BeppoSAX and GRBs: History and Legacy

Luigi Piro

Former BeppoSAX Project Scientist

INAF, Institute of Astrophysics and Planetology in Space, Rome

The BeppoSAX Mission

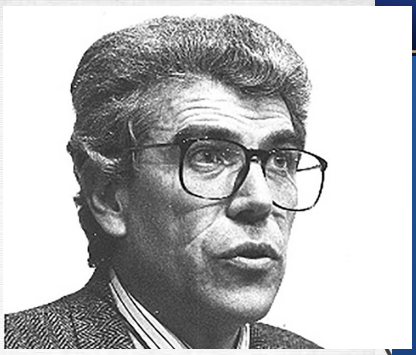
Program of ASI with partecipation of NIVR.

Prime Contractors: Alenia Spazio for space segment;
Telespazio for ground segment.
Main subcontractors: Laben for payload, Fokker for AOCS

Scientific Responsibility: BSAX Consortium
IAS, Roma, IFCAI, Palermo, ITESRE, Bologna, IFCTR, Milano,
Uni Roma & Ferrara
SSD-ESA
SRON
M.P.E (Garching) supported telescope calibrations.

BeppoSAX hist

- Proposal to Italian National S
in 1981 in response to an AO
The AO guidelines : science
scientific community; develo
national space industry; inte
partecipation.
- OOXA Orbiting X-Ray Astron
Observatory) and SAX (Satel
Astronomia X), a CMB propo
- SAX: Consortium of institute
multi-detector approach (m
consortium), SRON and SSD,
orbit, to take full advantage
and low modulation bkg & u
TTC @Malindi in Kenya. Lau
base with injection at 600 k
experimental Italian module



PROPOSTA AL

PIANO SPAZIALE NAZIONALE

PER UN

SATELLITE PER ASTRONOMIA IN RAGGI X

PREPARATA DA

F. Waldner	Istituto di Fisica - Università	Bari
G. Maggi	Istituto Nazionale Fisica Nucleare - Sezione	Bari
W. Dusi	Istituto TESRE/CNR	Bologna
F. Frontera	Istituto TESRE/CNR	Bologna
G. Spada *	Istituto TESRE/CNR	Bologna
E. Costa	Istituto di Astrofisica Spaziale/CNR	Frascati
M. Ranieri	Istituto di Astrofisica Spaziale/CNR	Frascati
P. Ubertini	Istituto di Astrofisica Spaziale/CNR	Frascati
G. Boella	Istituto di Fisica Cosmica/CNR	Milano
N. D'Amico	Istituto di Fisica - Università	Palermo
N.R. Robba	Istituto di Fisica - Università	Palermo
G. Gerardi	Istituto Fisica Cosmica e Informatica/CNR	Palermo
S. Re	Istituto Fisica Cosmica e Informatica/CNR	Palermo
G.C. Perola	Istituto Osservatorio Astronomico - Università	Roma
L. Scarsi*	Istituto di Fisica - Università	Roma
	e	
	Istituto Fisica Cosmica e Informatica/CNR	Palermo
J.A.M. Bleeker	Huygens Laboratory	Leiden
G. Manzo	Space Science Department/ESA	Noordwijk
A. Peacock	Space Science Department/ESA	Noordwijk
B.G. Taylor	Space Science Department/ESA	Noordwijk
A.C. Brinkman	Space Research Laboratory	Utrecht

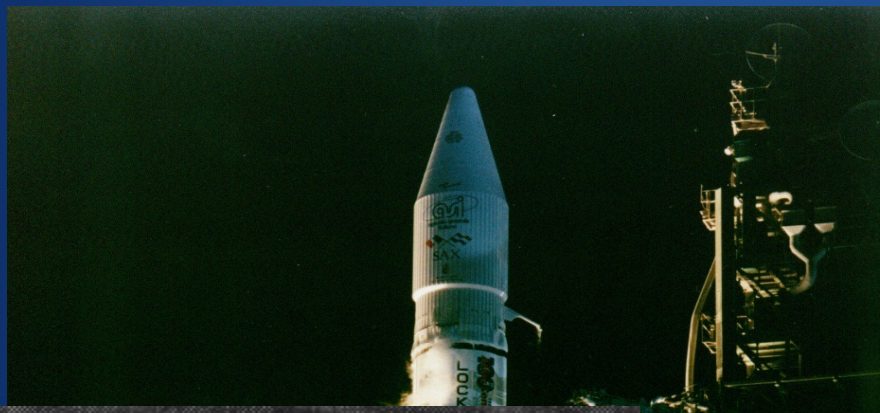
GIUGNO 1981

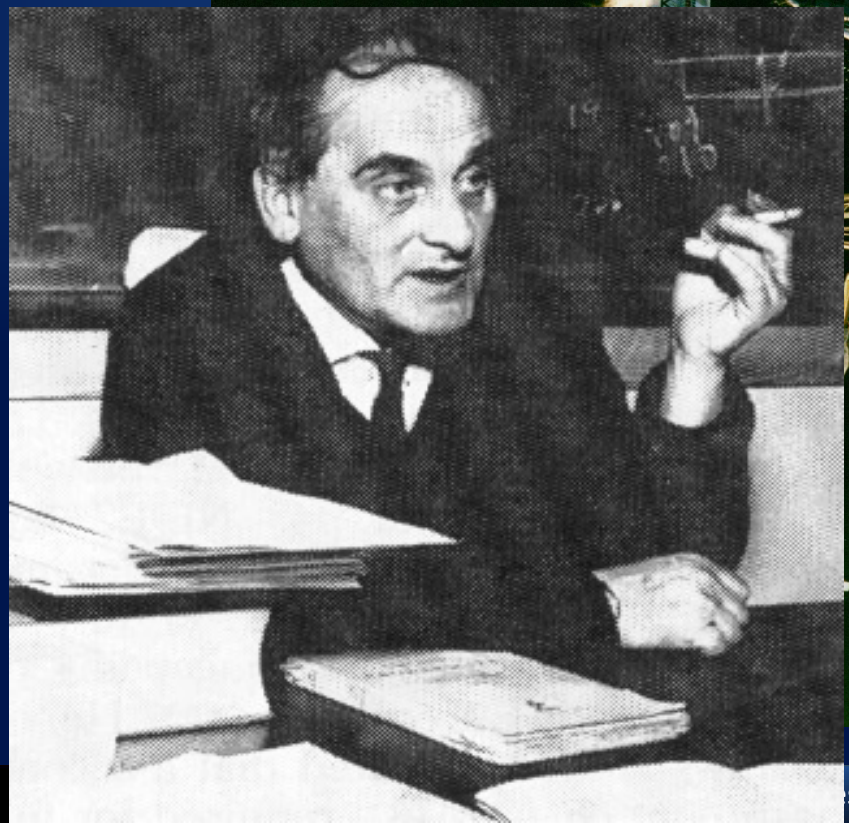
BeppoSAX hystory (cont'd)

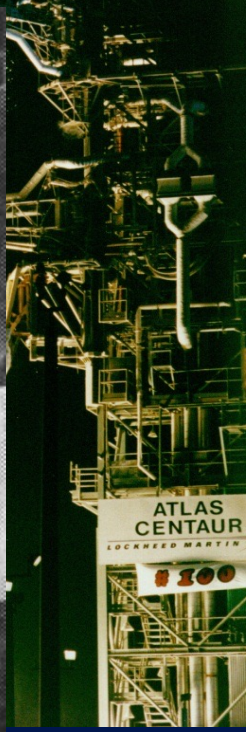
- After assessment phase carried out by Aeritalia (now Thales Alenia Spazio) in 1982 SAX was selected by PSN following the advice of an Advisory Panel composed by E. Amaldi, G. Occhialini, B. Rossi and L. Woltjer
- Jan.86: Challenger disaster. Sax program stopped for more than 1 year
- mid 87: SAX re-oriented for a launch with Atlas-Centaur. New phase B started in 1988
- 1993: The Minister of Universities & Scientific & Technological Research U. Colombo suspended the program and requested independent advise from the European Science Foundation. On Nov.11, the SAX program was presented by L. Scarsi, G.C. Perola & L. Piro to the ESF board, chaired by H. Schnopper.

Launch and orbit

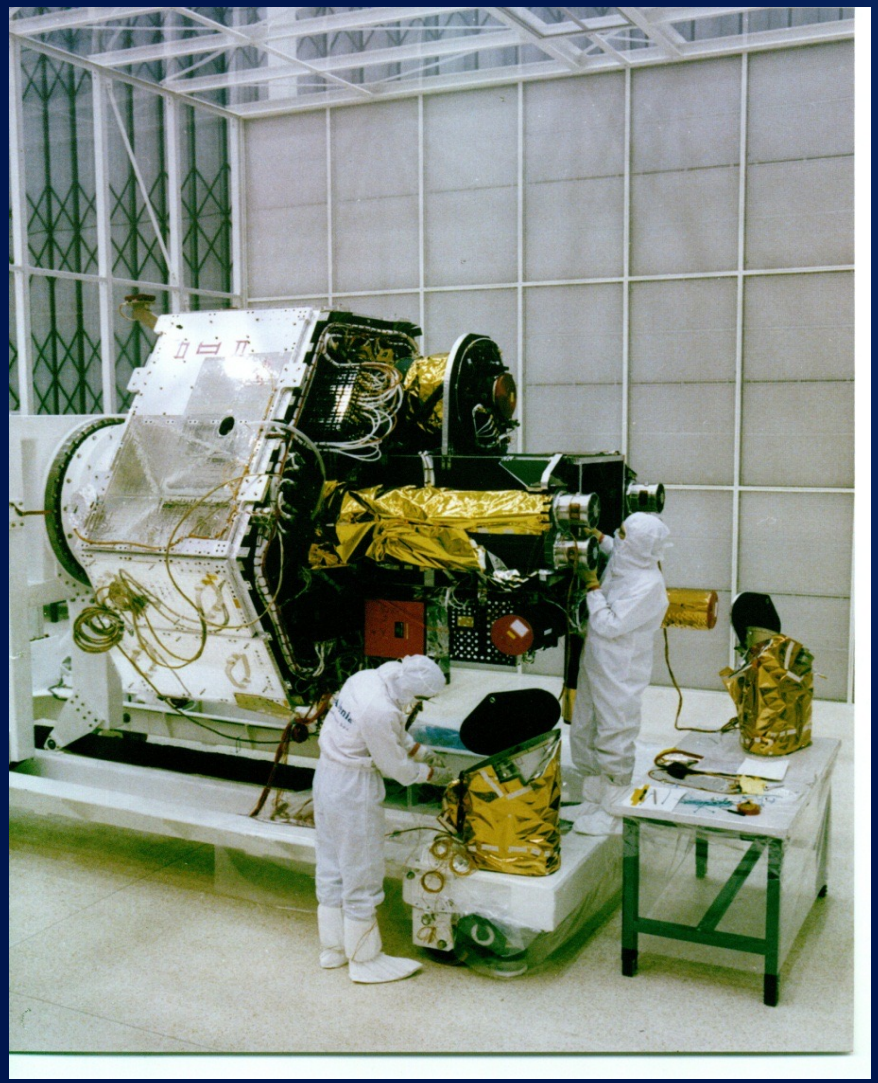
- Launched from Cape Canaveral on April 30, 1996 4:31 GMT and injected at 600 km, 3.9° orbit
- Named, after launch BeppoSAX, after Giuseppe Beppo Occhialini by the Italian Minister of Research Salvini

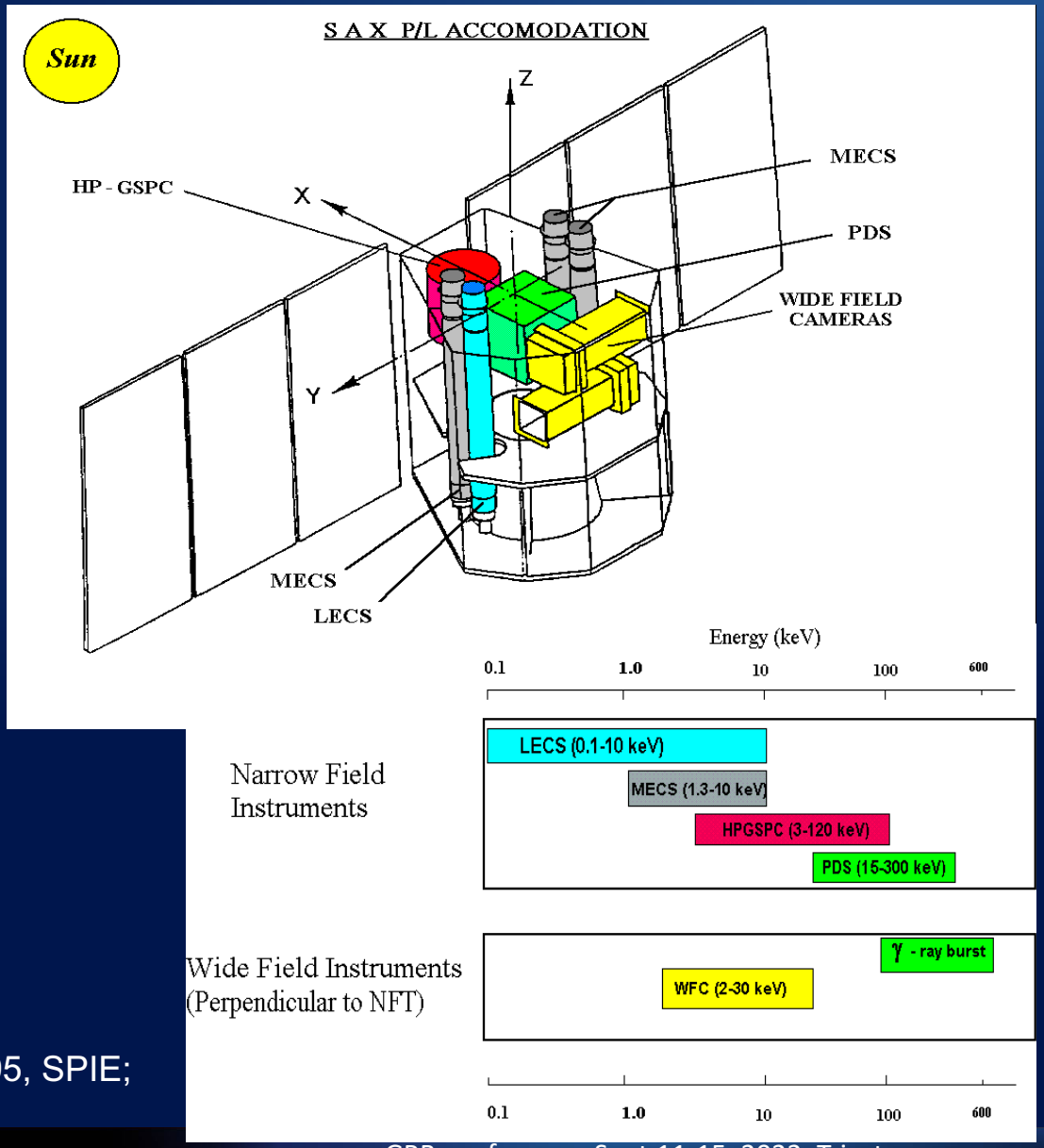






BeppoSAX instruments



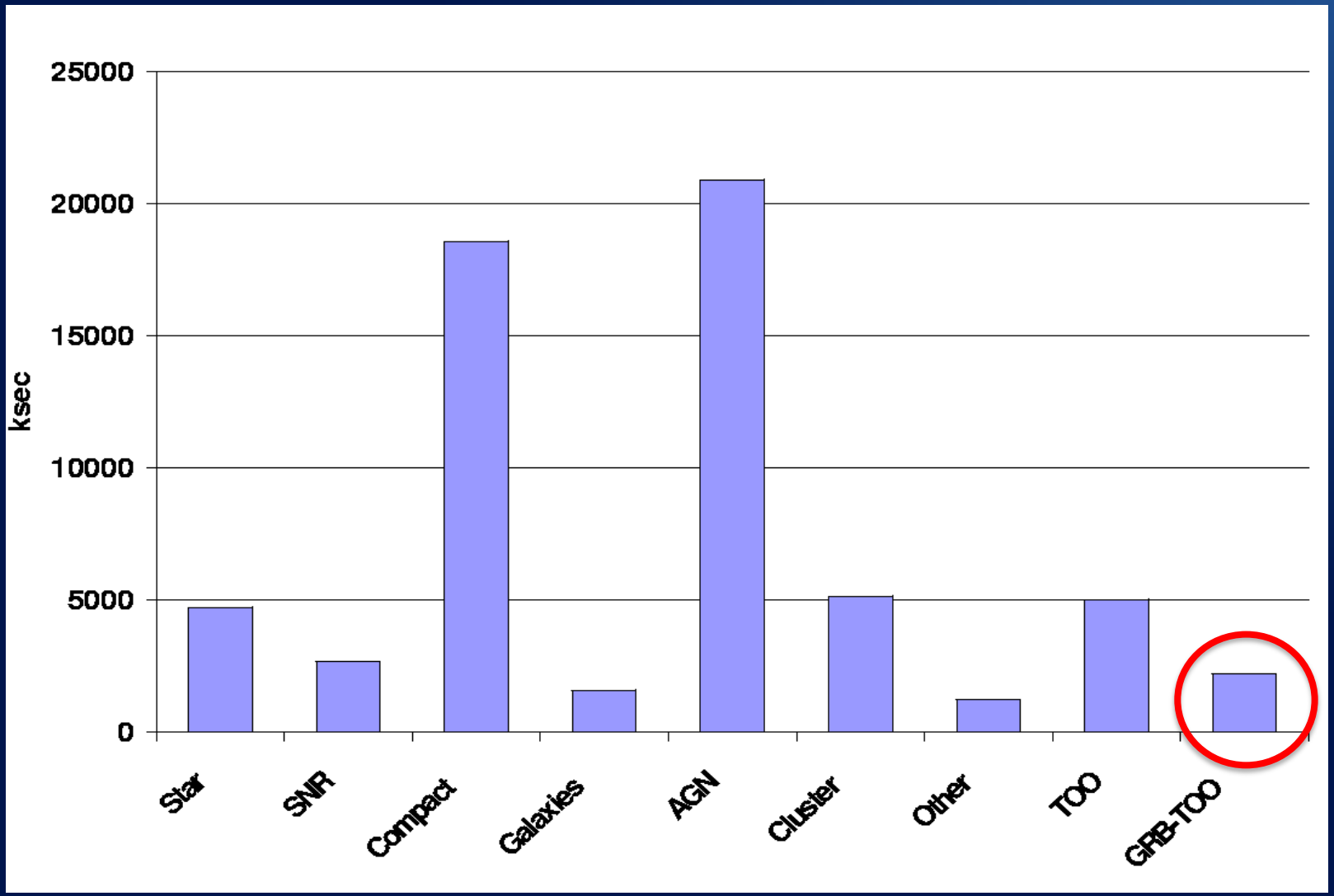


•Piro, Scarsi & Butler, 1995, SPIE; Boella et al 1996, A&AS

Summary of Operative Life (I)

