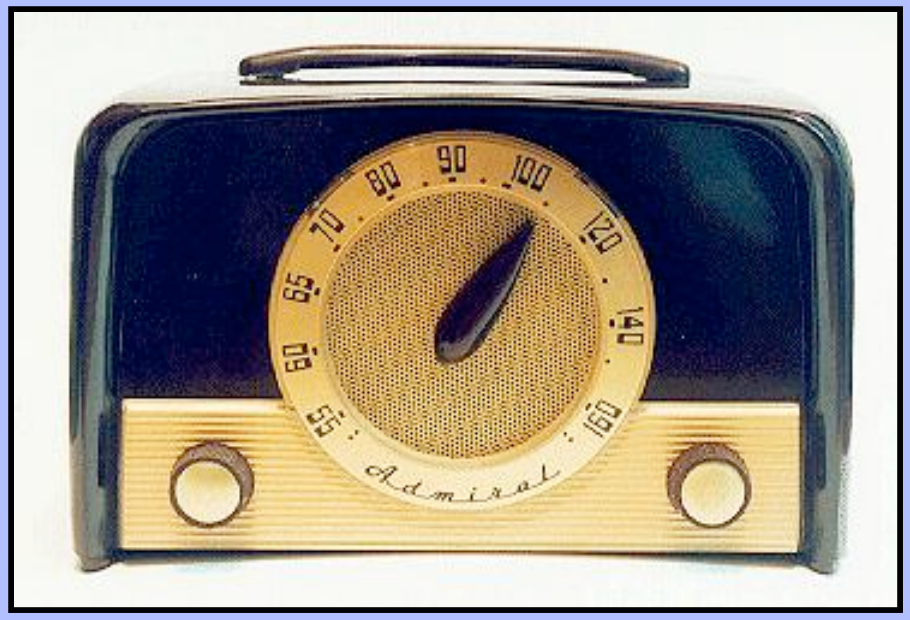
A Radio Perspective on the GRB-SN Connection



Alicia M. Soderberg

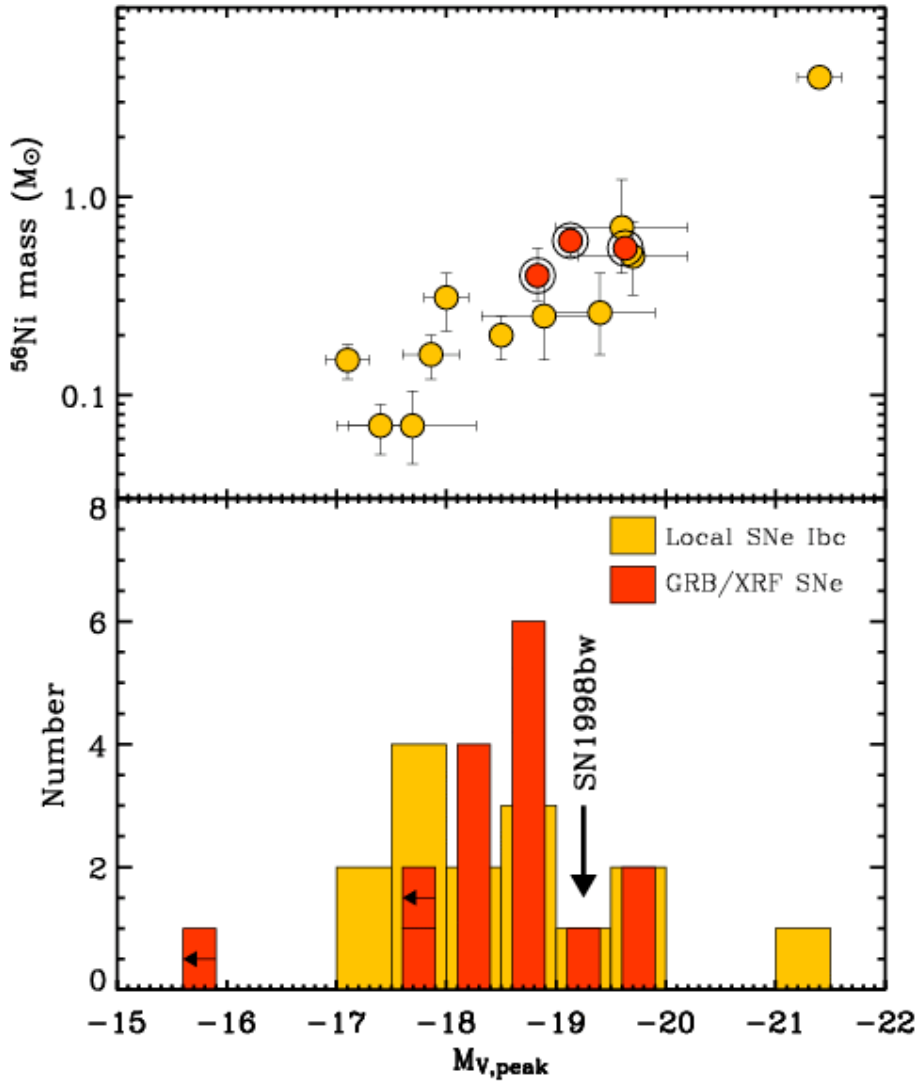
Caltech

KITP GRB/SN Meeting, Feb 7 2006

OutLine & PunchLine

1. Optical data **cannot** be used to distinguish between GRB-SNe and typical SNe Ibc.
2. Radio observations are **crucial** since they trace the fastest ejecta.
3. Thanks to our large VLA survey of local SNe Ibc we place direct constraints: **<10% of SNe Ibc host GRB jets and <2% are like SN1998bw.**
4. Broad-lined SNe ("hypernova") show no evidence for relativistic ejecta. **Our radio data rule out the standard unification models.**

An Optical Perspective on the GRB-SN Connection



M_V a rough proxy for ^{56}Ni

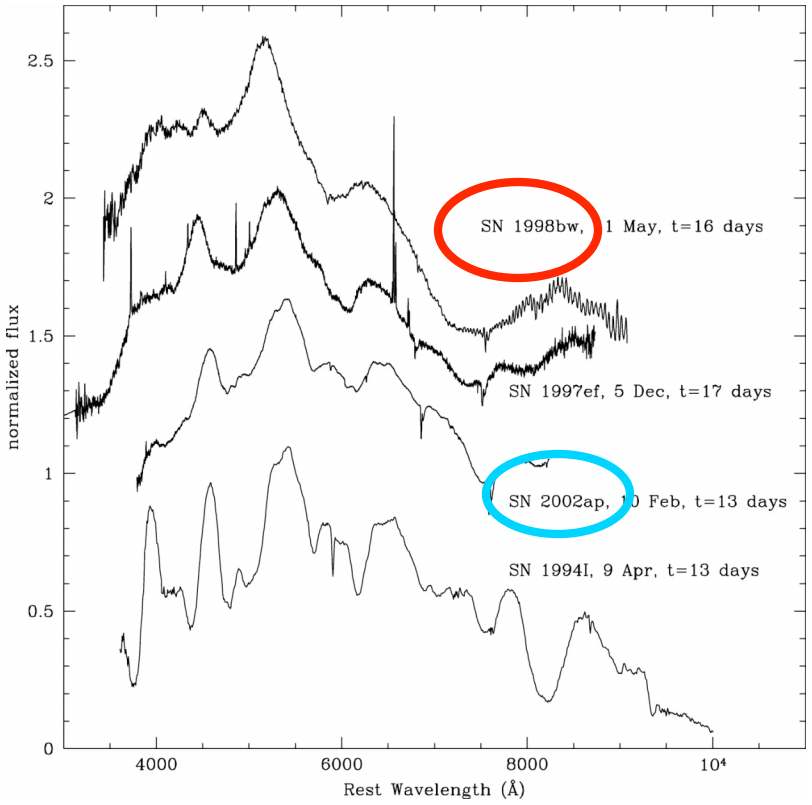
1. M_V dist^n are similar
2. SN1998bw is **NOT** the brightest event
3. Broad-lined SNe (5% of local pop^n) are not overluminous.

