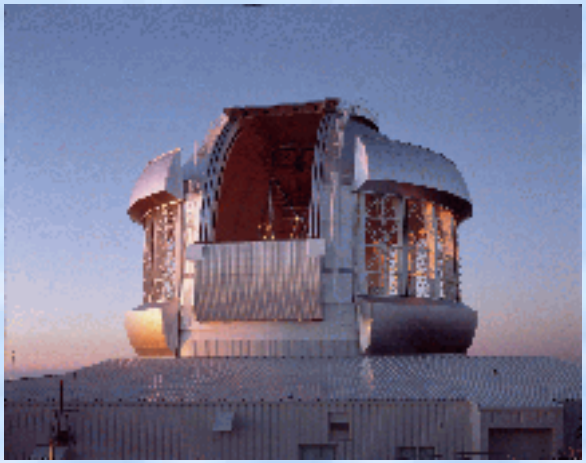
Fast and Flexible:
Rapid Response Observations with Gemini



Paul Price
Institute for Astronomy
University of Hawaii

Len Cowie
Brian Schmidt
Derek Fox
Alicia Soderberg
Yuzuru Yoshii

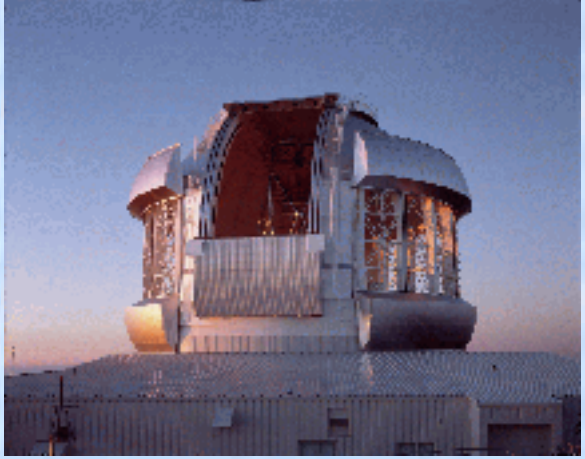
Toni Cowie
Mike Dopita
Edo Berger
Dale Frail
Takeo Minezaki

Kathy Roth
Bruce Peterson
Shri Kulkarni
Bryan Penprase
Brad Cenko

Nick Kaiser
Eugene Magnier

John Tonry
Jim Heasley

Ken Chambers
Will Burgett

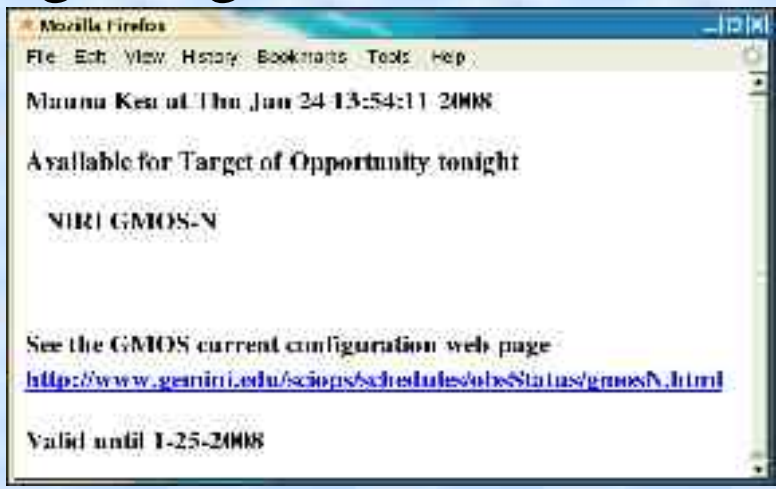


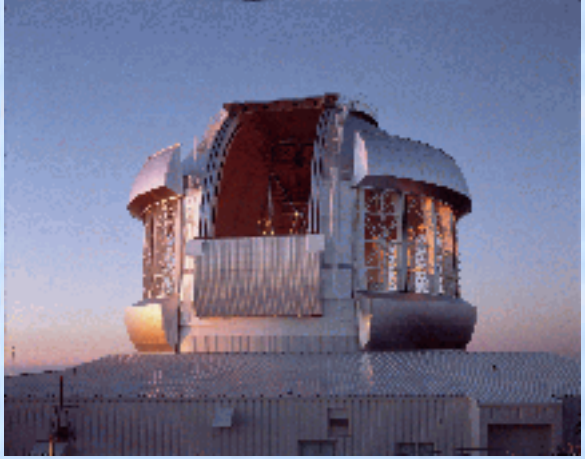
Gemini ToOs

- Gemini observes (mostly) in queue mode
  - ToO causes minimal interruption to science programs
  - Interrupted programs don't lose time
- Pre-defined observation templates using PIT
  - Simple for scientist and Observatory
  - Limits mis-communication in the heat of the moment
- ToO classes:
  - “Rapid”: immediate, e.g., GRBs and other flashes
  - “Standard”: soon, anything with unknown position at proposal time, e.g., SN

Jukebox Instruments

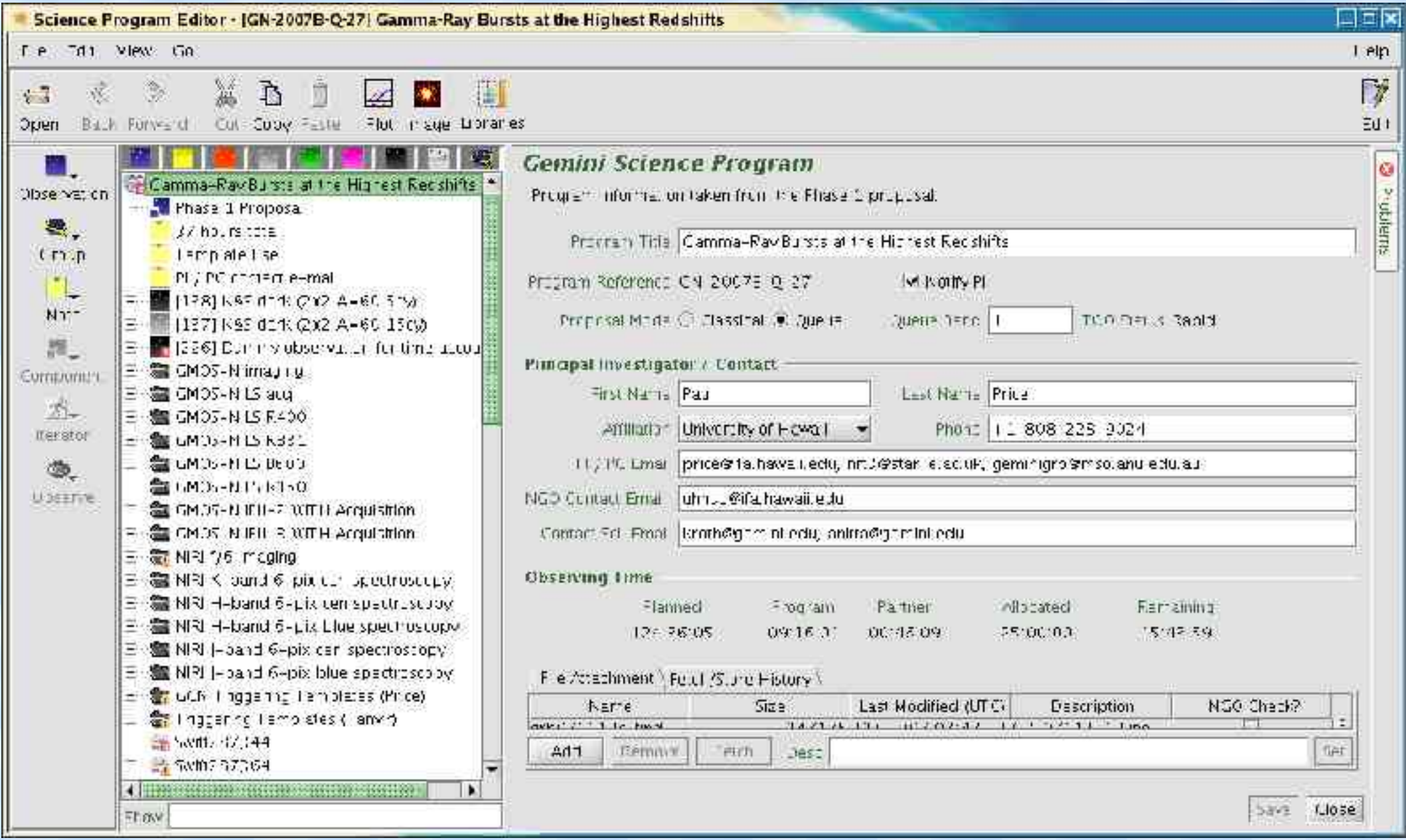
- Multiple instruments available on a single night
  - GMOS and NIRI (Gemini North)
- Flexibility
  - Wavelengths: optical vs NIR
  - Modes: imaging vs spectroscopy
  - Optical spectroscopy in bright time
  - NIR imaging in dark time

