GREG SOLLIE

CATHOLIC HIGH SCHOOL

PHYSICS

CENTER FOR COMPUTATION & TECHNOLOGY

LA-SiGMA

Louisiana Alliance for Simulation-Guided Materials Applications

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RESEARCH OUTLINE

Universal Gravitation Instructional Module

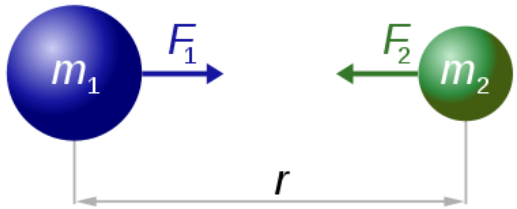
- Traditional Gravitational Content
  - History
  - Kepler's Laws
  - Newton's Law of Universal Gravitation
- Computational Science – Parallel Computing
  - Description
  - Components
  - Discovery
- Modeling
  - Galaxy formation
  - N-body problems
  - Supercomputer

INSTRUCTIONAL MODULE

Universal Laws of Gravitation

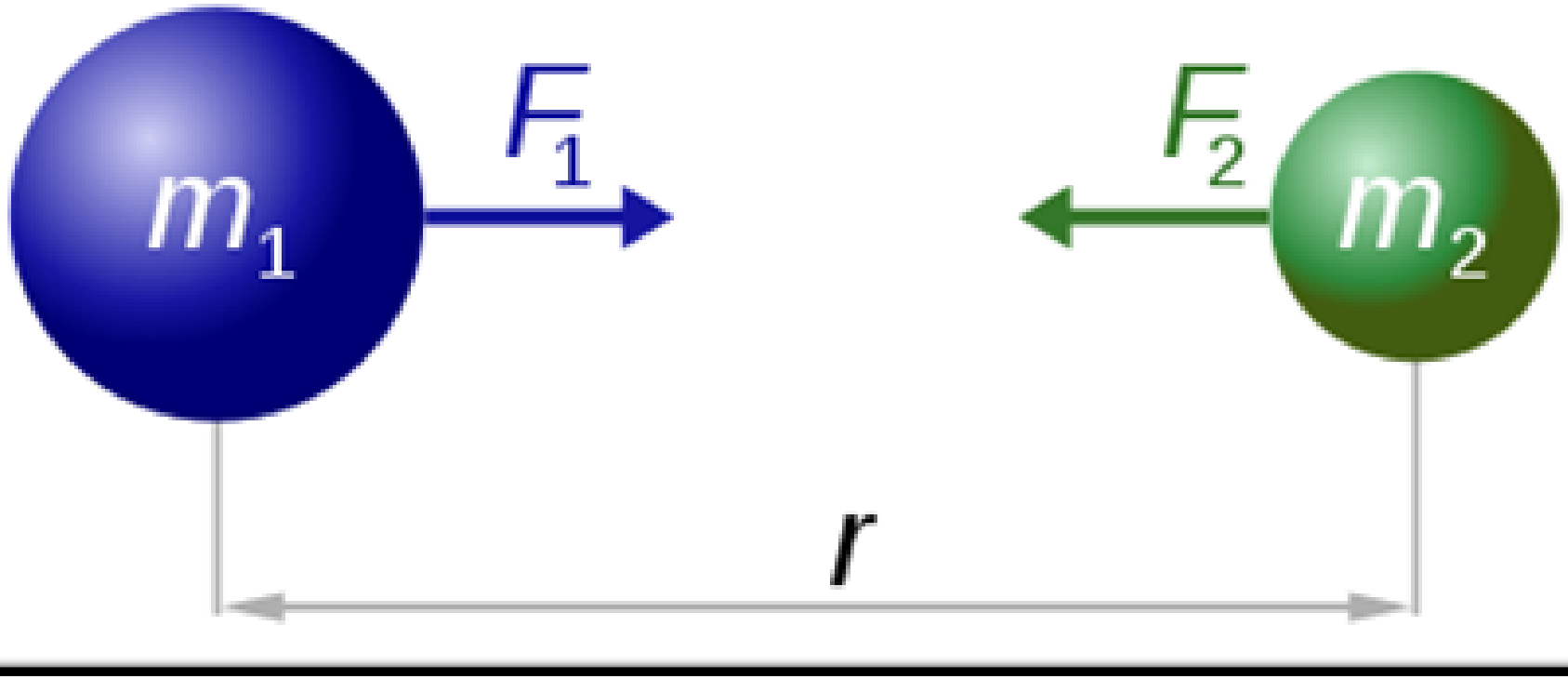
- Newton's Law of Universal Gravitation

$$F_G = \frac{Gm_1m_2}{d^2}$$



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

2 BODIES



INSTRUCTIONAL MODULE

Universal Laws of Gravitation

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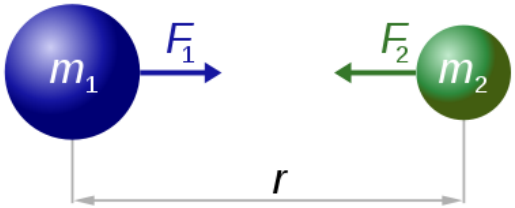
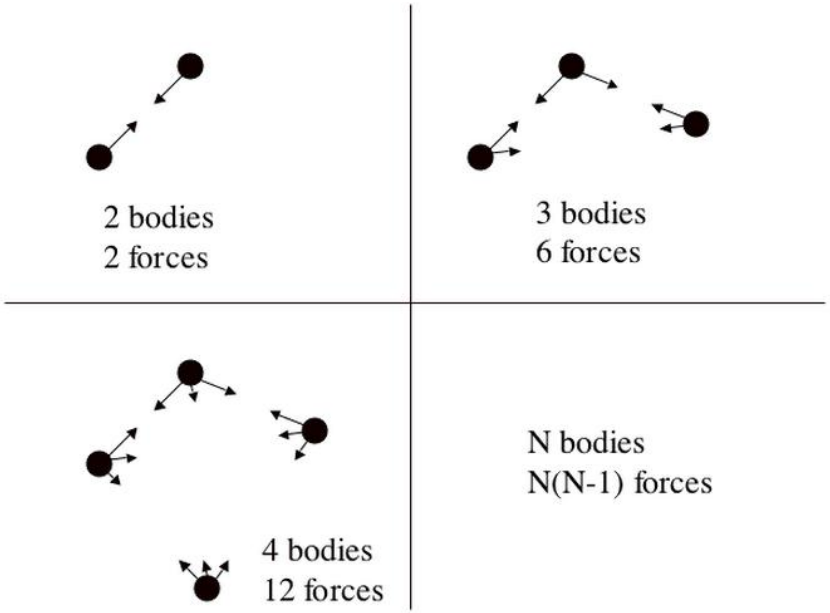
$$F_G = \frac{Gm_1m_2}{d^2}$$

