JINR group results in the ATLAS experiment

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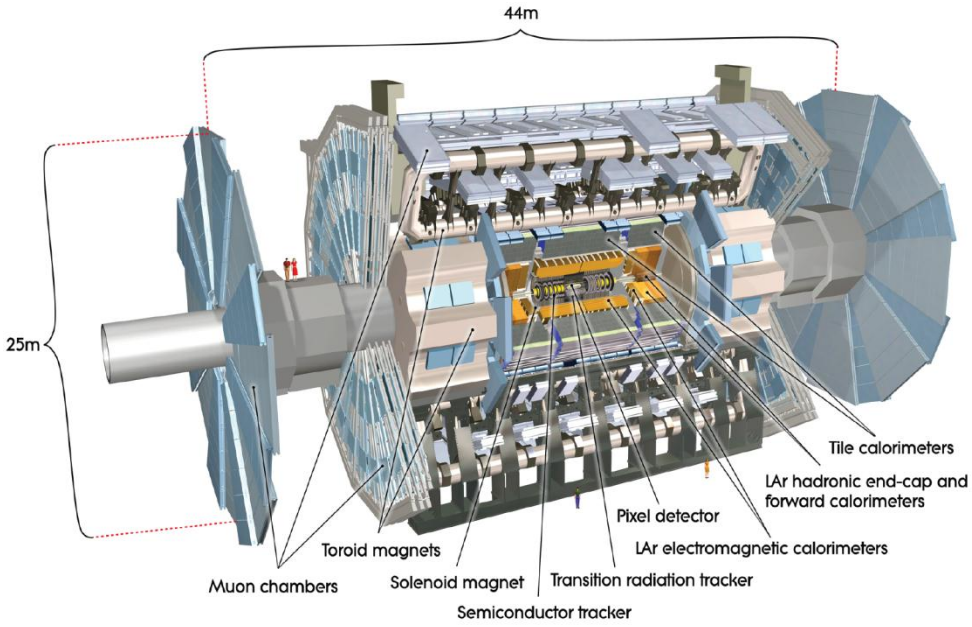
Introduction

The ATLAS detector:

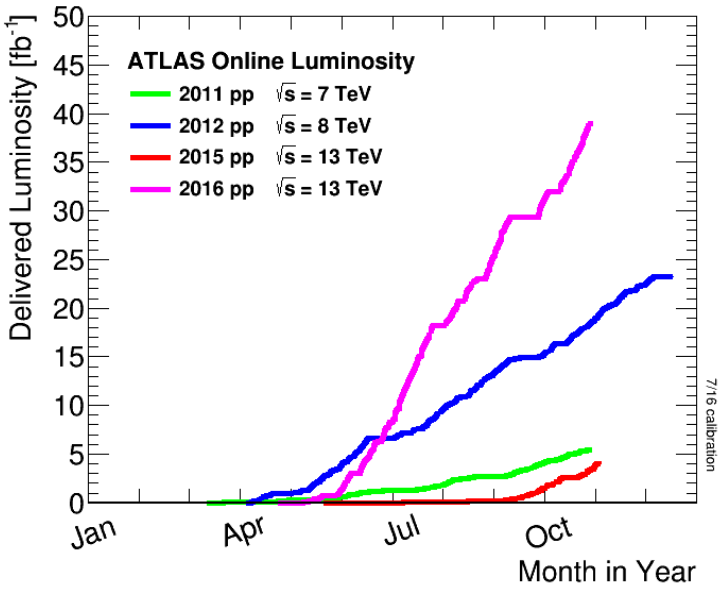
- **Inner detector** inside 2 T solenoid magnetic field within $|\eta| < 2.5$
- **Electromagnetic** and **hadronic calorimeters** covering up to $|\eta| < 4.9$
- **Muon spectrometer** inside toroid magnetic system with $|\eta| < 2.7$



Very good detector performance in the LHC **Run-2 period**

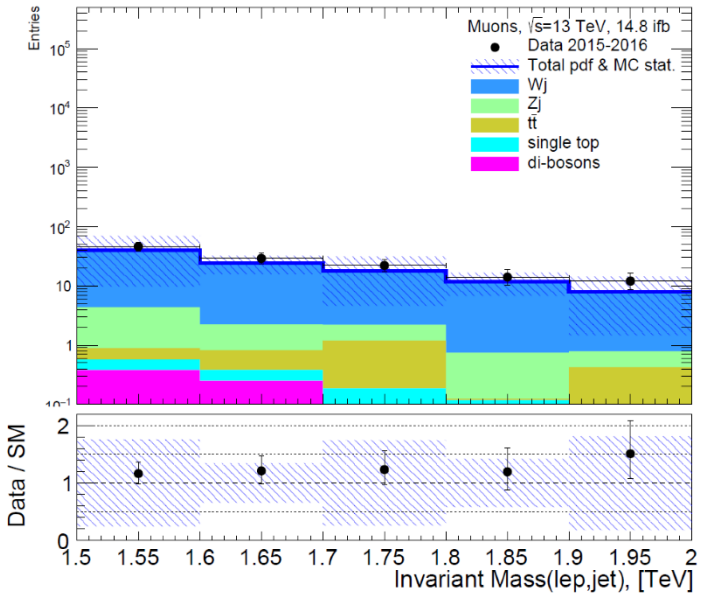
2016 (2015) data-taking:

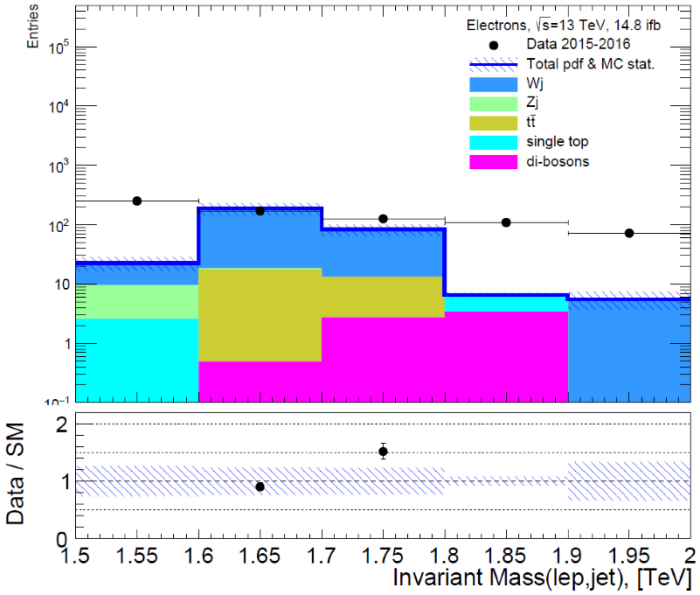
- proton-proton collisions at $\sqrt{s}$ = 13 TeV
- integrated luminosity: 33.3 – 33.9 fb^{-1} (3.2 – 3.3 fb^{-1}) after data-quality requirements
- peak stable luminosity: $1.37 \cdot 10^{34}$ cm^{-2} s^{-1} ($5.02 \cdot 10^{33}$ cm^{-2} s^{-1})
- pile-up: <μ> = 24.9 (13.6)
- peak pile-up: <μ> = 51.1 (28.1)



Search for Quantum Black Holes

- predicted in low-scale quantum gravity theories
- one important example: ADD model of large extra dimensions (n additional spatial dimensions of size R, and new fundamental scale M_D: $M_{Planck}^2 \approx M_D^{2+n} R^n$)
- Quantum Black Holes with masses near M_D
- expected to decay into low-multiplicity final states
- analysis considers decays into 1 high-p_T lepton (e or μ) and 1 high-p_T jet
- signal region with high invariant mass of the lepton-jet system





- 13 TeV data is used for the search
- comparison between data and simulation in the validation regions is being performed
- work is in progress, supporting note is under preparation

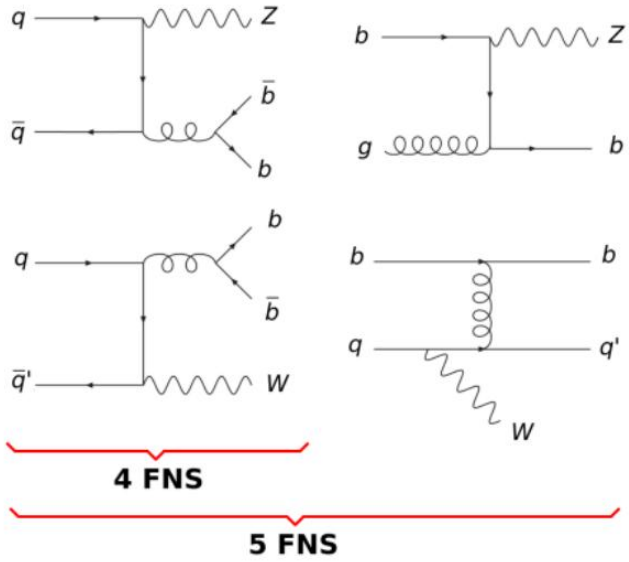
W/Z + b-jet production measurement

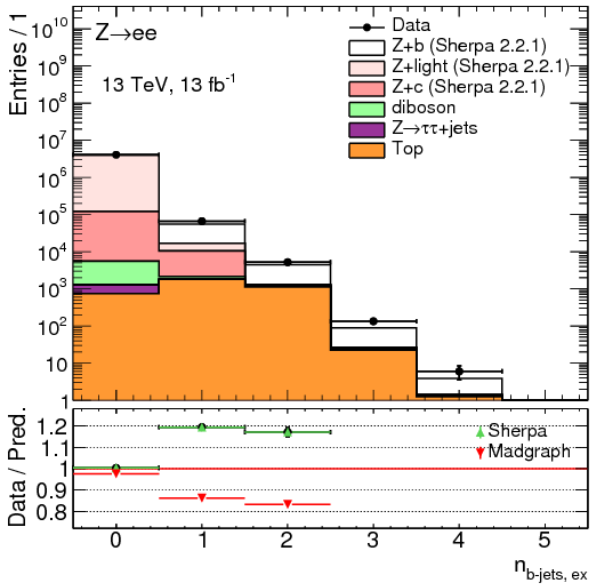
Motivation:

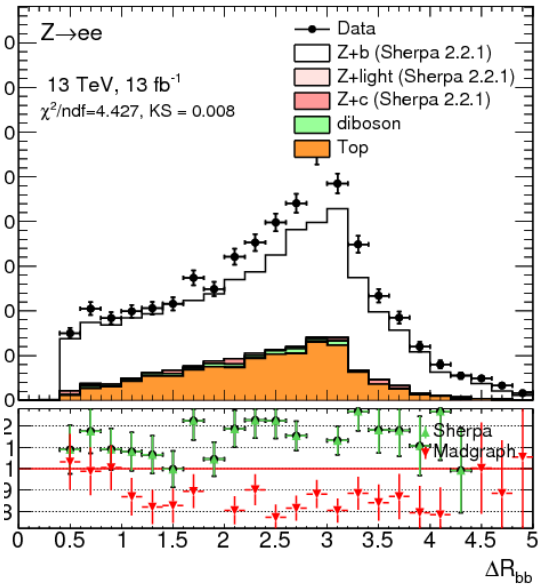
- Test of pQCD predictions (available at NLO for up to 2 jets)
- Sensitivity to intrinsic heavy flavor component in proton PDF
- Important background for $H \to b\bar{b}$ and various BSM studies

Goals of the measurement:

- Inclusive cross-sections for W and Z with 1 and 2 b-jets
- Differential cross-sections in: leading jet p_T and y, di-b-jet kinematics ($\Delta\phi_{bb}$, ΔR_{bb}, m_{bb})
- Ratio $\sigma(W+b)/\sigma(Z+b)$ at least in 1 and 2 jet bins
- Compare parton-level distributions with theory predictions







