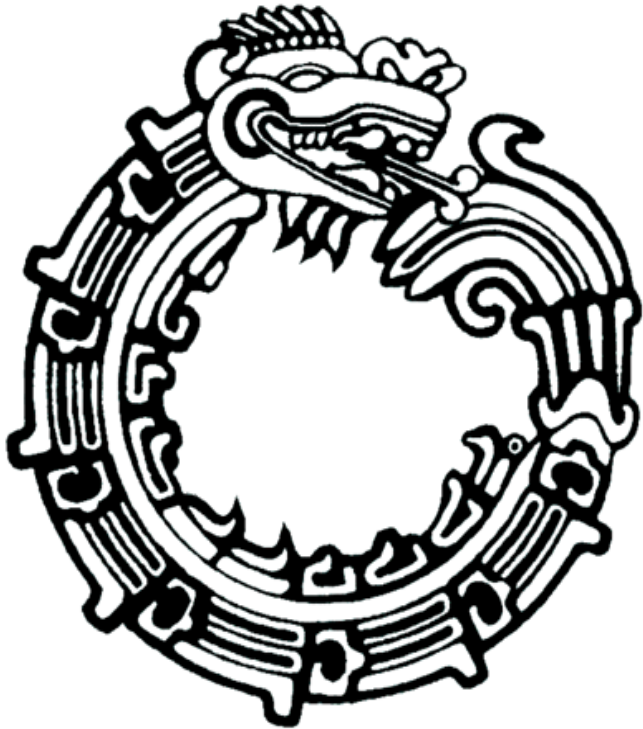
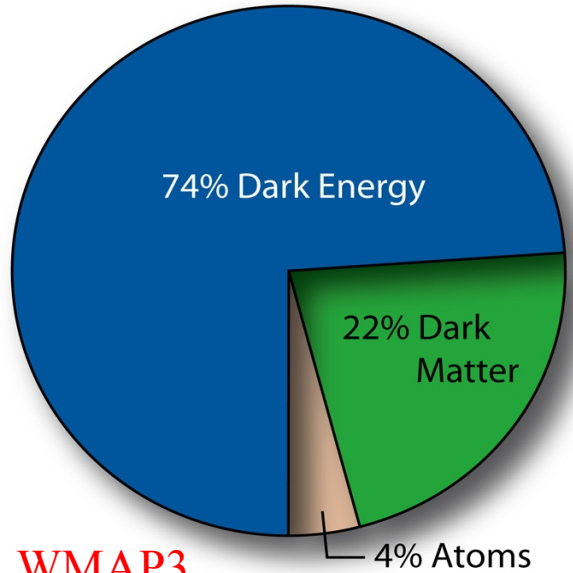
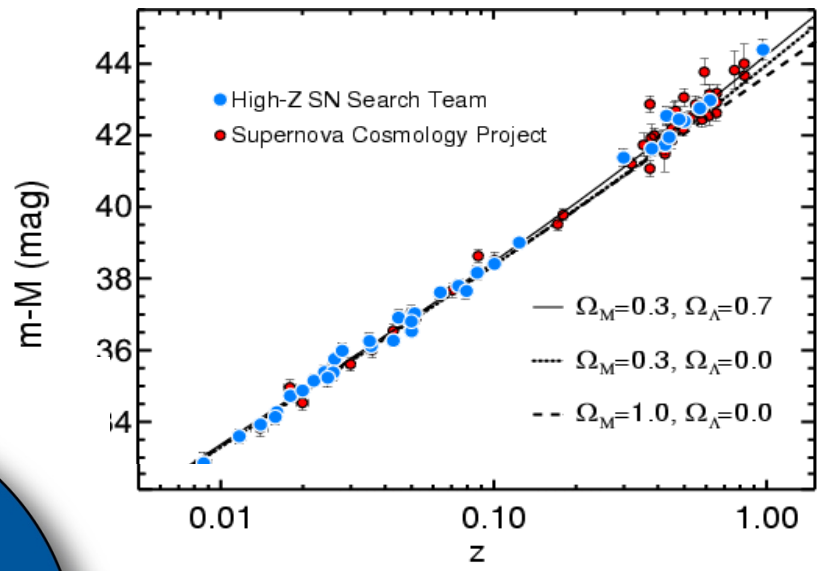


The Origin and Structure of the Universe



- What is the Universe made of ?
- What laws govern its evolution ?
- What was the origin of structure ?
- How have present structures arisen ?
 - the dimensionality of space-time
 - the standard model of particle physics
 - the periodic table/element abundances
 - planets, stars, black holes and galaxies
 - large-scale and cosmological structure

