Results and plans of the JINR team in ATLAS:
physics, software, hardware

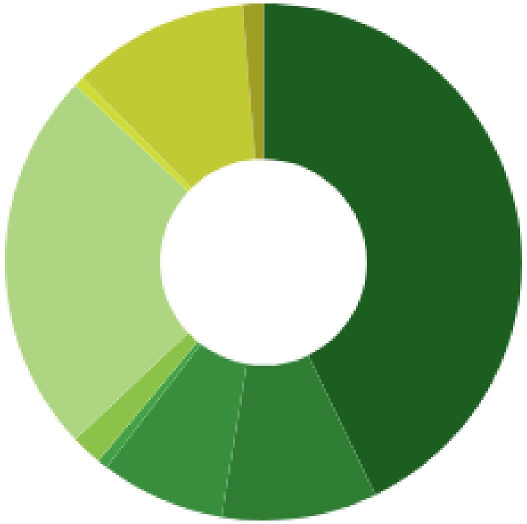
I. Yeletskikh

On behalf of the JINR ATLAS team

OUTLINE

- **JINR team in ATLAS**
- **Contribution to physics analyses**
  - Higgs physics
  - B-physics and light states
  - BSM Searches
  -
  - Standard model measurements
  - Simulation and theoretical support
- **Contributions to software development**
  - Database development
  - Reconstruction and simulation software: e/gamma, calorimeter, trigger
  - Simulation and other
- **ATLAS upgrade**
  - Commitments, current activities, plans
- **Conclusions and plans**

JINR team in ATLAS Collaboration

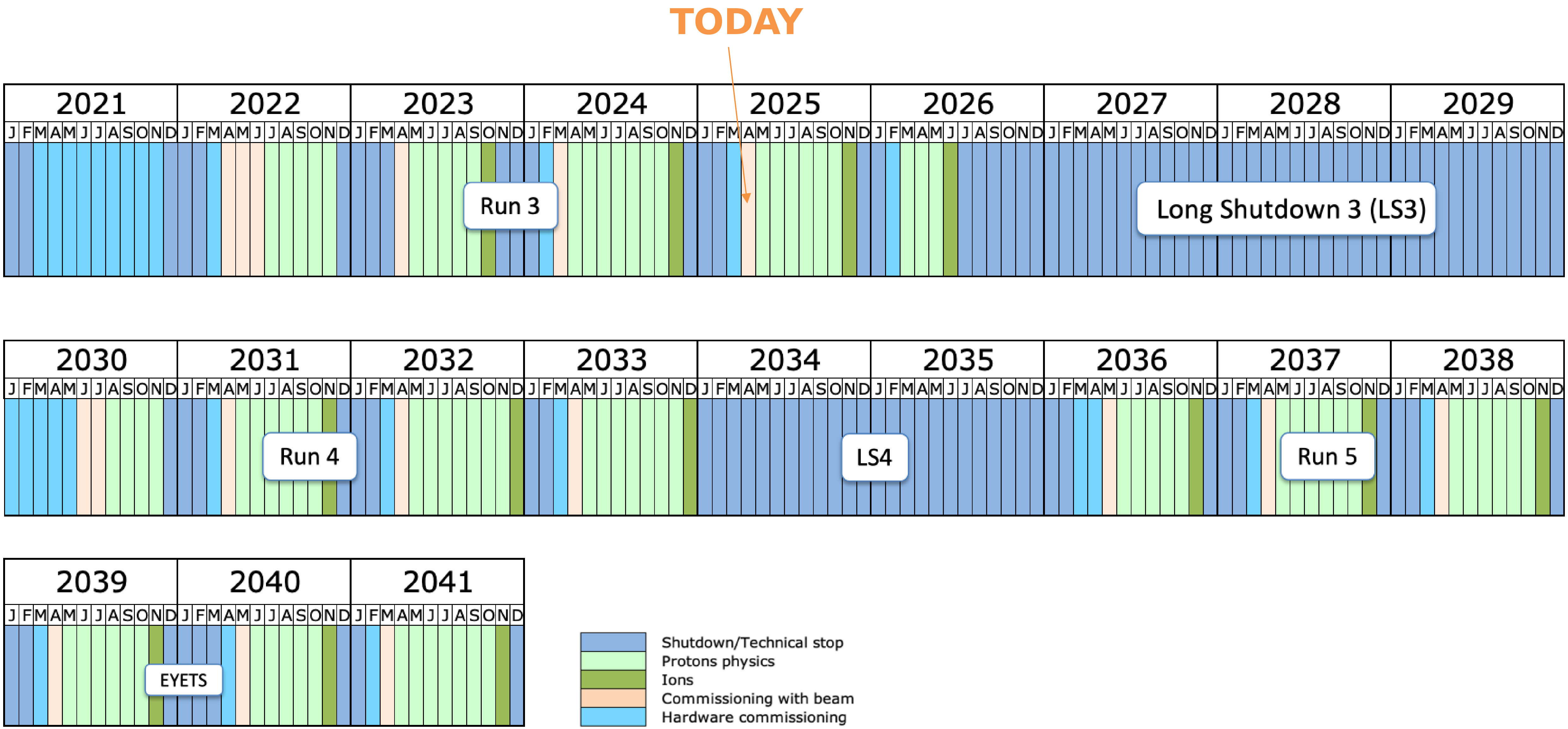


- **66** Physicist
- **15** Physics PhD student
- **12** Physics masters/diploma student
- **1** Undergraduate/summer student
- **3** Engineer with PhD
- **37** Engineer without PhD
- **1** Engineering student
- **17** Technician or equivalent
- **2** Administrator/other

- **48** on Authorlist (A)
- **1** Signing-Only (a)
- **37** counted for M&O (M)
- **0** qualifying members (q)
- **45.25** for Operation Tasks (O, o)

DLNP: Atanov N., Atanova O., Batusov V., Bednyakov V., Boyko I., Chizhov M., Davydov Yu., Dedovich D., Demichev M., Didenko A., Dolovova O., Dydyshko Y., Elkin V., Ershova A., *Filimonov S.*, Gerasimov V., Gladilin L., Glagolev V., Gongadze A., Gongadze I., Gongadze L., Gostkin M., Gritsai K., Ivanov Y., Kalinovskaja L., Karpov S., Karpova Z., Kharchenko D., Kostyukhina I., Kruchonak U., *Kuchinskaya O.*, Koultchitski Y., Lyabline M., Lyashko I., Lykasov G., Lyubushkin V., Lyubushkina T., Malyukov S., Minashvili I. (jr.), Nefedov Y., Plontikova E., Potrap I., Prokhorov A., *Ramakoti E.*, Romanov V., Rusakovich N., Sapronov A., Serochkin M., Shalyugin A., Shelkov G., Shiyakova M., *Shreyber I.*, *Soldatov E.*, Souslov I., Tropina A., Tsiareska P., Usubov Z., Vasyukov A., Yeletskikh I., Yermolchyk V., Zhemchugov A.
LIT: Alexandrov E., Aleksandrov I., Gromova N., Iakovlev A., Kazymov A., Mineev M., Shigaev V., Zrelov P.
VBLHEP: Ahmadov F., *Amirkhanov A.*, *Anisenkov A.*, *Bobrovnikov V.*, *Buzykaev A.*, Cheplakov A., Fillipov Y., Kukhtin V., Ladygin E., Makarov A., Manashova M., *Maslennikov A.*, *Rezanova O.*, Soloshenko A., Shaykhatdenov B., *Snesarev A.*, *Tikhonov Yu.*, Turtuvshin T., Zimin N.

LHC long term operation plan

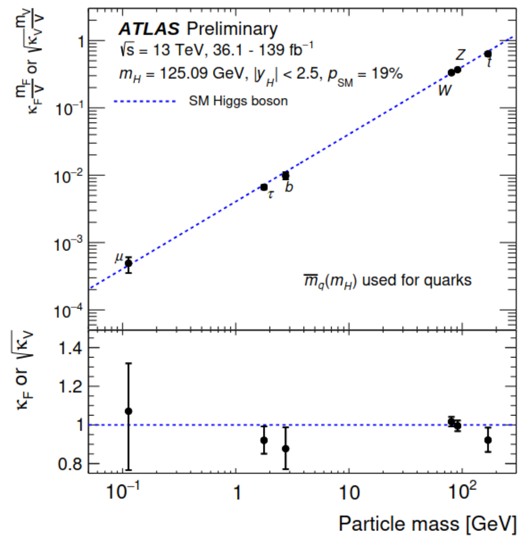


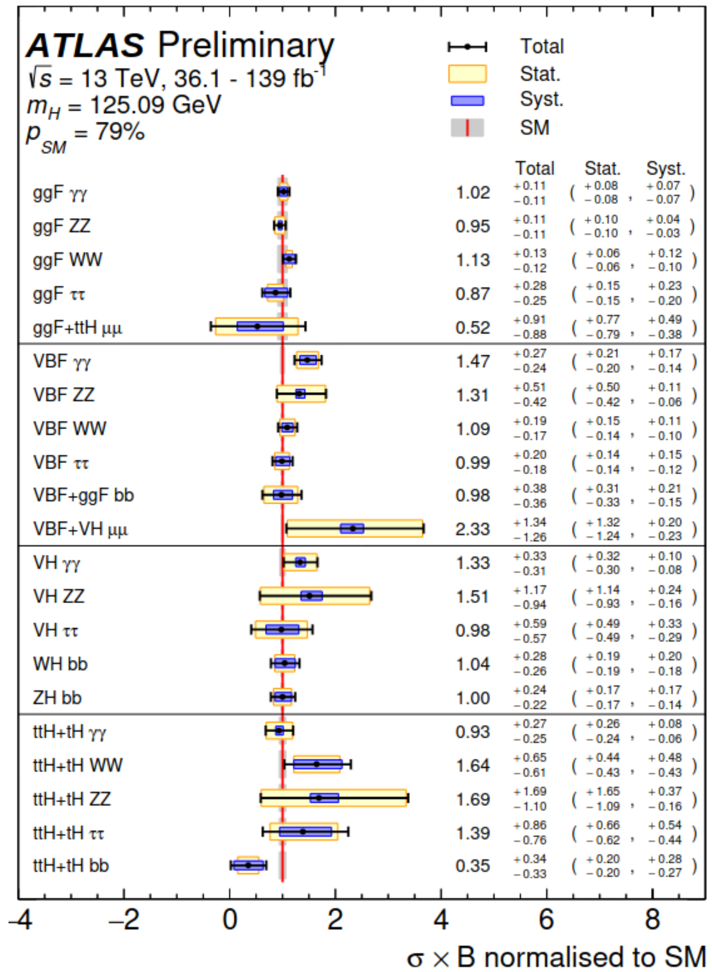
Last update: November 24

Higgs physics

- After Higgs discovery, one of the main tasks is measurement of its couplings
- Some of them are still to be measured
- Values of these couplings as well as interference contributions are sensitive to new physics
- To gain sensitivity – many complementary measurements have to be made
- Data statistics is important for these analyses to reduce uncertainties

Production cross section	Loops	Main interference	Effective modifier	Resolved modifier
$\sigma(ggF)$	✓	t–b	κ_g^2	$1.040\,\kappa_t^2 + 0.002\,\kappa_b^2 - 0.038\,\kappa_t\kappa_b - 0.005\,\kappa_t\kappa_c$
$\sigma(VBF)$	-	-	-	$0.733\,\kappa_W^2 + 0.267\,\kappa_Z^2$
$\sigma(qq/qg \to ZH)$	-	-	-	κ_Z^2
$\sigma(gg \to ZH)$	✓	t–Z	$\kappa_{(ggZH)}$	$2.456\,\kappa_Z^2 + 0.456\,\kappa_t^2 - 1.903\,\kappa_Z\kappa_t$ $- 0.011\,\kappa_Z\kappa_b + 0.003\,\kappa_t\kappa_b$
$\sigma(WH)$	-	-	-	κ_W^2
$\sigma(t\bar{t}H)$	-	-	-	κ_t^2
$\sigma(tHW)$	-	t–W	-	$2.909\,\kappa_t^2 + 2.310\,\kappa_W^2 - 4.220\,\kappa_t\kappa_W$
$\sigma(tHq)$	-	t–W	-	$2.633\,\kappa_t^2 + 3.578\,\kappa_W^2 - 5.211\,\kappa_t\kappa_W$
$\sigma(b\bar{b}H)$	-	-	-	κ_b^2
Partial decay width				
Γ^{bb}	-	-	-	κ_b^2
Γ^{WW}	-	-	-	κ_W^2
Γ^{gg}	✓	t–b	κ_g^2	$1.111\,\kappa_t^2 + 0.012\,\kappa_b^2 - 0.123\,\kappa_t\kappa_b$
$\Gamma^{\tau\tau}$	-	-	-	κ_τ^2
Γ^{ZZ}	-	-	-	κ_Z^2
Γ^{cc}	-	-	-	$\kappa_c^2\ (= \kappa_t^2)$
$\Gamma^{\gamma\gamma}$	✓	t–W	κ_γ^2	$1.589\,\kappa_W^2 + 0.072\,\kappa_t^2 - 0.674\,\kappa_W\kappa_t$ $+0.009\,\kappa_W\kappa_\tau + 0.008\,\kappa_W\kappa_b$ $-0.002\,\kappa_t\kappa_b - 0.002\,\kappa_t\kappa_\tau$
$\Gamma^{Z\gamma}$	✓	t–W	$\kappa_{(Z\gamma)}^2$	$1.118\,\kappa_W^2 - 0.125\,\kappa_W\kappa_t + 0.004\,\kappa_t^2 + 0.003\,\kappa_W\kappa_b$
Γ^{ss}	-	-	-	$\kappa_s^2\ (= \kappa_b^2)$
$\Gamma^{\mu\mu}$	-	-	-	κ_μ^2





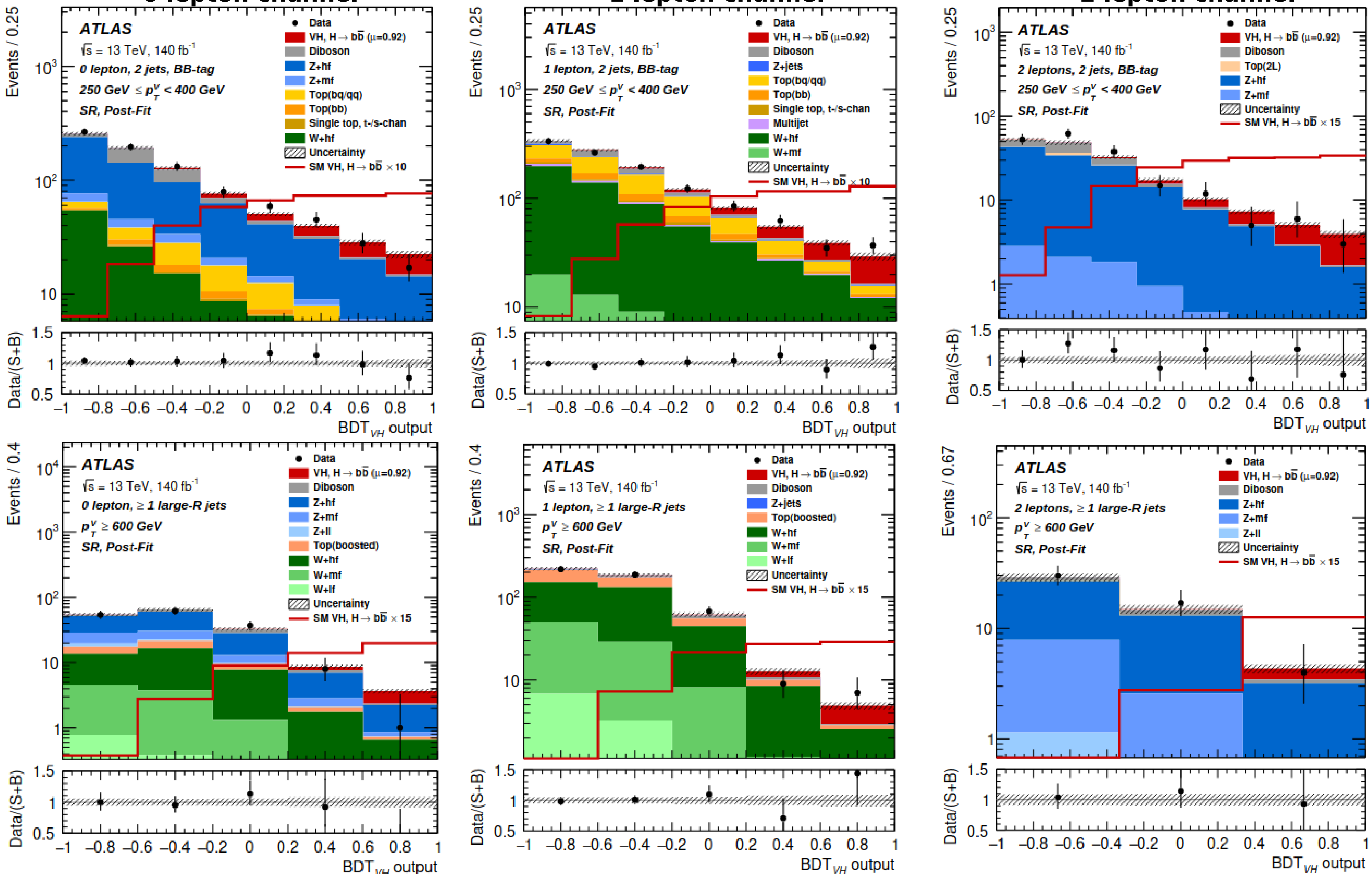
Measurements of *WH* and *ZH* production with Higgs boson decays into bottom quarks and direct constraints on the charm Yukawa coupling

Differential cross-sections of the Higgs boson produced in association with W or Z bosons have been measured in H→bb channel.   Vector boson pT specrum is split into ranges 75-150-250-400-600-inf GeV.

0 lepton channel | **1 lepton channel** | **2 lepton channel**

250 GeV < pT < 400 GeV

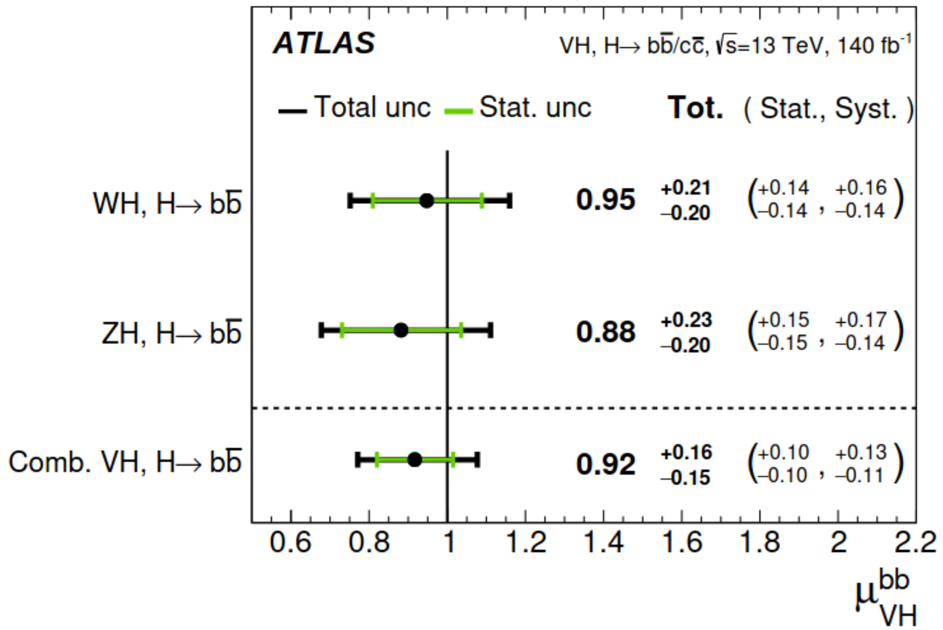
pT > 600 GeV



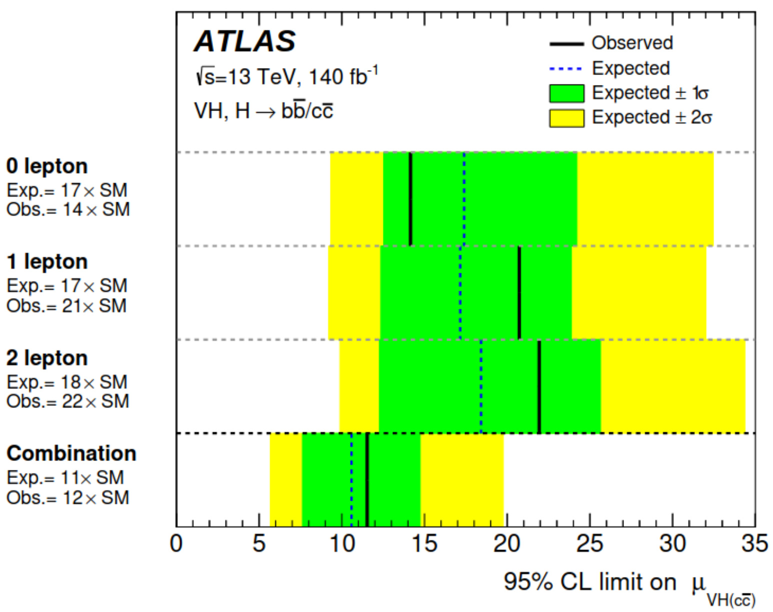
F.Ahmadov
ArXiv:2410.19611, accepted by JHEP

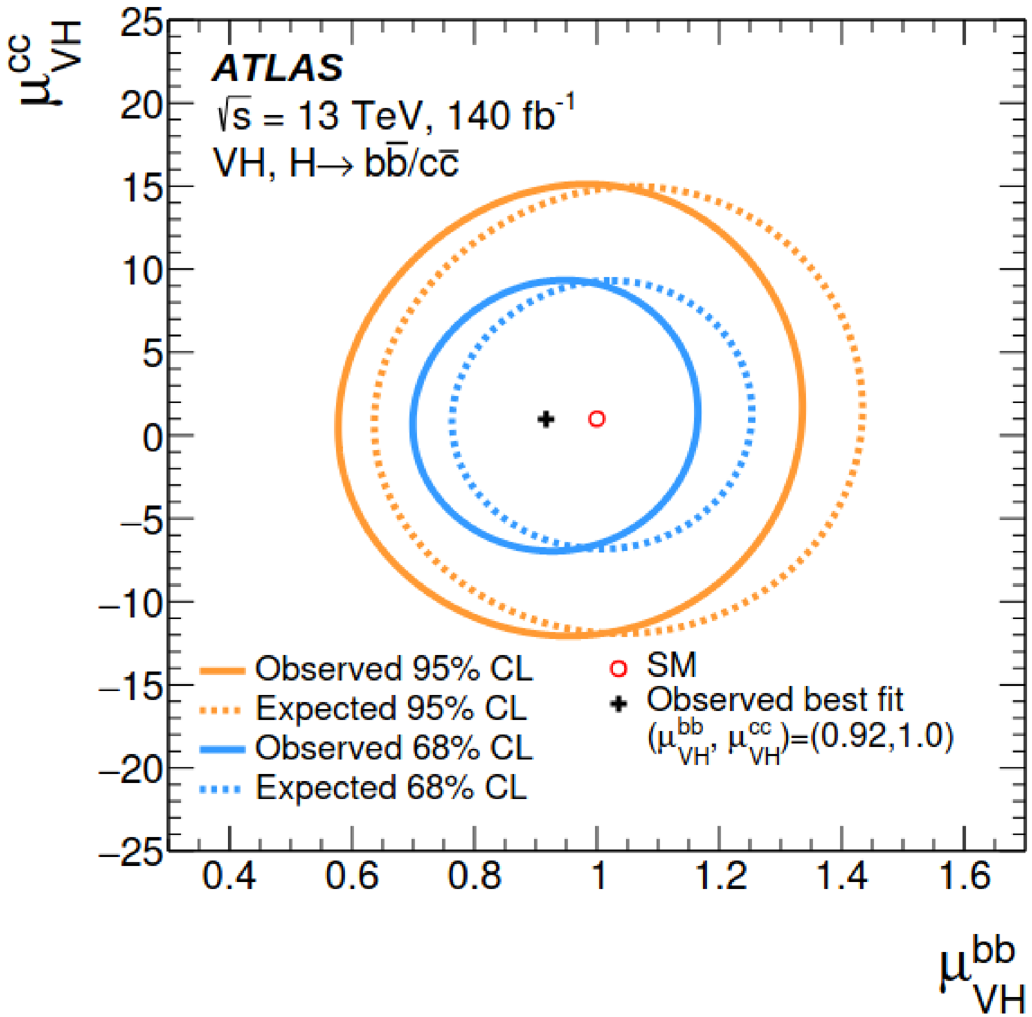
Measurements of WH and ZH production with Higgs boson decays into bottom quarks and direct constraints on the charm Yukawa coupling

Signal strength of *H→bb* in the VH production channels has been measured relative to that predicted by Standard Model.



Limit is set on *H→cc* signal strength relative to SM.



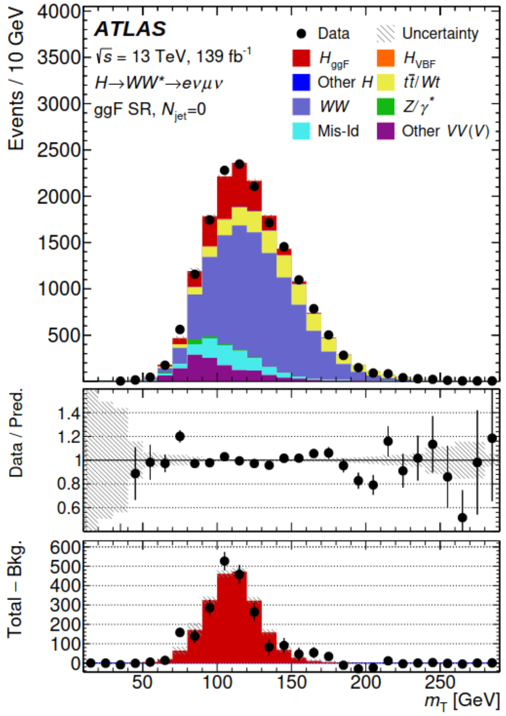


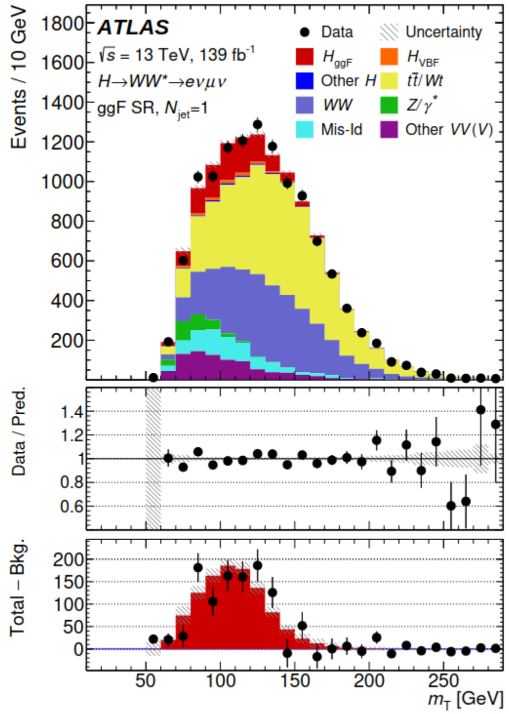
$$\mu_{VH}^{bb} = 0.92^{+0.16}_{-0.15} = 0.92 \pm 0.10\,(\text{stat.})^{+0.13}_{-0.11}\,(\text{syst.}),$$

$$\mu_{VH}^{cc} = 1.0^{+5.4}_{-5.2} = 1.0^{+4.0}_{-3.9}\,(\text{stat.})^{+3.7}_{-3.5}\,(\text{syst.}).$$

F.Ahmadov
ArXiv:2410.19611, accepted by JHEP

Higgs boson production via ggF and VBF is measured in the $H \to WW^* \to e\nu\mu\nu$ decay channel. Observed production cross sections are in agreement with SM predictions.



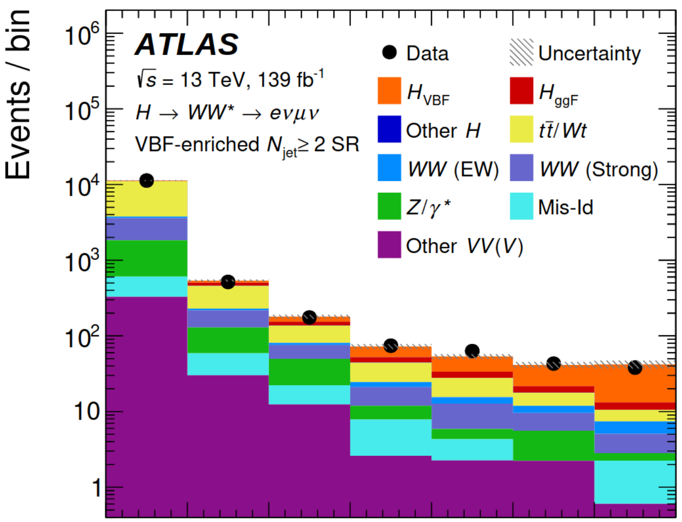


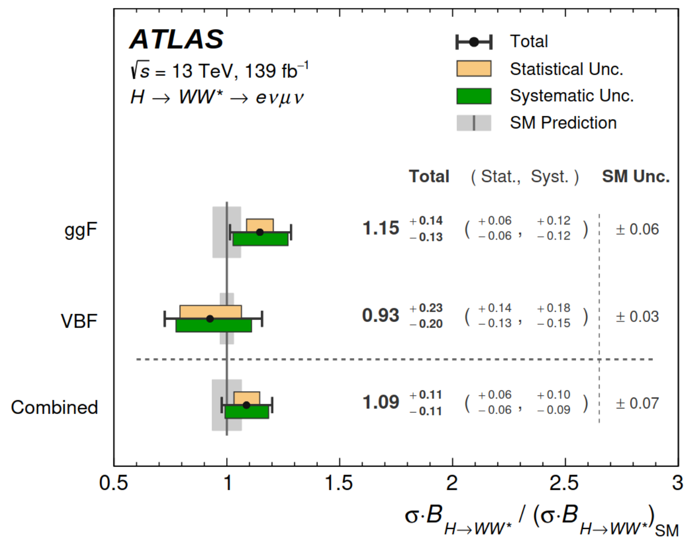
$$\sigma_{\text{ggF}} \cdot \mathcal{B}_{H\to WW^*} = 12.0 \pm 1.4 \text{ pb}$$
$$= 12.0 \pm 0.6 \text{ (stat.)}^{+0.9}_{-0.8} \text{ (exp. syst.)} \,^{+0.6}_{-0.5} \text{ (sig. theo.)} \pm 0.8 \text{ (bkg. theo.) pb}$$
$$\sigma_{\text{VBF}} \cdot \mathcal{B}_{H\to WW^*} = 0.75 \,^{+0.19}_{-0.16} \text{ pb}$$
$$= 0.75 \pm 0.11 \text{ (stat.)} \,^{+0.07}_{-0.06} \text{ (exp. syst.)} \,^{+0.12}_{-0.08} \text{ (sig. theo.)} \,^{+0.07}_{-0.06} \text{ (bkg. theo.) pb,}$$

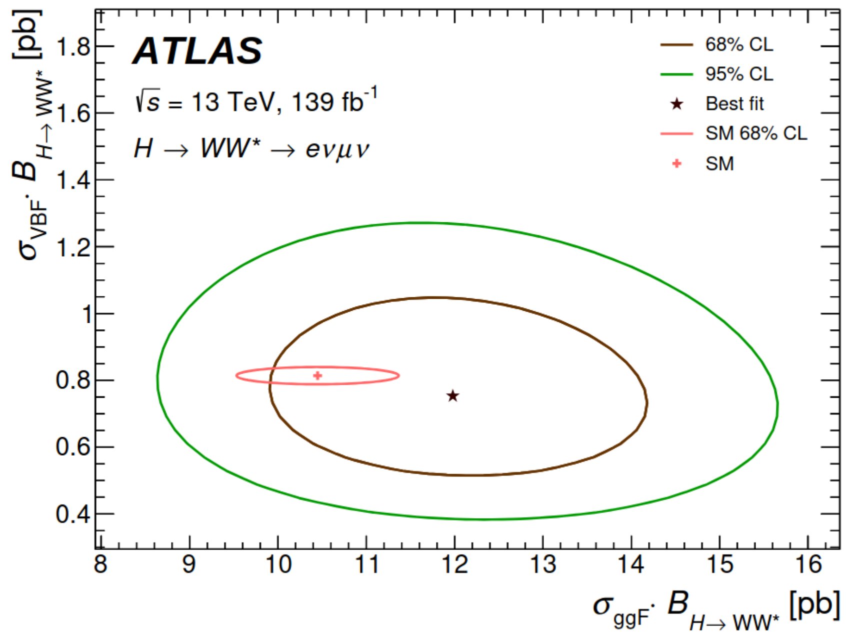
compared to the SM predicted values of 10.4 ± 0.5 and 0.81 ± 0.02 pb for ggF and VBF [11],[9] respectively. The combined cross section times branching ratio, $\sigma_{\text{ggF+VBF}} \cdot \mathcal{B}_{H\to WW^*}$, obtained from fitting a single POI, is measured to be

$$\sigma_{\text{ggF+VBF}} \cdot \mathcal{B}_{H\to WW^*} = 12.3 \pm 1.3 \text{ pb}$$
$$= 12.3 \pm 0.6 \text{ (stat.)} \,^{+0.8}_{-0.7} \text{ (exp. syst.)} \pm 0.6 \text{ (sig. theo.)} \pm 0.7 \text{ (bkg. theo.) pb,}$$

compared to the SM predicted value of 11.3 ± 0.5 pb.

