SYNTHETIC OBSERVATIONS OF THE HIGH-REDSHIFT UNIVERSE

KIRK BARROW

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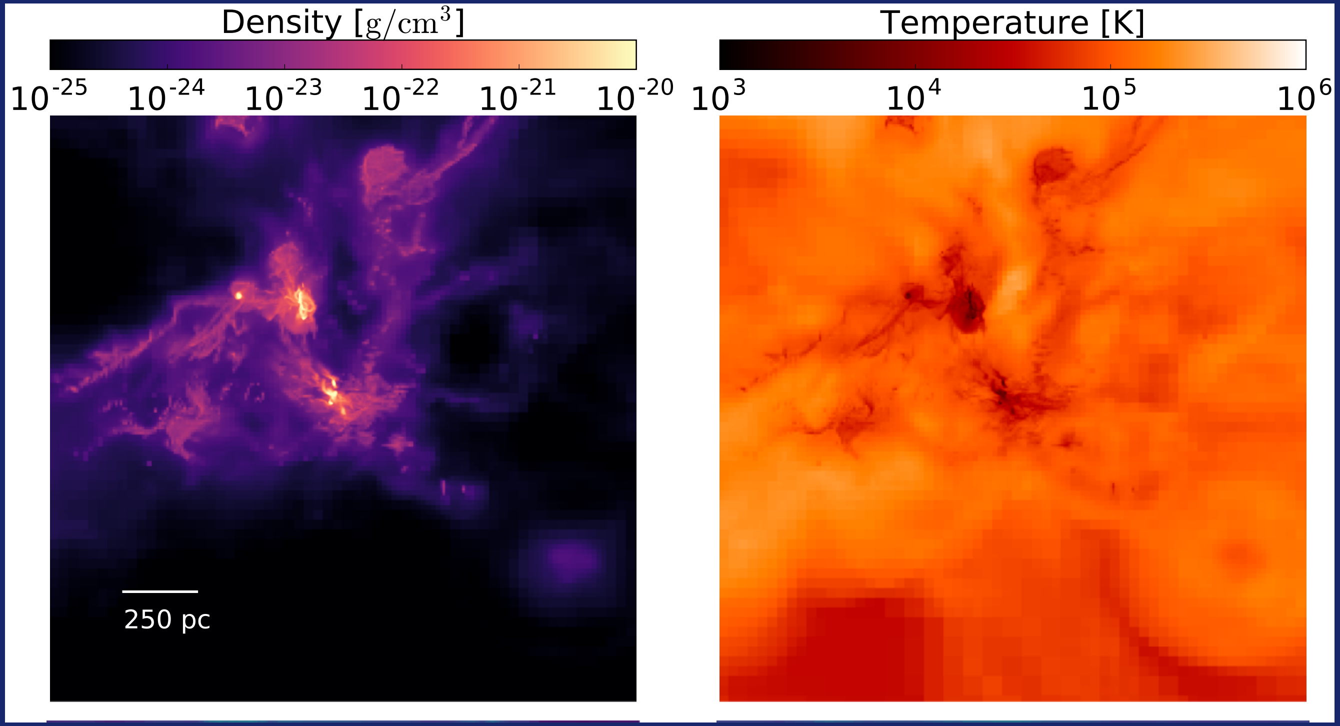
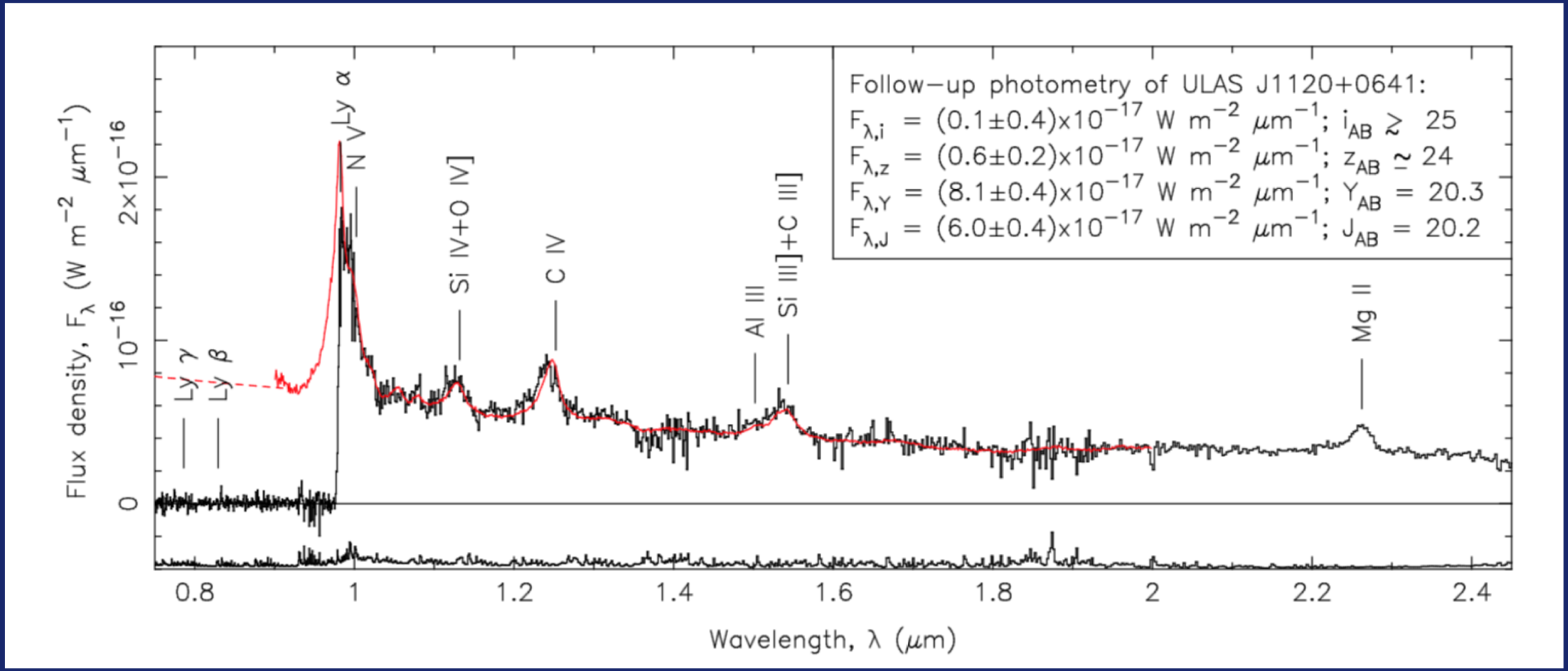
DECEMBER 6, 2018

BARROW ET AL. 2017,BARROW ET AL. 2018A,BARROW ET AL. 2018B

DIRECT-COLLAPSE BLACK HOLES?



