The Standard Model and Beyond: ATLAS

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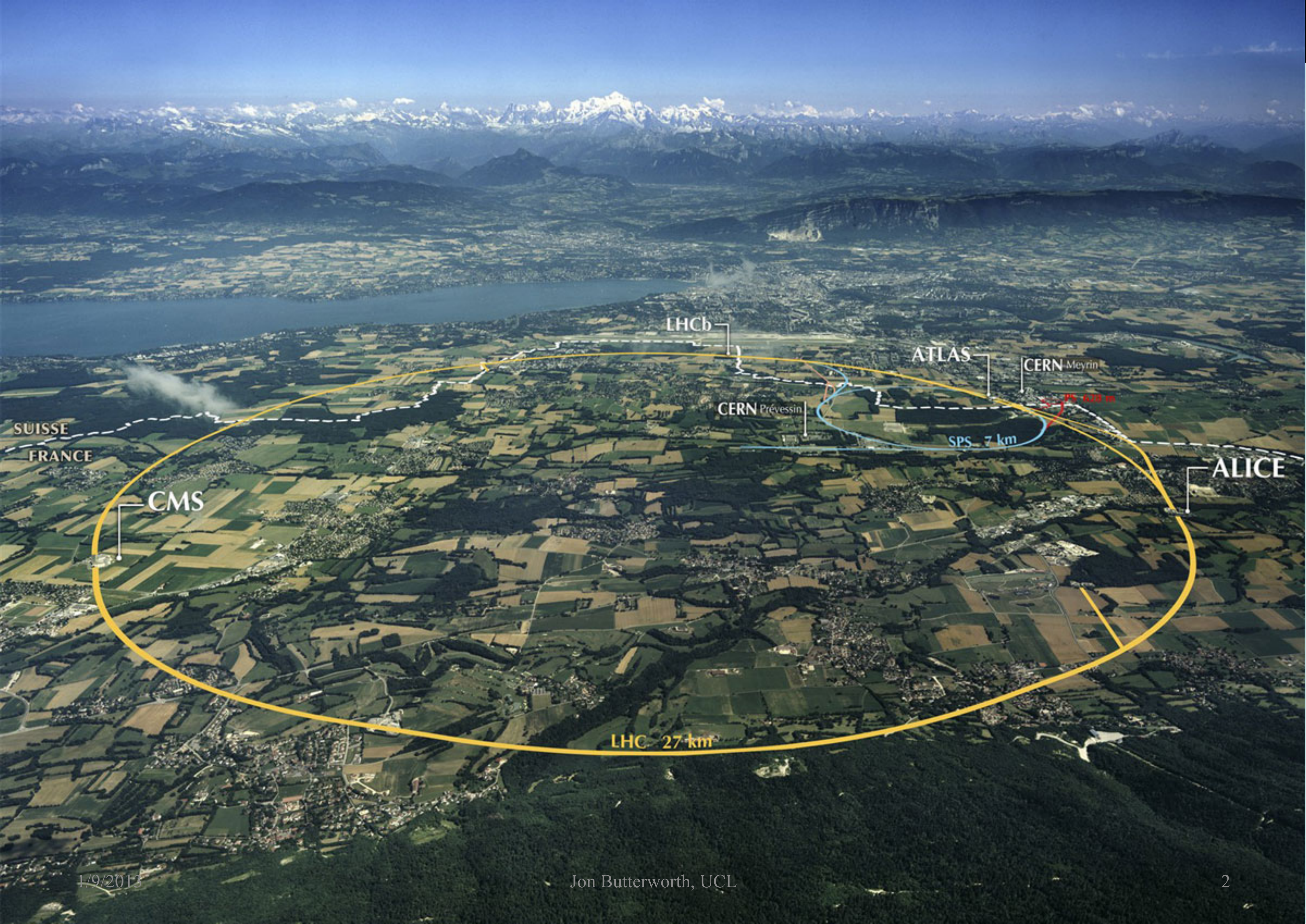
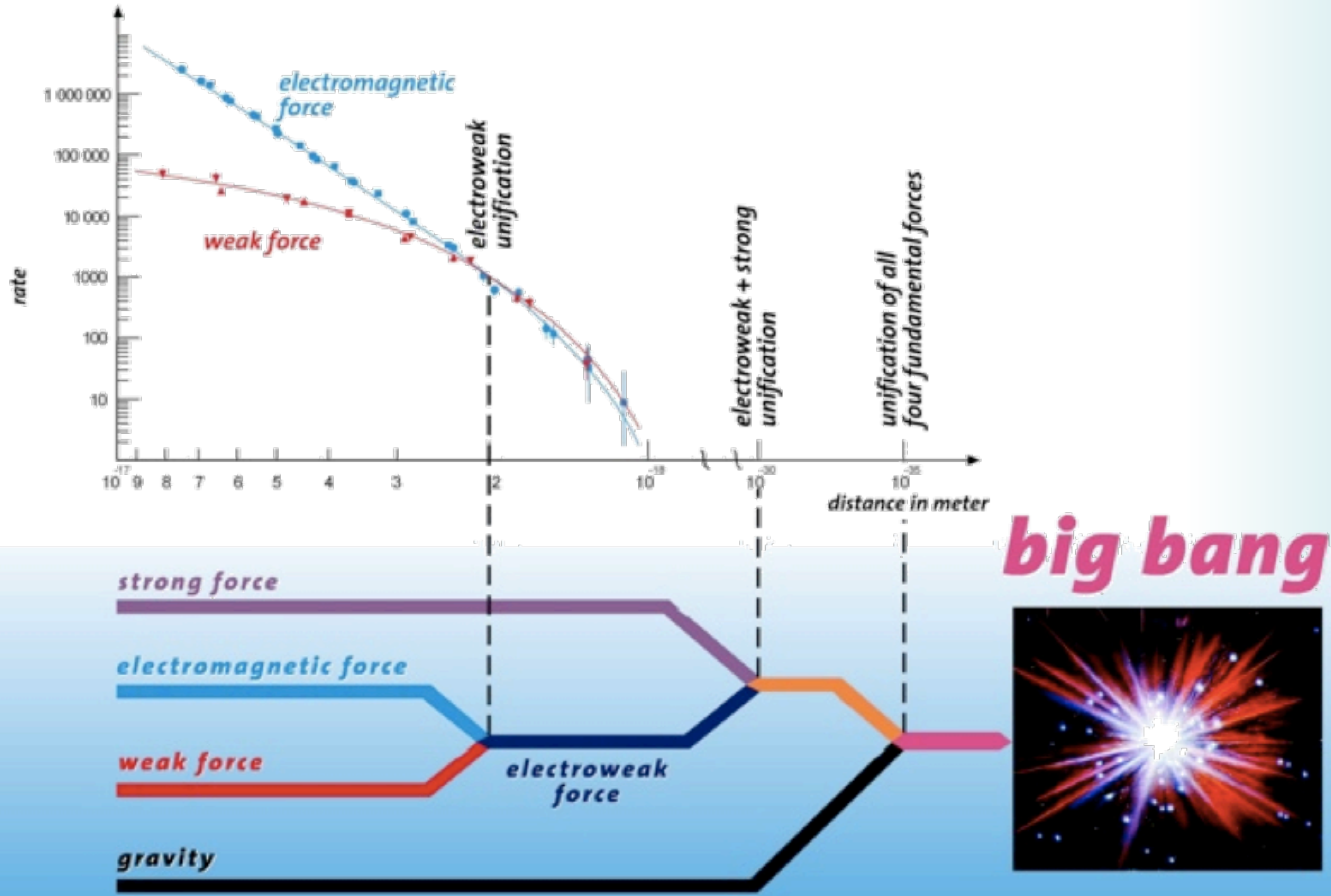
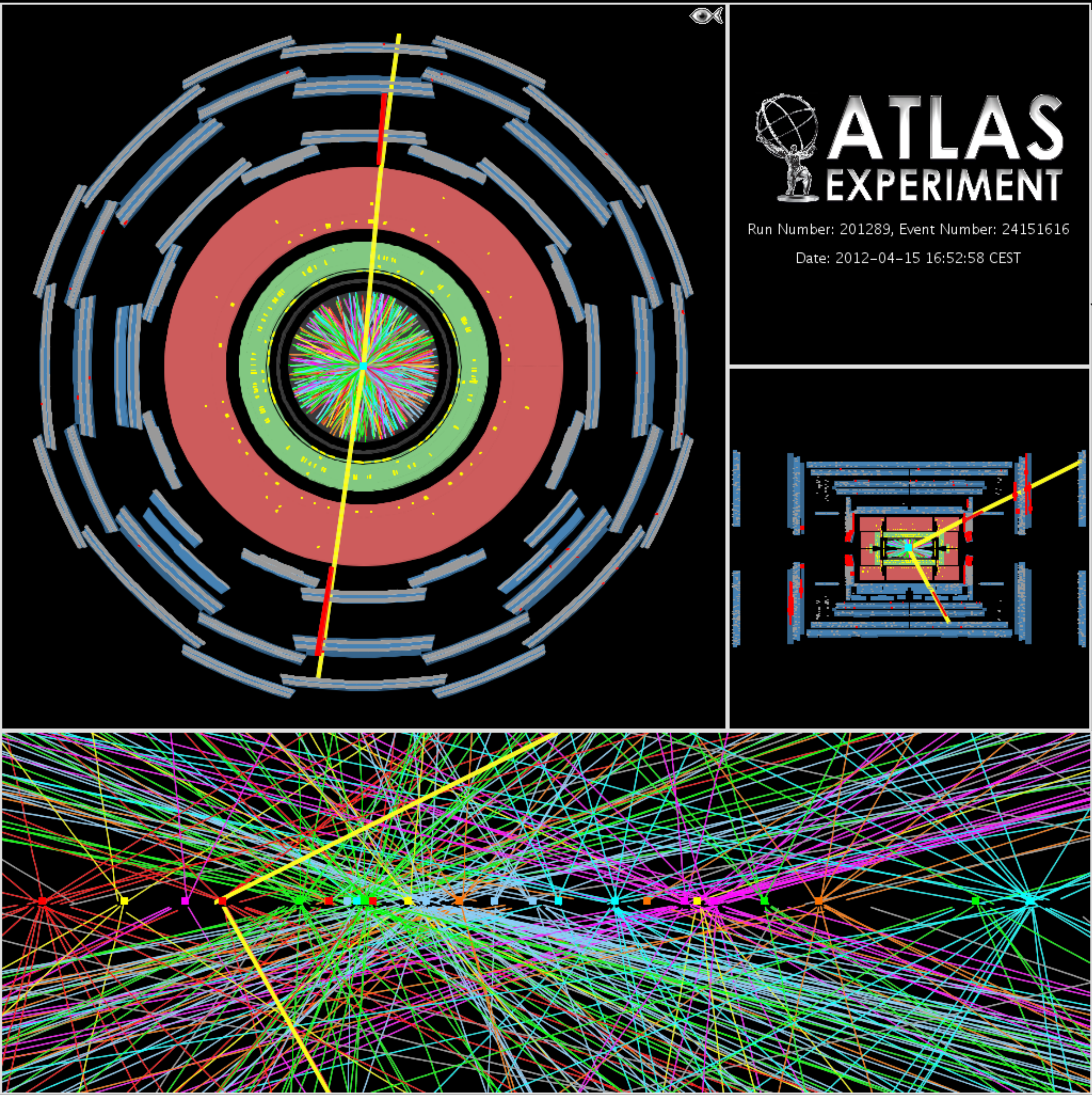
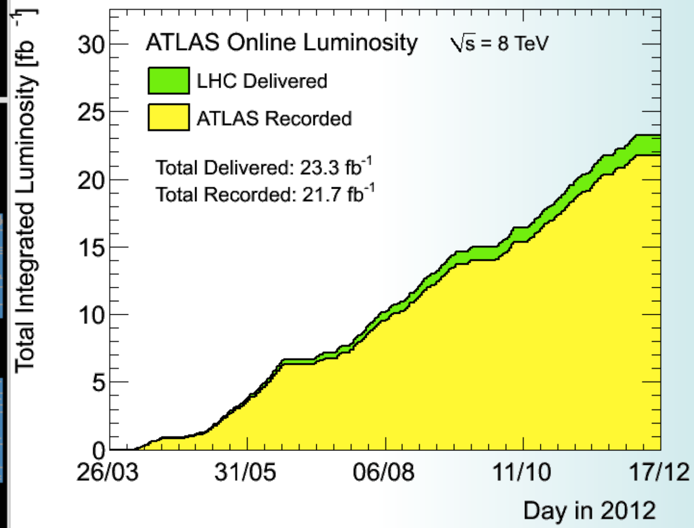
Corfu Summer Institute 1/9/2013

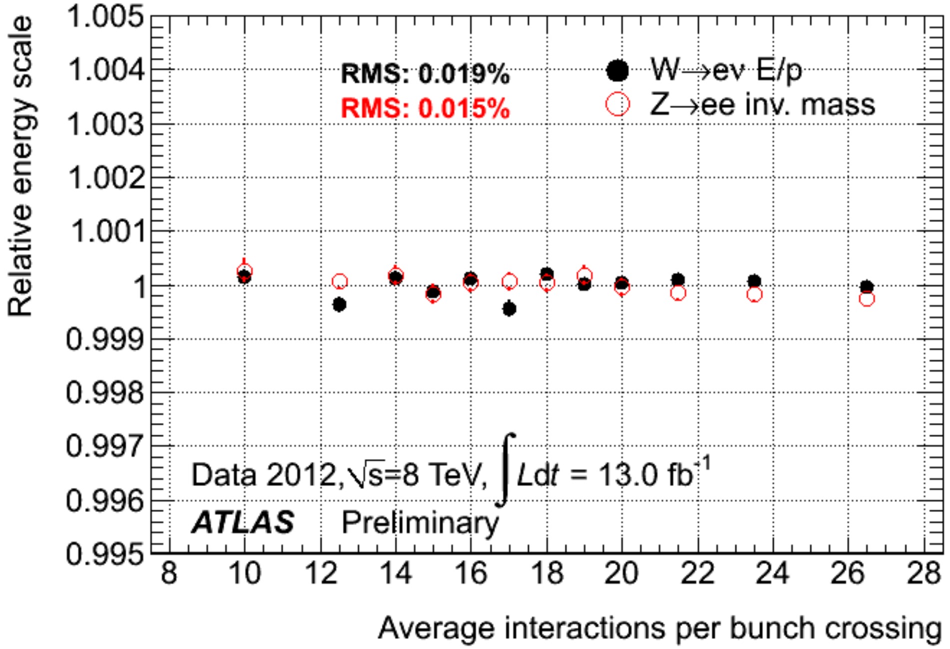

LHCb
ATLAS
CERN Meyrin
PS 628 m
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km

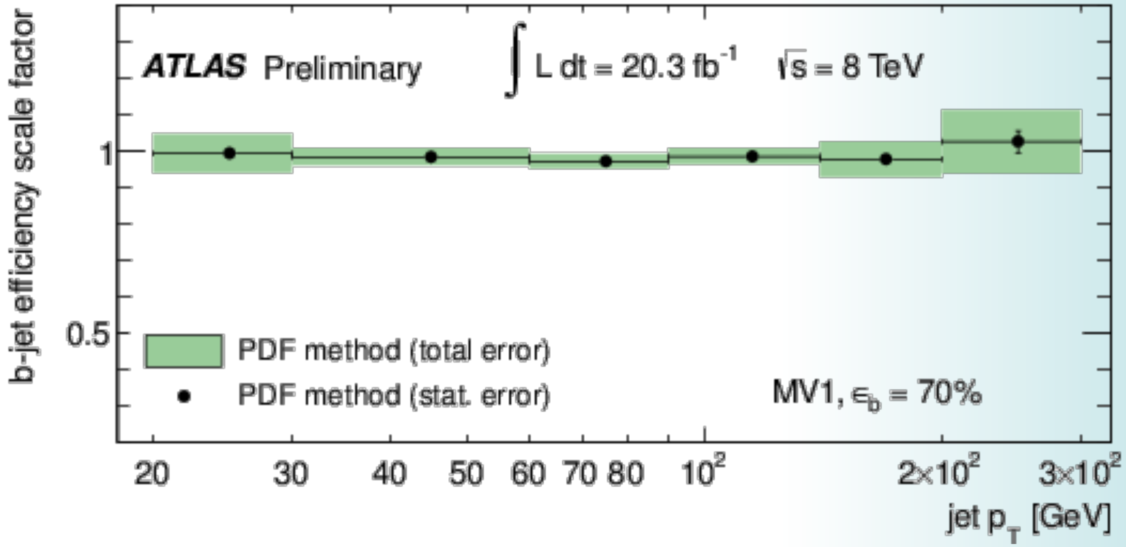


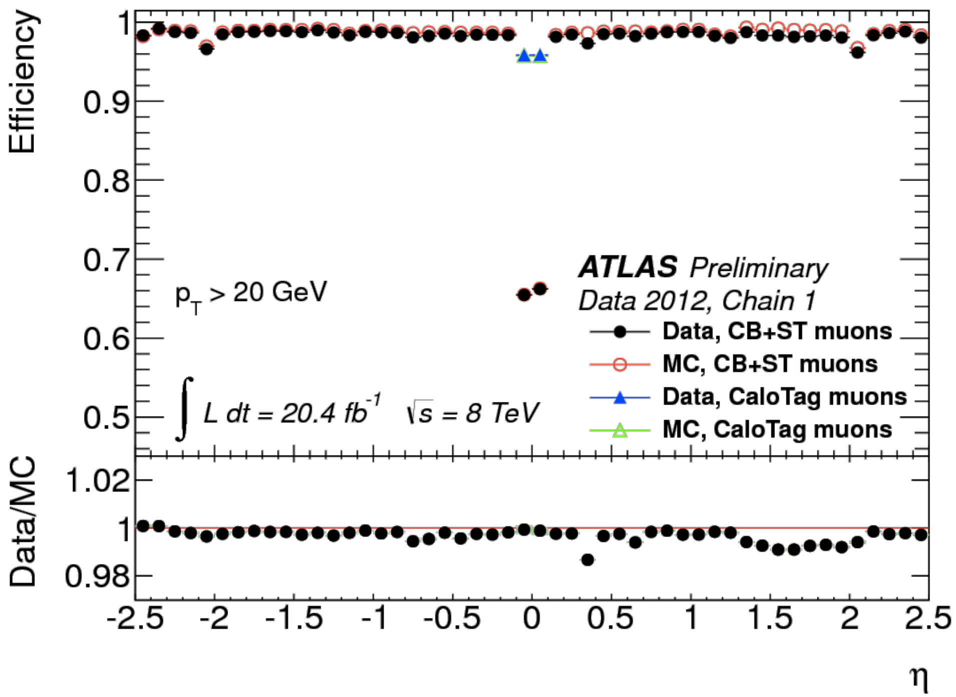
electromagnetic force
weak force
electroweak unification
electroweak + strong unification
unification of all four fundamental forces
rate
1 000 000
100 000
10 000
1000
100
10
distance in meter
big bang
strong force
electromagnetic force
weak force
electroweak force
gravity

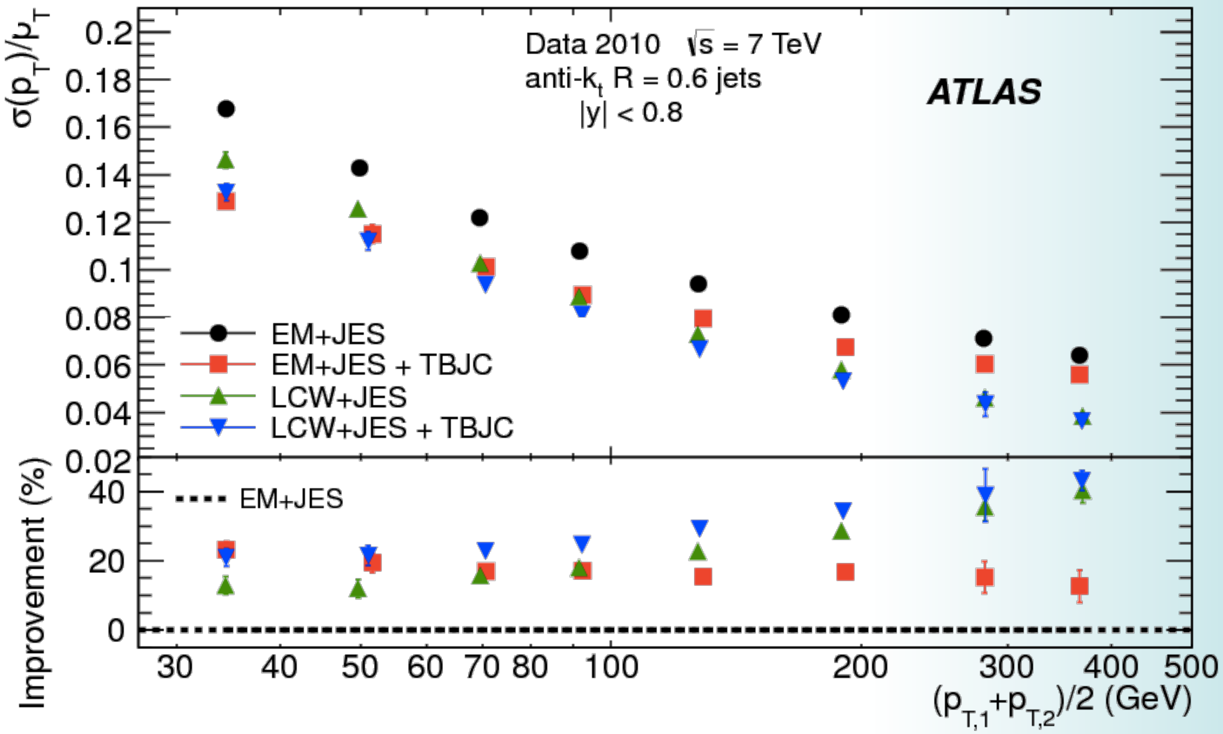

ATLAS
EXPERIMENT
Run Number: 201289, Event Number: 24151616
Date: 2012-04-15 16:52:58 CEST


