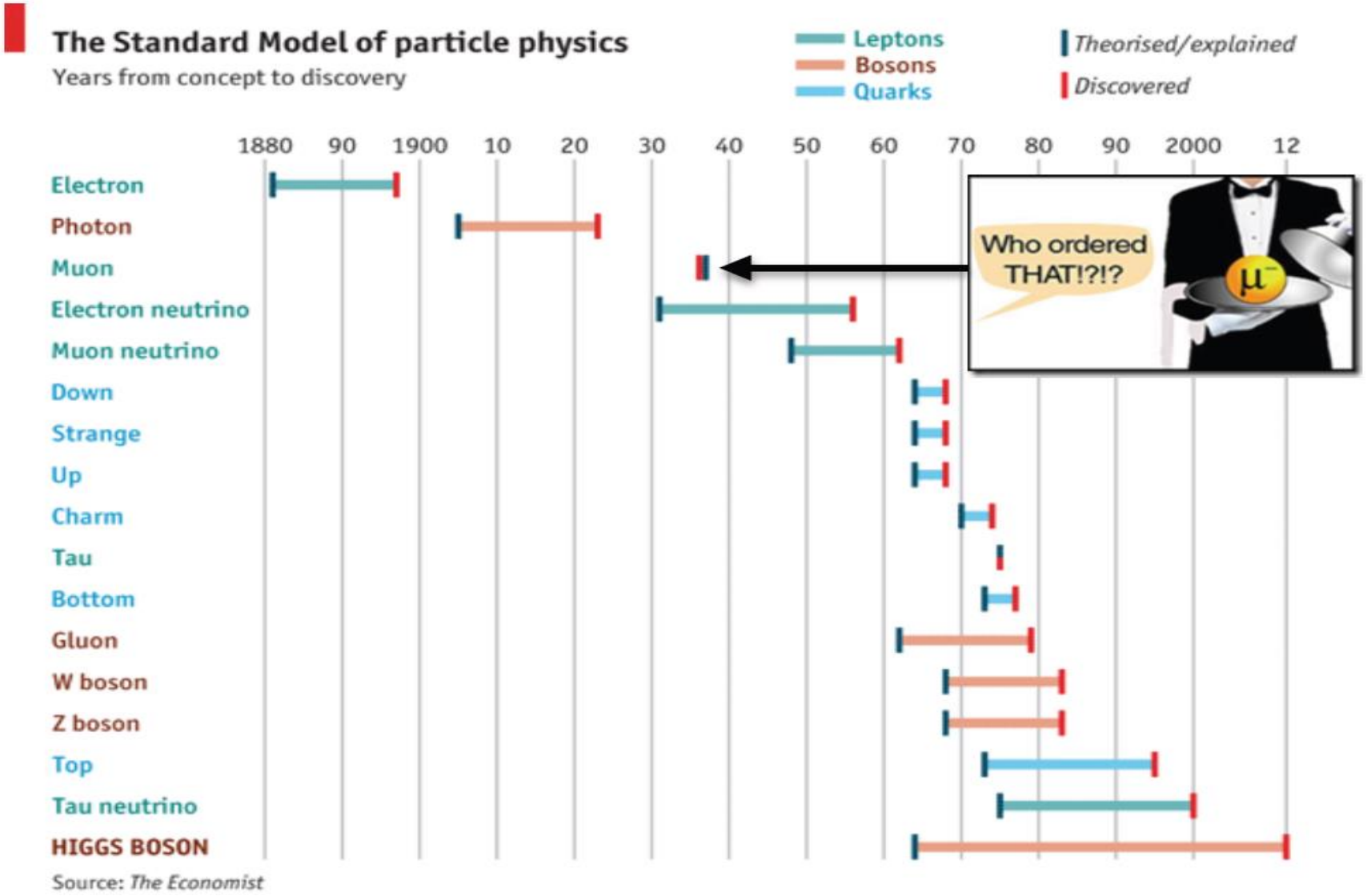
Introduction to particle physics: experimental part

Searches for New Physics

First results from Run II

Prof. dr hab. Elżbieta Richter-Wąs

Uncharted discoveries?

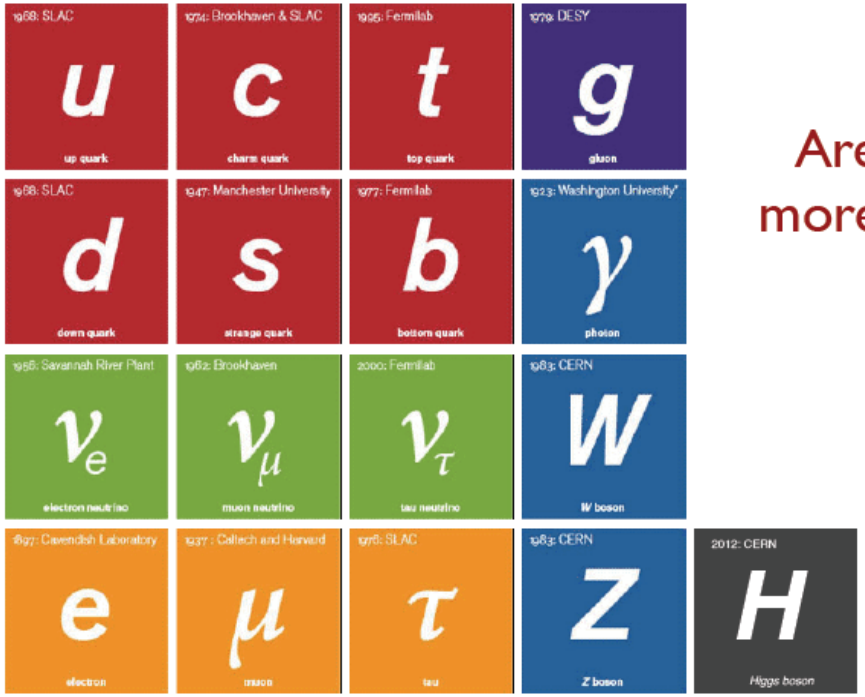


Many unanswered questions….

Why there are 3 families of particles? Are there more?

Why is the top quark so heavy?

Why there's more matter then anti-matter?



Are there more forces?

How do neutrinos get mass?

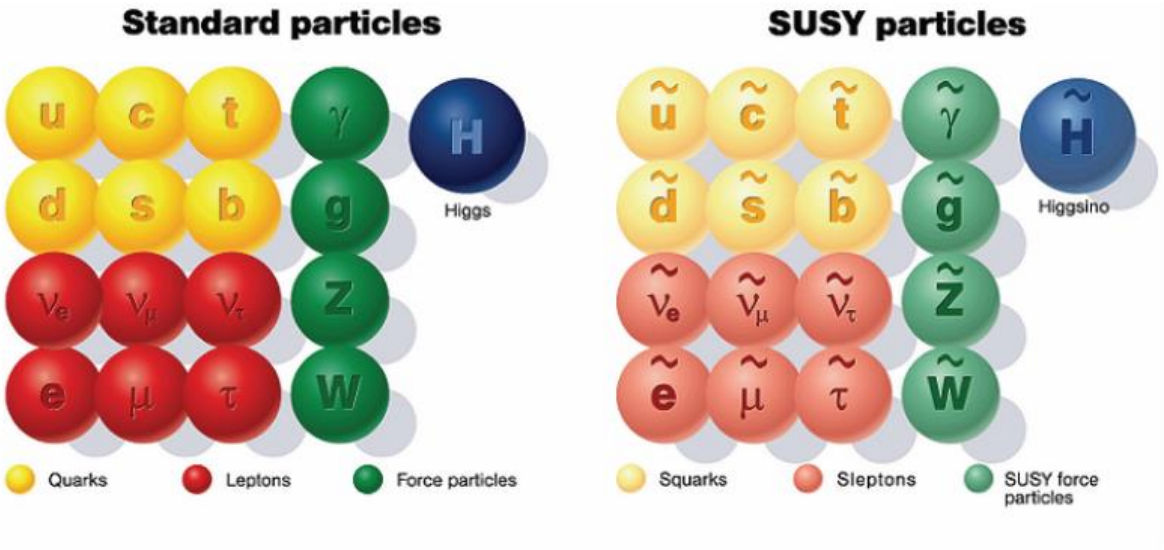
What keeps the Higgs mass so small?

How do we incorporate gravity?

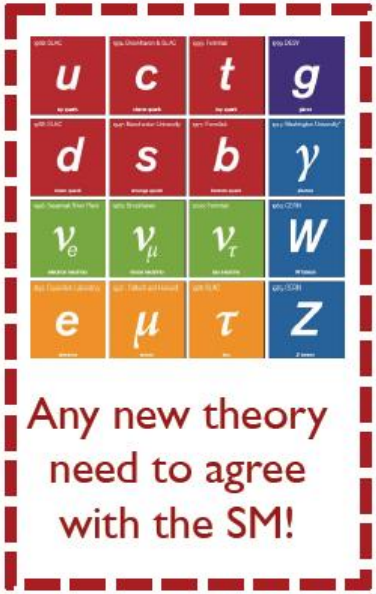
What is Dark Matter?

… as many possible answers to probe!

- Super-symmetry?



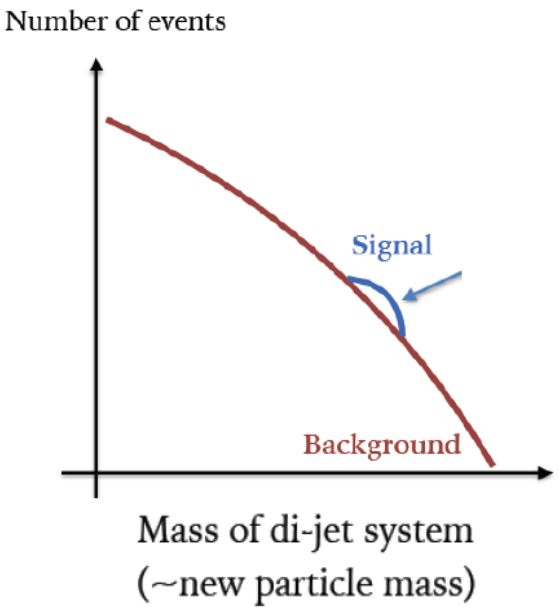
- Composite quark and/or leptons?
- New Heavy bosons?
- Gravitons?
- Dark Matter particles?
- …



How would new phenomena manifest?

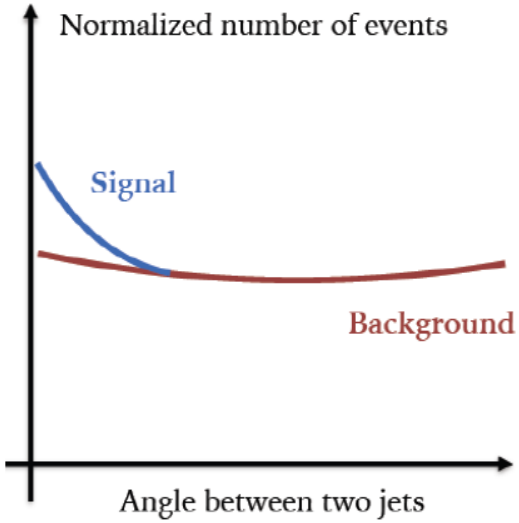
New particles:

resonant excess (bump) over Standard Model background



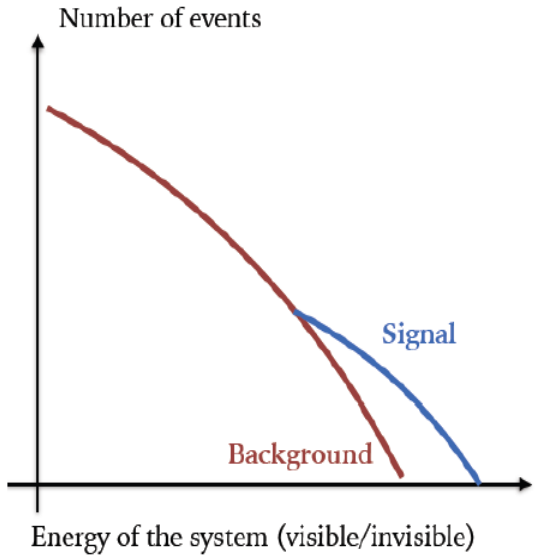
New interactions:

more central production (~Rutherford experiment)

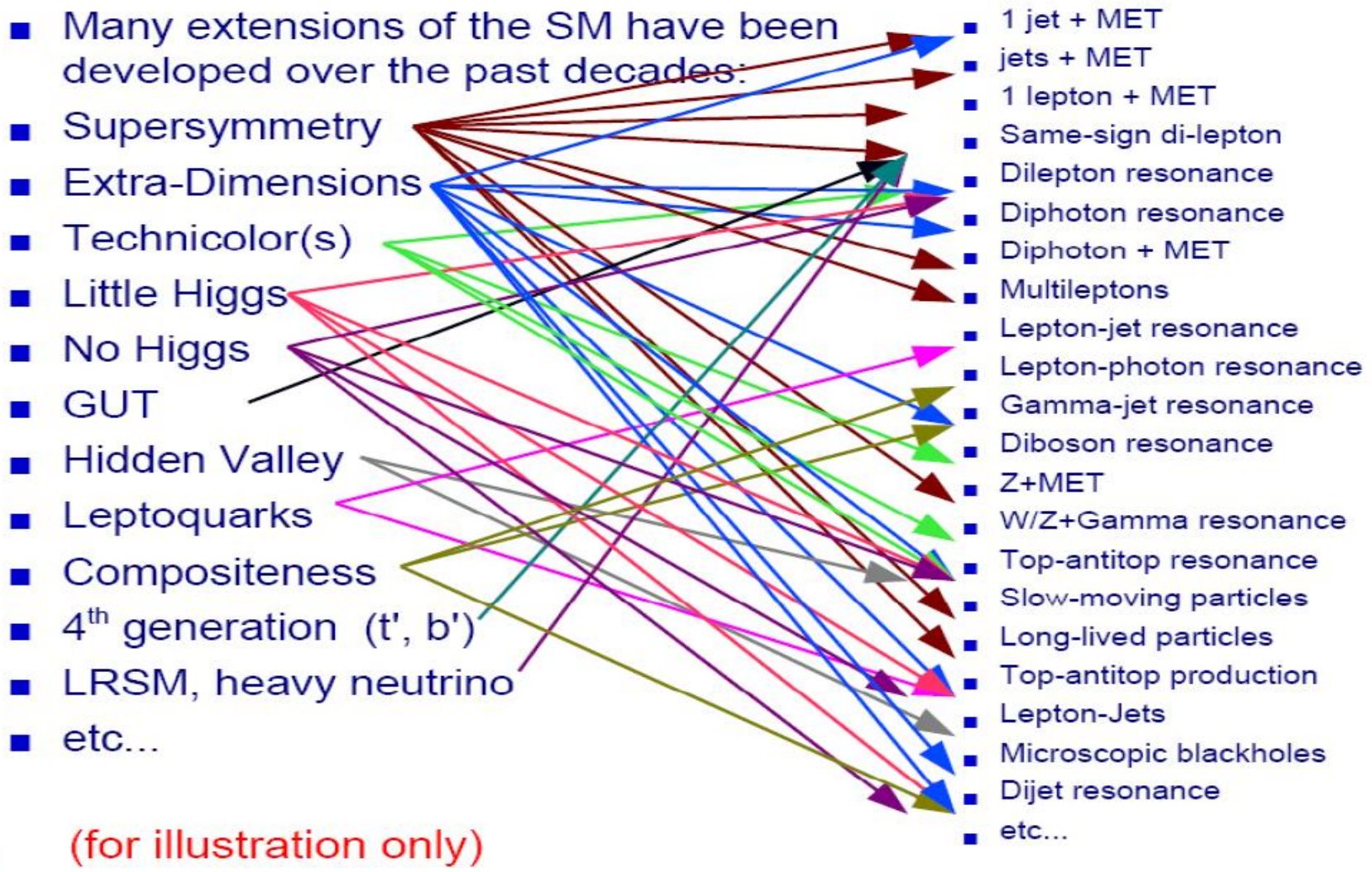


New particles and states:

