

Death By Black Hole

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Pinon Teacher's Workshop

Presentation stolen shamelessly from
Phil Plait (the Bad Astronomer)

DISCLAIMER!

What you are about to see is for entertainment purposes only. No one has EVER been killed by a black hole in the entire history of the human race and everything in this presentation is EXTREMELY unlikely to harm life on Earth. So relax and enjoy!

7 WAYS A BLACK HOLE CAN KILL YOU

What is a Black Hole?



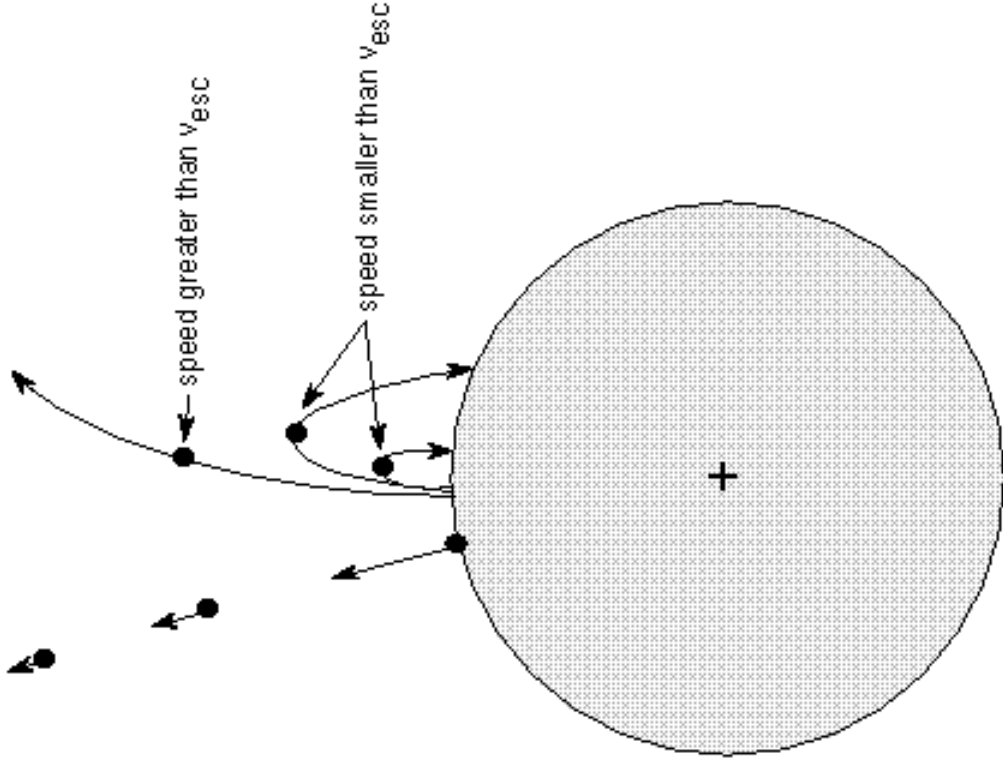
**DEFINITION: A BLACK HOLE IS WHERE THE
ESCAPE VELOCITY IS FASTER
THAN THE SPEED OF LIGHT.**

Escape Velocity

DEFINITION: THE MINIMUM VELOCITY AT WHICH SOMETHING MUST TRAVEL AWAY FROM A BODY SUCH THAT GRAVITY OF THE OBJECT CANNOT STOP IT.

7 WAYS A BLACK HOLE CAN KILL YOU

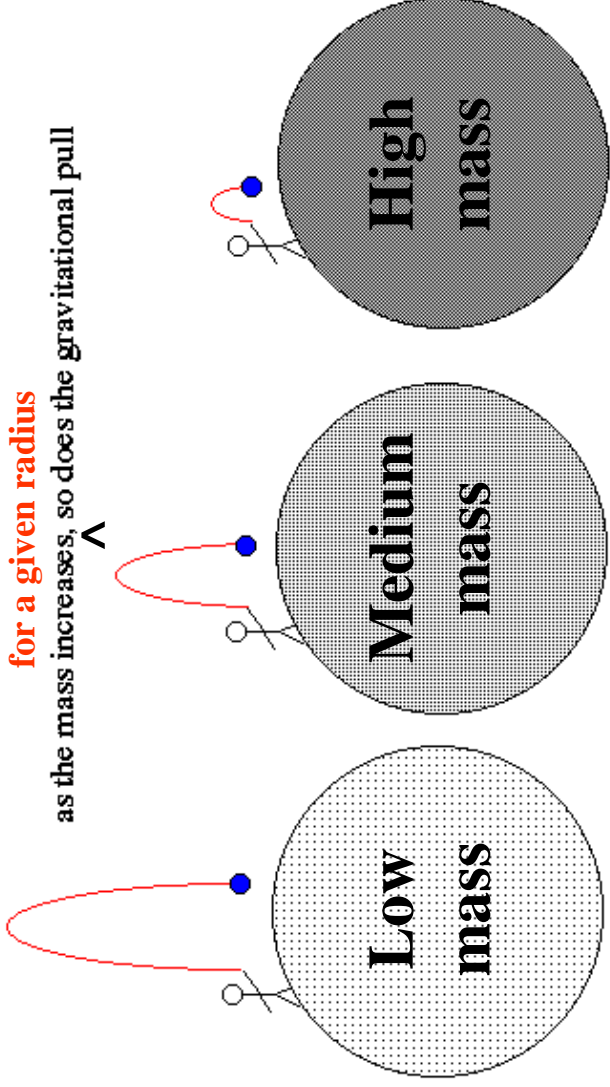
Escape Velocity (2)



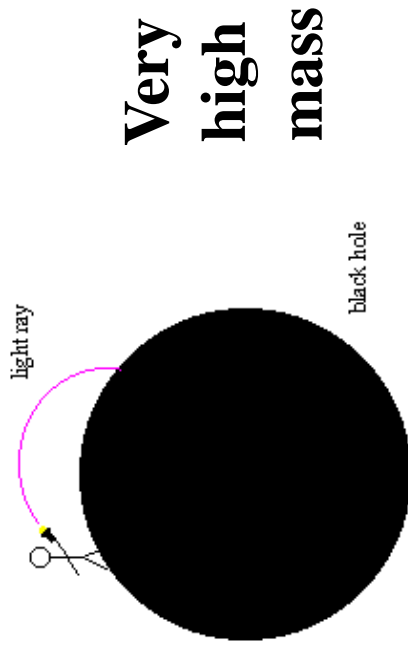
Escape velocity
depends on the
gravity
of the object

Escape Velocity (3)

Black Hole

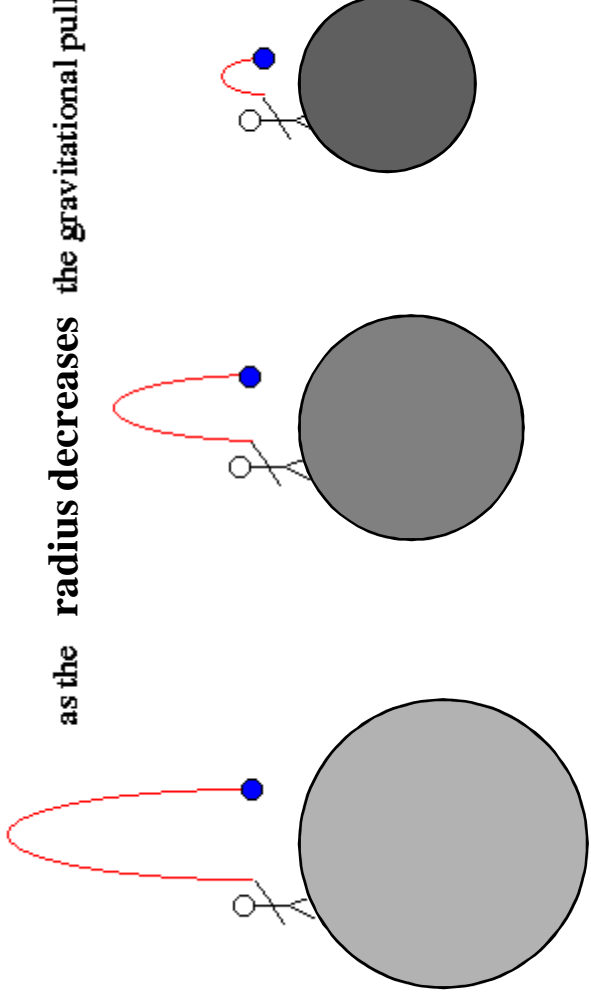


if the gravitational pull is such that even light cannot escape, then a black hole forms



Escape Velocity (4)

as the radius decreases the gravitational pull increases



if the gravitational pull is such that even light cannot escape, then a black hole forms



What is a Black Hole?

**IT'S AN OBJECT OF HIGH ENOUGH MASS
AND SMALL ENOUGH RADIUS
SUCH THAT
THE ESCAPE VELOCITY IS
FASTER THAN LIGHT.**

NOTHING CAN ESCAPE.

