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Searching for Gamma-Ray Bursts Optical Counterparts in the Very Wide Survey Data

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CONCLUSION AND FUTURE

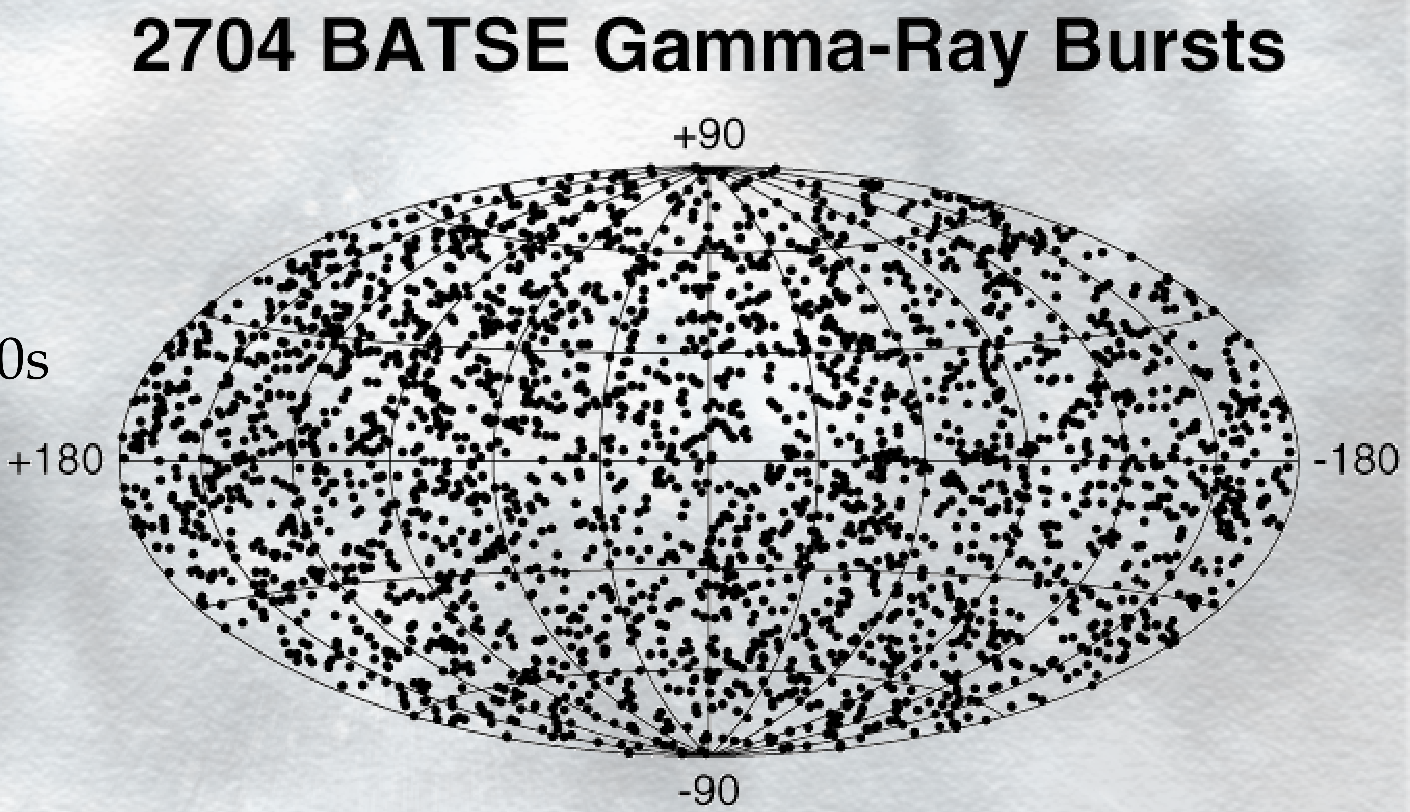
I-1 Prompt Emission

Short and bright flash of gamma-ray and x-ray photons

- Frequency: 2.day^{-1}
- Energy: 10^{52} erg
- Duration: 10ms-100s
- 2 classes:

→ Short GRB t<2s

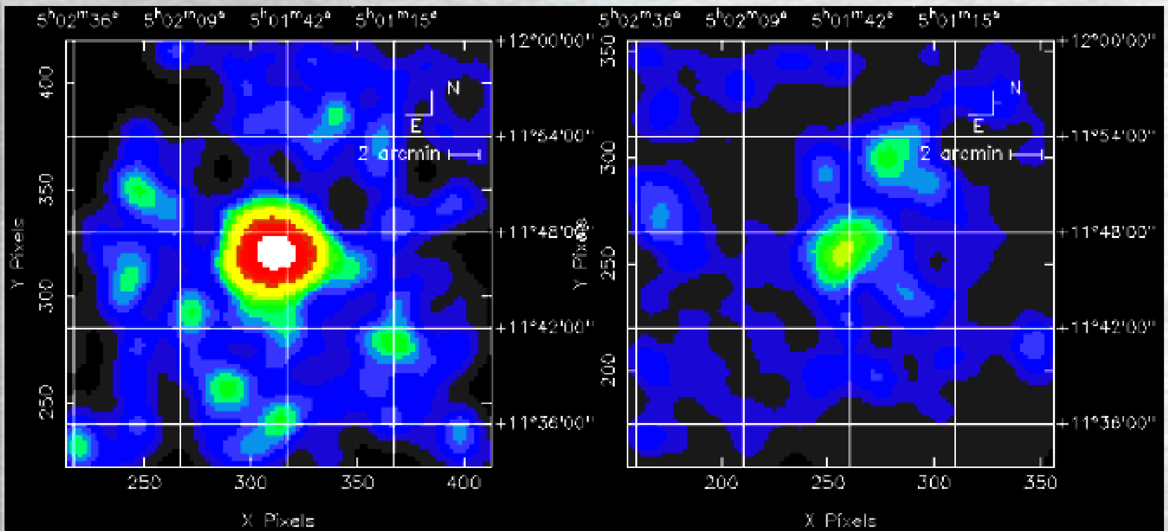
→ Long GRB t>2s



I-2 Afterglow

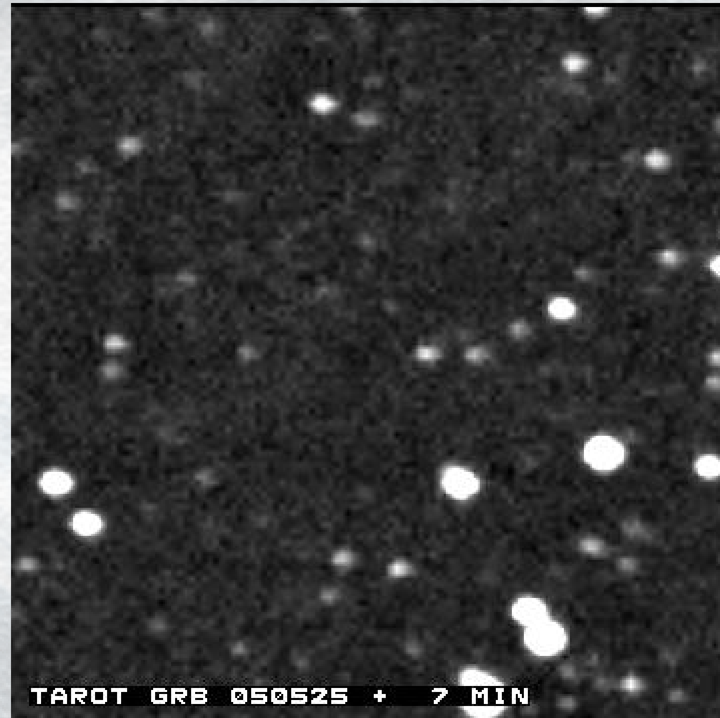
Counterpart of the GRB at other wavelengths (x-ray to radio)

