AMEGO @ TeVPA
Mission: J. Perkins @ Thu 2:30 pm
AGN: T. Venters @ Thu 5pm
DM: M. Meyers @ Fri 5pm

AMEGO and Type Ia Supernovae: Alarm, Probe and Diagnosis

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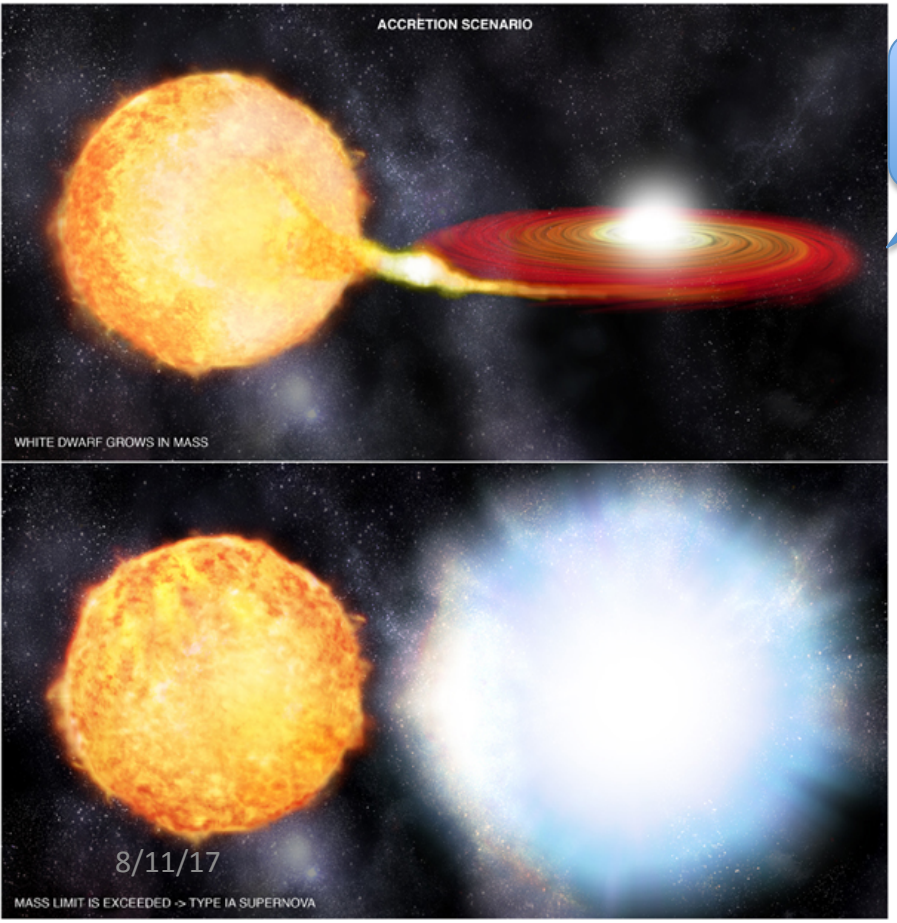
https://asd.gsfc.nasa.gov/amego/

Kepler's SNR
Credit: NASA/ESA/JHU/
R.Sankrit & W.Blair

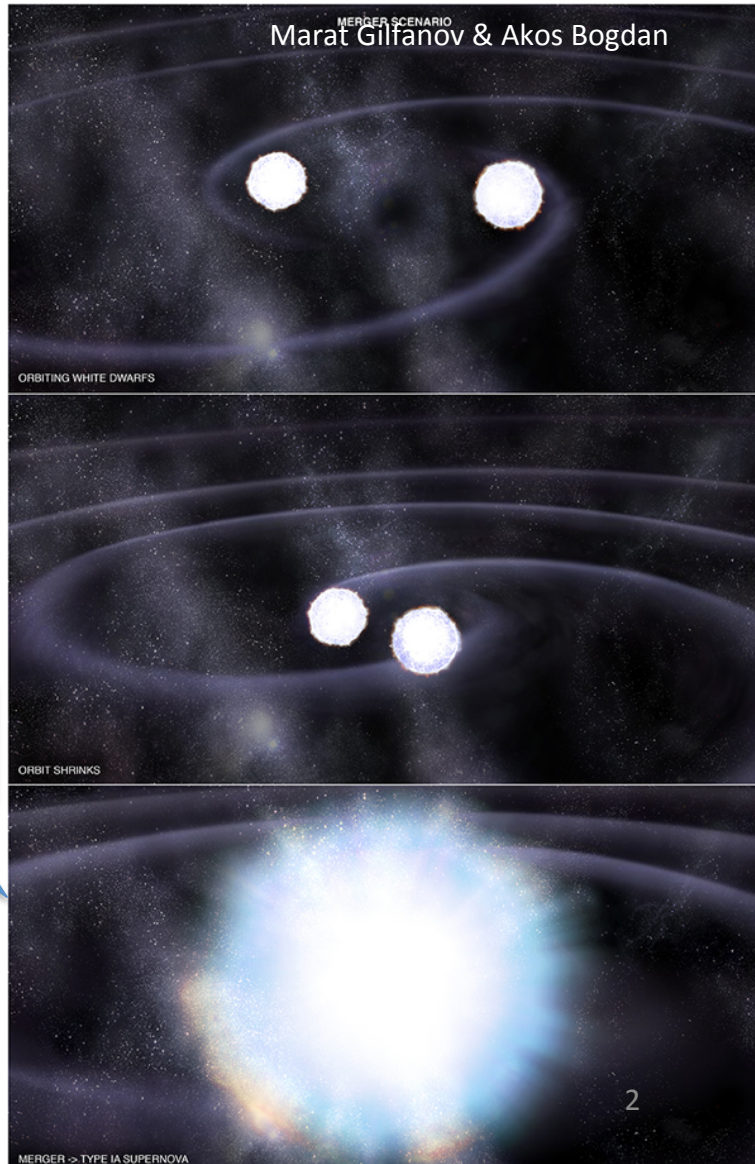
Type Ia Supernova (SN Ia)

- Progenitor model: single vs. double degenerate scenarios



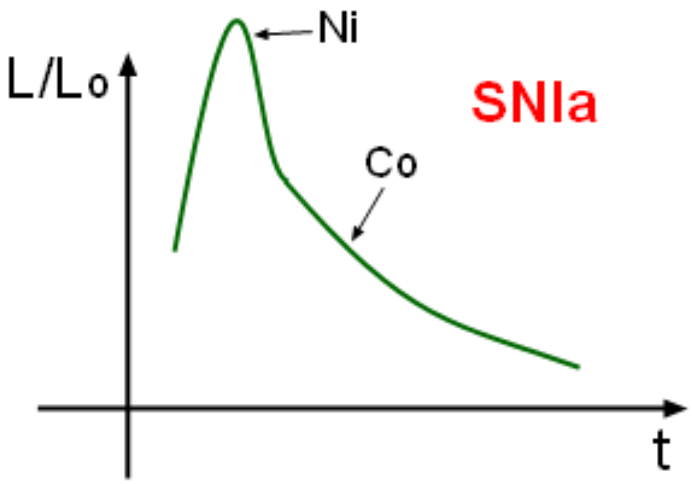
Accretion scenario (single)

Merger scenario (double)



Type Ia Supernova

- "Standardizable candle" —> cosmic distance indicator & cosmic acceleration
- Nucleosynthesis sites of iron-group elements;
- Light curve is powered by ^{56}Ni decay followed by ^{56}Co decay (^{56}Ni is the dominant product of SN Ia)



