23.4.4. ***Kinematic limits***: In a three-body decay the maximum of $|\boldsymbol{p}_3|$, [given by Eq. (23.22)], is achieved when $m_{12} = m_1 + m_2$, *i.e.*, particles 1 and 2 have the same vector velocity in the rest frame of the decaying particle. If, in addition, $m_3 > m_1, m_2$, then $|\boldsymbol{p}_3|_{\max} > |\boldsymbol{p}_1|_{\max}, |\boldsymbol{p}_2|_{\max}$.

23.4.5. ***Multibody decays***: The above results may be generalized to final states containing any number of particles by combining some of the particles into "effective particles" and treating the final states as 2 or 3 "effective particle" states. Thus, if $p_{ijk\ldots} = p_i + p_j + p_k + \ldots$, then

$$m_{ijk\ldots} = \sqrt{p^2{}_{ijk\ldots}}\ , \tag{23.25}$$

and $m_{ijk\ldots}$ may be used in place of *e.g.*, m_{12} in the relations in Sec. 23.4.3 or 23.4.3.1 above.

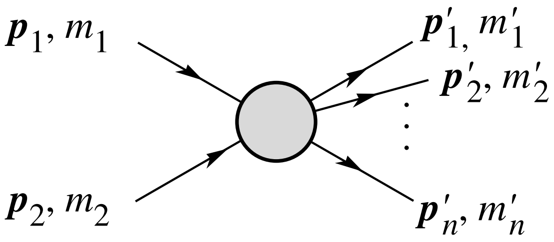

Figure 23.4: Variable definitions for production of an n-body final state.

23.5. Cross sections

The differential cross section is given by

$$d\sigma = \frac{(2\pi)^4|\mathscr{M}|^2}{4\sqrt{(p_1\cdot p_2)^2 - m_1^2 m_2^2}} \times\ d\Phi_n(p_1+p_2;\ p_3,\ \ldots,\ p_{n+2})\ . \tag{23.26}$$

[See Eq. (23.13).] In the rest frame of m_2(lab),

$$\sqrt{(p_1\cdot p_2)^2 - m_1^2 m_2^2} = m_2 p_{1\,\text{lab}}\ ; \tag{23.27a}$$

while in the center-of-mass frame

$$\sqrt{(p_1\cdot p_2)^2 - m_1^2 m_2^2} = p_{1\text{cm}}\sqrt{s}\ . \tag{23.27b}$$