X-Ray Afterglow (GRB970228)



Costa et al. 1997

Optical Afterglow (GRB050525)



Klotz et al

Association with host galaxies (mostly irregular) and supernovae (Ib, Ic)

Courbes de lumière

Decreasing like a power law with time, containing eventually a **break**

Mean parameters:

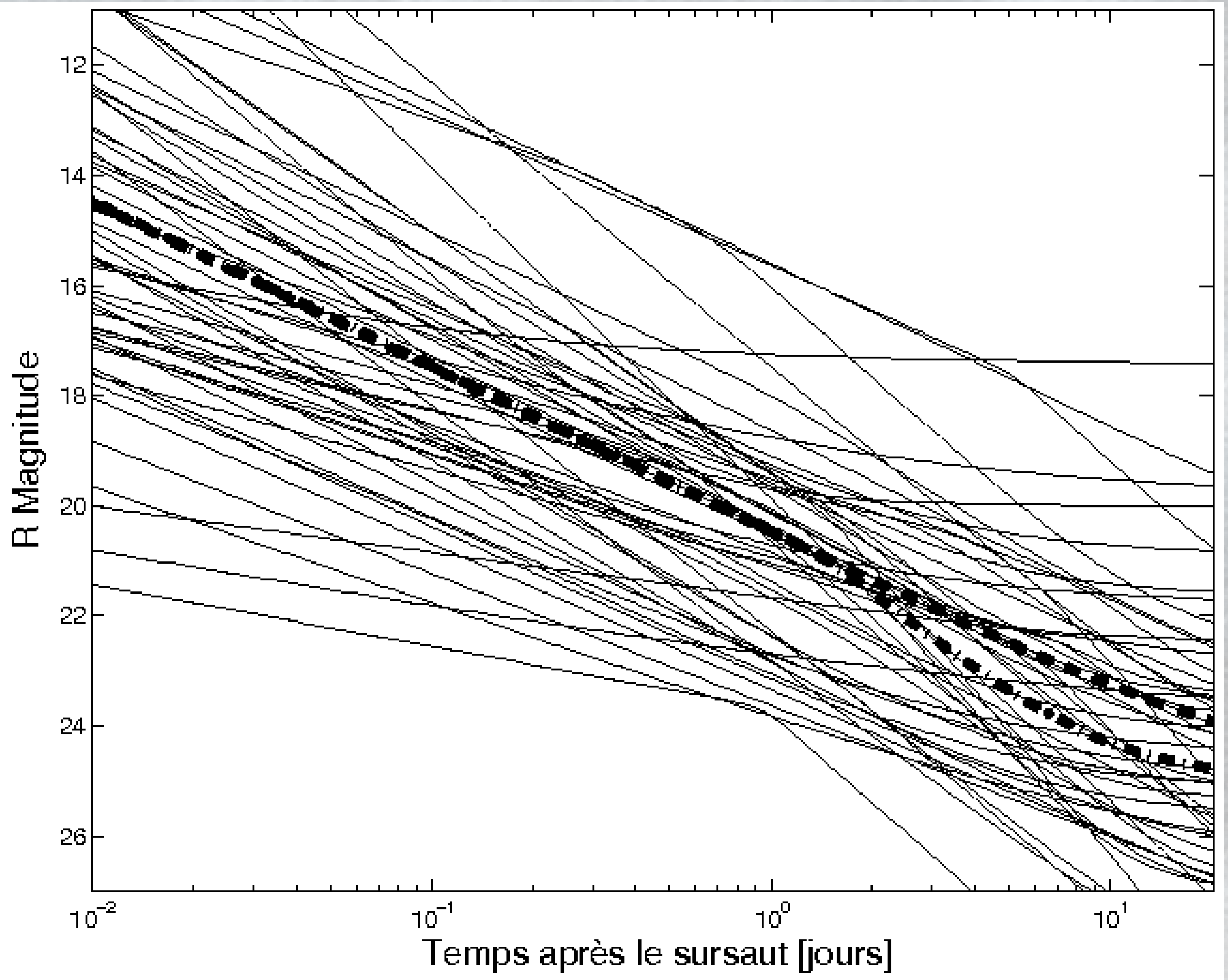
$\alpha_0 \sim 1{,}2$

$\alpha_1 \sim 2$

$t_b \sim 1{,}5$ day

$m_1 \sim 20{,}5$

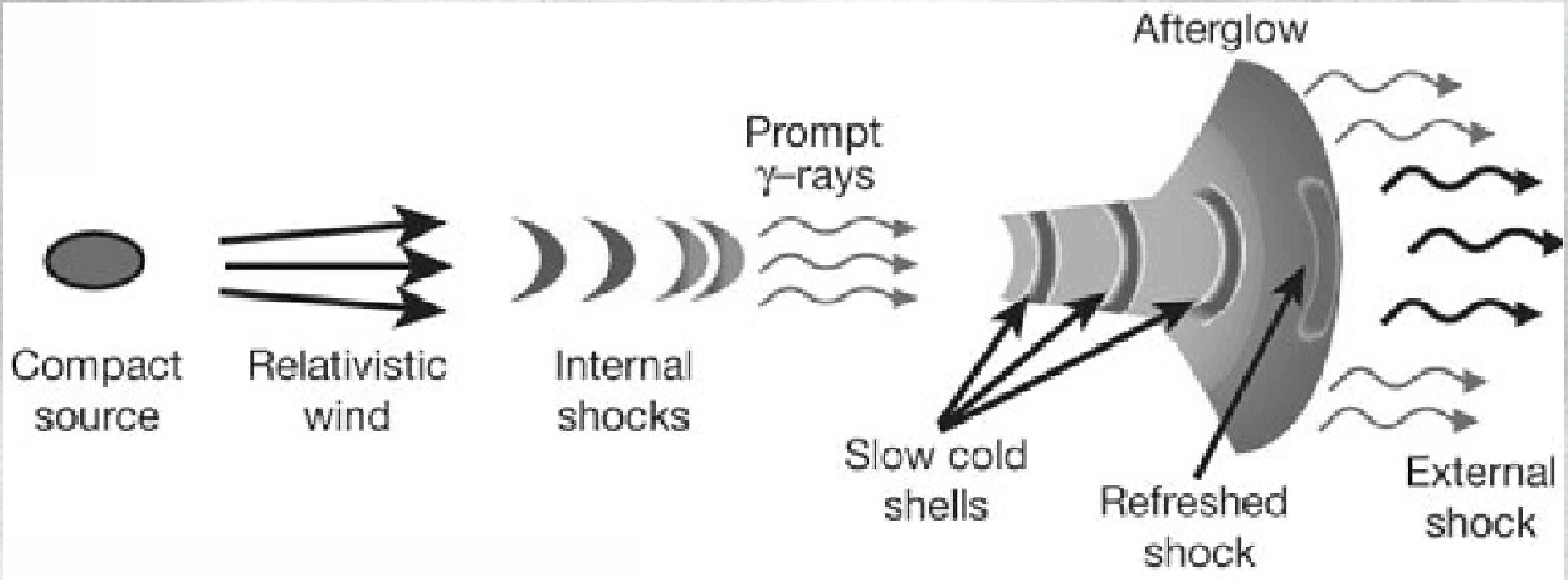
$m_{host} \sim 25$



$$m(t) = -2{,}5 \log\left[10^{(-0{,}4\, m_b)}\left(\left(t/t_b\right)^{(n\alpha_0)} + \left(t/t_b\right)^{(n\alpha_1)}\right)^{(-1/n)} + 10^{(-0{,}4\, m_{host})}\right]$$

I-3 Fireball Model

