

# Watching The Cow shock its environment: the millimeter-wavelength perspective

**Anna Ho (Graduate Student, Caltech)**

with Sterl Phinney, Vikram Ravi, Shri Kulkarni, Dan Perley,  
and the SMA, ALMA, and ATCA teams

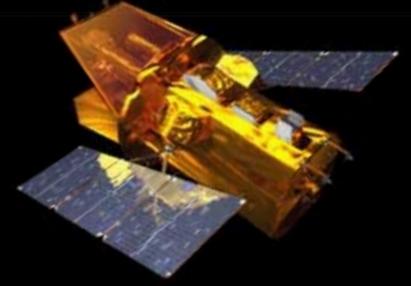
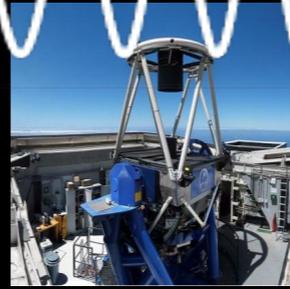
**ah@astro.caltech.edu**



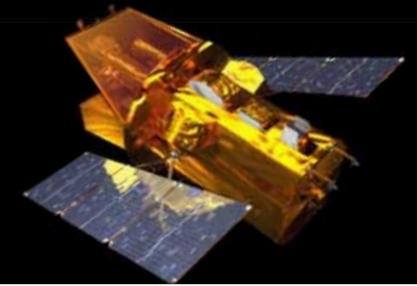
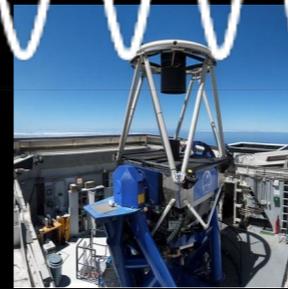
*The Submillimeter Array  
image credit Nimesh Patel*

**AAS Press Panel | 10 January 2018**

radio millimeter infrared visible ultraviolet x-ray



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radio



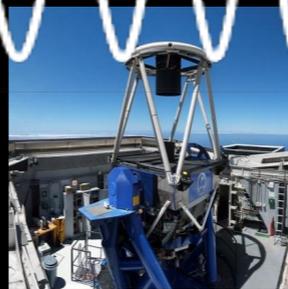
millimeter



infrared



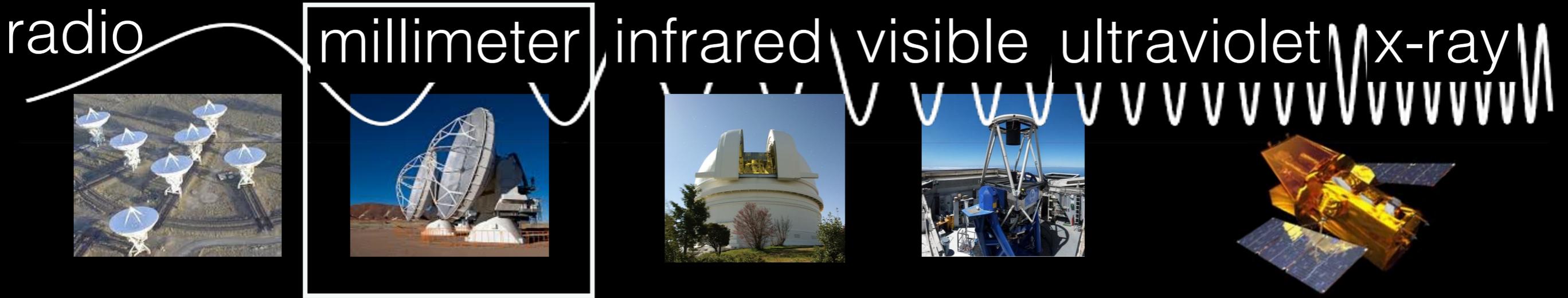
visible



ultraviolet



x-ray



## Punchline:

1. Millimeter telescopes are rarely used to follow up cosmic explosions
2. To our surprise, the Cow was one of the brightest millimeter transients ever observed, brighter than any supernova!
3. This opens a new window for millimeter astronomy

