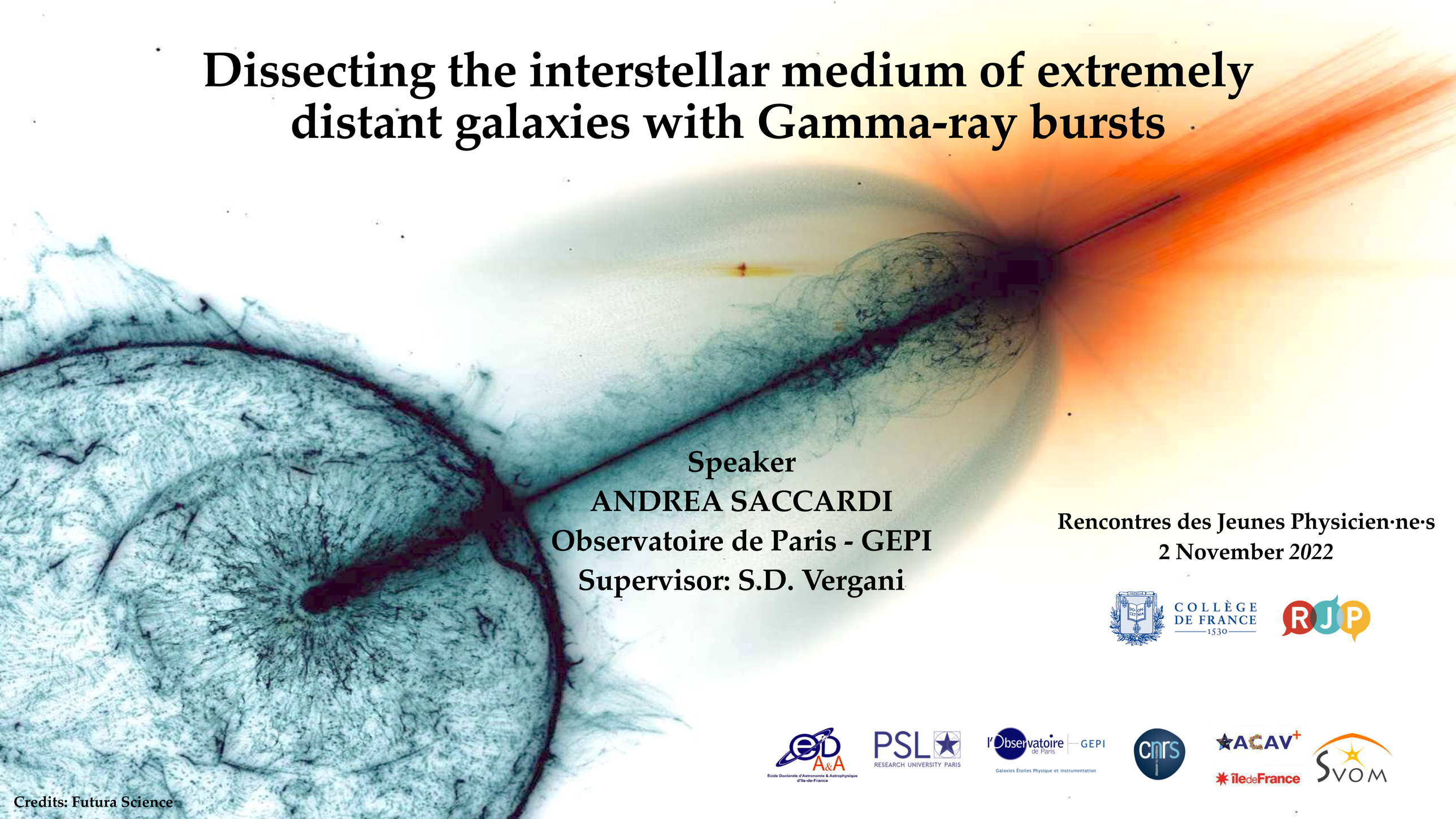
Dissecting the interstellar medium of extremely distant galaxies with Gamma-ray bursts

