2016 JSI Workshop: Astrophysics in the Era of Gravitational Wave and Multimessenger Observations, Annapolis, November 9 - 11, 2016

INTEGRAL update of γ-ray follow-up of GW and HEN events and future perspectives

I am very grateful to that meeting organisers that gave me the chance to see Neil once more...

He was nice as usual and we shortly talk each other about future programs...

Angel… …SDC),
Erik Ku… …Roland
D…

…ology
…Planetologia Spaziali

Gerhels Memorial Meetings,
National Academy
Washington DC,
May 21 - 22, 2018

International Contribution to European Progams & Neil's contribution to INTEGRAL

Pietro Ubertini
Institute for Space Astrophysics and Planetology-INAF

INFN

iaps Institute for Space Astrophysics and Planetology
Istituto di Astrofisica e Planetologia Spaziali

Istituto di Astrofisica e Planetologia Spaziali di Roma
INAF Istituto Nazionale di Astrofisica

Neil:

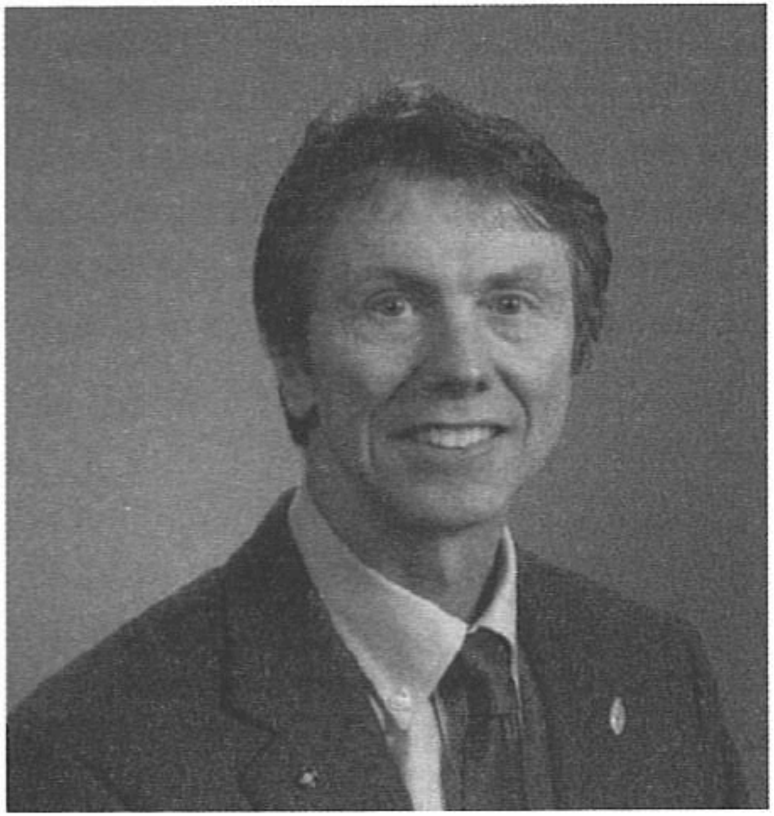
an important person in my life,

a colleague,

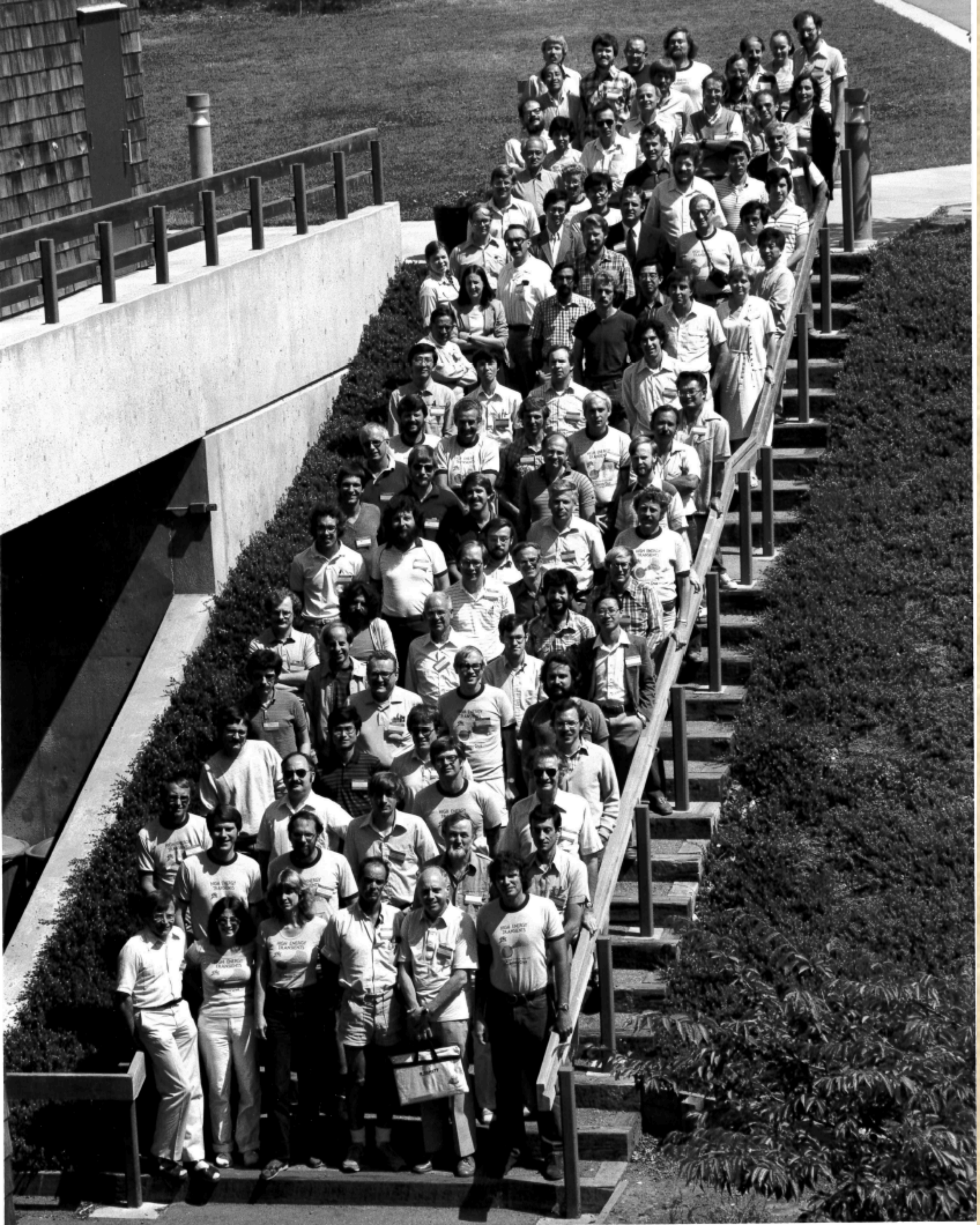
a lighthouse in my scientific choices,

but, even more important,

a friend...



Neil was a gentleman, a generous person and a scientist. He was always positive whenever he was approached by a student, colleague or lay person along his travels, when climbing, or in his everyday life.



The first meeting together:

"High Energy Transients in Astrophysics"

Santa Cruz, CA, 1983

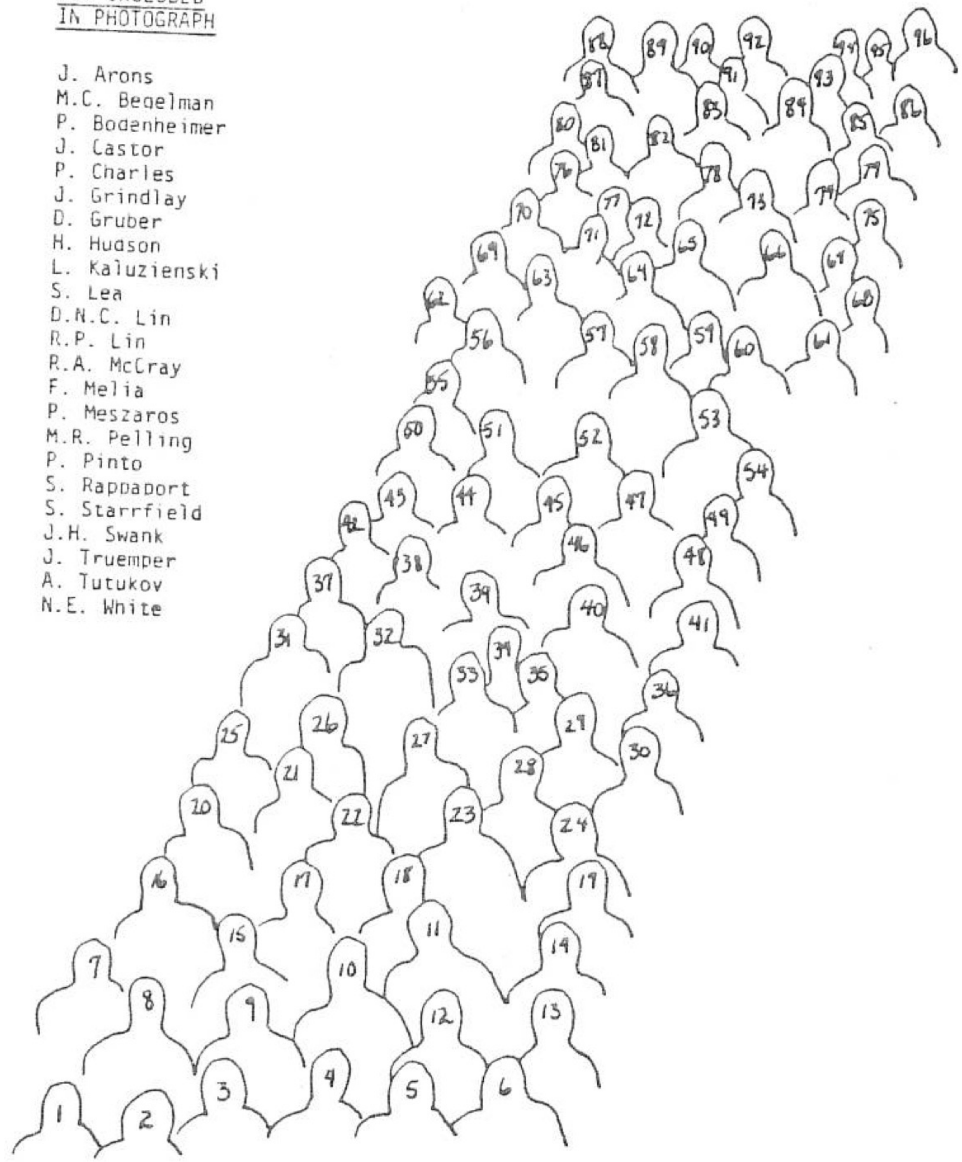
At that meeting participated a lot of "young" scientists that will become major player in the future of gamma-ray astronomy…