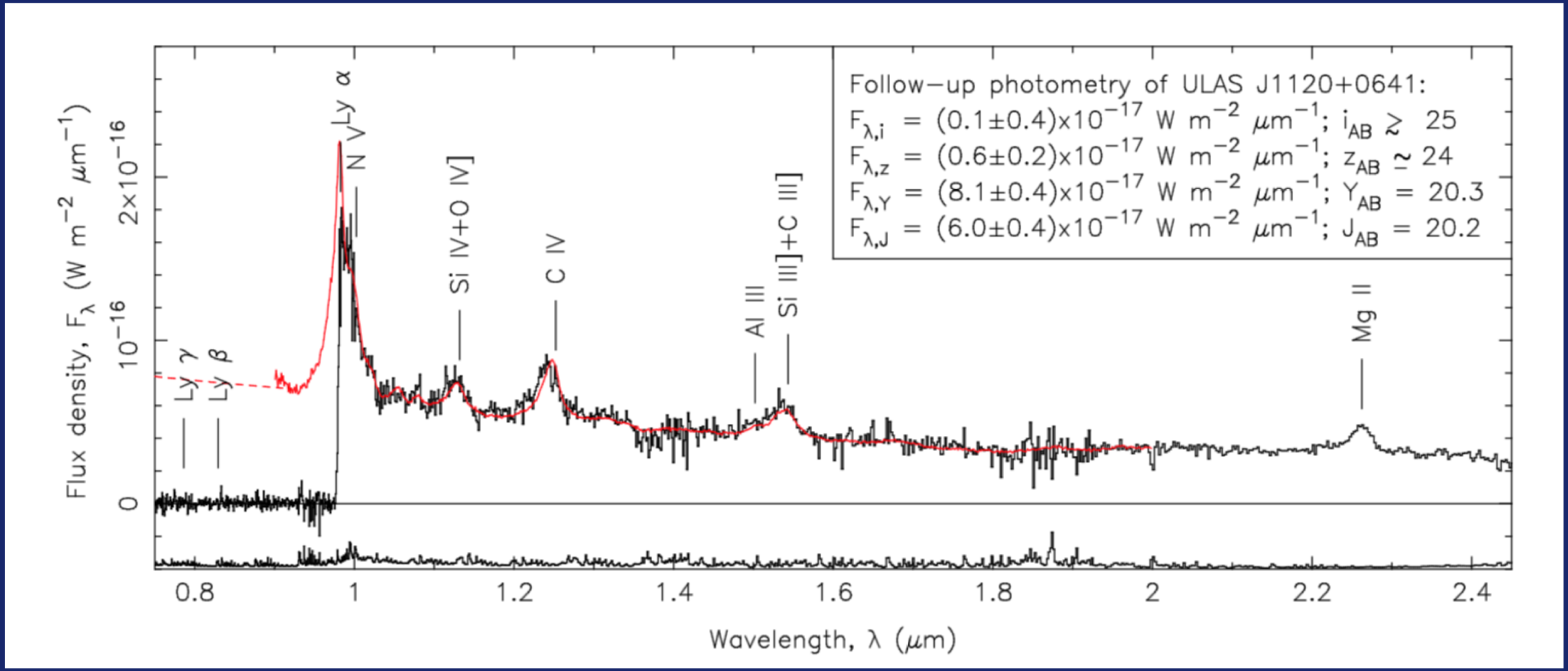
DIRECT-COLLAPSE BLACK HOLES



- $z=7.085$
- $M_{bh} = 2 \times 10^9 M_\odot$

Mortlock et al. 2011

DIRECT-COLLAPSE BLACK HOLES

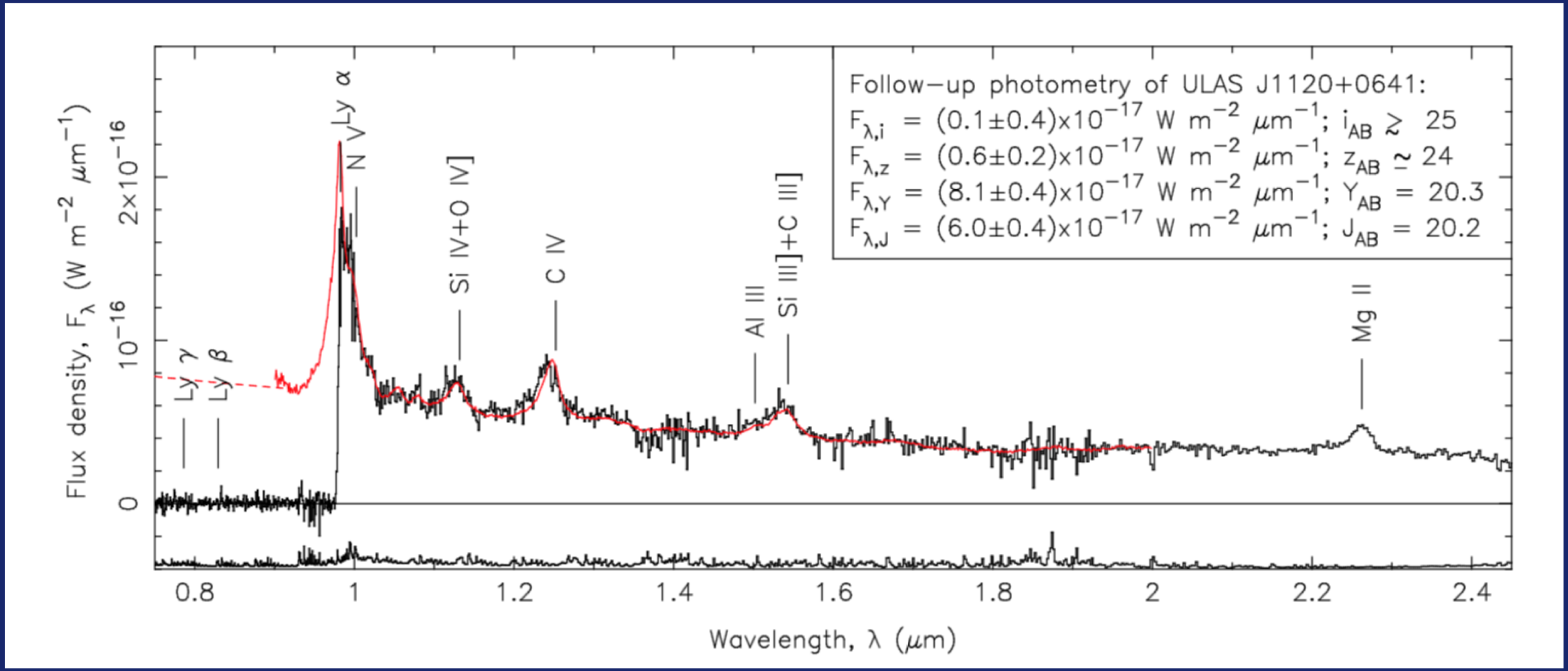


Mortlock et al. 2011

- z=7.085
- $M_{bh} = 2 \times 10^9 M_{\odot}$

$Mdot_{edd}$ -> +3.815 orders of magnitude

DIRECT-COLLAPSE BLACK HOLES

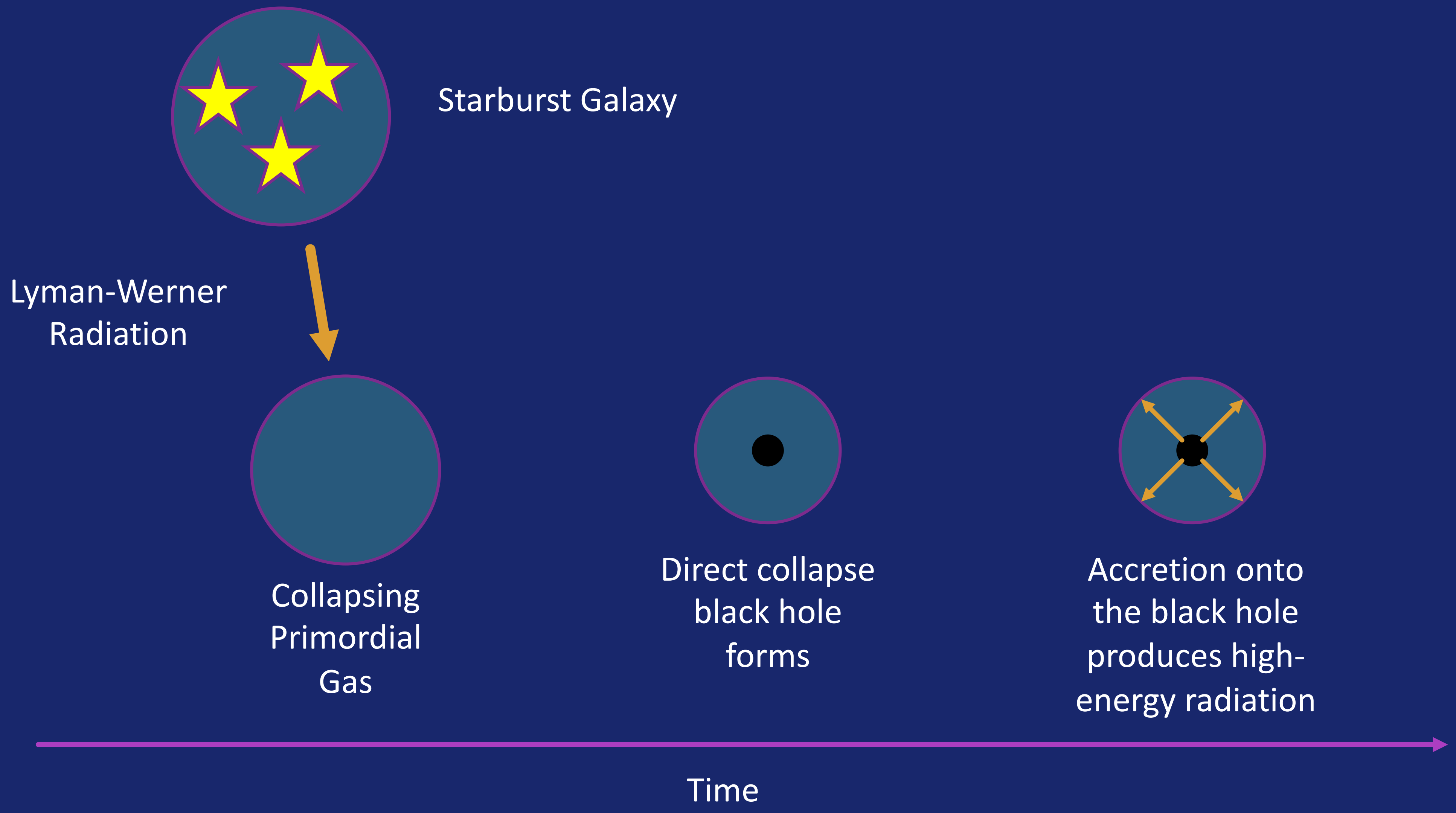


Mortlock et al. 2011

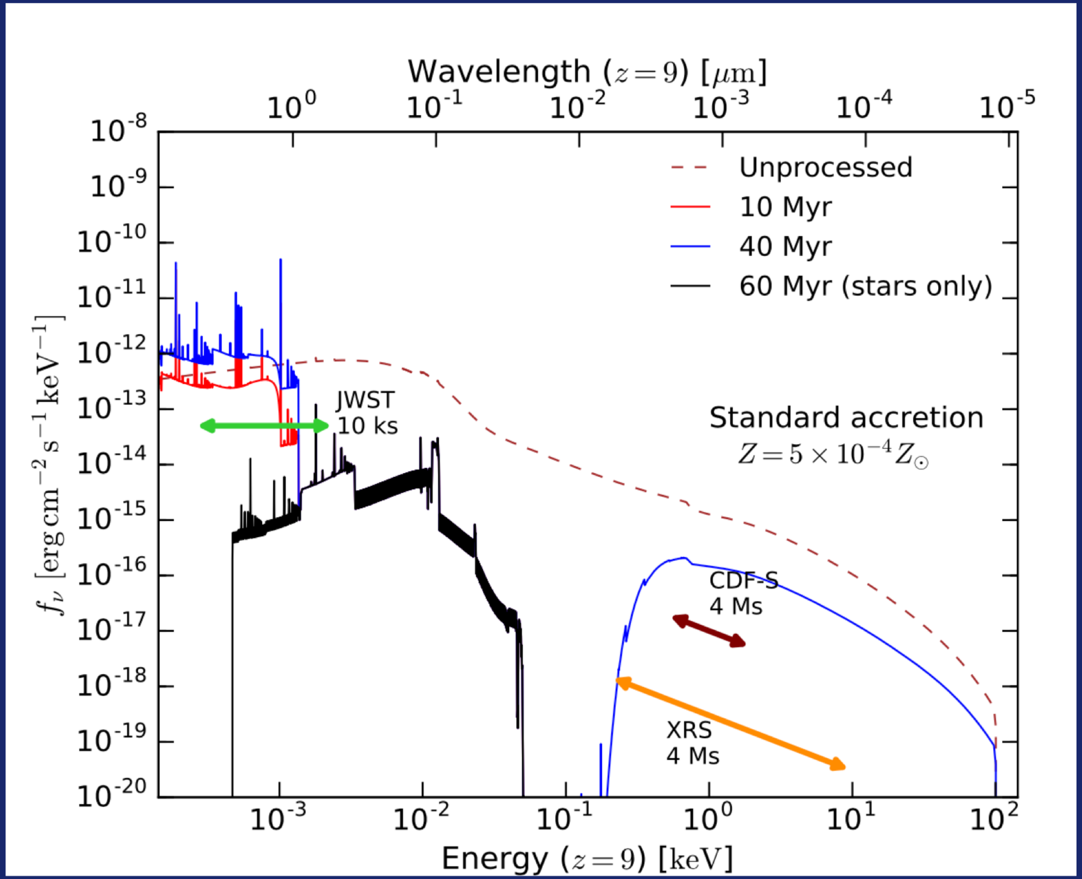
- $z=7.085$
- $M_{bh} = 2 \times 10^9 M_{\odot}$
- $L_{bh} = 6.3 \times 10^{13} L_{\odot}$
- $1.4 L_{Edd}$

