UBA @ ATLAS

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The group at UBA has specialized in the area of jets/b-jets at the three levels of the ATLAS data processing chain

Data taking (*trigger*):

- L1 (hardware): Measurement of the b-jet trigger efficiency using FTK tracks
- HLT (software): tuning of b-jet trigger and improvement of jet trigger efficiency

Data reconstruction (*performance*):

- Jet energy calibration and resolution
- Identification of W-bosons using jet substructure
- Identification b-jets produced via gluon splitting ($g \to b\bar{b}$)

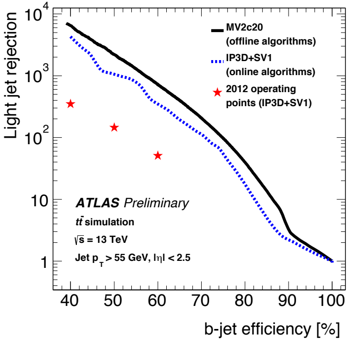
Data analysis (*physics*):

- Precision measurements of QCD jet cross sections:
  - Inclusive jets (see G. Marceca's talk tomorrow)
  - Dijets (see G. Marceca's talk tomorrow)
  - Multijets
- Searches
  - Supersymmetry: 3bjet+0lepton or multijets final states
  - Exotics: extra dimensions, composite quarks, DM, FC Higgs couplings

TRIGGER

Tuning of b-jet trigger

- Jet is tagged by applying a likelihood ratio test on discriminant variables
- Algorithm is tuned to achieve predefined tagging efficiency points
- Large improvement of b-jet trigger performance between Run 1 and Run 2
- Offline efficiency is higher because of more sophisticted tracking



twiki.cern.ch/twiki/bin/view/AtlasPublic/BJetTriggerPublicResults

Improvement of the jet trigger performance in 2017

Methodology:

- Jet energy corrected using longitudinal structure of the calorimeter shower and tracking information

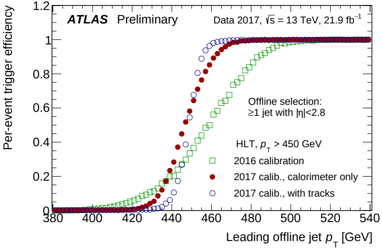
Consequence:

- Trigger efficiency rises much more rapidly

Application:

- Higher fraction of useful events for a given trigger rate

Trigger efficiency vs leading jet p_T

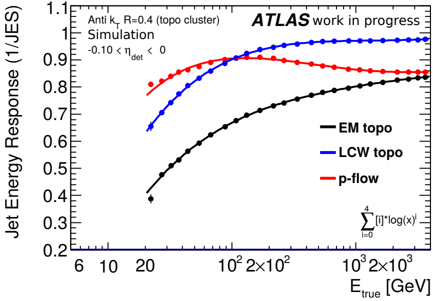


twiki.cern.ch/twiki/bin/view/AtlasPublic/JetTriggerPublicResults

PERFORMANCE

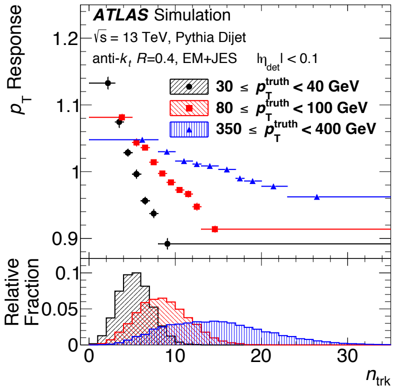
MC-based jet energy calibration

- Jets are reconstructed from different constituents
- Response: Average fraction of the true jet energy measured at calorimeter level
- The jet energy is corrected by 1/Response



Global sequential calibration

- Jet response depends on variables sensitive to particle composition and distribution of energy in the jet (for instance, number of tracks, n_{trk})
- Resolution improves after correcting for this effect



