ИТЭФ в ATLAS в 2015 г.

- Вклад ИТЭФ в ATLAS в 2015 г.
- **ИТЭФ в Upgrade Phase-II и поиск тяжелого бозона Хиггса**
  - перекрытие FCal по jet p_T и η и H→WW→$l\nu l\nu$
  - планы LAr по модернизации FCal
  - планы группы ИТЭФ по моделированию FCal и sFCal
- ИТЭФ в Run-II по изучению канала H→WW→$l\nu l\nu$ →А. Гаврилюк
- Публикации по тематике группы ИТЭФ в ATLAS
- Предварительные планы группы на 2016 г.

И.И. Цукерман, ИТЭФ, Москва, Россия,

Совещание российских групп ATLAS, НИИЯФ МГУ, Москва, Россия, 19.01.2016

Вклад ИТЭФ в ATLAS в 2015 г.

- ATLAS database support and development: 0.4 FTE
- Support of ATLAS computers at CERN: 0.17 FTE

  См. доклады С. Макарычева на прошлом совещании
- Data quality shifts in LAr 0.05 FTE

  См. доклад А. Гаврилюка
- FCal monitoring in Run-II

  Только 8 мертвых каналов из 3524, новых не появилось
- MC physics studies for LAr Upgrade Phase-2

  См. доклады И. Цукермана на прошлом и нынешнем совещаниях
- SM-like H→WW→$l\nu l\nu$ searches at 13 TeV

  См. доклады А. Гаврилюка на прошлом и нынешнем совещаниях

FCal and H→WW→lνlν at HL-LHC: reminder

- Real FCal coverage for jets potentially can be reduced when HL-LHC will start the operation

Reason: positive ion build-up at high |η| → reduced HV in LAr gap
(assumption: no change of current FCal, no miniFCal in front of current FCal)

- One of questions from LAr Phase-II upgrade community:

how (VBF) Higgs boson searches will be affected by possibly reduced coverage for tagging jets and E_T^{miss} ?

- A study was performed to provide some answers

- For **jets** it is based on the NEW Common Analysis Framework (CAF) of the H→WW (HSG3) Working Group for **13 TeV** data
- For $\mathbf{E_T^{miss}}$ a modified private ITEP group code is used

(8 TeV-based jet and E_T^{miss} studies were presented at our previous meeting)

FCal coverage and H→WW→lvlv at 13 TeV

- 3.2 fb^{-1} of 13 TeV data were analyzed aiming to search for signal from high mass Higgs boson in H→WW→lvlv mode
- 13 TeV MC15a+b signal/background samples were tested
  13 TeV kinematics is closer to HL-LHC conditions than 8 TeV one
- Similar cuts to those used in high mass paper applied
  Small modifications of cuts; only eμ final state
- Results for data, signal and backgrounds are shown
  - Fractions of events survived additional cut on $|\eta_{jet}|<x$ (x=3.2 – 4.5)
  - Fractions of events after cut p_T(jet)>40-70 GeV in $|\eta|>2.5$
  - The same but p_T(jet)>30-60 GeV in $|\eta|<2.5$ for p_T>70 GeV in $|\eta|>2.5$
- COM note was submitted, updated late December
  A.G and I.T., ATL-COM-PHYS-2015-1431, contains all studies

FCal and reduced jet coverage: details

- HWW group v8 PxAODs at **13 TeV** (data and MC15a+b)

  Signal: ggF, VBF, masses 125 GeV – 1 TeV (NWA: up to 3 TeV)
  Backgrounds: WW, ttbar, Wt, Z+jets with di-lepton final state

- Run 2 Common Analysis Framework

  Standard code and high-mass definitions for run and read modes
  Only WW→eμ + μe final state
  To be replaced by MC15b later

- Selections used: similar to Run 1 with some changes

  - Very hard cuts on lepton p_T, hard cuts on MET, M(*ll*)…
  - at least 2 jets with high-p_T , anti b-tagging, different jet vetos etc
  - two options (ΔY(jj)>4.0 / M(jj)>500 GeV and ΔY(jj)>2.5 / M(jj)>250 GeV)

- New cuts on η(jet), p_T(jet) added after official cutflow

Results for SM-like high mass Higgs boson

Table shows fractions of events after **hard VBF selections** survived the additional cut on the jet coverage: **13 TeV MC**

