

WG1-VBF

STSX VBF BINNING

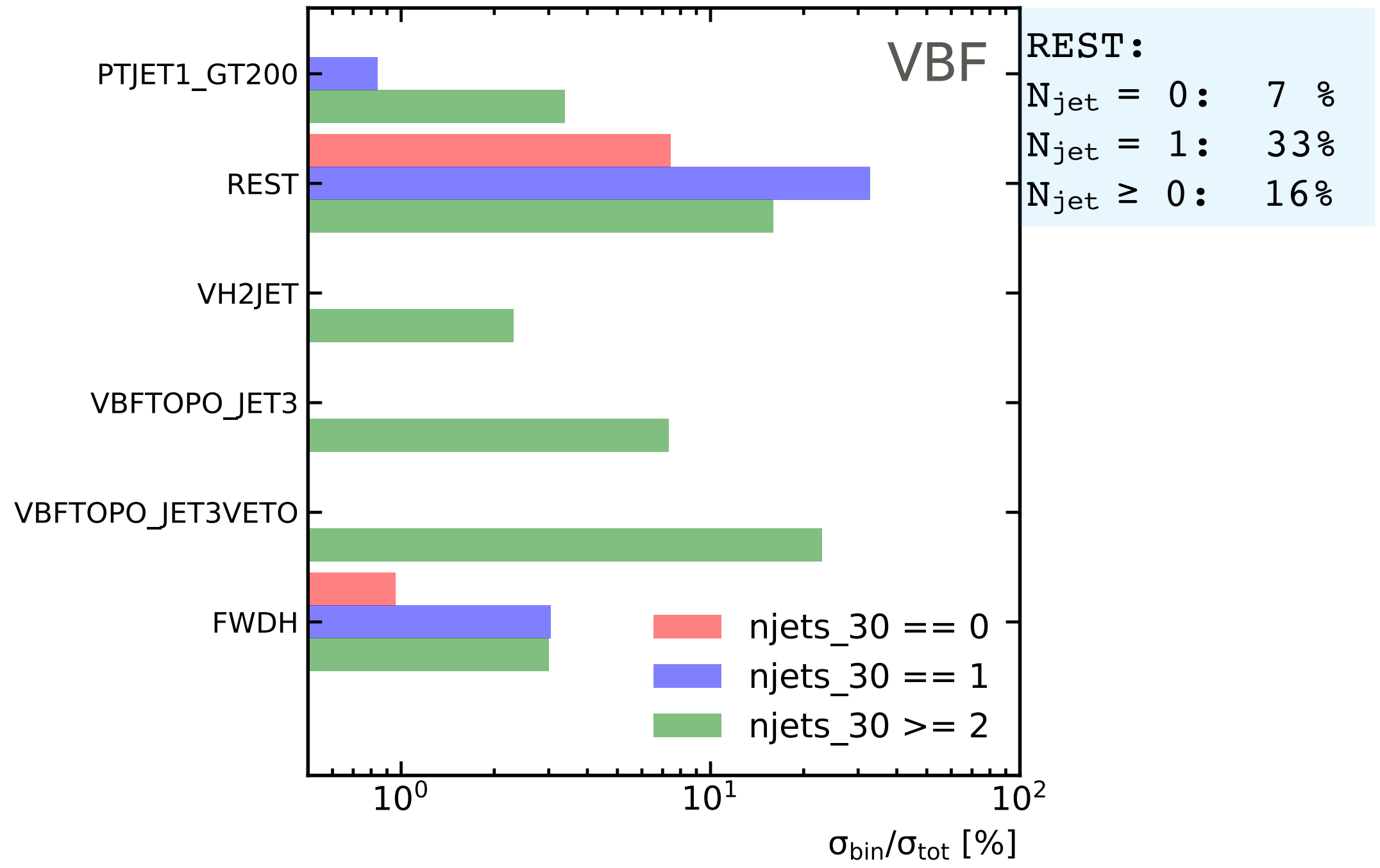
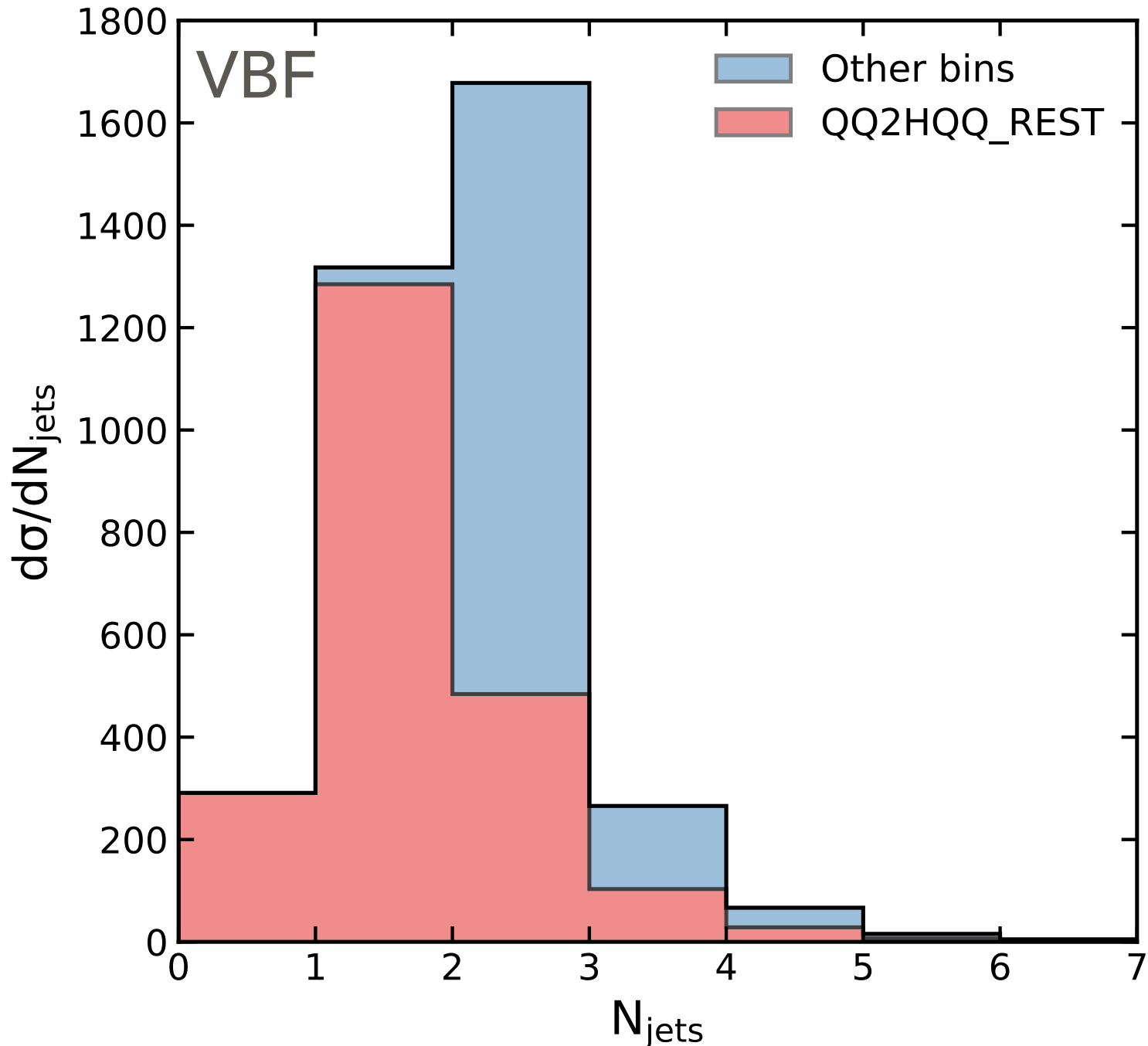
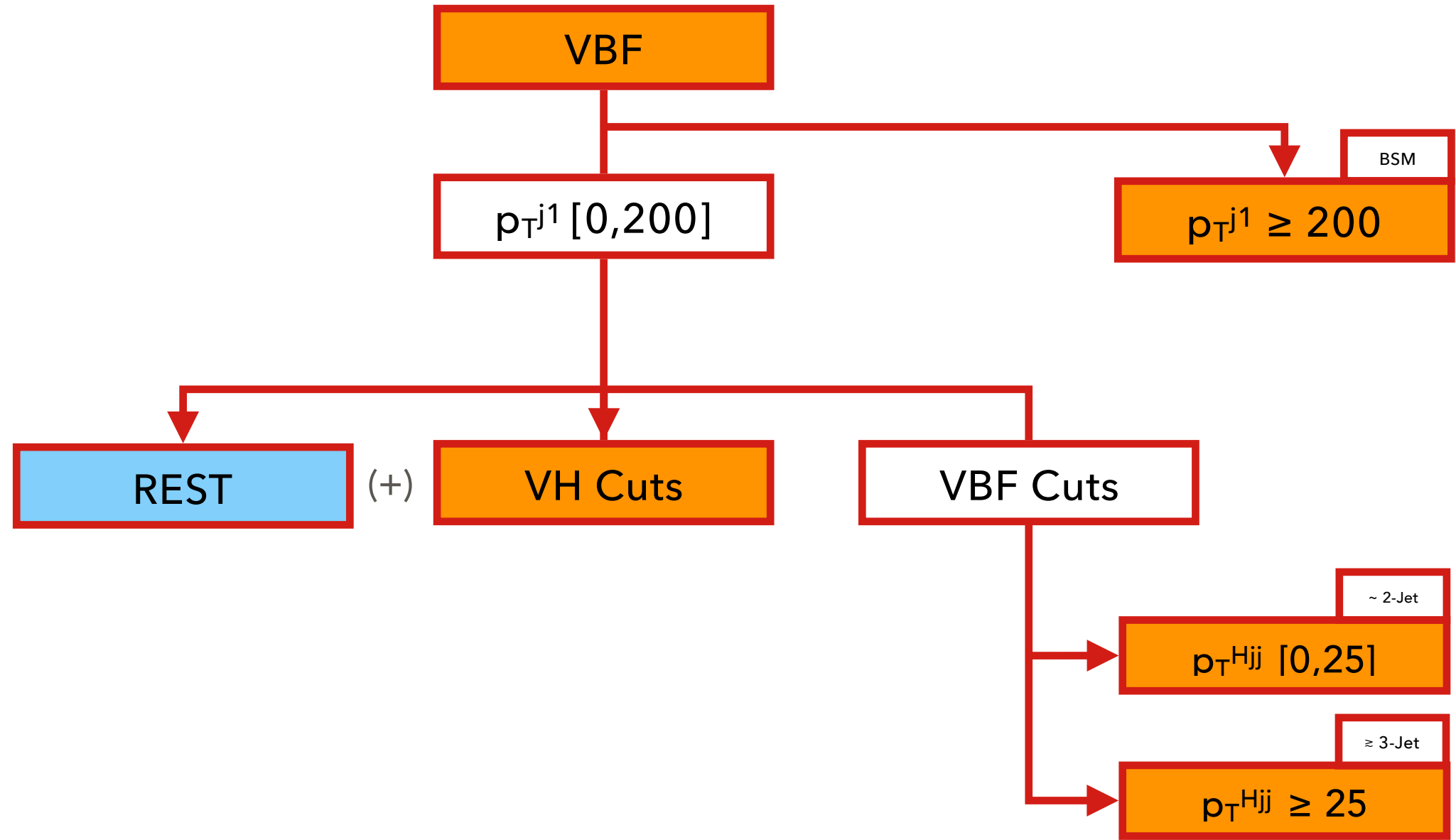
C. Bertella, A. Karlberg, Y. Haddad
21/11/2018



