# SN Ia asymmetry and the gamma-ray escape time

Naveh Levanon & Noam Soker
Technion, Israel

# Characterizing the late-time bolometric light curve

- Total energy set by $^{56}$Ni mass

- Light curve decline set by gamma-ray escape time $t_0$

- $t_0$ set by the mean gamma-ray optical depth, weighted by the $^{56}$Ni distribution

- Late bolometric light curve defined in full by $\rho$, $X_{Ni} \rightarrow t_0$

RADIOACTIVE DECAY ENERGY DEPOSITION IN SUPERNOVAE
AND THE EXPONENTIAL/QUASI-EXPONENTIAL BEHAVIOR
OF LATE-TIME SUPERNOVA LIGHT CURVES

DAVID J. JEFFERY [1] [2]

Department of Physics, University of Nevada, Las Vegas
Las Vegas, Nevada 89154-4002

[1]  Department of Physics, University of Nevada, Las Vegas, 4505 S. Maryland Parkway, Las Vegas, Nevada 89154-4002, email: jeffery@physics.unlv.edu

[2]  Present address: Middle Tennessee State University, Department of Physics & Astronomy, Wiser-Patten Science Hall, 1301 East Main Street, Murfreesboro, Tennessee 37132

# What can be learned from $t_0$?

- Strizinger+06, Scalzo+14: construct quasi-bolometric light curves, <u>assume an ejecta model</u> and get the total ejecta mass $M_{ej}$. A significant fraction of SNe are sub-$M_{ch}$.

- Wygoda+17: compare models to observed $t_0$ range to constrain the models. $M_{ch}$ models have too large $t_0$.

- Does the picture change when allowing an asymmetric $^{56}$Ni distribution?

# Effect of asymmetry on $t_0$

- Assuming $L_{\mathrm{bol}}(t) = Q_{\mathrm{dep}}(t)$, the luminosity is not affected by asymmetry at late times

- But the gamma-ray deposition is affected through $t_0$

- We want to quantify how much asymmetry is allowed given the observed $t_0$ values

