b-Tagged Dijets in 2016: *750 GeV?*

Laurie McClymont, Andreas Korn

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   - *Analysis Plan for LHCP 2016*

3) **Flavour Fraction and Fitting Studies**
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1) **Introduction to Analyses**

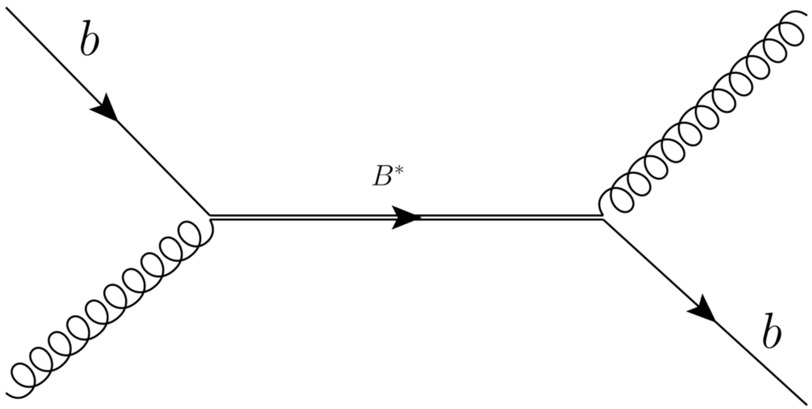
2) Future Plans for Analyses

3) Flavour and Fit Studies

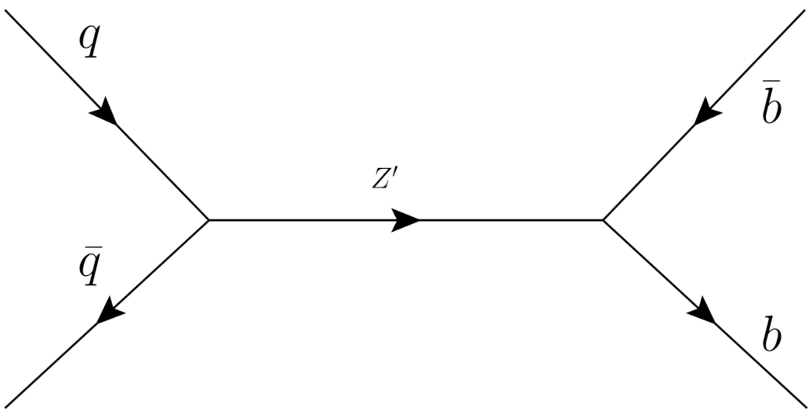
Exotic b-Tagged Dijet Motivation

- **Dijets are a powerful and general search for Beyond Standard Model Theories**
  - Exotic dijet resonant searches have been performed at ATLAS
  - They are sensitive to many BSM models (q*, QBH, W')

- **Many BSM models predict resonances that decay to b-quark(s)**



b*

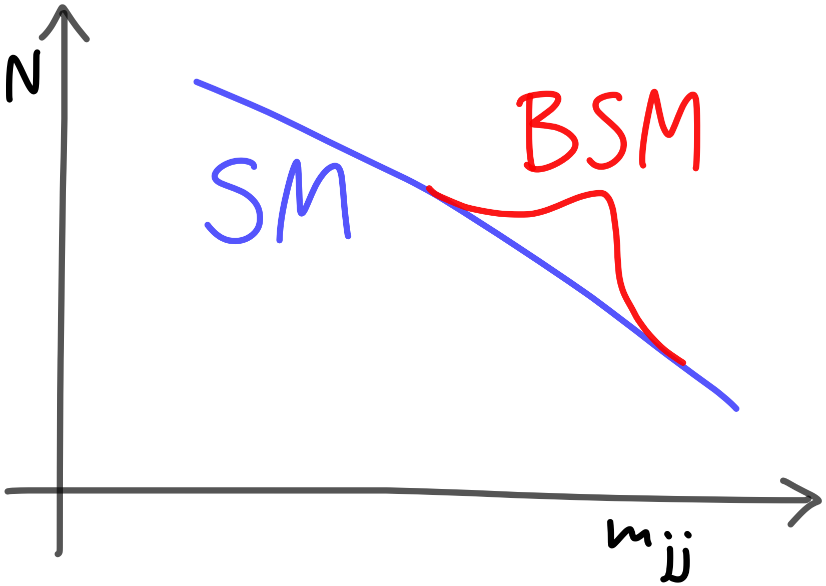


Z' Boson

- **b-Tagging Increases Sensitivity to Such Models**
  - QCD background is dominated by light jets *(light = u, d, s and gluon)*
  - b-Tagging can reduce the QCD background.
  - Increase sensitivity to such types of models

Analysis Strategy

- **Resonance Analysis**
  - Follow inclusive dijet search
  - Study dijet invariant mass



Two Steps:

- **Fit to Background**
  - Use smoothly falling function:

$$f(z) = p_1 (1 - z)^{p_2} (z)^{p_3}$$

where, $z = m/\sqrt{s}$

- **Search for Discrepancies from Fit**
  - BumpHunter algorithm is used
  - Finds most discrepant region
  - Find p-Value using pseudo-experiments

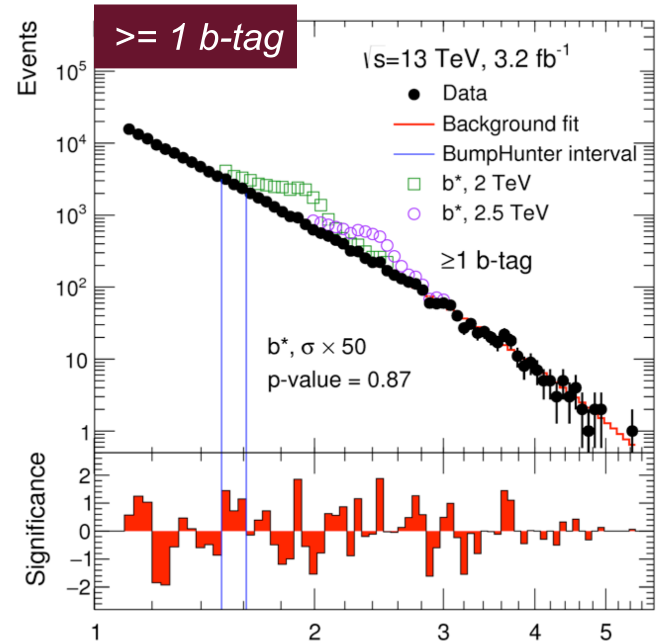
- **Moriond Result for b-Tagged Dijet Analysis**
  - First such analysis from ATLAS
  - 3.2 fb^{-1}, excluding IBL-off data

