INTEGRAL Studies of Supernovae and Classical

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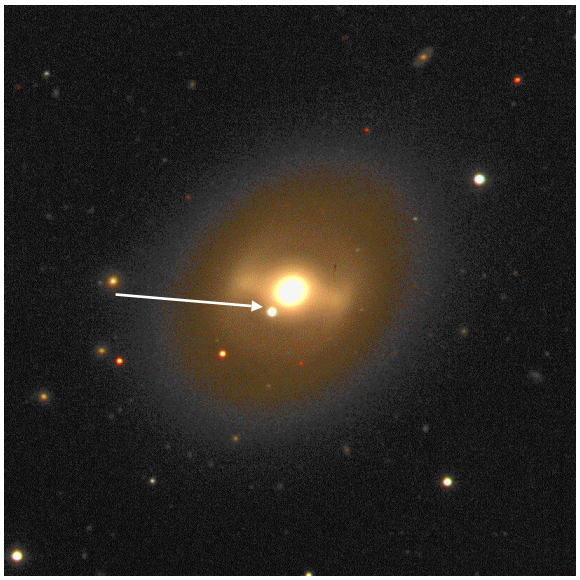
INTEGRAL/SPI SN

^{56}Ni → ^{56}Co → ^{56}Fe

6.1 d
158, 812 keV

78.8 d
847, 1238 keV

Type Ia SN
NGC 936
D ~ 16 Mpc



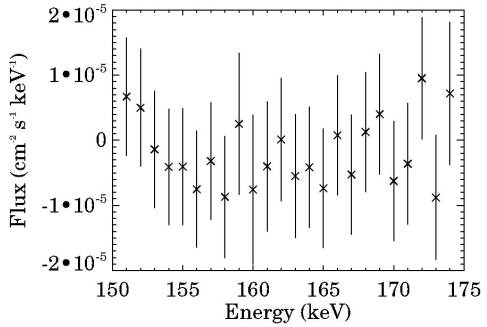
No evidence for lines

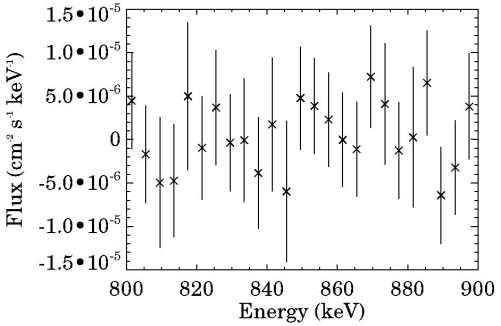
Fit (broad) 158 keV feature:
$F = (-2.7 \pm 3.0) \times 10^{-5}$ cm^{-2} s^{-1}

$F_{lim}(99\%) < 3.9 \times 10^{-5}$ cm^{-2} s^{-1}

Fit (entire) 800-900 keV feature--
Flux in 812 line:
$F = 1.5 \pm 8.0) \times 10^{-5}$ cm^{-2} s^{-1}

