

Jet Vertex Charge Reconstruction

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Motivation

- The identification of the sign of the charge of the b -quark contained in a jet (**b -jet**) helps reducing combinatorics in final states with multiple b -jets
- The **Jet Vertex Charge (JVC)** tool [1] is a new algorithm designed to reconstruct b -jet charge
- It relies on tracks and vertices reconstructed in the Inner Detector and muons reconstructed in the Muon System

Jet Charge

$$Q_{\text{jet}} = \frac{\sum_{i \in \text{Tr}} q_i \cdot (p_T^i)^\kappa}{\sum_{i \in \text{Tr}} (p_T^i)^\kappa}$$

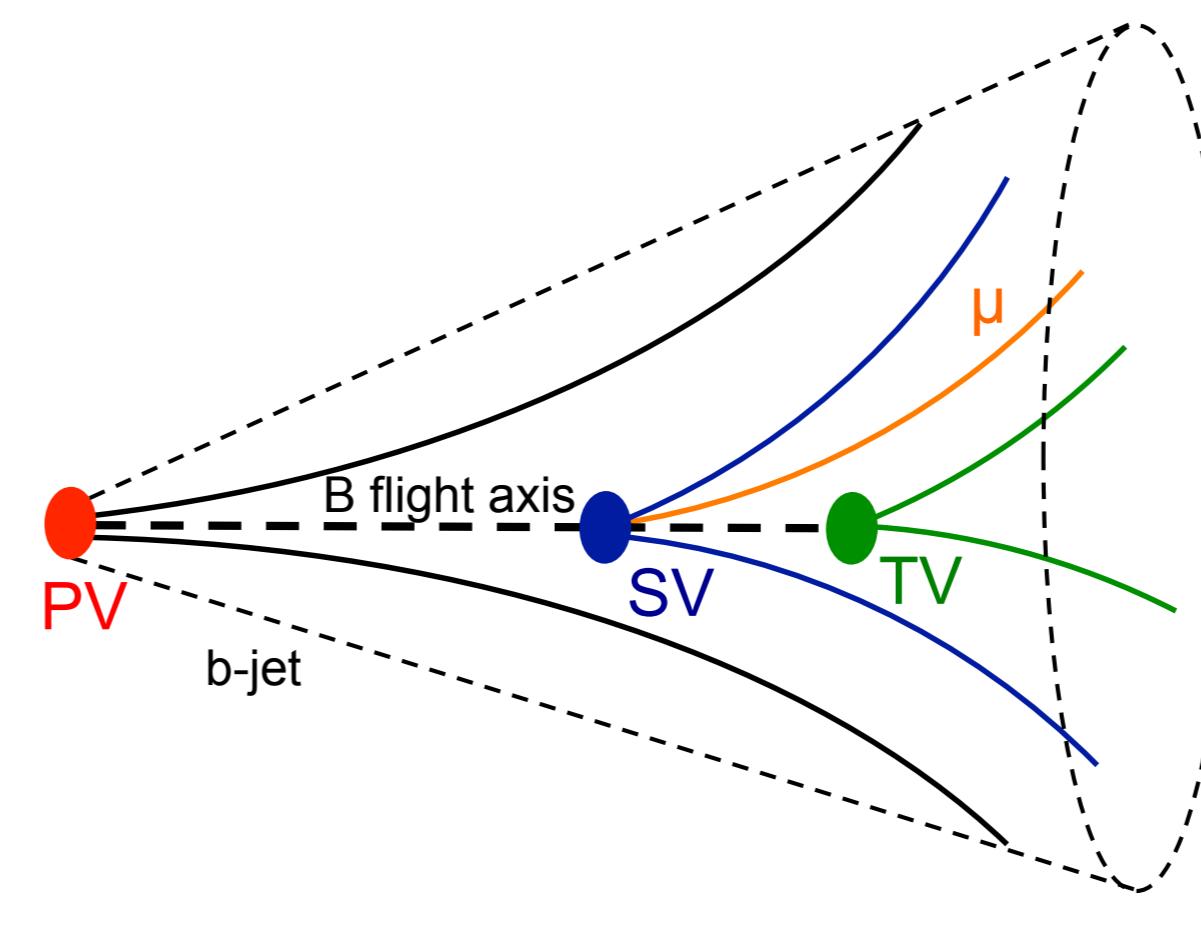
- Jet charge** [2,3,4,5] is computed using:
 - Track charges q_i
 - Track transverse momenta p_T^i
 - Normalisation factor κ
- In this algorithm, two versions of this variable are used:
 - Q_J , reconstructed using selected tracks
 - $Q_J^{\text{all tracks}}$, reconstructed using a looser track selection, used only in the absence of Q_J