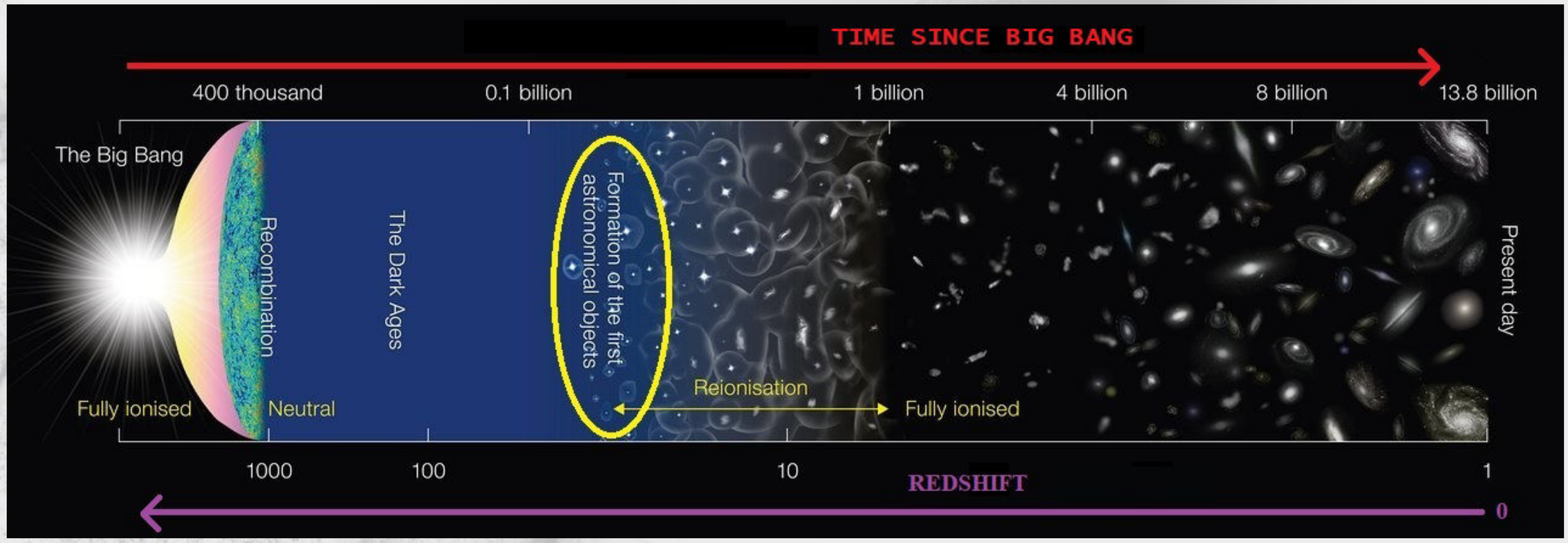


Speaker
ANDREA SACCARDI
Observatoire de Paris - GEPI
Supervisor: S.D. Vergani

Rencontres des Jeunes Physicien·ne·s
2 November *2022*

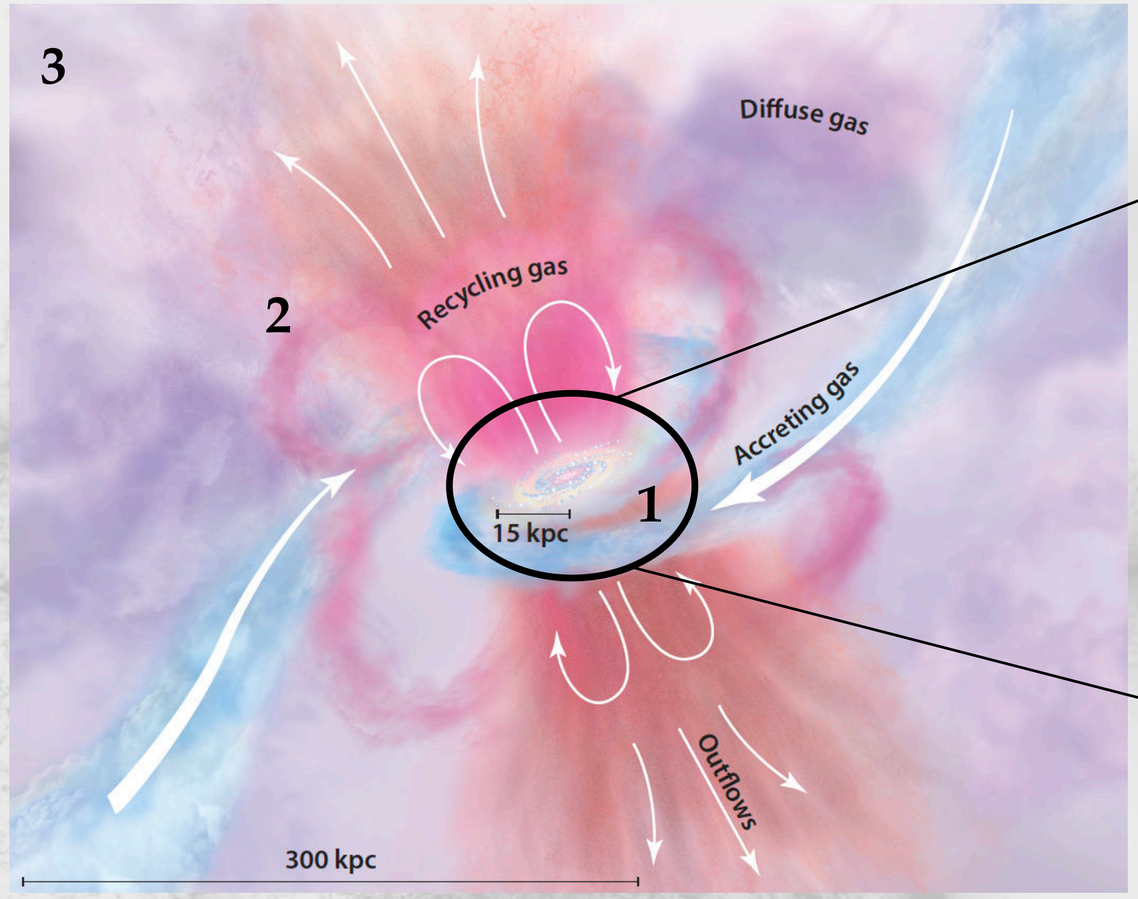
Credits: Futura Science

-What are the first objects to be formed in the Universe?
-How do galaxies form and evolve?
-What is the interplay between star formation and the inter-stellar gas?



Credits: ESO

THE CONSTITUENTS OF A GALAXY



Credits: Tumlinson et al. 2017

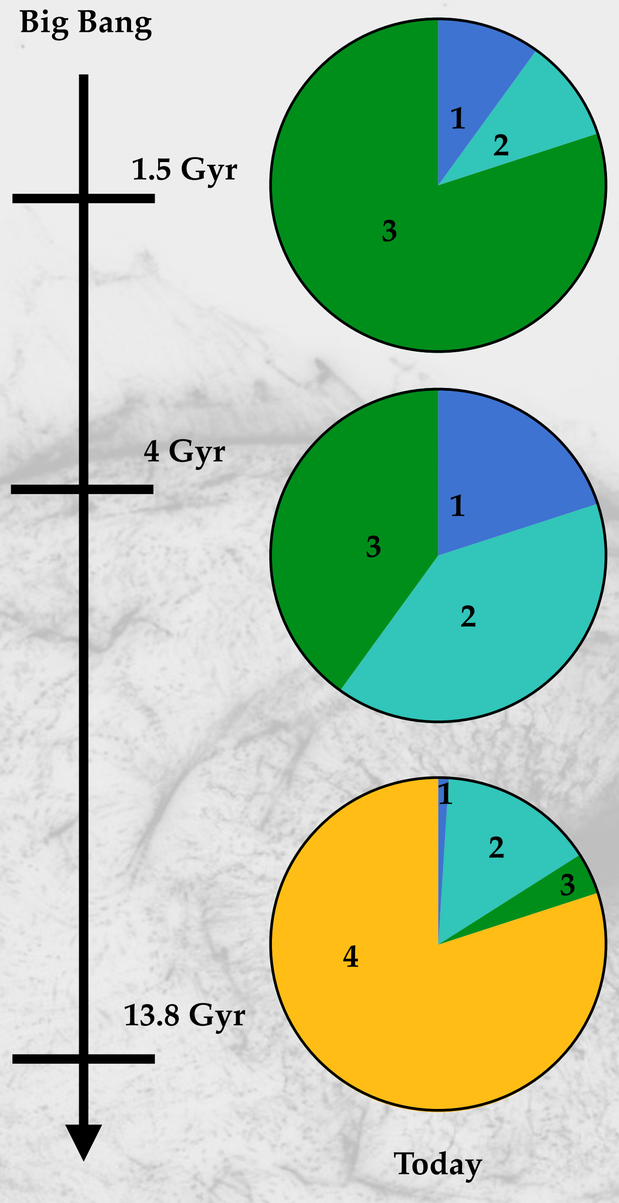
Credits: NASA

-Stars
-Neutral Gas
-Ionized Gas
-Dust

1. Inter-stellar medium (ISM)
2. Circum-galactic medium (CGM)
3. Inter-galactic medium (IGM)

Stellar explosions contaminate the surrounding medium, composed by gas and dust, with heavy elements called "Metals"