larger multiplicity of objects at high masses

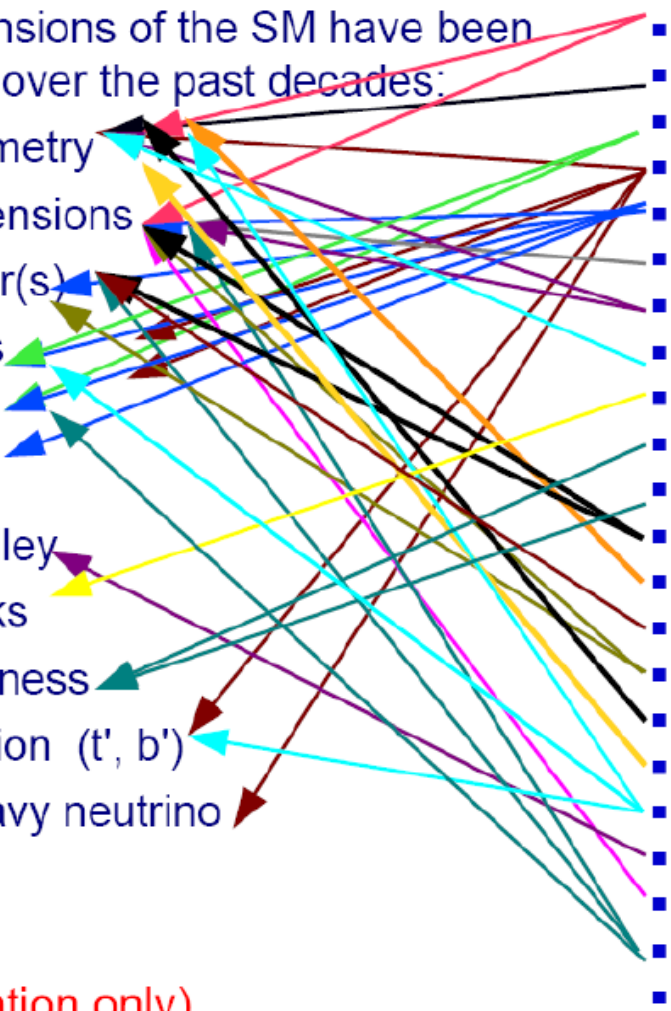


Long list of models and signatures



Long list of models and signatures

- Many extensions of the SM have been developed over the past decades:
- Supersymmetry
- Extra-Dimensions
- Technicolor(s)
- Little Higgs
- No Higgs
- GUT
- Hidden Valley
- Leptoquarks
- Compositeness
- 4th generation (t', b')
- LRSM, heavy neutrino
- etc...



- 1 jet + MET
- jets + MET
- 1 lepton + MET
- Same-sign di-lepton
- Dilepton resonance
- Diphoton resonance
- Diphoton + MET
- Multileptons
- Lepton-jet resonance
- Lepton-photon resonance
- Gamma-jet resonance
- Diboson resonance
- Z+MET
- W/Z+Gamma resonance
- Top-antitop resonance
- Slow-moving particles
- Long-lived particles
- Top-antitop production
- Lepton-Jets
- Microscopic blackholes
- Dijet resonance
- etc...

(for illustration only)

A complex 2D problem

Experimentally, a **signature standpoint** makes a lot of sense:

→ Practical

→ Less model-dependent

→ Important to cover every possible signature

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt$[fb^{-1}]	Mass limit ($\sqrt{s}$ = 7 TeV / $\sqrt{s}$ = 8 TeV)	Reference
Inclusive Searches						
MSUGRA/CMSSM	0-3 e, μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.8 TeV	1507.05525
$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 850 GeV	1405.7875
$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	20.3	$\tilde{q}$ 100-440 GeV	1507.05525
$\tilde{q}\tilde{q}, \tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$ 780 GeV	1503.03290
$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.33 TeV	1405.7875
$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	0-1 e, μ	2-6 jets	Yes	20	$\tilde{g}$ 1.26 TeV	1507.05525
$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20	$\tilde{g}$ 1.32 TeV	1501.03555
GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm$ 1.6 TeV	1407.0603
GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$ 1.29 TeV	1507.05493
GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$ 1.3 TeV	1507.05493
GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$ 1.5 TeV	1507.05493
GGM (higgsino NLSP)	2 e, μ (Z)	2 jets	Yes	20.3	$\tilde{g}$ 850 GeV	1503.03290
Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale 865 GeV	1502.01518
3rd gen. $\tilde{g}$ med.						
$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.25 TeV	1407.0600
$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	1308.1841
$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	1407.0600
$\tilde{g}\tilde{g}, \tilde{g}\to bt\tilde{\chi}_1^-$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 TeV	1407.0600
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	$\tilde{b}_1$ 100-620 GeV	1308.2631
$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$ 275-440 GeV	1404.2500
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$ 110-167 GeV 230-460 GeV	1208.4305, 1209.2102
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3	$\tilde{t}_1$ 90-191 GeV 210-700 GeV	1506.08616
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-240 GeV	1407.0608
$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$ 150-580 GeV	1403.5222
$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1+Z$	3 e, μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$ 290-600 GeV	1506.08616
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	$\tilde{\ell}$ 90-325 GeV	1403.5294
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 140-465 GeV	1403.5294
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 100-350 GeV	1407.0350
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ 700 GeV	1402.7029
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 e, μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ 420 GeV	1403.5294, 1402.7029
$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0h\tilde{\chi}_1^0, h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0$ 250 GeV	1501.07110
$\tilde{\chi}_3^0\tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$ 620 GeV	1405.5086
GGM (wino NLSP) weak prod.	1 $e, \mu+\gamma$	-	Yes	20.3	$\tilde{W}$ 124-361 GeV	1507.05493
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	1310.3675
Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^\pm$ 482 GeV	1506.05332
Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$ 832 GeV	1310.6584
Stable $\tilde{g}$ R-hadron	trk	-	-	19.1	$\tilde{g}$ 1.27 TeV	1506.05332
GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e}, \tilde{\mu})+\tau(e, \mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$ 537 GeV	1411.6795
GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$ 435 GeV	1409.5542
$\tilde{g}\tilde{g}, \tilde{\chi}_1^0\to eev/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}_1^0$ 1.0 TeV	1504.05162
GGM $\tilde{g}\tilde{g}, \tilde{\chi}_1^0\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$ 1.0 TeV	1504.05162
RPV						
LFV $pp\to\tilde{\nu}_\tau+X, \tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu, e\tau, \mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$ 1.7 TeV	1503.04430
Bilinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.35 TeV	1404.2500
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 750 GeV	1405.5086
$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu+\tau$	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 450 GeV	1405.5086
$\tilde{g}\tilde{g}, \tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 917 GeV	1405.5086
$\tilde{g}\tilde{g}, \tilde{g}\to q\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 870 GeV	1405.5086
$\tilde{g}\tilde{g}, \tilde{g}\to t_1t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$ 850 GeV	1404.2250
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	$\tilde{t}_1$ 100-308 GeV	ATLAS-CONF-2015-026
$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$	2 e, μ	2 b	-	20.3	$\tilde{t}_1$ 0.4-1.0 TeV	ATLAS-CONF-2015-015
Other						
Scalar charm, $\tilde{c}\to c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	$\tilde{c}$ 490 GeV	1501.01325

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Mass scale [TeV]

Inclusive searches

3rd gen gluino med.