Four Types of Black Holes

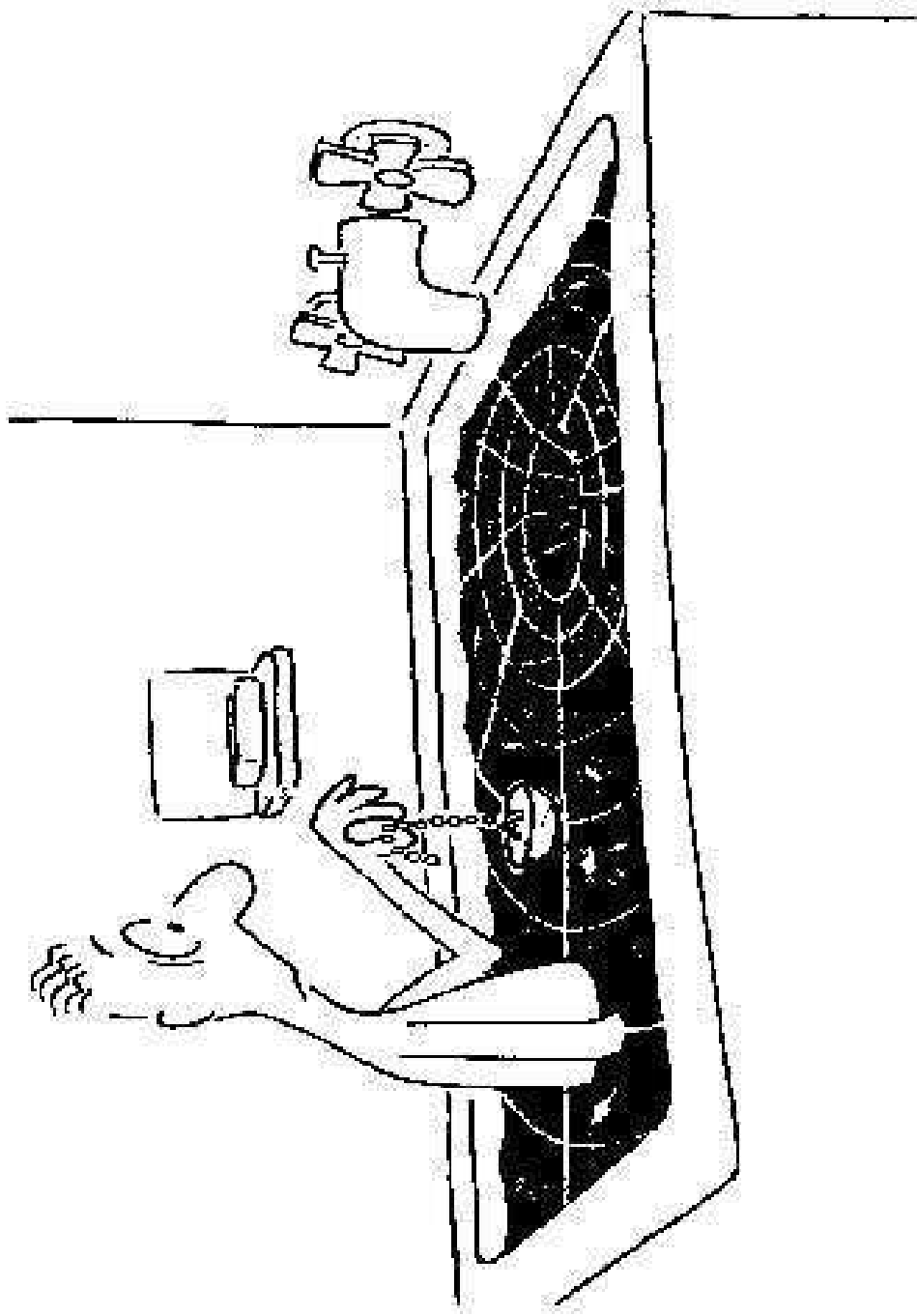
- Mini-Black Holes – 10^{12}kg
- Stellar Mass Black Holes – 3 – 100 times the mass of our Sun
- Mid-Size Black Holes – a few thousand to 100,000 times the mass of our Sun
- Massive and Supermassive black holes – Millions to billions of times the mass of our Sun

The First Way A Black Hole Can Kill You

1. FALLING IN

2. 3. 4. 5. 6. 7. 8.

Down the Drain



7 WAYS A BLACK HOLE CAN KILL YOU

Forcing the Issue

The force of gravity from an object depends on

- 1) the mass of the object
- 2) your distance from it

$$F = \frac{Gm_1m_2}{r^2}$$

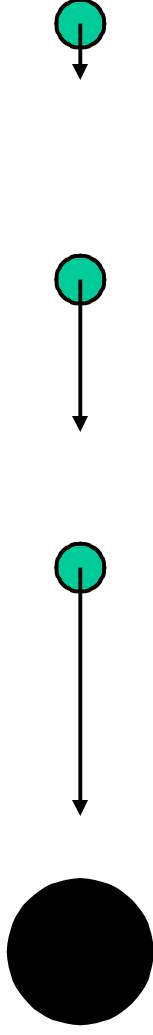
So if it's really **massive**, or you're really **close**, the force is high.

**BLACK HOLES ARE REALLY MASSIVE,
AND YOU CAN GET
REALLY, REALLY CLOSE**

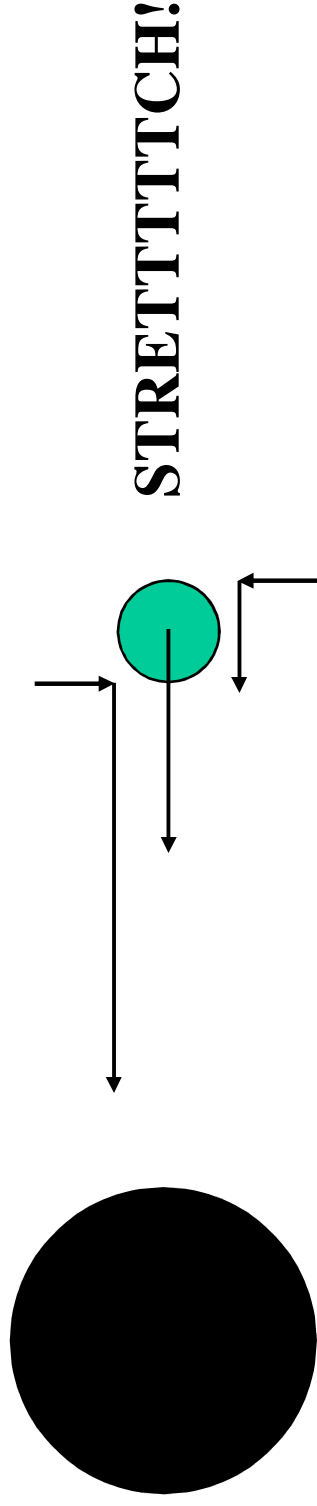
But this means....

7 WAYS A BLACK HOLE CAN KILL YOU

The force you feel **CHANGES** as you get closer.



Something closer to the black hole feels **MORE** force.



IF YOU FALL IN FEET FIRST, YOU HAVE A PROBLEM.

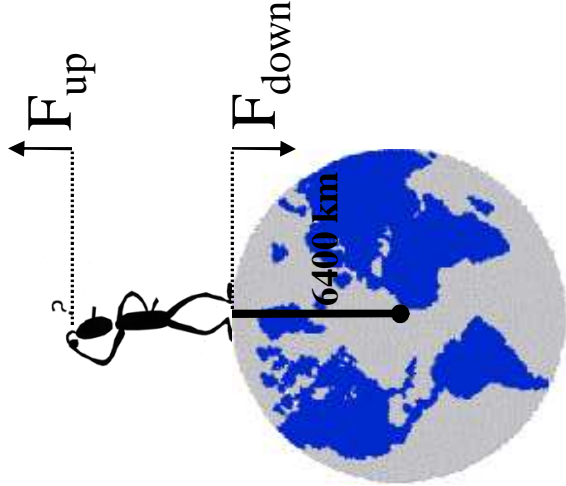
The change in force is called a **TIDE**

Tides on surface of Earth (distance = 6400 km)
: 1/1,000,000th of a g

(for a 3 solar mass black hole)

DISTANCE	FORCE (g)
6400 km	0.5
2000	18
1000	144
100	150,000
10	150,000,000

BLACK HOLE TIDES



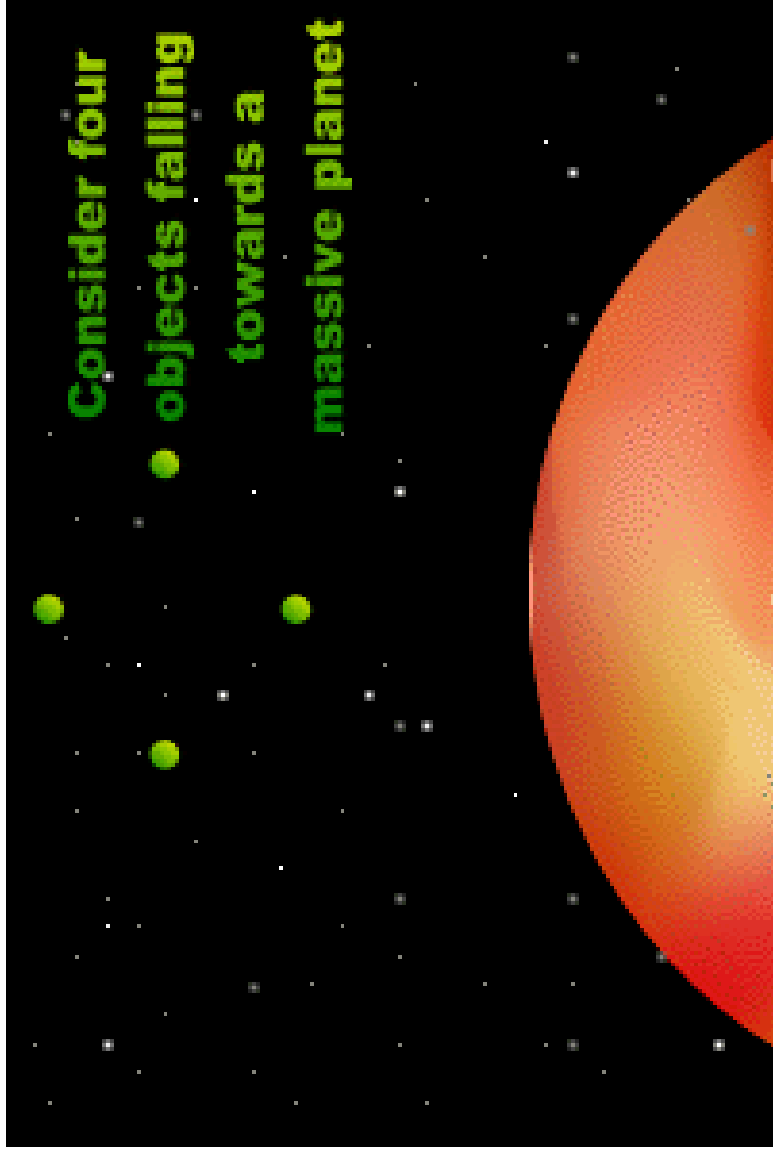
The Second Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION

3.
4.
5.
6.
7.