Soderberg et al., 2006a, ApJ, 636, 391

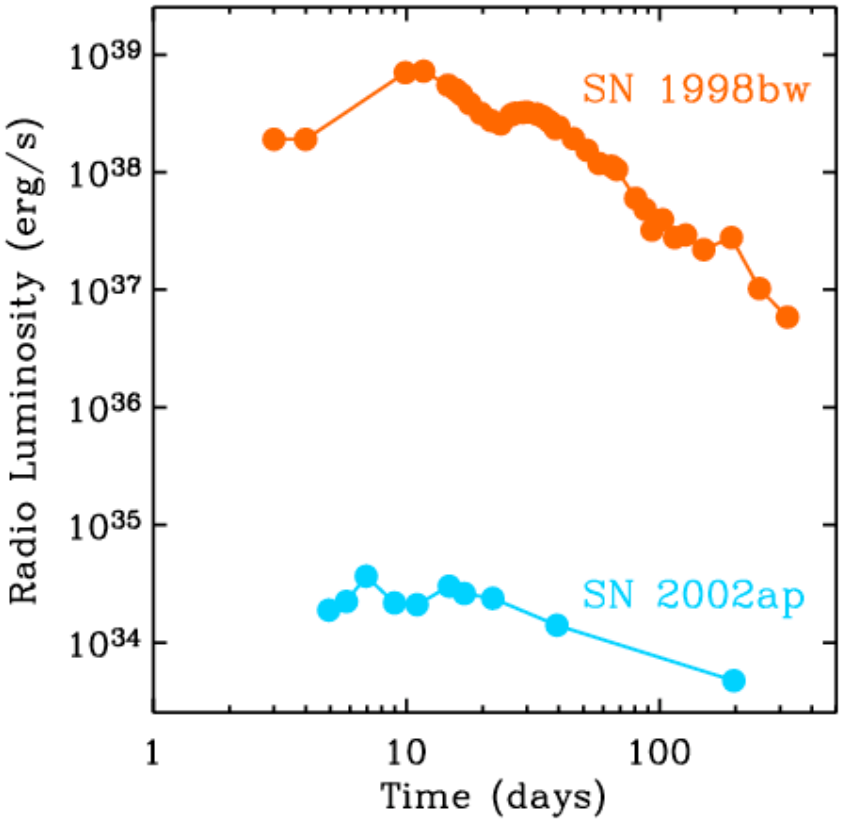
Optical Just Doesn't Cut It

SN2002ap was spectroscopically identical to **SN 1998bw**

L_{opt} ~ 0.2 x 98bw **BUT** L_{radio} ~ 10^{-4} x 98bw

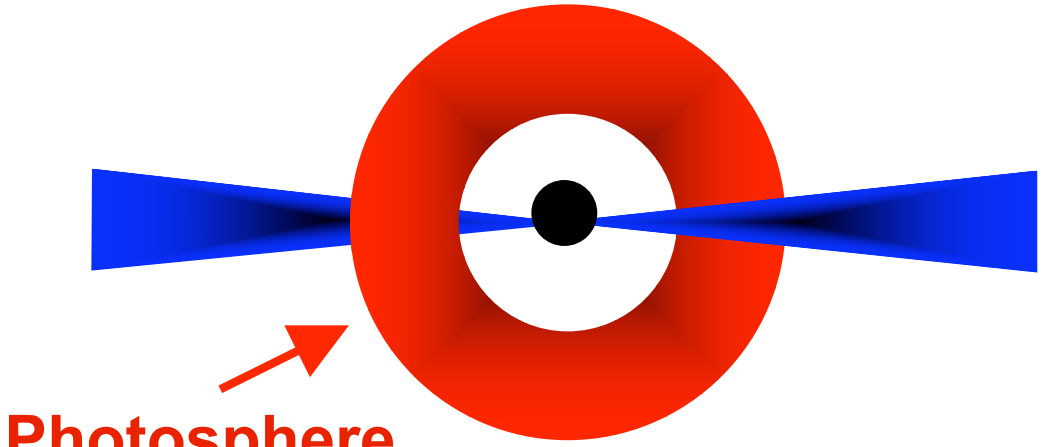


(Mazzali et al 2002)



(Kulkarni et al 1998, Berger 2002)

Radio Emission Traces the ***Fastest*** Ejecta



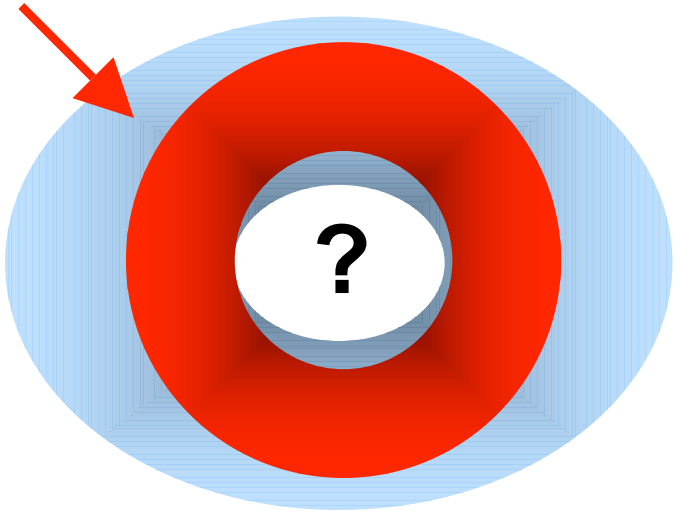
Photosphere

v ~ 0.03, E ~10^{51} erg

Fastest Ejecta

v ~ 0.1c to Γ **~ few**

E ~ 10^{45} to **10^{51} erg**



$$L_{radio} \propto E_{fast}$$

Radio Calorimetry

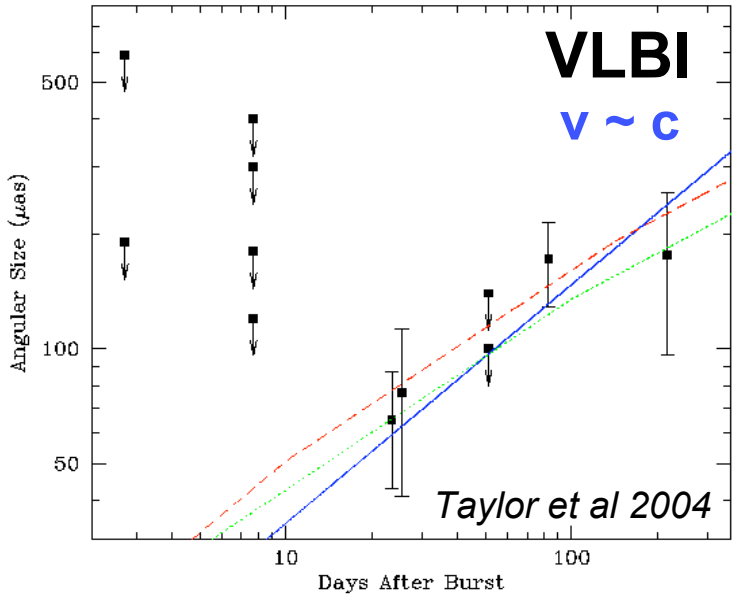
When $M_{sw} \approx E_0 / c^2$ the blast-wave becomes non-relativistic and nearly spherical:

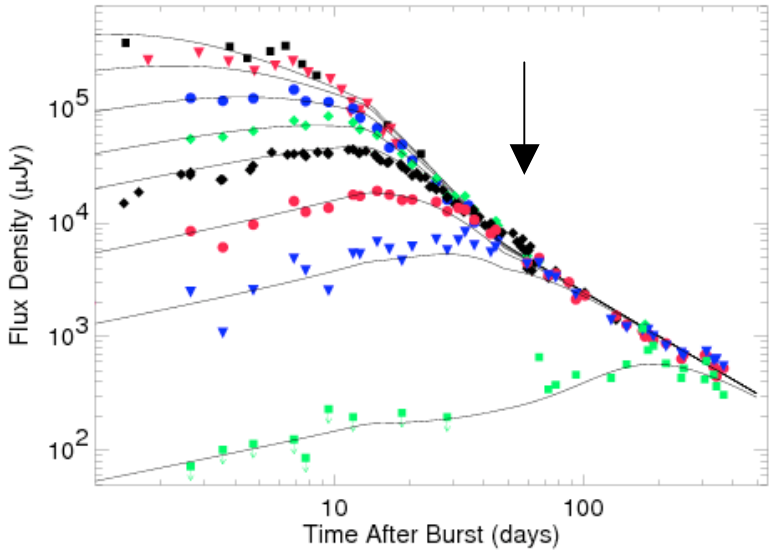
- Observed Flattening
- $t_{NR} \sim 65\ (E_{iso,52} / n_0)^{1/3}$ days

	970508	980703	030329
t_{NR} (days)	90	40	50
R (10^{17} cm)	3.7-6	1-2.5	2-4
E_{ST} (10^{51} erg)	**1.5 - 4**	**1 - 6**	**0.7 - 2.2**