1.4 $Mdot_{edd}$ -> +5.486 orders of magnitude

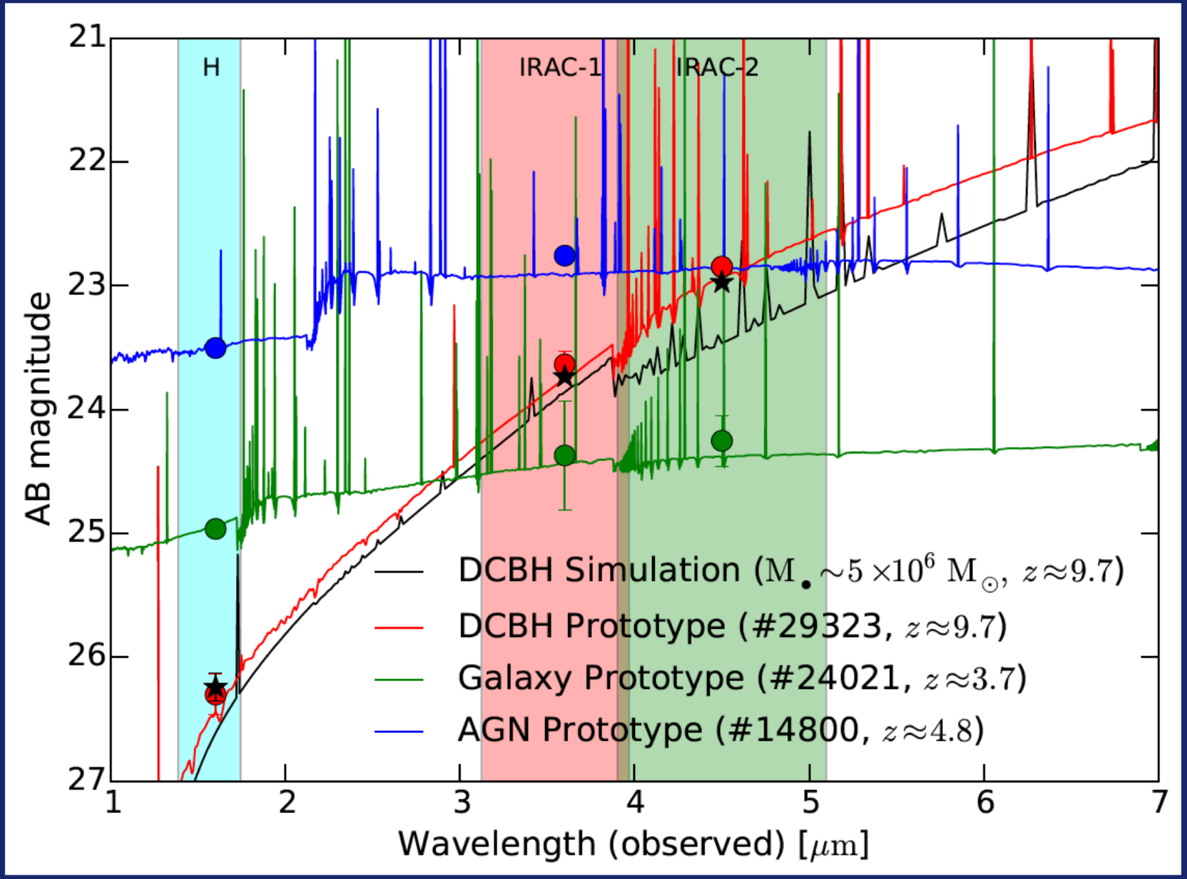
PHYSICAL SCENARIO



LITERATURE

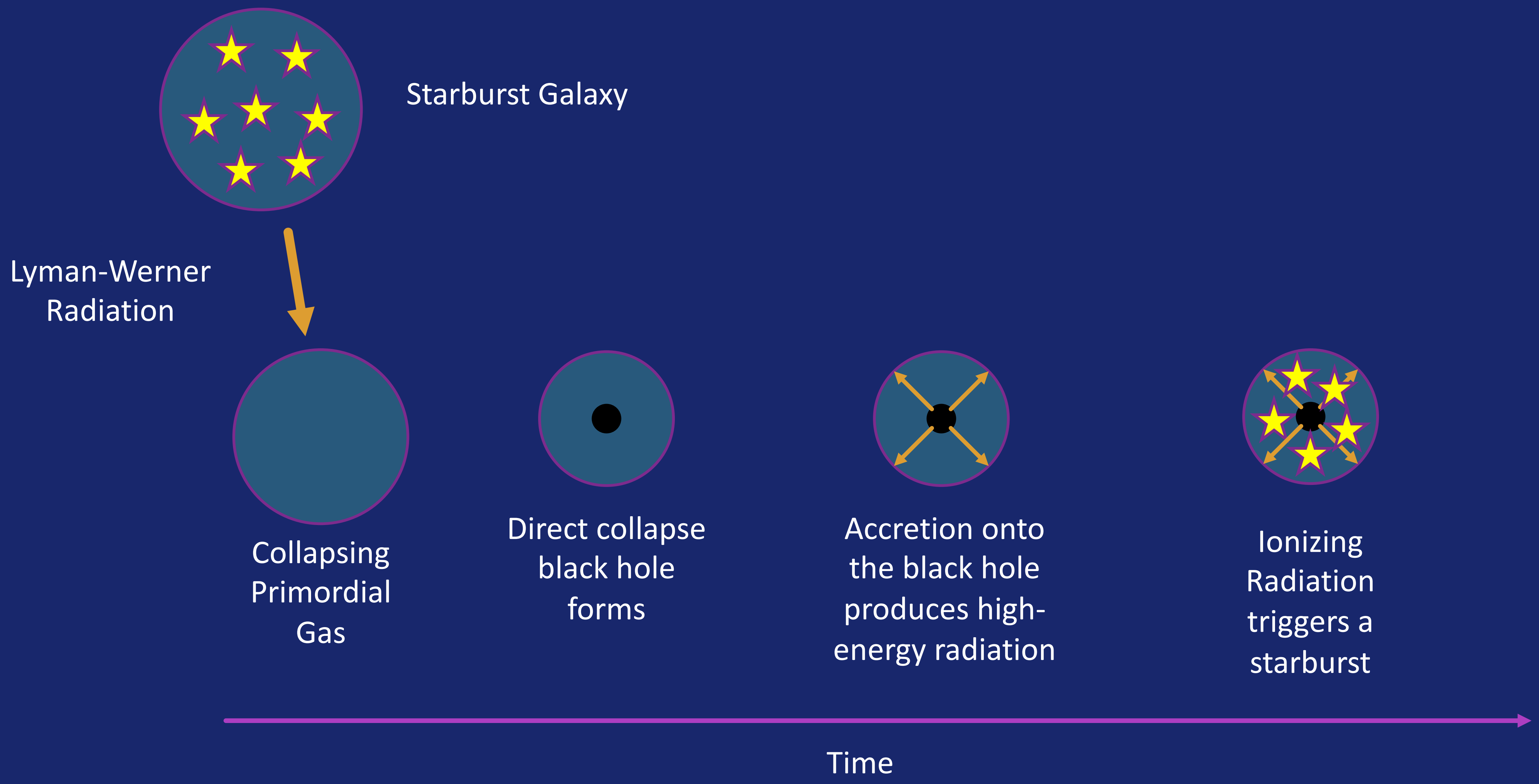


Natarajan et al. 2017

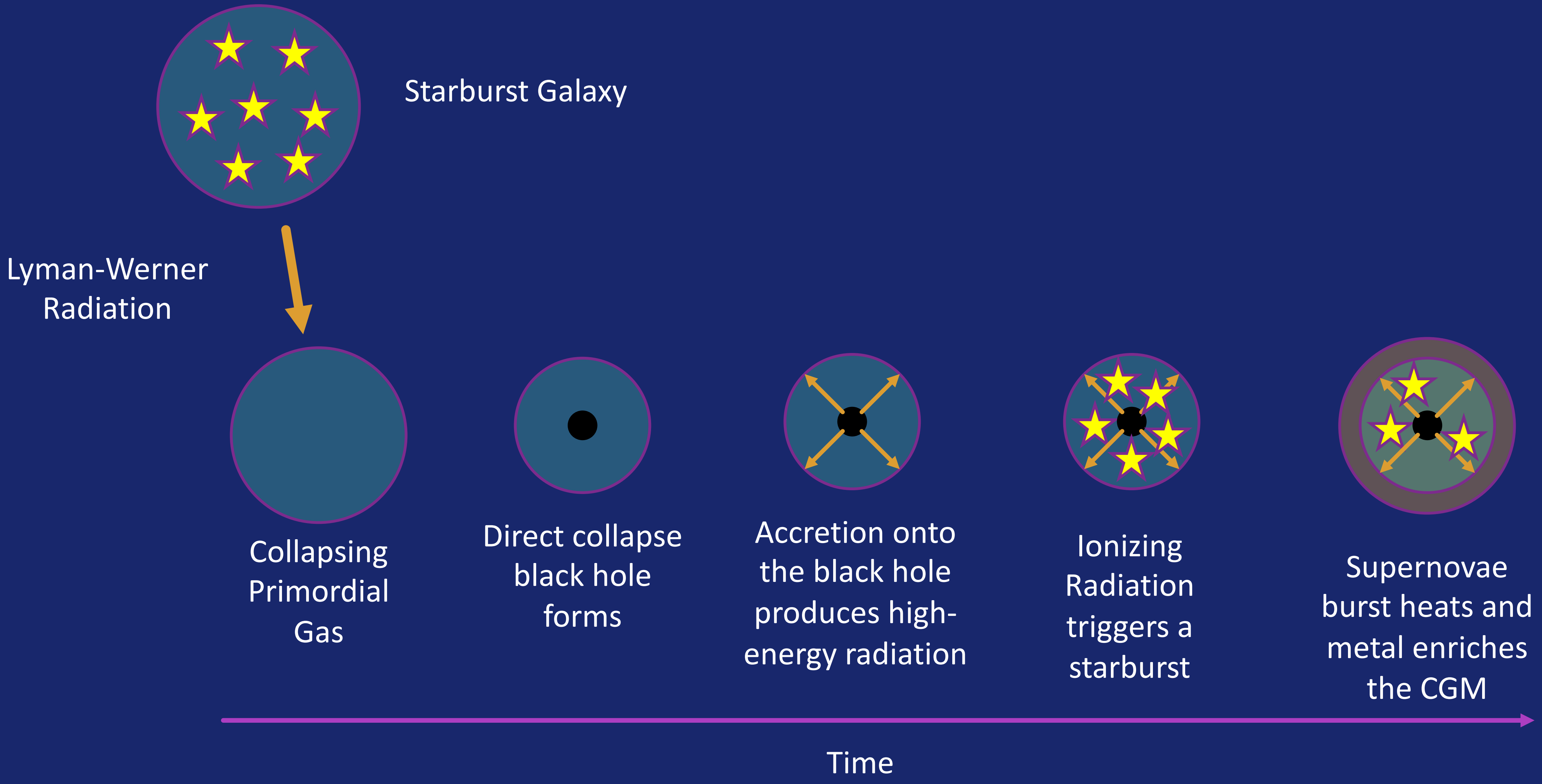


Pacucci et al. 2016

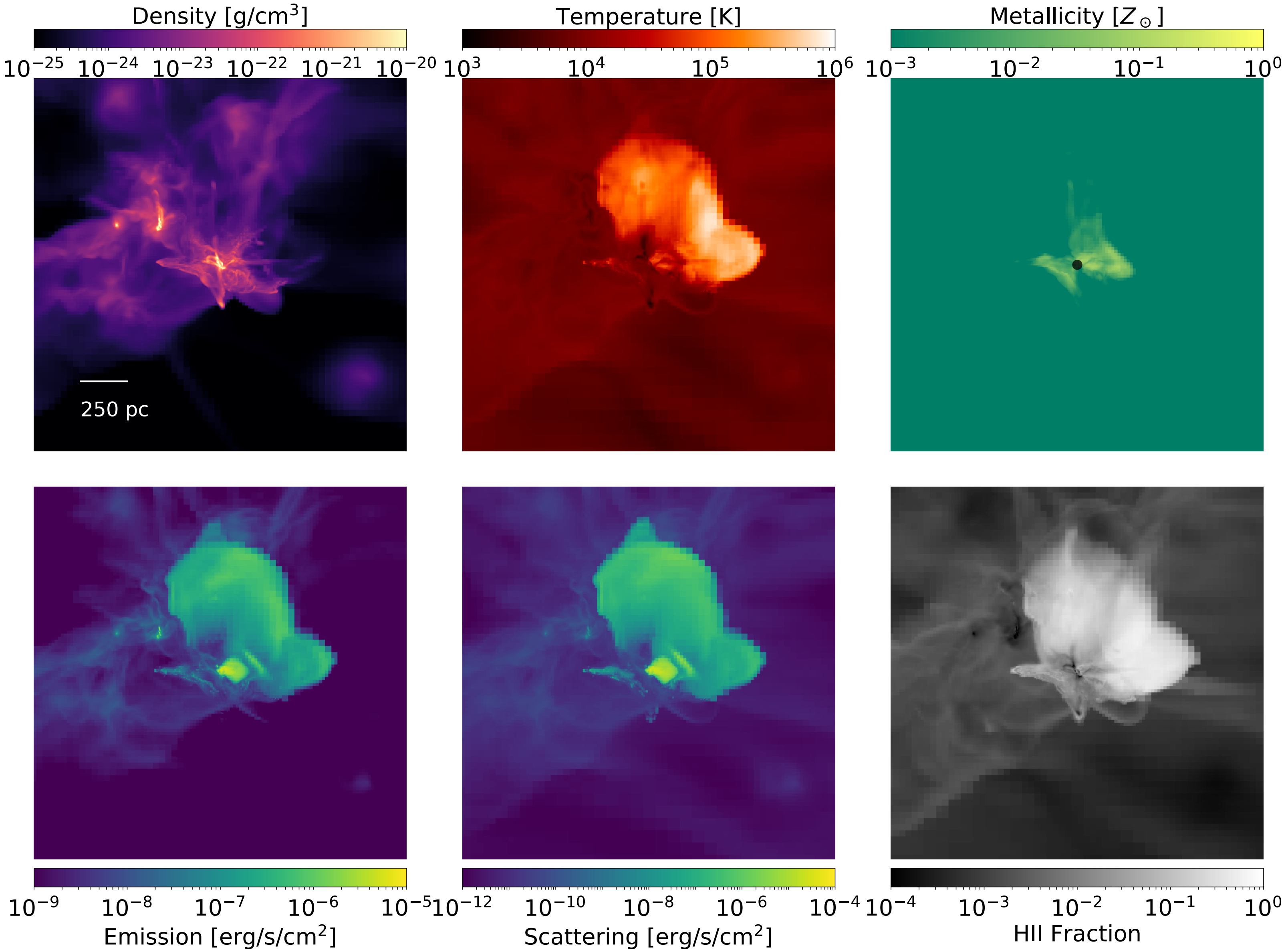
PHYSICAL SCENARIO



PHYSICAL SCENARIO



RESULTS



