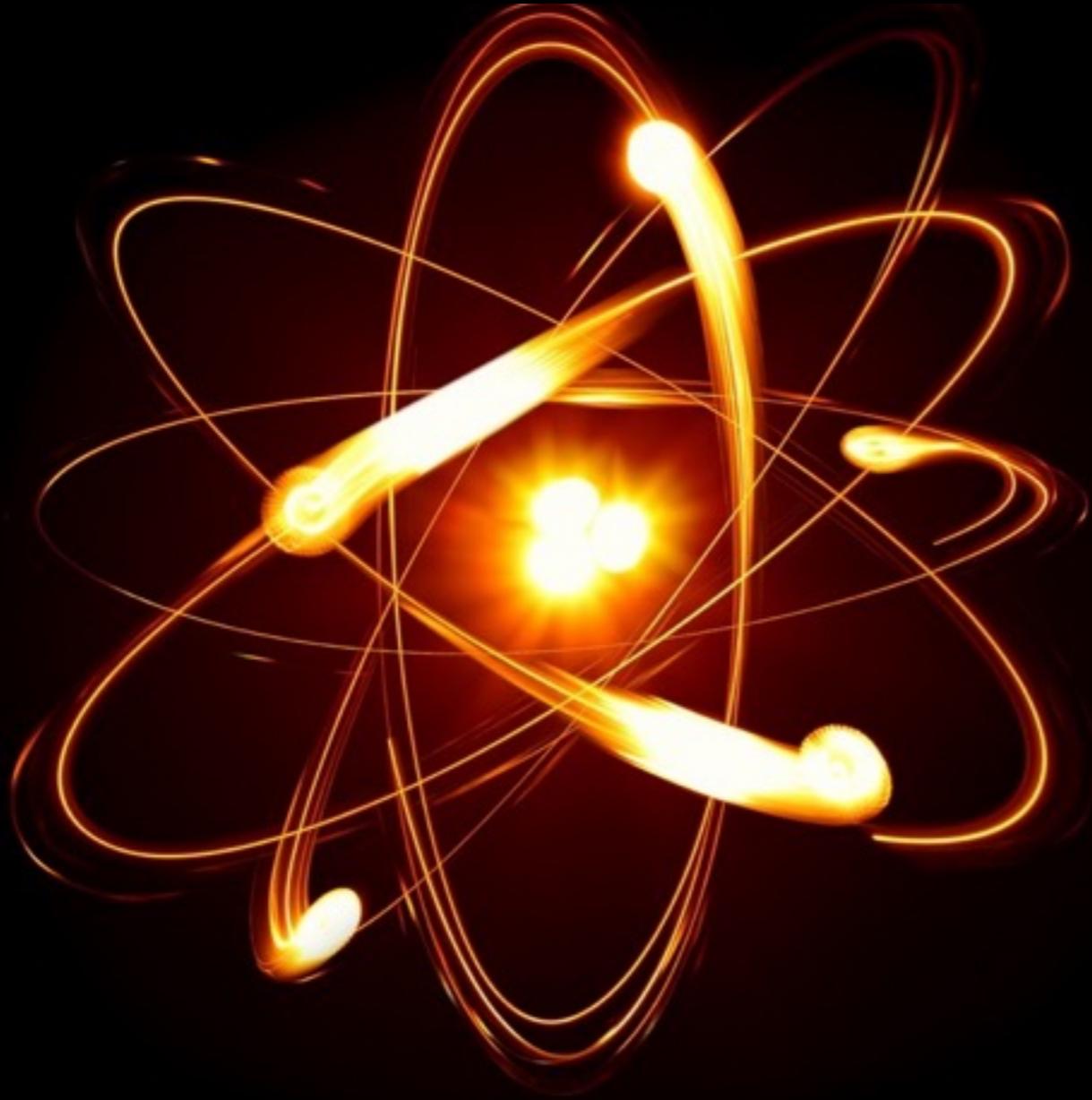


THE BRIGHTEST EXPLOSIONS IN THE  
UNIVERSE

**GAMMA-RAY BURSTS**

# MAKING GAMMA RAYS



Radio



AM radio



Amateur radio

Microwave



Aircraft communication



