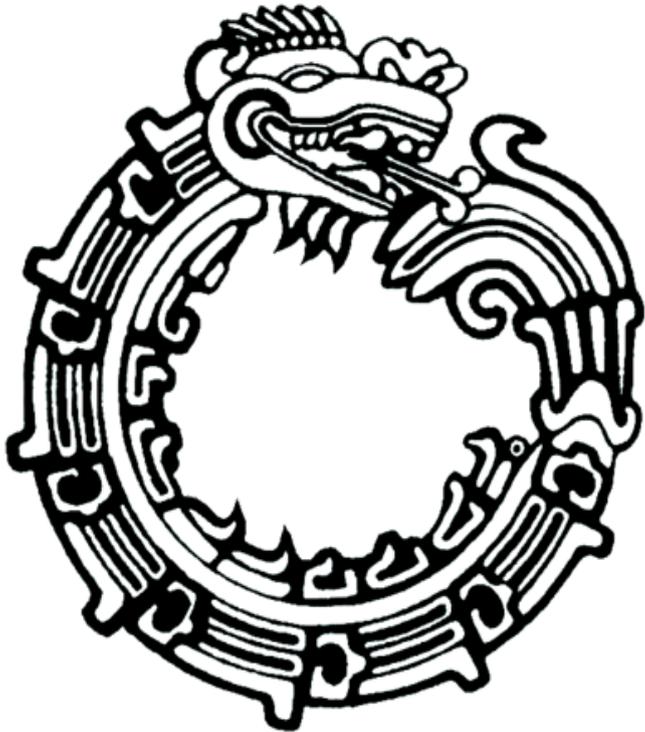
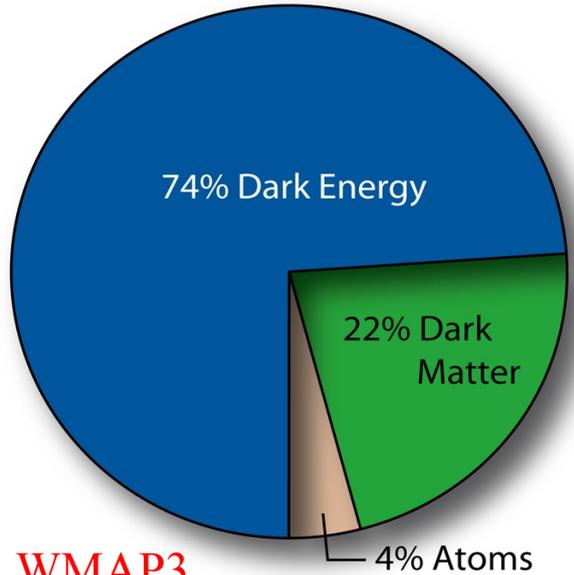
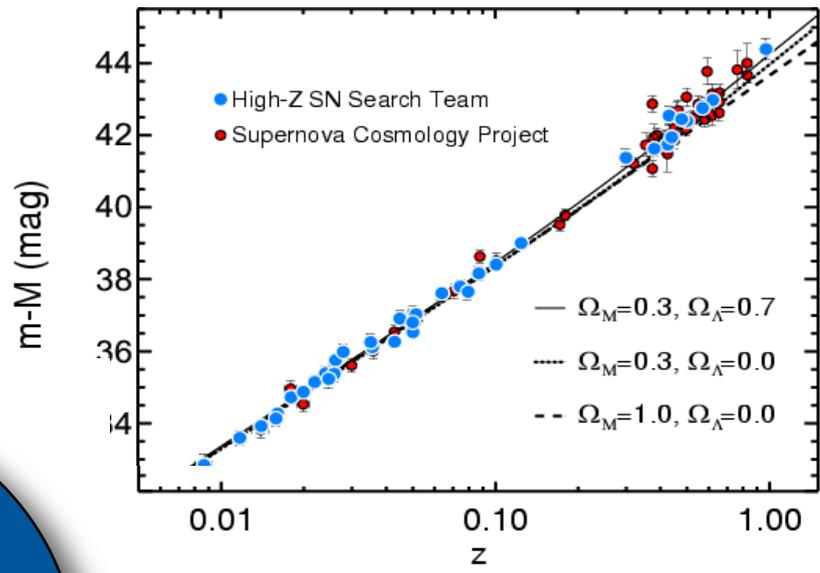