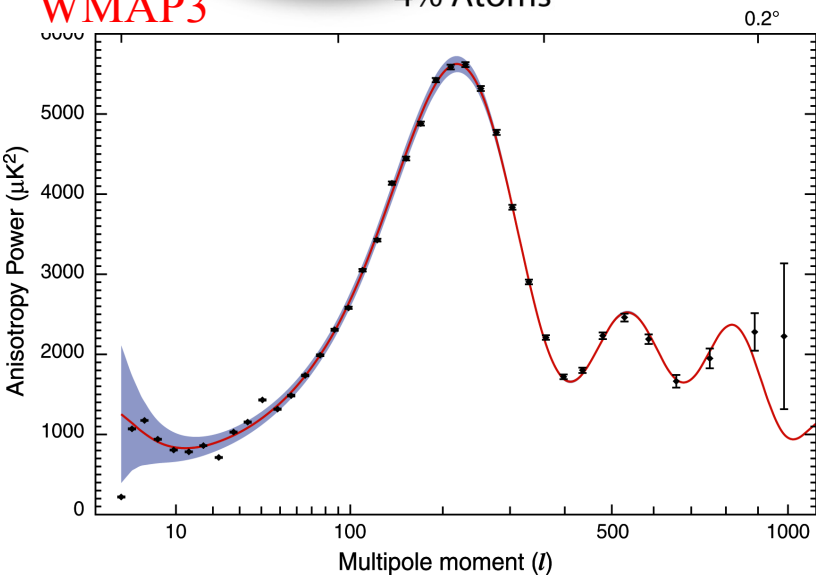
HST A2218



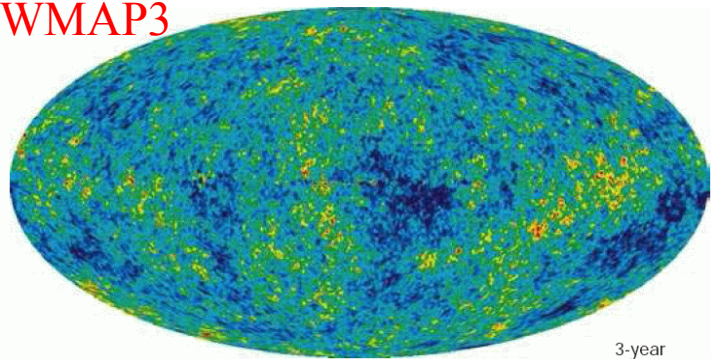
Dark Matter and Dark Energy

- dominate the current energy density of the Universe
- are inferred on the basis of astronomical data alone
- are most likely explained by physics at extremely high energies
- are tested by purely astronomical (DE) or by mixed (DM) experiments

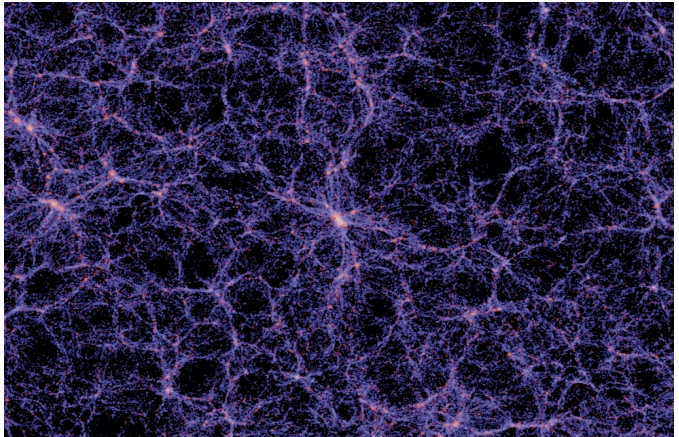
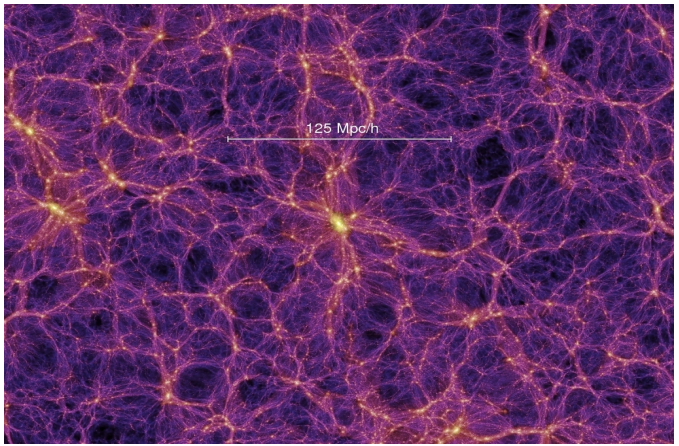
WMAP3



WMAP3

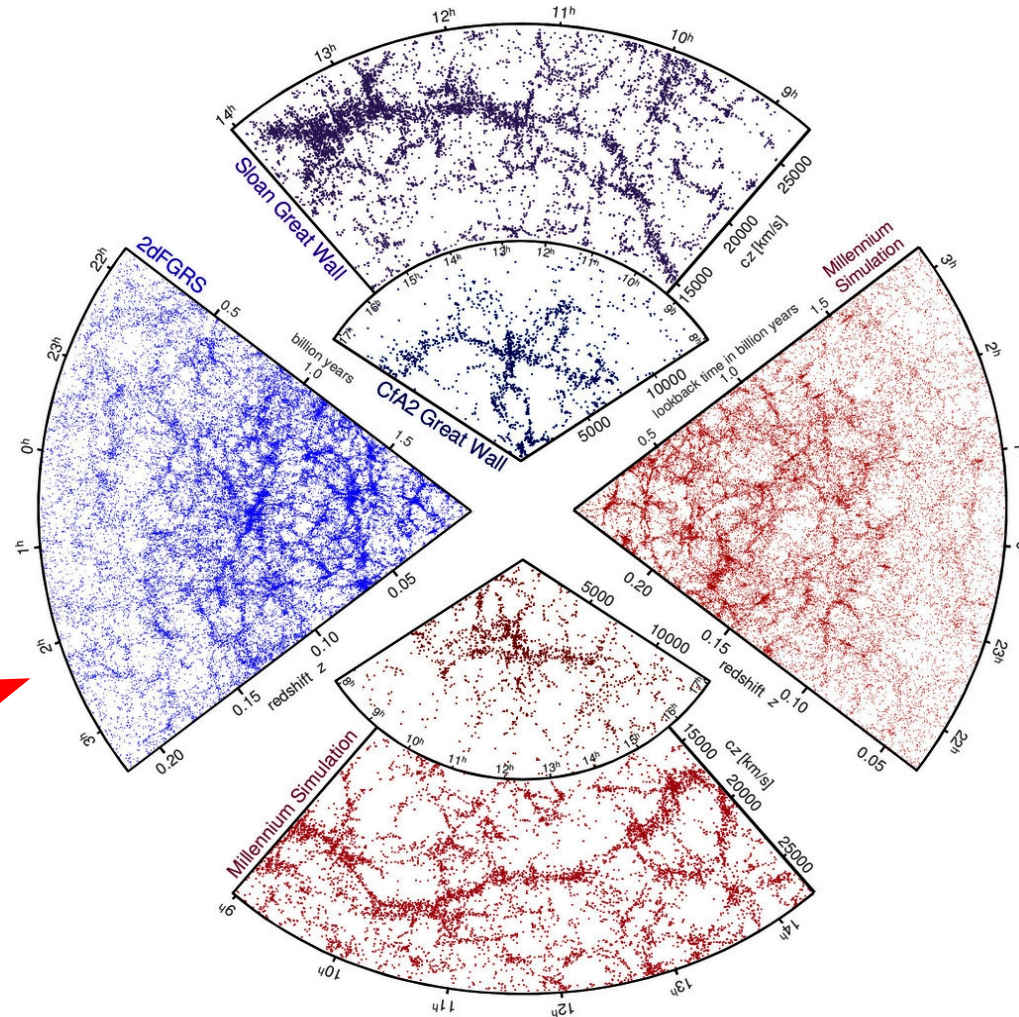
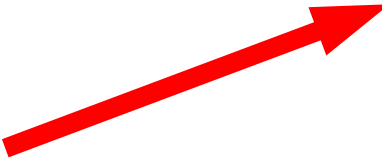