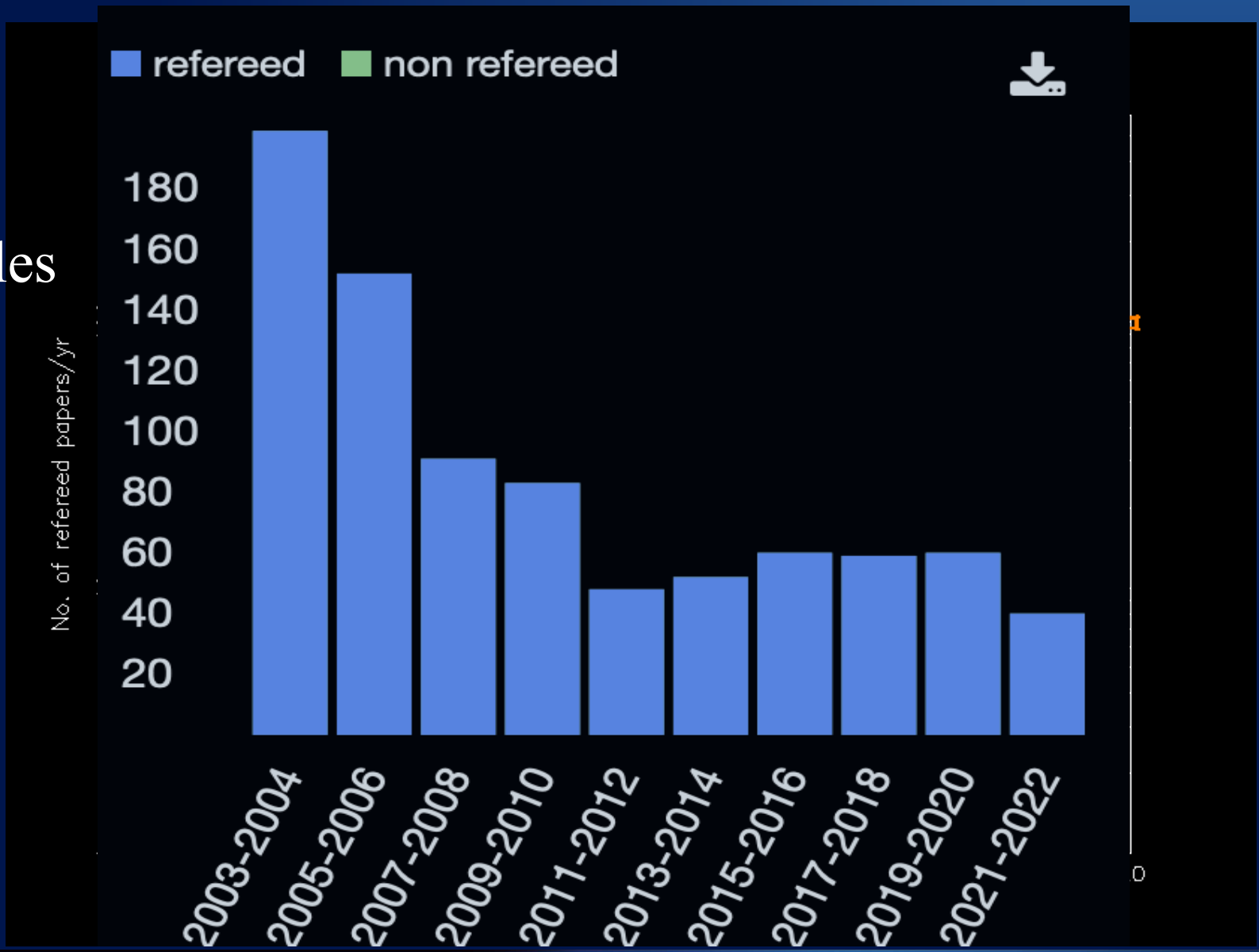
- 30715 orbits
- 62 millions seconds of Observations (~17500 hrs)
- 5 Announcements of Opportunity
- 1500 observations
- 56 GRBs localized in real-time by WFCs (including 8 X-ray flashes)
- 36 GRB Follow-up with NFI (including 2 X-ray flashes)
- 151 Target Of Opportunity (not GRBs or XRFs)

Scientific Programme

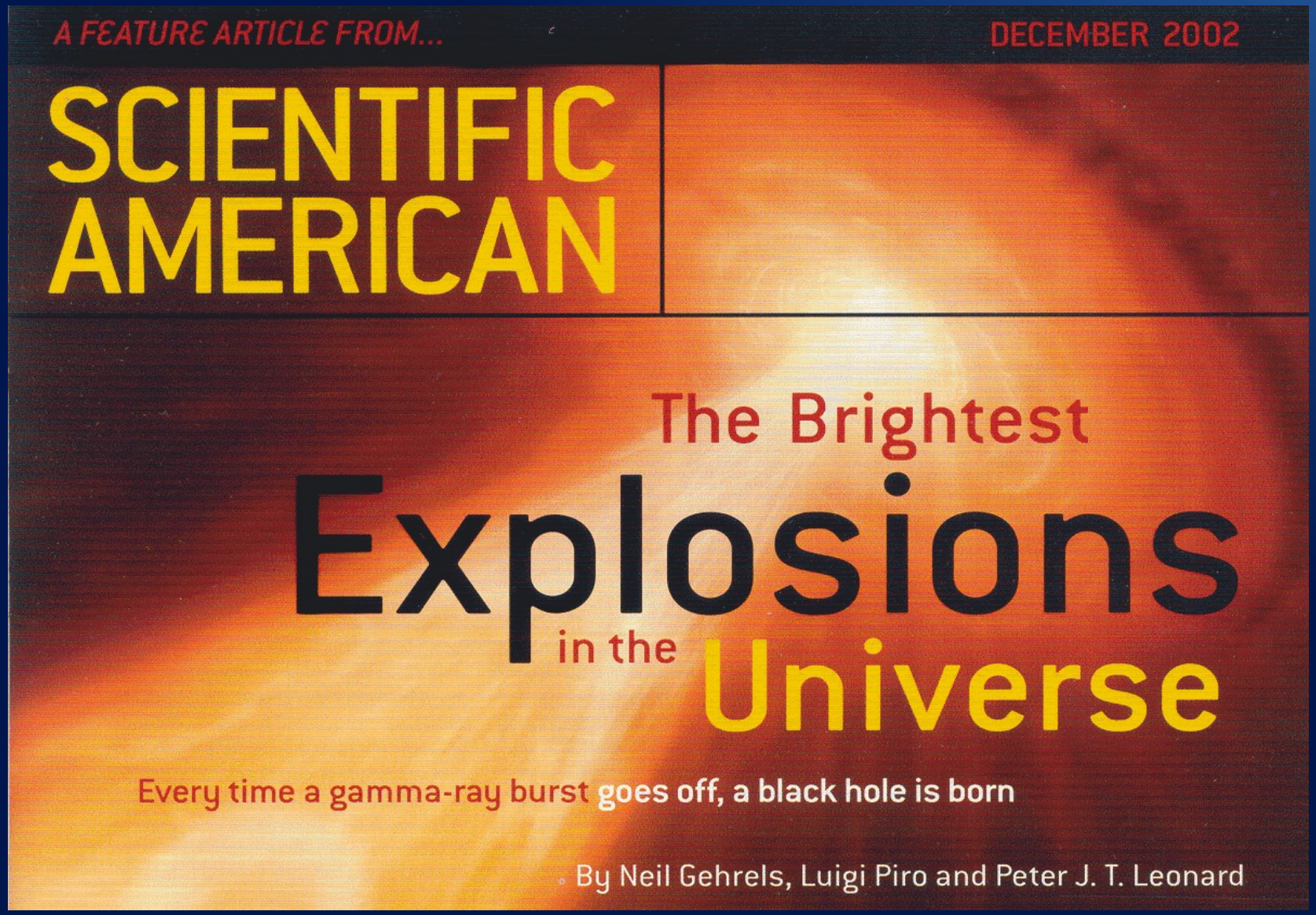


BSAX publications

As of today:
>1700 ref. articles



GRBs


A FEATURE ARTICLE FROM...
DECEMBER 2002
SCIENTIFIC AMERICAN
The Brightest
Explosions
in the Universe
Every time a gamma-ray burst goes off, a black hole is born
By Neil Gehrels, Luigi Piro and Peter J. T. Leonard

BeppoSAX & GRB: a designed goal

SAX Observers' Handbook

Issue 1.0

Jul. 7, 1995

prepared by:

L. Piro

with the contributions of:

R.C. Butler, L. Chiappetti, G. Conti, E. Costa, D. . Frontera, S. Giarrusso, R. Jager, M.C. Maccaron Mineo, A. Parmar, G.C. Perola, S. Re, B. Sacco, I M. Trifoglio.

on behalf of the
SAX Scientific Steering Comn

6.1.6. Transient searches and follow-up observations; gamma-ray bursts

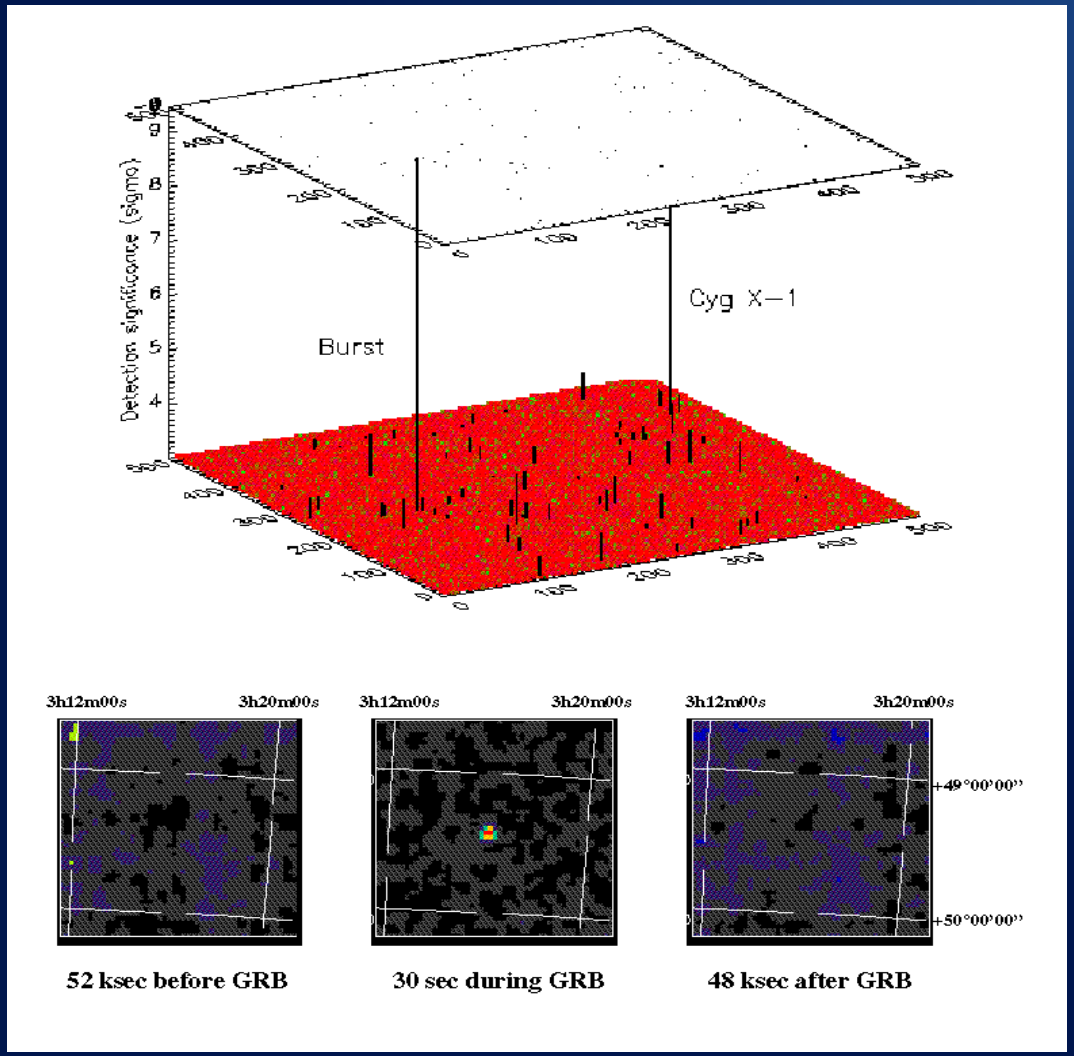
An X-ray source is classified as transient on the basis of its sudden appearence, very often at a previously source-free location, and limited duration above a minimum detectable flux. They can be subdivided into two categories. The bright transients can reach a peak brightness over that of the Crab and decay in several months; a fiducial decay time scale of 100 days can be adopted as representative; estimates of their outburst rate are rather uncertain, an indicative rate can be adopted of 5×10^{-4} deg^{-2} yr^{-1} above 50 mCrab, corresponding to about 20 transients in one year, averaged over the entire sky: most events of this type do however occur in the Galactic disk. The weak, fast transients last from a few minutes to several hours and are distributed isotropically over the sky.

The bright (pulsar) transients with a known recurrence period were dealt with in Sect. 5.1.2; here we deal with the others. The combination of the WFC's and NFI's on SAX offers a very exciting opportunity to both detect new transients and, for the bright ones of long duration, to study in detail their evolution during the decay. For what concerns the search of new transients, an observational strategy will be implemented for the WFC's in the secondary mode to survey the largest fraction of the sky which will be accessible at any one time down to a few mCrab, in order to maximize the number of bright transients that can be discovered within at most 100 days after their outburst; the same strategy should also provide a wealth of useful data for the weak and fast

these objects on a TOO basis could be 10^6 s per year.

