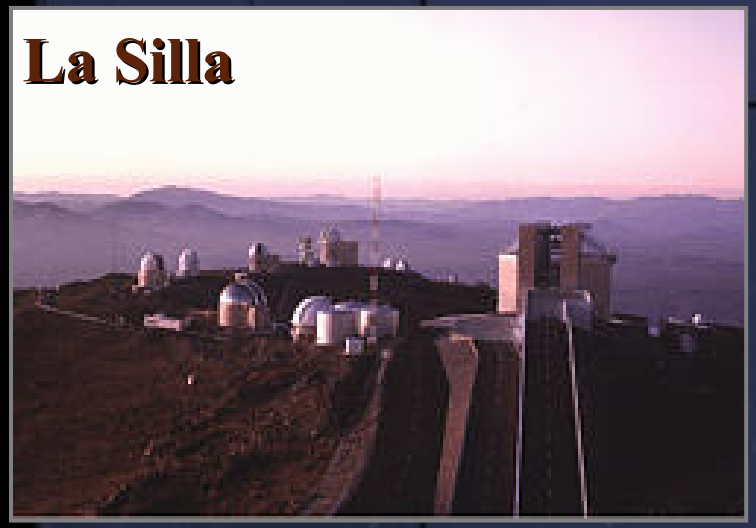
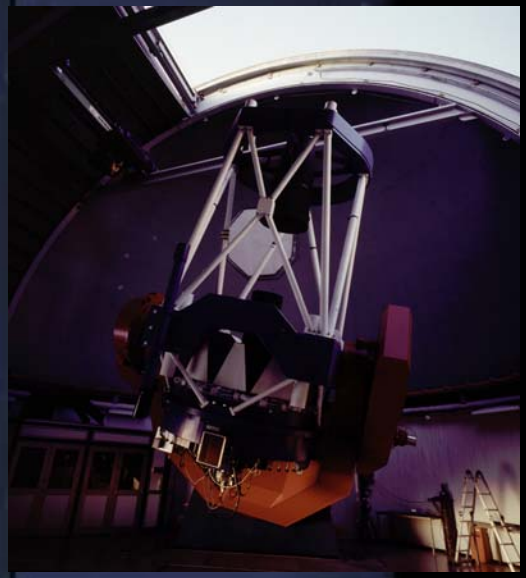
La Silla & Other Searches for Optical Transients

Arne Rau (Caltech)

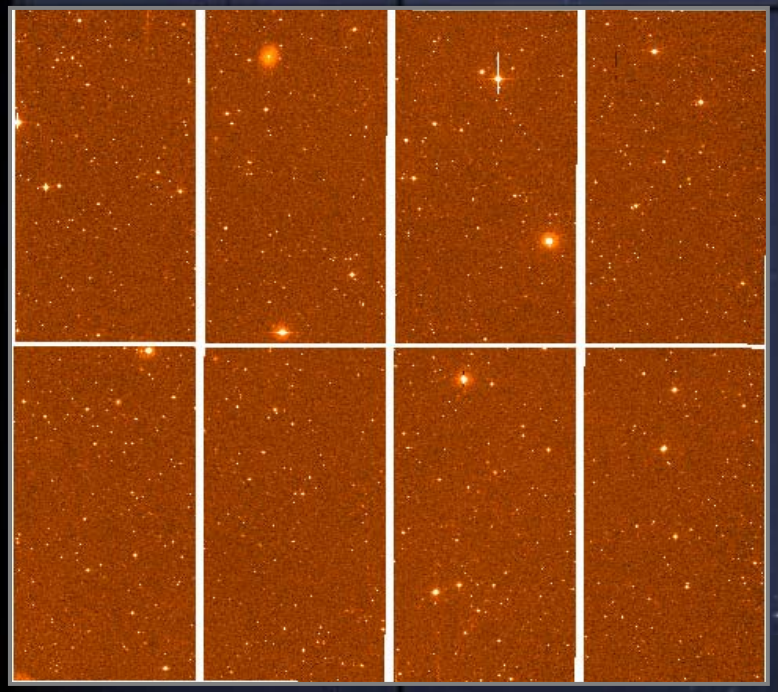


I. WFI @ La Silla 2.2m Telescope



Timeline:

- 1997: GRB afterglow discovery
  (van Paradijs et al., Costa et al.)
- 1997: orphans proposed (J. Rhoads)
- 1998: MPG/ESO proposal (PI: J. Greiner)
- 1999: observations
- …
- 2006: AR et al., A&A in press, astro-ph/0603284

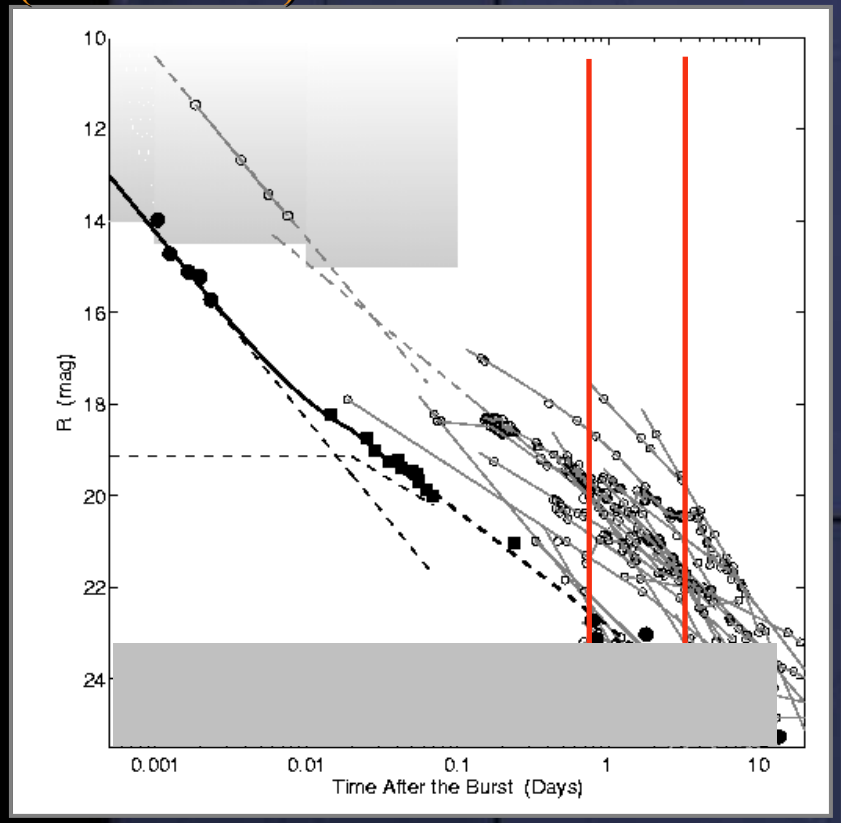


Wide Field Imager:

- MPG/ESO facility
- 4x2 2kx4k CCDs
- field of view: 34'x33'
- plate scale: 0.238 "/pixel