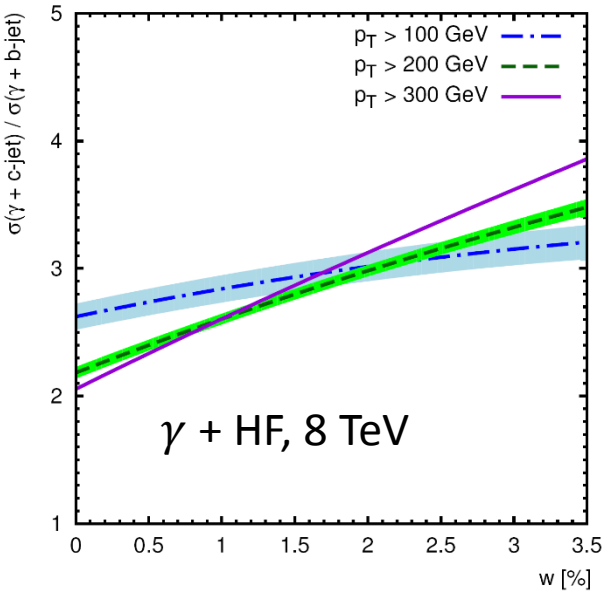
- Use SHERPA 2.2.1 and MADGRAPH; ALPGEN to be added for comparison at reconstruction level
- Reasonable agreement found so far

Analysis is in progress, aiming at summer conferences

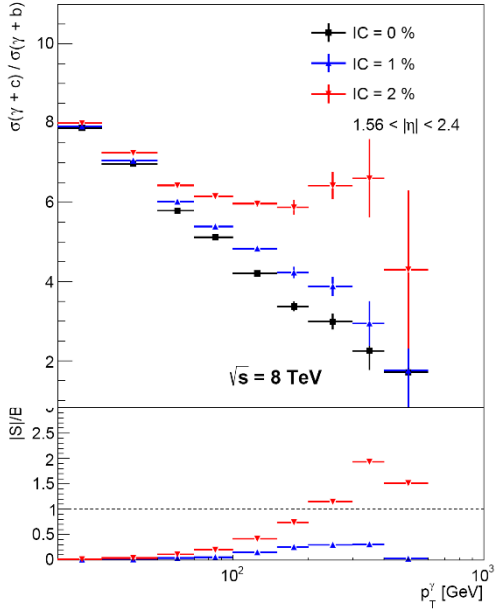
Intrinsic charm in proton PDF

Theoretical studies:

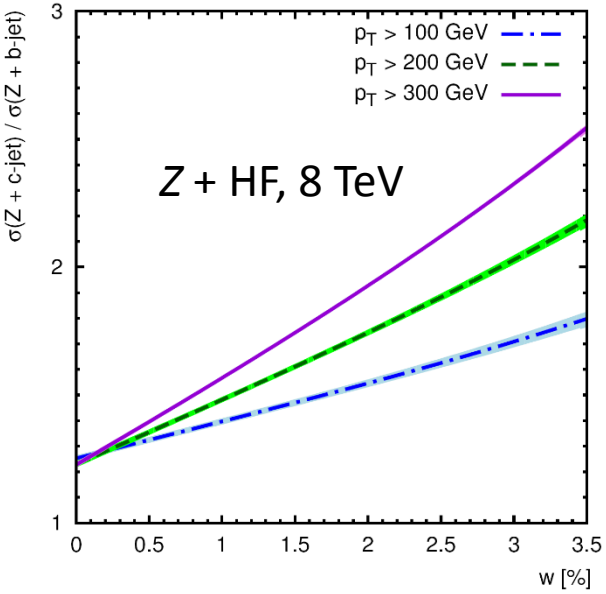
- proposed in the BHPS model in 1980
- calculations of the cross-sections and spectra predictions for the Z/γ + HF production processes
- considerable reduction of QCD scale uncertainties when considering the ratios: $\sigma(\gamma + c)/\sigma(\gamma + b)$ and $\sigma(Z + c)/\sigma(Z + b)$
- sensitivity to intrinsic charm at high Z/γ p_T and $1.5 < \eta < 2.4$



Experimental studies are just started:

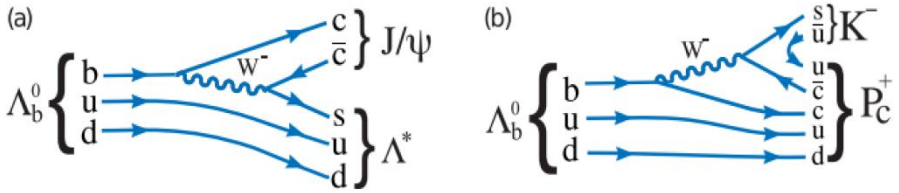


- measurements of $\sigma(\gamma + c)$ and $\sigma(\gamma + b)$ using Run-1 data
- signal events generated with SHERPA are being checked



Search for pentaquarks in Λ_b^0 decays

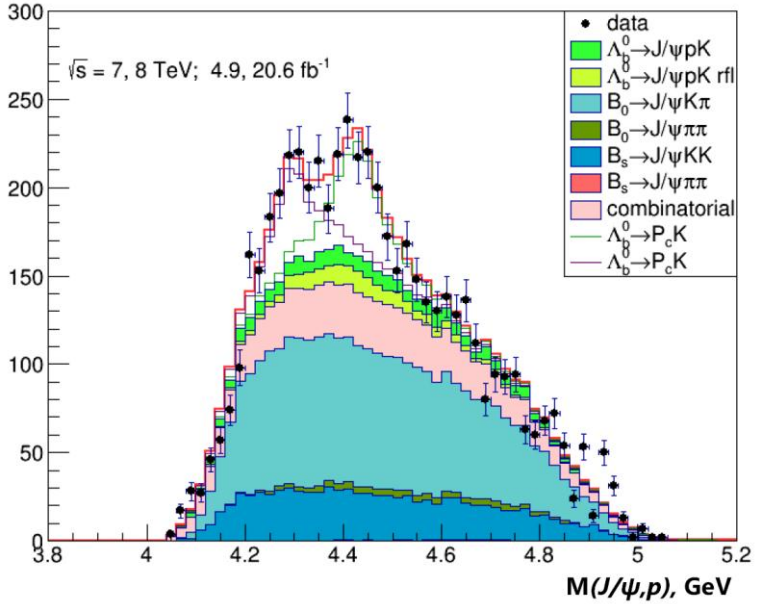
- LHCb discovered new intermediate resonance $J/\psi p$ states in Λ_b^0 decays

