# PTF, LSSN, BOSS, Nyx

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# Projects

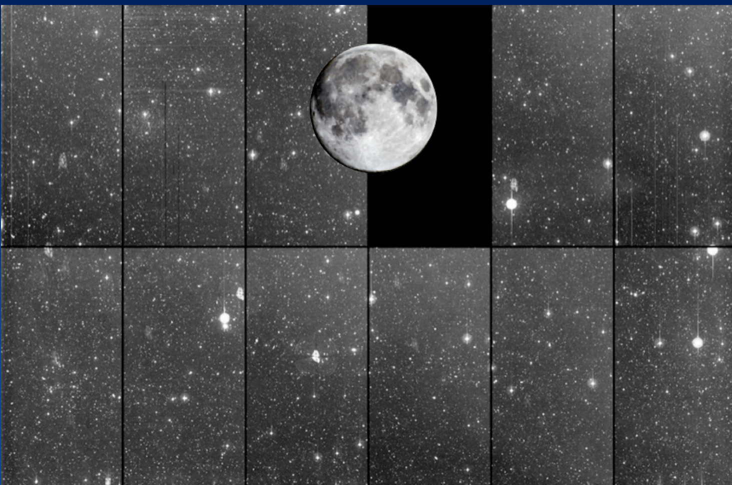
- Palomar Transient Factory / La Silla Supernova Search / Baryon Oscillation Spectroscopic Survey
  - Large Imaging / Spectroscopic Surveys
  - Real-Time analysis component

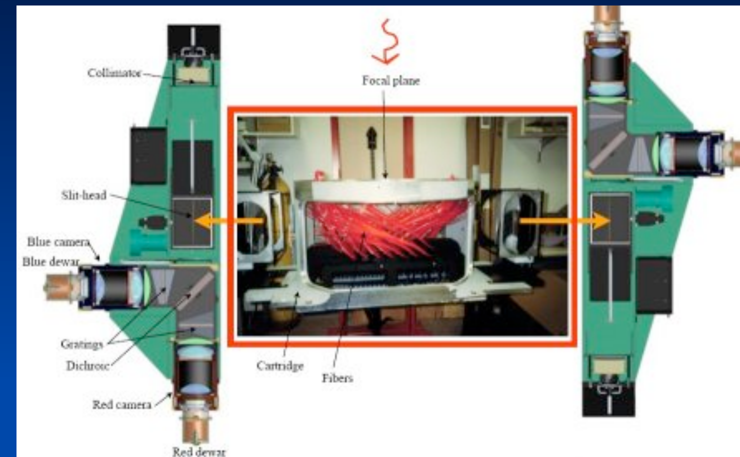
- BOSS / Nyx
  - Large scale simulations to understand the systematics involved in the analysis of the observations
  - Both pure n-body and n-body+hydro simulations

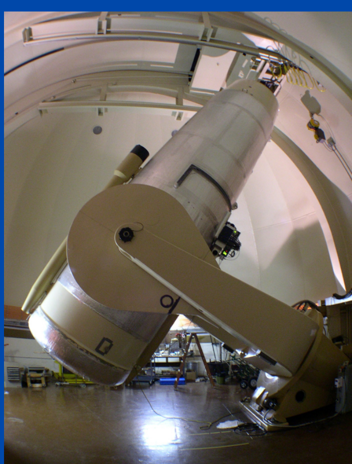
BOSS → BigBOSS & PTF → ZTF

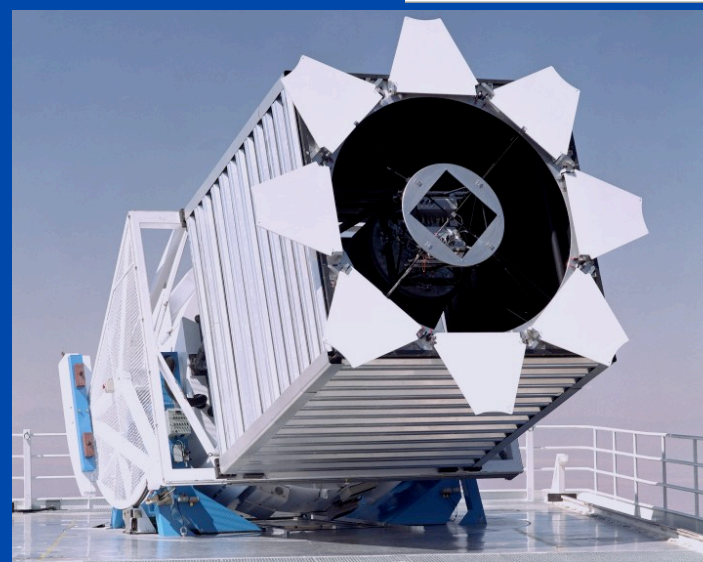
All are large, multi-lab, multi-university, international collaborations where users need to see some/most of the data.