$$E_{rel} \approx (1\text{-}5) \times 10^{51}\ \text{erg}$$

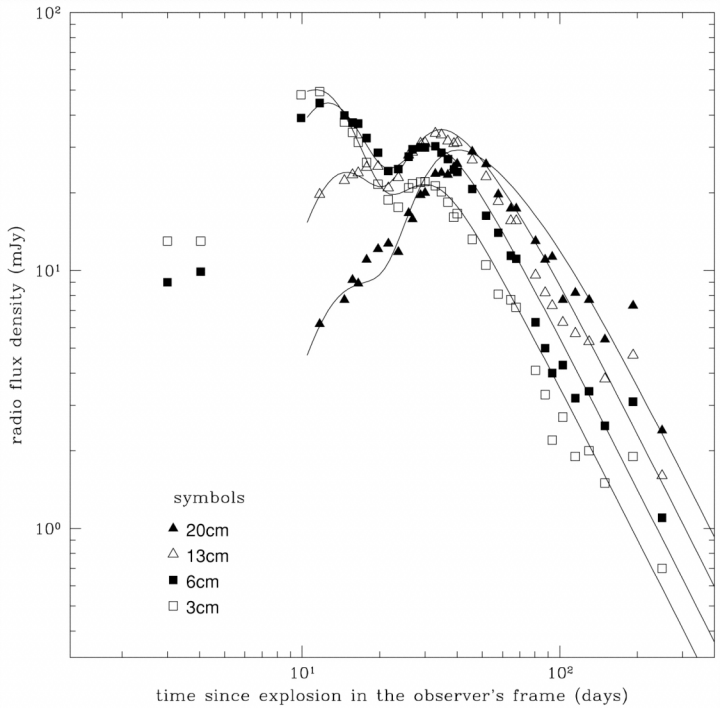
GRB 030329





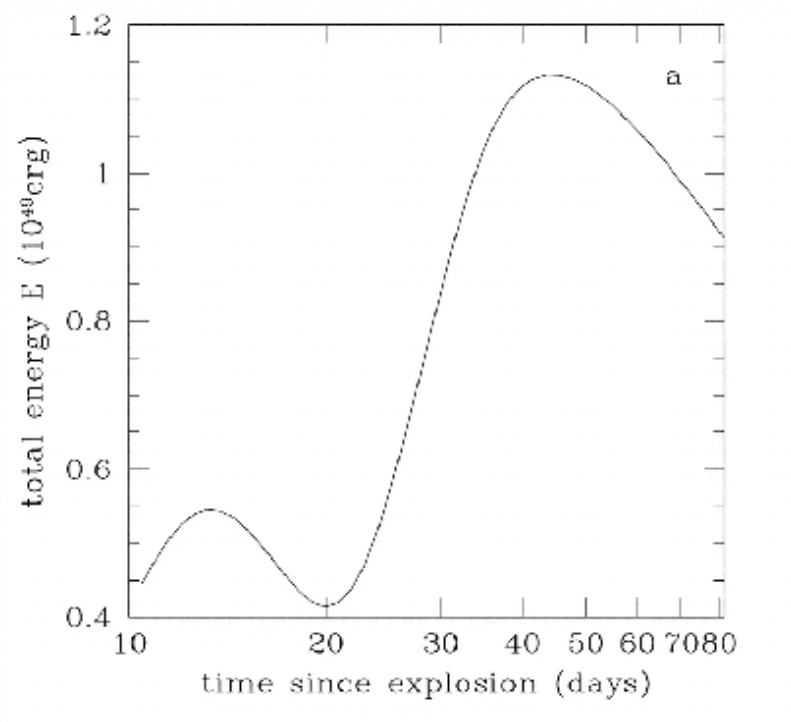
Frail et al 2005

Radio Calorimetry



SN1998bw / GRB980425

d ~ 36 Mpc



$E \sim 10^{49}$ erg

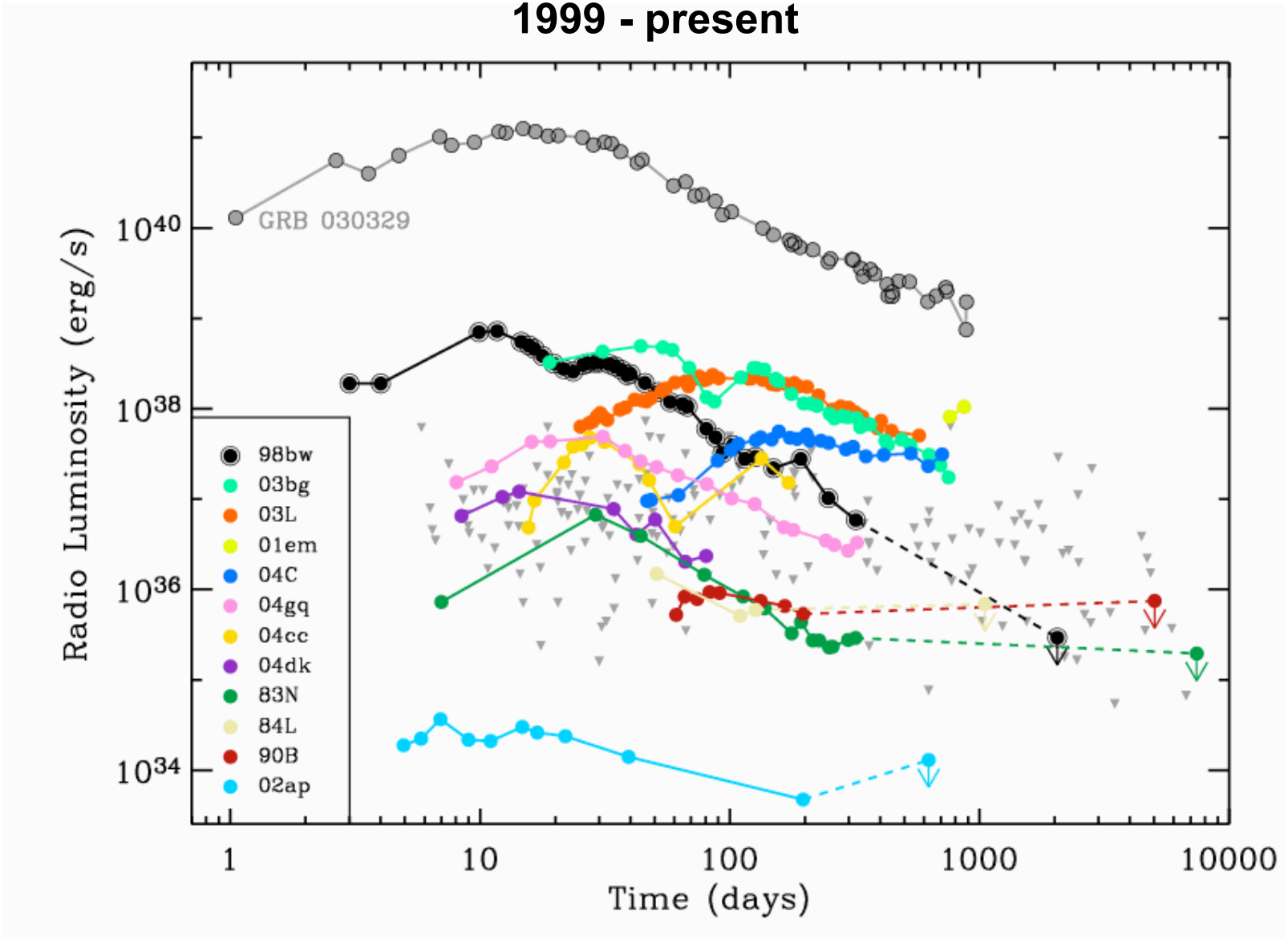
$\Gamma \sim 3$

Mildly aspherical

(Kulkarni et al. 1998; Li & Chevalier 1999)

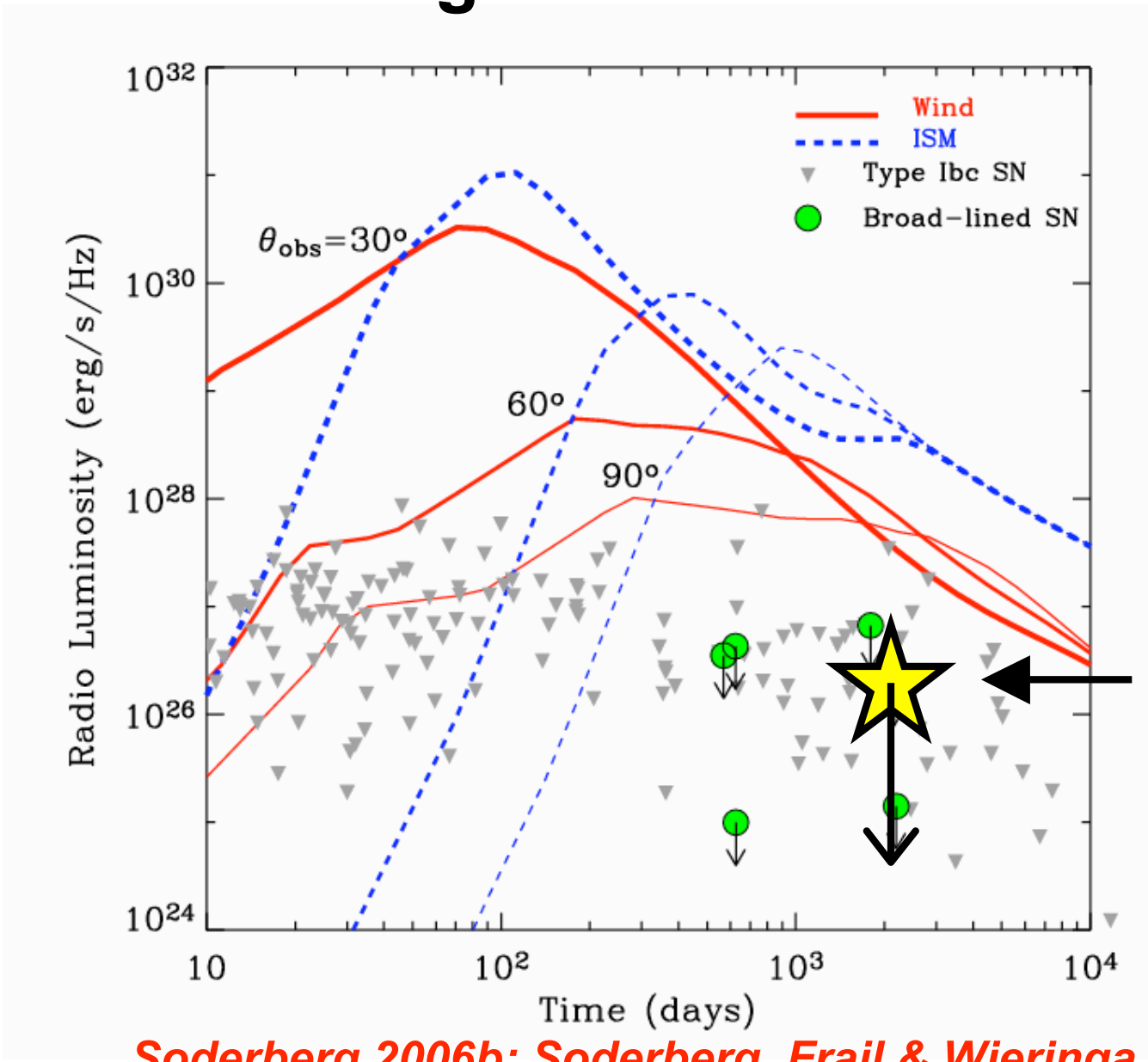
The Caltech/NRAO Radio Survey of SNe Ibc

