ATLAS Run2 Results

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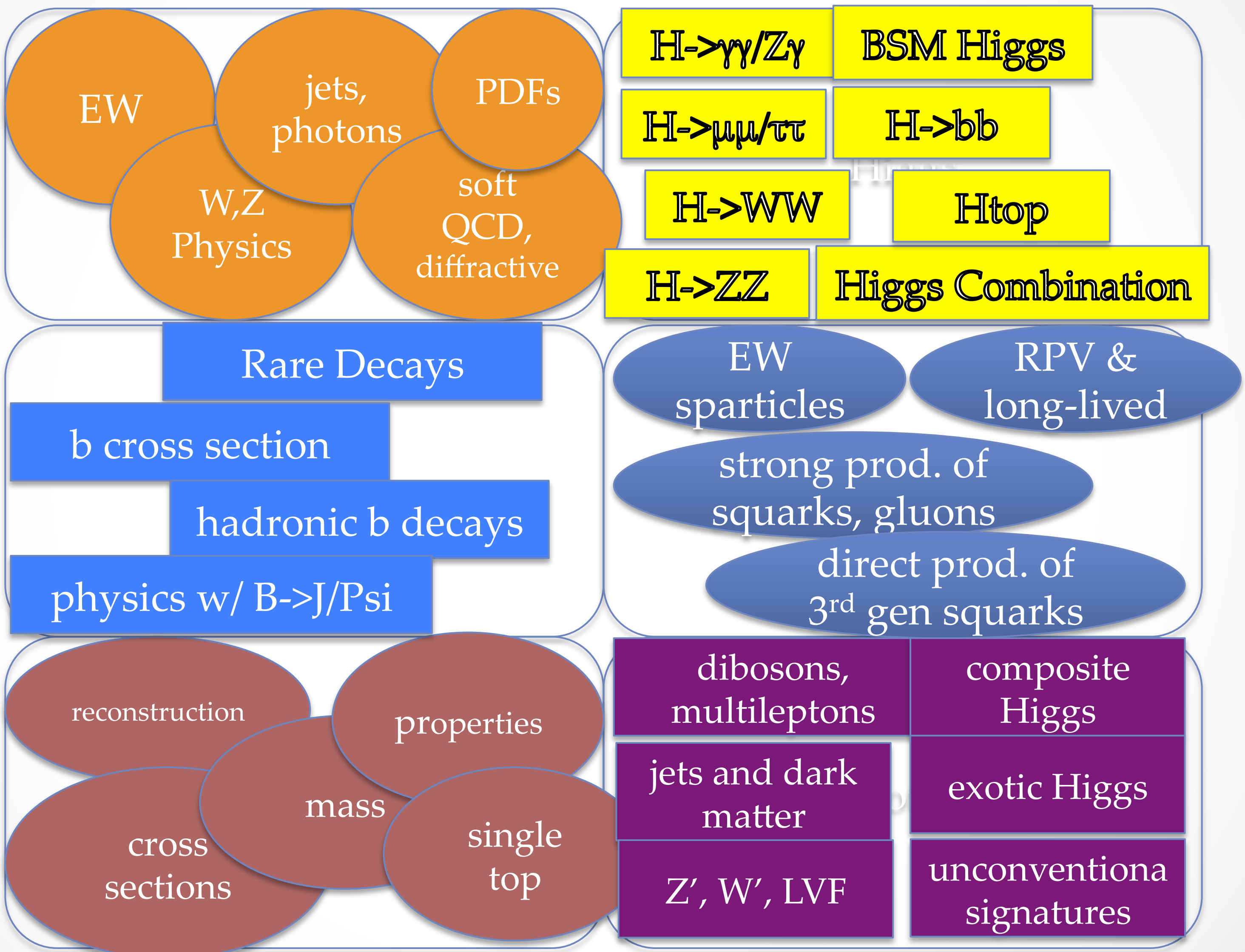
Yale University

US LHC Users Association Meeting @ LBL
Thursday, November 3, 2016

many groups, many people, many results

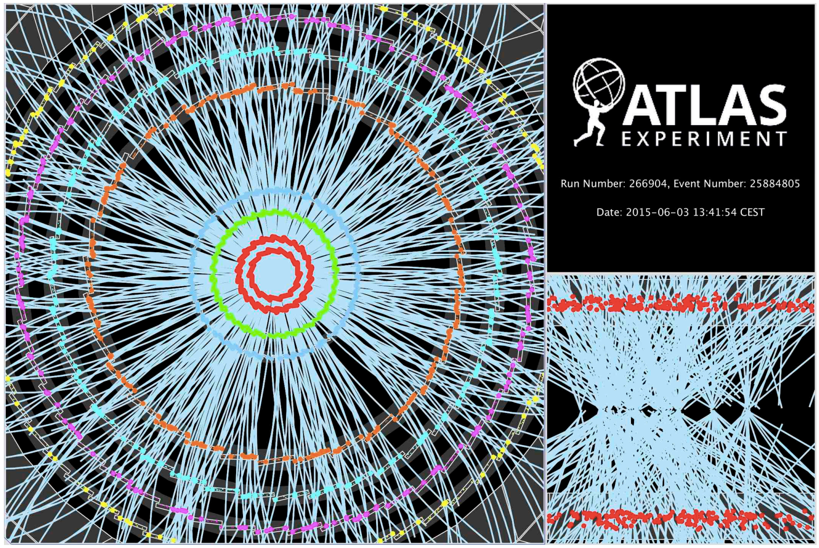
Standard Model	Higgs
B Physics	Supersymmetry
Top Physics	Exotics

many groups, many people, many results



*Ian Hinchliffe presented status and exotics results this morning

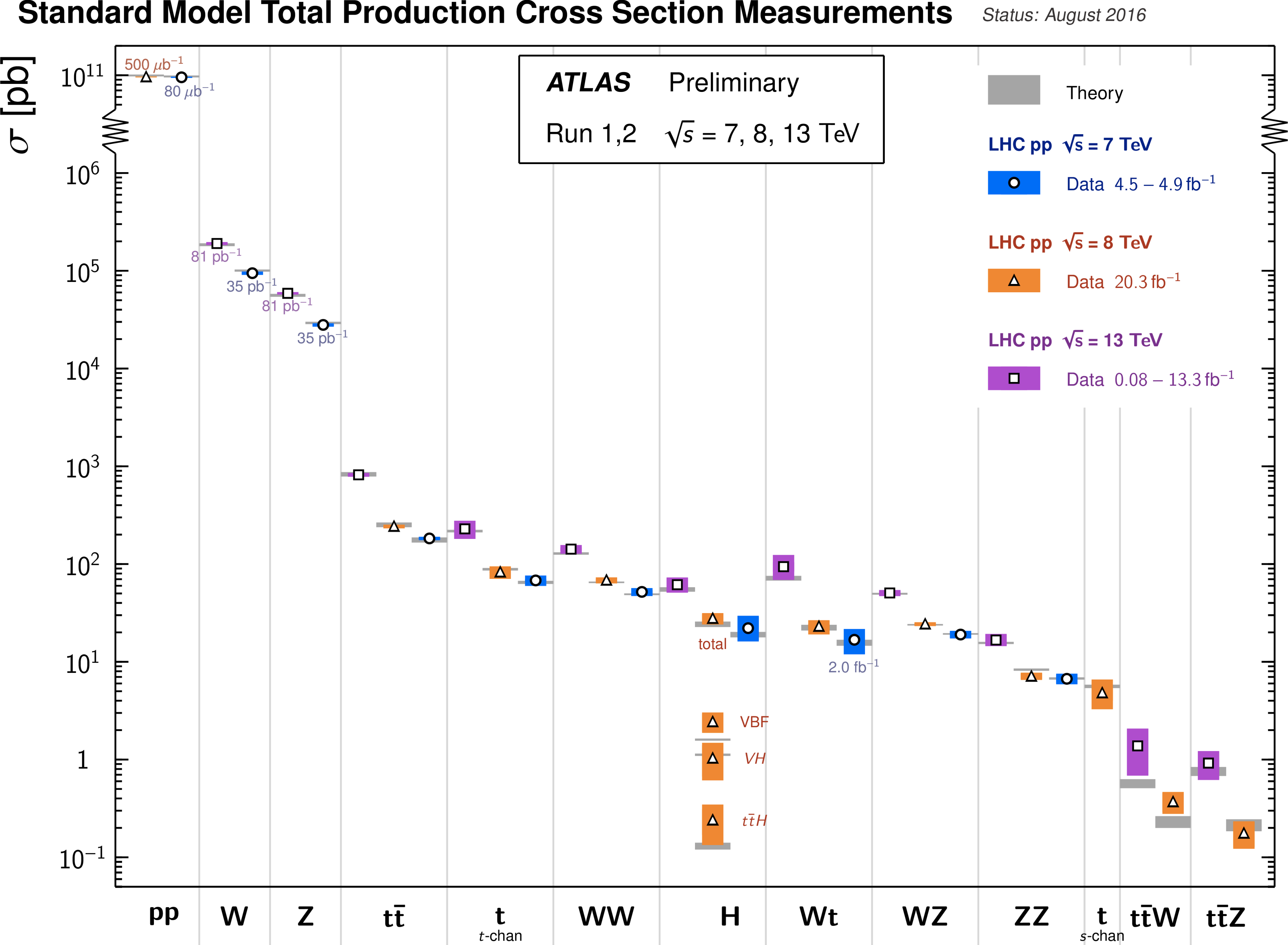
Standard Model Results



Run 2's higher center of mass energy provides a new regime for testing the SM

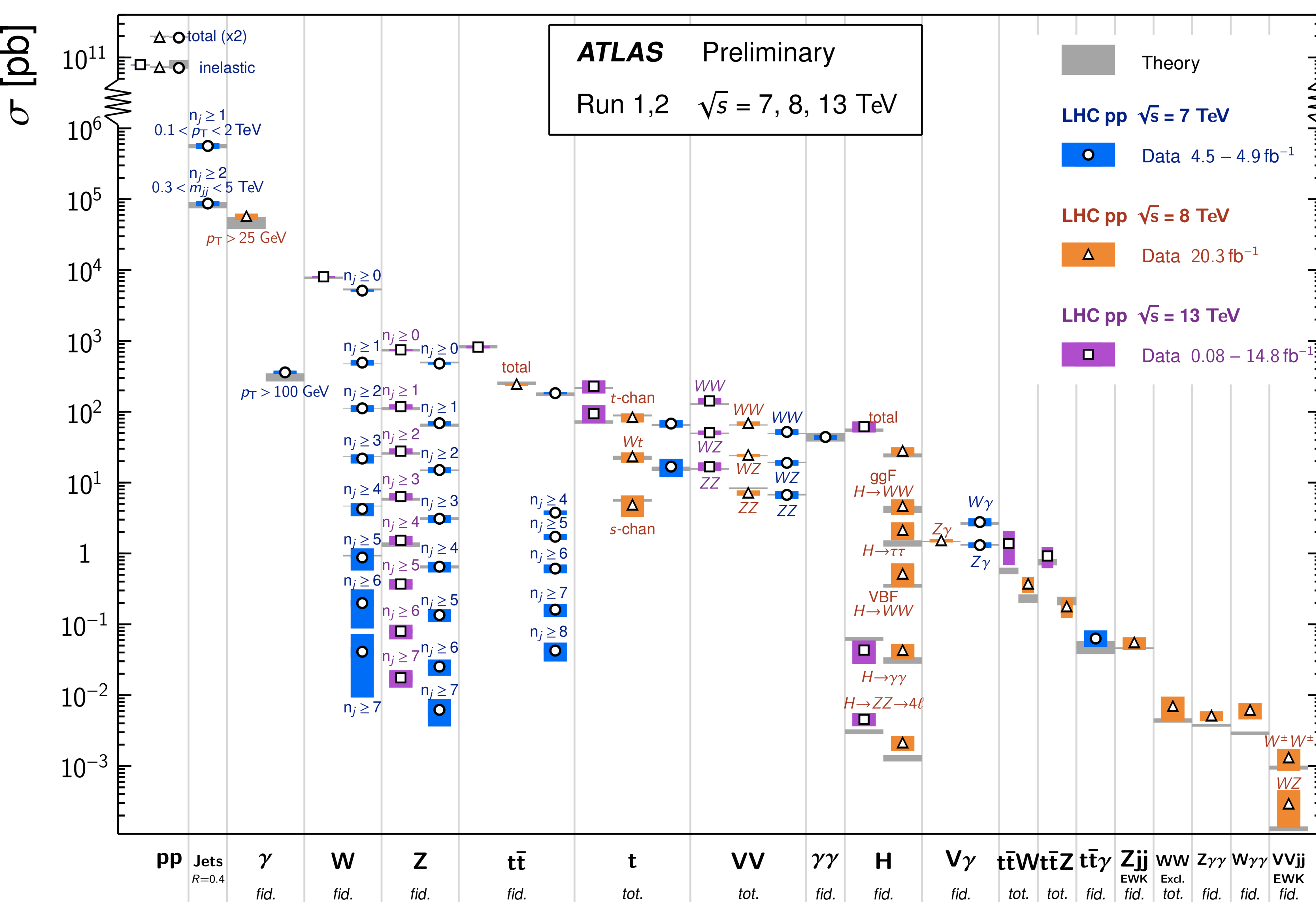
Larger datasets allow for precision measurements and hunts for rare processes

