Universidad de Oviedo
Universidá d'Uviéu
University of Oviedo

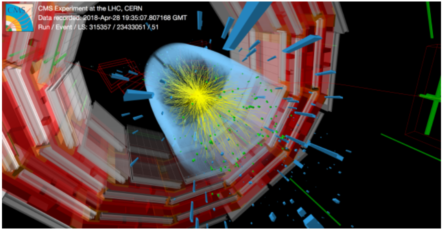
SERGIO SÁNCHEZ CRUZ
(ON BEHALF OF THE ATLAS AND
CMS COLLABORATIONS)

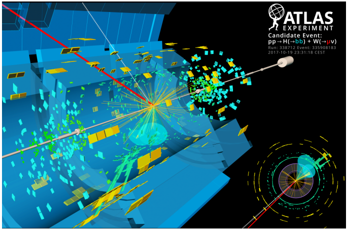
TOP2018 (Bad Neuenahr)

PERFORMANCE AND TOP QUARKS AS A CALIBRATION TOOL

Outline of the presentation

- Status of the ATLAS and CMS experiments
- Object performance of the experiments
- Usage of top quark events as calibration tools



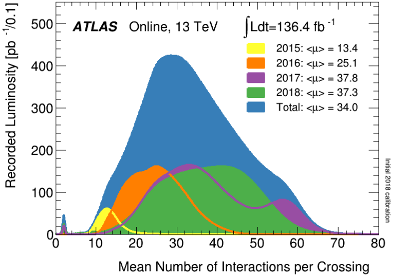


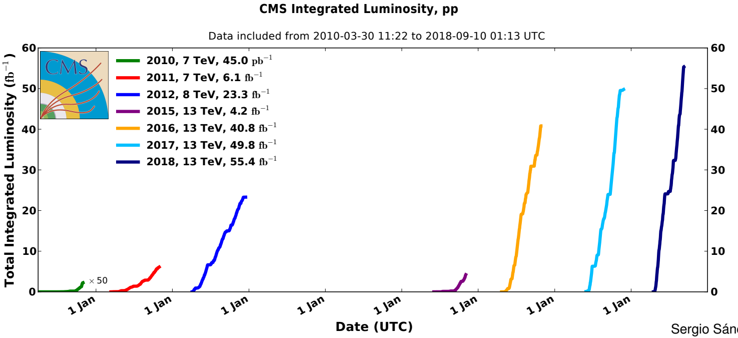
Section 1

Status of the ATLAS and CMS experiments

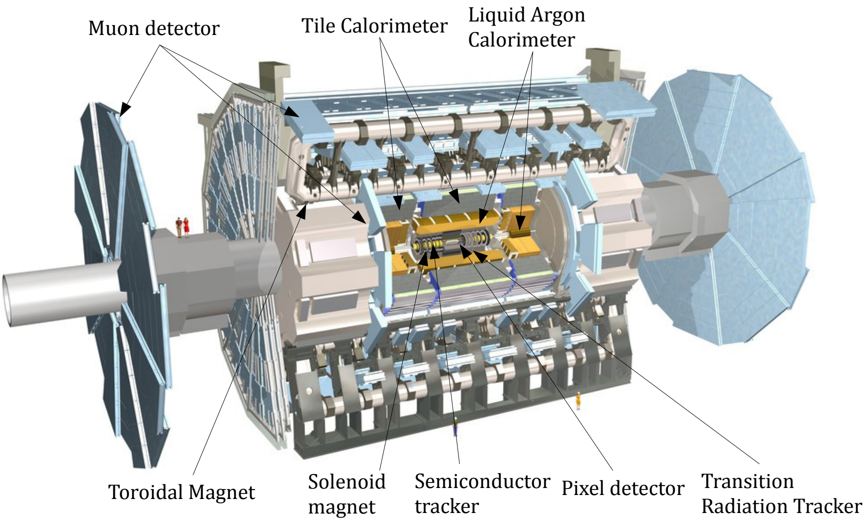
INTRODUCTION

- Excellent performance of the LHC since 2012
- Expectation to deliver 150 fb^{-1} during Run 2
  - Target almost achieved
  - More than 55 fb^{-1} delivered in 2018
  - Still a month of data taking
- Many thanks to the LHC team