# Toy asymmetric model

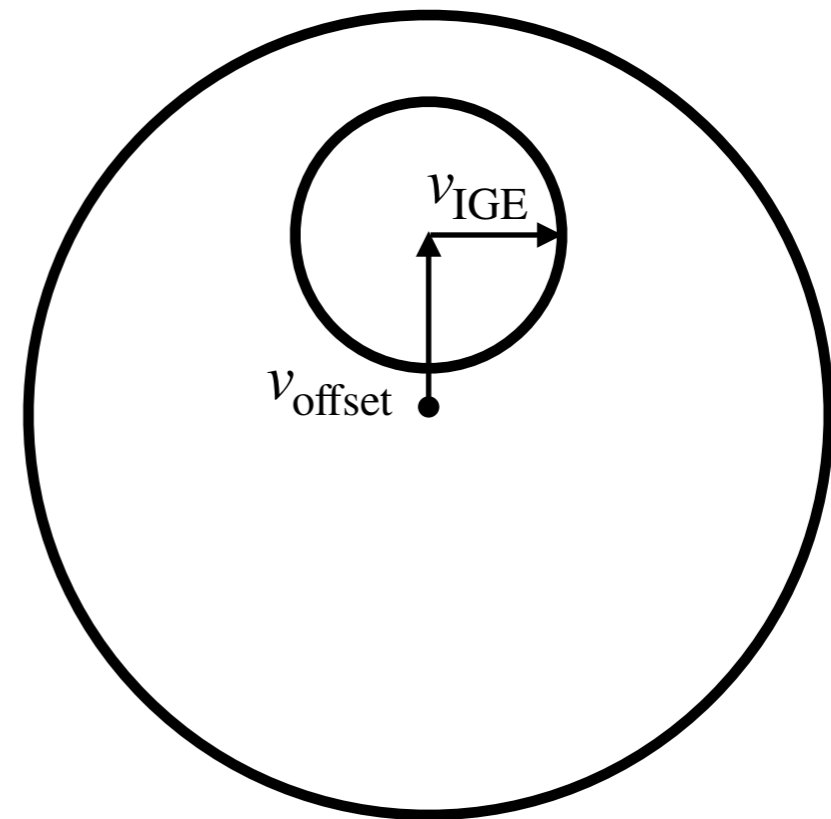- Spherical density profile

$$\rho \propto e^{-v/v_e}$$

- IGE zone offset from the center

  - $v_{IGE}$ - radius of IGE zone
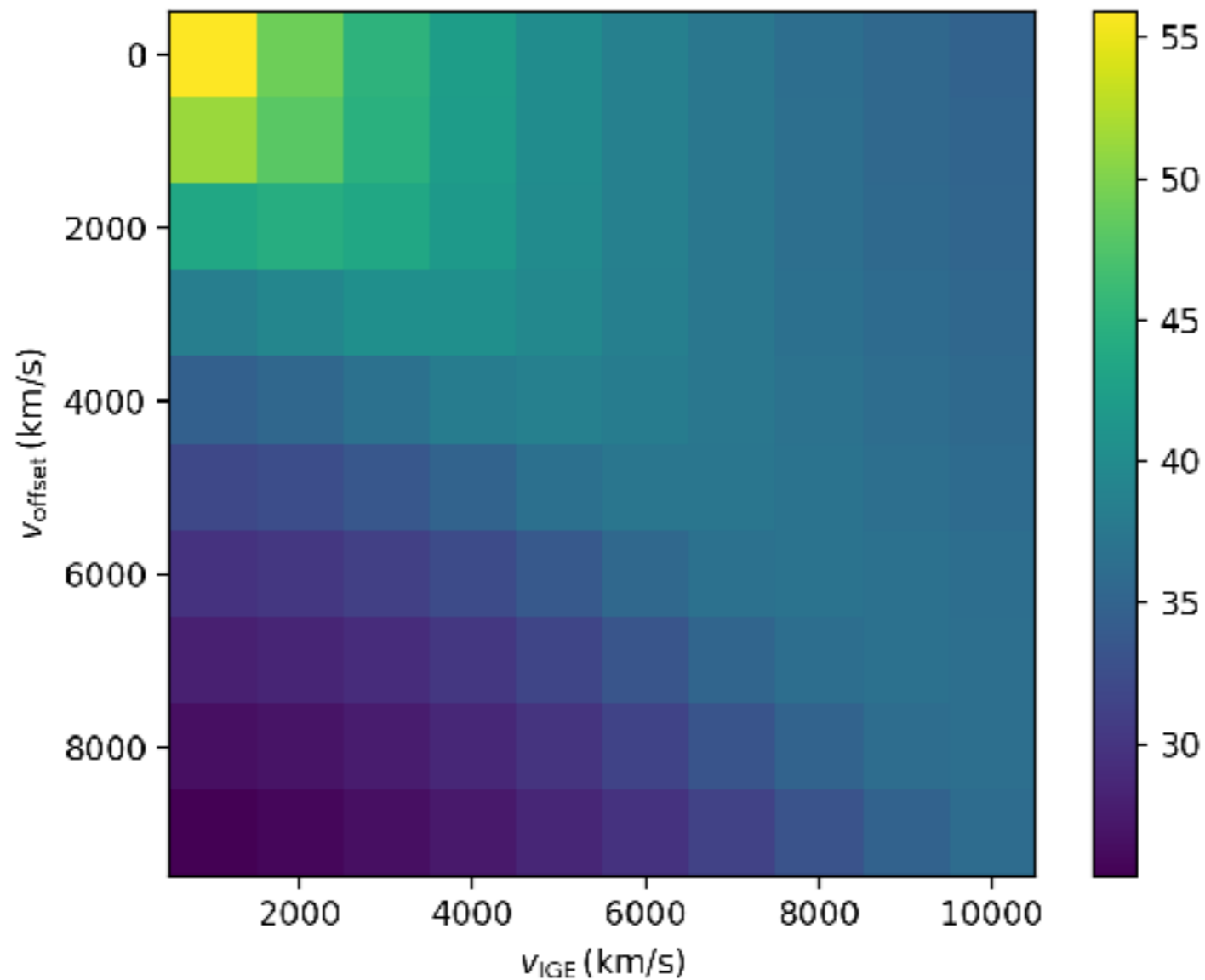
  - $v_{offset}$ - offset of IGE zone