# PTF Camera & BOSS Spectrograph







# PTF Science

| PTF Key Projects | |
|---|---|
| *Type Ia Supernovae* | Dwarf novae |
| Transients in nearby galaxies | Core collapse SNe |
| RR Lyrae | Solar system objects |
| *Deep co-additions for LRG/ELG* | AGN / *QSO's* |
| AM CVn | Blazars |
| Galactic dynamics | LIGO & Neutrino transients |
| Flare stars | Hostless transients |
| Nearby star kinematics | Orphan GRB afterglows |
| Rotation in clusters | Eclipsing stars and planets |
| Tidal events | H-alpha  sky-survey |

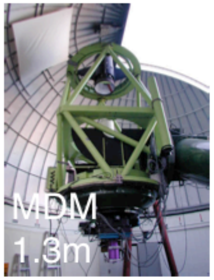
The power of PTF resides in its diverse science goals and follow-up.

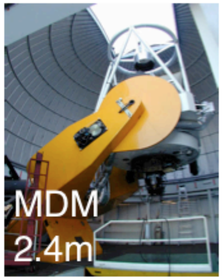
# PTF Science

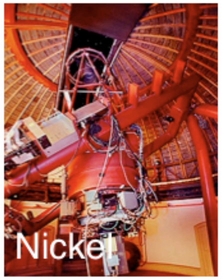
- Detected transients will be followed up using a wide variety of optical and IR, photometric and spectroscopic followup facilities.

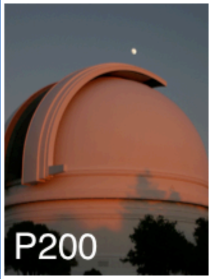




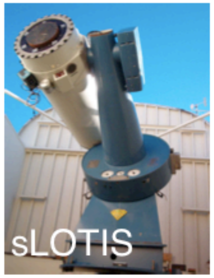



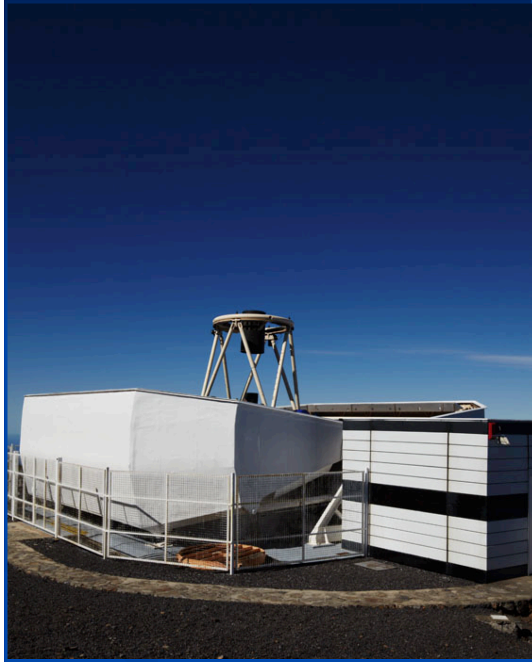









Liverpool Telescope

The power of PTF resides in its diverse science goals and follow-up.