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1. Technical challenges: electronics expensive, telescopes not sensitive, need good weather
2. Astrophysical challenges: explosions fade quickly at these wavelengths

**In this case, we were fast. Five days after the discovery:**

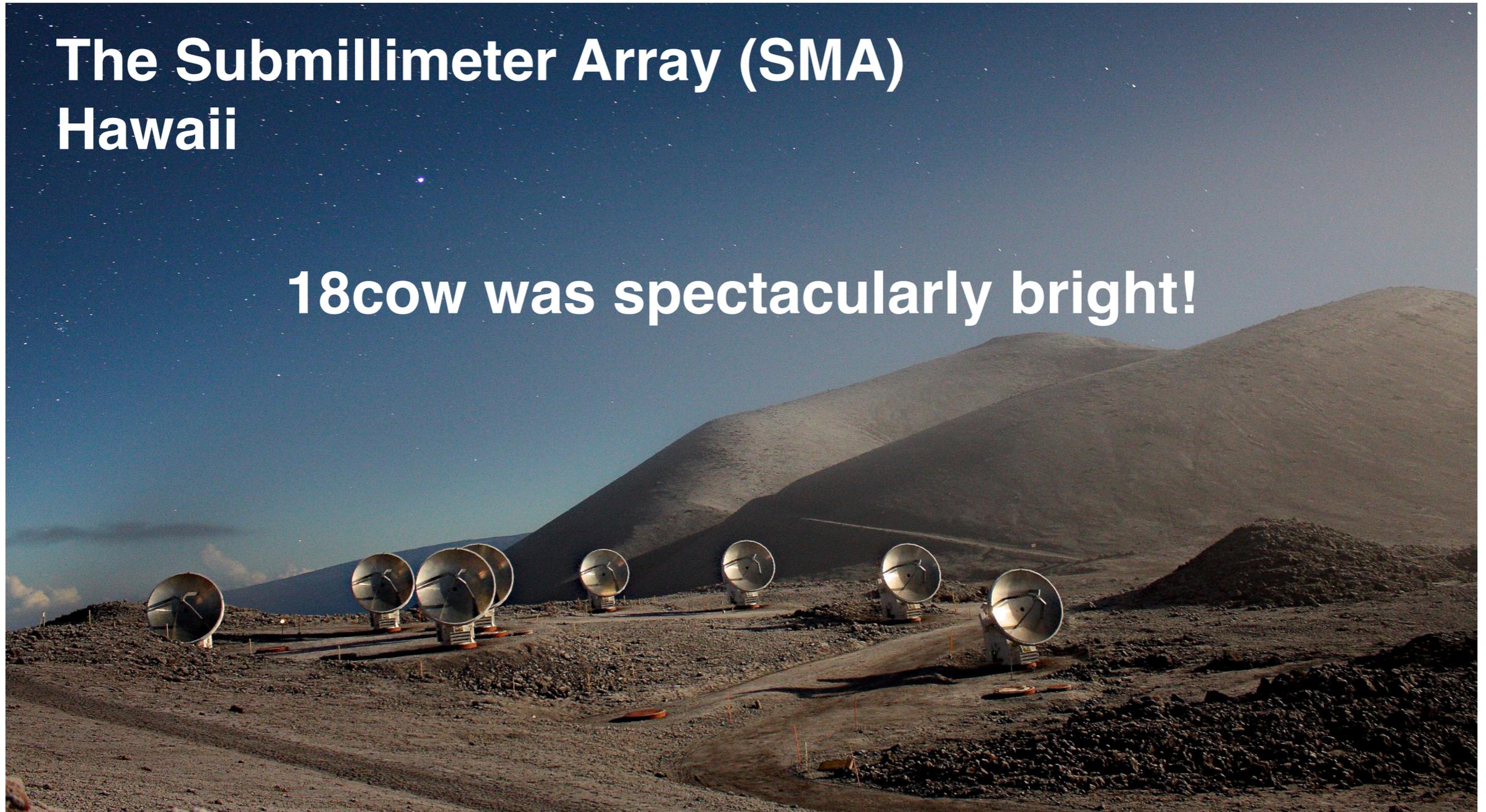
# The Submillimeter Array (SMA) Hawaii



**In this case, we were fast. Five days after the discovery:**

**The Submillimeter Array (SMA)  
Hawaii**

**18cow was spectacularly bright!**



**In this case, we were fast. Five days after the discovery:**

## **The Submillimeter Array (SMA) Hawaii**

**18cow was spectacularly bright!**

On 22/06/2018 19:10, Anna Ho wrote:  
> 33 mJy?!