Finally, the **gamma-ray bursts**. The PDS shields will be used to monitor gamma-ray bursts with fluence f_g greater than 10^{-6} erg cm^{-2} in the energy band from 60 to 600 keV; the time resolution (down to 0.48 ms) will allow a detailed study of their time profile. Information on the position in the sky, with uncertainty of ~10' or worse, depending on intensity and direction, can also be obtained. On the basis of the first CGRO/BATSE catalog, ~ 60 bursts per year are expected above the given fluence threshold. Furthermore, ~ 10 bursts with $f_g > 10^{-7}$ erg cm^{-2} ($f_g \sim 100\, f_X$) are expected to fall in 3 years in the FOV of the WFC's and be detected: hence, for these bursts, an independent 5' position might also be obtained, along with spectral and temporal information on the X-ray tail of their emission. This program does not require dedicated observing time, the proponents should therefore provide the scientific motivation and require access to the gamma-ray burst monitor data and to the WFC data for a cross correlation analysis and for the use of the

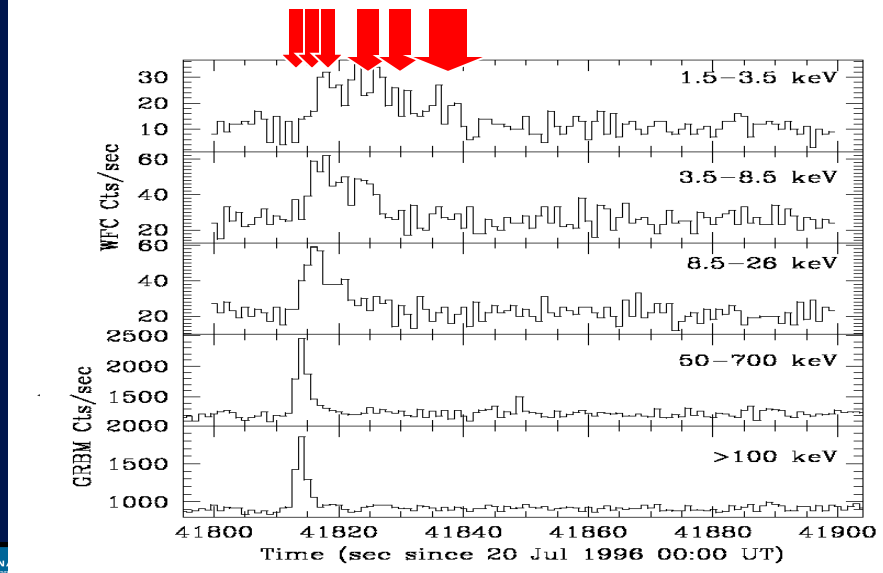
GB960720: the 1st GRB by BeppoSAX

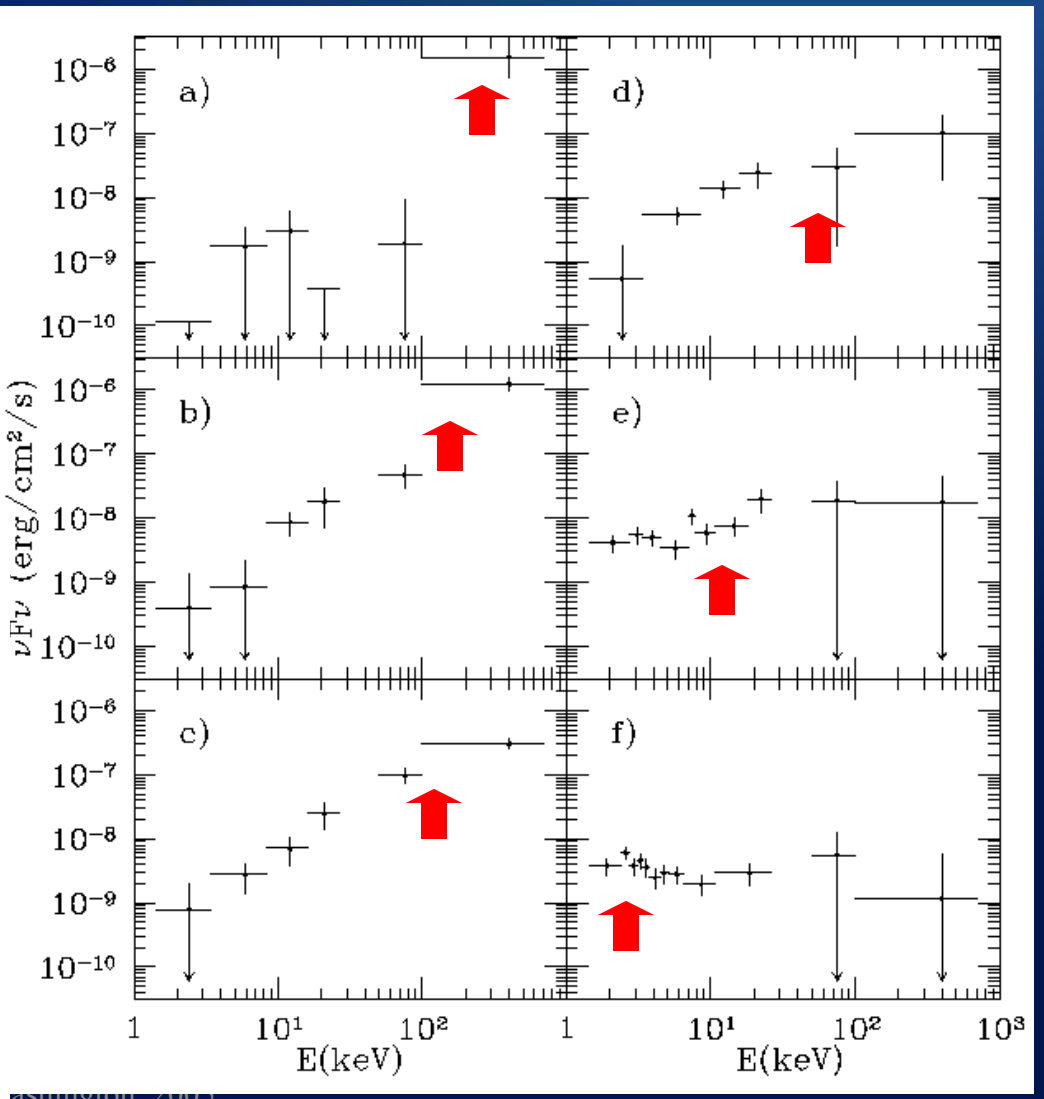


•Piro et al. 1997 A&A

Prompt vs afterglow emission: internal vs external shock

- In contrast with the afterglow, the prompt emission is characterized by strong hard-to-soft spectral evolution from X- to Gamma rays (e.g. GRB960720 Piro et al 1997)



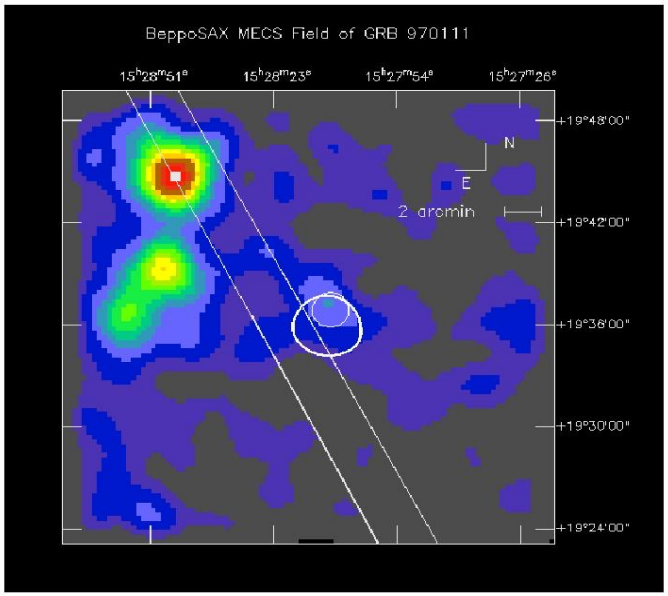


Setting up GRB operations with BSAX

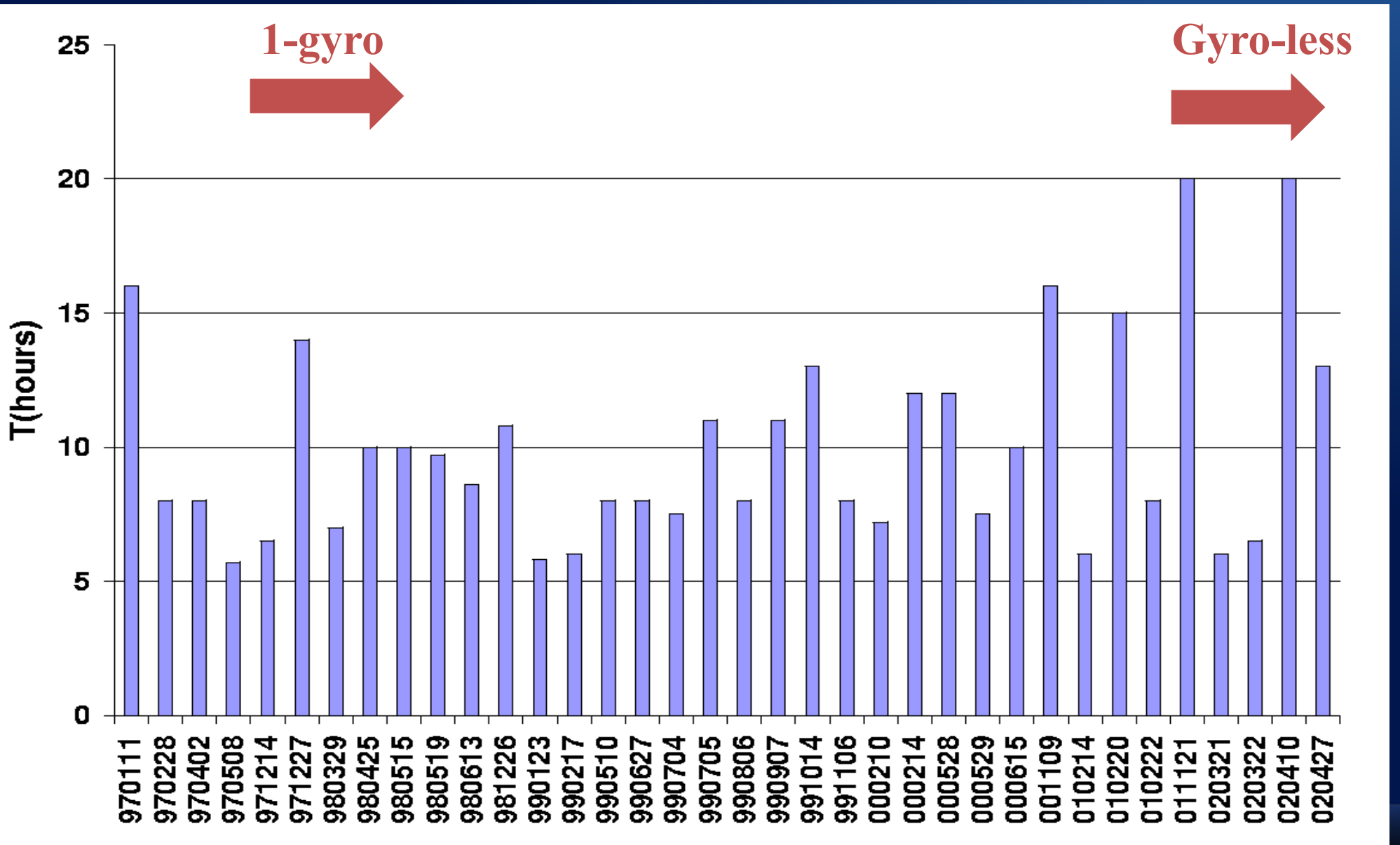
- Organization for GRB follow up under Project Scientist responsibility:
  - SOC(TSPZ) : check GRBM/WFC 24/7 => alert PS (supported by science and instrument teams) for validation
  - TOO follow-up under Project observing time (DDT equivalent the 1st year)
  - Follow-up with other facilities within scientific agreements
  - Project scientist tasked by SSSC to derive GRB positions for public distribution (both WFC and afterglow)
  - Refined analysis of afterglows with SDC

GRB970111: the 1st fast localization & follow-up of a GRB

- Triggered by GRBM and localized by the WFC of BeppoSAX
- fast follow-up (16 hrs after the GRB) by the NFI. Previous attempts: 3 weeks
- MECS (2-10 keV) image
  (Feroci et al 1998 A&A)

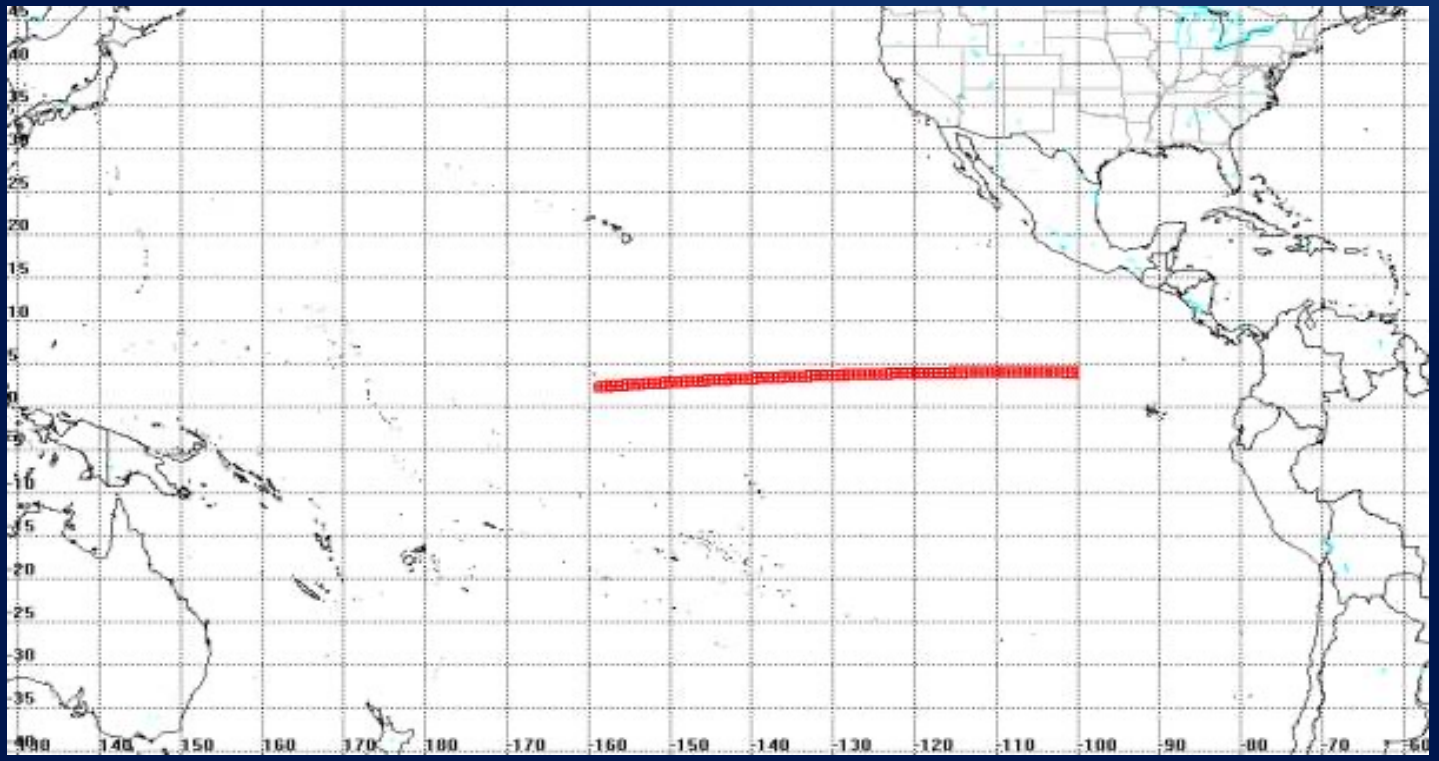


Start time of TOO from GRB



The end

- Switched-off on April 30, 2002 (The last observation was a GRB Target of Opportunity)
- Re-entered on 29 April 2003, 22:06 UTC.
- “Rest in pieces in the Pacific Ocean” (J. Trumper)



Team Awards

The High Energy Astrophysics Division
of the
American Astronomical Society
hereby awards the
1998 BRUNO ROSSI PRIZE
to
The BeppoSAX Team
For the discovery of the X-ray and optical afterglow of gamma-ray bursts, making possible the solution to the 30 year old problem of fixing the distances to the gamma-ray burst sources.

Gordon Garmire
Chair, HEAD

Founded 1899

Alan Marscher
Secretary-Treasurer, HEAD

THE COMMISSION OF THE EUROPEAN UNION - RESEARCH DIRECTORATE GENERAL

We, the 2002 Descartes Prize Grand Jury, hereby certify that the research work entitled
"Solving the gamme-ray burst riddle: the universe's biggest explosions"
entered by Prof. Edward VAN DEN HEUVEL, University of Amsterdam (NL)
in association with Prof. Jan van PARADIJS, Dr. Titus GALAMA, Dr. Paul GROOT (University of Amsterdam - NL) • Dr. Chryssa KOUVELIOTOU (NASA/MSFC - US) • Dr. John HEISE, Dr. Jean Dr. Luigi PIRO, Dr Enrico COSTA (CNR/IASF, Roma - I) • Prof. Filippo FRONTERA (University of Ferrara - I) • Dr. Elena PIAN (INAF, Trieste - I) • Dr. Luciano NICASTRO, Dr Marco FEROCI (CNR/IASF, Pal Dr. Jens HJORTH, Dr. Holger PEDERSEN (University of Copenhagen - DK) • Dr Alberto CASTRO-TIRADO (LAEFF/INTA - E) • Dr. Jochen GREINER (AIP - D) • Dr. Nial TANVIR, Dr. Ralph WIJERS (Cambridge
has been judged to be worthy the award of the

Descartes Prize 2002

Yves Michot

Il Presidente della Repubblica

Roma, 20 gennaio 1998

Illustre Professore,

La ringrazio per la Sua lettera e per la gentile comunicazione del prestigioso riconoscimento che l'American Astronomical Society ha assegnato alla gestione italo-olandese del satellite "Beppo-Sax" dell'Agenzia Spaziale Italiana.