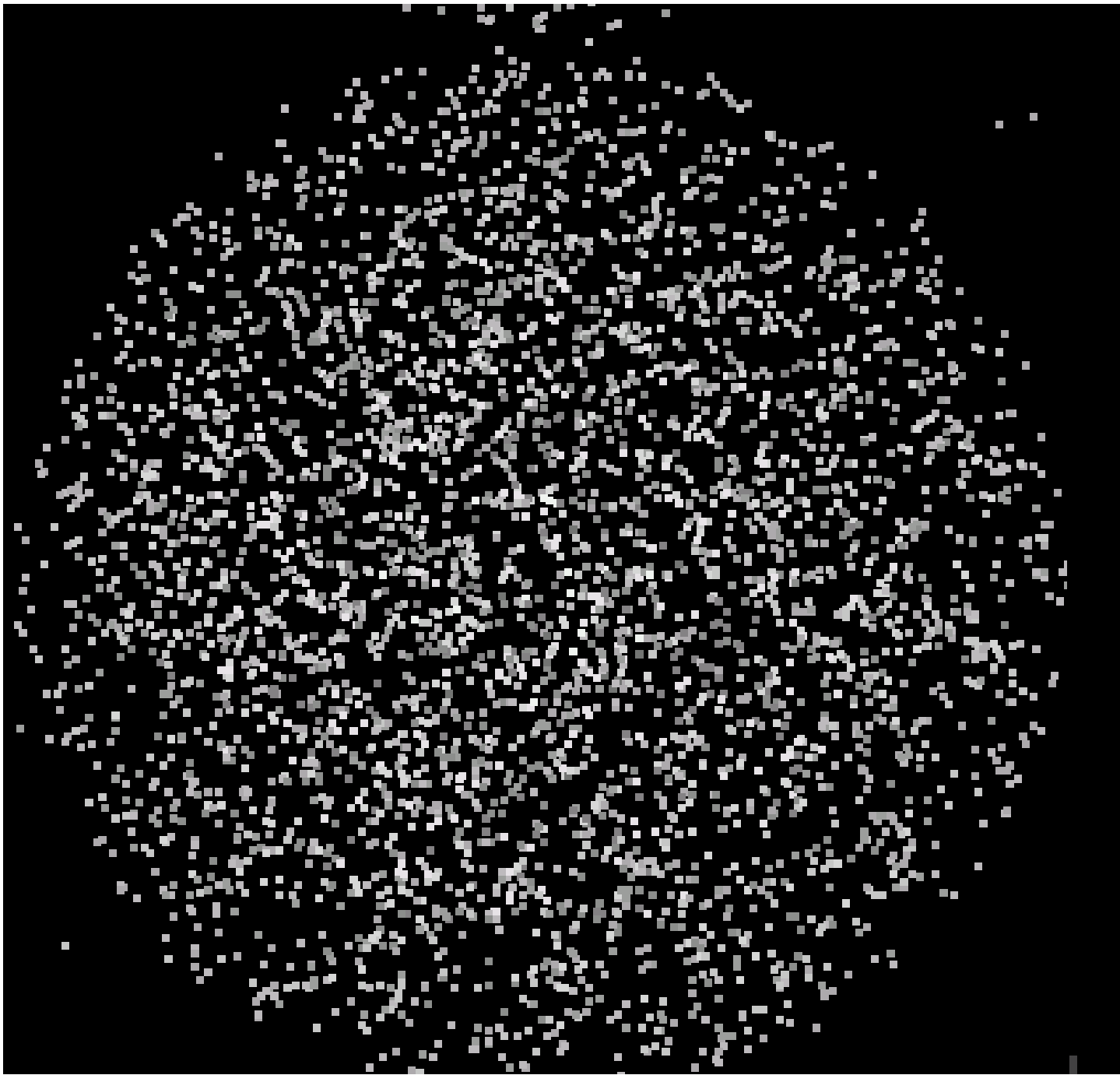


$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

- N-body Problems
  - the problem of predicting the motion of group objects that interact with each other.



N- BODIES



COMPUTATIONAL SCIENCE

- **Computer science subfield**
  - Constructs and analyzes mathematical models
  - Uses computer simulation from theoretical computer science to solve problems in various scientific disciplines.
- **Parallel Computing**
  - Definition
  - Design
  - Advantages
  - N-body modeling & simulation

