

Università degli Studi di Bologna

# Astronomia a Raggi-X

*Storia di un premio Nobel*



Giorgio G.C. Palumbo    Dipartimento di Astronomia

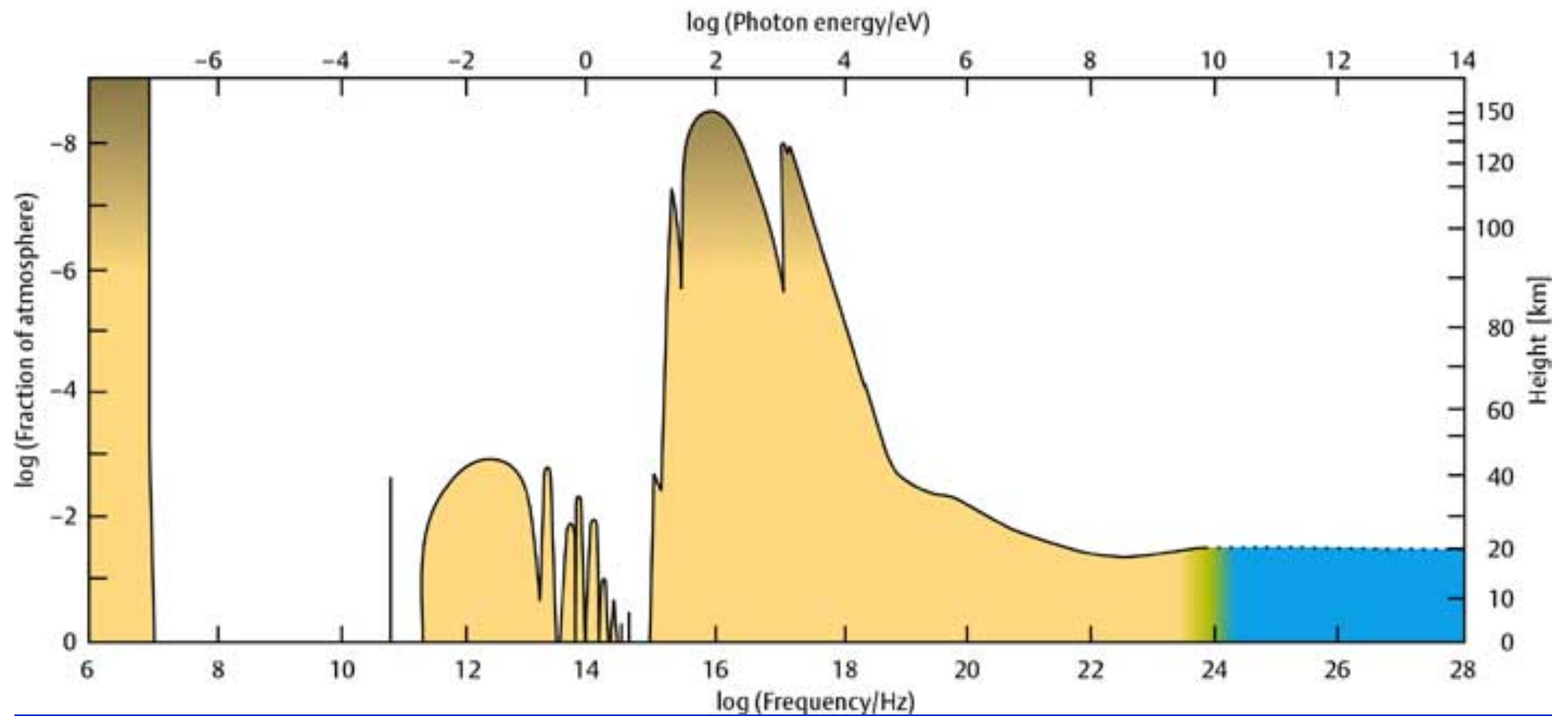


**Wilhelm Konrad  
Roentgen 1845-1923**

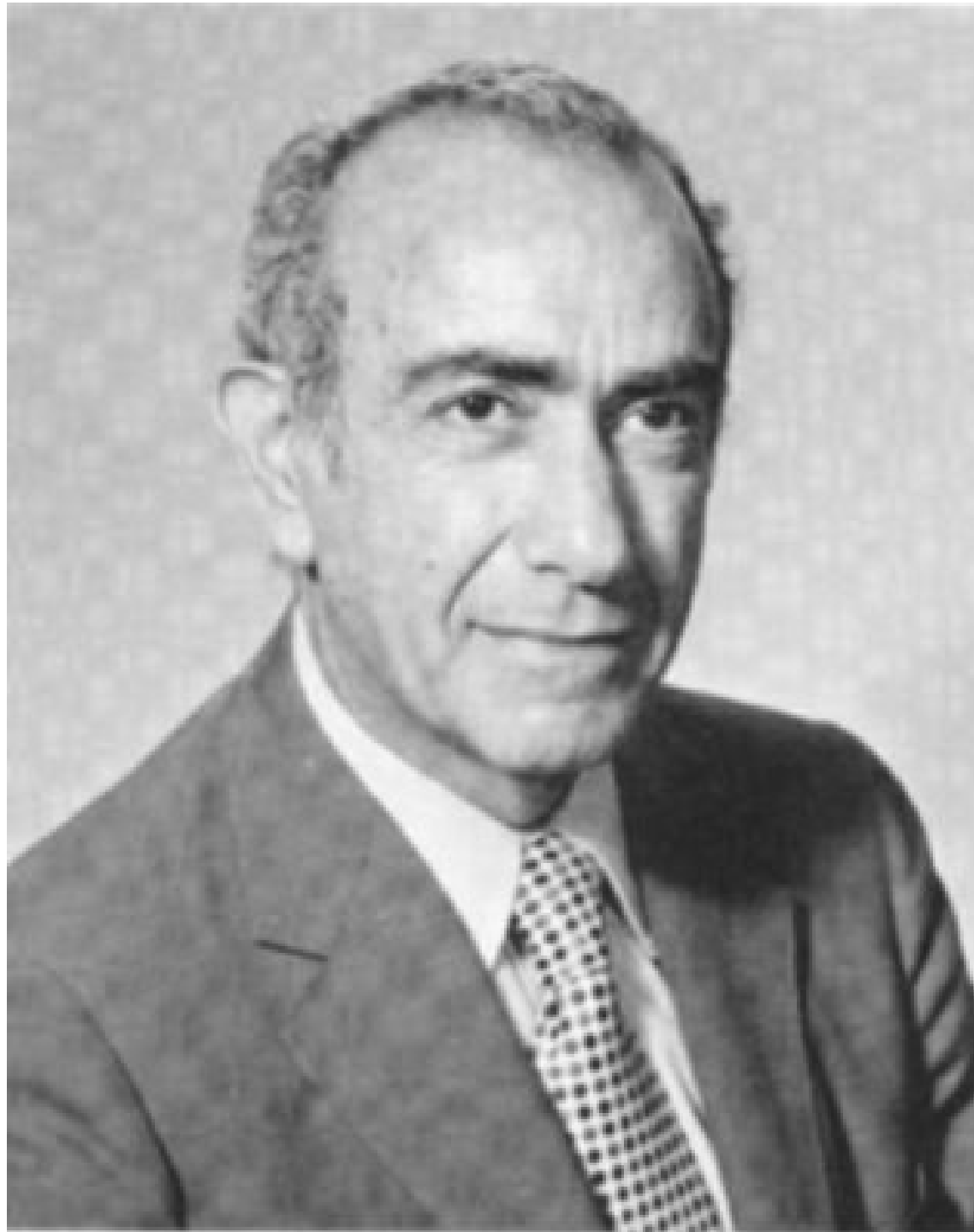
Primo Premio Nobel per  
la Fisica (1901) per la  
scoperta dei raggi X

# Il generatore di raggi X di Roentgen e le sue prime applicazioni





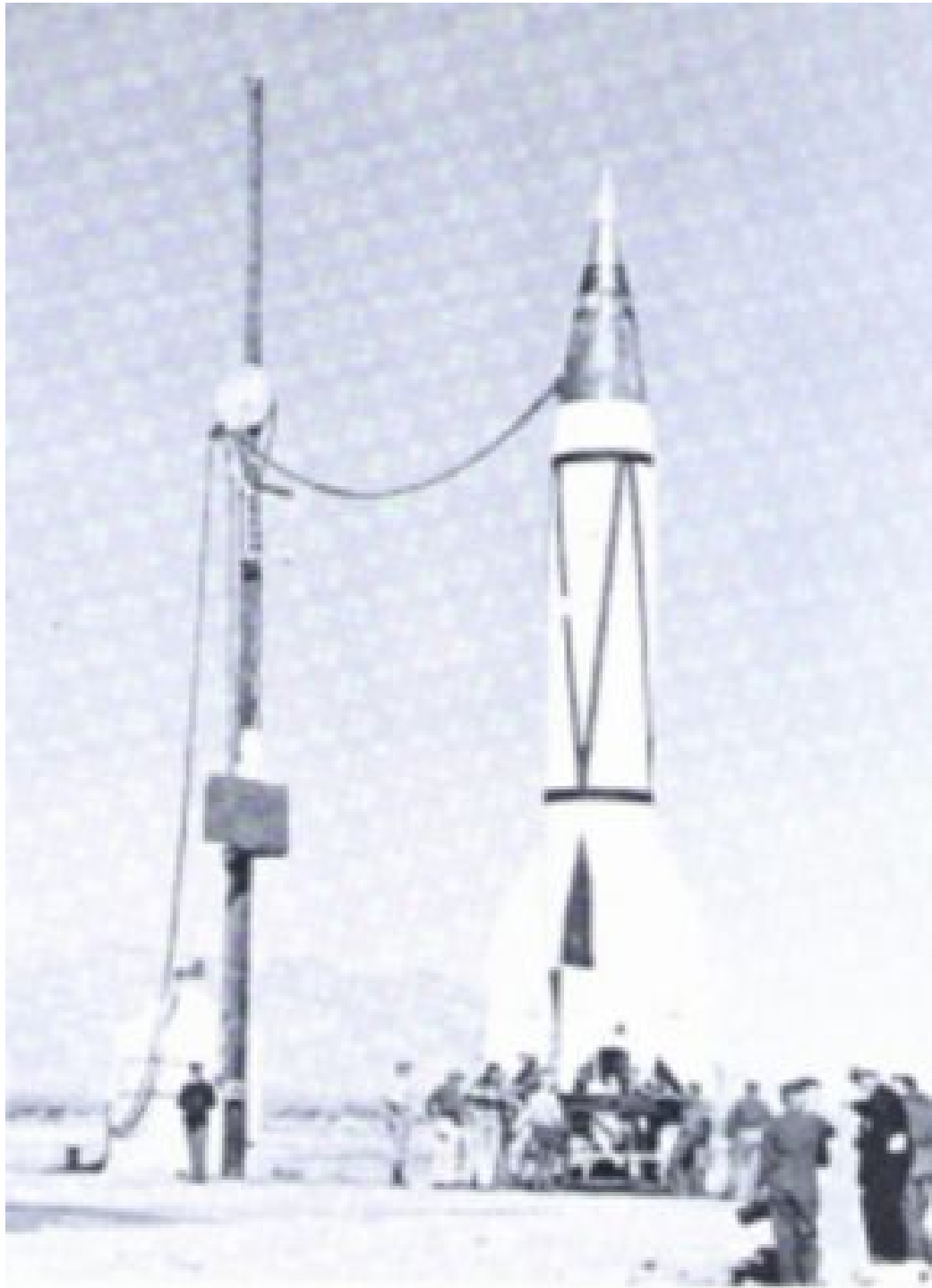
**Trasparenza dell'atmosfera alla radiazione elettromagnetica**



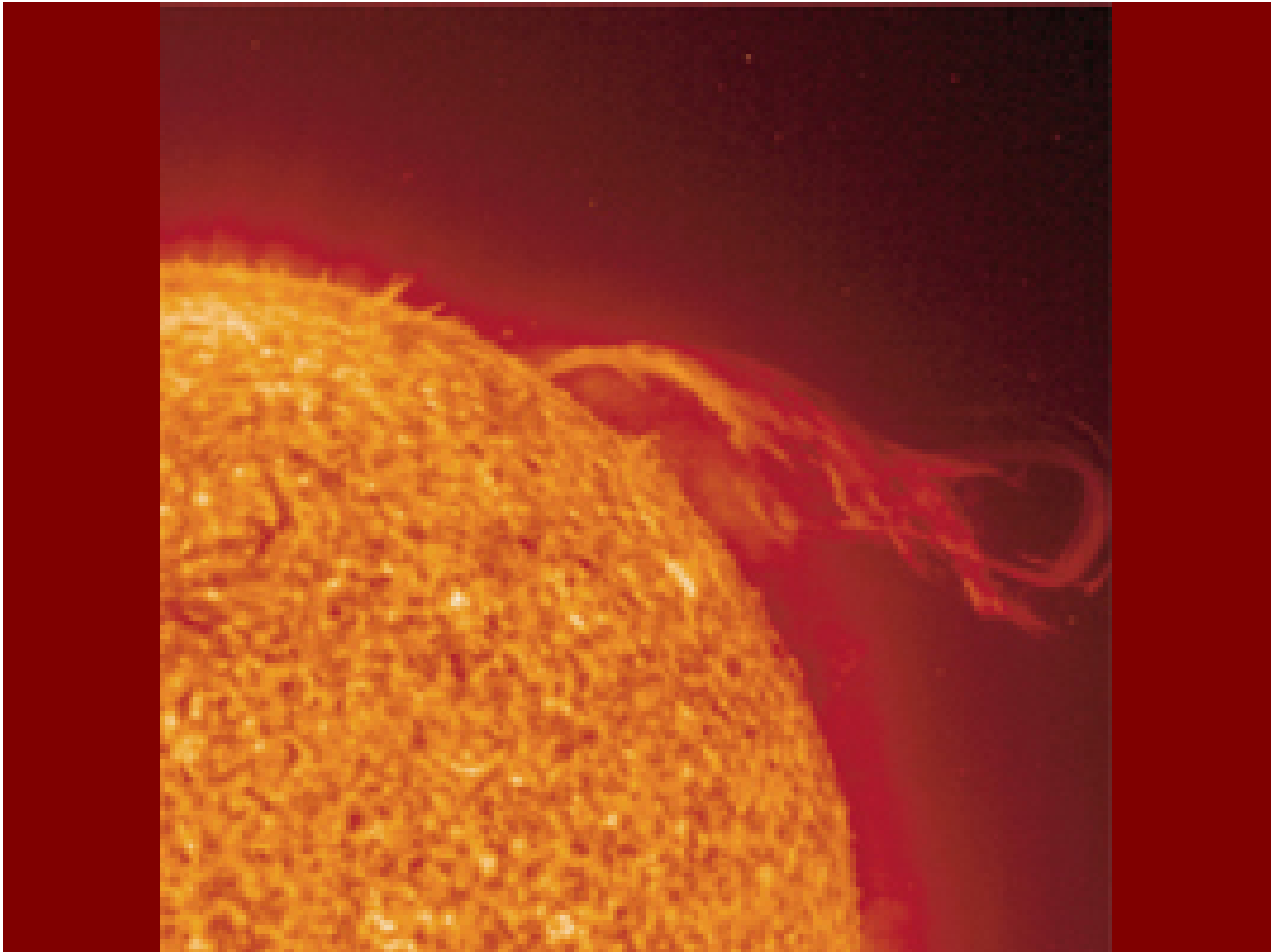
Herbert Friedman

(1916-2000)

NRL



**Lancio e recupero di  
un razzo V 2 (1947)**

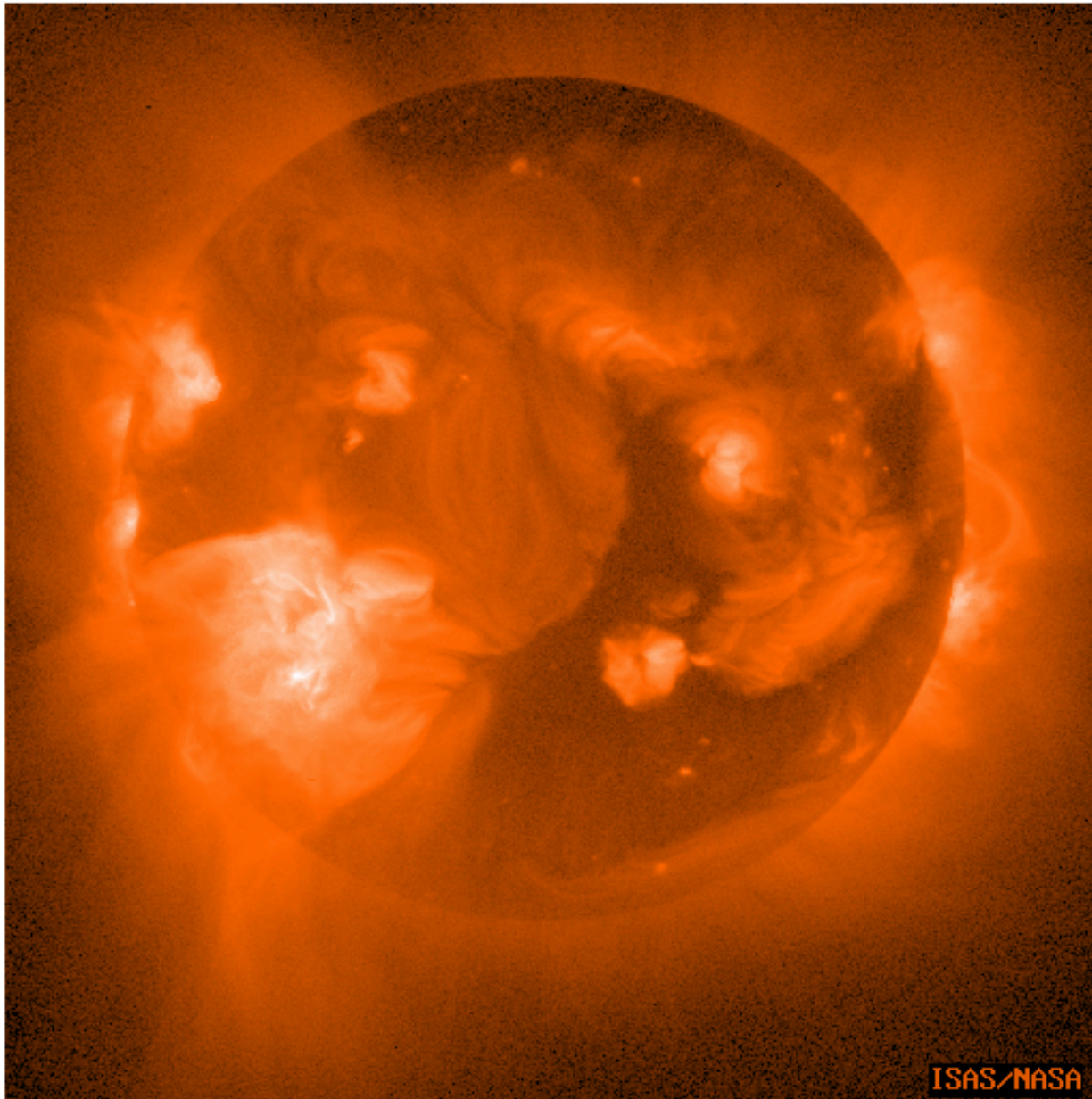




**Razzi Aerobee a  
bordo di un  
cacciatorpediniere  
nell'Oceano Pacifico  
pronti per il lancio  
durante una  
spedizione (1950)**



**Sole in raggi X  
visto dal  
satellite giapponese  
Yohkoh  
(1991)**



Yohkoh X-ray Solar Image File yoko\_sxt.by  
Image on 1991 Oct. 25 in band 3 - 45 Angstrom units.



**Riccardo Giacconi**

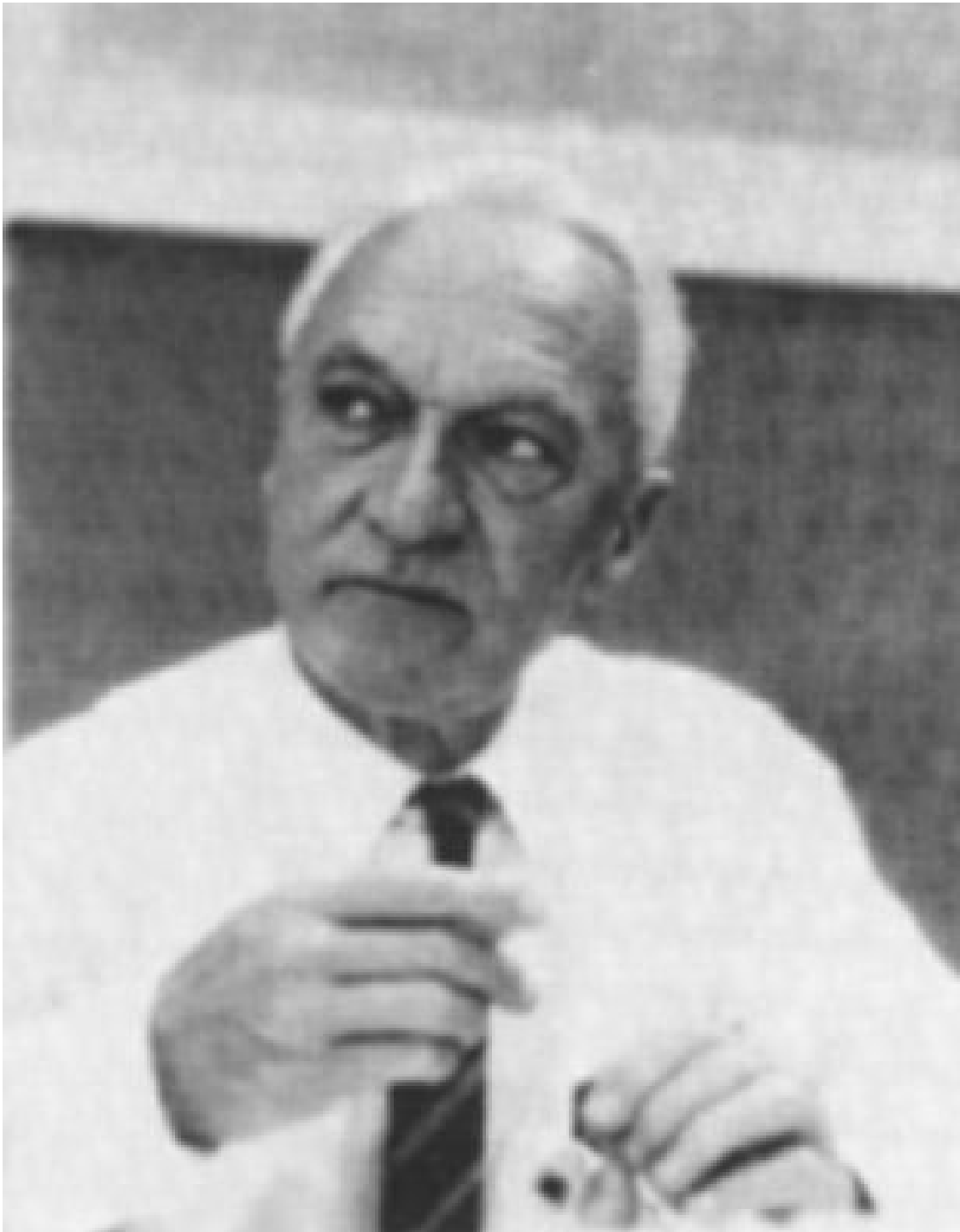
**(Genova 1931)**

**Laureato a Milano  
con Giuseppe  
(Beppo) Occhialini**

**(1954)**



**Riccardo Giacconi  
Herb Gursky & in  
Princeton**



**Bruno Rossi  
(1905-1993)**

**veneziano**

**laureato a Bologna**

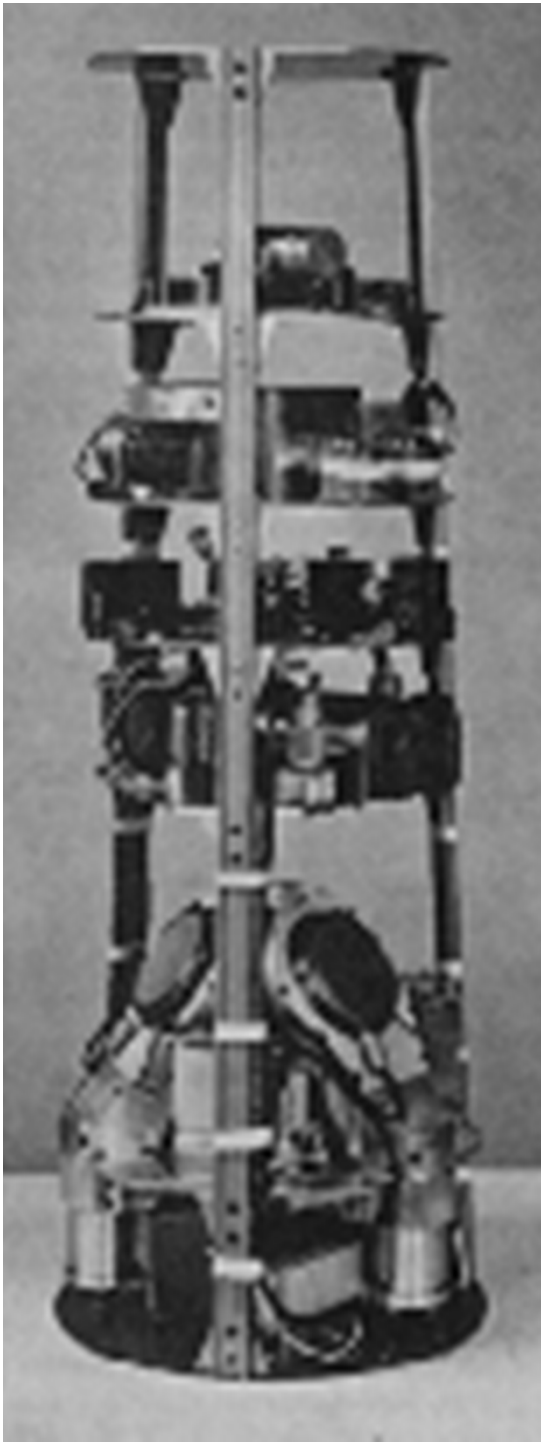
**a seguito delle  
leggi razziali  
emigrato negli  
U.S.A.**

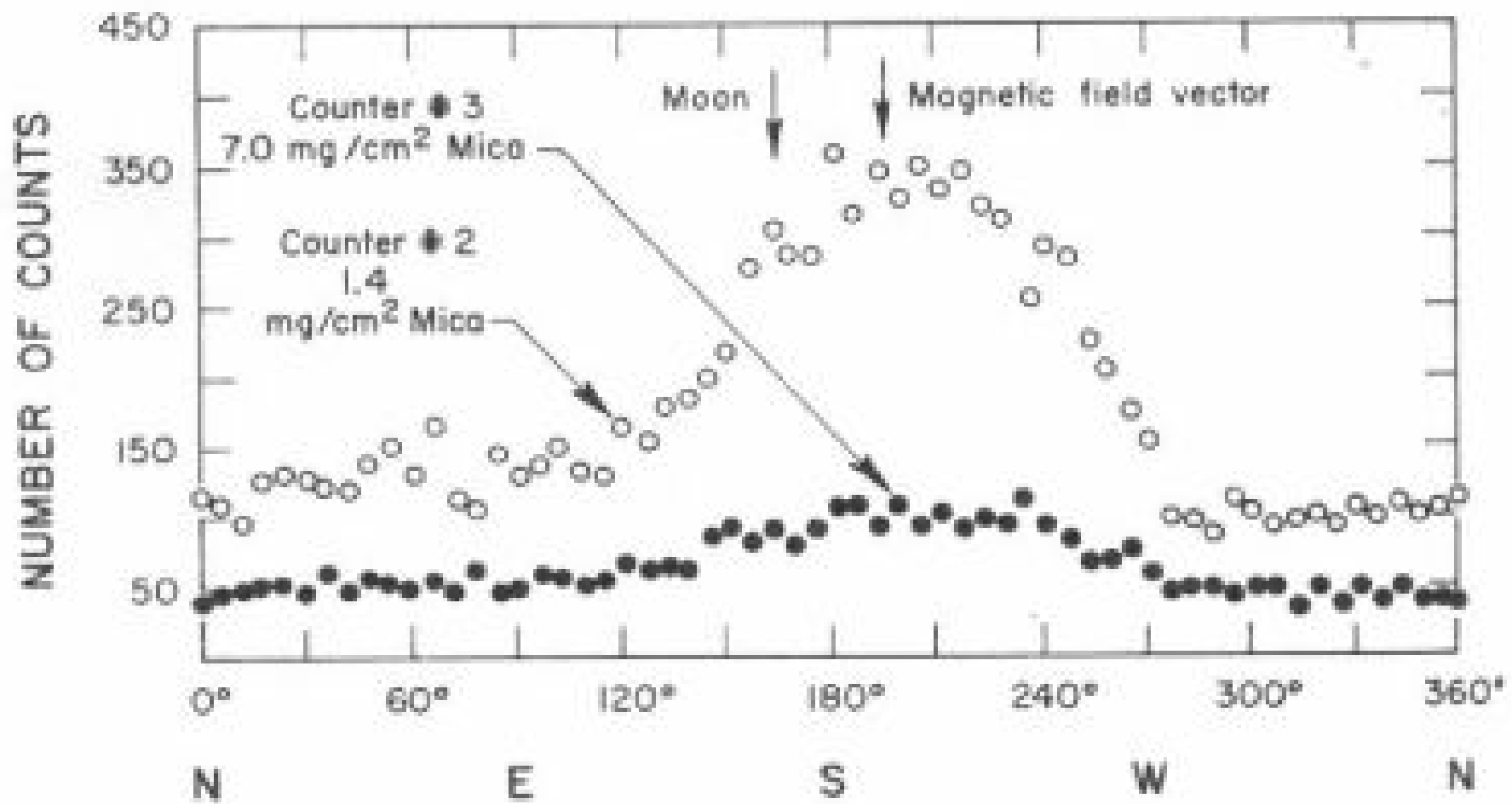
**Partecipa al  
progetto  
Manhattan poi è  
prof. a MIT**