1983 PHOTOGRAPH IDENTIFICATION CHART

1. Friedrich Meyer
2. Lynn Cominsky
3. Carol Ambruster
4. Sterling Colgate
5. Reuven Ramaty
6. Stan Woosley
7. Wolfgang Pietsch
8. Richard Wallace
9. Dan Morris
10. Bradley E. Schaefer
11. Ed Fenimore
12. Richard Lingenfelter
13. Kevin Hurley
14. J.M. McKinley
15. James C. Higdon
16. Christian Motch
17. I. Fushiki
18. W. Nagel
19. Greg Zylstra
20. R. Bussard
21. Don Lamb
22. R.M. Hjellming
23. D. Dravins
24. D. Hartmann
25. J.G. Kirk
26. R. Klein
27. Ed Chupp
28. Steve Matz
29. R. London
30. Ed Liang
31. Tom Prince
32. Wojtech H. Zurek
33. Paul C. Joss
34. H. Herold
35. Albert Petschek
36. Robert Sarracino
37. Don Pakey
38. Brand Fortner
39. John Grunsfeld
40. R. Yahel
41. W. Brinkmann
42. Bob Wagoner
43. Wolfgang Voges
44. Doyle Evans
45. Neil Gehrels
46. Gerald Share
47. G.J. Fishman
48. Patrick Nolan
49. John Laros
50. Hajime Inoue
51. Yuzuru Tawara
52. Jim Matteson
53. Geoff Hueter
54. George Nakano
55. Upendra Desai
56. Alice Harding
57. Ravi Manchanda
58. Jan van Paradijs
59. Fumiaki Nagase
60. Brin Cooke
61. Graziella Pizzichini
62. Alanna Connors
63. T.L. Cline
64. J.P. Norris
65. Mark Jennings
66. James Terrell
67. M.Y. Fujimoto
68. Reiun Hoshi
69. Bruce Fryxell
70. Richard Ward
71. Ronald Taam
72. Nobuyuki Kawai
73. Tom Weaver
74. Noriaki Shibazaki
75. J. Brainerd
76. Minoru Oda
77. Mike Howard
78. James E. Felten
79. Ray Klebesadel
80. Bill Wheaton
81. Z.R. Wang
82. Walter Lewin
83. Paul Gorenstein
84. P. Ubertini
85. Joseph Ventura
86. B.M. Belli
87. Yang Lan-Tian
88. Jeff McClintock
89. George Ricker
90. John Faulkner
91. Bonnard Teegarden
92. Kent Wood
93. W.S. Paciesas
94. Fred Lamb
95. Sue Robinson
96. George Blumenthal

PARTICIPANTS NOT INCLUDED IN PHOTOGRAPH

J. Arons
M.C. Begelman
P. Bodenheimer
J. Castor
P. Charles
J. Grindlay
D. Gruber
H. Hudson
L. Kaluzienski
S. Lea
D.N.C. Lin
R.P. Lin
R.A. McCray
F. Melia
P. Meszaros
M.R. Pelling
P. Pinto
S. Rappaport
S. Starrfield
J.H. Swank
J. Truemper
A. Tutukov
N.E. White



The first meeting together:

“High Energy Transients in Astrophysics”

Santa Cruz, CA, 1983

Neil and Jerry Fishman on the right

At that meeting participated a lot of “young” scientists that will become major player in the future of gamma-ray astronomy…

Ekkart Kendziorra (left) and Pietro


Tom Prince


Dieter Hartman


Nobuyuki Kawai


Tom Cline


Alice Harding Ravi Manchanda Ian van Paradijs

Peter Mezaros and
Josh Grindlay
participants not
in the picture


Don Lamb

The collaboration starts thanks to the SN87a blast and NASA baloon campaign organized in in Alice Springs: we were already there with the POKER experiment since 1986 to study the Galaxy Centre

- **NSBF Balloon campaign Spring 1989 from Australia (ALICE SPRING) devoted to SN87A and Galactic Centre observations**
- **Different experiments for High Energy Astrophysics: EXITE, GRIP, GRIS, HEXAGONE, LAPEX and POKER**

Resolved In 2004 by INTEGRAL detecting a weak diffuse emission and gamma ray sources

GRIS result by Neil et al., ApJ,385,L13, 1991

No. 1, 1991 GALACTIC CENTER POSITRON ANNIHILATION RADIATION L15

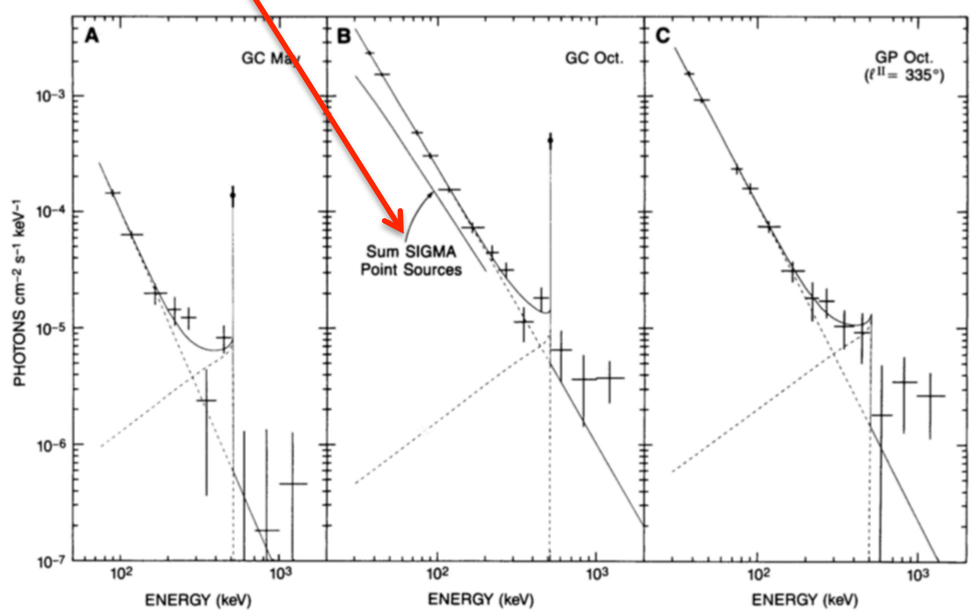
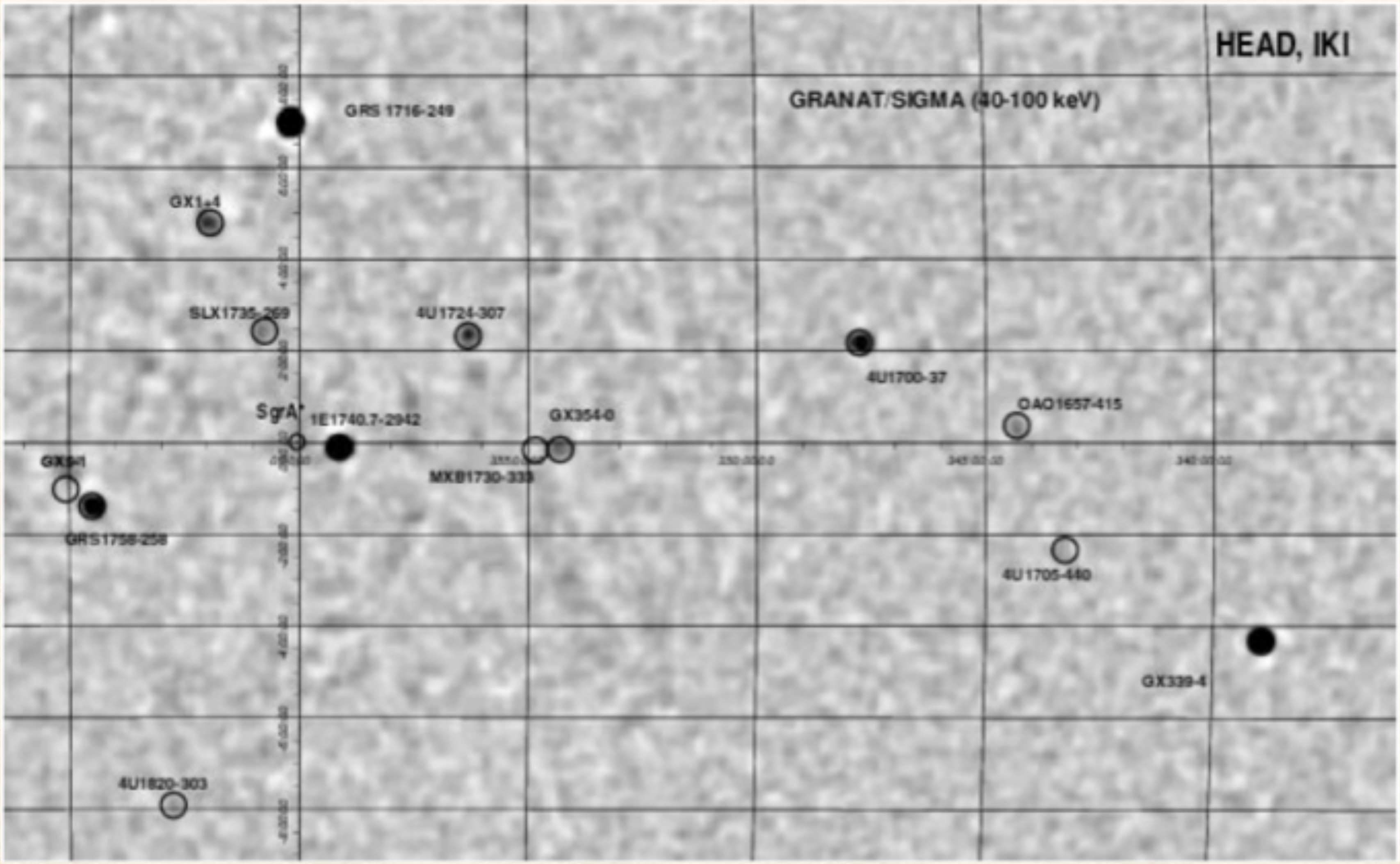
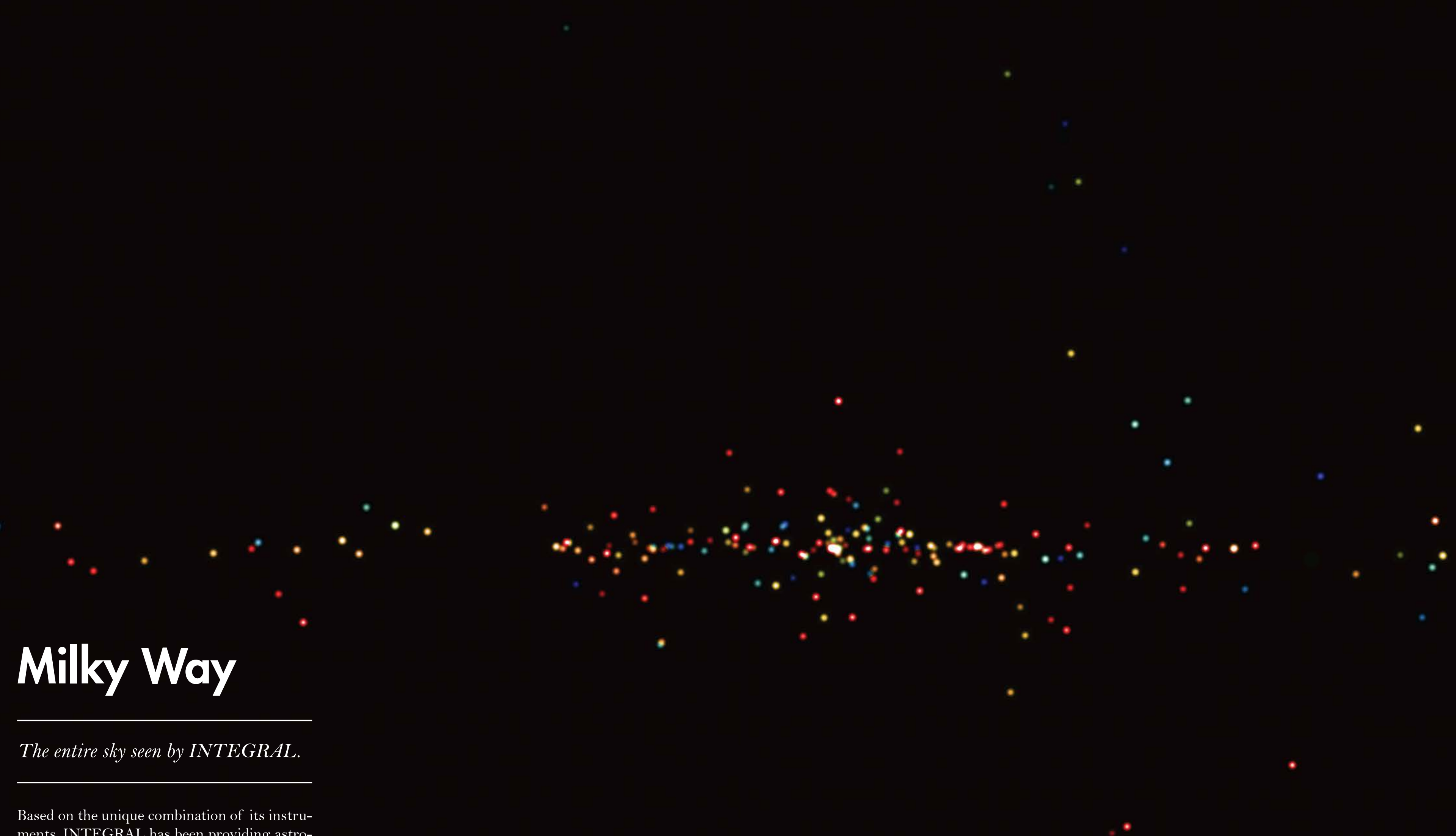