$F_{lim}(99\%) < 2.1 \times 10^{-4}$ cm^{-2} s^{-1}

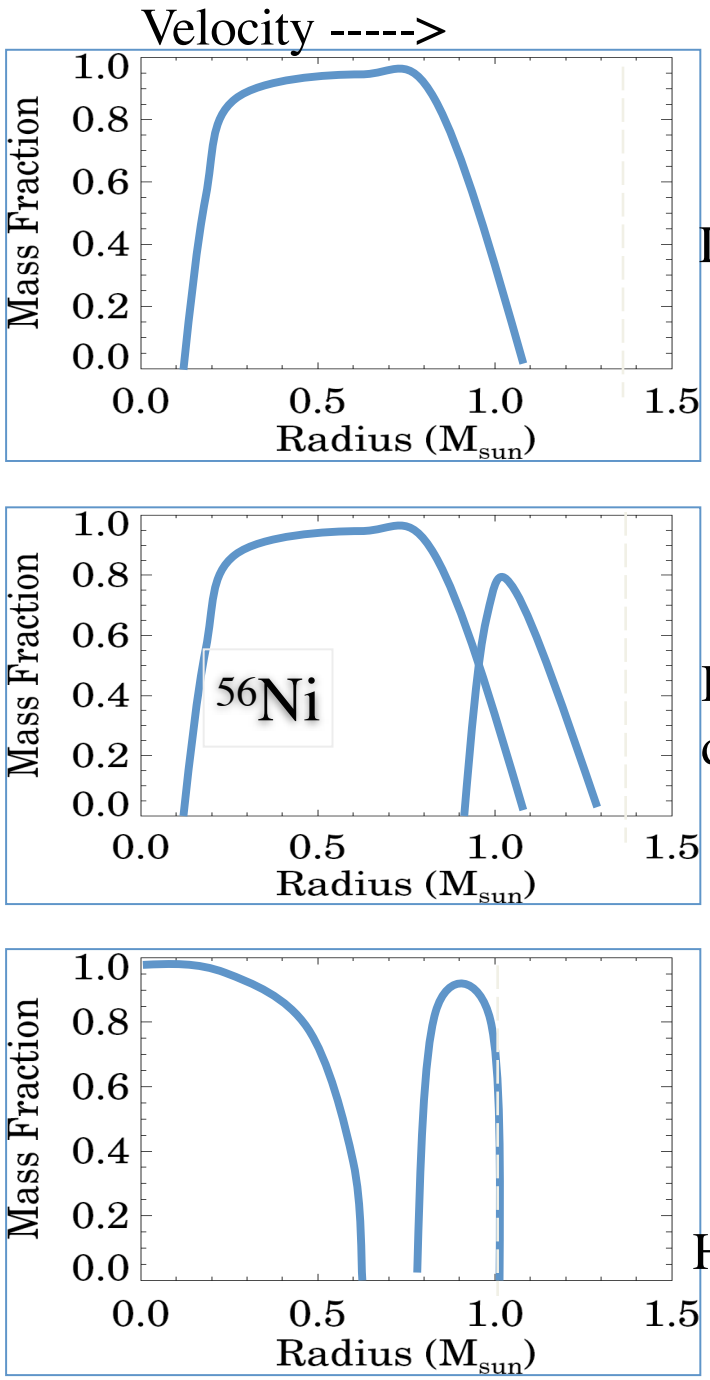




Limit < 0.25 $M_\odot$
^{56}Ni in surface

Wait for D<10 Mpc

Thermonuclear SN Models - schematic



Deflagration

Delayed detonation

He-detonation

γ-ray lines: come only from 'optically' thin regions.