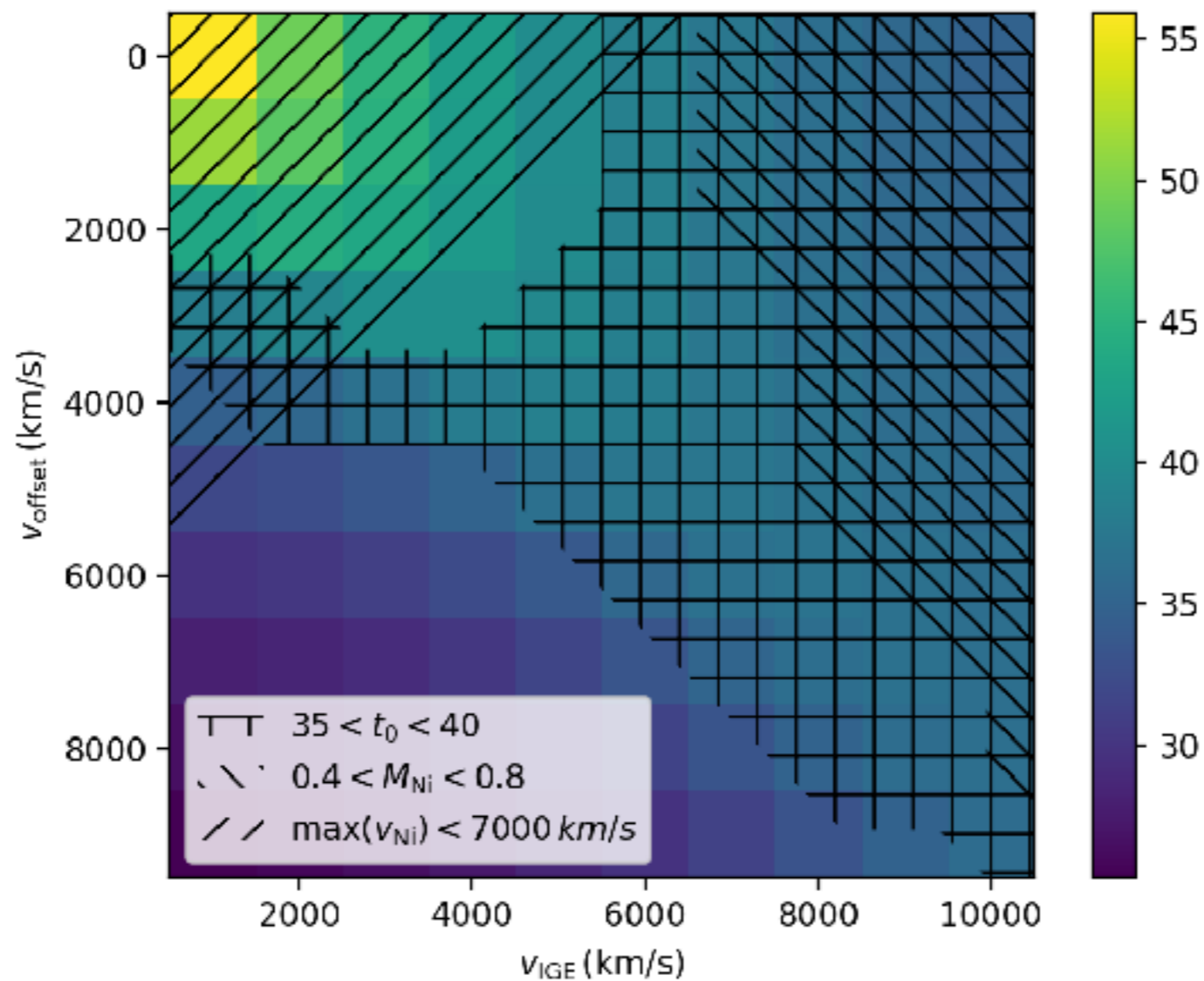  - Constant $^{56}$Ni fraction

- Limit the zone at 10,000 km/s

# Results: sub-$M_{\text{ch}}$ models
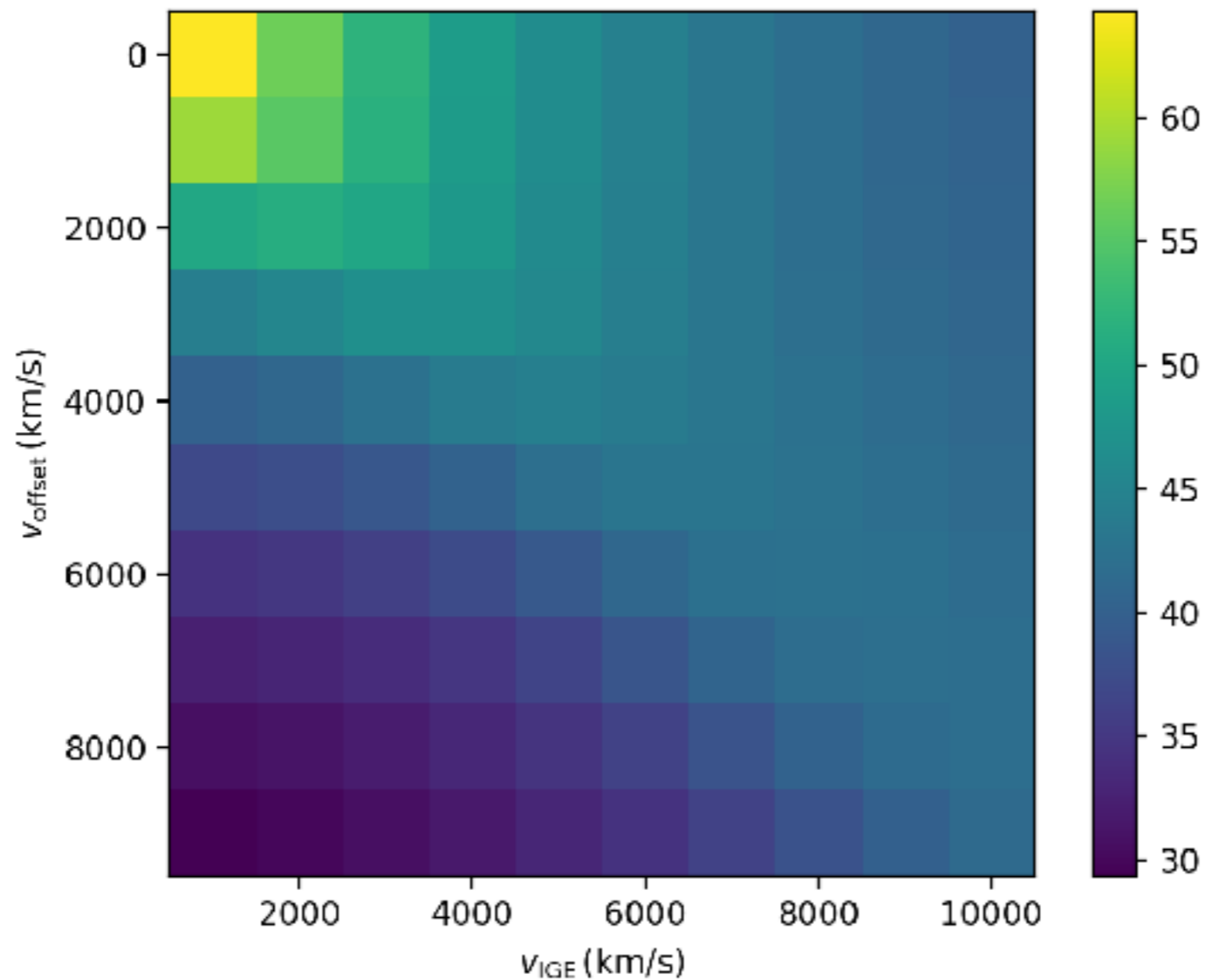
- $M$=1 M$_\odot$, $E$=1e51 erg