Northeastern
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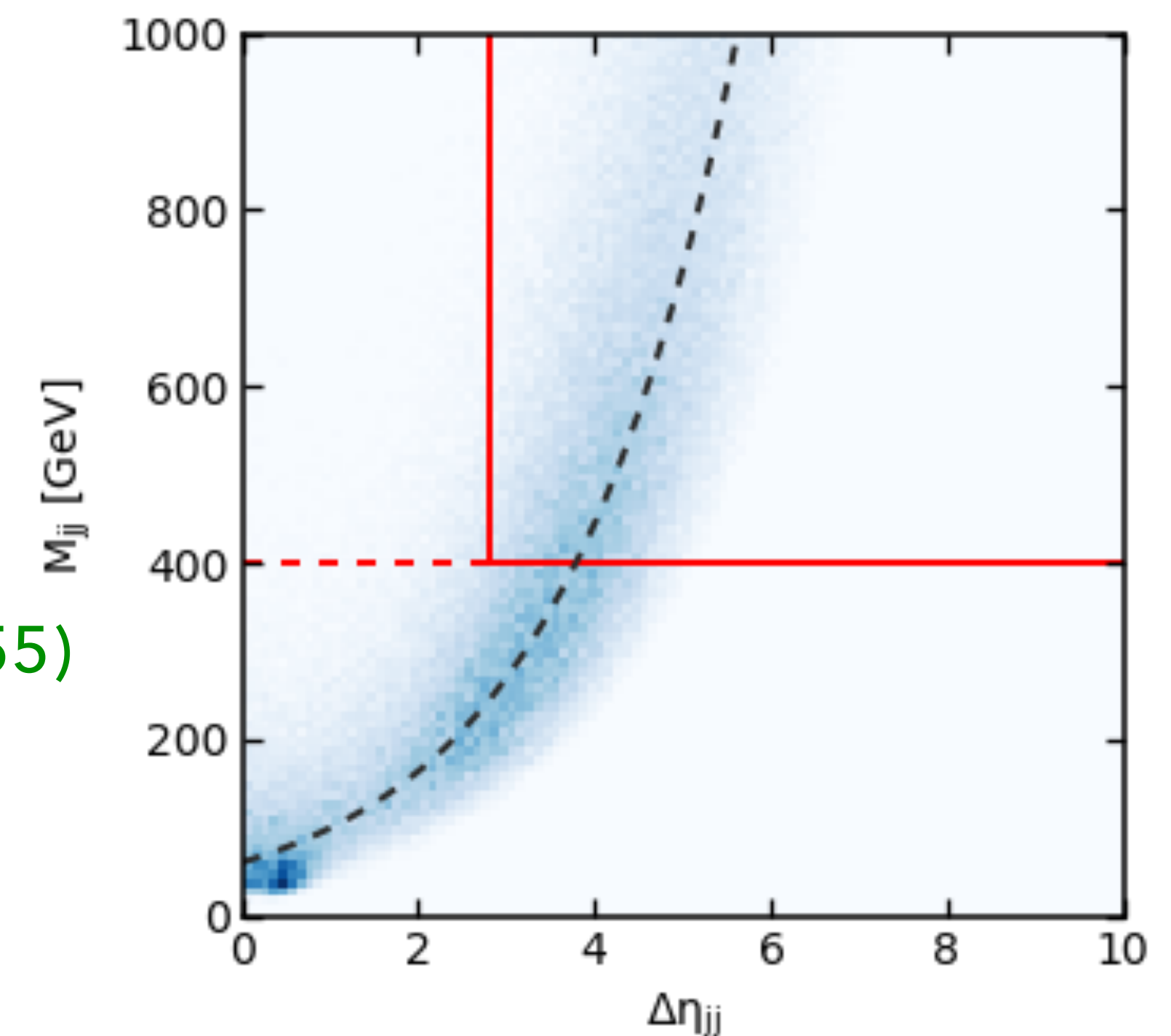
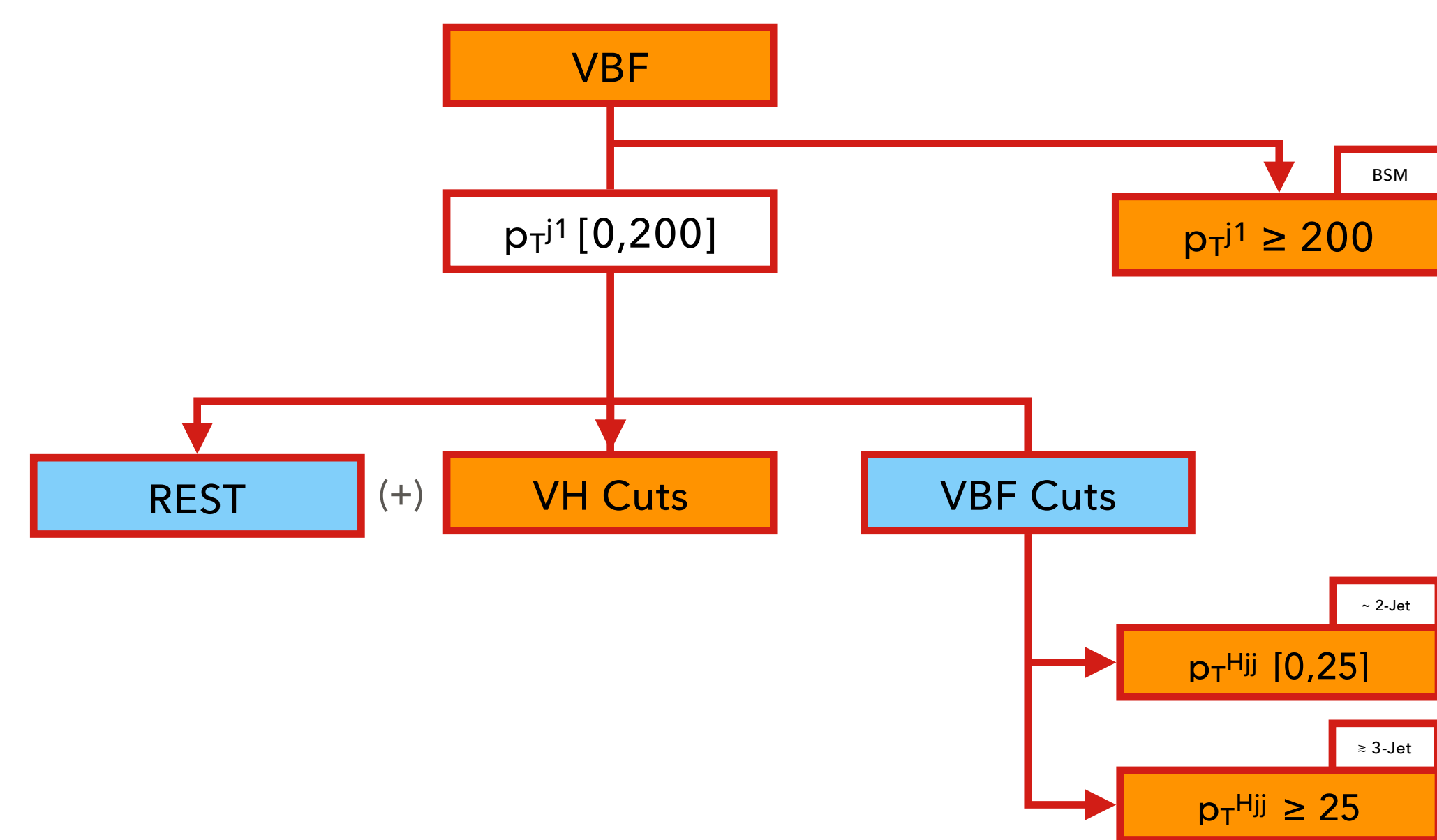
CURRENT STAGE-1 VBF

- Almost 56% of the VBF events lands on < 2 jets region due to the p_T threshold
- Events with multiple kinematics land in the REST bin, making uncertainties estimation more complicated:
 - $0 < m_{jj} < 60$ GeV and $120 < m_{jj} < 400$ GeV, < 2 jets events and $\Delta\eta_{jj} < 2.8$ & $m_{jj} > 400$ GeV
- **We could benefit by adding a 0 and 1-jet category**