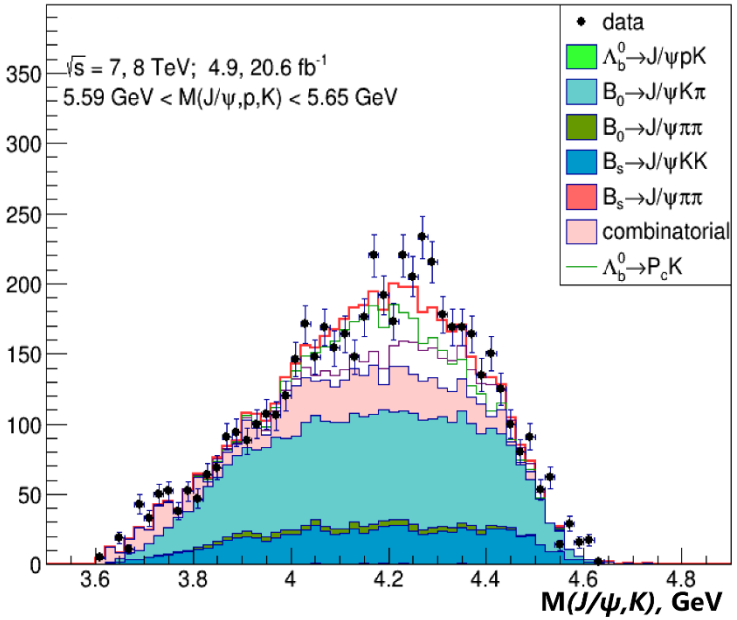


- interpreted as $uudc\bar{c}$ pentaquark states: $P_c^+(4380)$ with spin 3/2 and $P_c^+(4450)$ with spin 5/2
- confirmation from other experiments is needed, as well as properties measurements

Signal structure is detected:

- M_1 = 4.294 ± 0.016 GeV
- M_2 = 4.430 ± 0.013 GeV
- no signs of new resonances in M(J/ψ,K) or M(p,K) distributions
- most of the angular variables are well described by simulation
- work is ongoing





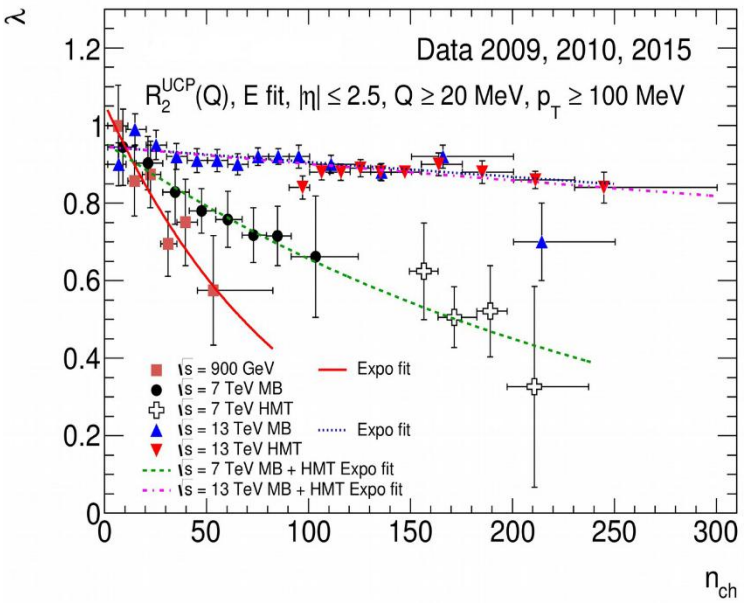
Bose-Einstein correlations

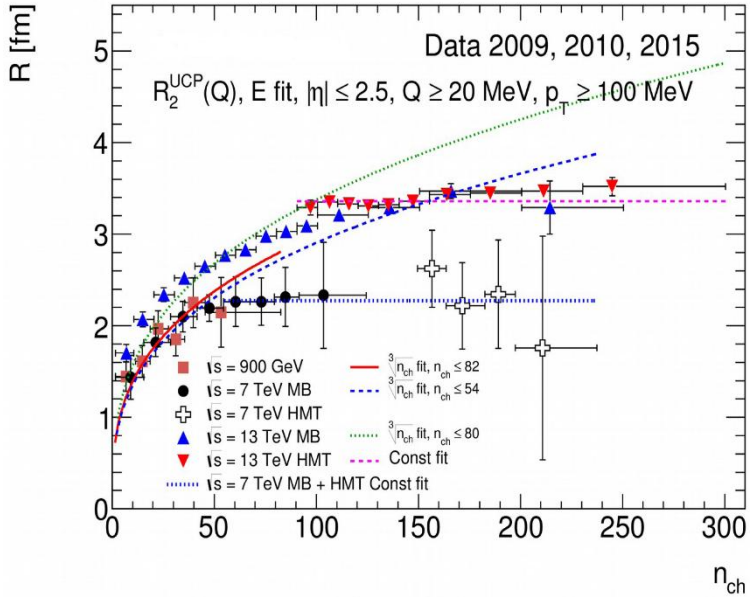
Study of two-particle Bose-Einstein correlations of like-sign charged hadrons (p_T > 100 MeV and $|\eta| < 2.5$):

- measurement in terms of the double-ratio correlation function: $R_2(Q) = C_2^{data}(Q)/C_2^{MC}(Q)$, where two-particle correlation function $C_2(Q) = \rho(p_1, p_2)/\rho_0(p_1, p_2)$ and $Q^2 = -(p_1 - p_2)^2$; reference two-particle density function ρ_0 is constructed using unlike-sign particle pairs

13 TeV results:

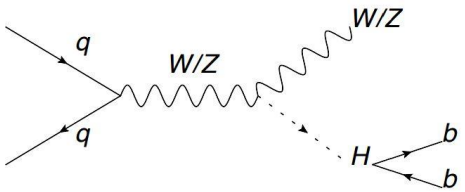
- correlation strength λ is approximately constant against charged particles multiplicity n_{ch}
- correlation radius R increases with multiplicity up to $n_{ch} \approx 90$
- saturation of the correlation radius for high multiplicity $n_{ch} > 90$
- dependence of the λ and R parameters on the average transverse momentum of the particle pair is also investigated



