AT2018cow: the poster-child relativistic explosion for high-frequency time-domain astronomy

2017.A.00047.T

ABSTRACT

AT2018cow is the nearest relativistic supernova in 20 years, and could be a new member of the rare class of low-luminosity GRBs. Five days after the initial optical discovery, we found a very strong detection at 230 GHz with the SMA, and initiated a nightly monitoring program. This is the first time a relativistic supernova has been observed so early at sub-millimeter wavelengths. Sub-mm observations offer a unique diagnostic, especially of the reverse shock, of relativistic blastwaves. There is an extensive worldwide campaign to observe AT2018cow across the electromagnetic spectrum. Given our bright sub-millimeter detection, this event also has the possibility to become a poster child for high-frequency time-domain astronomy. To complement our ongoing SMA monitoring campaign, here we request ALMA observations in Bands 6, 7, 8, and 9. The proposed ALMA observations, combined with our approved decimeter to centimeter ATCA observations, and the ongoing Swift X-ray monitoring, will fully capture the forward shock (the afterglow) and the reverse shock, thereby enabling us to measure the circum-explosion density, the blastwave energy, and the microphysics of this relativistic shock.

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ESTIMATED 12M TIME:	**2.6 h**	**ESTIMATED ACA TIME:**	**0.0 h**	**ESTIMATED NON-STANDARD MODE TIME (12-M):**	**1.2 h**

CO-PI NAME(S): (Large & VLBI Proposals only)	
CO-INVESTIGATOR NAME(S):	Daniel Perley; Shri Kulkarni; Vikram Ravi; Bjorn Emonts
DUPLICATE OBSERVATION JUSTIFICATION:	

REPRESENTATIVE SCIENCE GOALS (UP TO FIRST 30)

SCIENCE GOAL	POSITION	BAND	ANG.RES.(")	LAS.(")	ACA?	NON-STANDARD MODE
Monitor AT2018cow in Band 7	ICRS 16:16:00.2200, 22:16:04.800	7	1.138 - 0.103	0.000	N	N
Monitor AT2018cow in Band 8	ICRS 16:16:00.2200, 22:16:04.800	8	0.968 - 0.087	0.000	N	Y
Monitor AT2018cow in Band 9	ICRS 16:16:00.2200, 22:16:04.800	9	0.585 - 0.053	0.000	N	Y
Monitor AT2018cow in Band 6	ICRS 16:16:00.2200, 22:16:04.800	6	1.649 - 0.149	0.000	N	N
Total # Science Goals : 4						

SCHEDULING TIME CONSTRAINTS	There are time constraints.	**TIME ESTIMATES OVERRIDDEN ?**	No

Context. In the final collapse and explosion of a massive star, $>10^{51}$ erg are liberated as the iron core collapses to a neutron star or a black hole, driving a spherical shock that unbinds the star in a core collapse (CC) supernova (SN). In a small subset (0.1%) of CC SNe a relativistic bipolar jet is launched, drills through the envelope, and shocks the circumstellar medium (CSM). Internal shocks in the jet produce a long-duration gamma-ray burst (GRB) while the shock of the CSM results in an "afterglow" that radiates across the EM spectrum for days to months. The accompanying type "Ic-BL" SN has significantly higher energies and photospheric velocities (hence the terminology broad-line or BL) than normal CC SNe.

A major focus of scientific investigation over the past two decades has been to understand the connections between "extreme" supernovae with successful relativistic jets and ordinary supernovae without them. One challenge is the sheer rarity of energetic, relativistic SNe: they are typically only found at great distances where they are difficult to study. Breakthroughs have resulted from nearby, once-in-a-generation events that can be studied in great detail.

Until now, SN 1998bw ($d = 38$ Mpc) has been the paragon of such events (Galama et al. 1998; Kulkarni et al. 1998). SN 1998bw was a relativistic SN accompanied by the first confirmed "low-luminosity GRB," GRB 980425. Despite the fact that the rate of LLGRBs might be 10–100× larger than that of classical GRBs, only six have been discovered to date because of their lower intrinsic luminosities, and thus smaller accessible detection volume. Modeling of the radio emission from LLGRBs suggests quasi-spherical ejecta coupled to mildly relativistic ($\Gamma\beta \approx 4$) material. A popular view is that these events have jets which failed to penetrate the surface ("choked jet") with the gamma rays arising from shock breakout into the dense CSM (Bromberg et al. 2011). Indeed, several have shown early shock breakout signatures (e.g. Soderberg et al. 2006).

