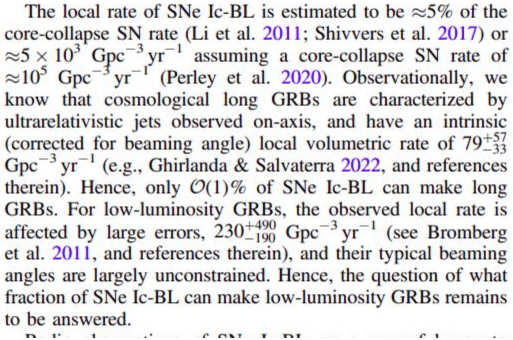
Ic-BL GRB connection

- Can we rule out the possibility that all Type Ic-BL SNe have GRB
- I.e., is all Ic-BL SNe hide a GRB?
- What is the ratio: GRB rate / Ic-BL rate ?
- If the expected ratio is consistent with 1 -
- Can we rule this option by searching for the late-time spherical radio emission?

Can we rule out that all Ic-BL produce GRBs - Rates

- Rates (Corsi+2023) - 1%
- However:
- I get: (Gpc^{-3} yr^{-1})
- 79 / (10^5 x 0.75 x 0.01) ~ O(10%)



The local rate of SNe Ic-BL is estimated to be $\approx$5% of the core-collapse SN rate (Li et al. 2011; Shivvers et al. 2017) or $\approx 5 \times 10^3$ $Gpc^{-3}\,yr^{-1}$ assuming a core-collapse SN rate of $\approx 10^5$ $Gpc^{-3}\,yr^{-1}$ (Perley et al. 2020). Observationally, we know that cosmological long GRBs are characterized by ultrarelativistic jets observed on-axis, and have an intrinsic (corrected for beaming angle) local volumetric rate of 79^{+57}_{-33} $Gpc^{-3}\,yr^{-1}$ (e.g., Ghirlanda & Salvaterra 2022, and references therein). Hence, only $\mathcal{O}(1)$% of SNe Ic-BL can make long GRBs. For low-luminosity GRBs, the observed local rate is affected by large errors, 230^{+490}_{-190} $Gpc^{-3}\,yr^{-1}$ (see Bromberg et al. 2011, and references therein), and their typical beaming angles are largely unconstrained. Hence, the question of what fraction of SNe Ic-BL can make low-luminosity GRBs remains to be answered.

Li 2011 (II fraction)

Graur 2017 (Ic-BL fraction out of II)

Beaming corrected GRB rate - Ghirlanda & Salvaterra 2022

- However, given the uncertanties - consistent with O(100%)

Can we rule out that all Ic-BL produce GRBs - Search

- Sample of 35 Ic-BL (Taddia+2019)
- VLASS - 1st epoch (3.3x10^6 sources)
- I found 2 matches - however, can not rule out galaxy extended emission
- Predictions (Levinson+2002; Frail, Waxman, Kulkarni 2000)

$$f_\nu \approx 2h^2 \left(\frac{1+z}{2}\right)^{1/2} \left(\frac{\xi_e}{0.3}\right) \left(\frac{\xi_B}{0.3}\right)^{3/4} \left(\frac{d_L}{R_0}\right)^{-2} \times n_0^{3/4} E_{51} \nu_9^{-1/2} \left[\frac{t}{t_{\mathrm{SNT}}(1+z)}\right]^{-9/10} \mathrm{mJy}\ .$$

- E51=1, n0=1 - requires, e_B<0.03 (0.01) for 6 (1) detections
- **<u>We can not rule out that 100% of the Ic-BL are associated with GRBs</u>**

Transients detection - problems and mitigation

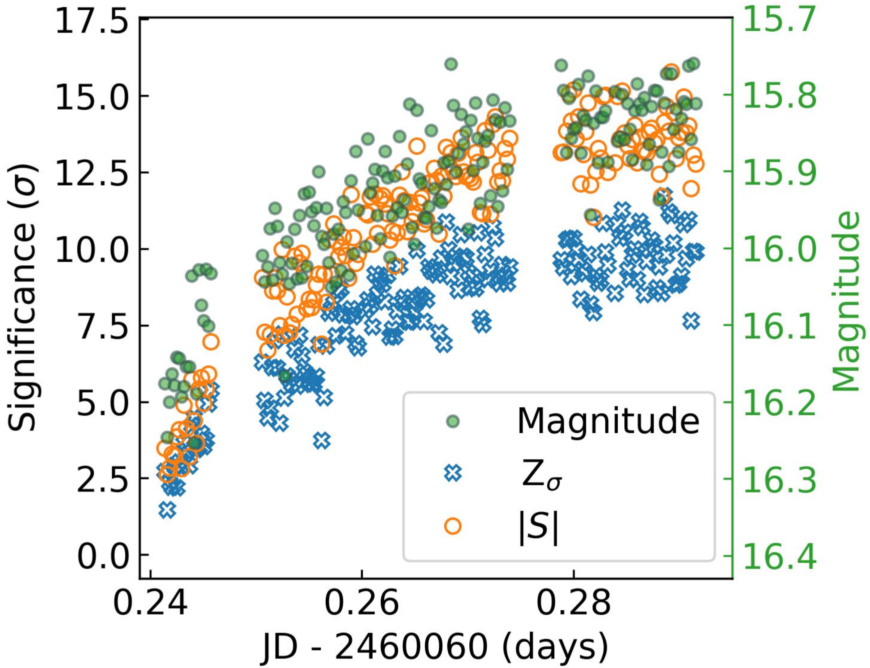
- Transients detection suffers from a large number of false alarms
- Solutions: Human scanning | ML+human classification+scanning
- ZOGY (Zackay, Ofek, Gal-Yam 2016) - solved:
  - Numerical stability (and anti-symmetry)
  - Error propagation
  - Source noise + astrometric noise (via error propagation)
- Assumptions in image subtraction:
- **Perfect registration**
- Nyquist sampled, Flux matching error, PSF errors, background-dominated noise

