Systematics and biases in observations of supernovae associated with gamma-ray bursts

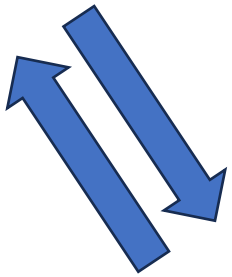
S. Belkin (sergey.belkin@monash.edu) and A. Pozanenko

Seventeen Marcel Grossmann Meeting, Pescara, 7 -12 July 2024

Disclaimer

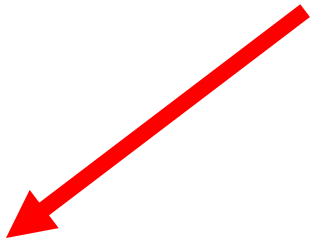
Belkin and Pozanenko, 2023

"*Systematics and Biases in Observations of Supernovae Associated with Gamma-Ray Bursts*"



Practical notices on optical observations of the SN-GRBs with meter-class telescopes

Introduction: GRBs



Short GRBs	Long GRBs
Duration less than ~ two seconds (presumably)	Duration more than ~ two seconds
NS+NS or NS+BH mergers	Core-collapse supernova (Ic)

Introduction: SN-GRB statistics

July 2, 1967

↓

First-ever GRB detection

↓

More than 13470 GRBs
(the data is as of August 29, 2021;
Hurley masterlist)

April 25, 1998

↓

First SN-GRB confirmation

↓

50 SN-GRBs
(the data is as of December 27, 2023;
Belkin et al., 2024)

→ 27 spectroscopically confirmed

↓

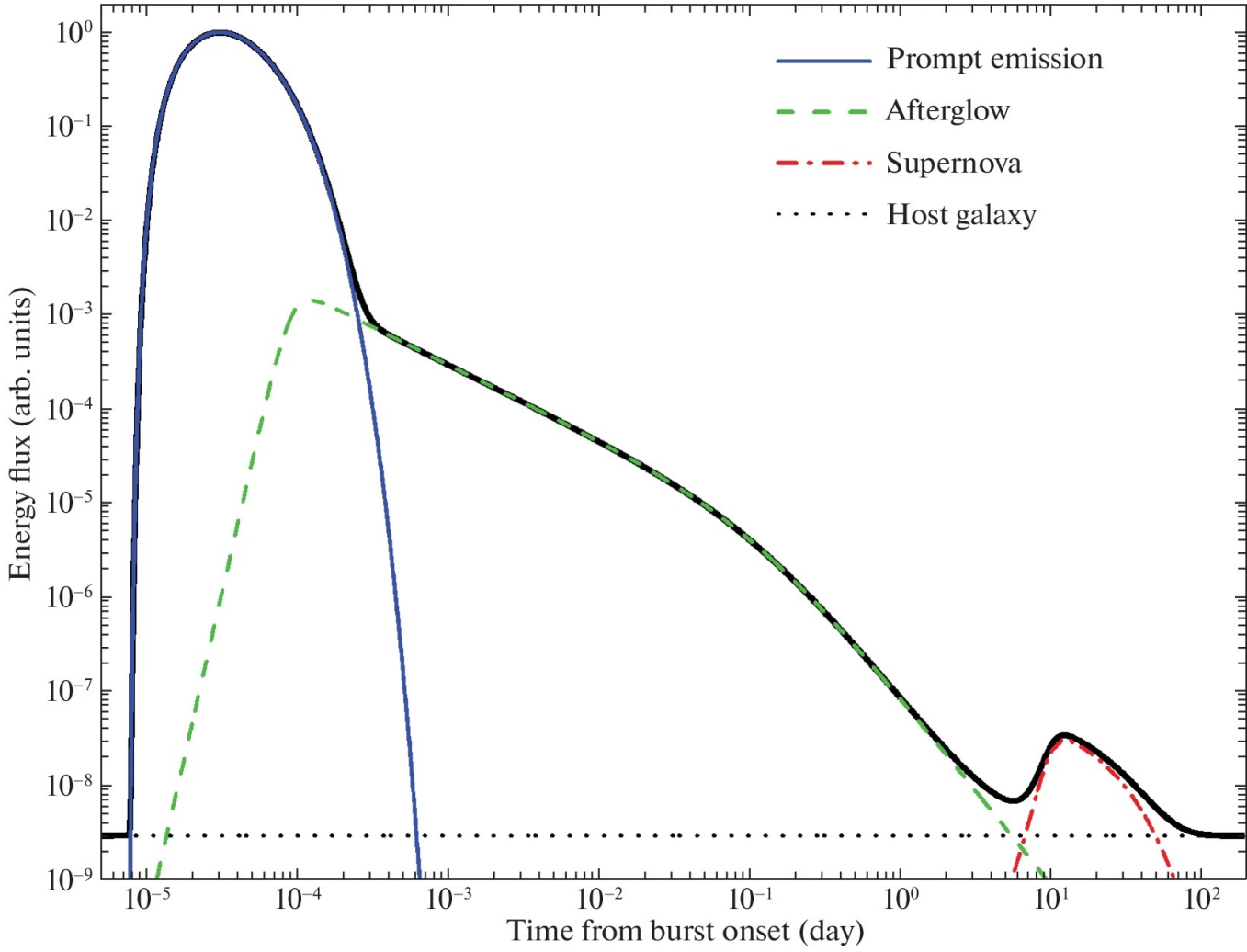
SN-GRBs are $\lesssim 0.4\%$ of all GRBs