NEUTRAL GAS: INVISIBLE



1. Molecular Gas+Dust
2. Stars
3. Atomic Gas
4. Ionized gas

In the early Universe most of the gas in galaxies is in the neutral phase

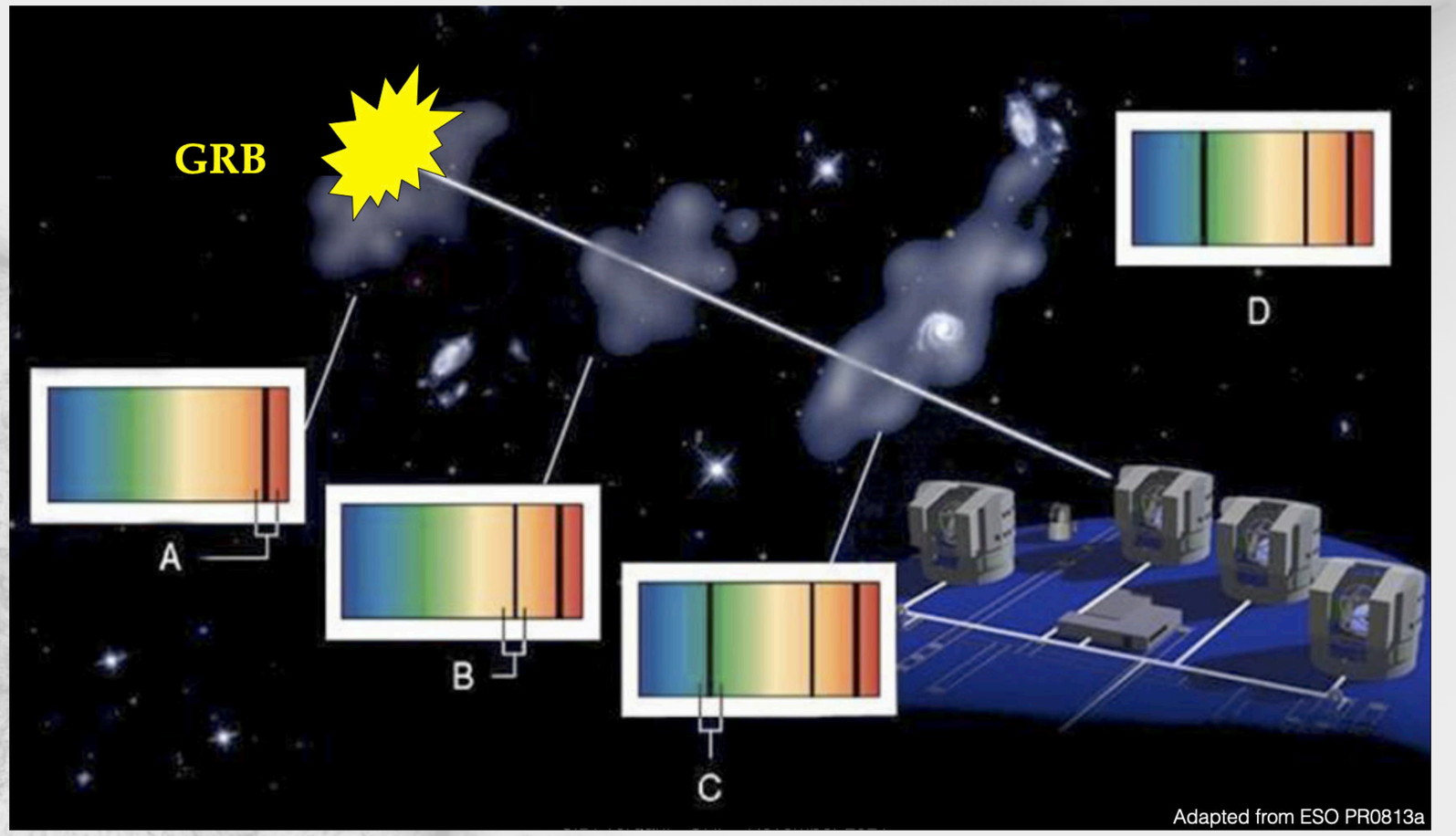
The neutral gas doesn't emit light so it's hard to see…

↓

Background Source

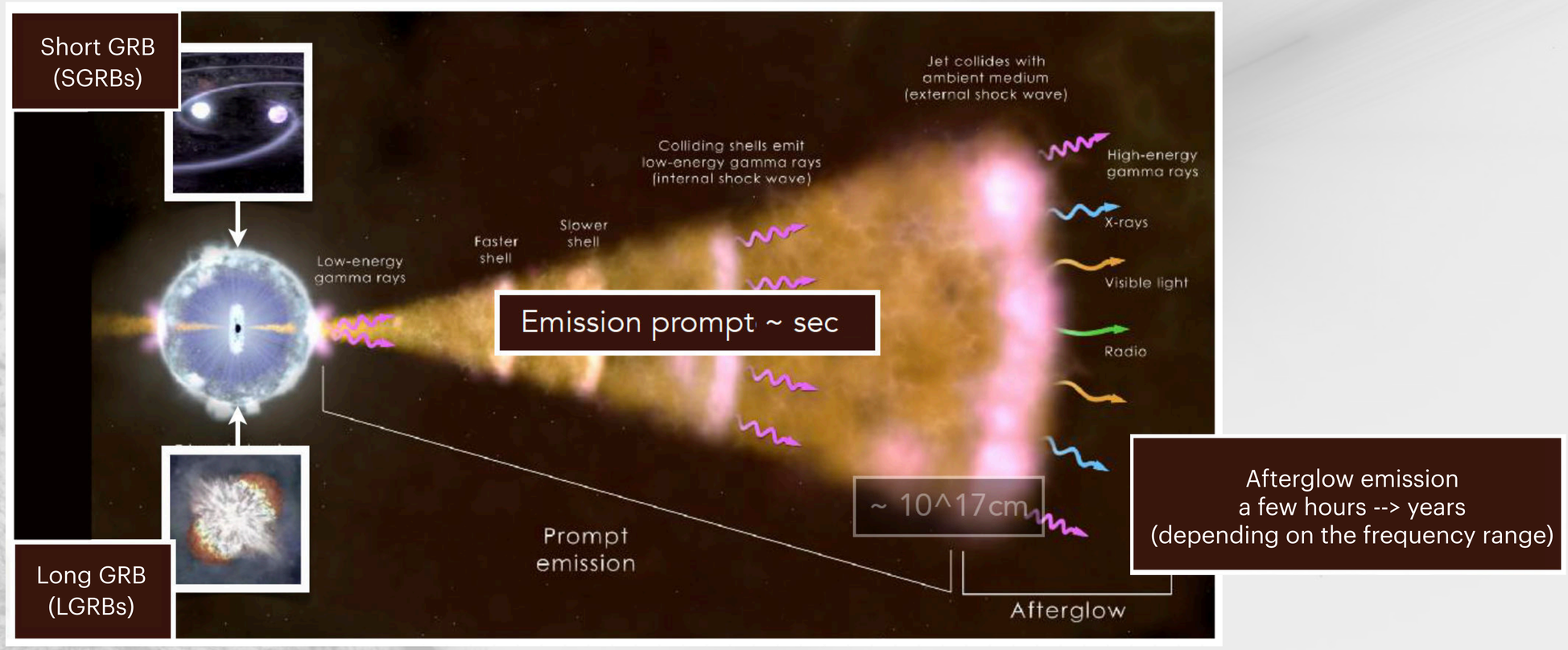
If a bright source shines through the gas, it will absorb the light at different frequencies depending on the atoms composing the gas

GRBs are unique powerful background sources to probe first galaxies



Credits: ESO

Ultra-Relativistic Jet produced by a new-born accreting black hole



SGRBs are linked with the merging of two compact objects.