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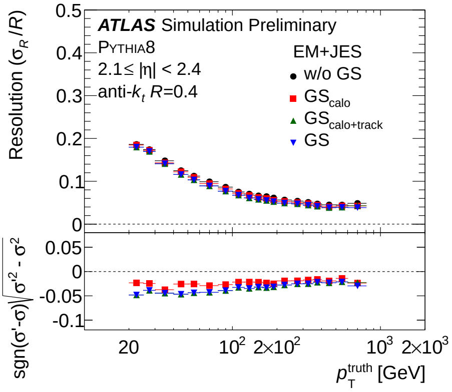
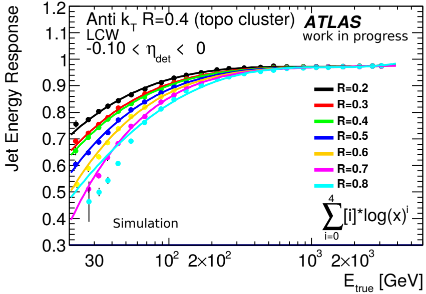


ATLAS-CONF-2015-002

Calibration of jets of different sizes



Our group leads the team deriving the data-driven jet energy calibrations for anti-k_t jets with $R = 0.2$ and $R = 0.6$

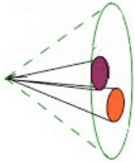
Applications:

SM precision measurements:

- Allow direct comparison with CMS
- Help to understand R=0.4 vs R=0.6 data/theory differences
- Constrain hadronisation and UE models (non-perturbative effects)

Jet substructure:

- Reclustering of large-R jets from R=0.2 jets:
  intrinsic pile-up subtraction and per-subjet calibration



Searches:

- Improve signal acceptance of analyses, like h→aa→bbbb

PHYSICS

Search for new phenomena in high-mass final states with a photon and a jet from *pp* collisions at $\sqrt{s} = 13\,\text{TeV}$ with the ATLAS detector

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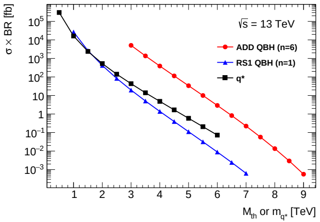
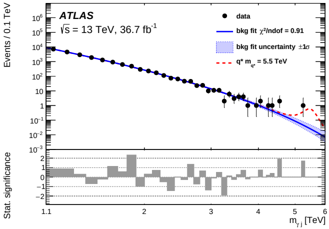
Search for high-mass γ+jet resonances

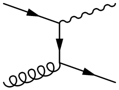
- Signals:
  - Evaporation of non-thermal quantum black holes:
    - QBH ADD with 6 extra dimensions (n=6)
    - QBH RS1 with 1 extra dimension (n=1)
  - Decay of excited quark (q^*)
- Complements dijets search



- Focus on s-channel production of a resonance
- Strategy: Search for bump in the steeply falling background from SM $\gamma +$ jet production



- Main background: SM t-channel $\gamma +$ jet production



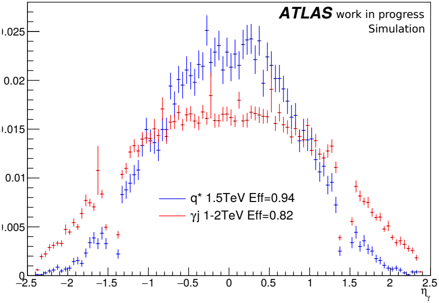
Selection

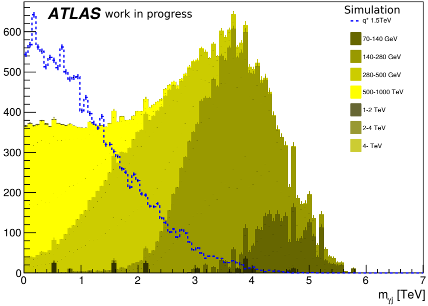
Only some examples

Cuts to improve signal-to-noise ratio:

$|\eta^{\text{photon}}| < 1.37$

$\Delta\eta(j,\gamma) < 1.6$





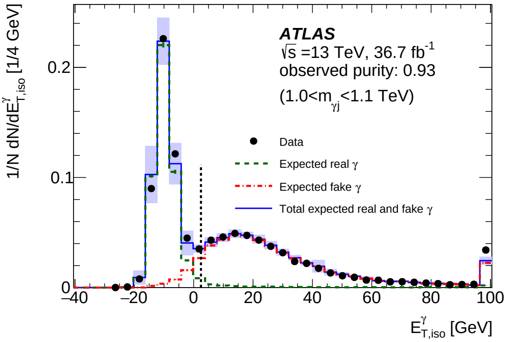
Highest p_{T} photon and jet candidates are taken

Purity Measurement

True and fake photon contributions evaluated with template fit on photon isolation distribution ($E^{\gamma}_{T,iso}$):

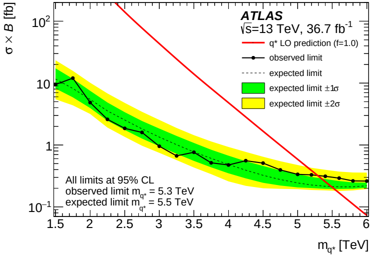
- Fakes: Data in a CR (orthogonal to SR)
- True photons: MCs
- $E^{\gamma}_{T,iso} = E_{T,iso} - 0.0022 \times E^{\gamma}_{T}$
- $E_{T,iso}$: Energy around the photon within $\Delta R = 0.4$.
- The purity is $\sim 92\% \pm 4\%$

Template fit

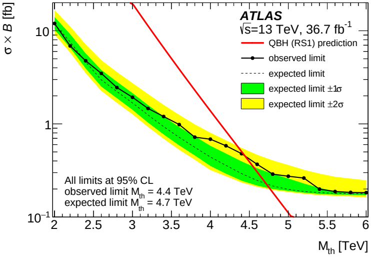


Upper limits on cross-sections and lower limits on the masses

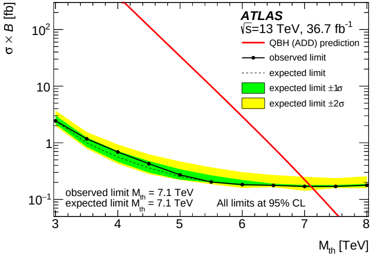
q^*



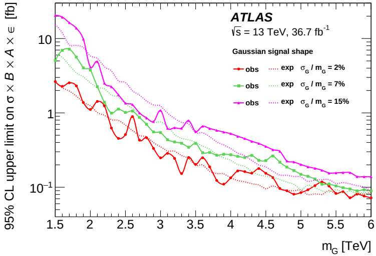
RS1



ADD



Gaussian signals



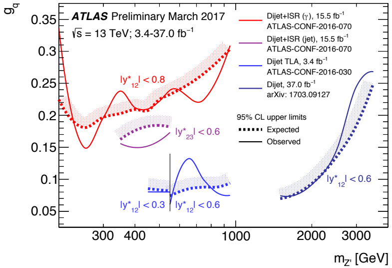
- No significant deviation from the background-only hypothesis is observed
- Cross-section limits for generic Gaussian-shaped resonances are extracted

Two analyses in progress:

1. Search for resolved dijet resonances produced in association with a photon or a jet
2. Search for flavour-changing Higgs couplings

1. Resolved Dijet+ISR

ATLAS searches for DM mediators

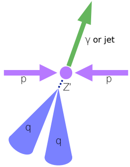


Traditional high-mass dijet search:

- Low-mass reach limited by jet trigger prescales

Alternative:

- Resolved Dijet+ISR, 4 channels:
  - Trigger on ISR object: γ or jet
  - Dijet system: $b\bar{b}$ or inclusive



Scope of Dijet+ISR search:

- Search for new particles decaying into a pair of jets
- Alternatively:
  - Set model-specific limits on $m_{Z'}$ using MC signals
  - Set model-independent limits for reinterpretation using Gaussian shapes