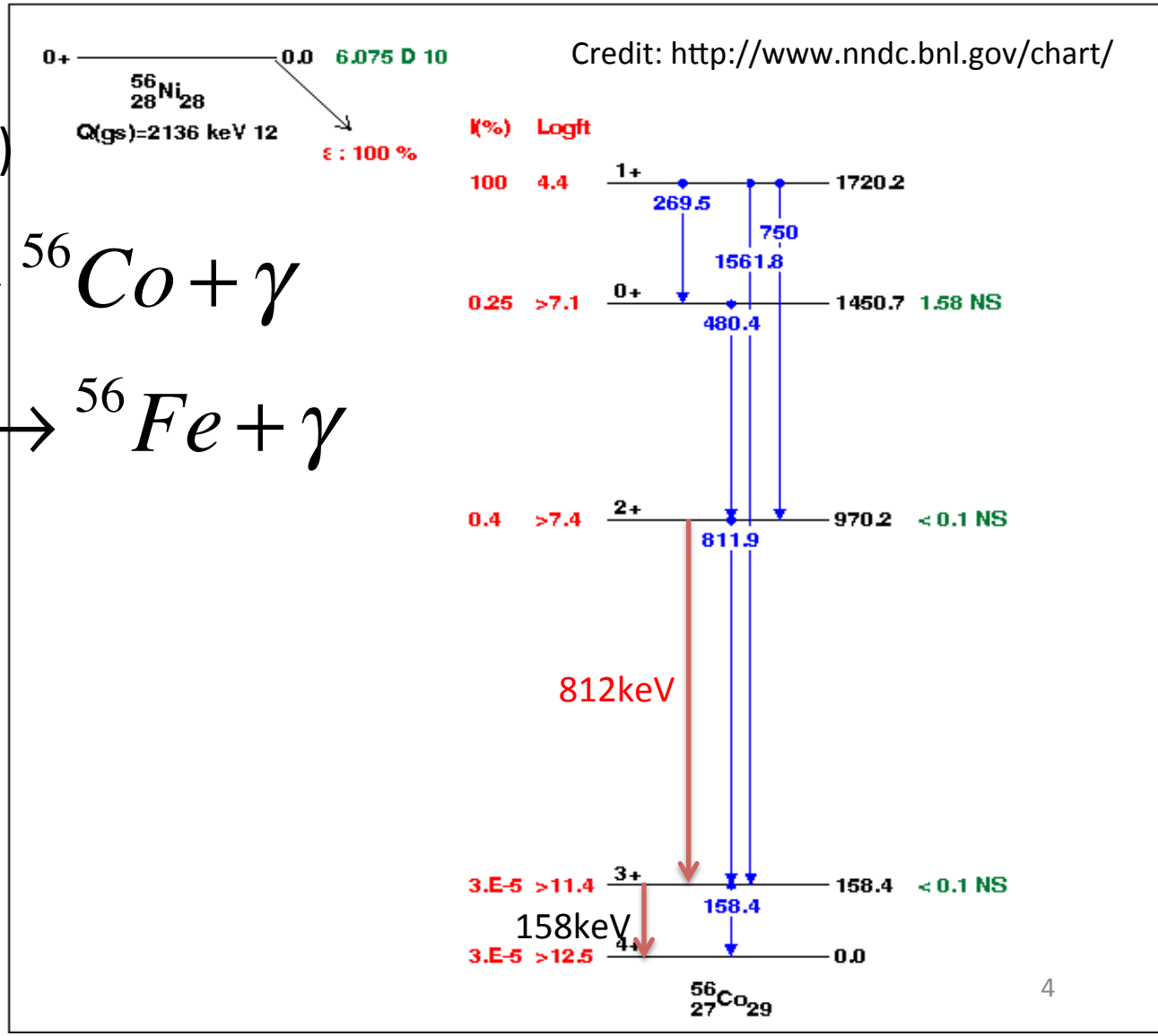
Gamma-rays from SN Ia

Type Ia SN:
(confirmed by SN2014J)

$$^{56}Ni \xrightarrow{\tau=8.8\,days} {}^{56}Co + \gamma$$

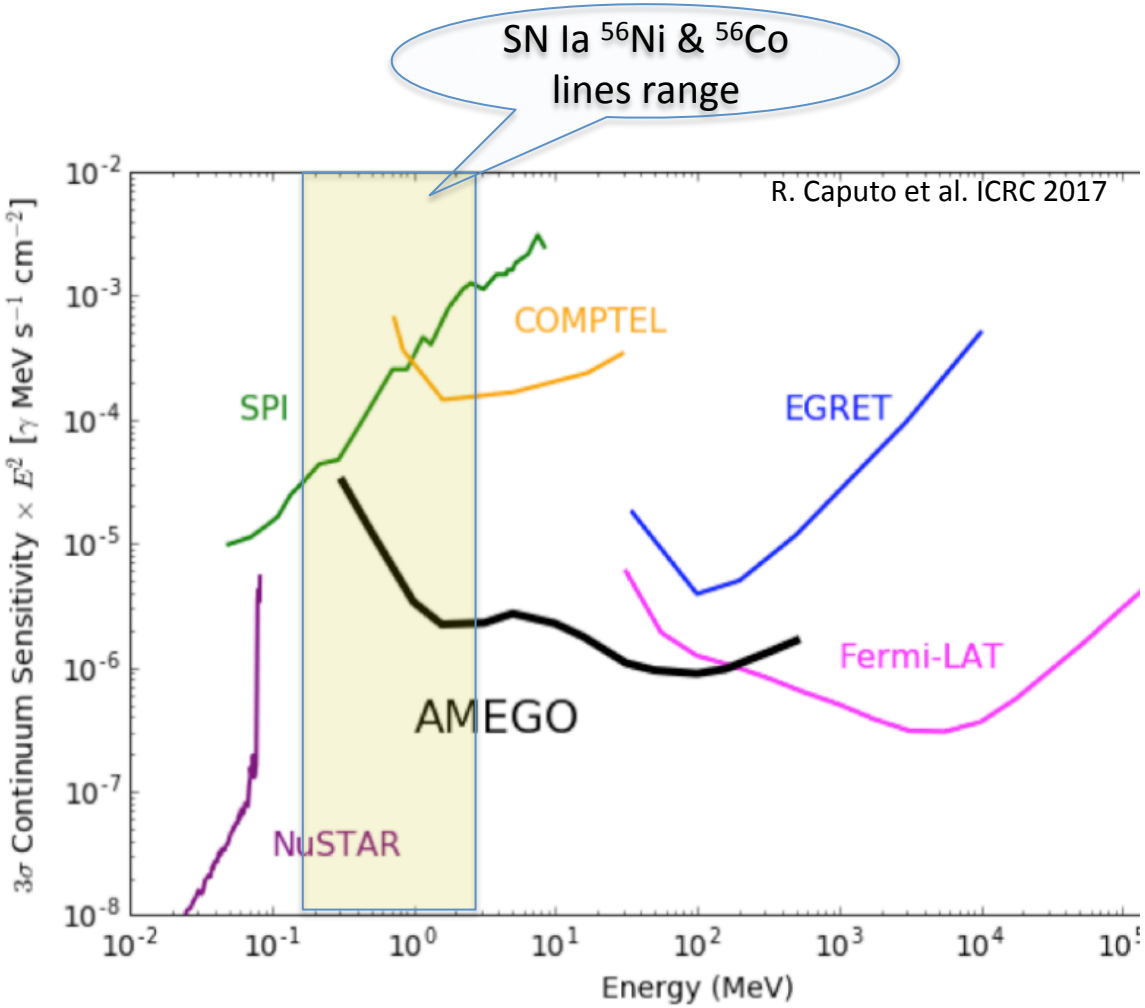
$$^{56}Co \xrightarrow{\tau=111.3\,days} {}^{56}Fe + \gamma$$