## Stime prima dell'esperimento

Sole	$10^6 \text{ cm}^{-2} \text{ s}^{-1}$
Sole a 8 anni luce	$2,5 \cdot 10^{-4} \text{ cm}^{-2} \text{ s}^{-1}$
Sirio se $L_x = L_o$	$0,25 \text{ cm}^{-2} \text{ s}^{-1}$
Stelle flare, Stelle peculiari A, Crab Nebula	?
Luna, fluorescenza	$0,4 \text{ cm}^{-2} \text{ s}^{-1}$
Luna, vento solare	$(0 - 1,6) \cdot 10^3 \text{ cm}^{-2} \text{ s}^{-1}$
=====	
Sco X-1	$28 \pm 1.2 \text{ cm}^{-2} \text{ s}^{-1}$

**Lancio del 1962**  
**Giacconi, Gursky, Paolini (AS&E)**  
**&**  
**Rossi (MIT)**

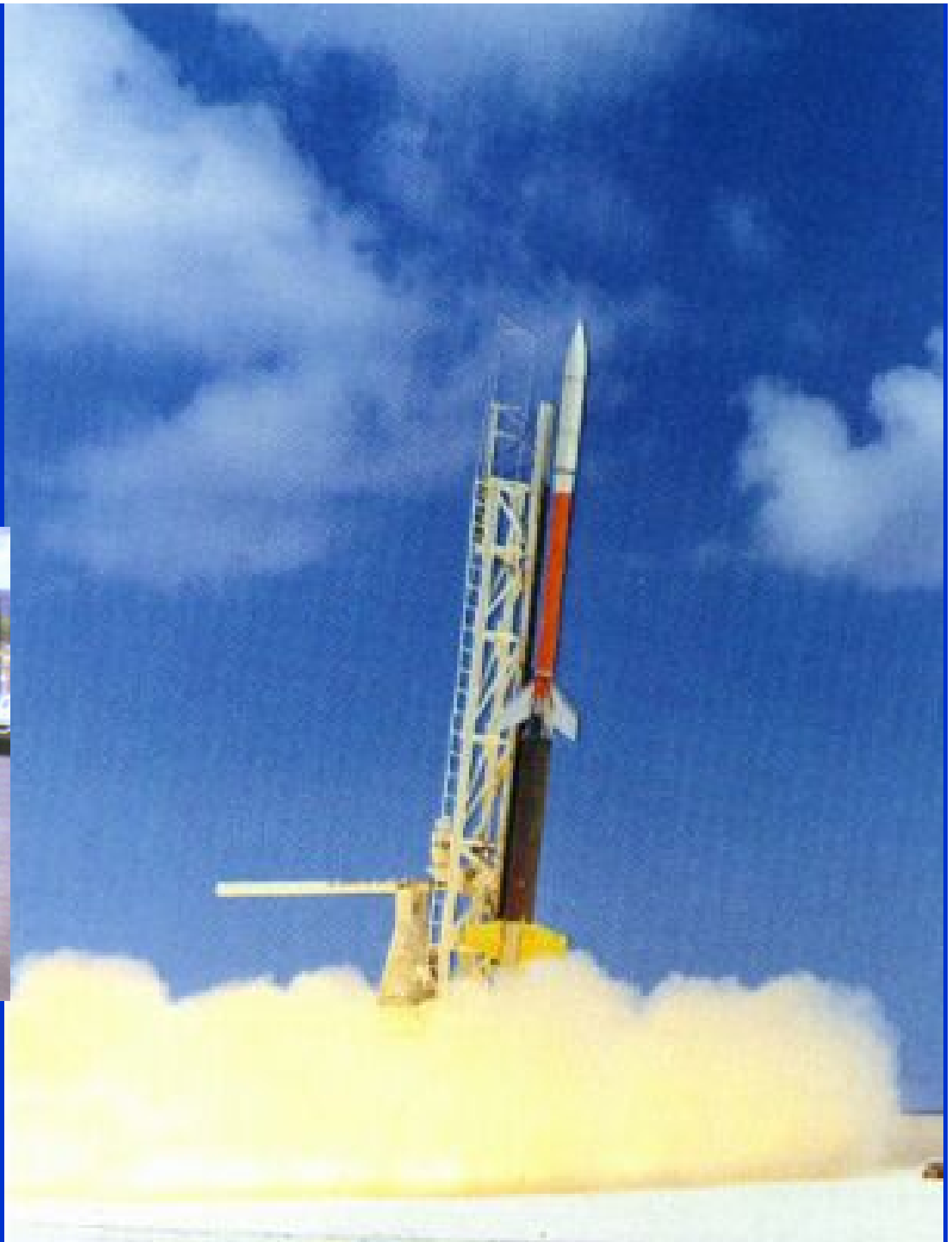




Azimuthal distributions of recorded counts from Geiger counters flown during June, 1962. (R. Giacconi et al., *Physical Review Letters* 9 (1962), 439)



**Lancio di razzi negli  
anni '60 dal deserto  
del New Mexico**

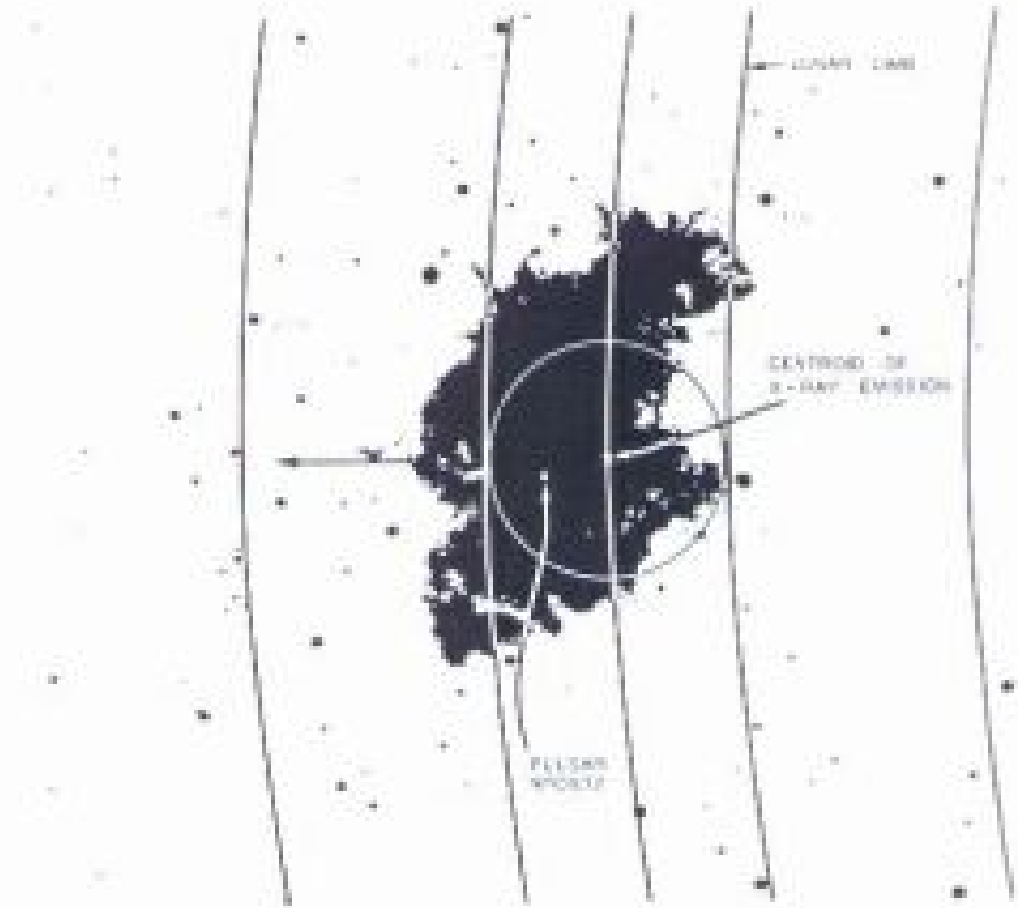
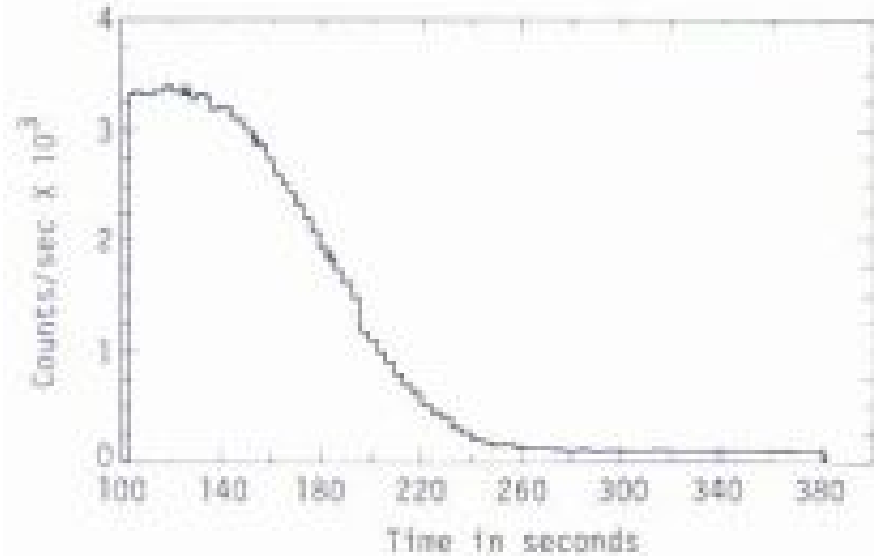






**Trasporto del razzo alla rampa di lancio**





**Determinazione della posizione della Nebulosa del Granchio (Crab Nebula) con il metodo dell'occultazione lunare**



**Il prof. Luigi Broglio, presidente del Consiglio direttivo scientifico in seno all'Istituto per la Ricerca Spaziale. Ha progettato il satellite italiano.**

CORRIERE DELLO  
**SPAZIO**

MENSILE DI AERONAUTICA E ASTRONAUTICA DIRETTO DA MANER LUALDI

In questo numero:

**PARLA  
TITOV**

**GLI U. S. A.  
DOPO GLENN**

**I PRIMI  
DIECI UOMINI  
DELLO SPAZIO**

**IL GIRO  
D'ITALIA  
SPAZIALE**

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Spedizione in abbonamento  
postale - Gruppo III

APERITIVO  
**CYNAR**

CONTRO IL LOGORIO DELLA VITA MODERNA

**IL SATELLITE ITALIANO**

Ecco la piattaforma galleggiante da cui un razzo vettore Scout lancerà, forse già nel prossimo anno, il primo satellite italiano su un'orbita equatoriale. (Vedi a pagina 5).



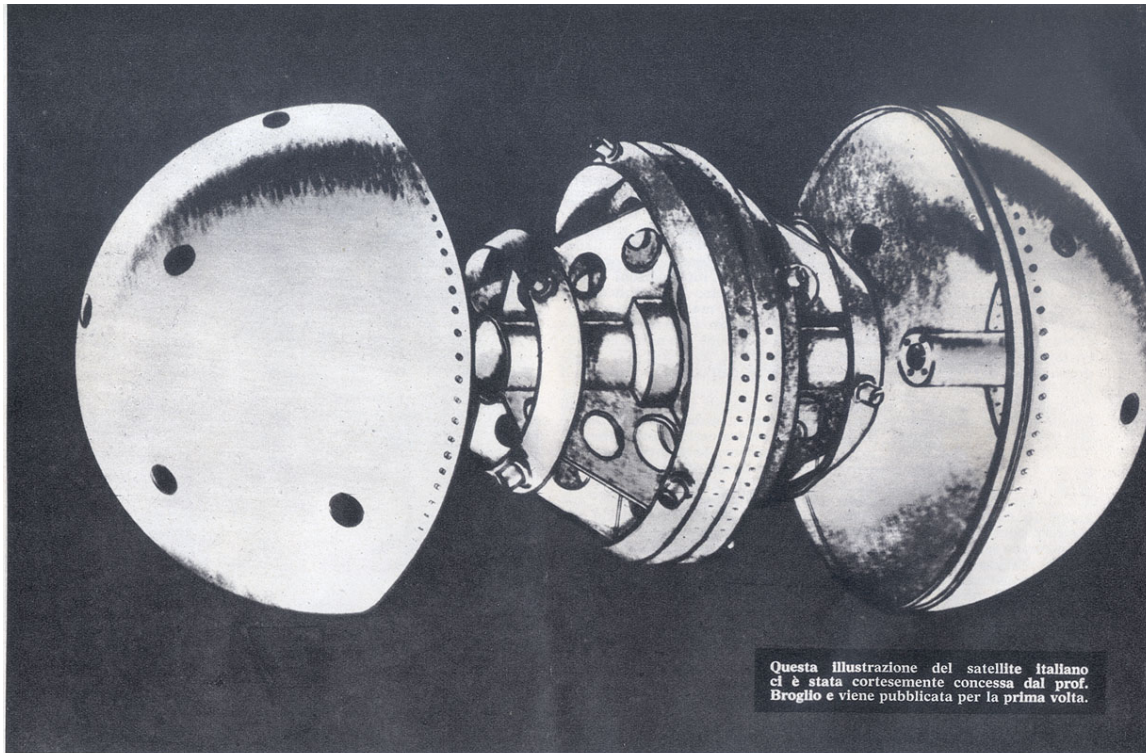
*vi dà la "carica"!*  
**FYNSEC**



**La piattaforma di  
lancio italiana  
S. Marco in Kenya**

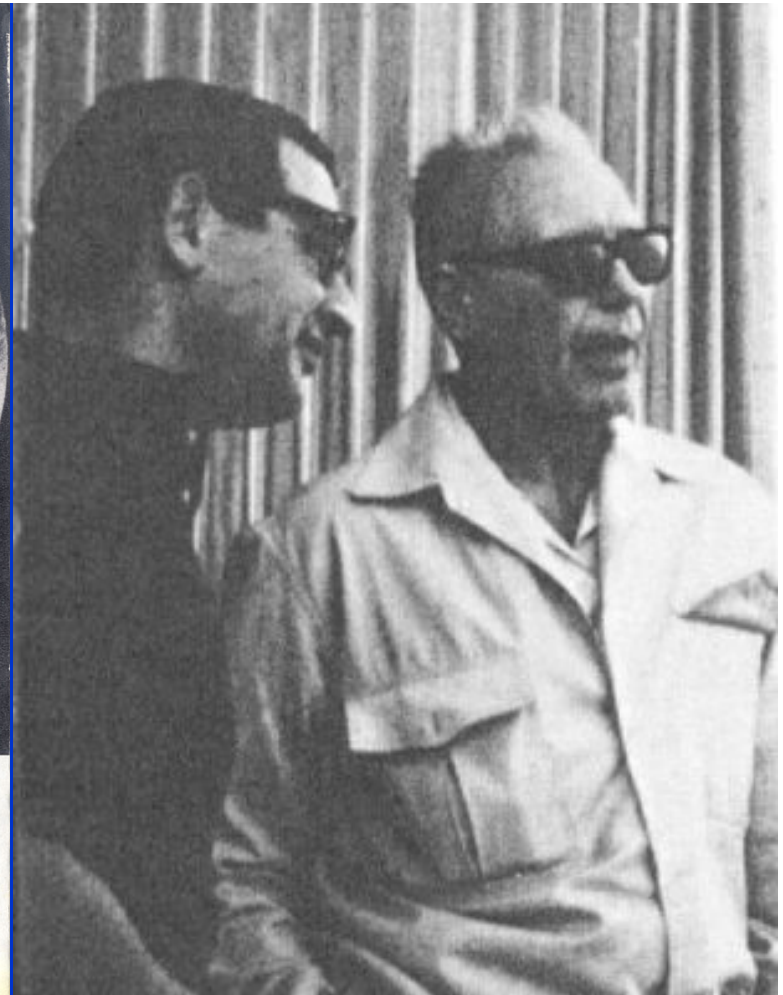


**La piattaforma S. Rita**



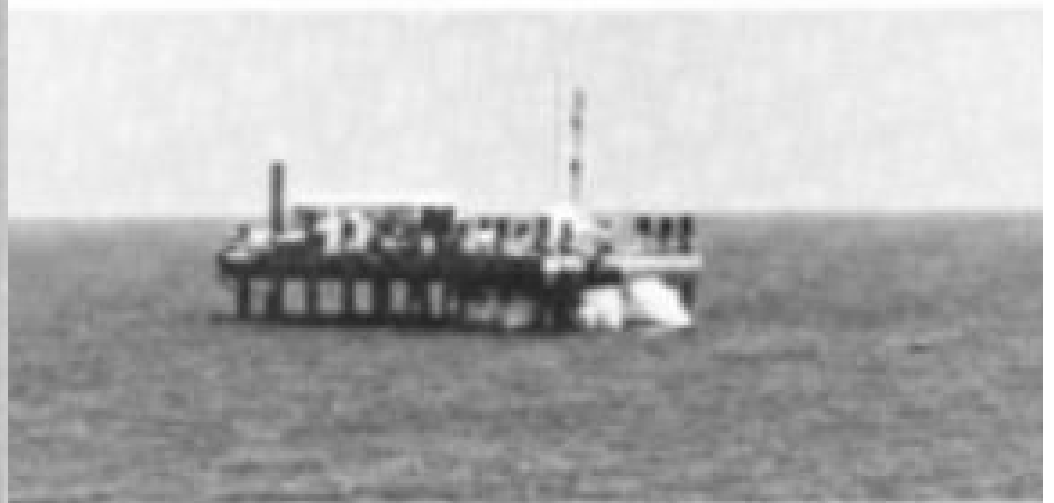
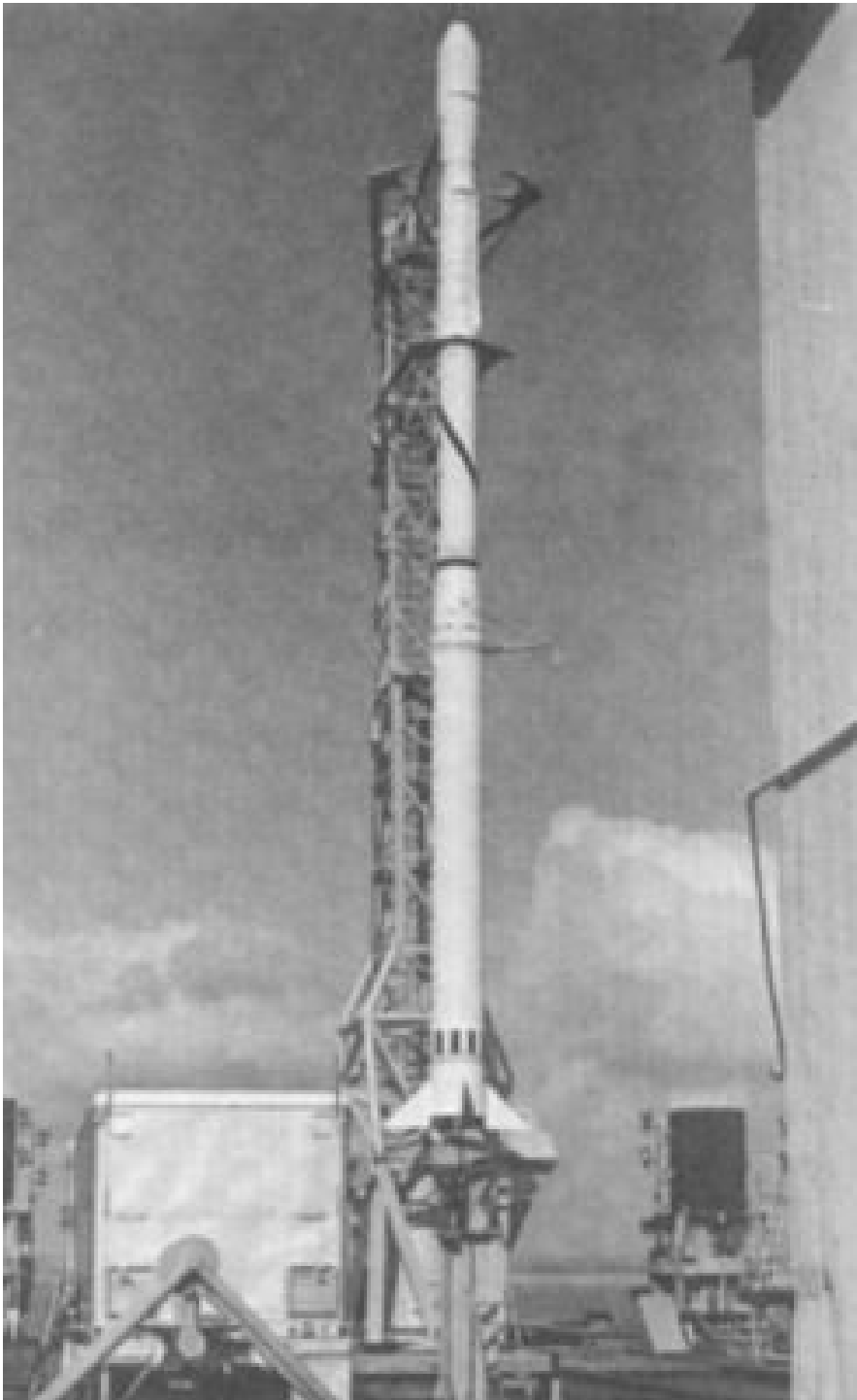
Questa illustrazione del satellite italiano ci è stata cortesemente concessa dal prof. Broglio e viene pubblicata per la prima volta.

## ECCO IL SATELLITE ITALIANO CHE SARÀ LANCIATO NEL 1963



**Riccardo Giacconi e Luigi Broglio poco prima del lancio di UHURU dalla base italiana di Malindi in Kenya nel 1969**

**Lancio del satellite X  
UHURU dalla base  
italiana di Malindi in  
Kenya**

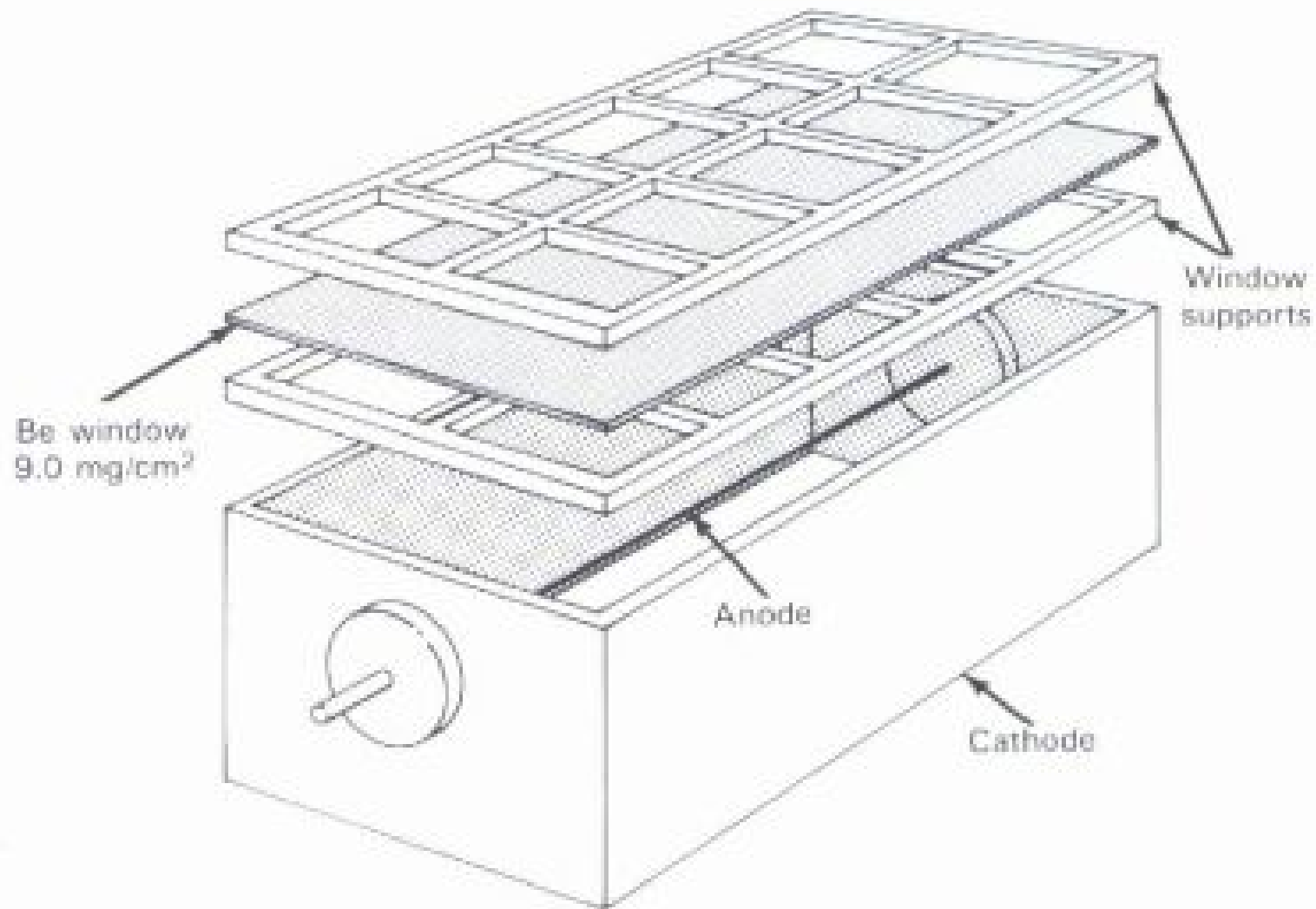




**UHURU**

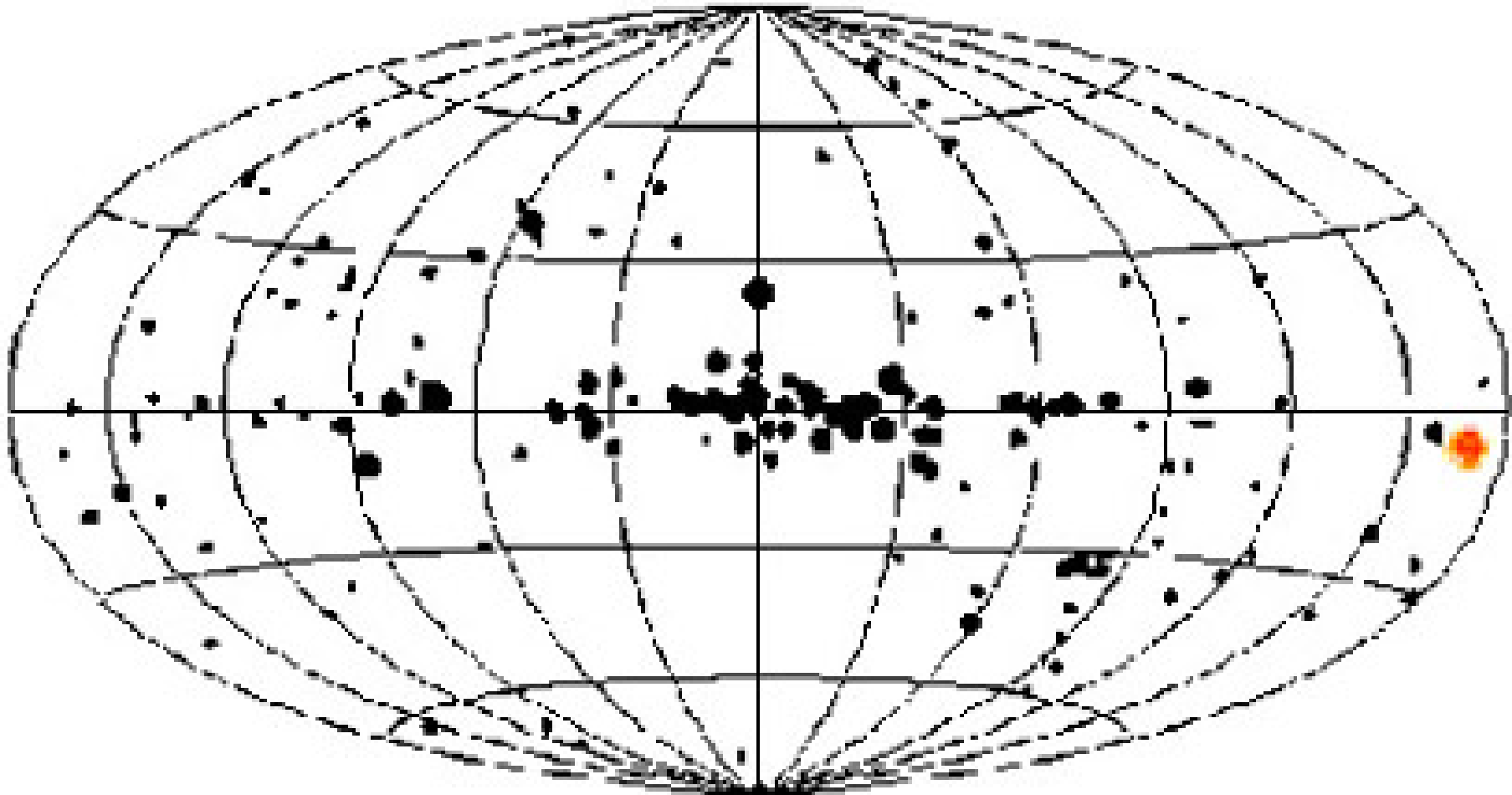
**il primo satellite  
per astronomia X  
1969**



