Dalle stelle
a casa nostra

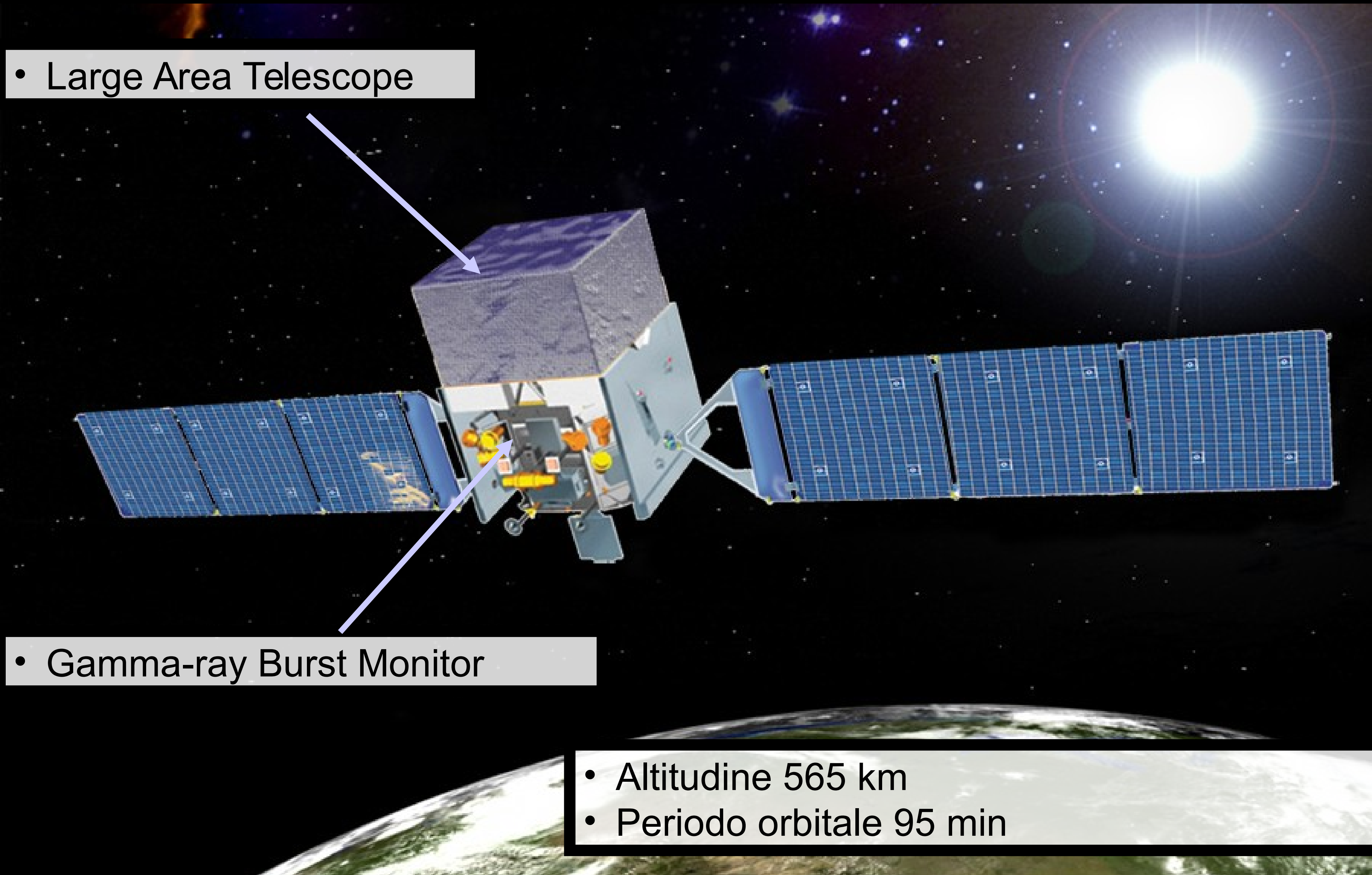
Massimiliano Razzano
(Università di Pisa & INFN-Pisa)

LNF - Notte dei Ricercatori 2016

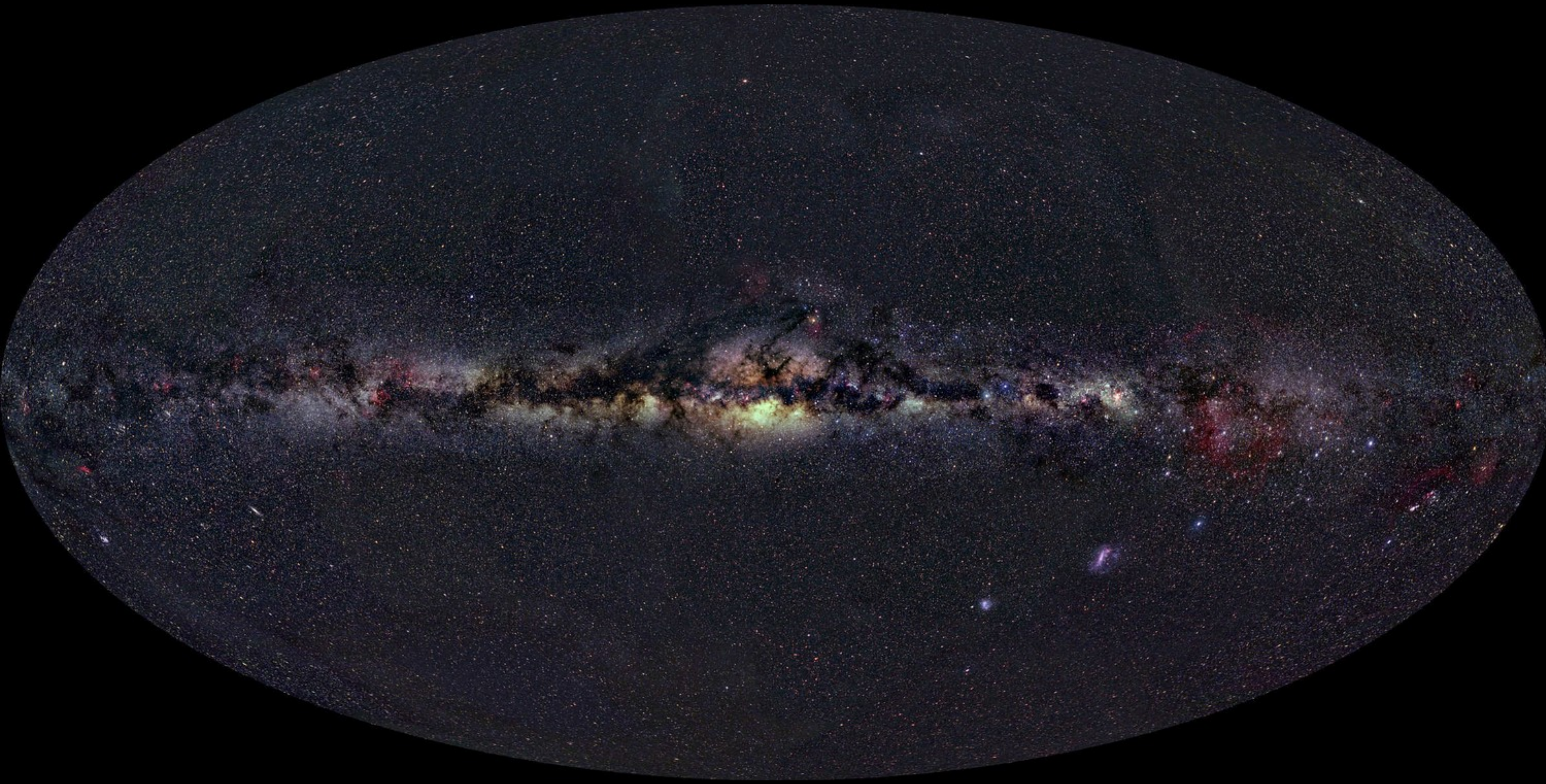
frascati scienza

11 giugno 2008

Fermi Gamma Ray Large Area Telescope

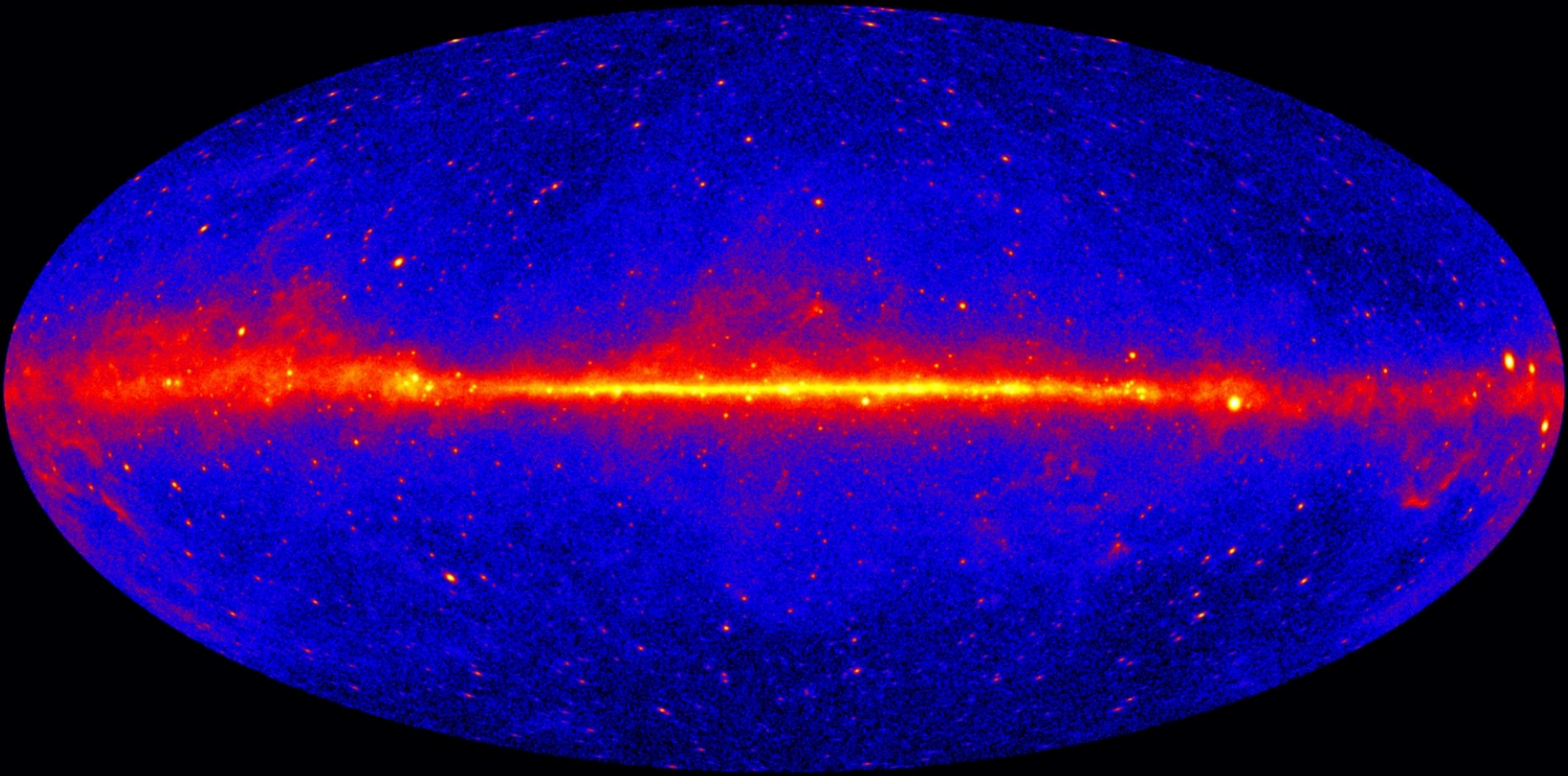


La Via Lattea



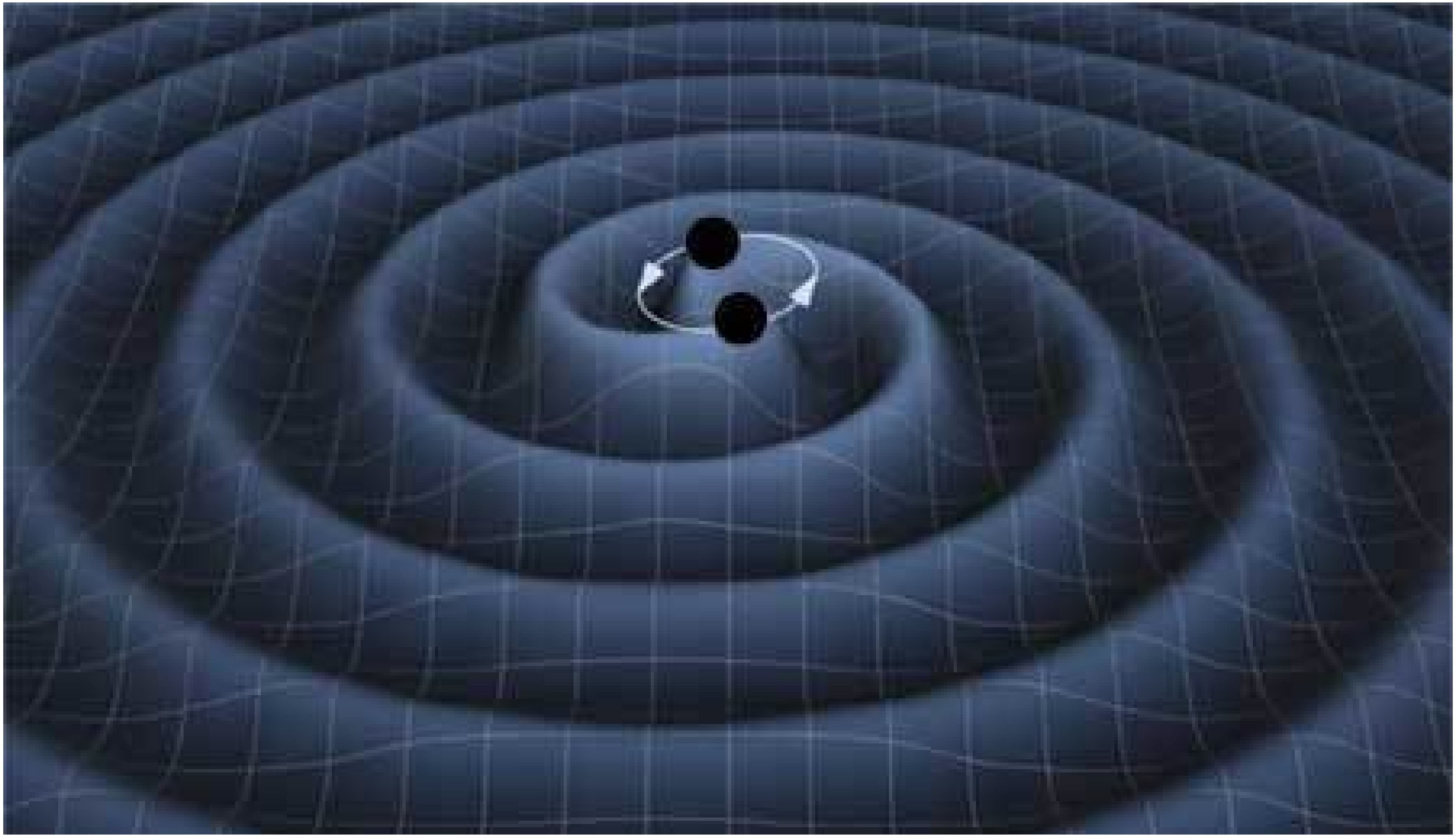
Credits: NASA/APOD

…vista con i raggi gamma



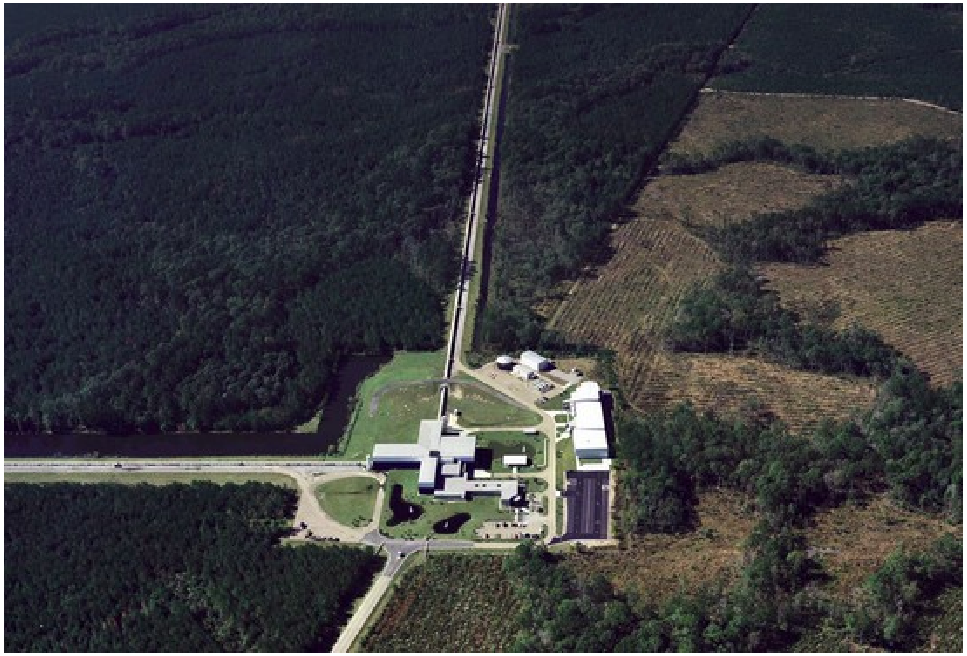
5 yrs, Milky way in gamma rays, E>1 GeV, front-converting events
(2008-2013 © NASA/Fermi-LAT)