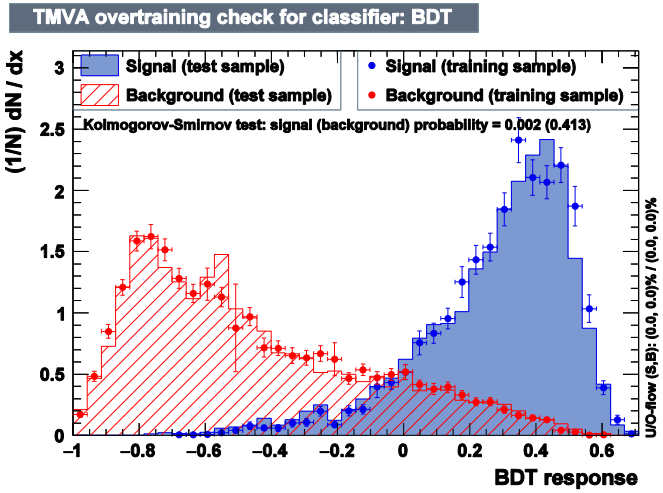


Search for the SM Higgs via V(h→$b\bar{b}$)

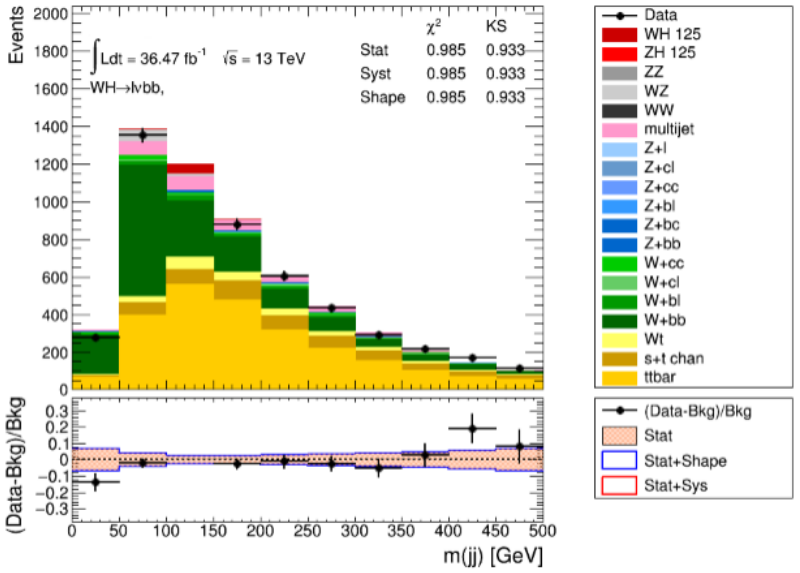
Search for the Standard Model Higgs boson produced in association with a vector boson and decaying to a $b\bar{b}$ pair:

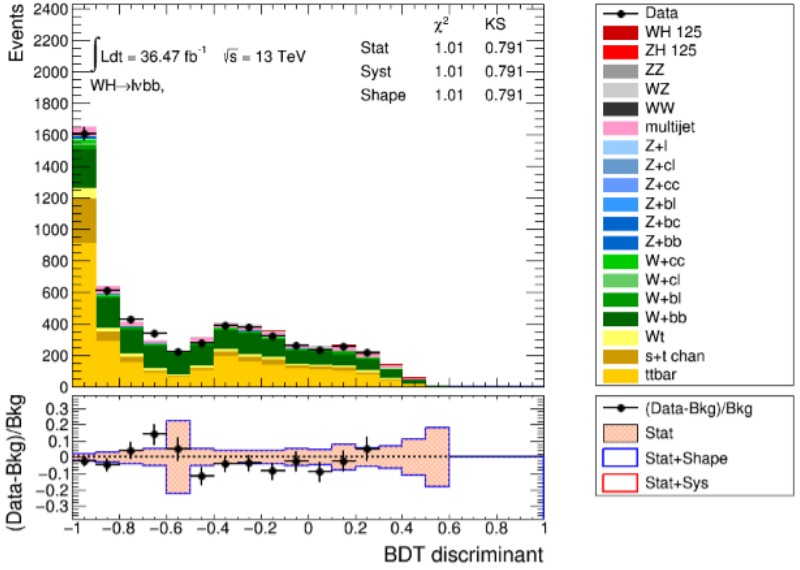


- 3 categories with 0, 1 or 2 charged leptons (*e* or μ)
- multivariate discriminants (BDTs) are used to separate between signal and background
- BDTs are trained specifically in each category