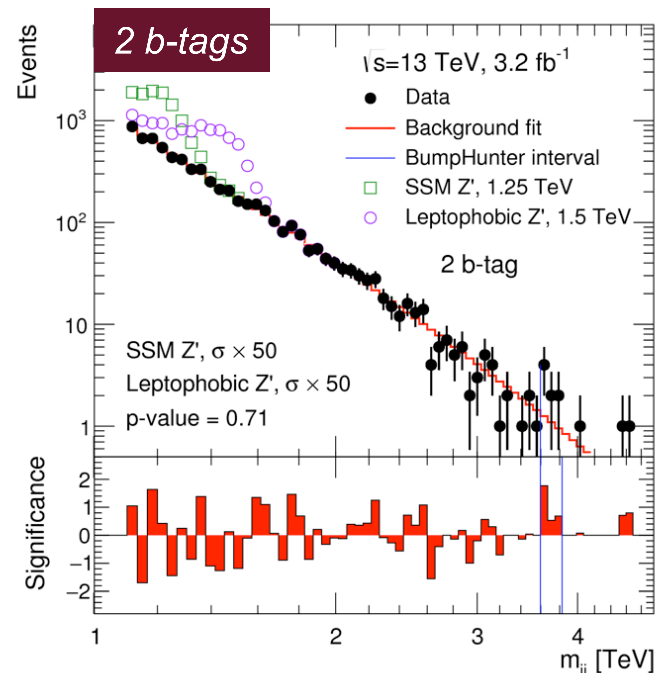
- **Event Selection** (Full list in backup)
  - **HLT_j360,** Lowest unprescaled trigger
  - **m_{jj} > 1.1 TeV,** On trigger plateau
  - **|y*| < 0.6**, *y*= 0.5 *Δy*
    - *Central region more sensitive to BSM*

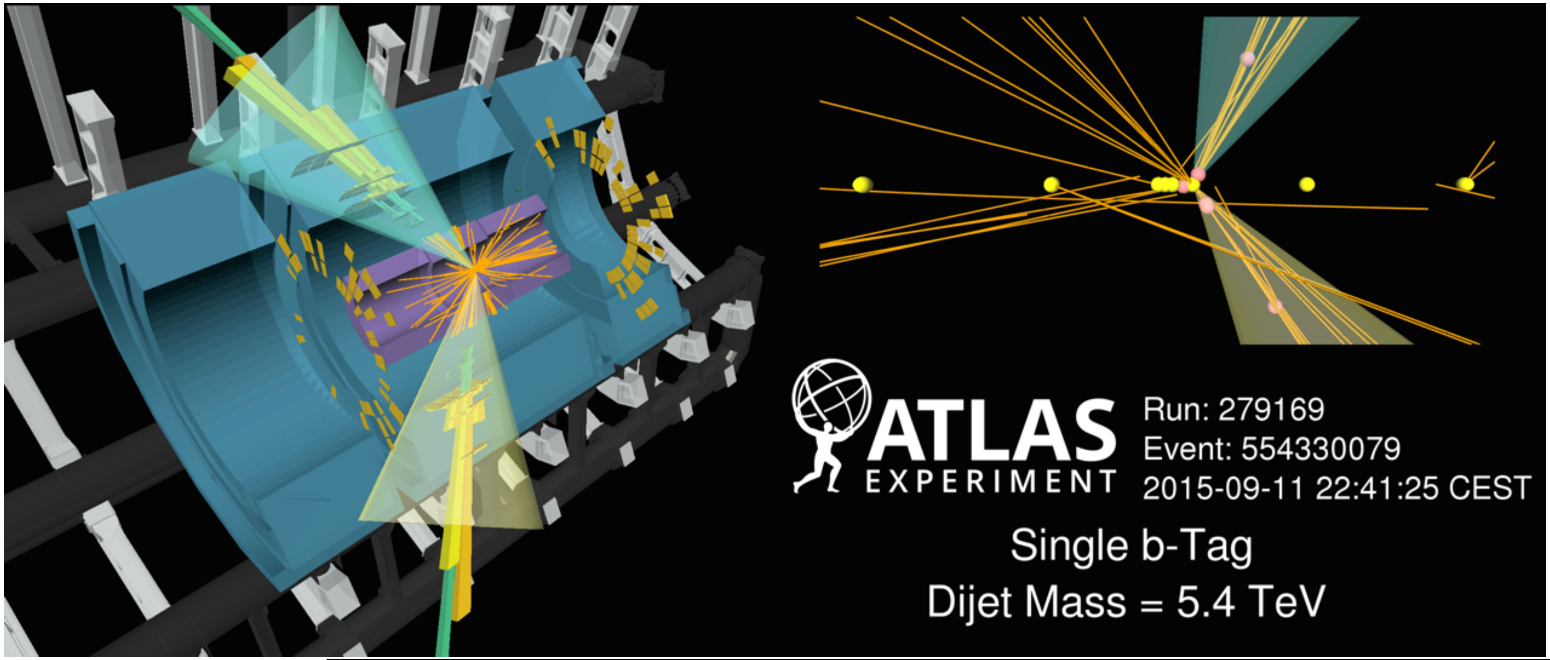
- **b-Tagging = MV2c20 @ 85% Eff. WP**
  - Two categories; >= 1 b-tag, 2 b-tag.

