

GISMO

(Giant IR and SubMm Space Observatory)

by

Tim Hawarden

**UK Astronomy Technology Centre,
Royal Observatory, Edinburgh
(tgh@roe.ac.uk)**

5 May 2004
GISMO Presentation, Paris

WHY BUILD A GIANT FIR/subMM SPACE TELESCOPE?

λ **Fir/subMM? (difficult)**

λ **GIANT? (expensive)**

λ **SPACE? (expensive AND difficult)**

FIR/subMM? (difficult)

- λ **Much of the electromagnetic radiation by which we must study the Universe is in the FIR/subMM:**
 - v **Distant objects are redshifted → We see them better in the IR**
 - **Most astronomical systems have lots of DUST in them → Visible light is blocked**

FIR/subMM? (difficult)

- λ Much of the electromagnetic radiation by which we must study the Universe is in the FIR/subMM:
 - v Distant objects are redshifted → We see them better in the IR
 - Most astronomical systems have lots of DUST in them → Visible light is blocked

A Hubble Space Telescope image of the Tadpole galaxy, a barred spiral galaxy with a long, narrow tail of stars extending from its core. The galaxy is oriented diagonally across the frame. The background is filled with numerous other galaxies and stars of various colors, including red, orange, and blue. The text is overlaid on the right side of the image.

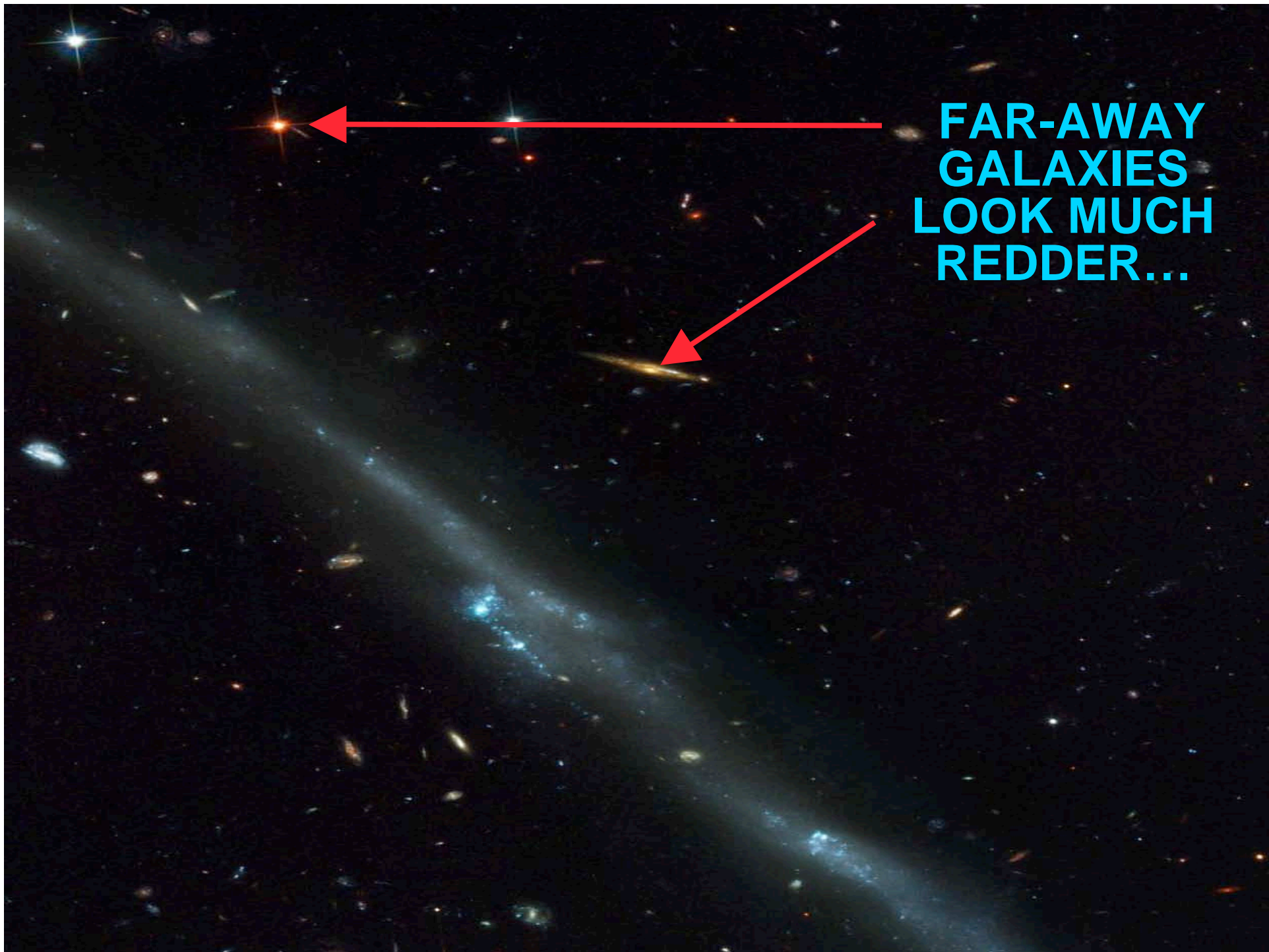
**HST image
of the
“TADPOLE”
interacting
galaxy**

**Quite nearby:
Blue stars**

A deep space photograph showing a bright blue galaxy filament against a dark background filled with distant galaxies and stars. The filament is a long, narrow, and slightly curved structure composed of numerous bright blue points of light, likely representing star-forming regions or active galactic nuclei. It stretches from the upper left towards the lower right. The background is a vast field of galaxies, many appearing as small, faint, yellowish or reddish points, interspersed with a few larger, more prominent galaxies. The overall scene is set against the deep black of space, with some stars showing diffraction spikes.