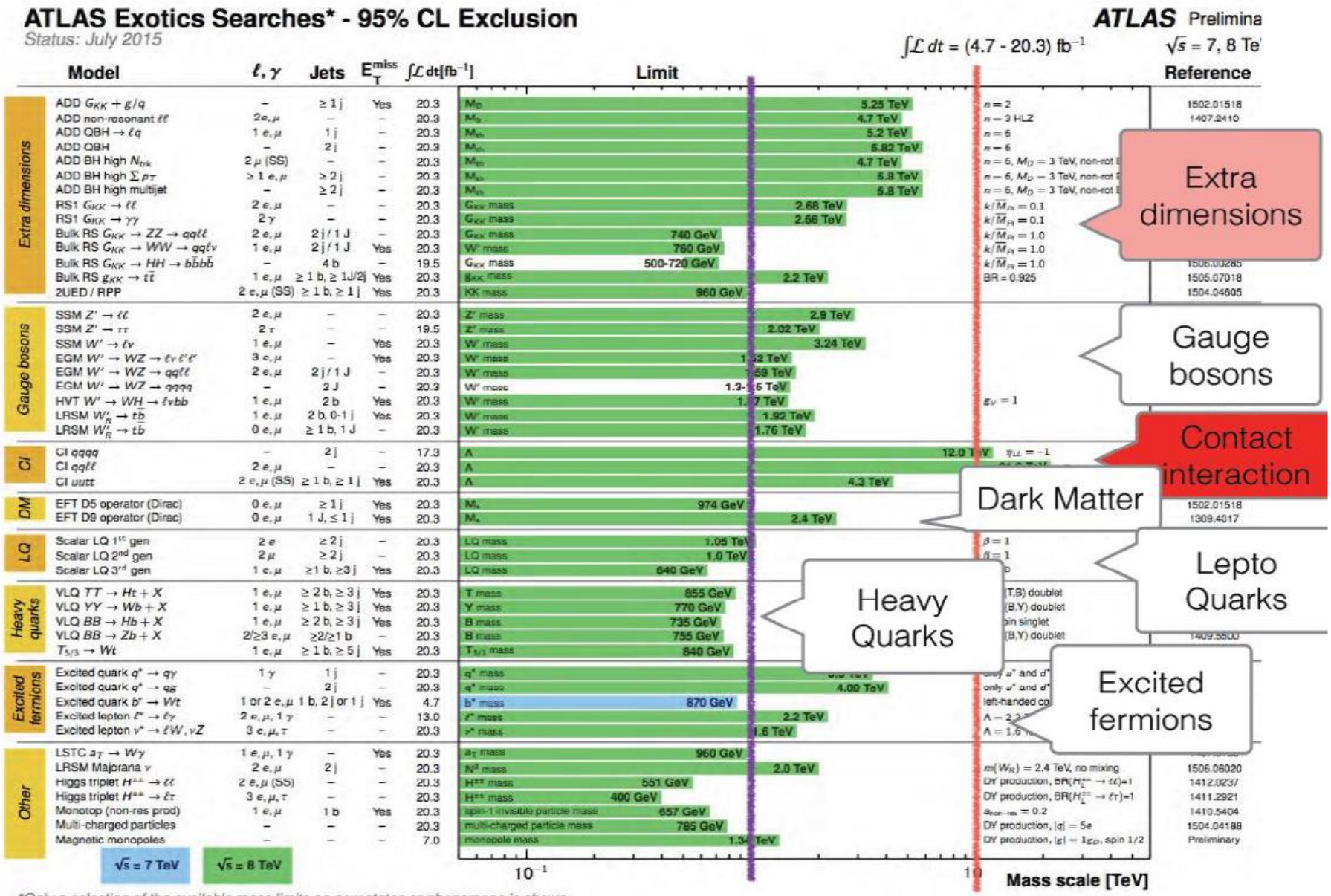
3rd gen. squarks

1 TeV

EW direct

Long-lived

RPV

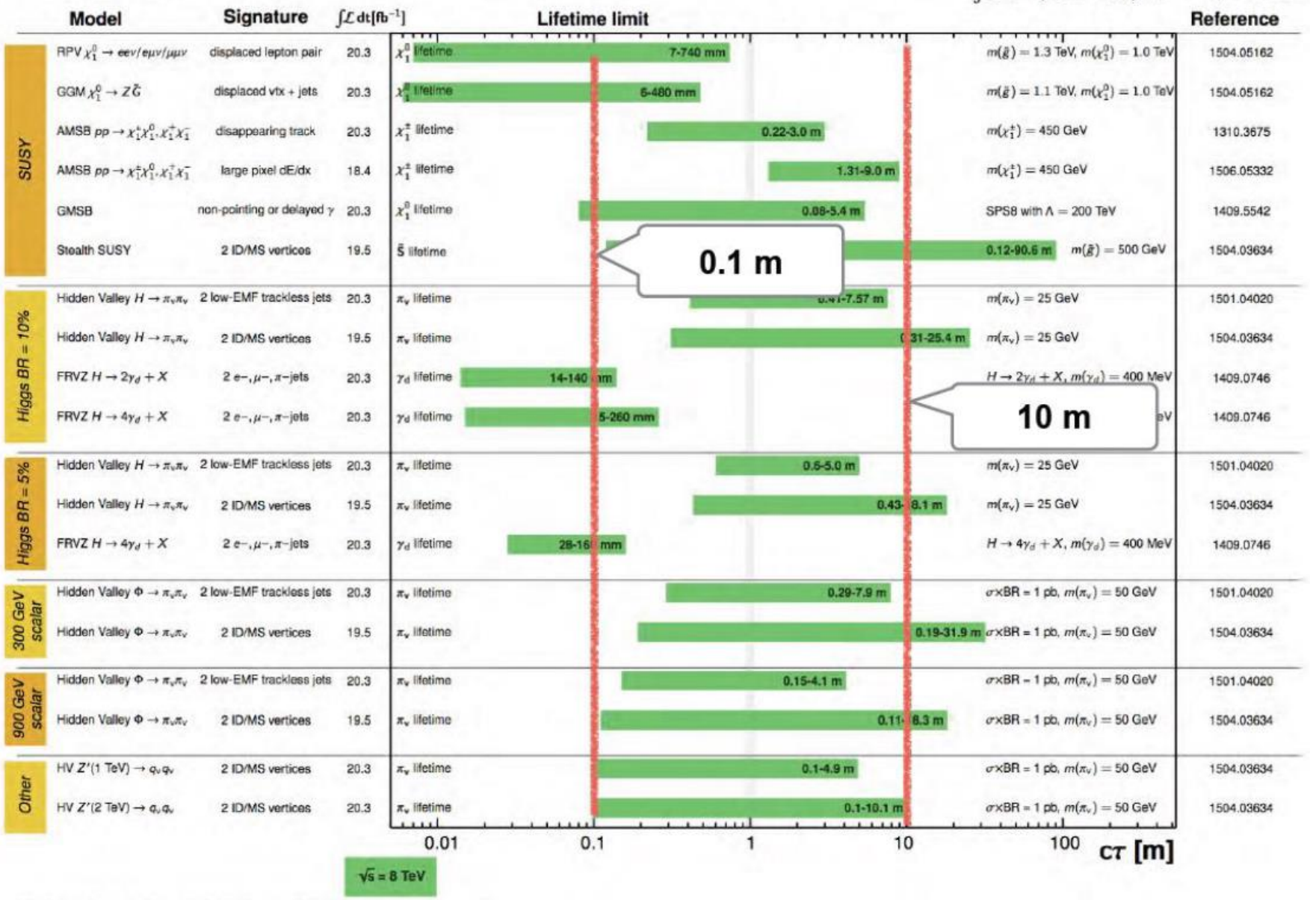

ATLAS Exotics Searches* - 95% CL Exclusion
Status: July 2015
ATLAS Preliminary
$\int \mathcal{L}\,dt$ = (4.7 - 20.3) fb^{-1}
$\sqrt{s}$ = 7, 8 TeV
Model
ℓ, γ
Jets
E_T^{miss}
$\int \mathcal{L}\,dt$[fb^{-1}]
Limit
Reference
Extra dimensions
Gauge bosons
CI
DM
LQ
Heavy quarks
Excited fermions
Other
ADD $G_{KK} + g/q$
ADD non-resonant $\ell\ell$
ADD QBH $\rightarrow \ell q$
ADD QBH
ADD BH high N_{trk}
ADD BH high $\sum p_T$
ADD BH high multijet
RS1 $G_{KK} \rightarrow \ell\ell$
RS1 $G_{KK} \rightarrow \gamma\gamma$
Bulk RS $G_{KK} \rightarrow ZZ \rightarrow qq\ell\ell$
Bulk RS $G_{KK} \rightarrow WW \rightarrow qq\ell\nu$
Bulk RS $G_{KK} \rightarrow HH \rightarrow b\bar{b}b\bar{b}$
Bulk RS $g_{KK} \rightarrow t\bar{t}$
2UED / RPP
SSM $Z' \rightarrow \ell\ell$
SSM $Z' \rightarrow \tau\tau$
SSM $W' \rightarrow \ell\nu$
EGM $W' \rightarrow WZ \rightarrow \ell\nu\ell'\ell'$
EGM $W' \rightarrow WZ \rightarrow qq\ell\ell$
EGM $W' \rightarrow WZ \rightarrow qqqq$
HVT $W' \rightarrow WH \rightarrow \ell\nu bb$
LRSM $W'_R \rightarrow t\bar{b}$
LRSM $W'_R \rightarrow t\bar{b}$
CI $qqqq$
CI $qq\ell\ell$
CI $uutt$
EFT D5 operator (Dirac)
EFT D9 operator (Dirac)
Scalar LQ 1st gen
Scalar LQ 2nd gen
Scalar LQ 3rd gen
VLQ $TT \rightarrow Ht + X$
VLQ $YY \rightarrow Wb + X$
VLQ $BB \rightarrow Hb + X$
VLQ $BB \rightarrow Zb + X$
$T_{5/3} \rightarrow Wt$
Excited quark $q^* \rightarrow q\gamma$
Excited quark $q^* \rightarrow qg$
Excited quark $b^* \rightarrow Wt$
Excited lepton $\ell^* \rightarrow \ell\gamma$
Excited lepton $\nu^* \rightarrow \ell W, \nu Z$
LSTC $a_T \rightarrow W\gamma$
LRSM Majorana ν
Higgs triplet $H^{\pm\pm} \rightarrow \ell\ell$
Higgs triplet $H^{\pm\pm} \rightarrow \ell\tau$
Monotop (non-res prod)
Multi-charged particles
Magnetic monopoles
$\sqrt{s}$ = 7 TeV
$\sqrt{s}$ = 8 TeV
Extra dimensions
Gauge bosons
Contact interaction
Dark Matter
Lepto Quarks
Heavy Quarks
Excited fermions
10^{-1}
1
10
Mass scale [TeV]
1 TeV
10 TeV
*Only a selection of the available mass limits on new states or phenomena is shown.

ATLAS Long-lived Particle Searches* - 95% CL Exclusion

Status: July 2015

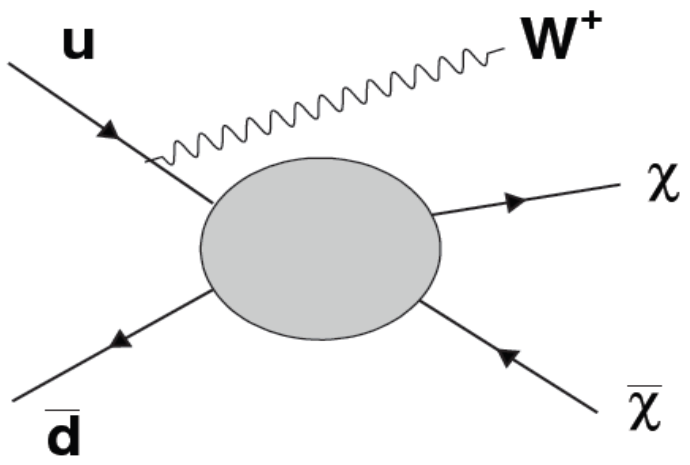
ATLAS Preliminary

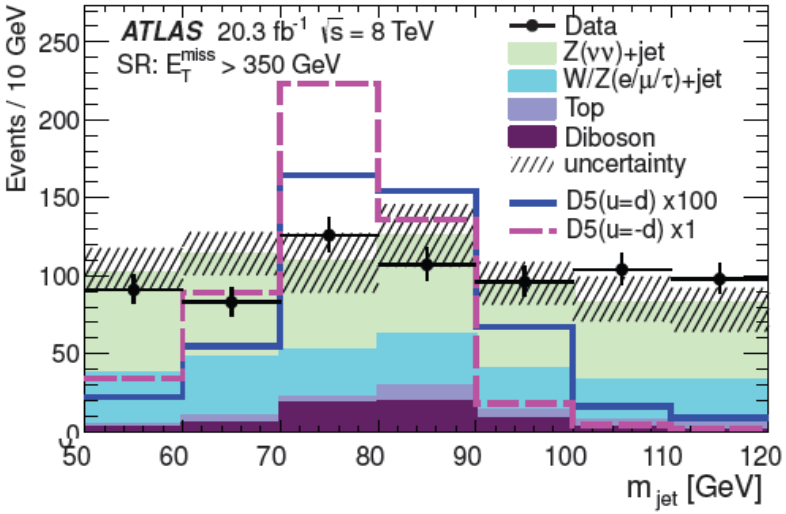
$\int \mathcal{L}\,dt$ = (18.4 - 20.3) fb^{-1} $\sqrt{s}$ = 8 TeV



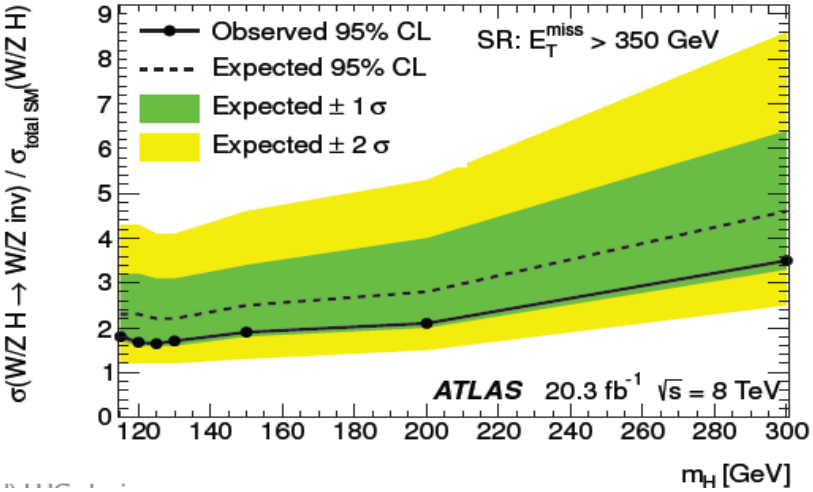
*Only a selection of the available lifetime limits on new states is shown.

ATLAS dark matter search





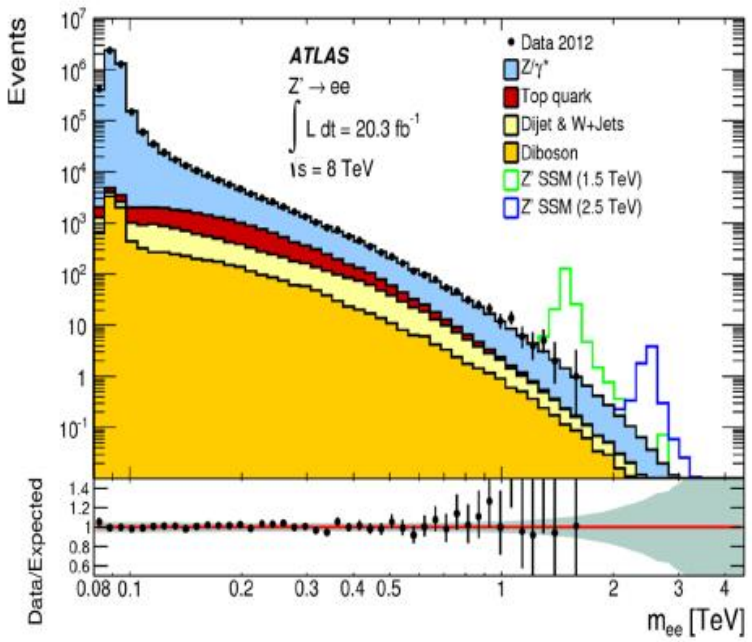
- Pair production of WIMPs plus W or Z bosons decaying and reconstructed as a single massive jet in association with large missing transverse momentum from the undetected WIMPS particles
- The interaction is unknown…
  - ✓ But this doesn't stop the search!



New heavy W and Z like particles

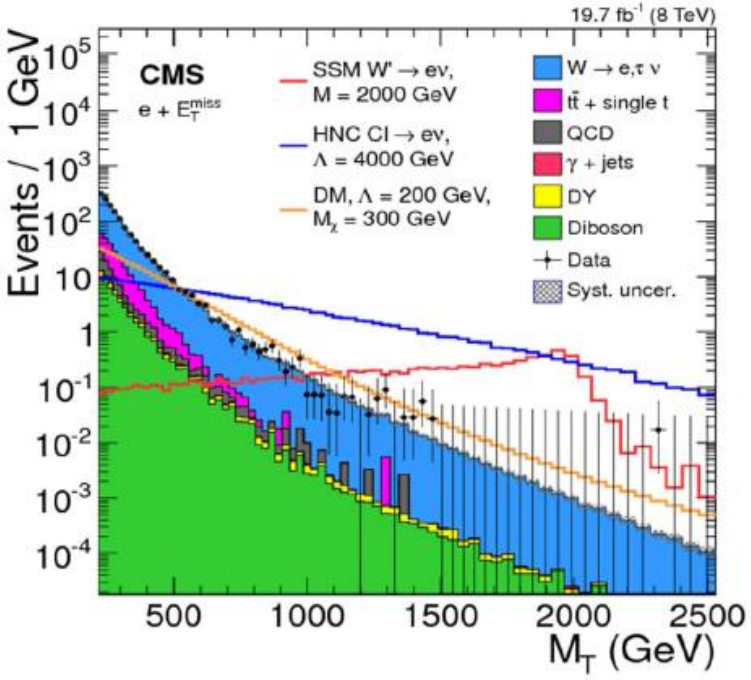
These searches are quite straight-forward, following basically the same analyses as for the familiar W and Z bosons

Z': Di-lepton pairs



Phys. Rev. D 90 (2014) 052005

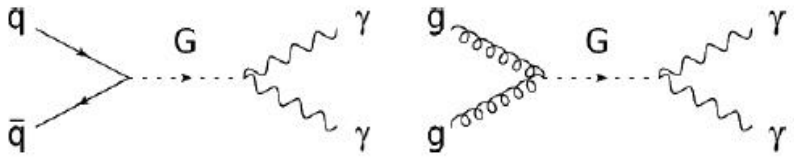
W': Lepton + ETmiss

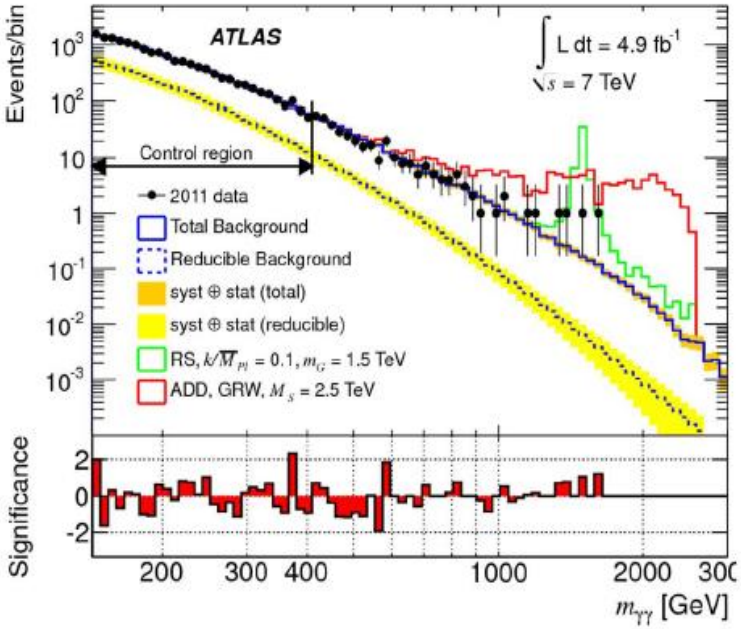


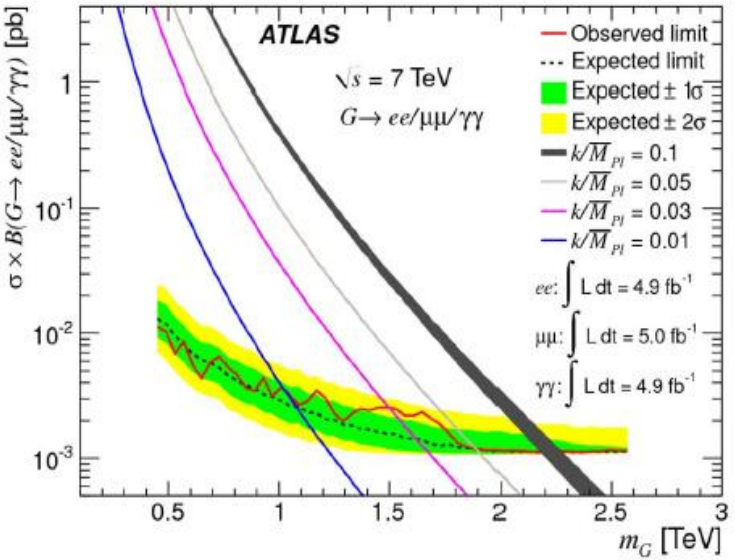
arXiv:1408.2745v1[hep-ex] sub. to Phys. Rev. D

New particles decaying into two photons

Example for a search of extra dimension signals (Kaluza-Klein Graviton in the Randall-Sundrum and Arkani-Hamed, Dimopoulos and Dvali models)





