Measuring cosmic star-formation history using ALMA data of Gamma-Ray Burst host galaxies

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Outline

- Introduction of GRB
- Tools
- Data of GRBs
- SED fitting
- Discussion & Conclusion
- Future Work
- Reference

Introduction of GRB

GRB

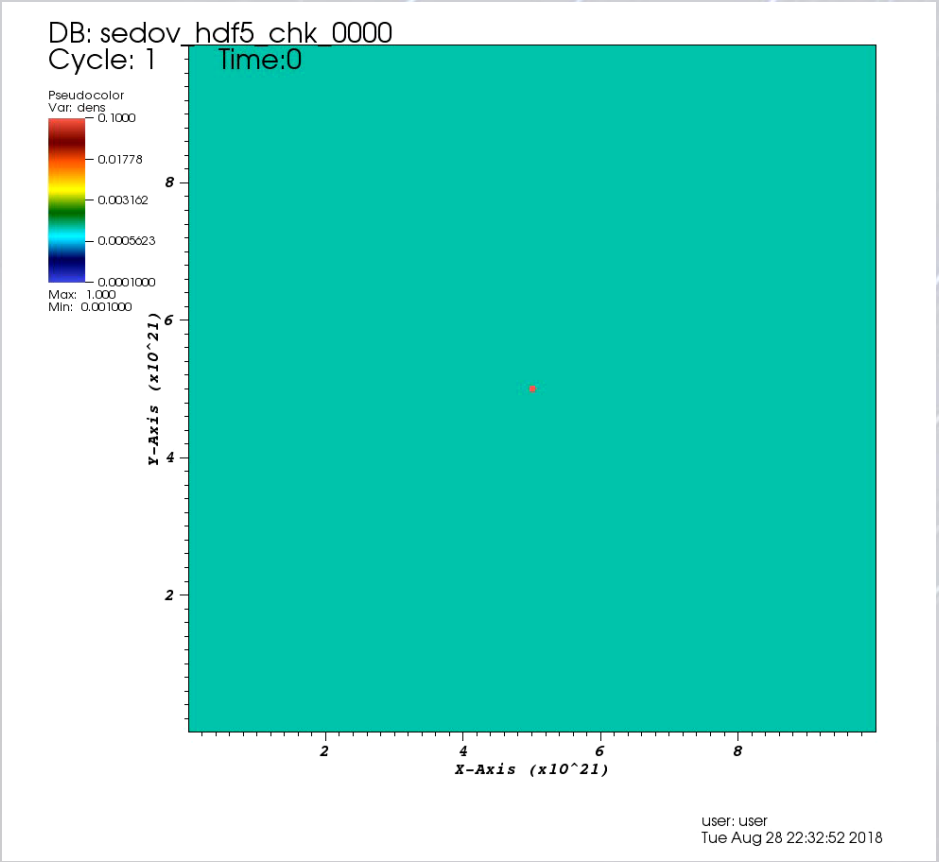
Gamma-Ray Burst

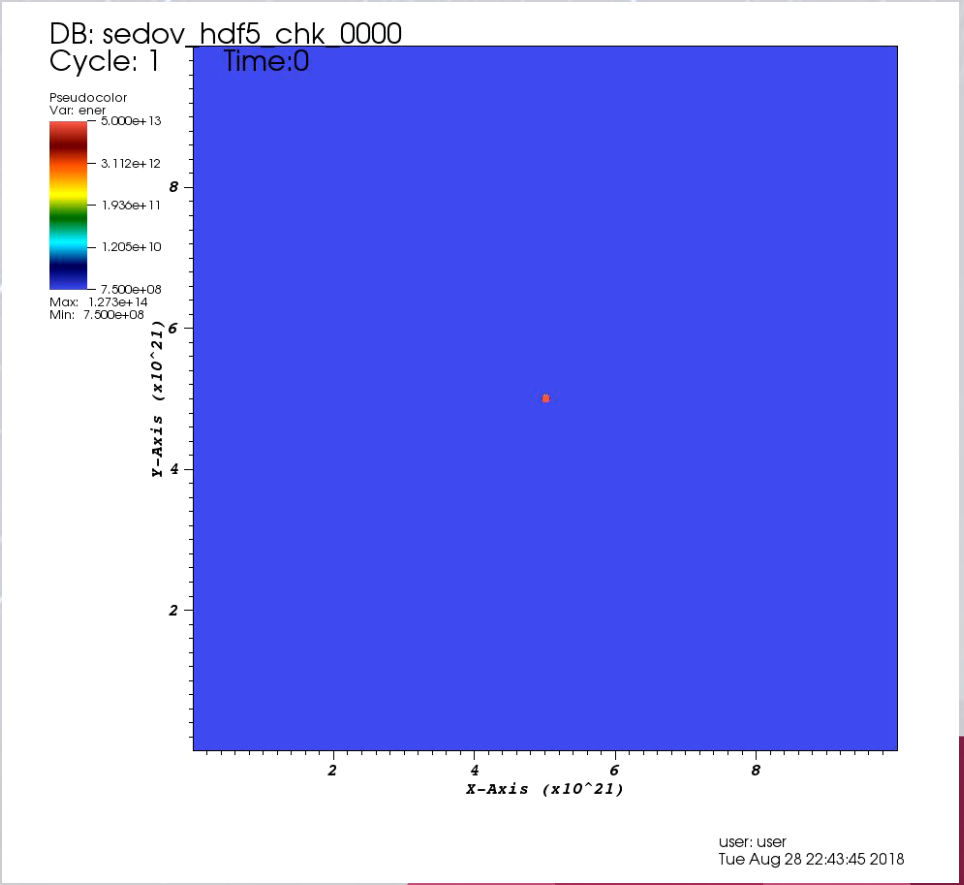
Associated with explosions of massive stars

Long-duration GRBs are powerful tracers of star-forming galaxies (Hjorth et al. 2012).

Robust Redshift ~8 (Tanvir et al. 2009, Savaterra et al. 2009)

Is expected to be a tracer of the cosmic star-formation history





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Tools

Tools

CASA

CIGALE

CIGALE

Code Investigating GALaxy Emission

Written in Python

to study the evolution of galaxies by comparing modelled galaxy spectral energy distributions (SEDs)