7 WAYS A BLACK HOLE CAN KILL YOU

Spaghetti what?



7 WAYS A BLACK HOLE CAN KILL YOU

Why the long face?



7 WAYS A BLACK HOLE CAN KILL YOU

The Third Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. **BE NEAR ONE WHEN IT'S BORN**
- 4.
- 5.
- 6.
- 7.

7 WAYS A BLACK HOLE CAN KILL YOU

Cold War, Hot Topic

**Vela Satellites flown to detect
nuclear explosions on Earth
in 1960s and 1970s
by looking for gamma rays**



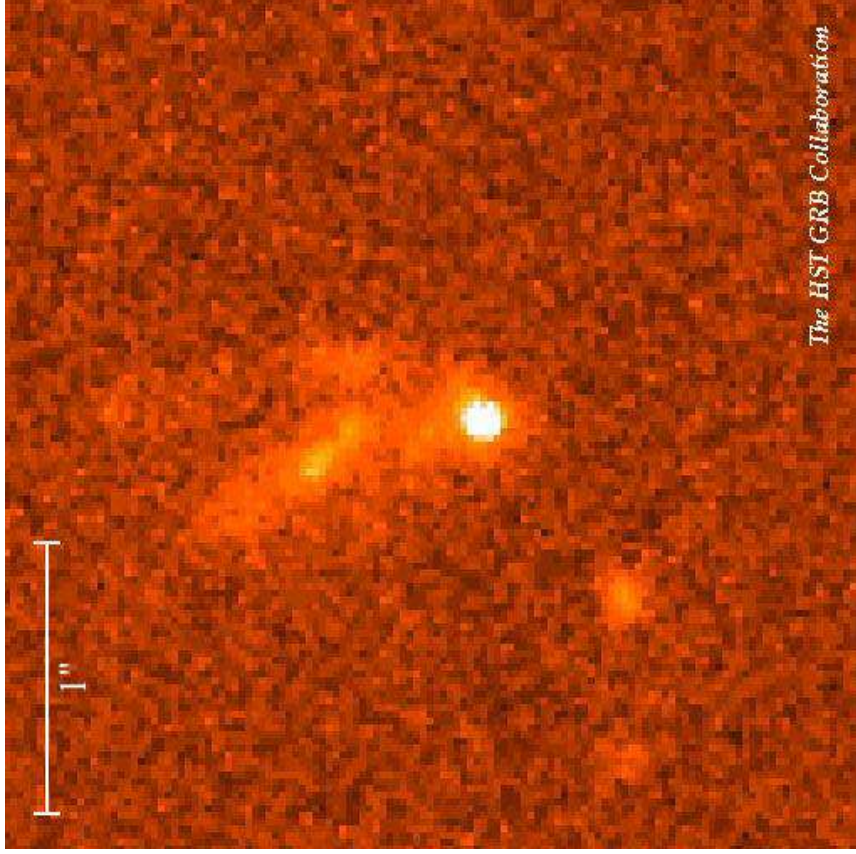
Over their lifetime, they detected 73 events.

NOT ONE WAS OF THIS EARTH

7 WAYS A BLACK HOLE CAN KILL YOU

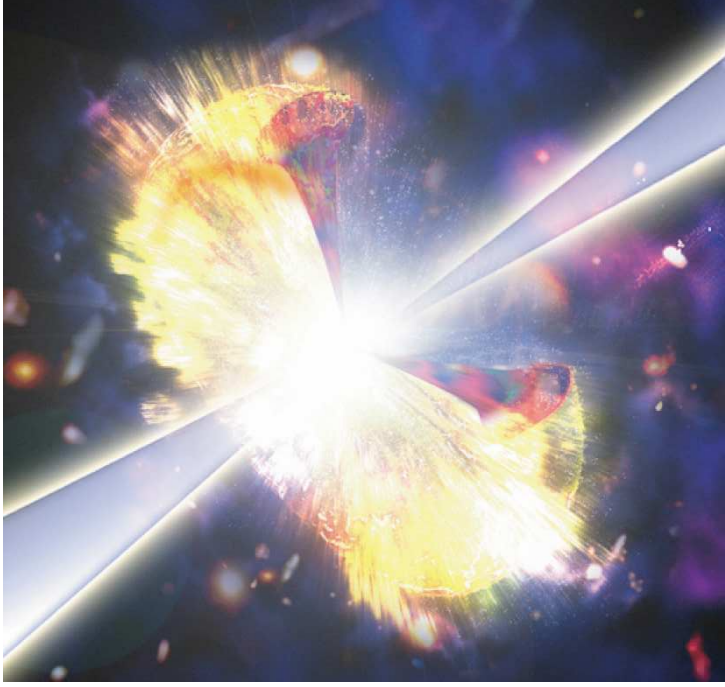
Gamma Ray Bursts

**GRBs happen every day,
somewhere in the Universe**



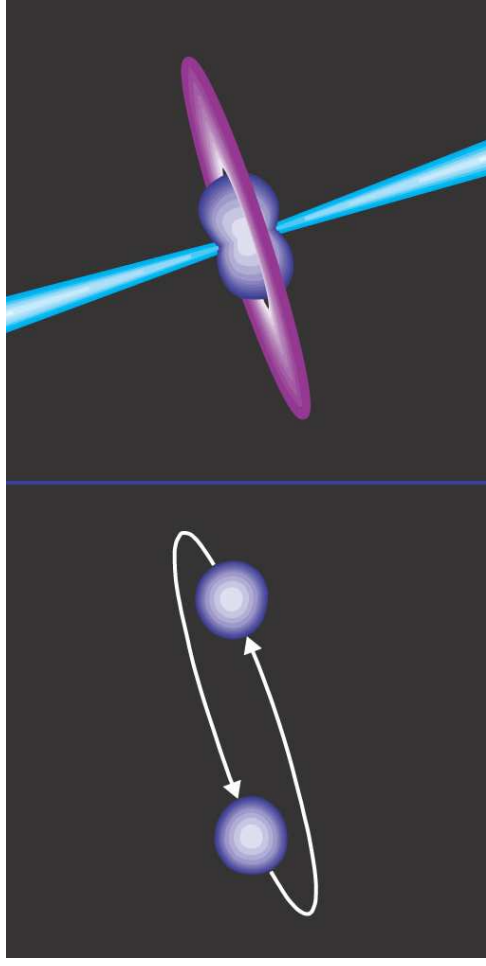
7 WAYS A BLACK HOLE CAN KILL YOU

The Birth of a Black Hole



Hypervnova!

**Coalescing
neutron stars**



Birth Pangs

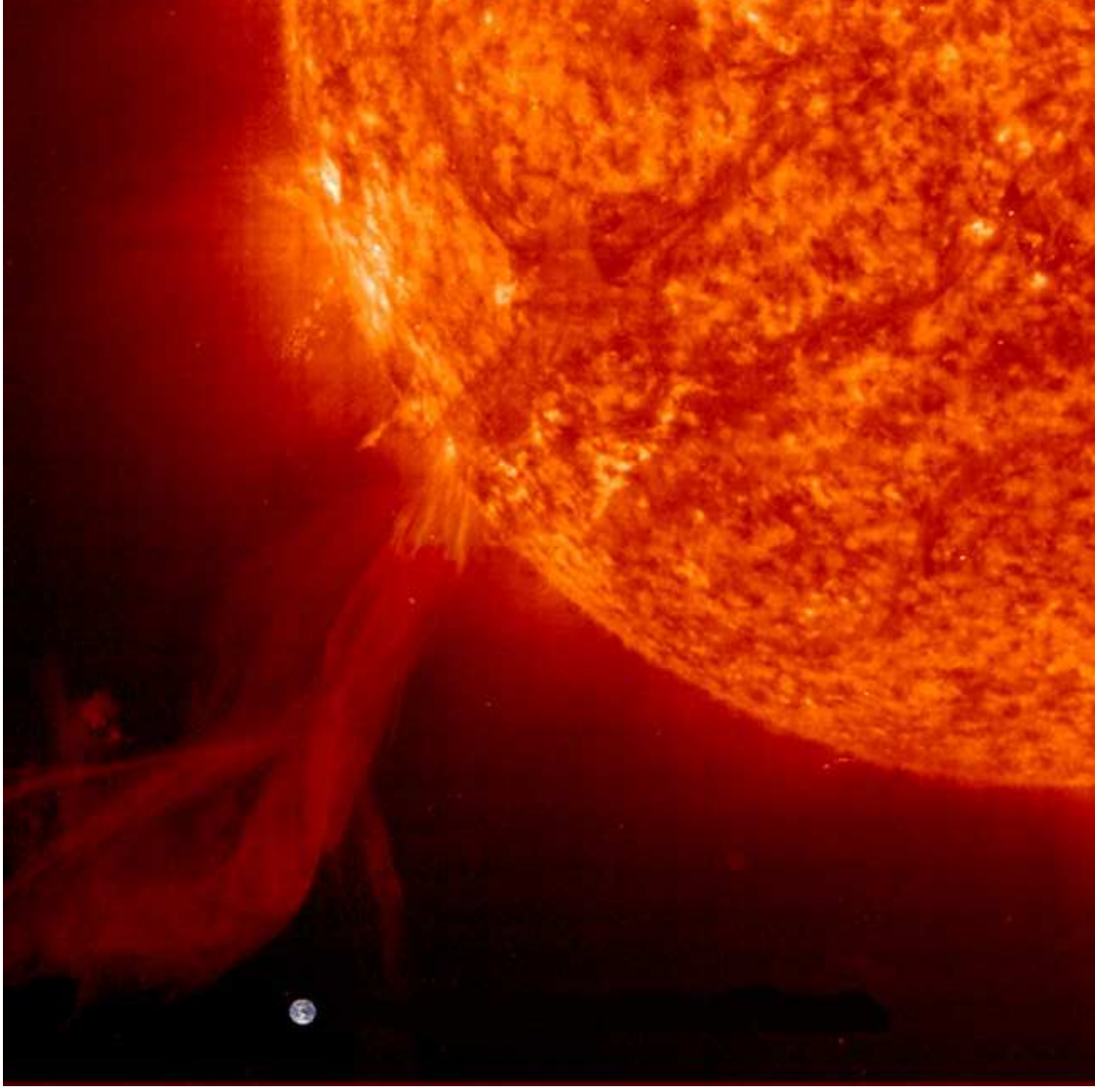
Energy generated in a GRB = 10^{52} ergs