ATLAS Online Luminosity
$\sqrt{s}$ = 8 TeV
LHC Delivered
ATLAS Recorded
Total Delivered: 23.3 fb^{-1}
Total Recorded: 21.7 fb^{-1}
Total Integrated Luminosity [fb^{-1}]
0
5
10
15
20
25
30
26/03
31/05
06/08
11/10
17/12
Day in 2012


Relative energy scale
RMS: 0.019%
RMS: 0.015%
W→eν E/p
Z→ee inv. mass
Data 2012, √s=8 TeV, ∫Ldt = 13.0 fb-1
ATLAS Preliminary
Average interactions per bunch crossing


b-jet efficiency scale factor
ATLAS Preliminary
∫ L dt = 20.3 fb-1 √s = 8 TeV
PDF method (total error)
PDF method (stat. error)
MV1, εb = 70%
jet pT [GeV]


Efficiency
pT > 20 GeV
ATLAS Preliminary
Data 2012, Chain 1
Data, CB+ST muons
MC, CB+ST muons
Data, CaloTag muons
MC, CaloTag muons
∫ L dt = 20.4 fb-1 √s = 8 TeV
Data/MC
η


σ(pT)/pT
Data 2010 √s = 7 TeV
anti-kt R = 0.6 jets
|y| < 0.8
ATLAS
EM+JES
EM+JES + TBJC
LCW+JES
LCW+JES + TBJC
Improvement (%)
EM+JES
(pT,1+pT,2)/2 (GeV)

Measurements

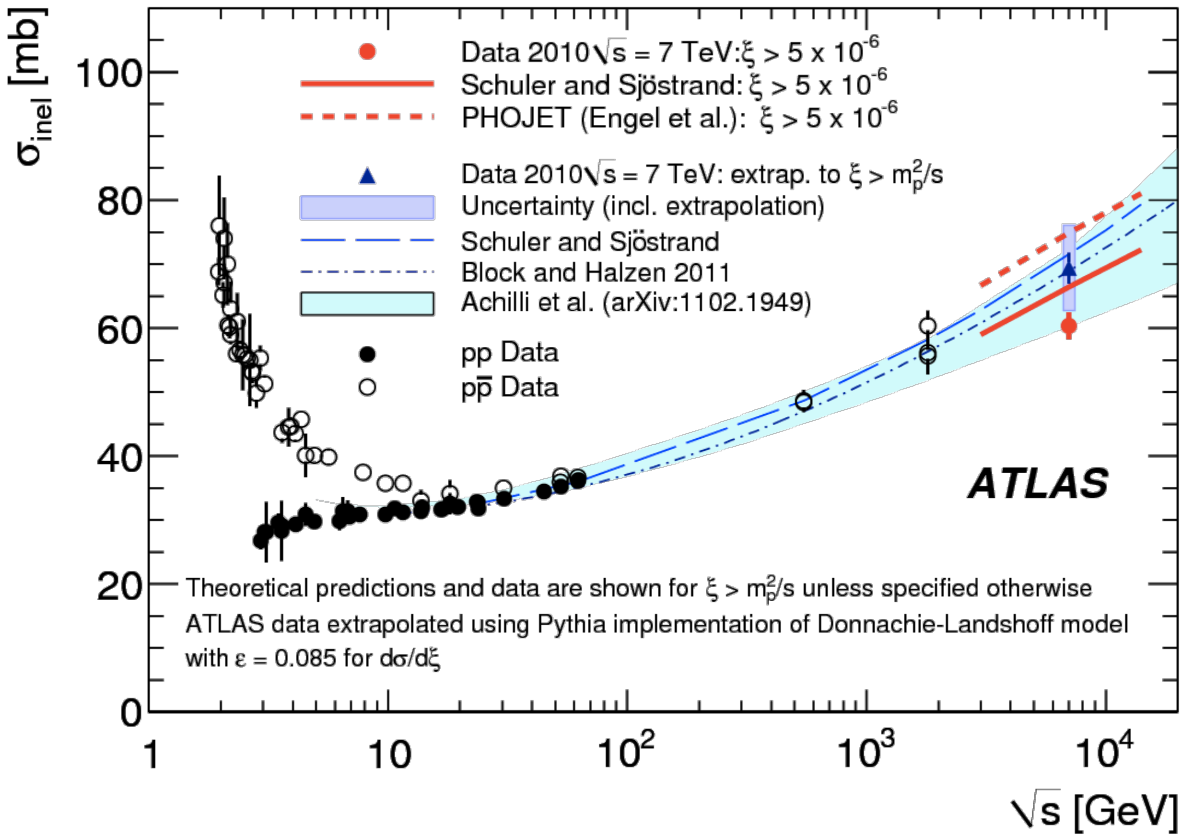
Discovery

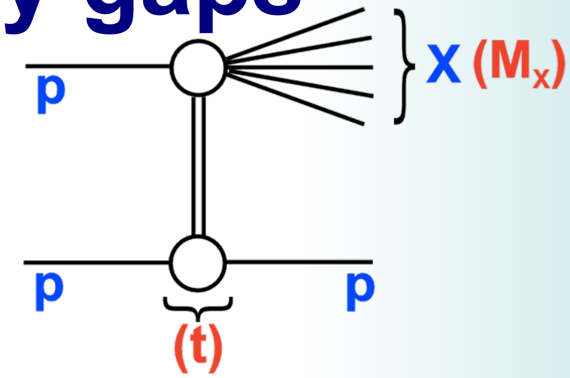
Searches

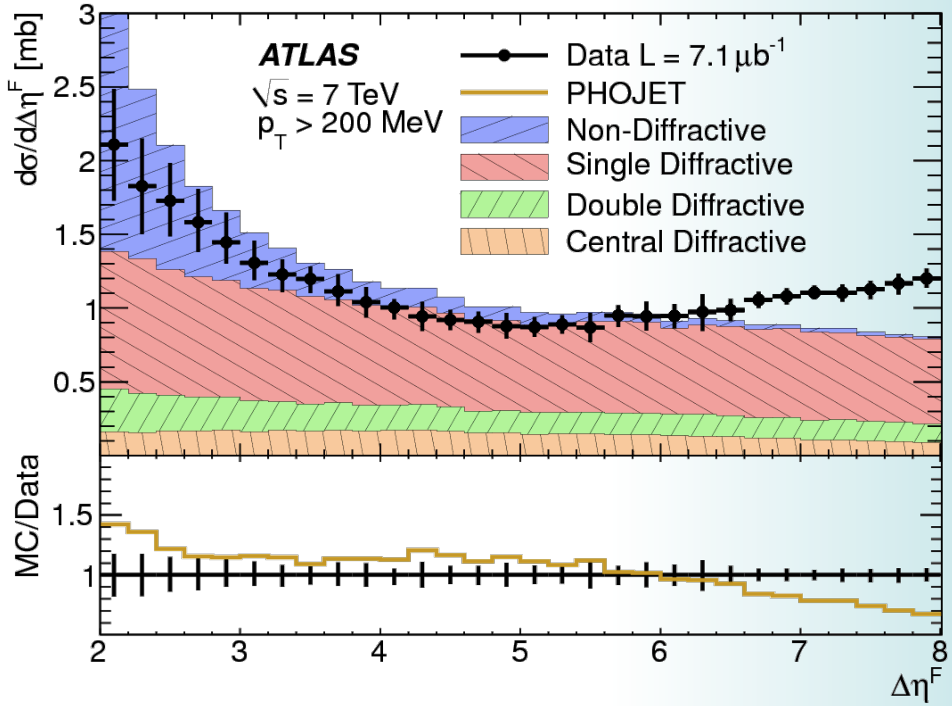
Measurements

Low scales, high cross section:

Inelastic cross section & rapidity gaps

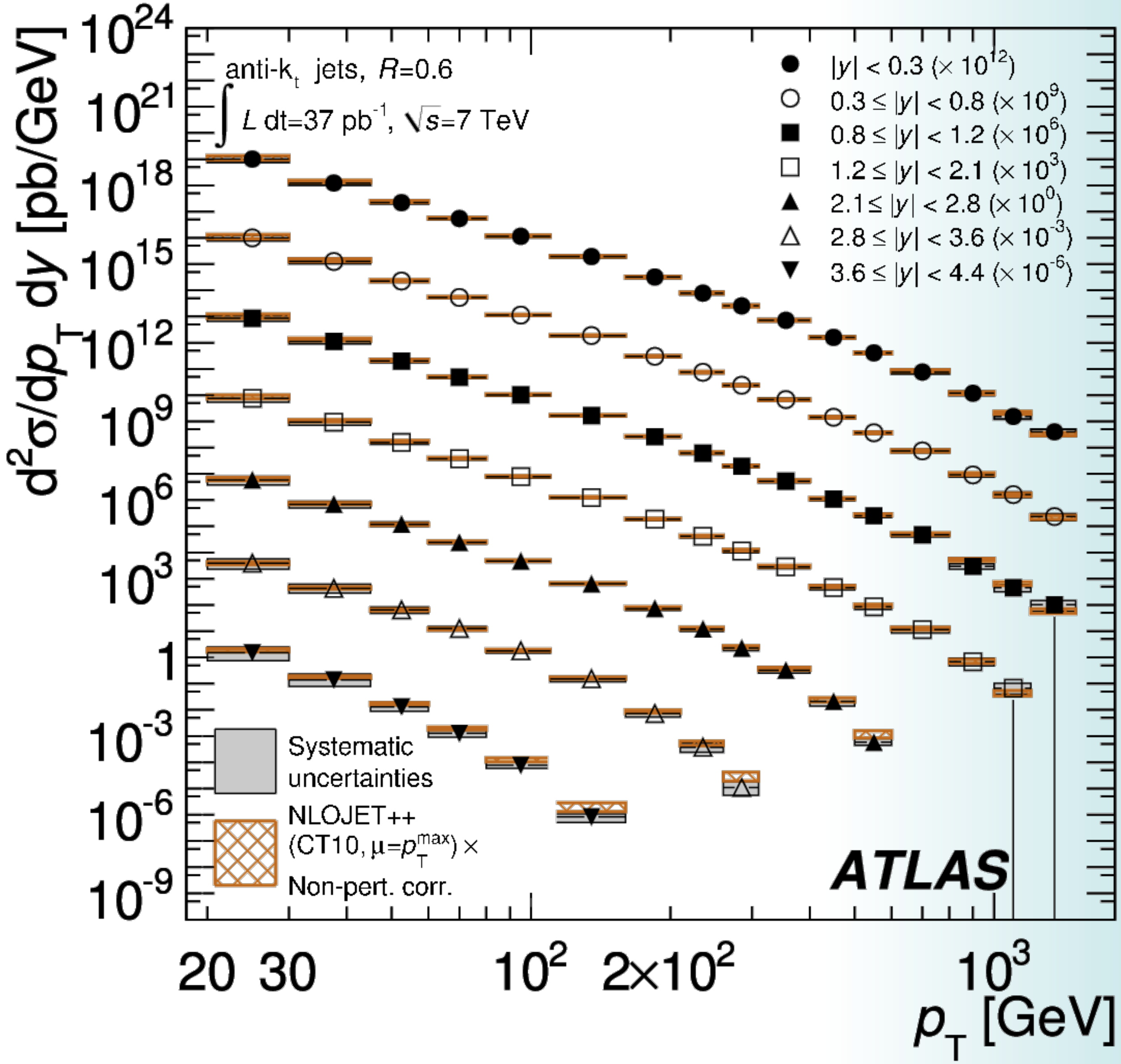






Jets at the highest scales

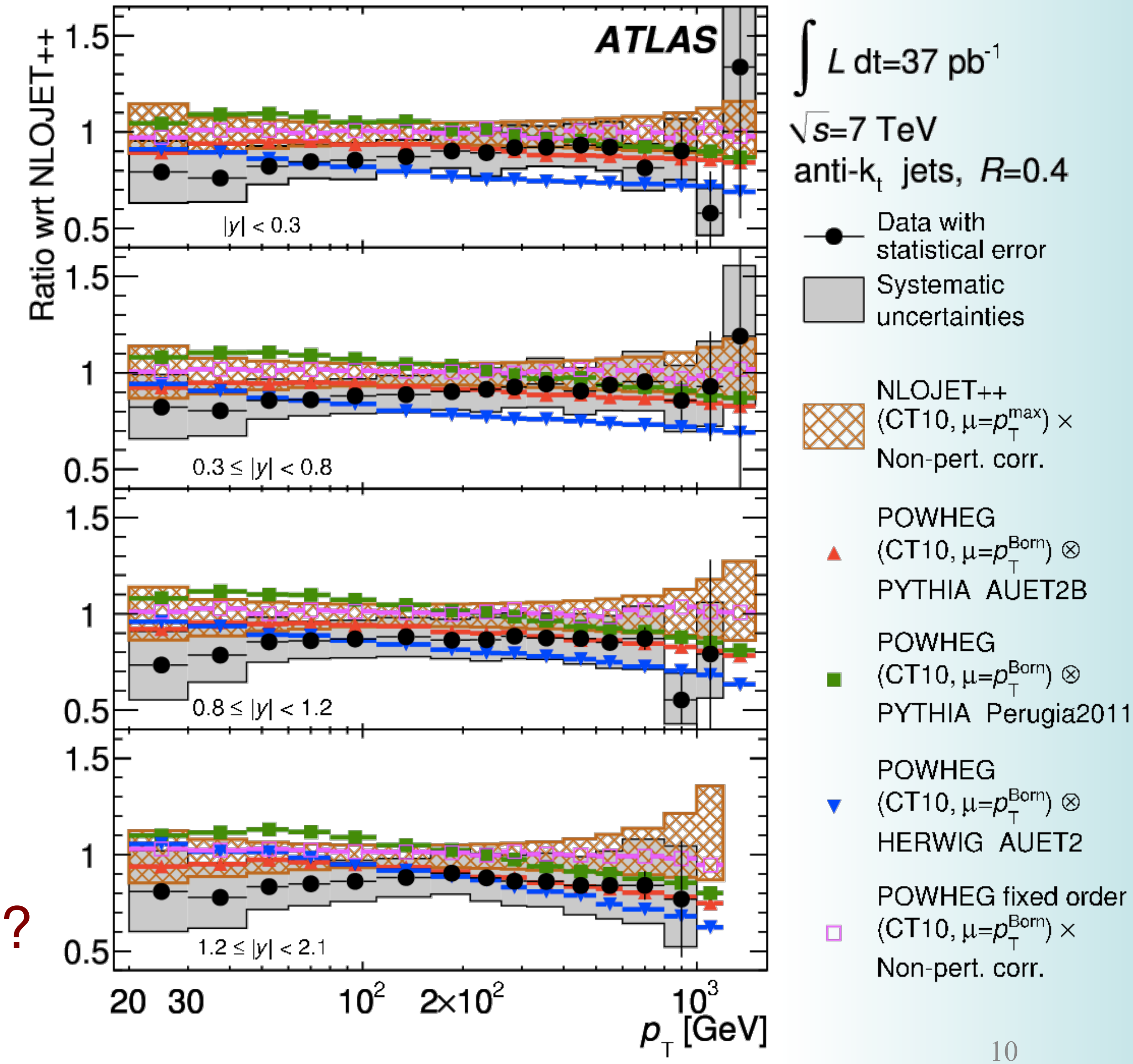
- Highest transverse momentum jets; at the TeV scale
  - *arXiv:1009.5908 (EPJC),arXiv: 1112.6297 (PRD)*
  - *arXiv:1106.0208 (PRL)*



Jets at the highest scales

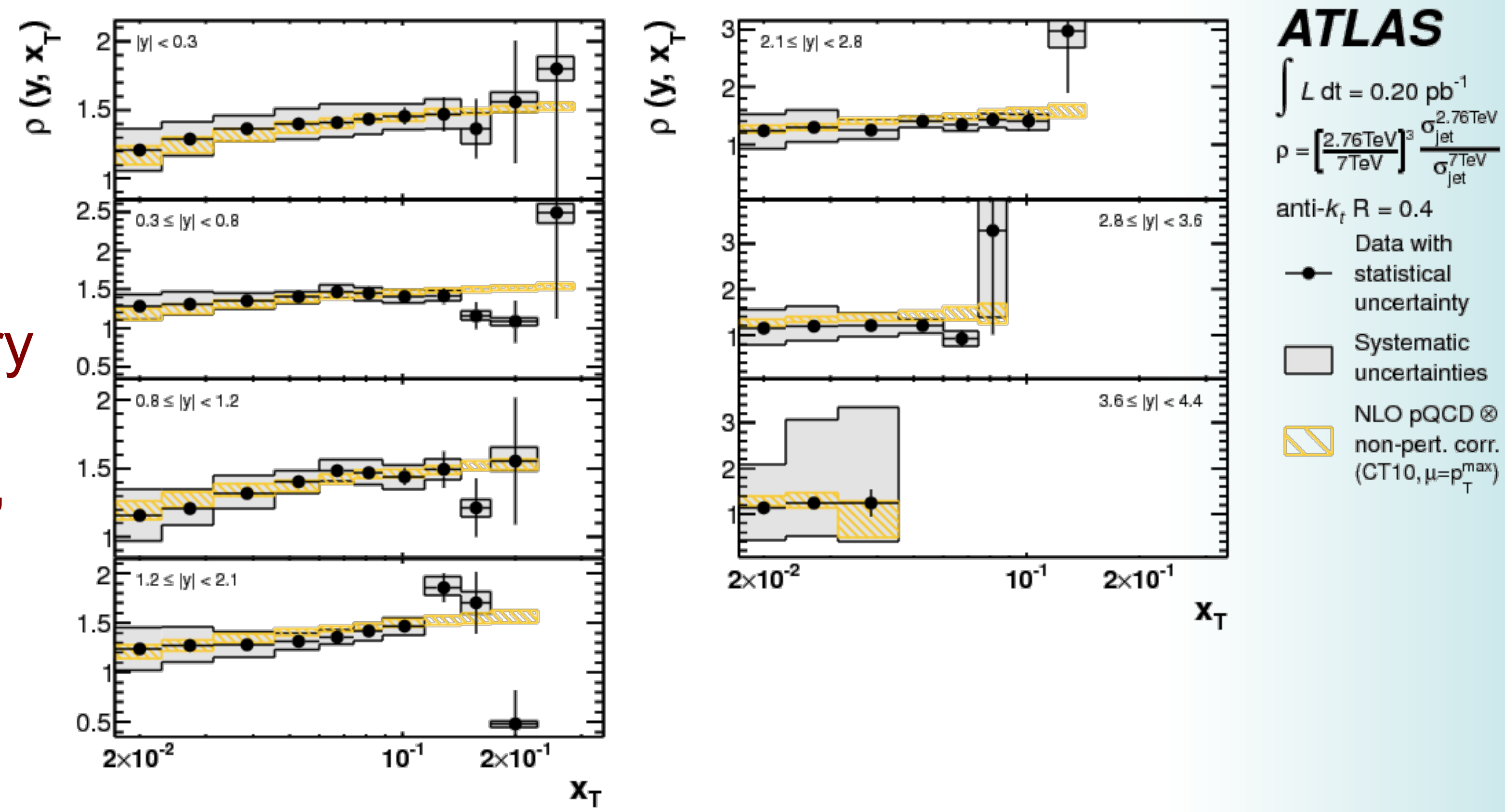
- Highest transverse momentum jets; at the TeV scale
  - *arXiv:1009.5908 (EPJC),arXiv: 1112.6297 (PRD)*
  - *arXiv:1106.0208 (PRL)*
- General agreement with NLO QCD calculations (after soft corrections)

  Significant spread in “NLO” predictions. ME/PS matching? MC tune (UE)? PDFs?