↔ Not enough for statistical analysis =(

Introduction: IKI GRB-FuN

Interfering factors

- Active phase
- Afterglow
- Supernova
- Host galaxy

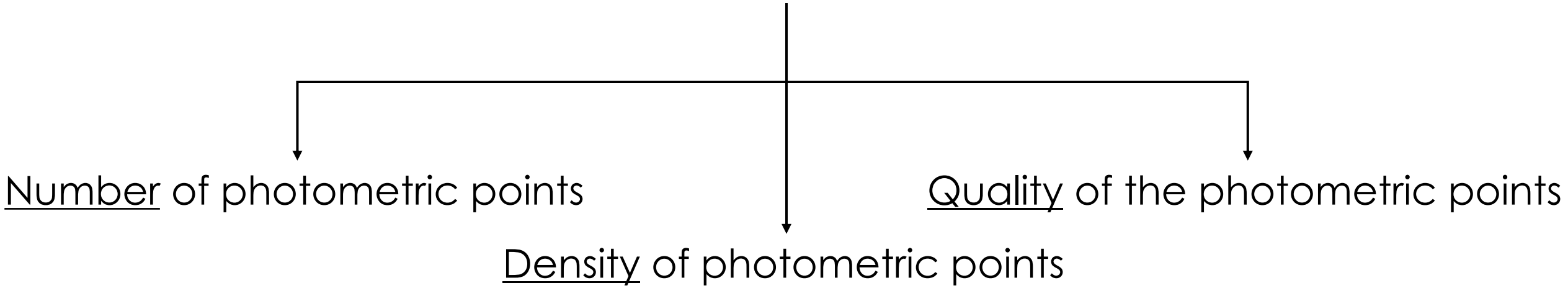


Pozanenko et al., 2021

Precision

$$F_\nu^{OT}(t) = F_\nu^{AG}(t) + F_\nu^{SN}(t) + F_\nu^{host}(t)$$

$$= at^{-b} + A\frac{exp\left(-(t-t_0)\,/\,\tau_{fall}\right)}{1+exp(-(t-t_0)\,/\,\tau_{rise})} + F_\nu^{host}$$



Selective effects

- Distant source
- Bright afterglow
- Bright host galaxy
- Host galaxy extinction
- SN location in the host galaxy
- Bad weather