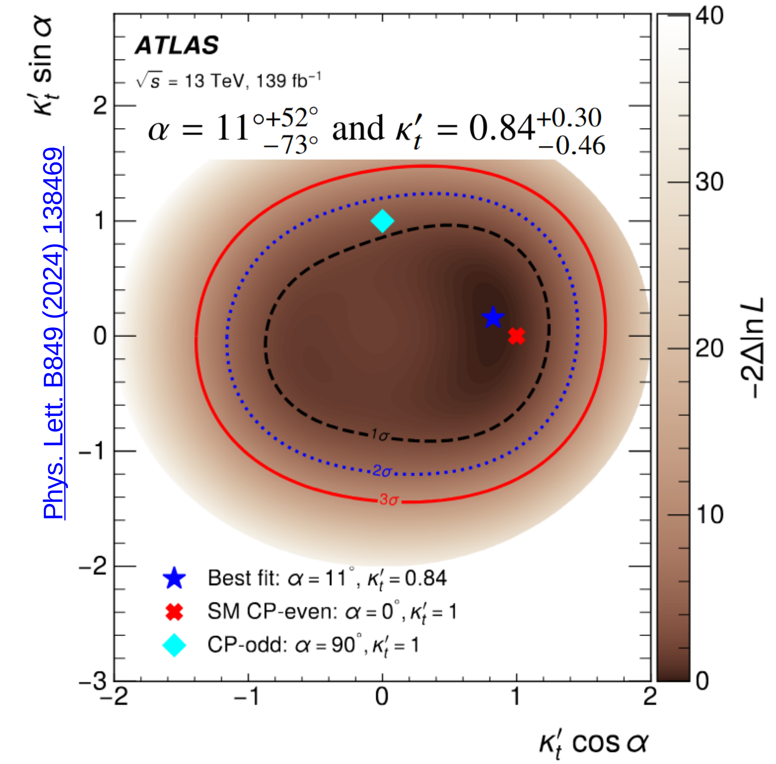






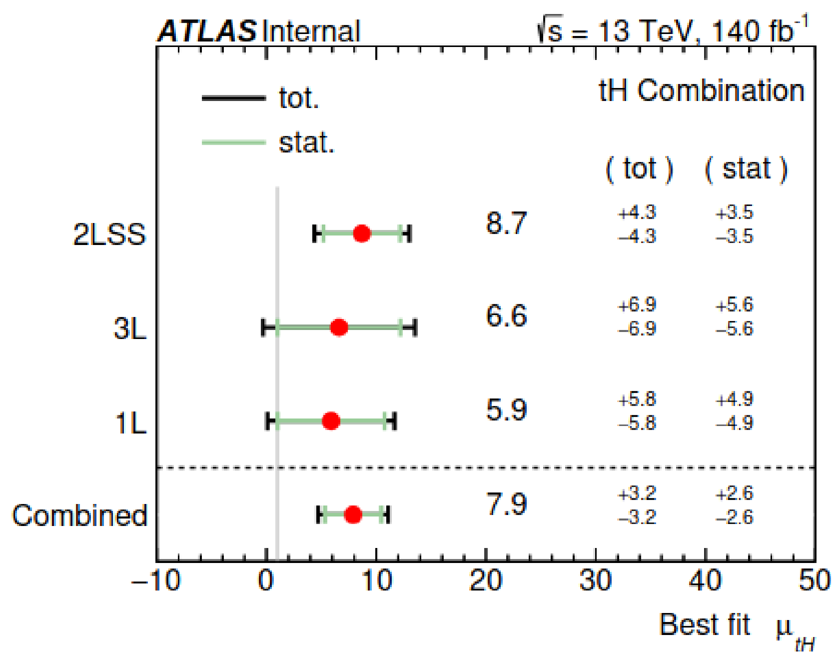
Currently the results are being updated with all lepton flavours included in Higgs boson reconstruction

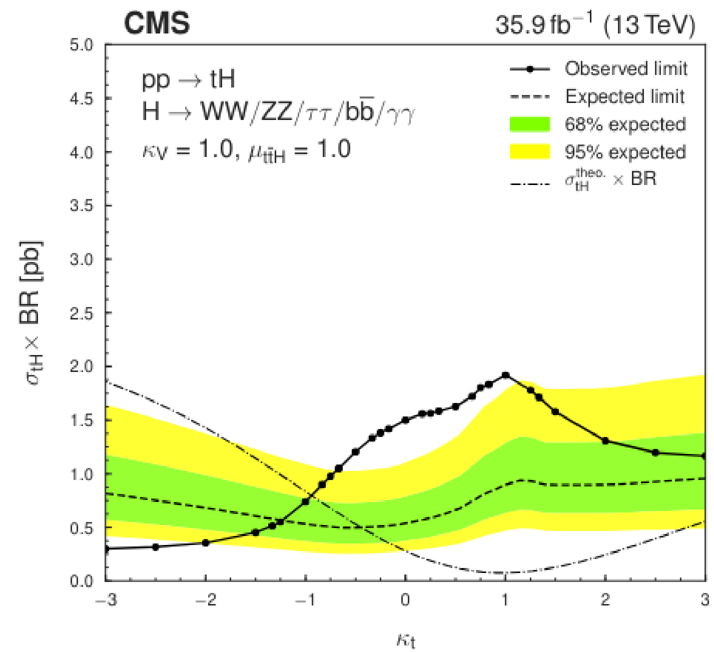
E.Ramakoti
Phys.Rev.D 108 (2023) 032005

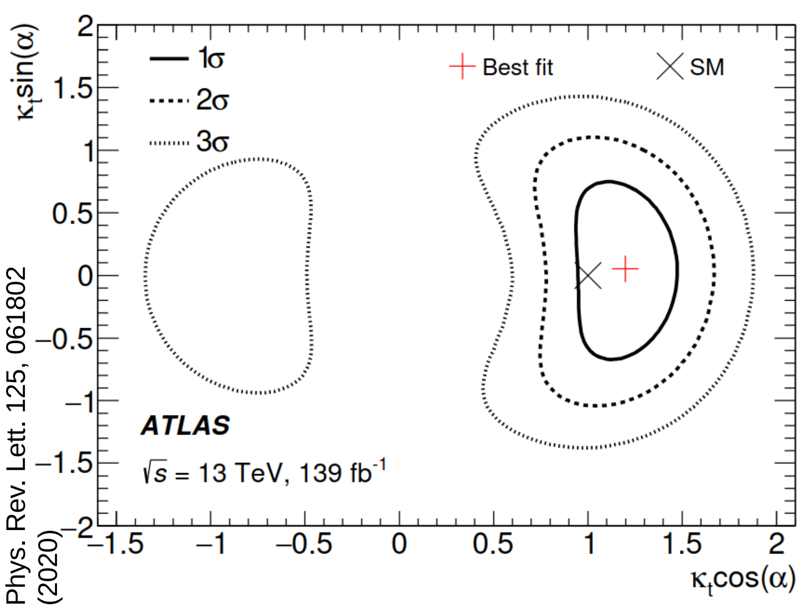


Probing the CP nature of the top-Higgs Yukawa coupling is one of the important tests of SM. Current measurements of the phase of this coupling are consistent with SM but suffer from high uncertainties – several complementary measurements in different cjannels have to made.

One of them directly sensitive to phase is Higgs production in association with single top quark. Phases other than 0 predict higher cross-section of tH production







Full Run2 searches for tH production are planned to be published from both ATLAS and CMS.
Looking forward to Run3 analysis and Run4 data.

N.Huseynov, I.Boyko, O.Dolovova, A.Tropina, A.Didenko, I.Yeletskikh

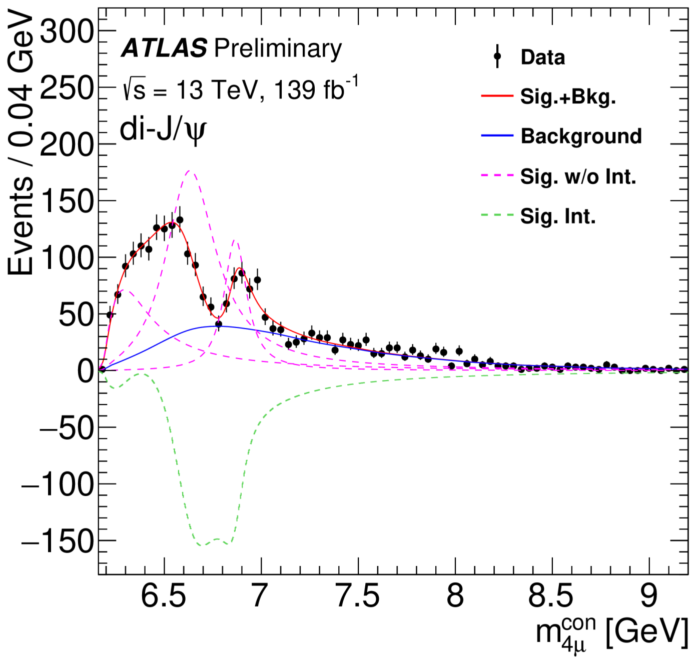
B-physics and light states

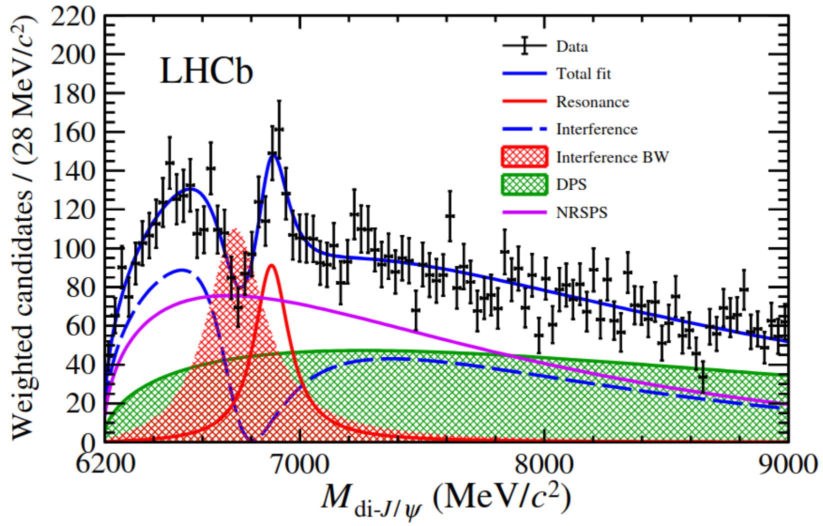
- CP-violation studies in B-hadron decays
- Exotic hadrons – tetraquarks and pentaquarks
- Measurements of charmed and beauty hadron production, spectra of heavy mesons

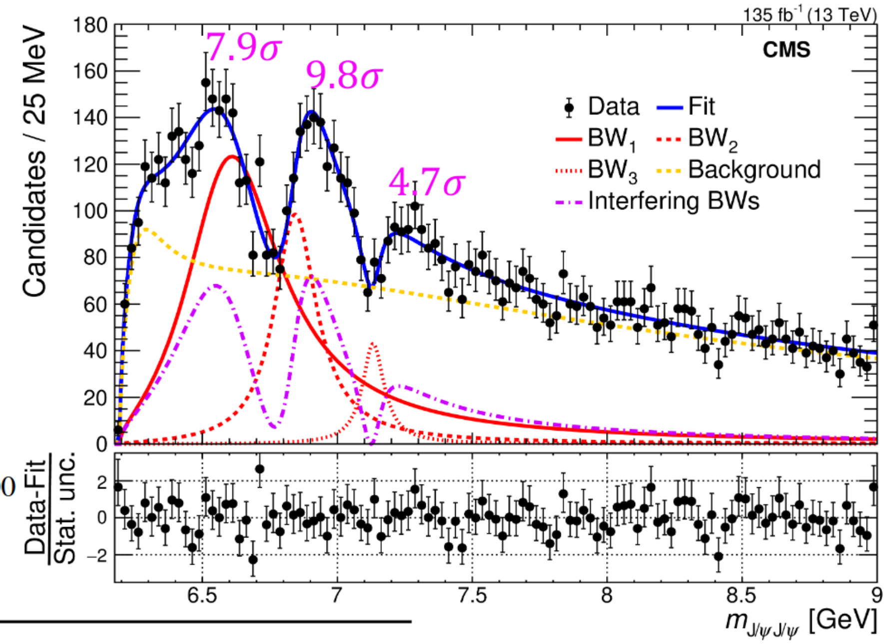
Resonant production of charmonia pairs: fully charmed tetraquarks

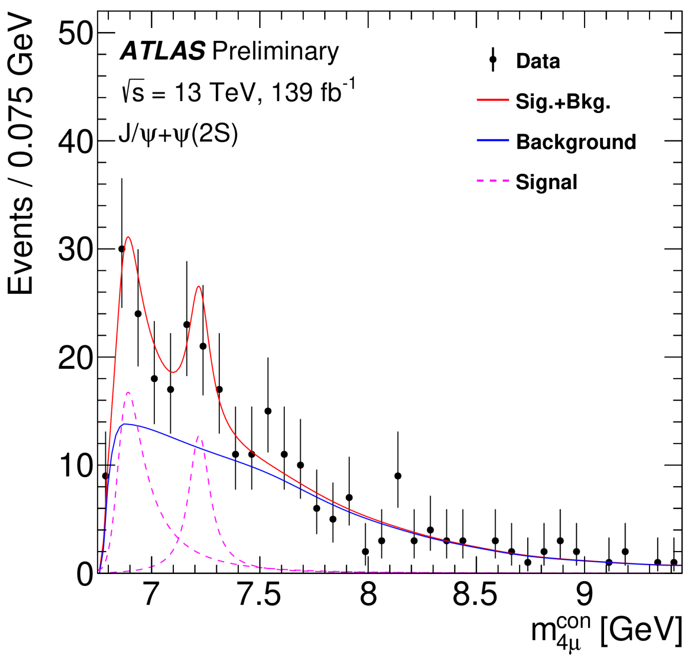
A.Didenko, I.Yeletskikh, L.Gladilin

Phys. Rev. Lett. 131 (2023) 151902









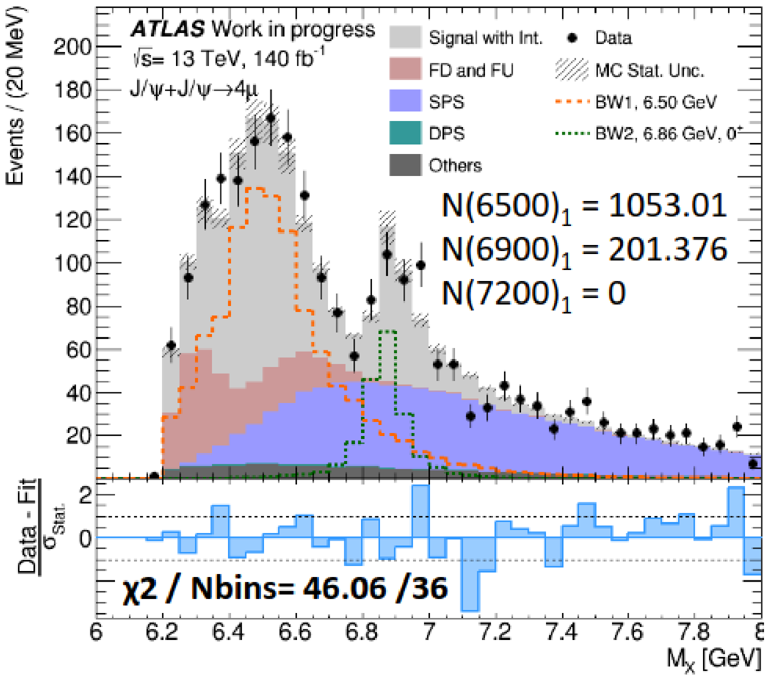
(GeV)	m_0	Γ_0	m_1	Γ_1
di-J/ψ	$6.22 \pm 0.05^{+0.04}_{-0.05}$	$0.31 \pm 0.12^{+0.07}_{-0.08}$	$6.62 \pm 0.03^{+0.02}_{-0.01}$	$0.31 \pm 0.09^{+0.06}_{-0.11}$
	m_2	Γ_2	—	
	$6.87 \pm 0.03^{+0.06}_{-0.01}$	$0.12 \pm 0.04^{+0.03}_{-0.01}$	—	
(GeV)		m_3	Γ_3	
J/ψ+$\psi(2S)$	model A	$7.22 \pm 0.03^{+0.02}_{-0.03}$	$0.10^{+0.13+0.06}_{-0.07-0.05}$	—
	model B	$6.78 \pm 0.36^{+0.35}_{-0.54}$	$0.39 \pm 0.11^{+0.11}_{-0.07}$	—

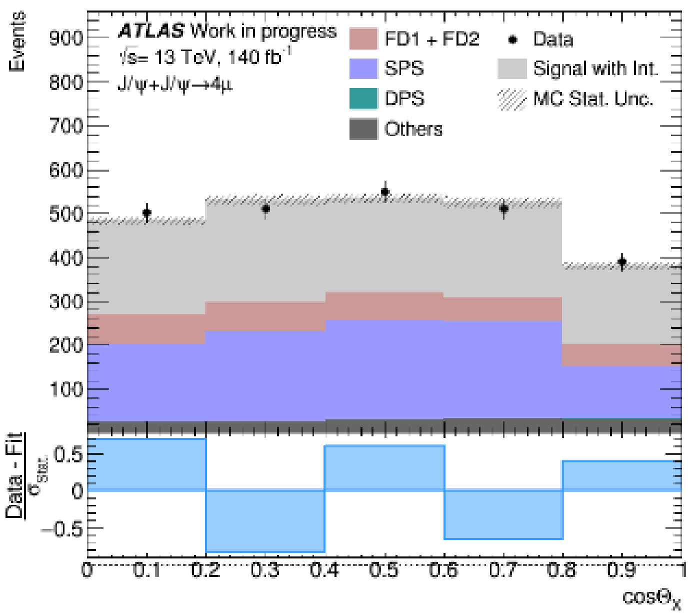
Observation of the prominent resonant signals (X-6900) may be explained by contributions from fully charmed tetraquarks.
X-7200 observation still to be confirmed.
Spin-parity properties are unknown – angular analysis is needed
Searches for other decay channels

Resonant production of charmonia pairs: fully charmed tetraquarks

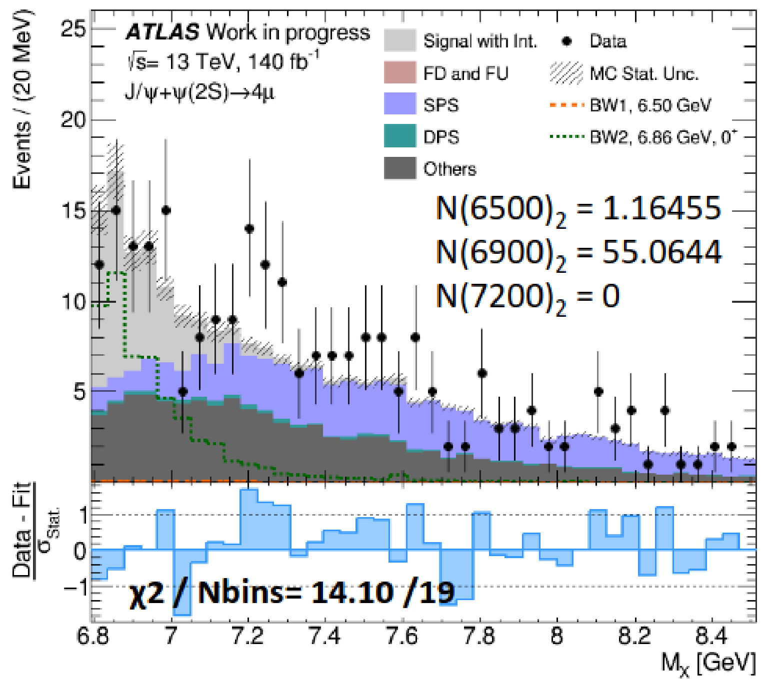
A.Didenko, I.Yeletskikh, L.Gladilin

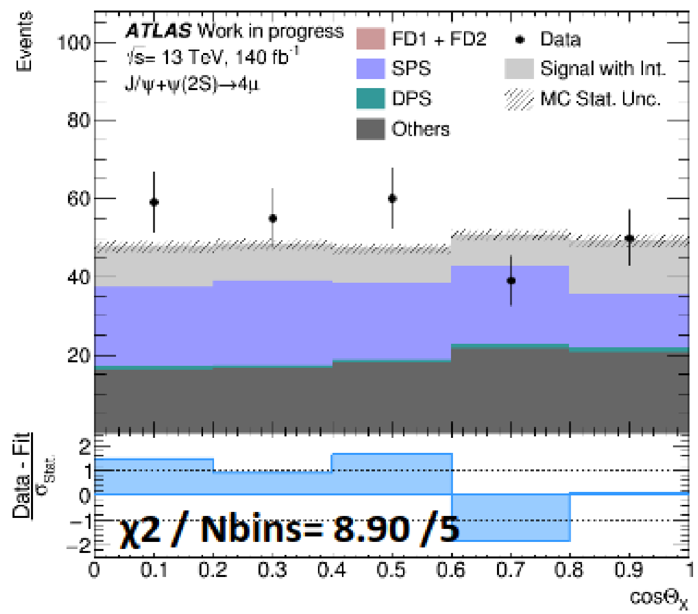
$J/\psi + J/\psi \rightarrow 4\mu$



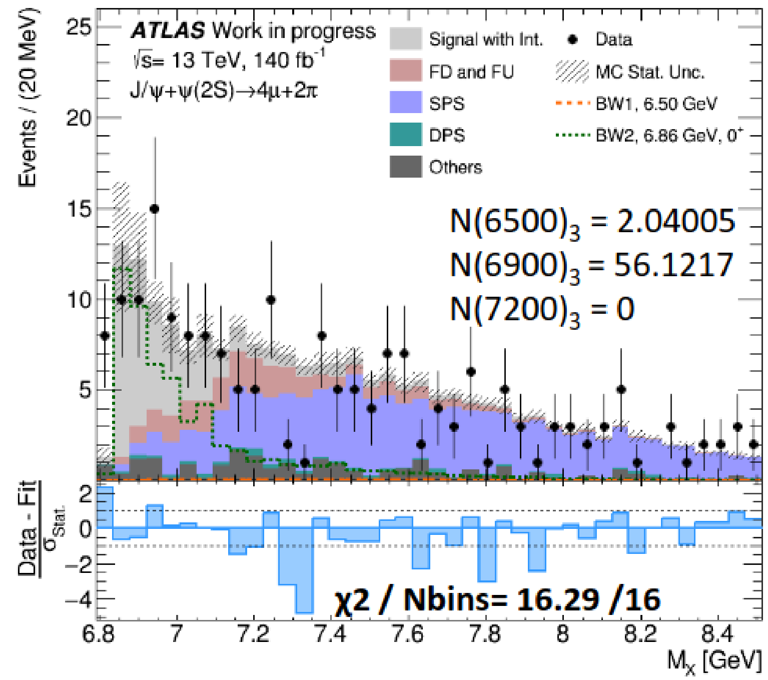


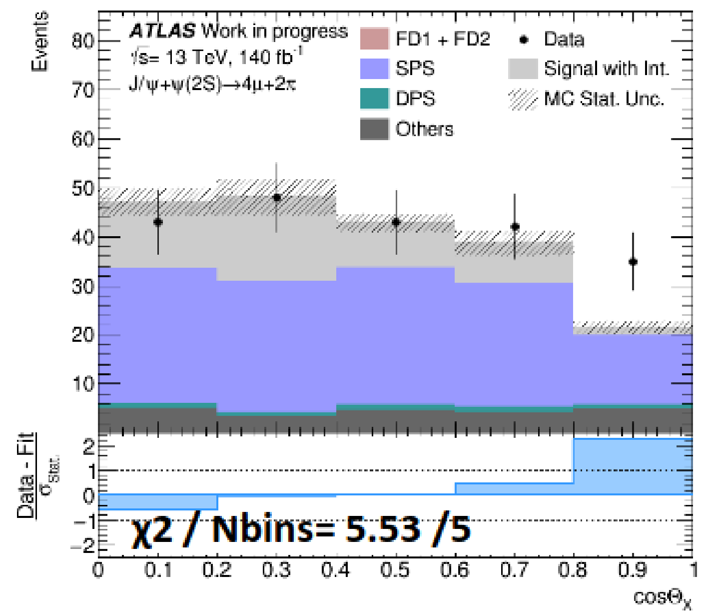
$J/\psi + \psi(2S) \rightarrow 4\mu$

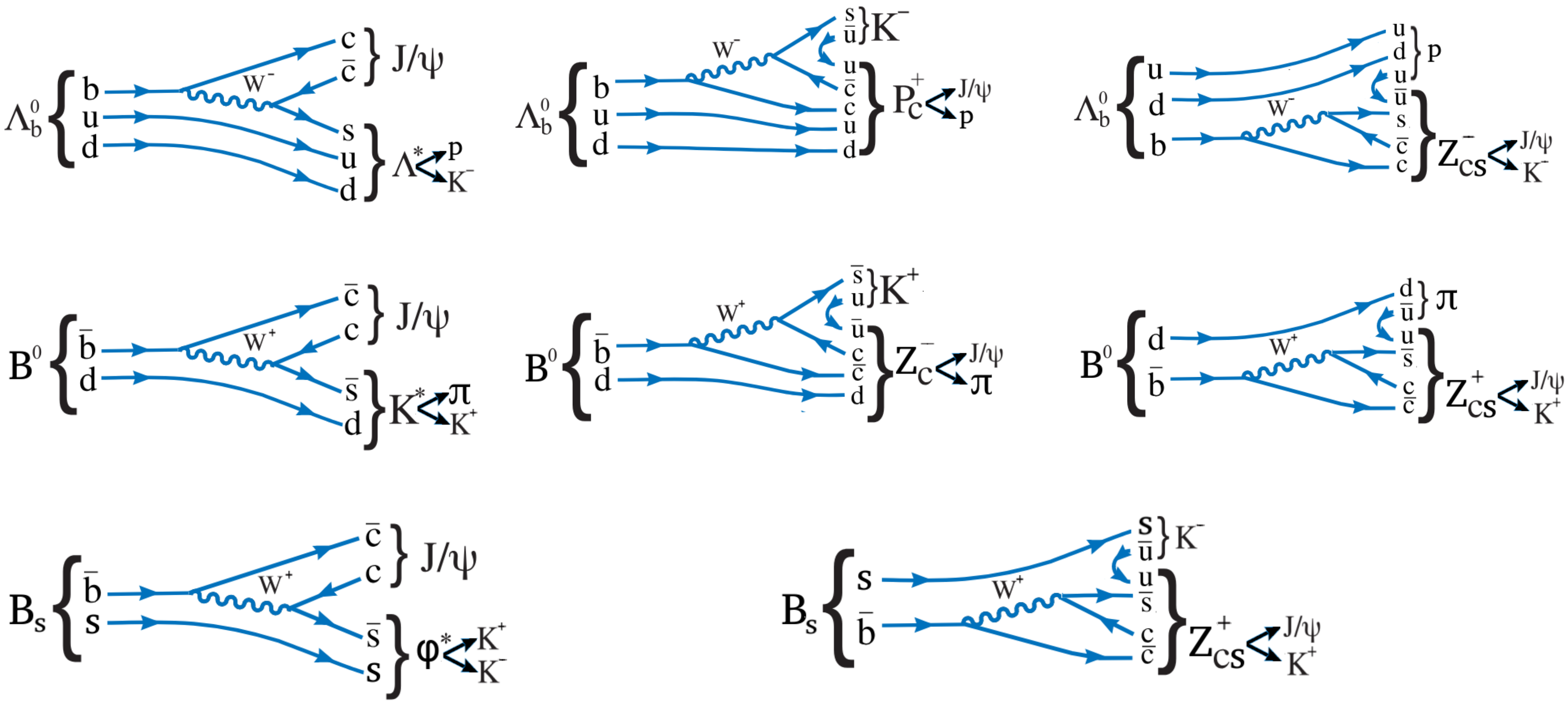


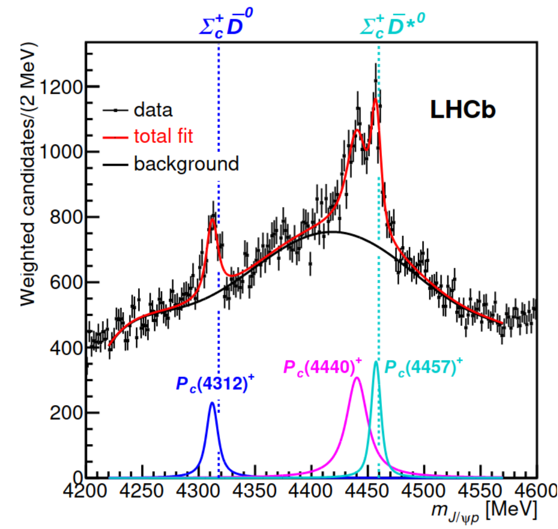


$J/\psi + \psi(2S) \rightarrow 4\mu + 2\pi$









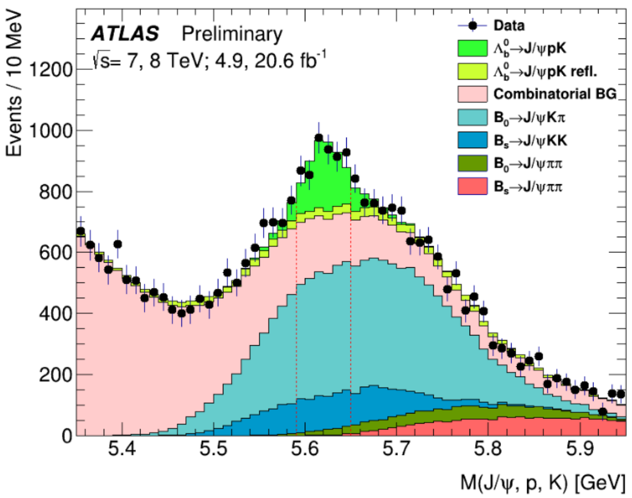
Several experiments observed contributions from multiquark candidates to decays of heavy hadrons.

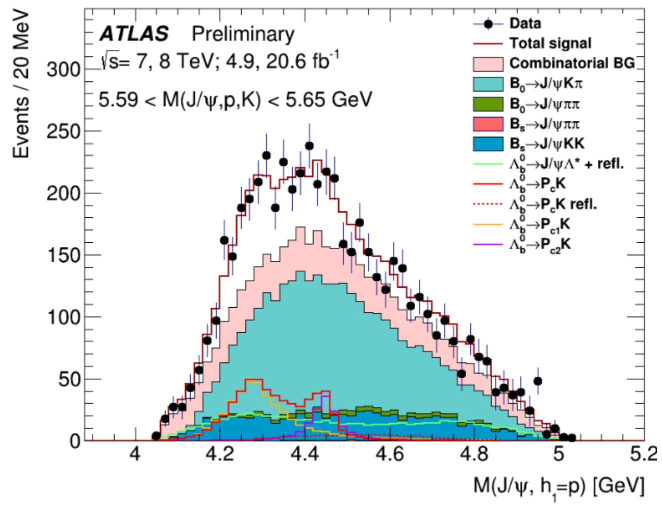
These contributions are often mixed with each other and interfere with background decays, which complicates their analysis.

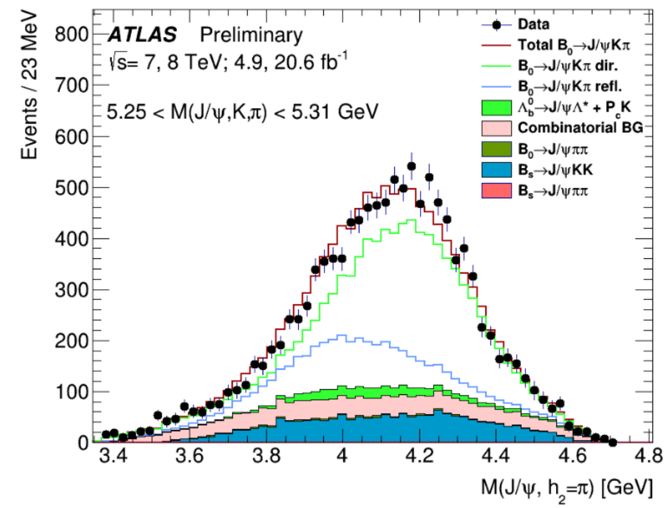
During last 10 years, pentaquarks and tetraquarks with hidden charm, pentaquarks and tetraquarks with hidden charm and open strangeness in decays to Jpsi and light charged hadron were discovered. Some of them are studied in ATLAS data.

