Search for new heavy spin-1 resonance Z* at ATLAS detector in dilepton channel

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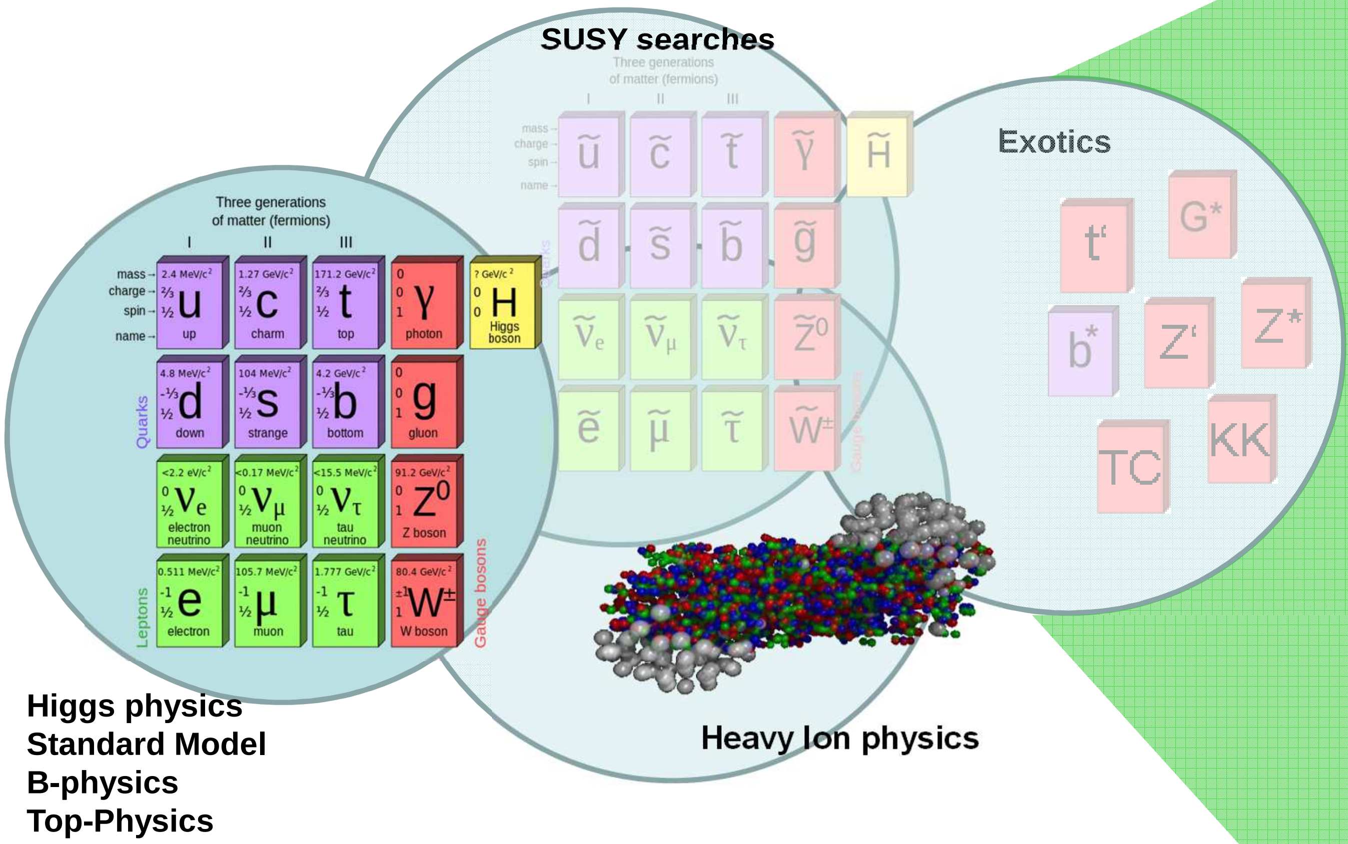


Lots of theories beyond the Standard Model predict new heavy resonances decaying into dileptons:

Z’. Repeats properties of Z-boson despite heaving mass of order 1 or few TeV. These bosons are ingredients in Little Higgs models, some Grand Unification scenarios, SuperGravity and SUSY theories, technicolor or Kaluza-Klein models.

