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53rd International Winter Meeting on Nuclear Physics
Bormio, January 26-30 , 2015

Review of Recent ATLAS Results

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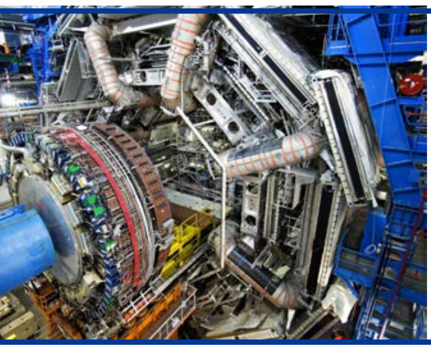
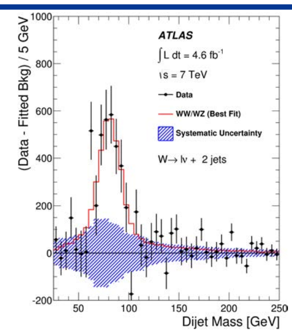
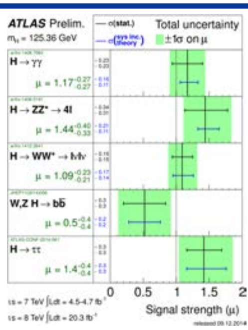
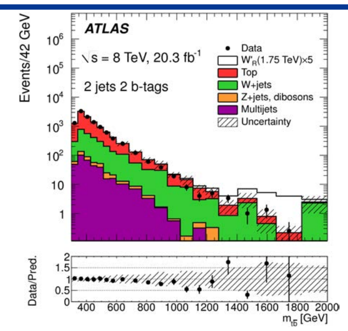
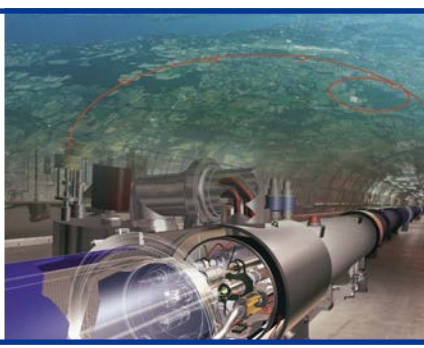






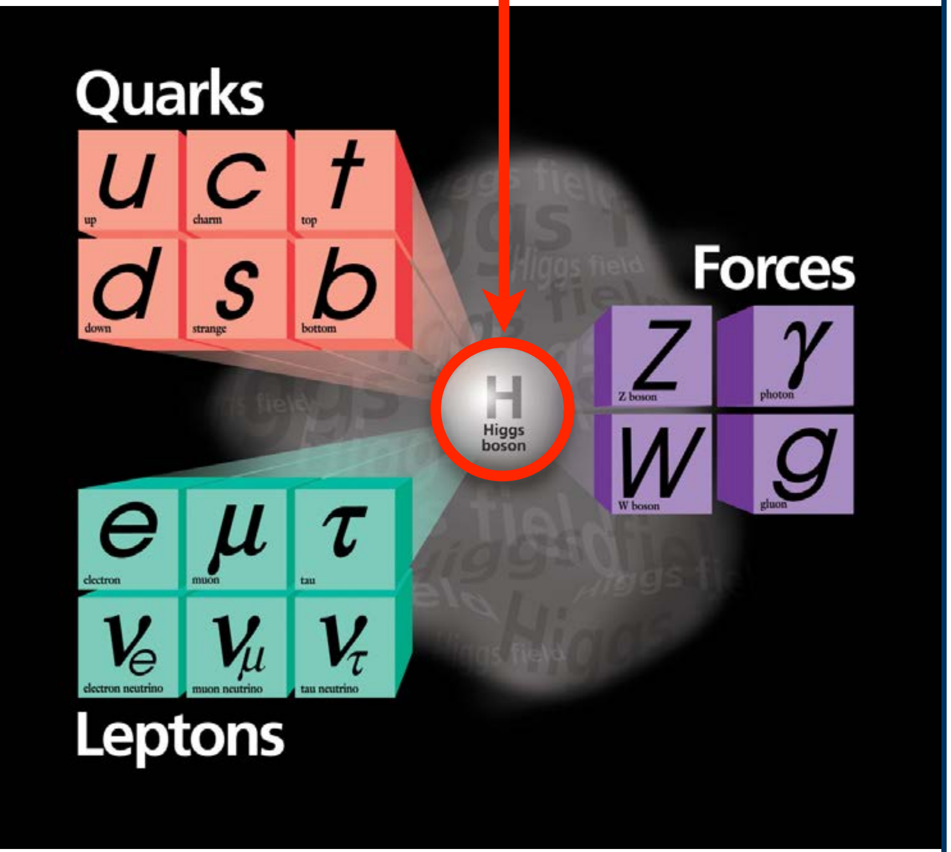




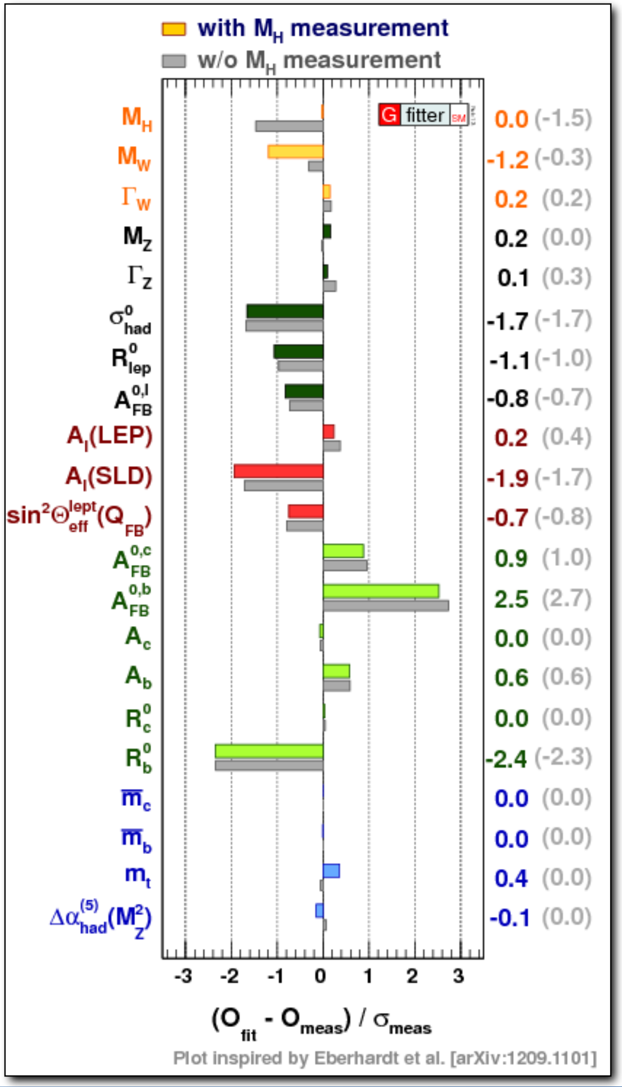
on behalf of the ATLAS Collaboration

The Status of the Standard Model

- **all fundamental SM particles** now **confirmed** by experiment (Higgs boson since 2012)

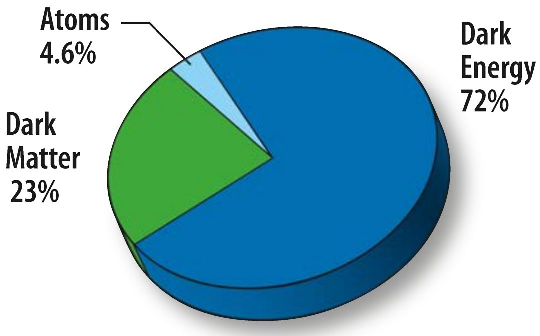


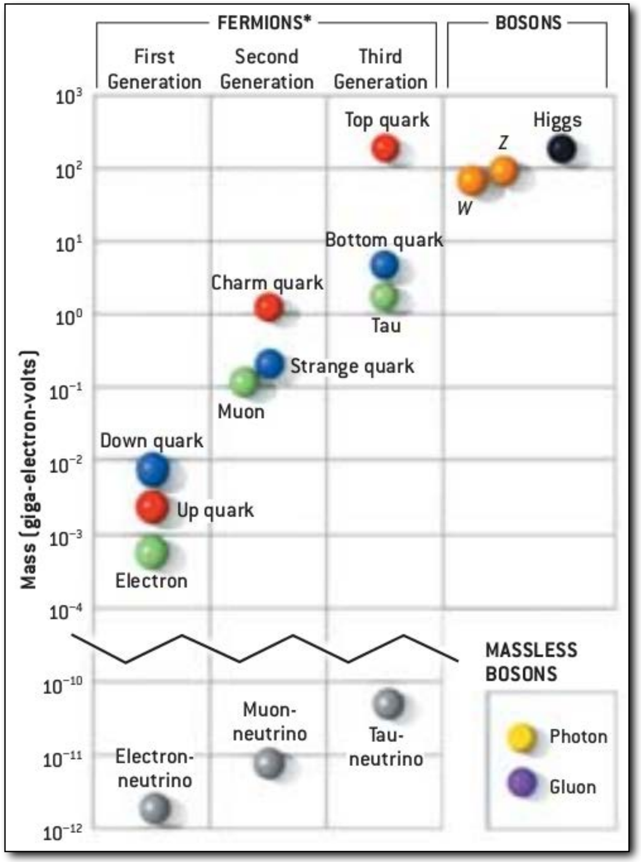
- extensive **experimental tests yield** very **consistent picture**



The Need for "New Physics" (Beyond the SM)

- unexplained **observations**:
  - dark energy, dark matter
  - no antimatter
- **omissions**:
  - gravity not included in SM
- arbitrary(?) **free parameters**:
  - three particle generations
  - many different masses
  - unification of forces?
- **fine tuning** ("hierarchy problem"):
  - Higgs mass much smaller than assoc. corrections





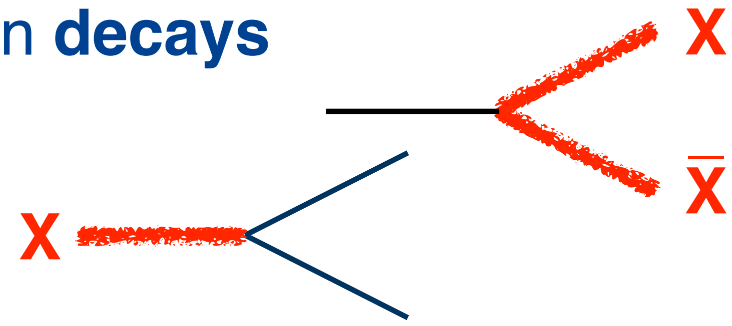
Example(!): Supersymmetry

Class of **SM extensions** to potentially

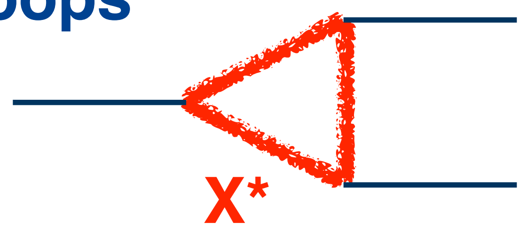
- solve the hierarchy problem
- provide dark matter candidate - if lightest SUSY particle (LSP) is stable (↔ “R parity” conserved)
- unify forces at high scales
- **minimal supersymmetric SM** (MSSM):

Searching for New Particles

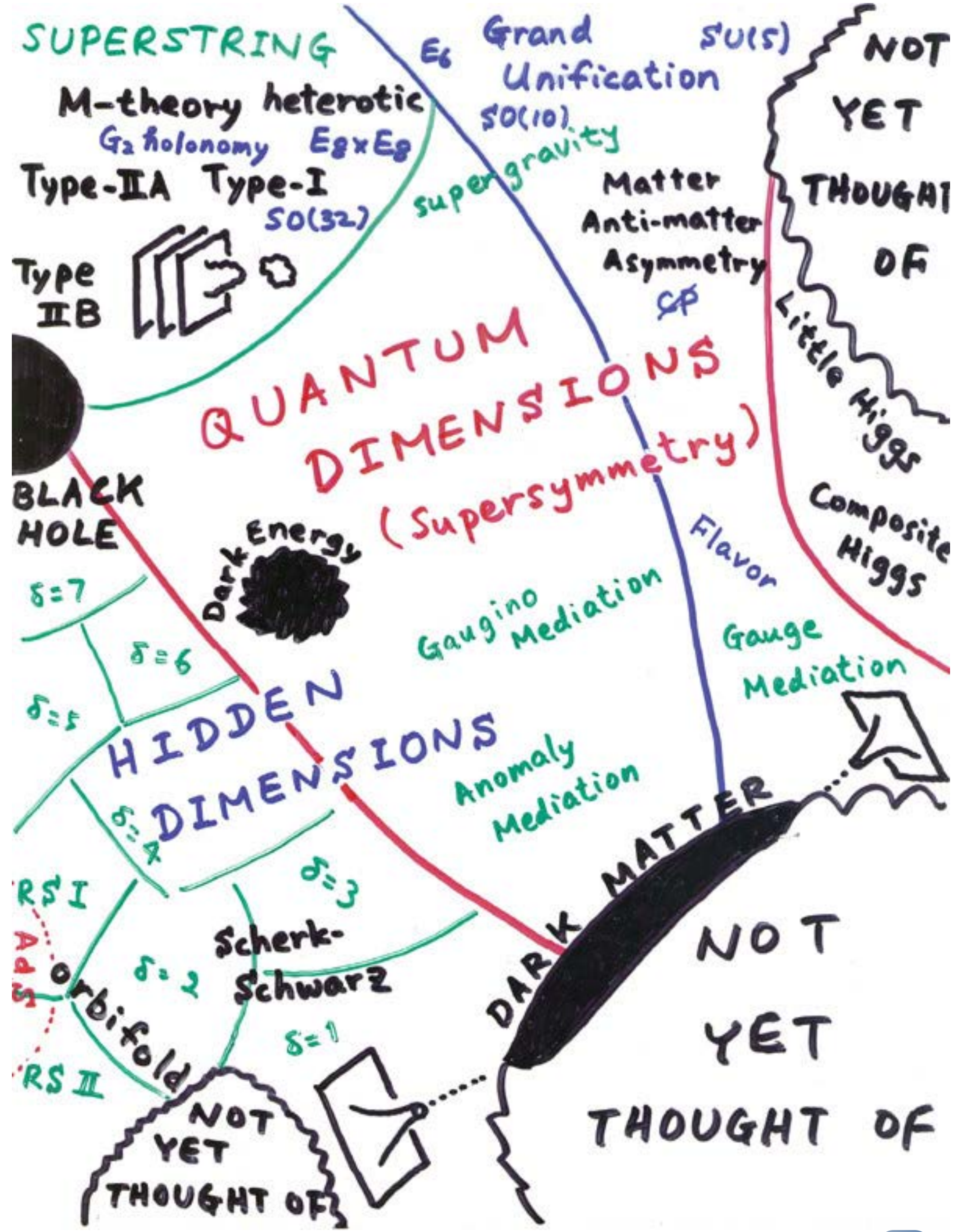
- in **decays**



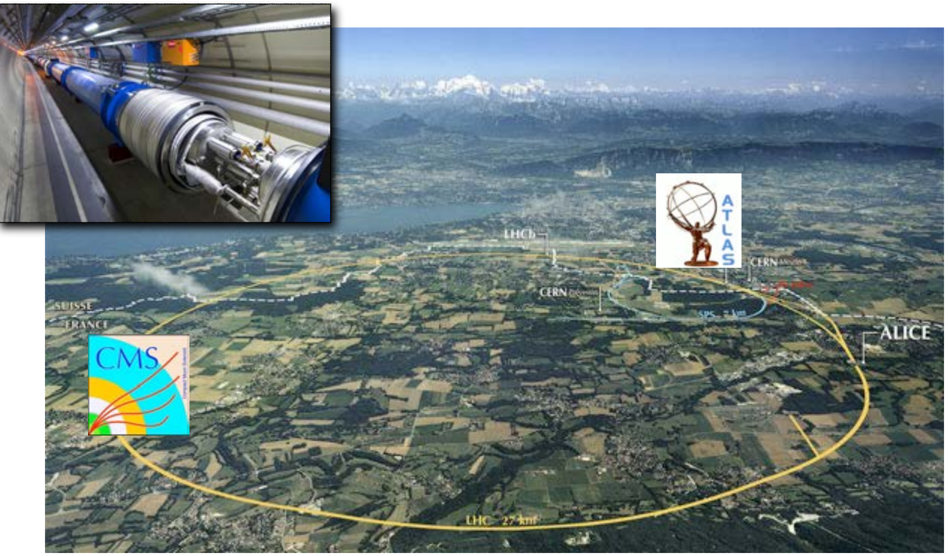
- in **loops**

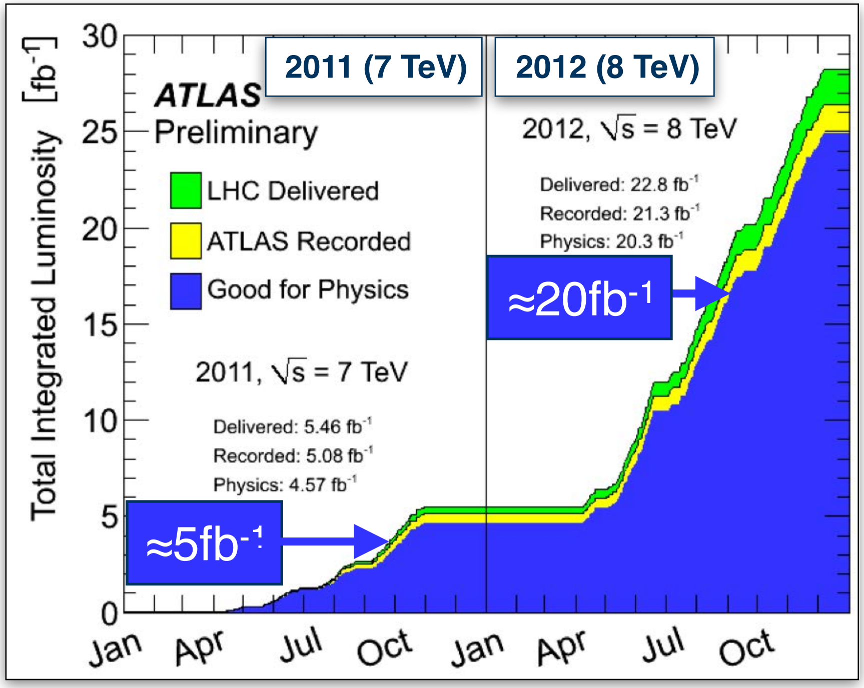


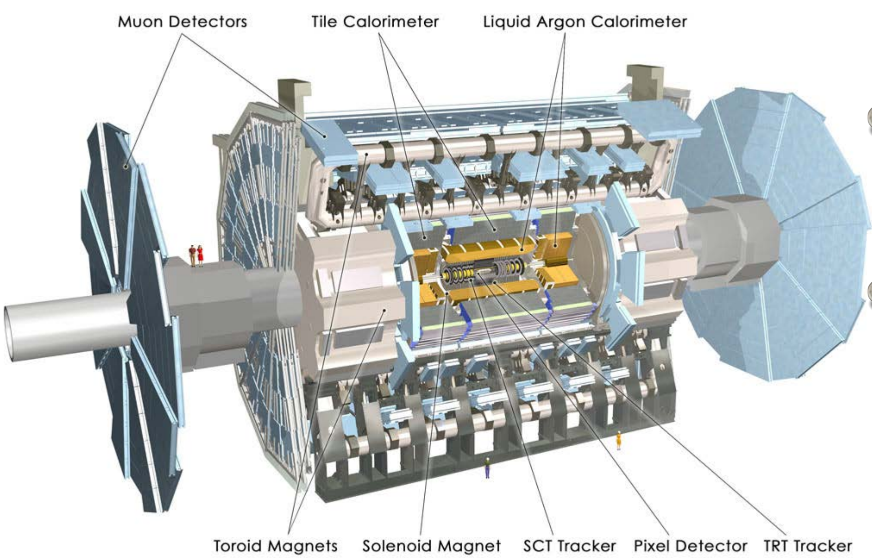
- **need** unprecedented **precision**/sample sizes and/or **collision energies**
- need to be ready for **(m)any signature(s)**



LHC / ATLAS Run1

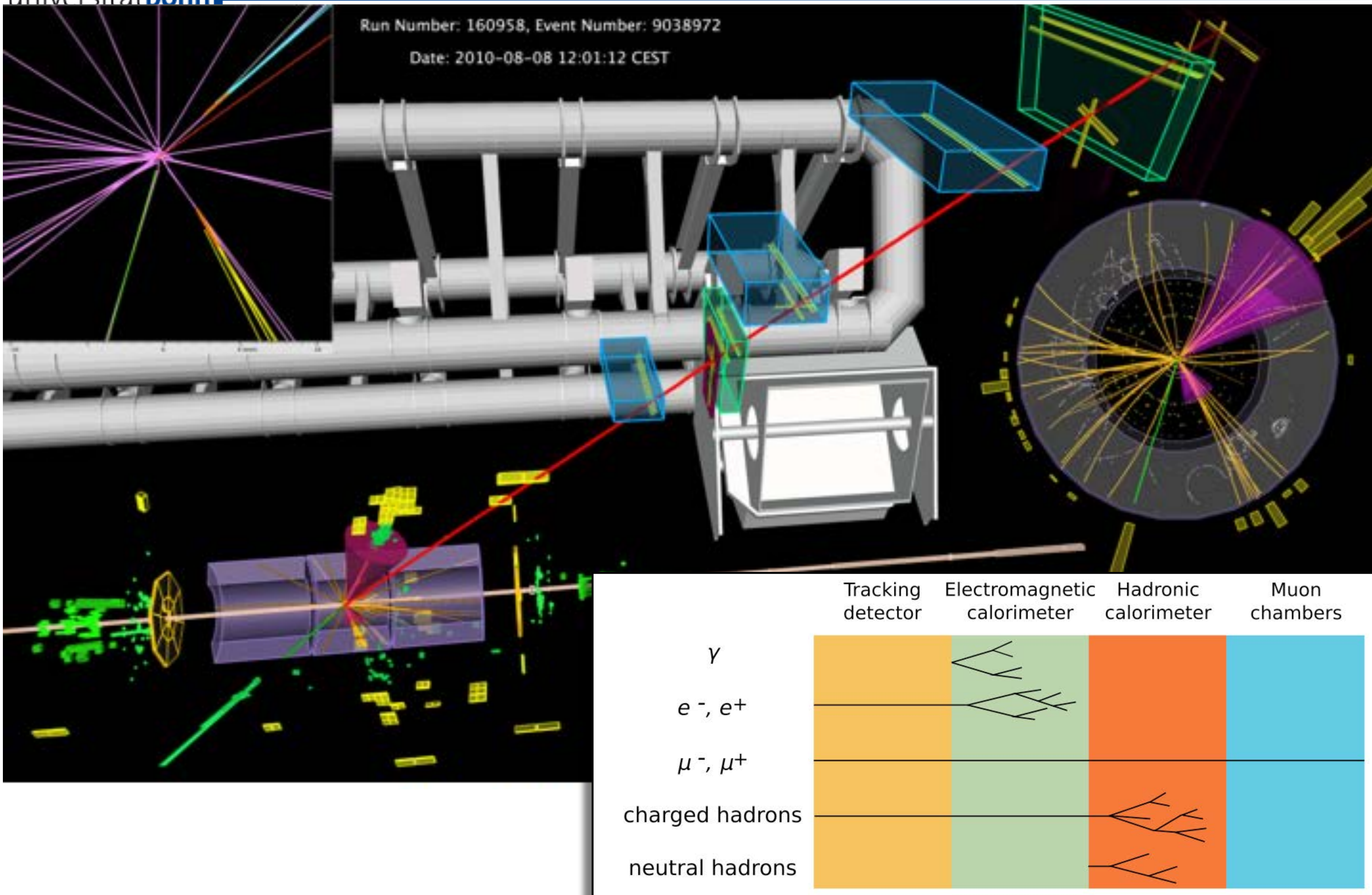




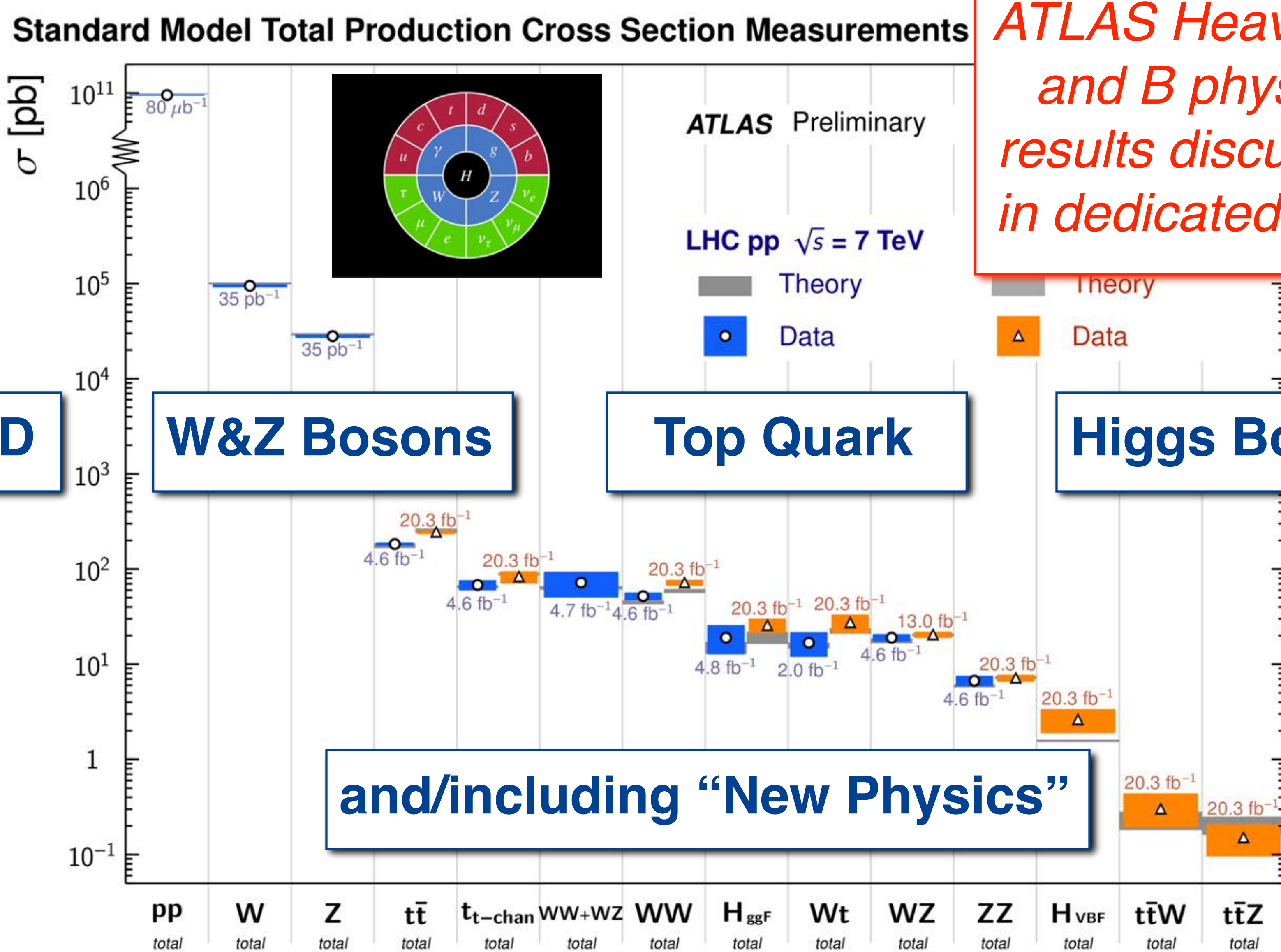


- **excellent** accelerator and detector **performance**
- many **other** crucial **prerequisites**: trigger, reconstruction, calibration, simulation, computing, theory, … (none of them covered in this talk)

Particle Signatures in ATLAS



Selected(!) Measurements & Searches involving:



ATLAS Heavy Ion and B physics results discussed in dedicated talks

QCD

W&Z Bosons

Top Quark

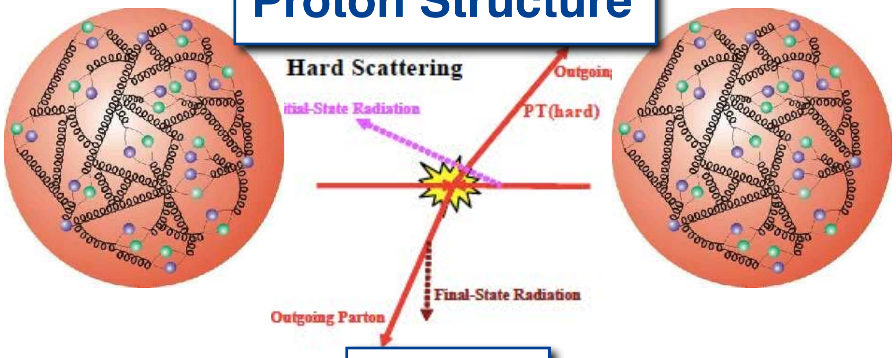
Higgs Boson

and/including “New Physics”

