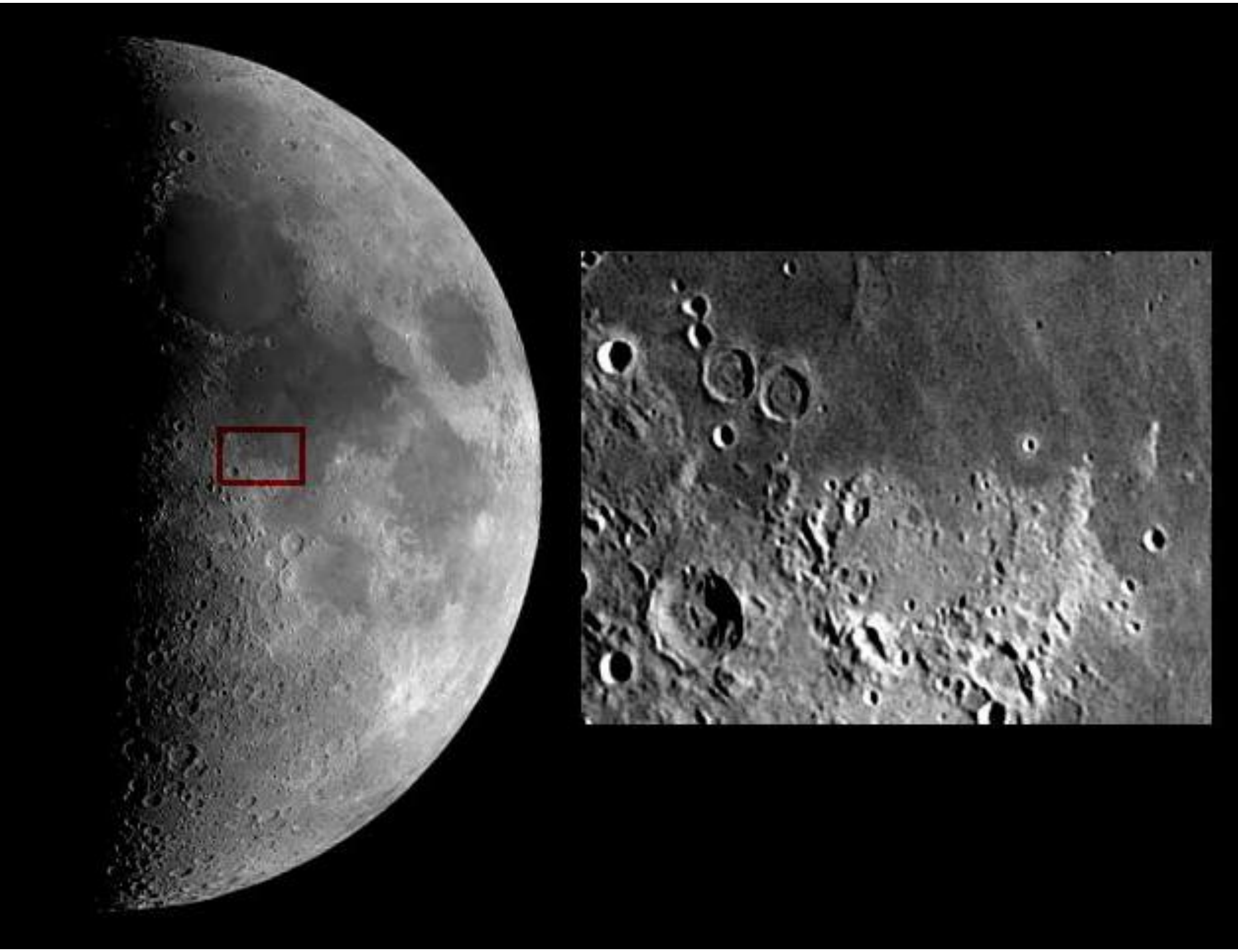
# guardare lontano, lontano…

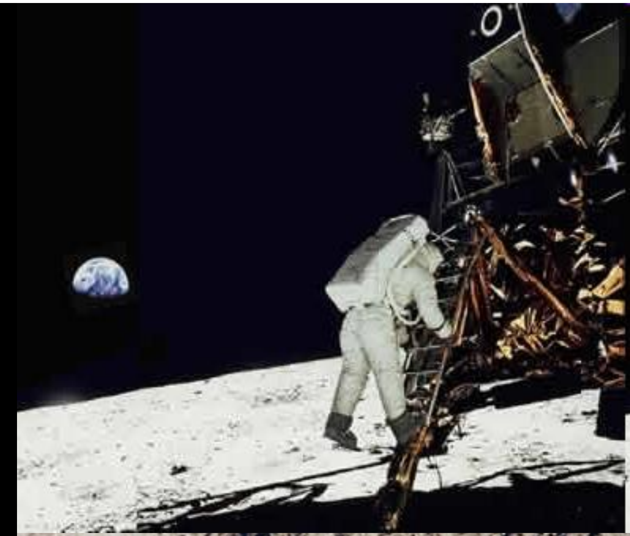
## l’oggetto piu’ distante dell’Universo

Ruben Salvaterra


Quale e' l'oggetto piu' distante dell'Universo?
A: la Luna
B: un pianeta
C: una galassia
D: una stella
remixito.fr

