LUSciD Cosmology Status Report, 1Q2007

Milestones and Deliverables

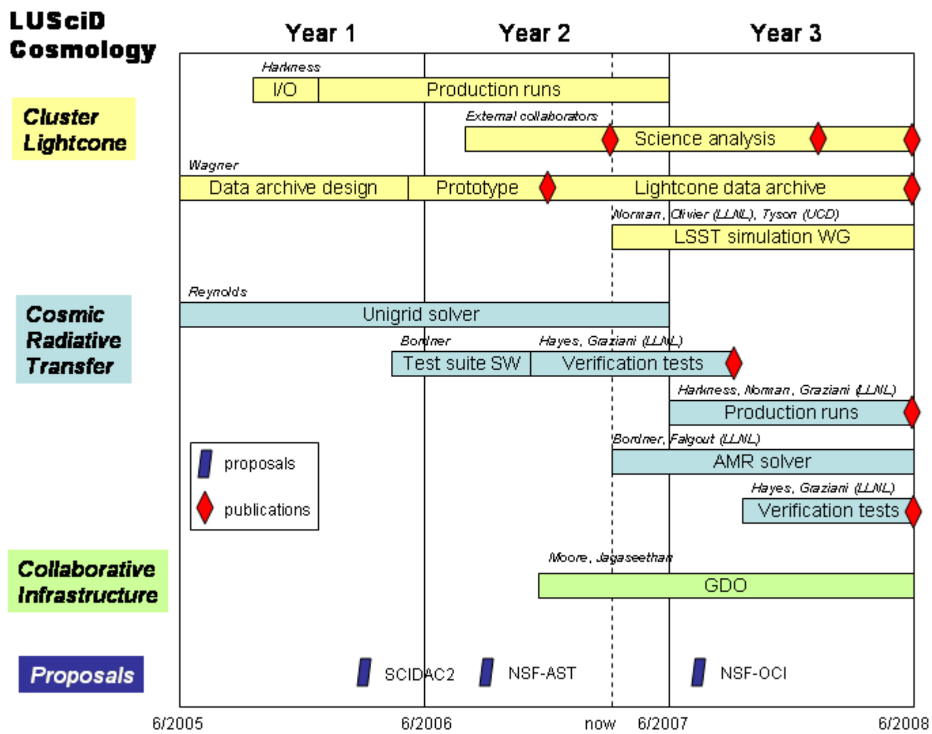

Fig. 1. Cosmology project timeline.

The project timeline shown above summarizes the main activities within the cosmology project. Progress is as follows:

Production runs (Harkness)

We completed tiles 2 and 6 of our initial seven tile series, and a third (tile 5) is nearly finished. Table 1 summarizes the properties of the first seven light cone simulations which we expect to complete by the end of 2Q07. Any one of these would classify as the largest adaptive mesh refinement (AMR) cosmological hydrodynamics simulations ever performed, both in terms of grid points, and processor count. These simulations stress Thunder, often beyond the breaking point. Our progress has been slow as of late due to long queue wait times and inexplicable write failures (a new problem). Details are given below in the data management section of this proposal.

Table 1: Status of Lightcone simulations on Thunder

#	Mpc	N(cell)	N(cpu)	Z(stop)	L1	L2	L3	Tiling	Status
1	851.71	896	1372	3.00	291146	44055	10826	14x14x7	done
2	851.71	896	1372	2.63	376048	78321	22406	14x14x7	done

3	730.04	768	1728	2.29	286503	77790	25141	12x12x12	done
4	730.04	768	1728	1.99				12x12x12	queue
5	608.36	640	1000	1.72	192434	63644	22820	10x10x10	run
6	608.36	640	1000	1.48	240849	108667	46117	10x10x10	done
7	486.69	512	512	1.26	131595	66238	30314	8x8x8	done

Column headings: (1) tile number, (2) box size in comoving megaparsecs, (3) AMR base grid size=$(\text{Ncell})^3$, (4) number of CPUs used, (5) stopping redshift, (6-8) number of level 1, 2, and level 3 subgrid patches generated, (9) CPU tiling, (10) status.

Science analysis (Norman, Harkness, Wagner)
A first paper from the Lightcone simulations has been submitted for publication [1]. A "mock" Lightcone was generated from a single tile by a scaling and stacking procedure to serve as a testbed for data handling and analysis of the full Lightcone data. While the mock Lightcone was not generated using LLNL resources (the simulation was done at SDSC during the start-up phase of this project), it verifies the correctness and scientific potential of the full Lightcone. The mock Lightcone was analyzed for upcoming cluster surveys using the Sunyaev-Zeldovich effect (SZE), and is not directly relevant to the LSST project. However, the same data is ideally suited for creating simulated LSST images provided some procedure can be developed to populate the Lightcone volume with galaxies (see below).

Lightcone data archive (Wagner)
We are developing a data archive for the eventual publication of the Lightcone simulations. A prototype of this—the Simulated Cluster Archive (SCA) [2]--was made operational this quarter and a paper describing it was accepted for publication in a special volume on the National Virtual Observatory. The archive supports browsing and retrieval of raw and processed data from Enzo simulations. Our archive consists of three components: (1) the SCA data collection, stored in SDSC's HPSS mass store and managed by SRB;(2) an application written for the Zope web server, which accesses the SRB through its Python API; and (3) the user interface, which is a collection of dynamically generated webpages created by (2), reflecting the content of (1).