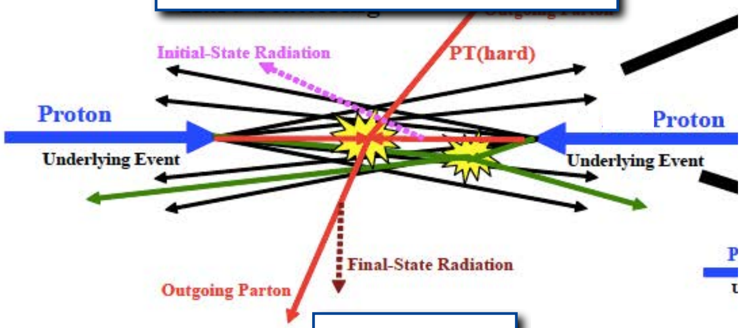
QCD

QCD Processes are Everywhere

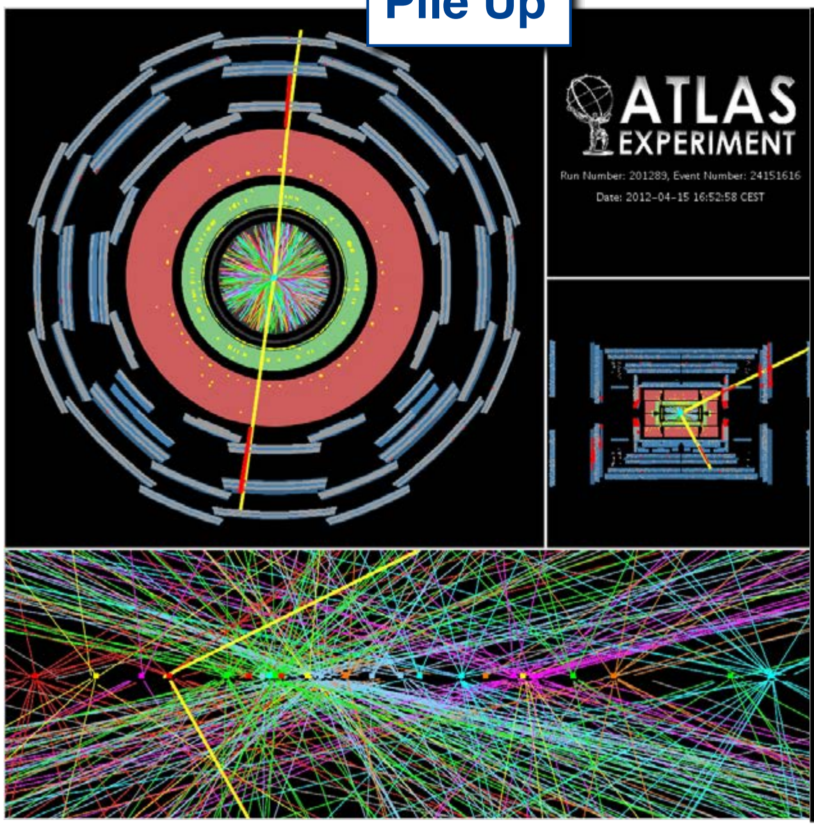
Proton Structure



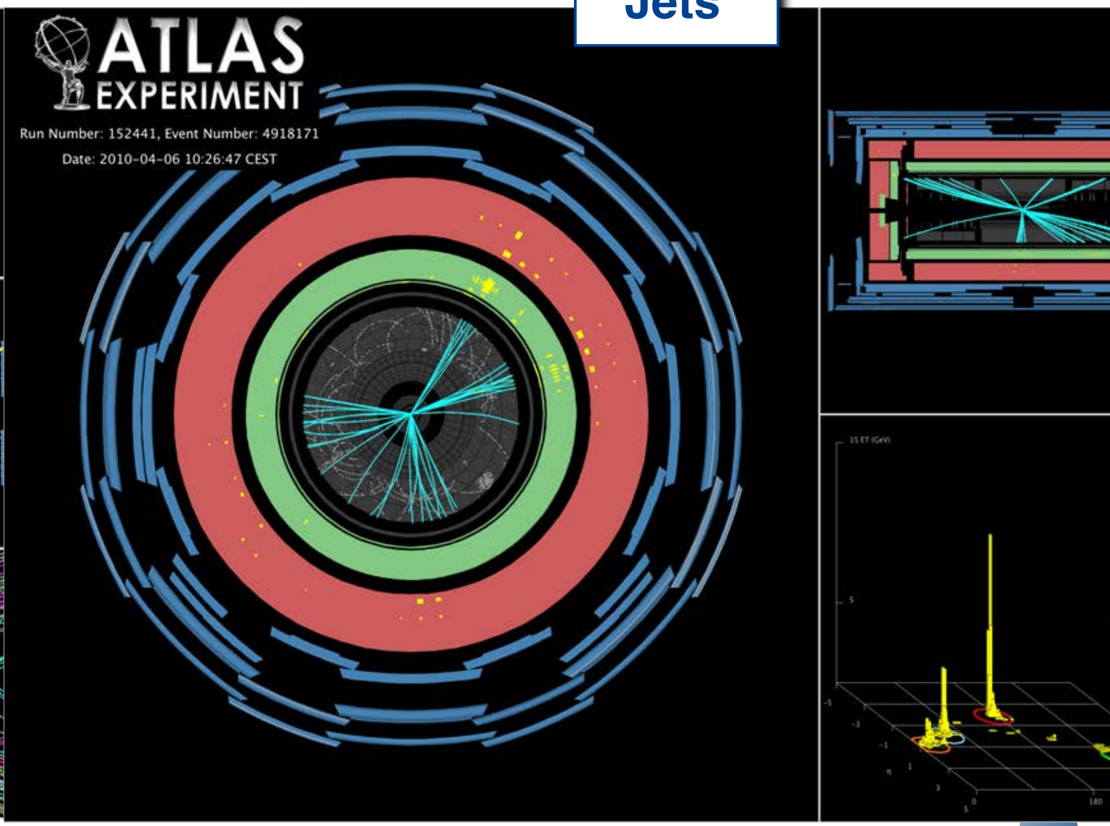
Underlying Event



Pile Up

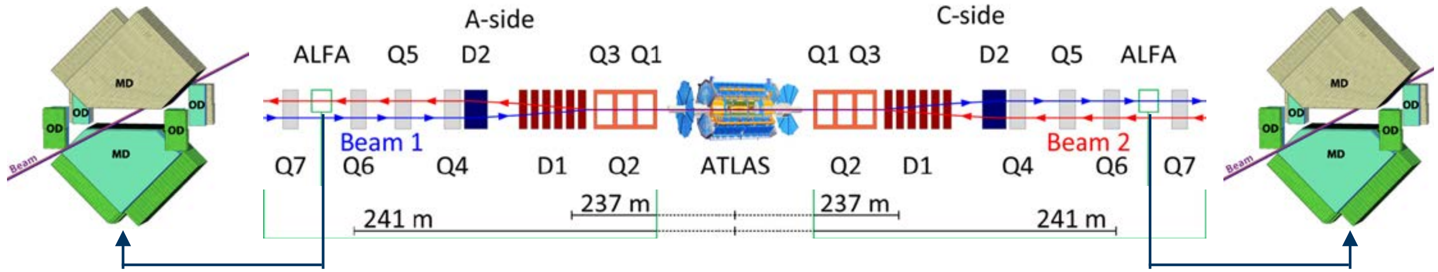


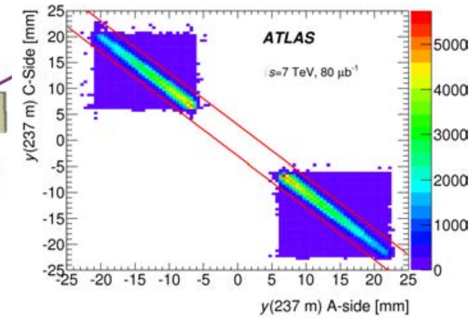
Jets



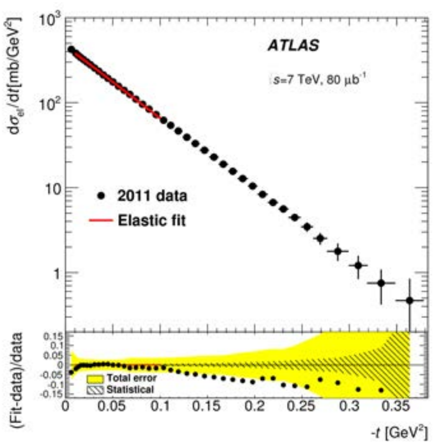
Total pp Cross Section

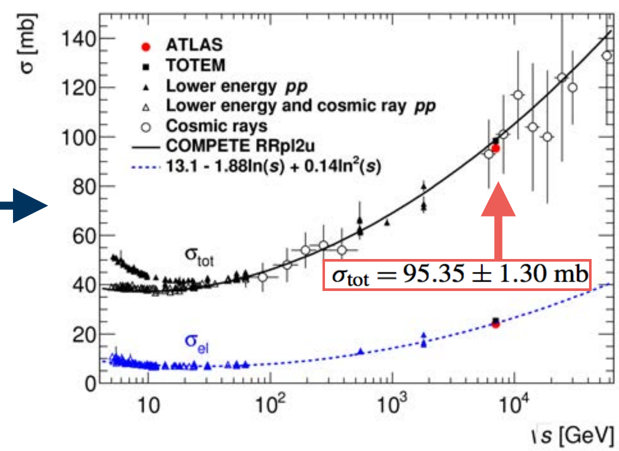
Nucl. Phys. B (2014) 486

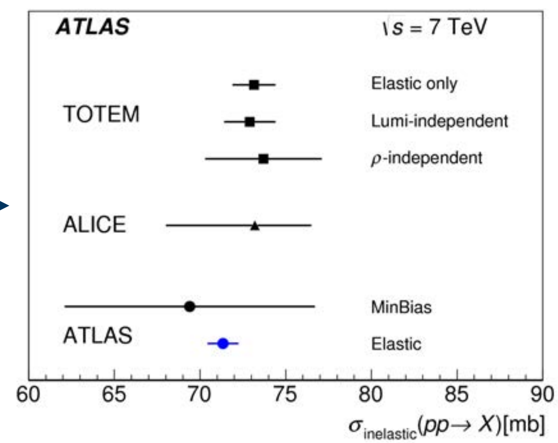




- measure **small-angle elastic pp scattering** by correlating signals in **ALFA detectors** ≈240m away from the interaction point
- 4h **low-luminosity run** with special beam optics/clean conditions





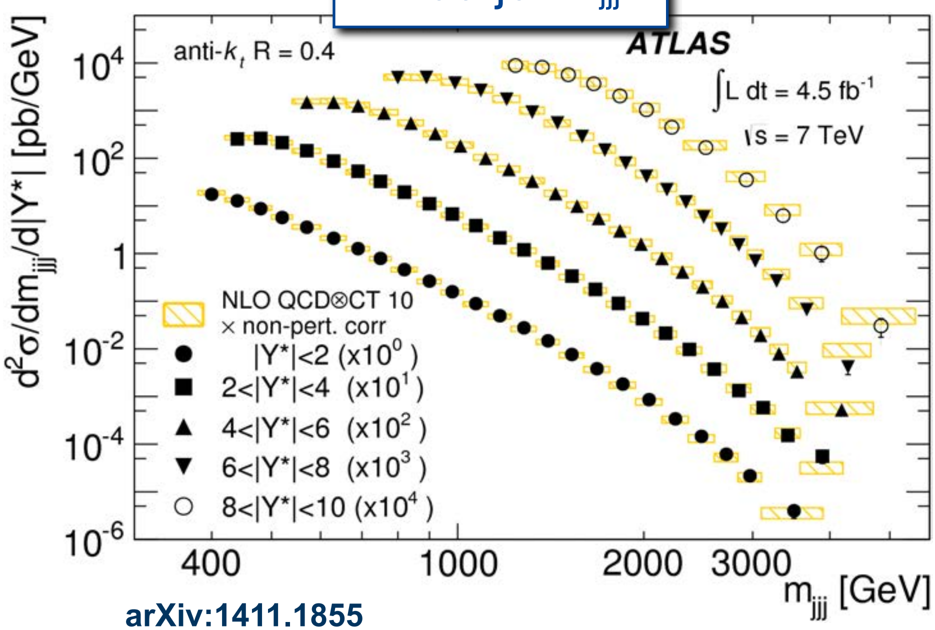


- measure **elastic cross section** as a function of momentum transfer
- **total cross section** (optical theorem) $\sigma_{\mathrm{tot}}^2 = \frac{16\pi(\hbar c)^2}{1+\rho^2} \left.\frac{d\sigma_{\mathrm{el}}}{dt}\right|_{t\to 0}$
- **inelastic cross section** (from subtraction) $\sigma_{\mathrm{inel}} = 71.34 \pm 0.36\ (\mathrm{stat.}) \pm 0.83\ (\mathrm{syst.})\ \mathrm{mb}$

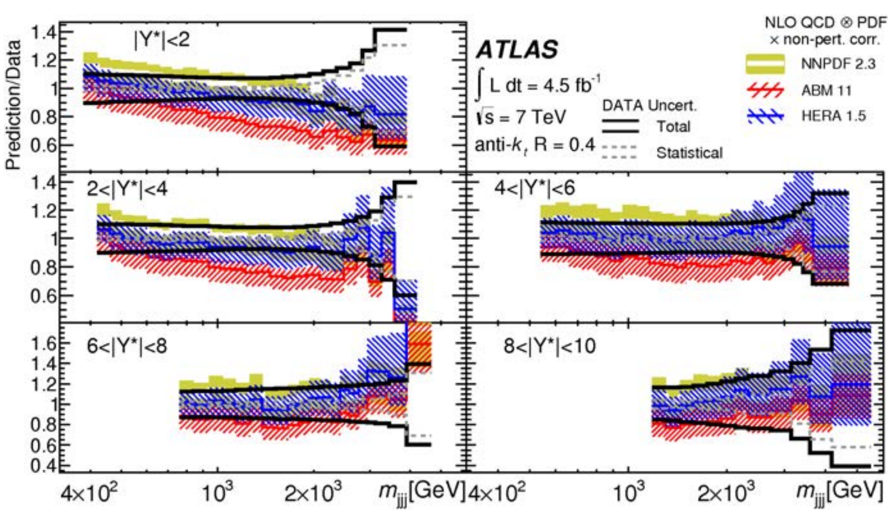
Jet Cross Sections

arXiv:1411.1855, subm. to EPJC
arXiv:1410.8857, acc. by JHEP

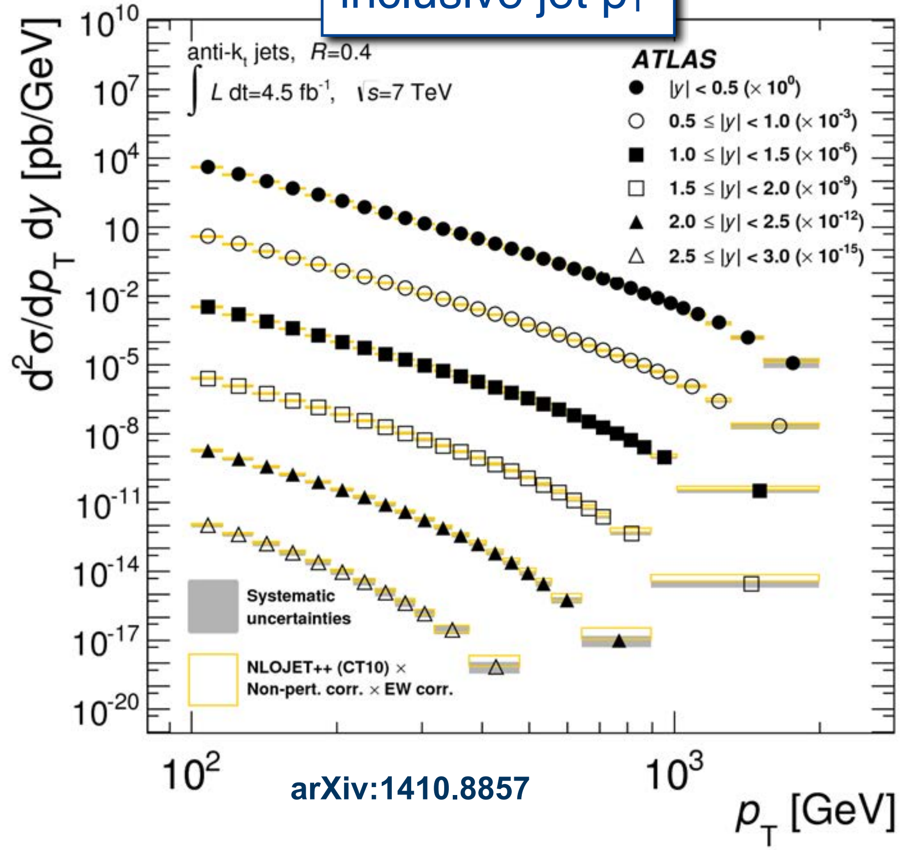
three-jet m_{jjj}



arXiv:1411.1855



inclusive jet p_T



arXiv:1410.8857

- **good agreement with** NLO pQCD **predictions** for most proton PDF sets **over 8 orders of magnitude**

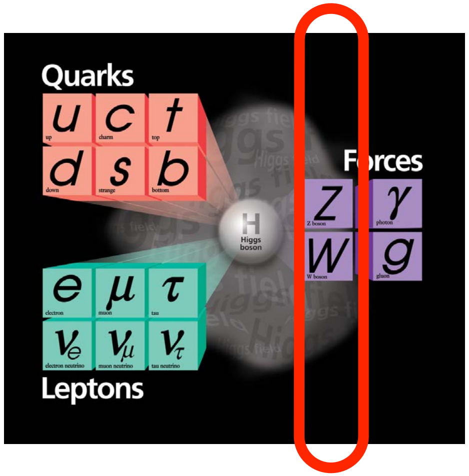
Summary QCD

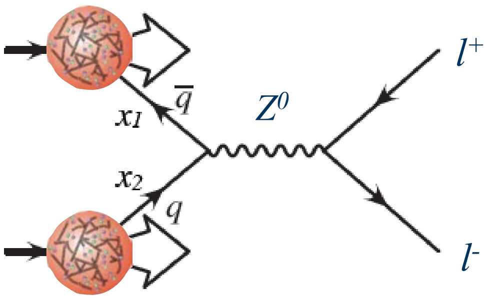
- experimental **handle on** large range of **QCD** processes
- provide input to **model pp collisions** and access to **properties of strong IA**
- NLO **pQCD able to describe** huge range in **jet kinematics**
- in particular **no signs of BSM physics** (e.g. via high-mass di-jet resonances) **yet**

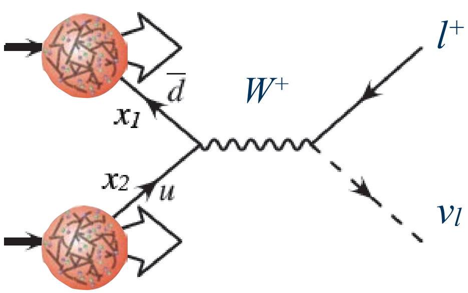
W and Z Bosons

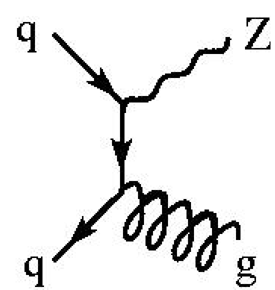
W and Z Bosons: Cornerstones of the SM

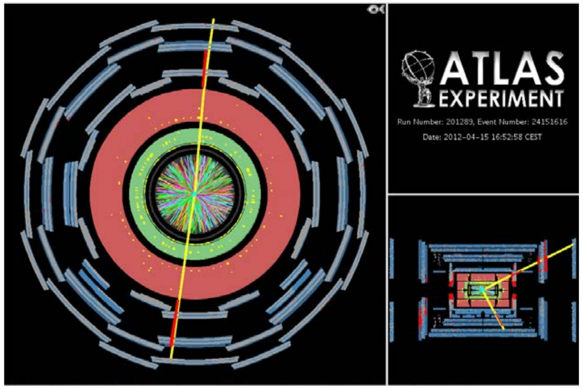
- mediators of the **weak interaction**
- decay into fermion pairs; esp. leptonic modes provide **distinct exp. signature**
- relevant to **signal and background** processes **in SM and BSM** analyses
- sensitive to **proton structure**

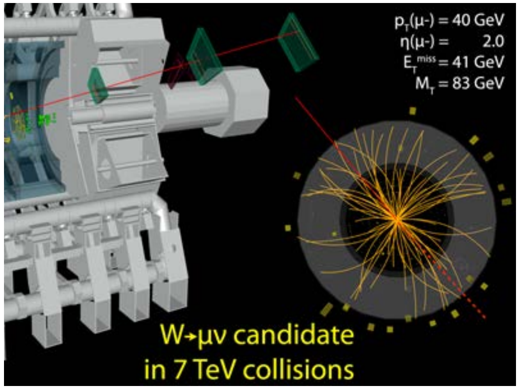


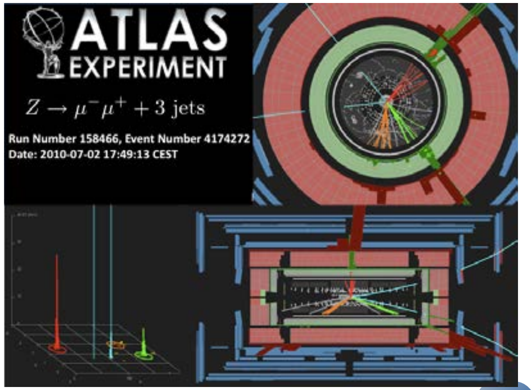








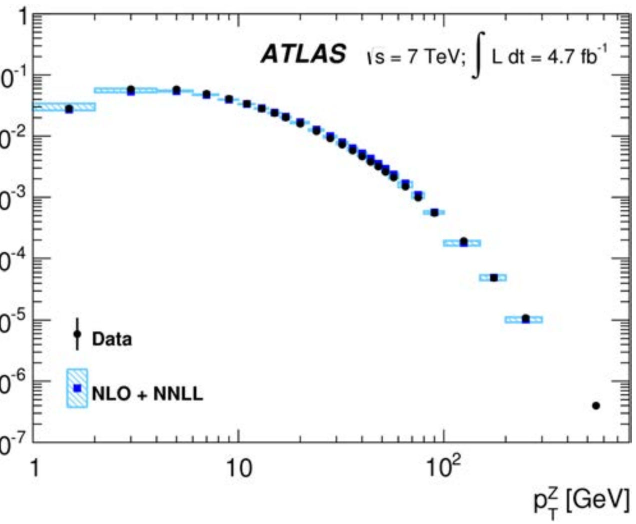


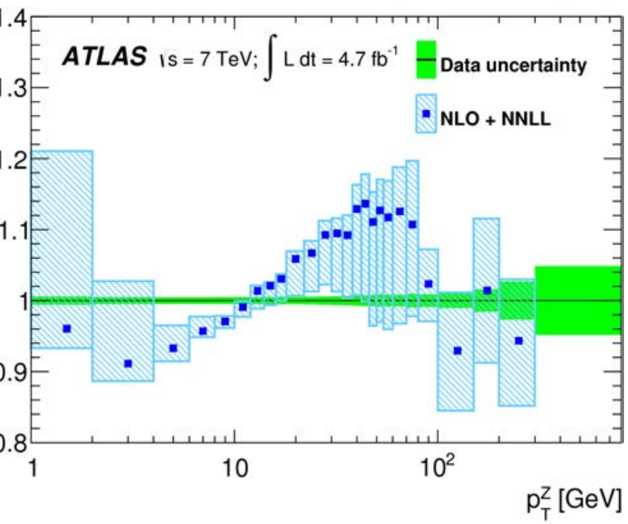


Differential Distributions

Z p_T

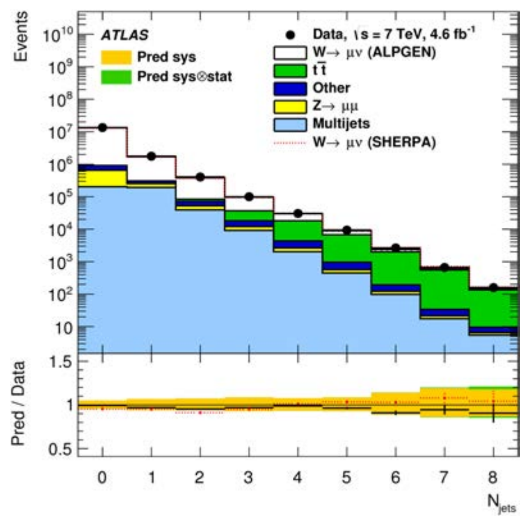
JHEP09 (2014) 145

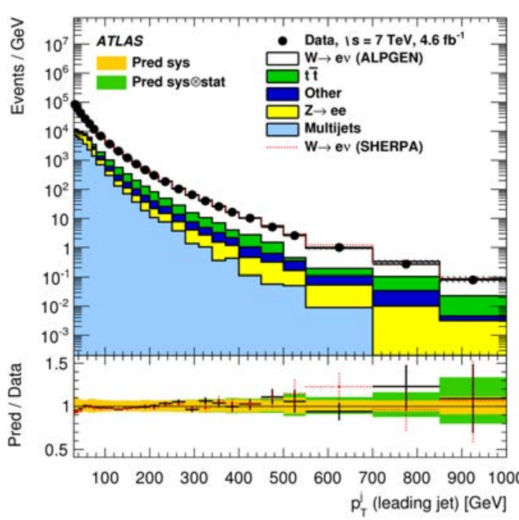




Jets in W events

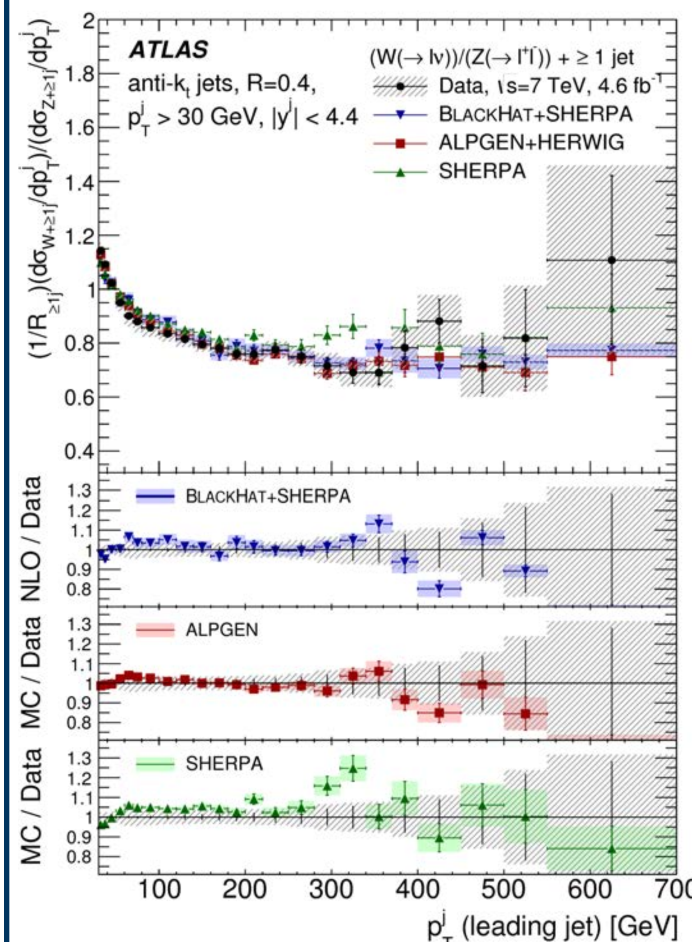
arXiv:1409.8639, acc. by EPJC



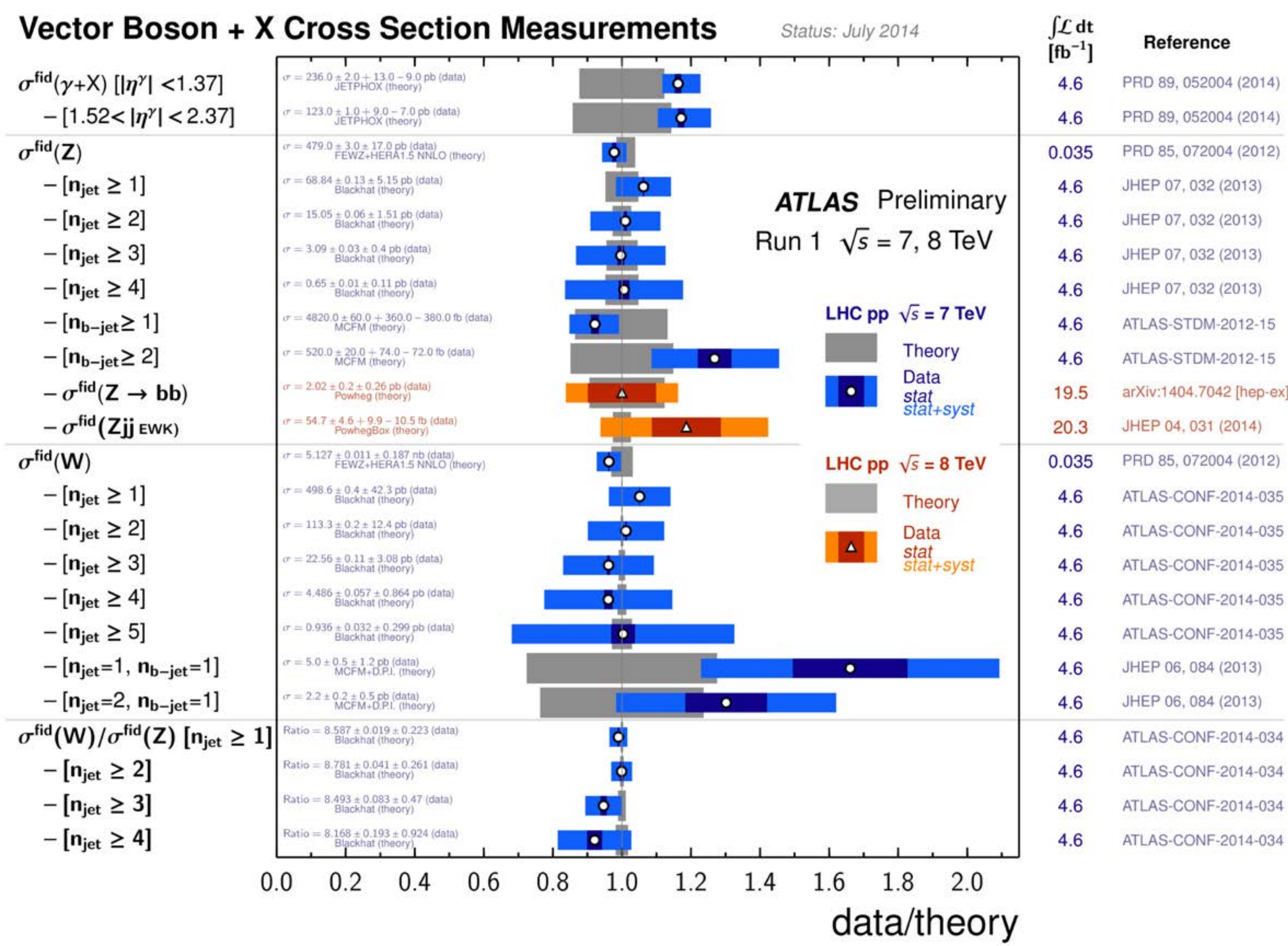


W/Z ratio

Eur. Phys. J. C74 (2014) 3168

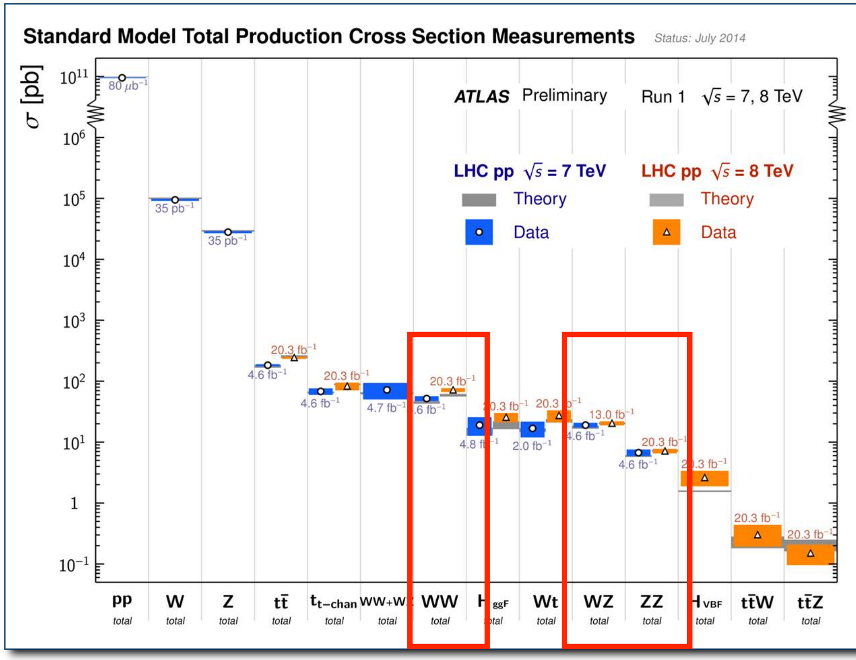


Single Boson Cross Sections Data/Theory

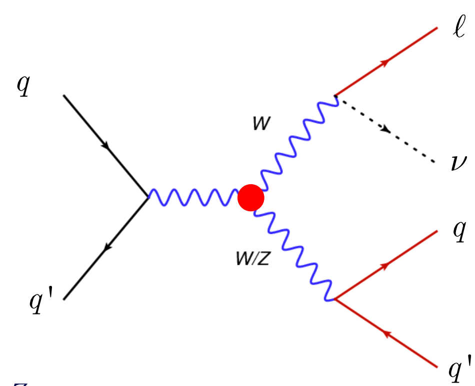


Diboson Production

- WW, WZ, ZZ production is **rare**
- add important options to **test** the **electroweak sector** of the SM
- **background processes** in Higgs boson studies and BSM searches
- **potential BSM signals**



- **triple gauge boson couplings** (TGC) particularly interesting for BSM searches → **“anomalous” TGC?**