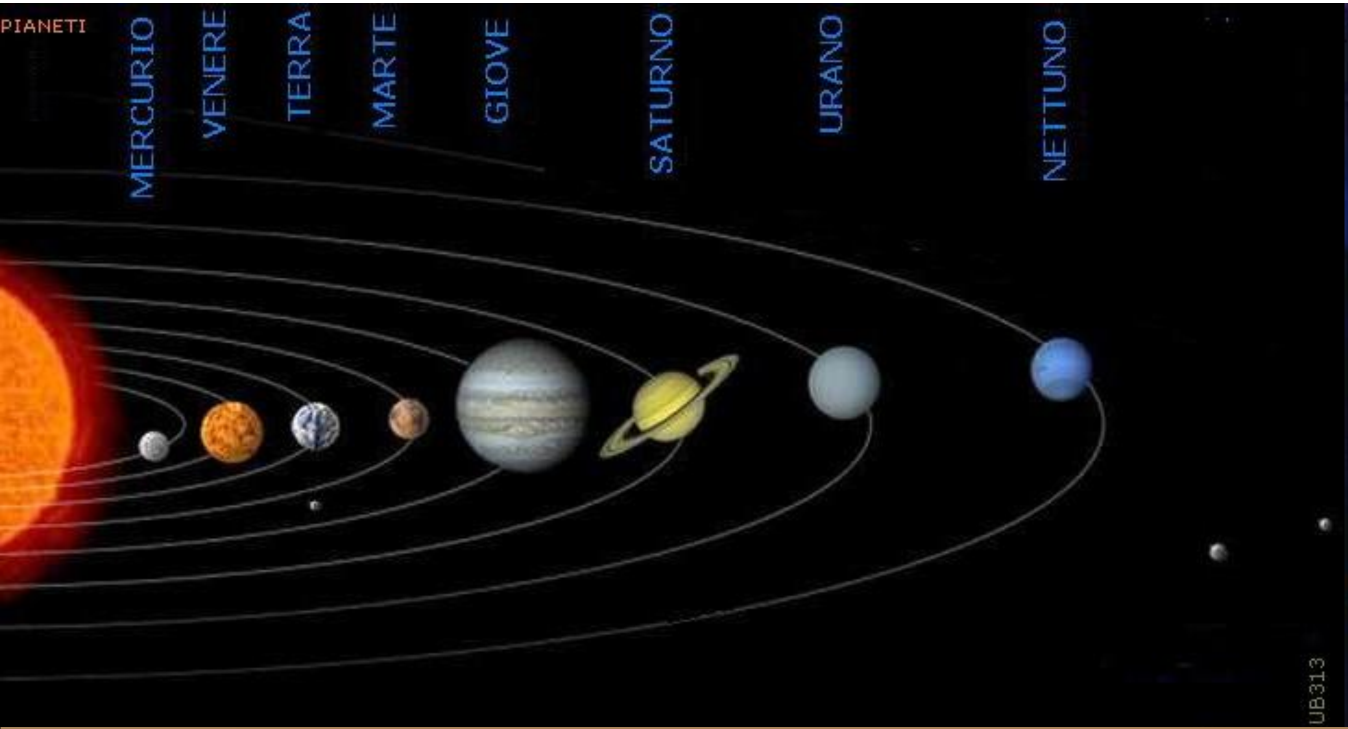
# la luna





l’oggetto piu’ lontano su cui siamo stati

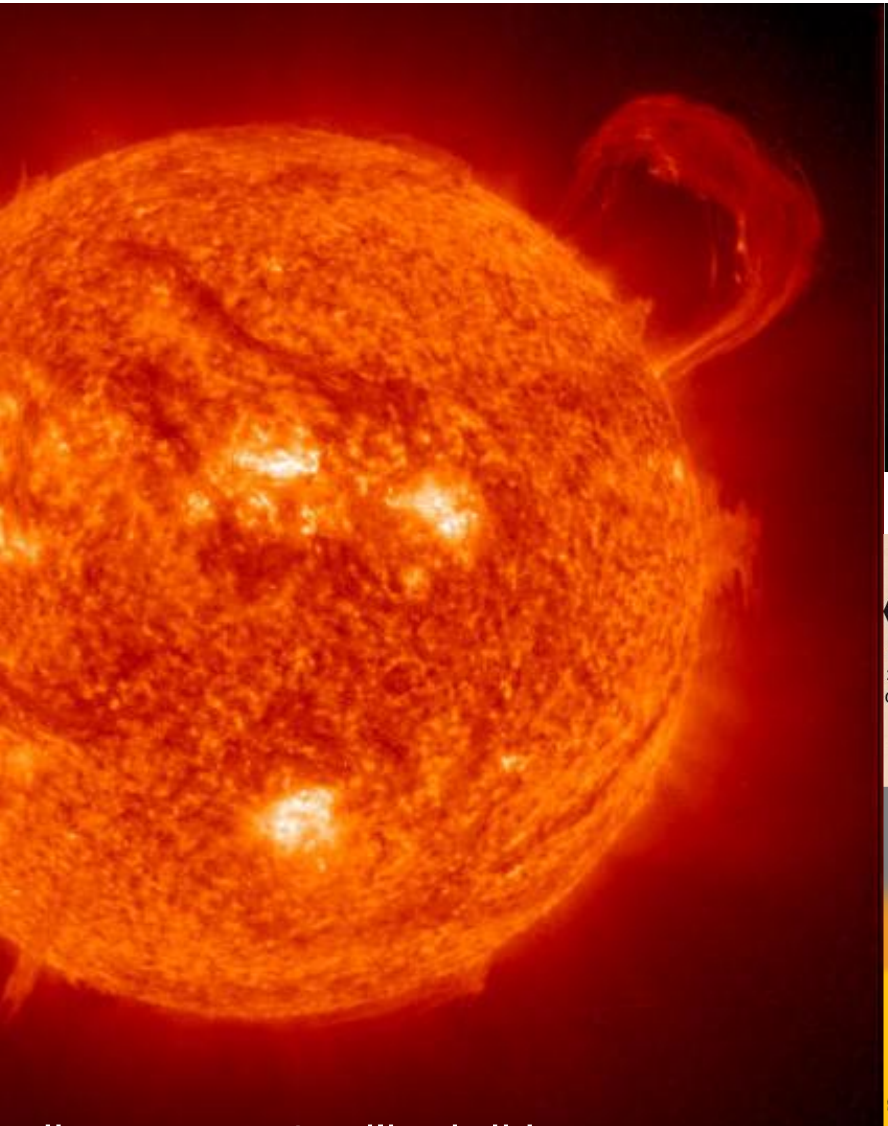
# i pianeti


PIANETI
MERCURIO
VENERE
TERRA
MARTE
GIOVE
SATURNO
URANO
NETTUNO
UB313

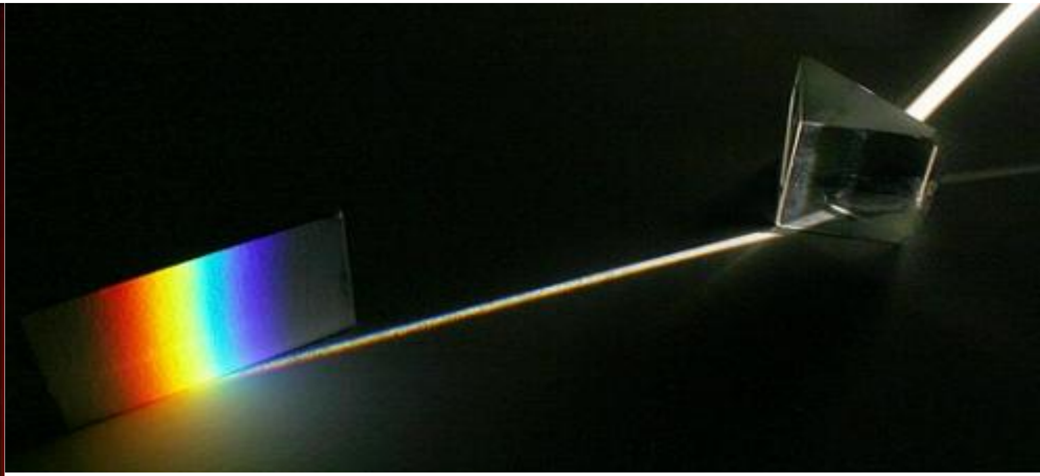

Voyager II a 100 AU


opportunity

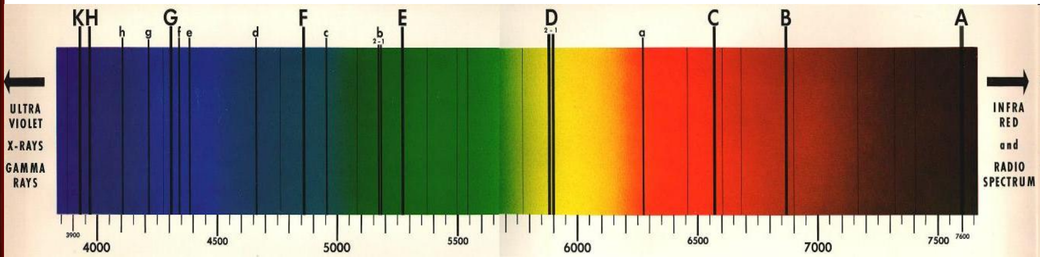
# Il sole: la stella più vicina



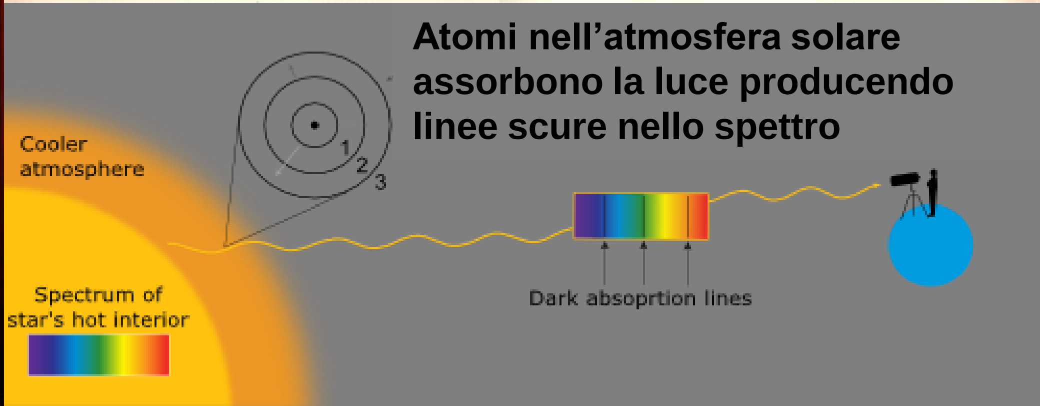
distanza: 150 milioni di km



spettro del sole




**Atomi nell'atmosfera solare assorbono la luce producendo linee scure nello spettro**



# Proxima Centauri

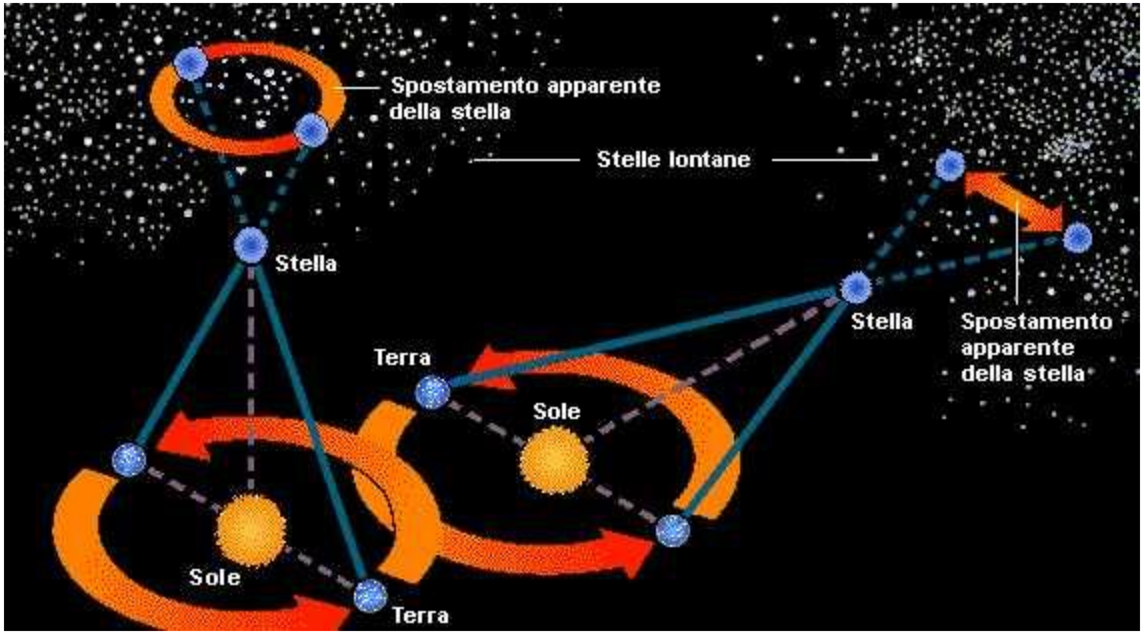


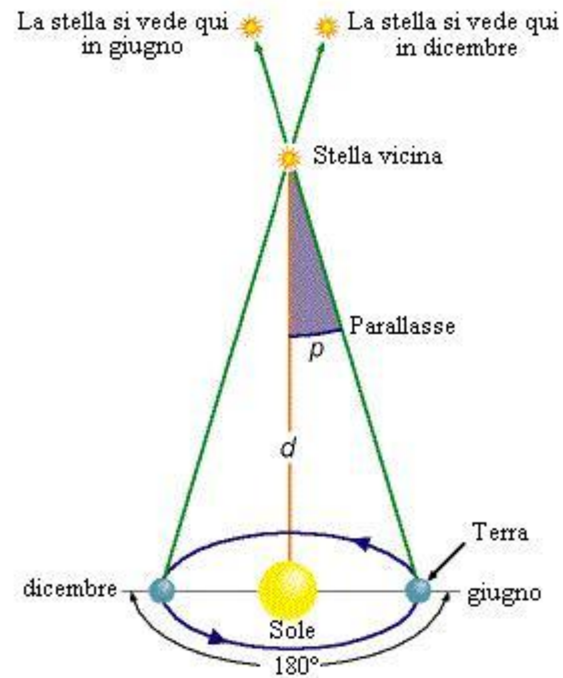
a-Sole

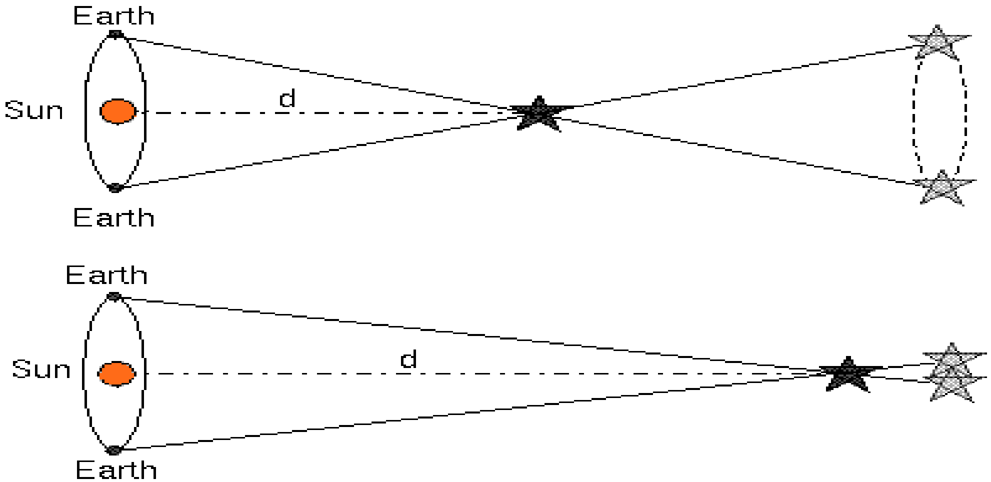
è

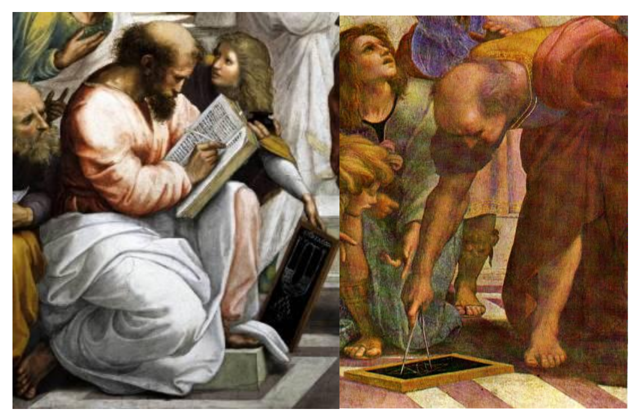
i luce

# misurare la distanza delle stelle

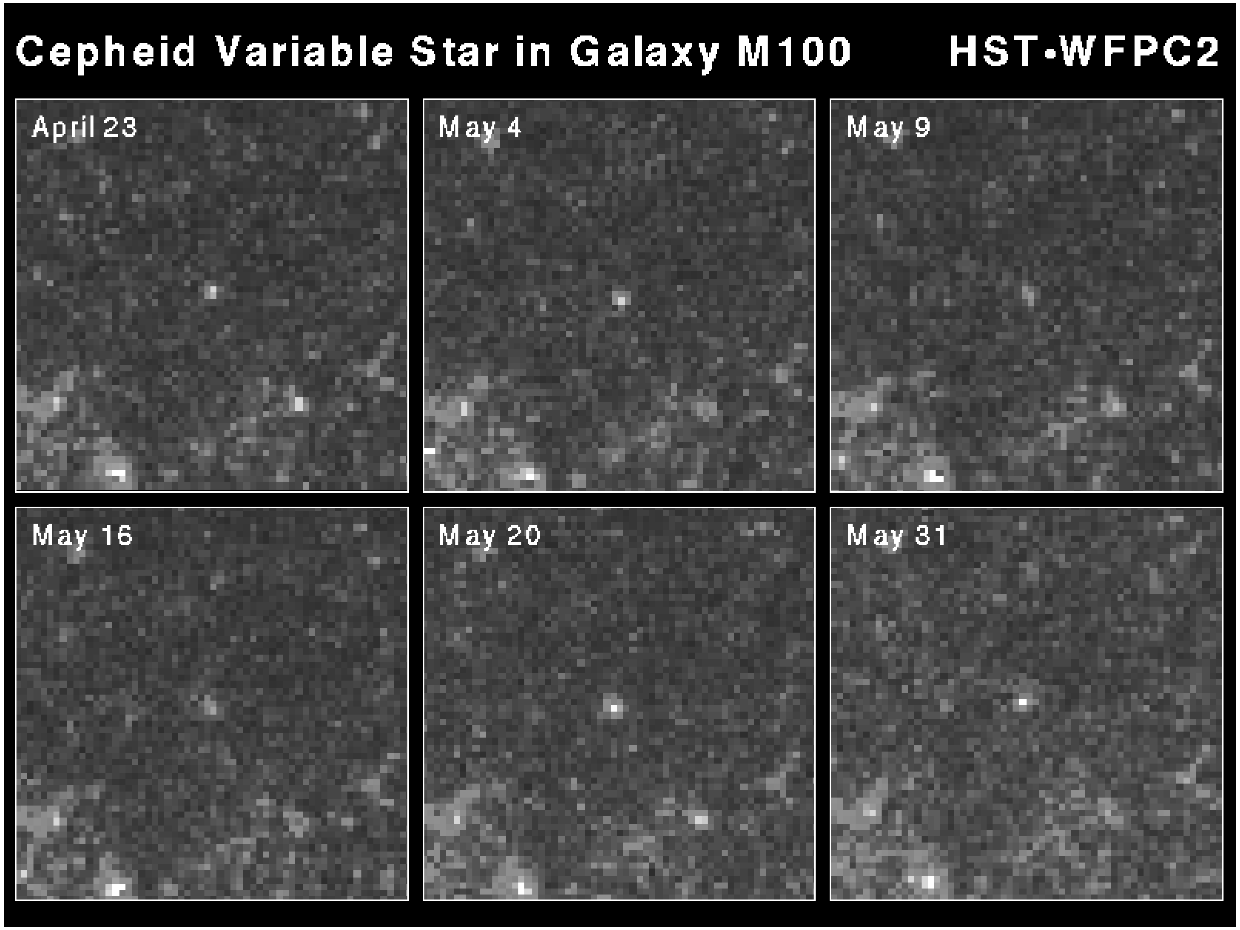


# le cefeidi





flusso≈L/4pi $D^2$

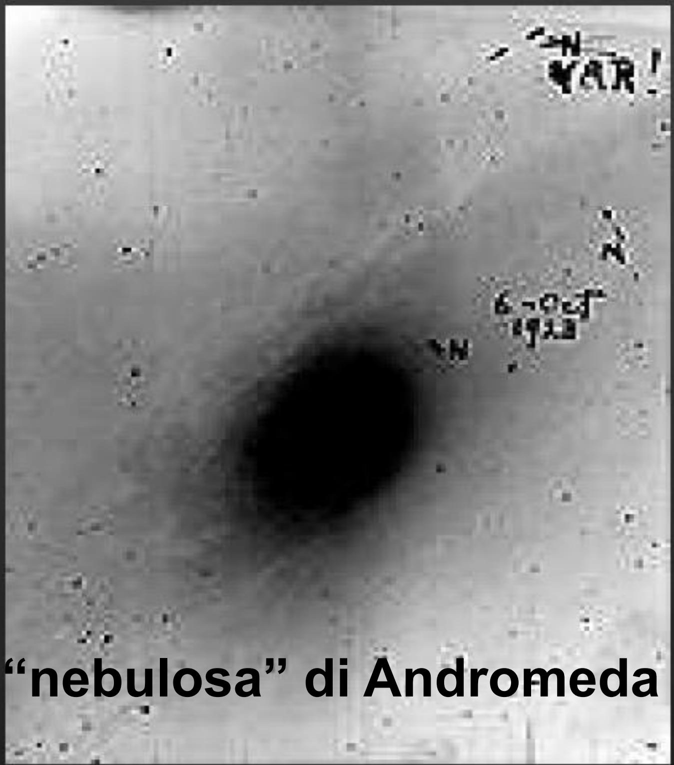
52 milioni di anni luce

dalla variabilità si può risalire alla distanza

# Hubble I: le altre galassie

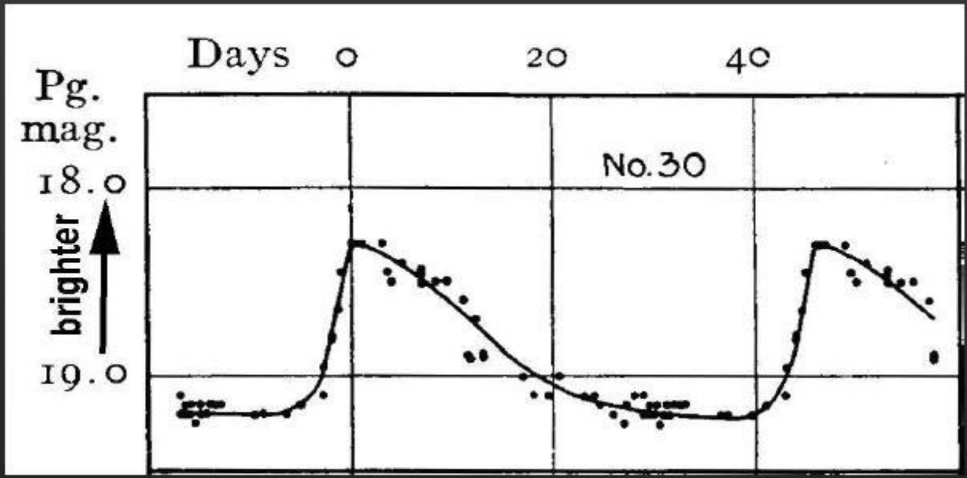
Mount Wilson Observatory

ottobre 1923:
Erwin Hubble osserva le nebulose con il 100” (2.5 m) di Mount Wilson




**“nebulosa” di Andromeda**

**DISTANZA: 2,2 milioni di anni luce**



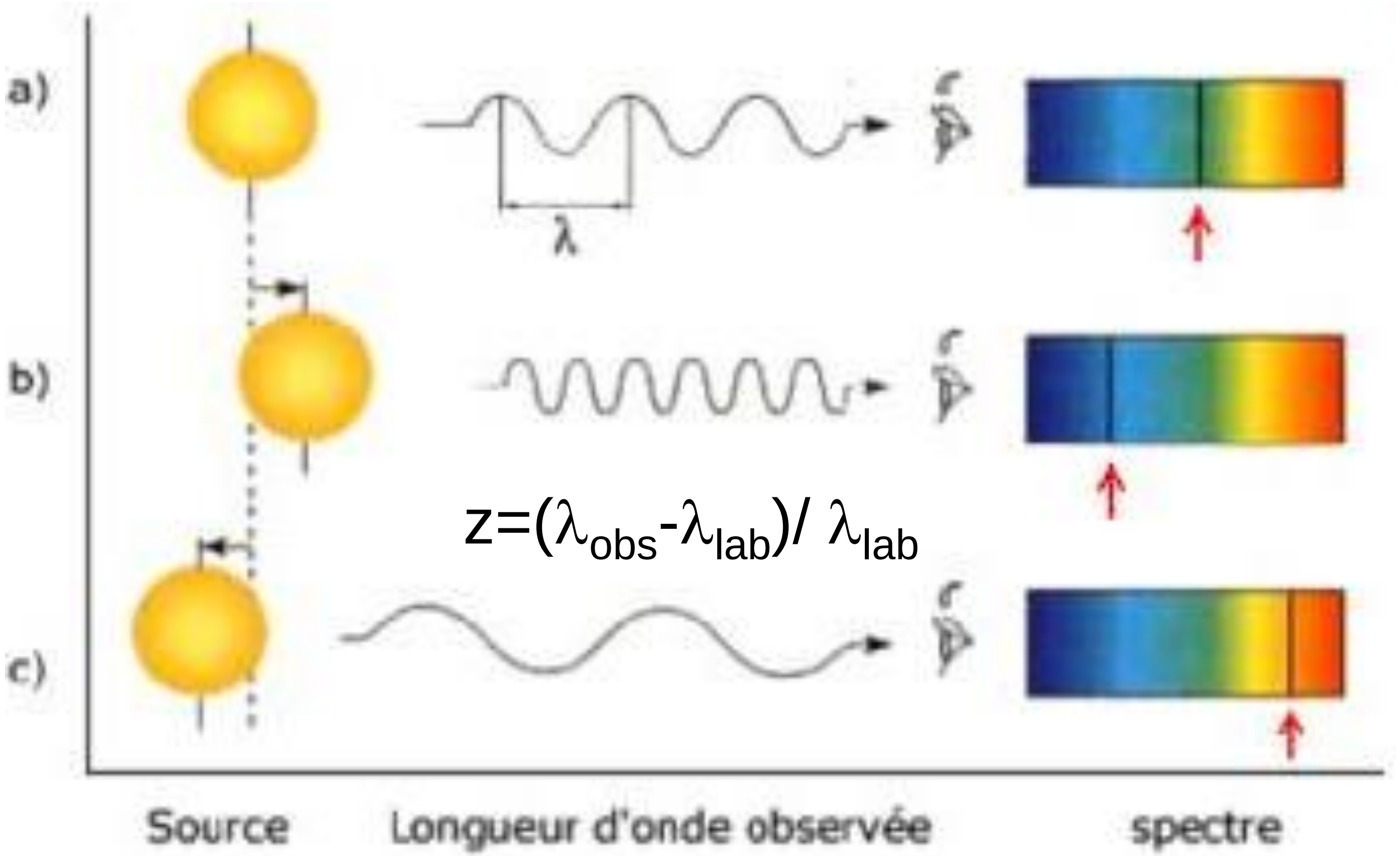

**Andromeda è una galassia con miliardi di stelle**

# effetto Doppler

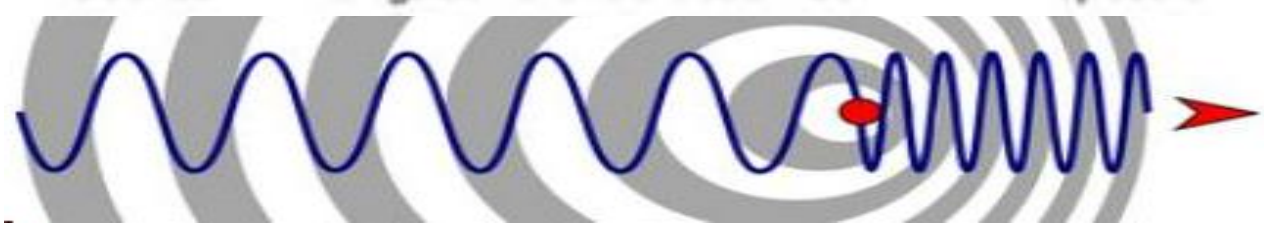
ferma

si avvicina

si allontana




$z=(\lambda_{obs}-\lambda_{lab})/\ \lambda_{lab}$



**PIU' ROSSA** **PIU' BLU**

# Hubble II: le galassie si allontanano

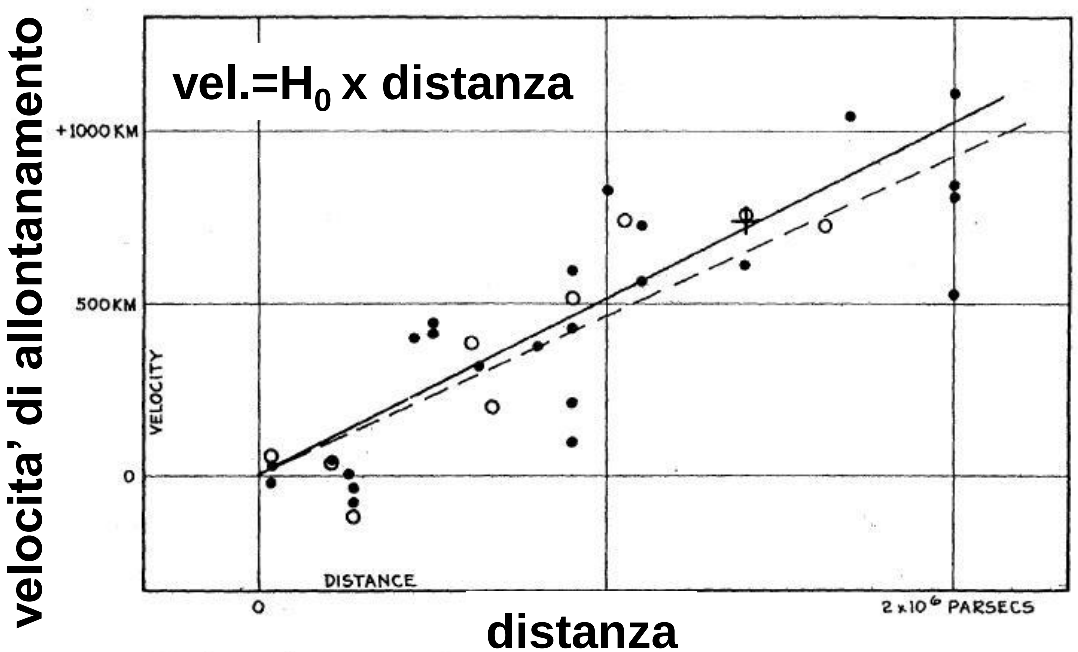
**piu' le galassie sono distanti e piu' si allontanano (piu' e' grande il redshift)**

*A RELATION BETWEEN DISTANCE AND RADIAL VELOCITY AMONG EXTRA-GALACTIC NEBULAE*

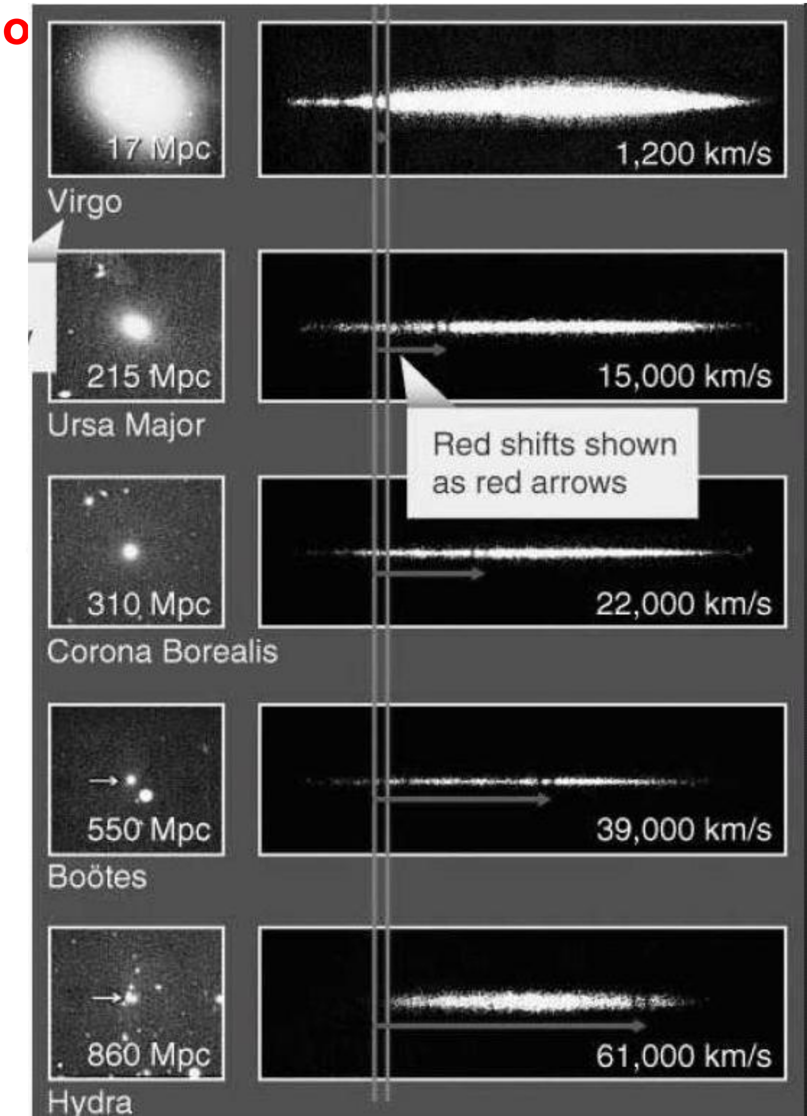
BY EDWIN HUBBLE

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

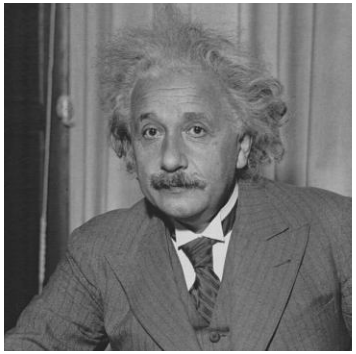
Communicated January 17, 1929




Velocity-Distance Relation among Extra-Galactic Nebulae.

