# BAT vs EAGLE: The Star-Formation Properties of the Observed and Simulated AGN Universe.

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## Abstract

We present a comparison of the star formation (SF) properties of a sample of local hard X-ray selected AGN to the EAGLE hydrodynamical simulations. We find good agreement in the SFR distributions and sSFR values which lie below the sSFR main sequence, indicative of quenching of the SF. We also track the cosmic evolution of AGN within EAGLE, finding AGN selected at different epochs can show similar behaviour but different host galaxy properties. We also show that quasar-like events have the greatest impact in suppressing SF in EAGLE, with a dependency on the specific accretion rate.

## Motivation

Scholtz et al. (2018) showed that AGN feedback from the EAGLE simulations broadens the specific Star Formation Rate (sSFR) distributions of high mass galaxies. Comparing EAGLE to a sample of high-redshift AGN, they found very good agreement between the observed and simulated sSFR distributions. The mode of both of these distributions lie below the sSFR main sequence but above the average galaxy population. We investigate if a similar situation occurs in the local universe, and use EAGLE to identify what drives SF quenching occurs within EAGLE.

## Part I – Star forming properties

We use a sample of hard X-ray (14 – 195keV) selected AGN from the Swift-BAT 58 month all sky catalogue. In order to measure the host galaxy properties, we collect counterpart optical and IR photometry and fit their Spectral Energy Distributions. We then compared the Star Formation Rate (SFR) distributions and their position on the sSFR main sequence to a sample of simulated AGN in EAGLE volume and flux matched to those from Swift-BAT. We find Anderson-Darling test agreements of 20% in the SFR distributions. The trend in the $L_{14\text{-}195\mathrm{KeV}}$ v SFR is reproduced well by EAGLE (Fig. 1). The luminosity ditribution is not so well produced, however this is due to the short variability timescale of the AGN luminosity. Both EAGLE and BAT AGN lie below the sSFR main sequence, however above the average galaxy population (Fig. 2), consistent with Scholtz et al. (2018).