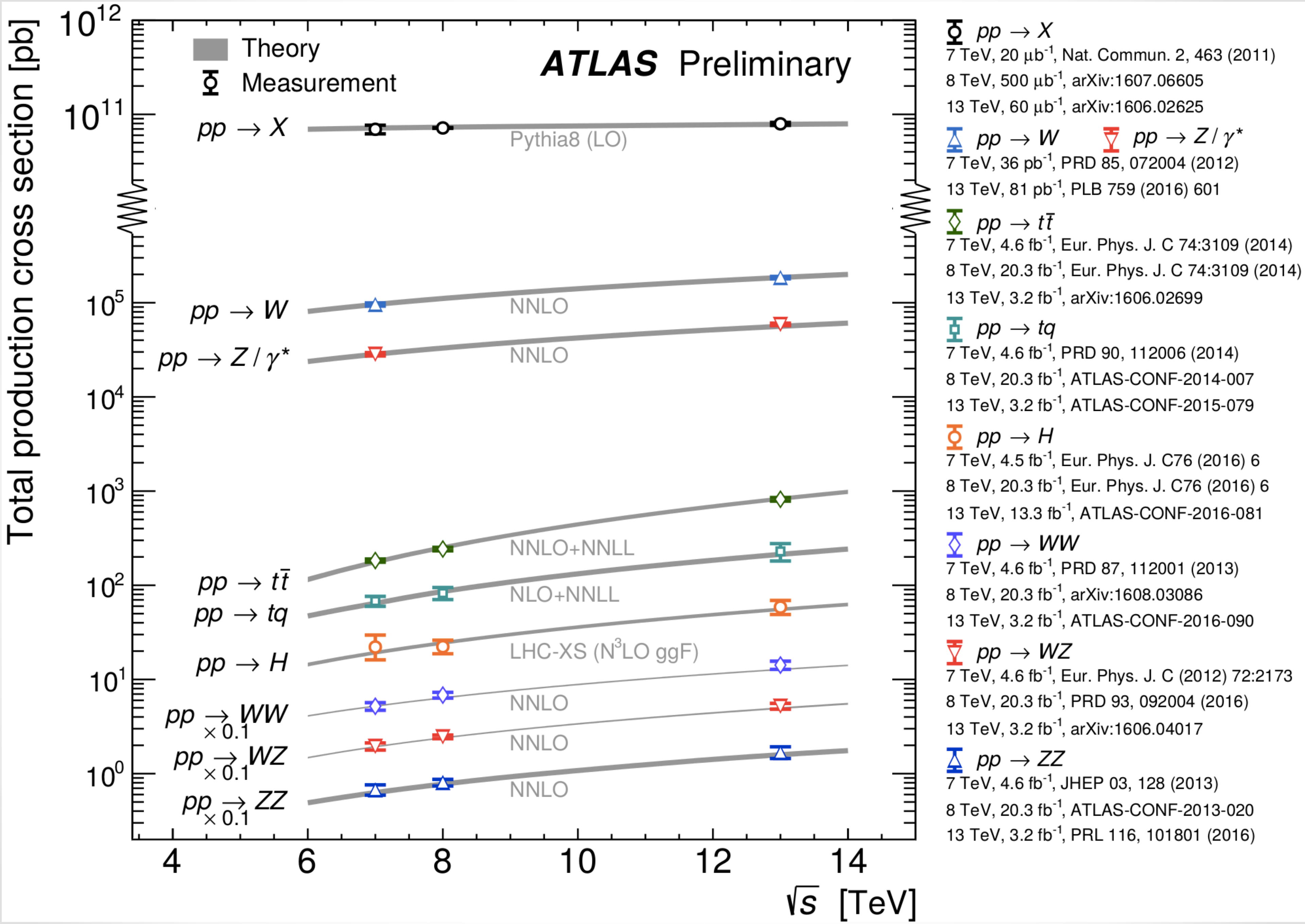
Some of these measurements take time and an excellent understanding of the data, so some of the most exciting recent SM results are from Run 1


Standard Model Total Production Cross Section Measurements
Status: August 2016
ATLAS Preliminary
Run 1,2 √s = 7, 8, 13 TeV
Theory
LHC pp √s = 7 TeV
Data 4.5 – 4.9 fb⁻¹
LHC pp √s = 8 TeV
Data 20.3 fb⁻¹
LHC pp √s = 13 TeV
Data 0.08 – 13.3 fb⁻¹
σ [pb]
500 μb⁻¹
80 μb⁻¹
81 pb⁻¹
35 pb⁻¹
81 pb⁻¹
35 pb⁻¹
total
VBF
VH
tt̄H
2.0 fb⁻¹
pp
W
Z
tt̄
t
t-chan
WW
H
Wt
WZ
ZZ
t
s-chan
tt̄W
tt̄Z

Standard Model Production Cross Section Measurements

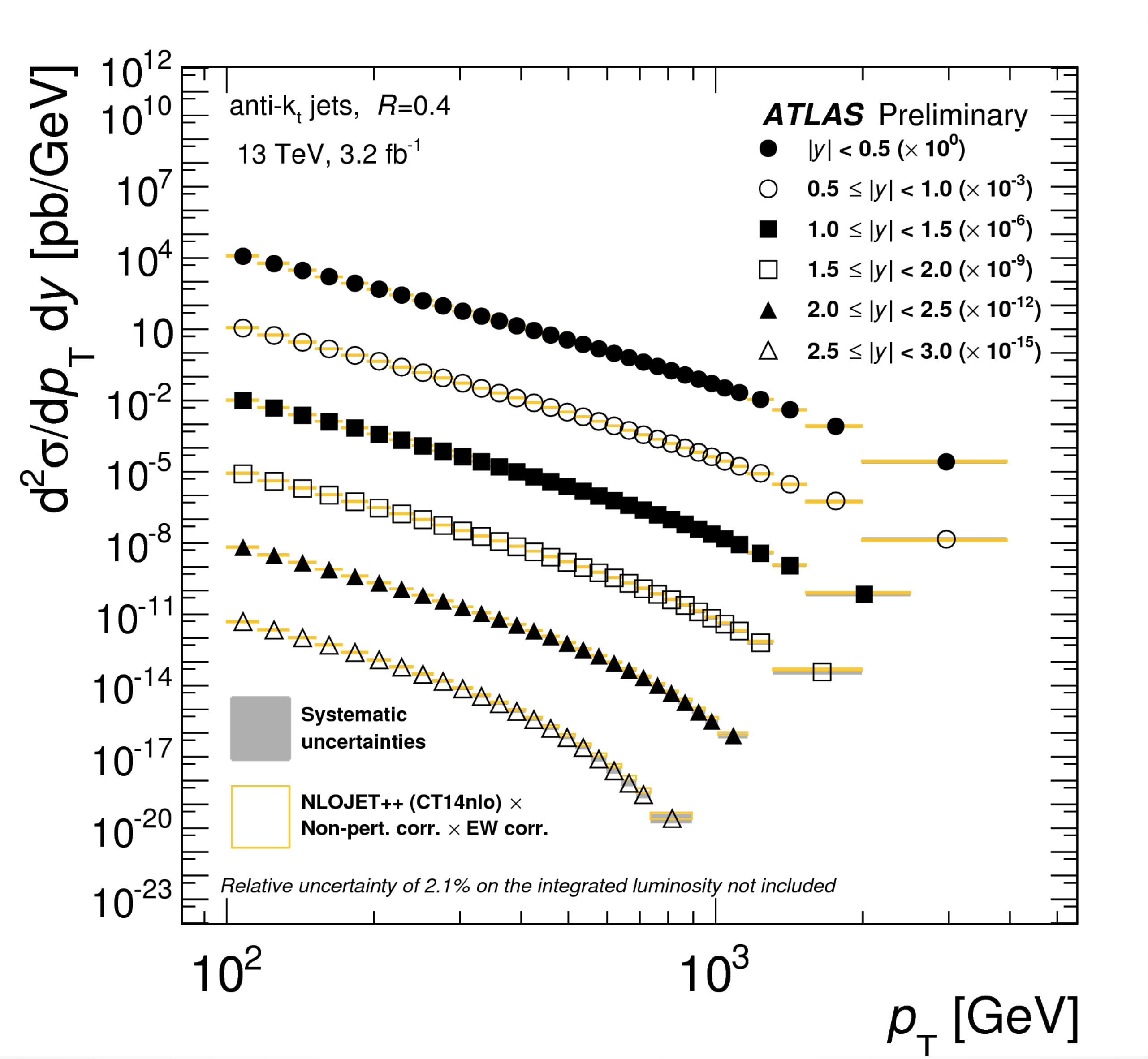
Status: August 2016





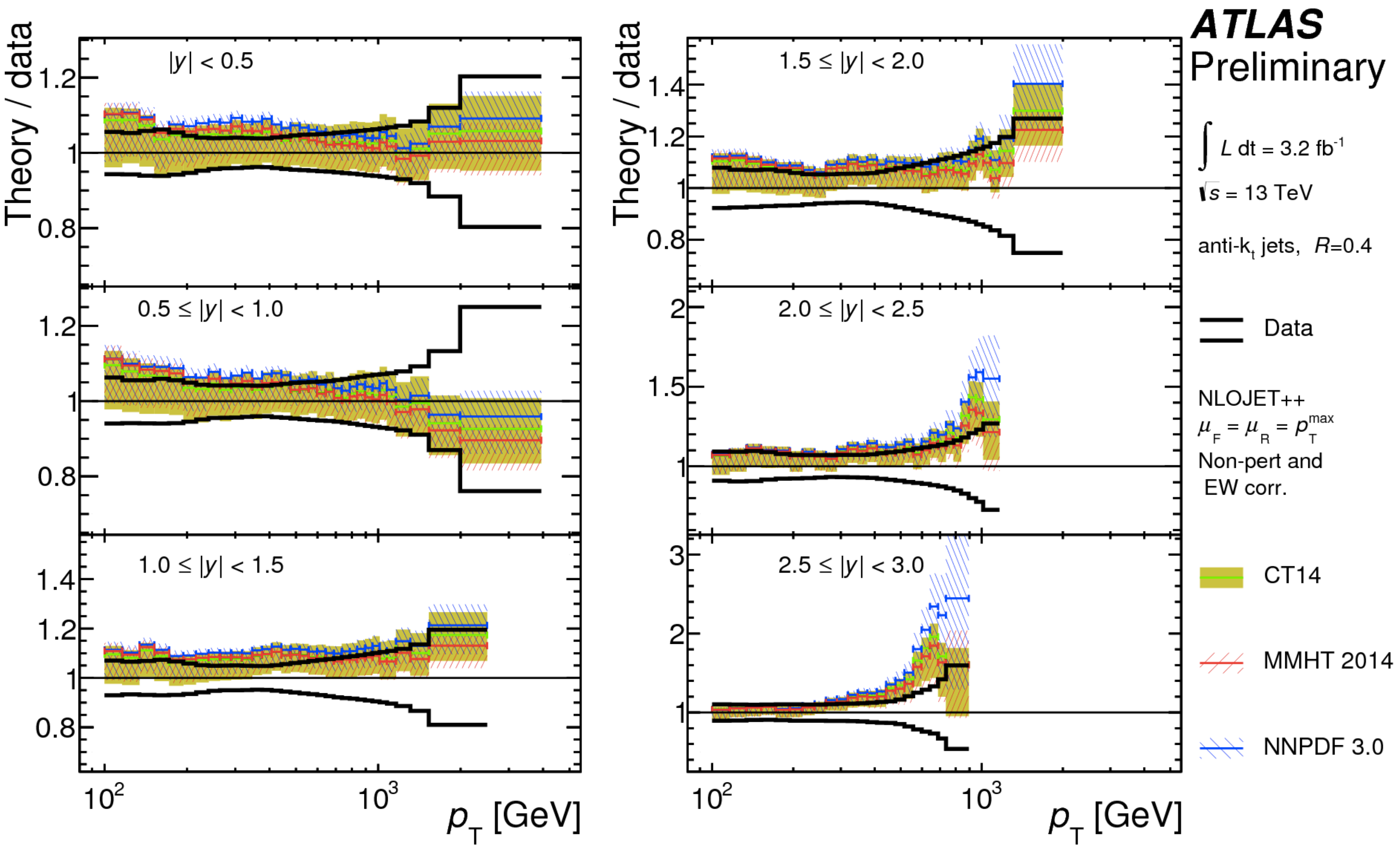
ATLAS Preliminary
Theory
Measurement
Total production cross section [pb]
$\sqrt{s}$ [TeV]
pp → X
Pythia8 (LO)
pp → W
NNLO
pp → Z / γ*
NNLO
pp → $t\bar{t}$
NNLO+NNLL
pp → tq
NLO+NNLL
pp → H
LHC-XS (N³LO ggF)
pp → WW × 0.1
NNLO
pp → WZ × 0.1
NNLO
pp → ZZ × 0.1
NNLO
pp → X
7 TeV, 20 μb⁻¹, Nat. Commun. 2, 463 (2011)
8 TeV, 500 μb⁻¹, arXiv:1607.06605
13 TeV, 60 μb⁻¹, arXiv:1606.02625
pp → W pp → Z / γ*
7 TeV, 36 pb⁻¹, PRD 85, 072004 (2012)
13 TeV, 81 pb⁻¹, PLB 759 (2016) 601
pp → $t\bar{t}$
7 TeV, 4.6 fb⁻¹, Eur. Phys. J. C 74:3109 (2014)
8 TeV, 20.3 fb⁻¹, Eur. Phys. J. C 74:3109 (2014)
13 TeV, 3.2 fb⁻¹, arXiv:1606.02699
pp → tq
7 TeV, 4.6 fb⁻¹, PRD 90, 112006 (2014)
8 TeV, 20.3 fb⁻¹, ATLAS-CONF-2014-007
13 TeV, 3.2 fb⁻¹, ATLAS-CONF-2015-079
pp → H
7 TeV, 4.5 fb⁻¹, Eur. Phys. J. C76 (2016) 6
8 TeV, 20.3 fb⁻¹, Eur. Phys. J. C76 (2016) 6
13 TeV, 13.3 fb⁻¹, ATLAS-CONF-2016-081
pp → WW
7 TeV, 4.6 fb⁻¹, PRD 87, 112001 (2013)
8 TeV, 20.3 fb⁻¹, arXiv:1608.03086
13 TeV, 3.2 fb⁻¹, ATLAS-CONF-2016-090
pp → WZ
7 TeV, 4.6 fb⁻¹, Eur. Phys. J. C (2012) 72:2173
8 TeV, 20.3 fb⁻¹, PRD 93, 092004 (2016)
13 TeV, 3.2 fb⁻¹, arXiv:1606.04017
pp → ZZ
7 TeV, 4.6 fb⁻¹, JHEP 03, 128 (2013)
8 TeV, 20.3 fb⁻¹, ATLAS-CONF-2013-020
13 TeV, 3.2 fb⁻¹, PRL 116, 101801 (2016)