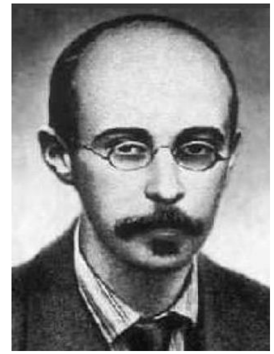


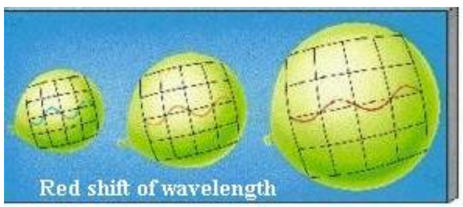
# l’universo si espande

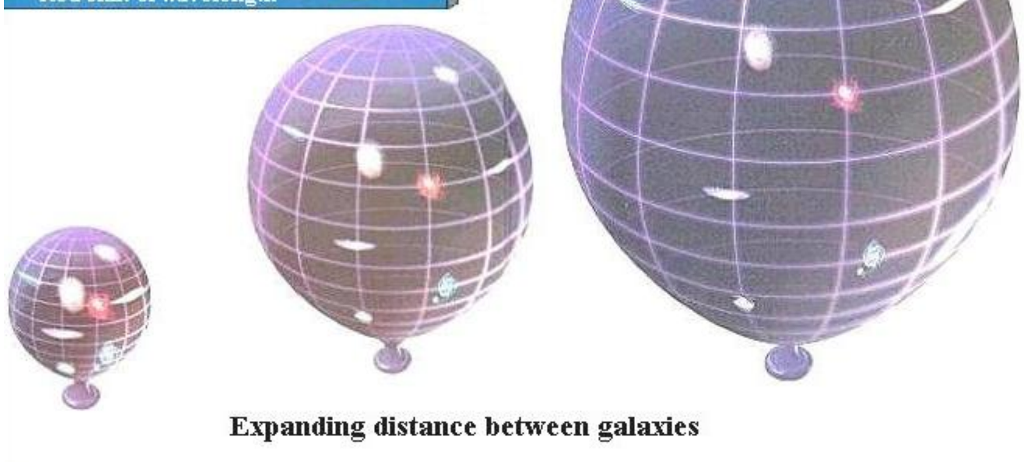


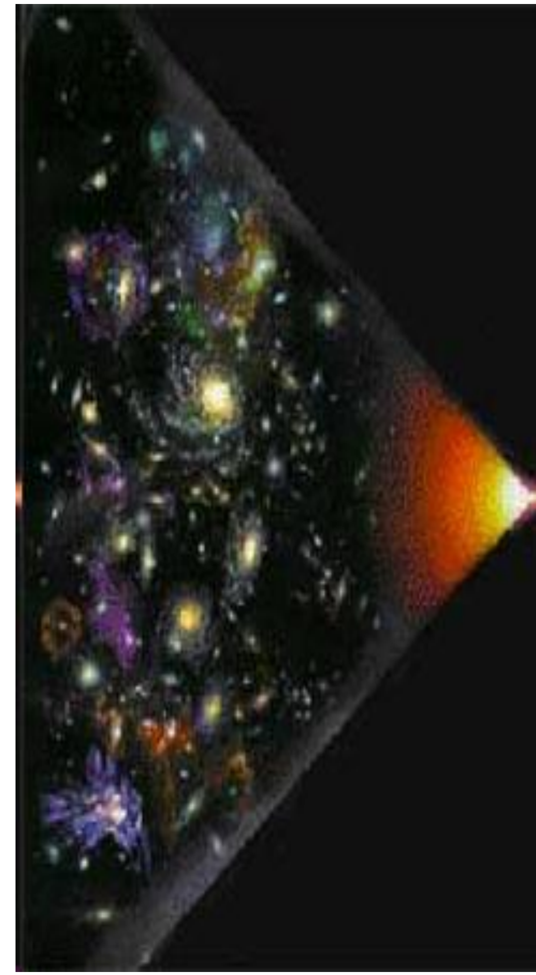
Albert Einstein

Alexander Friedmann



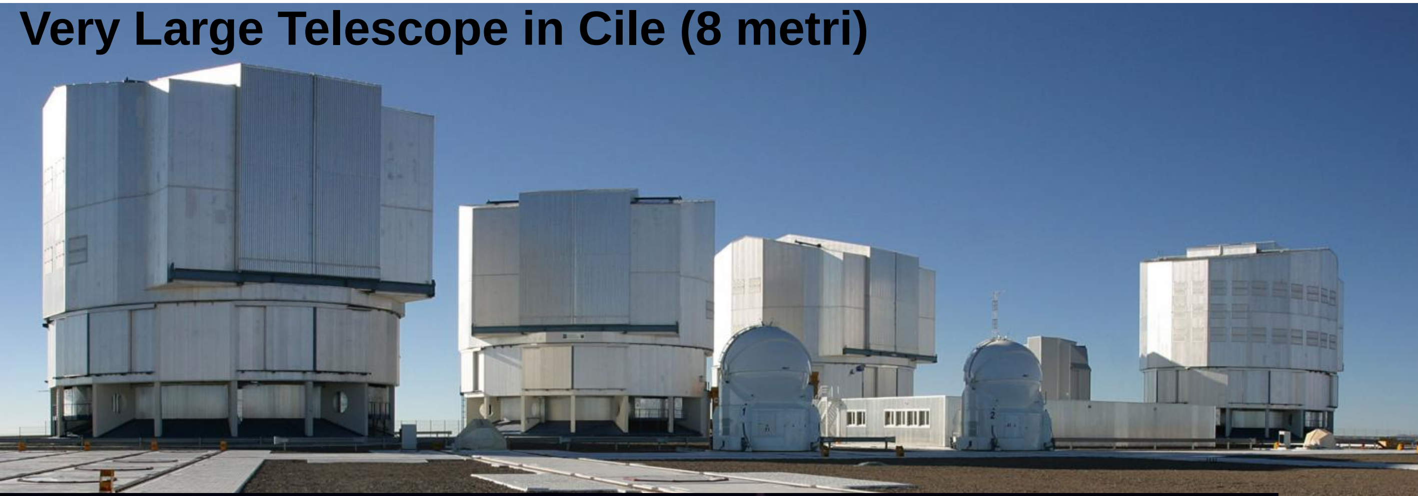


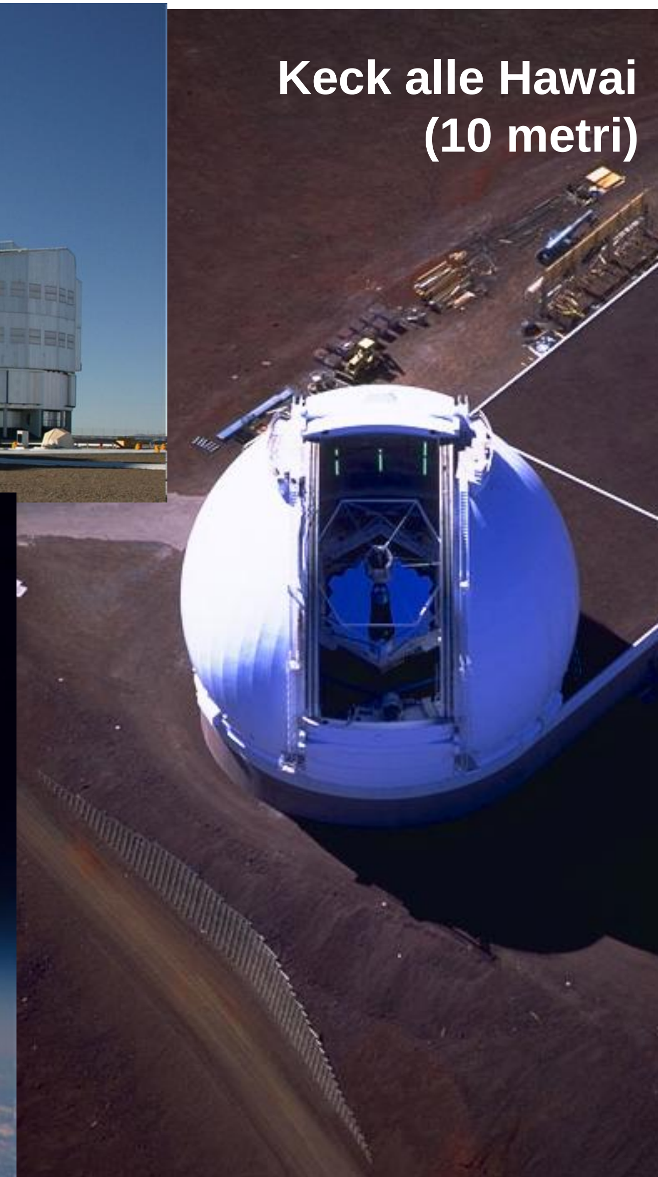



Il Big Bang e’ avvenuto circa 13,6 miliardi di anni fà

# osservare le galassie oggi



**Very Large Telescope in Cile (8 metri)**

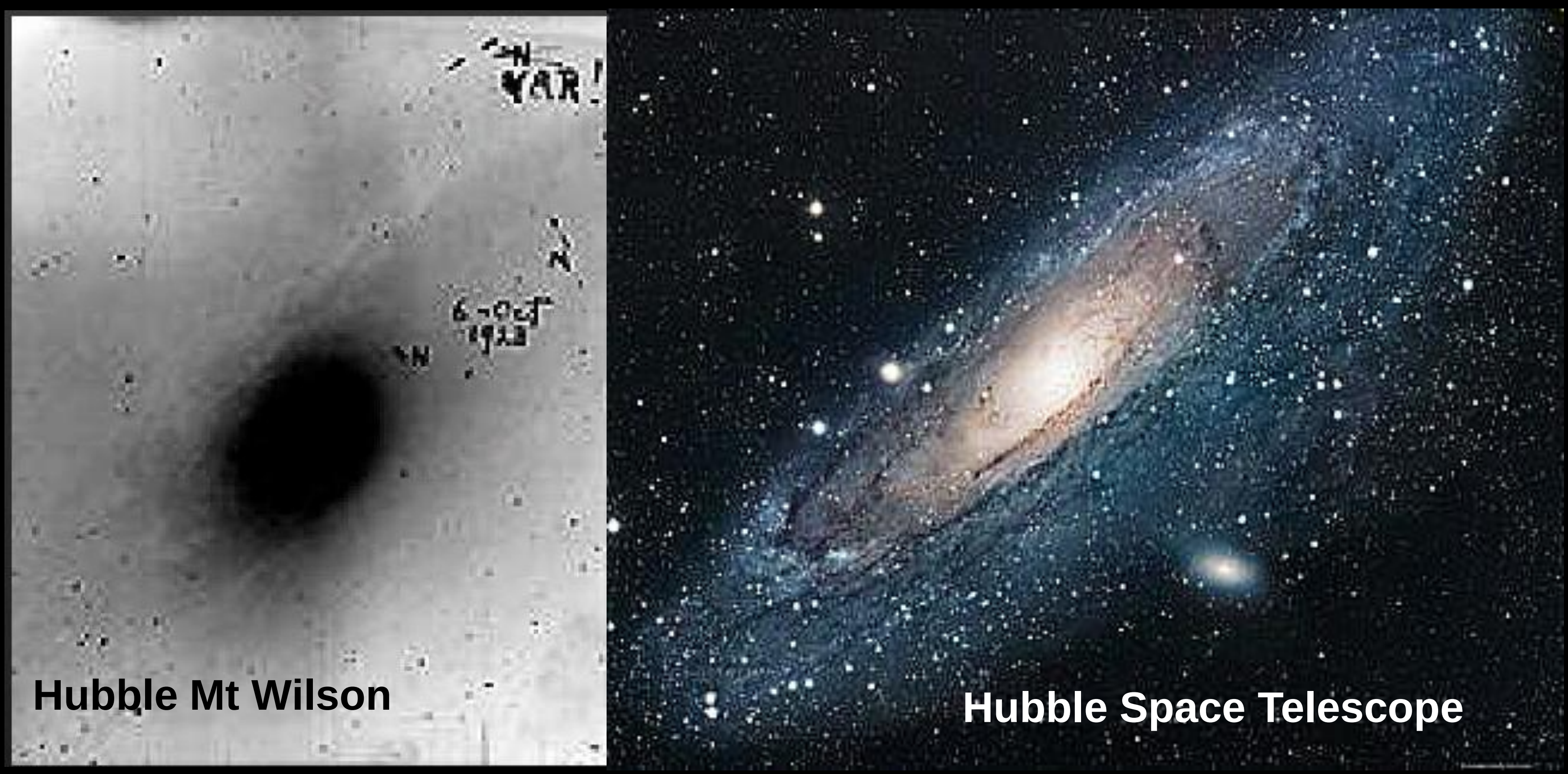


**Keck alle Hawai (10 metri)**

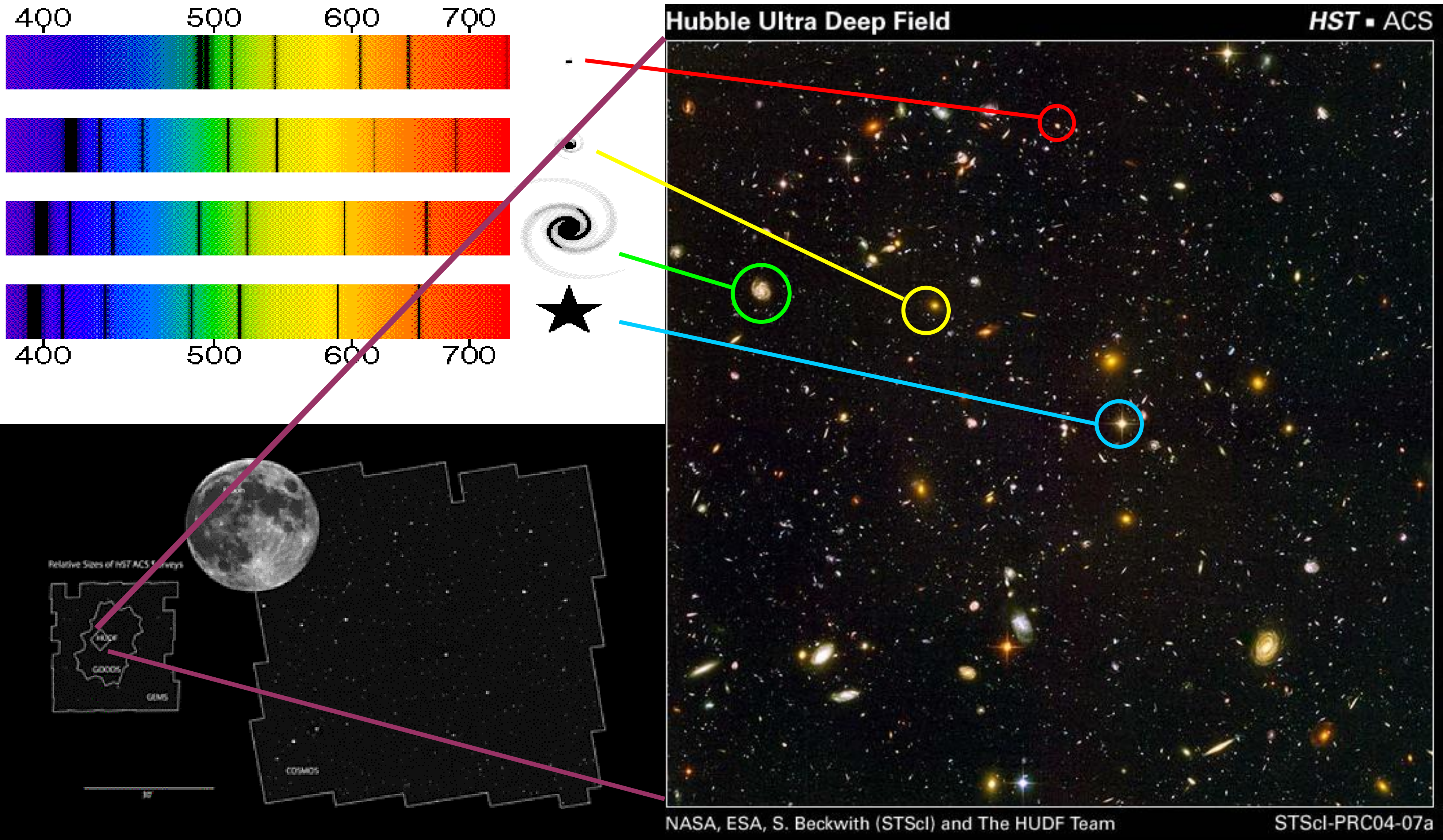
**Hubble Space Telescope nello spazio (2,5 metri)**

# osservare le galassie oggi

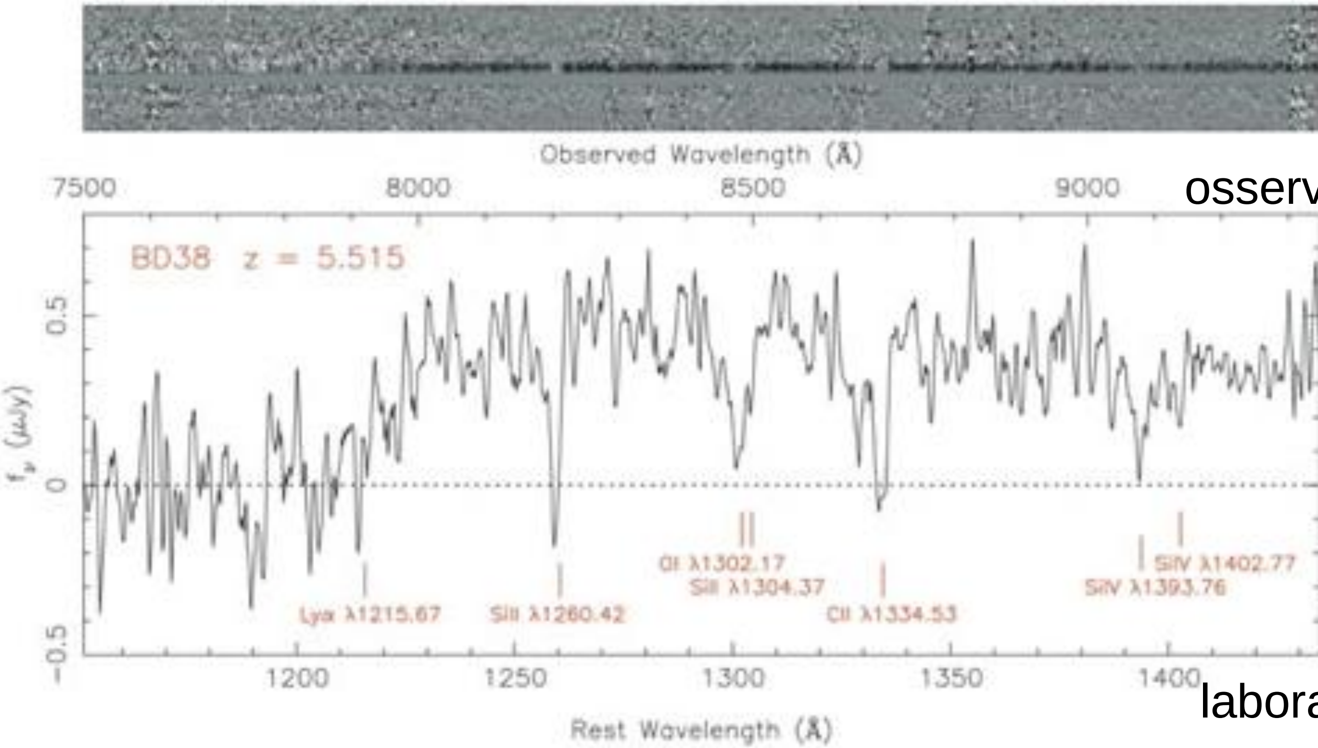
galassia di Andromeda (M31)