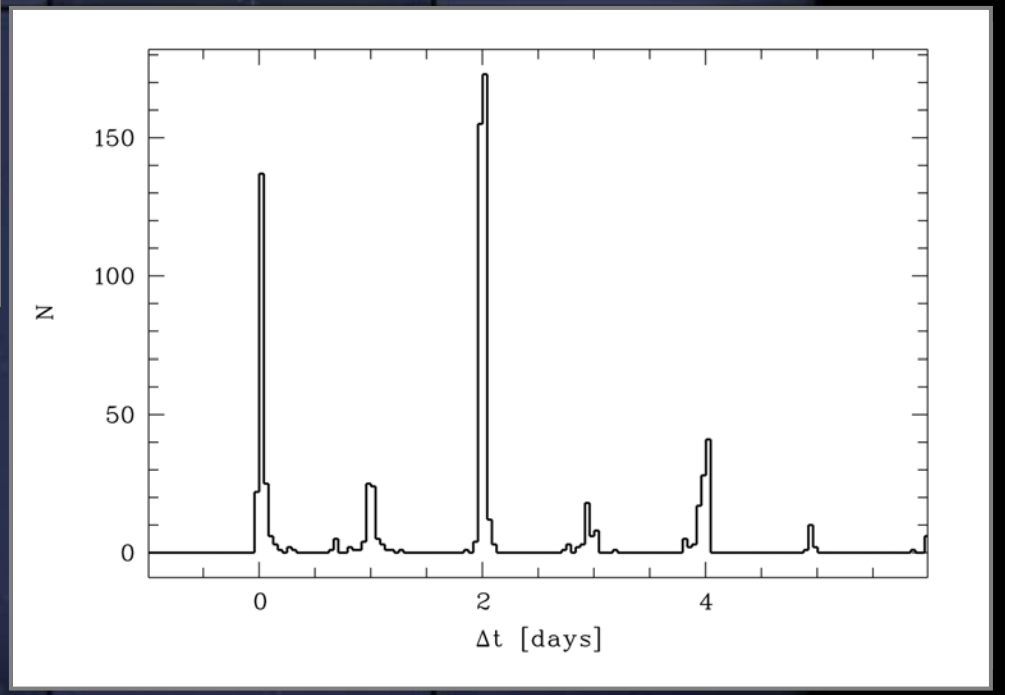
Strategy & Performance

(Fox et al 2003)



Strategy:

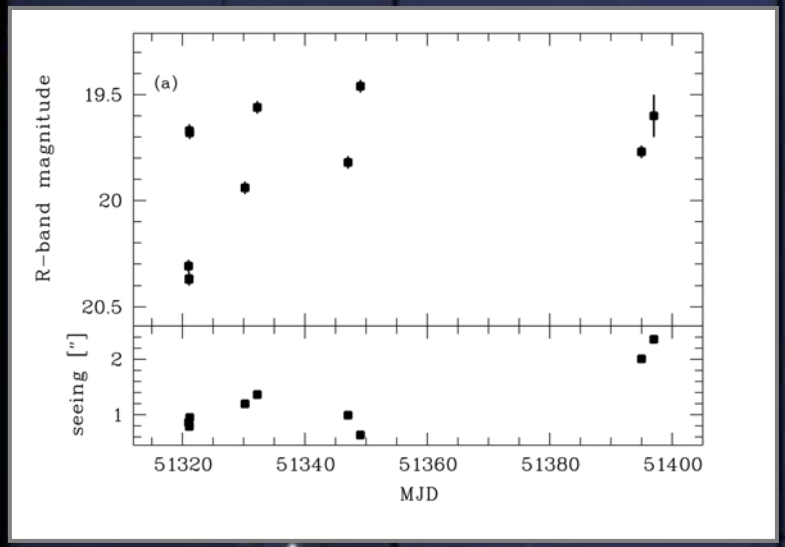
- imaging every 2 nights
  → on-axis afterglow with ≥ 2 detections
  + limits before & after
- R_{lim} = 23 mag (10 σ)



Performance:

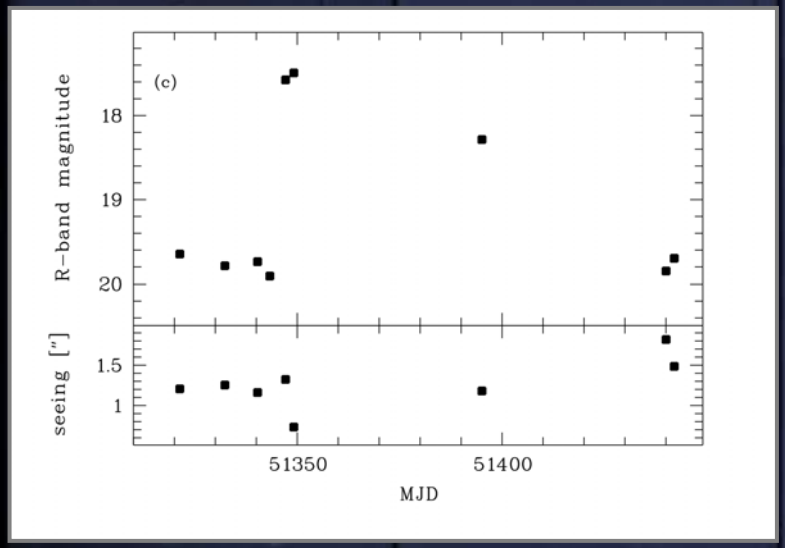
- 7 southern fields
  (2-8 subsets each)
- ~12 deg^2 in 11-25 nights
- median seeing 1"
- 25% loss