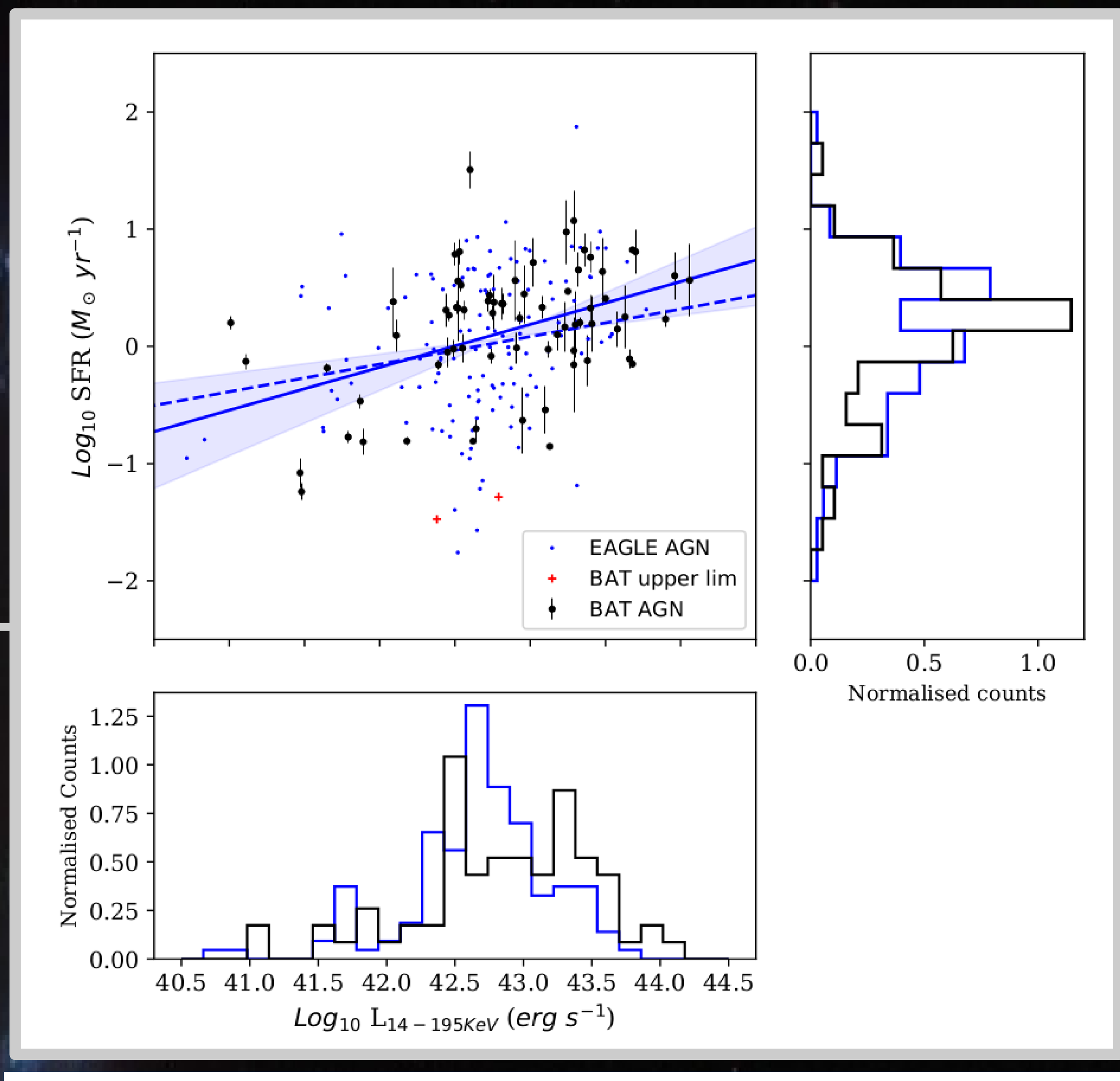


Figure 1: Lx vs SFR for the volume and flux matched Swift-BAT AGN (Black) and EAGLE AGN (Blue). The best fitting line (solid blue) comes from the Linmix bayesian fitting code with 95% confidence limits shaded. EAGLE's prediction is given by the blue dotted line. Distributions are shown in the side panels.