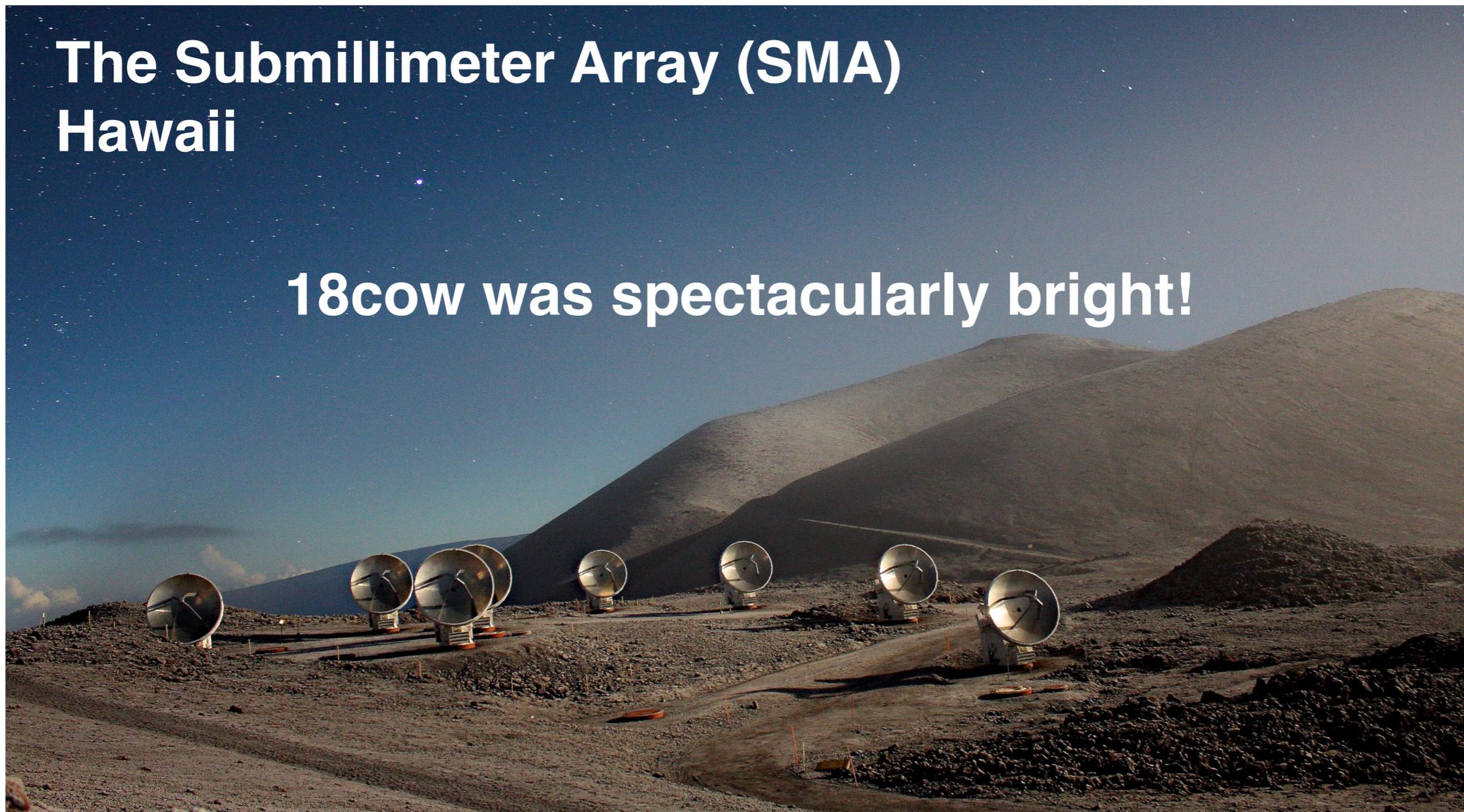
**Daniel Perley** D.A.Perley@ljmu.ac.uk  
to Anna ▼

