Probing the Early Universe with Gamma Ray Bursts

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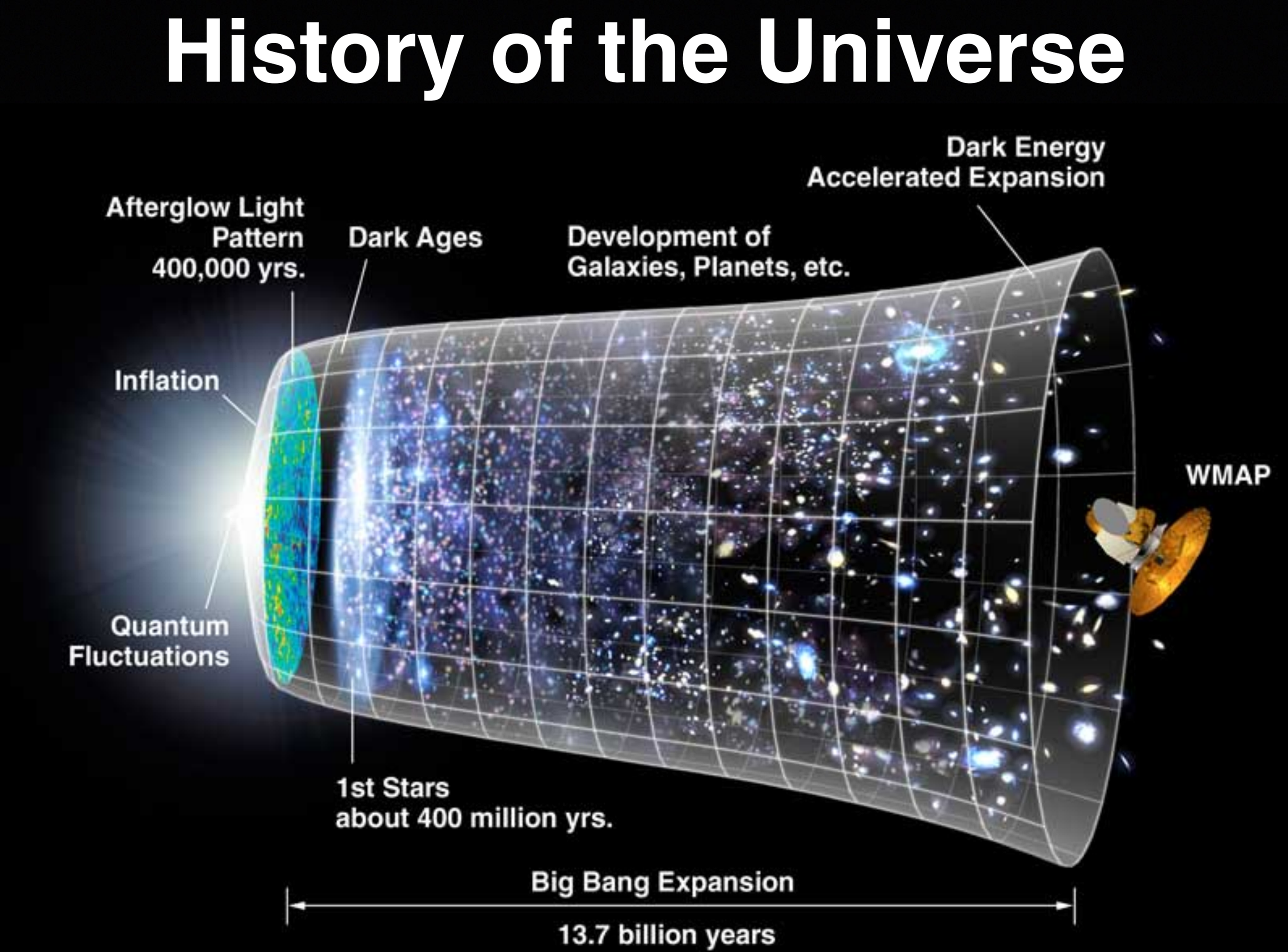
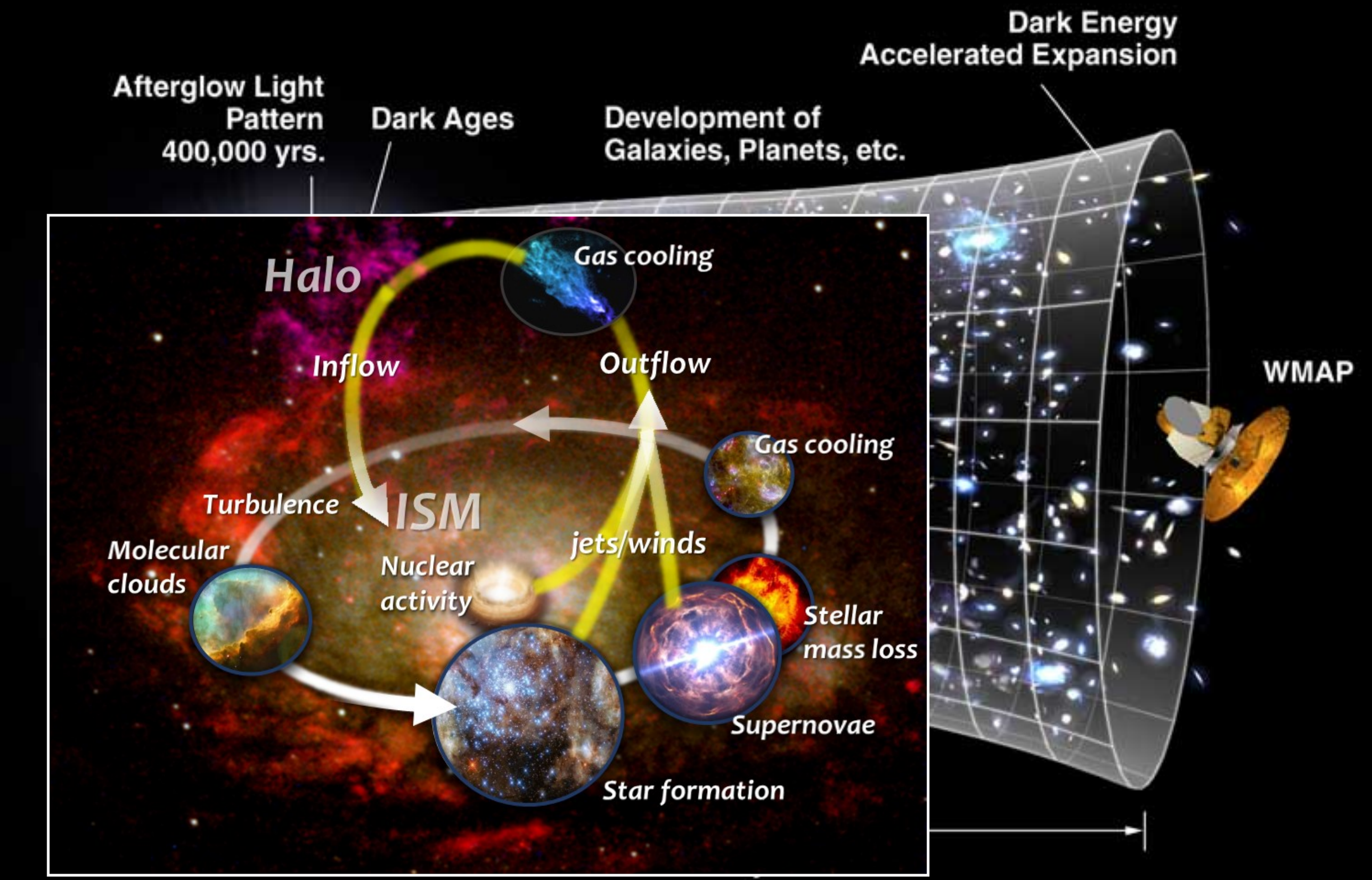
Department of Physics