Inclusive jet cross sections, √s = 13 TeV

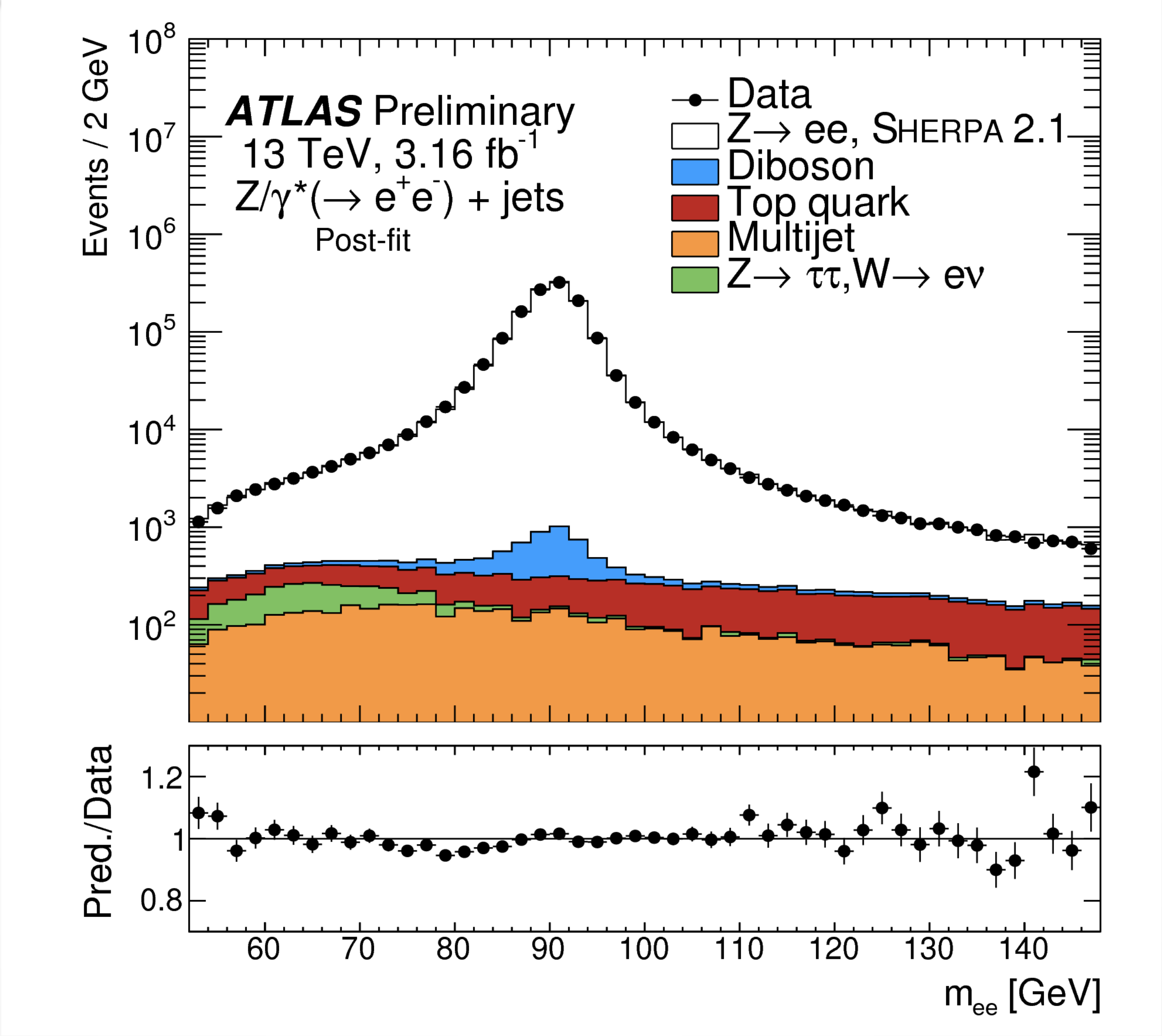


ATLAS-CONF-2016-092 Aug 21, 2016

unfolded jet cross sections, NLO predictions



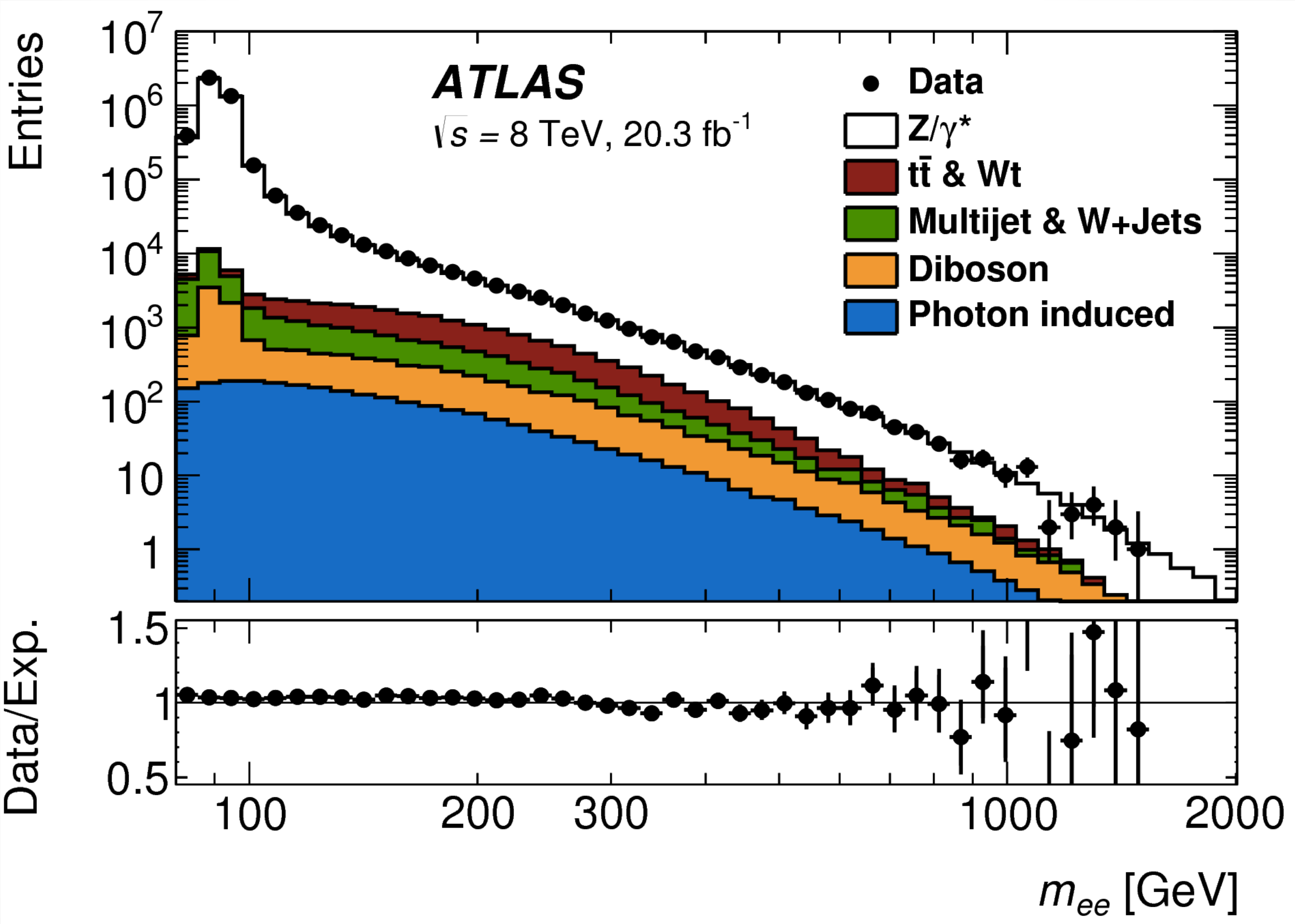
Z + jets cross section, $\sqrt{s}$ = 13 TeV



ATLAS-CONF-2016-046 ICHEP, 2016 Result

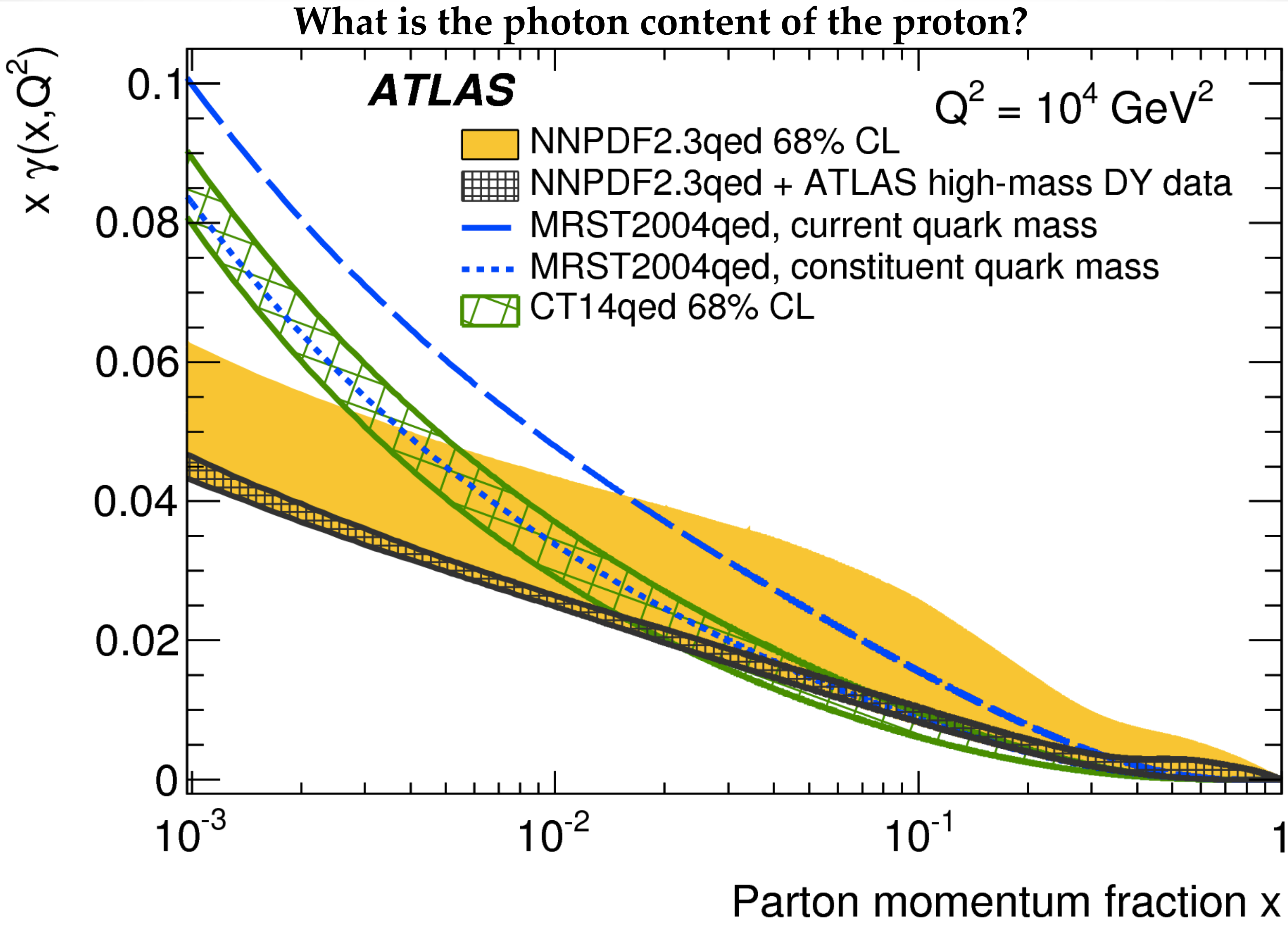
High Mass Drell Yan cross section, √s = 8 TeV