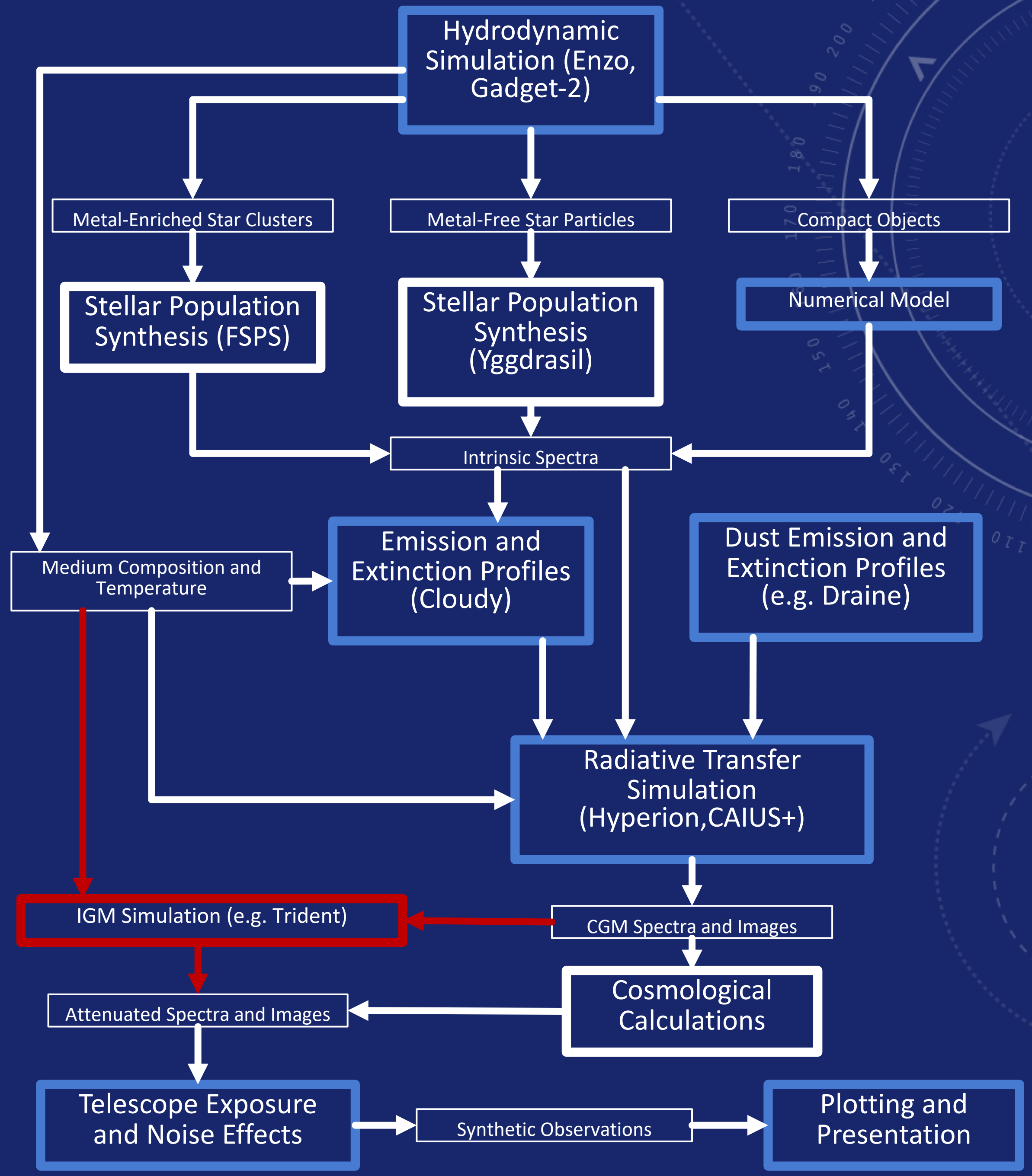
Simulation:
Aykutalp et al. 2019
(to be submitted)

CAIUS PIPELINE

Future Additions
Future Overhauls

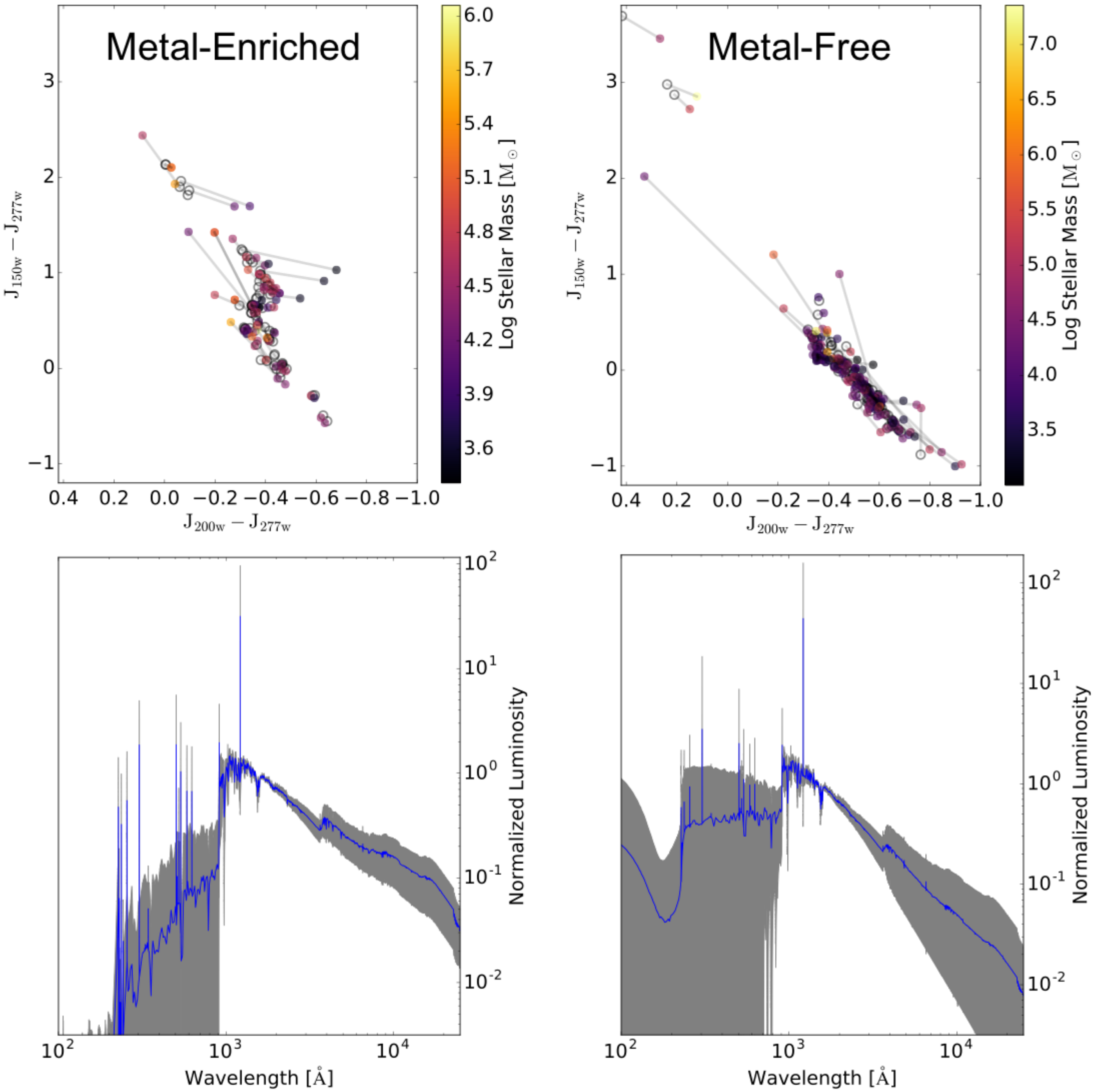
Calculations

Inputs



CAIUS PIPELINE

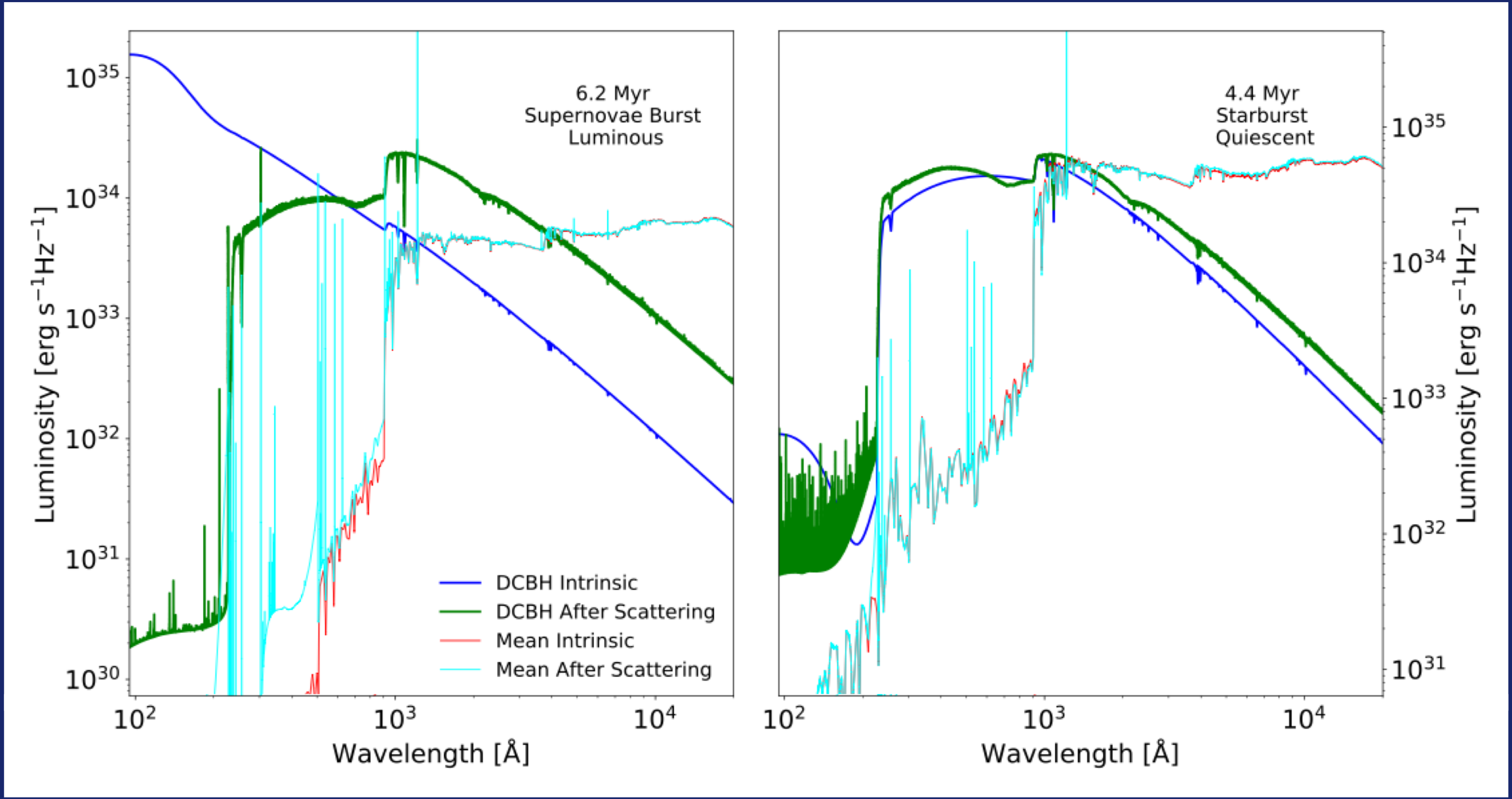
Metal free and metal-enriched hosting halos have distinct spectra and colors