# PTF Pipeline

Observatory

*100GB/night*

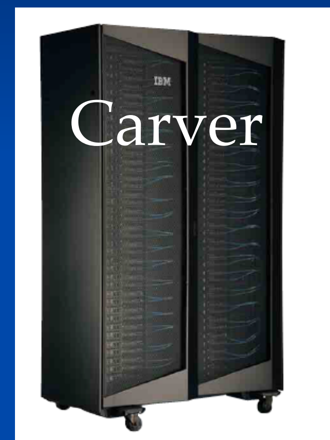
Data Transfer Nodes

Processing / db

Science Gateway Node 2

*1TB/night*

Subtractions



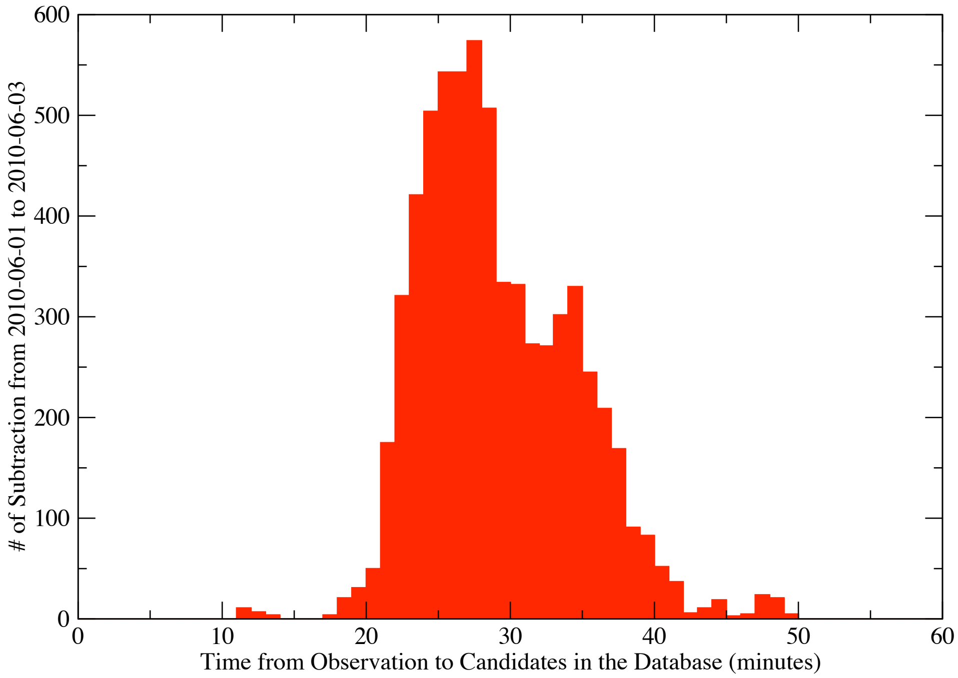

PTF Collaboration via Web

*20MB/night*

Science Gateway Node 1

NERSC GLOBAL FILESYSTEM
250TB (190TB used)

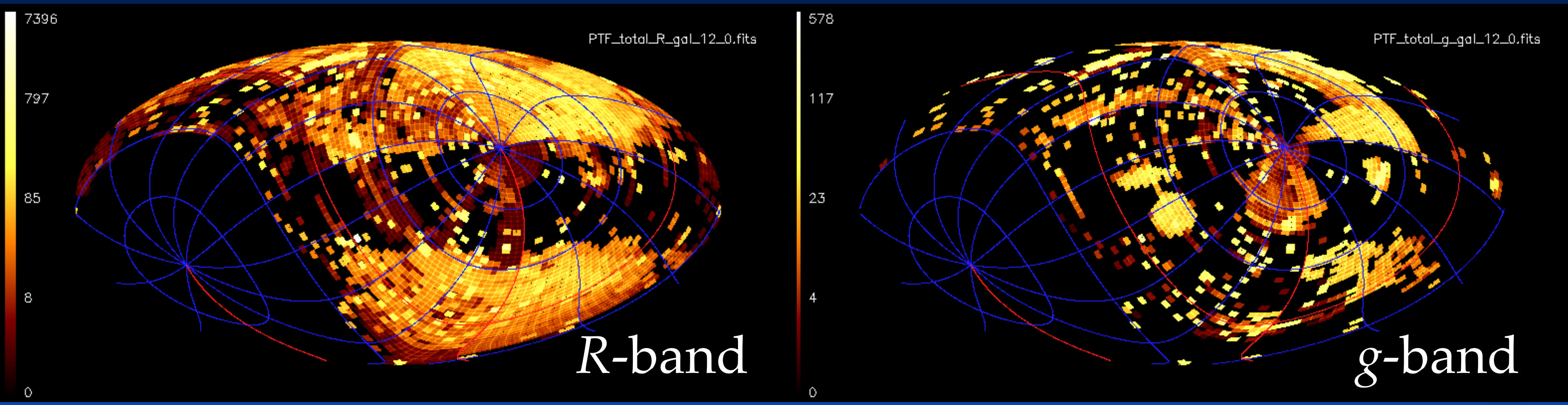
# Turn-around




UCB machine learning algorithm is applied to all candidates and reports are generated on the best targets and what they are likely to be (SN, AGN, varstar) by comparison to extant catalogs as well as the PTF reference catalog. These come out ~15 min after a group of subtractions are loaded into the database.