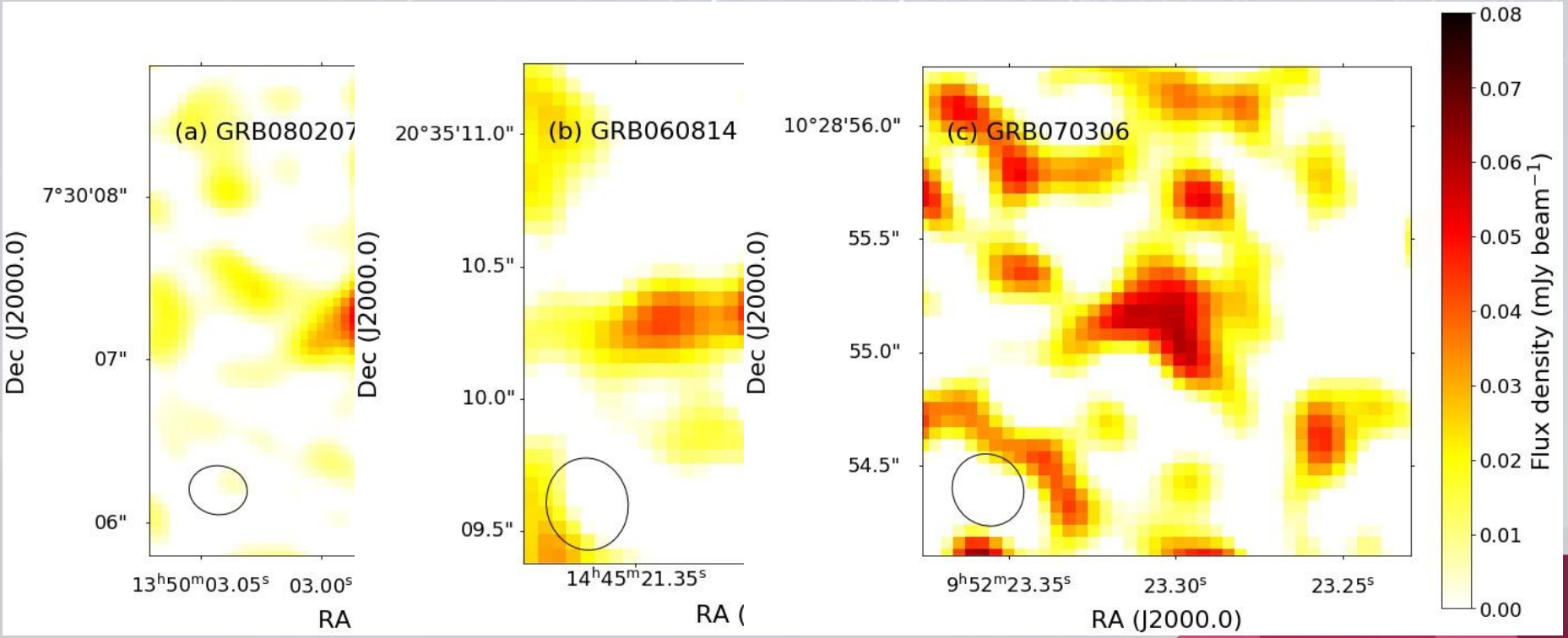
Far-ultraviolet to radio

Data of GRBs

No publication yet based on this data

Sky coordinate

GRB	RA	DEC
080207	13:50:02.97	+07:30:07.51
060814	14:45:21.31	+20:35:10.96
070306	09:52:23.31	+10:28:55.49


(a) GRB080207
7°30'08"
07"
06"
Dec (J2000.0)
13h50m03.05s
03.00s
RA
(b) GRB060814
20°35'11.0"
10.5"
10.0"
09.5"
Dec (J2000.0)
14h45m21.35s
RA (
(c) GRB070306
10°28'56.0"
55.5"
55.0"
54.5"
Dec (J2000.0)
9h52m23.35s
23.30s
23.25s
RA (J2000.0)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Flux density (mJy beam−1)

Wavelength in rest-frame

ID	Frequency(GHz)			Bandwidth
	Start	Centre	End	
17	335.495	336.495	337.495	2.000GHz
19	337.432	338.432	339.432	2.000GHz
21	347.495	348.495	349.495	2.000GHz
23	349.495	350.495	351.495	2.000GHz

Wavelength in rest-frame

Frequency in average=343.47925GHz

Observed Wavelength=873 μm

GRB	z(redshift)	Wavelength in rest-frame(micrometer)
080207	2.086	282.9
060814	1.923	298.7
070306	1.496	349.8

Flux

GRB	Flux(milliJansky)		Flux standard variation
080207	1.43	±	0.13
060814	0.1453	±	0.009
070306	0.05	±	0.011

SED fitting

Table 2. Multi-wavelength data of GRB 080207 host galaxy.

GRB080207

Table 4. Multi-wavelength data of GRB 070306 host galaxy.

GRB070306				
Observed wavelength (μm)	Band	Flux (μJy)	Telescope/Instrument	Reference