**Yes, it's madness!!**

**In this case, we were fast. Five days after the discovery:**

**The Submillimeter Array (SMA)  
Hawaii**

**18cow was spectacularly bright!**



**This is the first time a cosmic explosion has  
been seen to *brighten* at millimeter wavelengths!**

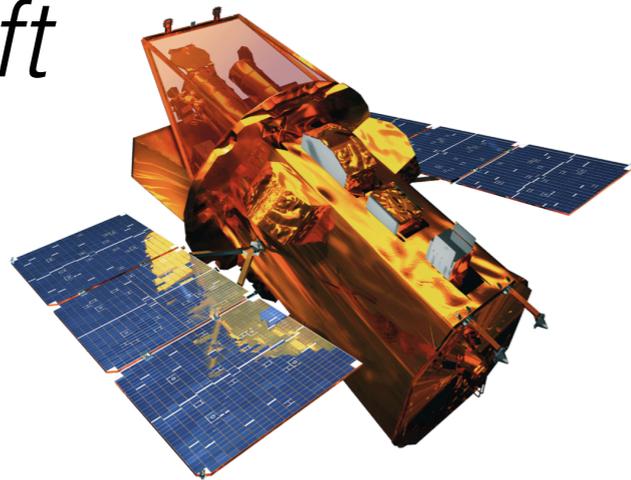
**Motivated by our SMA data, we requested ALMA time**