We can watch the attenuating medium lift off -- flux vs. time

We can see the Doppler profiles of the emission regions -- spectra

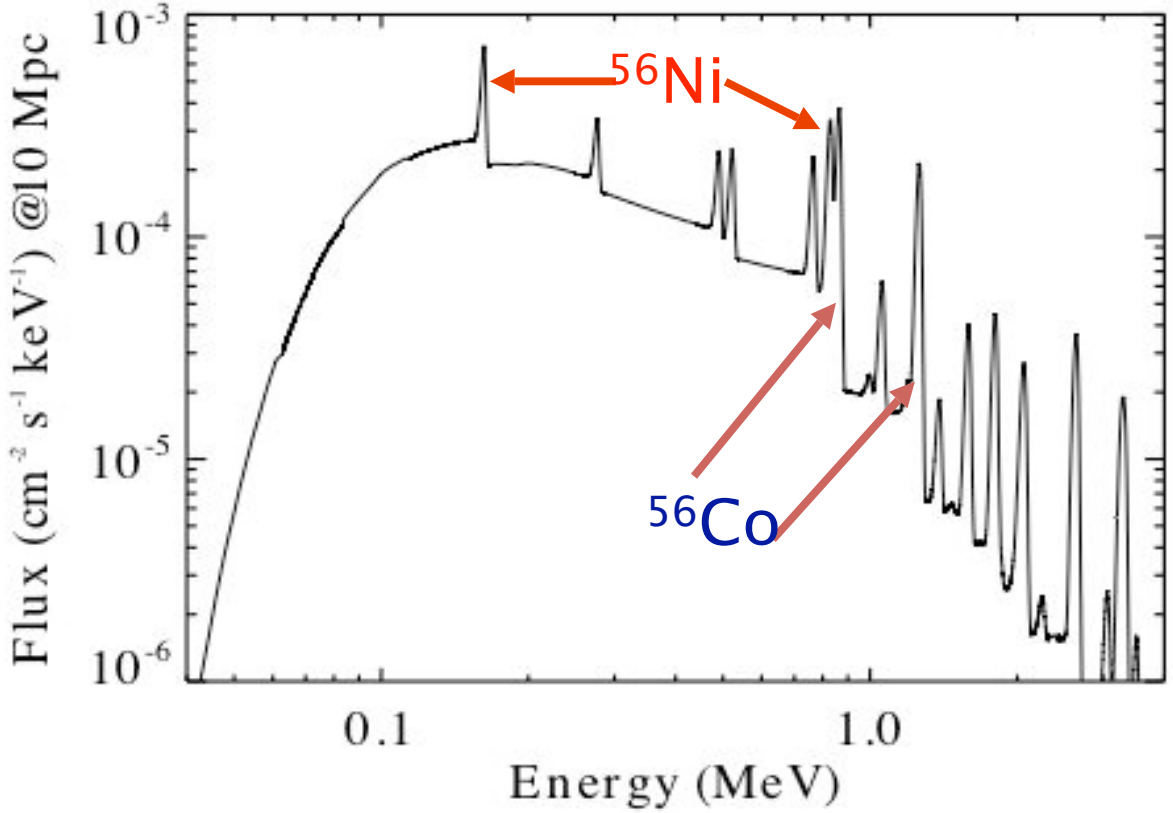
Thermonuclear supernova γ-

$$^{56}Ni \longrightarrow ^{56}Co \longrightarrow ^{56}Fe$$

158 keV
812 keV
etc.

847 keV
1238 keV
etc.

DD2002c
Hoeflich et al.
@25 days



Lines are doppler broadened to 3-5%

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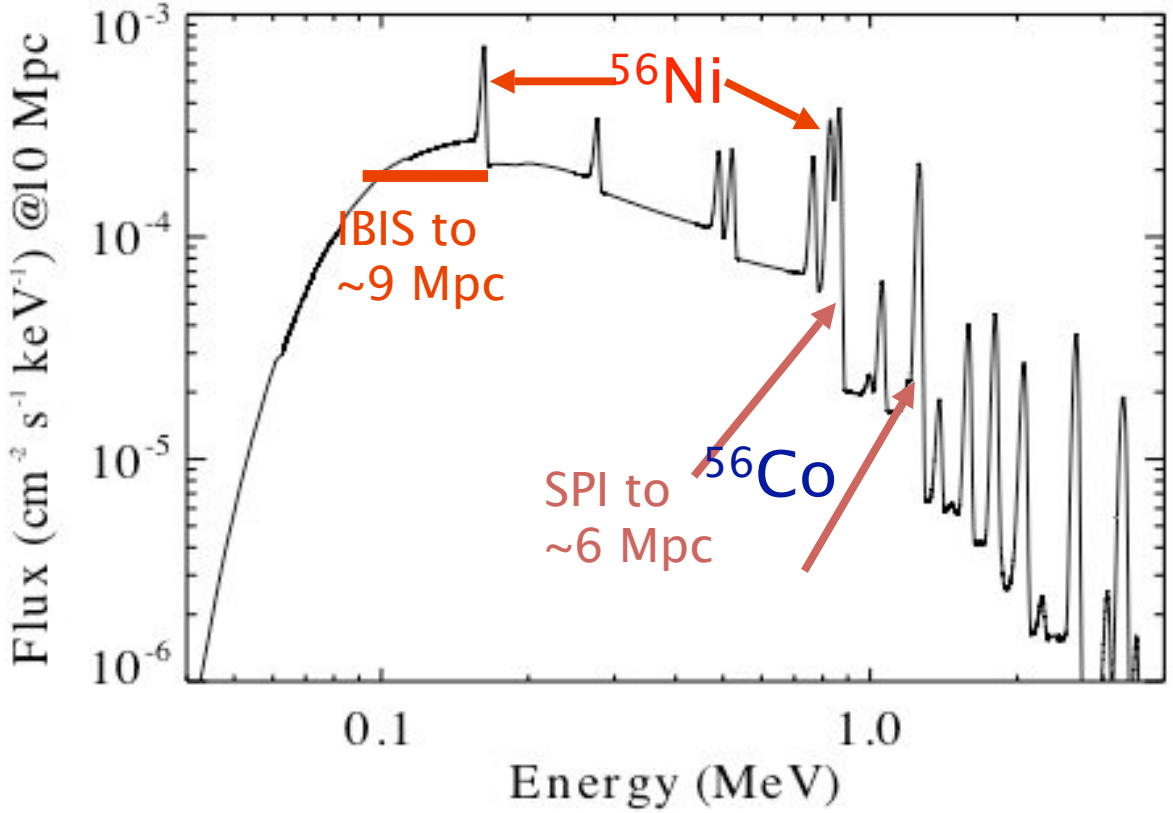