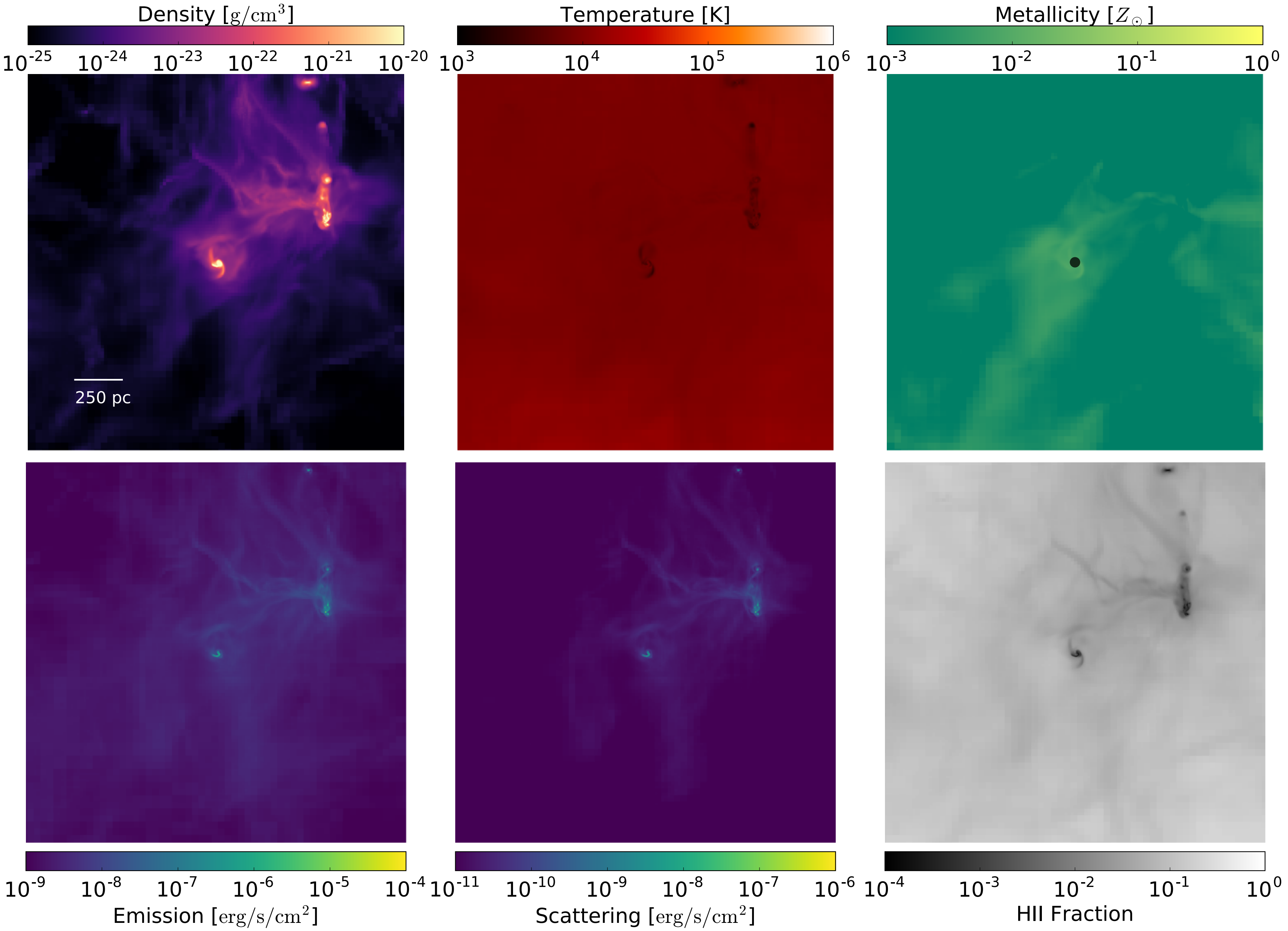
RESULTS

Active

Quiescent



RESULTS



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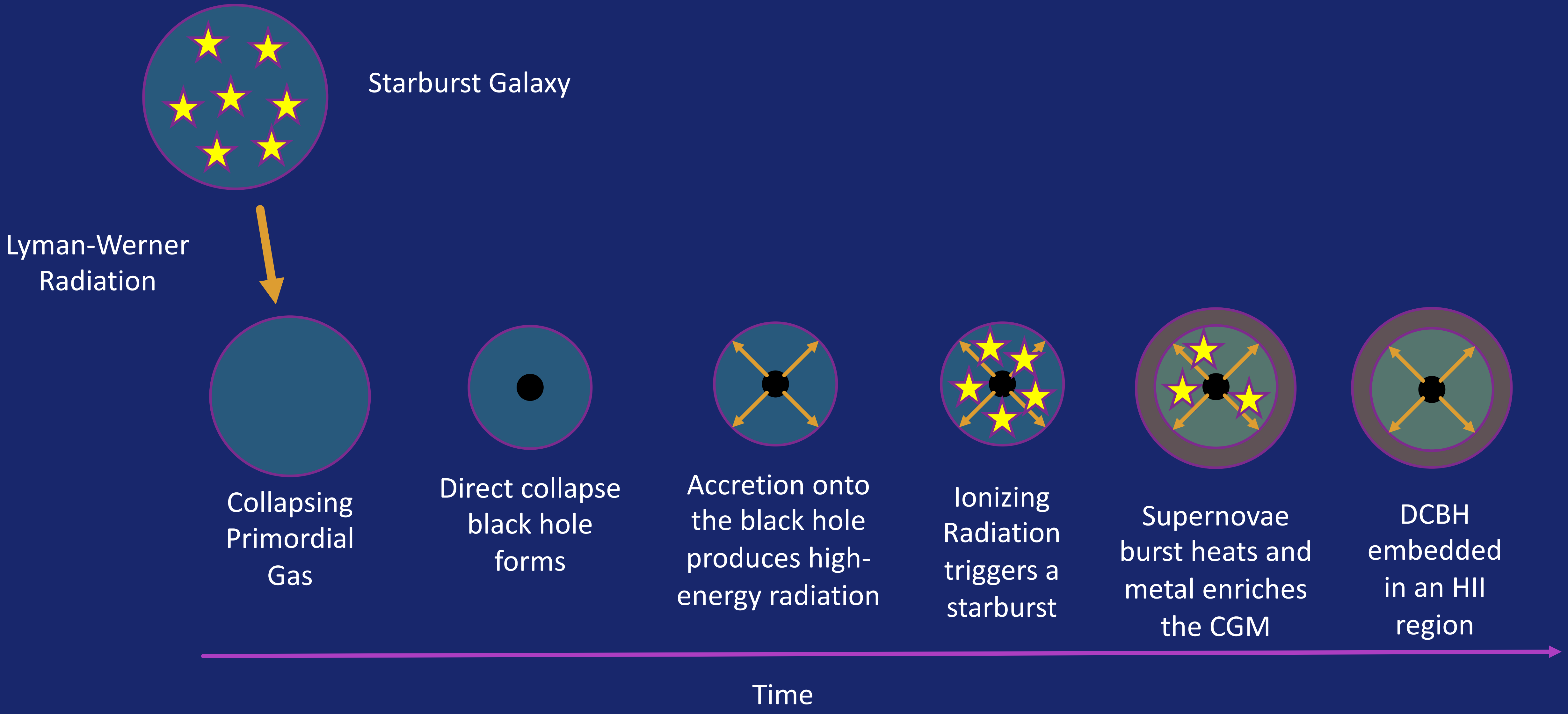
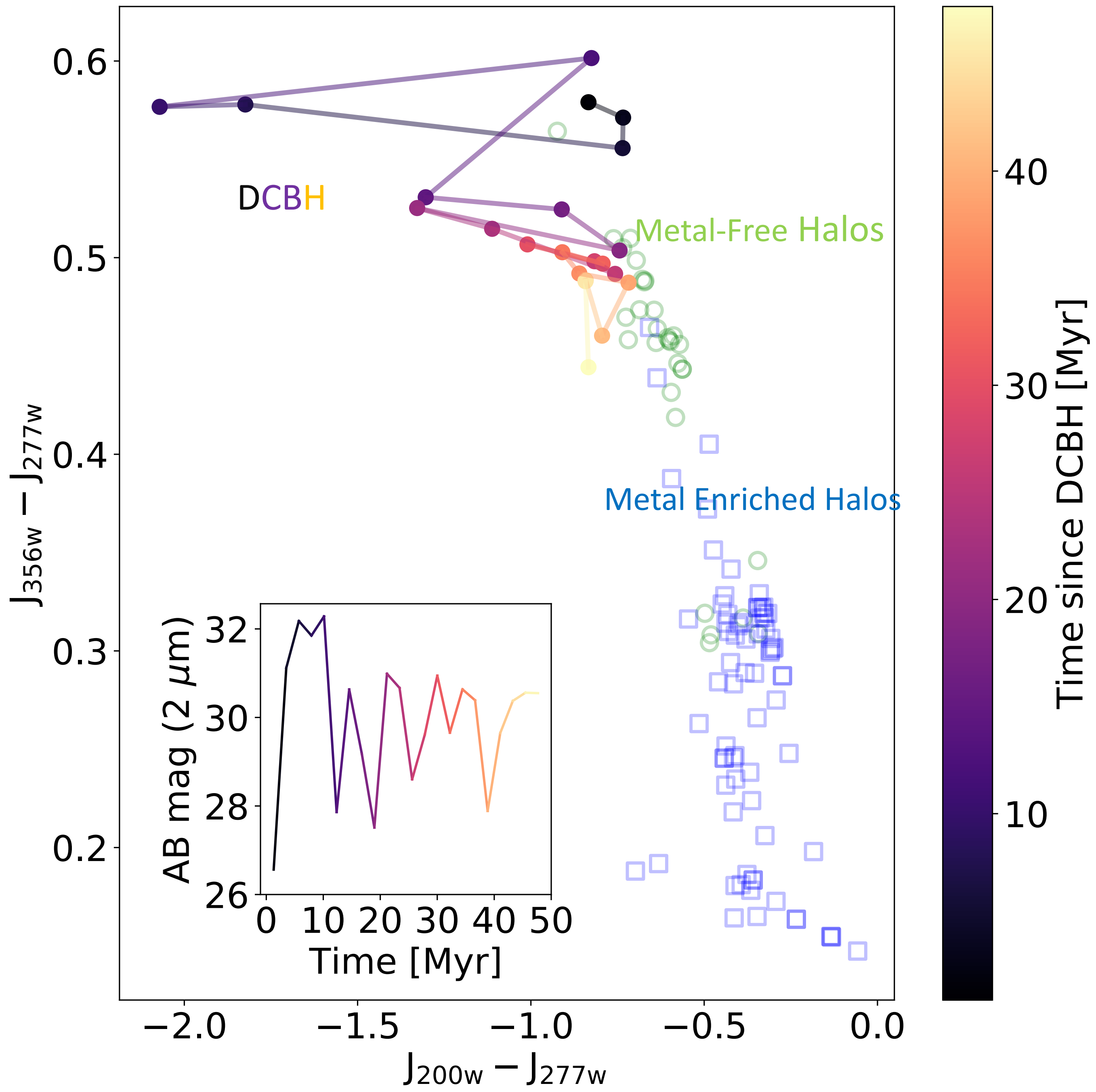