Significance of AT2018cow. At 60 Mpc, the recently discovered AT2018cow (ATel #11727; discovered by ATLAS) is the nearest relativistic supernova since SN 1998bw. It was classified as Ic-BL using optical spectroscopy (ATels #11740, #11742, #11753). A relativistic outflow has been confirmed by luminous X-ray and radio emission (ATel #11737, ATel #11739, ATel #11749). Together with the early thermal optical spectra, possibly signifying shock breakout, this evidence suggests that AT2018cow is a new member of the family of LLGRB-like explosions (see Figure 1), and only the second discovered optically (iPTF16asu; Whitesides et al. 2017). AT2018cow is unique in its lack of gamma rays and an early luminous, long UV outburst. This points to large amounts of energy injected below the photosphere, in addition to the shock energy seen in the radio.

In addition, our Zwicky Transient Facility imaging constrains the rise time to 5 magnitudes within 3 days, making this also a member of the class of fast-rising and luminous ($M_{\rm peak} < -20$) transients discovered in the past few years but previously only observed at cosmological distances (Drout et al. 2014; Pursiainen et al. 2018;

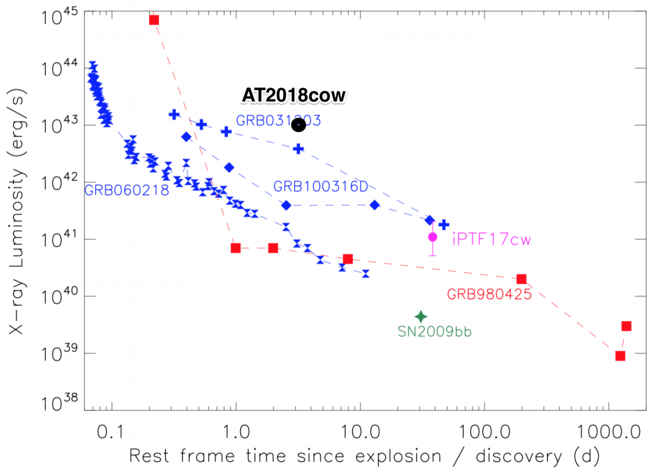

Figure 1. X-ray luminosity of AT2018cow compared to low-luminosity GRBs. Modified from Corsi et al. (2017).

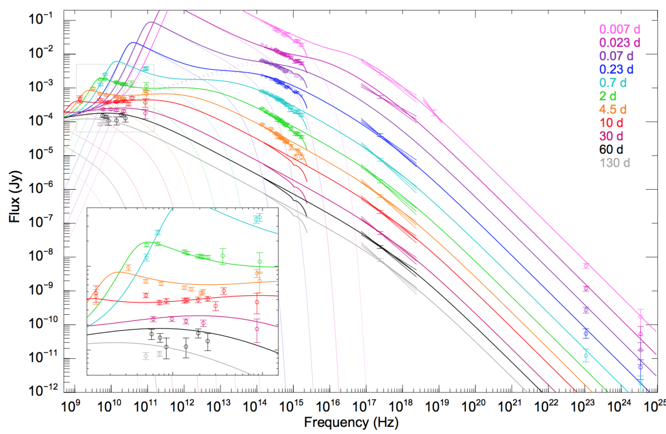

Figure 2. Panchromatic observations of the afterglow of GRB 130427A, reproduced from Perley et al. (2014). The initial spectral peak is due to the reverse shock, and the subsequent spectral peak is due to the more slowly evolving forward shock.

Rest et al. 2018). ***Thus AT2018cow may be a keystone event, linking together several classes of poorly-understood explosions.***

Importance of sub-millimeter observations. Figure 2 (see also Laskar et al. 2016) illustrates the unique diagnostic provided by sub-mm observations. Note that emission *peaks in the sub-mm bands*. In contrast, for most other types of explosions the peak flux lies in the decimeter bands. There are two sources of emission: the forward shock and the **reverse** shock.[1] In the sub-mm band the reverse shock dominates over the forward shock. The physical parameters of the relativistic outflow and the circumstellar medium can be inferred from broadband radio observations (radio, decimeter to sub-mm) in conjunction with X-ray observations (e.g. from Swift). See Laskar et al. (2018) for an example of such modeling.