Currently there is quite limited knowledge about internal structure of these states, spin-parity properties, and predictions for other states in spectrum and other decay modes are uncertain.

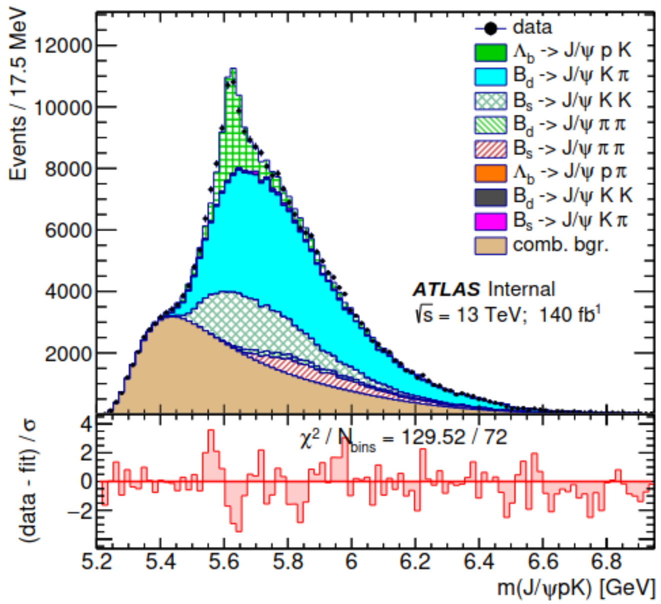
PoS(Beauty2019)01

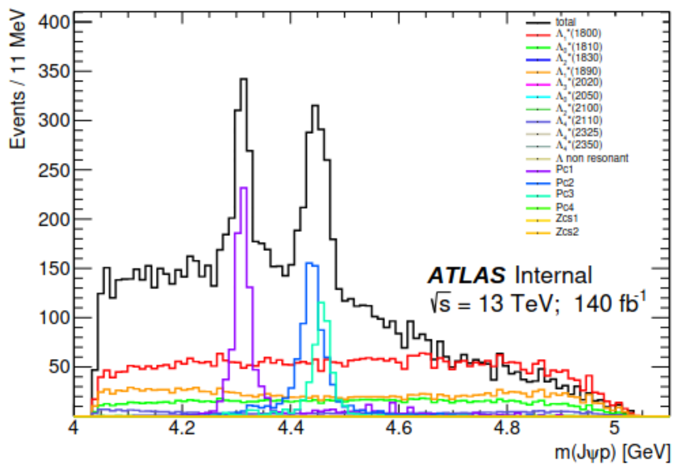


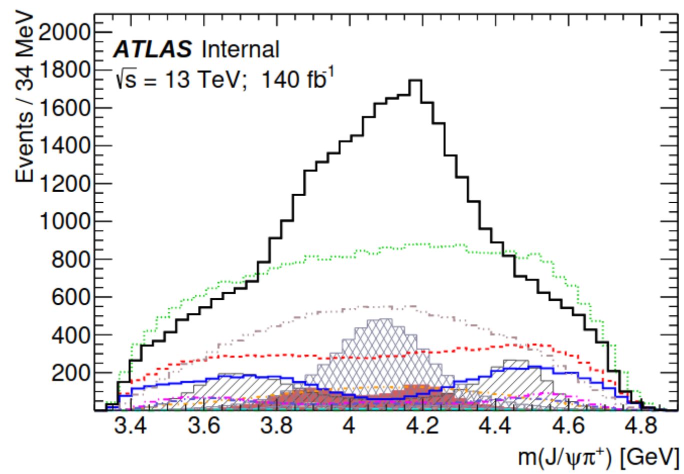




Run1







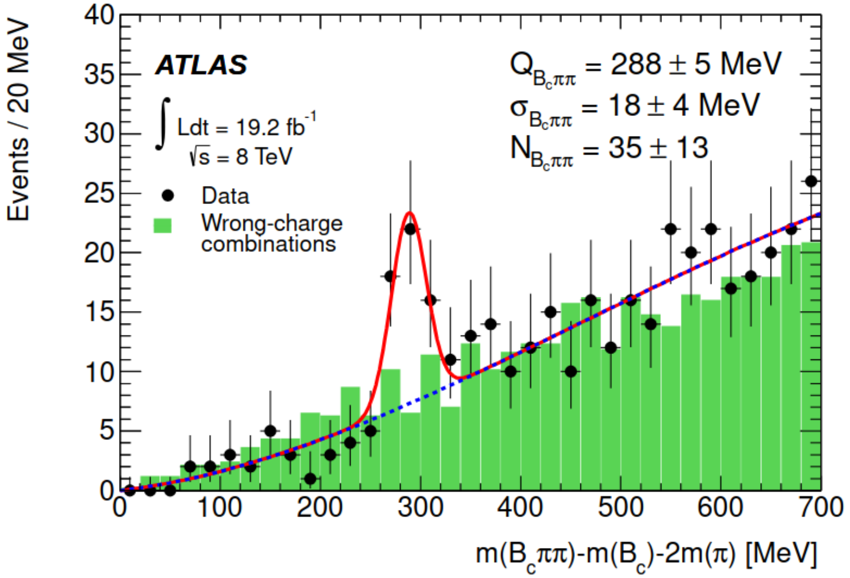
Run2

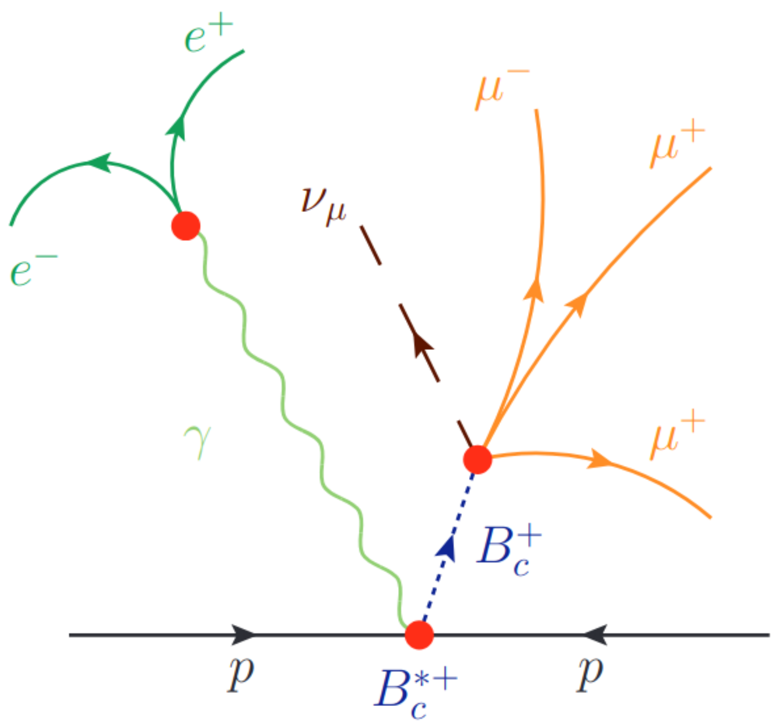
ATLAS data confirmed pentaquarks (at the level of only ~2.5 sigma) in RunI data. Currently analyses are ongoing w.r.t. Pc and Zc, Zcs states with Run2 data.

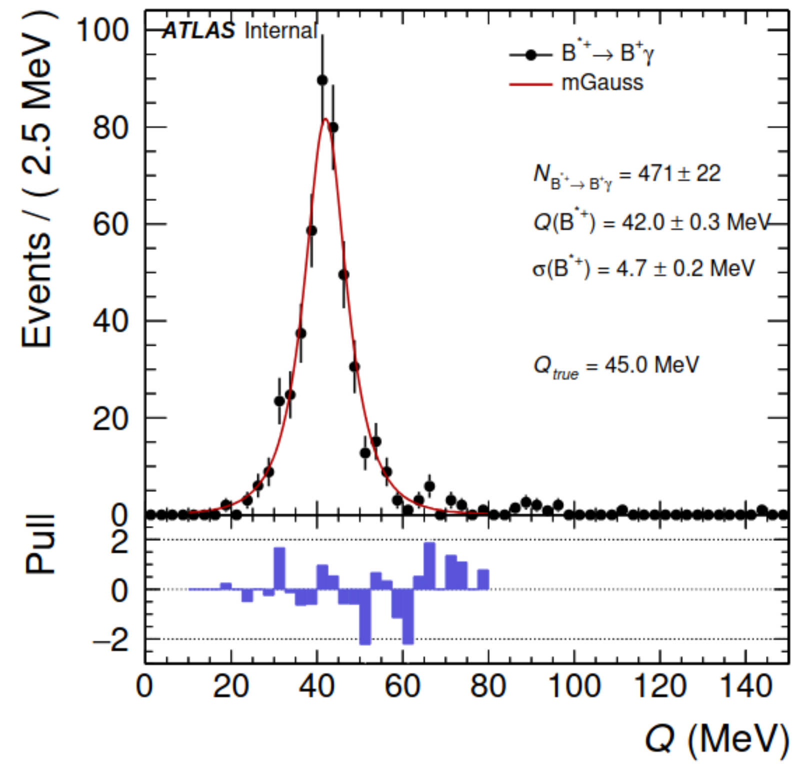
Study of B_c mesons provides important inputs for theory being a unique bound state of heavy quarks. So far – $B_c(2S)$ doublets are observed experimentally:

CMS PRD 102 (2020) 092007, LHCb PRL 122 (2019) 232001, ATLAS PRL 113 (2014) 212004

There is prediction of B_c^* state with mass mass difference w.r.t. ground state of 50-70MeV. The analysis depends substantially on the reconstruction of soft photons.



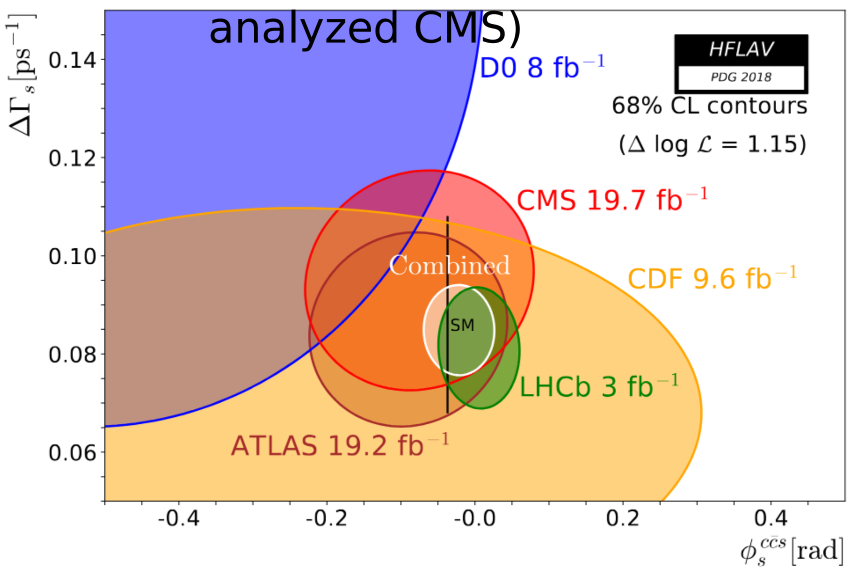


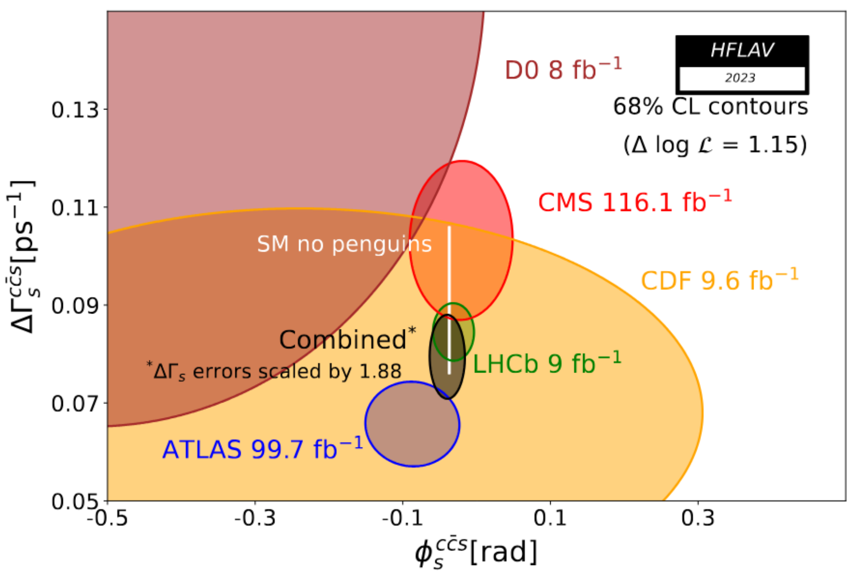


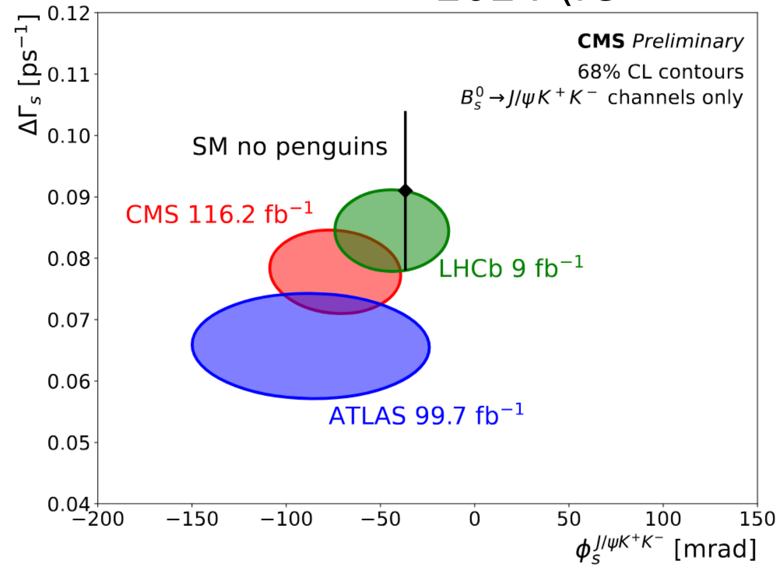
Example of B^{+*} reconstruction representing one of the backgrounds and using the same soft photon reconstruction. For the photon reconstruction, Event Picking service was used, developed by JINR team.

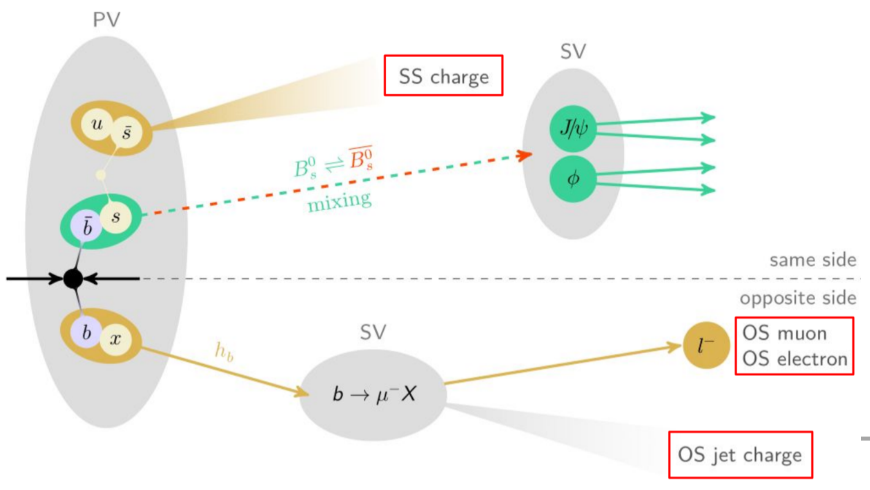
CP violation in $B_s \to J/\psi\ \varphi(1020)$ decays due to interference between direct decays and B_s flavour mixing.
The main observable is CPV phase φ_s predicted by global fits to be **-37 ± 1** mrad
ATLAS analysis was performed using 2015-2017 data, full Run2 analysis is now ongoing...

2018 2023 2024 (re-analyzed CMS)









$$\phi_s = -0.087 \pm 0.036\ (\text{stat.}) \pm 0.021\ (\text{syst.})\ \text{rad}$$
$$\Delta\Gamma_s = 0.0657 \pm 0.0043\ (\text{stat.}) \pm 0.0037\ (\text{syst.})\ \text{ps}^{-1}$$
$$\Gamma_s = 0.6703 \pm 0.0014\ (\text{stat.}) \pm 0.0018\ (\text{syst.})\ \text{ps}^{-1}$$

Result uncertainty depends substantially on the performance of *b*-tagger and quality of multi-dimensional fits of the decay parameters.

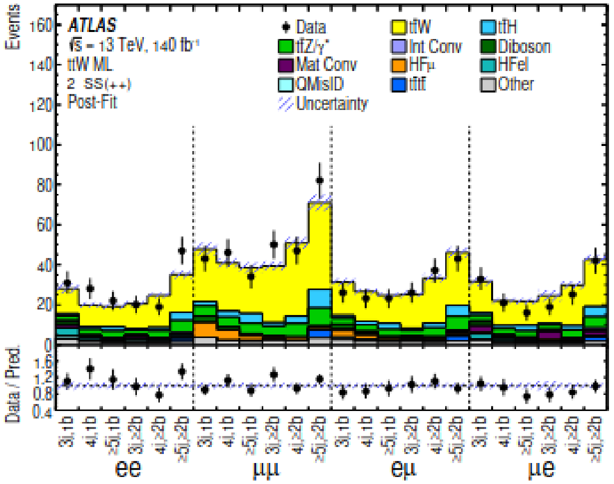
Standard Model measurements

Proton structure

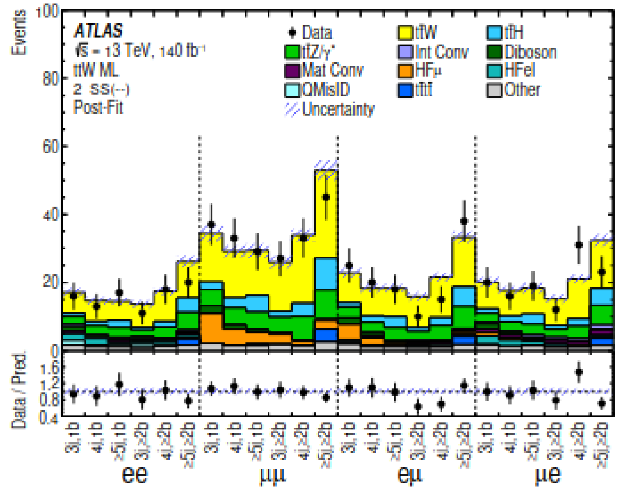
Reconstruction performance

Theoretical support and events modeling

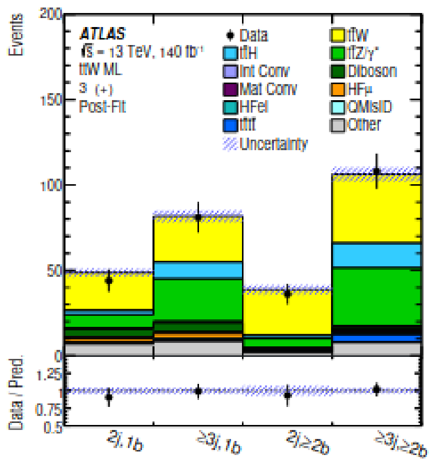
Cross-section of the top-antitop pairs produced in association with W-bosons has been measured with ATLAS Run2 13TeV data

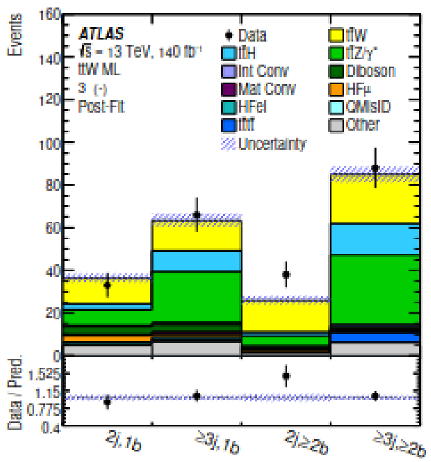


(a)

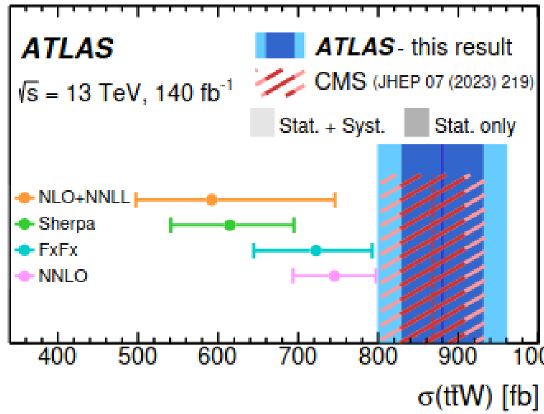


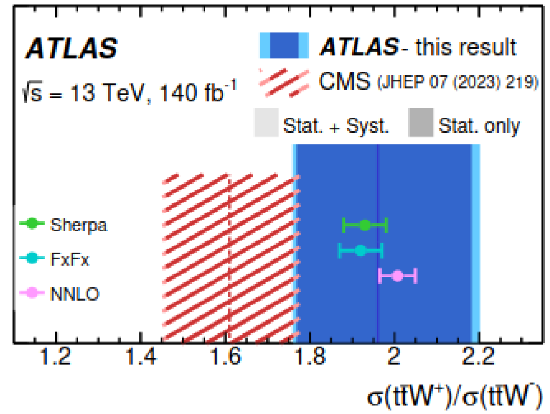
(b)



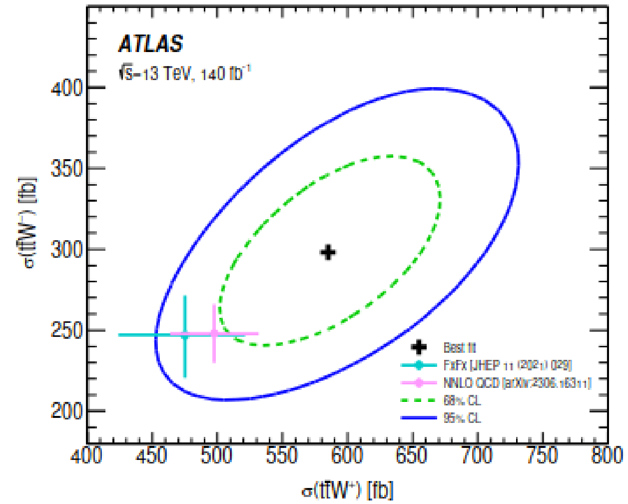


Comparison of data to MC prediction in 2-lepton (top) and 3-lepton (bottom) channels





Inclusive cross section and ratio between W+ and W- production cross sections.



$$\sigma(t\bar{t}W^+) = 583 \pm 34\,(\text{stat.}) \pm 47\,(\text{syst.}) = 583 \pm 58\ \text{fb},$$
$$\sigma(t\bar{t}W^-) = 296 \pm 28\,(\text{stat.}) \pm 29\,(\text{syst.}) = 296 \pm 40\ \text{fb}.$$

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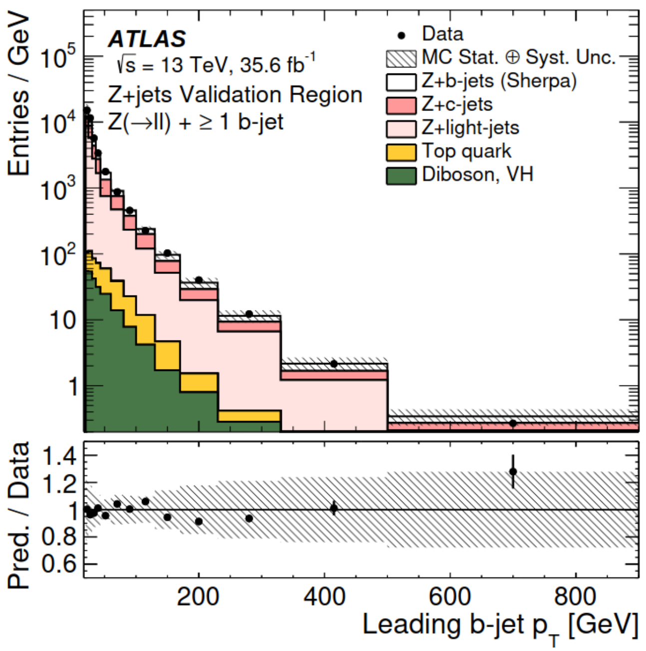
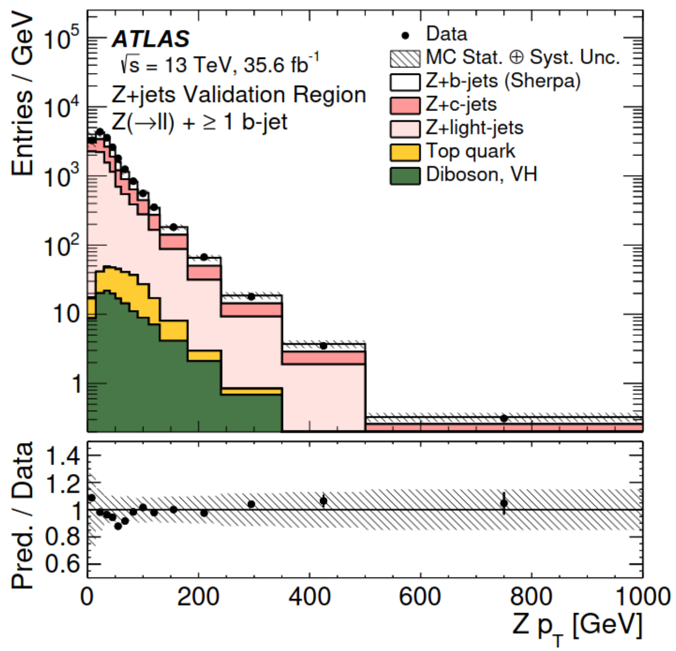
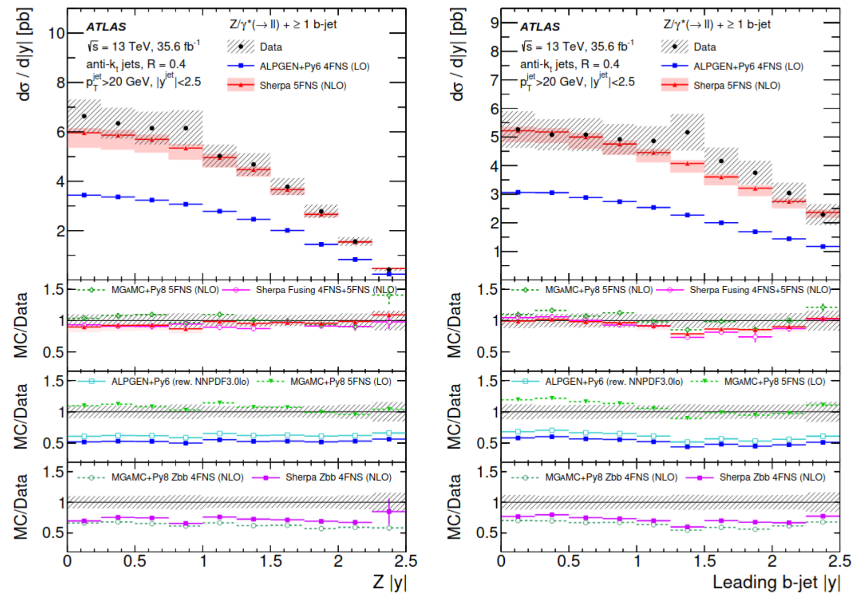


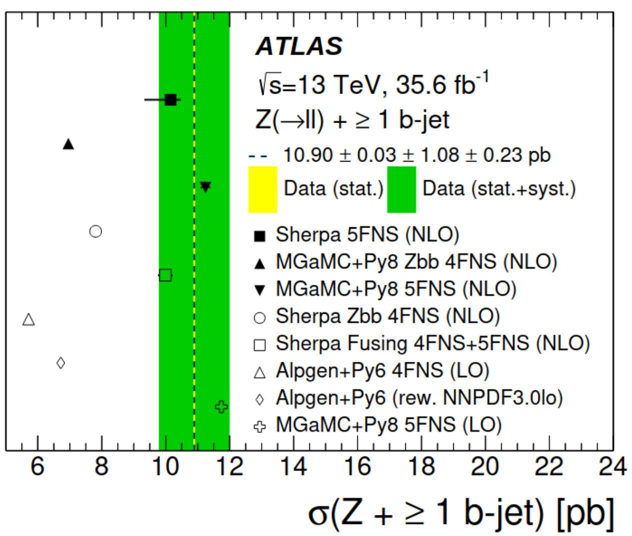
ATLAS
√s = 13 TeV, 35.6 fb-1
Z+jets Validation Region
Z(→ll) + ≥ 1 b-jet
Data
MC Stat. ⊕ Syst. Unc.
Z+b-jets (Sherpa)
Z+c-jets
Z+light-jets
Top quark
Diboson, VH
Entries / GeV
Pred. / Data
Leading b-jet p_T [GeV]



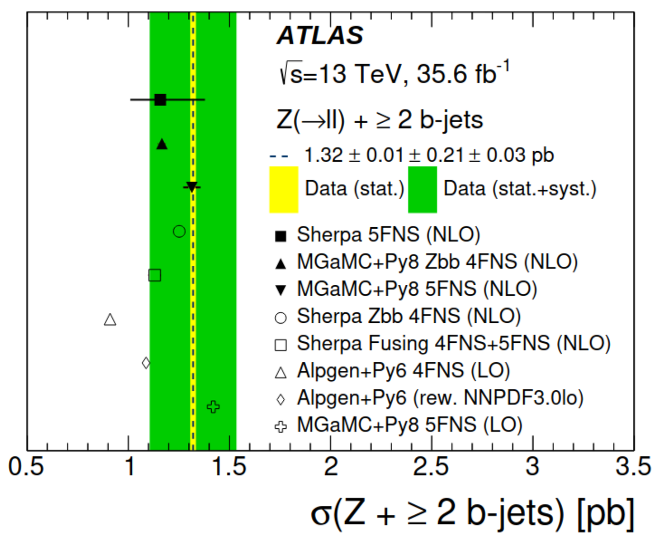
ATLAS
√s = 13 TeV, 35.6 fb-1
Z+jets Validation Region
Z(→ll) + ≥ 1 b-jet
Data
MC Stat. ⊕ Syst. Unc.
Z+b-jets (Sherpa)
Z+c-jets
Z+light-jets
Top quark
Diboson, VH
Entries / GeV
Pred. / Data
Z p_T [GeV]



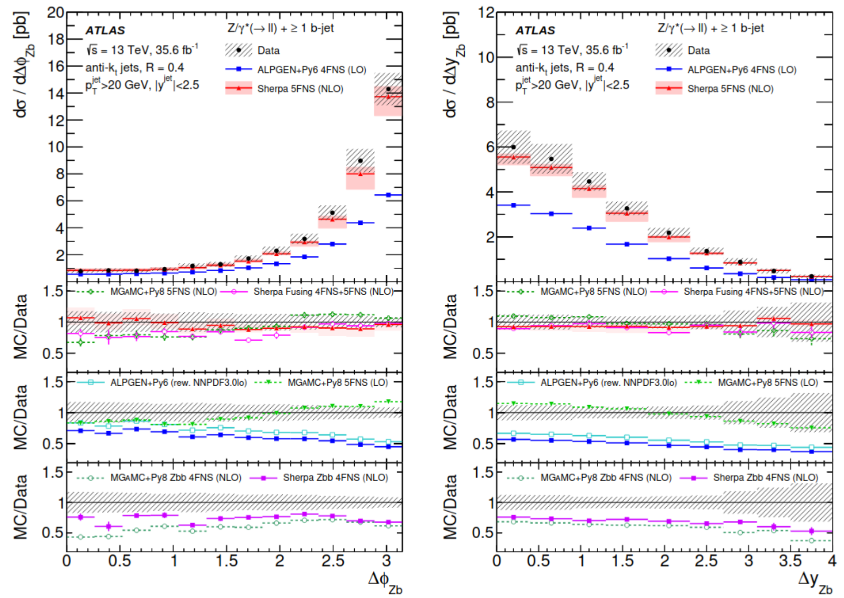
ATLAS
Z/γ*(→ ll) + ≥ 1 b-jet
√s = 13 TeV, 35.6 fb-1
anti-kt jets, R = 0.4
Data
ALPGEN+Py6 4FNS (LO)
Sherpa 5FNS (NLO)
MGaMC+Py8 5FNS (NLO)
Sherpa Fusing 4FNS+5FNS (NLO)
ALPGEN+Py6 (rew. NNPDF3.0lo)
MGaMC+Py8 5FNS (LO)
MGaMC+Py8 Zbb 4FNS (NLO)
Sherpa Zbb 4FNS (NLO)
MC/Data
Z |y|
Leading b-jet |y|