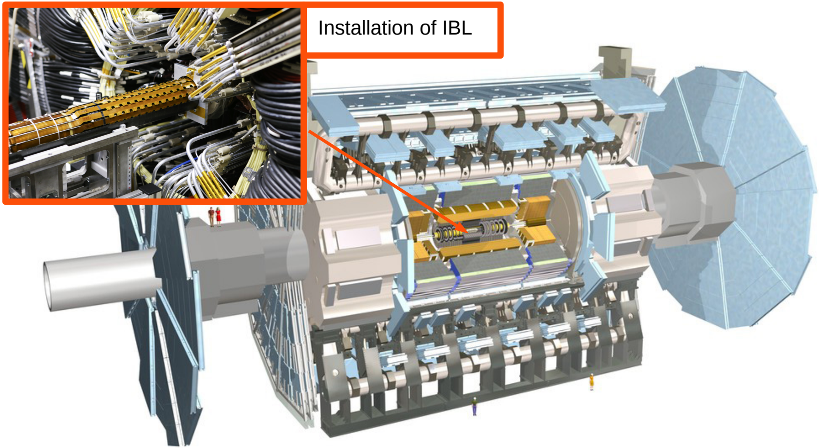




ATLAS DETECTORS



UPGRADES IN ATLAS

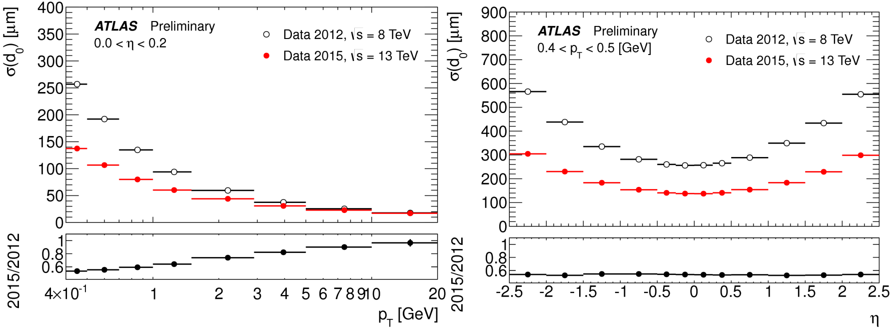


- Consolidation of the detector and trigger before run II:
  - Installation of the Insertable B Layer (IBL) (2014)
  - Additional muon chambers in the extended endcap region (1.1 $< \eta <$ 1.3) (2013)
  - Developments in trigger: topological L1 that allows to correlate objects from muon and calorimeter triggers (2015)

