Gamma Ray Bursts and the GLAST Burst Monitor

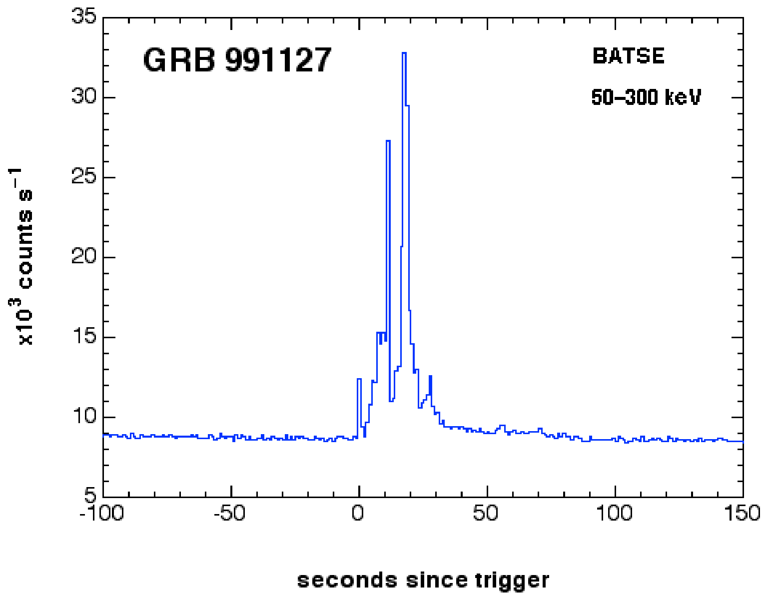
Chip Meegan
VP62

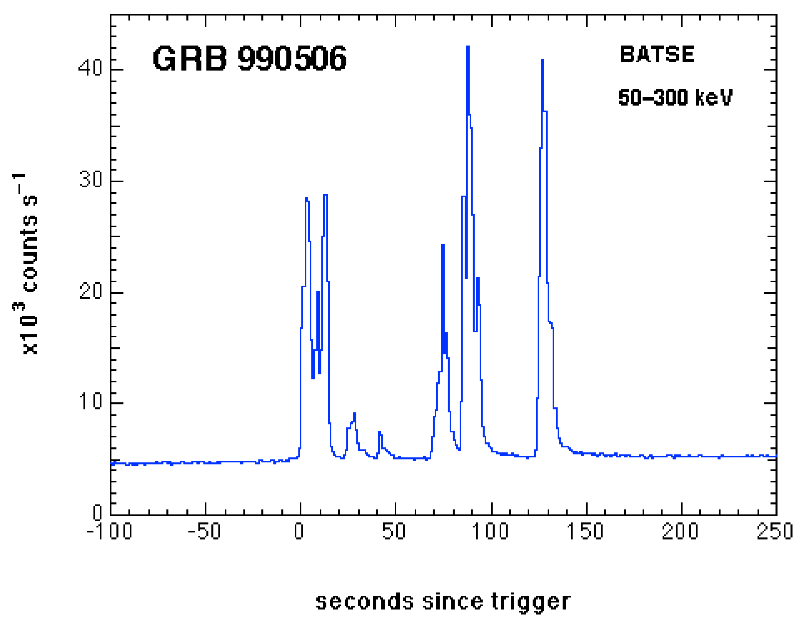
Outline

- GRBs: the last millennium
- GRBs: since the millennium – Swift
- GRBs: the future – GLAST and GBM

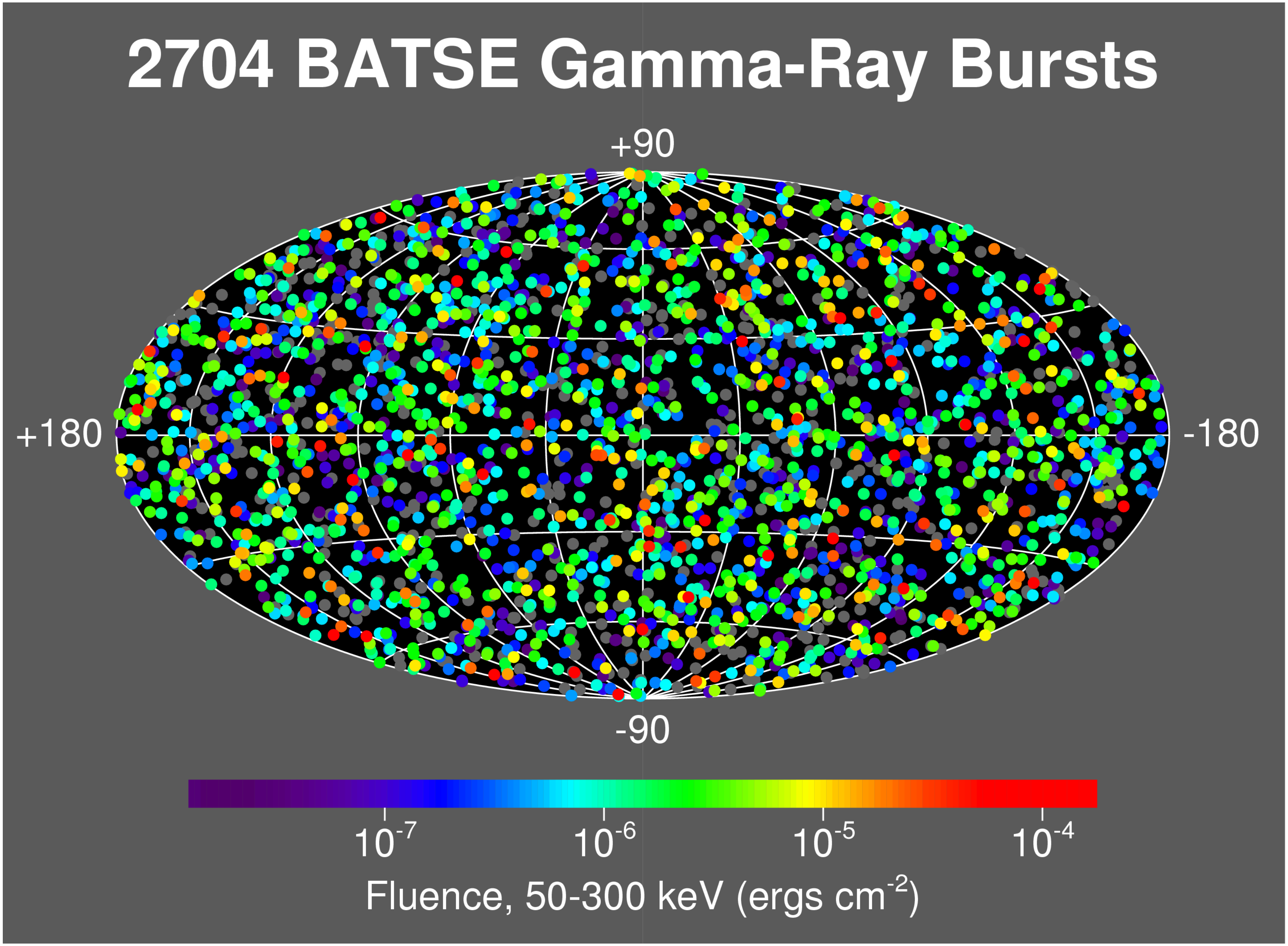
Gamma-Ray Bursts

- Discovered in 1967 by Vela satellites
- Durations <1 s to > 100 s
- Energy primarily 10-1000 keV
- Rate of a few per day
- Not seen in other wavelengths until 1997
- Many theories of origin proposed