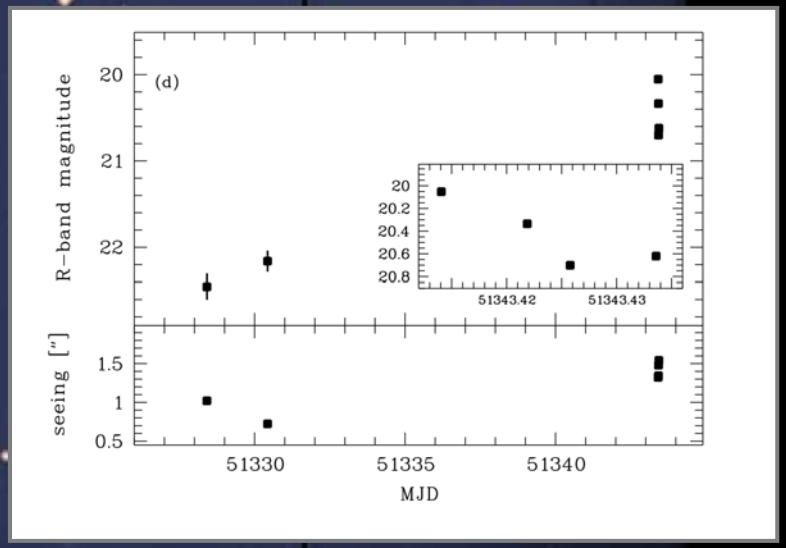
Reduction and Transient Search



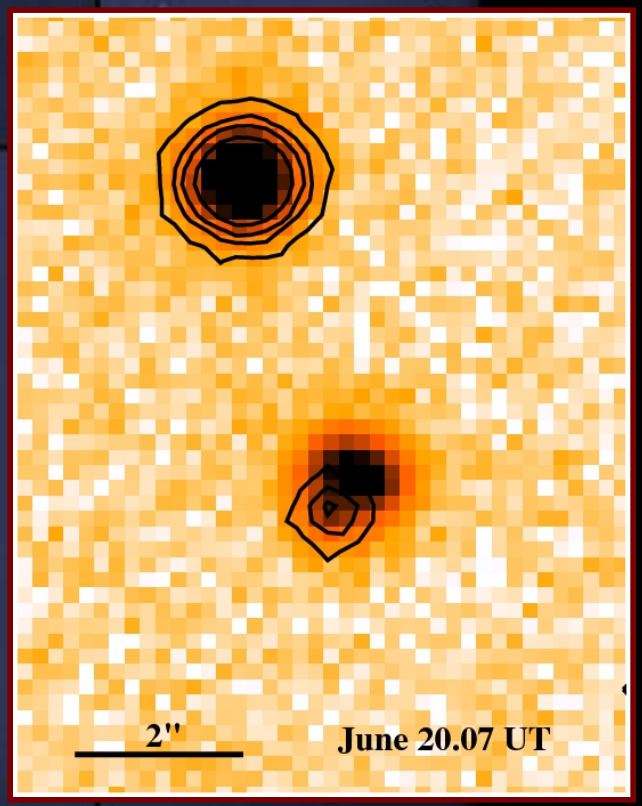
Transient Search:

- **differential photometry ($\Delta R > 0.75$ mag)**
- **12000 candidates**
  $\Rightarrow$ 4 transient sources in >2 obs.