Jets as a probe of the proton

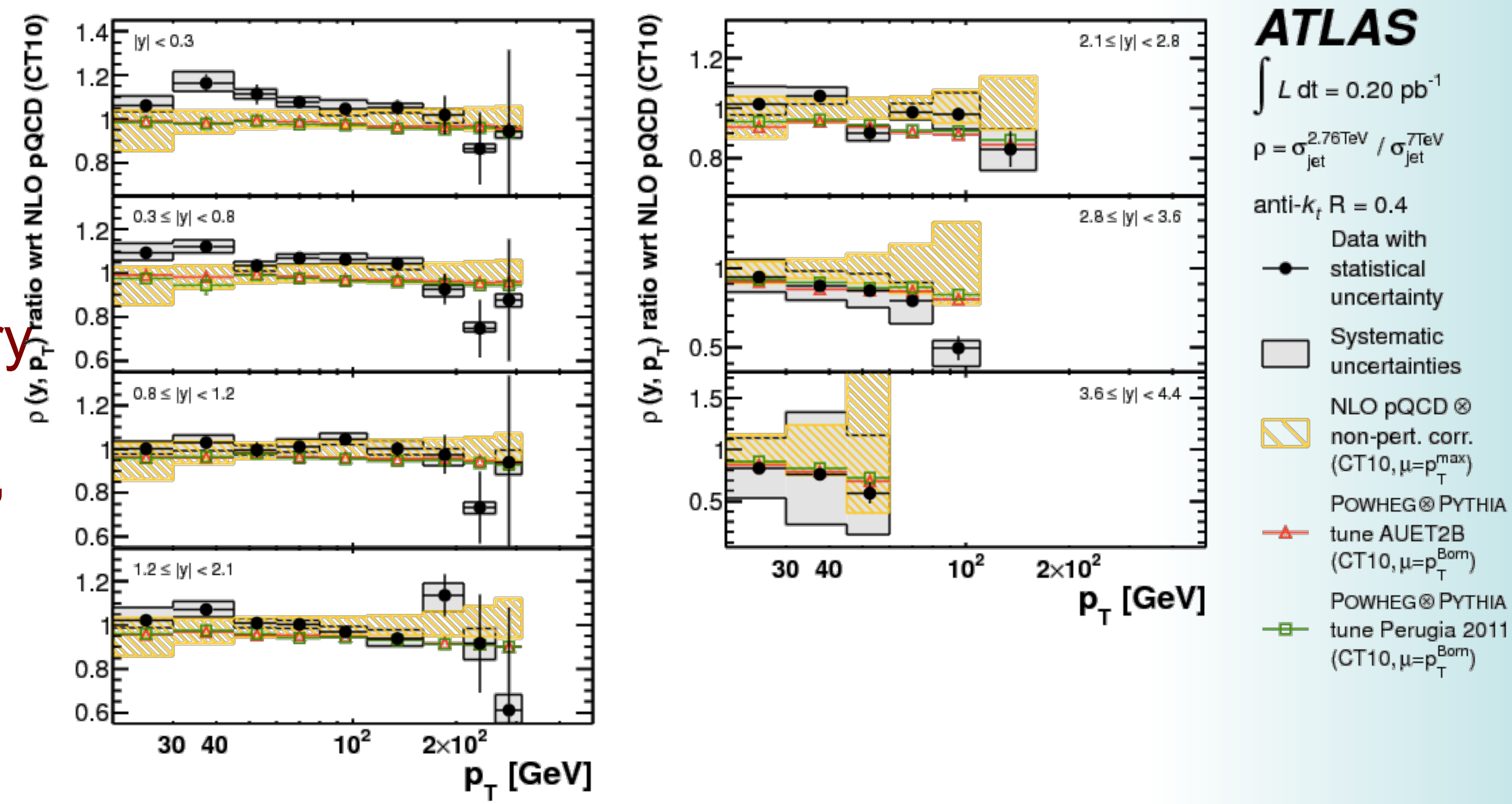
- Use 2.76 TeV CM data to measure cross sections.
- Ratios;
  - in x_T, many theory uncertainties ~cancel (same x, different Q^2)



arXiv:1304.4739

Jets as a probe of the proton

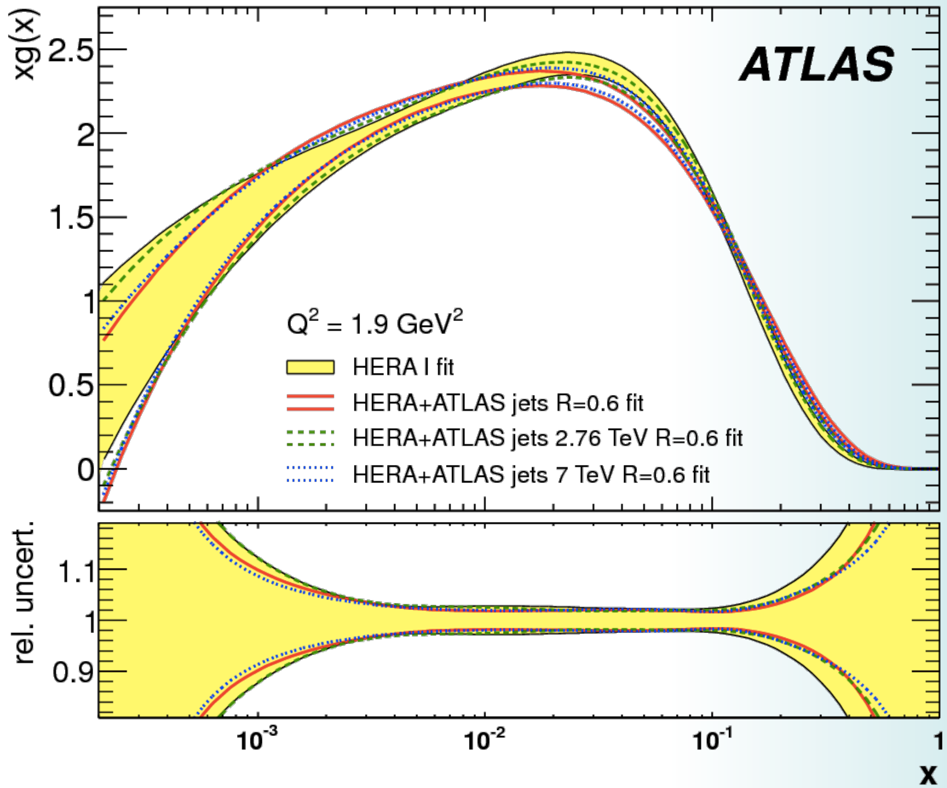
- Use 2.76 TeV CM data to measure cross sections.
- Ratios;
  - in x_T, many theory uncertainties ~cancel (same x, different Q^2)
  - In p_T, jet energy scale ~cancels (dominant experimental uncertainty)



arXiv:1304.4739

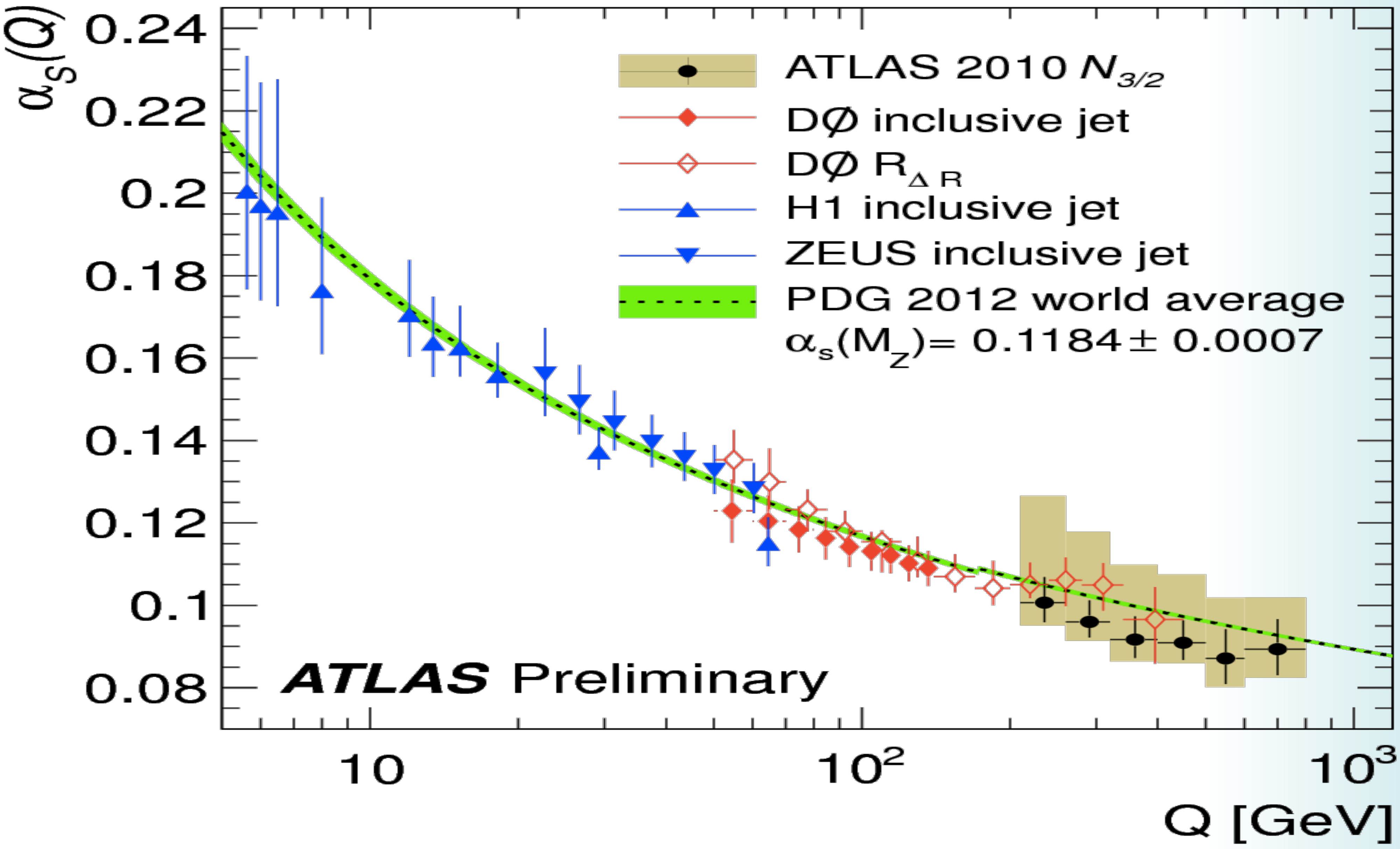
Jets as a probe of the proton

- Illustrative fit to HERA and ATLAS data
- Valence quarks heavily constrained by HERA
- High x gluon and sea quarks modified by addition of ATLAS data



ATLAS-CONF-2012-128

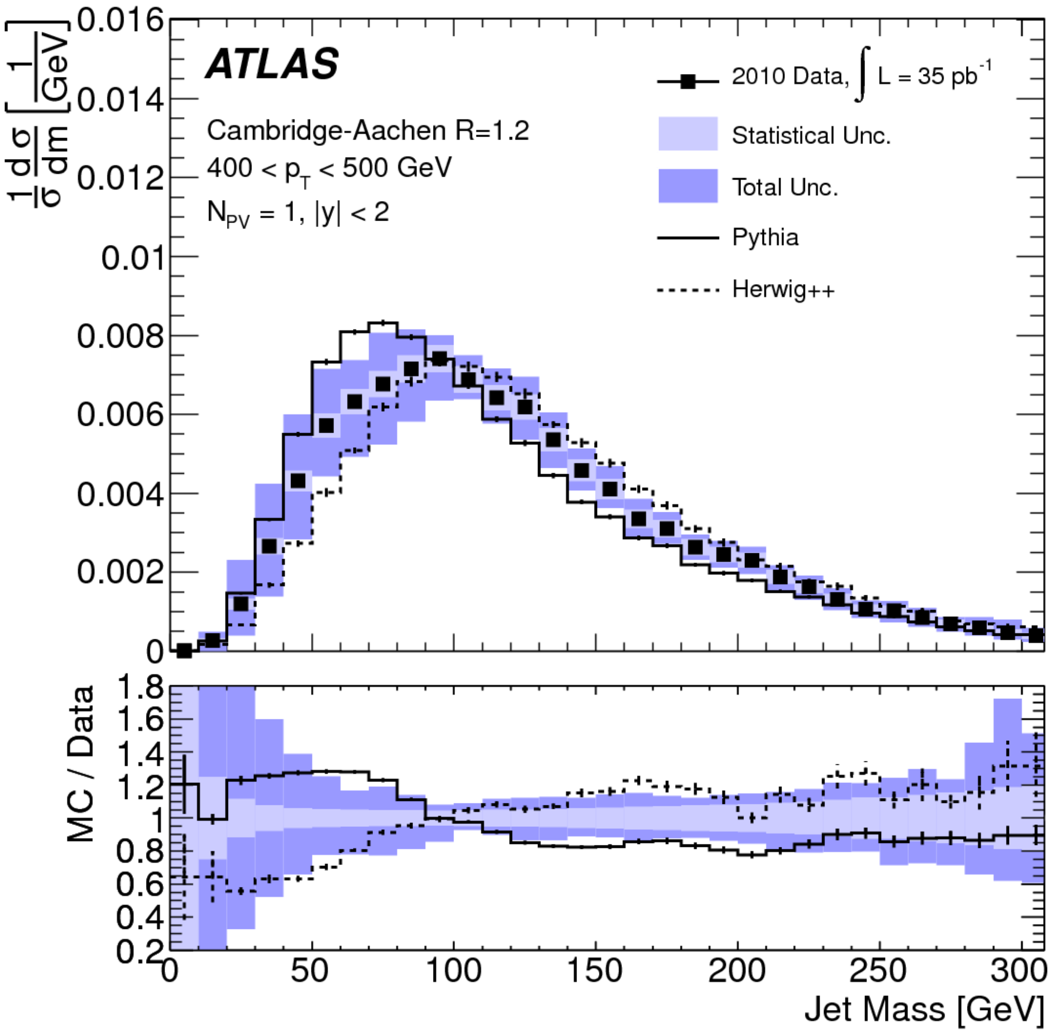
Running of the strong coupling

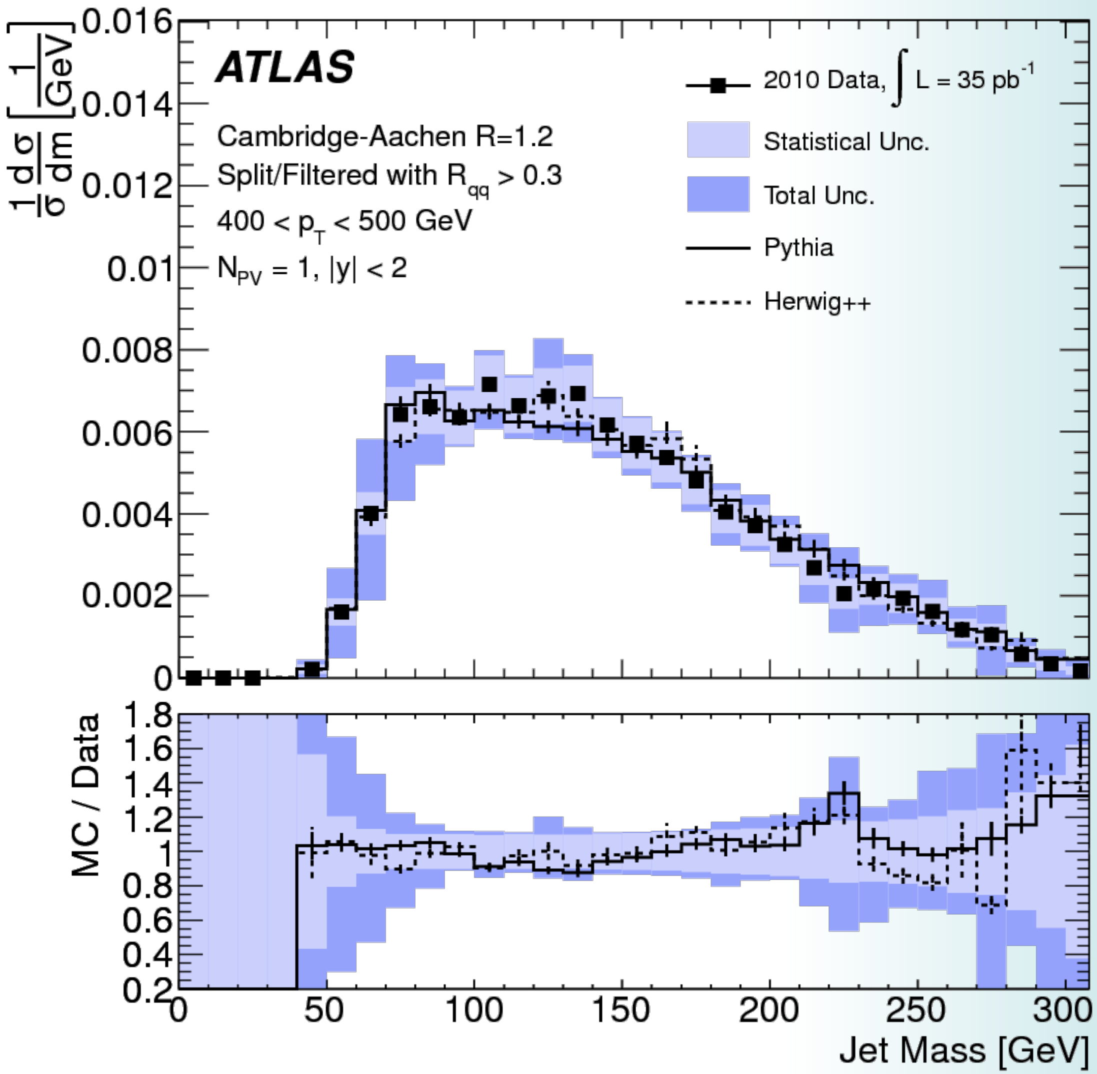


Jet properties

- Final stage of jet structure is “soft” non-perturbative QCD.
  - Formation of hadrons from gluons, 100 MeV energy scales (Λ_{QCD})
- Vast phase space between quark-gluon scatter (100’s GeV, few TeV) and Λ_{QCD}
- Most of jet substructure can be analysed perturbatively
- EWSB scale (~100 GeV) lies in this region
  - Jets may contain objects with EW-scale mass (W,Z,H,t,?)