Process/ coverage	H total 300 GeV	H total 600 GeV	H total 900 GeV	Total BGR	Real data	Top BGR
$\|\eta\|<4.5$	1	1	1	1	1	1
$\|\eta\|<4.0$	**0.84**	**0.79**	**0.80**	**0.88**	**14/16**	**0.88**
$\|\eta\|<3.7$	0.67	0.61	0.59	0.79	13/16	0.80
$\|\eta\|<3.5$	0.53	0.51	0.44	0.70	12/16	0.73
$\|\eta\|<3.3$	**0.43**	**0.39**	**0.33**	**0.56**	**12/16**	0.64
$\|\eta\|<3.2$	0.36	0.35	0.27	0.51	12/16	0.58

- Smaller loss of BGR w.r.t. signal, data/MC is ok
- Main (top) background is a bit less affected than total background
- Reduction of signal and BGR rates is a bit stronger than at 8 TeV

Results for SM-like high mass Higgs boson

Table shows fractions of events after **hard VBF selections** survived the additional cut on forward jet p_T: **13 TeV MC**

Process/ coverage	**H total 300 GeV**	**H total 600 GeV**	**H total 900 GeV**	**Total BGR**	**Real data**	**Top BGR**
Nominal	1	1	1	1	1	1
p_T(fw)>40	0.92	0.90	0.90	0.83	13/16	0.84
p_T(fw)>50	0.84	0.80	0.82	0.73	13/16	0.70
p_T(fw)>60	0.73	0.70	0.71	0.63	10/16	0.61
p_T(fw)>70	**0.64**	**0.63**	**0.61**	**0.59**	**10/16**	0.57

- Similar loss of BGR w.r.t. signal, data/MC is ok
- Top background is affected the same way as total background
- Reduction of signal and BGR rates is a bit stronger than at 8 TeV

Results for SM-like high mass Higgs boson

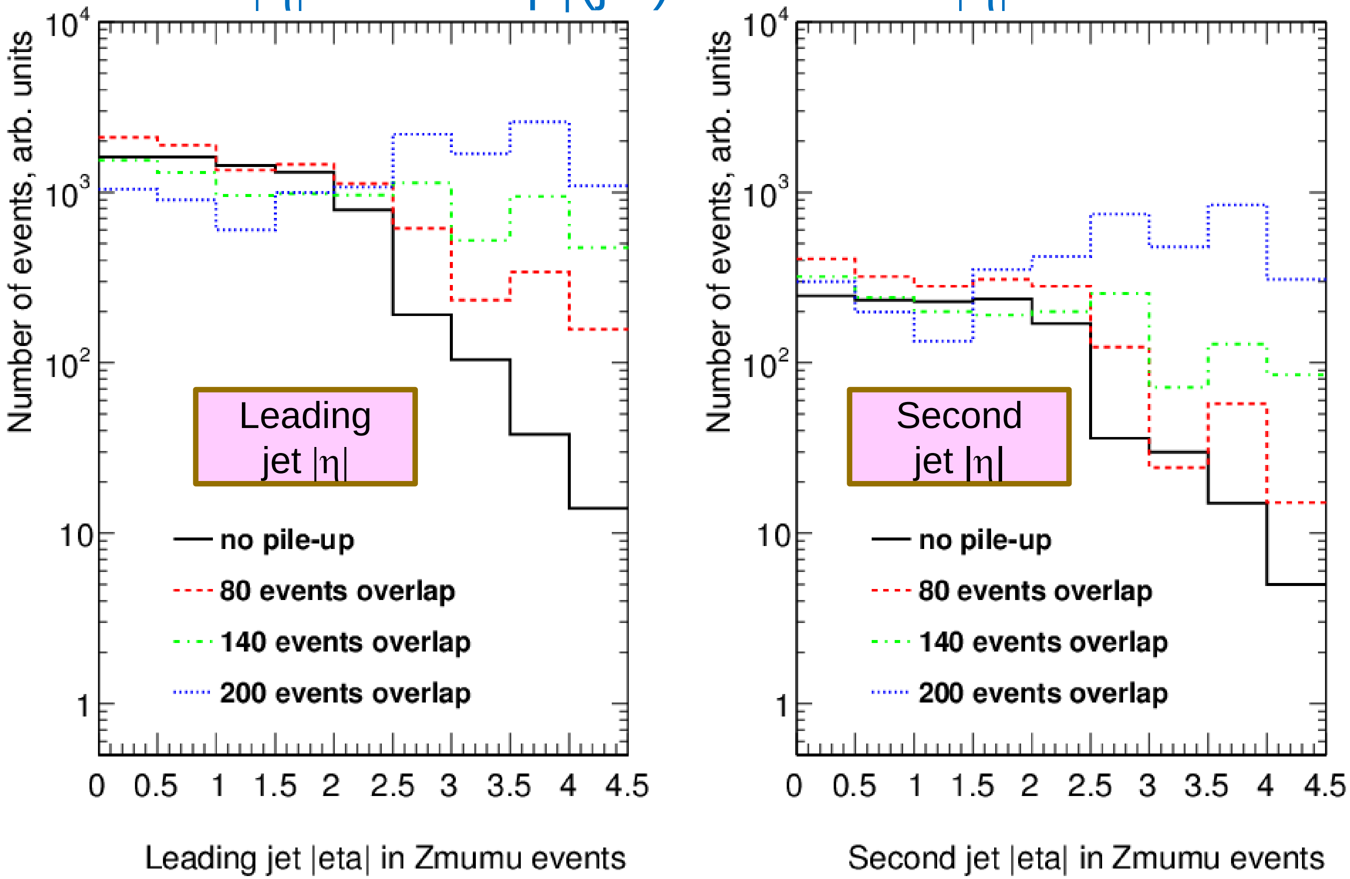
Table shows fractions of events after **hard VBF selections** survived additional cut on forward jet p_T >70GeV and on central jet p_T : **13 TeV MC**