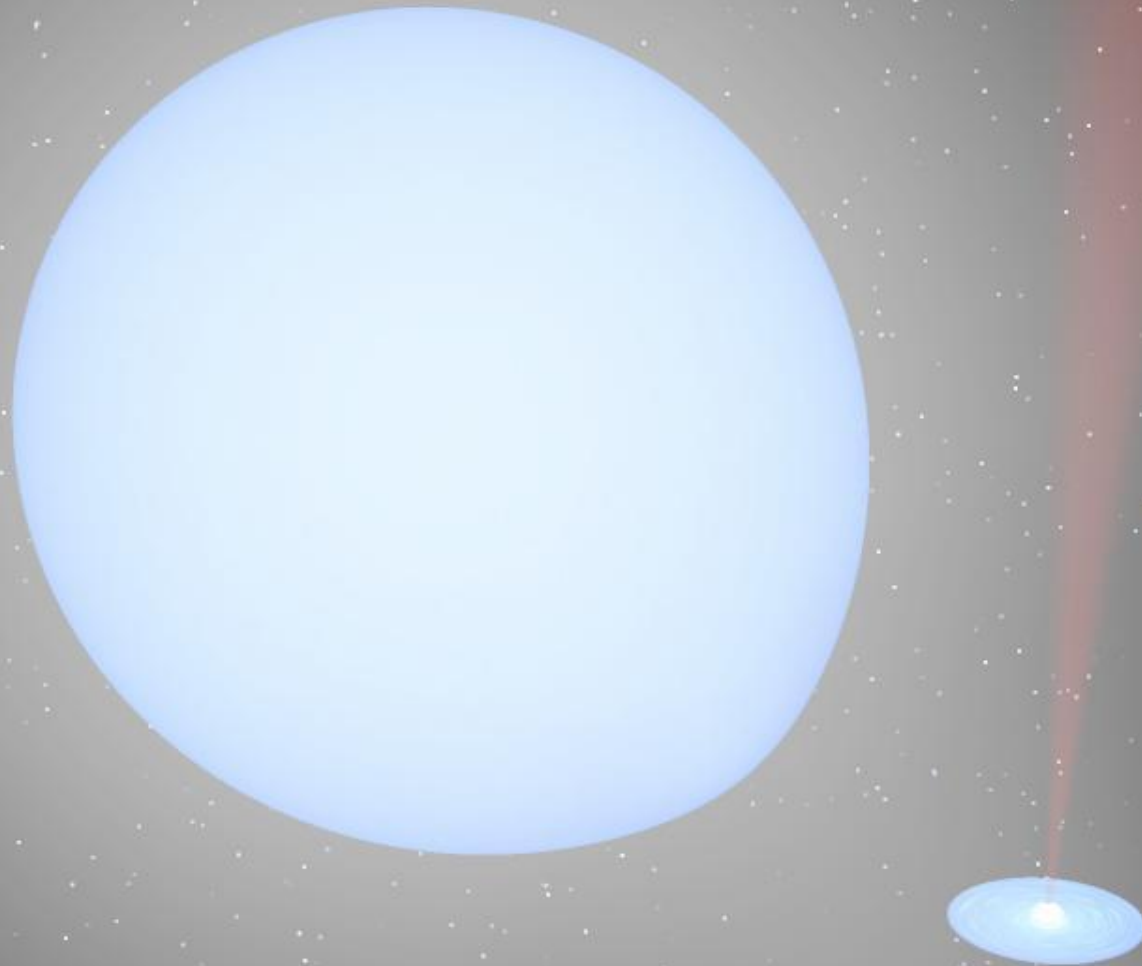


*Schematic of a thin window gas proportional counter. The beryllium window is cemented between a supporting "sandwich," which in turn is hermetically sealed to the cathode to preserve the gas integrity. An X-ray photon entering the counter produces a cloud of electron-ion pairs in the gas. The electrons drift to the anode, producing an electric signal.*

## II IV Catalogo di UHURU



# Cyg X-1



**ANS (Astronomische Nederlandse Satelliet)  
collaborazione NL USA (AS&E)**

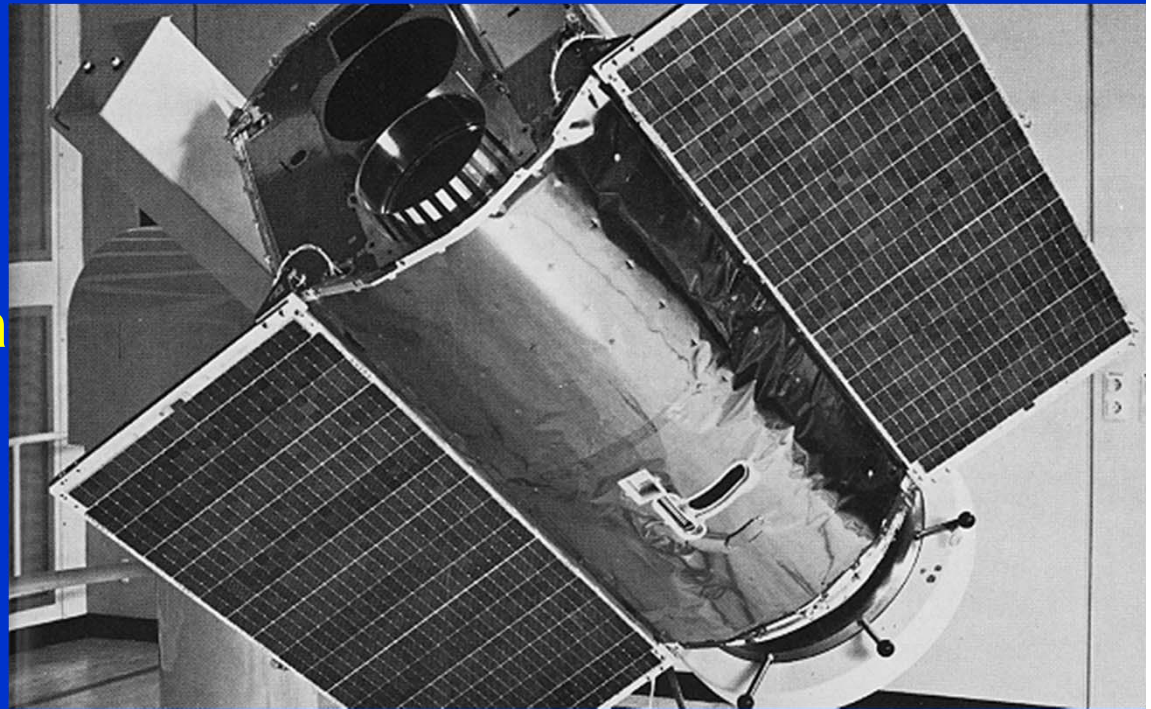
**Lanciato da uno scout USA nell' agosto 1974 e  
terminato nel 1977**

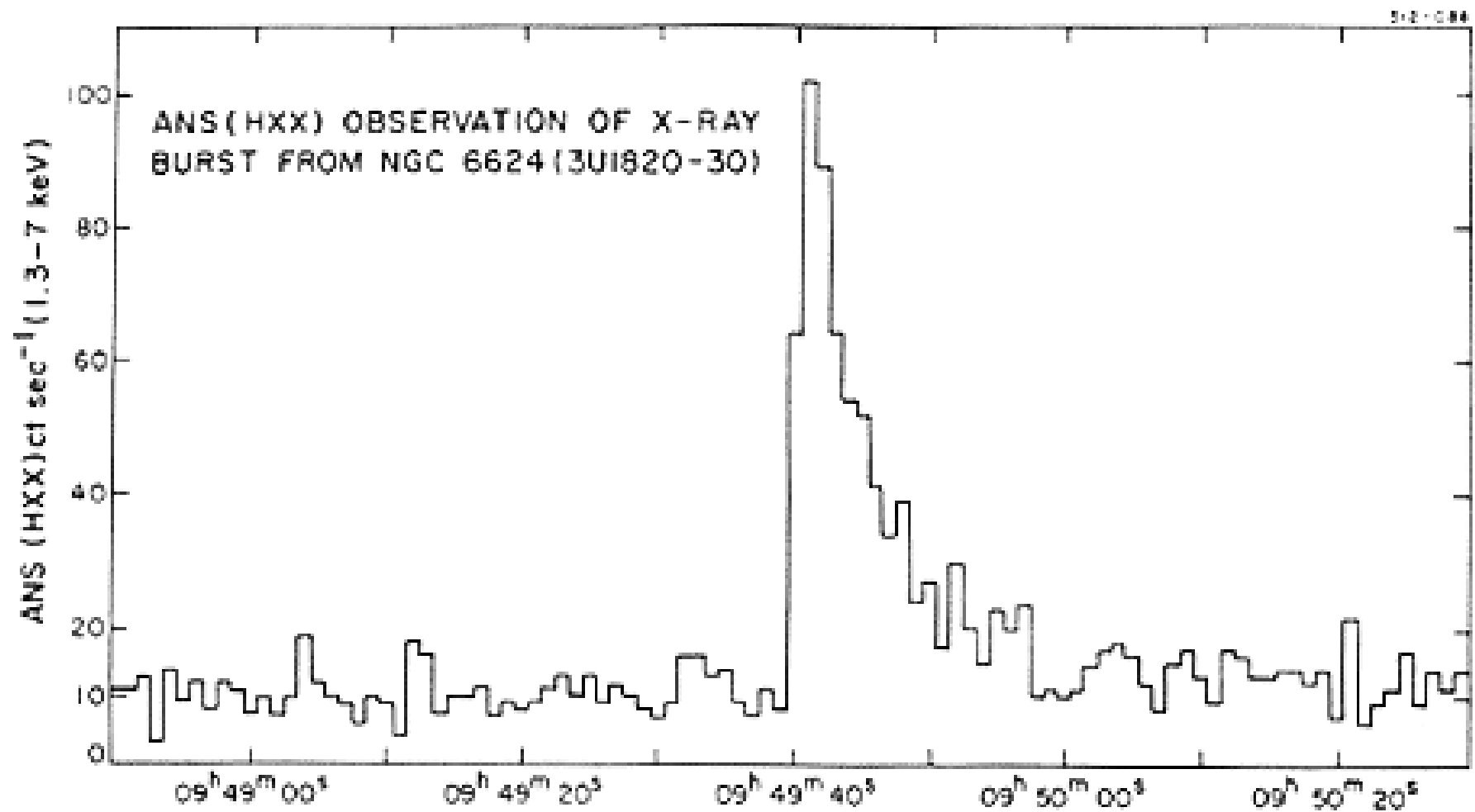
**Banda 0.1-30 keV e 150-330 nm**

**Soft x bursts**

**Raggi X da Capella**

**Flares da UV Ceti**





**Lanciato il 15 ottobre  
1974  
dalla piattaforma italiana  
S. Marco in Kenya.**

**Collaborazione USA UK.  
Terminato il 14 marzo  
1980**

**Banda osservata 0.3-40  
keV**





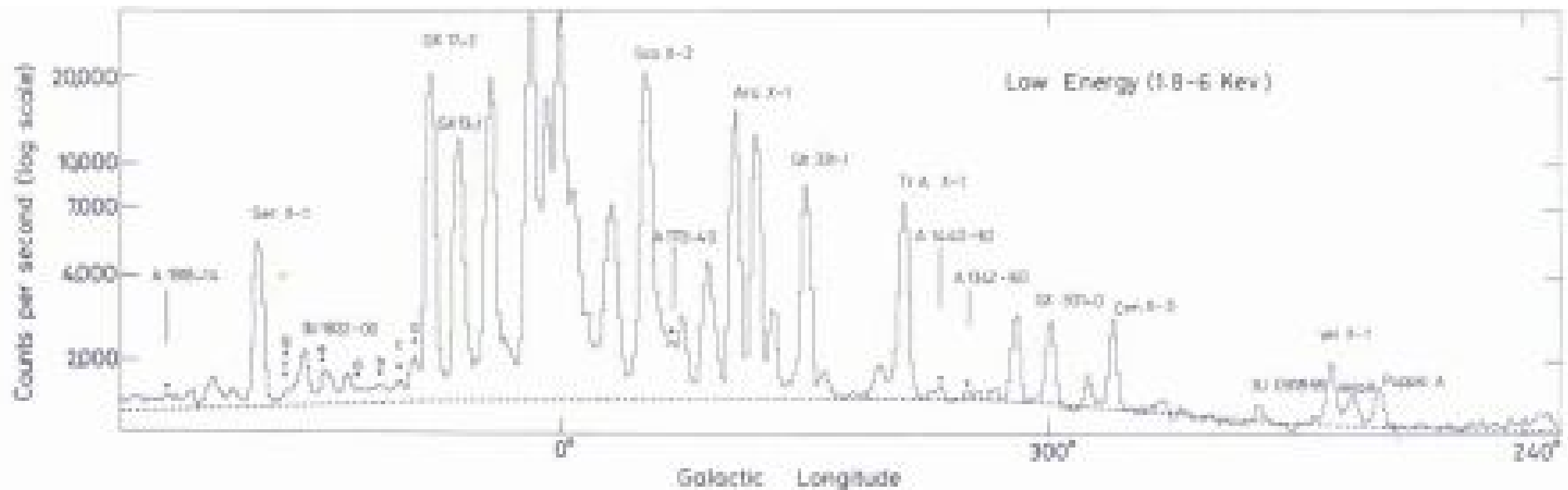


Fig. 1.3 An orbital X-ray scan of the central half of the galactic plane. Two detectors scanned the sky, each with  $0.7^\circ \times 1.0^\circ$  field of view. The two collimators were beamed at different angles to and so were located in great circles do not appear at identical longitudes in this figure. Note the improvement in the ability to detect weak sources. (Courtesy of R. Pounds, University of Leicester.)

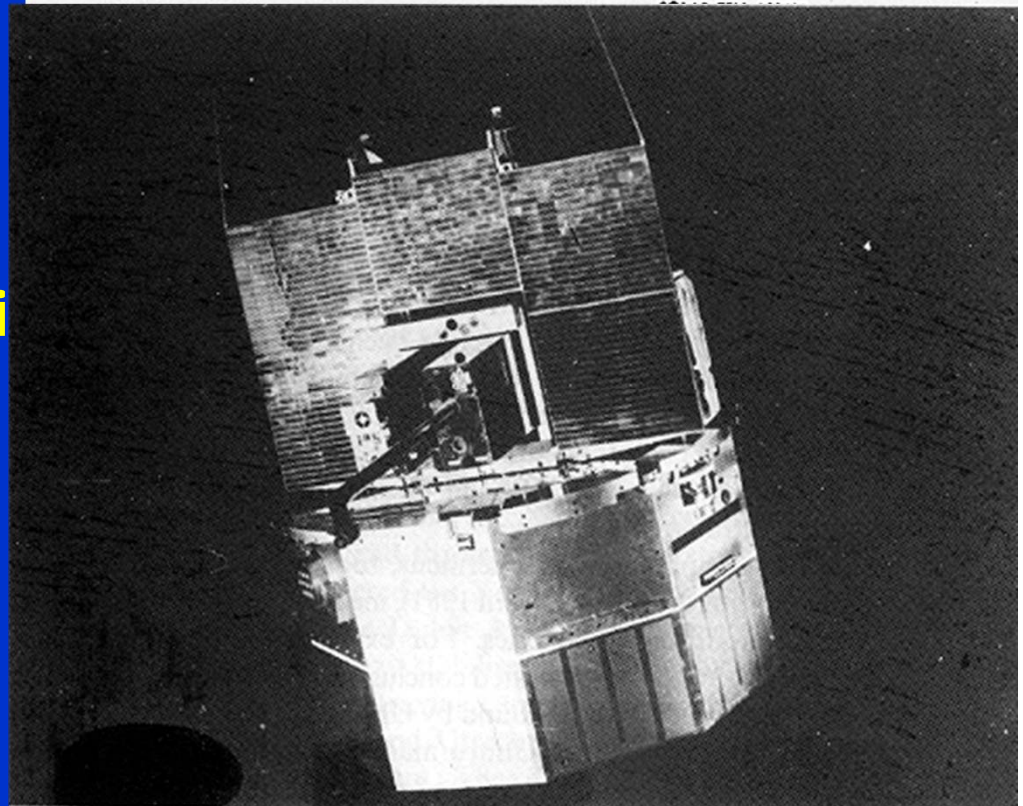
**Dati del satellite inglese Ariel V che ha scoperto l'importanza dell'emissione X dai nuclei delle galassie attive (AGN) e della riga di emissione del Fe, pulsars, transienti**



**OSO-7 Orbiting Solar Observatory U.S.A.**  
**Lancio: 29 settembre 1971 terminato 9 luglio**  
**1974**

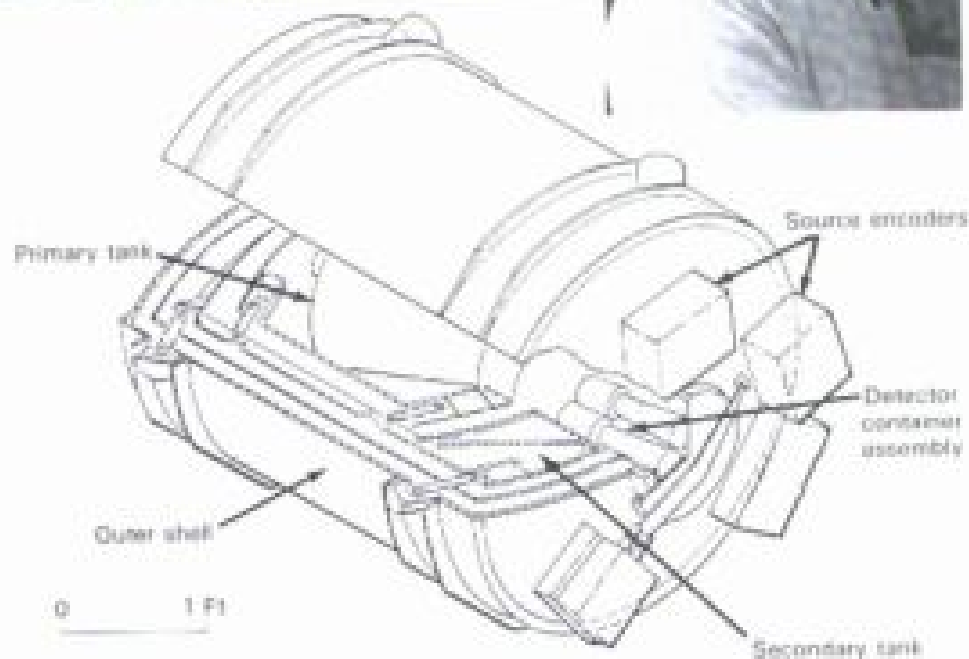
**Energia: 1keV-10MeV**

**Survey X,**  
**Periodicità in Vela X-1,**  
**Gamma da flares solari**





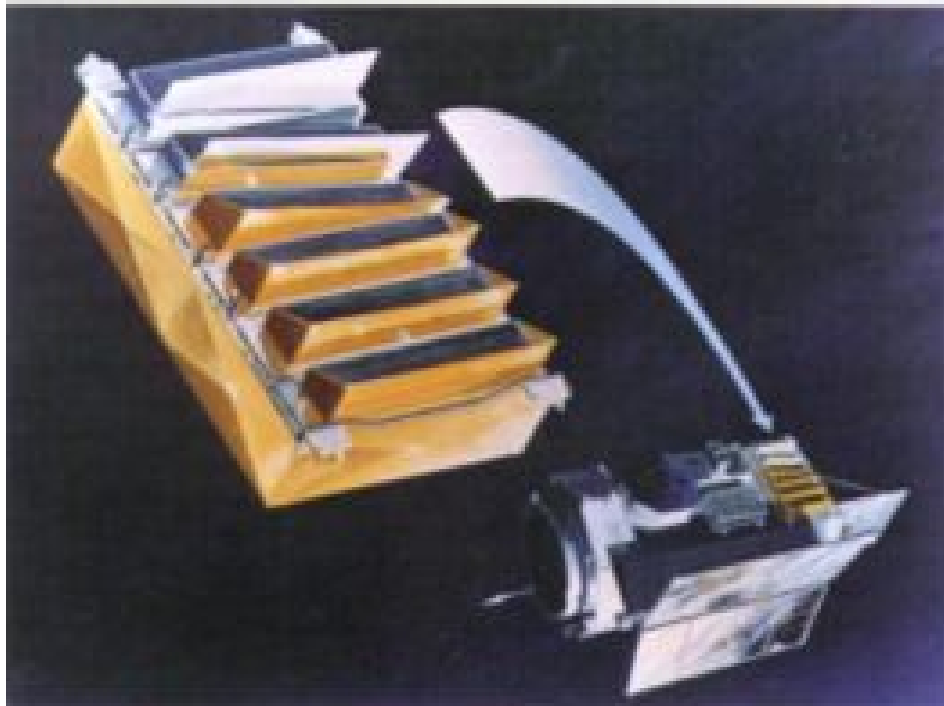
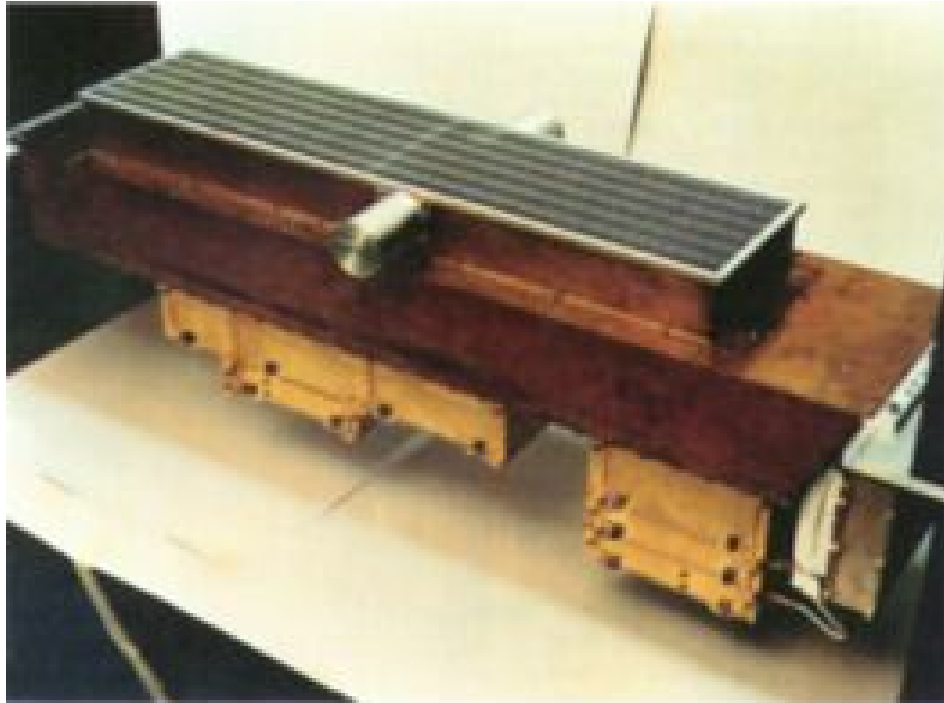
**Il satellite HEAO-1  
con i pannelli solari  
montati che  
fornivano 400 W di  
potenza necessari  
ad operare  
l'osservatorio**



**Spettrometro a stato solido, esperimento B-5, volato su HEAO-1**

**I cristalli di germanio e silicio erano raffreddati con metano e ammoniaca solidi.**

**Scienziato responsabile: Elihu Boldt del Goddard Space Flight Center della NASA**



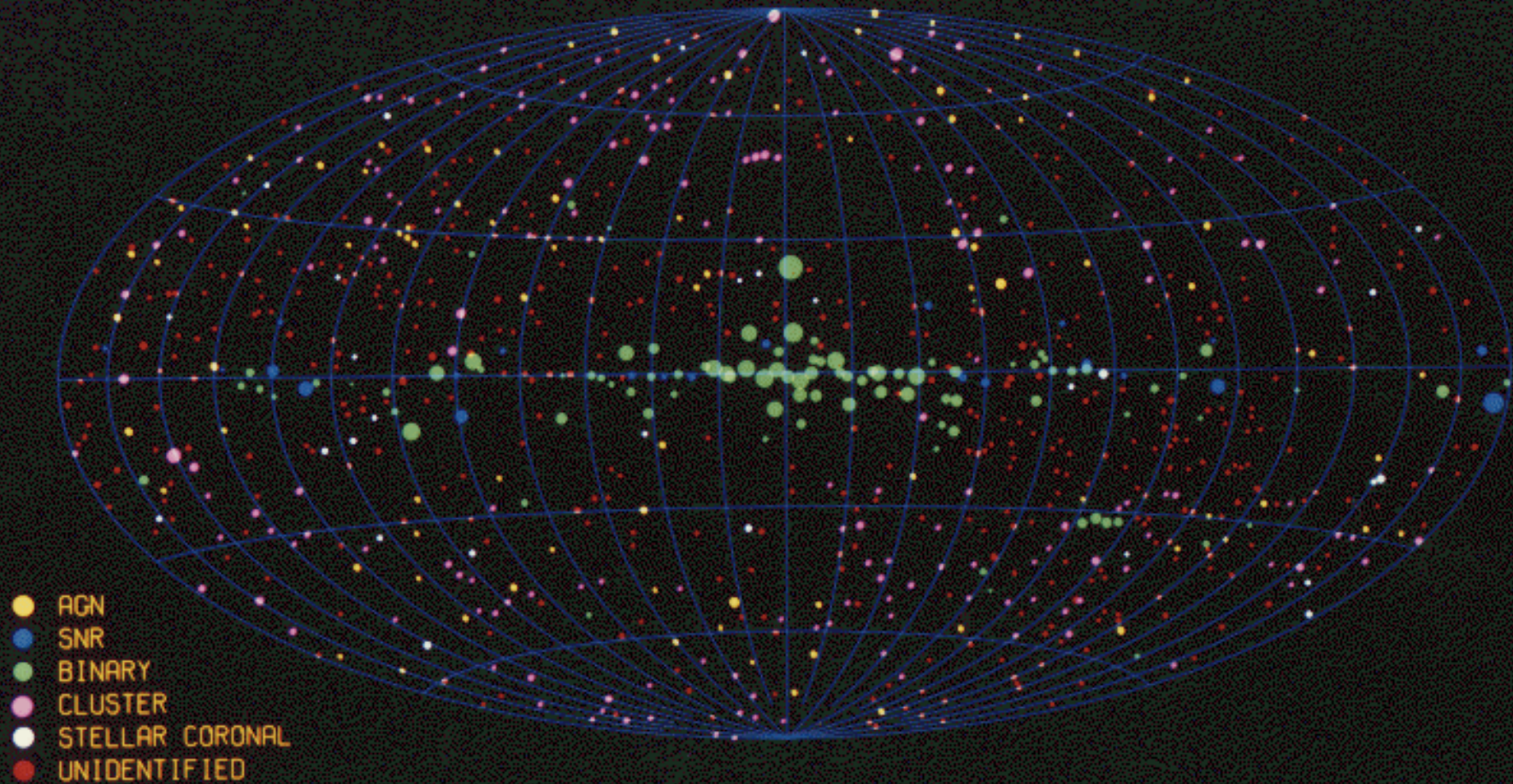
**Esperimento A-2 a bordo  
di HEAO-1 per rivelare  
Raggi X Cosmici**

**Sei rivelatori collimati di  
contatori proporzionali  
con finestre sottili e  
relativa elettronica per  
misurare emissione ed  
assorbimento di raggi X  
con energia compresa tra  
0.2 e 60 keV**