**BUT IN THE
BACKGROUND:**

**FAR-AWAY
GALAXIES
LOOK MUCH
REDDER...**








**... AND SOME ARE
ALMOST
INVISIBLE**



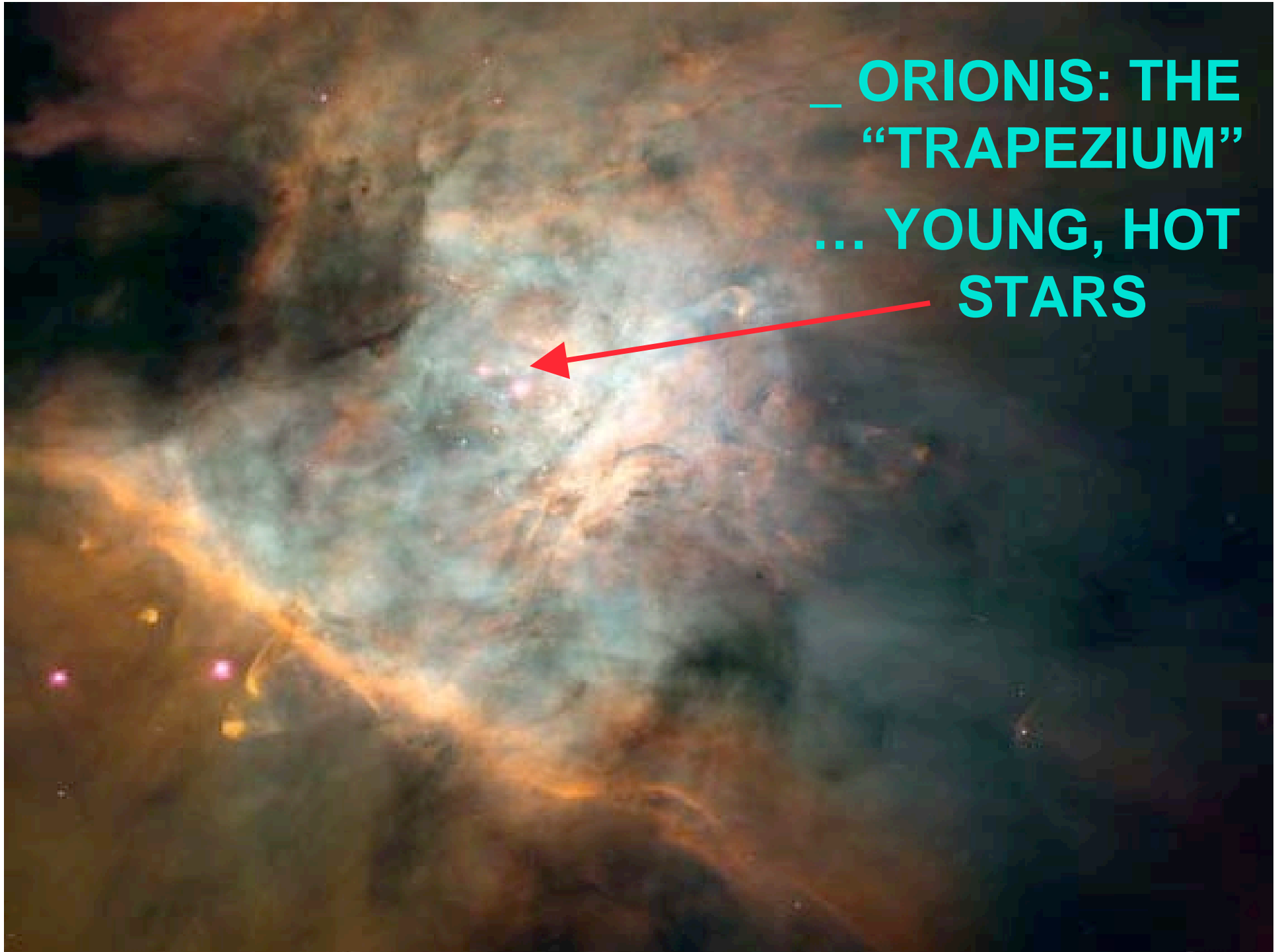
FIR/subMM? (difficult)

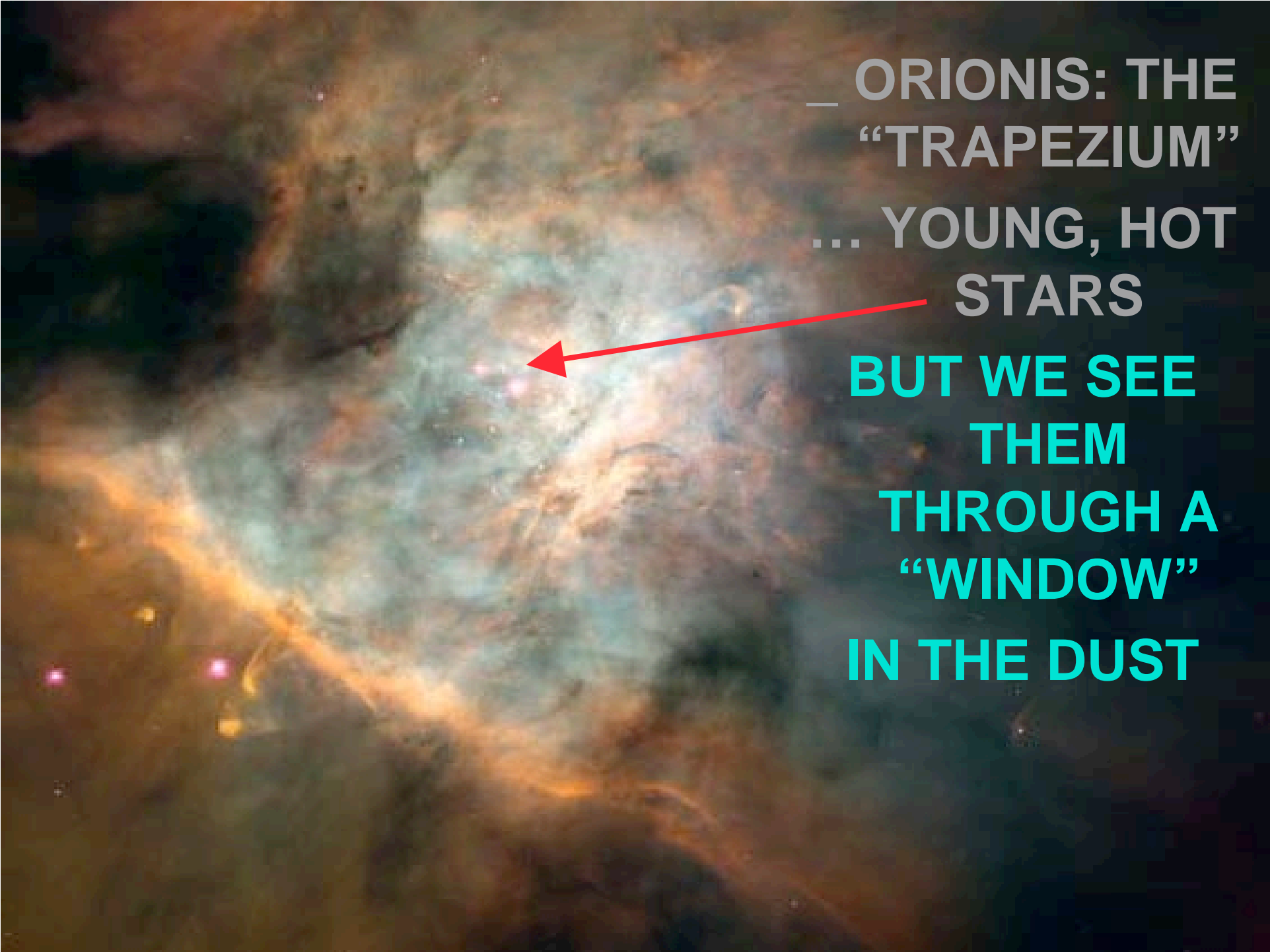
- λ Much of the electromagnetic radiation by which we must study the Universe is in the FIR/subMM:
 - v Distant objects are redshifted → We see them better in the IR
 - **Most astronomical systems have lots of DUST in them → Visible light is blocked**

