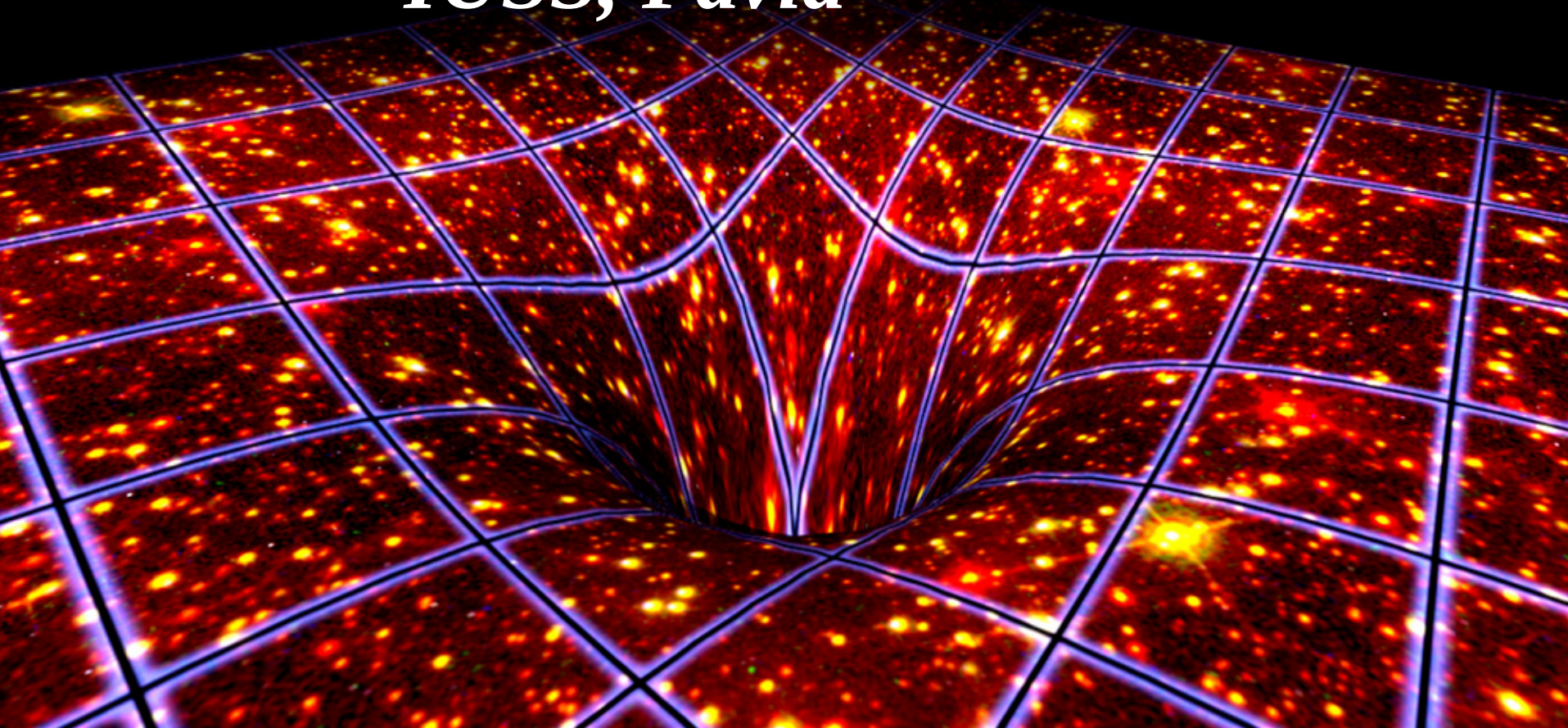
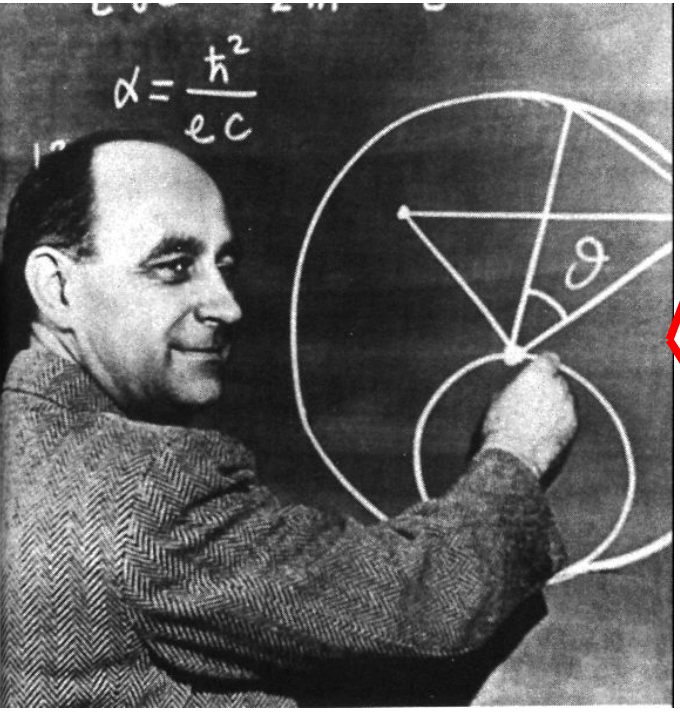
# Physics in space

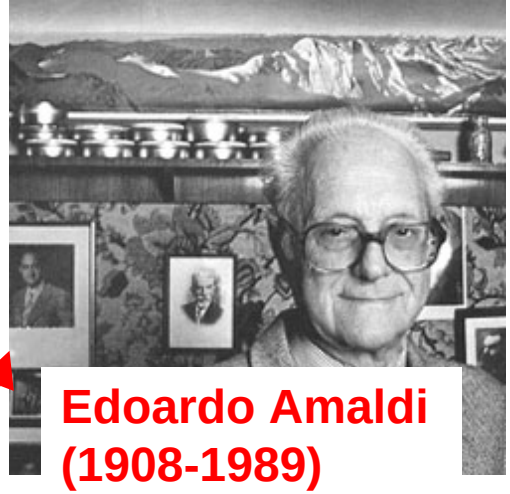
*Giovanni F. Bignami*
*IUSS, Pavia*



# Cultural Heritage




Enrico Fermi (1901-1954)



Edoardo Amaldi (1908-1989)

Bruno Rossi (1904-1993)

Riccardo Giacconi

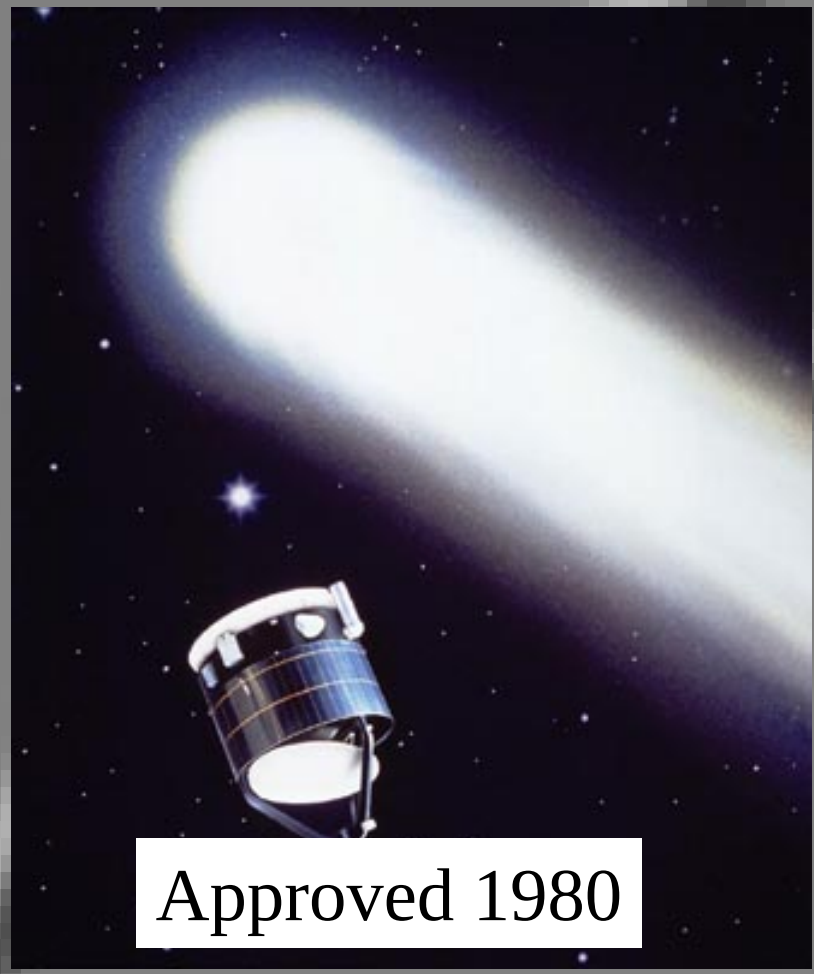
Beppo Occhialini (1907-1993)

**CERN 1954**

**ESRO 1962**

**ESA 1975**
**Chair SPC 78-81**
**Chair SSAC 81-83**

Approved 1983



Approved 1980

**1983: started Horizon 2000 long term ESA planning exercise with a survey committee**

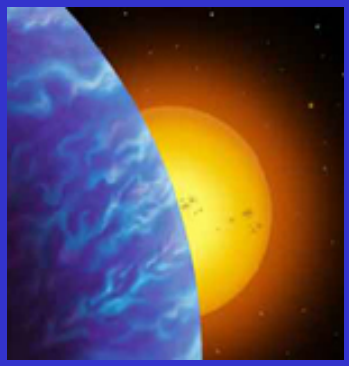
**20 years later…:**

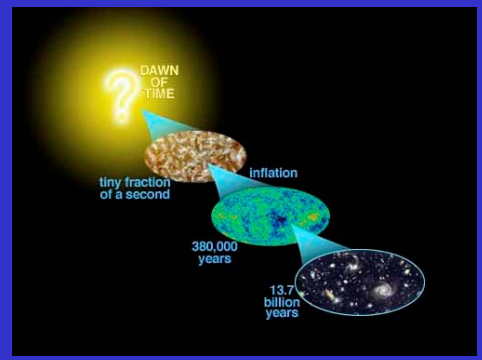
Space Science for Europe

# Cosmic Vision 2015-2025

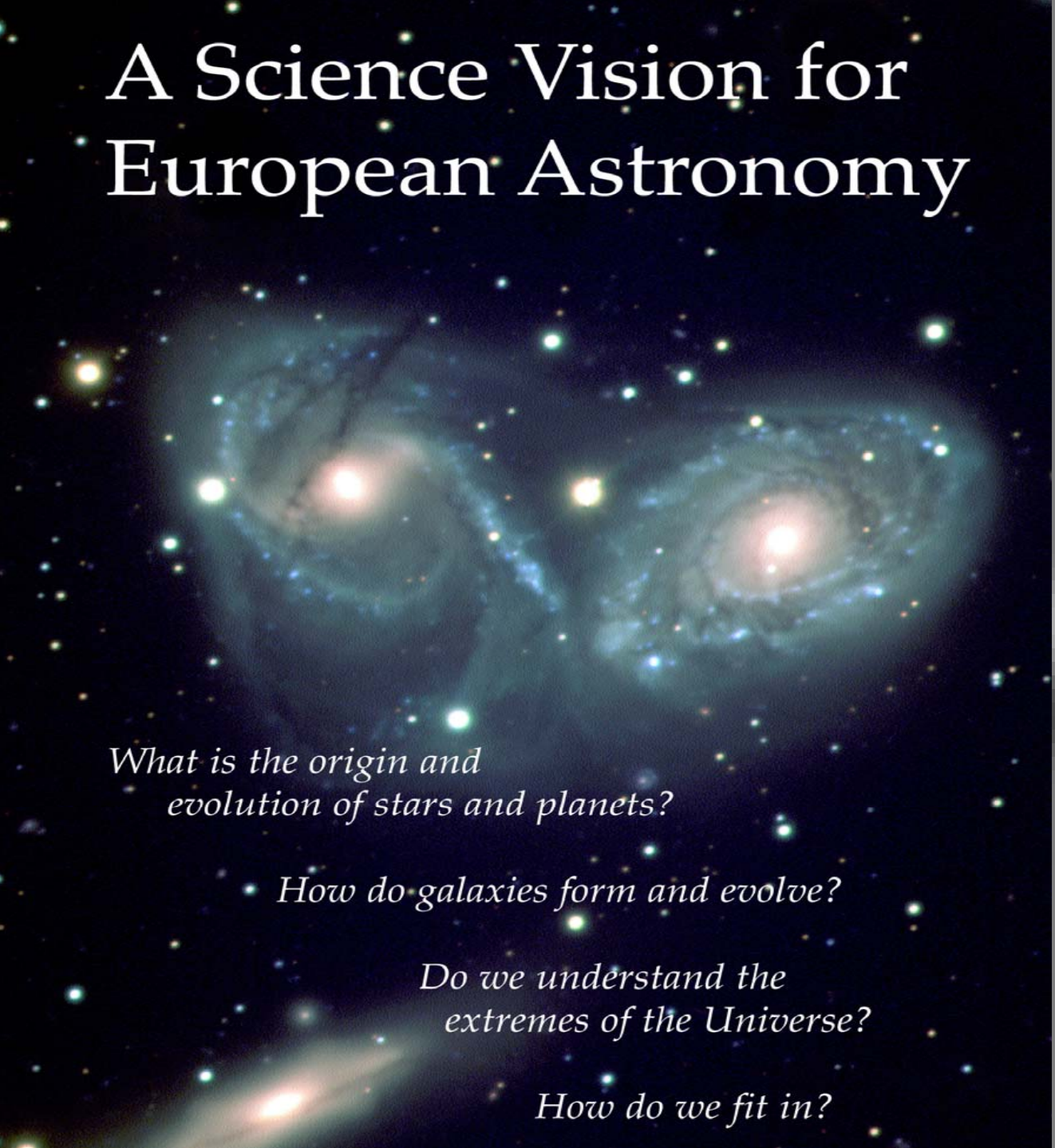
# Grand themes

1. What are the conditions for life and planetary formation?
2. How does the Solar System work?
3. What are the fundamental laws of the Universe?
4. How did the Universe originate and what is it made of?





