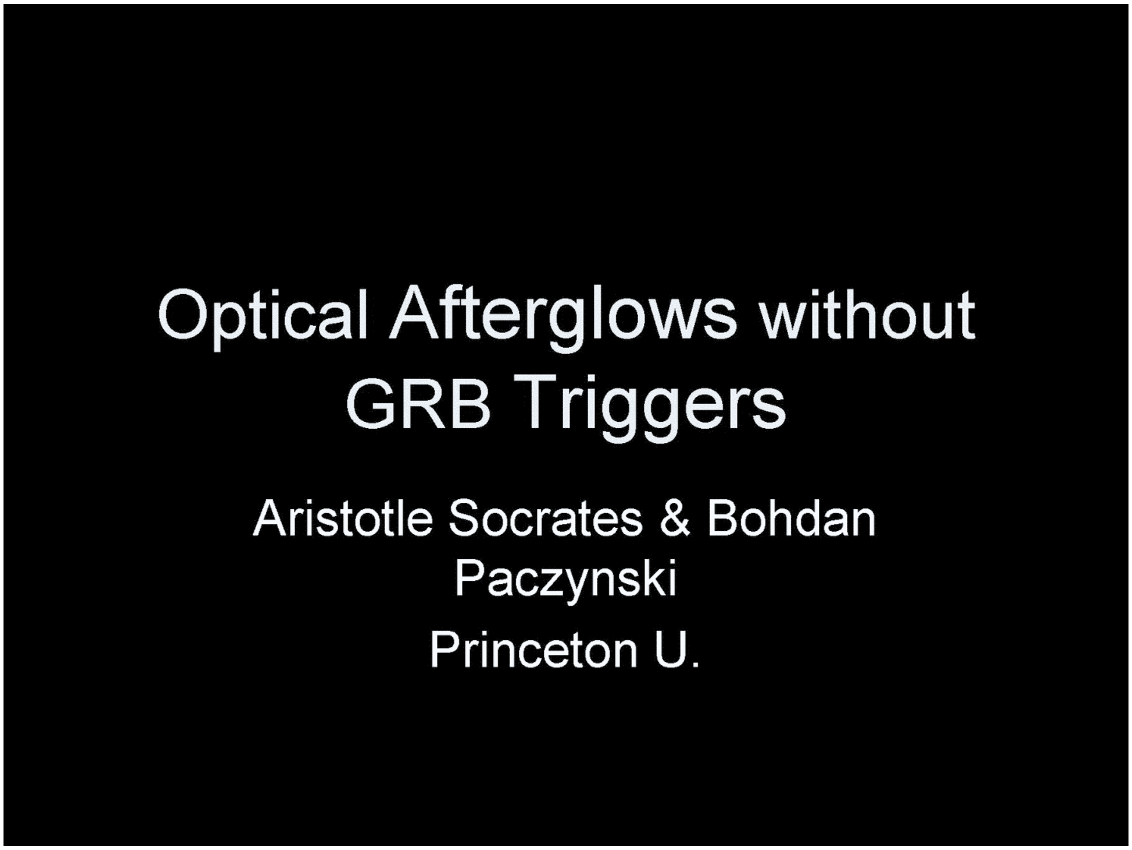
