NNbTag: a Neural Network method for b-tagging

Apply *multivariate* methods for b-tagging (*per* jet algorithm)

- Combine the available b-tag methods (*e.g.* JetProbability, SecVtx (to include...))
- Event Reconstruction and Selection:
  - Jet Clustering $\eta - \phi$ R = 0.4 (`JetCluModule`)
  - $E_{T,Jet} \geq 7.5$ GeV.
  - Consider only **Si** Tracks reconstructed with `OutsideInAlg`.
  - **Exclusive** track-jet association (*i.e.* **one** track $\leftrightarrow$ **one** jet).
  - b jet-flavor assigned if `OBSP` b parton in jet cone.
  - At least two **decay tracks** $\Rightarrow$.
    - $d_0 \geq 0$ cm.
    - Track Prob. $P_{trk} < 0.3$.
    - **good_svx** tracks. $\Rightarrow$
      - $P_T \geq 1.0$ GeV/c.
      - Impact Parameter $|d_0| < 0.1$ cm.
      - $|z_0 - z_{PV}| < 5.0$ cm.

NNbTag: Choice of Vriables

Input variables $\Rightarrow$ Physics information on jet.

Hadronic Mass:

$$M_{trk} = \sqrt{\left(\sum_{trk\in Jet} E_{trk}\right)^2 - \left(\sum_{trk\in Jet} \vec{P}_{trk}\right)^2}.$$

Charge Fraction:

$$\mathrm{C.F.} = \frac{\sum_{trk\in Jet} E_{trk}}{E_{T,Jet}}$$

Mean S.I.P.:

$$<\mathrm{SIP}>= \frac{1}{N_{trk}} \sum_{trk\in Jet} \frac{|d_0|}{\sigma_d}$$

$\mathbf{<P_T^{rel}>}$, $\mathbf{<\Delta(R)>}$: Product decays from massive hadrons less boosted $\Rightarrow$ difference in jet topology.

$$<P_T^{rel}> \quad = \quad \frac{1}{N_{trk}} \sum_{trk\in Jet} |\vec{P}_{T,trk}^{rel}|$$

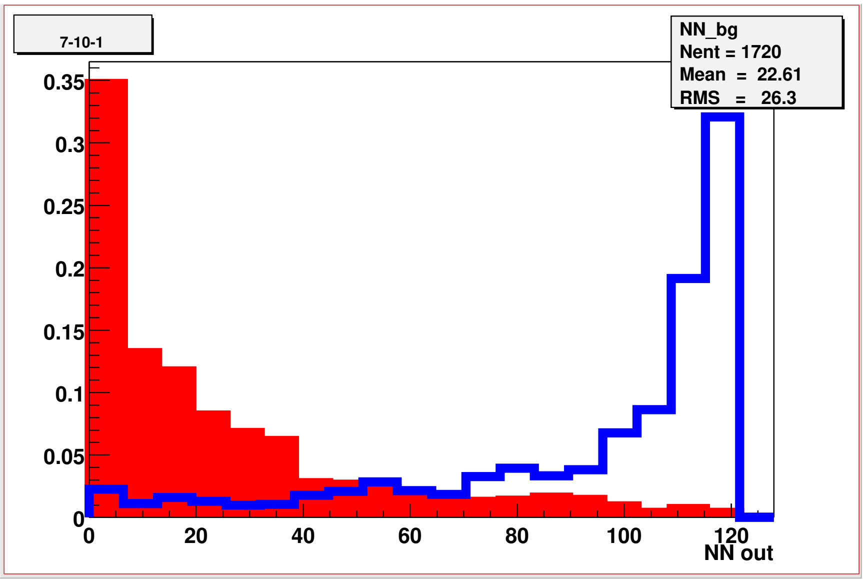
$$<\Delta(R)> \quad = \quad \frac{1}{N_{trk}} \sum_{trk\in Jet} \Delta(R)$$

Jet Probability (from offline 3.12.0)

Track Multiplicity

Methodology

- Using the TOTEM *neurochip* as Feed Forward Neural Network.
- Training using:
  - jets associated with b-quark from $Z \rightarrow b\bar{b}$ for "signal": Target $NN_{out} = 128$;
  - jets from $Z \rightarrow q\bar{q}$ where $q = u, d, s$ for background: Target $NN_{out} = 0$;
  - Training sample size: 2500 + 2500 jets.
- Used architecture 7-10-1.
- Testing on same kind of jets and different events.



Distribution of NN_{out} for b-jets (white) and q-jets (red).

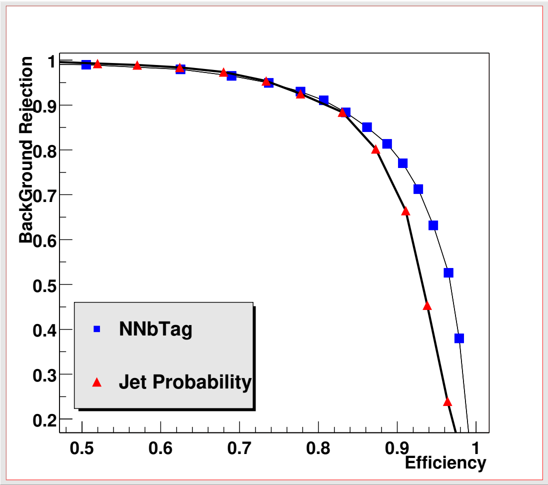
NNbTag: Preliminary Results

Efficiencies, Background rejection *vs* cut.

$$\mathrm{Eff}_{cut} = \frac{\#b - \text{jets NN}_{\text{out}} > \text{cut}}{\#\text{total } b - \text{jets}}$$

$$\mathrm{Bkr}_{cut} = 1 - \frac{\#q - \text{jets NN}_{\text{out}} > \text{cut}}{\#\text{total } q - \text{jets}}$$

NNbTag		
cut	Eff.(%)	Bkr. (%)
56	86.2	84.7
64	83.4	87.3
72	80.1	89.6
80	77.7	91.4
88	73.7	93.3
96	69.0	95.0
104	62.5	96.7
112	50.5	97.9



Efficiency *vs* Background Rejection (NNbTag and JetProb (offline 3.12.0))

Future Plans: Include `SecVtx` information and new infos `JetProb` module.