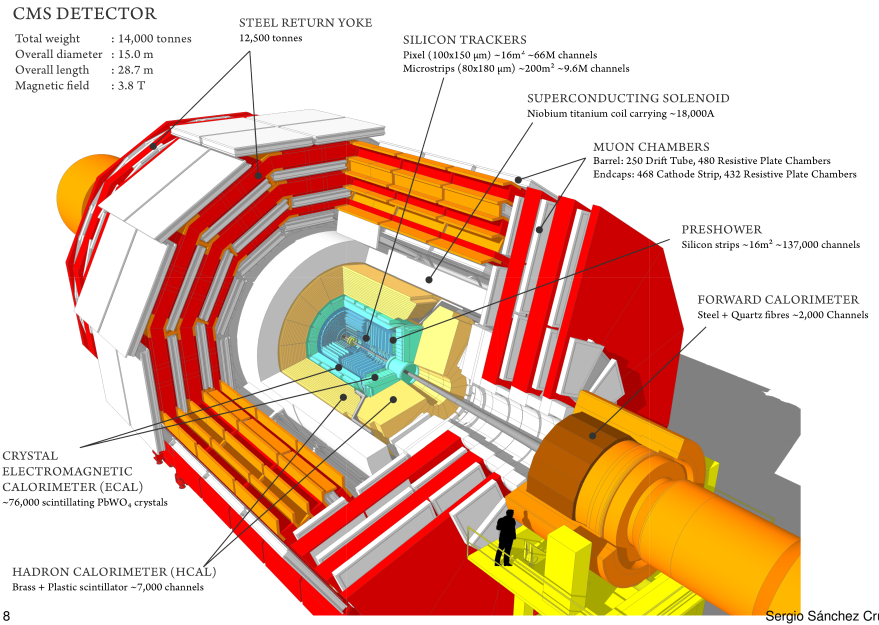
ATLAS PIXEL UPGRADE

IDTR-2015-007

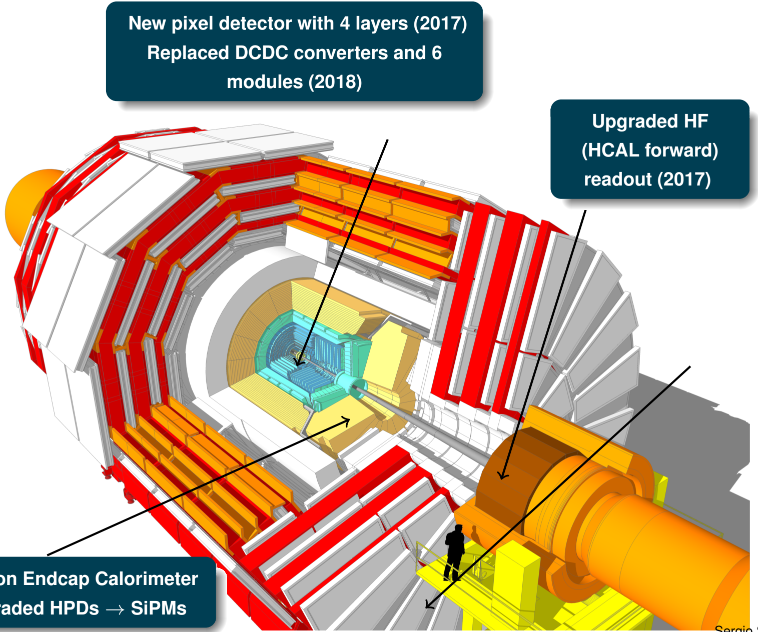
- Insertion of the IBL provides improved track parameter resolution
  - Important for b-tagging performance
- Additional redundancy if failures in some pixel layers occur



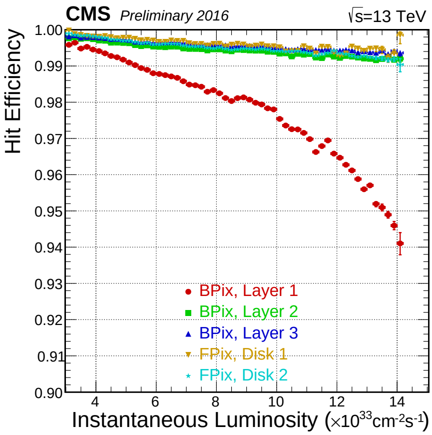
CMS DETECTOR

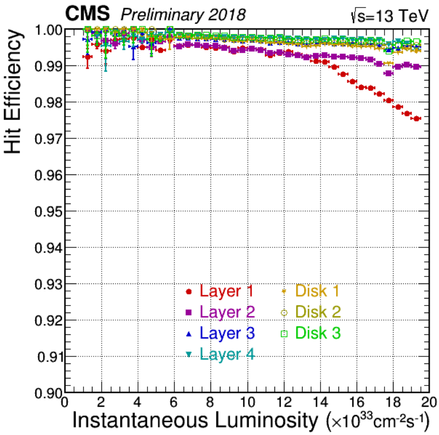


CMS DETECTOR



CMS PIXELS

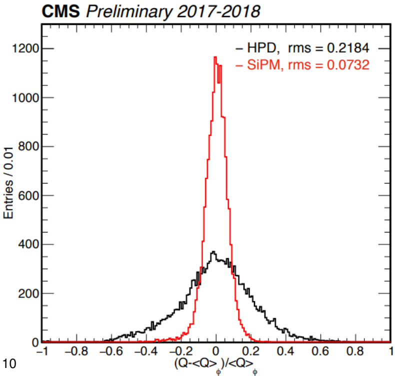




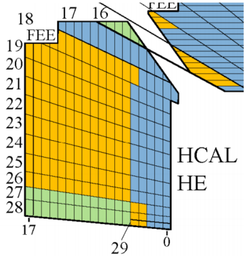
- Installation of a new pixel detector completed in 2017
- Significant increase of tracking efficiency