Process/ coverage	H total 300 GeV	H total 600 GeV	H total 900 GeV	Total BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(ce)>30	0.59	0.61	0.60	0.51	10/16	0.53
p_T(ce)>40	0.48	0.52	0.50	0.35	9/16	0.42
p_T(ce)>50	0.36	0.43	0.39	0.23	6/16	0.28
p_T(ce)>60	**0.30**	**0.36**	**0.33**	**0.13**	**4/16**	**0.14**

- A bit larger loss of BGR w.r.t. signal, data/MC is ok
- Total BGR is reduced the same way as main (top) BGR
- With cut like in scoping document signal reduction factor is >3!

Jet |η|-spectra at different p_T cuts for Z→μμ vs μ

p_T(jet)>**50** GeV at |η|>2.5 and p_T(jet)>**30** GeV at |η|<2.5



Central region: shapes with and w/o pile-up not very different, due to JVF
Forward region: almost all jets come from pile-up despite 50 GeV cut on p_T
Normalization: after selection of events with two good muons

Summary

Based on Run2 HWW CAF for data and MC15 samples:

- Smaller FCal η coverage for jets can result to loss of (VBF) H→WW→lνlν signal (and BGR), namely ≈20% for $|\eta|<4.0$
  Acceptance loss is ≈65% (≈40%) for H (BGR) if FCal is excluded.
- Increasing jet p_T threshold in $|\eta|>2.5$ gives rise to reduction of H and BGR rates by ≈40% for realistic $p_T>70$ GeV cut
- Increasing jet p_T threshold to 60 GeV in $|\eta|<2.5$ (at fixed $p_T>70$ GeV in $|\eta|>2.5$) results to reduction of H (BGR) rates by ≈70% (80%) respectively
- No disagreement with real data observed

FCal at HL-LHC

- FCal может работать без заметной модификации вплоть до LHC Upgrade Phase-II (до 2024 г.)

- Почему может быть нужна модернизация при $L>5\times10^{34}$ см$^{-2}$ с$^{-1}$:
  1) накопление пространственного ионного заряда в LAr–зазоре
  2) потенциальная опасность закипания LAr

- Три варианта модернизации переднего калориметра
  1) замена секций FCal на аналогичные, но с меньшим в 2.5 раза зазором (**sFCal**, с поперечной гранулярностью как у FCal или вчетверо лучшей)

  2) размещение небольших калориметров (miniFCal) прямо перед EM-секциями FCal для уменьшения плотностей потоков энергии в них

  3) Сохранение FCal в существующем виде (при жестком контроле)

- ближайшие планы ИТЭФ: моделирование сигнала и фонов от VBF H→WW→lνlν для вариантов 1 и 3.

FCal/sFCal and related LAr milestones

- Schedule of related LAr milestones

  - Review of FCal/sFCal/miniFCal options by June 2016
  - IDR of all LAr Phase-II Projects in Q3 2016
  - TDR of all LAr Phase-II Projects in Q3 2017

From A. Straessner, LAr Week December 2015 with I.T. modifications

- Issues related to FCal/sFCal simulations

  - January 2016: all MC samples are available
  - January-March 2016: analysis status reports
  - March-June 2016: preparation of FCal/.sFCal comparisons
  - June-July 2016: ATLAS review

- MC samples which include VBF H→WW→lνlν signal and background

  - Three geometries (FCal, sFCal with standard and improved granularity)
  - Four pile-up options (no pile-up, 80, 140 and 200 overlapped MB events)
  - 125 GeV, 1000 GeV and some other values of SM-like H masses
  - Possibly top, WW and Z→ττ backgrounds