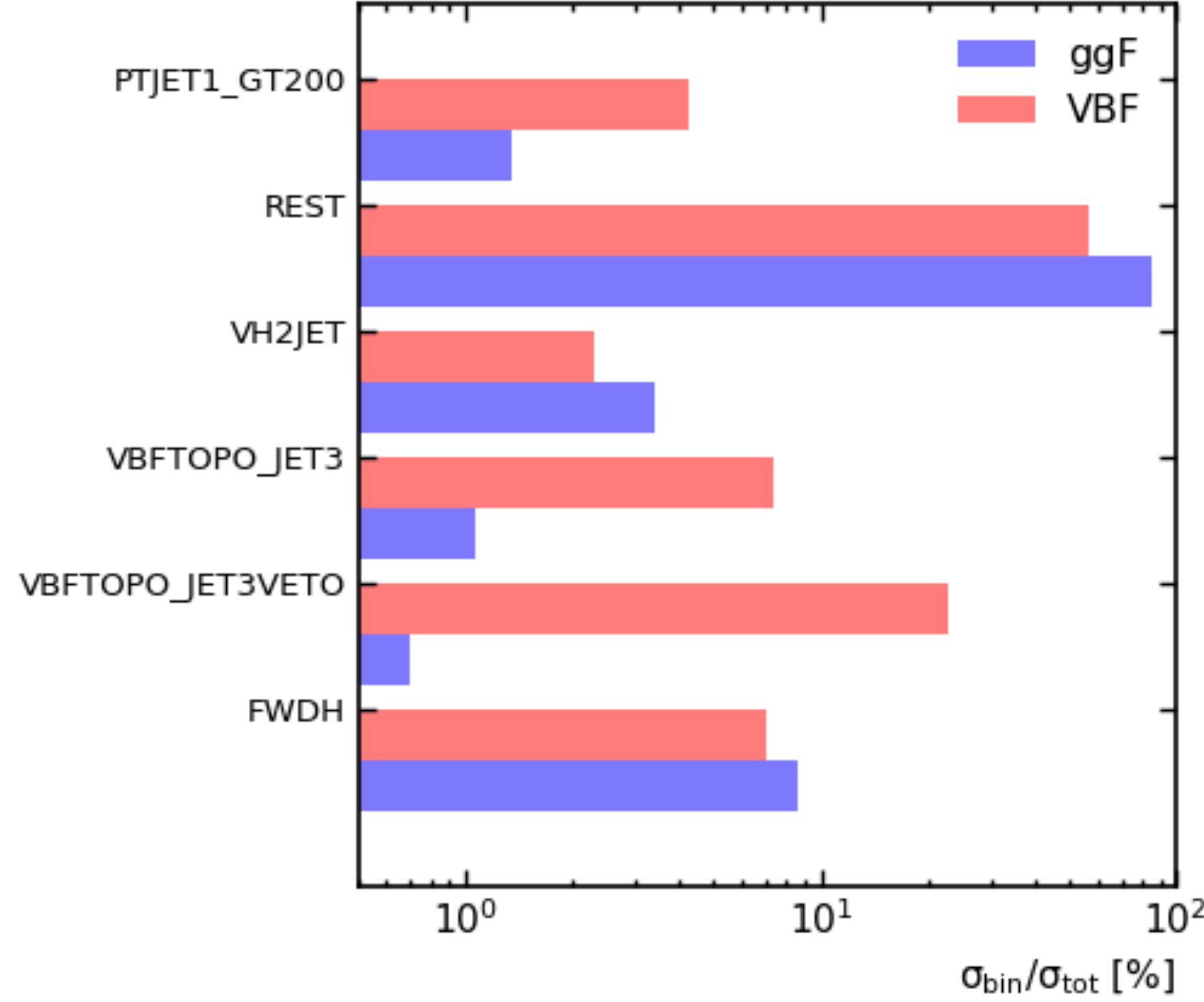
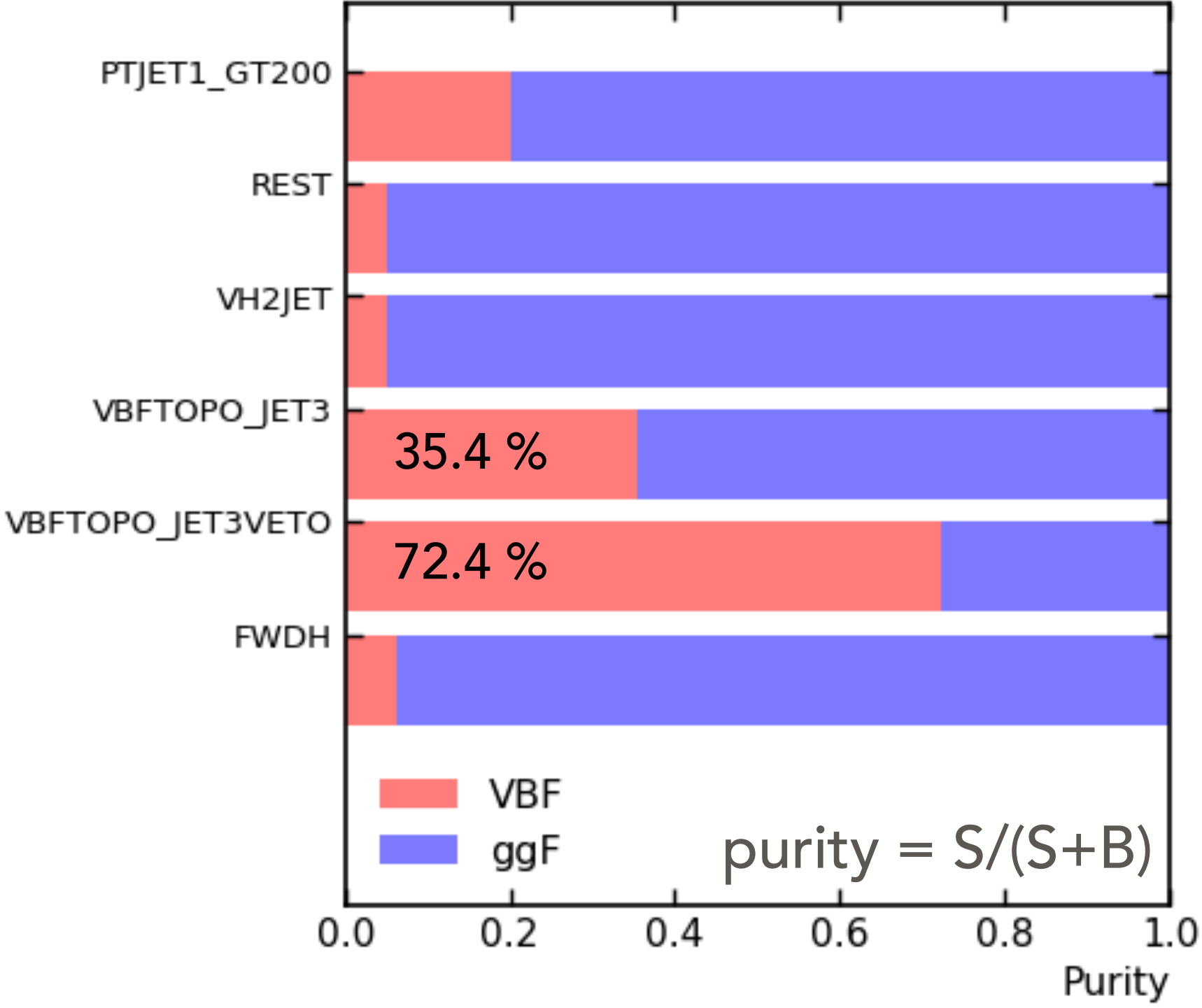
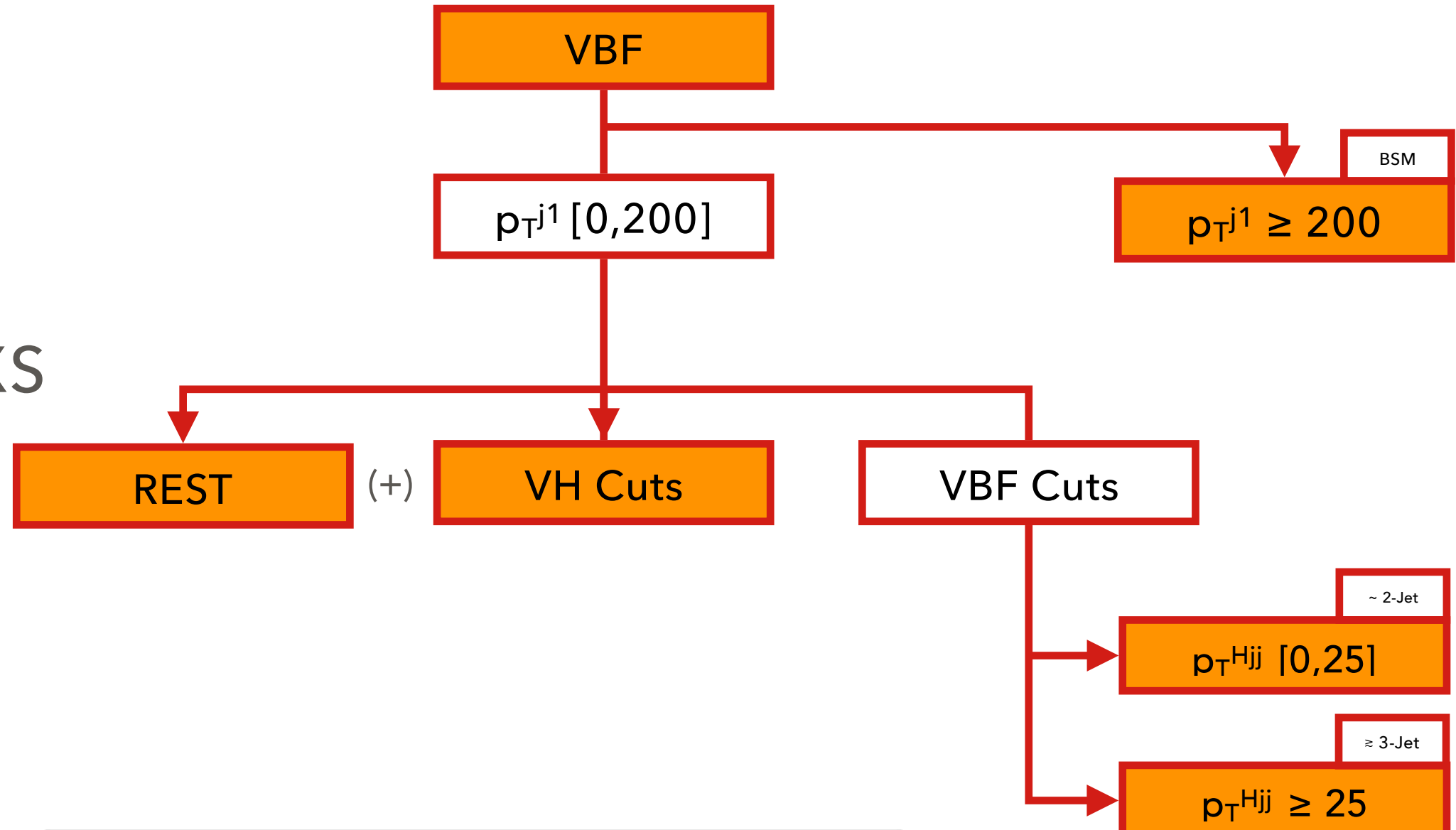
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 - **We could benefit by adding a 0 and 1-jet category**
- **VBF bins are defined by $\Delta y_{jj} > 2.8$ and $M_{jj} > 400$**
- **Can cut in Δy_{jj} be ignored, as the cut $M_{jj} > 400$ GeV covers already the VBF phase-space?**
 - This might affect the electroweak corrections on VBF
 - This cut recommend by theory (Terrasse, Rauch and al, 1802.09955)
 - p_{Tj1} or p_{TH} cut might be enough to control EWK corrections?