A detailed view of the Orion Nebula, showing a complex structure of glowing gas and dust. The central region is bright and blue, surrounded by darker, reddish-brown filaments and clouds. Several bright stars are visible, particularly in the lower-left quadrant. The overall appearance is that of a vast, turbulent cloud of interstellar material.

**STARS ARE
FORMED
IN CLOUDS OF
GAS AND
DUST:
THE ORION
NEBULA**

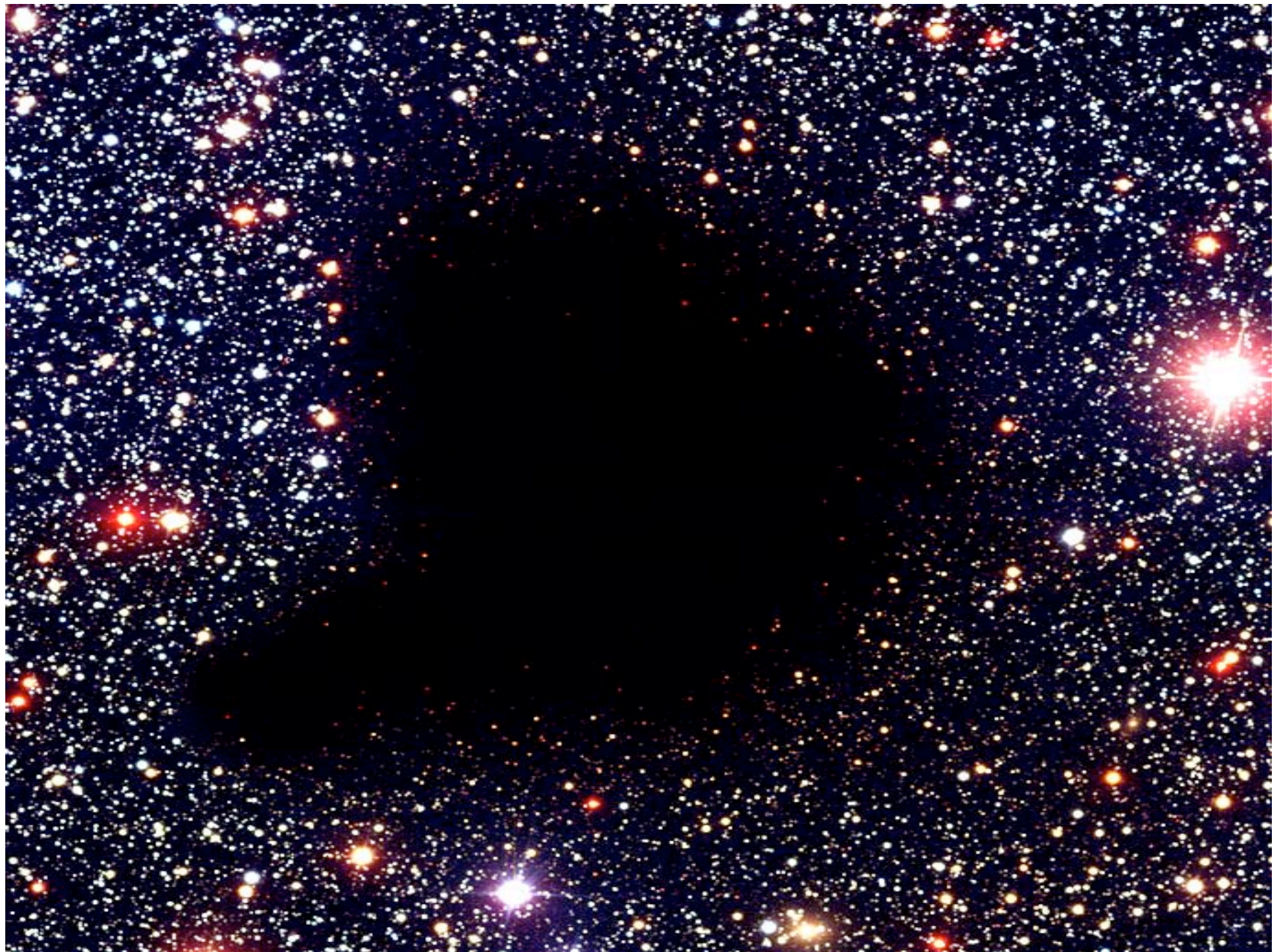
**_ ORIONIS: THE
“TRAPEZIUM”
... YOUNG, HOT
STARS**




The image shows the Orion Nebula, a large interstellar cloud of dust, hydrogen, helium and other ionized gases. The central region is dominated by the Trapezium cluster of stars, which are young and hot. The nebula's structure is complex, with various filaments and regions of different colors, including blue, green, and orange. A red arrow points from the text on the right towards the Trapezium stars, highlighting the 'window' through which they are visible.

