*FIRST*
The Origin of FIRST Generation Objects

# FIRST Project



History of Universe

Big Bang
0.5Myr
Dark Age
0.1Gyr
1Gyr
14Gyr
CMB
First Objects
Reionization
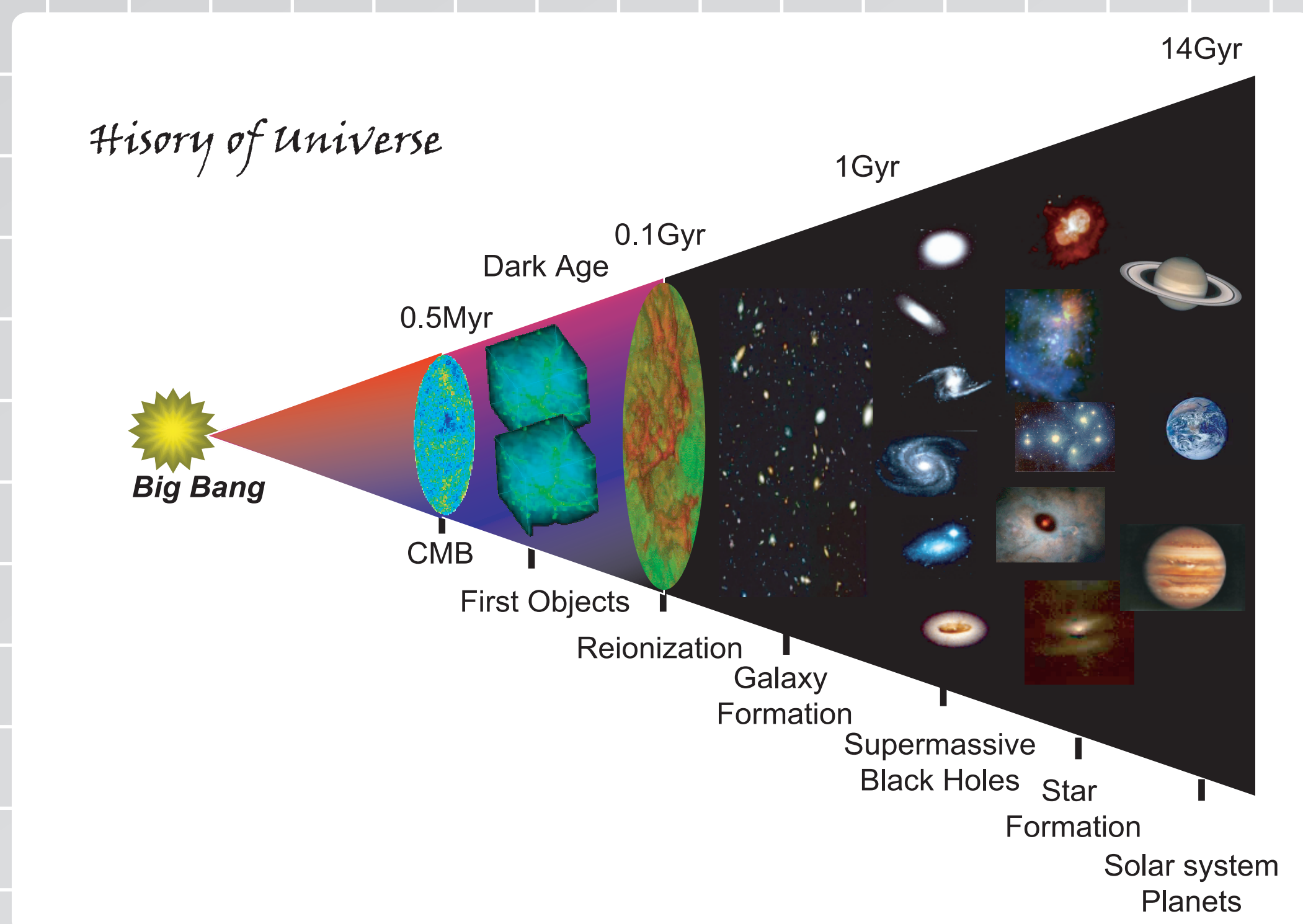Galaxy Formation
Supermassive Black Holes
Star Formation
Solar system Planets

This project is the collaboration between astrophysicists and computer scientists, aiming at the elucidation of the evolution of first generation objects through large-scale radiation hydrodynamic (RHD) simulations with a high-performance hybrid computer system. The project is funded by a Specially Promoted Research in Grants-in-Aid for Scientific Research over four years (2004~2007) with the budget of JPY329.5 million (US$2.8 million), approved by The Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan. Under this project, we have developed a new type of hybrid computer dedicated for astrophysical RHD, called FIRST simulator, in the collaboration with the Division of High Performance Computing Systems.

## FIRST Simulator



Fig.1 - Blade-GRAPE X64 (136.8GFLOPS)



Fig.2 - FIRST simulator (256 nodes, 36.1TFLOPS)

The FIRST simulator is a hybrid PC cluster, where a newly-developed board for gravity calculations, called Blade-GRAPE X64 (Fig.1), is embedded in each node. The Blade-GRAPE is composed of four GRAPE-6 chips that are dedicated chips based on the pipeline architecture, and is designed for PCI-X bus in a PC cluster. The theoretical peak performance of Blade-GRAPE is 136.8GFLOPS. Each board has 16MB memory and can calculate the self-gravity of 260,000 particles simultaneously at the maximum. The Blade-GRAPE is directly connected via PCI-X bus, and occupies the space of two PCI-X bus slots. Each server PC is equipped with multi-port Gigabit Ethernet NIC to be connected to a special interconnection network with commodity Ethernet switches.

Using Blade-GRAPEs, we have constructed a 256 node hybrid PC cluster system, that is, FIRST simulator (Fig.2). The host PC cluster node is a 2U-size of 19-inch rack mountable server PC (HP ProLiant DL380 G4) that has dual Xeon processors in SMP configuration. The peak performance of FIRST simulator is 36.1TFLOPS, where the host PC cluster is 3.1 TFLOPS and the Blade-GRAPEs are 33 TFLOPS. All nodes are connected uniformly with each other via multi-port Gbit ether interconnect switch. The total memory of FIRST simulator is 1.6TB. Also, the Gfarm Grid file system, which is the commodity-based distributed file system that federates local disk of each node, is installed. With Gfarm, the storage of 22TB is available as a seamless file server. In Figure 2, a 256 node FIRST simulator is shown.

The Blade-GRAPE boards were manufactured by Hamamatsu Metrics Co. and the 2Uservers were procured from Nihon Hewlett-Packard Co. Also, Bestsystems Inc. and Sumi-Sho Computer Systems Co. are joined in the development of the system.