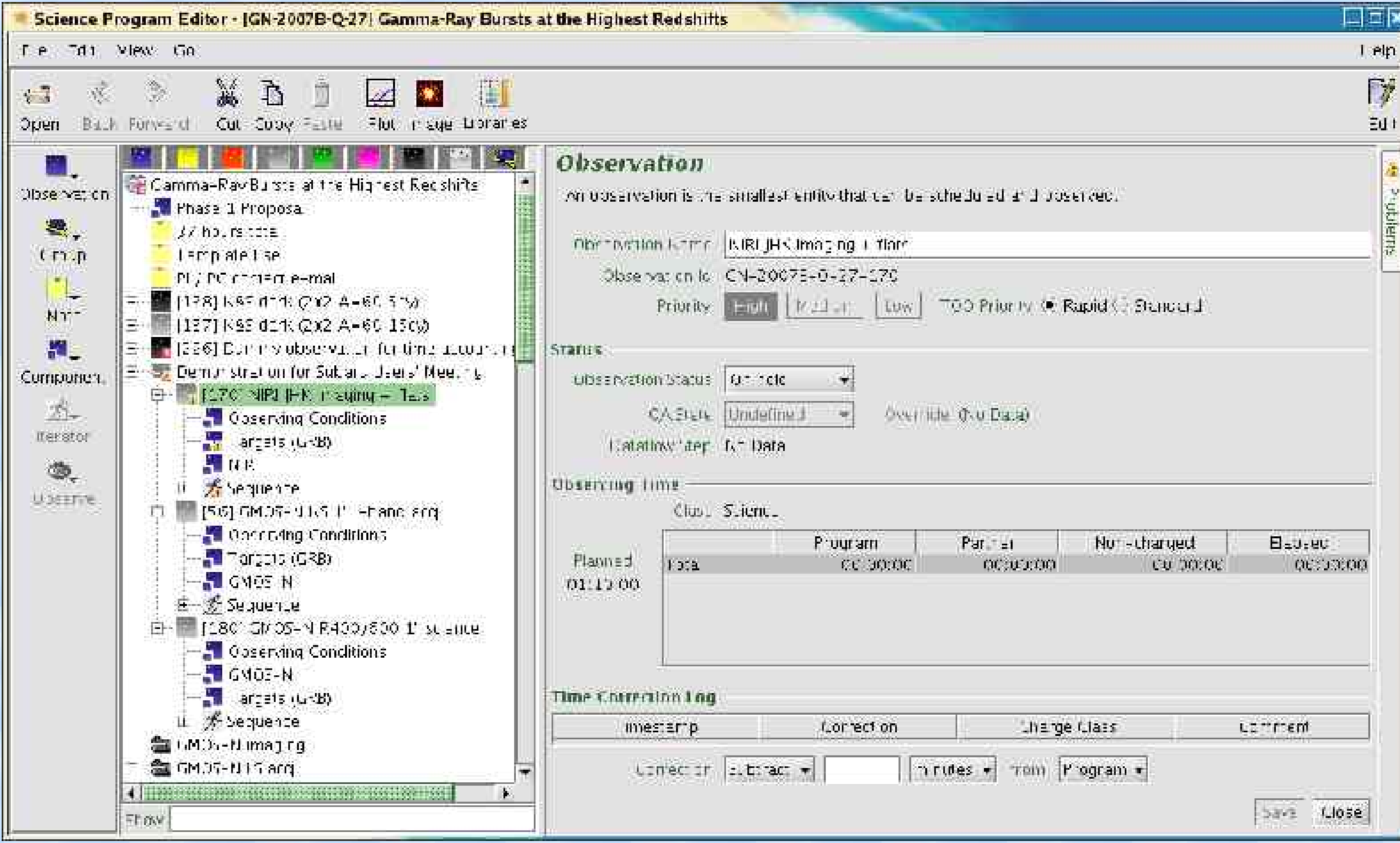




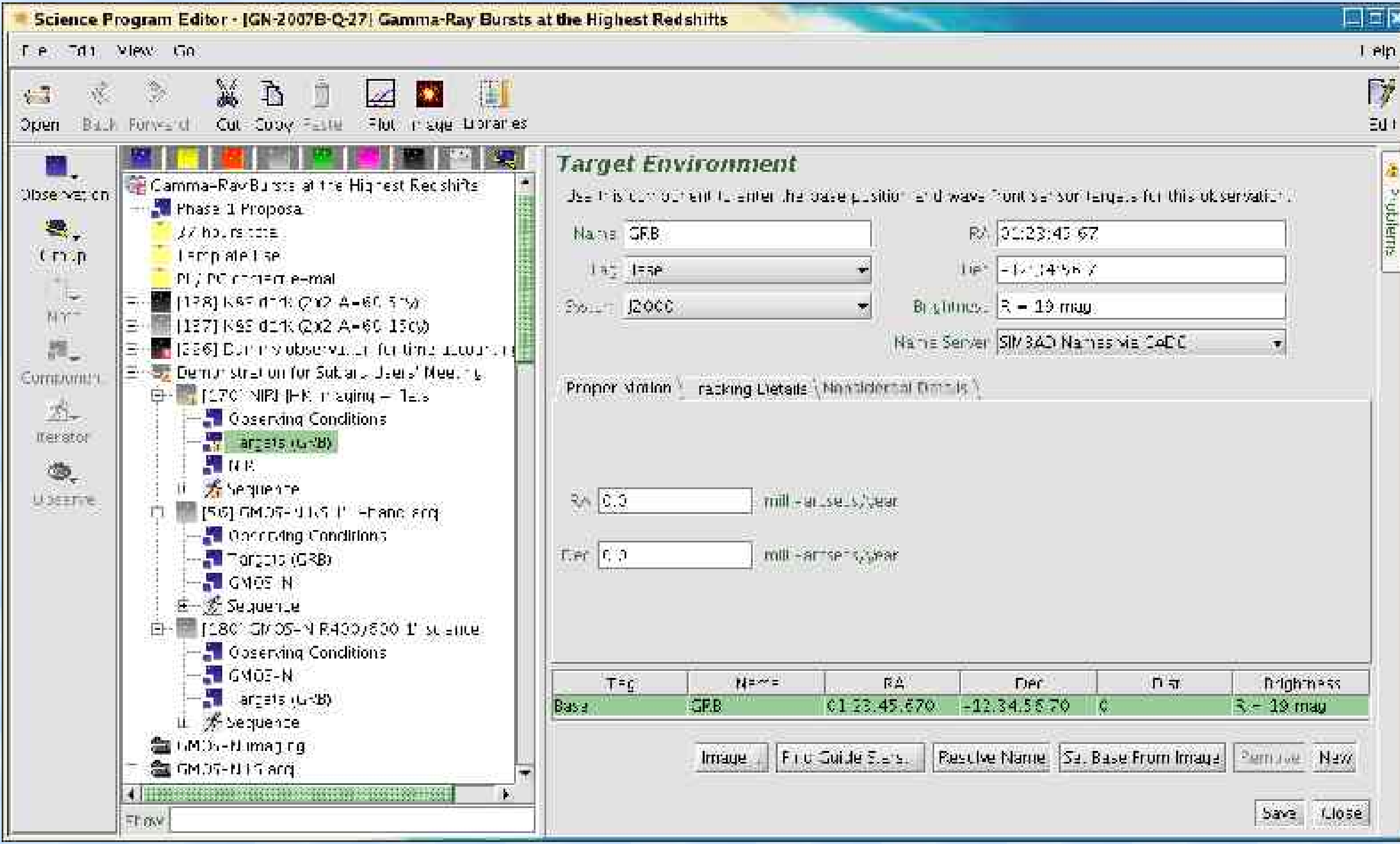
PIT Triggering

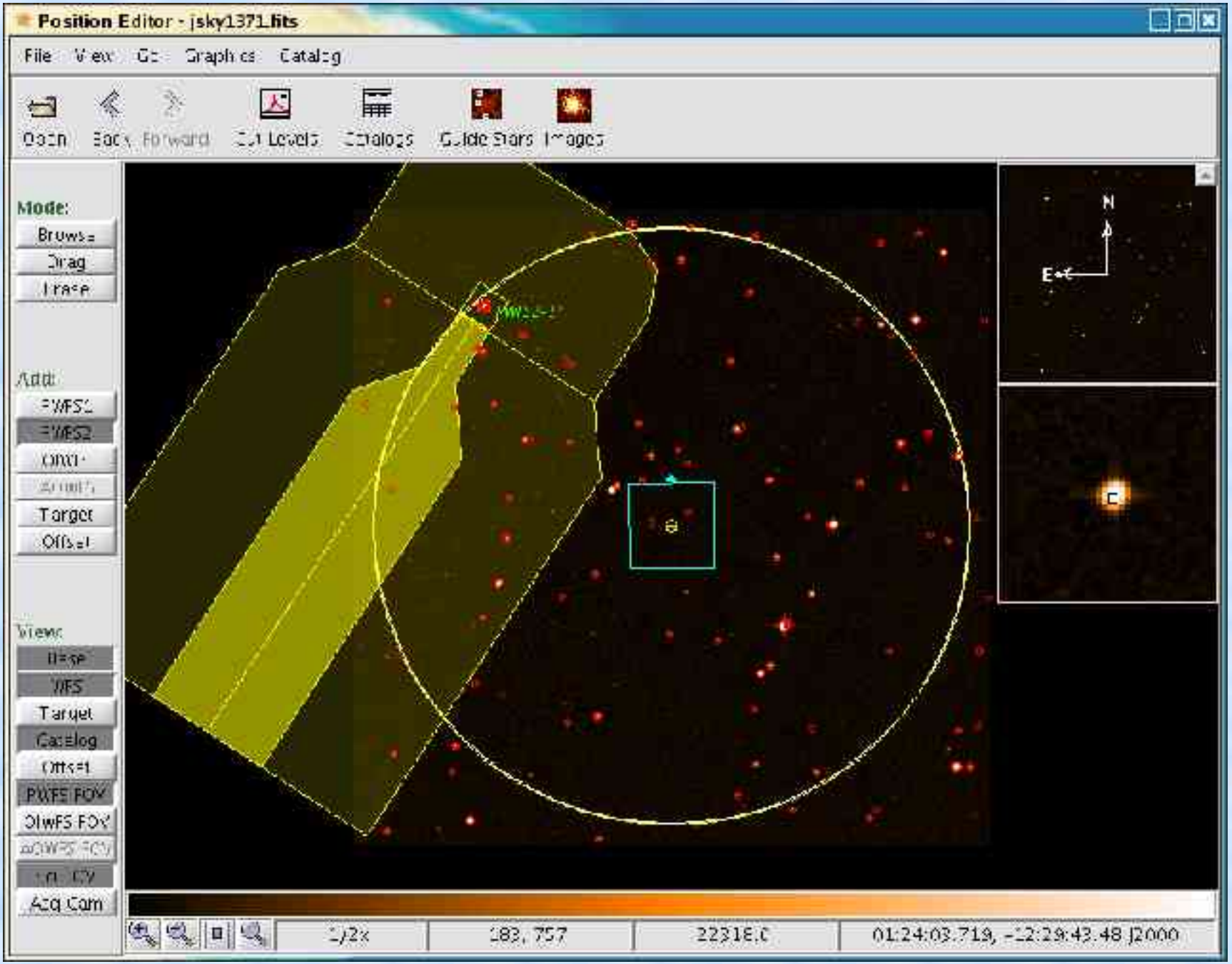
- Select pre-defined observation template
- Fill in coordinates, magnitude
- Select a guide star
- Can check/change:
  - Grating, slit
  - Exposure time, number of exposures
  - Calibrations
  - Required conditions
- Set state to “Ready” and upload

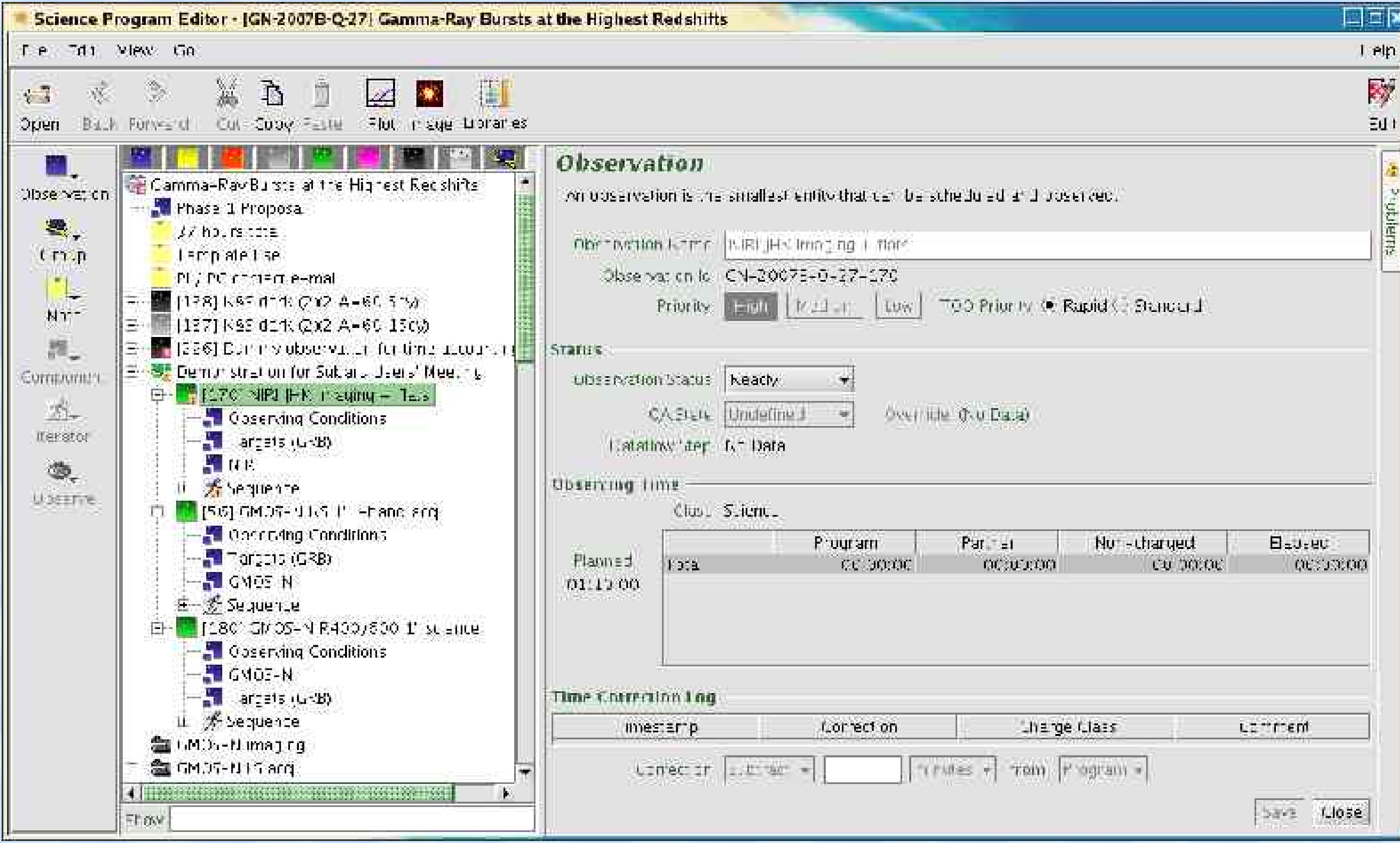

Science Program Editor - [GN-2007B-Q-27] Gamma-Ray Bursts at the Highest Redshifts
Open
Back
Forward
Cut
Copy
Paste
Plot
Libraries
Edit
Observation
Group
Note
Components
Iterator
Observe
Gamma-Ray Bursts at the Highest Redshifts
Phase I Proposal
Gemini Science Program
Program Title
Gamma-Ray Bursts at the Highest Redshifts
Program Reference
GN-2007B-Q-27
Notify PI
Proposal Mode
Classical
Queue
Queue Band
Principal Investigator / Contact
First Name
Paul
Last Name
Price
Affiliation
University of Hawaii
Phone
+1 808 225 9021
PI / PC Email
price@ifa.hawaii.edu
NGO Contact Email
Contact For Email
Observing Time
Planned
Program
Partner
Allocated
Remaining
File Attachment
Fault / Site History
Name
Size
Last Modified (UTC)
Description
NGO Check?
Add
Remove
Fetch
Get
Save
Close
Problems



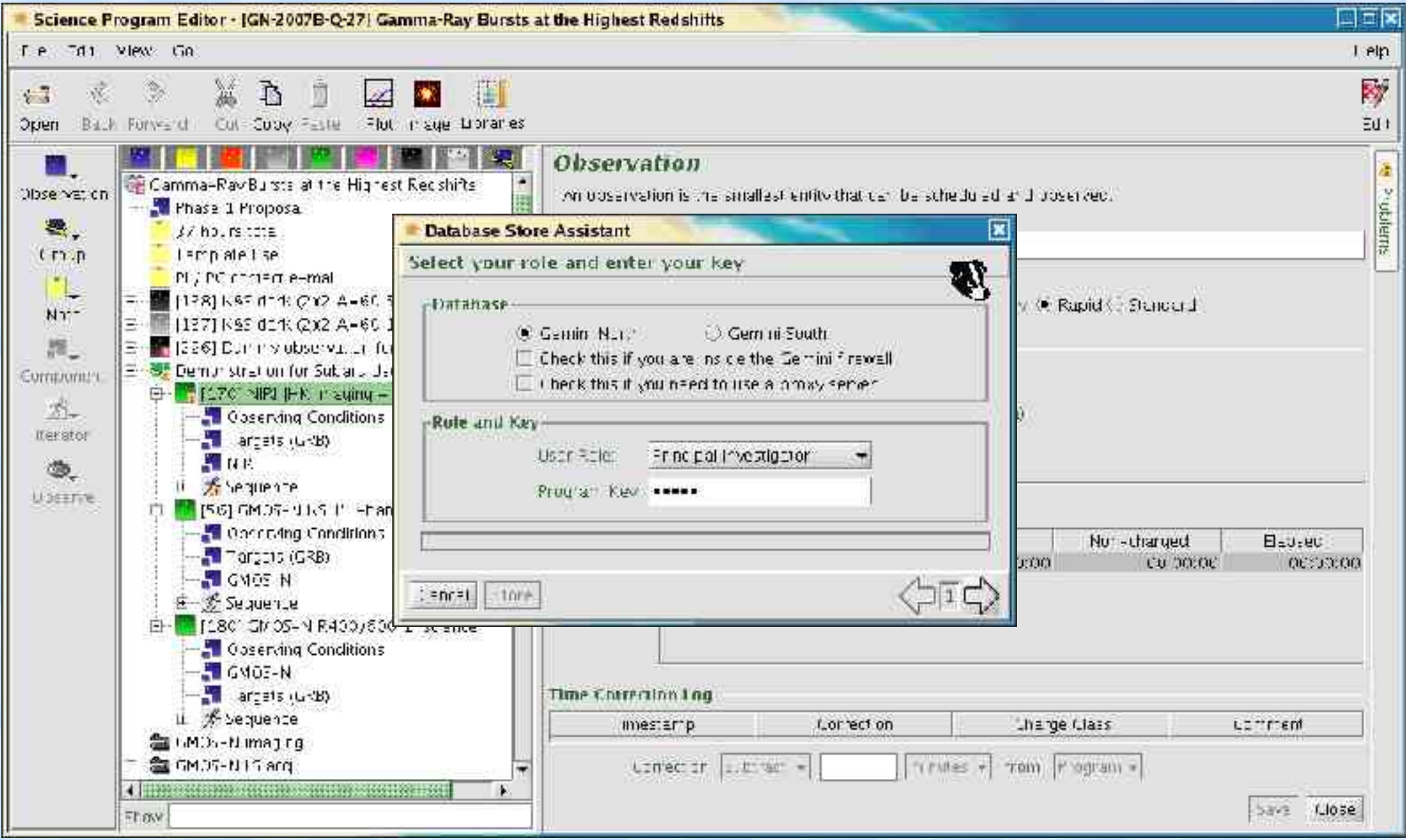
Science Program Editor - [GN-2007B-Q-27] Gamma-Ray Bursts at the Highest Redshifts
View
Go
Open
Cut
Libraries
Observation
Group
Component
Iterator
Gamma-Ray Bursts at the Highest Redshifts
Phase 1 Proposal
Observing Conditions
Sequence
Targets (GRB)
GMOS-N
Observation
Priority
Status
Observing Time
Science
Planned
Program
Elapsed
Time Correction Log
Correction
Comment
Minutes
Program
Close