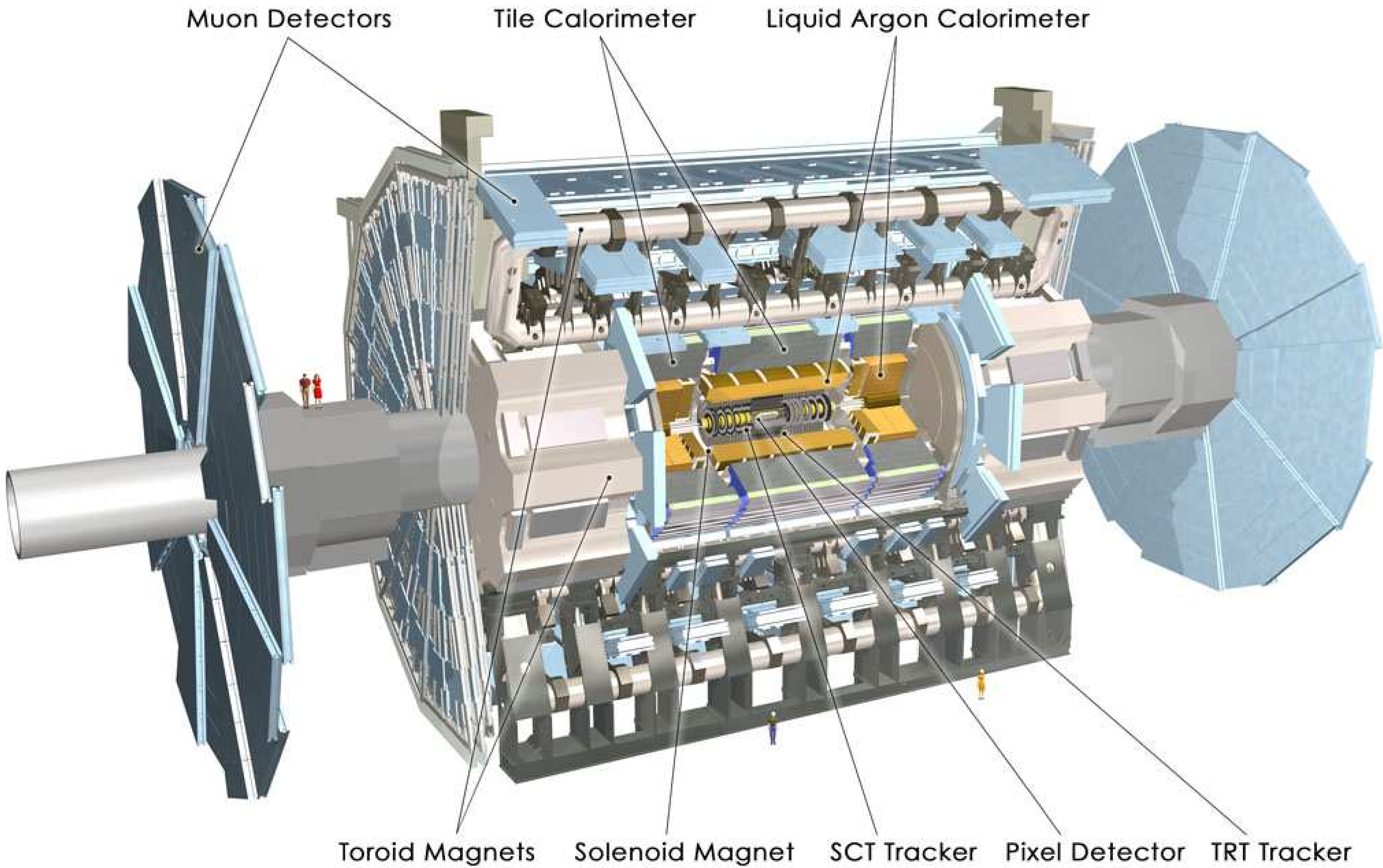
Z*. This spin-1 resonance is described via the following Lagrangian interaction with the SM fermions:

$$L = \frac{g^*}{\Lambda} \bar{\Psi} \sigma^{\mu\nu} \Psi \left[\partial_\mu Z^*_\nu - \partial_\nu Z^*_\mu \right]$$

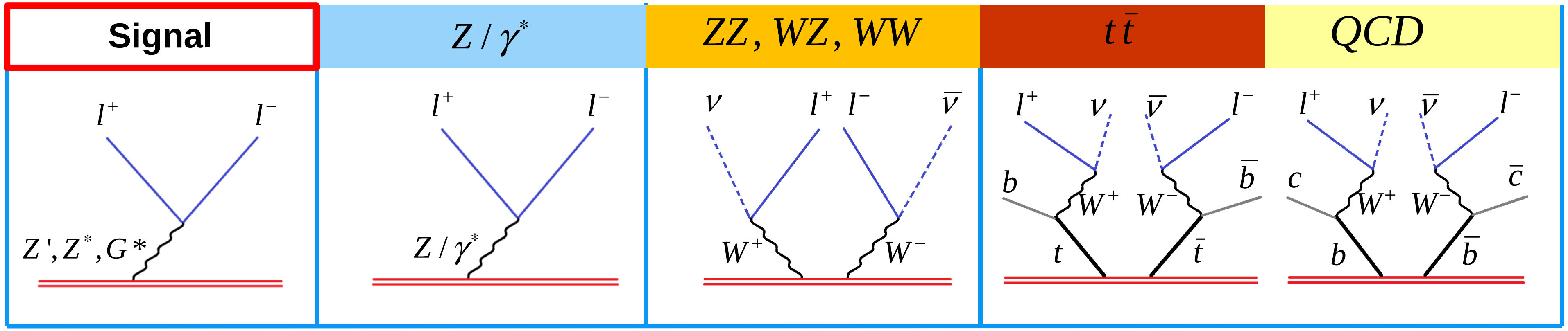
Z* bosons emerge in several theories, solving the ‘hierarchy problem’, e.g., in Simplest Little Higgs models, in Composite Higgs models, some realizations of Technicolor, etc.