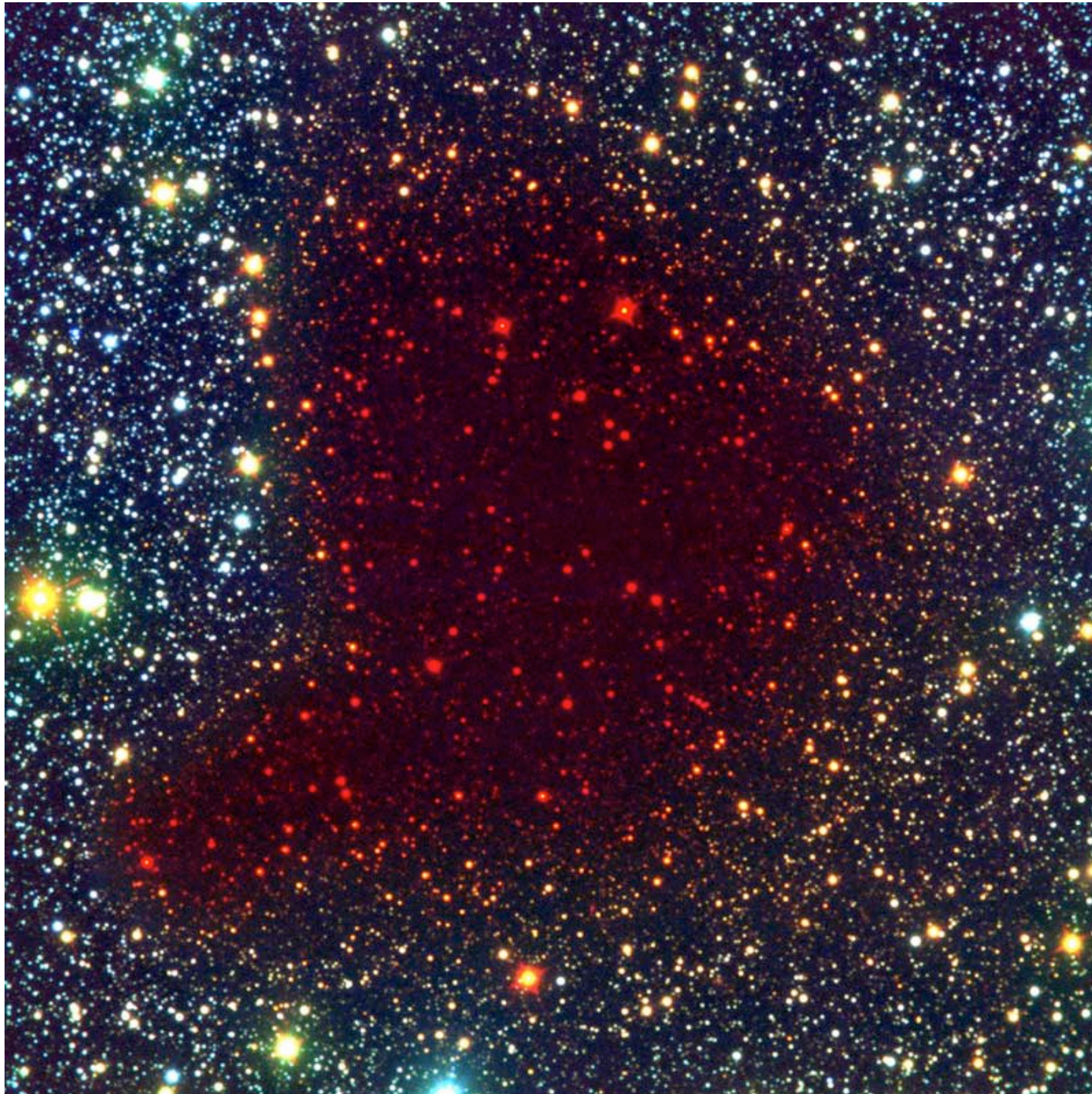
**_ ORIONIS: THE
“TRAPEZIUM”
... YOUNG, HOT
STARS**

**BUT WE SEE
THEM
THROUGH A
“WINDOW”
IN THE DUST**



A dense field of stars in space, with a bright star on the right side. The stars are of various colors, including white, yellow, orange, and red, set against a dark blue background. The text is centered in the image.

**HOW CAN WE
SEE
THROUGH
DUST
WITHOUT A
WINDOW?**



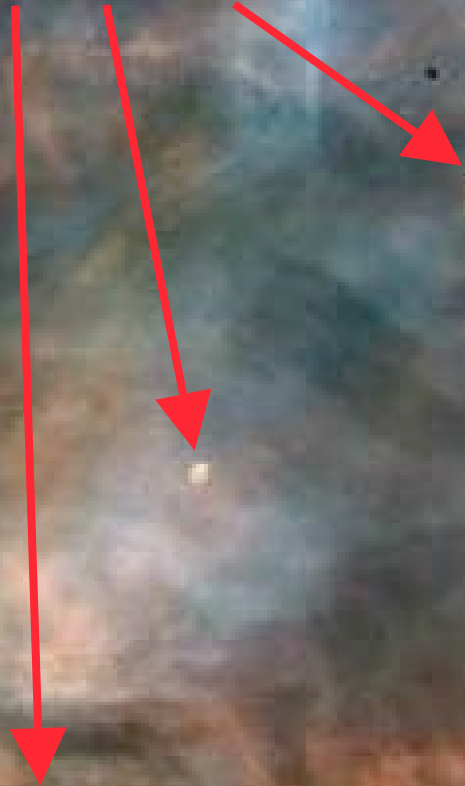
**.. BY USING
INFRARED
LIGHT**

**...this image
uses light 2
to 4 times
longer in
wavelength
than that
by which
we see...**



**AND THE
INFRARED
CAN SHOW US
EVEN MORE..**

**WHAT ARE
THESE??**

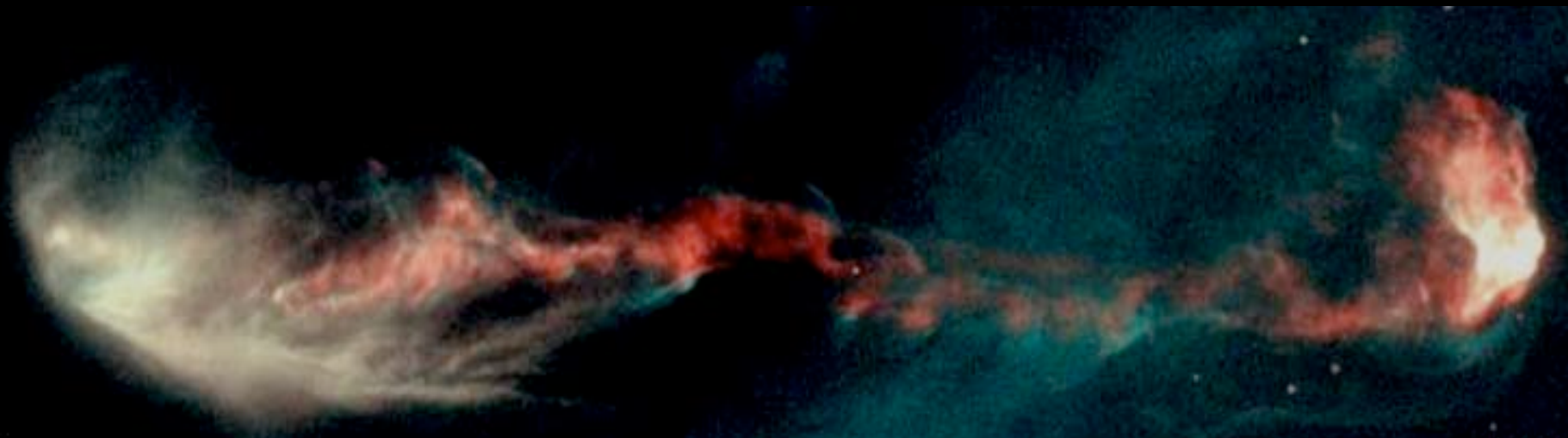


A blurry, low-resolution image of a star field. The background is a mix of dark blue and purple hues, suggesting a nebula or a distant galaxy. In the center, there is a prominent, bright yellow star. Other smaller, dimmer stars are scattered throughout the field. The overall image has a grainy, pixelated appearance.

**BABY STARS
STILL WRAPPED
IN DUST**




**YOUNG
STARS DO
MANY
EXCITING
THINGS**



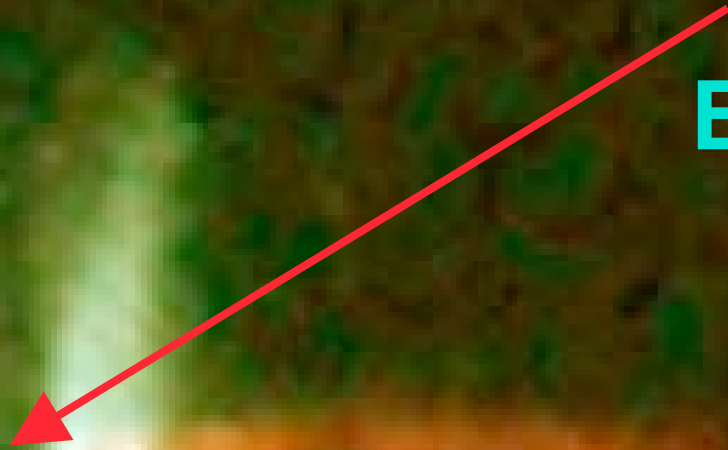
HH47



A blurry night photograph of a road illuminated by a streetlight. The light creates a bright, hazy glow on the left side of the road, and a car is visible in the distance on the right. The overall image is out of focus, emphasizing the text overlay.


**BUT WE STILL
CANT SEE
THEM
CLEARLY...**

**...THE STAR
ITSELF IS
INVISIBLE,
EVEN IN THIS
NEAR-
INFRARED
PICTURE,
BEHIND ITS
DISC OF DUST**



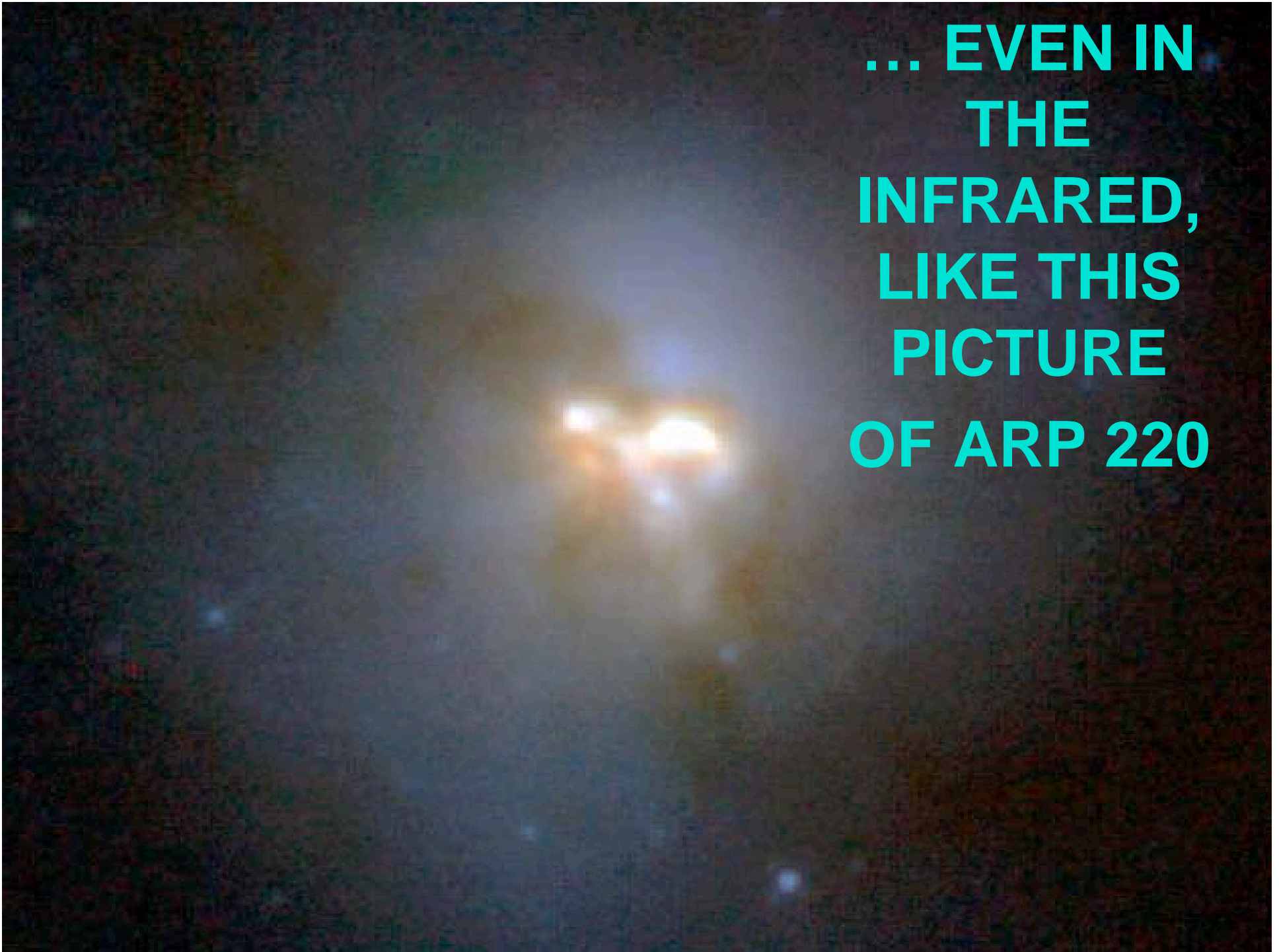
**GALAXIES,
TOO, ARE
FULL OF
DUST**

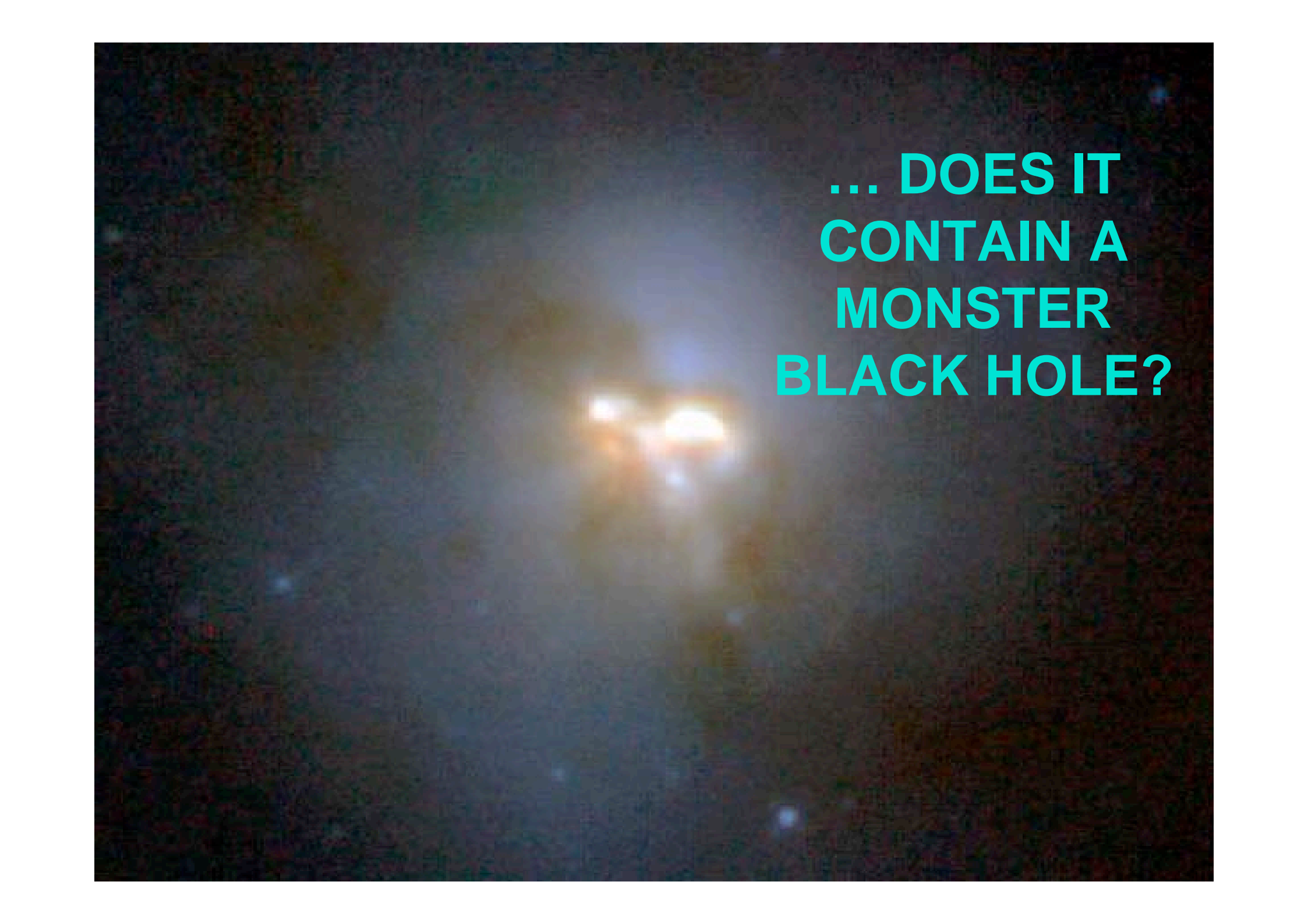




**AND WE
CAN'T SEE
WHATS
HAPPENING,
ESPECIALLY
IN THEIR
CENTRES...**

**... EVEN IN
THE
INFRARED,
LIKE THIS
PICTURE
OF ARP 220**



The image is a dark, grainy astronomical photograph. In the center, there is a bright, multi-colored source of light, appearing as a cluster of yellow, orange, and blue points. The background is a dark, almost black field with several scattered, faint blue and white stars. The overall appearance is that of a deep-space observation, possibly of a galaxy core or a star-forming region.

**... DOES IT
CONTAIN A
MONSTER
BLACK HOLE?**



**..OR EVEN
TWO
MONSTERS?**

**.....WE NEED THE FAR
INFRARED AND
SUBMILLIMETRE TO SEE
WHATS GOING ON**

5 May 2004
GISMO Presentation, Paris

WHY BUILD A GIANT FIR/subMM SPACE TELESCOPE?


λ Fir/subMM? (difficult)

λ GIANT? (expensive)


λ SPACE? (expensive AND difficult)

GIANT? (expensive)