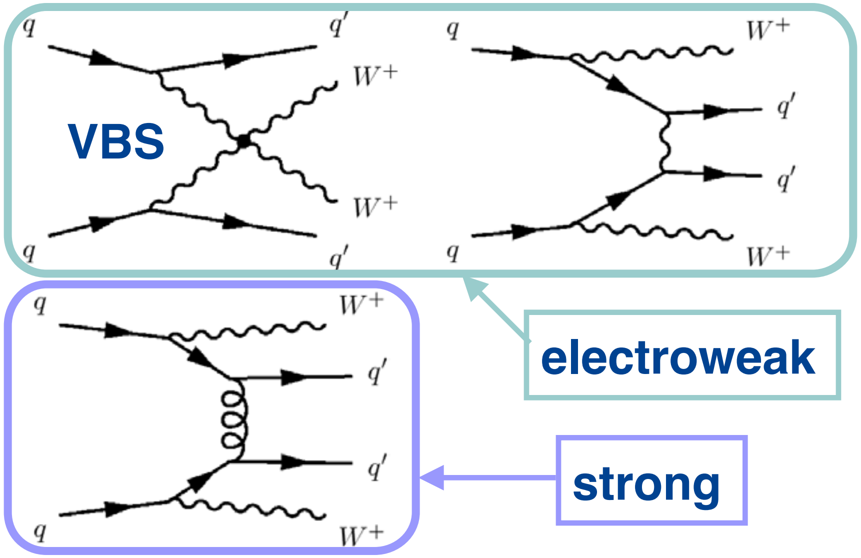


- in SM: $\lambda_\gamma = \lambda_Z = 0 \quad \kappa_\gamma = \kappa_Z = g_1^Z = 1$
- current analyses use: $\lambda_\gamma = \lambda_Z \equiv \lambda \qquad \Delta\kappa_Z = \Delta g_1^Z - \Delta\kappa_\gamma \tan\theta_W$
(i.e. 3 parameters)

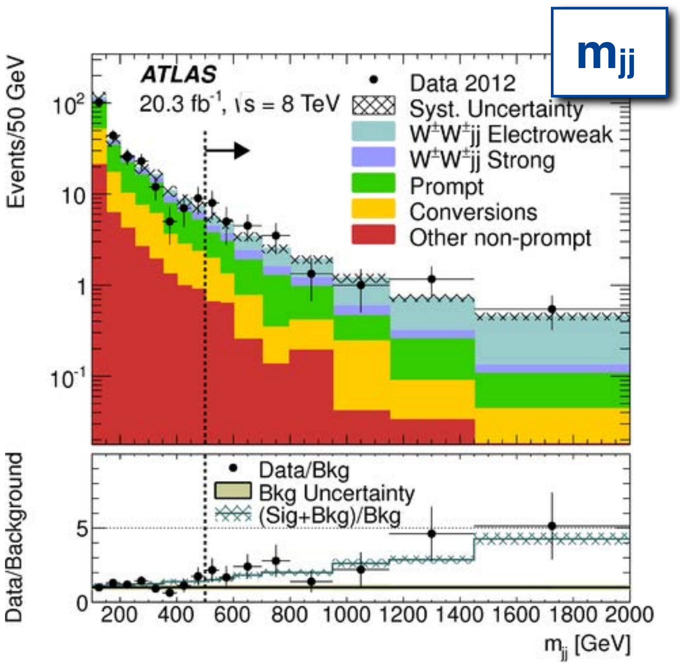
$$\text{with} \quad \Delta\kappa_Z = \kappa_Z - 1, \Delta\kappa_\gamma = \kappa_\gamma - 1, \Delta g_1^Z = g_1^Z - 1$$

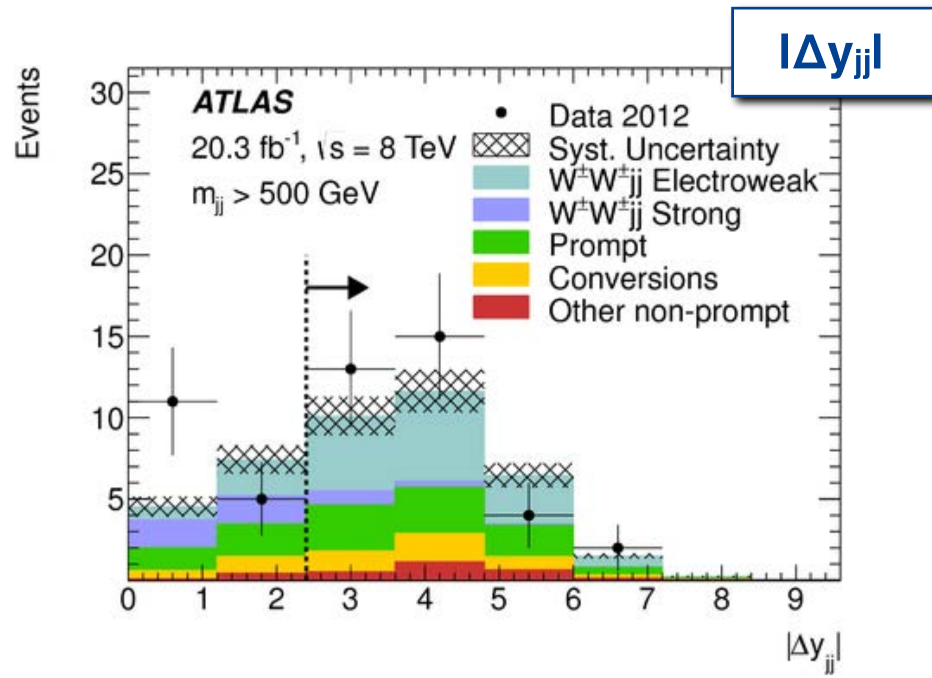
W±W±jj Production

Phys. Rev. Lett. 113 (2014) 141803



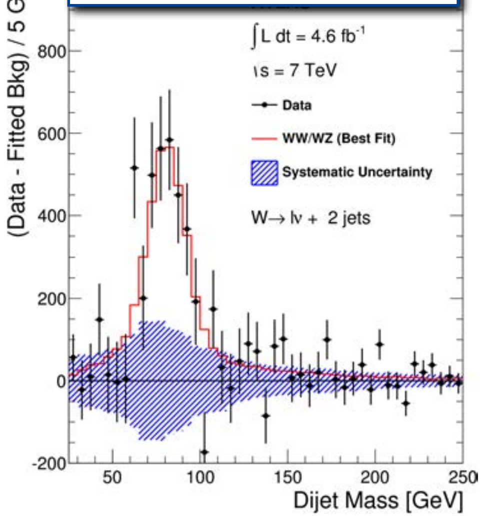
- select events with **same-charge WW pair + two jets**
- 4.5σ evidence for WWjj
- 3.6σ **evidence for electro-weak WWjj production**





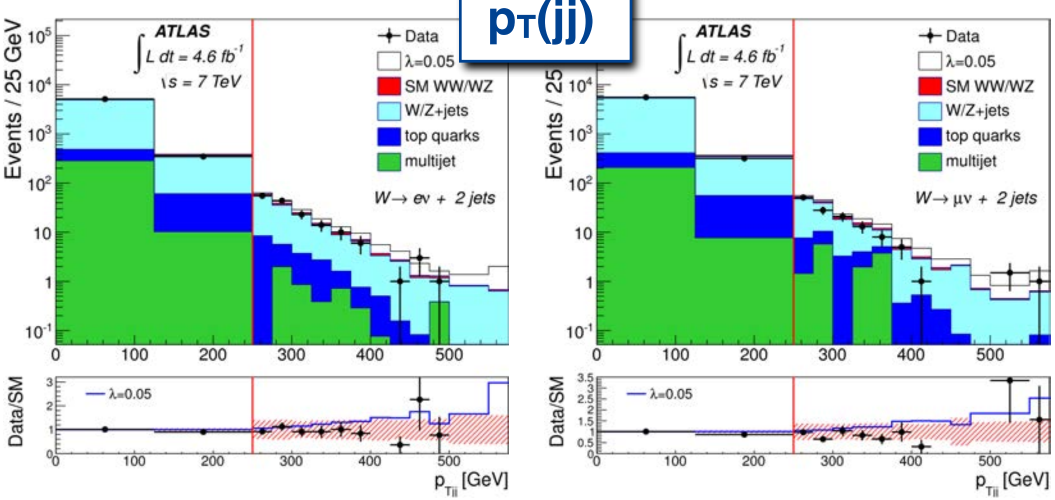
TGC from WW and WZ Events

BG-subtr. **m(jj)**

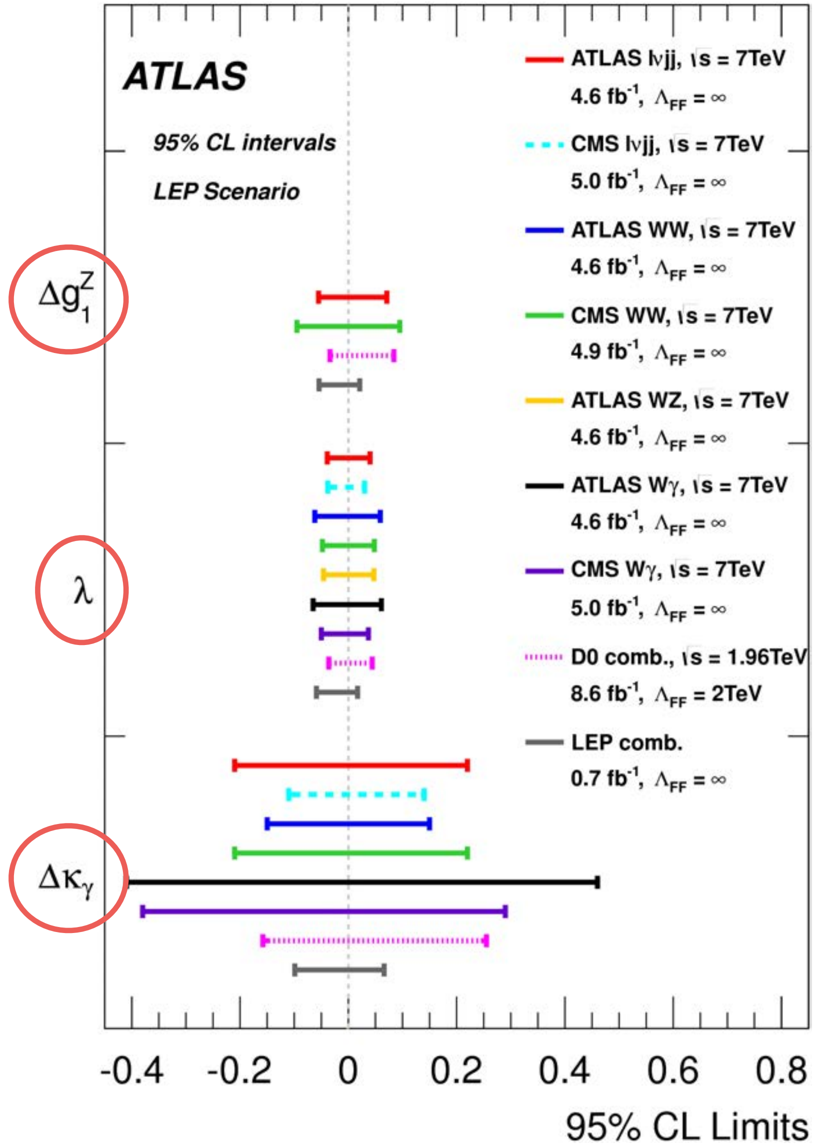


- select W→lν+2j
- comb. WW+WZ signal with 3.4σ
- use p_T of dijet system to set limits on aTGC

p_T(jj)

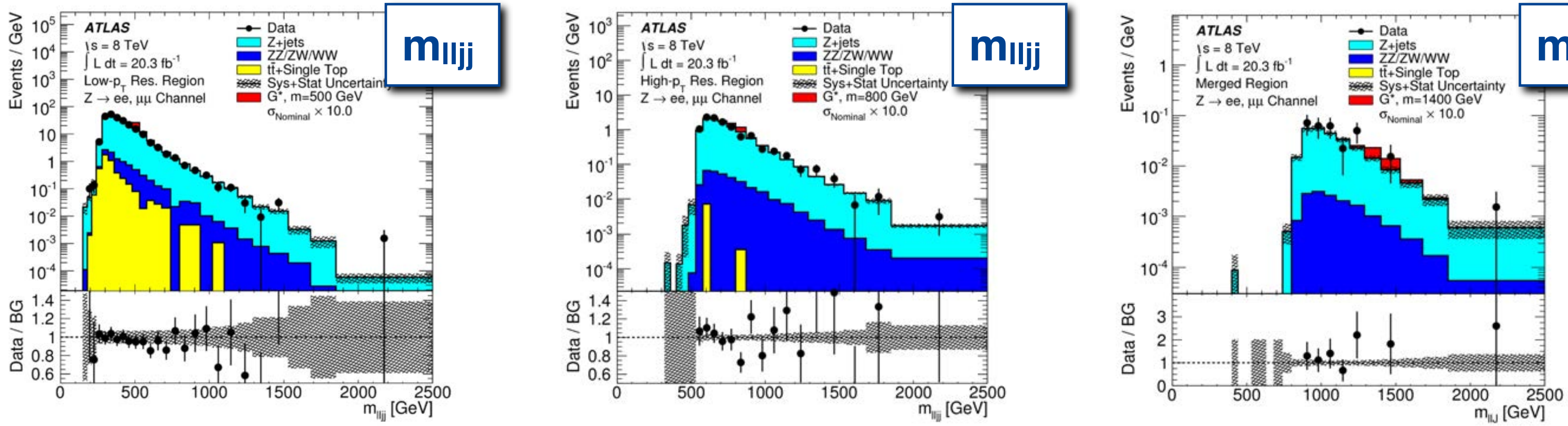


W→eν + 2 jets **W→μν + 2 jets**

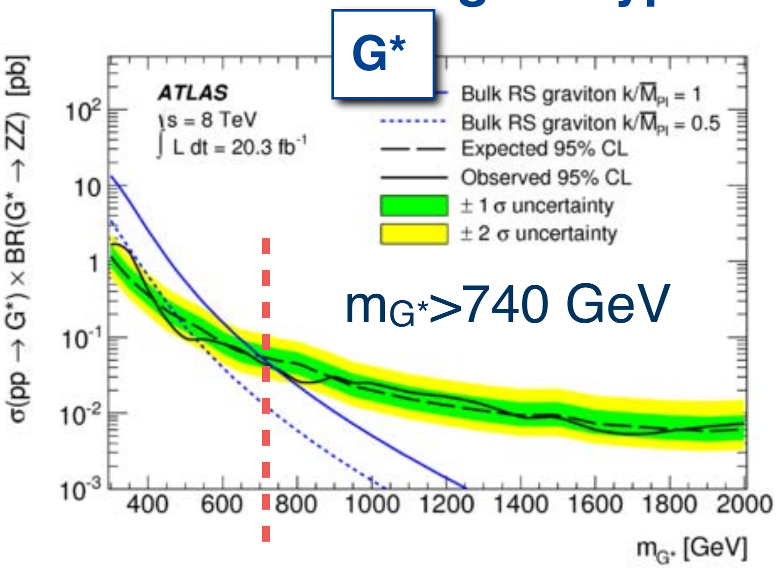


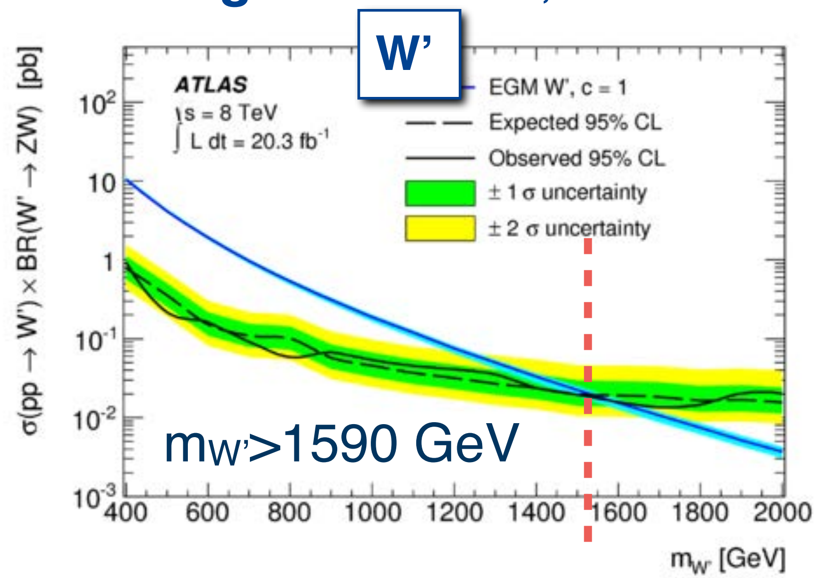
Heavy Diboson Resonances?

arXiv:1409.6190, acc. by EPJC



- select **events with a lepton pair and two jets**
- three different selections (optimised for different resonance p_T)
- **two** different **signal hypotheses** (“ Bulk RS **graviton** G* ”, “ EGM **W’** ”)





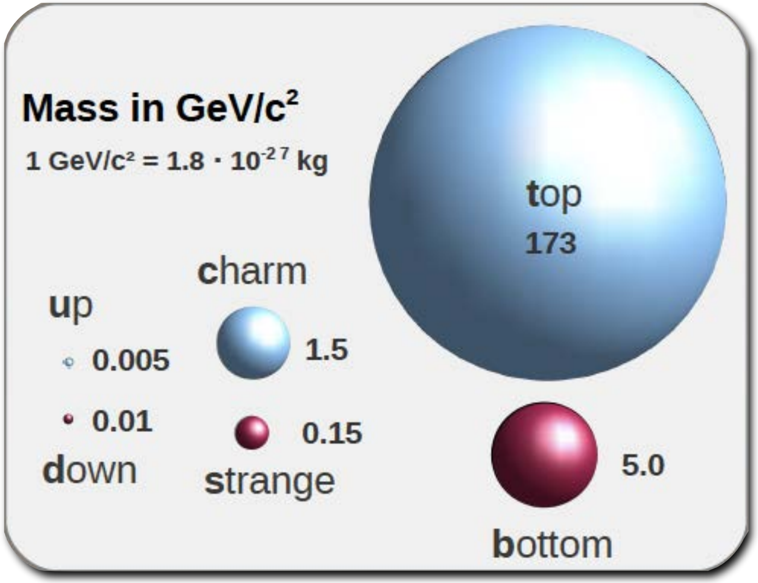
W & Z Boson Summary

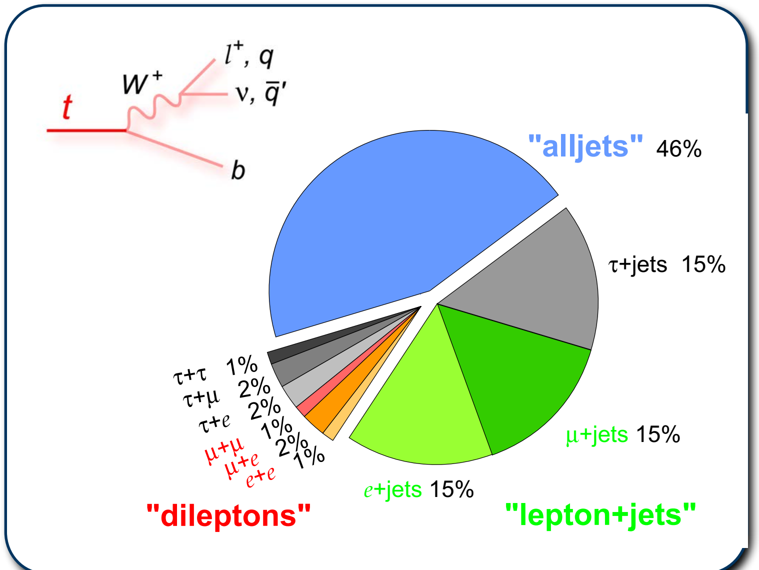
- rich set of **precise measurements** of **single-boson** (+jets) **cross sections**
  - used to **test and tune modelling** of electroweak and strong processes
  - input to **proton structure** analyses
- **also measured** rare **di-boson production**
  - adds further tests of electroweak SM
  - contrain anomalous TGC
- **limits on BSM particle production**

Top Quark

The Top Quark is Special

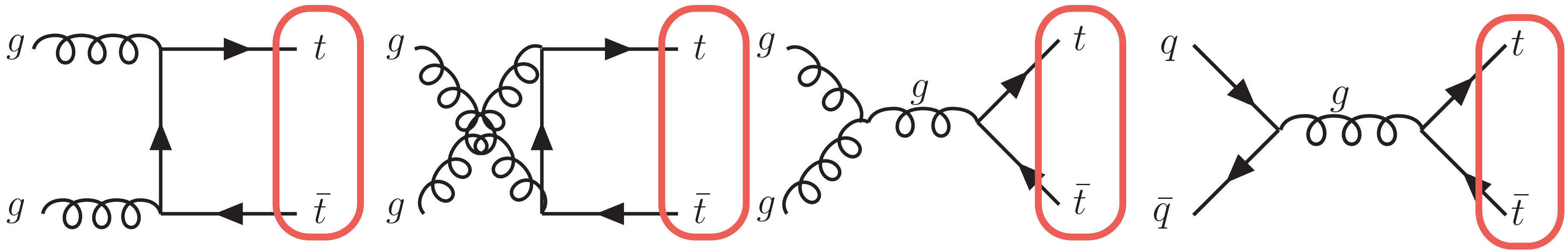
- **large mass:**
  heaviest fundamental SM particle and by far the heaviest quark
- **short lifetime:**
  only quark to decay before hadronisation (no bound states)
- **large coupling to Higgs** ($y_t \approx 1$)
- **accident of nature or more fundamental** reasons?
- **rich** experimental **signature**



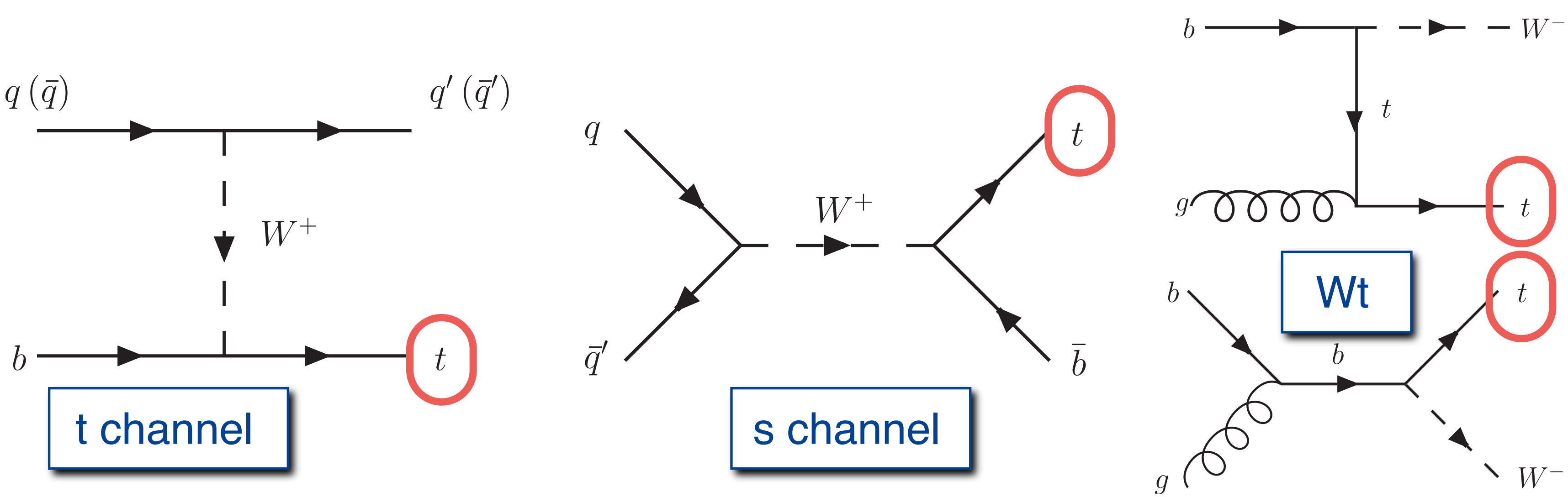


Top Quark Production

- mainly **top pair production** via strong interaction

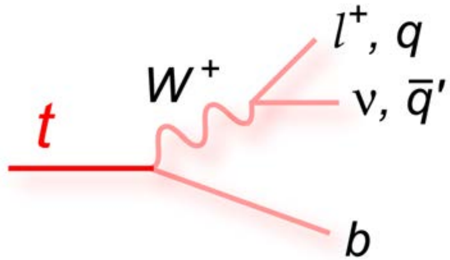


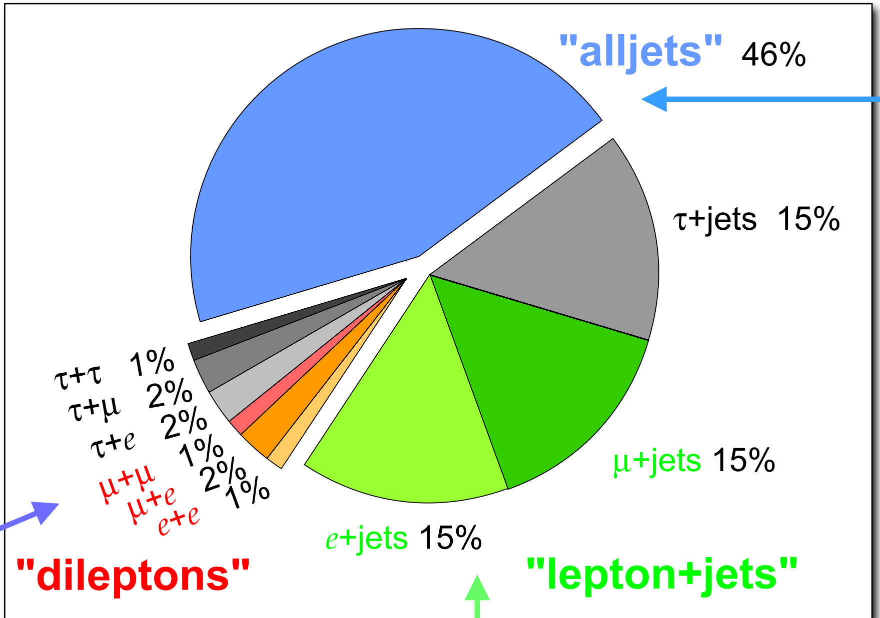
- also **single top production** via weak interaction



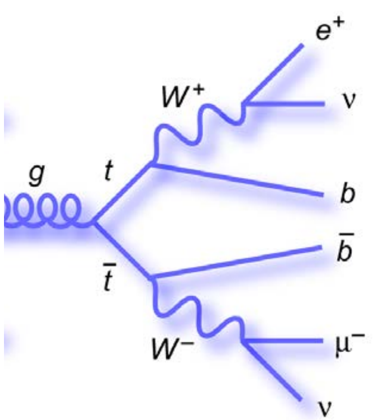
Top Quark Pair Decays

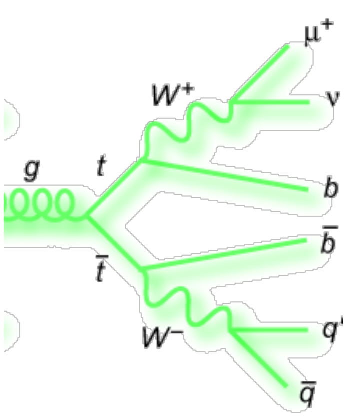
- **weak decay into** a **W and** down-type (almost always **b**) **quark**

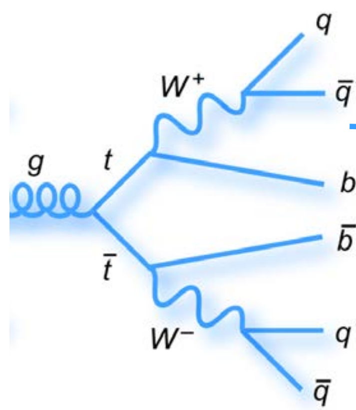




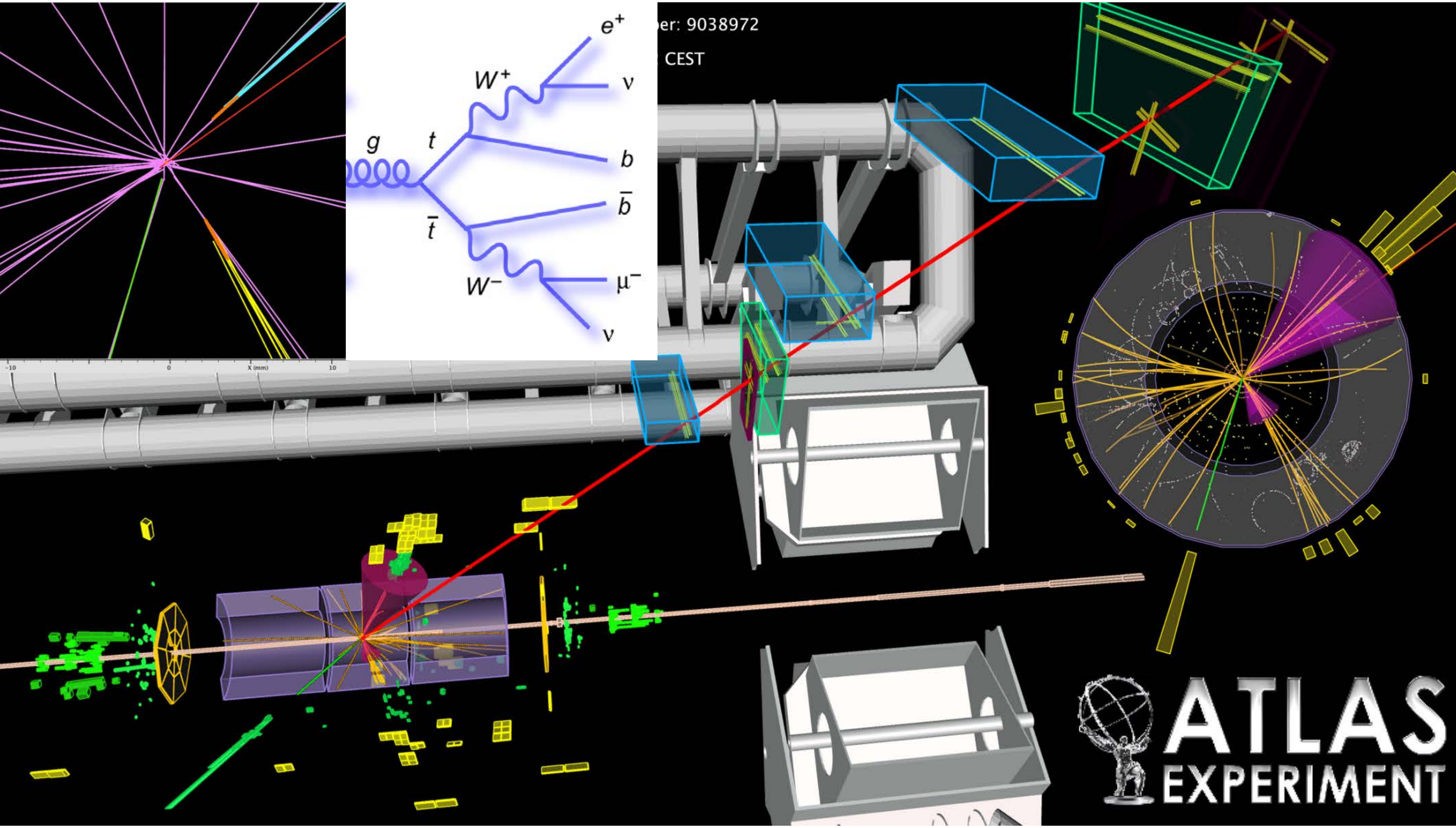
- **signature of top pair decay:**
  2 b quark jets, charged leptons, neutrinos, light quark jets