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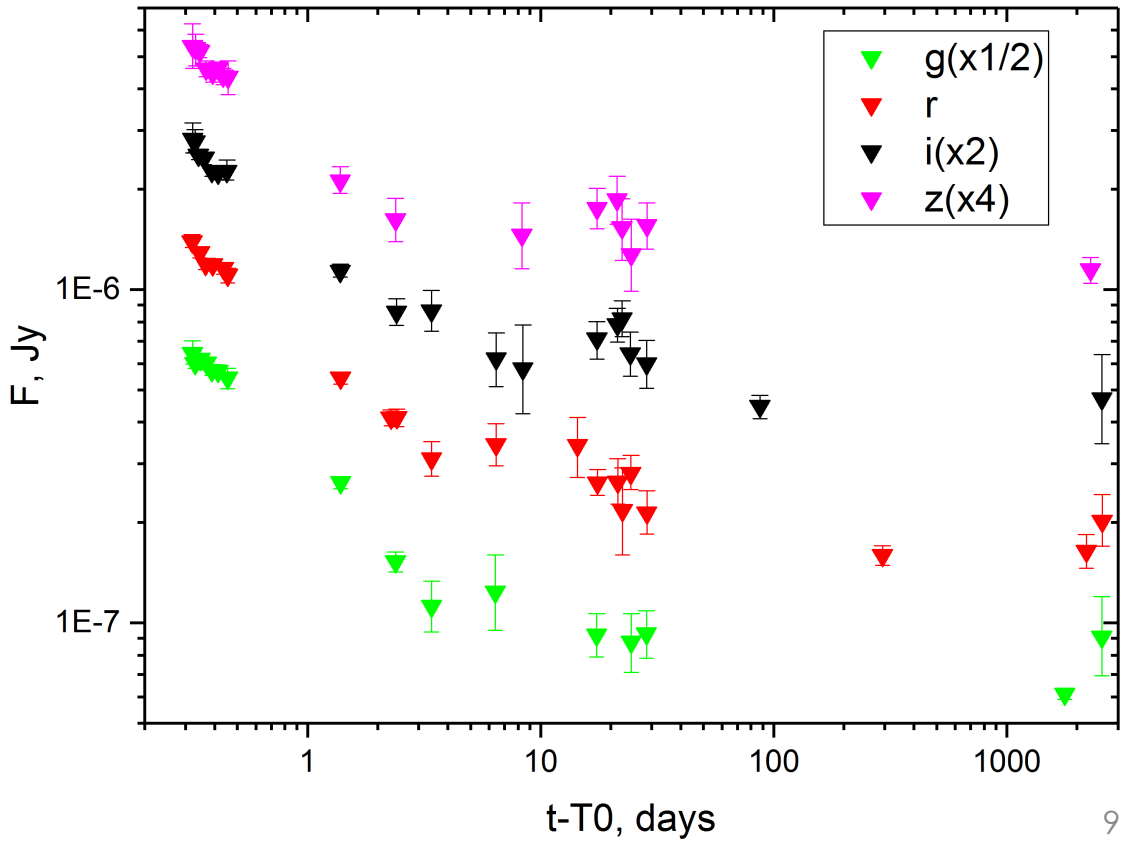
4π vs cone

E.g. GRB 071112C at the redshift z=0.812
Klose et al., 2019



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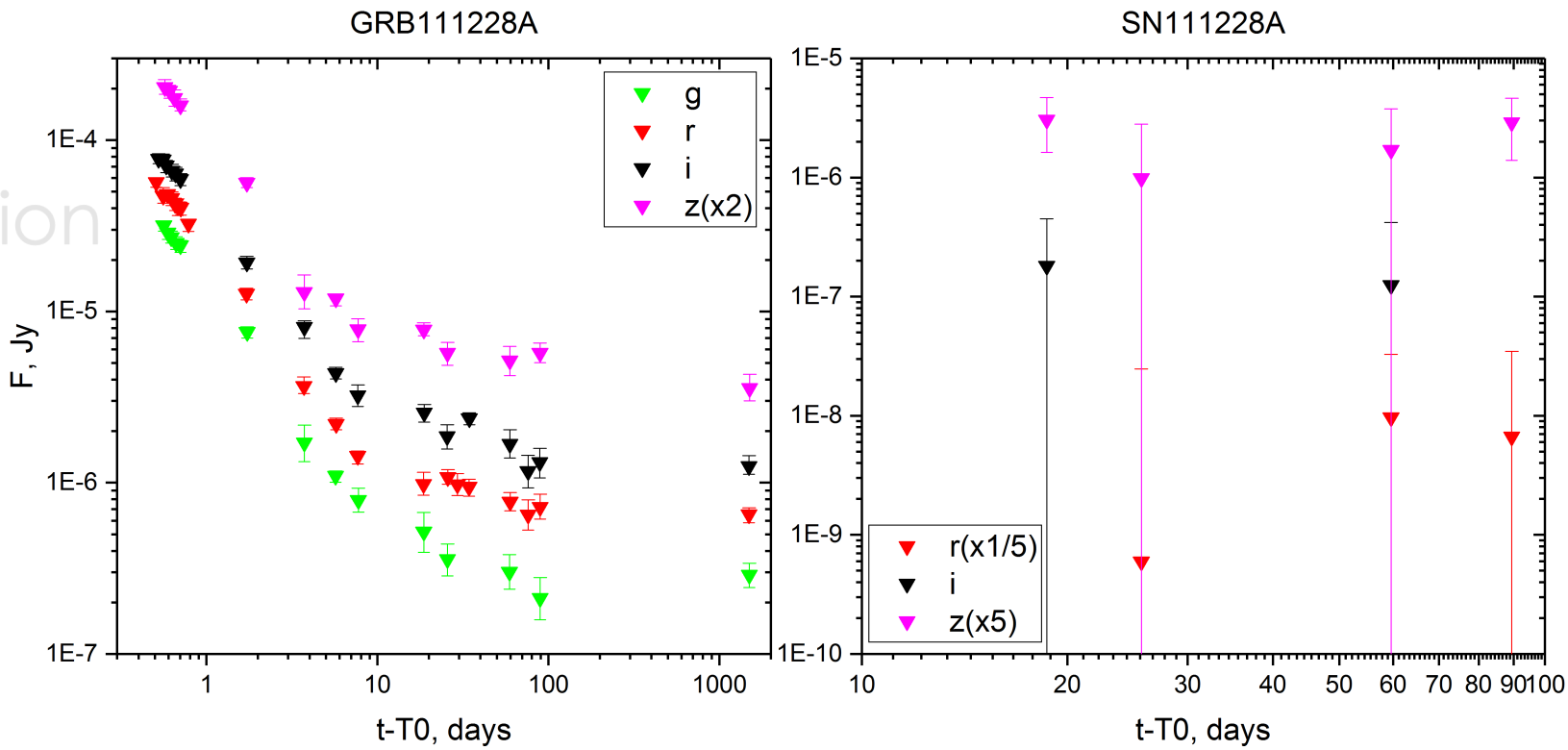
Viewing angle?