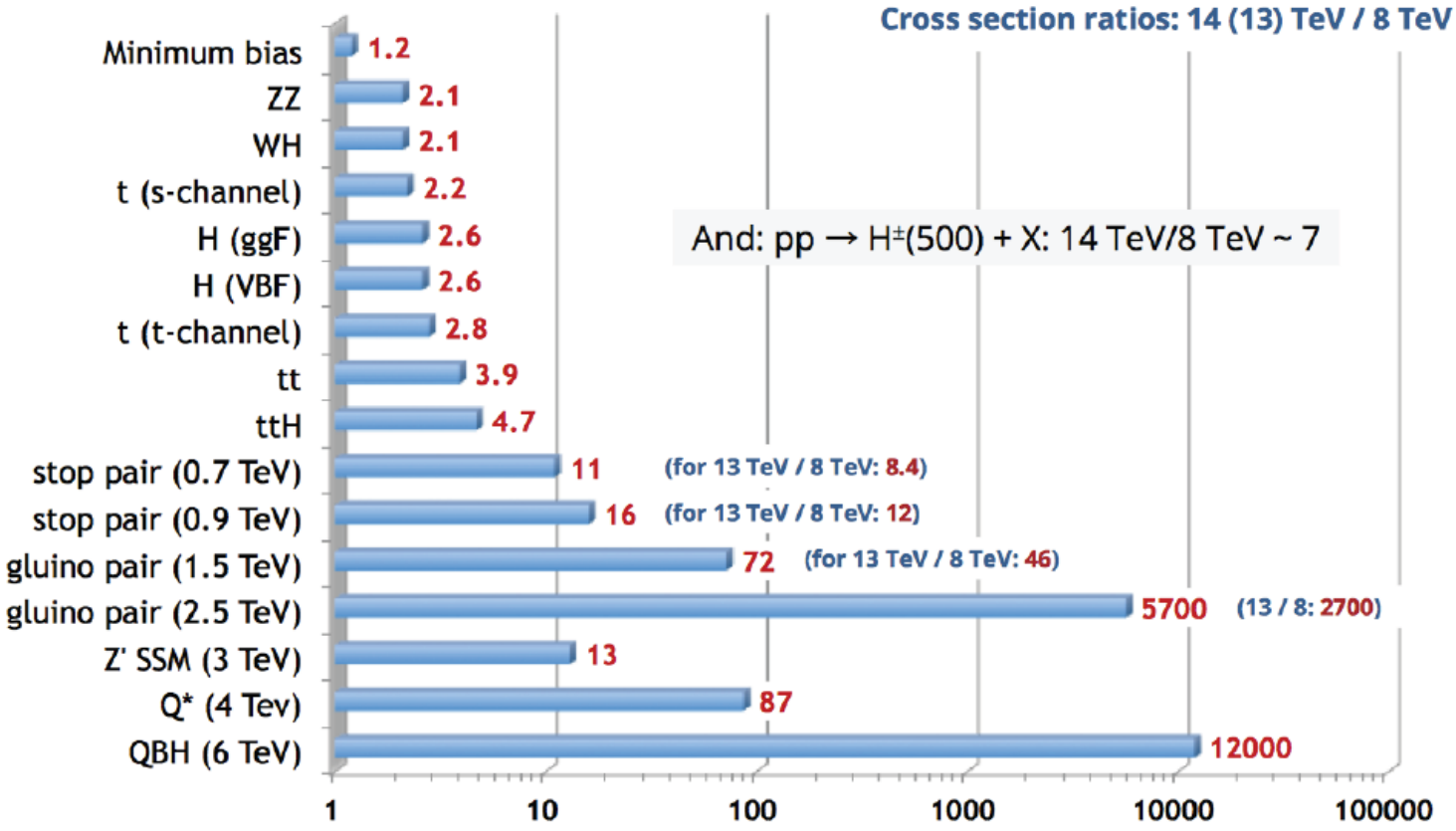


New J Phys 15 (2013) 043007

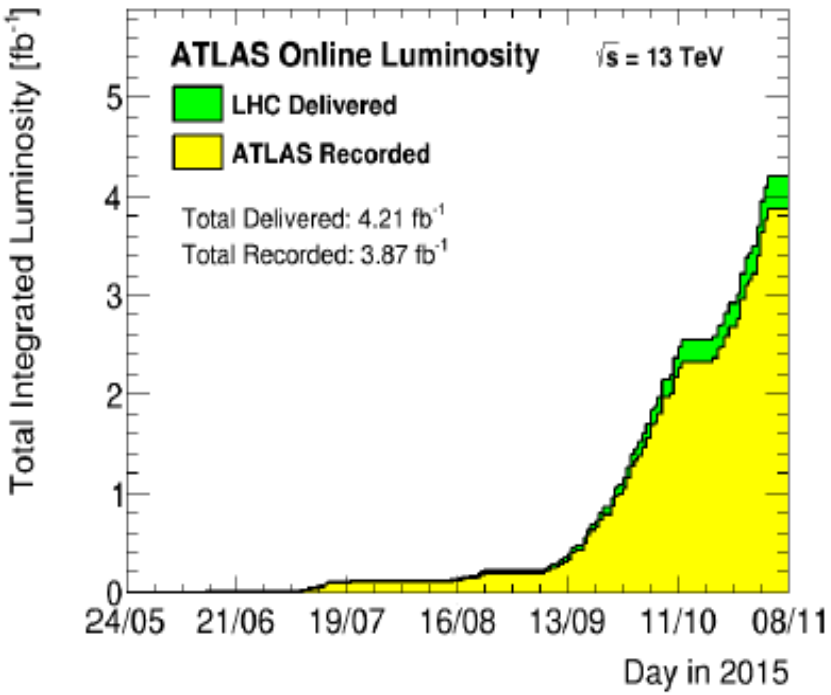
LHC Run 2

Hugely increased potential for discovery of heavy particles at 13 TeV

Perfect occasion for young motivated physicists: join the search!

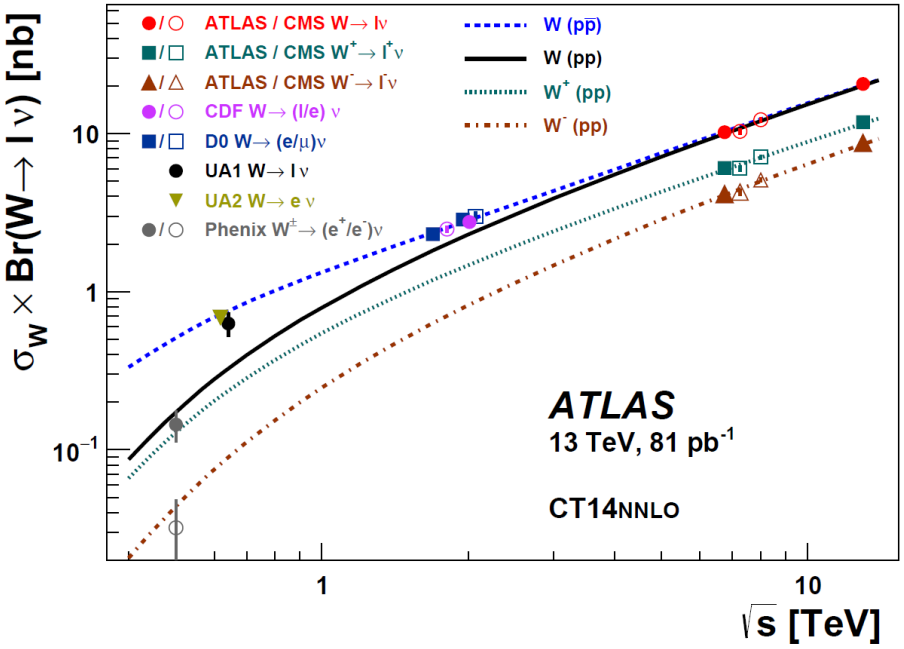


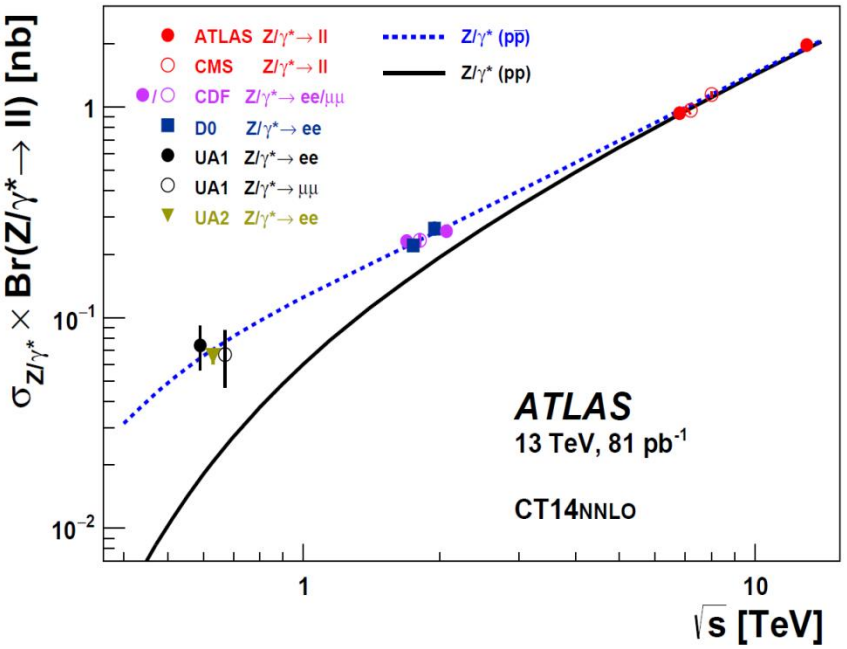
Summarizing 2015 for ATLAS

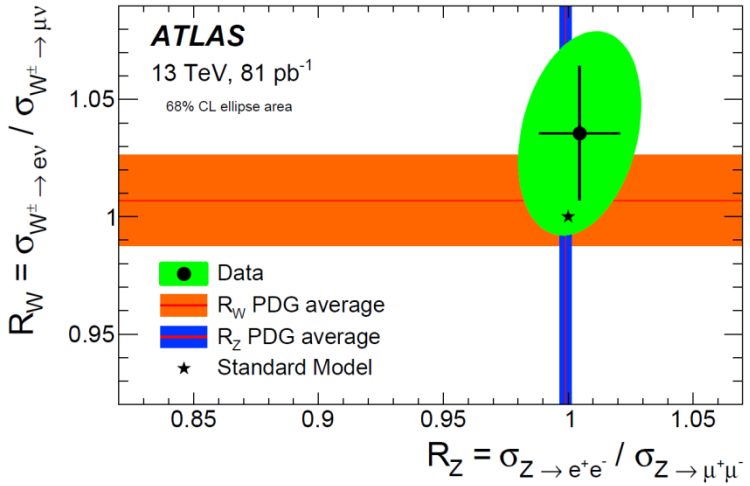


- important to understand background control regions
- but also essential to keep "eyes wide open" for possible signals

W, Z cross-section at 13 TeV







Glimpse at the Higgs in the discovery channels

Mass taken to be ATLAS-CMS Combined value ***(PRL 114, 191803)***: $m_H = 125.09 \pm 0.24\ GeV$

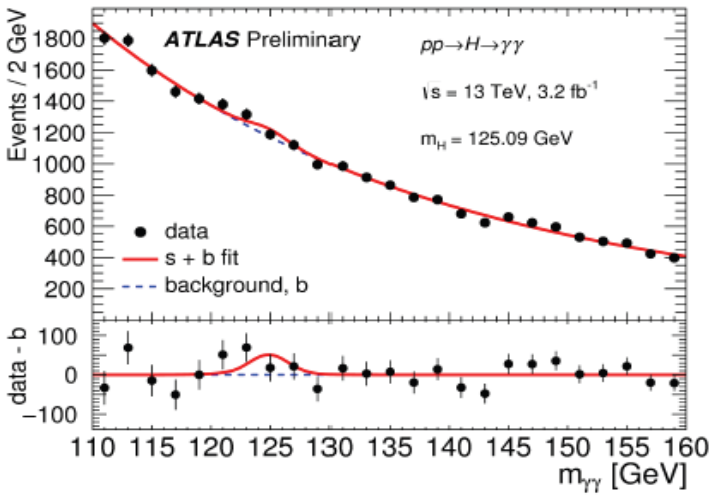
Diphoton Channel

Fully inclusive analysis

- Photon ET thresholds: 0.25 $m_{\gamma\gamma}$ and 0.35 $m_{\gamma\gamma}$
- Track and Calorimeter based isolation criteria
- Simple fit function for background estimate
- **Number of candidate events fitted**:
  113 ± 74 (stat) +43/-25 (syst)

Sensitivity to SM Higgs: **1.9σ** (Observed **1.5σ**)

ATLAS-CONF-2015-060



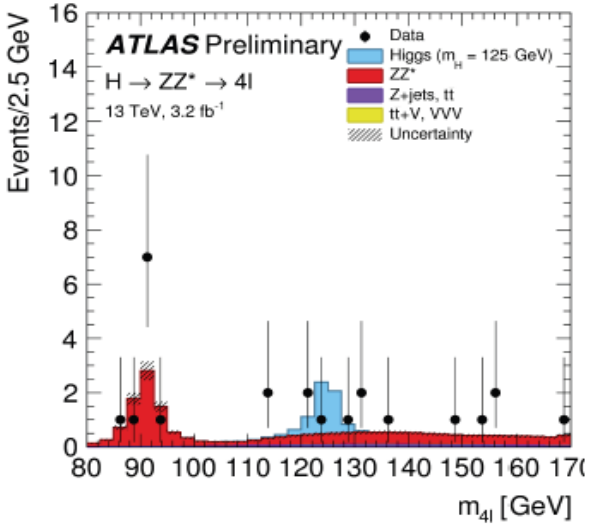
Four lepton Channel

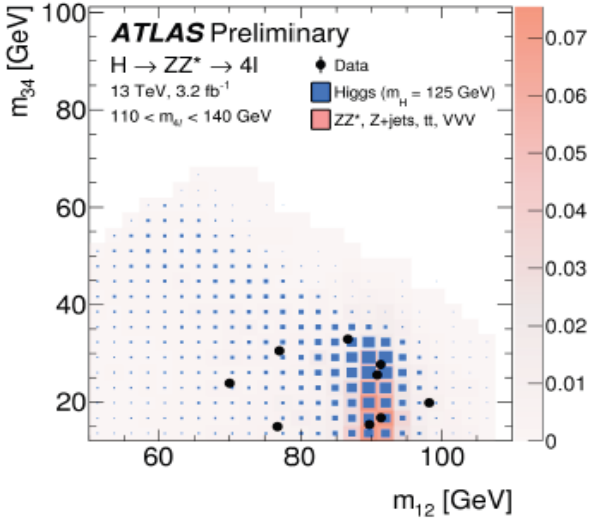
Fully Inclusive analysis

- Electron pT thresholds: 6, 10, 15, 20 GeV
- Muon pT thresholds: 7, 10, 15, 20 GeV
- Irreducible background (ZZ) from MC
- Reducible from CRs (from Isolation and IP)
- **Nb of candidates in [120,130] GeV**: **4**
- **From fit**:
  1.0 +2.3/-1.5