# A Science Vision for European Astronomy



*What is the origin and evolution of stars and planets?*

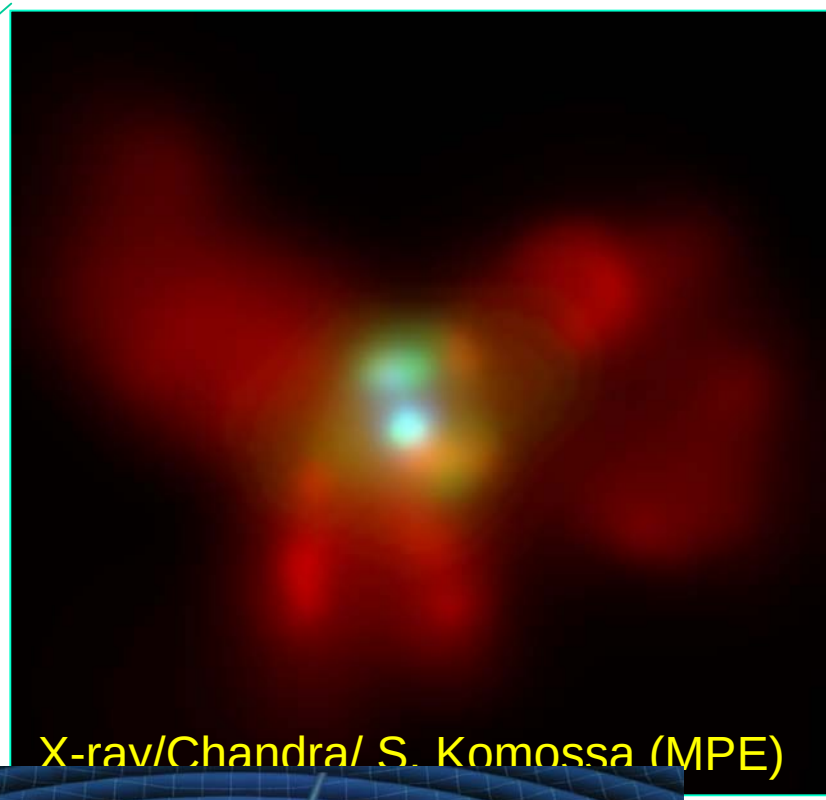
*How do galaxies form and evolve?*

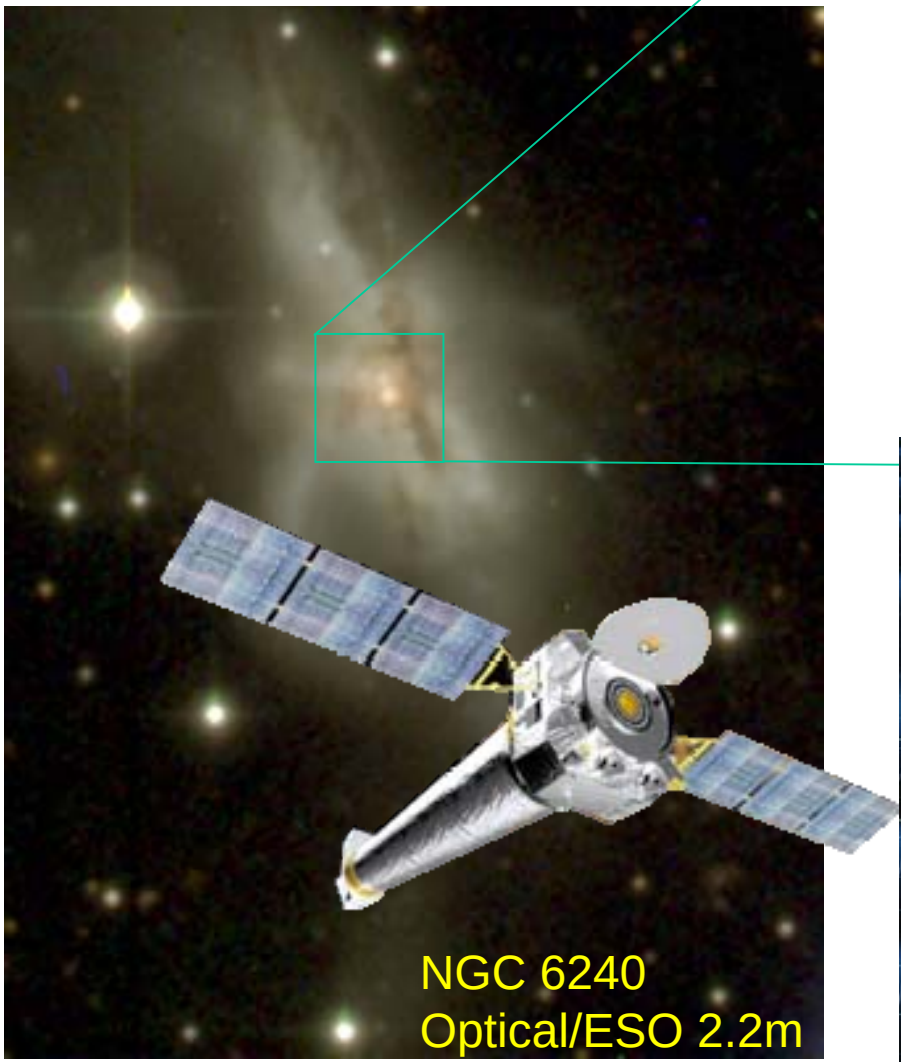
*Do we understand the extremes of the Universe?*

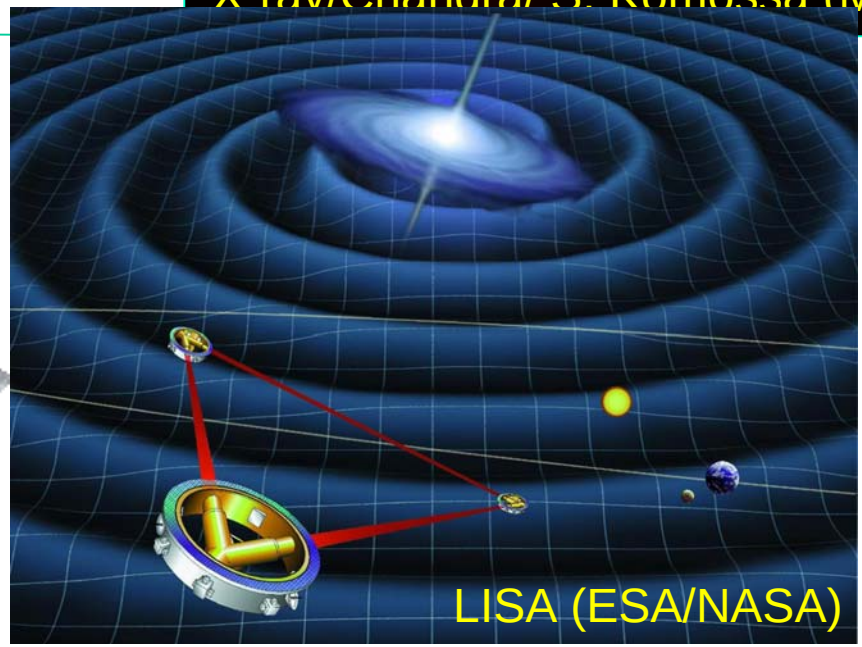
*How do we fit in?*

**Astronet**

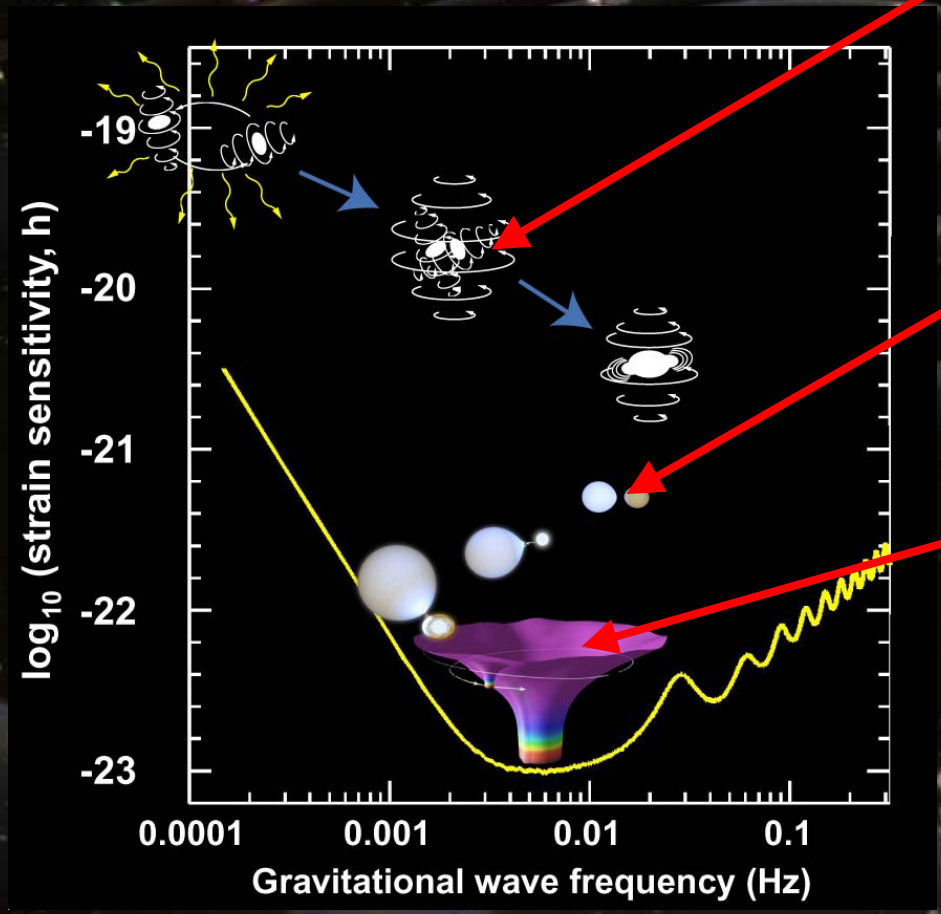
# The physics of gravitation at work



# LISA: A Universe Full of Strong GW Sources




Massive Black Hole Binary (BHB) inspiral and merger

Ultra-compact binaries

Extreme Mass Ratio Inspiral (EMRI)

Cosmic backgrounds, superstring bursts?