CMS Hadronic calorimeter upgrade

- Upgrade of the HCAL endcap (HE) front-end and electronics ($1.3 < |\eta| < 3.0$)
- Replacement of Hybrid photodetectors to silicon photomultipliers
- Several improvements thanks to the upgrade
  - Higher longitudinal segmentation
  - Better signal-to-noise ratio



2017



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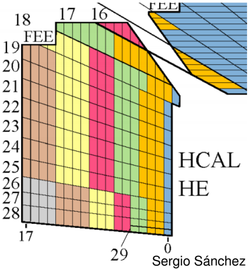
2018

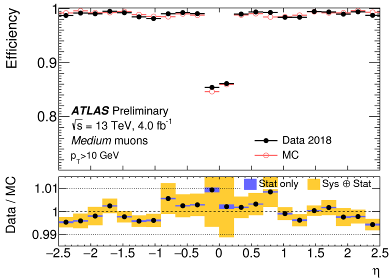


Section 2

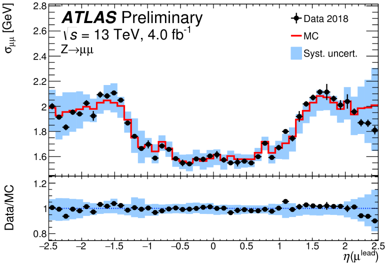
Object performance of the experiments

ATLAS MUON PERFORMANCE

ATLAS-MUON-2018-001



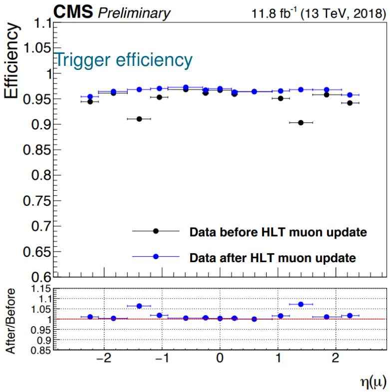
- Efficiency for muon identification in 2018
- Measured in using tag-and-probe in $\mu\mu$ events
- Efficiency consistent with simulations



- Resolution of dimuons as a function of η in 2018
- Measured by evaluating the smearing of the Z peak produced by the detector
- Good resolution, particularly in the central region

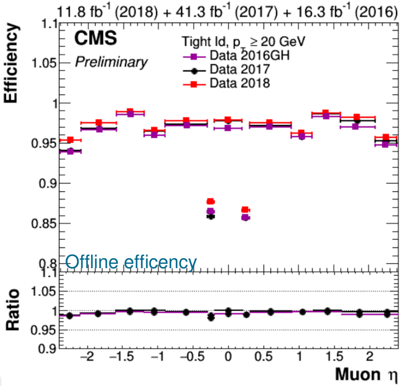
CMS Muon performance

CMS-DP-2018-042



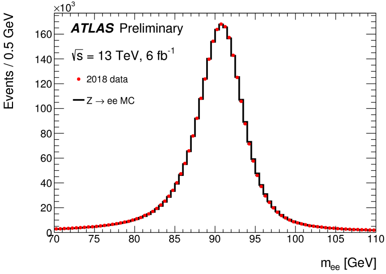
- Introduced enhanced trigger strategy in 2018
- Efficiency measured in $\mu\mu$ events
- Significant efficiency recovery in localized η regions

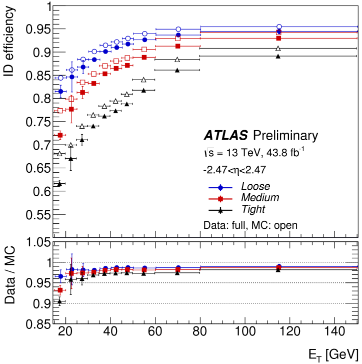
- Evolution of muon identification criteria during Run 2
- Efficiency measured in $\mu\mu$ events
- Overall very stable
- Marginal increase of efficiency in 2018