Previous preliminary results but never published by ATLAS or CMS

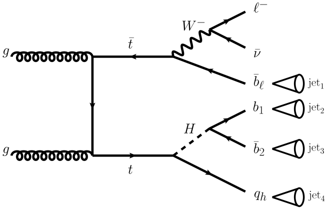
2. Flavour-changing Higgs couplings

Motivation:

- Search for *Htq* FC coupling
- CMS reported 2.4σ in $H \to \mu\tau$
- SM BR($t \to Hc$) $\sim 10^{-15}$
- In 2HDM BR $\sim 10^{-3}$

Strategy:

- Event selection: MET+lepton+4jets (2 b-jets)
- Top and Higgs mass constrains
- Main background: $t\bar{t}$ semileptonic



Conclusions

Extensive range of activities in jets/b-jets by the Buenos Aires group in ATLAS

Trigger

- Tuning and measurement of efficiency of b-jet trigger.
- Optimization of jet trigger bandwidth through improvement of resolution.

Performance:

- Identification of gluon-splitting b-jets and boosted W-boson large-R jets using machine learning MVA techniques.
- Ample involvement in jet energy calibration and resolution, coordinators of the data-driven effort to calibrate jets of different sizes.

Physics:

- Main analysts of the QCD precision measurements on the inclusive, dijet-mass and multijet production cross-sections.
- Search for exotic particles in the γ+jets and dijets+ISR channels, and BSM FC Higgs couplings in the 4jets(3b)+lepton+$E_{\mathrm{T}}^{\mathrm{miss}}$ channel.
- Supersymmetry searches in two jet channels: 3bjet+0L and multijets.

Back-up slides

Search for new phenomena in high-mass final states with a photon and a jet from *pp* collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

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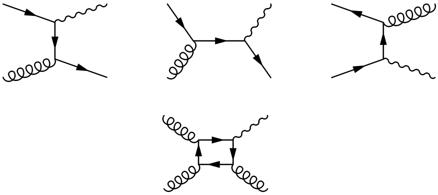
arXiv:1709.10440 [hep-ex]

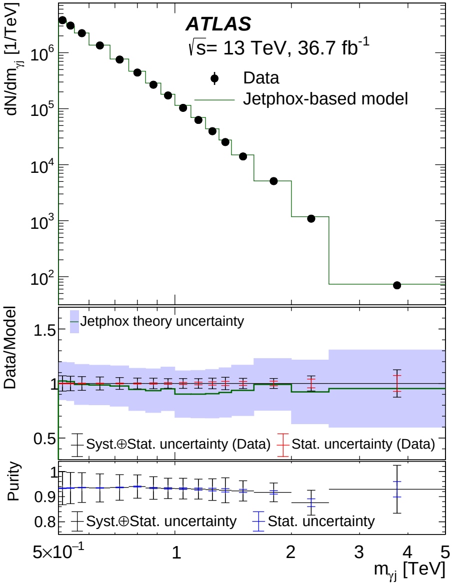
Background

- **Irreducible background:**
  - "Prompt" production:
    - Compton scattering of a quark and a gluon
    - quark-antiquark annihilation
    - gluon annihilation (not at tree-level)
  - "Fragmentation" production (multi-jet production):
    - Photons from hadron decays
    - Photons radiating off a quark



- **Reducible background:**
  - *Fakes:* Events with a jet but without a photon (for instance dijet events)
  - Significantly reduced by using tight photon ID and isolation selection

Purity-corrected $m_{\gamma j}$ distribution vs theory prediction



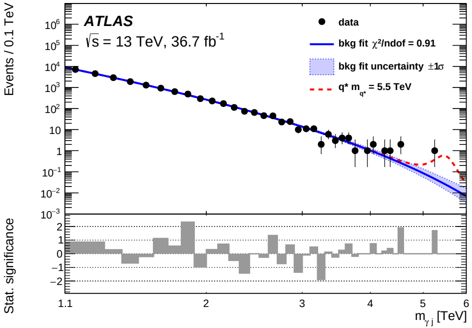
Background Modelling

Fit function to data:

$$f_b(x \equiv \mathrm{m}_{\gamma j}/\sqrt{s}) = p_a(1-x)^{p_b} x^{-\sum_{n=0}^{k} p_n \log^n x}$$