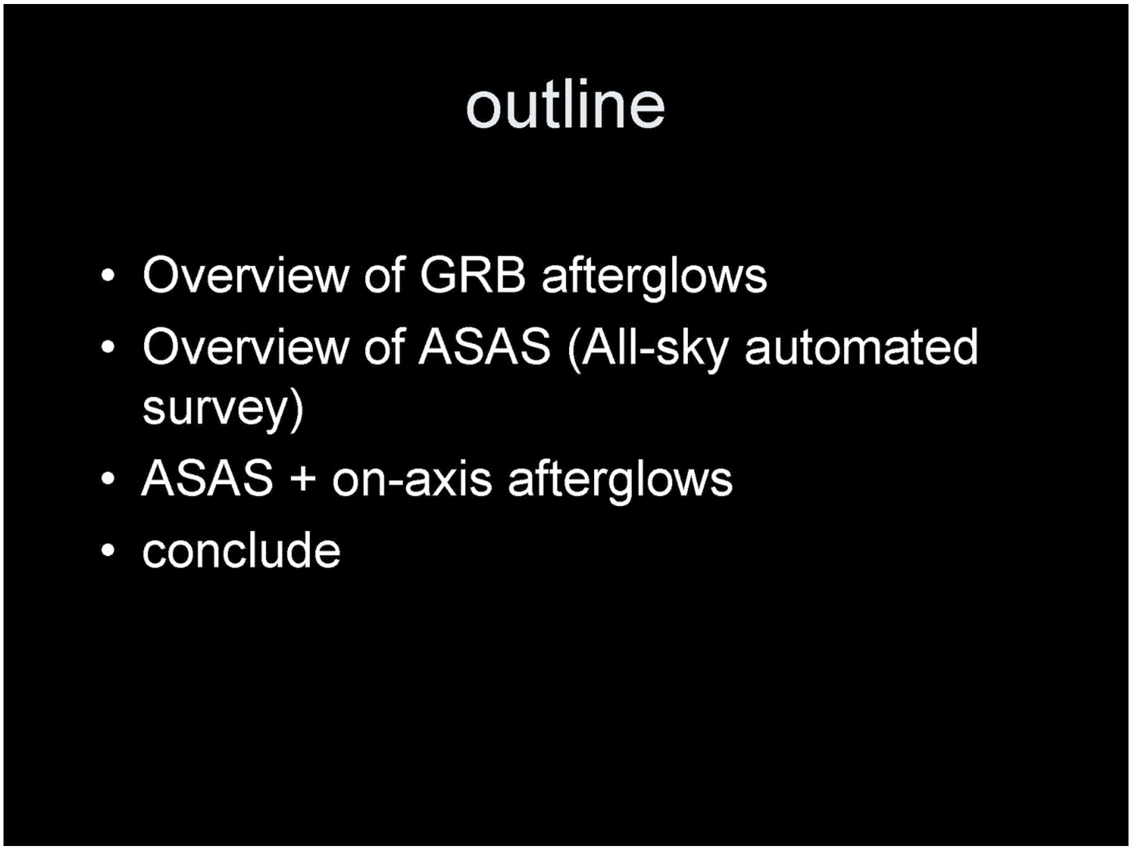