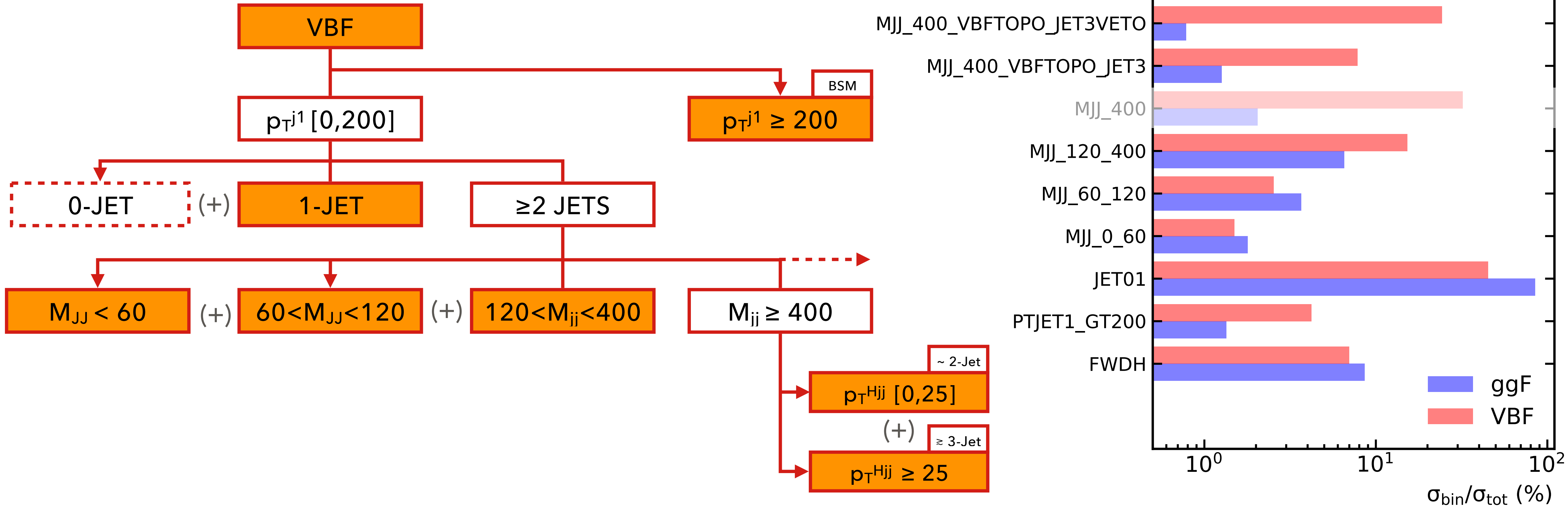


CURRENT STAGE-1 VBF

- Looking at the composition of the current STSX-VBF bins
 - Most of the GGF events lands in REST as well as most of the VBF XS
 - Can we add additional bin to put aside the 0-1 jet events ?**
 - More than 20% ggF contamination in the VBF-like bin
 - Can we have a more finer binning for VBF-like events?**
 - Can we increase the purity/significance of the VBF bins?**

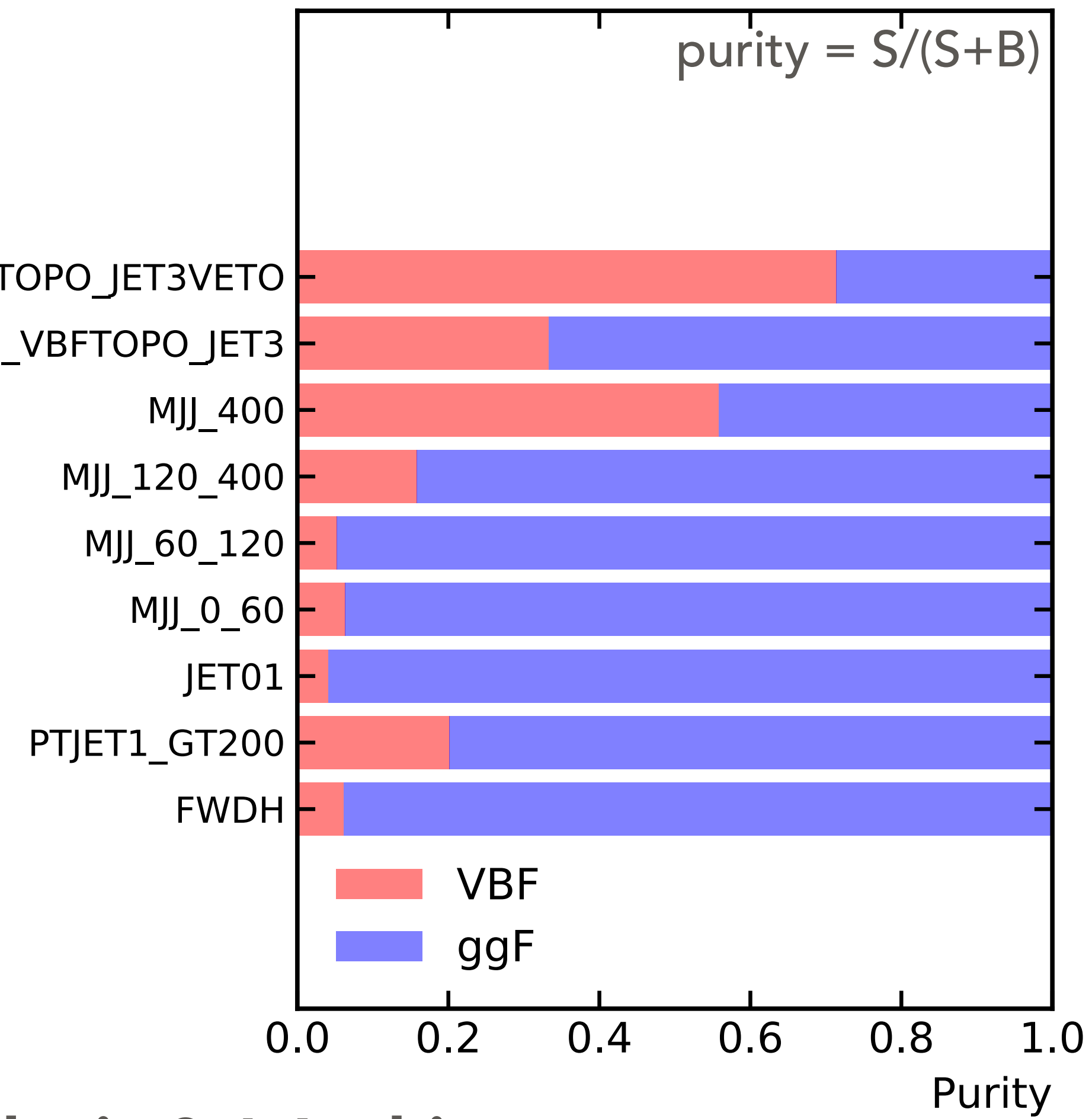
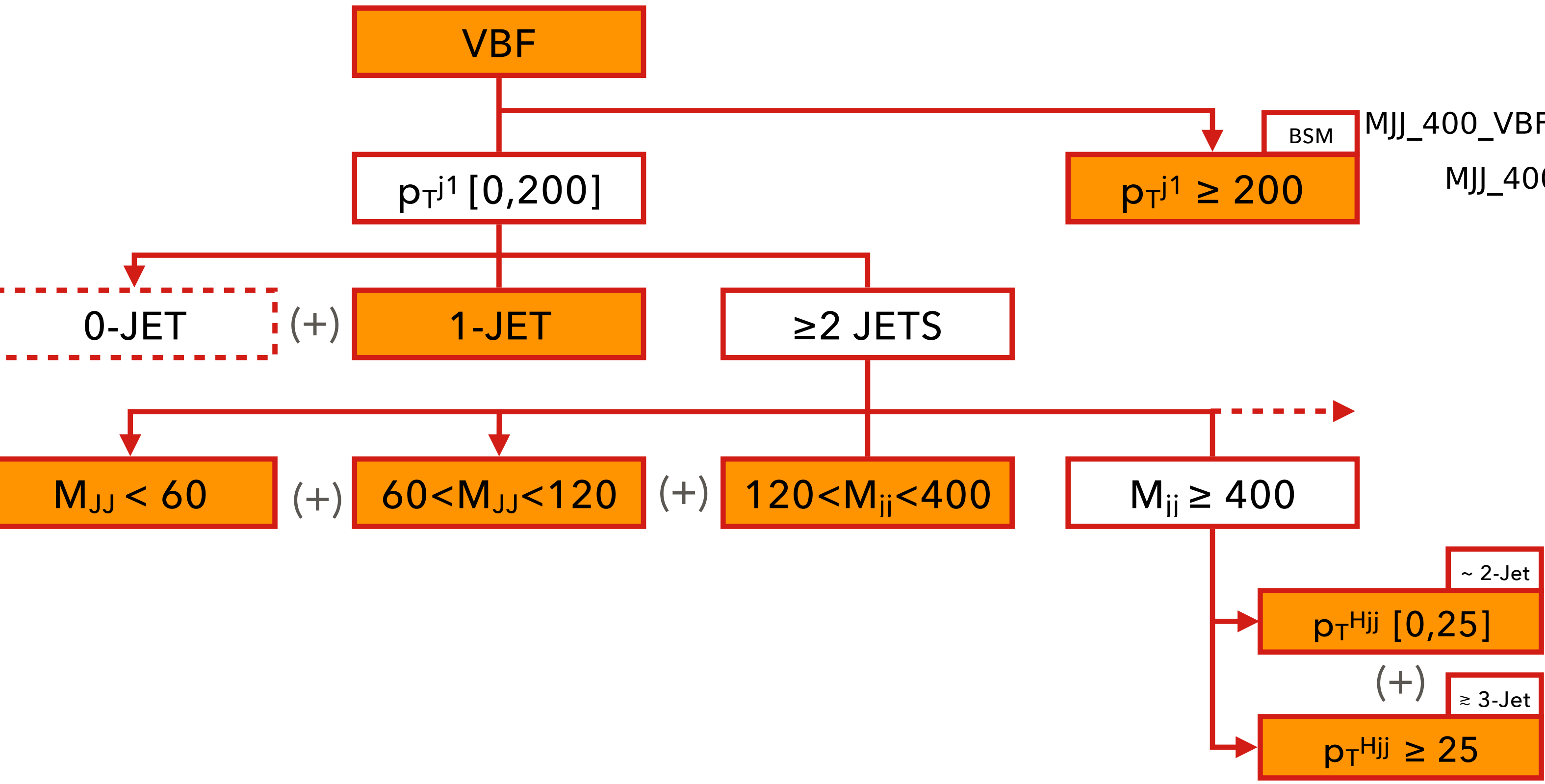