Il conferimento del premio "Bruno Rossi" è una ulteriore conferma della considerazione della comunità scientifica internazionale per il lavoro italiano al più alto livello tecnologico, tenuto conto del rilievo dei risultati conseguiti nell'attività di ricerca realizzata.

Nel manifestare a Lei e ai collaboratori impegnati nel progetto sentimenti di vivissimo plauso per l'importante riconoscimento, sono lieto di farLe giungere i più fervidi auguri di successo per l'impegnativo lavoro dell'Agenzia.

Con molta cordialità

On. Prof. Sergio DE JULIO
Presidente Agenzia
Spaziale Italiana
Via di Villa Patrizi, 13
ROMA

19-FEB-1998 16:40 P.02

AR. P. 98/2859
16 FEB. 1998

Il Presidente del Consiglio dei Ministri

Roma, 13 FEB. 1998

Gentile Presidente,

sono veramente lieto per il prestigioso riconoscimento conferito all'équipe di scienziati italiani che hanno partecipato alla realizzazione della missione "Beppo-SAX".

Desidero, perciò, esprimerLe il mio personale apprezzamento e le mie più vive congratulazioni per gli eccellenti risultati conseguiti che testimoniano l'impegno e la competenza delle strutture del nostro Paese che operano nel settore della ricerca spaziale.

Nell'augurare all'ASI sempre maggiori successi ed affermazioni nazionali ed internazionali sempre più rimarchevoli, La prego di gradire le mie più vive cordialità.

Con molta amicizia
C. Prodi

Romano Prodi

Prof. Sergio DE JULIO
Presidente ASI
Via di Villa Patrizi, 13
00161 ROMA

OCenW

Ministry of Education, Culture and Science
P.O. box 25000
NL-2700 LZ Zoetermeer
The Netherlands
Phone +31 79 3232323
Fax +31 79 3232320
Telex 32636 MINO NL

Dr. L. Piro
SAX Mission Scientist
Instituto Astrofisica Spaziale CNR
Via Fosso del Cavaliere
1-00133 ROMA
ITALY

Your letter	Ref.	Contact	Zoetermeer
	OWB/NTM/1998/15566	Bezemer	April 23, 1998
Subject: Sax		Phone: 079-3234244	

Dear dr. Piro,

For years the Ministry of Education, Culture and Science and the Ministry of Economic Affairs supported the design and manufacture of the Italo - Netherlands research satellite SAX. Lately reports have reached me of the very successful scientific operation of the SAX; these reports are more than confirmed by the recent award of the Bruno Rossi prize by the American Astronomical Society.

On behalf of the Netherlands government it is a pleasure for me to congratulate you and your collaborators in both the Italian and Netherlands astronomical communities on the successful execution of a technologically and scientifically challenging project.

Yours sincerely,
Minister of Education, Culture and Science,

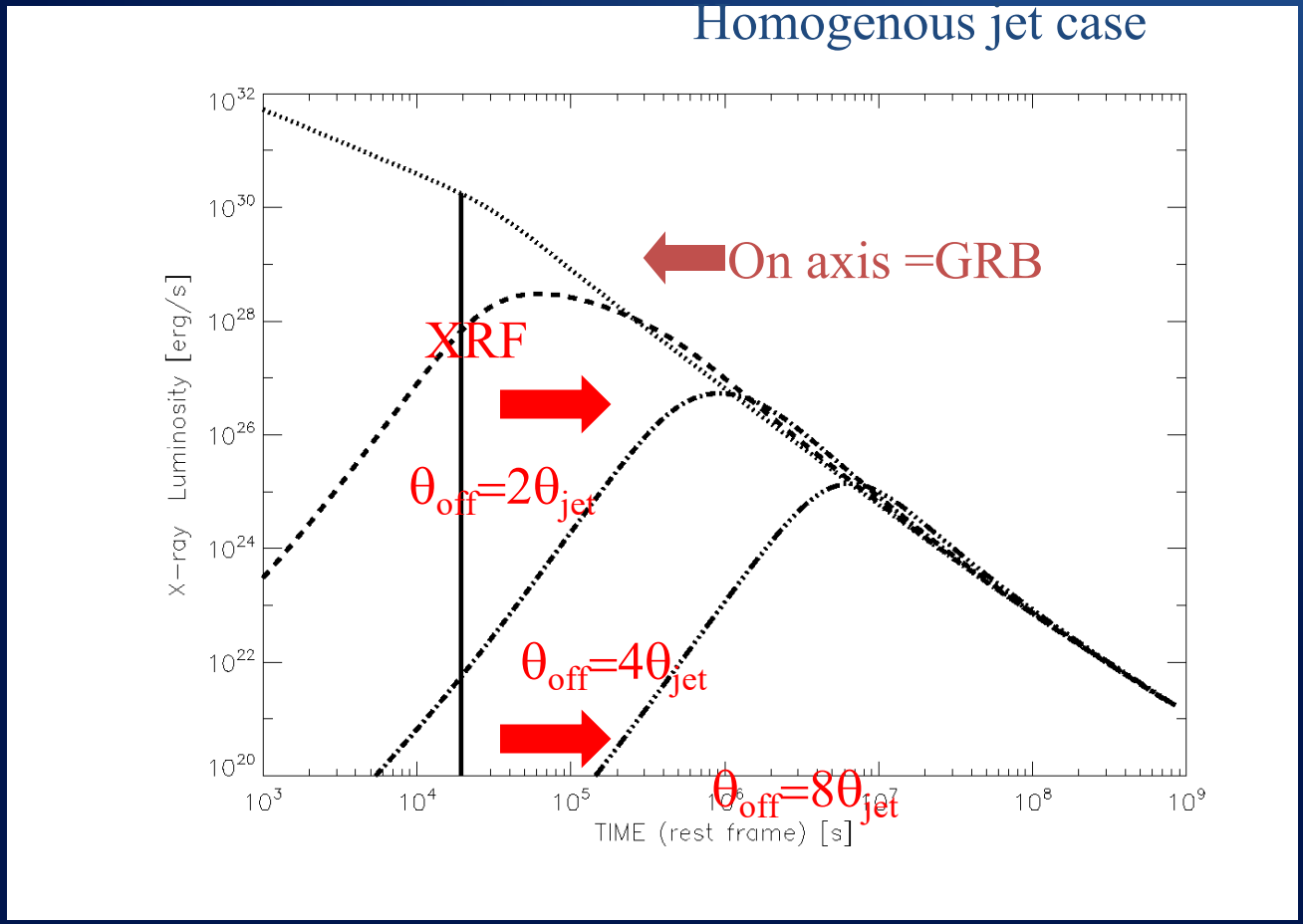
Dr. J.M.M. Ritzen

BSAX achievements on GRB

- Long GRB
- The first discoveries: afterglows(970228), cosmological origin (970508), relativistic outflow origin (970508)
- Prompt vs afterglow observational signatures: internal vs external shock in the fireball model
- collimated flows (jet breaks)
- Environment and progenitor:
  - X-ray absorption,
  - Wind vs ISM
  - Late-time reburstring
  - Precursors
  - X-ray lines
- Amati et al relations
- Deviations from standard fireball model (Flares, late time reburstring)
- Dark GRB (absorption in star forming region and high z Universe)
- X-Ray Flashes (off-axis GRB, high z events,..)

L. Piro - Washington 2005

Off-axis afterglows



•D'Alessio, Piro, Rossi, 05

L. Piro - Washington 2005

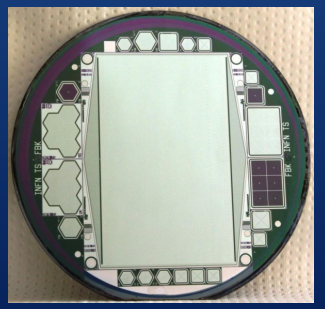
Satellite Operations

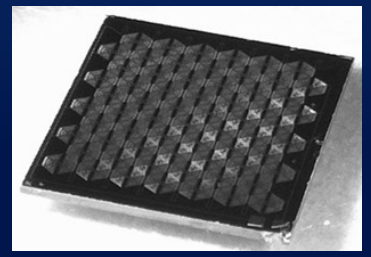
- All systems & subsystems working successfully for the entire lifetime
- May 97 1MECS switched off
- June 97 1 gyro mode, Oct 2002 gyroless mode successfully implemented with performances similar to the full-gyromode

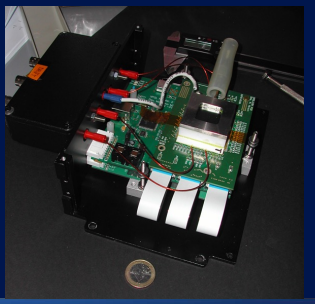
Technical challenges

- 92-94 HPGSPC discharging: redisign of part of the detector
- WFC spark: rewiring
- Ion plasma effect in LECS & MECS (high negative voltage of window would have accelerated ions, producing strong flux of bremmsstrahlung X-rays): kapton windows (nicknamed “mutanda” (underware))
- T-3months: leakage of calibration source of the HPGSPC in the PDS (producing unacceptable cnt rate in GRBM!): addition of a shield

BeppoSAX heritage







- Development of the HE astronomical community in Italy
  - Capability to manage (scientificall and programmatically) a complex observatory (5 instruments, 8 detectors)
  - Cutting edge technology in BSAX institutes (X-ray optics (XMM, Jet-X/SWIFT), Cryo microcalorimetes (Athena)..),Polarimetry, Gamma-ray instrumentation
  - New satellites, missions: X-ray Observatory by ESA: (New) Athena, Theseus, IXPE, nanosats,…
  - Creation of a strong Italian community in the GRB/time domain field and broad-band energy analysis (organization, s/w developments and tools, calibrations, science)
- Development of Italian Space industry: Alenia Spazio, LABEN (now Thales Alenia Space)
- ASI:
  - Malindi Ground Station for several missions (AGILE, SWIFT, HETE2, Fermi,..)
  - The Science Data Center, created for BSAX, evolved in multi astronomical mission data center (ASI-SDC)

Follow up of BSAX on GRBs: SWIFT

- NASA MIDEX call in 1998: 6 mission proposals + 1 MO on GRBs
- 2 mission proposals “replicating” the BSAX GRB procedure with a much faster on board control
- FIREBALL (PI: J. Kurfess) & SWIFT (PI: N. Gehrels)

BSAX heritage….

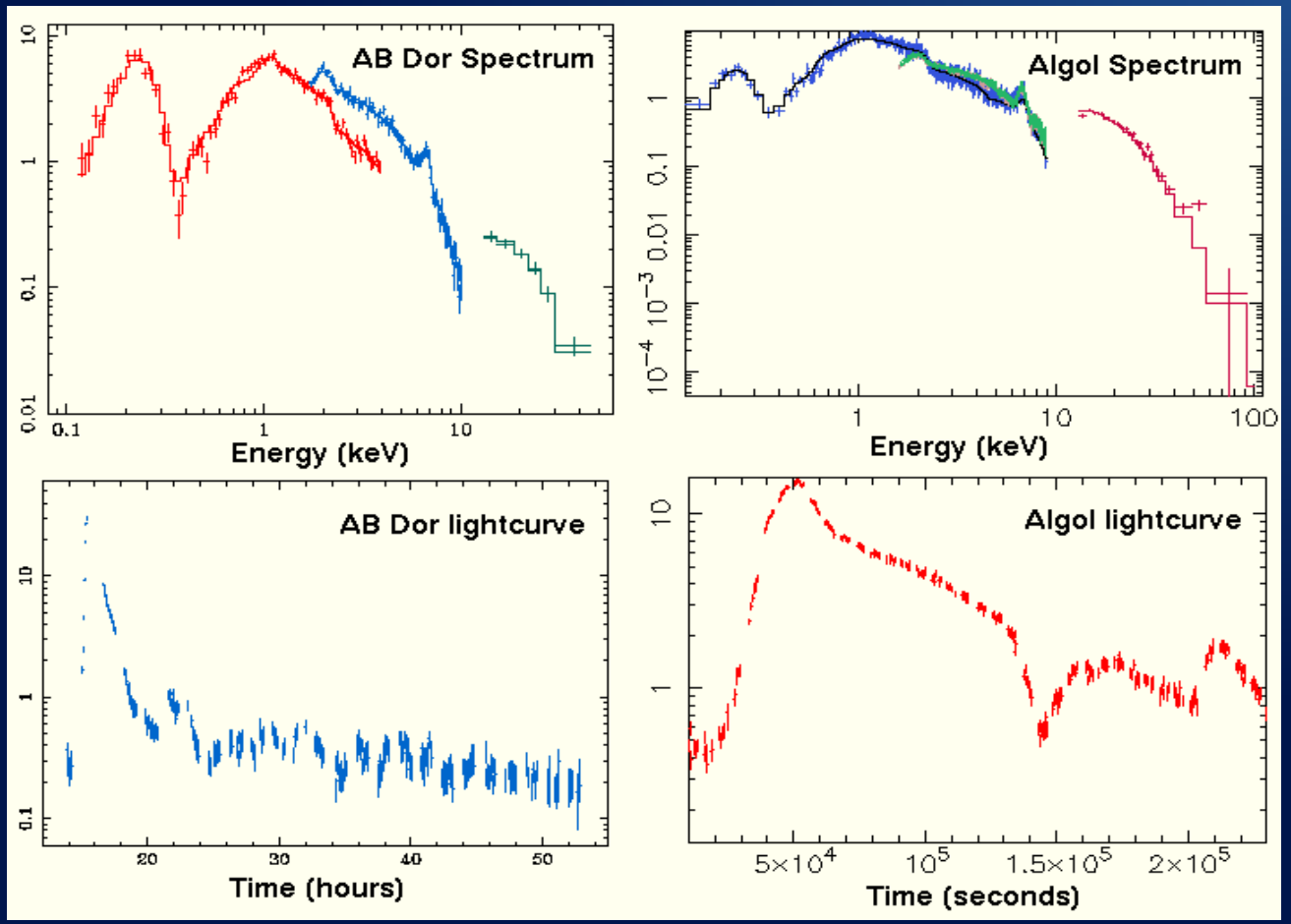
It was a time when smoking was an habit and helped keeping up with the pressure and sleepless nights, especially with GRBs…

End

BeppoSAX & Murphy's law

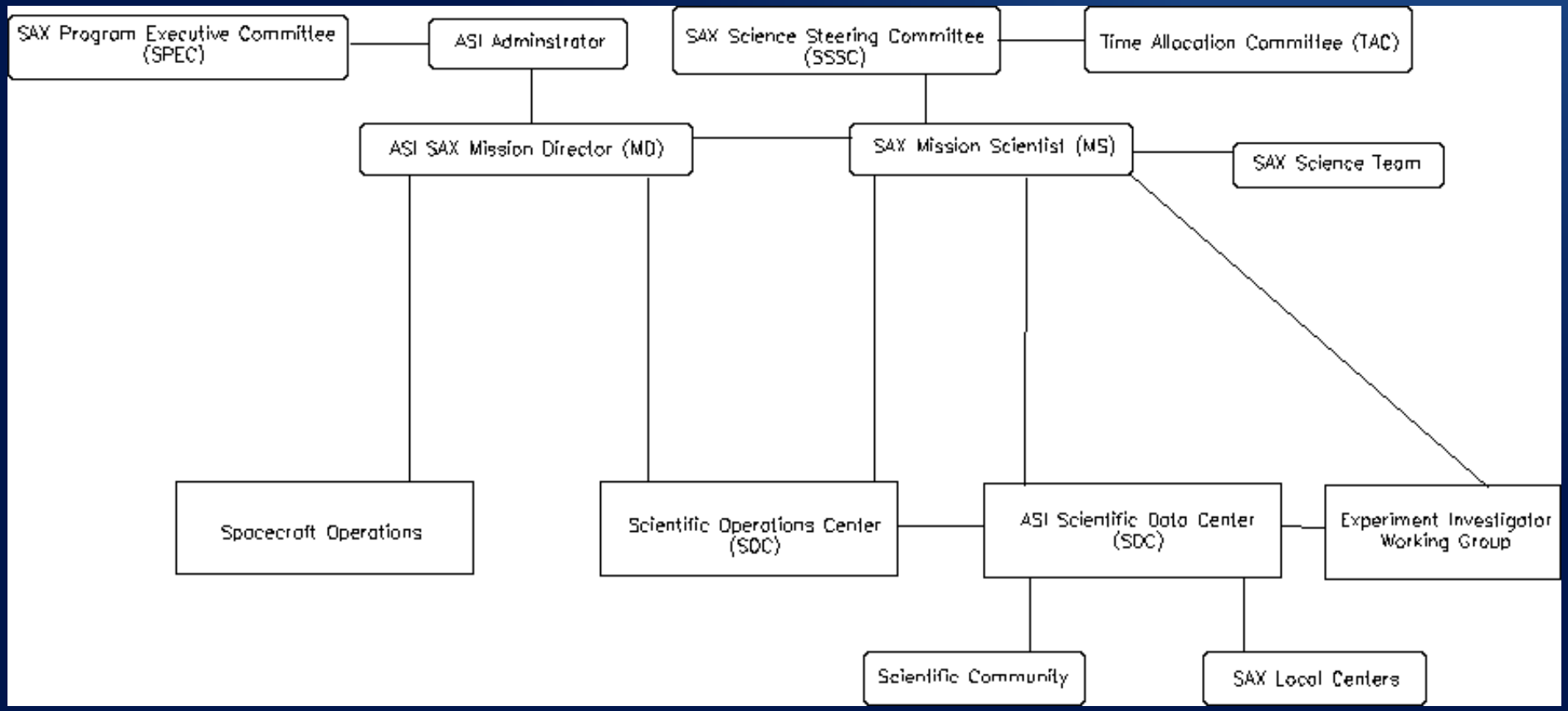
- Notwithstanding their random nature, GRB observed by BeppoSAX would go off at times maximizing nuisance to the team

Broad band observations of stars



- Wide-band X-ray spectrum and 2-10 keV lightcurve of AB Doradus and Algol, a rapidly rotating youngstar Courtesy of R. Pallavicini, Palermo Observatory, G. Tagliaferri Brera-MerateObservatory, F. Favata, Space Science Department of ESA and J. Schmitt, University of Hamburg, Germany.