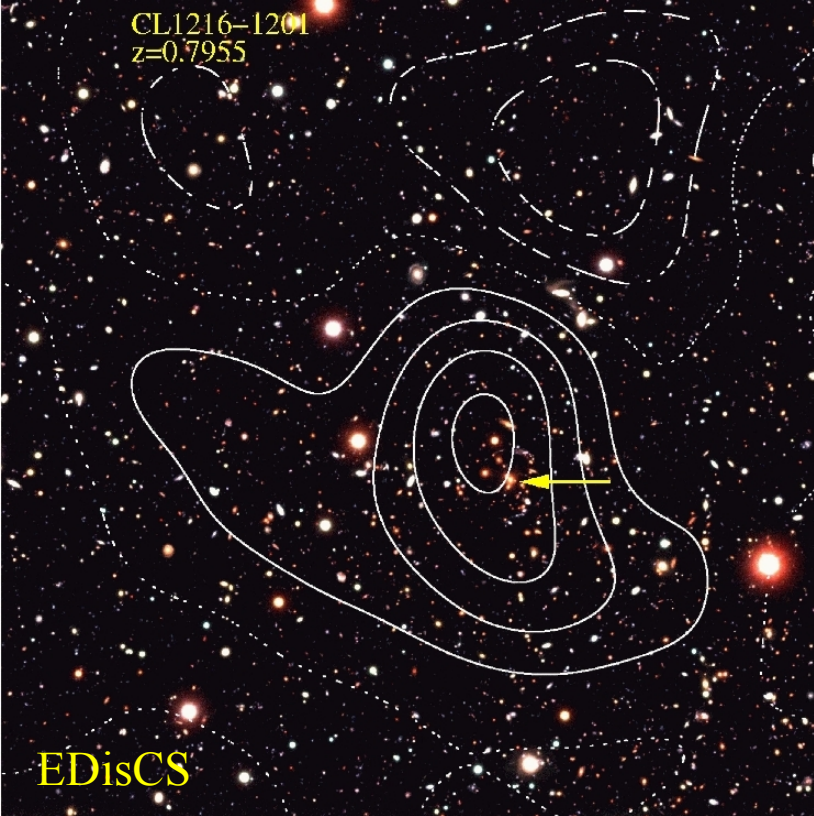
3-year



Simulating Cosmic Evolution..

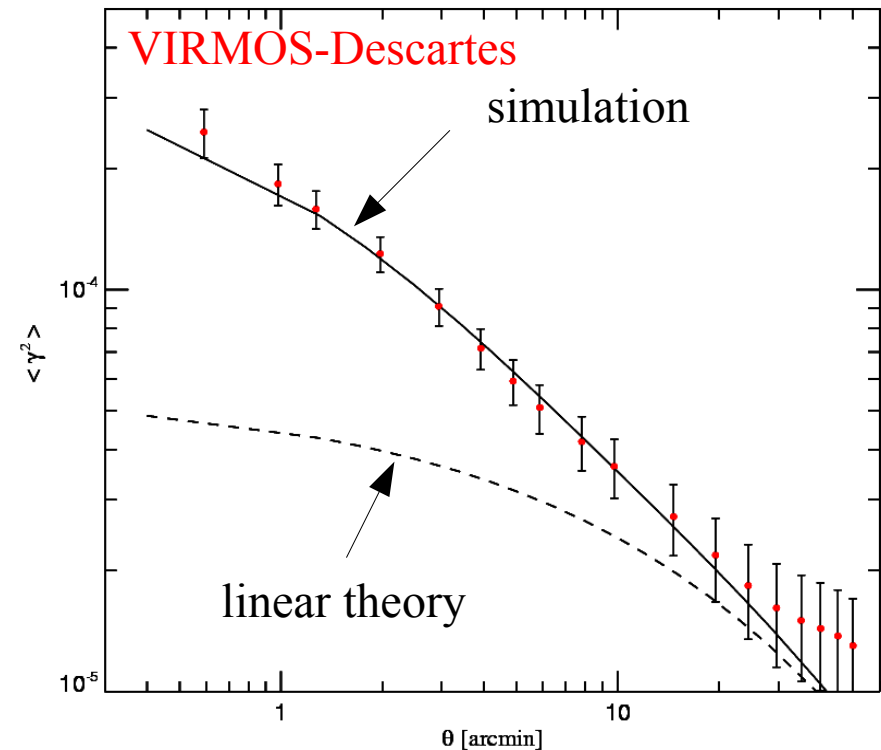
..allows theoretical models of Dark Matter and Dark Energy to be compared quantitatively to astronomical observations