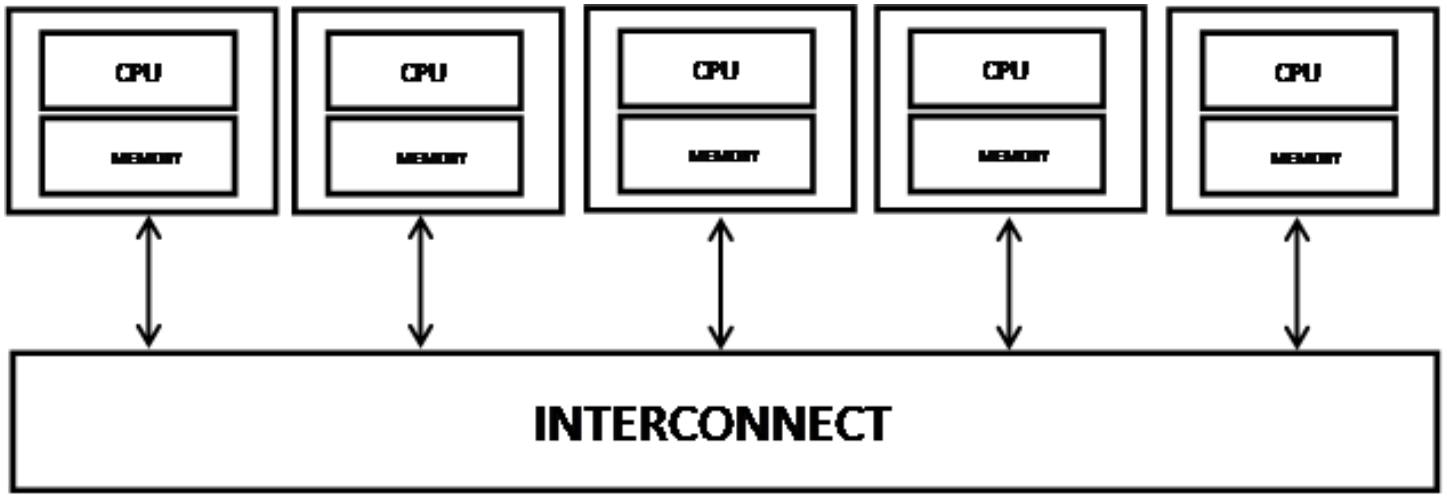
BCCD

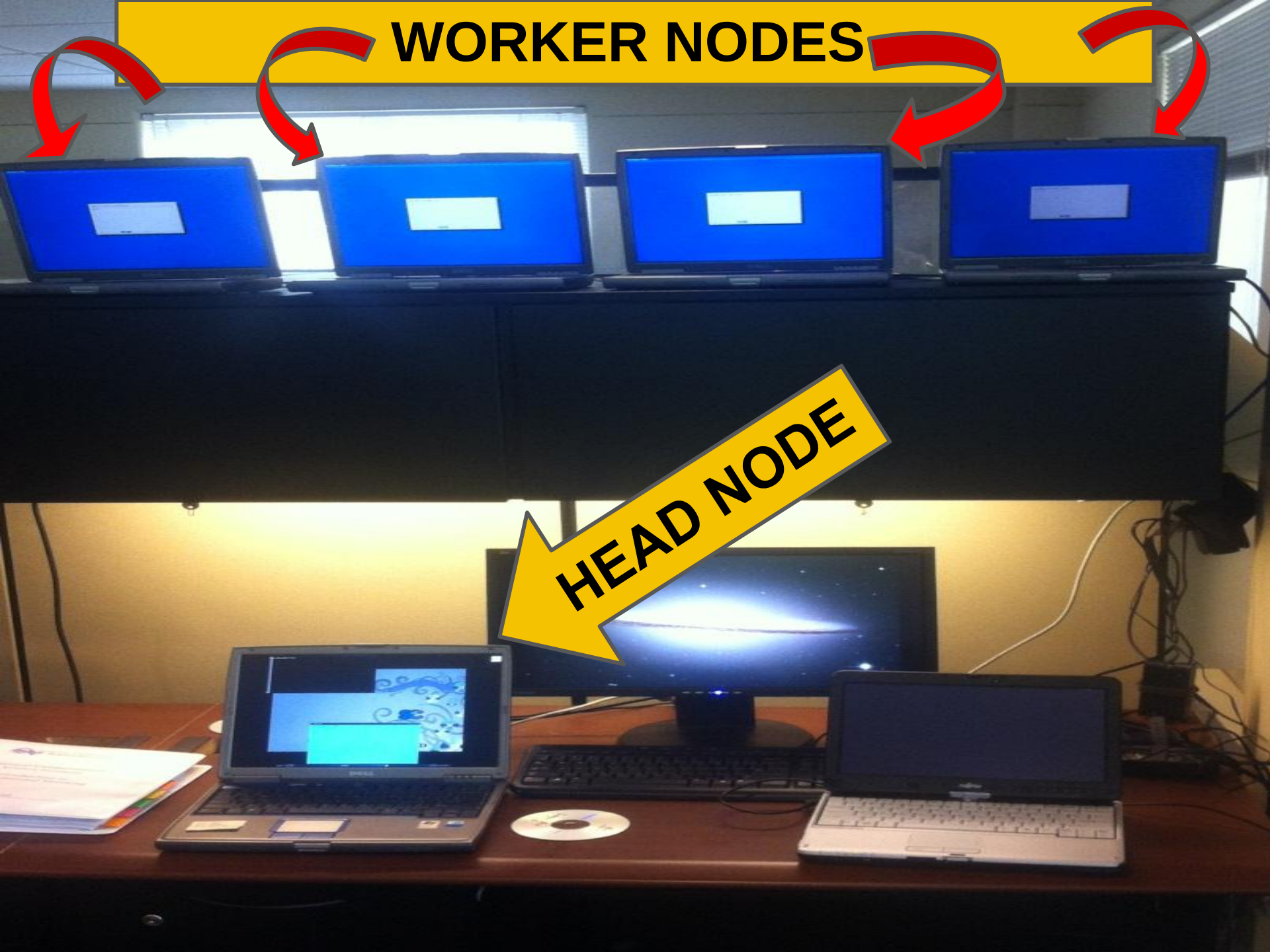
SHODOR
a national resource for computational science education

BCCD
Version 3

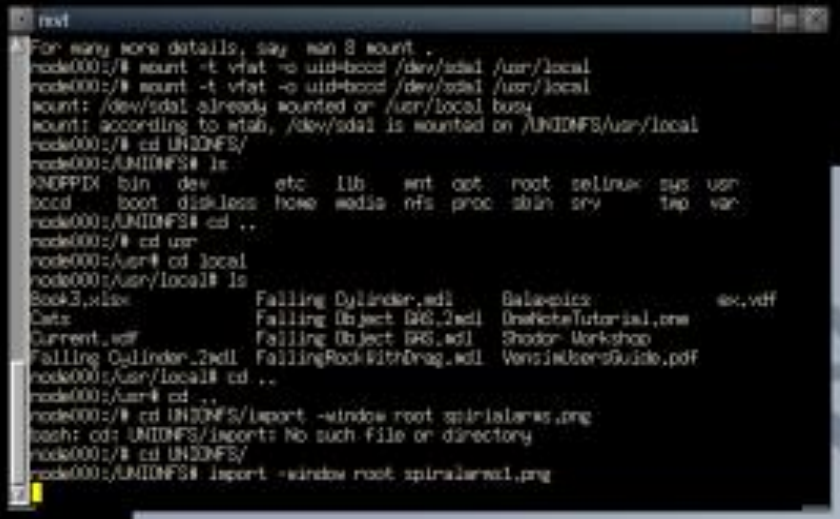
Bootable Cluster CD

- Facilitates instruction of aspects of parallel computing.
- BCCD image provides a **non-destructive overlay** to run a full-fledged parallel computing environment.