Microwave oven

Infrared



TV Remote Control



Night vision goggles

Visible



Ultraviolet



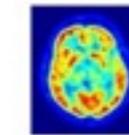
UV light from the Sun

X-ray



Airport security scanner

Gamma-ray



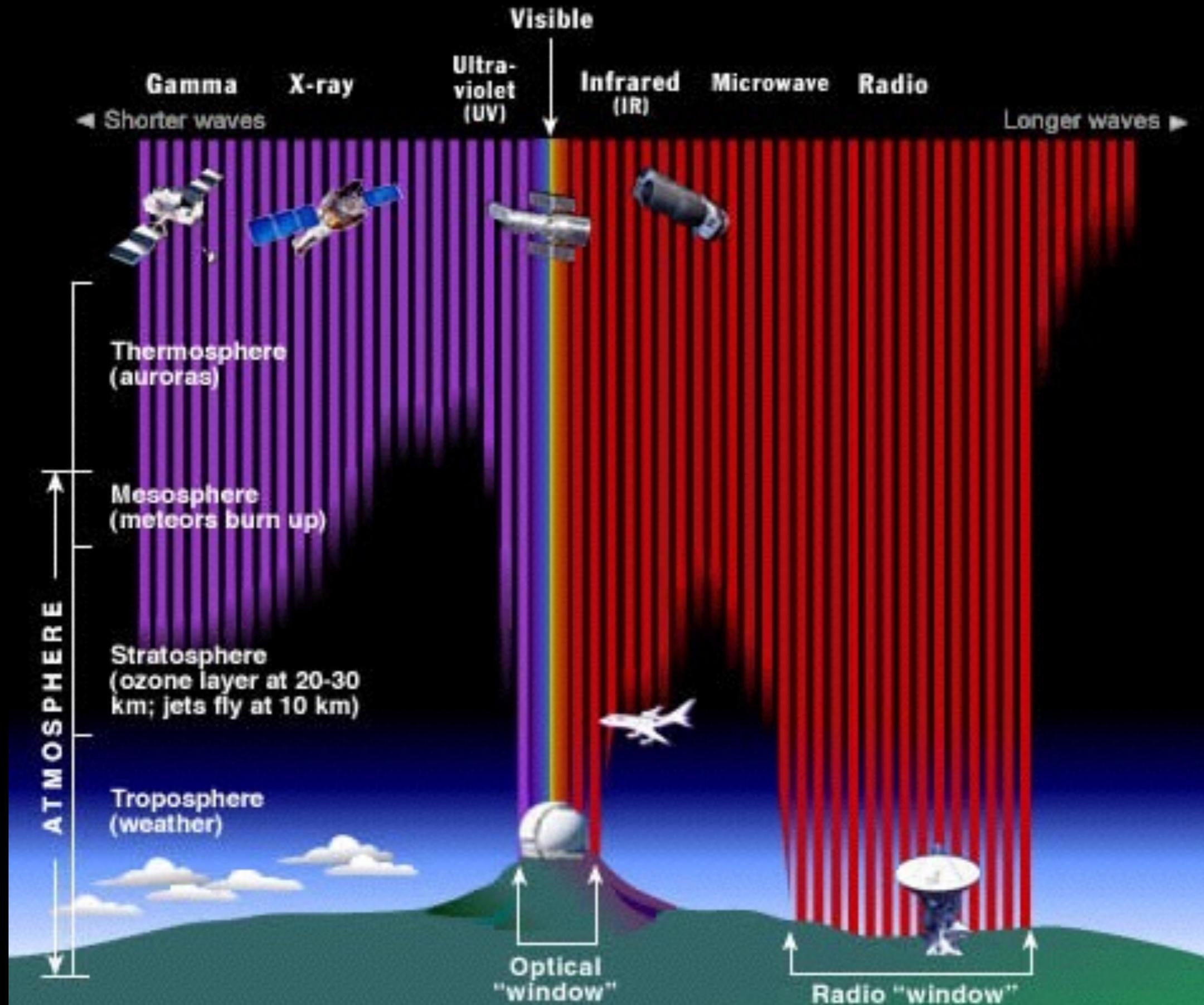
PET scan



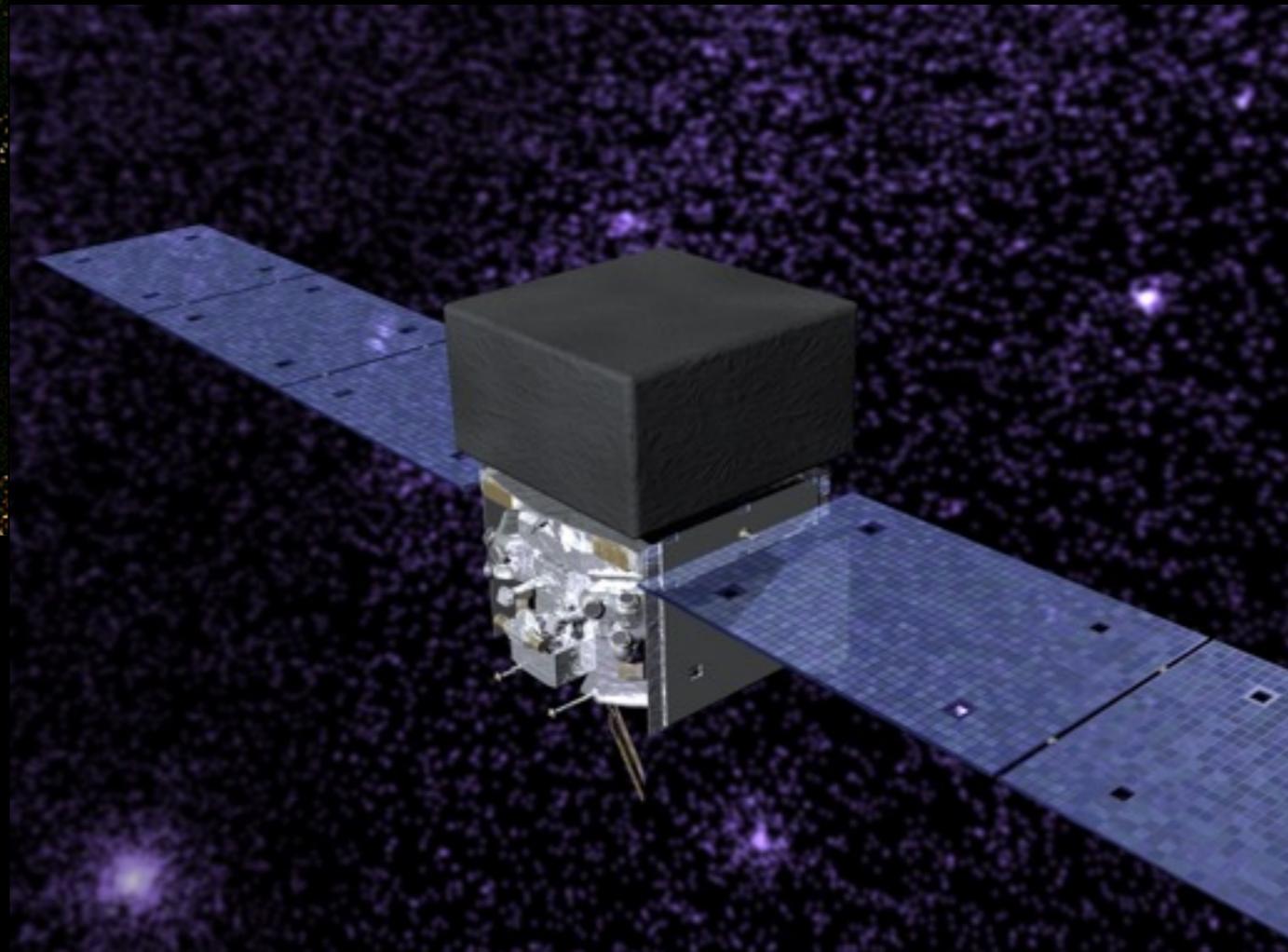
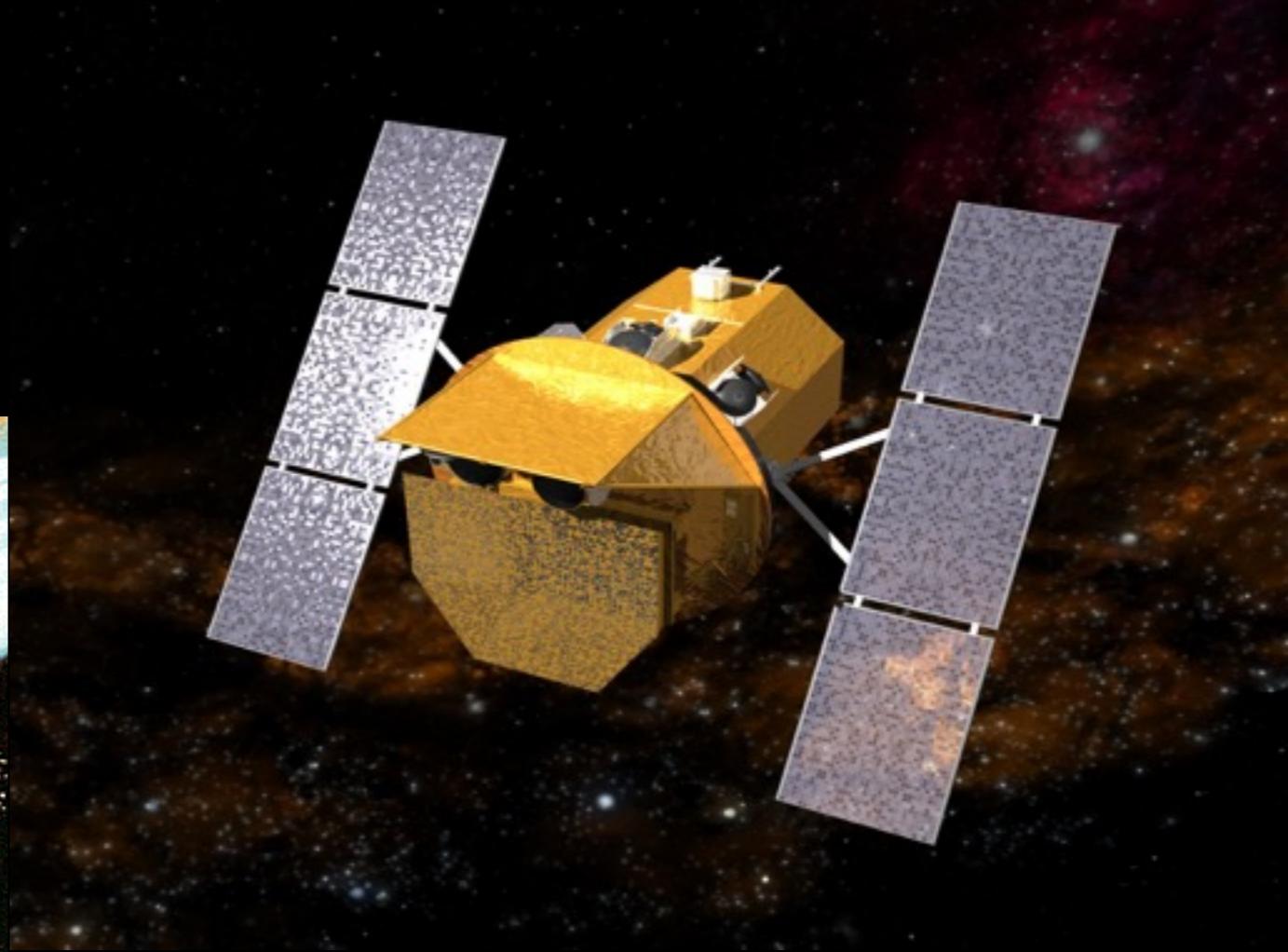
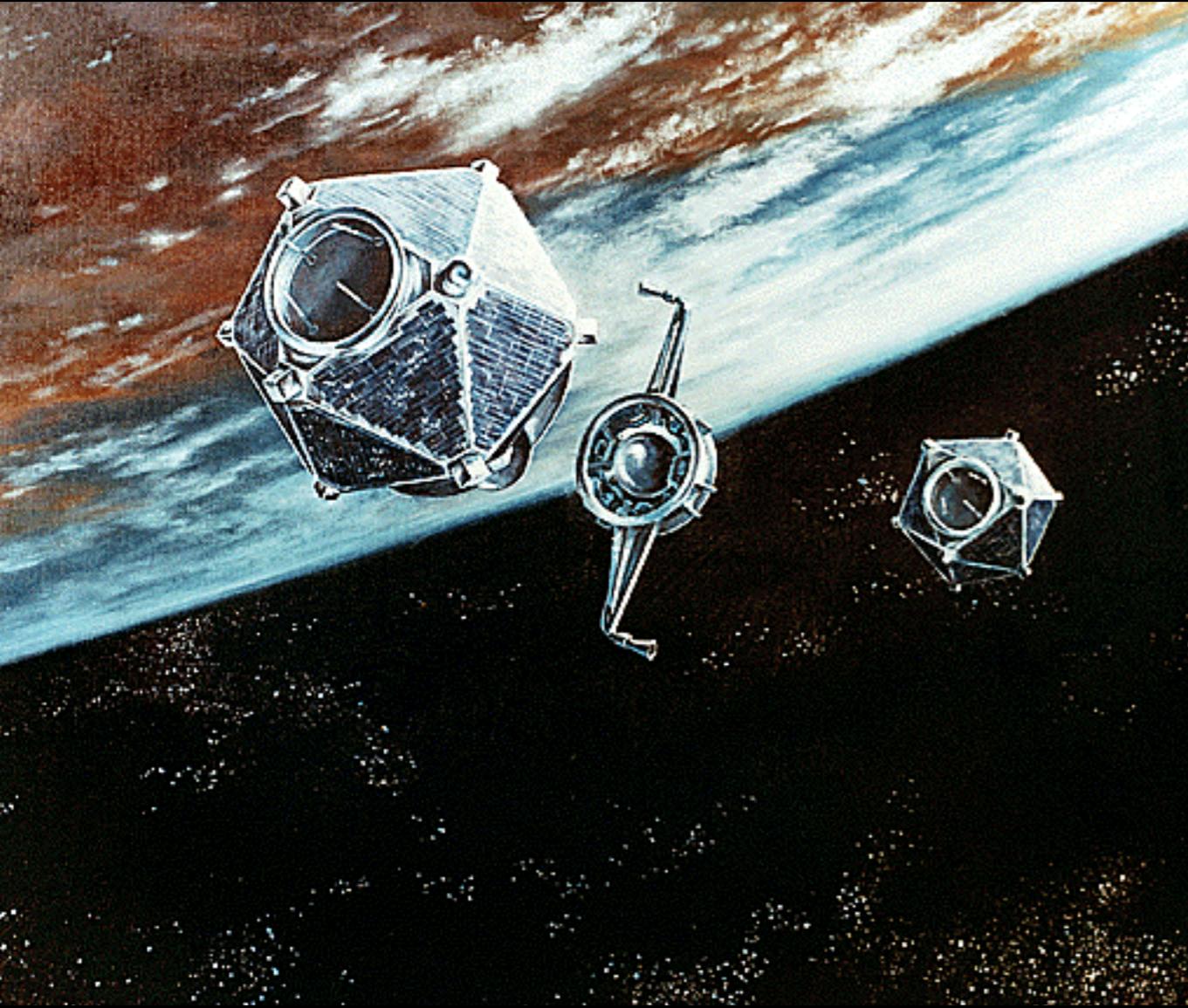
Terrestrial gamma-ray flashes