CMS-DP-2018-034

ATLAS ELECTRON PERFORMANCE



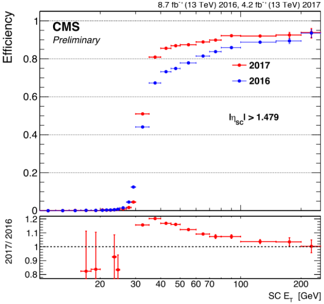


- Excellent resolution in energy of di-electron in Drell-Yan events
- Consistent with expectations

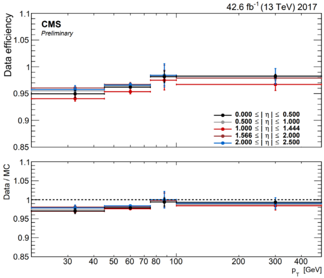
ATLAS-EGAM-2018-003

- High electron reconstruction and identification efficiency
- Measured with tag-and-probe in *ee* events
- Different working points studied, consistent with expectations

CMS ELECTRON PERFORMANCE



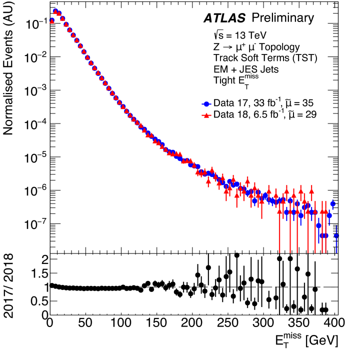
- Significant increase of lepton trigger efficiency in 2017
- Total rate of the same order
- Mainly due to new pixel detector

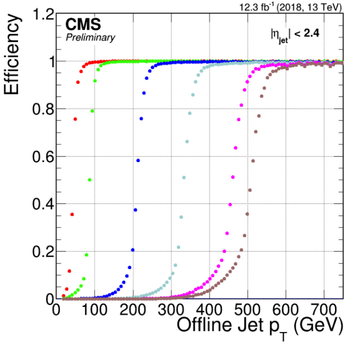


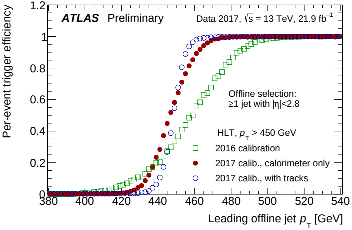
- Good lepton efficiency in 2017 data
- Measured with tag-and probe in ee events

CMS-DP-18-017

Jets and MET performance



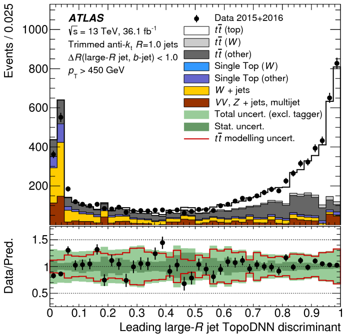


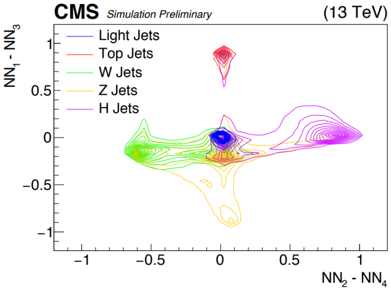


- Stable performance of the MET resolution in ATLAS
- Excellent performance of the jet triggers in ATLAS and CMS in 2017 and 2018

Boosted objects

- Decay product of particles are collimated into a single jet at high p_T
- Multivariate analysis techniques employed to indentify such jets
- DNNs developed by the two collaborations to distinguish among the different flavors
  - Exploit jet mass reconstruction and jet substructure





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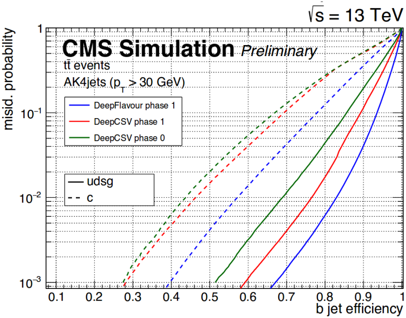
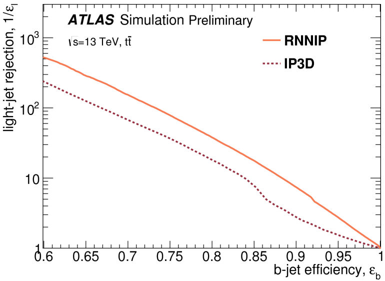
CMS-DP-2017-027