NEW STAGE-1 VBF



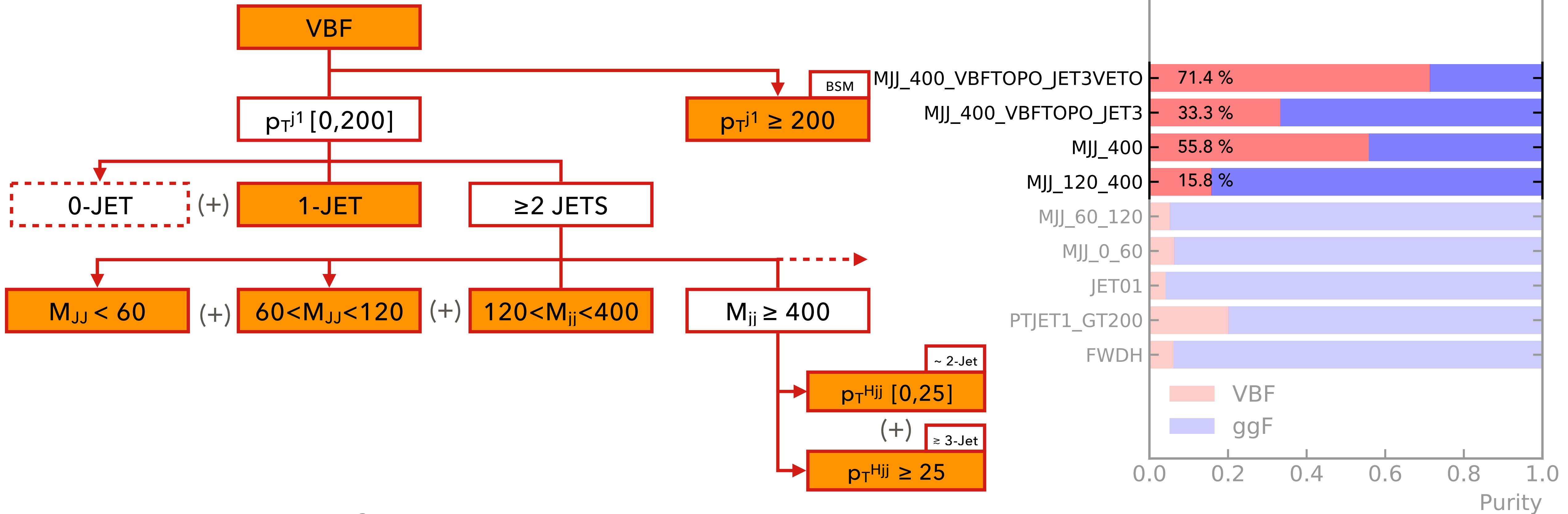
- The event with a jet failing the p_T threshold requirements will be in 0-1 Jet bin
- REST bin will be replaced by $M_{jj} < 60$ GeV bin
- The systematics uncertainties on M_{jj} estimation becomes straightforward by removing the $\Delta\eta_{jj}$ cut

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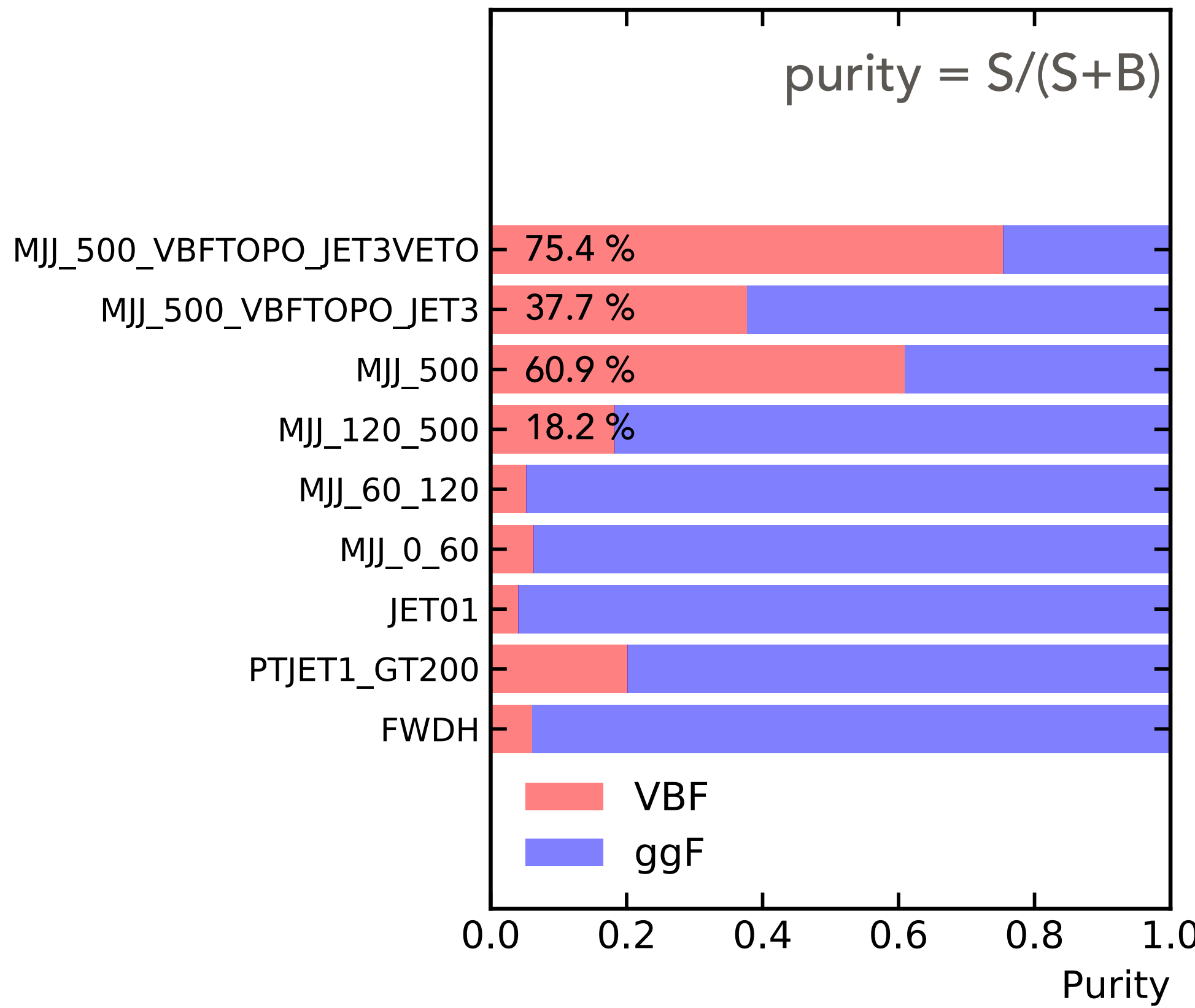
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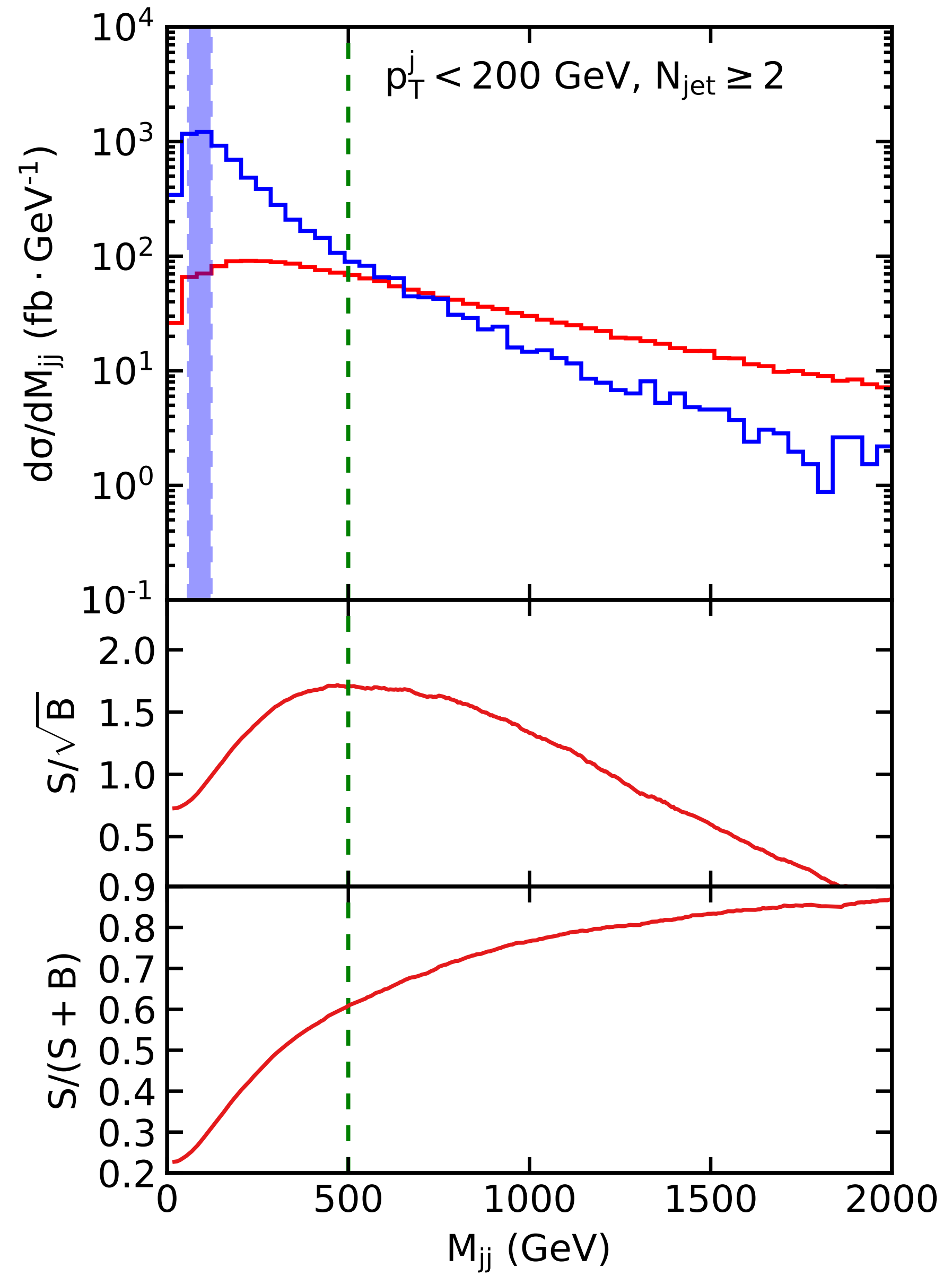
- The event with a jet failing the p_T threshold requirements will be in 0-1 Jet bin
- REST bin will be replaced by $M_{jj} < 60$ GeV bin
- The systematics uncertainties on M_{jj} estimation becomes straightforward by removing the $\Delta\eta_{jj}$ cut
- VBF purity in VBFTOPO_JET3VETO bin reduced by 1% after removing the $\Delta\eta_{jj}$
 - **Can the M_{jj} cut be optimised further to enhance significance and VBF purity?**