Onde gravitazionali



Primo segnale 14 settembre 2015

LIGO



Laser Interferometer Gravitational Observatory

Virgo

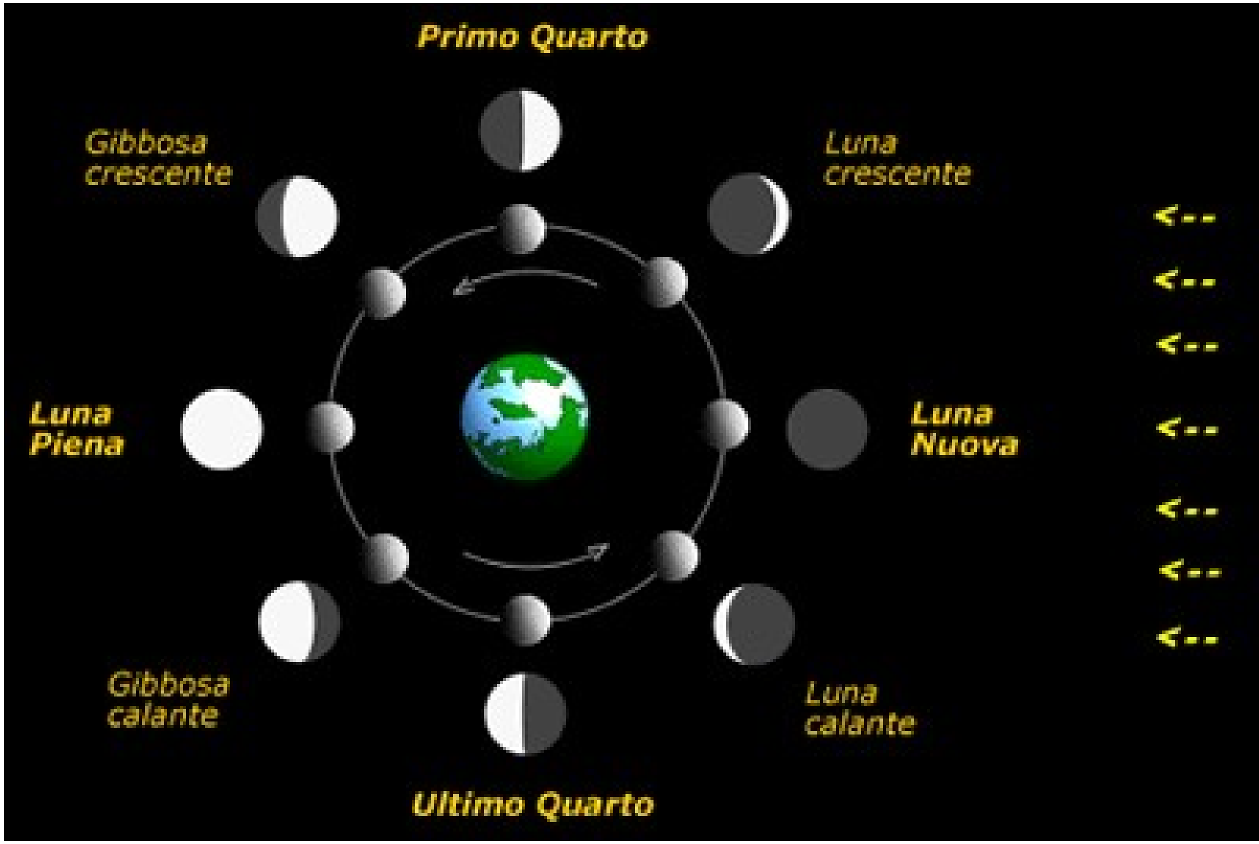
QUANTO COSTA ATTERRARE SU UNA COMETA?
1,4 miliardi di euro
Missione Rosetta
Per la prima volta nella storia umana, l'atterraggio su una cometa
...CIRCA LO STESSO PREZZO DI...
4,2
Airbus A380
Ingegneria di alto livello, ma non ti portano nello spazio...
CHI HA PAGATO PER QUESTO?
€3,50
costo per cittadini europei
(Dal 1996 al 2015, quindi €0.20/persona/anno)
Costo della missione Rosetta per persona
€3,50
Costo di un biglietto del cinema per Interstellar
€9
scienceogram.org
Immagini Rosetta/cometa: ESA; dati da ESA, Airbus e cinema The Space
Tutti i dati e le fonti visita scienceogram.org

...a cosa serve tutto questo?

“Che anno è, che giorno è?”

Calendario INFN 2015

calendari lunari



Fasi lunari
- **Facile da vedere**
- **Aggiungere un giorno**
- **Periodo sinodico 29,53**
- **→ Sfasamento**

Esempio
Calendario islamico
(2016 = 1437)

calendari luni-solari

Fasi lunari e Sole
Mese intercalare

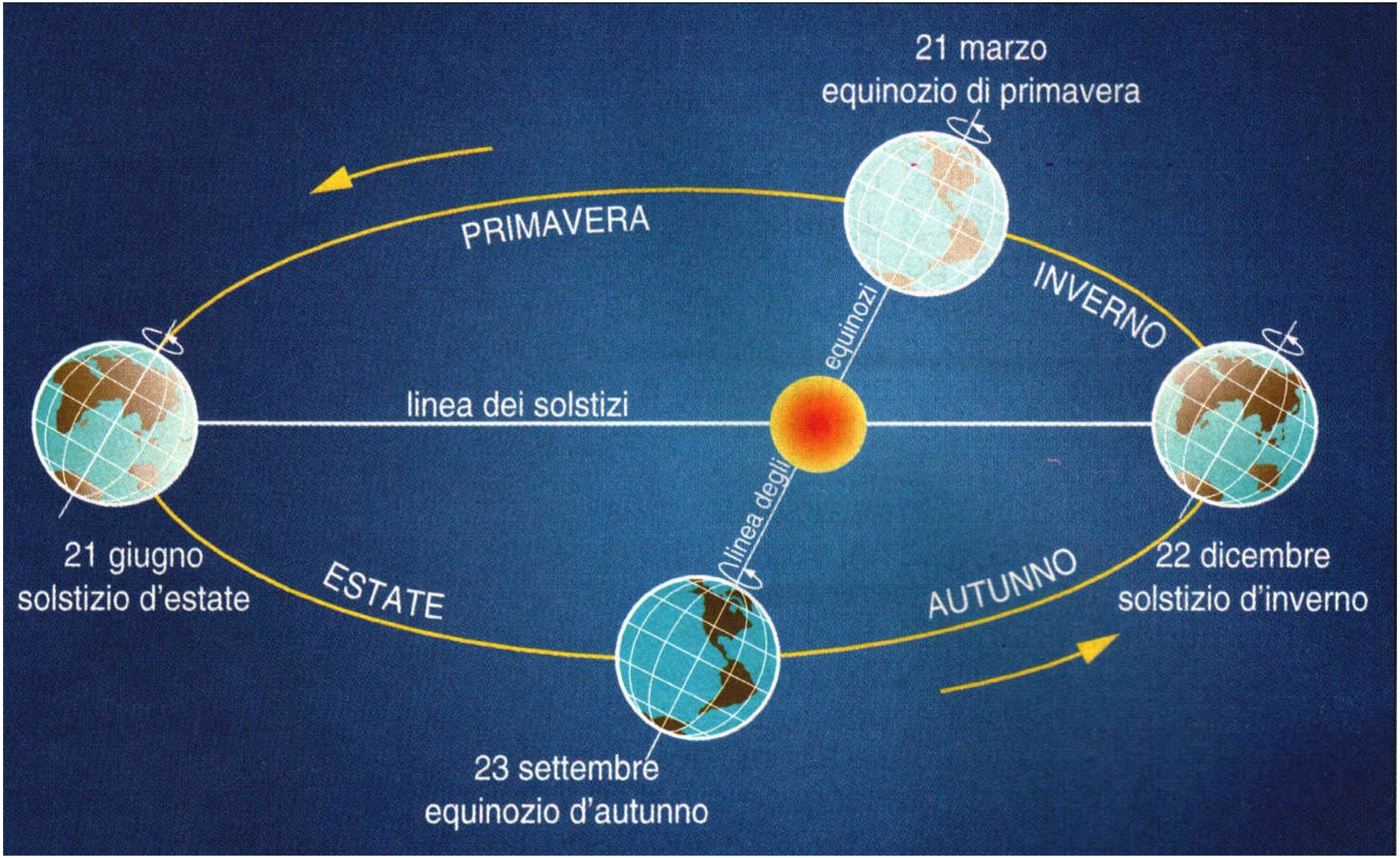
Attuali:
Ebraico, buddista, Indu

Storici
Cinese, Giapponese, Greco

אדר ב.
ADAR 2.

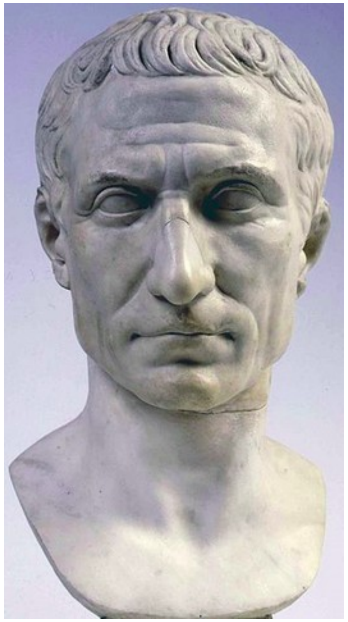
		1927 5687 תרפ"ז	1929 5689 תרפ"ט	1932 5692 תרצ"ב	1935 5695 תרצ"ה	1938 5698 תרצ"ח	1940 5700 ת"ש	1943 5703 תש"ג	1946 5706 תש"ו	1948 5708 תש"ח	
	1	Sa -Mar. 5	W -Mar. 13	W -Mar. 9	W -Mar. 6	Fr -Mar. 4	M -Mar. 11	M -Mar. 8	M -Mar. 4	Fr -Mar. 12	
	2	Su -Mar. 6	Th-Mar. 14	Th-Mar. 10	Th-Mar. 7	Sa -Mar. 5	Tu-Mar. 12	Tu-Mar. 9	Tu-Mar. 5	Sa -Mar. 13	
	3	M -Mar. 7	Fr -Mar. 15	Fr -Mar. 11	Fr -Mar. 8	Su -Mar. 6	W -Mar. 13	W -Mar. 10	W -Mar. 6	Su -Mar. 14	
	4	Tu-Mar. 8	Sa -Mar. 16	Sa -Mar. 12	Sa -Mar. 9	M -Mar. 7	Th-Mar. 14	Th-Mar. 11	Th-Mar. 7	M -Mar. 15	
	5	W -Mar. 9	Su -Mar. 17	Su -Mar. 13	Su -Mar. 10	Tu-Mar. 8	Fr -Mar. 15	Fr -Mar. 12	Fr -Mar. 8	Tu-Mar. 16	
	6	Th-Mar. 10	M -Mar. 18	M -Mar. 14	M -Mar. 11	W -Mar. 9	Sa -Mar. 16	Sa -Mar. 13	Sa -Mar. 9	W -Mar. 17	
	7	Fr -Mar. 11	Tu-Mar. 19	Tu-Mar. 15	Tu-Mar. 12	Th-Mar. 10	Su-Mar. 17	Su -Mar. 14	Su -Mar. 10	Th-Mar. 18	
	8	Sa -Mar. 12	W -Mar. 20	W -Mar. 16	W -Mar. 13	Fr -Mar. 11	M -Mar. 18	M -Mar. 15	M -Mar. 11	Fr -Mar. 19	
	9	Su -Mar. 13	Th-Mar. 21	Th-Mar. 17	Th-Mar. 14	Sa -Mar. 12	Tu-Mar. 19	Tu-Mar. 16	Tu-Mar. 12	Sa -Mar. 20	
	10	M -Mar. 14	Fr -Mar. 22	Fr -Mar. 18	Fr -Mar. 15	Su -Mar. 13	W -Mar. 20	W -Mar. 17	W -Mar. 13	Su -Mar. 21	
	11	Tu-Mar. 15	Sa -Mar. 23	Sa -Mar. 19	Sa -Mar. 16	M -Mar. 14	Th-Mar. 21	Th-Mar. 18	Th-Mar. 14	M -Mar. 22	
	12	W -Mar. 16	Su -Mar. 24	Su -Mar. 20	Su -Mar. 17	Tu-Mar. 15	Fr -Mar. 22	Fr -Mar. 19	Fr -Mar. 15	Tu-Mar. 23	
Fast of Esther	13	Th-Mar. 17	M -Mar. 25	M -Mar. 21	M -Mar. 18	W -Mar. 16	Sa -Mar. 23	Sa -Mar. 20	Sa -Mar. 16	W -Mar. 24	תענית אסתר
Purim	14	Fr -Mar. 18	Tu-Mar. 26	Tu-Mar. 22	Tu-Mar. 19	Th-Mar. 17	Su -Mar. 24	Su -Mar. 21	Su -Mar. 17	Th-Mar. 25	פורים
Shushan Purim	15	Sa -Mar. 19	W -Mar. 27	W -Mar. 23	W -Mar. 20	Fr -Mar. 18	M -Mar. 25	M -Mar. 22	M -Mar. 18	Fr -Mar. 26	שושן פורים
	16	Su -Mar. 20	Th-Mar. 28	Th-Mar. 24	Th-Mar. 21	Sa -Mar. 19	Tu-Mar. 26	Tu-Mar. 23	Tu-Mar. 19	Sa -Mar. 27	
	17	M -Mar. 21	Fr -Mar. 29	Fr -Mar. 25	Fr -Mar. 22	Su -Mar. 20	W -Mar. 27	W -Mar. 24	W -Mar. 20	Su -Mar. 28	
	18	Tu-Mar. 22	Sa -Mar. 30	Sa -Mar. 26	Sa -Mar. 23	M -Mar. 21	Th-Mar. 28	Th-Mar. 25	Th-Mar. 21	M -Mar. 29	
	19	W -Mar. 23	Su -Mar. 31	Su -Mar. 27	Su -Mar. 24	Tu-Mar. 22	Fr -Mar. 29	Fr -Mar. 26	Fr -Mar. 22	Tu-Mar. 30	
	20	Th-Mar. 24	M -Apr. 1	M -Mar. 28	M -Mar. 25	W -Mar. 23	Sa -Mar. 30	Sa -Mar. 27	Sa -Mar. 23	W -Mar. 31	
	21	Fr -Mar. 25	Tu-Apr. 2	Tu-Mar. 29	Tu-Mar. 26	Th-Mar. 24	Su -Mar. 31	Su -Mar. 28	Su -Mar. 24	Th-Apr. 1	
	22	Sa -Mar. 26	W -Apr. 3	W -Mar. 30	W -Mar. 27	Fr -Mar. 25	M -Apr. 1	M -Mar. 29	M -Mar. 25	Fr -Apr. 2	
	23	Su -Mar. 27	Th-Apr. 4	Th-Mar. 31	Th-Mar. 28	Sa -Mar. 26	Tu-Apr. 2	Tu-Mar. 30	Tu-Mar. 26	Sa -Apr. 3	
	24	M -Mar. 28	Fr -Apr. 5	Fr -Apr. 1	Fr -Mar. 29	Su -Mar. 27	W -Apr. 3	W -Mar. 31	W -Mar. 27	Su -Apr. 4	
	25	Tu-Mar. 29	Sa -Apr. 6	Sa -Apa. 2	Sa -Mar. 30	M -Mar. 28	Th-Apr. 4	Th-Apr. 1	Th-Mar. 28	M -Apr. 5	
	26	W -Mar. 30	Su -Apr. 7	Su -Apr. 3	Su -Mar. 31	Tu-Mar. 29	Fr -Apr. 5	Fr -Apr. 2	Fr -Mar. 29	Tu-Apr. 6	
	27	Th-Mar. 31	M -Apr. 8	M -Apr. 4	M -Apr. 1	W -Mar. 30	Sa -Apr. 6	Sa -Apr. 3	Sa -Mar. 30	W -Apr. 7	
	28	Fr -Apr. 1	Tu-Apr. 9	Tu-Apr. 5	Tu-Apr. 2	Th-Mar. 31	Su -Apr. 7	Su -Apr. 4	Su -Mar. 31	Th-Apr. 8	
	29	Sa -Apr. 2	W -Apr. 10	W -Apr. 6	W -Apr. 3	Fr -Apr. 1	M -Apr. 8	M -Apr. 5	M -Apr. 1	Fr -Apr. 9	

Calendario Solare



ereo = 365g 6h 9,5 m = 365.256366 g = circa 365 giorni e ¼

“Cos'è un anno?”