**THIS IS 10X THE
SUN'S TOTAL ENERGY
OVER ITS ENTIRE LIFETIME.**

**ENOUGH ENERGY TO VAPORIZE
THE EARTH
100 BILLION TIMES OVER.**

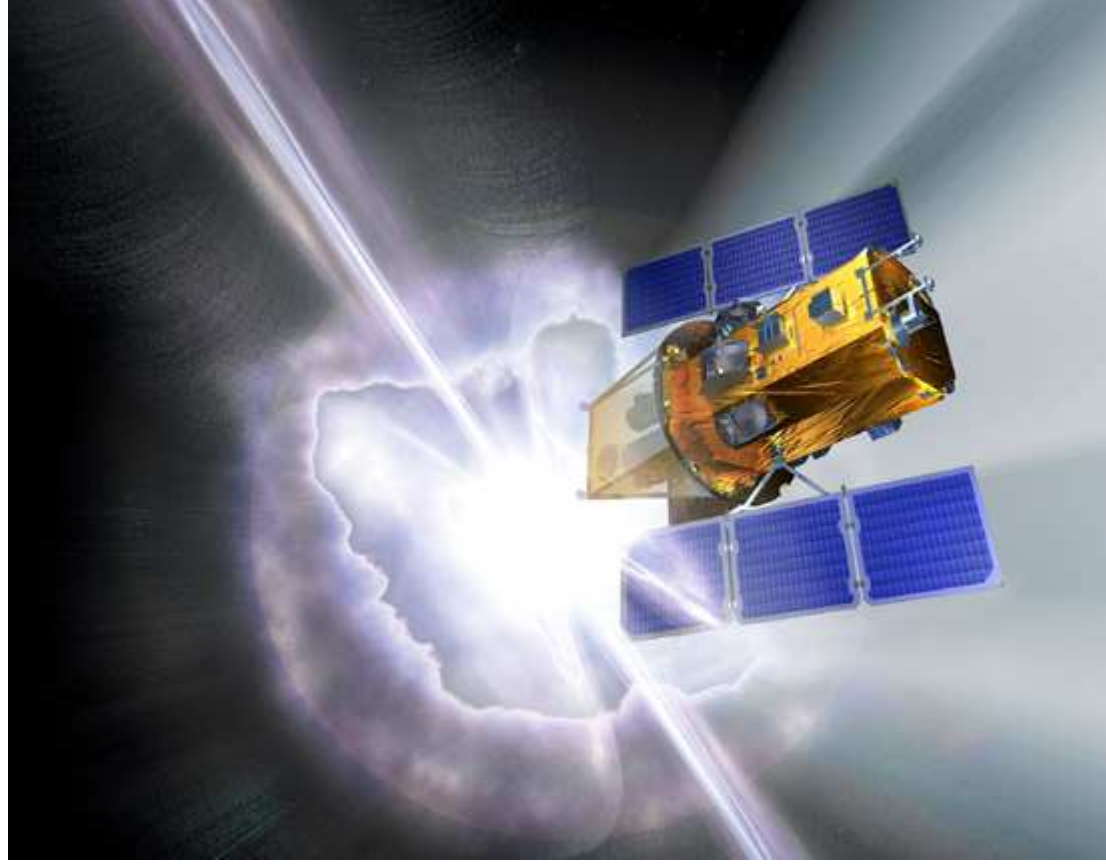
7 WAYS A BLACK HOLE CAN KILL YOU

Pffsssst!



7 WAYS A BLACK HOLE CAN KILL YOU

NASA's Swift Response



**SWIFT WILL
DETECT
>100 GRBS
PER YEAR**

**Launched November
20, 2004**

Detected over 200 burst
so far

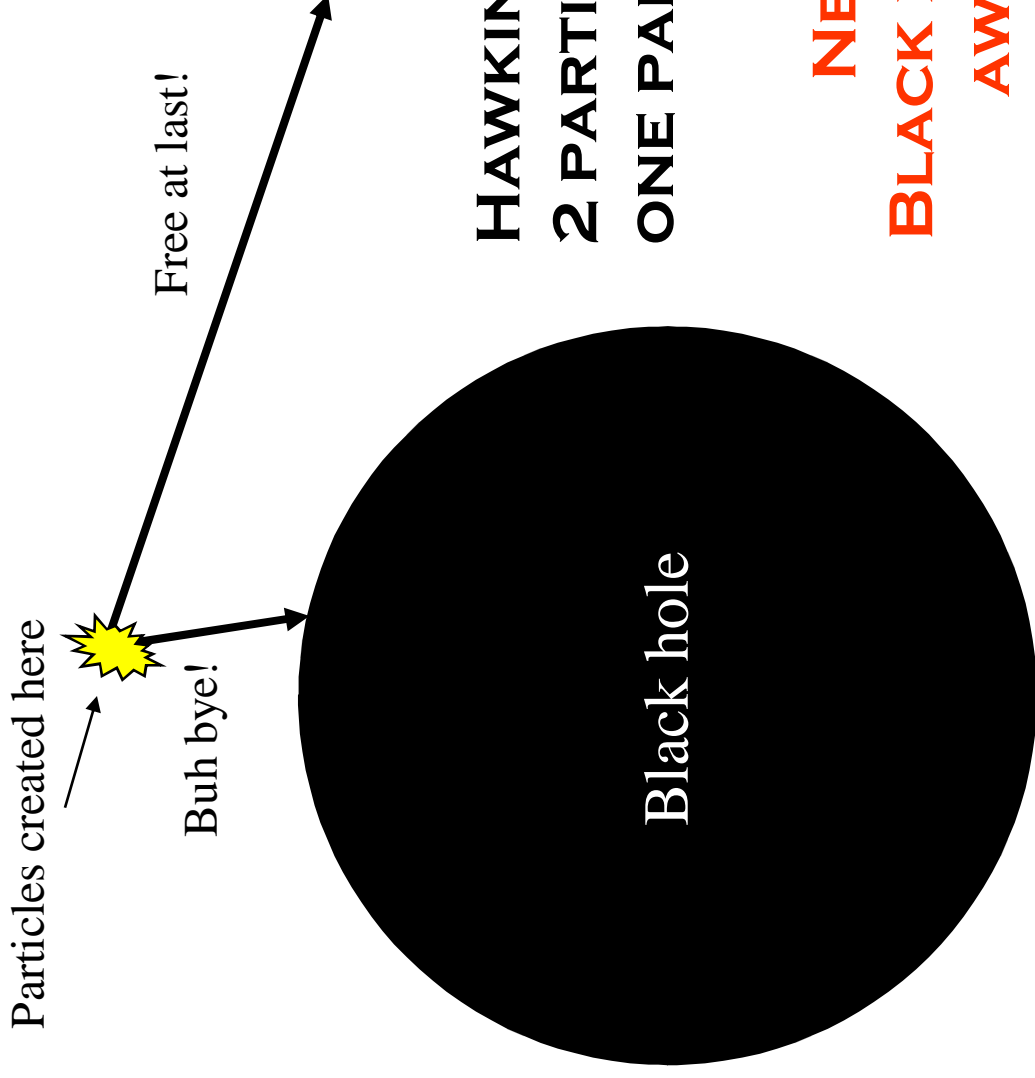
7 WAYS A BLACK HOLE CAN KILL YOU

The Fourth Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. BE NEAR ONE WHEN IT'S BORN
4. **BE NEAR ONE WHEN IT DIES**
- 5.
- 6.
- 7.

7 WAYS A BLACK HOLE CAN KILL YOU

Pair Production



**HAWKING RADIATION:
2 PARTICLES CREATED,
ONE PARTICLE LEAVES**

**NET EFFECT:
BLACK HOLES RADIATE
AWAY ENERGY**

Size Does Matter

Hawking radiation depends on size/mass of the black hole:
smaller holes radiate faster!