Top Pair Candidate Event

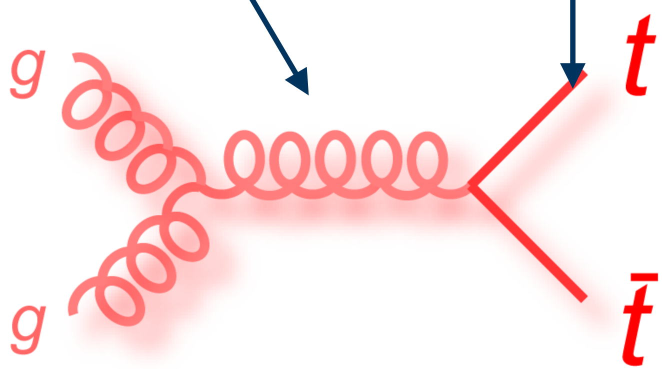


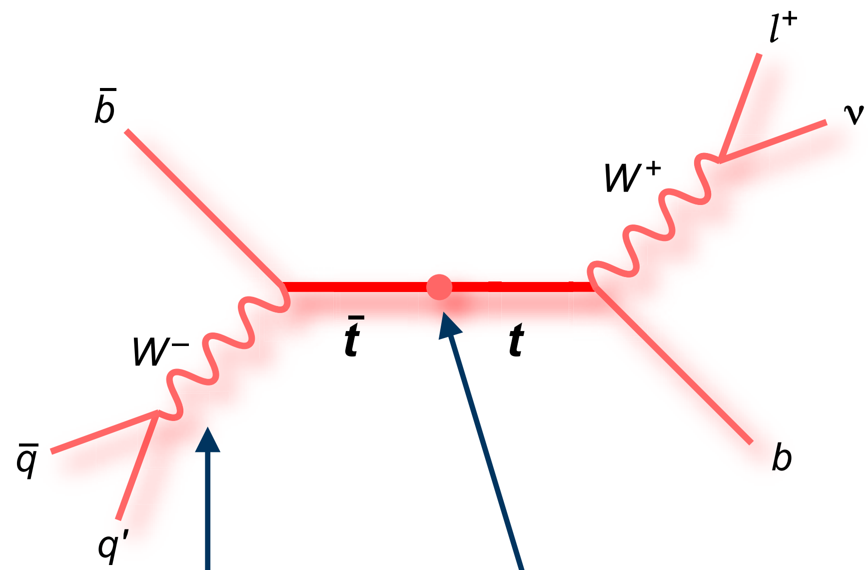
$t\bar{t} \rightarrow W^{+}b\ W^{-}\bar{b} \rightarrow e^{+}\nu_{e}\, b\ \mu^{-}\, \bar{\nu}_{\mu}\bar{b}$

Top Quark Measurements

production
cross section
kinematics
new resonances?

properties
mass
charge
lifetime, width
polarisation

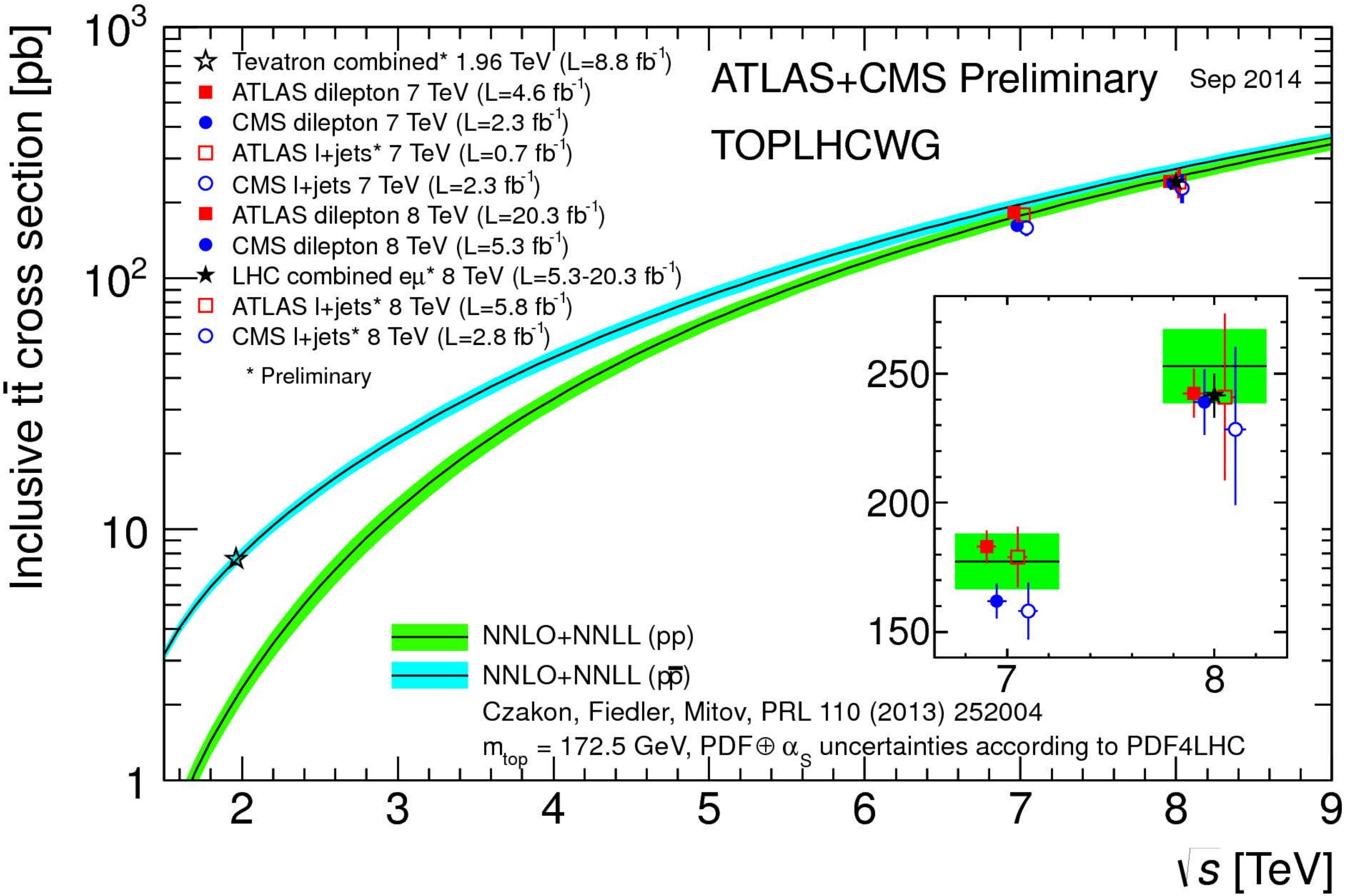




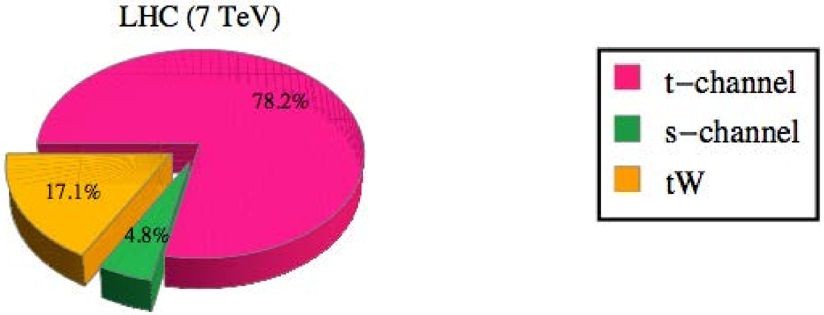
decay
branching ratios
W helicity
new decays?

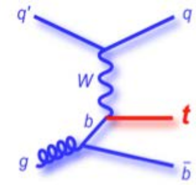
correlations
spin correlations
charge asymmetry

Top Pair Production Cross Section

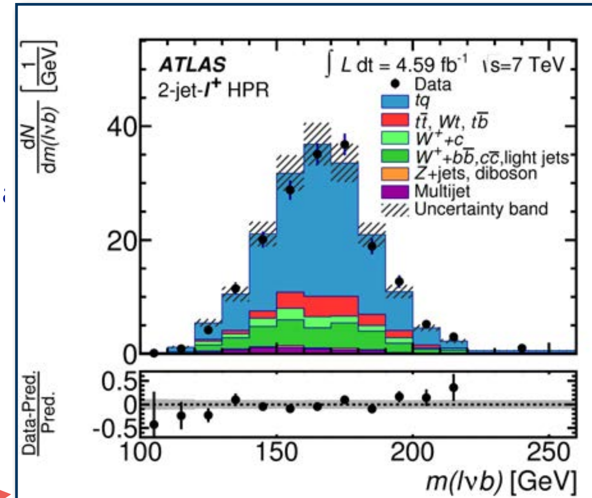


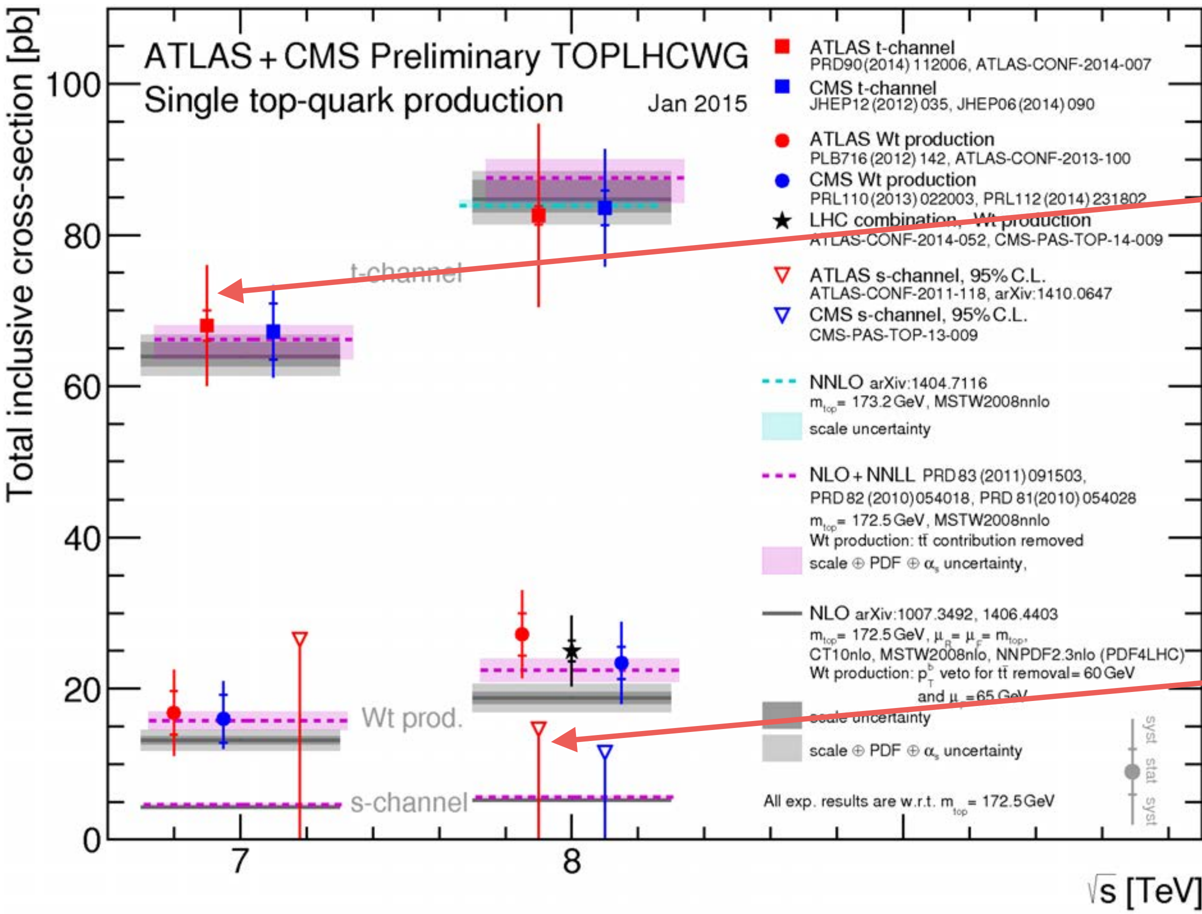
Single Top Production Cross Section

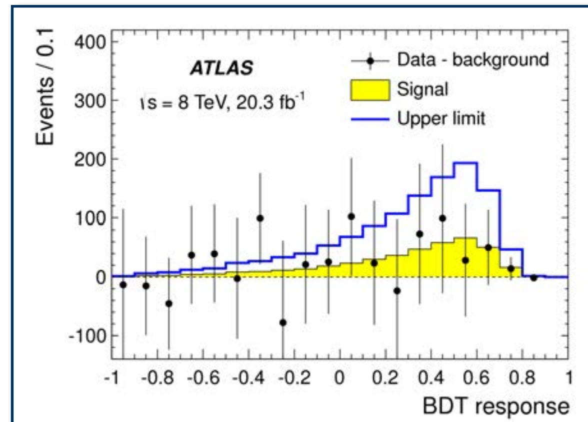


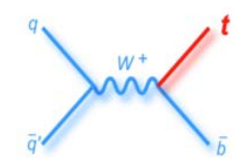


t-channel



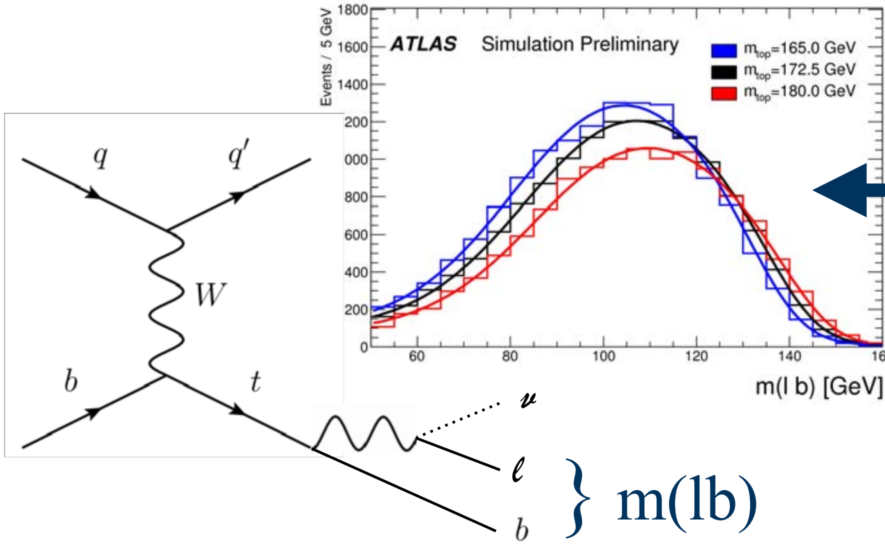




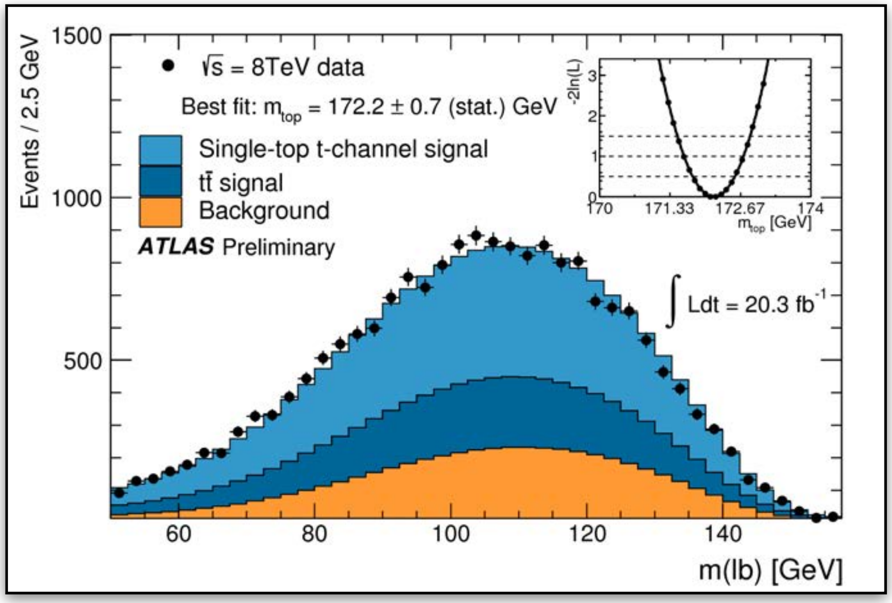


s-channel

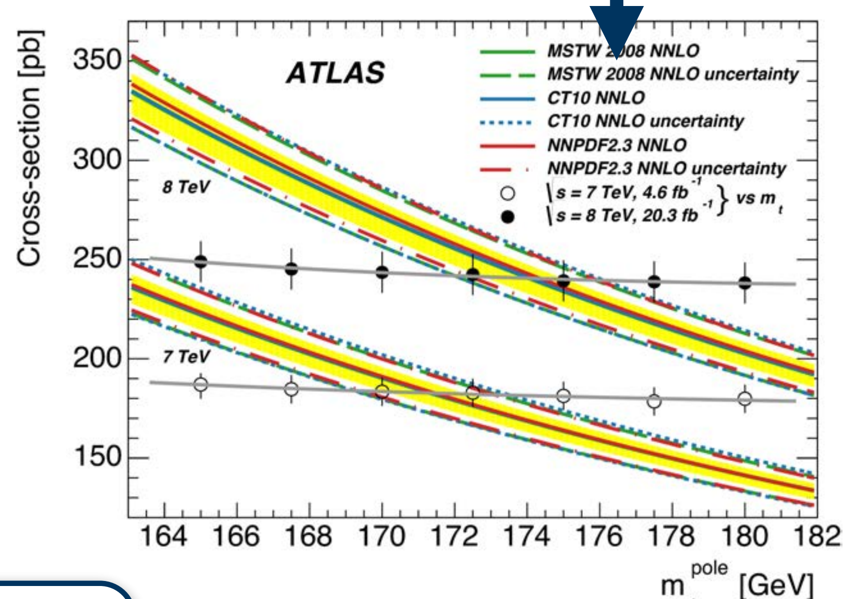
Top Quark Mass



- recent examples:
  - "**template fit**" to lepton-b mass in single-top events
  - exploit dependence of production **cross section** on top mass



ATLAS-CONF-2014-055



7+8TeV

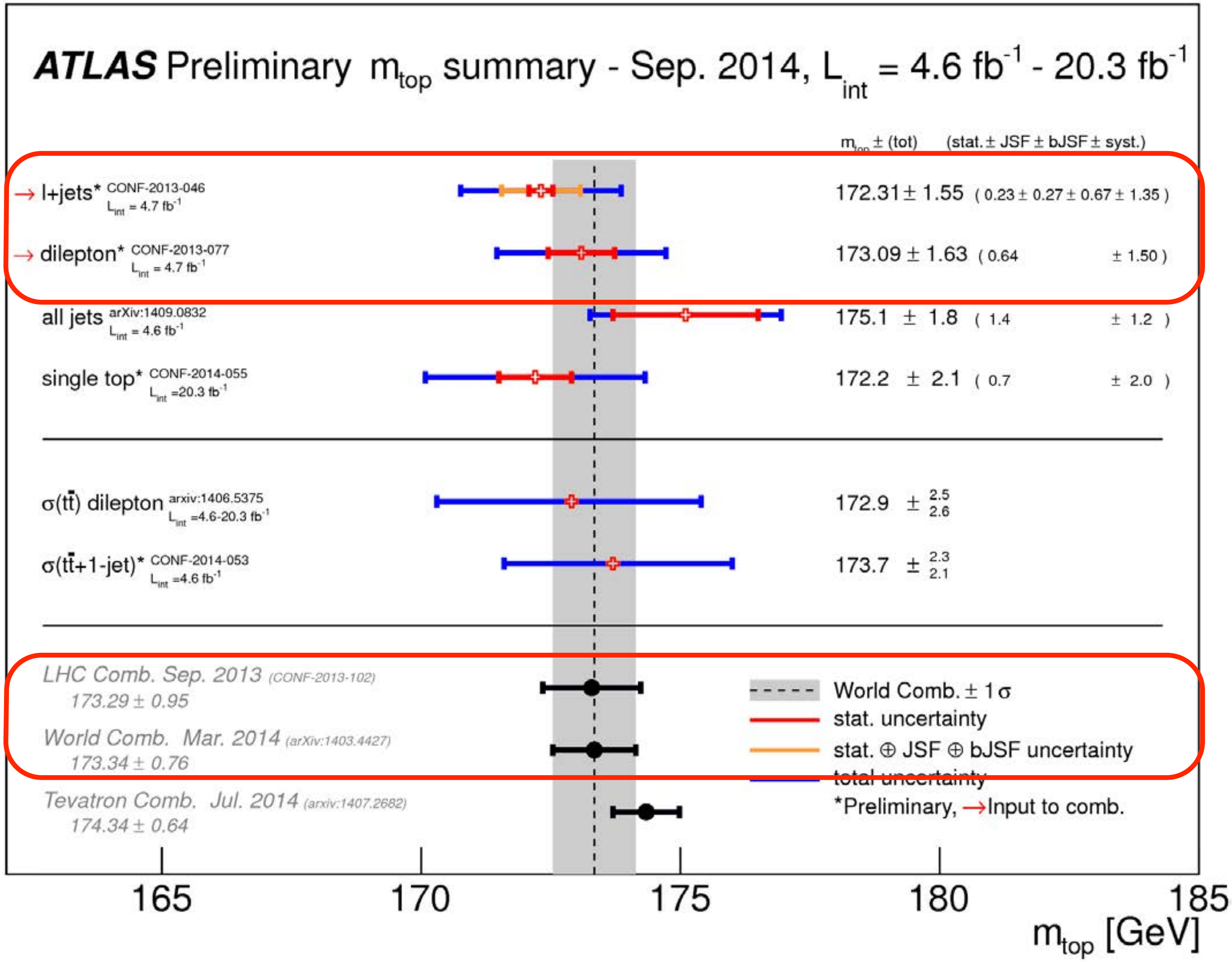
Eur. Phys. J. C74 (2014) 3109

Top Quark Mass

from **direct reconstruction**

from **cross section**

combination with CMS and Tevatron



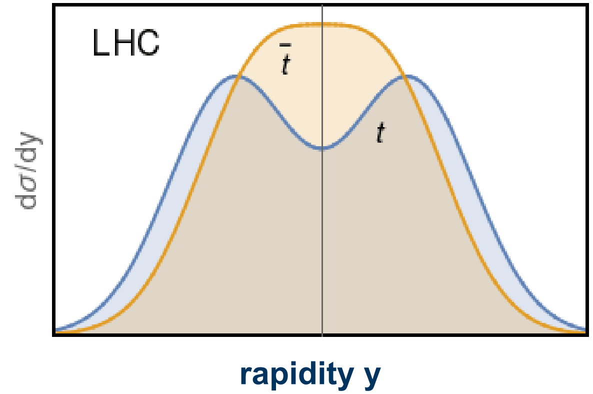
World Combination (ATLAS+CMS+Tevatron): **173.3±0.8 GeV (0.5%)**

Top Pair Charge Asymmetry

JHEP 02 (2014) 107

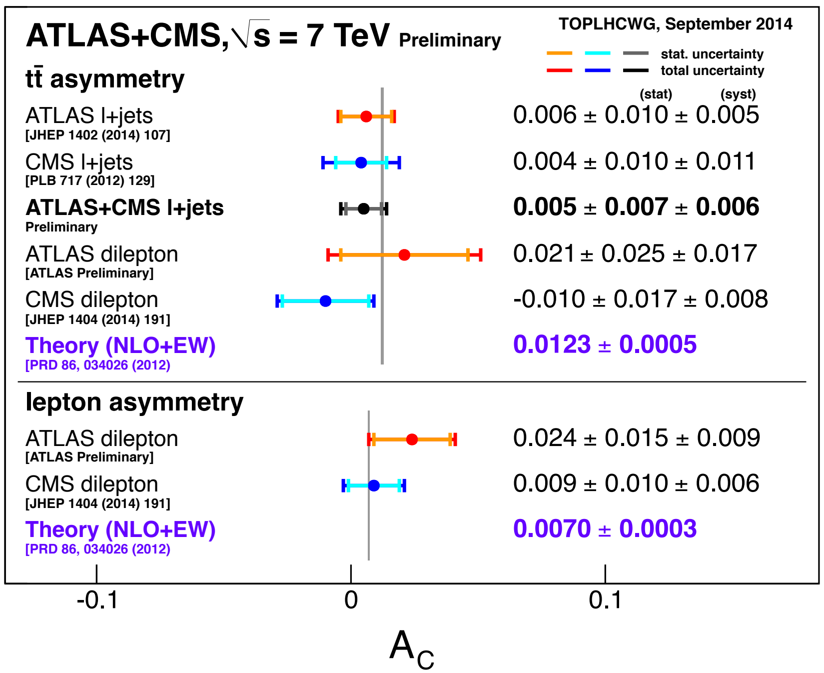
- **Definition:** $$A_C = \frac{N(\Delta|y| > 0) - N(\Delta|y| < 0)}{N(\Delta|y| > 0) + N(\Delta|y| < 0)}$$

$$\Delta|y| = |y_t| - |y_{\bar{t}}|$$

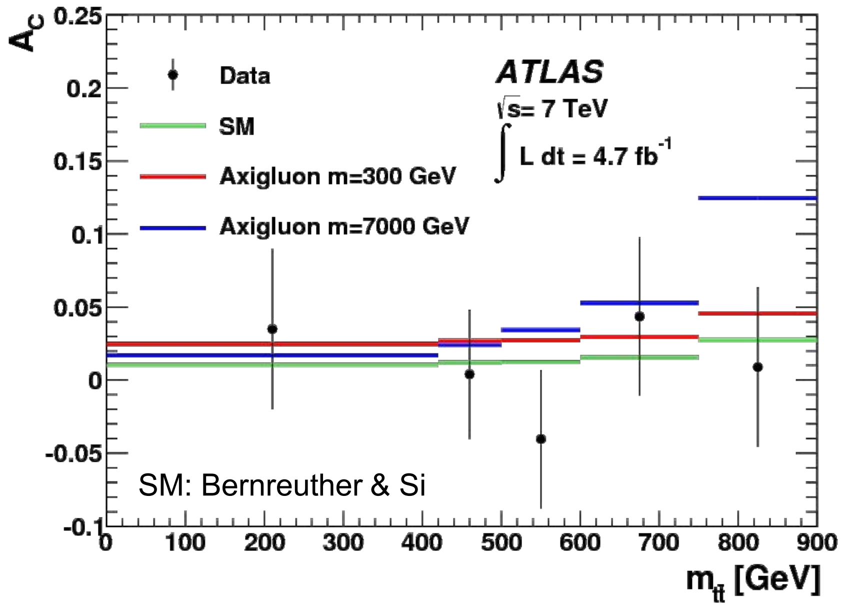


- SM expectation: 1.2%

- **Measurements:**



- Comparison with **New Physics** Models:



Top Quark Summary

- broad and **diverse experimental program** of precision measurement and searches
- precise information on the **mass** based on several complementary approaches; “world combination” with 0.5% uncertainty
- **single top production** has become important tool
- various ways to **constrain BSM physics**

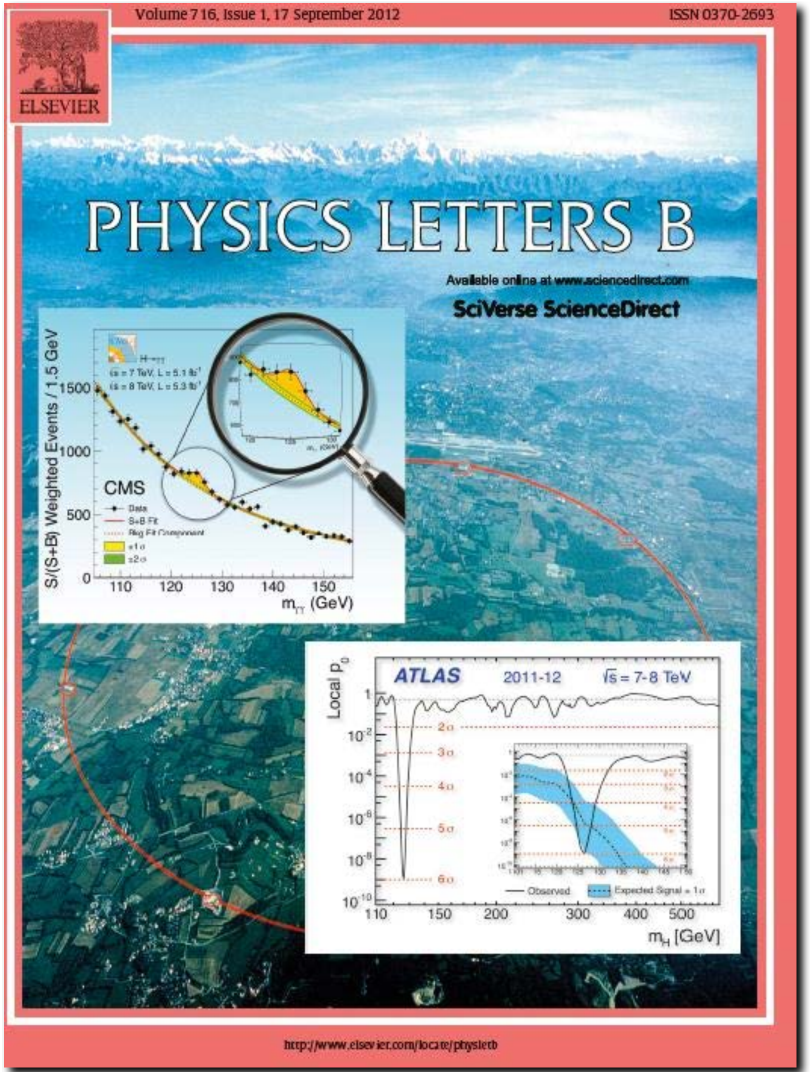
Higgs Boson

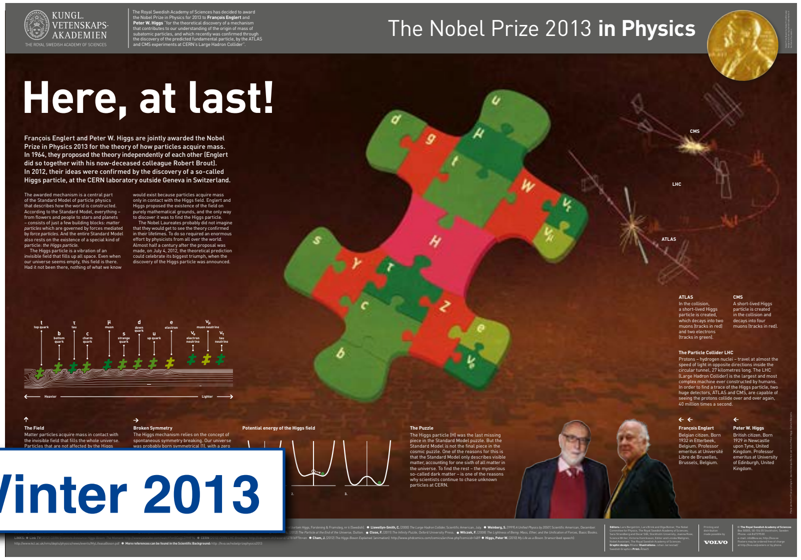
The Higgs Boson: New & Fundamentally Different

- only fundamental **spin-0** particle
- external potential
- "**background field**" (non-zero vacuum expectation value)
- **mass-dependent coupling** to other particles
- "saves" the electroweak SM

