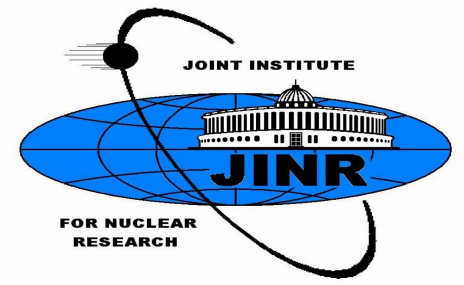


Updates on physics research and detector upgrade in the ATLAS experiment at the LHC (JINR participation)

E. Khramov

18 January 2021

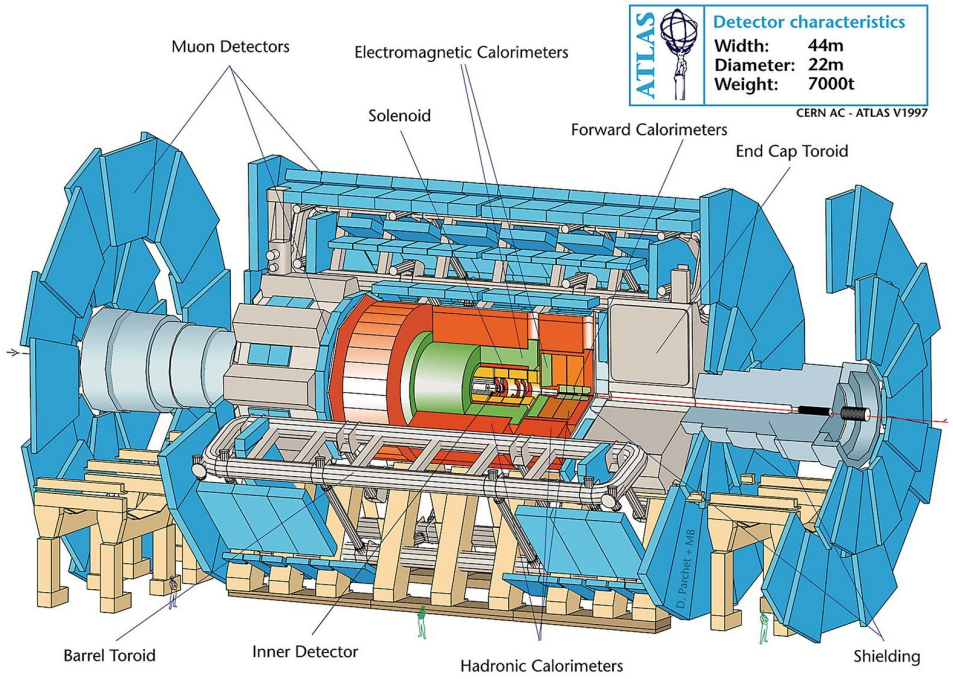
The ATLAS Collaboration

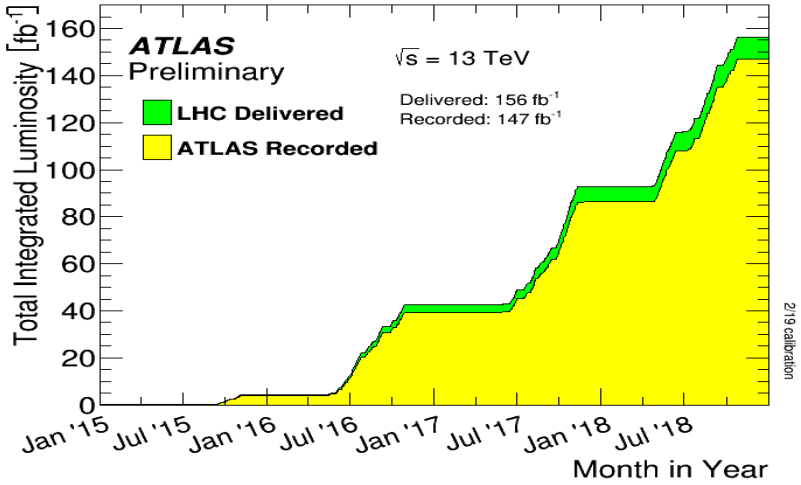
NUMBER OF INSTITUTES: 250

NUMBER OF AUTHORS: 1929

NUMBER OF PARTICIPANTS: 8525

NUMBER OF COUNTRIES: 44



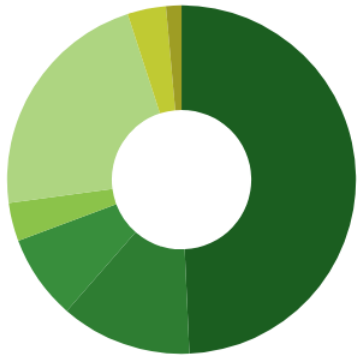


JINR-ATLAS team was deeply involved in designing, construction, tests and assembly of the major systems of ATLAS:

- Inner Detector
- Tile Calorimeter
- Liquid Argon Endcap Calorimeter
- Muon detector
- Common Items:
  - Magnet system
  - Warm Structure, etc.