- Anno Giuliano (dal 45 a.C.)
- 365.25 giorni → Anno bisestile
- Troppo lungo di 11m 14s...

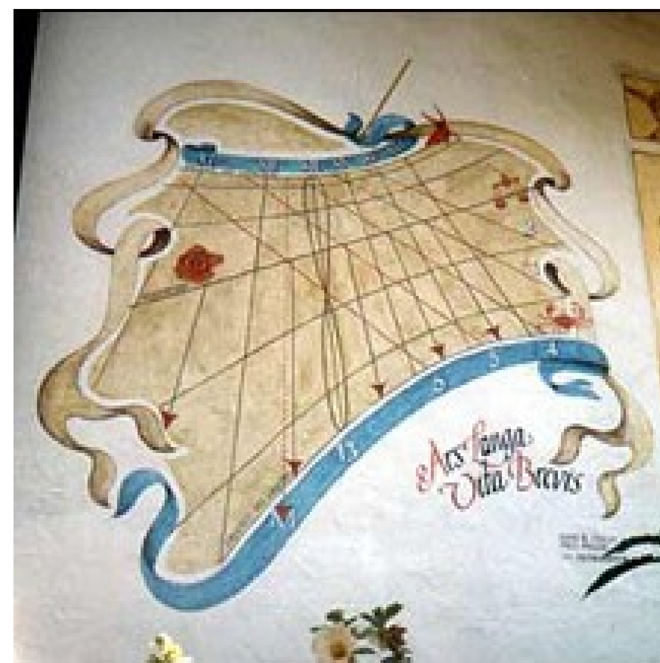
- Anno Gregoriano (dal 1582)
- 365.2425 giorni
- Anno bisestile
  - Ogni 4 anni
  - Anni secolari solo divisibili per 400

“Che ora è?”


QUOTA SIT HORA PETIS
DUM PETIS IPSA FUGIT
PERMANET
ANTE
SOLEM
NOMEN
DOMINI
VITA FUGIT
SICUT UMBRA
VIII · IX
VI · V · IV
X · XI · XII · I · II · III
A SOLIS ORTU USQUE AD OCCASUM

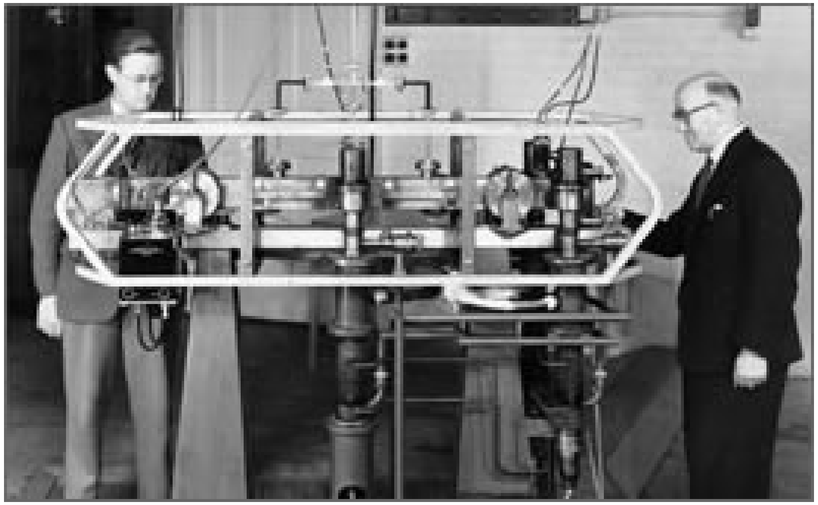

HORAS NON NUMERO NISI SERENAS
X XI XII I II III IIII V VI VII VIII


VIII IX X XI XII I II III IV V VI
IO TI SEGNO LE ORE
TU RIEMPILE D'AMORE
A.D. MMV

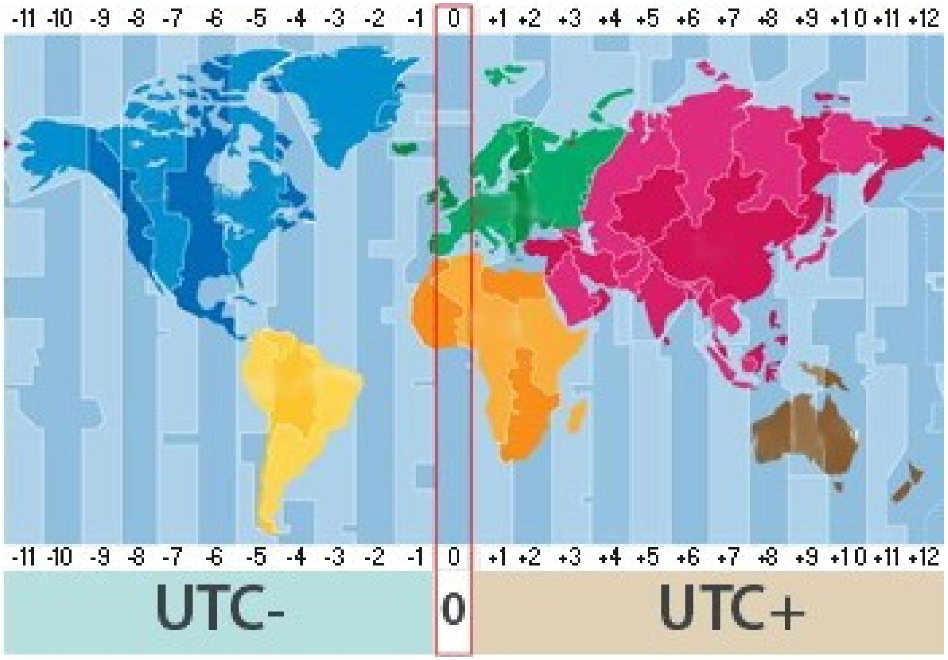

Ars Longa
Vita Brevis

“Che ora è?”

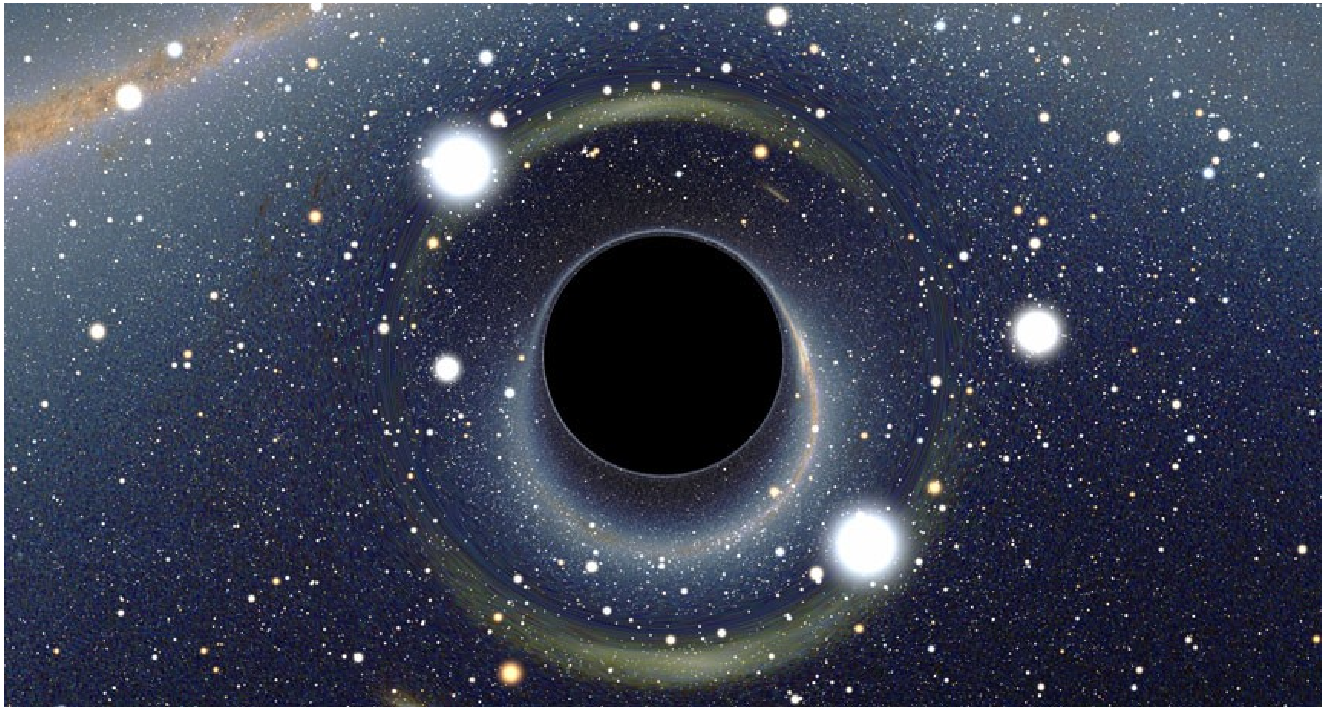
- Dal 1967, tempo basato su orologi atomici
- Continua sincronizzazione con Tempo Universale (basato sulla rotazione della Terra)

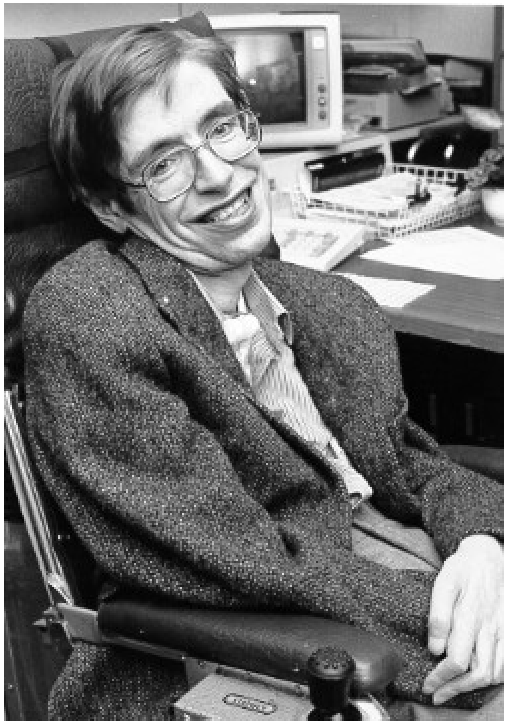


Essen e Parry, 1955



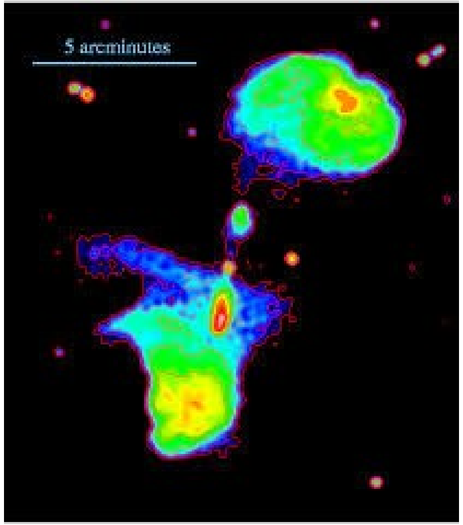
Dai buchi neri primordiali...





1974 – I buchi neri primordiali possono "evaporare"

...a una nuova sfida...



Radiotelescopio Dwingeloo

...a un oscuro articolo...

Limits on cosmic radio bursts with microsecond time scales

It has been suggested[1] that black holes of mass $\leq 10^{15}$ g evaporate in $\sim 10^{10}$ yr, ultimately annihilating into a burst of energetic photons and particles. This explosion would produce γ-rays directly, and a radio pulse with a characteristic frequency of ~3 GHz and an energy of $\sim 10^{32}$ erg may also be generated[2]. It has been shown[2–4] that such a radio burst would be far more easily detected than the corresponding γ-ray burst. Estimates of the energy in the radio burst are uncertain by many orders of magnitude, and it is, of course, not known whether any primordial black holes exist at all; however, the implications of a detection would be enormous for quantum and gravitational physics.

distance result in a much higher detection limit.

These limits could be improved by using larger telescopes for longer times and simultaneous observations with more than one antenna. Interference rejection in particular would be greatly facilitated by using two or more widely spaced antennas. Large improvements could be achieved either by using a fast multichannel dedispersing backend or possibly by observing at higher frequencies.

We thank V. Radhakrishnan for discussions. The Dwingeloo radiotelescope is operated by the Netherlands foundation for Radioastronomy (S.R.Z.M.) with the financial support of the Netherlands Organization for the Advancement of Pure Research (Z.W.O.).

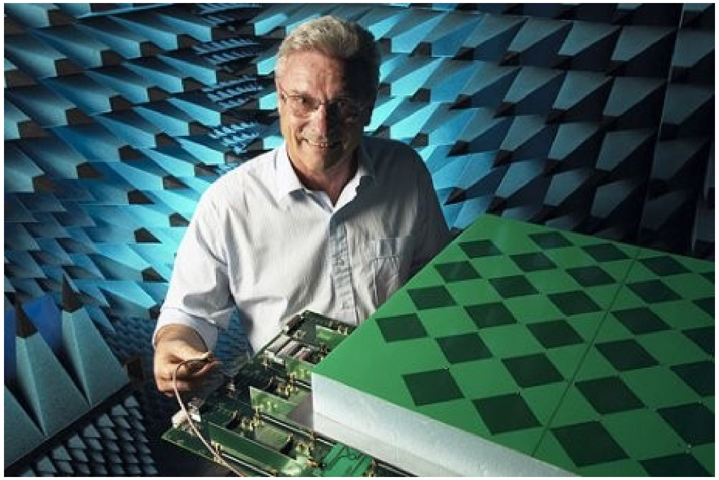
J. D. O'Sullivan

Netherlands Foundation for Radio Astronomy, Dwingeloo, The Netherlands

R. D. Ekers
P. A. Shaver

Kapteyn Astronomical Institute, University of Groningen, Groningen, The Netherlands

...fino al nostro PC...