Планы ИТЭФ в ATLAS на 2016 г. - 1

- ATLAS database support and development and hadron calorimeter studies: 0.4? FTE
- Support of ATLAS computers at CERN: 0.17 FTE
- Calorimeter shifts in ACR: 0.2? FTE
- Data quality shifts in LAr 0.2? FTE

  Цель – достичь экспертного уровня
- Continuation of FCal monitoring in Run-II

Планы ИТЭФ в ATLAS на 2016 г. - 2

- Participation in LAr Upgrade Phase-2

  - physics simulations of VBF H→WW for FCal and sFCal

    we plan to use HWW Run-II CAF for the analysis

  - preparation to possible hardware activity (discussions started)

- H→WW→lνlν in run-2

  - participation in CONF note preparation (Moriond 2016)
  - studies of correlation of variables, 8 vs 13 TeV comparisons
  - inclusion of same-flavor final state (ee+ $\mu\mu$)
  - lνlν+lνqq paper?

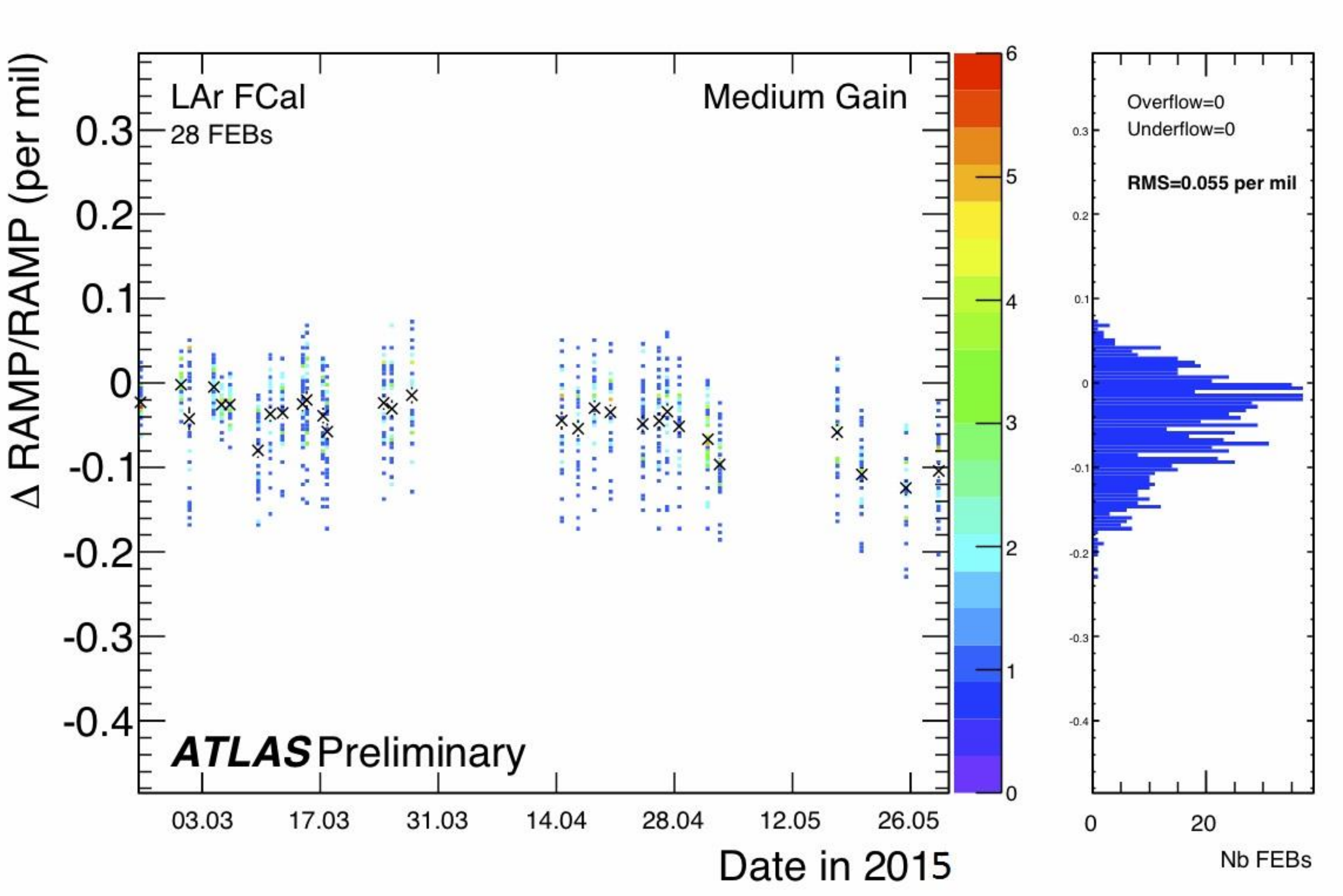
Публикации по тематике группы ИТЭФ

1. ATLAS and CMS Collaborations, Combination of the Higgs boson production and decay rates and couplings using pp collision data at 7 and 8 TeV by the ATLAS and CMS experiments, ATLAS-CONF-2015-044, CMS-PAS-HIG-15-002, 15 September 2015.
2. ATLAS Collaboration, Determination of spin and parity of the Higgs boson in the $WW^* \to e\nu\mu\nu$ decay channel with the ATLAS, EPJC 75 (2015) 231.
3. ATLAS Collaboration, Search for a high-mass Higgs boson decaying to a W boson pair in pp collisions at 8 TeV with the ATLAS detector, arXiv:1509.04670, submitted for publication in JHEP.
4. ATLAS Collaboration, Observation and measurements of Higgs boson decay to WW^* with the ATLAS detector, Phys. Rev. D92 (2015) 012006.
5. I. Tsukerman for the ATLAS Collaboration, Beyond the Standard Model Higgs boson searches using the ATLAS Experiment, Proceedings of ICNFP-2014 Int. Conference, Kolymbari/Crete, Greece, August 2014, EPJ Web of Conferences 95, 04071 (2015).
6. I. Tsukerman for the ATLAS and CMS Collaborations, Two years with the Higgs boson Proceedings of ICSSNP2014 Int. Session-Conference, MEPhI/Moscow, Russia, November 2014, Ядерная физика и инжиниринг, 2014, том 5, N9-10, стр. 708-715.
7. A.A. Gavrilyuk and I.I. Tsukerman, “An impact of ATLAS FCal performance at very high LHC luminosity to searches for Higgs boson in $H \to WW \to \ell\nu\ell\nu$ channel”, ATL-COM-PHYS-2015-1431, December 2015.

А.А. Гаврилюк выступил также на Курчатовской молодежной школе и молодежной конференции, посвященной 70-летию ИТЭФ с докладом о поиске $H \to WW$ в ATLAS (ноябрь 2015), который будет опубликован в ЯФ и Инжиниринг.