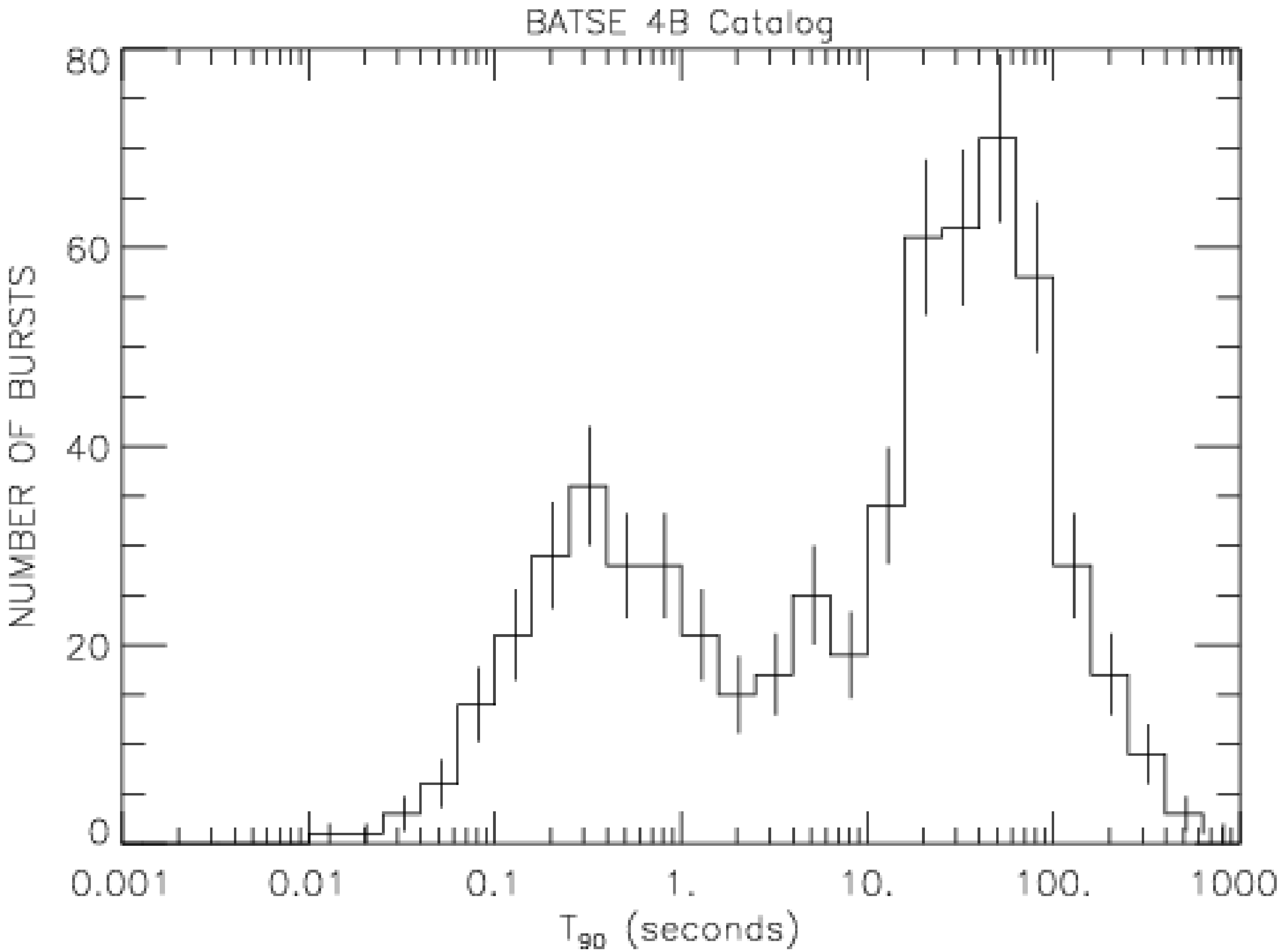


The Compton Gamma Ray Observatory (1991-2000)

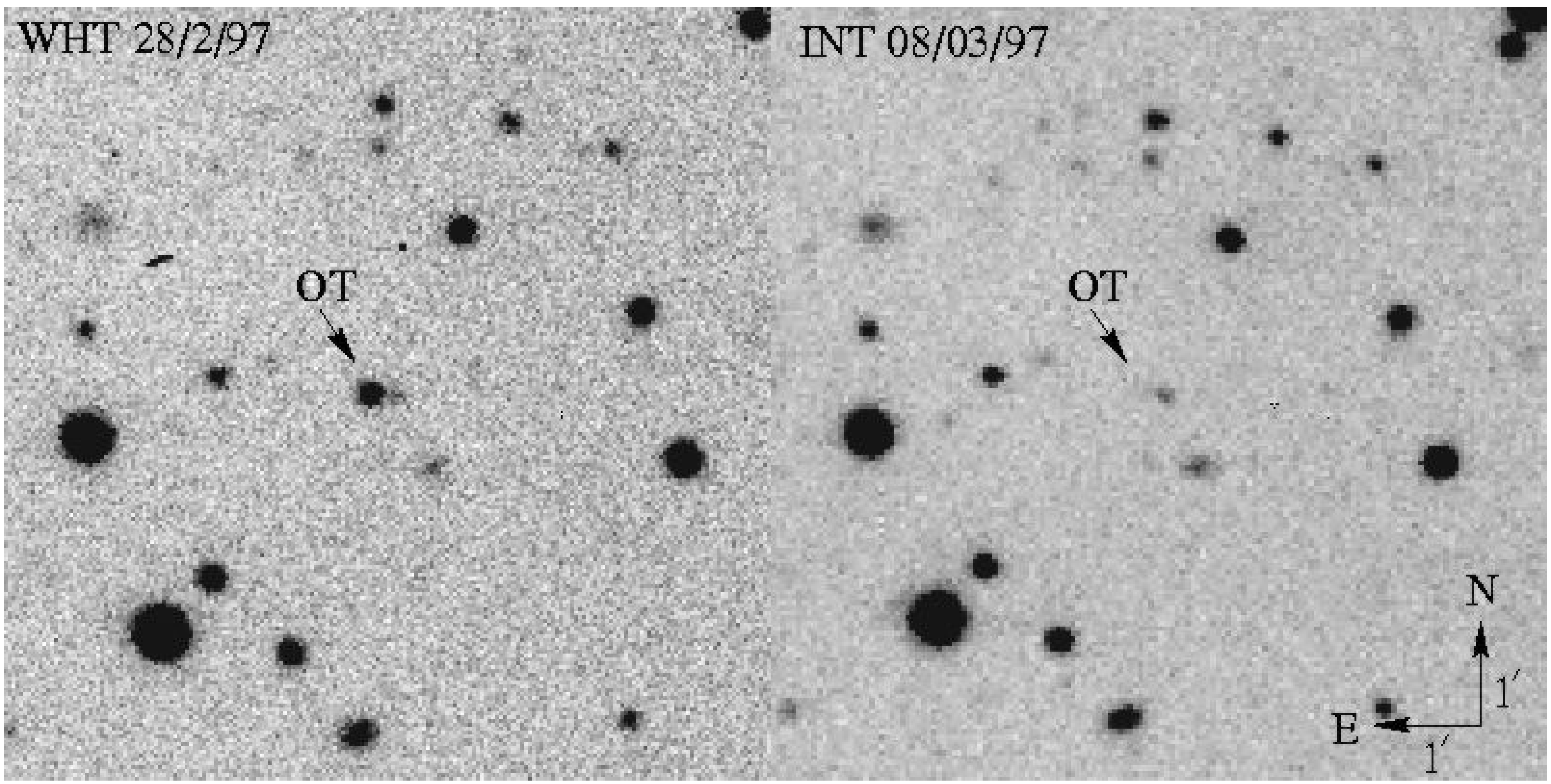


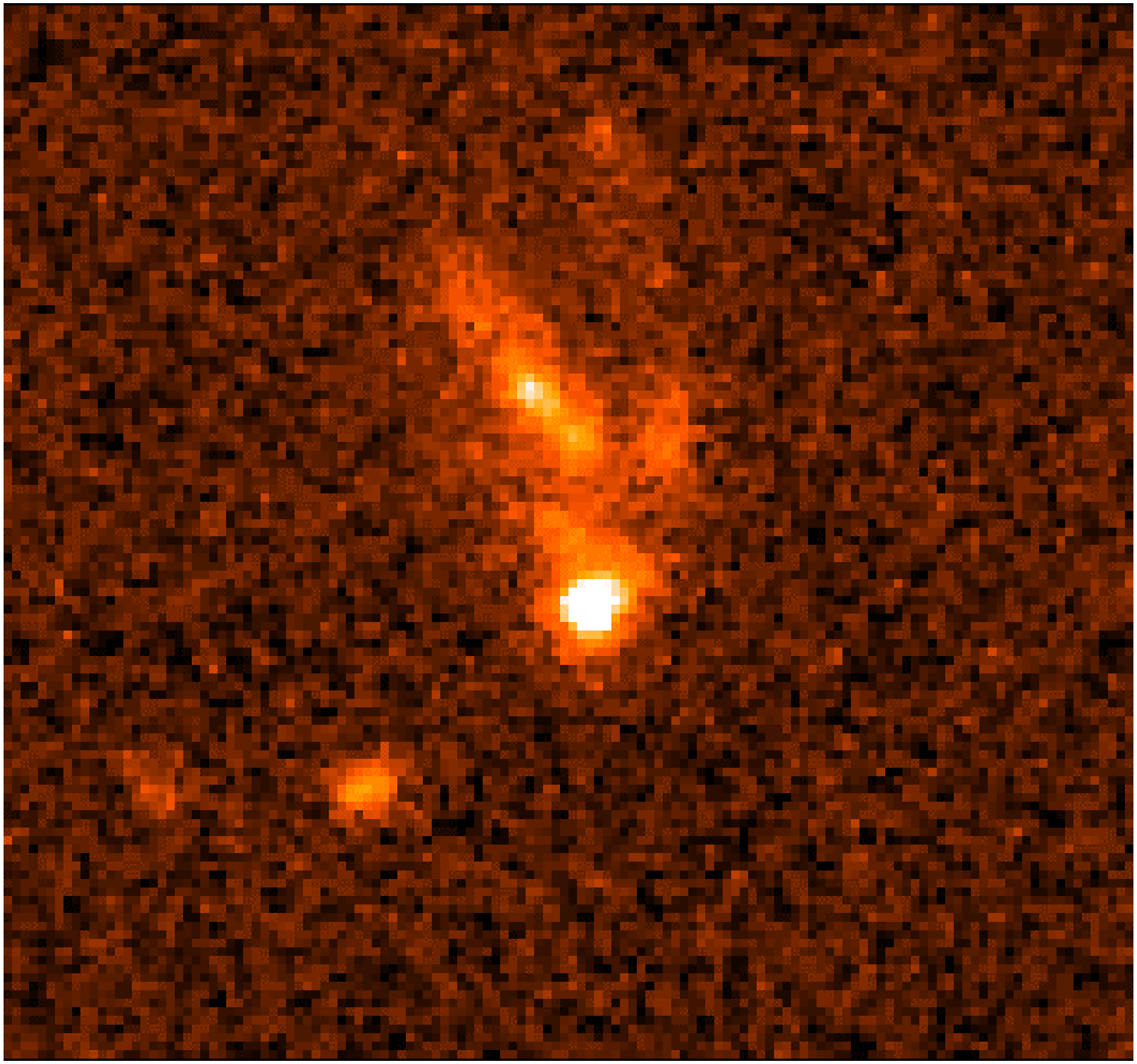
2704 BATSE Gamma-Ray Bursts
+90
+180
-180
-90
10-7
10-6
10-5
10-4
Fluence, 50-300 keV (ergs cm-2)