Jet “grooming” and subjets

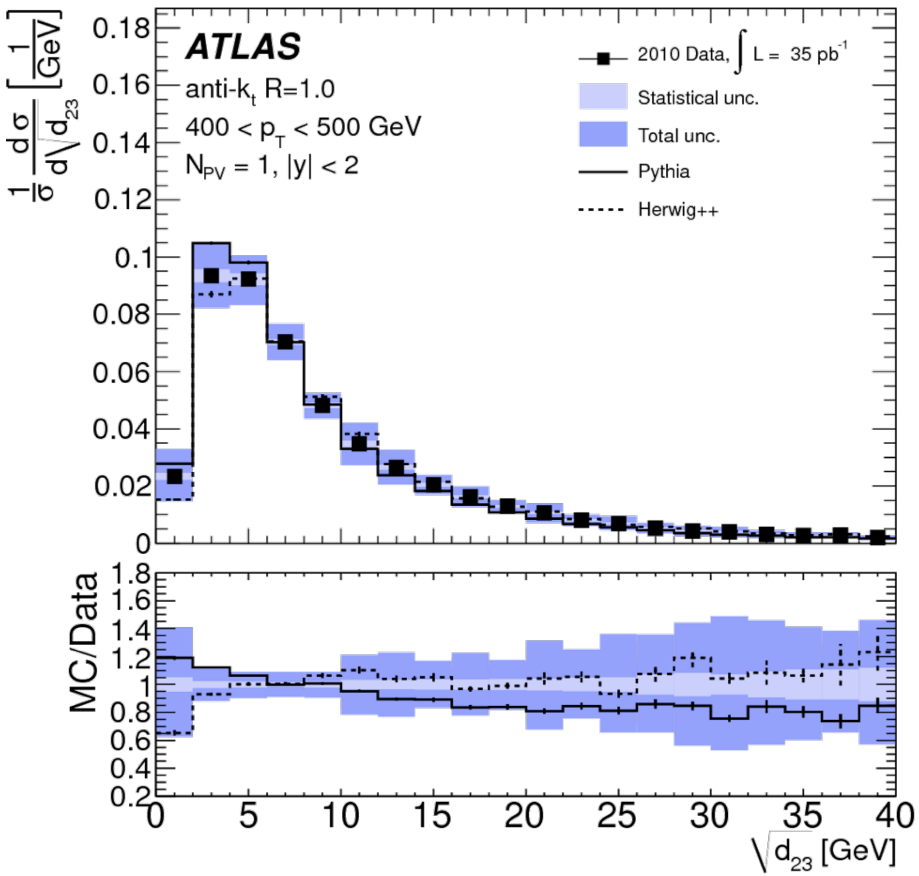


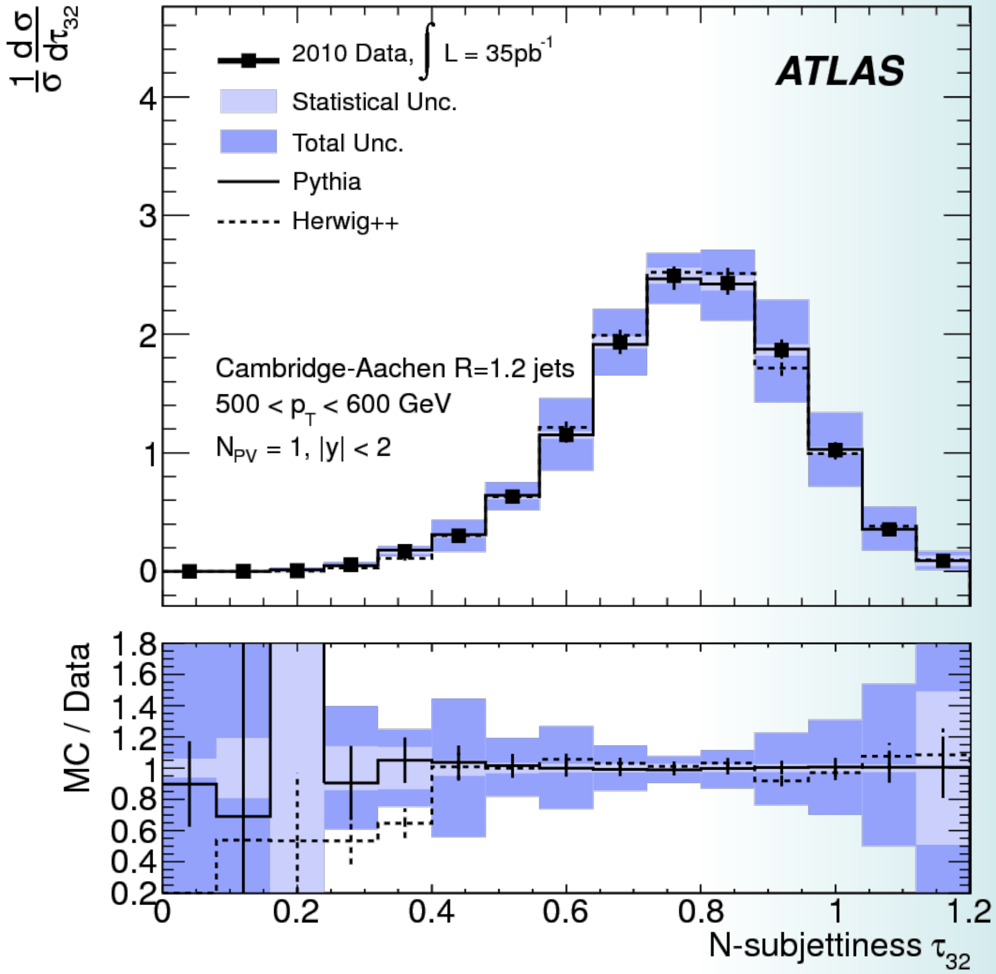


arXiv:1203.4606

Jet grooming and subjets

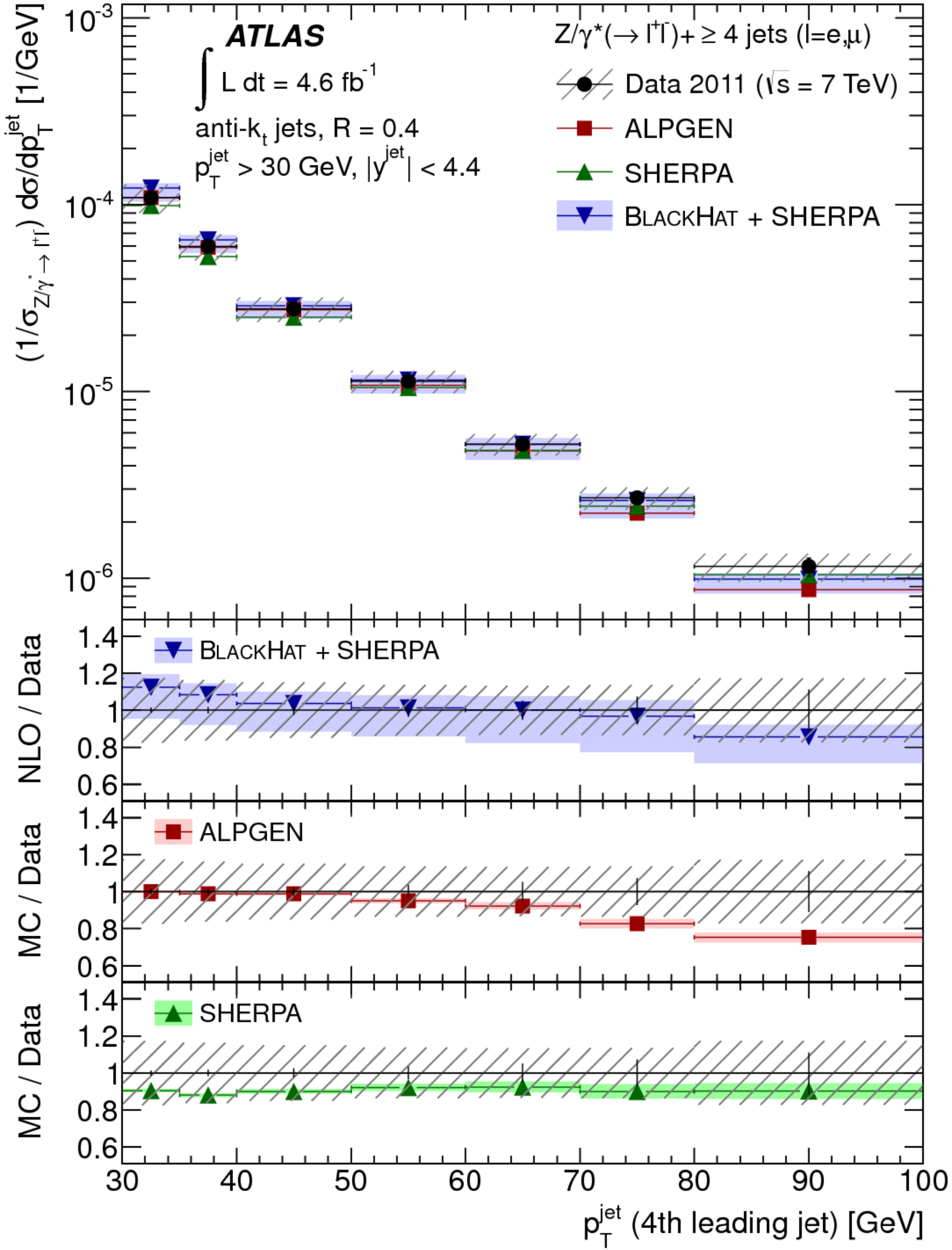
- k_T scale, N-subjettiness

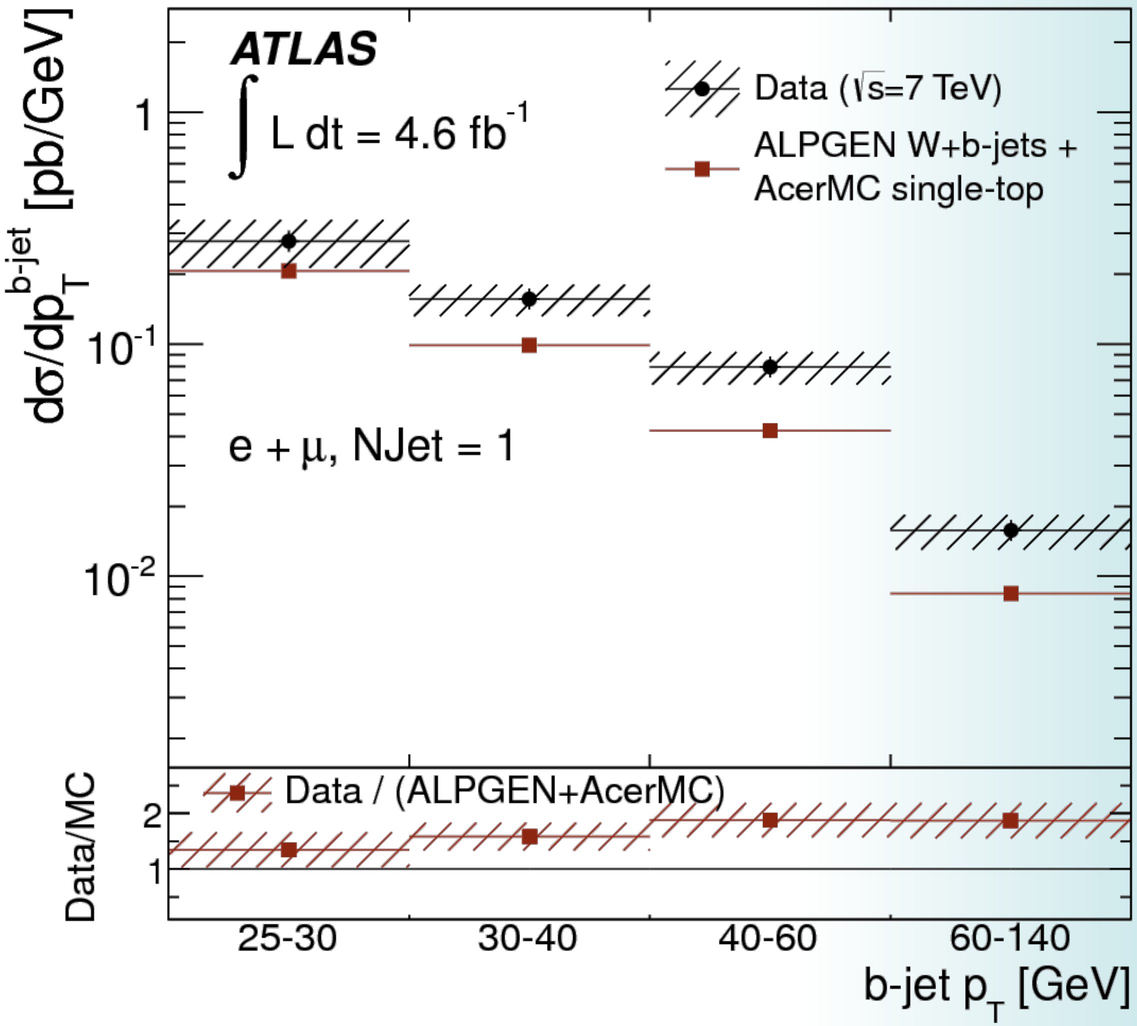




arXiv:1203.4606

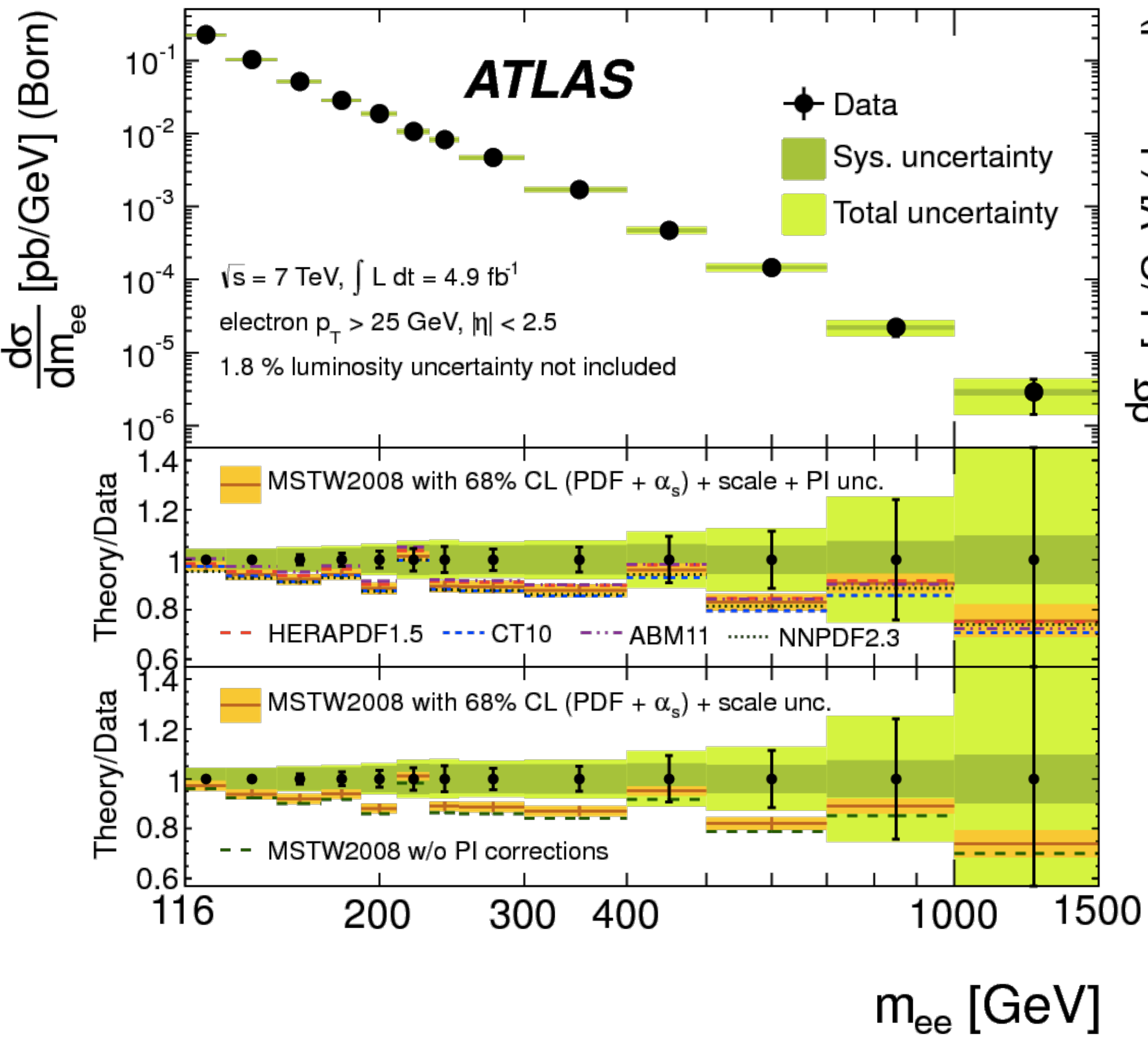
Vector bosons and (b) jets

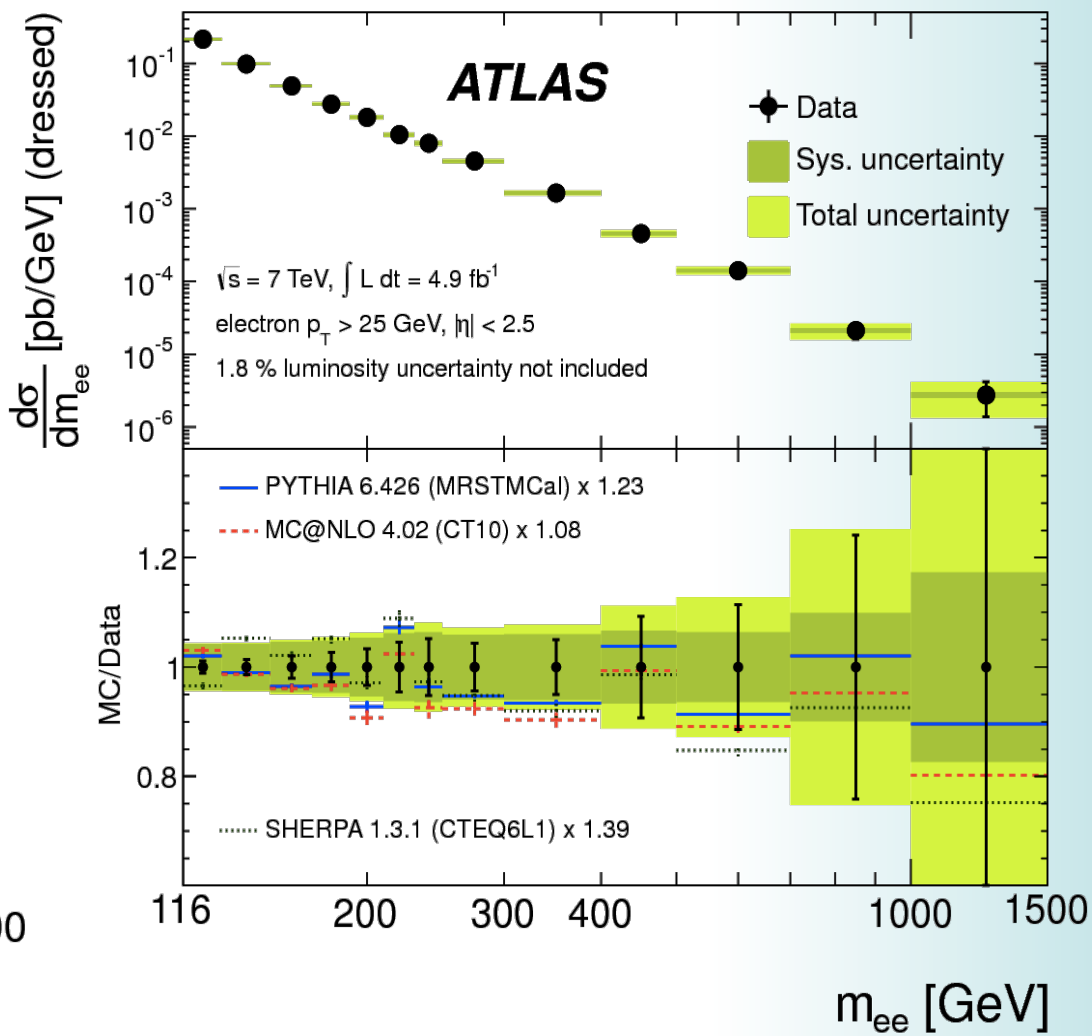




arXiv:1304.7098
arxiv:1302:2929

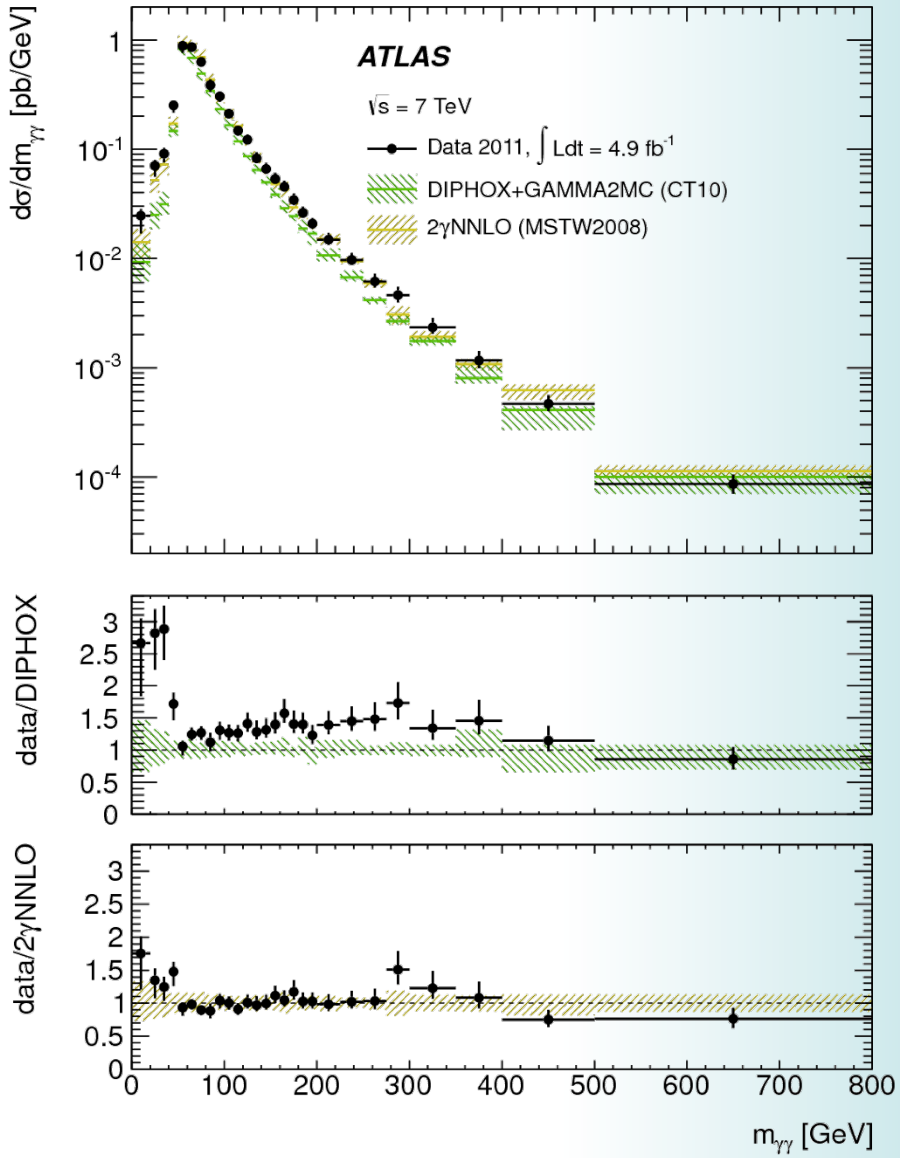
Lepton pairs





A word on Photons

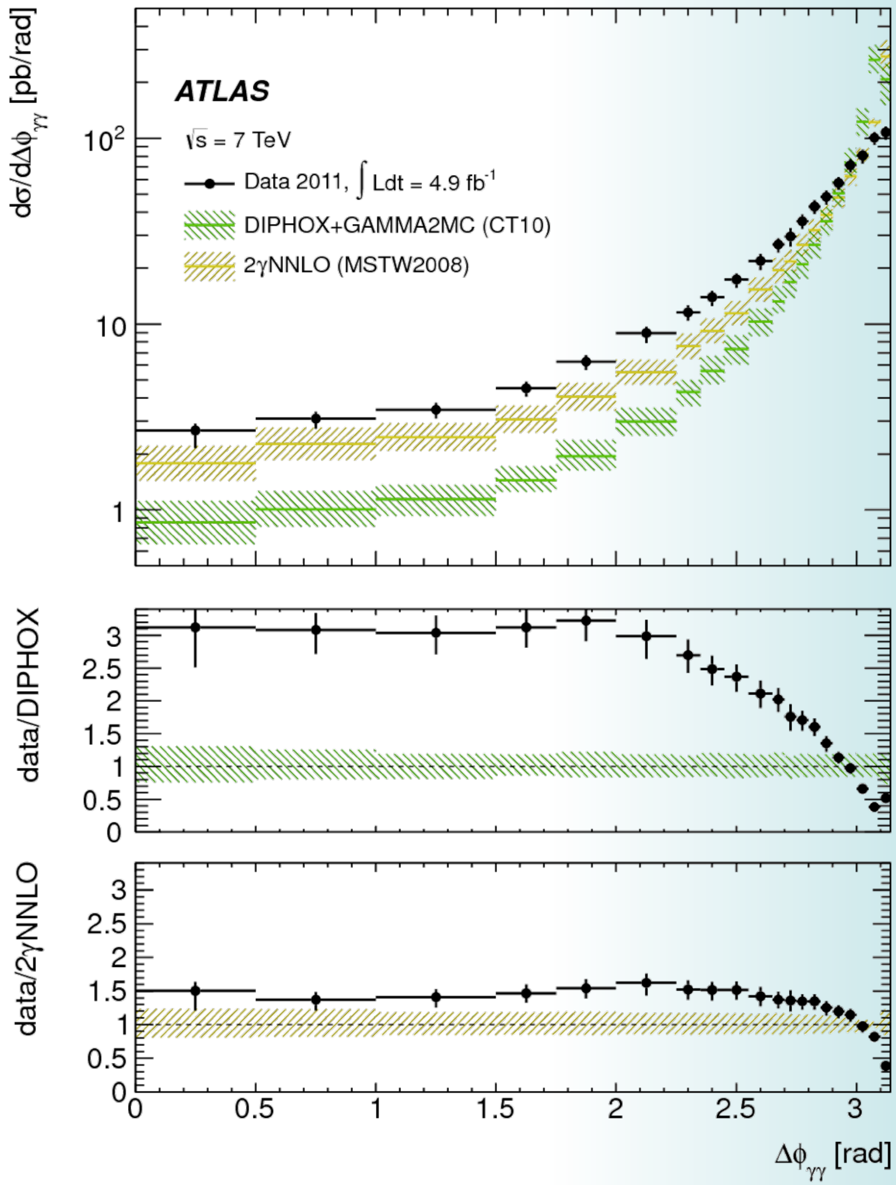
- Similar physics, complementary systematics to jet studies
- Key background for Higgs