FIG. 1.—(*a–c*) Spectra and model fits for the 1988 GRIS observation of the Galactic center (GC) and Galactic plane (GP). Data between 52 and 68 keV have large statistical and systematic uncertainties due to the presence of strong background lines in this range and are not plotted. The sum of SIGMA point sources 1E1740.7 − 2942 and GRS 1758 − 258 in 1990 (Paul et al. 1991) are shown for comparison in (*b*)

In 2000 - 37 sources - SIGMA 40-100 keV (Revnivtsev+ 2004)





Milky Way

The entire sky seen by INTEGRAL.

Based on the unique combination of its instruments, INTEGRAL has been providing astronomers with a new view of the entire sky in hard X-rays and soft gamma rays for almost 14 years. By revealing both the diffuse emission from our Galaxy, the Milky Way, and the population of individual sources that shine brightly at these energies, INTEGRAL has broadened our understanding of several classes of sources, galactic and extragalactic alike.

POKER results useful from the 2 point sources, 1740.7-2942 and GRS 1758-255: None was coincident with SGR A* and they were both variable though persisten

Bazzano et al., APJ,385,L17, 1992

TABLE 1

RECENT OBSERVATIONS OF THE GALACTIC CENTER HIGH-ENERGY SOURCE (1E 1740.7 − 2942)

Date	Experiment	Type[a]	Range (keV)	Model: Power Law — Flux at 40 keV (10^{-4} photons cm^{-2} s^{-1} keV)	Model: Power Law — Slope (photons)	References
1988 Apr 12	GRIP	I	30–10000	5.64 ± 0.33	2.05 ± 0.15	1
1988 Oct[b]	GRIS	WFI	30–8000	19.8 ± 5.2	2.28 ± 0.06	2
1989 Mar–Apr	TTM–HEXE	I-NFI	2–200	5.5[c]	1.88 ± 0.07	3
1989 May 22	HEXAGONE	WFI	25–800			
1990 Mar–Apr	GRANAT	I	3–300			
1990 Apr–Sep–Oct	SIGMA	I	35–1300			
1991 Spring	SIGMA	I	35–1300			
1989 May 17	POKER	NFI	15–150			

[a] I: imaging instrument; NFI: narrow field instrument (FOV ≤ 2°); WFI: wid

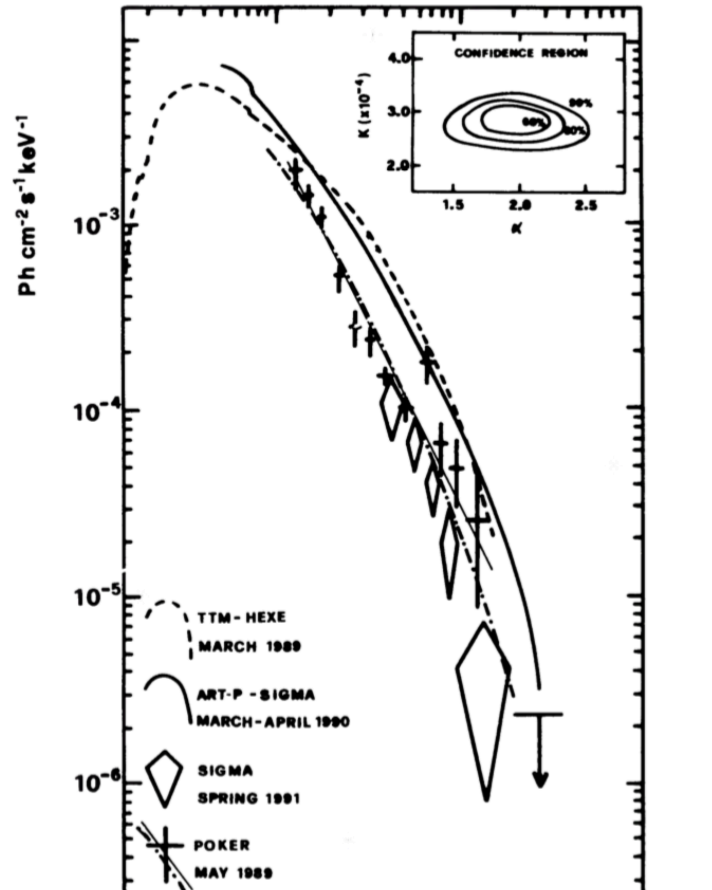
[b] The GRIS May 1988 observation starts from ≅80 keV.

[c] No error quoted in the paper.

[d] Comptonized fit only quoted in the paper.

[e] Average of nine different measurements.

REFERENCES.—(1) Cook et al. 1991; (2) Gehrels et al. 1991; (3) Skinner et al. 19
et al. 1991; (7) this *Letter*.



…..so idea that we should resolve the gamma ray puzzle in the Galaxy centre become more hot that ever…a compelling science case!

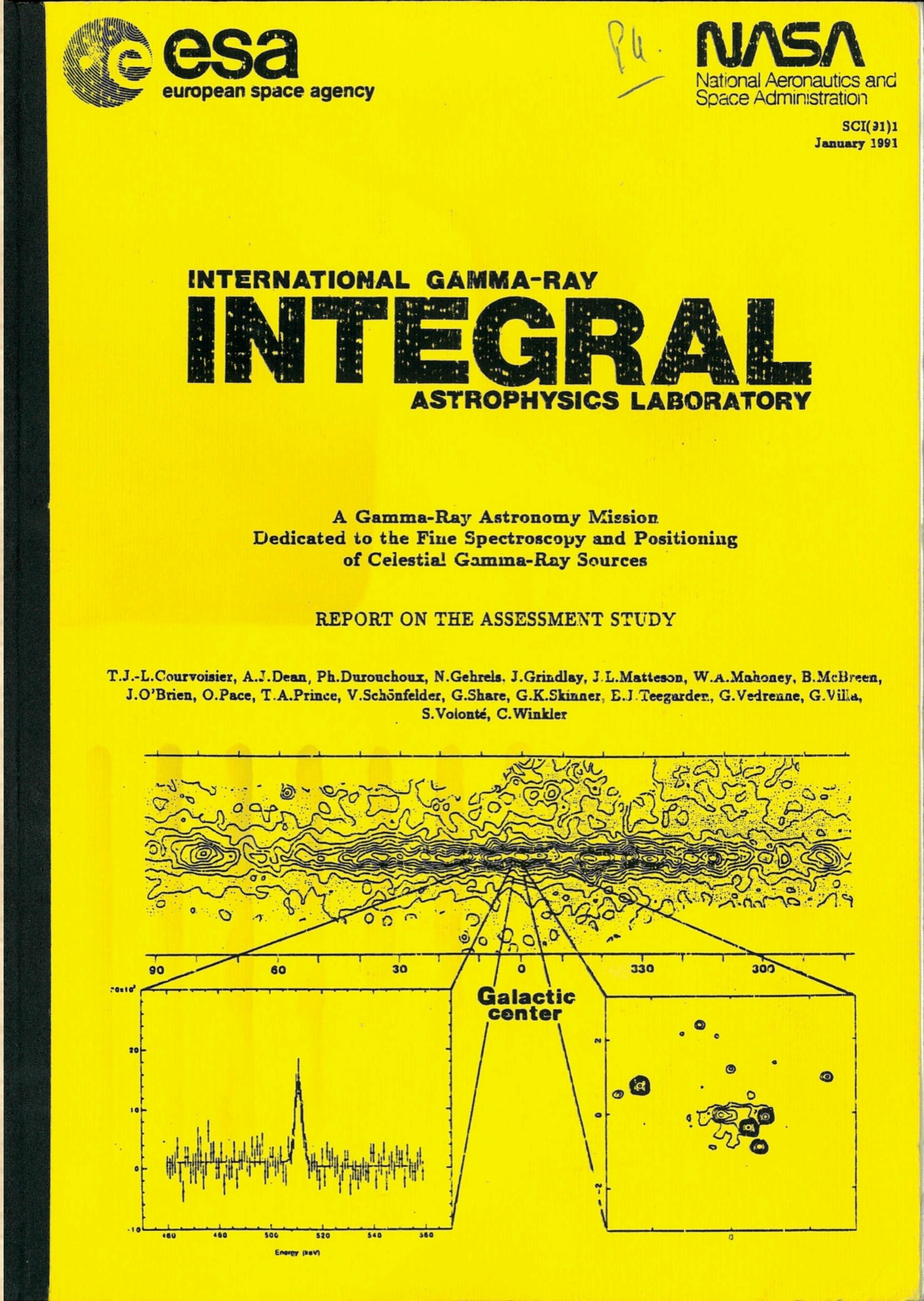
The opportunity was the M1 ESA call: a 500M€ mission + US strong contribution, the NAE spectrometer... But Cassini- Huygens won