BeppoSAX Organigram



EUROPEAN SCIENCE FOUNDATION

1 quai Lezay-Marnésia 67080 Strasbourg Cedex France Telex 890 440 Fax (33) 88 37 05 32 Telephone (33) 88 76 71 00

GAD/CW

Direct Line

sent by fax
fax number: +39 6 4404186

Professor Gian Pietro Puppi
Commissario Agenzia Spaziale Italiana
Via di Villa Patrizi 13
00100 Rome
Italie

A. S. I.
13 DIC. 1993
Prot. N. 020043

30 November 1993

Dear Professor Puppi,

Following an indication of Professor Colombo, the Chairman of the European Space Science Committee (ESSC), Professor H. Völk, charged Professor H. Schnopper to convene the SAX Working Group (headed by Professor L. Scarsi) for a presentation and a discussion at the ESSC meeting which took place in ESA headquarters in Paris on 11 November 1993.

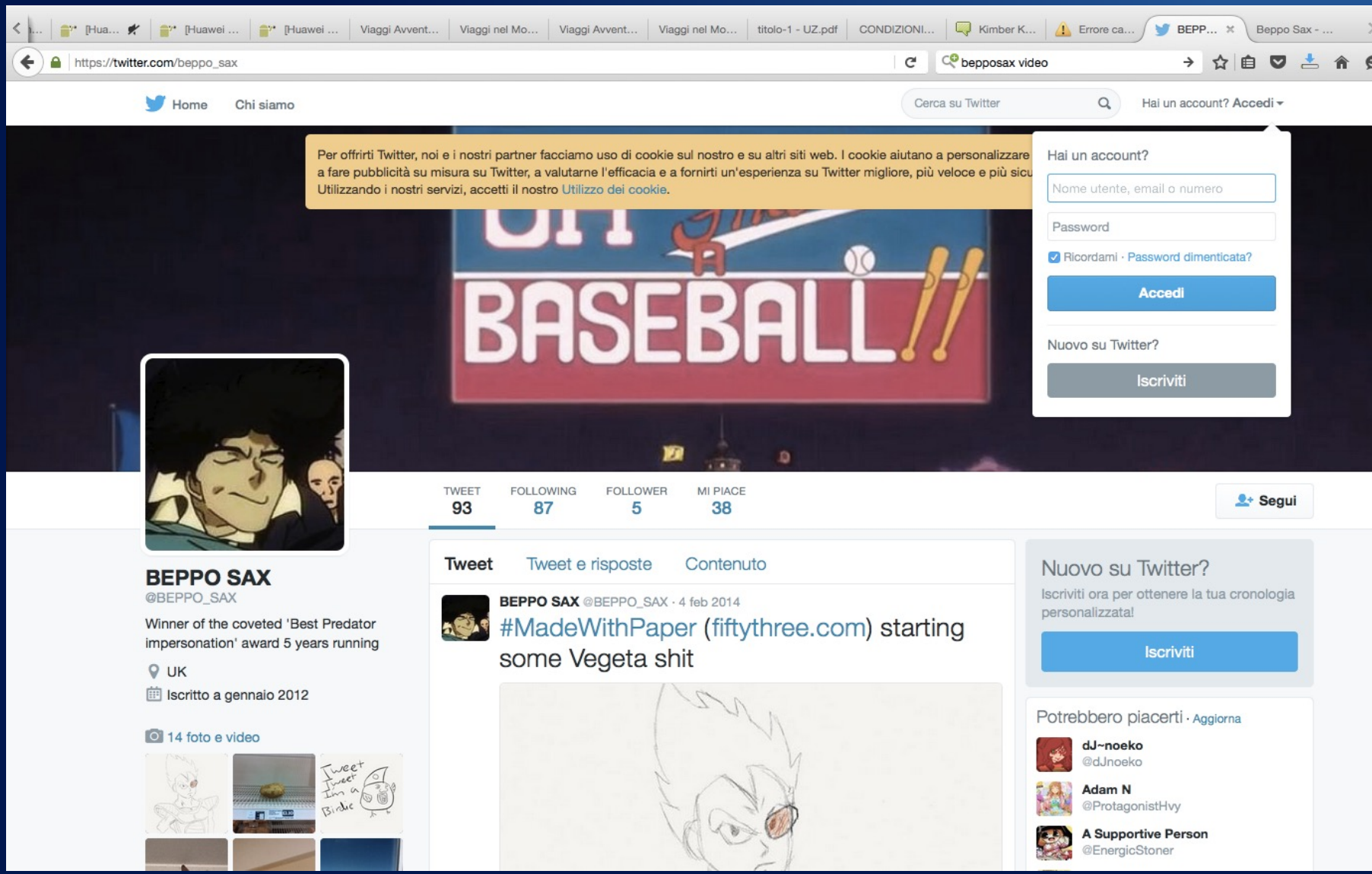
The attached document is the result of this presentation and the following discussion between the SAX Working Group and the panel of experts convened by Professor H. Schnopper.

Because of the short notice, the panel could not thoroughly examine the project, and therefore, managerial and financial aspects were not developed. However, based on the scientific arguments put forward by the SAX Working Group, the panel of experts recommends that the Italian Space Agency (ASI) should continue to support SAX.

Yours sincerely,

Giovanni Dalu

cc. Professor U. Colombo, Minister for Universities and Scientific and Technological Research
cc. Professor Livio Scarsi, Chairman of the SAX Science Steering Committee


https://twitter.com/beppo_sax
bepposax video
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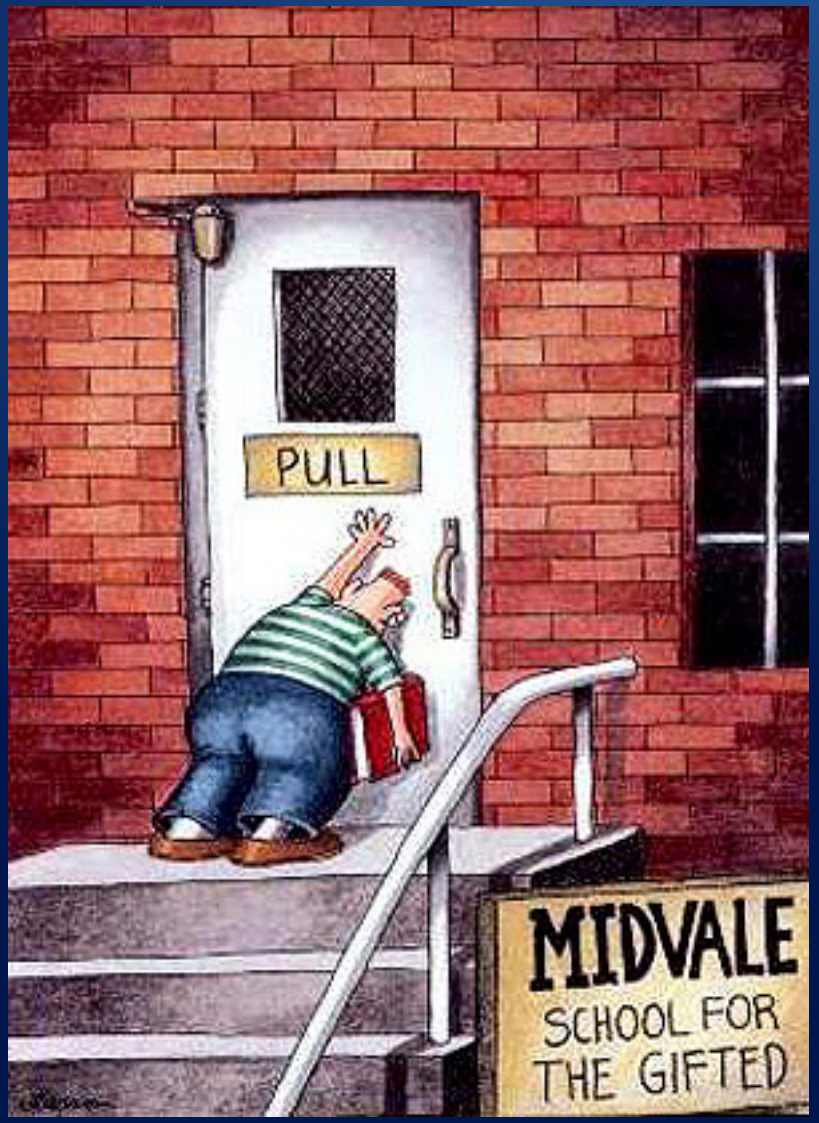
Hai un account? Accedi
Per offrirti Twitter, noi e i nostri partner facciamo uso di cookie sul nostro e su altri siti web. I cookie aiutano a personalizzare
a fare pubblicità su misura su Twitter, a valutarne l'efficacia e a fornirti un'esperienza su Twitter migliore, più veloce e più sicu
Utilizzando i nostri servizi, accetti il nostro Utilizzo dei cookie.
Hai un account?
Nome utente, email o numero
Password
Ricordami · Password dimenticata?
Accedi
Nuovo su Twitter?
Iscriviti
BASEBALL!!
TWEET 93
FOLLOWING 87
FOLLOWER 5
MI PIACE 38
Segui
BEPPO SAX
@BEPPO_SAX
Winner of the coveted 'Best Predator impersonation' award 5 years running
UK
Iscritto a gennaio 2012
14 foto e video
Tweet
Tweet e risposte
Contenuto
BEPPO SAX @BEPPO_SAX · 4 feb 2014
#MadeWithPaper (fiftythree.com) starting some Vegeta shit
Nuovo su Twitter?
Iscrivi ora per ottenere la tua cronologia personalizzata!
Iscriviti
Potrebbero piacerti · Aggiorna
dJ~noeko
@dJnoeko
Adam N
@ProtagonistHvy
A Supportive Person
@EnergicStoner


facebook
Iscriviti
l.piro@tin.it
Accedi
Stai riscontrando dei problemi?
BEPPO SAX
è su Facebook.
Per connetterti con BEPPO SAX, iscriviti subito a Facebook.
Iscriviti
Accedi
Crea una Pagina
Recenti
2016
2015
2014
2013
BEPPO SAX
Negozio d'abbigliamento
Contattaci
Diario
Informazioni
Instagram
Pinterest
Altro
Cerca post in questa Pagina
PERSONE
2070 "Mi piace"
10 visite
INFORMAZIONI
BEPPO SAX ha aggiunto 2 nuove foto.
Ieri alle 8:00 ·
#dondup #cesena #summer #beauty #design #dress #fashion #glam #hair
#heels #instagood #jewelry #love #me #model #nails #outfit #photooftheday
#purse #shoes #shopping #style #styles #stylish #swag #TagsForLik

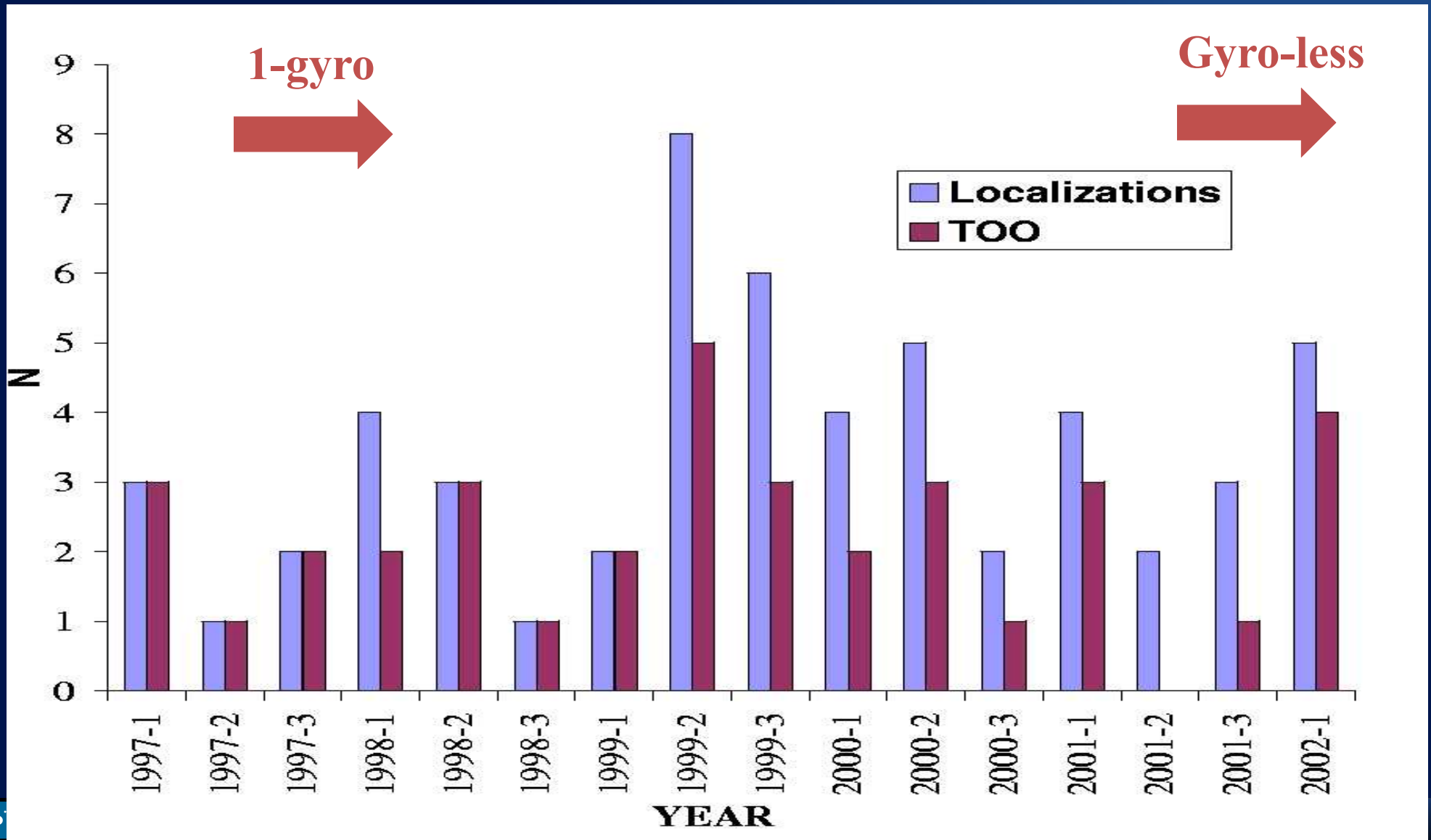
Lesson learned (?)

- X-ray community needs pushing together in one (proper) direction or…



© Gary Larson

Number of GRB localizations and fast TOOs



BeppoSAX hystory (cont'd)

- After assessment phase carried out by Aeritalia (now Alenia Spazio) in 1982 SAX was selected by PSN following the advice of an Advisory Panel composed by E. Amaldi, G. Occhialini, B. Rossi and L. Woltjer

Predicted lauch dates in early 80's

- BSAX: 1989 (launch:1996) (Scarsi et al 83)
- AXAF: 1992 (launch:1999) (Giacconi 83)
- XTE: 1990 (launch:1995)(Bradt et al. 83)

BSAX hystory (cont'd)

- 1993: The Minister of Universities & Scientific & Technological Research U. Colombo requested independent advise from the European Science Foundation. On Nov.11, the SAX program was presented by L. Scarsi, G.C. Perola & L. Piro to the ESF board, chaired by H. Schnopper.