Only a few GRBs have multi-epoch observational campaigns extending to high frequencies, and most of them are cosmological. GRB 110715A ($z = 0.82$) was detected in Band 6 with a flux density of 5 mJy four days post-burst (Sánchez-Ramírez et al. 2017) and GRB 161219B ($z = 0.15$) was detected in Band 3 with a flux density of

[1] As the ejecta shocks the CSM it slows down. Slower moving ejecta runs into the faster moving ejecta. This is the origin of the reverse shock.

1 mJy one day post-burst (Laskar et al., GCN#20328). Only one source is comparable to AT2018cow, and that is GRB 171205A ($z = 0.037$, 170 Mpc). Observations were undertaken 6 days post-burst (Perley et al., GCN#22252) with detections of 28 mJy in Band 3 (92 GHz) and 16 mJy in band 7 (353 GHz).

A multi-band radio campaign. For the past three nights, we have been monitoring AT2018cow with the SMA and AMI (see Table 1). We found a strong detection at 230 GHz that rose by nearly a factor of 3 in 24 hours, as well as a 0.5 mJy detection at 15 GHz. Separately, NOEMA has reported detections at 90 GHz (approx. 6 mJy) and 150 GHz (ATel #11749). We have been awarded time with the ATCA to conduct observations on June 26 at 5.5 GHz, 9 GHz, 22 GHz, and 34 GHz.

Obs. Date (UT)	Days Since Explosion	Facility	Frequency	Time on source	Flux Density (mJy)
June 21	5	SMA	230 GHz	3.5h	13.26 ± 0.35
June 22	6	SMA	230 GHz	10h25m	33.02 ± 0.46
June 22	6	AMI	15 GHz		0.5
June 23	7	SMA	230 GHz	9h40m	38.32 ± 0.43
June 23	7	SMA	345 GHz	9h40m	35.1 ± 1.7

Table 1. Observations from our SMA+AMI campaign to monitor the spectral evolution of AT2018cow.

The most puzzling behavior of the afterglow emission of AT2018cow is the *rise* at 230 GHz (see Table 1). The variability on a timescale of a day confirms the relativistic, synchrotron nature of the source (brightness temperature $\gtrsim 2 \times 10^{10}$ K). The simplest explanation is that fresh energy continues to be injected. Indeed, there was a hint of this phenomenon in the centimeter afterglow of SN1998bw/GRB980425 (Kulkarni et al. 1998) This conjecture is supported by the very gradual decline of the X-ray flux (GCN #11761), and will be tested by our proposed ALMA monitoring observations.

Observing request and future plans. We anticipate that AT2018cow will be by far the best-studied relativistic explosion at mm and sub-mm wavelengths. We have been granted SMA time for nightly monitoring at 230 GHz and 345 GHz for the next three nights. As noted above ATCA observations will be undertaken mid-week. Here we request time for (1) wide-band ALMA observations at a single epoch (**as soon as possible**, and ideally coeval with the ATCA observations) and (2) a second epoch 7-12 days from then when the source fades below SMA sensitivity.

ALMA can play a crucial role by being the only telescope observing above 350 GHz, an important and largely unexplored frequency region in which the multi-wavelength SED of the shockwave may be peaking. For the first epoch, we ask for observations in Bands 7, 8, and 9. The Band 7 observations are to tie the ALMA and SMA measurements to the same scale. The Bands 8 and 9 observations are key because the peak frequency appears to be very high (at least for now) and these observations will greatly improve our constraints about it and confirm in particular whether it is above, below, or in the sub-mm band at each epoch. For the second epoch, when the source has faded below SMA sensitivity, we ask for observations in Band 6 and Band 7.

By identifying the synchrotron peak frequency, we can infer key parameters such as the blast-wave radius (and hence the expansion speed of the ejecta), and density of the circum-explosion medium. As the ejecta decelerate, the total energy input can be estimated from the spectral evolution. Furthermore, recent GRB observations have shown that asymmetries and irregularities and the presence of multiple outflow components often confuse these diagnostics (Sheth et al. 2003), so frequent and multi-band monitoring provide important constraints for modeling.

The proposed project is a major component of the thesis of PI Anna Ho. We envisage a joint ALMA-SMA-ATCA paper on the timescale of one month.

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2017.A.00047.T

This is a ScienceGoal in the "Target Of Opportunity" proposal
Time Constrained to **execute during one** of the following windows

SG : 1 of 4 Monitor AT2018cow in Band 7 Band 7

Measure the Band 7 continuum flux density of AT2018cow

Science Goal Parameters

Ang.Res.	LAS	Requested RMS	RMS Bandwidth	Rep.Freq.	Cont. RMS	Cont. Bandwidth	Poln.Prod.	Non-standard mode
1.1384" - 0.1027"	0.0"	100 µJy, 768 µK-94.3 mK	6414.96 km/s, 7.5 GHz	350.500000 GHz	99.827 µJy, 766.7 µK-94.2 mK	7.500 GHz	XX,YY	No

Use of 12m Array (43 antennas)

t_total(all configs)	t_science(C43-1,C...	t_total()	Imaged area	#12m pointing	12m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate
0.9 h	0.3 h	0.0 h	5.5 "	1	offset	16.6 "	453.5 s	2.9 GB	2.5 MB/s

Use of ACA 7m Array (10 antennas) and TP Array

t_total(ACA)	t_total(7m)	t_total(TP)	Imaged area	#7m pointing	7m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate

Spectral Setup : Single Continuum

Center Freq (Sky)	Center Freqs. SPWs	Eff #Ch p.p.	Bandwidth	Resolution	Vel. Bandwidth	Vel. Resolution	RMS
343.500000	336.500000	128	1875.00 MHz	15.625 MHz	1670.5 km/s	27.841 km/s	190.87 µJy, 1.6 mK
	338.500000	128	1875.00 MHz	15.625 MHz	1660.6 km/s	27.677 km/s	187.63 µJy, 1.5 mK
	348.500000	128	1875.00 MHz	15.625 MHz	1612.9 km/s	26.882 km/s	195.26 µJy, 1.5 mK
	350.500000	128	1875.00 MHz	15.625 MHz	1603.7 km/s	26.729 km/s	200 µJy, 1.5 mK

1 Target

No.	Target	Ra,Dec (ICRS)	V,def,frame --OR--z
1	1-AT2018cow	16:16:00, 22:16:04	4139.15 km/s,lsrk,RADIO

Expected Source Properties

	Peak Flux	SNR	Pol.	Pol. SNR	Linewidth	RMS (over 1/3 linewidth)	linewidth / bandwidth used for sensitivity
Line	0.00 uJy	0.0	0.0%	0.0	0 km/s		
Continuum	4.00 mJy	40.1	0.0%	0.0			

Dynamic range (cont flux/line rms): N/A

Justification for requested RMS and resulting S/N (and for spectral lines the bandwidth selected) for the sensitivity ca...

It is difficult to anticipate how this source will evolve. Based on our SMA observations, and being very conservative, we estimate that the source will fade by an order of magnitude before our ALMA observation. The flux would then be roughly 4 mJy in each band. For a 10-sigma detection, we require 0.4 mJy RMS in Band 7. However, for Band 7, the difference in reaching 0.1 mJy RMS instead of 0.4 mJy RMS (factor 4 better signal-to-noise) is only 2.5 minutes of extra observing time per epoch due to the large overheads. To increase the efficiency of our ALMA observations, and because we do not know how rapidly our target is fading (or what the spectral index will be) we therefore request to reach 0.1 mJy RMS.

Justification of the chosen angular resolution and largest angular scale for the source(s) in this Science Goal.

We aim to measure the flux density of a bright unresolved source in a field at high Galactic latitude. The current compact configuration is therefore suitable.

Justification of the correlator set-up with particular reference to the number of spectral resolution elements per line ...

We are making continuum measurements to constrain the broad-band spectrum in combination with our SMA observations at 230 and 345 GHz, and our AMI measurements at 15 GHz.