Duration distribution

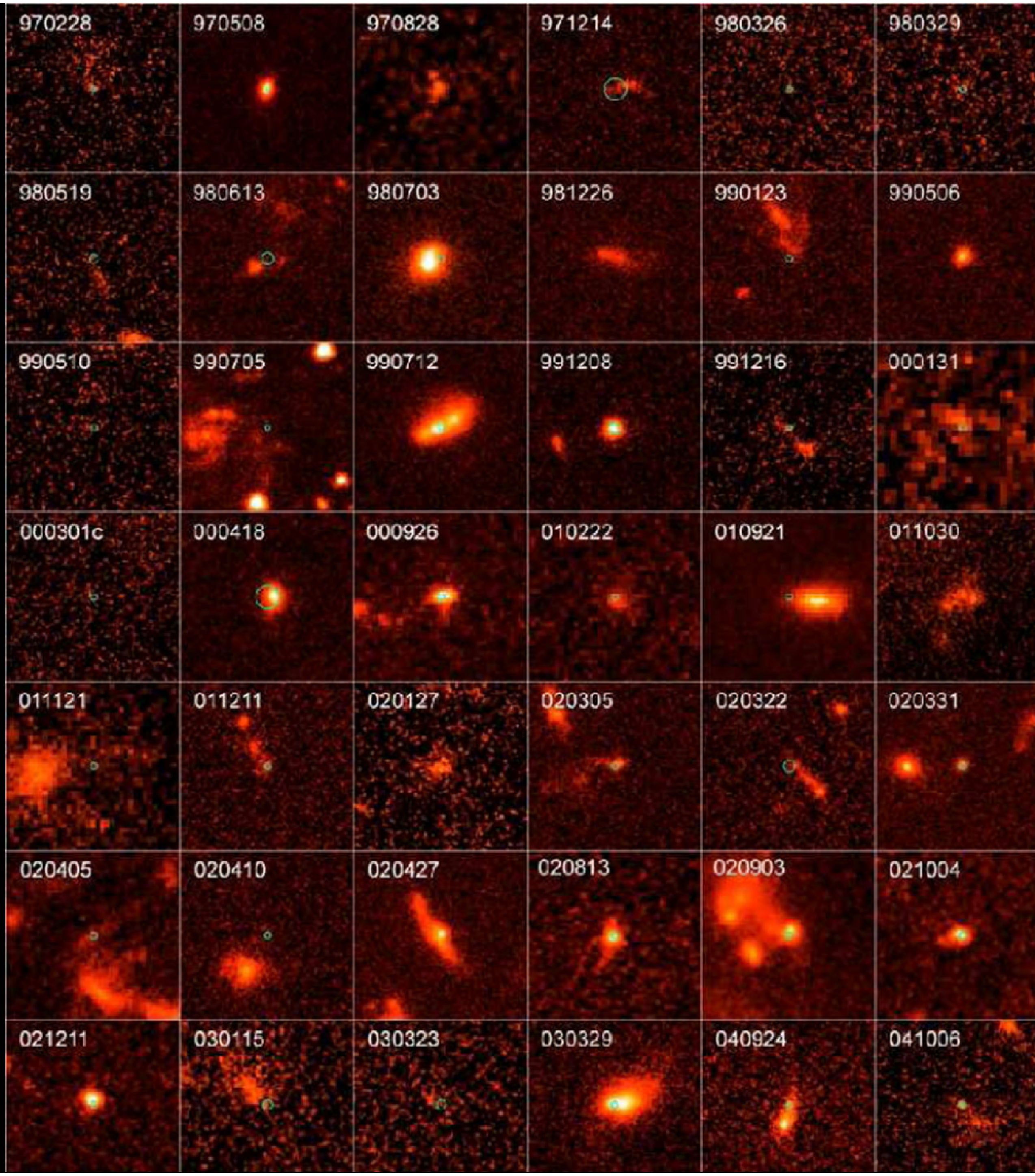


First optical afterglow from a GRB





HST observations of GRB990123 at 16, 59, and 380 days.


970228
970508
970828
971214
980326
980329
980519
980613
980703
981226
990123
990506
990510
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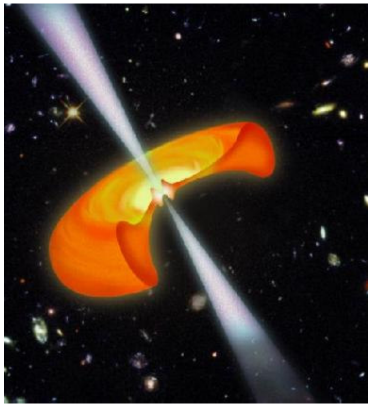
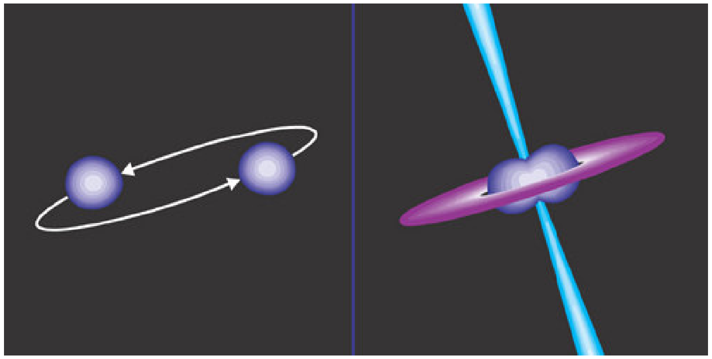
990712
991208
991216
000131
000301c
000418
000926
010222
010921
011030
011121
011211
020127
020305
020322
020331
020405
020410
020427
020813
020903
021004
021211
030115
030323
030329
040924
041006

Central Engines of GRBs



Hypernova

Gravitational collapse of the core of a massive, rapidly rotating star to form a black hole.



Compact Star Mergers

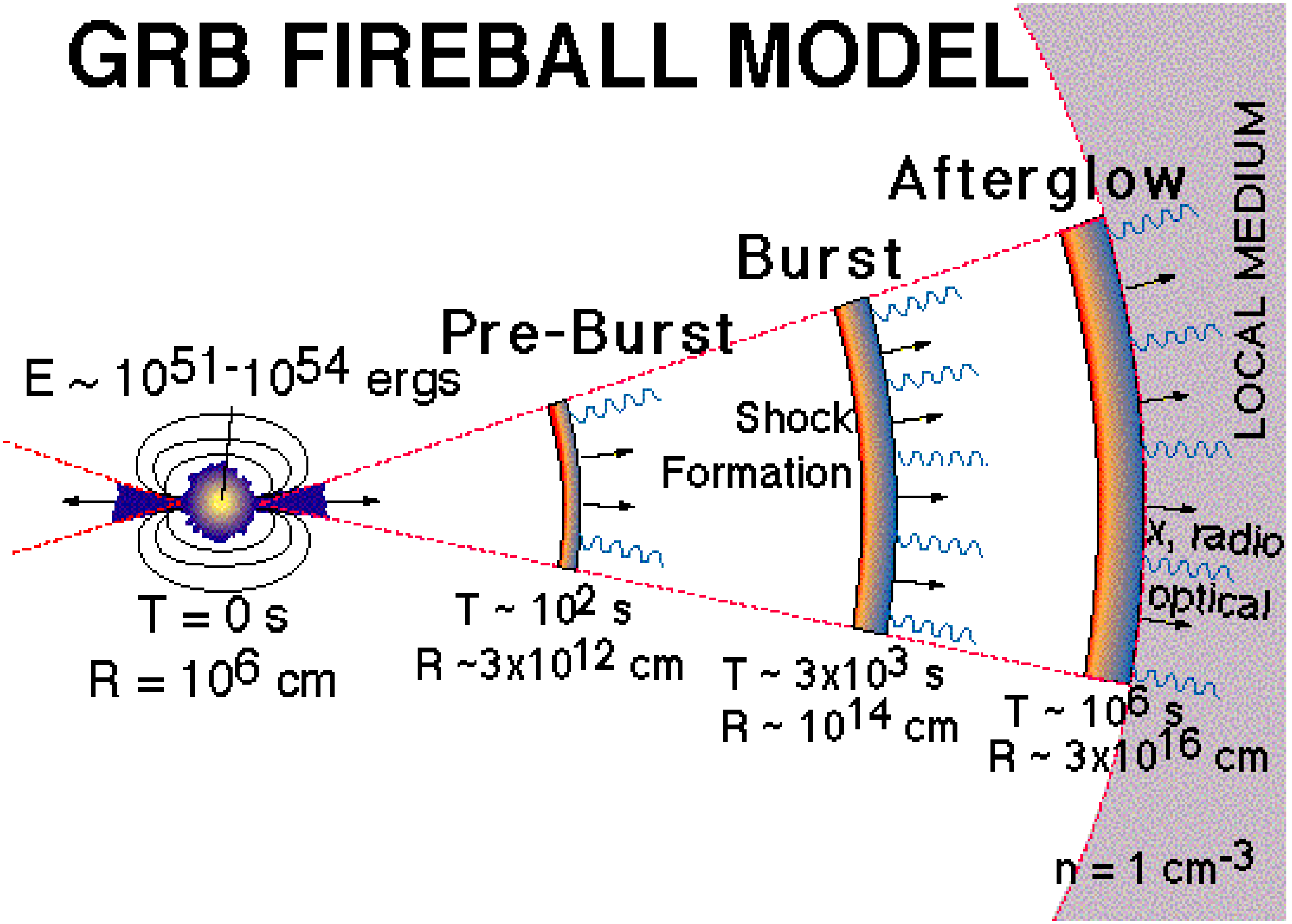
NS-NS or NS-BH binary orbit decays by gravitational radiation, merges to form a black hole.

Supranova

A supernova leaves a rapidly rotating neutron star, which later collapses to a black hole.