6 September 2007 | www.nature.com/nature | £10

THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

# nature

**THE K/T IMPACT**
Baptistina asteroids in the frame

**BIOMETRICS**
The questions you meant to ask

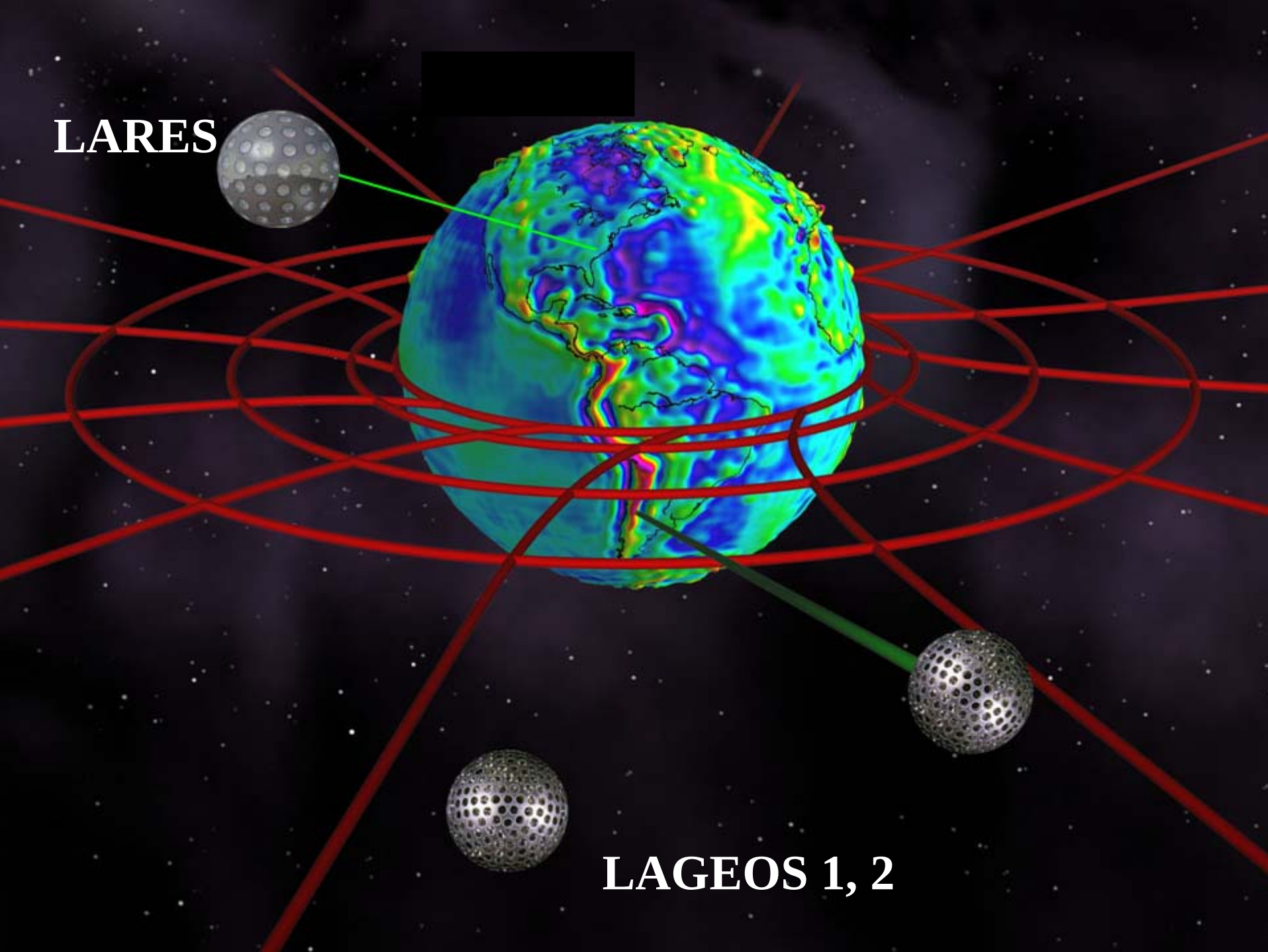
**TSUNAMIS**
Tracking risk off the Myanmar coast

**NATUREJOBS**
Hydrogen technology

# THE RIDDLE OF INERTIA

How Earth's rotation reshapes space and time

36


LARES
LAGEOS 1, 2

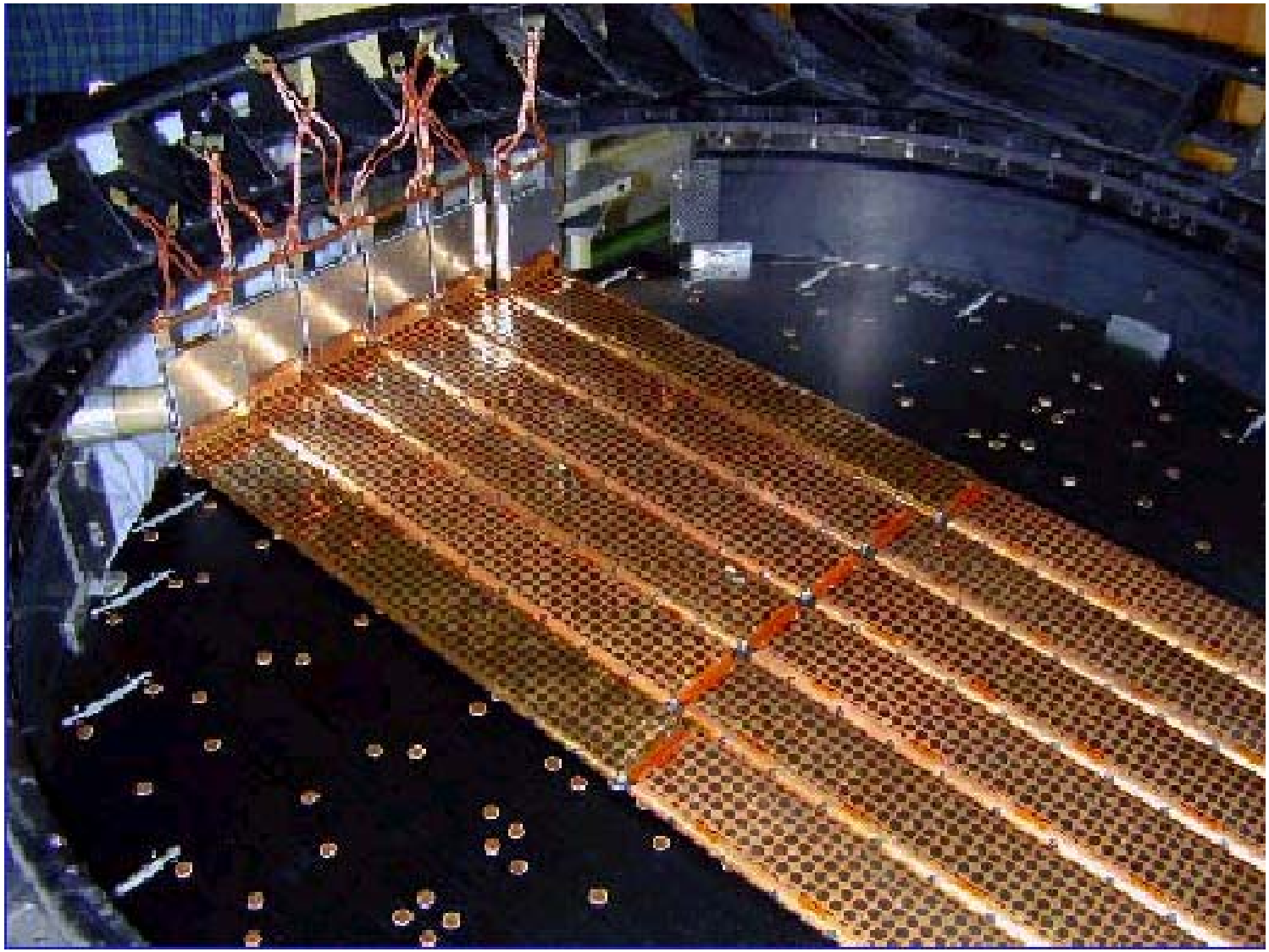
# Particle Astrophysics: Matter, Antimatter, Dark Matter Strange Matter….

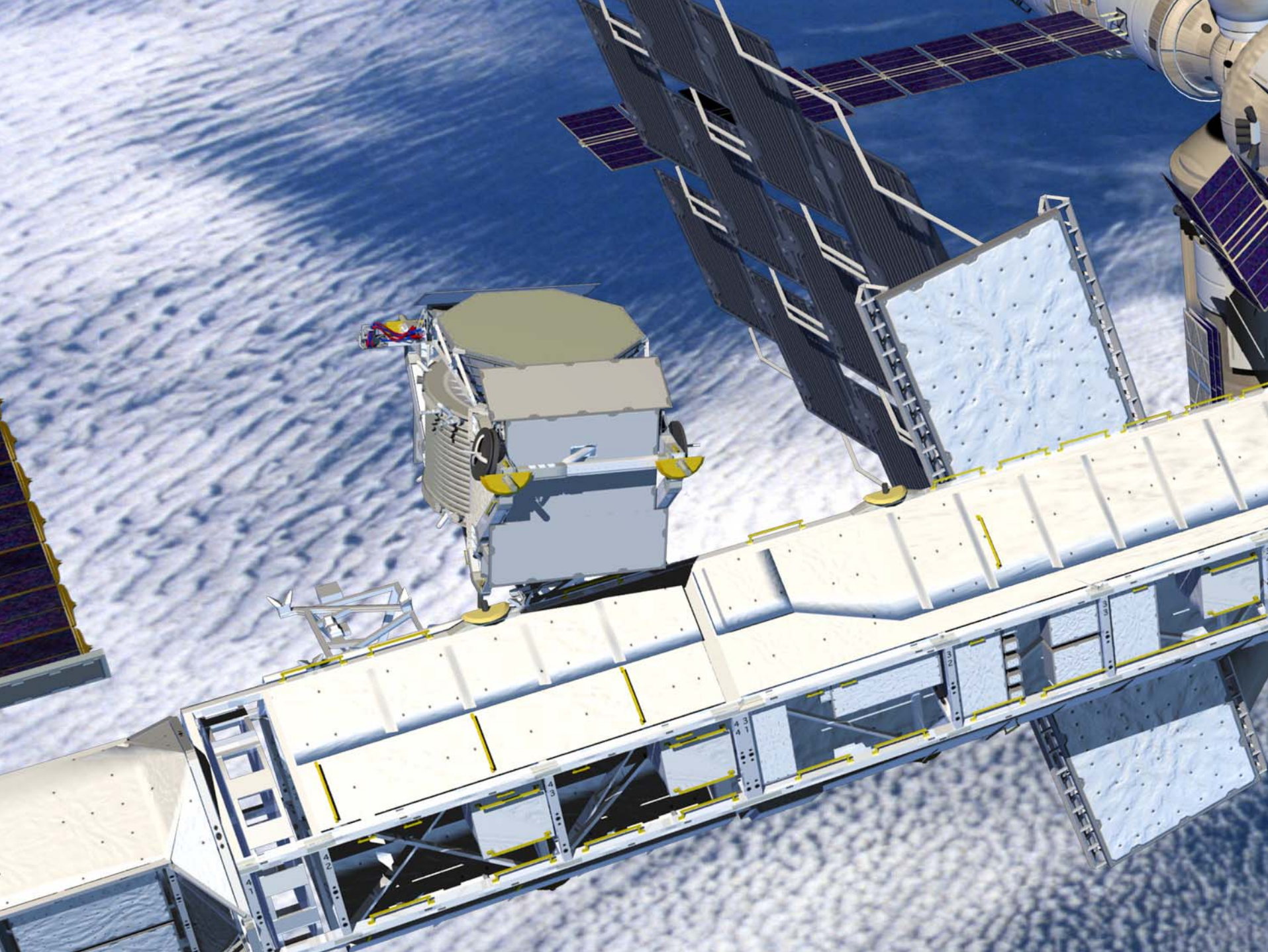
PaMeLa

a **P**ayload for **A**ntimatter **M**atter **E**xploration and **L**ight–nuclei **A**strophysics

# AMS-01

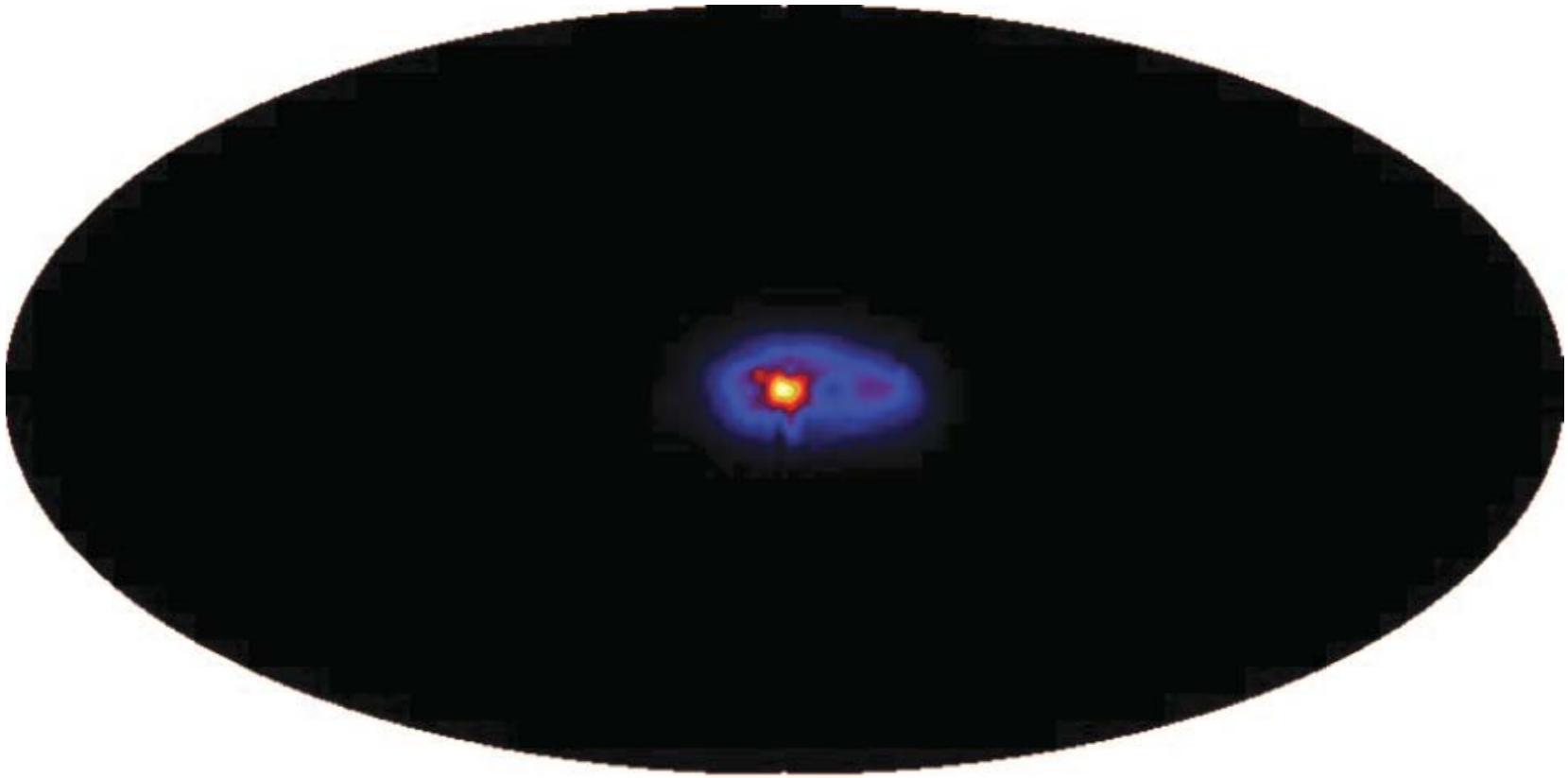
# AMS-01 Tracker  Planes with Silicon Ladders Installed



