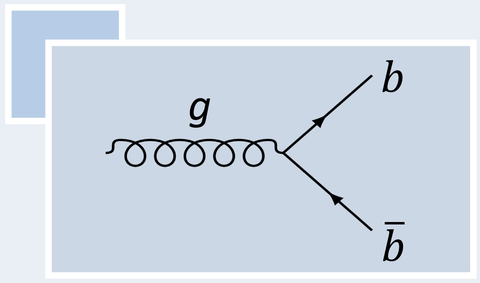
Rejecting $g \to b\bar{b}$ in the ATLAS *b*-jet High Level Trigger

Aims

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

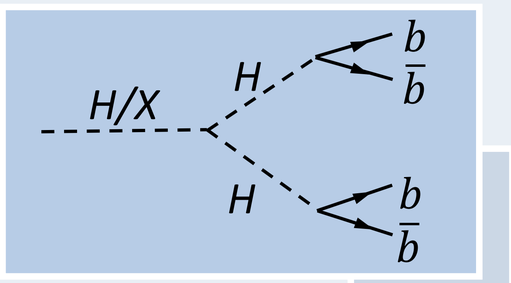


b-jet Trigger

- Triggers require jets containing single-*b*-hadrons (*b*-jets)
  - Would benefit from readout rate reduction
- Rejecting jets containing 2 *b*-hadrons (*bb*-jets) reduces background

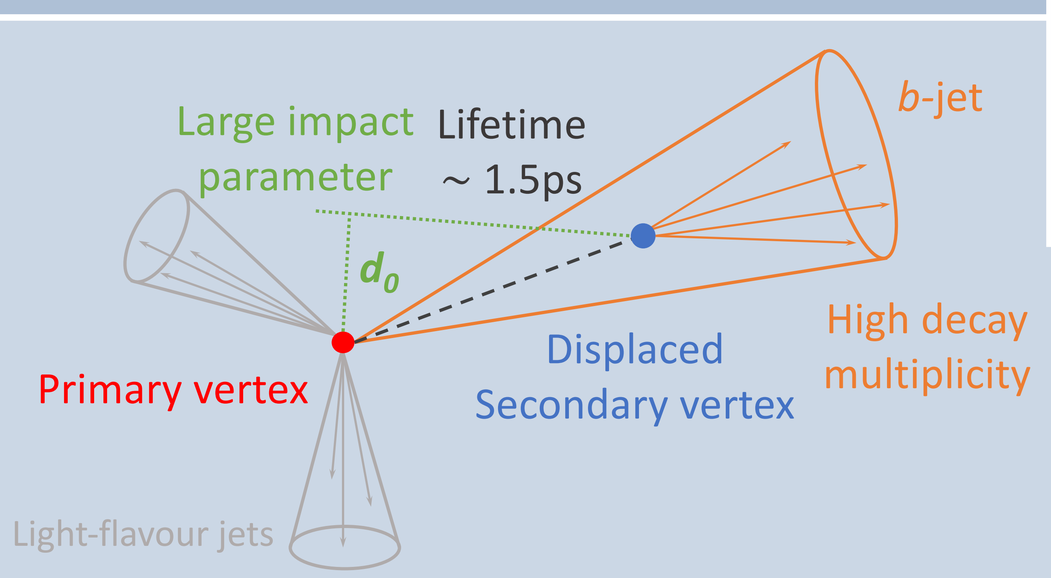
$HH \to 4b$

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



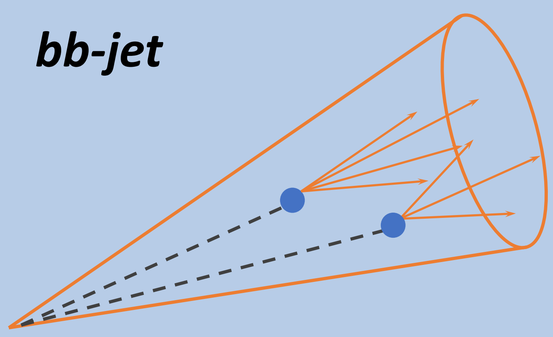
b-tagging Algorithm

- Separates *b*-jets from *c*- & light-flavour jets
- Run 3 trigger *b*-tagger: GN1 – a Graph Neural Network
- Labels single *b*-jets and *bb*-jets inclusively as '*b*-jets'
- **Problem**: *bb*-jets are identified as single-*b*-jets