**Scenziato responsabile  
Elihu Boldt del GSFC della  
NASA**

# HEAO A-1 ALL-SKY X-RAY CATALOG

NAVAL RESEARCH LABORATORY





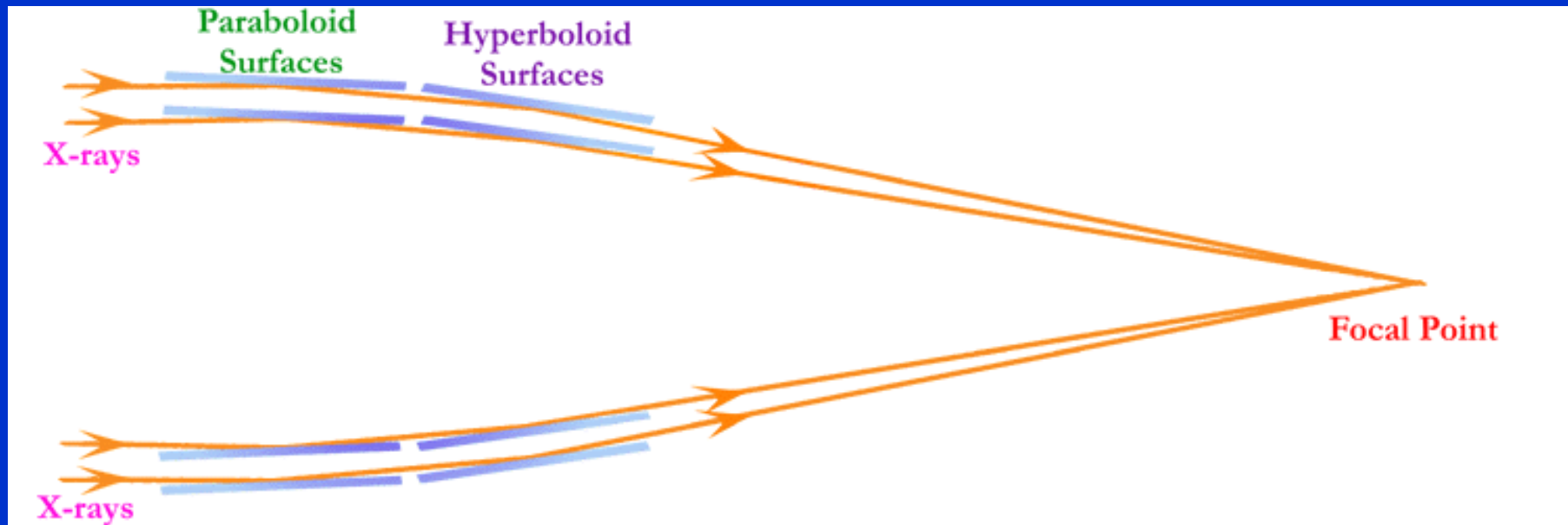
**Il satellite HEAO-2, in volo rinominato Einstein, con gli specchi montati per le ultime prove a terra.**

**Foto presa alla Perkin-Elmer Corp.**

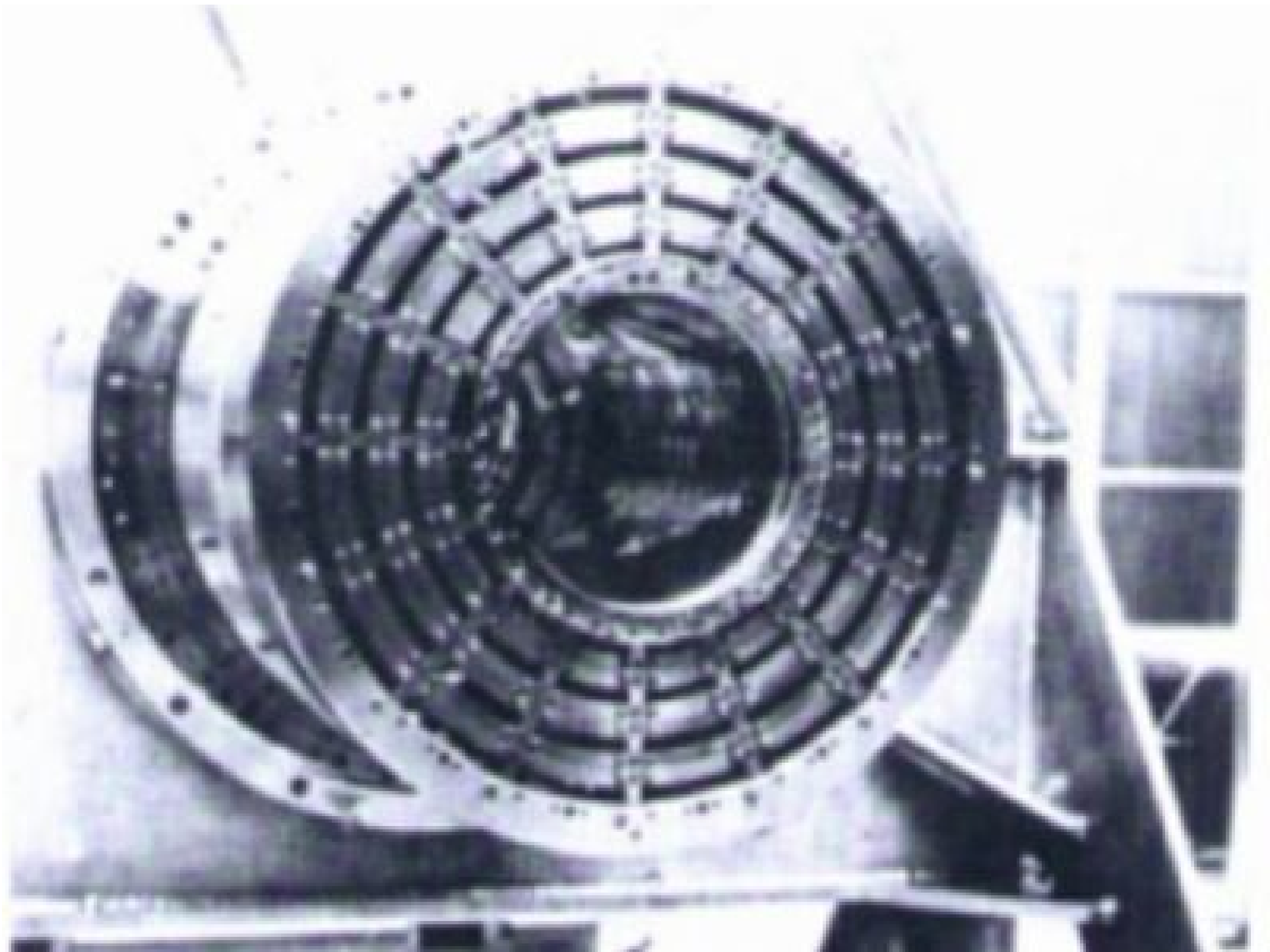
**Primo strumento che produce immagini**

**Lancio: 12 Novembre 1978 terminato Aprile 1981**

**Spettroscopia ad alta risoluzione, sorgenti in Andromeda, gas nelle galassie, X in jets, Survey**



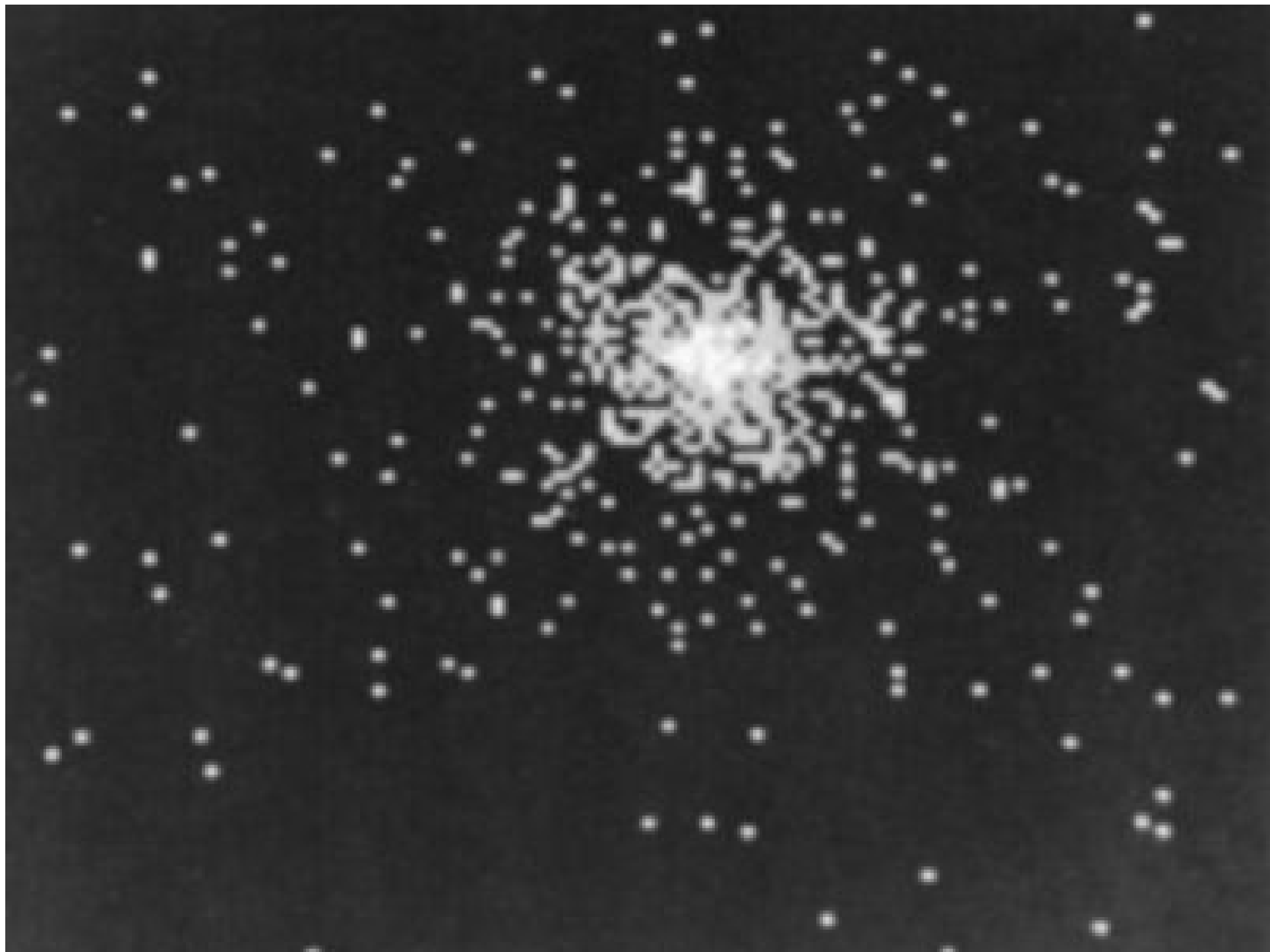
**Principio di funzionamento degli specchi per raggi X**

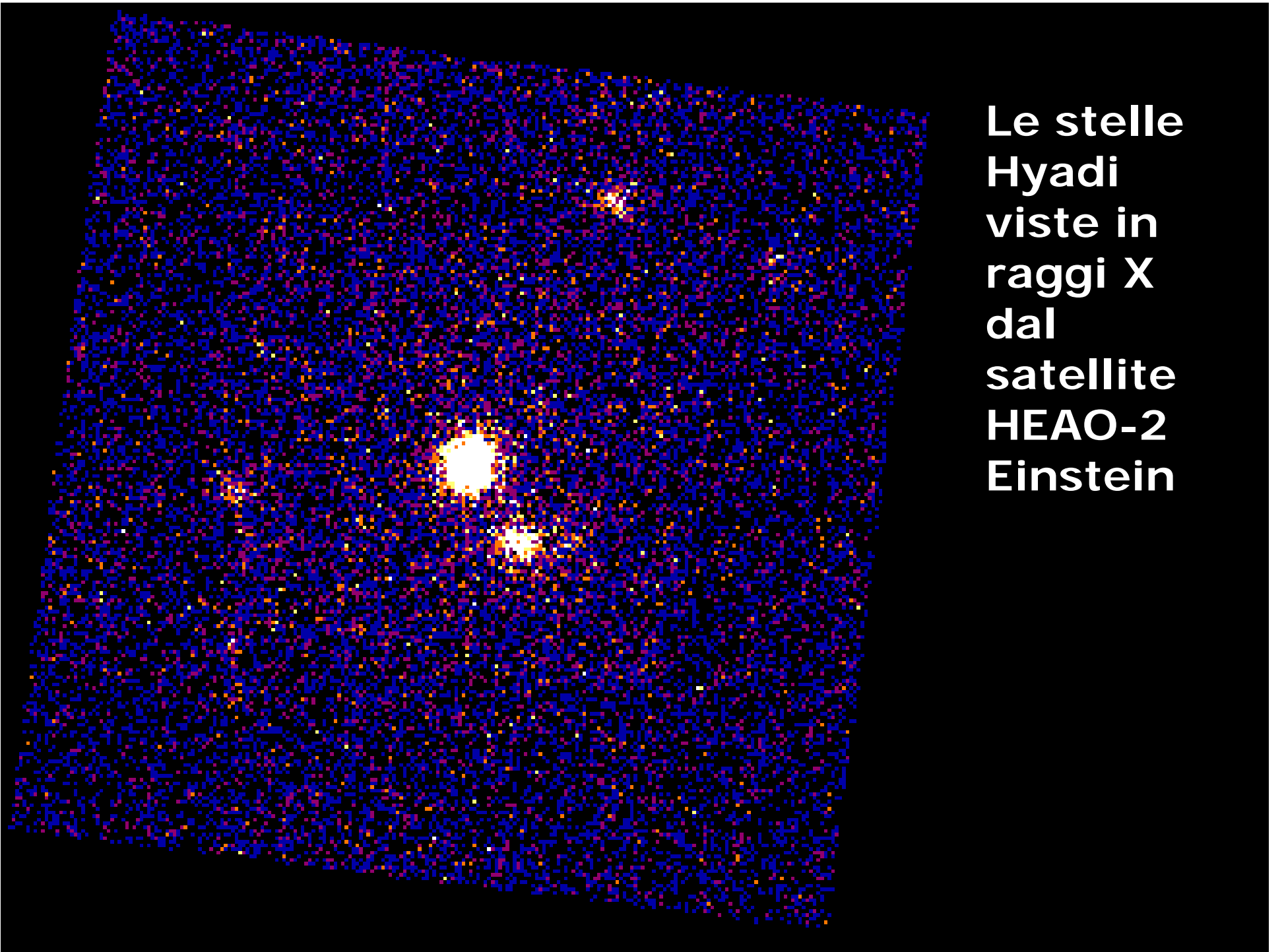




## Sorgente di raggi X per calibrare i telescoppi

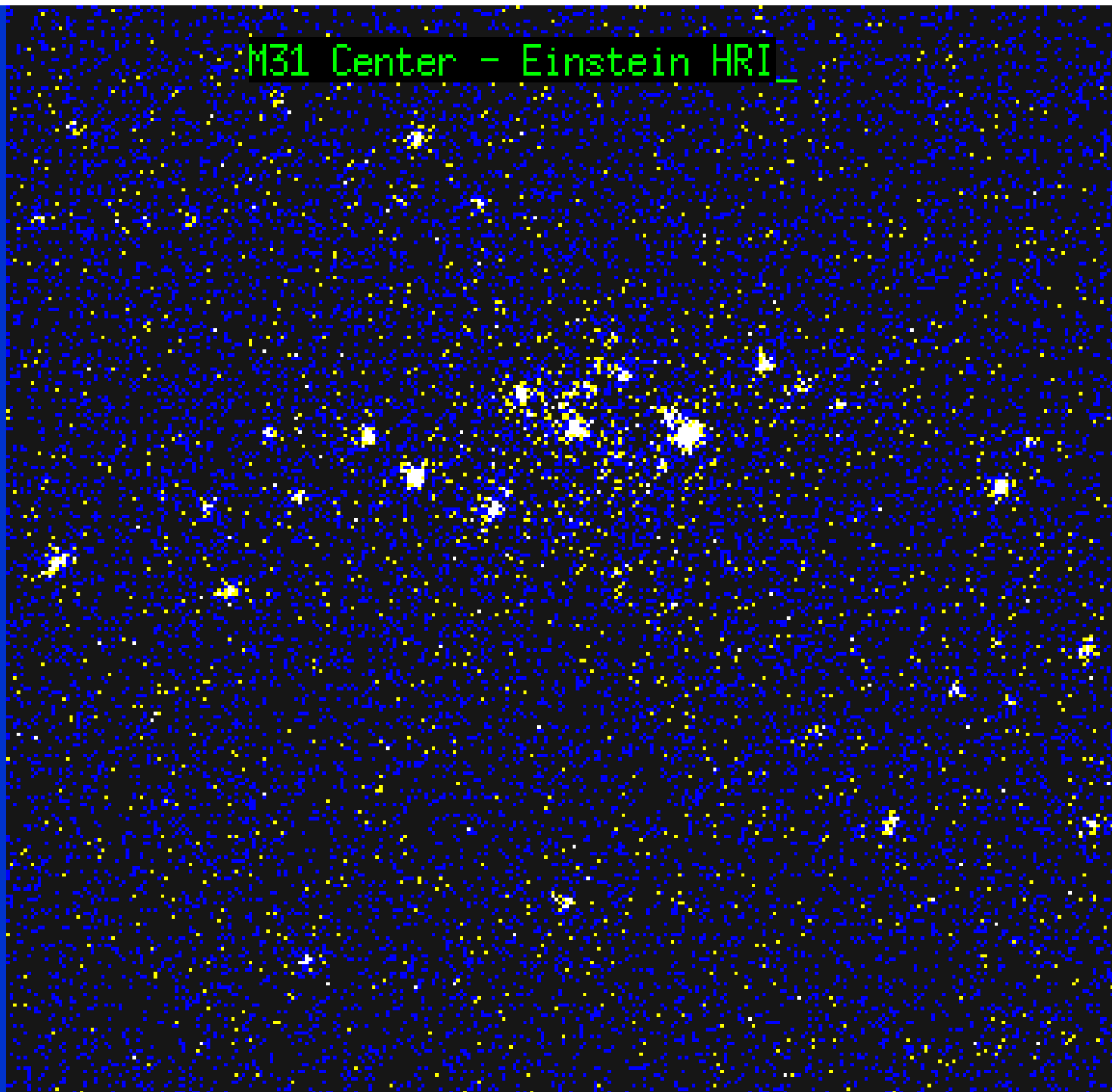




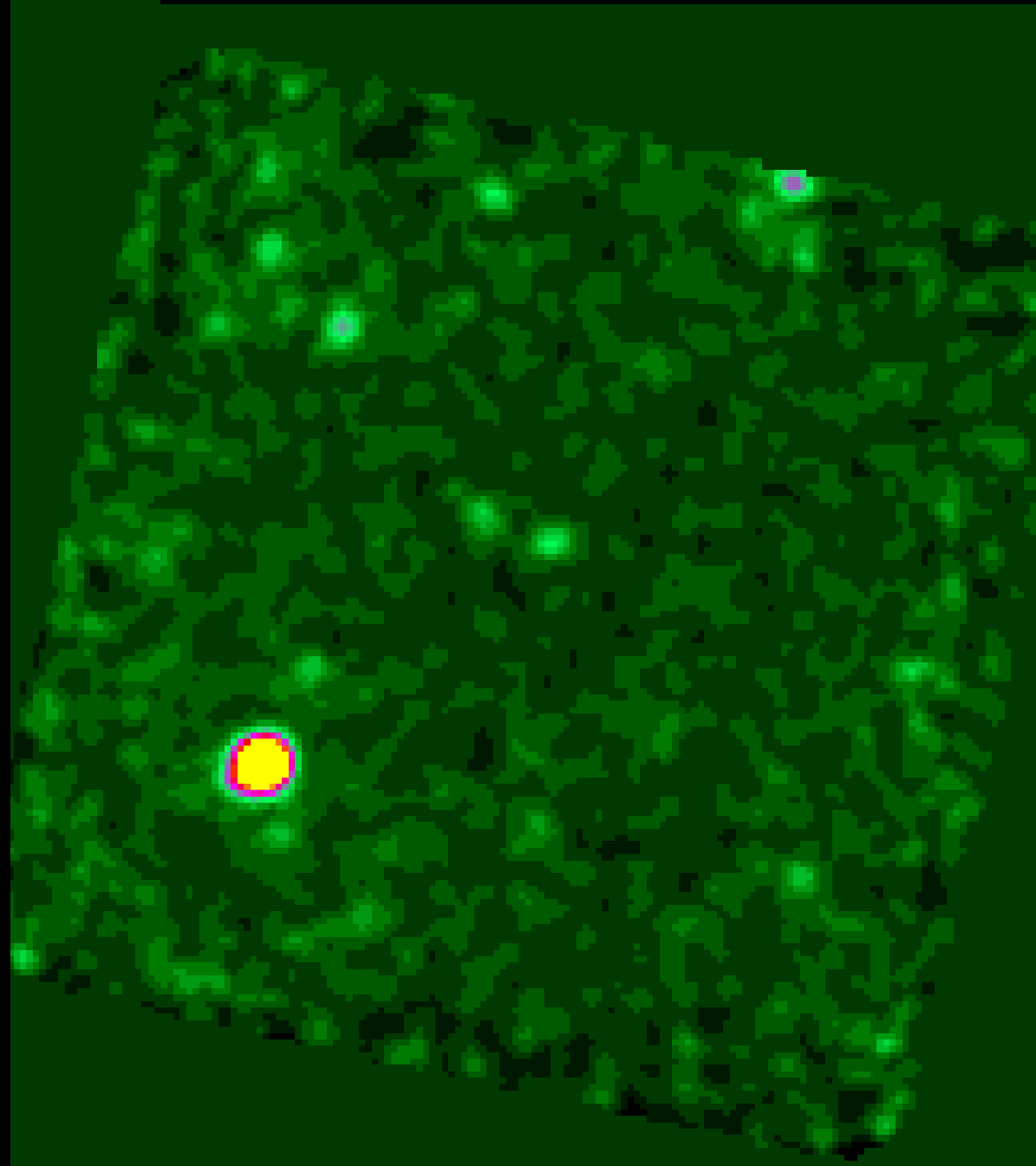


**Le stelle  
Hyadi  
viste in  
raggi X  
dal  
satellite  
HEAO-2  
Einstein**

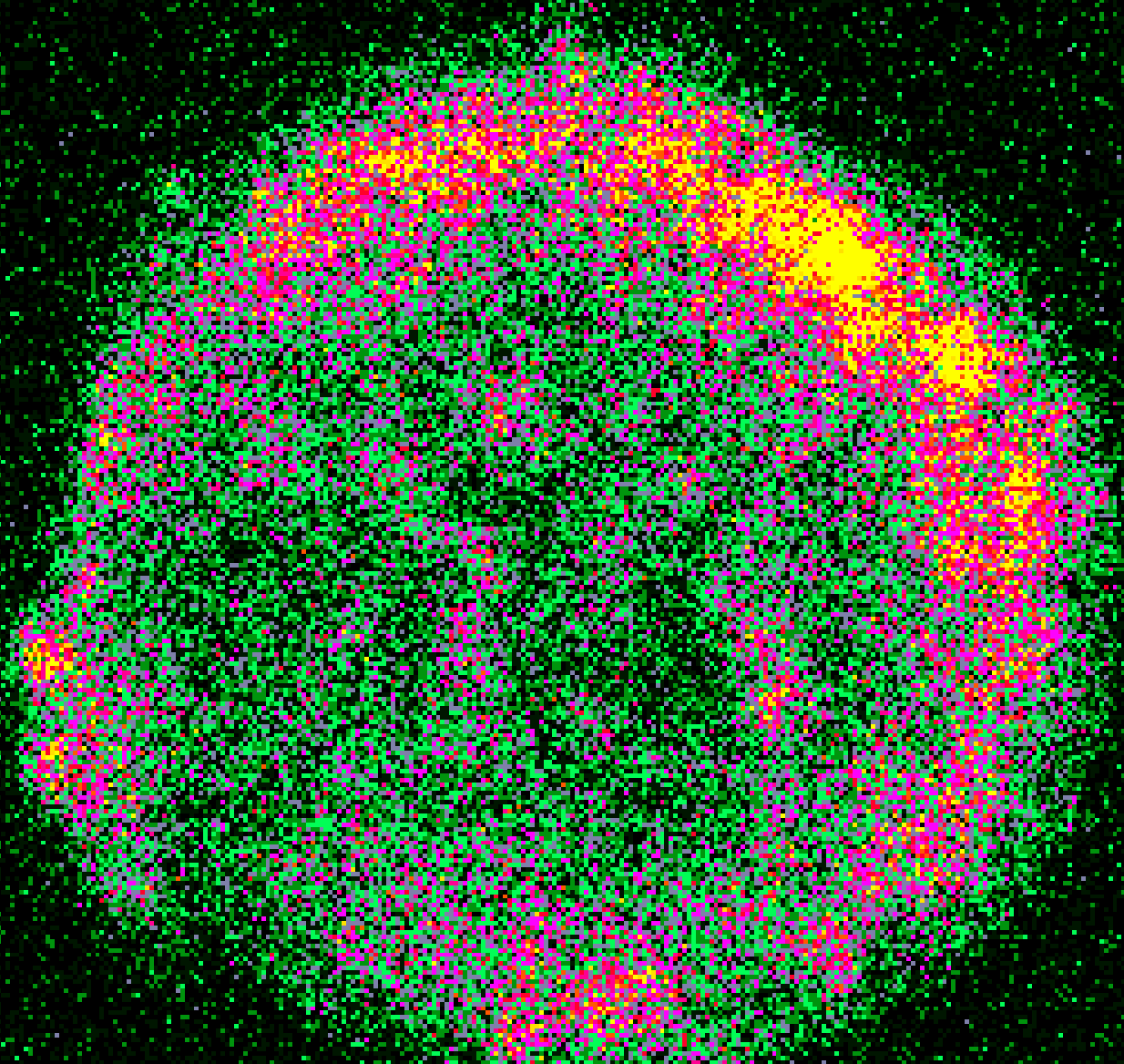
M31 Center - Einstein HRI



Pleiades Star Cluster - Einstein IPC



# Tycho's Supernova Remnant - Einstein HRI





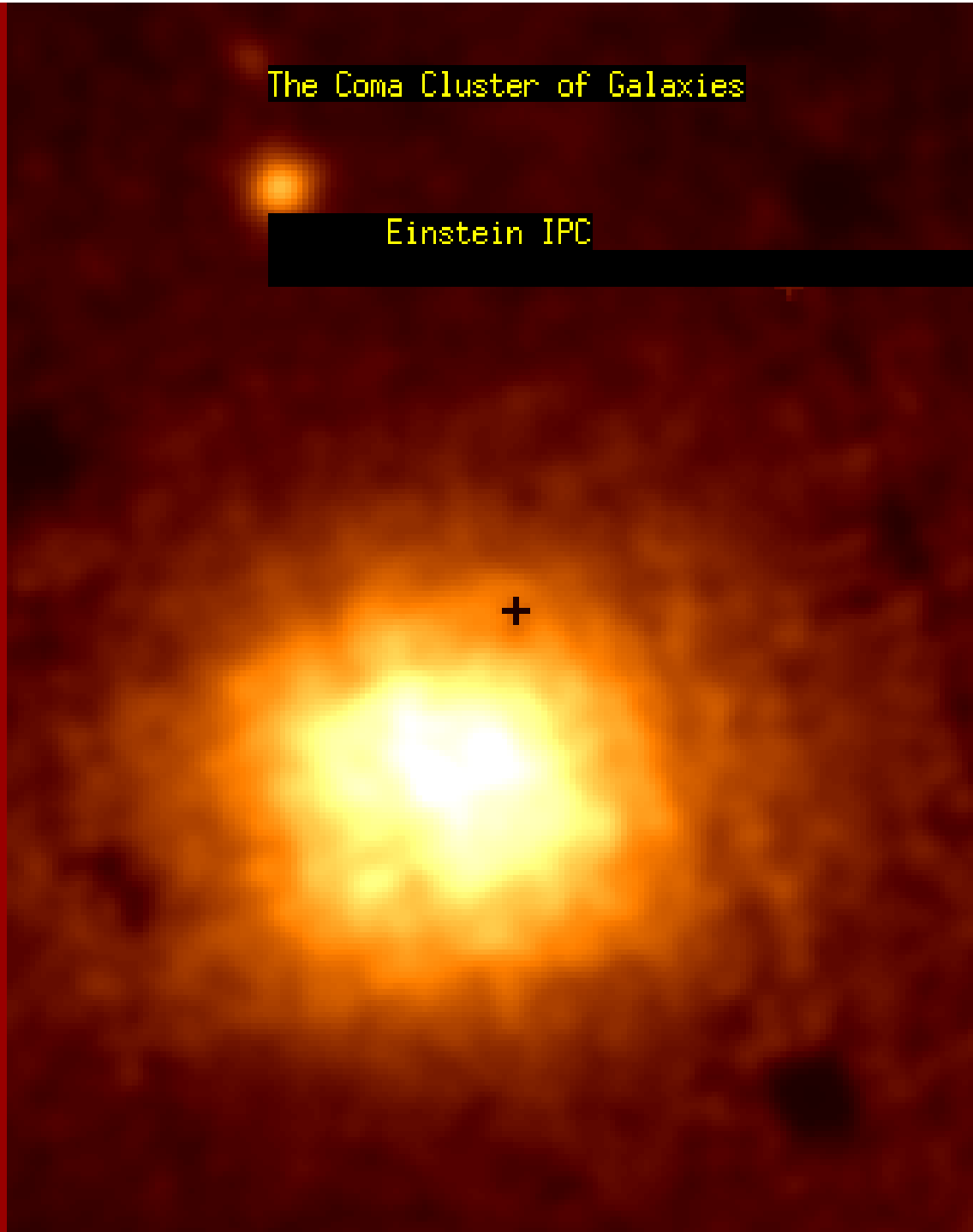
Ammasso di  
galassie in  
Perseo visto  
dal satellite  
Einstein in  
raggi X