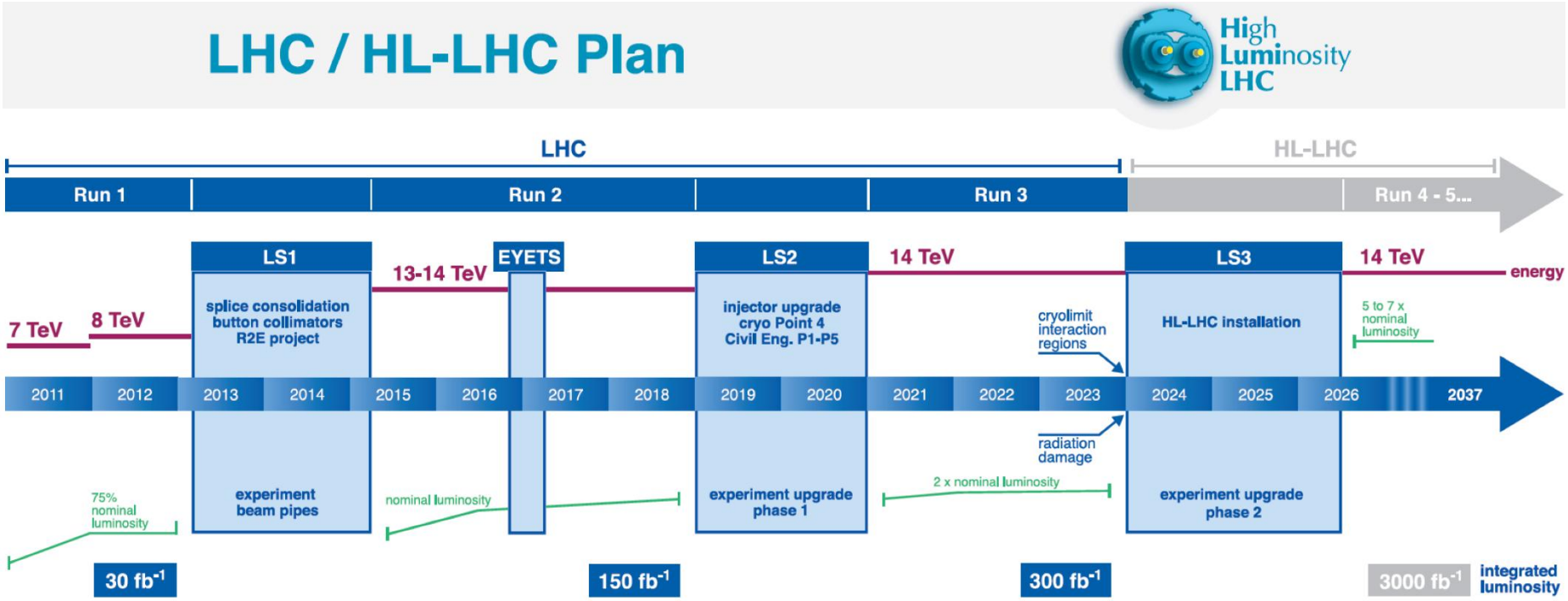


- complete 2015+2016 dataset is being analyzed

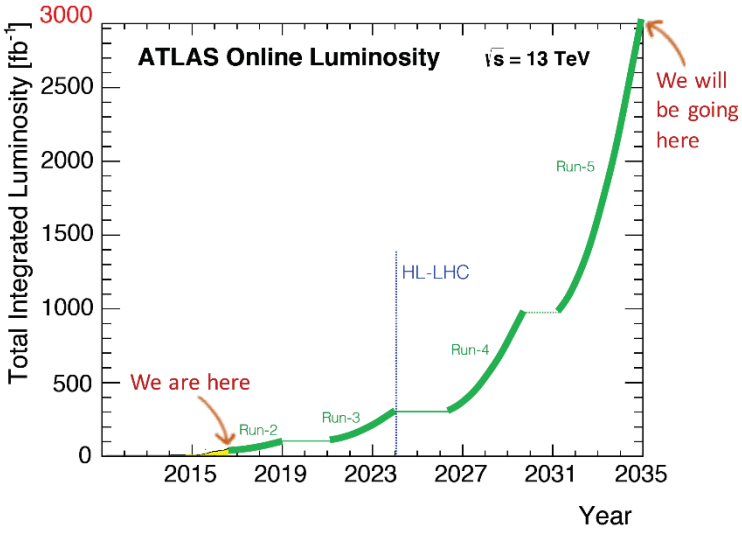




ATLAS detector upgrade



The ATLAS detector will be upgraded to cope with the increased instantaneous luminosity



JINR participation in the ATLAS upgrade project during 2014-2016 was supported by the Ministry of Education and Science of the Russian Federation (grant RFMEFI61014X0005)

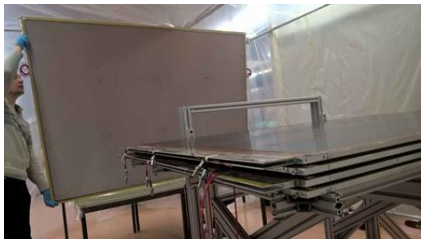
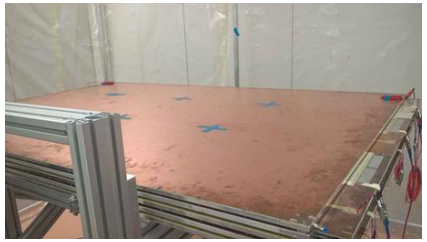
Micromegas

Phase 1 upgrade of the muon spectrometer:

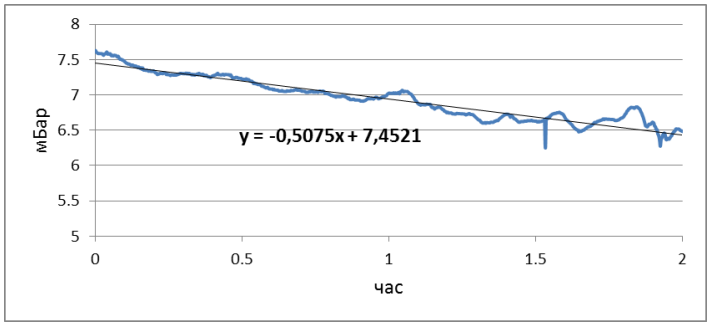
replacement of the innermost forward muon tracking stations by the New Small Wheels (quadruplets made of Micromegas and sTGC)

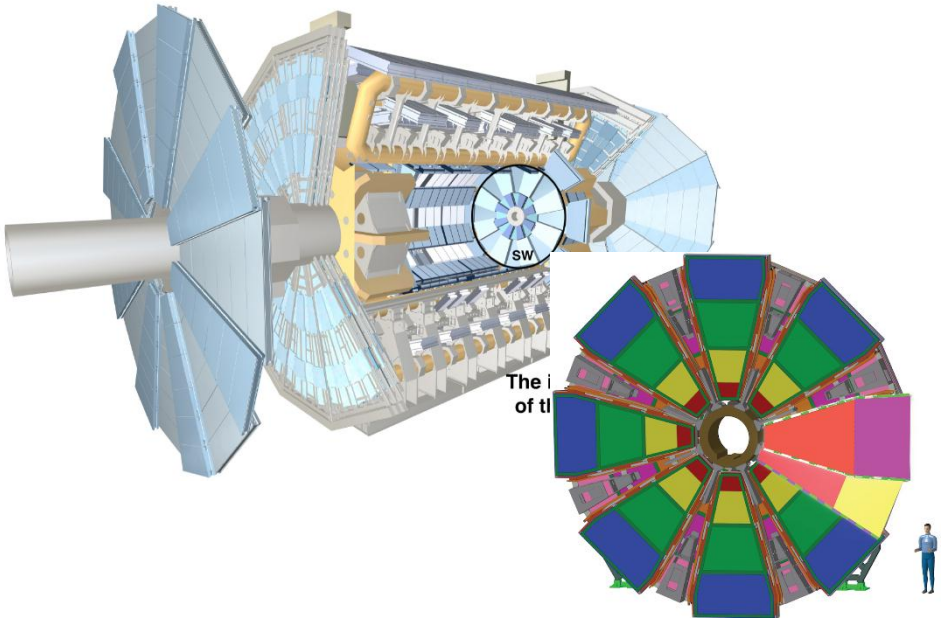
- the first LM2 Micromegas quadruplet (of 32) was assembled