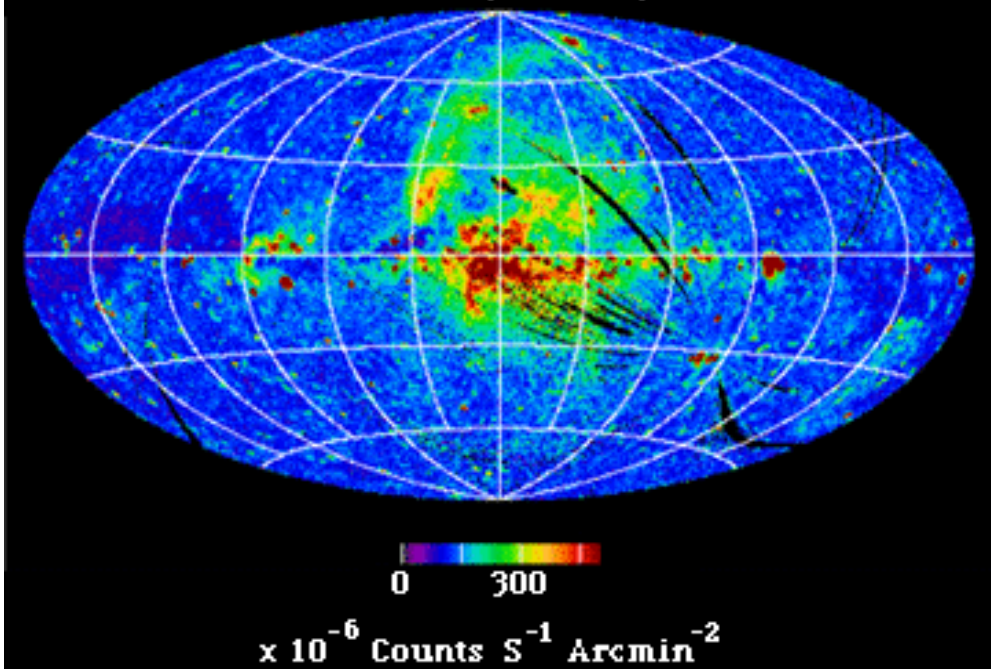


Measurements of lensing..

- ..can constrain the distribution and hence the nature of Dark Matter
- ..can measure global geometry and so constrain Dark Energy
- ..for large statistical samples can measure σ_8 and $P(k)$



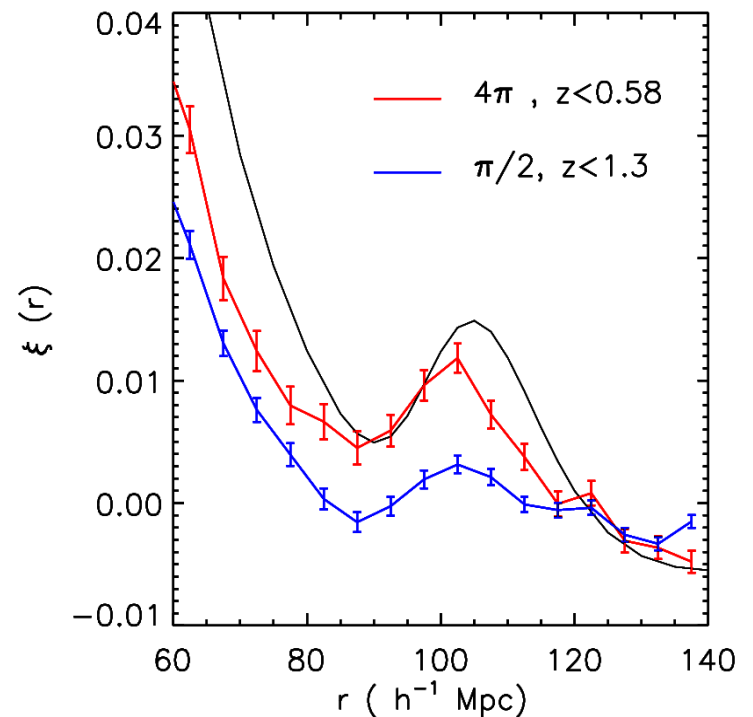
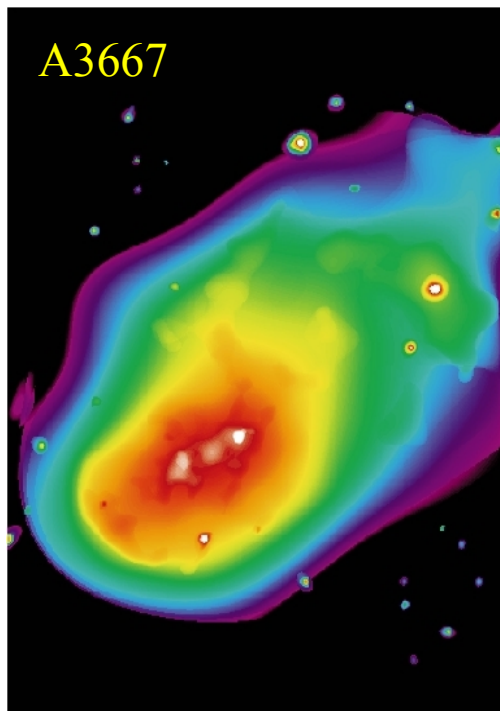
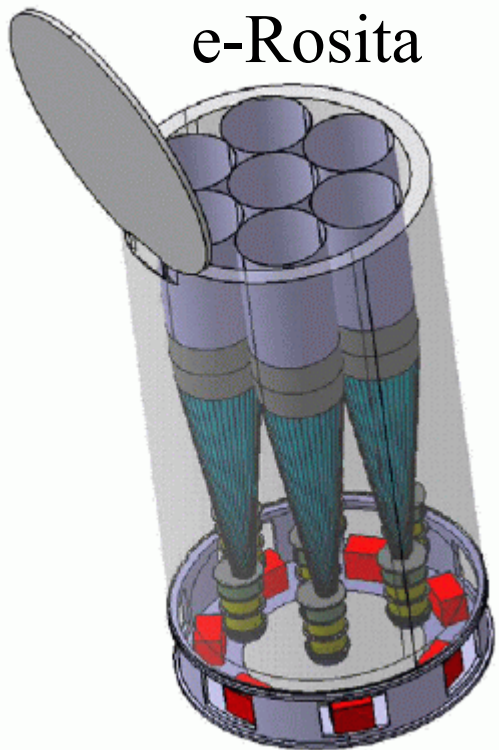
ROSAT PSPC All-Sky Survey at 1.5 keV



X-ray surveys of clusters..