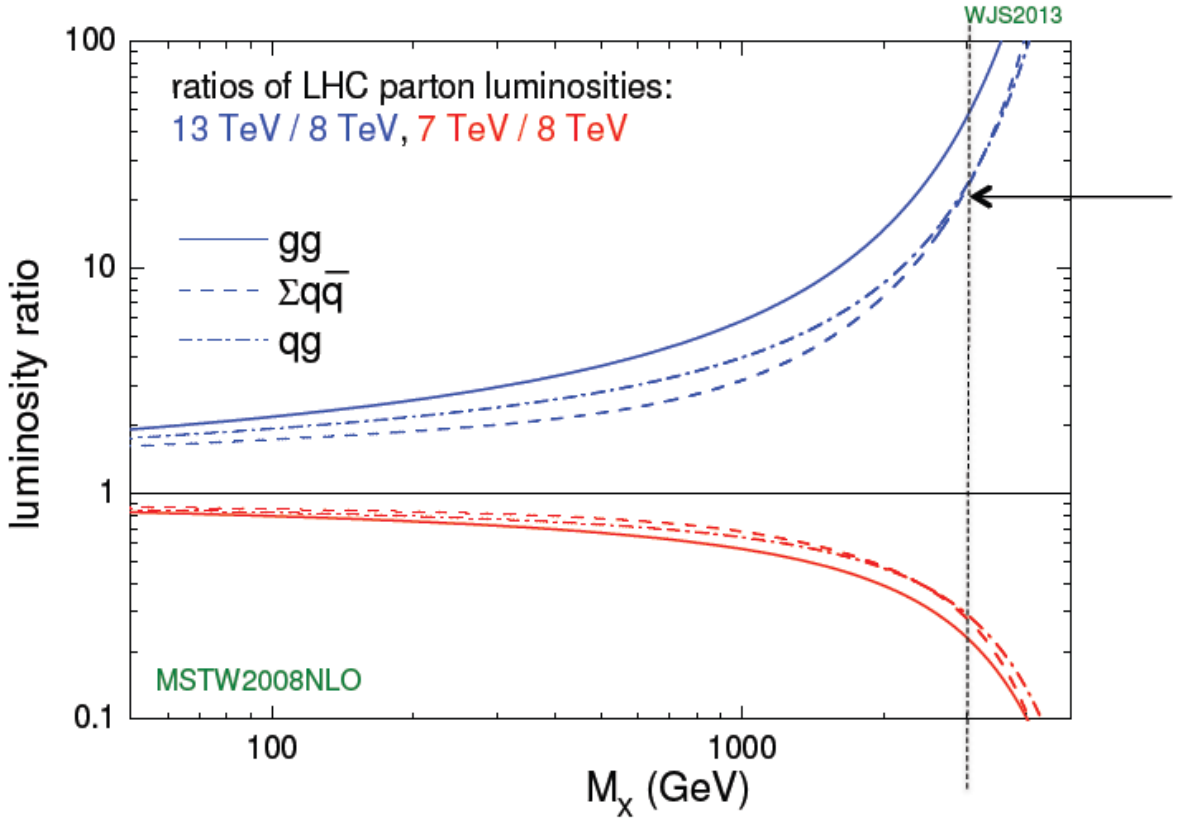
Sensitivity to SM Higgs: **2.8σ**
(Observed **0.7σ**)

ATLAS-CONF-2015-059





Early searches for New Phenomena



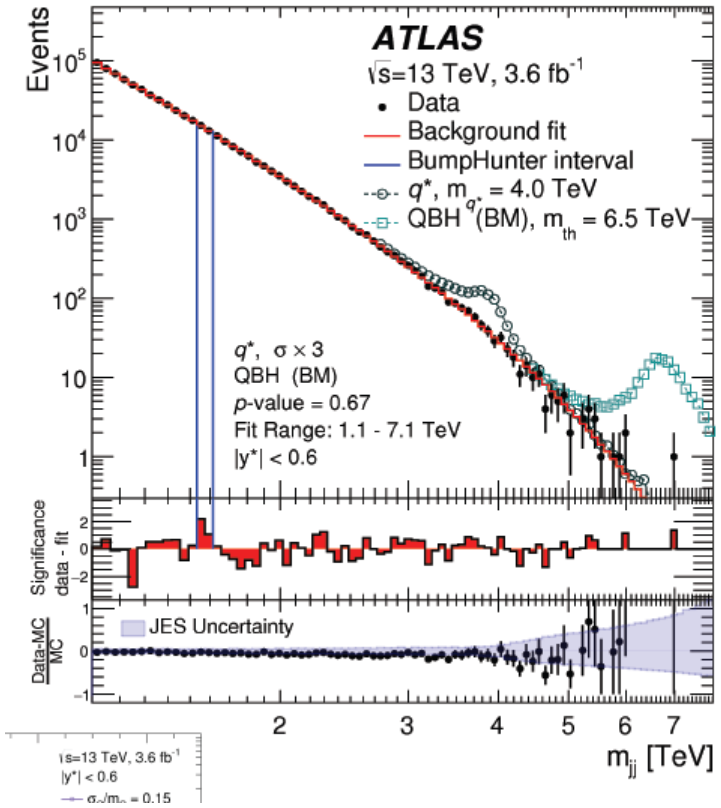
Ratio of 13 TeV / 8 TeV
Cross sections:

- Z' at 3 TeV: **20**
- q* at 4 TeV: **56**
- QBH at 5 TeV: **370**
- QBH at 6 TeV: **9000**

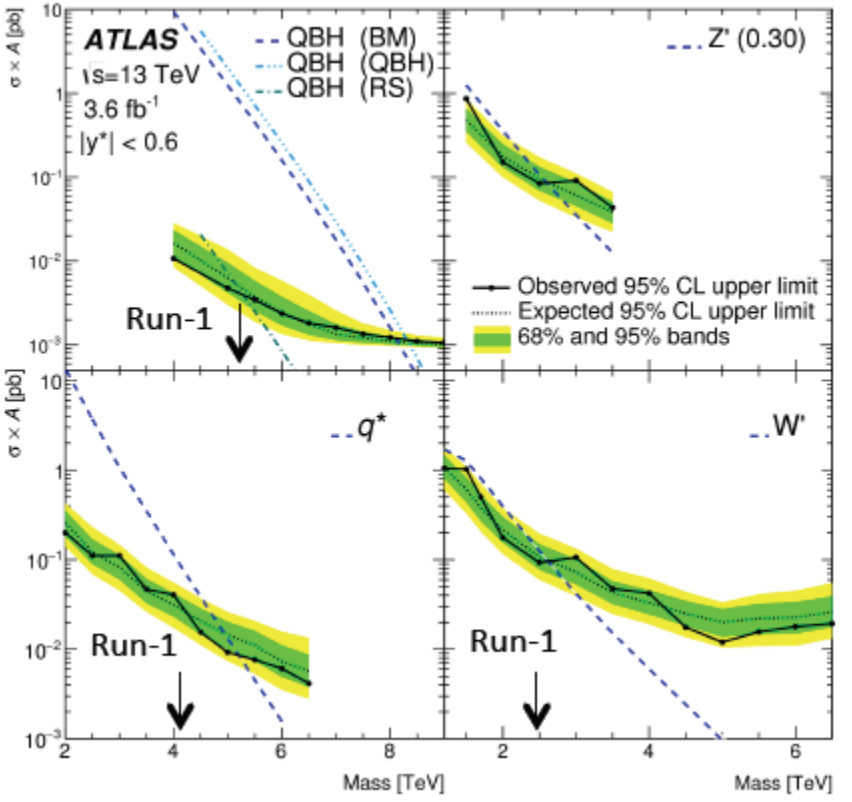
Dijet Resonant Searches

1512.01530

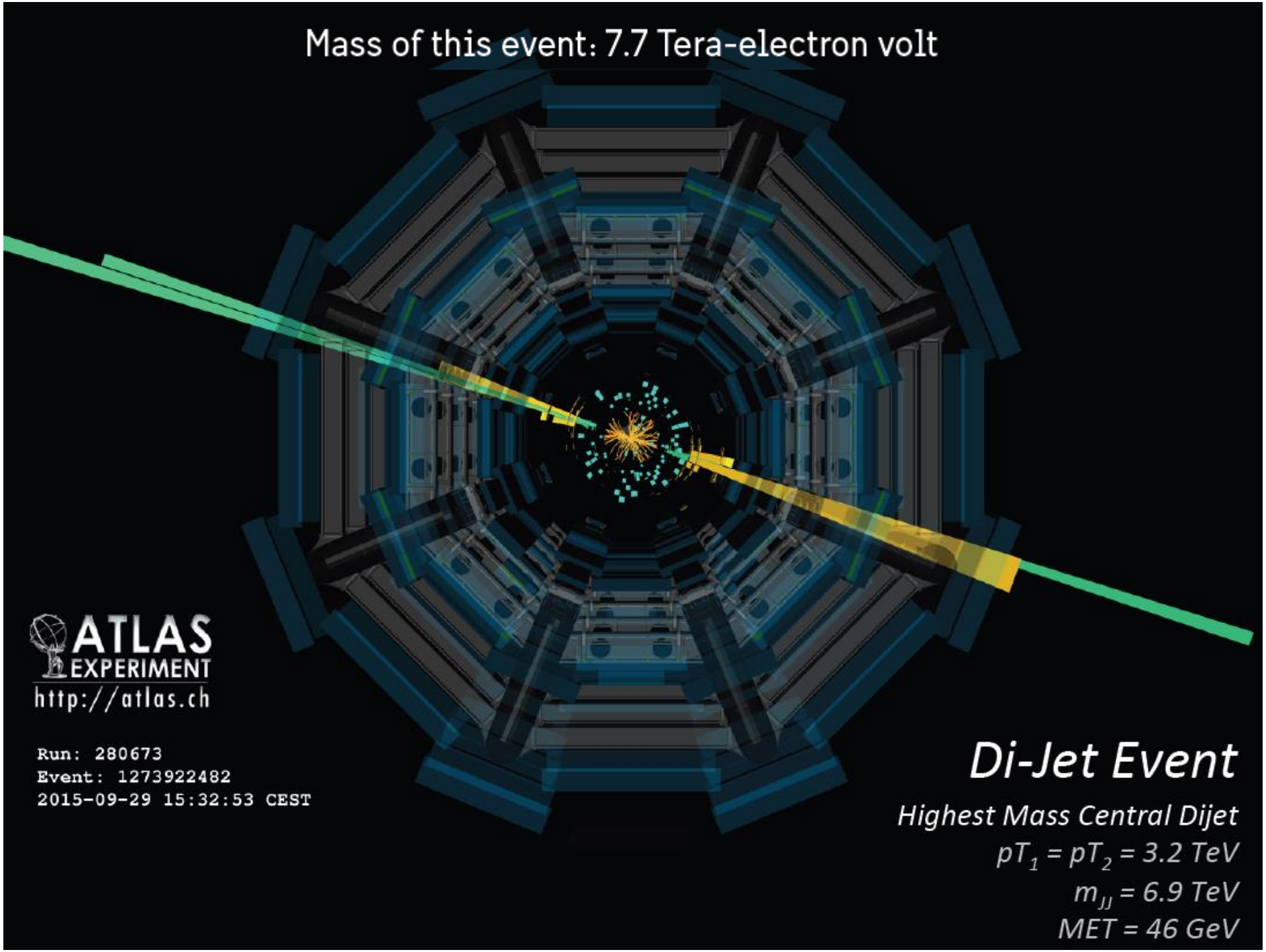
- Sensitive to Quantum Black Holes, Excited quarks, W', Z'



No significant excess found



Limits on QBH reaching 8 TeV


Mass of this event: 7.7 Tera-electron volt
ATLAS
EXPERIMENT
http://atlas.ch
Run: 280673
Event: 1273922482
2015-09-29 15:32:53 CEST
Di-Jet Event
Highest Mass Central Dijet
$pT_1 = pT_2 = 3.2$ TeV
$m_{JJ} = 6.9$ TeV
MET = 46 GeV

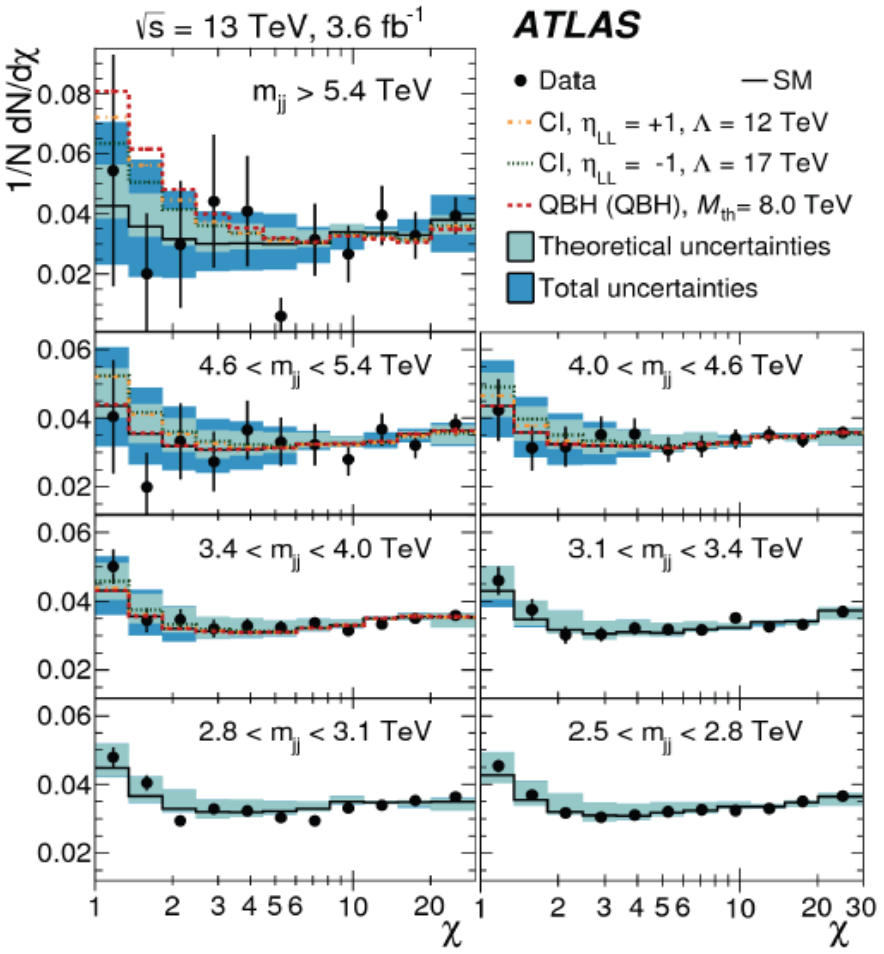
Dijet Angular Searches

Search in dijet mass bins using angular distribution

$$\chi = e^{2|y^*|} \sim \frac{1+\cos\theta^*}{1-\cos\theta^*}$$

1512.01530

Search for distortions of the dijet angular distribution from Contact Interactions of particles at much higher masses O(Λ) with color-singlet left-handed chiral couplings (in 4-fermion effective field theory)



No deviations observed, limits set at 12 TeV on Λ (for η_{LL} = 1)

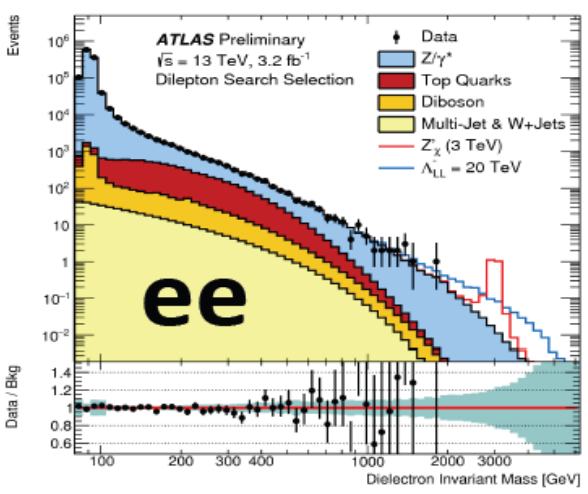
Dilepton Resonances (LFC and LFV)

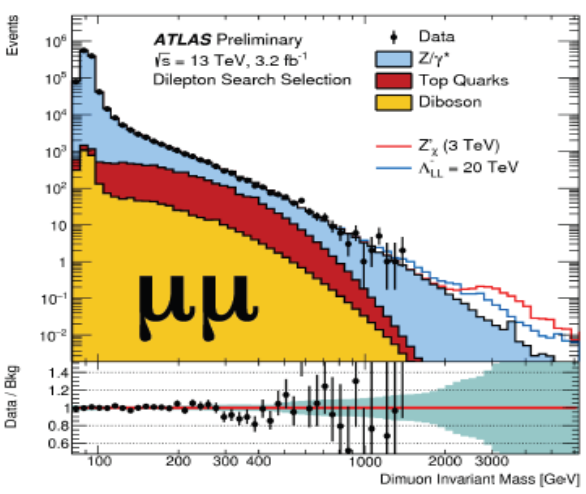
Search for Z' in dilepton (LFC) and (LFV) *(in eμ decays)*