Non si  
vedono le  
singole  
galassie ma  
il gas diffuso  
nello spazio  
tra una  
galassia e  
l'altra  
ritenuto fino  
ad allora  
"vuoto"

The Coma Cluster of Galaxies

Einstein IPC

+



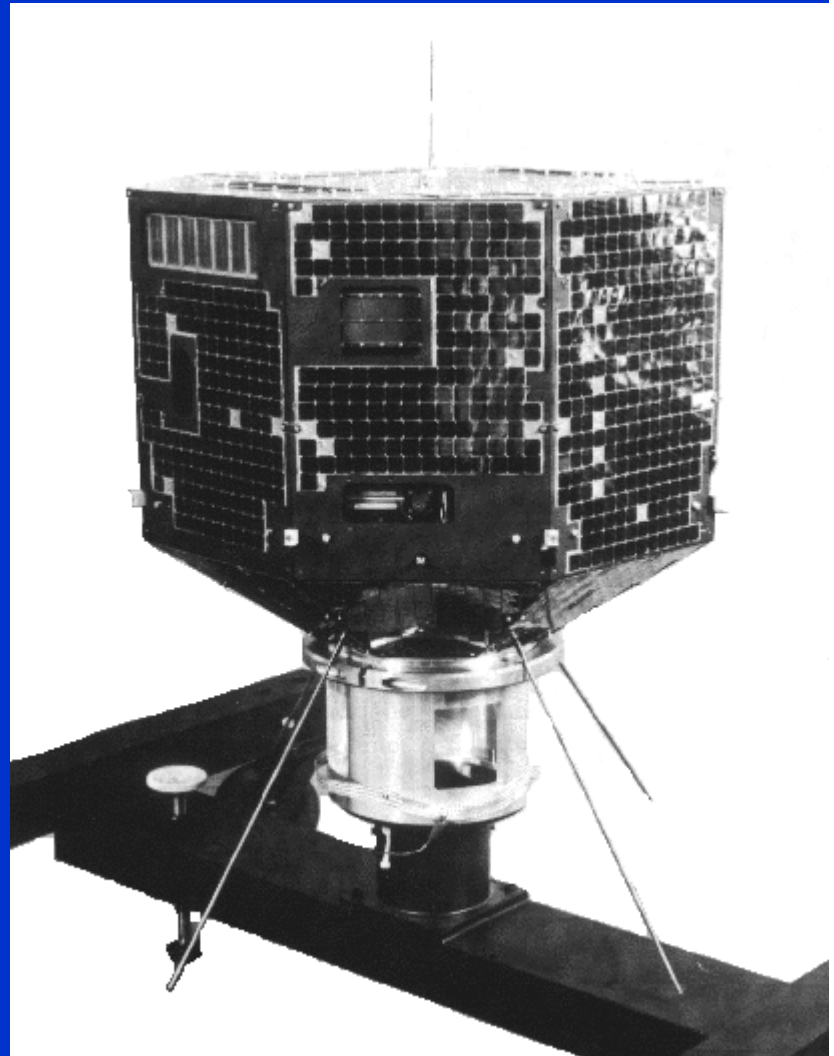


## Hakucho Giappone

lancio: 21 febbraio 1979 terminato 16 aprile 1985

energia 0.1-100 keV

transienti e bursts

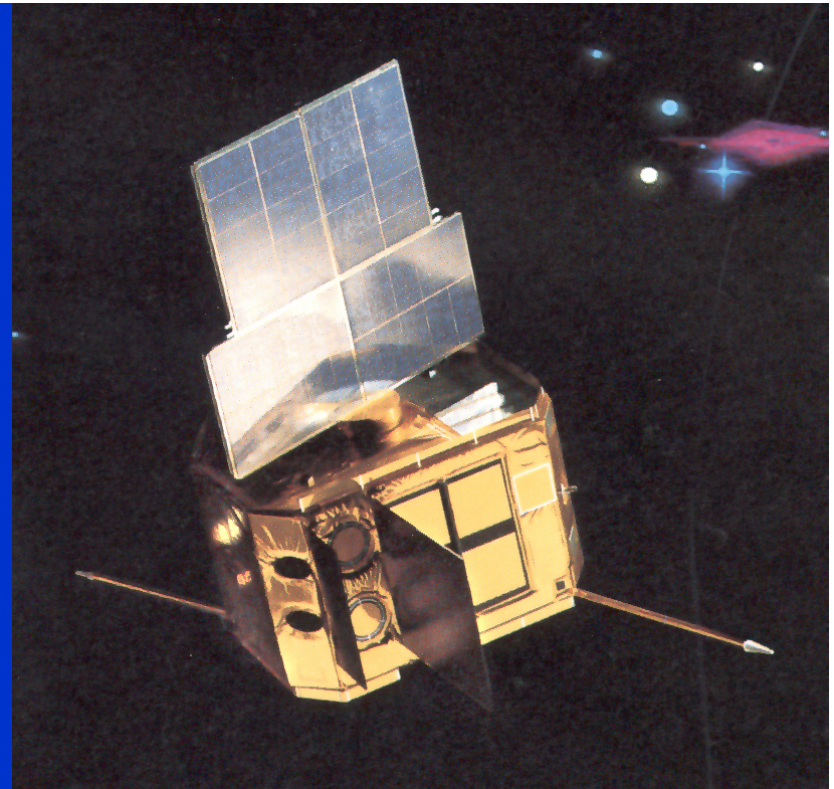


## EXOSAT ESA

lancio: 26 maggio 1983 terminato 9 aprile 1986

orbita molto eccentrica: durata 90 ore

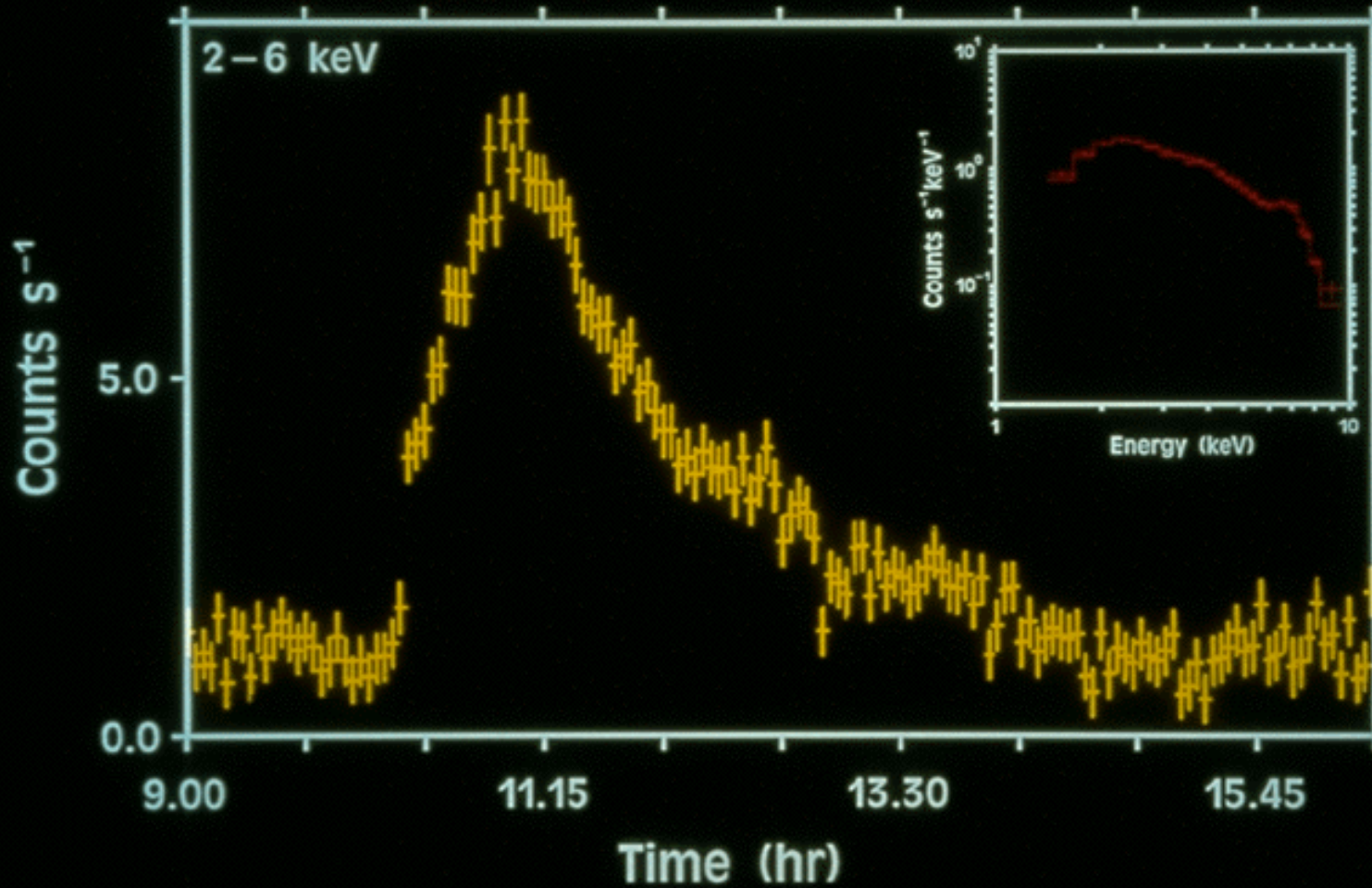
energia: 0.05-2 keV e 1-50keV



**QPOs, binarie nelle Nubi di Magellano, variabilità in AGN, binarie a lungo periodo, Fe in molte sorgenti galattiche ed extragalattiche, spettri ad alta risoluzione e bassa energia.**

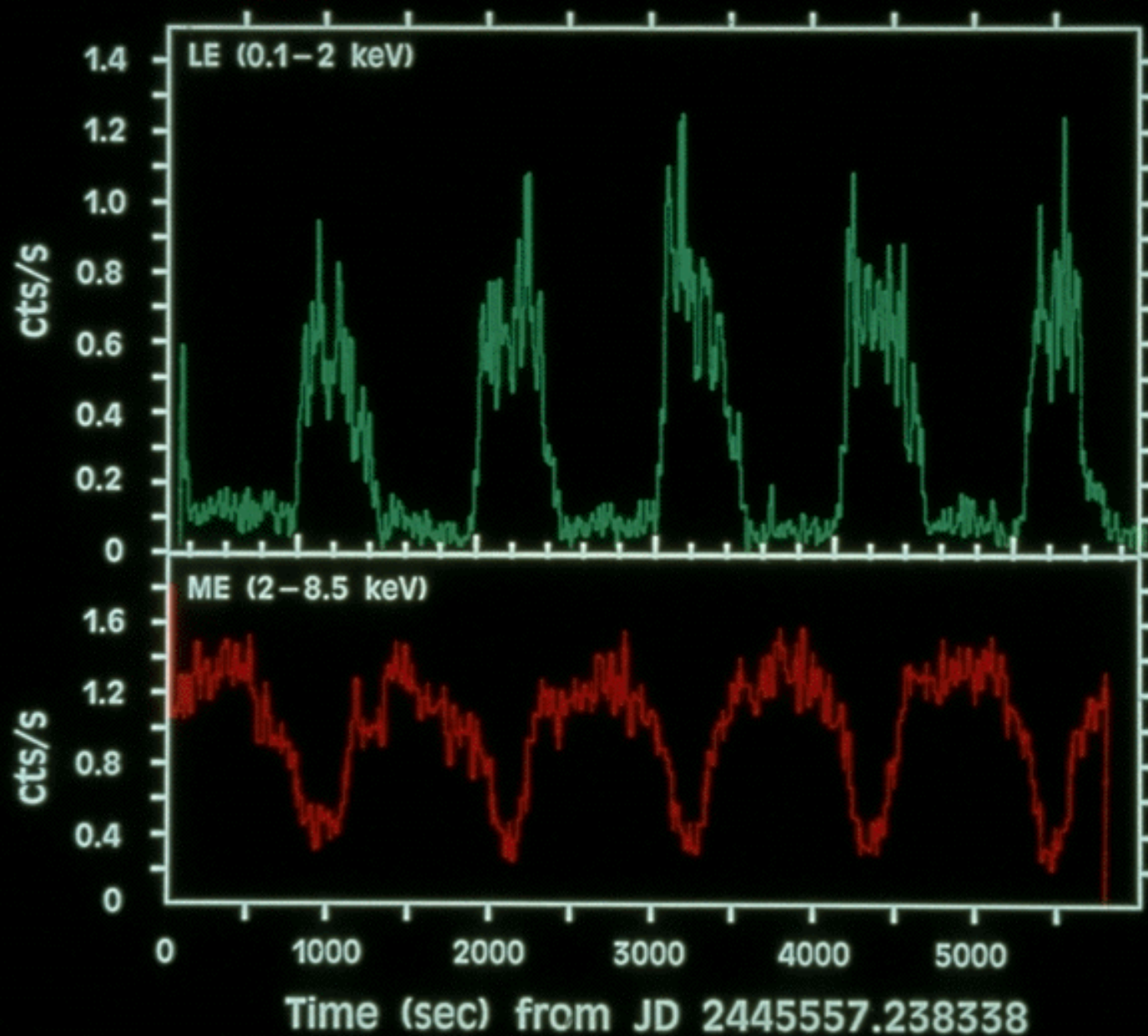
EXOSAT/ME

ALGOL



EXOSAT

AM Her

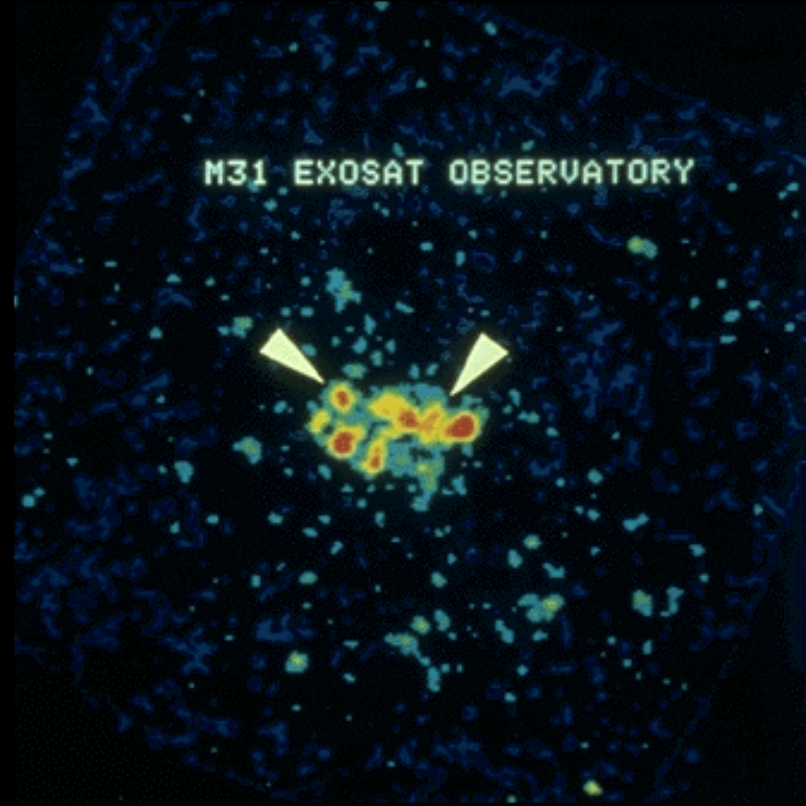




M31 EINSTEIN HRI

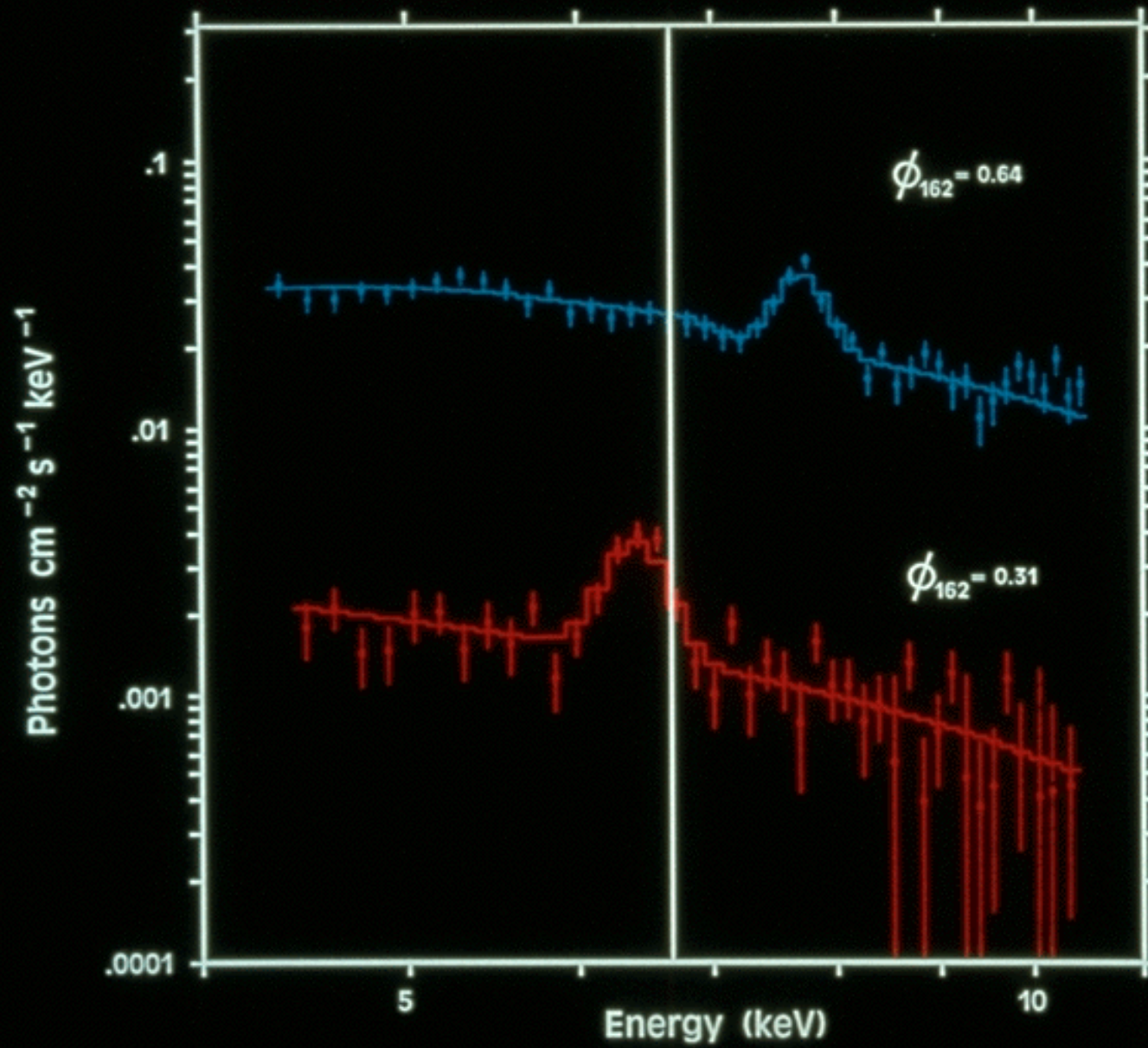


M31 EXOSAT OBSERVATORY



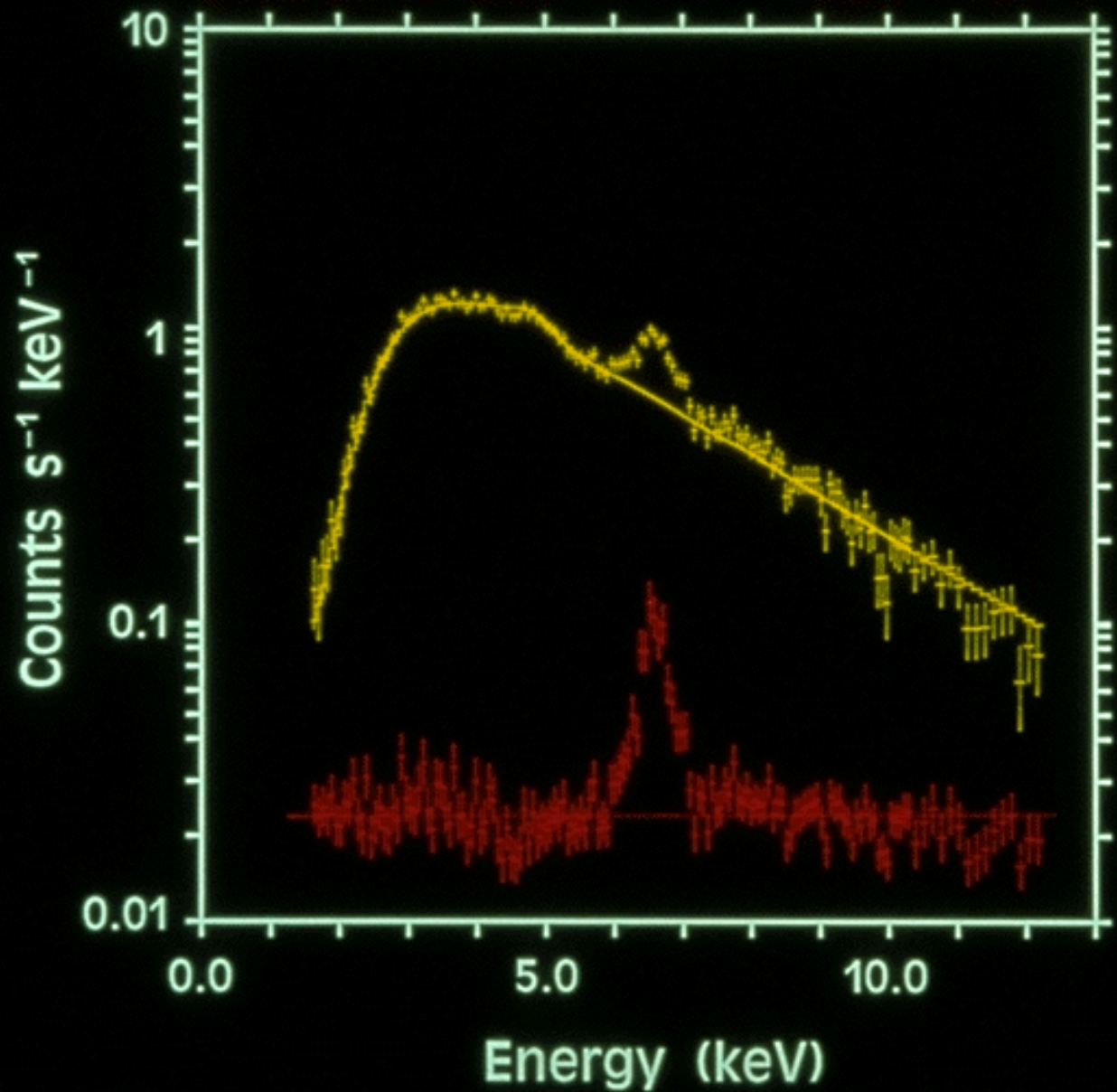
EXOSAT/GSPC

SS 433

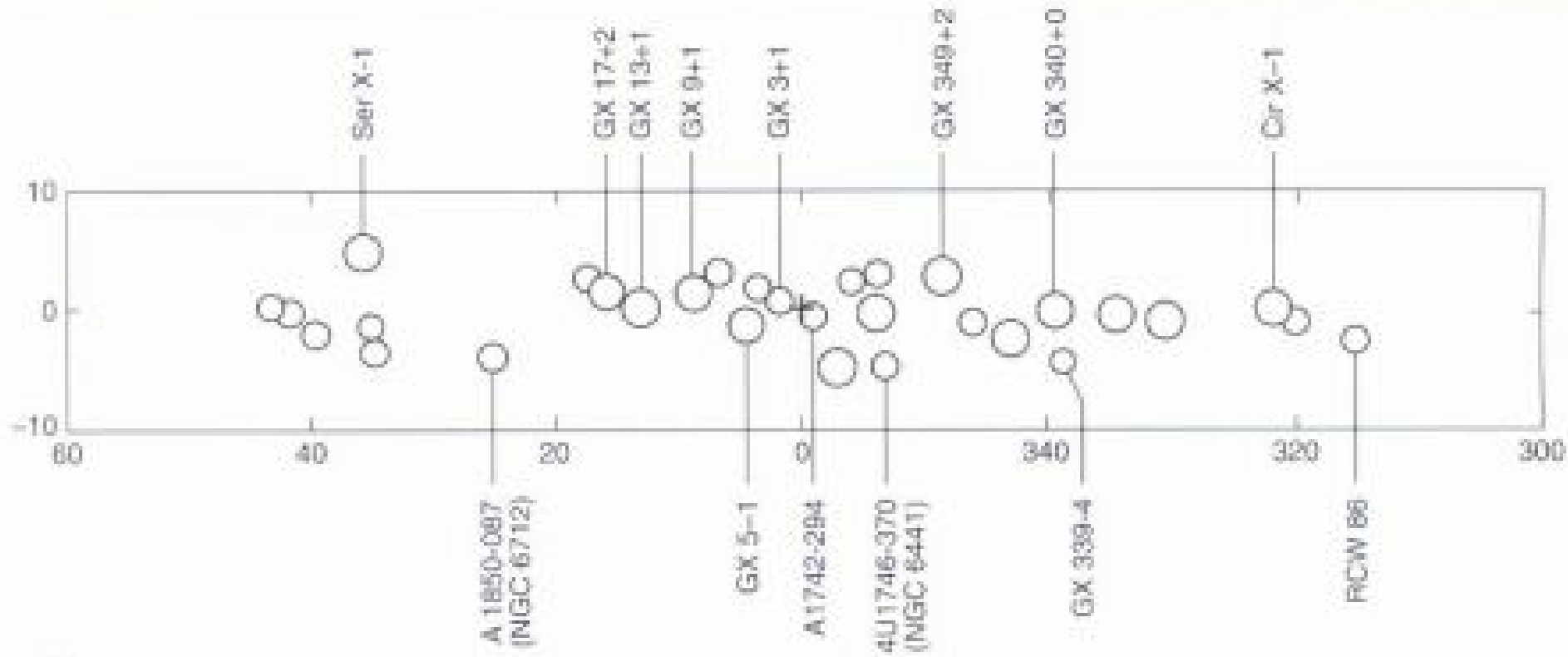
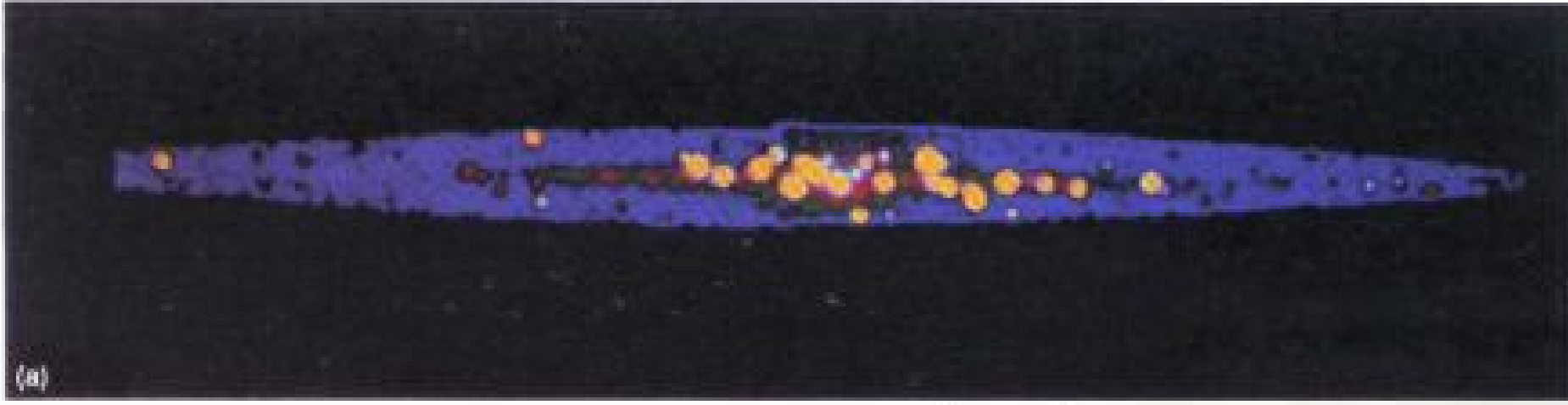