- ..can identify large samples over most of the sky and to $z > 1$
- ..can image the structure of nearby clusters and study their formation
- ..with optical redshifts and SZ data can measure baryon oscillations and the growth rate of structure

e-Rosita



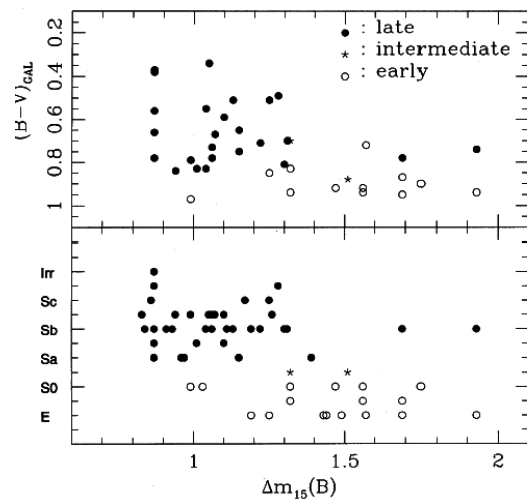
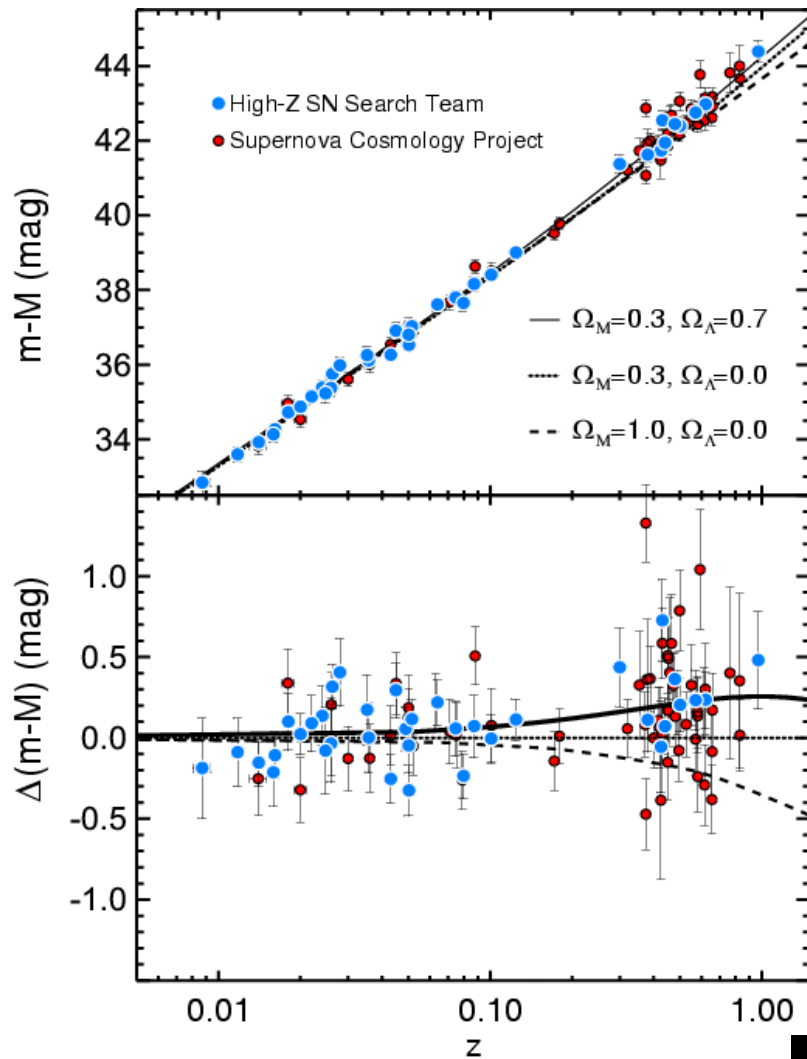
Type Ia Supernovae...

- .. are near-standard candles which show that cosmic expansion is accelerating
- .. appear to be a one-parameter family

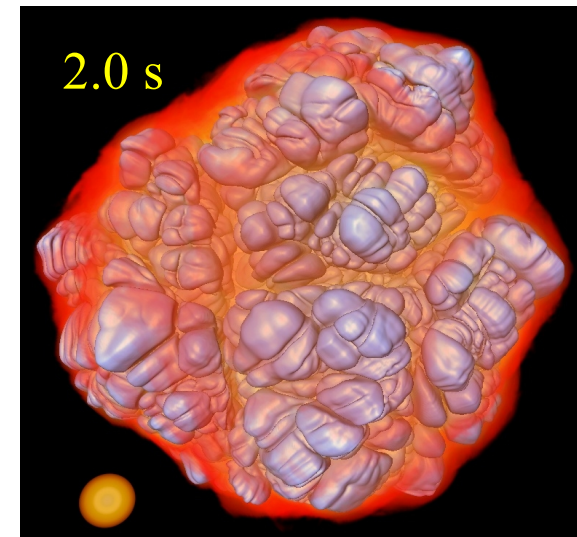
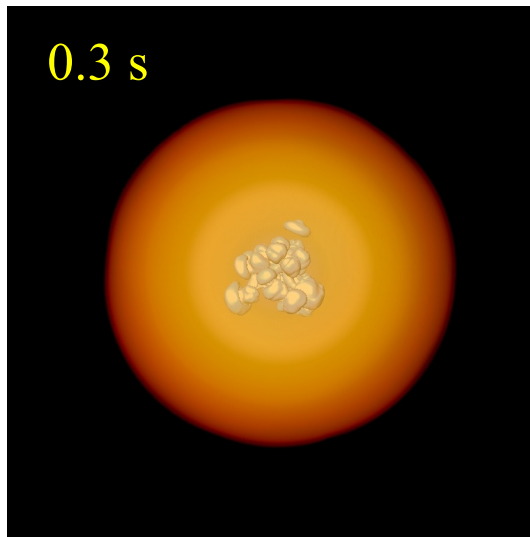
BUT..