Optical Afterglows without GRB Triggers

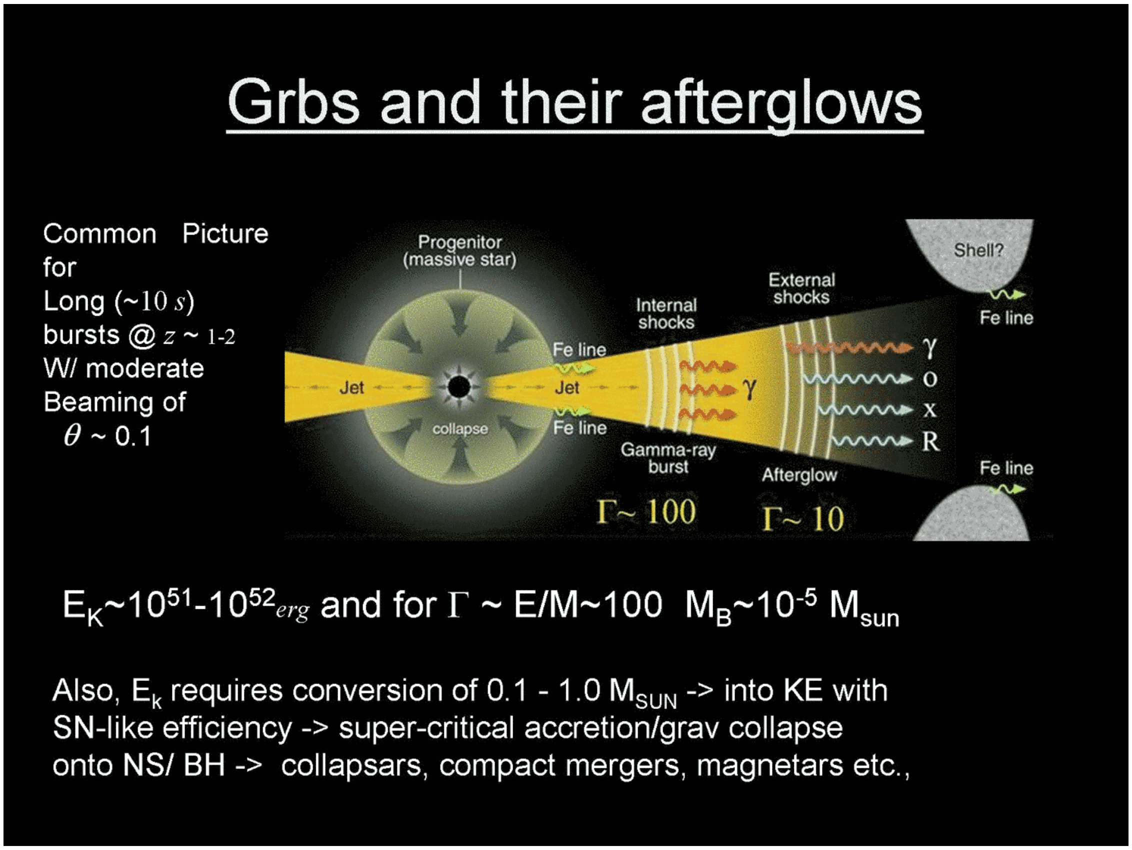
Aristotle Socrates & Bohdan Paczynski

Princeton U.



outline

- Overview of GRB afterglows
- Overview of ASAS (All-sky automated survey)
- ASAS + on-axis afterglows
- conclude