1999 - present



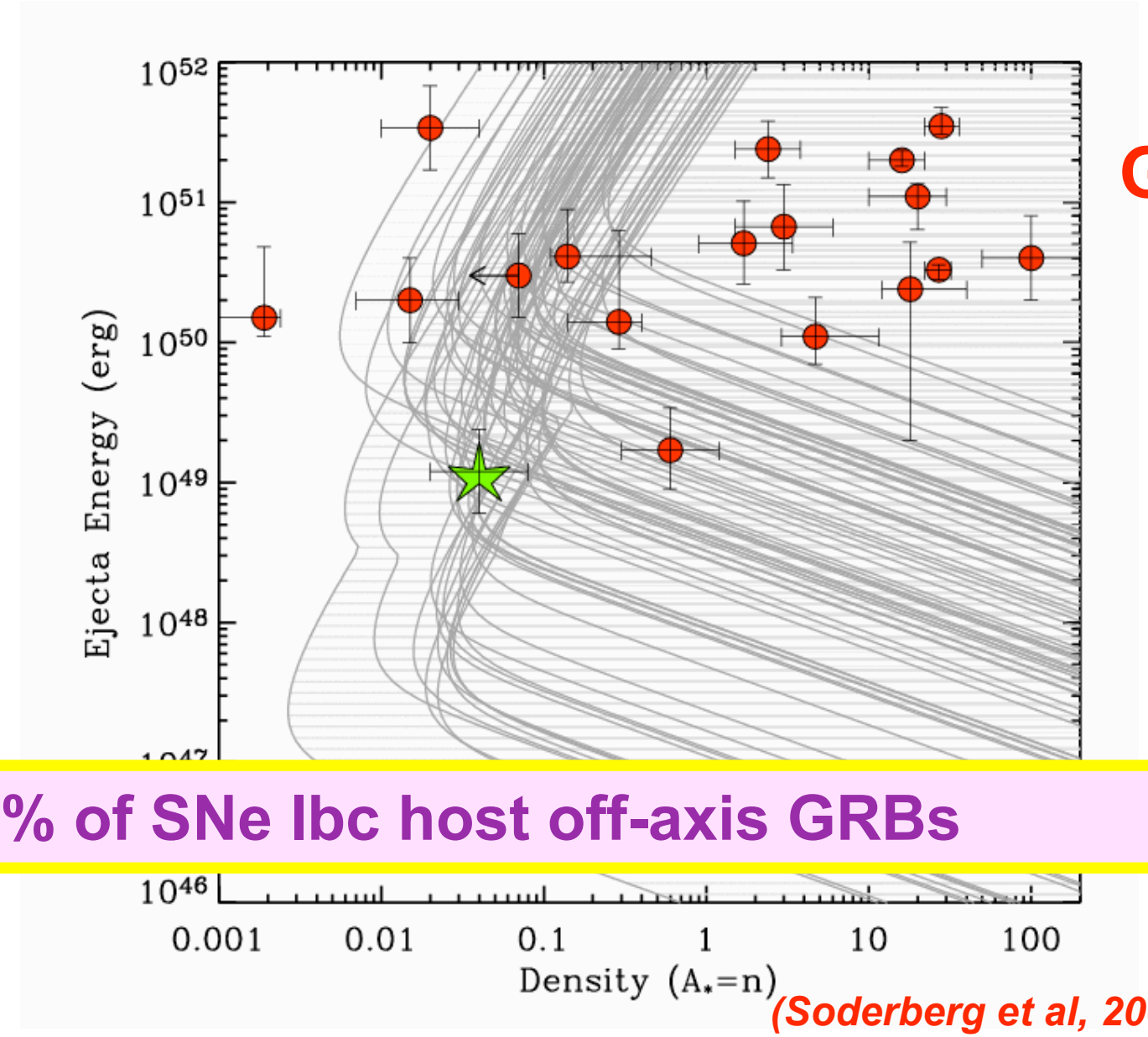
(Weiler 1986; Kulkarni 1998; Berger 2002; Soderberg 2004,2005a,2006b & in prep)

Constraining Off-Axis GRB Jets



Soderberg 2006b; Soderberg, Frail & Wieringa 2004

Constraints on Energy & Density



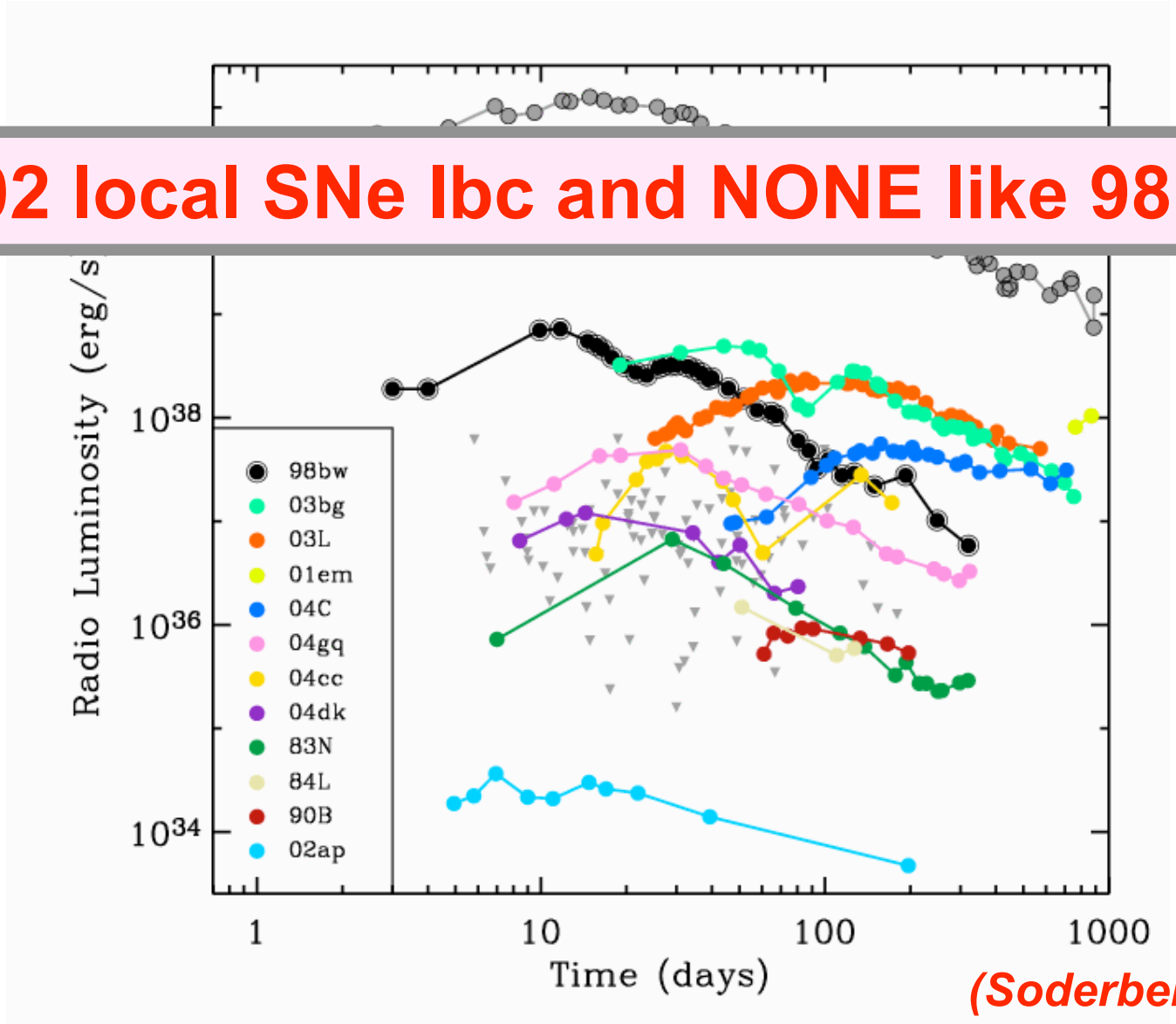
GRBs

< 10% of SNe Ibc host off-axis GRBs

(Soderberg et al, 2006b)