- .. have quite diverse spectra
- .. vary with host galaxy properties
- .. may vary with redshift

Better understanding is needed to reach firm conclusions

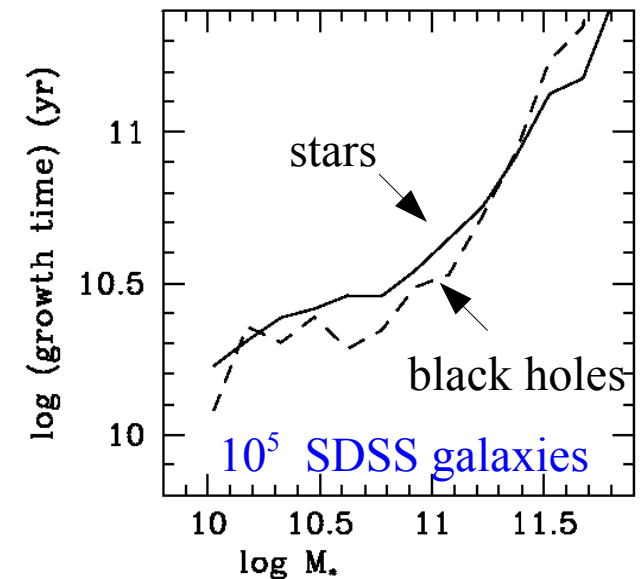
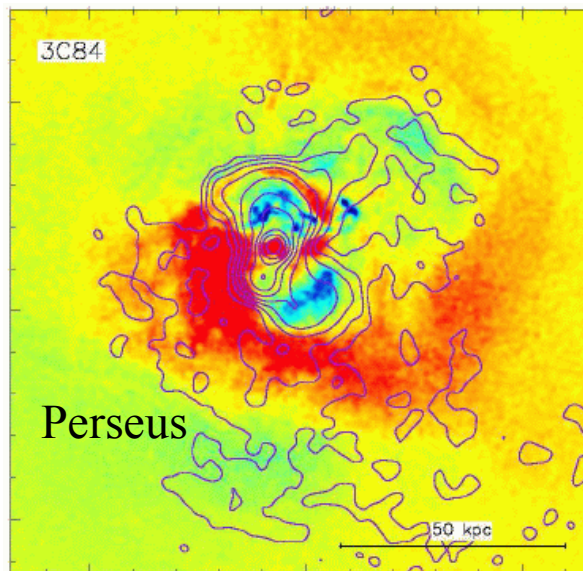
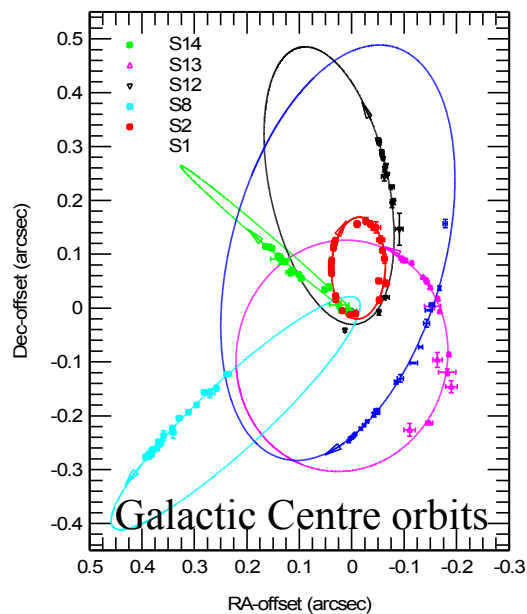
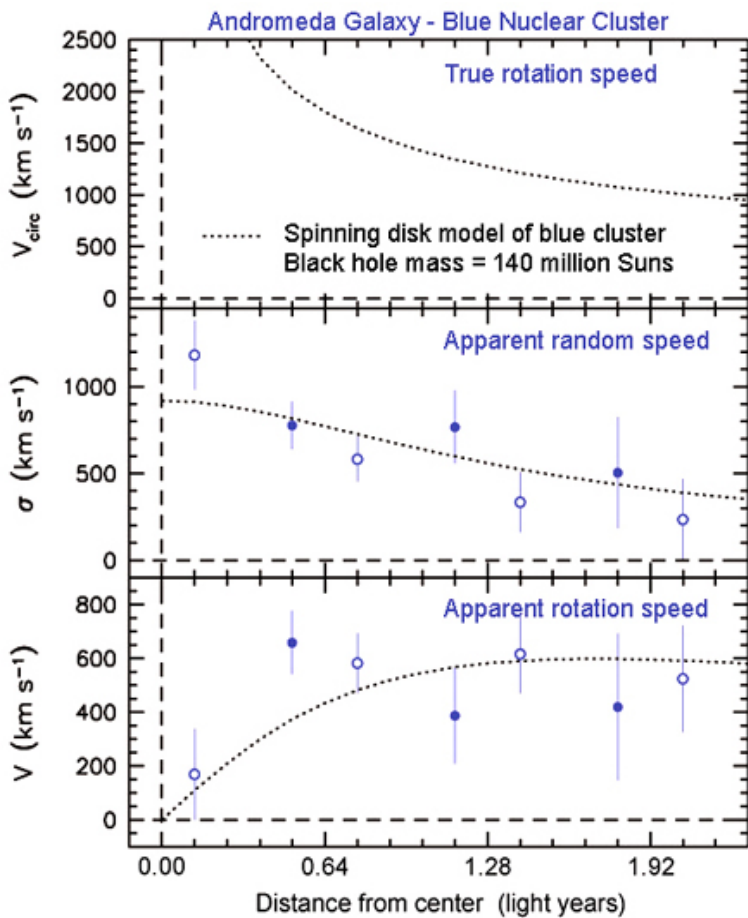


Hamuy et al. 2000



Black holes in Galaxy Nuclei..

- ..are established definitively in some cases
- ..seem to be present in all massive galaxies
- ..are tightly linked to the stellar bulge
- ..are growing in step with the stellar galaxy
- ..strongly influence growth of the most massive galaxies



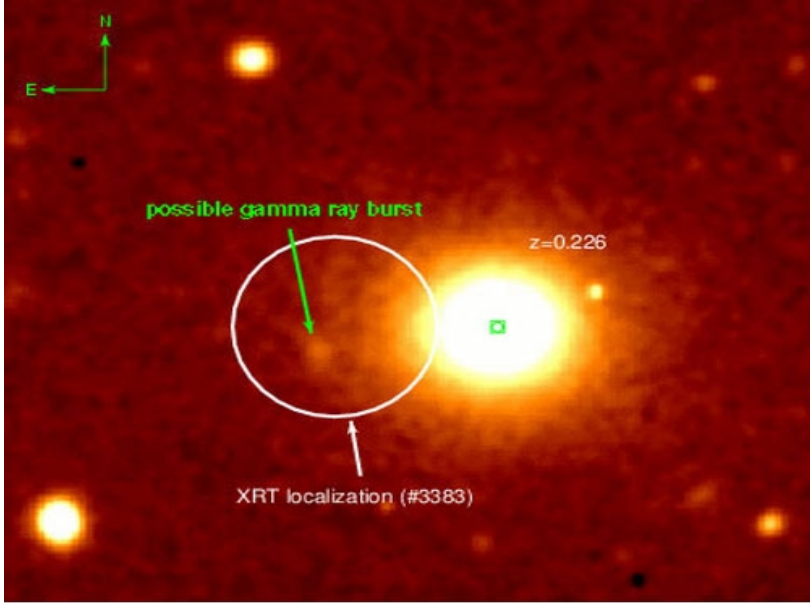
Gamma-ray Bursts..