DL1dbb

- A Deep Neural Network
- Further separates single-*b*-jets and *bb*-jets tagged by GN1



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 info
- Jet kinematics
- Track variables

→ DNN →

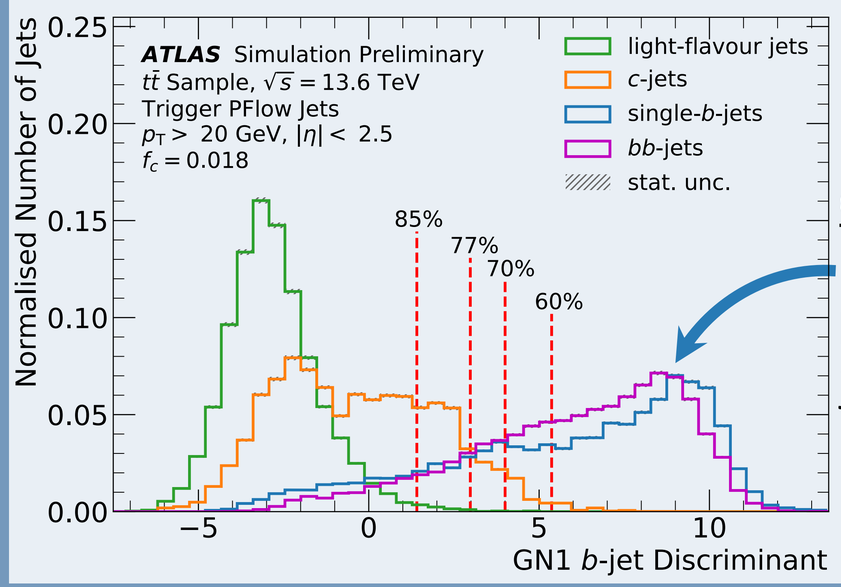
Outputs

p_b

p_{bb}

bb-jet Rejection in GN1 and DL1dbb:

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

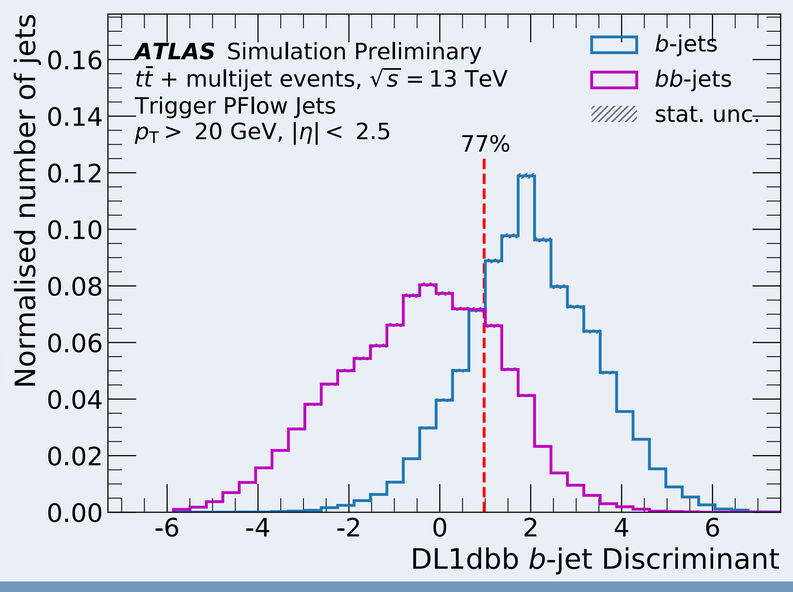


GN1:

Large overlap between *b*- and *bb*-jets distributions

DL1dbb:

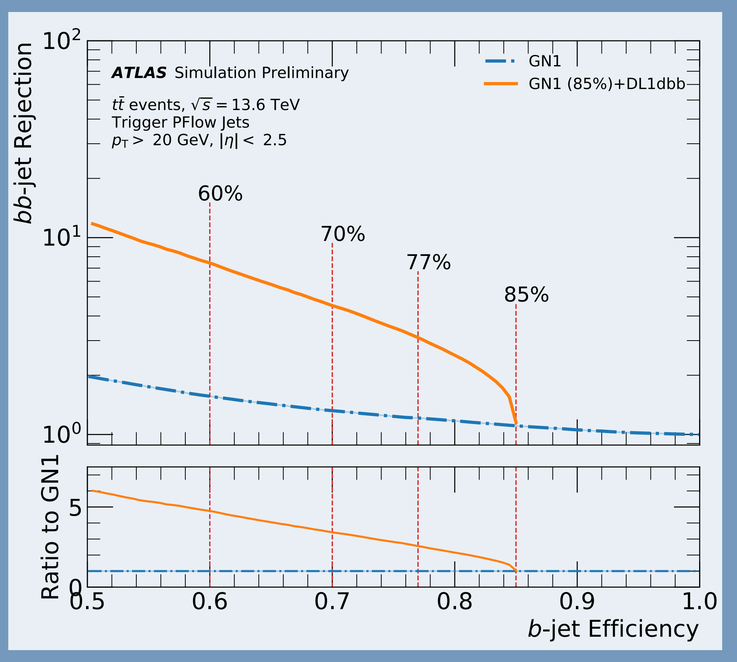
- Much smaller overlap between *b*- and *bb*-jets
- A more dedicated algorithm

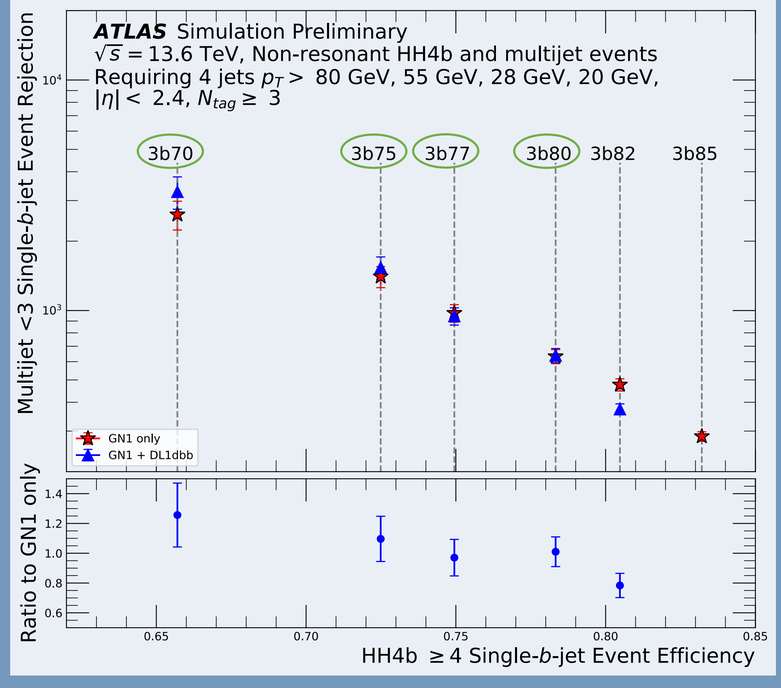


The combined tagging scheme:

Trigger jets → ***GN1*** → ***DL1dbb***

A factor of ~3 in *bb*-jet rejection (70% WP) from the combined tagging scheme compared to GN1





For a 3b trigger:

Combined tagging scheme gives higher background rejection while maintaining HH4b signal efficiency above 80% GN1 working point

Conclusions:

- **DL1dbb offers a solution for rejecting *bb*-jets from gluon splitting in the HLT, and a potential reduction in readout rates**
- **Together with GN1, it can reduce more multijet background than GN1 alone while maintaining HH4b signal efficiency**

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ATLAS EXPERIMENT