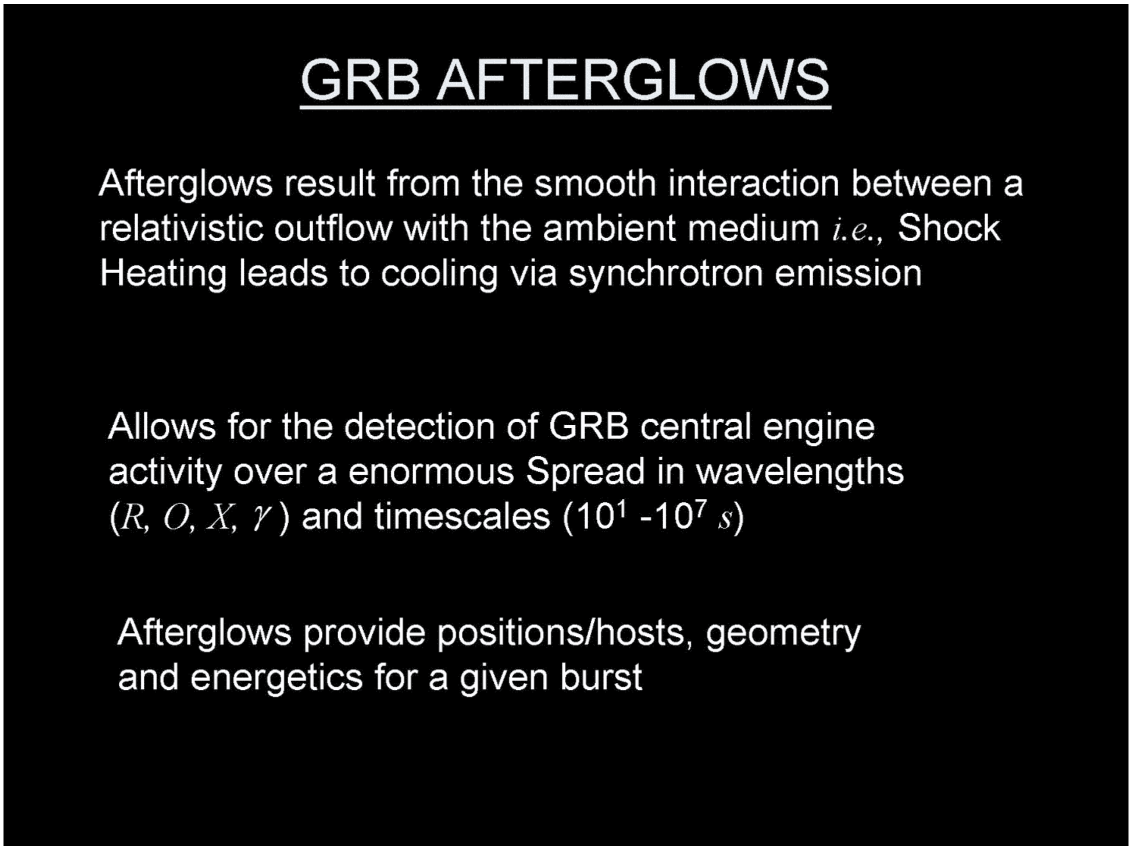


Grbs and their afterglows

Common Picture for Long (~10 s) bursts @ z ~ 1-2 W/ moderate Beaming of $\theta \sim 0.1$

$E_K \sim 10^{51}$-10^{52} erg and for $\Gamma \sim E/M \sim 100$ $M_B \sim 10^{-5}\ M_{sun}$

Also, E_k requires conversion of 0.1 - 1.0 M_{SUN} -> into KE with SN-like efficiency -> super-critical accretion/grav collapse onto NS/ BH -> collapsars, compact mergers, magnetars etc.,



GRB AFTERGLOWS

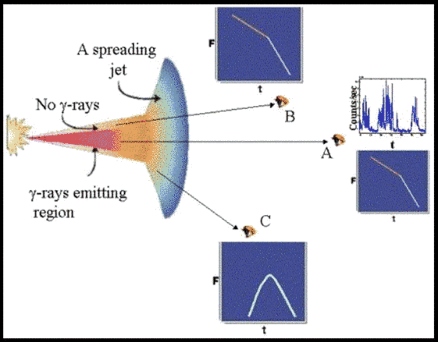
Afterglows result from the smooth interaction between a relativistic outflow with the ambient medium *i.e.*, Shock Heating leads to cooling via synchrotron emission

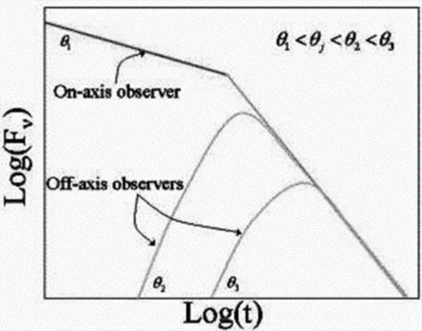
Allows for the detection of GRB central engine activity over a enormous Spread in wavelengths (R, O, X, γ) and timescales (10^1 -10^7 s)

Afterglows provide positions/hosts, geometry and energetics for a given burst

BEAMING & AFTERGLOW LIGHTCURVES

Nakar & Piran 2003



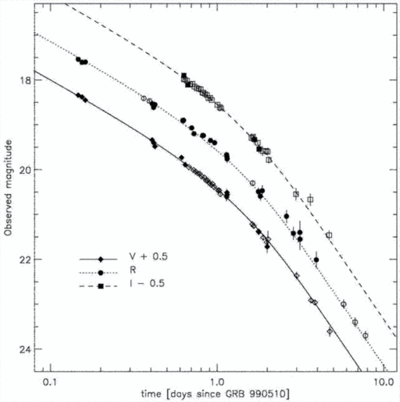


Concept of the jet break: At early times, the jet "thinks" it is spherically symmetric such that $F(t) \sim t^{-1}$. This is true as long as $\Gamma > \theta_j$.
When $\Gamma \sim \theta_j$, then the jet Realizes that it is a jet and start to expands. As spreading and Lateral emission occur, $F(t) \sim t^{-2}$ due to the Reduction in beaming and the increase in de-acceleration.

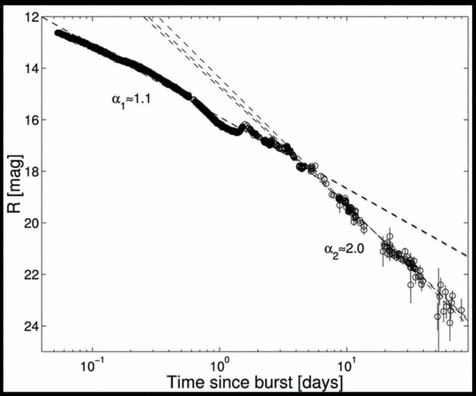
The timescale of the jet break t_j constrains θ_j and the total burst Energy. Off-axis afterglows detected in absence of GRB triggers are Referred to as "orphan" afterglows.

OPTICAL AFTERGLOW EXAMPLES

990510; Harrison et al. 1999
z~1.5, θ_j~0.1, t_j~ 1day
E$_{\rm BURST}$ ~10^{51} $ergs$

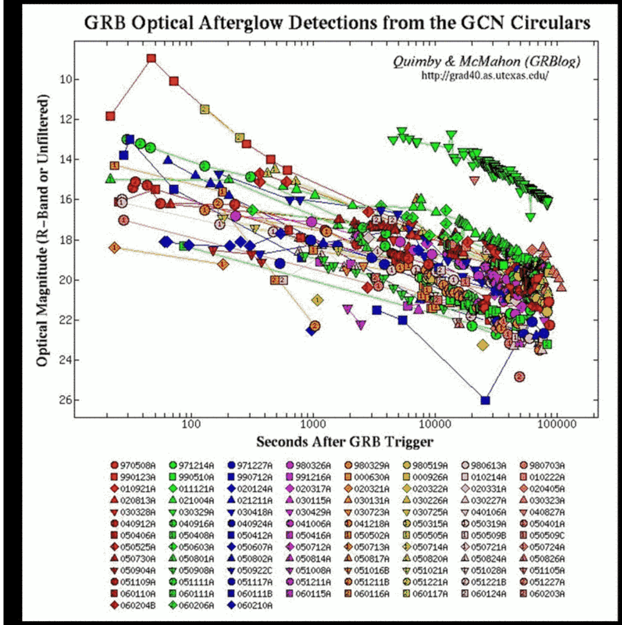


030329; Lipkin et al. 2004
z~0.15, θ_j~0.1, t_J ~ 1day
E$_{\rm BURST}$~ 10^{51} $ergs$



Large viewing angles increases detectability, but the rapid fall-off in flux $F(t) \sim 1/t^2$ heavily decreases the number of detectable late-time "orphan-Afterglows" (c.f. *Dalal et al. 2002*).

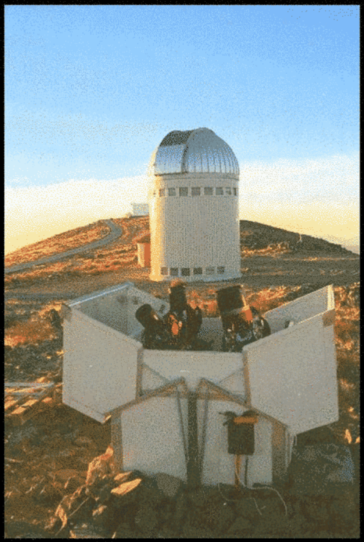
EARLY TIME BEHAVIOUR



10 $s < t < 1$ day, $F(t) \sim 1/t$. Implies that detectability of on-Axis afterglows Is independent of limiting Magnitude IF you can cover The whole sky Before the jet break at ~ 1 day ~ 10^5 s. Therefore instruments that are deep & narrow are comparable
To those that are Shallow And wide.

Perhaps an independent Method of detecting GRB Central engine activity is to look for on-axis
Afterglows with an All-sky survey that can scan the entire sky within a night.

Overview of ASAS (All-sky automated survey)



ASAS consists of four small instruments;
Two Located in las campanas, chile and two (coming soon) In hawaii

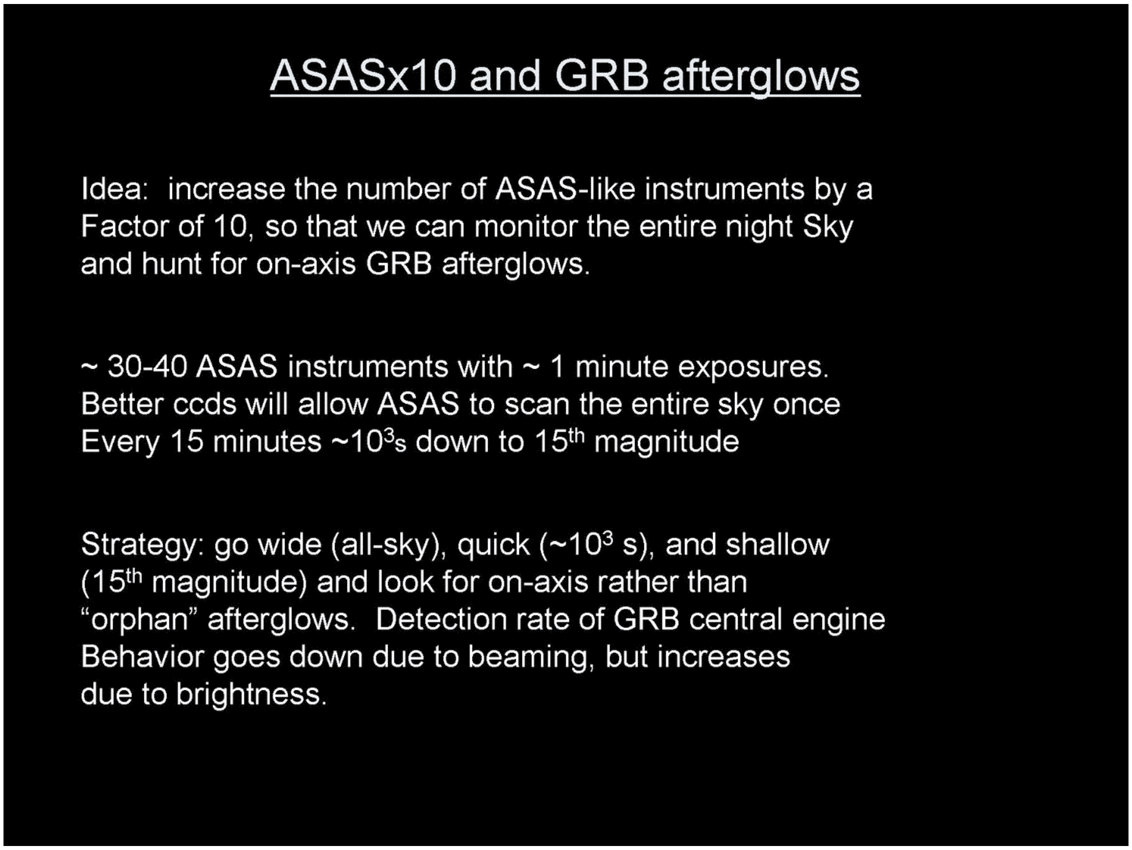
Primary objective is to monitor the Variability of bright stars

7cm aperture and focal length of 20cm

Each camera has single 2K x 2K CCD
With 15 micron pixels

Each camera reaches 14th magnitude stars
In 2 minute exposures with a fov of 9°x 9°

To date ASAS has catalogued ~10^7 stars, 5×10^4 variable stars and 10^4 eclipsing Binaries.

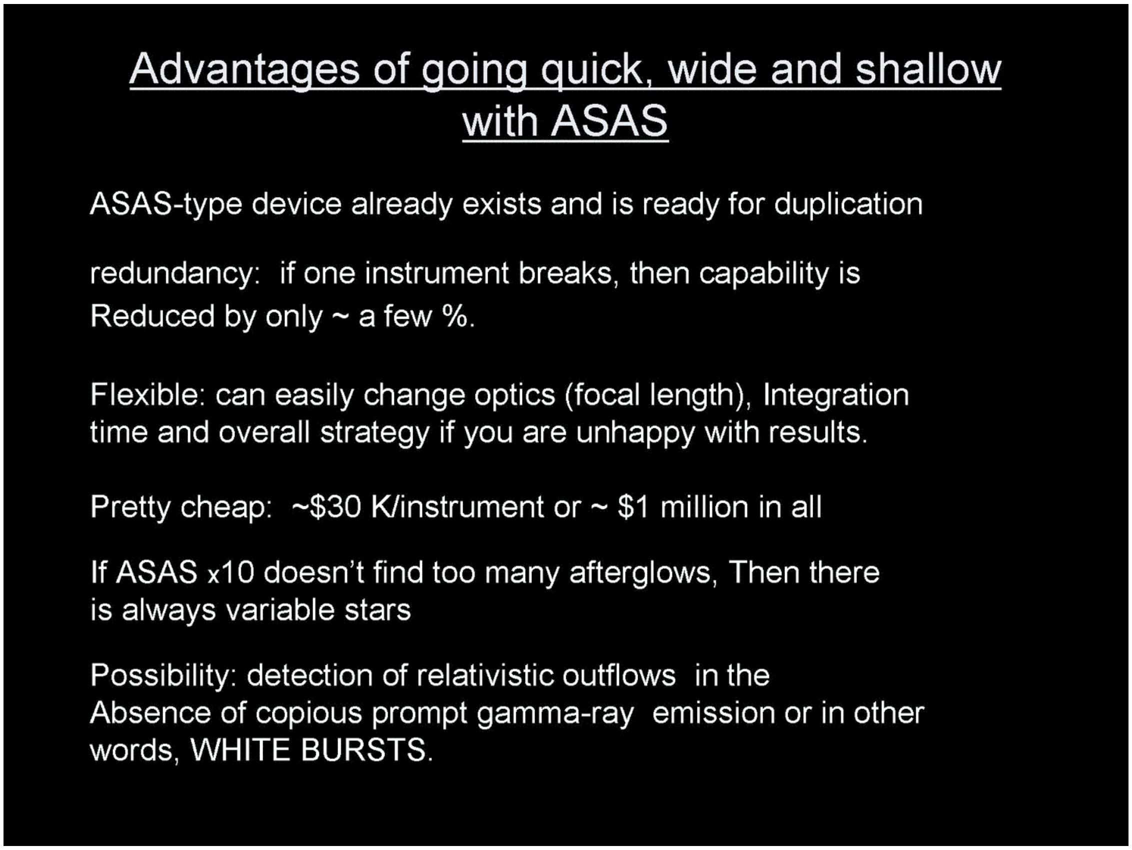


ASASx10 and GRB afterglows

Idea: increase the number of ASAS-like instruments by a Factor of 10, so that we can monitor the entire night Sky and hunt for on-axis GRB afterglows.

~ 30-40 ASAS instruments with ~ 1 minute exposures. Better ccds will allow ASAS to scan the entire sky once Every 15 minutes ~10^3s down to 15th magnitude

Strategy: go wide (all-sky), quick (~10^3 s), and shallow (15th magnitude) and look for on-axis rather than "orphan" afterglows. Detection rate of GRB central engine Behavior goes down due to beaming, but increases due to brightness.