Summer 2012

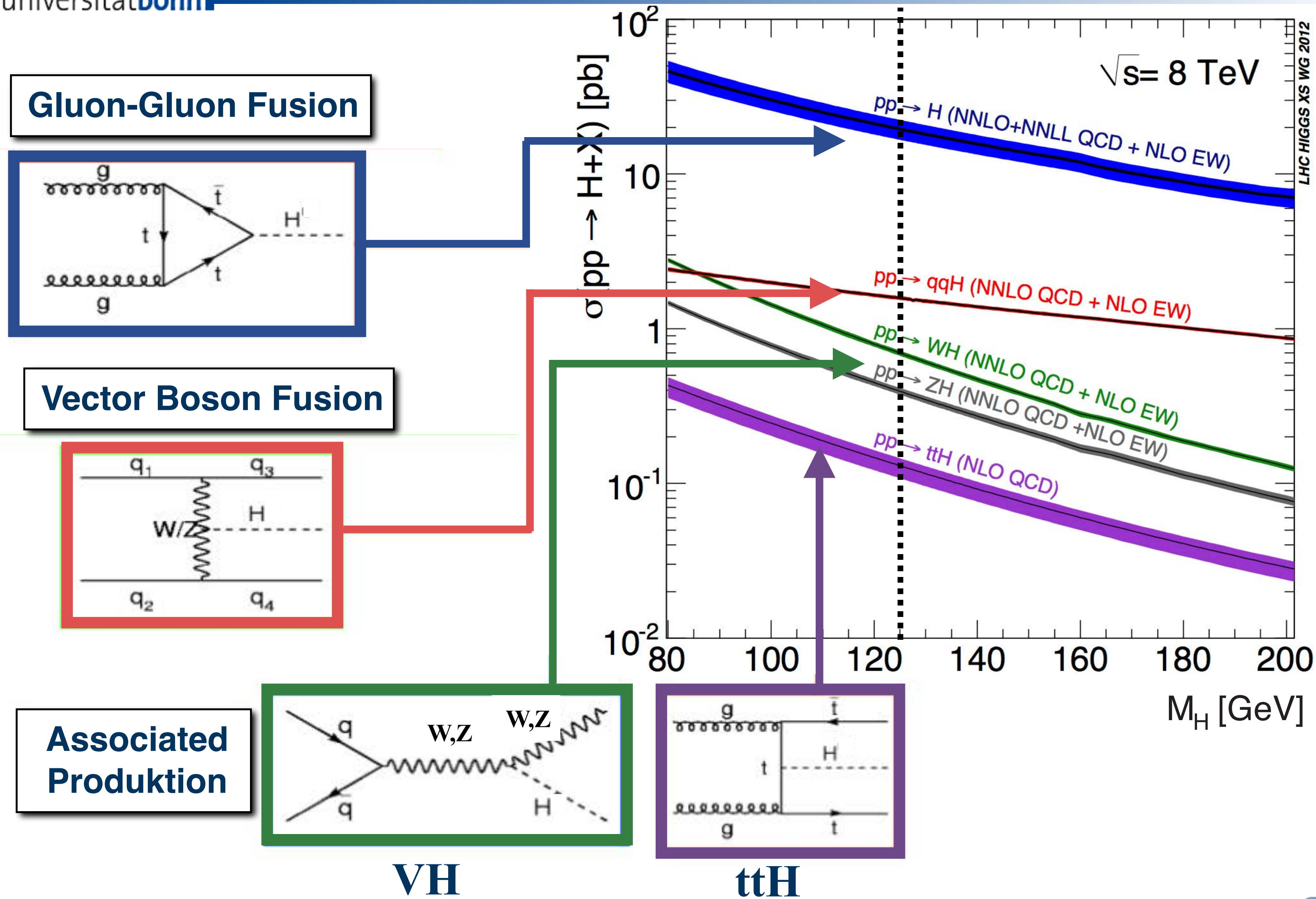
Phys. Lett. B712 (2012) 1



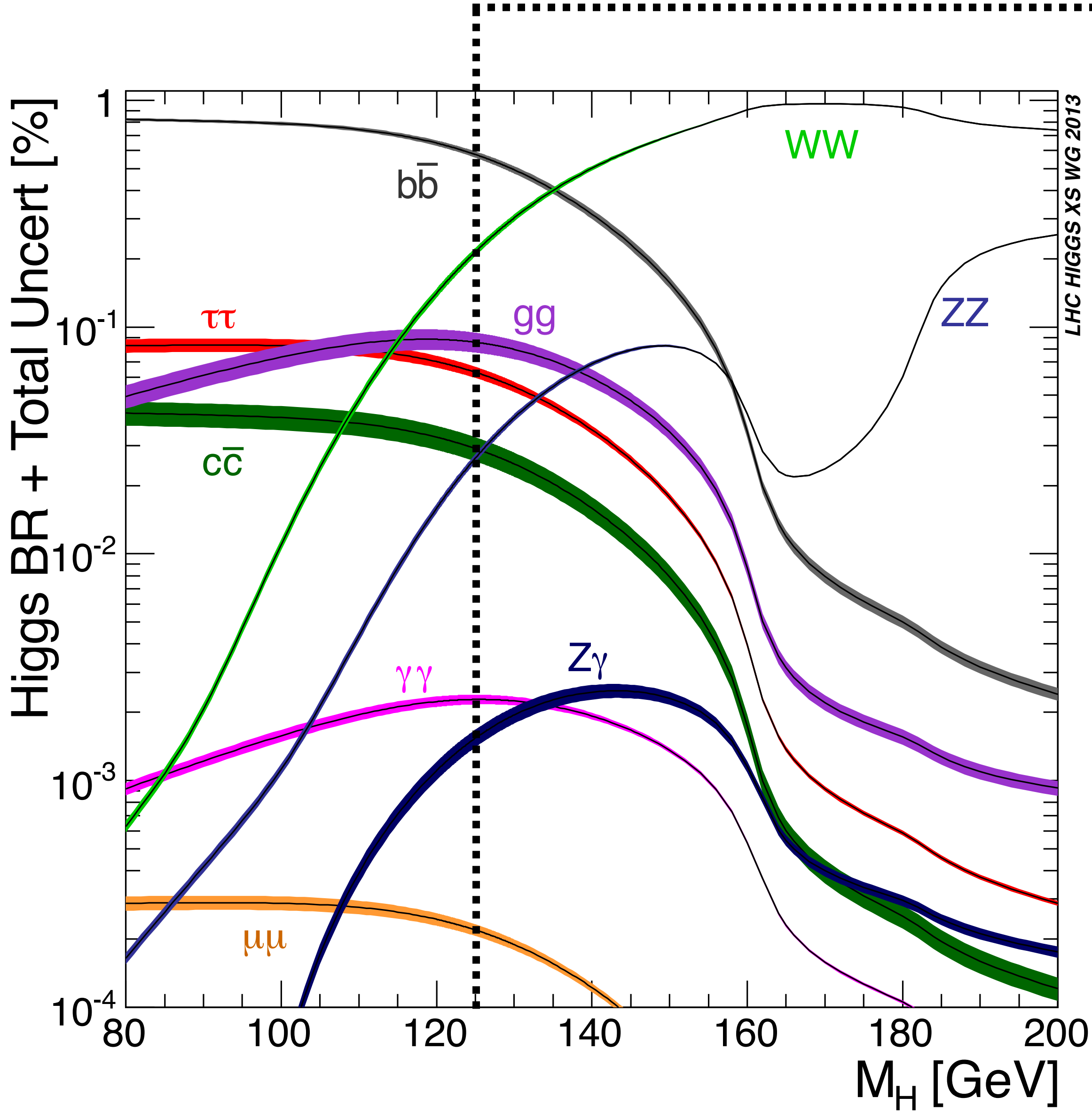


Winter 2013

Higgs Boson Production at the LHC

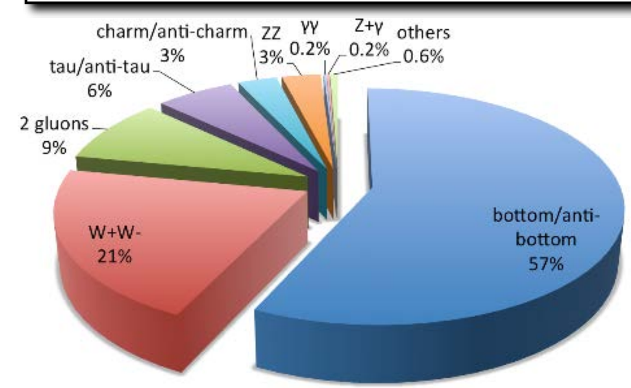


Higgs Boson Decays



for M_H=125 GeV:

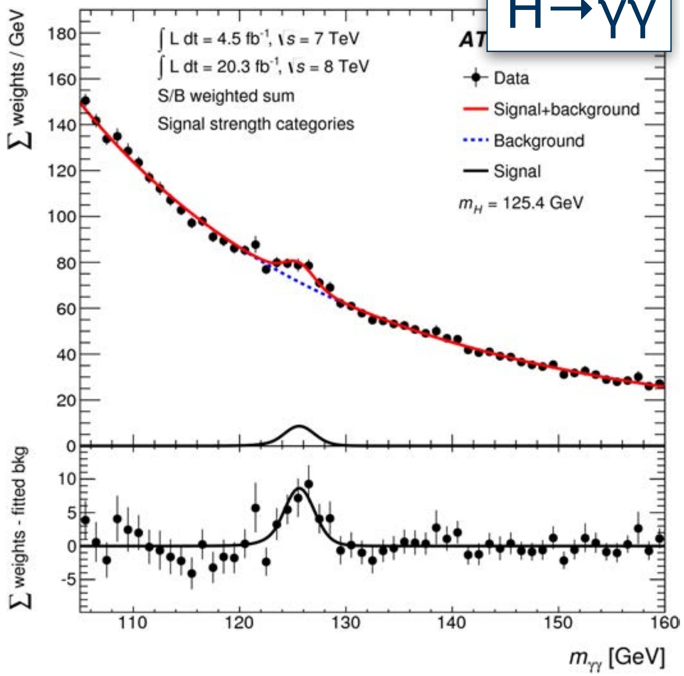
$H \rightarrow b\bar{b}$	58%
$H \rightarrow WW^*$	22%
$H \rightarrow \tau\tau$	6.3%
$H \rightarrow ZZ^*$	2.6%
$H \rightarrow \gamma\gamma$	0.23%
$H \rightarrow Z\gamma$	0.15%
$H \rightarrow \mu\mu$	0.002%



7+8TeV

Higgs Boson Signals: Decays to Bosons

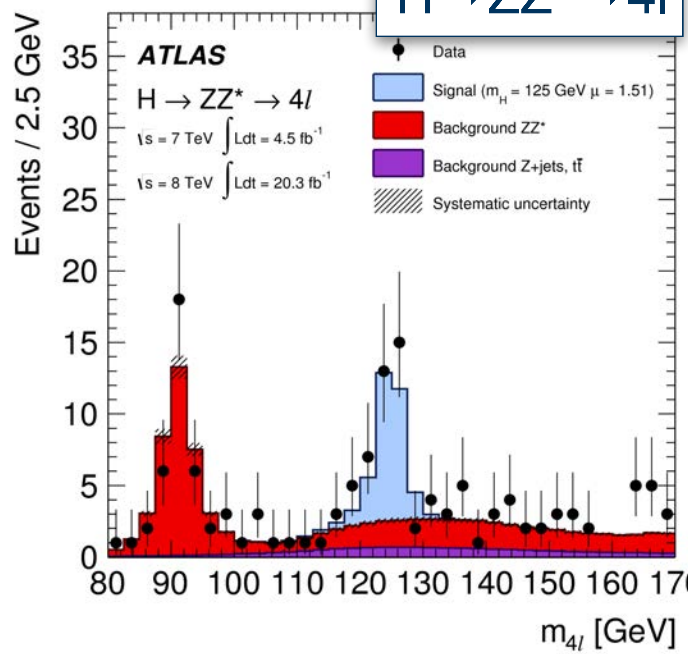
H→γγ



5.2σ (5.7σ)

Phys. Rev. D 90 (2014) 112015

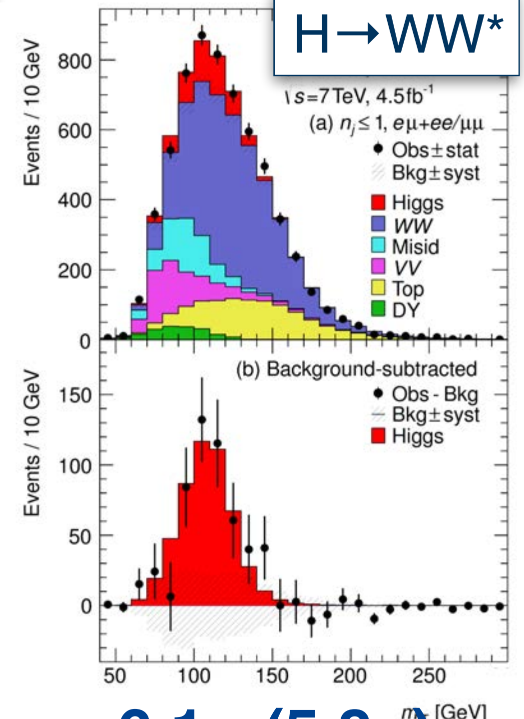
H→ZZ*→4l



8.1σ (6.2σ)

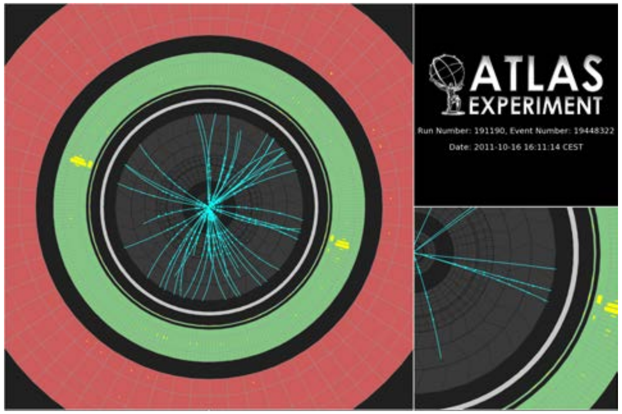
Phys. Rev. D 91 (2014) 012006

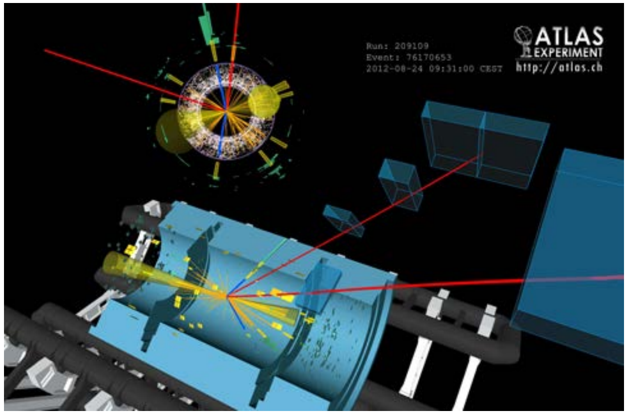
H→WW*

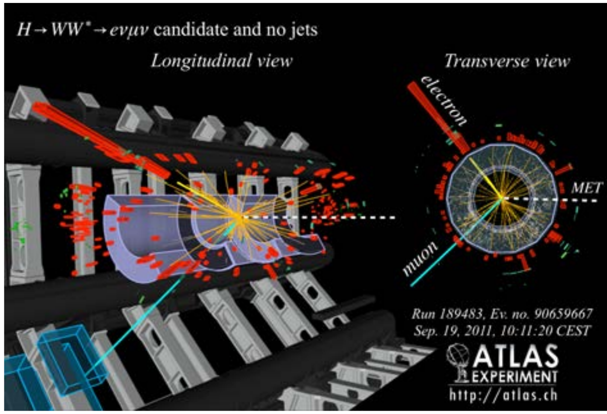


6.1σ (5.8σ)

arXiv:1412.2641, subm. to PRD

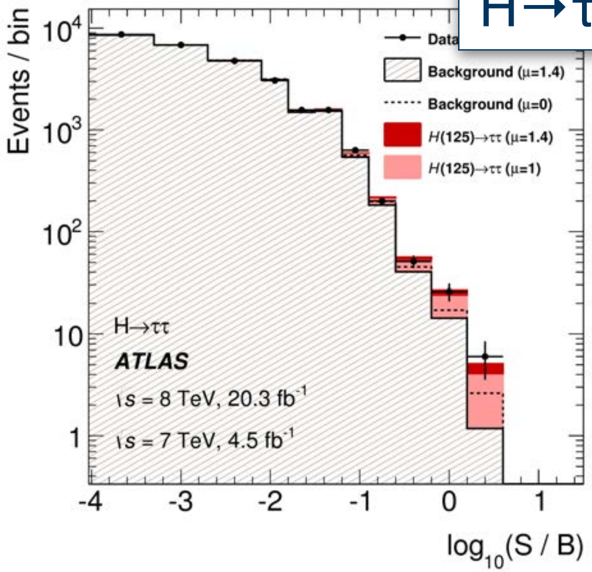




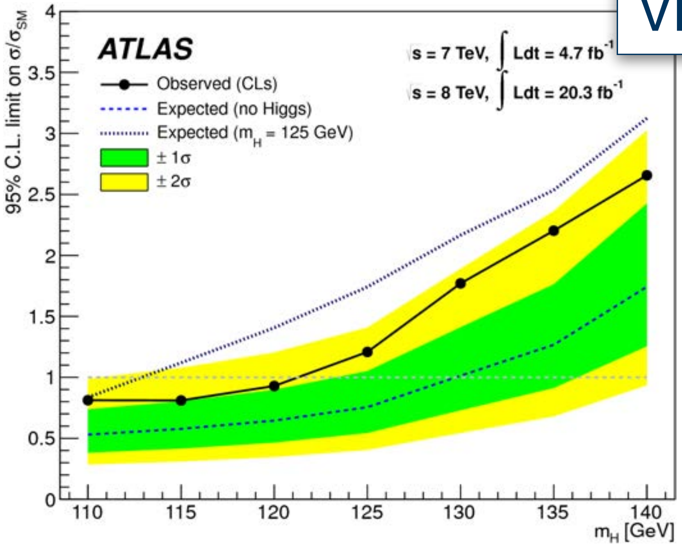


Higgs Boson Signals: Decays to Fermions

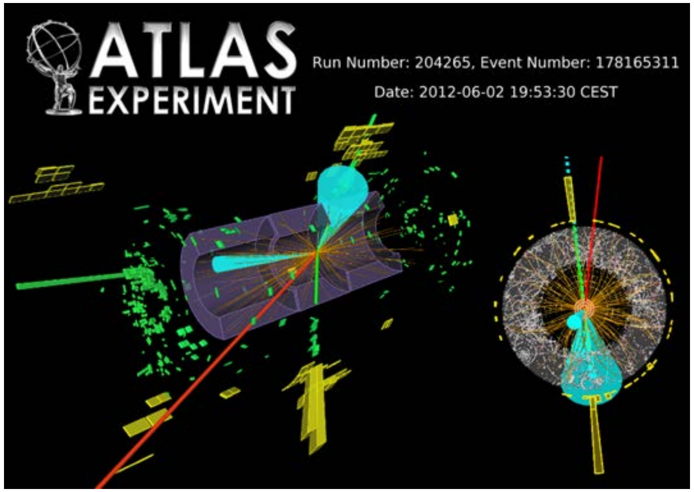
H→ττ



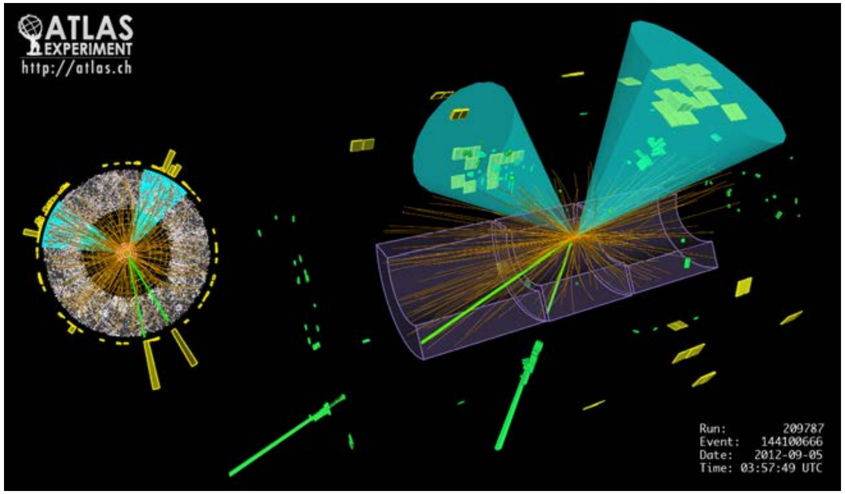
VH→bb



- 4.5σ (3.4σ)
- 1.4σ (2.6σ)

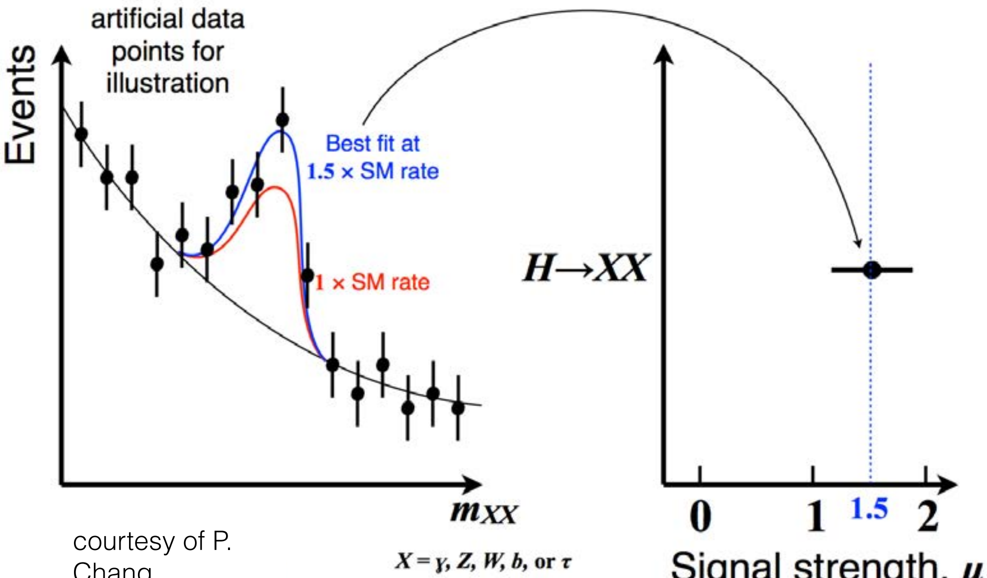


arXiv:1501.04943, subm. to JHEP



JHEP01 (2015) 069

Higgs Boson Signal Strength: Decays

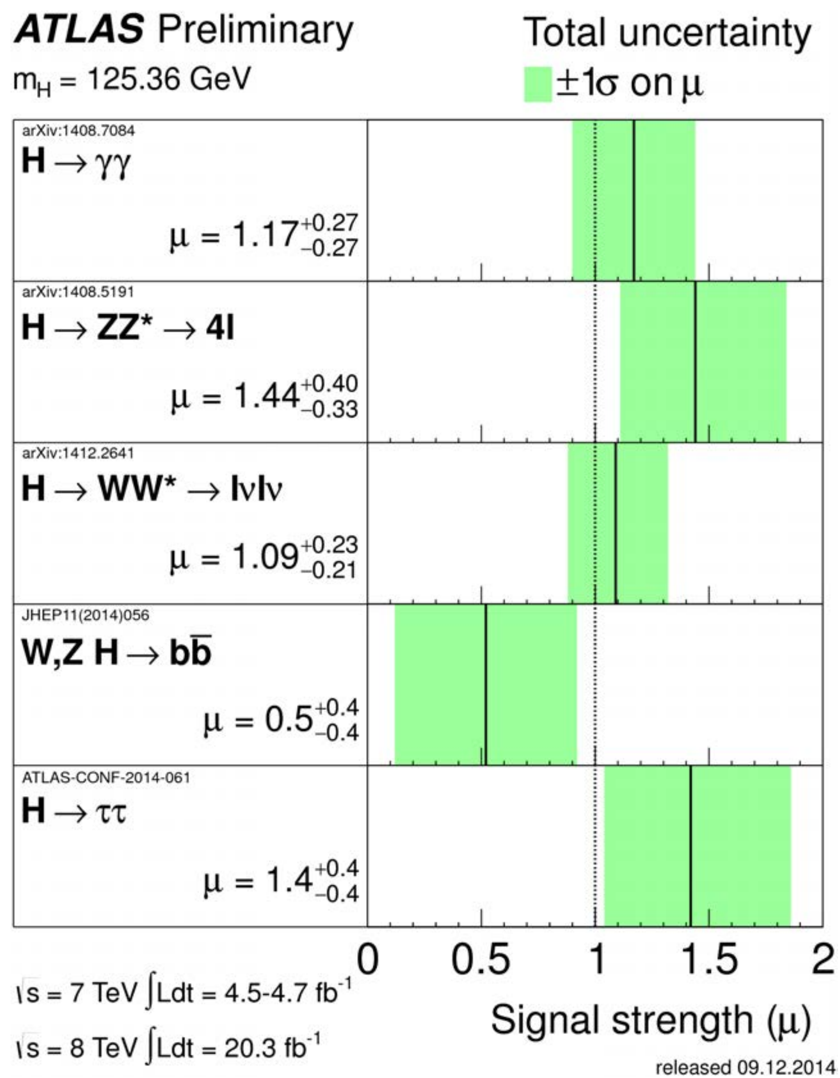


courtesy of P. Chang

$$\mu_{P,X} \sim \frac{\left(\sigma_P \times Br_X\right)_{\text{Data}}}{\left(\sigma_P \times Br_X\right)_{\text{Theory}}}$$

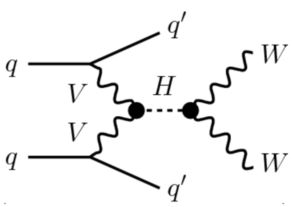
$P \in \{ggF, VBF, VH, ttH\}$

$X \in \{\gamma\gamma, ZZ, WW, bb, \tau\tau\}$

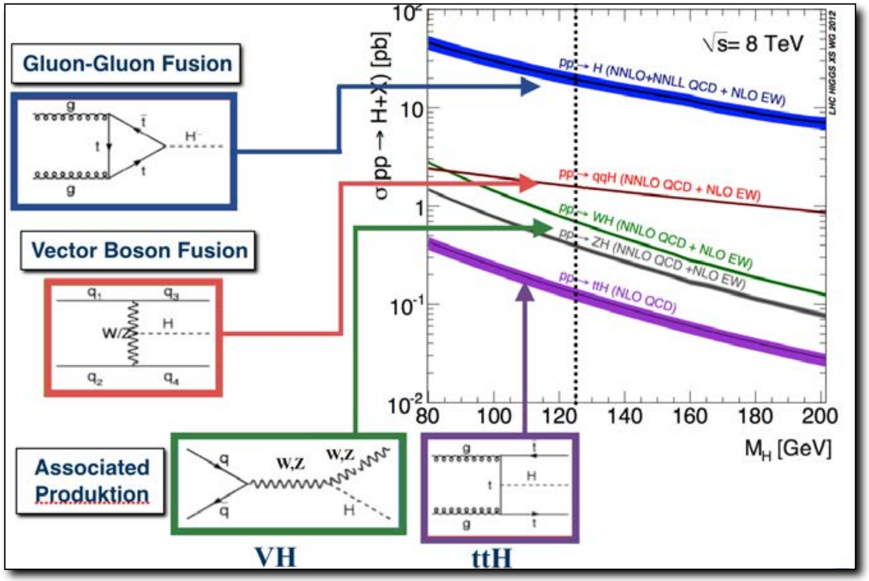


Higgs Boson Signal Strength: Production Modes

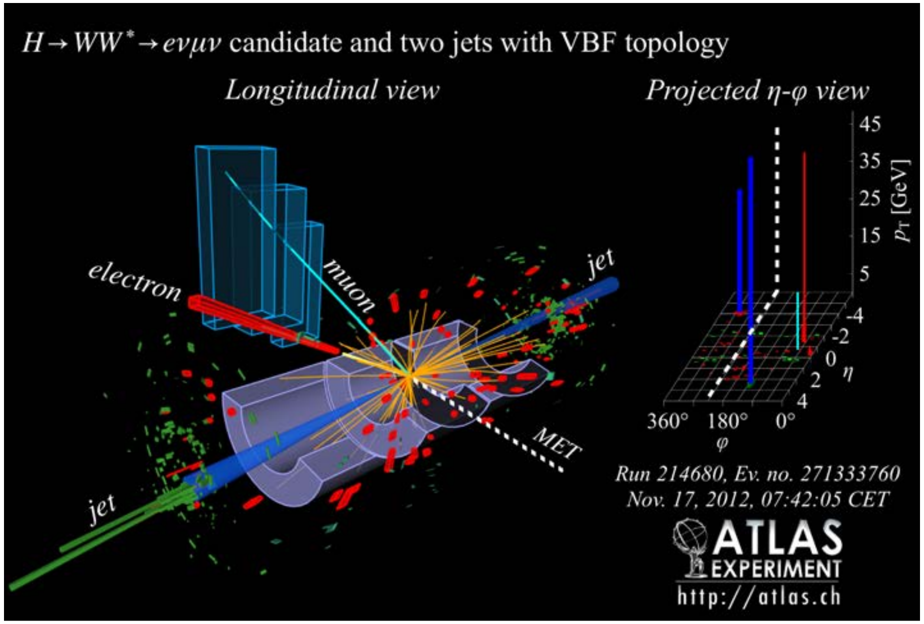
- ggF dominates; other modes?
- **e.g. VBF** provides distinct signature:

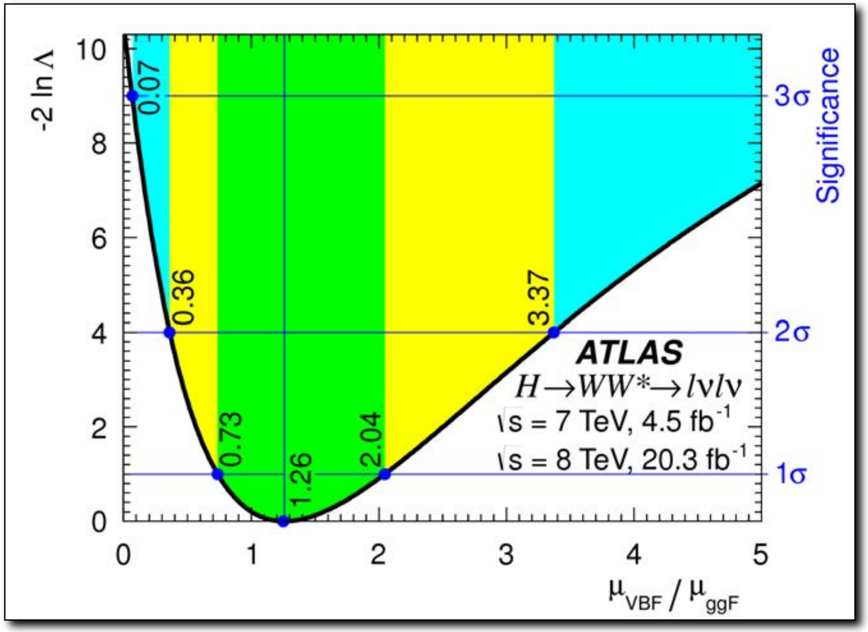


two hard jets with large rapidity separation; Higgs decay products typically in between



- 3.2σ **VBF H→WW* evidence** from μ_{VBF}/μ_{ggF} analysis (>4σ for all decays)





arXiv:1412.2641, subm. to PRD

Higgs Coupling Analysis Concept

- Higgs boson **couplings to other particles** enter measured signal strength **via combination of production and decay**
- coupling analysis currently requires **assumptions / approximations:**
  - **single, narrow, scalar** $J^P=0^+$ **resonance** at observed mass

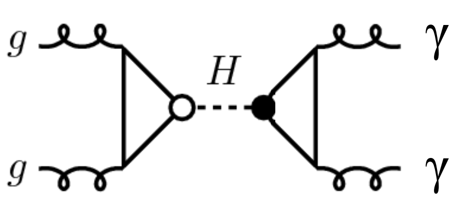
$$(\sigma \cdot BR)(i \to H \to f) = \frac{\sigma_i \cdot \Gamma_f}{\Gamma_H}$$

- **parametrise** possible **deviations** via multiplicative modifiers ("scale factors"):

$$\kappa_i^2 = \frac{\sigma_i}{\sigma_i^{SM}} \qquad \kappa_j^2 = \frac{\Gamma_j}{\Gamma_j^{SM}}$$

with effective scale factors for couplings via loops and total width

- **e.g.**



$$\frac{\sigma \cdot \mathrm{B}\,(gg \to H \to \gamma\gamma)}{\sigma_{\mathrm{SM}}(gg \to H) \cdot \mathrm{B}_{\mathrm{SM}}(H \to \gamma\gamma)} = \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_H^2}$$

