

**Amplitude Dependent Tune Spread and Magnetic Field Errors of the LHC Low- $\beta$  Quadrupoles,**  
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1211 Geneva 23, Switzerland - The nonlinear effects in low- $\beta$  insertions are studied on the basis of the amplitude dependent tune spread. Several methods of estimating the tune spread in a situation of predominantly random multipole errors, typical of low- $\beta$  quadrupoles, are compared. The chosen method is applied to the case of the LHC low- $\beta$  triplets, where the effects of the anti-symmetric layout of the insertions and of the finite crossing angle are examined, and the critical magnets of the triplet identified. The multipole errors that dominate the tune spread are determined, and on the basis of nominal error tables and their correlations, tolerances for the multipoles of the order  $n = 3, 4, 5$  and  $6$  are given. The effects of the quadrupole end errors and of their orientation are also studied, and the most favourable ordering proposed.