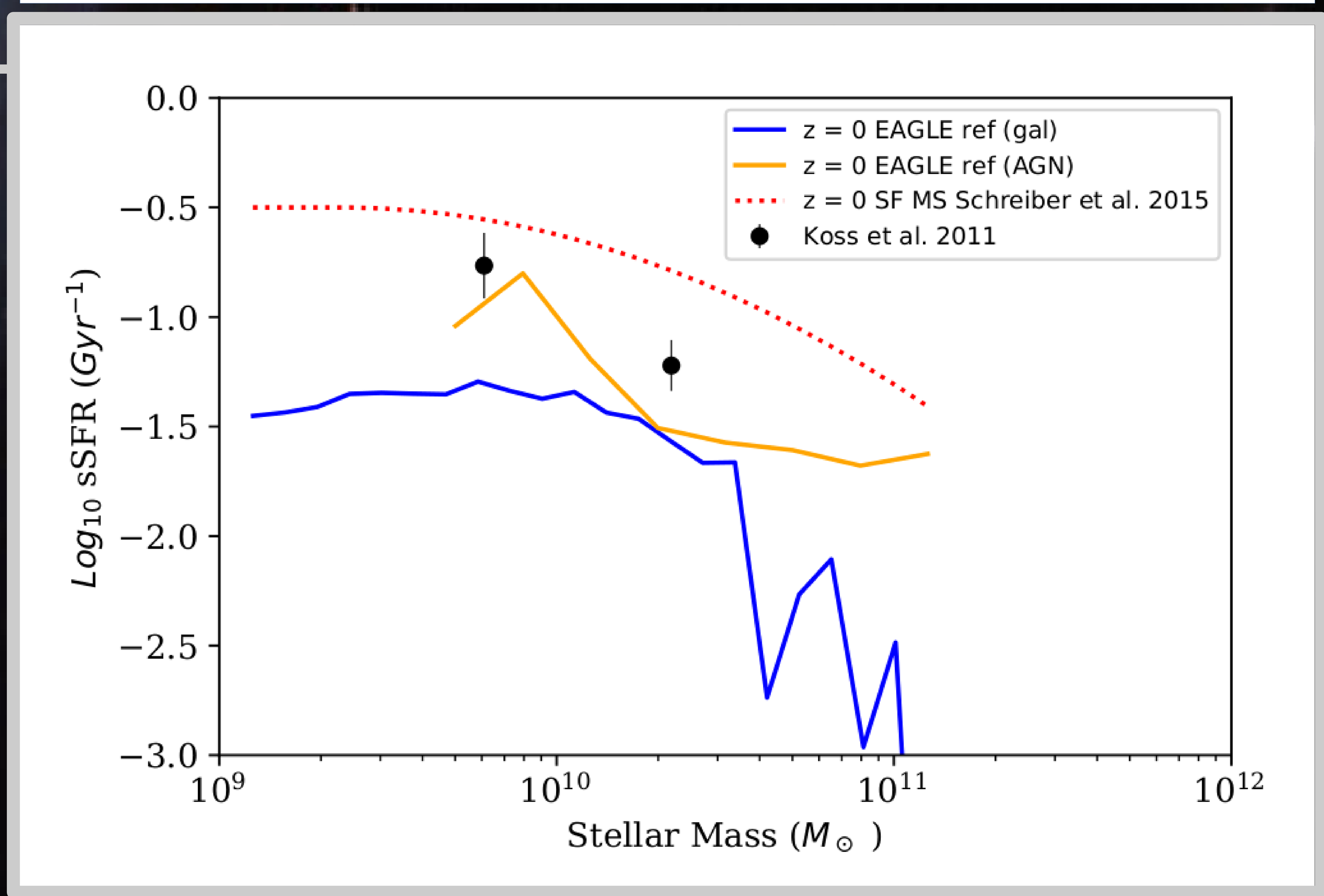


Figure 2: sSFR versus stellar mass for a subset of our Swift-BAT AGN using masses from Koss et al. 2011. Both our BAT AGN and EAGLE AGN (ornage line) lie below the sSFR main sequence (red), however above the average galaxy population. This is in good agreement with other studies.

## Part II – Average Evolution of host galaxies

We also track our EAGLE AGN sample and that of Scholtz et al. (2018) in low time resolution data (20 snapshots) in order to identify the epoch and conditions of quenching. Within EAGLE, AGN follow the SF main sequence before SF quenches (Fig 3). This starts after the rapid black hole growth phase, beyond which AGN feedback becomes effective (Bower et al. 2017, McAlpine et al. 2018).

## Part III – Quasar-like events in EAGLE

In order to explore the detailed effects of AGN feedback within EAGLE we also use high time resolution data (1 Myr) from EAGLE and look at all local galaxies which undergo a quasar-like episode ($L_{BOL} > 10^{45}$ erg s$^{-1}$) in the last 700 Myr, splitting by specific accretion rate. We also find that Quasar-like episodes can suppress SF in galaxies within EAGLE. This shut down has a dependance on the specific accretion rate $\lambda \propto \dot{m} / M_*$. Higher $\lambda$ objects are more affected by singular high accretion events, with both the Black Hole Accretion Rate and SFR significantly affected. Lower $\lambda$ objects, however, are minorly affected by the peak accretion event and have their SF more gradually quenched (Fig 5).