B-TAGGING PERFORMANCE



- Excelent *b*-tagging performance
- Significant gain with the addition of the pixel layer
- Higher performance of deep flavor discriminant



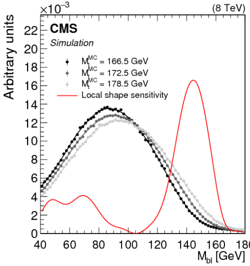
- Comparison of *b*-tagging algorithms
- Significantly better performance of RNNIP
  - RNN exploiting correlation of track impact parameters

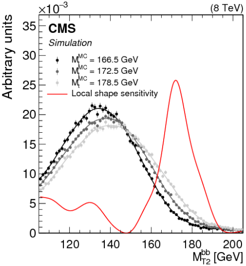
Section 3

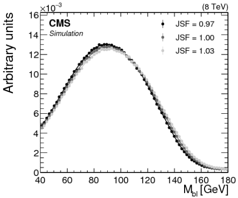
Top quark events as calibration tools

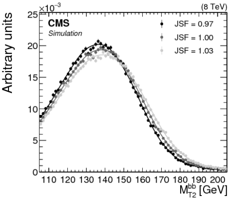
In-situ parameter dermination (I)

- Some top analyses provide in-situ determination of relevant parameters
- Top mass measurements are quite affected by jet energy scale
- Dileptonic 8 TeV measurement used as an example
  - In-situ determination methods are used in other CMS and ATLAS analyses









- Simultaneous fit to M_{bl} and M_{T2}^{bb}
  - Variables differently sensitive to jet resolution and m_t
- 1D fit, 2D fits and hybrid fit are performed
- $JSF^{2D} = 1.011 \pm 0.015$
- Hybrid: $m_t = 172.22 \, ^{+0.89}_{-0.93}$ GeV
- 1D fit: $m_t = 172.39 \, ^{+0.91}_{-0.95}$ GeV

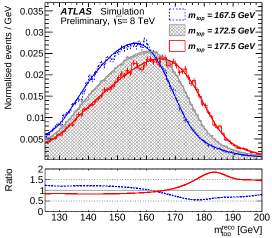
PhysRevD.96.032002

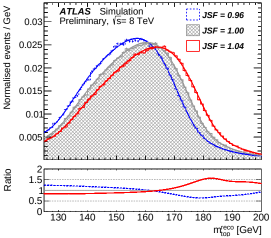
In-situ parameter determination

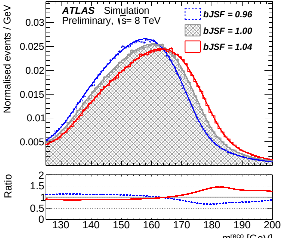
ATLAS-CONF-2017-071

Top mass

- Similar approach used previously by ATLAS
- Two free parameters taken into account: JSF and bJSF
- Different topology and variables used



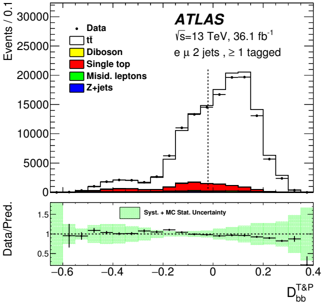


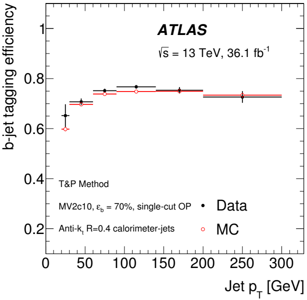


- m_t = 172.08 $\pm$ 0.91 GeV
- JSF = 1.005 $\pm$ 0.001
- bJSF = 1.008 $\pm$ 0.005S

Calibration - btagging

- Tag-and-probe method can be applied in $e\mu$ events to assess b-tag performance in data
- $t\bar{t}$ enriched region is selected and an MVA to select b-jets