# le galassie lontane



# lo spettro di una galassia lontana




$$z = \frac{\lambda_{obs} - \lambda_{lab}}{\lambda_{lab}} = \frac{7900 - 1215}{1215} = 5{,}5 \longrightarrow$$ 12,6 miliardi di anni luce

**la luce di questa galassia ci ha messo 12,6 miliardi di anni a raggiungerci e' partita quando l'Universo aveva solo 1 miliardo di anni !**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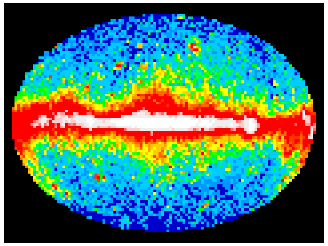
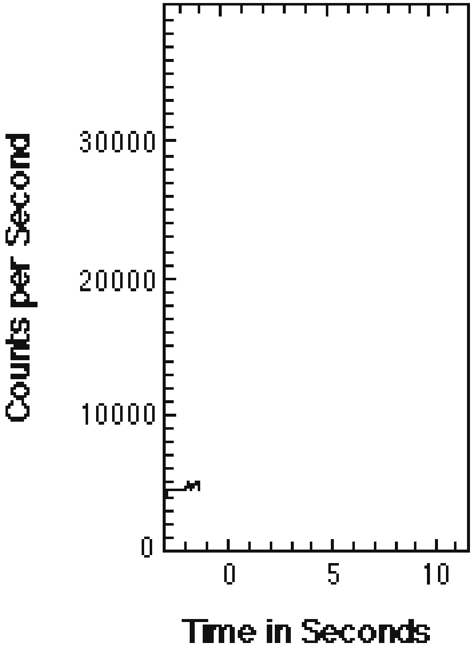
Quale e’ l’oggetto piu’ distante dell’Universo?
A la Luna
B un pianeta
C una galassia
una stella

# i Gamma-ray Burst (GRB)

sono forti lampi visti nei raggi gamma della durata di pochi secondi

avvengono con una frequenza di ~1/2 al giorno





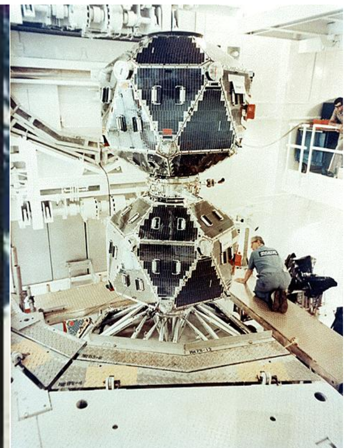

In pochi secondi emettono luce come

il Sole per 3000 miliardi di anni

tutta la nostra Galassia per 100 anni

# come sono stati scoperti?

Negli anni ’60 vengono lanciati i satelliti Vela per verificare il trattato di non prolificazione nucleare

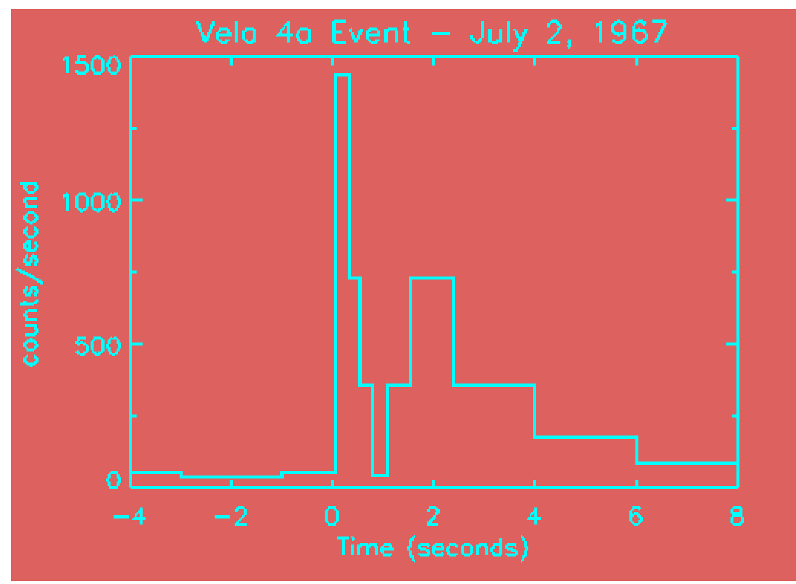


The Astrophysical Journal, 182:L85–L88, 1973 June 1


OBSERVATIONS OF GAMMA-RAY BURSTS OF COSMIC ORIGIN

Ray W. Klebesadel, Ian B. Strong, and Roy A. Olson

University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico
*Received 1973 March 16; revised 1973 April 2*



# cosa sono?

A due anni dalla pubblicazione della scoperta erano gia' state elaborate decine di teorie differenti per spiegare i GRB tanto che…

"For theorists who may wish to enter this broad and growing field, I should point out that there are a considerable number of combinations, for example, comets of antimatter falling onto white holes, not yet claimed."

—M. Ruderman[1]

# cosa sono?

| Model # | Author | Year Pub | Reference | Main Body | 2nd Body | Place | Description |
|---|---|---|---|---|---|---|---|
| 1. | Colgate | 1968 | CJPhys, 46, S476 | ST | | COS | SN shocks stellar surface in distant galaxy |
| 2. | Colgate | 1974 | ApJ, 187, 333 | ST | | COS | Type II SN shock brem, inv Comp scat at stellar surface |
| 3. | Stecker et al. | 1973 | Nature, 245, PS70 | ST | | DISK | Stellar superflare from nearby star |
| 4. | Stecker et al. | 1973 | Nature, 245, PS70 | WD | | DISK | Superflare from nearby WD |
| 5. | Harwit et al. | 1973 | ApJ, 186, L37 | NS | COM | DISK | Relic comet perturbed to collide with old galactic NS |
| 6. | Lamb et al. | 1973 | Nature, 246, PS52 | WD | ST | DISK | Accretion onto WD from flare in companion |
| 7. | Lamb et al. | 1973 | Nature, 246, PS52 | NS | ST | DISK | Accretion onto NS from flare in companion |
| 8. | Lamb et al. | 1973 | Nature, 246, PS52 | BH | ST | DISK | Accretion onto BH from flare in companion |
| 9. | Zwicky | 1974 | Ap&SS, 28, 111 | NS | | HALO | NS chunk contained by external pressure escapes, explodes |
| 10. | Grindlay et al. | 1974 | ApJ, 187, L93 | DG | | SOL | Relativistic iron dust grain up-scatters solar radiation |
| 11. | Brecher et al. | 1974 | ApJ, 187, L97 | ST | | DISK | Directed stellar flares on nearby stars |
| 12. | Shklovskii | 1974 | SovAstron, 18, 390 | WD | COM | DISK | Comet from system's cloud strikes WD |
| 13. | Shklovskii | 1974 | SovAstron, 18, 390 | NS | COM | DISK | Comet from system's cloud strikes NS |
| 14. | Bisnovatyi- et al. | 1975 | Ap&SS, 35, 23 | ST | | COS | Absorption of neutrino emission from SN in stellar envelope |
| 15. | Bisnovatyi- et al. | 1975 | Ap&SS, 35, 23 | ST | SN | COS | Thermal emission when small star heated by SN shock wave |
| 16. | Bisnovatyi- et al. | 1975 | Ap&SS, 35, 23 | NS | | COS | Ejected matter from NS explodes |
| 17. | Pacini et al. | 1974 | Nature, 251, 399 | NS | | DISK | NS crustal starquake glitch; should time coincide with GRB |
| 18. | Narlikar et al. | 1974 | Nature, 251, 590 | WH | | COS | White hole emits spectrum that softens with time |
| 19. | Tsygan | 1975 | A&A, 44, 21 | NS | | HALO | NS corequake excites vibrations, changing E & B fields |
| 20. | Chanmugam | 1974 | ApJ, 193, L75 | WD | | DISK | Convection inside WD with high B field produces flare |
| 21. | Prilutski et al. | 1975 | Ap&SS, 34, 395 | AGN | ST | COS | Collapse of supermassive body in nucleus of active galaxy |
| 22. | Narlikar et al. | 1975 | Ap&SS, 35, 321 | WH | | COS | WH excites synchrotron emission, inverse Compton scattering |
| 23. | Piran et al. | 1975 | Nature, 256, 112 | BH | | DISK | Inv Comp scat deep in ergosphere of fast rotating, accreting BH |
| 24. | Fabian et al. | 1976 | Ap&SS, 42, 77 | NS | | DISK | NS crustquake shocks NS surface |
| 25. | Chanmugan | 1976 | Ap&SS, 42, 83 | WD | | DISK | Magnetic WD suffers MHD instabilities, flares |
| 26. | Mullan | 1976 | ApJ, 208, 199 | WD | | DISK | Thermal radiation from flare near magnetic WD |
| 27. | Woosley et al. | 1976 | Nature, 263, 101 | NS | | DISK | Carbon detonation from accreted matter onto NS |
| 28. | Lamb et al. | 1977 | ApJ, 217, 197 | NS | | DISK | Mag gating of accret disk around NS causes sudden accretion |
| 29. | Piran et al. | 1977 | ApJ, 214, 268 | BH | | DISK | Instability in accretion onto rapidly rotating BH |
| 30. | Dasgupta | 1979 | Ap&SS, 63, 517 | DG | | SOL | Charged intergal rel dust grain enters sol sys, breaks up |
| 31. | Tsygan | 1980 | A&A, 87, 224 | WD | | DISK | WD surface nuclear burst causes chromospheric flares |

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| 29. | Piran et al. | 1977 | ApJ, 214, 268 | BH | | DISK | Instability in accretion onto rapidly rotating BH |
| 30. | Dasgupta | 1979 | Ap&SS, 63, 517 | DG | | SOL | Charged intergal rel dust grain enters sol sys, breaks up |
| 31. | Tsygan | 1980 | A&A, 87, 224 | WD | | DISK | WD surface nuclear burst causes chromospheric flares |

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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 32. | Tsygan | 1980 | A&A, 87, 224 | NS | | DISK | NS surface nuclear burst causes chromospheric flares |
| 33. | Ramaty et al. | 1981 | Ap&SS, 75, 193 | NS | | DISK | NS vibrations heat atm to pair produce, annihilate, synch cool |
| 34. | Newman et al. | 1980 | ApJ, 242, 319 | NS | AST | DISK | Asteroid from interstellar medium hits NS |
| 35. | Ramaty et al. | 1980 | Nature, 287, 122 | NS | | HALO | NS core quake caused by phase transition, vibrations |
| 36. | Howard et al. | 1981 | ApJ, 249, 302 | NS | AST | DISK | Asteroid hits NS, B-field confines mass, creates high temp |
| 37. | Mitrofanov et al. | 1981 | Ap&SS, 77, 469 | NS | | DISK | Helium flash cooled by MHD waves in NS outer layers |
| 38. | Colgate et al. | 1981 | ApJ, 248, 771 | NS | AST | DISK | Asteroid hits NS, tidally disrupts, heated, expelled along B lines |
| 39. | van Buren | 1981 | ApJ, 249, 297 | NS | AST | DISK | Asteroid enters NS B field, dragged to surface collision |
| 40. | Kuznetsov | 1982 | CosRes, 20, 72 | MG | | SOL | Magnetic reconnection at heliopause |
| 41. | Katz | 1982 | ApJ, 260, 371 | NS | | DISK | NS flares from pair plasma confined in NS magnetosphere |
| 42. | Woosley et al. | 1982 | ApJ, 258, 716 | NS | | DISK | Magnetic reconnection after NS surface He flash |
| 43. | Fryxell et al. | 1982 | ApJ, 258, 733 | NS | | DISK | He fusion runaway on NS B-pole helium lake |
| 44. | Hameury et al. | 1982 | A&A, 111, 242 | NS | | DISK | e- capture triggers H flash triggers He flash on NS surface |
| 45. | Mitrofanov et al. | 1982 | MNRAS, 200, 1033 | NS | | DISK | B induced cyclo res in rad absorp giving rel e-s, inv C scat |
| 46. | Fenimore et al. | 1982 | Nature, 297, 665 | NS | | DISK | BB X-rays inv Comp scat by hotter overlying plasma |
| 47. | Lipunov et al. | 1982 | Ap&SS, 85, 459 | NS | ISM | DISK | ISM matter accum at NS magnetopause then suddenly accretes |
| 48. | Baan | 1982 | ApJ, 261, L71 | WD | | HALO | Nonexplosive collapse of WD into rotating, cooling NS |
| 49. | Ventura et al. | 1983 | Nature, 301, 491 | NS | ST | DISK | NS accretion from low mass binary companion |
| 50. | Bisnovatyi- et al. | 1983 | Ap&SS, 89, 447 | NS | | DISK | Neutron rich elements to NS surface with quake, undergo fission |
| 51. | Bisnovatyi- et al. | 1984 | SovAstron, 28, 62 | NS | | DISK | Thermonuclear explosion beneath NS surface |
| 52. | Ellison et al. | 1983 | A&A, 128, 102 | NS | | HALO | NS corequake + uneven heating yield SGR pulsations |
| 53. | Hameury et al. | 1983 | A&A, 128, 369 | NS | | DISK | B field contains matter on NS cap allowing fusion |
| 54. | Bonazzola et al. | 1984 | A&A, 136, 89 | NS | | DISK | NS surface nuc explosion causes small scale B reconnection |
| 55. | Michel | 1985 | ApJ, 290, 721 | NS | | DISK | Remnant disk ionization instability causes sudden accretion |
| 56. | Liang | 1984 | ApJ, 283, L21 | NS | | DISK | Resonant EM absorp during magnetic flare gives hot synch e-s |
| 57. | Liang et al. | 1984 | Nature, 310, 121 | NS | | DISK | NS magnetic fields get twisted, recombine, create flare |
| 58. | Mitrofanov | 1984 | Ap&SS, 105, 245 | NS | | DISK | NS magnetosphere excited by starquake |
| 59. | Epstein | 1985 | ApJ, 291, 822 | NS | | DISK | Accretion instability between NS and disk |
| 60. | Shklovskii et al. | 1985 | MNRAS, 212, 545 | NS | | HALO | Old NS in Galactic halo undergoes starquake |
| 61. | Tsygan | 1984 | Ap&SS, 106, 199 | NS | | DISK | Weak B field NS spherically accretes, Comptonizes X-rays |
| 62. | Usov | 1984 | Ap&SS, 107, 191 | NS | | DISK | NS flares result of magnetic convective-oscillation instability |
| 63. | Hameury et al. | 1985 | ApJ, 293, 56 | NS | | DISK | High Landau e-s beamed along B lines in cold atm. of NS |
| 64. | Rappaport et al. | 1985 | Nature, 314, 242 | NS | | DISK | NS + low mass stellar companion gives GRB + optical flash |
| 65. | Tremaine et al. | 1986 | ApJ, 301, 155 | NS | COM | DISK | NS tides disrupt comet, debris hits NS next pass |
| 66. | Muslimov et al. | 1986 | Ap&SS, 120, 27 | NS | | HALO | Radially oscillating NS |
| 67. | Sturrock | 1986 | Nature, 321, 47 | NS | | DISK | Flare in the magnetosphere of NS accelerates e-s along B-field |
| 68. | Paczynski | 1986 | ApJ, 308, L43 | NS | | COS | Cosmo GRBs: rel e+/- opt thk plasma outflow indicated |
| 69. | Bisnovatyi- et al. | 1986 | SovAstron, 30, 582 | NS | | DISK | Chain fission of superheavy nuclei below NS surface during SN |
| 70. | Alcock et al. | 1986 | PRL, 57, 2088 | SS | SS | DISK | SN ejects strange mat lump craters rotating SS companion |
| 71. | Vahai et al. | 1988 | A&A, 207, 55 | ST | | DISK | Magnetically active stellar system gives stellar flare |

# cosa sono?

TABLE 1 (Continued)

| Model # | Author | Year Pub | Reference | Main Body | 2nd Body | Place | Description |
|---|---|---|---|---|---|---|---|
| 72. | Babul et al. | 1987 | ApJ, 316, L49 | CS | | COS | GRB result of energy released from cusp of cosmic string |
| 73. | Livio et al. | 1987 | Nature, 327, 398 | NS | COM | DISK | Oort cloud around NS can explain soft gamma-repeaters |
| 74. | McBreen et al. | 1988 | Nature, 332, 234 | GAL | AGN | COS | G-wave bkgrd makes BL Lac wiggle across galaxy lens caustic |
| 75. | Curtis | 1988 | ApJ, 327, L81 | WD | | COS | WD collapses, burns to form new class of stable particles |
| 76. | Melia | 1988 | ApJ, 335, 965 | NS | | DISK | Be/X-ray binary sys evolves to NS accretion with recurrence |
| 77. | Ruderman et al. | 1988 | ApJ, 335, 306 | NS | | DISK | e+/- cascades by aligned pulsar outer-mag-sphere reignition |
| 78. | Paczynski | 1988 | ApJ, 335, 525 | CS | | COS | Energy released from cusp of cosmic string (revised) |
| 79. | Murikami et al. | 1988 | Nature, 335, 234 | NS | | DISK | Absorption features suggest separate colder region near NS |
| 80. | Melia | 1988 | Nature, 336, 658 | NS | | DISK | NS + accretion disk reflection explains GRB spectra |
| 81. | Blaes et al. | 1989 | ApJ, 343, 839 | NS | | DISK | NS seismic waves couple to magnetospheric Alfen waves |
| 82. | Trofimenko et al. | 1989 | Ap&SS, 152, 105 | WH | | COS | Kerr-Newman white holes |
| 83. | Sturrock et al. | 1989 | ApJ, 346, 950 | NS | | DISK | NS E- field accelerates electrons which then pair cascade |
| 84. | Fenimore et al. | 1988 | ApJ, 335, L71 | NS | | DISK | Narrow absorption features indicate small cold area on NS |
| 85. | Rodrigues | 1989 | AJ, 98, 2280 | WD | WD | DISK | Binary member loses part of crust, through L1, hits primary |
| 86. | Pineault et al. | 1989 | ApJ, 347, 1141 | NS | COM | DISK | Fast NS though Oort clouds, fast WD bursts only optical |
| 87. | Melia et al. | 1989 | ApJ, 346, 378 | NS | | DISK | Episodic electrostatic accel and Comp scat from rot high-B NSs |
| 88. | Trofimenko | 1989 | Ap&SS, 159, 301 | WH | | COS | Different types of white, "grey" holes can emit GRB |
| 89. | Eichler et al. | 1989 | Nature, 340, 126 | NS | NS | COS | NS - NS binary members collide, coalesce |
| 90. | Wang et al. | 1989 | PRL, 63, 1550 | NS | | DISK | Cyclo res & Raman scat fits 20, 40 keV dips, magnetized NS |
| 91. | Alexander et al. | 1989 | ApJ, 344, L1 | NS | | DISK | QED mag resonant opacity in NS atmosphere |
| 92. | Melia | 1990 | ApJ, 351, 601 | NS | | DISK | NS magnetospheric plasma oscillations |
| 93. | Ho et al. | 1990 | ApJ, 348, L25 | NS | | DISK | Beaming of radiation necessary from magnetized neutron stars |
| 94. | Mitrofanov et al. | 1990 | Ap&SS, 165, 137 | NS | COM | DISK | Interstellar comets pass through dead pulsar's magnetosphere |
| 95. | Dermer | 1990 | ApJ, 360, 197 | NS | | DISK | Compton scattering in strong NS magnetic field |
| 96. | Blaes et al. | 1990 | ApJ, 363, 612 | NS | ISM | DISK | Old NS accretes from ISM, surface goes nuclear |
| 97. | Paczynski | 1990 | ApJ, 363, 218 | NS | NS | COS | NS-NS collision causes ν collisions to drive super-Ed wind |
| 98. | Zdziarski et al. | 1991 | ApJ, 366, 343 | RE | MBR | COS | Scattering of microwave background photons by rel e-s |
| 99. | Pineault | 1990 | Nature, 345, 233 | NS | COM | DISK | Young NS drifts through its own Oort cloud |
| 100. | Trofimenko et al. | 1991 | Ap&SS, 178, 217 | WH | | HALO | White hole supernova gave simul burst of g-waves from 1987A |
| 101. | Melia et al. | 1991 | ApJ, 373, 198 | NS | | DISK | NS B- field undergoes resistive tearing, accelerates plasma |
| 102. | Holcomb et al. | 1991 | ApJ, 378, 682 | NS | | DISK | Alfen waves in non-uniform NS atmosphere accelerate particles |
| 103. | Haensel et al. | 1991 | ApJ, 375, 209 | SS | SS | COS | Strange stars emit binding energy in grav. rad. and collide |
| 104. | Blaes et al. | 1991 | ApJ, 381, 210 | NS | ISM | DISK | Slow interstellar accretion onto NS, e- capture starquakes result |