LGRBs are associated with the collapse of massive stars

THE GRB OBSERVATION

Satellite Alert

Fermi

Swift

Telescope Trigger

Minutes - Hours

Ground based Telescopes

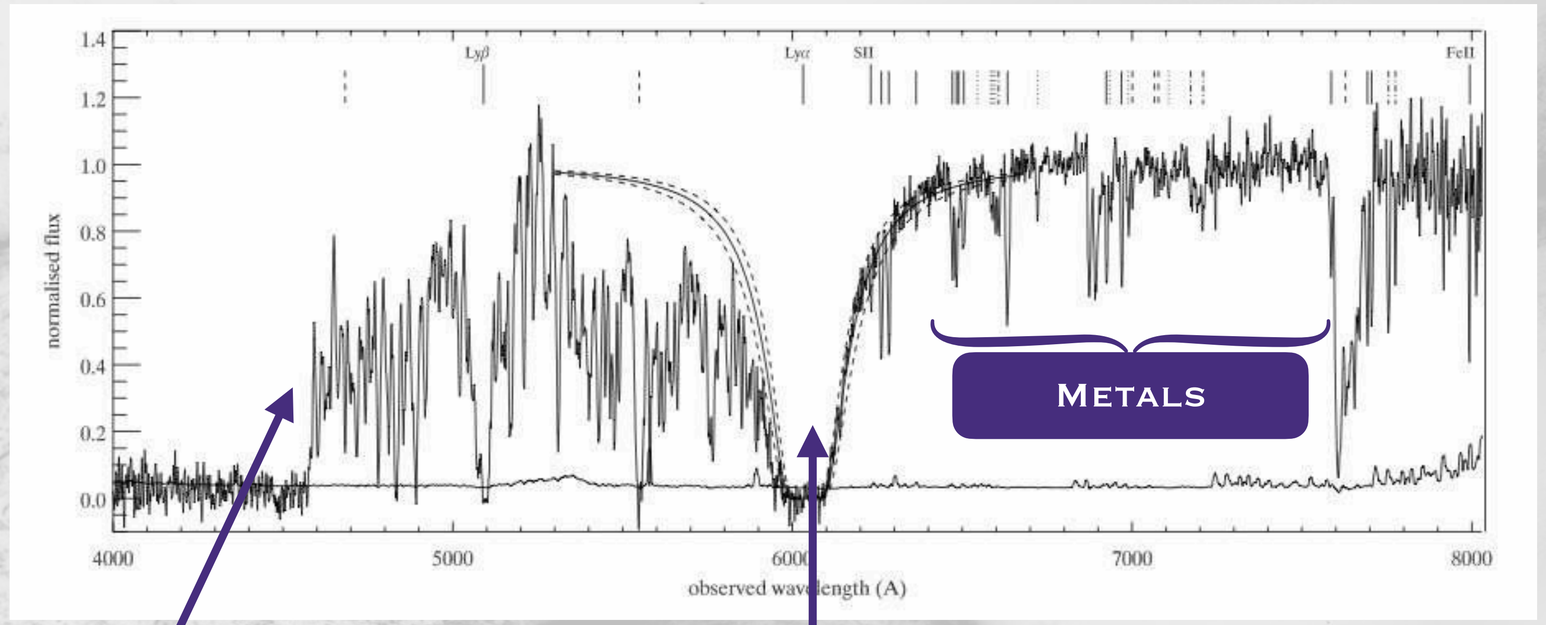
Spectroscopy

Photometry

AN EXAMPLE OF A GRB OPTICAL SPECTRUM

LYMAN ALPHA FOREST
INTERGALACTIC MEDIUM (IGM)

GRB 050730 z=3.968



METALS

LYMAN LIMIT

HI (LYMAN ALPHA)
NEUTRAL HYDROGEN

R. L. C. Starling+2005

From the analysis of the absorption lines we can measure:

- ***Redshift of the absorbers***
- ***Column densities of the ions of different chemical elements (neutral hydrogen N_{HI} and Metals N_X)***

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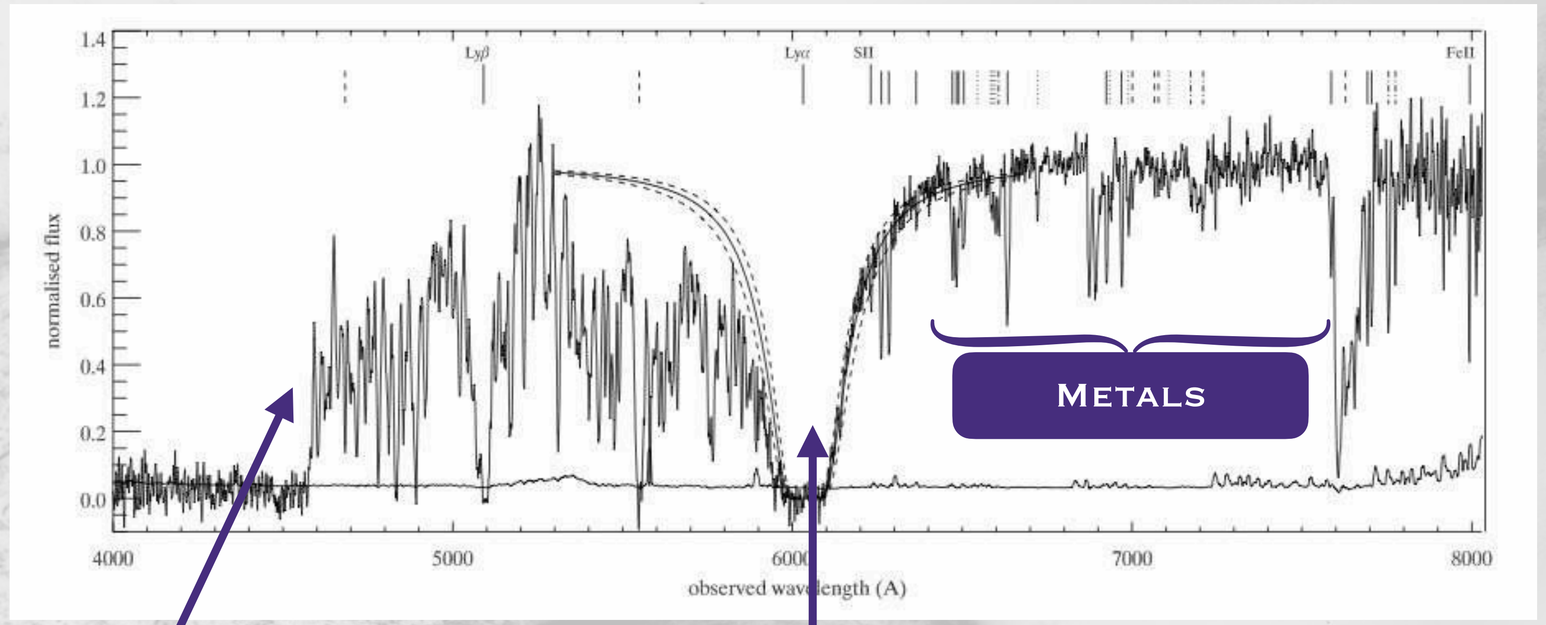

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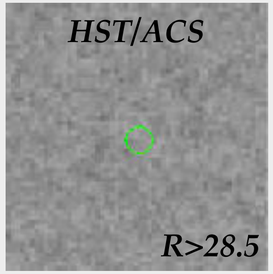
Tool to select and study in detail faint star-forming galaxies

