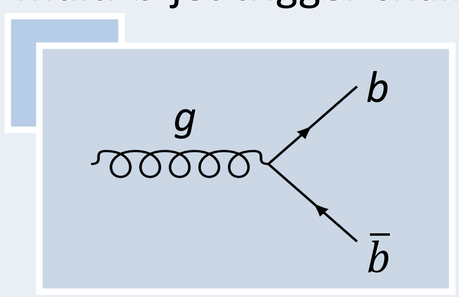
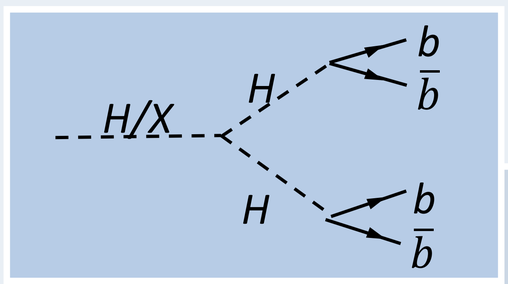
Rejecting $g \to b\bar{b}$ in the ATLAS *b*-jet High Level Trigger

Aims:

- Reject *bb*-jets from $g \to b\bar{b}$ splitting
- Increase sensitivity for analyses that use the multi-b-jet trigger chains, e.g. $\mathrm{HH} \to 4\mathrm{b}$





b-jet Trigger

- Reduce rate from ~5 kHz in L1 to 30 Hz in main physics stream
- Rejecting $g \to b\bar{b}$ in *b*-tagging reduce the backgrounds, allowing for more signal acceptance at the same rate

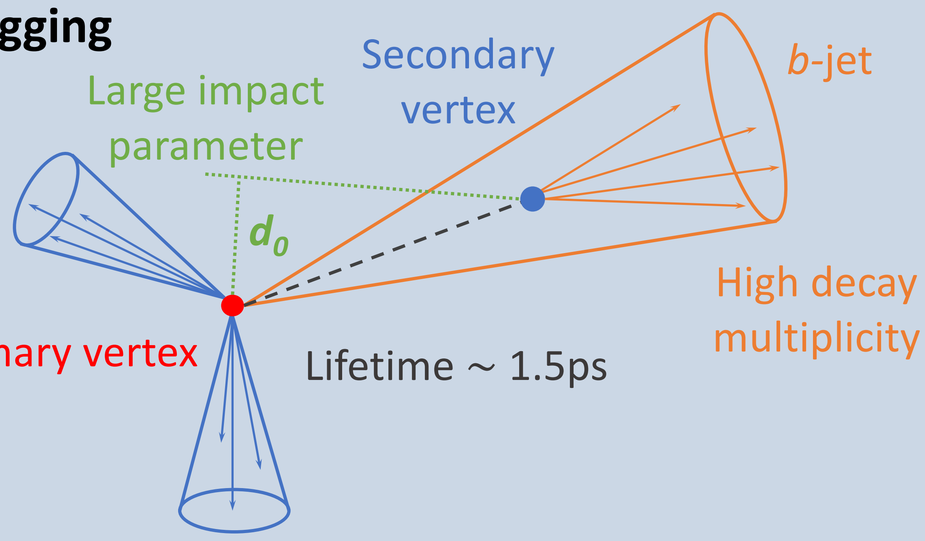
$\mathbf{HH \to 4b}$

- Highest branching ratio, however…
- Large background from QCD multijet events, including small angle $g \to b\bar{b}$ splitting

DL1d

- Deep neural network
- Identifies *b*-jet, *c*-jet and light-jet
- Labels single *b*-jets and *bb*-jets inclusively as '*b*-jets'
- **Problem**: *bb*-jets are identified as single *b*-jets