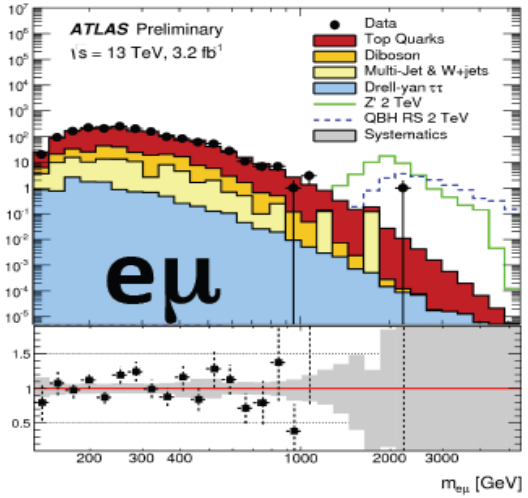
ATLAS-CONF-2015-070

ATLAS-CONF-2015-072

- Main background DY is taken from MC
- Top and diboson extrapolated at very high masses using a functional form
- Background from MC except for MJ in dielectron uses Matrix method (based on electron ID)







Highest di-electron mass event at 1.8 TeV

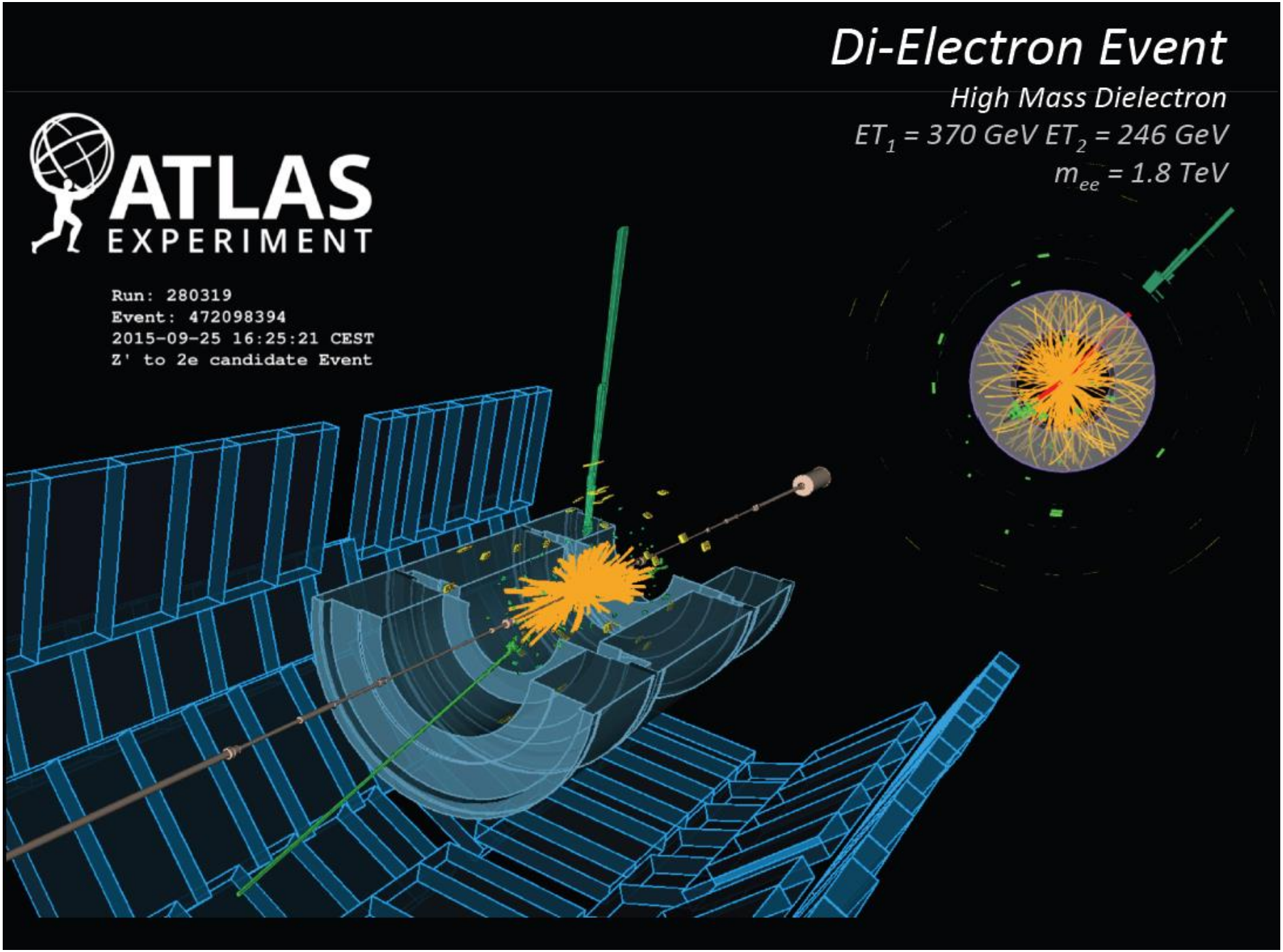
Highest di-muon mass event at 1.4 TeV

Highest eμ mass event at 2.1 TeV

No Excess found !

95% CL Limit on SSM Z' at 3.4 TeV (2.9 TeV from Run-1)

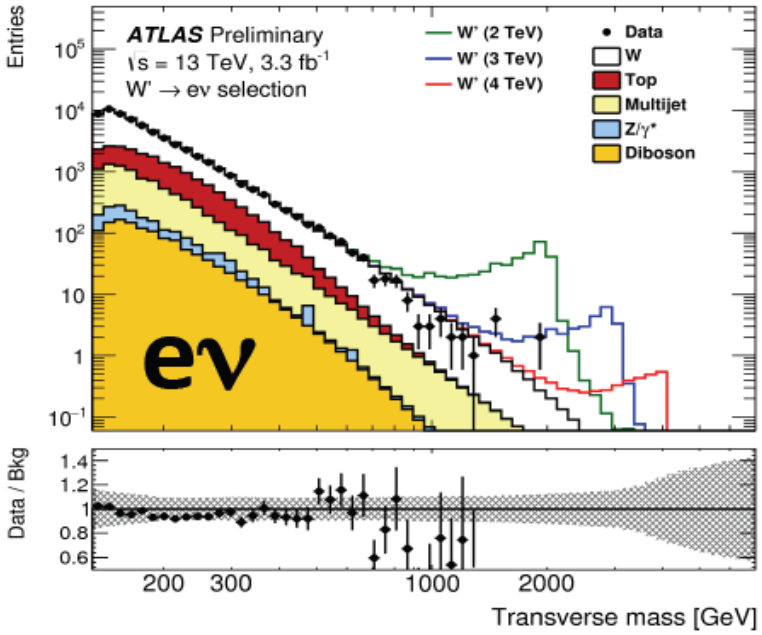
95% CL Limit on SSM LFV Z' at 3.0 TeV (2.5 TeV from Run-1)

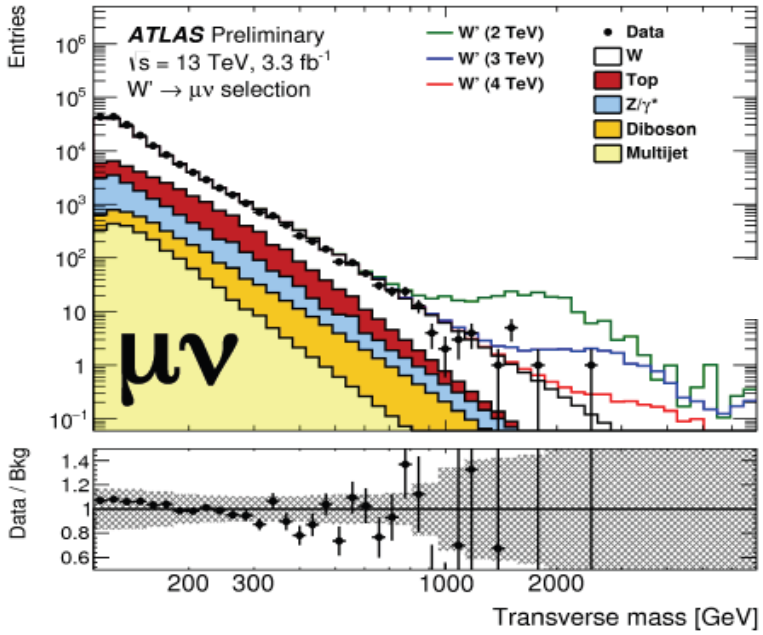

Di-Electron Event
High Mass Dielectron
ET_1 = 370 GeV ET_2 = 246 GeV
m_{ee} = 1.8 TeV
ATLAS
EXPERIMENT
Run: 280319
Event: 472098394
2015-09-25 16:25:21 CEST
Z' to 2e candidate Event

Search for Resonant Lepton-MET

- Search for W' in lepton-MET final states

ATLAS-CONF-2015-063





Highest electron-MET mass event at 1.95 TeV

Highest muon-MET mass event at 2.2 TeV

No Excess found !

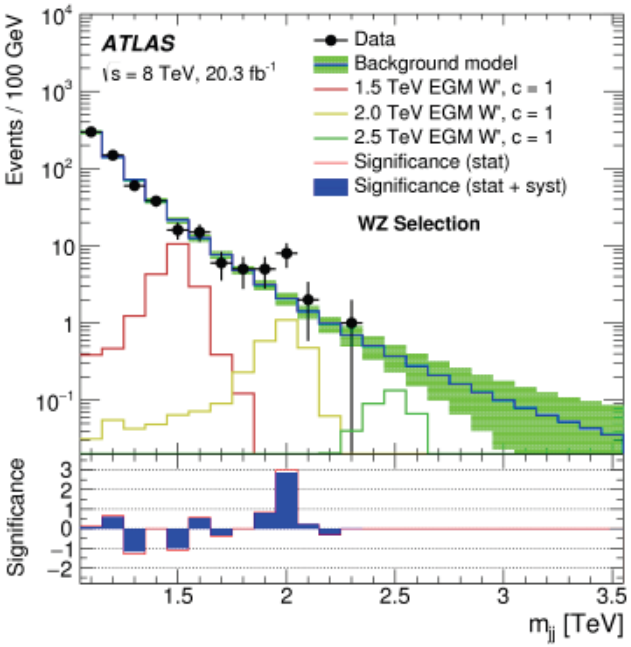
95%CL Limit on SSM W' at 4.1 TeV (3.2 TeV at Run-1)

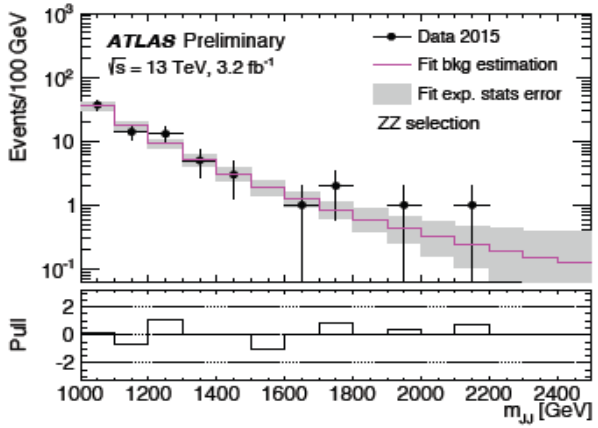
Fully hadronic JJ Diboson Searches

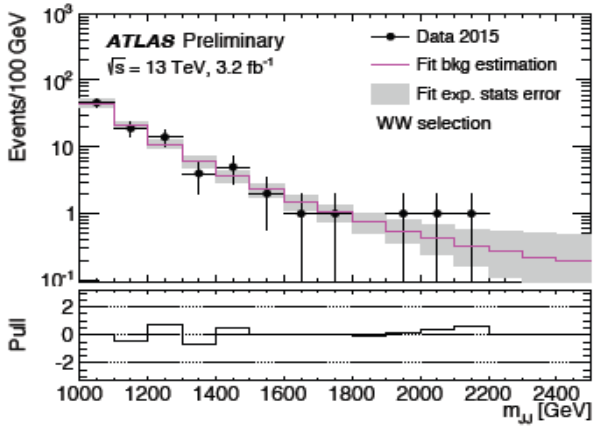
ATLAS-CONF-2015-073

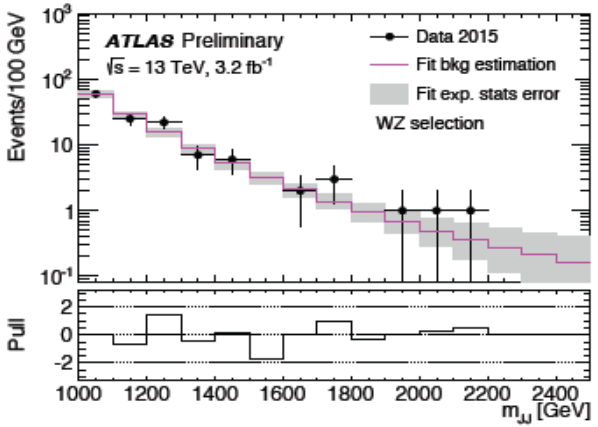
Run-1

- **Modest excess at Run-1:** **3.4σ** local / **2.5σ global**
- **Analysis very similar to Run 1**, with functional fit of the background
- **No significant excess is observed**
  however sensitivity not high enough for conclusive probe of the Run 1 excess





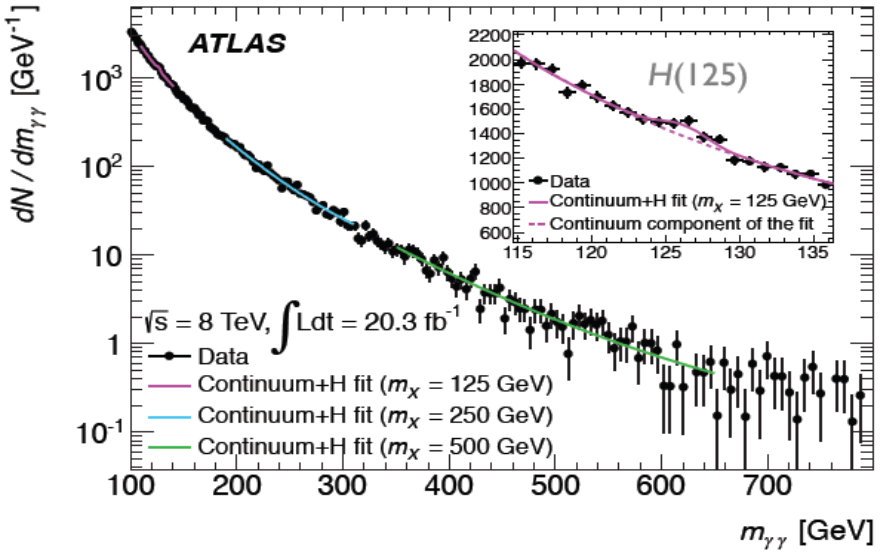




Search for Two Photons Resonance latest Run I results

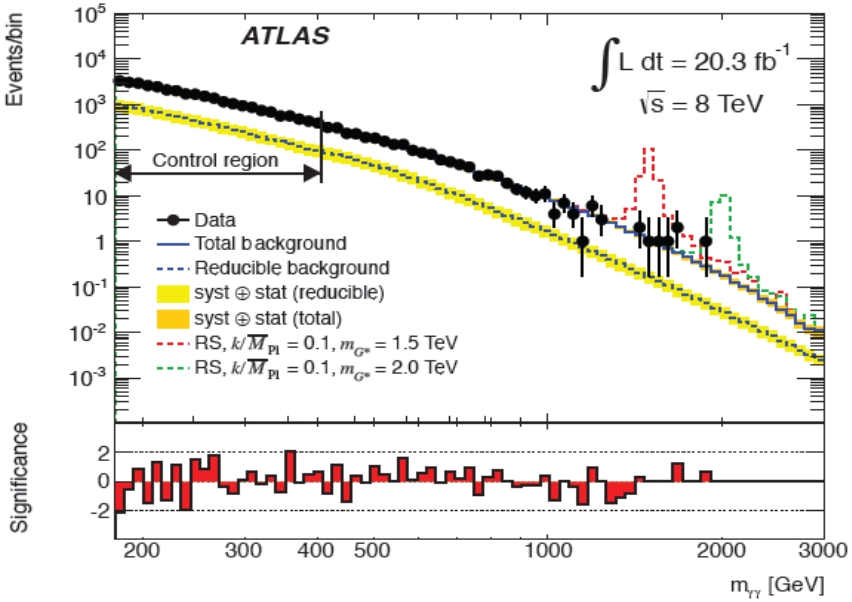
Search for scalar diphoton resonances in the mass range 65-600 GeV with the ATLAS detector in pp collision data at $\sqrt{s}$ = 8 TeV