14.3 COMMERCIAL ASSUMPTIONS

- Cost estimates are in Italian Lire at mid 81 economical conditions.
  Estimates performed by foreign companies in AU have been converted in Italian Lire by applying 1981 ESA conversion rates.
  This method of conversion, not totally correct if the program is entirely carried out in Italy, has been used considering the participation of foreign countries into the project.

- Furthermore not being feasible and possible for the short time available, for the limited budget and technical knowledge developed up to now in the program, to specify in detail the subsystem activities, a detailed quotation from all the possible companies involved have not been performed.
  Therefore Aeritalia has derived in house the cost figures, on the basis of cost comparison with historical data, and logical extrapolation driven by the particular nature of the program.

- The costs presented being an engineering estimate are evidently very preliminary and budgettary and do not contain any overhead on subcontractors or contingency on estimates.

- The cost of the payloads is not included in the present study but only system activities and integration of the overall satellite. The payload is understood to be as a bought-out equipment received by CNR.
  Beside the interface control, the AIT activities for the payload will be limited to the verification and

control of the milestones effecting the overall schedule.

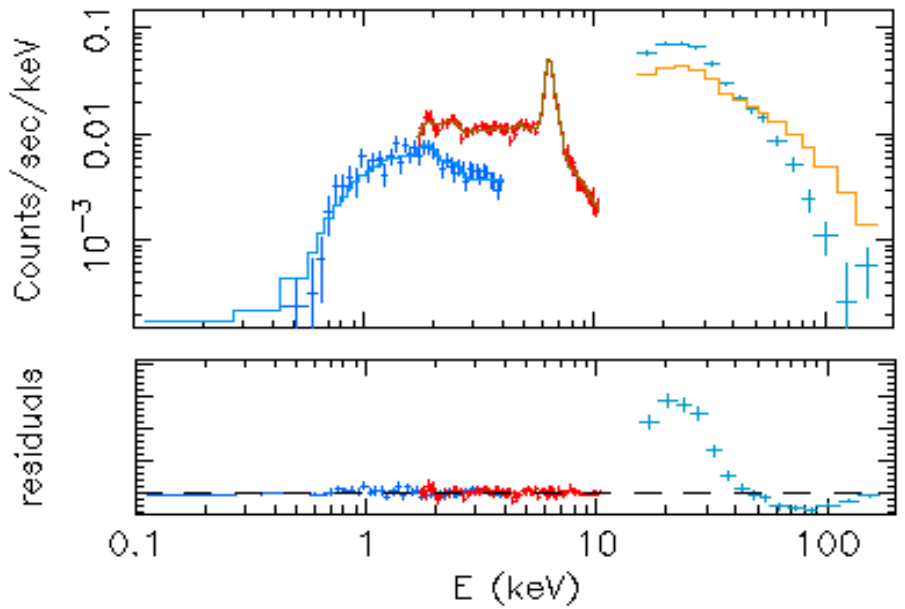
- In accordance to the Space philosophy mentioned before no amount for spares either for FU assembly or for operation has been included in the present estimate.

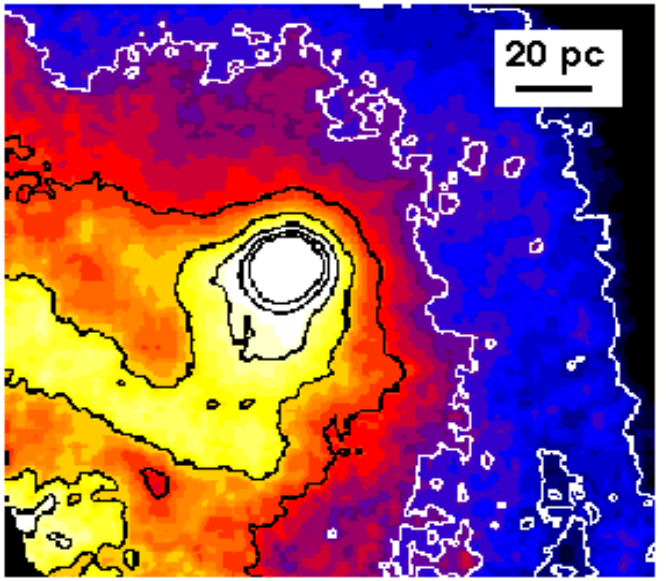
14.4 COST ESTIMATE

The cost estimate for the overall program including phase A and B are planned by Aeritalia in the following:

ACTIVITIES		Mlit	%
- Prime management		6500	7.2
- Sub/co management		6380	7
- Product Assurance		3000	3.3
- System Engineering		6440	7.1
- AIV (system)		6400	7.1
SUB-SYSTEM	- Structure	6600	7.2
	- Mechanisms	868	0.96
	- Thermal control	2260	2.5
	- Power/Pyro	5520	6.1
	- APS	4140	4.6
	- Electrical Dis.	1140	1.3
	- Solar Array	3325	3.7
	- TT&C	6444	7.1
	- Data Handling	8500	9.4
	- AMCS	16200	17.9
	- GSE	6440	7.1
- Launch support		400	0.44
TOTAL		90557	100

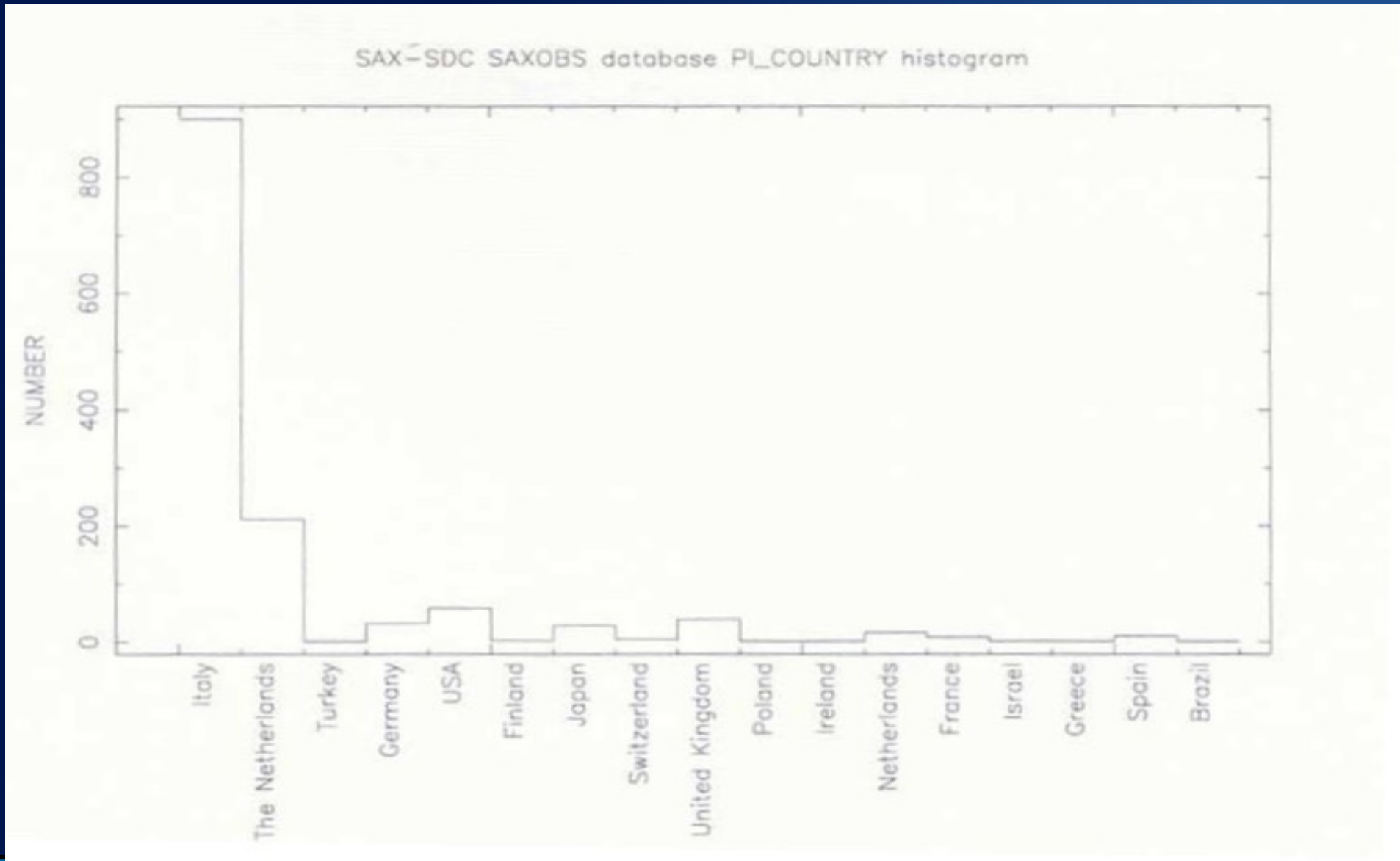
Dusty absorber in Circinus Galaxy in X-ray and IR





- ***The BeppoSAX LECS+MECS best fit spectrum of the Circinus Galaxy (plot to the left) shows a flatcontinuum and very strong iron emission. The extrapolation of this 0.1-10 keV spectrum to higher energies(PDS data) shows a further component, likely due to nuclear radiation transmitted trough a thick (~4x1024cm-2) absorber. Independent evidence of this absorber is shown on the right image taken in the nearinfrared (H-K color): the yellow-white lane is thought to trace a dusty-gaseous bar that drives gas into thenuclear region causing the absorption inferred from the X-rays. Courtesy of G Matt, III University, Rome,Italyand R. Maiolino, Arcetri Observatory, Florence, Italy***

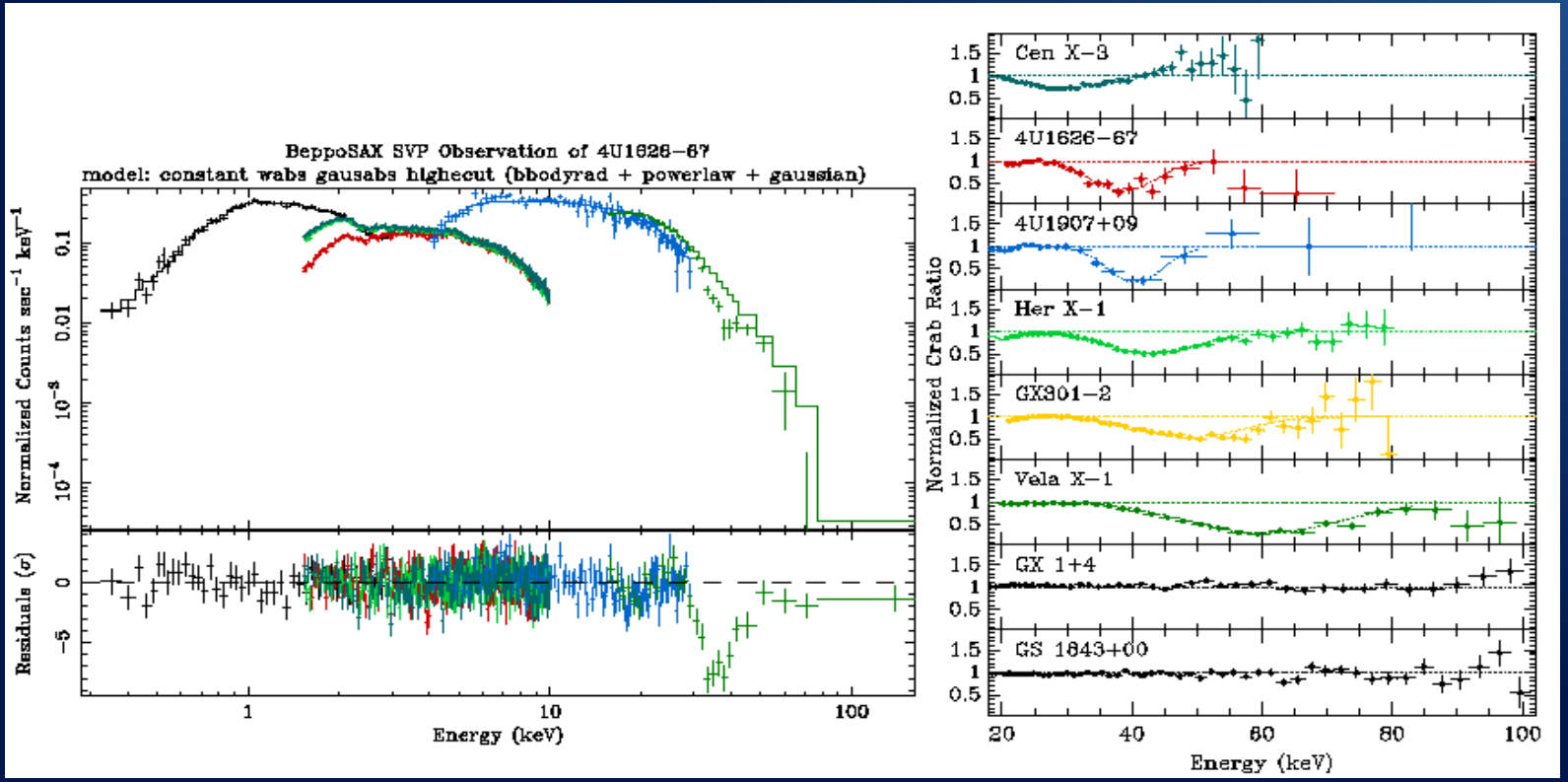
Summary of Operative Life (III)



Summary of Operative Life (II)

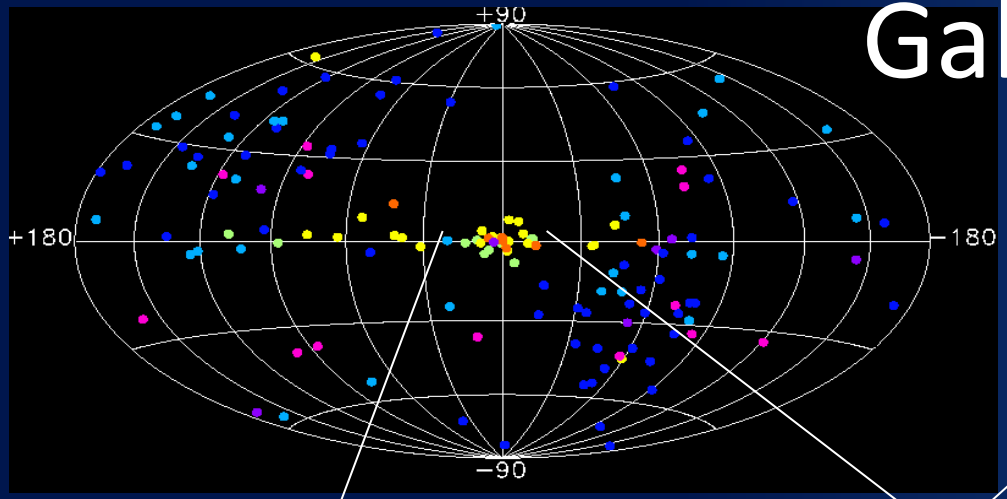
CLASS	AO1+SVP	AO2	AO3	AO4	AO5	TOTAL
Stars	1623	1165	795	850	277	**4710 ks**
Comp. Gal.	6710	3562	3238	3164	1907	**18580 ks**
SNR	520	470	443	887	350	**2670 ks**
Norm. Gal.	351	362	333	258	285	**1588 ks**
AGN	5314	4363	3914	3693	3623	**20906 ks**
Clusters	1074	1031	1212	1414	405	**5136 ks**
Other	291	211	622	0	100	**1223 ks**
Gen. TOO	1049	1262	1257	913	532	**5013 ks**
GRB TOO	501	572	550	440	142	**2205 ks**
TOTAL	**17433 ks**	**12996 ks**	**12363 ks**	**11618 ks**	**7621 ks**	**62033 ks**

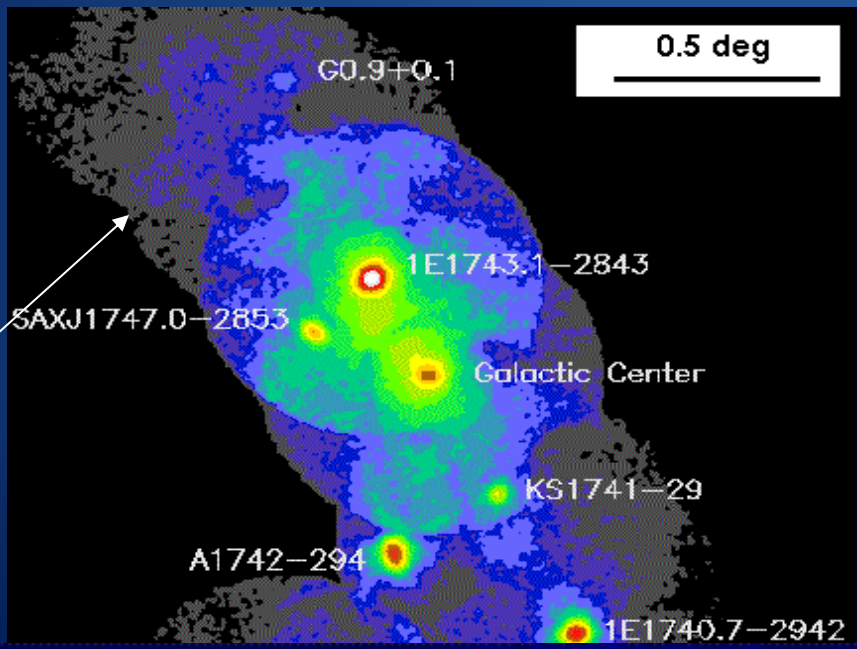
Cyclotron lines in X-ray Pulsars by BeppoSAX