JINR in the ATLAS Collaboration

- Institutes Active Members - total 140
  - Professional Status



- **69** Physicist
- **17** Physics PhD student
- **11** Physics masters/diploma student
- **0** Undergraduate/summer student
- **5** Engineer with PhD
- **31** Engineer without PhD
- **0** Engineering student
- **5** Technician or equivalent
- **2** Administrator/other

  - Lists

- **35** on Authorlist (A)
- **28** Signing-Only (a)
- **31** counted for M&O (M)
- **2** qualifying members (q)
- **35.5** for Operation Tasks (O, o)

DLNP: Batusov V., **Batusov T.**, Bednyakov V., Boyko I., Budagov Y., Chelkov G., Cherepanova E**.**, Chizhov M., Chubinidze Z., Dedovich D., Demichev M., Elkin V., Ershova A., Gladilin L., Glagolev V., Gongadze A., Gongadze L., Gostkin M., Huseinov N., Ivanov Y., Kalinovskaja L., Karpov S., Karpova Z., Kharchenko D., Khramov E., **Kochergin I.**, Kostyukhina I., Koval O., Kruchonak U., Kultchitsky Y., Lyabline M., Lykasov G., Lyubushkin V., Lyubushkina T., Malyukov S., Minashvili I., Minashvili I.(jr.), Nefedov Y., Plontikova E., Potrap I., Prokoshin F., Rusakovich N., Sadykov R., Sapronov A., Shiyakova M., Tsiareshka P., Turchikhin S., Yeletskikh I., Zhemchugov A., Shalyugin A., ~~**Shilin V.**~~, Usov Y., Usubov Z., ~~**Vasilyev S.**~~, Vasyukov A.

LIT: Alexandrov E., Aleksandrov I., Gromova N., Iakovlev A., Kazymov A., Mineev M., ~~Oleinik D.~~, ~~Petrosyan A.~~, Shigaev V., Zrelov P.

VBLHEP: Ahmadov F., Cheplakov A., Kukhtin V., Ladygin E., Manashova M., Soloshenko A., Zimin N., Fillipov Y., Shaykhatdenov B., Turtuvshin T.

JINR in the ATLAS Human resources

A total number of personnel in the JINR group participating in the ATLAS Physics program is 32**+2** including 6 professors, 12 postdocs and 14+**2** young scientists, students and engineers. The whole Team provides 29 FTE.

Besides the participation in the analysis itself members of the ATLAS-JINR Team are also playing managerial roles in the Collaboration. In the recent period we were taking responsibilities of conveners and sub-conveners of the ATLAS Working Groups (WG) as well as technical contacts persons with others Working Groups, such as Standard Model WG, B-Physcs sub-group, Trigger Performance etc.

Major part of them is engaged in the project for many years. They have well recognized reputation within the Collaboration and beyond, solid background and necessary skills to fulfill all our obligations.

DLNP: Batusov V., **Batusov T.**, Bednyakov V., Boyko I., Budagov Y., Chelkov G., Cherepanova E**.**, Chizhov M., Chubinidze Z., Dedovich D., Demichev M., Elkin V., Ershova A., Gladilin L., Glagolev V., Gongadze A., Gongadze L., Gostkin M., Huseinov N., Ivanov Y., Kalinovskaja L., Karpov S., Karpova Z., Kharchenko D., Khramov E., **Kochergin I.**, Kostyukhina I., Koval O., Kruchonak U., Kultchitsky Y., Lyabline M., Lykasov G., Lyubushkin V., Lyubushkina T., Malyukov S., Minashvili I., Minashvili I.(jr.), Nefedov Y., Plontikova E., Potrap I., Prokoshin F., Rusakovich N., Sadykov R., Sapronov A., Shiyakova M., Tsiareshka P., Turchikhin S., Yeletskikh I., Zhemchugov A., Shalyugin A., ~~**Shilin V.**~~, Usov Y., Usubov Z., ~~**Vasilyev S.**~~, Vasyukov A.

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JINR in the ATLAS M&O

During the 2020 period JINR has successfully secured all requested OTs of Class 1 and 2 providing:

189 shifts versus 168 shifts requested in 2020

The main task is participation in the ATLAS SLIMOS/TI - Safety shifter, and we would like to continue to cover this kind of shifts in that way.

At the beginning of the 2020 period the Class 3 shifts were covered at the level of ~70 (**~77** / **~90**)%.