Result: Black Hole + Accretion Disk

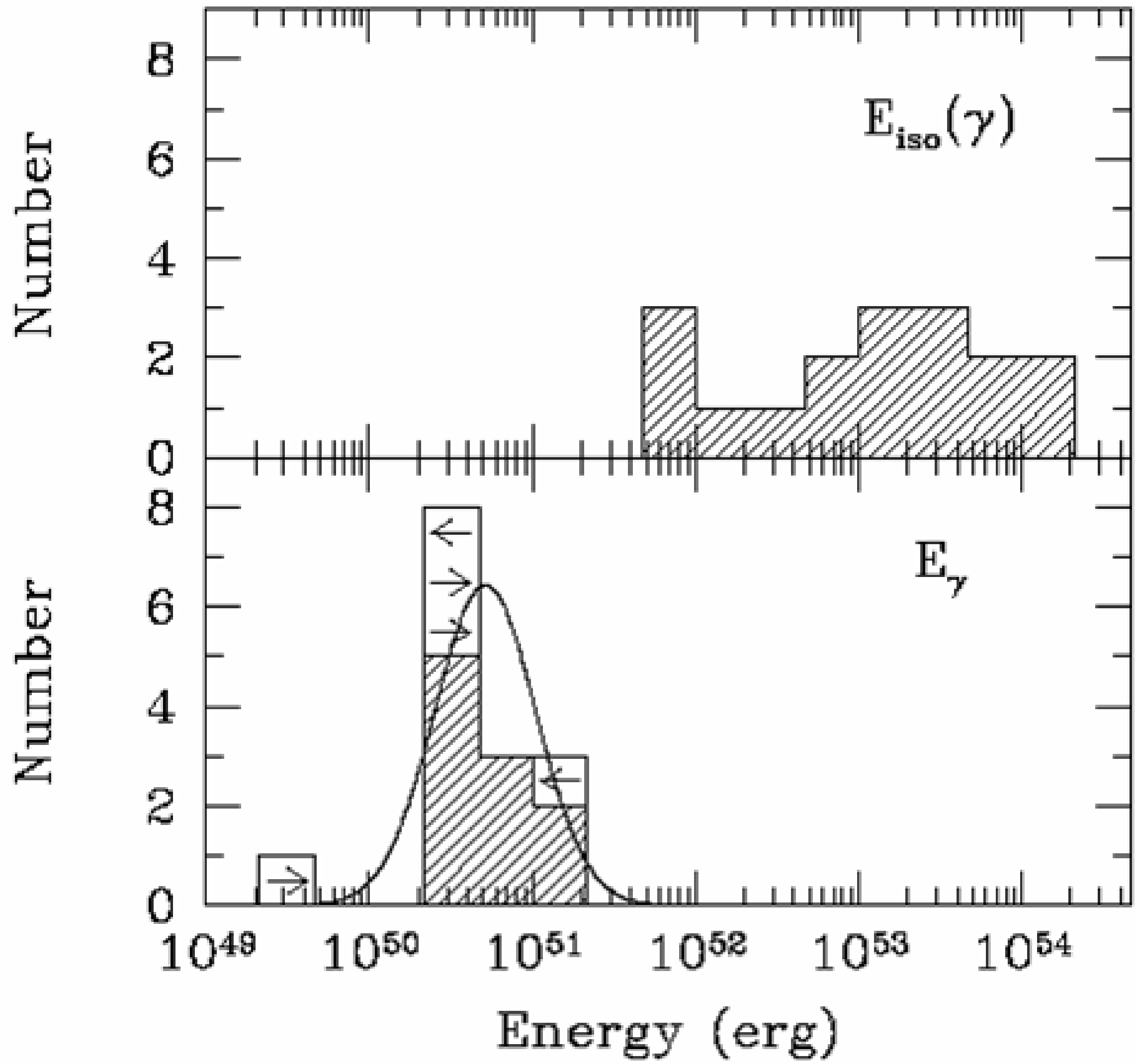
GRB FIREBALL MODEL



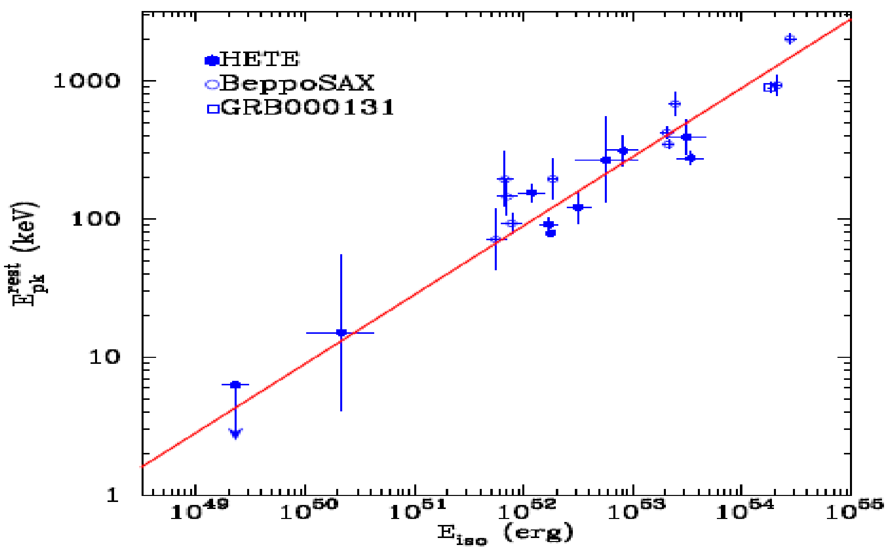
GRBs at the Millennium

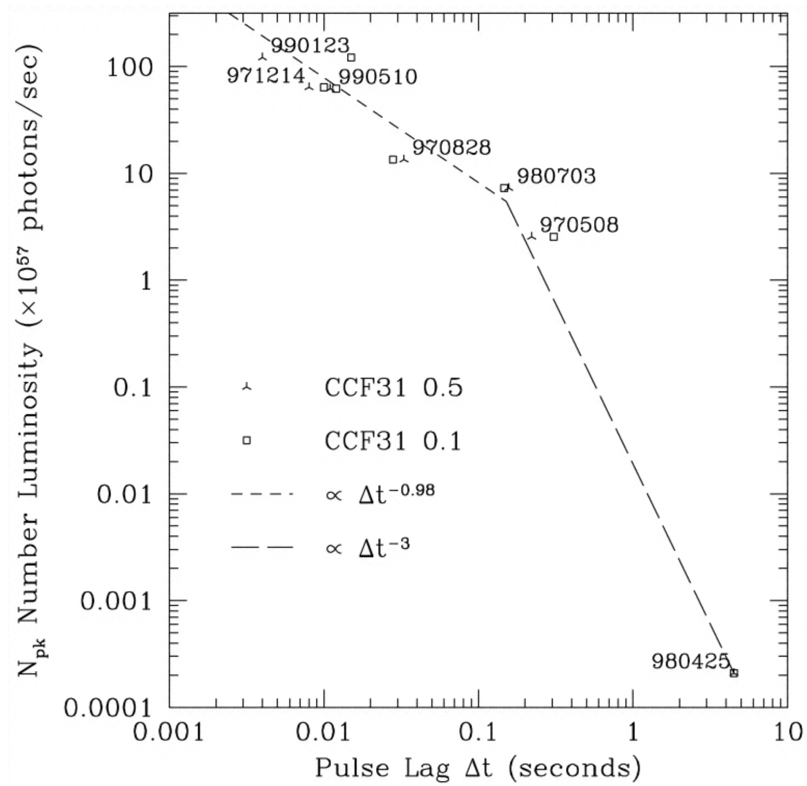
- Cosmological origin confirmed.
- Many (~20) redshifts measured.
- Most powerful events known (10^{51} ergs/s).
- Long GRBs are probably hypernovae.
- Often have optical & X-ray afterglows.
- Prompt emission not well understood.

Energy Emitted (corrected for beaming)



Pseudo-redshifts



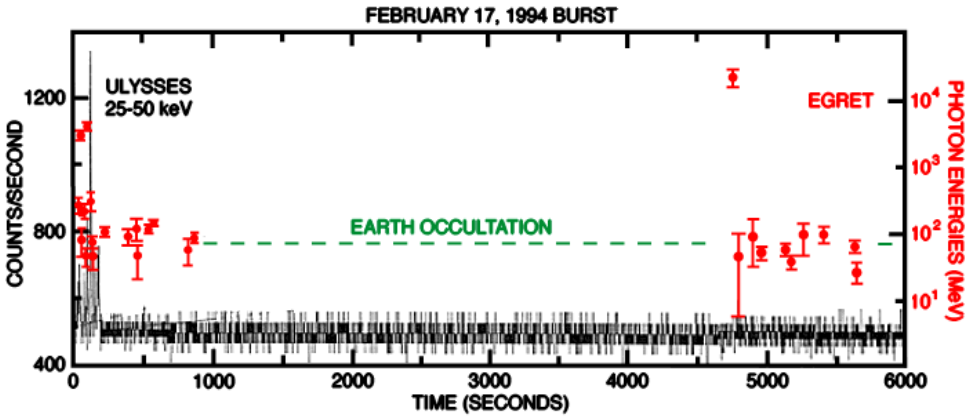


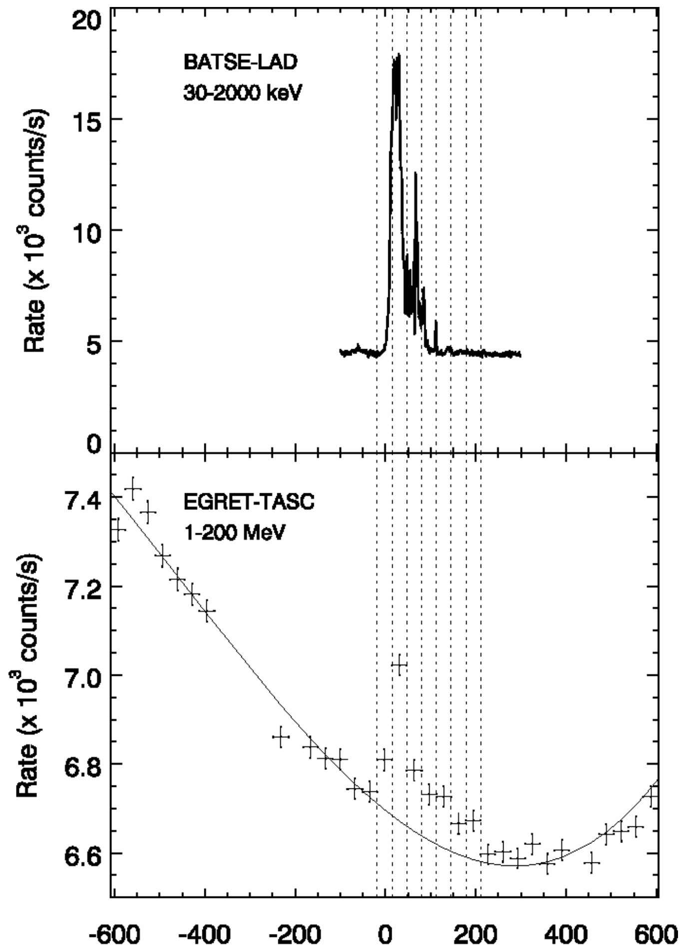
$E_{iso} \propto \nu_{peak}^{2}$ (Amati)