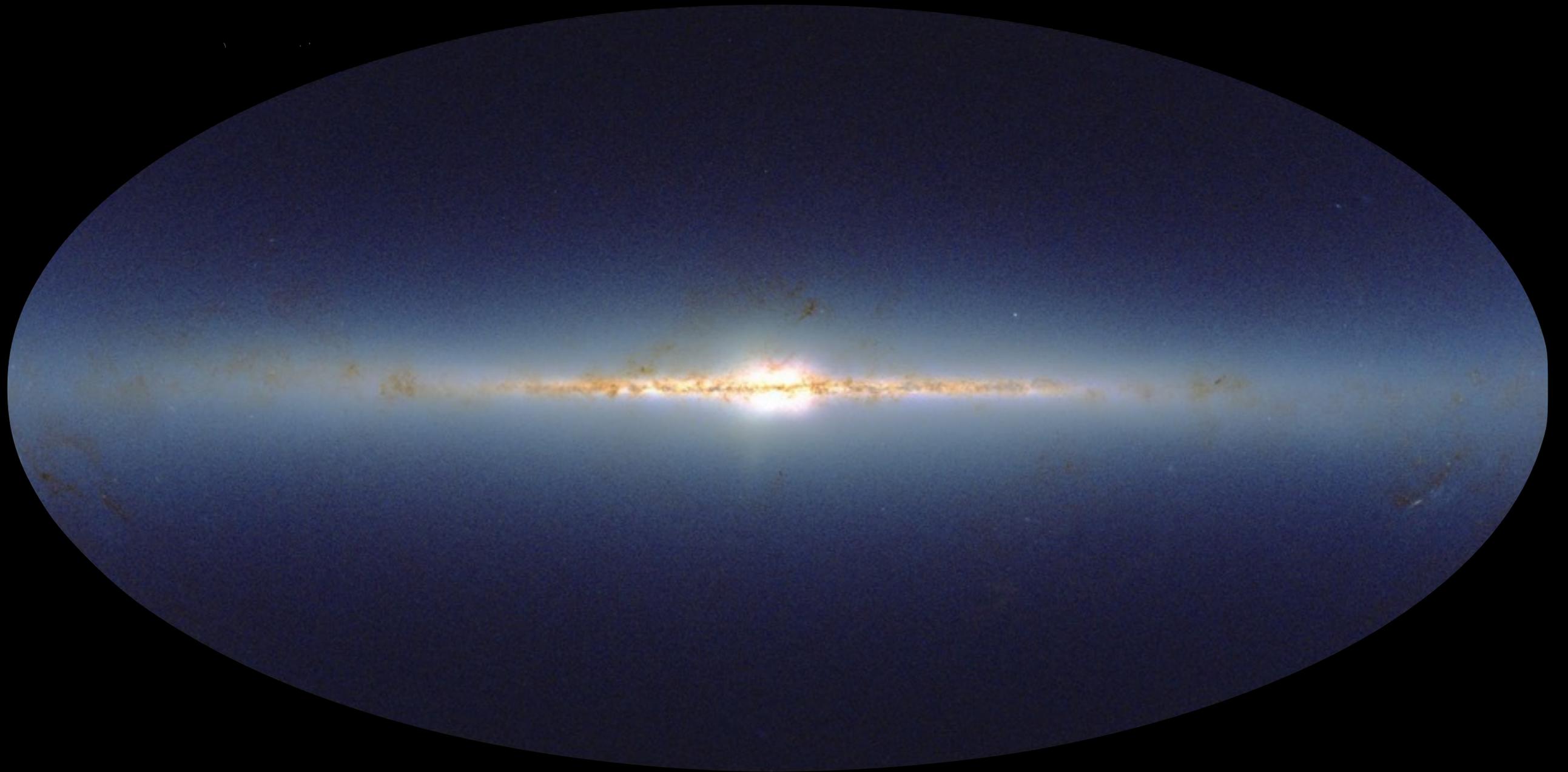
# OBSERVING A GRB



# OBSERVING A GRB

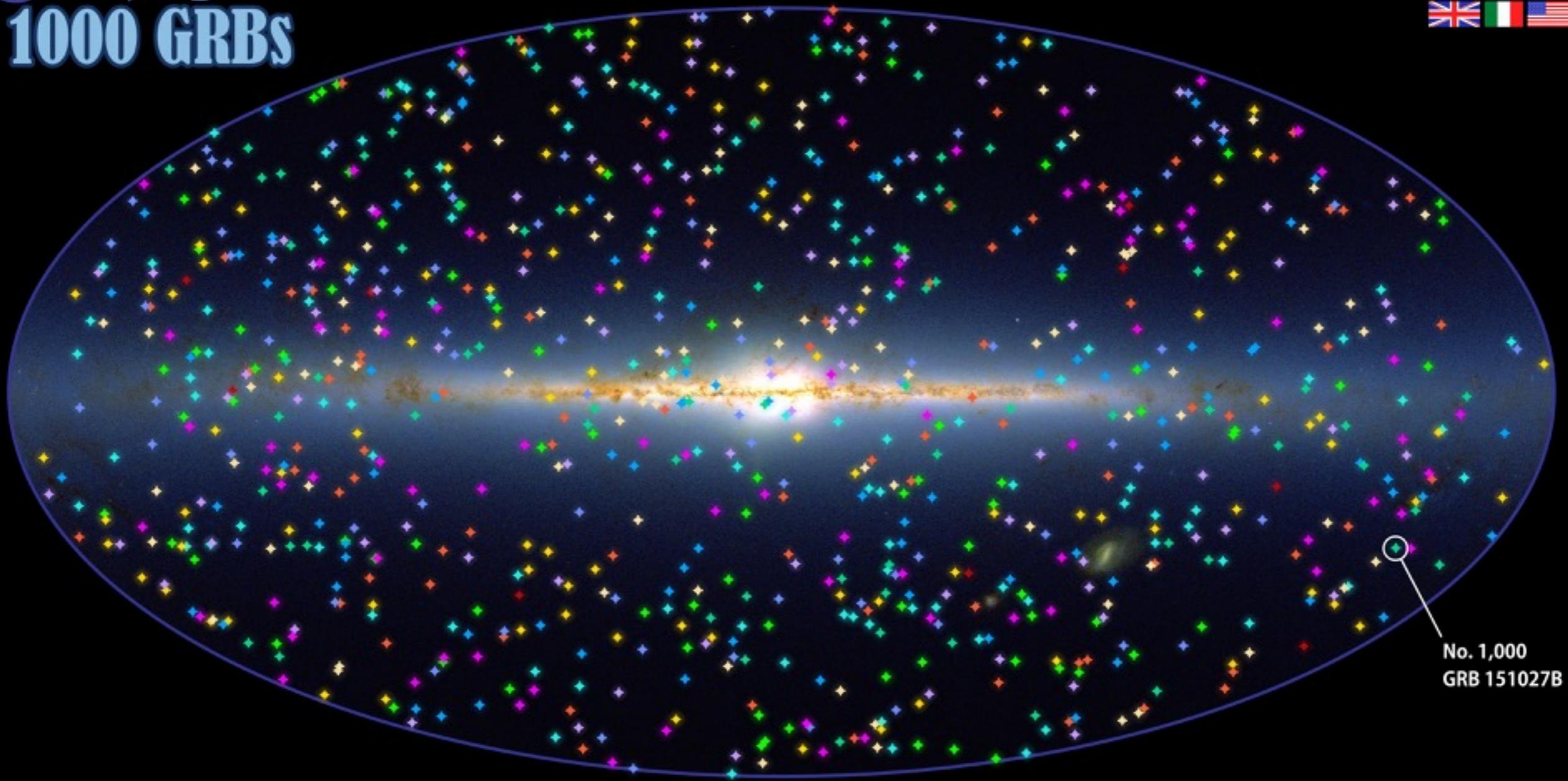


# OBSERVING A GRB



# OBSERVING A GRB

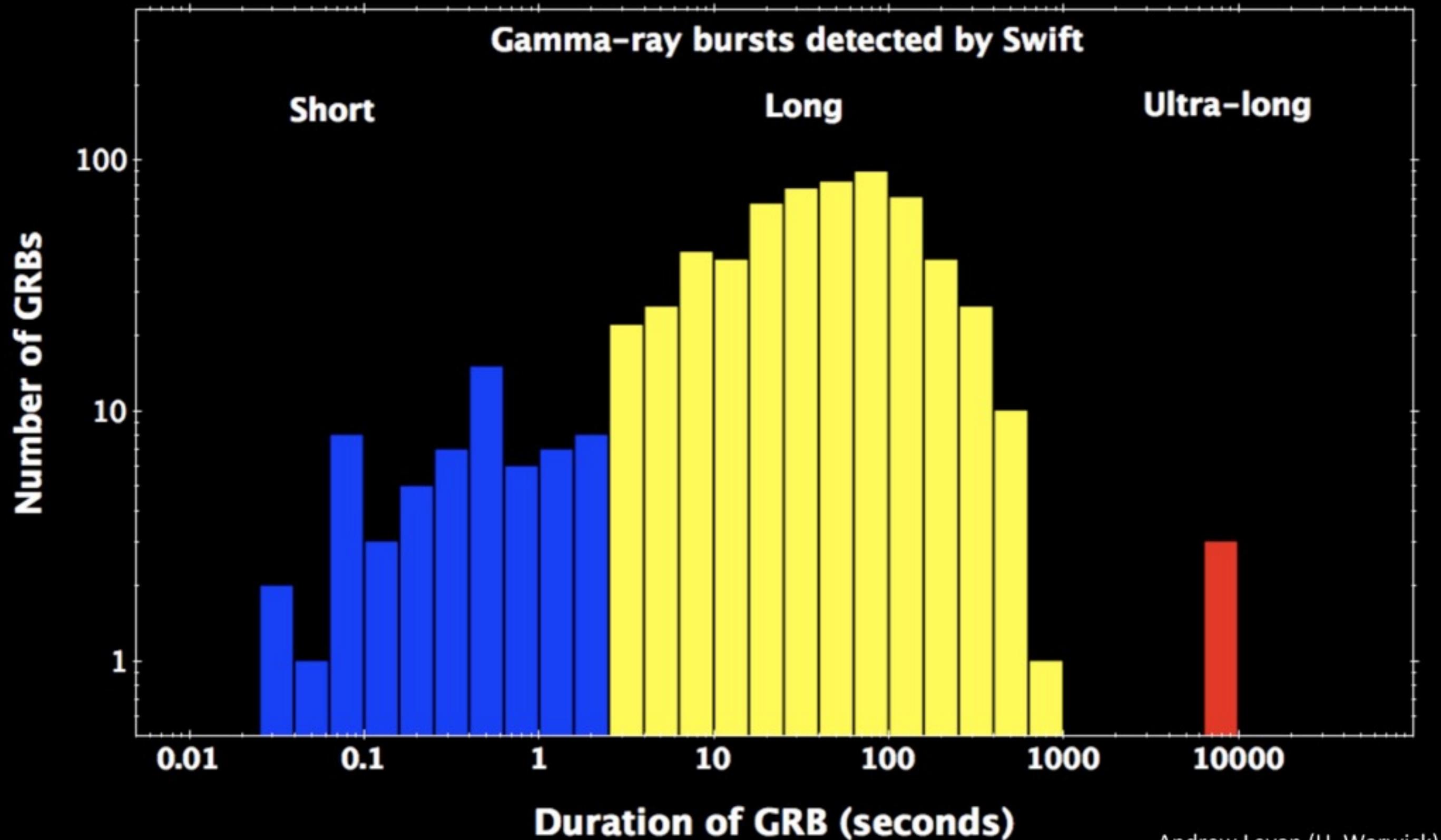