~ 5.4 (**+ ~0.5 + ~1**) FTEs out of 7.6 FTEs requested in 2020

This coverage was mainly due to “Grid Data Processing & Analysis” and “DAQ/HLT Control & Configuration” and authorship qualification tasks. There are several minor tasks usually provided by JINR Team members in the detector sub-systems

JINR in the ATLAS Physics during the 2020

1. Study of the applicability of the Standard Model and verification of SM predictions (including interactions of heavy ions), defining the structure of the proton at ultra-high energies (PDFs), tuning and improvement of relevant computer codes and events generators etc.

– 1 prof., 2 postdocs (2.5 FTE)

2. Search for (and study the characteristics of) additional exotic (including chiral Z*, W*) bosons in Drell-Yan and two-jet processes.

– 1 prof., +1 PhD student (2 FTE)

3. Search for manifestations of Long Lived Supersymmetry (or Beyond-SM physics) mainly in inclusive events with many (more that 4) hadron jets accompanied by the large missing energy and Displaced Vertices.

– 1 student (1 FTE)

4. Search for (supersymmetric) charged Higgs bosons via their specific decay modes (3 leptons, etc).

– 1 postdoc, 1 master student (2 FTE)

JINR in the ATLAS Physics during the 2020

5. Search for a valence-like nonperturbative component of heavy quarks in the proton (intrinsic heavy quarks) via specific final state topology in the pp-interactions

+

6. A new comprehensive study of the gluon structure of the proton, etc.

– 2 prof., 1 postdoc, 1 PhD student (2.5 FTE)

7. Search for new hadrons and baryons containing heavy c- and b-quarks, study the properties.

– 1 prof., 2 postdocs, 1 engineer (3.5 FTE)

8. VH(→bb)

– 1 postdoc, 1 master student (2 FTE)

9. BSM → V/H(→J)+gamma

– 1 postdoc

10. Quantum Black Holes

– 2 postdocs (2 FTE)

11. SM precision measurements (W /Z + b-jet x-section)

– 1 postdoc (1 FTE)

JINR in the ATLAS Physics during the 2020

12. B_c excited states

– 1 prof., 2 postdocs, 1 engineer (3.5 FTE)

13. Pentaquark

– 1 prof., 1 postdoc, 1 master student (2 FTE)

14. ttH/W

– 1 postdoc (0.8 FTE)

15. tH

– 2 postdocs, 1 engineer (1.2 FTE)

16. BEC

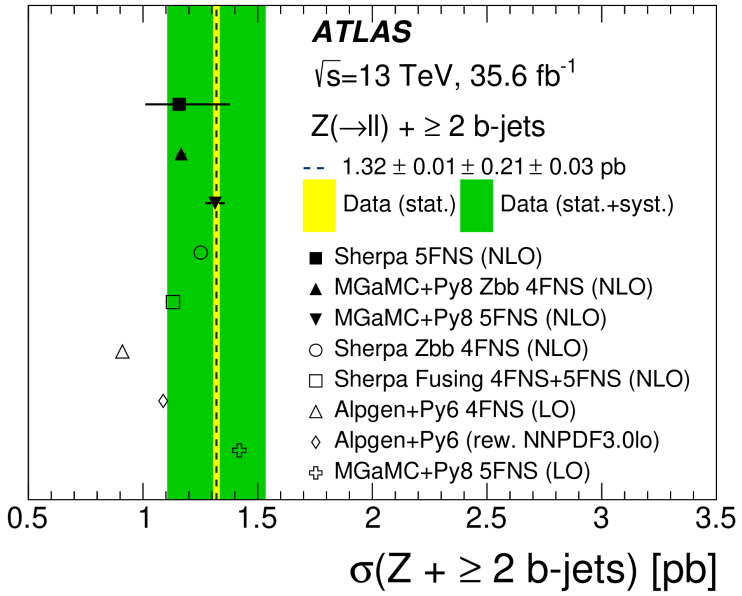
– 1 prof., 2 engineers (3 FTE)

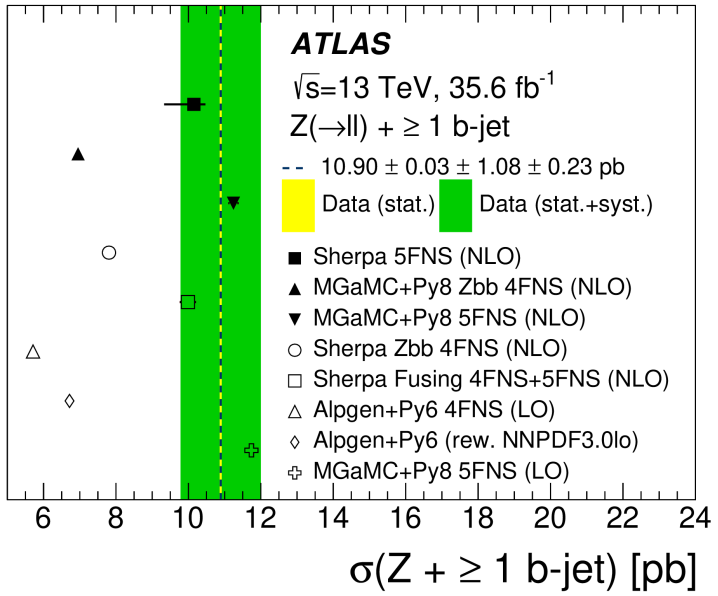
During the 2020 it was published 5 papers and 4 other publications with significant participation of the JINR staff, 6-7 publications more this year, more than 2 *talks at 2 different conferences*