The Origin and Structure of the Universe



- 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

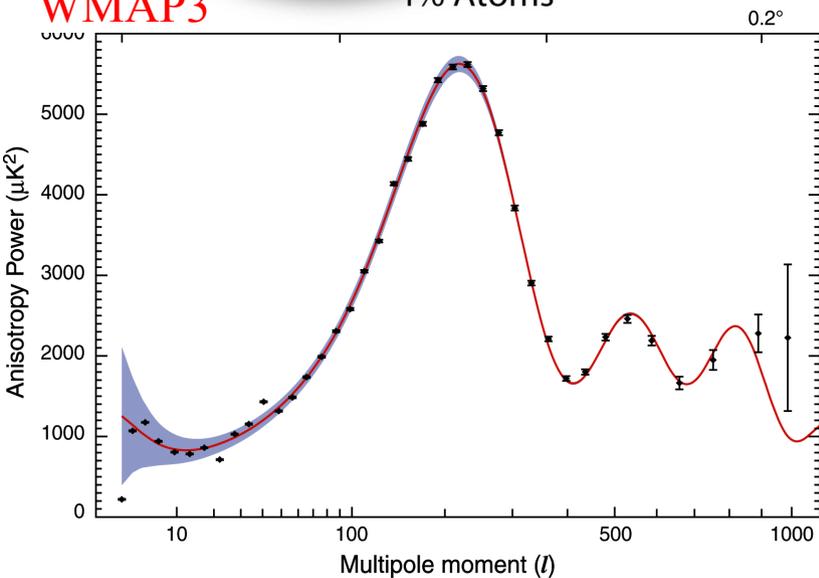
HST A2218



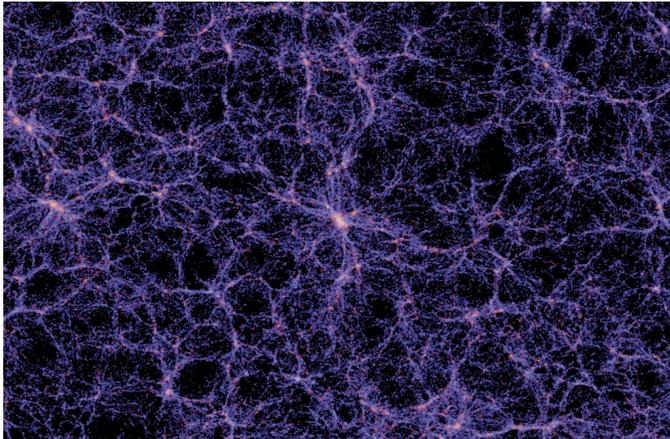
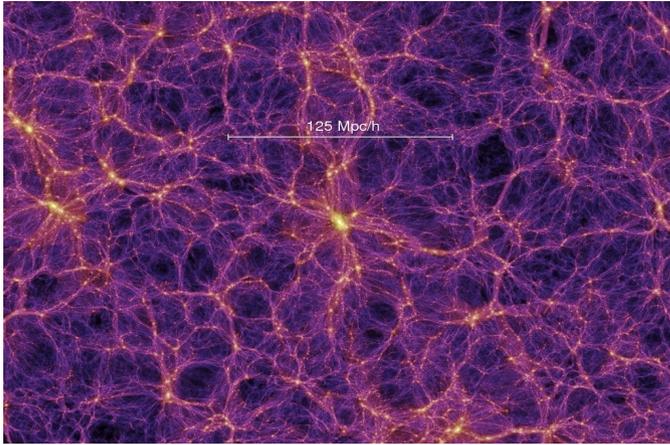
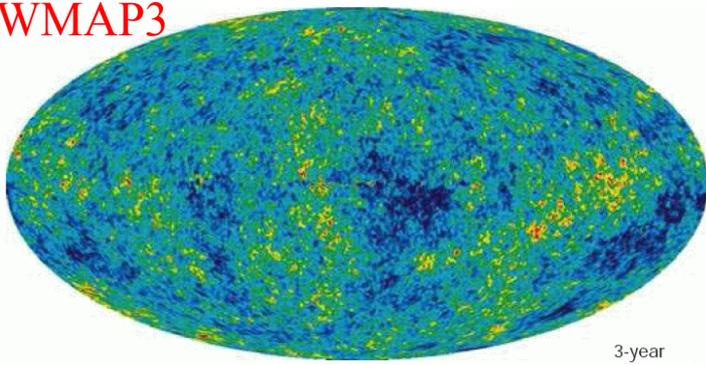
Dark Matter and Dark Energy