- Collapse of a massive star into a black hole
- Internal shocks within the ejecta → **prompt emission**
- External shocks on the interstellar medium → **afterglow**



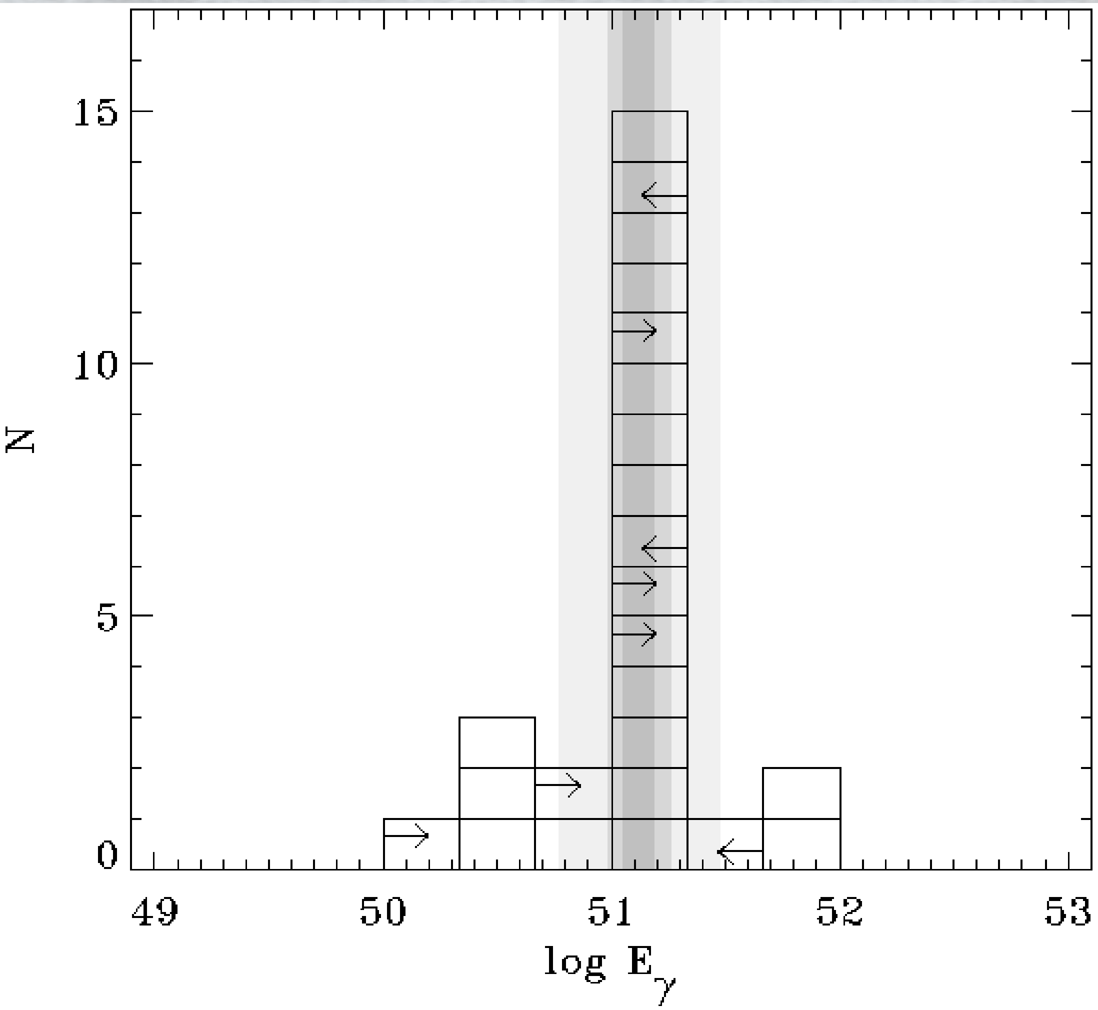
Collimation of the prompt emission

Breaks in the light curves

Total energy more clustered (3.10^{51} erg):
Are GRBs standard candles?

But afterglow emission largely isotropic

→ Prediction of afterglows not associated with a visible GRB:
Orphan afterglows



Bloom et al. 2003

I-4 Scientific Justifications

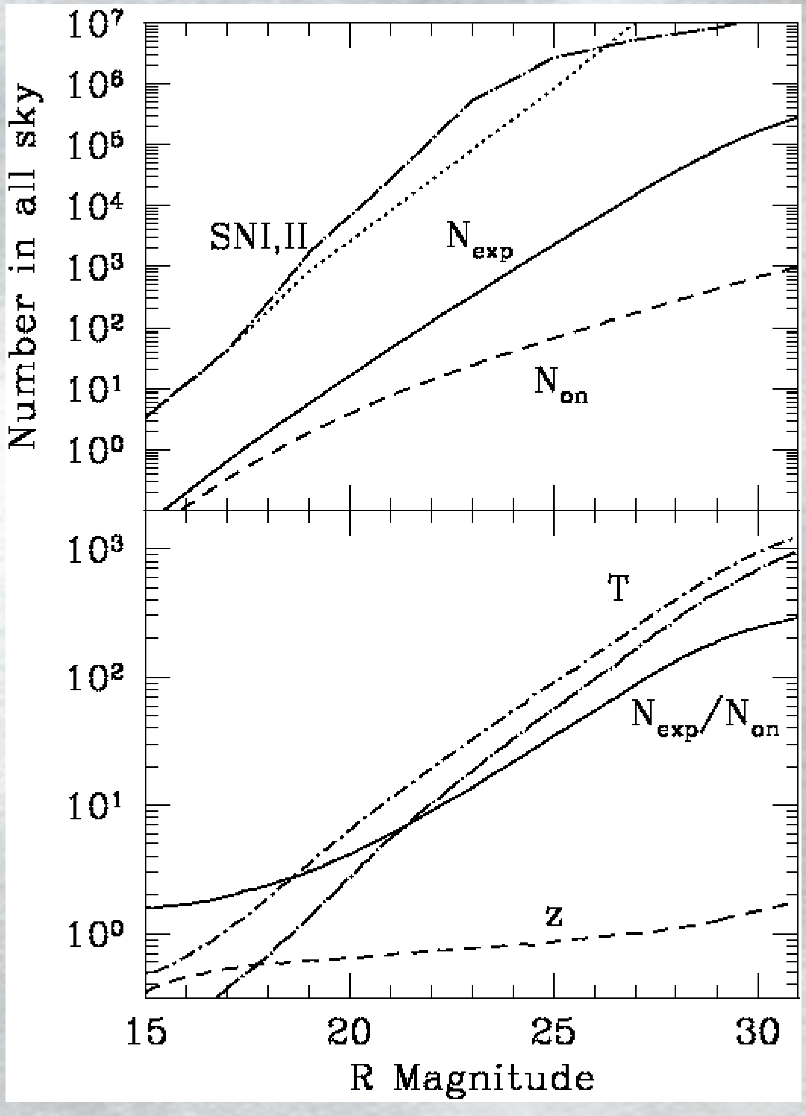
- Local population of GRBs
- More associations with supernovae
- Constraint on the opening angle of the jet θ
- Collimation factor:

$$f_c = \frac{1}{(1-\cos\theta)} \approx \frac{2}{\theta^2}$$

- Connected with the number of afterglows but depending on the model used

$$\beta = \frac{N_{tot}}{N_{GRB}}$$

→ Validation of the current afterglow models



Totani & Panaitescu 2002

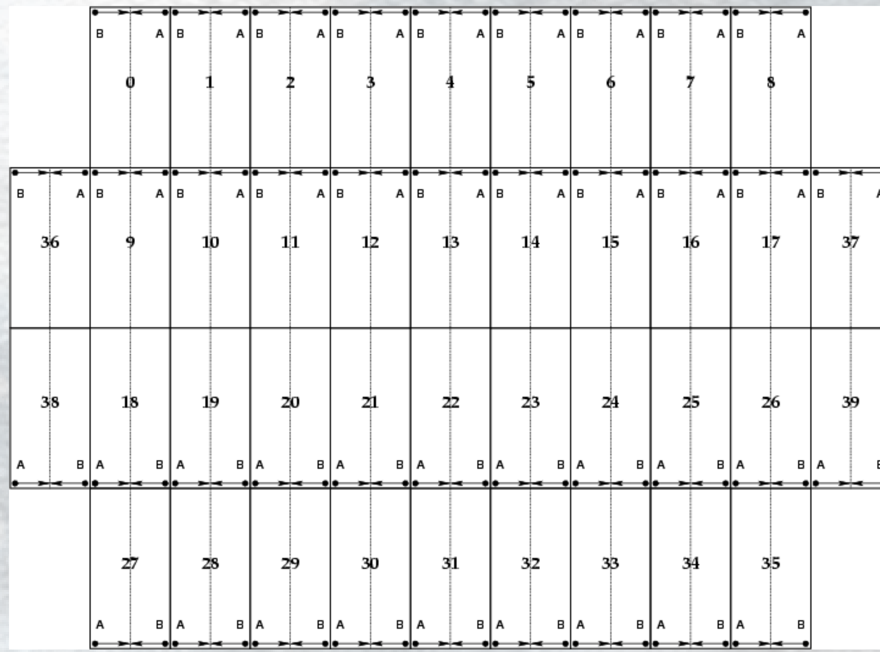
II-1 Canada-France-Hawaii Telescope

CHFT

- Located on the Mauna Kea, in Hawaii
- 3,6 meters mirror
- Instruments: MegaCAM, WIRcam, Espadon, etc...