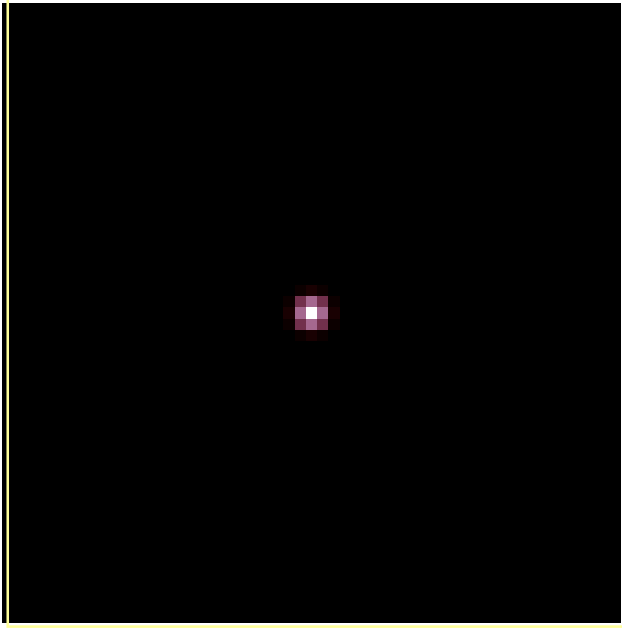
In fact, radiation emitted goes as $1/\text{mass}^3$

Stellar black hole lives for 10^{67} years

A MINI BLACK HOLE

(MASS = 10^{12} KG)

**CREATED IN THE BIG BANG
WOULD BE EXPLODING NOW**



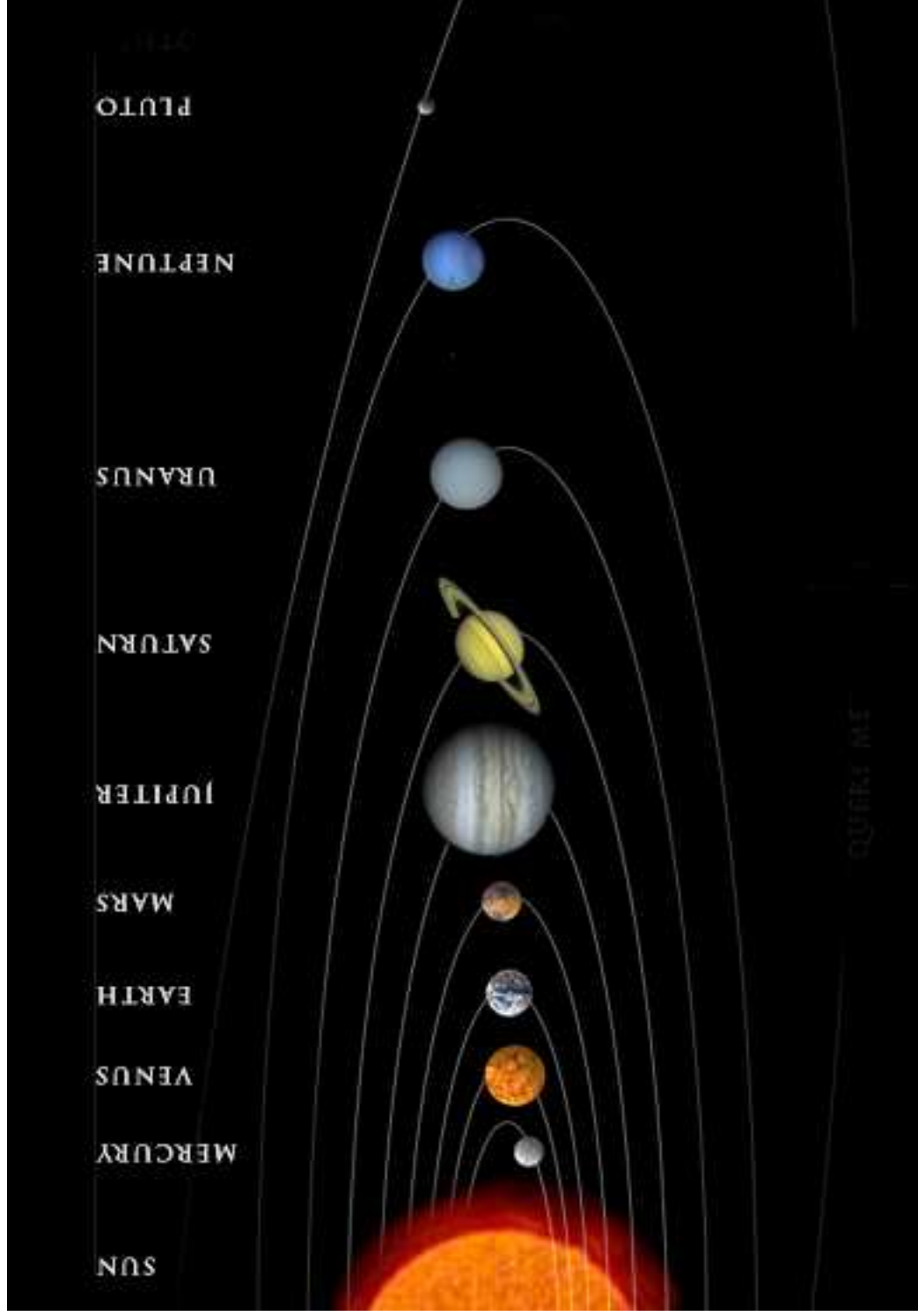
**EMITS HIGHER ENERGY
RADIATION FASTER AS SIZE SHRINKS.
KABOOM!**

7 WAYS A BLACK HOLE CAN KILL YOU

The Fifth Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. BE NEAR ONE WHEN IT'S BORN
4. BE NEAR ONE WHEN IT DIES
5. JUST PASSING THROUGH
- 6.
- 7.

not It's a Wonderful Day in the Neighborhood



7 WAYS A BLACK HOLE CAN KILL YOU

Orbit Simulation

Go to orbit animation

7 WAYS A BLACK HOLE CAN KILL YOU

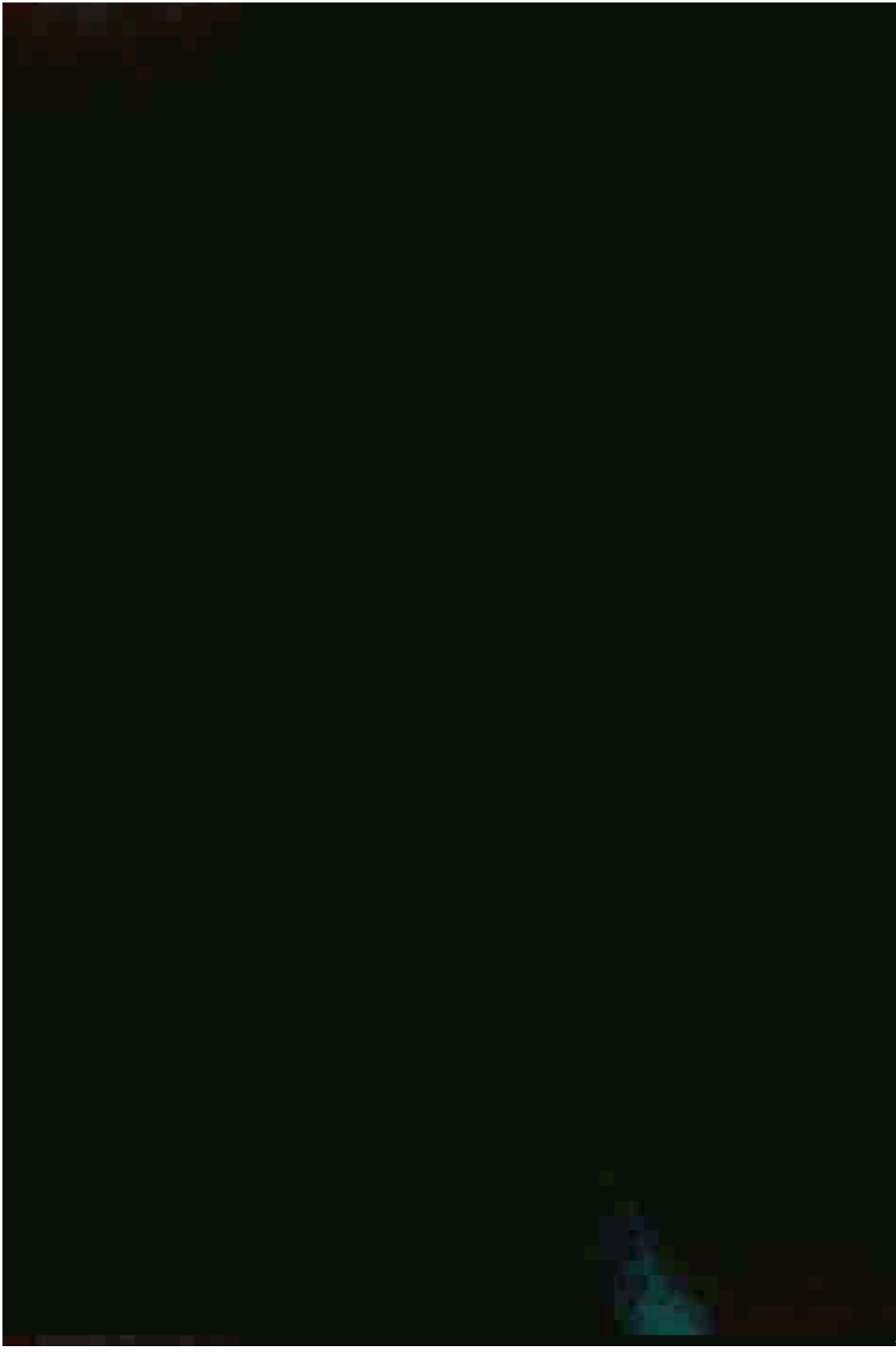
7 WAYS A BLACK HOLE CAN KILL YOU



The Sixth Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. BE NEAR ONE WHEN IT'S BORN
4. BE NEAR ONE WHEN IT DIES
5. JUST PASSING THROUGH
6. **BE NEARBY WHEN THEY MERGE**
- 7.