- 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

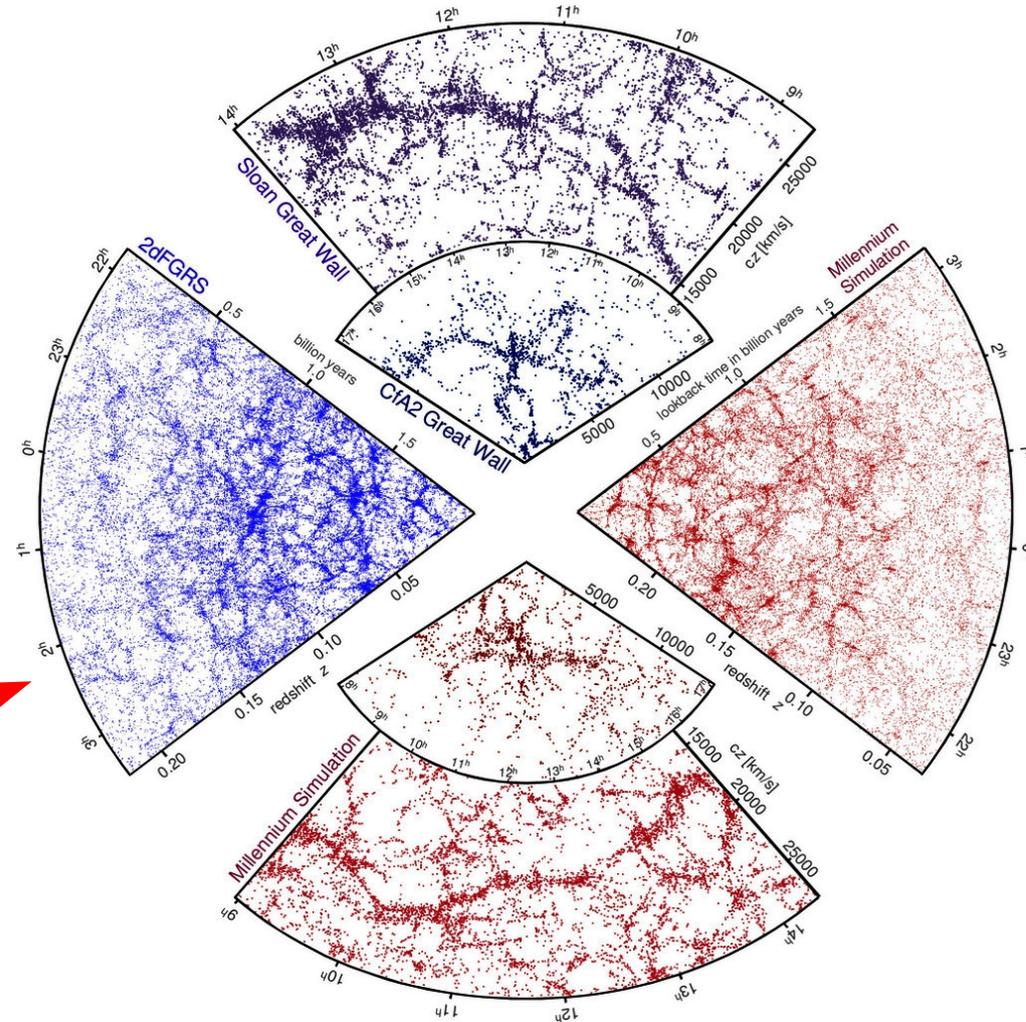


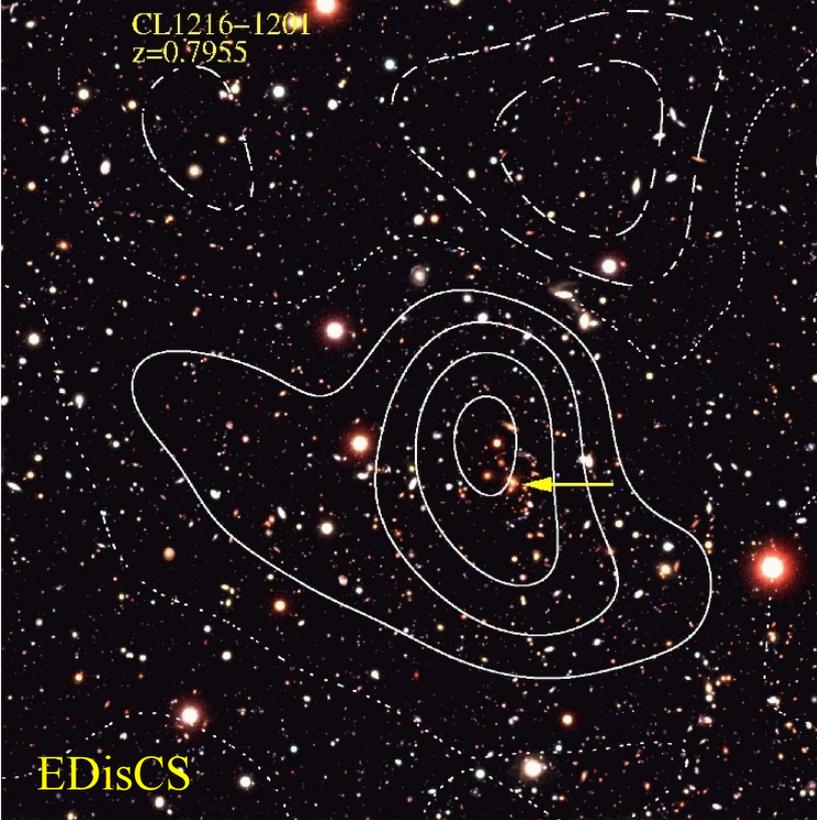
WMAP3



Simulating Cosmic Evolution..

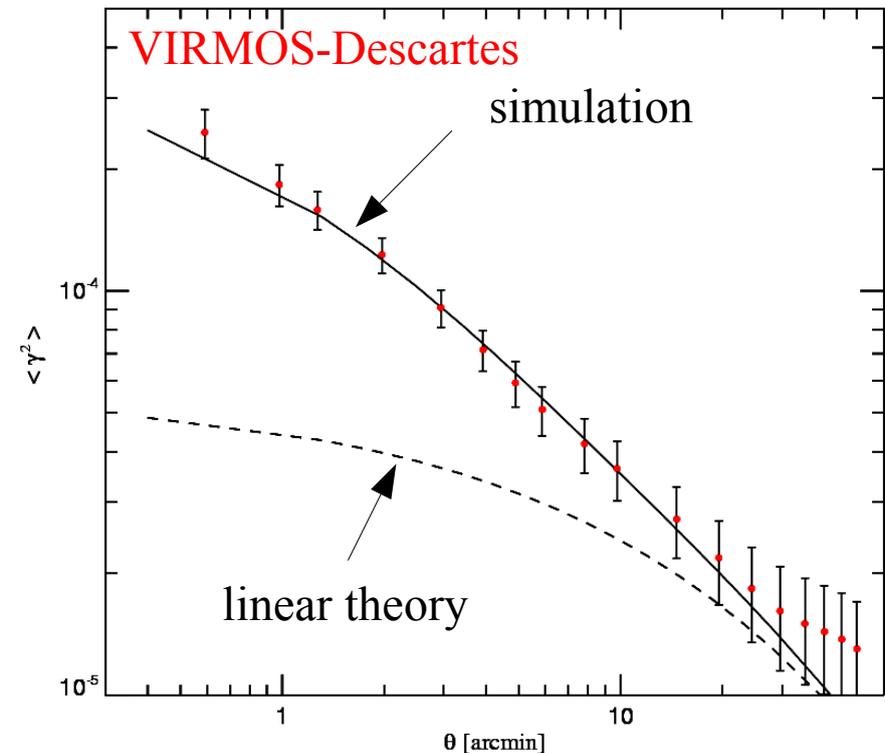
..allows theoretical models of Dark Matter and Dark Energy to be compared quantitatively to astronomical observations