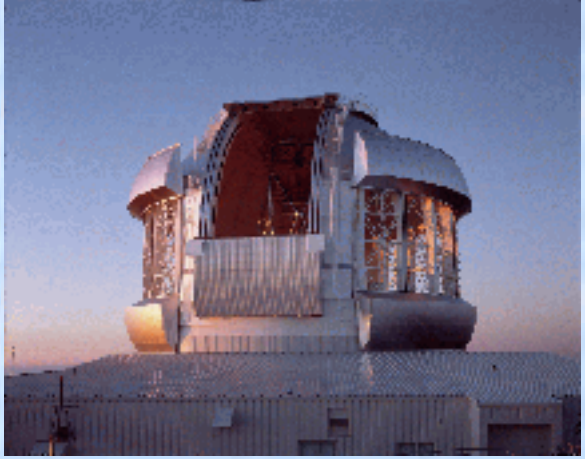

Science Program Editor - [GN-2007B-Q-27] Gamma-Ray Bursts at the Highest Redshifts
Open
Cut
Target Environment
Name GRB
RA
Brightness R = 19 mag
Proper Motion
Tracking Details
Observing Conditions
Targets (GRB)
GMOS-N
Sequence
Tag
Name
RA
Dec
Brightness
Base
GRB
R = 19 mag
Image
Resolve Name
New
Save
Close


Position Editor - jsky1371.fits
File
Graphics
Catalog
Open
Back
Forward
Cut Levels
Catalogs
Guide Stars
Images
Mode:
Browse
Drag
Erase
Add:
PWFS1
PWFS2
Target
Offset
View:
Base
AO
Target
Catalog
Offset
PWFS FOV
OIWFS FOV
Acq Cam
N
E
C
1/2x
283, 757
2231E.0
01:24:03.719, -12:29:43.48 J2000



Science Program Editor - [GN-2007B-Q-27] Gamma-Ray Bursts at the Highest Redshifts
View
Open
Forward
Copy
Plot
Libraries
Observation
Phase 1 Proposal
Observing Conditions
Sequence
Observing Conditions
Targets (GRB)
GMOS-N
Sequence
Observing Conditions
GMOS-N
Sequence
Observation
Priority
High
Low
Rapid
Status
Ready
Undefined
Observing Time
Science
Program
Elapsed
Close

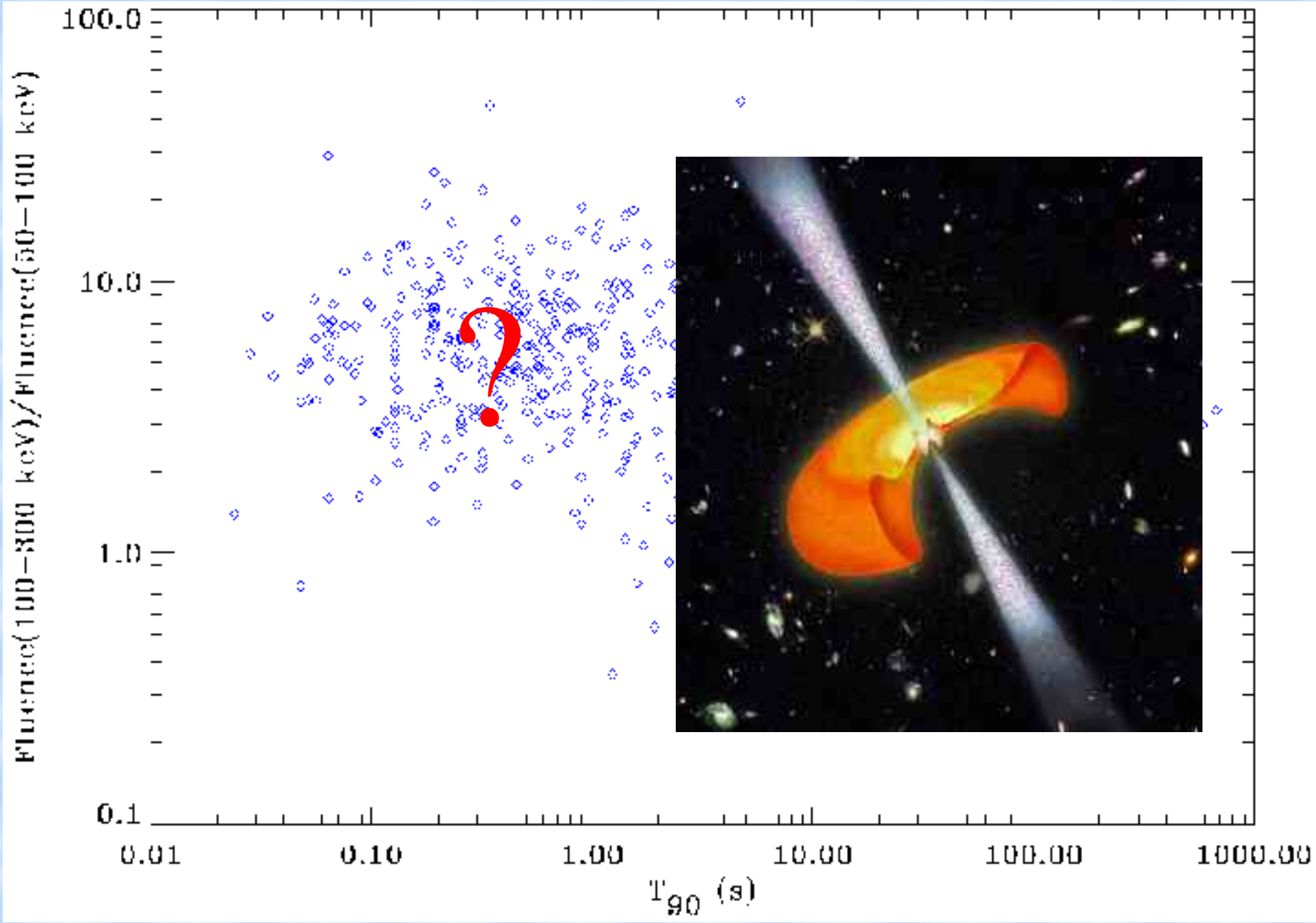

Science Program Editor - [GN-2007B-Q-27] Gamma-Ray Bursts at the Highest Redshifts
Open
Observation
Database Store Assistant
Select your role and enter your key
Database
Gemini North
Gemini South
Role and Key
User Role:
Principal Investigator
Program Key:
Cancel
Time Correction Log
Timestamp
Correction
Change Class
Comment
Save
Close



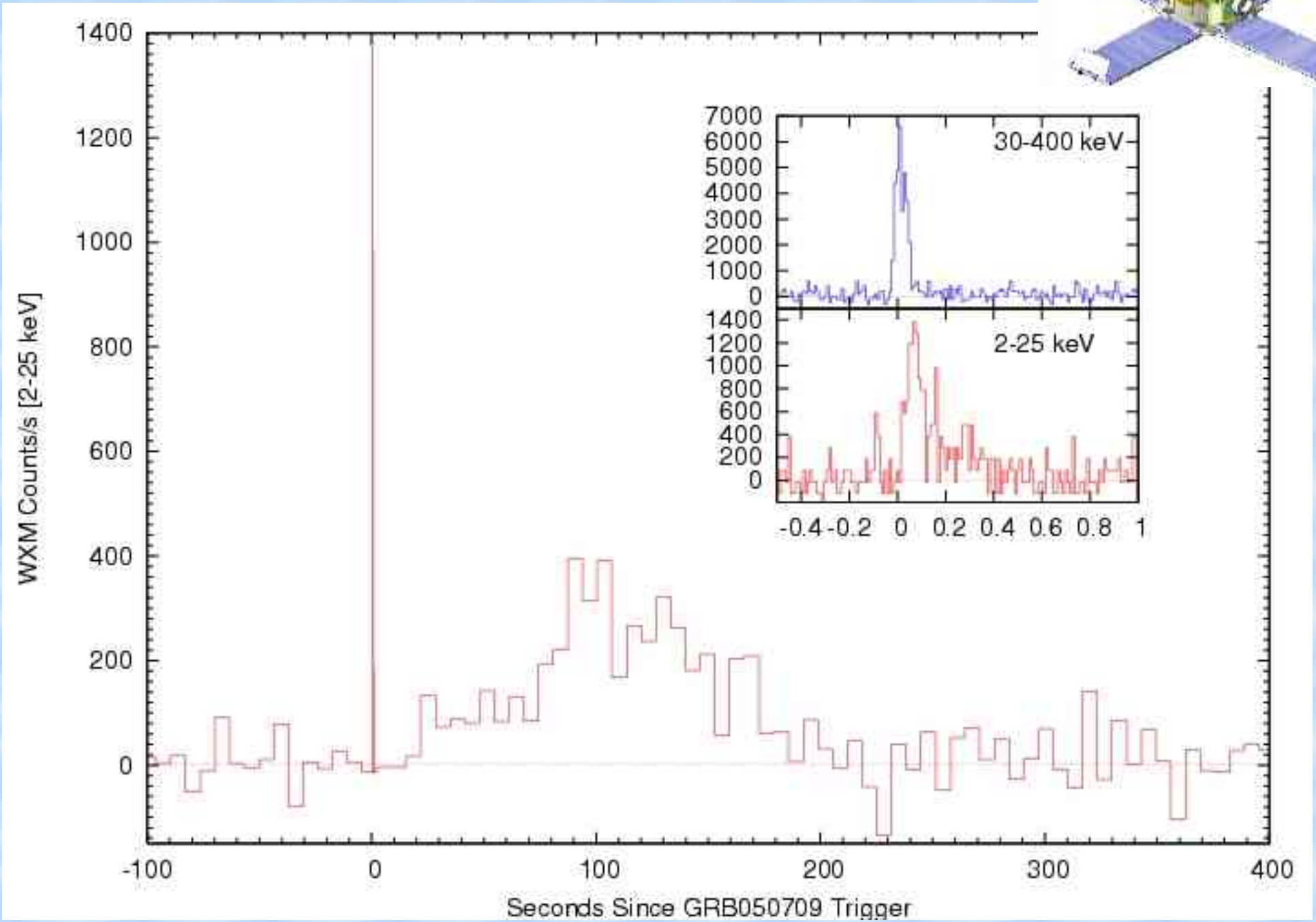
WWW Triggering

- Developed by Brian Miller, by request
- Bypass PIT
  - No human interaction required
  - FAST!
- Suitable for computer-controlled triggering (e.g., via GCN)
- Convenient even when rapid response not required
- `./gemini.pl GN-2007A-Q-19 BLAH 140 Swift263361 9:52:23.52 10:28:57.72 NIRI -note “Please observe this GRB as soon as possible.”`
- `https://128.171.88.221:8443/too?prog=GN-2007A-Q-19&password=BLAH&obsnum=140&target=Swift263361&ra=9:52:23.52&dec=10:28:57.72&note=Please%20observe%20this%20GRB%20as%20soon%20as%20possible%2E%0A&posangle=0&ready=true&group=Swift263361&gstarget=1005-0178236&gsra=9:51:57.44&gsdec=10:30:33.86&gsmag=13.88&gsprobe=PWFS2`

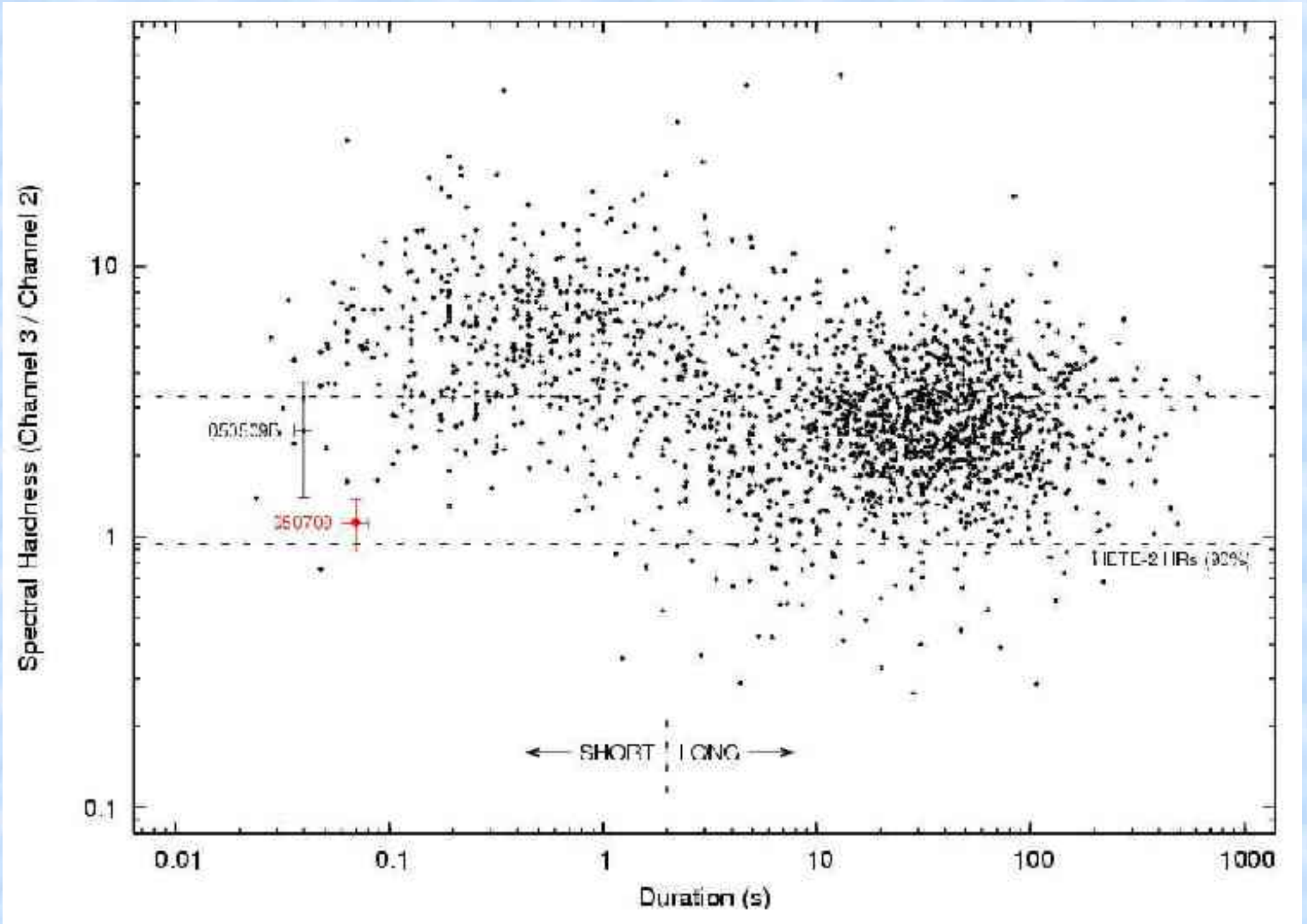
Short/Hard GRBs



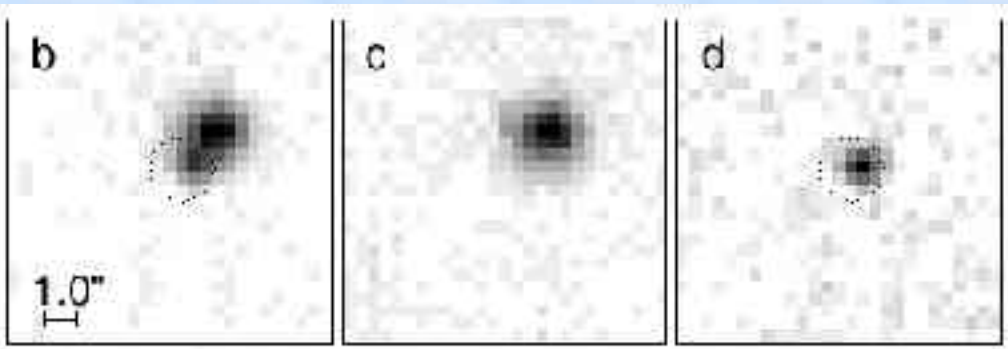
GRB 050709

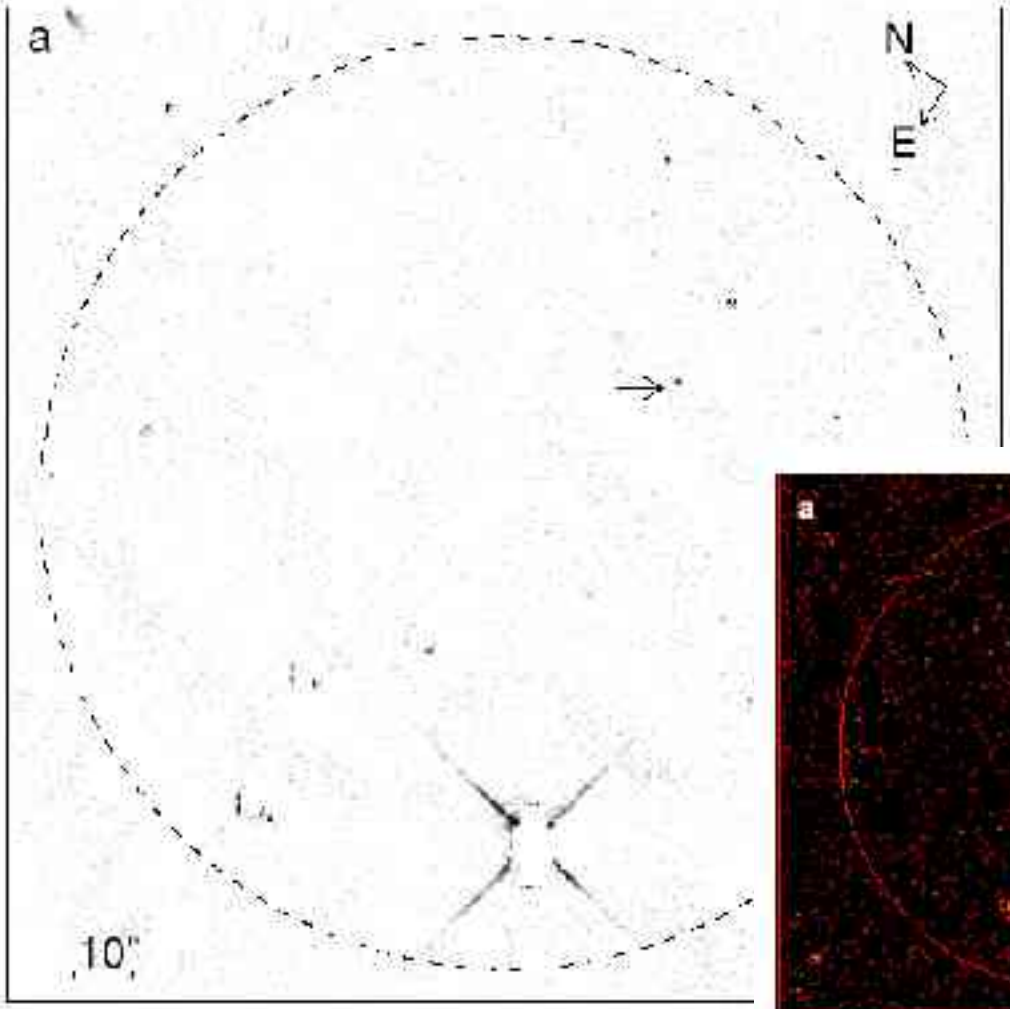

WXM Counts/s [2-25 keV]
Seconds Since GRB050709 Trigger
30-400 keV
2-25 keV

GRB 050709


Spectral Hardness (Channel 3 / Channel 2)
10
1
0.1
050509B
050709
HETE-2 FRs (90%)
SHORT
LONG
0.01
0.1
1
10
100
1000
Duration (s)

GRB 050709





TITLE: GCN GRB OBSERVATION REPORT
NUMBER: 3612
SUBJECT: GRB 050709: optical afterglow candidate
DATE: 05/07/14 22:02:37 GMT
FROM: Paul Price at IfA,UH <price@ifa.hawaii.edu>

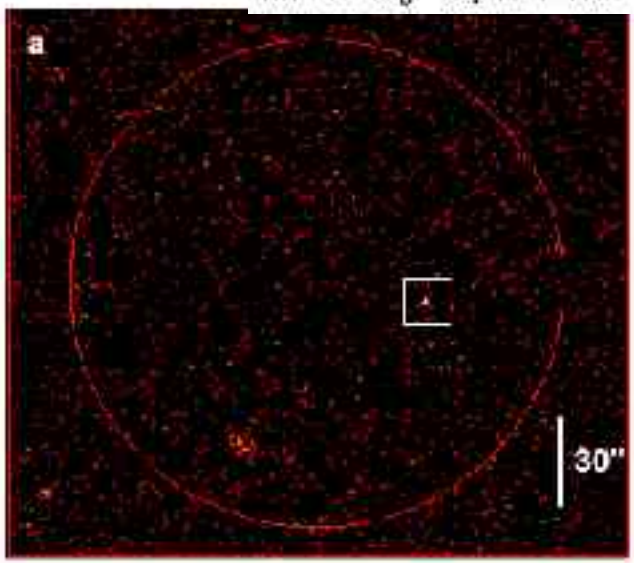
P. A. Price (IfA, Hawaii), E. L. Jensen, U. G. Jorgensen, D. Hjorth, J. P. U. Fynbo, D. Watson, J. M. Castro Ceron, K. Pedersen, H. Pedersen, and J. Sollerman (DARK Cosmology Centre, Niels Bohr Institute) report:

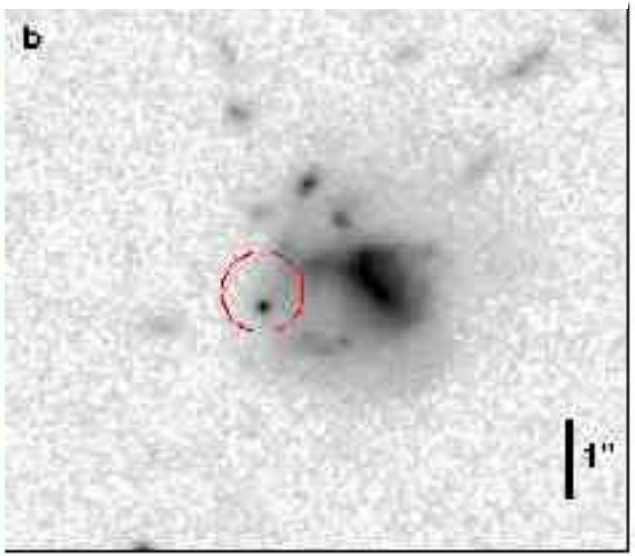
We have performed PSF matched image subtraction on the images acquired by Jensen et al. (GCN #3589). The images were obtained from the Danish 1.54m+DFOSC at La Silla on 2005 July 11.3 and 12.3 UT.

PSF-matched image subtraction using the Pan-STARRS Optimal Image Subtraction (POI Sub) code reveals a residual, in the sense that the source fades between the first and the second epochs. The position of the variable source corresponds to the source identified by Jensen et al. (GCN #3589) on the edge of a nearby galaxy (z=0.16; Price, Foth & Fox, GCN #3505) as consistent with the Chandra source (Fox et al., GCN #3585). This detection of optical variability increases the likelihood that this source is the afterglow of the short/hard GRB 050709.

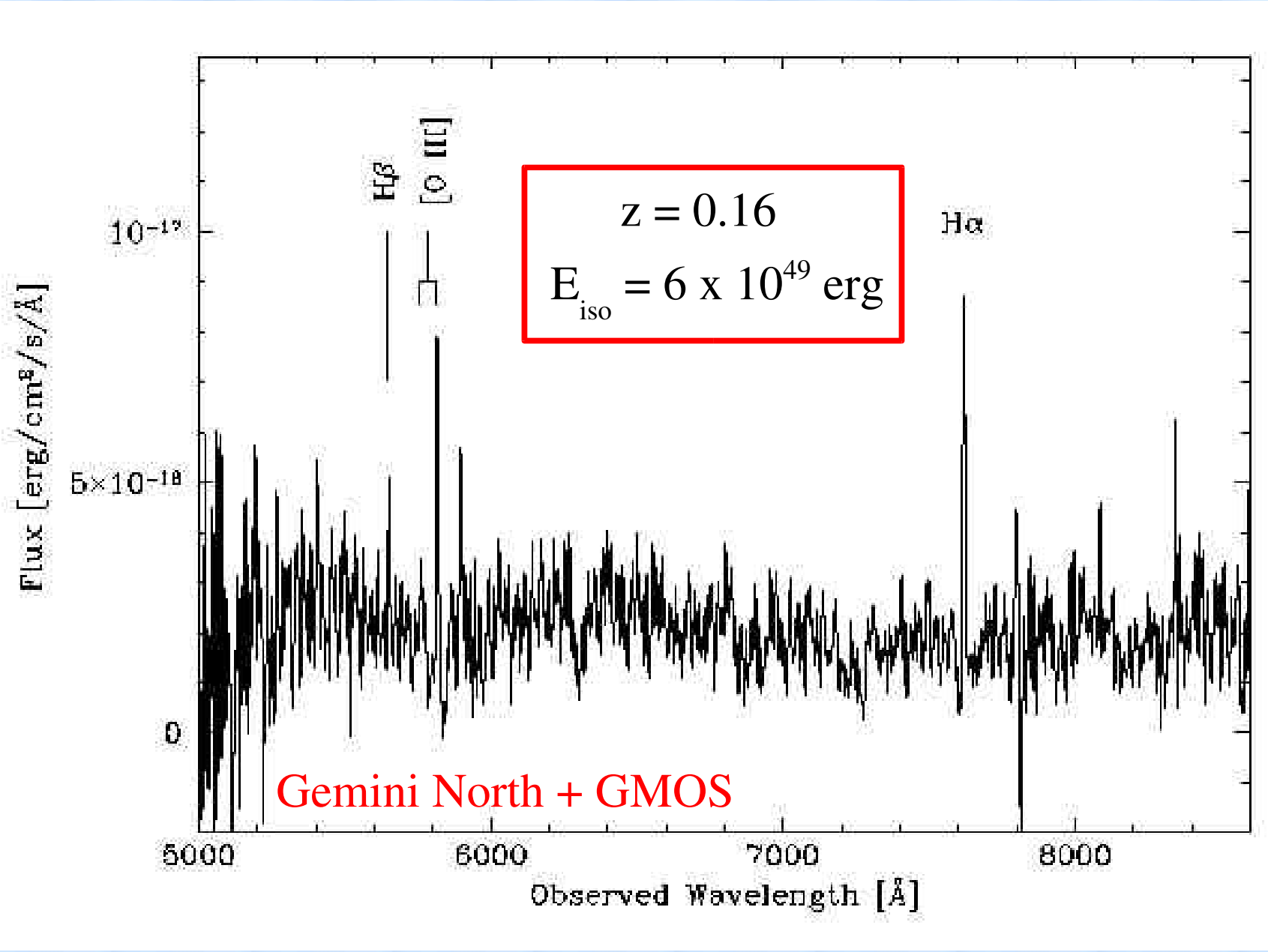
A figure showing the subtraction is available at
http://www.ifa.hawaii.edu/~price/grb050709candidate.jpg

This message may be cited.