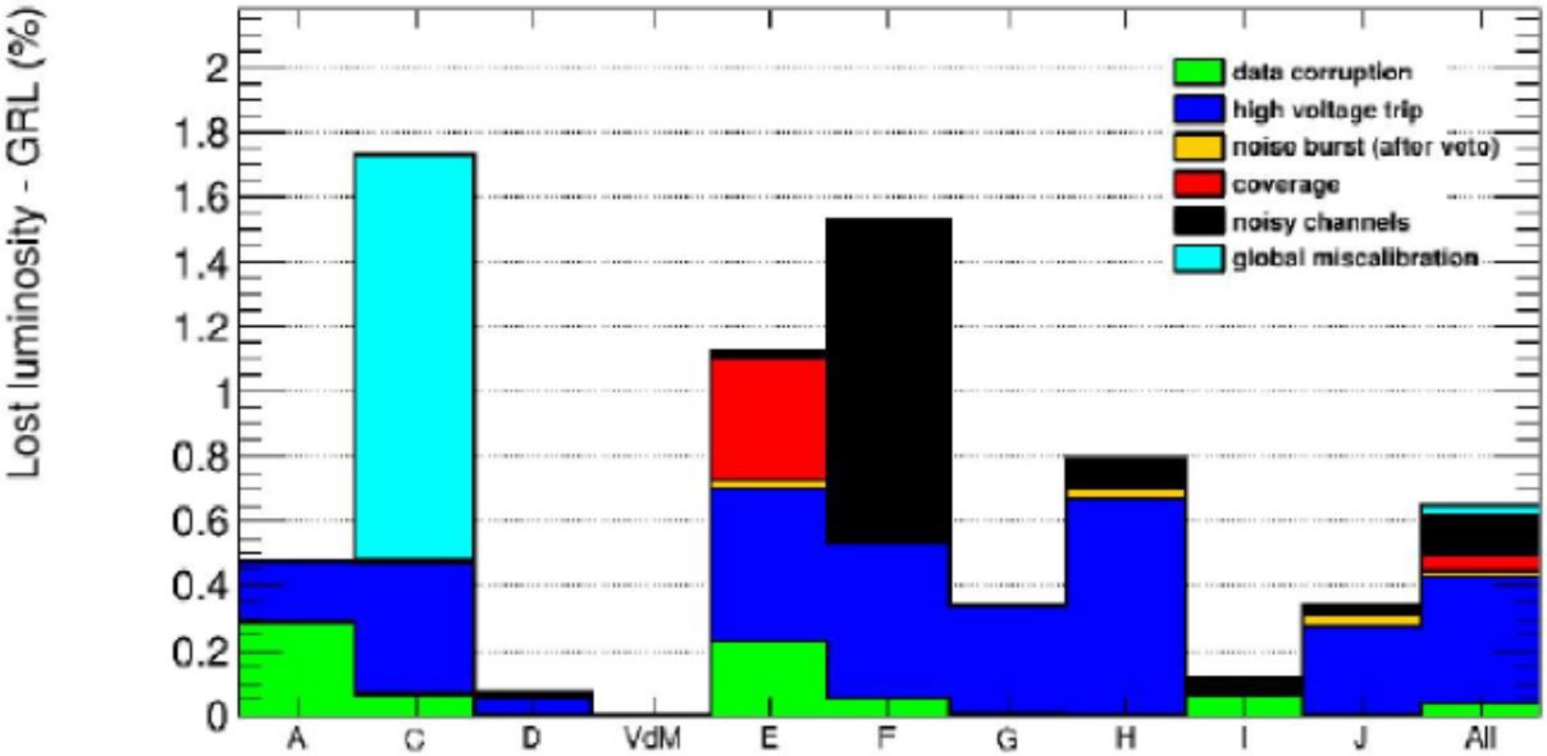
Backup slides

Поведение FCal в 2015 г.



Стабильность коэффициентов усиления FEBов переднего калориметра со временем в первой половине 2015 г.

LAr DQ в ATLAS в 2015 г.



Проверка качества данных 2015 г. с жидко-аргонового калориметра. Суммарная неэффективность по 125 сеансам (4 пбн$^{-1}$) составила 0.67%, с наибольшими вкладами 0.38% из-за сбоев ВВ питания и 0.12% из-за шумящих каналов.

Results for SM-like high mass Higgs boson

Table shows fractions of events after **soft VBF selections** survived the additional cut on the jet coverage: **13 TeV MC**

Process/ coverage	H total 300 GeV	H total 600 GeV	H total 900 GeV	Total BGR	Real data	Top BGR
|η|<4.5	1	1	1	1	1	1
|η|<4.0	**0.87**	**0.84**	**0.83**	**0.94**	**73/77**	**0.95**
|η|<3.7	0.74	0.71	0.65	0.90	71/77	0.92
|η|<3.5	0.63	0.63	0.52	0.85	69/77	0.87
|η|<3.3	**0.55**	**0.53**	**0.42**	**0.78**	**68/77**	0.83
|η|<3.2	0.47	0.49	0.37	0.74	67/77	0.79

- Much smaller loss of BGR w.r.t. signal, data/MC is ok
- Main (top) background is affected the same as total background
- Reduction of signal rates is a bit smaller than at hard cuts

Results for SM-like high mass Higgs boson

Table shows fractions of events after **soft VBF selections** survived the additional cut on forward jet p_T: **13 TeV MC**