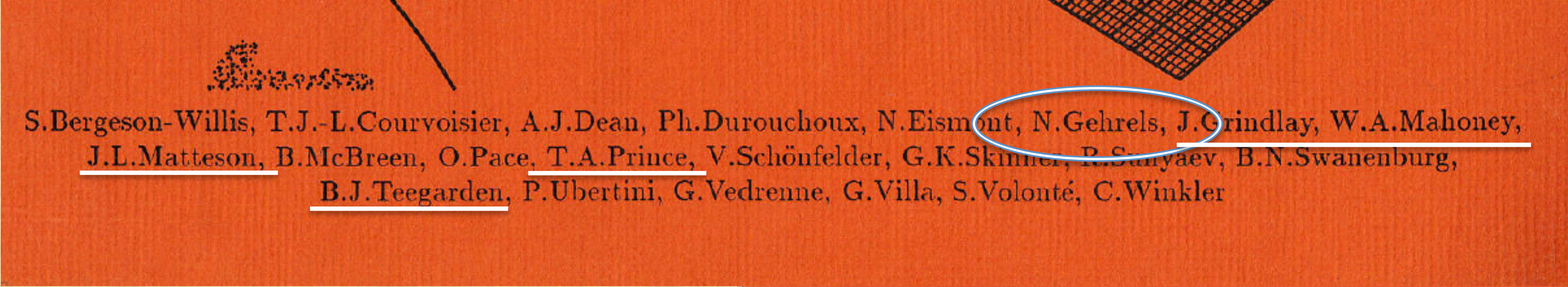
Then the gamma-ray community tried M2…

INTEGRAL
ESA-NASA REPORT on the Assessment Study, January 1991

A Gamma−ray Astronomy Mission dedicated to the Fine Spectroscopy and Positioning of Celestail Gamma −Ray Sources

Signed by 19 scientist from Europe and US including Neil

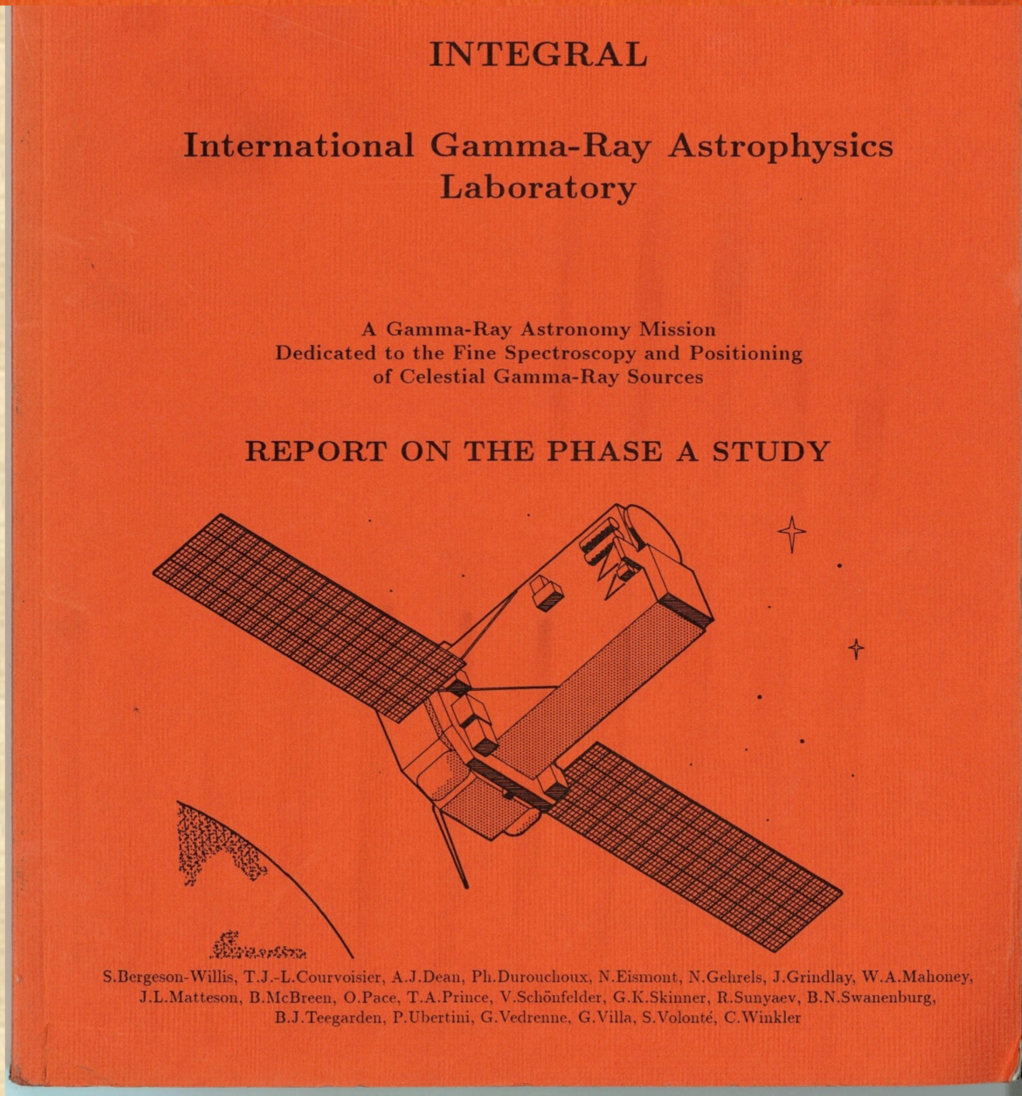




INTEGRAL
REPORT ON the PHASE A STUDY, April 1993

A Gamma–ray Astronomy Mission dedicated to the Fine Spectroscopy and Positioning of Celestail Gamma –Ray Sources

Signed by 22 scientist including Neil and inputs form collaborators



ESA SELECT IBIS as high resolution Imager

esa estec

european space research and technology centre

EUROPEAN SPACE AGENCY
Keplerlaan 1 - 2200 AG Noordwijk - The Netherlands
Central Fax - (31)+1719-17400
Integral Fax - (31)+1719-85941

FROM: K. Clausen — DATE: 20 February, 1995

TELEPHONE: (31)+1719-83467 — NUMBER OF PAGES: 3

TO: P. Ubertini / IAS/CNR / FX = +39 6 941 68 47

COPIES: Prof. G. Bignami / Ist. Fisica / FX = +39 2 236 2946
S. Volonté / ESA HQ D/SCI / FX = +33 1 5369 7236
C. Winkler / SA

OUR REF.: PG/10.3.2/KC/175/ap

SUBJECT:

The ISEC in its third meeting, 16/17 February 95, appreciated your suggestion to forward a proposal for a re-scoped imager instrument which in parts makes use of elements of the EIDOS instrument for which no funding could be found.

This is to confirm that the ISEC will consider your proposal within the ongoing evaluation process if submitted not later than 16th March, 1995.

The proposal should be based on the Integral AO package with the following amendments:

Resources allocation

The spacecraft resources allocated for instrument and DPE including margin as required in EID-A, 3.5

geometry	:	not to exceed proposed EIDOS envelope
mass	:	500 Kg
power sunlight	:	200 W
power eclipse	:	10 W
data rate	:	17 ... 57 Kb/s

Scientific requirements

High energy performance shall have priority over low energy performance.

esa
european space agency
agence spatiale européenne

8/10 rue Mario NIKIS
75738 PARIS CEDEX 15

Directorate of Scientific Programme

Tel. : + 33 (1) 53 69 71 03
Fax : + 33 (1) 53 69 72 36

Date :	Nb. of Pages :	ASTRONOMY

From : S. VOLONTE

To : ISSC Members :

Prof. G.F. Bignami (Chairman) Ist. di Fisica Cosmica, Milano	(39-2) 2666017
Dr. N. Gehrels NASA/GSFC Code 661	(1-301) 2861682
Dr. A. Giménez INTA, Torrejón (Madrid)	(34-1) 5201 586
Dr. W. Hermsen SRON, Utrecht	(31-30) 540860
Dr. G. Kanbach MPe, Garching	(49-89) 3299 3569
Dr. I. Mitrafanov Russian Space Research Inst., Moscow	(7-095) 310 7023 333 5178
Dr. J. Paul CE Saclay, DAPNIA/SAp, Gif-sur-Yvette	(33-1) 6908 7996
Dr. M. Watson Physics & Astronomy, Univ. Leicester	(44-116) 252331
ESA/ESTEC :	
C. Winkler, SSD/SA	(31-1719) 84690
K. Clausen, INTEGRAL Project	(31-1719) 85941
S. Volonté, ESA/D/SCI	(33-1) 53 69 72 36

The New Gamma-Ray Astronomy

Nucleosynthesis sites, Galactic black holes, gamma-ray bursters, blazars—all yield up secrets and surprises when observed with the latest gamma-ray detectors.

Neil Gehrels and Jacques Paul

Our understanding of the gamma-ray sky is being revolutionized. Seven years ago, gamma-ray astronomers knew of only a scattering of very bright sources. Now, thanks to two international observatories, the gamma-ray sky appears to be teeming with variety—unstable sources that change violently on short time scales, steady sources that glow radioactively and others whose nature we barely understand.

In the vanguard of this revolution are NASA's Compton Gamma Ray Observatory and the Russian–French mission known as Granat. Compton, which was launched in 1991, has four instruments on board that together span the energy range from 20 keV to 30 GeV. Launched in 1989, Granat has two instruments that image the sky from 3 keV to 1.3 MeV. The sensitivities and angular resolutions of these six instruments are an order of magnitude better than anything flown before. Just as important, because they operate simultaneously, the entire suite of instruments covers six decades in photon energy. This huge stretch of the electromagnetic spectrum equals, in logarithmic size, the entire ground-based regime from radio through ultraviolet.

The physical mechanisms that produce gamma rays in astronomical sites are quite different from those at work in other wavelength bands. Gamma rays come from the realm of nonthermal astrophysics, where particle acceleration and other far-from-equilibrium processes predominate. This is quite different from emission in infrared, optical, ultraviolet and x-ray wavebands, which is produced by mostly thermal processes. Ironically, the gamma-ray band's closest ties are to the wavelength band farthest from it—radio—where nonthermal emission also reigns. As in physics laboratories, astrophysical gamma rays are produced by nuclear de-excitation, matter–antimatter annihilation, particle collisions, cyclotron processes, bremsstrahlung and Compton upscattering.

The new findings from Compton and Granat cover many areas of Galactic and extragalactic astrophysics. Gamma rays from particle interactions in large solar flares have been found to last hours after the optical flare is over. New Galactic transients have been discovered with exotic properties such as jets, pulses, flares and positron annihilation. Gamma-ray lines from supernovae have been detected and used to map the sites of nucleosynthesis in the Galaxy. A new kind of distant active galaxy has been discovered whose bright and variable gamma radiation presumably originates in jets flowing out from the galactic nucleus. The once utterly mysterious gamma-ray bursters have been found to be isotropic on the sky and, like solar flares, have long-duration afterglows of 100 MeV gamma rays.

There are several overarching themes that not only tie these results together but also illustrate their significance to other areas of astrophysics. We concentrate on four of them that have particularly exciting new gamma-ray results—nucleosynthesis, Galactic black holes, gamma-ray bursts and active galactic nuclei. We also discuss prospects for future progress in gamma-ray astronomy.