VBF BIN OPTIMISATION

- For one cut optimisation we use the simple significance estimator S/\sqrt{B} , with ggH treated as background and boundaries that defines the VH hadronic bin

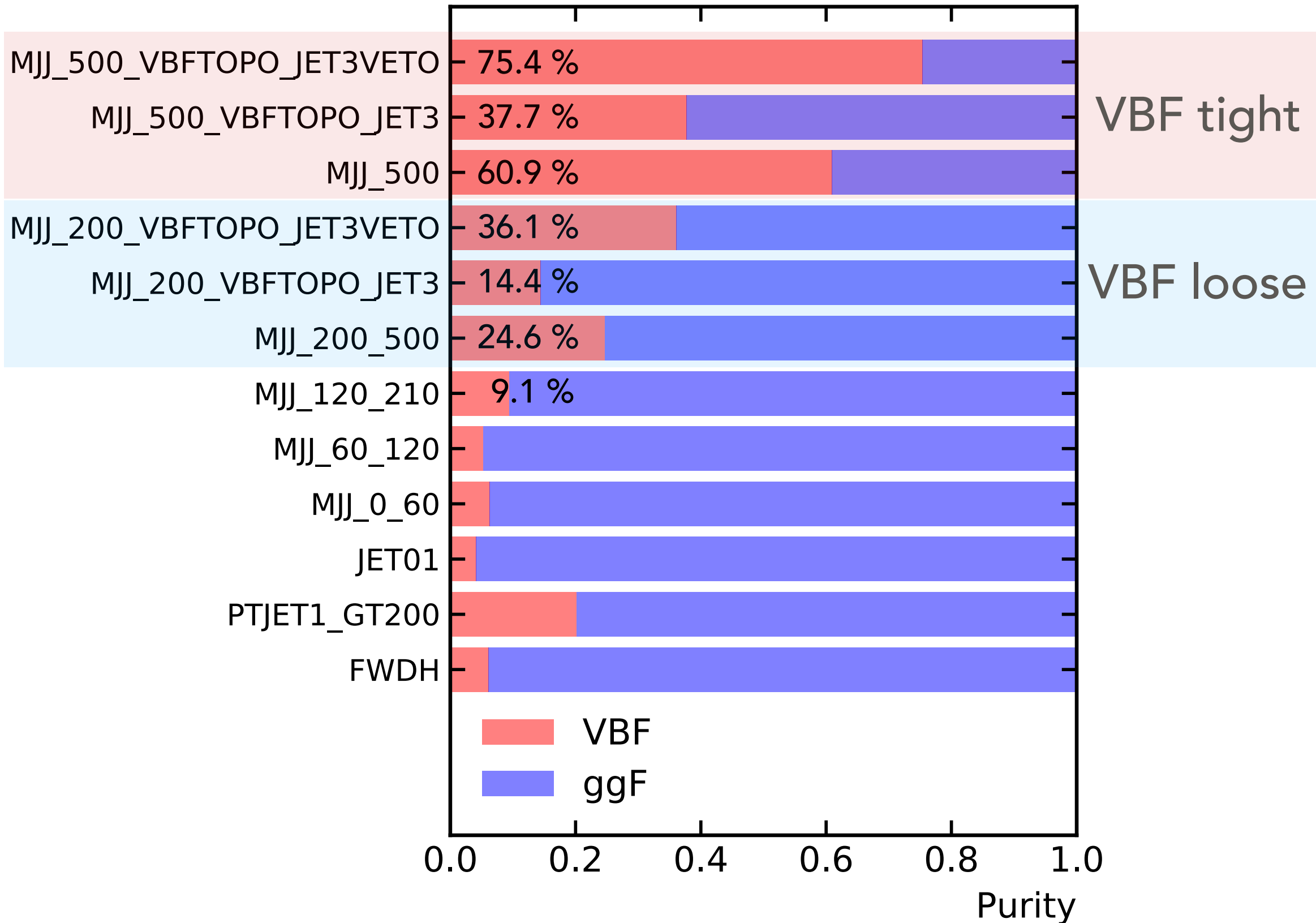
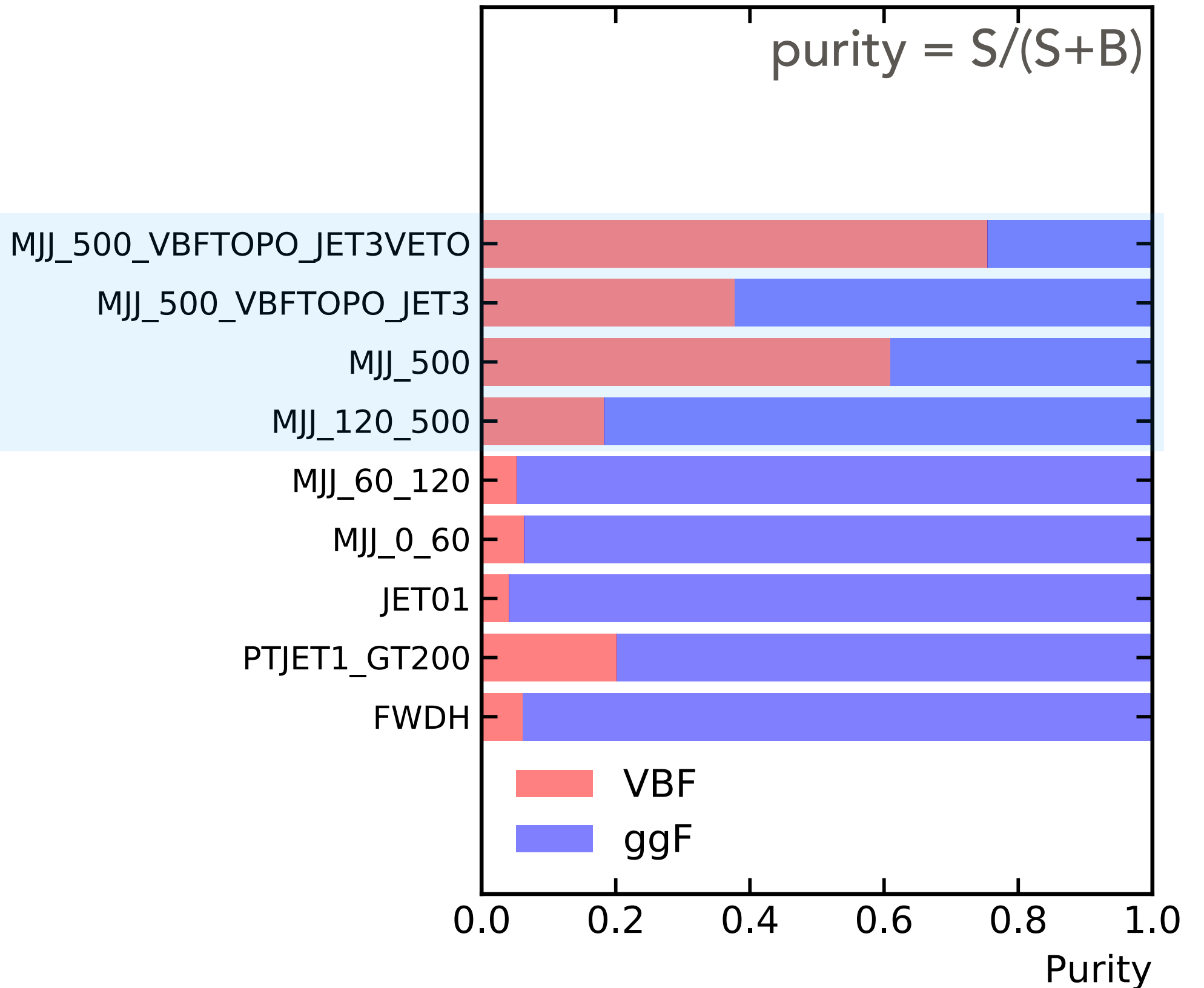


- Pushing the threshold to $M_{jj} > 500$ GeV increase the purity of VBF signal in the VBFTOPO_JET3VETO from 71.4% to 75.4%