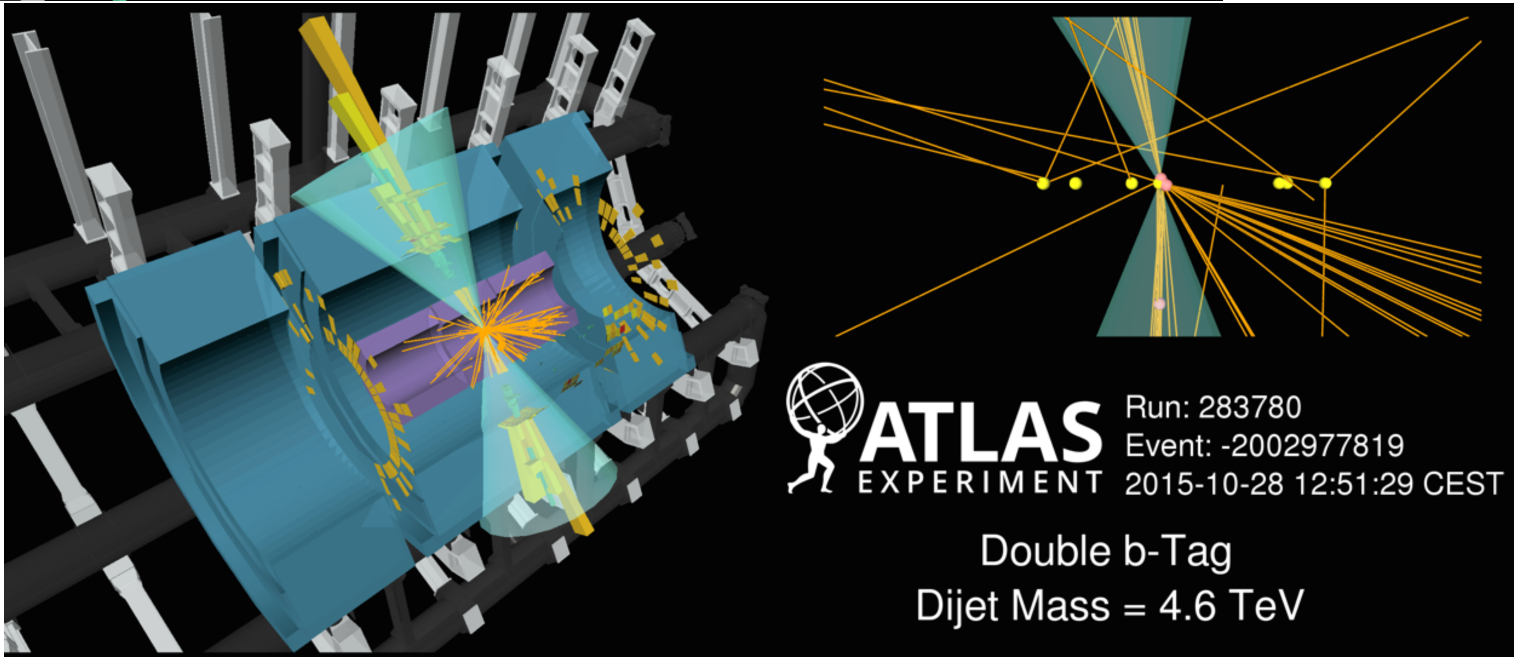
bumpHunter p-Values = 0.87, 0.71
(>= 1 b-tag, 2 b-tag)

Limits Set	ATLAS *13 TeV, 3.2fb^{-1}*	CMS *8 TeV, 3.2fb^{-1}*
b* Quark	2.1 TeV	1.54 TeV
Z' Boson	1.5 TeV *(Leptophobic)*	1.68 TeV *(Sequential SM)*






ATLAS
EXPERIMENT
Run: 279169
Event: 554330079
2015-09-11 22:41:25 CEST
Single b-Tag
Dijet Mass = 5.4 TeV


ATLAS
EXPERIMENT
Run: 283780
Event: -2002977819
2015-10-28 12:51:29 CEST
Double b-Tag
Dijet Mass = 4.6 TeV

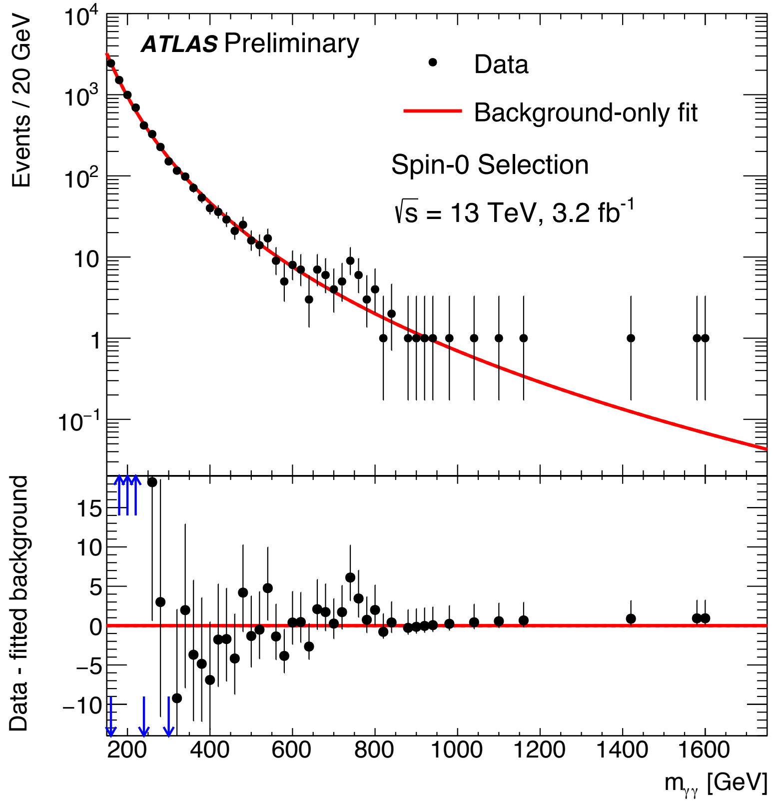
1) Introduction to Analyses

2) <u>Future Plans for Analyses</u>

3) Flavour and Fit Studies

Dibjet - 2016 Timescales

- **Motivation to go to lower masses**
  - **Cross over between γγ and bb?**
  - Weak limits on BSM in bb at low mass
    - Further discussion,
      e.g. arXiv:1512.04933
  - **We should study this region...**



- **Currently two parallel plans**

- **Reuse 2015 data for LHCP 2016**
  - **Focus on low mass, 750 GeV**
  - Fast paced analysis (13-18th June)