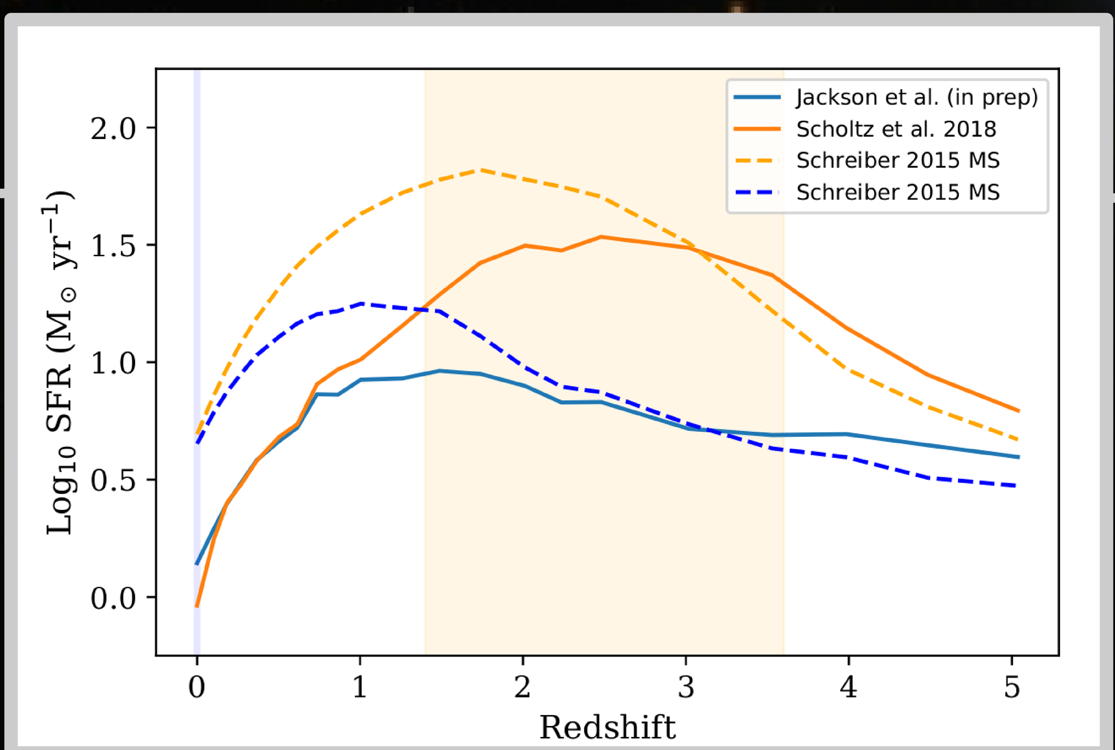


Figure 3: The cosmic evolution of the average SFR for the EAGLE samples used in Scholtz et al. (2018) and this research compared to their respective SF main sequences. The shaded areas are the respective selection epochs. They initially follow their respective SFR main sequences before diverging at different points.

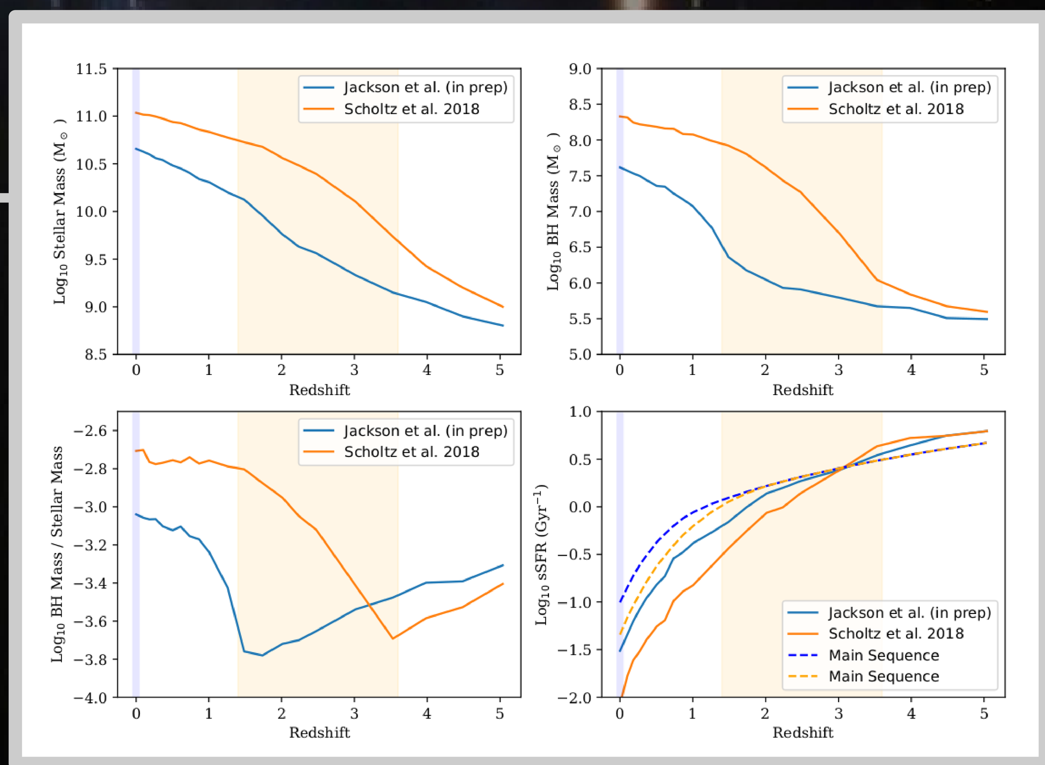

Figure 4: The cosmic evolution of the avergae stellar mass, average black hole mass, average black hole growth rate and average sSFR for the EAGLE AGN sample used in this research and those used in the comparison sample in Scholtz et al. (2018).