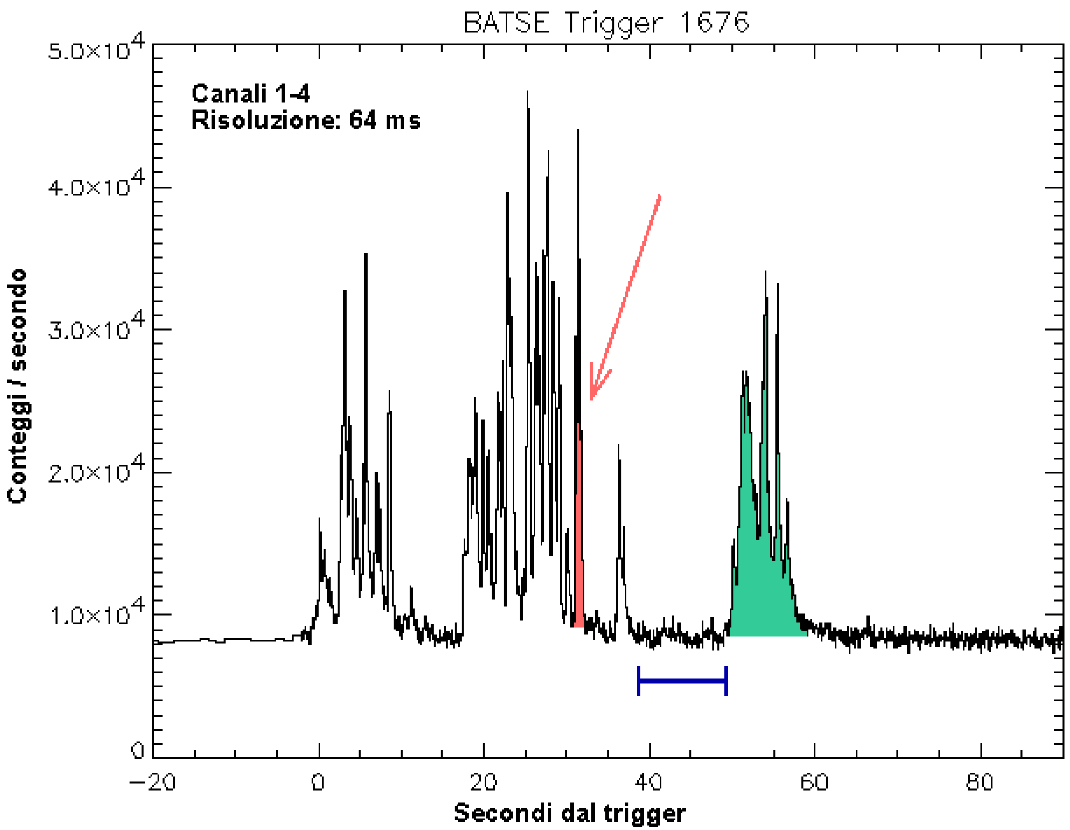
# cosa sono?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 105. | Frank et al. | 1992 | ApJ, 385, L45 | NS | | DISK | Low mass X-ray binary evolves into GRB sites |
| 106. | Woosley et al. | 1992 | ApJ, 391, 228 | NS | | HALO | Accreting WD collapses to NS |
| 107. | Dar et al. | 1992 | ApJ, 388, 164 | WD | | COS | WD accretes to form naked NS, GRBs, cosmic rays |
| 108. | Hanami | 1992 | ApJ, 389, L71 | NS | PLAN | COS | NS - planet magnetospheric interaction unstable |
| 109. | Meszaros et al. | 1992 | ApJ, 397, 570 | NS | NS | COS | NS - NS collision produces anisotropic fireball |
| 110. | Carter | 1992 | ApJ, 391, L67 | BH | ST | COS | Normal stars tidally disrupted by galactic nucleus BH |
| 111. | Usov | 1992 | Nature, 357, 472 | NS | | COS | WD collapses to form NS, B-field brakes NS rotation instantly |
| 112. | Narayan et al. | 1992 | ApJ, 395, L83 | NS | NS | COS | NS - NS merger gives optically thick fireball |
| 113. | Narayan et al. | 1992, | ApJ, 395, L83 | BH | NS | COS | BH-NS merger gives optically thick fireball |
| 114. | Brainerd | 1992 | ApJ, 394, L33 | AGN | JET | COS | Synchrotron emission from AGN jets |
| 115. | Meszaros et al. | 1992 | MNRAS, 257, 29P | BH | NS | COS | BH-NS have νs collide to γs in clean fireball |
| 116. | Meszaros et al. | 1992 | MNRAS, 257, 29P | NS | NS | COS | NS-NS have νs collide to γs in clean fireball |
| 117. | Cline et al. | 1992 | ApJ, 401, L57 | BH | | DISK | Primordial BHs evaporating could account for short hard GRBs |
| 118. | Rees et al. | 1992 | MNRAS, 258, 41P | NS | ISM | COS | Relativistic fireball reconverted to radiation when hits ISM |

… piu' teorie che eventi!

# cosa sono?

Primo indizio : variabilita' su tempi molto brevi ~0.001 secondi



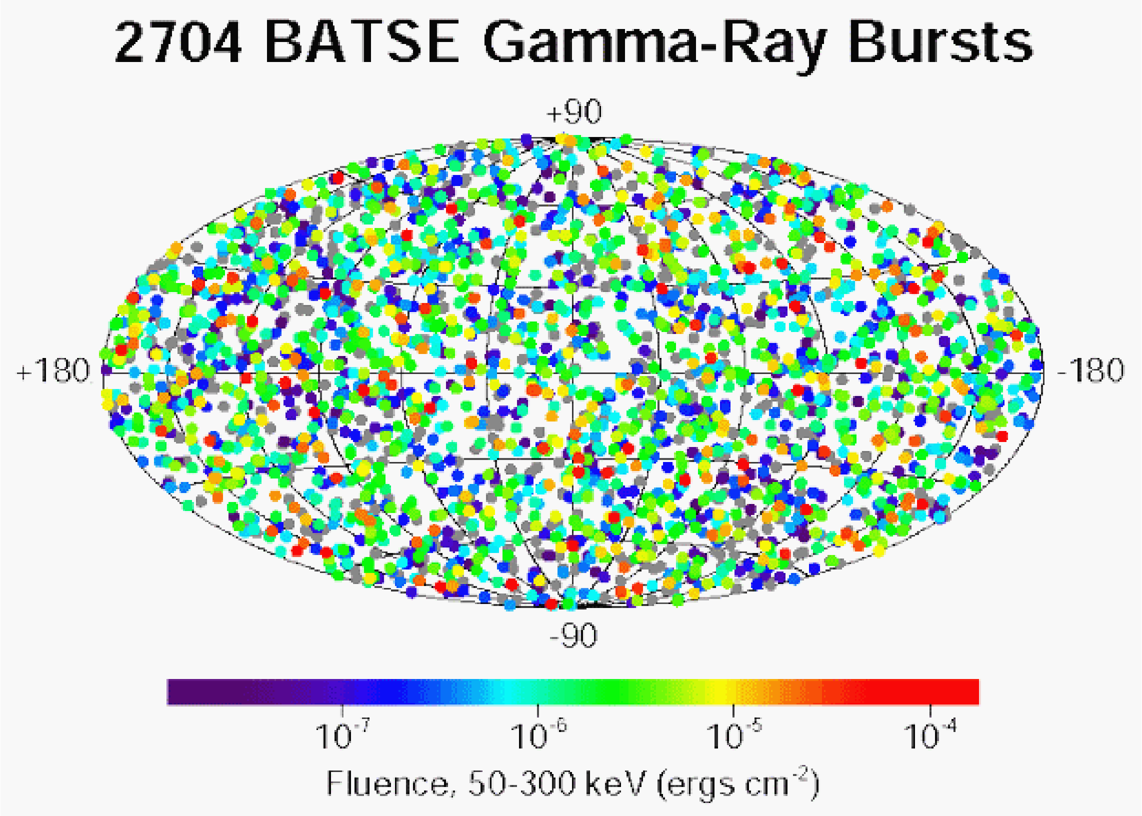

$$L < c \times \delta t$$

Una variazione della luminosita' e' il risultato di una modifica nella sorgente che deve avvenire a velocita' minore della velocita' della luce

$$L < c \times \delta t = 3 \cdot 10^8 \,\mathrm{m/s} \times 10^{-3}\,\mathrm{s} = 300\ \mathrm{km}$$

# cosa sono?

Secondo indizio

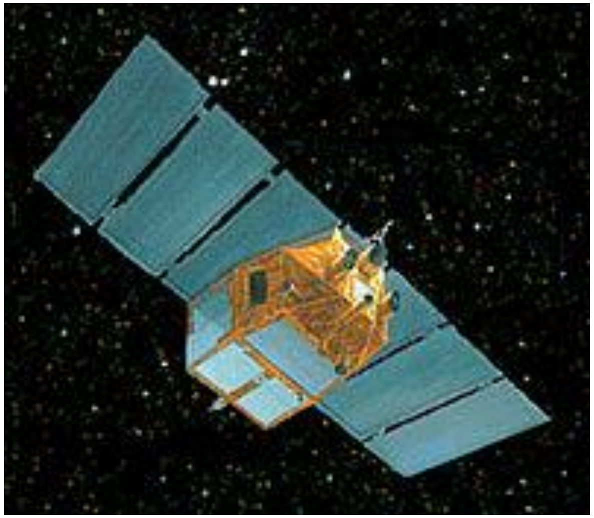



BATSE su CGRO

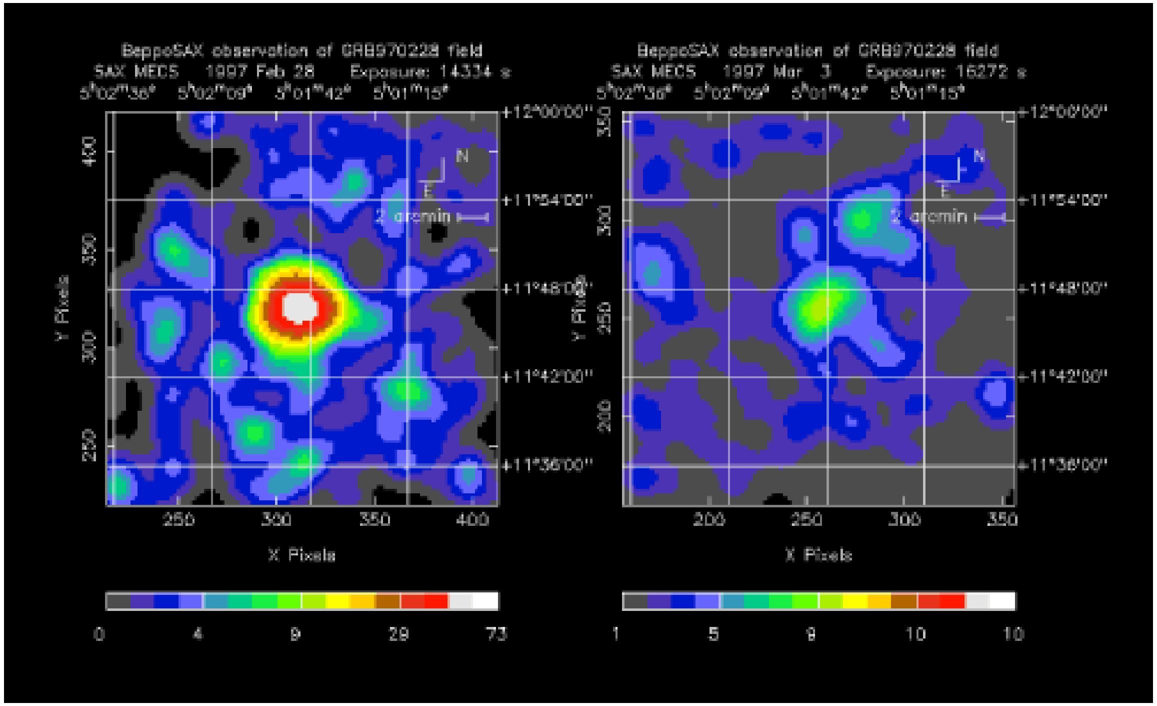
Sono distribuiti isotropicamente quindi extragalattici

# BeppoSAX: l’afterglow

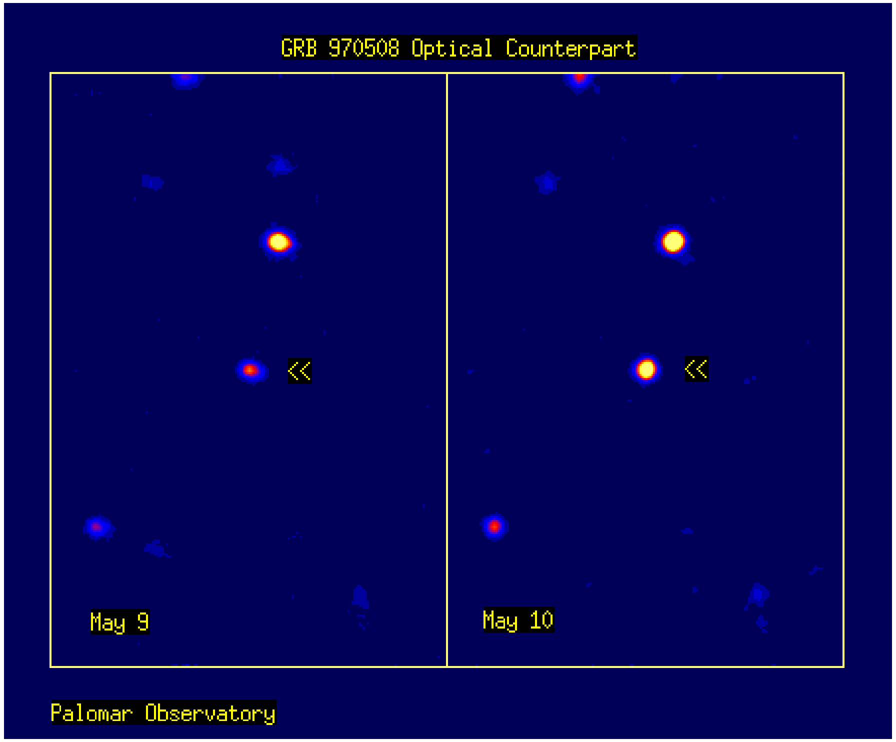
La svolta la si ha con la ricerca delle controparti a altre lunghezze d’onda e in particolare nei raggi X (in gamma poca risoluzione spaziale, in ottico/radio troppe sorgenti)

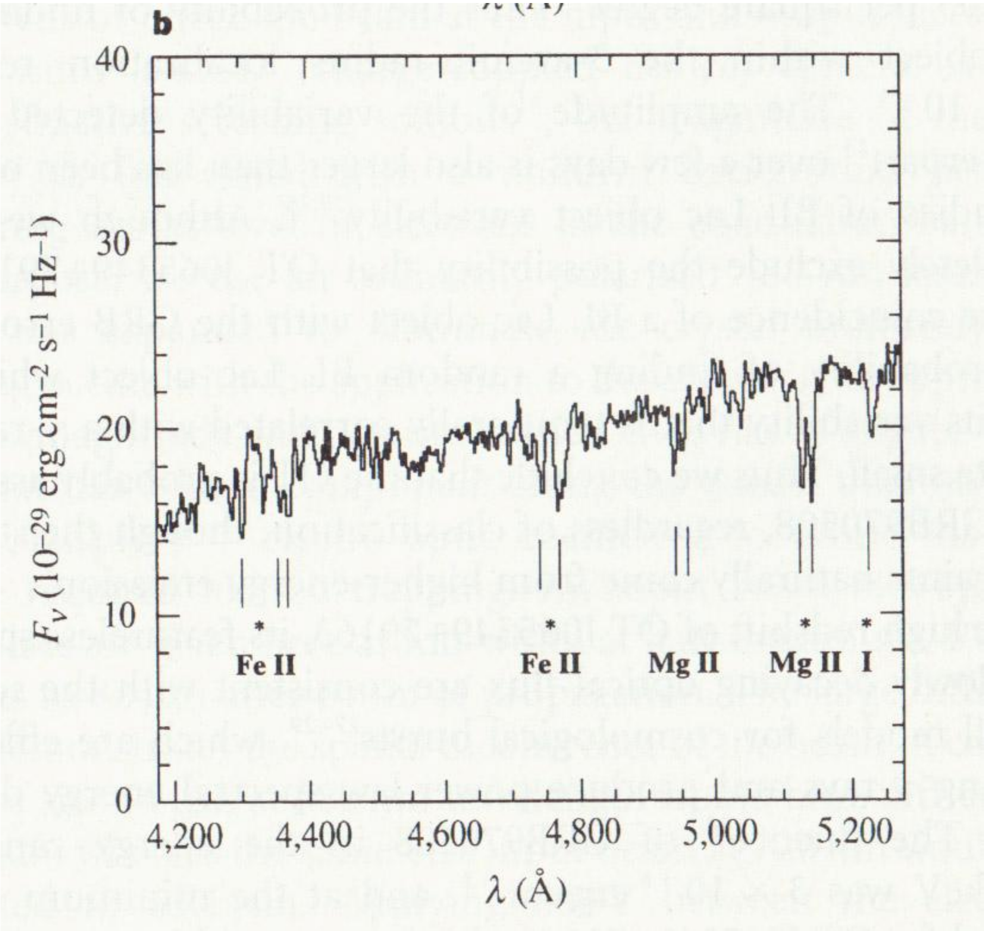


BeppoSAX (Italia-Olanda)