$E_{\gamma} \propto \nu_{peak}^{1.5}$ (Ghirlanda)

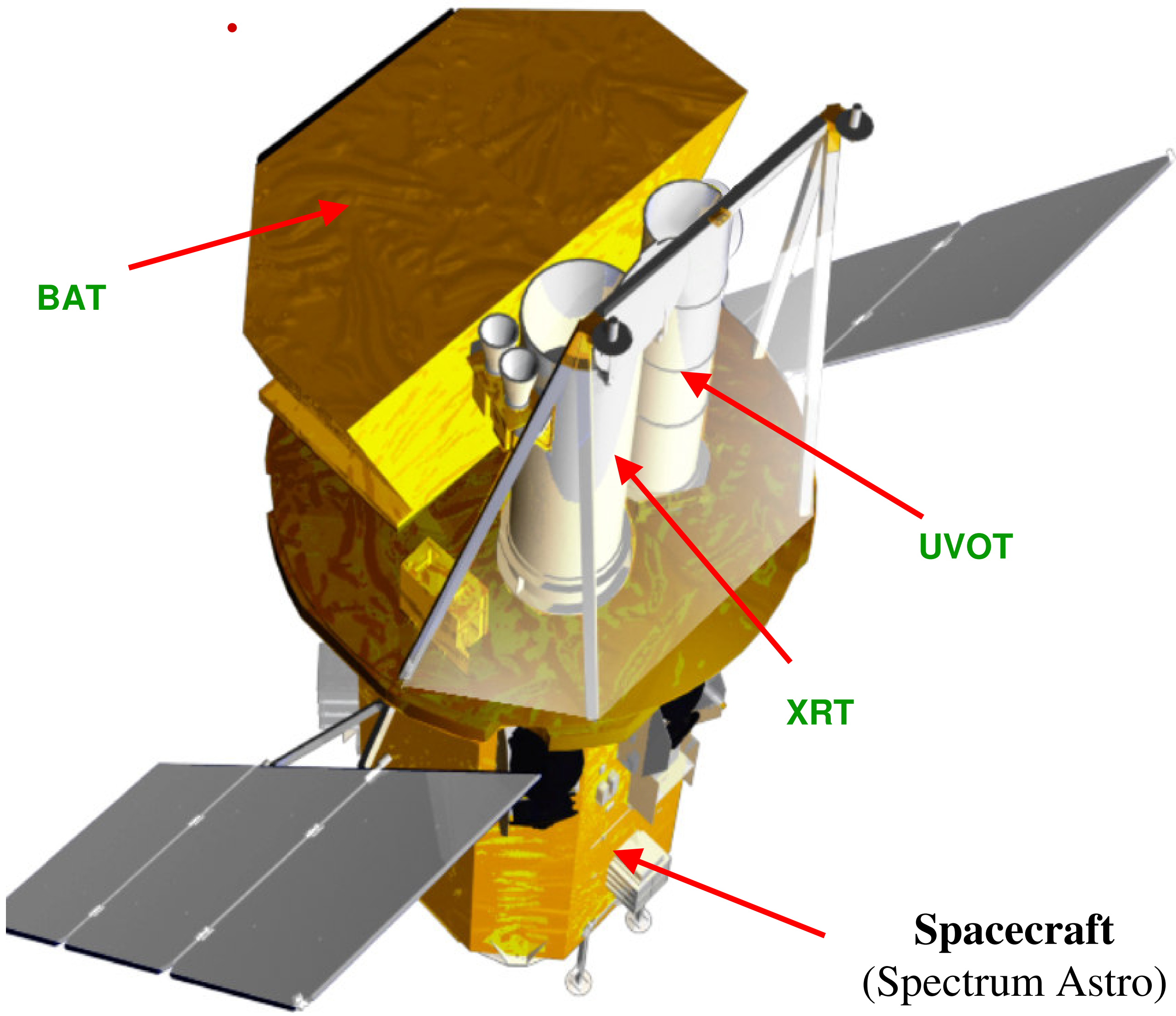
Lag – Luminosity (Norris)

Delayed High-Energy Emission





Swift Observatory



Orbit

600 km x 28° inclination

Data Downlinks

TDRSS rapid (2 kbps)
ASI Malindi gnd station

Operations

Ops Center @ Penn State
Science Center @ GSFC

BAT

New CdZnTe detector
~100 GRBs/yr

XRT

Arcsec GRB positions
CCD spectroscopy

UVOT

Sub-arcsec positions
Grism spectroscopy

Spacecraft

Autonomous slews 20-75s

Swift Results

- Have detected 119 GRBs so far.
- Have ~30 redshifts.
- One burst (050904) has $z = 6.29$.
- Flares in X-ray afterglows.
- Sources of short bursts.

Swift Short GRB Summary

Name	Redshift	Detections	Host	E_{iso}(15-350keV)
050509b	0.225	XT	Elliptical	1.1×10^{48} erg
050709	0.161	XT, OT	SF galaxy	6.0×10^{49}
050724	0.258	XT, OT, RT	Elliptical	3.0×10^{50}
050813	0.722*	XT	Cluster	1.7×10^{50}

* if associated with cluster

Conclusions:

- Short GRBs have $>10^3$ lower E_{iso} than long GRBs
- Association with ellipticals for 2 GRBs argues against collapsar origin
- Observations support a NS-NS merger model

The Gamma-Ray Large Area Space Telescope

The Large Area Telescope will observe in the largely unexplored high energy (>30 MeV) region of the spectrum.

The GLAST Burst Monitor will observe bursts at lower energies (10 keV - 30 MeV) and alert the LAT to bursts outside its field of view to allow spacecraft repointing.

Launch: September 2007

GBM Collaboration

National Space Science & Technology Center

University of Alabama in Huntsville

Michael Briggs
William Paciesas
Robert Preece
Narayana Bhat
Valerie Connaughton(SSC)
Marc Kippen (LANL)

NASA Marshall Space Flight Center

Charles Meegan (PI)
Steve Elrod (PM)
Fred Berry (LSE)
Gerald Fishman
Chryssa Kouveliotou
Robert Wilson
Colleen Wilson-Hodge

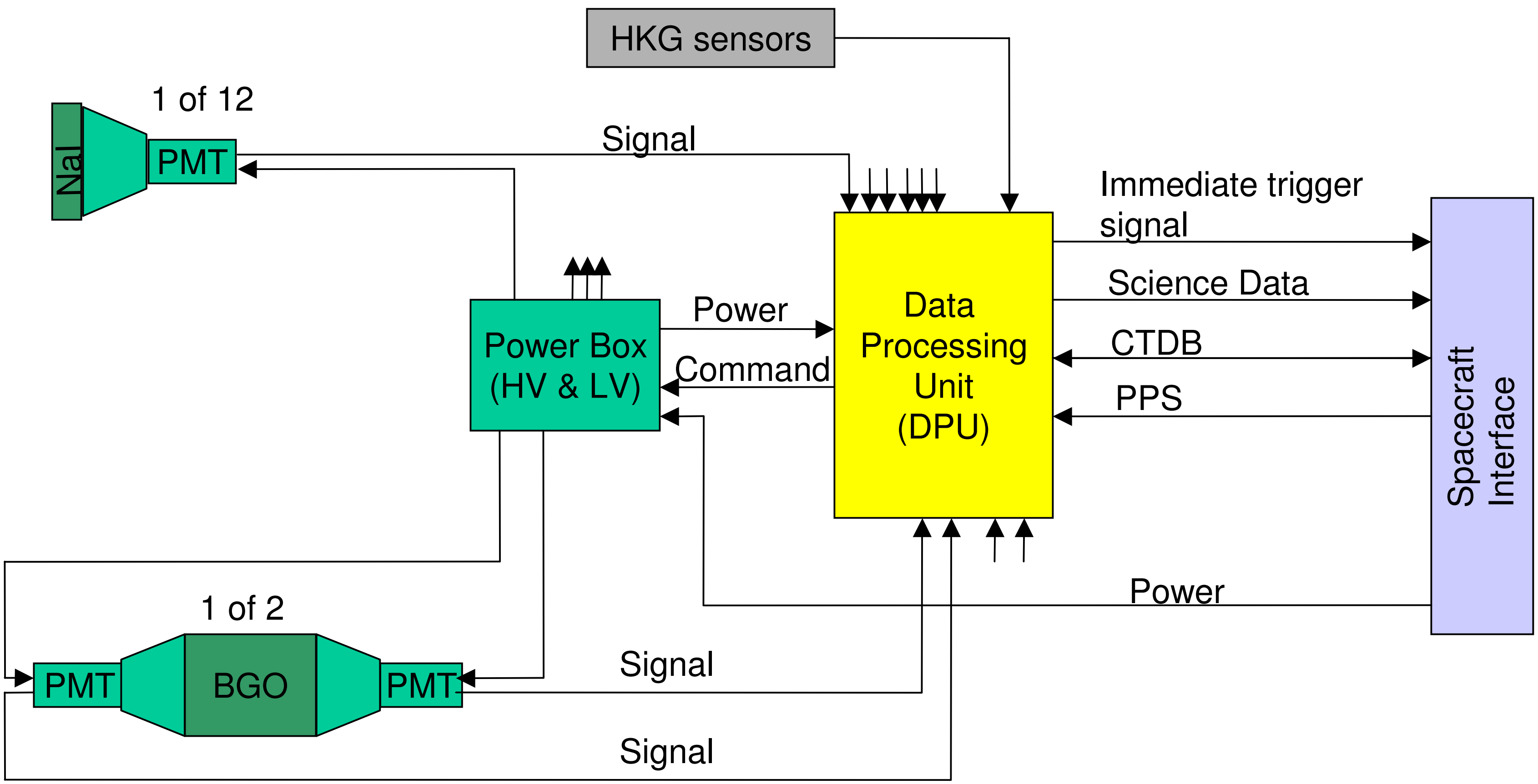
Max-Planck-Institut für extraterrestrische Physik