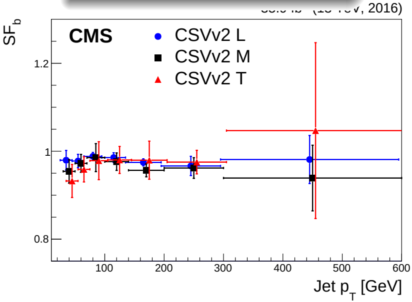
- Modeling uncertainties are dominating, JES relevant at low and high p_T
- Alternative combinatorial likelihood method uses events with one and two b-tagged jets
- Events with 1 and 2 b-jets written as a function of ϵ_b and ϵ_j
- Solved by maximizing likelihood
  - Comparable results

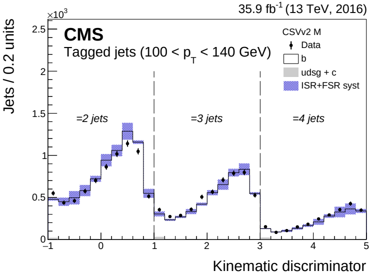
JHEP08(2018)089

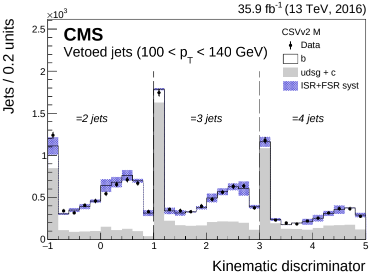
CALIBRATION - BTAGGING

JINST 13 (2018) P05011

- $t\bar{t}$-enriched region is build in the $e\mu$ channel
  - Additional criteria imposed in $m_{e\mu}$ and E_T^{miss}
  - Discriminant based on event topology to tag the b-jets
- Measurement also performed in single lepton events
  - Full reconstruction of the $t\bar{t}$ system is possible





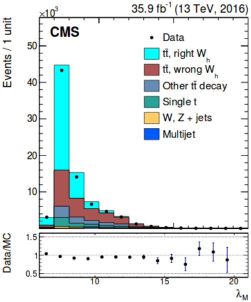


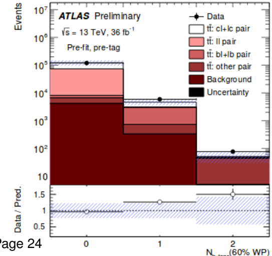
Calibration

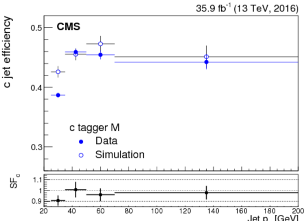
c-(mis)tagging

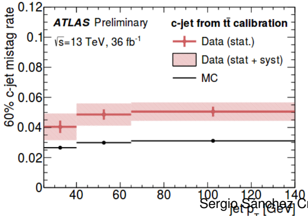
JINST 13 (2018) P05011
ATLAS-CONF-2018-001

- Efficiency of tagging algorithms is relevant
  - Testing c-tagging algorithm
  - Evaluation of mistag in b-tagging
- About 50 % of hadronic W decay into c
- Different methods are used to estimate the hadronic W yield in semileptonic $t\bar{t}$ events
- Categories are built depending on the number events passing tagging criteria
- c-tagging efficiencies are parameterized and determined

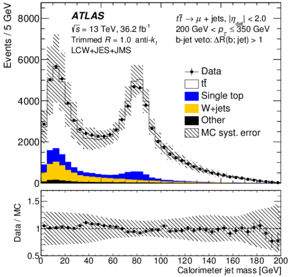


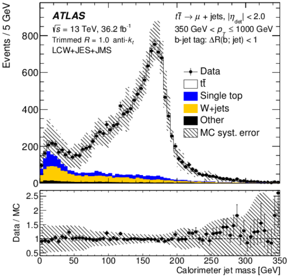


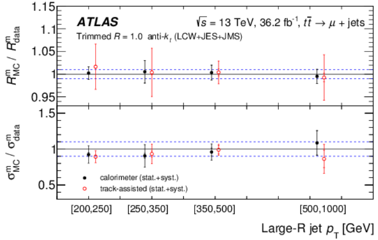




RESPONSE AND RESOLUTION OF LARGE R JETS







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- In-situ determination of jet energy and response using top and W masses
- Single muon events with a jet and a large jet selected
- Mass of the large R jet is used to calibrate the response and resolution