E.g. GRB 111228A
Klose et al., 2019



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- **Host galaxy extinction**
- SN location in the host galaxy
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Observational bias ⇄ most SN-GRBs are in one (R) filter

Larger wavelengths + particular telescopes specifications

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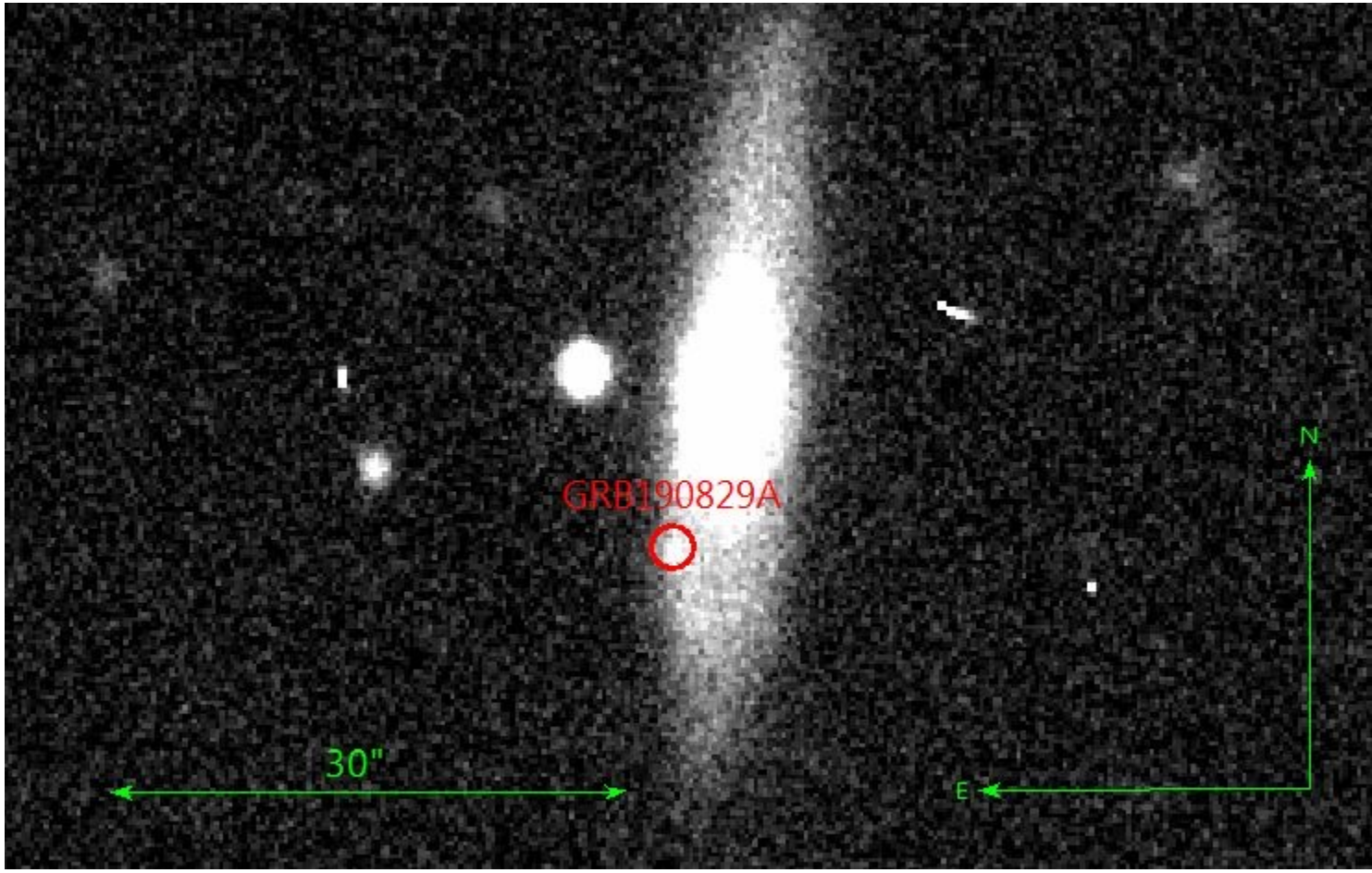