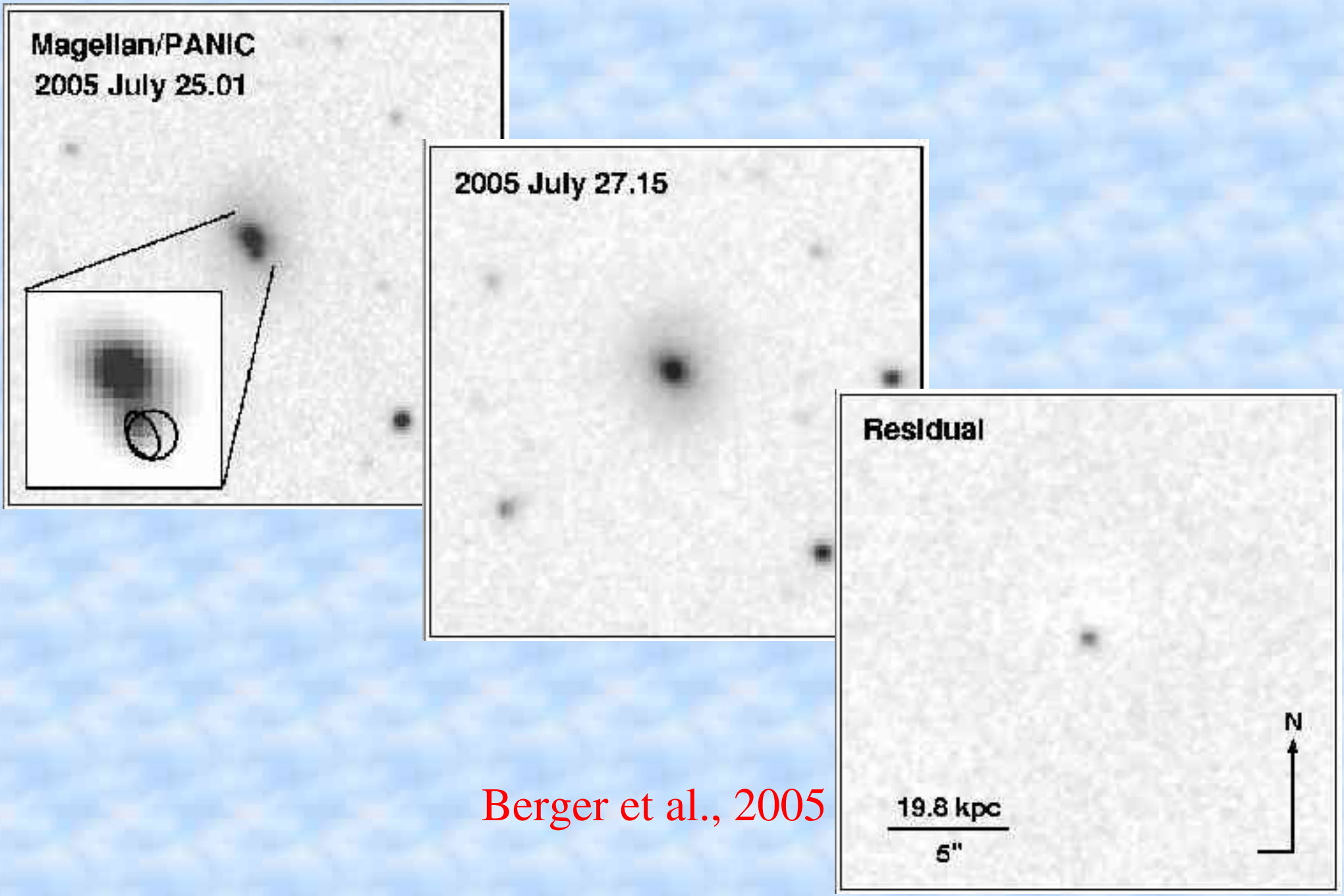




GRB 050709

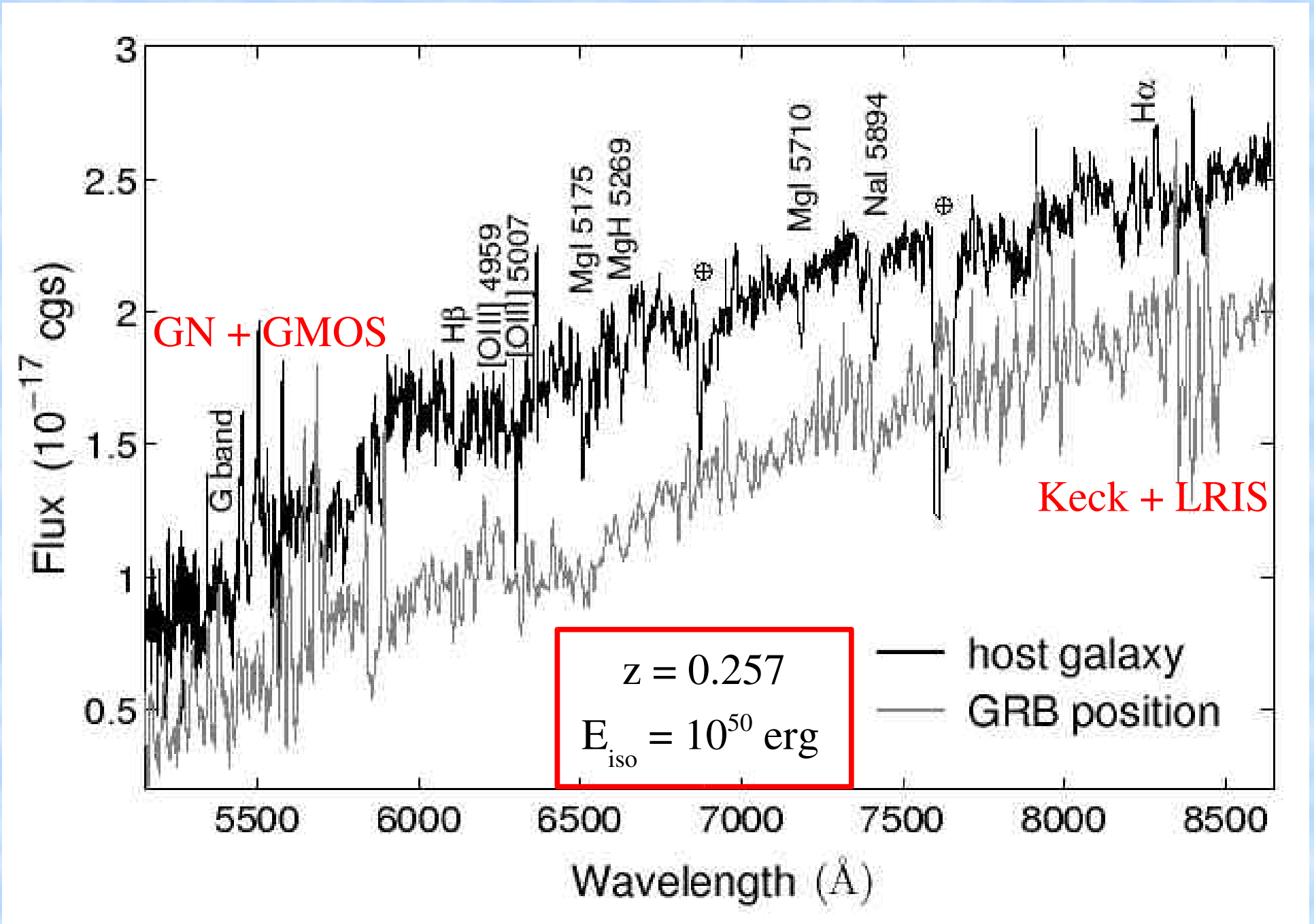

z = 0.16
$E_{iso} = 6 \times 10^{49}$ erg
Hβ
[O III]
Hα
Gemini North + GMOS
Flux [erg/cm²/s/Å]
10⁻¹⁷
5×10⁻¹⁸
0
5000
6000
7000
8000
Observed Wavelength [Å]

GRB 050724



Berger et al., 2005

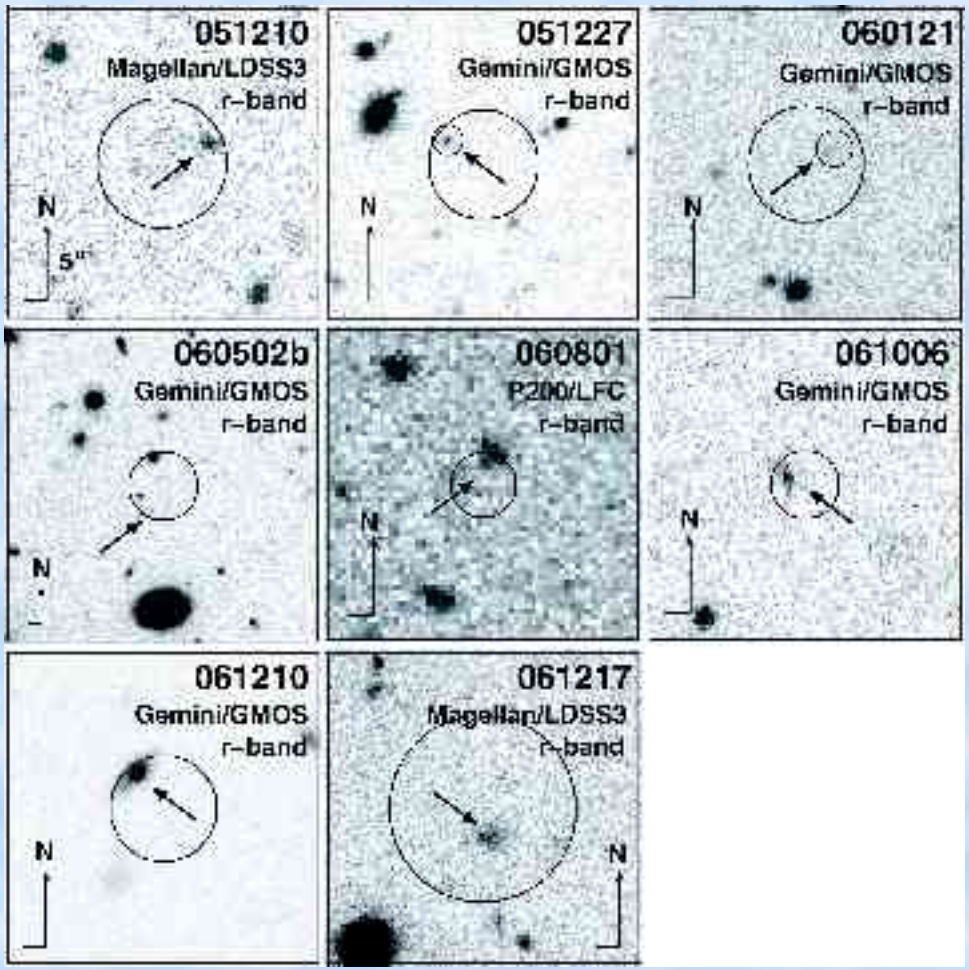
GRB 050724

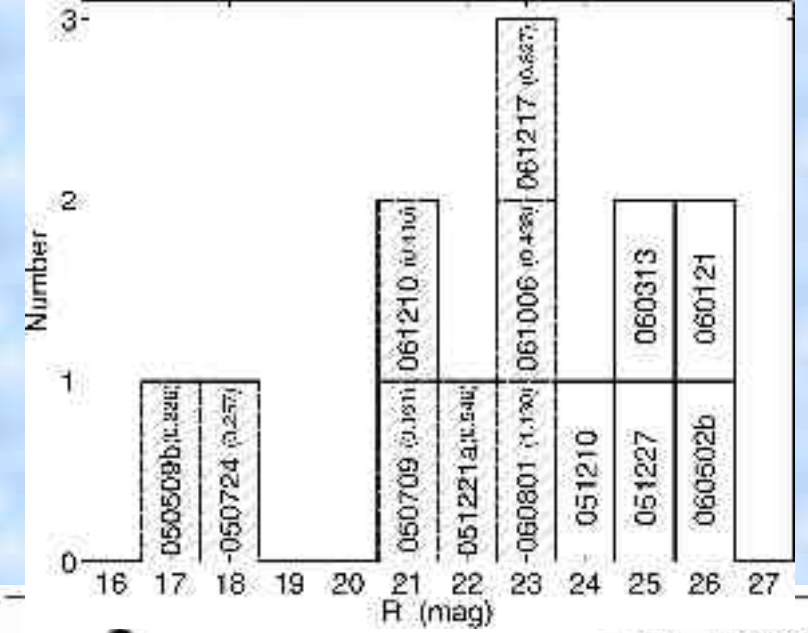

GN + GMOS
Keck + LRIS
G band
Hβ
[OIII] 4959
[OIII] 5007
MgI 5175
MgH 5269
⊕
MgI 5710
NaI 5894
⊕
Hα
z = 0.257
E_iso = 10^50 erg
host galaxy
GRB position
Flux (10^-17 cgs)
Wavelength (Å)
0.5
1
1.5
2
2.5
3
5500
6000
6500
7000
7500
8000
8500

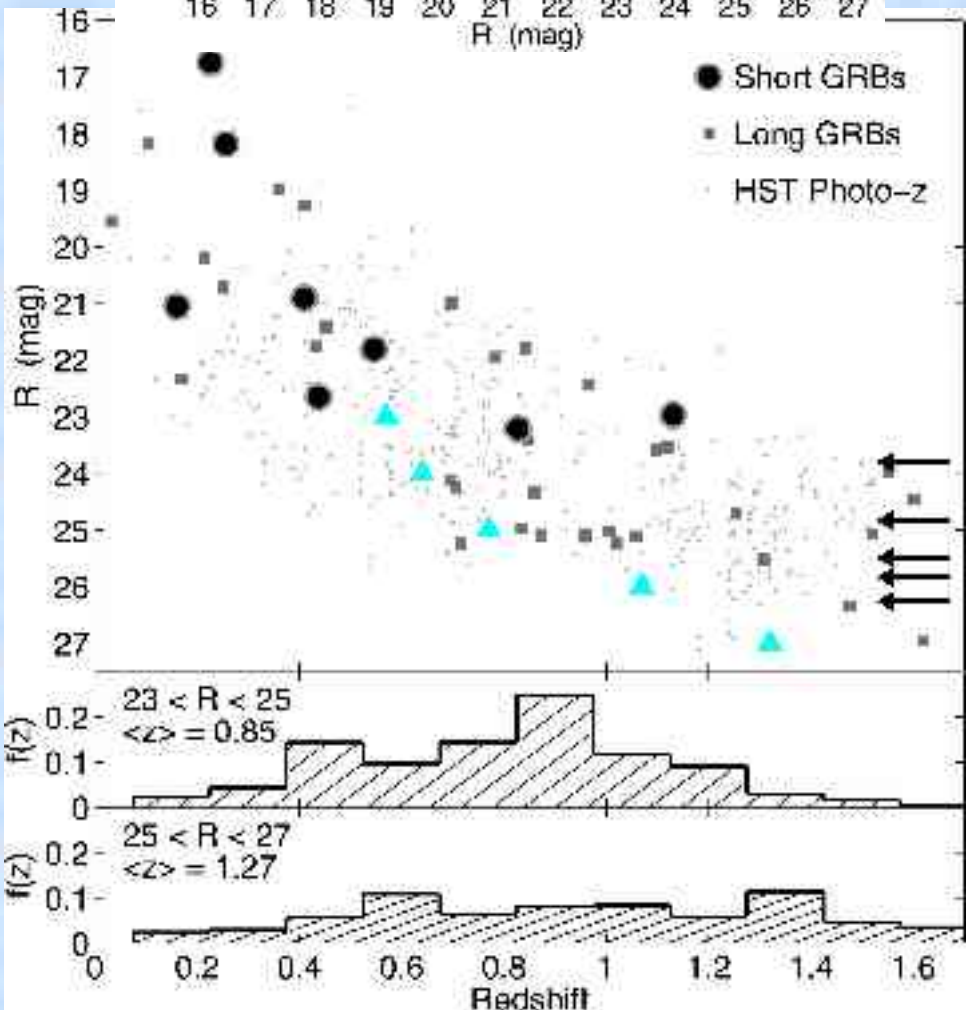
Some short conclusions

- Short/hard GRBs are of cosmological origin
  - Relatively low redshift compared to long/soft GRBs
- Typical energy release of several 10^{49} erg
- Observed in both star forming galaxies and ellipticals
  - Points to compact merger

But not all SHBs are at low z!



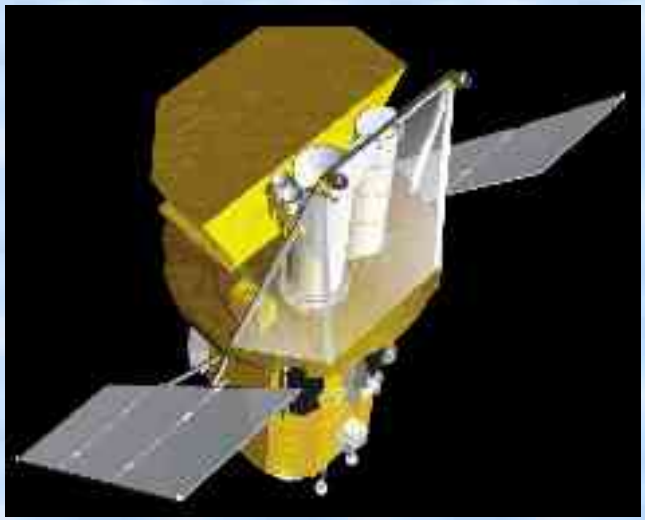




Suggests a significant fraction of SHBs are at z >~ 1

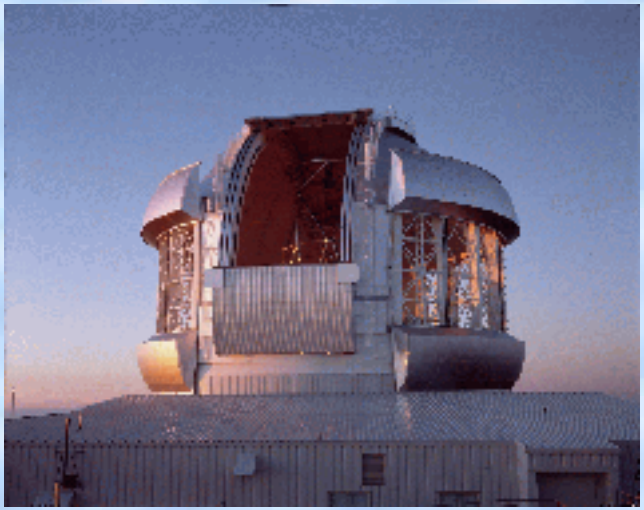
Berger et al., 2007

Long/Soft GRBs to the Edge of the Universe ...