Justification and additional details of specific time constraints.

We request two epochs of observations in Band 7. It is crucial for the first epoch to be scheduled as soon as possible, because the mm/sub-mm flux density is evolving significantly on a timescale of days. Furthermore, we intend to synchronize our ALMA observations with our ongoing SMA campaign. The second epoch should be 7-12 after the first epoch. We will work with our Contact Scientist during phase-2 to specify that these observations are performed with the appropriate cadence.

2017.A.00047.T

This is a ScienceGoal in the "Target Of Opportunity" proposal
Time Constrained to **execute during one** of the following windows

SG : 2 of 4 Monitor AT2018cow in Band 8 Band 8

Measure the Band 8 continuum flux density of AT2018cow

Science Goal Parameters

Ang.Res.	LAS	Requested RMS	RMS Bandwidth	Rep.Freq.	Cont. RMS	Cont. Bandwidth	Poln.Prod.	Non-standard mode
0.9684" - 0.0874"	0.0"	400 µJy, 3.1 mK-377.4 mK	5457.387 km/s, 7.5 GHz	412.000000 GHz	283.974 µJy, 2.2 mK-267.9 mK	7.500 GHz	XX,YY	Yes

Use of 12m Array (43 antennas)

t_total(all configs)	t_science(C43-1,C...	t_total()	Imaged area	#12m pointing	12m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate
0.4 h	0.1 h	0.0 h	4.7 "	1	offset	14.1 "	302.3 s	2.7 GB	2.5 MB/s

Use of ACA 7m Array (10 antennas) and TP Array

t_total(ACA)	t_total(7m)	t_total(TP)	Imaged area	#7m pointing	7m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate

Spectral Setup : Single Continuum

Center Freq (Sky)	Center Freqs. SPWs	Eff #Ch p.p.	Bandwidth	Resolution	Vel. Bandwidth	Vel. Resolution	RMS
405.000000	398.000000	128	1875.00 MHz	15.625 MHz	1412.3 km/s	23.539 km/s	592.96 µJy, 4.9 mK
	400.000000	128	1875.00 MHz	15.625 MHz	1405.3 km/s	23.421 km/s	622.23 µJy, 5.1 mK
	410.000000	128	1875.00 MHz	15.625 MHz	1371.0 km/s	22.850 km/s	552.86 µJy, 4.3 mK
	412.000000	128	1875.00 MHz	15.625 MHz	1364.3 km/s	22.739 km/s	570.12 µJy, 4.4 mK

1 Target

No.	Target	Ra,Dec (ICRS)	V,def,frame --OR--z
1	1-AT2018cow	16:16:00, 22:16:04	4139.15 km/s,lsrk,RADIO

Expected Source Properties

	Peak Flux	SNR	Pol.	Pol. SNR	Linewidth	RMS (over 1/3 linewidth)	linewidth / bandwidth used for sensitivity
Line	0.00 uJy	0.0	0.0%	0.0	0 km/s		
Continuum	4.00 mJy	14.1	0.0%	0.0			

Dynamic range (cont flux/line rms): N/A

Justification for requested RMS and resulting S/N (and for spectral lines the bandwidth selected) for the sensitivity ca...

It is difficult to anticipate how this source will evolve. Based on our SMA observations, and being very conservative, we estimate that the source will fade by an order of magnitude before our ALMA observation. The flux would then be roughly 4 mJy in each band. For a 10-sigma detection, we require 0.4 mJy RMS in Band 8.

Justification of the chosen angular resolution and largest angular scale for the source(s) in this Science Goal.

We aim to measure the flux density of a bright unresolved source in a field at high Galactic latitude. The current compact configuration is therefore suitable.

Justification of the correlator set-up with particular reference to the number of spectral resolution elements per line ...

We are making continuum measurements to constrain the broad-band spectrum in combination with our SMA observations at 230 and 345 GHz, and our AMI measurements (or upper limits) at 90 GHz.

Justification and additional details of specific time constraints.