Allows to modify the functional form simply by adding or removing dof:

- $k = 0$ (1) is used for QBH (q^*) signal search



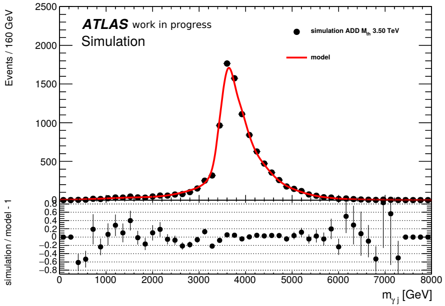
Uncertainty on the Background Modelling

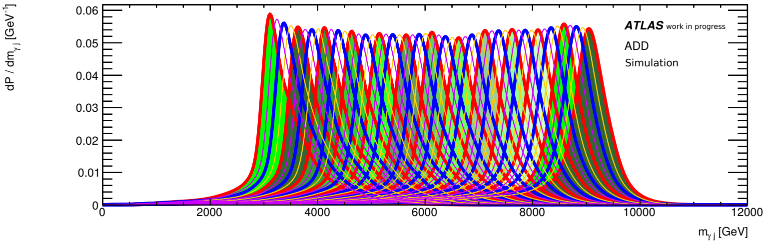
Non-closure from the choice of the functional form (spurious signal):

- σ_{spurious} evaluated with a s+b fit on bkg-only simulated dataset
- Number of signal events is taken as possible bias due to non perfect modelling of the background shape

Signal Modelling

- Non-parametric distribution at a certain mass point is estimated using a kernel density estimation (KDE)
- Global model created by morphing all the pdfs at fixed mass



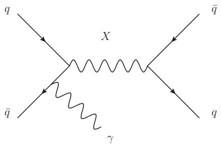


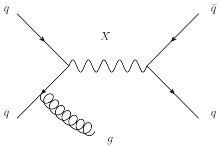
Search for resolved dijet resonances produced in association with a photon or a jet

(work in progress)

Analysis description

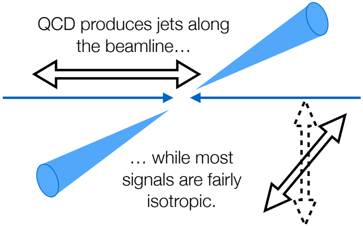
- Search for resolved dijet resonance in two channels:
  - Jets with no flavour requirement
  - At least two b-tagged jets
- High-p_{T} ISR object used for triggering
- ISR object can be a jet or a photon
  - Challenge in jet case: Which jet is ISR?
  - Factor to consider:
    - Efficiency for selecting correct jet pair in signal
  - Solution:
    - Consider leading p_{T} jet as ISR (appropriate until $\sim$ 700 GeV)
- Smooth background from QCD can be described by fitting data
- Upper range of the search set by dijet high-mass search
- Lower range set by point at which a single large-R jet is preferable to reconstruct the Z'

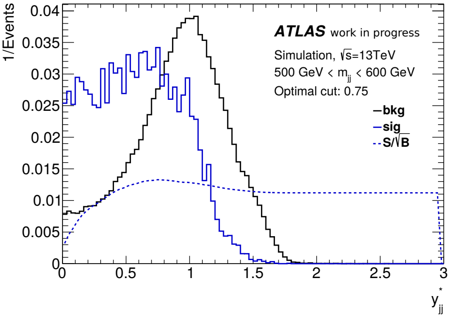




Cut to improve signal-to-noise ratio

$y^* < 0.75$





Limit setting cartoon

Photon ISR **Jet ISR**

Two triggers:

- Single photon: $170 < m_{jj}[\text{GeV}] < 300$
- Photon + three jets: $m_{jj}[\text{GeV}] > 300$