G*. One of the possible solutions to the Hierarchy problem is to let gravitational field propagate in some extra dimensions. In this scenario the effects of gravity in 4-dimensional space-time weaken to be consistent with observations. Excited states of gravitons in these theories can interact with SM particles.

QBH. Quantum black holes are predicted in some theories of Quantum gravity.

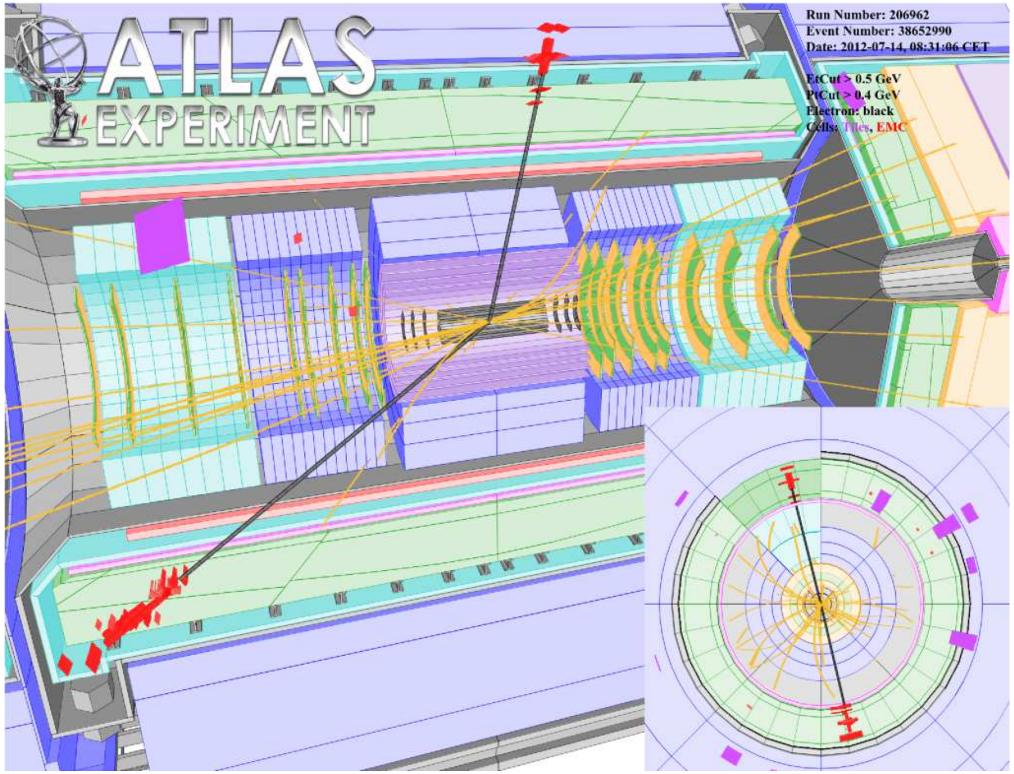

Muon Detectors
Tile Calorimeter
Liquid Argon Calorimeter
Toroid Magnets
Solenoid Magnet
SCT Tracker
Pixel Detector
TRT Tracker