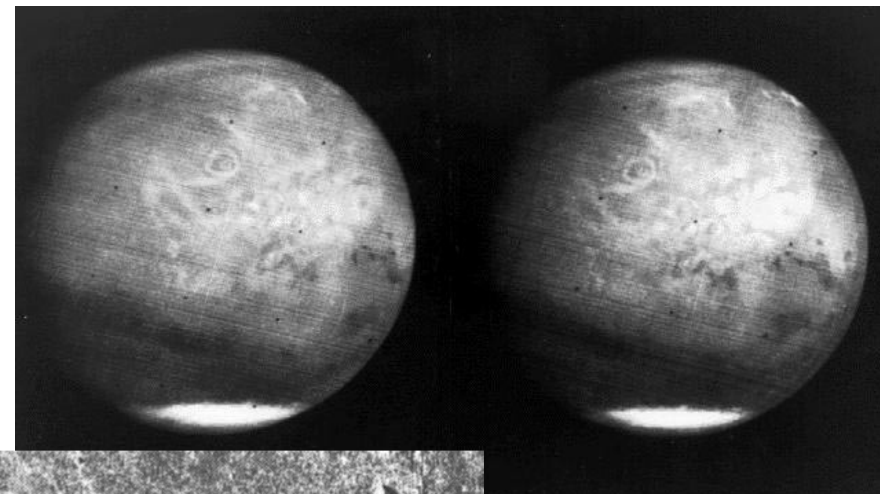


WiFi ZONE

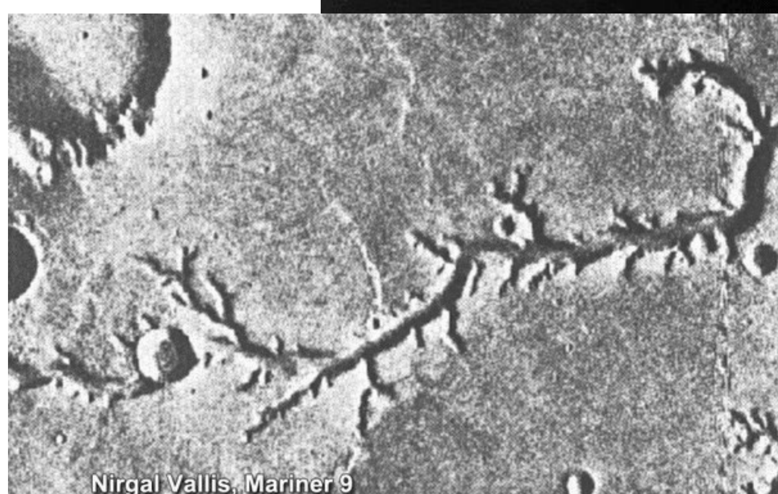
Chip Fast Fourier Transform
Inserita dal 1999 nei Wifi

Un linguaggio per tutti

Interactive Data Language – 1977 (RSI Software)
Predecessore : Rufus (1970)
Laboratory for Asmospheric and Space Physics (Boulder, Colorado)

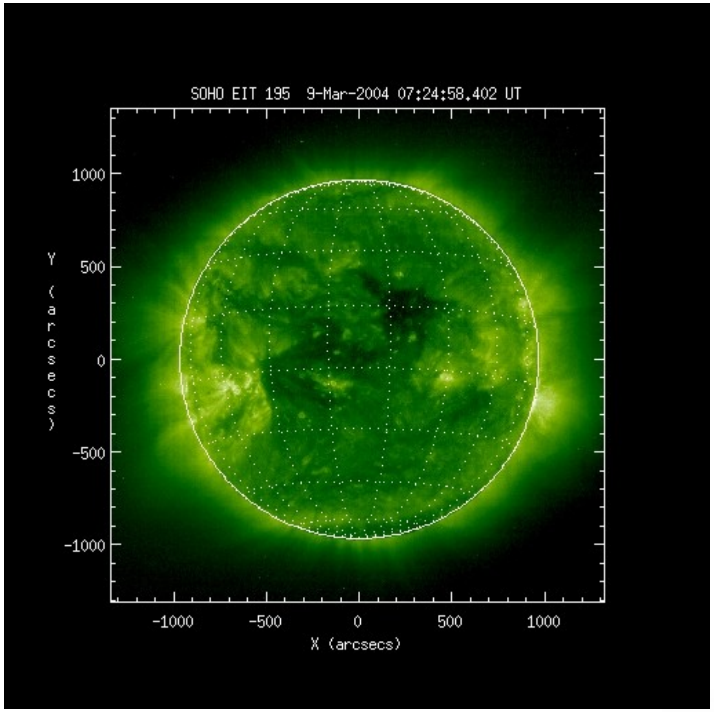


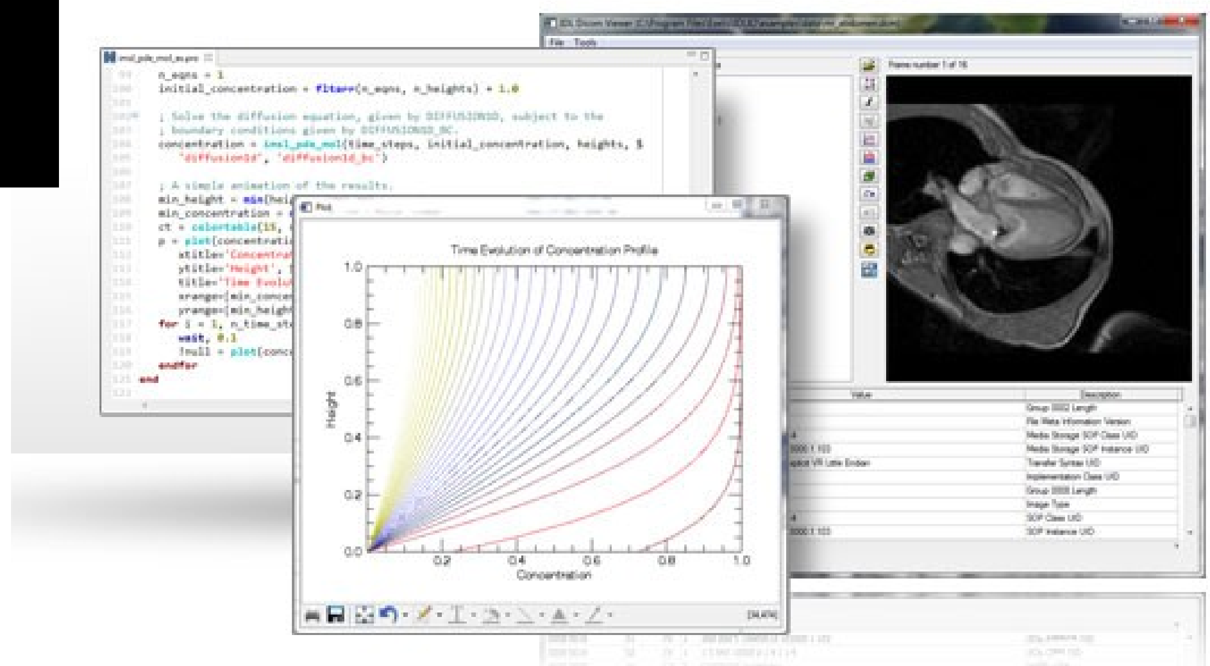
1969



1971

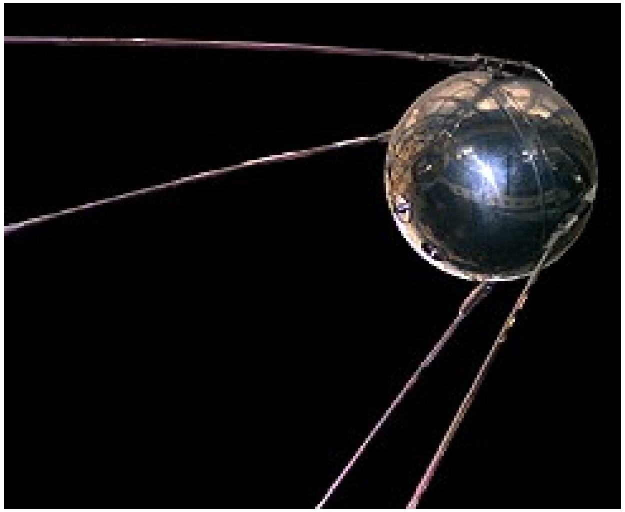
Un linguaggio per tutti





Dove siamo?

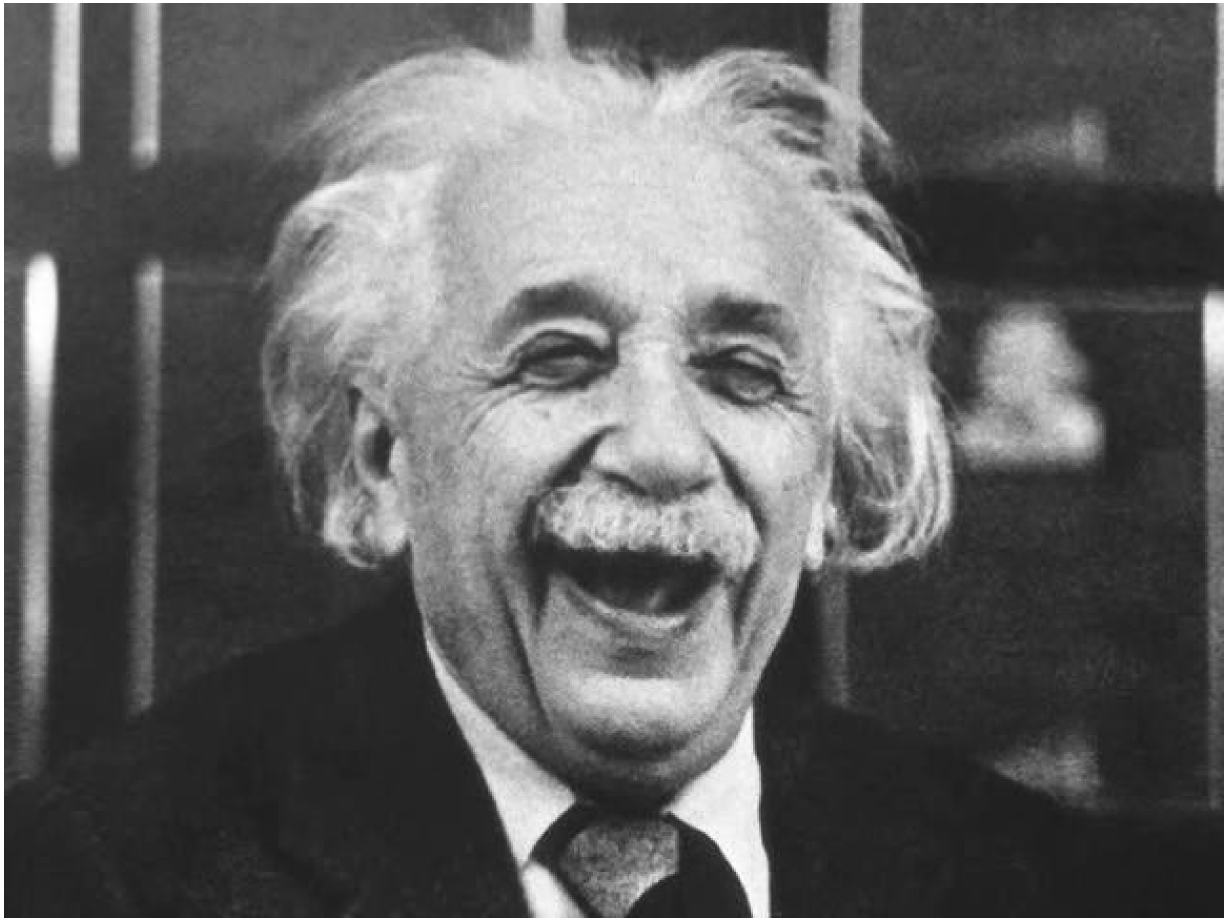
Storia del GPS



1957 – W. Guier e G. Weiffenbach misurano orbita di Sputnik 1
1958 – “Problema inverso”
1973 – lanciato programma GPS
1978 – Lancio GPS
1998 – Direttiva di Clinton su uso civile GPS
2000 – Selective Availability disattivata
2016 - 31 satelliti, 24 operativi a 20 mila km

Come funziona?

Ma se il GPS funziona...



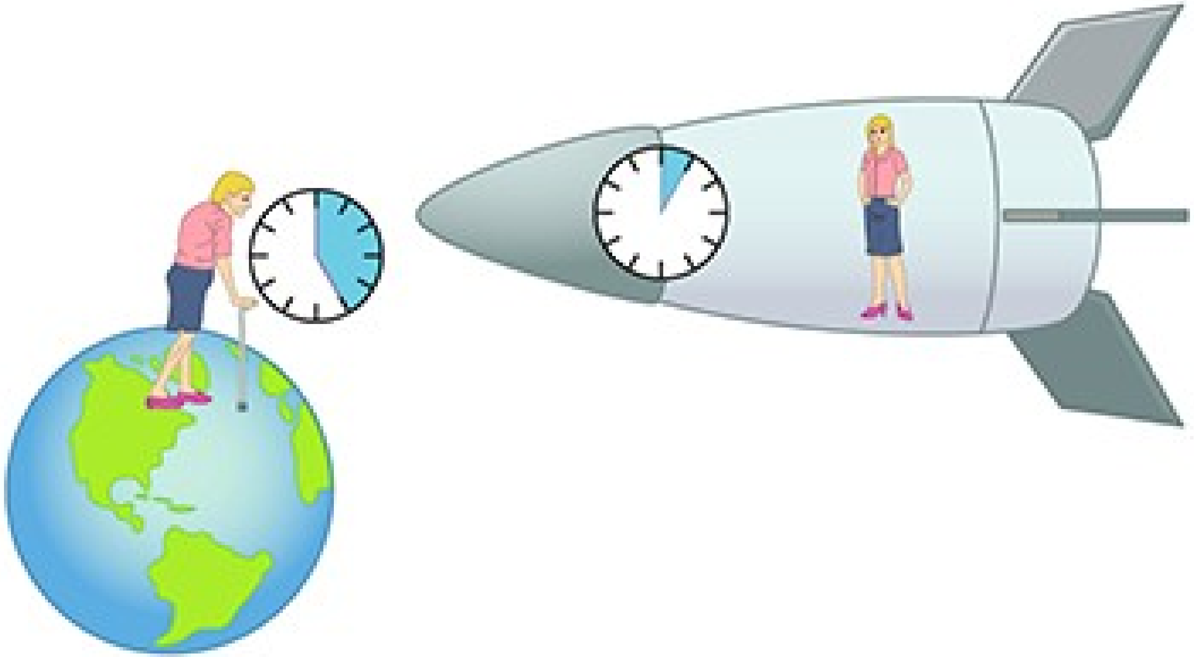
...è grazie a lui !

Teoria della Relatività

ciale (1905)

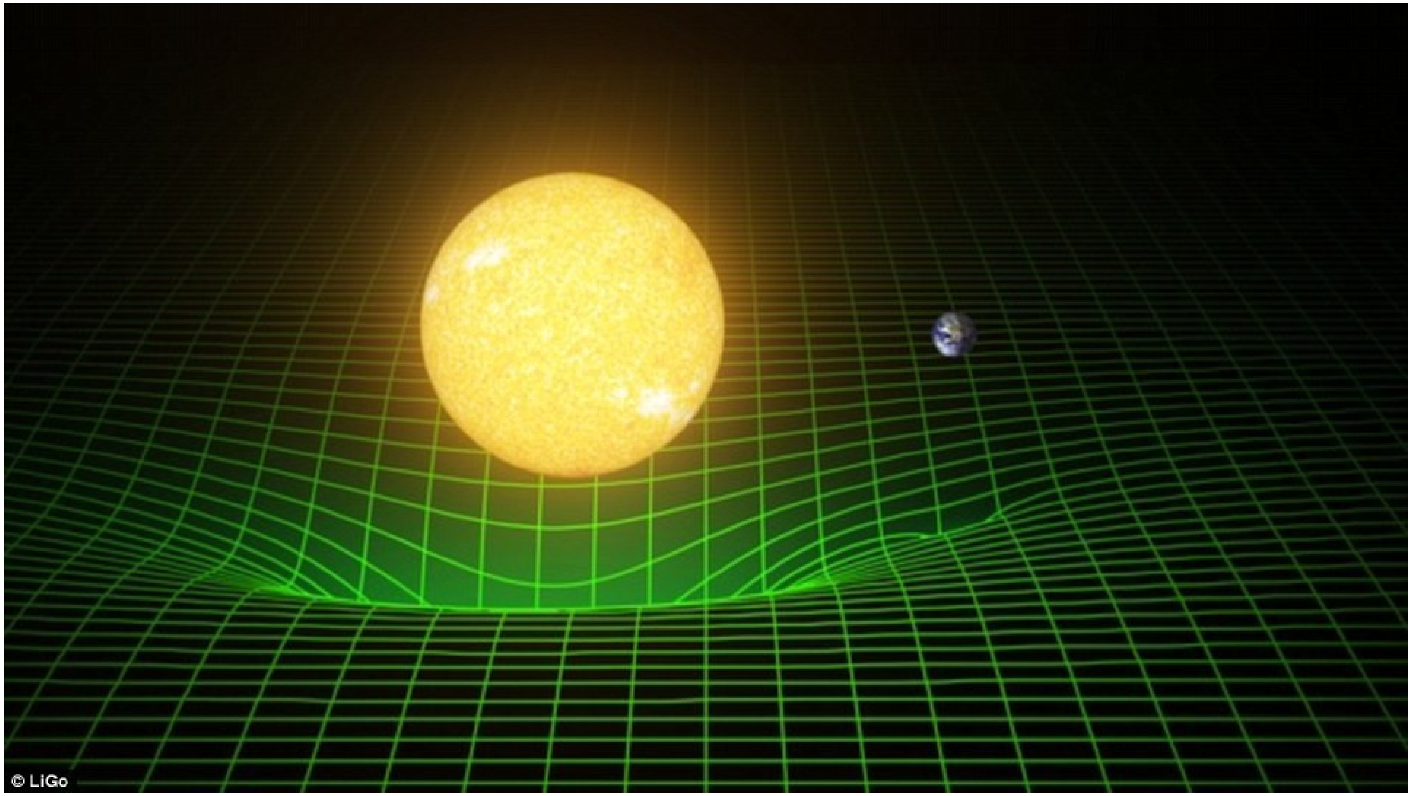
ca a velocità prossime a quelle della luce