Giselher Lichti (Co-PI)
Andreas von Keinlin
Volker Schönfelder
Roland Diehl
Jochen Greiner
Helmut Steinle

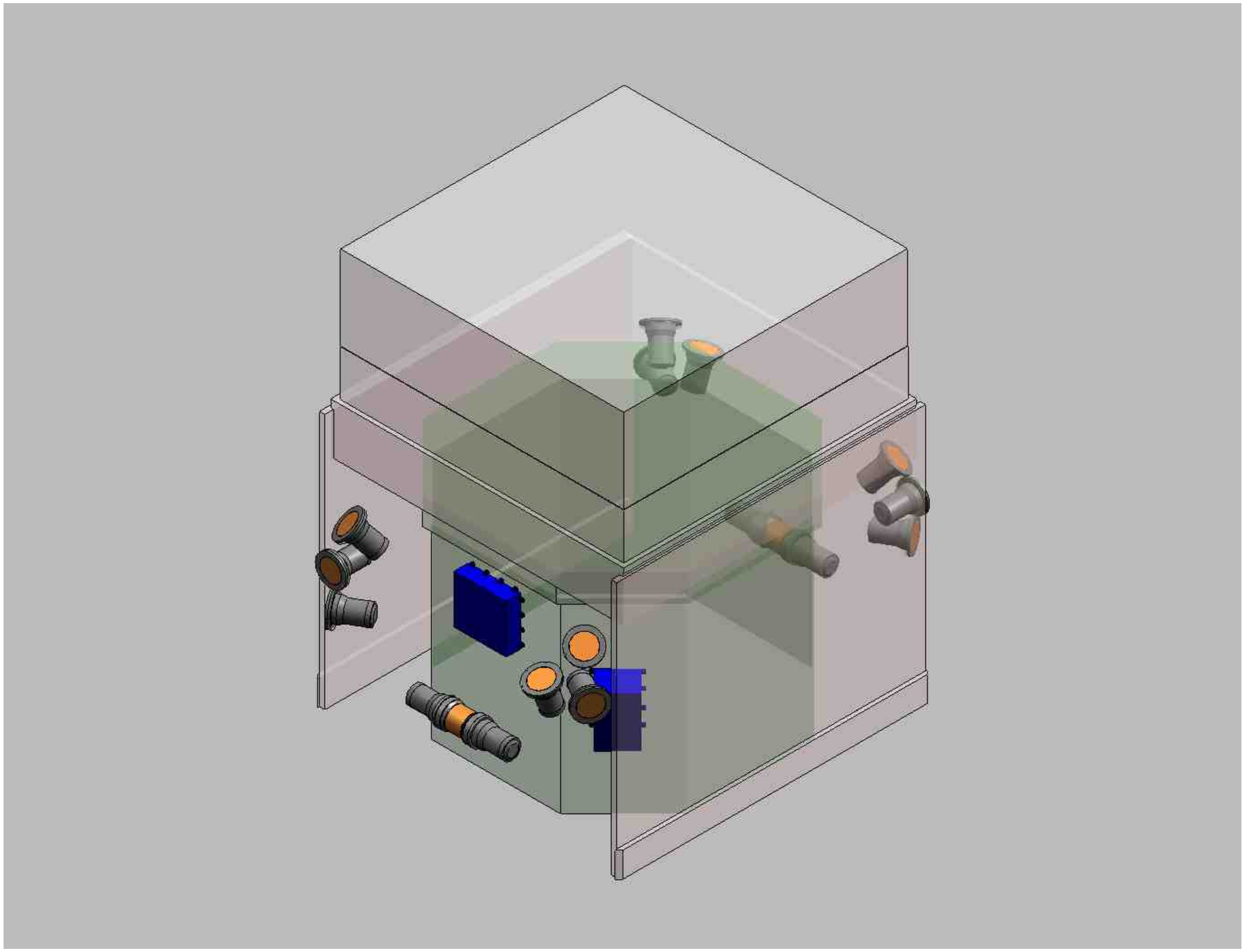
On-board processing, flight software, systems engineering, analysis software, and management