Of 51 total publications from PTF, the 6 that appeared in *Science* and *Nature* were primarily there due to follow-up commencing within hours of their discovery.

# BigBOSS Target Selection




PTF has observed 25,000 sq. deg. of sky with 2.1M images over 4 years.

BAO with spectroscopy requires that we know what objects to get spectra of: QSO's, LRG's, ELG's…

PTF, iPTF & ZTF provide us with a great way to perform this target selection.

# BigBOSS Target Selection

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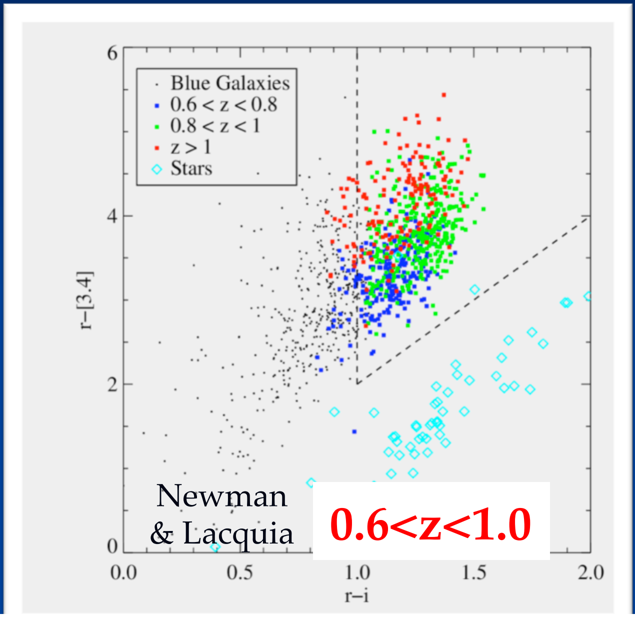
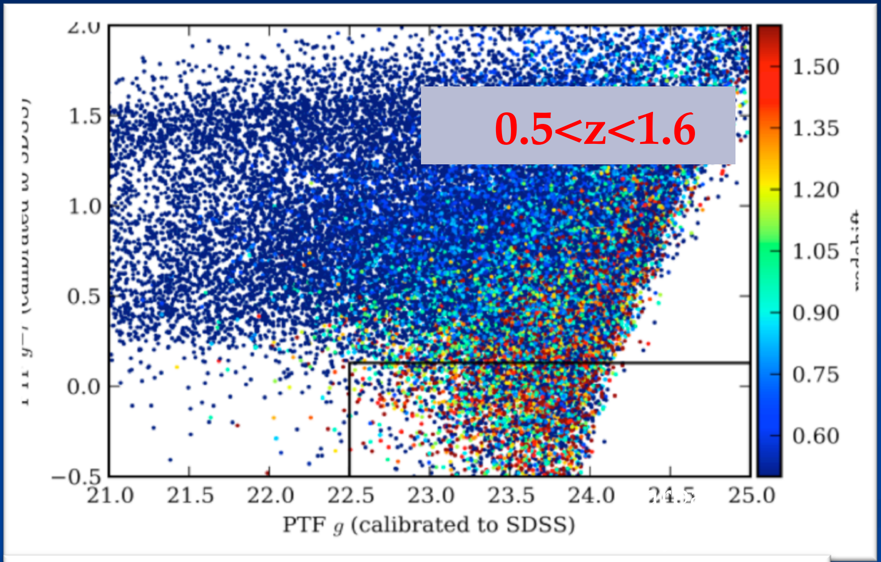
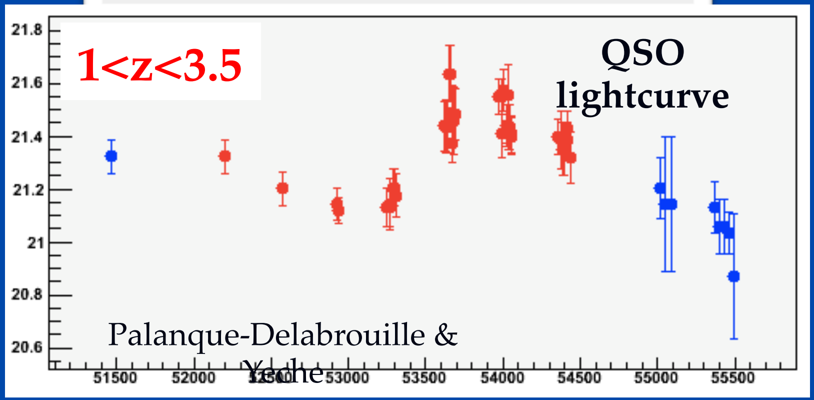
## 4 million Luminous Red Galaxies