*Swift*  
1000 GRBs



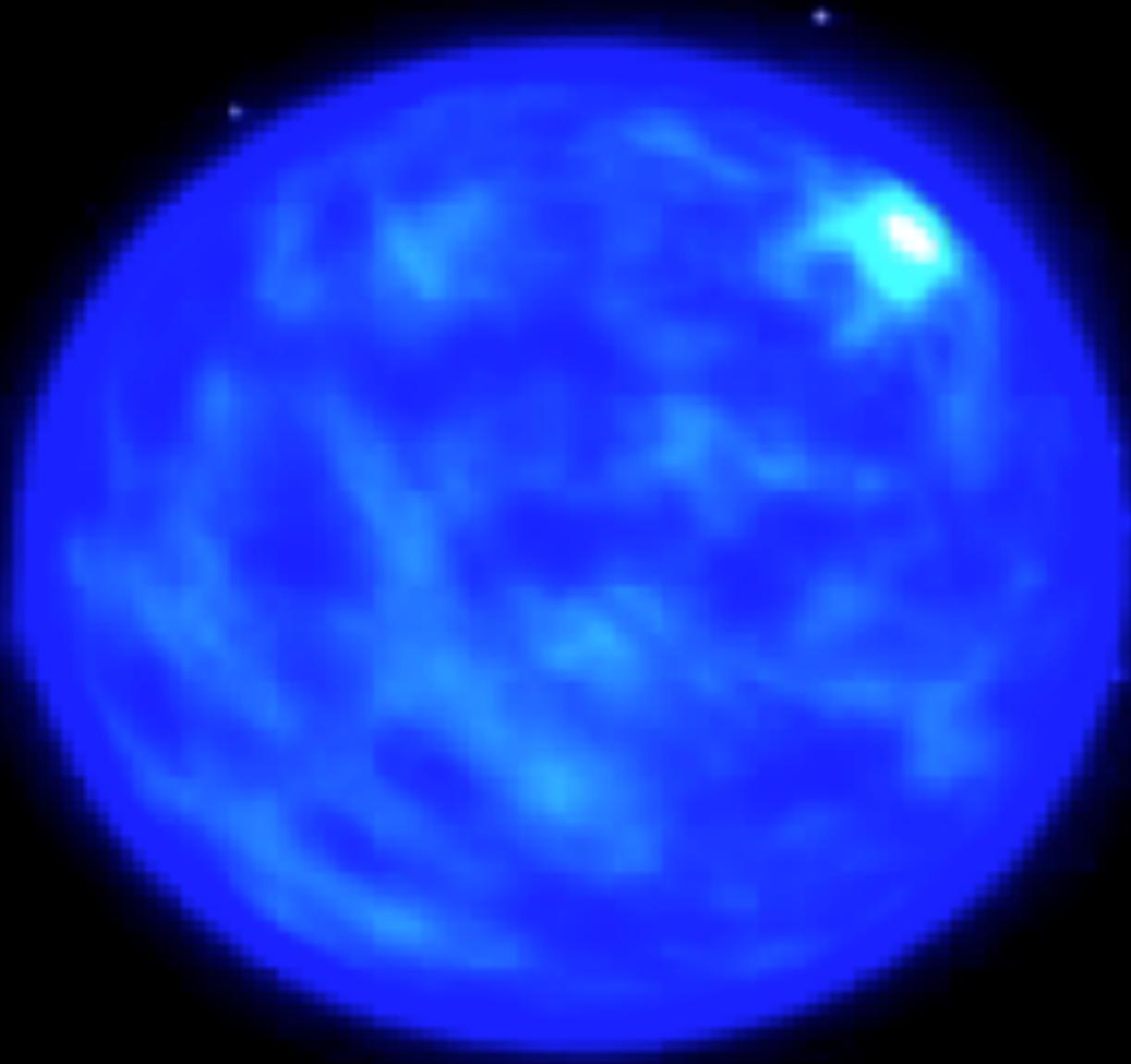
No. 1,000  
GRB 151027B

<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>
9	88	102	86	103	89	84	81	92	96	95	75 to Oct. 27