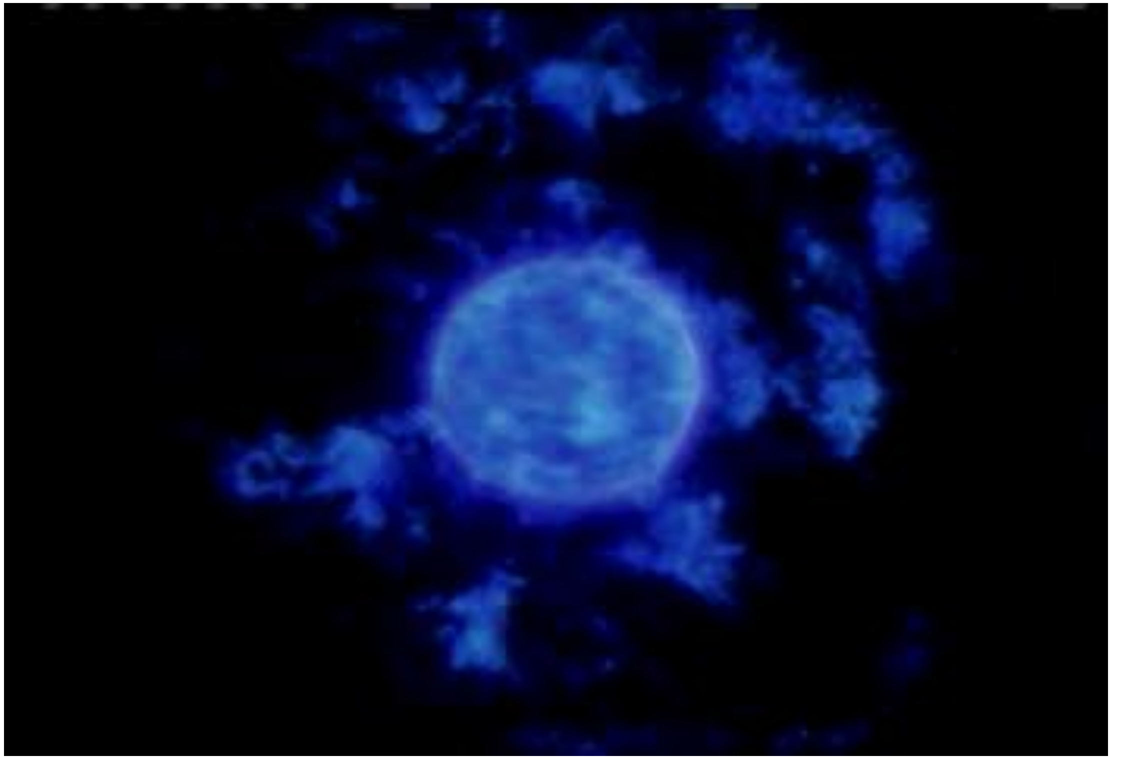
# e la prima misura della distanza



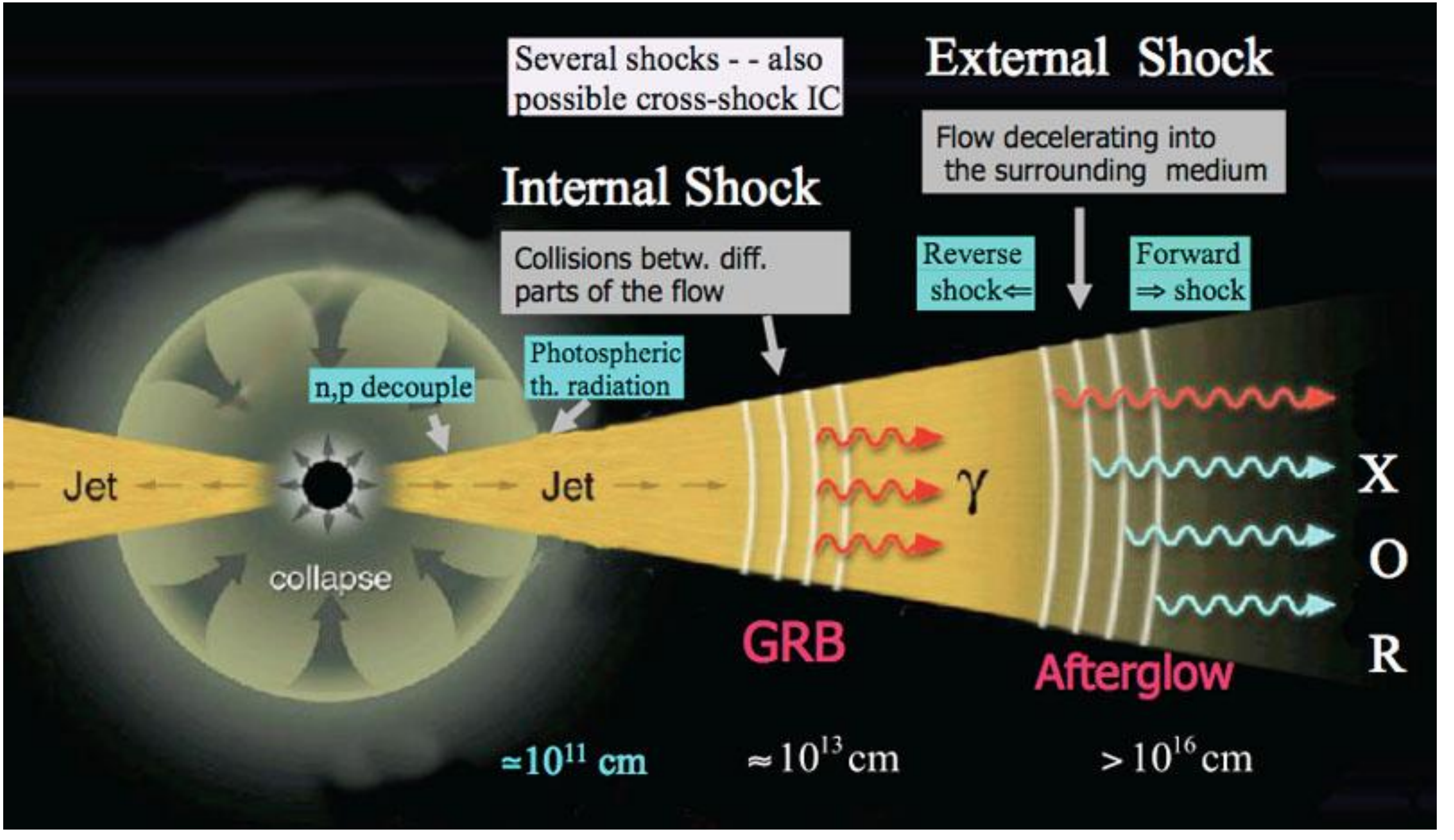

sono ben al di fuori della nostra Galassia!

# cosa sono?



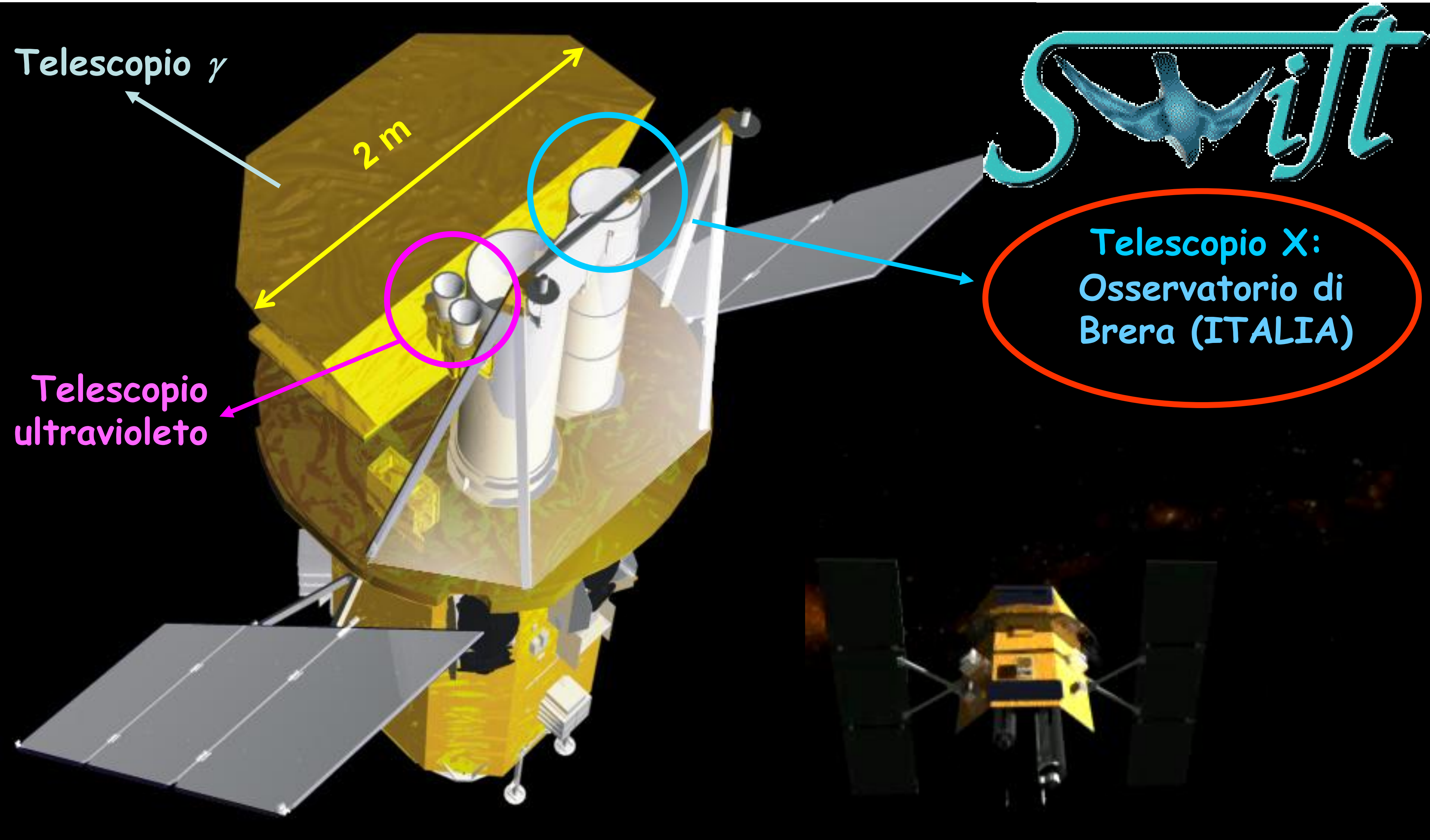
la morte di una stella 20-30 volte piu’ grande del Sole

# cosa sono?

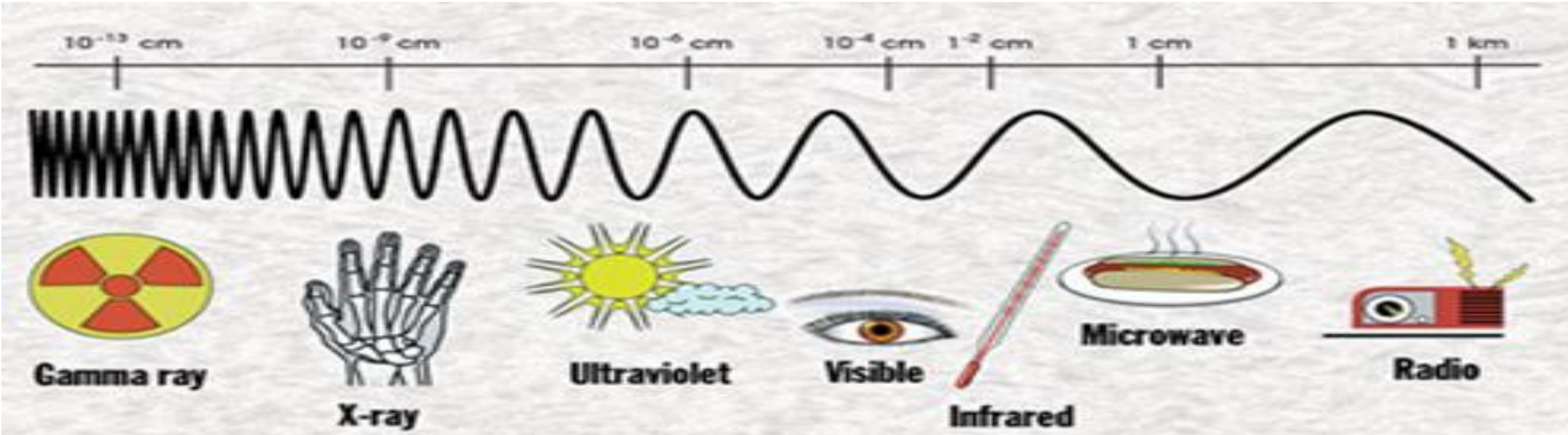


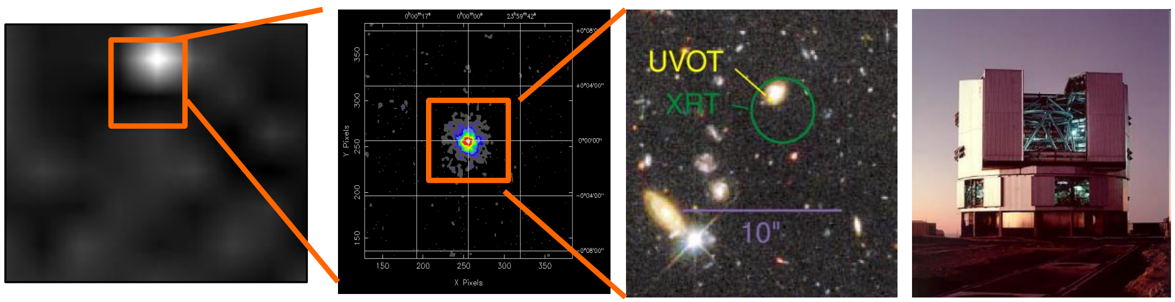
Several shocks - - also possible cross-shock IC
External Shock
Flow decelerating into the surrounding medium
Internal Shock
Collisions betw. diff. parts of the flow
Reverse shock⇐
Forward ⇒ shock
Photospheric th. radiation
n,p decouple
Jet
Jet
γ
X
O
R
collapse
GRB
Afterglow
≃10^11 cm
≈10^13 cm
>10^16 cm

# come li osserviamo ora?



# i GRB: bisogna essere rapidi!




scoperta

posizione

posizione precisa

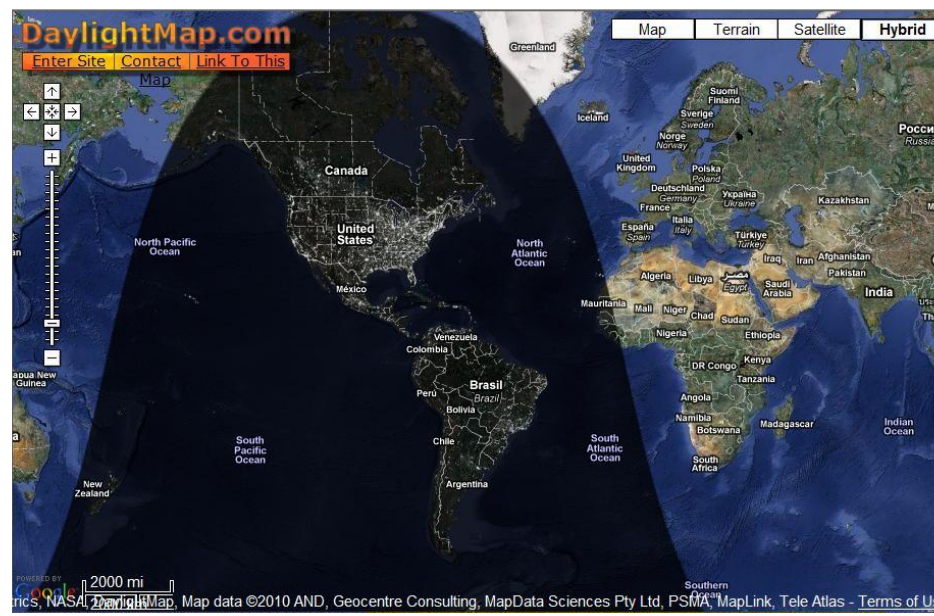
spettro distanza

**mentre emissione gamma dura pochi secondi quella nei raggi X e nell'ottico dura anche alcuni giorni ma per misurare la distanza occorre osservare prima possibile quando la luminosita' e' ancora molto alta**

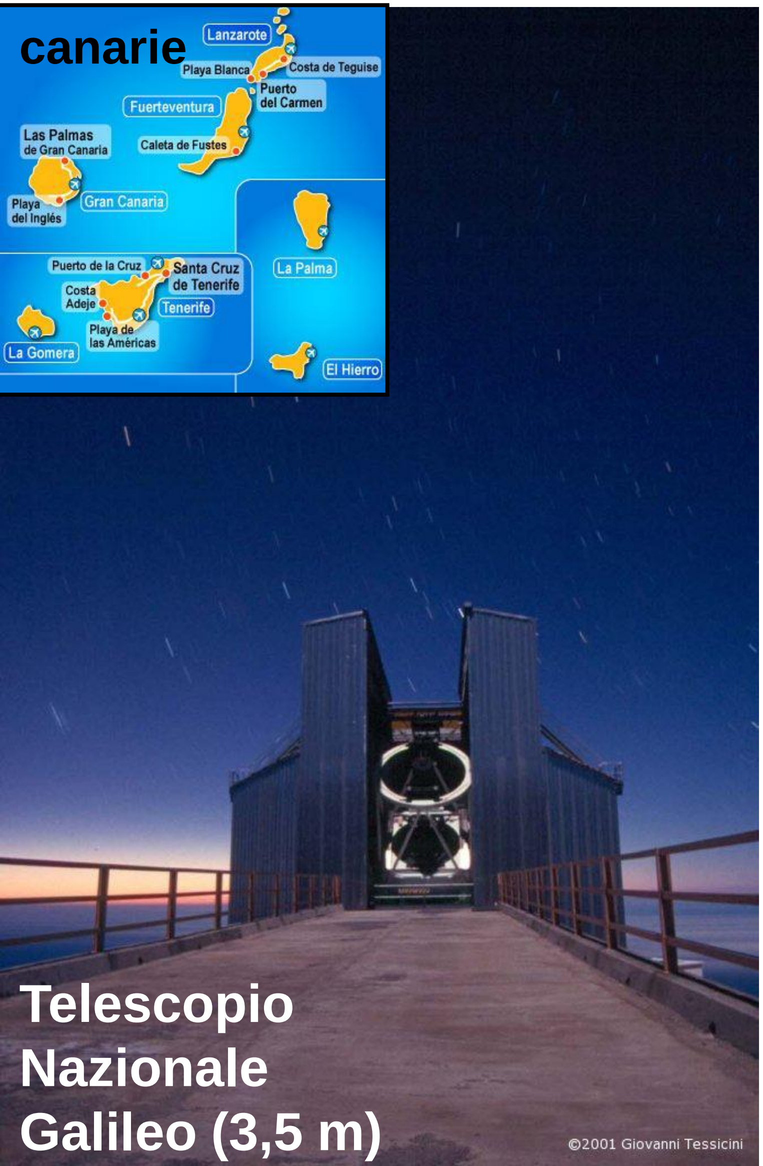
# il GRB del 23 aprile 2009

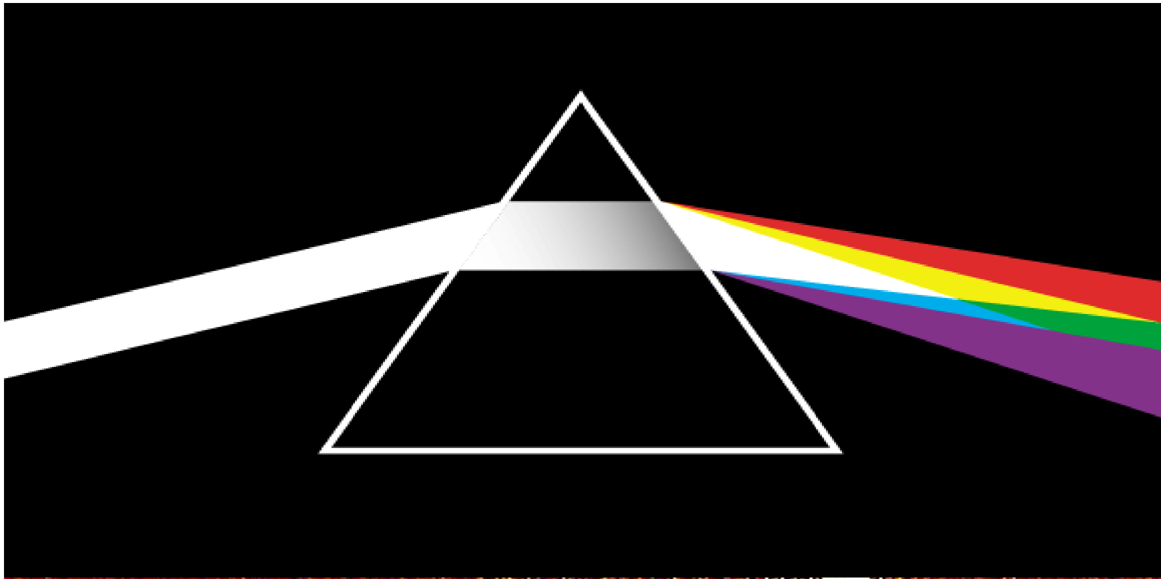
07:55:19 a.m. (ora di Greenwich)
del 23 aprile 2009