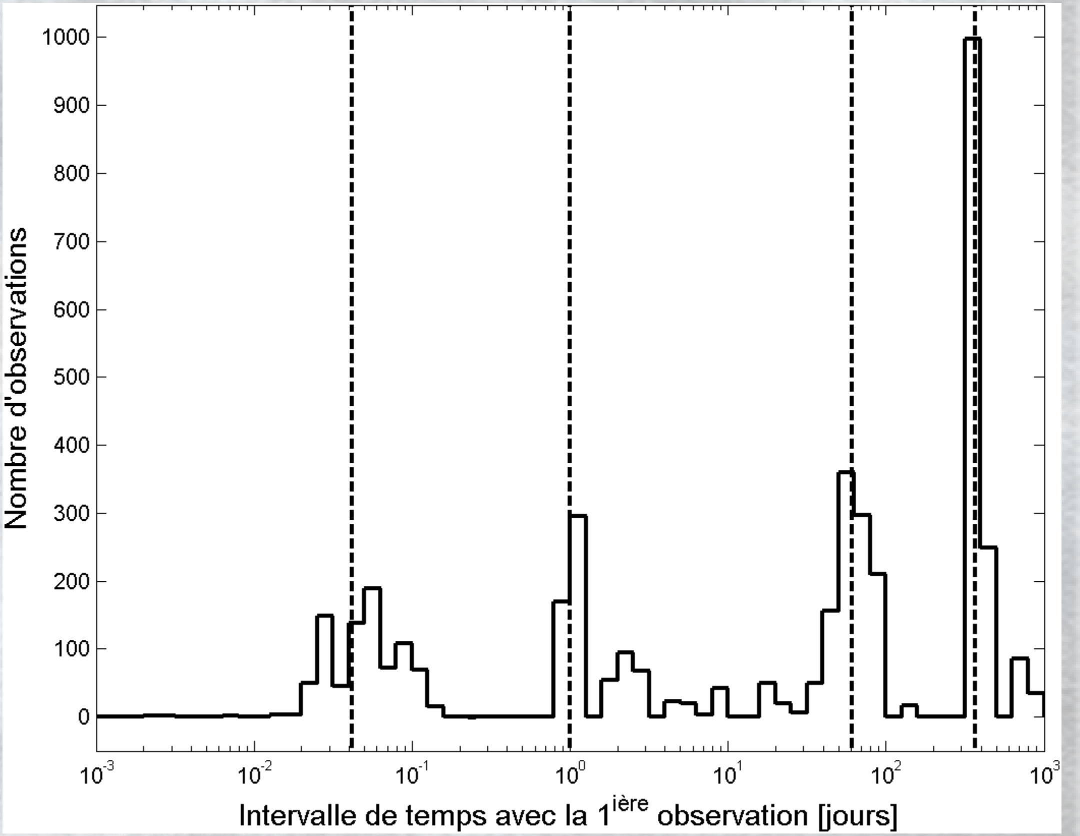
MegaCAM

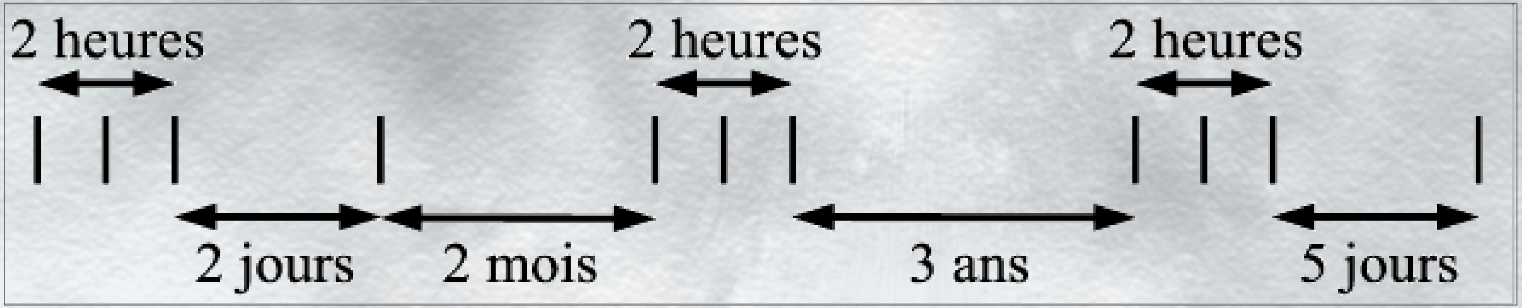
- 340 millions of pixels
- 36 CCDs
- 1 square degree with 0,185''.pixel^{-1}
- 5 filters: u* g' r' i' z'



Very Wide Survey

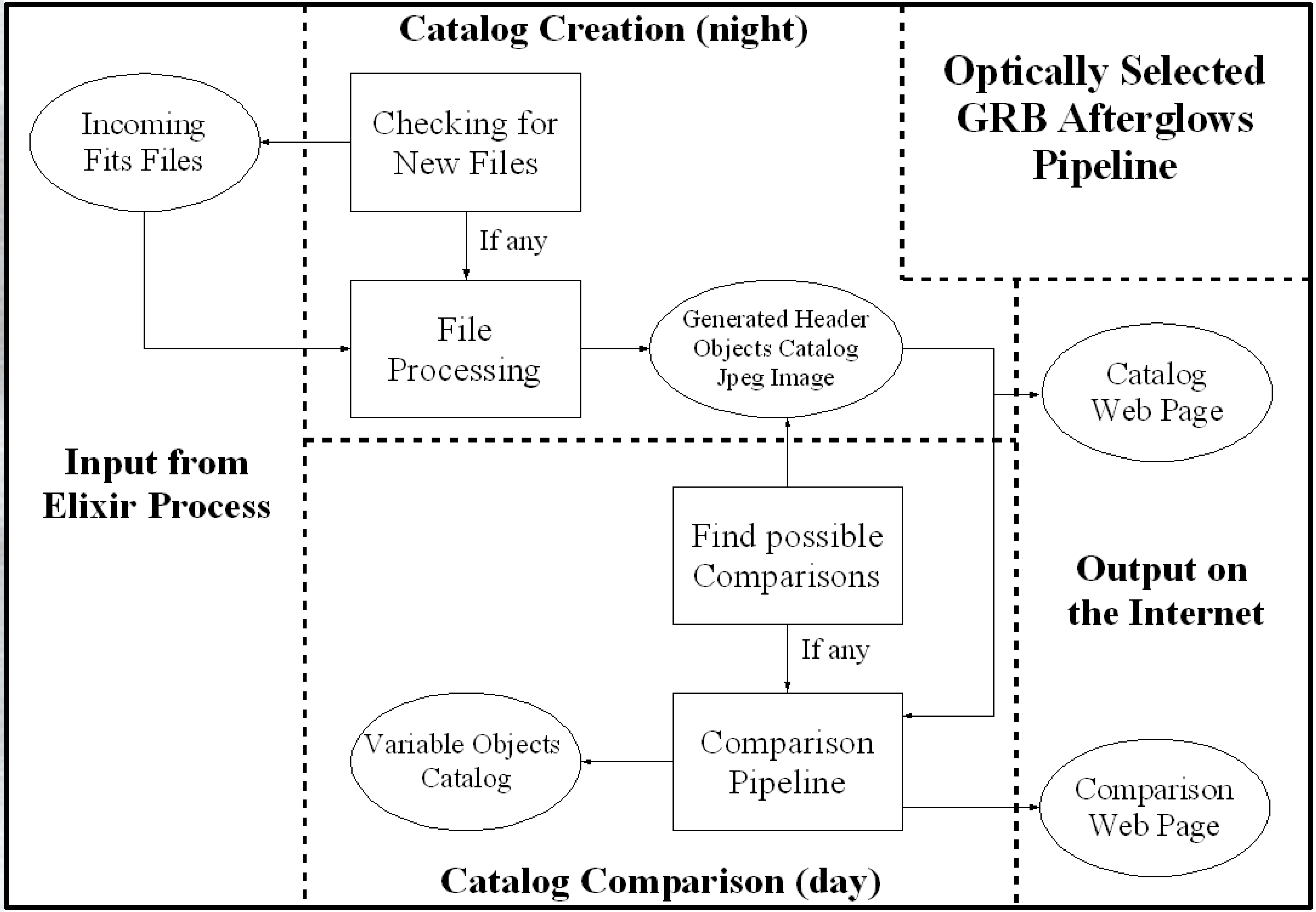
- Part of the Legacy Survey
- 5 years of observations
- 1200 square degrees
- 3 filters: g' r' i'
- Observational strategy optimised for detection and follow-up of Trans-Neptunian Objects (TNO)





II-2 Real Time Analysis System

Automatic process of MegaCAM images to detect variable sources



Characterisation of variable objects

- **Rejection or validation** by a member of the collaboration
- Choice between **13 classes** (seeing problem, CCD defect, variable star, afterglow candidate, ...)
- Help for the characterisation :

  → Visualisation of selected objects on **thumbnails**

  → **Figures** showing evolution and variation

  → Display of **parameters** (magnitude, FWHM, ...)

  → Automatic search in **images of the DSS**

  → **Online form** allowing the search of objects in the entire Very Wide Survey database

Thanks to these tools, the characterisation of variable sources is **fast and easy**

II-3 Statistics

- 2231 images processed
- 87475622 objects analyzed

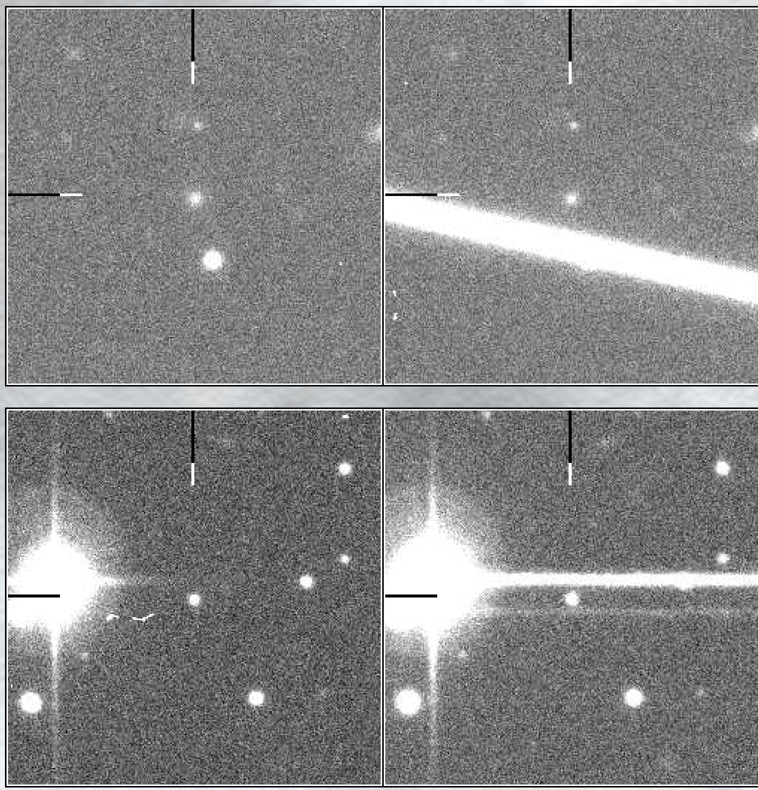
Filter	N_{obs}	S_{obs} [°²]	δ_{pos} ['']	M_{lim}	N_{obj}/deg^2	% error
g'	536	481,1	0,46	23,1	31910	0,53
r'	1106	993,2	0,53	22,6	45332	0,49
i'	589	530,6	0,52	22,5	51075	0,17

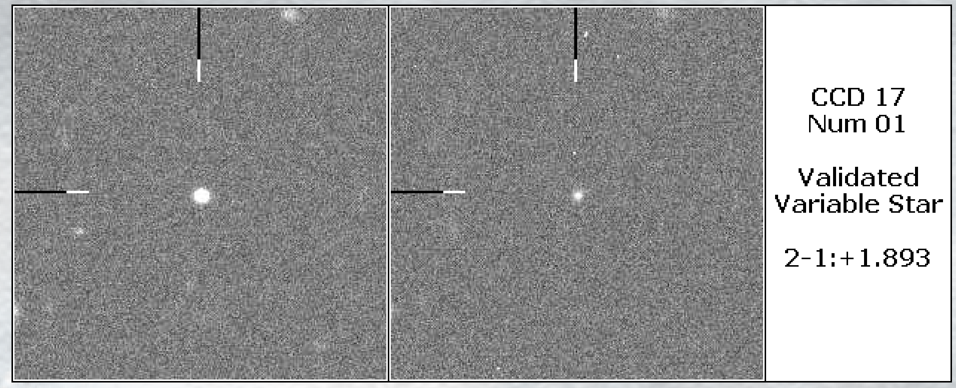
- 1048 comparisons done
- 42424 variable objects → less than 800 per million astrophysical objects

Type	N_{cmp}	S_{cmp} [°²]	N_{ast}	N_{sin}	N_{var}	N^6
Triple	535	471,8	20801	-	29450	624
Double	513	448,4	-	3234	12974	802

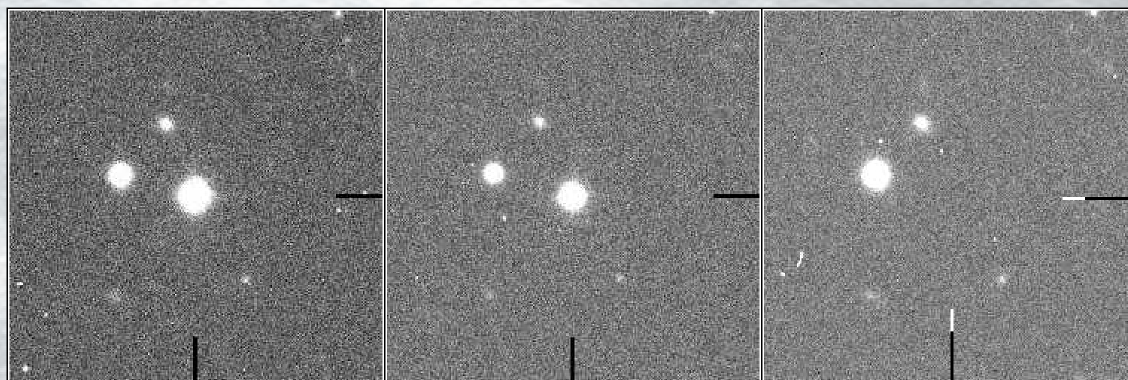
II-4 Variable Objects

- More than 90% of variables objects are false detections
- 1951 variable stars
- 20801 moving objects