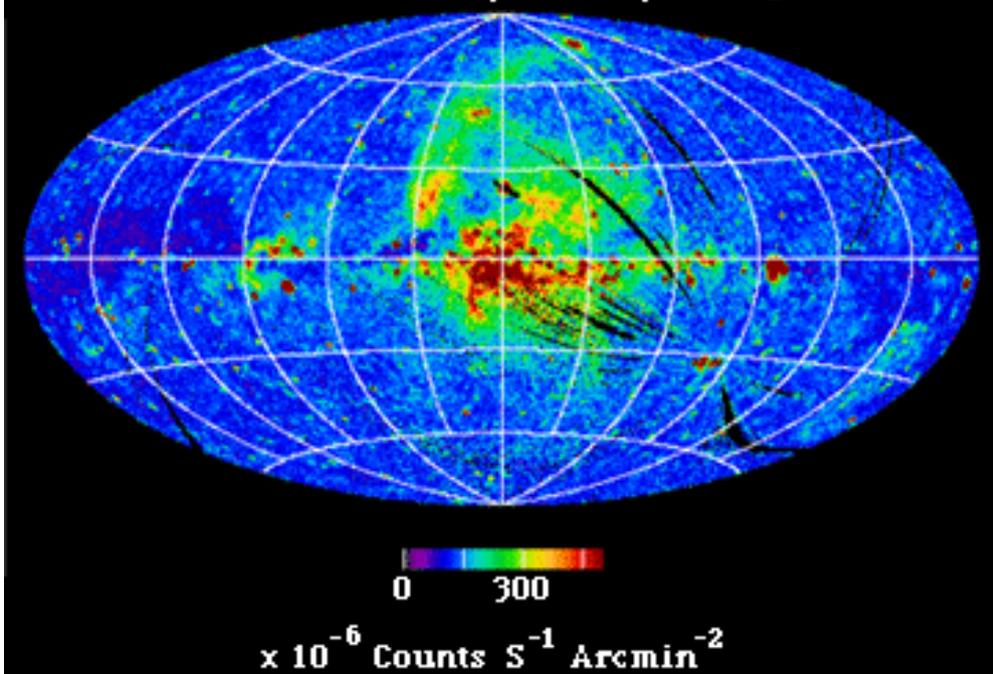


Measurements of lensing..

- ..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 $P(k)$



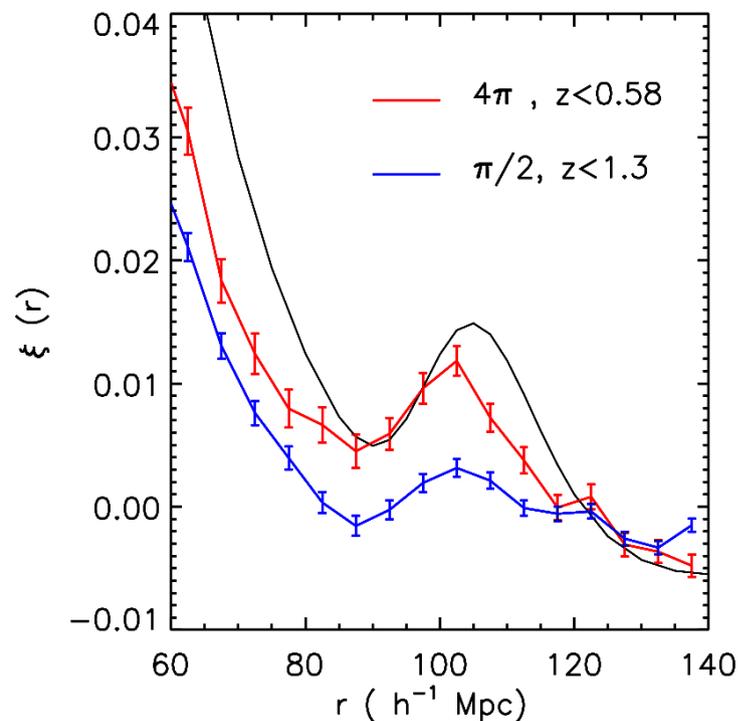
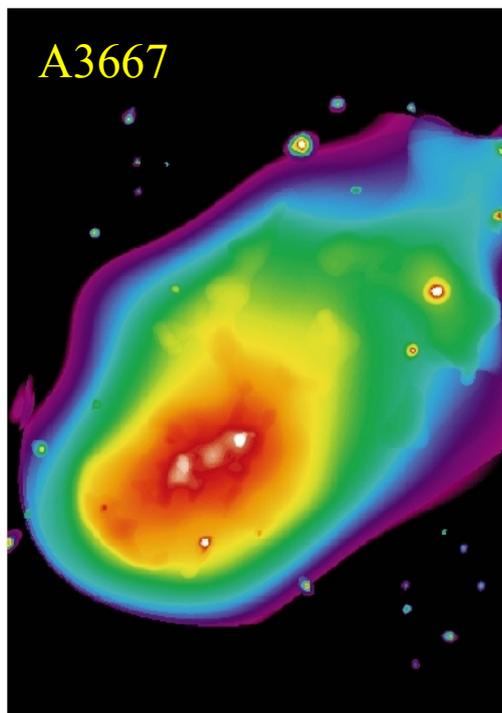
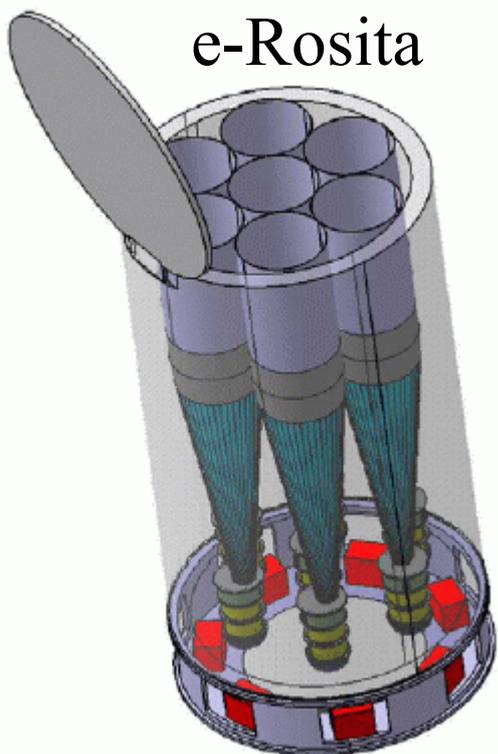
ROSAT PSPC All-Sky Survey at 1.5 keV