ATLAS
√s=13 TeV, 35.6 fb-1
Z(→ll) + ≥ 1 b-jet
10.90 ± 0.03 ± 1.08 ± 0.23 pb
Data (stat.)
Data (stat.+syst.)
Sherpa 5FNS (NLO)
MGaMC+Py8 Zbb 4FNS (NLO)
MGaMC+Py8 5FNS (NLO)
Sherpa Zbb 4FNS (NLO)
Sherpa Fusing 4FNS+5FNS (NLO)
Alpgen+Py6 4FNS (LO)
Alpgen+Py6 (rew. NNPDF3.0lo)
MGaMC+Py8 5FNS (LO)
σ(Z + ≥ 1 b-jet) [pb]



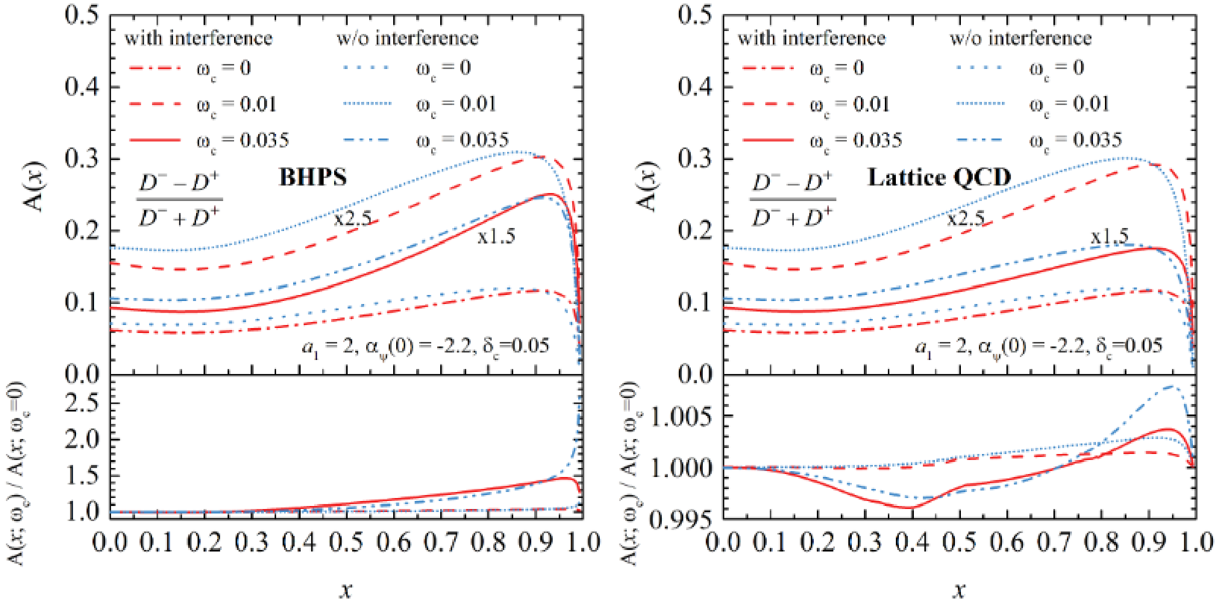
ATLAS
√s=13 TeV, 35.6 fb-1
Z(→ll) + ≥ 2 b-jets
1.32 ± 0.01 ± 0.21 ± 0.03 pb
Data (stat.)
Data (stat.+syst.)
Sherpa 5FNS (NLO)
MGaMC+Py8 Zbb 4FNS (NLO)
MGaMC+Py8 5FNS (NLO)
Sherpa Zbb 4FNS (NLO)
Sherpa Fusing 4FNS+5FNS (NLO)
Alpgen+Py6 4FNS (LO)
Alpgen+Py6 (rew. NNPDF3.0lo)
MGaMC+Py8 5FNS (LO)
σ(Z + ≥ 2 b-jets) [pb]



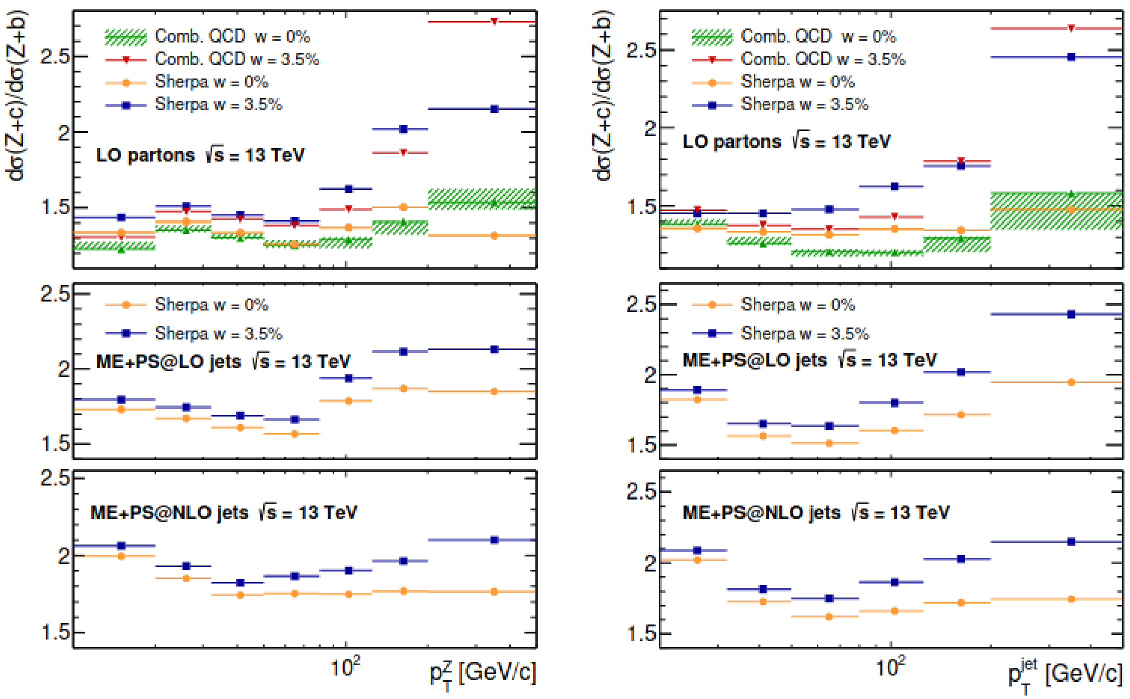
ATLAS
Z/γ*(→ ll) + ≥ 1 b-jet
√s = 13 TeV, 35.6 fb-1
anti-kt jets, R = 0.4
Data
ALPGEN+Py6 4FNS (LO)
Sherpa 5FNS (NLO)
MC/Data
Δφ_Zb
Δy_Zb

Probing intrinsic charm in proton: Z+jet spectra, D-antiD meson asymmetry

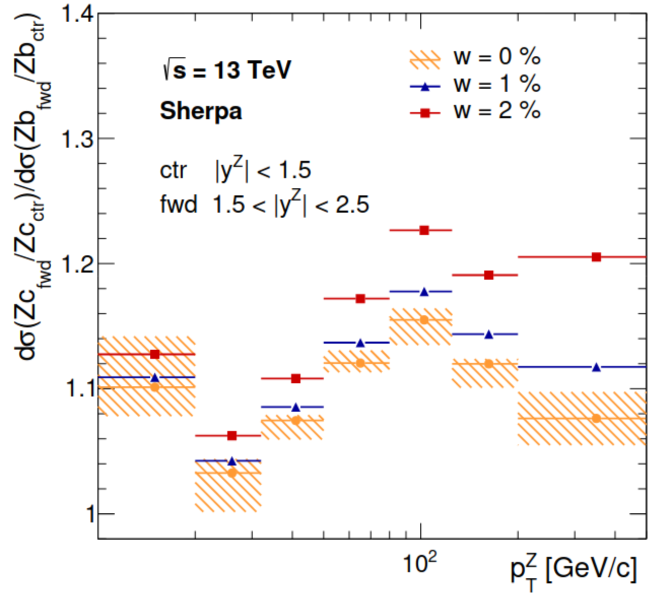
e-print:2501.02507



Phys. Rev. D 97, 114019 (2018)



Electroweak boson + heavy jets production as well as asymmetry in heavy meson production may be used to probe intrinsic heavy quarks.



Best modeling of Z+b and Z+c at 7 TeV and 8 TeV pp-collisions is achieved with Sherpa 5FS.
Sensitivity to intrinsic charm in proton is limited by parton shower and high order QCD corrrections. Current limit on IC contribution is ~2%.
13 TeV data analysis may increase this sensitivity.

G.Lykasov, V.Bednyakov, G.Lykasov, A.Prokhorov, M.Malyshev, S.Turchikhin

Refined TMD gluon density in a proton from the HERA and LHC data

A.V. Lipatov[1,2], G.I. Lykasov[2], M.A. Malyshev[1,3]

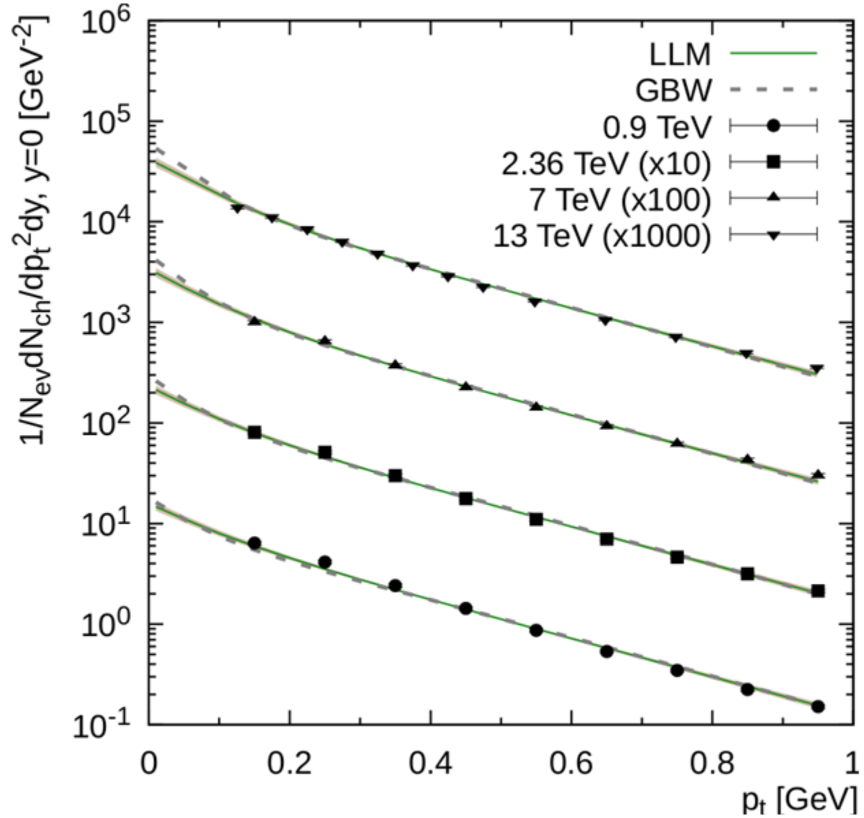
April 16, 2024

[1] *Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, 119991, Moscow, Russia*
[2] *Joint Institute for Nuclear Research, 141980, Dubna, Moscow region, Russia*
[3] *Moscow Aviation Institute, 125993, Moscow, Russia*

Abstract

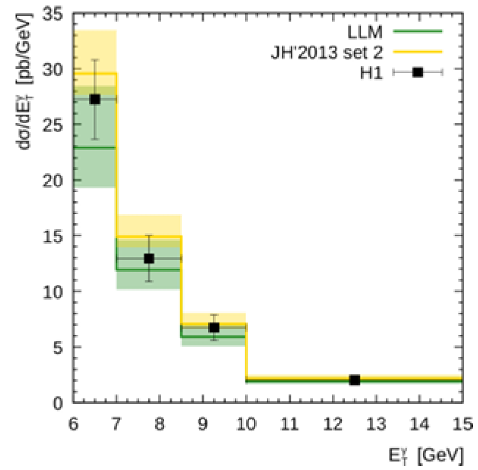
We update the phenomenological parameters of the Transverse Momentum Dependent (TMD, or unintegrated) gluon density in a proton proposed in our previous studies. This analysis is based on the analytical expression for starting gluon distribution which provides a self-consistent simultaneous description of HERA data on proton structure function $F_2(x, Q^2)$, reduced cross section for the electron-proton deep inelastic scattering at low Q^2 and soft hadron production in pp collisions at the LHC conditions. We extend it to the whole kinematical region using the Catani-Ciafaloni-Fiorani-Marchesini (CCFM) evolution equation. Expl
QCD processes, we performed a con
comprising a total of 509 points frc
derived TMD gluon density in a pr
HERA.

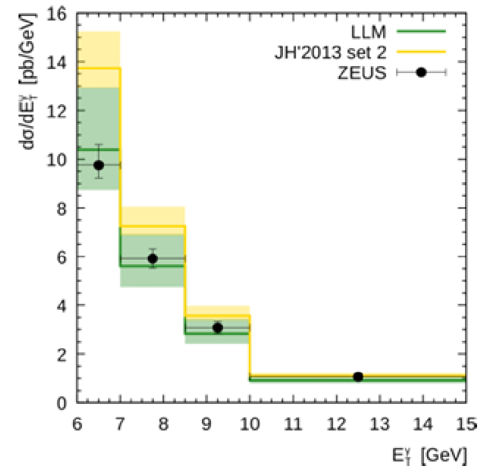
Experiment	Collaboration	Year	Reference	Collision	$\sqrt{s}$/GeV	Number of point
incl. c-jet	CMS	2017	[43]	pp	2.76	5
incl. c-jet	CMS	2017	[43]	pp	5.02	5
incl. b-jet	ATLAS	2011	[42]	pp	7	46
incl. b-jet	CMS	2012	[46]	pp	7	98
$F_2^c(x, Q^2)$	H1	2010, 2011	[47, 48]	ep	0.319	25
$F_2^c(x, Q^2)$	ZEUS	2014	[49]	ep	0.319	18
$F_2^b(x, Q^2)$	H1	2014	[47]	ep	0.319	12
$F_2^b(x, Q^2)$	ZEUS	2014	[49]	ep	0.319	17
$\sigma^c_{\rm red}(x, Q^2)$	H1, ZEUS	2018	[50]	ep	0.319	51
$\sigma^b_{\rm red}(x, Q^2)$	H1, ZEUS	2018	[50]	ep	0.319	27
incl. $H \to \gamma\gamma$	CMS	2023	[51]	pp	13	37
incl. $H \to \gamma\gamma$	ATLAS	2018	[51]	pp	13	27
incl. $H \to ZZ^*$	CMS	2023	[52]	pp	13	54
incl. $H \to ZZ^*$	ATLAS	2020	[53]	pp	13	54
incl. γ	H1	2010	[44]	ep, low Q^2	0.319	25
incl. γ	ZEUS	2014	[45]	ep, low Q^2	0.319	8



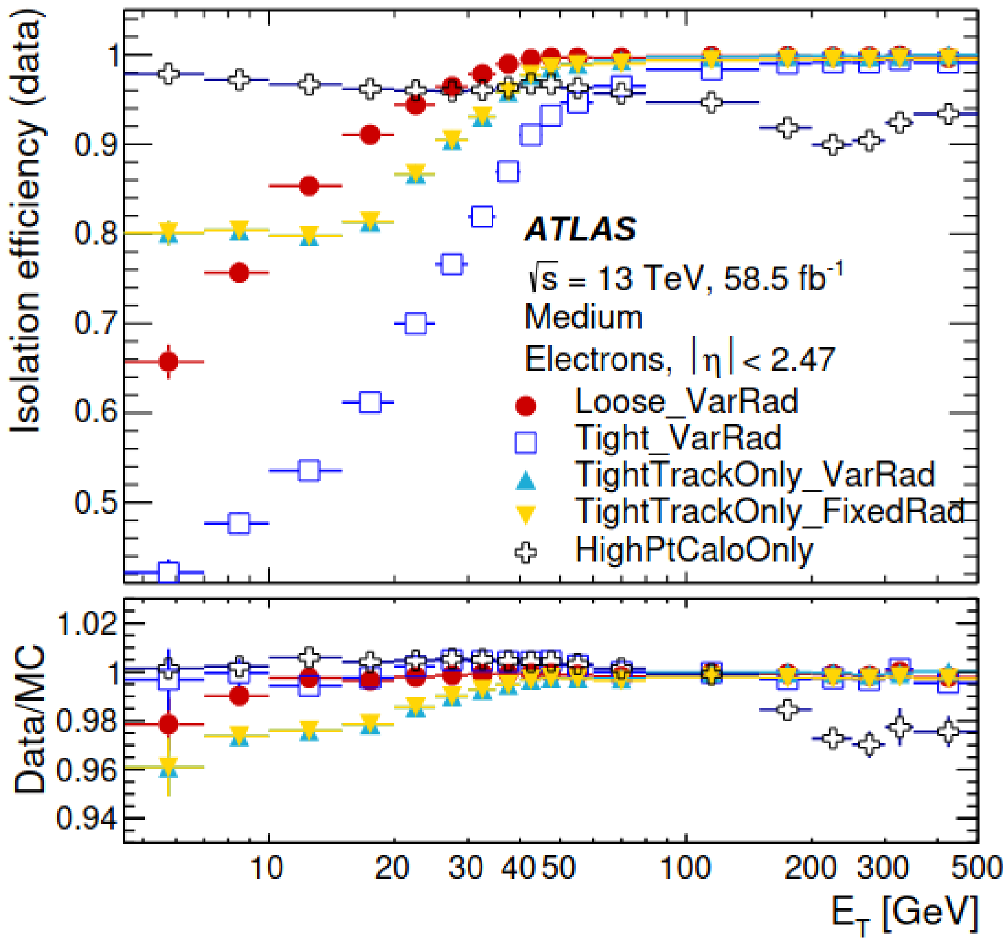
e-print:2404.09550

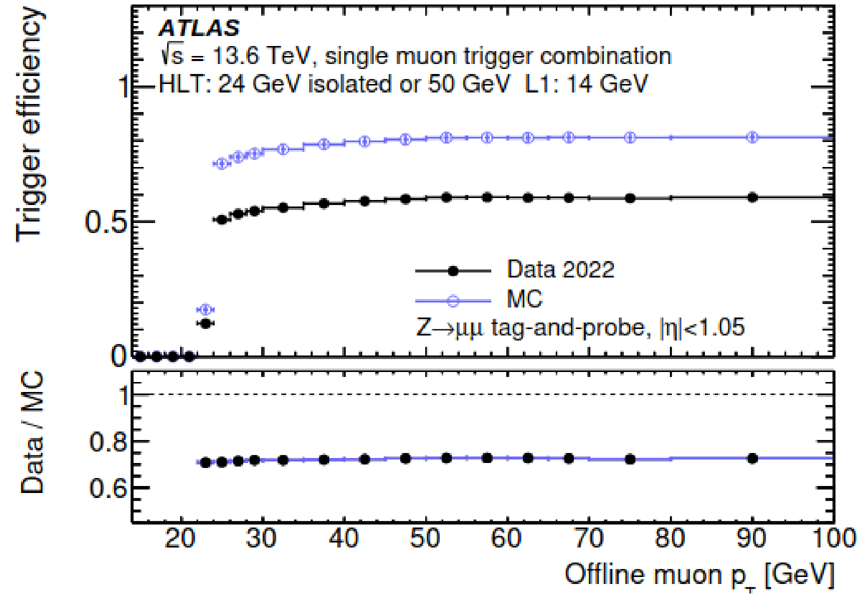
Phys.Lett.B 848 (2024) 138390

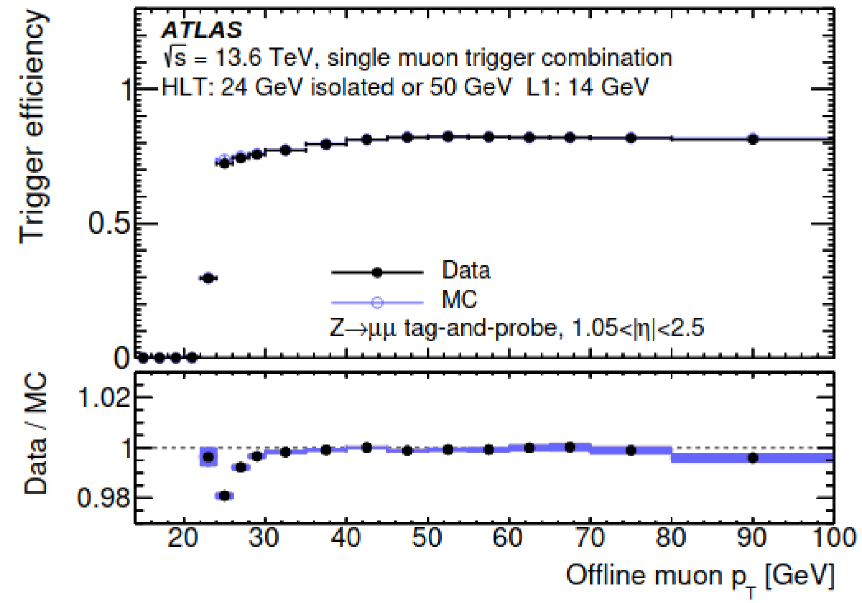




JINR group took active part in performance studies, in particular, in measurements of E/gamma reconstruction efficiencies, muon trigger efficiencies in Run 2 data.

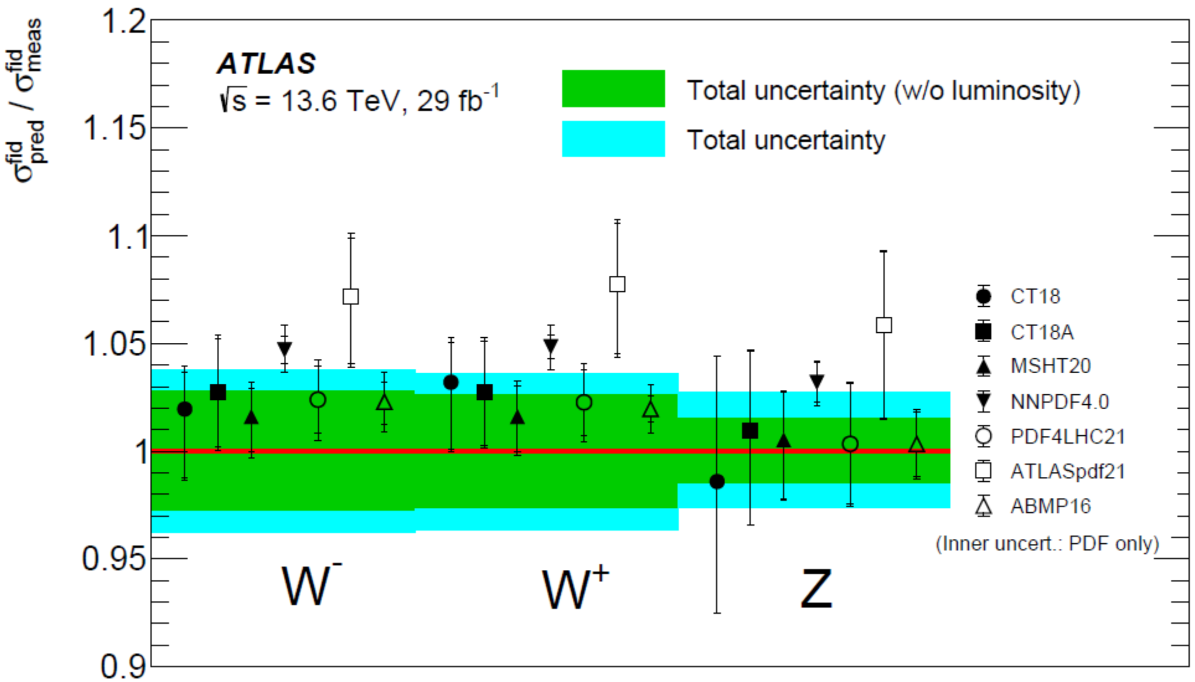




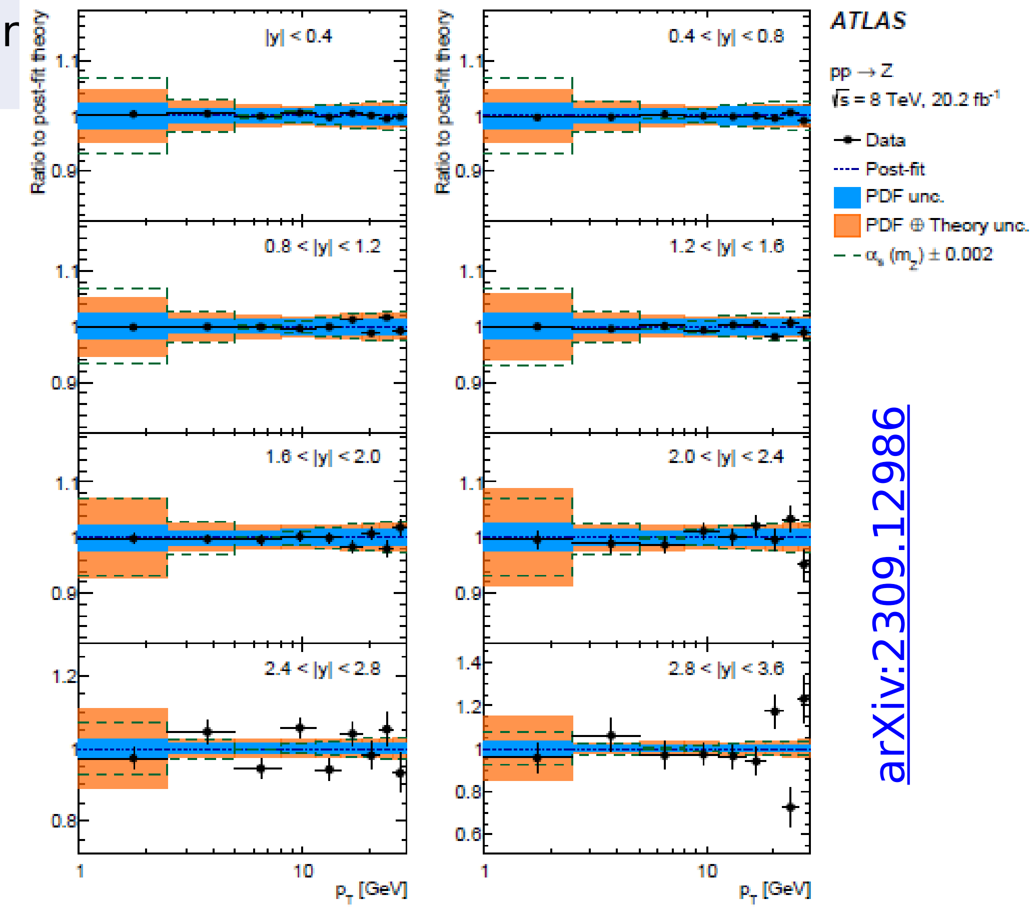


JINST 19 (2024) P06029
JHEP 05 (2024) 162

- JINR team develops MC generators and radiation correction libraries: **DIZET, MCSANC, ReneSANCe**
- They are used in several SM studies at ATLAS and other exper



Physics Letters B 854:138725



arXiv:2309.12986

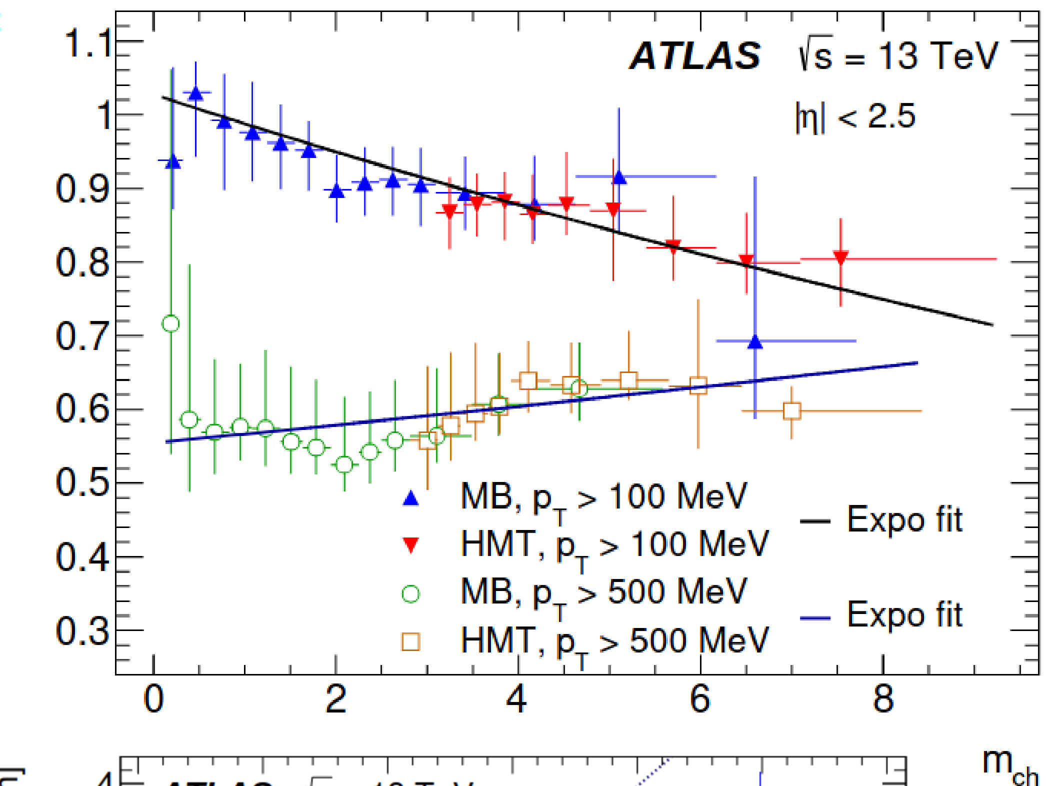
Measurement of vector boson production cross sections and their ratios using pp collisions at √s = 13.6 TeV with the ATLAS detector

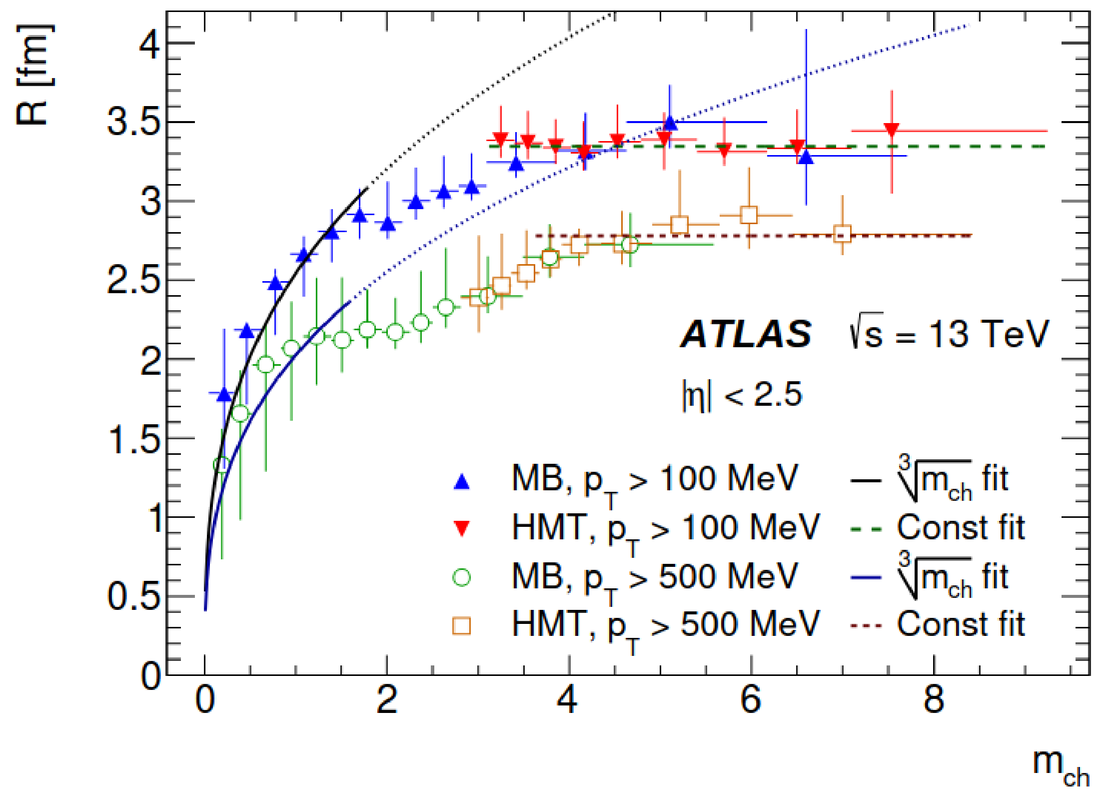
Theoretical predictions are calculated using ReneSANCe generator

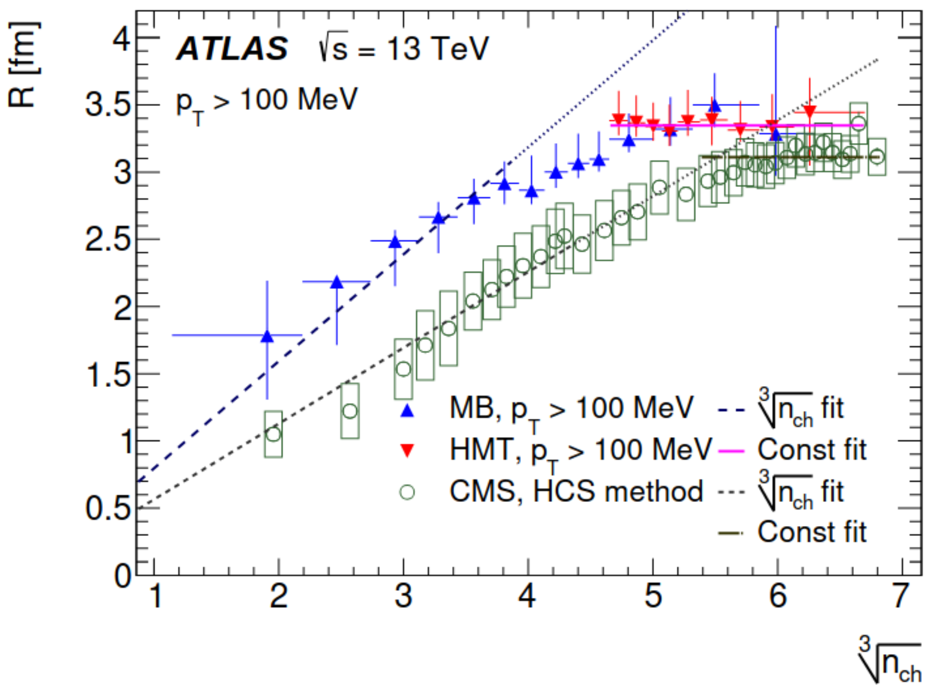
A precise determination of the strong-coupling constant from the recoil of Z bosons with the ATLAS experiment at $\sqrt{s}$ = 8 TeV

Higher order effects on the cross-section normalization from QED initial-state radiation and from electroweak virtual corrections are considered at next-to-leading order are calculated using ReneSANCe

Eur. Phys. J. C 82 (2022) 608







Bose-Einsteins correlation parameters (radius and amplitude) are measured using Min Bias and High Multiplicity streams of ATLAS data.