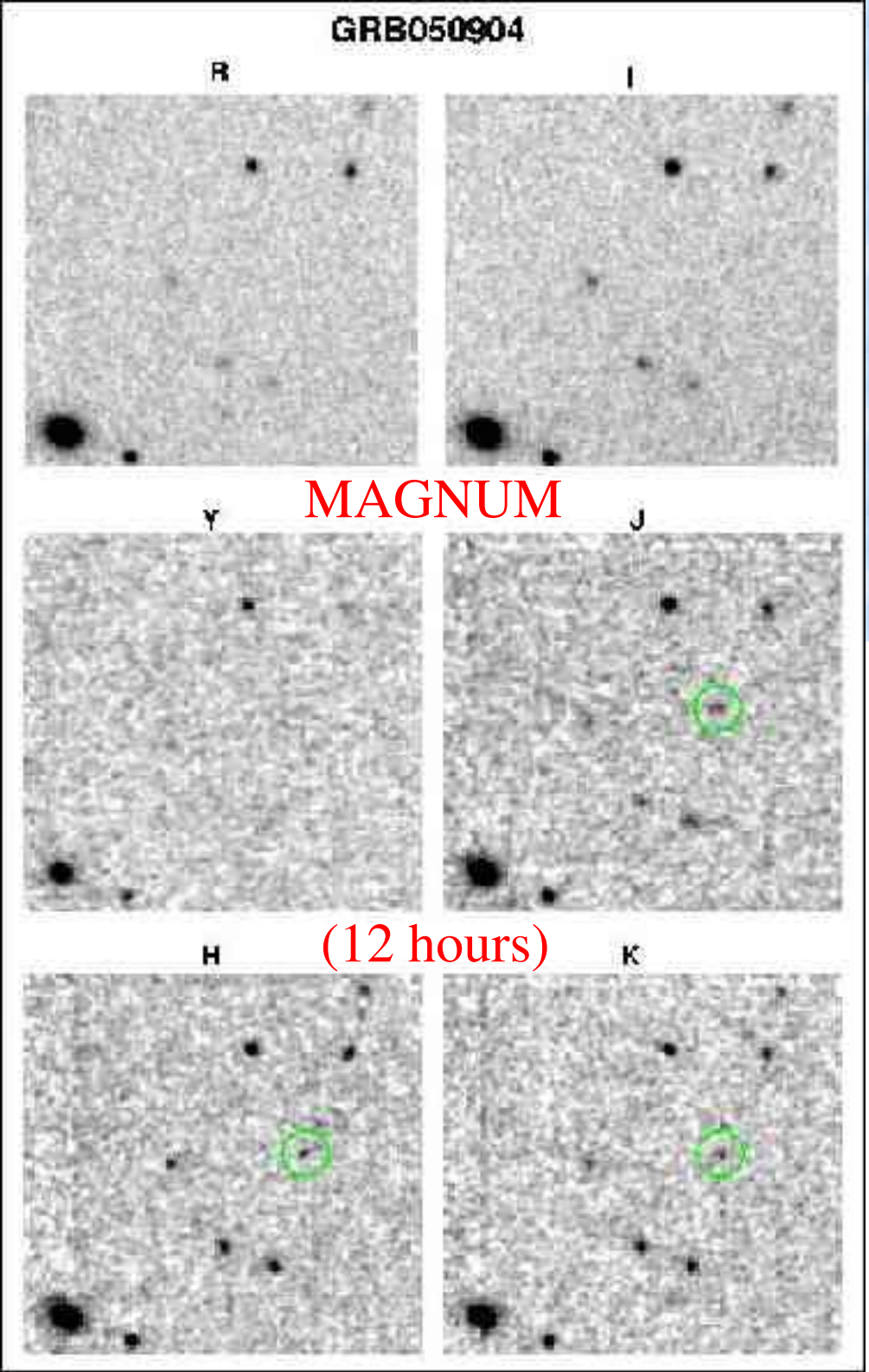


Swift:
x-ray position to a few arcsec

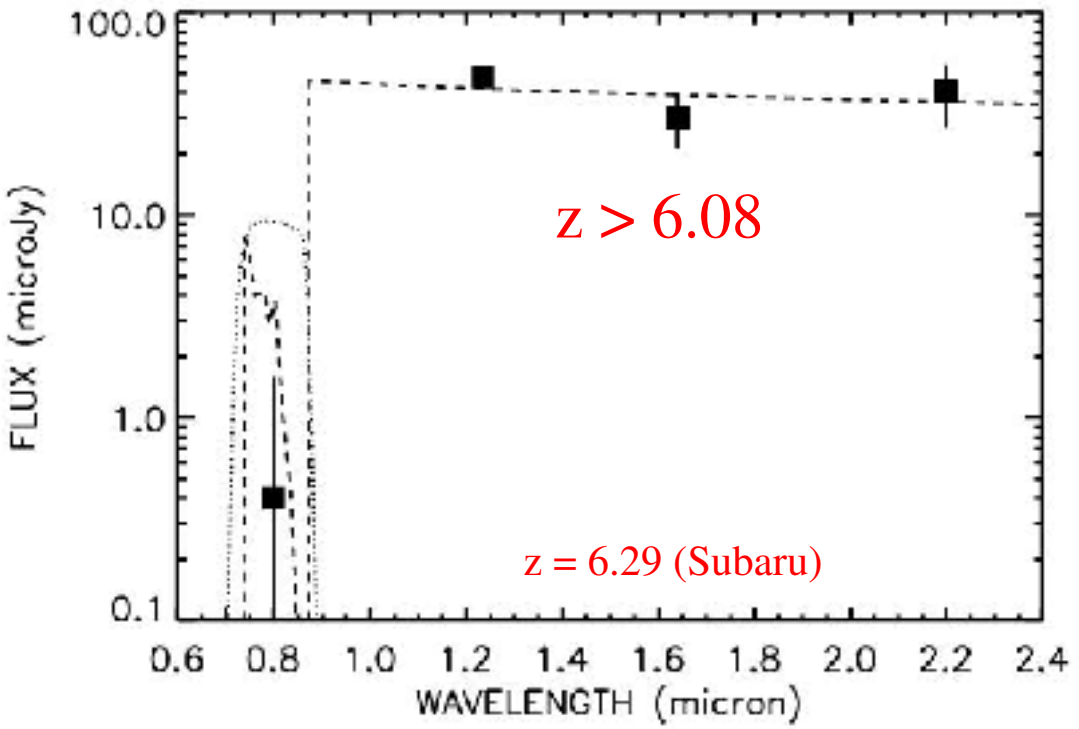
MAGNUM:
Precise position, colour

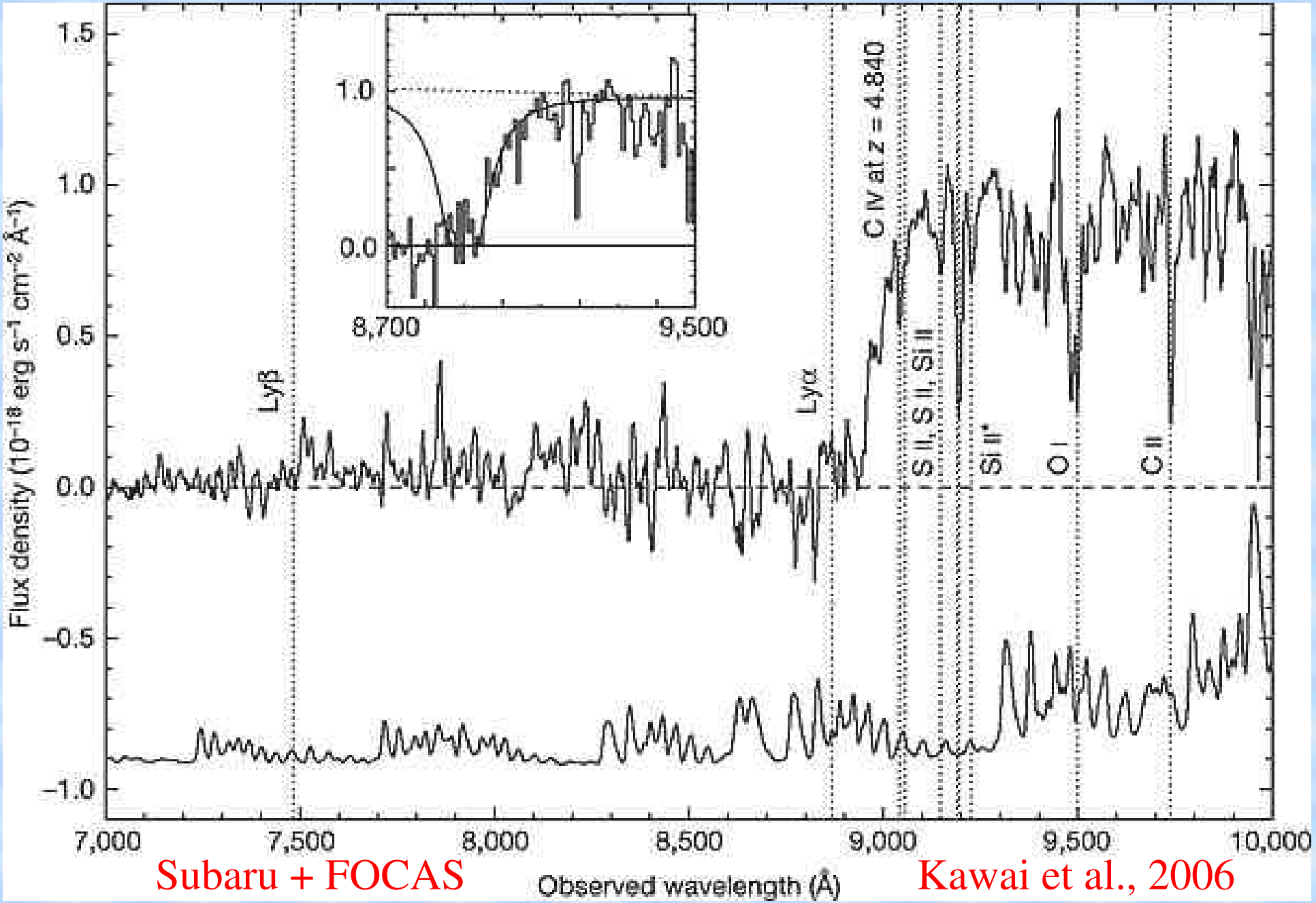


Gemini North:
Spectroscopy



- 4' position from Swift
- Optical observations at 3h didn't see anything
- Bright NIR afterglow