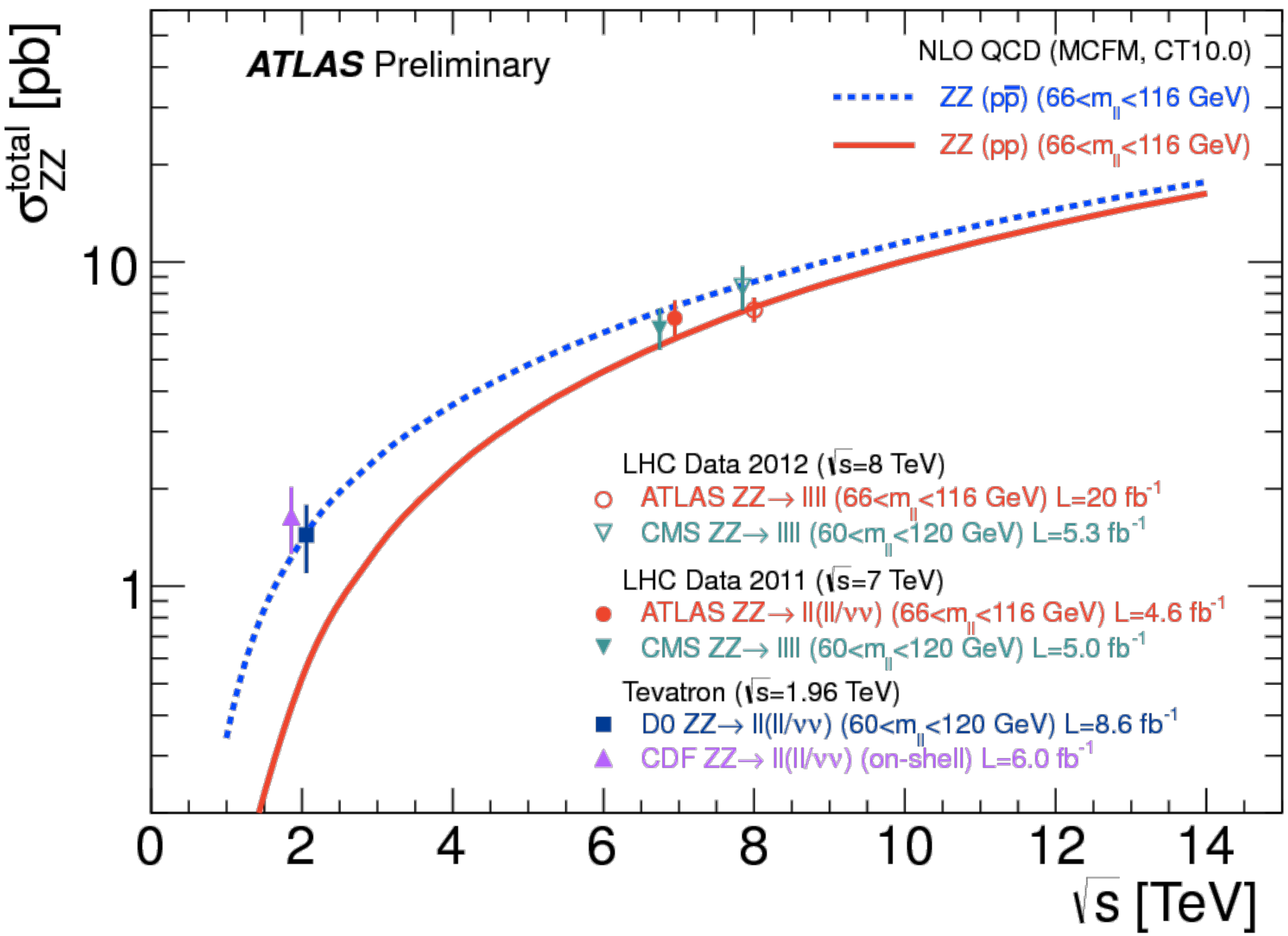
arXiv:1211.1913
arXiv:1210.5033

A word on Photons

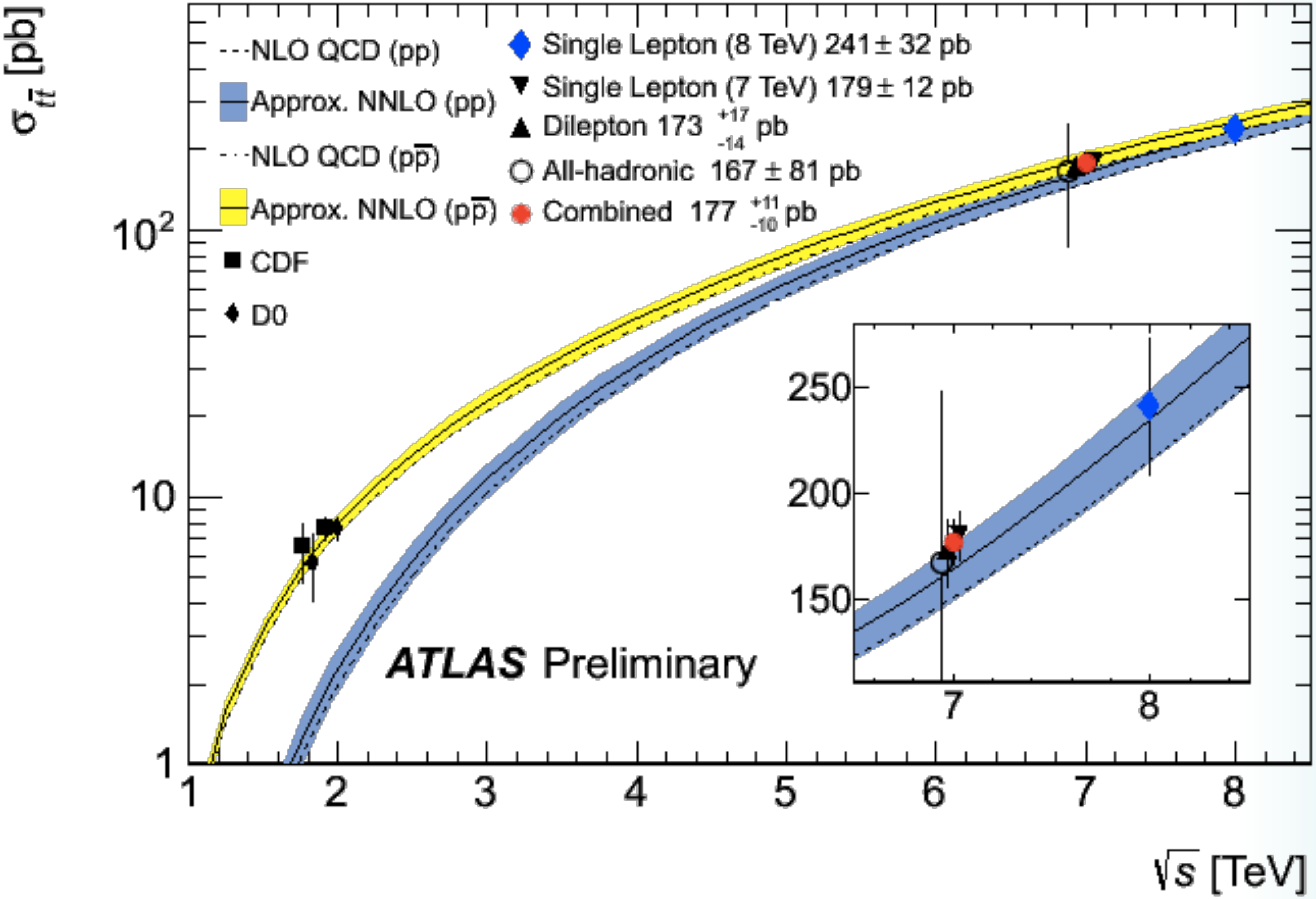
- Similar physics, complementary systematics to jet studies
- Key background for Higgs
- Diphoton + jet measurements badly needed!



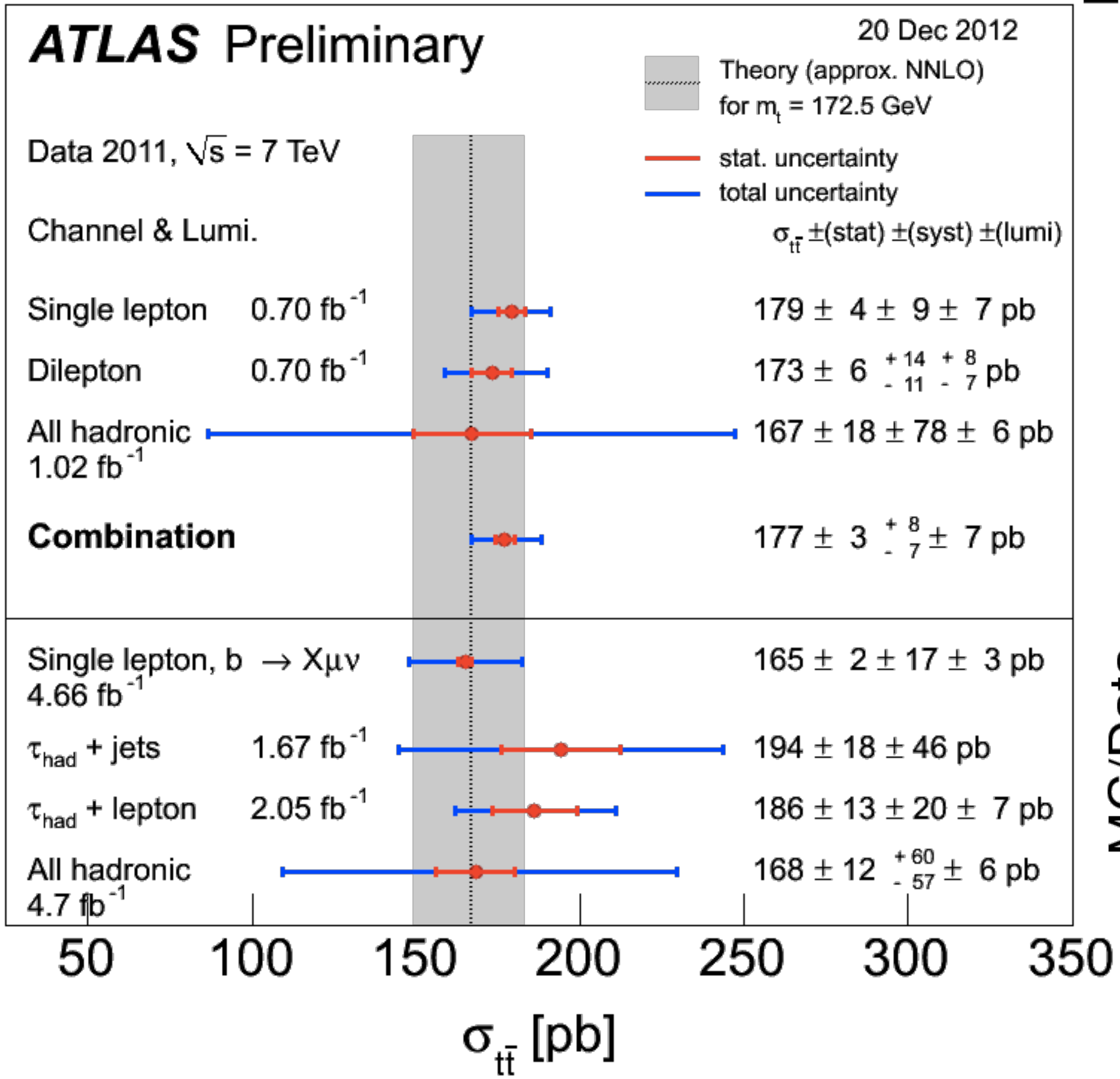
arXiv:1211.1913
arXiv:1210.5033

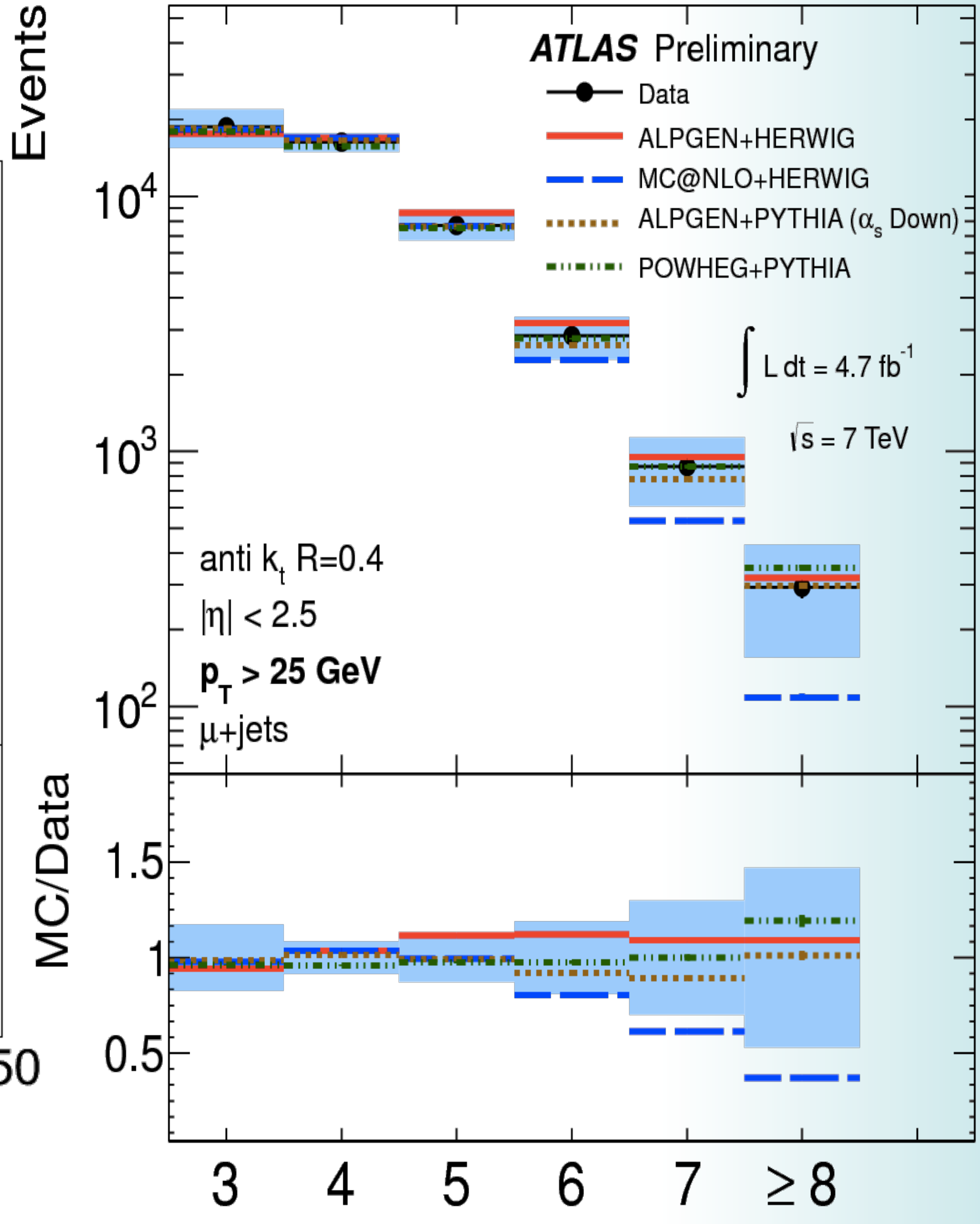


ATLAS Preliminary
NLO QCD (MCFM, CT10.0)
ZZ (pp̄) (66<m_ll<116 GeV)
ZZ (pp) (66<m_ll<116 GeV)
LHC Data 2012 (√s=8 TeV)
ATLAS ZZ→ llll (66<m_ll<116 GeV) L=20 fb^-1
CMS ZZ→ llll (60<m_ll<120 GeV) L=5.3 fb^-1
LHC Data 2011 (√s=7 TeV)
ATLAS ZZ→ ll(ll/νν) (66<m_ll<116 GeV) L=4.6 fb^-1
CMS ZZ→ llll (60<m_ll<120 GeV) L=5.0 fb^-1
Tevatron (√s=1.96 TeV)
D0 ZZ→ ll(ll/νν) (60<m_ll<120 GeV) L=8.6 fb^-1
CDF ZZ→ ll(ll/νν) (on-shell) L=6.0 fb^-1
σ_ZZ^total [pb]
√s [TeV]

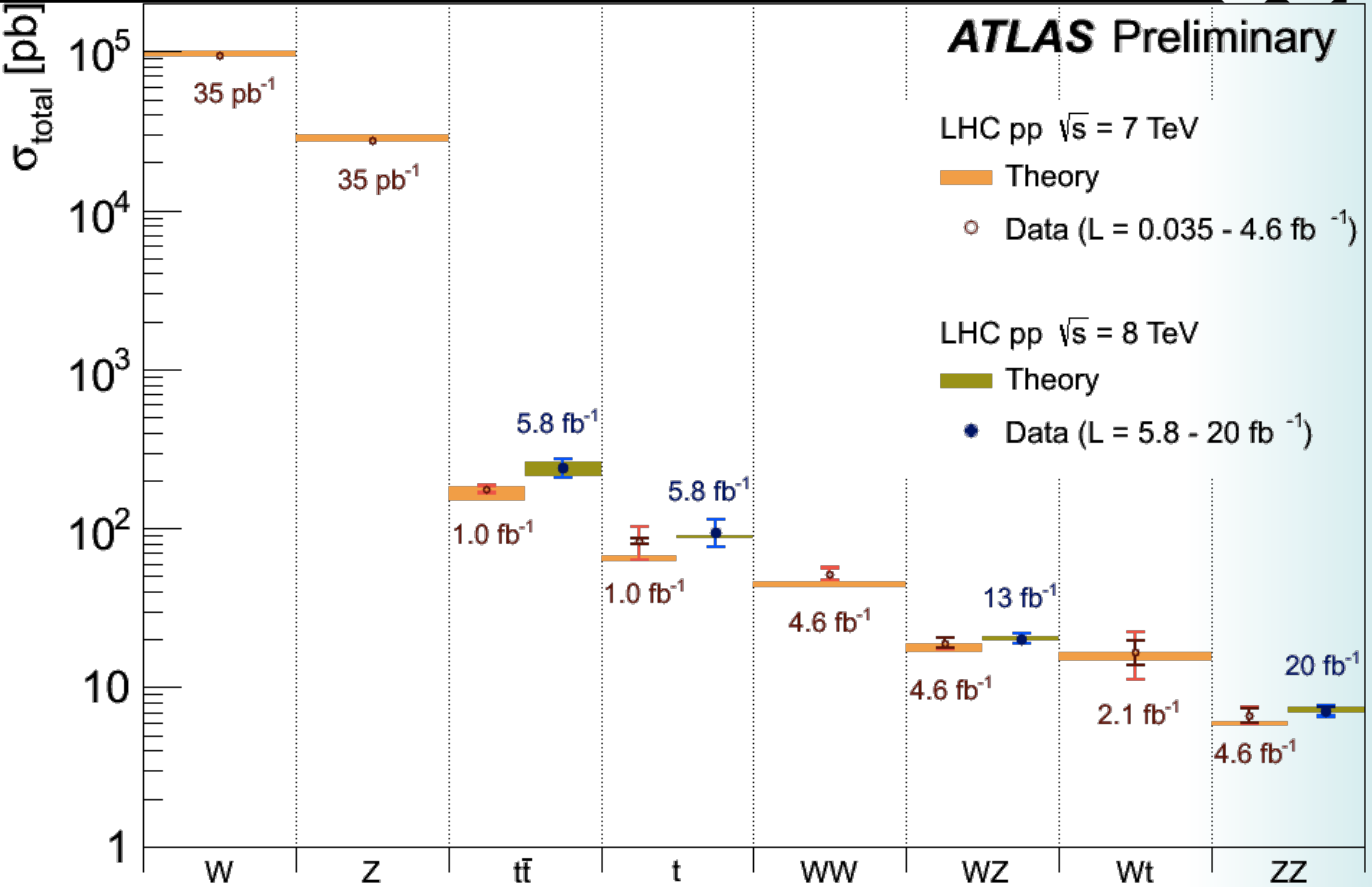


NLO QCD (pp)
Approx. NNLO (pp)
NLO QCD (p$\bar{p}$)
Approx. NNLO (p$\bar{p}$)
CDF
D0
Single Lepton (8 TeV) 241 ± 32 pb
Single Lepton (7 TeV) 179 ± 12 pb
Dilepton 173 $^{+17}_{-14}$ pb
All-hadronic 167 ± 81 pb
Combined 177 $^{+11}_{-10}$ pb
ATLAS Preliminary
$\sigma_{t\bar{t}}$ [pb]
$\sqrt{s}$ [TeV]





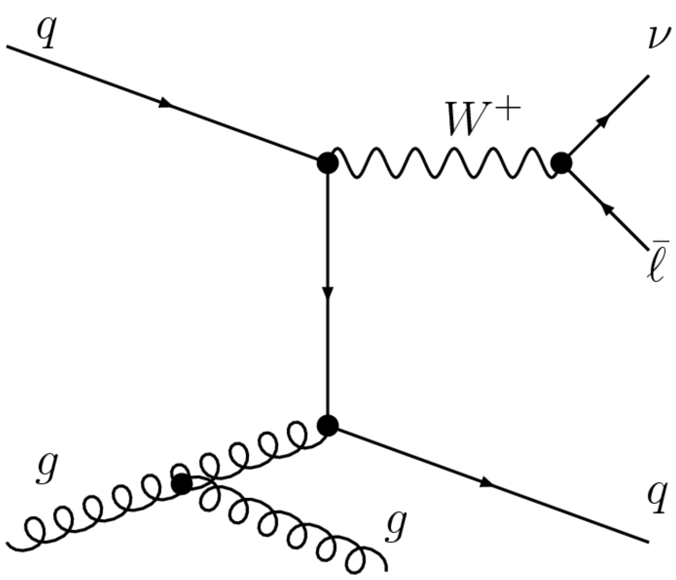
ATLAS-CONF-2012-155

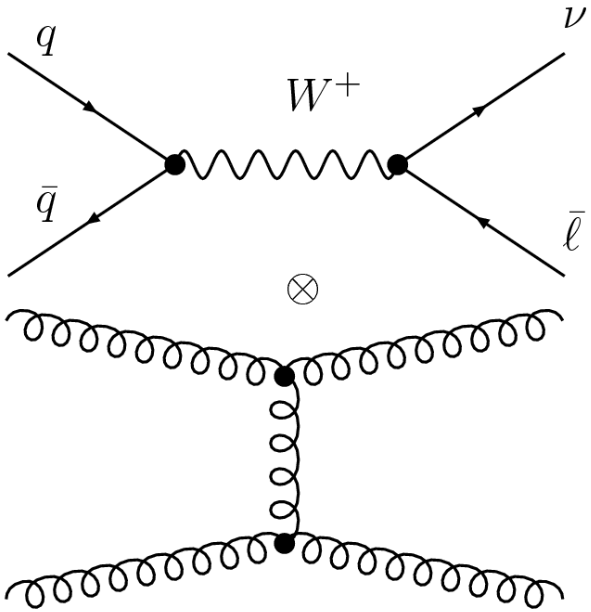

ATLAS Preliminary
LHC pp √s = 7 TeV
Theory
Data (L = 0.035 - 4.6 fb^{-1})
LHC pp √s = 8 TeV
Theory
Data (L = 5.8 - 20 fb^{-1})
σ_{total} [pb]
10^5
10^4
10^3
10^2
10
1
35 pb^{-1}
35 pb^{-1}
1.0 fb^{-1}
5.8 fb^{-1}
1.0 fb^{-1}
5.8 fb^{-1}
4.6 fb^{-1}
4.6 fb^{-1}
13 fb^{-1}
2.1 fb^{-1}
4.6 fb^{-1}
20 fb^{-1}
W
Z
$t\bar{t}$
t
WW
WZ
Wt
ZZ