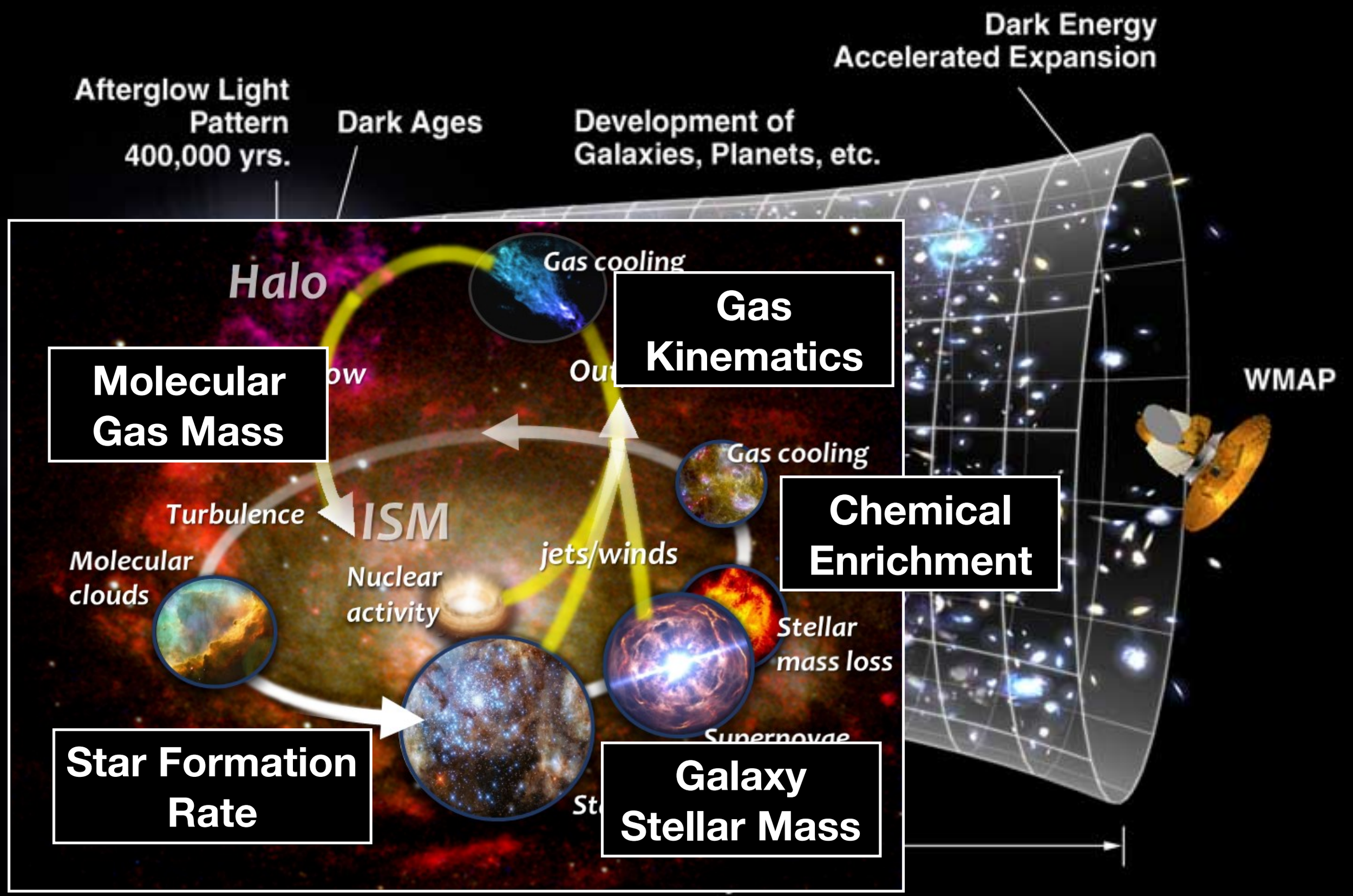
History of the Universe



The galactic baryon cycle

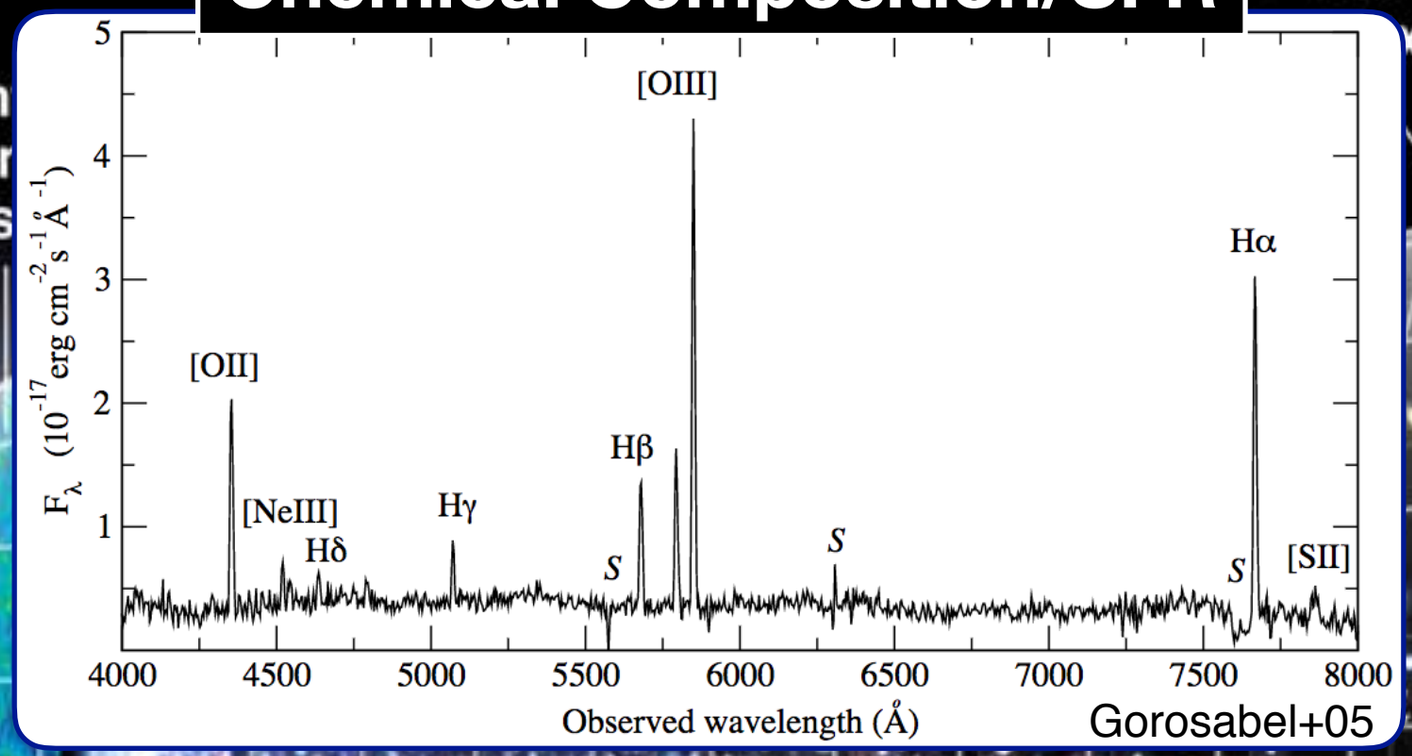


The galactic baryon cycle



Observations of nearby galaxies

Chemical Composition/SFR



Gorosabel+05

Stellar Mass/SFR

Credit: Robert Gendler

Afterglow Ligh
Patterr