VBF BIN OPTIMISATION-2

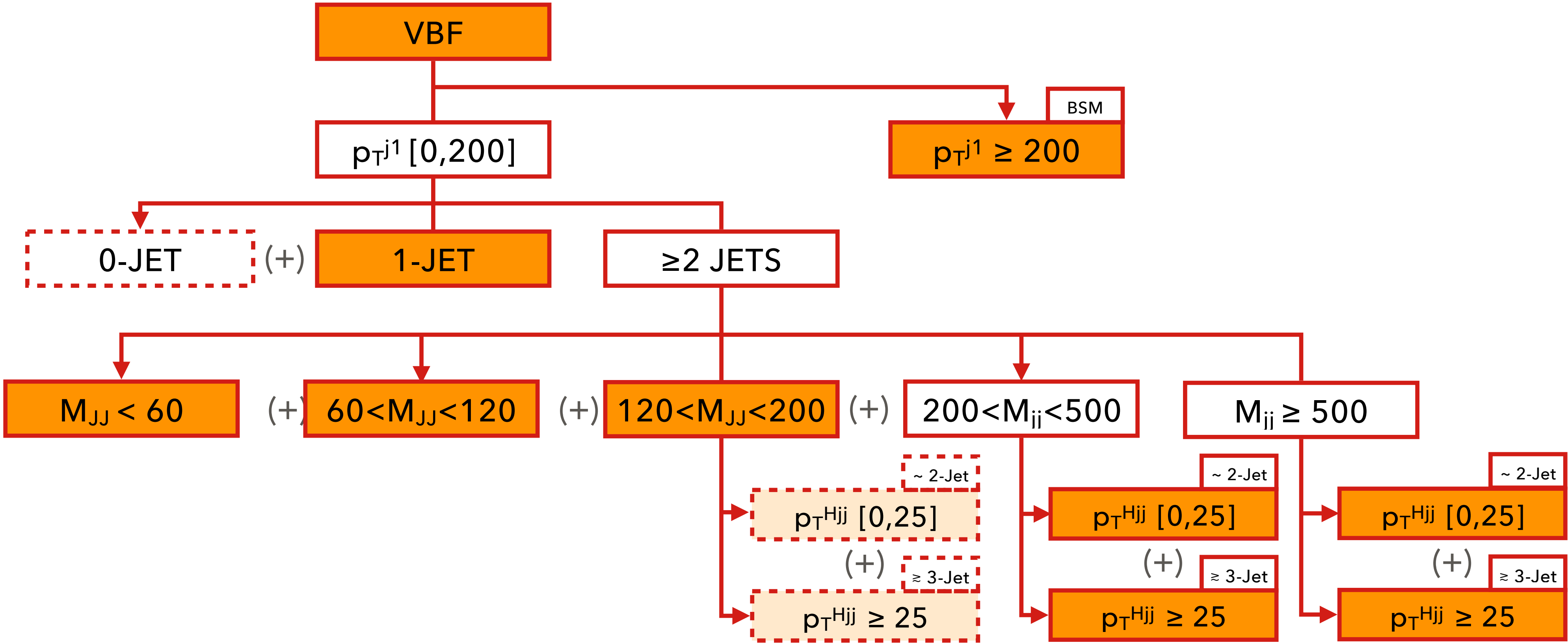
- Ideally we would like to increase as much we can the number of bins, but this is constrained by the experiment and what can be measured with the available statistics at Run2
- For Run2 a loose and tight VBF bins can be defined by splitting the Mjj_120_500 bin following the same procedure as before



CONCLUSION

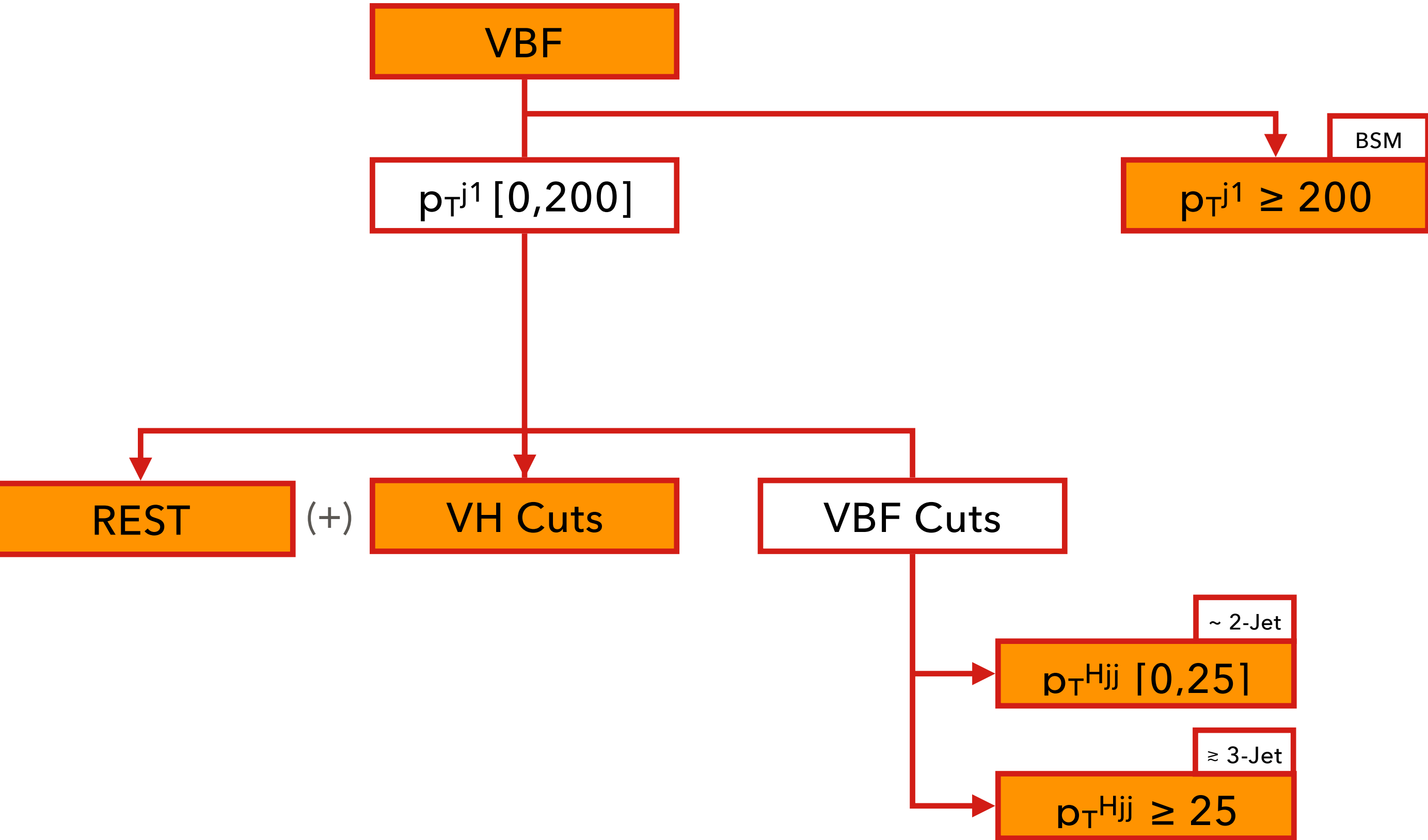
- A new binning is here proposed that enhances the purity in the bin of interest
 - Optimisation done independently of the Higgs decays
 - Unwrapping the REST categories into Jet and Mjj bins
 - Binning can still be improved by adding other processes (ex: VH)
 - Bin population will depends on the analysis (ID's, Triggers, ... etc)
- Toward a finer binning
 - The use of these finer bins will depend on the available statistics at Run2, but can be used for calculating uncertainties
 - A simple split in Mjj (as other channel VH: p_T^V , ggH: p_T^H) will simplify the systematic definition
- We aim to finalised the VBF uncertainty scheme for HXSWG workshop

CONCLUSION



BACKUP SLIDES

CURRENT STAGE-1 VBF



DELTA RABIDITY JETS

From arXiv:1802.09955 :

" We can clearly observe that the VBF approximation can be considered valid only for dijet invariant mass cuts above 500 GeV and for rapidity gaps above 2.

..... Recent experimental analyses do not implement selection criteria for the VBF region as tight as originally envisaged [14-20], and rely on a multitude of multi-variate analysis techniques instead [36]. While for the Higgs plus two jet case the validity of the VBF approximation has been confirmed within a tight selection [21, 22], essentially nothing is known quantitatively for additional radiation as relevant to the veto on central jets (CJV), or virtually any observable exploiting properties of the radiation pattern of the underlying electroweak production process."

.....

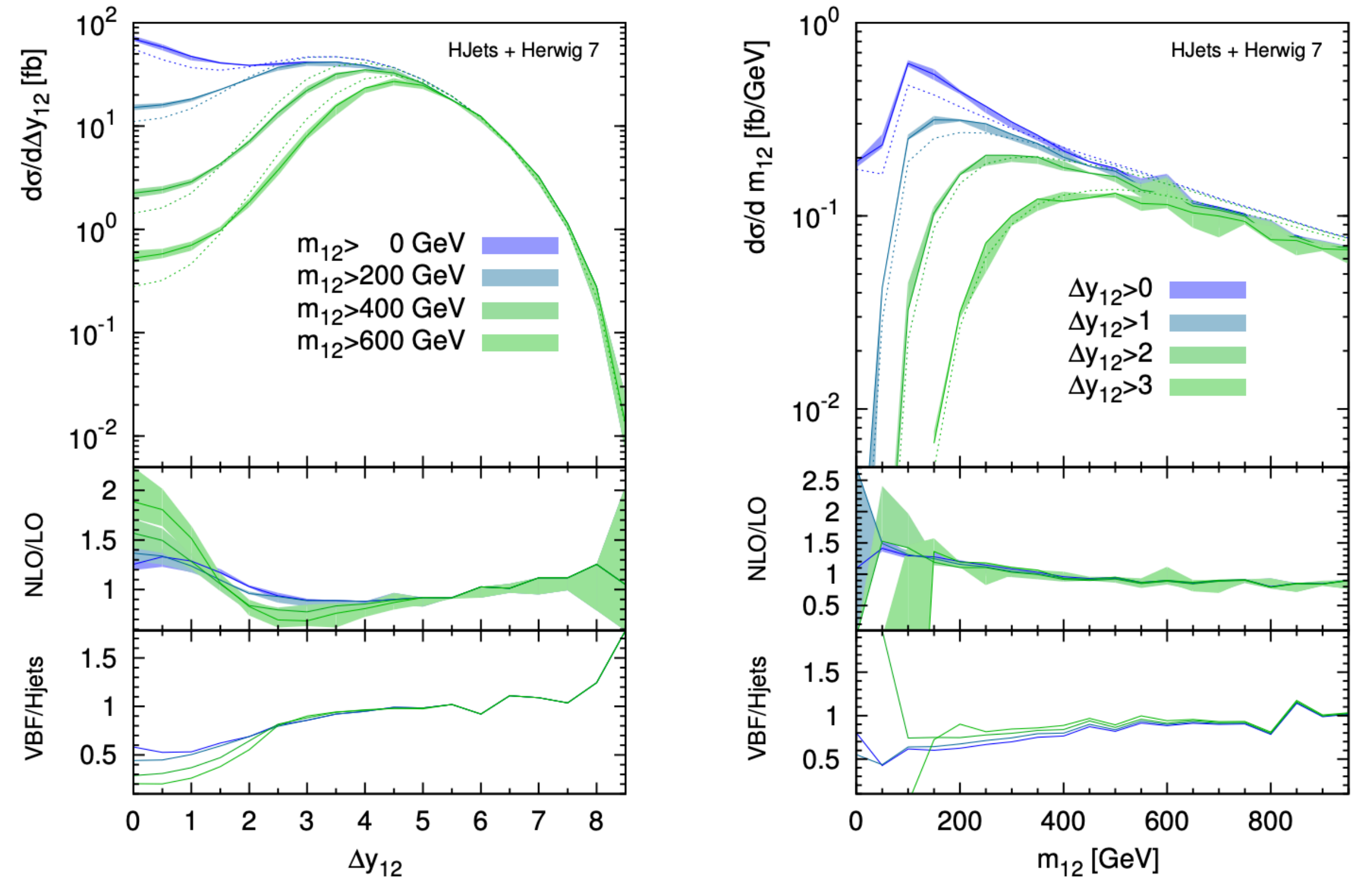


FIG. 4. The rapidity separation Δy_{12} of the leading two jets, for different cuts on their invariant mass (left) and the jet-jet invariant mass m_{12} as a function of the rapidity gap requirement (right). We compare NLO QCD predictions in the full calculation (solid) to the approximate results (dashed).

