Computational Cosmology in Chicago

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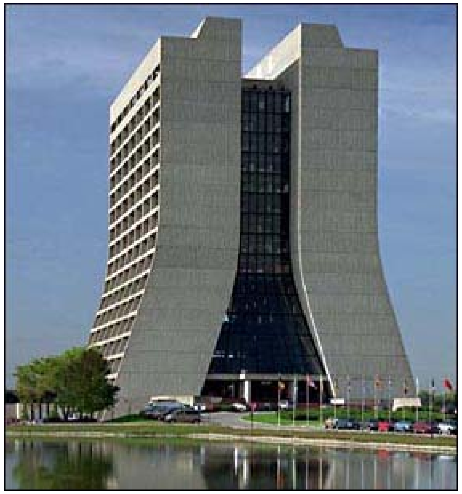
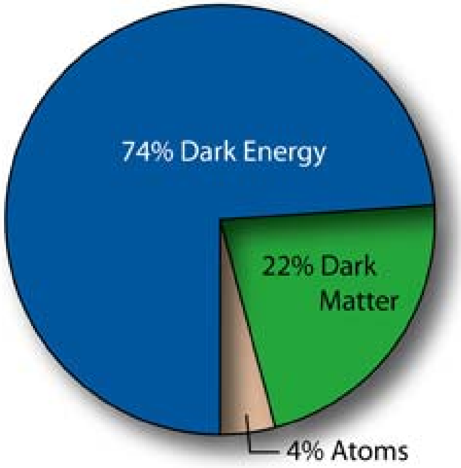
Fermilab



Dark Energy



Dark energy ranks as one of the most important discoveries in cosmology, with profound implications for astronomy, high-energy theory, general relativity, and string theory.

Dark Energy Task Force Report

Dark Energy Landscape

- Stage II:
  SNLS, ESSENCE, SDSS-II, CfASP, NSF, KAIT, CSP, QUEST, HST, PanSTARRS-1, PISCO, SPT, ACT, XCS, RCS2, DLS, KIDS, DEEP2
- Stage III:
  DES, HETDEX, WFMOS, PanSTARRS-4, ODI, 1000PLS, ALPACA, CIX, CCAT
- Stage IV:
  LSST, JDEM (SNAP, DESTINY, JEDI, ADEPT), SKA

Dark Energy Probes

- Supernovae Ia:

  standard candles, luminosity distance vs redshift

- Weak Lensing:

  several measures of evolving matter distribution

- Baryon Acoustic Oscillations:

  standard ruler, angular-diameter distance vs redshift

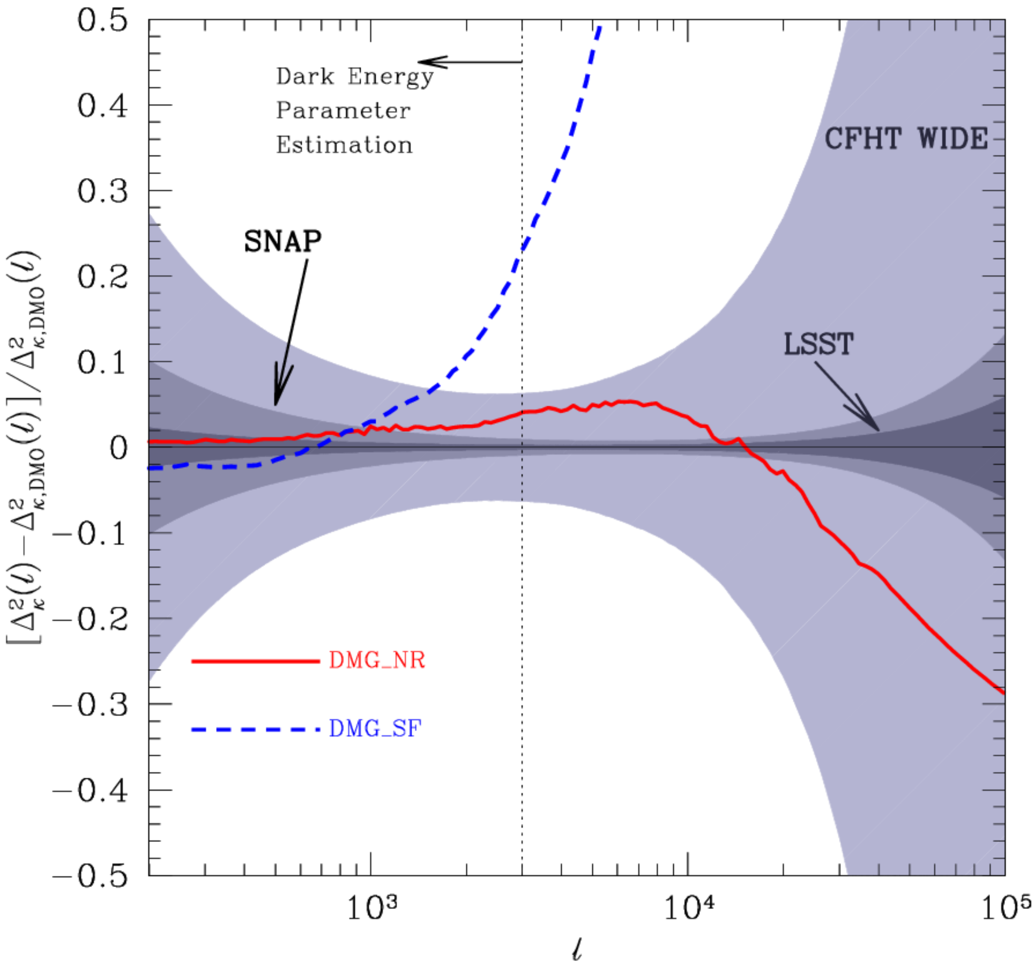
- Clusters of Galaxies:

  number counts vs redshift

Computational Cosmology for Fundamental Physics

Weak lensing + BAO:

- Directly probe the evolution of the dark energy.
- Unfortunately, we exist.
- *Baryonic effects can be calibrated by simulations*.
- The required computational effort is massive.



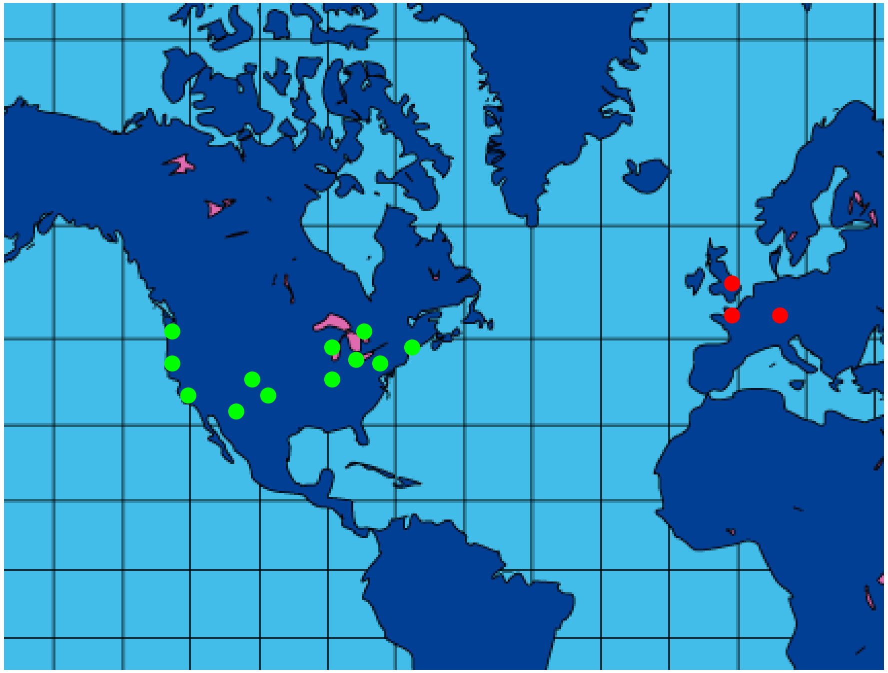
(Rudd et al 2007)

Computational Cosmology for Astrophysics

Galaxy Formation:

- 🙂 Direct comparison with most observations.
- 🙁 Important physics (such as star formation) will not be understood any time soon.
- 🙂 There exist simple scaling laws in the ISM.
- 🙁 Models based on those laws make wrong galaxies.

Computational Cosmology in the World



- Europe: Research mostly done by large groups:

  Virgo Consortium [>30 people] (Germany + UK)

  Project Horizon [>20 people] (France)

- USA/Canada: Large number of small groups (10-12 people) Chicago (FNAL+KICP+ANL), UWashington, Harvard, CITA, SLAC, LANL, Princeton, UCLA, UIUC, Berkeley, UMass…

Computing Needs

- Modern state-of-the art cosmological simulations require in excess of 1,000,000 CPU-hours (100 CPU-years). Simulations of 3,000,000 CPU-hours are not far away (and will be needed for calibrating DE experiments).
- A single simulation produces a Terabyte-scale data set.
- Even rudimentary analysis requires intermediate-level computing capability.

The time of “this is a workstation to analyze your simulation” is over.

Solution (a-la LQCD)

- National consortium/collaboration (the level of integration may vary)

- Powerful local, intermediate-level resources (10,000 CPU, spread over several places: FNAL, SLAC, ANL, LANL, …)
  - Analysis and visualization
  - Launching pad for national centers (30,000 CPU scale; development, porting, scaling)

- United approach to funding agencies and national supercomputer centers.

Our Plan

- build-up local resources on par with other US groups
- create a Chicago-wide collaboration (FNAL, KICP, ANL)
- convince higher-ups
- overtake other US groups in local computing resources (reach 1,000 – 2,000 cores; there are good reasons why FNAL is the best place for that)
- move towards a national consortium/collaboration:
  - join with DOE labs (LANL, LBL, SLAC)
  - invite universities to join
- get lots of money along the way… (people, software support)

5-month Update

- FRA Collaborative Award (FNAL+UC)
- ANL LDRD awarded for 3 years
- 560 cores by the end of the year at FNAL
- ¼ ANL FTE working on data managements
- ¼ ANL FTE working on visualization
- Learning from FLASH
- A joint ANL/FNAL postdoctoral fellow to work on DES simulations (Fall 2008)
- Lots of proposal writing…