400,000 yrs

Inflation

Quantum
Fluctuations

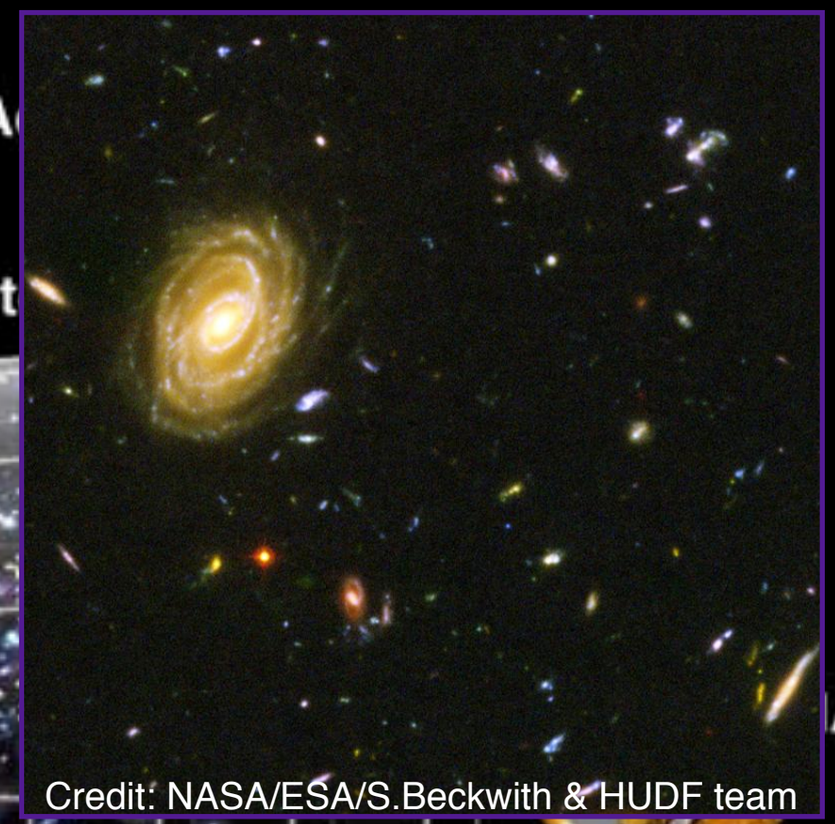
1st Stars
about 400

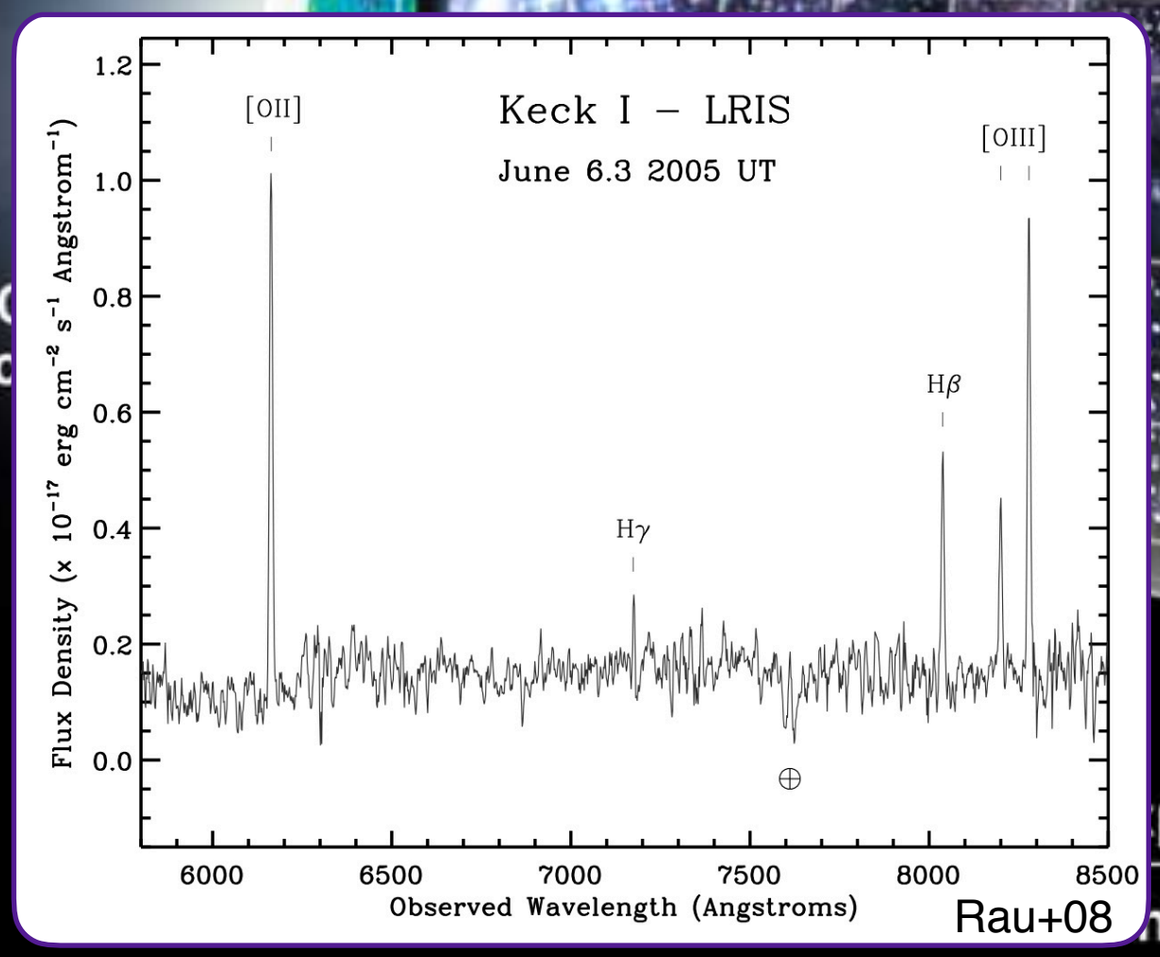
Dark Energy
xpansion

WMAP

13.7 billion years

Increasingly distant galaxies


Credit: NASA/ESA/S.Beckwith & HUDF team



Rau+08

Afterglow Light Pattern 400,000 yrs.