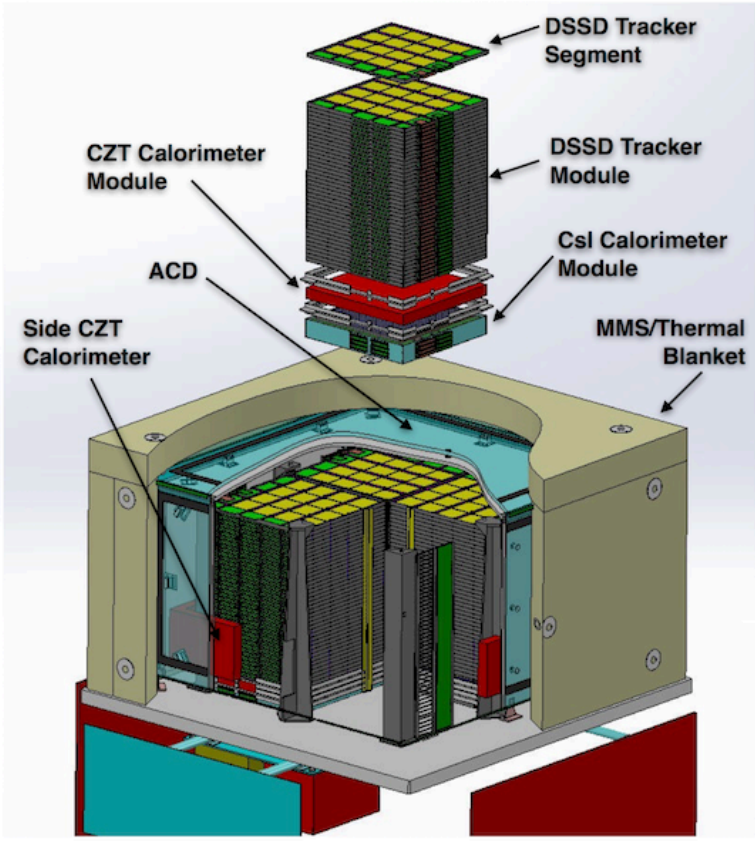
- Line energy span from 158keV to 2.6MeV



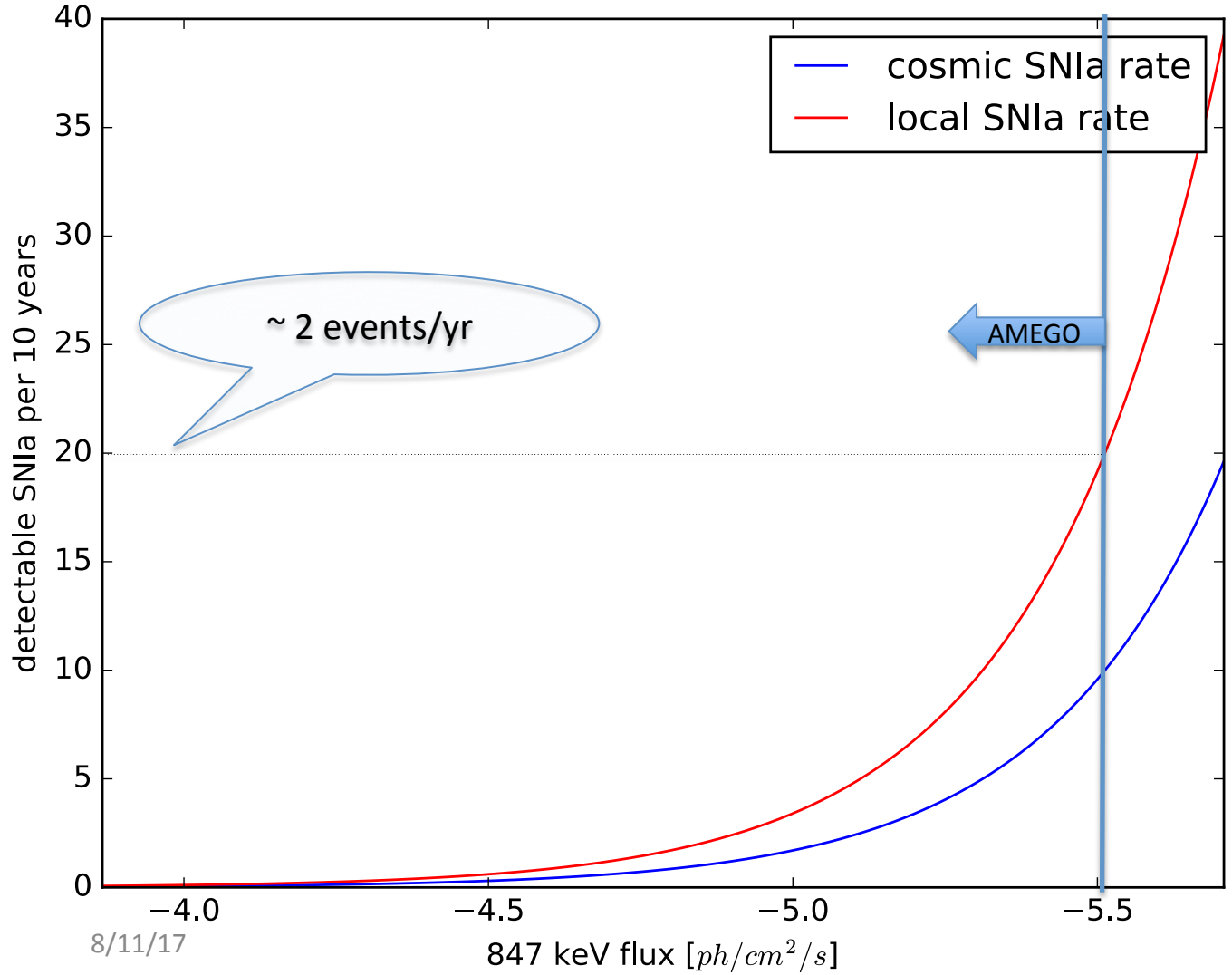
AMEGO: All-sky Medium Energy Gamma-ray Observatory