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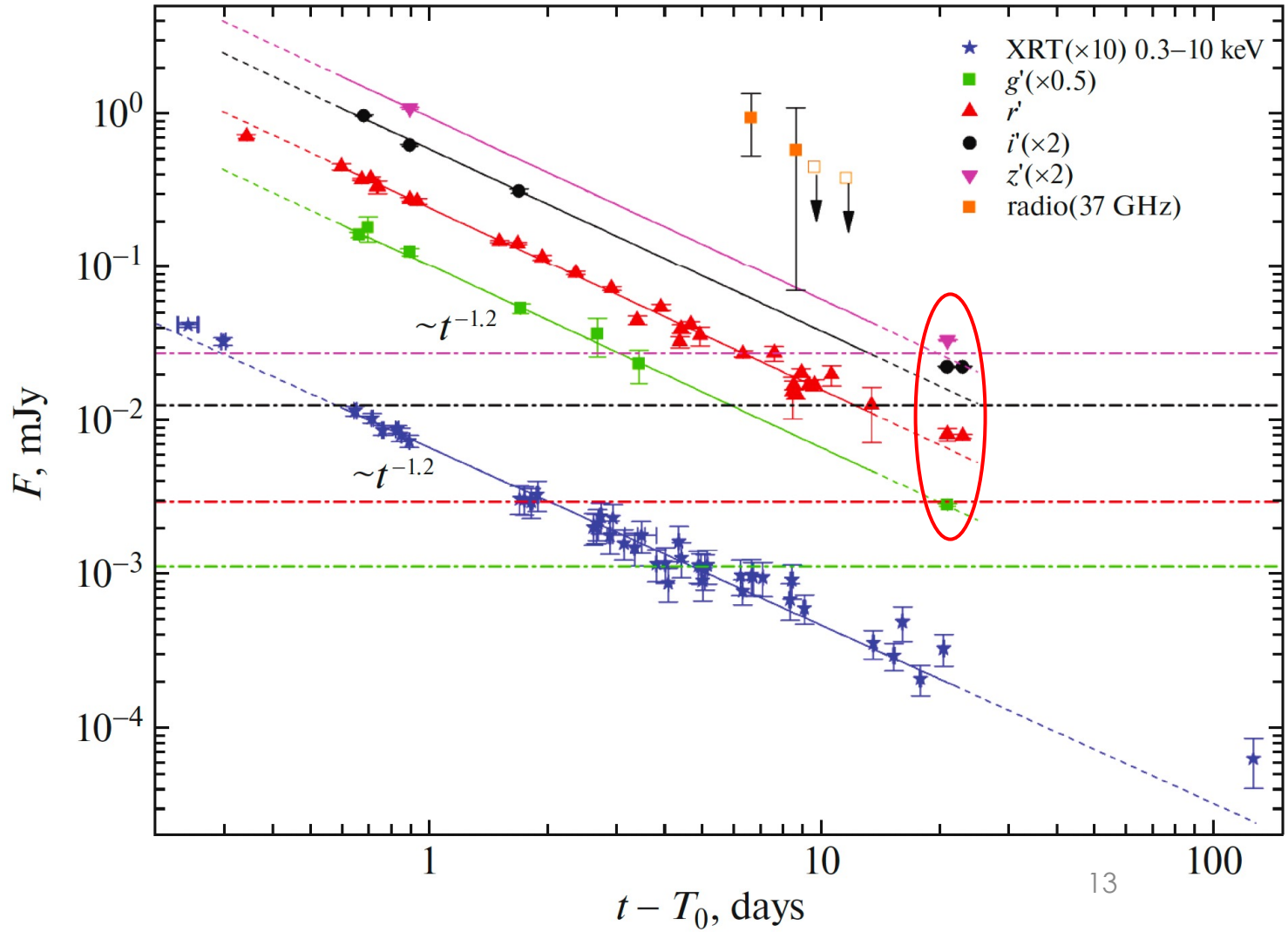