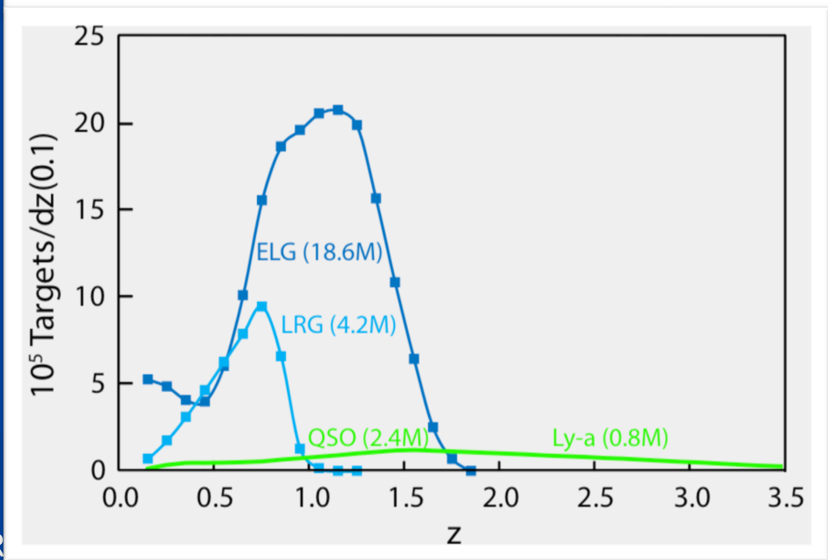



## 18 million Emission Line Galaxies




## 2.5 million Quasars

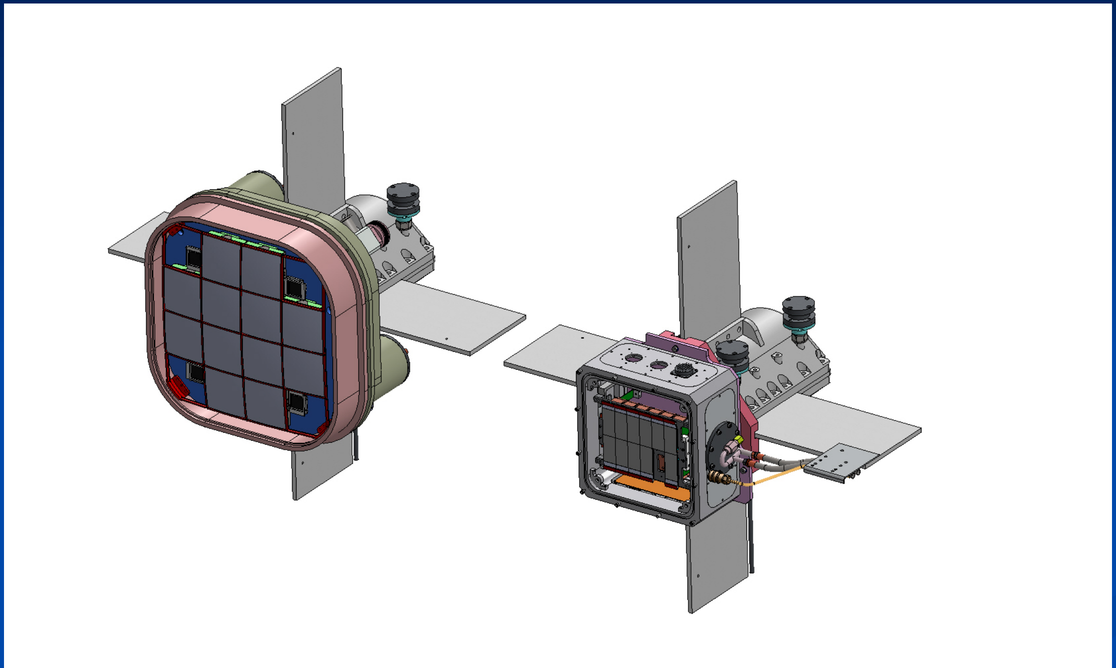





BERKELEY LAB

NERSC

# Future



| Telescope | AΩ |
|---|---|
| *i*PTF / PTF | 8.7 |
| DES | 11.7 |
| ZTF | 46.5 |
| LSST | 82.2 |

ZTF (36 deg.$^2$)    *i*PTF (7.2deg.$^2$)

ZTF can perform the BigBOSS LRG / ELG target selection in 2 filters in 1 year and find *all* local SNe Ia in northern hemisphere.