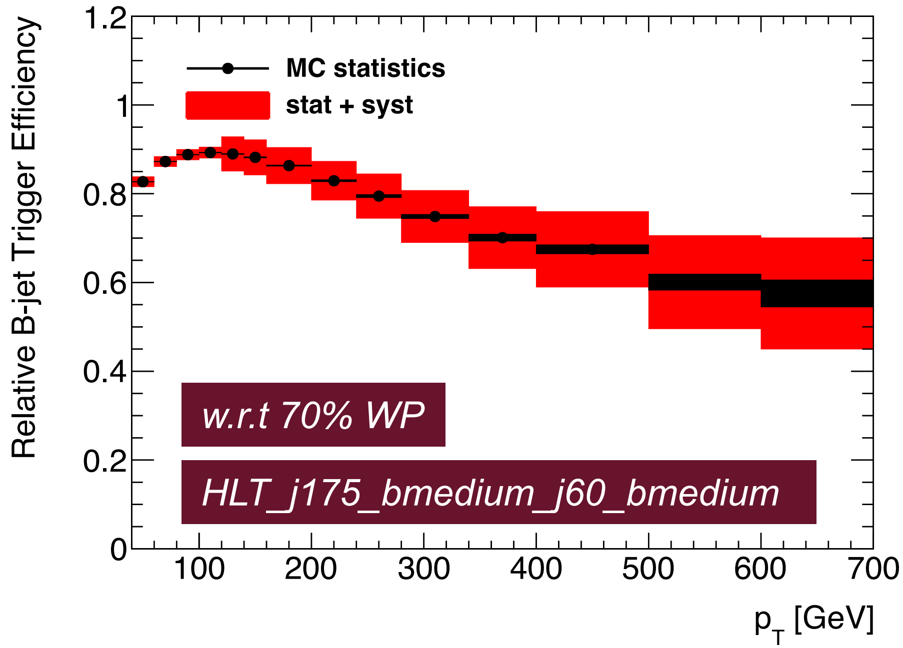
- **Use 2016 data for ICHEP 2016**
  - More luminosity; **High and low mass analyses**
  - More time for this analyses (3rd-10th August)

Extending to Lower Masses - bJet Triggers

- **We can get to lower masses**
  - 2015: limited by trigger usage.
  - Possible with use of new triggers

- **b-Jet Triggers**
  - **HLT_j175_bmedium_j60_bmedium**
  - Trigger on two onine b-tagged jets
  - We get to m_{jj} = 500 GeV

- **b-Jet Triggers have been studied**
  - b-jet trigger efficiencies exist
  - Derived using fully leptonic ttbar
    - Set of special b-jet triggers
    - Offline selection eμ and 2 b-jets



$$\text{b-Jet Trig Eff. wrt offline} = \frac{\text{\# b-Jets pass offline and online b-tagging}}{\text{\# b-Jets online b-tagging}}$$

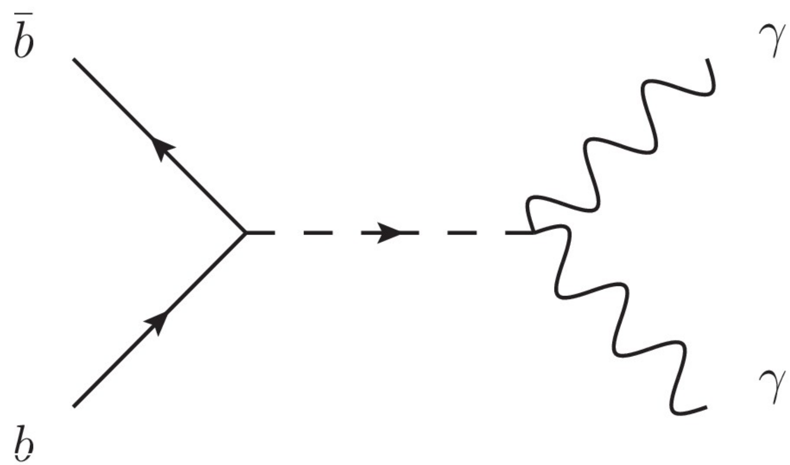
Sensitivity Study using b-Jet Triggers

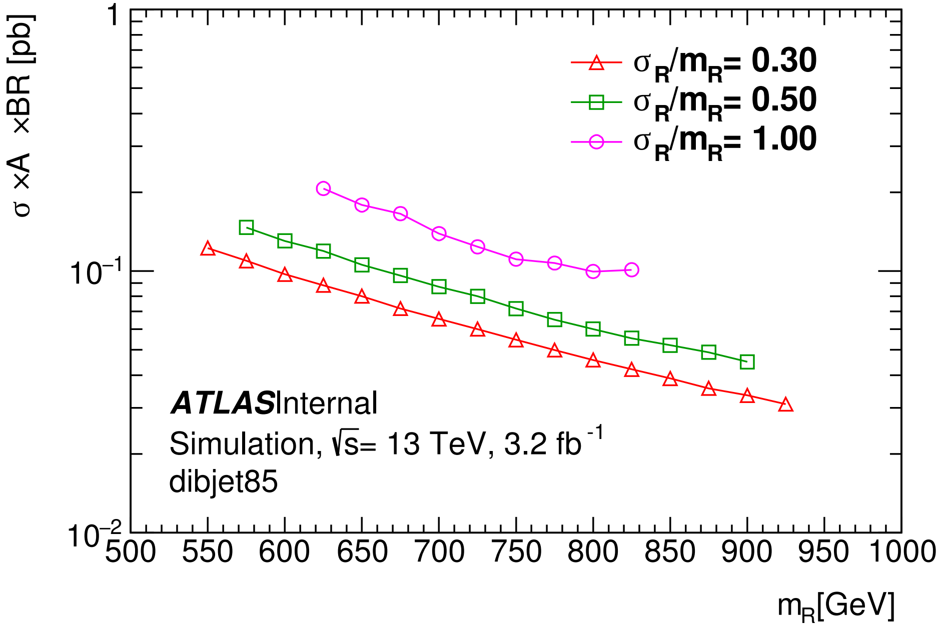
- **Consider simple scalar model**
  - **Couples to only γγ and bb**
  - Using ‘observed’ $\sigma_{\gamma\gamma}$ and Γ
  - We get $\boldsymbol{\sigma_{bb}}$ **~ 2.1 pb** for 13 TeV
  - No limit exists at $\sqrt{s}$ = 13 TeV

- **Quick sensitivity study on 2015 data**
  - Fit to data, **500 < m_{jj} < 1000 GeV**
    - **Blind 700-800 GeV**
  - ~10% acceptance (from Z’)
  - Find **expected** Gaussian limits
  - No systematics considered yet

- **Event Selection** (full list in backup)
  - **HLT_j175_bmedium_j60_bmedium**
  - **2 b-tagged jets (70% WP)**

- **σ_{bb} ~ 2 pb limit can be set (optimistic)**
- **We can try and exclude with 2015 data.**





1) Introduction to Analyses

2) Future Plans for Analyses

3) <u>Flavour and Fit Studies</u>

Introduction

Flavour fractions with just offline tagging

- Show that offline tagging doesn't sculpt background
- Show that after offline tagging we are have good bb purity
- Offline b-tagging gives upper limit on non-b flavour contribution

Why not include online tagging?
- Different WPs in MC and Data so not comparable!