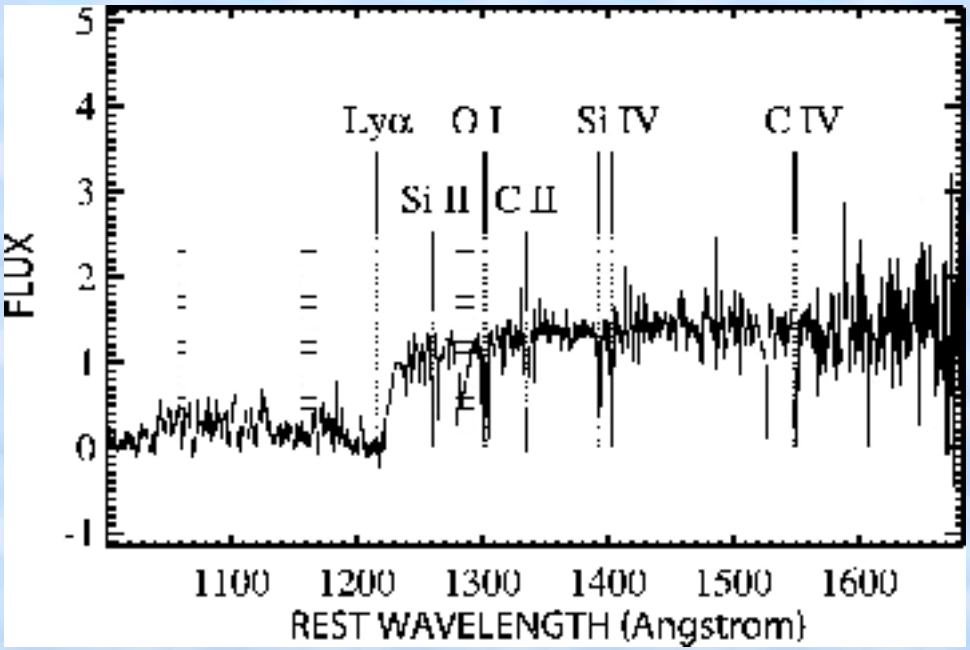


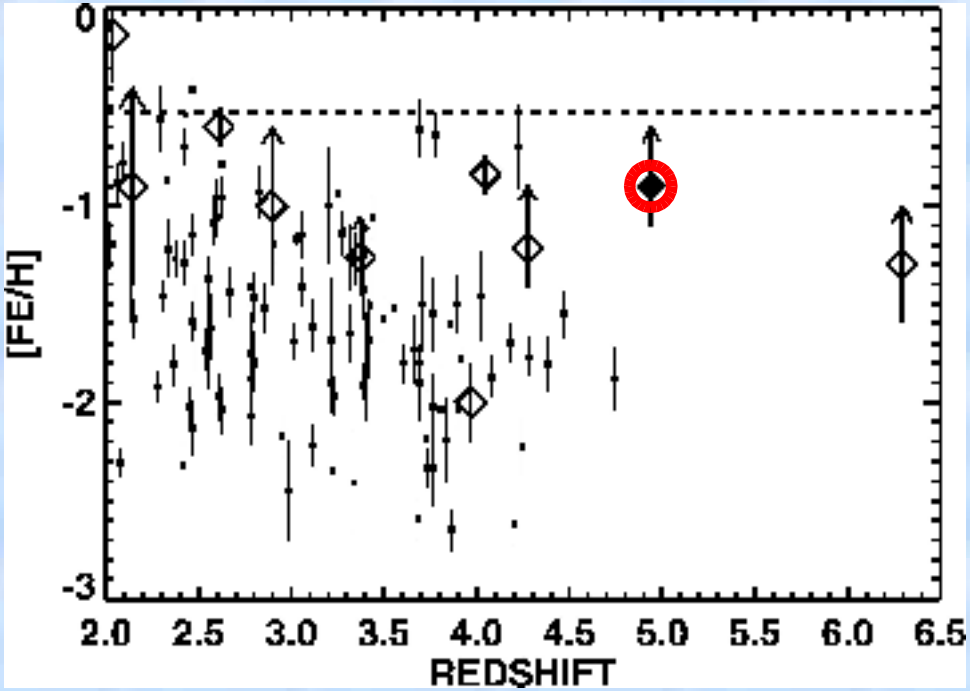


Subaru + FOCAS

Kawai et al., 2006

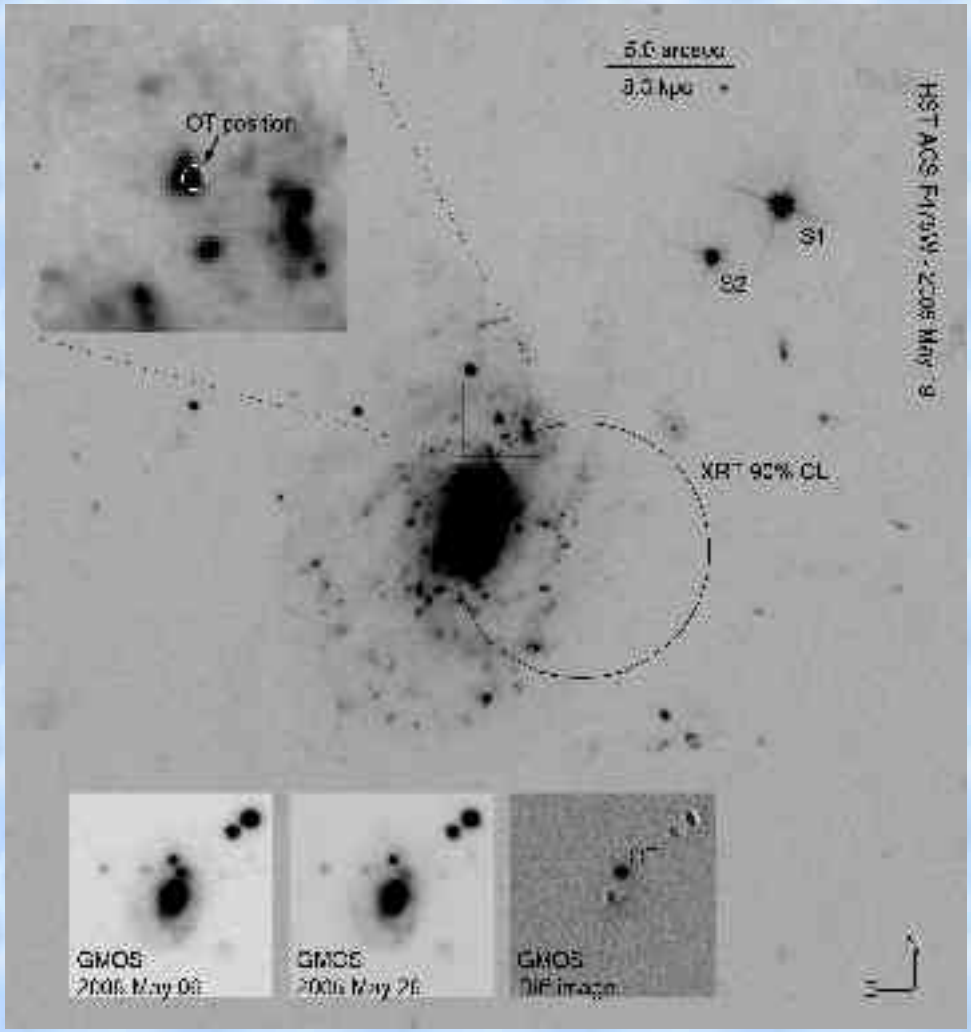
Spectroscopy of a z ~ 5 galaxy
GRB 060510B

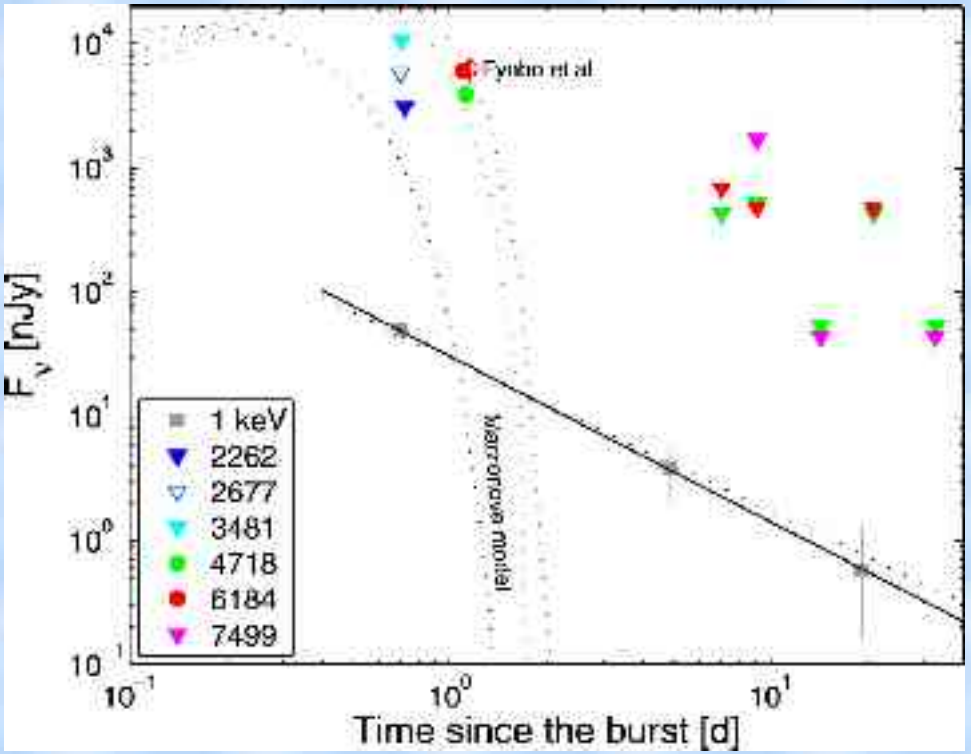




Price et al., 2007

No SN for a L/S GRB

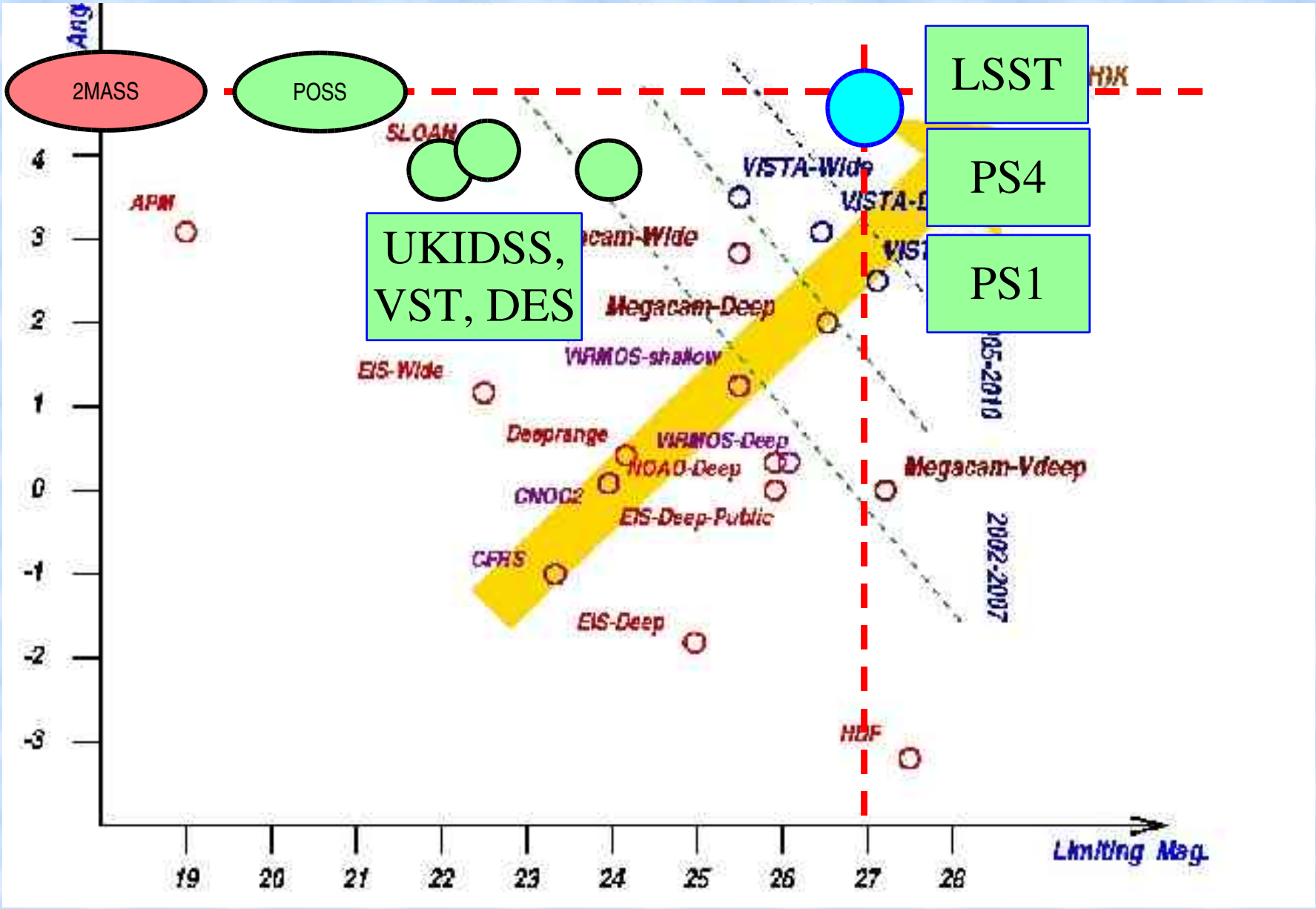




z = 0.09

Ofek et al., 2007

Transients from synoptic surveys

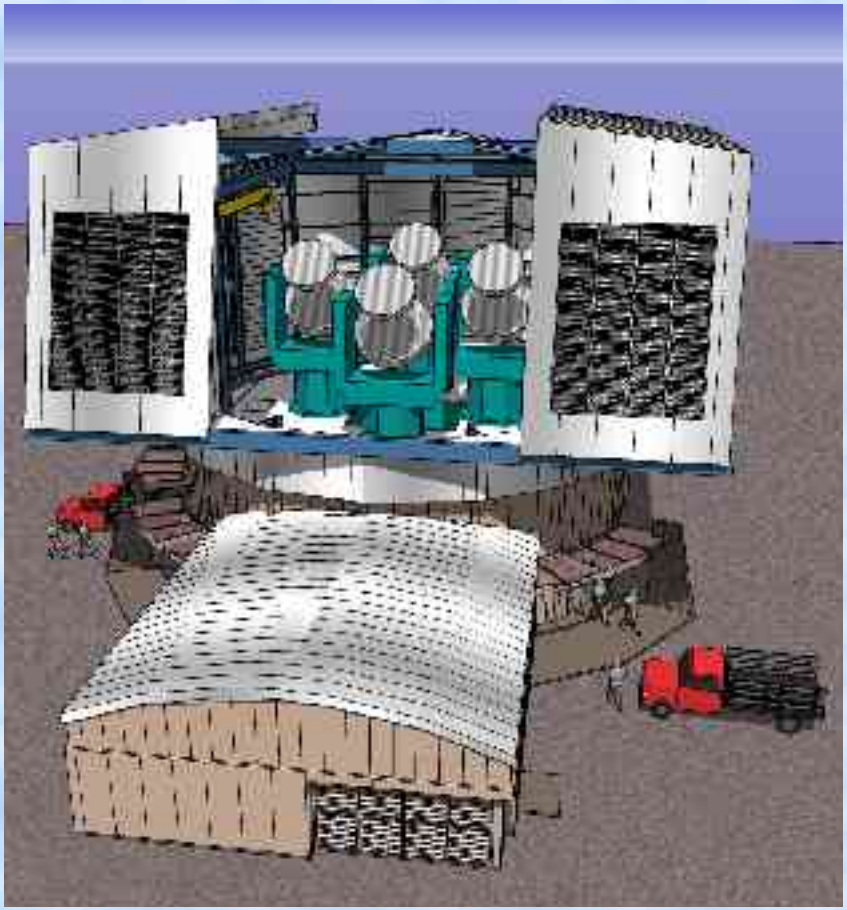


Synoptic surveys are happening...

- Palomar-QUEST: 500 $\deg^2$ per night to 21 mag
- SDSS-II: 300 $\deg^2$ per night to 22 mag
- CFHTLS/SNLS: 1 $\deg^2$ per night to 25 mag
- Pan-STARRS 1: 6000 $\deg^2$ per night to 23 mag
- Pan-STARRS 4: 6000 $\deg^2$ per night to 24 mag
- LSST: 8000 $\deg^2$ per night to 25 mag

Pan-STARRS

- Panoramic Survey Telescope And Rapid Response System
- A fore-runner to the LSST, funded by AFRL
- A dedicated optical survey instrument, 54 m^2deg^2
  - 4 individual 1.8m telescopes, each with a gigapixel camera
  - Orthogonal transfer CCDs



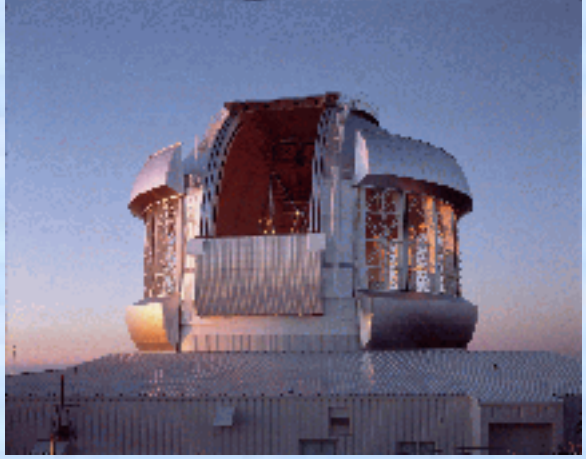
PS1 Status

- Telescope, camera, pipeline all working
- Collimating optical elements
- PS1 Science Consortium founded
- Operations commence this year

Synoptic survey transients

- SNe
- GRBs / orphan afterglows
- Stellar disruptions / AGNs
- Asteroids
- ?????

