(19) Phase advance
$0 \leq \mu \leq 2\pi$

(20) $\varepsilon_N(39\%) = 2\pi$

$\varepsilon = \varepsilon_N / \gamma\beta$

Convention for beam size:
Often people use $\varepsilon(95\%)$

$$\varepsilon(95\%) = \frac{\varepsilon_N(95\%)}{\gamma\beta} = \frac{6 \times \varepsilon_N(39\%)}{\gamma\beta}$$

(21) 2 liner

(22) $$x = \sum_i \frac{\Theta_i \beta_i^{1/2} \beta_0^{1/2}}{2\sin\pi\nu} \cos(\psi_{i0} - \pi\nu)$$

$$x^2 = \frac{1}{4\sin^2\pi\nu} \beta_0 \sum_i \Theta_i \beta_i^{1/2} \cos(\psi_{i0} - \pi\nu) \times \sum_j \Theta_j \beta_j^{1/2} \cos(\psi_{j0} - \pi\nu)$$

$$x^2 = \frac{\beta_0}{4\sin^2\pi\nu} \left[\sum_i \Theta_i^2 \beta_i \cos^2(\psi_{i0} - \pi\nu) + \sum_{i \neq j} \Theta_i \Theta_j \sqrt{\beta_i \beta_j} \cos(\psi_{i0} - \pi\nu) \times \cos(\psi_{j0} - \pi\nu) \right]$$

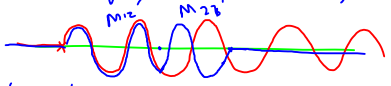
small, fluctuation - Random Phase Approx.

$$\langle x^2 \rangle = \frac{\beta_0}{4\sin^2\pi\nu} N \langle \Theta_i^2 \beta_i \cos^2(\psi_{i0} - \pi\nu) \rangle$$

$\cos^2 \to 1/2$

where $N \equiv$ # errors

(24) 3-Bump: use eqns 3.55



Steps: $\begin{pmatrix} 0 \\ 0 \end{pmatrix} \to \begin{pmatrix} 0 \\ \theta_1 \end{pmatrix} \to M_{12}\begin{pmatrix} 0 \\ \theta_1 \end{pmatrix} \to M_{12}\begin{pmatrix} 0 \\ \theta_1 \end{pmatrix} + \begin{pmatrix} 0 \\ \theta_2 \end{pmatrix}$

$\to M_{23}\left(M_{12}\begin{pmatrix} 0 \\ \theta_1 \end{pmatrix} + \begin{pmatrix} 0 \\ \theta_2 \end{pmatrix}\right) \to M_{23}\left(M_{12}\begin{pmatrix} 0 \\ \theta_1 \end{pmatrix} + \begin{pmatrix} 0 \\ \theta_2 \end{pmatrix}\right) + \begin{pmatrix} 0 \\ \theta_3 \end{pmatrix}$

$= \begin{pmatrix} 0 \\ 0 \end{pmatrix}$