Sample and Jet Selection

- 4-jets and dilepton $t\bar{t}$ events simulated at $\sqrt{s} = 13$ TeV
- Jets with $p_T > 20$ GeV and $|\eta| < 2.5$

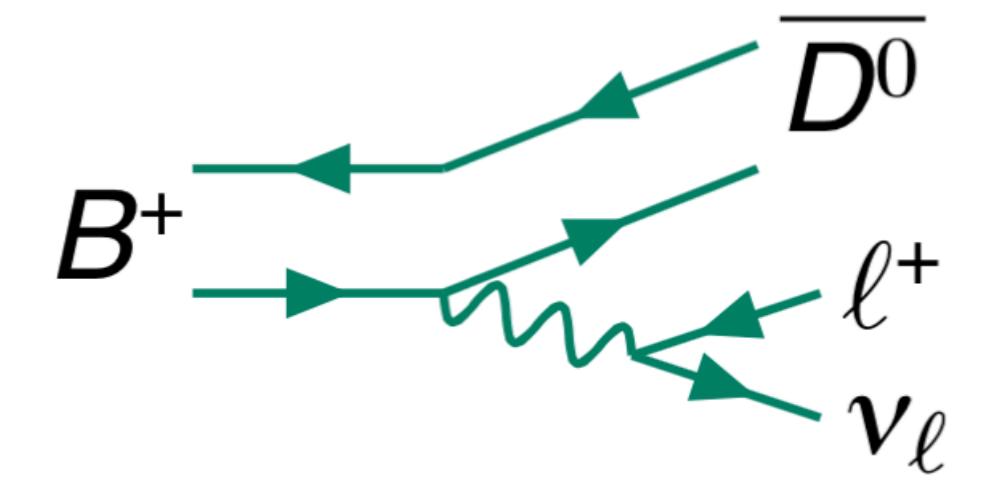
Jet Vertex Charge

- Special version of Jet Charge, i.e. **Jet Vertex Charge**, reconstructed using the tracks associated to the displaced b - or c -hadron vertices in b -jets
- JetFitter** algorithm [7] used to reconstruct the displaced vertices from the PV to b - to c -hadron decay chain
- This algorithm assumes that all vertices within the jet are aligned



Soft Muon Charge

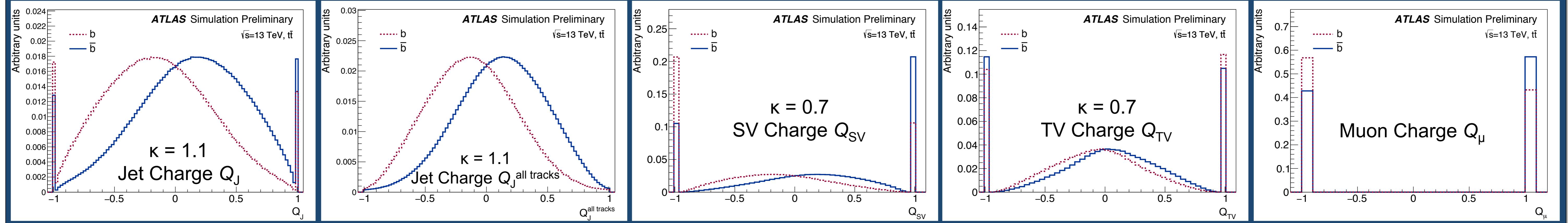
- Muons from b - and c -hadron decays provide info about b -jet charge:
 - Muon from b -decay has the same charge as the b -jet
 - Muon from c -decay has the opposite charge to the b -jet
 - Muon origin inferred from muon momentum projected along and transverse to jet axis