(Parenthesis)

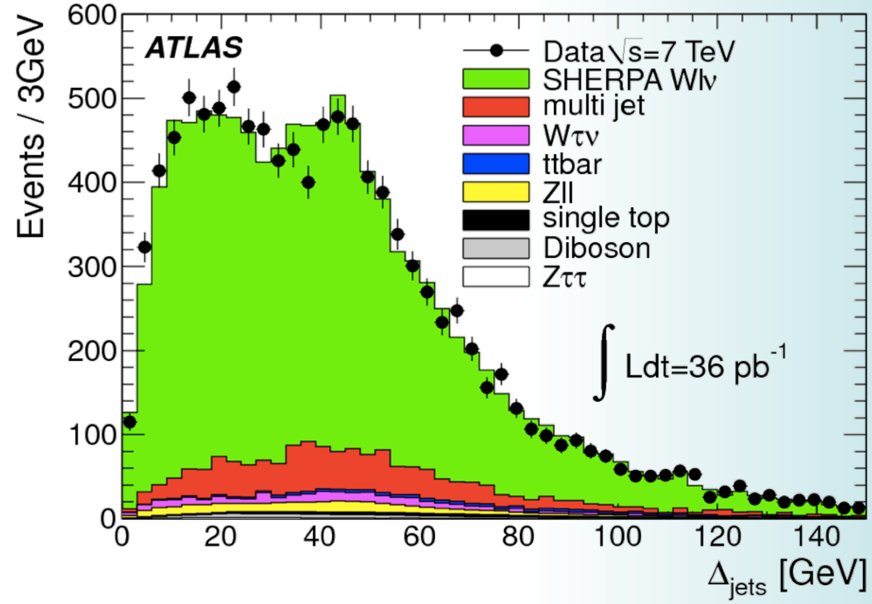
- First measurements of minimum bias, charged particle multiplicities, underlying event all vital for this precision.
- Underlying event contribution from double-parton-interactions
  - Rare “clean” events
  - Probes confinement in a new way
  - Significant background to some exotica (like-sign etc)

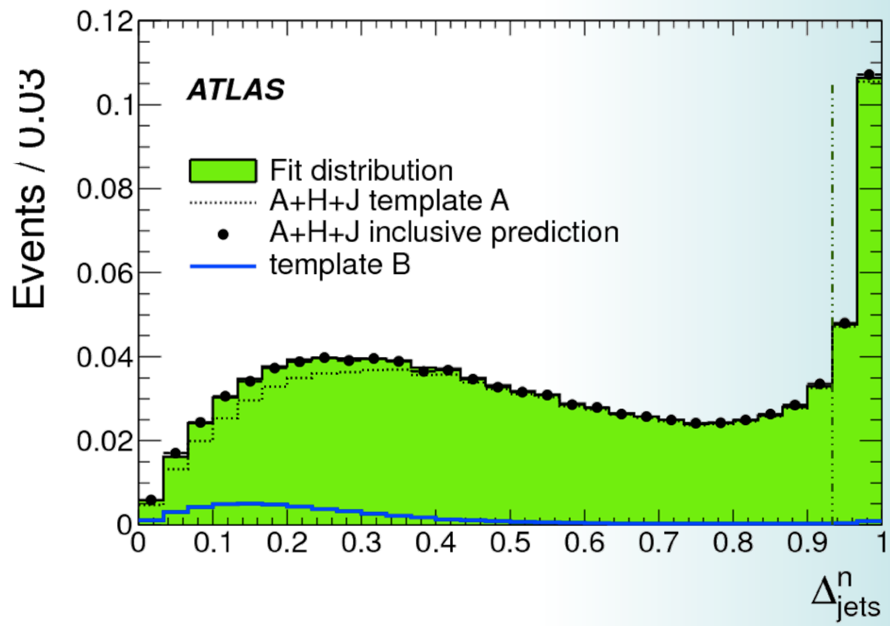
Double-parton interactions



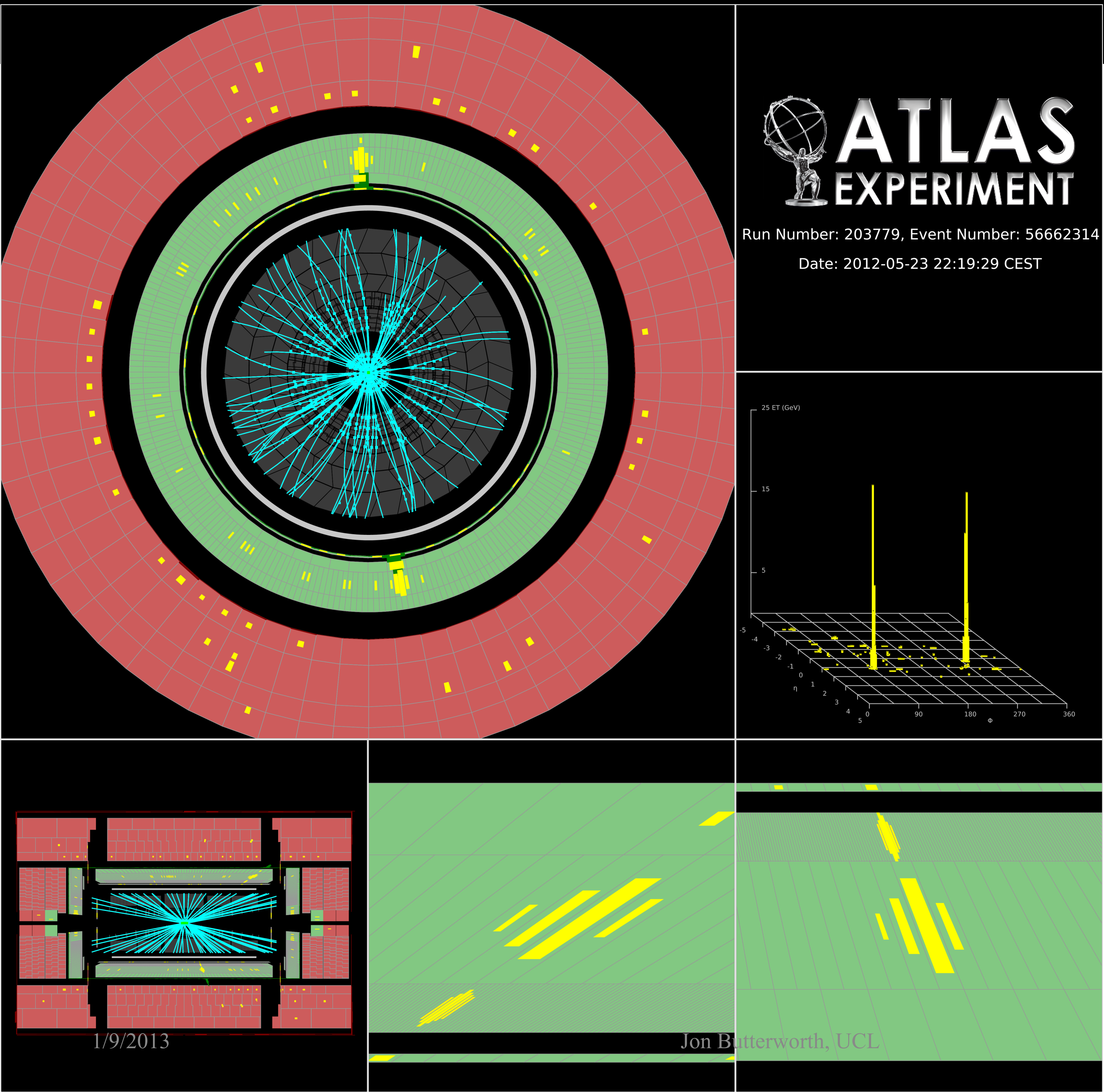


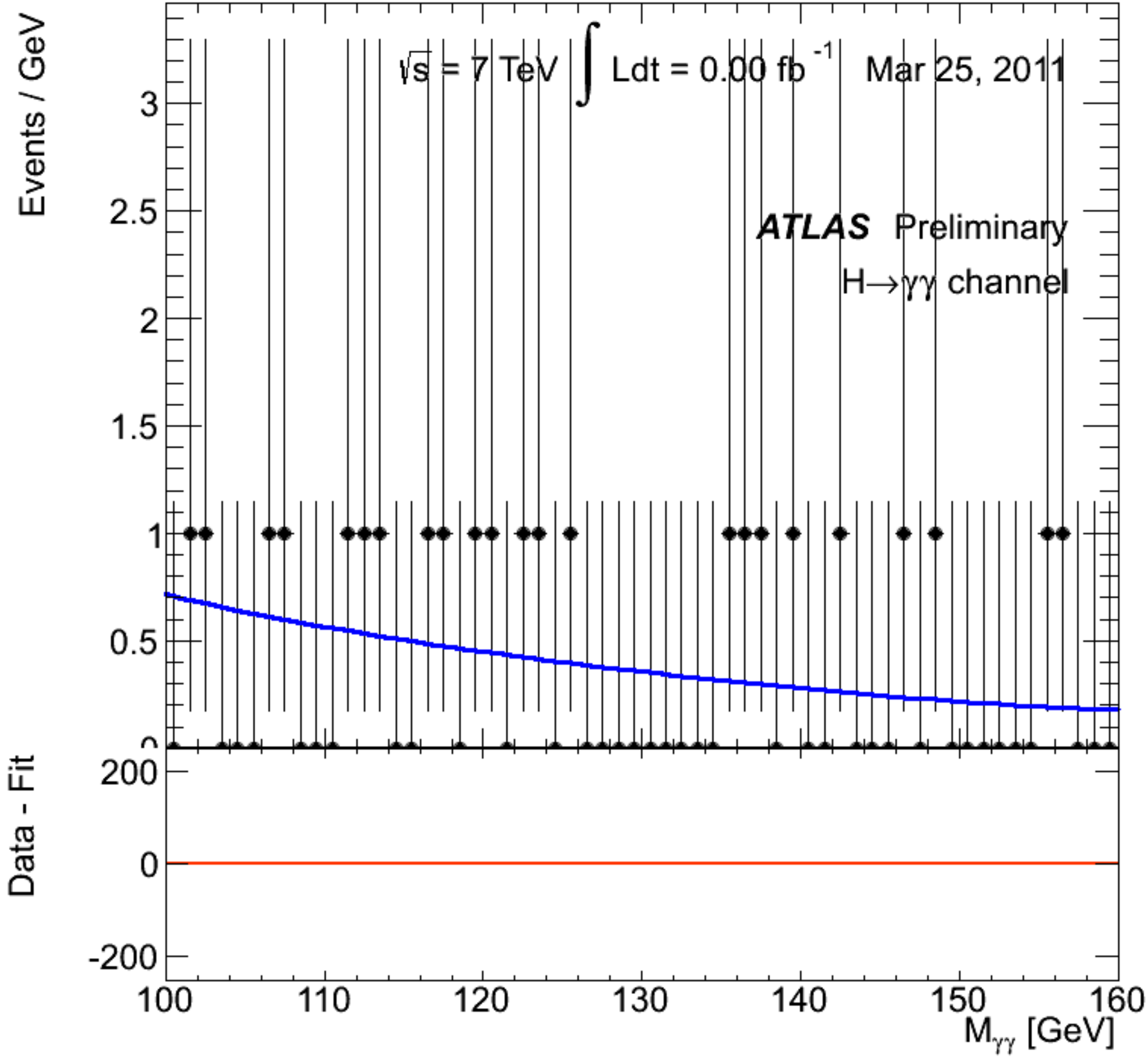
$$\Delta^{\rm n}_{\rm jets} = \frac{|\vec{p}_{\rm T}^{\,J_1} + \vec{p}_{\rm T}^{\,J_2}|}{|\vec{p}_{\rm T}^{\,J_1}| + |\vec{p}_{\rm T}^{\,J_2}|}.$$



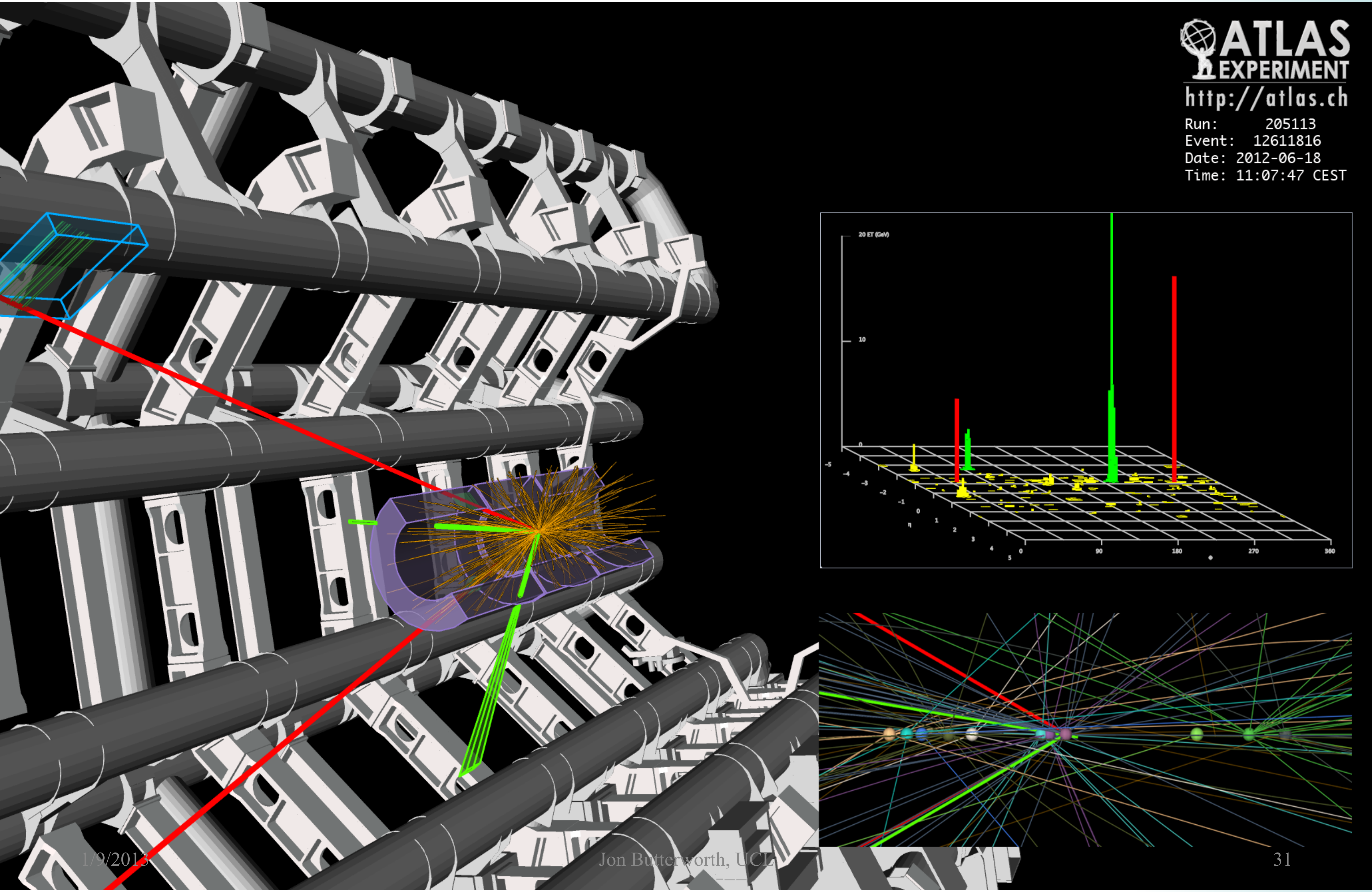


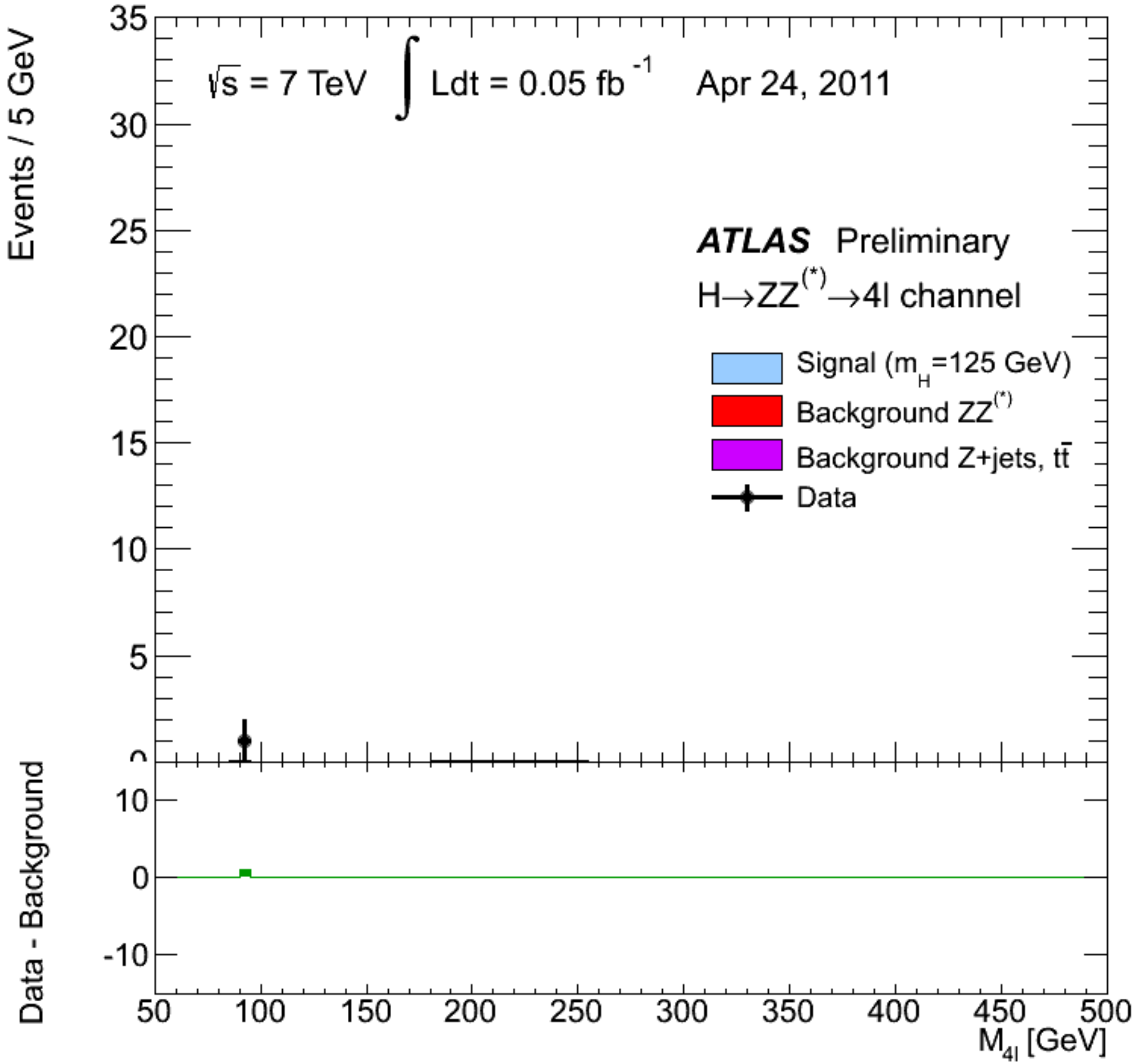
Discovery


ATLAS EXPERIMENT
Run Number: 203779, Event Number: 56662314
Date: 2012-05-23 22:19:29 CEST
25 ET (GeV)
15
5
-5
-4
-3
-2
-1
0
1
2
3
4
5
η
0
90
180
270
360
Φ