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



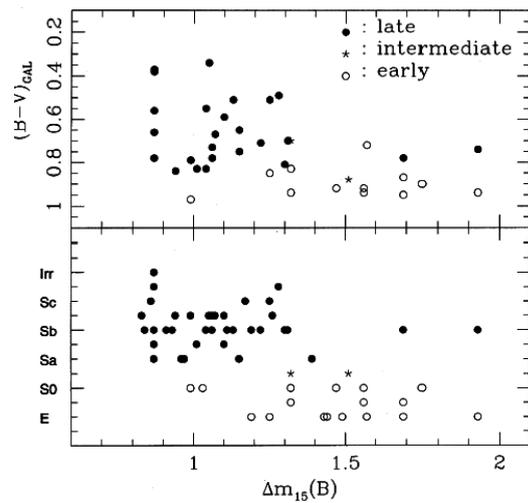
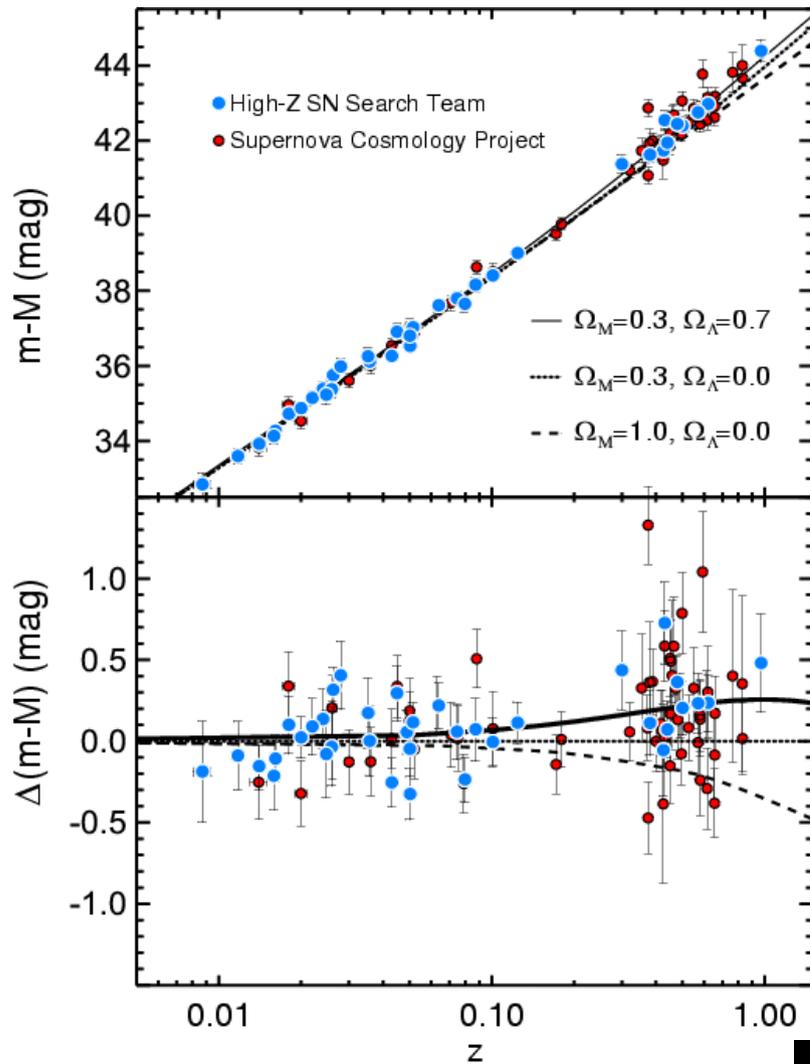
Type Ia Supernovae...

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

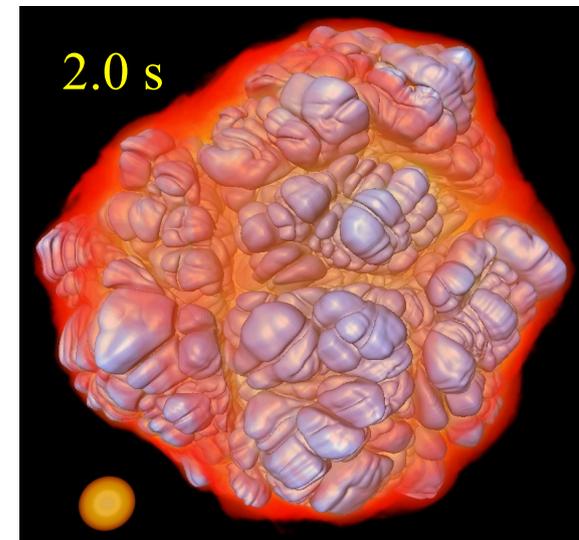
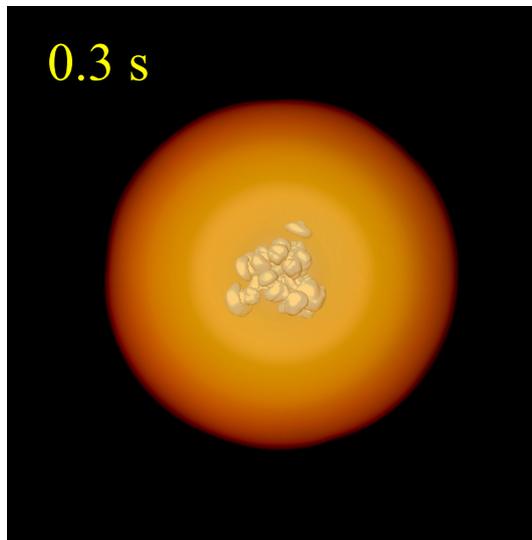
BUT..