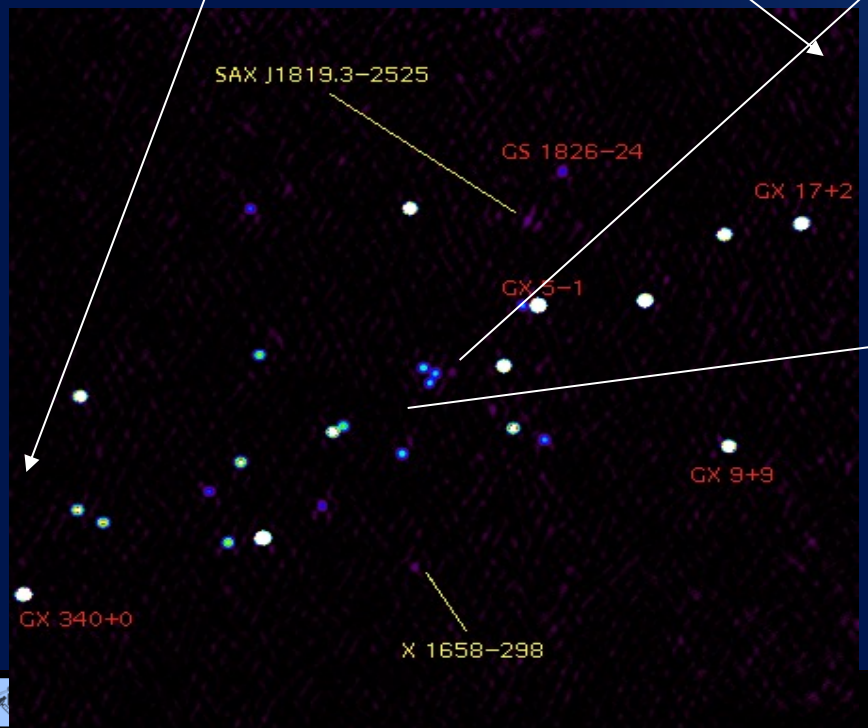


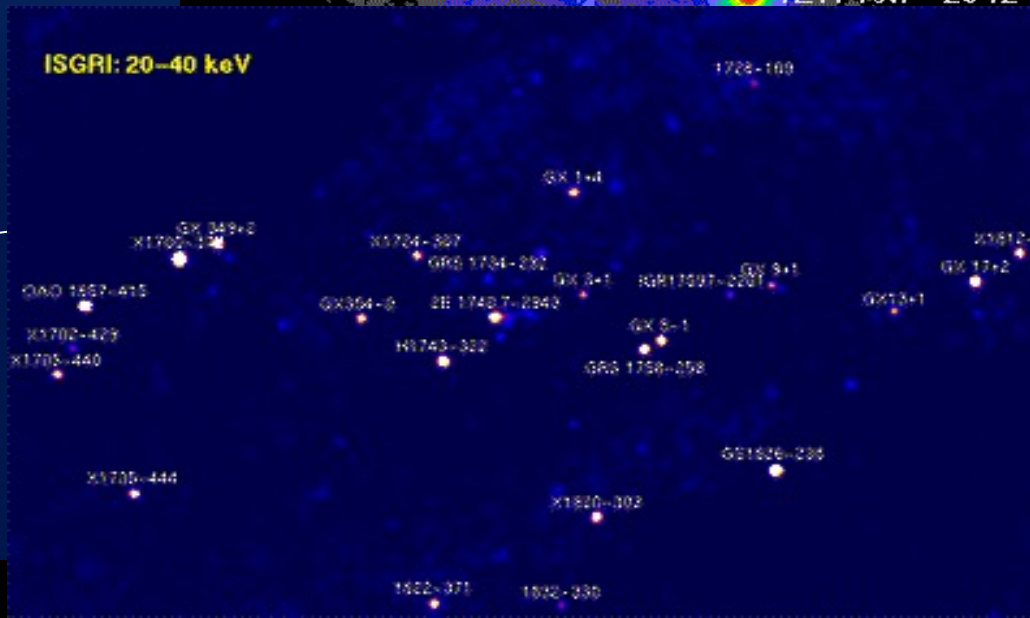
- ***The BeppoSAX observation of eight binary pulsars led to the detection of cyclotron lines in six of them. Inthree cases (the 4.8 sec high-mass X-ray pulsar Cen X-3; the 7.7 sec low-mass X-ray binary pulsar4U1626-67; and the 700 sec high-mass X-ray pulsar GX301-2) such features were never observed before.The broad-band spectrum of 4U1626-67 is shown on the left side. The figure on the right shows the spectraof the eight pulsars divided by the spectrum of the Crab Nebula, a technique that is used to visualize spectralfeatures such as cycrotron lines. Courtesy of M. Orlandini and D. Dal Fiume, TeSRE Institute, CNR,Bologna, Italy.***

The population of compact sources in our Galaxy

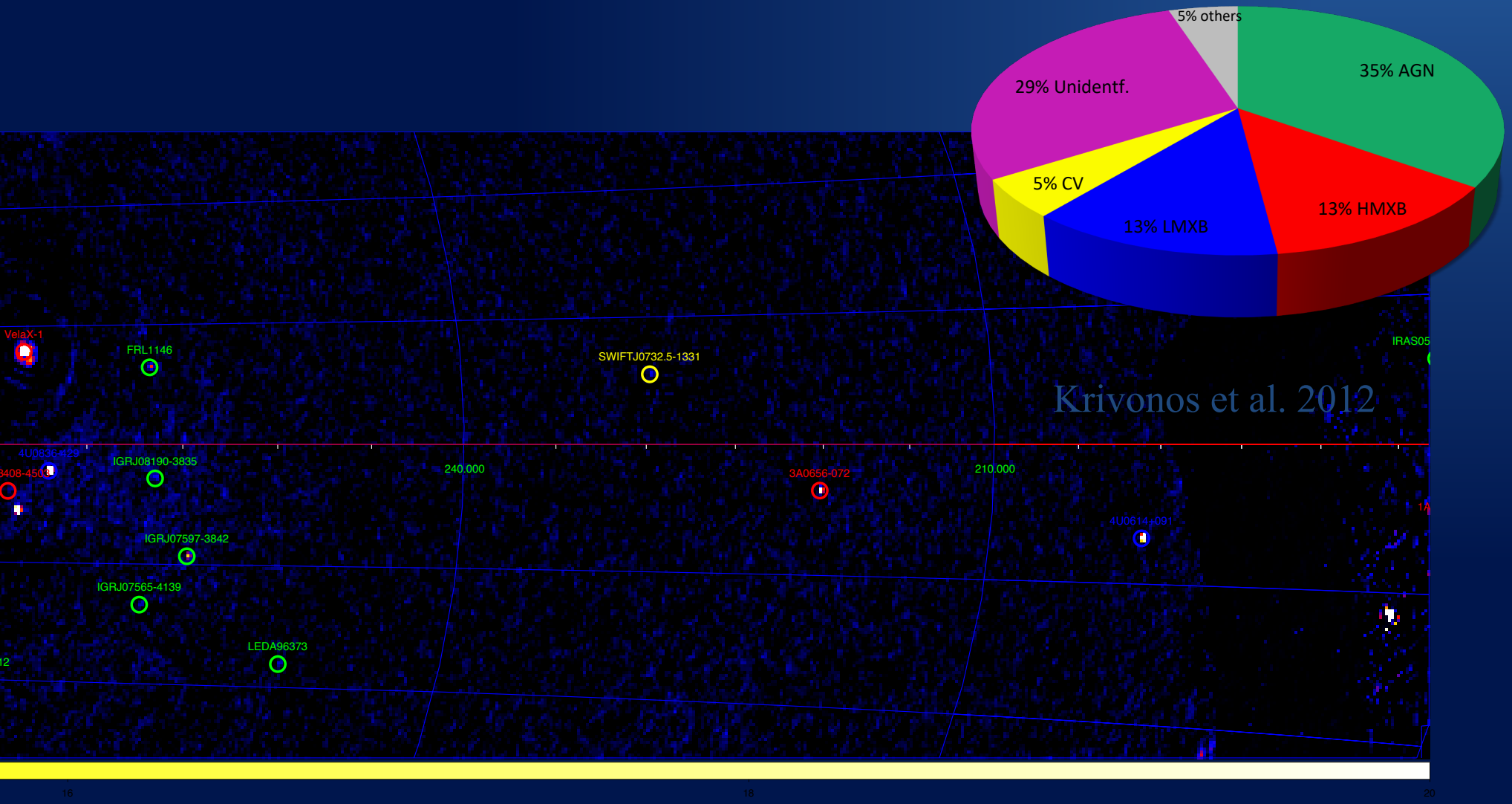






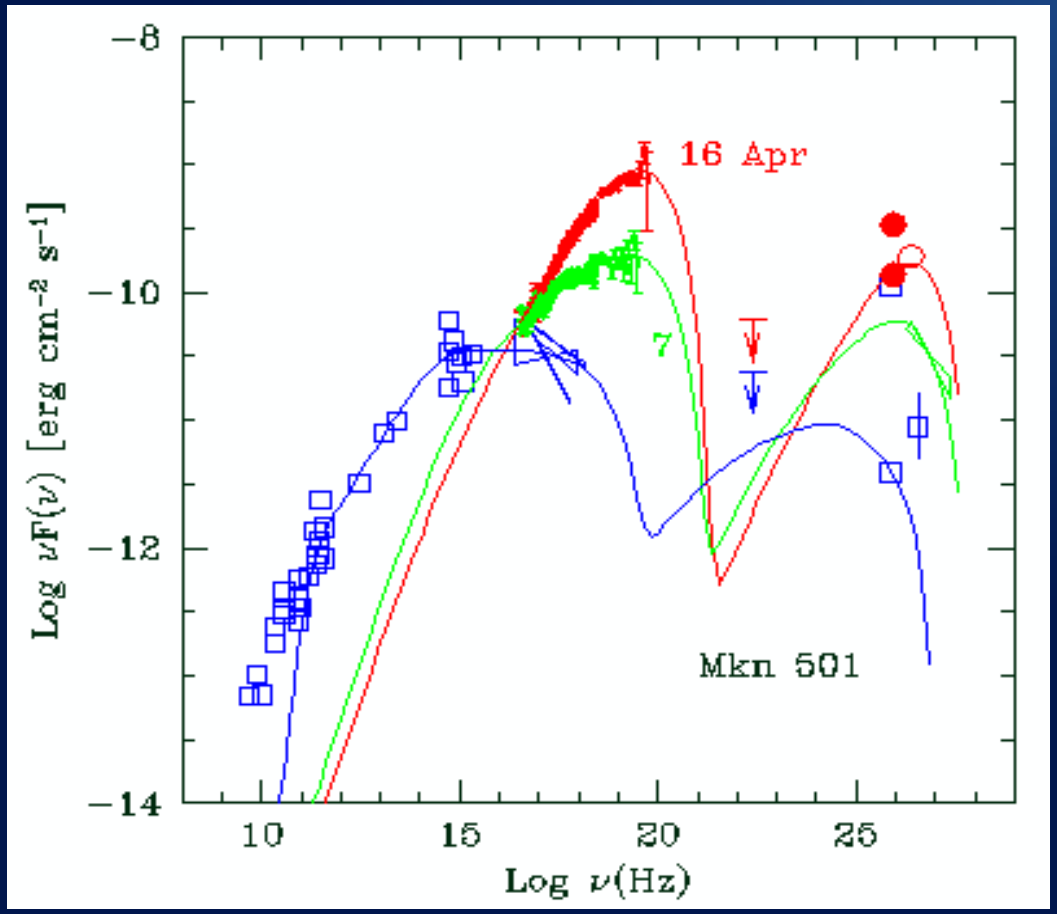


The hard X-ray sky, IBIS mosaic in the 18-60 keV



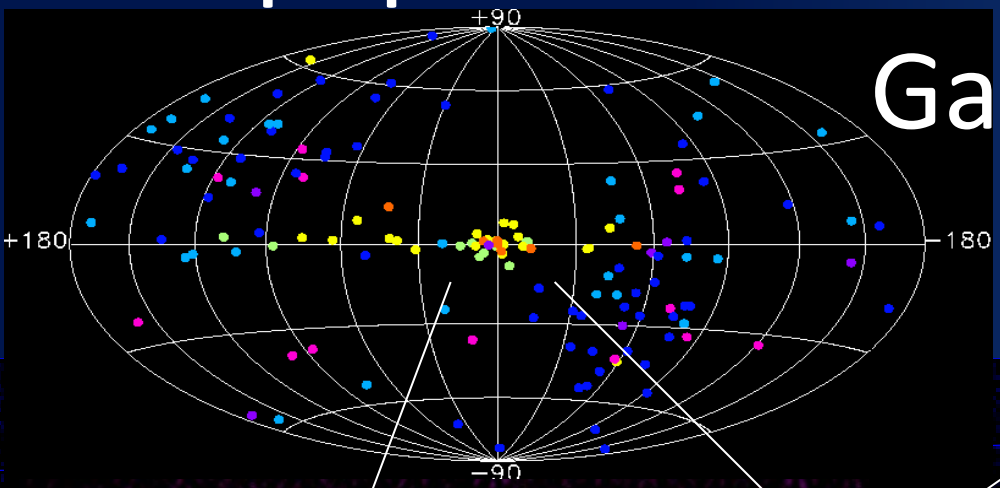
- ***Steering Committee:***
- ***L. Scarsi, J. Bleeker, G. Boella, B. Taylor,***

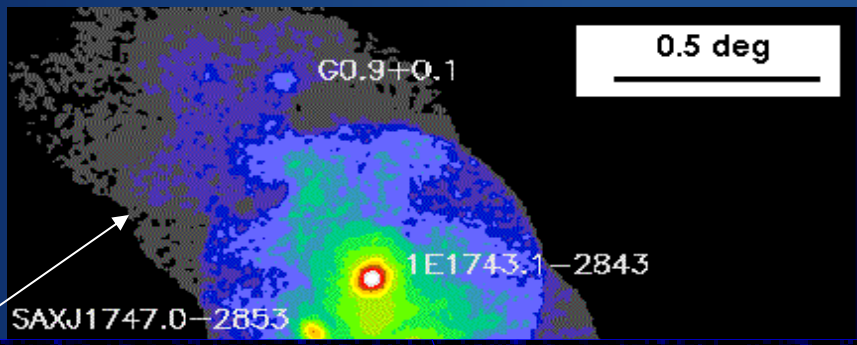
Broad band X-ray spectrum and UHE emission in Blazar