Transient #4: origin unknown



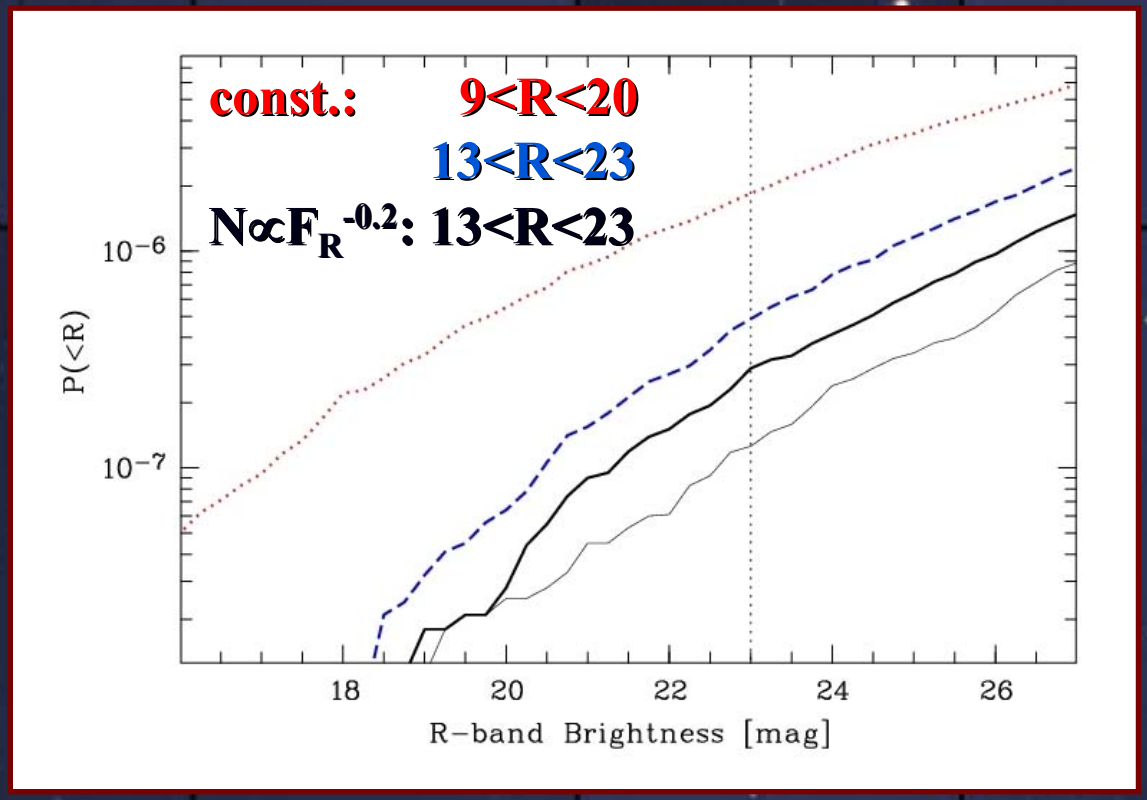
- ΔR~1.5 mag in 2 days
- flare star, supernova, afterglow, asteroid ?
- not associated with a triggered burst

Afterglow detection efficiency

$F_R \propto t^{-\alpha 1}$: $t \leq t_b$ $\quad 0.4<\alpha_1<1.8$; 0.4 days$<t_b<$4 days

$\propto t^{-\alpha 2}$: $t > t_b$ $\quad 1.4<\alpha_2<2.8$ (Zeh et al. 2005)

detection probability for random event at given magnitude



→1 afterglow detection for 10^7 bursts per year and full sky (R_{lim}=23)

GRB collimation

$$f_c \equiv N_A / N_\gamma < N_{MC} / N_\gamma < N_{MC} / (N_{\gamma,obs} \cdot f_\gamma \cdot f_D \cdot f_S) < 12500$$

$$f_c < f_B^{-1} < 75 \ldots 500$$ (Guetta et al. 2005; Frail et al. 2001)