Lines are doppler broadened to 3-5%

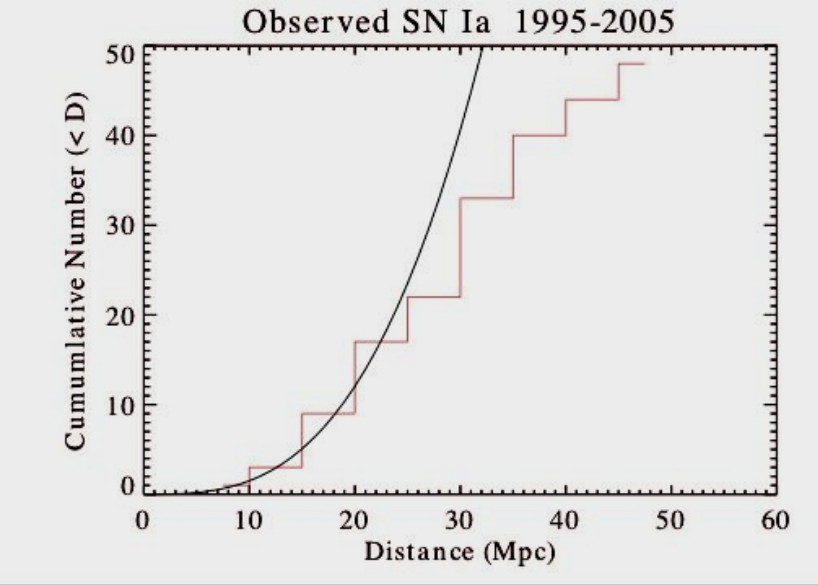
On the number of SNe we can study…

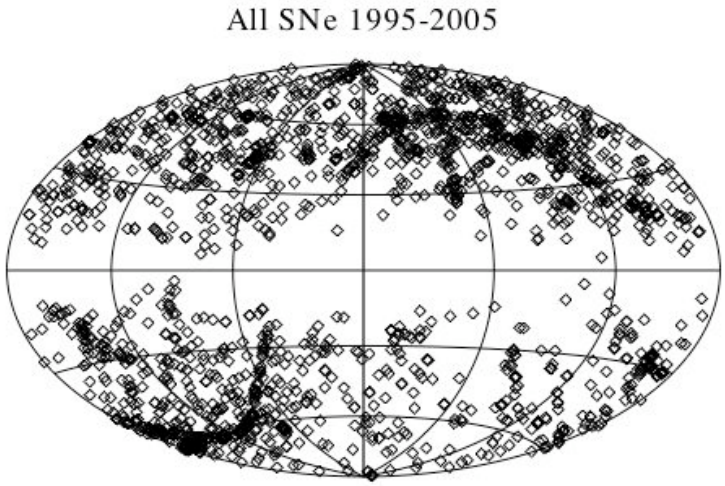
Calan/Tololo Survey --> 0.21 SN Ia / 10^{10} L_{sun}(B) / century

SDSS --> 0.017 10^{10} L_{sun}(B) / Mpc^{-3}

- 19 y^{-1} SN Ia within D = 50 Mpc (Peak 847 keV Flux ≥ 1.2 10^{-6} cm^{-2} s^{-1})