Constraining on-axis Ejecta (< 30º)

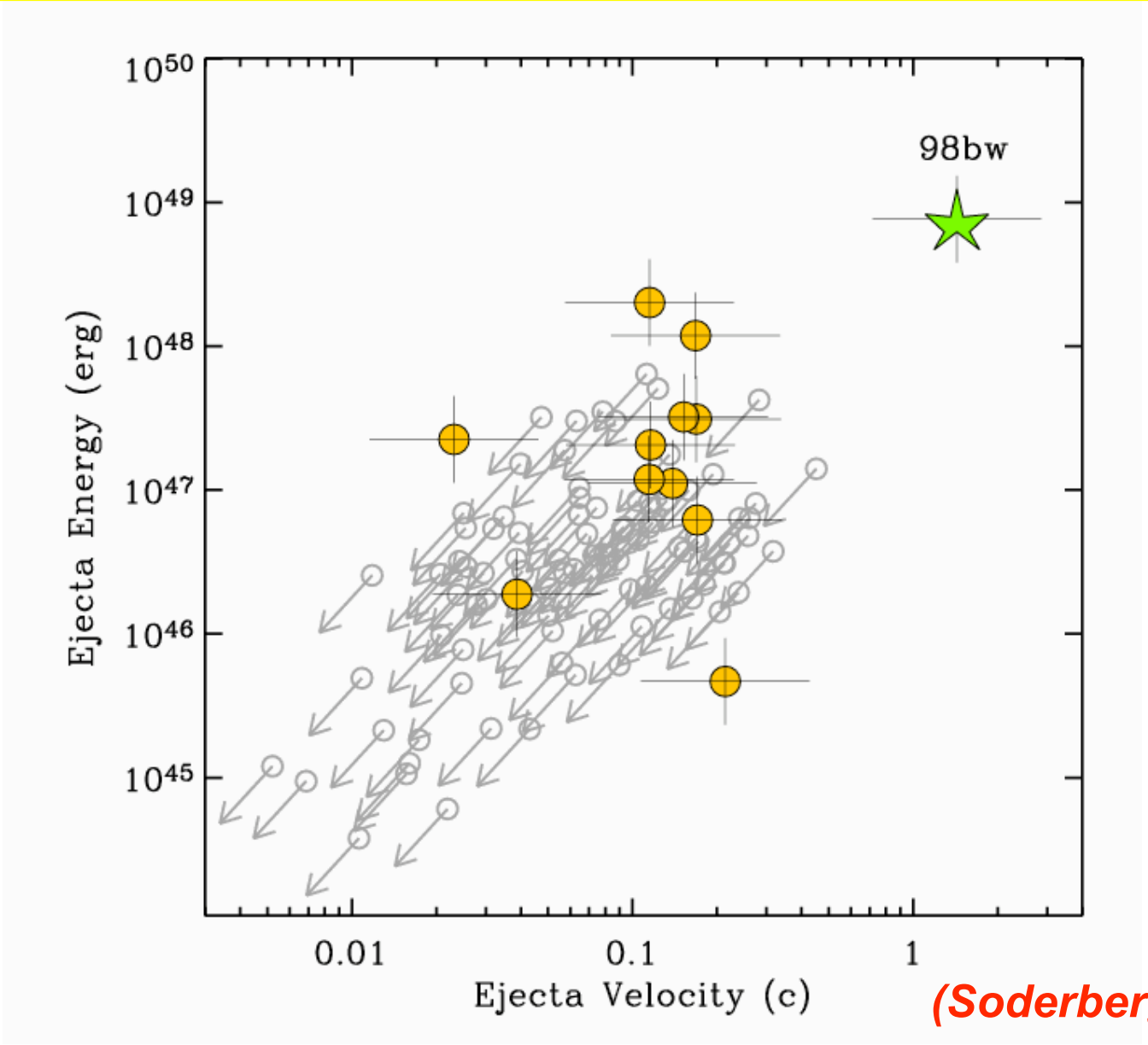
102 local SNe Ibc and NONE like 98bw



11/17

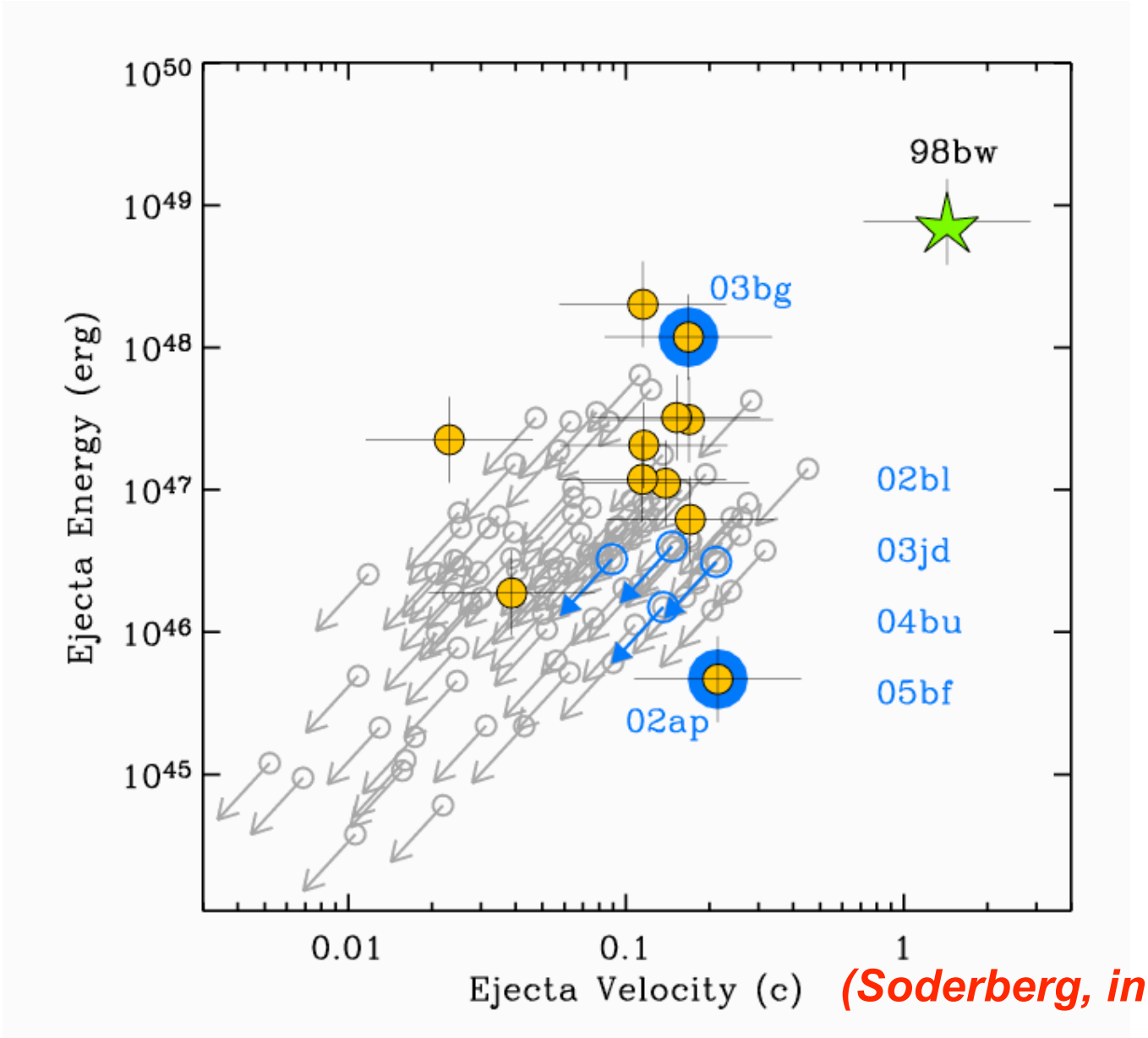
(Soderberg, in prep)