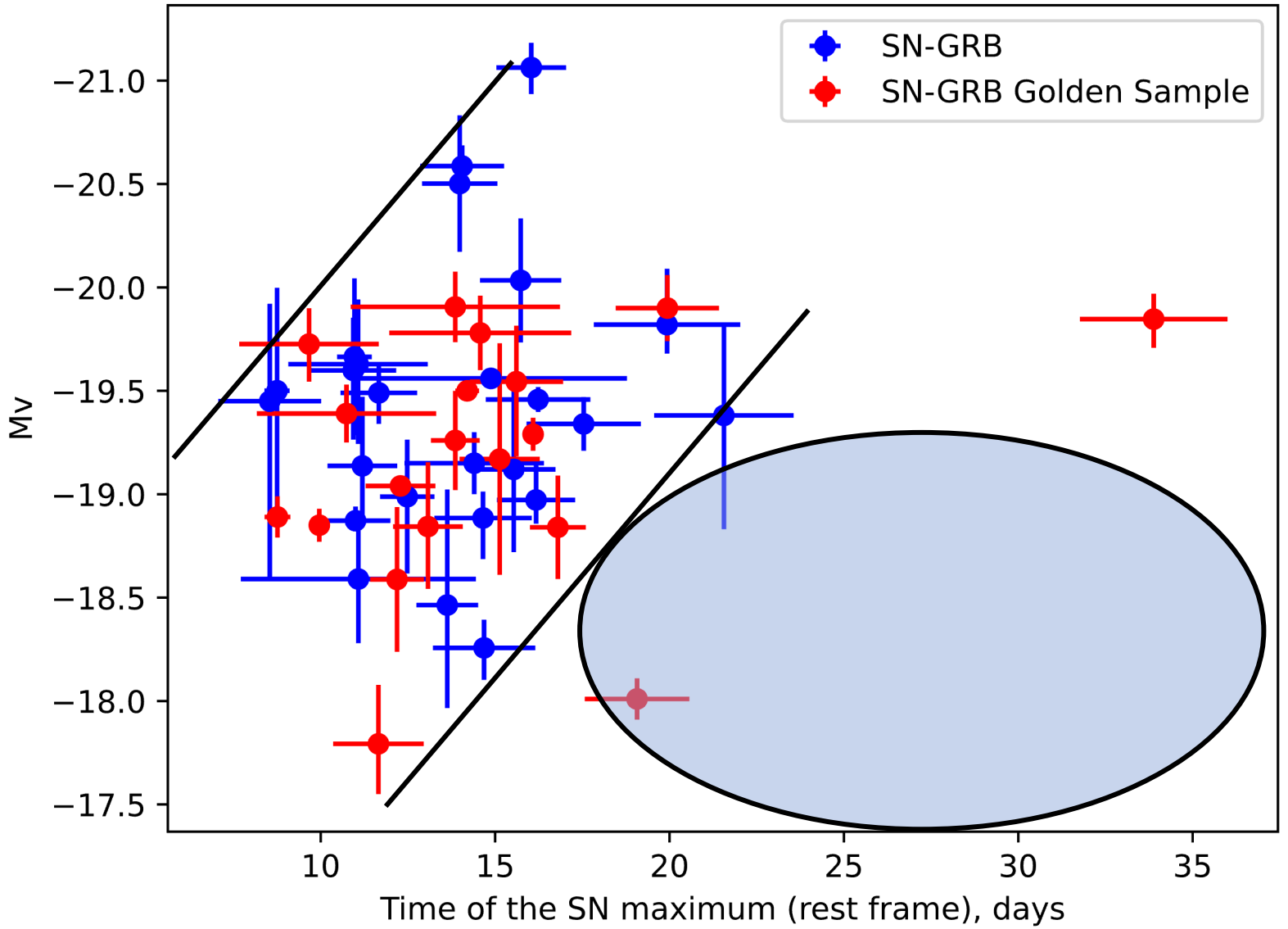
Belkin et al., 2020