Conclusion:

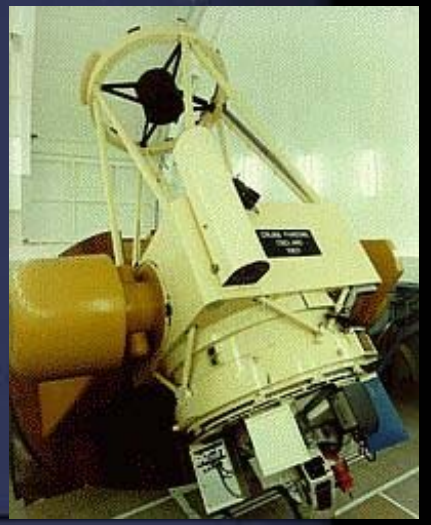
- **significantly larger in sky coverage required**
- **with same strategy in 150 nights:**

50 deg^2 $\Rightarrow$ $f_c < 500$

330 deg^2 $\Rightarrow$ $f_c < 75$

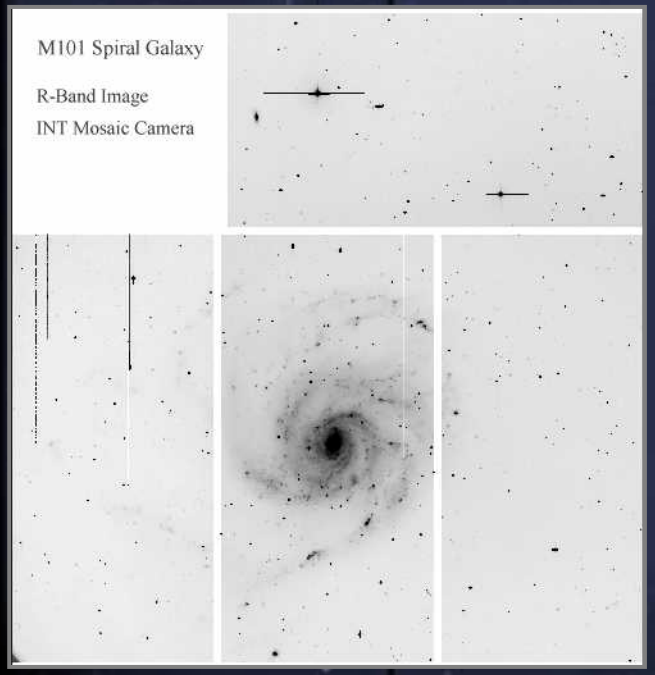
2500 deg^2 $\Rightarrow$ $f_c < 10$

II. Faint Sky Variability Survey @ La Palma 2.5m Telescope (INT)



General:

- PI: E. van den Heuvel
- 1998 - 2001
- 4 2kx4k CCDs Wide Field Camera
  field of view: 33'x33'
  plate scale: 0.333 "/pixel
- data reduction: Groot et al. 2003



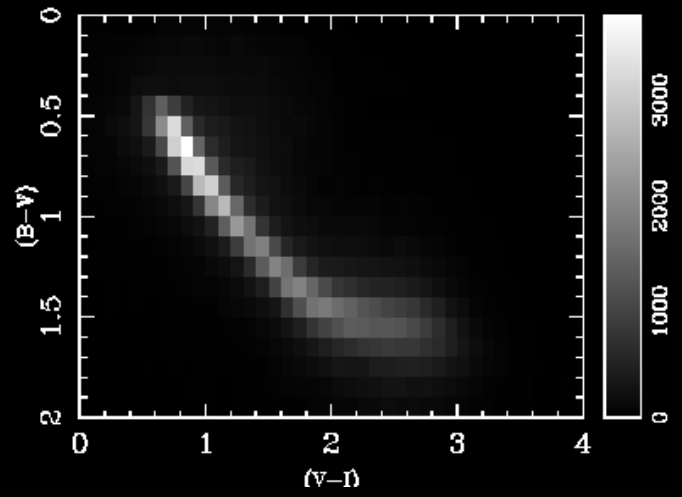
Aim:

- photometric and astrometric variable objects at V=16-24mag
- time scales between 24min and several days (+ yearly)
- 78 fields @ mid- & high galactic latitudes (~21 deg^2)
- BVI colors
- Morales-Rueda et al. 2006, MNRAS sub.