How good are these numbers? Take confirmed SNIa, Tully Nearby GC Distances

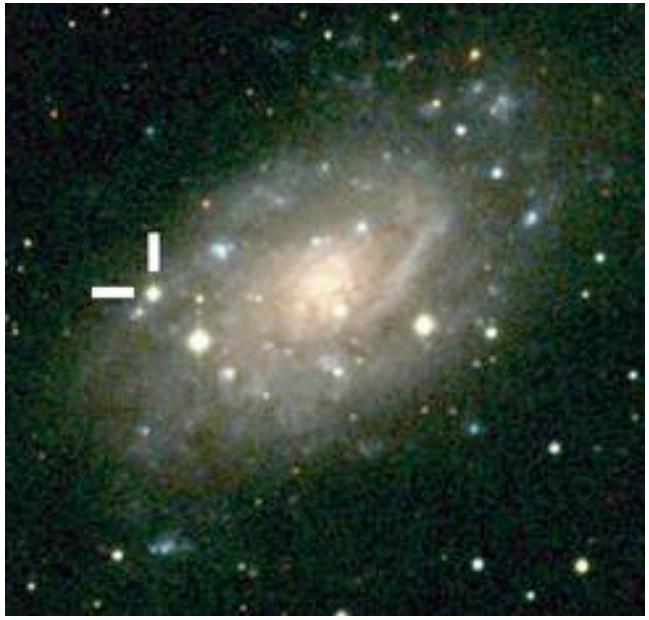


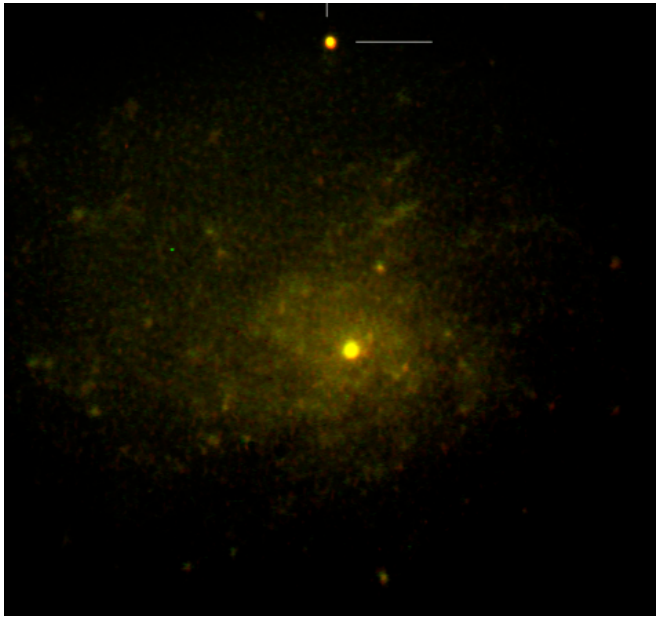


1 y^{-1} at D < 20 Mpc seems safe (> 20σ for F_{lim}= 1 10^{-6})

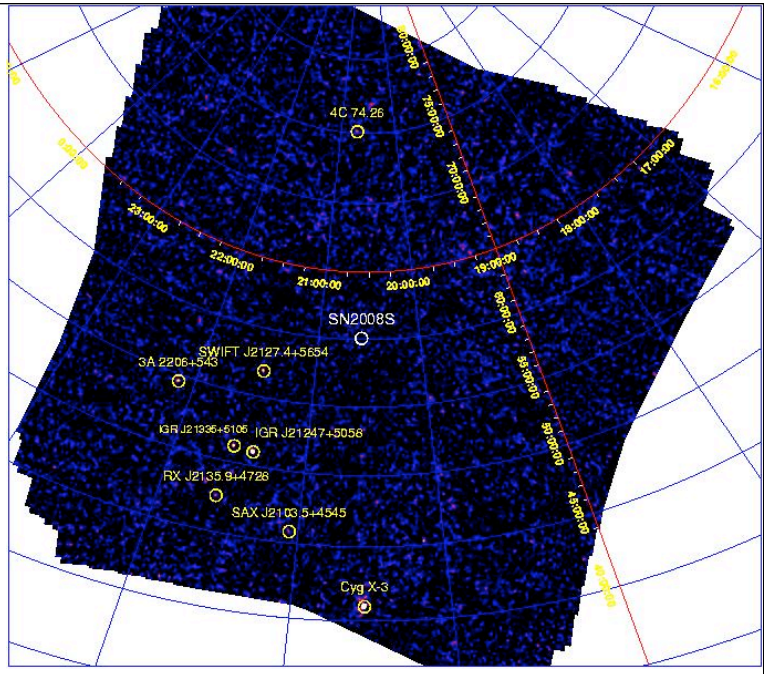
Core Collapse Supernovae

- Main objective is shock/csm interaction
- ^{56}Ni/^{56}Co lines possible only for local group, or major asymmetries (jets)
- Two good chances: SN 2004dj, SN 2008S

