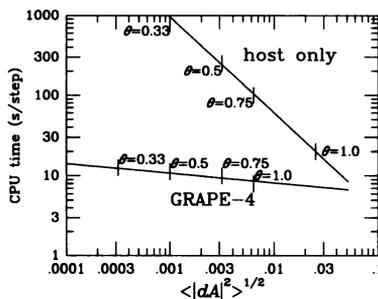


# COSMOLOGICAL $N$ -BODY SIMULATIONS WITH GRAPE-4

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We compared the calculation performance of cosmological  $N$ -body simulations with and without GRAPE-4. A modified Barnes-Hut treecode was used for these simulations. GRAPE(GRAVity piPE) is a special-purpose computer for gravitational  $N$ -body simulations. The newest hardware GRAPE-4 achieved a quite high peak performance (1.08 Tflops). In cosmological  $N$ -body simulations, a large number of particles is required and fast algorithms such as Barnes-Hut treecode or  $P^3M/PM$  are usually used. GRAPE-4 can accelerate such algorithms. In particular, the PCI interface recently completed allows us to use fast host computer, thus it improved the performance of these fast algorithms. Figure 1 shows the CPU time per one timestep as functions of force calculation error for both systems with and without GRAPE-4.



*Figure 1.* CPU time per one timestep plotted as functions of force calculation error for both systems with and without GRAPE-4. A modified Barnes-Hut treecode was used for the simulations. The force calculation error is defined as RMS of the difference between the force calculated with treecode and direct summation code. The initial particle distribution is homogeneous sphere. The number of particle is 262144. The critical particle number for Barnes' vectorization scheme,  $n_{\text{crit}}$ , is 8000 and 1 for systems with and without GRAPE-4, respectively. Here,  $\theta$  denotes the opening parameter.