Why are Radio-Galaxies Prolific Producers of Type Ia Supernovae?

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-- an extention of an earlier work
-- comparison of Type Ia rates in radio-loud and radio-quiet galaxies

Data Sample

- New SN DB (Cappellaro, Evans and Turatto (1999)), about 5x statistics of the previously used one (Evans, van den Bergh and Clure (1989)).
- Used NED to find galaxy positions with morphological type T<= -1.5
- Spacially correlated (20 to 45" cuts) the SN locations with radio surveys:
  - NRAO VLA at 1.4 GHz, North of -40 deg.
  - Parkes-NIT-NRAO at 4.85 GHz south.
- Separate into classes:
  - radio-loud (>10^29 erg/s/Hz – faint limit of lum. fun. for radio)
  - radio-faint (4 x 10^27 < P < 10^29 erg/s/Hz – above thermal process
  - radio-quiet (< 4 x 10^27 erg/s/Hz)

Data Sample

Table 1: SN samples

galaxies	Evans N	Evans Control Time	Evans SNe	Cappellaro N	Cappellaro Control Time	Cappellaro SNe
radio-quiet	178	2270	0	1738	7127	7.5
radio-faint[1]	–	–	–	212	1770	4.0
radio-loud	19	847	4	267	2199	9.5
total	197	3117	4	2217	11096	21

[1]Due to the scanty statistic the *radio-faint* subclass was not adopted in our previous paper (Della Valle & Panagia 2003). Radio-faint galaxies were included in the radio-quiet subclass.

Get the fraction of radio-loud galaxy of 0.12 +- 0.02, comparable to value 0.140 +- 0.024 (Ledlow and Owen (1996))

Data Sample

The study sample is not biased toward brighter galaxies.

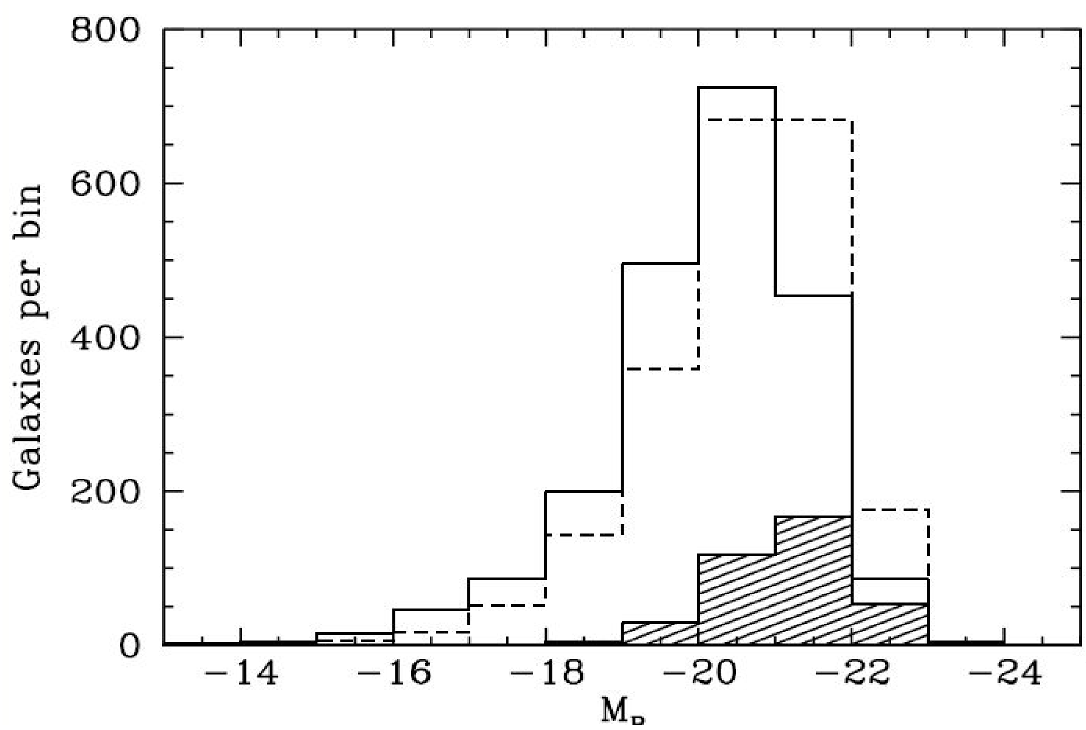


Fig. 1 Distribution of early-type galaxies in the Cappellaro et al. (1999) sample as a function of their absolute B-band magnitudes. The solid line is the distribution of the entire sample, the shaded histogram is the distribution of radio-loud galaxies, and the dashed histogram is the general luminosity function of elliptical galaxies, adapted from Muriel et al.(1995).