mpo di un oggetto in moto scorre più lentamente

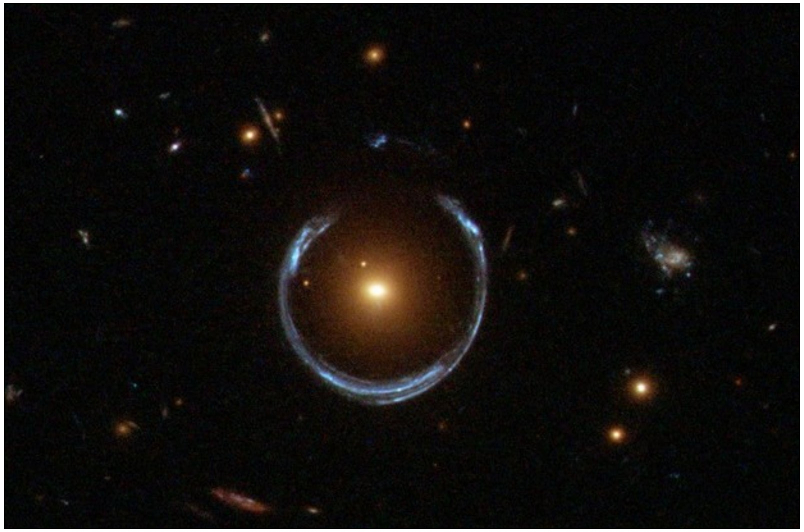


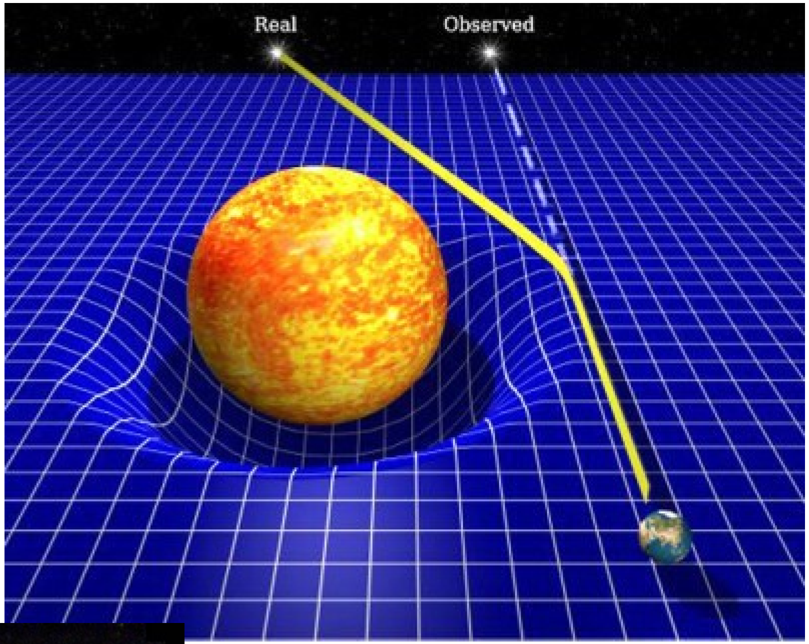
Teoria della Relatività

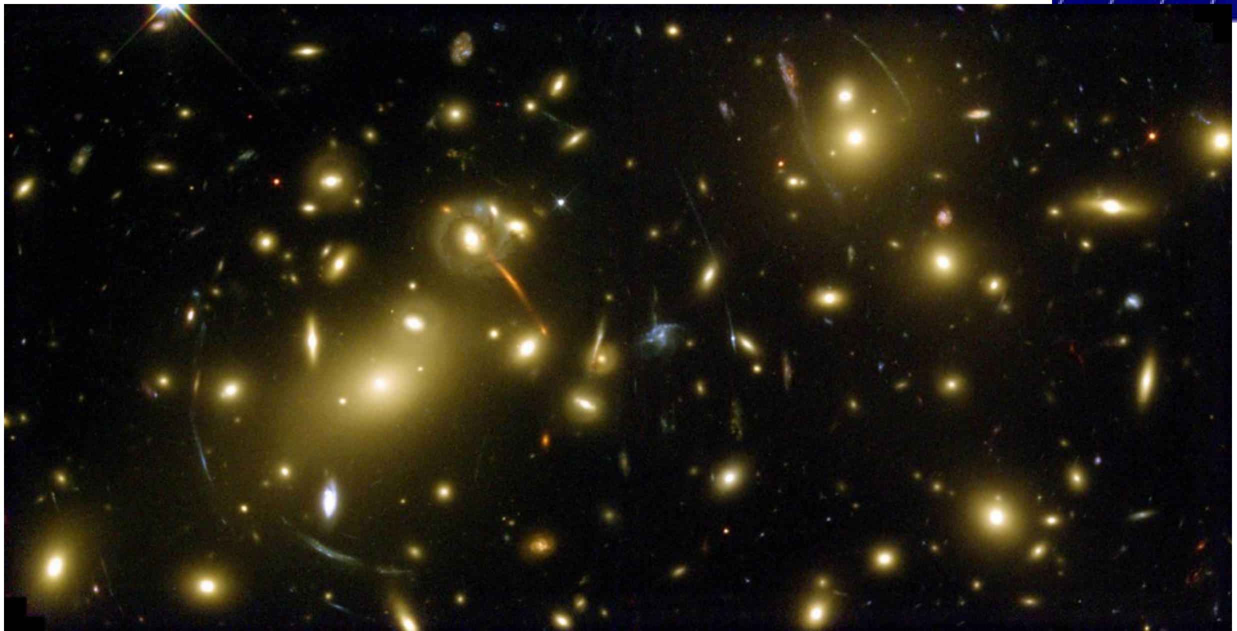
- **Generale (1915)**
  - Moto accelerato e gravità
  - Deformazione dello spazio tempo
  - Onde gravitazionali



Teoria della Relatività

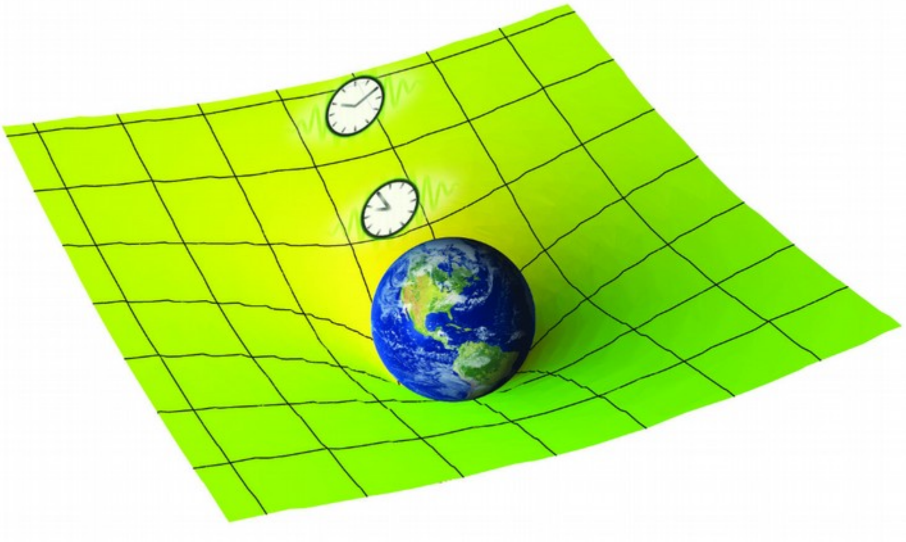






Lenti gravitazionali

Teoria della Relatività



1 giorno →

1 giorno + 30 microsecondi →

Errori di relatività

Relatività speciale
-7 microsecondi

Relatività Generale
+45 microsecondi

Risultato

45-7 = 38 microsecondi al giorno
=10 Km !

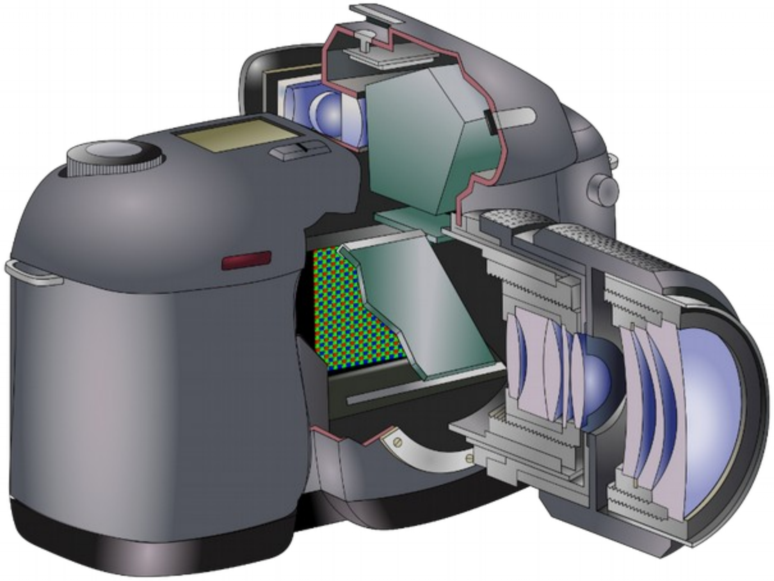
Occhiali

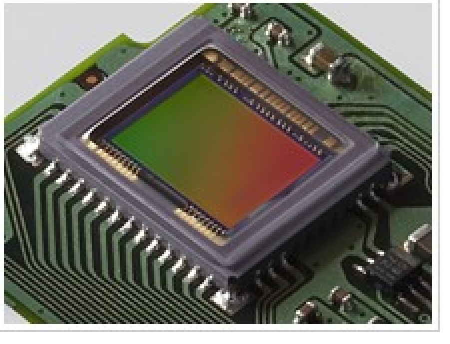
- Anni 70 - Plastica resistente ai graffi
- T. Wideven (NASA Ames)
  - per visori e elmetti astronauti
- Dal 1983 in commercio

- DiamondHard Technology
- Pellicola di Diamond-like Carbon (DLC)

- EagleEye Optics
  - Protezione UV per astronauti

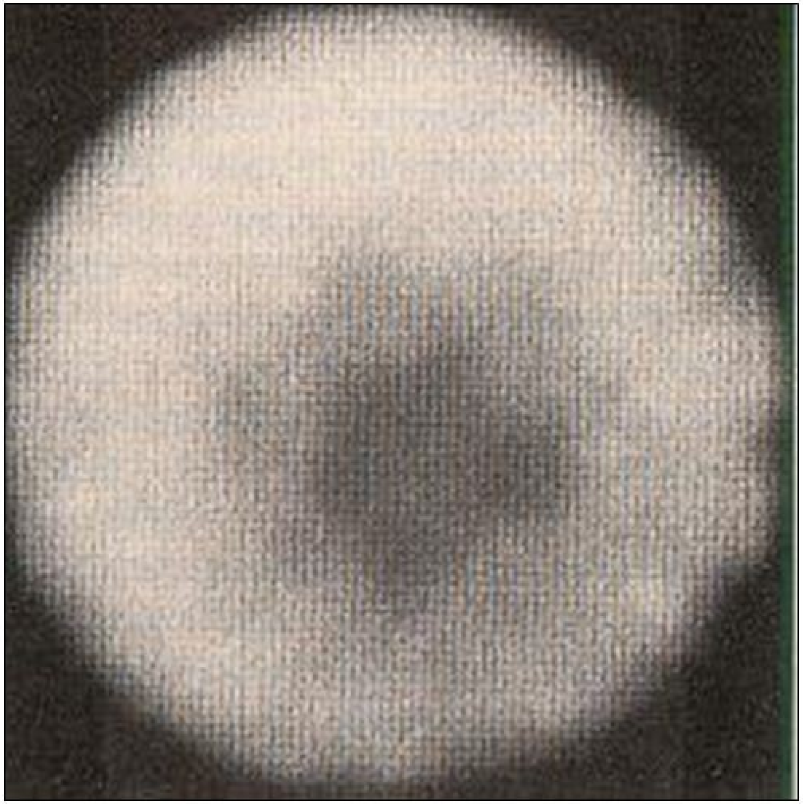
Facciamo qualche foto...





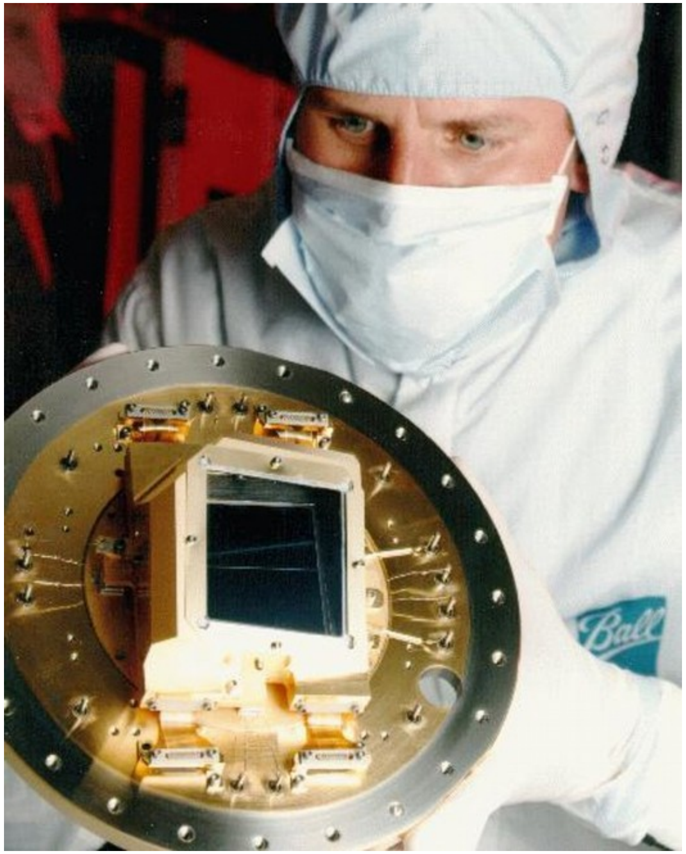
Facciamo qualche foto...

- Charge Coupled Device (CCD)
- Sviluppato da W. Boyle e G. Smith nel 1969
- Premio Nobel per la Fisica 2009
- Larghissimo uso in astronomia
    - Sensibile ed efficiente



Urano, 1975
(Jet Propulsion Laboratory)

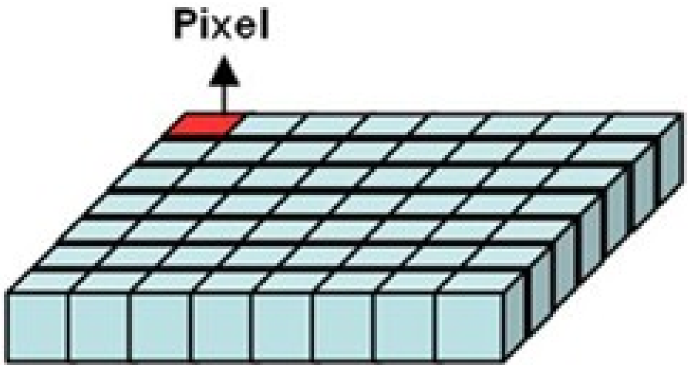
Nello spazio...