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

Better understanding is needed to reach firm conclusions

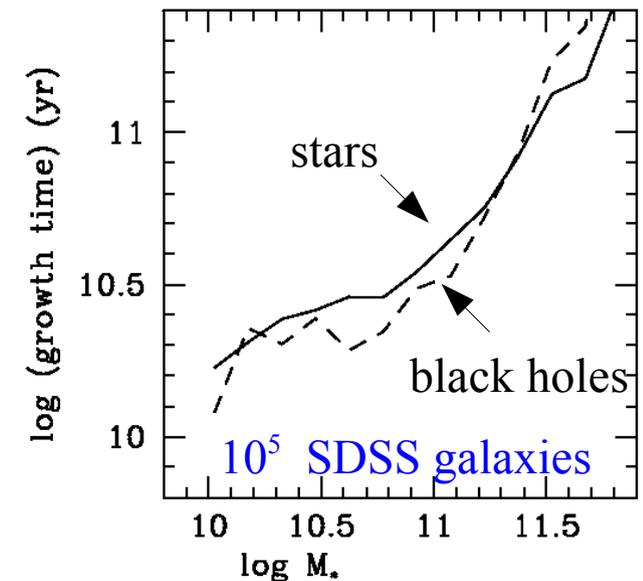
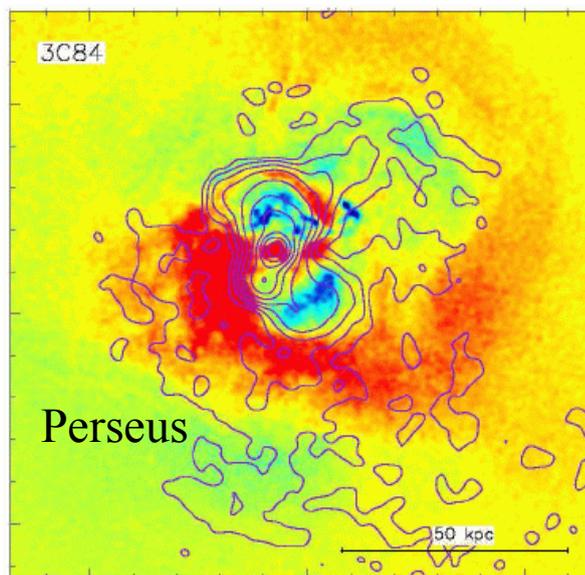
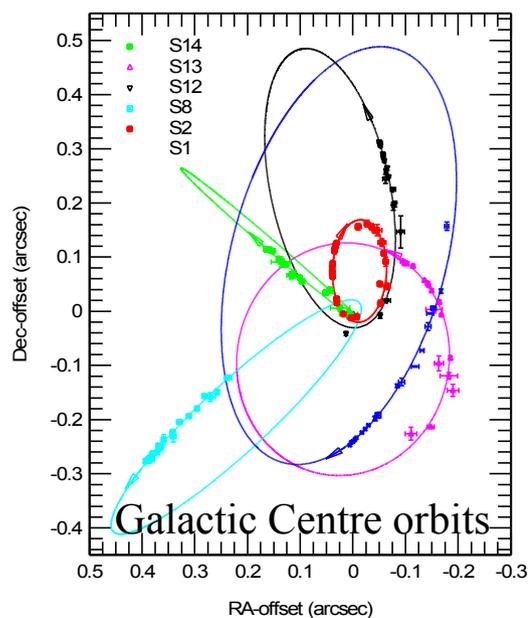
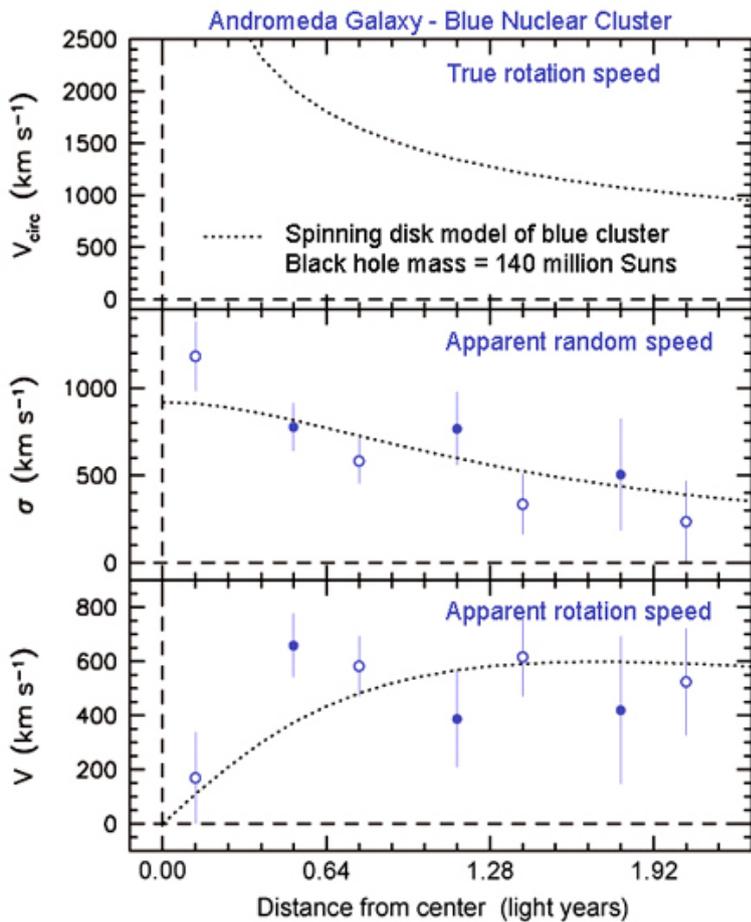


Hamuy et al. 2000



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



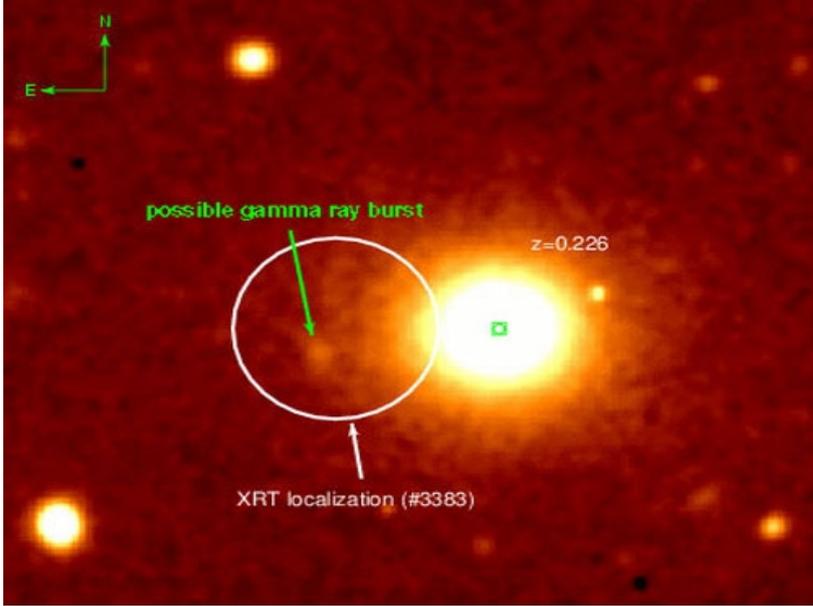
Gamma-ray Bursts..