Dark Ages

Development of Galaxies, Planets, et

Inflation

AP

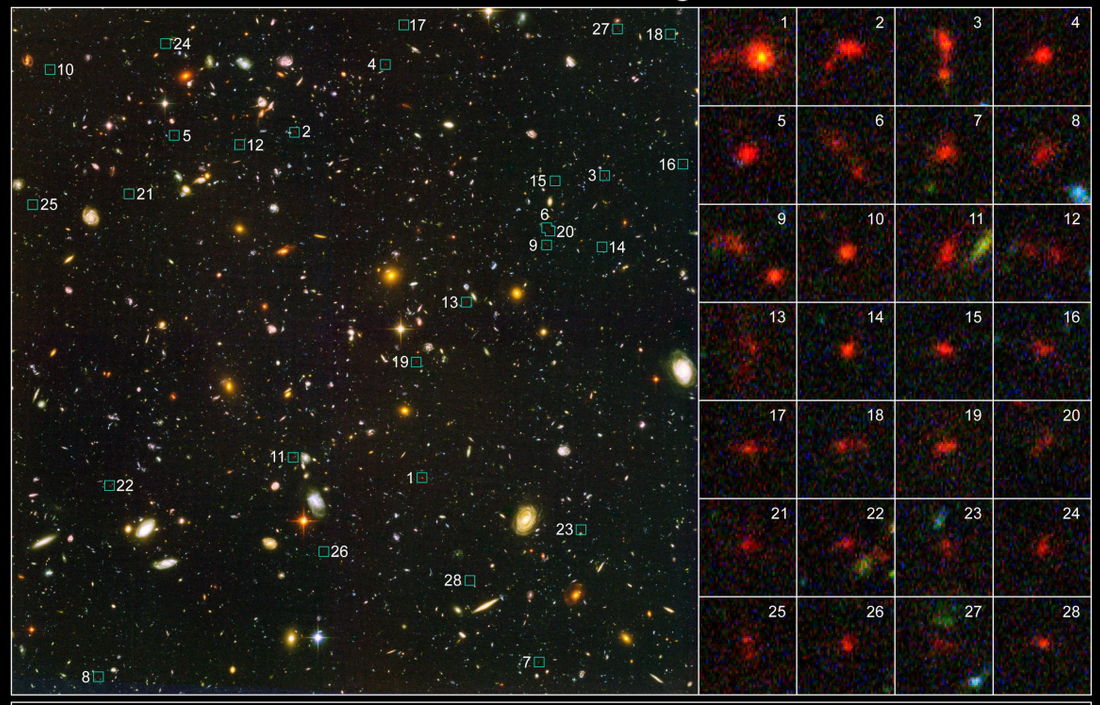
pansion

n years

Credit: Robert Gendler

Very distant galaxies

Credit: NASA/ESA/R.Bouwens & G.Illingworth



Distant Galaxies in the Hubble Ultra Deep Field
Hubble Space Telescope • Advanced Camera for Surveys

NASA, ESA, R. Bouwens and G. Illingworth (University of California, Santa Cruz)

Afterglow Light Pattern 400,000 yrs.

Dark Age

Inflation

Quantum Fluctuations

1st Stars about 400 million yrs.