..may be forming stellar mass black holes

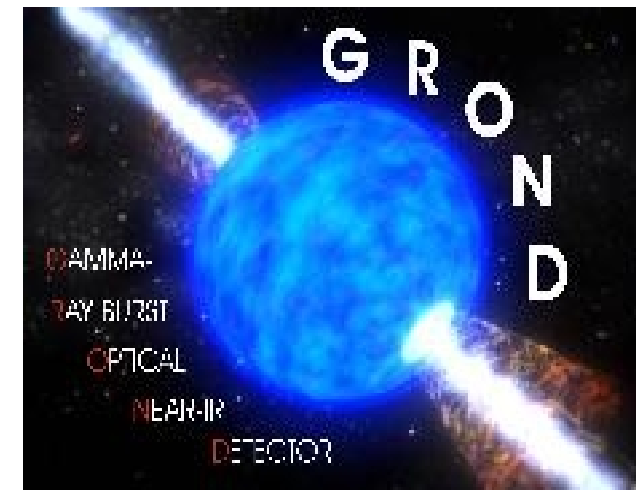
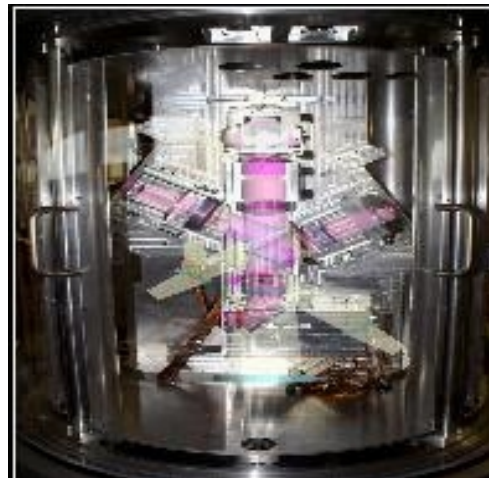
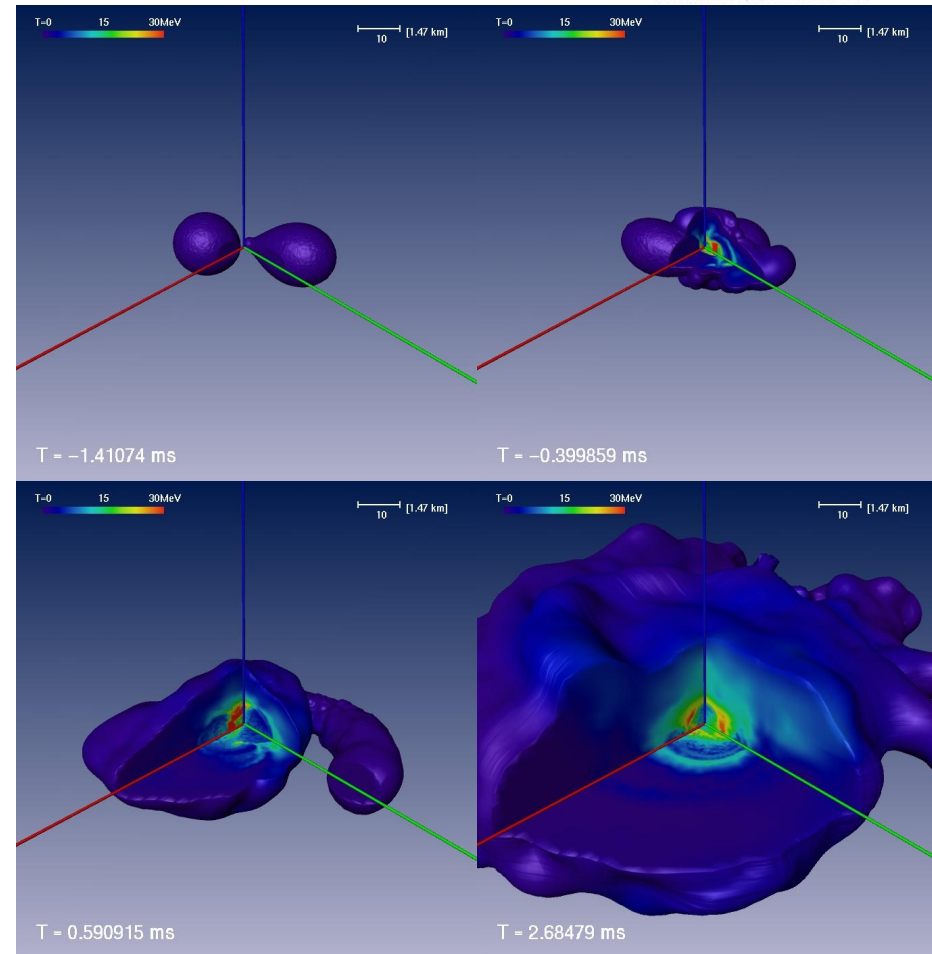
..are being localised in large numbers by SWIFT