Organization and participation in the Physics&Computing Russian Institutes meetings

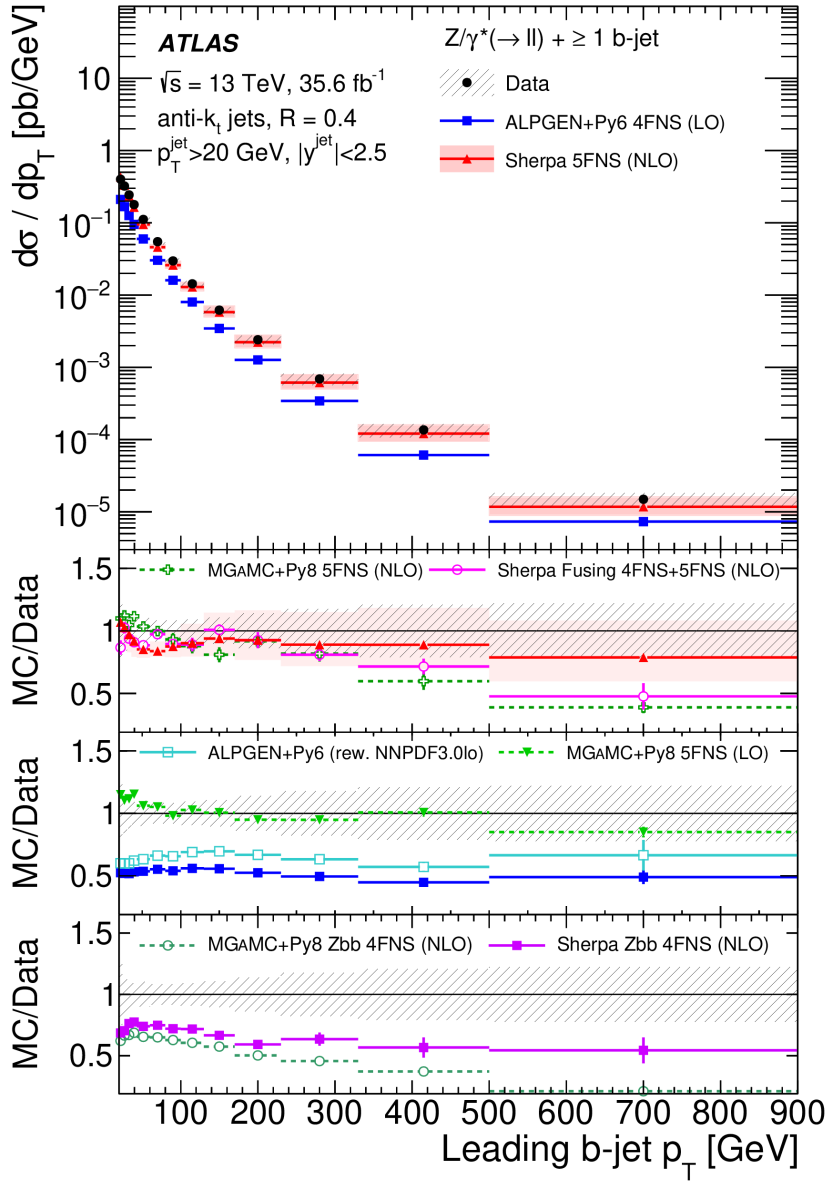
SM precision measurements

Z + ≥1 or ≥2 b-jets @ 13 TeV (35.6 fb^{-1})