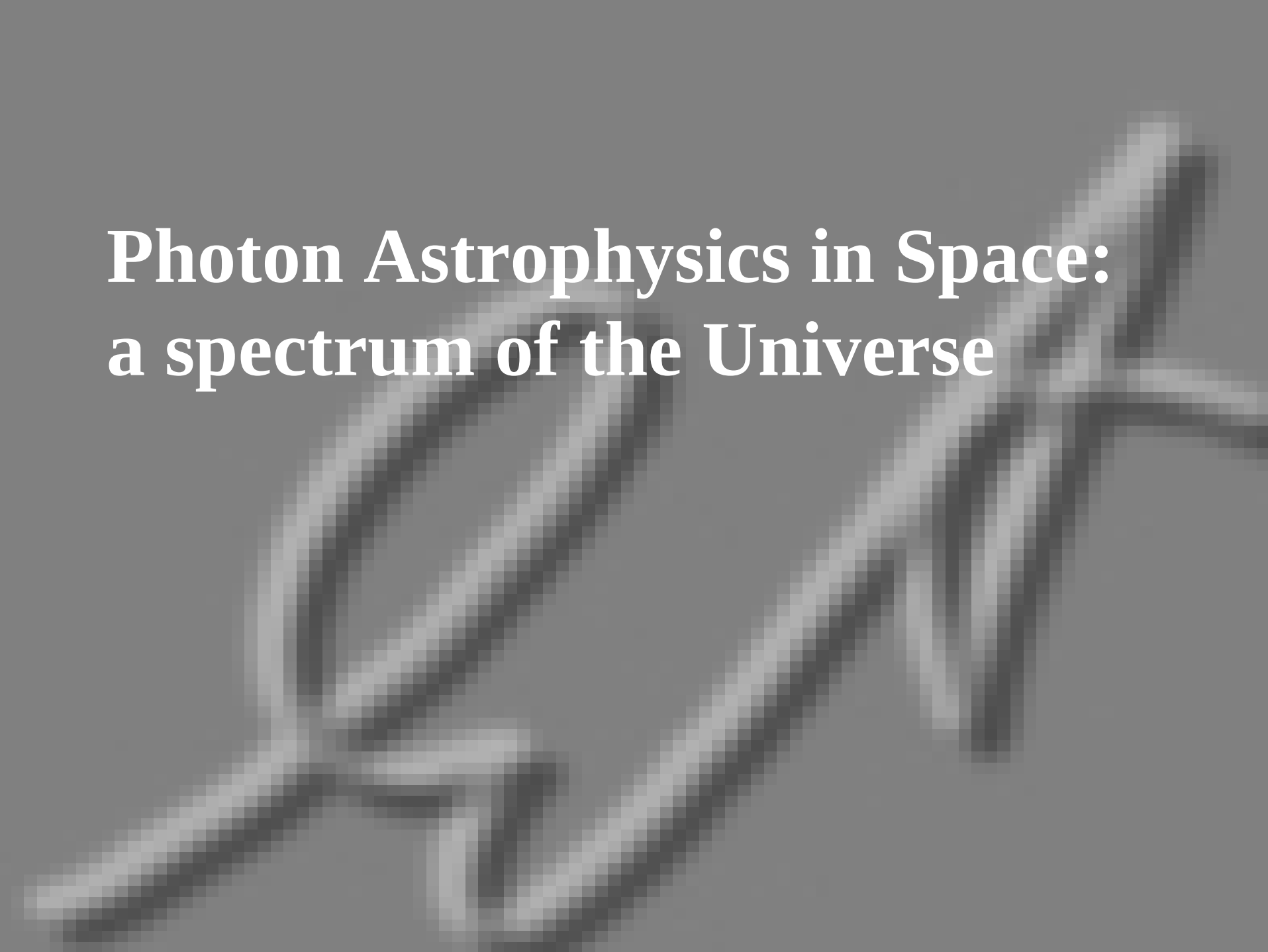


# An asymmetric distribution of positrons in the Galactic disk revealed by γ-rays

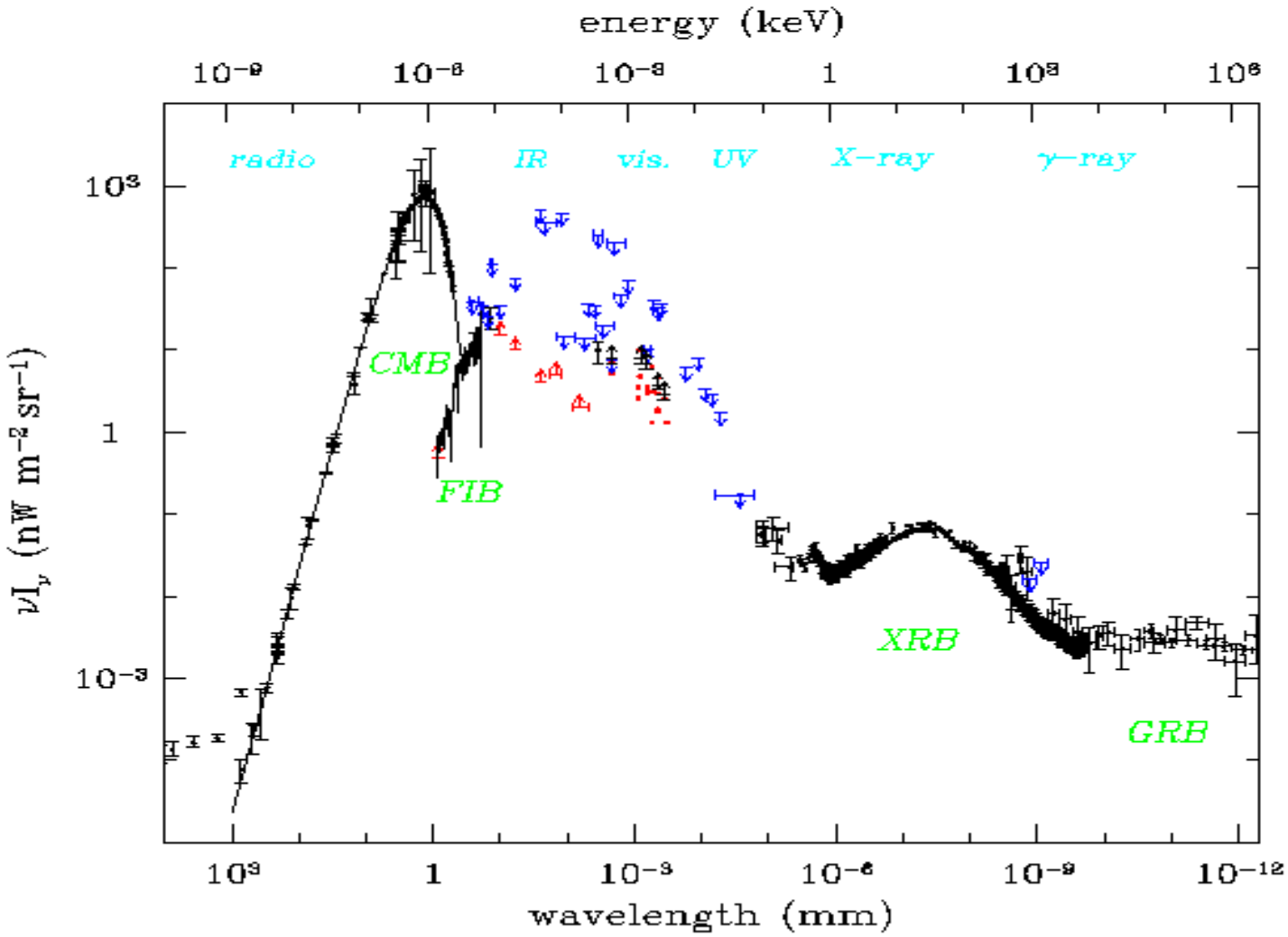
Georg Weidenspointner[1,2,3], Gerry Skinner[1,4,5], Pierre Jean[1], Jürgen Knödlseder[1], Peter von Ballmoos[1], Giovanni Bignami[1,8], Roland Diehl[2], Andrew W. Strong[2], Bertrand Cordier[6], Stéphane Schanne[6] & Christoph Winkler[7]