Process/ coverage	H total 300 GeV	H total 600 GeV	H total 900 GeV	Total BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(fw)>40	0.91	0.91	0.91	0.88	70/77	0.90
p_T(fw)>50	0.84	0.84	0.84	0.83	69/77	0.84
p_T(fw)>60	0.75	0.75	0.73	0.75	63/77	0.76
p_T(fw)>70	**0.68**	**0.69**	**0.65**	**0.72**	**62/77**	0.73

- Similar loss of BGR w.r.t. signal, data/MC is ok
- Top background is affected the same way as total background
- Reduction of signal and BGR rates is a bit smaller than at hard VBF cuts

Results for SM-like high mass Higgs boson

Table shows fractions of events after **SOFT VBF selections** survived additional cut on forward jet p_T >70GeV and on central jet p_T : **13 TeV MC**

Process/ coverage	H total 300 GeV	H total 600 GeV	H total 900 GeV	Total BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(ce)>30	0.64	0.65	0.62	0.61	59/77	0.65
p_T(ce)>40	0.50	0.53	0.50	0.41	47/77	0.46
p_T(ce)>50	0.37	0.42	0.39	0.28	36/77	0.31
p_T(ce)>60	**0.29**	**0.34**	**0.33**	**0.18**	**29/77**	**0.20**

- A bit larger loss of BGR w.r.t. signal, data/MC is ok
- Total BGR is reduced the same way as main (top) BGR
- With cut like in scoping document signal reduction factor is >3!