nergy
nsion

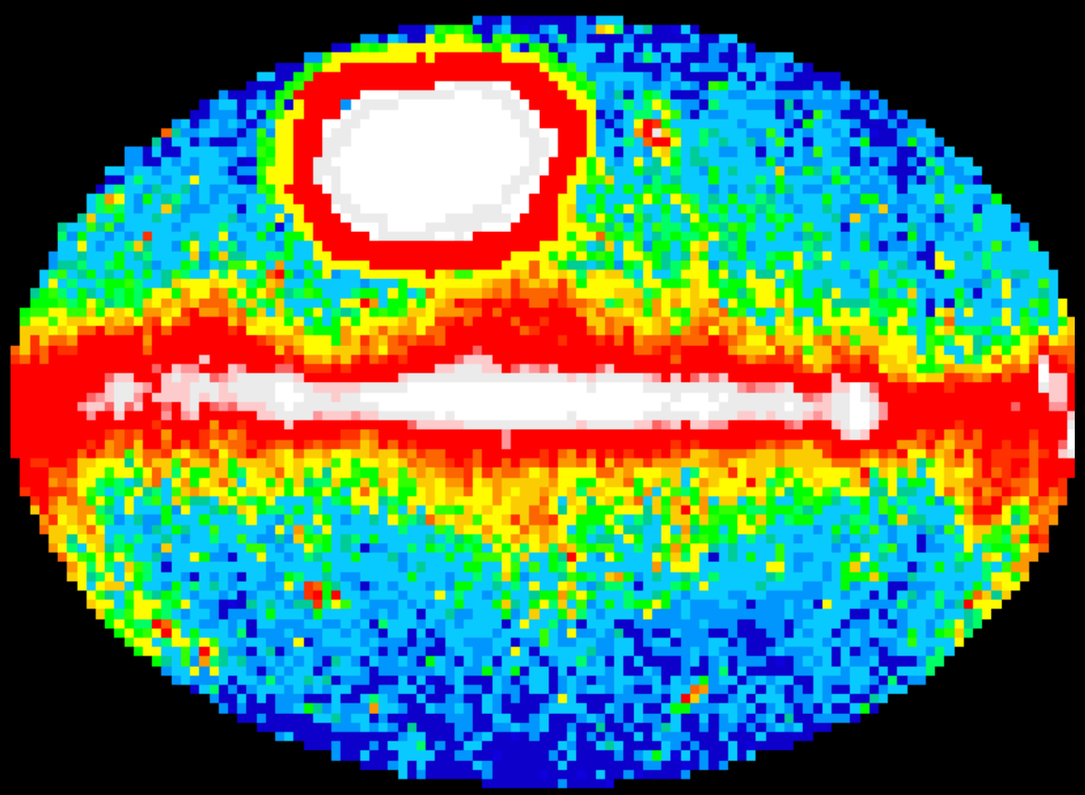
WMAP

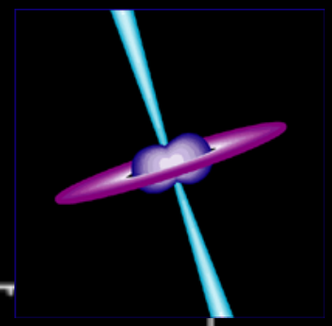
Big Bang Expansion

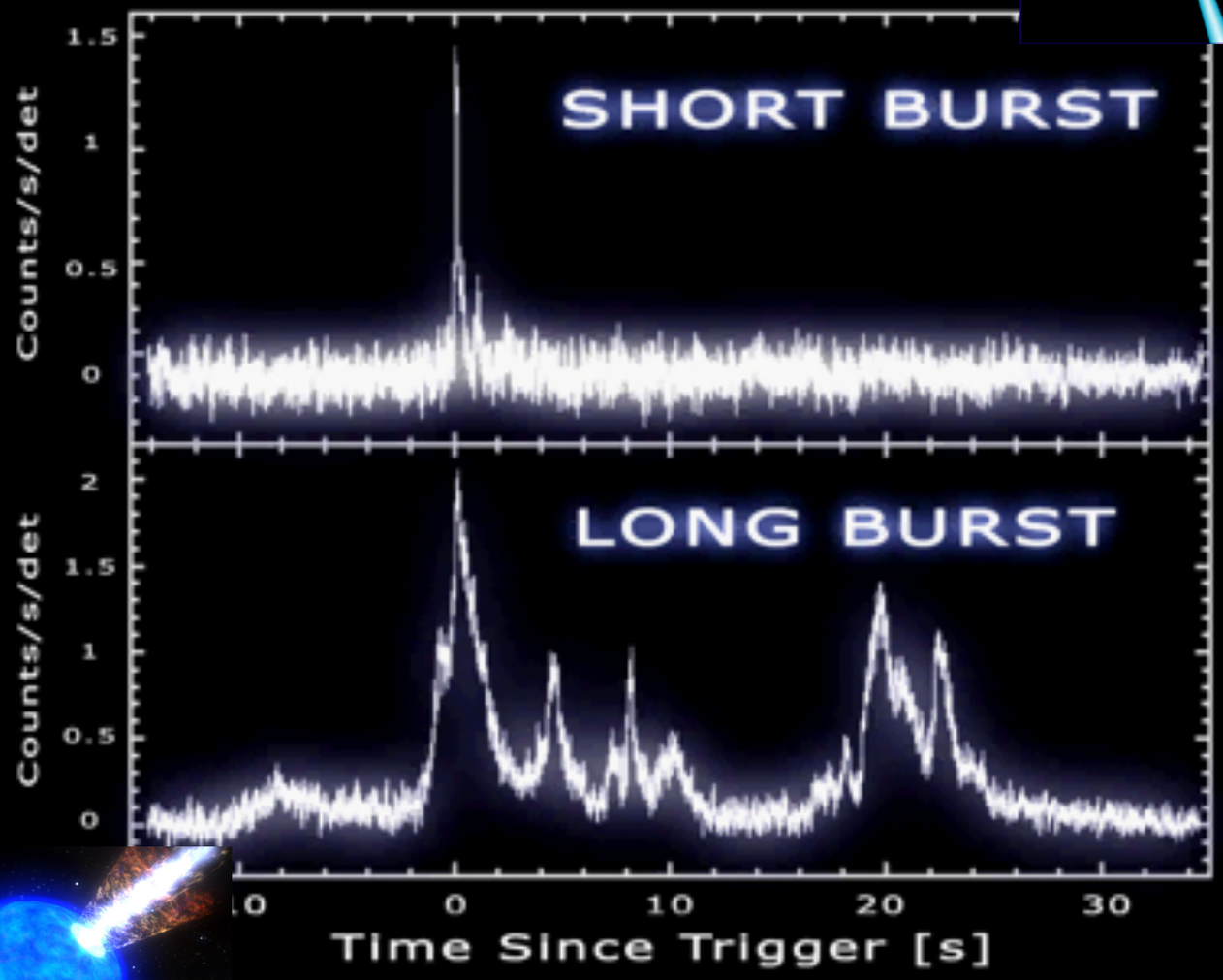
13.7 billion years

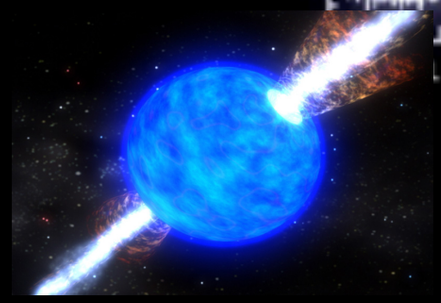
Using GRBs as a probe of cosmic chemical build-up

Gamma Ray Bursts (GRBs)