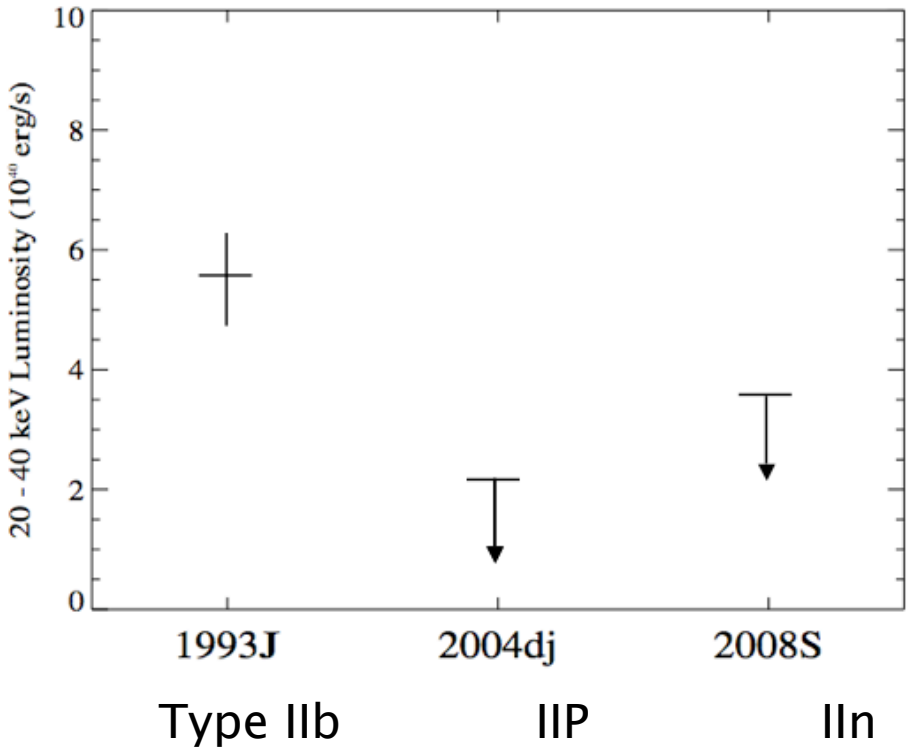


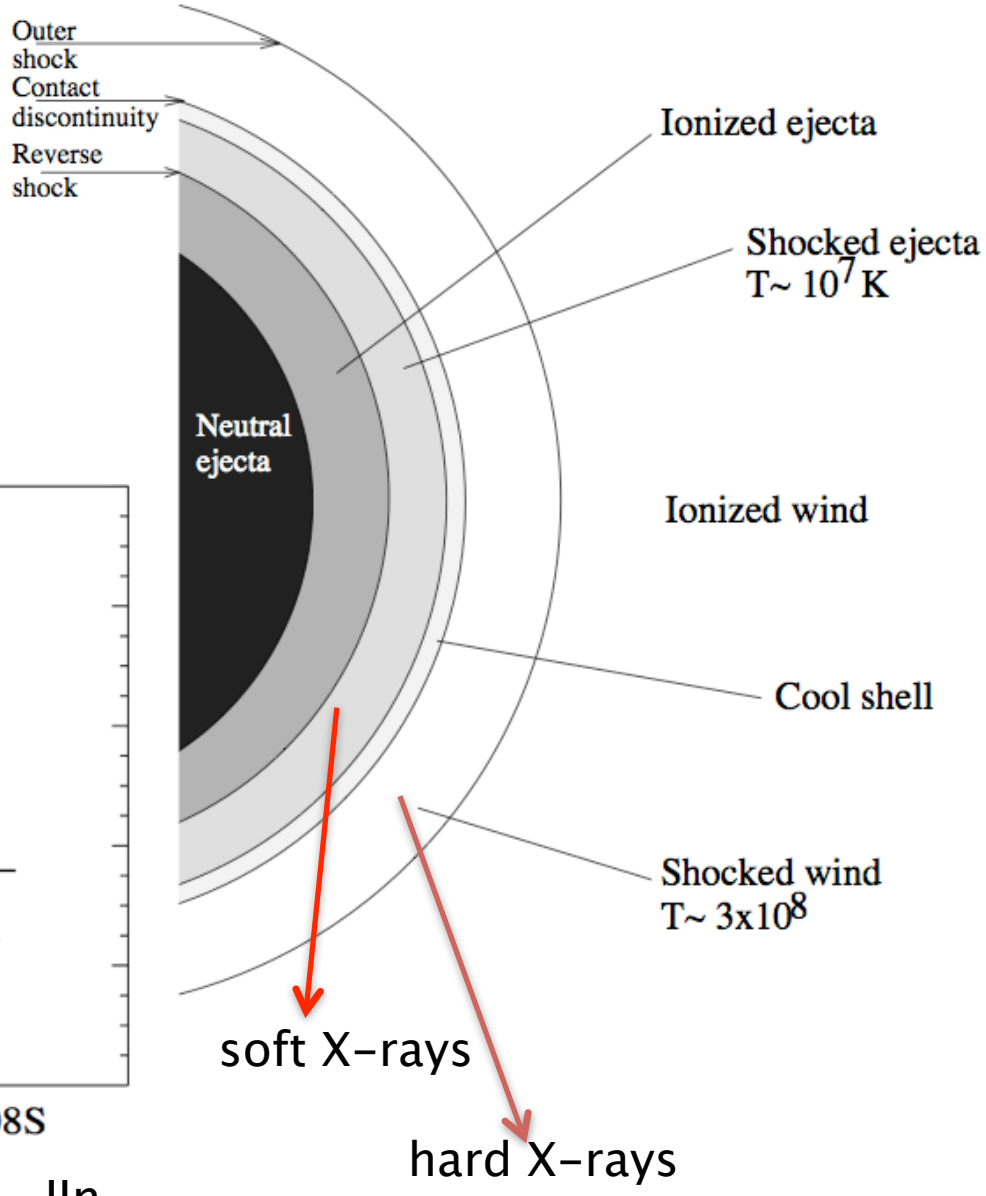


SN 2004dj & 2008S



Compared to SN 1993J





Future strategies

- SN Ia $D < 10$ Mpc