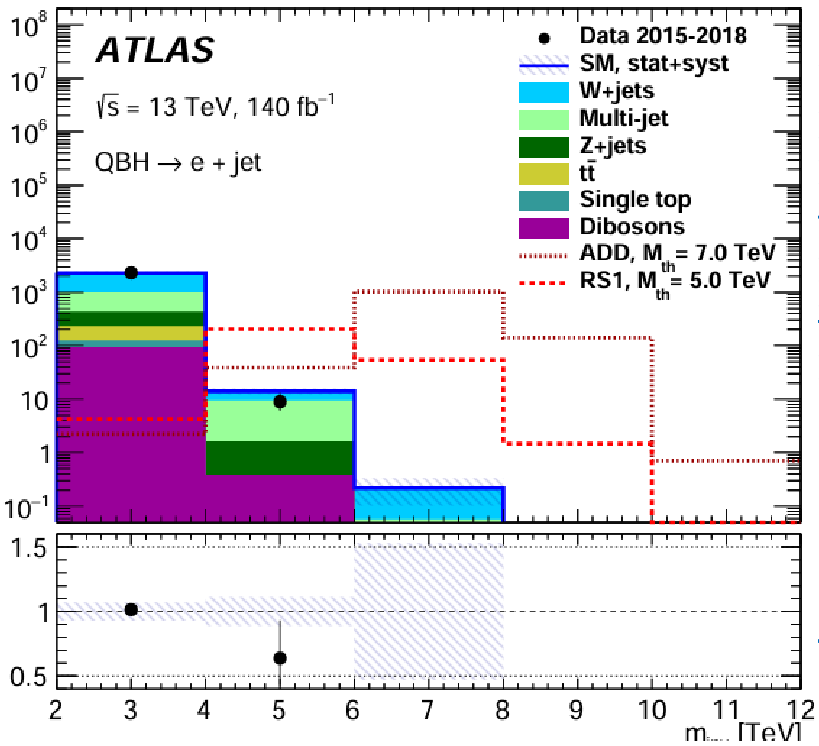
For high multiplicity events correlation radius reach saturation at:

$$R = 3.35^{+0.20}_{-0.09}(\text{total})\ \text{fm}$$

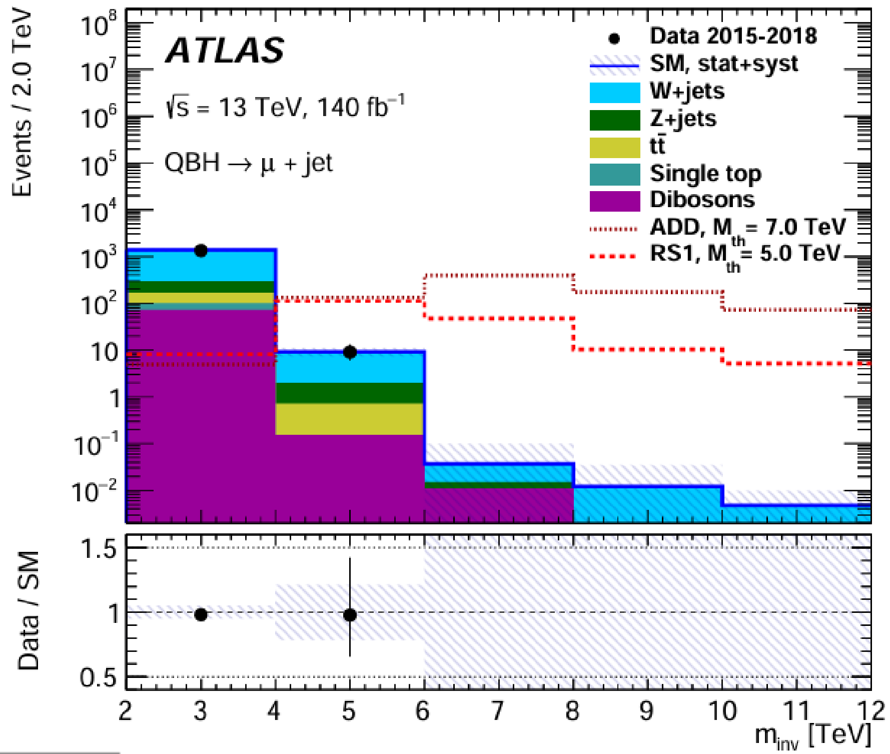
Results are compared to CMS measurements, showing same qualitative behavior

Direct searches for beyond SM phenomena

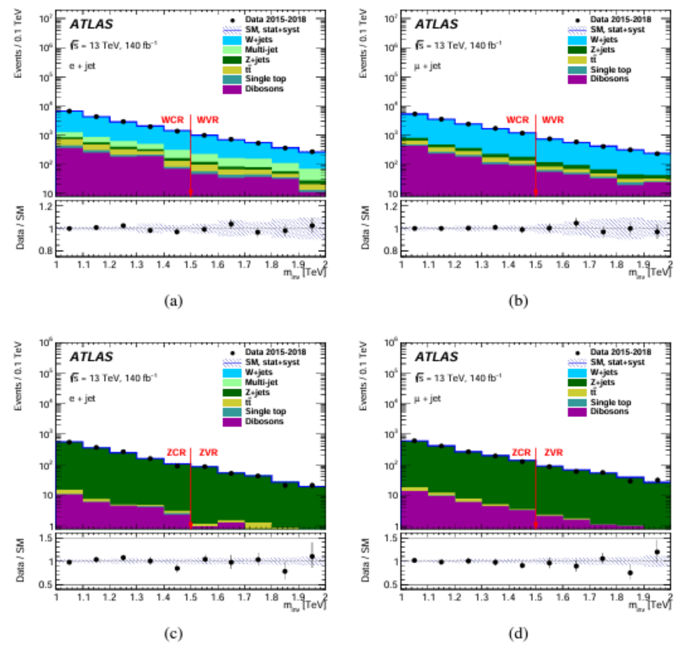
- Direct searches benefit mostly from increasing energy of collider, high luminosity is more important for precise SM tests
- Most of analyses do not rely on specific theoretical models, performing instead a ‘look elsewhere’ searches.
- Searches for ‘beyond SM’ physics are also good tests of SM and modeling quality.



Phys. Rev. D. 109 (2024) 032010



	SVR electron+jet	SVR muon+jet	SR electron+jet	SR muon+jet
Observed data	9053	5504	2319	1359
Fitted events	8900 ± 320	5380 ± 200	2290 ± 110	1386 ± 70
W+jets	5590 ± 270	4190 ± 200	1290 ± 70	1087 ± 54
Multijet	1670 ± 200		570 ± 47	
Z+jets	646 ± 73	439 ± 27	199 ± 17	131 ± 13
$t\bar{t}$	527 ± 10	351 ± 7	109 ± 5	69 ± 5
Single top	143 ± 7	112 ± 5	31 ± 2	28 ± 2
Dibosons	335 ± 22	289 ± 14	94 ± 9	72 ± 8
Expected events	9390 ± 340	5260 ± 220	2647 ± 94	1303 ± 55
W+jets	6090 ± 270	4080 ± 210	1654 ± 65	1016 ± 48
Multijet	1690 ± 210		577 ± 38	
Z+jets	598 ± 85	408 ± 23	186 ± 18	122 ± 12
$t\bar{t}$	546 ± 14	366 ± 7	109 ± 6	71 ± 5
Single top	141 ± 7	104 ± 4	29 ± 2	28 ± 2
Dibosons	327 ± 23	298 ± 12	92 ± 10	66 ± 8

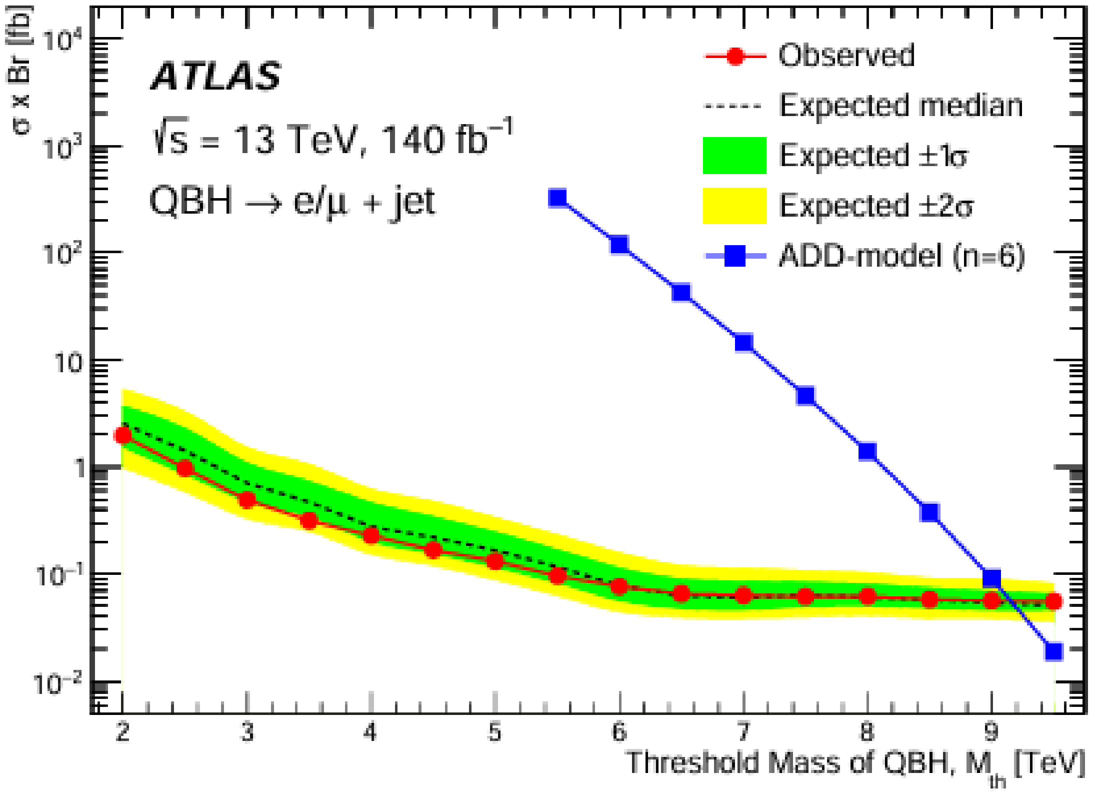


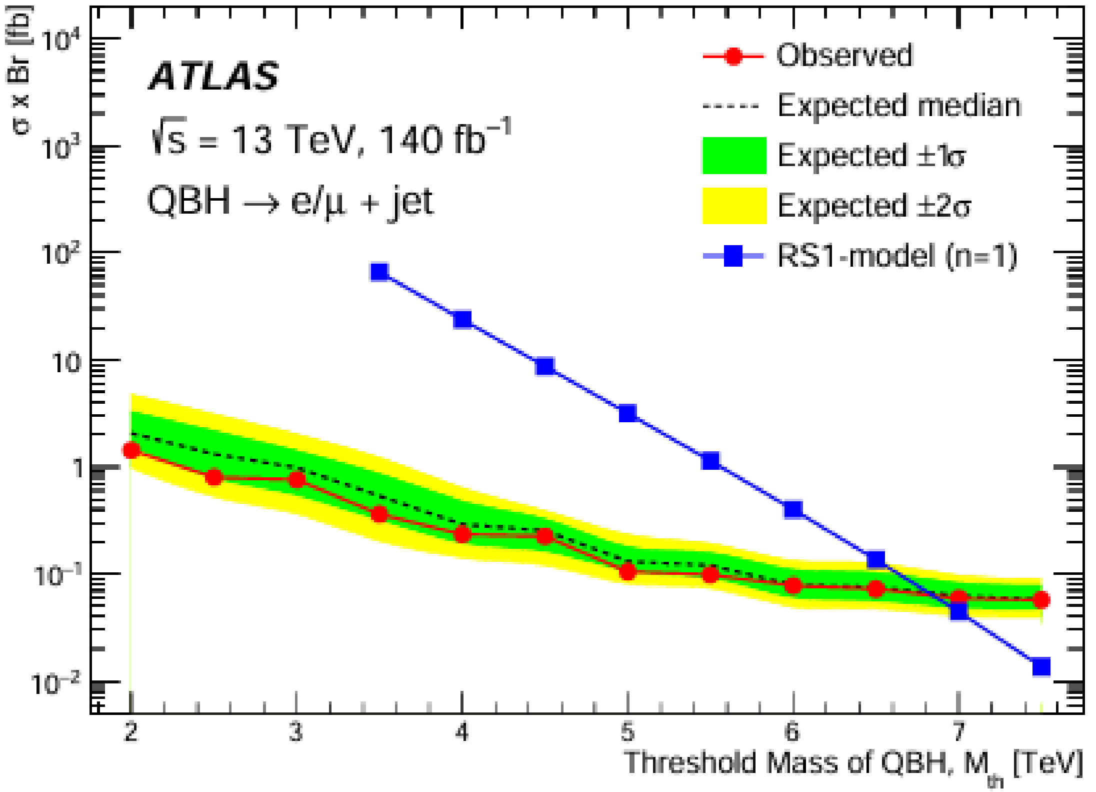
JINR team played a leading role in the search for QBH in lepton+jet final states at ATLAS.

Full Run2 data are analyzed. Plots show invariant mass distributions of the electron+jet (left) and muon+jet (right).

Predicted QBH signals in the Arkani-Hamed-Dimopoulos-Dvali model (ADD) and Randall-Sundrum (RS1) models are shown.

Few CR and VR are analysed to ensure accurate description for all background processes.



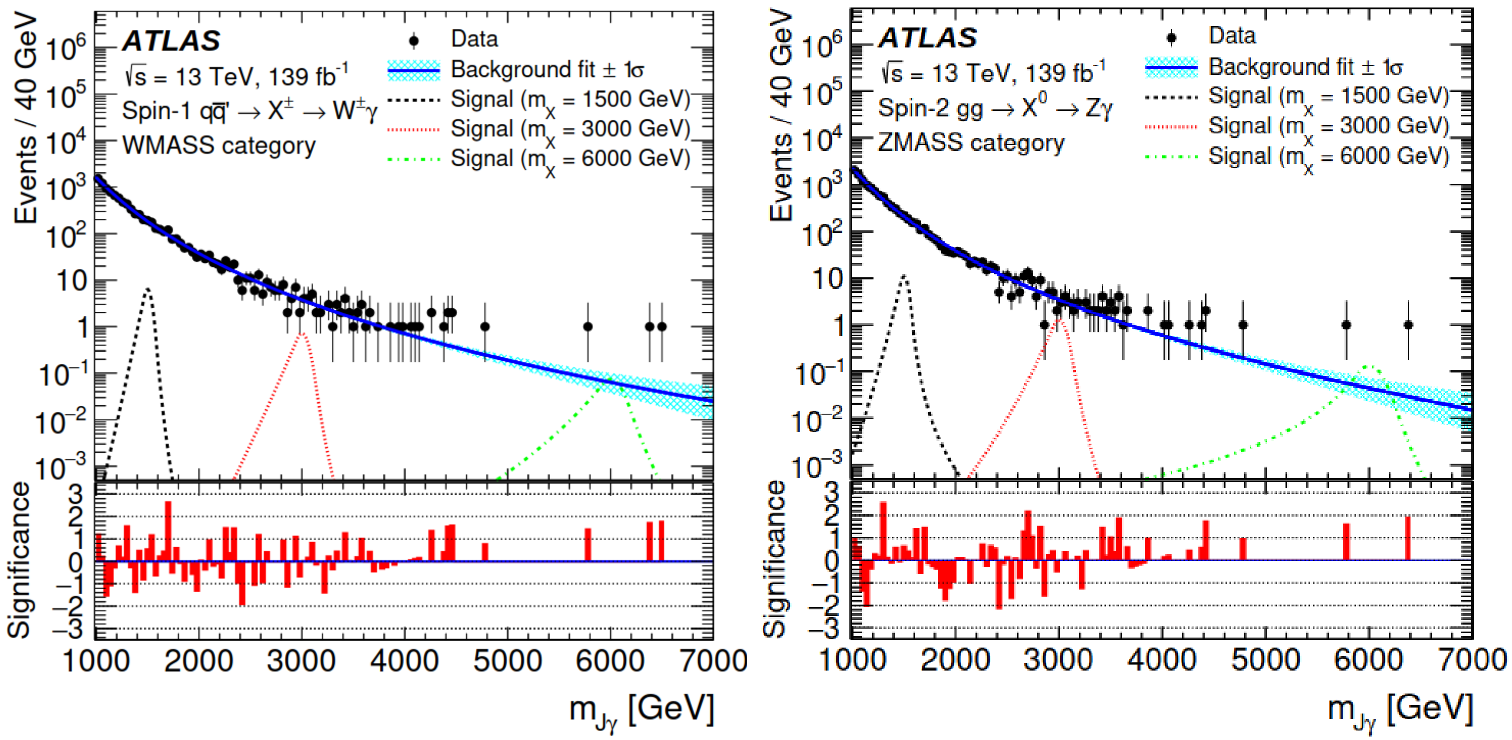


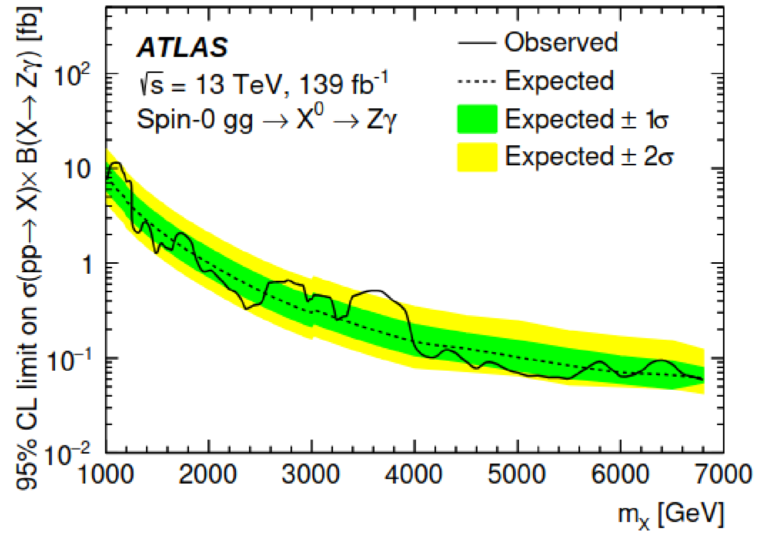
Phys. Rev. D. 109 (2024) 032010

Channel	ADD $\sigma \times Br$ [fb]	ADD M_{th} [TeV]	RS1 $\sigma \times Br$ [fb]	RS1 M_{th} [TeV]	Model-independent $\sigma(m_{\text{inv}} > 5\text{ TeV}) \times Br$ [fb]
Electron+jet	0.091	9.0	0.099	6.6	0.095
Muon+jet	0.083	9.0	0.087	6.7	0.084
Combined	0.056	9.2	0.061	6.8	0.052

New mass/cross-section limits are set for the ADD and RS1 models as well as for model-independent approach.

JHEP07(2023)125



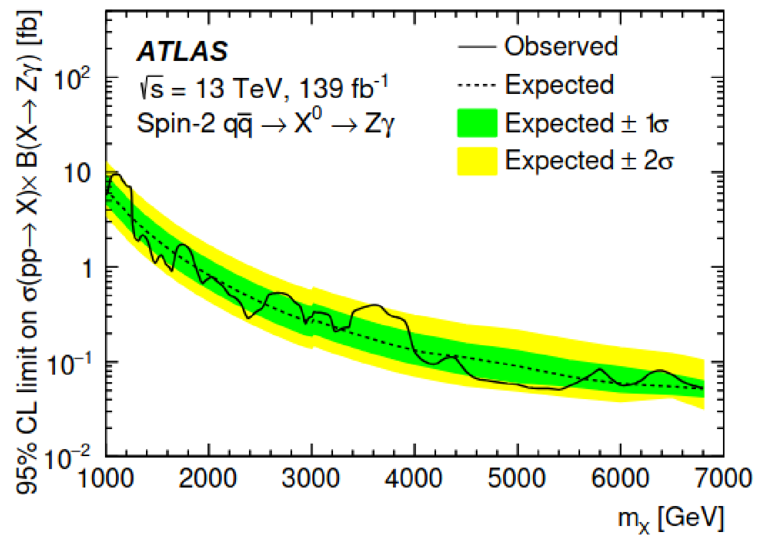


(a)

Search for deviations from SM predictions is performed in $Z\gamma$, $W\gamma$ final states with full Run2 dataset between 1 and 6.5TeV.

Good agreement between data and SM prediction is observed overall.

The largest deviation from expectation is 2.5σ for spin-0 channel at 3.64TeV.

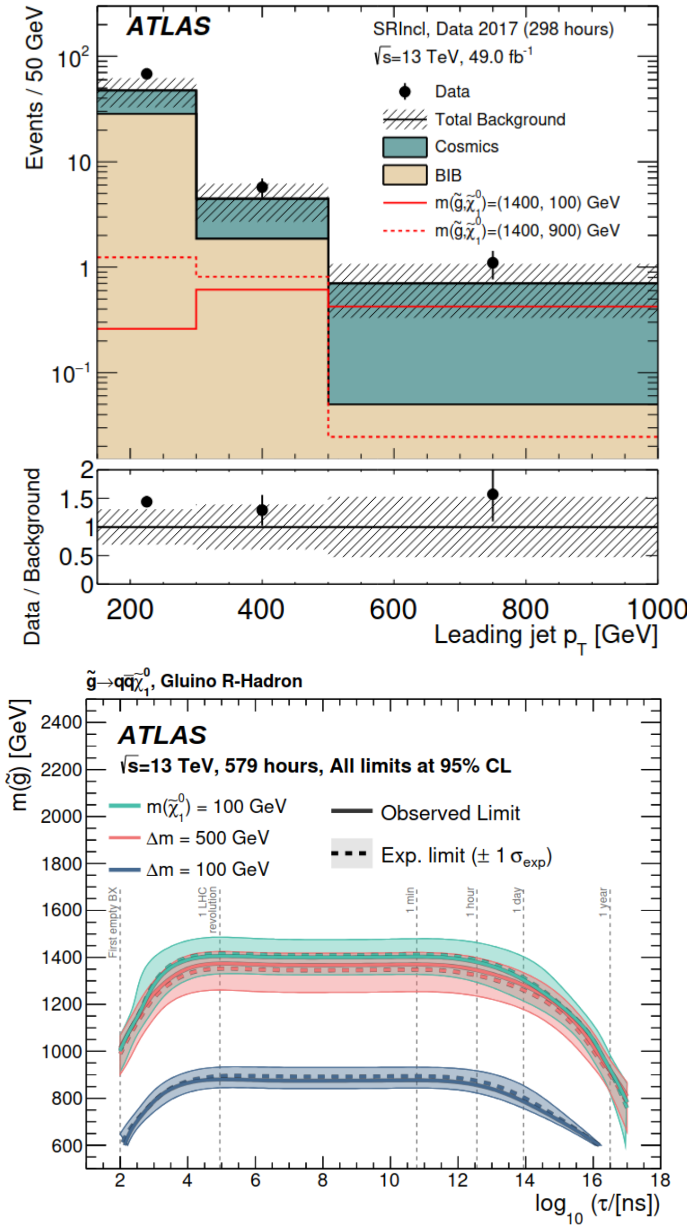


(c)

Other BSM searches

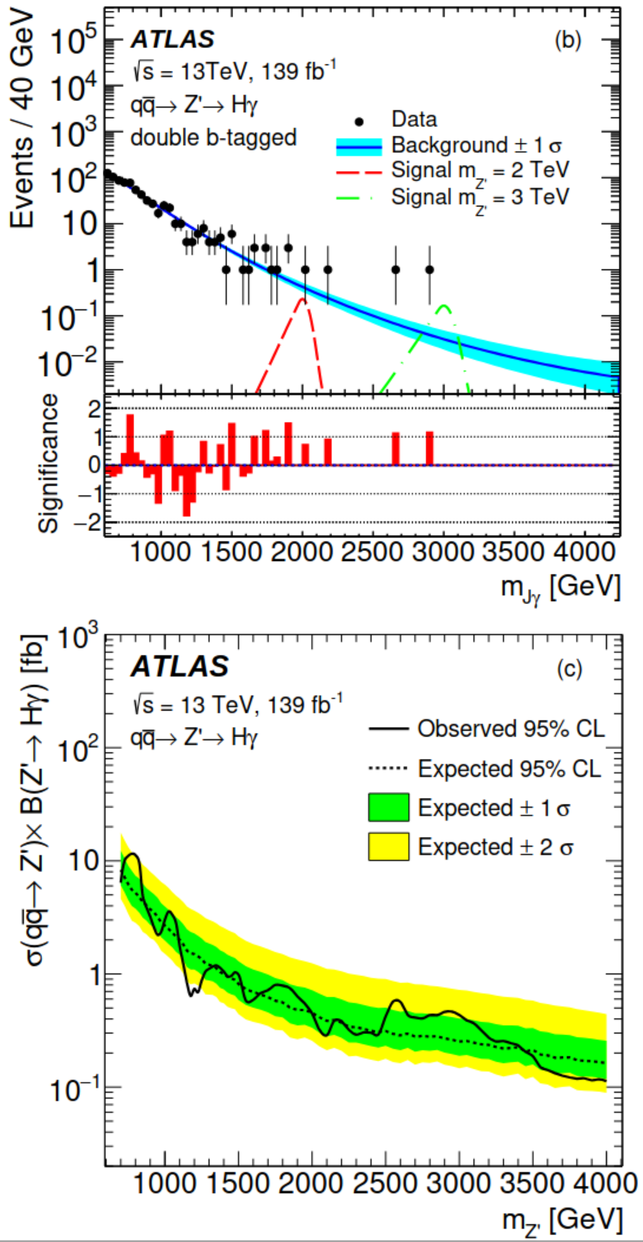
E.Khramov, E.Cherepanova, V.Bednyakov,
M.Chizov, I.Yeletskikh, M.Chizhov, E.Soldatov .