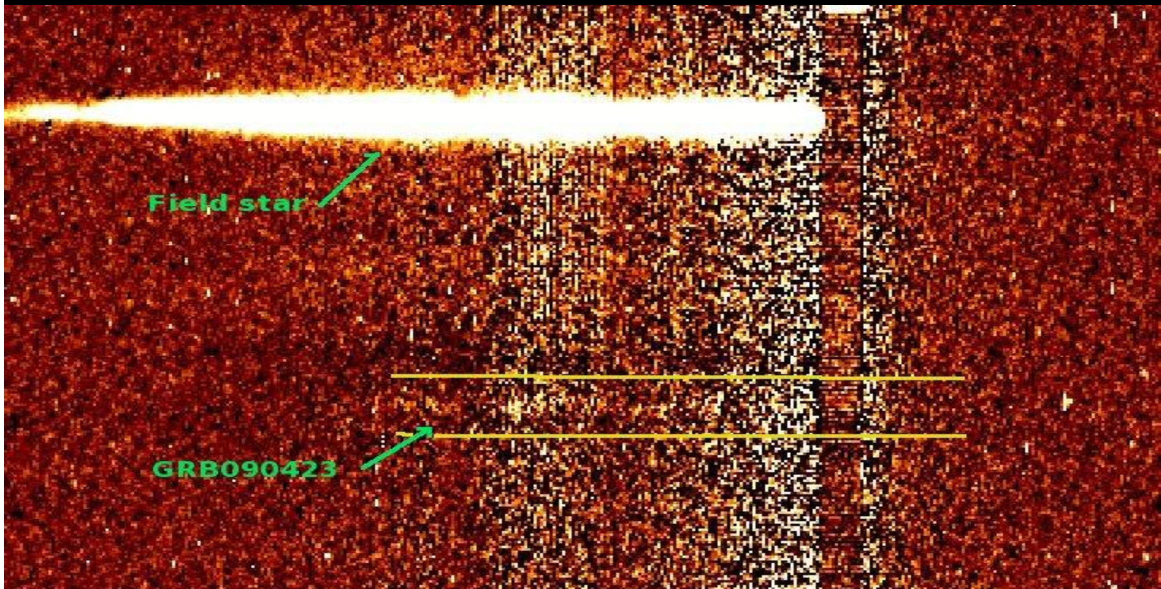




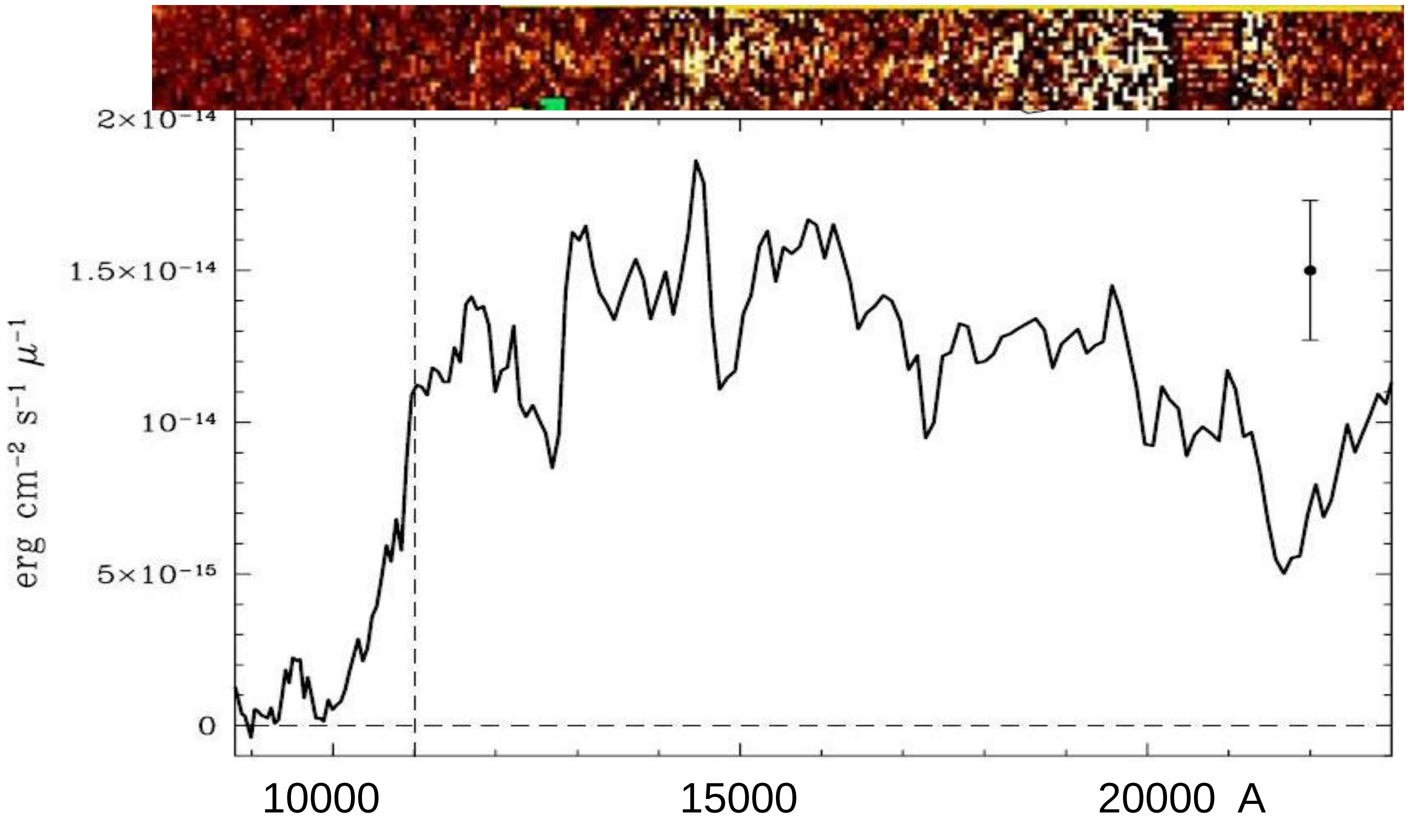
# il GRB del 23 aprile 2009





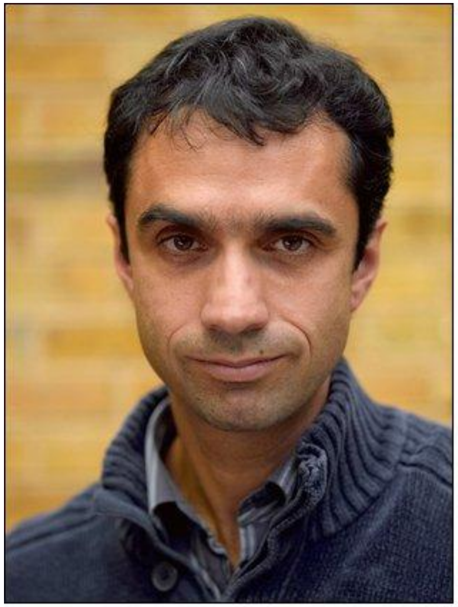
# il GRB del 23 aprile 2009



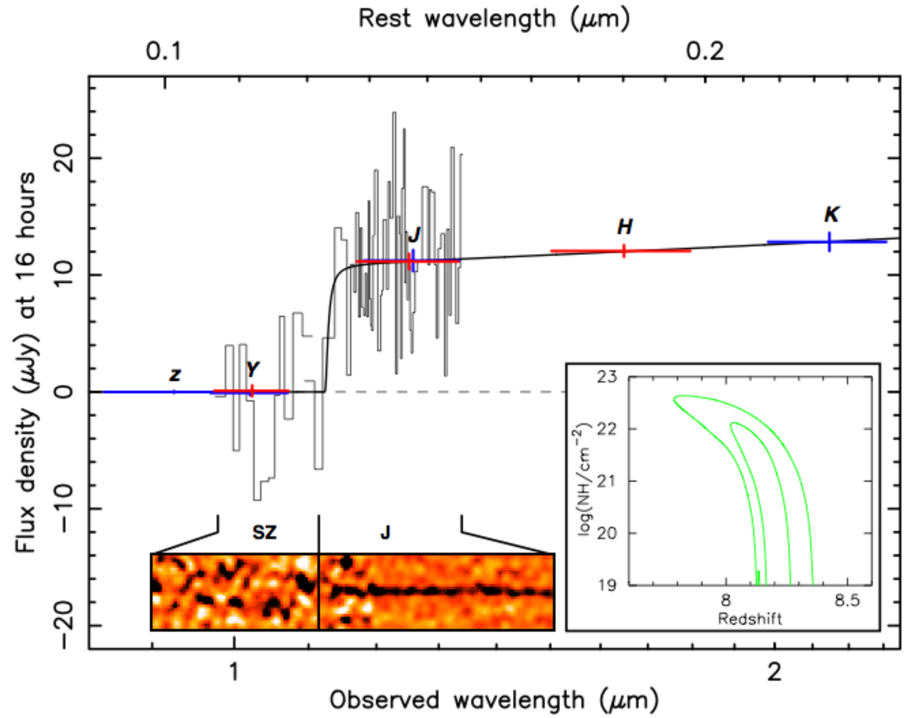

$$z=\frac{\lambda_{obs}-\lambda_{lab}}{\lambda_{lab}}=\frac{11100-1215}{1215}=8{,}1 \longrightarrow$$ 13 miliardi di anni luce

122900000000000000000000 km

# gli “antagonisti”



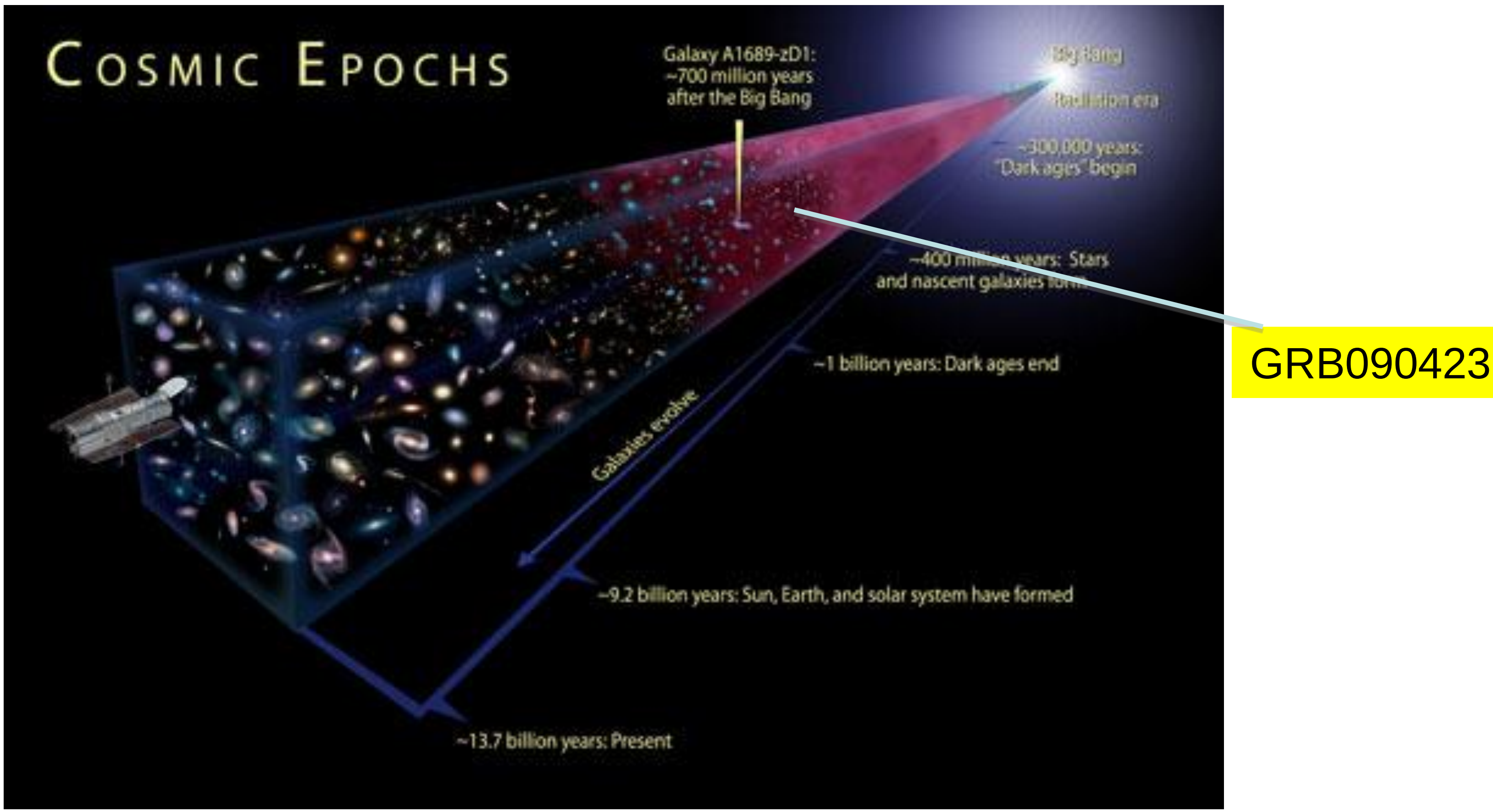
Professor Nial Tanvir
*Gamma-ray Bursts; the Biggest Bangs*