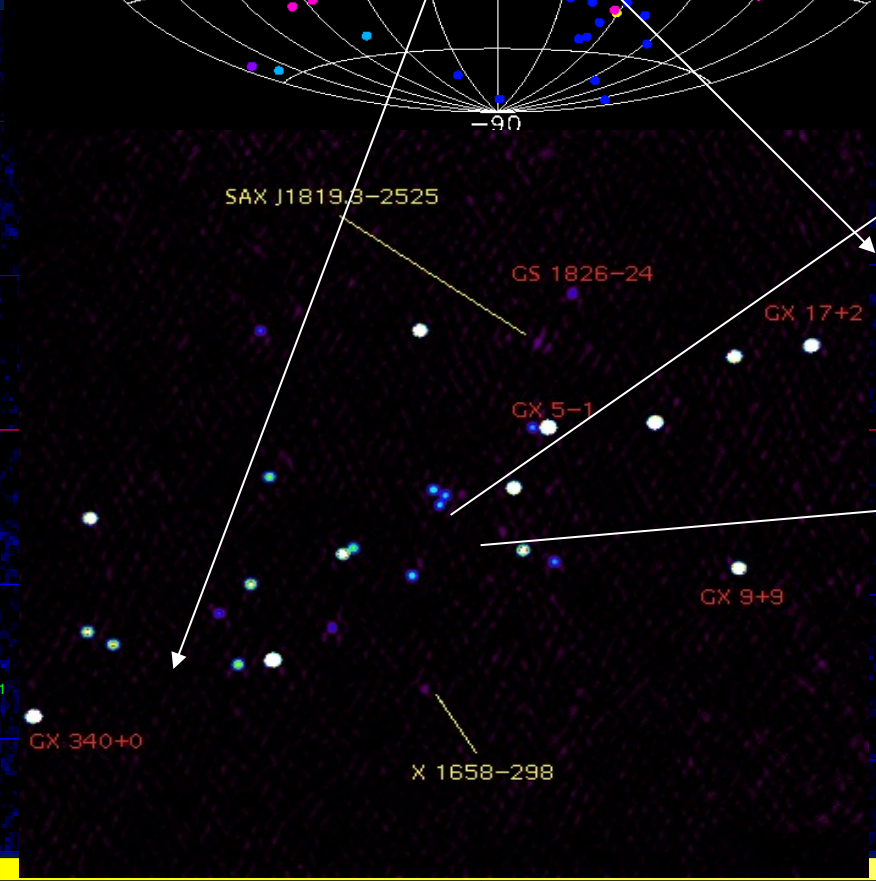


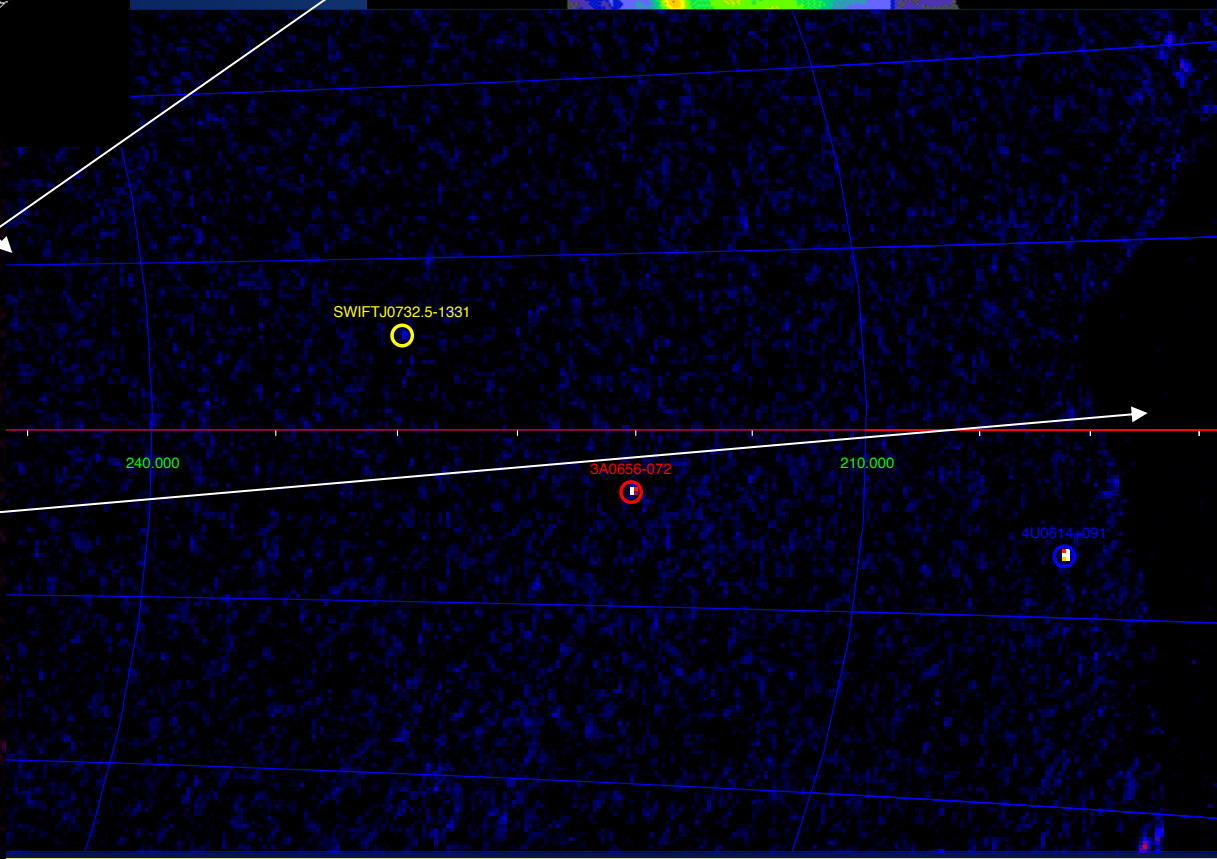
- BL Lacertae object MKN 501 during a very high intensity state. Courtesy of E. Pian, TeSRE Institute, CNR, Bologna, Italy

The population of compact sources in our Galaxy

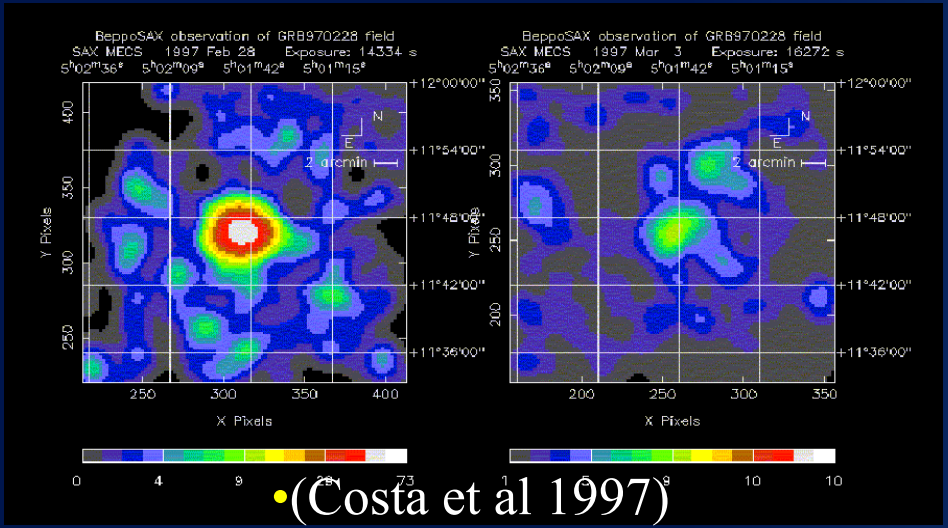




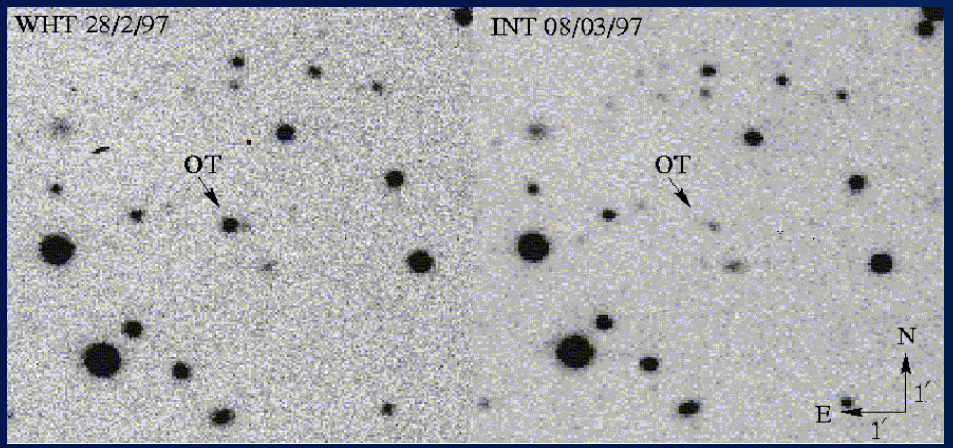




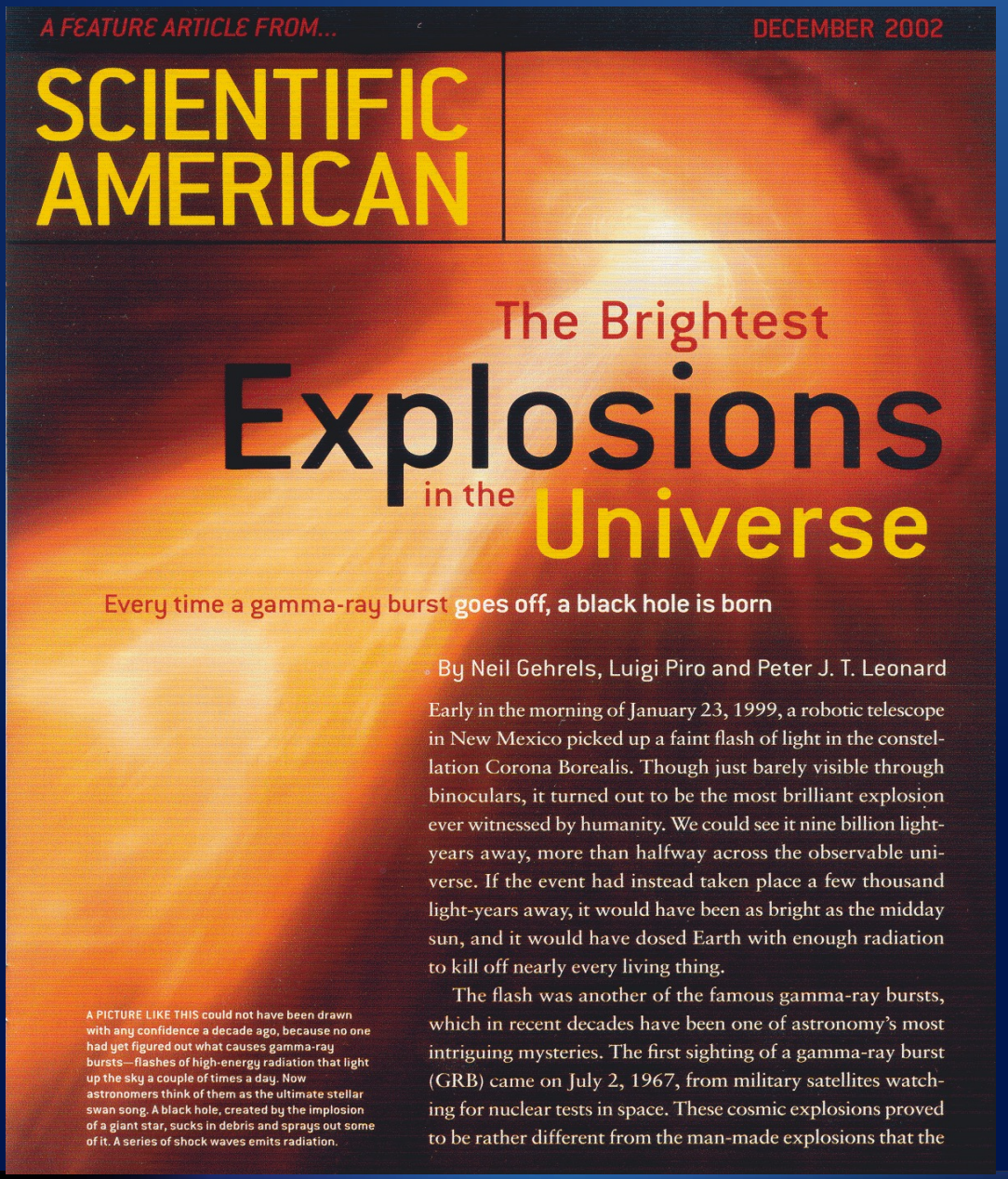
GRBs



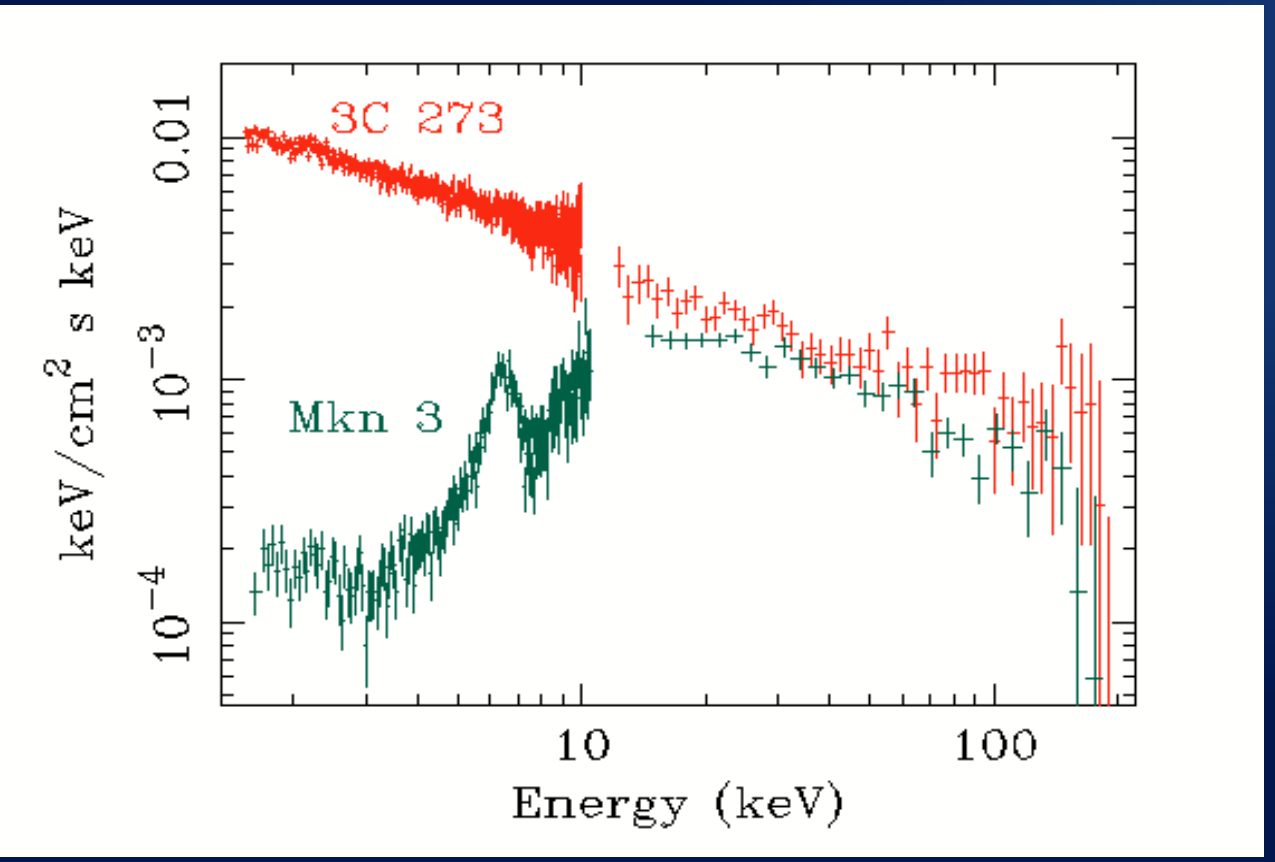
•(Costa et al 1997)



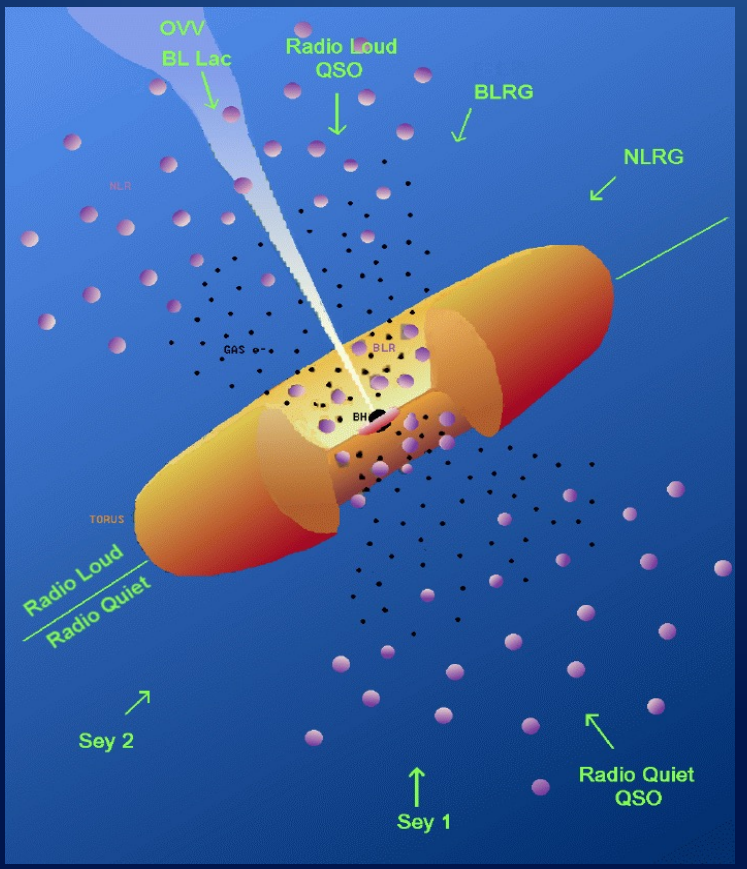
•(van Paradijs et al 1997)



Heavily Obscured (CT) AGNs



BeppoSAX broad-band X-Ray spectra of two Active Galactic Nuclei: the Quasar 3C273 and the Seyfer type2 galaxy MKN 3. Courtesy of M. Cappi, L. Bassani, TeSRE , CNR.



Adapted from Urry and Padovani
Courtesy of M. Polletta, ITESRE/CNR, Bologna, Italy