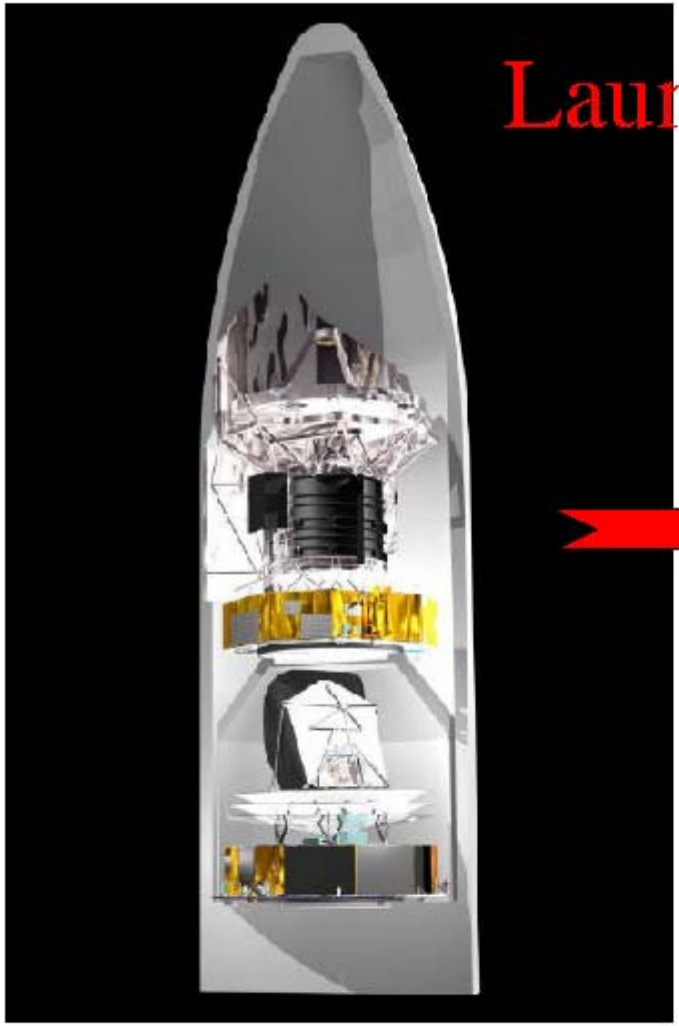


# Photon Astrophysics in Space: a spectrum of the Universe

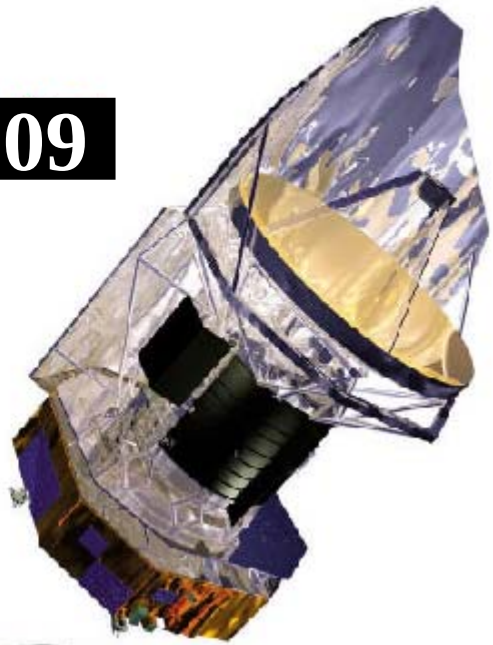


# Cosmic background from radio to gamma rays

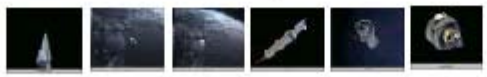




Launch in **2009**



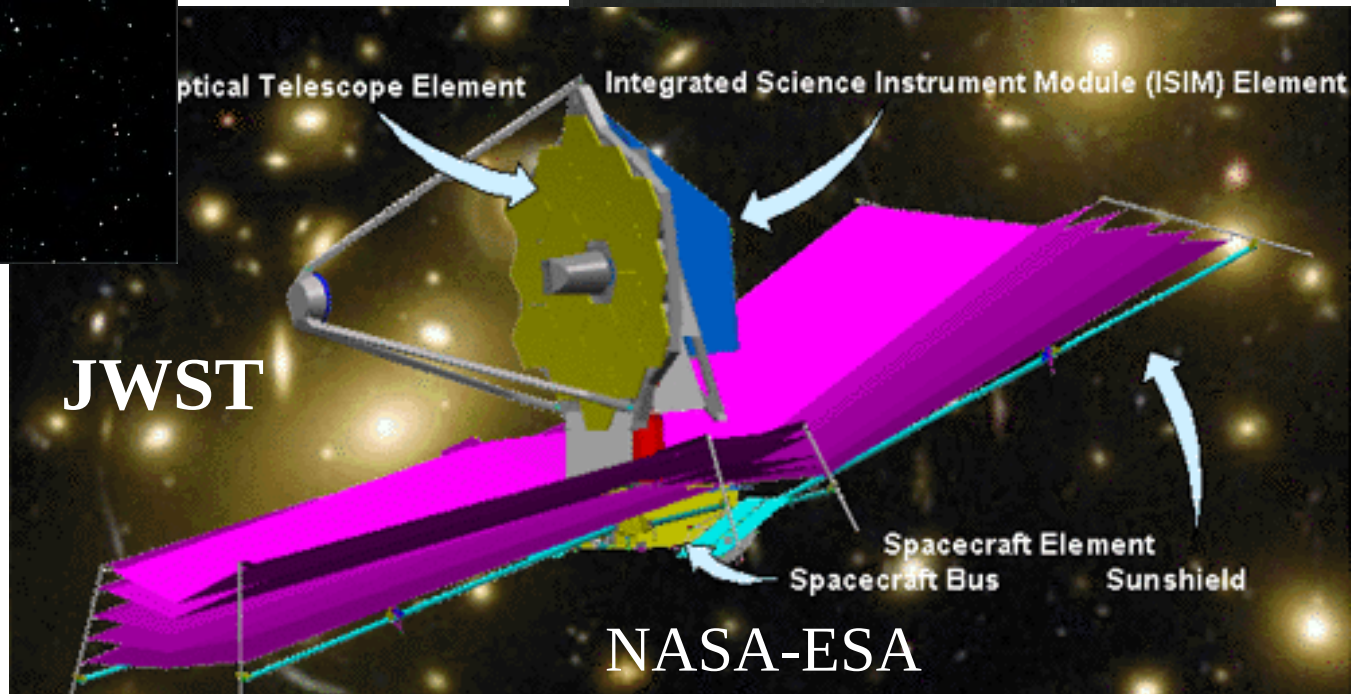
PLANCK



esa ASTROPHYSICS


Herschel
ESA


GAIA
ESA

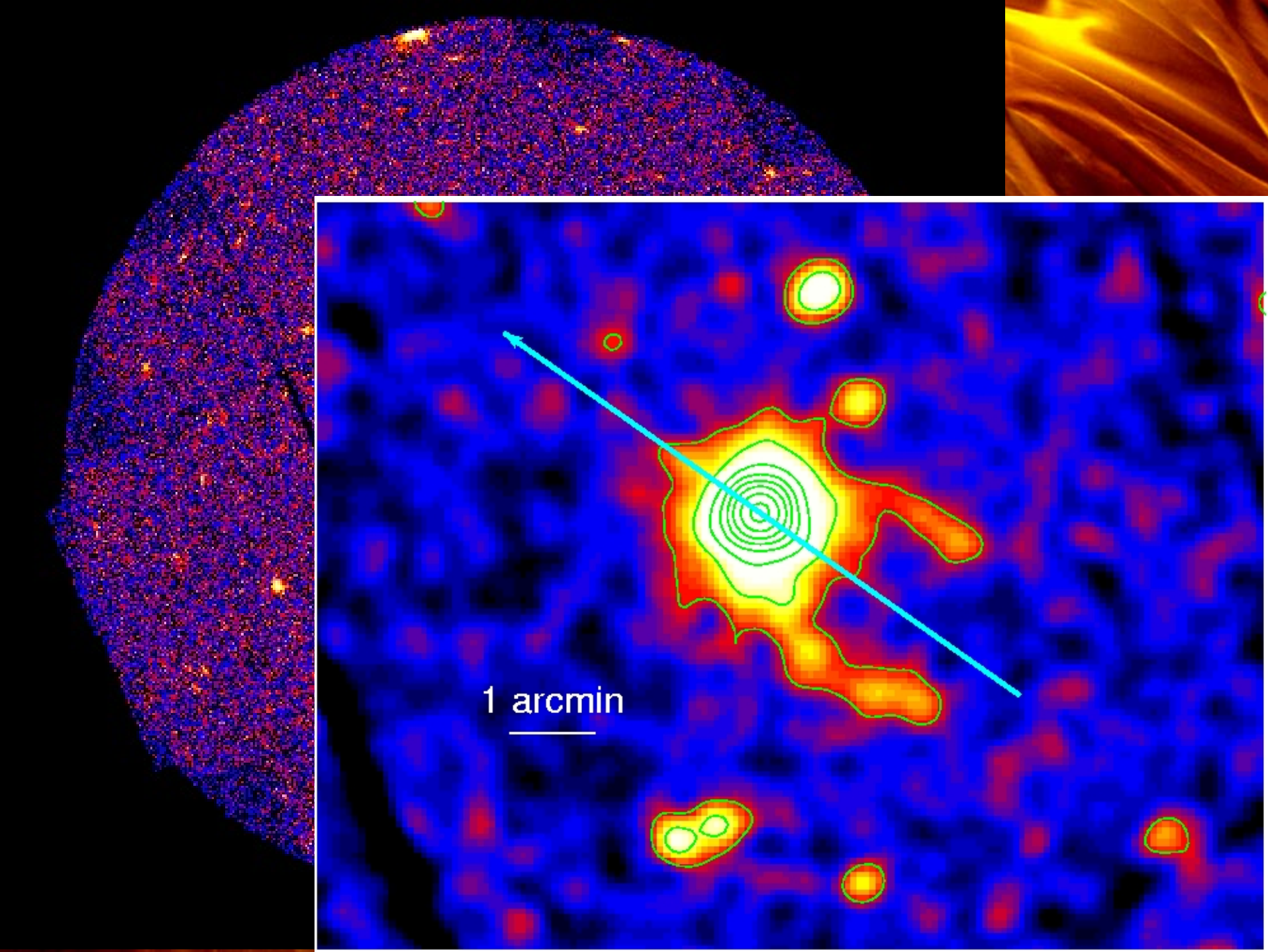

ptical Telescope Element
Integrated Science Instrument Module (ISIM) Element
JWST
Spacecraft Element
Spacecraft Bus
Sunshield
NASA-ESA

# High-Energy Astrophysics: an Italian Specialty

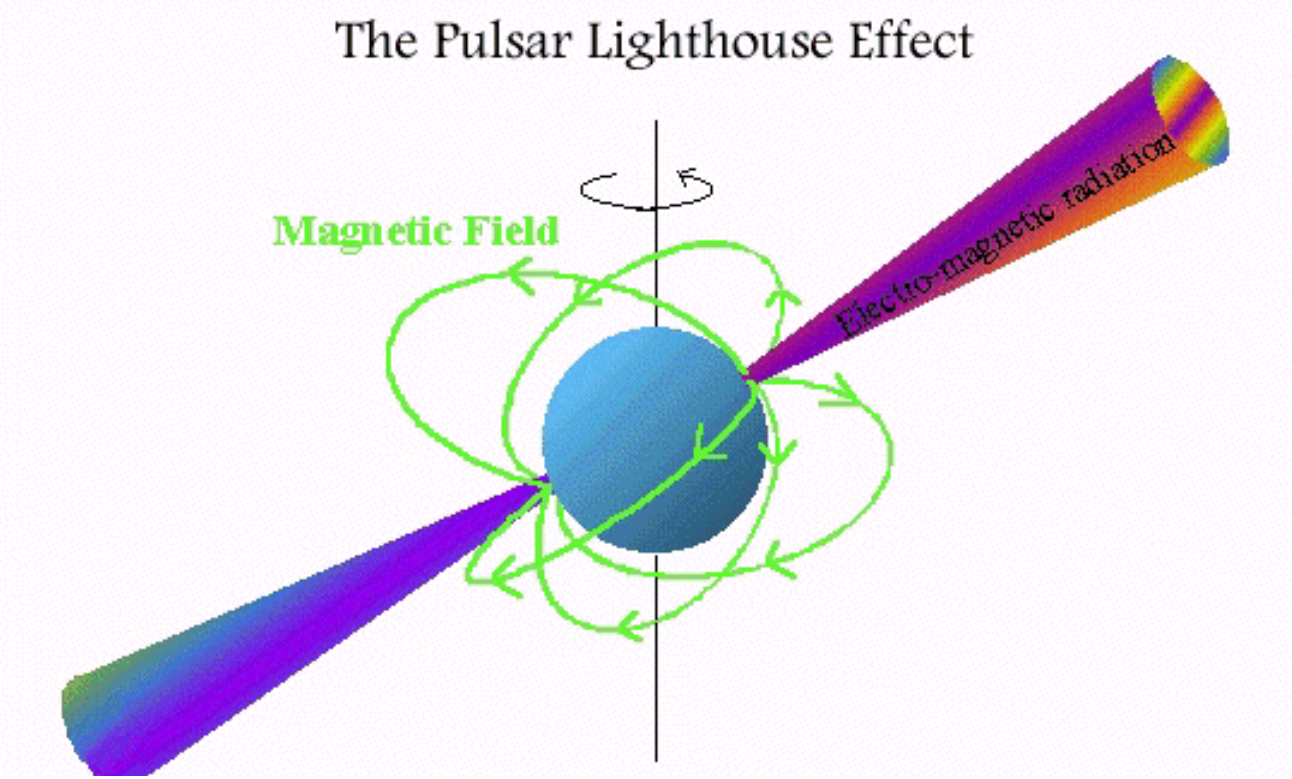

Cos-b
Exosat
1975
BEPPO-SAX
XMM-Newton
Integral
Swift
Agile
Fermi
40 years of Italy &High-Energy Astrophysics
1st ESA satellite
2 Italian National missions
2 Italian PI Instruments
5 missions currently active
Simbol X
2015

# Newton
# and
# Neutron Star Physics:

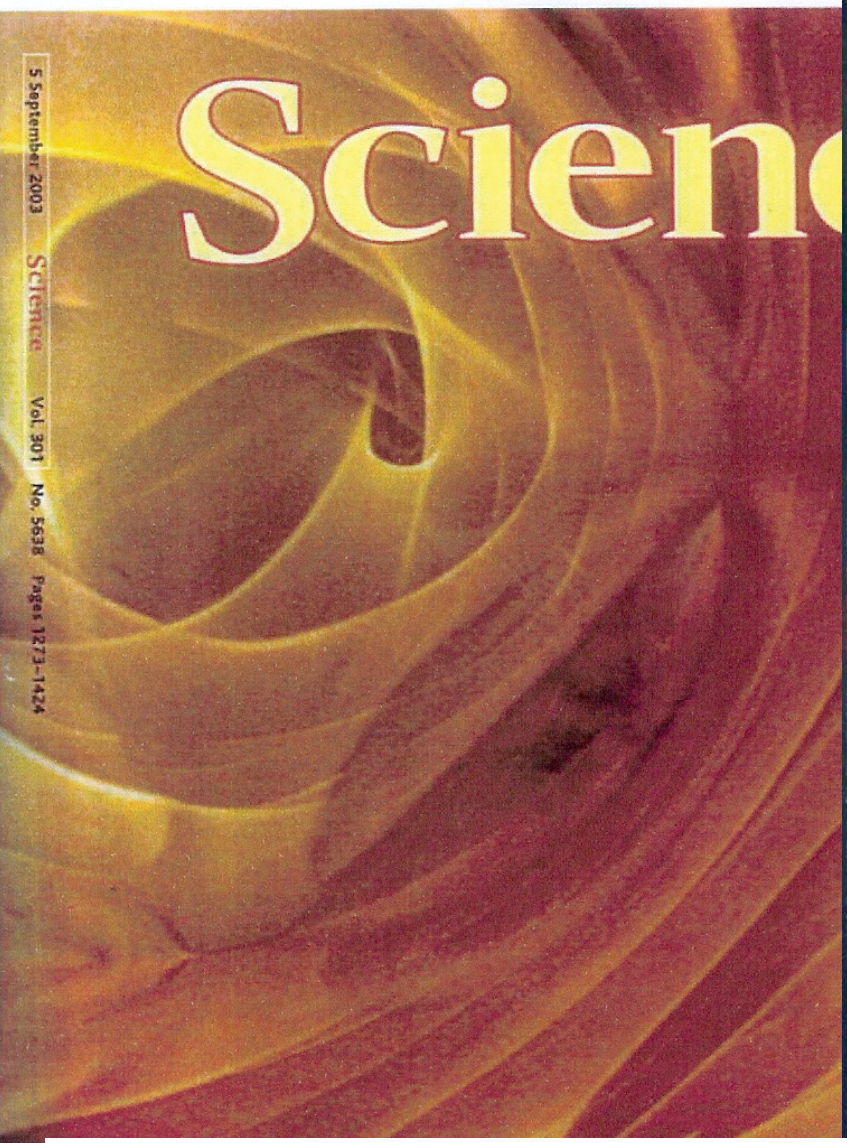
***Evidence for particle acceleration***
***In situ magnetic field measurement***