A search for the decays of stopped long-lived particles



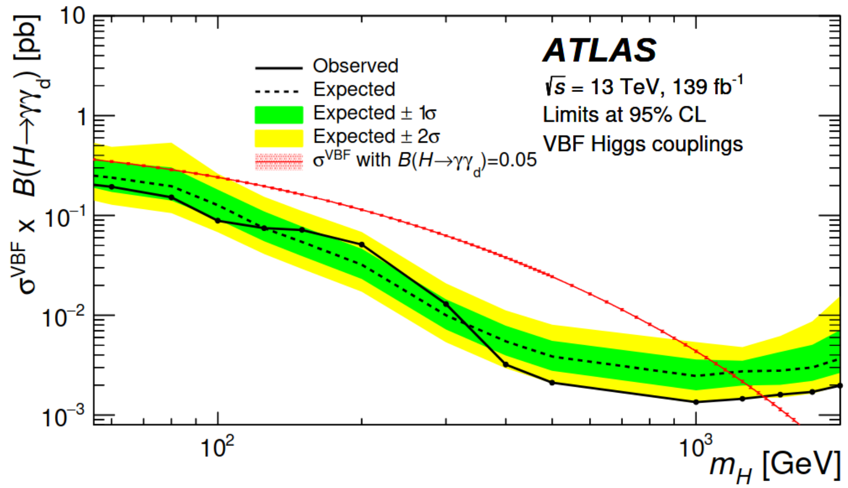
JHEP 07 (2021) 173

Search for heavy resonances decaying into a photon and a hadronically decaying Higgs boson



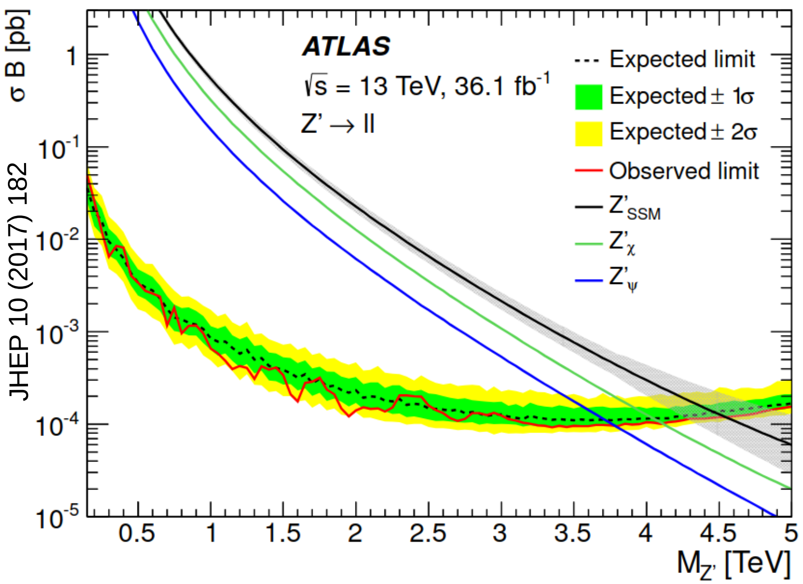
Phys. Rev. Lett. 125, 251802 (2020)

Search for heavy Higgs to invisible



Eur. Phys. J. C 82 (2022) 105

Search for heavy bosons to dilepton



JHEP 10 (2017) 182

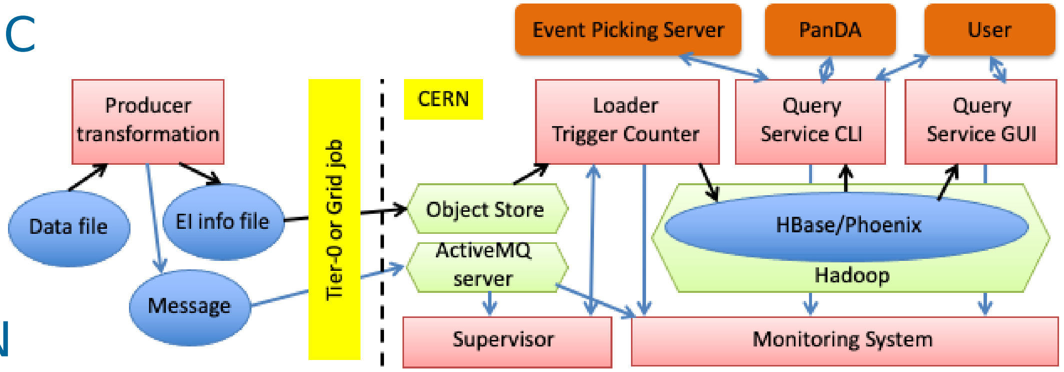
ATLAS software development

- Database development
- E/gamma reconstruction, calorimeter software
- Muon trigger software
- Simulation and other

- The EventIndex is the global catalogue of all ATLAS events
- For each event, each data format and each processing version, it contains:
  - Event identifiers (run and event number)
  - Location (GUID of the file containing it) and provenance
  - Trigger and other useful metadata
- Main use case is event picking for detailed analysis and/or displays
- The core data storage system was reimplemented during 2021 and deployed in 2022 for the start of LHC Run3
  - Hbase for the dataset and event tables
  - Phoenix interface for SQL queries
  - New client query service CLI implemented
- Web service is available outside of CERN (need CERN SSO authorization)

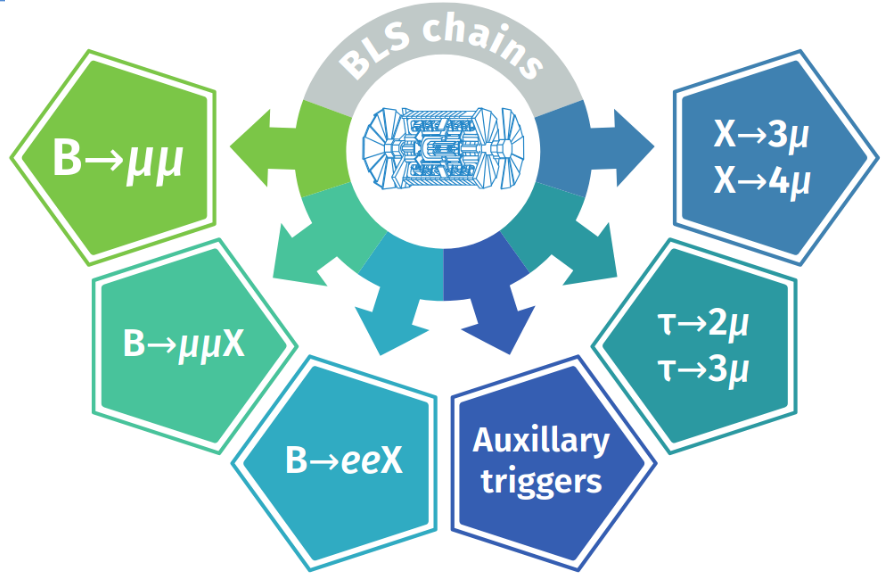
- **https://atlas-event-picking.cern.ch/eventpicking**

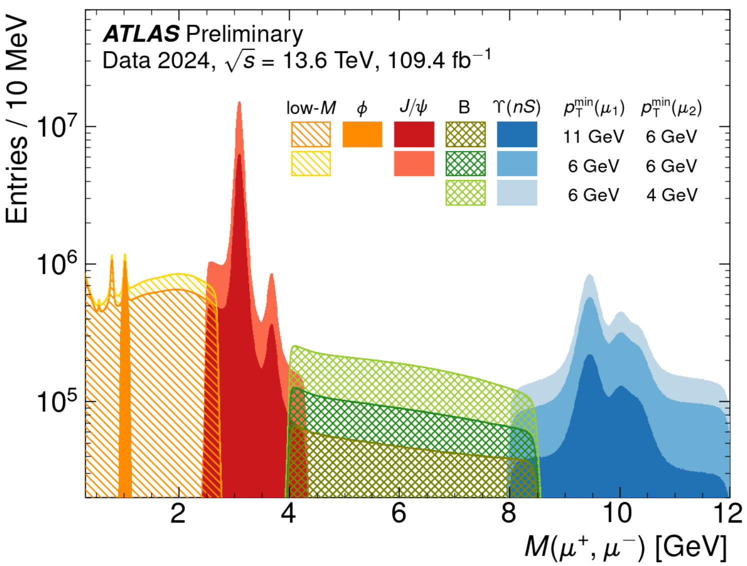
Request	Number of events	Version	Time
γγ -> WW	50k	1.0.0	2 weeks
		manual	3 months
γγ -> WW	136k	Beta version	3 months
B_c^* -> B_c	16K	1.2.37	84h
Z -> TauTau	11K	1.2.37	40h

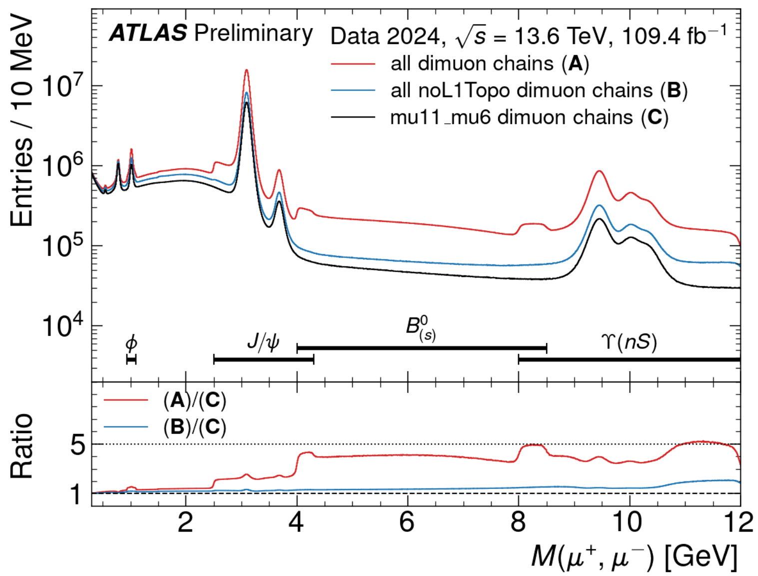


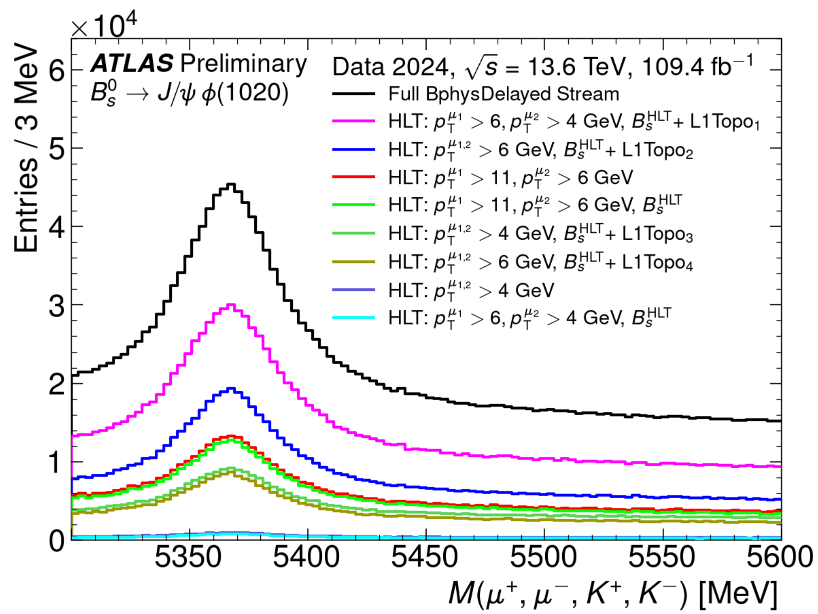
JINR significantly contributed to the development of the muons trigger software.

- Dimuon trigger chains for *J/ψ, Y, B→μμ* decays for spectroscopy, rare decays and hadron production studies
- *B→μμ*X triggers that combine dimuon and inner detector track information – for CP violation studies and R(K*) measurements
- *B*→eeX topology for R(K*) analysis
- Multimuon triggers used for exotic state searches



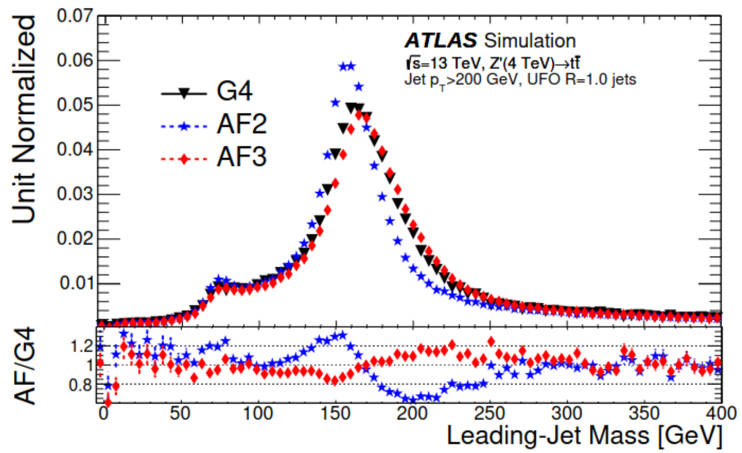


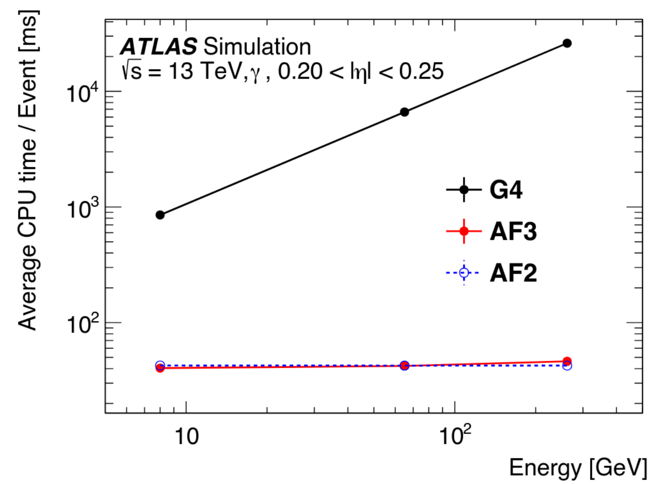




E.Ramakoti, I.Yeletskikh, E.Khramov, A.Tropina, A.Didenko, V.Bobrovnikov

JINR contributed to the development of AtlFast3 – fast calorimeter simulation which showed much better simulation quality as compared to AF2 while keeping good CPU efficiency.



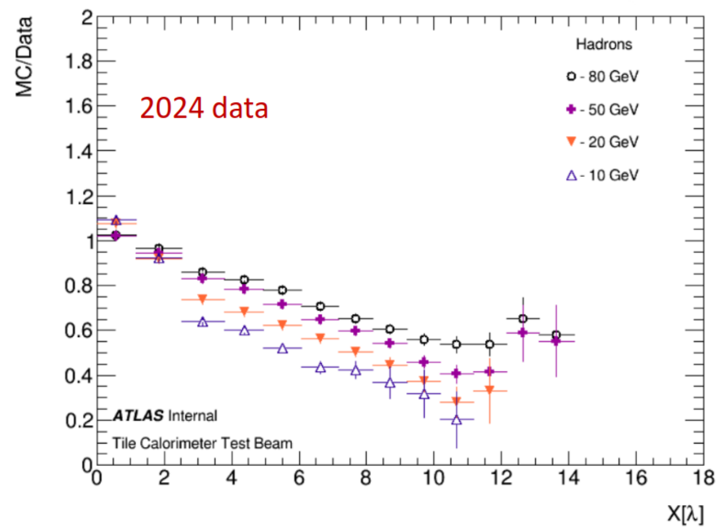


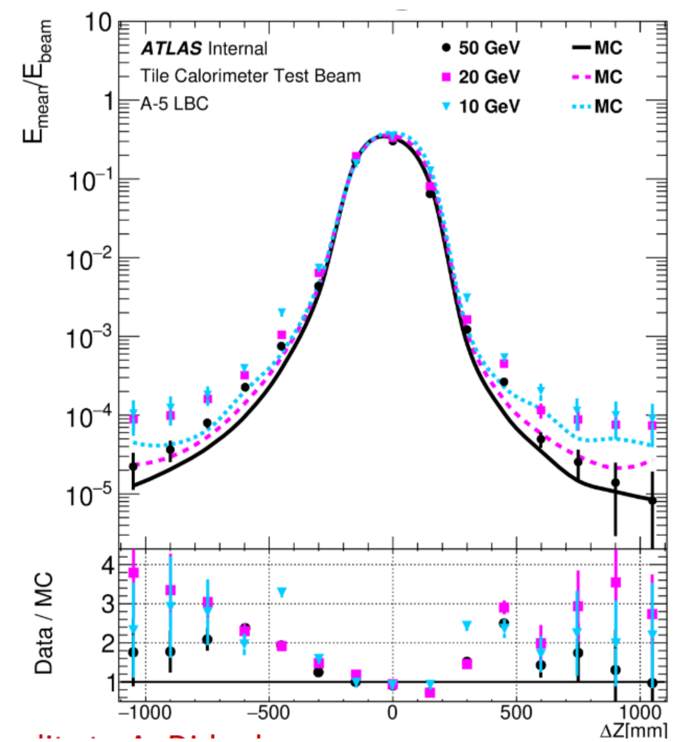
Comput Softw Big Sci 6 (2022) 7

Measurements of the hadronic shower shapes (transverse and longitudinal) in calorimeter are performed at TestBeam facilities.

Corrections are obtained for modeling of the calorimeter response.

Cuts are optimized to distinguish different particle types.





For 2025 we get ATLAS software development grant for electron/photon identification/efficiency software, electron calibration tool.

E.Ramakoti, I.Yeletskikh, E.Khramov, A.Tropina,
A.Didenko, V.Bobrovnikov, A.Vasyukov,
Z.Chubinidze

Software for Liquid Argon Calorimeter calibration tasks.
Migration of the athena configuration software to CA format.
Development and support of the ATLAS conditions databases, database monitoring
TDAQ system, development of the operational monitoring systems, network monitoring
Slimos

6.12 FTE Class3 delivered in 2024
A lot of this software experience is used in other JINR projects: SPD, Baikal-GVD, etc.

JINR group participation in the upgrade program

<u>JINR team fulfilled all obligations</u> on participation in the **Phase-1** Upgrade program of the ATLAS detector.

The most significant contribution was made in the upgrade of the Muon Spectrometer: 32 large-scale Micromegas quadruplets for New Small Wheel were manufactured in the JINR DLNP workshop, delivered to CERN and installed in the ATLAS detector. They show good efficiency during Run3 of the data taking.

Our plans for the **Phase-2** of the ATLAS upgrade aimed at HL-LHC operation included:

- Muon Spectrometer:
  - BI readout panels
  - power distribution system
  - RPC gas system
- LAr Calorimeters:
  - optical link components
- High Granularity Timing Detector
  - half-disk instrumentation stand
  - transportation tools and cavern installation

Production site for RPC panels is ready,
3 BI panels were manufactured and tested

Prototype cables were produced
and used at CERN in half-crate tests

The tools were designed at DLNP and assembled,
delivery to CERN is planned in about two months

David Francis (UAB, 12/05/2022):

	2022	2023	2024	2025	
LAr	-	552	388	102	
Tile	-	49	-	-	
Muon	113	193	88	36	
HGTD	11	197	330	63	
TDAQ	10	64	-	-	+465 in 2027
SUM	134	1,055	806	201	=2,196

September 2022

ATLAS Phase-II activities at JINR (Dubna)

Problems:
- bank transactions
- logistics, custom

MoU item	Muon	kCHF
5.3.3.4	BI readout panels (design, production)	99
5.3.5	Power distribution (design, production, installation)	83
5.3.6	RPC gas system (design, production, installation)	139
5.8.4	RPC HV/LV, DCS (procurement, installation)	109

✓ Still waiting for invoice from CERN for 100kCHF (for PCB)
✓ Production site (NSW) for RPC strip panel is ready to start
✓ 3 BIL-RPC panels are made, good quality is demonstrated

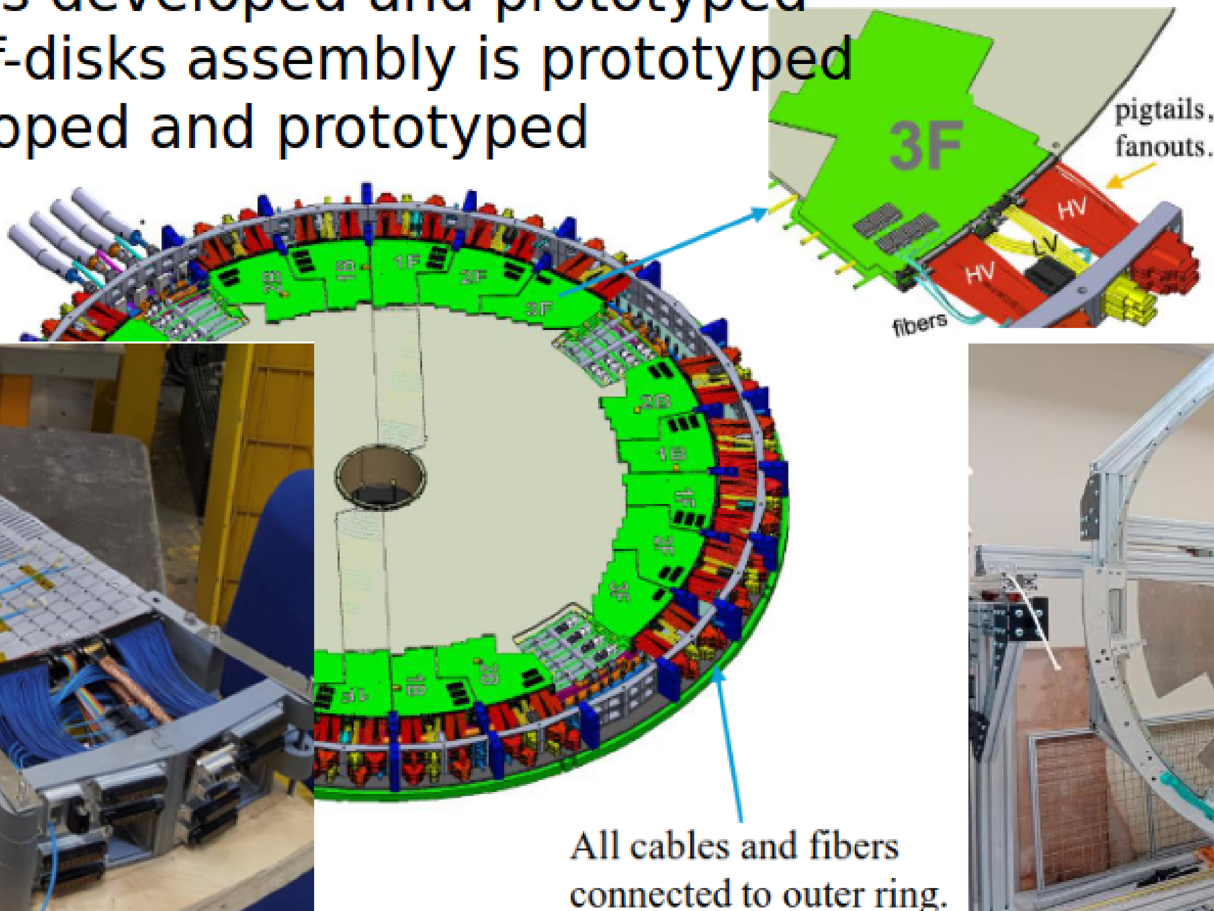
MoU item	HGTD	2023 kCHF	2024 kCHF	Comment
8.1.1	LGAD sensors	19.8	142.0	Procurement
8.2.4.2	30V to 10V DC-DC convertor	32.7	9.0	
8.2.4.3	Controllers and crates	18.3	5.0	
8.3.2.1	DCS servers	6.1	10.0	
8.3.2.2	Network switches	0.8		
8.3.2.3	Network patch cards	0.1		
8.3.2.4	ELMB2 boards	14.6	1.6	
8.3.3	Interlocks and Protection System	3.4	15.75	
8.5.6	Cables and connectors	27.4	153.7	
8.6.2.1	Half-disk instrumentation stand	28.5	28.5	Production in Dubna
8.7.1	Tool for transport and cavern installation	20.0	20.0	Production in Dubna (?)
	SUM	**171.7**	**385.55**	**Agreed with PL**
		197	330	From David

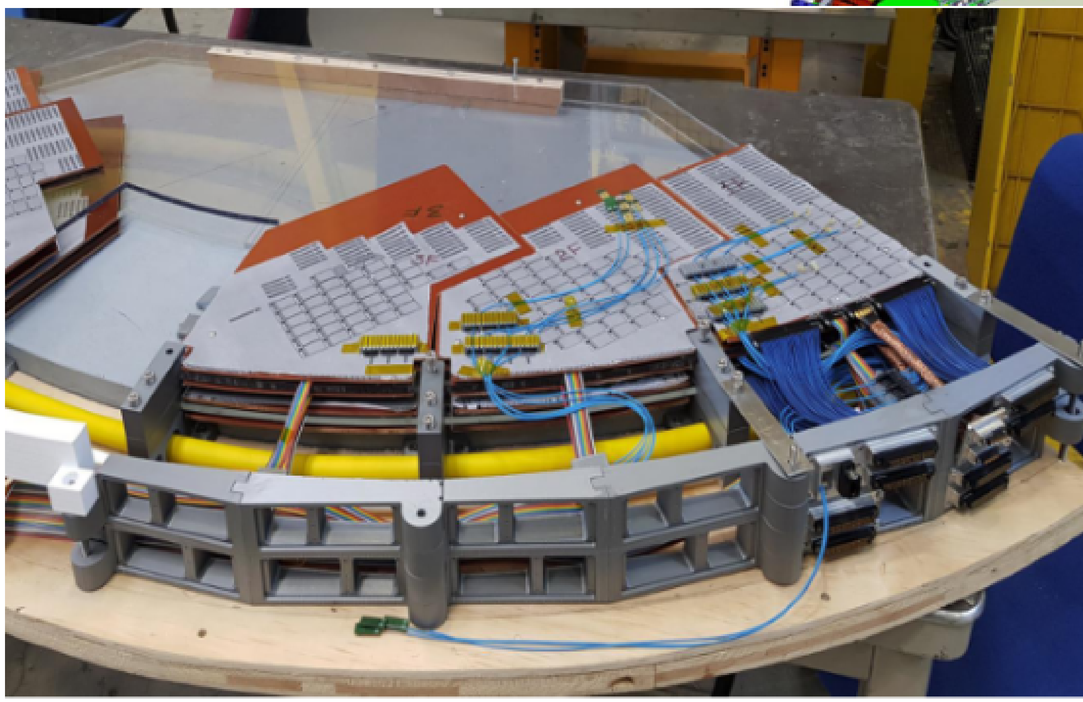
MoU item	LAr	kCHF
3.1.1.4	Optical link components (production)	495
3.2.1.2	Data processing (procurement)	547

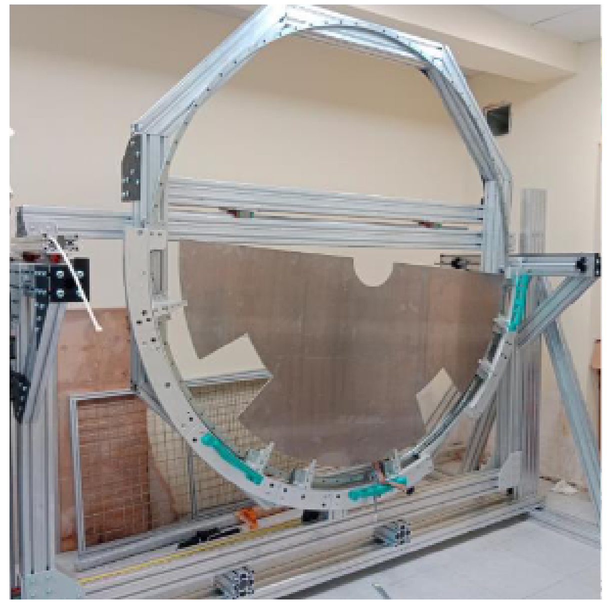
✓ Common work with Lebedev Inst. (+461kCHF)
✓ Waiting for the final design of optical cables
✓ 2023 – production of prototypes (preproduction?) – 10kCHF
– radiation tests

JINR in ATLAS upgrade

- JINR takes active part in the new HGTD (High Granularity Timing Detector) development and production:
  - Layout of the electrical and optical services inside the HGTD designed
  - Systems for temp., humidity and pressure monitoring designed
  - 3D model of services is developed and prototyped
  - Dedicated tool for half-disks assembly is prototyped
  - Cable routing is developed and prototyped







Conclusions and plans

- In 2019-2025 we were continuing our participation in the ATLAS Physics program – Higgs physics, SM physics, B-physics, Exotics, etc. Several high-class results are obtained with determining contributions from JINR physicists.
- We tried to increase our involvement in software development during last years.
- New Run3 data will allow higher precision for many of the measurements, e.g., Higgs physics, hadron spectra, etc.
- Even more expectations are from Run4 high luminosity operation.

- Data analysis, software and hardware development expertise gained at ATLAS is used in other JINR projects (Baikal-GVD, MPD, SPD, etc.)
- JINR team welcomed 12 new members from other institutes, some of them actively work on physical analysis.
- Prohibition from collaboration w.r.t. new members (and even new external users) is one of the challenges for the future.
- Plans for old and new upgrade commitments are evolving...

THANK YOU FOR ATTENTION!

BACKUP

ATLAS physics studies

1. Development of the ReneSANCe MC generator used in precise SM measurements at ATLAS	**1 prof., 3 postdoc (2.0 FTE, Kalinovskaya L., Sadykov R., Yermolchuk V., Prokhorov A.)**
2. Modeling of di-J/ψ and $J/\psi+Z(W)$ production	**1 PhD student (1FTE, A.Prokhorov)**
3. Minbias measurements at 13.6TeV	**1 prof., 2 engineers (1.5 FTE, Koultchitski Y., Plotnikova E., Tsiareshka P.)**
4. Intrinsic charm and D+D- asymmetry produced in proton-proton collisions	**1 prof. (1.0 FTE, Lykasov G.)**
5. Hbb VH to bb+cc resolved+boosted	**1 postdoc, 1 PhD student (1.0 FTE, Ahmadov F., Manashova M.)**
6. Studies of tH(bb), application of neural networks to the data analysis	**4 postdoc, 2 PhD students, 1 m.student (2.6 FTE, I.Boyko, N.Huseynov, I.Yeletskikh, I.Souslov, A.Tropina, A.Didenko)**

ATLAS physics studies

7. Searches for Quantum Black Holes in lepton+jet final states	**2 postdocs (2 FTE, Karpov S., Karpova Z.)**
8. B_c, B^*_c excited states studies	**1 prof., 1 postdoc, 1 engineer (1 FTE, Gladilin L., Lyubushkina T., Lyubushkin V.)**
9. Studies of exotic states in *B*-hadron decays and fully charmed tetraquarks	**1 prof., 1 postdoc, 2 PhD students (2.4 FTE, Gladilin L., Yeletskikh I., Vasyukov A., Didenko A.)**
10. Higgs boson decays to bottom and charm quarks produced in associated with a W or Z boson	**1 postdoc (0.7FTE, Ahmadov F.)**

ATLAS physics studies

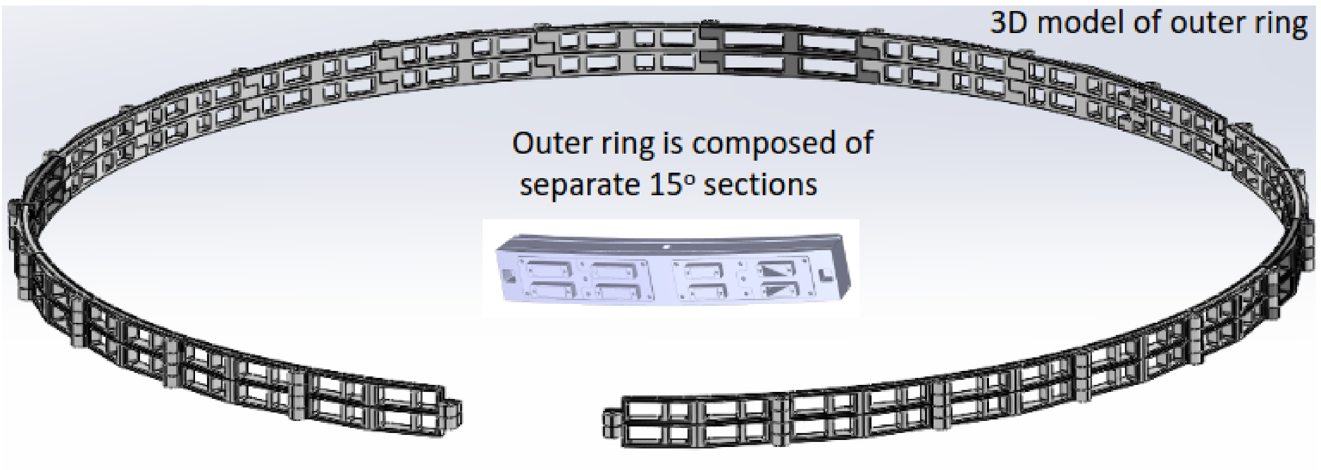
11. Measurement of $Z(\to\nu\nu)\gamma$+jets differential cross section, cross section measurements on production of $ZZ \to ll\nu\nu$ and $ZZjj \to ll\nu\nu\ jj$	**1 postdoc, (0.5 FTE, Soldatov E.)**
12. Measurement of the Higgs boson production cross section via ggF and VBF in $H\to WW^*\to l\nu l\nu$	**1 postdoc (0.3 FTE, Ramakoti E.)**
13. Measurement of the CP-violating phase in the B-meson decays	**1 postdoc (0.6 FTE, Lyubushkin V.)**

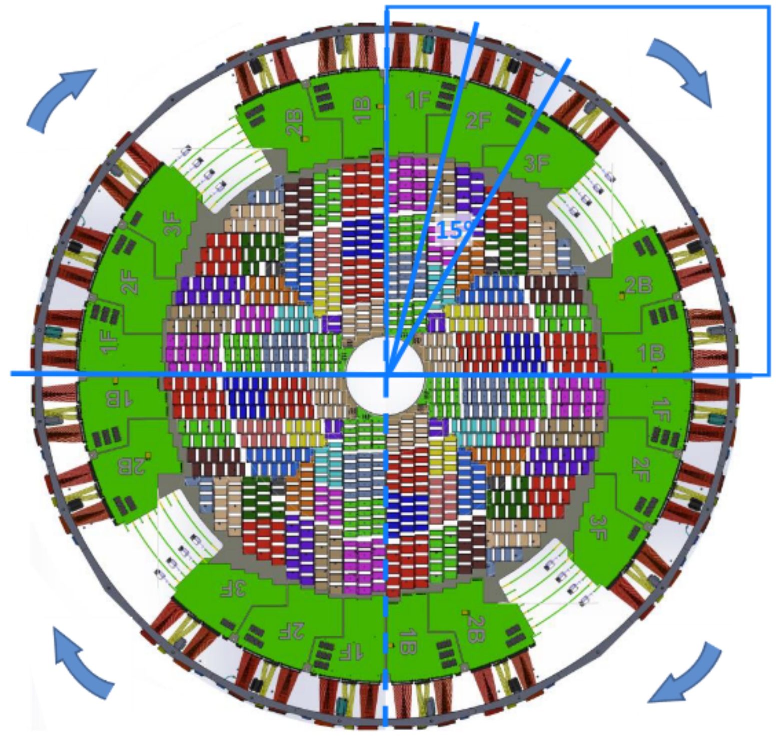
ATLAS software/simulation support

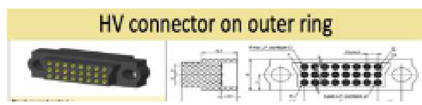
1. ‘Event index’ database development: Event picking service	**1 postdoc, 1 PhD (1.0FTE, E.Alexandrov)**
2. REST API development for database monitoring	**2 PhD students (1.5FTE, A.Gazzaev, D.Kokaev)**
3. Calorimeter simulation and software development, E/gamma reconstruction and performance	**3 postdoc, 2 PhD students (1.5FTE, A.Didenko, A.Tropina, N.Guseynov, E.Ramakoti, O.Rezanova, E.Soldatov)**
4. Software & Computing Infrastructure activities	**1 physicist, 0.3FTE A. Buzykaev**
5. Muon system software (trigger, new small wheel operation, other)	**4 Postdoc, 1 physicist (1.7FTE, V.Lyubushkin, I.Minashvili, S.Filimonov, I.Shreyber, O.Kuchinskaya)**

JINR in ATLAS upgrade

- Commitments to ATLAS w.r.t. RPC panels production and delivery are completely fulfilled.
- JINR takes active part in the new HGTD (High Granularity Timing Detector) development and production:
  - The scheme of modules layout and peripheral electronics was suggested, number of identical components maximized
  - The outer ring is designed and modelled