Result

Table 3: SN rates in units of SNe per century per 10^{10} $L_{\odot}^{B}$

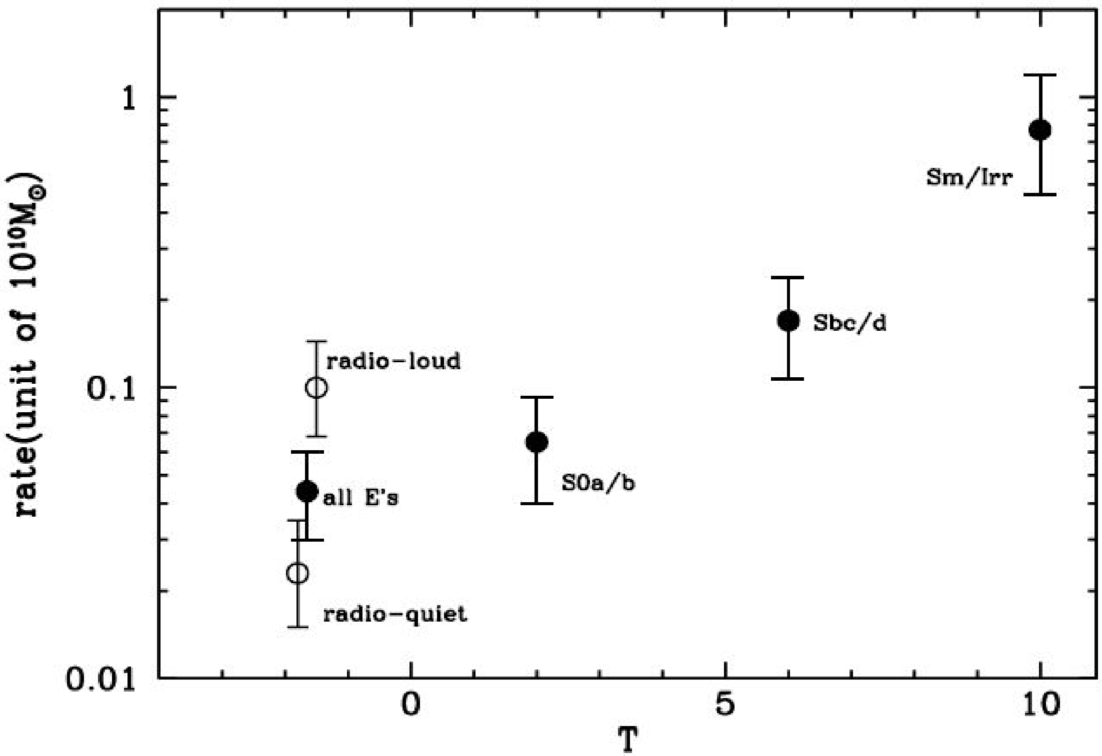
	rate	1σ	2σ	3σ
radio-loud	0.43	$^{+0.19}_{-0.14}$	$^{+0.38}_{-0.23}$	$^{+0.60}_{-0.30}$
radio-faint	0.23	$^{+0.18}_{-0.11}$	$^{+0.36}_{-0.16}$	$^{+0.59}_{-0.19}$
radio-quiet	0.11	$^{+0.06}_{-0.03}$	$^{+0.11}_{-0.06}$	$^{+0.18}_{-0.07}$

Table 4: SN rates in units of SNe per century per 10^{10} $M_{\odot}$

	rate	1σ	2σ	3σ
radio-loud	0.100	$^{+0.044}_{-0.032}$	$^{+0.089}_{-0.054}$	$^{+0.141}_{-0.070}$
radio-faint	0.052	$^{+0.041}_{-0.025}$	$^{+0.082}_{-0.038}$	$^{+0.135}_{-0.046}$
radio-quiet	0.023	$^{+0.012}_{-0.008}$	$^{+0.024}_{-0.013}$	$^{+0.035}_{-0.018}$
all E's	0.044	$^{+0.016}_{-0.014}$		
S0a/b	0.063	$^{+0.027}_{-0.025}$		
Sbc/d	0.170	$^{+0.068}_{-0.063}$		
Irr	0.77	$^{+0.42}_{-0.31}$		

Factor of ~4 enhancement in radio-loud, compared to radio-quiet galaxies.