..may be forming stellar mass black holes

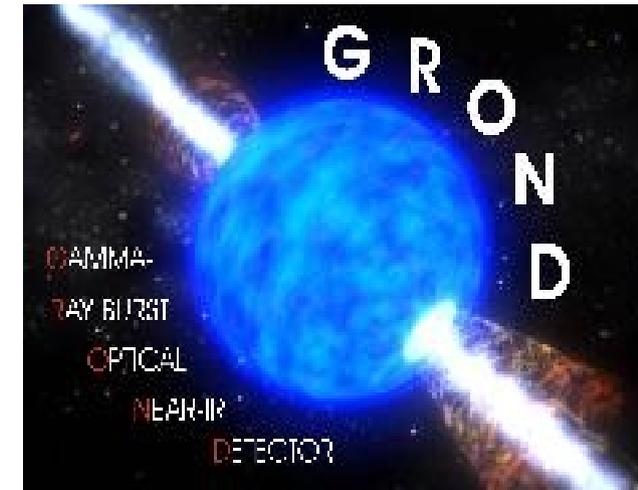
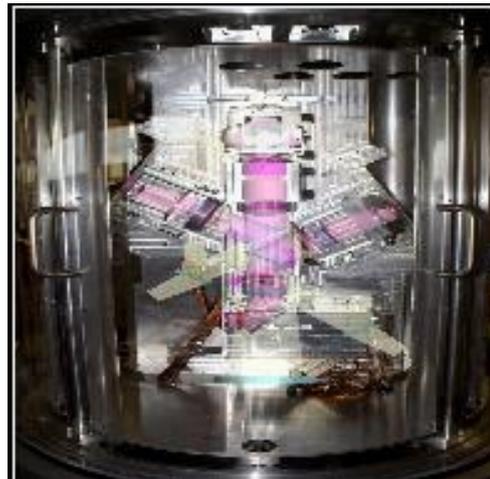
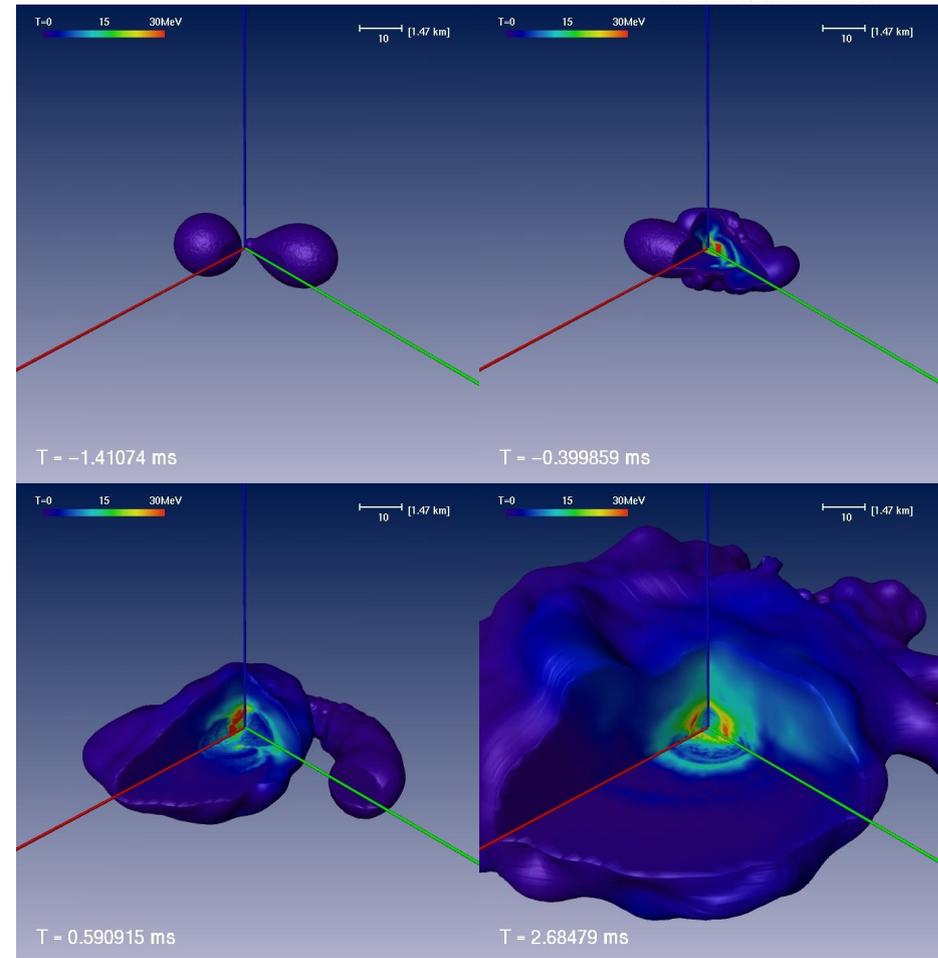
..are being localised in large numbers by SWIFT