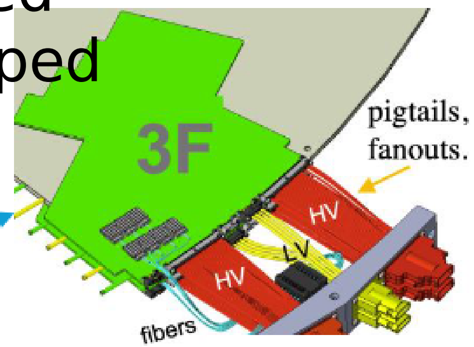


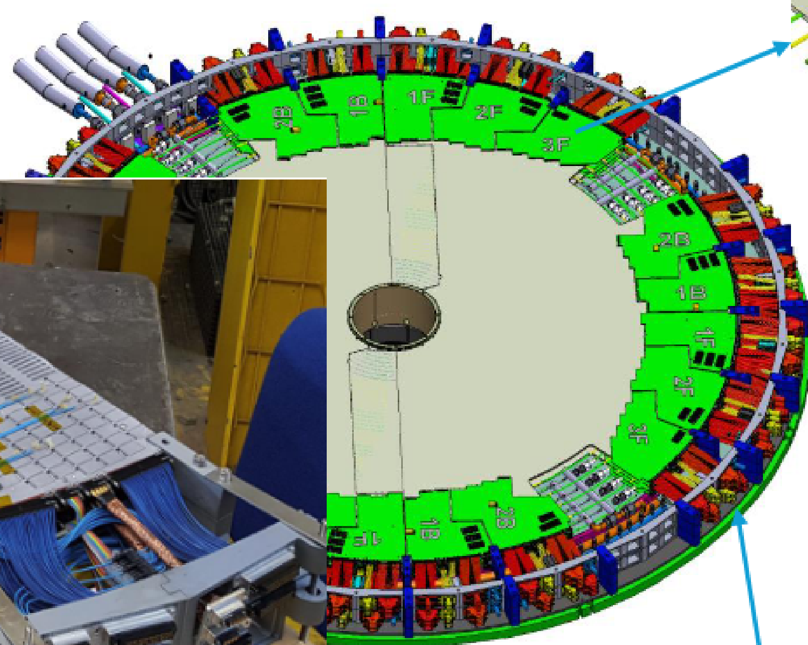
15° section of outer ring, 3D printed from PEEK

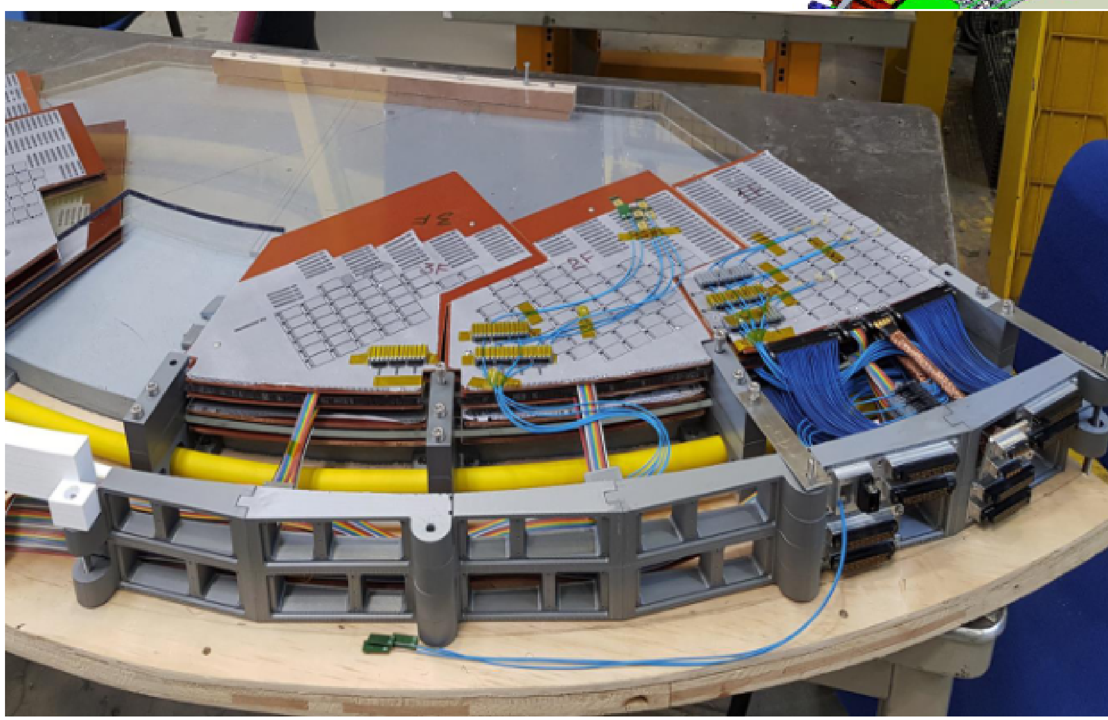
AL plates with flanges

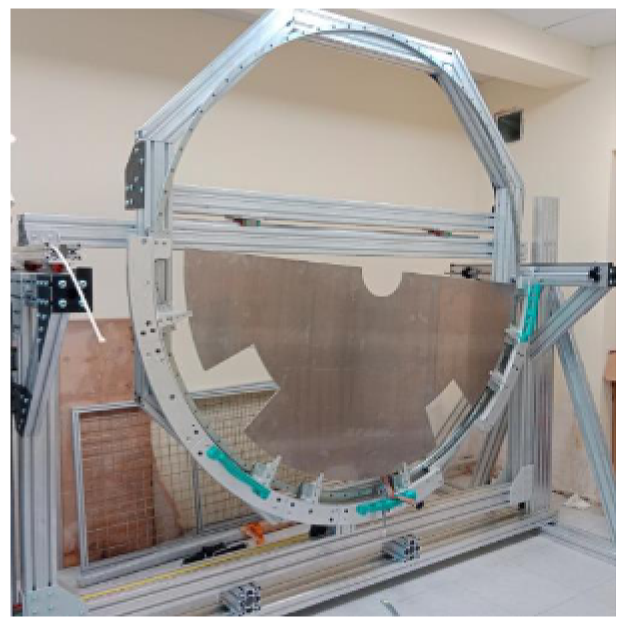
JINR in ATLAS upgrade

- JINR takes active part in the new HGTD (High Granularity Timing Detector) development and production:
  - Layout of the electrical and optical services inside the HGTD designed
  - Systems for temp., humidity and pressure monitoring designed
  - 3D model of services is developed and prototyped
  - Dedicated tool for half-disks assembly is prototyped
  - Cable routing is developed and prototyped

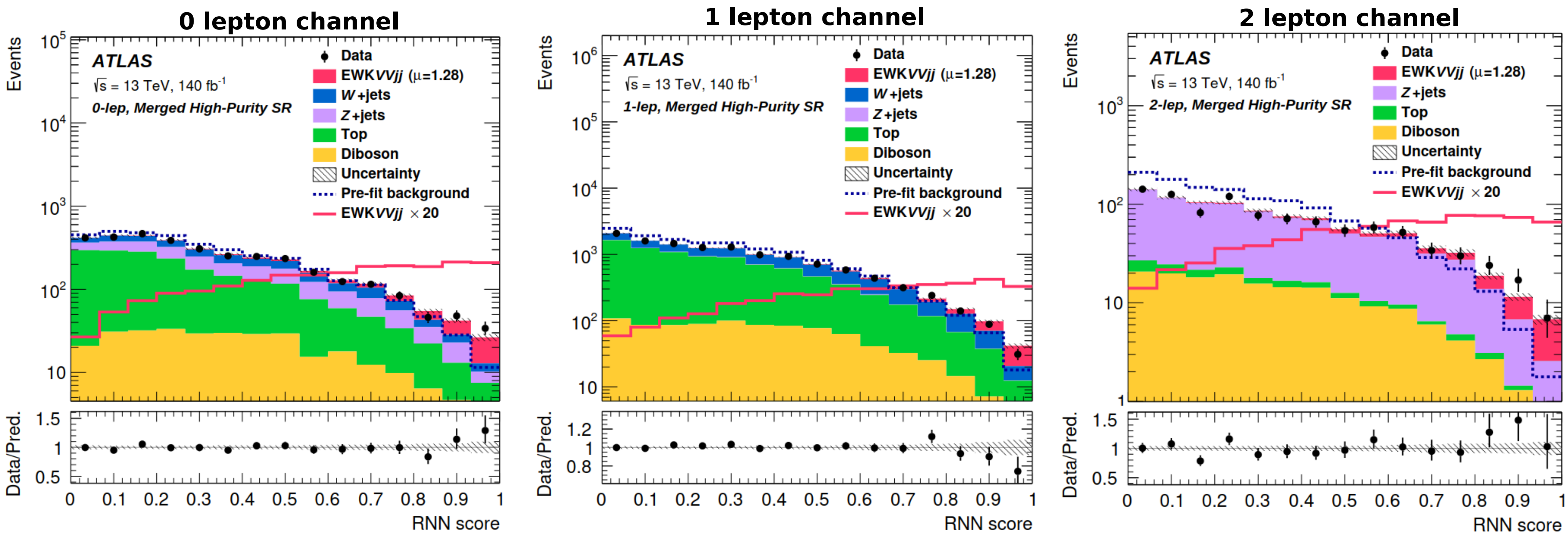






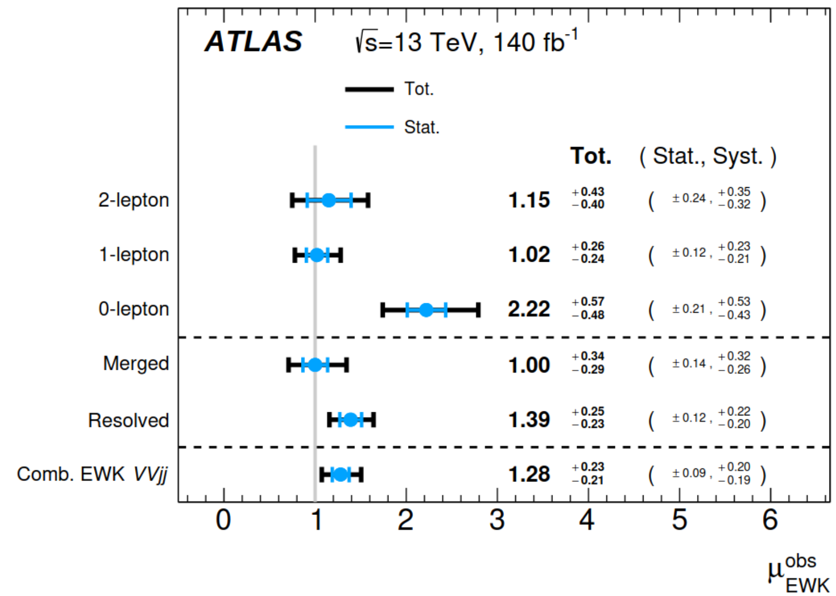


WW, WZ, ZZ production in association with high-mass dijet system



Electroweak diboson + 2jets production has been measured with ATLAS Run2 data. Signal in 0-lep, 1-lep and 2-lep channels is observed with total significance of 7.4σ.

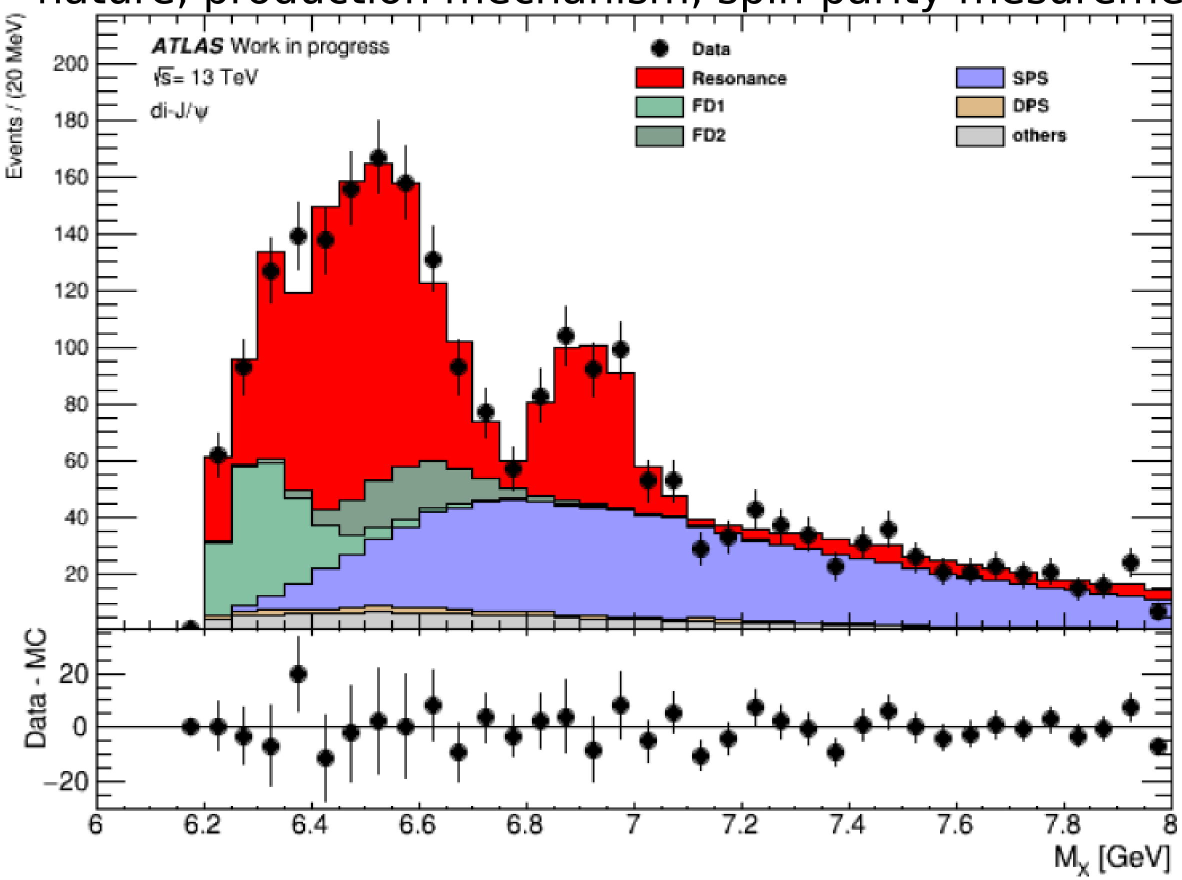
Measured signal strength **1.28**+0.23−0.21 is consistent with SM predictions.
Corresponding cross-section is **29.2 ± 4.9 fb** (expected 20.4 ± 3.5)
Limits on anomalous gauge couplings are set.

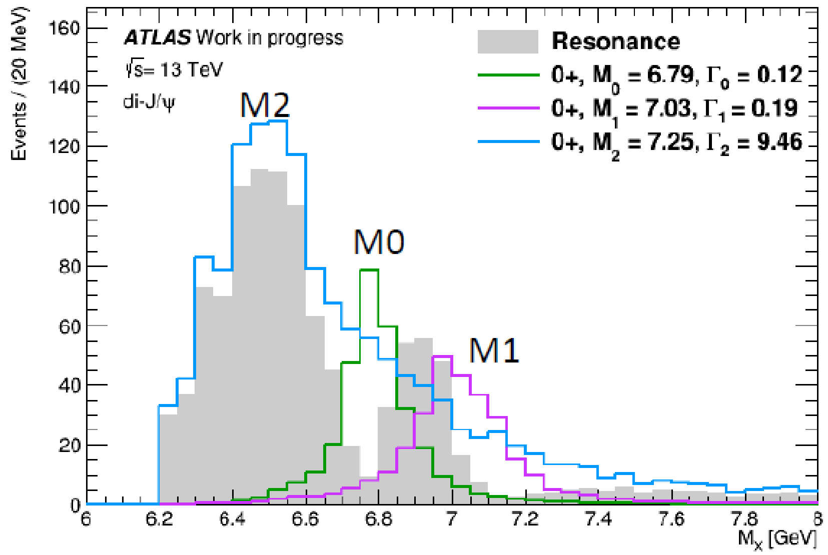


arXiv:2503.17461
Submitted to EPJC

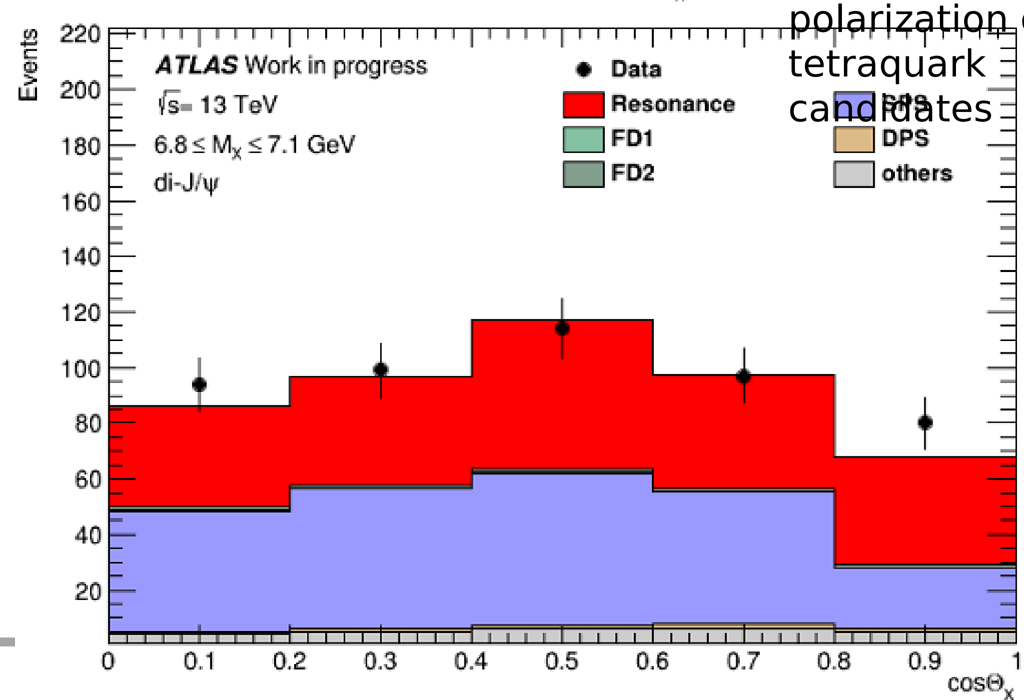
J/ψ-pair resonant production at ATLAS: fully charmed tetraquarks

JINR group performs an amplitude analysis of the recently discovered (by ATLAS, CMS and LHCb) di-J/ψ and J/ψ-ψ(2S) resonances. Purpose is to reveal the structure of the new states, their possible fully charmed tetraquark nature, production mechanism, spin-parity mesurement, etc.





Analysis of the angular distributions of the decay products allows sensitivity to the spin-parities of the new states. Sensitivity to the production mechanisms are possible via pT spectra analysis and polarization of the tetraquark candidates

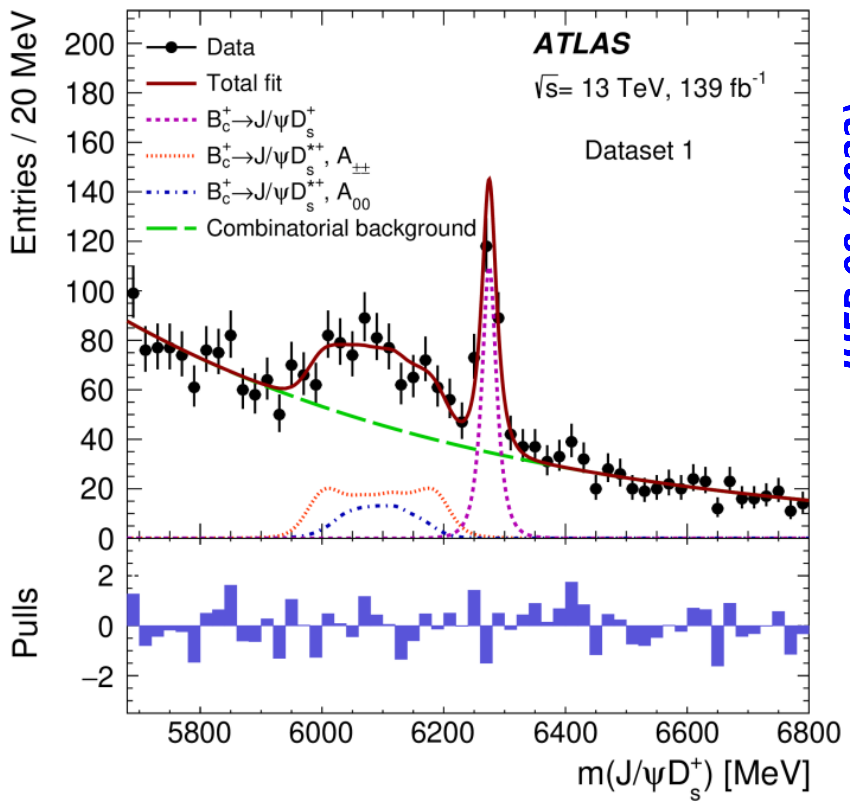


Signal interference effects play significant role in spectrum description. Best model corresponds to 0+ spin-parity of the X-6900 resonance

di-J/ψ	M, MeV	Γ, MeV
BW_0	6786.78	121.93
BW_1	7027.48	188.99
BW_2	7248.51	9457.87

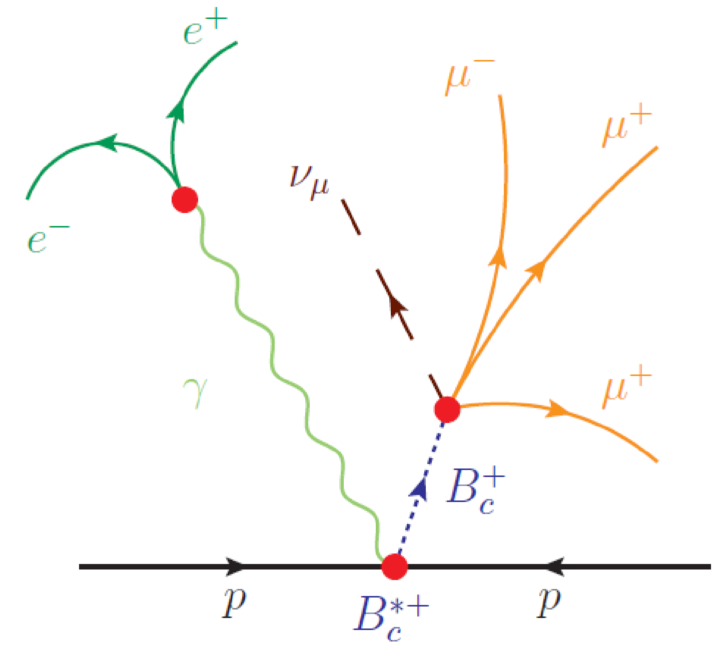
Phys. Rev. Lett. 131, 151902

Studies of B^{+*} and B_c^*



JHEP 08 (2022) 087

Study of B_c mesons spectra is an interesting ground for the physics of systems of different heavy quarks.
Besides B_c ground state, only B_c(2S) states were observed experimentally.
B_c* decays involve a very soft photon which is challenging w.r.t. reconstruction.



Parameter	low p_T tracking	all tracks
$Q_{B_c^{*+}}$ [MeV]	55.8 ± 1.4	55.3 ± 1.5
$\sigma_{B_c^{*+}}$ [MeV]	5.2 ± 1.6	4.5 ± 1.5
$N_{B_c^{*+}}$	162 ± 44	143 ± 45
Q_{B^+} [MeV]	42.4 ± 0.6	42.6 ± 0.8
σ_{B^+} [MeV]	2.3 ± 0.8	2.8 ± 0.3
N_{B^+}	93 ± 27	102 ± 36

Alternative decay channels of B_c* are being studied by JINR team at ATLAS:
$B_c^* \to B_c\gamma$ with subsequent leptonic decay of B_c

Gluon TMD density in proton from LHC data

Refined TMD gluon density in a proton from the HERA and LHC data

A.V. Lipatov[1,2], G.I. Lykasov[2], M.A. Malyshev[1,3]

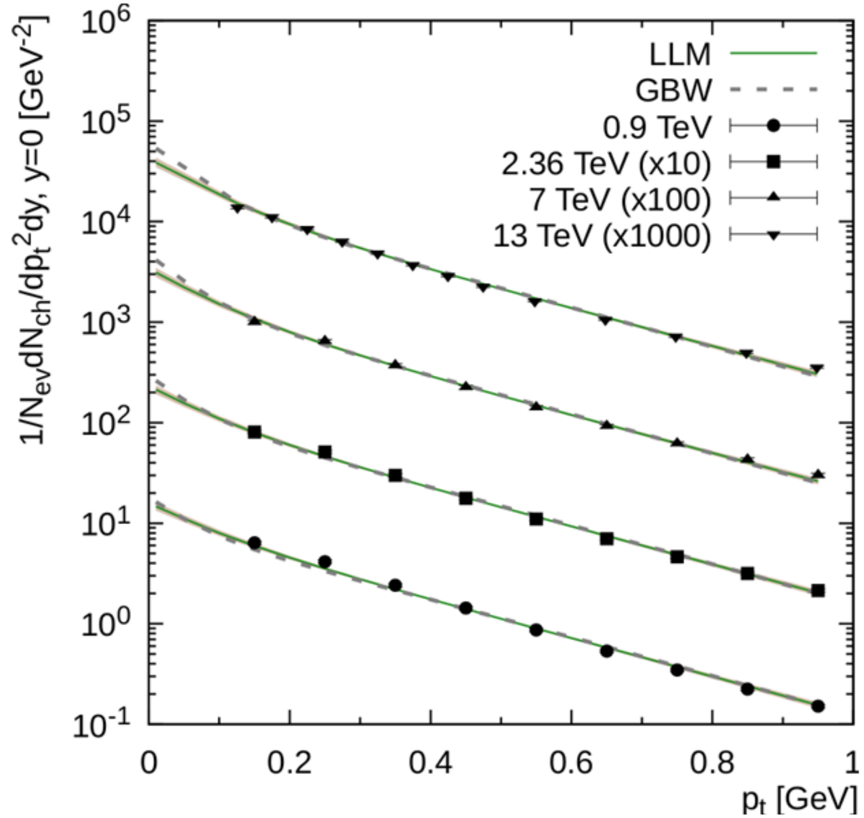
April 16, 2024

[1] *Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, 119991, Moscow, Russia*
[2] *Joint Institute for Nuclear Research, 141980, Dubna, Moscow region, Russia*
[3] *Moscow Aviation Institute, 125993, Moscow, Russia*

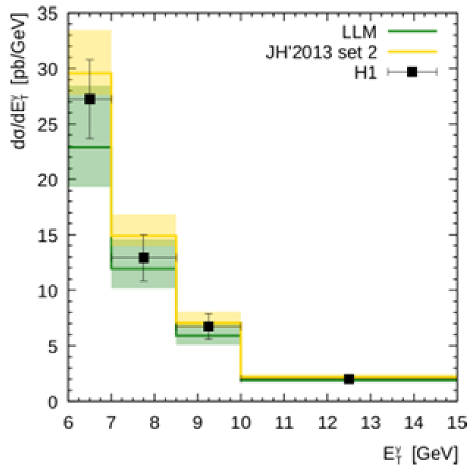
Abstract

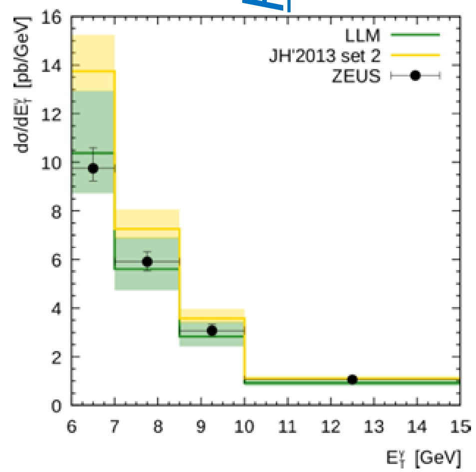
We update the phenomenological parameters of the Transverse Momentum Dependent (TMD, or unintegrated) gluon density in a proton proposed in our previous studies. This analysis is based on the analytical expression for starting gluon distribution which provides a self-consistent simultaneous description of HERA data on proton structure function $F_2(x, Q^2)$, reduced cross section for the electron-proton deep inelastic scattering at low Q^2 and soft hadron production in pp collisions at the LHC conditions. We extend it to the whole kinematical region using the Catani-Ciafaloni-Fiorani-Marchesini (CCFM) evolution equation. Expl
QCD processes, we performed a con
comprising a total of 509 points frc
derived TMD gluon density in a pı
HERA.

Experiment	Collaboration	Year	Reference	Collision	$\sqrt{s}$/GeV	Number of point
incl. c-jet	CMS	2017	[43]	pp	2.76	5
incl. c-jet	CMS	2017	[43]	pp	5.02	5
incl. b-jet	ATLAS	2011	[42]	pp	7	46
incl. b-jet	CMS	2012	[46]	pp	7	98
$F_2^c(x, Q^2)$	H1	2010, 2011	[47, 48]	ep	0.319	25
$F_2^c(x, Q^2)$	ZEUS	2014	[49]	ep	0.319	18
$F_2^b(x, Q^2)$	H1	2014	[47]	ep	0.319	12
$F_2^b(x, Q^2)$	ZEUS	2014	[49]	ep	0.319	17
$\sigma^c_{\rm red}(x, Q^2)$	H1, ZEUS	2018	[50]	ep	0.319	51
$\sigma^b_{\rm red}(x, Q^2)$	H1, ZEUS	2018	[50]	ep	0.319	27
incl. $H \to \gamma\gamma$	CMS	2023	[51]	pp	13	37
incl. $H \to \gamma\gamma$	ATLAS	2018	[51]	pp	13	27
incl. $H \to ZZ^*$	CMS	2023	[52]	pp	13	54
incl. $H \to ZZ^*$	ATLAS	2020	[53]	pp	13	54
incl. γ	H1	2010	[44]	ep, low Q^2	0.319	25
incl. γ	ZEUS	2014	[45]	ep, low Q^2	0.319	8



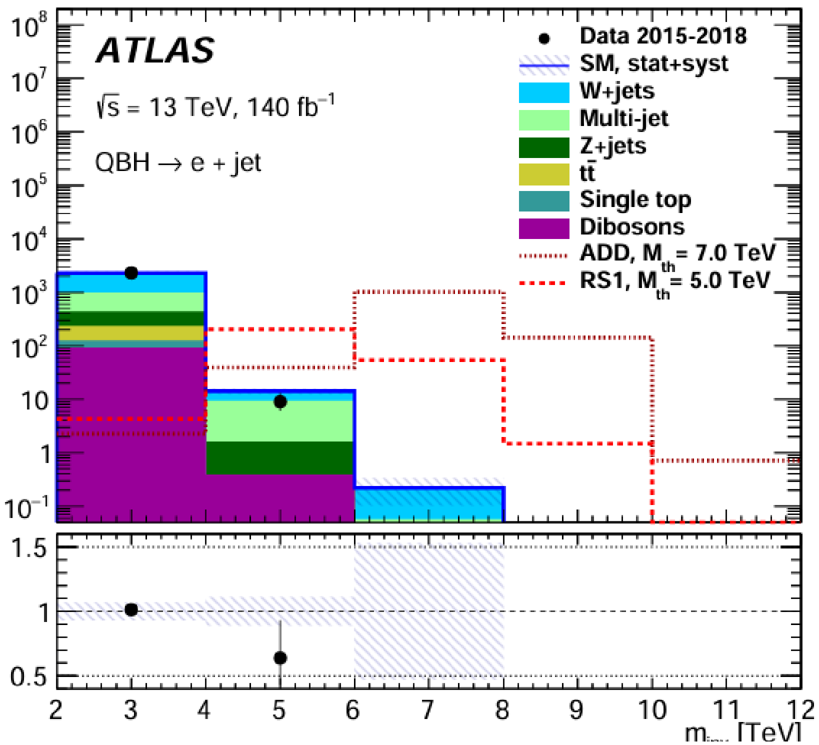
e-print:2404.09550
Phys.Lett.B 848 (2024) 138390

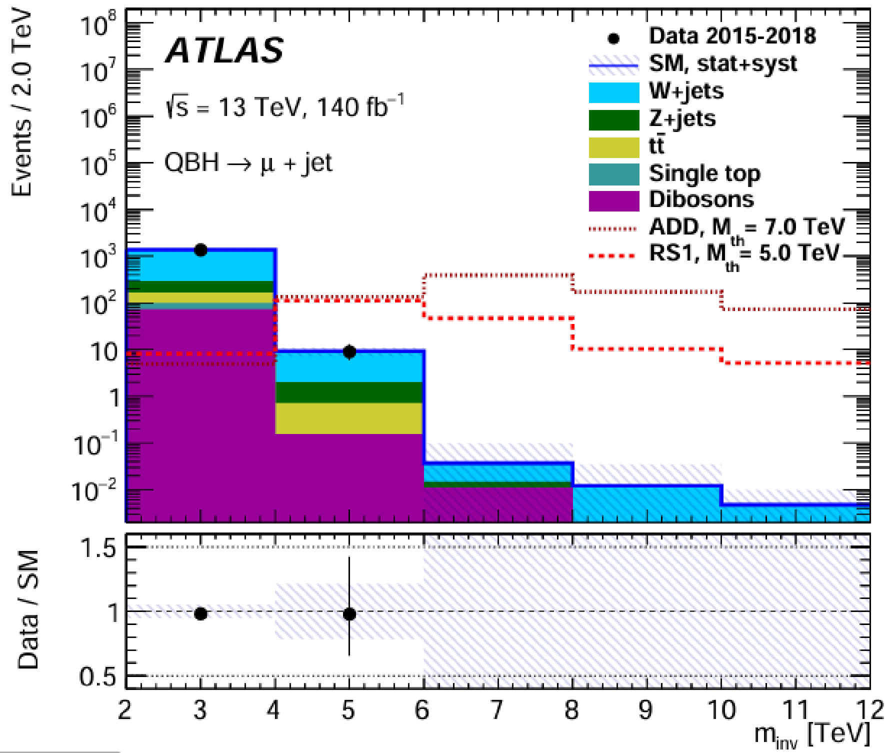




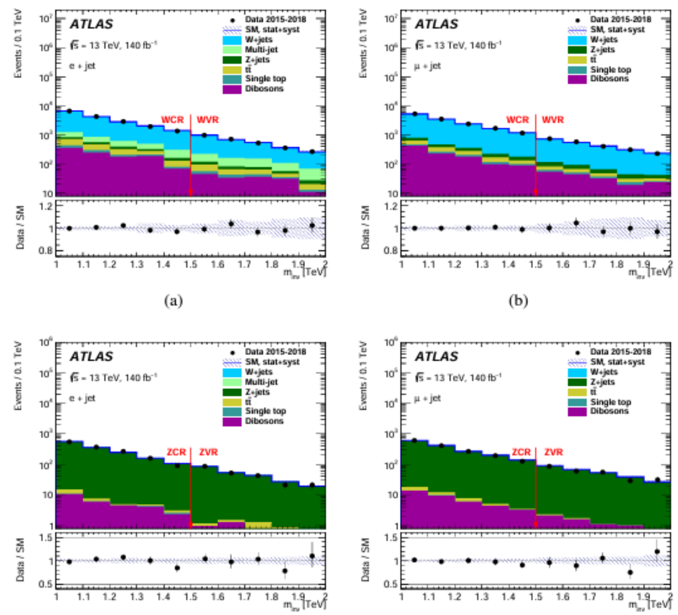
Search for Quantum Black Holes in lepton+jet final states

s. Rev. D. 109 (2024) 032010





	SVR electron+jet	SVR muon+jet	SR electron+jet	SR muon+jet
Observed data	9053	5504	2319	1359
Fitted events	8900 ± 320	5380 ± 200	2290 ± 110	1386 ± 70
W+jets	5590 ± 270	4190 ± 200	1290 ± 70	1087 ± 54
Multijet	1670 ± 200		570 ± 47	
Z+jets	646 ± 73	439 ± 27	199 ± 17	131 ± 13
$t\bar{t}$	527 ± 10	351 ± 7	109 ± 5	69 ± 5
Single top	143 ± 7	112 ± 5	31 ± 2	28 ± 2
Dibosons	335 ± 22	289 ± 14	94 ± 9	72 ± 8
Expected events	9390 ± 340	5260 ± 220	2647 ± 94	1303 ± 55
W+jets	6090 ± 270	4080 ± 210	1654 ± 65	1016 ± 48
Multijet	1690 ± 210		577 ± 38	
Z+jets	598 ± 85	408 ± 23	186 ± 18	122 ± 12
$t\bar{t}$	546 ± 14	366 ± 7	109 ± 6	71 ± 5
Single top	141 ± 7	104 ± 4	29 ± 2	28 ± 2
Dibosons	327 ± 23	298 ± 12	92 ± 10	66 ± 8



(a) (b) (c) (d)

JINR team played a leading role in the search for QBH in lepton+jet final states at ATLAS.

