Nomination for the JINR Prize 2021

Title: "The Higgs boson properties study in b anti-b pair decay channel and search for New physics with the ATLAS detector at the Large Hadron Collider".

For the ”Scientific-research experimental work”.

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All results presented in this application were obtained with the direct and crucial participation of the authors of the application. The authors of this application are the principal authors of the publications listed below within the ATLAS collaboration.

Among the main goals of the multipurpose detectors ATLAS and CMS at the Large Hadron Collider (LHC), there are first of all the discovery of the Higgs boson and study of its properties as well as search for the New Physics beyond the Standard Model. The first goal was successfully achieved, in 2012 the Higgs boson was discovered and, moreover, the Standard Model was validated many times.
The search for the manifestation of the New Physics is continued by the precision measurements of the Higgs boson properties and attempts to discover such new states as the heavy boson and long-lived particles.

JINR personnel took part in measurements of the Standard Model Higgs boson decaying into a b anti-b pair and produced in association with a W or *Z* boson decaying into leptons, using proton-proton collision data collected between 2015 and 2018 by the ATLAS detector. The measurements use collisions produced by the Large Hadron Collider at a centre-of-mass energy of $\sqrt{s}$=13 TeV, corresponding to an integrated luminosity of 139fb^{-1}. The production of a Higgs boson in association with a *W* or *Z* boson is established with observed (expected) significances of 4.0 (4.1) and 5.3 (5.1) standard deviations, respectively. Cross-sections of associated production of a Higgs boson decaying into bottom quark pairs with an electroweak gauge boson, W or Z, decaying into leptons are measured as a function of the gauge boson transverse momentum in kinematic fiducial volumes. The cross-section measurements are all consistent with the Standard Model expectations, and the total uncertainties vary from 30% in the high gauge boson transverse momentum regions to 85% in the low regions. Limits are subsequently set on the parameters of an effective Lagrangian sensitive to modifications of the WH and ZH processes as well as the Higgs boson decay into b anti-b pair (see Fig. 1).

Also, a search for long-lived particles, which have come to rest within the ATLAS detector, is presented. The subsequent decays of these particles can produce high-momentum jets, resulting in large out-of-time energy deposits in the ATLAS calorimeters. These decays are detected using data collected during periods in the LHC bunch structure when collisions are absent. The analysed dataset is composed of events from proton-proton collisions produced by the Large Hadron Collider at a centre-of-mass energy of $\sqrt{s}$ = 13 TeV and recorded by the ATLAS experiment during 2017 and 2018. The dataset used for this search corresponds to a total live time of 579 hours. The results of this search are used to derive lower limits on the mass of gluino R-hadrons, assuming a branching fraction B($\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0$) = 100%, with masses of up to 1.4 TeV excluded for gluino lifetimes of 10^{-5} to 10^3 s (see Fig. 2).

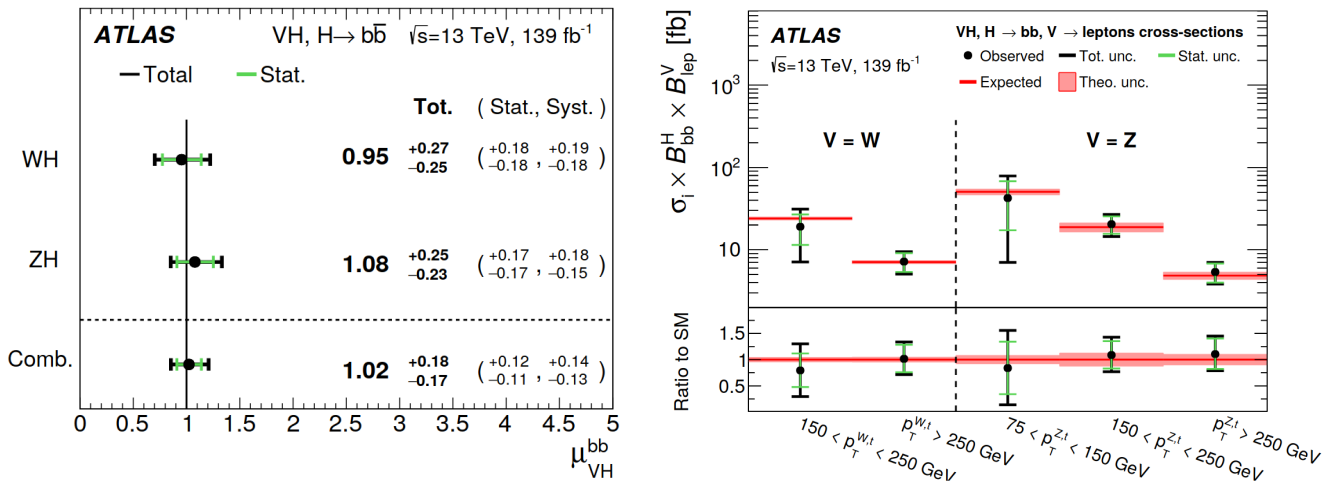

Fig. 1: left:the fitted values of the Higgs boson signal strength μ^{bb}_{VH} for m_H=125 GeV for the WH and ZH processes and their combination. The individual μ^{bb}_{VH} values for the (W/Z)H processes are obtained from a simultaneous fit with the signal strength for each of the WH and ZH processes floating independently. The probability of compatibility of the individual signal strengths is 71%; right: measured VH, V→ leptons cross-sections times the H→ b anti-b pair branching fraction in the reduced STXS scheme.