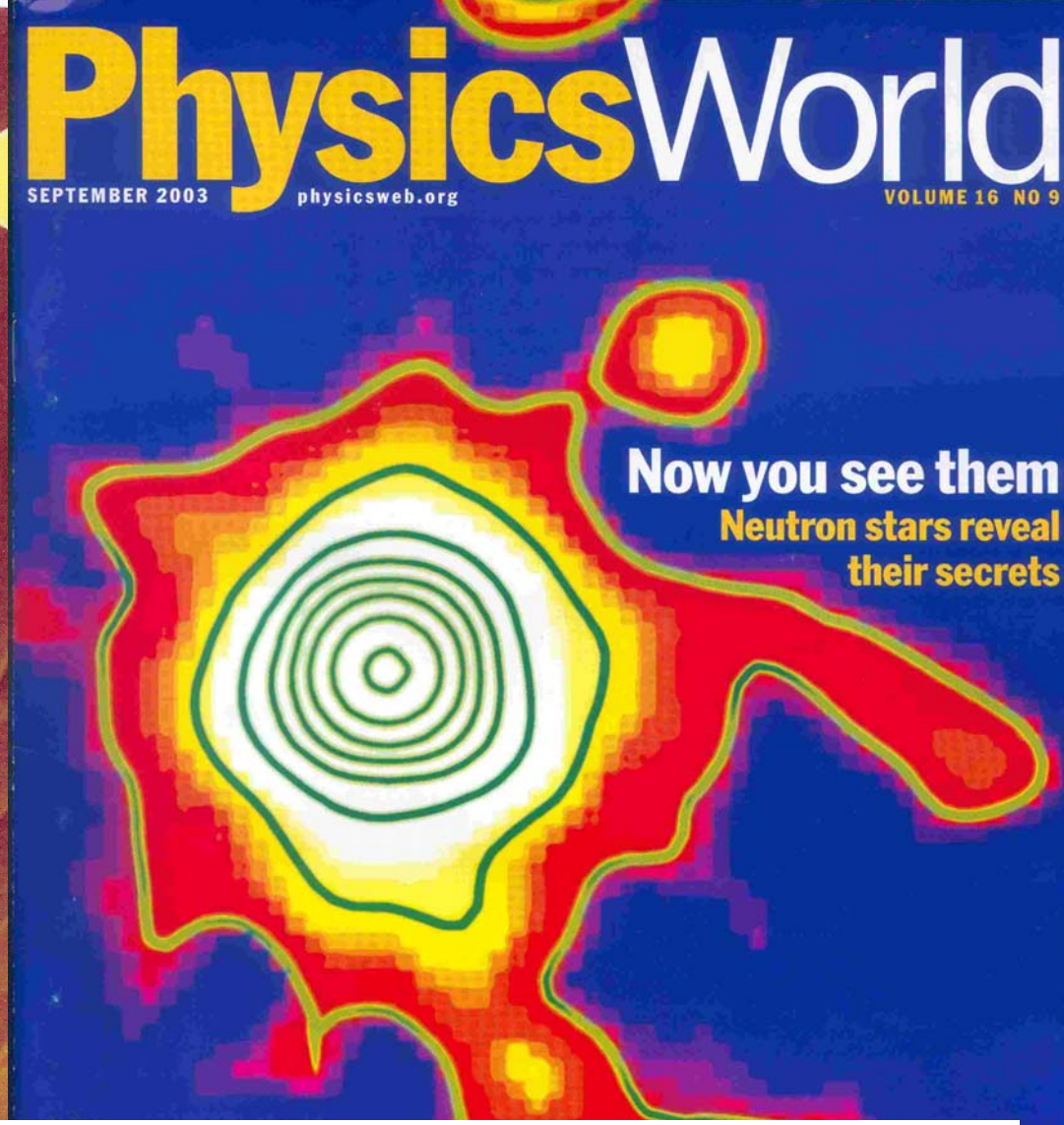

1 arcmin

# To produce keV photons in $10^{-5}$ G B field one needs $10^{14}$ eV electrons



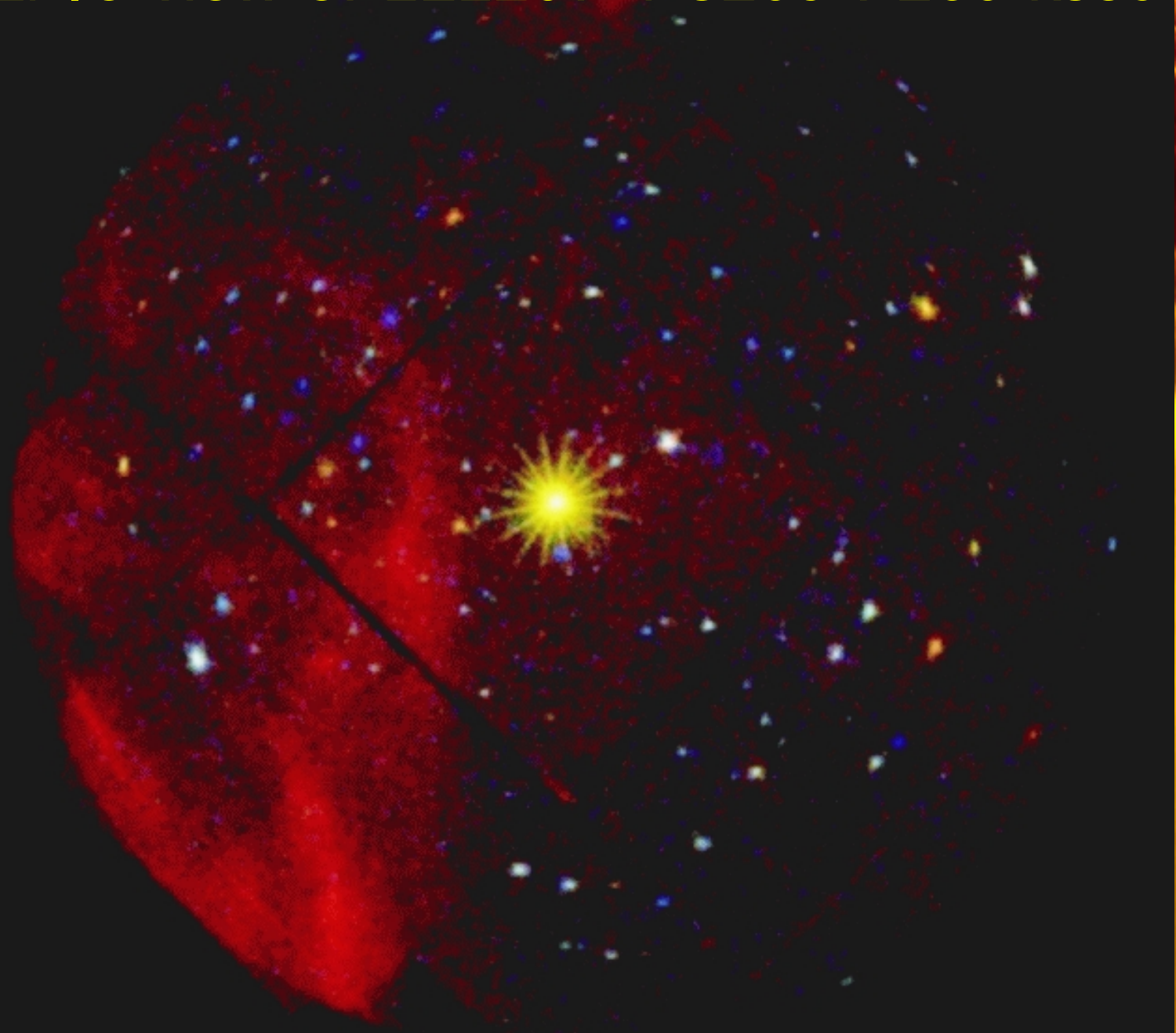

$$\Delta V_{max} \sim \frac{\Omega^2 B_p R^3}{2c^2} \sim \frac{I\Omega\dot{\Omega}}{e\dot{N}_0} \sim 2 \times 10^{14}\ \mathrm{V},$$



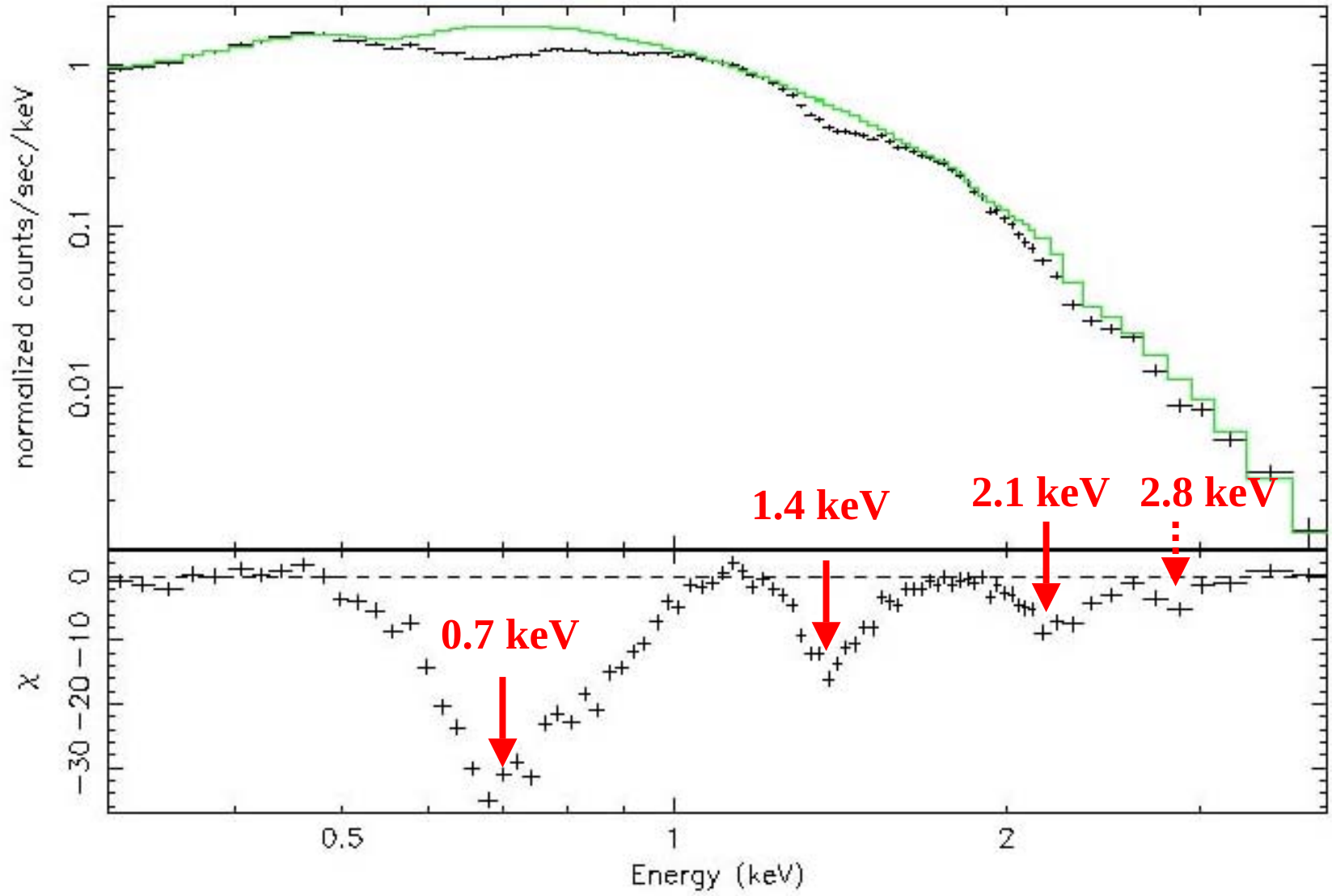




# Geminga accelerates electrons up to E $10^{14}$ eV

# EPIC view of 1E1207.4-5209 : 260 ksec



# How to measure the Magnetic Field of a NS



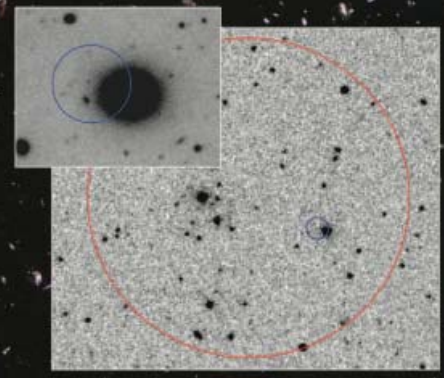
**IF electron cyclotron:** $\langle B \rangle$ **8** $10^{10}$ **G**