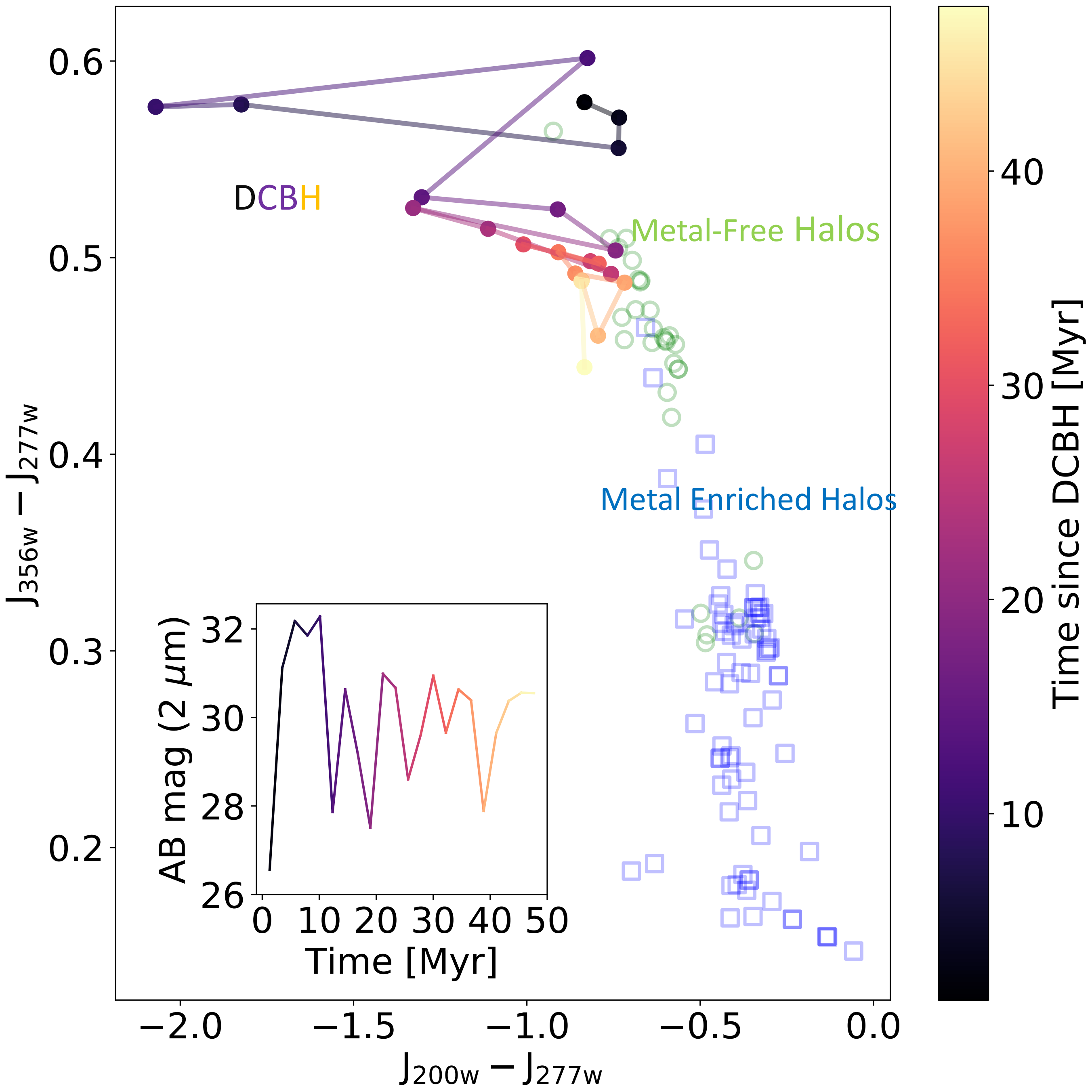
RESULTS

- The halo was brightest in F200w

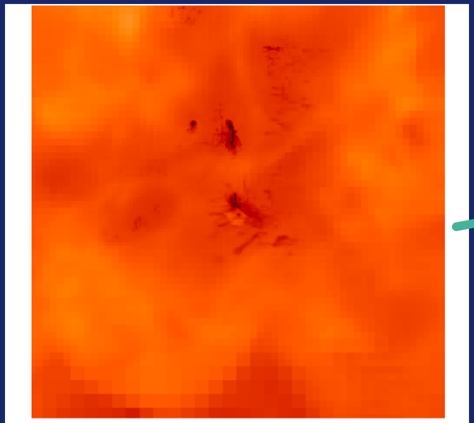


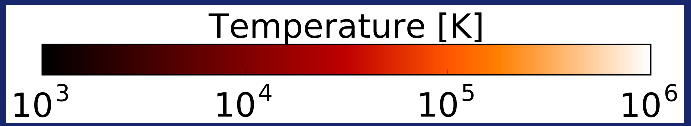
RESULTS

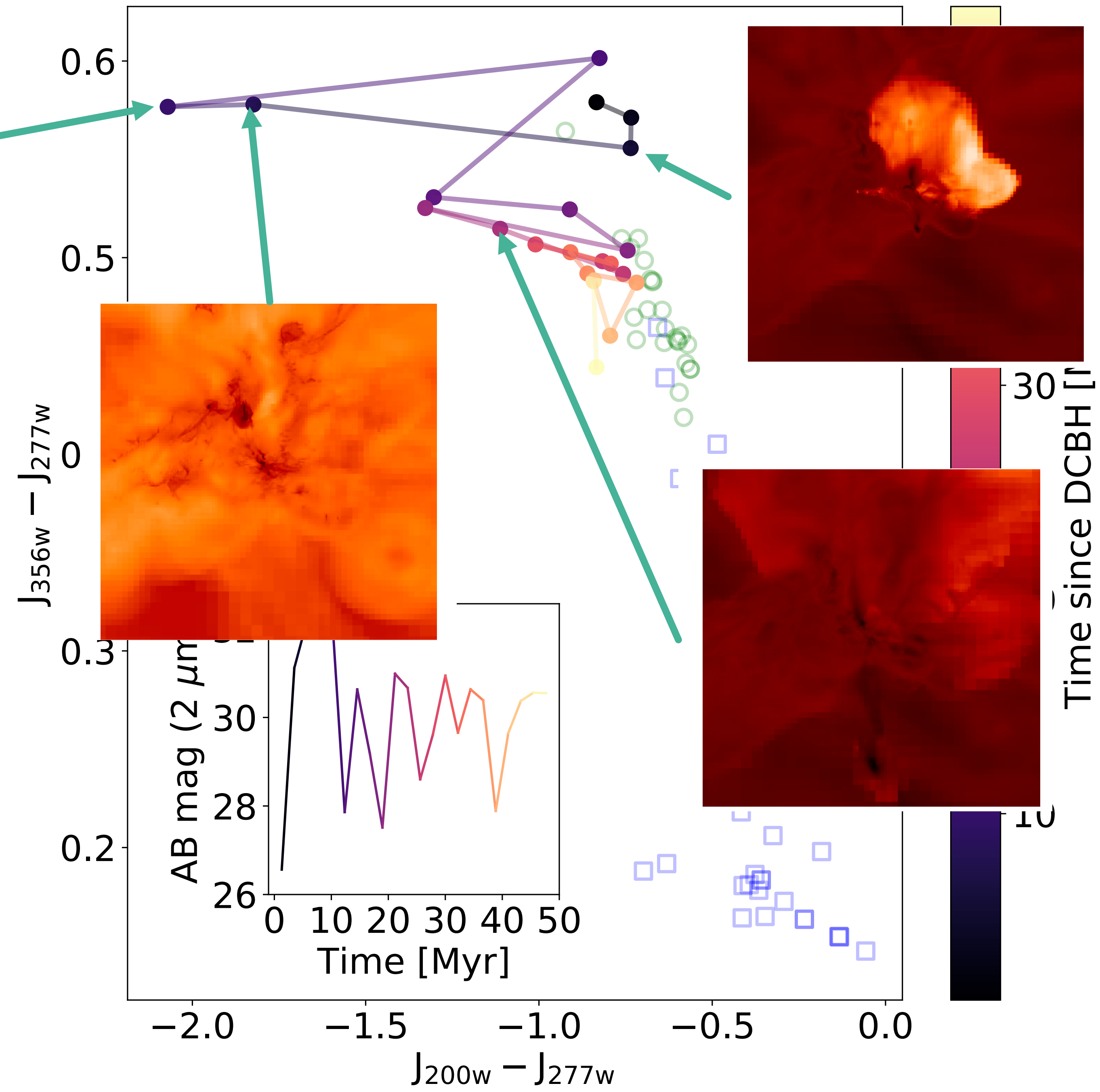
- The halo was brightest in F200w
- DCBH have distinct colors from both metal-free and metal-enriched galaxies after the initial starburst begins to die



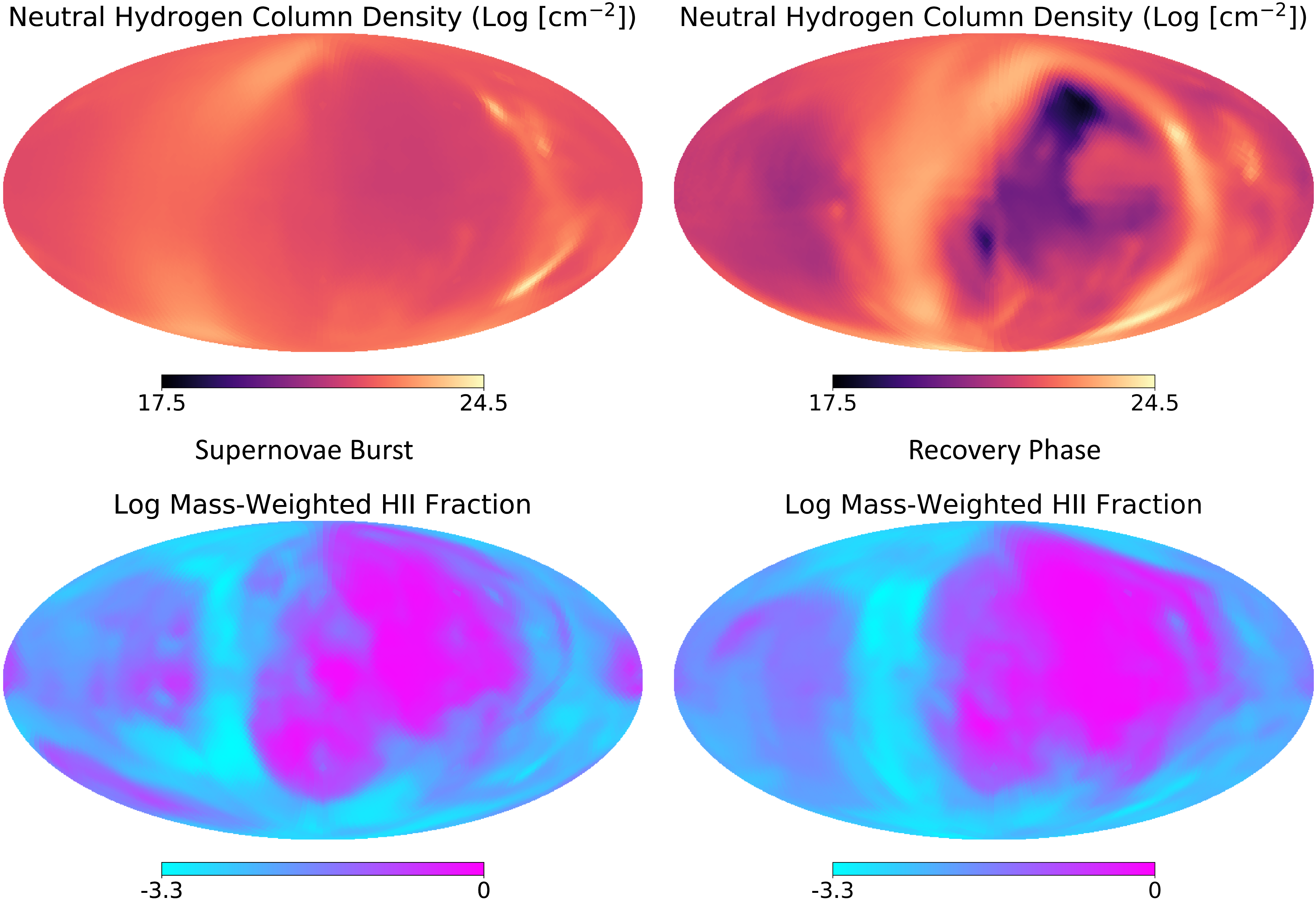
RESULTS




Temperature [K]
10^3
10^4
10^5
10^6

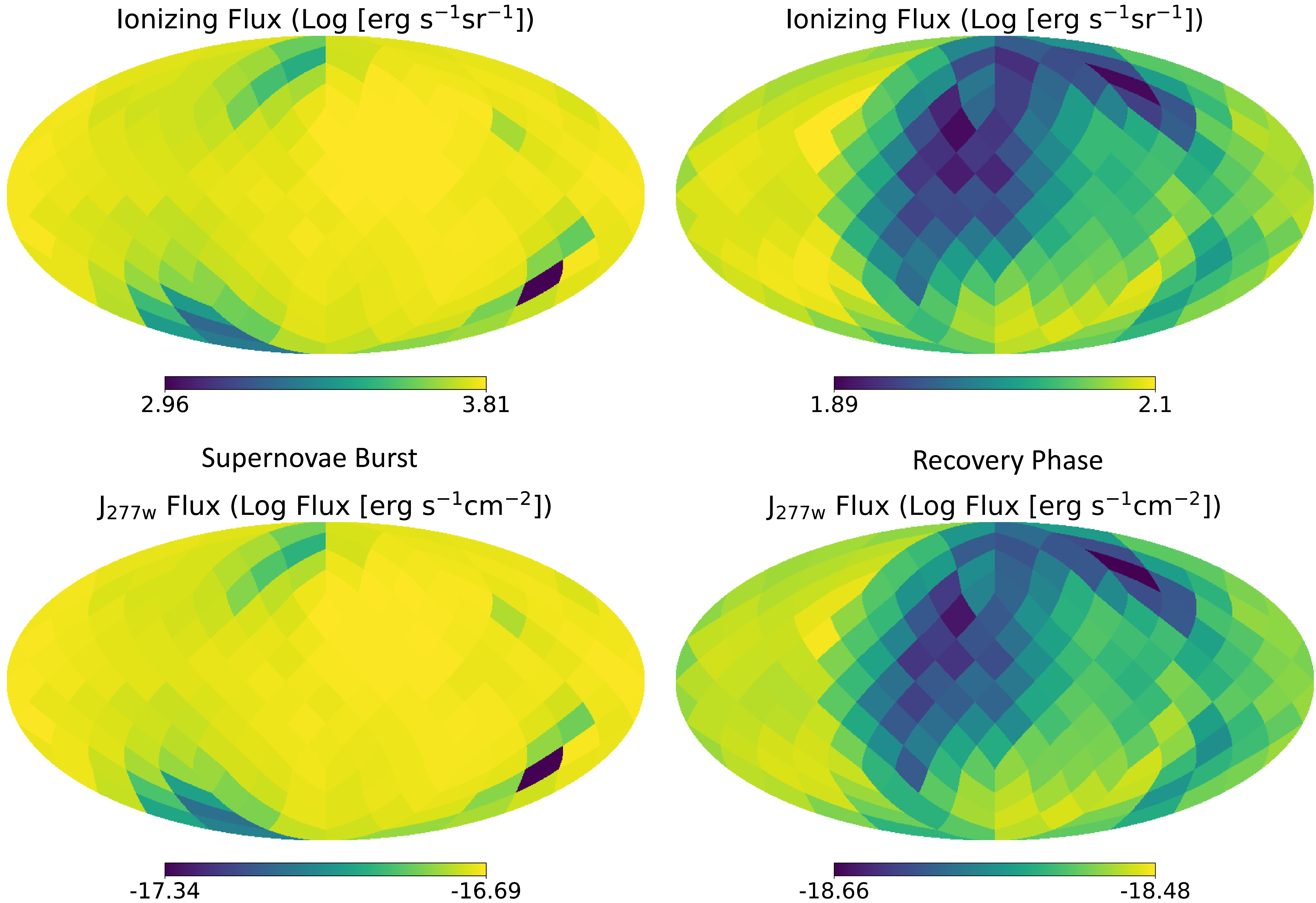

J356w − J277w
J200w − J277w
0.6
0.5
0.3
0.2
0
−2.0
−1.5
−1.0
−0.5
0.0
AB mag (2 μm
Time [Myr]
26
28
30
0 10 20 30 40 50
Time since DCBH [
30
10