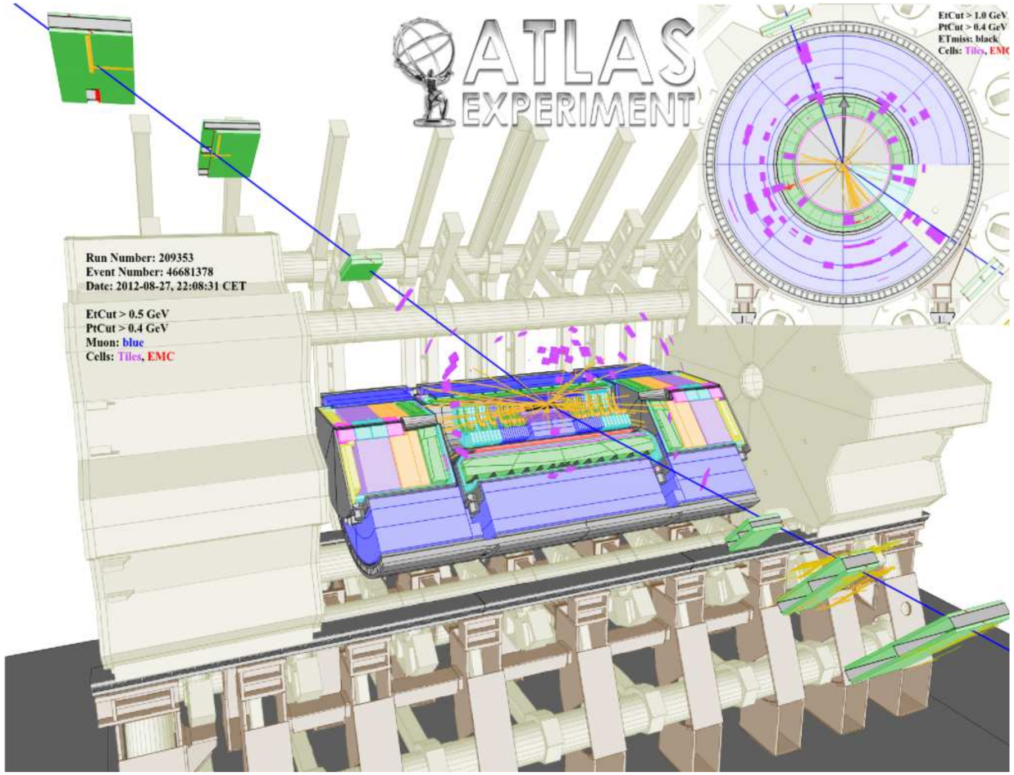
Dilepton channel features totally reconstructable kinematics and high quality of modelling backgrounds.



Electron candidates are formed from clusters of cells reconstructed in the electromagnetic calorimeter. They must have a well-reconstructed Inner Detector track pointing to the corresponding cluster and should satisfy a set of identification criteria that are optimized to maintain good performance in conditions with high pile-up. At least two reconstructed electron candidates within $|\eta| < 2.47$ are required. The leading and subleading electron must satisfy $E_T > 40$ GeV and $E_T > 30$ GeV, respectively. The region $1.37<|\eta|<1.52$ is excluded because it corresponds to a transition region between the barrel and endcap calorimeters which exhibits degraded energy resolution.

Muon tracks are first reconstructed separately in the Inner Detector and in the Muon Spectrometer. The two tracks are then matched and a combined fit is performed to the Inner Detector and Muon Spectrometer hits, taking into account the effects of multiple scattering and energy loss in the calorimeters. The muon momentum is taken from the combined fit. The muons are required to satisfy $p_T > 25$ GeV, and they are used to build opposite-sign muon pairs. Each muon is required to have a minimum number of hits in each of the Inner Detector components. To obtain optimal momentum resolution, at least one selected muon is required to have at least three hits in each of the stations (inner, middle, and outer) of the Muon Spectrometer, and at least one hit in two layers of the trigger chambers.