See Jeremy Perkin's talk





AMEGO Detectable SN Ia Rate Estimation



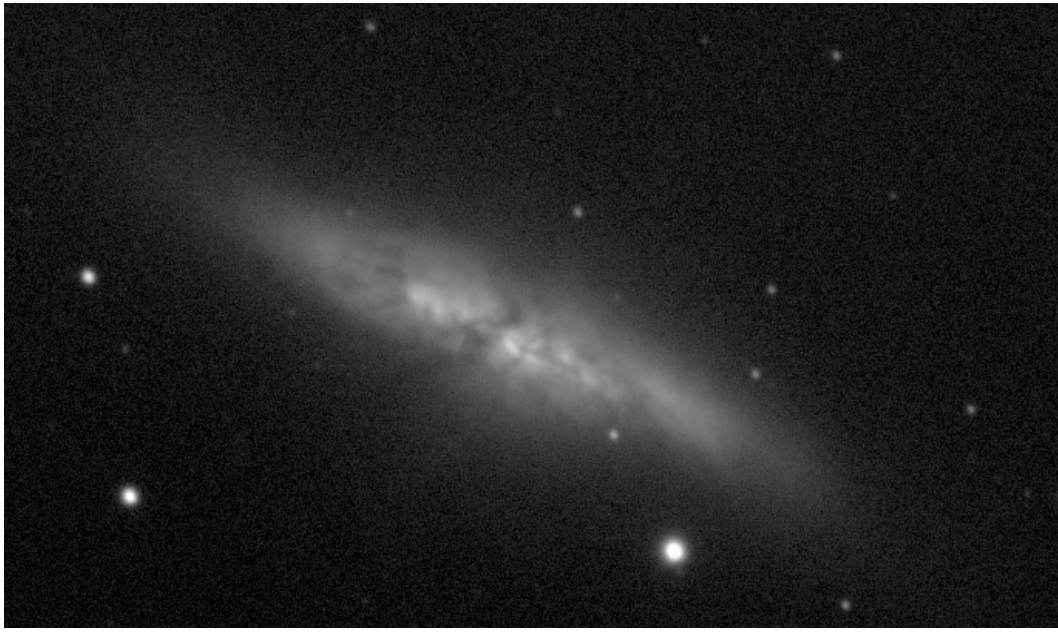
AMEGO sensitivity:

$F_{3\sigma} \sim 3\times10^{-6}\,\mathrm{ph/cm^2/s}$

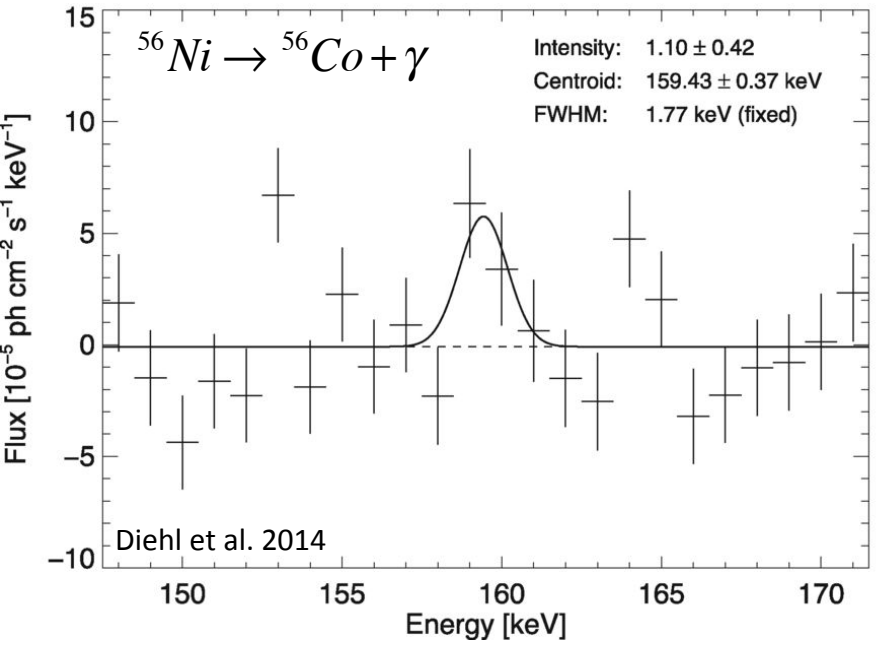
~ 20 SN Ia per 10 years
→ enough to sample SN Ia in gamma rays

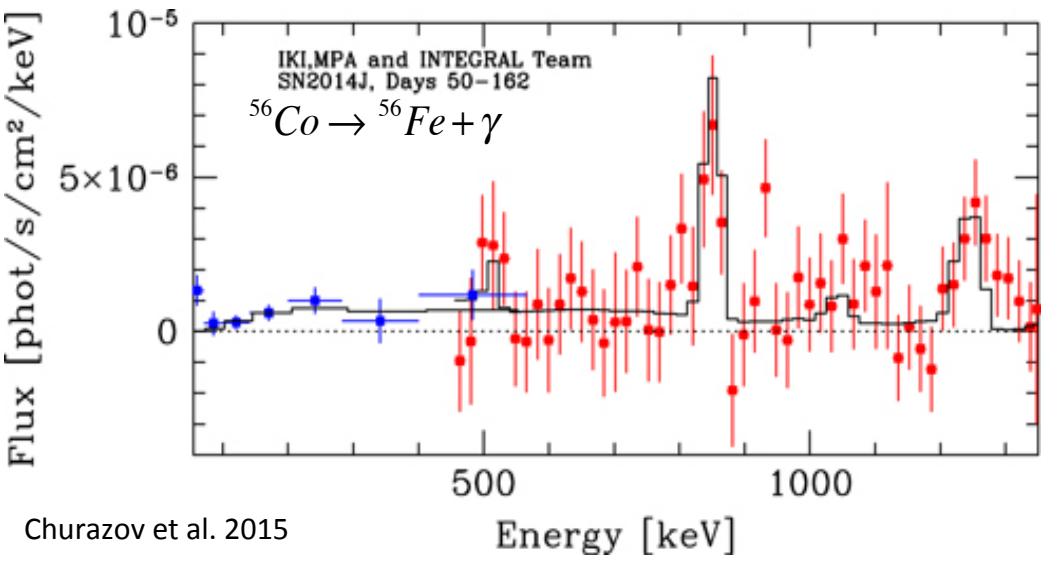
Nearest Recent Type Ia: SN2014J

- SN2014J in M82, at 3.5Mpc
- INTEGRAL/SPI data: Jan 31-Apr 24
- ^{56}Ni lines and ^{56}Co lines seen ~20 days after the explosion
- Strong ^{56}Co line detection at late times



SN2014J in M82
Credit: UCL/University of London Observatory/Steve Fossey/Ben Cooke/Guy Pollack/Matthew Wilde/Thomas Wright