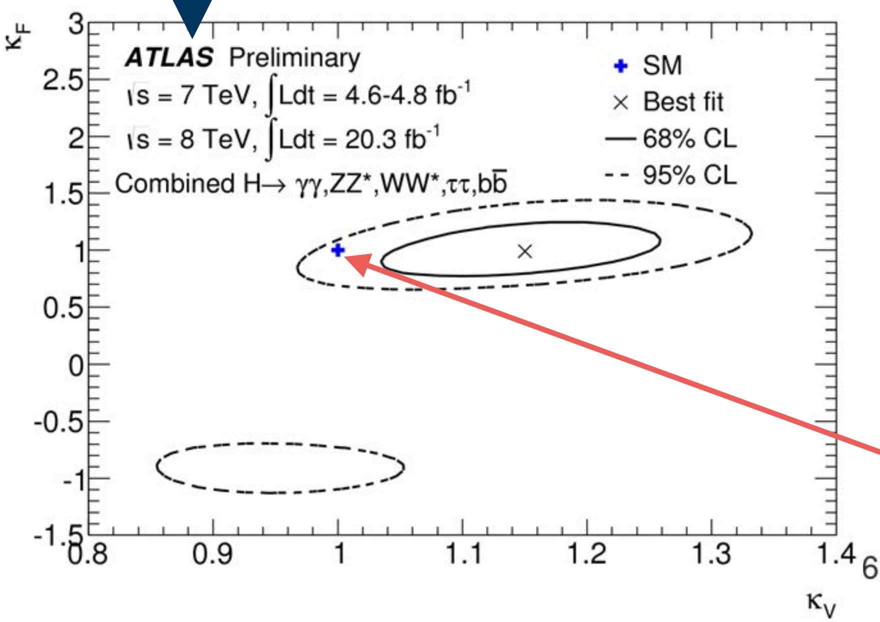
Higgs Coupling Scale Factors

Summary

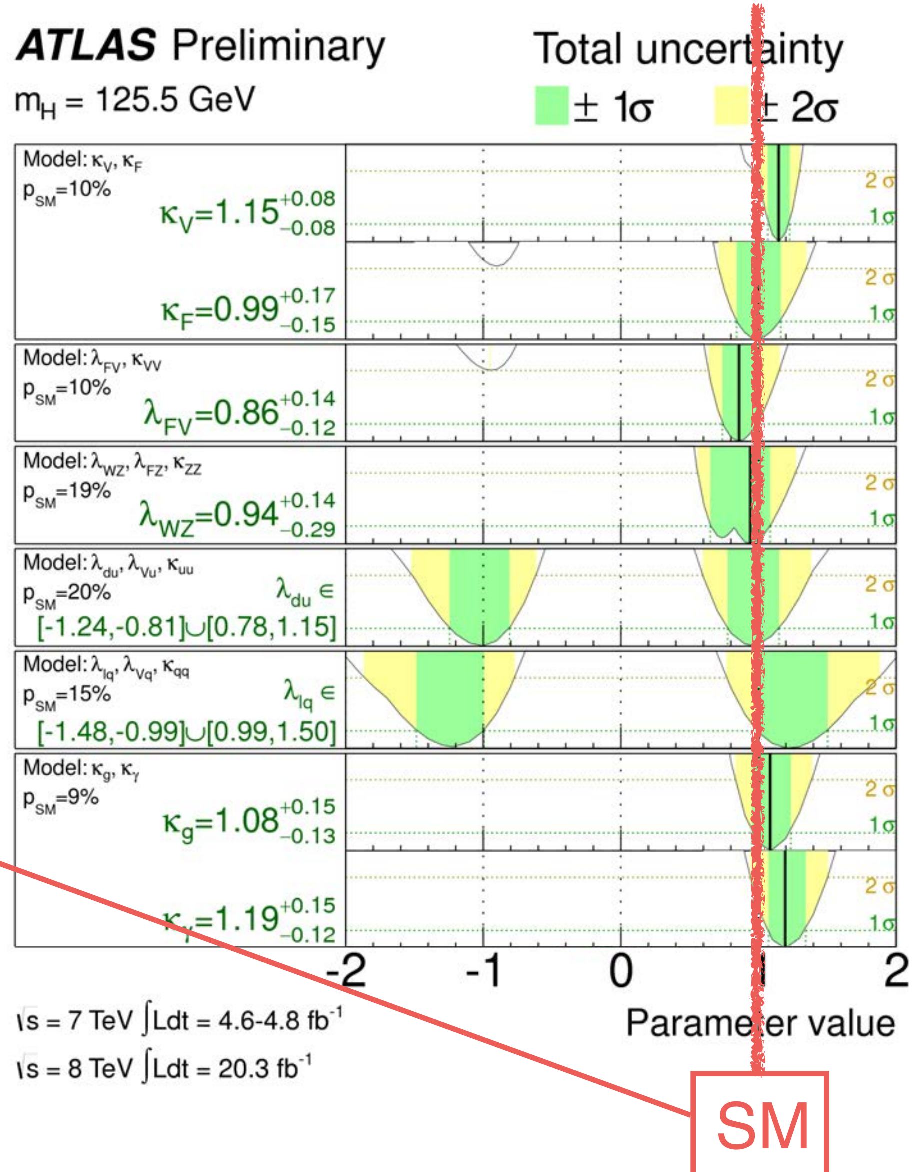
Fermions vs. Vector Bosons

assume $\kappa_V = \kappa_W = \kappa_Z$

$\kappa_F = \kappa_t = \kappa_b = \kappa_\tau = \kappa_g$

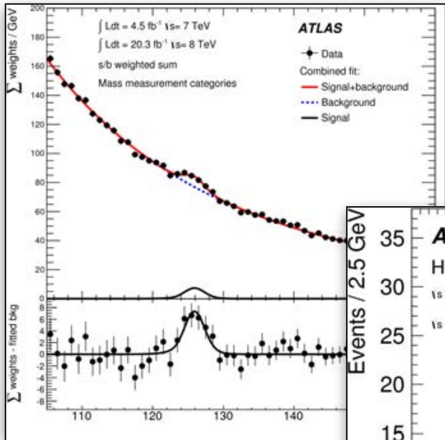


$$\kappa_V = 1.15 \pm 0.08 \,,\ \kappa_F = 0.99^{+0.17}_{-0.15}$$



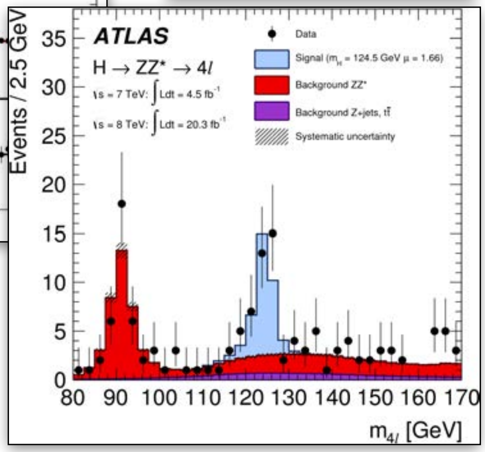
Higgs Boson Mass

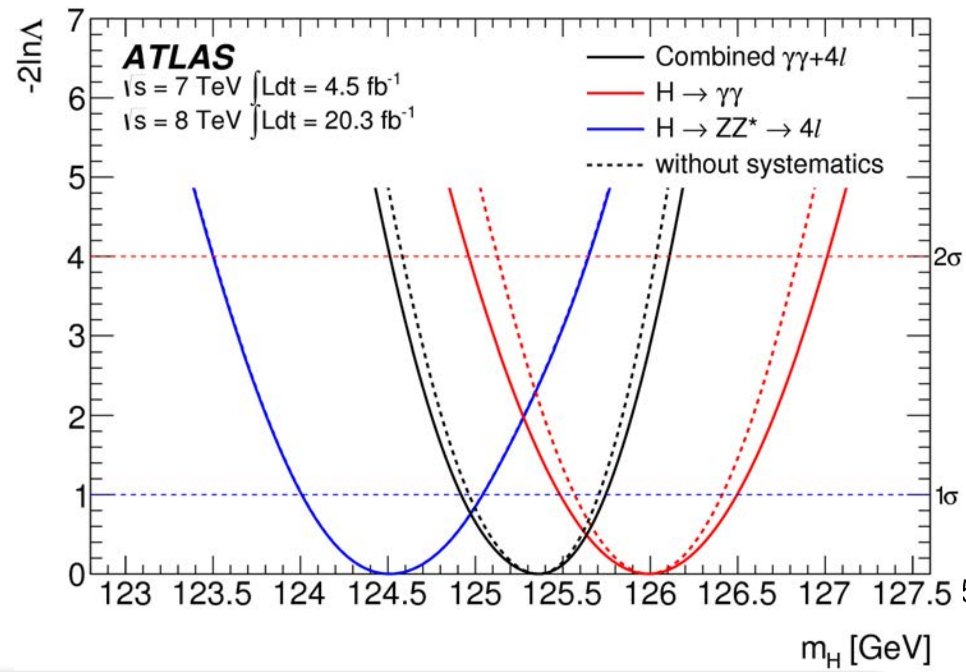
Phys. Rev. D90 (2014) 052004



H→γγ

H→ZZ*→4l





Channel	Mass measurement [GeV]
$H \to \gamma\gamma$	$125.98 \pm 0.42\,(\text{stat}) \pm 0.28\,(\text{syst}) = 125.98 \pm 0.50$
$H \to ZZ^* \to 4\ell$	$124.51 \pm 0.52\,(\text{stat}) \pm 0.06\,(\text{syst}) = 124.51 \pm 0.52$
Combined	$125.36 \pm 0.37\,(\text{stat}) \pm 0.18\,(\text{syst}) = 125.36 \pm 0.41$

- channels **compatible at 2.0σ** level (4.8%)

- also: 95% C.L. observed (expected) upper **limits on Higgs boson width**:

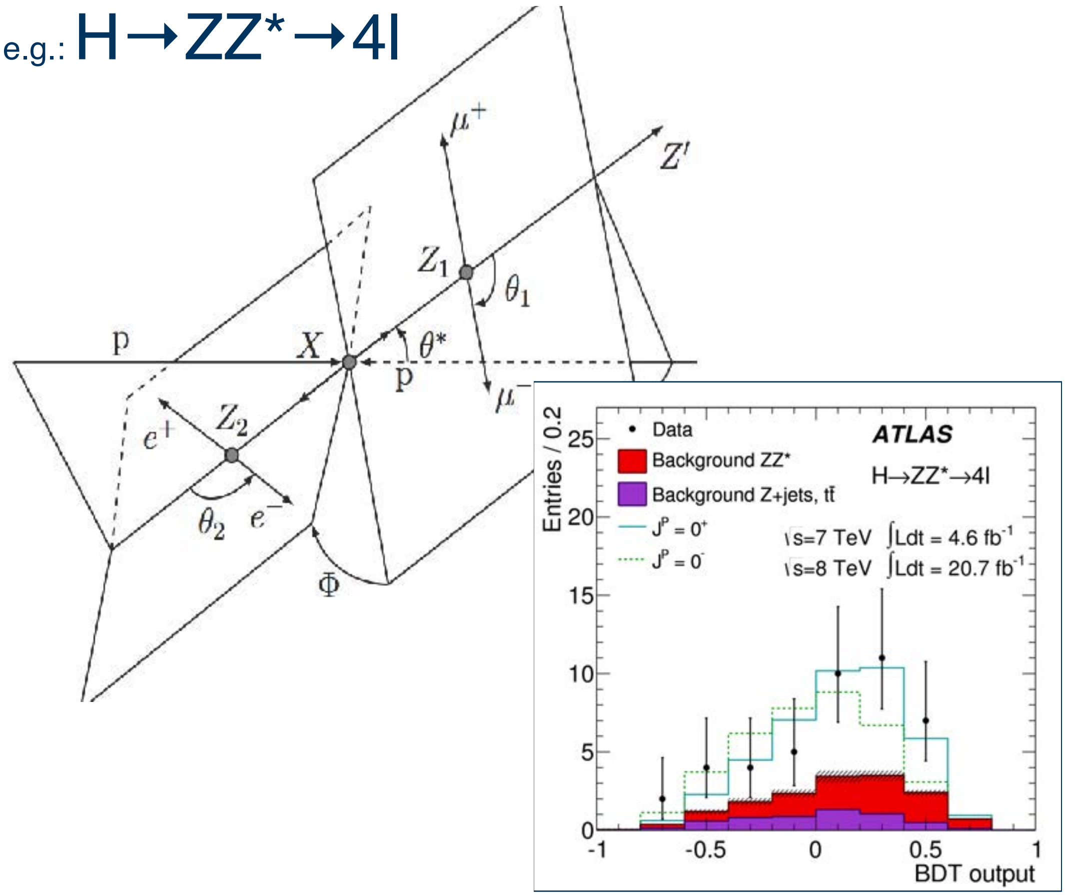
  γγ: 5.0 (6.2) GeV ZZ*: 2.6 (6.2) GeV

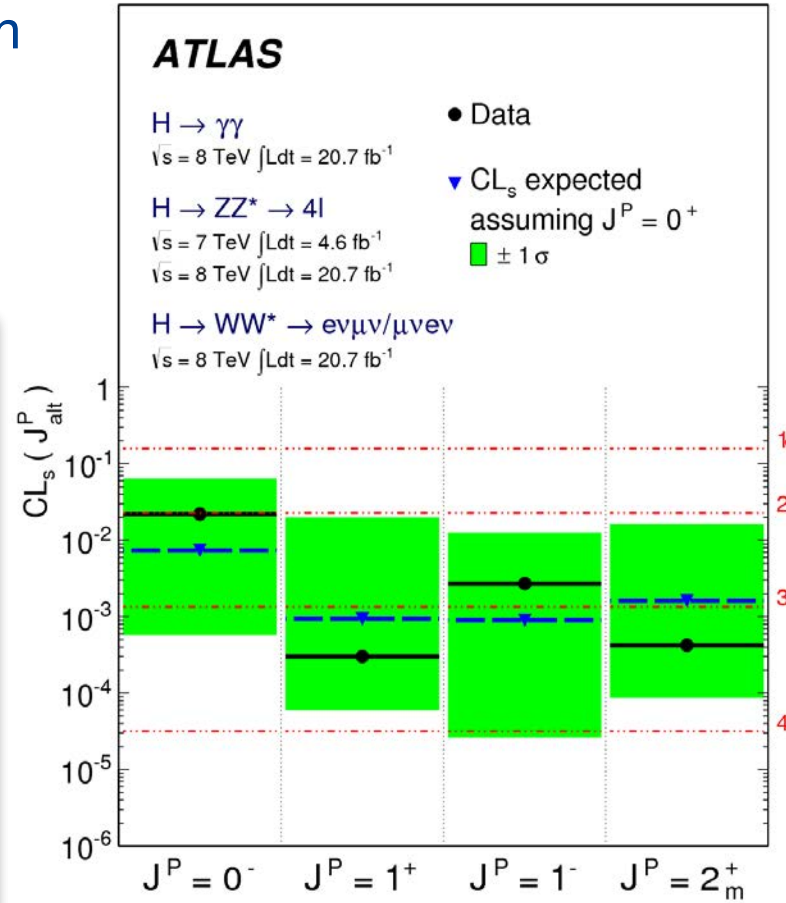
Higgs Boson Spin/Parity

Phys. Lett. B726 (2013) 120

- **analysis of** spin/parity-sensitive quantities in **ZZ*→4l**, **γγ** and **WW*→2l2ν** final states
- check **compatibility** of data **with SM $J^P=0^+$**
- **exclusion of alternative** J^P **hypotheses**

e.g.: H→ZZ*→4l





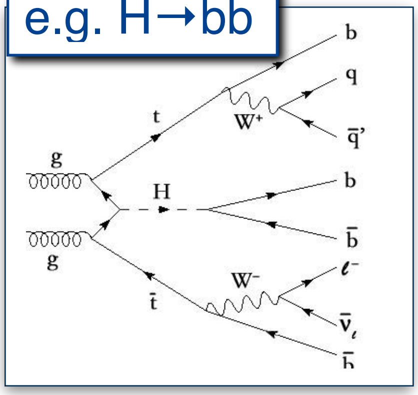
JP	Channels	CL[%]
0^-	ZZ	97.8
1^+	ZZ,WW	99.97
1^-	ZZ,WW	99.7
2^+	γγ,ZZ,WW	99.99

Search for Rare Higgs Production and Decays

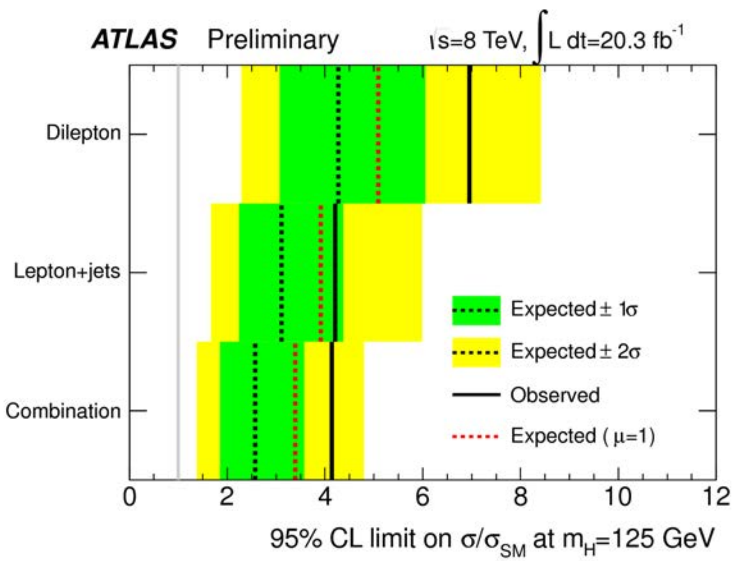
e.g. ttH production

ATLAS-CONF-2014-011

e.g. H→bb



- **only** Higgs **couplings to fermions** enter
- access **tH- coupling**
- **complex final states**
- large **top BG**



ll

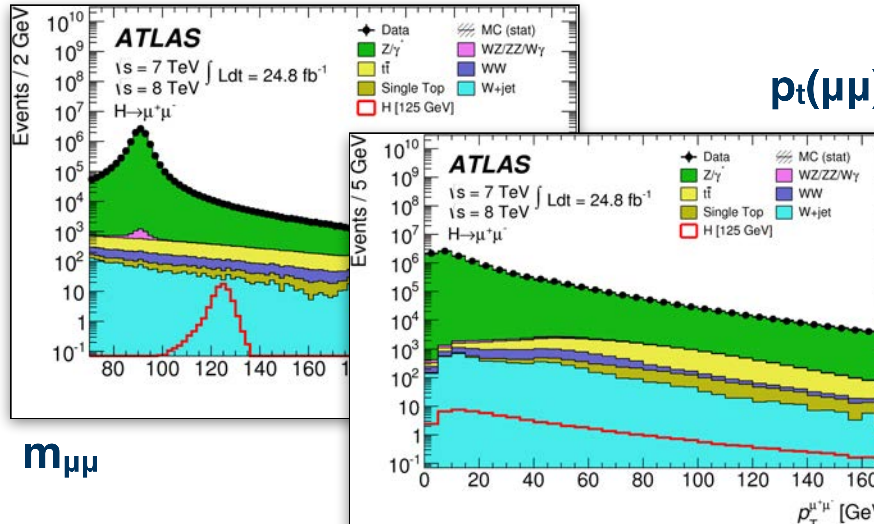
l+jet

comb.

- observed (expected) **limit: 4.1(2.6)xSM**

e.g. H→μμ decays

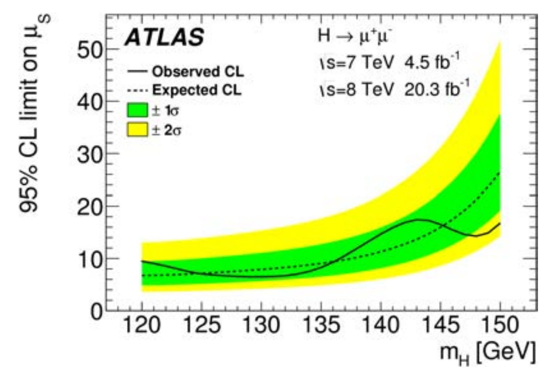
Phys. Lett. B738 (2014) 68



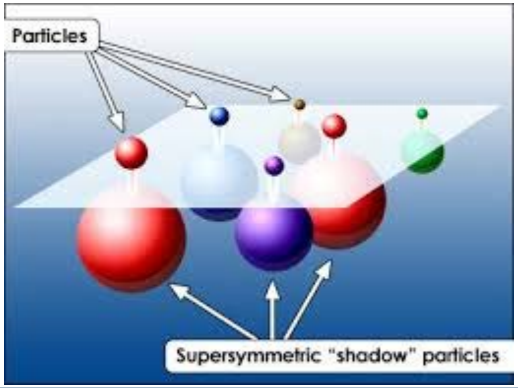
$p_t(\mu\mu)$

$m_{\mu\mu}$

- **no excess** seen (as expected)
- obs. (exp.) **limit: 7.0 (7.2) x SM**



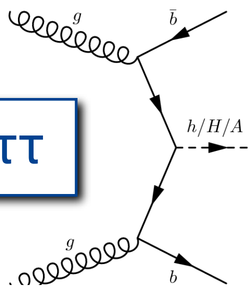
Higgs Bosons Beyond the SM

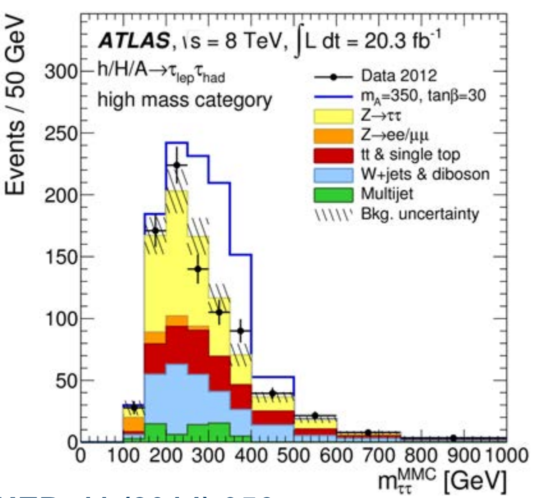


- **e.g.** minimal supersymmetric SM **(MSSM)**: need **5 Higgs Bosons** to give mass to all particles:

  3 neutral (h/H/A) and **2 charged** ($H^{\pm}$)

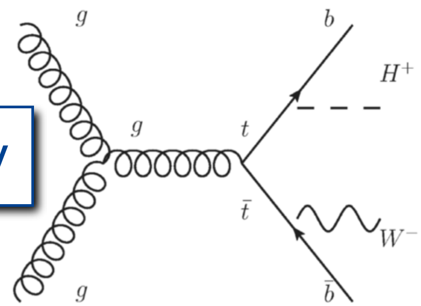
$h/H/A \rightarrow \tau\tau$

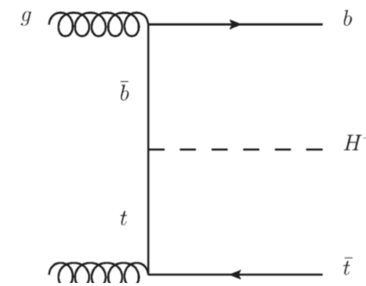


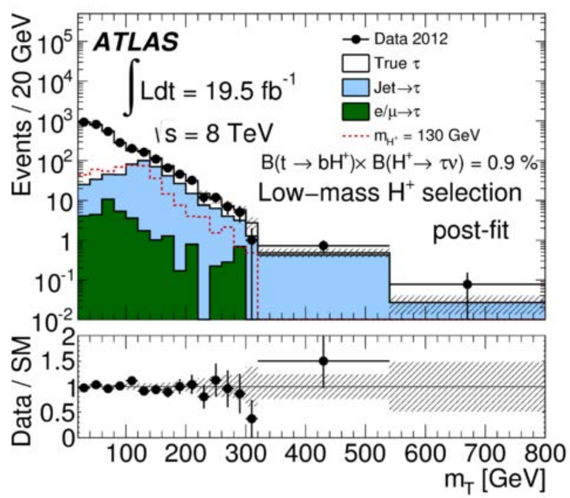


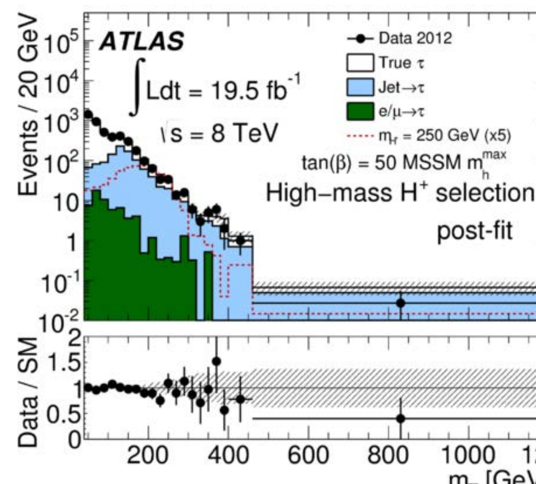
JHEP 11 (2014) 056

$H^{+} \rightarrow \tau\nu$



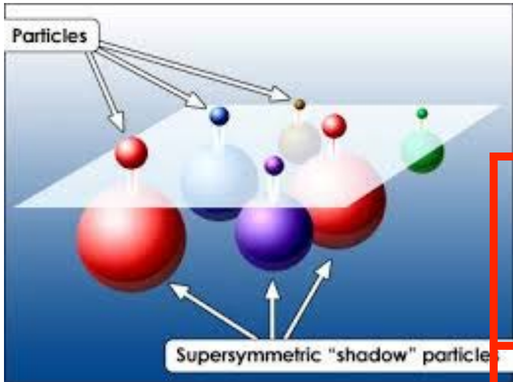






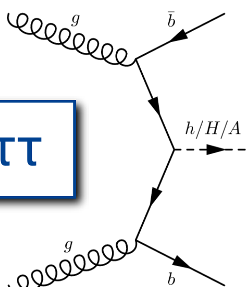
arXiv:1412.6663, subm. to JHEP

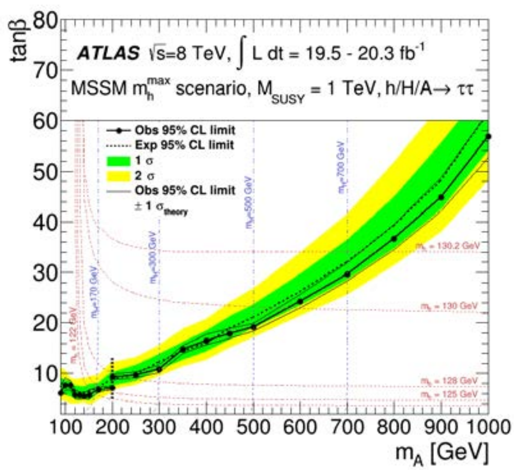
Higgs Bosons Beyond the SM



- **no signals** found
- **limits** set for different SUSY scenarios
- particularly stringent for low-mass H^+

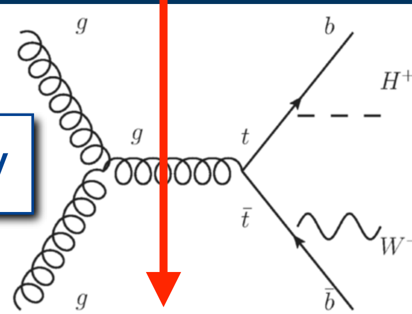
h/H/A→ττ

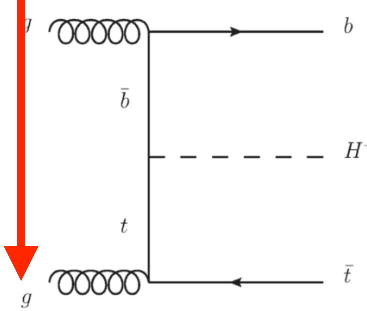


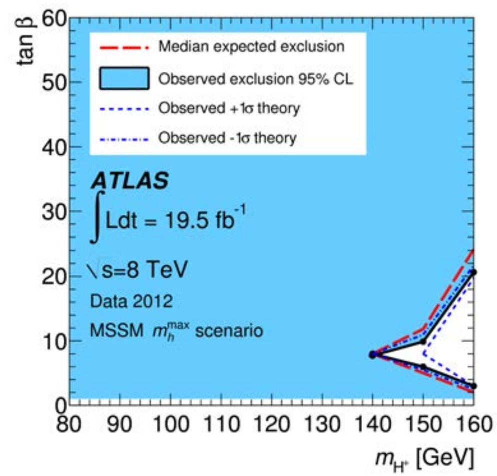


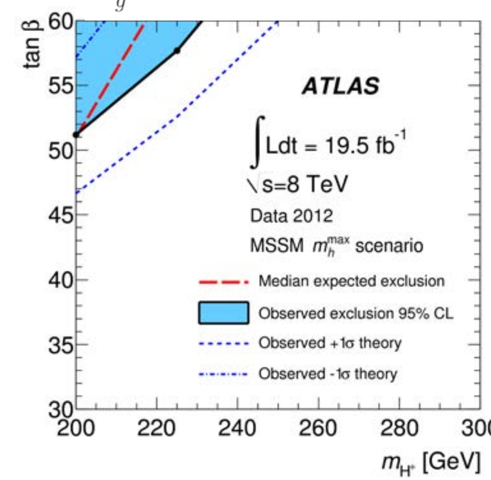
JHEP 11 (2014) 056

H⁺→τν









arXiv:1412.6663, subm. to JHEP

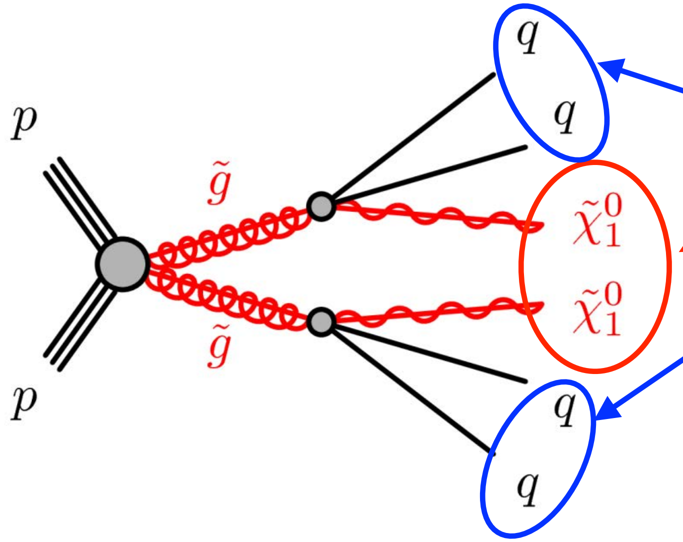
Higgs Boson Summary

- since observation of first signals Higgs physics program has expanded into a **wide range of measurements and searches**
- all measurements of the 125 GeV Higgs boson so far agree **with SM expectation**
- also provides **BSM physics probe**
- **no additional Higgs bosons** found **yet**

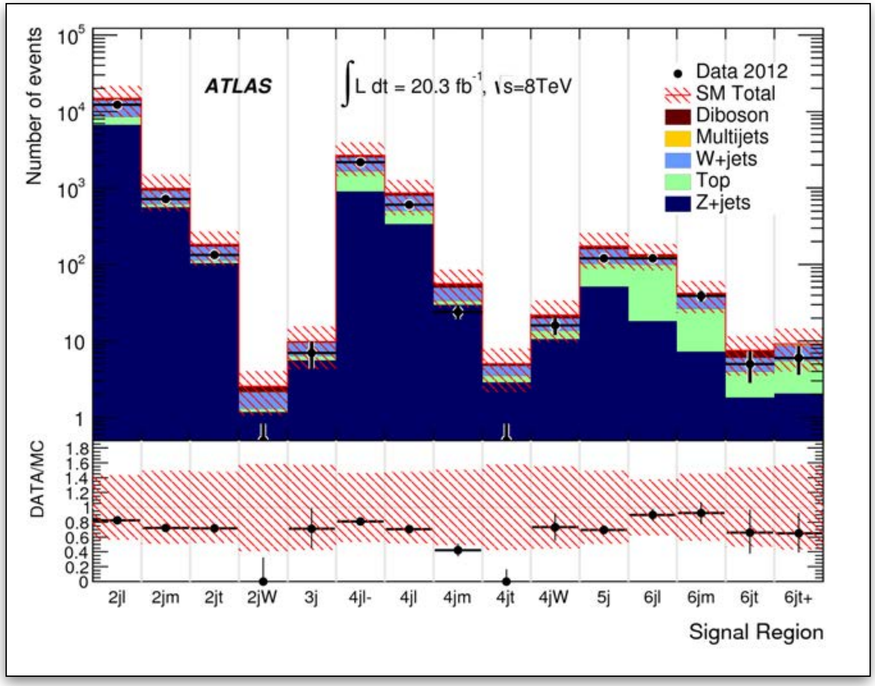
(A bit more on) BSM Searches

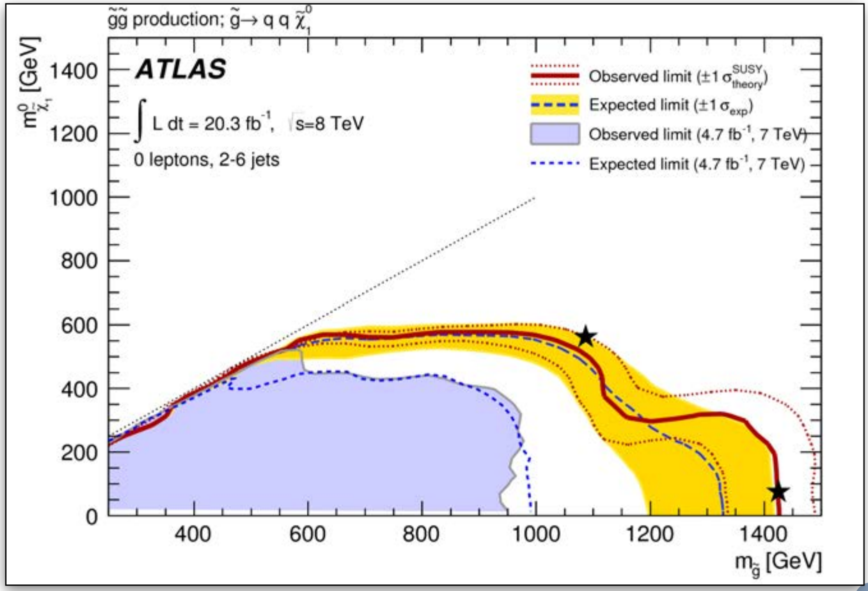
Search for Gluinos

JHEP09 (2014) 176



- select events with large **missing transverse energy** and high-pT **jets**
- define **15 signal regions** with different jet multiplicity, MET and jet p_T requirements
- **no excess** over SM BG found; set **limits on gluino mass** of ≈1.4 TeV (for massless LSP)





Many More SUSY Searches…

universitätbonn

Inclusive Searches

3rd gen. $\tilde{g}$ med.