**The longer the wavelength,
the more blurred the image**



**SOMETHING
WHICH LOOKS
LIKE THIS IN
VISIBLE
LIGHT
($\lambda = 0.5\mu\text{m}$)...**



**MIGHT LOOK LIKE
THIS IN THE FAR
INFRARED
($\lambda = 100\mu\text{m}$)...**

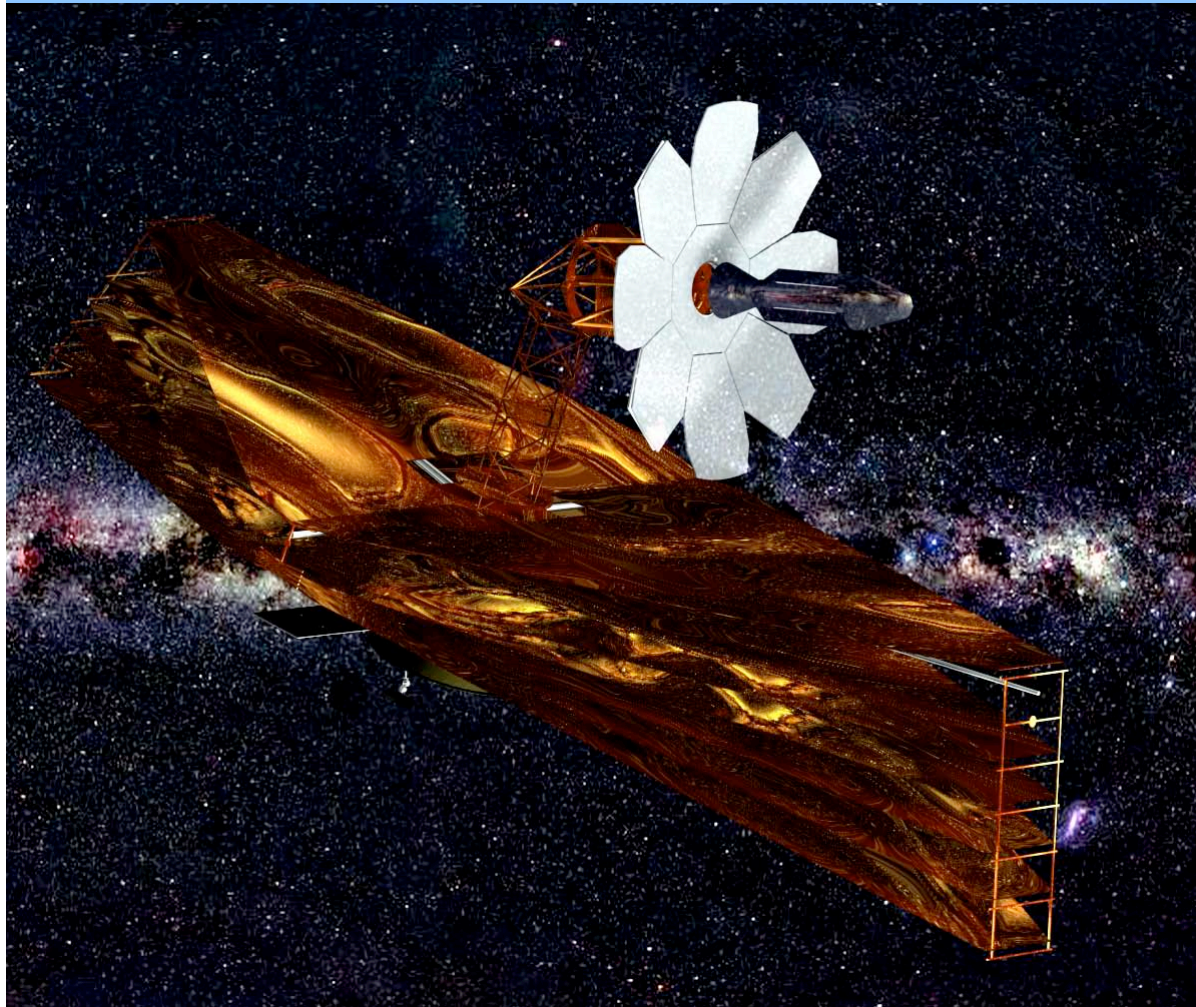
SPACE?

(expensive and difficult)

**Unfortunately, no far-IR and very little
sub-millimetre light can get through
the atmosphere...**

NASA PROPOSAL: SAFIR

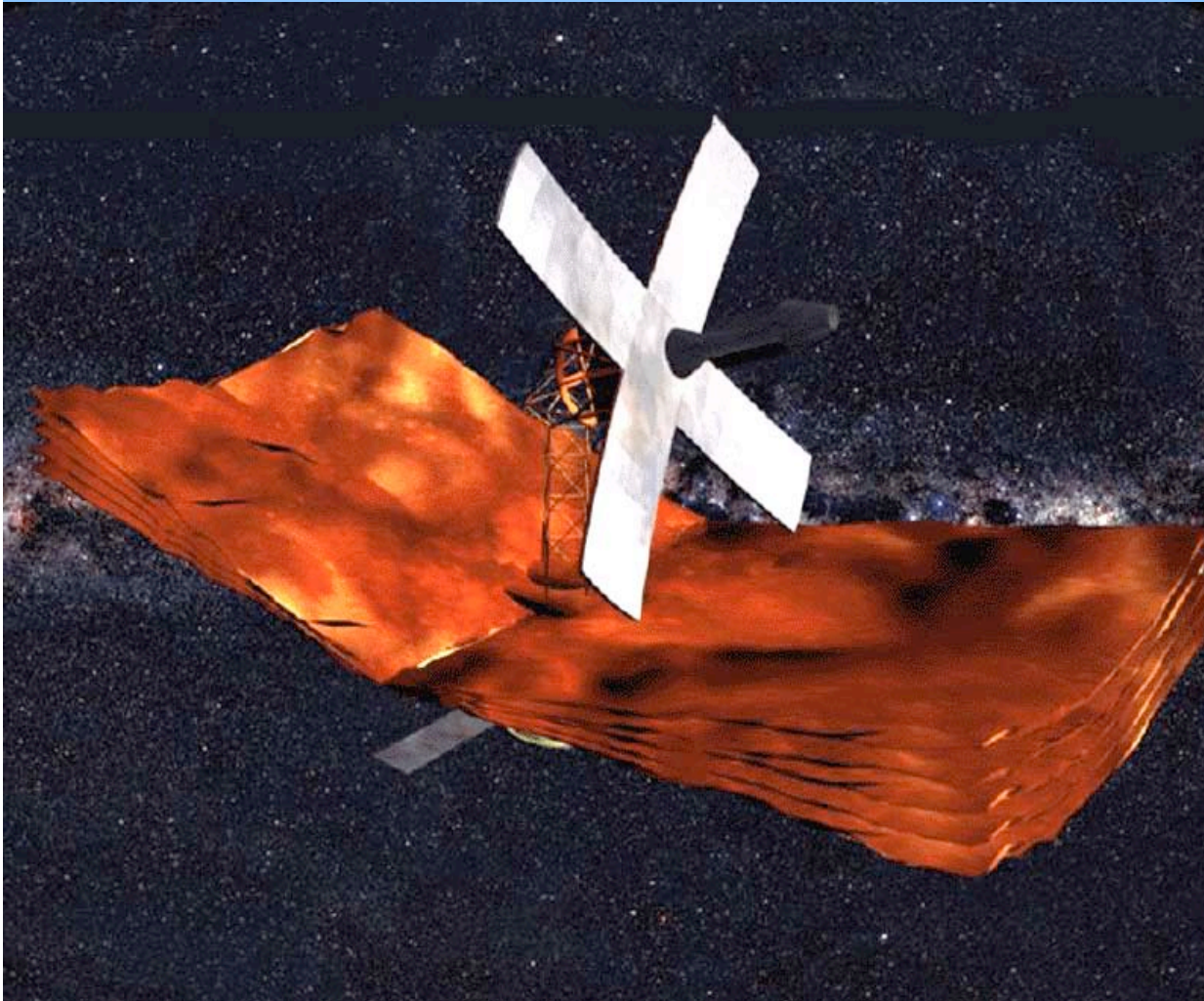
(10M, 4K telescope)
... in various possible “flavours”



a bigger, colder
JWST
with more
sunshade
layers???