More details on many of the results presented here can be found in the proceedings of the Fourth Compton Symposium.[1] And to get an idea of how far gamma-ray astronomy has come in the last 20 years, readers can compare our article here with Richard Lingenfelter and Reuven Ramaty's "Gamma-Ray Lines: A New Window to the Universe" (PHYSICS TODAY, March 1978, page 40).

Sites of nucleosynthesis

The modern era of theoretical nucleosynthesis sprang from a classic 1957 paper by Geoffrey Burbidge, Margaret Burbidge, William Fowler and Fred Hoyle.[2] These four astrophysicists set down the basis for the currently held belief that chemical elements derive their abundances from stellar evolution rather than the composition of primordial gas. Elements heavier than helium, we now believe, are the by-products of steady burning in stars, whereas some intermediate-mass elements and most elements heavier than iron are forged by explosive burning in supernovae and novae. (Exceptions are lithium, beryllium and boron, which are produced mostly by cosmic-ray interactions.)

Some of the isotopes produced in supernovae and novae are radioactive and emit gamma rays when they decay. Gamma-ray instruments can detect this radiation and determine the emitting isotope by its characteristic line spectrum. With this spectroscopic technique, abundances and matter distributions can be studied directly and, ultimately, the predictions of the theory of nucleosynthesis can be tested.

A partial list of lines important to gamma-ray astronomy is given in the table on page 27. The radioisotopes nickel-56, nickel-57, titanium-44 and aluminum-26 are particularly important since they are synthesized in supernovae and have a wide range of halflives—from days to millions of years.

NEIL GEHRELS *is an astrophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and is the project scientist for the Compton Gamma Ray Observatory.* JACQUES PAUL *is an astrophysicist at Saclay Nuclear Research Center in Gif-sur-Yvette, France.*

"An INTEGRAL view of the high-energy sky (the first 10 years)
Paris, 2012

The 1998 Vision for Gamma-Ray

THE NEW GAMMA-RAY ASTRONOMY

Nucleosynthesis sites, Galactic black holes, gamma-ray bursters, blazars—all yield up secrets and surprises when observed with the latest gamma-ray detectors.

Neil Gehrels and Jacques Paul

February 1998, Physics Today, American Institute of Physics, S-0031-9228-0010-9

THE FUTURE anticipated by Neil

Beyond Compton and Granat, there are two major missions being planned. The first is the International Gamma Ray Astrophysics Laboratory—INTEGRAL for short—which is an approved mission of the European Space Agency (ESA) with the participation of Russia and the US.[11] Its launch is scheduled for 2001. INTEGRAL's selected payload consists of two main instruments—an imager and a spectrometer—both of which are coded-aperture telescopes similar to Sigma but with improved detector technology.

The other major future mission is the Gamma-Ray Large Area Space Telescope (GLAST), which is being planned by NASA and the US Department of Energy and will include significant Japanese and European participation. The objective of GLAST will be to build on the successes of Compton's EGRET by observing the high-energy gamma-ray sky from 10 MeV to 300 GeV with high angular resolution and sensitivity.

In the meanwhile several European institutes were busy to build the experiments on board INTEGRAL and in USA FERMI and SWIFT

THE FUTURE is now!

Both Neil and Nanni have been key for the realization of

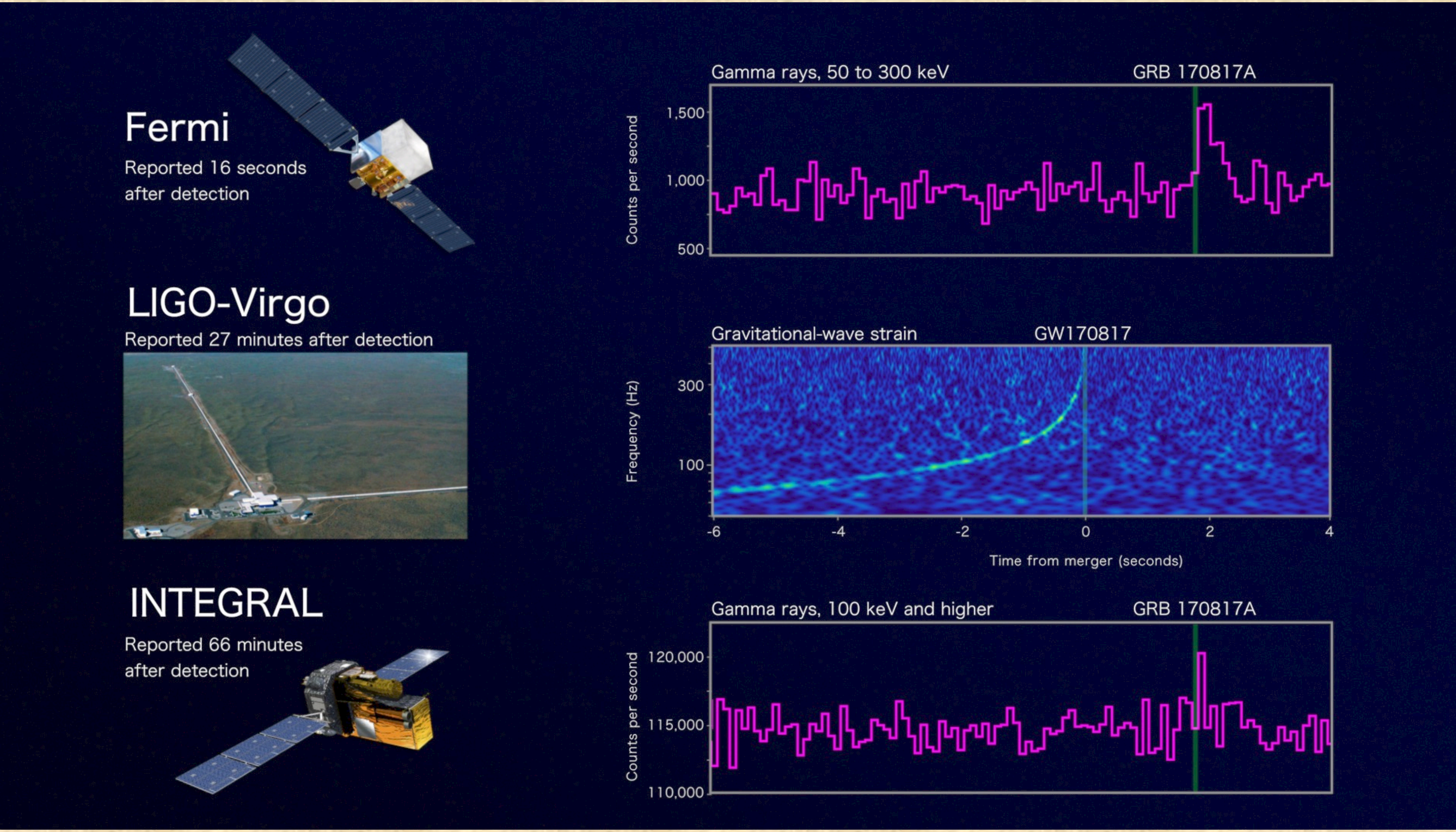
INTEGRAL (2002), FERMI and SWIFT (2004).

They have similar gamma ray detectors and the PIs and PSs have been collaborating since ever to Maximize the scientific return.

Neil has been a "bridge" between
USA and EUROPE

and his influence on the European gamma ray science had been fundamental!

THE FUTURE is now!



They would have been delighted to see their "babies" discovering the counterpart of Gravitational Waves and the forward step done …

2° INTEGRAL WORKSHOP

"The Transparent Universe", Saint Malo, September 1996

→ Neil, and Nanni, were always very active during the design, building and test of INTEGRAL.. and of all the other high energy instruments

INTEGRAL is the product of the Europe-US ideas driven by the γ–ray community and was finalized with a short turn-around

Neil was in the meanwhile driving the SWIFT mission!!

The gamma-ray sky was revolutionised by the new missions; from the:

GENERAL gamma-Ray point sources CATALOGUE

Macomb & Gehreles, 1999, ApJS, 120,335

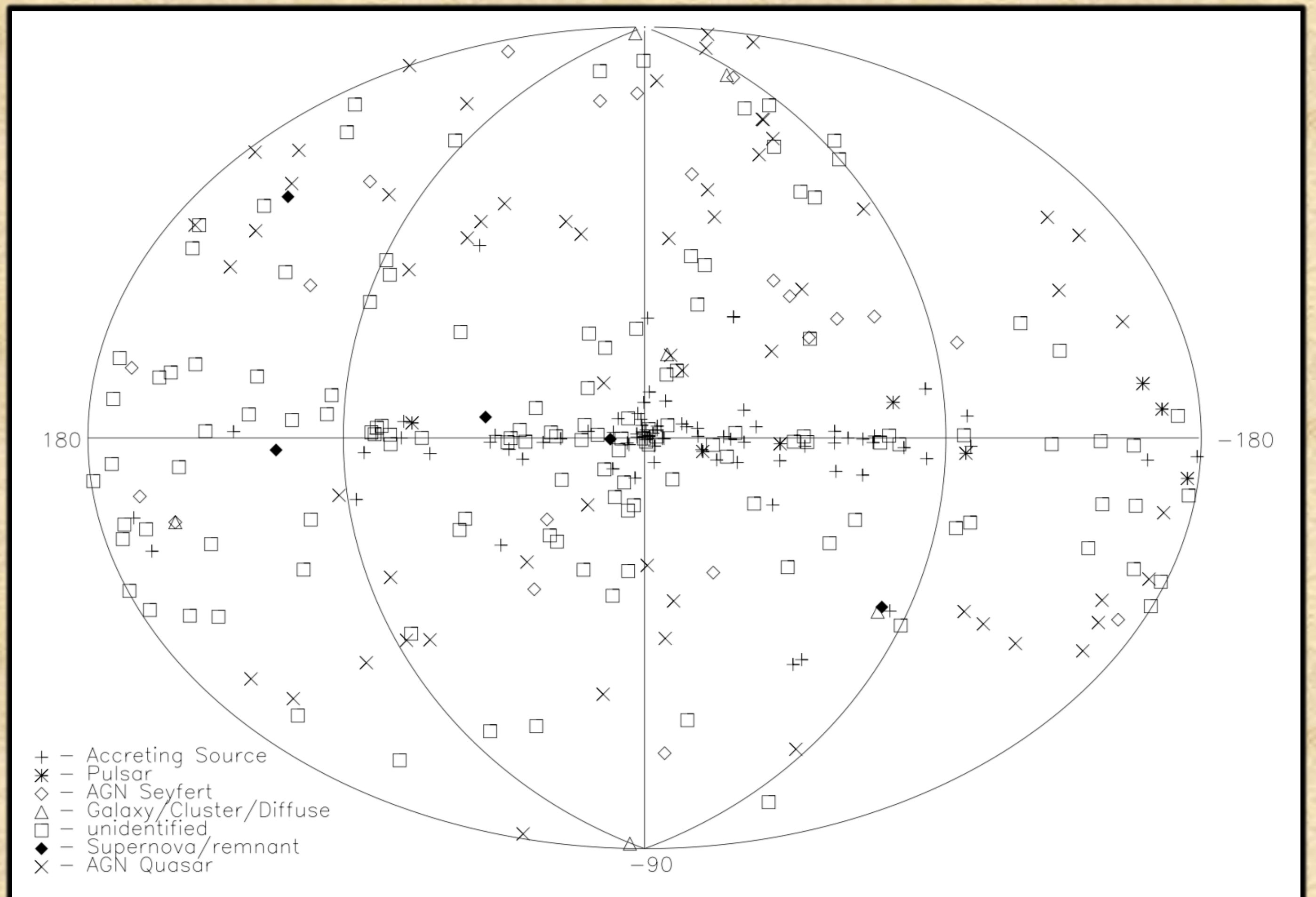
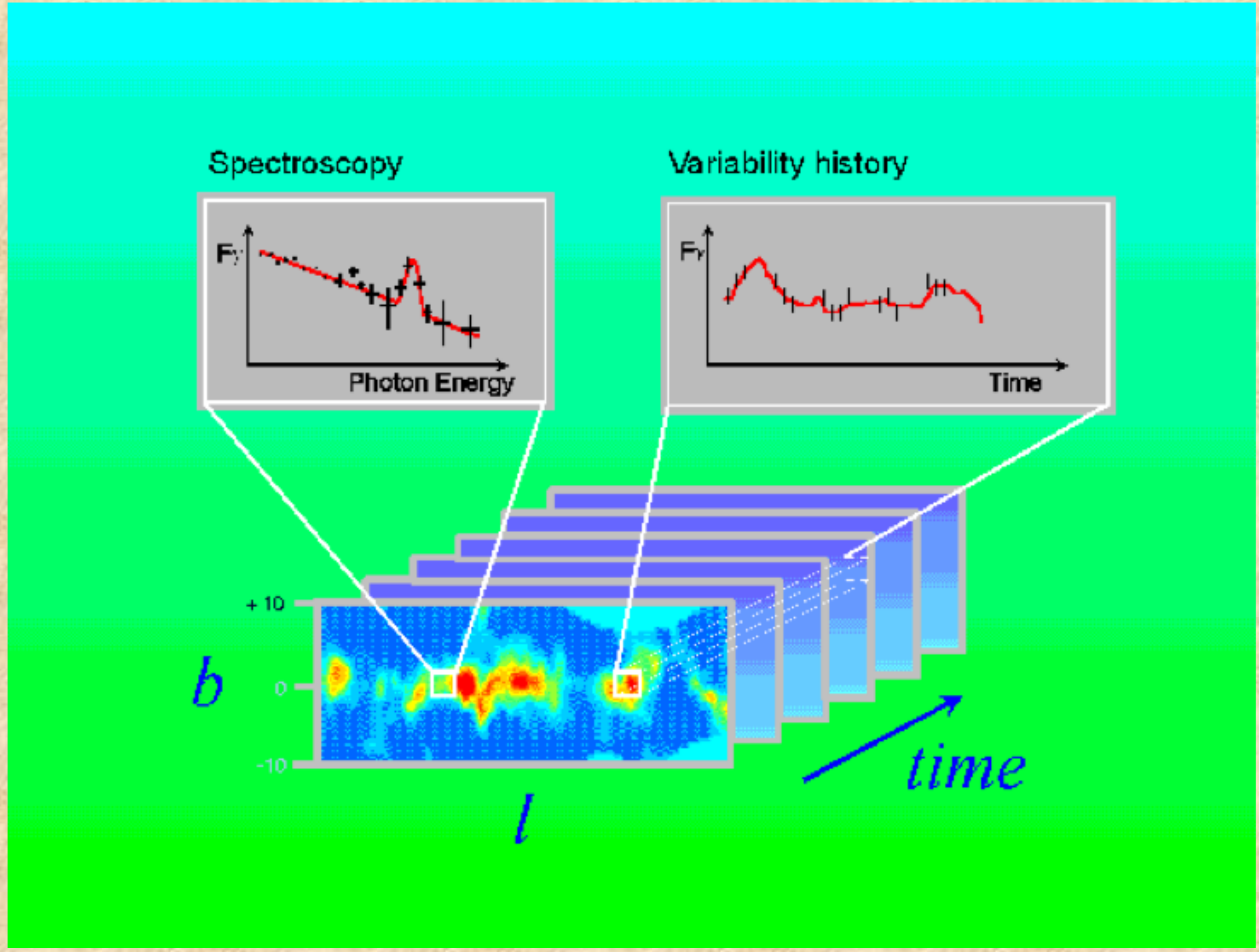


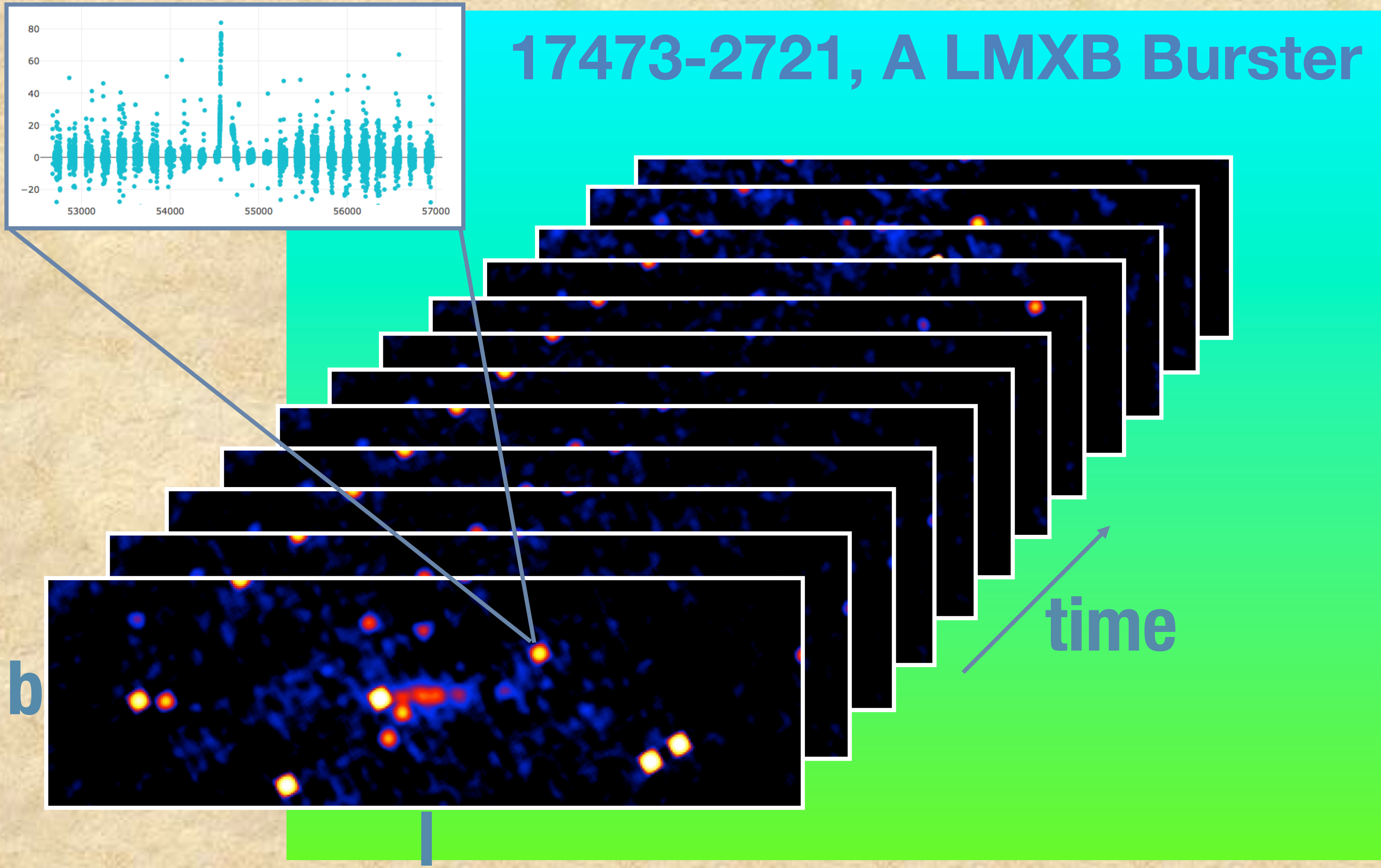
FIG. 1.—Distribution of gamma-ray point sources on the sky in Galactic latitudes.

309 objects listed reporting basic properties and characterized with emission from 50 keV up to 1 TeV.

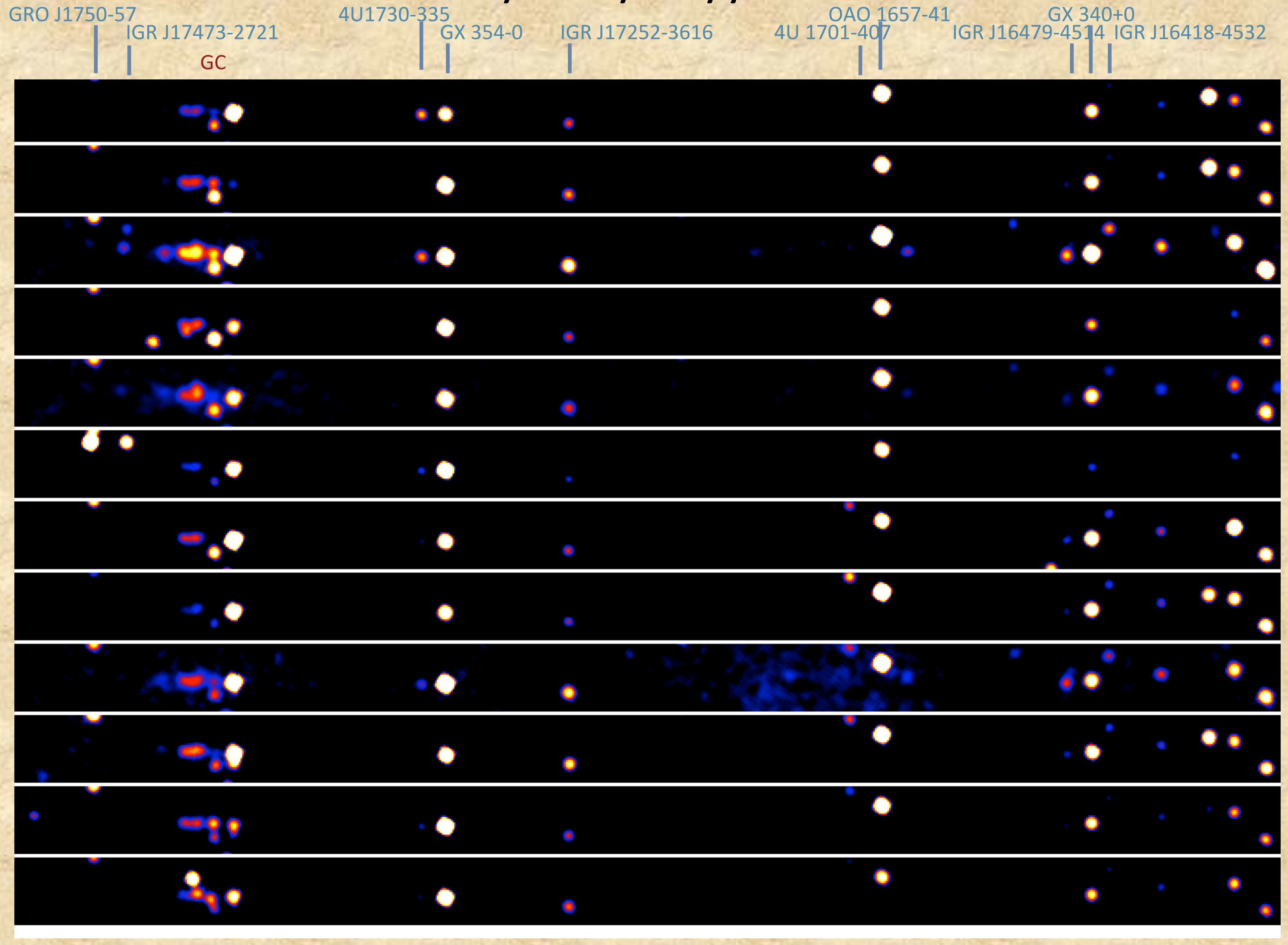
A little history … the promise..