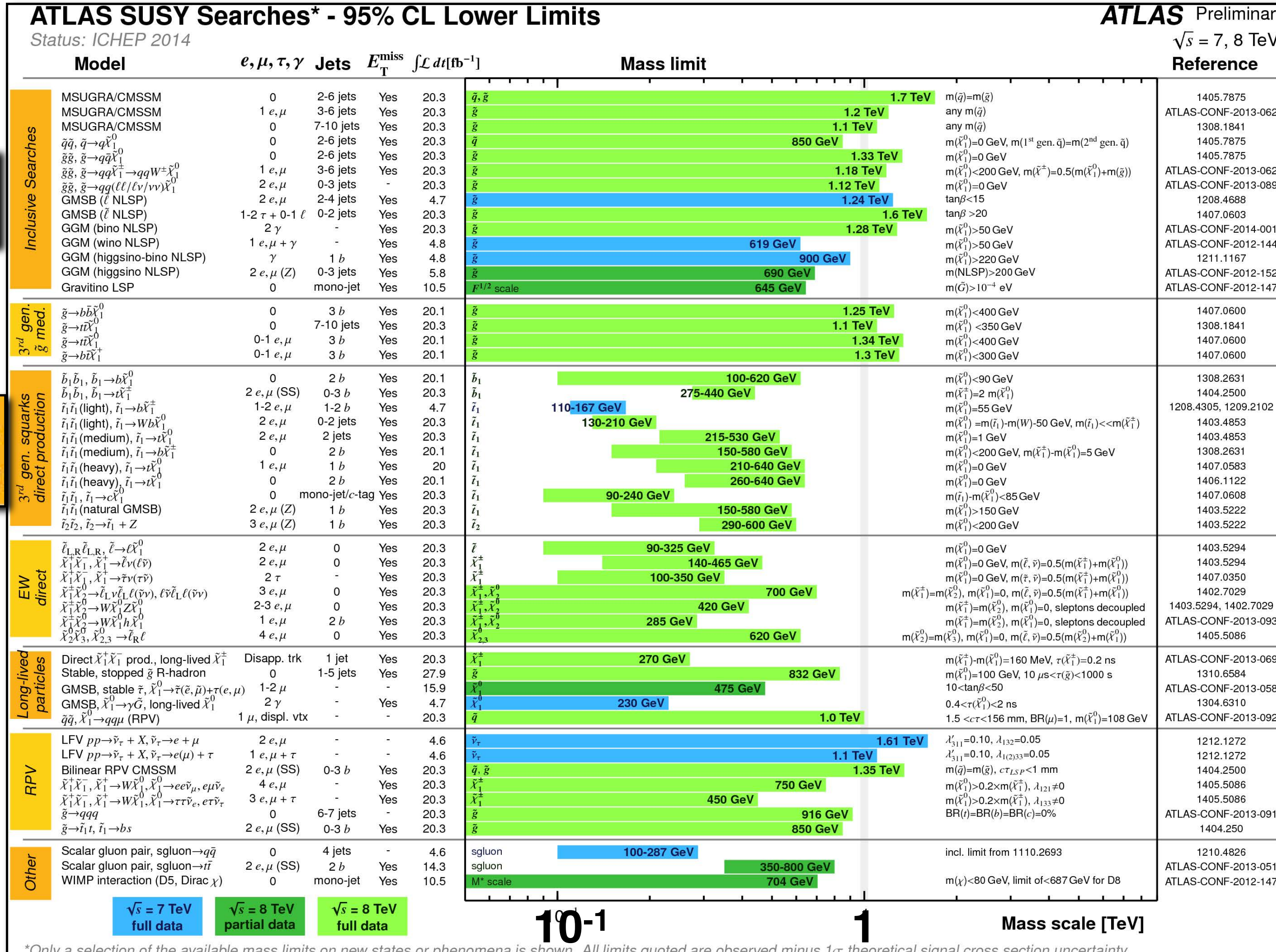
3rd gen. squarks direct production

EW direct

Long-lived particles

RPV

Other

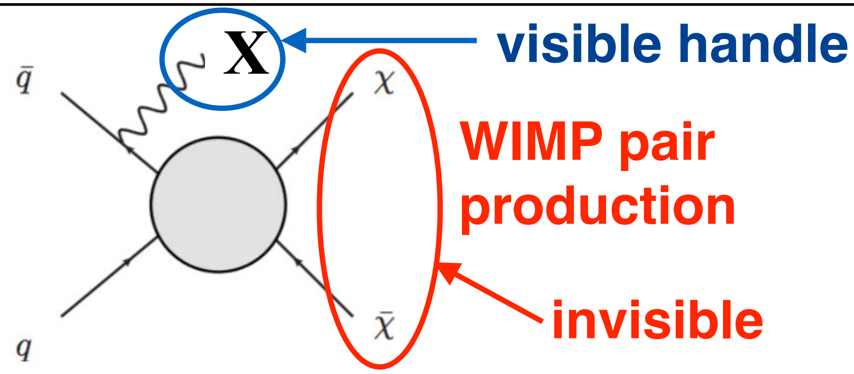


Mass scale [TEV]

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

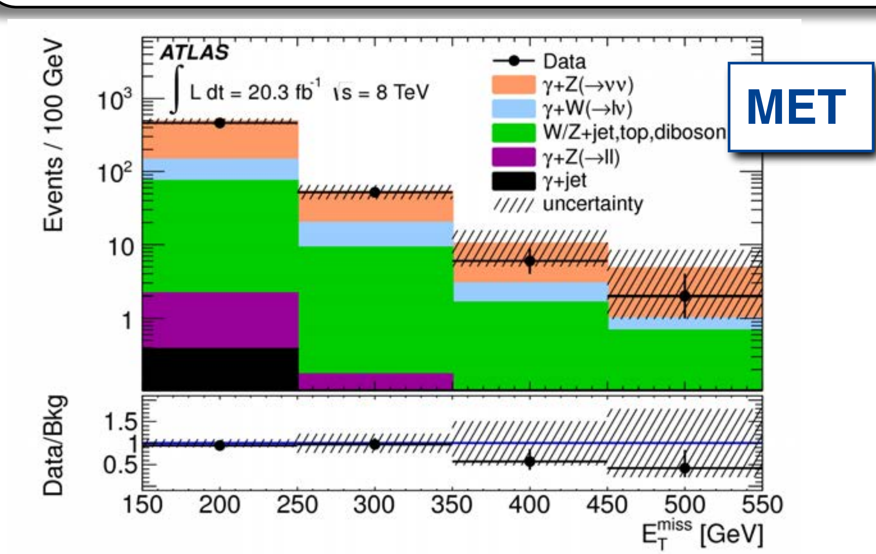
Dark Matter / WIMP Searches

- e.g. “mono-X” signature:



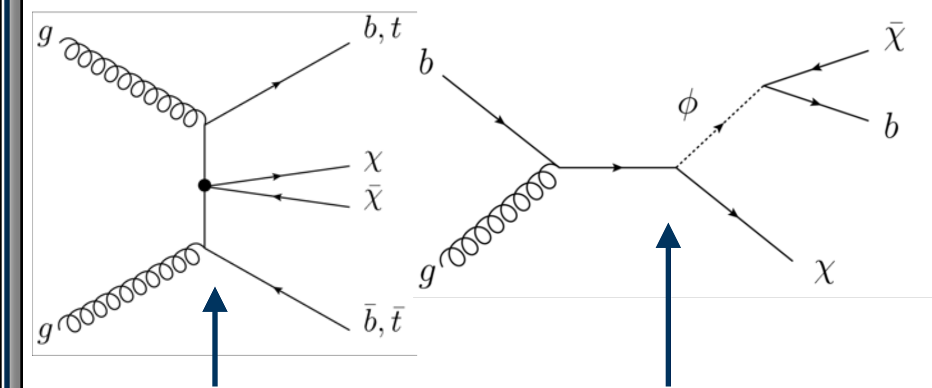
X = photon, jet, W/Z, …

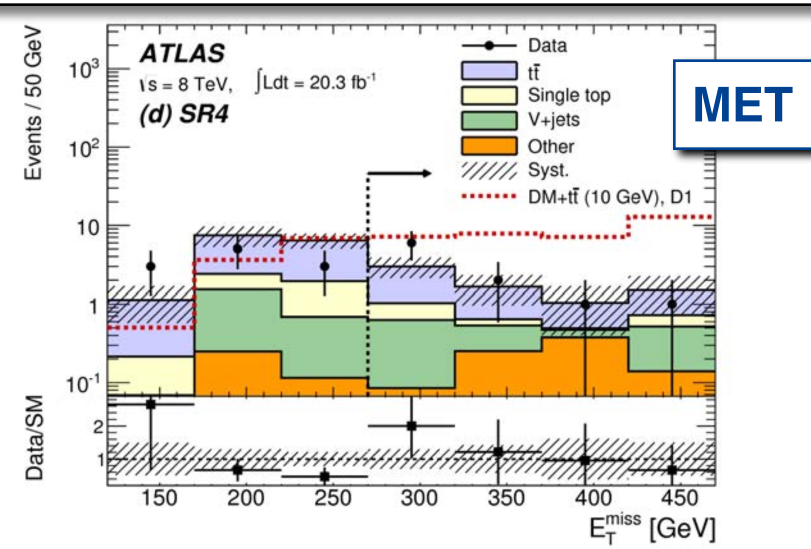
◯ = EFT or explicit mediator



arXiv:1410.4031, subm. to EPJC

- heavy quark (+ MET) signature:

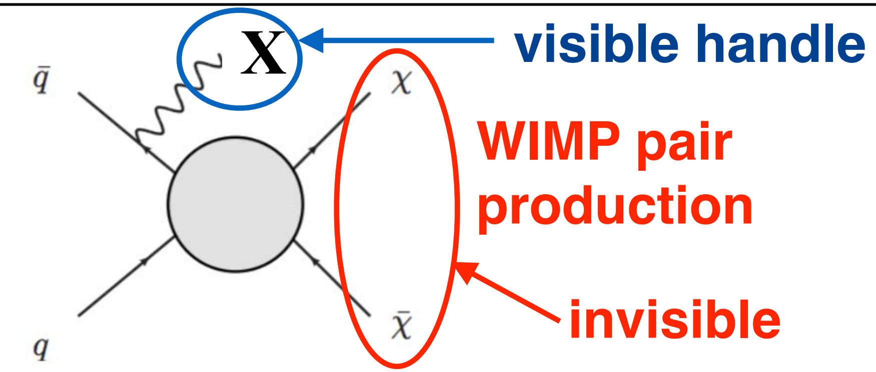




arXiv:1411.1559, acc. by PRD

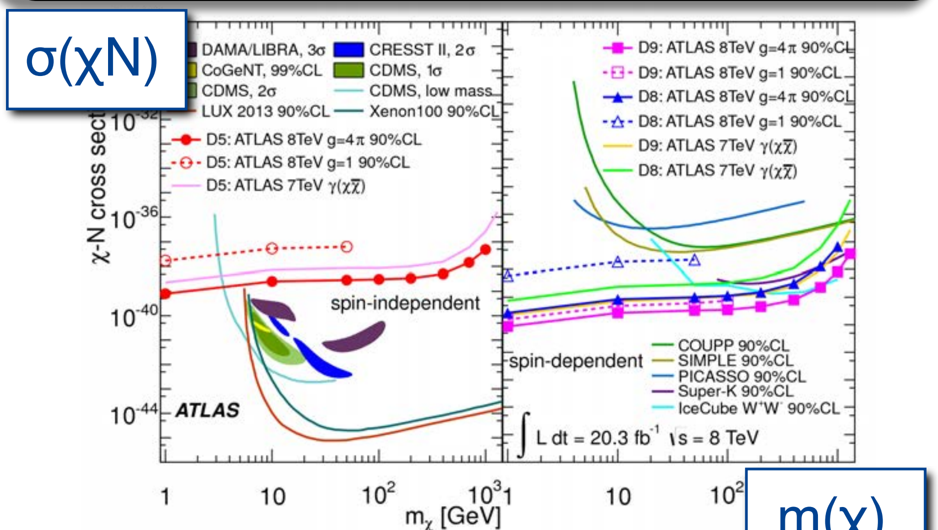
Dark Matter / WIMP Searches

- e.g. "mono-X" signature:



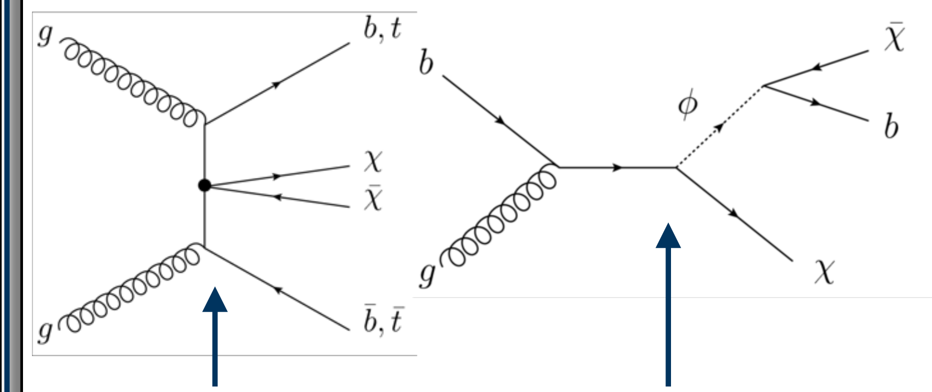
X = photon, jet, W/Z, …

= EFT or explicit mediator



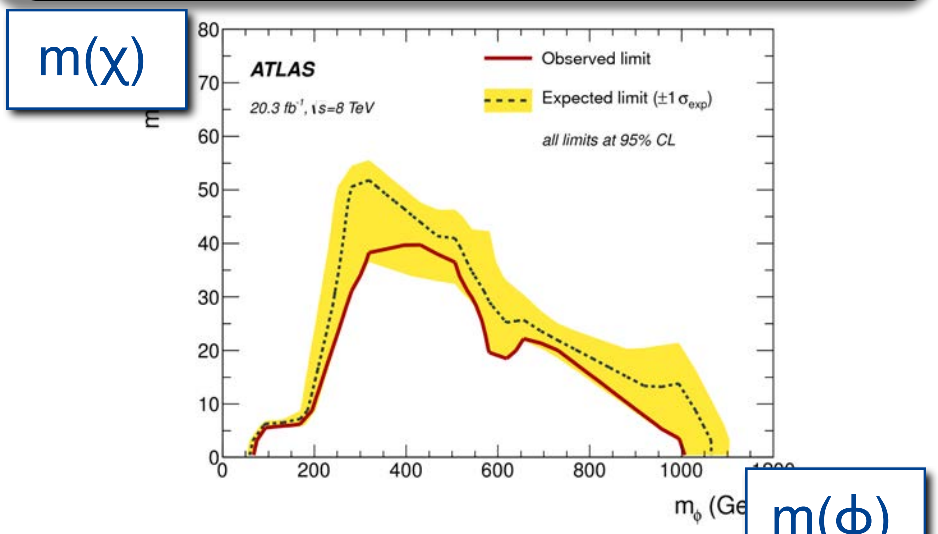
arXiv:1410.4031, subm. to EPJC

- heavy quark (+ MET) signature:



HQ pair +WIMPs (EFT)

"b-FDM" model



arXiv:1411.1559, subm. to EPJC,acc. by PRD

Many More BSM Physics Searches…

ATLAS Exotics Searches* - 95% CL Exclusion

Status: ICHEP 2014

ATLAS Preliminary

$\int \mathcal{L}\, dt = (1.0 - 20.3)\ \mathrm{fb}^{-1}$ $\sqrt{s}$ = 7, 8 TeV

	Model	ℓ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Extra dimensions	ADD $G_{KK} + g/q$	–	1-2 j	Yes	4.7	M_D 4.37 TeV	$n = 2$	1210.4491
	ADD non-resonant $\ell\ell$	2e, μ	–	–	20.3	M_S 5.2 TeV	$n = 3$ HLZ	ATLAS-CONF-2014-030
	ADD QBH $\to \ell q$	1 e, μ	1 j	–	20.3	M_{th} 5.2 TeV	$n = 6$	1311.2006
	ADD QBH	–	2 j	–	20.3	M_{th} 5.82 TeV	$n = 6$	to be submitted to PRD
	ADD BH high N_{trk}	2 μ (SS)	–	–	20.3	M_{th} 5.7 TeV	$n = 6$, $M_D = 1.5$ TeV, non-rot BH	1308.4075
	ADD BH high $\sum p_T$	≥ 1 e, μ	≥ 2 j	–	20.3	M_{th} 6.2 TeV	$n = 6$, $M_D = 1.5$ TeV, non-rot BH	1405.4254
	RS1 $G_{KK} \to \ell\ell$	2 e, μ	–	–	20.3	G_{KK} mass 2.68 TeV	$k/\overline{M}_{Pl} = 0.1$	1405.4123
	RS1 $G_{KK} \to WW \to \ell\nu\ell\nu$	2 e, μ	–	Yes	4.7	G_{KK} mass 1.23 TeV	$k/\overline{M}_{Pl} = 0.1$	1208.2880
	Bulk RS $G_{KK} \to ZZ \to \ell\ell qq$	2 e, μ	2 j / 1 J	–	20.3	G_{KK} mass 730 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2014-039
	Bulk RS $G_{KK} \to HH \to b\bar{b}b\bar{b}$	–	4 b	–	19.5	G_{KK} mass 590-710 GeV	$k/\overline{M}_{Pl} = 1.0$	ATLAS-CONF-2014-005
	Bulk RS $g_{KK} \to t\bar{t}$	1 e, μ	≥ 1 b, ≥ 1J/2j	Yes	14.3	g_{KK} mass 2.0 TeV	BR = 0.925	ATLAS-CONF-2013-052
	S^1/Z_2 ED	2 e, μ	–	–	5.0	$M_{KK} \approx R^{-1}$ 4.71 TeV		1209.2535
	UED	2 γ	–	Yes	4.8	Compact. scale R^{-1} 1.41 TeV		ATLAS-CONF-2012-072
Gauge bosons	SSM $Z' \to \ell\ell$	2 e, μ	–	–	20.3	Z' mass 2.9 TeV		1405.4123
	SSM $Z' \to \tau\tau$	2 τ	–	–	19.5	Z' mass 1.9 TeV		ATLAS-CONF-2013-066
	SSM $W' \to \ell\nu$	1 e, μ	–	Yes	20.3	W' mass 3.28 TeV		ATLAS-CONF-2014-017
	EGM $W' \to WZ \to \ell\nu\, \ell'\ell'$	3 e, μ	–	Yes	20.3	W' mass 1.52 TeV		1406.4456
	EGM $W' \to WZ \to qq\ell\ell$	2 e, μ	2 j / 1 J	–	20.3	W' mass 1.59 TeV		ATLAS-CONF-2014-039
	LRSM $W'_R \to t\bar{b}$	1 e, μ	2 b, 0-1 j	Yes	14.3	W' mass 1.84 TeV		ATLAS-CONF-2013-050
	LRSM $W'_R \to t\bar{b}$	0 e, μ	≥ 1 b, 1 J	–	20.3	W' mass 1.77 TeV		to be submitted to EPJC
CI	CI $qqqq$	–	2 j	–	4.8	Λ 7.6 TeV	$\eta = +1$	1210.1718
	CI $qq\ell\ell$	2 e, μ	–	–	20.3	Λ 21.6 TeV	$\eta_{LL} = -1$	ATLAS-CONF-2014-030
	CI $uutt$	2 e, μ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	Λ 3.3 TeV	$\lvert C\rvert = 1$	ATLAS-CONF-2013-051
DM	EFT D5 operator (Dirac)	0 e, μ	1-2 j	Yes	10.5	M_* 731 GeV	at 90% CL for $m(\chi) < 80$ GeV	ATLAS-CONF-2012-147
	EFT D9 operator (Dirac)	0 e, μ	1 J, ≤ 1 j	Yes	20.3	M_* 2.4 TeV	at 90% CL for $m(\chi) < 100$ GeV	1309.4017
LQ	Scalar LQ 1[st] gen	2 e	≥ 2 j	–	1.0	LQ mass 660 GeV	$\beta = 1$	1112.4828
	Scalar LQ 2[nd] gen	2 μ	≥ 2 j	–	1.0	LQ mass 685 GeV	$\beta = 1$	1203.3172
	Scalar LQ 3[rd] gen	1 e, μ, 1 τ	1 b, 1 j	–	4.7	LQ mass 534 GeV	$\beta = 1$	1303.0526
Heavy quarks	Vector-like quark $TT \to Ht + X$	1 e, μ	≥ 2 b, ≥ 4 j	Yes	14.3	T mass 790 GeV	T in (T,B) doublet	ATLAS-CONF-2013-018
	Vector-like quark $TT \to Wb + X$	1 e, μ	≥ 1 b, ≥ 3 j	Yes	14.3	T mass 670 GeV	isospin singlet	ATLAS-CONF-2013-060
	Vector-like quark $TT \to Zt + X$	2/$\geq$3 e, μ	$\geq$2/$\geq$1 b	–	20.3	T mass 735 GeV	T in (T,B) doublet	ATLAS-CONF-2014-036
	Vector-like quark $BB \to Zb + X$	2/$\geq$3 e, μ	$\geq$2/$\geq$1 b	–	20.3	B mass 755 GeV	B in (B,Y) doublet	ATLAS-CONF-2014-036
	Vector-like quark $BB \to Wt + X$	2 e, μ (SS)	≥ 1 b, ≥ 1 j	Yes	14.3	B mass 720 GeV	B in (T,B) doublet	ATLAS-CONF-2013-051
Excited fermions	Excited quark $q^* \to q\gamma$	1 γ	1 j	–	20.3	q^* mass 3.5 TeV	only u^* and d^*, $\Lambda = m(q^*)$	1309.3230
	Excited quark $q^* \to qg$	–	2 j	–	20.3	q^* mass 4.09 TeV	only u^* and d^*, $\Lambda = m(q^*)$	to be submitted to PRD
	Excited quark $b^* \to Wt$	1 or 2 e, μ	1 b, 2 j or 1 j	Yes	4.7	b^* mass 870 GeV	left-handed coupling	1301.1583
	Excited lepton $\ell^* \to \ell\gamma$	2 e, μ, 1 γ	–	–	13.0	ℓ^* mass 2.2 TeV	$\Lambda = 2.2$ TeV	1308.1364
Other	LSTC $a_T \to W\gamma$	1 e, μ, 1 γ	–	Yes	20.3	a_T mass 960 GeV		to be submitted to PLB
	LRSM Majorana ν	2 e, μ	2 j	–	2.1	N^0 mass 1.5 TeV	$m(W_R) = 2$ TeV, no mixing	1203.5420
	Type III Seesaw	2 e, μ	–	–	5.8	$N^\pm$ mass 245 GeV	$\lvert V_e\rvert$=0.055, $\lvert V_\mu\rvert$=0.063, $\lvert V_\tau\rvert$=0	ATLAS-CONF-2013-019
	Higgs triplet $H^{\pm\pm} \to \ell\ell$	2 e, μ (SS)	–	–	4.7	$H^{\pm\pm}$ mass 409 GeV	DY production, BR($H^{\pm\pm} \to \ell\ell$)=1	1210.5070
	Multi-charged particles	–	–	–	4.4	multi-charged particle mass 490 GeV	DY production, $\lvert q\rvert = 4e$	1301.5272
	Magnetic monopoles	–	–	–	2.0	monopole mass 862 GeV	DY production, $\lvert g\rvert = 1 g_D$	1207.6411

$\sqrt{s}$ = 7 TeV $\sqrt{s}$ = 8 TeV

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

*Only a selection of the available mass limits on new states or phenomena is shown.

Extra dimensions

Gauge bosons

CI

DM

LQ

Heavy quarks

Excited fermions

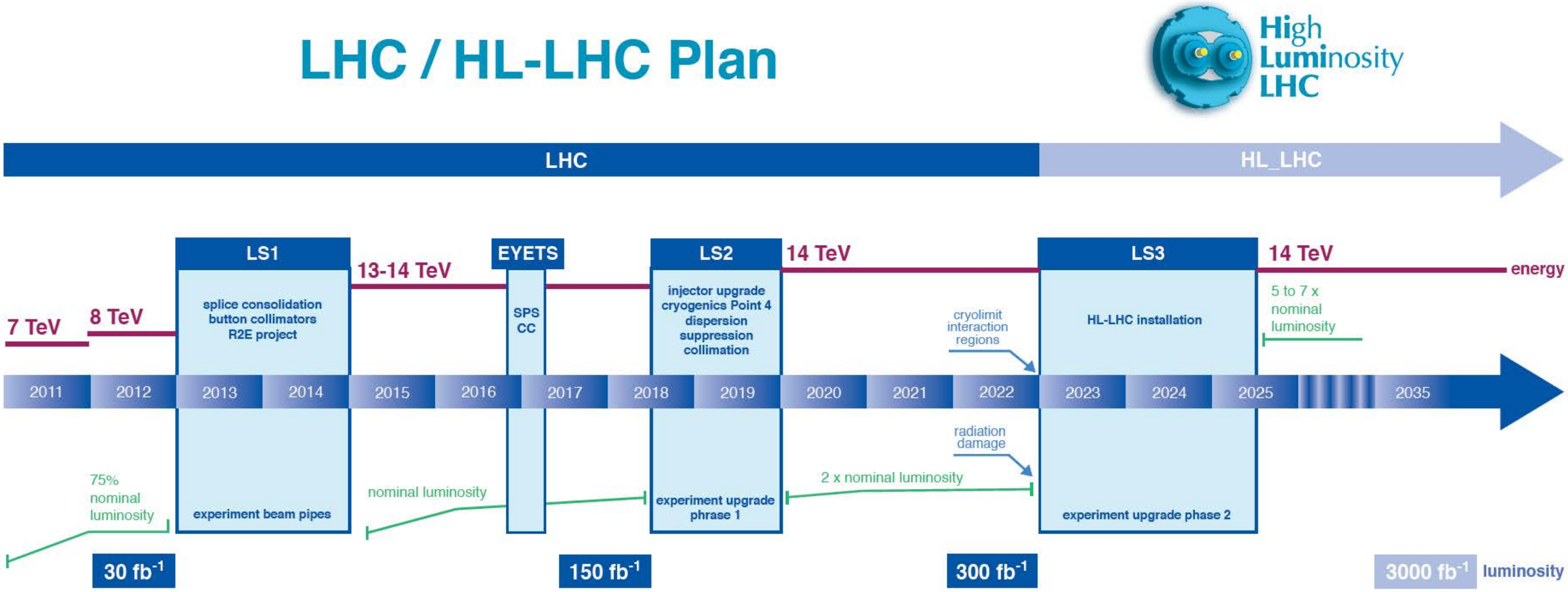
Other

mass scale [TEV]

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/ExoticsPublicResults

Outlook

- **Run2** to start this year with **higher energies** and **larger datasets**

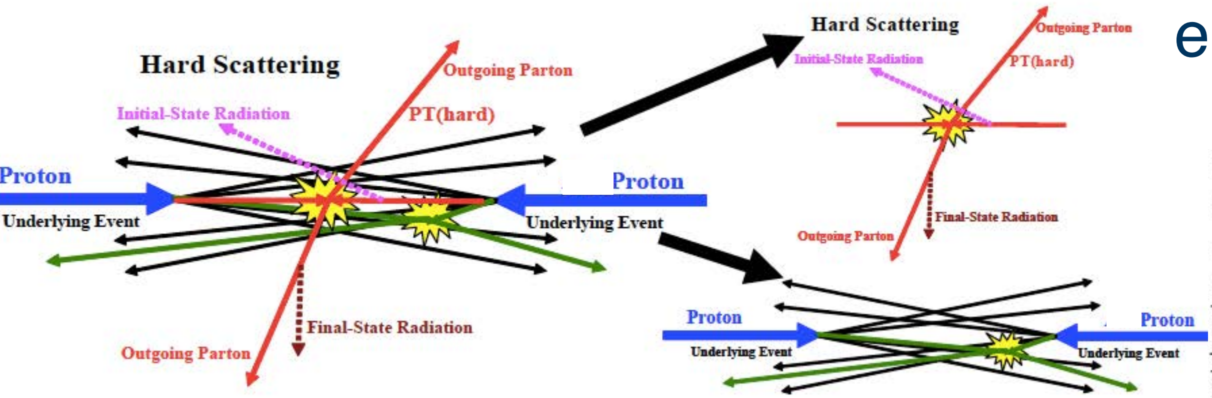


→ **Lyn Evans's Talk**

Additional Material

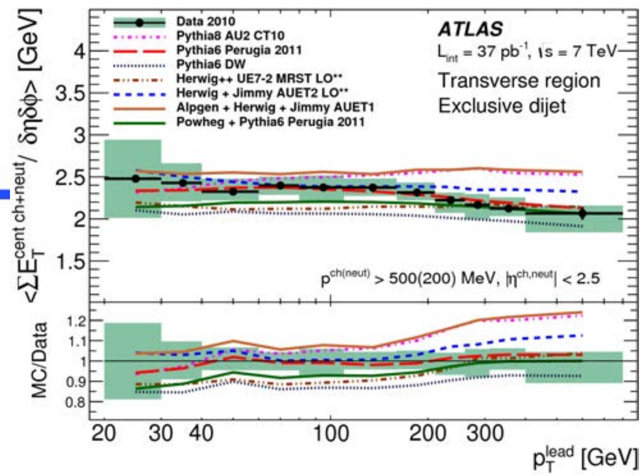
Underlying Event in Jet Events

Eur. Phys. J. C74 (2014) 2965

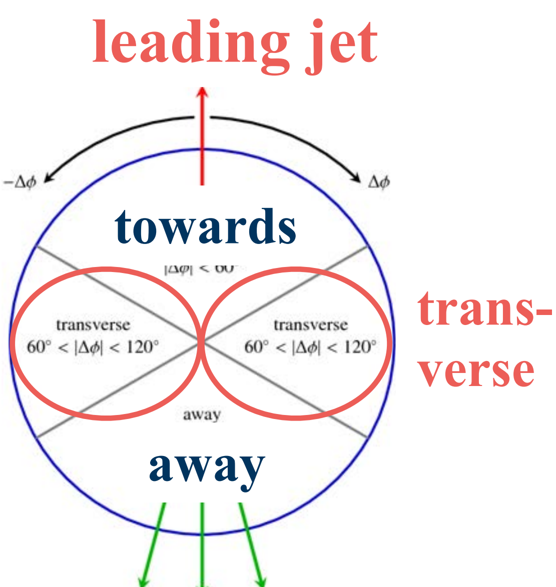


e.g:

<ΣE_T> (leading jet p_T)

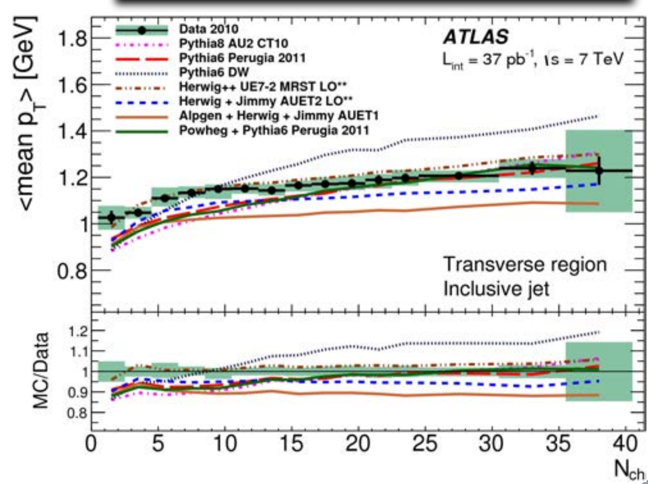


- **study** UE-relevant observables **in azimuthally transverse region w.r.t** the highest-p_t **jet**
- inclusive (>0 jets) and excl. (=2 jets) selections



Charged tracks $\sum p_T$ N_{ch} mean p_T
Calo clusters $\sum E_T$, $\lvert\eta\rvert < 4.8$ $\sum E_T$, $\lvert\eta\rvert < 2.5$
Jets p_T^{lead}

<Σp_T> (#ch. particles)



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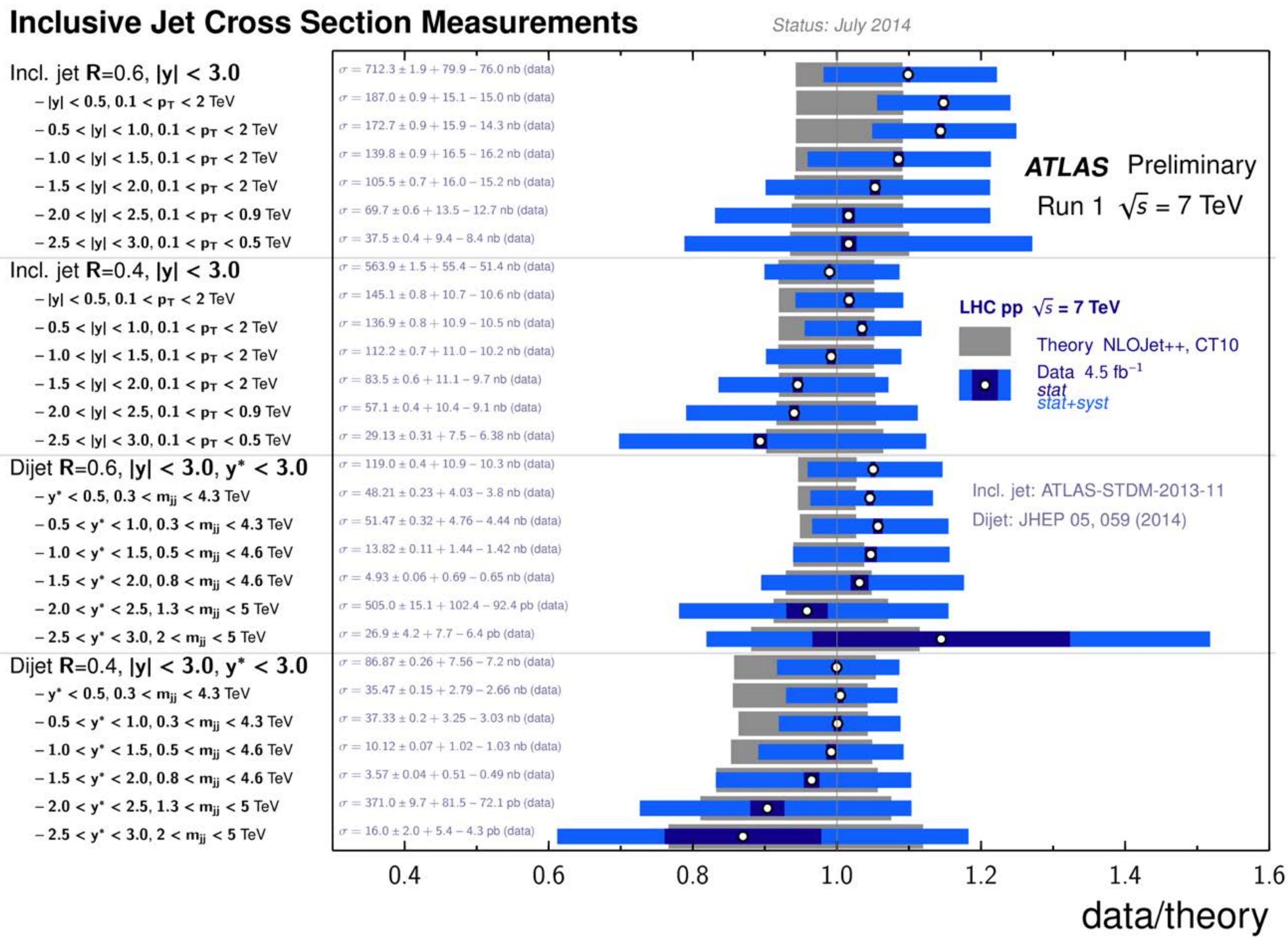
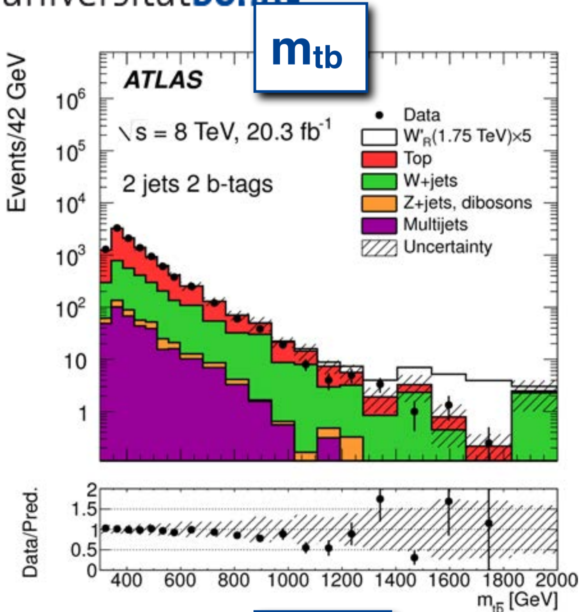
Jet Cross Sections Data/Theory

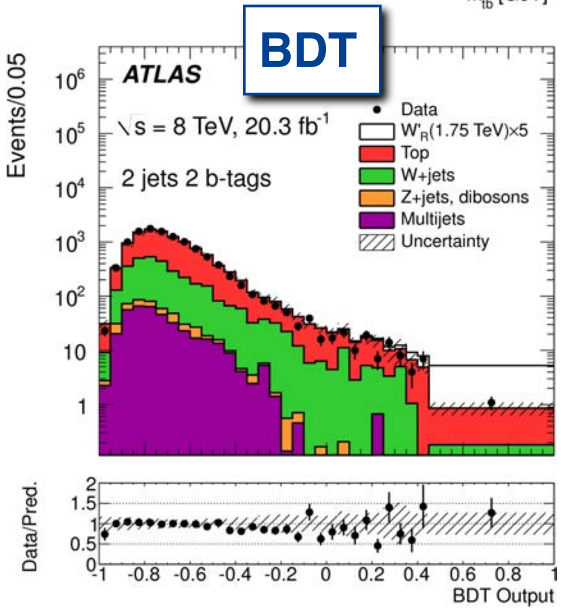


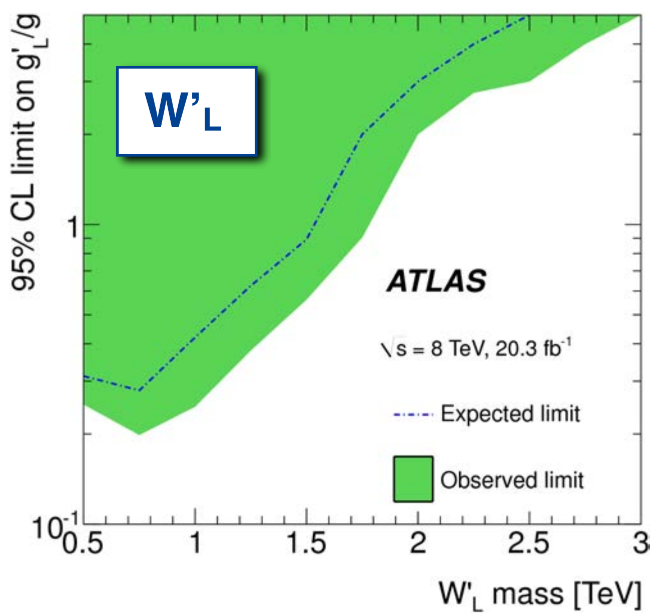
Heavy Gauge Bosons?

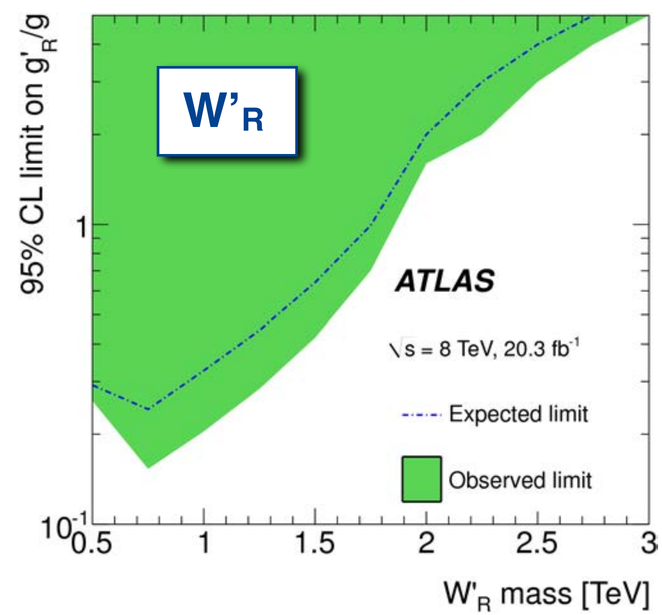
arXiv:1410.4103, subm. to PLB

- **e.g.** search for **W'→tb→lepton+jets**
- invariant top-b mass combined with other quantities into boosted decision tree
- **limits** obtained in terms of coupling and mass **for left and right-handed W'**

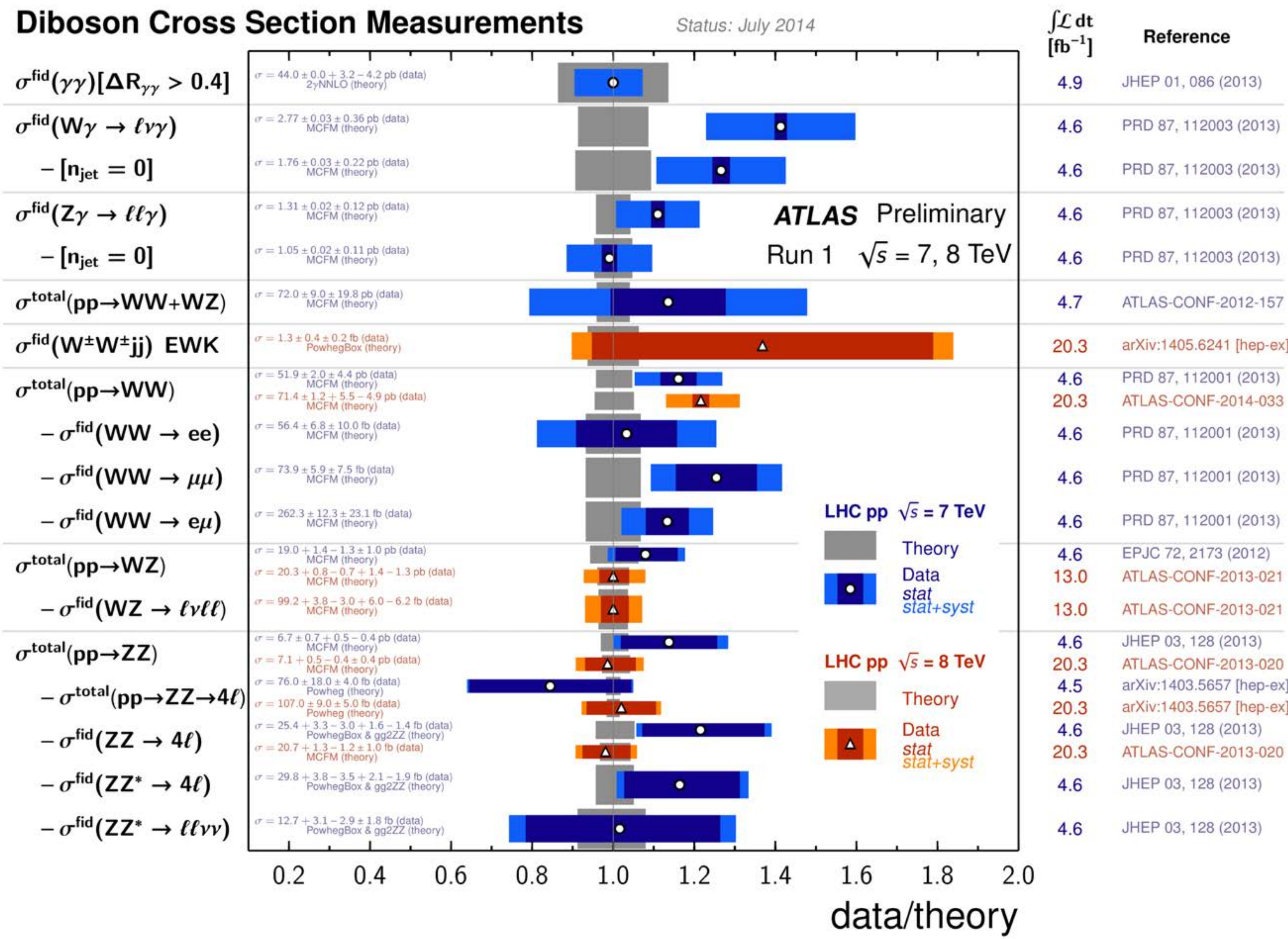




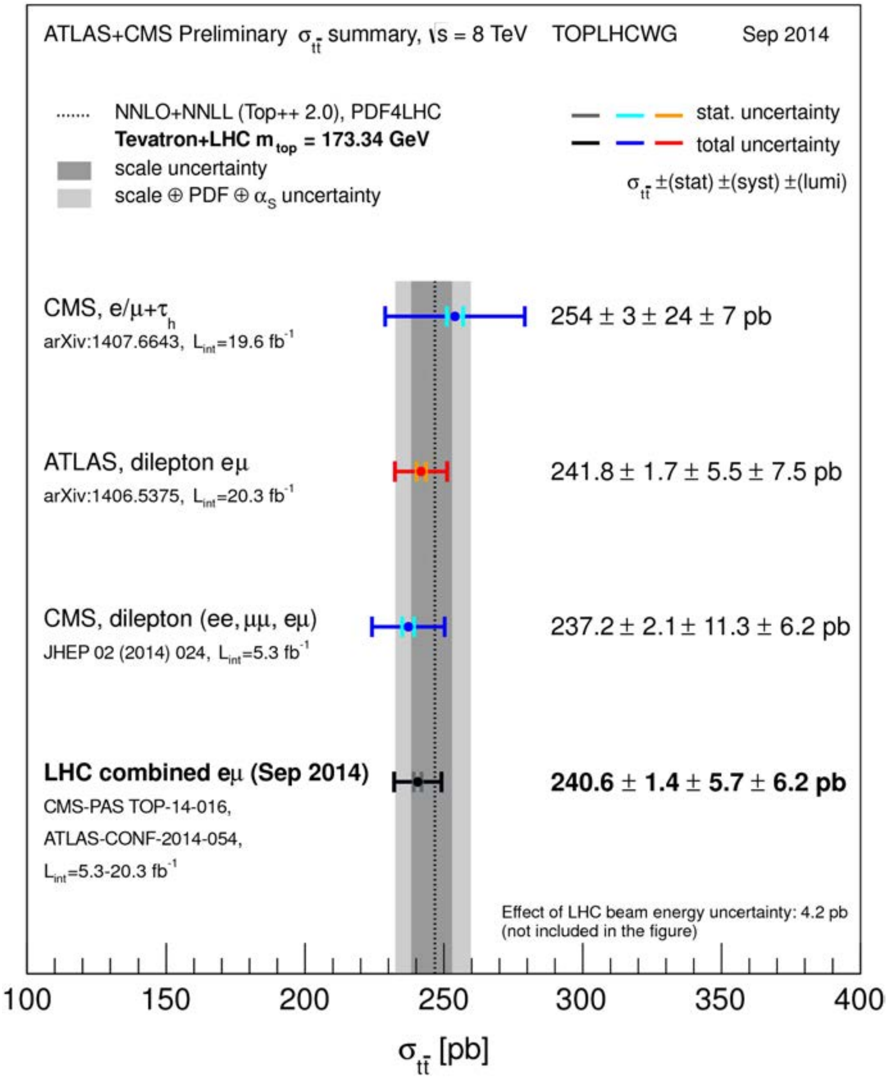


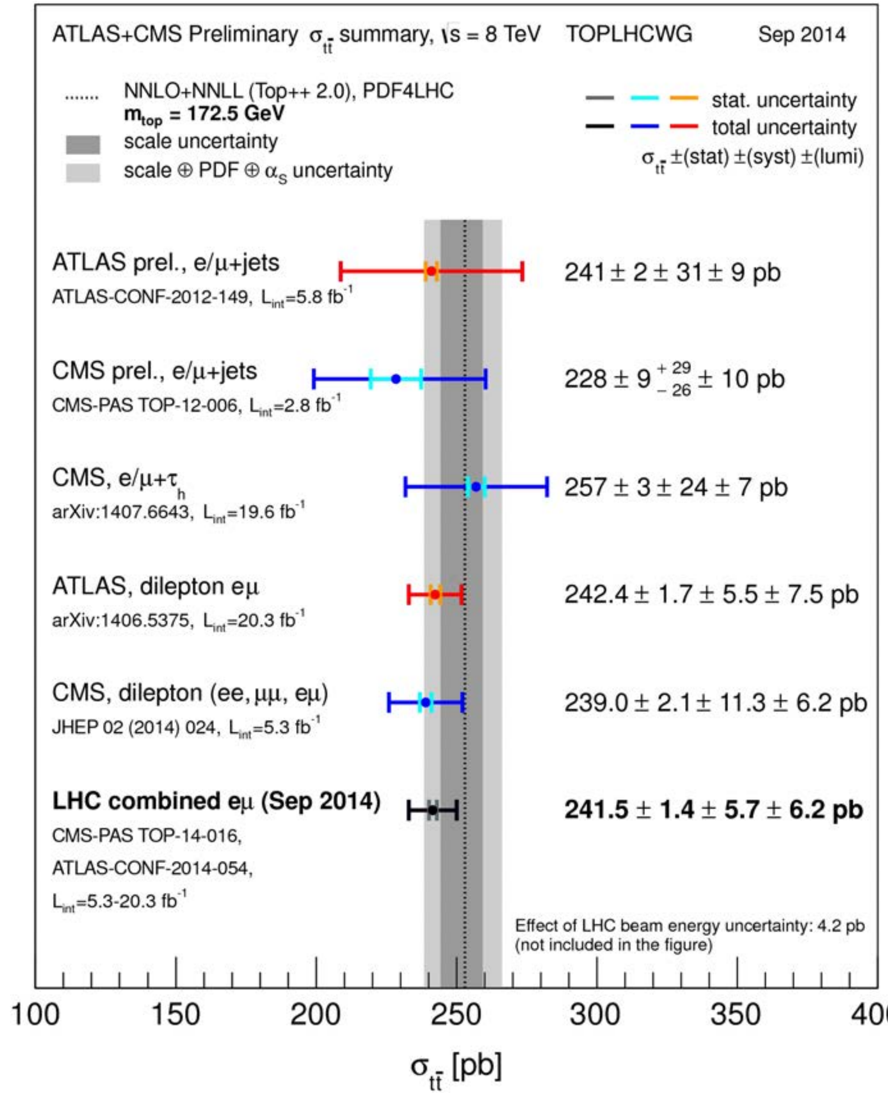


Diboson Cross Sections



Top Pair Production Cross Section





Higgs Boson Width Limit from Off-Shell ZZ Events

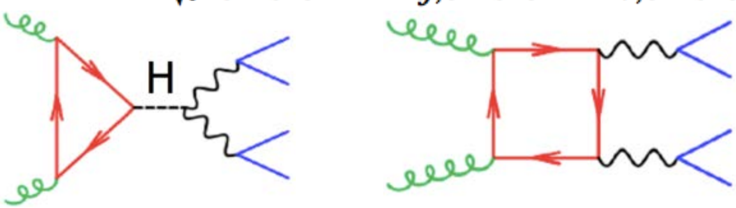
ATLAS-CONF-2014-042

$$\frac{d\sigma_{pp\to H\to ZZ}}{dM^2_{4l}} \propto \frac{g^2_{Hgg}\, g^2_{HZZ}}{(M^2_{4l}-m^2_H)^2+m^2_H\Gamma^2_H}$$

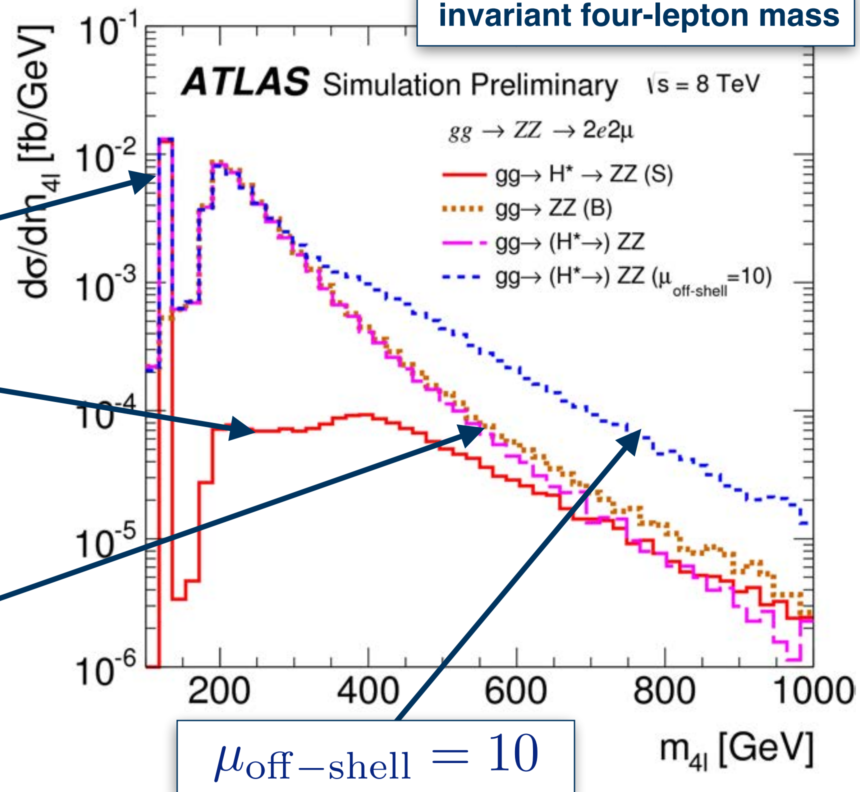
$$\sigma^{gg\to H\to ZZ}_{\text{on-shell}} \propto \mu_{\text{on-shell}} = \frac{\kappa^2_{g,\text{on-shell}}\cdot\kappa^2_{V,\text{on-shell}}}{\Gamma_H/\Gamma^{SM}_H}$$

$$\sigma^{gg\to H^*\to ZZ}_{\text{off-shell}} \propto \mu_{\text{off-shell}} = \kappa^2_{g,\text{off-shell}}\cdot\kappa^2_{V,\text{off-shell}}$$

- negative interference with gg→ZZ BG $\propto \sqrt{\mu_{\text{off-shell}}} = \kappa_{g,\text{off-shell}}\cdot\kappa_{V,\text{off-shell}}$



invariant four-lepton mass

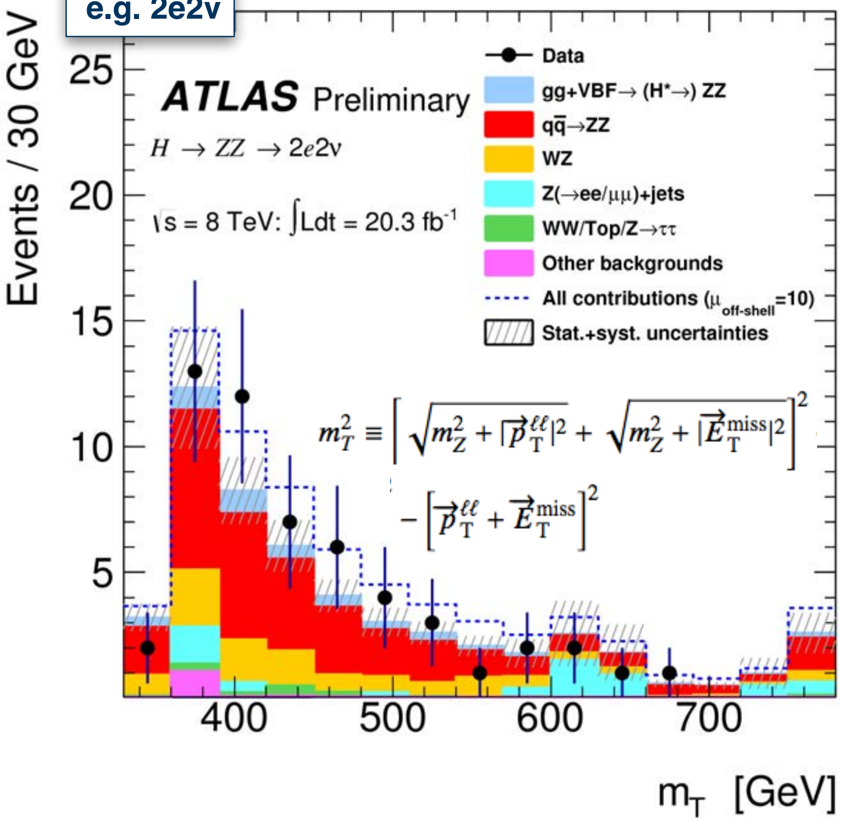


$\mu_{\text{off}-\text{shell}} = 10$

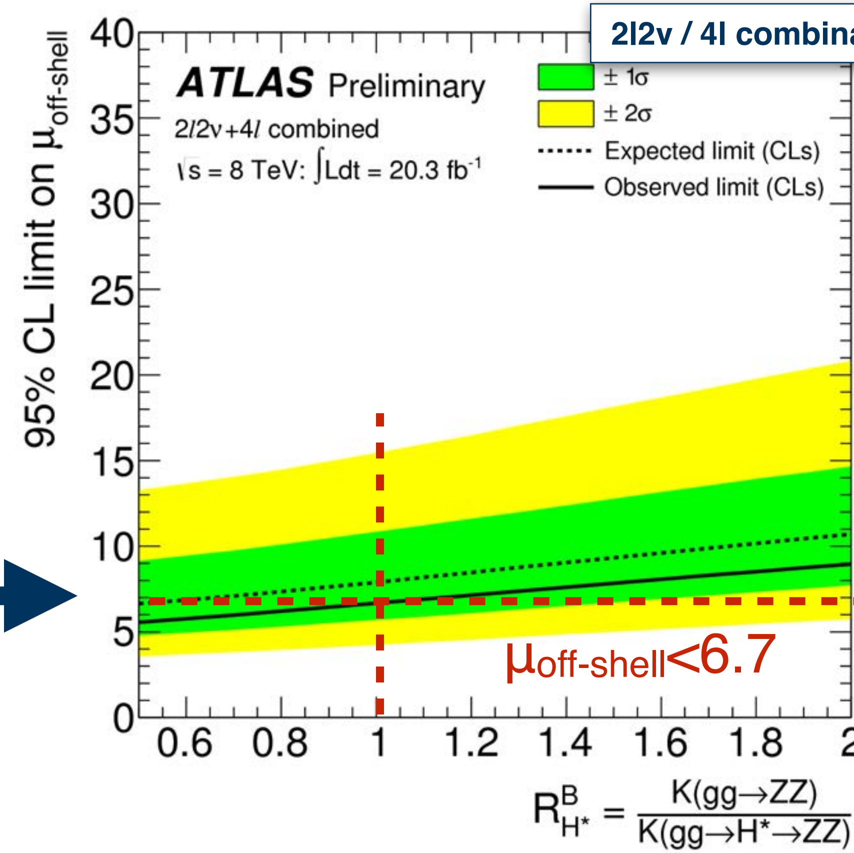
- main goal: **measure off-shell** Higgs **signal strength**
- assuming same on-shell and off-shell Higgs couplings, can use this result to **constrain the total Higgs boson width**
- analyses in two channels (**4l and 2l2v final states**)
- parallel analyses with different techniques (e.g. cut-based and ME for 4l)

Higgs Boson Width Limit from Off-Shell ZZ Events

e.g. 2e2v



2l2v / 4l combination



Γ_H/Γ_{SM}	Observed	Expected
R_H^B=0.5	4.8	7.0
R_H^B=1	5.7	8.5
R_H^B=2	7.7	12.0

- **fit $\mu_{on\text{-}shell}$** (including low-mass region)
- **assume equal** on/off-shell **coupling**
- **obtain width limit** from $\mu_{on\text{-}shell}/\mu_{off\text{-}shell}$

8TeV

The Higgs Boson as BSM Probe

- use Higgs coupling analysis to **look for BSM particles in loop-mediated production and decays**

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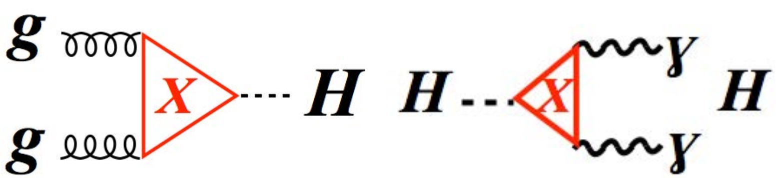

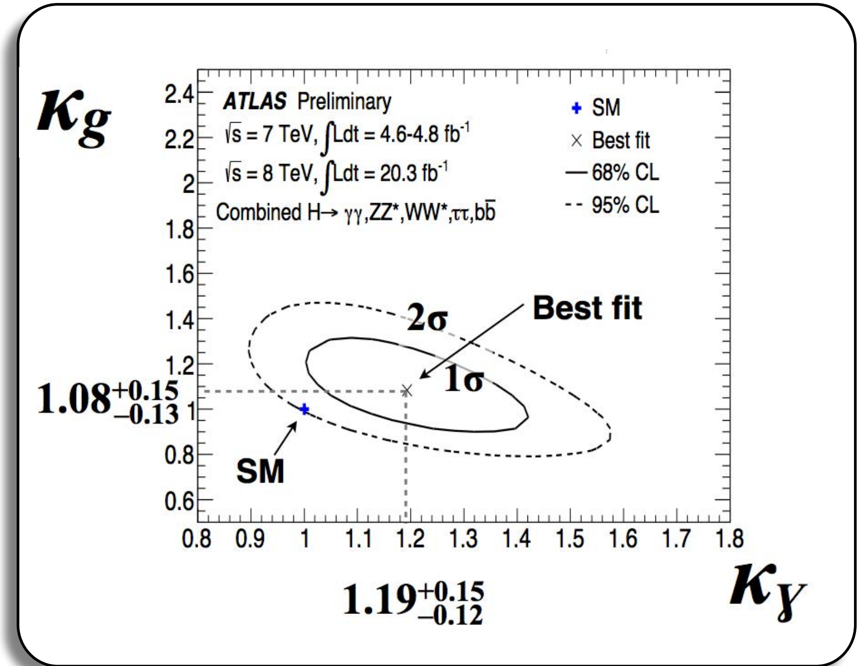

- reconsider Higgs coupling analysis in the framework of **various BSM scenarios**

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- e.g. heavy Higgs boson arising from additional EW singlet: