Optical Transients

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Cosmic Genesis and Fundamental Physics
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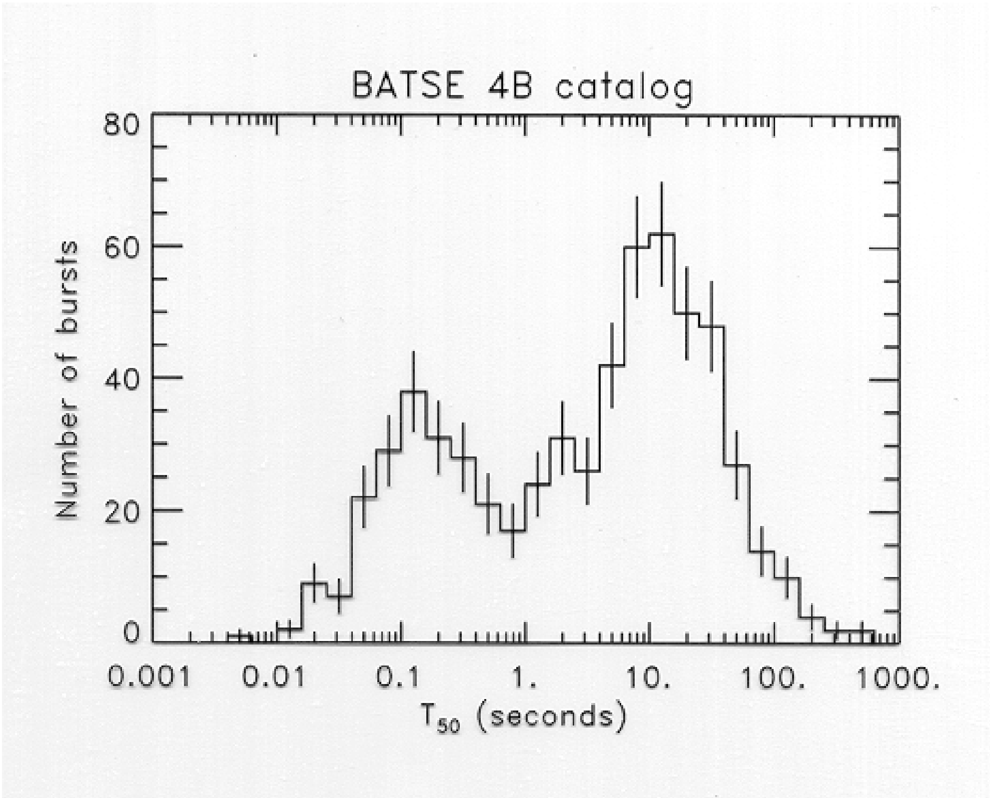
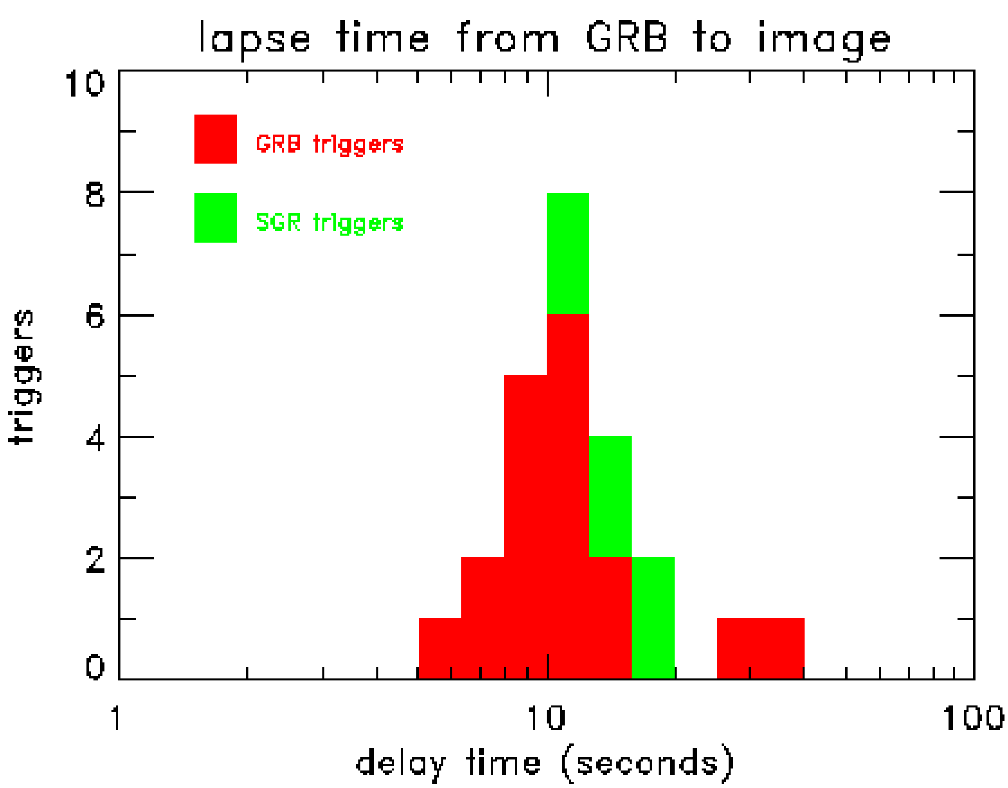
Optical Transients

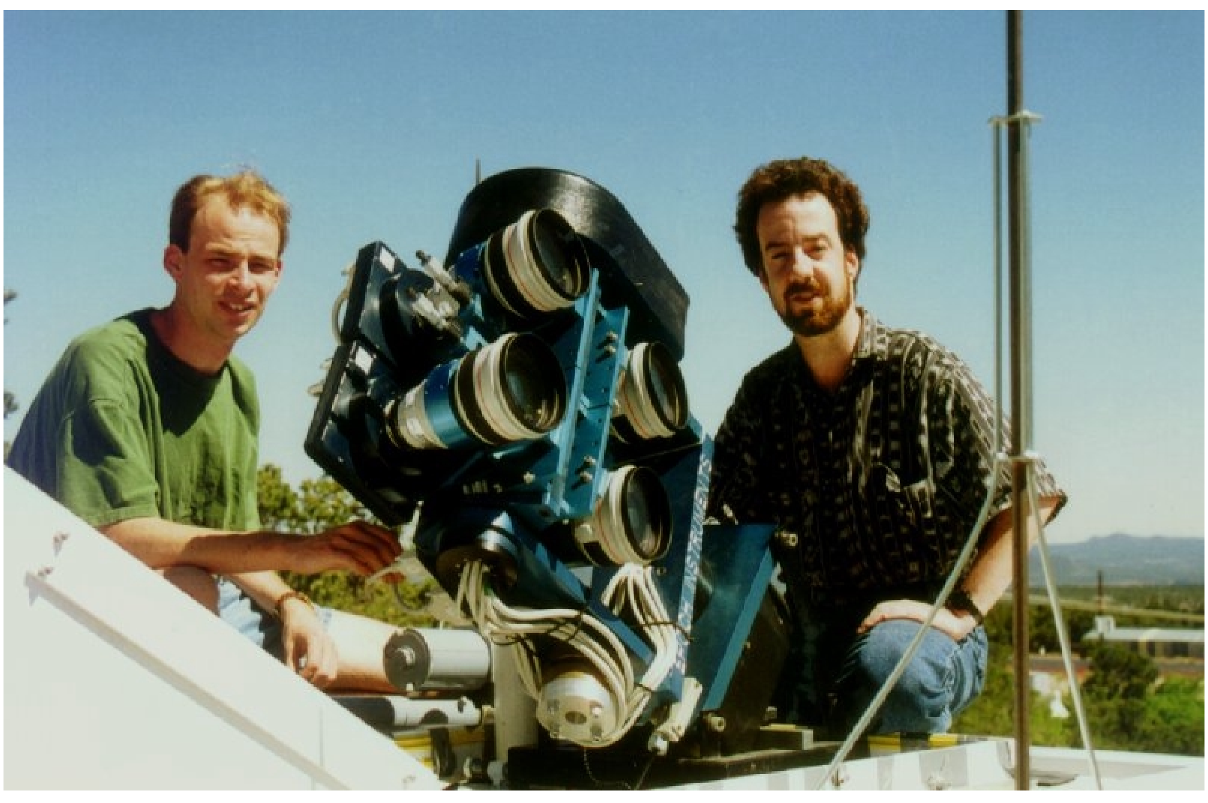
	Type	Characteristic Time	
	Pulsar	Milliseconds	
☆	Meteor	Seconds	
☆	Gamma-ray burst	Seconds	50 events/str-year
*	Soft gamma-ray repeater	Seconds	
☆	AGN	Hours	
☆	Asteroid	Hours	
☆	Comet	Hours	
	Flare star	Hours	
*	X-ray Transient	Hours	
☆	Supernova	Days	
☆	Variable star	Days	
	Gravitational microlensing	Days	
	Gravitational lensing delay	Years	

☆ Detected by ROTSE-I camera array
* Observed by ROTSE-I camera array


BATSE 4B catalog
Number of bursts
0
20
40
60
80
0.001
0.01
0.1
1.
10.
100.
1000.
T50 (seconds)


lapse time from GRB to image
GRB triggers
SGR triggers
triggers
0
2
4
6
8
10
1
10
100
delay time (seconds)


ROTSE I

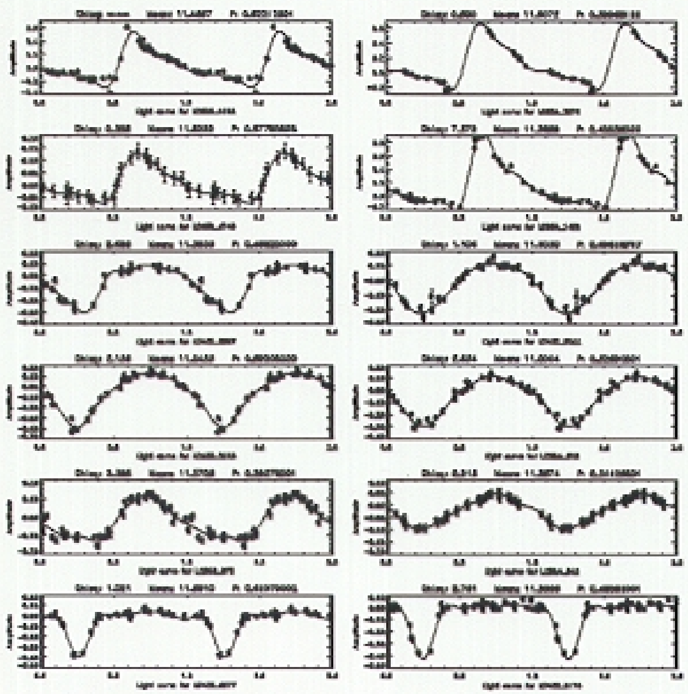


ROTSE Sky Patrols: A Variable Bonanza

- ROTSE-I images the entire sky 2x/night
- Monitors ~10^7 stars north of -30° dec
- Accurate photometry to 15th magnitude

ROTSE Variable Survey I: A test project

- 4 months of data from 6% of ROTSE sky
- 1950 variables found, 90% new
- Full survey will contain 30,000 variables!
- All types (RR Lyraes, Contact Binaries, CVs, Cepheids, LPVs, Eclipsing….)
- Continual monitoring of aperiodic sources

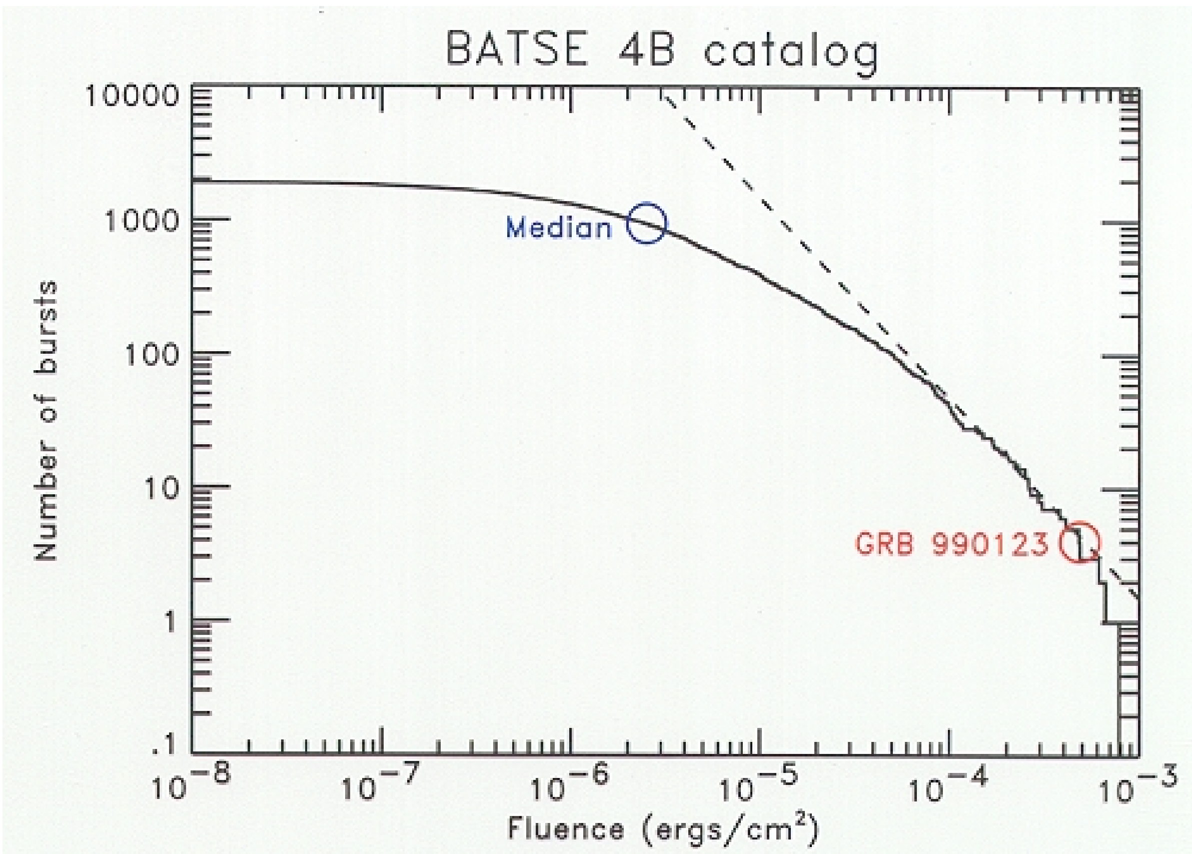


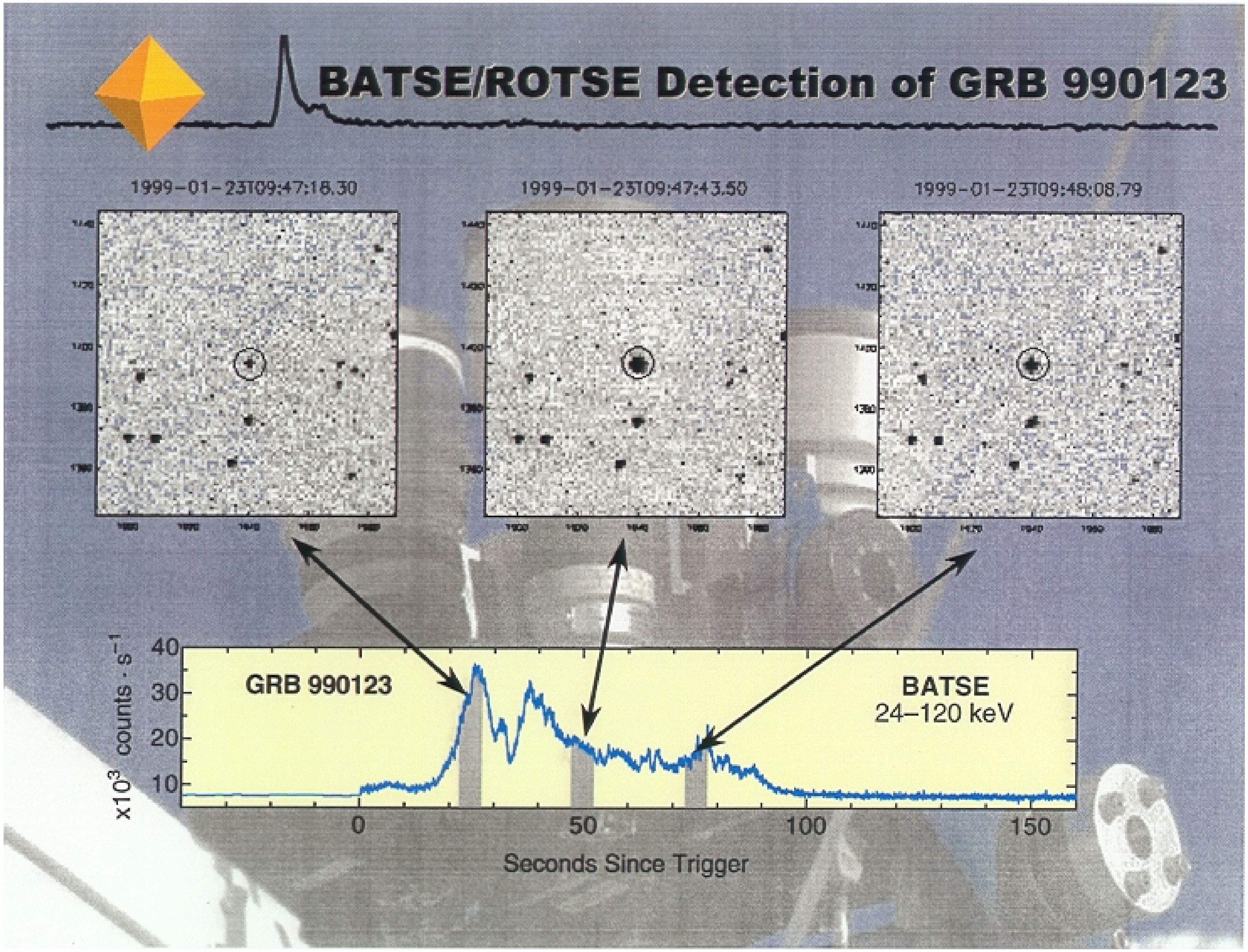
RR Lyraes

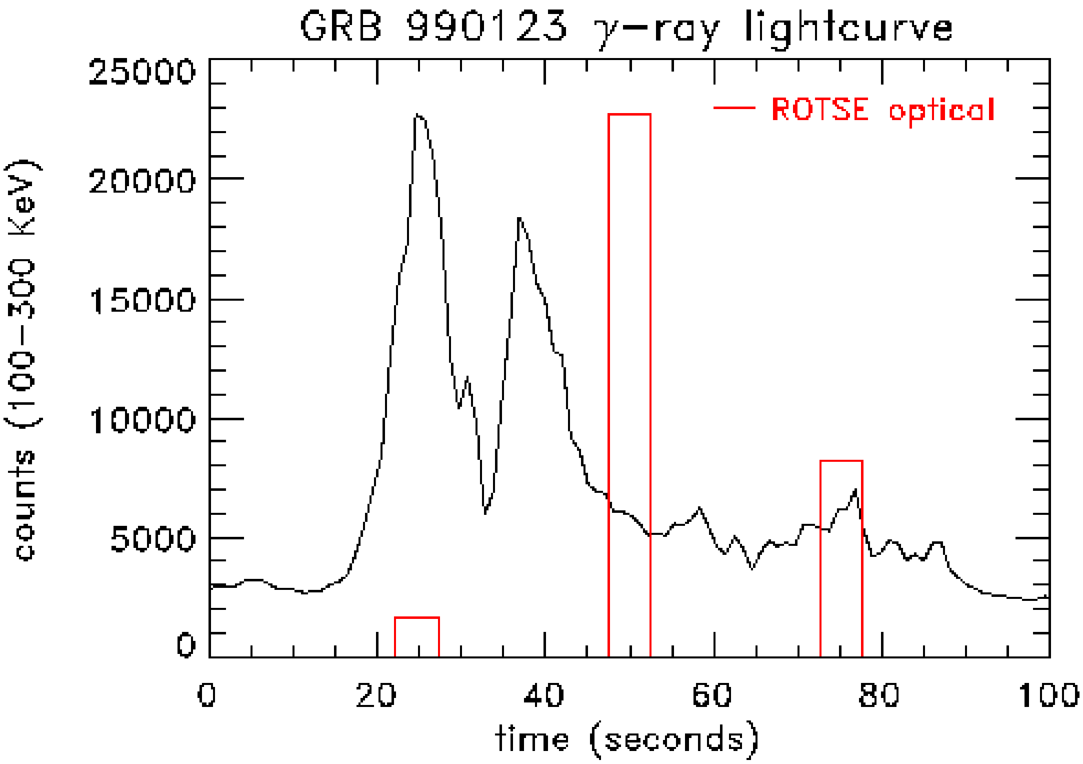
Contact Binaries

RRc's

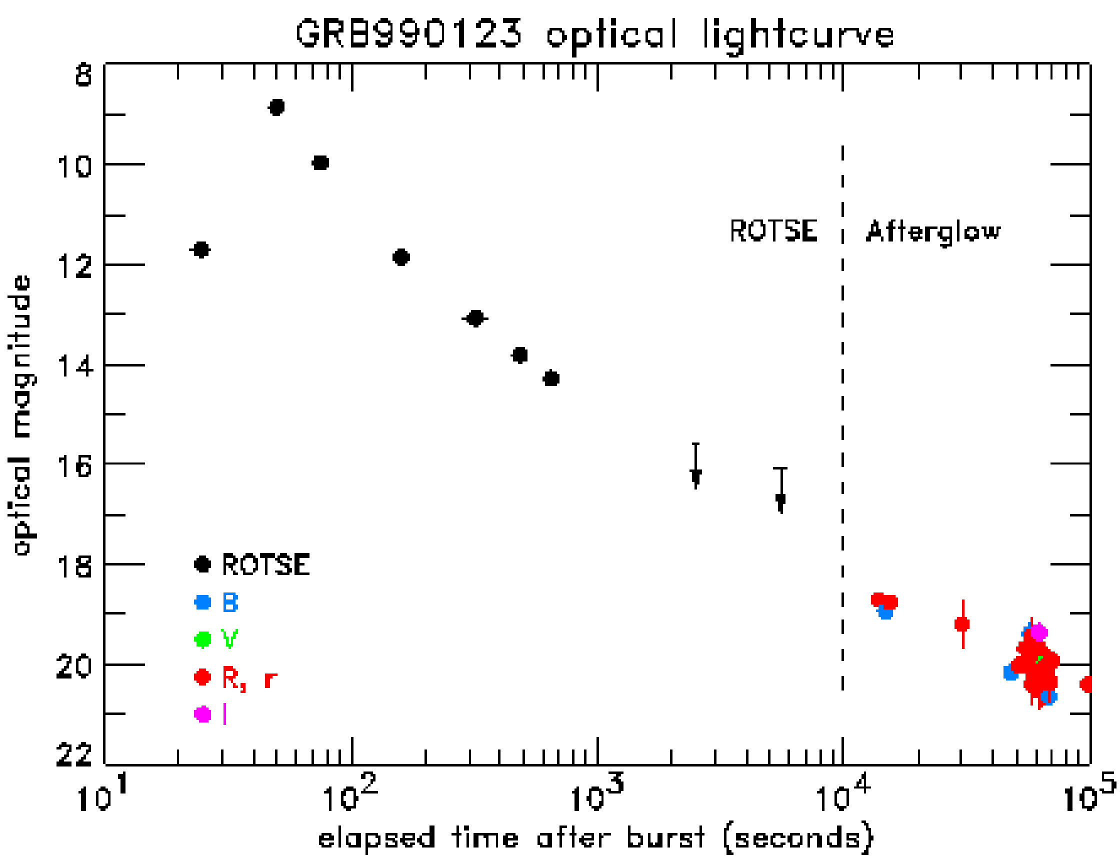
Eclipsing


BATSE 4B catalog
Number of bursts
Fluence (ergs/cm^2)
Median
GRB 990123
10000
1000
100
10
1
.1
10^{-8}
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}


BATSE/ROTSE Detection of GRB 990123
1999-01-23T09:47:18.30
1999-01-23T09:47:43.50
1999-01-23T09:48:08.79
GRB 990123
BATSE
24–120 keV
x10³ counts · s⁻¹
40
30
20
10
0
50
100
150
Seconds Since Trigger



GRB 990123 γ-ray lightcurve
ROTSE optical
counts (100-300 KeV)
time (seconds)
0
5000
10000
15000
20000
25000
0
20
40
60
80
100



GRB990123 optical lightcurve
ROTSE
Afterglow
ROTSE
B
V
R, r
I
optical magnitude
elapsed time after burst (seconds)
8
10
12
14
16
18
20
22
10^1
10^2
10^3
10^4
10^5

Lessons from GRB990123

1) GRB environment is optically transparent

2) Prompt optical radiation exists
   reverse shock model supported

3) GRB990123 was extremely bright
   ~0.1% of energy in optical

4) GRB was probably exceptionally bright in optical, relative to parent population

5) Future observations with satellite triggers
   a) Search for short duration bursts
   b) Study shapes of optical lightcurves
   c) Study correlation of optical and γ-ray lightcurves
   d) Study spectral distribution of radiation
   e) Increase number of optically localized bursts

6) Future observations – untriggered
   a) Search for "orphan" optical transients

Triggered Observations

Only $\sim \frac{1}{10}$ of all triggers can be observed promptly.

Fast response favors small telescopes since $I \propto MR^2 \propto R^5$.

ROTSE-I optical aperture (11 cm) is marginal.

a) Distribute telescopes globally.

b) Required aperture is tradeoff between sensitivity and response time.

c) Large focal ratios are preferred.

d) Dedicated instruments are essential.

Untriggered Observations

Detected GRB rate ~ 50 events/str-year

Sky scan rate: $\frac{d\Omega}{dt} \propto \frac{\$\$\$}{f^2}$

a) Get large format CCD cameras and matching optics

b) Small focal ratios are strongly preferred

c) (a) and (b) are a prerequisite for most non-GRB transient surveys

ROTSE program

1 ROTSE-I telephoto lens array:
$16° \times 16°$, 0.08 str

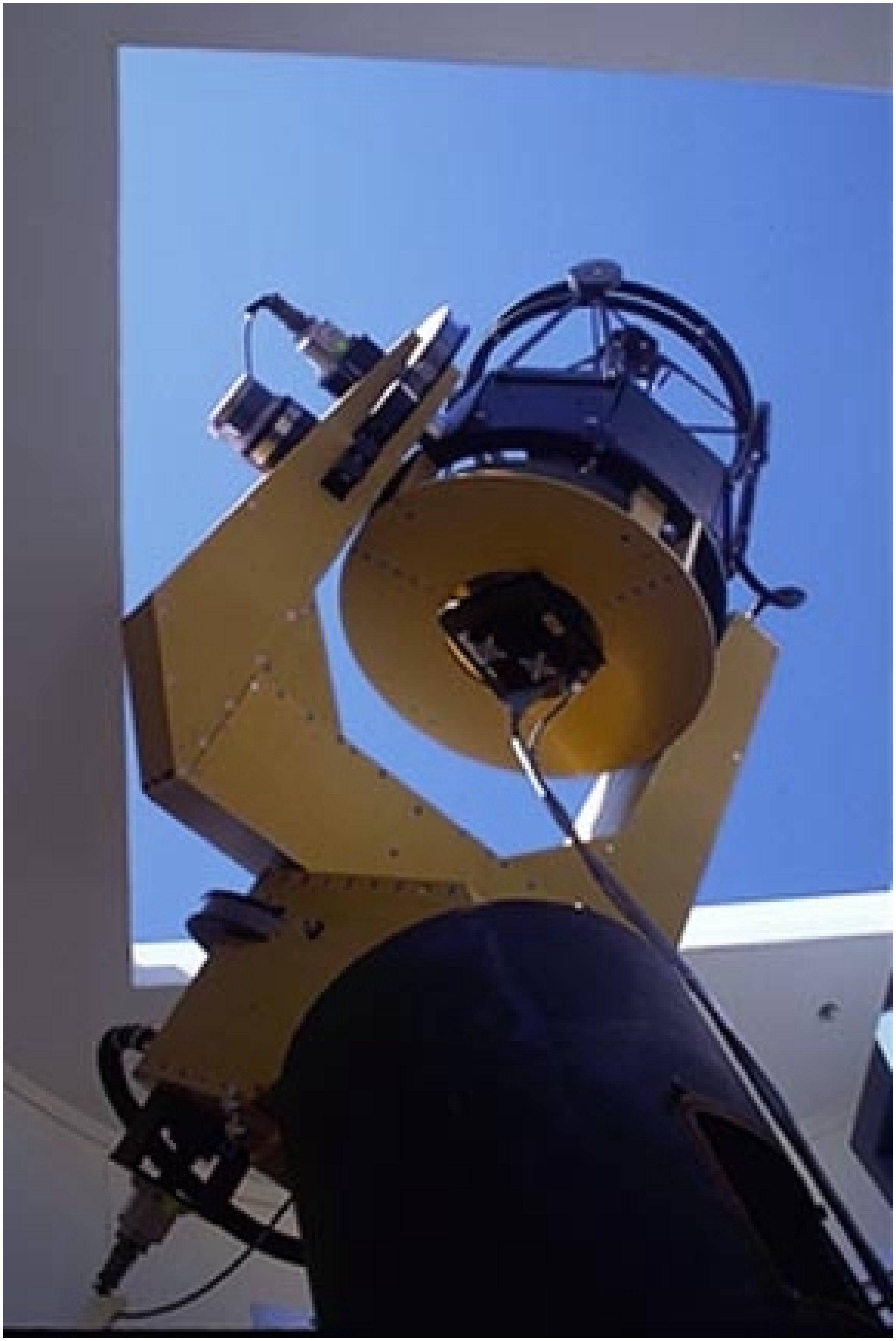
2 ROTSE-II 0.45 m aperture telescope:
$1.9° \times 1.9°$, 0.0011 str

8 ROTSE-III 0.45 m aperture telescopes:
$1.9° \times 1.9°$, 0.0011 str

Deploy ROTSE-III in Australia, Canary Islands, Israel ?, Namibia ?, ???