0.35949[a]	u	2.24±1.18	SDSS	Perley et al. (2013), Jaunsen et al. (2008)
0.45045[a]	g	2.78±0.24	GROND	Perley et al. (2013), Krühler et al. (2011)
0.46404[a]	g	2.4±0.41	SDSS	Perley et al. (2013), Jaunsen et al. (2008)
0.60980[a]	r	2.29±0.2	GROND	Perley et al. (2013), Krühler et al. (2011)
0.61223[a]	r	2.56±0.66	SDSS	Perley et al. (2013), Jaunsen et al. (2008)
0.6550	R	2.46±0.21	VLT/FORS2	Perley et al. (2013), Krühler et al. (2011)
0.76047[a]	i	2.88±0.37	GROND	Perley et al. (2013), Krühler et al. (2011)
0.84669[a]	I	3.42±0.65	NOT/ALFOSC	Perley et al. (2013), Jaunsen et al. (2008)
0.89293[a]	z	2.71±0.46	GROND	Perley et al. (2013), Krühler et al. (2011)
1.2500	J	8.37±0.64	VLT/ISAAC	Perley et al. (2013), Krühler et al. (2011)
1.23646[a]	F125W	6.4±0.18	HST/WFC3	Perley et al. (2013)
1.52791[a]	F160W	7.79±0.22	HST/WFC3	Perley et al. (2013)
1.63302[a]	H	9.26±0.35	GROND	Perley et al. (2013), Krühler et al. (2011)
1.65	H	12.21±1.43	VLT/ISAAC	Perley et al. (2013), Krühler et al. (2011)
2.16	K	10.29±0.99	VLT/ISAAC	Perley et al. (2013), Krühler et al. (2011)
3.5075[a]	3.6	10.65±0.48	Spitzer/IRAC	Perley et al. (2013)
4.4365[a]	4.5	12.28±0.59	Spitzer/IRAC	Perley et al. (2013)
97.903[a]	100μm	4900±700	*Herschel*/PACS	Hunt et al. (2014)
153.94[a]	160μm	10700±2000	*Herschel*/PACS	Hunt et al. (2014)
873[b]	band7	50±11	ALMA	This work
100000	S/3GHz	11.34±2.84[c]	VLA	Perley et al. (2015)

[a] Effective wavelength (http://svo2.cab.inta-csic.es/theory/fps3/index.php?mode=browse).
[b] Central wavelength of the spectral windows used for the continuum image (Fig. 1c).
[c] NOT used in the model without radio emission in SED fitting analysis to avoid the possible contaminated flux from the long-lived afterglow.

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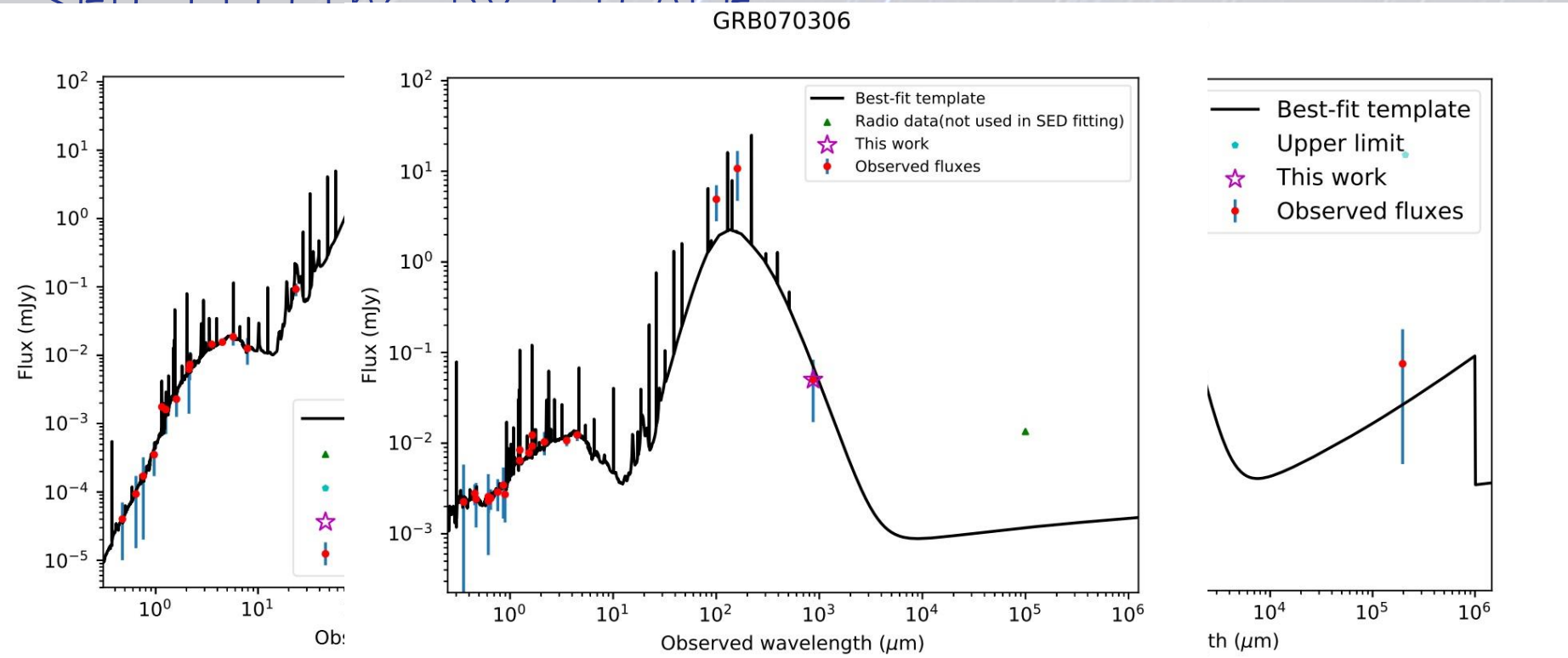
d flux from the long-lived afterglow.

SED fitting by CIGALE



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Results of SED fitting

Table 7. Physical parameters of GRB 070306 hosts in different model conditions.

	GRB 070306			
Physical parameters	AGN	Radio emission	Both	None of these two[a]
Stellar mass ($M_\odot$)	$2.99^{+0.45}_{-0.45} \times 10^{10}$	$3.07^{+0.46}_{-0.46} \times 10^{10}$	$3.02^{+0.47}_{-0.47} \times 10^{10}$	$3.05^{+0.44}_{-0.44} \times 10^{10}$
SFR ($M_\odot$ yr^{-1})	$37.60^{+2.23}_{-2.23}$	$38.63^{+1.93}_{-1.93}$	$38.25^{+1.91}_{-1.91}$	$37.93^{+2.19}_{-2.19}$
Total IR luminosity ($L_\odot$)	$(2.58^{+0.26}_{-0.26}) \times 10^{11}$	$(2.67^{+0.20}_{-0.20}) \times 10^{11}$	$(2.66^{+0.22}_{-0.22}) \times 10^{11}$	$(2.59^{+0.26}_{-0.26}) \times 10^{11}$
Better IMF	Chabrier (2003)	Chabrier (2003)	Chabrier (2003)	Chabrier (2003)
Reduced χ^2	2.34	2.39	2.40	2.34

[a] Indicate that this model setting have the closet reduced χ^2 value to 1, and considered the best fit in this paper.

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Discussion & Conclusion

Reduced chi^2 of different models

Table 10. Physical parameters of GRB 070306 hosts comparing to previous work.

	GRB 070306			
Physical parameters	Krühler et al. (2011)	Hunt et al. (2014)	Perley et al. (2015)	Best-fit(None of those two)
Stellar mass ($M_\odot$)	2.45×10^{10}	1.12×10^{10}	$5^{+0.1}_{-0.2} \times 10^{10}$	$3.05^{+0.44}_{-0.44} \times 10^{10}$
SFR ($M_\odot$ yr^{-1})	$12.59^{+12.53}_{-4.65}$	144.1	17^{+7}_{-5}	$37.93^{+2.19}_{-2.19}$
Total IR luminosity ($L_\odot$)		15.1×10^{11}		$(2.59^{+0.26}_{-0.26}) \times 10^{11}$
IMF	Chabrier (2003)	$S2C^{1.8}$	$S2C^{1.6}$	Chabrier (2003)

S2C means that the original setting of IMF is Salpeter (1955). But they use some factor to transform Chabrier (2003) in order to fair comparing to others.
$^{1.8}$Shows that divided by using factor 1.8 from Salpeter (1955) to Chabrier (2003)
$^{1.6}$Shows that divided by using factor 1.6 from Salpeter (1955) to Chabrier (2003)
^{M} Shows that times the factor in Madau & Dickinson (2014) (0.61 for stellar mass and 0.63 for SFR) from Salpeter (1955) to Chabrier (2003).

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Conclusion

$$SFR_{GRB080207} = 397.38 \pm 19.86 (M_{\odot} yr^{-1})$$

$$SFR_{GRB060814} = 55.55 \pm 9 (M_{\odot} yr^{-1})$$

$$SFR_{GRB070306} = 37.93 \pm 2.19 (M_{\odot} yr^{-1})$$

$$SFR\left(M_{\odot} yr^{-1}\right) = 1.722 \times 10^{-10} L_{FIR} (L_{\odot} s^{-1})$$ Kennitcutt(1998)

All three host galaxies are more closer to SFR from Kennitcutt relation comparing to the previous literature.