With more data and more time, we can extend the reach to very high mass



JHEP 08 (2016) 009

High Mass Drell Yan cross section, $\sqrt{s}$ = 8 TeV

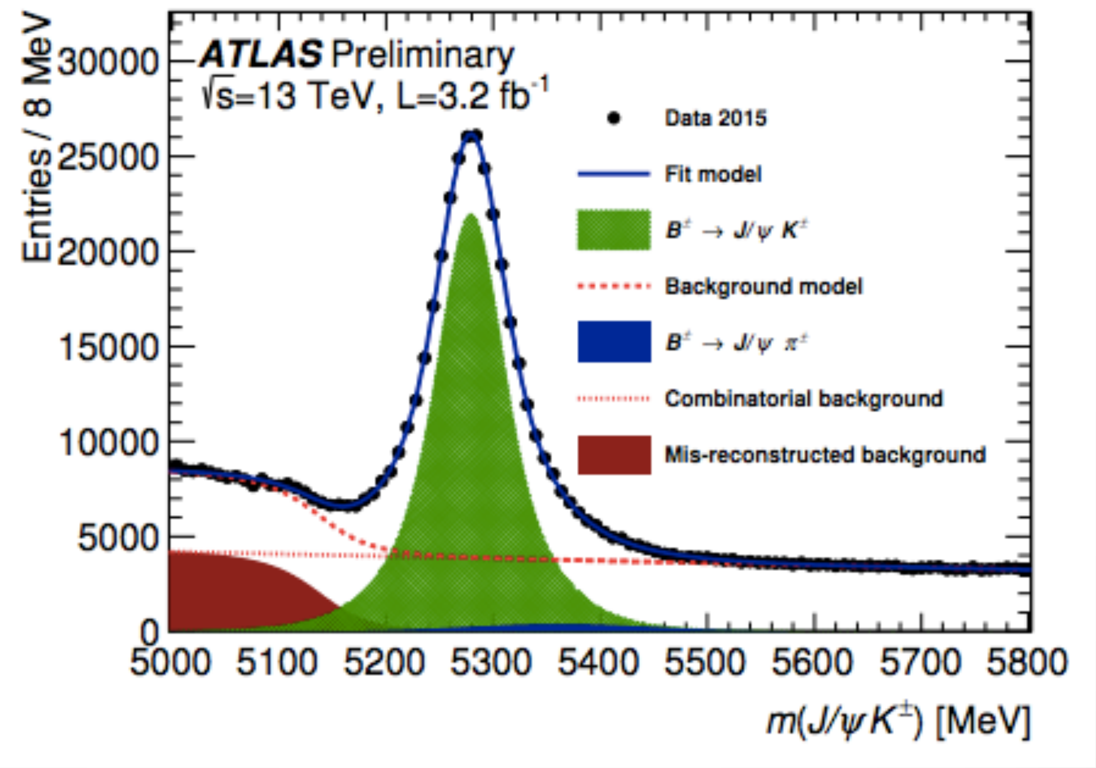


JHEP 08 (2016) 009

b Physics Results

- Efficient tagging of b-quarks is critical within the ATLAS physics program and, as we learned from the TeVatron, hadron colliders have an important role to play in b physics!
- Burden is largely on tracking performance
- We can test the track calibrations by reconstructing the b-quark mass

ATLAS-CONF-2015-064



b Physics Results

When tracking is tuned we can

- tag b-quark jets to select or veto physics processes
- dig into possible sources of CP violation, Flavor changing neutral currents

Recent Results with Run 1 Data

Measurement of the relative width different of the B^0-B^0bar system
JHEP06 (2016) 081

Study of the rare decays B^0_s and B^0 into muon pairs
Eur. Phys. J. C 76 (2016) 513

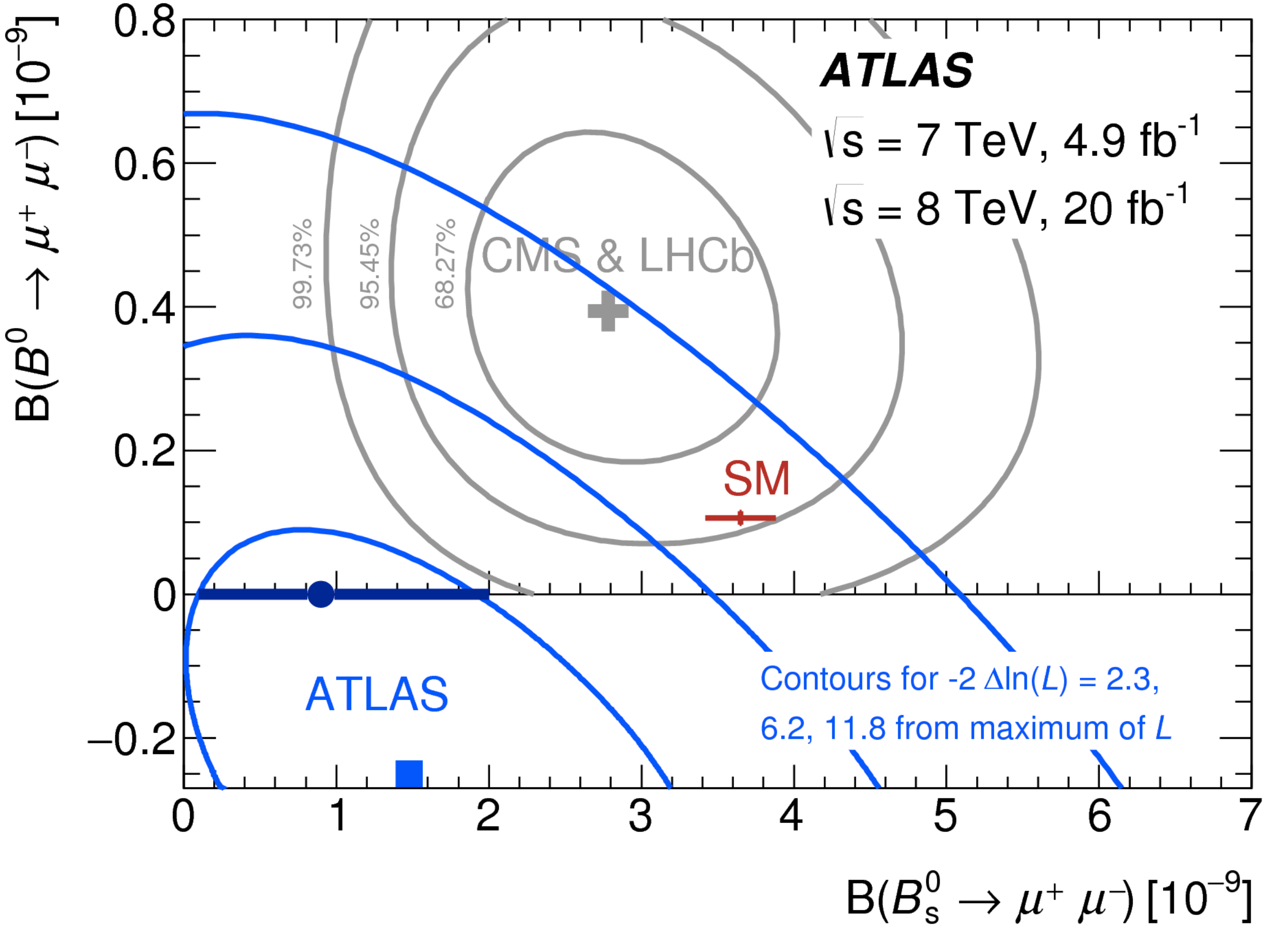
Measurement of the CP-violating phase φ_s and the B^0_s meson decay width difference with $B^0_s \to J/\Psi\ \phi$ decays
JHEP 2608 (2016) 147

Measurement of $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ meson production cross sections ($\sqrt{s}$= 7 TeV)
Nucl. Phys. B907 (2016) 717

Study of the rare decays B^0_s and B^0 to muon pairs

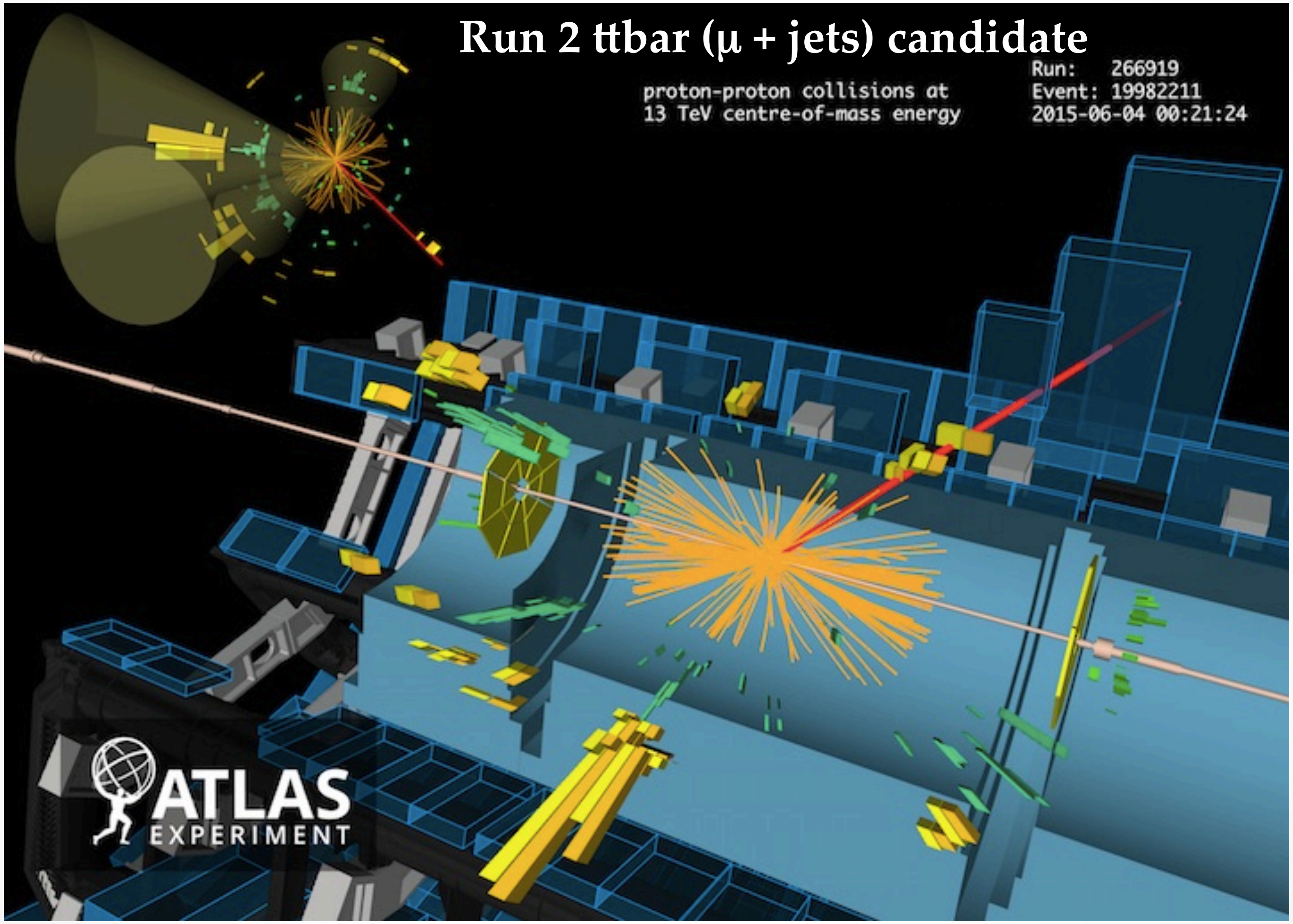
ATLAS: BF($B^0 \to \mu^+\mu^-$) < 4.2 x 10^{-10} @95% CL **CMS + LHCb**: BF = 3.9 +1.6 -1.4 x 10^{-10}

ATLAS: BF($B^0_s \to \mu^+\mu^-$) = 0.9 +1.1 –0.8 x 10^{-9} **CMS + LHCb**: BF = 2.8 +0.7 -0.6 x 10^{-9}



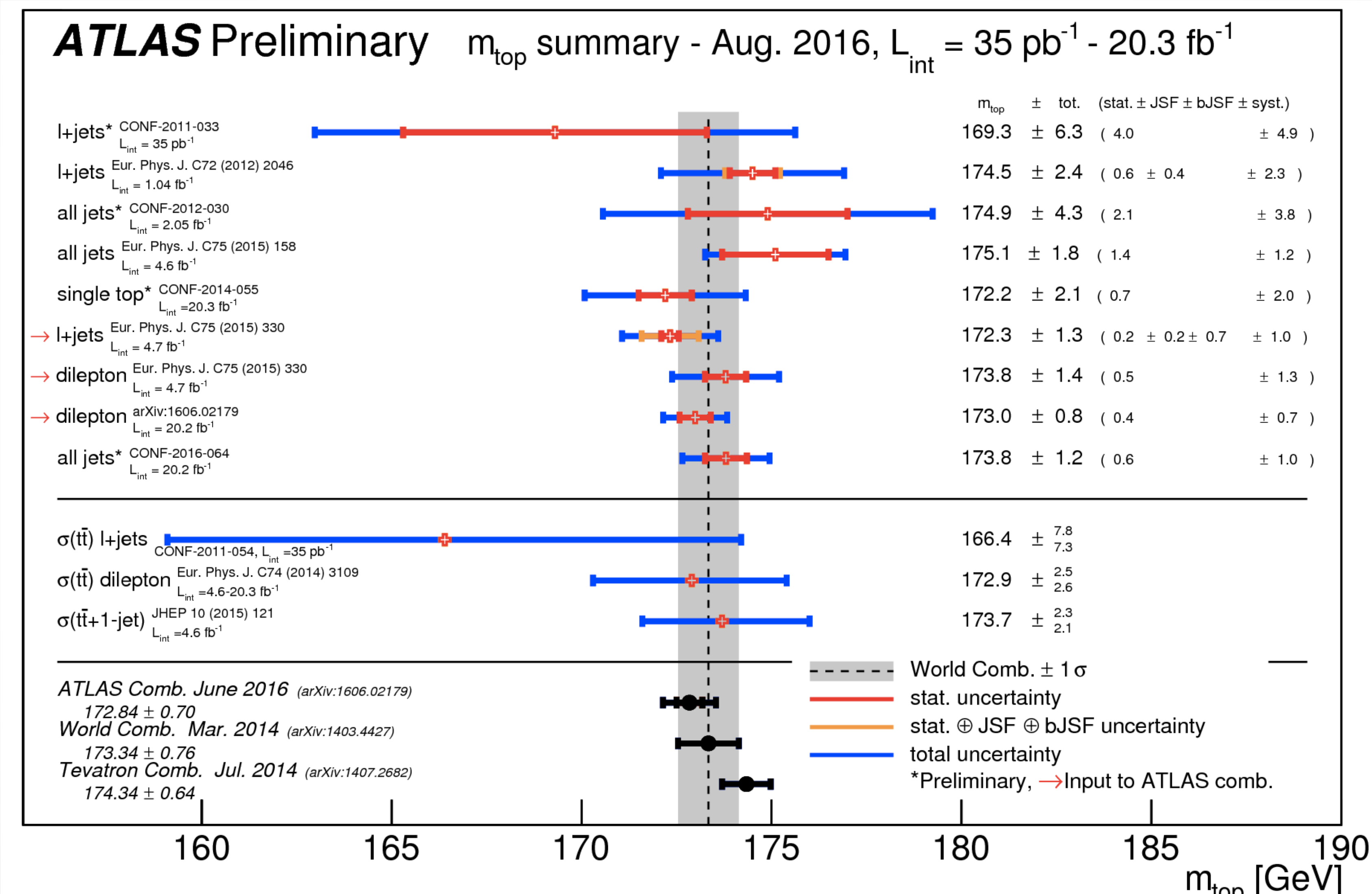
Eur. Phys. J. C 76 (2016) 513 Published Sept 21, 2016