**The Atacama Large Millimeter/Submillimeter Array  
Atacama Desert, Chile**

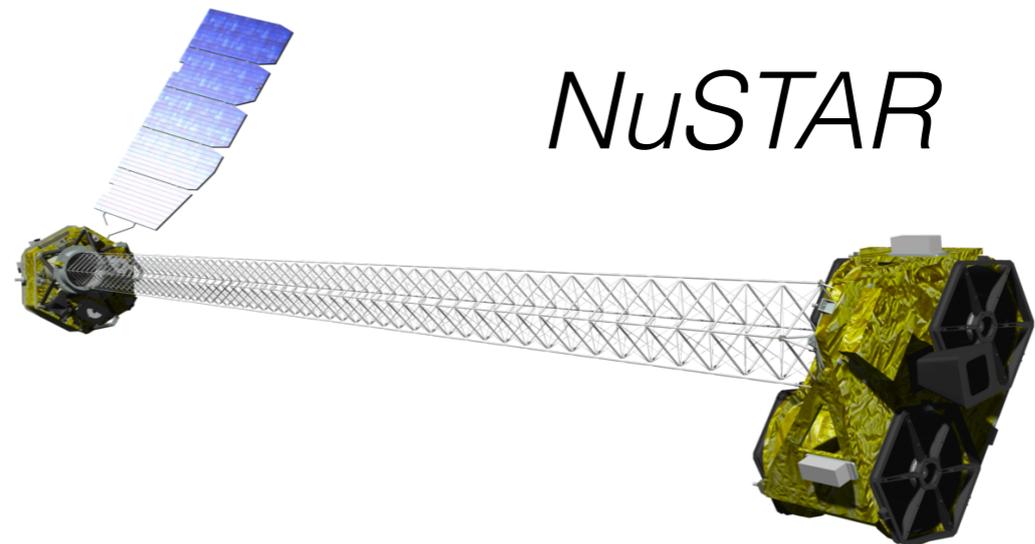


**and downloaded publicly available X-ray observations**

*Swift*



*NuSTAR*



## **With the SMA, ALMA, and X-ray data, we learned:**

1. The Cow released a large amount of energy into a dense environment

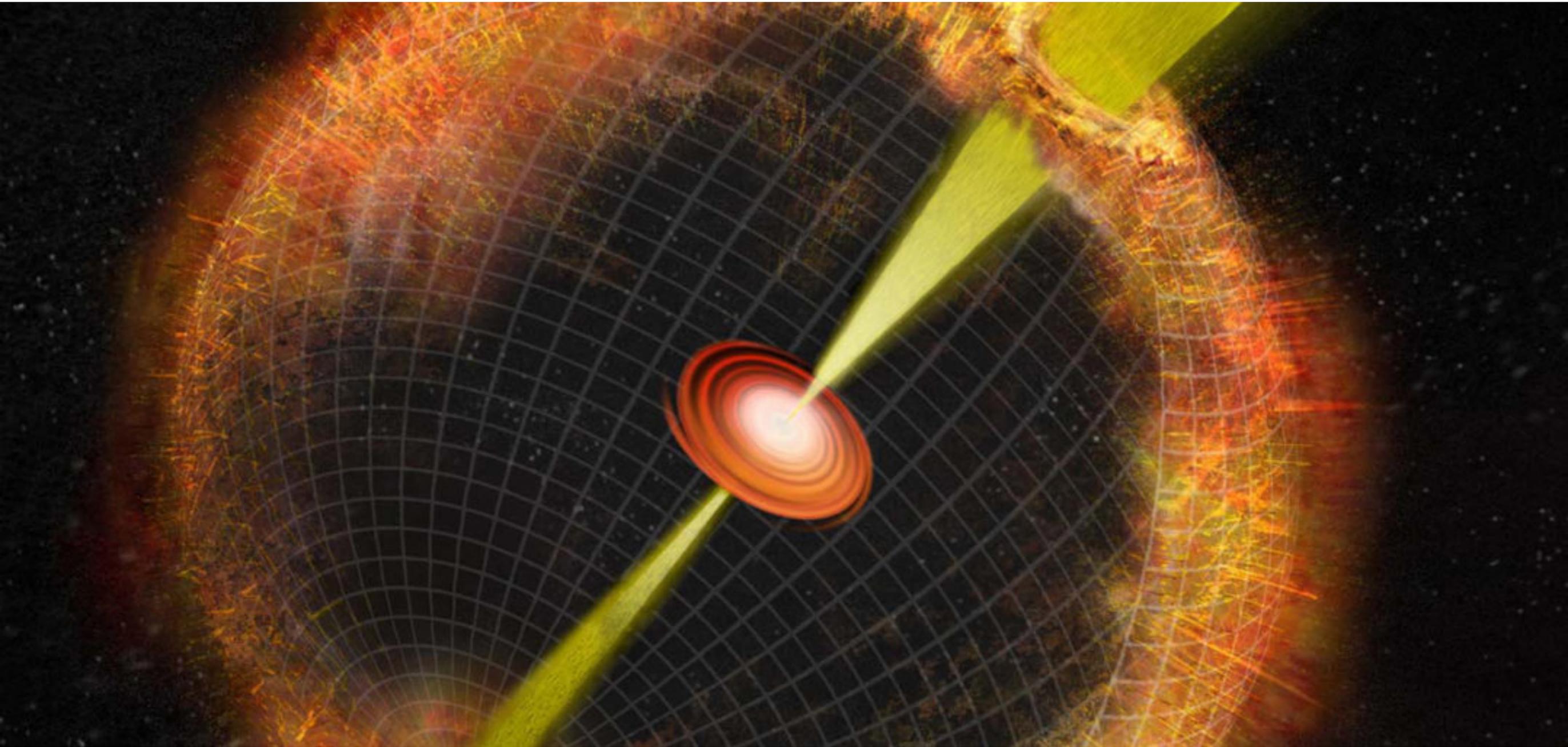
## **With the SMA, ALMA, and X-ray data, we learned:**