Mv-Tmax distribution

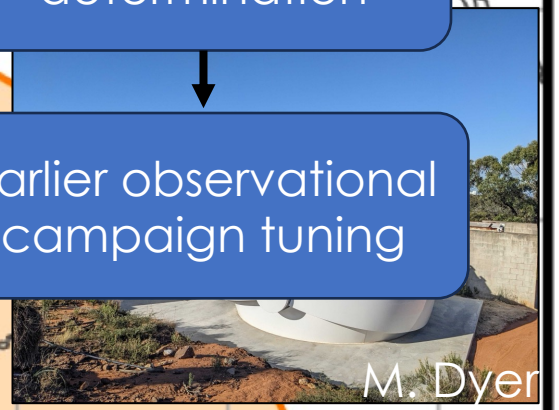


Wide-field telescopes contribution: GOTO example

- 16x40cm at each site → ~70 – 80 square degrees per site
- ~2 – 3 days observations cadency
- Limiting magnitude L~20.5

Wide-field telescopes contribution: GOTO example

Wide-field & Fast response → Earlier discovery of the GRB's optical counterpart → Faster redshift determination → Earlier observational campaign tuning



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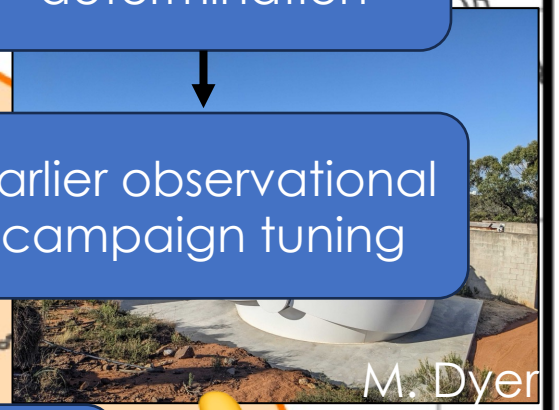
Fermi localization areas coverage → GRBs discovery → The more GRBs we observe, the more chances to catch SN-GRBs are