Detectors, power supplies, calibration, and analysis software

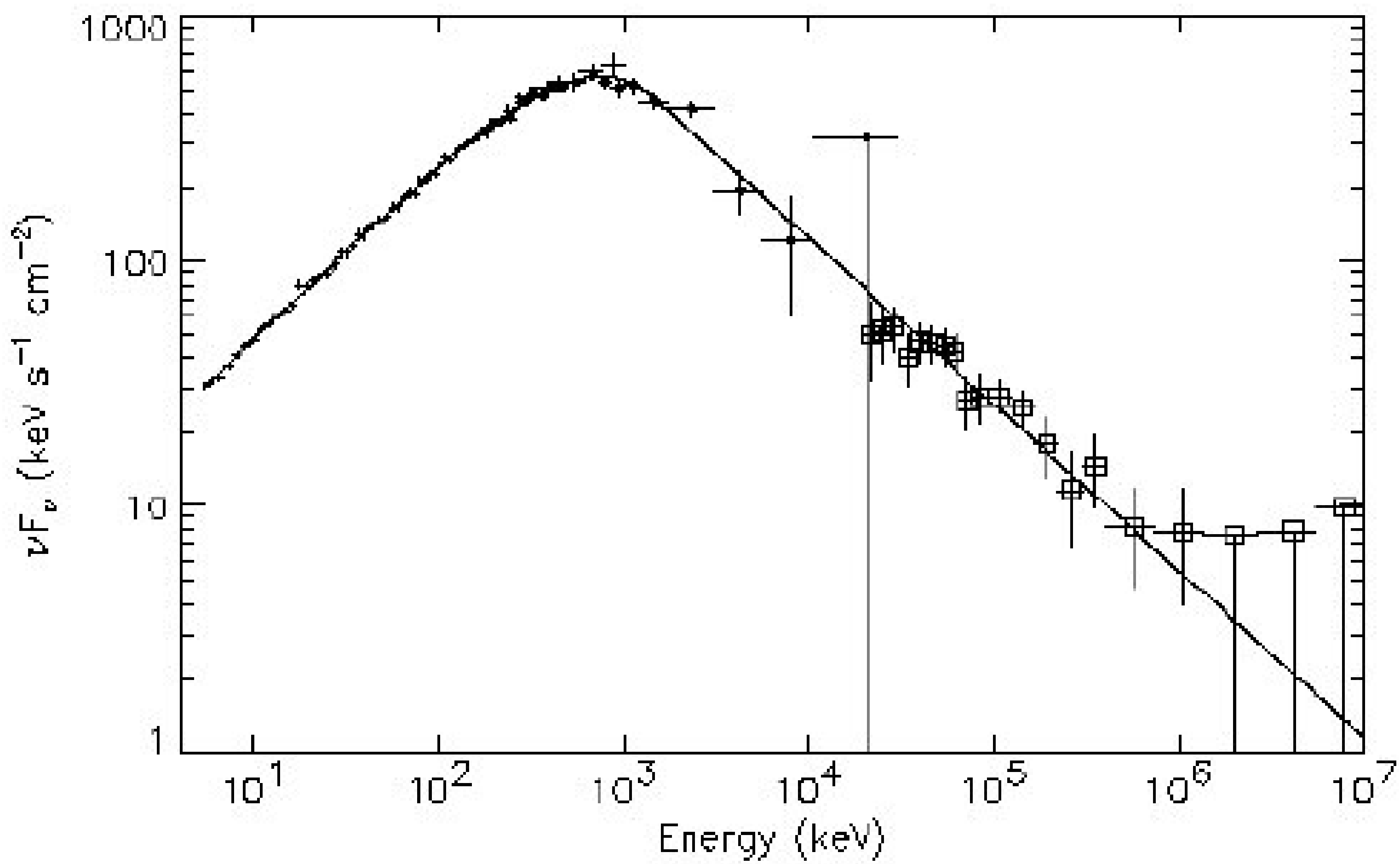
Instrument Functional Diagram



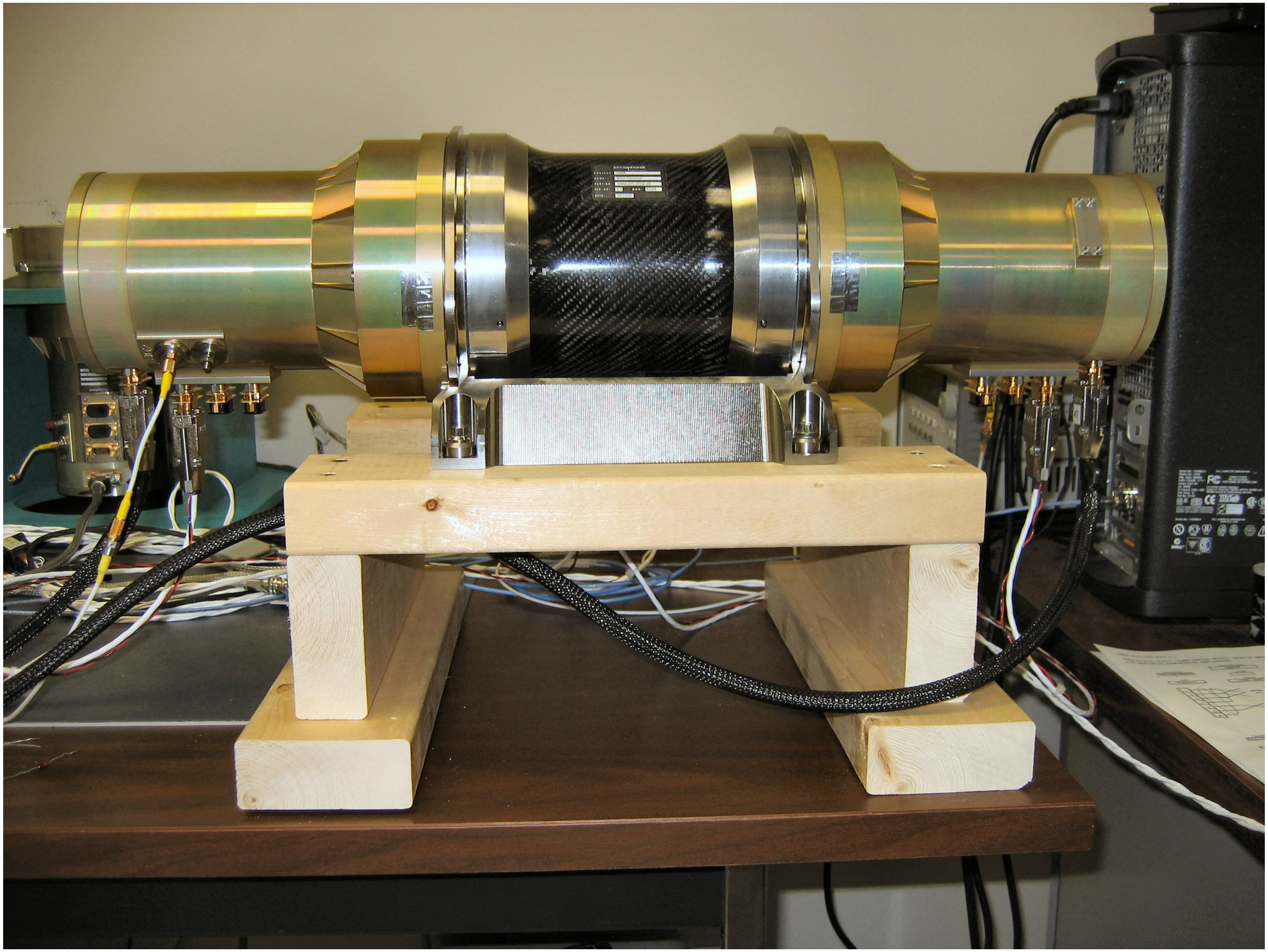
GBM Component Placement

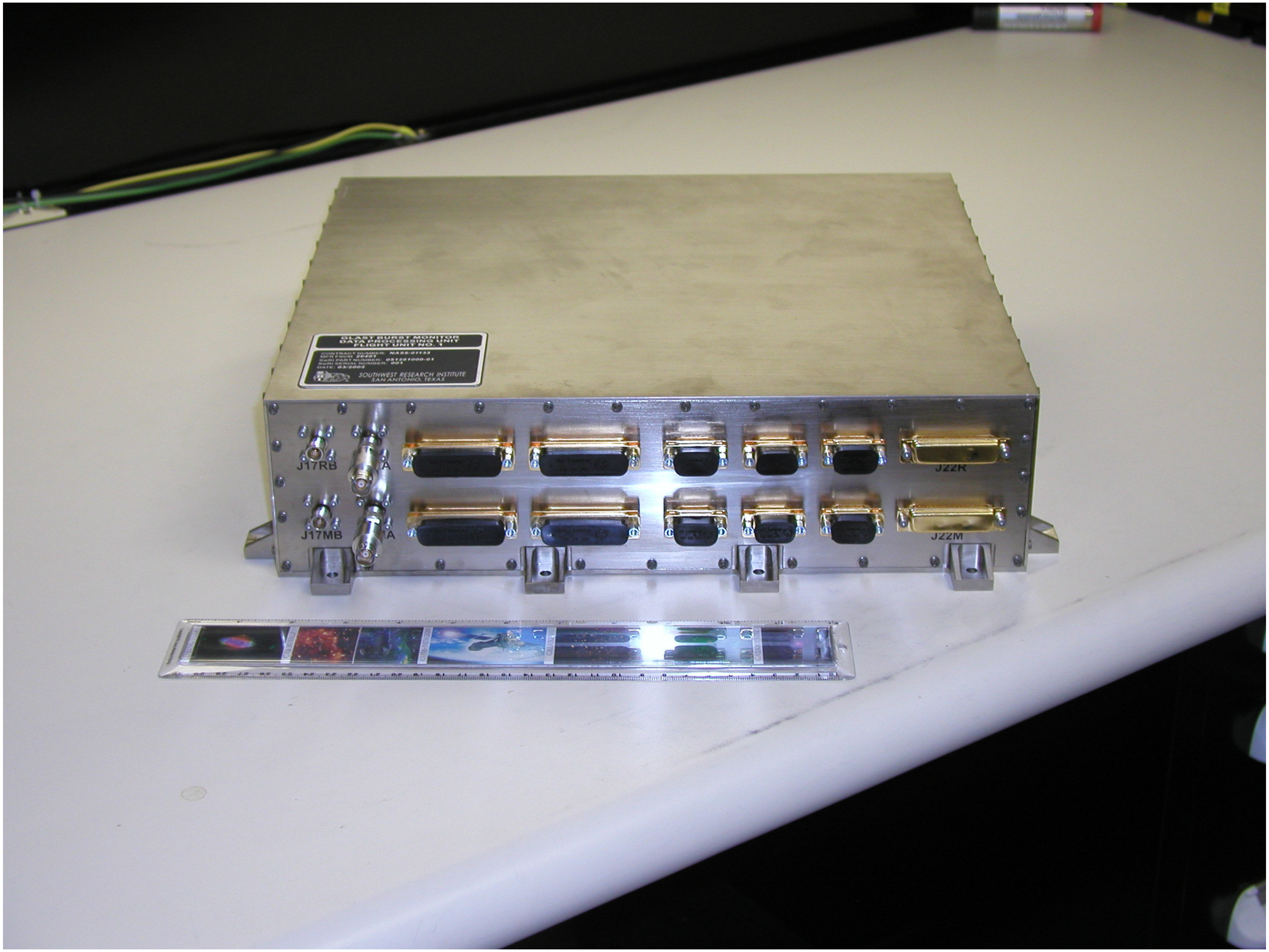


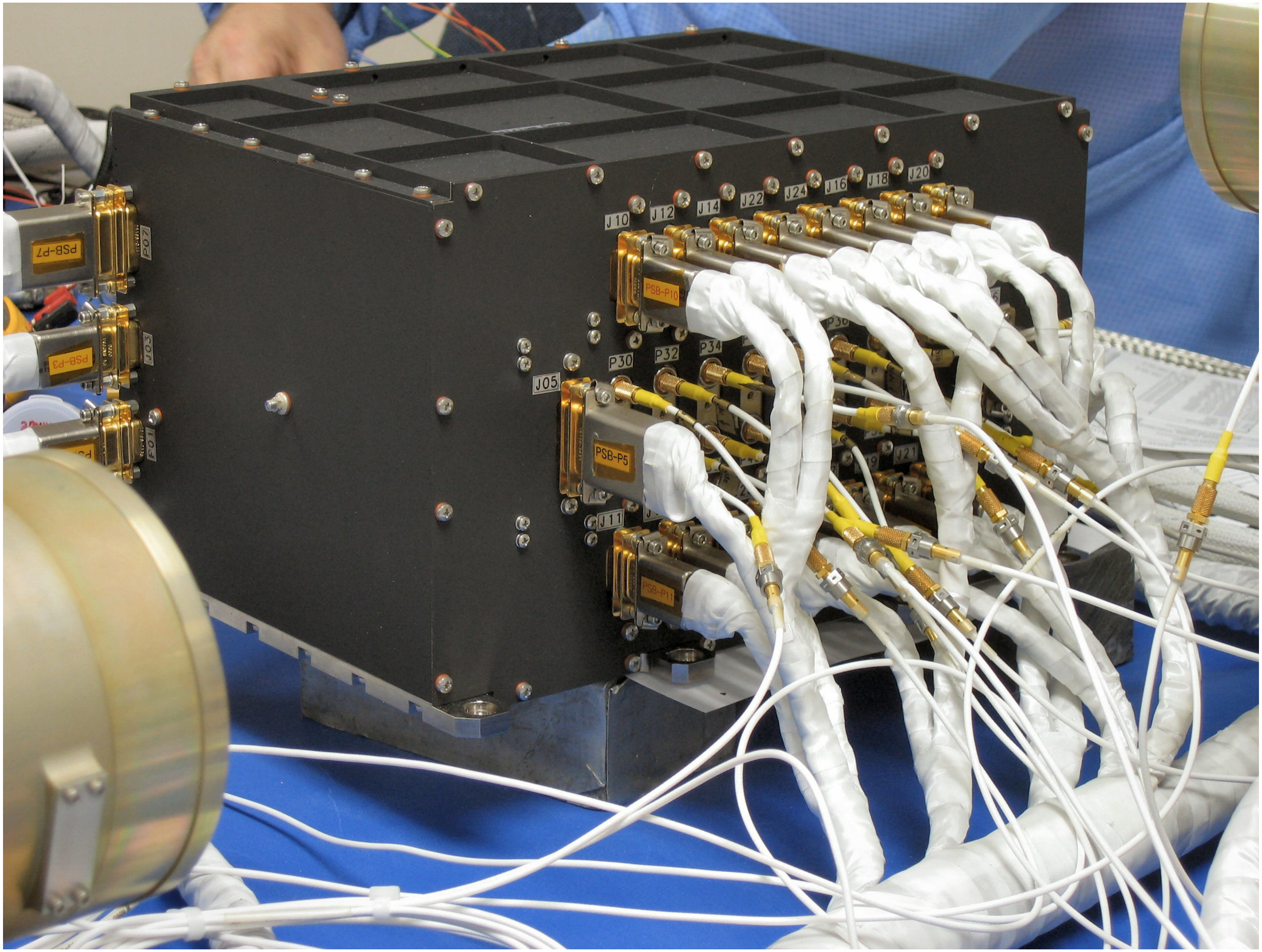
GRB Spectral Performance (GBM+LAT)