Note

- Vertex and muon charge are slightly diluted by neutral B -meson mixing
 - Ignored during optimisation

Charge Variables



Jet Categories and Multi-variate Analysis

- Jets split into exclusive categories depending on which charge variables are available
- For categories with multiple charges, information is combined into a Neural Network (NN)
- To improve the discrimination power, additional auxiliary variables are used, describing the quality of displaced vertices and the muons

Category abundance

Category	Untagged
C_j	11.4%
$C_{j,\mu}$	1.95%
C_{SV}	2.98%
$C_{j,\text{SV}}$	53.4%
$C_{j,\text{SV},\mu}$	10.0%
$C_{j,\text{SV},\text{TV}}$	15.4%
$C_{j,\text{SV},\text{TV},\mu}$	3.54%
$C_{\text{all tracks}}$	1.32%

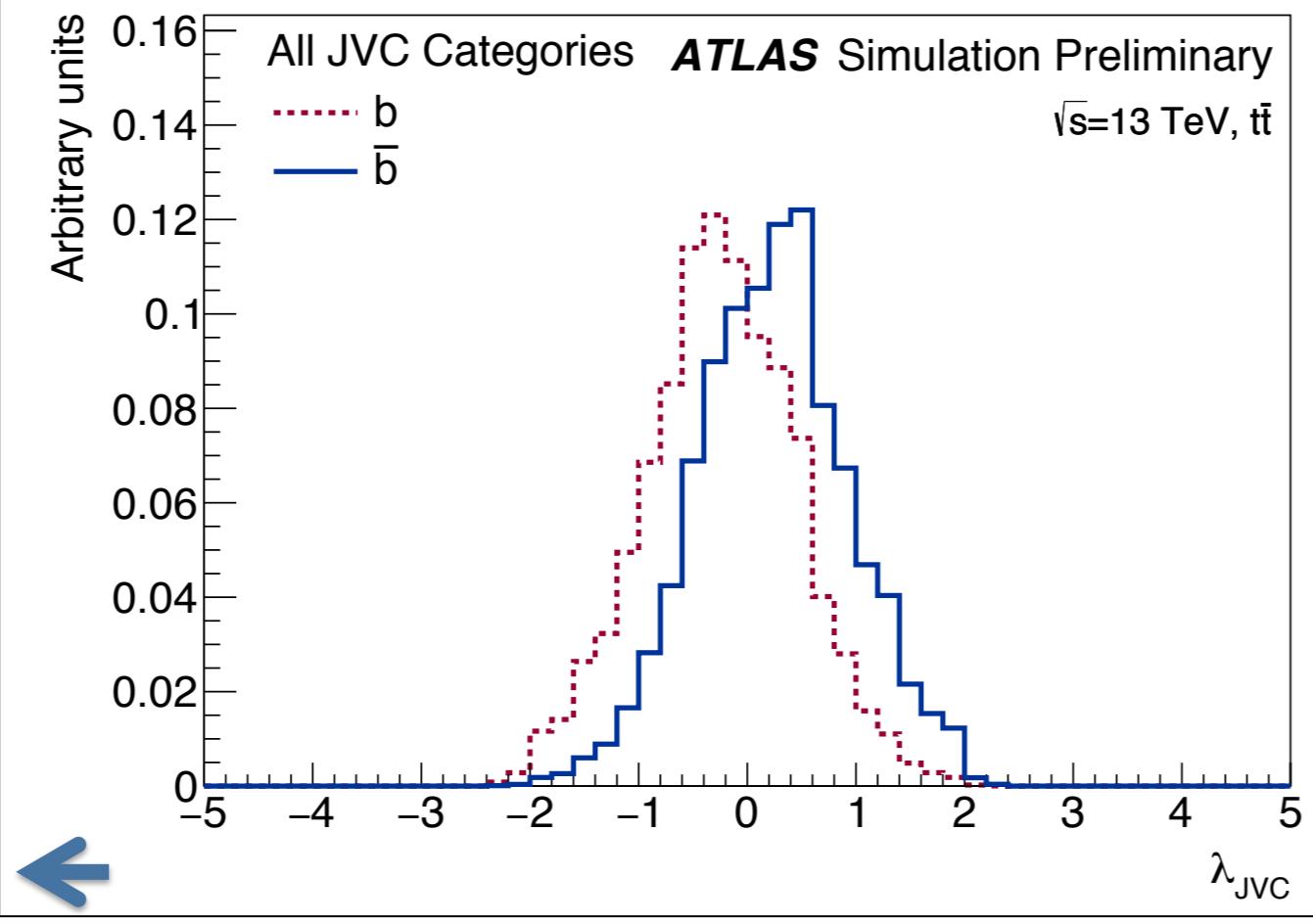
Performance

- Performance evaluated as negative b -jet rejection ($1 - \text{efficiency}$) vs positive b -jet efficiency
- Initial b -quark charge used so B^0 - \bar{B}^0 mixing is accounted for
- New Jet Vertex Charge discriminator λ_{JVC} improves background rejection compared to previous Q_J -based algorithm by 6-8 %
- Performance is slightly increased by applying a b -tagging requirement on the default Run 2 tagger [9]

Combined Discrimination

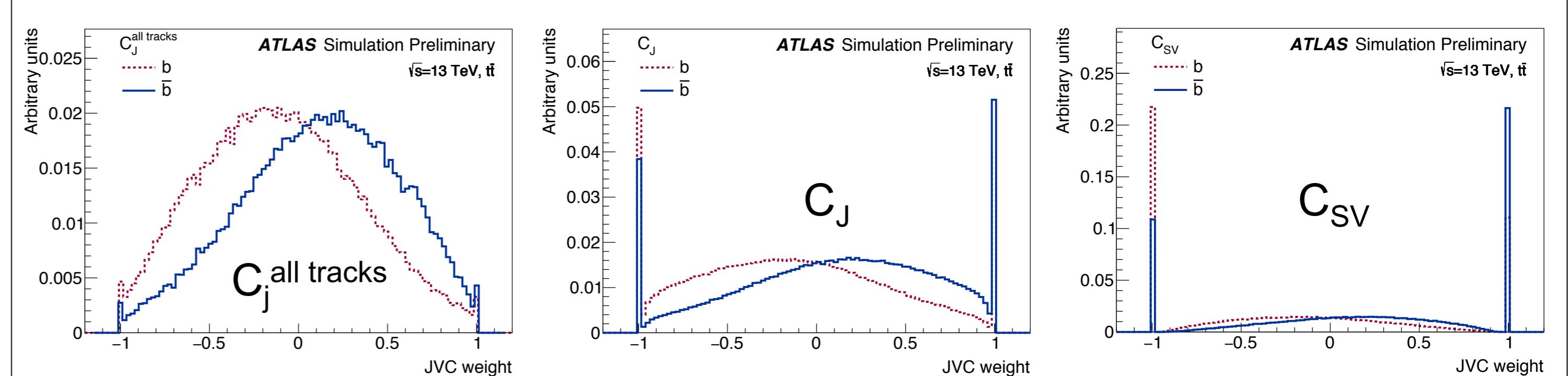
- To combine all categories, a **log-likelihood ratio** discriminant is constructed as:

$$\lambda_{\text{JVC}} = P_{\text{JVC}}(\bar{b}) / P_{\text{JVC}}(b)$$

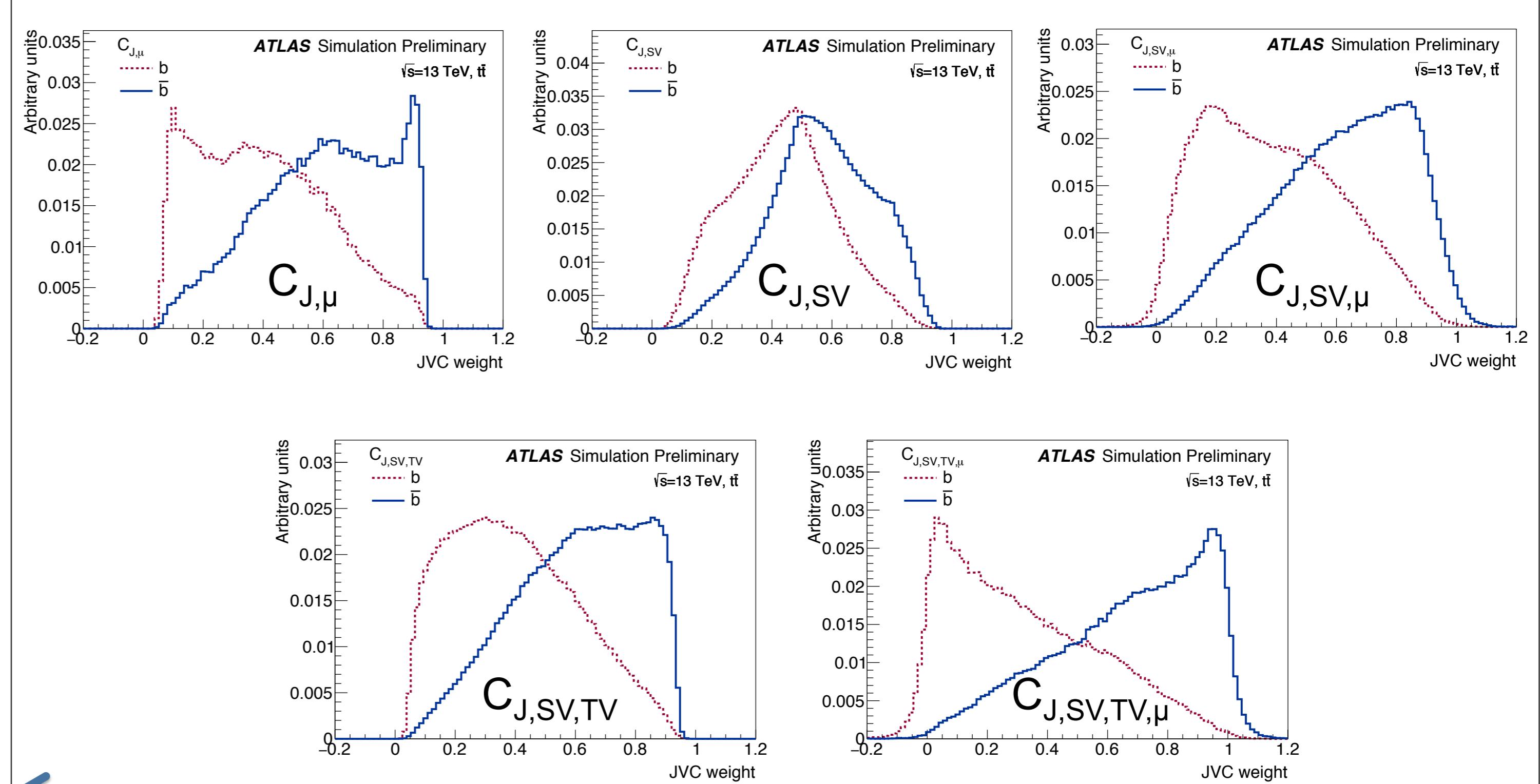


JVC Discriminators in each Category

Single-variable Discrimination



Multi-variate Discrimination



Various Performance Comparisons