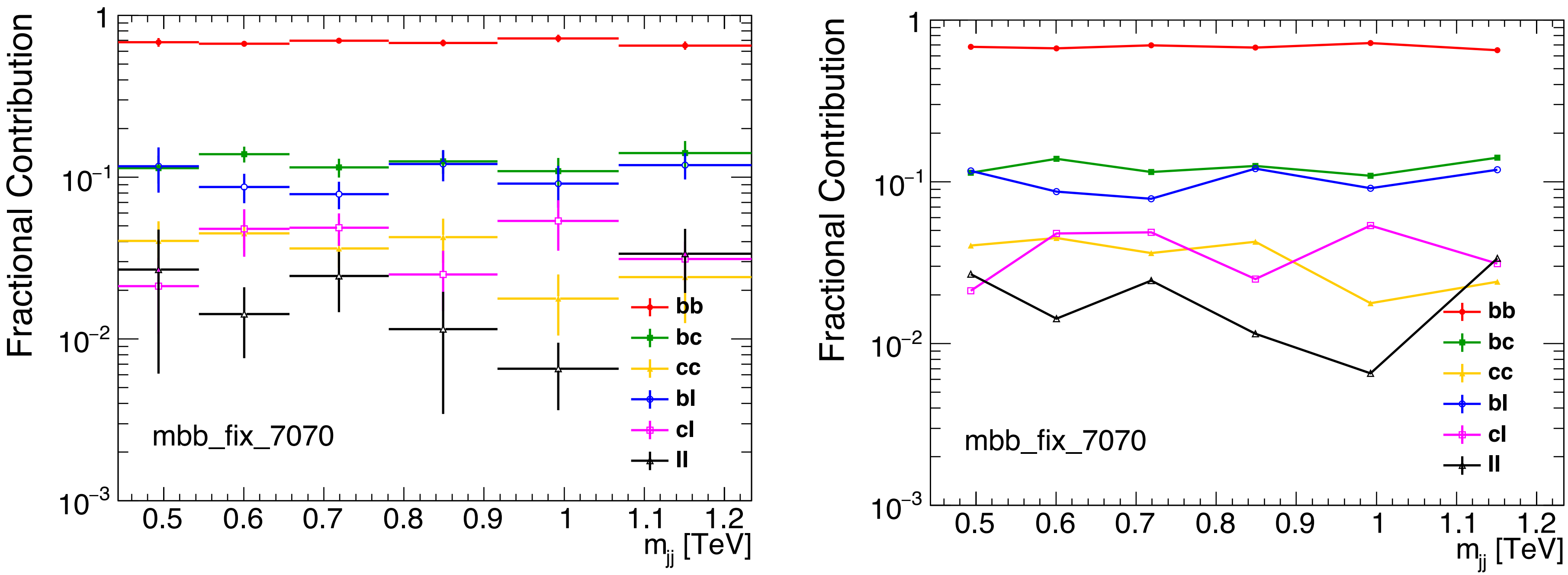
Use Pythia8 Dijet MC

<u>**Event Selection**</u>
Same as sensitivity study

- **No Trigger in MC**
- **Two b-Tags**
  - 70% Eff. WP

- Leading jet p_T > 200 GeV, $|\eta|$ < 2.5
- Subleading jet p_T > 80 GeV, $|\eta|$ < 2.5
- $|y^*|$ < 0.6
- 500 < m_{jj} < 1200 GeV

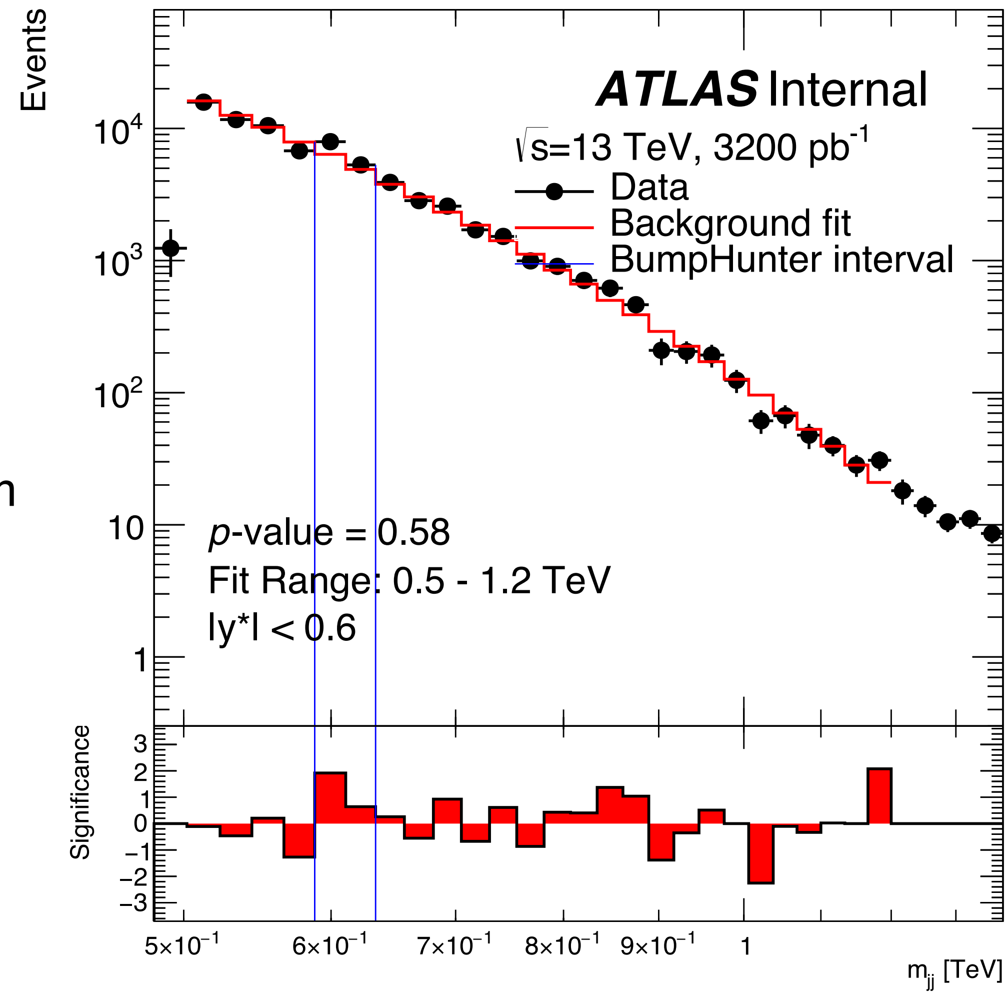
Flavour Composition 750 GeV - no Trigger