Conclusion

We determine the best model for each GRB host is

With AGN fraction$= 0.0012 \pm 0.0007$ for GRB080207

With Radio emission and radio data for GRB060814

Without these two models for GRB070306

Conclusion

We determine the IMF for each GRB host is

Salpeter(1955) for GRB080207

Chabrier(2003) for GRB060814

Chabrier(2003) for GRB070306

We believe with new data, our estimation is more reliable

Future Work

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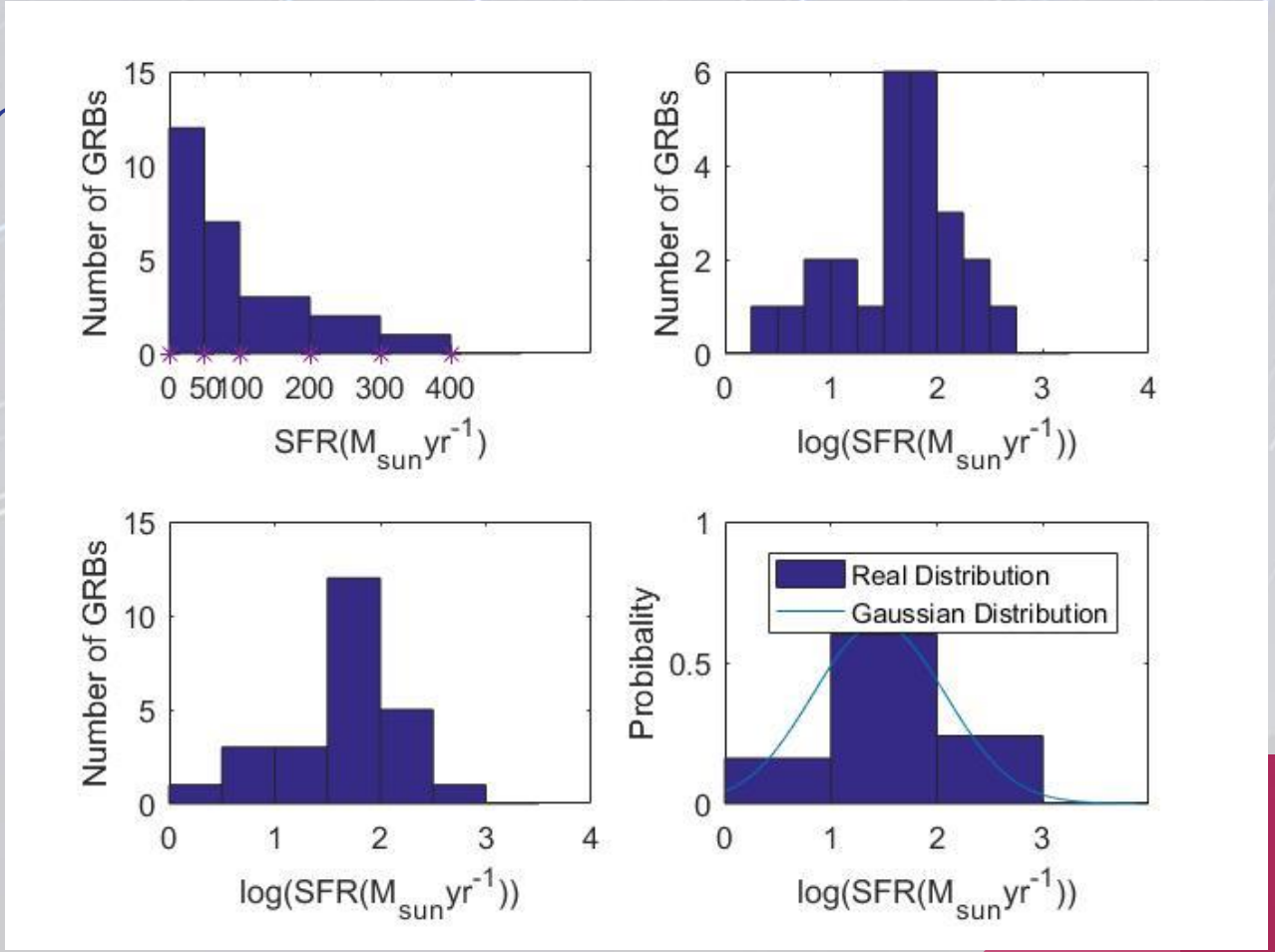
Compariso

Publish t



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Thanks for your attention