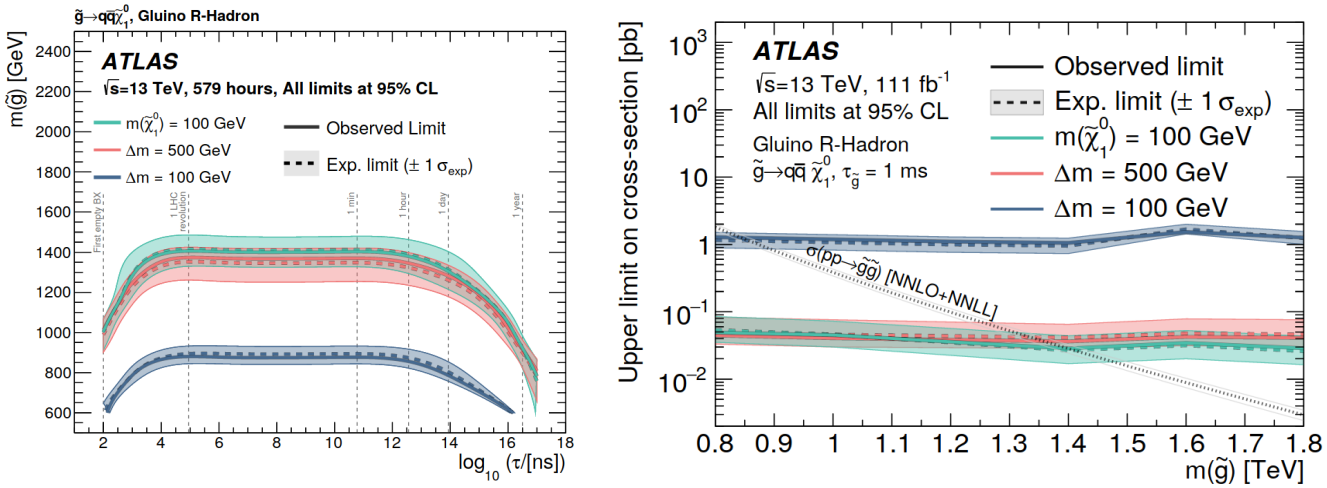

Fig 2: left: expected (dashed lines) and observed (solid lines) exclusion limits at 95% CL using the 2017 and 2018 datasets in the central signal regions. The limits are shown as a function of gluino mass and τ(g̃). The shaded coloured bands represent the ±1σ_{exp} variations from systematic and statistical uncertainties in the expected yields. The different sets of colours represent the limits for different assumptions about the gluino-neutralino mass splitting; right: expected (dashed lines) and observed (solid lines) signal cross-section exclusion limits at 95% CL using the 2017 and 2018 datasets in the central signal regions. The cross-section limits are shown as a function of gluino mass. The shaded coloured bands represent the ±1σ_{exp} variations from systematic and statistical uncertainties in the expected yields. The different sets of colours represent the limits for different assumptions about the gluino-neutralino mass splitting. The grey dotted line and band represent the NNLO+NNLL theory prediction and uncertainties in the production cross-section, respectively.

Moreover, a search for high-mass charged and neutral bosons decaying to Wγ and Zγ final

states is presented in this note. The analyses uses a data sample of $\sqrt{s}$ = 13 TeV proton-proton collisions with an integrated luminosity of 139 fb^{-1} collected by the ATLAS detector during LHC Run 2 operation. The sensitivity of the search is determined using models of the production and decay of spin-1 charged bosons and spin-0/2 neutral bosons. The range in resonance masses explored extends from 1.0 TeV to 6.8 TeV. At such high resonance masses, it is beneficial to target the hadronic decays of the *W* or *Z* boson and the analysis boson tagging to improve the sensitivity. No evidence for signals above the expected Standard Model backgrounds is observed, and cross-section upper limits are derived and presented for various boson production models (see Fig. 3).