- Show that offline tagging doesn't sculpt background
  => Flavour fractions are smooth (within errors)
- Show that after offline tagging we are have good bb purity
  => High b-jet purity (bb ~ 70%)
- Offline b-tagging gives upper limit on non-b flavour contribution
  => ll - will contribute ~ 1% or less

Spurious Signal Check

- **Look for spurious signal**
  - Fit to MC using fit function
  - Search for bumps using BH
  - Any features in MC that can't be fitted to will show.
- **bJet Trigger Emulated**
  - HLT_j175_bmedium_j60_bmedium
  - Use derived bJet Trigger Eff.
  - Justified by high b-jet purity
  - Smoothed using Landau fit
- **Event Selection**
  - Same as before
  - Fit range $0.5 < m_{jj} < 1.2$ TeV
  - Two 70% Offline b-tags
- **Calculate p-Values**
  - Using pseudo experiments



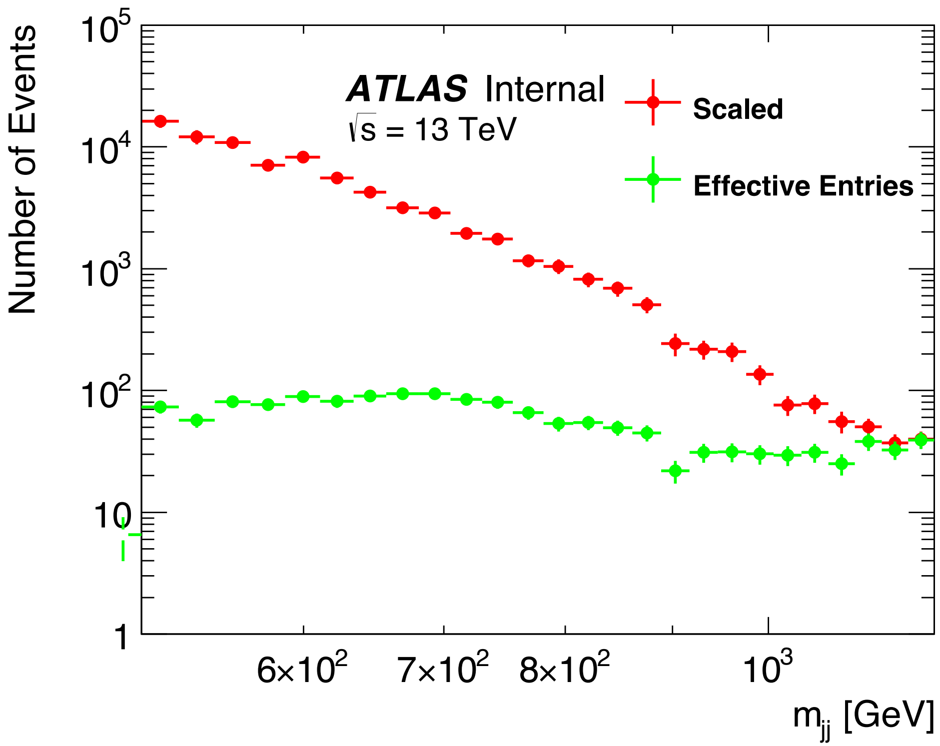
χ^2 p-value = 0.41

BumpHunter p-value = 0.58

Effective Entries

- Dijet is a rapidly falling spectrum in m_{jj}
  - We want MC with good stats across whole range

- To produce MC, produce several slices in m_{jj}, with the same number of entries
  - Effective Entries
- To create a representative distribution, re-weight by (σ x L / N_{eff})
  - Scaled distribution



- **No Trigger**
- Leading jet p_T > 200 GeV
- Subleading jet p_T > 80 GeV
- Jet $|\eta|$ < 2.5
- $|y^*|$ < 0.6

- **Trigger Eff. Applied**

- **Double b-tag 70%**

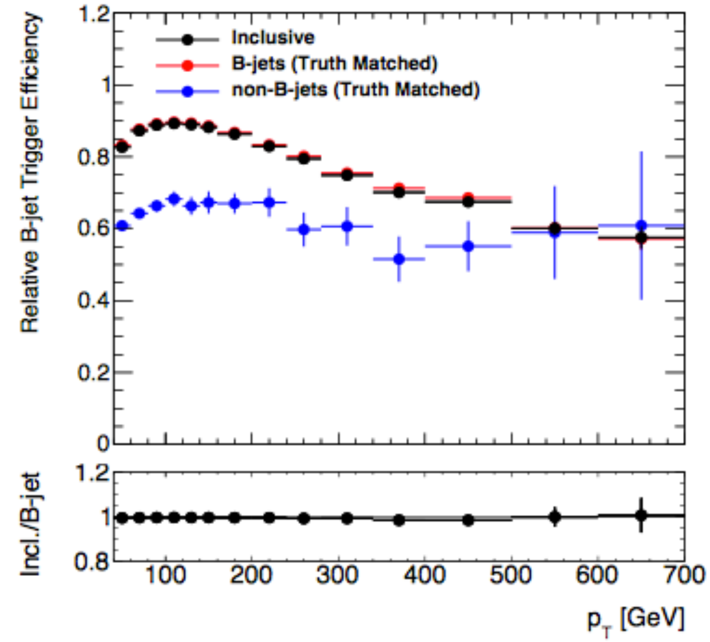
Scaled > Eff. Entries => <u>Not Poisson Like Errors</u>