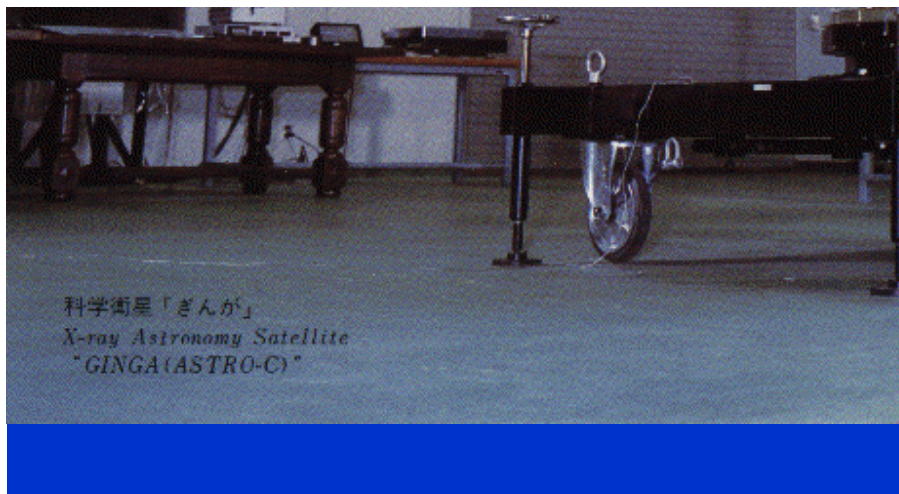
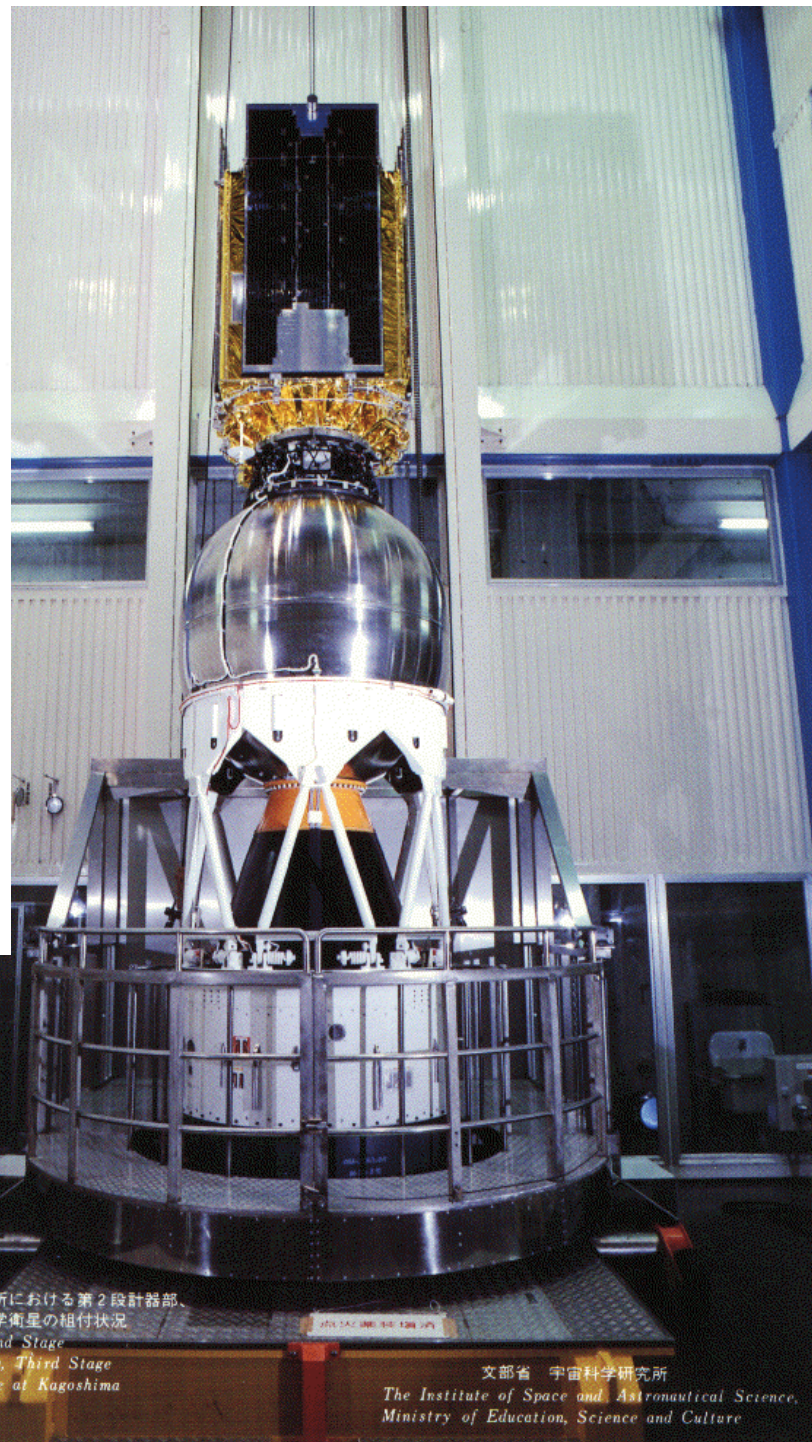
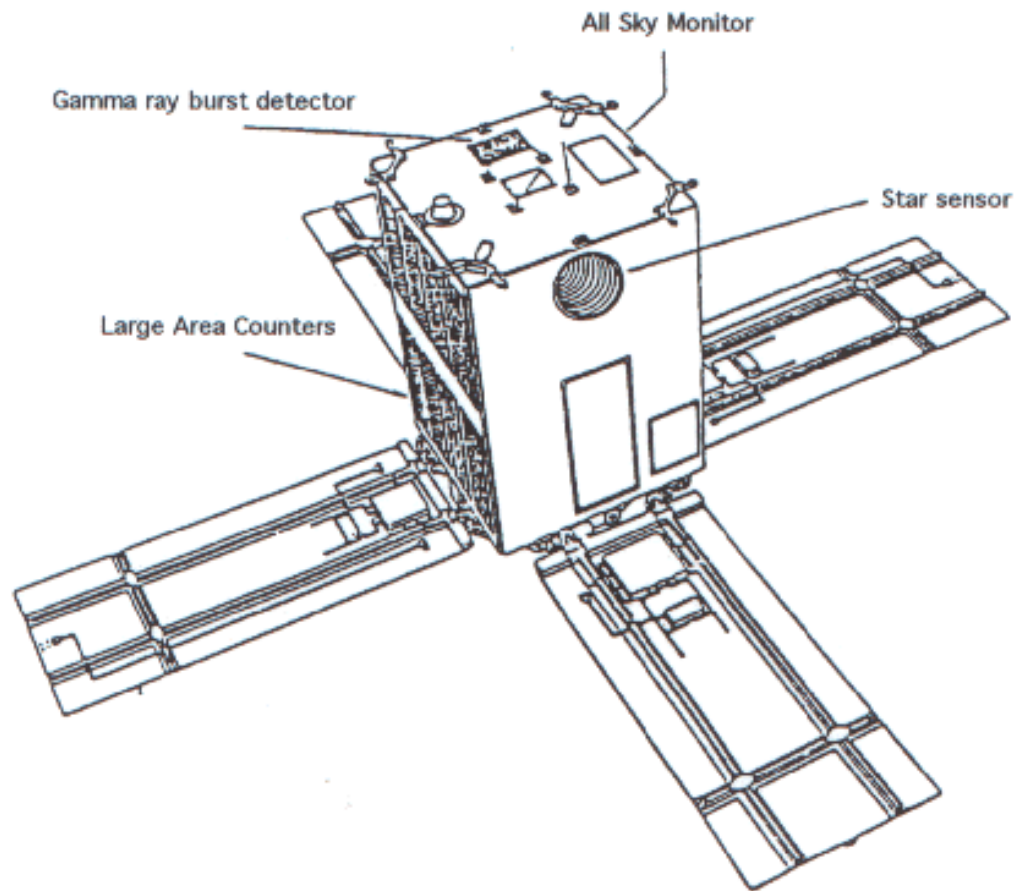
EXOSAT/GSPC

NGC 1275





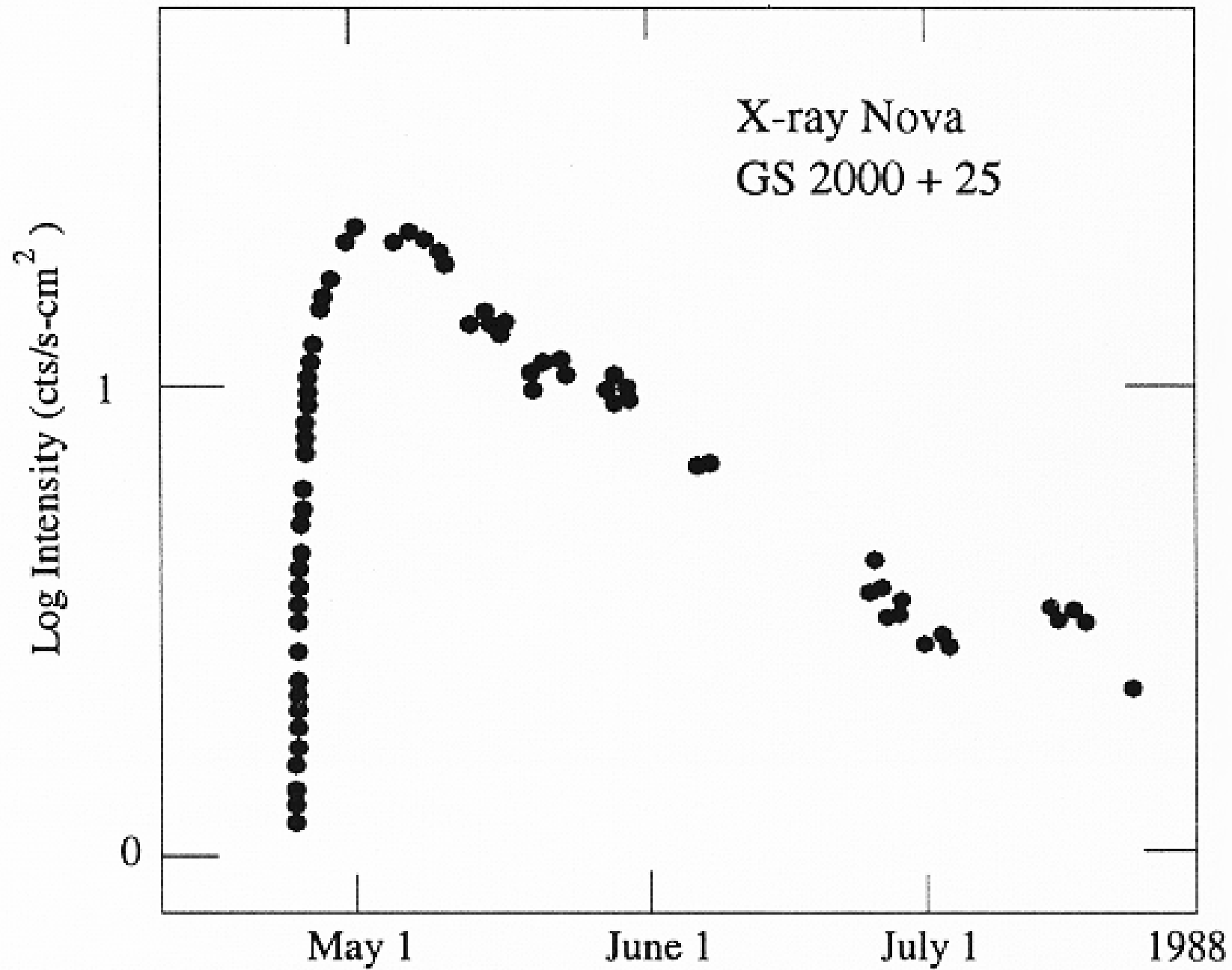


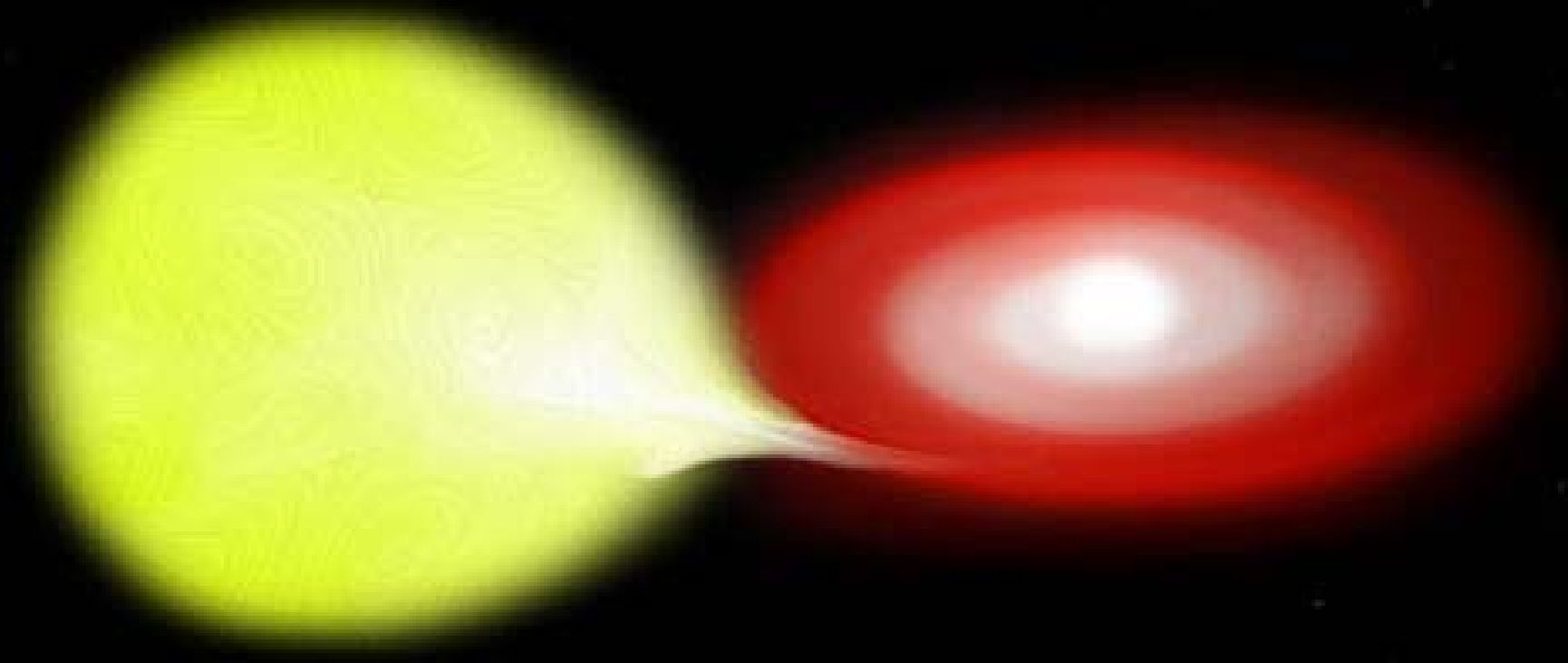


科学衛星「ぎんが」  
X-ray Astronomy Satellite  
"GINGA (ASTRO-C)"

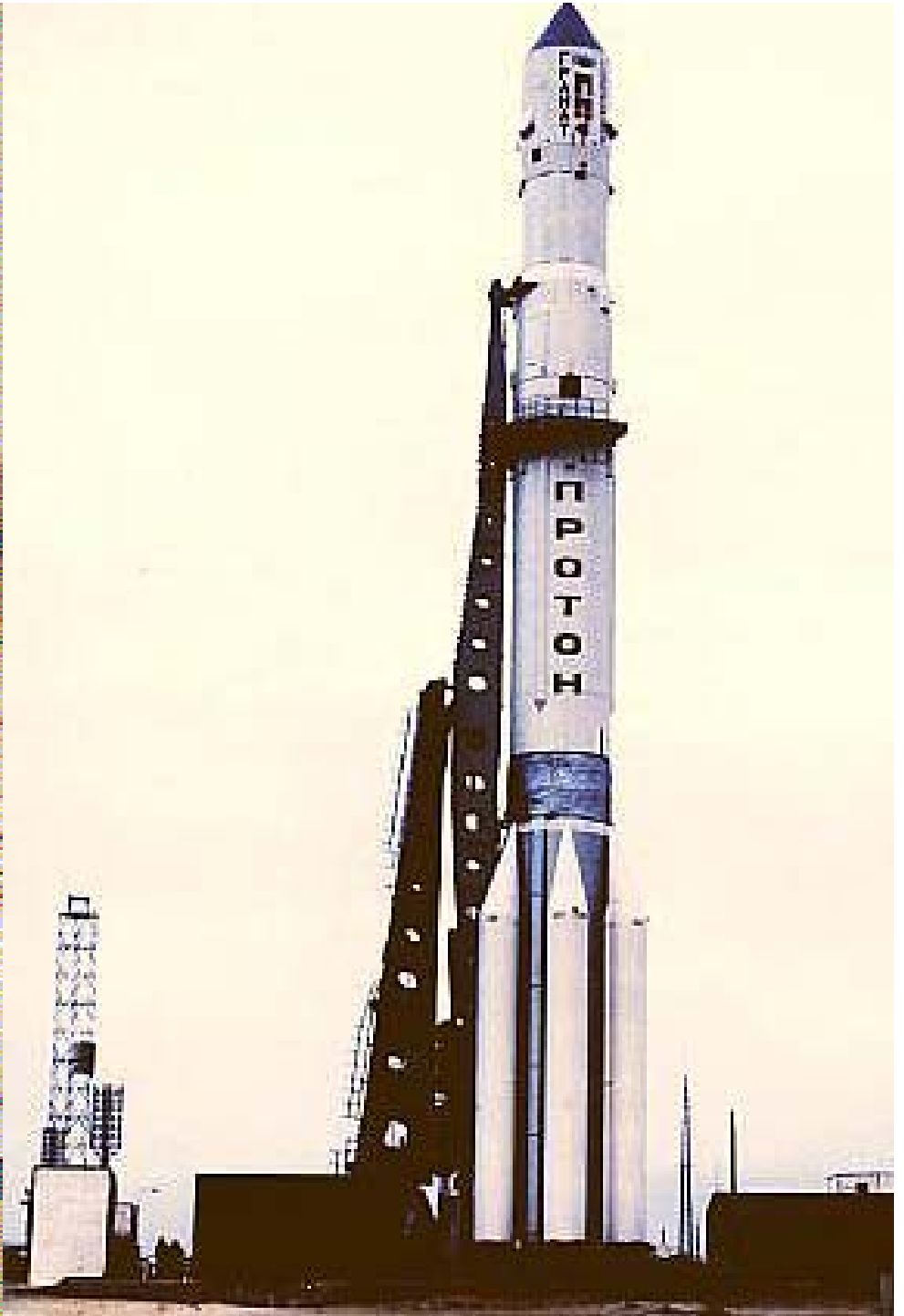
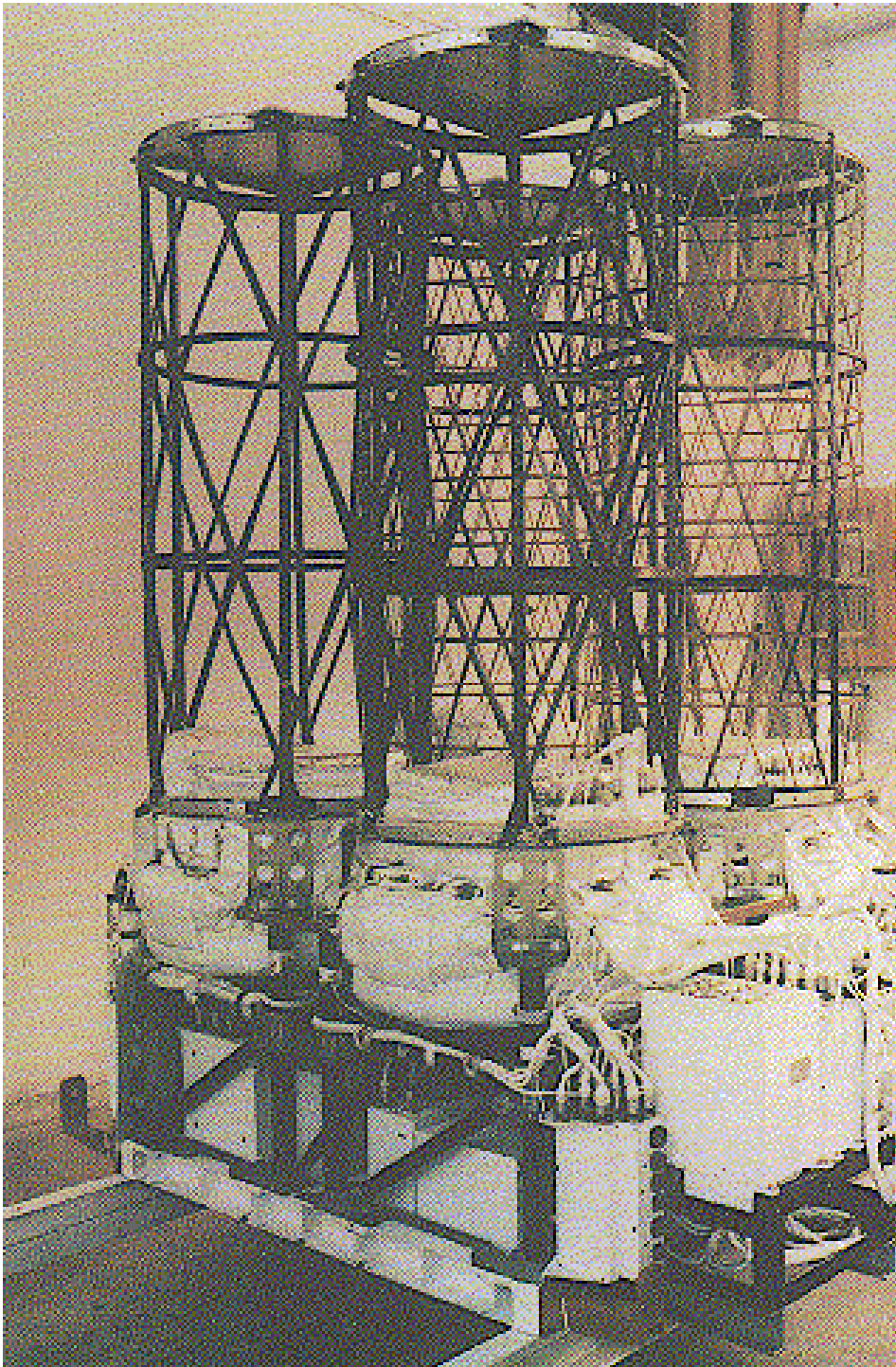
鹿児島宇宙空間観測所における第2段計器部、  
第3段モータ及び科学衛星の組付状況  
Integration of Second Stage  
Instrumentation Bay, Third Stage  
Motor, and Satellite at Kagoshima  
Space Center

文部省 宇宙科学研究所  
The Institute of Space and Astronautical Science,  
Ministry of Education, Science and Culture