RESULTS

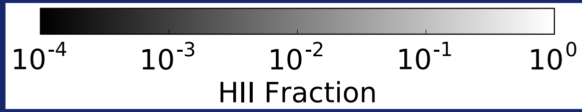


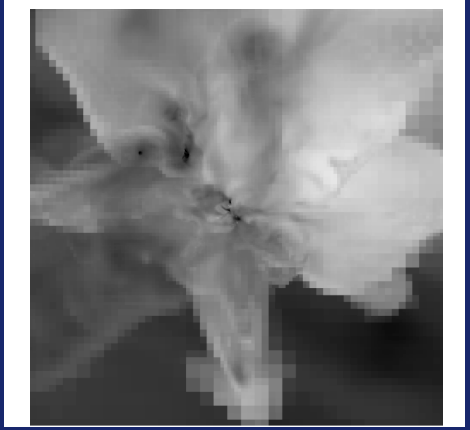
Neutral Hydrogen Column Density (Log [cm^{-2}])
17.5
24.5
Supernovae Burst
Neutral Hydrogen Column Density (Log [cm^{-2}])
17.5
24.5
Recovery Phase
Log Mass-Weighted HII Fraction
-3.3
0
Log Mass-Weighted HII Fraction
-3.3
0

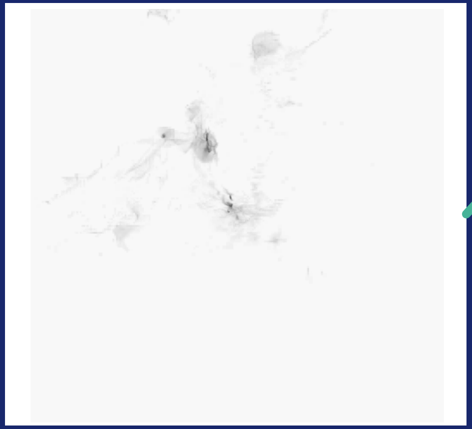
RESULTS

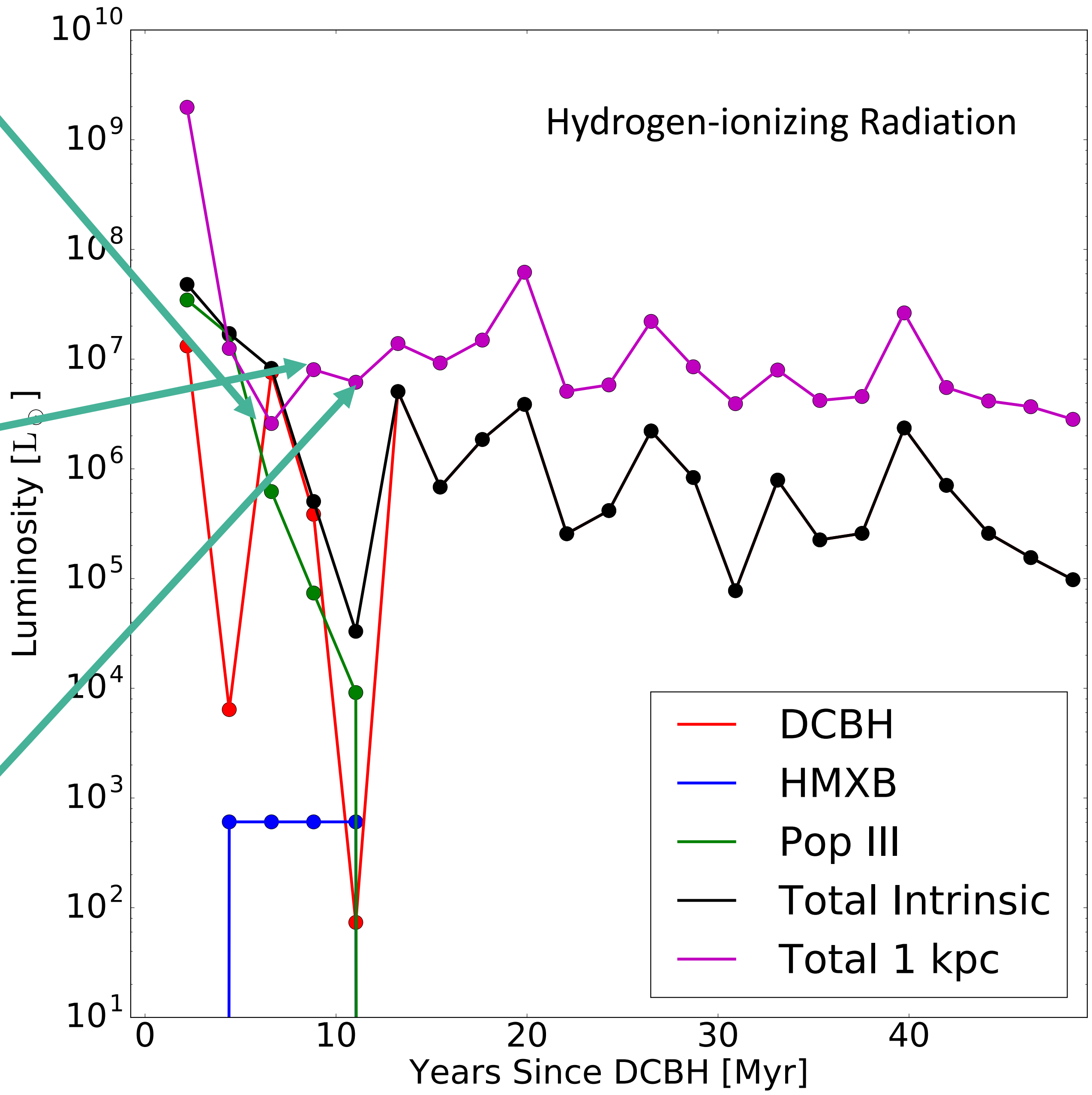

Ionizing Flux (Log [erg s^{-1}sr^{-1}])
2.96
3.81
Ionizing Flux (Log [erg s^{-1}sr^{-1}])
1.89
2.1
Supernovae Burst
J_{277w} Flux (Log Flux [erg s^{-1}cm^{-2}])
-17.34
-16.69
Recovery Phase
J_{277w} Flux (Log Flux [erg s^{-1}cm^{-2}])
-18.66
-18.48

