Mass variables

Variable Whishlist

The transverse projection used here is the *mass-preserving* projection, explained in more detail in arxiv:1105.2977.
It projects the four momentum

$$p = (p^0, p^x, p^y, p^z) \to (p^0_T, p^x, p^y, 0) \tag{1}$$

where $p^0_T = E_T$ as described below:

$$E_T = \sqrt{m^2 + \vec{p}_T^2} = \sqrt{E^2 - p_z^2} \tag{2}$$

(careful: NOT the same as $E \sin\theta$, which would be the *speed-preserving* projection). The transverse mass is then defined (using this E_T):

$$M_T^2 = (p_T + q_T)^2 = m_p^2 + m_q^2 + 2(E_T^p E_T^q - \vec{p}_T \cdot \vec{q}_T) \tag{3}$$

Here p and q denote the fourmomenta of visible and invisible particles respectively. M_T as defined above I have already implemented into my own WHIZARD version, since it is still a binary observable. Using this particular mass projection, one can/should then implement a treatment of M_{T2}, which is defined as follows:

$$M_{T2} = \min_{\vec{q}_{1,T} + \vec{q}_{2,T} = \vec{\not{p}}_T} (\max(M_T(q_{1,T}), M_T(q_{2,T}))) \tag{4}$$

where the minimization is done over all possible partitions $q_{i,T}$, that satisify the requirement of $\vec{q}_{1,T} + \vec{q}_{2,T} = \vec{\not{p}}_T$. The $q_{i,T}$ are used to calculate the respective transverse masses $M_T(q_{i,T})$. There exists fortran and C code by Chris Lester, which can probably be implemented and used, instead of writing an own routine. It can be found at `http://www.hep.phy.cam.ac.uk/~lester/mt2/index.html`.

Further interesting and imho necesarry variable additions, that require the use of multiple subevents are the scalar sum of E_T:

$$\sum_i E_T^i = \sum_i \sqrt{E_i^2 - p_{i,z}^2} \tag{5}$$

which is precisely the definition of H_T at CMS, when used for jets (only):

$$H_T = \sum_{i}^{N_{jets}} E_T^i \approx \sum_{i}^{N_{jets}} |\vec{p}_{i,T}| \tag{6}$$

where the last equation only holds for massless (partonic) jets, which is also often used as a definition.

We find $\not{H}_T$, when we use the transverse jet threemomenta:

$$\not{H}_T = \left| \sum_{i}^{N_{jets}} \vec{p}_{i,T} \right| \tag{7}$$

The upper variables are furthermore used to construct α_T in the following way:

$$\alpha_T = E_T^{j_2}/M_T = E_T^{j_2}/\sqrt{H_T^2 - \not{H}_T^2} \tag{8}$$

where $E_T^{j_2}$ is the transverse energy of the second hardest jet.

As for ATLAS, M_{T2} and m_{eff} are the most prominent variables, where the latter is defined as:

$$m_{eff} = |\not{\vec{p}}_T| + \sum_i |\vec{p}_{i,T}| \tag{9}$$