**Modello di NOVA: nana bianca in sistema binario**



# ROSAT (Roentgen Satellit)

Germania, USA e UK

Lancio 1 giugno 1990  
terminato

12 febbraio 1999

Energia 0.1-2.5 keV

Survey di tutto il cielo

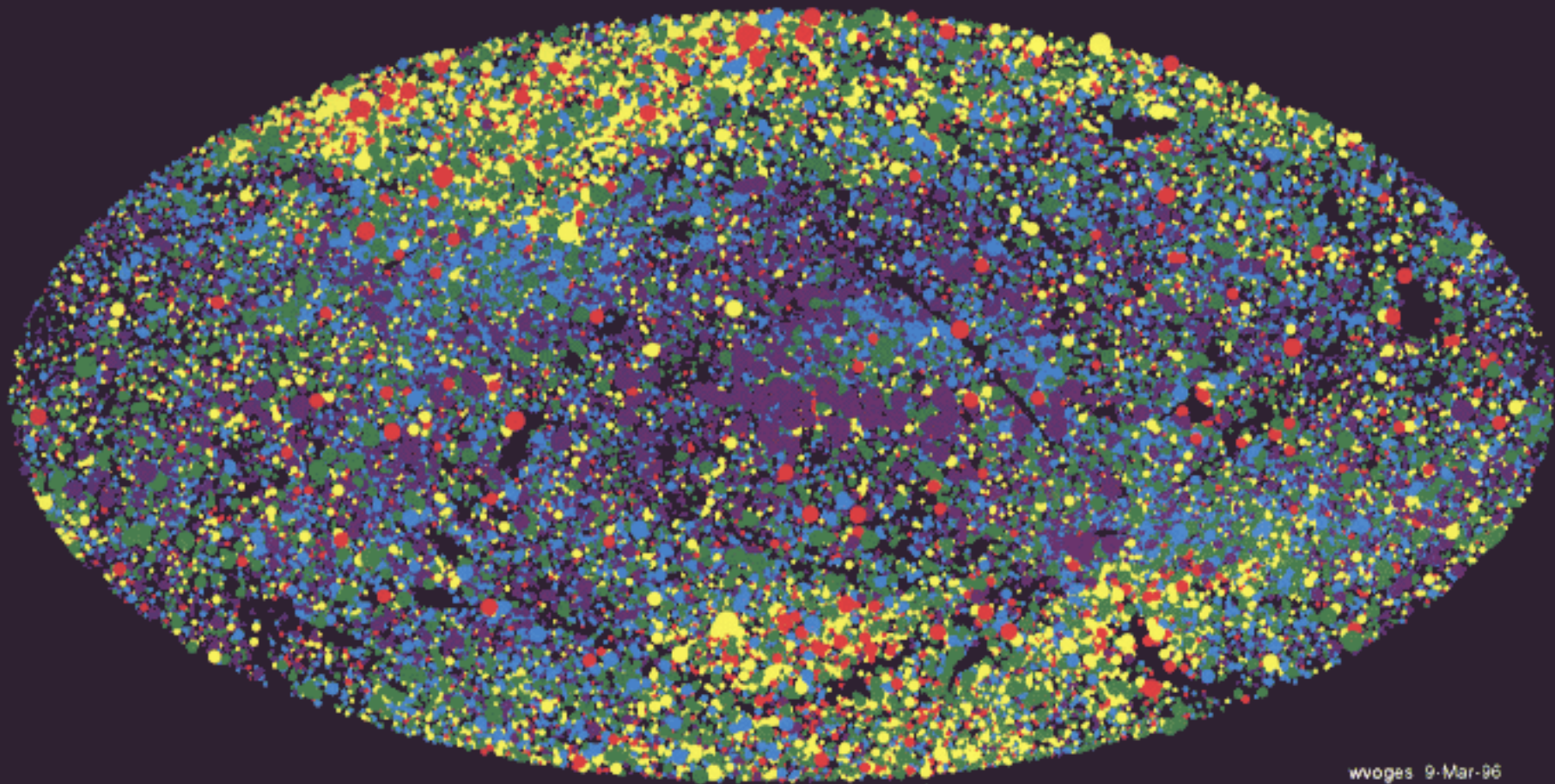
Puntamenti di ogni  
tipo di oggetto

Scopre che le comete  
emettono raggi X



# ROSAT ALL-SKY SURVEY Sources

Aitoff Projection  
Galactic II Coordinate System



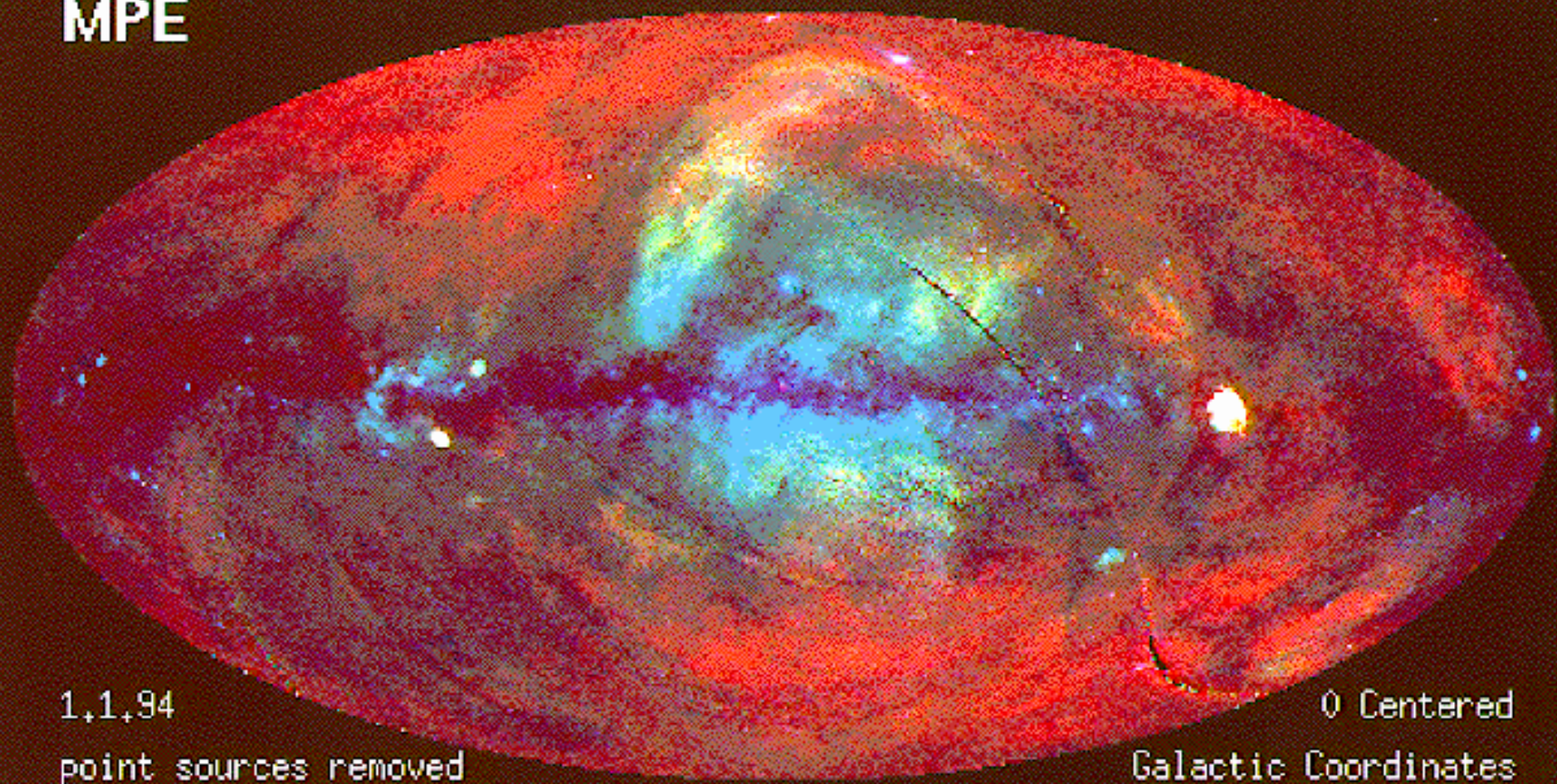
wvoges 9-Mar-96

Energy range: 0.1 - 2.4 keV

ROSAT PSPC  
MPE

All-Sky Survey

Multispectral

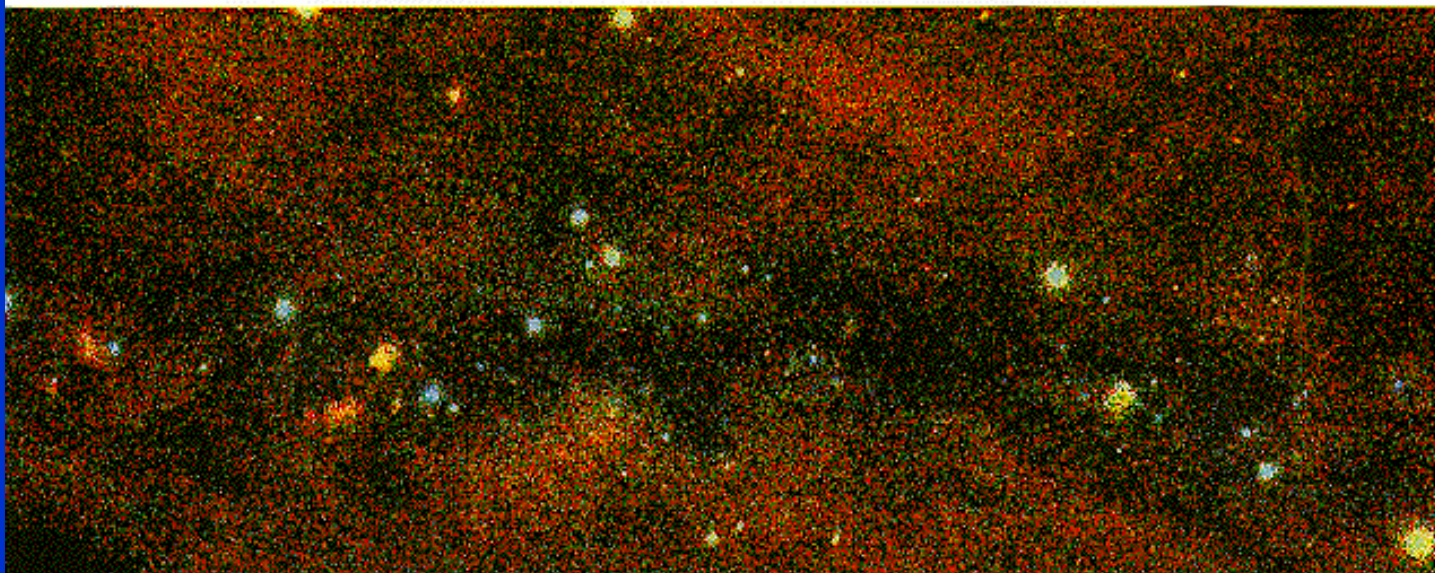
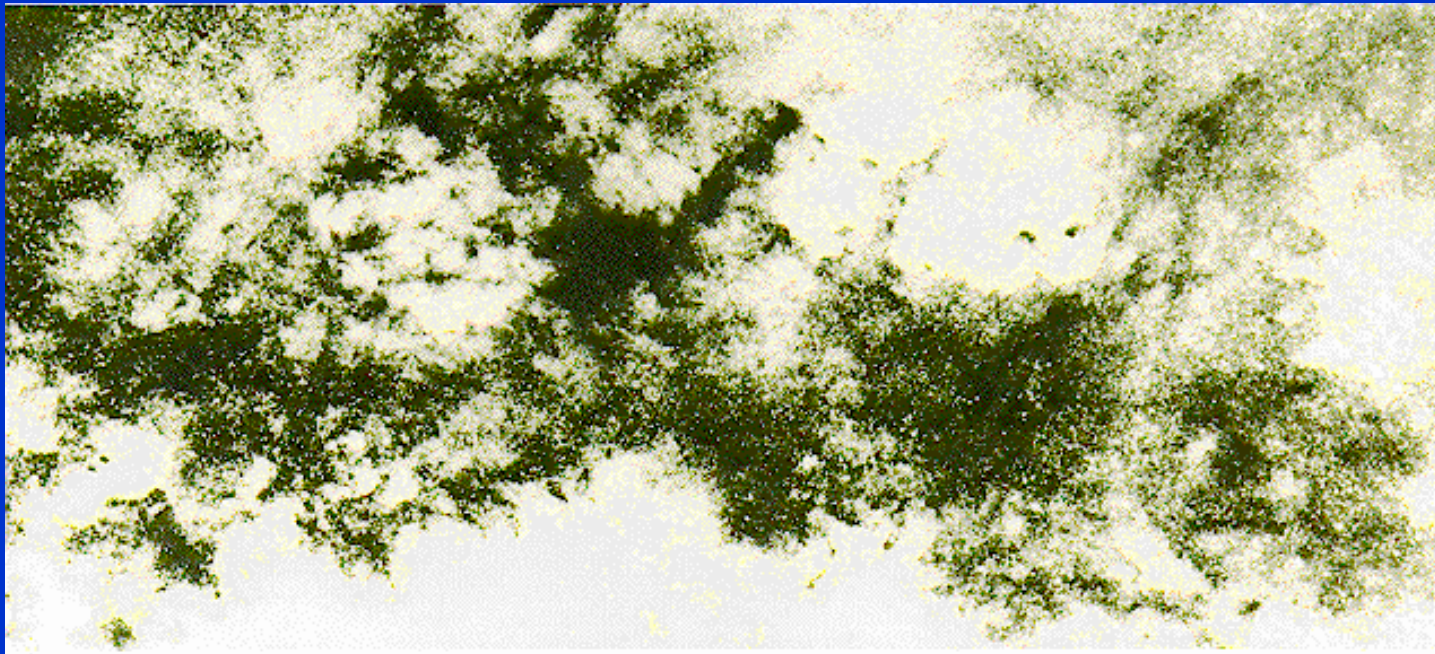


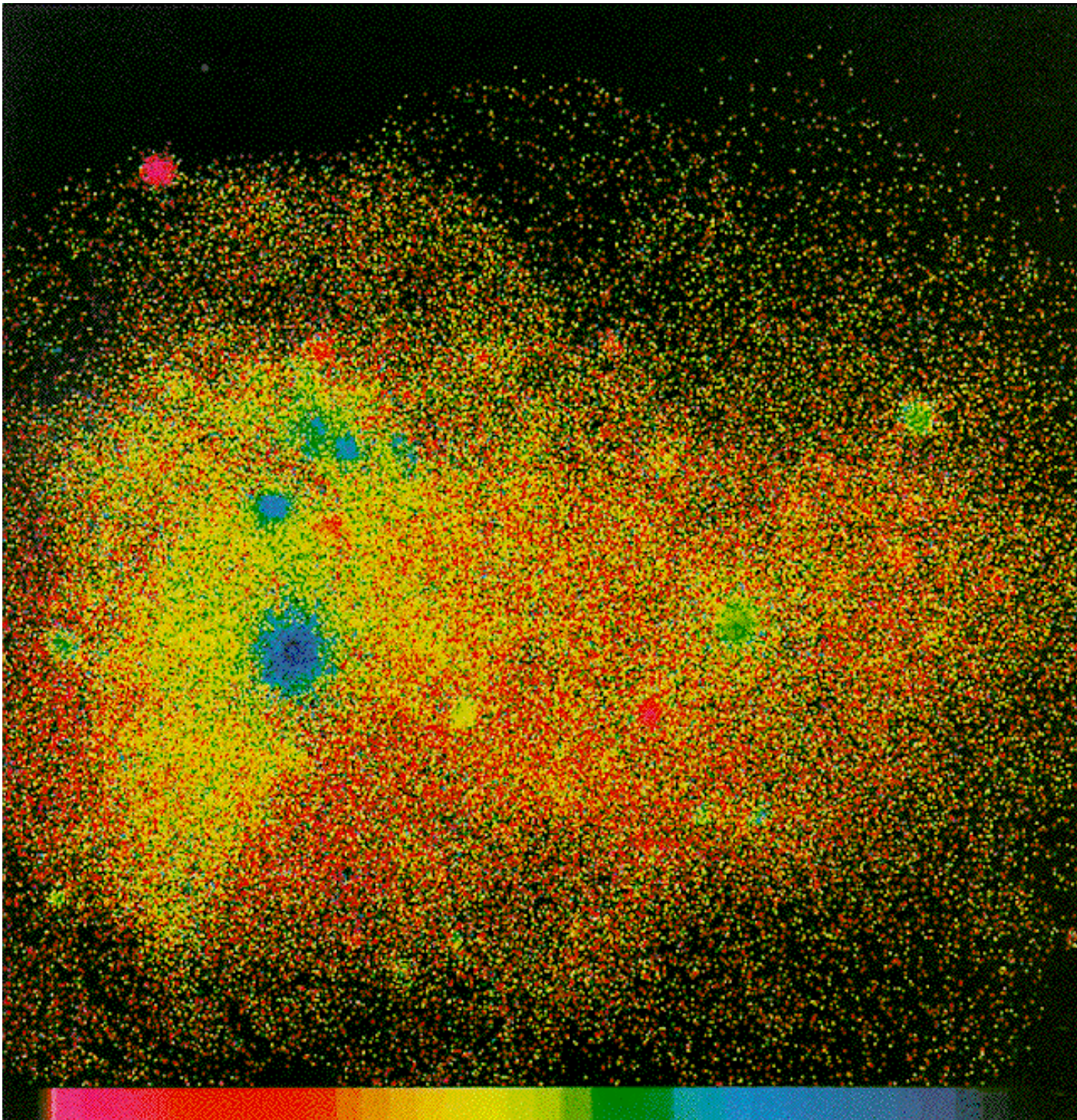
1,1,94  
point sources removed

0 Centered  
Galactic Coordinates



## Il Centro Galattico visto nella banda ottica e ROSAT





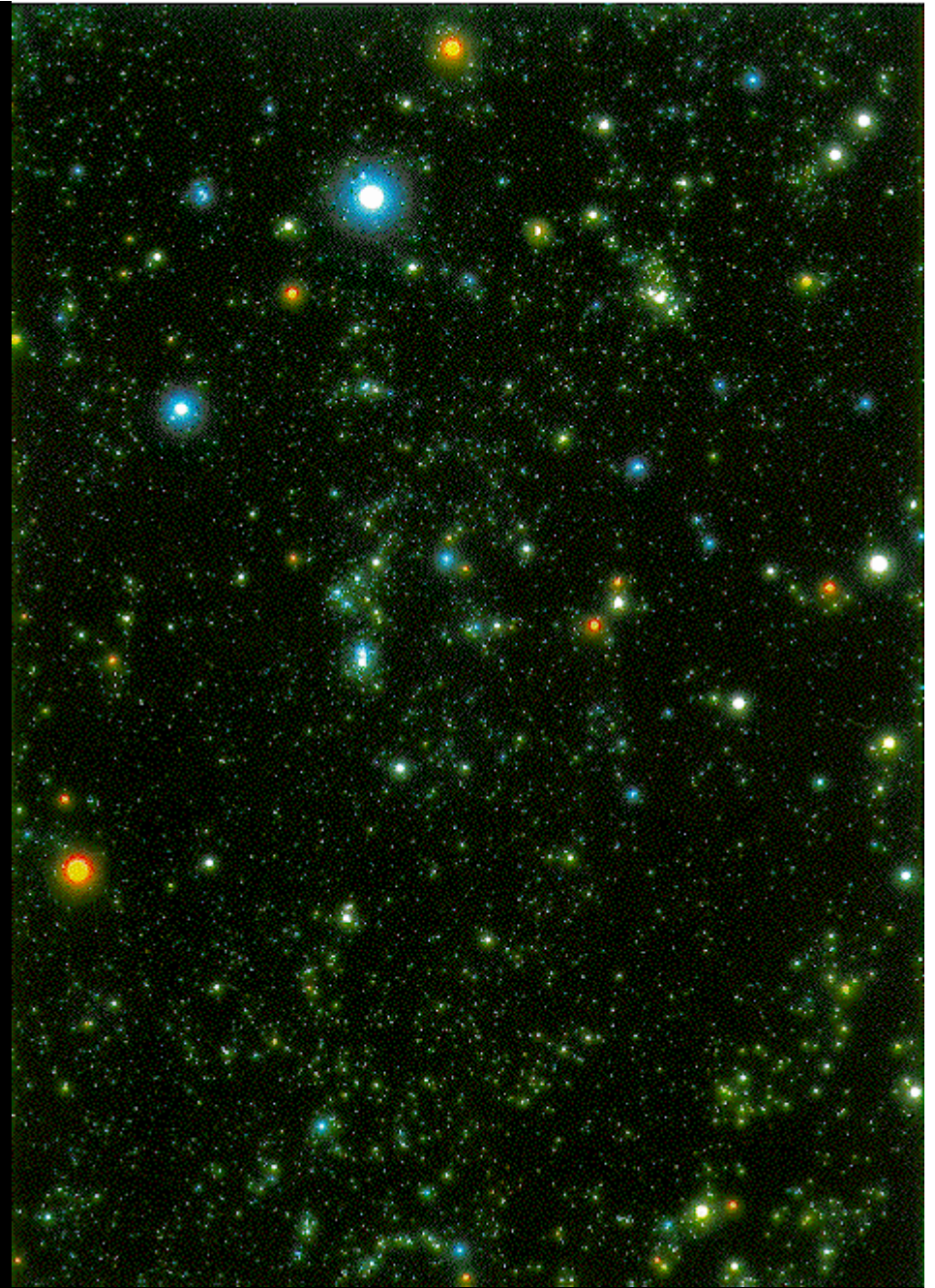
**La Grande  
Nube di  
Magellano**

**Mappa della  
temperatura**

**ROSAT**



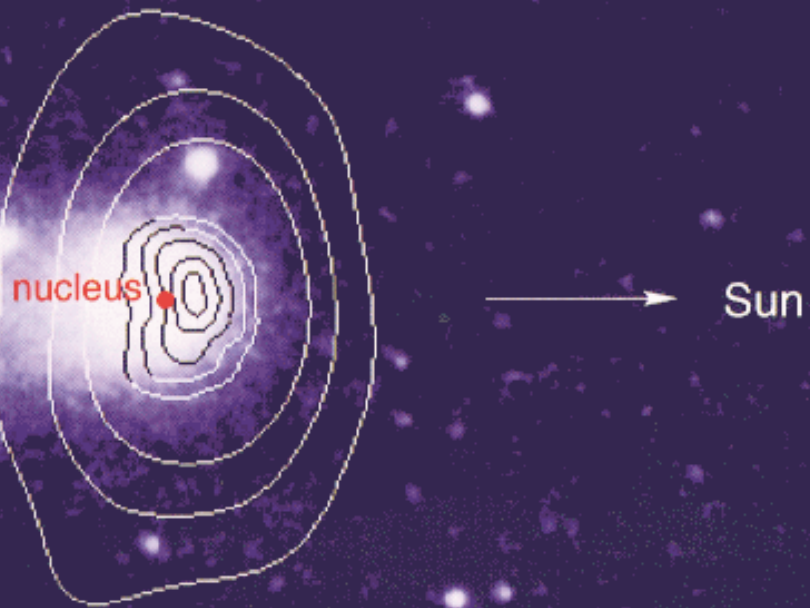
**Orione immagine ottica**



**Orione immagine X**

# Comet Hyakutake C/1996 B2

ROSAT HRI + ROSAT WFC + OPTICAL



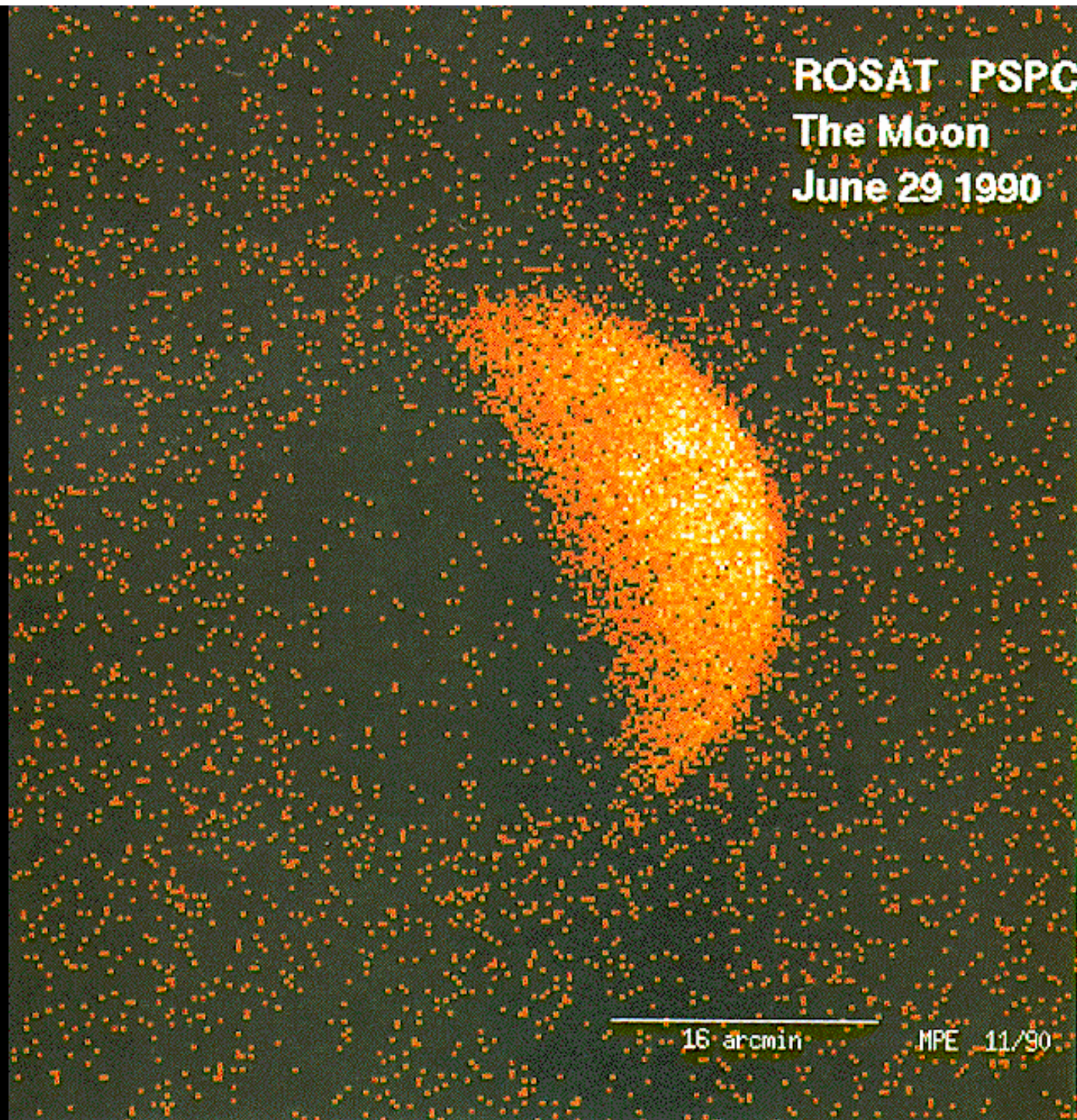
1 degree  
350 000 km

1996 March 27.77-27.85

ROSAT PSPC  
The Moon  
June 29 1990

16 arcmin

MPE 11/90



ROSAT PSPC  
MOND / GX 5-1



MPE 3.91

# **ASCA (Advanced Satellite for Cosmology and Astrophysics) Giappone e USA**

**Lancio: 20 Febbraio 1993 terminato**

**2 Marzo 1001**

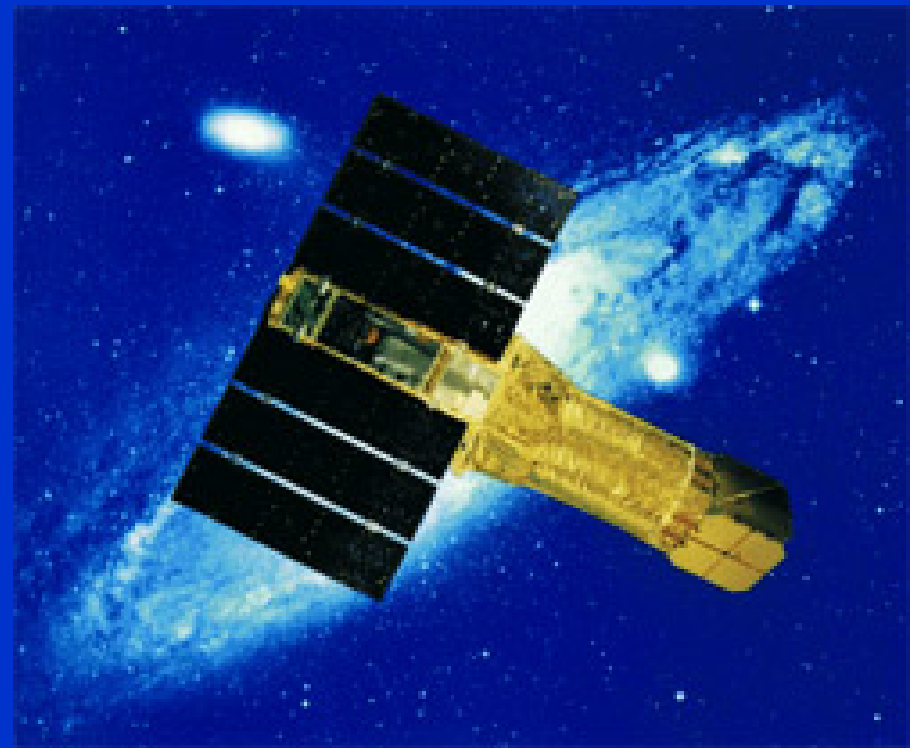
**Energia 0.4-10 keV usa  
per la prima volta un CCD**