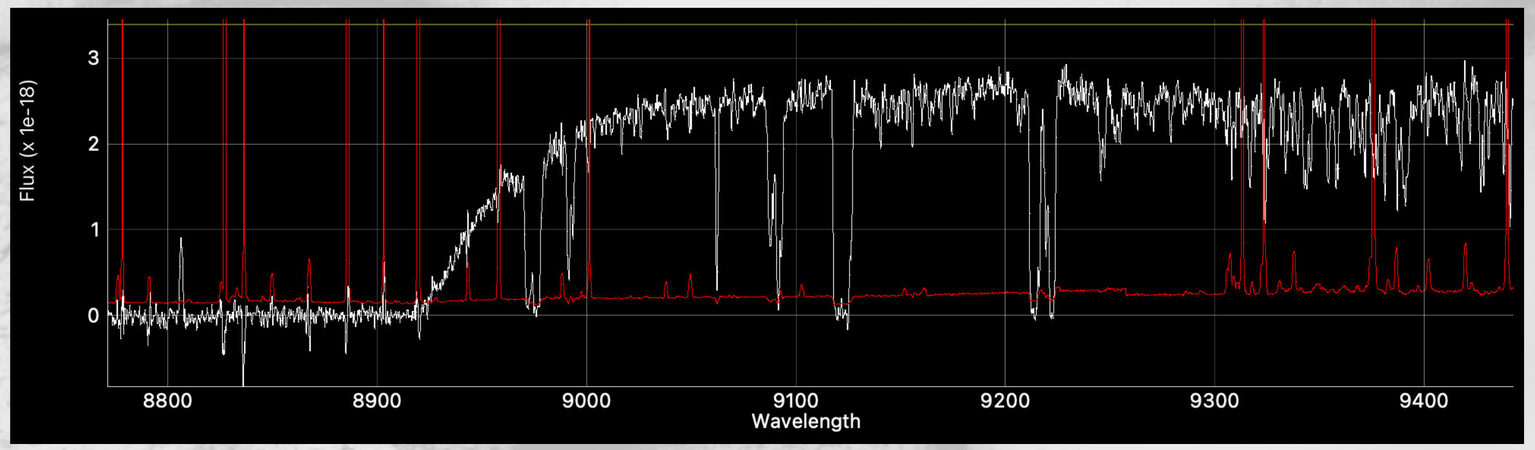


Chen+2005

OBSERVATIONS

European Southern Observatory (ESO) Very Large Telescope (VLT)/X-shooter Spectrum

After ~2.53h (obs frame) from the GRB trigger

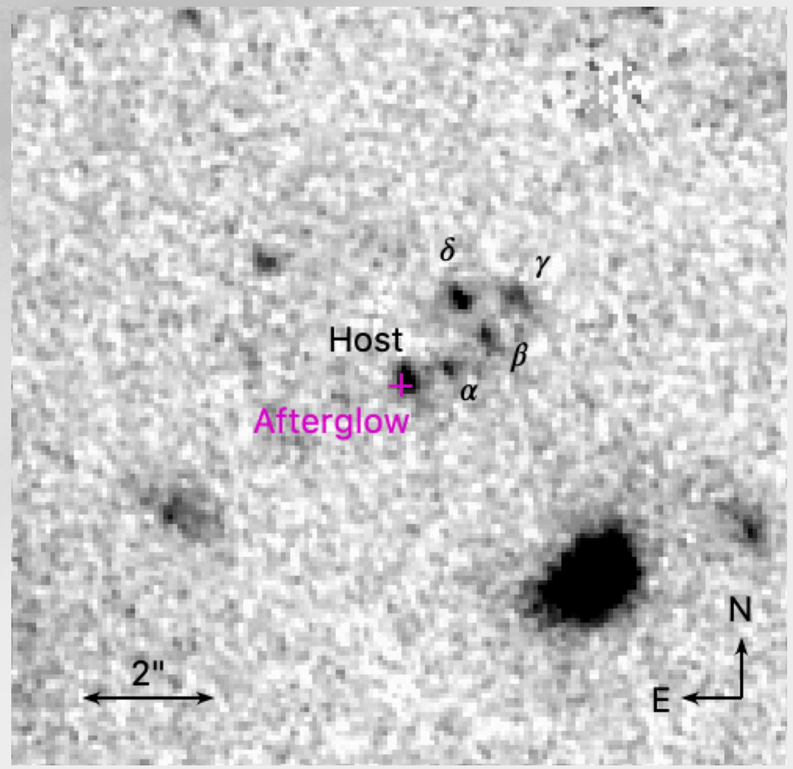


A. Saccardi, S.D. Vergani, A. De Cia et al. submitted

GRB 210905A
Redshift z=6.312
t=0.875 Gyr

Hubble Space Telescope (HST)/WFC3 Image

After ~250 days (obs frame) from the GRB trigger



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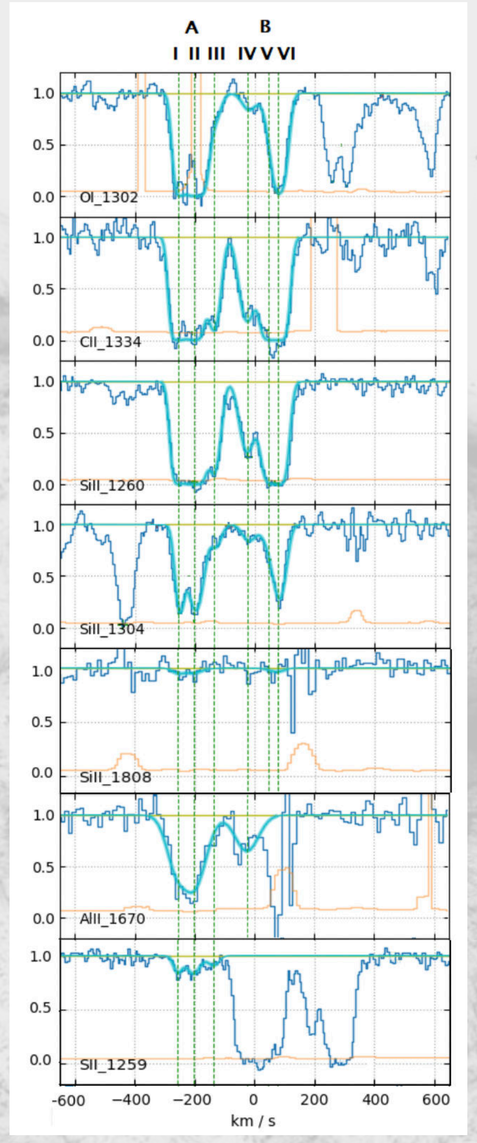
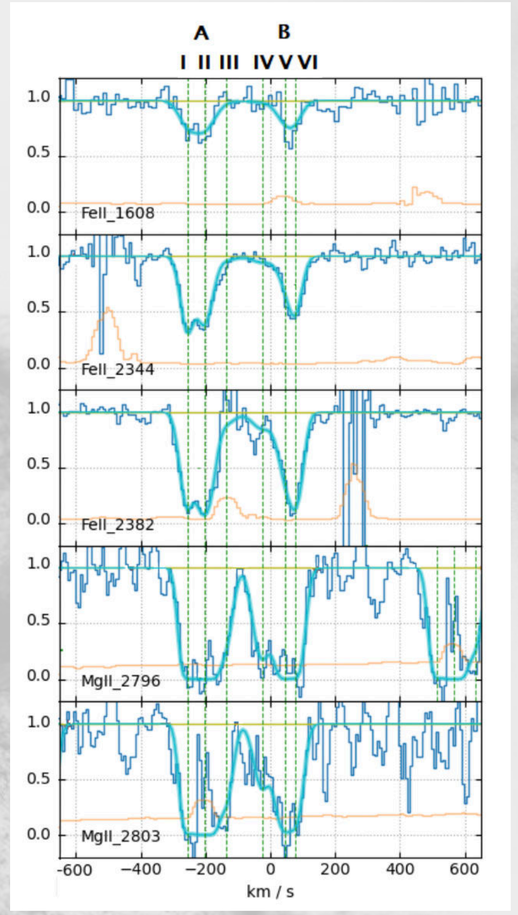
ANALYSIS