**IF proton** $\langle B \rangle$ **1.6** $10^{14}$ **G**

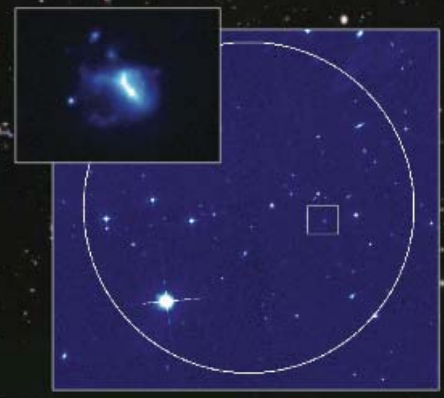
**Now we know**
**It was born slow**


6 October 2005 | www.nature.com/nature | $10
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

# nature



## SHORT GAMMA-RAY BURSTS
The birth of a black hole seen in the stars



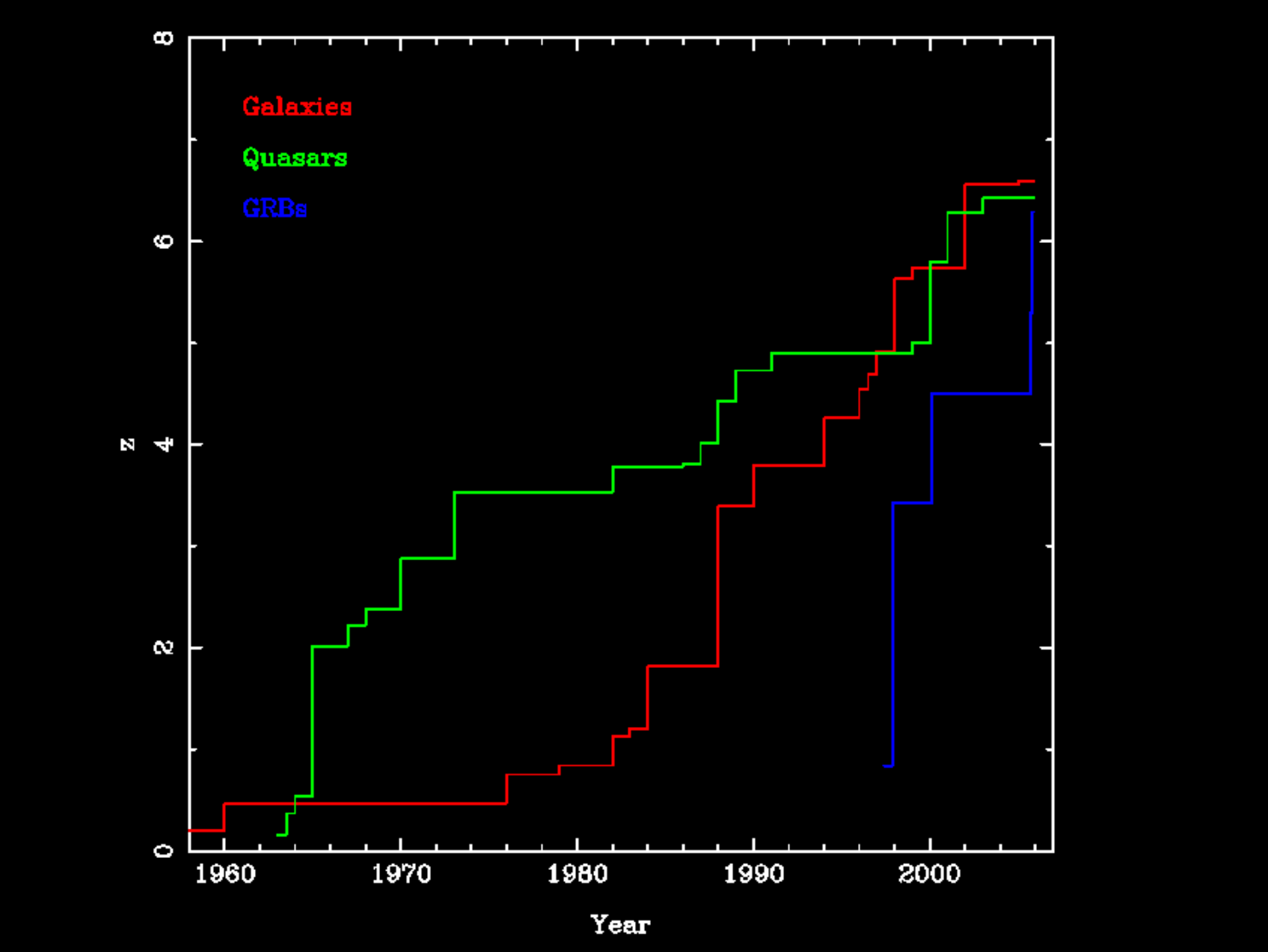
## INFLUENZA PANDEMIC
Genome sequence of the 1918 virus

## SEX PHEROMONES
A glint in the eye

## EARTHQUAKES
Pulling the trigger

**NATUREJOBS**
Project management

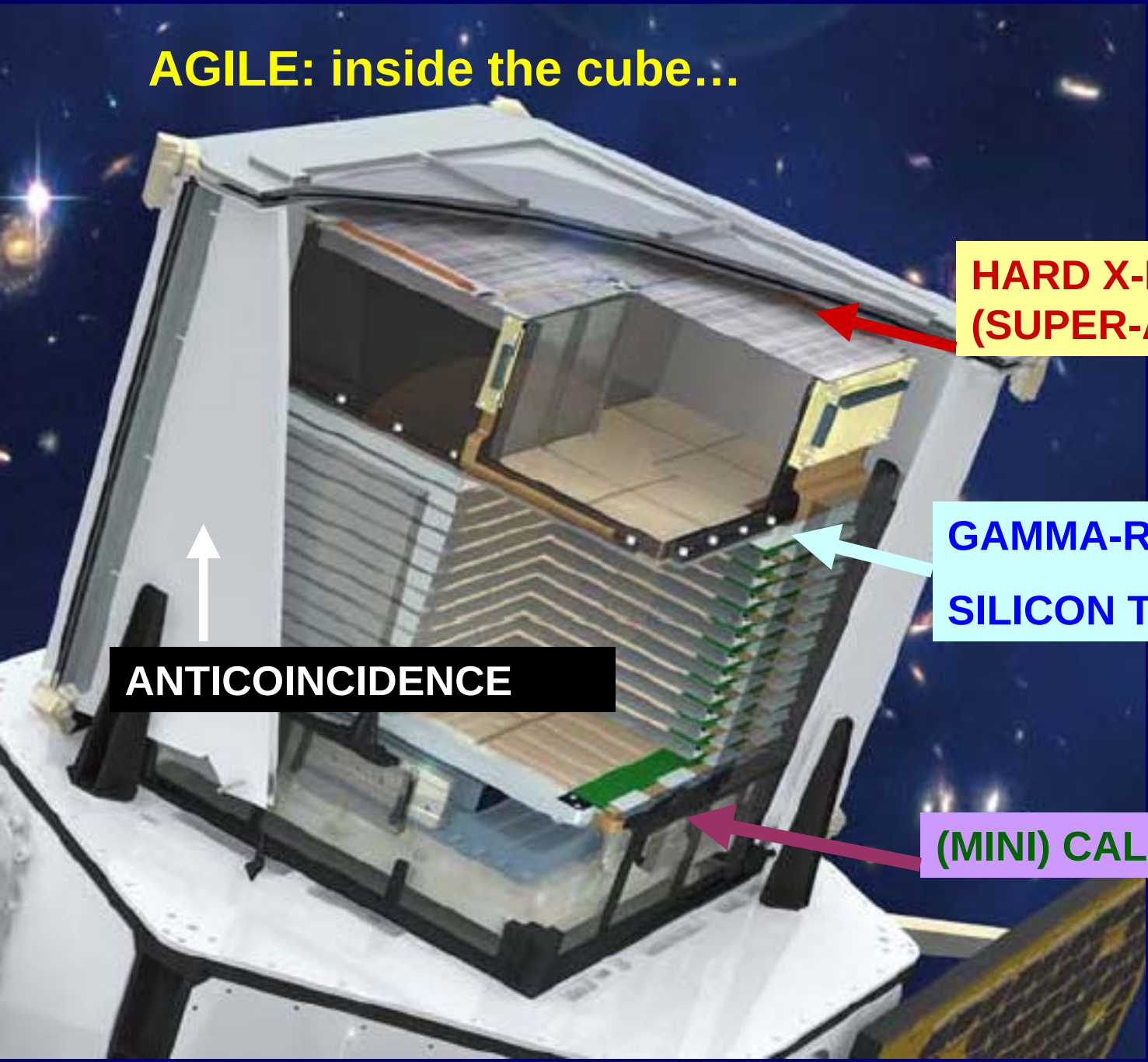
$10.00US $12.99CAN
40
0 71486 03070 6


Galaxies
Quasars
GRBs
z
0
2
4
6
8
1960
1970
1980
1990
2000
Year

# The AGILE Payload: the most compact instrument for high-energy astrophysics

It combines for the first time a gamma-ray imager (30 MeV- 30 GeV) with a hard X-ray imager (18-60 keV) with large FOVs (1-2.5 sr) and optimal angular resolution

# AGILE: inside the cube…



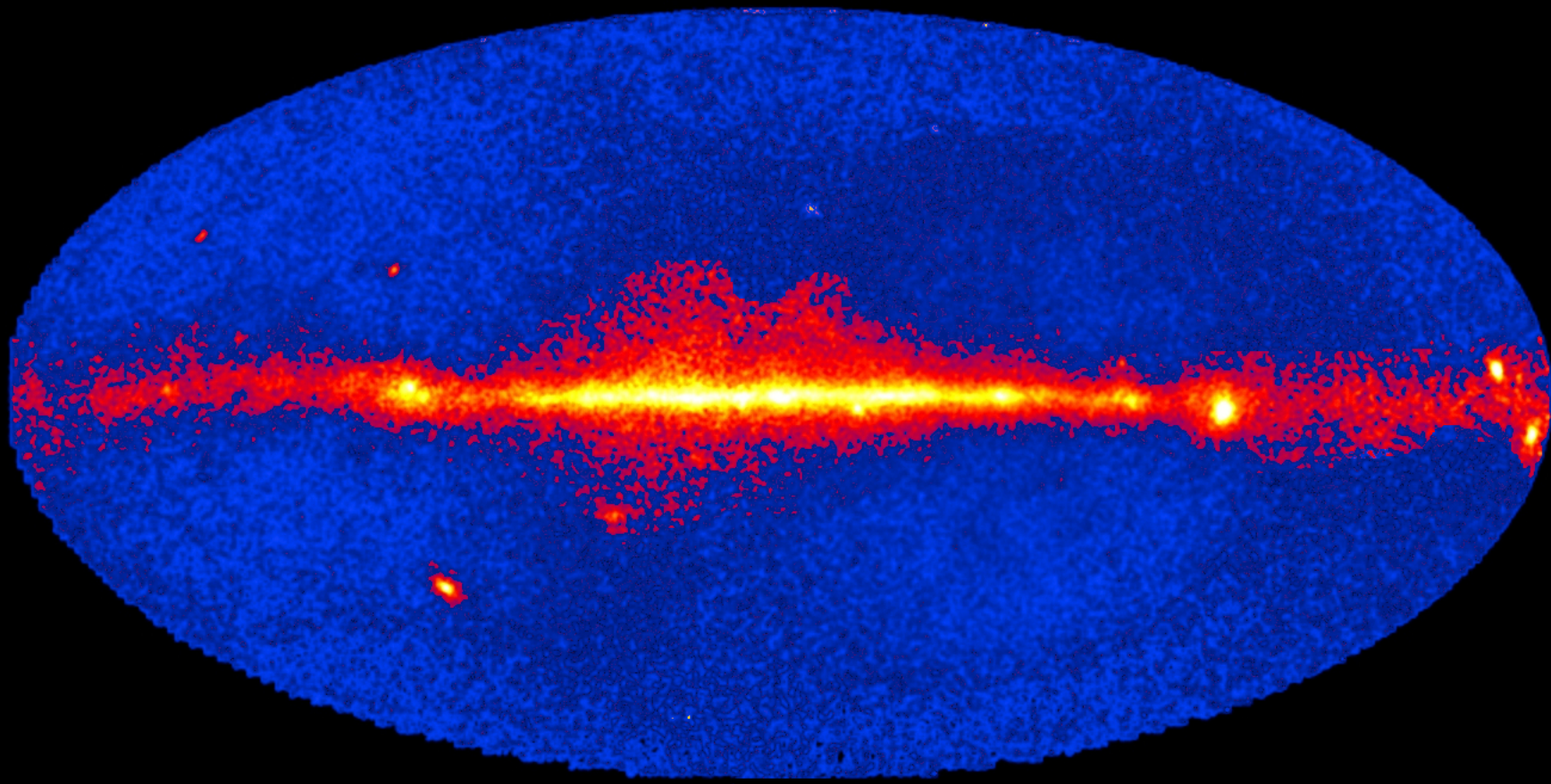
# AGILE's technical improvements:

- **BIG FoV: 1/5 of the sky**
- **Good angular resolution**
- **Small dead time**
- **Simultaneous gamma and X observations**

- **Silicon detectors (Italy is a world leader)**

- **The BIG FoV (similar to that of an human eye) is an important asset**

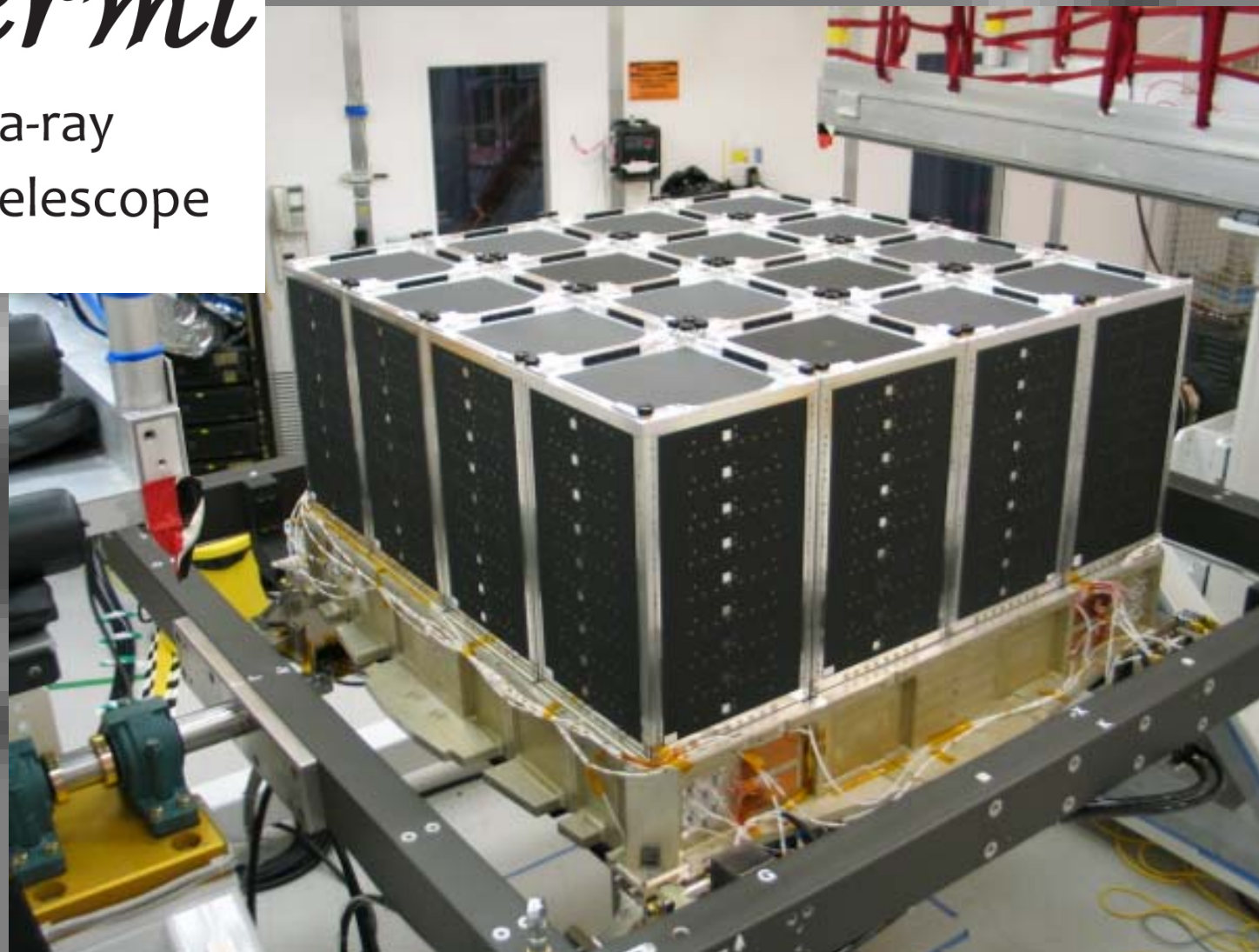
# AGILE



1 year in orbit

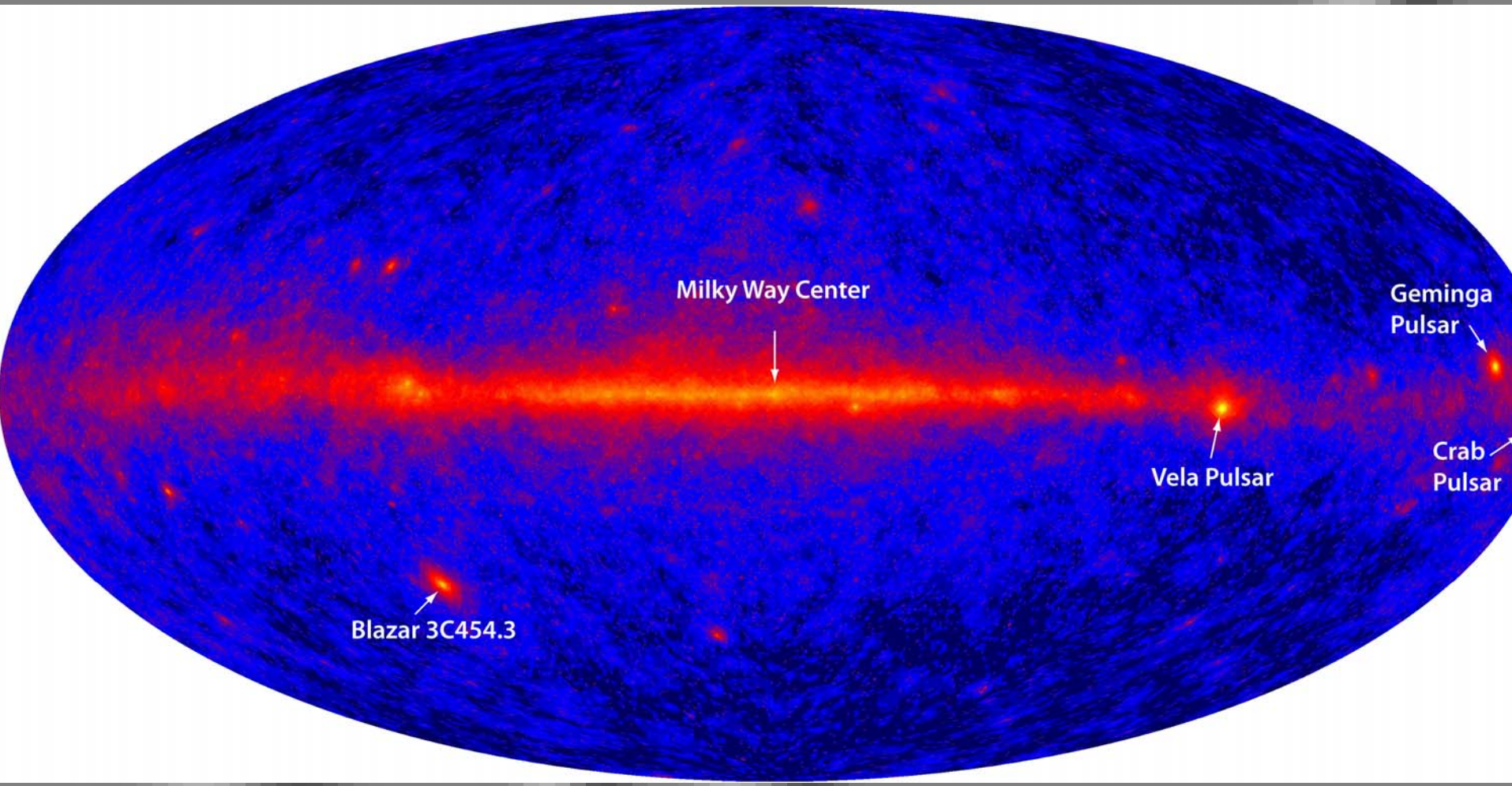
Fermi
Gamma-ray
Space Telescope

# and its Italian contribution :

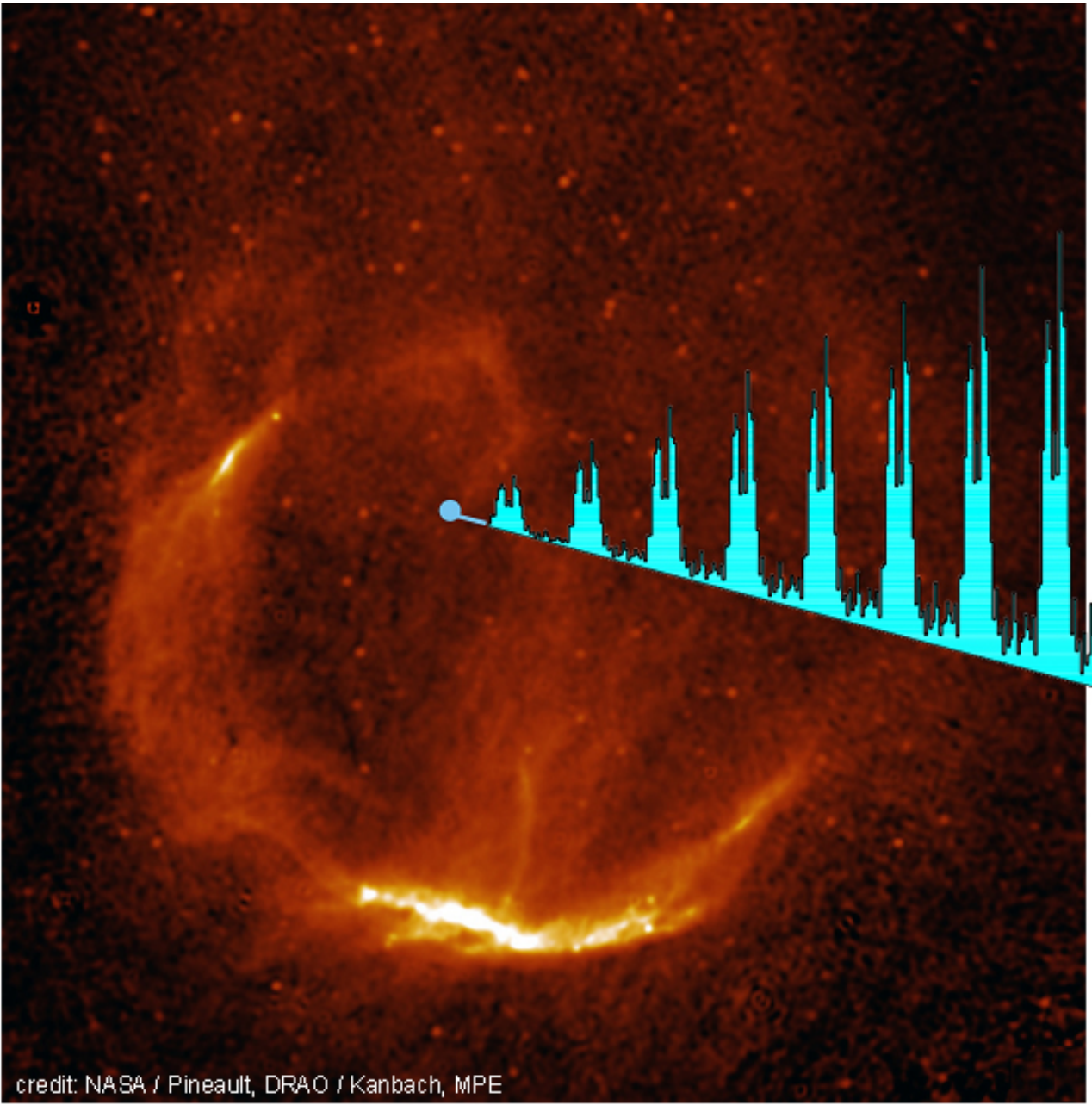


**Launched**
**June 11th**

# First light (4 days!!)



# First result: another Geminga




**P = 316.86 ms**

**P = 3.614 $10^{-13}$ s $s^{-1}$**

Science Express, 16 Oct. 2008