# Results: sub-$M_{ch}$ models
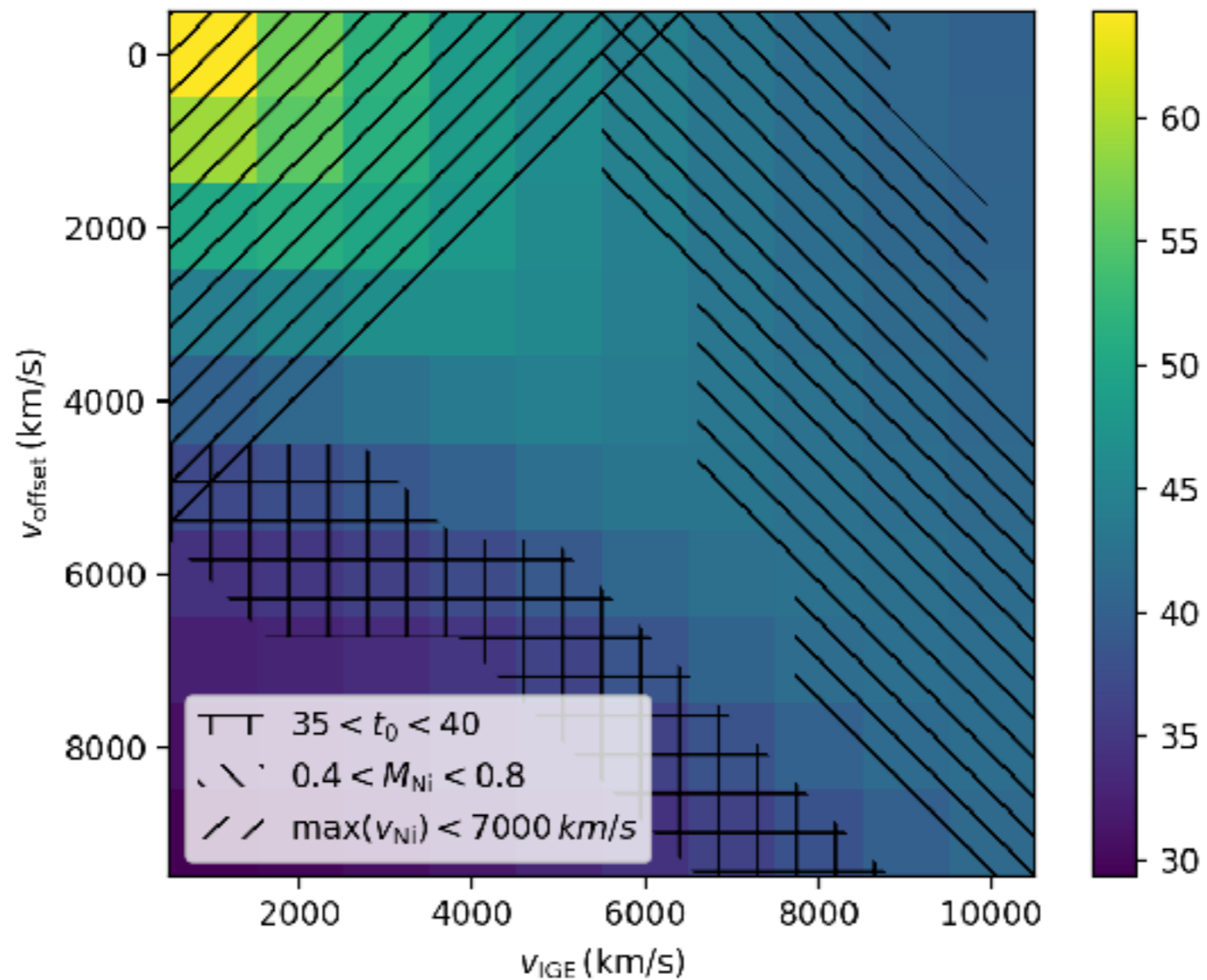
- $M$=1 M$_\odot$, $E$=1e51 erg

# Results: $M_{ch}$ models

- $M$=1.4 M$_\odot$, $E$=1.5e51 erg

# Results: $M_{ch}$ models

- $M$=1.4 M$_\odot$, $E$=1.5e51 erg

# Current conclusions (work in progress)

- Asymmetry not likely to mitigate the large $t_0$ issue for $M_{ch}$ models

- Try more suitable density profile

- An illustration of the $t_0$ constraint