Phys. Rev. Lett. 113, 171801



Search for high-mass diphoton resonances in pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector

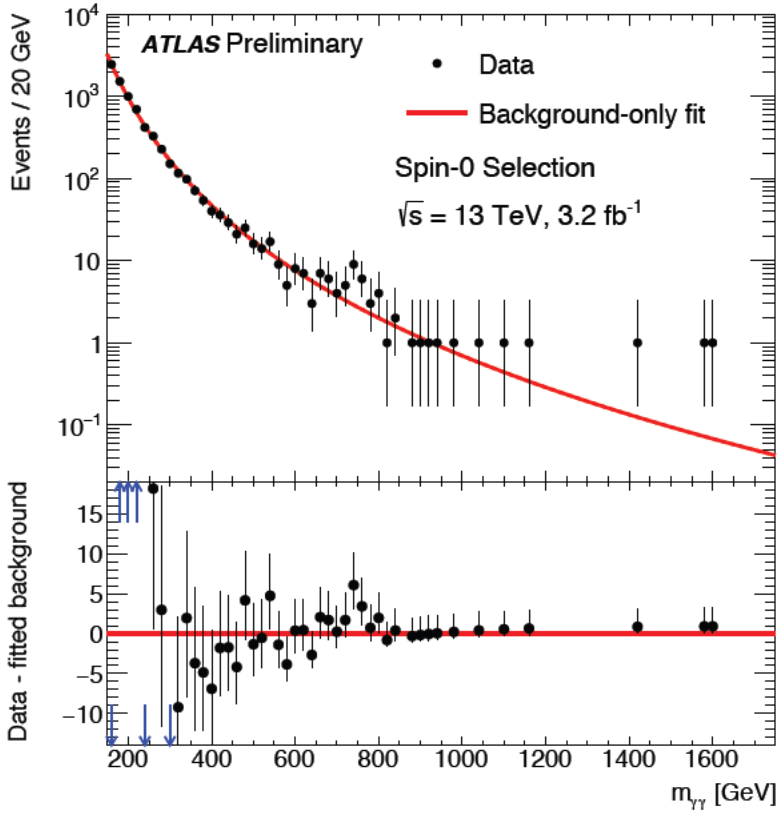
Phys. Rev. D 92, 032004 (2015)



Search for Two Photons Resonance latest Run II results

SPIN-0 ANALYSIS

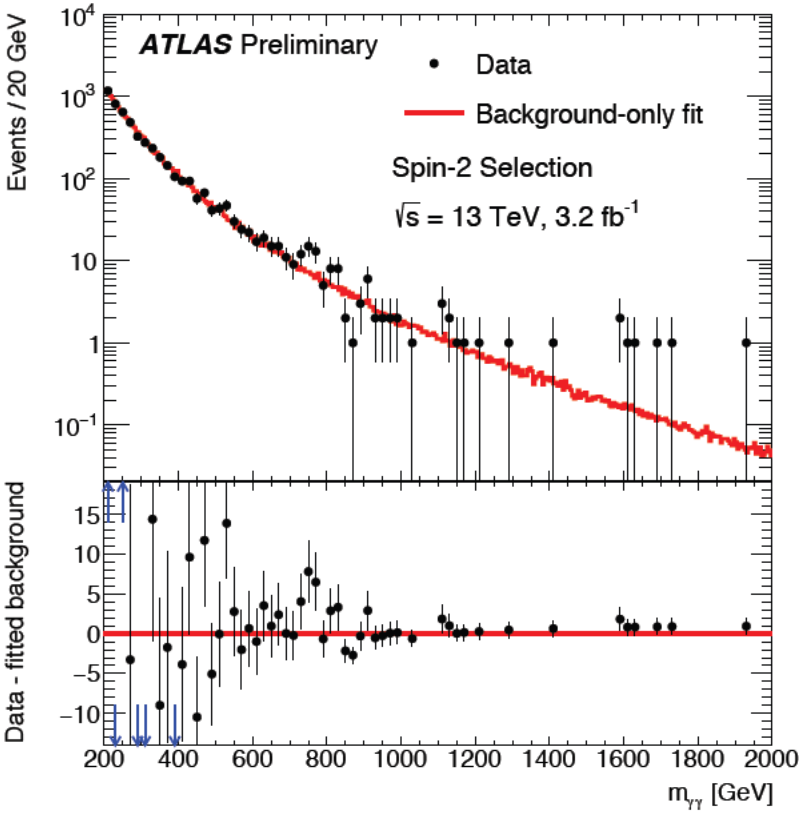
background-only fit



2878 events ($m_{\gamma\gamma}$ > 200 GeV)

SPIN-2 ANALYSIS

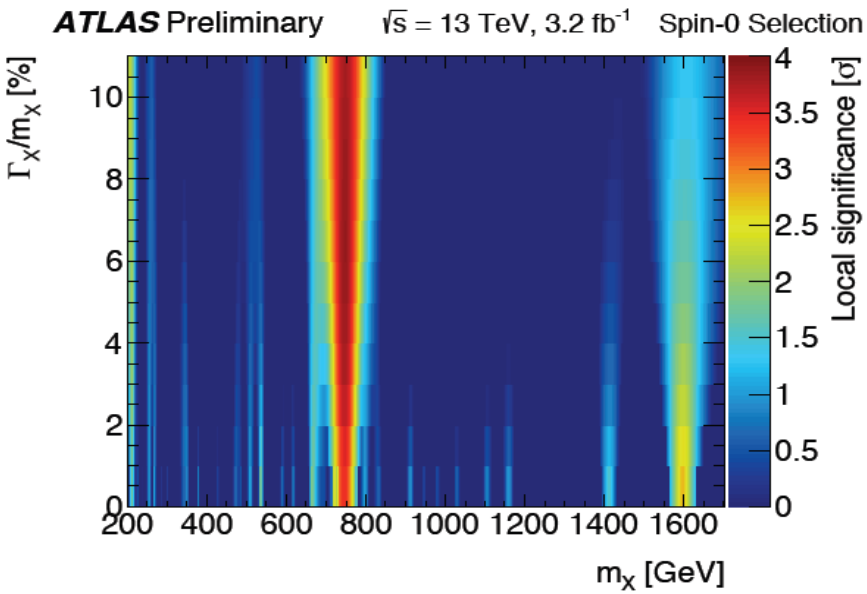
background-only fit



5066 events ($m_{\gamma\gamma}$ > 200 GeV)

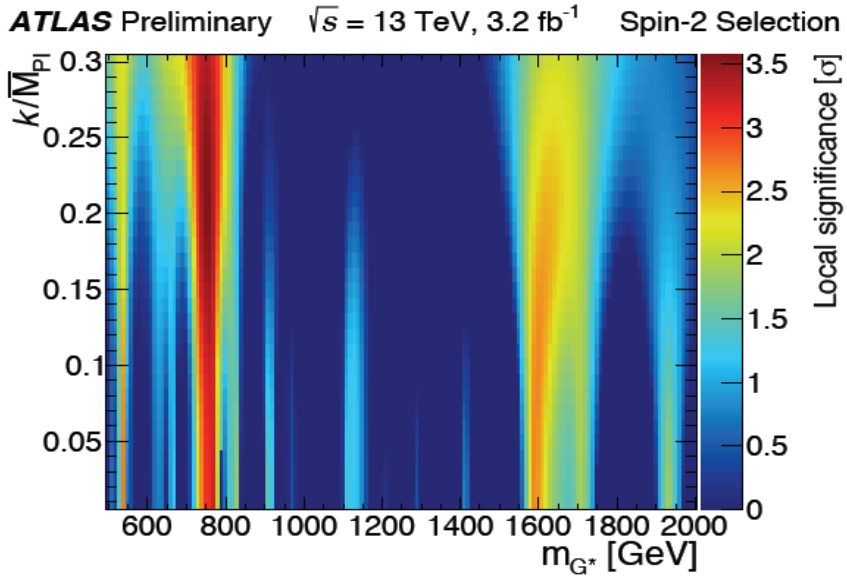
Search for Two Photons Resonance latest Run II results

SPIN-0 ANALYSIS



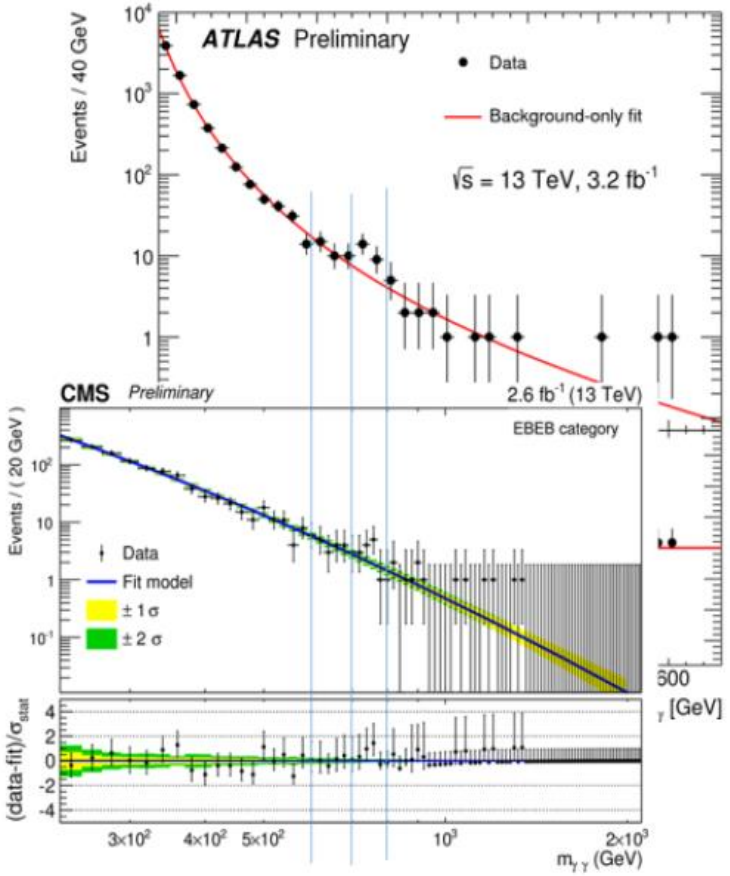
- Largest deviation from B-only hypothesis
  - ✓ m_X ~ 750 GeV, Γ_X ~ 45 GeV (6%)
  - ✓ Local Z = **3.9 σ**
  - ✓ Global Z = **2.0 σ**
    - m_X = [200 GeV - 2 TeV]
    - Γ_X/m_X = [1% - 10%]

SPIN-2 ANALYSIS



- Largest deviation from B-only hypothesis
  - ✓ m_G ~ 750 GeV, κ/M_{Pl} ~ 0.2 (Γ_G ~ 6% m_G)
  - ✓ Local Z = **3.6 σ**
  - ✓ Global Z = **1.8 σ**
    - m_X = [500 GeV – 3.5 TeV]
    - κ/M_{Pl} = [0.01 – 0.3]

Search for Two Photons Resonance latest Run II results



$\gamma\gamma$ peak around 750 GeV over flatland

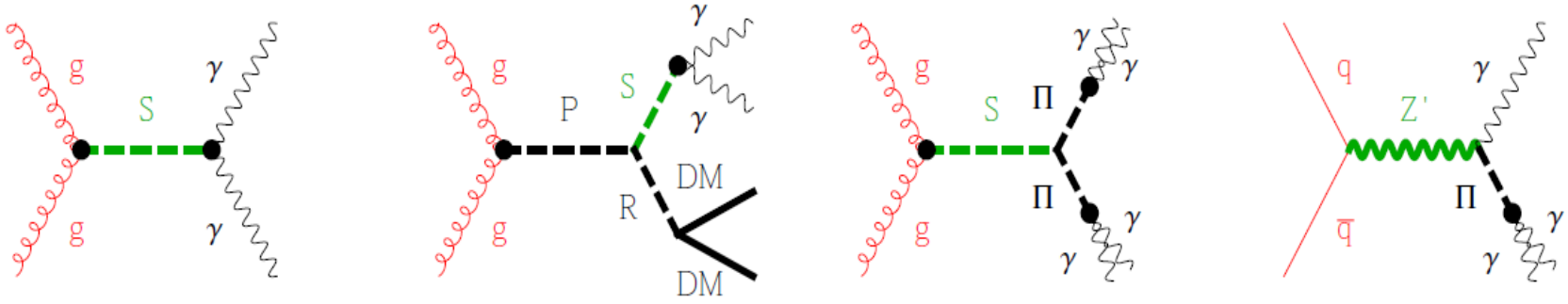
$\sigma(pp \to \gamma\gamma)$	CMS	ATLAS
8 TeV	(0.5 ± 0.6) fb	(0.4 ± 0.8) fb
13 TeV	(6 ± 3) fb	(10 ± 3) fb

Theoretically clean.
Experimentally simple.

ATLAS prefers large width $\Gamma/M \sim 0.06$.
CMS prefers narrow width.

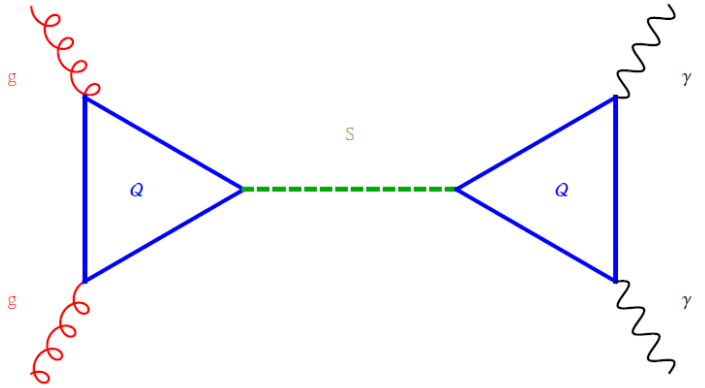
$\gamma\gamma$ not accompanied by hard extras.

What it could be?