..need better prompt follow-up to characterise their properties

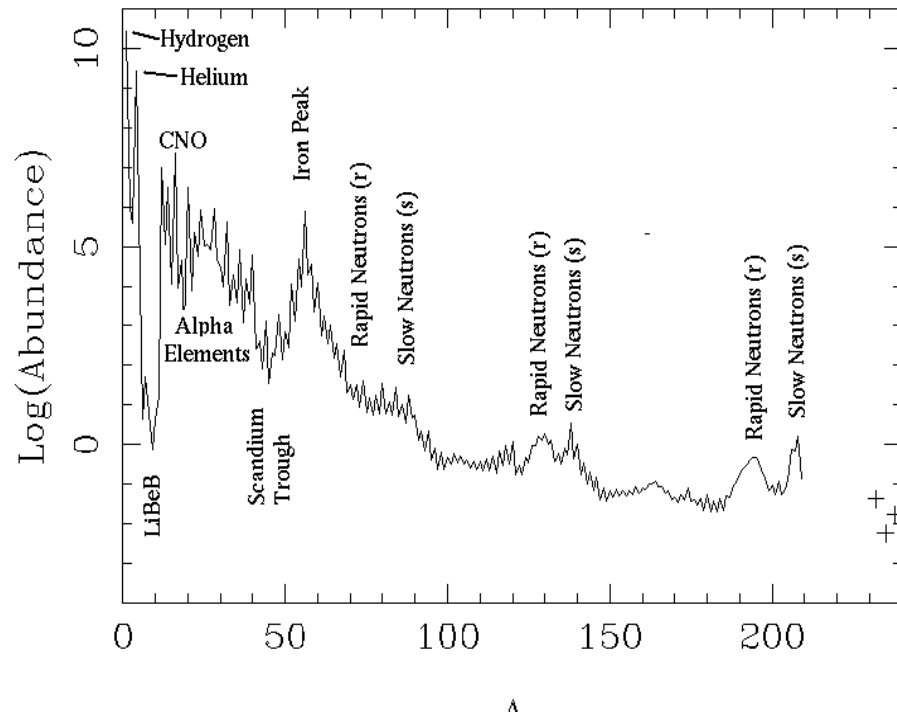
..need improved theoretical understanding



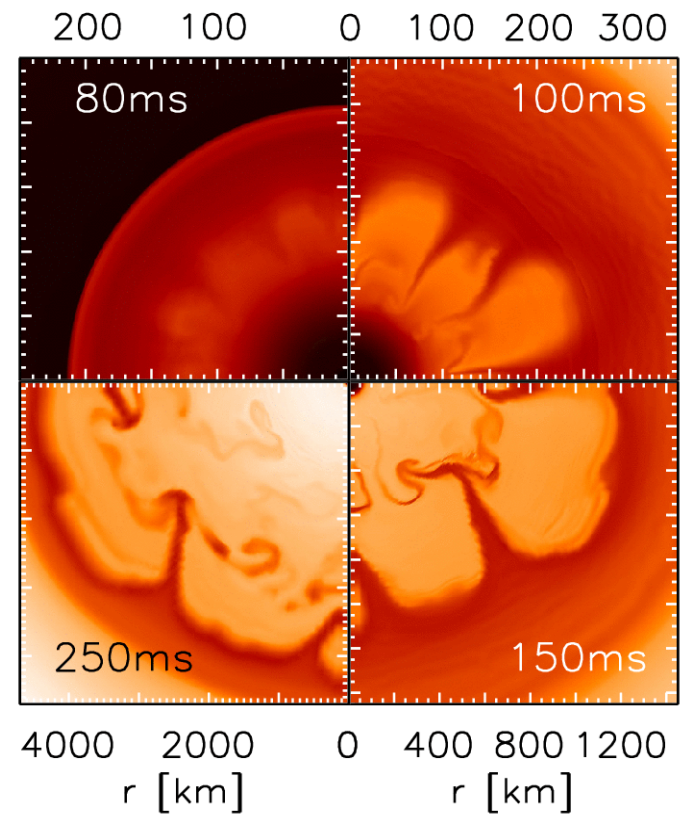
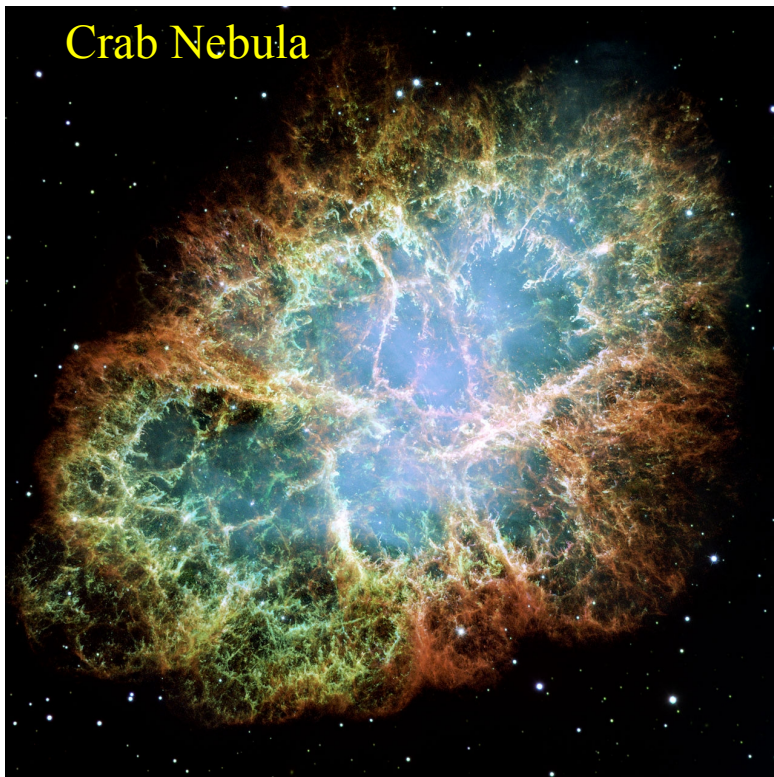
UC BERKELEY/WIYN TELESCOPE



The Element Abundances..



- ..are determined by nuclear physics operating in quiescent and in exploding stars
- ..can act as fossils of the history of galaxy formation
- ..are subject to large theoretical and observational uncertainties



Fresh minds address fundamental questions

- Area A JRG3** How many dimensions are there in Nature?
Is the Universe part of a Multiverse?
- Area C JRG4** Why is the Universe made of matter rather than antimatter?
- Area D JRG5** What do we learn about the early Universe from experiments at the LHC?
- Area E JRG8** Can precise measures of the distribution of galaxies and DM unveil the nature of DM/DE?
- Area F W3(LMU)** What do observations of galaxies at early times tell us about how galaxies were made?
- Area G JRG9** How are stellar life-cycles and galaxy formation histories reflected in element abundances?