χ^2 Variability Analysis

deviation of individual measurements from mean source brightness

non-variable



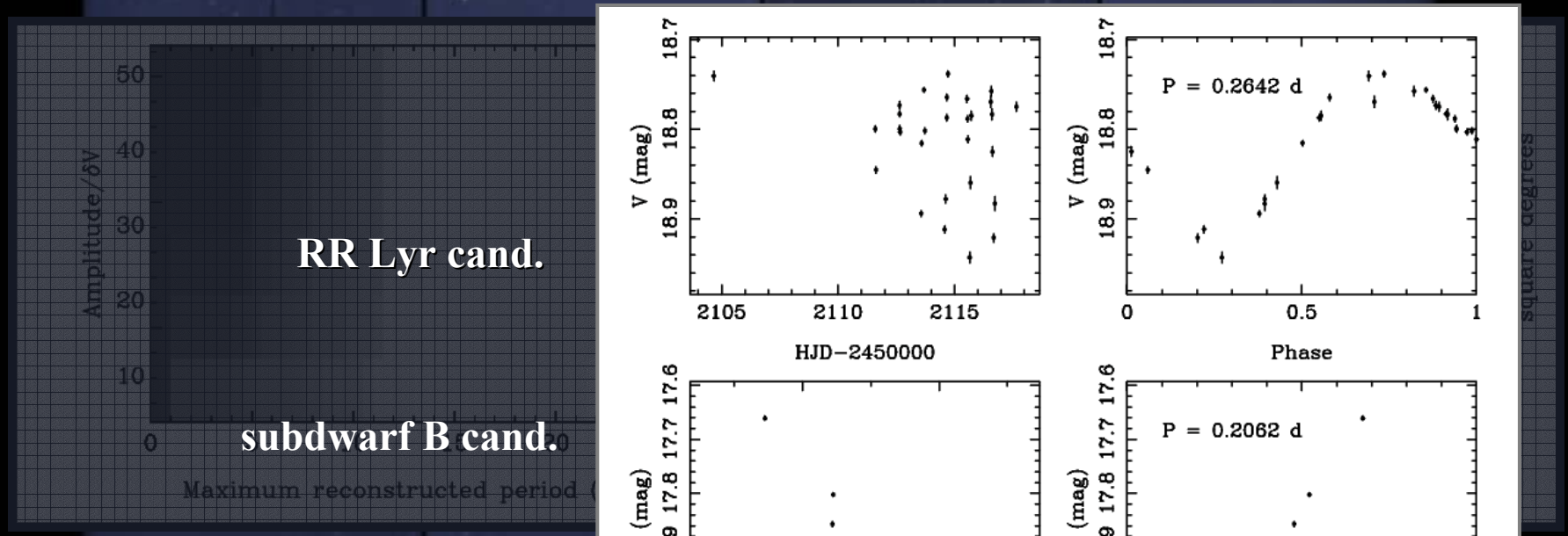
- **173276 sources total**
- **1% have short timescale variability**
- **3.5% at blue end**

(Morales-Rueda et al. 2006)