top Physics Results

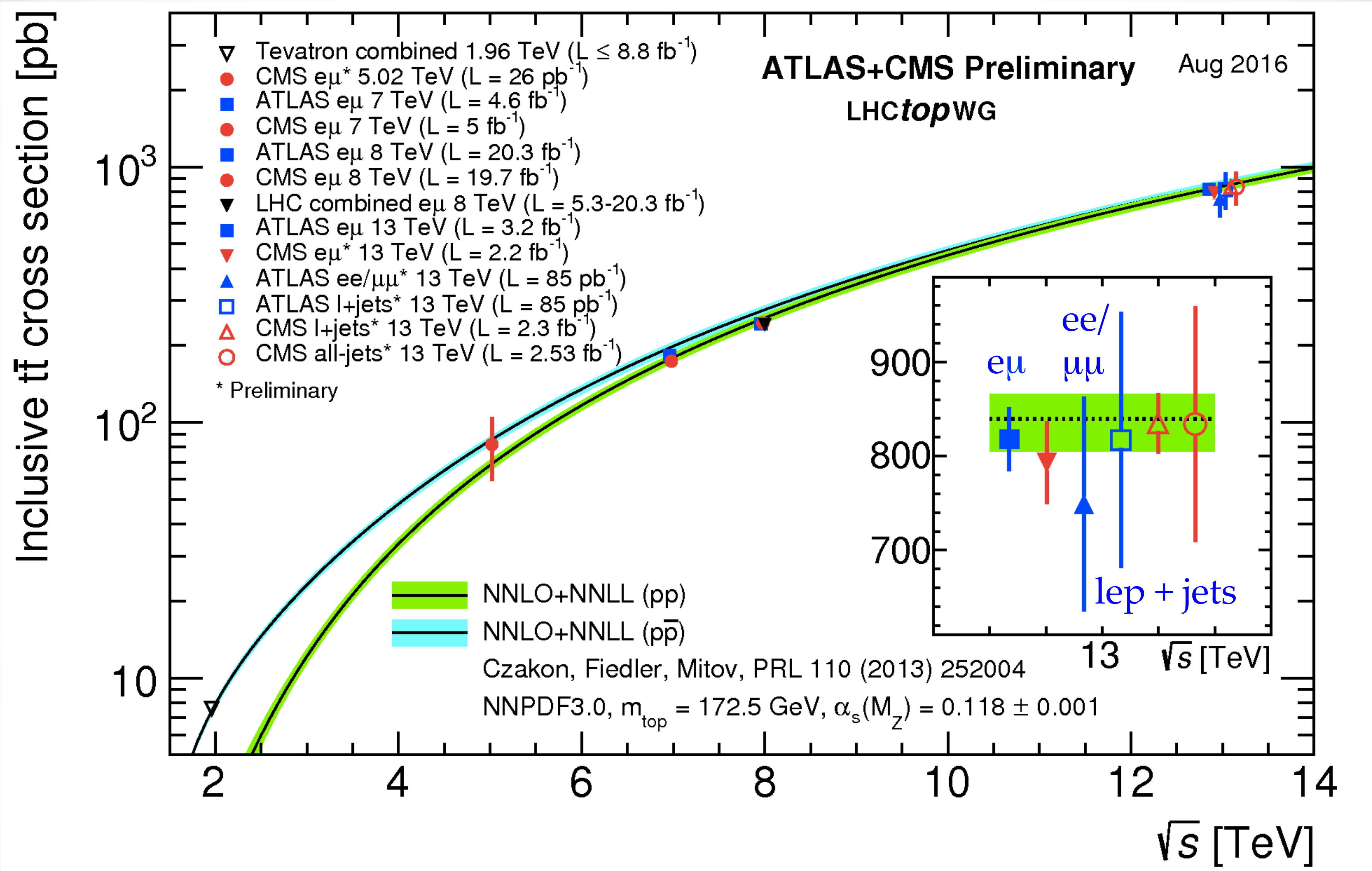


top quark mass (Run 1 data)

ATLAS Combination: **172.84 ± 0.70 GeV**

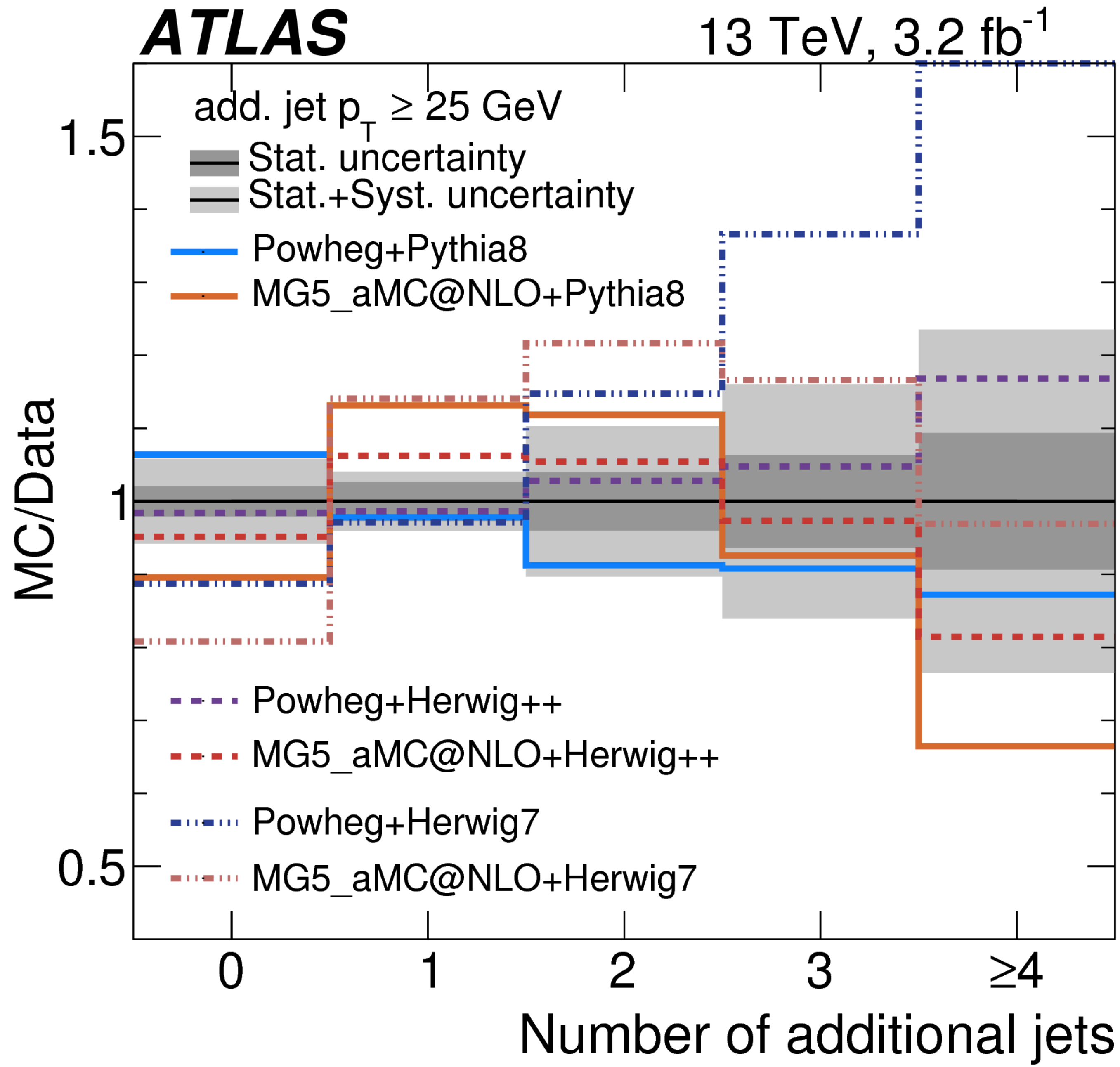


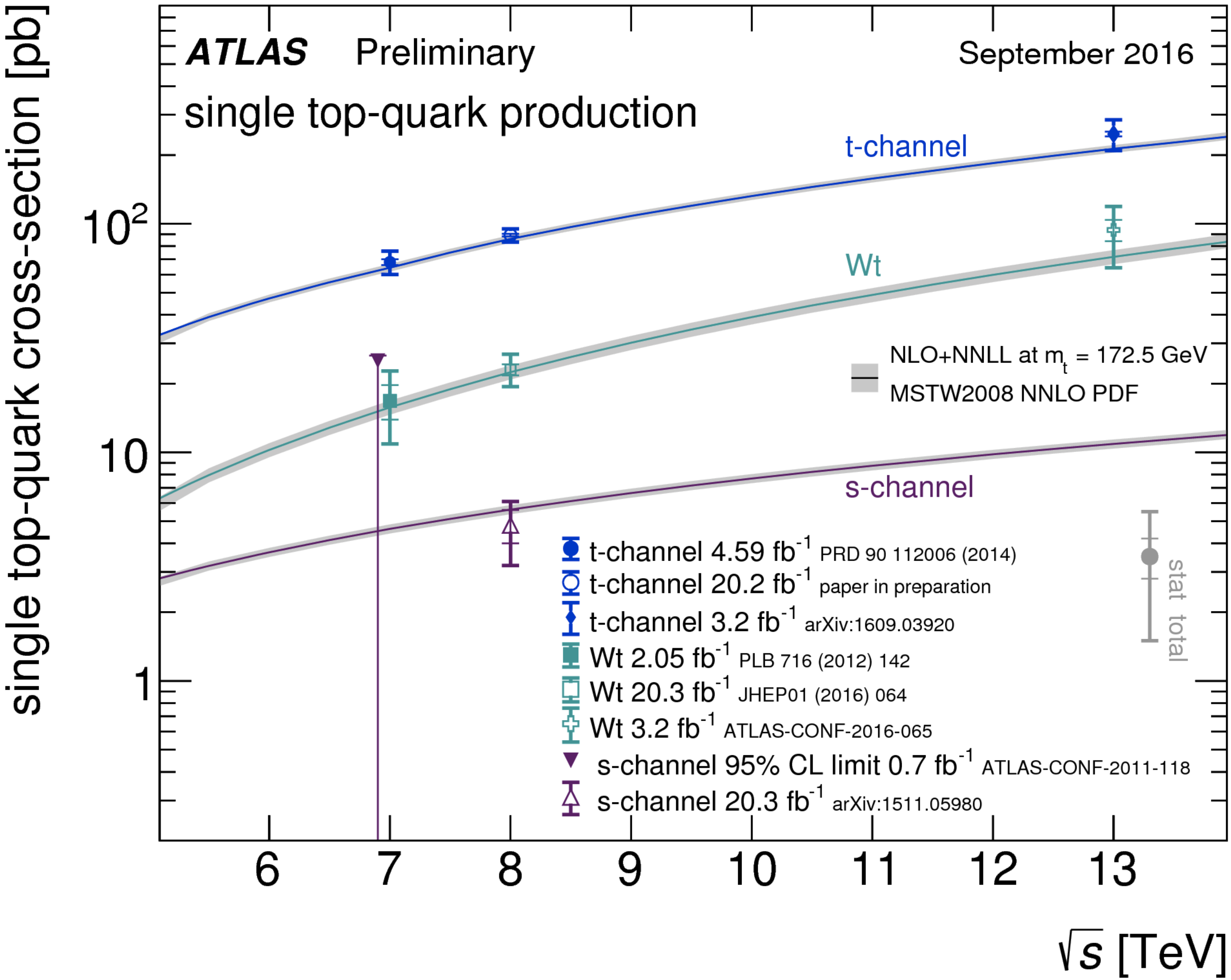
top pair production cross section



jet activity in top quark events with an electron, a muon and two tagged b-jets

Submitted to EPJC on Halloween, 2016




ATLAS Preliminary
September 2016
single top-quark production
t-channel
Wt
s-channel
NLO+NNLL at m_t = 172.5 GeV
MSTW2008 NNLO PDF
t-channel 4.59 fb^{-1} PRD 90 112006 (2014)
t-channel 20.2 fb^{-1} paper in preparation
t-channel 3.2 fb^{-1} arXiv:1609.03920
Wt 2.05 fb^{-1} PLB 716 (2012) 142
Wt 20.3 fb^{-1} JHEP01 (2016) 064
Wt 3.2 fb^{-1} ATLAS-CONF-2016-065
s-channel 95% CL limit 0.7 fb^{-1} ATLAS-CONF-2011-118
s-channel 20.3 fb^{-1} arXiv:1511.05980
stat total
single top-quark cross-section [pb]
$\sqrt{s}$ [TeV]
10^2
10
1
6
7
8
9
10
11
12
13