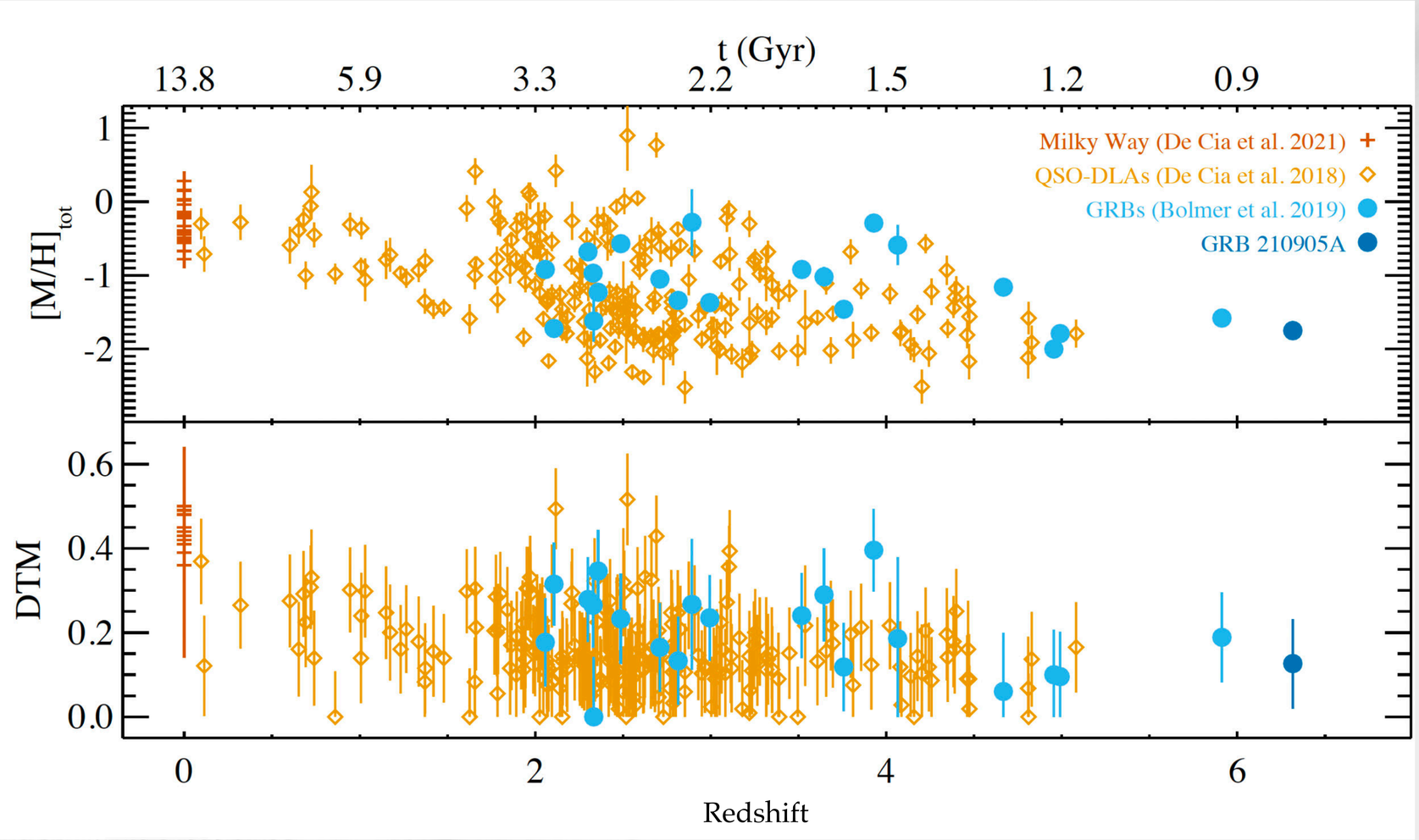


A. Saccardi, S.D. Vergani, A. De Cia et al. submitted

From the absorption properties:

- ***Metallicity and dust depletion***
- ***The distance of the gas clouds***
- ***Kinematic of the gas***
- ***Chemical composition***