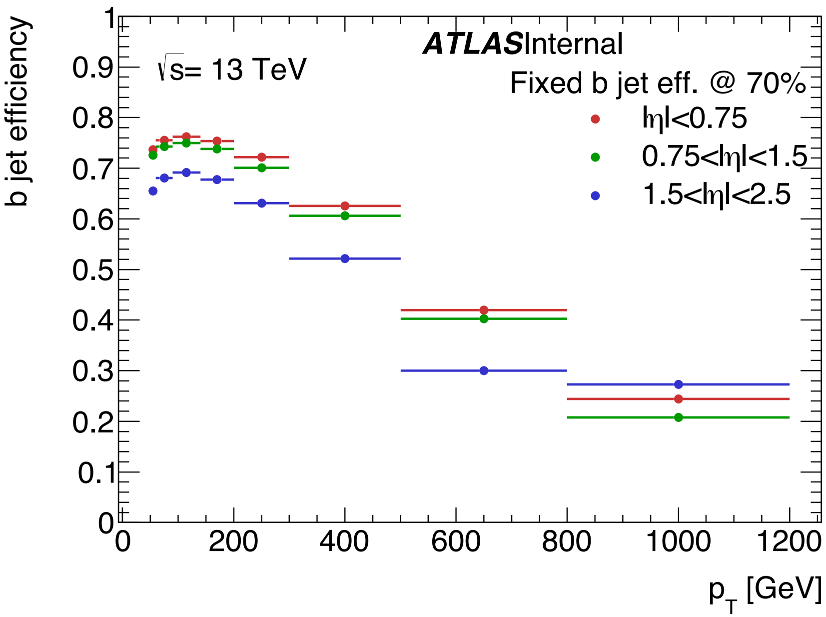
Next Steps

- **Currently Two Key Problems**
  - We have some plans to solve the issues

- **Showing that online trigger will not sculpt**
  - Using trigger currently in MC
    - Not the same WP
    - Low stats maybe a problem
    - Will give us an idea
  - Emulate light/c-jet efficiency
    - Light-jet efficiency estimation from ttbar
    - Fully leptonic sample
    - - So what non b-jets here?
  - Fit to Data with only trigger on
    - Show that it is smooth?

- **Low stats for spurious signal test**
  - Emulate offline tagging
  - Can usse eff. derived from ttbar
  - These exist from Moriond paper



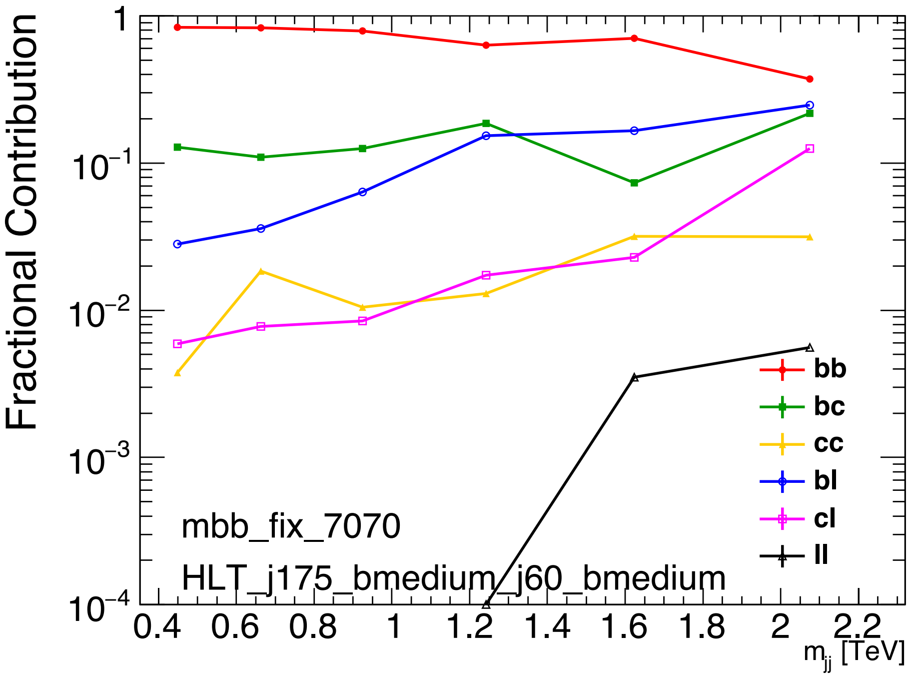


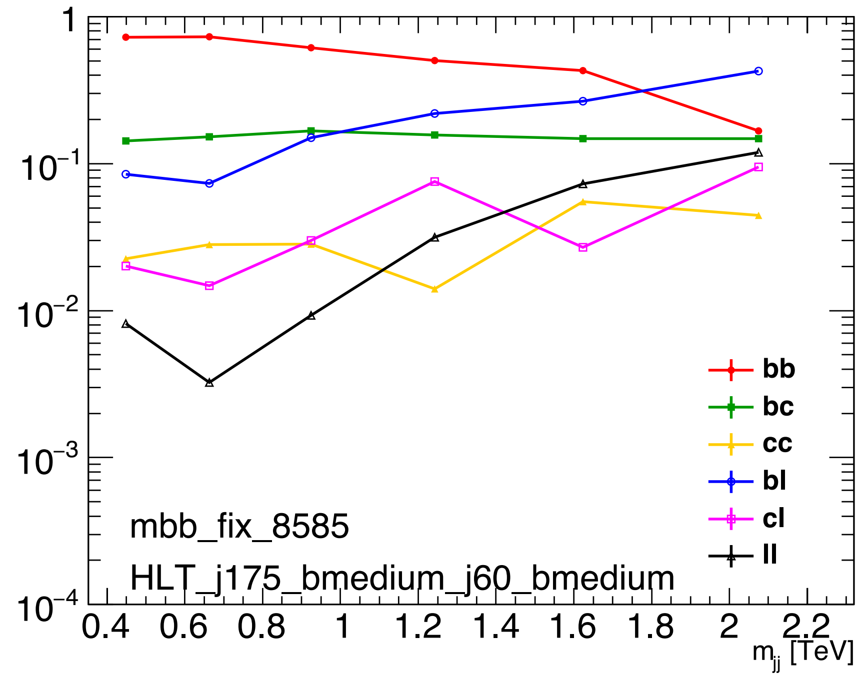
Backup!