single top

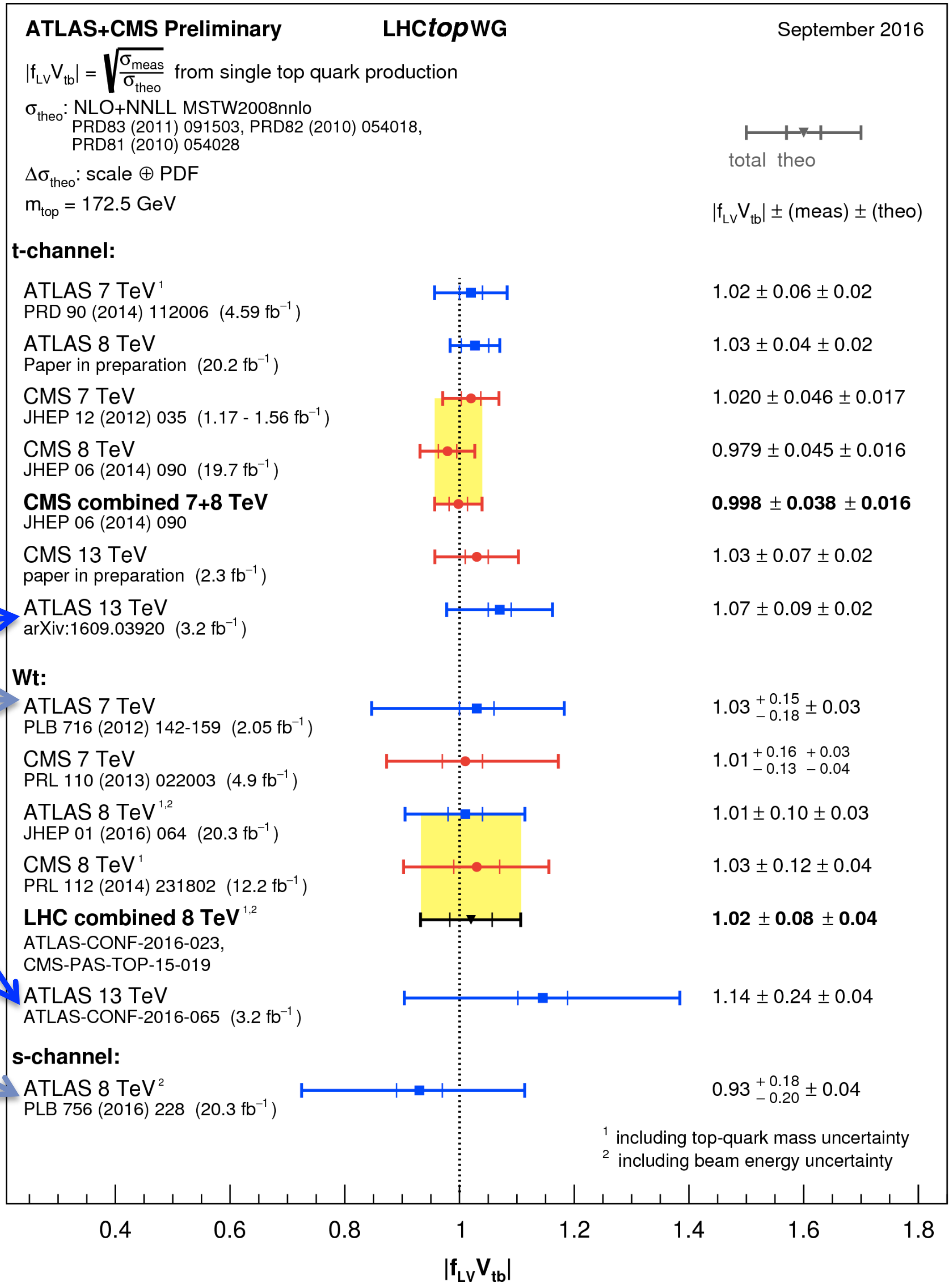
extracting CKM matrix element Vtb from single top measurements

t-channel

ATLAS 13 TeV

Wt

s-channel



SUSY Results

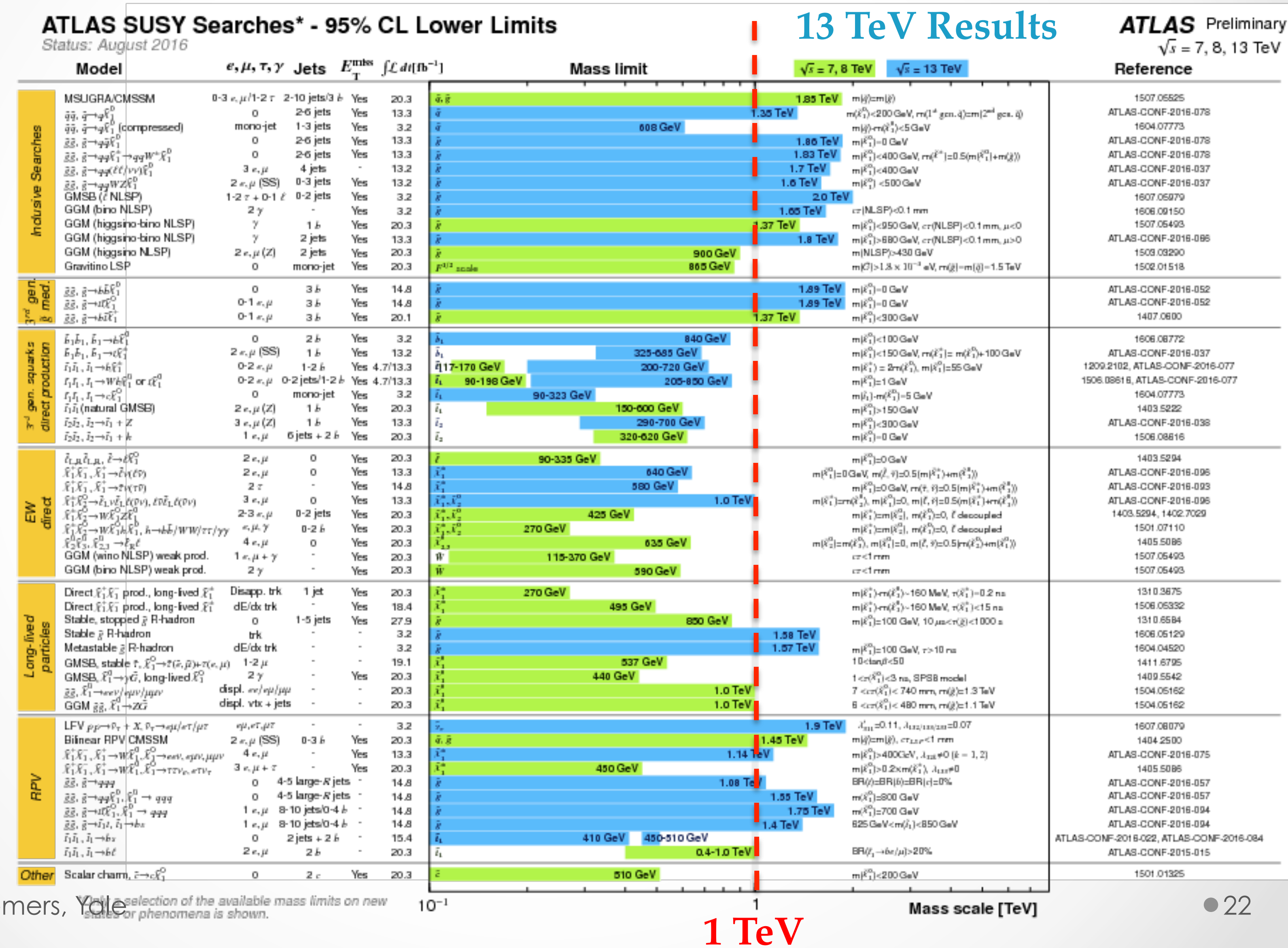
Inclusive Searches

3rd Generation

EW Direct

Long-lived Particles

RPV



$\sqrt{s}$ = 13 TeV: 12 submitted papers, 20 conference notes

Missing Transverse Energy + 1-2 tau
Missing Transverse Energy + di-photons
Missing Transverse Energy + 2 b-quarks

Zero leptons + 7-10 jets
Zero leptons + 2-6 jets

One lepton + **2-6 jets**
One lepton **stop**

multiple **b-jets**

monojet

LLP w/ pixel+Tile
LLP w/ pixel dE/dx

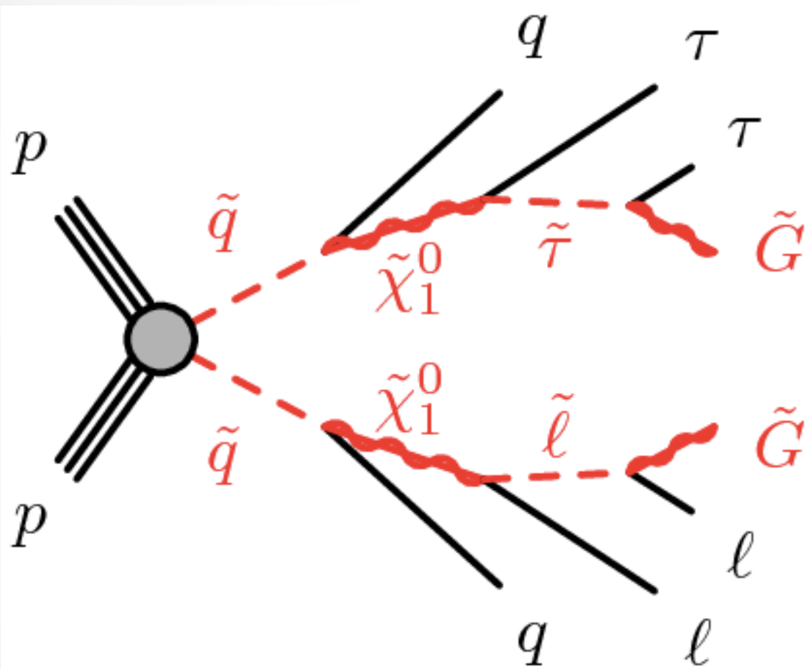
two or three **same-sign leptons**

SUSY Searches can be categorized in many ways. A convenient one is by final state particles.

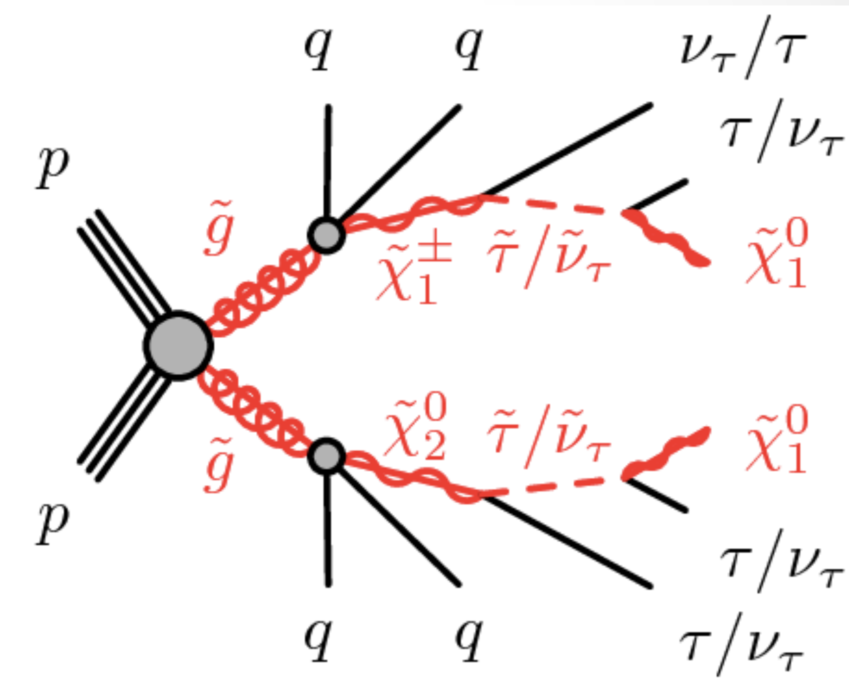
Here are the 12 submitted papers at $\sqrt{s}$ = 13 TeV, each with a 3.2 fb^{-1} dataset.