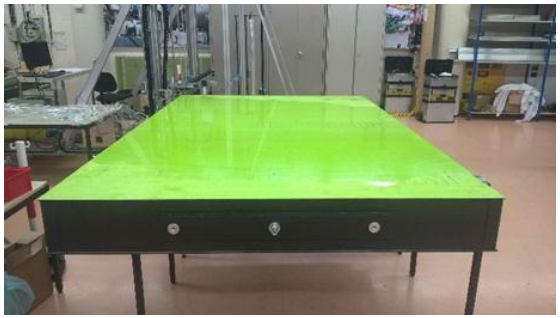
- and tested successfully for gas leakage





Two production lines are being developed at DLNP for the Micromegas chamber production (ATLAS & JINR) and for the quadruplet assembly

Stiffback is ready in place



Timepix, TileCal and HEC

Further upgrade of the ATLAS-TPX detectors network:

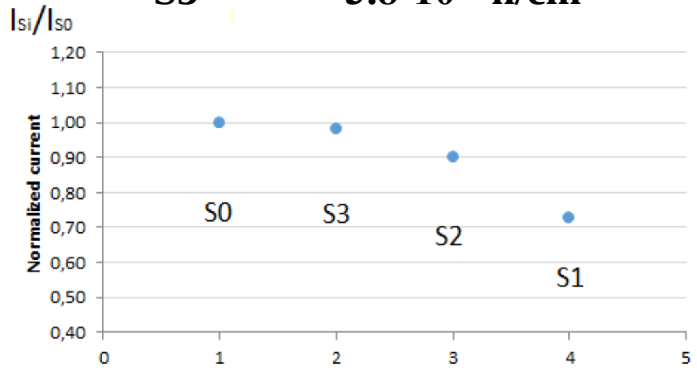
- additional Timepix detectors with sensors made of GaAs:Cr
- 7 detectors were produced in collaboration with Tomsk University and installed in the ATLAS pit
- more precise real-time measurements of the spectral characteristics and composition of the radiation field

Irradiation tests of the new scintillators UPS923:

- to be used in the “hot” zones of the Tile calorimeter
- 3 sets of samples (S1-S3) were exposed to different neutron fluences at the IBR-2m reactor
- current induced by ^{137}Cs was measured and compared to the control value
- 30% degradation was observed for the highest fluence
- 10^{14} n/cm^2 is an acceptable dose level

Integral neutron fluence:

S1	$1.8 \cdot 10^{14}$ n/cm^2
S2	$1.7 \cdot 10^{13}$ n/cm^2
S3	$3.8 \cdot 10^{12}$ n/cm^2



New trigger electronics for the hadronic end-cap LAr calorimeter:

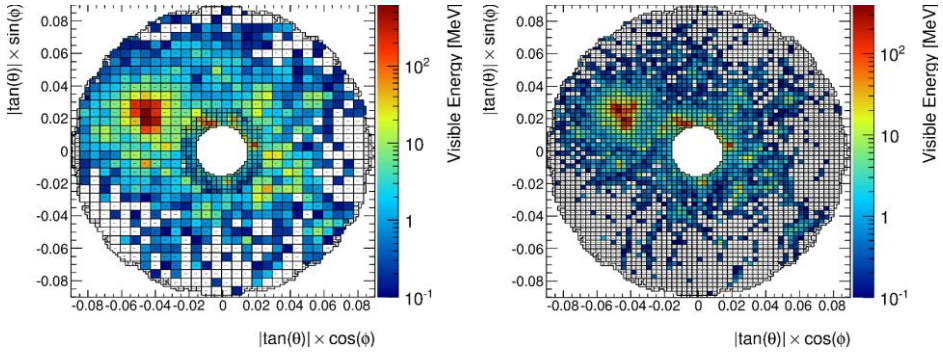
- prototype of the baseplane was produced
- passed successfully radiation hardness tests
- work is ongoing

Forward calorimeter

3 options for modernization of the forward calorimeters existed until the end of 2016:

- LAr miniFCal (a small LAr calorimeter in front of the FCal)
- “warm” miniFCal made of diamond sensors or high pressure krypton chamber
- sFCal (replacement of the present FCal with the new high-granularity LAr calorimeter)

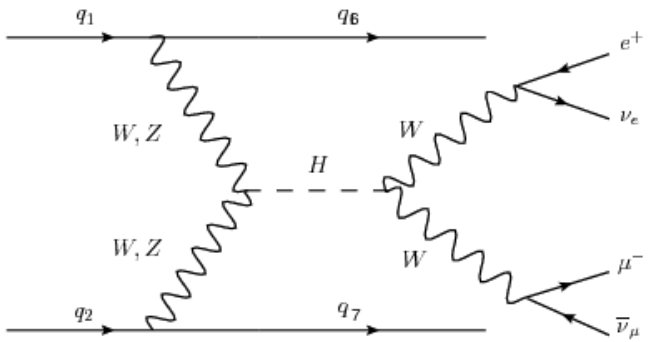
FCal sFCal



For each option, irradiation tests were performed at the IBR-2m reactor

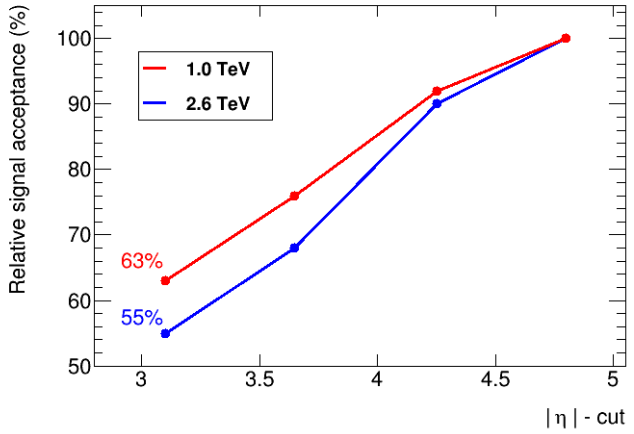
Despite of potential improvements in performance, sFCal option was rejected based on the results of the risk analysis