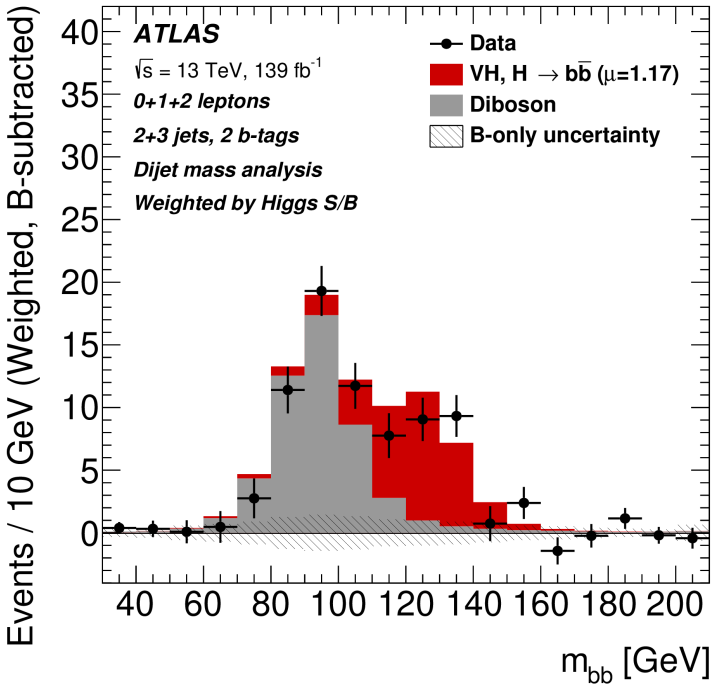


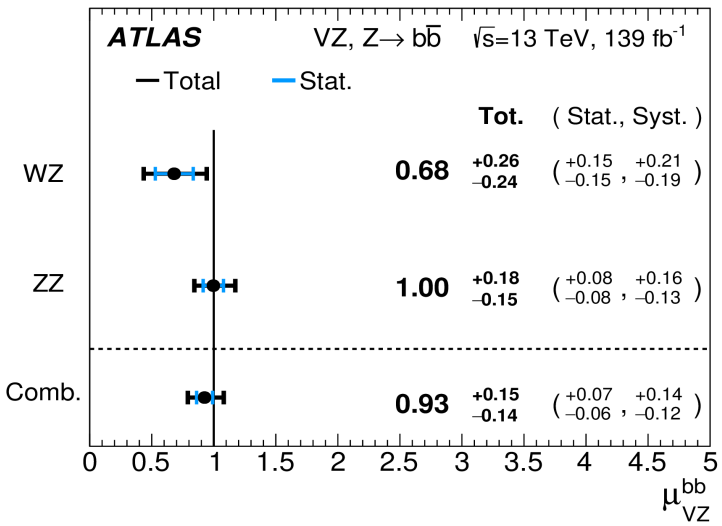
The 5-flavour number scheme predictions at NLO accuracy agree better with data than 4-flavour number scheme ones. The 4-flavour number scheme predictions underestimate data in events with at least one b-jet (JHEP 07 (2020) 44)

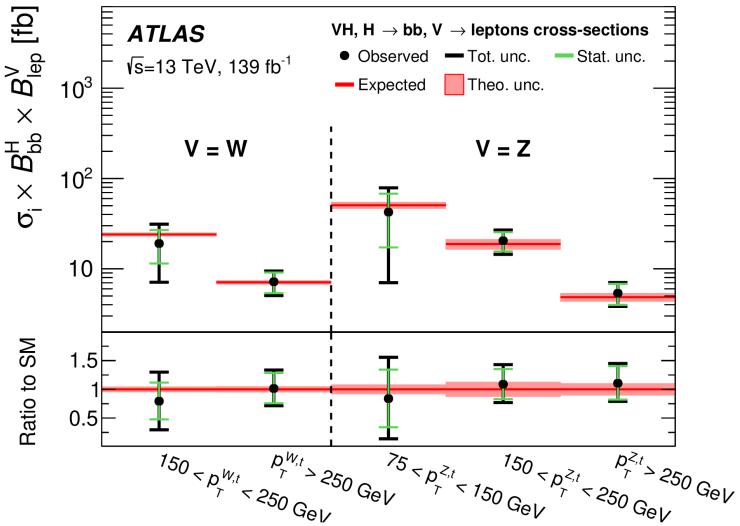


SM precision measurements

VZ/VH(→bb) @ 13 TeV (139 fb^{-1})