**Riga larga del Fe in AGN**

**Abbondanze corone  
stellari < del Sole**

**Abbondanze negli  
ammassi di galassie**

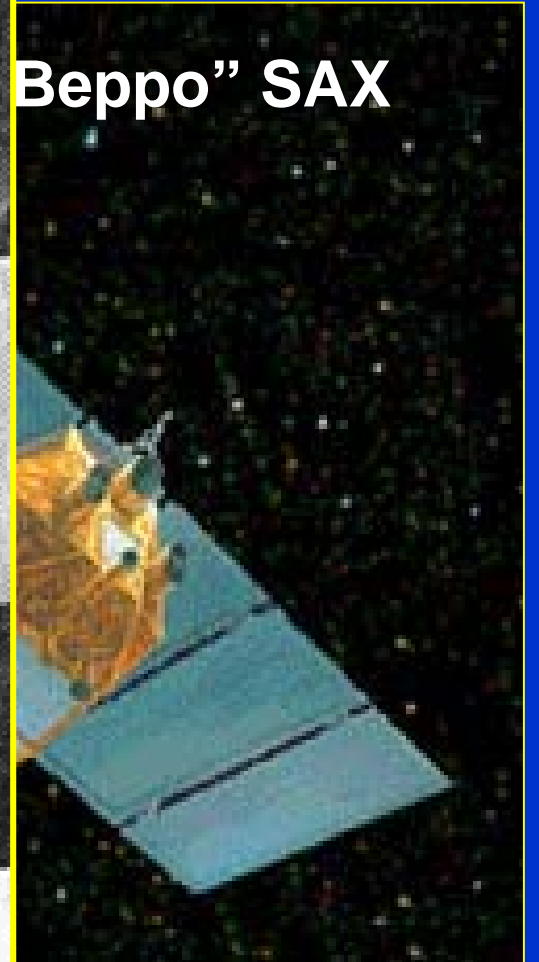
**Raggi X da SN 1006 non termici**



# Giuseppe "Beppo" Occhialini



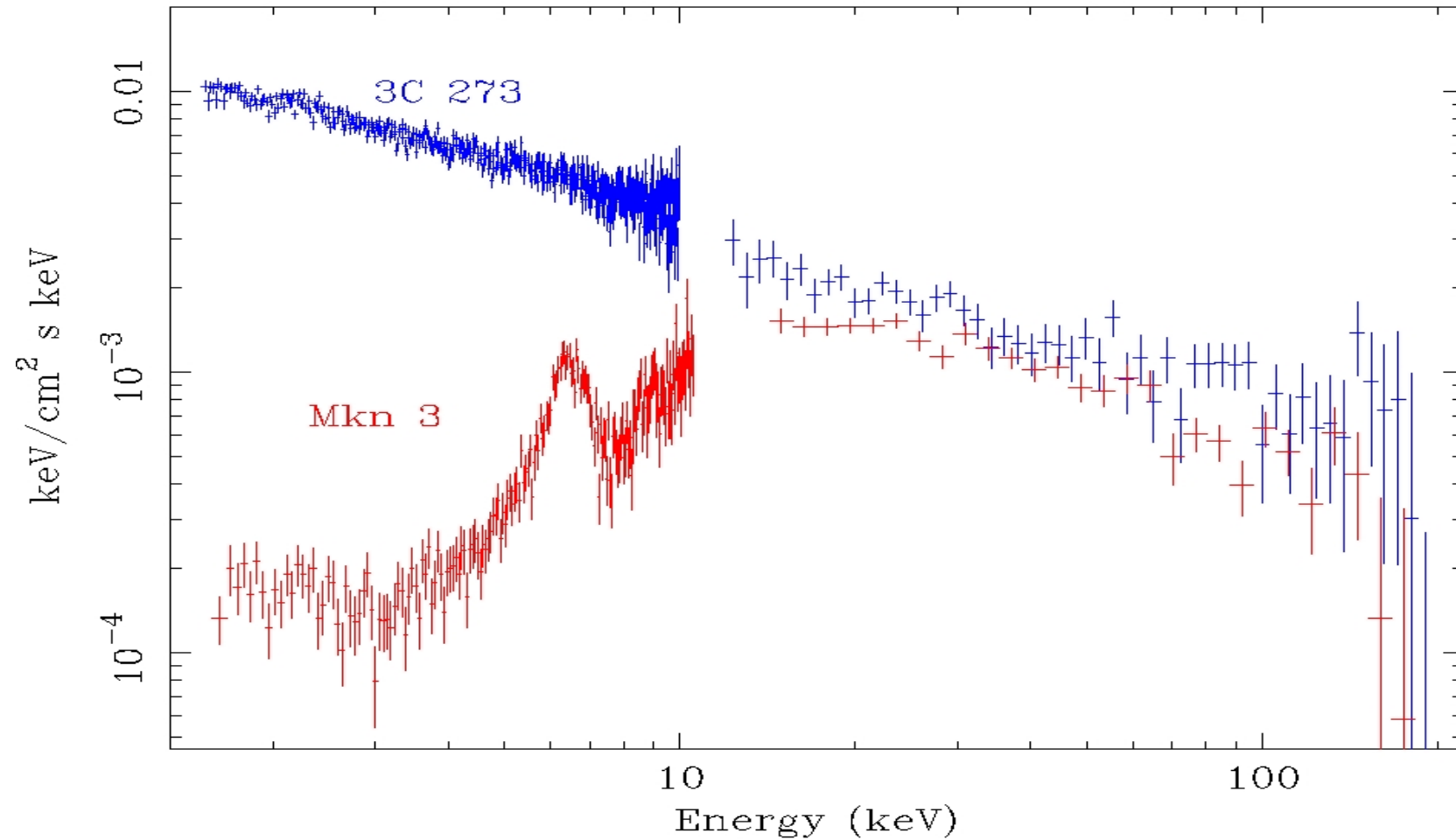
Beppo" SAX

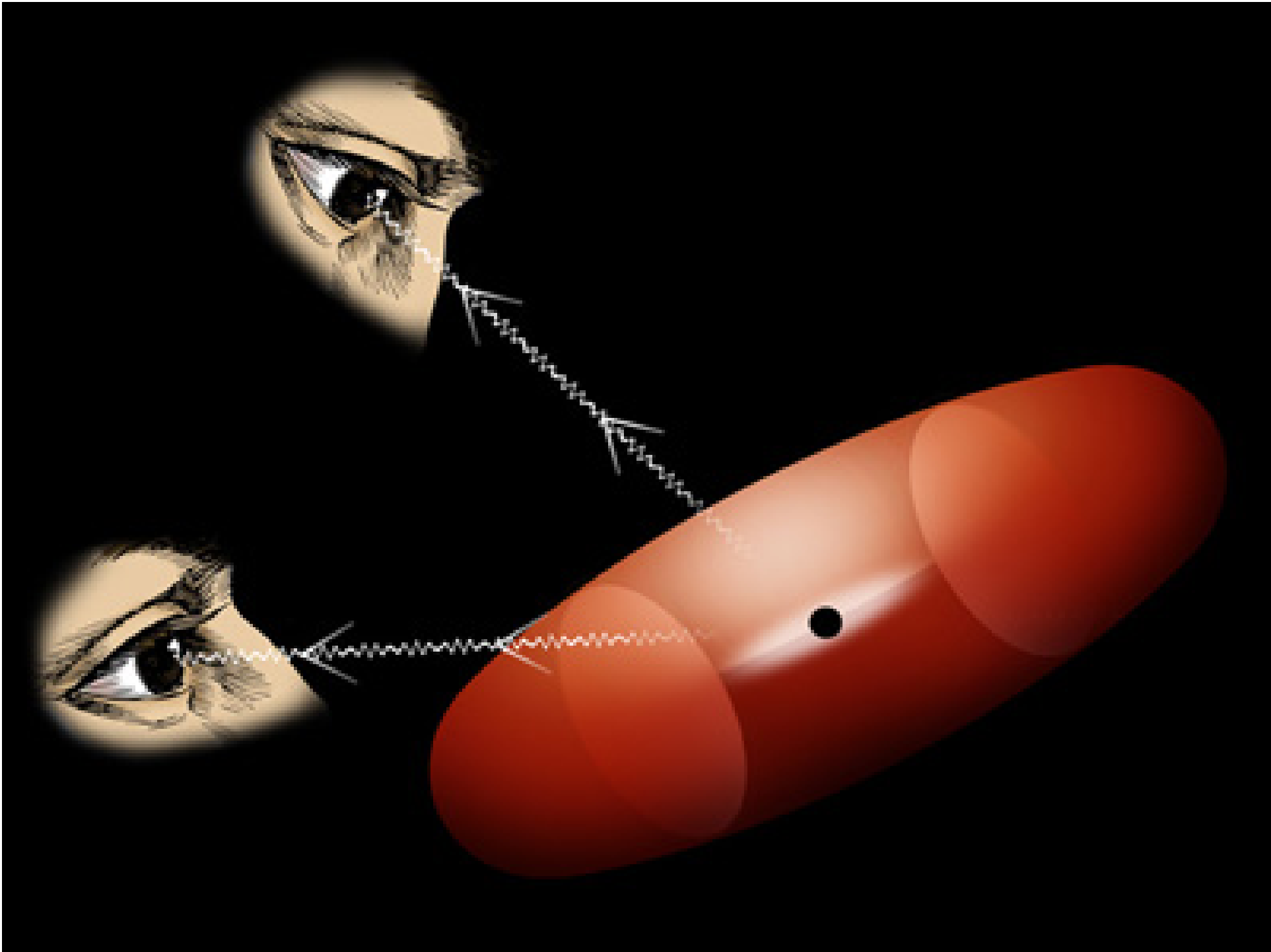




# Esempio di spettro X di una Seyfert 2 (Mkn3) confrontato con lo spettro del quasar 3c273

BeppoSAX spectra of 3C 273 and Mkn 3

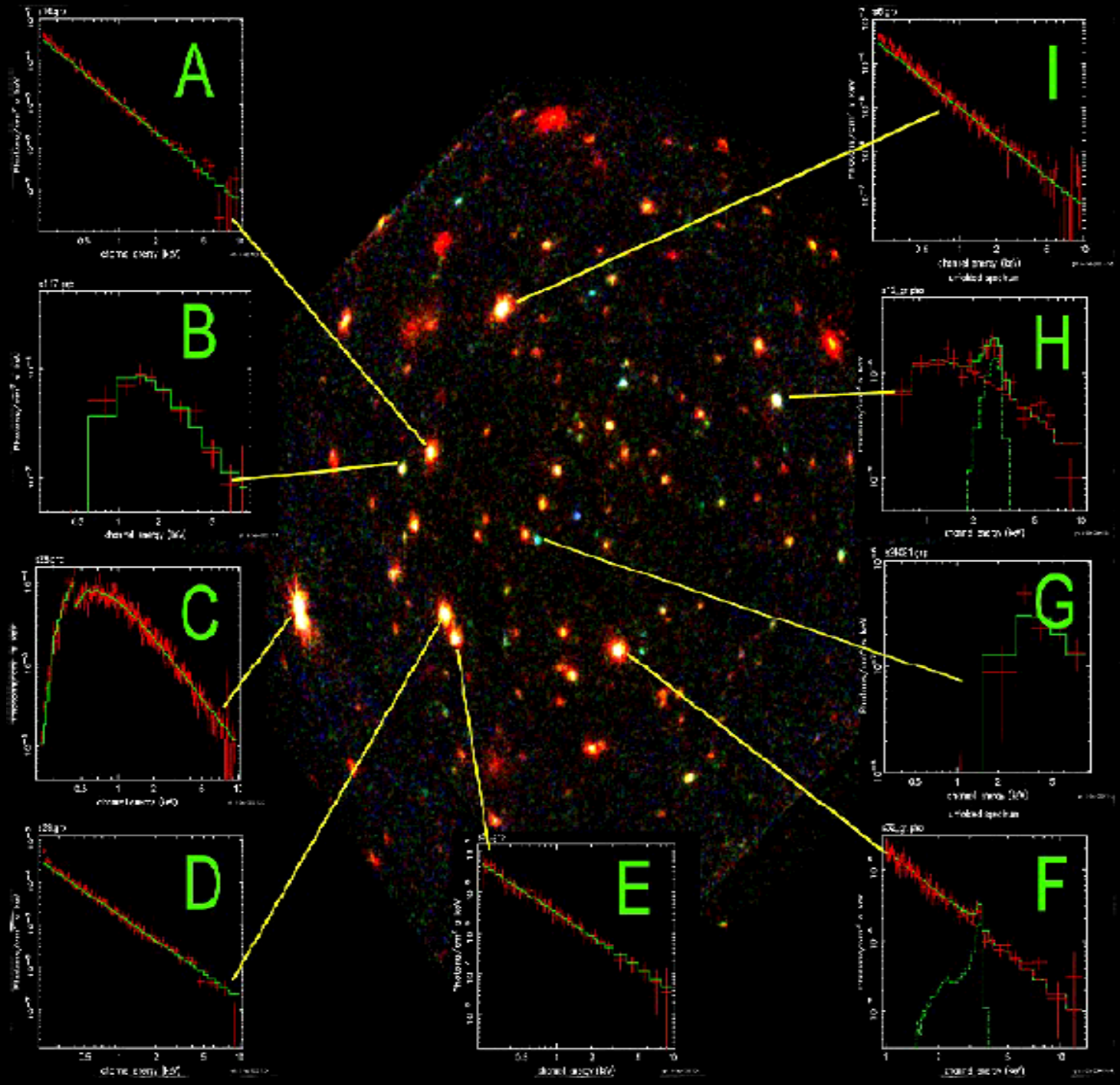






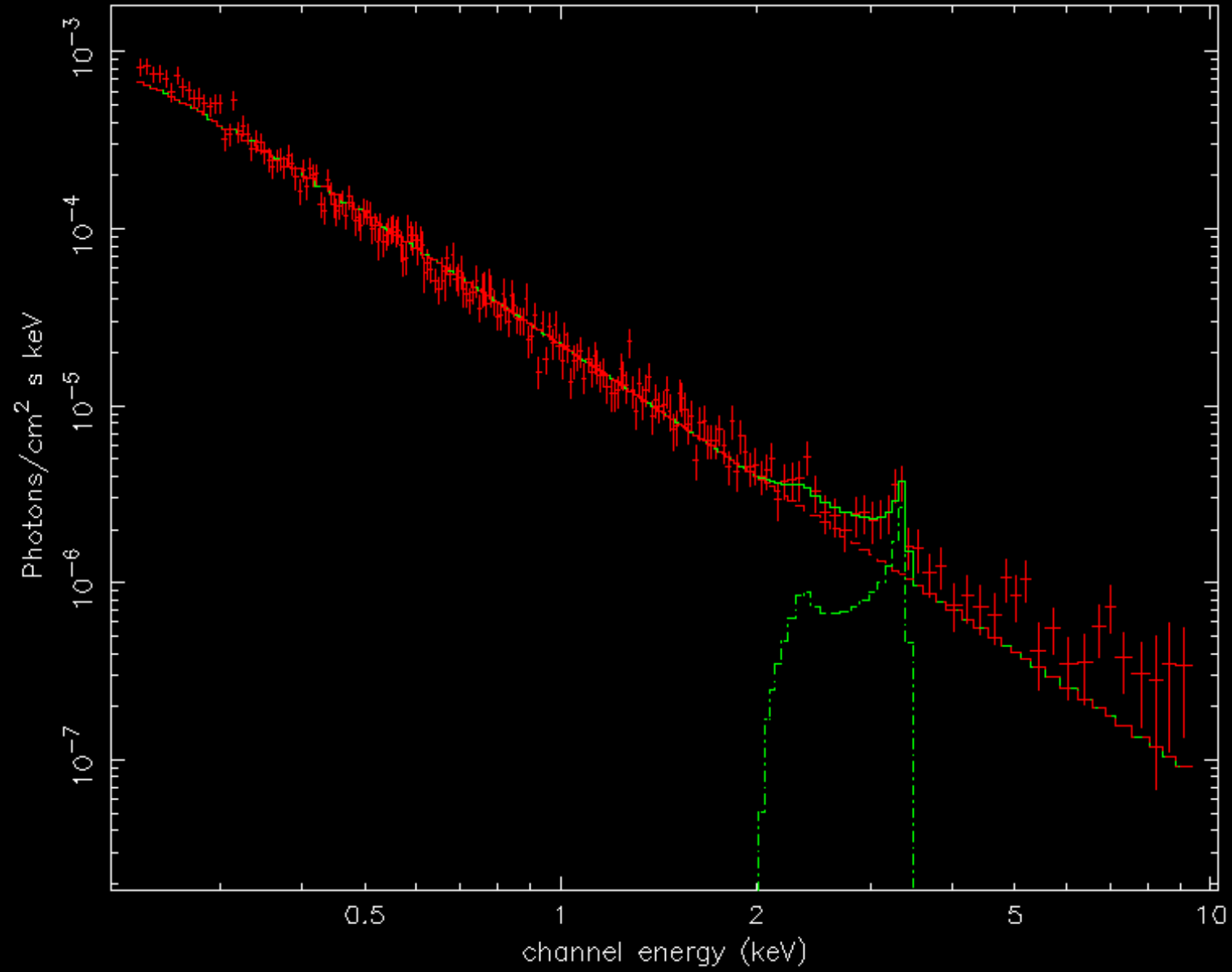


**Il satellite XMM-Newton dell'ESA**



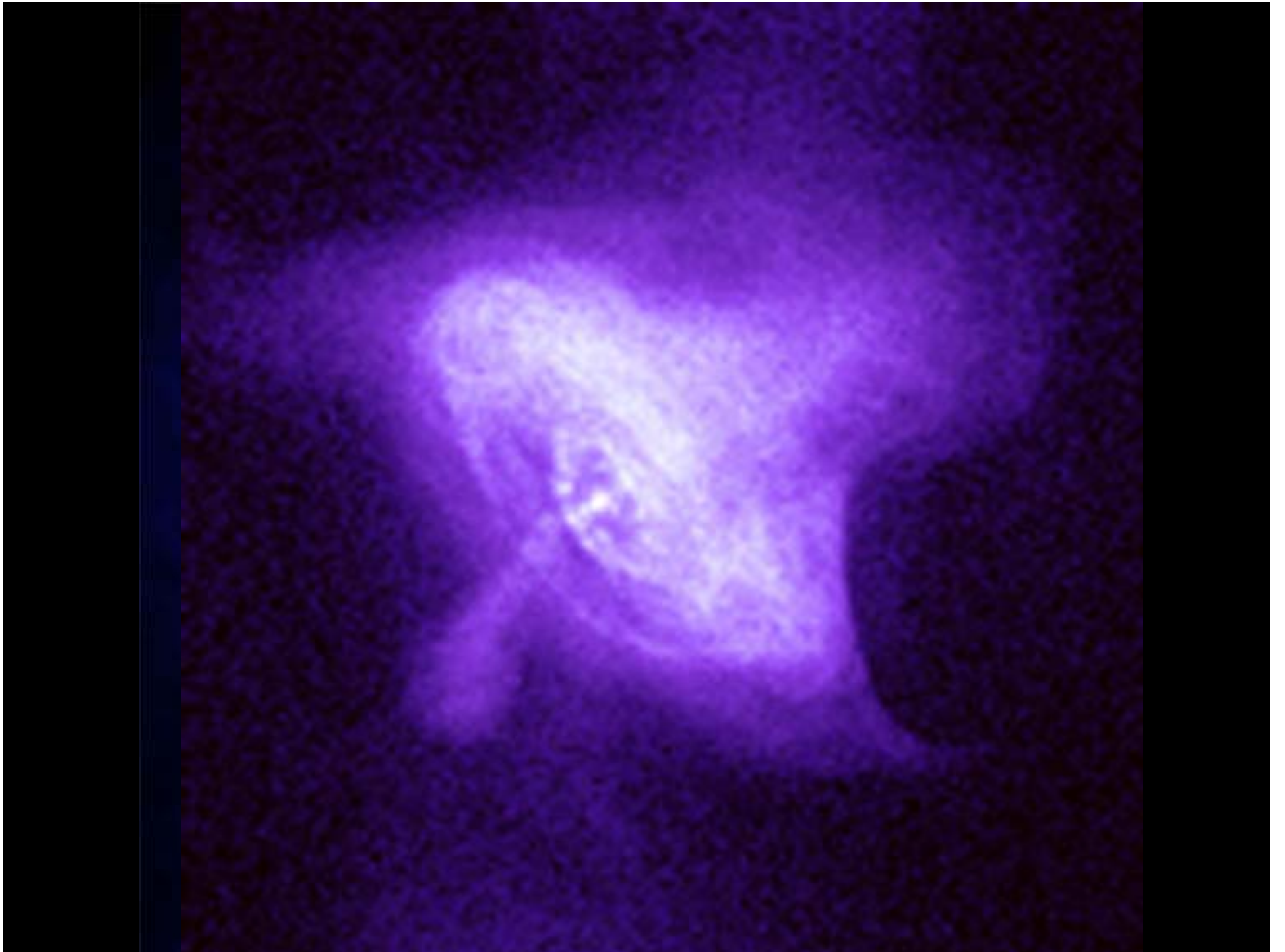
unfolded spectrum

s32.grp





**Chandra**

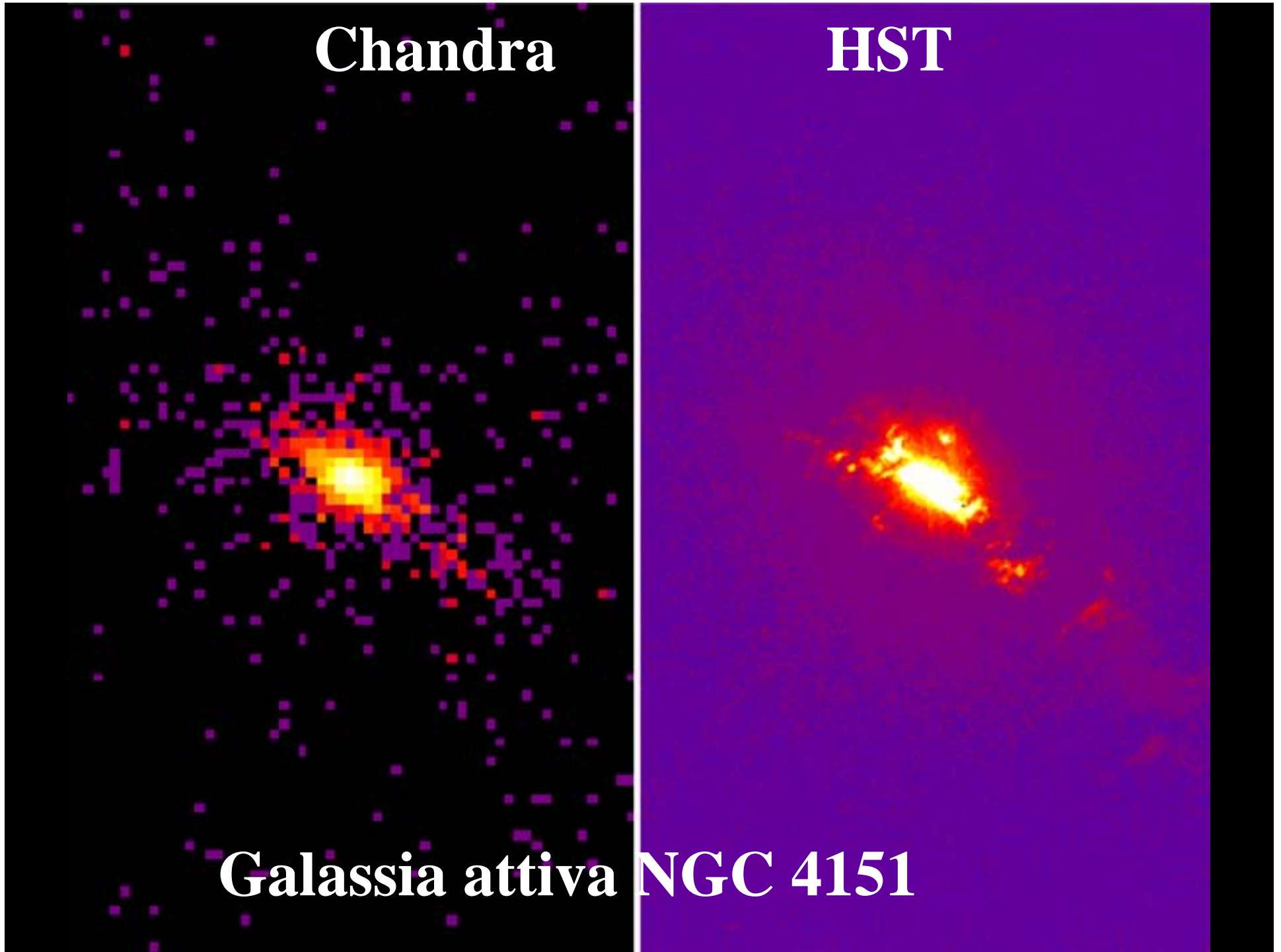




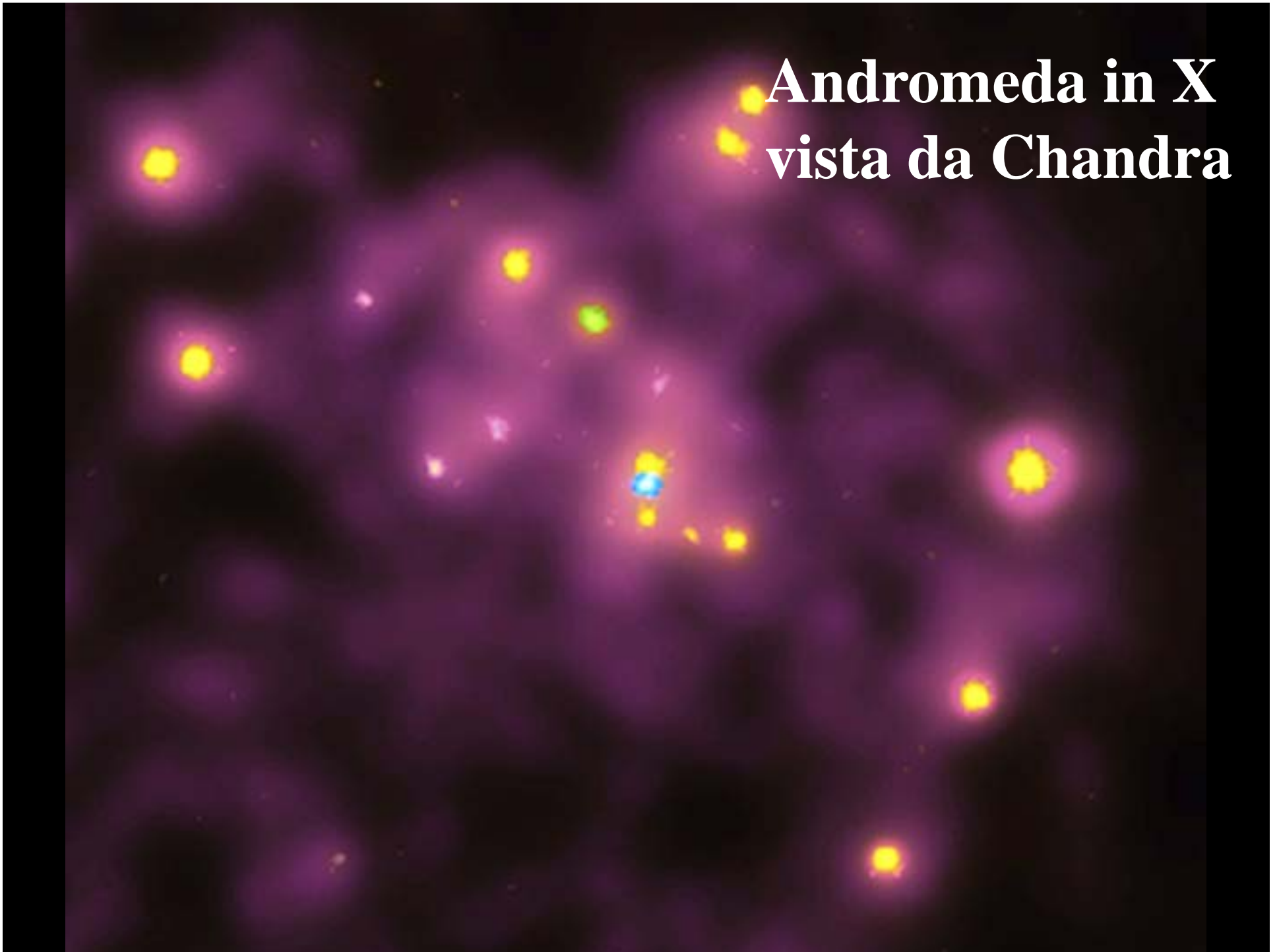
**Chandra**

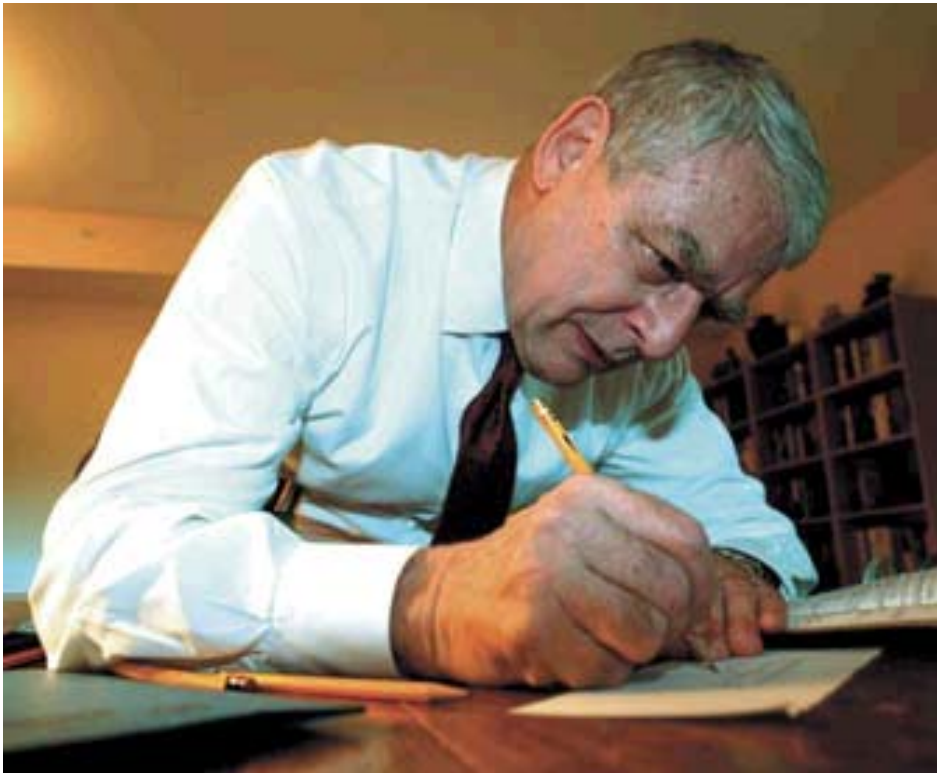
**HST**

**Galassia attiva NGC 4151**



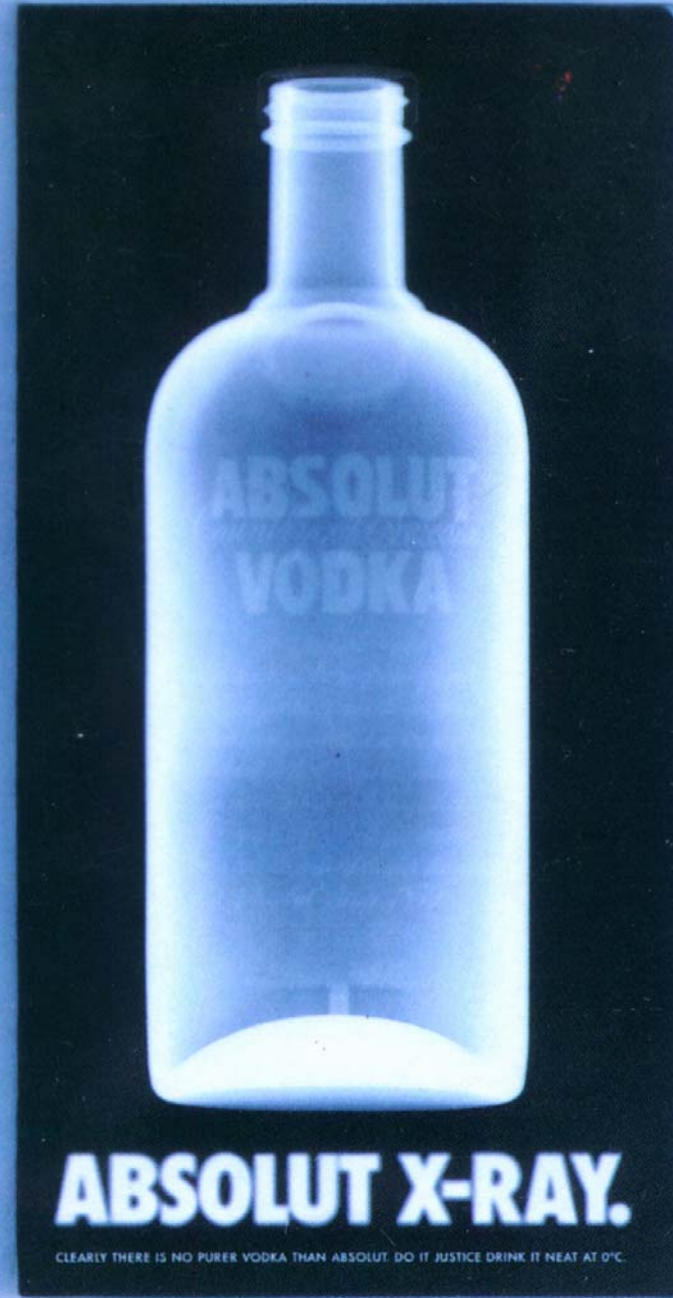
**Andromeda in X  
vista da Chandra**





**Riccardo Giacconi**  
**Premio Nobel per la Fisica**  
**2002**

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Absolut Vodka Collection n° 47

Viviamo tutti  
nelle fogne ma  
alcuni di noi  
guardano le  
stelle

Oscar Wilde