NASA PROPOSAL: SAFIR

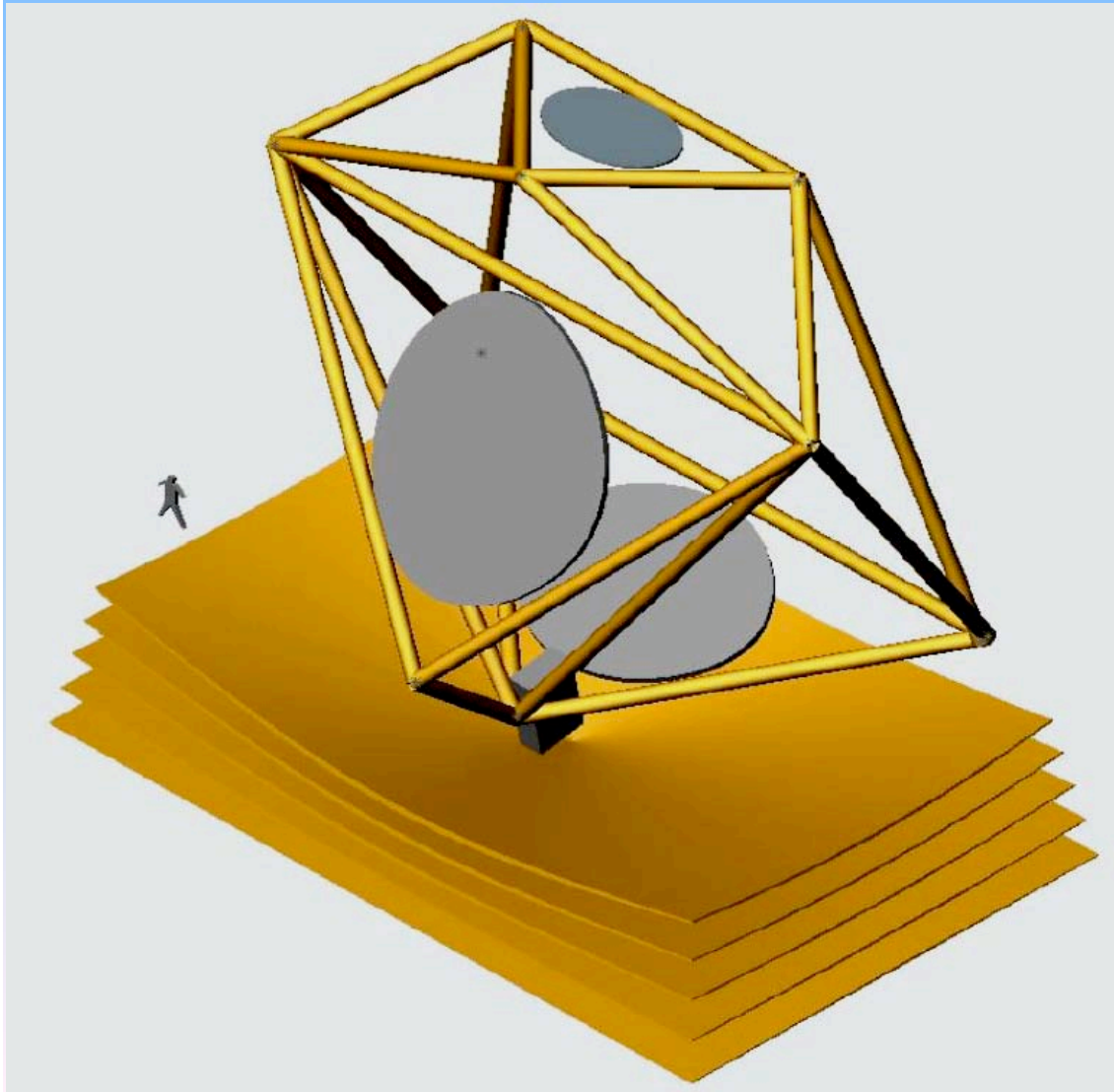
(10M, 4K telescope)



**a different
shape of
telescope?**

NASA PROPOSAL: SAFIR

(10M, 4K telescope)



a totally new
technology?
“DART” uses
membranes

ORIGIN OF THIS PROPOSAL:

**Invited review of technologies for lightweight,
cold, FIR telescopes in space**

**(for ESA workshop, “*New Perspectives for Post-Herschel FIR
Astronomy from Space*” Madrid, 1-5 Sept 2003)**

PERSONAL GOAL OF REVIEW:

An outline design for a telescope that is:

λ Large ($\gg 10\text{m}$)

λ Cold ($\ll 30\text{K}$)

λ To work in the FIR-submm (~ 20 to $\sim 700\ \mu\text{m}$),

..... and has a chance of flying in my lifetime...

RESULTS

λ Membranes have plenty of problems (cusps, wrinkles, uniformity, how to tension, shape control...)

λ “Stiff” technologies unlikely to offer >>10m aperture*

↑ Fresnel lenses being explored at LLNL for optical applications

→ *must be 50-1000x easier in FIR-submm!*

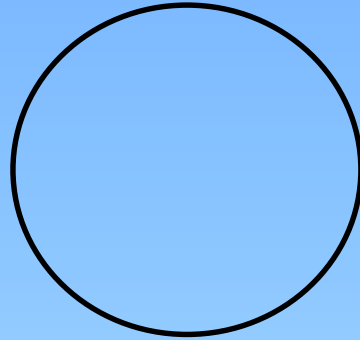
(inspiration: J. Early et al, proc SPIE, 5166, 148)

* But see TRW plans for 30m JWST-style telescope for 7-17_m:

C.F. Lillie et al., Proc SPIE, 4860, 84 (2003)

Fresnel Lenses

Ordinary
lens



Cross-
section:
Thick centre