The SCA user interface is similar to a file browser on your computer, except that the file and directory lists are obtained by remote requests to SRB's Metadata Catalog (MCAT) server. Zope scripts running on the SCA website dynamically convert the MCAT's output to attractively formatted html pages with active hyperlinks to subdirectories and files. The user downloads a file to his local machine by clicking on a link, which issues a SRBget command from the SCA webserver running on the LCA fileserver to an SRB server running on a host computer at SDSC.

LSST simulation working group (Norman, Olivier, Tyson)
The LSST simulation working group is a standing working group whose goal is to carry out an end-to-end simulation of the LSST telescope, camera, and analysis pipeline in realistic usage scenarios as proof-of-concept. Up until now, the WG has focused mainly on simulating the light path from the top of the Earth's atmosphere to the CCD detector. Beginning in February Norman began participating in WG telecoms to consider how one

could simulate the light path from cosmological distances to the top of the atmosphere. Good progress has been made on deliverables definition and time frame.

The goal is to produce, within a 6-9 month timeframe, a first simulation of a 10 square degree patch of the sky to a redshift depth of 3, containing some 10^7 galaxy images distorted by gravitational lensing. The Lightcone simulation covers ten times the sky area, and is ideally suited to calculating the weak lensing distortion. However, the simulation lacks the spatial resolution to form galaxies. Therefore some procedure must be identified to populate the Lightcone volume with galaxies in a reasonably self-consistent way. Norman and Darren Croton of UC Berkeley are in the early stages of developing some promising ideas on how to do this. Croton will visit Norman at UCSD in early May to develop a plan of action.

Radiation transport code development (Reynolds, Hayes)
During the last quarter, progress on Radiation Transport has quickened dramatically. In the past 3 months we have moved from an "alpha" version of the module based on a very simplified set of equations in our tests of the nonlinear and linear solver infrastructures, to a "beta" version of the module that is currently undergoing rigorous testing on radiation transport test problems. Specifically, we have incorporated the following enhancements: improved physics equations for the underlying model, a new radiation test problem, debugged the radiation flux limiter for non-cosmological flows, adaptive implicit time stepping for the radiation module and it's couplings to Enzo hydrodynamics, automatic adaptivity of model to user-defined grey radiation energy density spectrum, and numerous minor bug fixes in the underlying code.

In addition to code improvements, we have identified a set of target radiation transport verification tests and target applications that we wish to use as milestones toward a method paper on the new coupled radiation transport and hydrodynamics module.

LCAtest (Bordner)
LCAtest is a software testing environment developed by James Bordner for organizing parallel test problems, running them, and publishing results on the web. It is now in production for daily and weekly regression testing of all Enzo Subversion repository branches (http://ppcluster.ucsd.edu/lcatest/). Also, individual Enzo developers have recently started using LCAtest for their own testing and debugging. In addition to filling a vital need for Enzo development in general, LCAtest will provide a useful test environment for Hayes and Reynolds for their Enzo unigrid RT tests, and for subsequent Enzo AMR RT tests.

hypre-solve (Bordner)
Development has begun on "hypre-solve", in preparation for adding AMR radiation transfer support to Enzo. hypre-solve is designed to be a lightweight, flexible testing framework for setting up linear systems defined on AMR grids for realistic test problems, applying LLNL CASC's hypre linear solvers to the test problems, and analyzing solver performance, robustness, accuracy, and scaling.

Development will proceed in three stages: discretizing the Poisson equation (which is used in Enzo for computing self-gravity) and solving the resulting linear system with hypre's solvers. The scope of the test problems is an arbitrary collection of point masses and massive spheres discretized on a parallel distributed AMR hierarchy. I expect to finish implementing this first stage in a about month. Subsequent stages, which will build on the first stage, will be single-group RT problems, and multi-group AMR RT. After each stage is complete and solvers have been tuned, code will be migrated to the Enzo RT branch.

Summer plans

Norman, Reynolds, and Bordner will visit LLNL in early June to collaborate with Hayes and Falgout on aspects of the radiation transport component of the project, as well as to brief potential collaborators on its goals and progress. Norman will also visit with Olivier to discuss LSST image simulation progress. Wagner will visit CASC for 1-2 weeks this summer to work with the Visit team as well as to take stock of progress implementing GDO. Our goal is to have a functioning cosmology datagrid by the end of summer to enable both the Lightcone project and the radiation transport project. Border anticipates several follow-up visits to collaborate with Rob Falgout on aspects of hypre-solve.

Plans for follow-on proposals

We plan to use our June visit to LLNL to lay the groundwork for a LDRD proposal that would fund a summer intern in the summer of 2008 to work on the radiation transport project. There are also two calls for proposals anticipated from the NSF Office of Cyberinfrastructure (OCI) which we will respond to, one for data management with Reagan Moore, and one for petascale applications. Until these programs are announced, it is difficult to know how we will respond.

Publications

[1] The Santa Fe Light Cone Simulation Project: I. Confusion and WHIM in Upcoming Sunyaev-Zel'dovich Effect Surveys", E. J., Hallman, B. W. O'Shea, J. O. Burns, M. L. Norman, R. Harkness, & R. Wagner, Astrophysical Journal, submitted.

[2] "Theory Sky Node", R. Wagner & M. Norman, to appear in "Proceedings of the NVO Summer School", Eds. R. Plante, R. Hanish, (ASP, San Francisco).