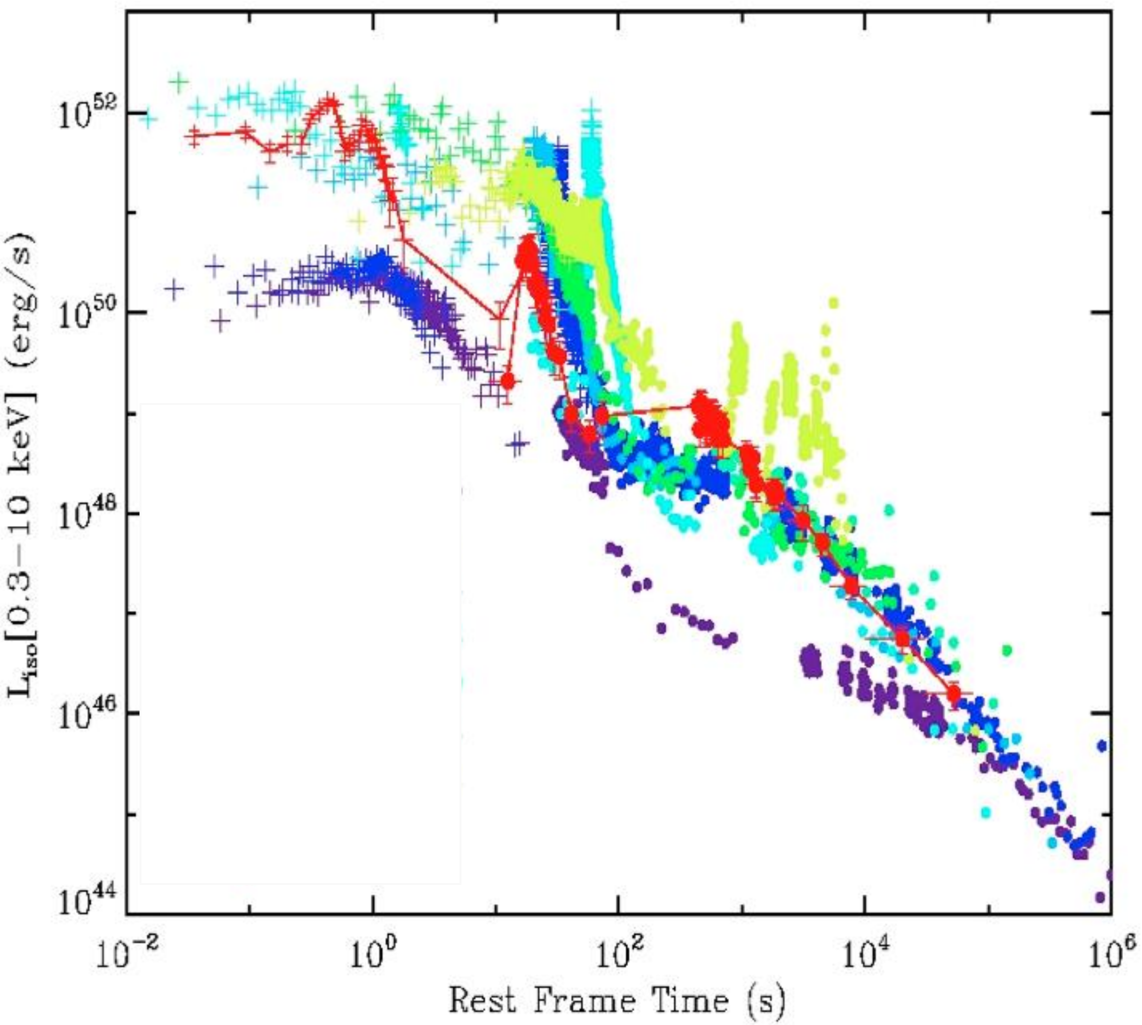
# Cosa abbiamo imparato

1. ESISTONO!



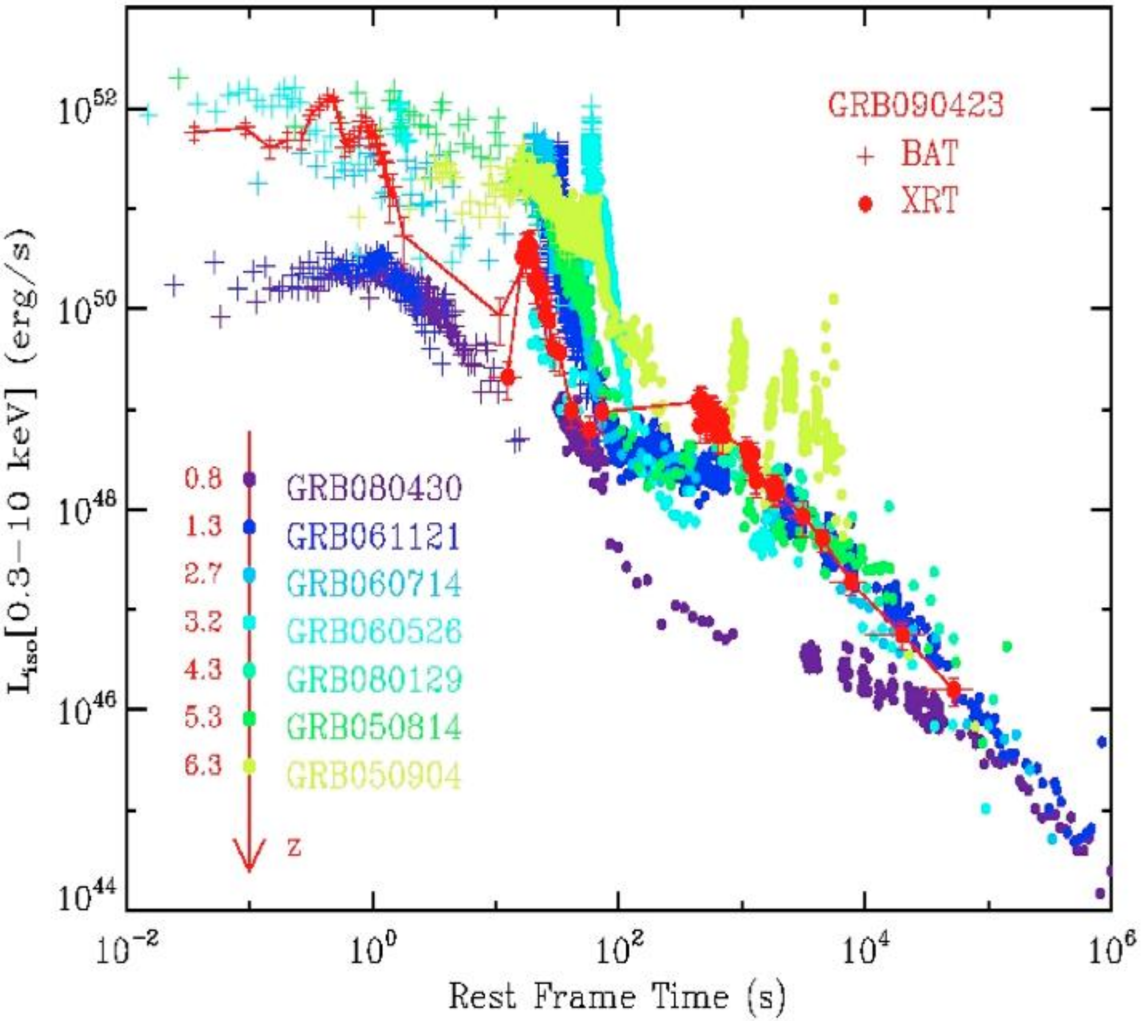
# cosa abbiamo imparato

2. confronto tra curve di luce per GRB a diverse distanze



# cosa abbiamo imparato

2. sono uguali a tutti gli altri



# guardare lontano, lontano…

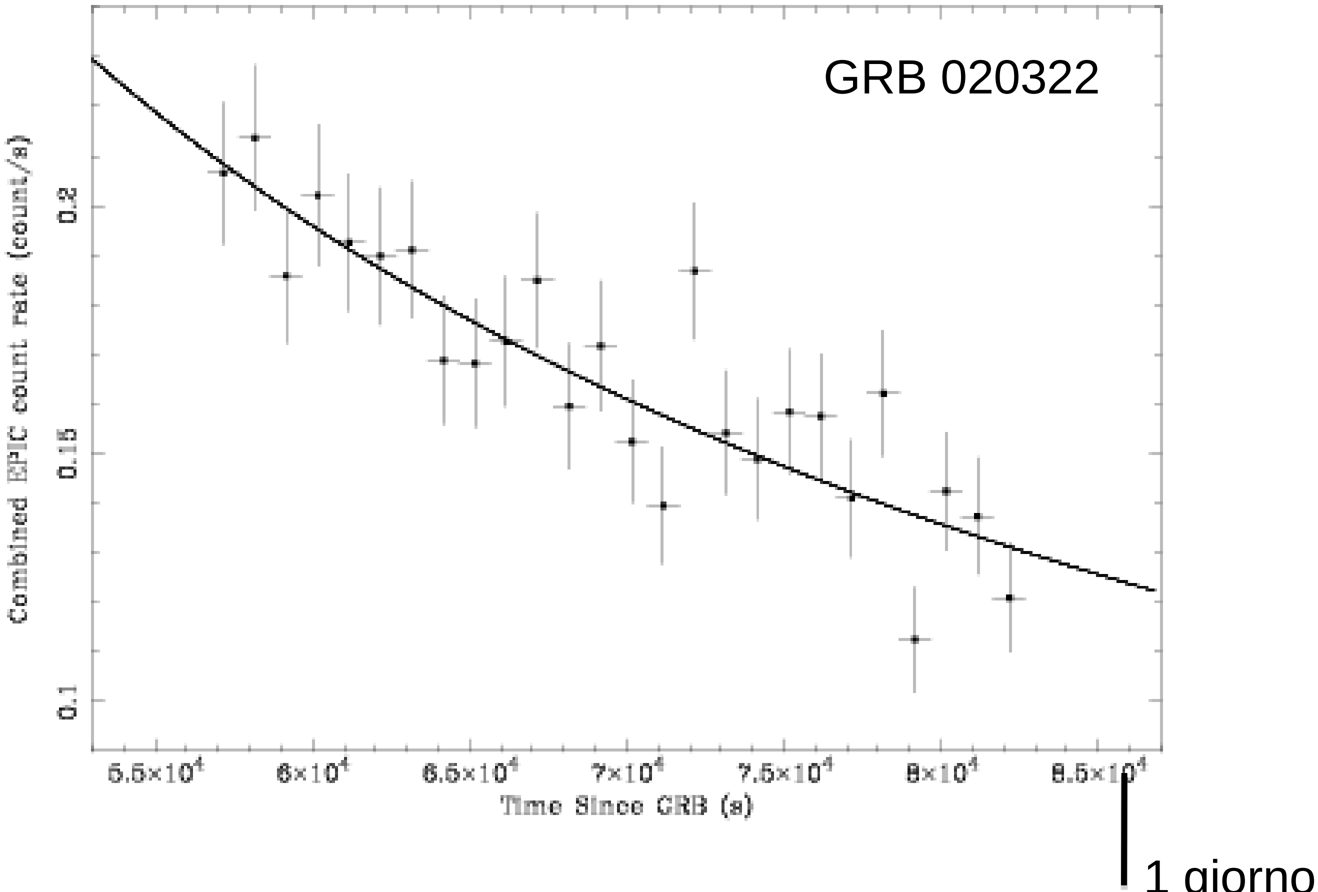
immaginiamo che la vita dell'Universo sia uguale a quella di un uomo (100 anni)

| | | | | | | |
|---|---|---|---|---|---|---|
| anno di osservazione | **1923** | **1980** | **1990** | **2000** | **2009** | **2015(?)** |
| galassia/stella piu' lontana conosciuta (miliardi di anni luce) | **0,002** | **7,7** | **10** | **12,6** | **13** | **13,3** |
| eta' dell'Universo (anni) | **100** | **50** | **19** | **7** | **4** | **2** |

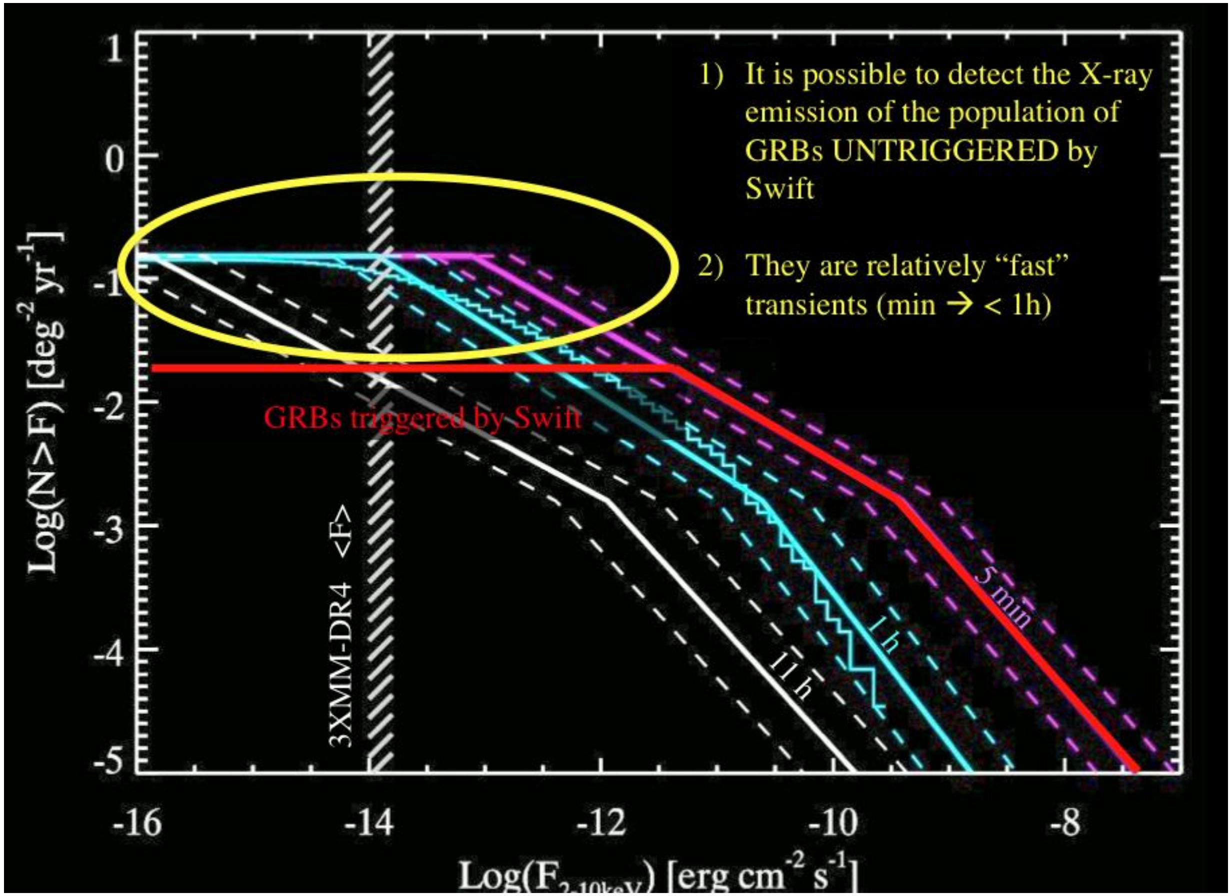
# GRB in EXTraS

cosa troveremo di sicuro: i target



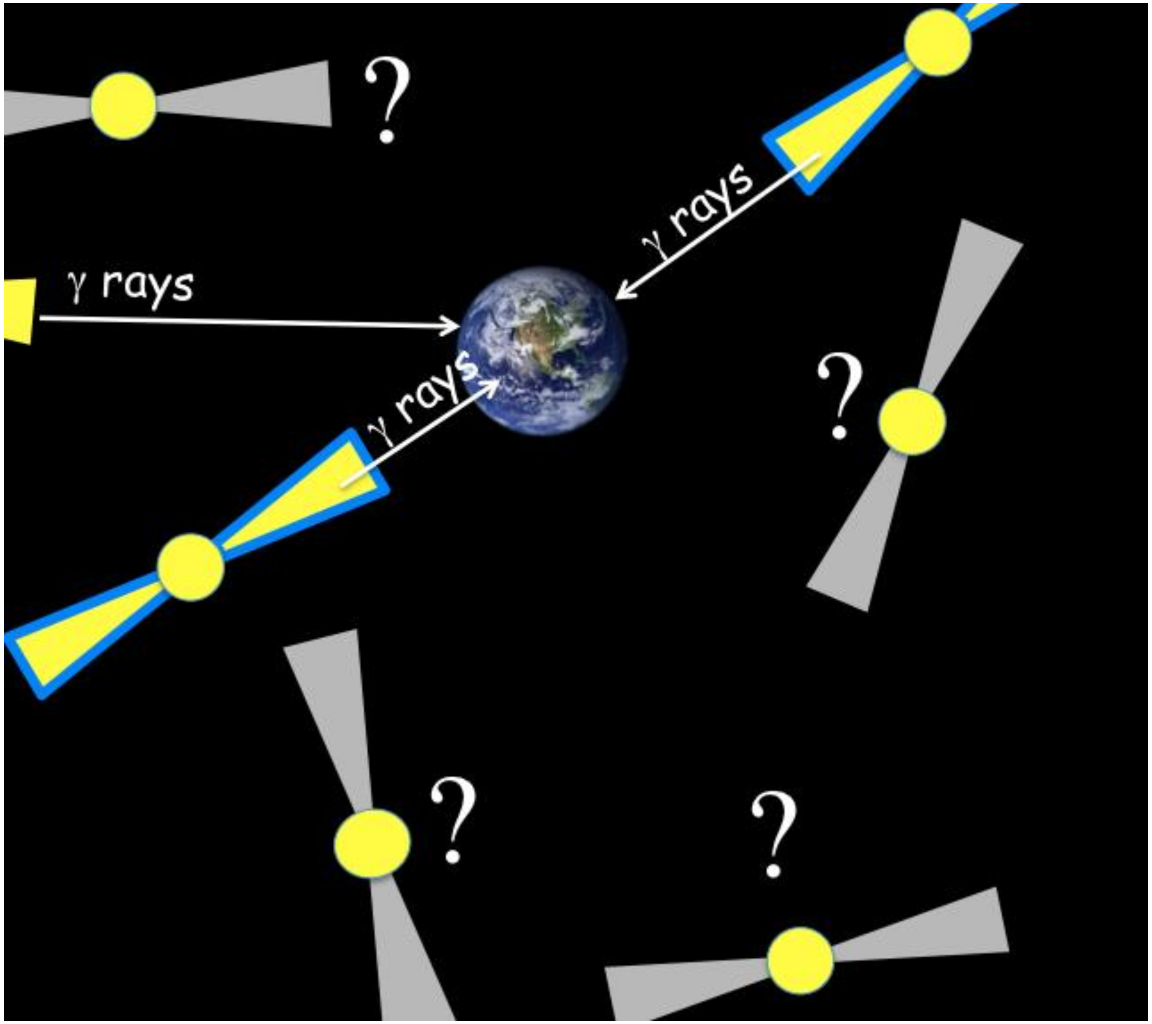
# GRB in EXTraS

Cosa vorremmo trovare: i piu' deboli

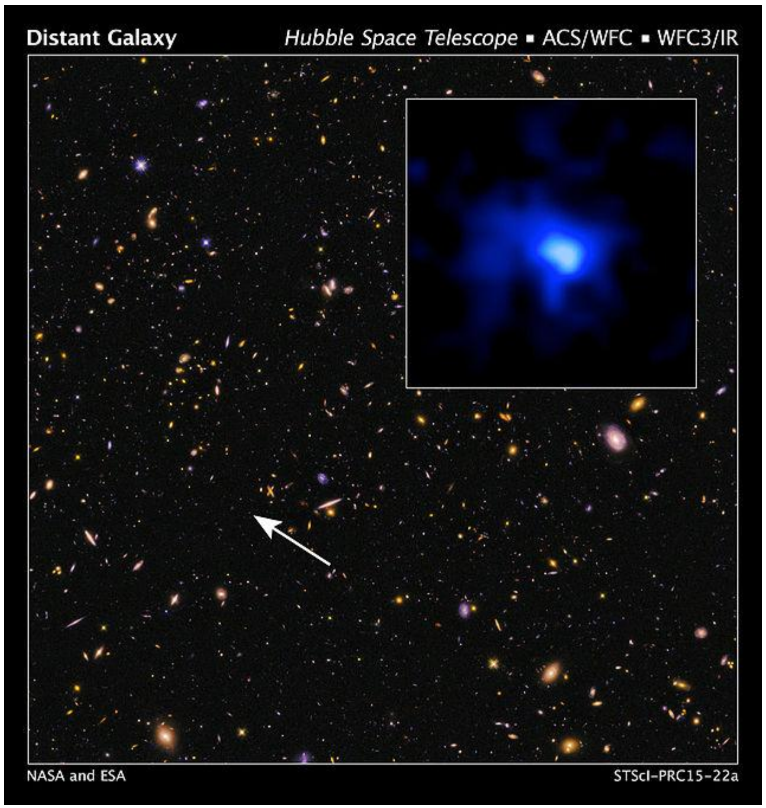


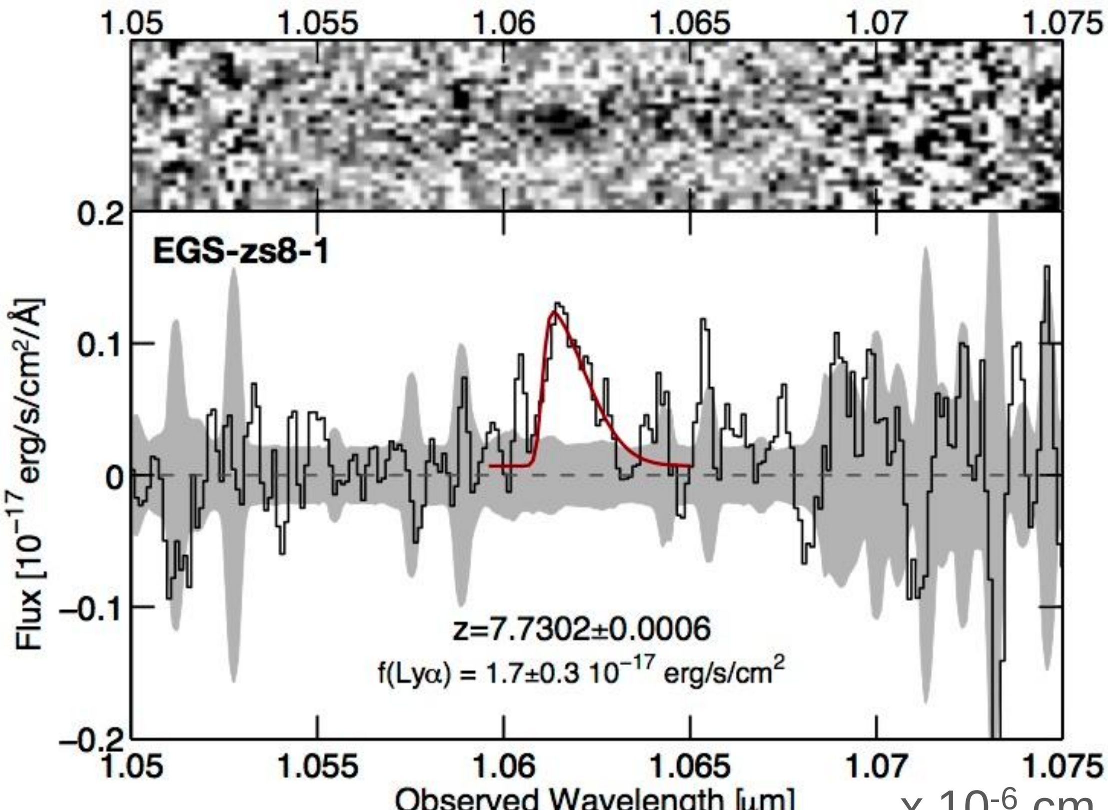
# GRB in EXTraS

cosa vorremmo trovare: gli “orfani”



# la galassia piu' lontana




x $10^{-6}$ cm

# il pianeta piu' lontano

~2000 pianeti extrasolari confermati dal 1994

13000 anni luce