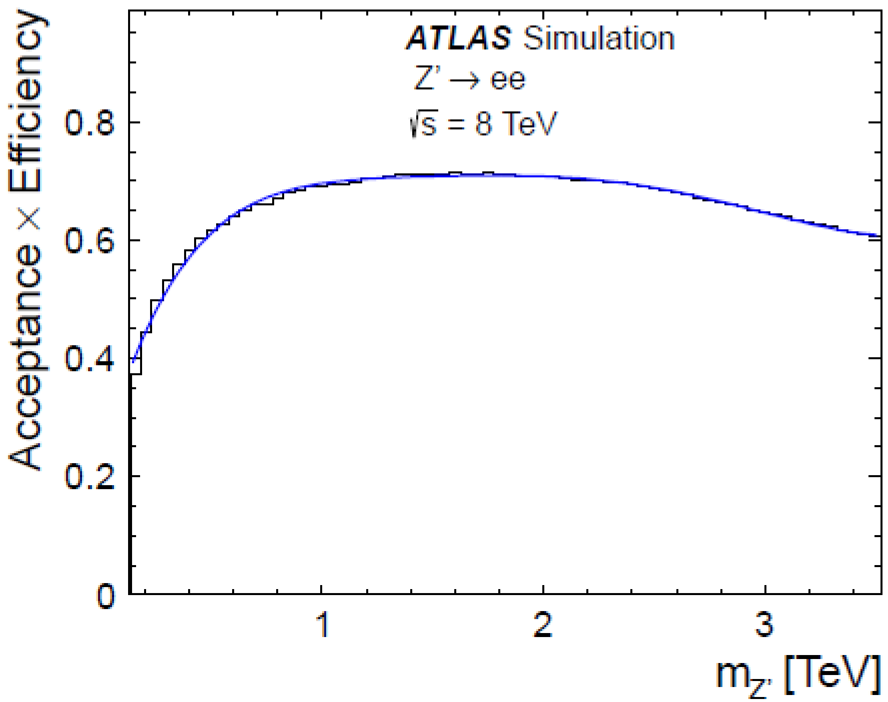


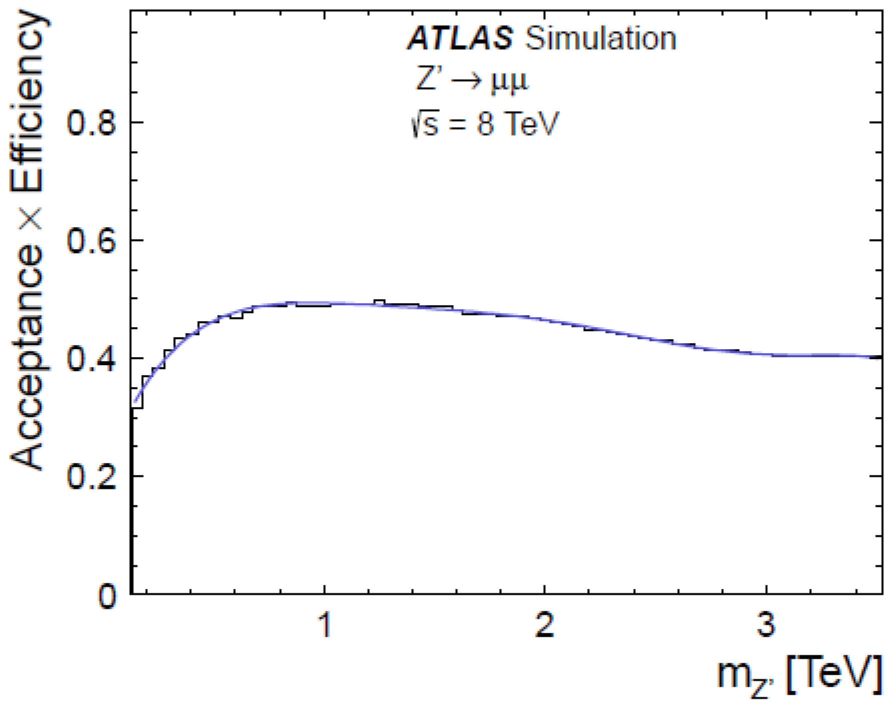


Graphical reconstruction of the highest invariant mass dielectron (left) and dimuon (right) events, selected in data of 2012 pp-collisions at LHC.

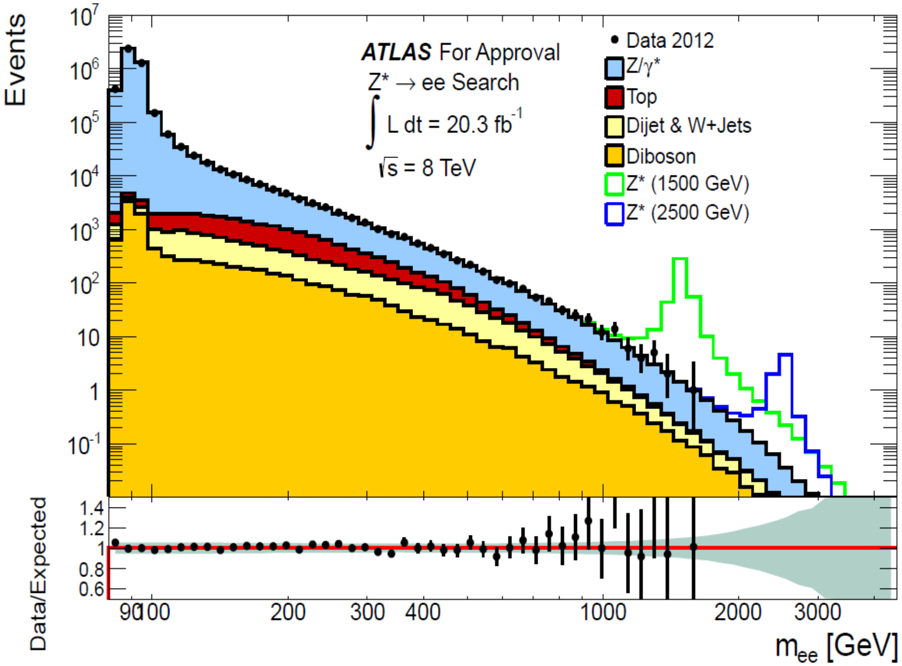
For dielectron event – reconstructed invariant mass is 1541 ГэВ, reconstructed transverse momenta and pseudorapidities: (588ГэВ, 1.25) and (584ГэВ, -0.29).