We request one epoch of observations in Band 8, synchronized with the first epoch of Band 7. It is crucial for the first epoch to be scheduled as soon as possible, because the mm/sub-mm flux density is evolving significantly on a timescale of days. Furthermore, we intend to synchronize our ALMA observations with our ongoing SMA campaign. We will work with our Contact Scientist during phase-2 to specify that these observations are performed with the appropriate cadence.

2017.A.00047.T

This is a ScienceGoal in the "Target Of Opportunity" proposal
Time Constrained to **execute during one** of the following windows

SG : 3 of 4 Monitor AT2018cow in Band 9 Band 9

Measure the Band 9 continuum flux density of AT2018cow

Science Goal Parameters

Ang.Res.	LAS	Requested RMS	RMS Bandwidth	Rep.Freq.	Cont. RMS	Cont. Bandwidth	Poln.Prod.	Non-standard mode
0.5850" - 0.0528"	0.0"	400 µJy, 3.1 mK-377.4 mK	6593.676 km/s, 15 GHz	682.000000 GHz	398.207 µJy, 3.1 mK-375.7 mK	15.000 GHz	XX,YY	Yes

Use of 12m Array (43 antennas)

t_total(all configs)	t_science(C43-1,C...	t_total()	Imaged area	#12m pointing	12m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate
0.8 h	0.3 h	0.0 h	2.8 "	1	offset	8.5 "	1198.0 s	12.4 GB	5.5 MB/s

Use of ACA 7m Array (10 antennas) and TP Array

t_total(ACA)	t_total(7m)	t_total(TP)	Imaged area	#7m pointing	7m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate

Spectral Setup : Single Continuum

Center Freq (Sky)	Center Freqs. SPWs	Eff #Ch p.p.	Bandwidth	Resolution	Vel. Bandwidth	Vel. Resolution	RMS
679.000000	676.000000	128	1875.00 MHz	15.625 MHz	831.5 km/s	13.859 km/s	1.12 mJy, 8.8 mK
	678.000000	128	1875.00 MHz	15.625 MHz	829.1 km/s	13.818 km/s	1.09 mJy, 8.4 mK
	680.000000	128	1875.00 MHz	15.625 MHz	826.6 km/s	13.777 km/s	1.11 mJy, 8.6 mK
	682.000000	128	1875.00 MHz	15.625 MHz	824.2 km/s	13.737 km/s	1.13 mJy, 8.7 mK

1 Target

No.	Target	Ra,Dec (ICRS)	V,def,frame --OR--z
1	1-AT2018cow	16:16:00, 22:16:04	4139.15 km/s,lsrk,RADIO

Expected Source Properties

	Peak Flux	SNR	Pol.	Pol. SNR	Linewidth	RMS (over 1/3 linewidth)	linewidth / bandwidth used for sensitivity
Line	0.00 uJy	0.0	0.0%	0.0	0 km/s		
Continuum	4.00 mJy	10.0	0.0%	0.0			

Dynamic range (cont flux/line rms): N/A

Justification for requested RMS and resulting S/N (and for spectral lines the bandwidth selected) for the sensitivity ca...

It is difficult to anticipate how this source will evolve. Based on our SMA observations, and being very conservative, we estimate that the source will fade by an order of magnitude before our ALMA observation. The flux would then be roughly 4 mJy in each band. For a 10-sigma detection, we require 0.4 mJy RMS in Band 9.

Justification of the chosen angular resolution and largest angular scale for the source(s) in this Science Goal.

We aim to measure the flux density of a bright unresolved source in a field at high Galactic latitude. The current compact configuration is therefore suitable.

Justification of the correlator set-up with particular reference to the number of spectral resolution elements per line ...

We are making continuum measurements to constrain the broad-band spectrum in combination with our SMA observations at 230 and 345 GHz, and our AMI measurements (or upper limits) at 90 GHz.

Justification and additional details of specific time constraints.

We request one epoch of observations in Band 9, synchronized with the first epoch of Band 7. It is crucial for the first epoch to be scheduled as soon as possible, because the mm/sub-mm flux density is evolving significantly on a timescale of days. Furthermore, we intend to synchronize our ALMA observations with our ongoing SMA campaign. We will work with our Contact Scientist during phase-2 to specify that these observations are performed with the appropriate cadence.