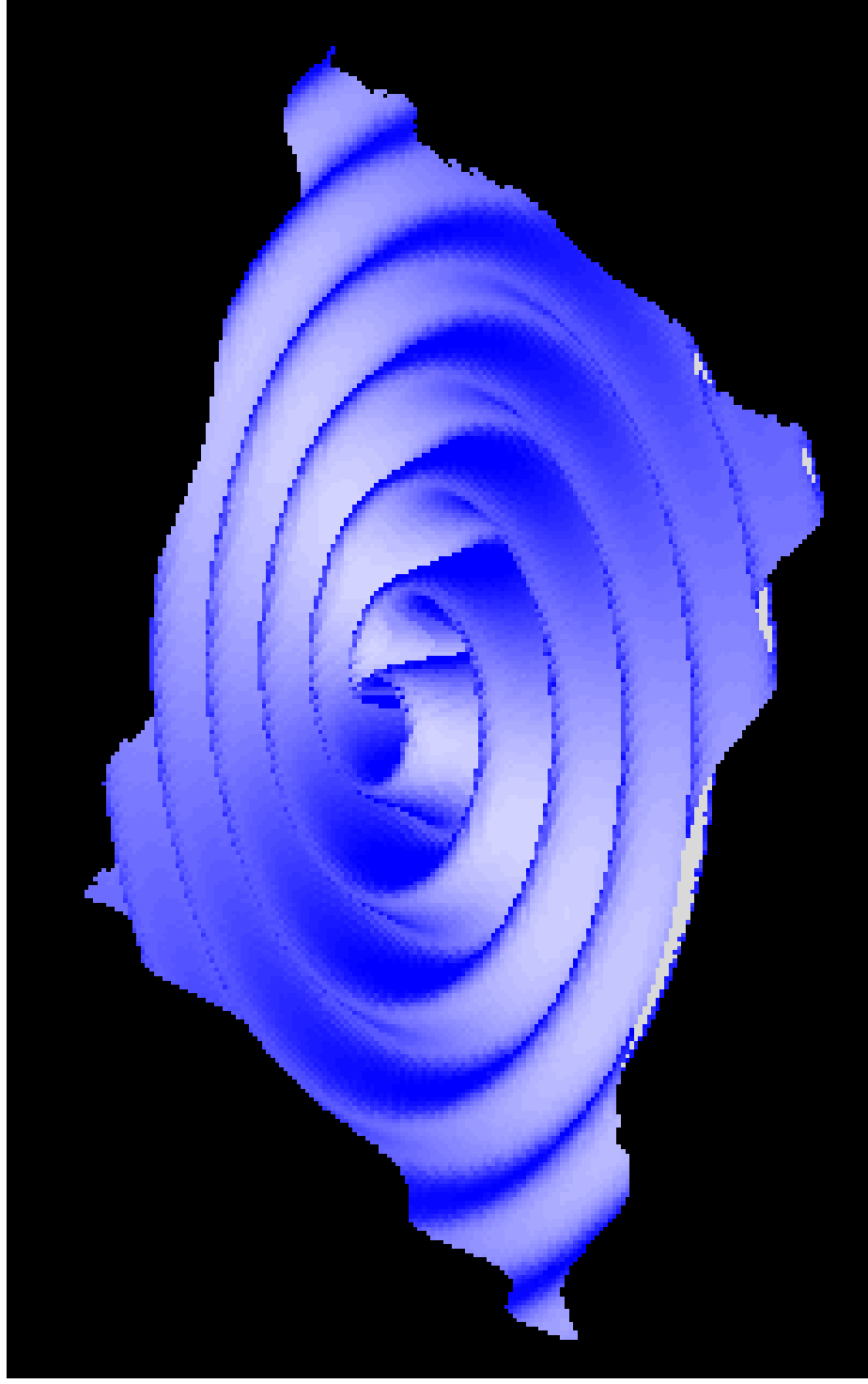
When Galaxies Collide



7 WAYS A BLACK HOLE CAN KILL YOU

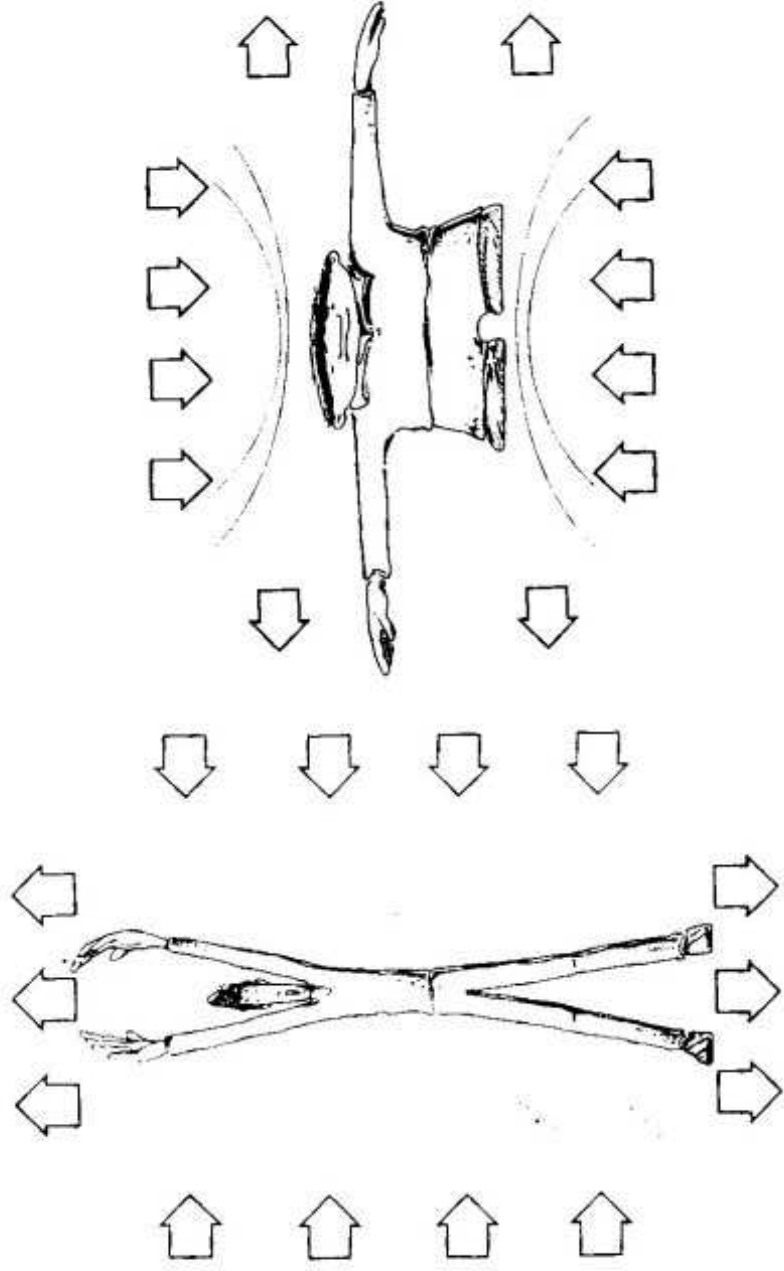
7 WAYS A BLACK HOLE CAN KILL YOU

Wave Bye Bye



**GRAVITATIONAL WAVES
EXPAND AND CONTRACT SPACE ITSELF**

The Long and the Short of It



7 WAYS A BLACK HOLE CAN KILL YOU

LIGO : Hunting Gravity Waves

- Two observatories (Washington and Louisiana)
- L-Shaped tubes
- Attempt to measure changes in length as gravity waves pass
- Sensitive to 10^{-18}m
- Sensitive to short wavelength gravity waves