Result

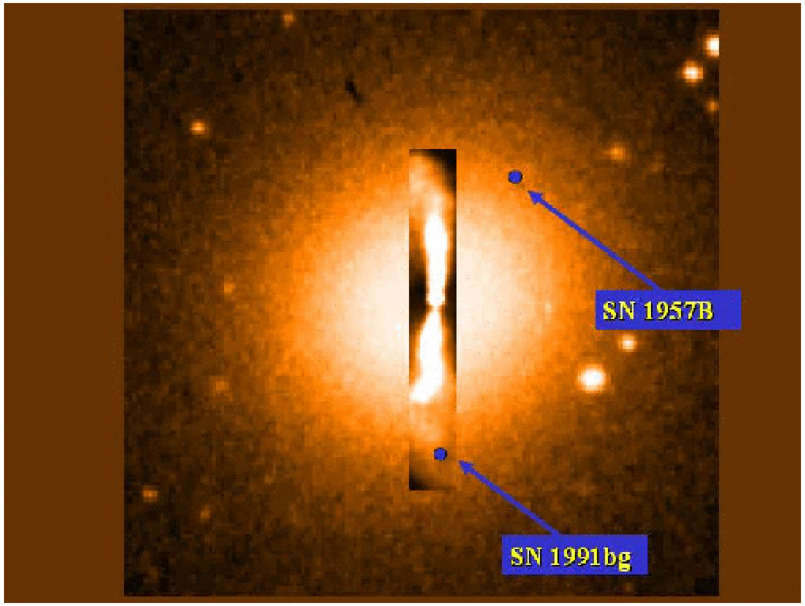

rate(unit of 10^10 M_⊙)
1
0.1
0.01
0
5
10
T
radio-loud
all E's
radio-quiet
S0a/b
Sbc/d
Sm/Irr

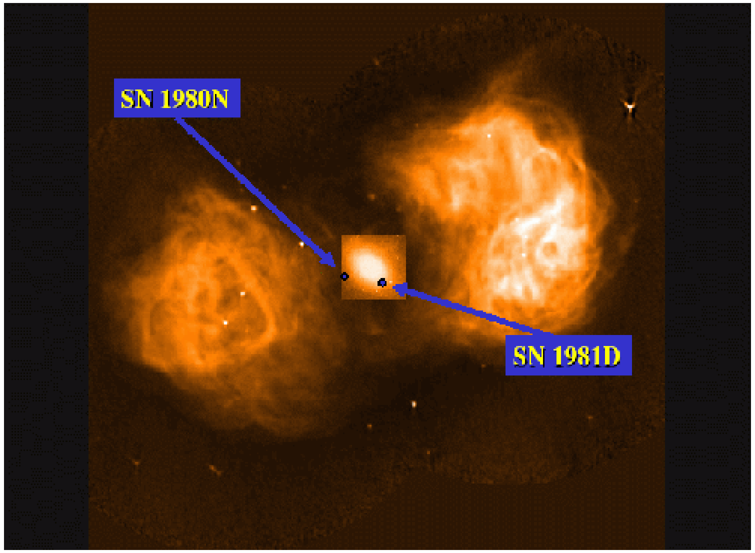
Explanation: a) jets are bad

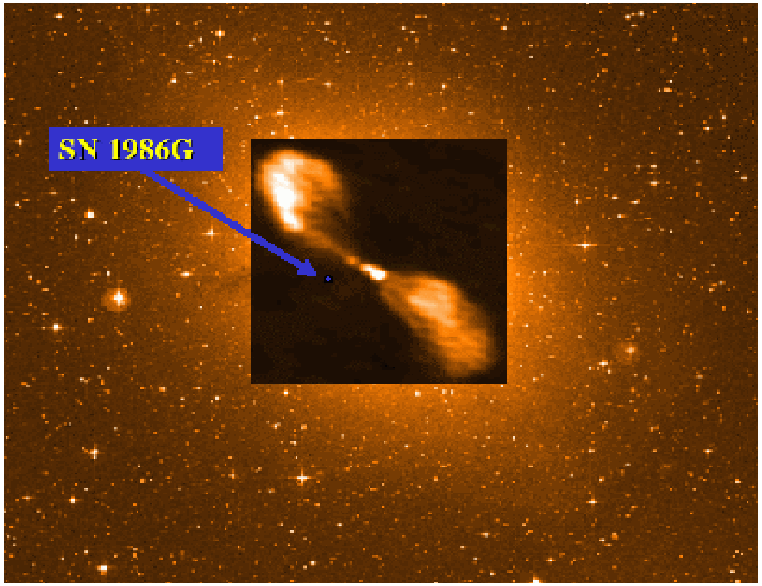
Some numerical estimates are presented to show that an increase in WD accreation rate due to jet-induced material mixing is unlikely to be substential. Also:

- There would be spacial correlation (next slide)
- Rate increase in throughout significant portion of the galaxy (??)
- For advocated jet parameters, there would be a strong 21cm line emission (never observed for jets)
- SNe in spirals are not associated with molecular clouds.