..and the thousands of sources: the history ...brought up to date...

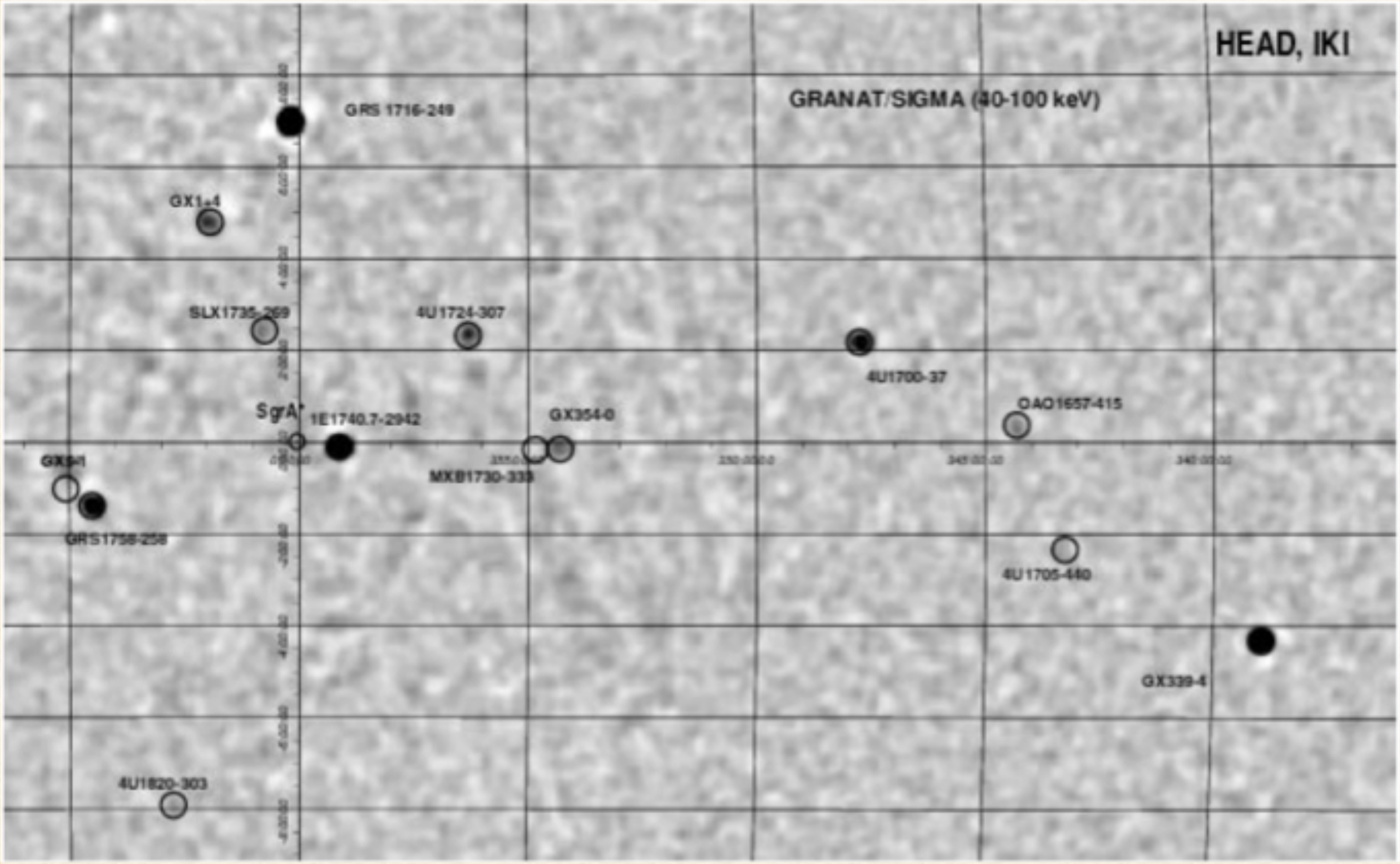


The Galaxy Plane year by year variation



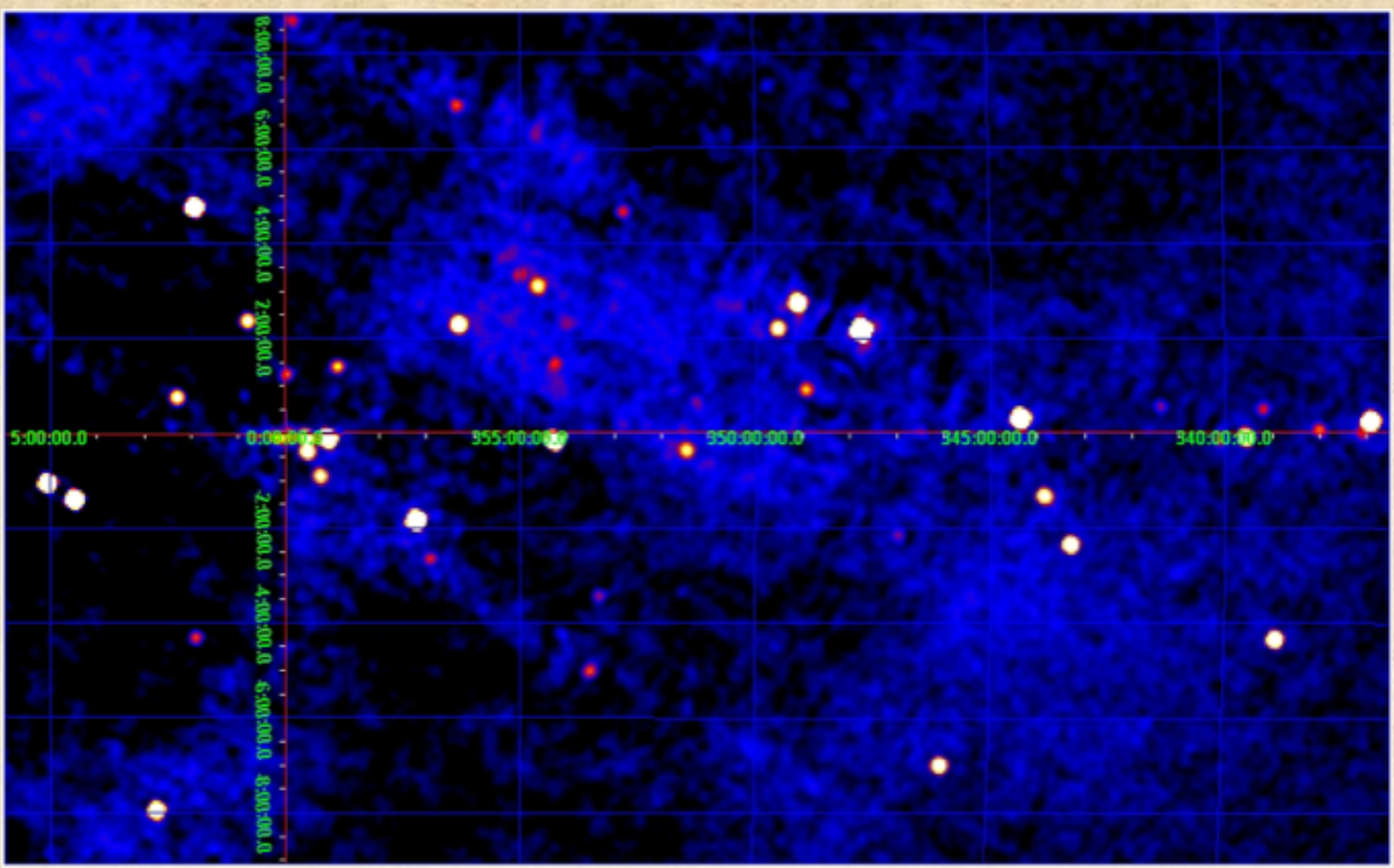
The hard X-Ray sky as known in 2000

In 2000 - 37 sources - SIGMA 40-100 (Revnivtsev+ 2004)