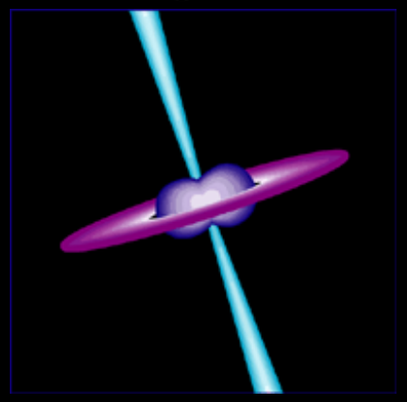


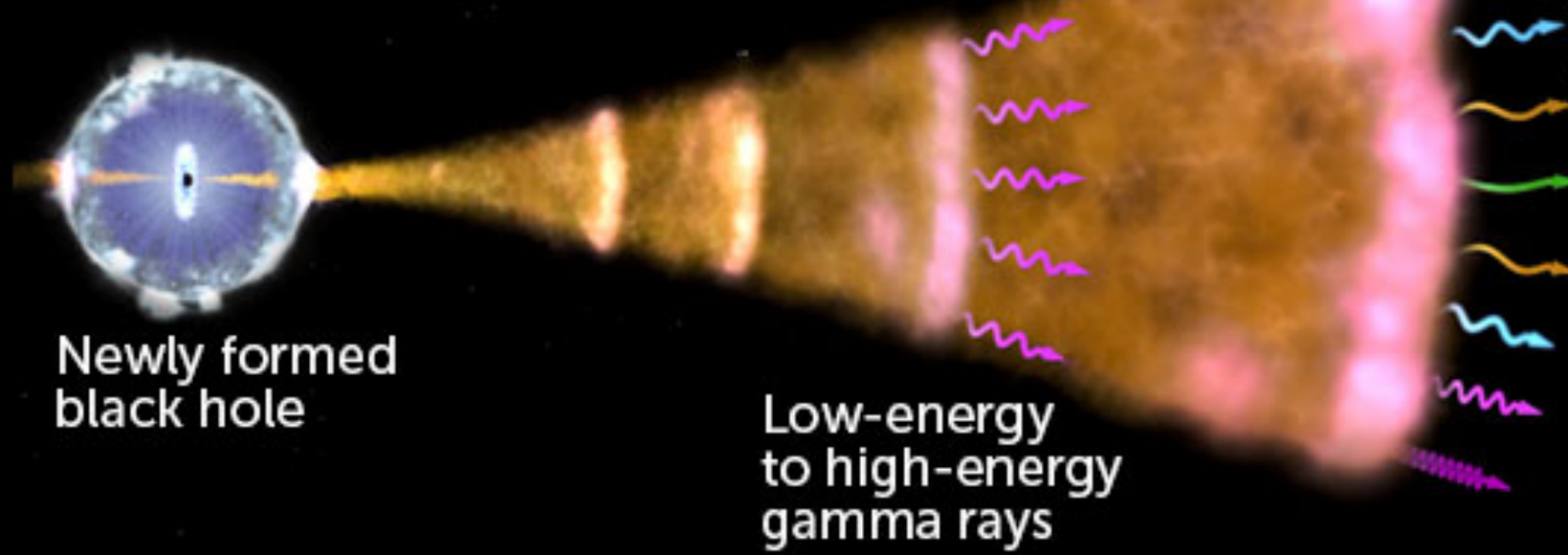


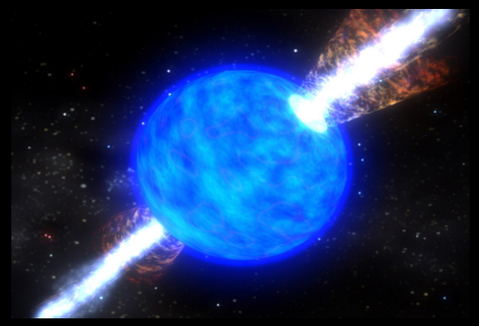


GRB emission mechanism

Compact star mergers

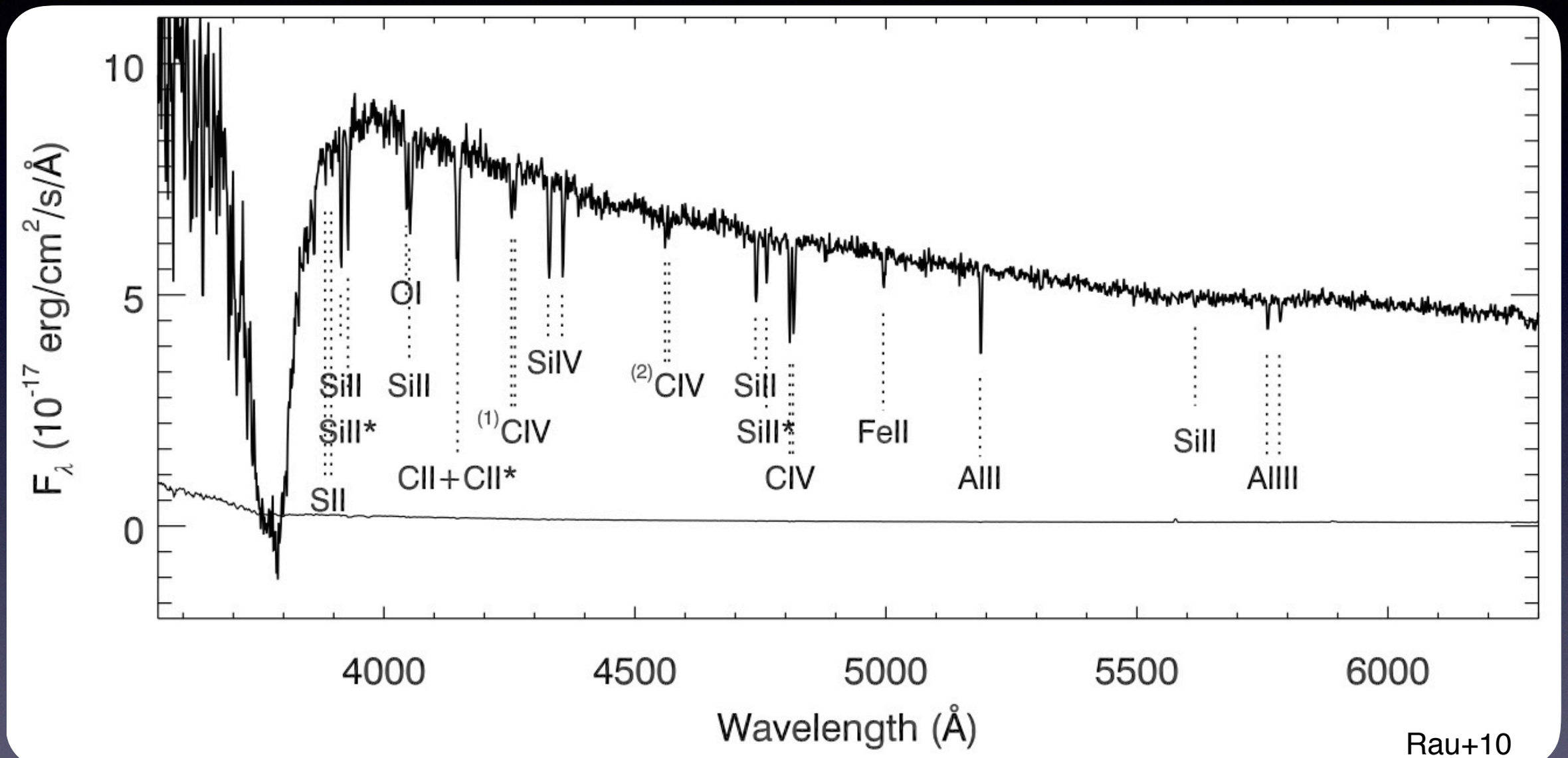






Core collapse of massive star

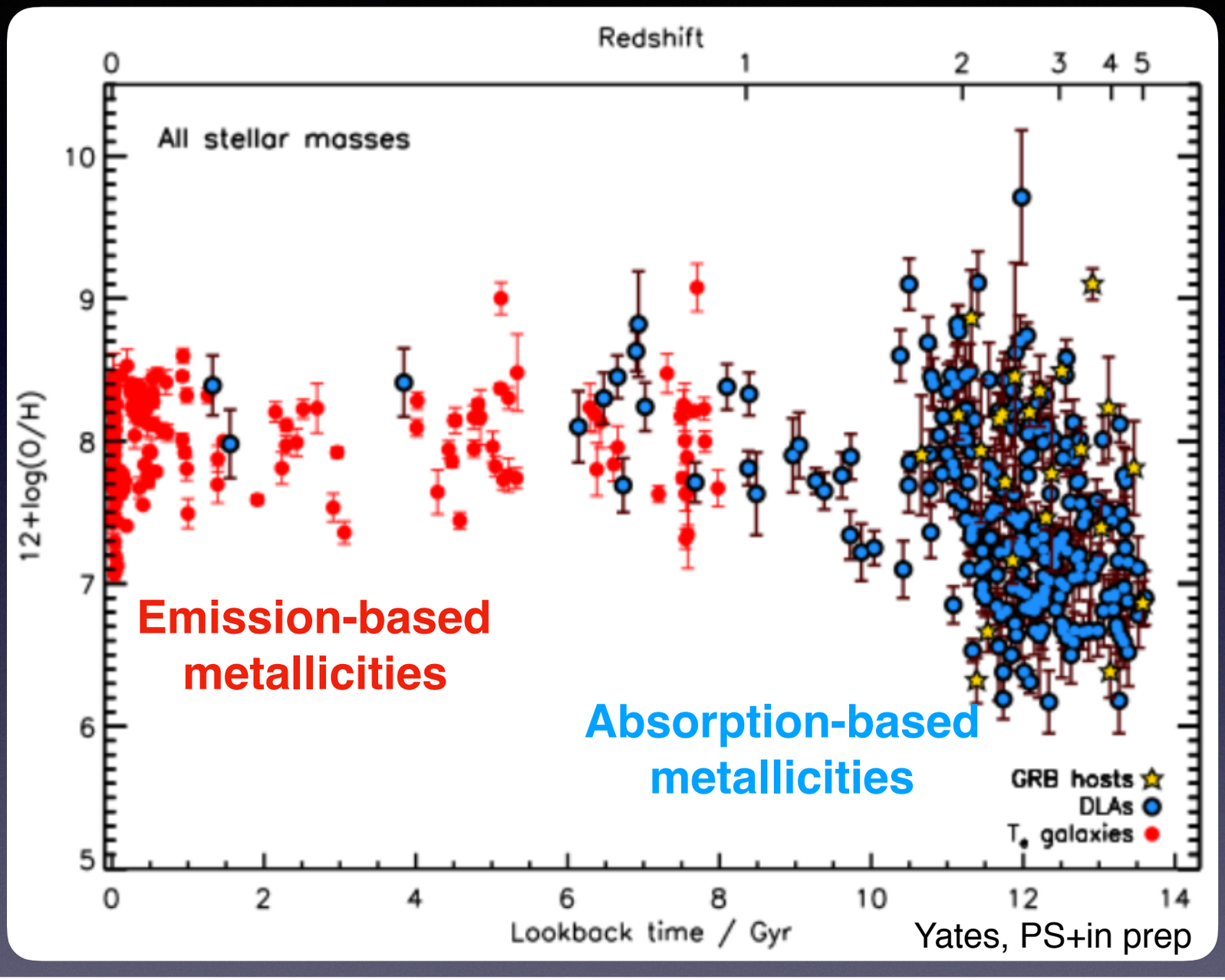
Metallicities in absorption