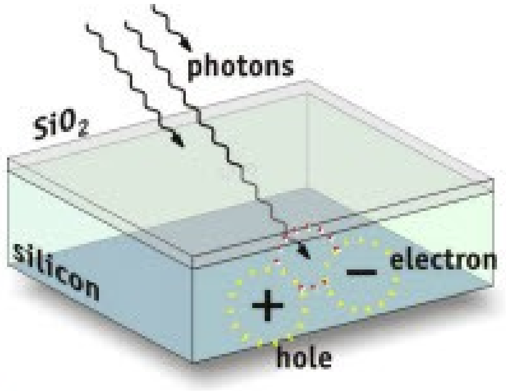


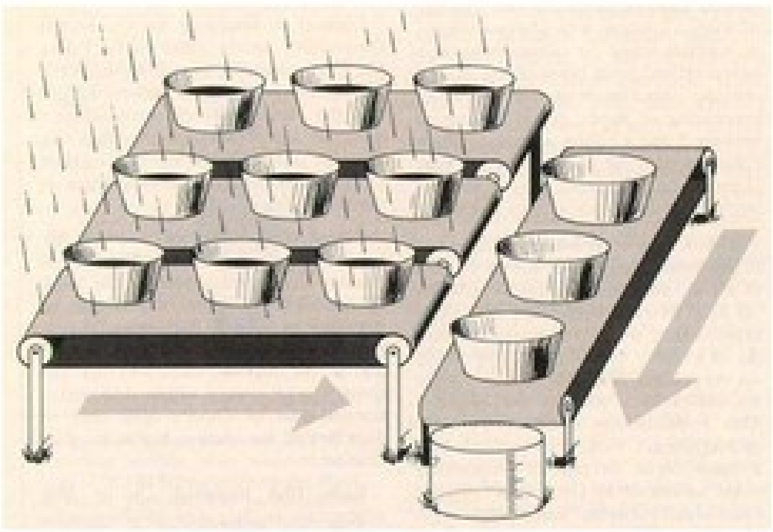
1996 - Hubble ACS (16 Mp)

2009 – Kepler (95 Mp)

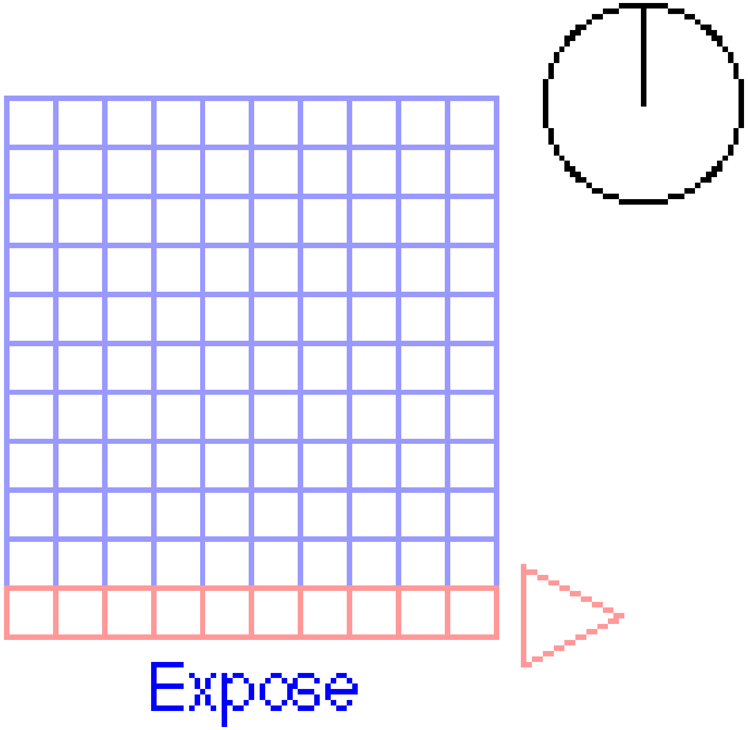
Come funziona?



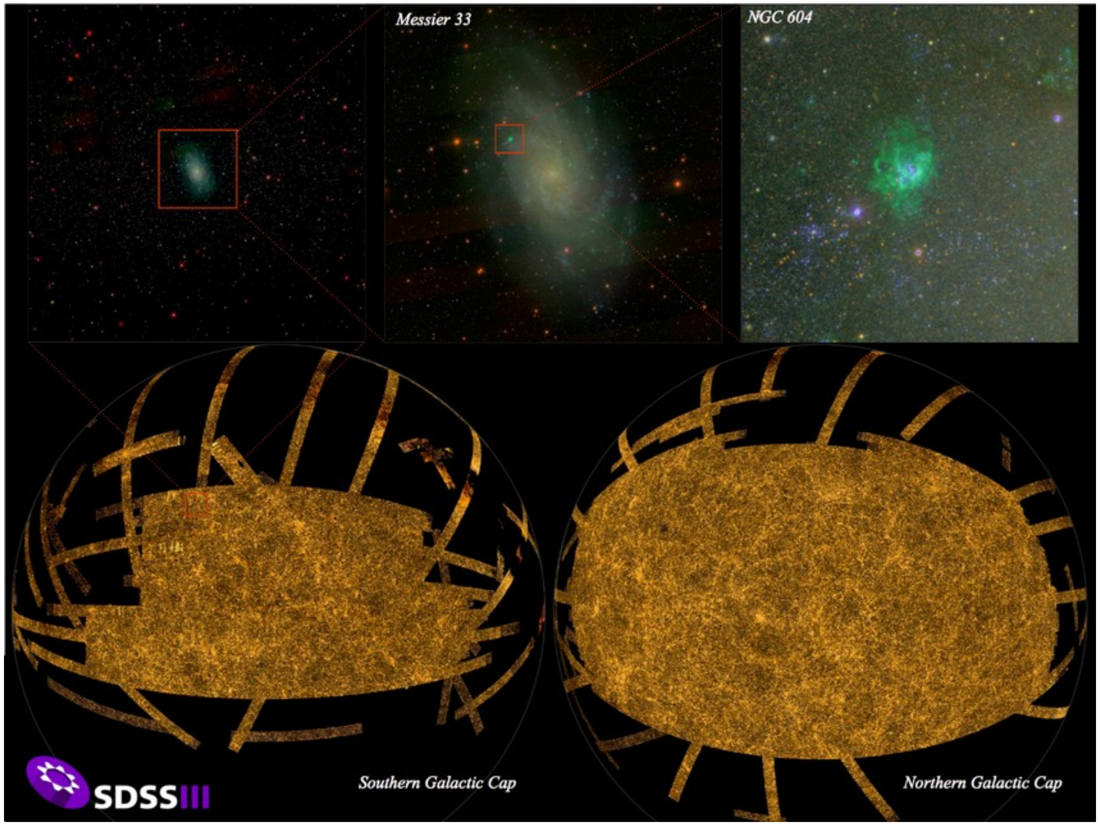




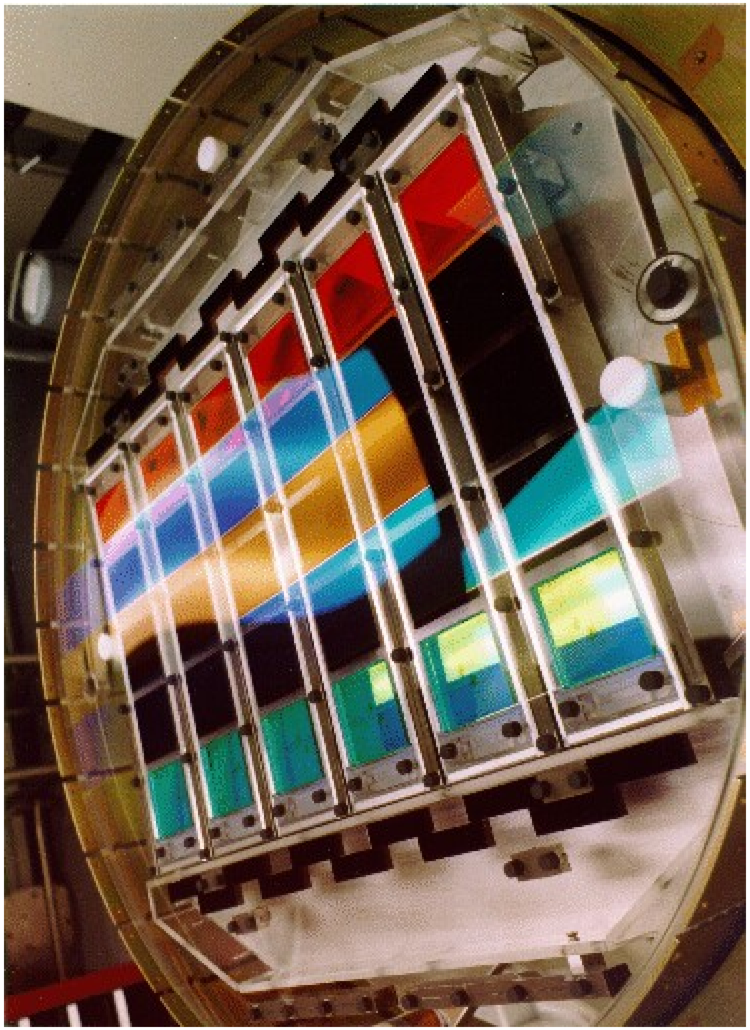
Come funziona?



...e a Terra



2000-2009 SDSS (120 Mpixel)

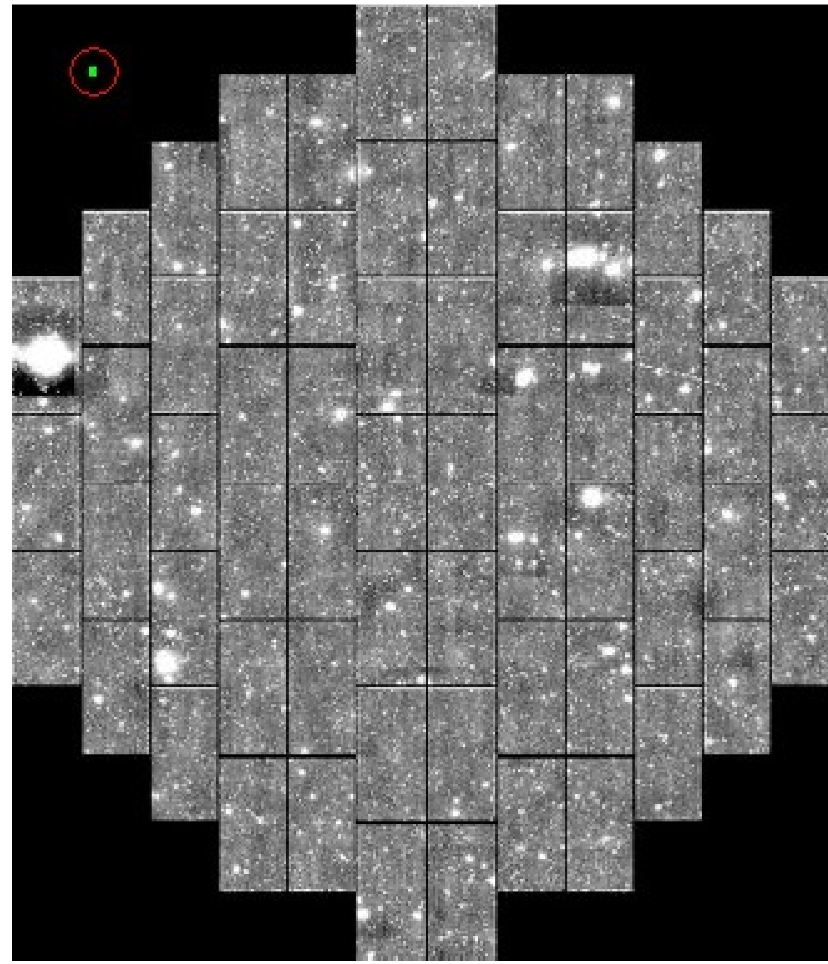


Mille miliardi di pixel

500 mila TV hd

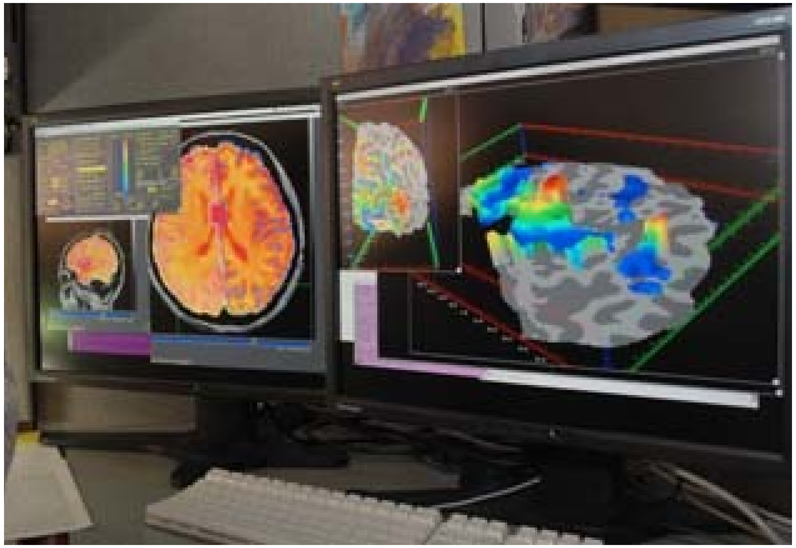
La più grande

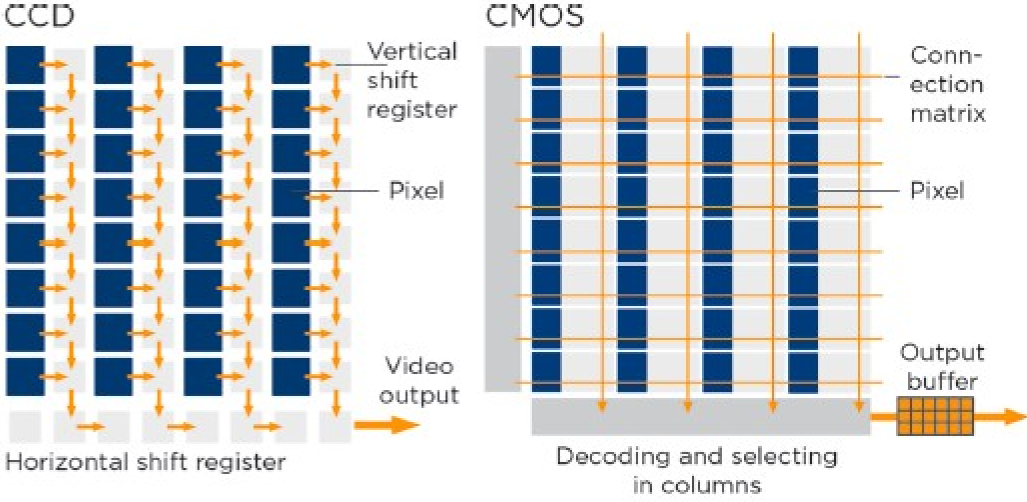
- Dark Energy Camera (DECam)
- 2013 -
- 520 Megapixel
- 3°x3°