Advantages of going quick, wide and shallow with ASAS

ASAS-type device already exists and is ready for duplication

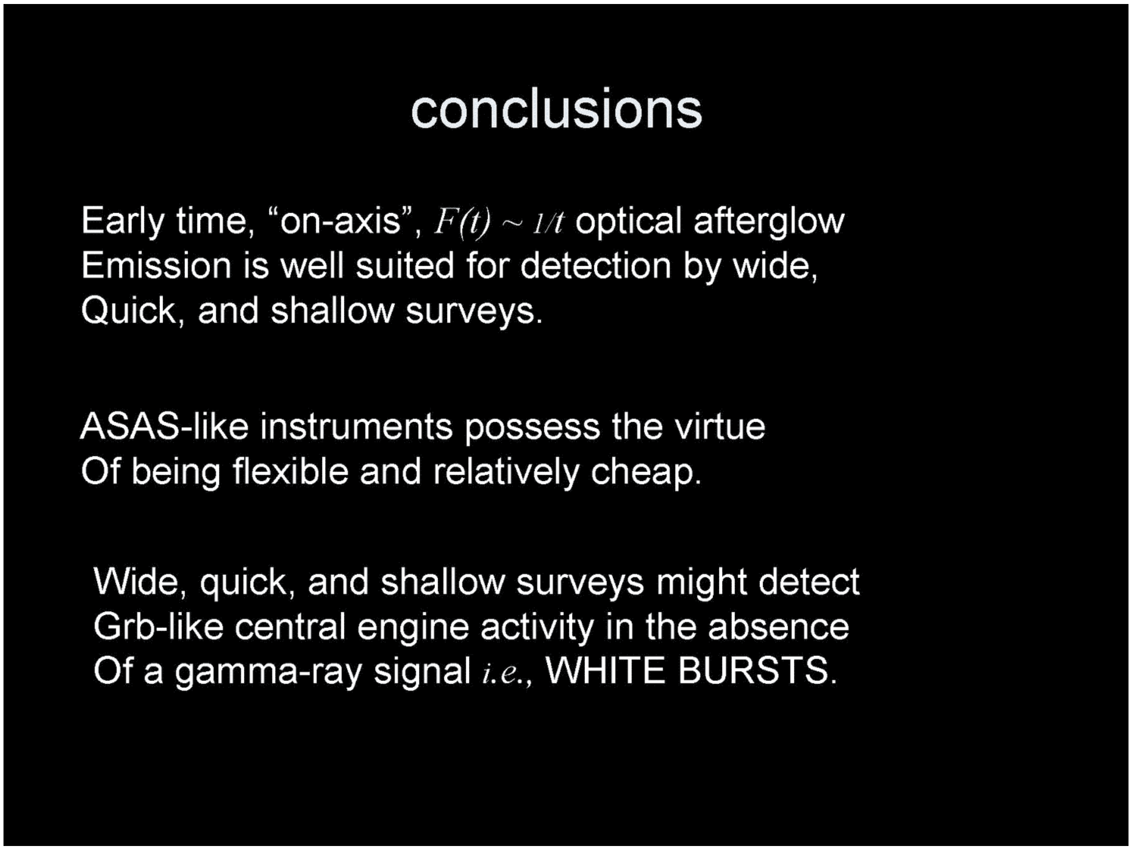
redundancy: if one instrument breaks, then capability is Reduced by only ~ a few %.

Flexible: can easily change optics (focal length), Integration time and overall strategy if you are unhappy with results.

Pretty cheap: ~$30 K/instrument or ~ $1 million in all

If ASAS x10 doesn't find too many afterglows, Then there is always variable stars

Possibility: detection of relativistic outflows in the Absence of copious prompt gamma-ray emission or in other words, WHITE BURSTS.



conclusions

Early time, “on-axis”, $F(t) \sim 1/t$ optical afterglow
Emission is well suited for detection by wide,
Quick, and shallow surveys.

ASAS-like instruments possess the virtue
Of being flexible and relatively cheap.

Wide, quick, and shallow surveys might detect
Grb-like central engine activity in the absence
Of a gamma-ray signal *i.e.*, WHITE BURSTS.