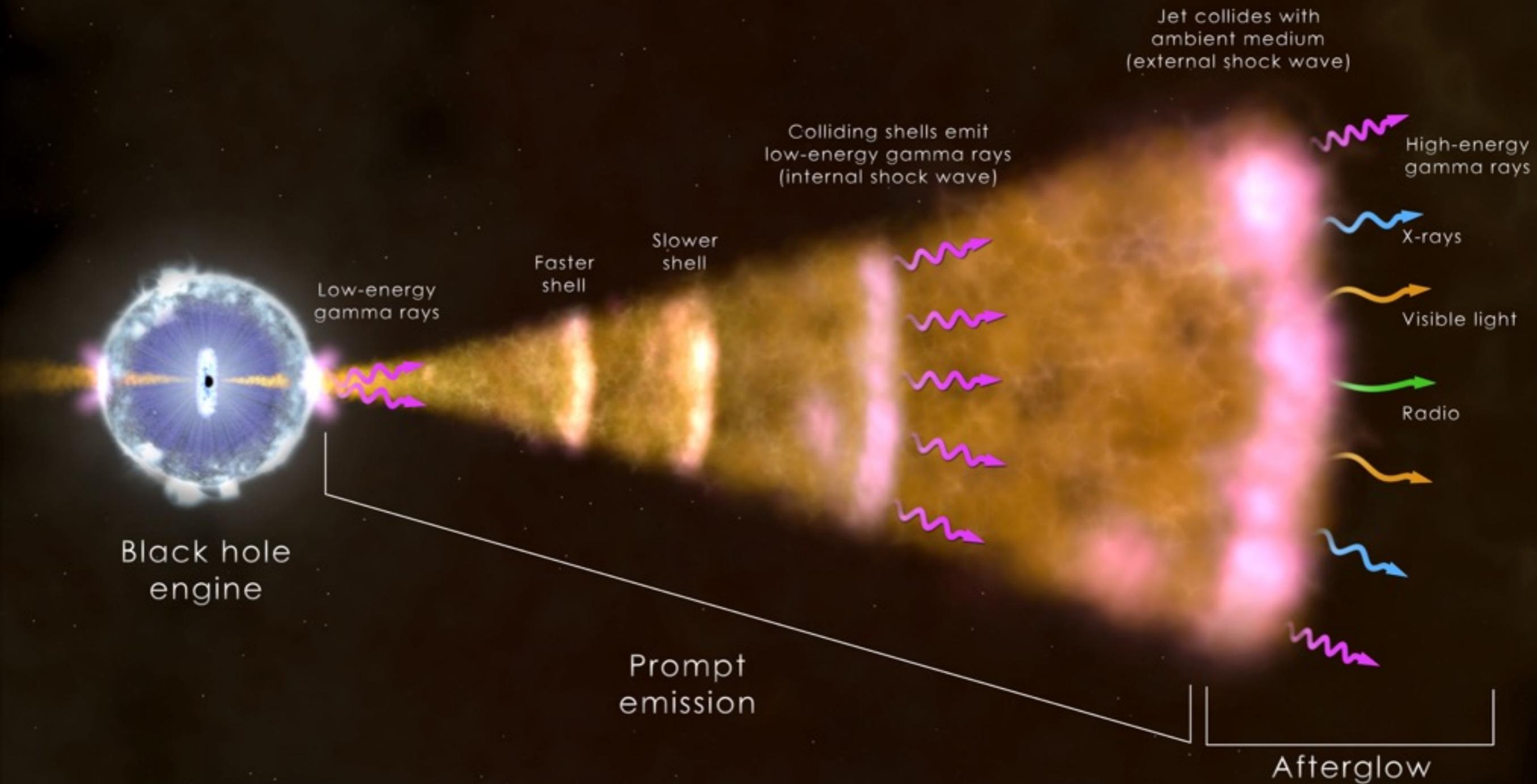
# OBSERVING A GRB



# LONG GAMMA RAY BURSTS

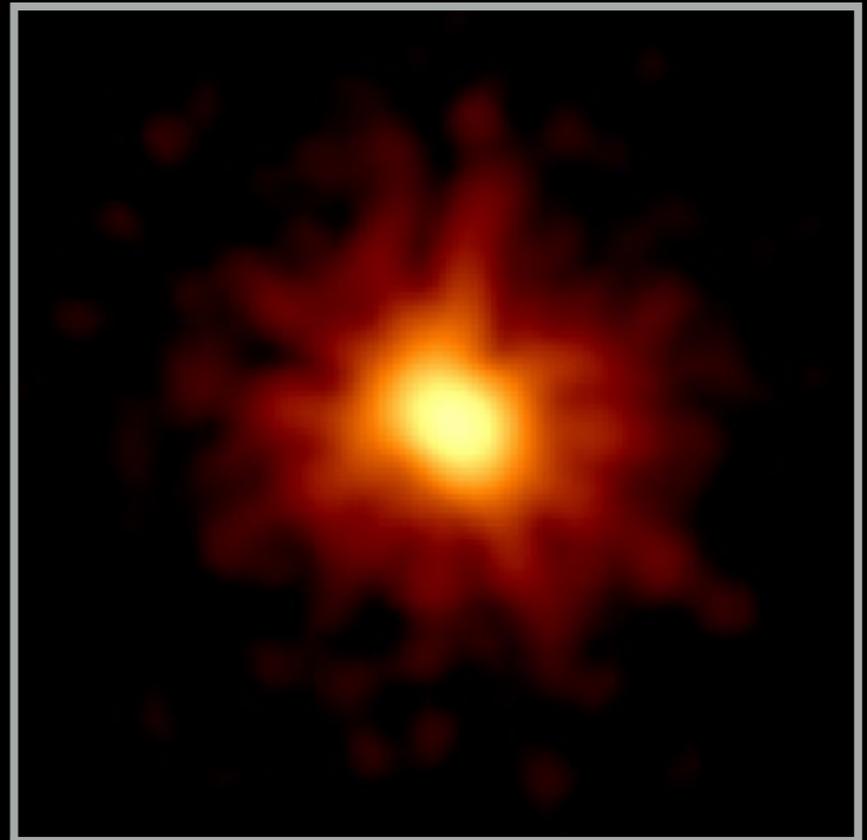


# LONG GAMMA RAY BURSTS



## LONG GAMMA RAY BURSTS

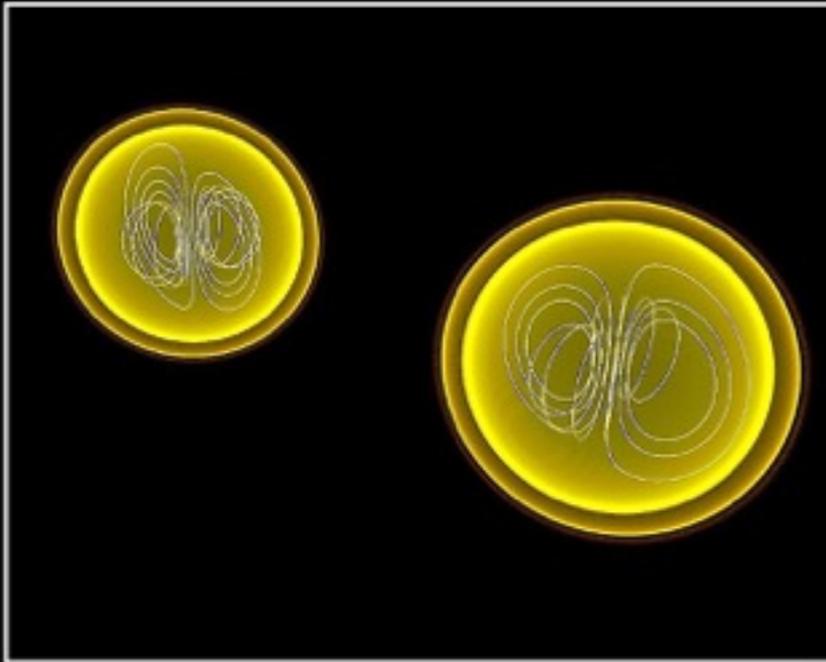
- ▶ GRB 080319B
- ▶ Most luminous optical object ever recorded by humankind
- ▶ Earth is looking right down a very narrow jet
- ▶ Most distant object viewable by an unaided eye (for 30s)