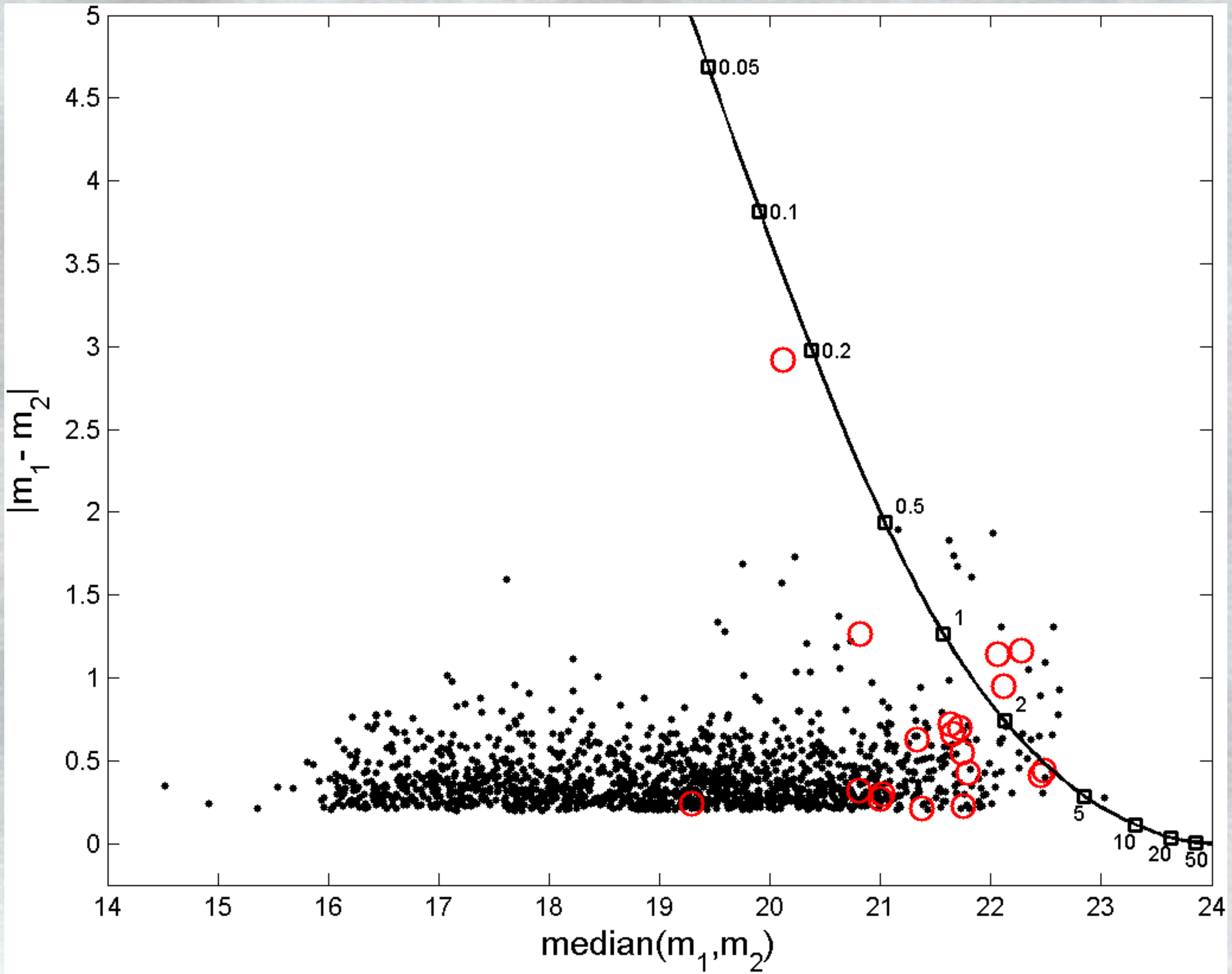
t_0 t_0+1 day



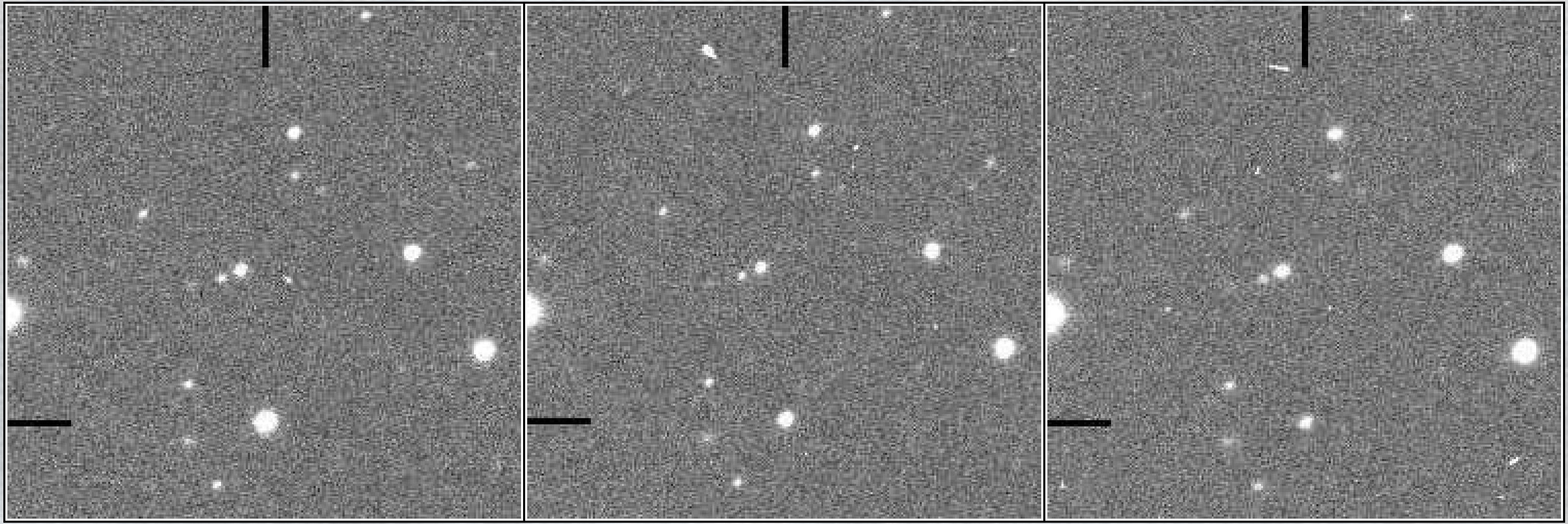
t_0 t_0+1 hour t_0+1 day

Afterglow Candidates

23 afterglow candidates but not confirmed



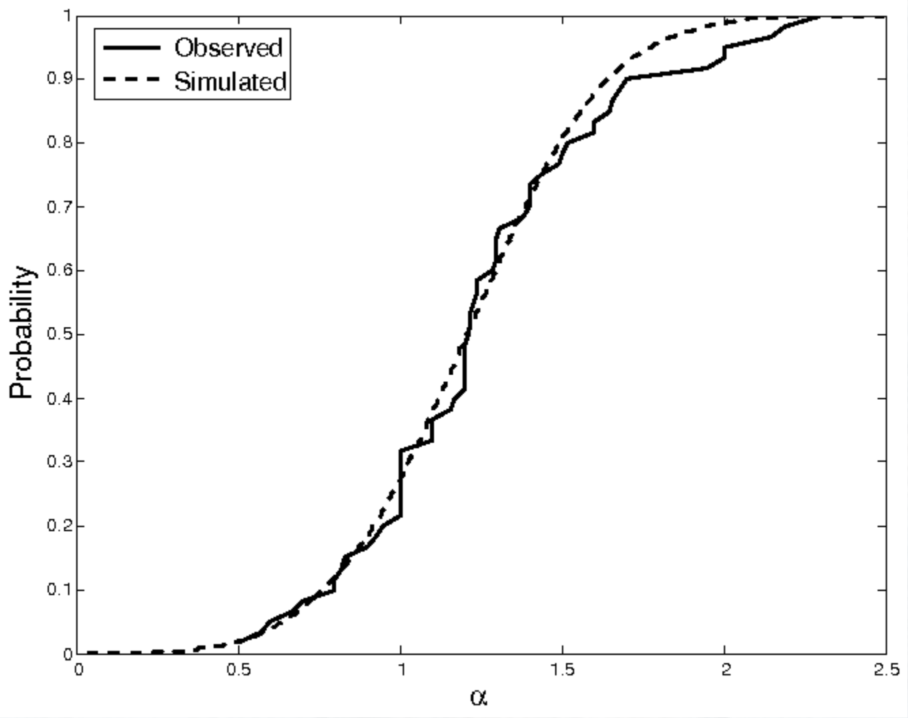
Our Best Candidate

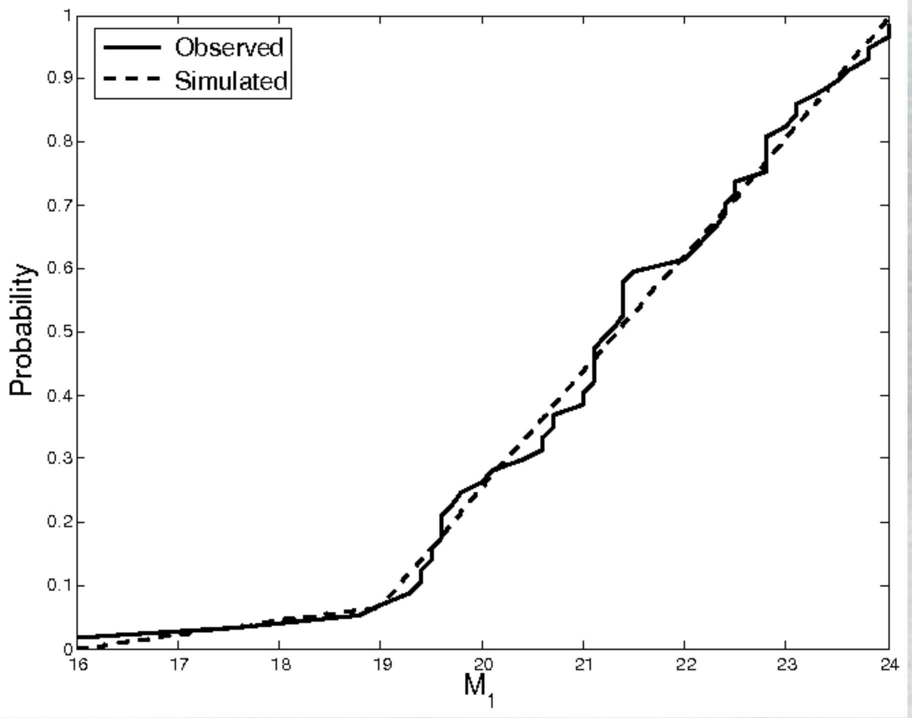


III-1 Simulations

- Main goals: → Compute the number of afterglows expected
  → Compare the RTAS efficiency with other strategies

- Simulation of simple afterglows based on real parameters
  → Date and position at random
  → α et m_1 draw according to the observed distribution





Comparing Strategies

- 4 strategies: → ROTSE-III Transient Search (Rykoff et al. 2005)
  → MPI/ESO (Rau et al. 2006)
  → Very Wide Survey (Malacrino et al. 2006)
  → Optimal survey

Strategy	**β**	**S_{obs} [°²]**	**t_{vis} [day]**	**δ_t**	**M_{lim}**	**N_{exp}**
ROTSE-III	2	65550	0,07	30 min	18	0,6
MPI/ESO	15	55	3,5	3 days	23	0,3
Very Wide Survey	11	1178	2,5	2 days	22,5	4,6
Optimal Survey	21	250	7,5	7 days	24	5,6

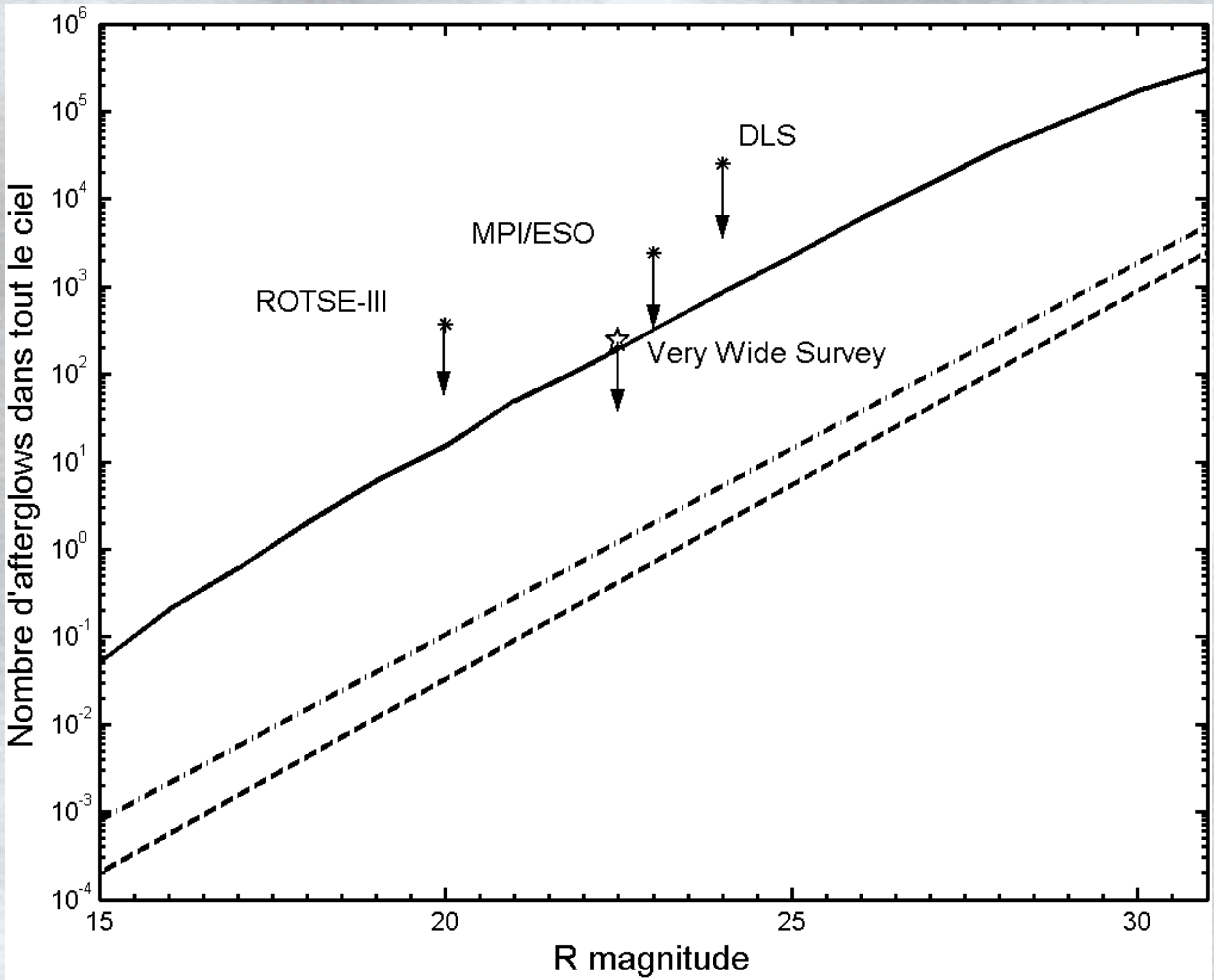
The Very Wide Survey is by far the best observational strategy
to detect optical afterglows

III-2 Constraint on the Number of Afterglows

- 459 comparisons analyzed
  → No doubtless afterglow detection

⟹ $N_{ag} \leq 11000.year^{-1}$

⟹ $\beta_{22,5} \leq 13,4$



Constraining the Collimation Factor ?

- GRBs without gamma-ray emission (failed GRB)
- GRBs without visible afterglow (about 50%)
- The link between β and f_c strongly depends on the model used
- For some models, $\theta_{gamma} / \theta_{afterglow}$ is constant → fc independant from β

→ **Very difficult to constrain physics of GRBs with orphan afterglow**

Using radio afterglows: **f_c > 20 – 100** (Levinson et al. 2002)

CONCLUSION AND FUTURE

No afterglow confirmation in the Very Wide Survey **BUT** the best constraints on the number of afterglows

The RTAS can be seen as a precursor of future large surveys

50 afterglows expected → 611 hours of observation with MegaCAM

PAN-STARRS: - 4 1.8 meters telescopes in Hawaii
- 3° field of view
- 6000°² observed per night down to r = 24

LSST: - 8.4 meters telescope in Chile
- 9,5°² field of view with 0,2".pixel^{-1} resolution
- 200000 images per year