DERIVING UNCERTAINTIES: Δ 'S

$$C(\{\sigma_0, \sigma_{\geq 1}\}) = \begin{pmatrix} (\Delta_0^y)^2 & \Delta_0^y \Delta_{\geq 1}^y \\ \Delta_0^y \Delta_{\geq 1}^y & (\Delta_{\geq 1}^y)^2 \end{pmatrix} + \begin{pmatrix} \Delta_{\text{cut}}^2 & -\Delta_{\text{cut}}^2 \\ -\Delta_{\text{cut}}^2 & \Delta_{\text{cut}}^2 \end{pmatrix}.$$

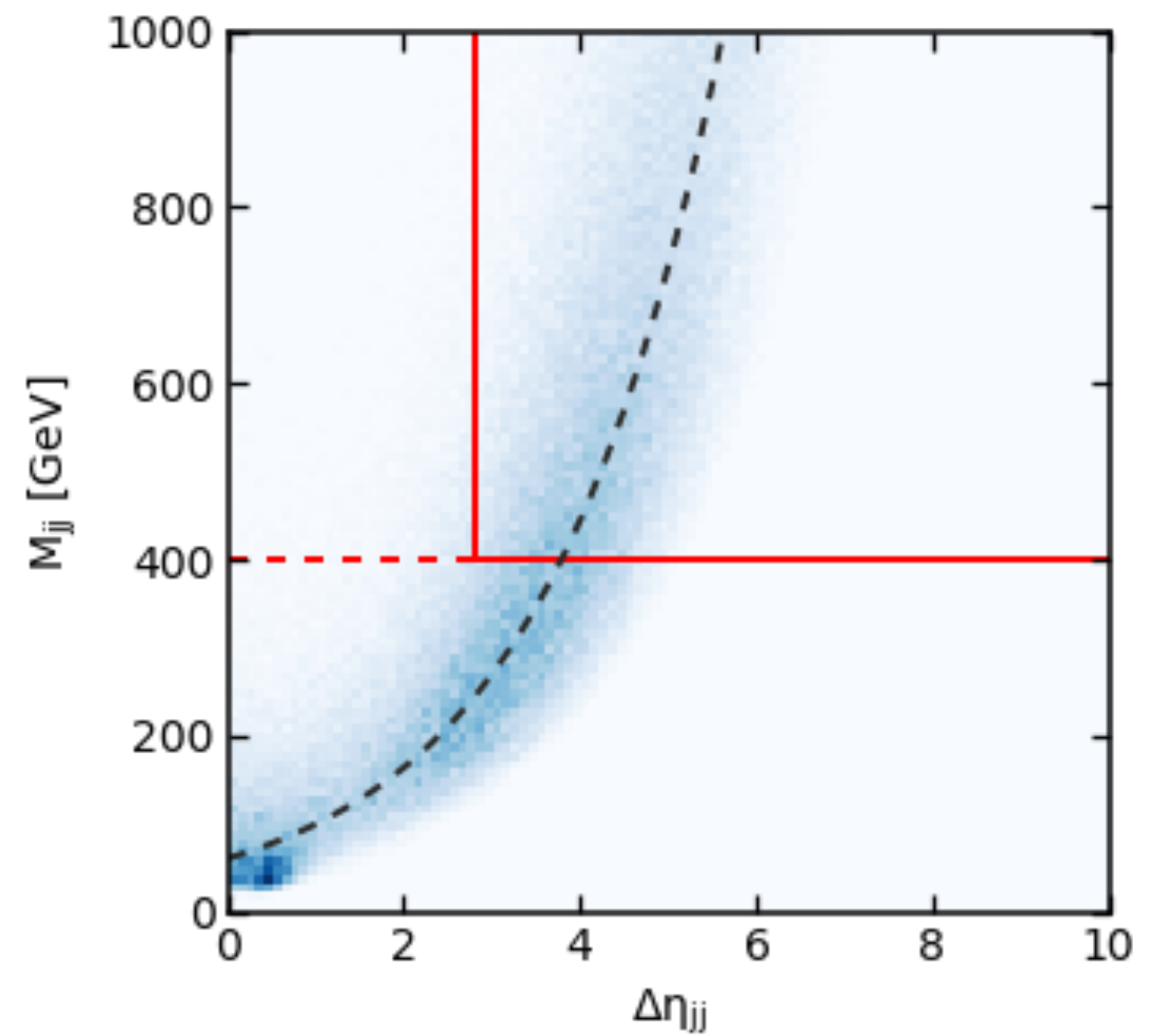
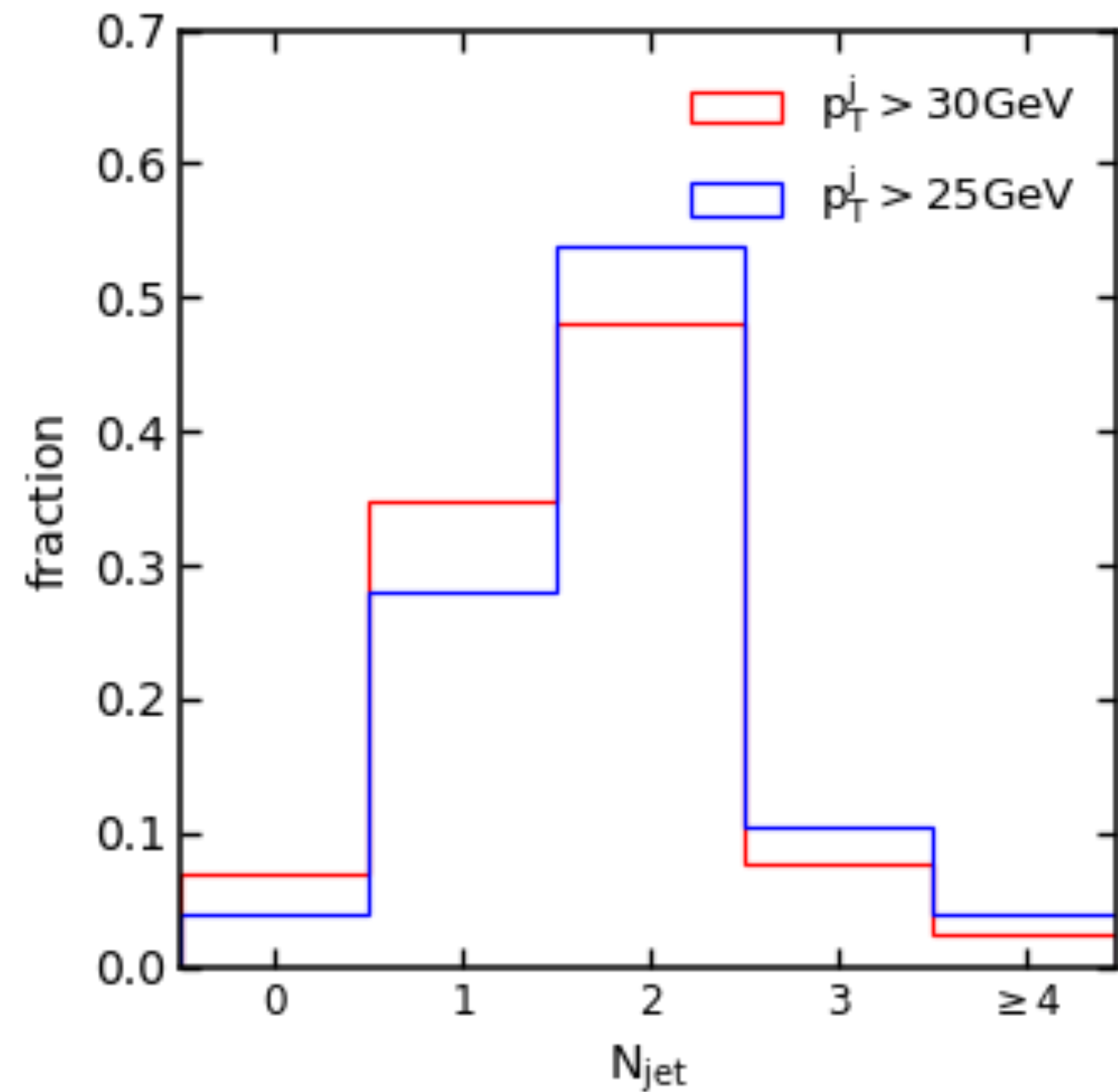
$$\kappa^y : \quad \{\Delta_{\geq 0}^y, \Delta_0^y, \Delta_{\geq 1}^y\} \quad \kappa_{\text{cut}} : \quad \{0, \Delta_{\text{cut}}, -\Delta_{\text{cut}}\},$$

$$\text{ST} : \quad \Delta_0^y = \Delta_{\geq 0}^y = \Delta_{\geq 0}^{\text{FO}}, \quad \Delta_{\geq 1}^y = 0, \quad \Delta_{\text{cut}} = \Delta_{\geq 1}^{\text{FO}}.$$

$$\text{ST}(\rho) : \quad \Delta_0^y = \Delta_{\geq 0}^{\text{FO}}, \quad \Delta_{\geq 1}^y = \rho \Delta_{\geq 1}^{\text{FO}}, \quad \Delta_{\text{cut}} = \sqrt{1 - \rho^2} \Delta_{\geq 1}^{\text{FO}}.$$

$$\text{JVE} : \quad \Delta_{\geq 0}^y = \Delta_{\geq 0}^{\text{FO}}, \quad \Delta_0^y = \epsilon_0 \Delta_{\geq 0}^{\text{FO}}, \quad \Delta_{\geq 1}^y = (1 - \epsilon_0) \Delta_{\geq 0}^{\text{FO}}, \quad \Delta_{\text{cut}} = \sigma_{\geq 0} \Delta(\epsilon_0).$$

VBF POPULATION & KINEMATIC REGION



- Almost 55% of the VBF events lands on < 2 jet region due to the p_T threshold
- These events populates the Rest bin on stage-1 VBF
 - Need to add a new bin that includes the 1-jet category

- $\Delta y_{jj} > 2.8$ have no big impact on the VBF bin
- The cut in Δy_{jj} is ignored as the cut $M_{jj} > 400$ GeV covers already the VBF phase-space