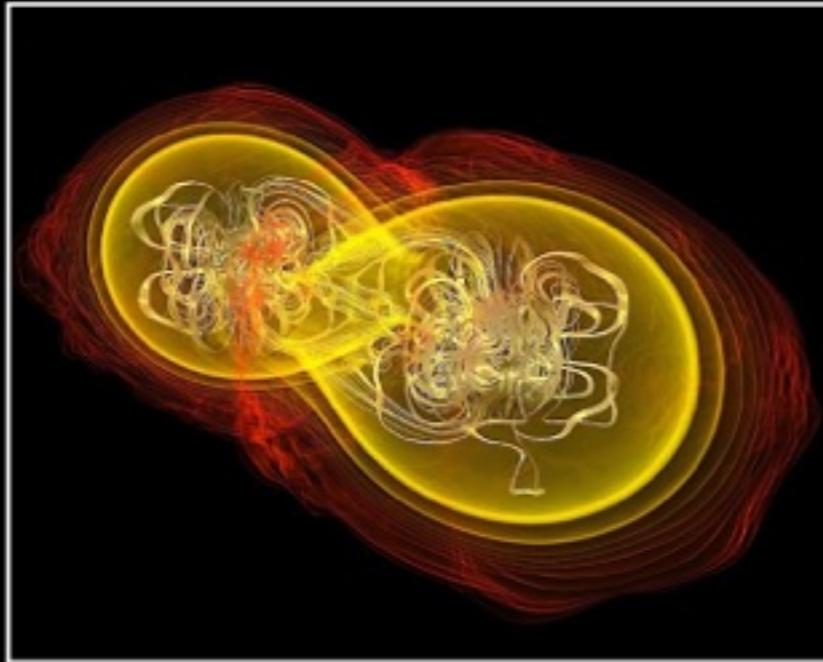
# SHORT GAMMA RAY BURSTS



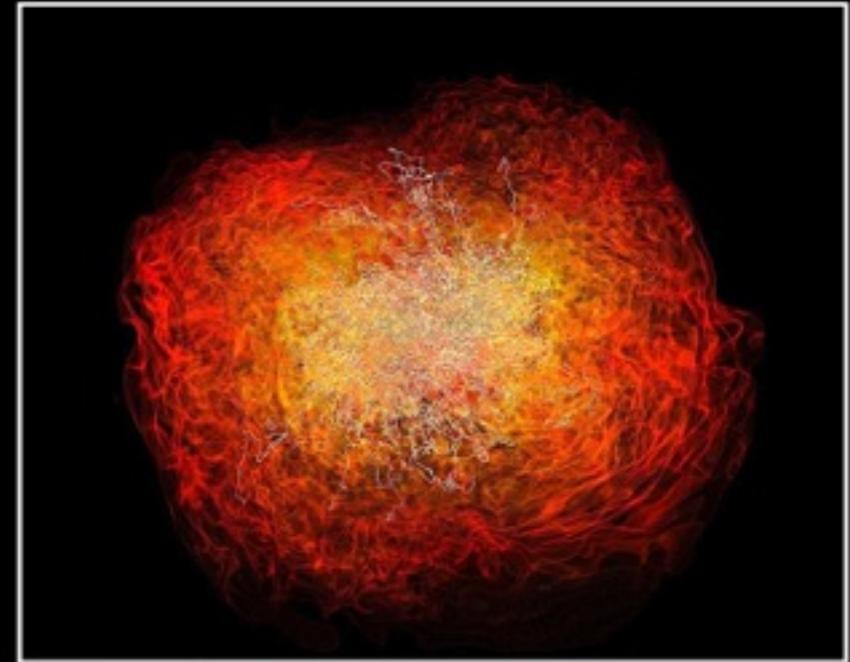
# SHORT GAMMA RAY BURSTS



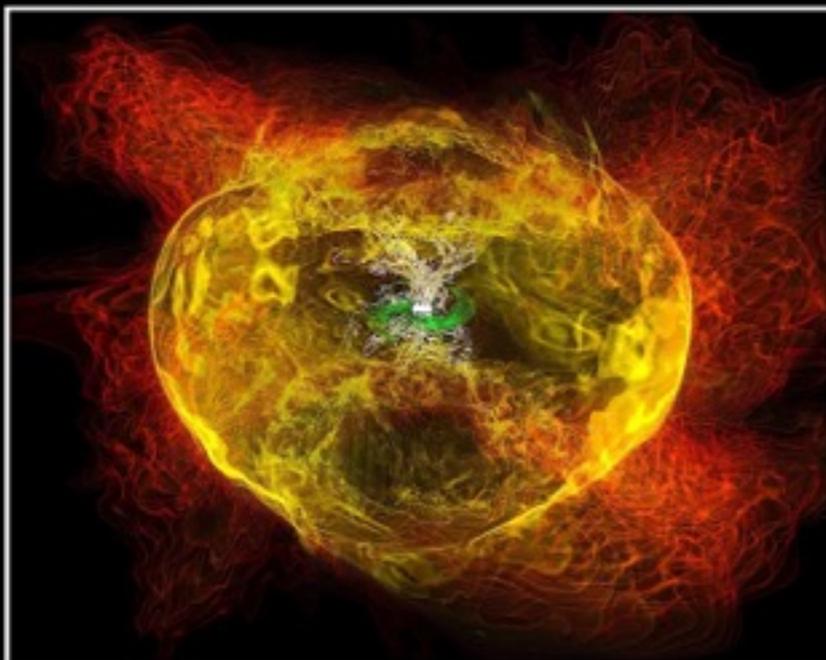
Simulation begins



7.4 milliseconds



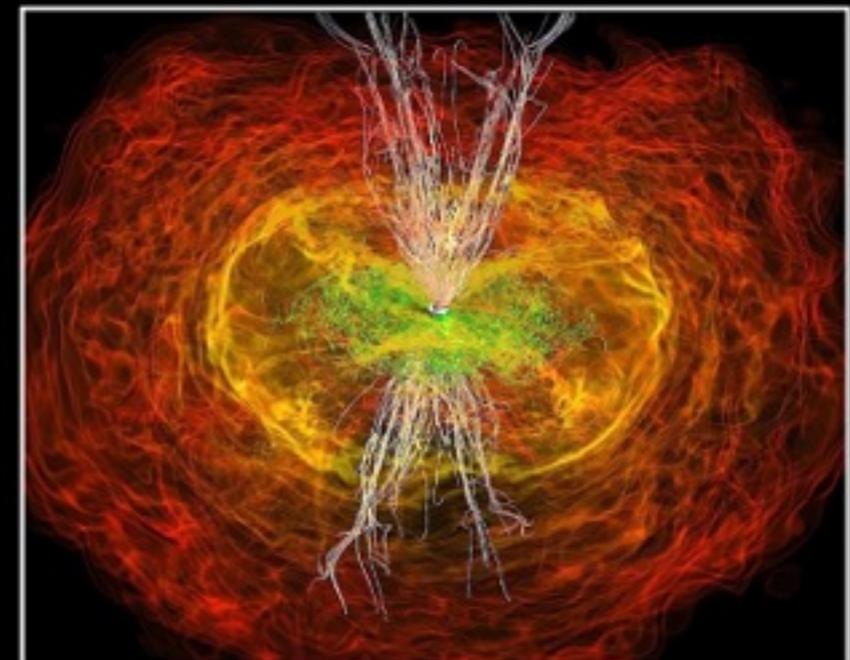
13.8 milliseconds



15.3 milliseconds



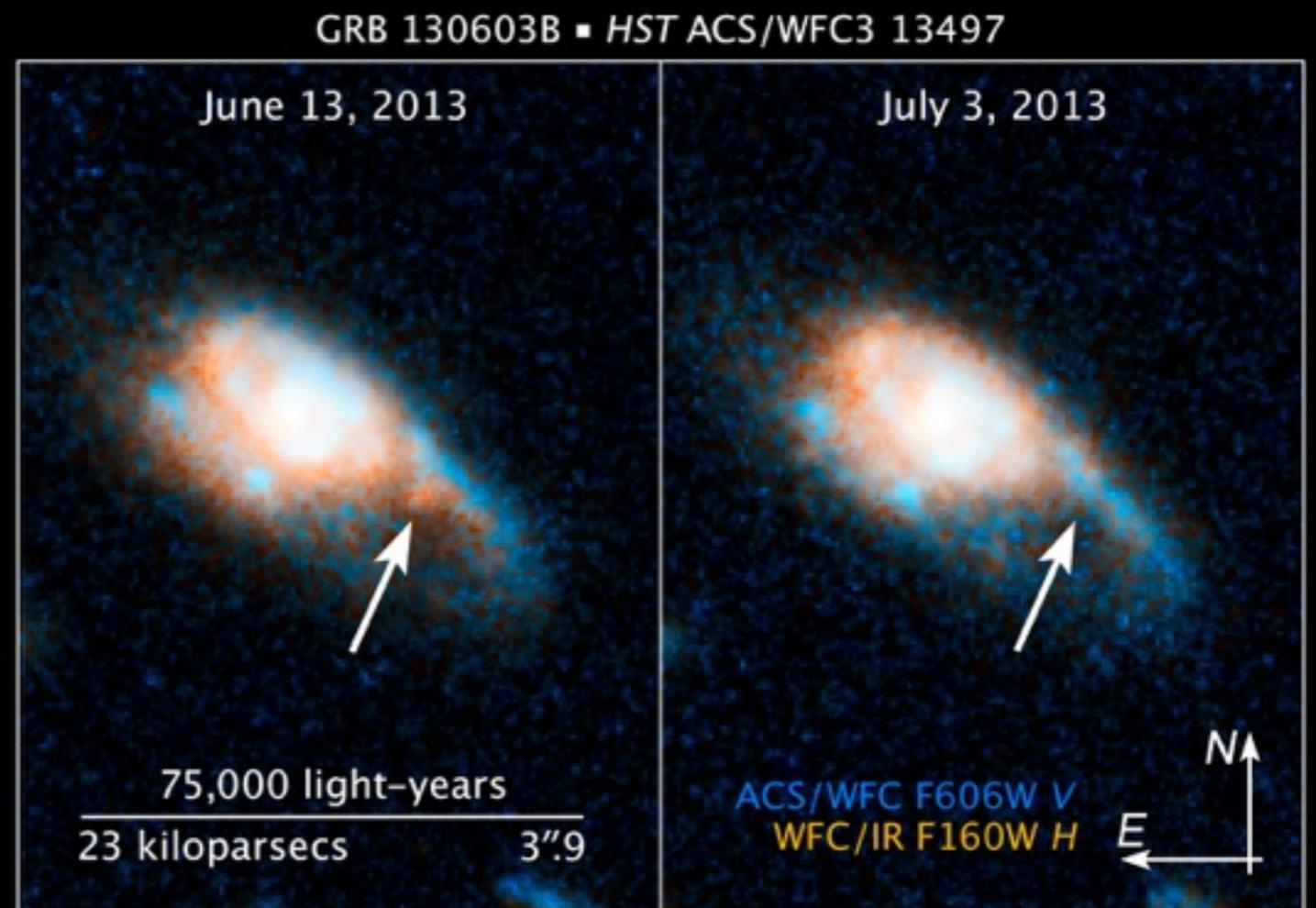
21.2 milliseconds



26.5 milliseconds

# SHORT GAMMA RAY BURSTS

- ▶ GRB 130603B
- ▶ First observational signs of neutron star merger
  - ▶ Kilonova