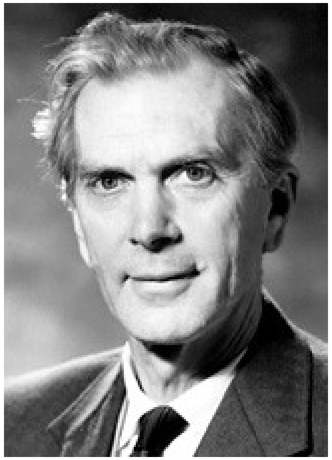
Dai laboratori agli ospedali

usate, ora man mano rimpiazzate da sensori CMOS

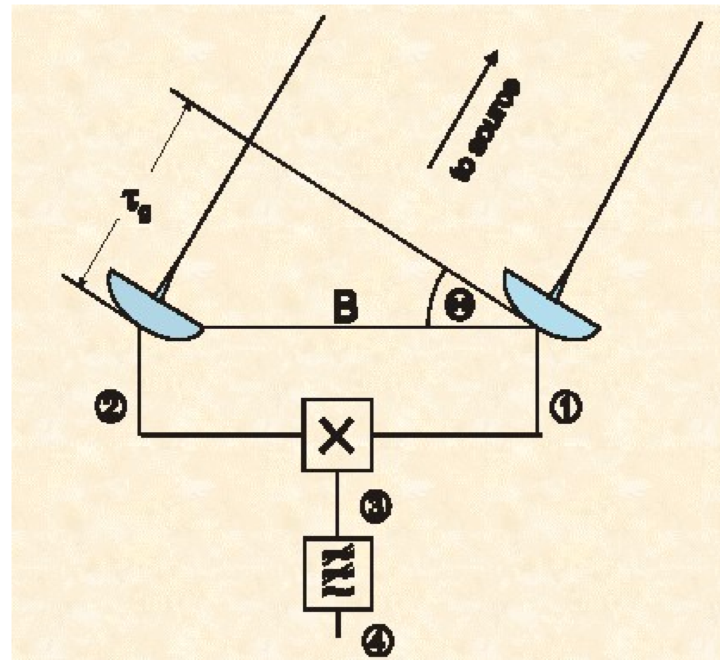




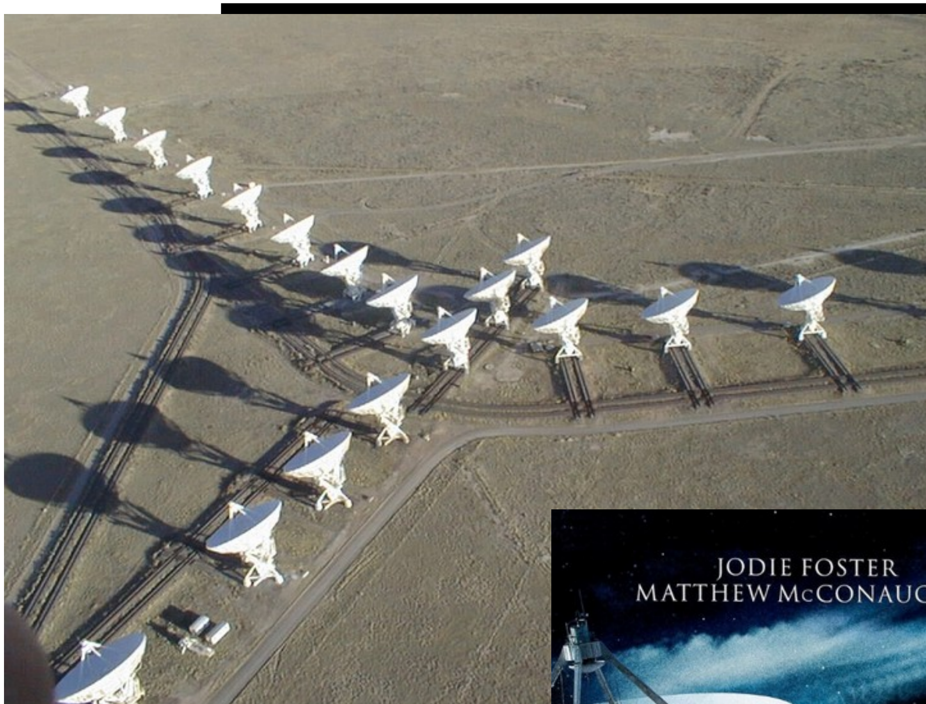
Una rete di radiotelescopi

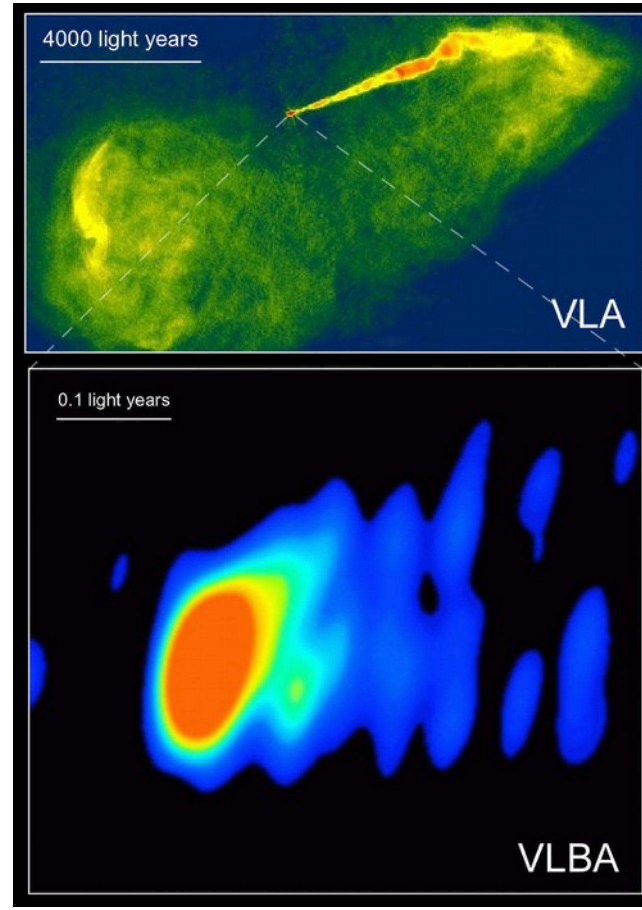


Martin Ryle (1918-1984)
Premio Nobel 1978

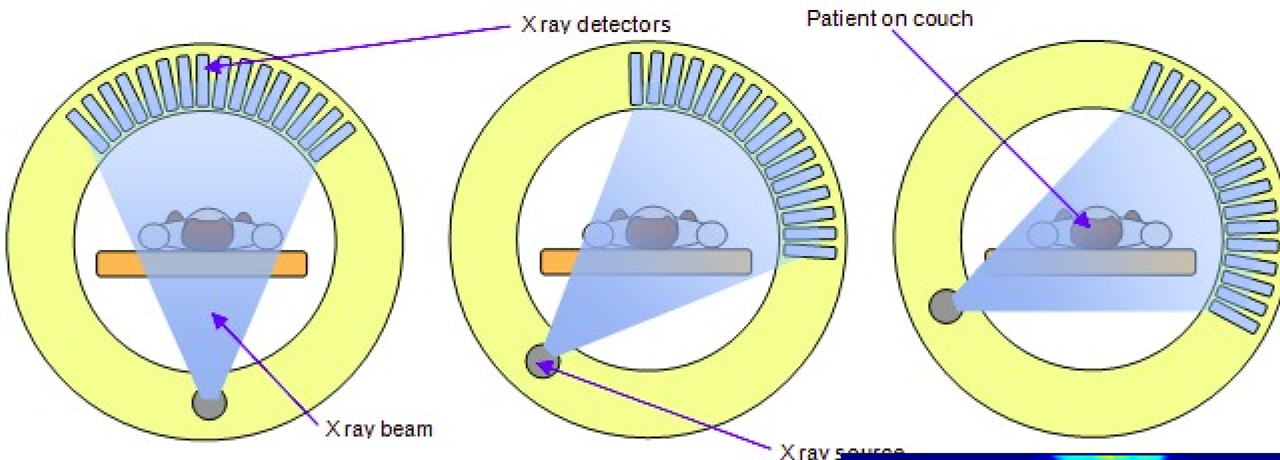


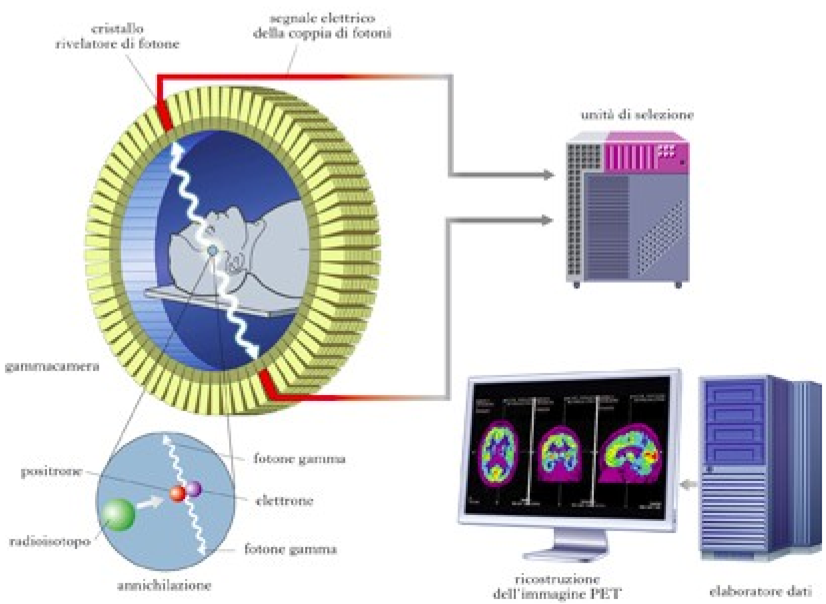
Una rete di radiotelescopi

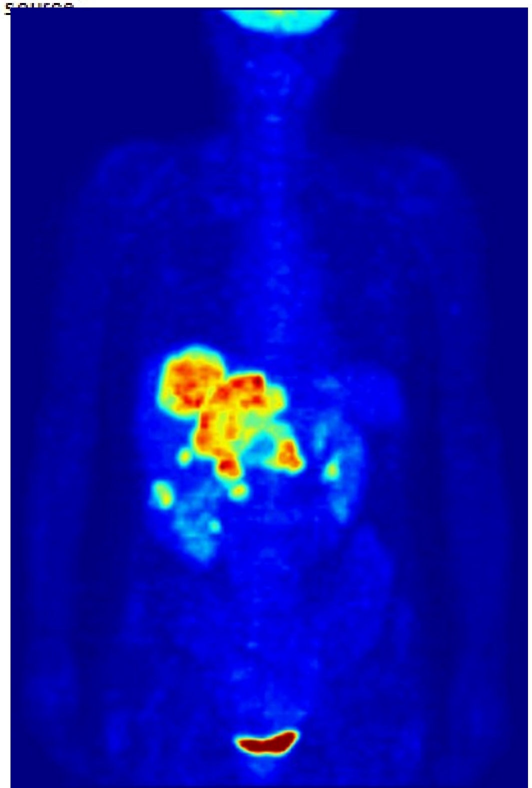




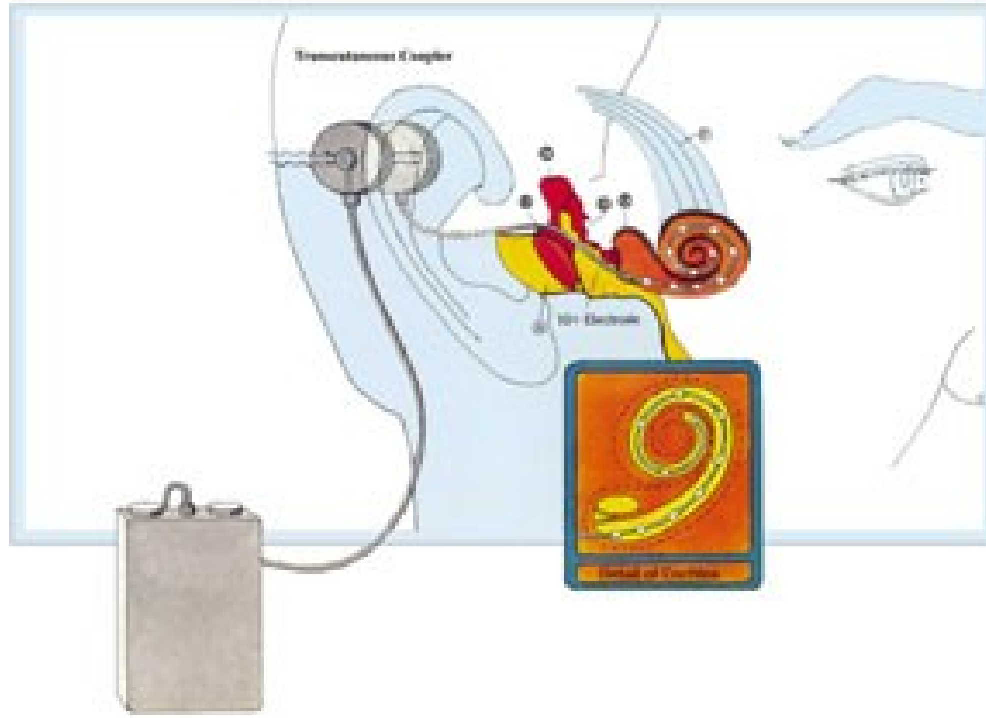
Una rete di radiotelescopi





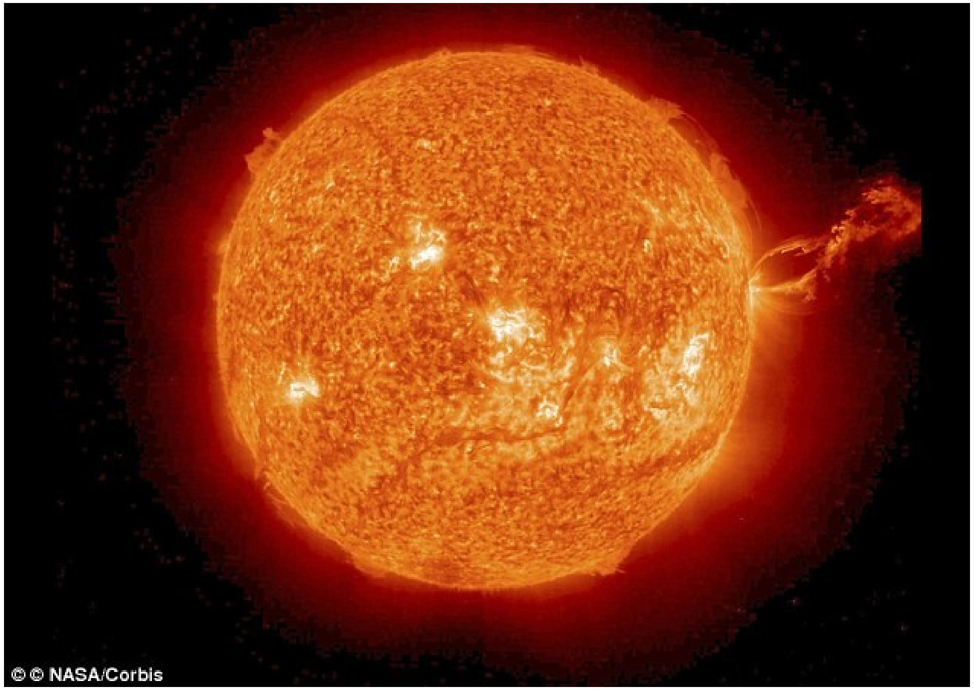


Orecchio bionico



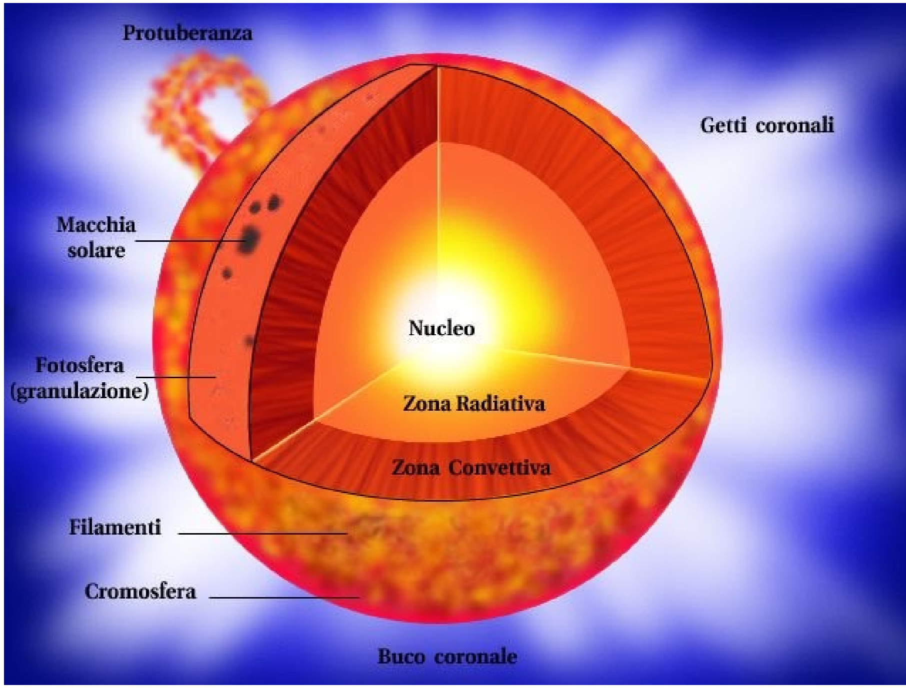
Impianto cocleare
1977 - Adam Kissian, ingegnere elettronico al NASA Kennedy Space Center

Dal Sole…

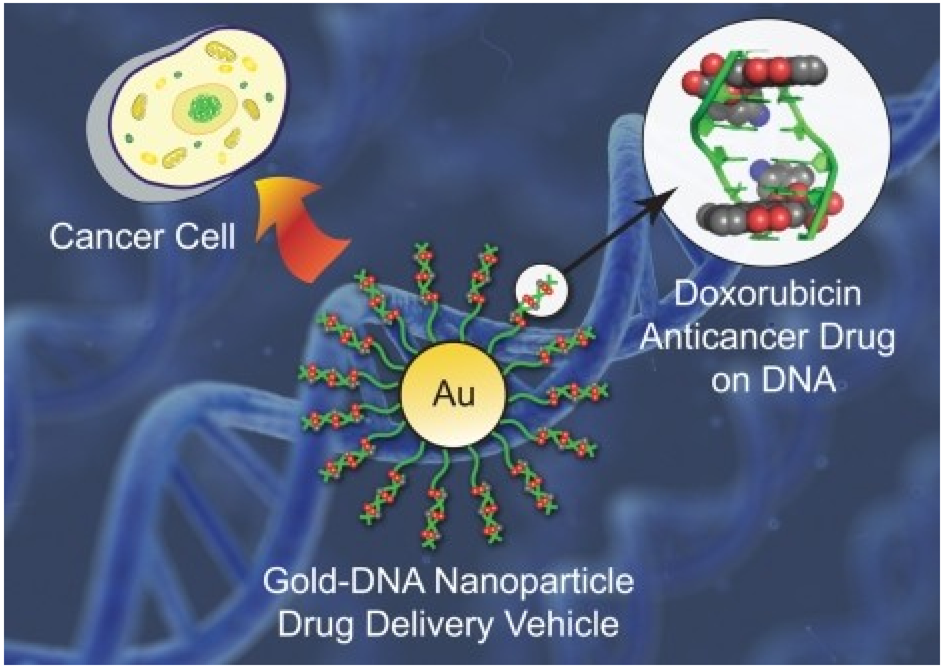


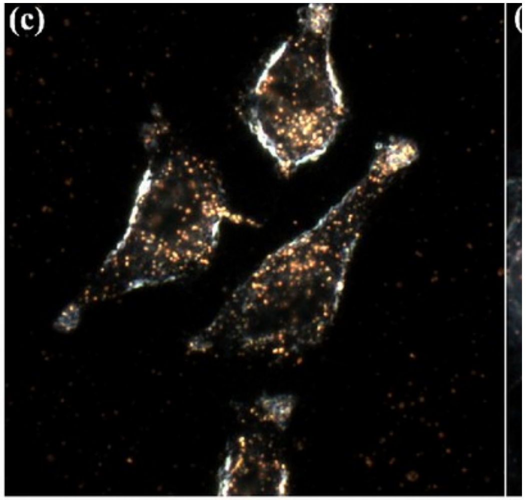
Modelli solari incompleti
Studio dell'opacità nell'interno del So