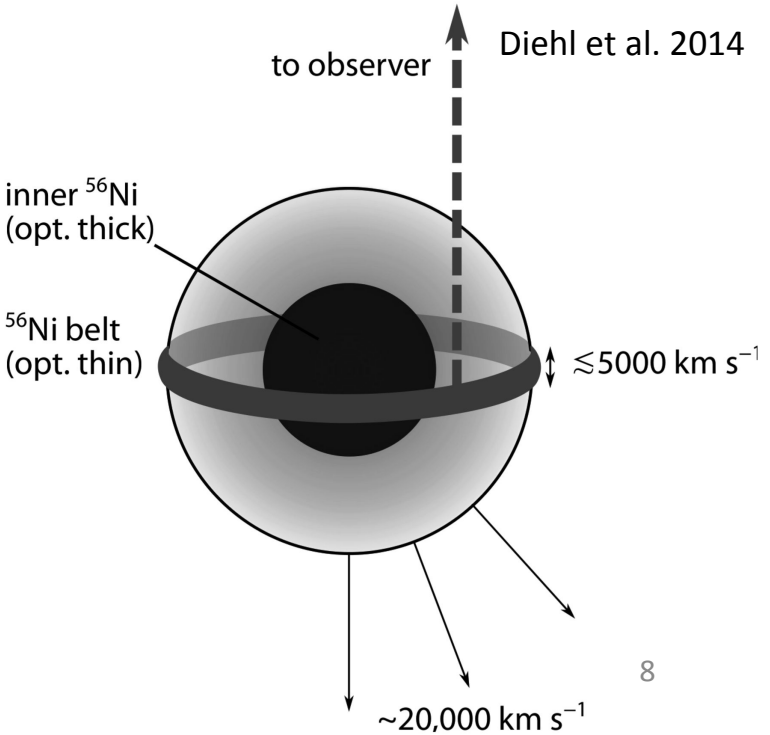




$$\tau_{^{56}Ni} = 8.8 \ days$$

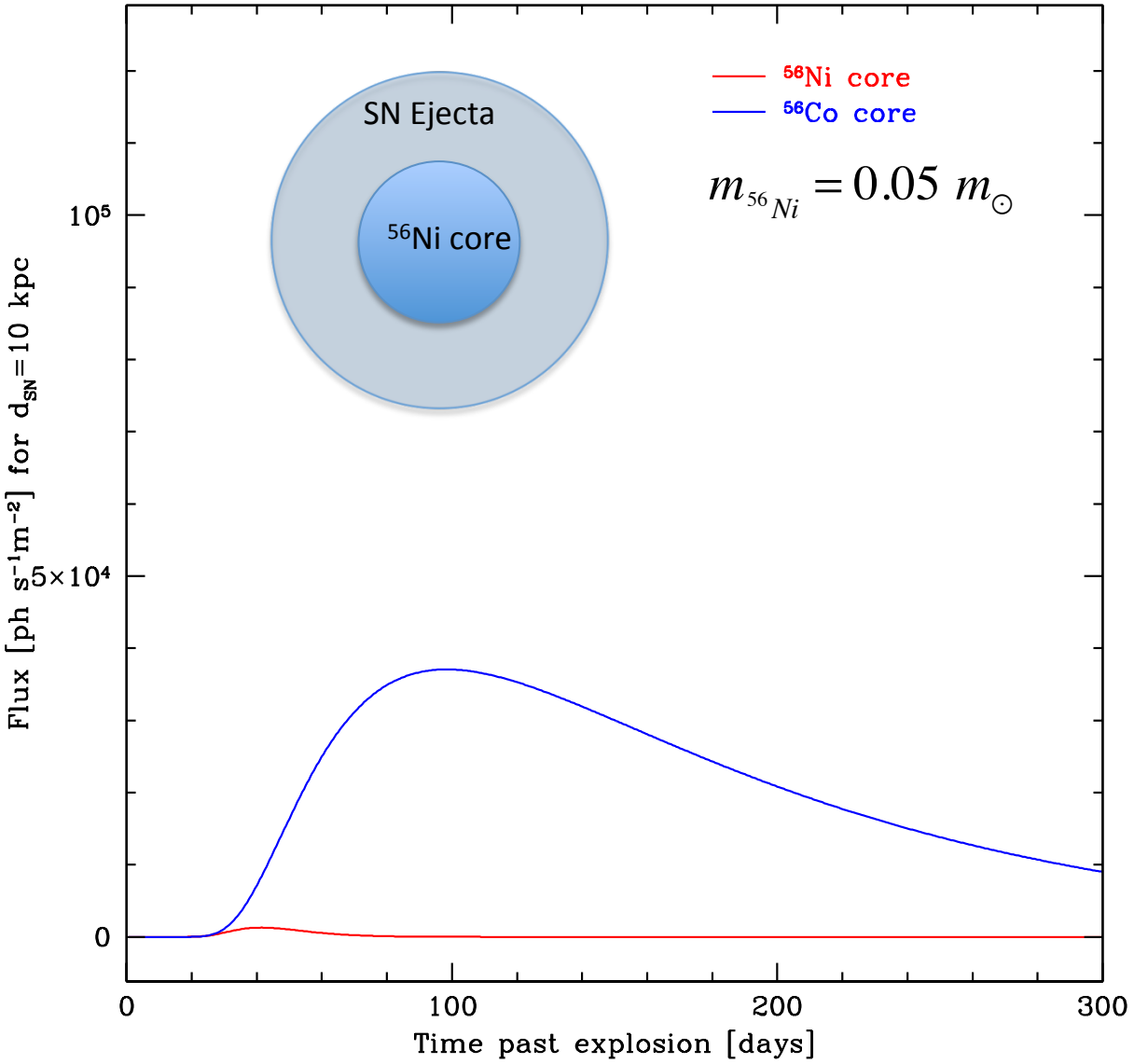
$$\tau_{^{56}Co} = 111.3 \ days$$

- Compton scattering—> opaque during first 10-20 day for gamma-ray lines—> early seen 56Ni lines: 56Ni belt model(Ni belt mass ~ 10% total Ni mass)



Light curves from SNIa shells

PRELIMINARY



Light curves from SNIa shells

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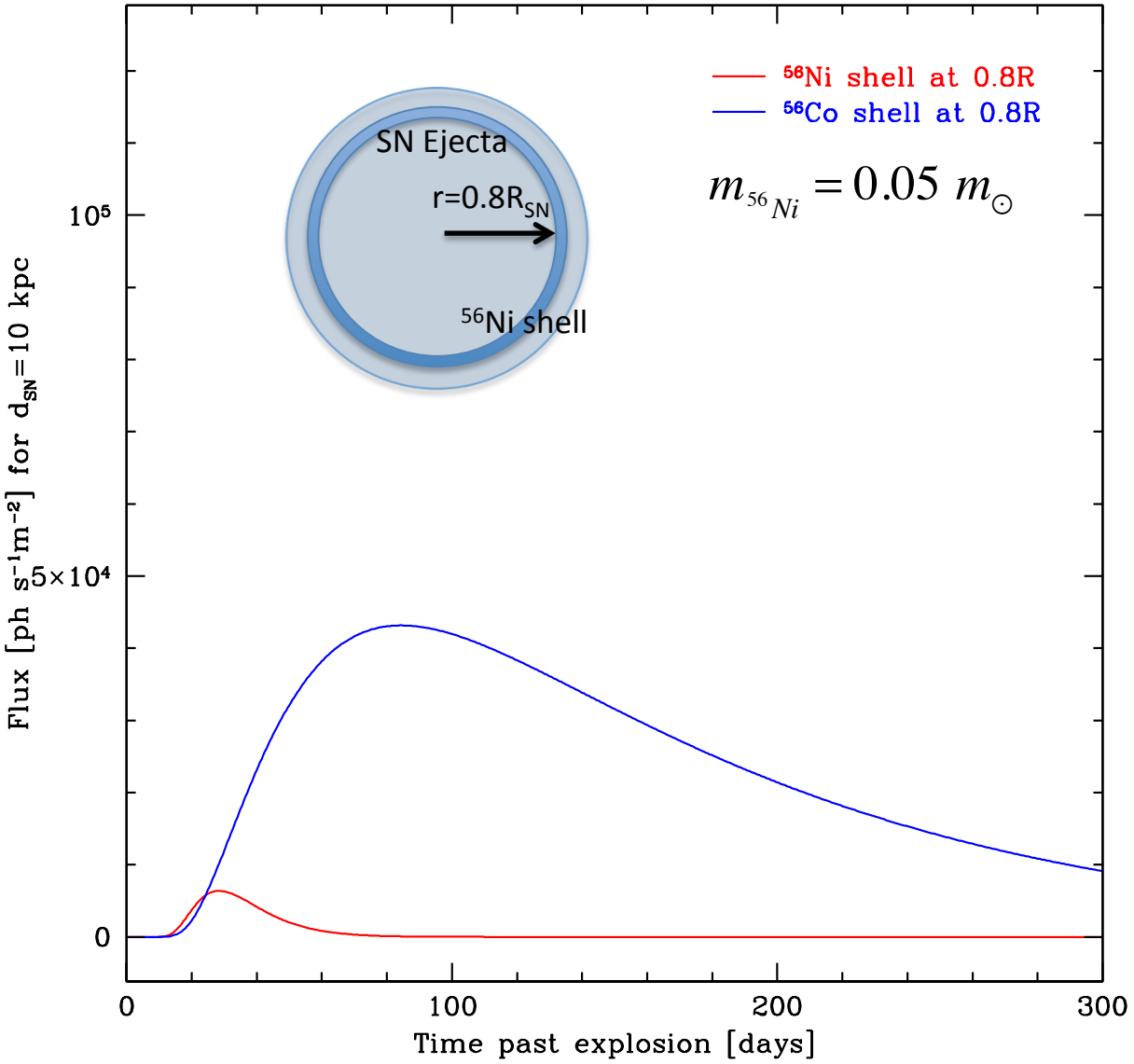