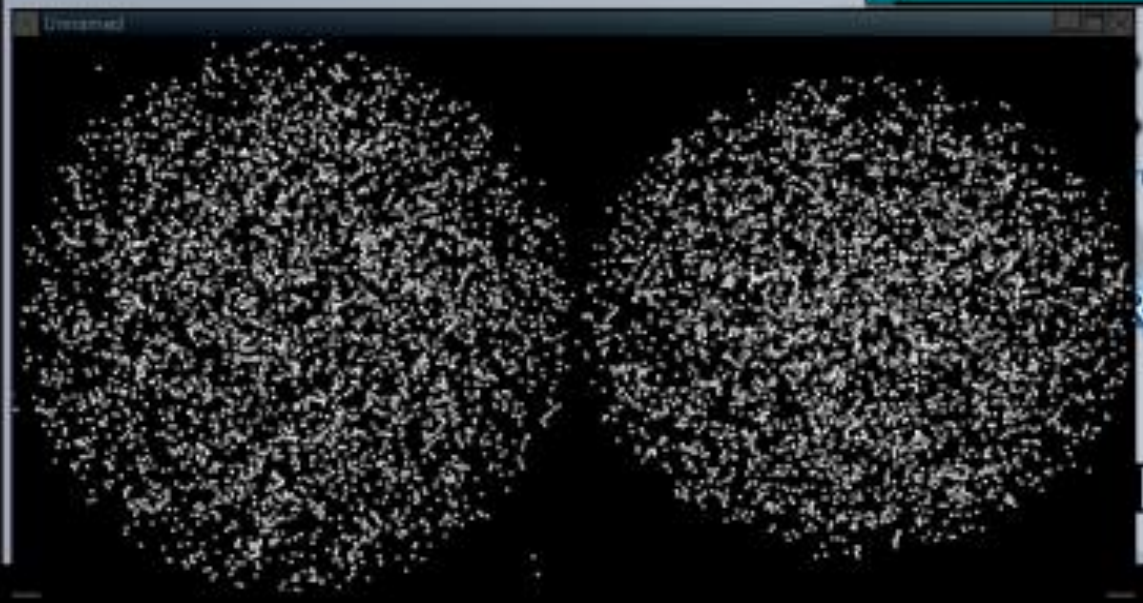



WORKER NODES
HEAD NODE

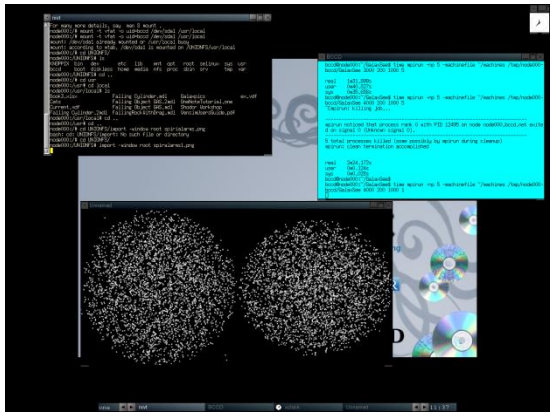
GALAXSEE


root
For many more details, say man 8 mount .
node000:/# mount -t vfat -o uid=bccd /dev/sda1 /usr/local
node000:/# mount -t vfat -o uid=bccd /dev/sda1 /usr/local
mount: /dev/sda1 already mounted or /usr/local busy
mount: according to mtab, /dev/sda1 is mounted on /UNIONFS/usr/local
node000:/# cd UNIONFS/
node000:/UNIONFS# ls
UNIONFS bin dev etc lib mnt opt root selinux sys usr
bccd boot diskless home media nfs proc sbin srv tmp var
node000:/UNIONFS# cd ..
node000:/# cd usr
node000:/usr# cd local
node000:/usr/local# ls
Box43.xlsx Falling Cylinder.wdl Galaxpics ex.vdf
Cats Falling Object BAG.2wdl OneNoteTutorial.one
Current.vdf Falling Object BAG.wdl Shador Workshop
Falling Cylinder.2wdl FallingRockWithDrag.wdl VensimUsersGuide.pdf
node000:/usr/local# cd ..
node000:/usr# cd ..
node000:/# cd UNIONFS/import -window root spiralarms.png
bash: cd: UNIONFS/import: No such file or directory
node000:/# cd UNIONFS/
node000:/UNIONFS# import -window root spiralarms1.png


BCCD
bccd@node000:~/GalaxSee$ time mpirun -np 5 -machinefile ~/machines /tmp/node000-
bccd/GalaxSee 3000 200 1000 5
real 1m31.898s
user 0m40.827s
sys 0m35.658s
bccd@node000:~/GalaxSee$ time mpirun -np 5 -machinefile ~/machines /tmp/node000-
bccd/GalaxSee 4000 200 1000 5
~C[mpirun: killing job...
mpirun noticed that process rank 0 with PID 12485 on node node000.bccd.net exite
d on signal 0 (Unknown signal 0).
5 total processes killed (some possibly by mpirun during cleanup)
mpirun: clean termination accomplished
real 2m24.172s
user 0m0.124s
sys 0m0.028s
bccd@node000:~/GalaxSee$
bccd@node000:~/GalaxSee$ time mpirun -np 5 -machinefile ~/machines /tmp/node000-
bccd/GalaxSee 4000 200 1000 1