  - ▶ Faint infrared light





# GAMMA RAY BURSTS

- ▶ Brightest electromagnetic events in the universe
- ▶ Large variation in duration
- ▶ Fueled by gravity
- ▶ Observing burst and afterglow will help unravel remaining mysteries

Size of star  
creating GRB

10 miles

1 million miles

100-1000 million miles

### Gamma-ray bursts detected by Swift

Short

Long

Ultra-long

100

10

1

0.01

0.1

1

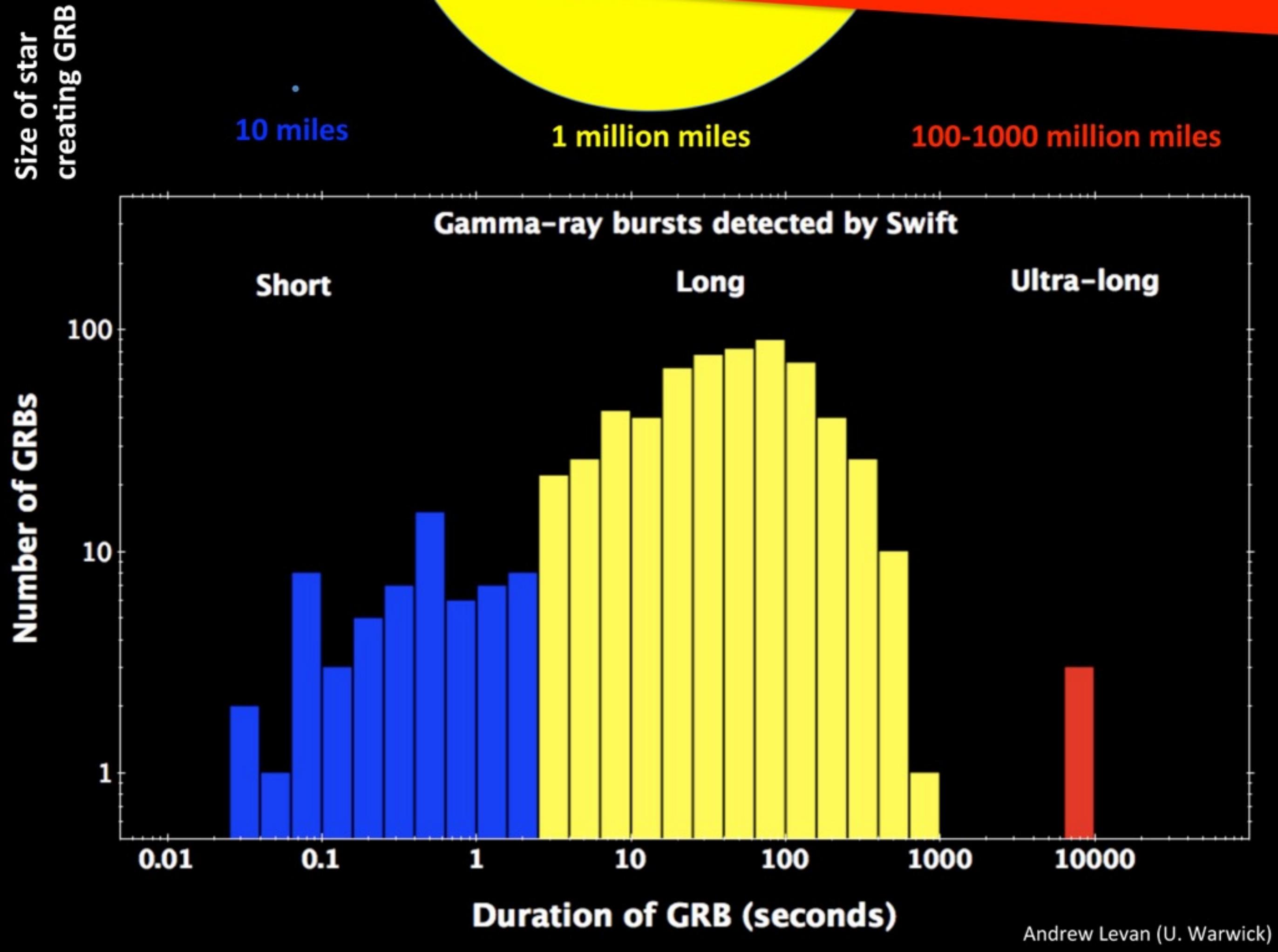
10

100

1000

10000

Duration of GRB (seconds)



# SHORT GAMMA RAY BURSTS