Explanation: a) jets are bad







Explanation: b) mergers are good

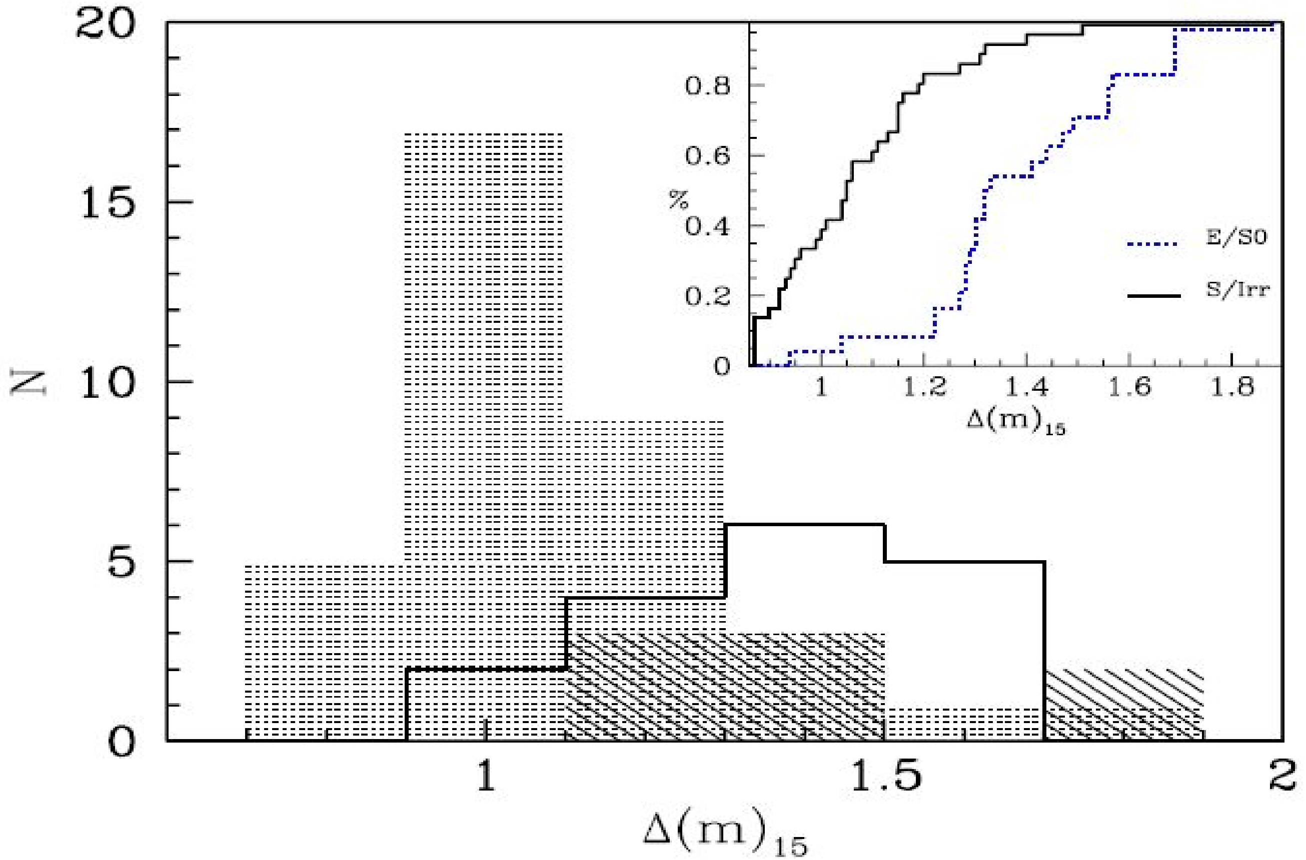
Interactions/mergers are responsible for radio emission; formations/capture of young stellar populations with higher SNe Ia rates.

On average, an elliptical galaxy has 0.14 x T_H/T_{loud} ~ 20 episodes, with interval $T_{loud}/0.14$ ~ 0.7 Gyr.

- Rates in other galaxy types.
- Find intermediate rate of decline between spirals and ellipticals.

In this scenario, there should be some amount of core-collapse events at an early stage of a star formation burst. Estimate (~30 Myr/1Gyr * (8/3) = 8%) -- compatible with no detection.

Rate of decline



The distribution of the lightcurve rates of decline for late (shade-dotted histogram) and early type galaxies (solid histogram) and the respective cumulative distributions. The dashed box indicates the rates of decline for 8 objects belonging to the sample listed in Table 2.