Floating Mean Periodogram

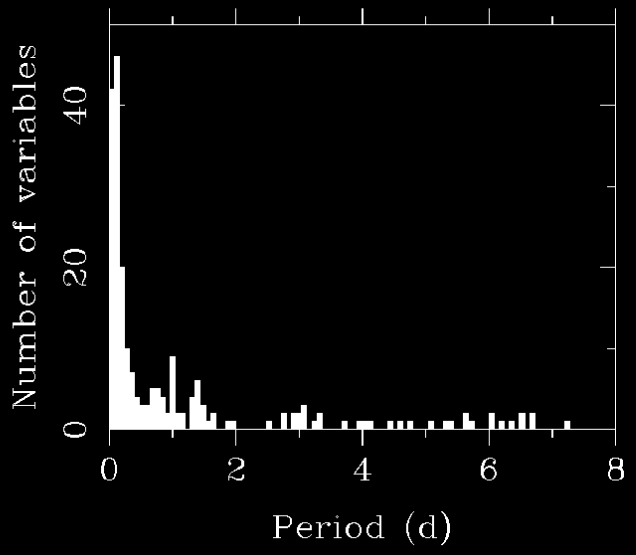
$$A(t) = \gamma + K \sin\left(2\pi \, (t-t_0) / P \right)$$

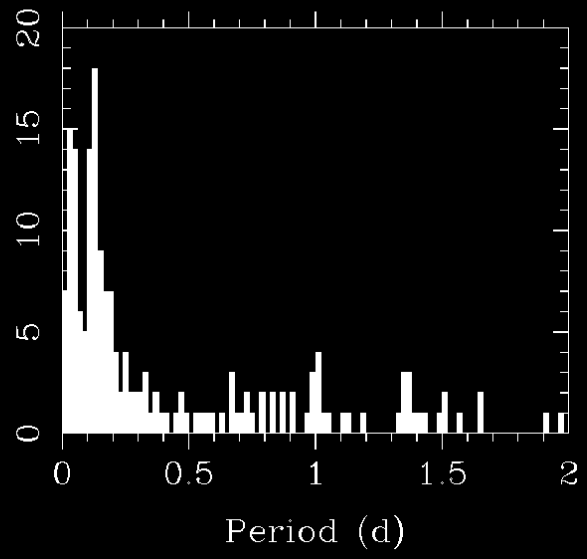
- amplitude & timescale for sinusoidal variability
- $K/\delta V$ and N_{obs} dependent

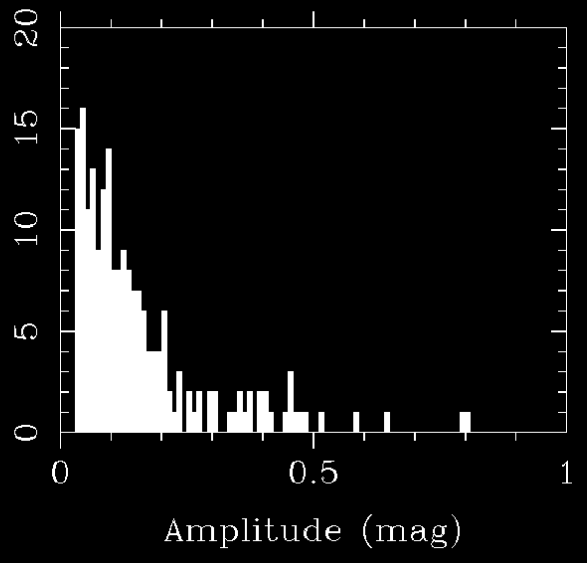


(Morales-Rueda et al. 2006)

timescale and amplitude distribution for 219 sources (ΔP < 10%, ΔK<10%)







(Morales-Rueda et al. 2006)

- bimodality at 43min & 2.9hrs
- 51% P < 6 hrs
- 20% 6 hrs < P < 1 d
- 19% 1 d < P < 4 d
- 10% 4d < P

Summary

La Silla - WFI:

- R-band survey for orphan afterglows
- 12 deg^2 in up to 25 nights, R<23
- 4 candidate transients (1x CV?, 1x FS?, 1x DN?, 1?)
- f_c<12500
- future survey strategy: - every two nights over 150 nights of 50 deg^2
  (330, 2500) $\Rightarrow$ f_c < 500 (75, 10)
  - immediate follow-up necessary

La Palma - FSVS:

- V-band survey for faint variability on timescales of 24min to several days
- 21 deg^2 down to V=24
- 1% off all sources variable, 3.5% at (B-V) < 0.38
- orphan afterglows & other one-time events→ Vreeswijk et al. in prep.