RESULTS



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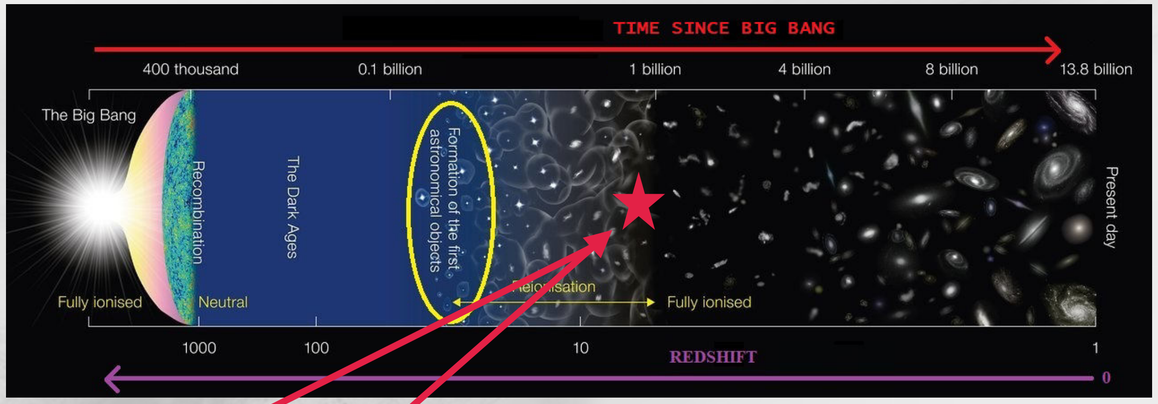
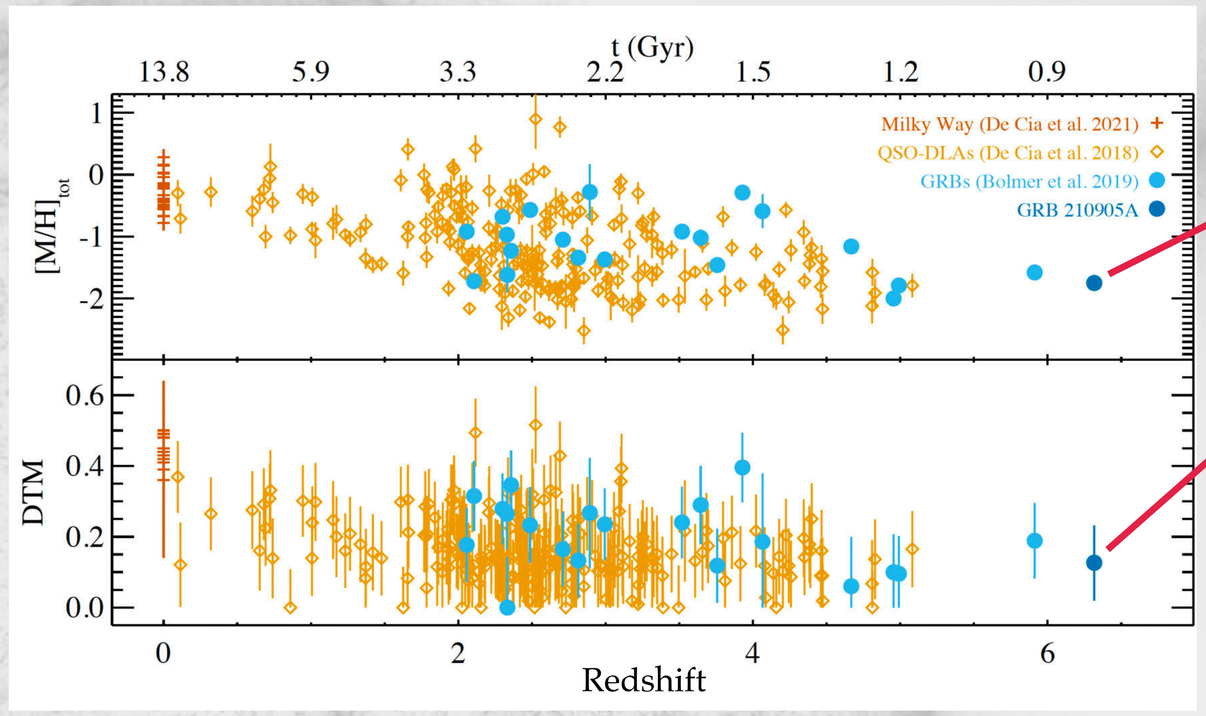
RESULTS



Credits: ESO



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Redshift z=6.312
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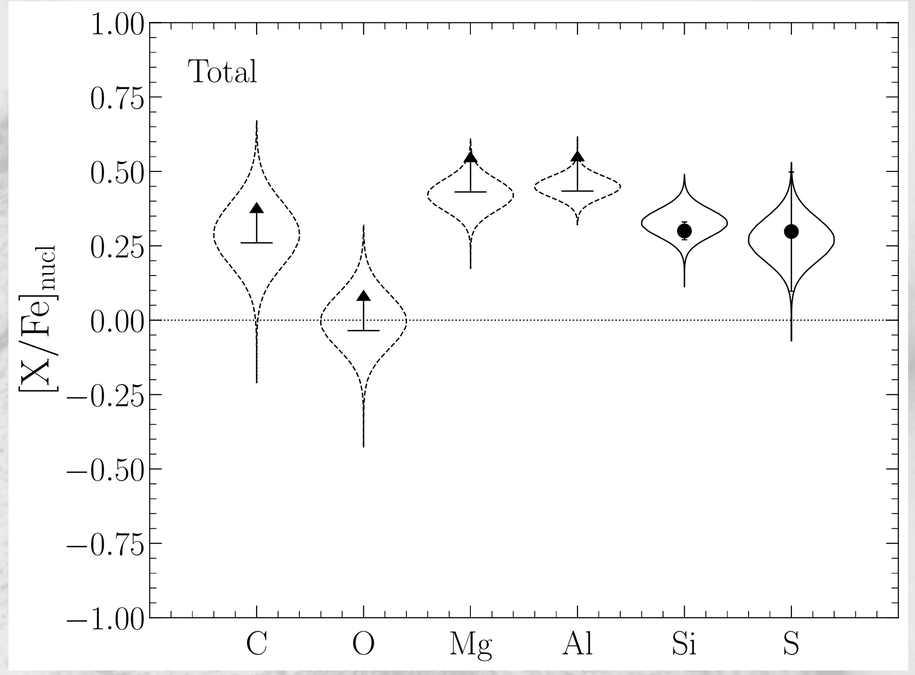
RESULTS

The overall host galaxy



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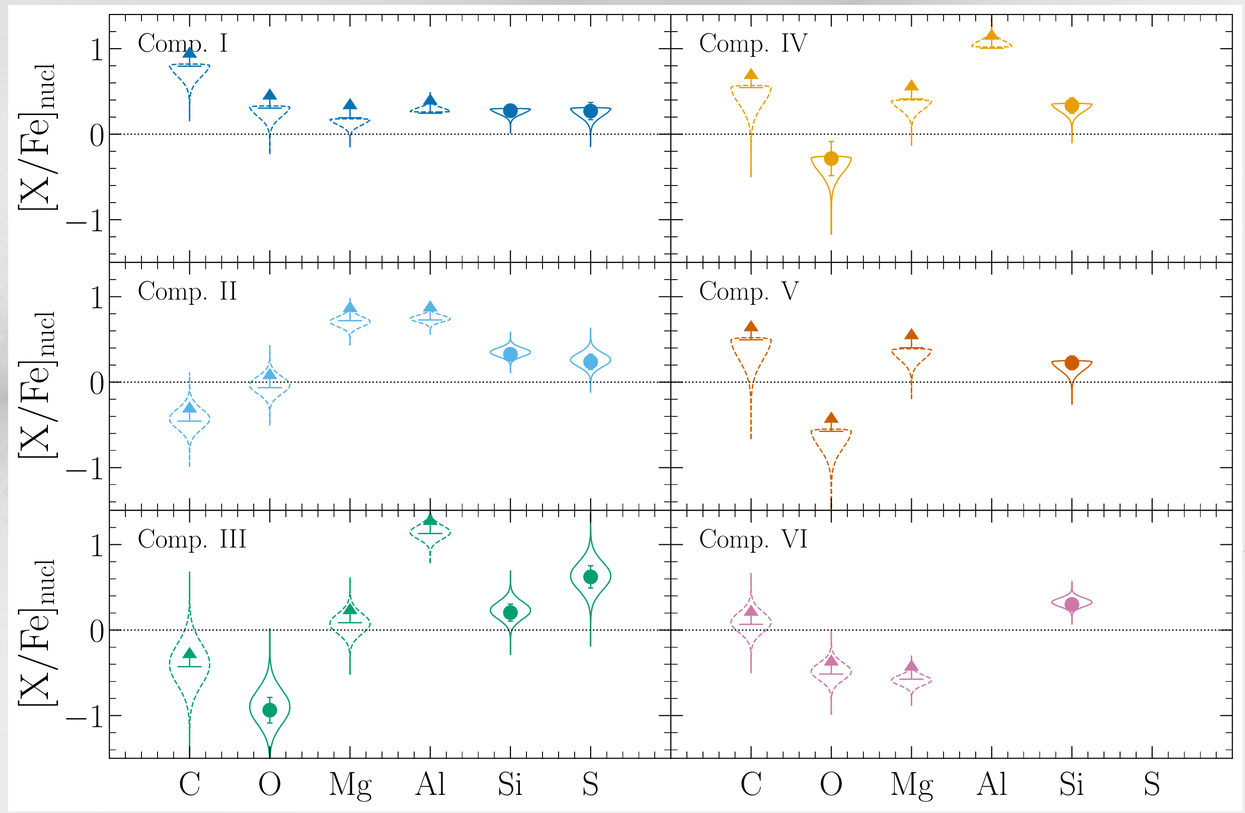
Component-by-component