< 2% of SNe Ibc are SN1998bw-like



(Soderberg, in prep)

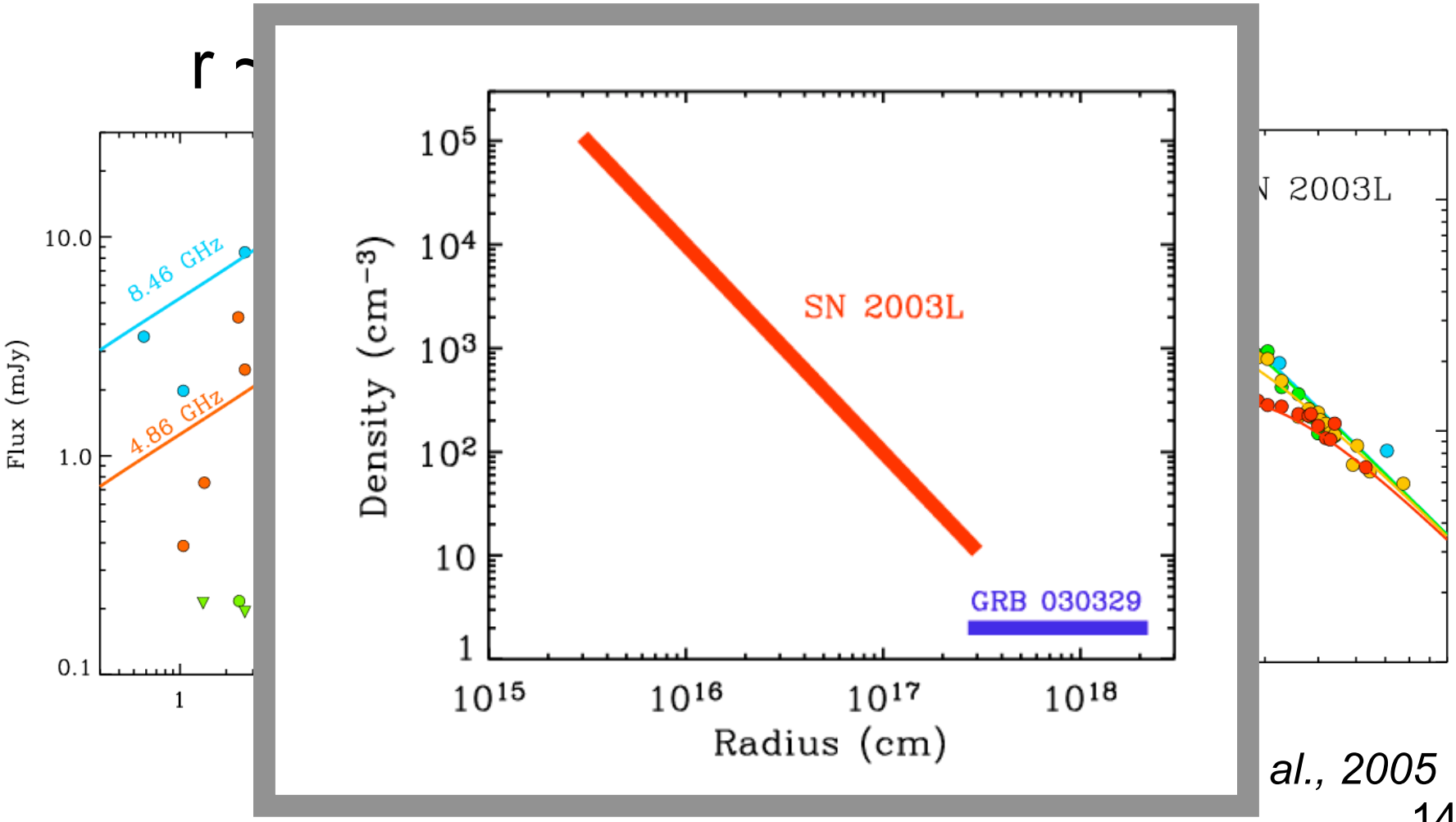
Broad-lined SNe are NOT Special



(Soderberg, in prep)