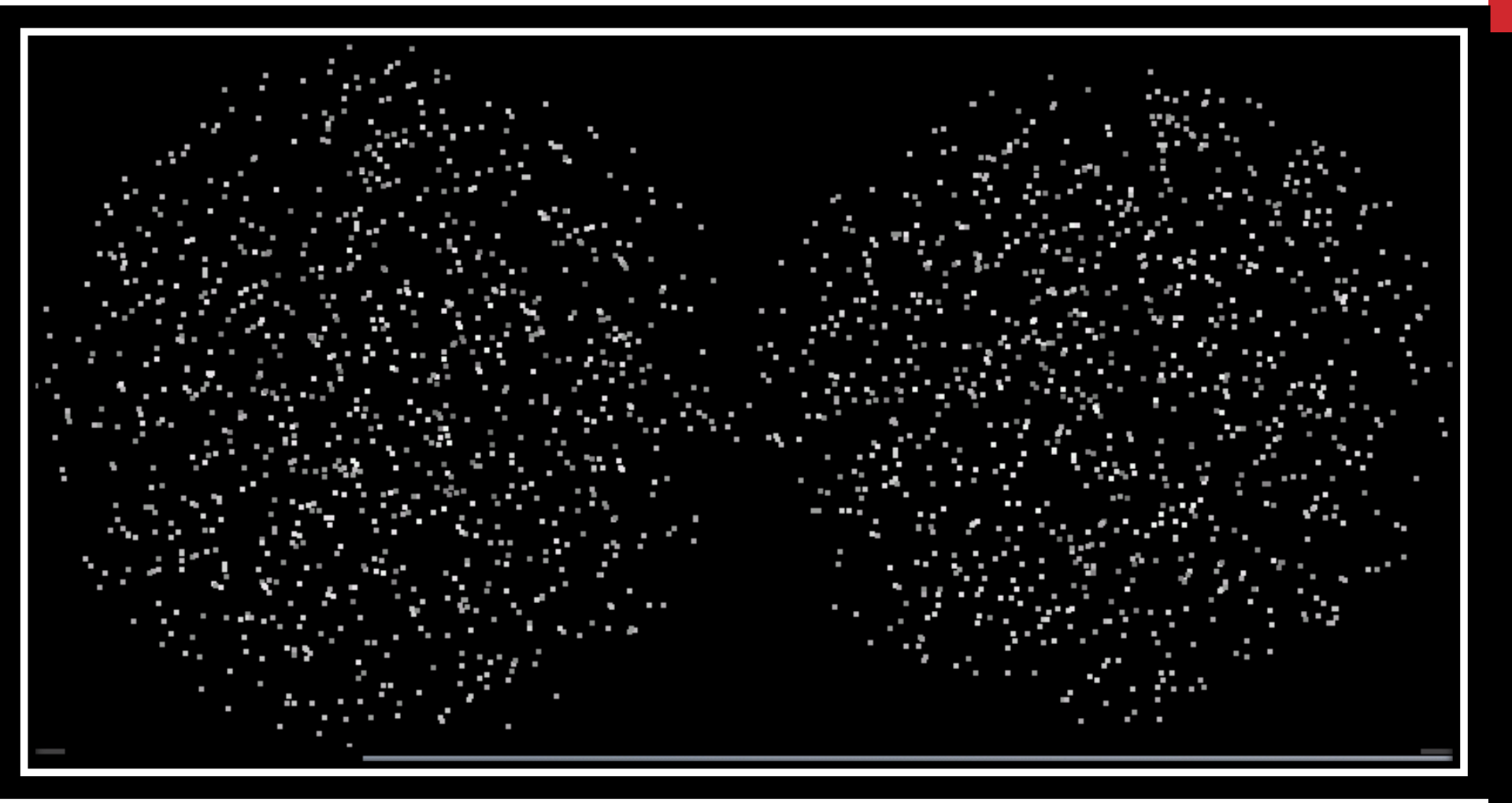

Unnamed

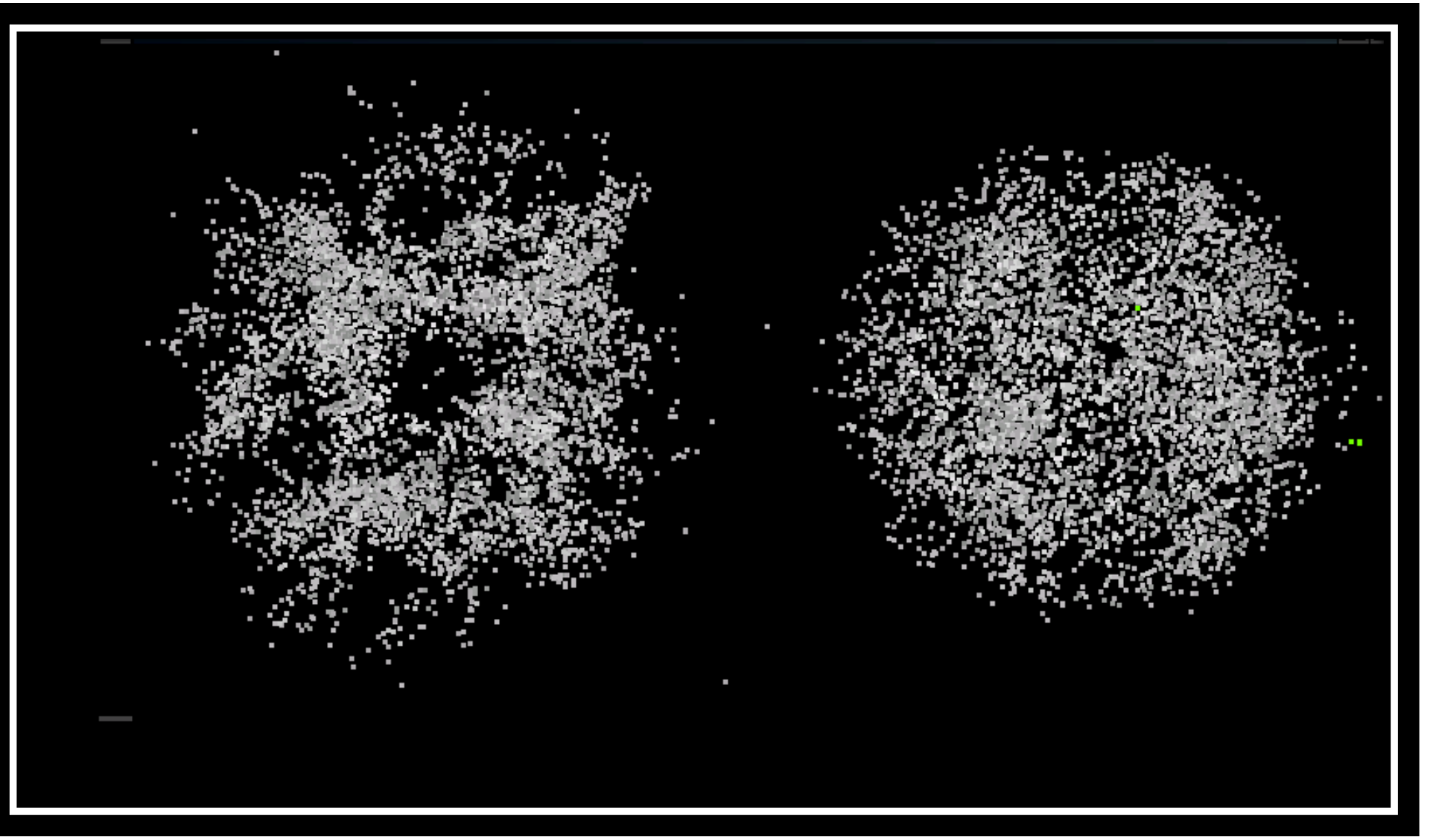
GALAXSEE



- Teaching module
- introducing simulation of N-body systems.
- Simple implementation of parallelism.
  - Most time in an N-body problem is spent calculating forces.
  - Worker nodes calculating accelerations are fed every particle’s information
  - Head node runs the main program and sends out, collects and visualizes results.