Rau+10

Absorption-derived metallicities are largely model-independent and sensitive down to very low metallicity values

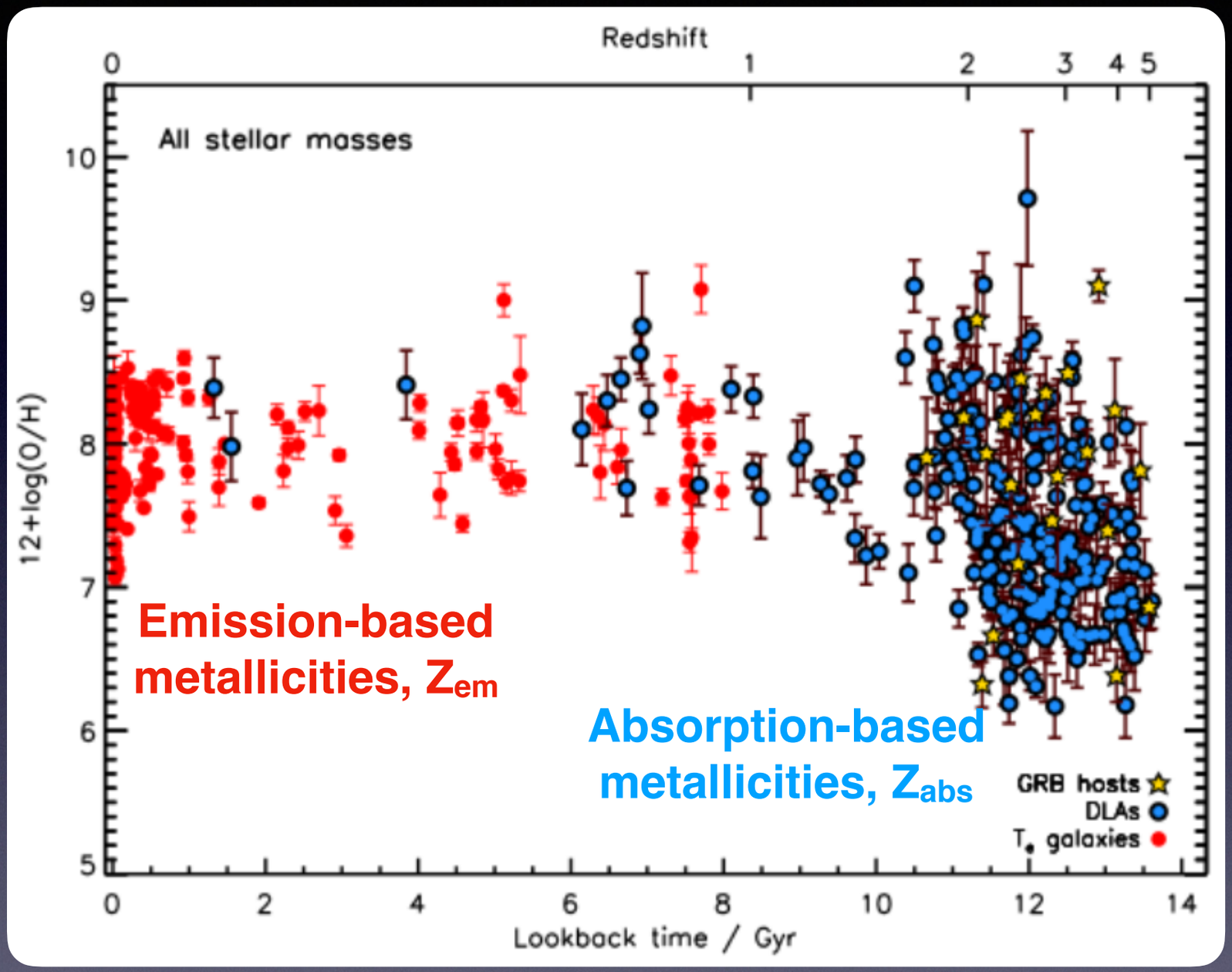
Cosmic chemical evolution



Want to….

- **measure host galaxy stellar mass and SFR**
- **cross calibrate absorption to emission-line derived metallicities**