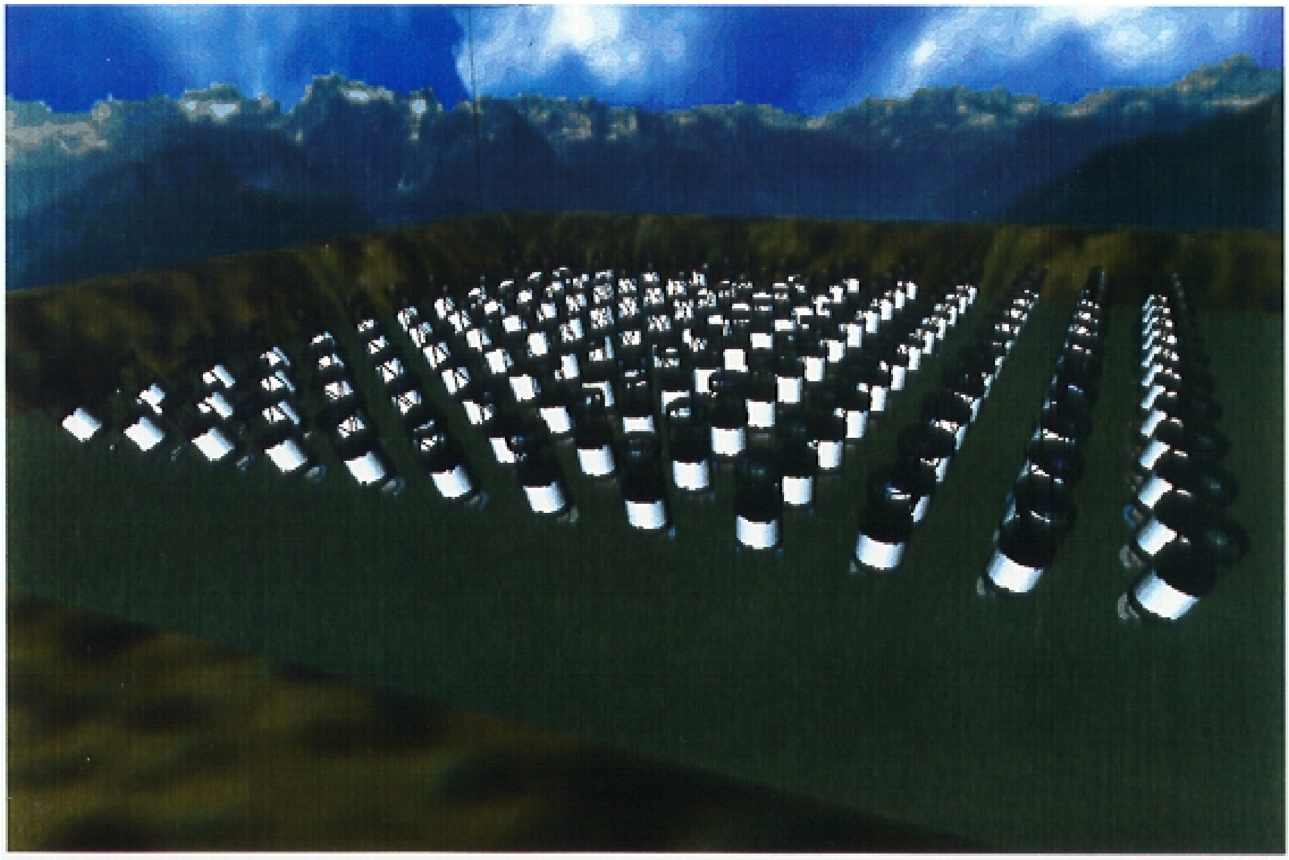
Time scale: 3 years

Funding: Michigan, LANL, NASA (?), NSF (?)



ROTSE-III unit costs

1)	0.45 m aperture telescope optics assembly	$67,000
2)	Fast slew telescope mount	$42,000
3)	Enclosure with motor-driven hatch	$21,000
4)	Ancillary computers, environment	$10,000
5)	TE cooled camera with thinned CCD	$60,000
	TOTAL	**$200,000**



TOMBO project

2 arrays, 12 x 12 telescopes (288 total)

each telescope: 5° x 5° FoV

GRB space mission schedules

January	2000	HETE-2 launch (~50 events/year)
January	2002	CGRO mission complete (~300 events/year)
October	2002	BALLERINA launch
	2003-2005	SWIFT (~300 events/year)
	2005	GLAST

Summary

1. Systematic study of optical transients is a developing field.

2. Gamma-ray burst optical counterparts push limits of current facilities and technology

3. Rapid robotic response, large field-of-view and continuous sky coverage are the three chief goals of the ROTSE project.

4. Such facilities are extremely compatible with the study of most other optical transients.