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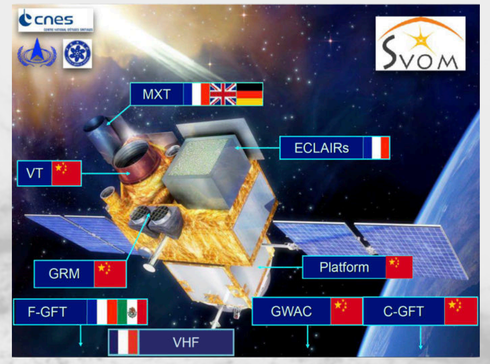
FUTURE OBSERVING FACILITIES

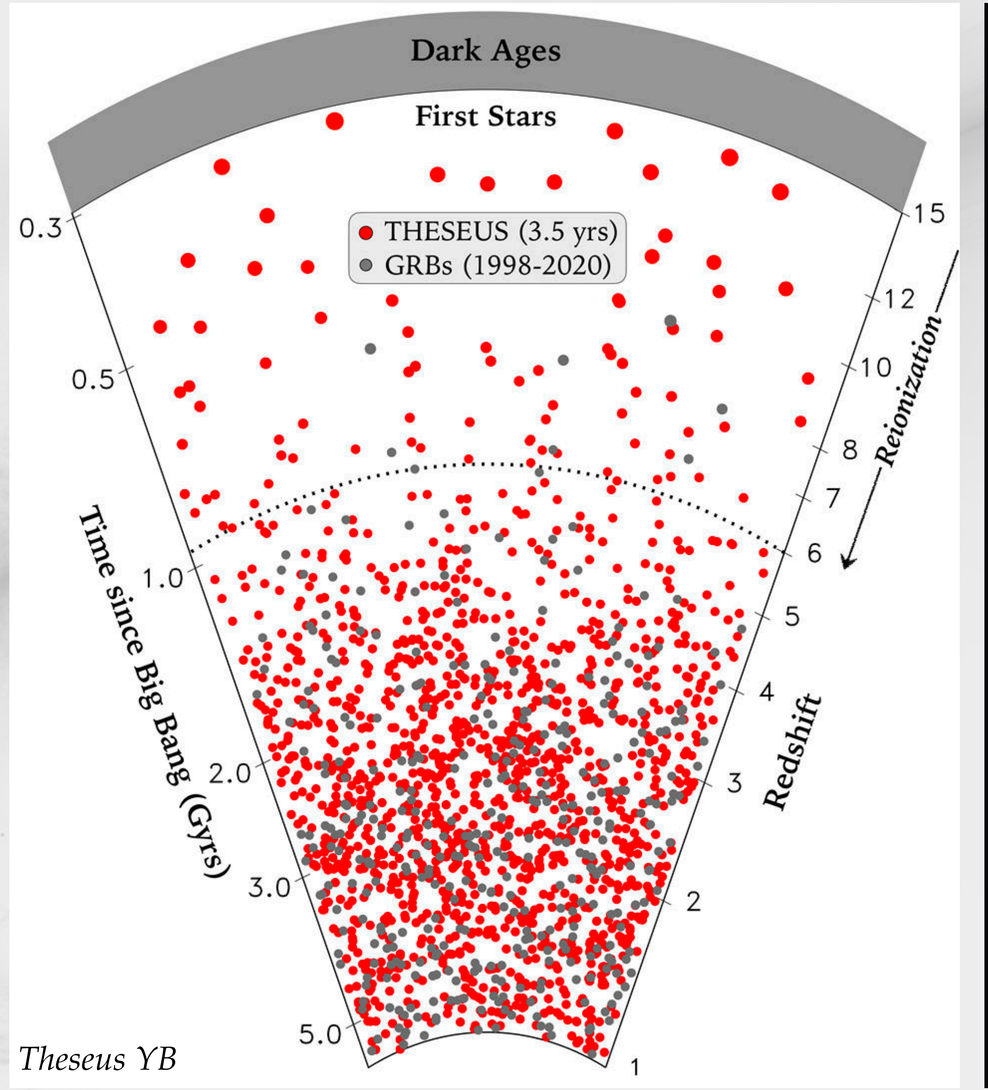
SVOM

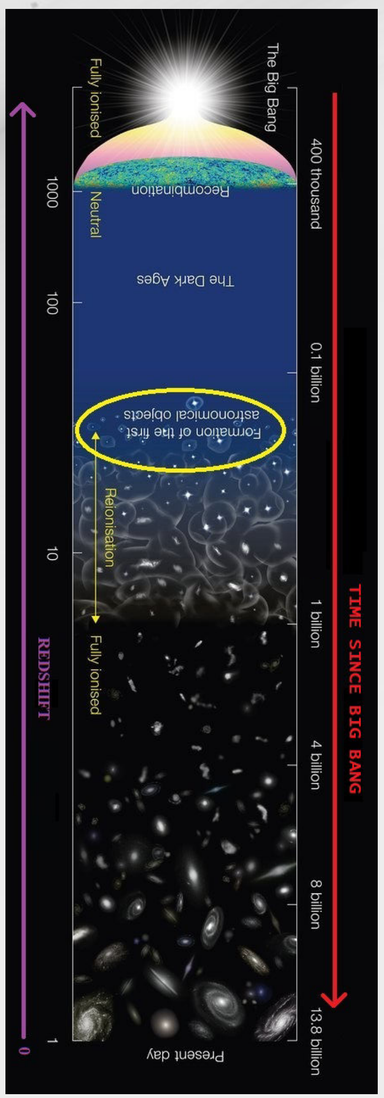


https://www.svom.eu/

THESEUS

http://www.isdc.unige.ch/theseus





Credits: ESO

-The formation and evolution of galaxies are key for the current extragalactic astrophysics

-Neutral gas dominates galaxies in the early Universe

-Bright background sources are needed to study the neutral gas

-GRBs are very powerful tools for this kind of studies

-Thanks to GRB 210905A we were able to obtain unique and detailed information of the neutral gas and its chemical composition for a galaxy when the Universe was t~0.9 Gyr

-The future is bright especially in France thanks to SVOM and we hope THESEUS

THANKS FOR YOUR ATTENTION

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