VBF heavy Higgs boson production:



- two forward jets
- no jet activity in the central region
- large invariant mass of the di-jet system

Signal loss due to degradation of the forward jets tagging efficiency



Summary

- Results obtained during last six months were presented
- ATLAS-JINR group significantly contributes to:
  - **ATLAS physics program**
    - ✓ W/Z + b-jet production measurement
    - ✓ Intrinsic charm in proton PDF
    - ✓ Search for Quantum Black Holes
    - ✓ Search for pentaquarks
    - ✓ Study of Bose-Einstein correlations
    - ✓ Search for the SM Higgs in the V(h$\rightarrow b\bar{b}$) channel
  - **ATLAS upgrade program**
    - ✓ Micromegas chambers and quadruplets for the New Small Wheels
    - ✓ Timepix detectors with sensors made of GaAs:Cr
    - ✓ Irradiation tests of the new scintillator for the Tile calorimeter
    - ✓ New trigger electronics for the HEC LAr calorimeter
    - ✓ Forward calorimeter
- Our contribution is publicly visible:
  - ❖ 8 papers + 8 ATLAS notes with major contribution from the JINR group
  - ❖ 3 international conference talks and 2 conference proceedings

BACKUP SLIDES

Recent ATLAS publications

Recent ATLAS publications with major JINR contribution:

- **papers**
  - ✓ Performance of the ATLAS Trigger System in 2015. arXiv:1611.09661, submitted to Eur. Phys. J. C
  - ✓ Study of the rare decays of B_S^0 and B^0 into muon pairs from data collected during the LHC Run 1 with the ATLAS detector. Eur. Phys. J. C 76 (2016) 513
  - ✓ A.V. Lipatov, G.I. Lykasov, Yu.Yu. Stepanenko, V.A. Bednyakov, Probing proton intrinsic charm in photon or *Z* boson production accompanied by heavy jets at the LHC. Phys.Rev. D94 (2016) 053011
  - ✓ A.A. Grinyuk, A.V. Lipatov, G.I. Lykasov, N.P. Zotov, Significance of nonperturbative input to the transverse momentum dependent gluon density for hard processes at the LHC. Phys.Rev. D93 (2016) no.1, 014035
  - ✓ Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at 7 and 8 TeV. JHEP08(2016)045
  - ✓ Search for the Standard Model Higgs boson decaying into $b\bar{b}$ and produced in association with top quarks decaying hadronically in pp collisions at √s=8 TeV with the ATLAS detector. JHEP05(2016)160

Recent ATLAS publications

Recent ATLAS publications with major JINR contribution:

- **papers**
  - ✓ Search for heavy resonances decaying to a Z boson and a photon in pp collisions at 13 TeV with the ATLAS detector. Phys. Lett. B 764 (2017) 11
  - ✓ Y.A. Kurochkin, Y.A. Kulchitsky, S. Harkusha, N.A. Russakovich, Hadron as coherent state on the horosphere of the Lobachevsky momentum space. Phys.Part.Nucl. Lett. 13 (2016) 3, 285-288
- **proceedings**
  - ✓ S. Turchikhin, *b*-hadron decays at ATLAS, PoS (BEAUTY2016) 009
  - ✓ Y. Kulchitsky, ATLAS Experiment at LHC and upgrade program, Fifth International Conference "Engineering of Scintillation Materials and Radiation Technologies", Minsk, Belarus, 26 - 30 September 2016, ISMART2016, Book of abstracts ISNB 978-985-553-380-2; 72 p
- **notes**
  - ✓ Search for new high-mass resonances in the dilepton final state using proton-proton collisions at 13 TeV with the ATLAS detector. ATLAS-CONF-2016-045
  - ✓ Two-particle Bose-Einstein correlations in pp collisions at 13 TeV measured with the ATLAS detector at the LHC. ATL-COM-PHYS-2016-1621

Recent ATLAS publications

Recent ATLAS publications with major JINR contribution:

- **notes**
  - ✓ Search for the Standard Model Higgs boson produced in association with a vector boson and decaying to a $b\bar{b}$ pair in pp collisions at 13 TeV using the ATLAS detector. ATLAS-CONF-2016-091
  - ✓ Search for the Associated Production of a Higgs Boson and a Top Quark Pair in Multilepton Final States with the ATLAS Detector. ATLAS-CONF-2016-058
  - ✓ Measurements of the Higgs boson production cross section via Vector Boson Fusion and associated WH production in the $WW^{*}\rightarrow \ell\nu\ell\nu$ decay mode with the ATLAS detector at $\sqrt{s}$=13TeV. ATLAS-CONF-2016-112
  - ✓ Combination of the searches for Higgs boson production in association with top quarks in the γγ, multilepton, and $b\bar{b}$ decay channels at $\sqrt{s}$=13 TeV with the ATLAS Detector. ATLAS-CONF-2016-068
  - ✓ Measurement of fiducial, differential and production cross sections in the $H\rightarrow\gamma\gamma$ decay channel with 13.3 fb^{-1} of 13 TeV proton-proton collision data with the ATLAS detector. ATLAS-CONF-2016-067
  - ✓ Search for squarks and gluinos in events with an isolated lepton, jets and missing transverse momentum at 13 TeV with the ATLAS detector. ATLAS-CONF-2016-054

Recent conference talks

- J. Mdhluli, V. Baranov, Yu. Davydov et al. “Neutron irradiation and damage assessment of plastic scintillators of the TILECAL section of the ATLAS detector”, SAIP-2016, 4-8 July 2016
- Y. Kulchitsky. “ATLAS Experiment at LHC and upgrade program”, Fifth International Conference "Engineering of Scintillation Materials and Radiation Technologies", Minsk, Belarus, 26 - 30 September 2016, ISMART2016
- Y. Kulchitsky. “Two particles Bose-Einstein Correlations at 0.9 and 7 TeV with the ATLAS detector”, International Conference “New trends in high-energy physics”, Becici, Montenegro, 2 - 8 October 2016