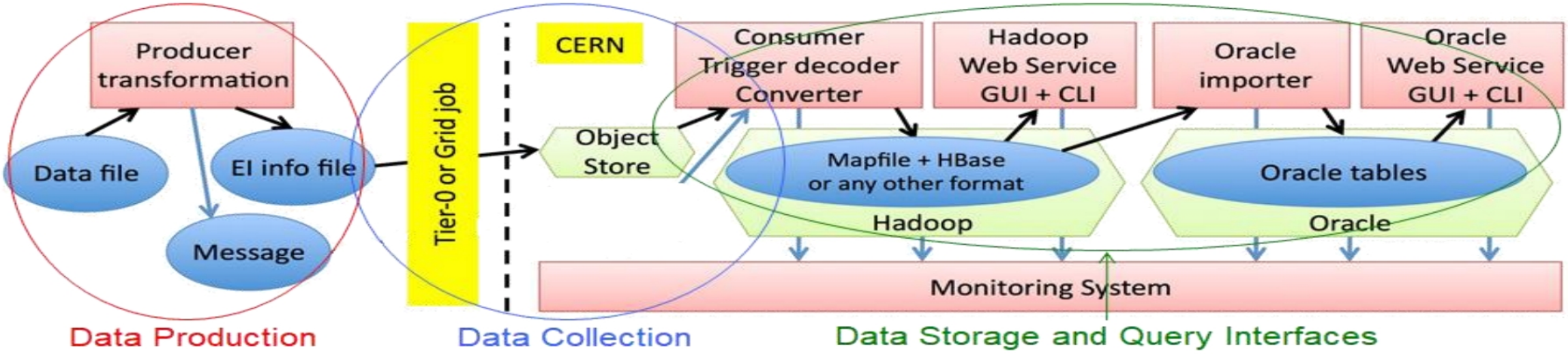


The production of a Higgs boson in association with a W or Z boson is established with observed (expected) significances of 4.0 (4.1) and 5.3 (5.1) standard deviations, respectively. Cross-sections of associated production of a Higgs boson decaying into bottom quark pairs with an electroweak gauge boson, 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.

arXiv:2007.02873

Events Indexing

EventIndex is a system to index the data or Monte Carlo events in the ATLAS experiment



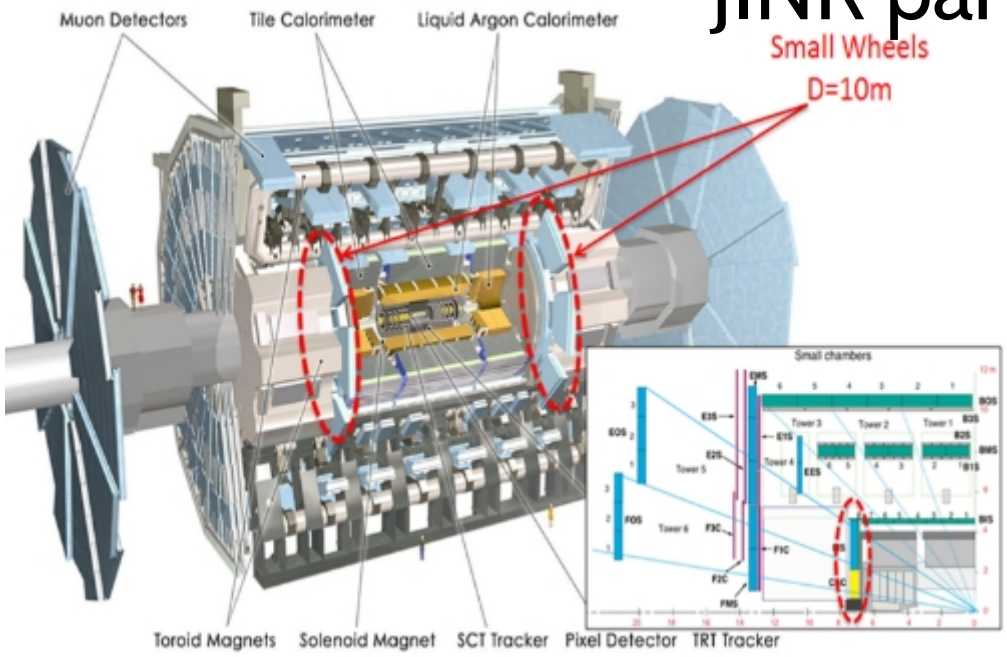
Application:

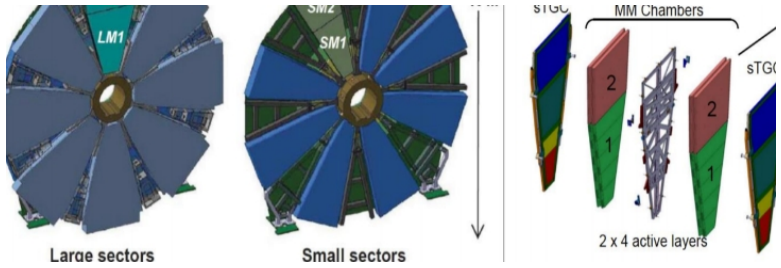
- Event picking
- Event selection or counting based on trigger decisions
- Checking data consistency
- Producing trigger chain overlapping matrices
- Producing data stream overlapping matrices
- Quick assessment of datasets content

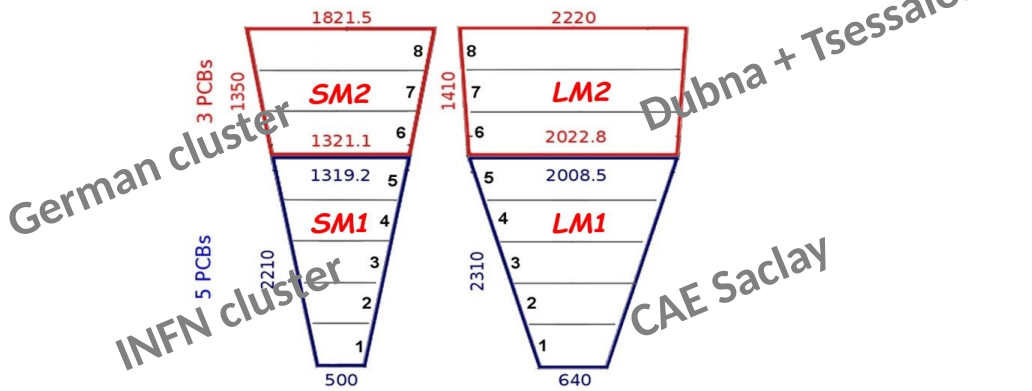
Organizing test server at JINR

Help in development for the NICA project

JINR participation in the ATLAS Upgrade (NSW)



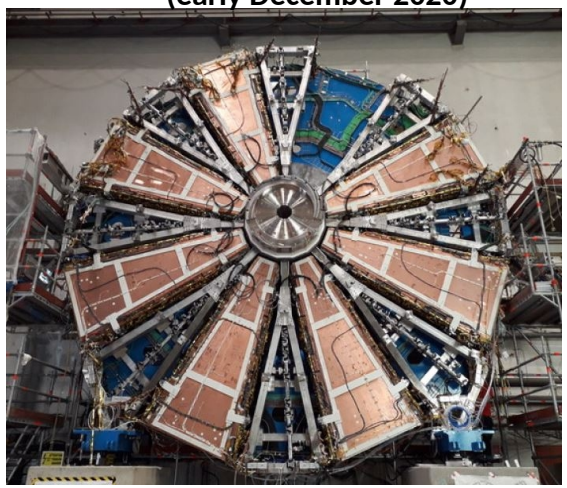




Main commitments in Phase-I – ATLAS Muon Spectrometer: all Large Micromegas modules production (LM2) for New Small Wheels (A & B)

- ✓ A special workshop was bult at DLNP for MM production and assembly
- ✓ MM production has started at the end of 2017
- ✓ 24 out of 32 quadruplets are already delivered to CERN!
- ✓ Remaining production will be finished by March 2021
- ✓ The team will move to CERN to participate in the wheel's assembly and NSW commissioning

NSW side A at bld. 191 CERN (early December 2020)



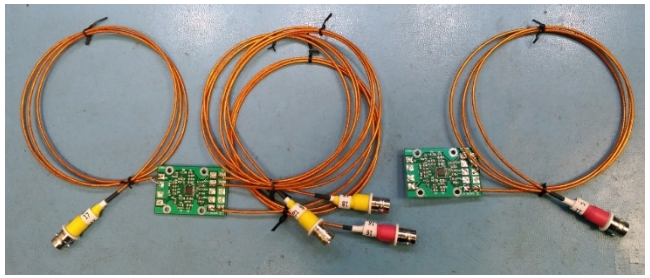
JINR participation in the ATLAS Upgrade (LAr, Muon)

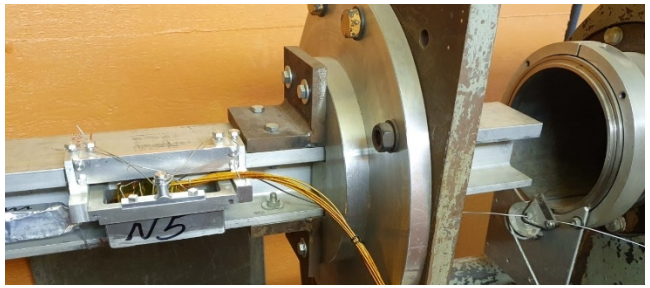
The MoU's for participation in the Phase-2 of the ATLAS Upgrade (2017-2025) have been signed by JINR in 2019, including TDAQ, Tile calorimeter and:

- **Muon Spectrometer**:
  - RPC design finalization
  - Setting up of production site at DLNP JINR
  - Start of production

Work is ongoing:

Al arm with samples moves towards reactor core.



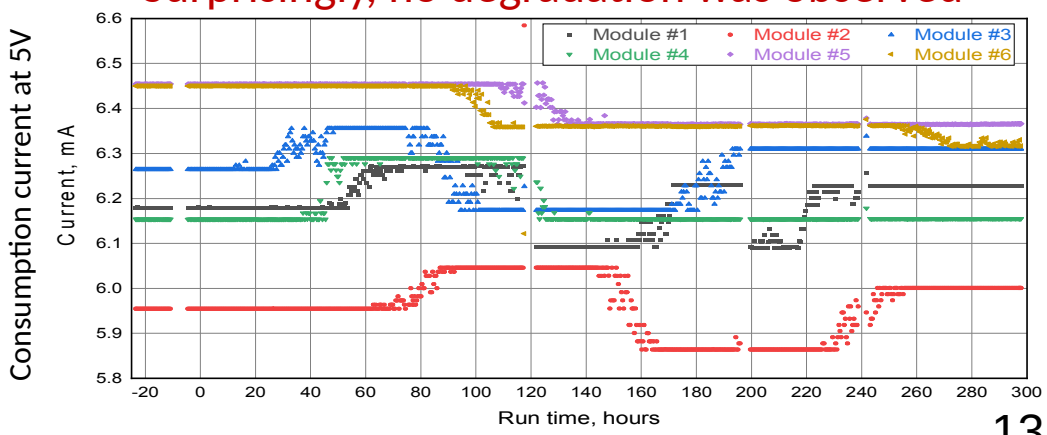


- **Liquid argon calorimeter**:
  - Trigger electronics design
  - Production of the optical "pigtails"
  - **Radiation tests at the IBR-2 reactor**

March'2020: High speed full differential amplifiers (to pass analog signals from the FEB to the fast ADC)

- IV-curve & waveform were measured on-line while NIEL of 10^{16}n/cm^2 and TID of 6.3 Mrad had being collected

Surprisingly, no degradation was observed

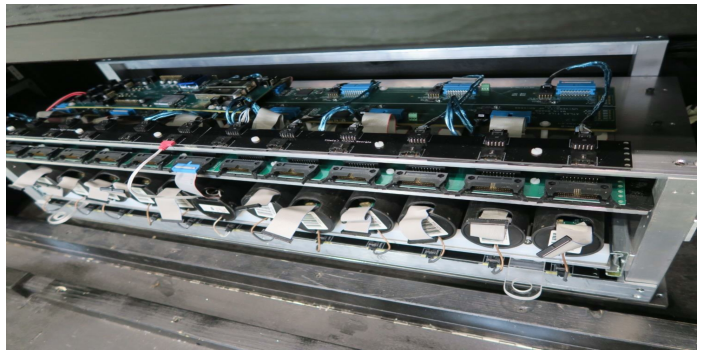


JINR participation in the ATLAS Upgrade (TileCal)

In 2020, the main work on the upgrade of the Tile Calorimeter (Phase 2) was aimed at creating of quality assurance test benches for quality control of the mini-drawer electronics

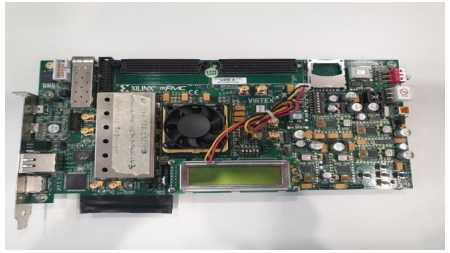
Within the framework of the Prometeo project:

- 12-channel HV power supply and LED system control unit with software (with PC control) manufactured and configured
- on the basis of the Daughter Board V4, Main Board V2 and VC707 Board, the first prototype of hardware and software for testing photomultiplier blocks is being created

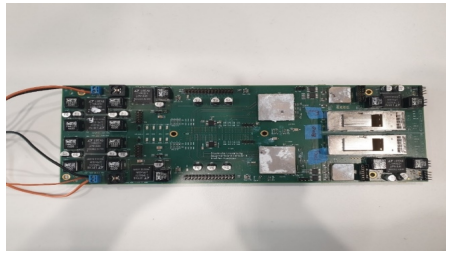


The first prototype of the test bench was made for simultaneous testing of 12 photomultiplier blocks.

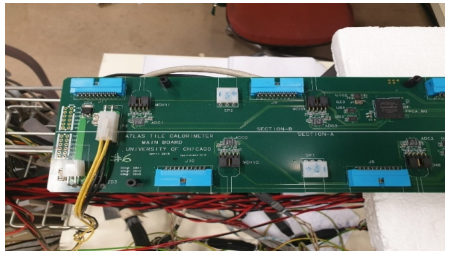
VC 707



Daughter Board V4



Main Board V2



In September 2020, HGTD has been approved by CERN Research Board as official ATLAS Phase-II upgrade project

The signing of the MoU is scheduled for the first half of 2021

Plans for 2021:

- *Continued research of prototypes of silicon LGADs on accelerator beams*
- *Preparation of technical requirements for tooling for transport and cavern installation*
- *Preparation of conceptual design of tools for surface assembly of the detector*

Conclusion and plans

- During the 2020 we were continuing our successful participation in the ATLAS Physics program and realization of attractive ideas in the ATLAS research program proposed by ATLAS at JINR
- ATLAS-JINR team participates in many ATLAS Physics Working Groups
- We actively involved in the Detector upgrade
- We kept contribution to detector maintenance: Class 1, 2 (112%) and 3 (~77/90%) shifts
- We plan to increase participation in Class 3 shifts by 1-2 FTEs this year
- We will keep going to strengthen our analysis activity
- We expect 6-7 publications this year