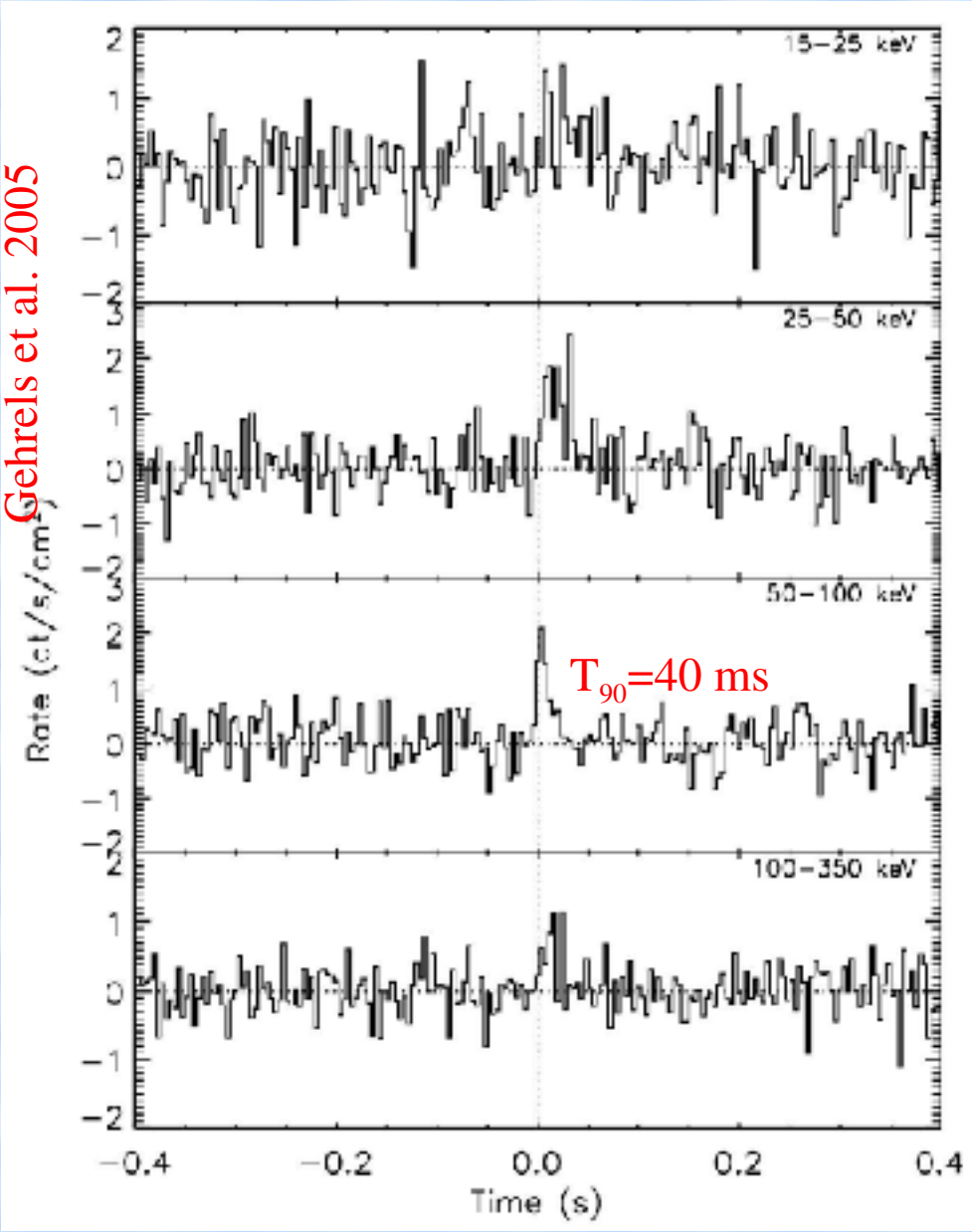
Many will require rapid spectroscopic and other follow-up observations



Conclusions

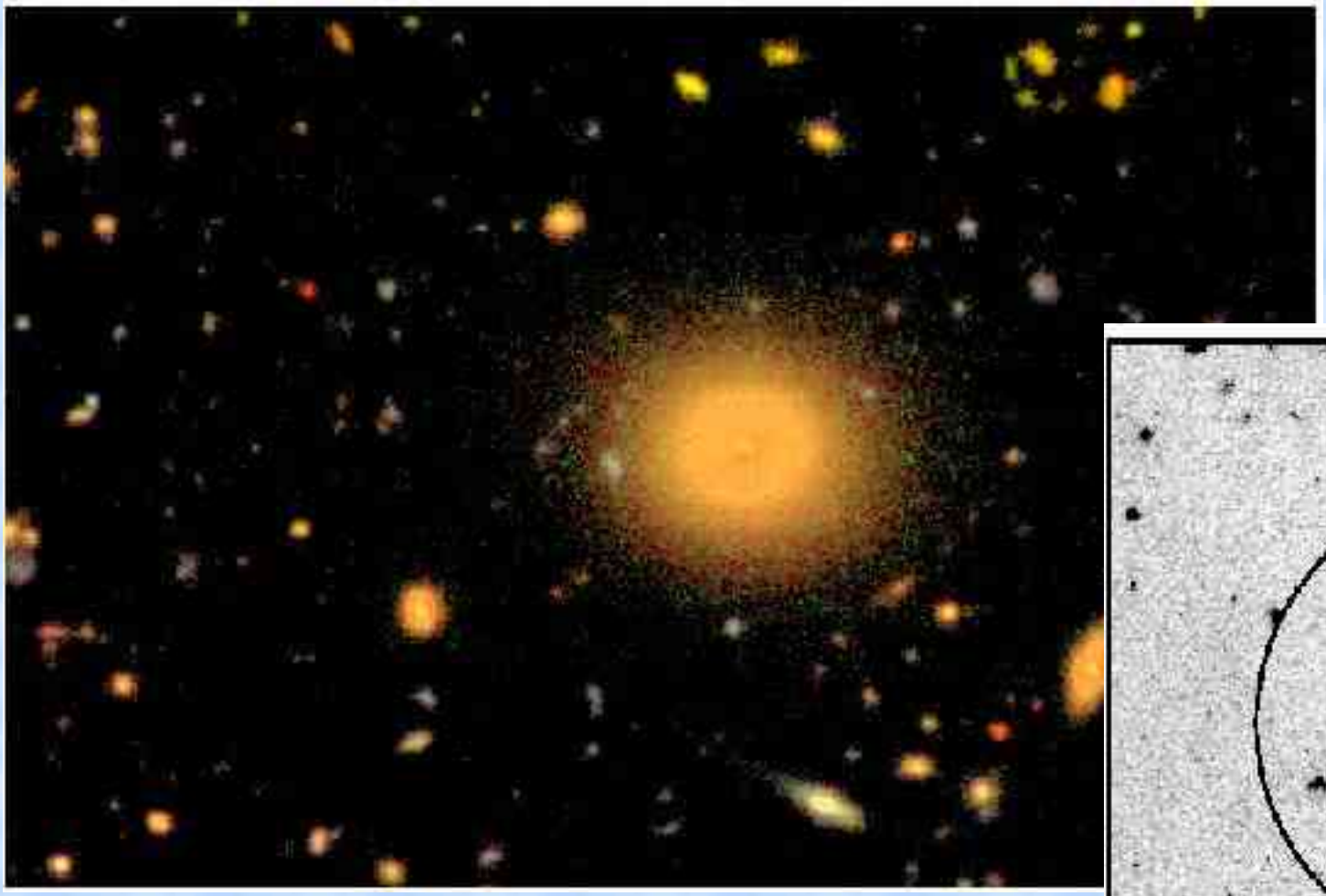
- S/H GRBs are cosmological
- L/S GRBs continue to turn up mysteries
- Transient science will soon blossom with synoptic surveys such as Pan-STARRS
- Gemini a wonderful instrument for transient science
  - Fast: queue mode, rapid response program
  - Flexible: jukebox instruments, helpful staff

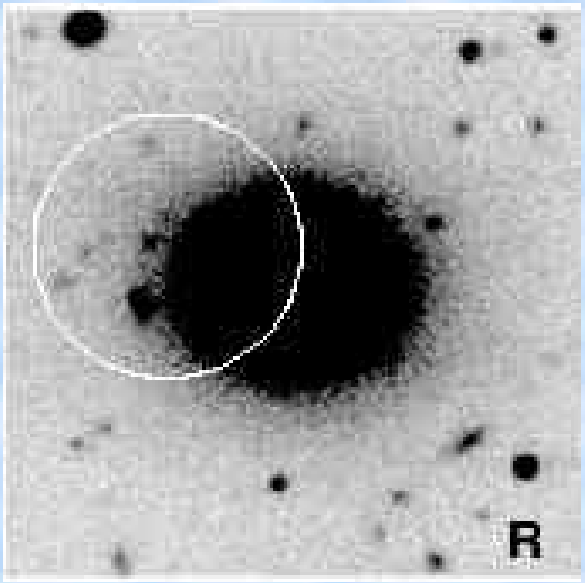
GRB 050509B: Swift Detection

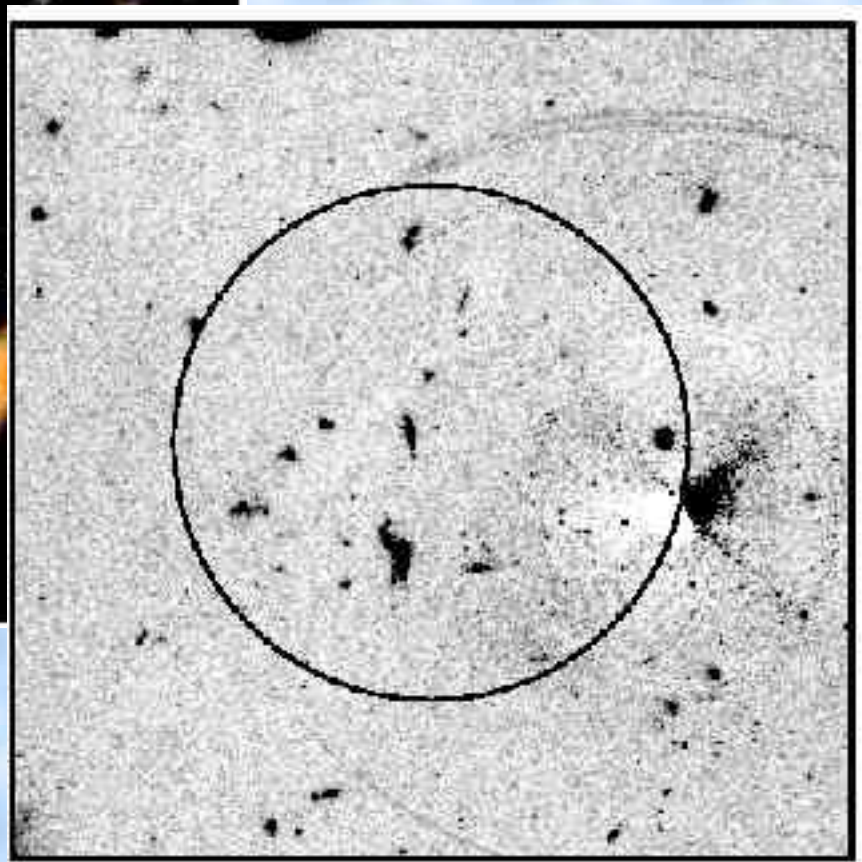


- BAT: very faint GRB
- XRT: T+62 s detects 11 photons(!)
- No optical, no radio. very faint limits
  - Low energy event and/or low density medium?
- Giant elliptical galaxy in cluster @ z=0.22 Host?

GRB 050509B







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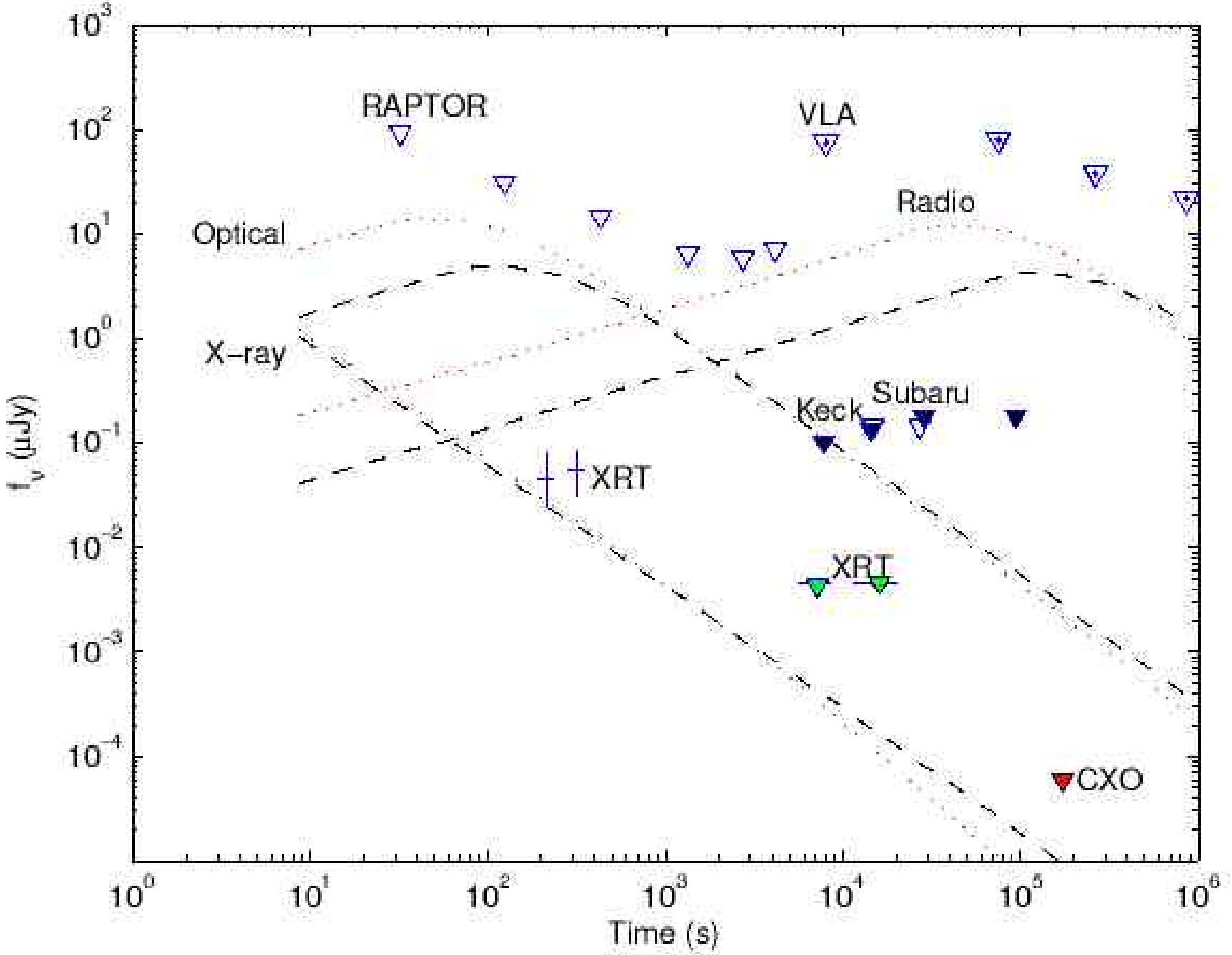
RAPTOR
VLA
Optical
Radio
X-ray
Keck
Subaru
XRT
XRT
CXO
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
f_ν (μJy)
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Time (s)