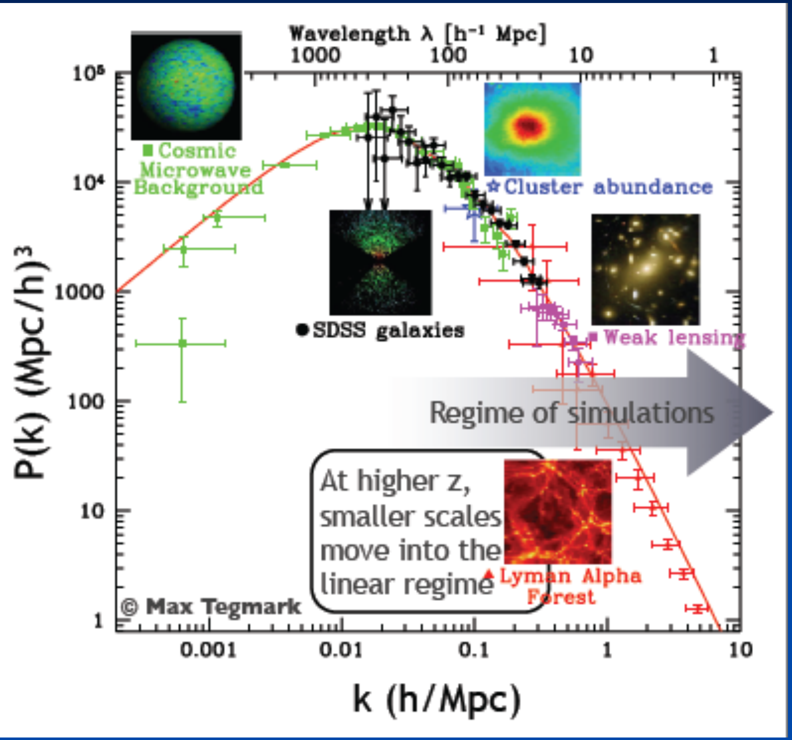
# Resources

ZTF will be 6 times larger than PTF, thus we will need to process about 10 GB per minute, using around 32 cores continuously through the night.

Will need to store all the data, up to 1.2 PB, and keep it spinning.

The database for PTF is currently 1TB in size and there are 1B objects in the subtraction pipeline (postgres). The static pipeline, useful for BigBOSS target selection, is 50B objects for individual images and 50B objects in the deep, co-added stack. ZTF will increase both of these by a factor of 2-3. Need some form of parallel db's.

# Simulations BOSS/BigBOSS




Baryon Acoustic Oscillations (BAO) from galaxy surveys (BOSS, DES, LSST)

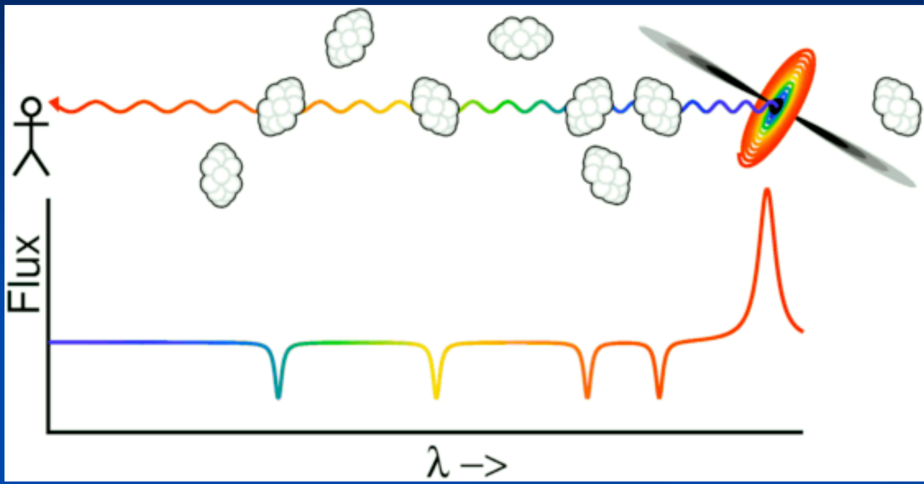
- Measurement: Geometry at z<1
- Challenge: Large volume N-body simulations to precisely determine BAO 'wiggles' in P(k) or peak in the correlation function.