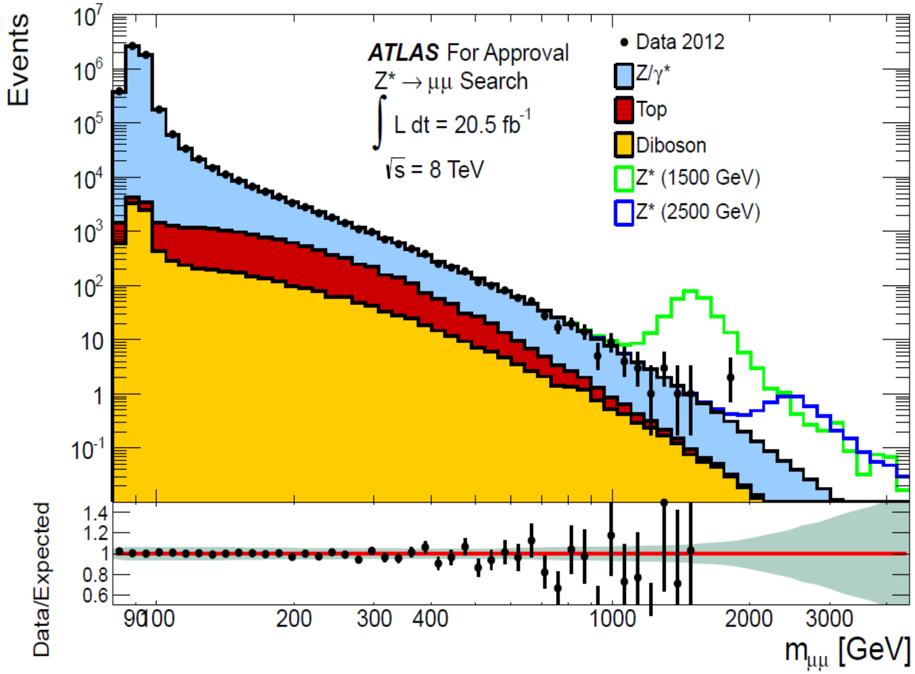
For dimuon event – reconstructed invariant mass is: 1844ГэВ, transverse momenta and pseudorapidities: (653ГэВ, 0.99) и (646ГэВ, -0.85).





Efficiency times acceptance for reconstructing new heavy resonance *X* (on the example of *Z'*) for dimuon and dielectron channels.