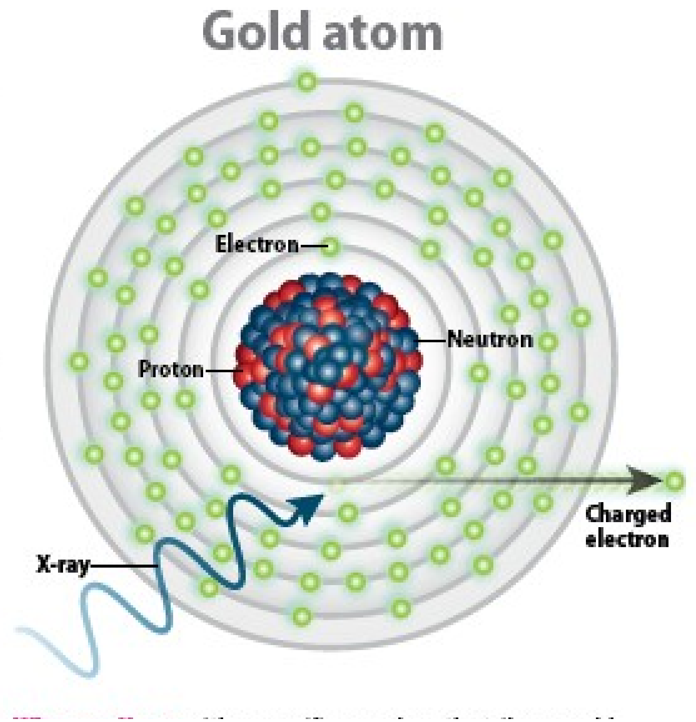
1983 – Opacity Project
(Ohio State University)



...alla lotta al cancro







Tantissimi altri esempi

Tecnologia per rivelatori di raggi X
- scanner degli aeroporti
- Monitoraggio processi fusione nucleare

Cromatografia a gas, usata per studiare il suolo marziano
- controlli sicurezza aeroporti

Misure posizioni stellari
- Sistema di riferimento per navigazione e tempo

Software di analisi (IDL, IRAF)
- Applicazioni industriali

Analisi immagini satellitari
- Impieghi in medicina, e non solo

Nuovissime tecnologie dallo spazio ogni anno
- NASA Spinoff

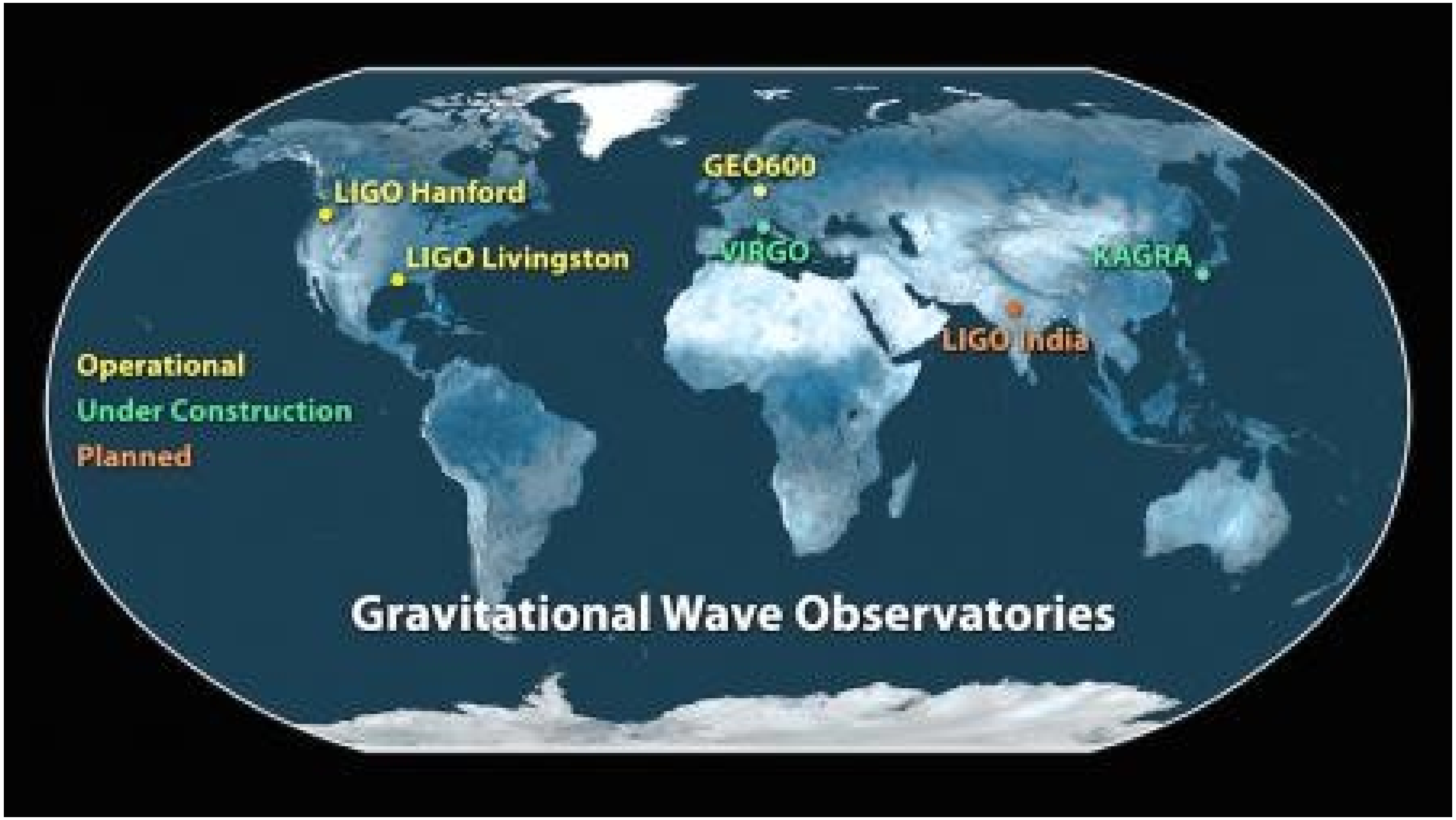
E molto, molto altro!

Non solo tecnologia...

Da sempre l'astronomia ha richiesto l'uso di telescopi sparsi in tutto il mondo, favorendo le prime collaborazioni scientifiche

Oggi, è una caratteristica della Big Science, da LHC ai telescopi spaziali

Non solo tecnologia...



Public Outreach

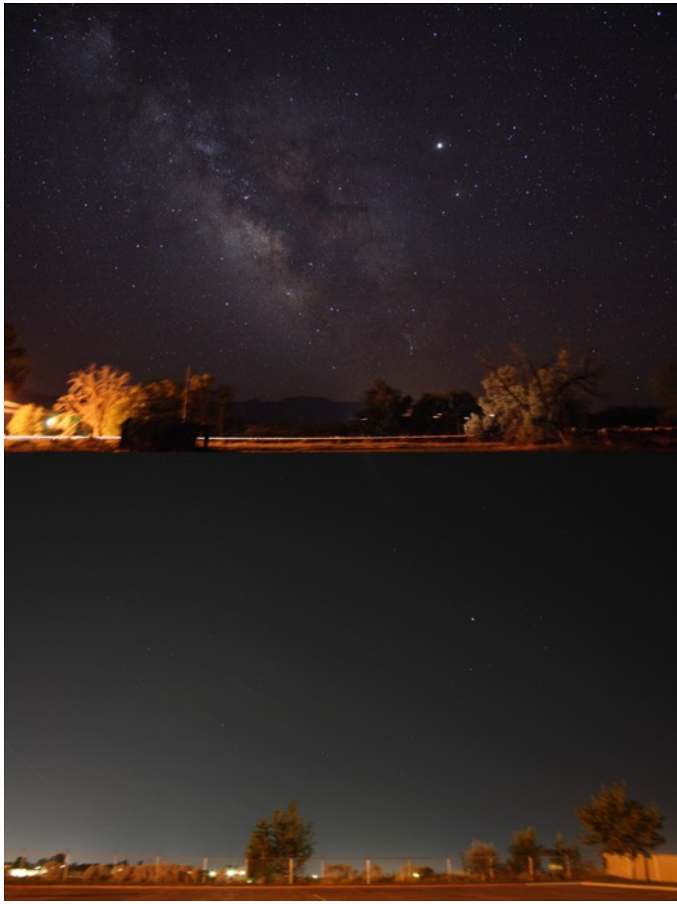
THE UNIVERSE
YOURS TO DISCOVER
INTERNATIONAL YEAR OF
ASTRONOMY
2009

GALILEO
MOBILE

Non solo tecnologia

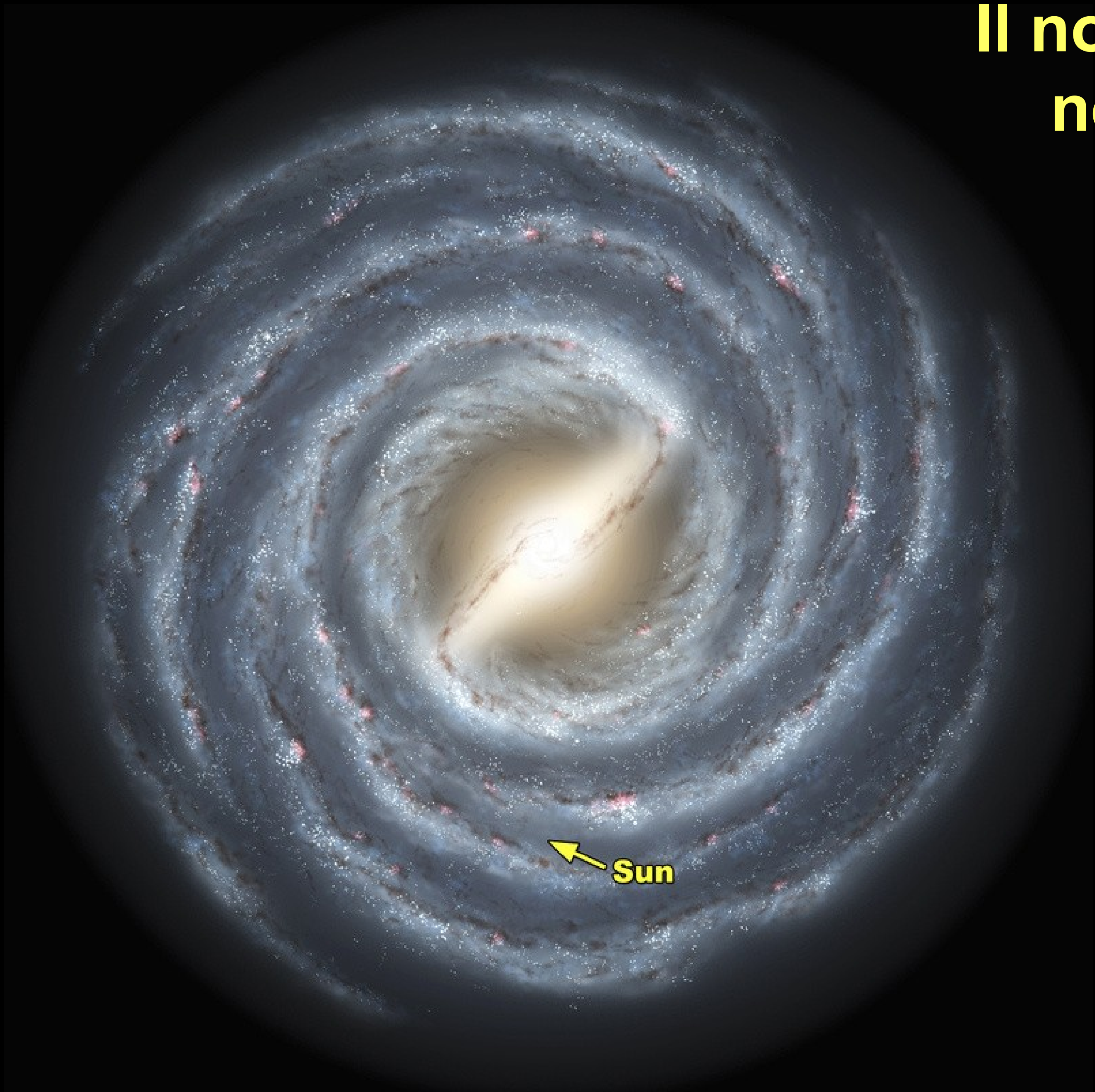
GALILEO MOBILE

Non solo tecnologia



Inquinamento luminoso

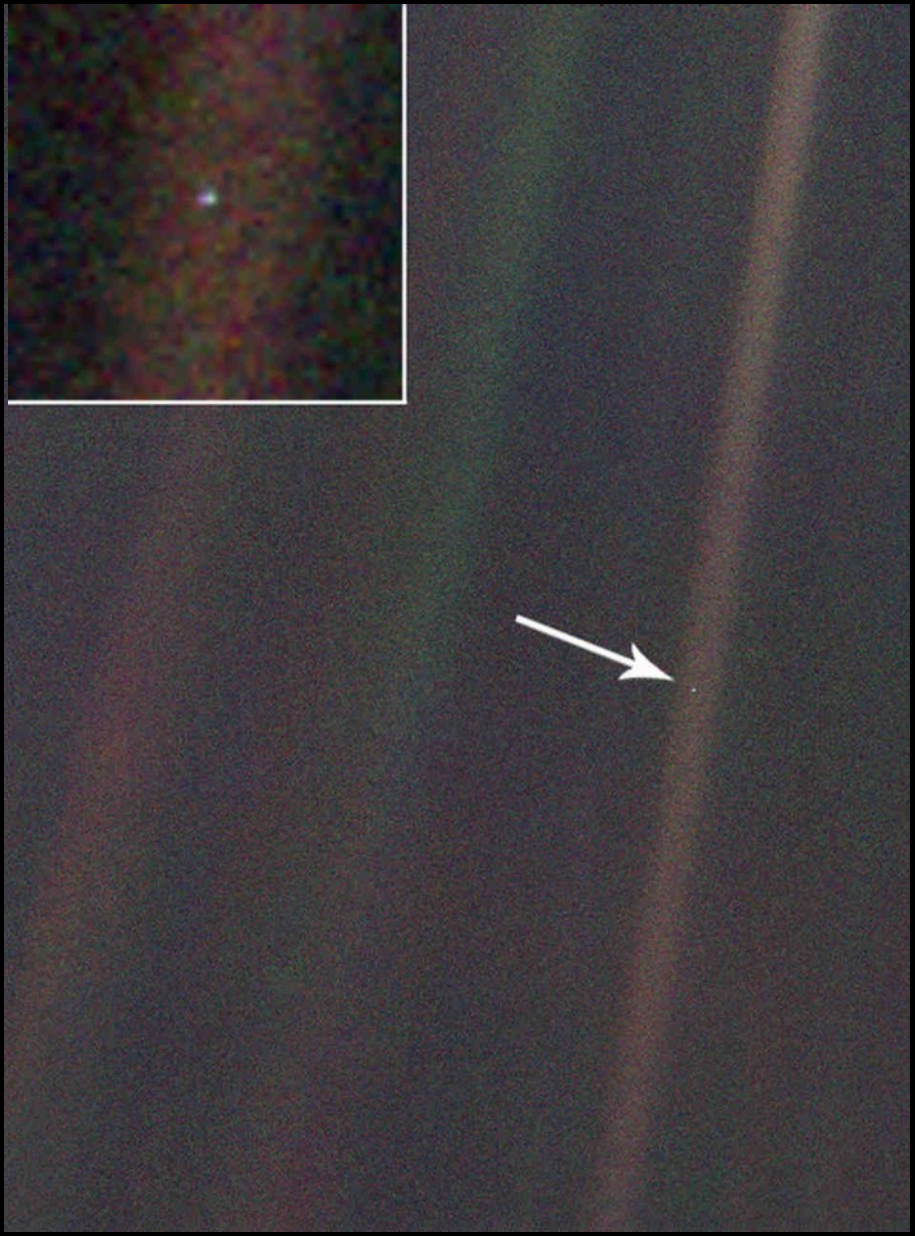
Il nostro posto nel cosmo



Pale Blue Dot

La nostra Terra
Vista da 6 miliardi di chilometri di distanza

Voyager 1,
14 febbraio 1990



Astronomy Picture of the Day (2012 August 1)