BAO from Lyman-alpha (BOSS)

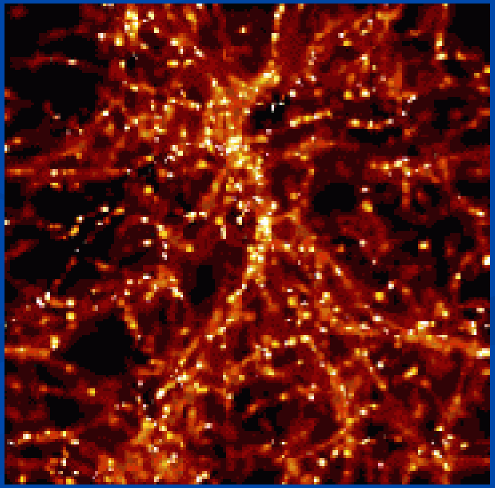
- Measurement: Geometry at z>2
- Challenge: Large volume N-body+hydro to model the neutral hydrogen distribution.

# Nyx Code

- We are trying to measure Baryon Acoustic Oscillations which act as a standard ruler in measuring the effects of cosmology, similar to CMB analysis. BAO experiments are being set up to measure these signals through the cataloging of luminous red galaxies and quasar absorption spectra.




- Critical to the success of these experiments are radiation-hydrodynamic simulations to relate the matter power spectrum to the observed flux decrements in the Lyman-$\alpha$ forest. One needs to follow the evolution of the universe from the initial matter structure (CMB) to the present, following the creation of gas clouds and quasars. We would like to resolve the Jean's scale (~10kpc) while doing a cosmologically significant box size (1 Gpc).

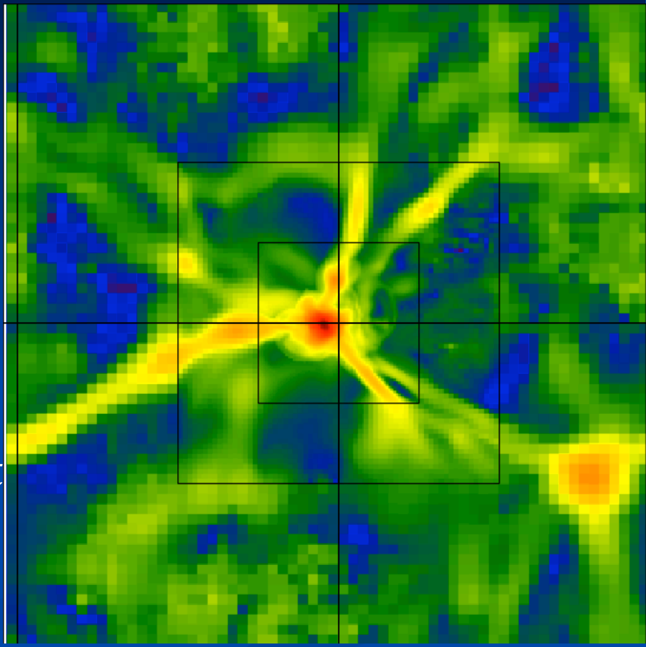


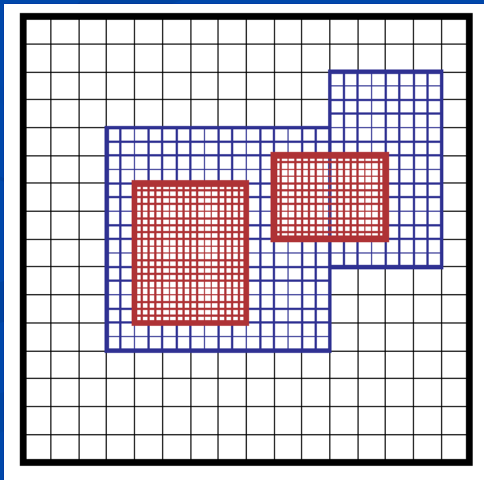
# Nyx Code

Nyx is a massively parallel code that solves the multicomponent compressible hydrodynamic equations with a general equation of state and includes self-gravity, chemistry (heating & cooling), and radiation.

It is an offshoot of the CASTRO code see Almgren et al., (2012) ApJ (should be on archive this week).