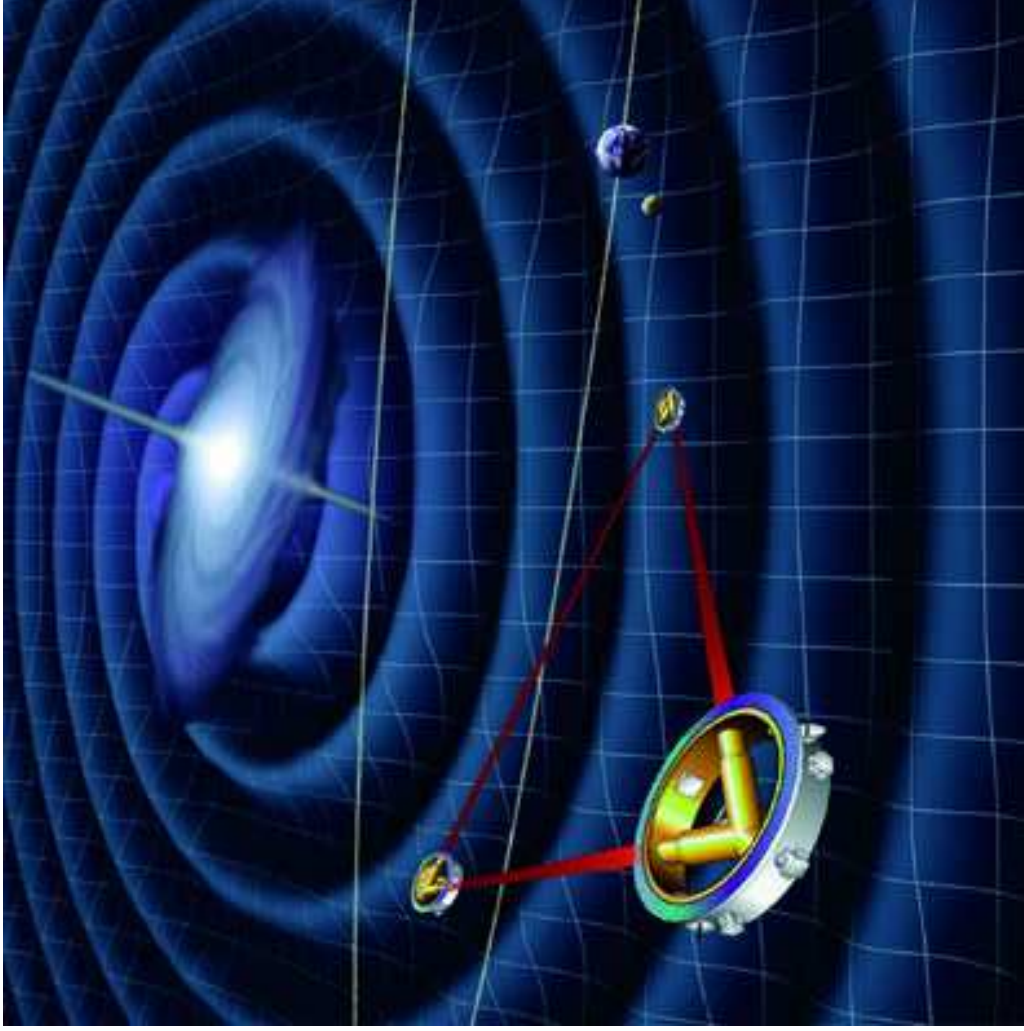


7 WAYS A BLACK HOLE CAN KILL YOU

ESA's Response: LISA

**3 “WAGON WHEELS”
THAT WILL DETECT
PASSING
GRAVITATIONAL
WAVES**

Target launch: 2011

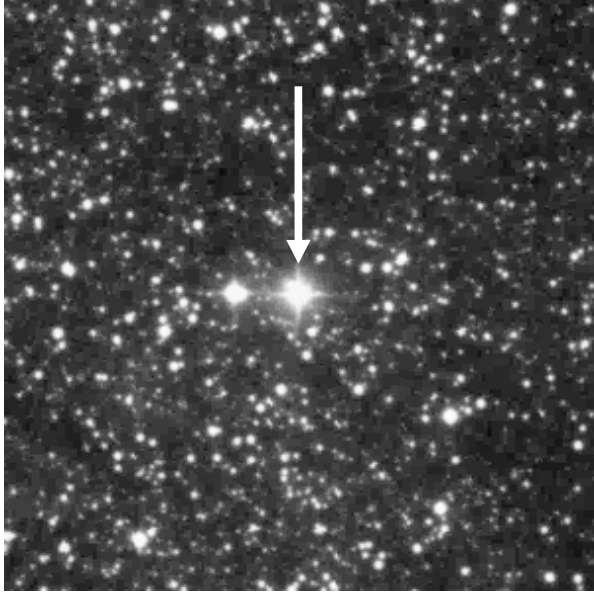


7 WAYS A BLACK HOLE CAN KILL YOU

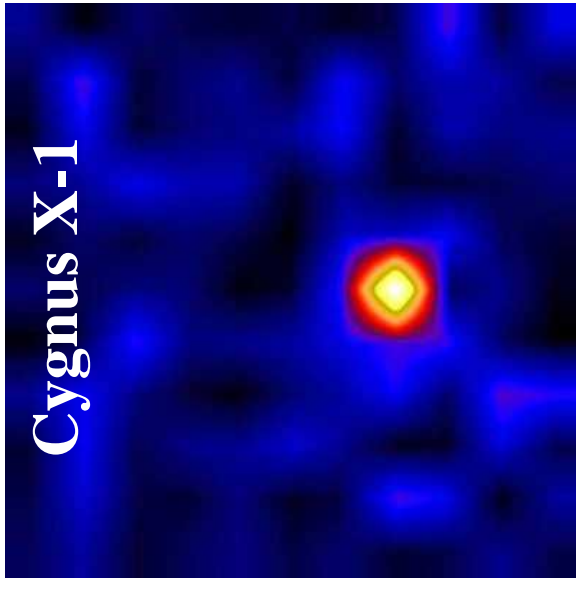
The Seventh Way A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. BE NEAR ONE WHEN IT'S BORN
4. BE NEAR ONE WHEN IT DIES
5. JUST PASSING THROUGH
6. BE NEARBY WHEN THEY MERGE
7. FRIED BY THE LIGHT

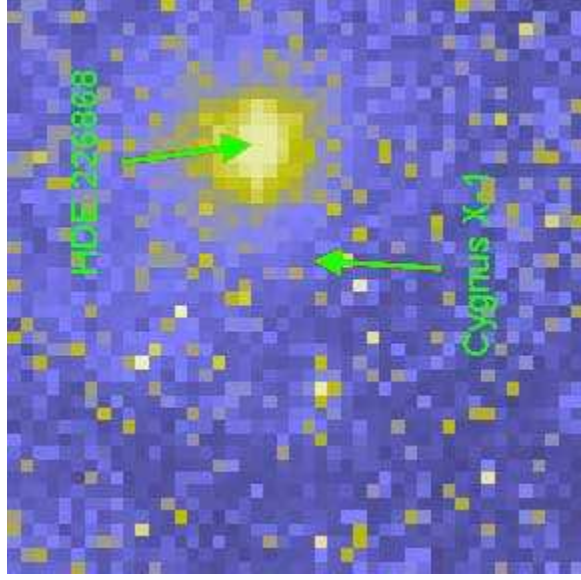
Traveling Companion



HD 226868: just your typical bloated supergiant star... but it has a secret



**HD 226868 in X-rays
(100,000x energy of Sun!)**



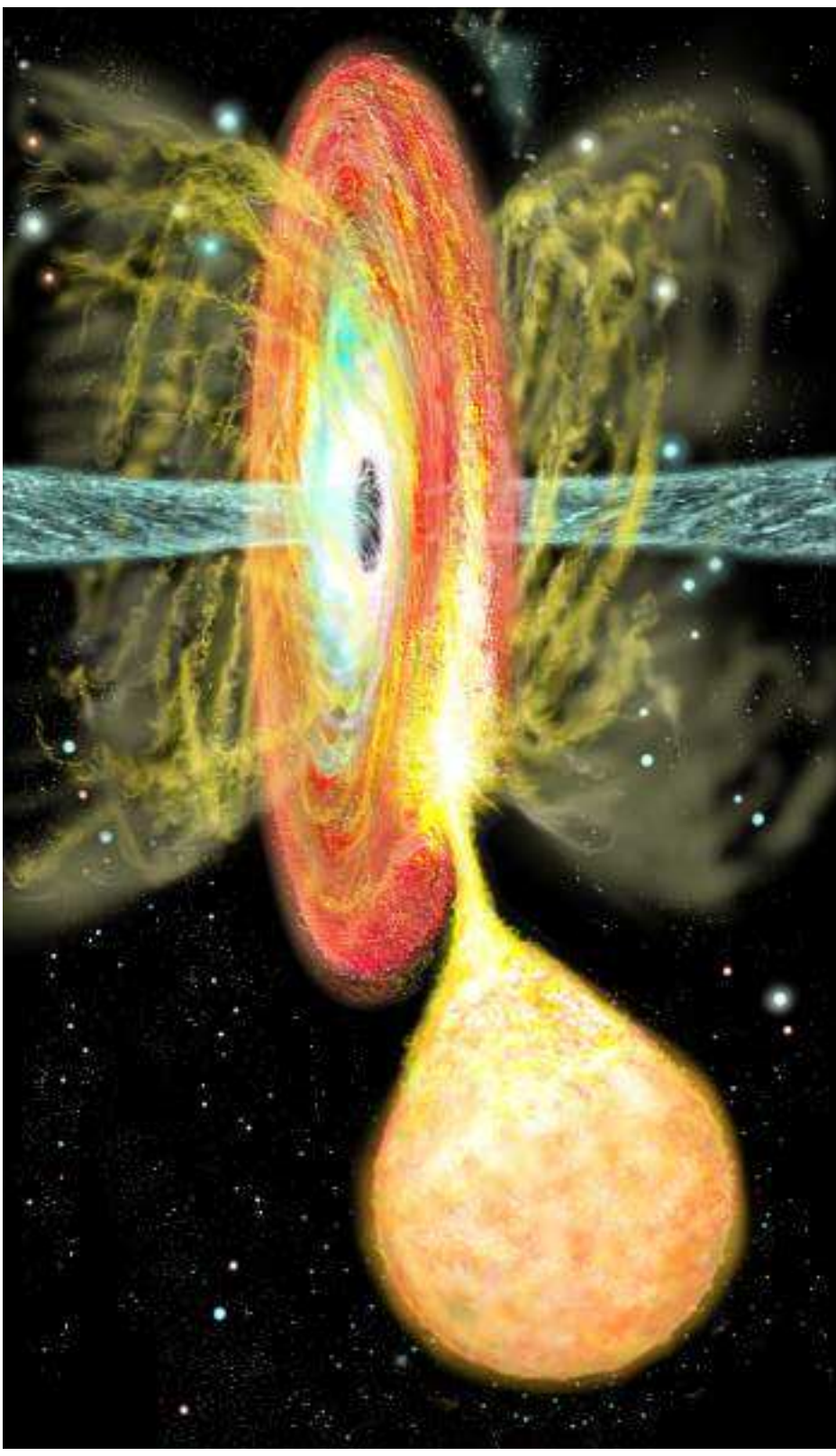
Hey, where is it?