Search for squarks and gluinos in events with τ_{had}, jets and MET

Gauge-mediated SUSY breaking model (GMSB)



simplified model of gluino pair production



Select events with a MET (> 180 GeV) + jet (> 120 GeV) trigger

SUSY-2016-01 (submitted to EPJC)

Search for squarks and gluinos in events with τ_{had}, jets and MET

Analysis divided into two mutually exclusive channels:

1 tau AND ≥ 2 taus

1 tau channel: 3 signal regions
compressed, medium mass, high mass

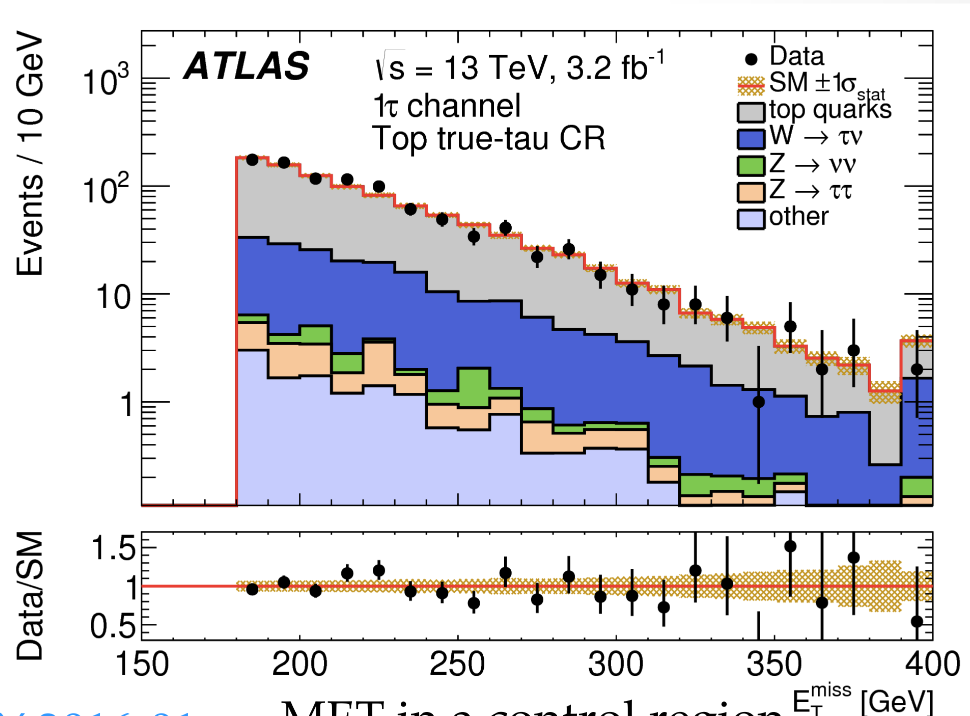
≥ 2 tau channel: 3 signal regions
compressed, high mass, GMSB

GMSB Model Parameters

- **SUSY-breaking scale in messenger sector (Λ)**
- **tanβ**
- messenger mass scale = 250 TeV
- # of mess. multiplets = 3
- sign of Higgsino mass term in superpotential = 1
- gravitino mass scale factor = 1