Flavour Composition 750 GeV - bJet Trigger

- HLT_j175_bmedium_j60_bmedium
- Leading jet p_T > 200 GeV, $|\eta|$ < 2.5
- Subleading jet p_T > 80 GeV, $|\eta|$ < 2.5
- $|y^*|$ < 0.6

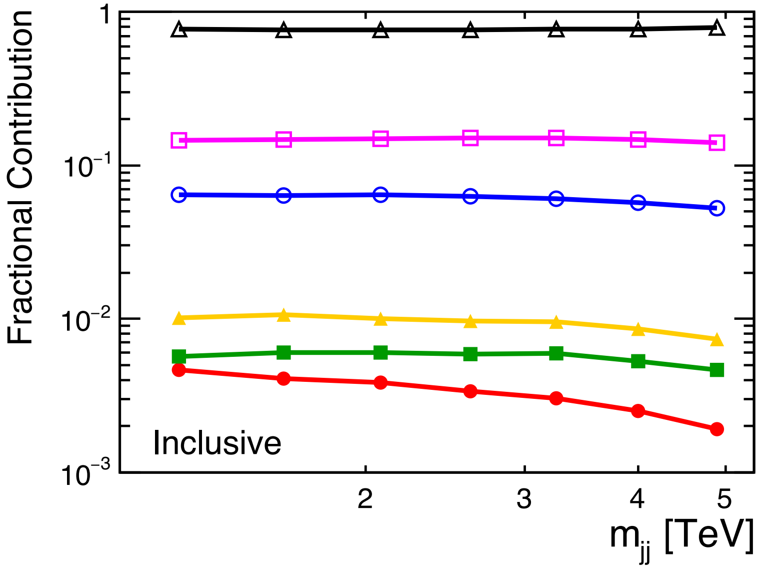
- No Trigger Eff. Applied
- 70% / 85% Eff. Point

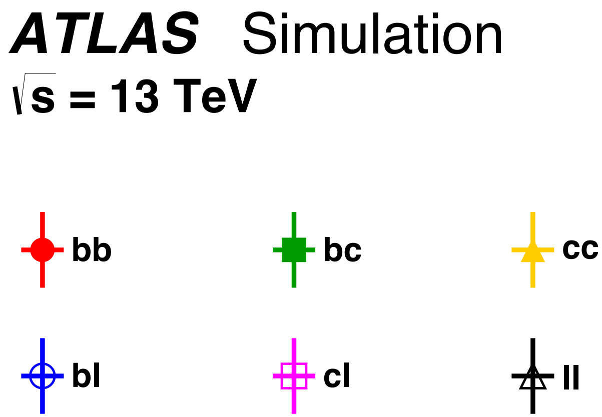


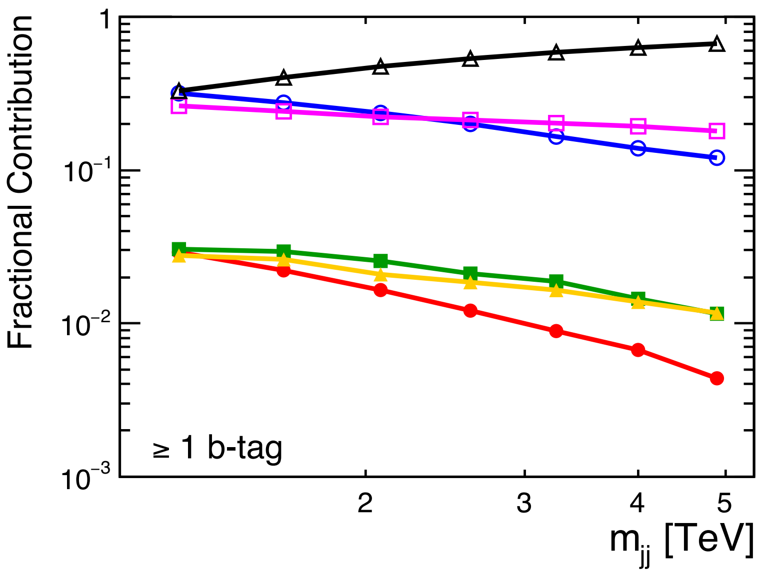


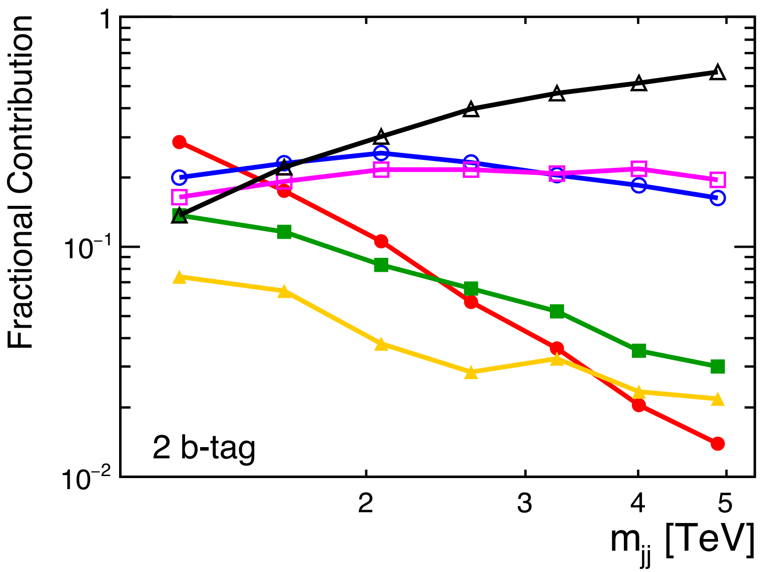
- **Dominant bb contribution**
- **Different Trigger WP in MC and Data**

Flavour Composition Moriond









Pseudo Plots