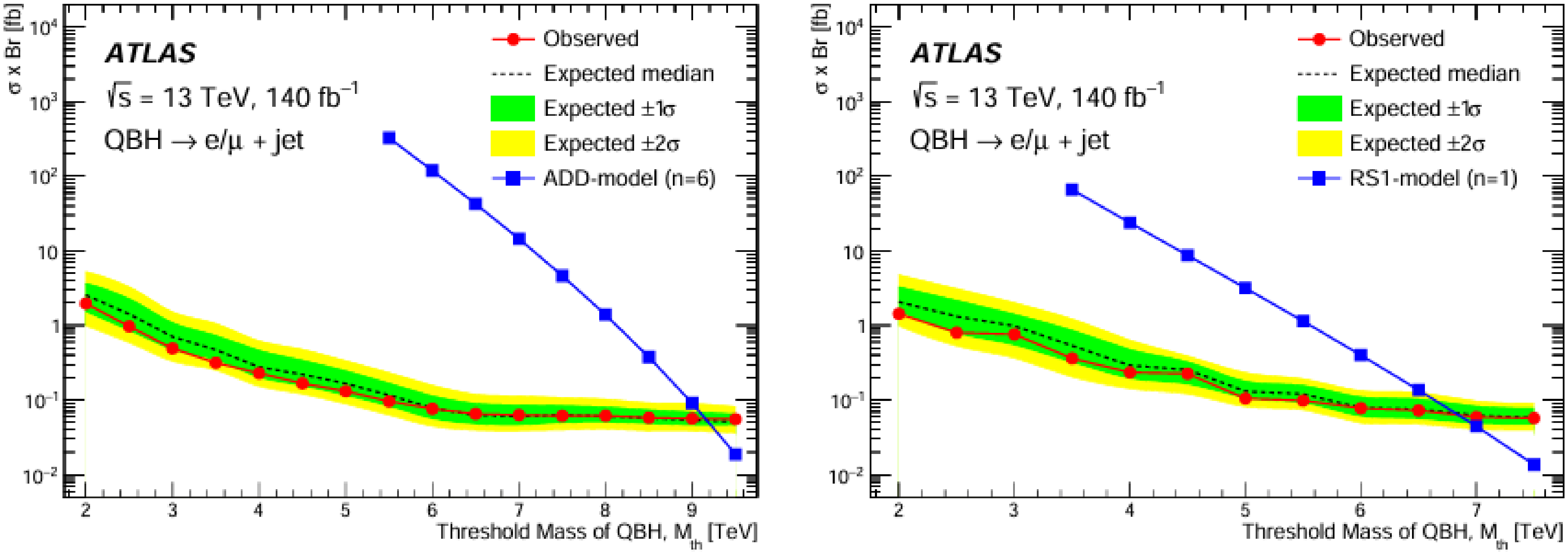
Full Run2 data are analyzed. Plots show invariant mass distributions of the electron+jet (left) and muon+jet (right).

Predicted QBH signals in the Arkani-Hamed-Dimopoulos-Dvali model (ADD) and Randall-Sundrum (RS1) models are shown.

Few CR and VR are analysed to ensure accurate description for all background processes.

Search for Quantum Black Holes in lepton+jet final states

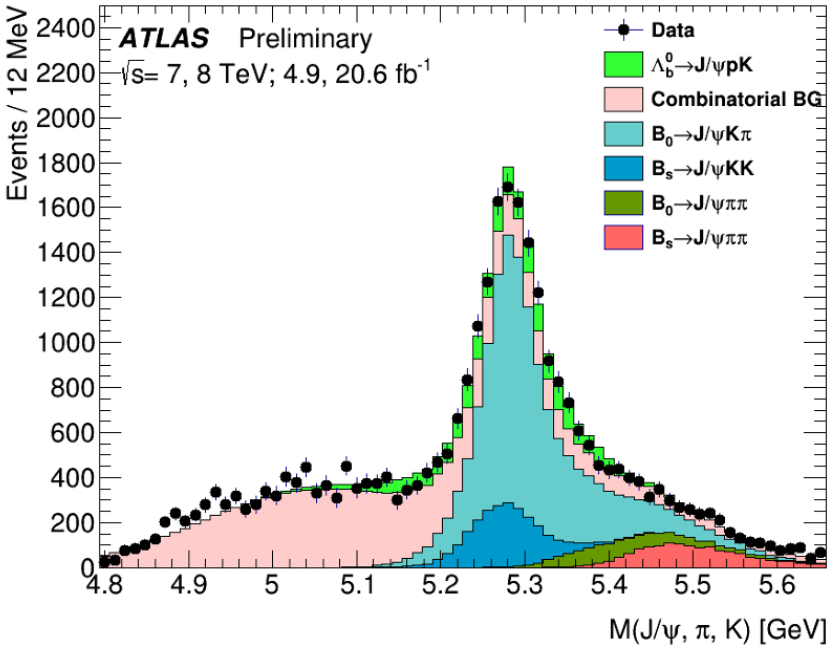
Phys. Rev. D. 109 (2024) 032010

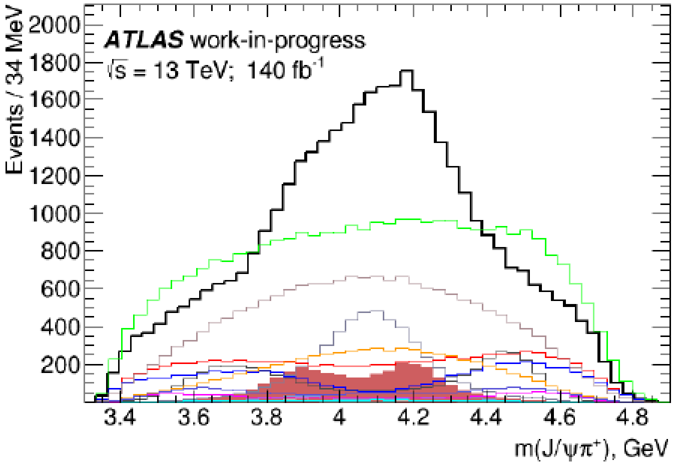


Channel	ADD $\sigma \times Br$ [fb]	ADD M_{th} [TeV]	RS1 $\sigma \times Br$ [fb]	RS1 M_{th} [TeV]	Model-independent $\sigma(m_{\mathrm{inv}} > 5\ \mathrm{TeV}) \times Br$ [fb]
Electron+jet	0.091	9.0	0.099	6.6	0.095
Muon+jet	0.083	9.0	0.087	6.7	0.084
Combined	0.056	9.2	0.061	6.8	0.052

New mass/cross-section limits are set for the ADD and RS1 models as well as for model-independent approach.

Other physics analyses in advanced state...

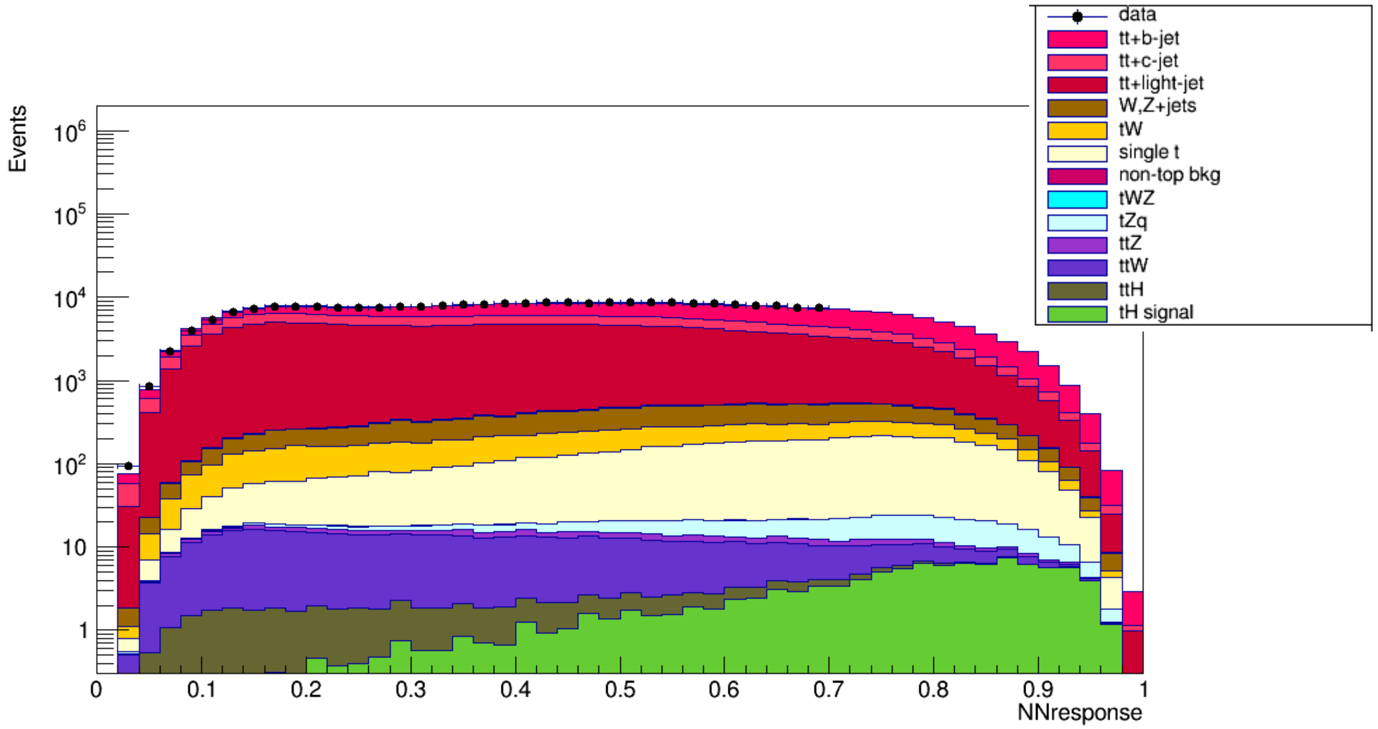




$Z_c(4200)$ mass	$4207^{+13}_{-22}(\mathrm{stat.})^{+8}_{-19}(\mathrm{syst.})$
$Z_c(4200)$ width	$185^{+38}_{-23}(\mathrm{stat.})^{+48}_{-11}(\mathrm{syst.})$

Amplitude analysis of the exotic contributions to B^0, B_s-meson decays.

$Z_c^{\pm}(4200)$ state is observed in the $J/\psi\pi$ invariant mass spectrum with significance >3.7σ. Mass, width and spin-parity characteristics are measured from ATLAS Run2 data.
Significant role is played by the interference effects between signals and background. Z_{cs} states contributions are discussed. To be released in 2024.



Search for the Higgs production in association with single top quark.

Aim of the analysis is observation of the SM signal and/or setting limit on the ITC models predicting higher production cross sections.
One of the JINR contributions is MVA analysis of the signal (*tH*) and background (*tt* mainly) processes. Few novel ML approaches have been developed to increase potential signal significance by ~1.7 compared to standard cut and count approaches.

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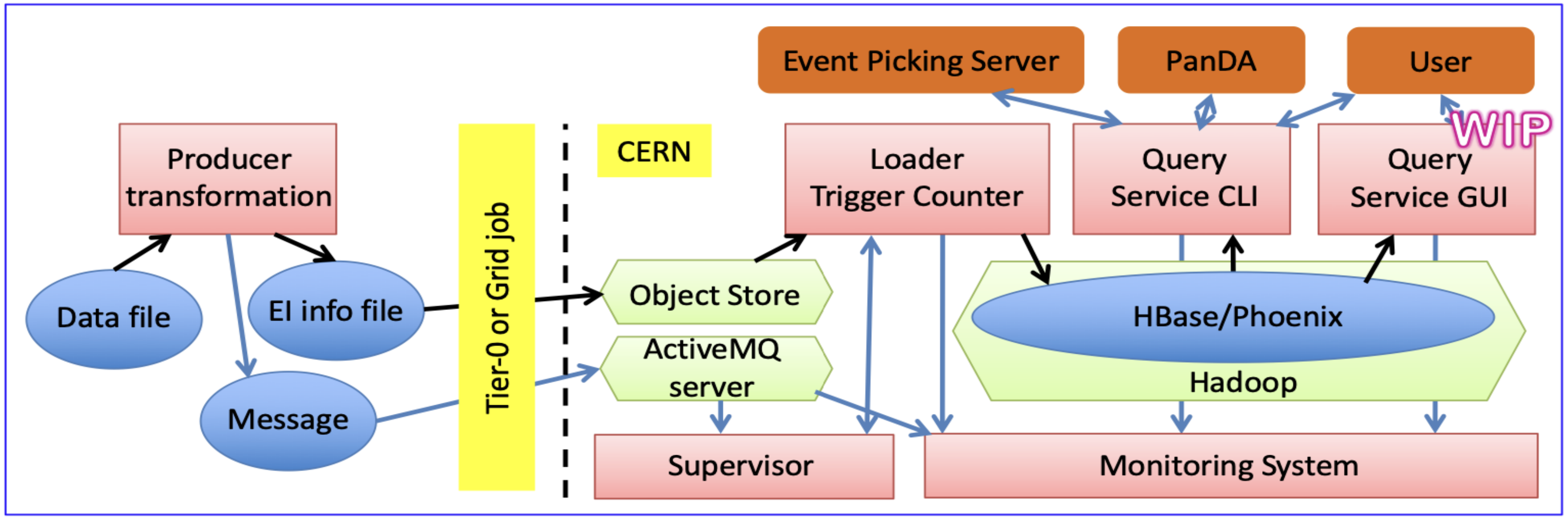
Event index: Event picking service



JINR team developed and tested the ‘Event Picking service’ that allow selection of the sets of ‘interesting’ events for physics analyses from the Event Index database.

2024 Operations:

Request	Number of events	Version	Time
γγ -> WW	50k	1.0.0	2 weeks
		manual	3 months
γγ -> WW	136k	Beta version	3 months
B_c^* -> B_c	16K	1.2.37	84h
Z -> TauTau	11K	1.2.37	40h
B_c^* -> B_c	240K	1.3.25	17 days

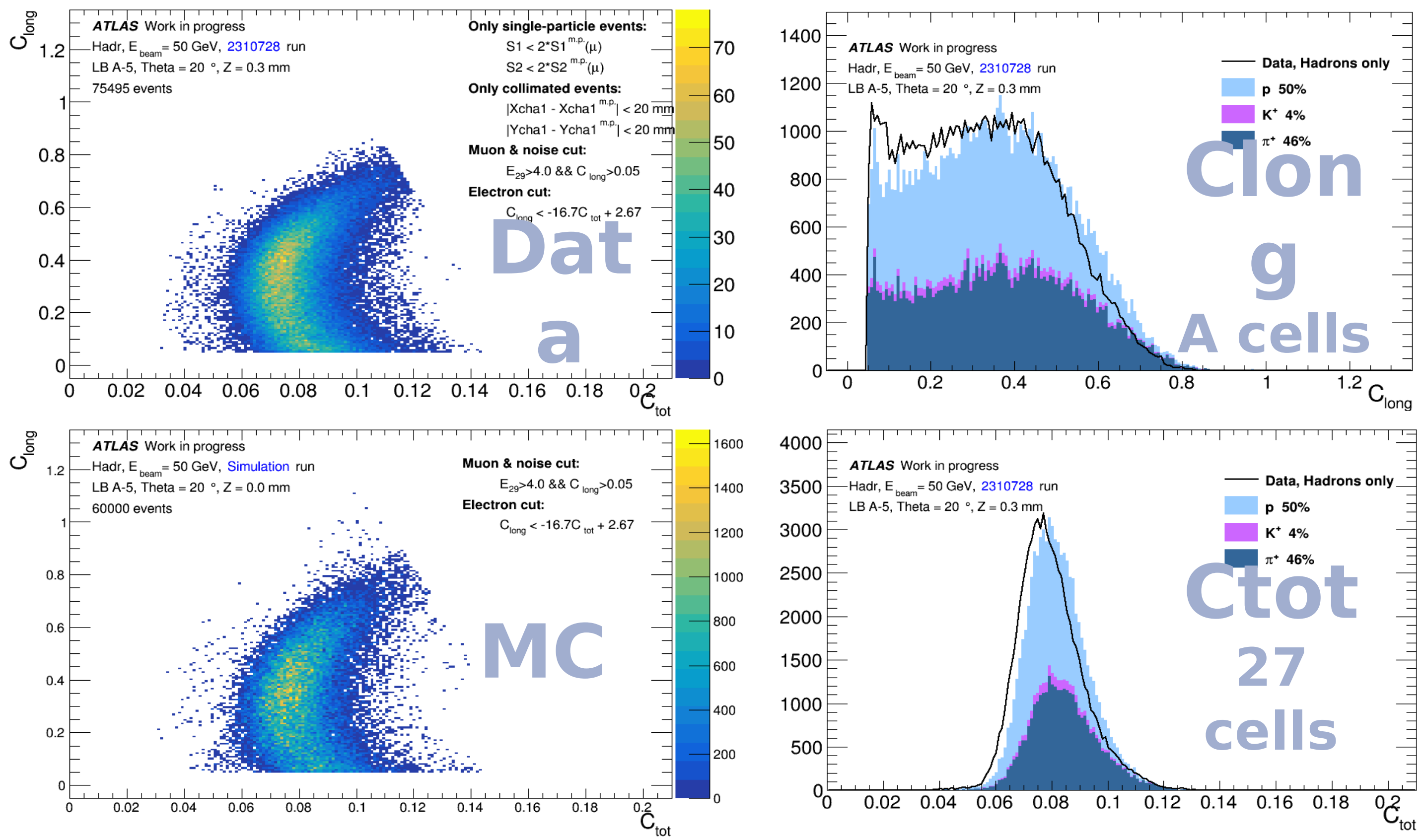
- The Event Picking Server is now fully functional and can be used for large scale operations
- Used so far by only a small number of analyses
- Largest number of events ~600k for the B_c^*–>$B_c\gamma$ analysis (see above)

Participation in TDAQ online project

- **Resource Manager development and support**
  - The Resource Manager is one of the core components of the **Data Acquisition system** of the ATLAS experiment at the LHC.
  - The Resource Manager **marshals the right for applications** to access resources which may exist in multiple but limited copies, in order to avoid conflicts due to program faults or operator errors.
- **P-BEAST Dashboard support**
  - This web application offers an interface to visualize any operational monitoring data published by the TDAQ system through configurable and customizable dashboards.
  - An example of an operational

Measurement of the hadronic shower shapes in ATLAS TileCal

- TestBeam data 2023 have been analized.
- Cuts for selection of beam hadrons/muons/electrons are developed
- Noise level in data is estimated and subtracted
- Transverse and longitudinal shower profiles are measured. Some discrepancies with Geant4 are observed
- Two JINR students completed ATLAS QT



Plans

- Finalize energies above 50 GeV (need to produce MC)
- Understand remaining puzzles:
  - ☐ Total energy deposition dependence on ΔZ
  - ☐ Feature in MC: 10 GeV in a single PMT
- Prepare article
- Tune Geant4 interaction model for better description of transverse profile

IR group participation in the upgrade program

fulfilled all obligations on participation in the **Phase-1** Upgrade program of the ATLA

The most significant contribution was made in the upgrade of the Muon Spectrometer: 32 large-scale Micromegas quadruplets for New Small Wheel were manufactured in the JINR DLNP workshop, delivered to CERN and installed in the ATLAS detector. They show good efficiency during Run3 of the data taking.

Our plans for the **Phase-2** of the ATLAS upgrade aimed at HL-LHC operation include:

- Muon Spectrometer:
  - BI readout panels
  - power distribution system
  - RPC gas system
- LAr Calorimeters:
  - optical link components
- High Granularity Timing Detector
  - half-disk instrumentation stand
  - transportation tools and cavern installation

Production site for RPC panels is ready, 3 BI panels were manufactured and test

Prototype cables were produced and used at CERN in half-crate test

The tools were designed at DLNP and assembled, delivery to CERN is planned in about two months

group participation in the ATLAS Phase-I upgrade program (2013-2

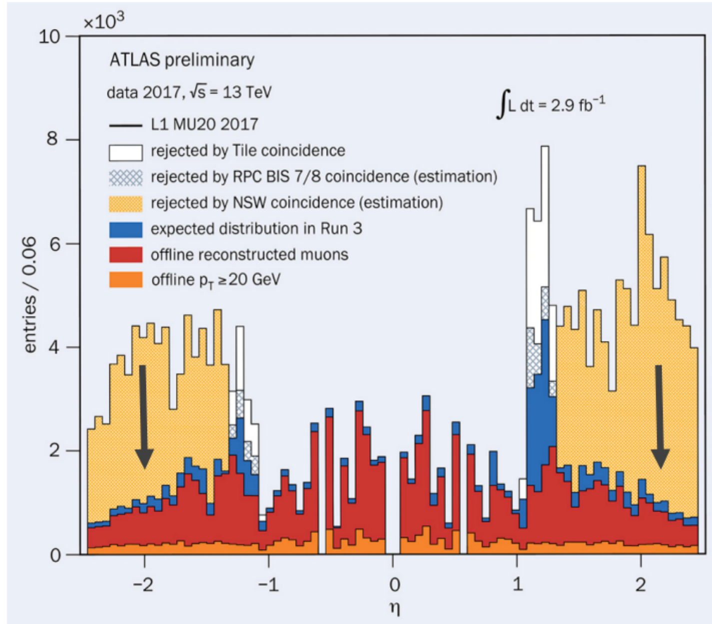
Muon Spectrometer – NSW project:
- Infrastructure development
- Production of large Micromegas quadruplets
- NSW assembly and commissioning

Factor 4 reduction in the rate of fake μ-triggers

Liquid Argon Calorimetry:
- Design of baseplane and preshaper
- Radiation tests and
- Simulation of signal degradation

TILE scintillator calorimeter:
- Min.bias trigger modules
- Development of new electronics for the readout Demonstrator

NSW: Reduction of fake μ triggers



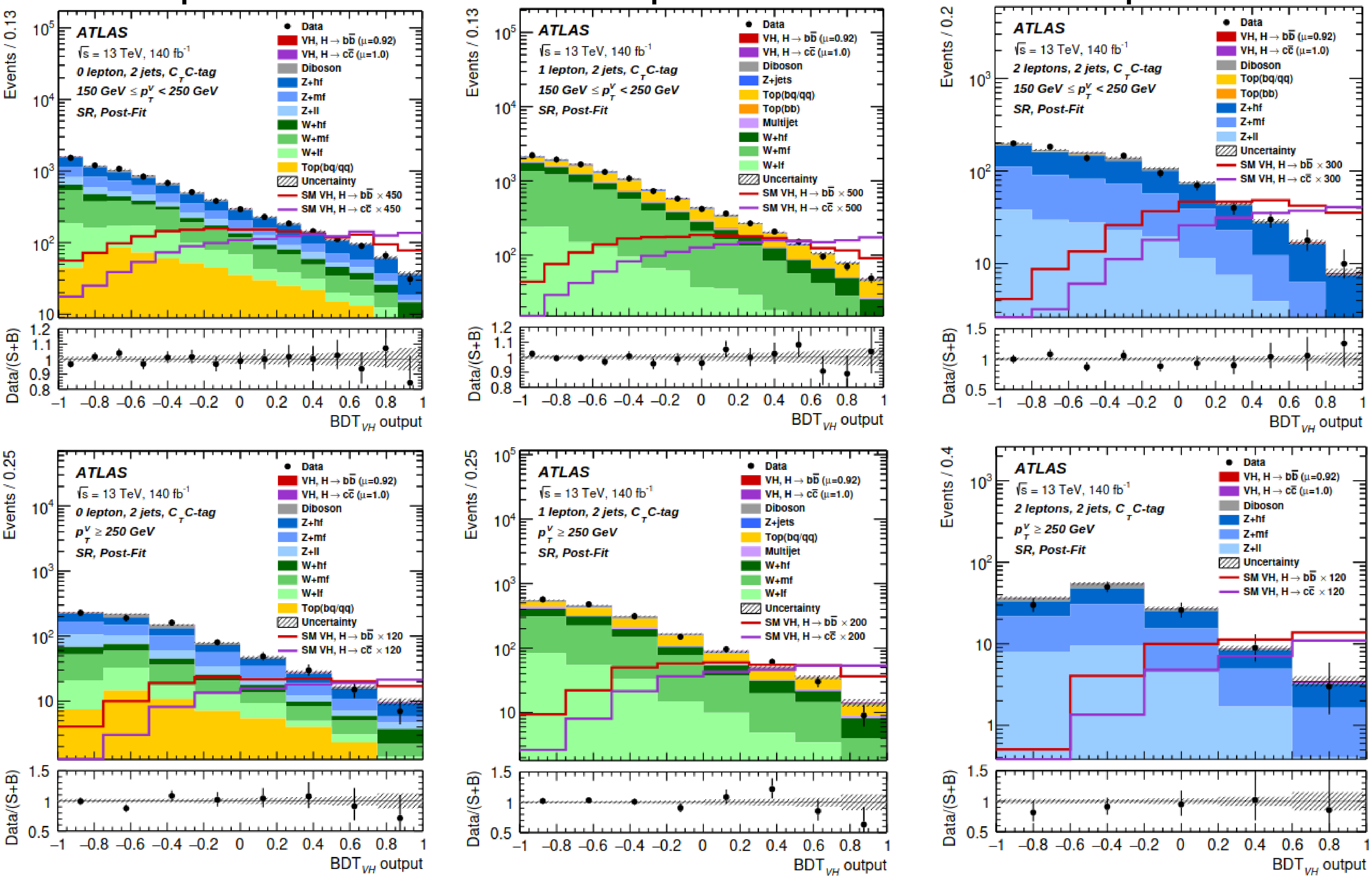
Measurements of WH and ZH production with Higgs boson decays into bottom quarks and direct constraints on the charm Yukawa coupling

In addition to $H \to bb$ channel, the $H \to cc$ channel has been analysed to set limit on cH coupling.
Vector boson pT specrum is split into ranges 75-150-250-inf GeV

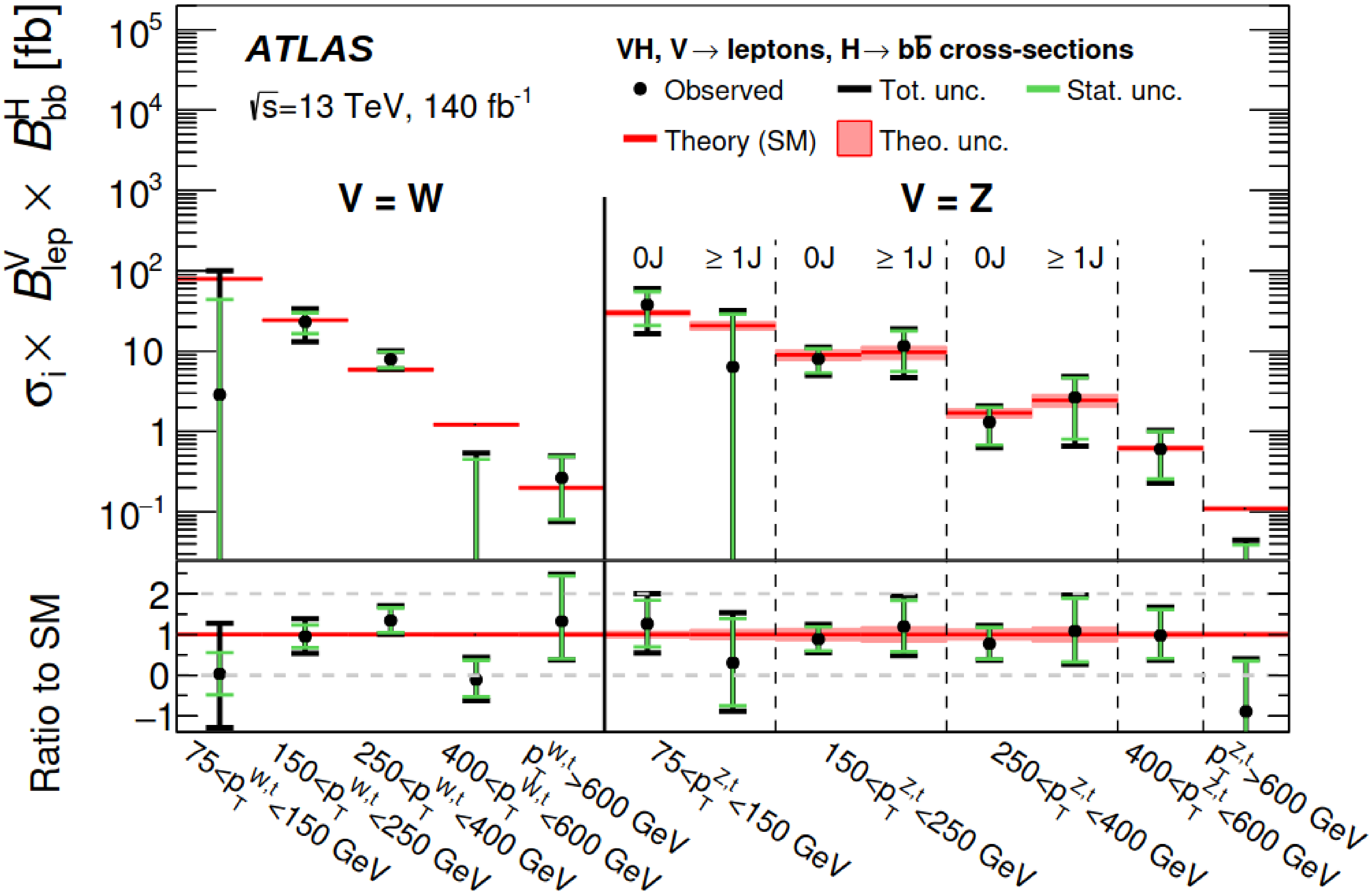
0 lepton channel | **1 lepton channel** | **2 lepton channel**

150 GeV < pT < 250 GeV

pT > 250 GeV



Summary of the differential cross section measurements in different channels



A.Ahmadov
ArXiv:2410.19611, accepted by JHEP