2017.A.00047.T

This is a ScienceGoal in the "Target Of Opportunity" proposal
Time Constrained to **execute during one** of the following windows

SG : 4 of 4 Monitor AT2018cow in Band 6 Band 6

Measure the Band 6 continuum flux density of AT2018cow

Science Goal Parameters

Ang.Res.	LAS	Requested RMS	RMS Bandwidth	Rep.Freq.	Cont. RMS	Cont. Bandwidth	Poln.Prod.	Non-standard mode
1.6488" - 0.1488"	0.0"	100 µJy, 768 µK-94.3 mK	9291.089 km/s, 7.5 GHz	242.000000 GHz	76.087 µJy, 584.4 µK-71.8 mK	7.500 GHz	XX,YY	No

Use of 12m Array (43 antennas)

t_total(all configs)	t_science(C43-1,C...	t_total()	Imaged area	#12m pointing	12m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate
0.4 h	0.1 h	0.0 h	8.0 "	1	offset	24.1 "	302.3 s	2.5 GB	2.4 MB/s

Use of ACA 7m Array (10 antennas) and TP Array

t_total(ACA)	t_total(7m)	t_total(TP)	Imaged area	#7m pointing	7m Mosaic spacing	HPBW	t_per_point	Data Vol	Avg. Data Rate

Spectral Setup : Single Continuum

Center Freq (Sky)	Center Freqs. SPWs	Eff #Ch p.p.	Bandwidth	Resolution	Vel. Bandwidth	Vel. Resolution	RMS
233.000000	224.000000	128	1875.00 MHz	15.625 MHz	2509.4 km/s	41.824 km/s	138.82 µJy, 1.2 mK
	226.000000	128	1875.00 MHz	15.625 MHz	2487.2 km/s	41.454 km/s	144.71 µJy, 1.3 mK
	240.000000	128	1875.00 MHz	15.625 MHz	2342.1 km/s	39.035 km/s	149.6 µJy, 1.2 mK
	242.000000	128	1875.00 MHz	15.625 MHz	2322.8 km/s	38.713 km/s	152.76 µJy, 1.2 mK

1 Target

No.	Target	Ra,Dec (ICRS)	V,def,frame --OR--z
1	1-AT2018cow	16:16:00, 22:16:04	4139.15 km/s,lsrk,RADIO

Expected Source Properties

	Peak Flux	SNR	Pol.	Pol. SNR	Linewidth	RMS (over 1/3 linewidth)	linewidth / bandwidth used for sensitivity
Line	0.00 uJy	0.0	0.0%	0.0	0 km/s		
Continuum	4.00 mJy	52.6	0.0%	0.0			

Dynamic range (cont flux/line rms): N/A

Justification for requested RMS and resulting S/N (and for spectral lines the bandwidth selected) for the sensitivity ca...

It is difficult to anticipate how this source will evolve. Based on our SMA observations, and being very conservative, we estimate that the source will fade by an order of magnitude before our ALMA observation. The flux would then be roughly 4 mJy in each band. For a 10-sigma detection, we require 0.4 mJy RMS in Band 6. However, for Band 6, the difference in reaching 0.1 mJy RMS instead of 0.4 mJy RMS (factor 4 better signal-to-noise) is negligible due to the large overheads. To increase the efficiency of our ALMA observations, and because we do not know how rapidly our target is fading (or what the spectral index will be) we therefore request to reach 0.1 mJy RMS.

Justification of the chosen angular resolution and largest angular scale for the source(s) in this Science Goal.

We aim to measure the flux density of a bright unresolved source in a field at high Galactic latitude. The current compact configuration is therefore suitable.

Justification of the correlator set-up with particular reference to the number of spectral resolution elements per line ...

We are making continuum measurements to constrain the broad-band spectrum in combination with our SMA observations at 230 and 345 GHz, and our AMI measurements (or upper limits) at 90 GHz.

Justification and additional details of specific time constraints.

We request one epoch of observations in Band 6, synchronized with the *second* epoch of Band 7. The reason for scheduling this band in the second epoch rather than the first epoch is that we anticipate the source to fade below the sensitivity threshold of the SMA. We will work with our Contact Scientist during phase-2 to specify that these observations are performed with the appropriate cadence.