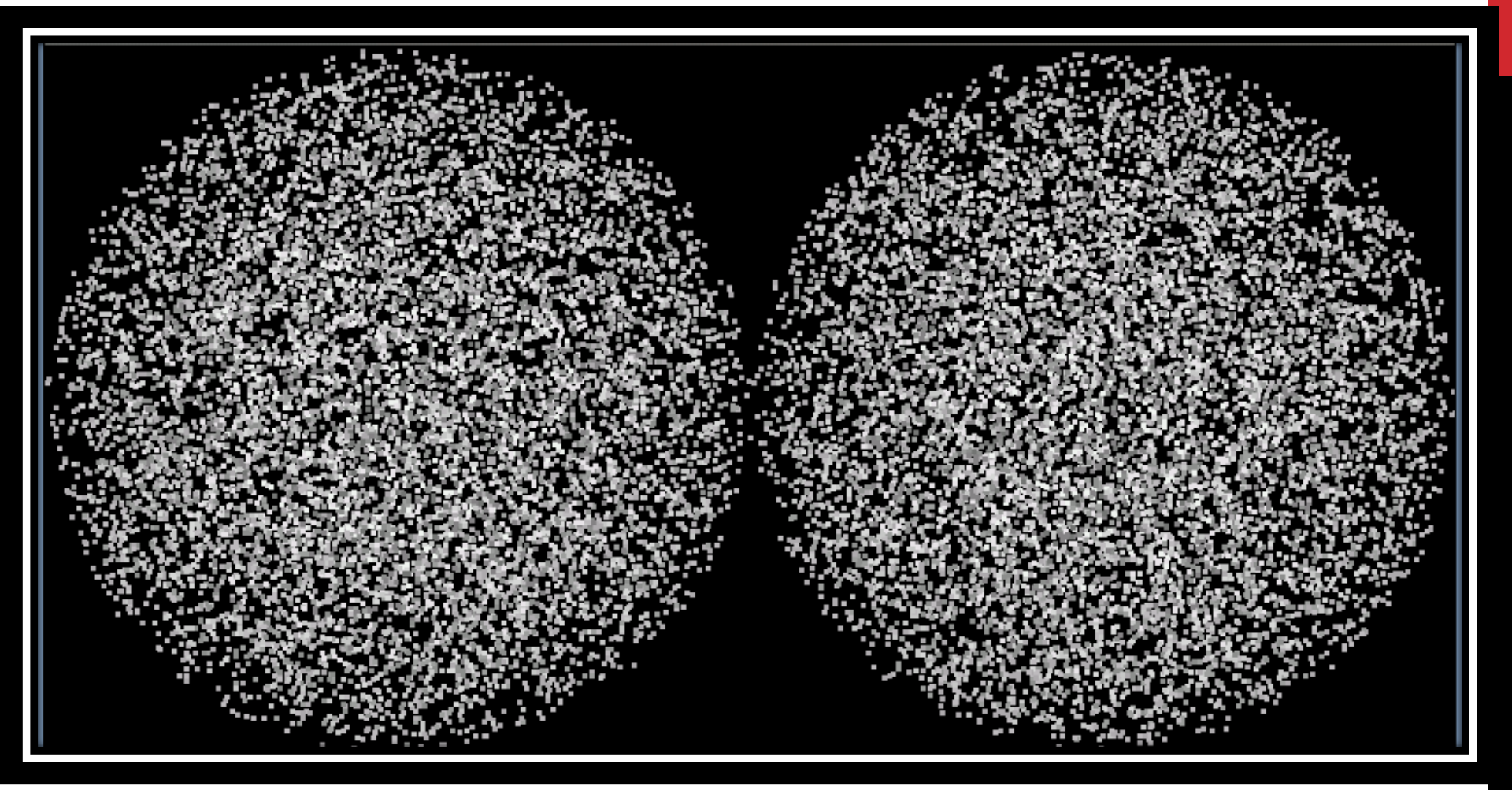
1000 BODIES



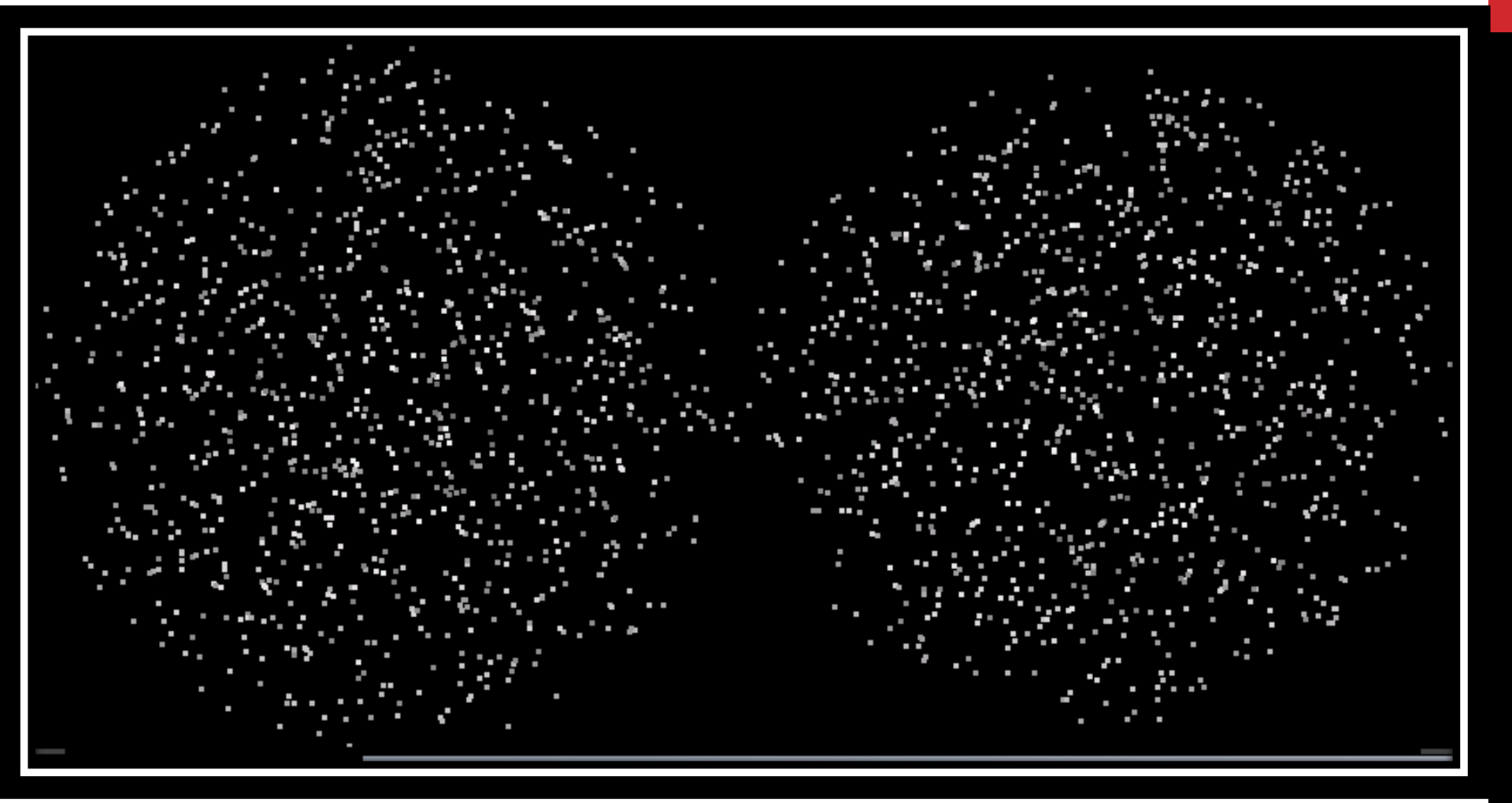


SPIRAL BANDS BEGINNING?