Light curves from SNIa shells

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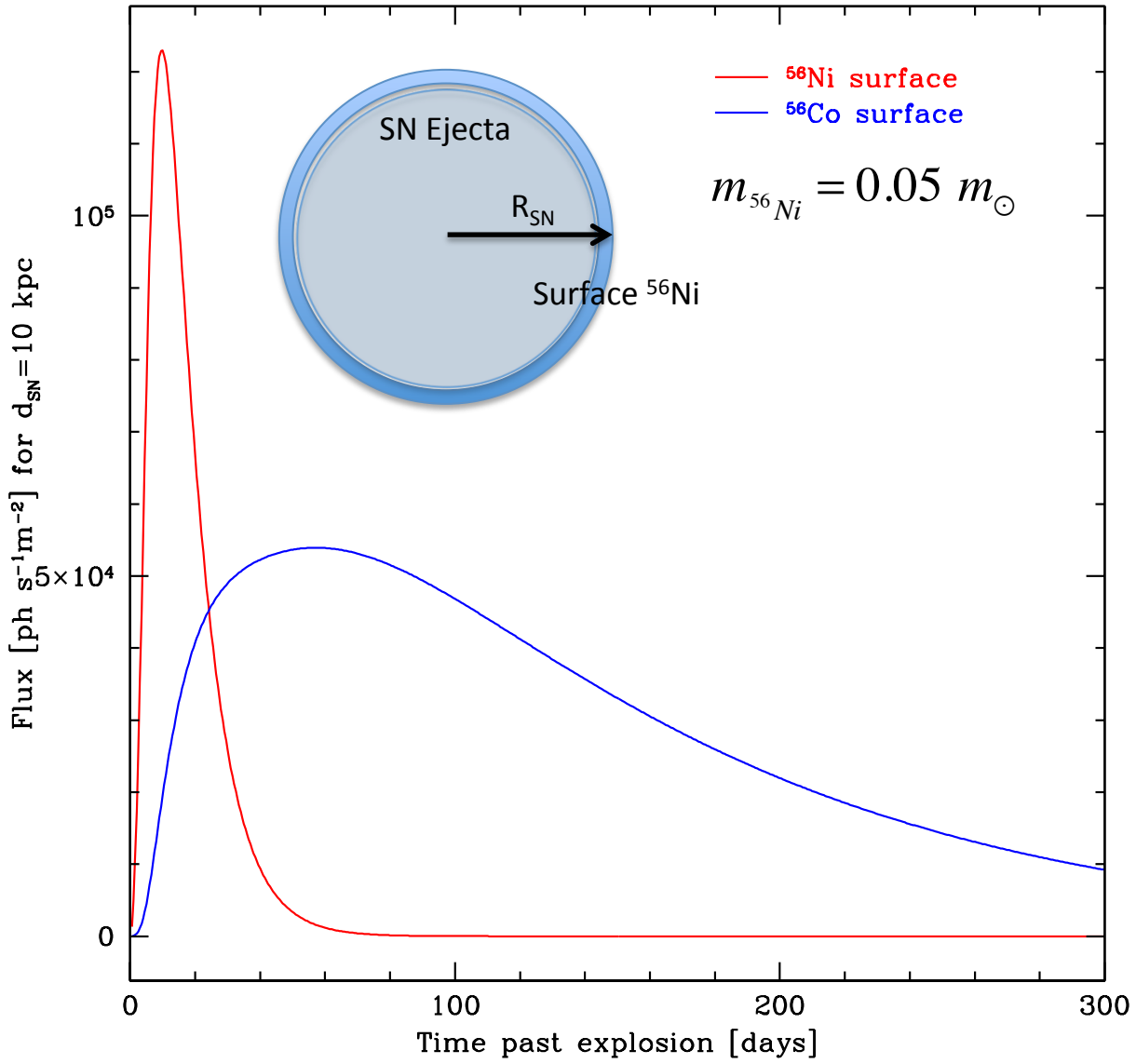

