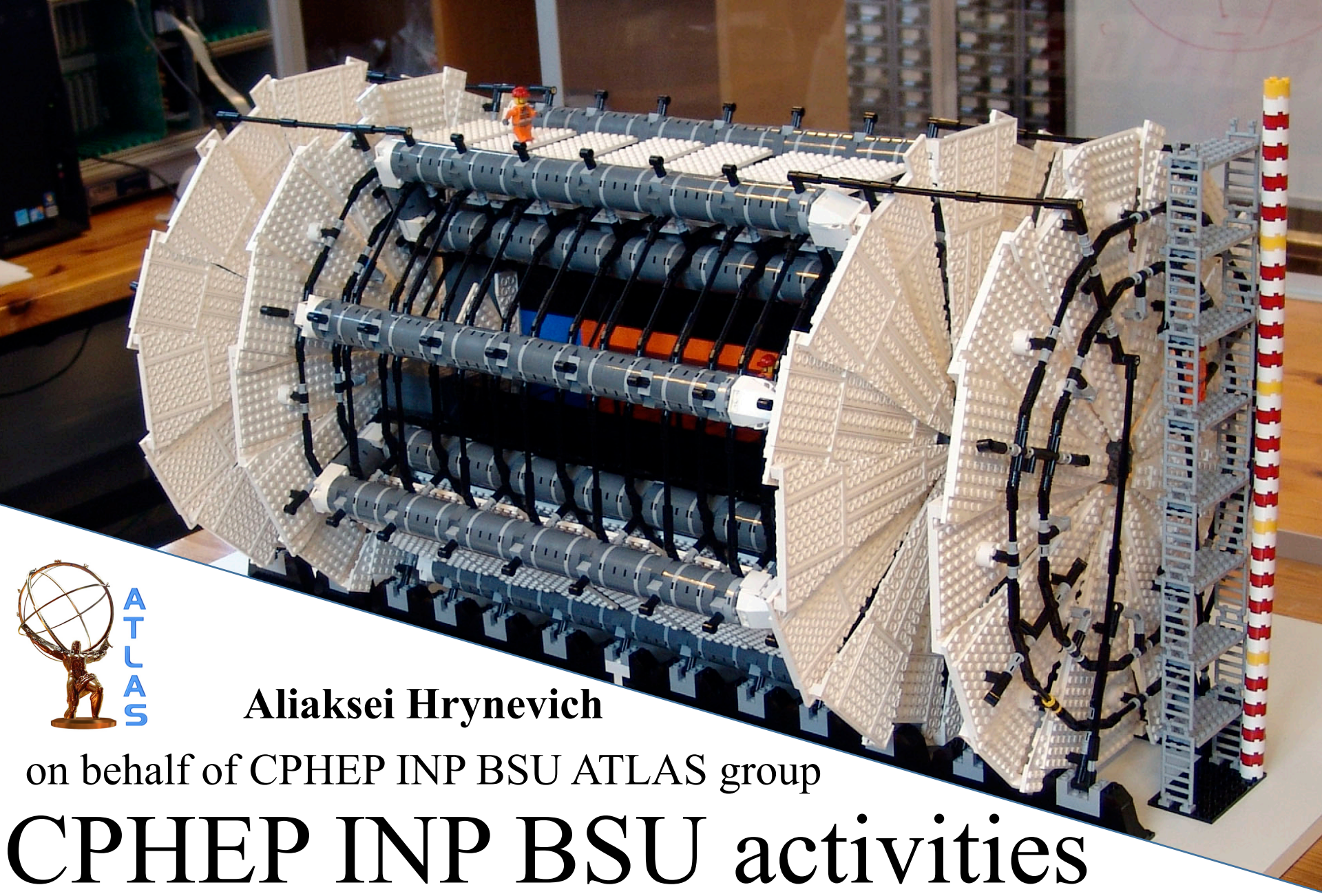


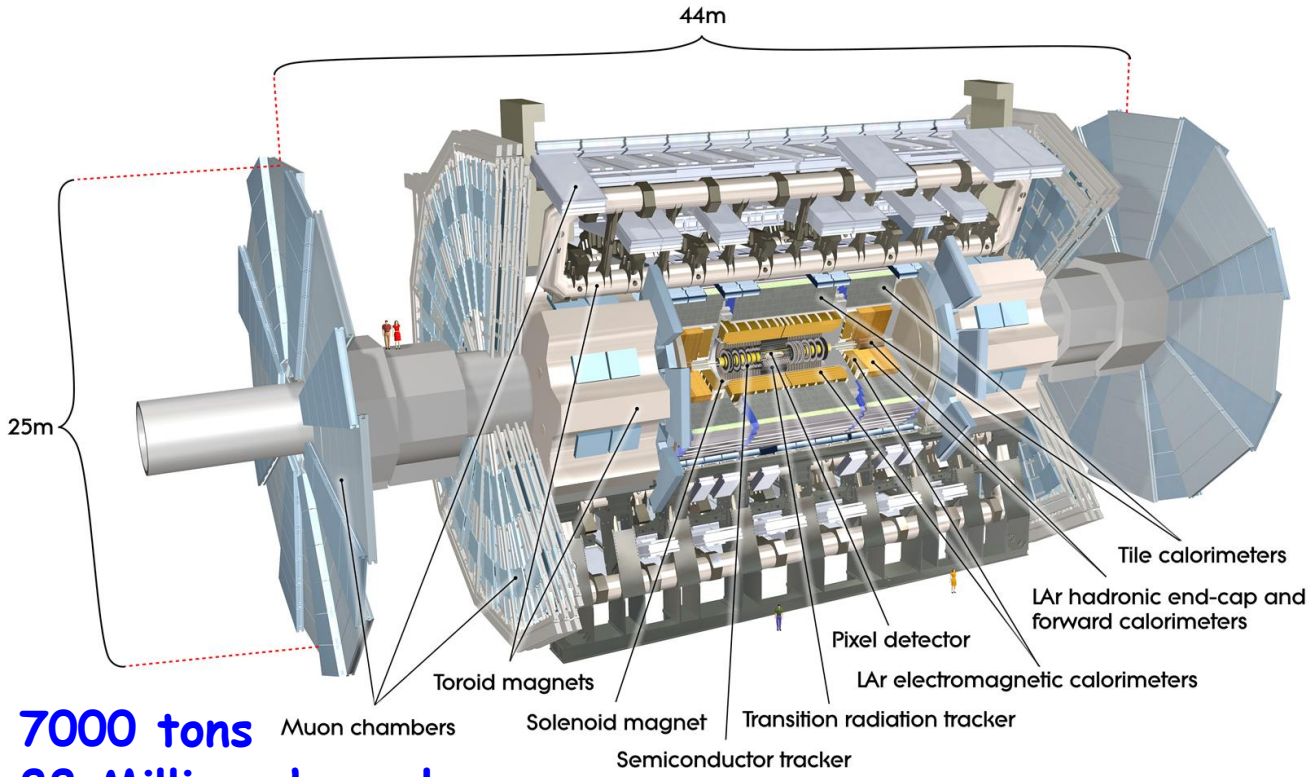
Aliaksei Hrynevich

on behalf of CPHEP INP BSU ATLAS group

CPHEP INP BSU activities in ATLAS experiment

January 17th, 2017

Overview of the ATLAS experiment



ATLAS is the largest multipurpose detector ever built.

7000 tons
88 Million channels
3000 km of cables
2T solenoid
Toroid (B ~ 0.5T in barrel; ~1T end-cap)

ATLAS has discovered Higgs boson in 2012. In addition it has a wide program of Standard Model measurements and searches of signatures Beyond Standard Model.

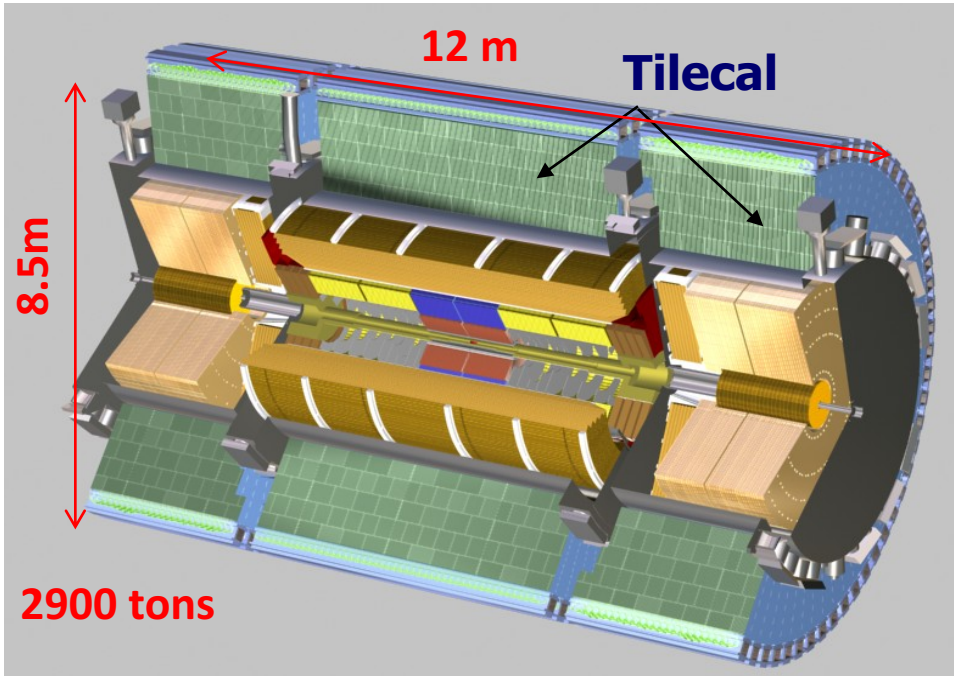
CPHEP INP BSU ATLAS Group

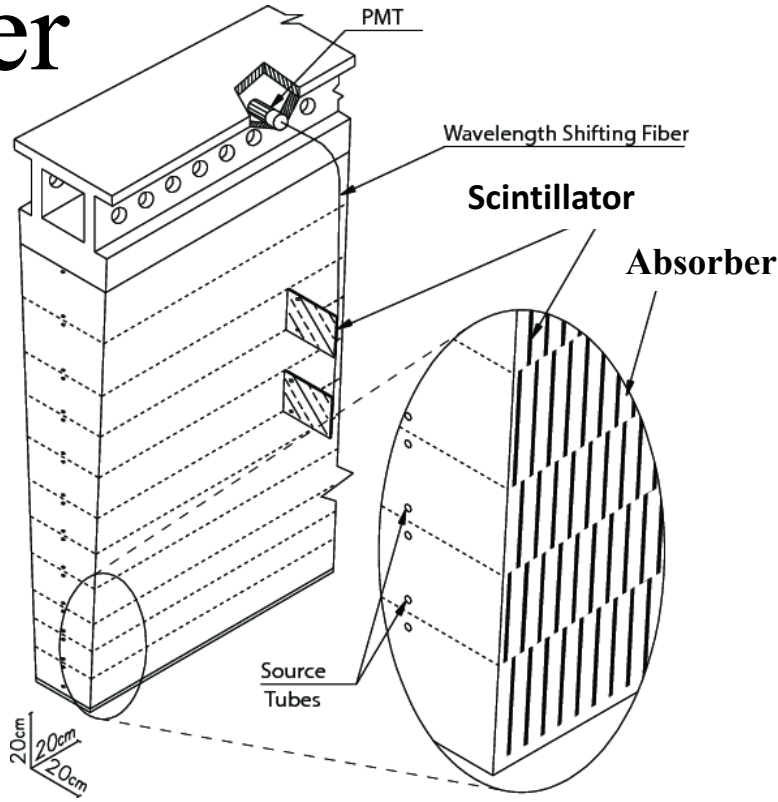
CPHEP INP BSU is currently presented in ATLAS experiment by 1 Doctor, 2 PhD students and 2 engineers.

17 persons in total from CPHEP INP BSU were involved in the ATLAS experiment activities since the institute joined ATLAS, taking part to:

- **Activities within the hadronic Tile Calorimeter working group**
- **Jet Energy Measurements**
- **Jet Cross Sections Measurements**
- **Parton Distribution Functions (PDF) constraints**
- **Physics Beyond Standard Model (BSM)**
- **Tile Calorimeter upgrade**

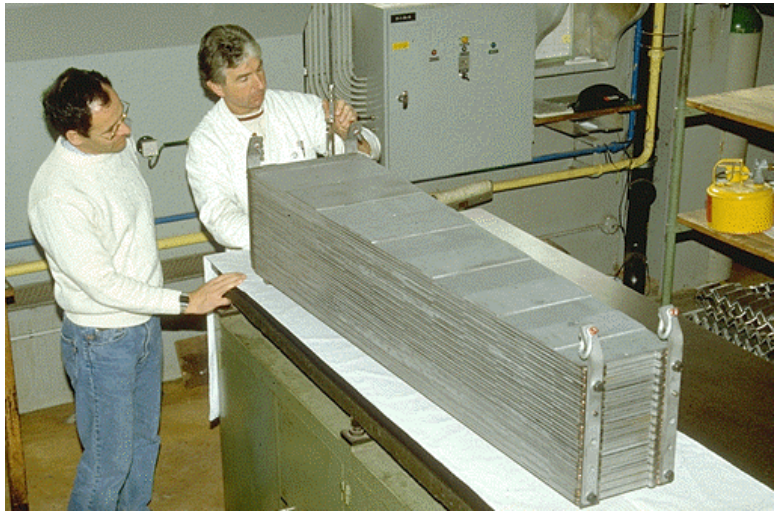
ATLAS Tile Calorimeter





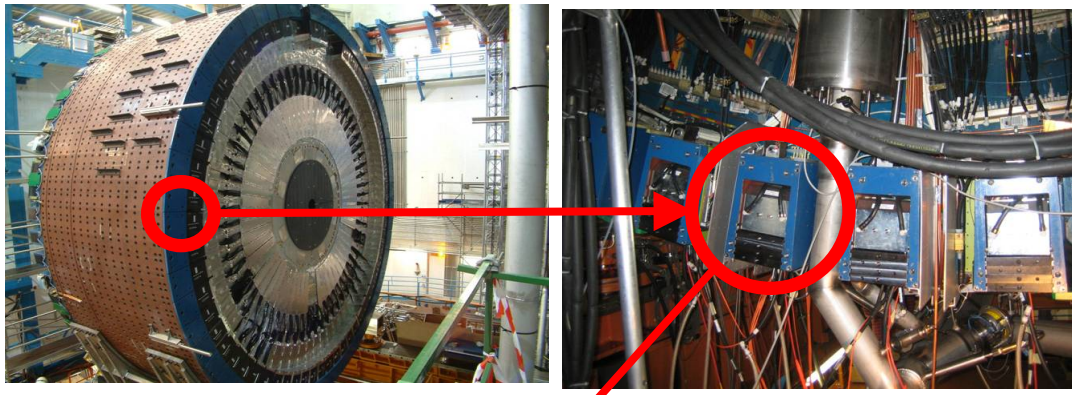
- Tile Calorimeter is the outer barrel of ATLAS calorimetry system, intended for energy measurements of jets and single hadrons within $|\eta| < 1.7$.
- The TileCal is made from plastic scintillators "tiles" and steel absorbers.
- The light from tiles is routed to PMTs and is read by the front-end electronics located in the outermost side of TileCal modules. The TileCal has a granularity of $\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$. The energy is measured by ~5000 cells.

Spacer absorber plates

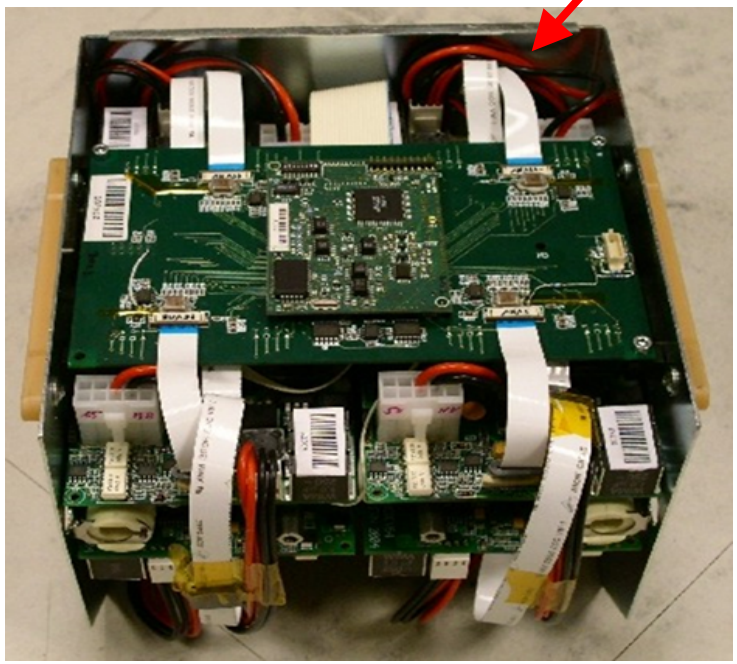


- Spacer plates are used as absorber in TileCal modules
- Nearly 300000 plates were produced from steel Fe-360 with 100 micron precision within 5 month on Minsk Traktor Plant facilities in 1998
- **Large effort where made by INP ATLAS participating in design, production and quality control of the spacer absorber plates**

Low Voltage Power Supplies (LVPS)



The signal amplification, shaping and digitisation is performed by the front-end electronics. **The electronics is powered by the LVPS, attached to each TileCal module.**



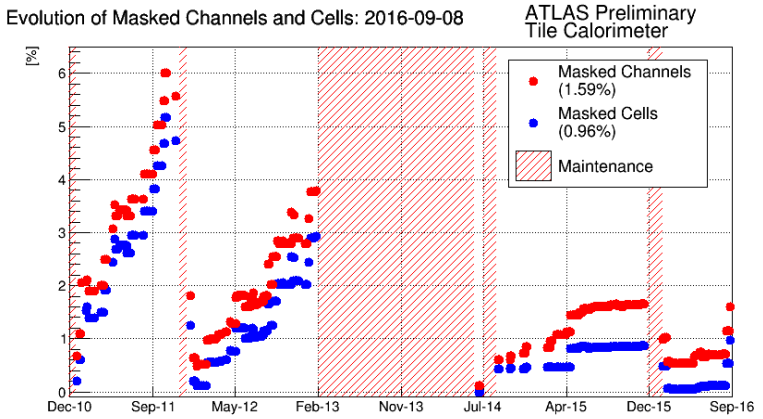
- The LVPS for TileCal were developed in 2001-2007. But the early tests showed the instability if its workflow.
- **The CPHEP INP BSU experts contributed to the redesign of the LVPS electric schemes starting from 2006, when major problems noticed. This allowed to fix early stability, voltage accuracy and control problems, and maintain TileCal in time.**

Data Quality Monitoring

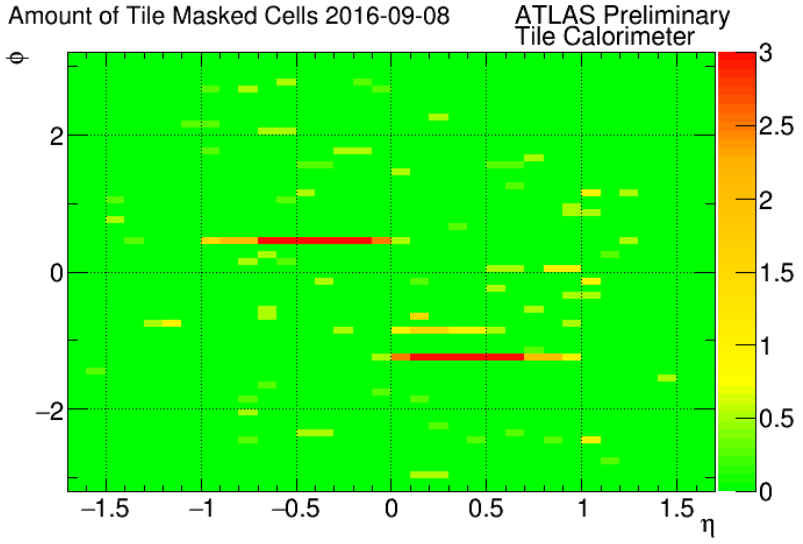
- **The performance of the TileCal is controlled by doing Offline Data Quality Monitoring Leader Shifts in TileCal for the every year of TileCal operations.**

- This allows to provide good quality data for each ATLAS measurement and avoid data with major problem arised during the data taking.

Evolution of TileCal masked cells in 2010-2016

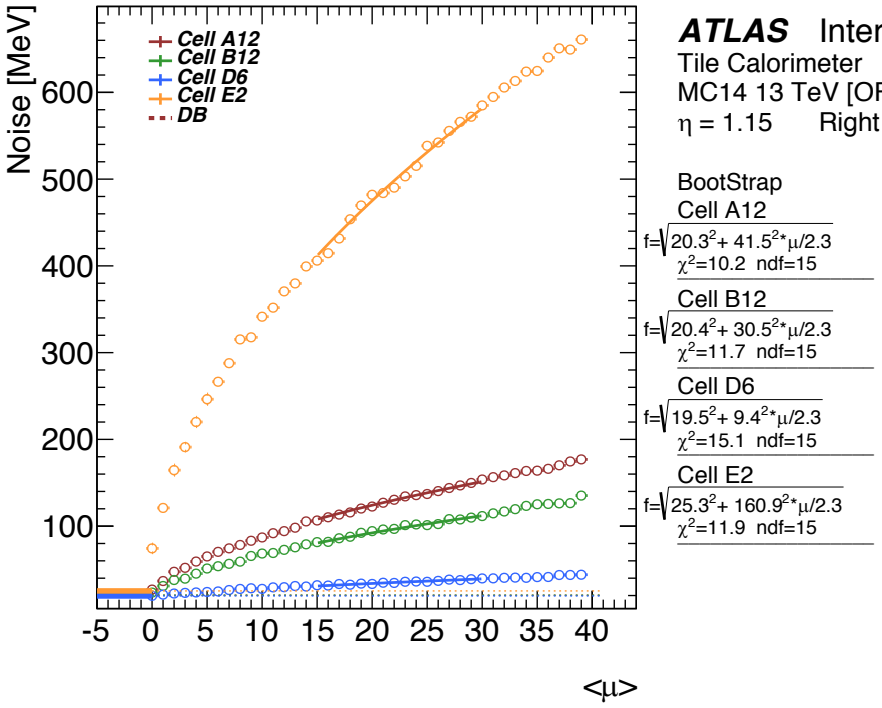


The eta-phi map of masked cells in 2016

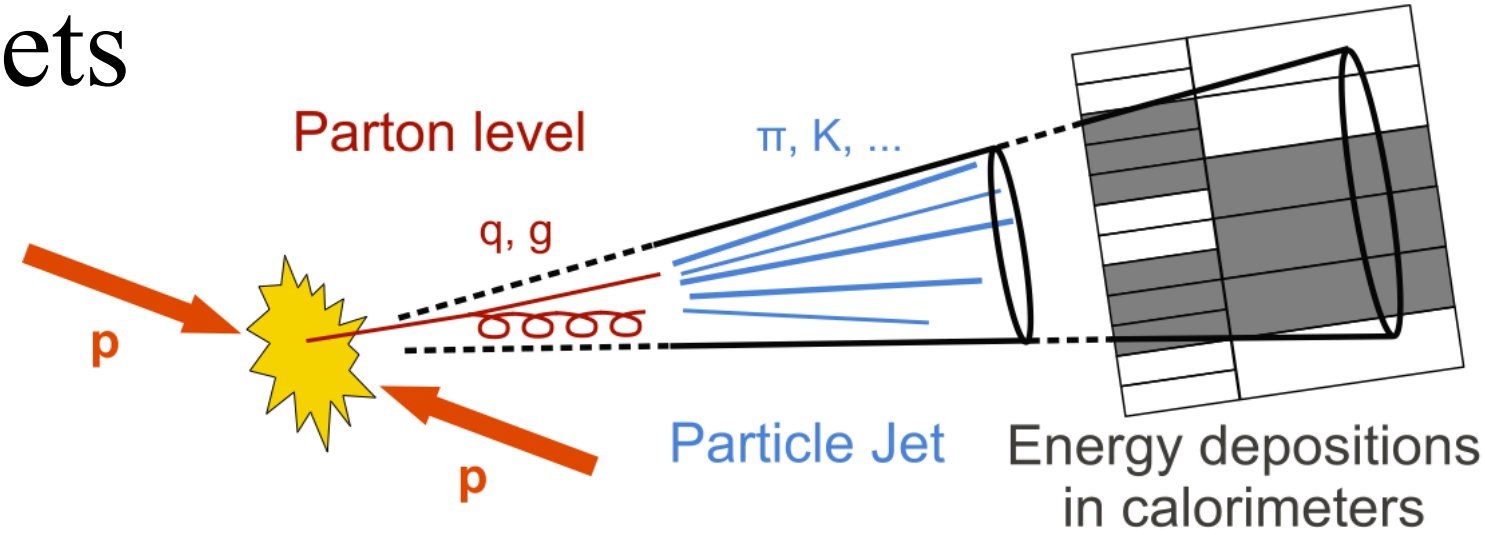


Pile-up Noise in TileCal Cells

- High luminosity pp collisions at the LHC are disturbed by the additional soft pp interactions, pile-up noise
- Pile-up noise in TileCal cells is increasing as the function of average number of interactions.
- **Pile-up noise is constantly monitored for each TileCal cell during the data taking and put into conditions DB.**
- The measured values of pile-up noise impact every ATLAS measurement/search with jets in final state.



Jets



Jets are collimated sprays of hadrons arising from the fragmentation of quark and gluons. Jets are the dominant features arising in pp collisions at the LHC.

Jets can be built:

- from partons knocked-out from protons
- from charged particles as results of parton evolution (i.e. hadronisation)
- from calorimeter inputs (energy deposits in active cells)

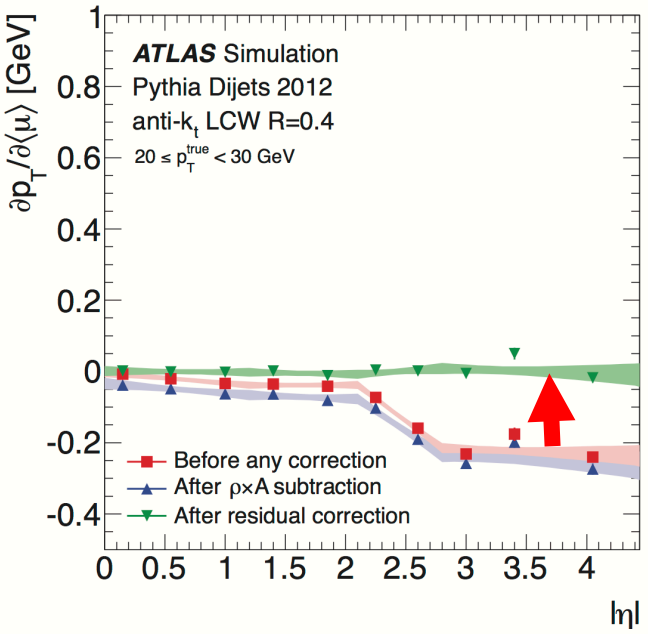
The jet measurements are important alone as the final state physics object. Jets are also used to study the proton structure, strong coupling constants, and the non-perturbative effects of hadronisation and underlying events.

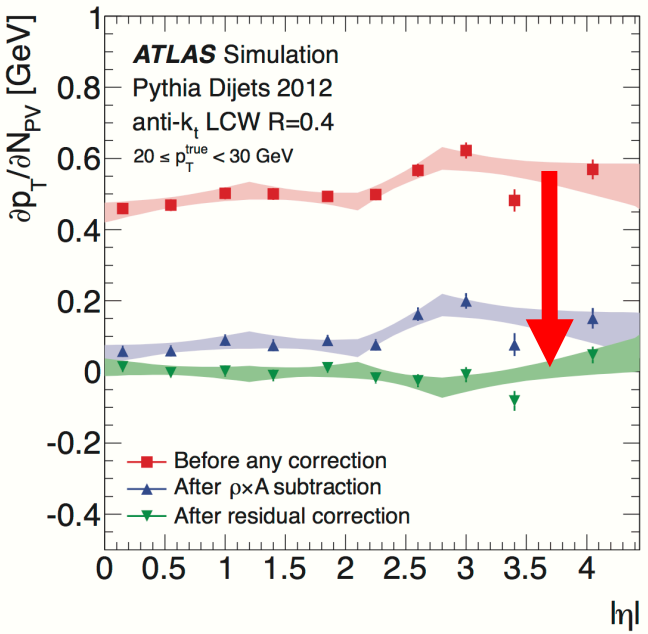
CPHEP INP ATLAS group participates in a wide variety of jet physics studies.

Jet Energy Measurements Pile-up correction

Eur. Phys. J. C (2016) 76:581

- Jets in ATLAS are built taking the topologically clustered cells as the input to the jet algorithm, intended to suppress noise.
- However, the contribution from multiple pp interaction, known as pile-up noise, has to be additionaly corrected on jet level.
- The criteria were developed to distinguish between the hard and pile-up jet vertex
- **CPHEP INP BSU experts contributed in derivation of this corrections, which allowed to reduce jet energy measurement dependence on pile-up.**





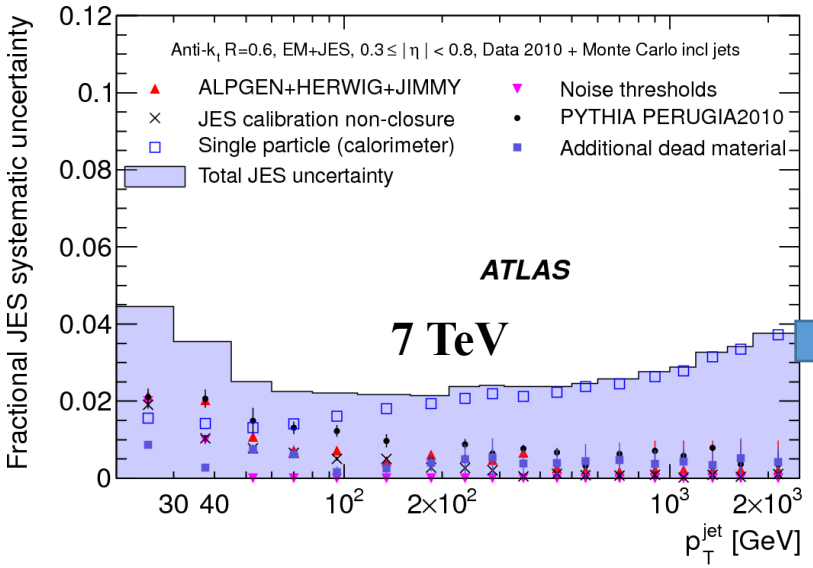
Jet Energy Measurements

The jet energy measurements in ATLAS are disturbed by calorimeter non-compensation, dead material, energy leakages, noise thresholds and reconstruction efficiencies.

The energy calibration relates the measured jet energy to the true energy of corresponding stable particles entering the jet.

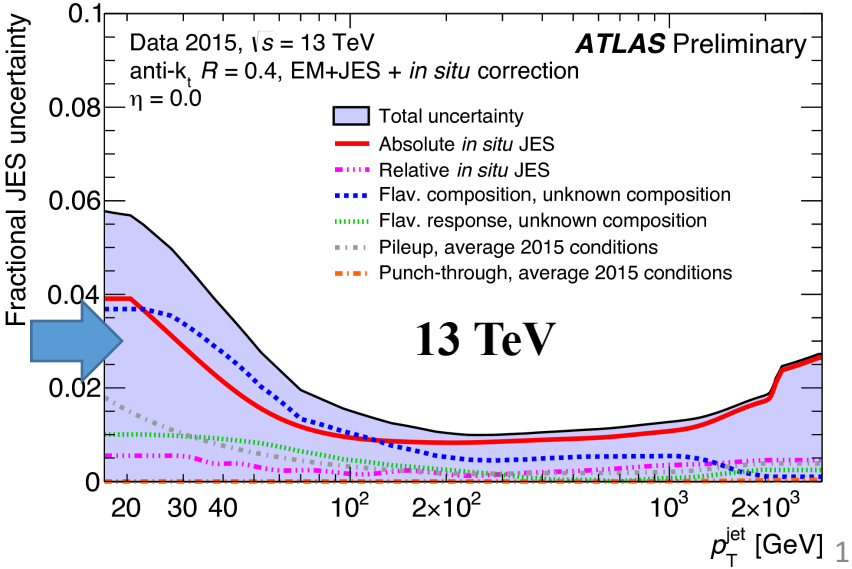
CPHEP INP BSU ATLAS group participated in jet energy measurements from the beginning of the ATLAS operations in 2009 and contributed to the improved precision of these measurements.

2010 Uncertainties
Obtained with single hadron response



8 TeV

2015 Uncertainties
Exploits Z/γ+jets and multijets balance techniques. ~80 unc. parameters



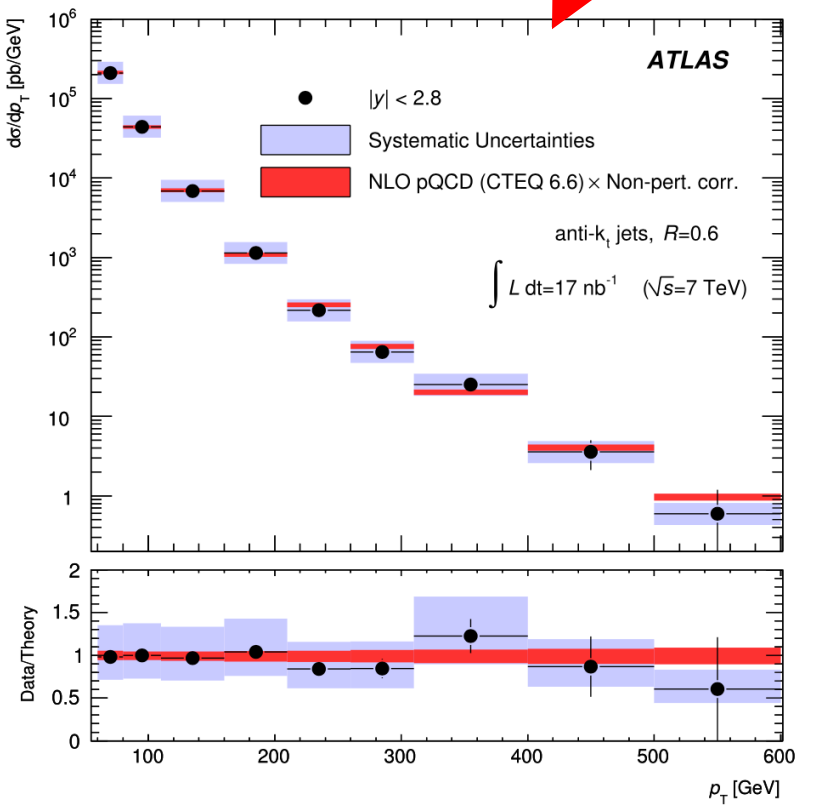
Eur.Phys.J. C71 (2011) 1512

Jet Cross Section Measurements

The inclusive and dijet cross sections have been measured for the first time in pp collisions using 2010 7 TeV ATLAS data with luminosity of 17 nb^{-1}.

The measurement allowed to extend the measured p_T distribution of inclusive jets and dijets up to 600 GeV and 2 TeV respectively.

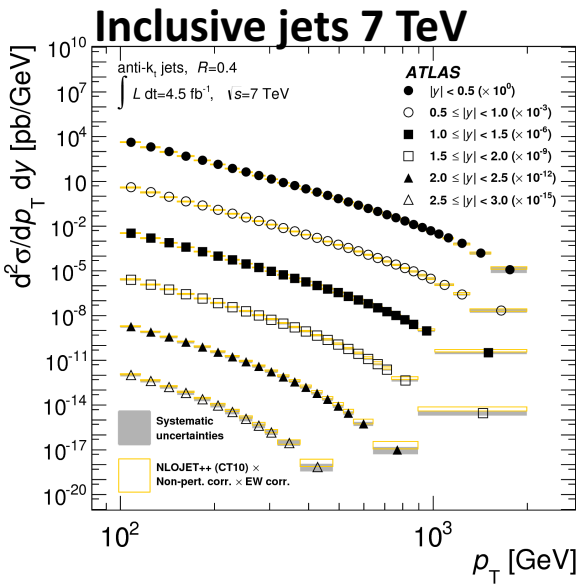
A good agreement with NLO predictions was observed within the systematic uncertainties of the measurement, dominated by the jet energy scale (40%)



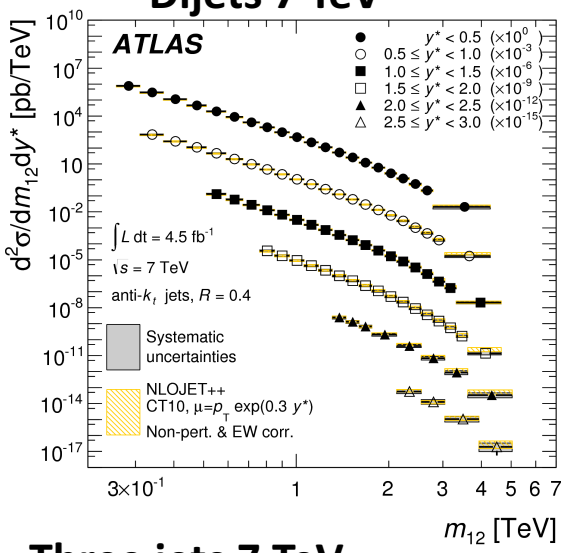
Jet Cross Section Measurements

The cross section measurements were improved further with the 7 TeV 4.5 fb^{-1} ATLAS pp data and improved jet energy scale.

J. High Energ. Phys.(2015)153

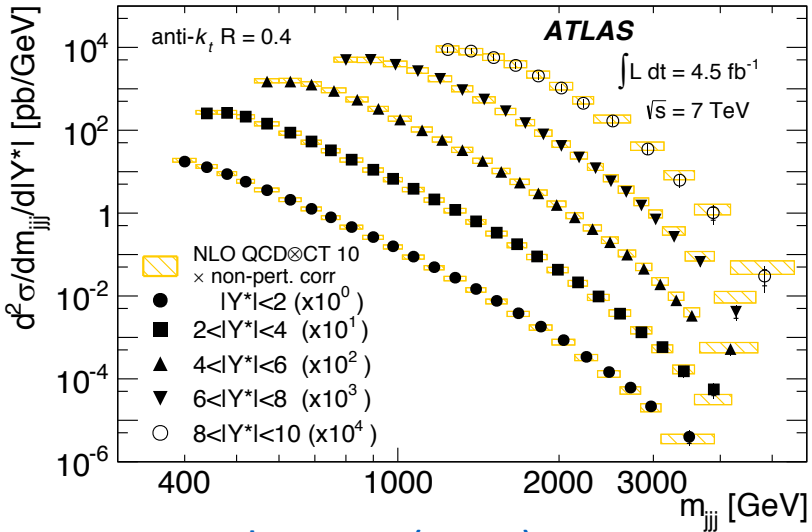


J. High Energ. Phys. (2014)59



An independent inclusive jet, dijet and three jet measurements were performed and allowed to probe the 5 TeV final states.

Three jets 7 TeV

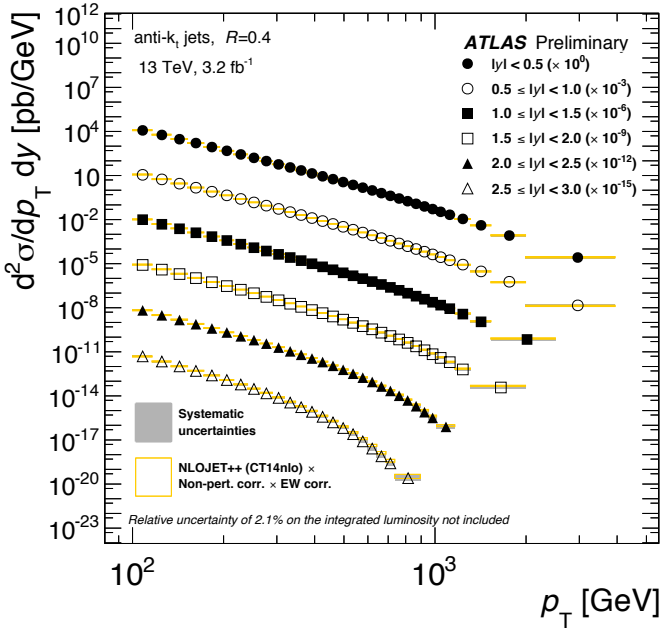


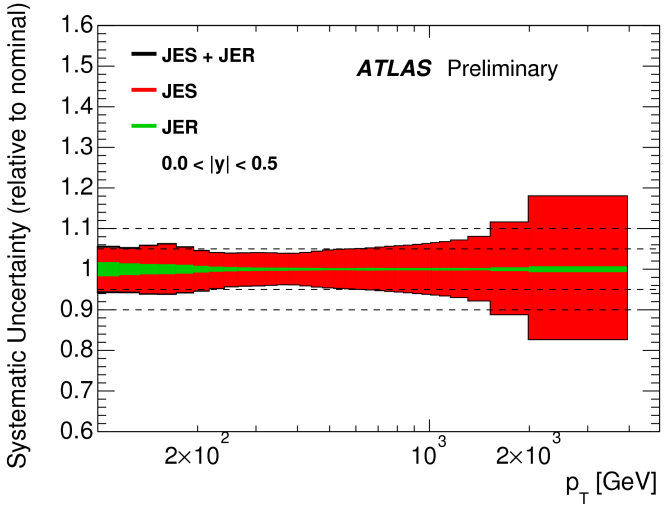
Eur. Phys. J. C (2015) 75: 228

Jet Cross Section Measurements

The inclusive jet cross section was performed at 13 TeV probing jets up to 4 TeV transverse momenta.

The improved JES allowed to produce the measurement with high accuracy of 5%. The uncertainty is increasing up to 20% at highest transverse momenta, but does not exceeding NLO uncertainties.





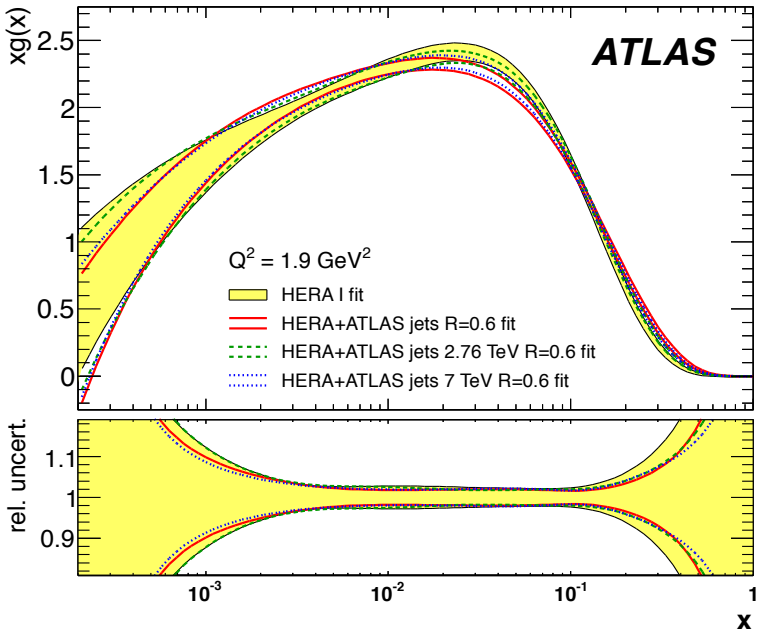
PDF Constraints

EPJC (2013) 73 2509

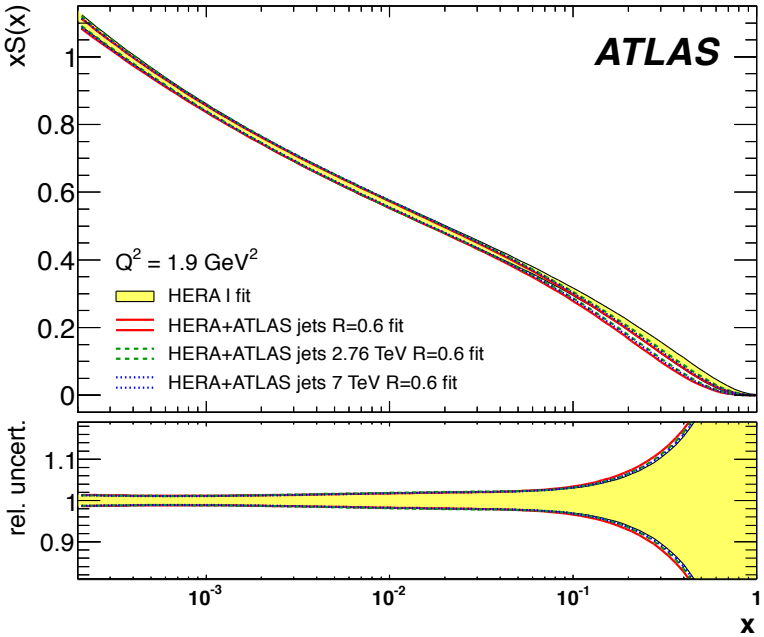
Jet cross section measurements are sensitive to the gluon PDF. **The usage of ATLAS measurements allowed to reduce PDF uncertainty at high Bjorken-x up to 0.4.**

The combination of various jet measurements can provide additional constraints to the PDFs.

Gluon PDF



Sea PDF



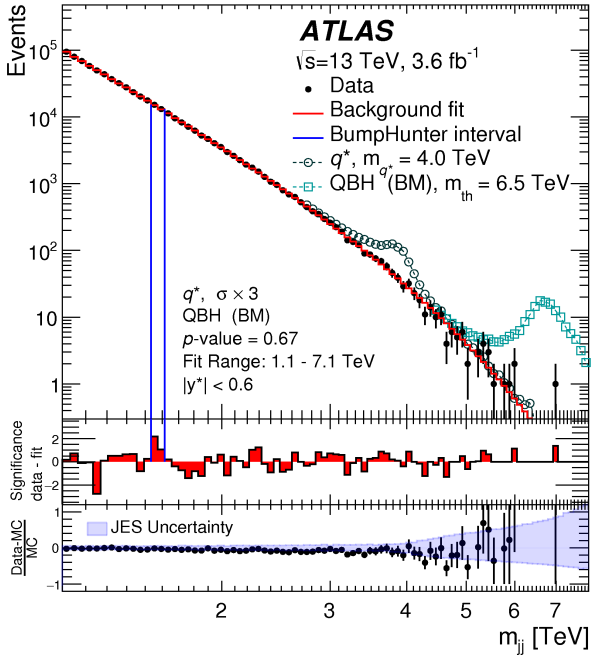
Physics Beyond The Standard Model

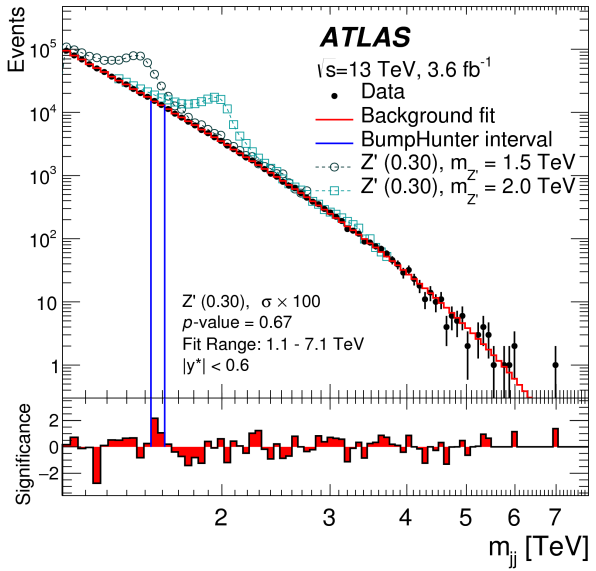
Physics Letters B 754 (2016) 302-322

Participation in searches of quantum black holes, excited quarks, W′ and Z′ bosons in high mass dijet events at √s=13 TeV pp collisions.

Dijet mass has been measured within 1.1 - 6.9 TeV.

No evidence of new physics phenomena was uncovered. **The 95% CL upper limits on the cross section for new processes were set.**

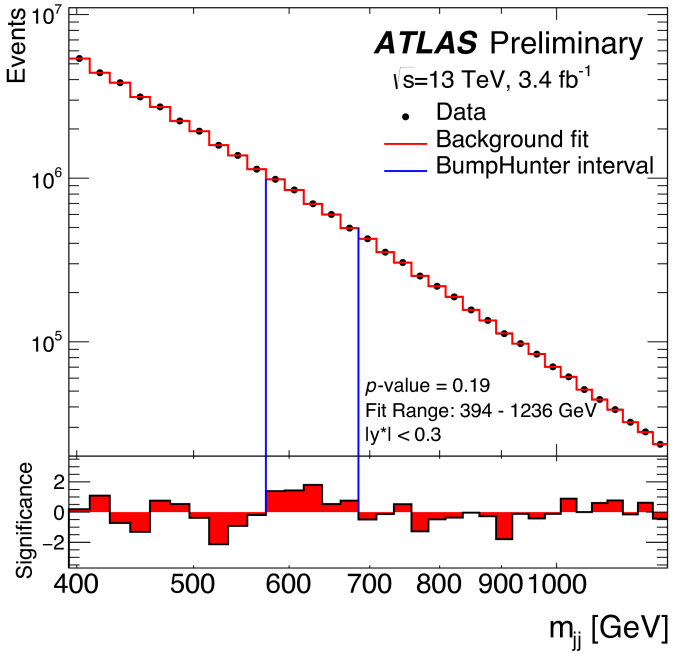




Physics Beyond The Standard Model

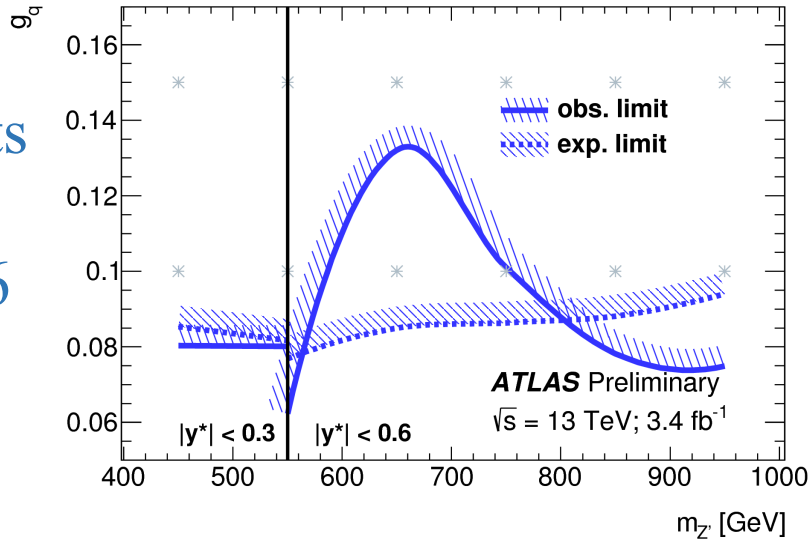
Searches of the Dark Matter mediators were performed as well at low dijet mass events at √s=13 TeV pp collisions.

Due to large SM multijet background, low dijet masses measurements are affected by the large trigger prescales given the limited bandwidth.



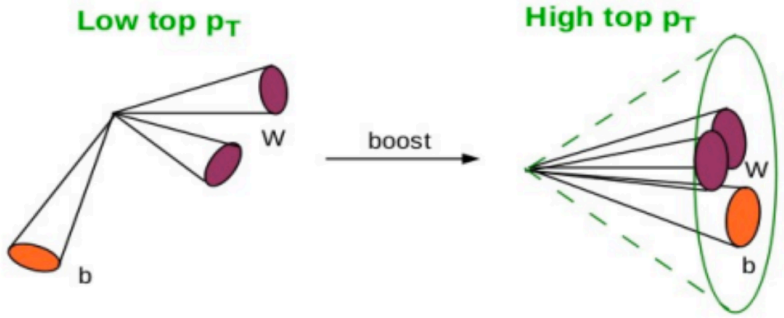
The Trigger-object Level Analysis strategy was performed for the first time, allowing to reduce the size of objects instead of removing events and produce a dijet mass measurement within 394 - 1236 TeV.

Limits to the Z′ coupling to quarks were obtained.



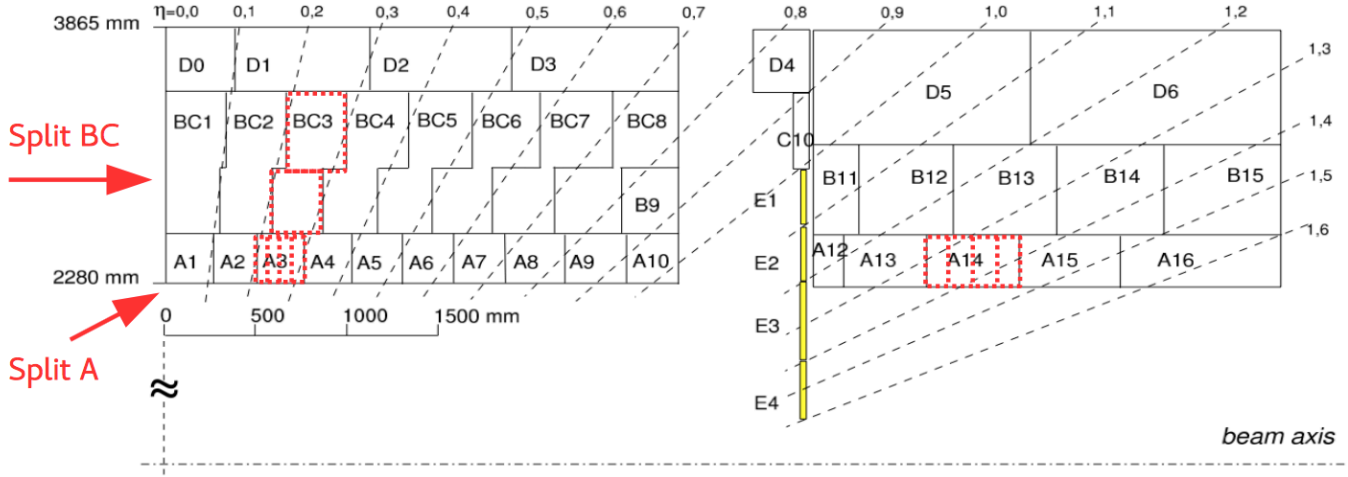
The TileCal Granularity Upgrade

- Higgs, W, Z, top (pT > 2 TeV) decay to narrow jets with jet radius smaller than 0.4 in φ x η
- Such narrow jets have substructure (2 or 3 subjets)



The TileCal phase 2 geometry upgrade

- Improve granularity using multianode PMTs (8x8 channel matrix)
  - Split BC cells (x2) → 3 → 4 longitudinal layers in LB
  - Split A cells (x4) → eta granularity = 0.1 → 0.025
- Not changing the detector (only PMTs and optical guide)
- This is an upgrade idea being studied in TileCal (not yet the baseline)



Wide participation of CPHEP INP ATLAS group in this project both from physics and electronics sides.

Summary

- CPHEP INP BSU has a small but productive ATLAS group participating in calorimetry, Standard Model and Beyond the Standard Model ATLAS activities
- A number of ATLAS performance and physics studies are relying on our contribution
- Our measurements induce a high interest in a high-energy physics community (plots appeared in the cover of European Physics Journal C twice)
- We have long term plans in ATLAS upgrade activities and physics program