Simplified Model Parameters

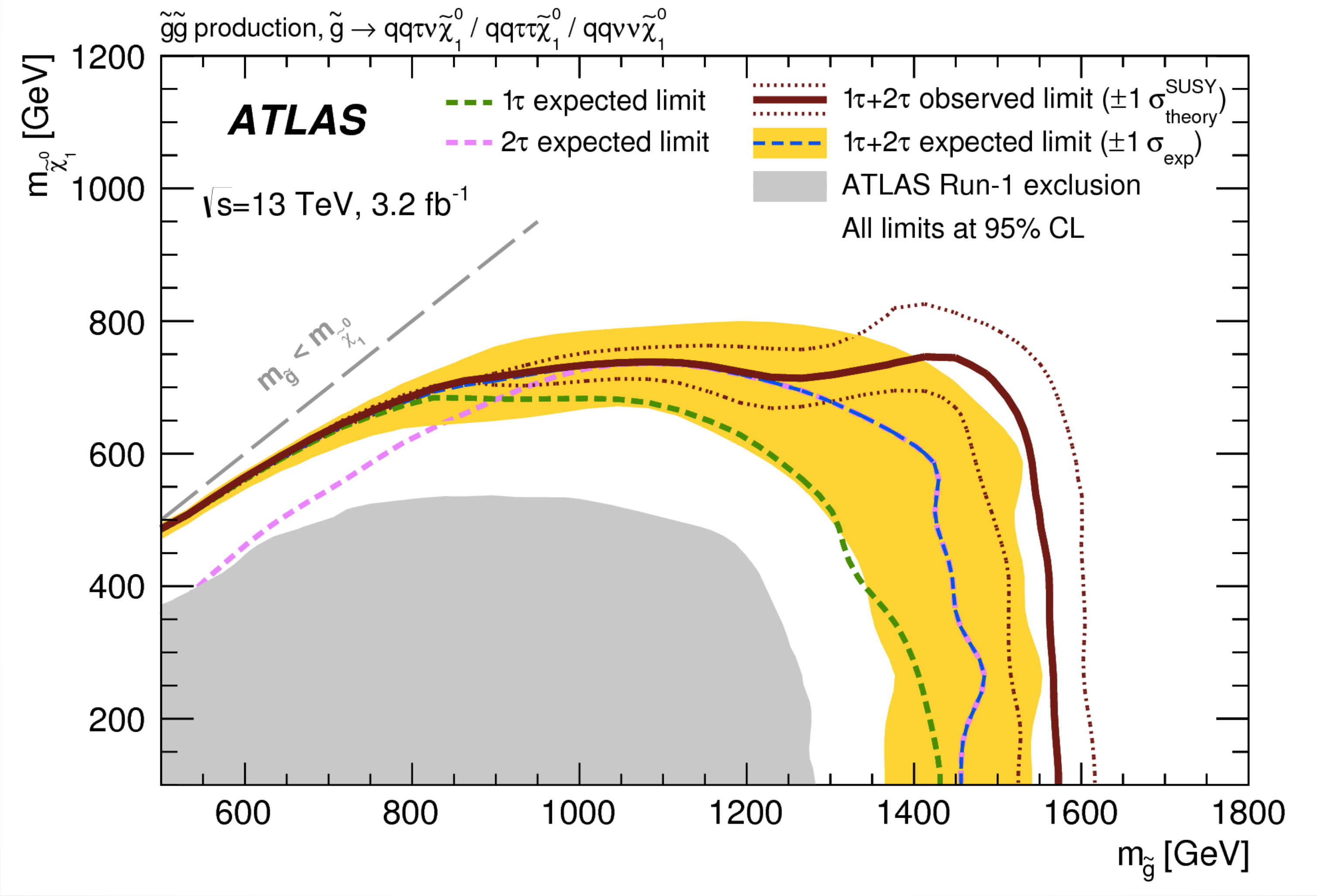
gluino and LSP masses



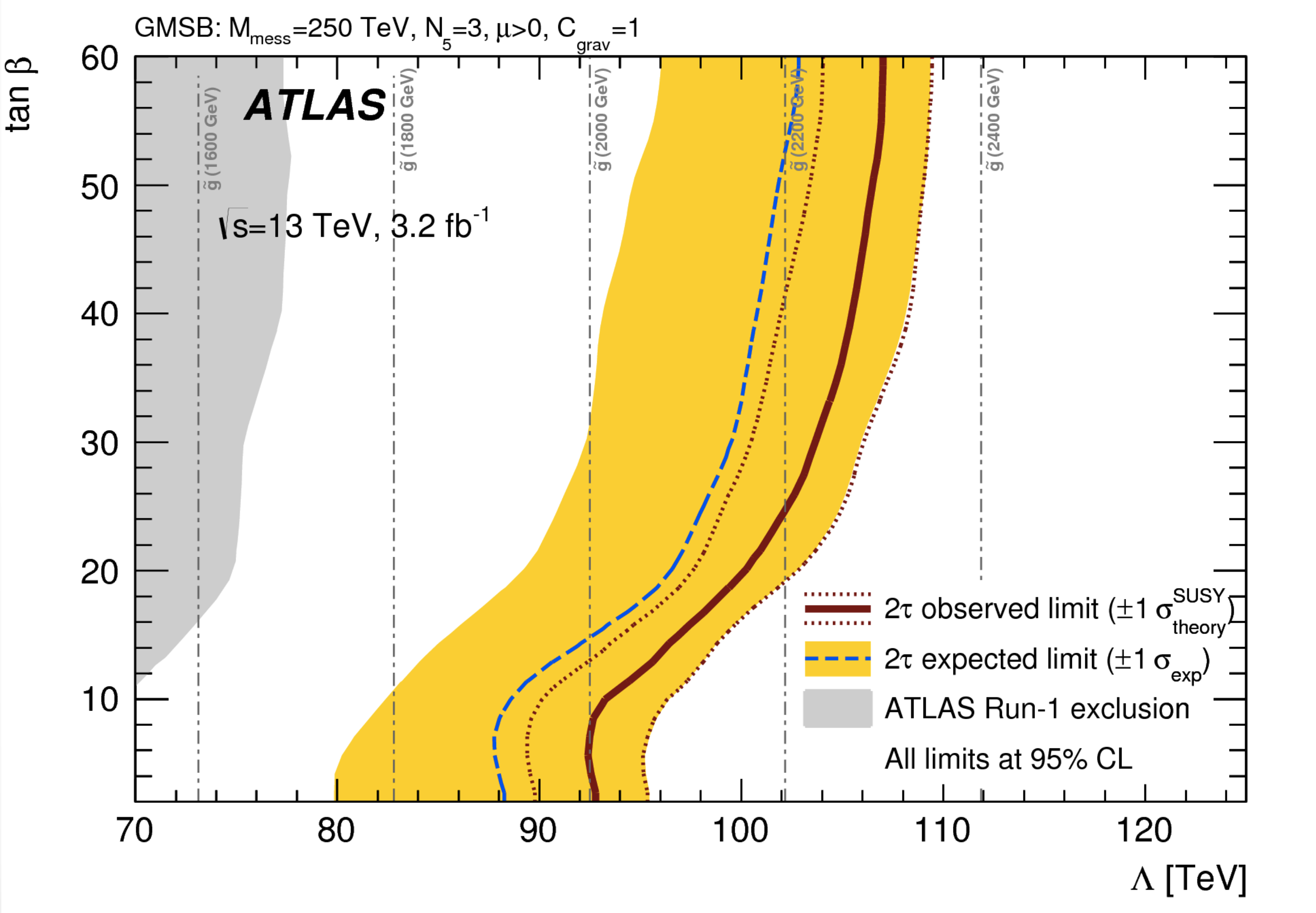
MET in a control region

SUSY-2016-01

Search for squarks and gluinos in events with τ_{had}, jets and MET



Search for squarks and gluinos in events with τ_{had}, jets and MET



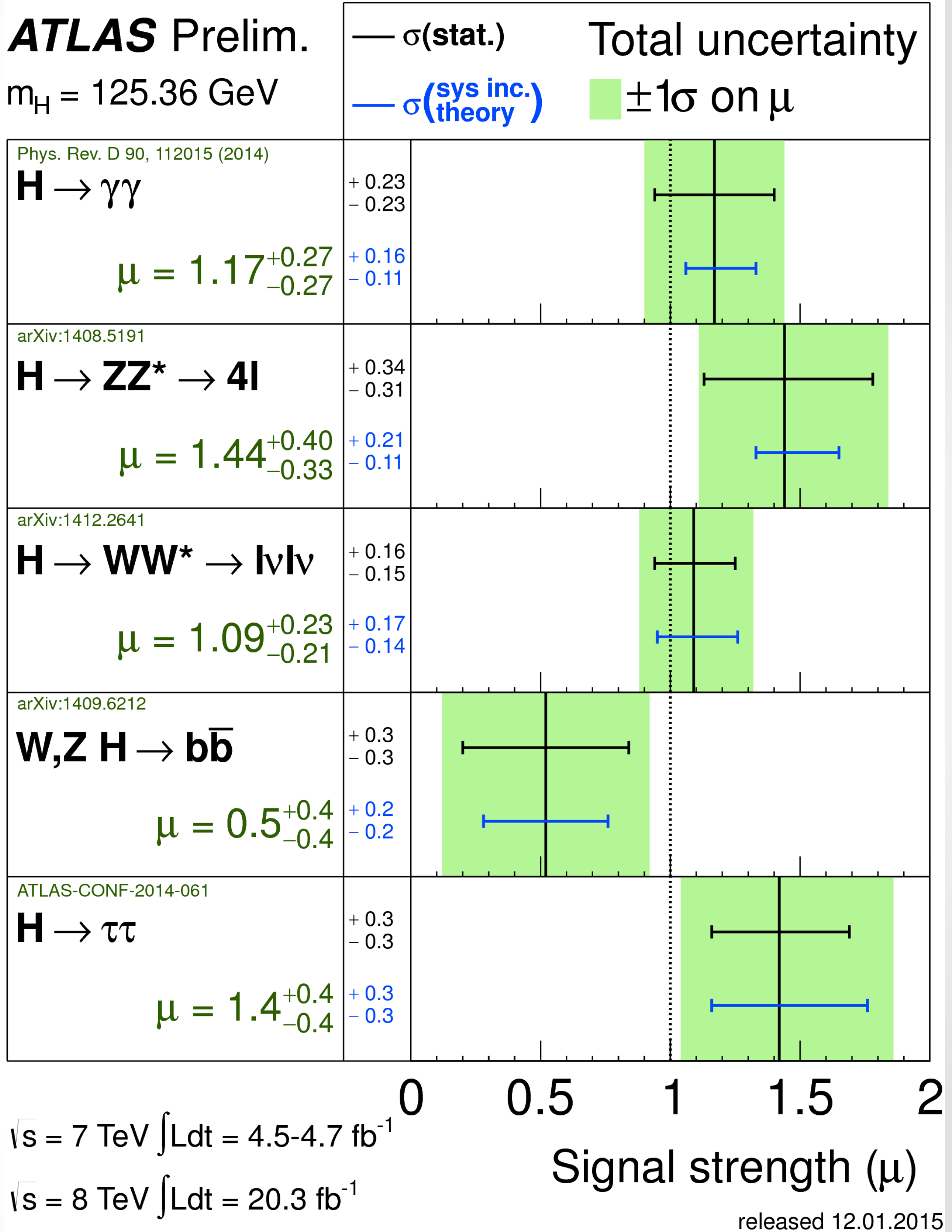
SUSY-2016-01

Higgs Results

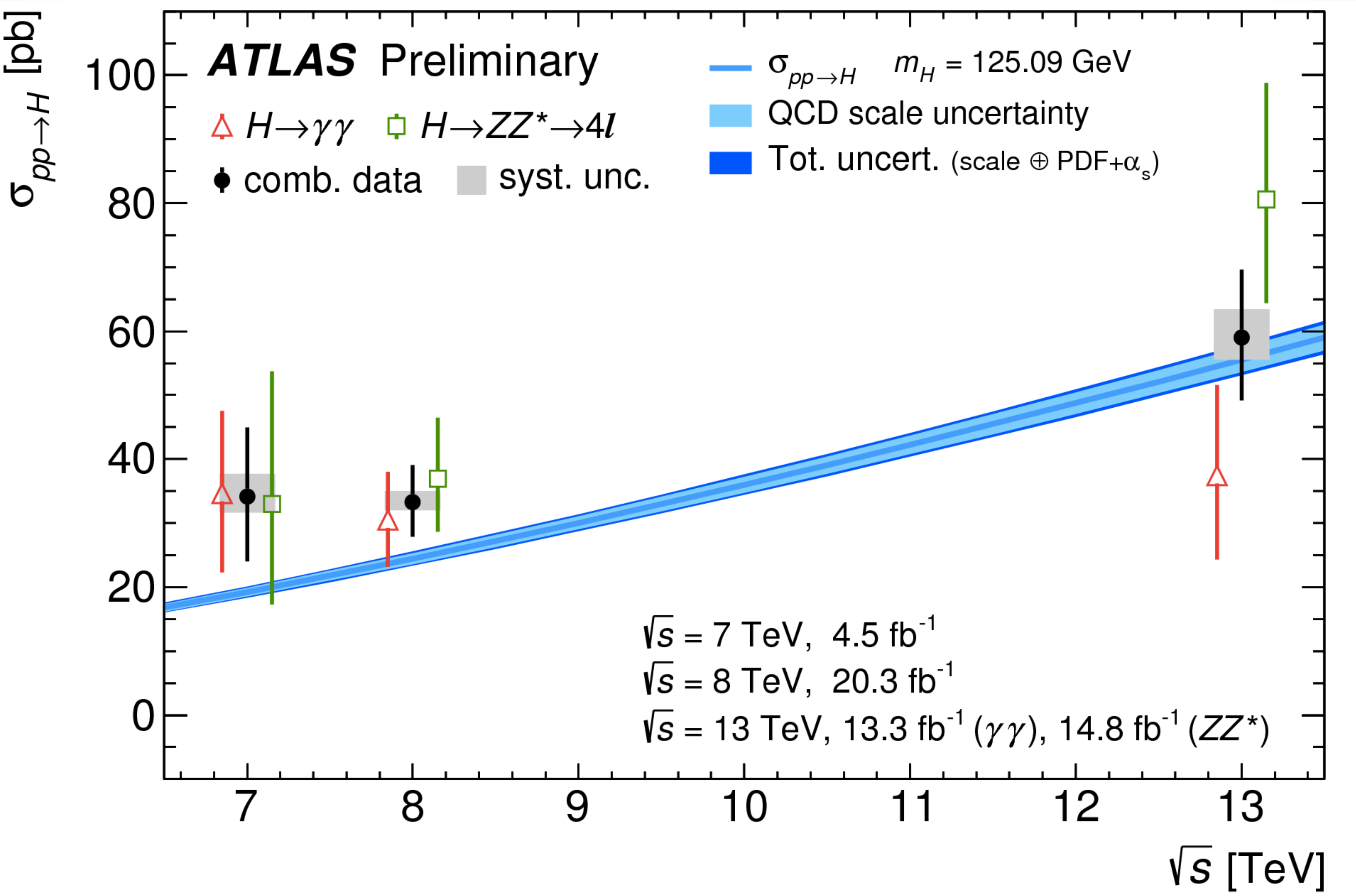
Where we stood with Run 1 Data:

Looking quite SM-like, but uncertainties were still large.

(Higgs Summary Plot)



Higgs re-discovery at √s = 13 TeV



ATLAS-CONF-2016-081

Run 2 Production and Decay

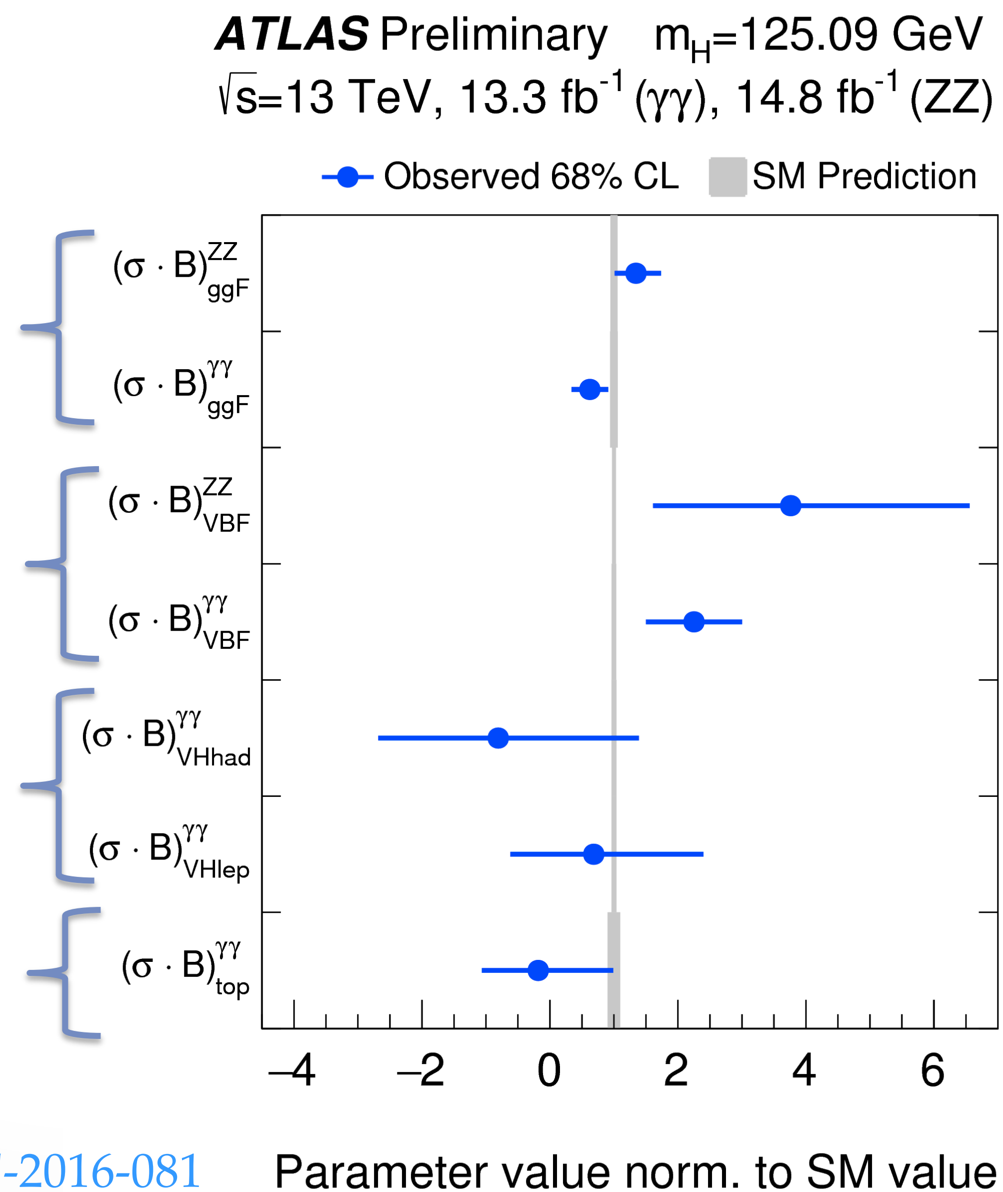
The "Golden Channels"
at √s = 13 TeV

gluon-gluon fusion

vector boson fusion

associated production
with a W or Z boson

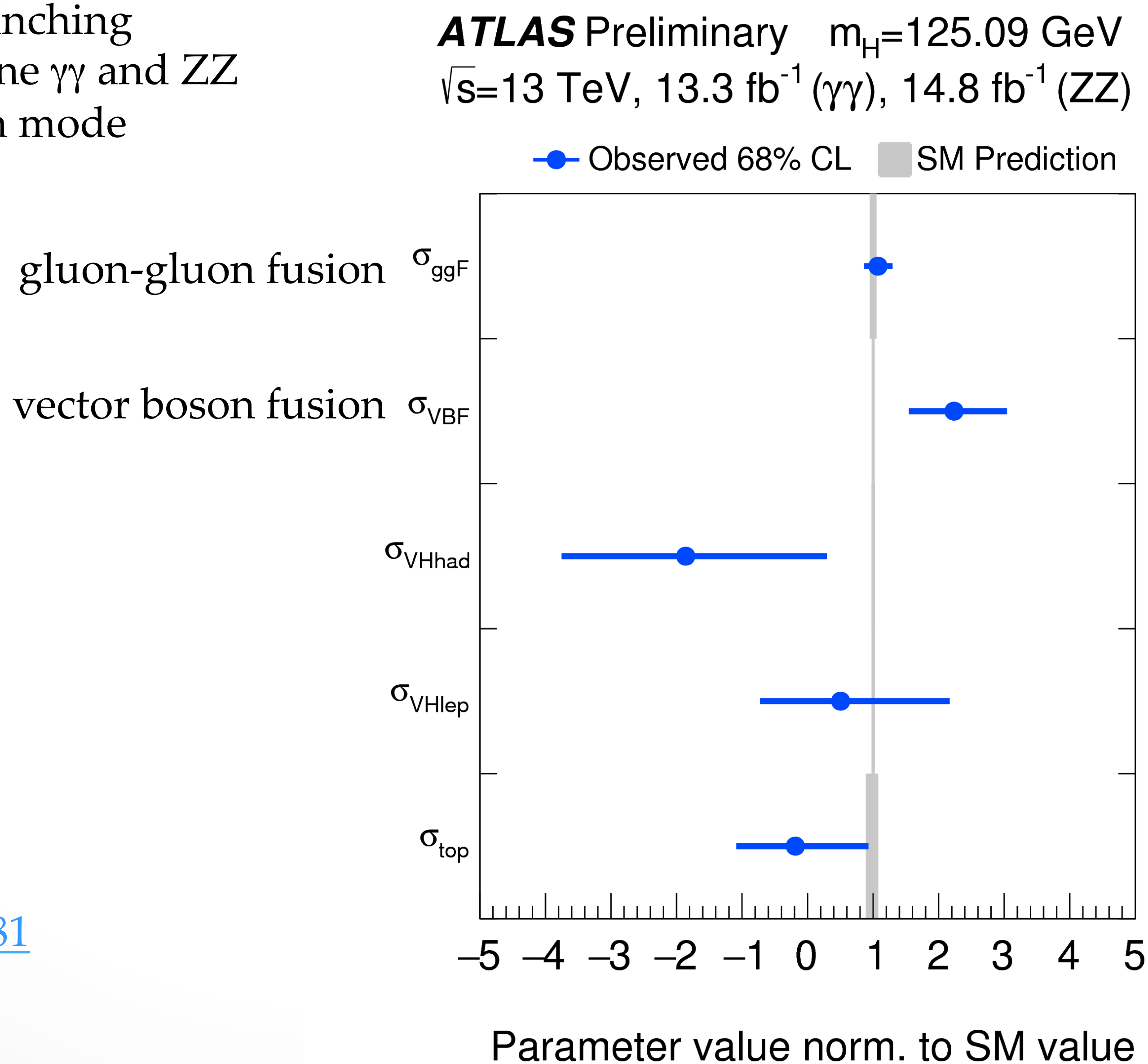
top



ATLAS-CONF-2016-081

Run 2 Production and Decay

If we assume SM branching ratios, we can combine γγ and ZZ to look at production mode



ATLAS-CONF-2016-081

Run 2 ($\sqrt{s}$=13 TeV) Higgs Results

Most recent paper submissions demonstrate that we are in an era of using the Higgs boson to hunt for new physics…

Search for MSSM Higgs bosons H/A and for a Z′ boson in the ττ final state
Accepted by EPJC http://arxiv.org/abs/1608.00890

Search for new resonances decaying to a W or Z boson and a Higgs boson in the eebb, eνbb, ννbb channels
Submitted to PLB http://arxiv.org/abs/1607.05621

Search for Higgs and Z boson decays to ϕγ
Submitted to EPJC https://arxiv.org/abs/1607.03400

Search for the Higgs boson produced in association with a W boson and decaying to four b-quarks via two spin zero particles
Accepted by EPJC https://arxiv.org/abs/1606.08391

Many other ATLAS results are presented at this meeting!

Ian Hinchliff: ATLAS Status and Outlook
Rachel Hyneman: Search for a high mass diphoton resonance
Mazin Khader: Analysis strategy/tools for a low mass H->2a -> 4b search
William Mccormack: Pixel Cluster Counting Luminosity Measurement
Samuel Meehan: Dark Matter, the Higgs and Jet Substructure
Qi Zeng: Searches for Resonances Decaying to VH/HH
Matthew Epland: Machine Learning Calibration of Large Radius Jets
Dayton Grogan: Multivariate Jet Calibration Using Neural Networks
Maximilian Swiatlowski: Searches for natural supersymmetry in multi-b final states
Haichen Wang: Search for new physics in high multiplicity hadronic final states
Rui Wang: Heavy resonance search using b-tagged di-jets

Conclusions

We continue to learn a tremendous amount from Run 1 data

Run 2's higher energy and larger datasets are already paying off in searches and in some measurements

http://lonestarartisans.com/this-is-a-marathon-not-a-sprint/

Thanks for your attention!