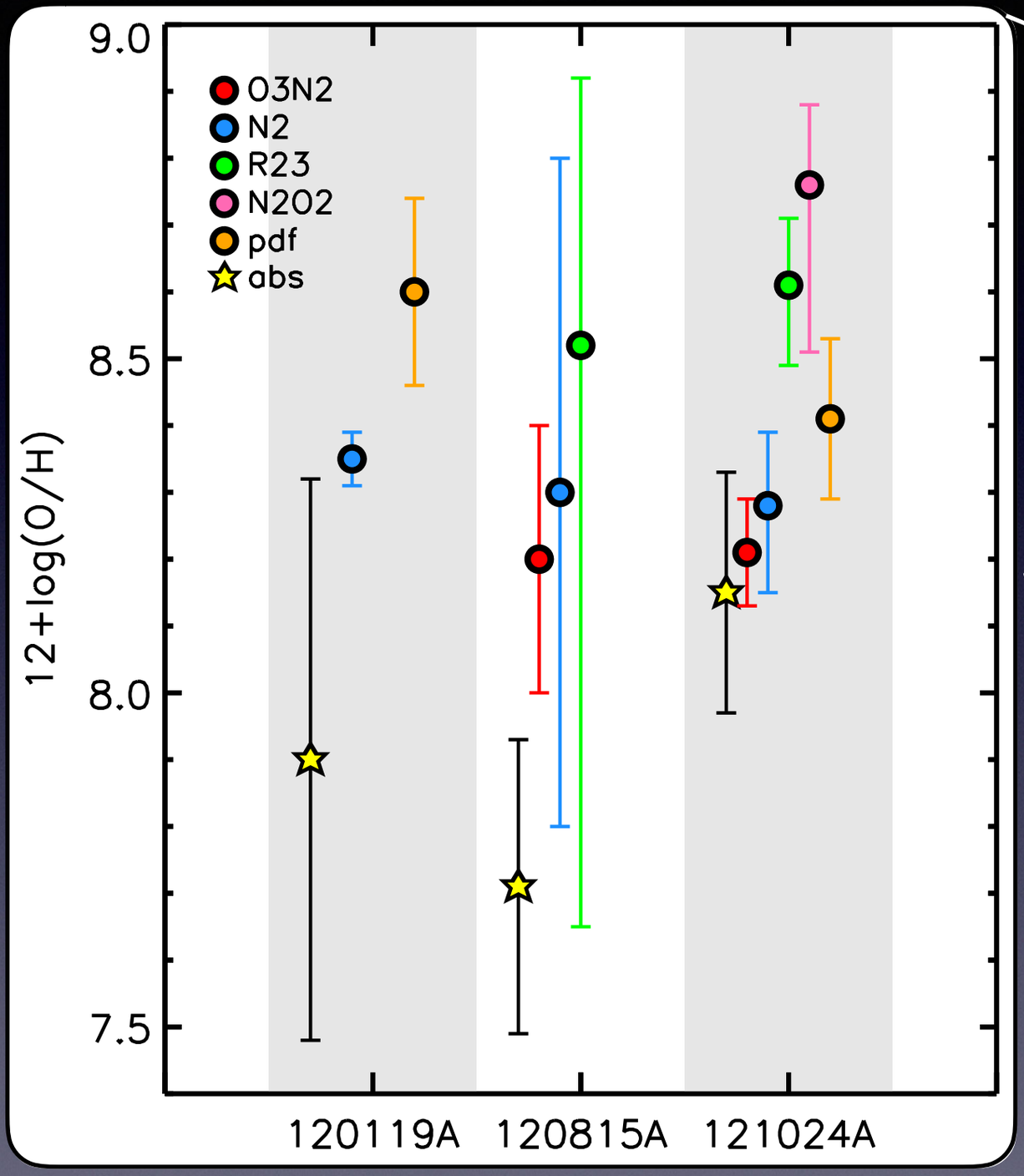
Cross-calibrate metallicity diagnostics



Z_{em}: More sensitive for more massive, chemically evolved galaxies

Z_{abs}: More sensitive for low-mass, chemically unenriched galaxies

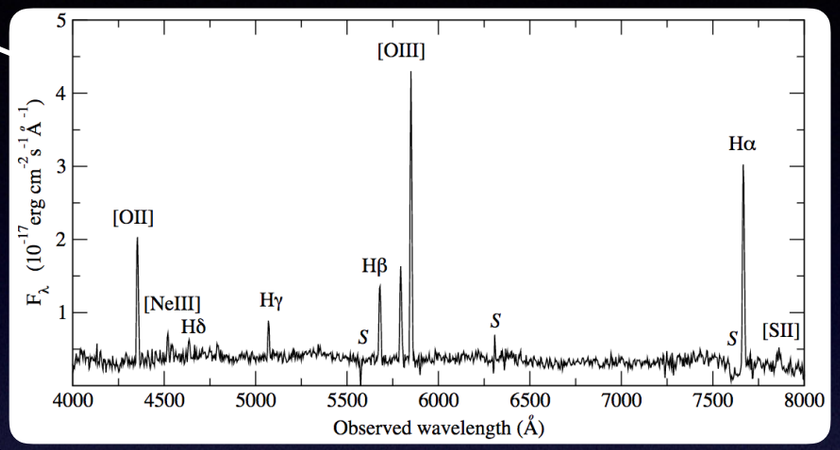
Cross-calibrate metallicity diagnostics



Yates, Schady+in prep

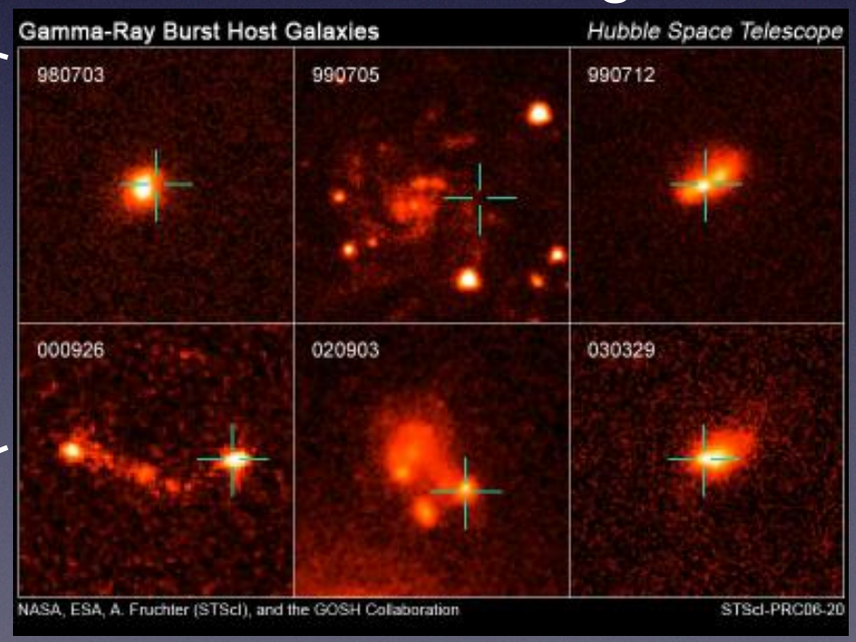
Emission-based metallicities

Highly model dependent

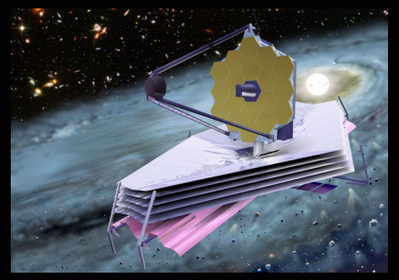


Absorption-based metallicities

Local rather than global



With JWST+GRBs can study discrepancy in metallicity diagnostics



Summary

- Long GRBs are excellent and unique probes of distant, star forming galaxies
- The imprint left on their afterglow spectra from intervening material provides a unique view of the chemical composition and conditions of the ISM in their host galaxies
- To optimise their use as probes of distant galaxies, need to investigate how properties inferred from absorption spectroscopy compare to emission-based analysis
- The future NASA JWST mission (all $9.66 of it!) promises significant headway in this area or research, and in the cosmic chemical evolution in general
- Future, sensitive infrared and X-ray missions (Theseus, ATHENA) will greatly increase high-z GRB samples