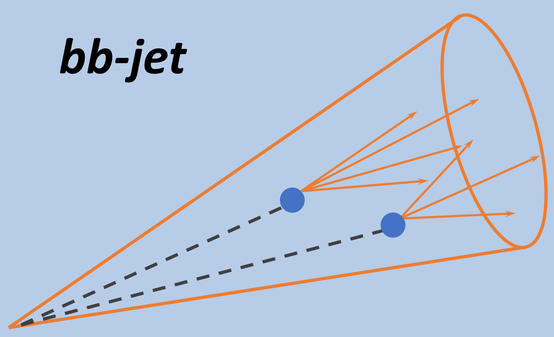
b-tagging



DL1dbb

- Further separates single *b*-jets and *bb*-jets tagged by DL1d
- Uses the same b-tagging input variables as DL1d

bb-jet



Compared to *b*-jets:

- Contains 2 *b*-hadrons instead of 1
- Lower fraction of energy carried by tracks from *b*-hadron decay
- Larger jet width

Inputs

- Secondary vertex & impact parameter properties
- Jet kinematics
- Track variables

→ Neural network →

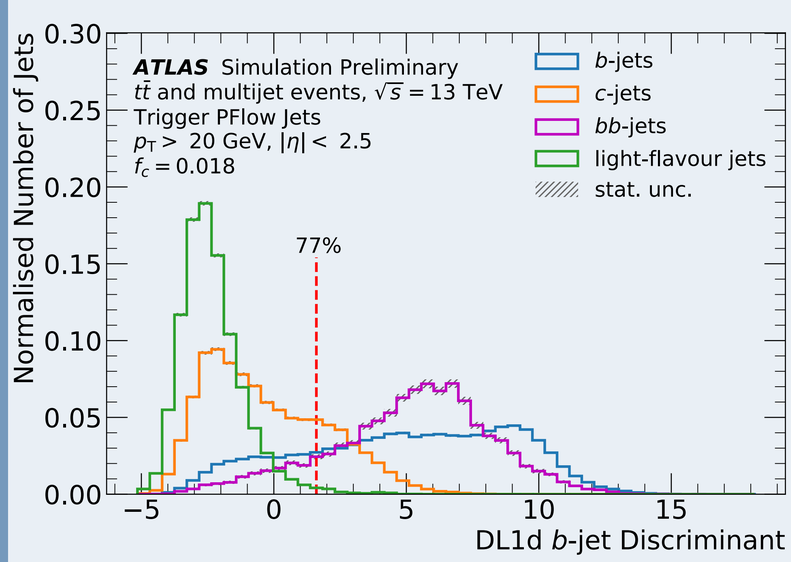
Outputs

p_b

p_{bb}

bb-jet Rejection in DL1d and DL1dbb:

***b*-jet discriminant** – log-likelihood ratio of jet probability outputs



DL1d:

- Good separation between *b*-, *c*- and light-jets
- Large overlap between *b*- and *bb*-jets
- At 77% *b*-jet efficiency: many *bb*-jets tagged

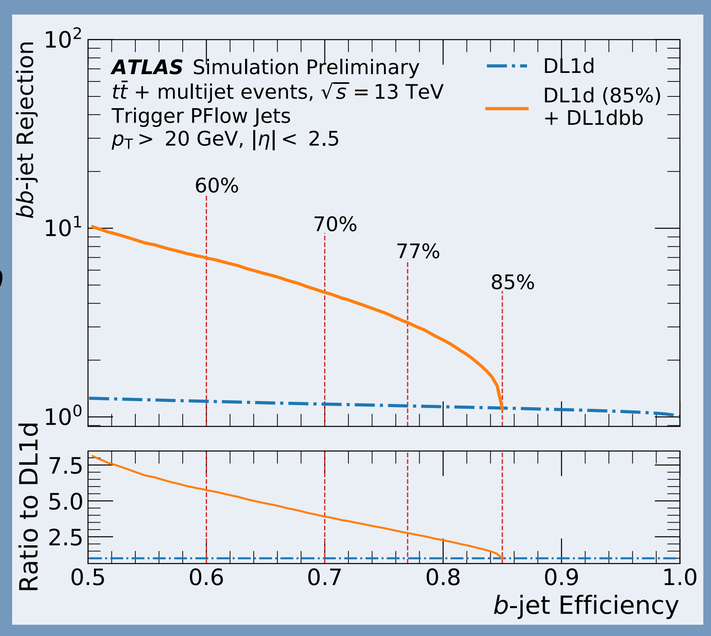
Combined tagging scheme:

Trigger jets

→ ***DL1d (85% working point)***

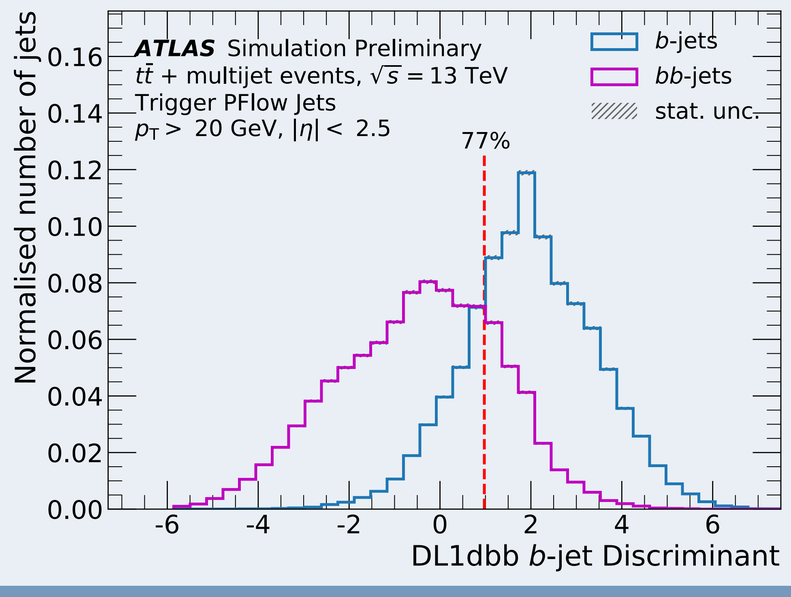
→ ***DL1dbb***

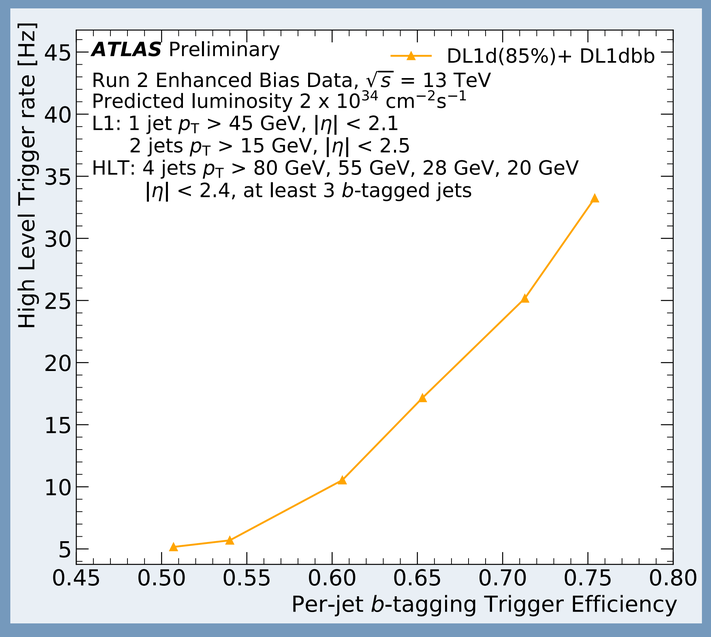
A factor of ~4 in *bb*-jet rejection (70% WP) from the combined tagging scheme compared to DL1d



DL1dbb:

- Only separates *b*- and *bb*-jets, with much less overlap in discriminant
- Could be used to separate jets passing DL1d





Trigger rate

- Tested on Run 2 data with a 4-jet trigger requiring 3 *b*-tagged jets
- Rate decreases steeply at high *b*-jet efficiencies
- Combined with DL1d can reduce current rates

Conclusions:

- **Combining DL1d at 85% working point and DL1dbb effectively rejects *bb*-jets and could reduce trigger rates.**
- **Allows lower minimum E_T thresholds in the HLT for higher luminosity in Run 3 while maintaining low readout rates.**

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ATLAS EXPERIMENT