Results


10^-4
10^-3
10^-2
10^-1
10^0
HII Fraction

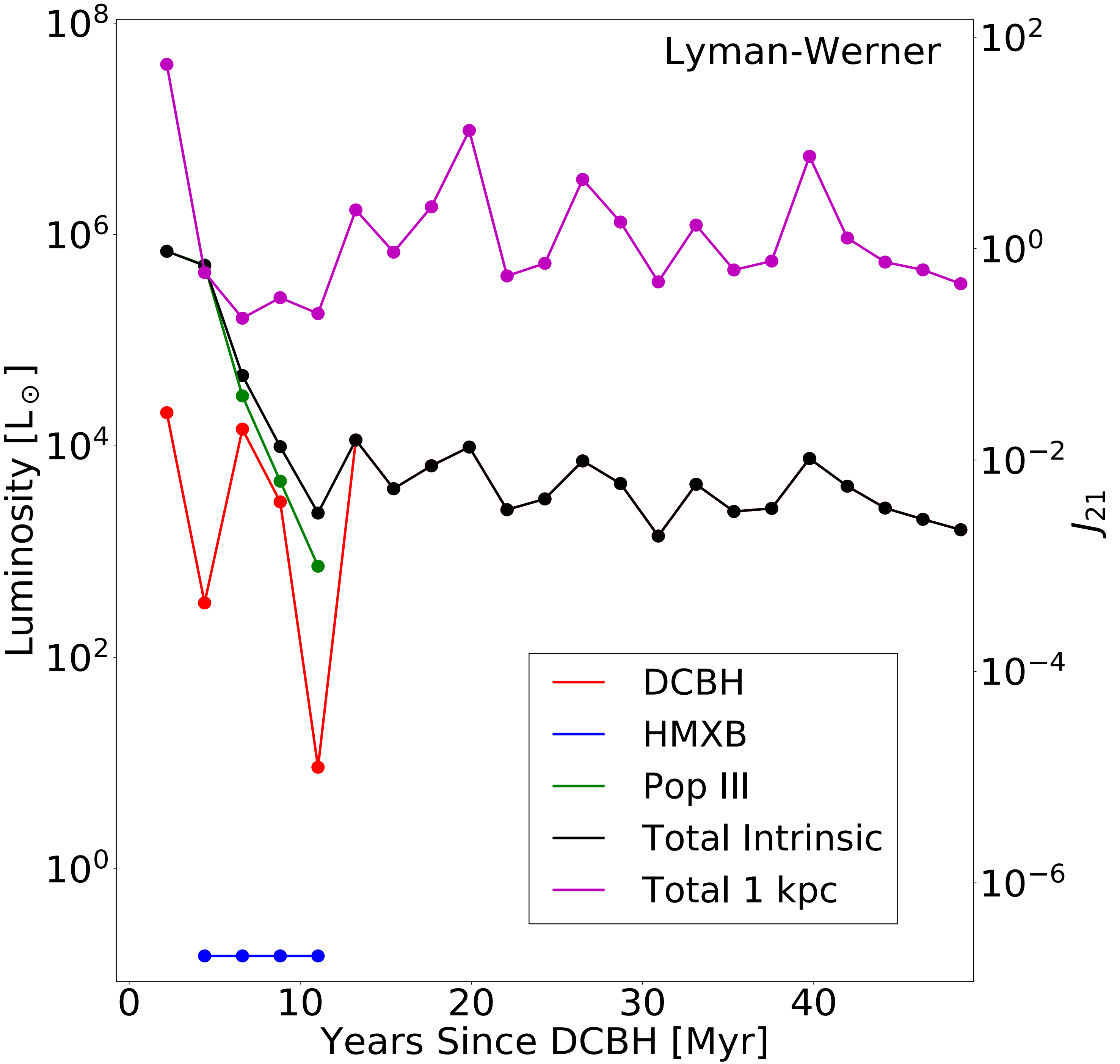




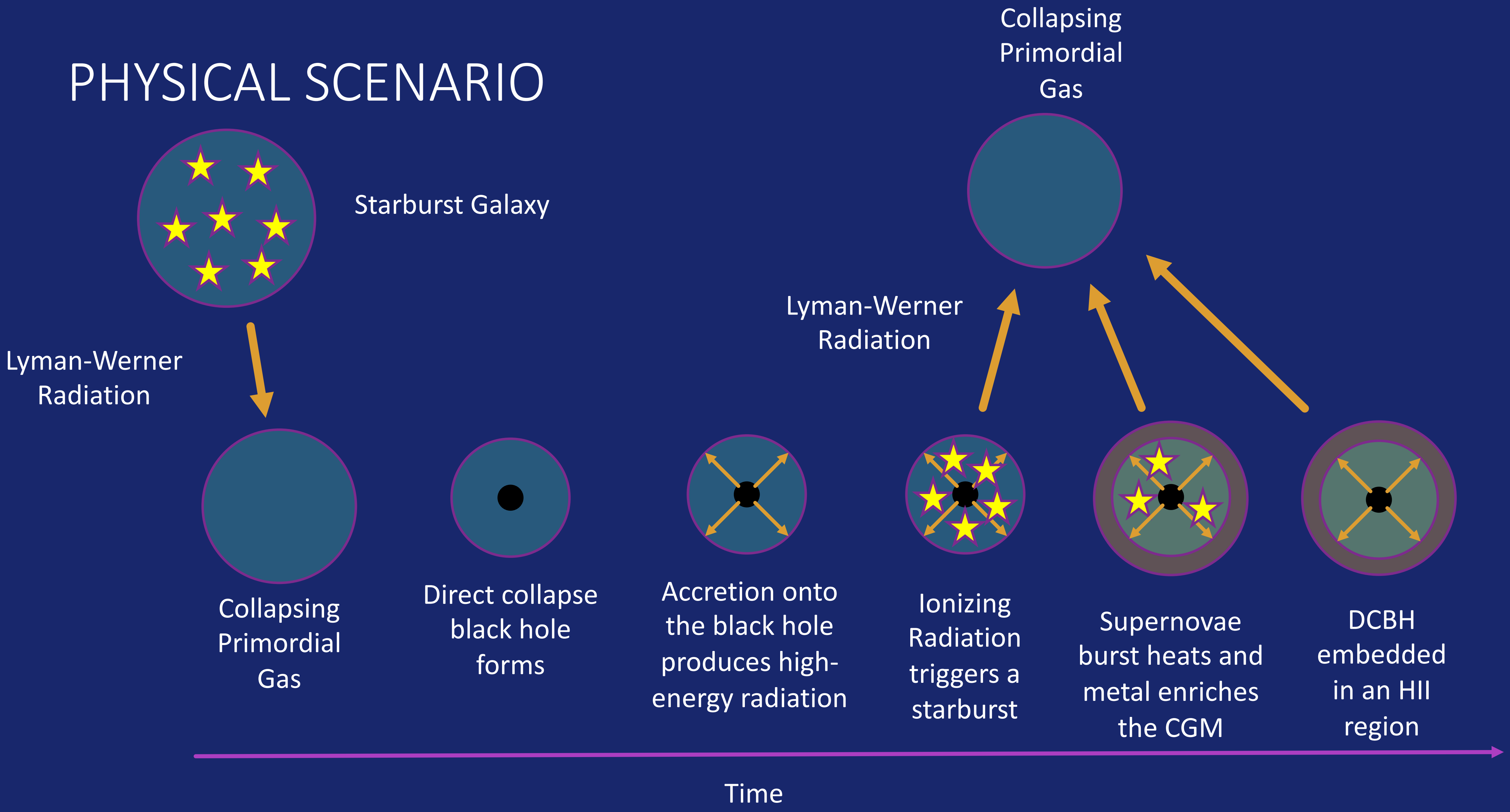

Hydrogen-ionizing Radiation
Luminosity [L☉]
Years Since DCBH [Myr]
10^10
10^9
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
0
10
20
30
40
DCBH
HMXB
Pop III
Total Intrinsic
Total 1 kpc

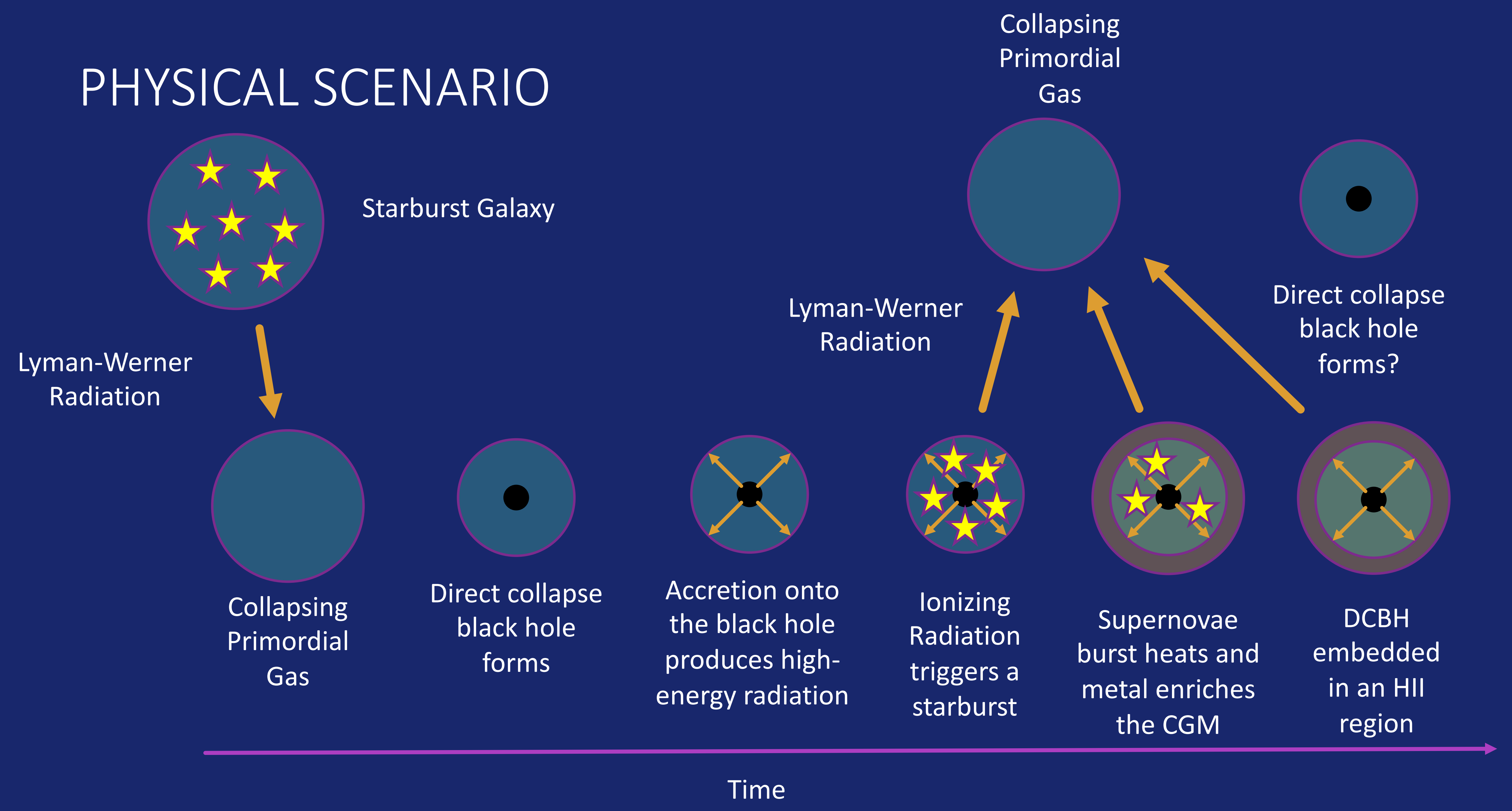
RESULTS

- LW radiation at 1 kpc is greater than the intrinsic LW luminosity of the stars and DCBH after 6.6 Myr
- $J_{LW,max} > 1000\ J_{21}$ at 200 pc
- HMXBs do not contribute



PHYSICAL SCENARIO

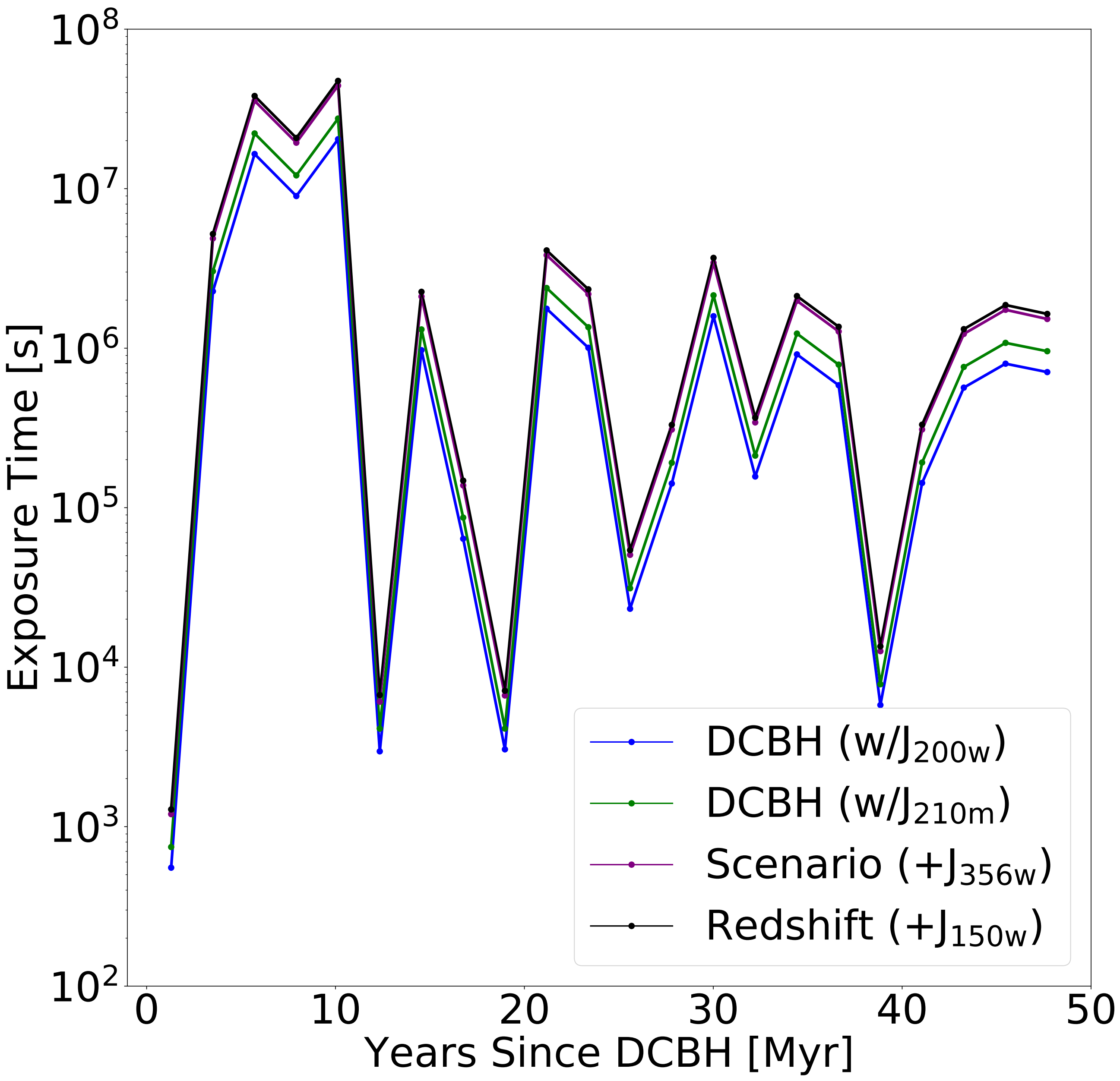



PHYSICAL SCENARIO
Starburst Galaxy
Lyman-Werner Radiation
Collapsing Primordial Gas
Direct collapse black hole forms
Accretion onto the black hole produces high-energy radiation
Ionizing Radiation triggers a starburst
Supernovae burst heats and metal enriches the CGM
DCBH embedded in an HII region
Lyman-Werner Radiation
Collapsing Primordial Gas
Direct collapse black hole forms?
Time

RESULTS

- Less than six hours are needed to confirm this DCBH scenario using the three filters in the color-color diagram and a fourth filter to detect a Lyman Alpha break (z >6) about 20% of the time

- Chon 2016 suggests a sky density that corresponds to one detection in 14 pointings of six hours.



SUMMARY

- DCBH may materially contribute to extragalactic ionizing radiation and may trigger star formation in dense primordial gas
- DCBH-hosting galaxies may contribute strong LW radiation through reprocessing
- DCBH may be observable with JWST