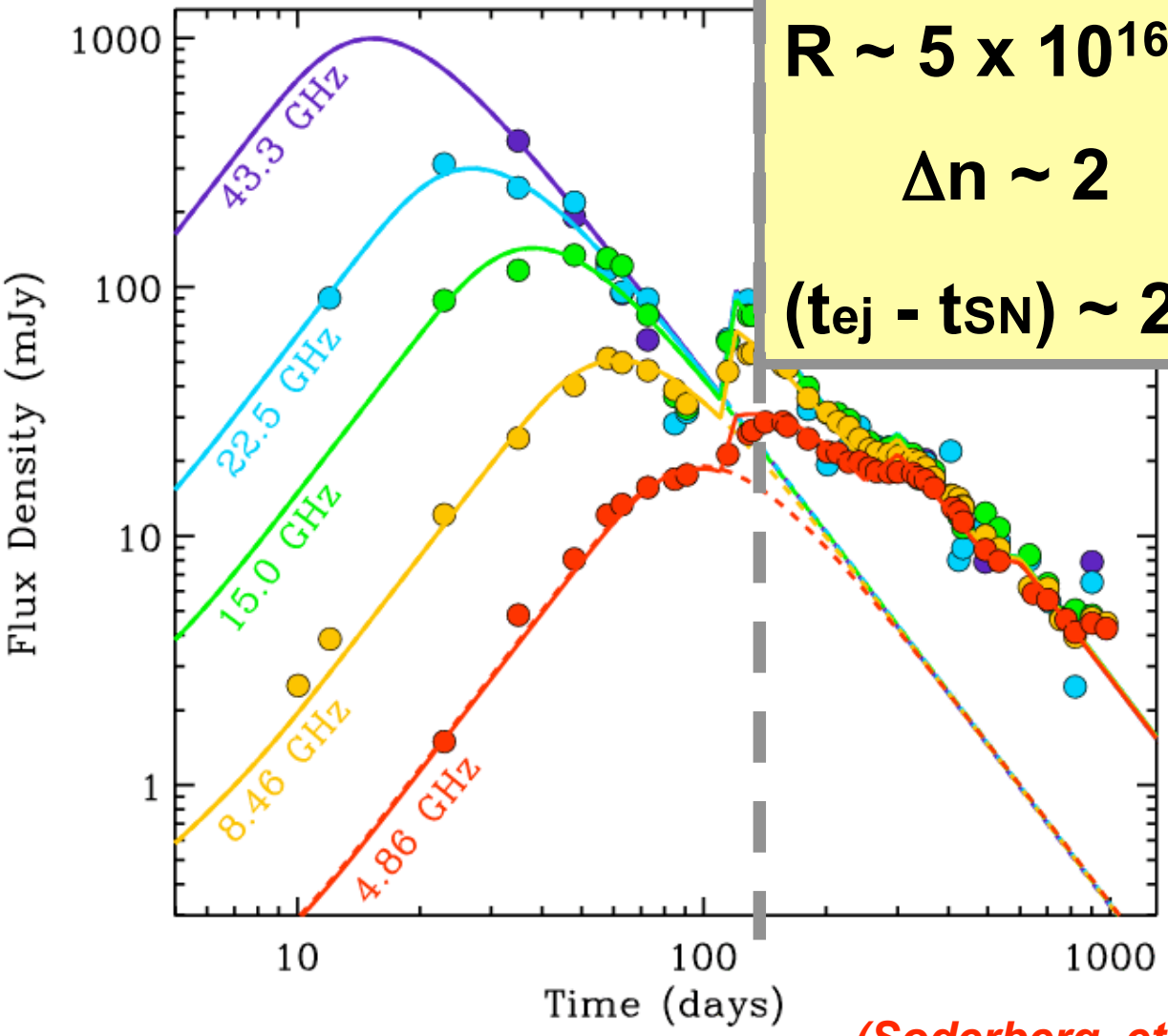
Radio SNe Ibc as a Tool:

A Unique Probe of the CSM



al., 2005

Radio SNe Ibc as a Tool: Unique Probe of the CSM



$R \sim 5 \times 10^{16}$ cm

$\Delta n \sim 2$

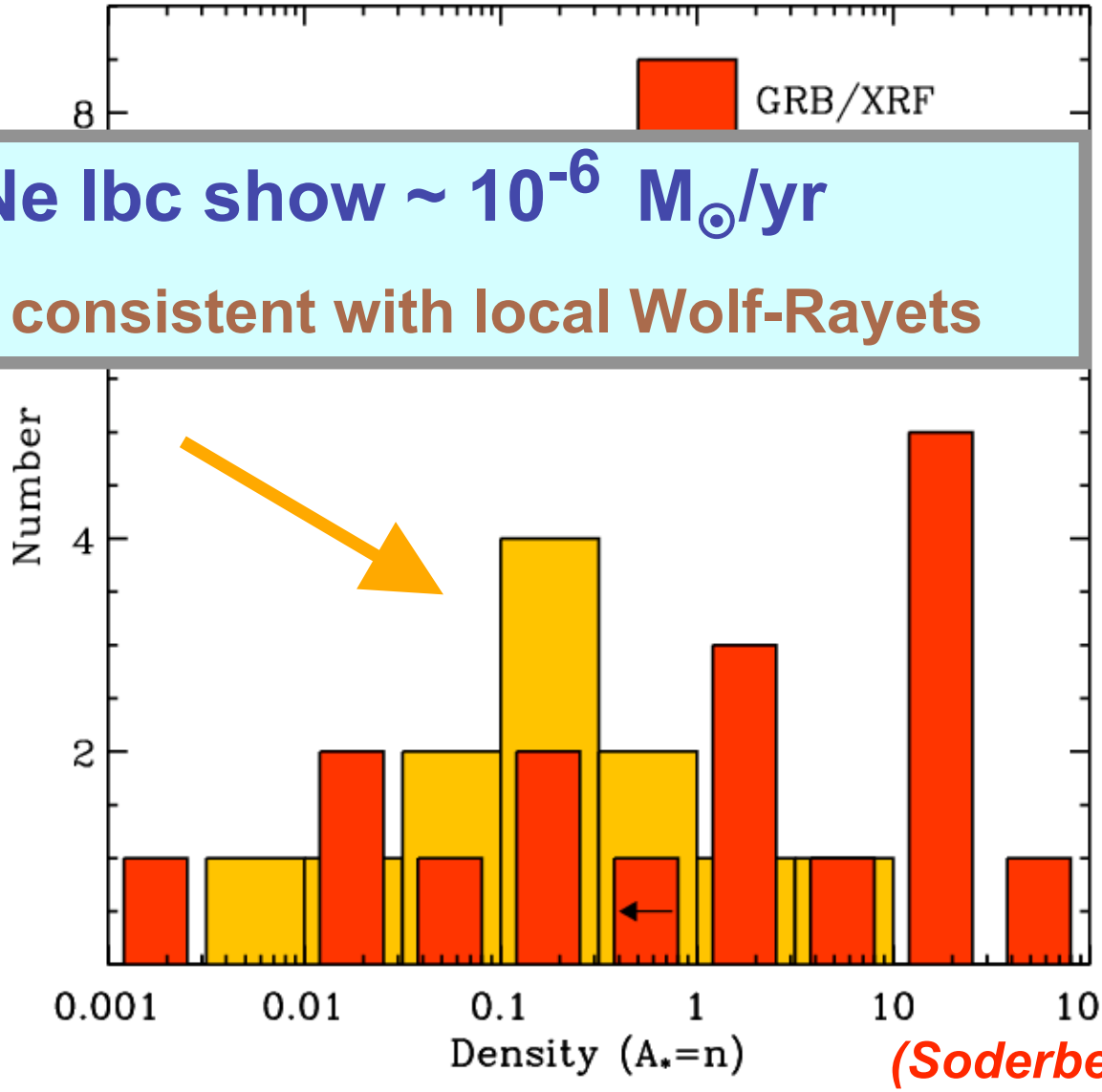
$(t_{ej} - t_{SN}) \sim 20$ yr

(Soderberg, et al., submitted)

Density Measurements for GRBs and SNe Ibc

Radio SNe Ibc show ~ 10^{-6} $M_\odot$/yr

➔ **Overall consistent with local Wolf-Rayets**



(Soderberg, in prep)

The High Points

1. Optical data suggest **similar Nickel-56 production mechanisms** for both local and GRB-associated SNe Ibc.

2. Our radio survey shows that **~10%** of SNe Ibc are radio bright, **<2 %** are like 98bw, **<10%** host off-axis GRB jets.

3. Broad lines do not serve as a proxy for bright optical luminosity, relativistic ejecta or off-axis GRB jets. **Asymmetries are not consistent with GRB jets.**