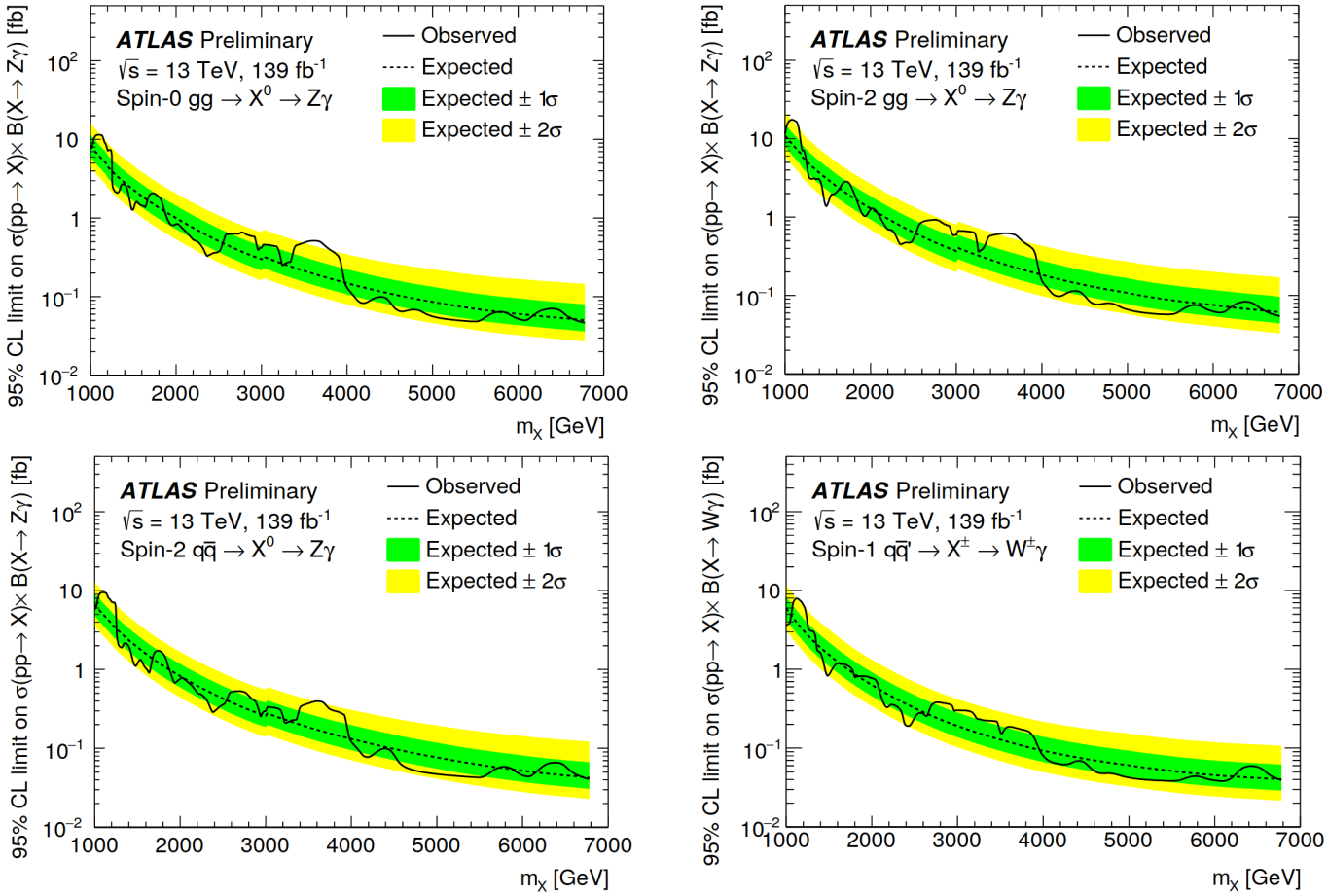

Fig. 3: The 95% CL upper limits on σ(pp→ X)× B(X→ W/Zγ) as a function of m_X for (a) spin-0 gg→ X^0 → Zγ, (b) spin-2 gg→ X^0 → Zγ, (c) spin-2 qq̄→ X^0 → Zγ and (d) spin-1 qq̄'→ $X^{\pm}$ → $W^{\pm}$γ. The observed limits are shown as a solid black line and the expected ones are shown as a dashed line with the 1σ (2σ) uncertainty band presented as the green (yellow) band. Small discontinuities in pp→ X^0→ Zγ limits are due to the drop of the BTAG category in the limit calculation for mass points with m_X>3000 GeV. Limits are derived with the asymptotic approach.

Publications:

1) F. Ahmadov et al, Measurements of WH and ZH production in the H→b anti-b decay channel in pp collisions at 13 TeV with the ATLAS detector, Eur. Phys. J. C 81 (2021) 178

2) E. Cherepanova et al, A search for the decays of stopped long-lived particles at $\sqrt{s}$=13 TeV with the

ATLAS detector, JHEP 07 (2021) 173
3) E. Khramov, Search for high-mass Wγ and Zγ resonances using 139 fb^{-1} of pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector, ATLAS-CONF-2021-041 (готовится публикация)