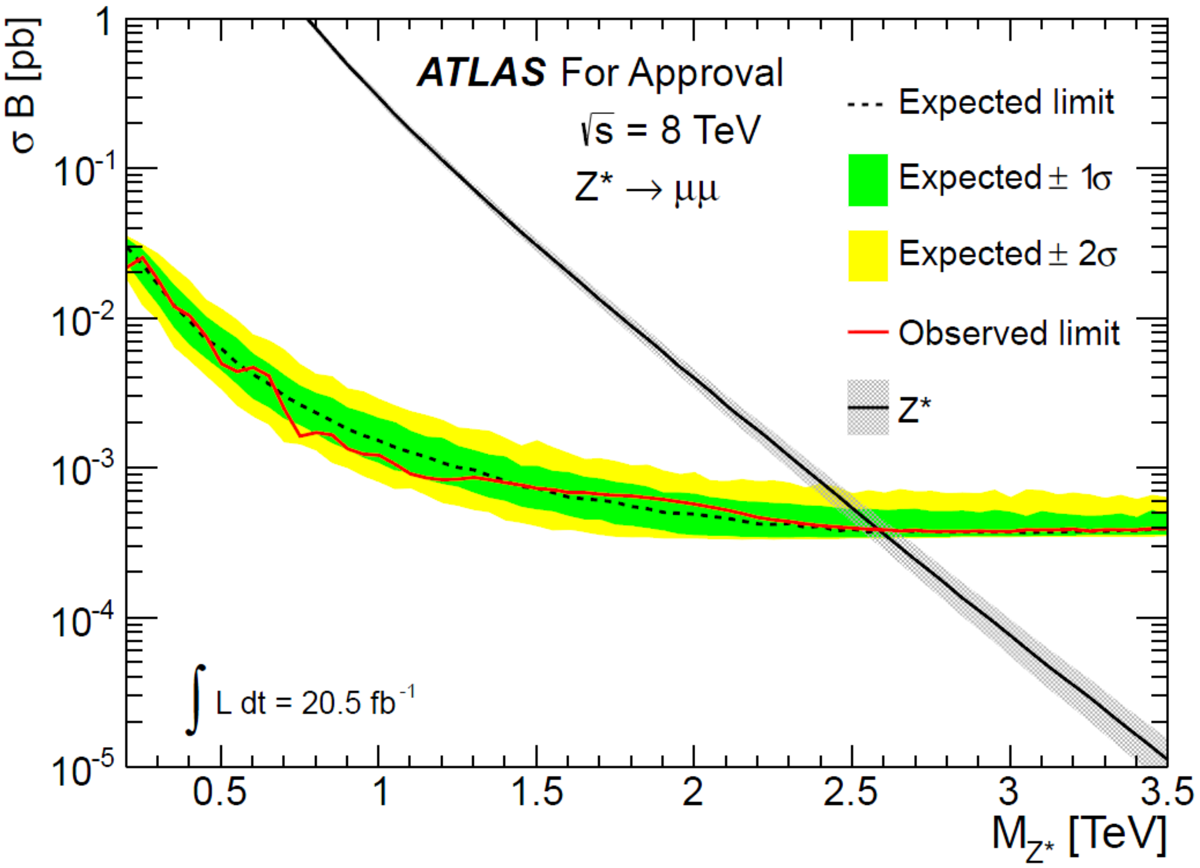


m_{ee} [GeV]	110 - 200	200 - 400	400 - 800	800 - 1200	1200 - 3000	3000 - 4500
Z/γ^*	122000 ± 7000	14000 ± 800	1320 ± 70	70 ± 5	10.0 ± 1.0	0.008 ± 0.004
Top	8200 ± 700	2900 ± 500	200 ± 80	3.1 ± 0.8	0.16 ± 0.08	< 0.001
Diboson	1880 ± 90	680 ± 40	94 ± 5	5.9 ± 0.4	1.03 ± 0.06	< 0.001
Dijet & W+jet	3900 ± 800	1290 ± 320	230 ± 70	9.0 ± 2.3	0.9 ± 0.5	0.002 ± 0.004
Total	136000 ± 7000	18800 ± 1000	1850 ± 120	88 ± 5	12.1 ± 1.1	0.011 ± 0.005
Observed	136200	18986	1862	99	9	0

$m_{\mu\mu}$ [GeV]	110 - 200	200 - 400	400 - 800	800 - 1200	1200 - 3000	3000 - 4500
Z/γ^*	111000 ± 8000	11000 ± 1000	1000 ± 100	49 ± 5	7.3 ± 1.1	0.034 ± 0.022
Top	7100 ± 600	2300 ± 400	160 ± 80	3.0 ± 1.7	0.17 ± 0.15	< 0.001
Diboson	1530 ± 180	520 ± 130	64 ± 16	4.2 ± 2.1	0.69 ± 0.30	0.0024 ± 0.0019
Total	120000 ± 8000	13700 ± 1100	1180 ± 130	56 ± 6	8.2 ± 1.2	0.036 ± 0.023
Observed	120011	13479	1122	49	8	0

Distributions of 2012 selected dilepton events in invariant mass – dielectron channel (letft), dimuon channel (right).
Plots include data distributions, the distributions of simulated SM background events.
The expectations for signals of Z* with masses of 1.5 and 2.5 TeV are also shown.
Beneath – there data/BG ratios, accompanied with BG systematics.

Tables show numbers of events in different invariant mass regions.



Since good agreement between data and SM background observed – we set statistical limits on cross-section times branching ratio of new resonance.

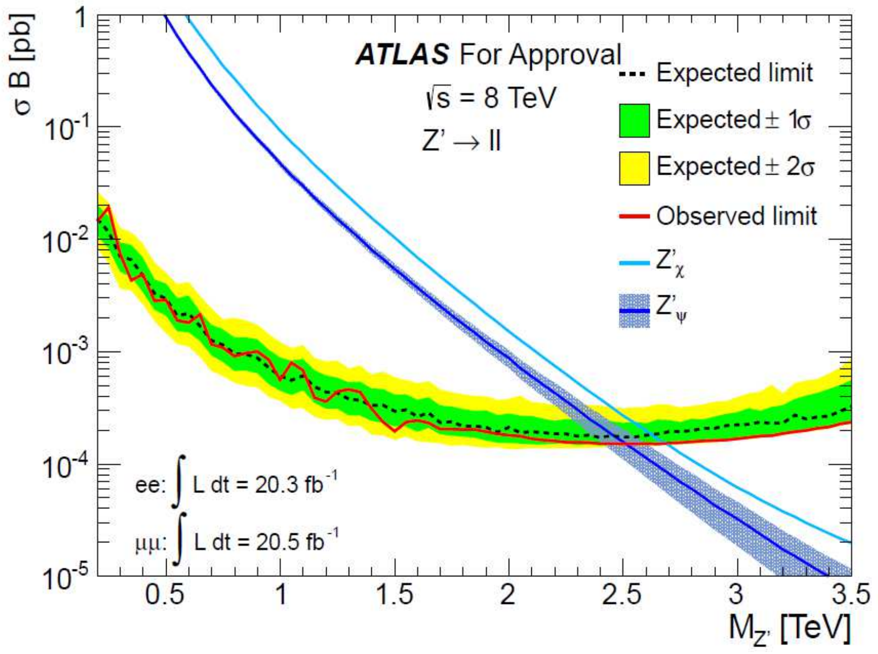
This is done for mass range of new resonance between 0.2 and 3.5 TeV. For each mass we found cross-section limit with 95% C.L.