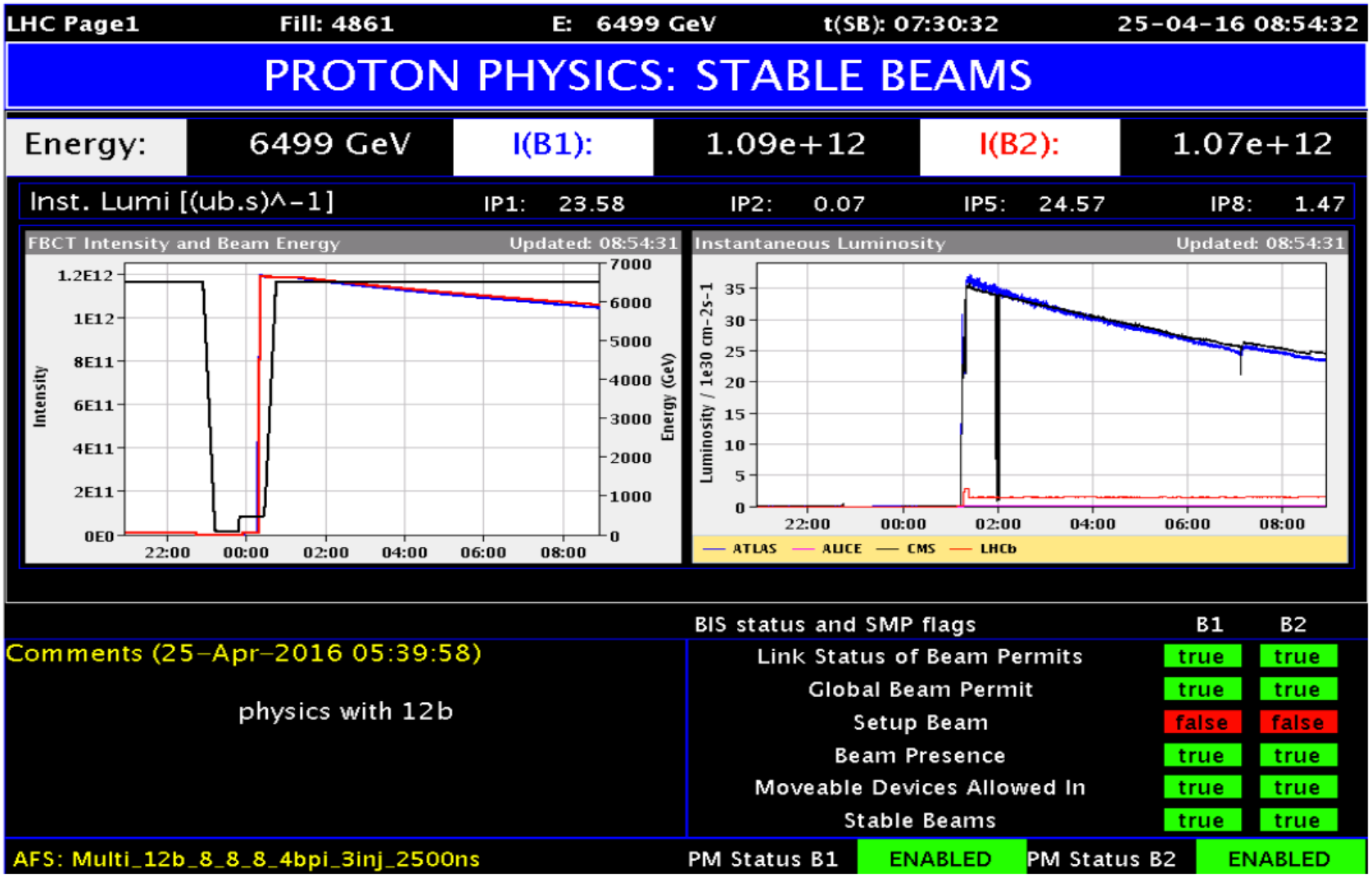
The Gold Rush: [INSPIRES][list]

Date	papers
16 Dec	10
25 Dec	101
1 Jan	137
1 Feb	212
1 Mar	263
1 Apr	?



Could be also background fluctuation!
We will know by the end of this summer.

Data 2016 !!!!!


LHC Page1
Fill: 4861
E: 6499 GeV
t(SB): 07:30:32
25-04-16 08:54:32
PROTON PHYSICS: STABLE BEAMS
Energy:
6499 GeV
I(B1):
1.09e+12
I(B2):
1.07e+12
Inst. Lumi [(ub.s)^-1]
IP1: 23.58
IP2: 0.07
IP5: 24.57
IP8: 1.47
FBCT Intensity and Beam Energy
Updated: 08:54:31
Intensity
Energy (GeV)
Instantaneous Luminosity
Updated: 08:54:31
Luminosity / 1e30 cm-2s-1
ATLAS
ALICE
CMS
LHCb
Comments (25-Apr-2016 05:39:58)
physics with 12b
BIS status and SMP flags
B1
B2
Link Status of Beam Permits
Global Beam Permit
Setup Beam
Beam Presence
Moveable Devices Allowed In
Stable Beams
AFS: Multi_12b_8_8_8_4bpi_3inj_2500ns
PM Status B1
ENABLED
PM Status B2
ENABLED

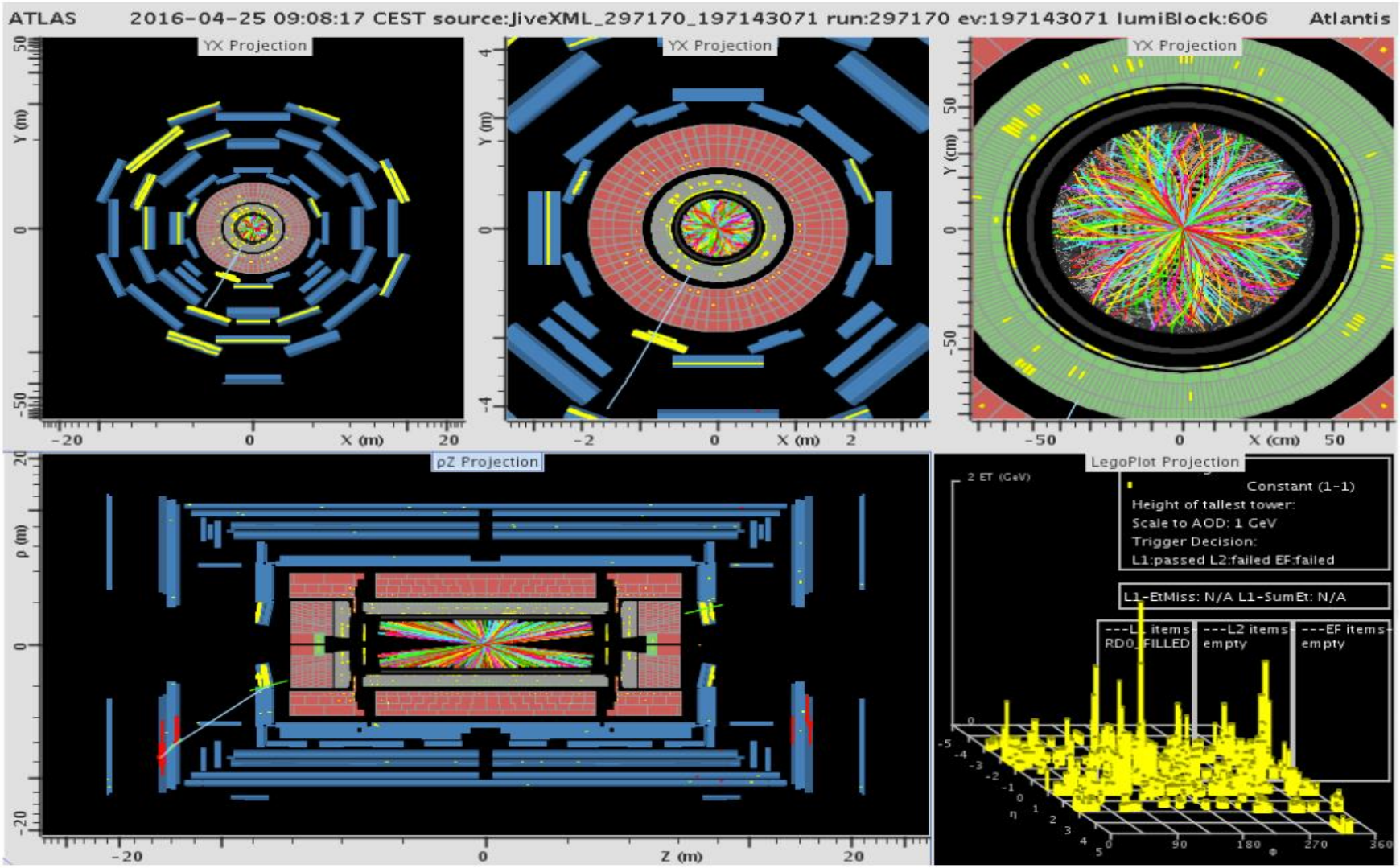
Data 2016 !!!!!

25-Apr-2016 08:59:24	Fill #: 4861	Energy: 6499 GeV	I(B1): 1.04e+12	I(B2): 1.06e+12
Accelerator Mode:	PROTON PHYSICS	Beam Mode:	STABLE BEAMS	
Active Filling Scheme:	Multi_12b_8_8_8_4bpi_3inj_2500ns			
Active Hypercycle:	6.5TeV_2016			

	ATLAS	ALICE	CMS	LHCb
Beta*	0.40 m	10.03 m	0.40 m	3.00 m
Crossing Angle (urad)	0(V)	200(V)	0(H)	-250(H)
Spectrometer Angle (urad)		0(V)		0(H)
Beam Separation (mm)	-.168(H)	.28(H)	-.14(V)	0(V)
Expected Collisions per turn	8	8	8	8

	ATLAS	ALICE	CMS	LHCb
BPTX: deltaT of IP (B1-B2)	0.09 ns	-0.01 ns	0.09 ns	-0.19 ns
Luminous size (x,y) in um	-999.0,-999.0	-999.0,-999.0	51.1,54.6	40.4,40.3
Luminous size (z) in mm	-999.0	-999.0	33.7	40.8
Lumi Centroid (x,y) in um	-999.0,-999.0	-999.0,-999.0	-524.9,996.7	810.6,-185.1
Lumi Centroid (z) in mm	-999.0	-999.0	-8.7	-5.5
Luminous Tilt in urads	-999.00,-999.00	-999.00,-999.00	122.73,-49.47	20.25,-52.45

Data 2016 !!!!!

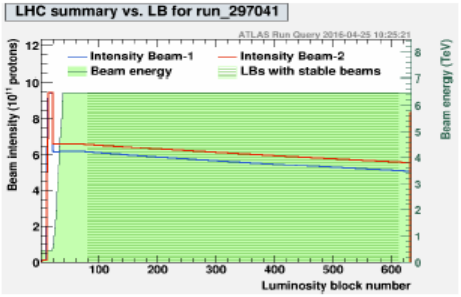

ATLAS 2016-04-25 09:08:17 CEST source:JiveXML_297170_197143071 run:297170 ev:197143071 lumiBlock:606 Atlantis
YX Projection
Y (m)
X (m)
YX Projection
Y (m)
X (m)
YX Projection
Y (cm)
X (cm)
pZ Projection
ρ (m)
Z (m)
LegoPlot Projection
2 ET (GeV)
Constant (1-1)
Height of tallest tower:
Scale to AOD: 1 GeV
Trigger Decision:
L1:passed L2:failed EF:failed
L1-EtMiss: N/A L1-SumEt: N/A
---L2 items empty
---EF items empty
η
φ

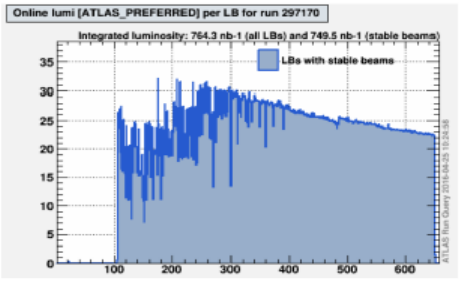
Data 2016 !!!!!

Sunday 23:35 – Monday 09:56

Run 29170

Stable Lumi 750nb-1
Peak mu 26

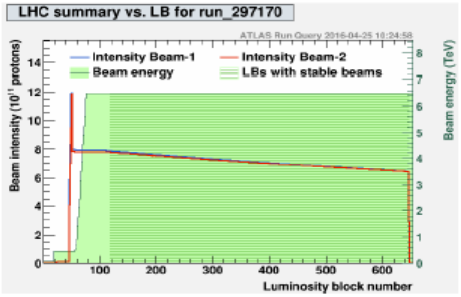


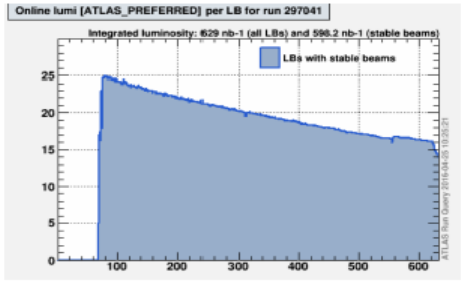


Saturday 23:39 – Sunday 09:39

Run 297041

Stable Lumi 600nb-1
Peak mu 20



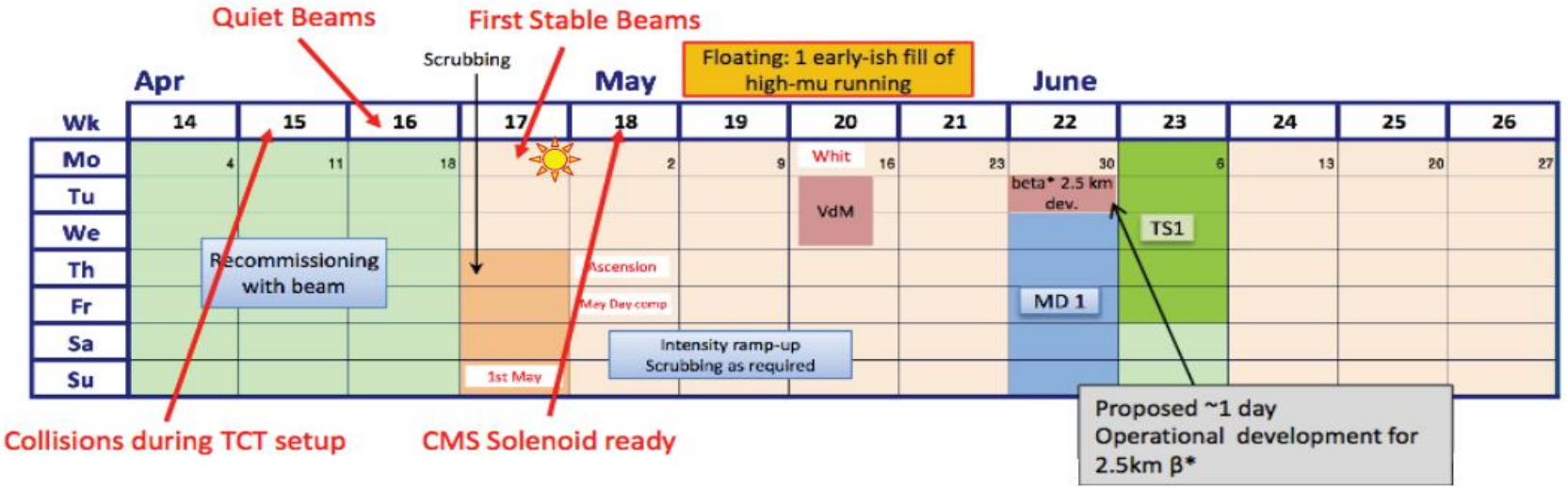


Run 296942	Stable Lumi	50nb-1
	Peak mu	19
Run 296939	Stable Lumi	65nb-1
	Peak mu	16

Total Lumi ~1.4pb^{-1}

i.e. Approx. ~7 kW and 0.6-0.8 kZ
(for each flavor e and mu)

Data 2016 !!!!!



Stay tuned for more news during summer conferences