Results for SM-like high mass Higgs boson

Table shows fractions of events after **hard VBF selections** survived the additional cut on forward jet p_T: **13 TeV MC**

Process/ coverage	H 125 GeV	ggF H 125 GeV	VBF H 125 GeV	WW BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(fw)>40	0.87	0.72	0.90	0.79	20/27	0.81
p_T(fw)>50	0.80	0.64	0.83	0.76	18/27	0.69
p_T(fw)>60	0.70	0.51	0.74	0.62	14/27	0.58
p_T(fw)>70	**0.64**	**0.50**	**0.66**	**0.55**	**13/27**	**0.54**

- Similar loss of BGR w.r.t. signal, data/MC is ok
- Top background is affected the same way as WW background

Results for SM-like high mass Higgs boson

Table shows fractions of events after **hard VBF selections** survived additional cut on forward jet p_T >70GeV and on central jet p_T : **13 TeV MC**

Process/ coverage	H 125 GeV	H ggF 125 GeV	H VBF 125 GeV	WW BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(ce)>30	0.62	0.47	0.65	0.50	12/27	0.51
p_T(ce)>40	0.51	0.32	0.55	0.35	11/27	0.40
p_T(ce)>50	0.41	0.22	0.44	0.29	7/27	0.30
p_T(ce)>60	**0.32**	**0.21**	**0.33**	**0.26**	**5/27**	**0.19**

- A bit larger loss of BGR w.r.t. signal, data/MC is ok
- WW BGR is reduced roughly the same way as top BGR
- With cut like in scoping document signal reduction factor is >3!

Results for SM Higgs boson

Table shows fractions of events after **soft VBF selections** survived the additional cut on the jet coverage: **13 TeV MC**

Process/ coverage	H 125 GeV	ggF 125 GeV	VBF 125 GeV	WW BGR	Real data	Top BGR
$\|\eta\|<4.5$	1	1	1	1	1	1
$\|\eta\|<4.0$	**0.87**	**0.95**	**0.84**	**0.90**	**102/107**	**0.95**
$\|\eta\|<3.7$	0.76	0.87	0.71	0.82	97/107	0.91
$\|\eta\|<3.5$	0.63	0.68	0.61	0.74	90/107	0.86
$\|\eta\|<3.3$	**0.53**	**0.57**	**0.52**	**0.67**	**88/107**	0.79
$\|\eta\|<3.2$	0.49	0.54	0.47	0.61	84/107	0.75

- Smaller loss of BGR w.r.t. signal, data/MC is ok
- Top background is a bit less affected than WW background
- Reduction of signal and BGR rates is a bit stronger than at 8 TeV

Results for SM-like high mass Higgs boson

Table shows fractions of events after **soft VBF selections** survived the additional cut on forward jet p_T: **13 TeV MC**

Process/ coverage	H 125 GeV	H ggF 125 GeV	H VBF 125 GeV	WW BGR	Real data	Top BGR
Nominal	1	1	1	1	1	1
p_T(fw)>40	0.87	0.77	0.91	0.82	93/107	0.88
p_T(fw)>50	0.81	0.71	0.85	0.78	87/107	0.82
p_T(fw)>60	0.72	0.61	0.76	0.70	74/107	0.73
p_T(fw)>70	**0.67**	**0.61**	**0.69**	**0.66**	**71/107**	0.69

- Similar loss of BGR w.r.t. signal, data/MC is ok
- Top background is affected the same way as WW background