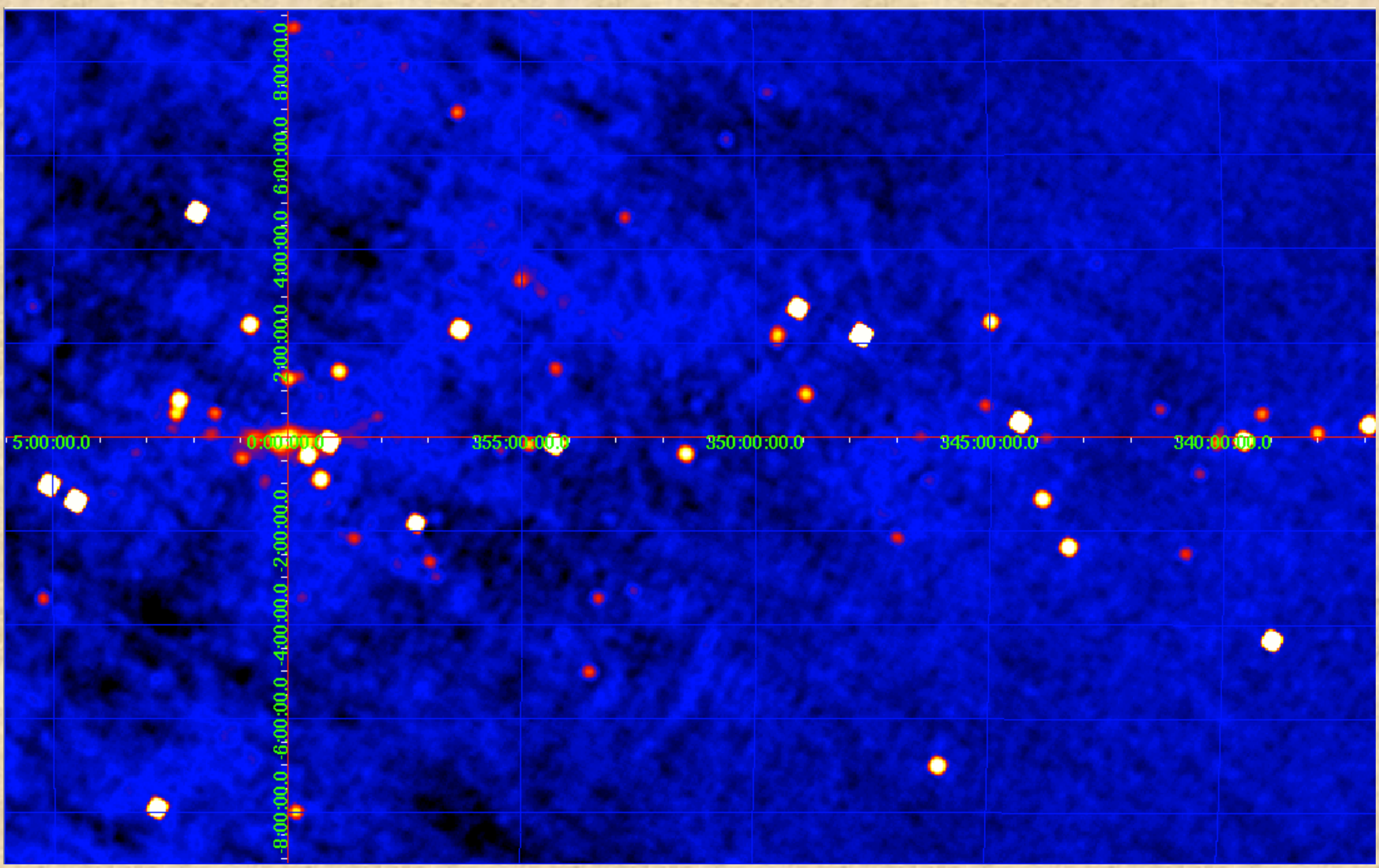


The hard X-Ray sky as known in 2005

In 2005 - 209 sources - IBIS/ISGRI 18-60 (Bird+ 2007)

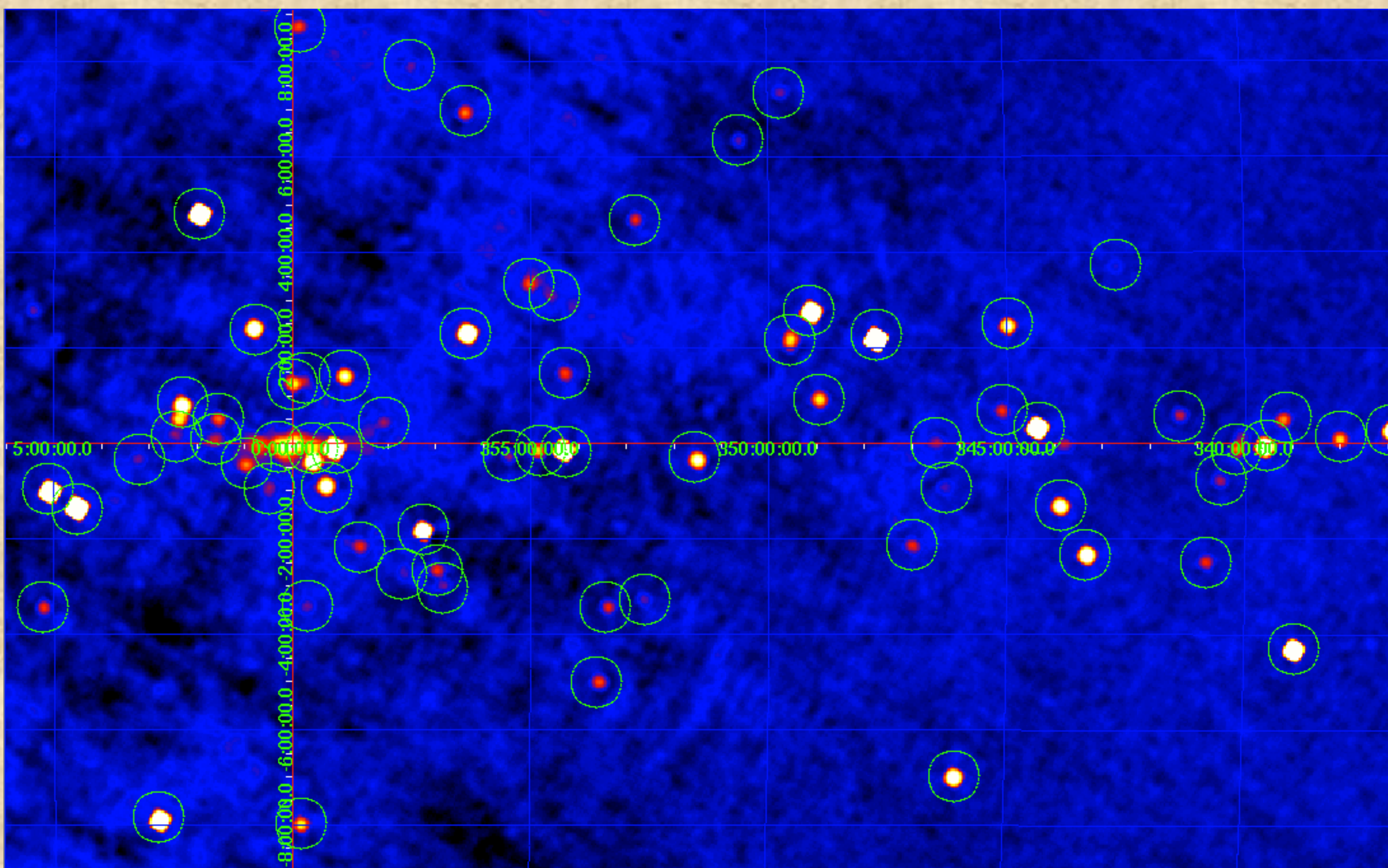


The hard X-Ray sky as known in 2012



In 2012 - 1000+ sources - IBIS/ISGRI 18-60 (In prep)

…full of new variable sources detected down to a fraction of a Crab with <arcmin positions



INTEGRAL User Group (IUG) November 2007, ESA-ESTEC Holland

Neil was always active, some time arriving from US in the morning and leaving the day after….

- Home
- Overview
- Announcements
- Registration
- Participants
- Scientific Program
- Location
- Accommodation
- Organizing Committees
- Contact

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Dublin Castle 2010

Cospar Working Group on The Future of Space Astronomy

A Global Road Map for the Next Decades

Roger Bonnet on April 20, 2010 appointed the "Future of Space Astronomy" Working Group under the aegis of Commission E – chaired by Neil -, with the aim to analyze the difficult situation of space astronomy over the next two decades and recommend ways to improve the prospects. **Nanni Bignami (Bremen, July 2010) endorsed the WG and its activity.**

Prof. R. M. Bonnet,
former COSPAR President

Prof. G. F. Bignami,
COSPAR President

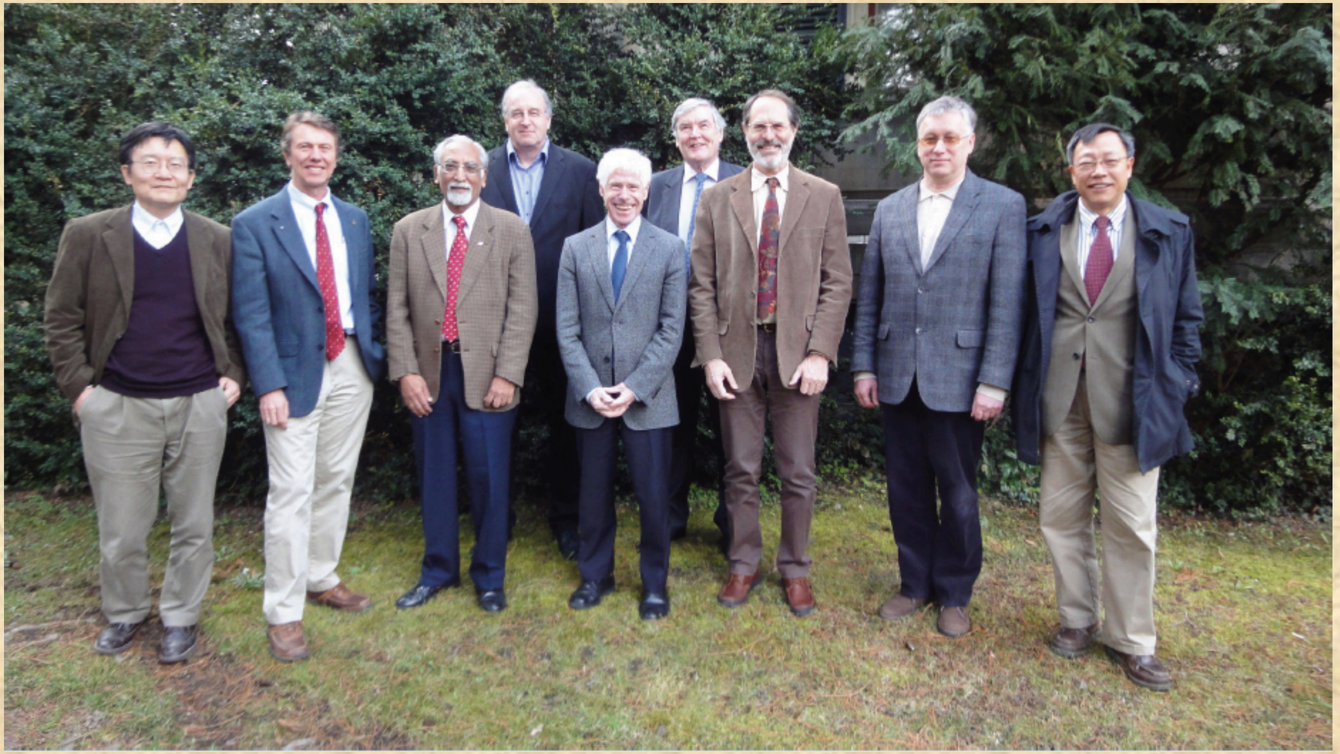
Having assessed the scientific needs and the current plans of the main space agencies worldwide, **the Working Group has identified some major concerns about the lack of a secured future for Space Astronomy.**

So, more recently we were working together on the:

A Global Road Map for the Next Decades

Presented @ the 39th COSPAR Assembly, July 14-22, 2012 Mysore, India

The work started in Bern, Swiss, May 15, 2011



Roger Bonnet (COSPAR)

Pietro Ubertini (Chair);

Neil Gehrels (Co-Chair);

Ian Corbett;

Paolo De Bernardis;

Marcos Machado;

Matt Griffin;

Michael Hauser;

Ravinder K. Manchanda;

Nobuyuki Kawai;

Shuang-Nan Zhang;

Mikhail Pavlinsky;

The results of the 3 years work have been very influential on the missions Selection Worldwide and most of the “High Priority” missions highlighted in the Roadmap have now been selected and are now in the completion Phase. Among them

ATHENA and LISA

the two large ESA missions due to launch 2018 and 2032
and planned in collaboration with
US, Japan and other countries

Received 15 July 2011; received in revised form 4 March 2012; accepted 5 March 2012
Available online 23 March 2012

Milano, May 2007


Milano, October 2011

Over the TUPUNGATO top!!

Thanks Neil!!
Ciao