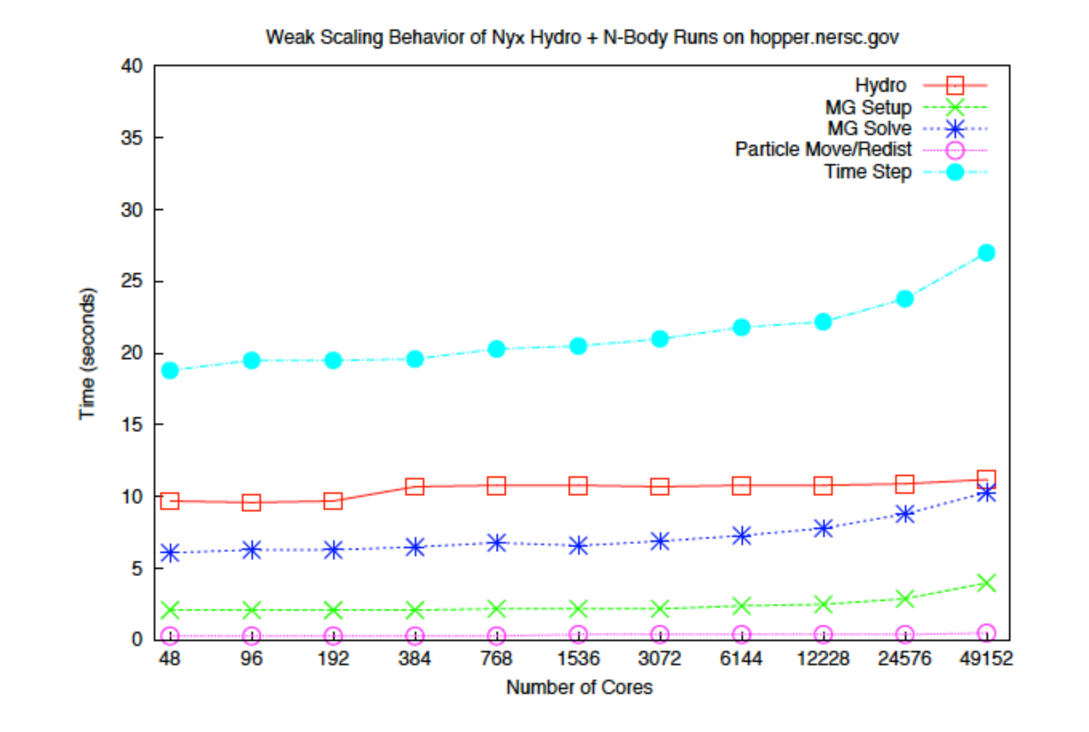
Nyx uses an Eulerian grid with adaptive mesh refinement (AMR). Our approach to AMR uses a nested hierarchy of logically-rectangular grids with simultaneous refinement of the grids in both space and time - the Boxlib formalism. Nyx uses an unsplit version of the piecewise parabolic method.





A hybrid MPI and OpenMP approach is used, so that we achieve the coarse-grained parallelization of distributing grids to MPI processes and fine-grained parallelization of threading individual loops over many cores.

# Nyx Code




Weak Scaling runs done on NERSC's Hopper, a Cray XE6, with 153,216 compute cores. With 2 twelve-core AMD 'MagnyCours' 2.1-GHz processors per node and only 32 GB of ram per node (1.3 GB/core) the machine is good, but not ideal for our setup. Ideal would be at least 2GB ram/core and the number of cores per node = $2^n$. (Edison…..)

The realistic results presented here (an actual cosmology calculation which was artificially replicated to keep the size/core the same throughout) show that Nyx can scale to 1/3 of Hopper (~50,000 cores) with just a 40% hit in time for the Multi-Grid Solve (gravity). I/O was able to get 97% of peak (35 GB/s).

# Resources for Simulations

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Current $1024^3$ runs on Hopper run on 10,000 cores in 4 hours. We will generate scores of these runs on a variety of scales to test the code and the systematics involved in our simulations. Output per time step is ~10GBs.

$4096^3$ runs are the largest we can do on hopper and get us to reasonable scales. 50Mpc with 10kpc resolution using one level of refinement. Output is on order of ~10TB per time step. These take several million cpu-hours. Analysis occurs both *in-situ* and with post-processing.

We would like to go to 1Gpc simulations while maintaining the same 10kpc resolution during the era of BigBOSS (preferably before). Mostly this is a memory issue. On Hopper we can get $64^3$ cells per node, Edison we can get $128^3$. This difference is quite important as Edison will allow us to do ~$10{,}000^3$ simulations. We would like to get to $100{,}000^3$….