- SN IIb, Ib, Ic $D < 8$ Mpc
- SN IIn (bright only) $D < 8$ Mpc

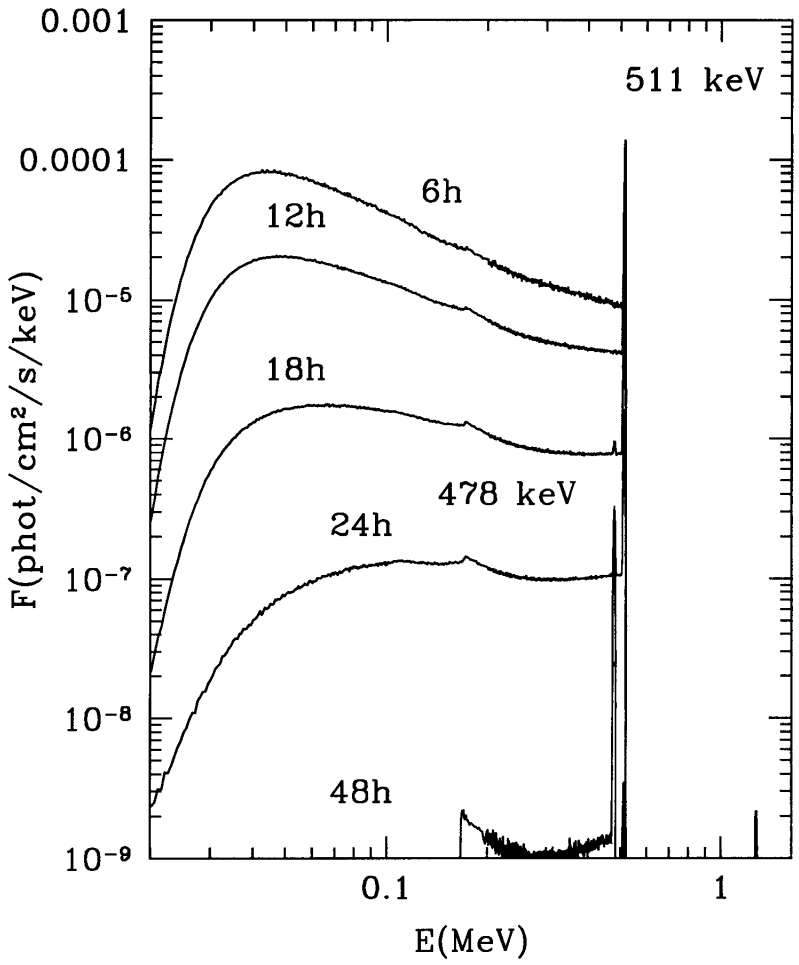
Plan in place for extensive coverage of very nearby SN.