Results for SM-like high mass Higgs boson

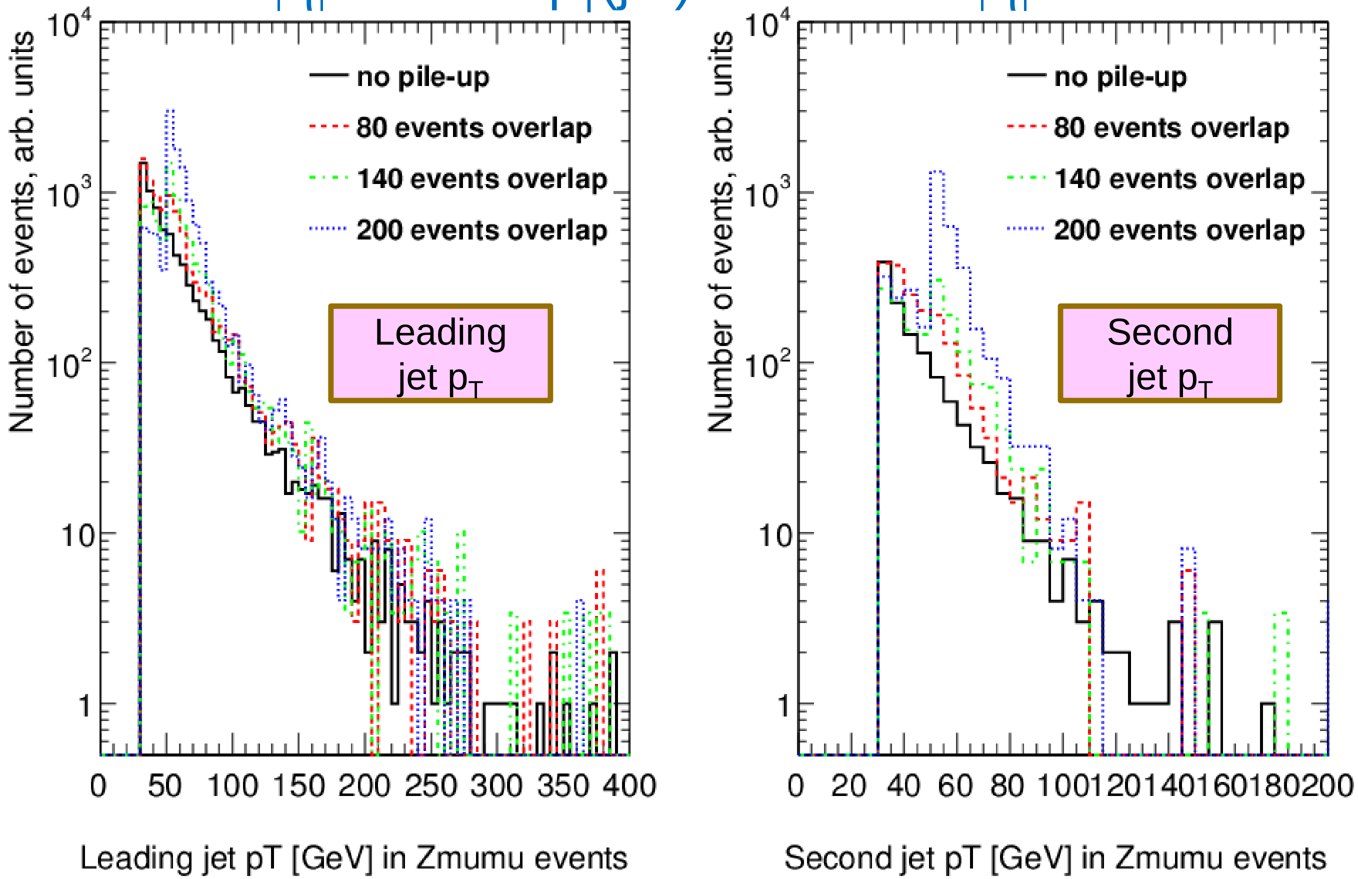
Table shows fractions of events after **soft VBF selections** survived additional cut on forward jet p_T >70GeV and on central jet p_T : **13 TeV MC**

Process/ coverage	**H 125 GeV**	**H ggF 125 GeV**	**H VBF 125 GeV**	**WW BGR**	**Real data**	**Top BGR**
Nominal	1	1	1	1	1	1
p_T(ce)>30	0.63	0.54	0.67	0.54	65/107	0.61
p_T(ce)>40	0.47	0.33	0.52	0.31	54/107	0.44
p_T(ce)>50	0.34	0.20	0.39	0.20	38/107	0.32
p_T(ce)>60	**0.26**	**0.17**	**0.29**	**0.15**	**28/107**	**0.20**

- A bit larger loss of BGR w.r.t. signal, data/MC is ok
- WW BGR is reduced roughly the same way as top BGR
- With cut like in scoping document signal reduction factor is about 4!

Jet p_T-spectra for $Z \to \mu\mu$ vs μ

p_T(jet)>**50** GeV at $|\eta|$>2.5 and p_T(jet)>**30** GeV at $|\eta|$<2.5



Increase of p_T at high μ due to forward jets from pile-up

Normalization: after selection of events with two good muons

Results for SM Higgs boson

Table shows fractions of events after **hard VBF selections** survived the additional cut on the jet coverage: **13 TeV MC**

Process/ coverage	H 125 GeV	ggF H 125 GeV	VBF H 125 GeV	WW BGR	Real data	Top BGR
$\lvert\eta\rvert<4.5$	1	1	1	1	1	1
$\lvert\eta\rvert<4.0$	**0.81**	**0.92**	**0.79**	**0.78**	**24/27**	**0.87**
$\lvert\eta\rvert<3.7$	0.67	0.89	0.64	0.63	21/27	0.75
$\lvert\eta\rvert<3.5$	0.52	0.55	0.51	0.50	17/27	0.64
$\lvert\eta\rvert<3.3$	**0.39**	**0.32**	**0.40**	**0.41**	**17/27**	0.57
$\lvert\eta\rvert<3.2$	0.33	0.30	0.34	0.32	17/27	0.51

- Smaller loss of BGR w.r.t. signal, data/MC is ok
- Top background is a bit less affected than WW background
- Reduction of signal and BGR rates is a bit stronger than at 8 TeV