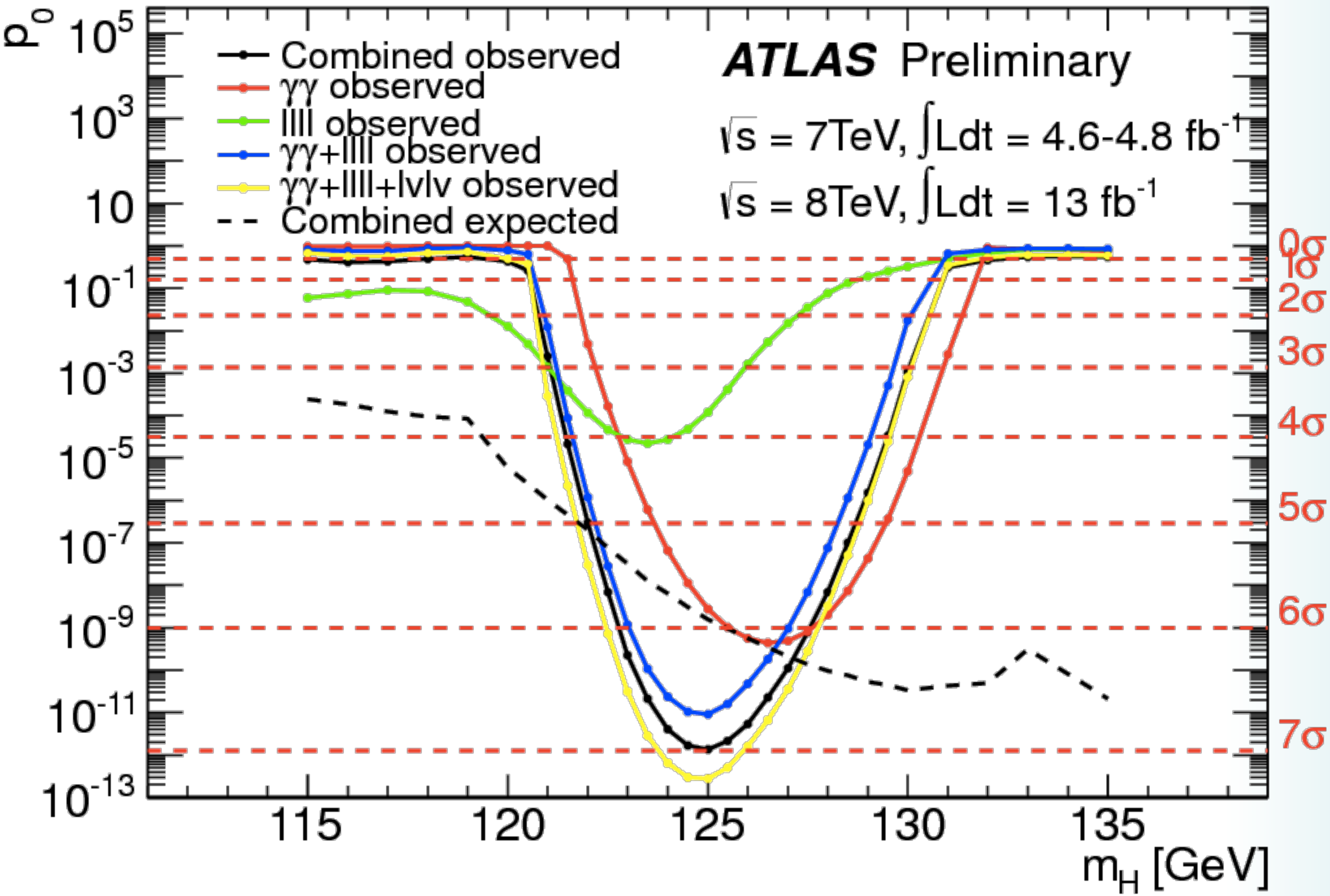


$\sqrt{s}$ = 7 TeV $\int$ Ldt = 0.00 fb^{-1} Mar 25, 2011
ATLAS Preliminary
H→γγ channel
Events / GeV
3
2.5
2
1.5
1
0.5
Data - Fit
200
0
-200
100
110
120
130
140
150
160
$M_{\gamma\gamma}$ [GeV]

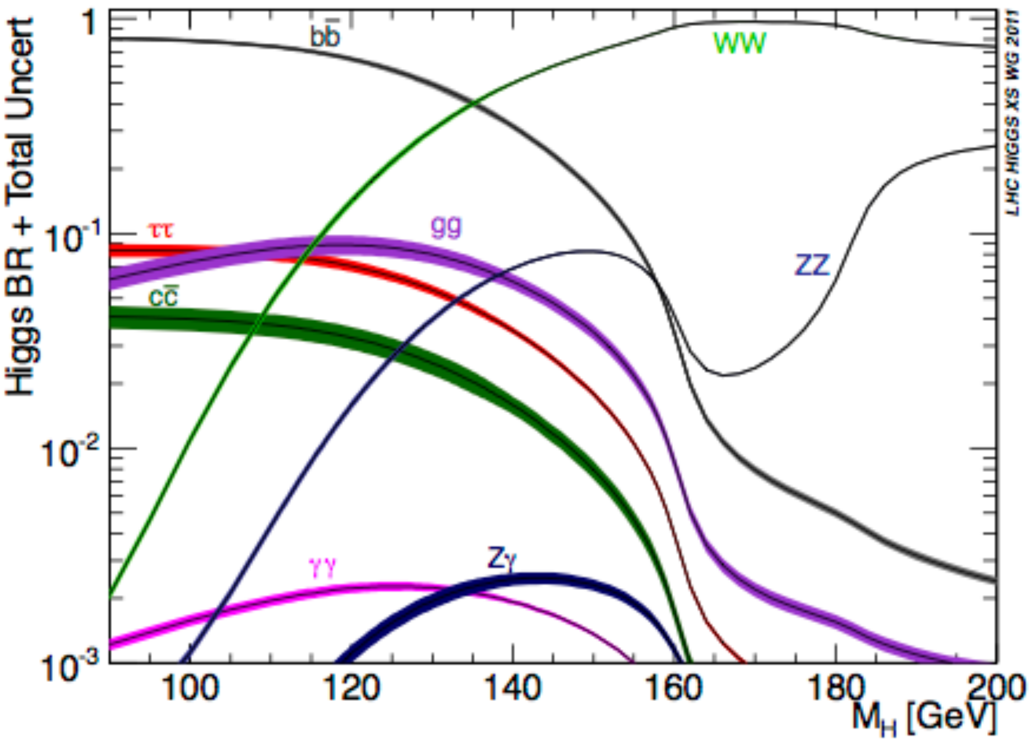

ATLAS EXPERIMENT
http://atlas.ch
Run: 205113
Event: 12611816
Date: 2012-06-18
Time: 11:07:47 CEST
20 ET (GeV)
10



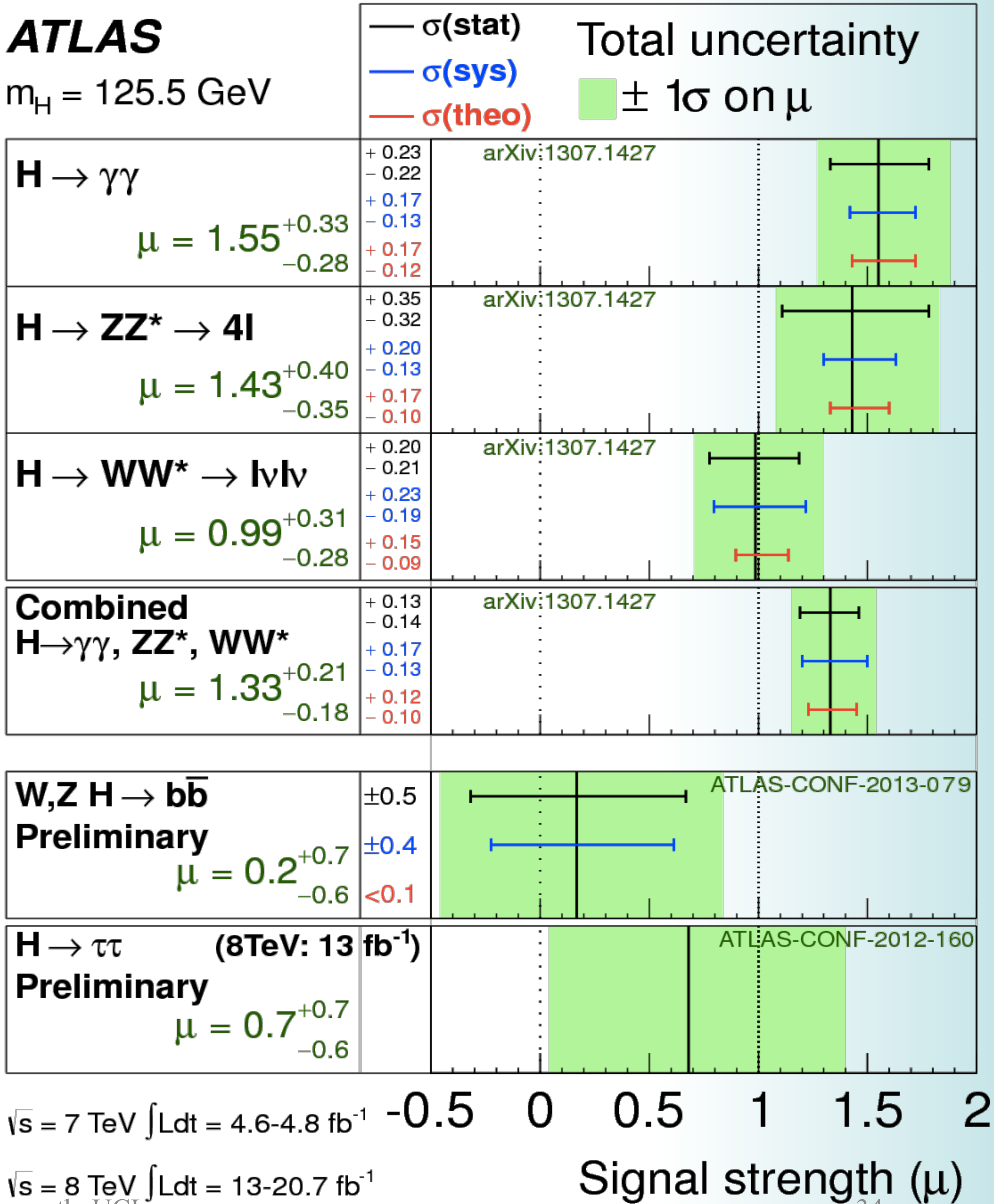
$\sqrt{s}$ = 7 TeV $\int Ldt$ = 0.05 fb^{-1} Apr 24, 2011
ATLAS Preliminary
$H \rightarrow ZZ^{(*)} \rightarrow 4l$ channel
Signal (m_H=125 GeV)
Background $ZZ^{(*)}$
Background Z+jets, $t\bar{t}$
Data
Events / 5 GeV
Data - Background
M_{4l} [GeV]



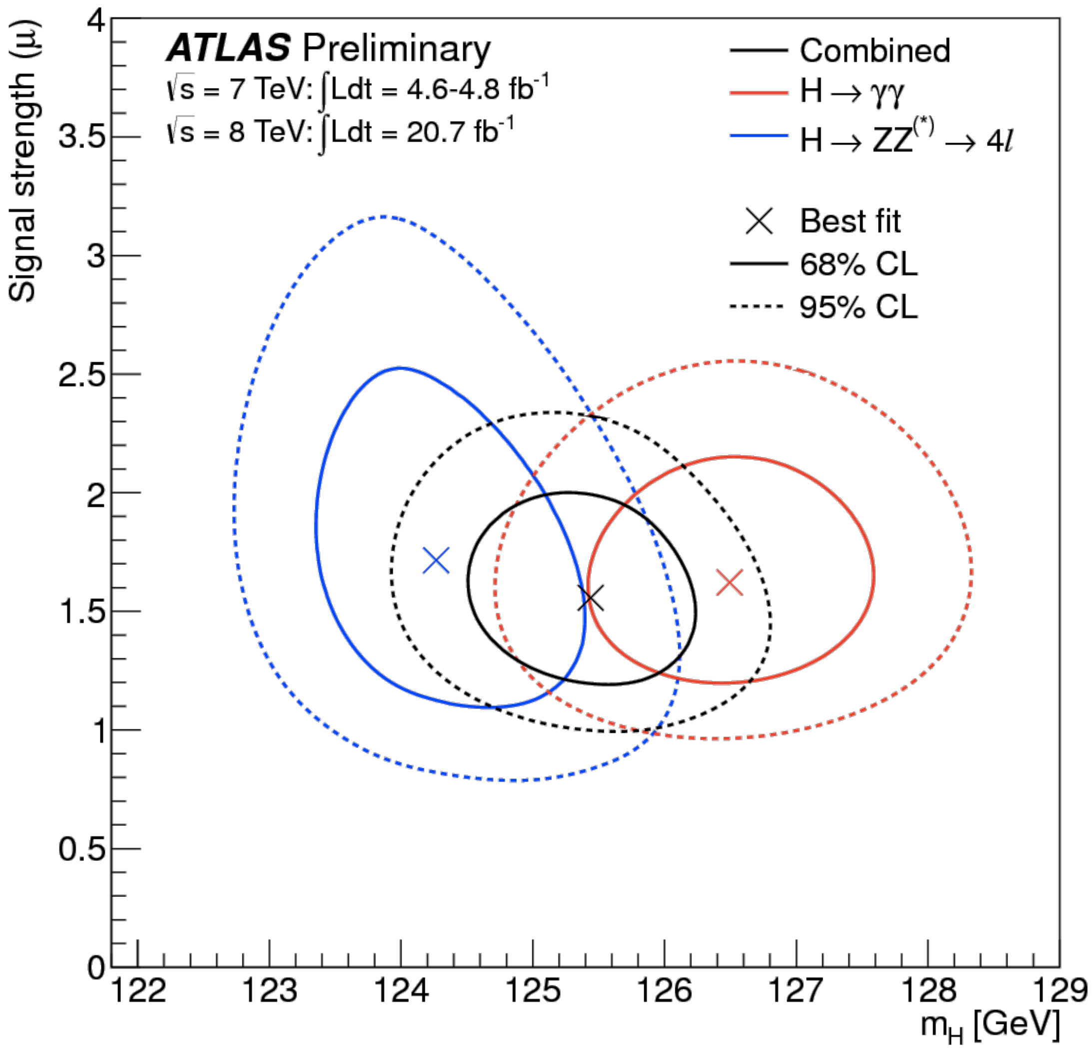
p_0
Combined observed
γγ observed
llll observed
γγ+llll observed
γγ+llll+lνlν observed
Combined expected
ATLAS Preliminary
$\sqrt{s}$ = 7TeV, $\int Ldt$ = 4.6-4.8 fb^{-1}
$\sqrt{s}$ = 8TeV, $\int Ldt$ = 13 fb^{-1}
0σ
1σ
2σ
3σ
4σ
5σ
6σ
7σ
10^5
10^3
10
10^{-1}
10^{-3}
10^{-5}
10^{-7}
10^{-9}
10^{-11}
10^{-13}
115
120
125
130
135
m_H [GeV]



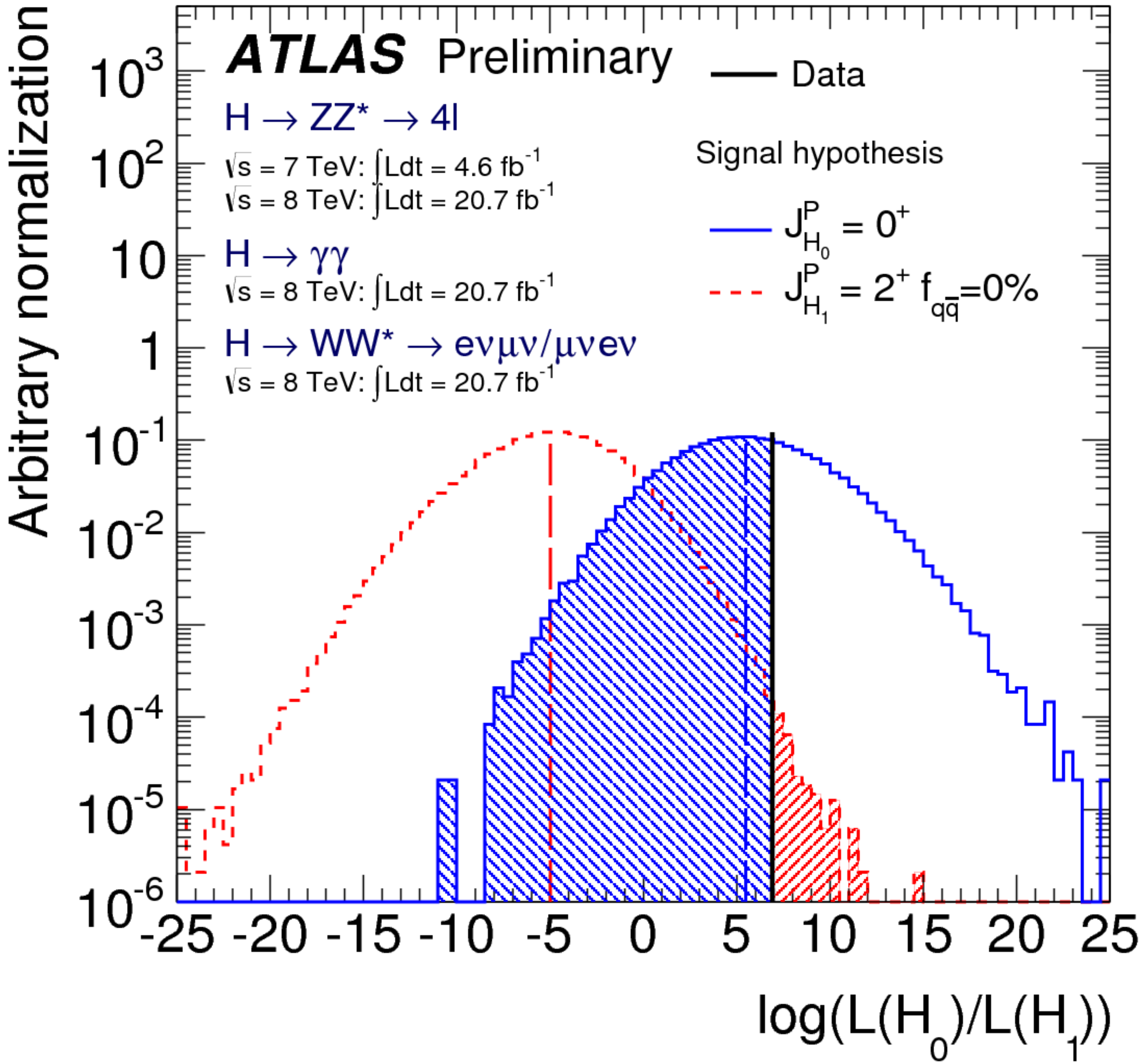
Higgs BR + Total Uncert
$b\bar{b}$
WW
$\tau\tau$
gg
$c\bar{c}$
ZZ
$\gamma\gamma$
$Z\gamma$
LHC HIGGS XS WG 2011
M_H [GeV]



ATLAS
m_H = 125.5 GeV
σ(stat)
σ(sys)
σ(theo)
Total uncertainty
± 1σ on μ
H → γγ
μ = 1.55 +0.33 −0.28
arXiv:1307.1427
H → ZZ* → 4l
μ = 1.43 +0.40 −0.35
H → WW* → lνlν
μ = 0.99 +0.31 −0.28
Combined H→γγ, ZZ*, WW*
μ = 1.33 +0.21 −0.18
W,Z H → $b\bar{b}$ Preliminary
μ = 0.2 +0.7 −0.6
ATLAS-CONF-2013-079
H → ττ (8TeV: 13 fb^{-1}) Preliminary
μ = 0.7 +0.7 −0.6
ATLAS-CONF-2012-160
√s = 7 TeV ∫Ldt = 4.6-4.8 fb^{-1}
√s = 8 TeV ∫Ldt = 13-20.7 fb^{-1}
Signal strength (μ)



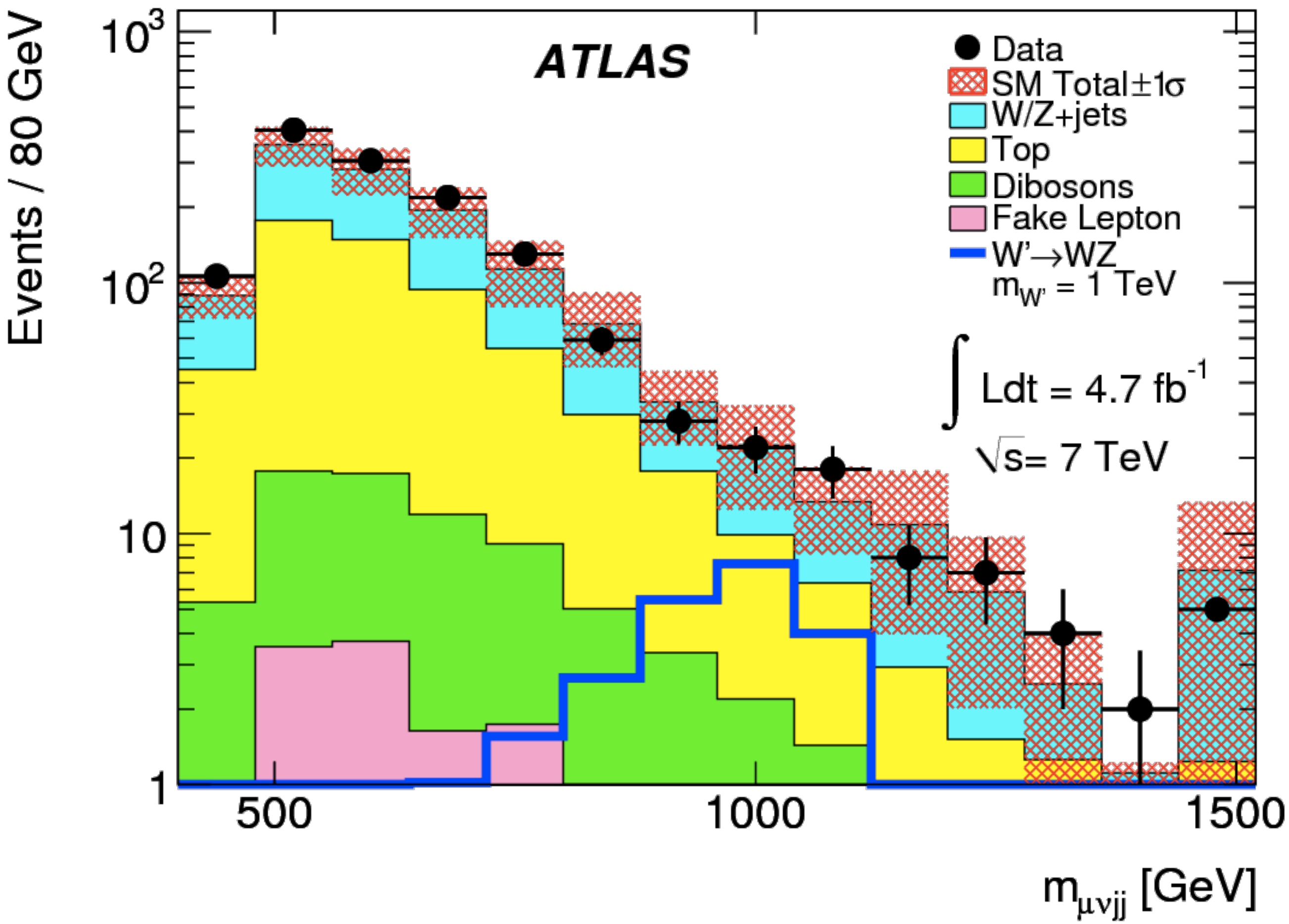
ATLAS Preliminary
√s = 7 TeV: ∫Ldt = 4.6-4.8 fb-1
√s = 8 TeV: ∫Ldt = 20.7 fb-1
Combined
H → γγ
H → ZZ(*) → 4l
Best fit
68% CL
95% CL
Signal strength (μ)
m_H [GeV]