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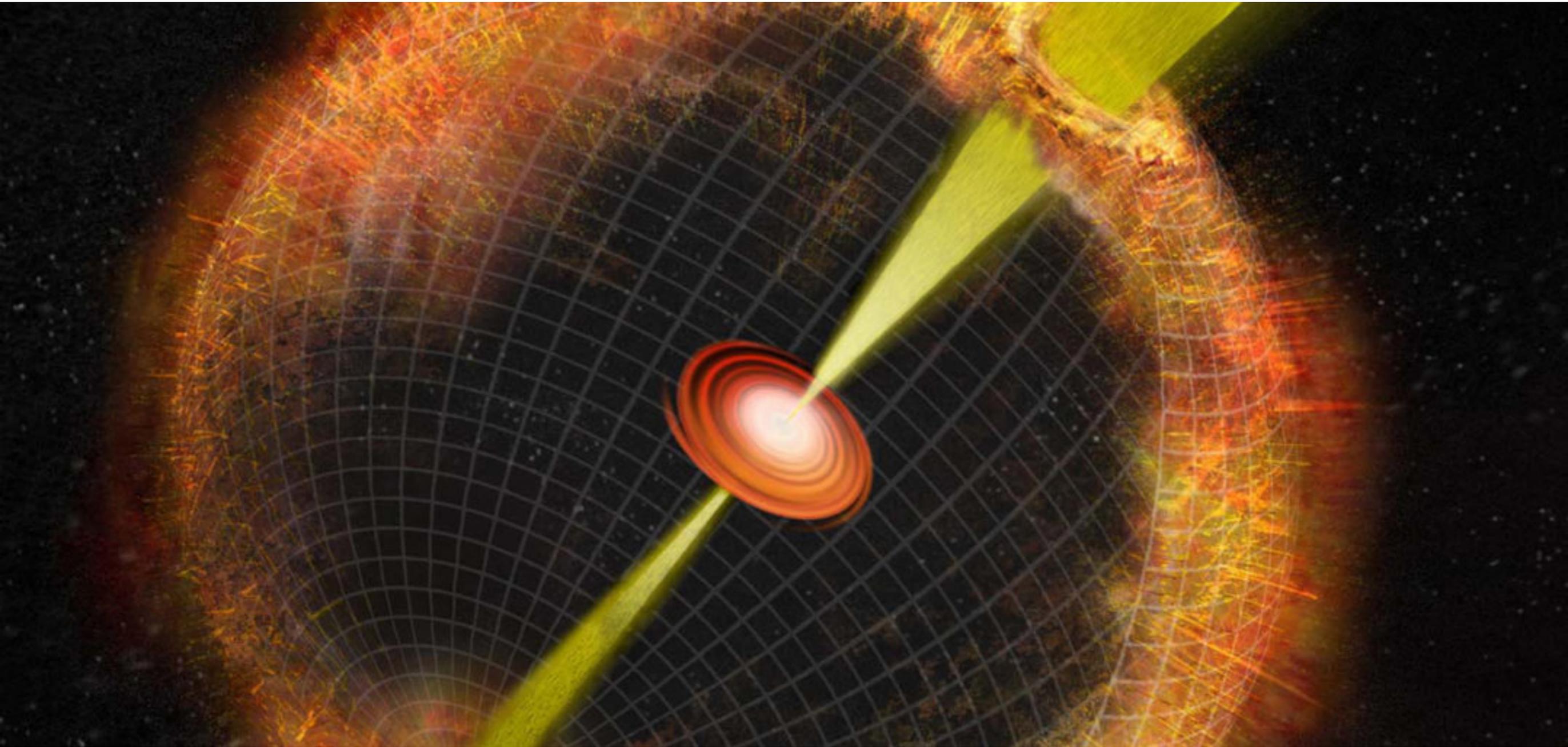
1. The Cow released a large amount of energy into a dense environment
2. The shockwave was traveling at one tenth of the speed of light
3. There must be ongoing energy production: an “engine”

# An engine can form in the death of star



*Image Credit: Bill Saxton/NRAO/AUI/NSF*

# An engine can form in the death of star



*Image Credit: Bill Saxton/NRAO/AUI/NSF*

**Astronomers witnessed the birth of an engine  
for the first time!**

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- (1) Large energy
- (2) Dense environment

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## **These circumstances are not unique to The Cow!**

The Cow is a prototype of a population of explosions that are prime targets for millimeter telescopes.

Millimeter observatories are an important window onto the deaths (and afterlives) of stars.

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