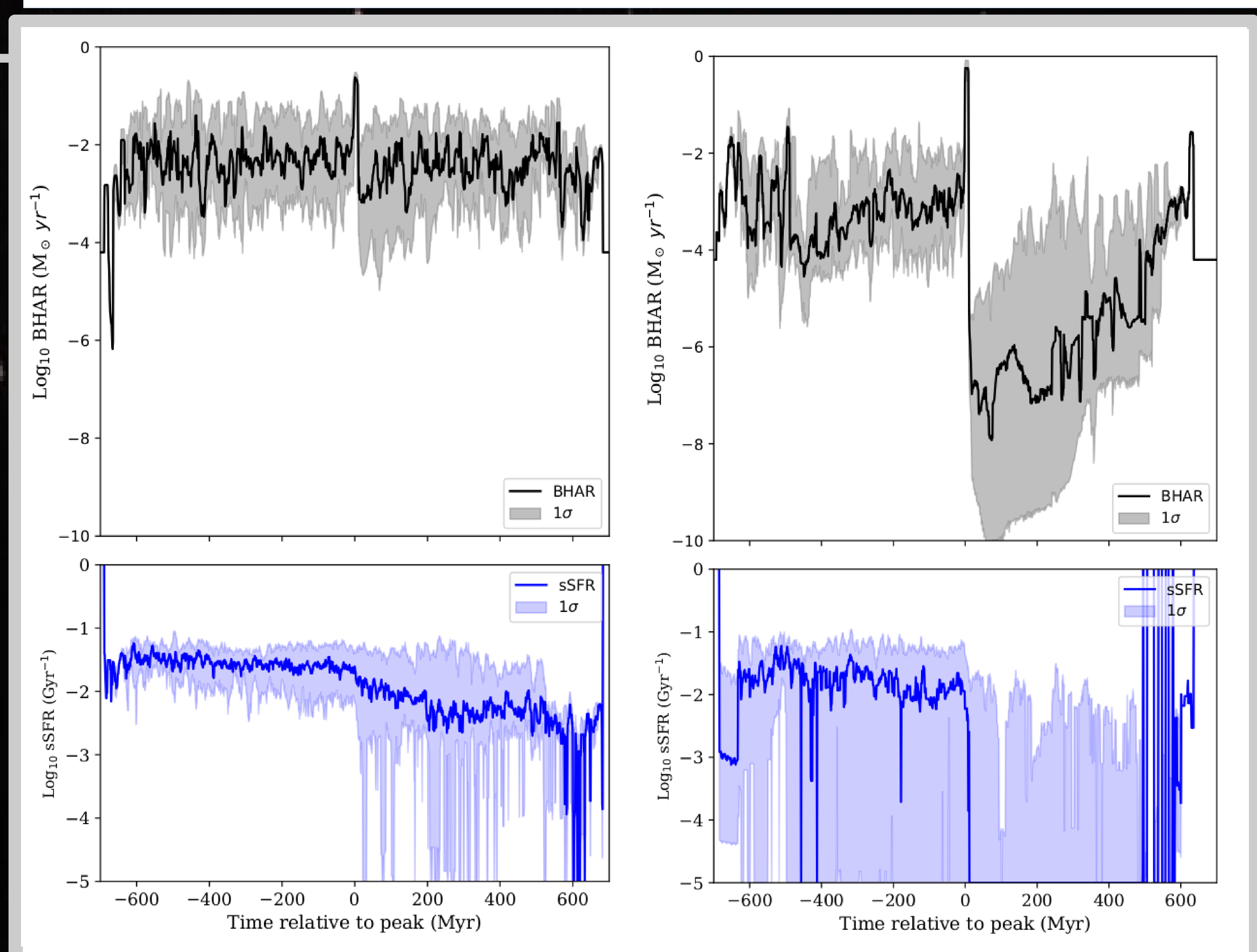


Figure 5: The BHAR (black) and sSFR (blue) high resolution timelines of the low specific accretion rate (left panel) and high specific accretion rate (right panel) galaxies which undergo a Quasar-like episode in the last 700 Myr. The median values of the populations are given by the solid lines and the 14th and 86th percentiles in the shaded regions.

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