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

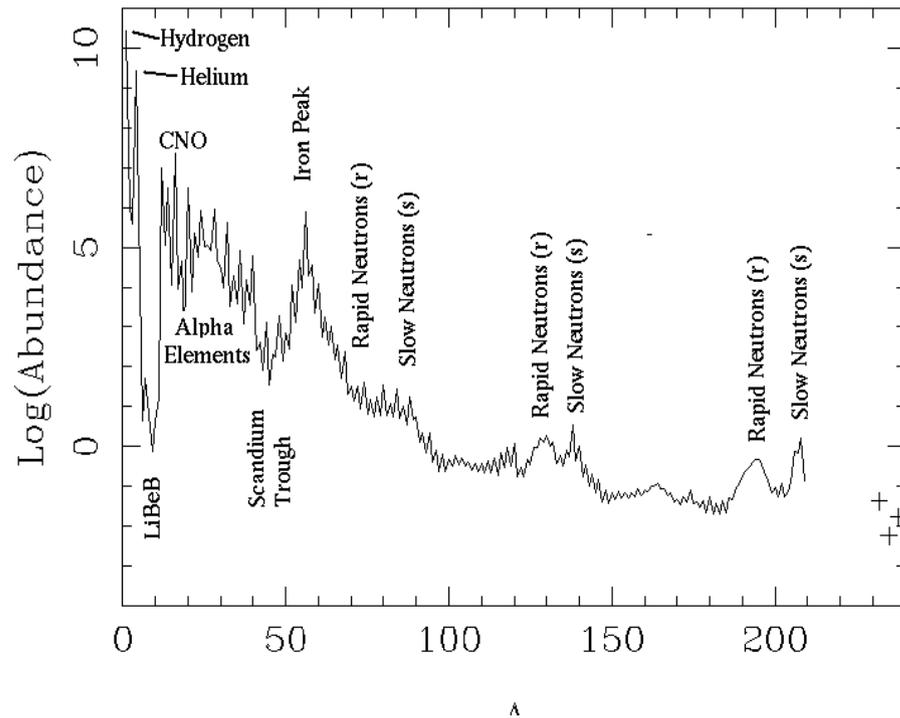
..need improved theoretical understanding



UC BERKELEY/WIYN TELESCOPE



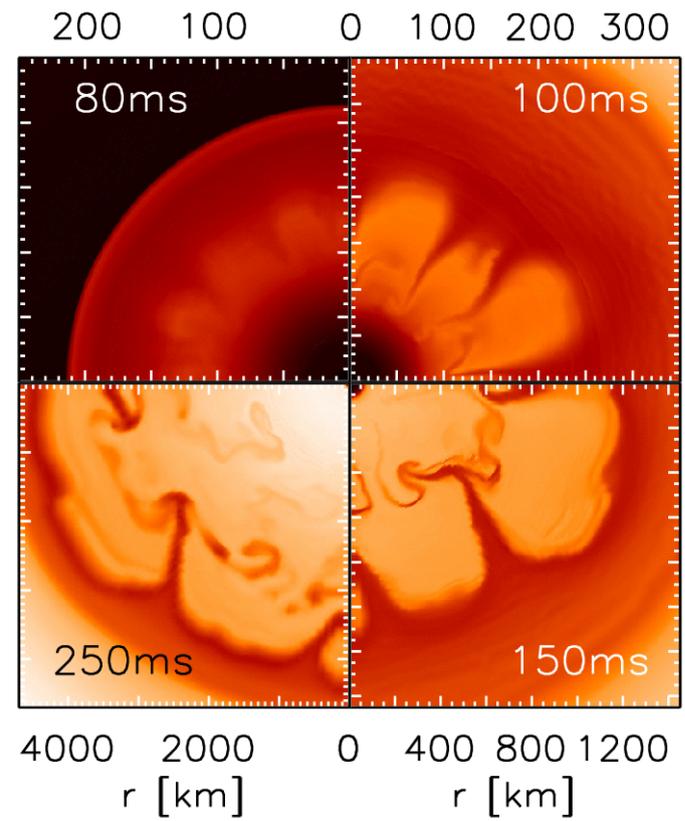
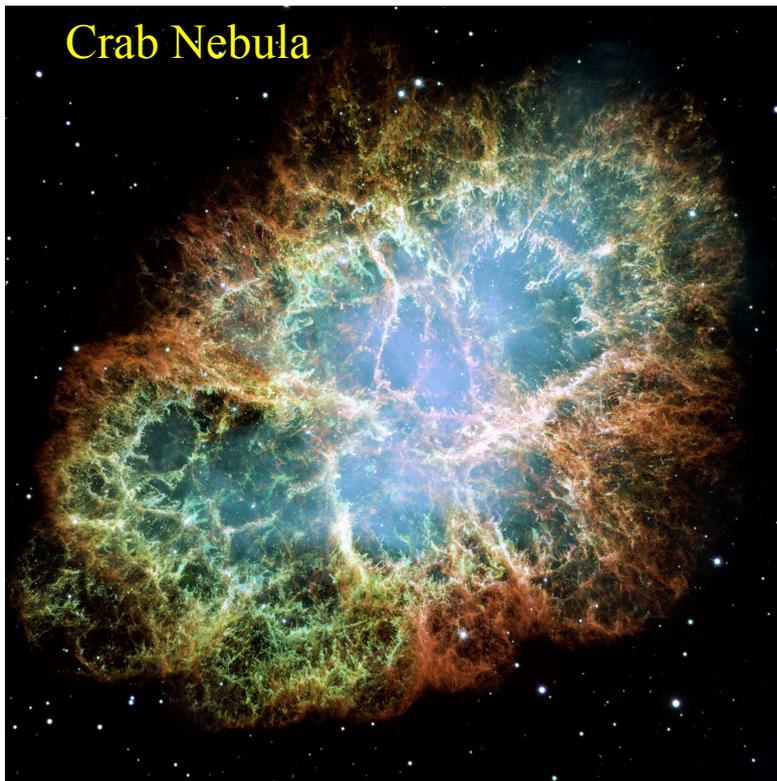
The Element Abundances..



..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?