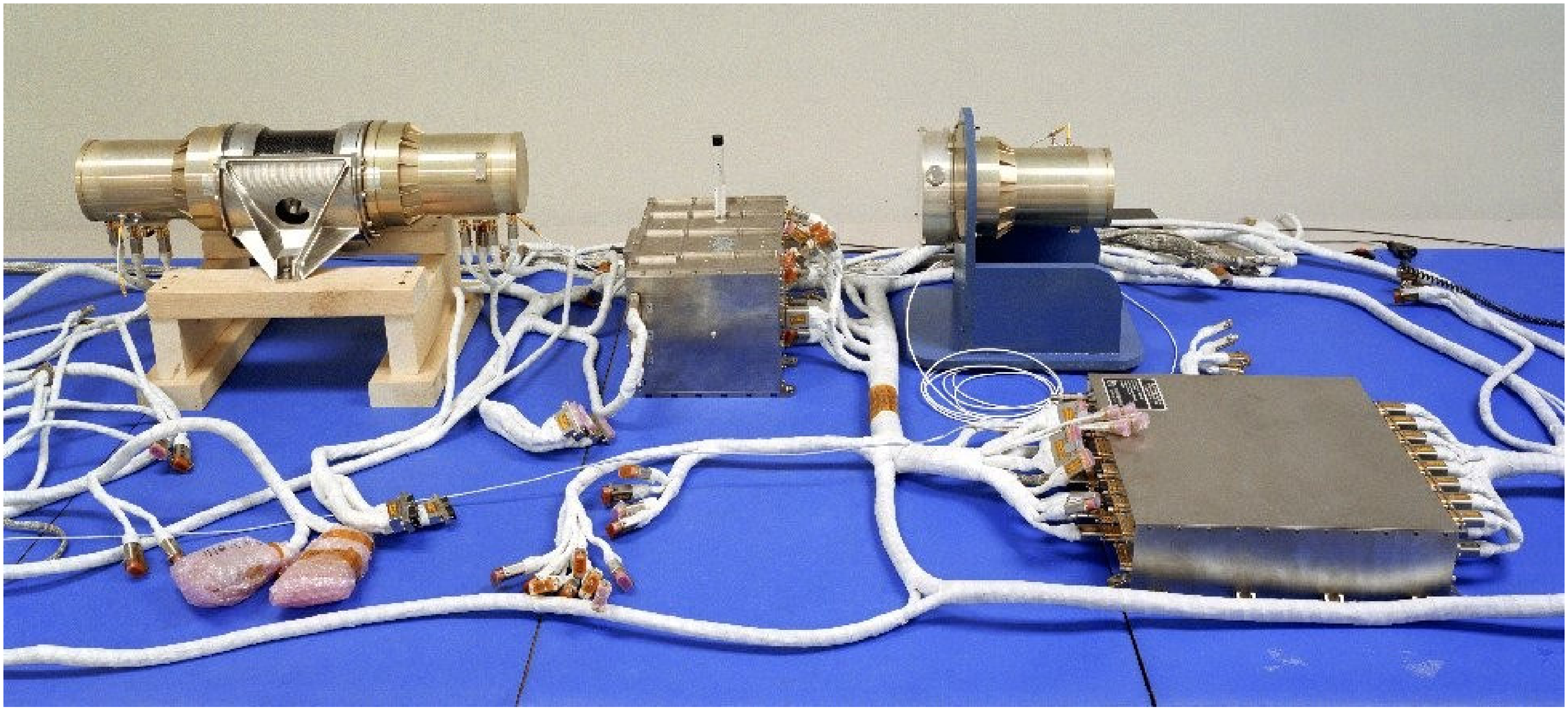


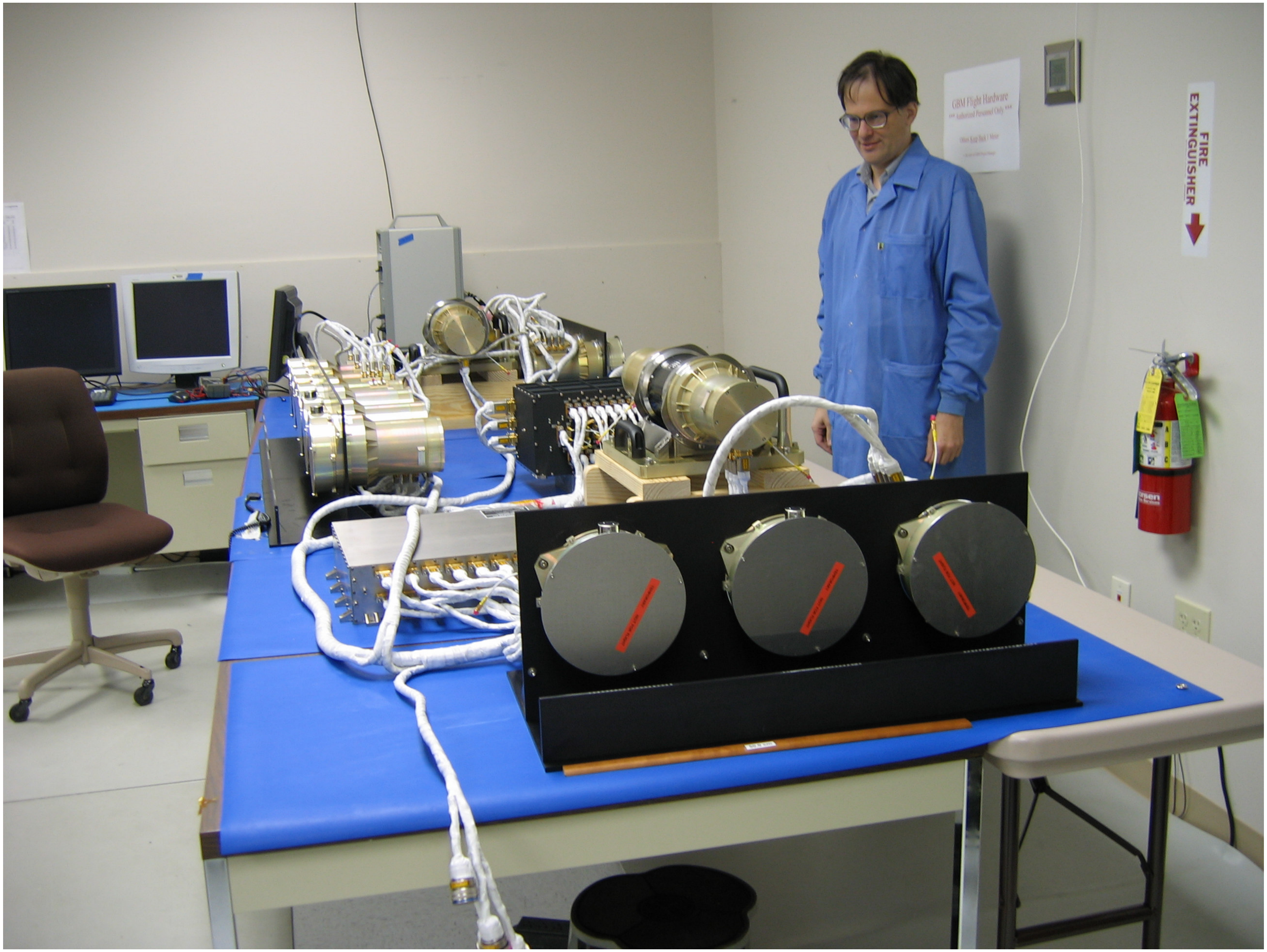
Simulated GBM and LAT response to time-integrated flux from bright GRB 940217




GLAST BURST MONITOR
DATA PROCESSING UNIT
FLIGHT UNIT NO. 1
CONTRACT NUMBER:
MFR FSCM
SwRI PART NUMBER: 051281000-01
SwRI SERIAL NUMBER: 001
DATE: 03/2005
SOUTHWEST RESEARCH INSTITUTE
SAN ANTONIO, TEXAS
J17RB
J17MB
J22R
J22M


PSB-P7
P07
PSB-P3
J03
J10
J12
J14
J22
J24
J16
J18
J20
PSB-P10
P30
P32
P34
J05
PSB-P5
J11




GBM Flight Hardware
*** Authorized Personnel Only ***
Others Keep Back 1 Meter
FIRE EXTINGUISHER

Summary

- GRB research is still hot.
- Large sample of redshifts is being accrued (67 so far).
- GRBs may soon be useful cosmological probes.
- GLAST will provide new spectral information.
- Trigger meetings will resume in 2007 (we hope)!