Light curves from SNIa shells

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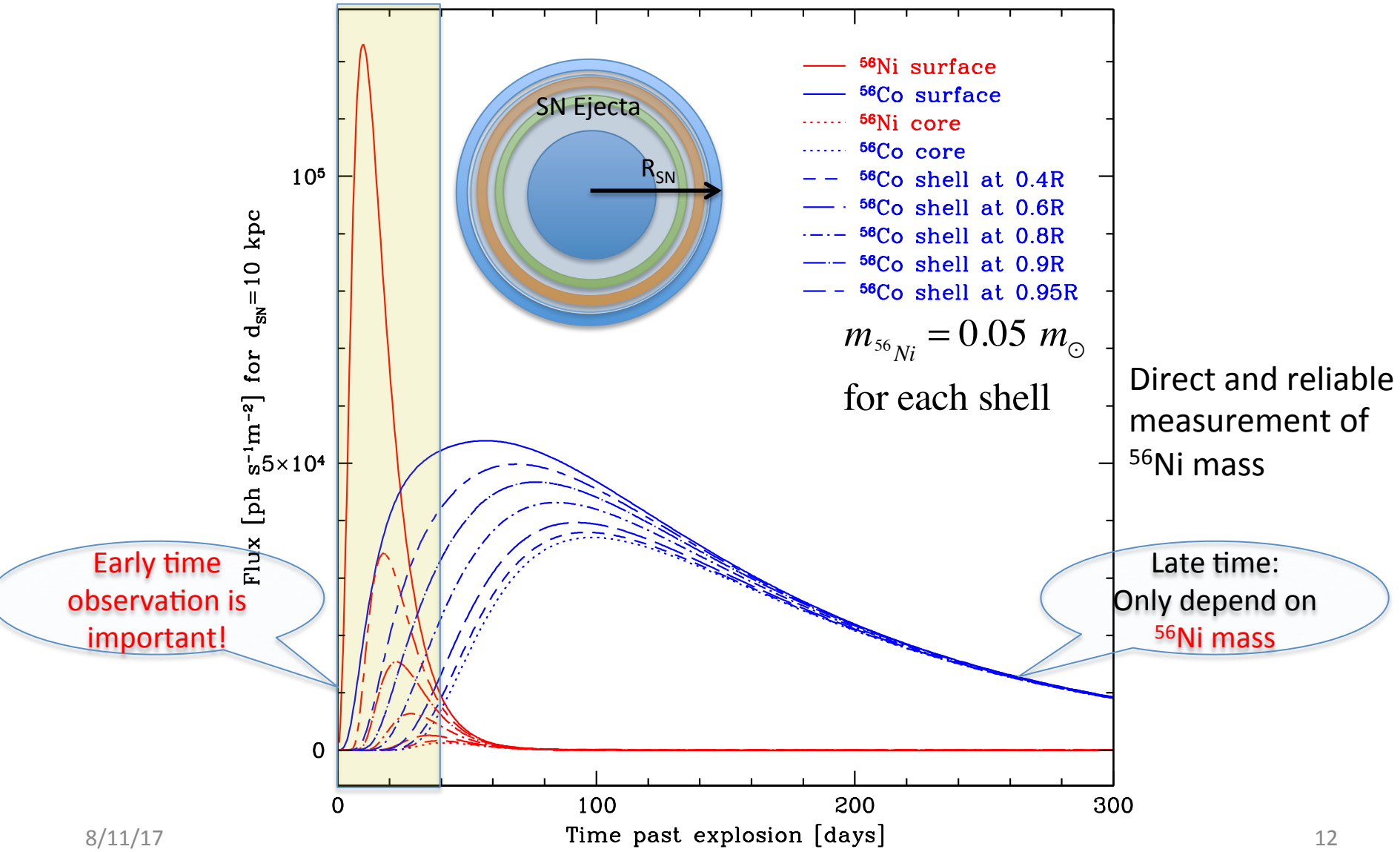
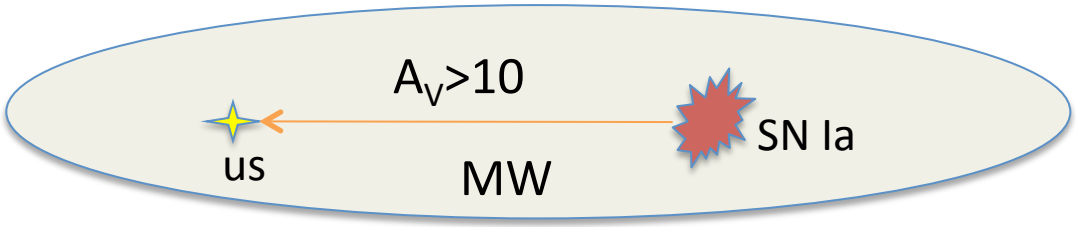


Direct and reliable measurement of ^{56}Ni mass

A Galactic/starburst SN Ia May Be Unnoticed

- Optical or IR? large extinction in the plane or in the starburst region—> faint

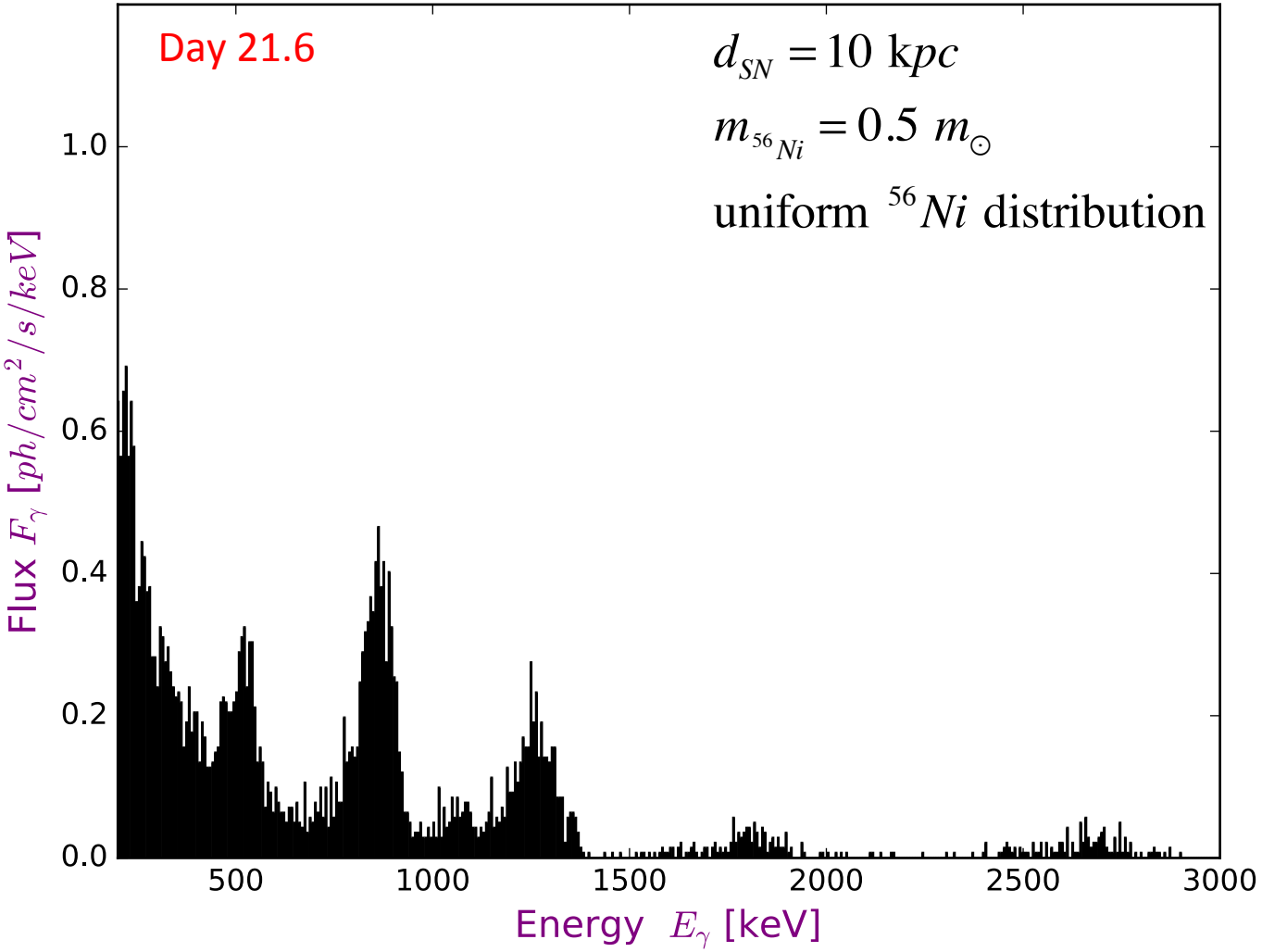


- Radio or soft X-ray? not seen for SN2014J
- Neutrinos? –> weak and in low energy
- GW? –> frequency lower than LIGO sensitivity
- A SN Ia could happen anywhere any time

—>It's possible that we'll miss it!