Pure spin 2 excluded at > 99.9%

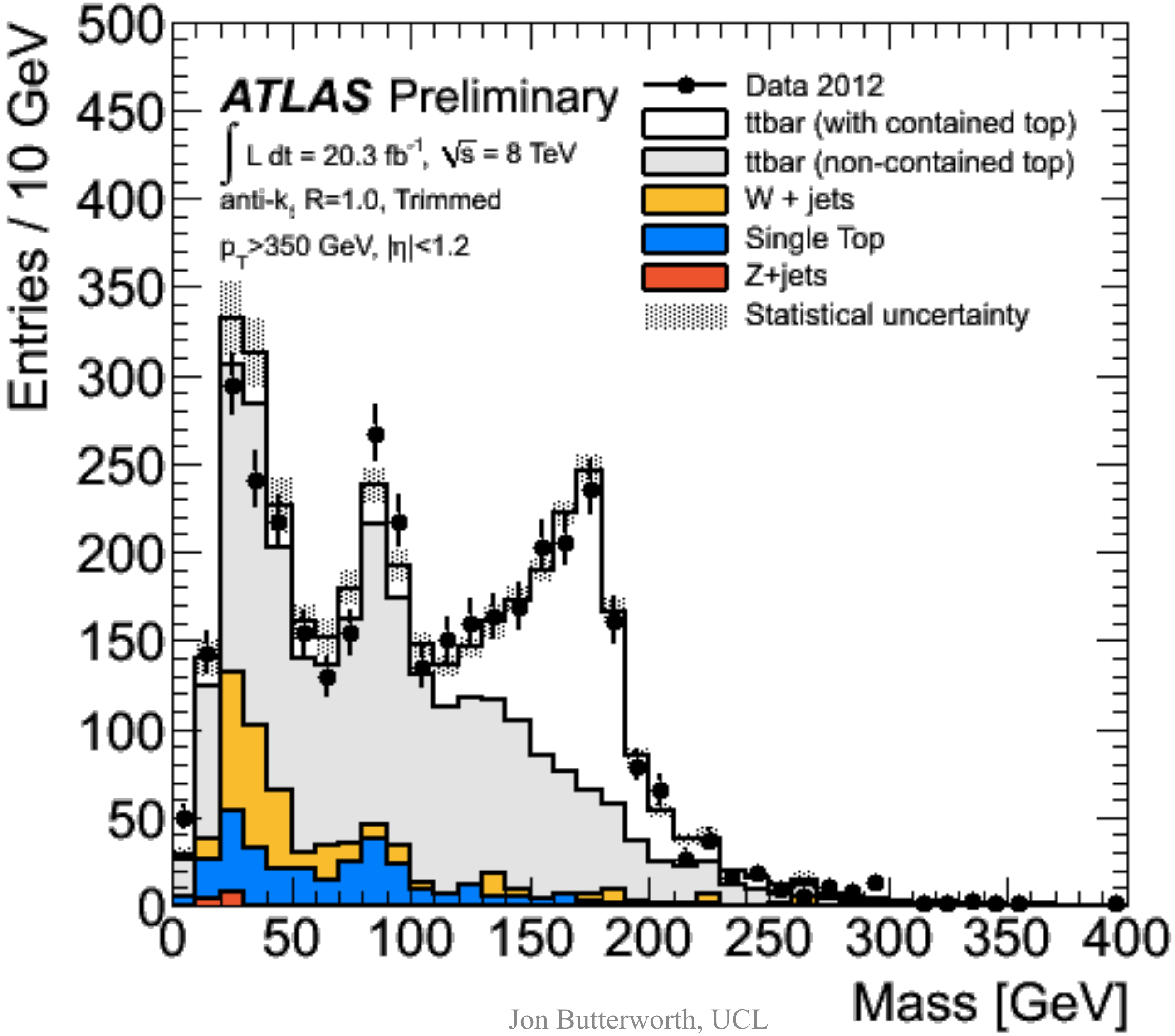
Searches

WZ/WW resonances

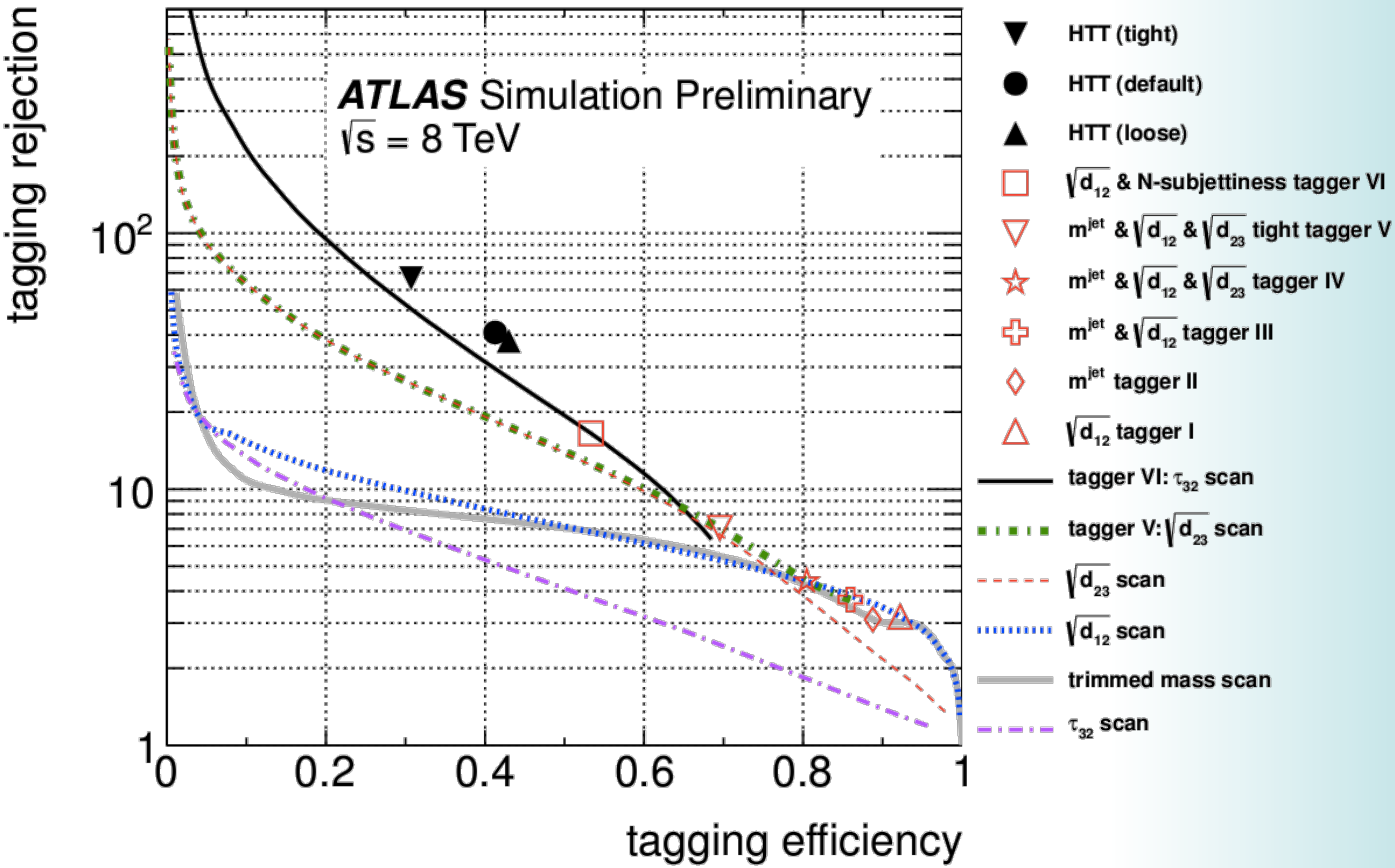


arXiv:1305.0125

Substructure in searches (boosted top, boosted W)



Substructure in searches



ATLAS SUSY Searches* - 95% CL Lower Limits

Status: EPS 2013

ATLAS Preliminary

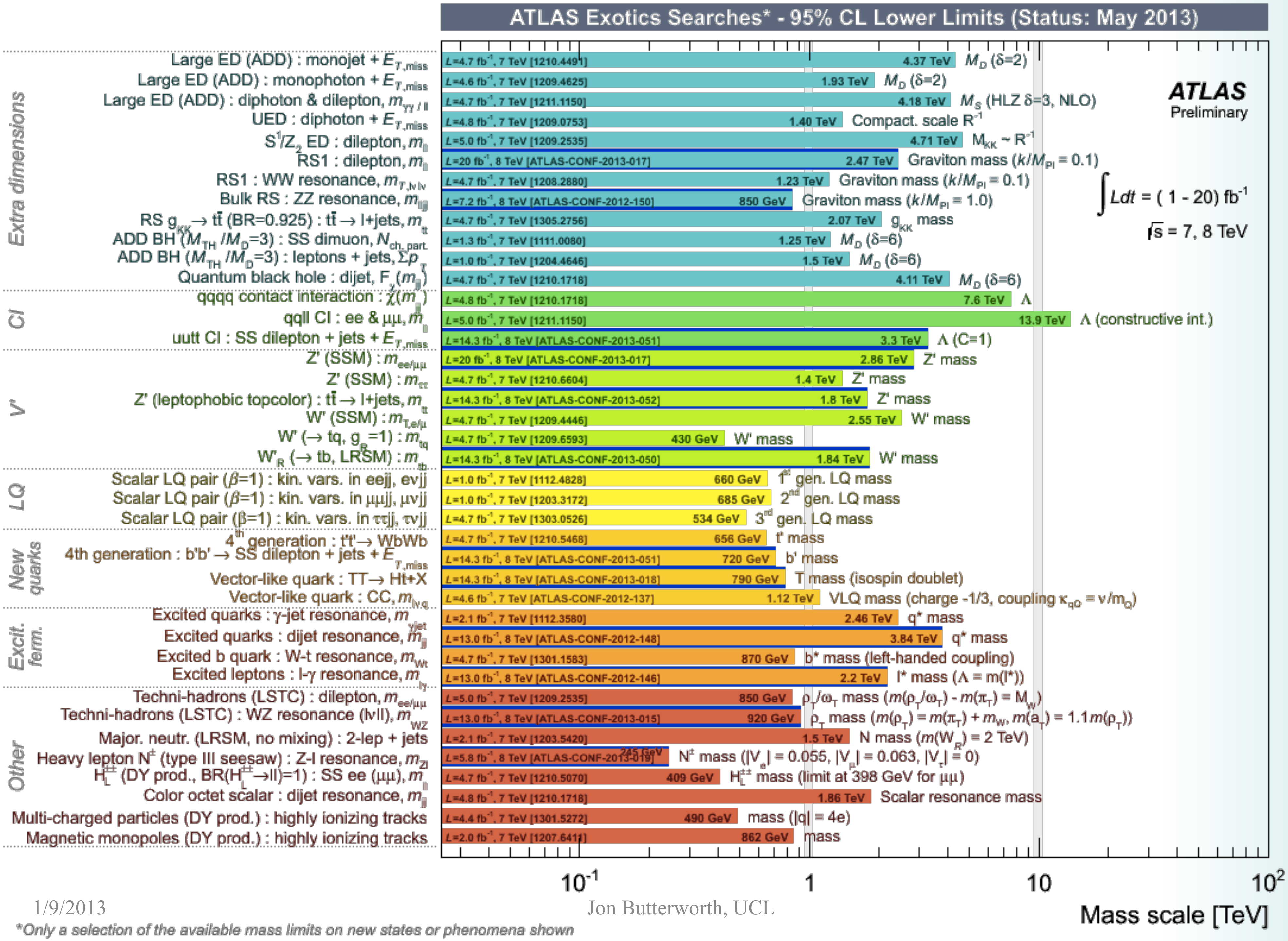
$\int \mathcal{L}\, dt = (4.4 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s}$ = 7, 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-054
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e,μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}\to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e,μ (SS)	3 jets	Yes	20.7	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$<650 GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{\ell}$ NLSP)	2 e,μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	$\tan\beta$>18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$ 1.07 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	1209.0753
	GGM (wino NLSP)	1 $e,\mu+\gamma$	0	Yes	4.8	$\tilde{g}$ 619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e,μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$ 690 GeV	$m(\tilde{H})$>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale 645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.14 TeV	$m(\tilde{\chi}_1^0)$ <200 GeV	ATLAS-CONF-2013-054
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-630 GeV	$m(\tilde{\chi}_1^0)$<100 GeV	ATLAS-CONF-2013-053
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 430 GeV	$m(\tilde{\chi}_1^\pm)=2\, m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e,μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 220 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{t}_1)-m(W)$-50 GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e,μ	2 jets	Yes	20.3	$\tilde{t}_1$ 225-525 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$=5 GeV	ATLAS-CONF-2013-053
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e,μ	1 b	Yes	20.7	$\tilde{t}_1$ 200-610 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 200 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)$+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}, \tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 600 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W^*\tilde{\chi}_1^0 Z^*\tilde{\chi}_1^0$	3 e,μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 315 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-035
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^\pm$ 270 GeV	$m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^\pm)$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 857 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	0	-	15.9	$\tilde{\chi}_1^0$ 475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	0	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ	0	Yes	4.4	$\tilde{q}$ 700 GeV	1 mm<$c\tau$<1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e+\mu$	2 e,μ	0	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e(\mu)+\tau$	1 $e,\mu+\tau$	0	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e,μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$ 1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6 jets	-	4.6	$\tilde{g}$ 666 GeV		1210.4813
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

10^{-1} 1 **Mass scale [TeV]**

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.


ATLAS Exotics Searches* - 95% CL Lower Limits (Status: May 2013)
ATLAS Preliminary
∫Ldt = (1 - 20) fb-1
√s = 7, 8 TeV
Extra dimensions
Large ED (ADD) : monojet + ET,miss | L=4.7 fb-1, 7 TeV [1210.4491] | 4.37 TeV | MD (δ=2)
Large ED (ADD) : monophoton + ET,miss | L=4.6 fb-1, 7 TeV [1209.4625] | 1.93 TeV | MD (δ=2)
Large ED (ADD) : diphoton & dilepton, mγγ / ll | L=4.7 fb-1, 7 TeV [1211.1150] | 4.18 TeV | MS (HLZ δ=3, NLO)
UED : diphoton + ET,miss | L=4.8 fb-1, 7 TeV [1209.0753] | 1.40 TeV | Compact. scale R-1
S1/Z2 ED : dilepton, mll | L=5.0 fb-1, 7 TeV [1209.2535] | 4.71 TeV | MKK ~ R-1
RS1 : dilepton, mll | L=20 fb-1, 8 TeV [ATLAS-CONF-2013-017] | 2.47 TeV | Graviton mass (k/MPl = 0.1)
RS1 : WW resonance, mT,lvlv | L=4.7 fb-1, 7 TeV [1208.2880] | 1.23 TeV | Graviton mass (k/MPl = 0.1)
Bulk RS : ZZ resonance, mlljj | L=7.2 fb-1, 8 TeV [ATLAS-CONF-2012-150] | 850 GeV | Graviton mass (k/MPl = 1.0)
RS gKK → tt̄ (BR=0.925) : tt̄ → l+jets, mtt | L=4.7 fb-1, 7 TeV [1305.2756] | 2.07 TeV | gKK mass
ADD BH (MTH /MD=3) : SS dimuon, Nch. part. | L=1.3 fb-1, 7 TeV [1111.0080] | 1.25 TeV | MD (δ=6)
ADD BH (MTH /MD=3) : leptons + jets, Σ pT | L=1.0 fb-1, 7 TeV [1204.4646] | 1.5 TeV | MD (δ=6)
Quantum black hole : dijet, Fχ(mjj) | L=4.7 fb-1, 7 TeV [1210.1718] | 4.11 TeV | MD (δ=6)
CI
qqqq contact interaction : χ(mjj) | L=4.8 fb-1, 7 TeV [1210.1718] | 7.6 TeV | Λ
qqll CI : ee & μμ, mll | L=5.0 fb-1, 7 TeV [1211.1150] | 13.9 TeV | Λ (constructive int.)
uutt CI : SS dilepton + jets + ET,miss | L=14.3 fb-1, 8 TeV [ATLAS-CONF-2013-051] | 3.3 TeV | Λ (C=1)
V'
Z' (SSM) : mee/μμ | L=20 fb-1, 8 TeV [ATLAS-CONF-2013-017] | 2.86 TeV | Z' mass
Z' (SSM) : mττ | L=4.7 fb-1, 7 TeV [1210.6604] | 1.4 TeV | Z' mass
Z' (leptophobic topcolor) : tt̄ → l+jets, mtt | L=14.3 fb-1, 8 TeV [ATLAS-CONF-2013-052] | 1.8 TeV | Z' mass
W' (SSM) : mT,e/μ | L=4.7 fb-1, 7 TeV [1209.4446] | 2.55 TeV | W' mass
W' (→ tq, gR=1) : mtq | L=4.7 fb-1, 7 TeV [1209.6593] | 430 GeV | W' mass
W'R (→ tb, LRSM) : mtb | L=14.3 fb-1, 8 TeV [ATLAS-CONF-2013-050] | 1.84 TeV | W' mass
LQ
Scalar LQ pair (β=1) : kin. vars. in eejj, evjj | L=1.0 fb-1, 7 TeV [1112.4828] | 660 GeV | 1st gen. LQ mass
Scalar LQ pair (β=1) : kin. vars. in μμjj, μvjj | L=1.0 fb-1, 7 TeV [1203.3172] | 685 GeV | 2nd gen. LQ mass
Scalar LQ pair (β=1) : kin. vars. in ττjj, τvjj | L=4.7 fb-1, 7 TeV [1303.0526] | 534 GeV | 3rd gen. LQ mass
New quarks
4th generation : t't'→ WbWb | L=4.7 fb-1, 7 TeV [1210.5468] | 656 GeV | t' mass
4th generation : b'b' → SS dilepton + jets + ET,miss | L=14.3 fb-1, 8 TeV [ATLAS-CONF-2013-051] | 720 GeV | b' mass
Vector-like quark : TT→ Ht+X | L=14.3 fb-1, 8 TeV [ATLAS-CONF-2013-018] | 790 GeV | T mass (isospin doublet)
Vector-like quark : CC, mlvq | L=4.6 fb-1, 7 TeV [ATLAS-CONF-2012-137] | 1.12 TeV | VLQ mass (charge -1/3, coupling κqQ = v/mQ)
Excit. ferm.
Excited quarks : γ-jet resonance, mγjet | L=2.1 fb-1, 7 TeV [1112.3580] | 2.46 TeV | q* mass
Excited quarks : dijet resonance, mjj | L=13.0 fb-1, 8 TeV [ATLAS-CONF-2012-148] | 3.84 TeV | q* mass
Excited b quark : W-t resonance, mWt | L=4.7 fb-1, 7 TeV [1301.1583] | 870 GeV | b* mass (left-handed coupling)
Excited leptons : l-γ resonance, mlγ | L=13.0 fb-1, 8 TeV [ATLAS-CONF-2012-146] | 2.2 TeV | l* mass (Λ = m(l*))
Other
Techni-hadrons (LSTC) : dilepton, mee/μμ | L=5.0 fb-1, 7 TeV [1209.2535] | 850 GeV | ρT/ωT mass (m(ρT/ωT) - m(πT) = MW)
Techni-hadrons (LSTC) : WZ resonance (lvll), mWZ | L=13.0 fb-1, 8 TeV [ATLAS-CONF-2013-015] | 920 GeV | ρT mass (m(ρT) = m(πT) + mW, m(aT) = 1.1m(ρT))
Major. neutr. (LRSM, no mixing) : 2-lep + jets | L=2.1 fb-1, 7 TeV [1203.5420] | 1.5 TeV | N mass (m(WR) = 2 TeV)
Heavy lepton N± (type III seesaw) : Z-l resonance, mZl | L=5.8 fb-1, 8 TeV [ATLAS-CONF-2013-019] | 245 GeV | N± mass (|Ve| = 0.055, |Vμ| = 0.063, |Vτ| = 0)
H±±L (DY prod., BR(H±±L→ll)=1) : SS ee (μμ), mll | L=4.7 fb-1, 7 TeV [1210.5070] | 409 GeV | H±±L mass (limit at 398 GeV for μμ)
Color octet scalar : dijet resonance, mjj | L=4.8 fb-1, 7 TeV [1210.1718] | 1.86 TeV | Scalar resonance mass
Multi-charged particles (DY prod.) : highly ionizing tracks | L=4.4 fb-1, 7 TeV [1301.5272] | 490 GeV | mass (|q| = 4e)
Magnetic monopoles (DY prod.) : highly ionizing tracks | L=2.0 fb-1, 7 TeV [1207.6411] | 862 GeV | mass
10-1
1
10
102
Mass scale [TeV]
*Only a selection of the available mass limits on new states or phenomena shown

And finally… what do we actually measure?

- Difference between “efficiency corrections” or “unfolding”, and “acceptance corrections”.
  - The first two generally mean correction for detector effects which no one but the experimentalists can do.
  - The third means extrapolating into kinematic regions which have not been measured at all
- Beware of the third, especially as we go to higher energies…

Unfold

Increase acceptance

Increase acceptance

Extrapolate

But how reliably?

And finally… what do we actually measure?

- Defining a region in which acceptance is ~100%,

For example… WW cross section

- ATLAS WW cross section (to e, μ), 7 TeV
  - efficiency/detector corrections to obtain fiducial cross section, 0.4-0.7
  - acceptance (phase space) , 0.07-0.16
- That missing 90% is stuff we *don't measure*
- The efficiency/detector efficiency won't change much at 13 TeV
- The acceptance may well drop further
- Garbage in, garbage out.

For example… Top cross section

- Current measurements extrapolate to 4π, 4 TeV>p_T>0
- Often not even possible to extract the acceptance from the papers (convoluted with efficiencies and migrations)
- Means for some, non-trivially-different, regions of phase space, we are just buying the theory
- Will be even more of a problem at higher beam energies.
- (see LHC Top Working group discussions, e.g. talk by Will Bell, 19/7/2012)

The beginning of physics above the Electroweak Symmetry Breaking scale