Classical Novae – key questions

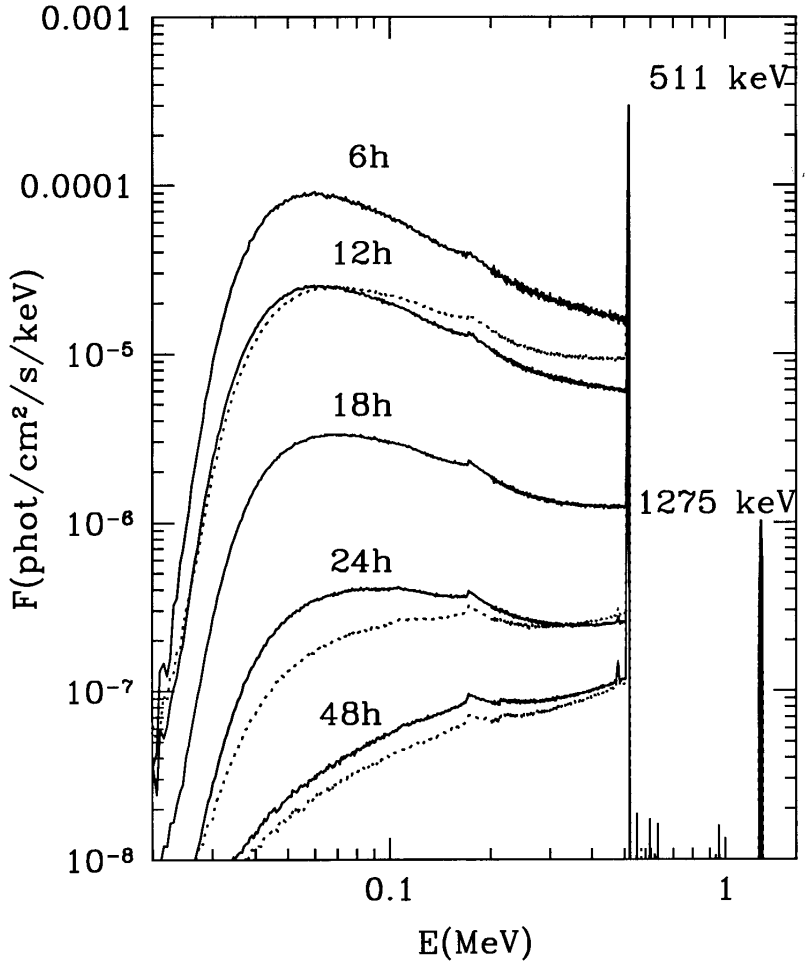
- **Ejected masses**: discrepancy between measured and predicted (some observed are larger than predicted)
- **Mixing** between accreted matter (solar-like) and white dwarf matter (CO or ONe WD): **how and when?**
- **Efficiency of convection**
- **Spatial distribution** and **nova rate** in the Galaxy
- Contribution of novae to **galactic content of**

Spectra – Hernanz et al.

CO



ONeMg



Summary

Much to be learned

Possible boost to INTEGRAL & gamma-ray astronomy

INTEGRAL events rare (1 per ~5 years)