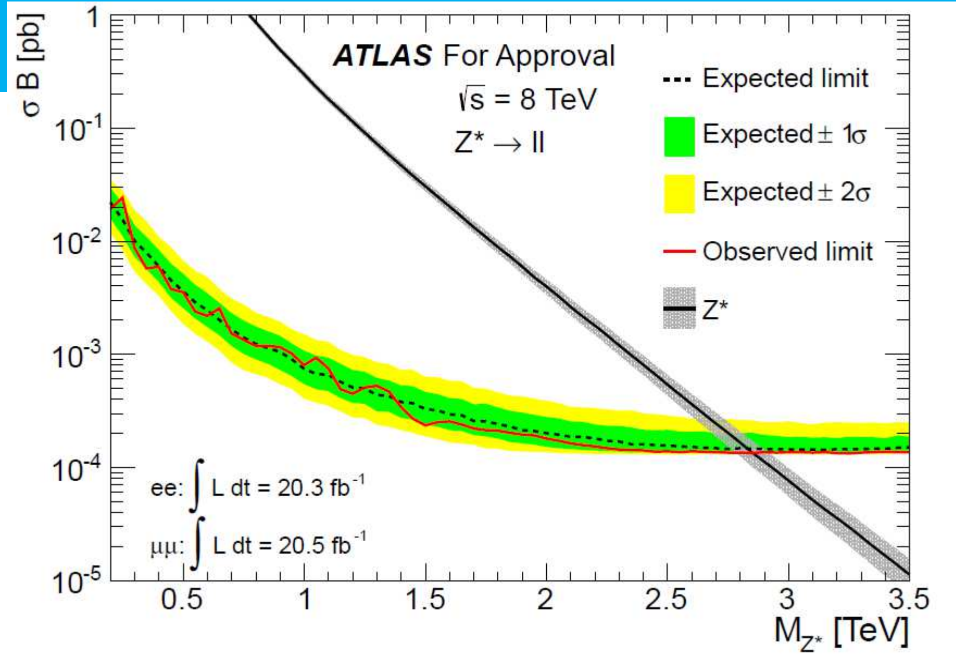
Above this – the existence of resonance is excluded.

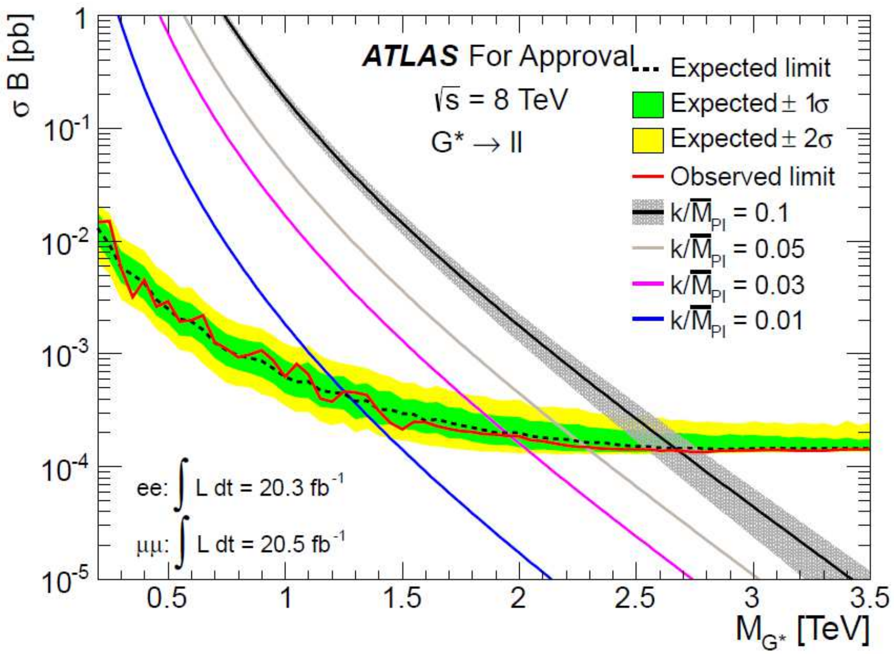
Expected limit (dashed line) is derived via comparing BG with “BG+signal” hypotheses.

Observed limit (solid red line) illustrates statistical comparison of data and “BG+signal” hypothesis.

Black line shows theoretical prediction for Z* cross-section times branching.







Plots show expected (dashed line) and observed (solid red) 95%-confidence-level upper limits on cross section times branching ratio for Z' (top left), techicolor (top right), Z* (middle left) and G*(bottom left).
The statistical analysis uses the combination of dielectron and dimuon data.
The inner (green) and outer (yellow) bands show the in which the limit is expected to lie in 68% and 95% of pseudo-experiments, respectively.

The solid grey, blue or pink lines are the theoretically predicted cross sections of new resonances.
The thickness of theoretical curves, where present, displays the theoretical uncertainty from the parton distribution functions set as well as α_s.

The observed (expected) limits on new resonance masses are found at the cross points between observed (expected) limit curves and theoretical curves. For *G** and MWT models several coupling hypotheses are considered, so several theoretical curves are plotted. The obtained observed limits are the following:

Z'_{χ}………………… .2.62 TeV	Z'_{ψ}………………… 2.51 TeV
Z'_{SSM}……………… 2.90 TeV	Z*………………… 2.85 TeV
G*(0.1)…………… 2.68 TeV	MWT(2)…………… 1.99 TeV

Thank you for attention