Translient (translational transient detector)

$$R = (T + \alpha_r \delta_{\vec{q}}) \otimes P_r + \epsilon_r,$$
$$N = (T + \alpha_n \delta_{\vec{p}}) \otimes P_n + \epsilon_n.$$

$$\mathcal{H}_0 : \vec{q} = \vec{p},$$
$$\mathcal{H}_1 : \vec{q} \neq \vec{p},$$

$$Z^2(x,y) \equiv ||\Im[\vec{z}]||^2 \qquad (22)$$
$$= \left\| \Im \left\{ \mathcal{F}^{-1} \left[\frac{4\pi\vec{k}}{m} \frac{\bar{\widehat{P}}_n \bar{\widehat{P}}_r (\widehat{P}_n \widehat{R} - \widehat{P}_r \widehat{N})}{|\widehat{P}_r|^2 \sigma_n^2 + |\widehat{P}_n|^2 \sigma_r^2} \right] \right\} \right\|^2,$$



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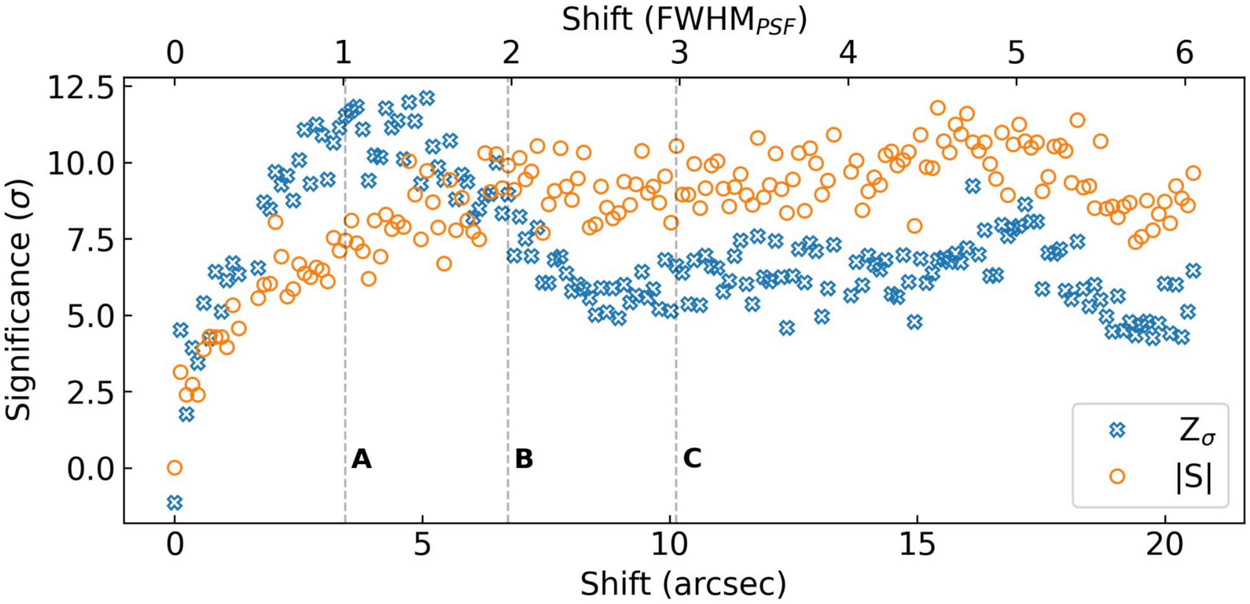

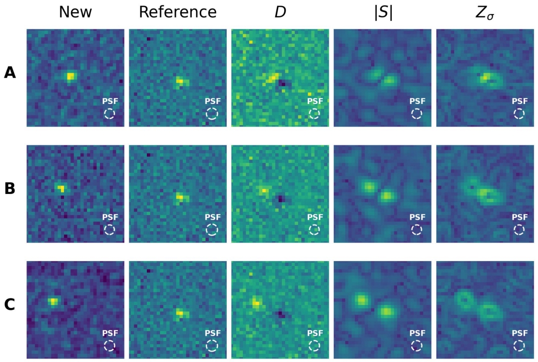

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