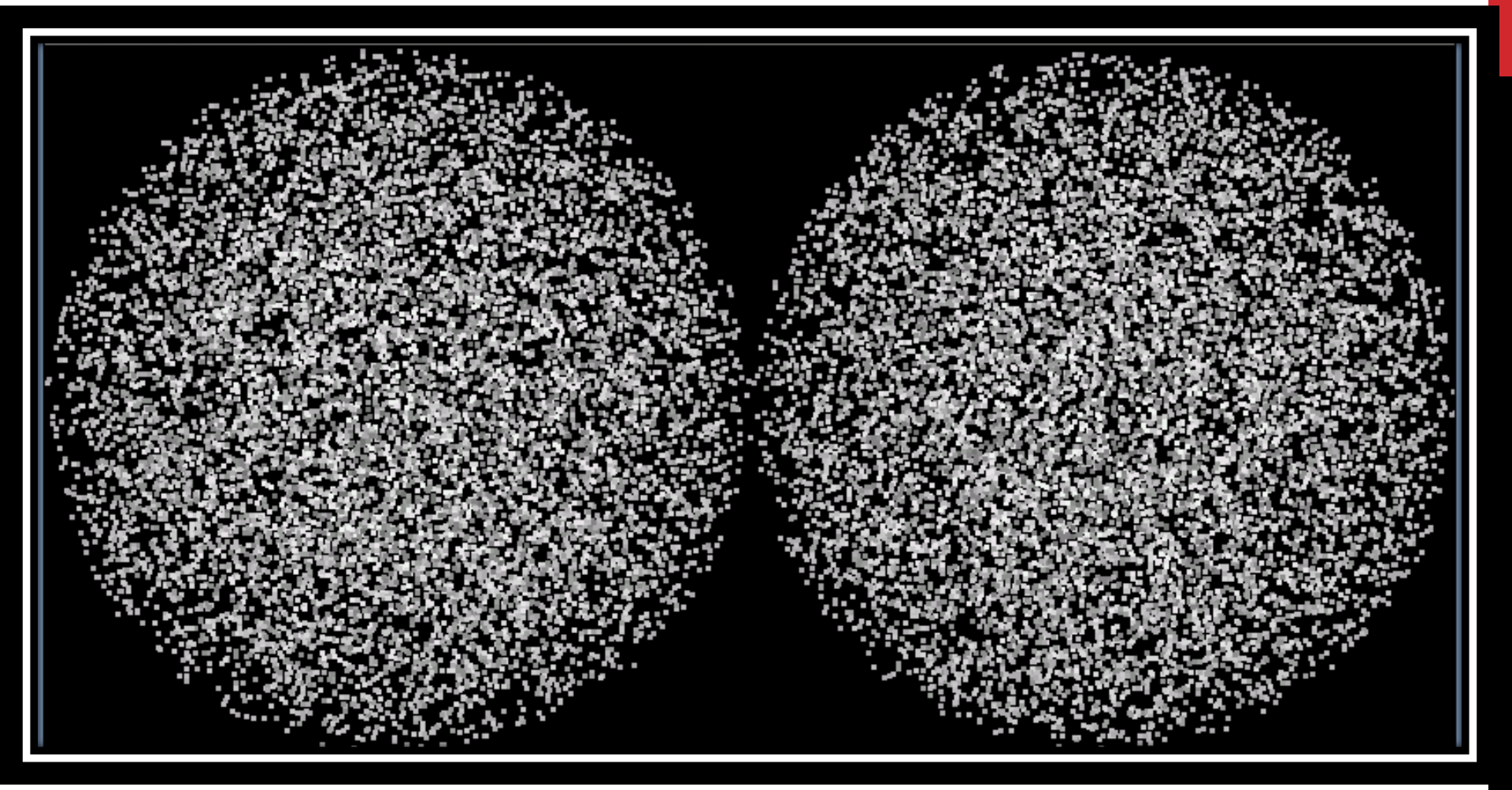
10,000 BODIES



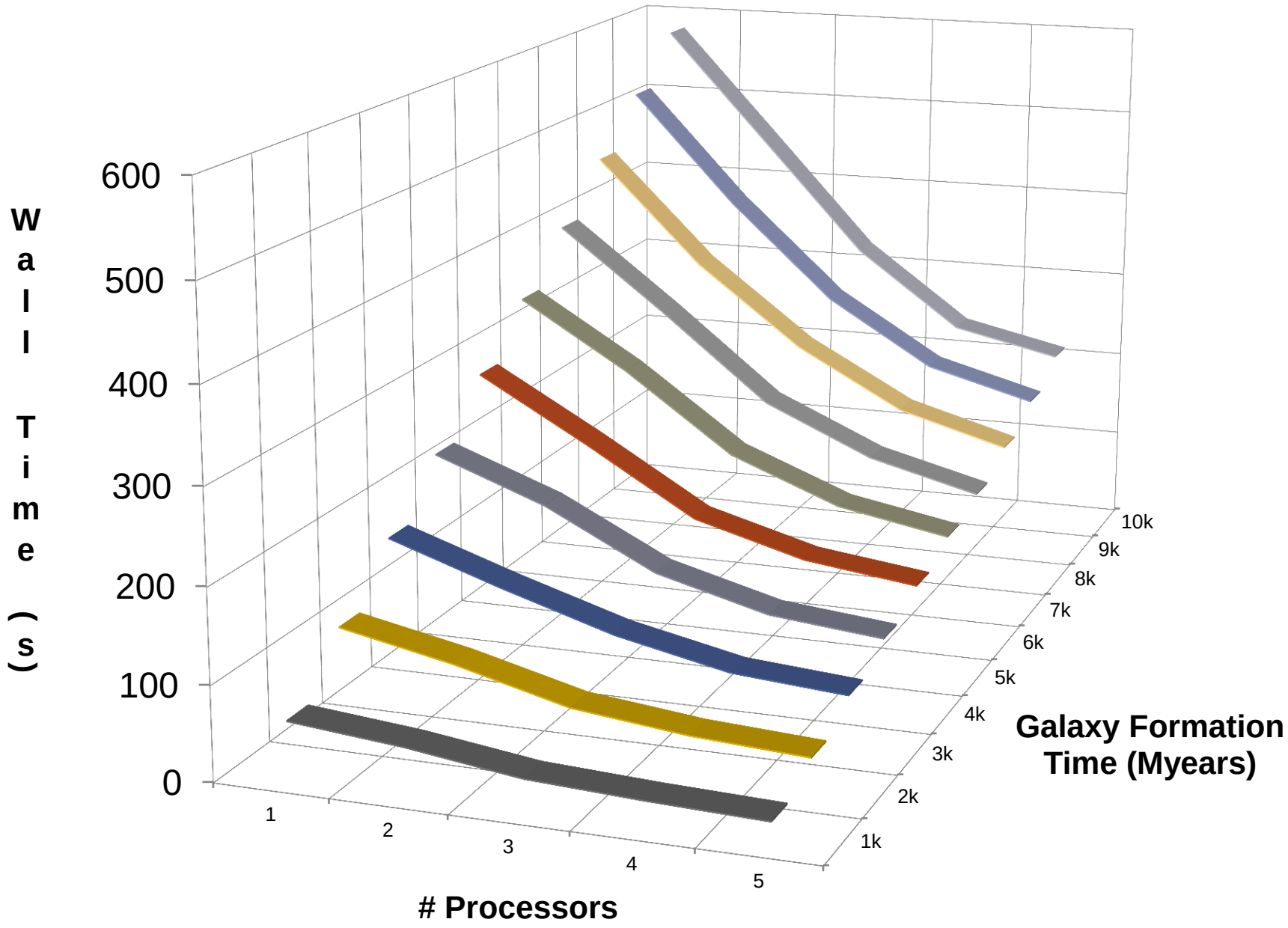
1000 BODIES



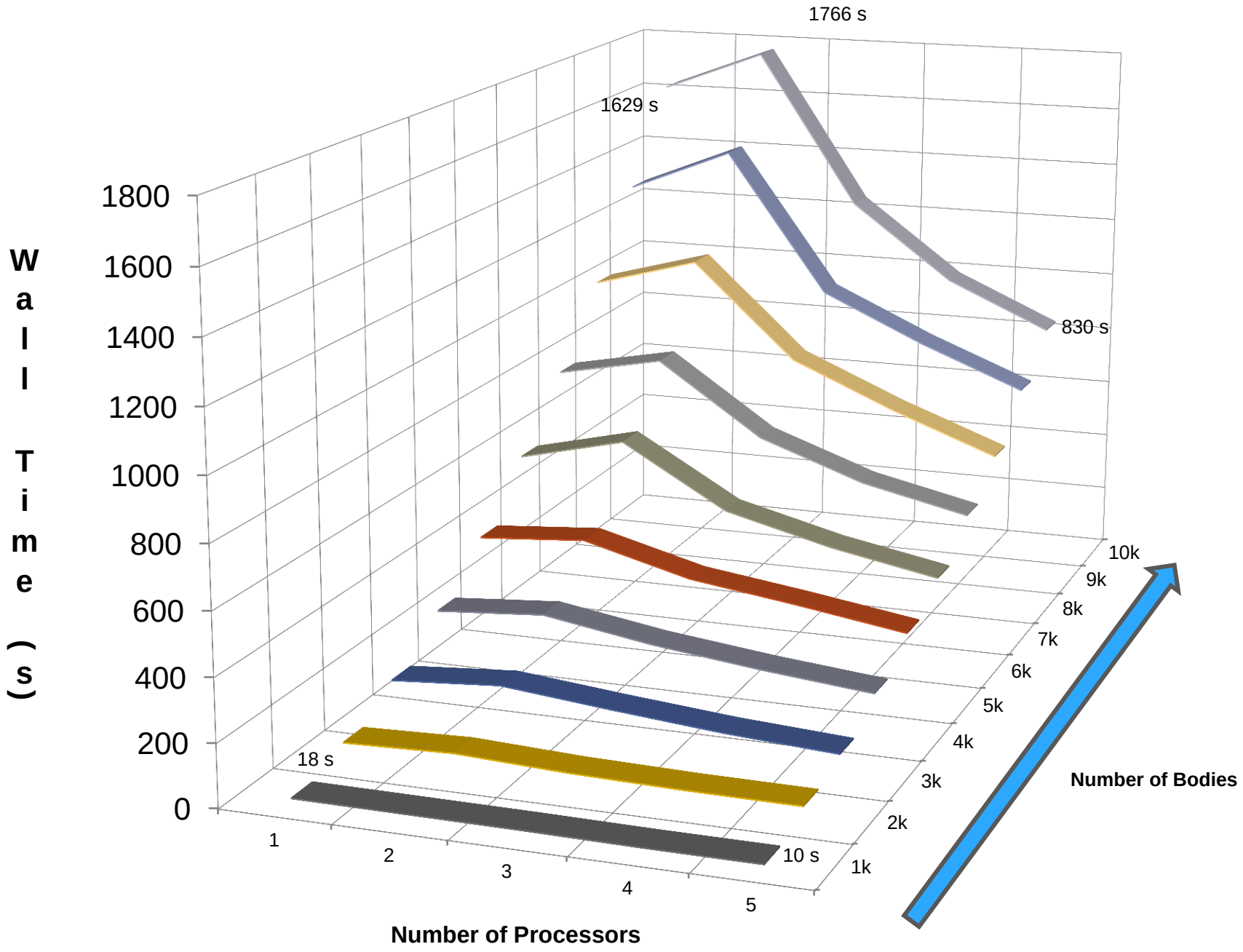
10,000 BODIES



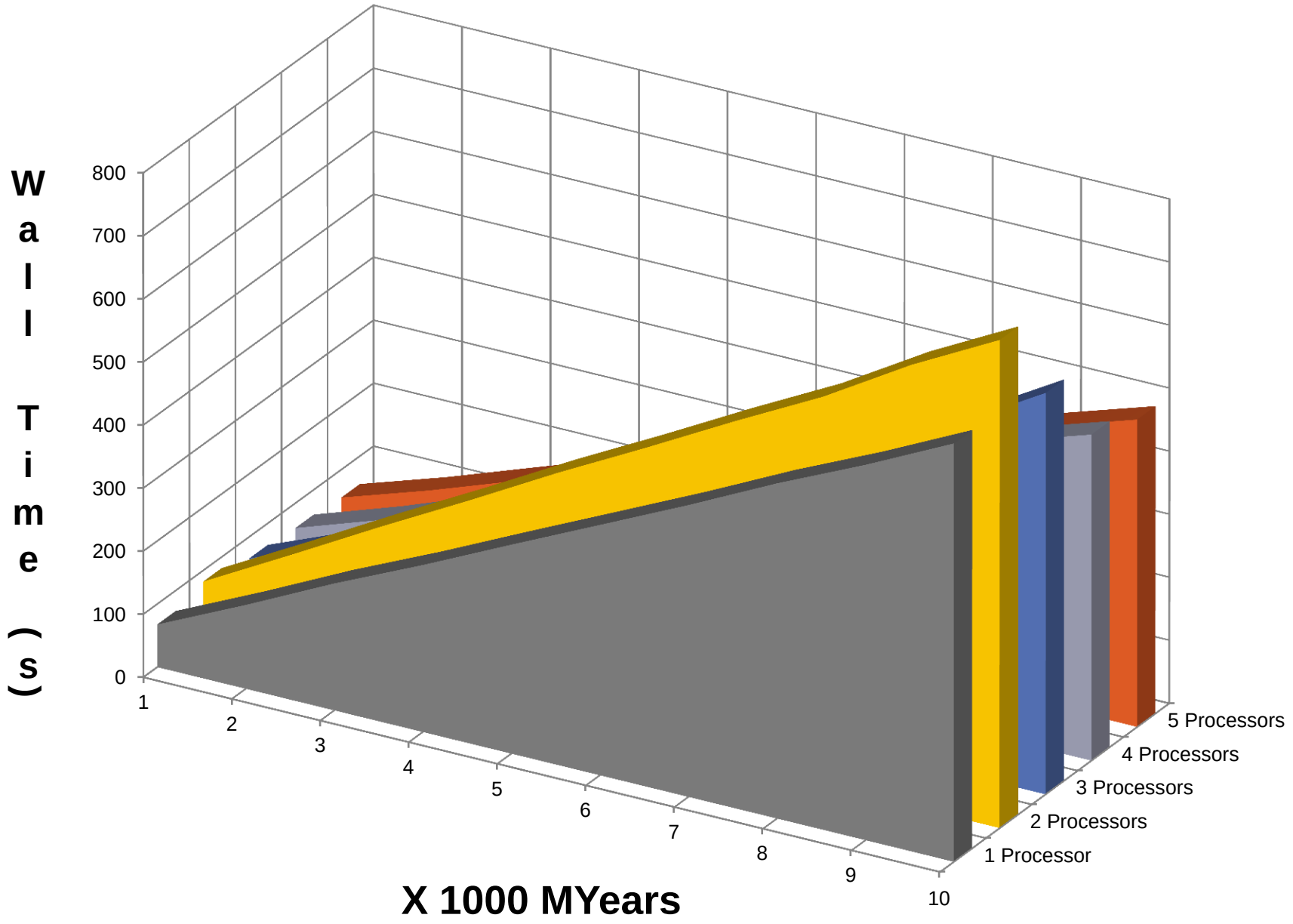
Wall Time vs. Processors as Galaxy Time Increases



Wall Time vs # Processors as N-Bodies Increase



Wall Time vs Galaxy Formation Time as Processors Increase



Wall Time vs Size of Elements as Processors Increase