The Hideous Vortex



7 WAYS A BLACK HOLE CAN KILL YOU

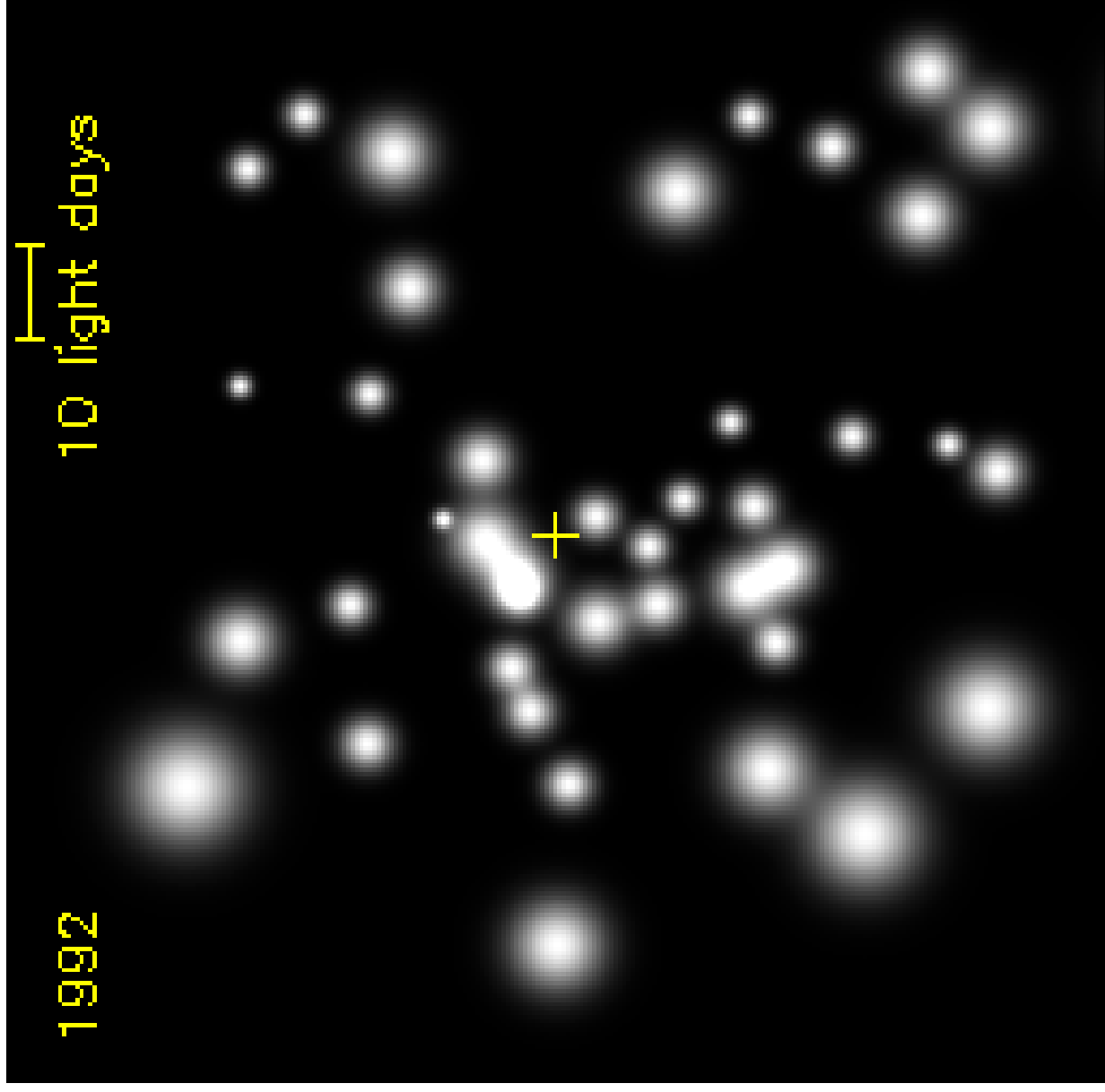
Disks and Fields and Jets, Oh My



7 WAYS A BLACK HOLE CAN KILL YOU

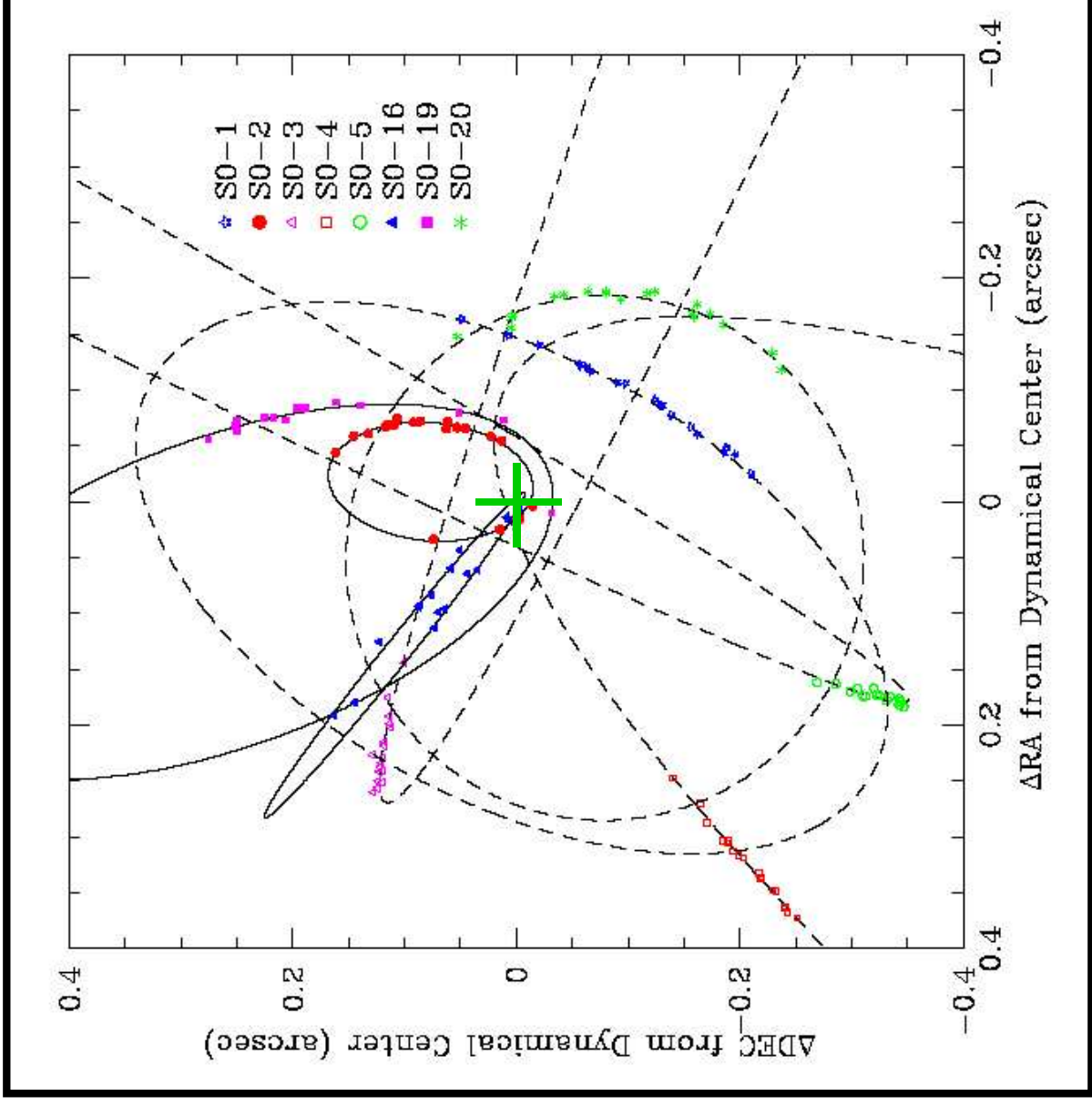
7 WAYS A BLACK HOLE CAN KILL YOU

EXTREME Close up



7 WAYS A BLACK HOLE CAN KILL YOU

The Monster in the Middle



Our GLAST Resort

**GAMMA-RAY
LARGE AREA
SPACE TELESCOPE**

Launch in 2007

**GLAST WILL SEE
THOUSANDS
OF
ACTIVE GALAXIES**



7 WAYS A BLACK HOLE CAN KILL YOU

The Eight Ways A Black Hole Can Kill You

1. FALLING IN
2. SPAGHETTIFICATION
3. BE NEAR ONE WHEN IT'S BORN
4. BE NEAR ONE WHEN IT DIES
5. JUST PASSING THROUGH
6. BE NEARBY WHEN THEY MERGE
7. FRIED BY THE LIGHT
8. ROASTED!

Roasted!

- Black holes can only eat so fast
- Matter piles up inside a black hole creating a hot plasma
- **VERY HOT PLASMA!**
- In large black holes, tidal forces are weak, so you would be fried before you were spaghettified!

7 WAYS A BLACK HOLE CAN KILL YOU

What's on the other side...?



7 WAYS A BLACK HOLE CAN KILL YOU