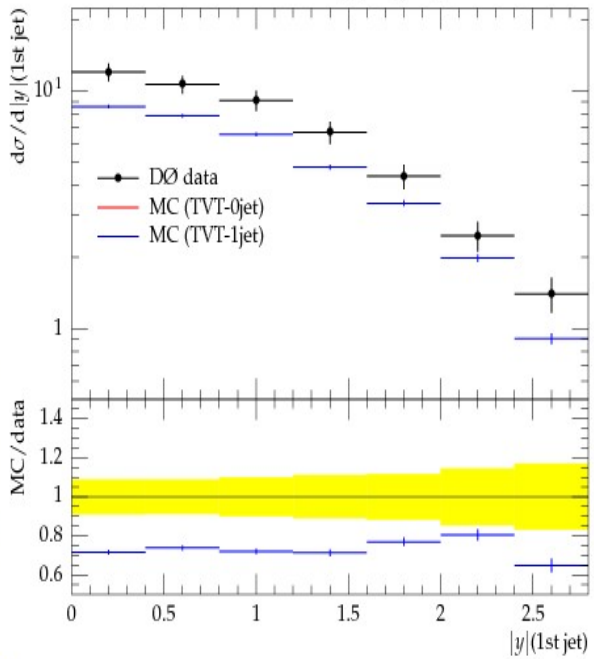
d01-x01-y01.ps:

Differential cross section in leading jet $p_\perp$



d02-x01-y01.ps:

Differential cross section in leading jet rapidity



d03-x01-y01.ps:

Differential cross section in Z/γ^* $p_\perp$

d04-x01-y01.ps:

Differential cross section in Z/γ^* rapidity

Workspace 1 | 04 Aug, Wed 18:15:01 | mcnet@mcnet: ~/day2/herwig/ME | plots - D0_2008_S7863608 - Mozilla Fire

Right Ctrl

Oracle VM VirtualBox

File Machine Help

New Settings Show Discard

MCnet
Running

Details Snapshots Description

General
Name: MCnet
OS Type: Ubuntu

System
Base Memory: 512 MB
Processor(s): 1
Boot Order: Floppy, C Disk
VT-x/AMD-V: Enabled
Nested Paging: Enabled

Display
Video Memory: 12 MB
3D Acceleration: Disabled
2D Video Acceleration: Disabled
Remote Display Server: Disabled

Storage
IDE Controller
IDE Secondary Master (CD/DVD): VBoxGues (31.95 ME
SATA Controller
SATA Port 0: MCnet.vn (Immutab

E.g. Jet Definitions
Jet Cone Radius

Terminal | Oracle VM VirtualBox | MCnet [Running] - Oracl...

Conclusions

* Extrapolation:

  Essential, but risky business, even from 2TeV to 7TeV

* A new paradigm: our "reference" points are changing

  Will need to re-calculate "new" underlying physics

  E.g. Discovered Higgs or SUSY particles & channels

  Can't take "reference" results off the shelf

  E.g. α_s *& default SM channels (jet production)*

* Working in a whole new landscape:

  Rely on the measurements *Take the theorists with a grain of salt*

  Our's is fundamentally an experimental field

There is nothing "Standard" about re-discovering the Standard Model

Welcome to the LHC Era

Thanks to: P. Nadolsky, K. Park, M. Guzzi, S. Berge, I. Schienbein, J.-Y. Yu, J. Owens,

Standard Model Benchmarks at the Tevatron and LHC

November 19 -20 2010

Fermilab

Hosted by: The CTEQ Collaboration, the LHC Physics Centers @ CERN, DESY, FERMILAB & the ATLAS Physics Analysis Center @ ANL

The workshop will consist of four half-day sessions dealing with
(1) The underlying event and minimum bias
(2) W and Z production
(3) Photon and jet production
(4) Heavy quark production

The workshop structure will allow for lively discussion between Tevatron and LHC experimentalists and phenomenologists on precision predictions and comparisons of data to these standard model cross sections. More information and registration is at: http://CTEQ.org

Organizing Committee:

Richard Cavanaugh, Illinois-Chicago/Fermilab
Joey Huston, Michigan State
Michelangelo Mangano, CERN
Fred Olness, SMU
Thomas Schoerner-Sadenius, DESY
Ian Shipsey, Purdue
Nikos Varelas, Illinois-Chicago
Rik Yoshida, Argonne
Marek Zielinski, Rochester

The LHC is now reporting its first measurements of standard model benchmark cross sections such as W,Z, photon, jet and heavy flavor production. The Tevatron has had several decades of experience in measuring and understanding these benchmark cross sections, and data samples nearing 10 inverse femtobarns.

We are announcing the first workshop sponsored by CTEQ, the three LHC Physics Centers at CERN, DESY, and Fermilab, and the Argonne Analysis Support Center, on "Standard Model Benchmarks at the Tevatron and LHC", to take place on Friday and Saturday, Nov. 19 and 20 at Fermilab.

The workshop will consist of four half-day sessions dealing with

(1) underlying event and minimum bias,
(2) W and Z production
(3) photon and jet production and
(4) heavy flavor production.

The workshop structure will allow for lively discussion between Tevatron and LHC experimentalists and phenomenologists, on precision predictions and comparisons of data to these standard model cross sections. More information will be posted at the website:

http://cteq.org.