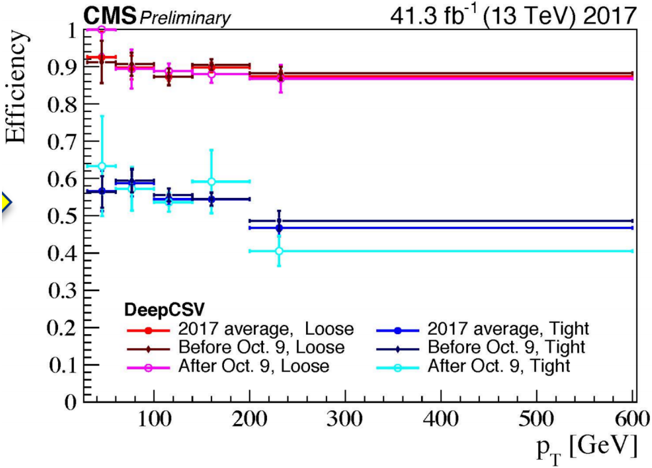
CONCLUSIONS

- Upgrades in the detectors have been successfully installed
- ATLAS and CMS are taking good data during run 2
- Many high quality results are expected
- Reviewed a couple of examples of $t\bar{t}$ topologies are used as calibration tool
- Knowledge of $t\bar{t}$ topologies allow to determine experimental parameters such as JES, or *b*-tag efficiencies

Back-up

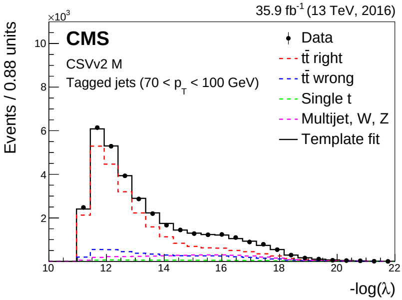
CMS PIXEL FAILURE

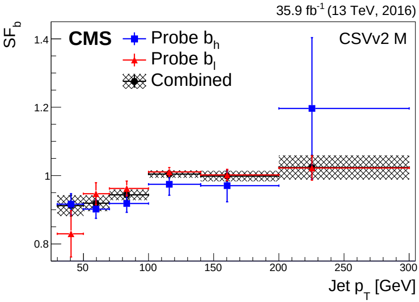
- About 5% of the DC/DC power units of the pixel failed in late 2017
  - Effect of the failures in the data quality is marginal
- Failure mechanism of the chips has been understood
  - Related to radiation
  - More robust design has been developed
  - Mitigation strategies have been followed so 2018 data is not affected



Calibration - btagging

- Tag-and-probe method is used in the single lepton channel
- Full reconstruction of the $t\bar{t}$ event allows to assign jets to quarks using a maximum likelihood test
- E_T^{miss} and likelihood are fitted to extract the signal yield





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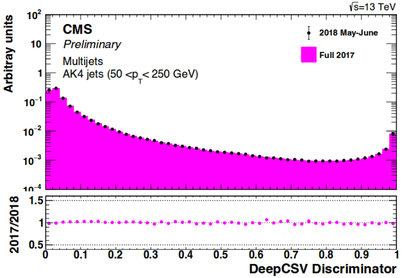
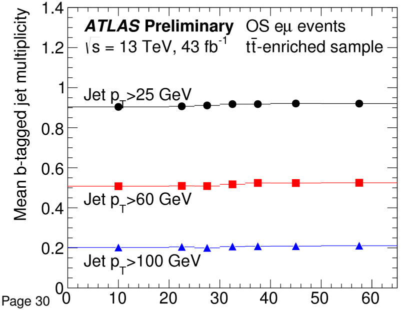
B-TAGGING PERFORMANCE



CMS-DP-2018-033

- DeepCSV discriminant combines information from secondary vertex and information from tracks of the secondary vertex
- Very stable along the years



- *b*-jet multiplicity as a function of number of interactions
- Very robust discriminator against pile-up

ATLAS-FTAG-2017-008