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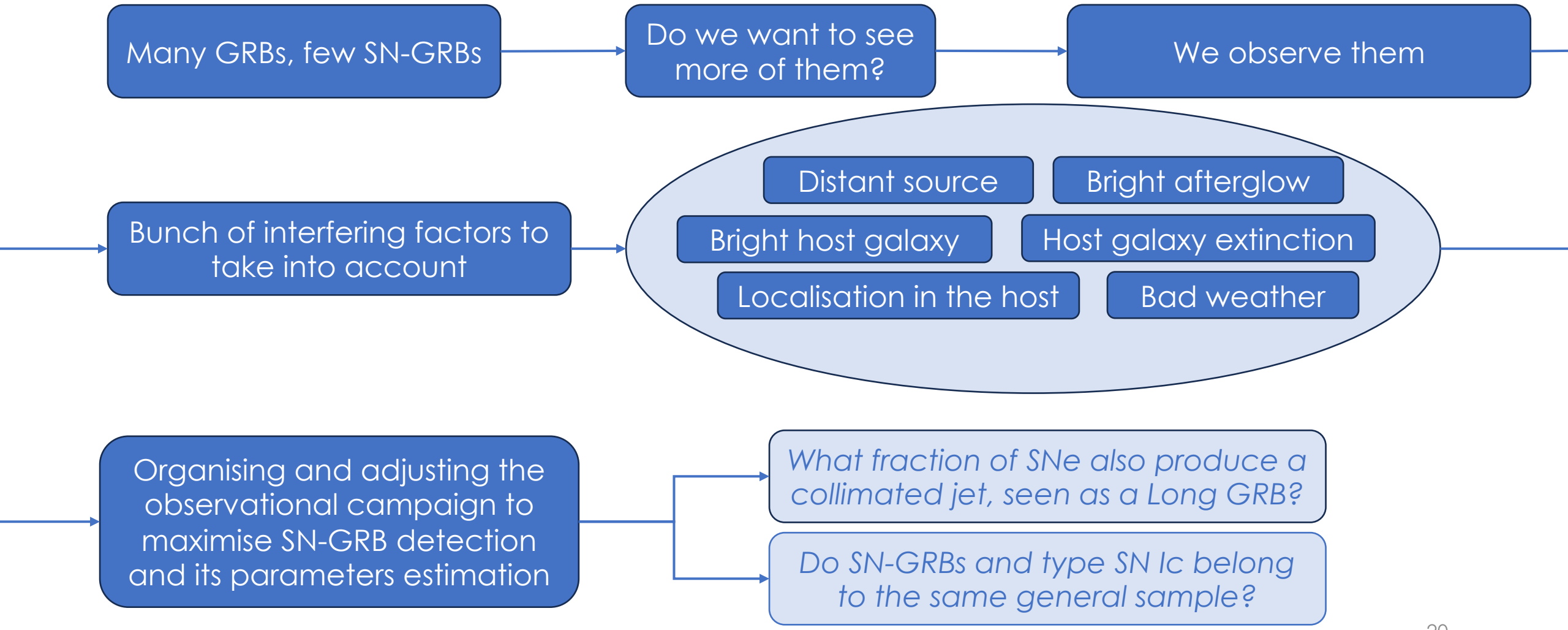
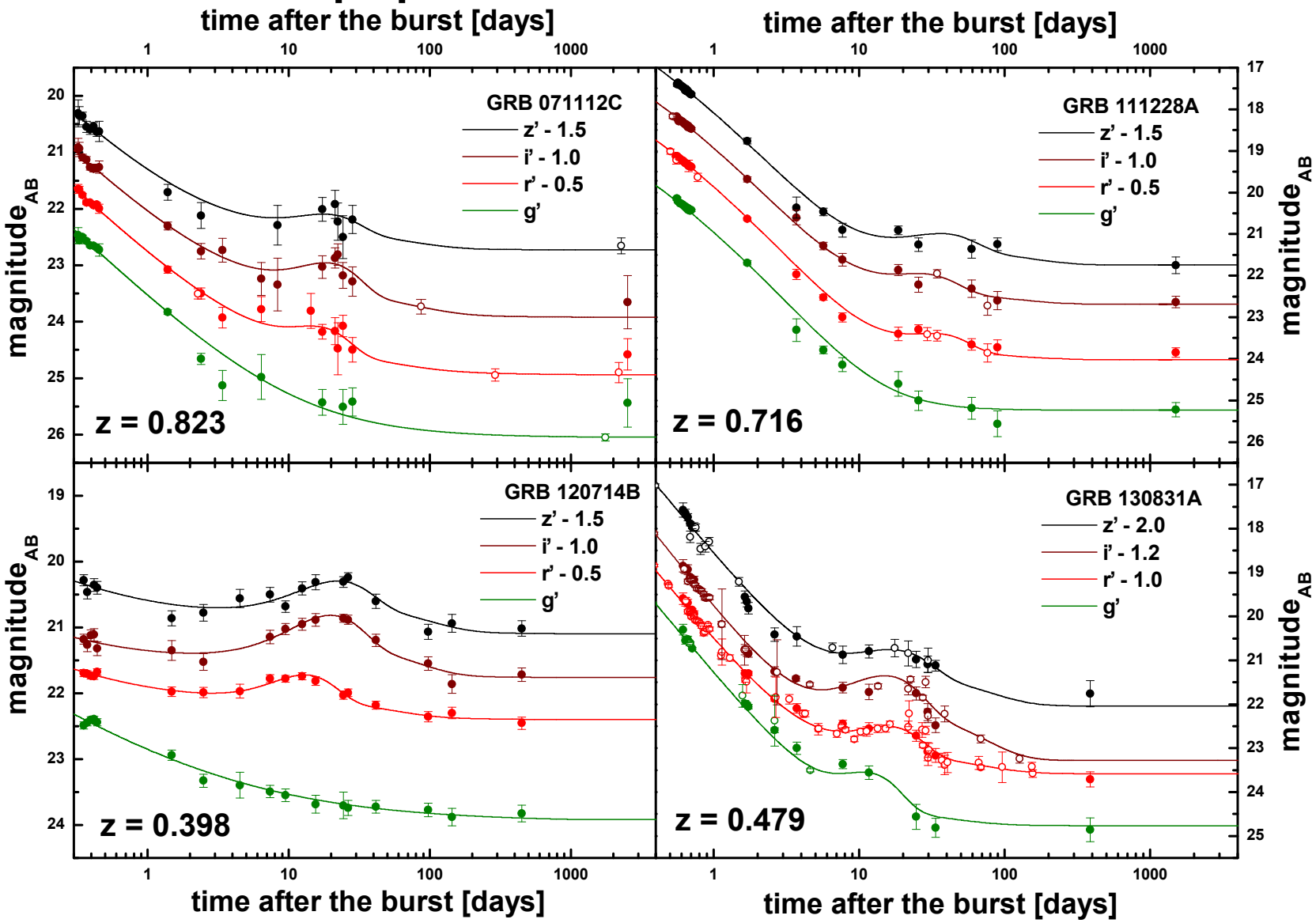
Takeaway


Many GRBs, few SN-GRBs
Do we want to see more of them?
We observe them
Bunch of interfering factors to take into account
Distant source
Bright afterglow
Bright host galaxy
Host galaxy extinction
Localisation in the host
Bad weather
Organising and adjusting the observational campaign to maximise SN-GRB detection and its parameters estimation
What fraction of SNe also produce a collimated jet, seen as a Long GRB?
Do SN-GRBs and type SN Ic belong to the same general sample?


Thank you for
your attention!

GRBs' LCs approximations



Klose et al., 2019