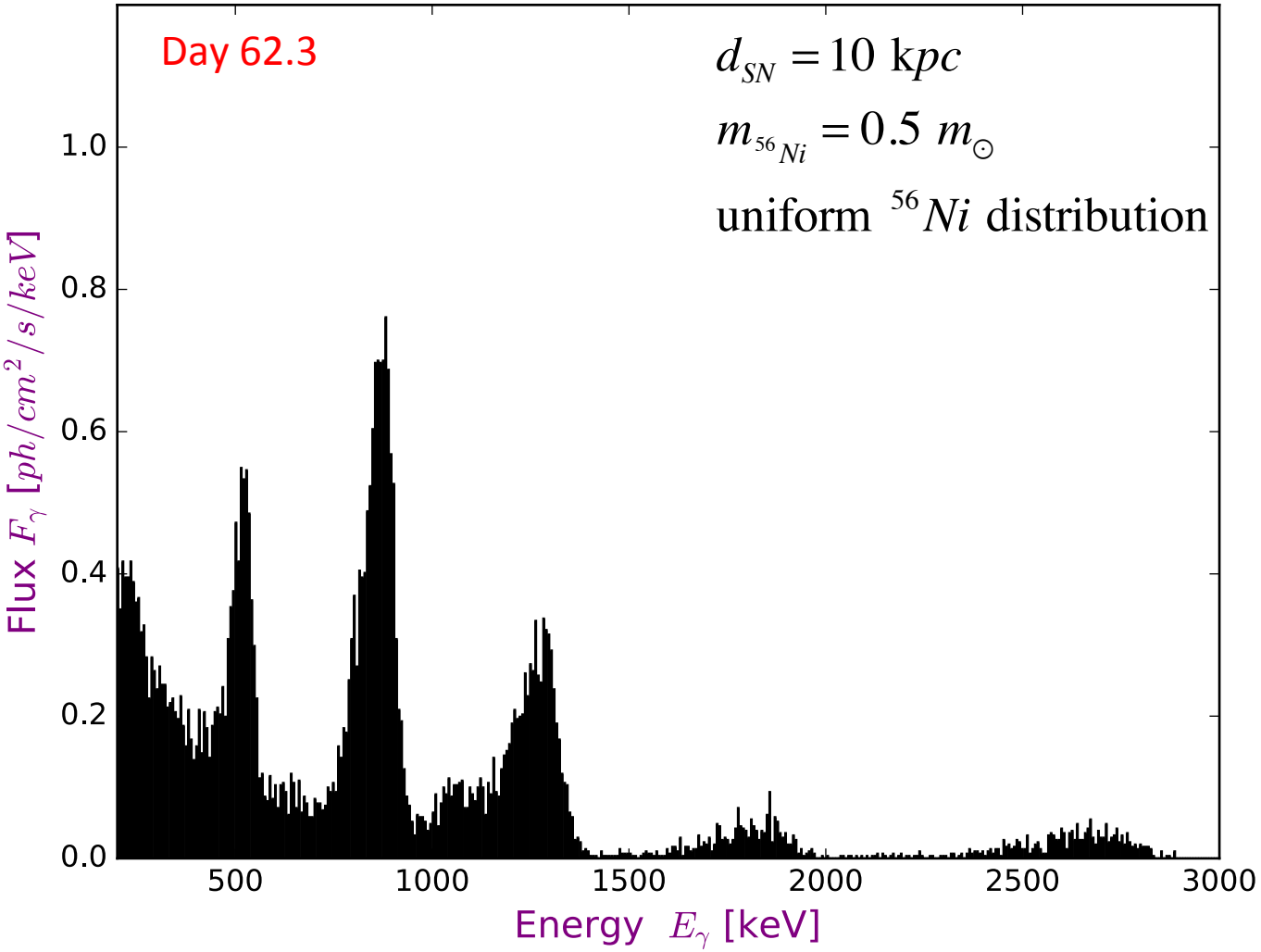
SN Ia Spectra for ^{56}Co lines

PRELIMINARY



SN Ia Spectra for ^{56}Co lines

PRELIMINARY



SN Ia Spectra for ^{56}Co lines

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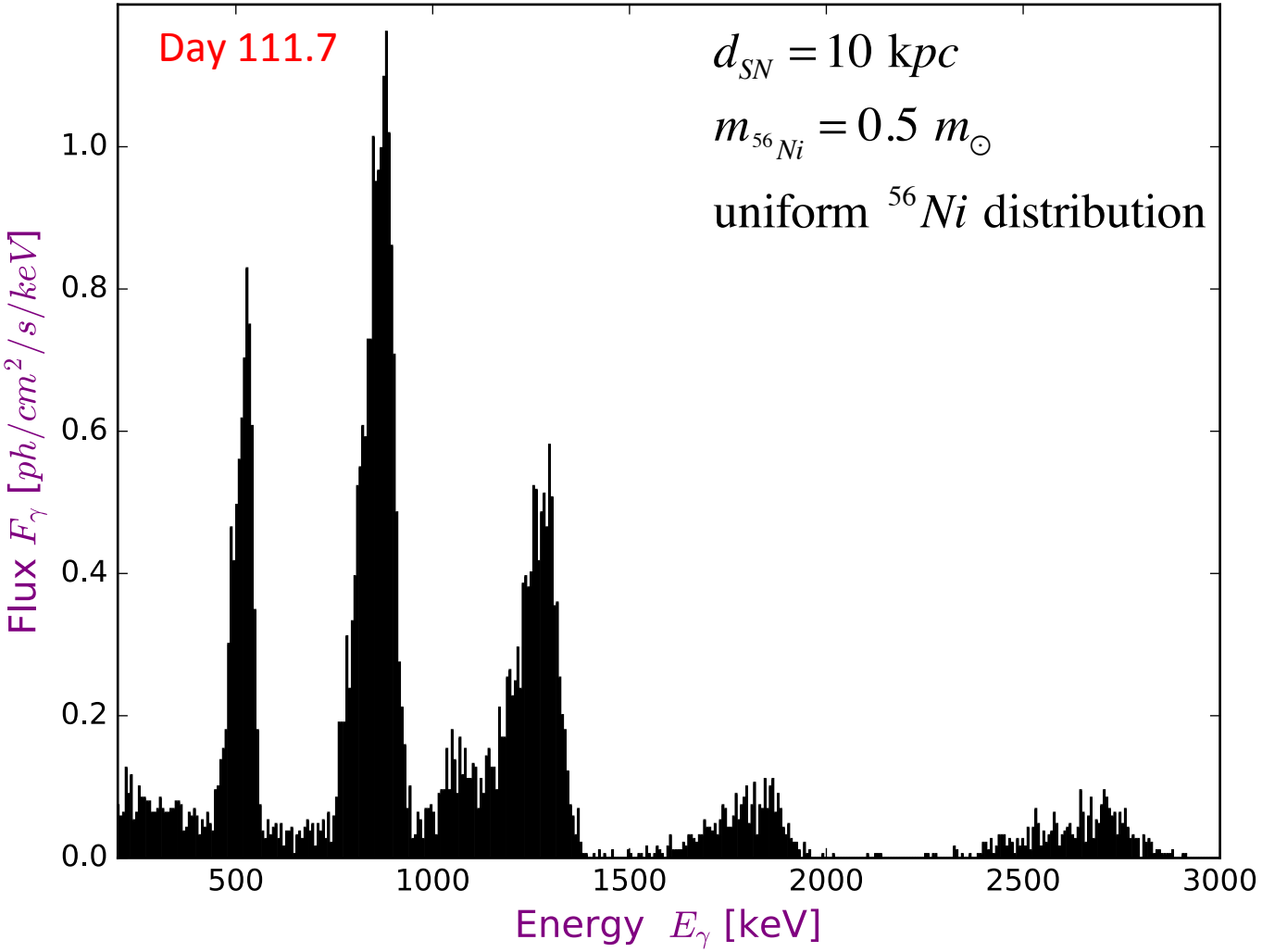
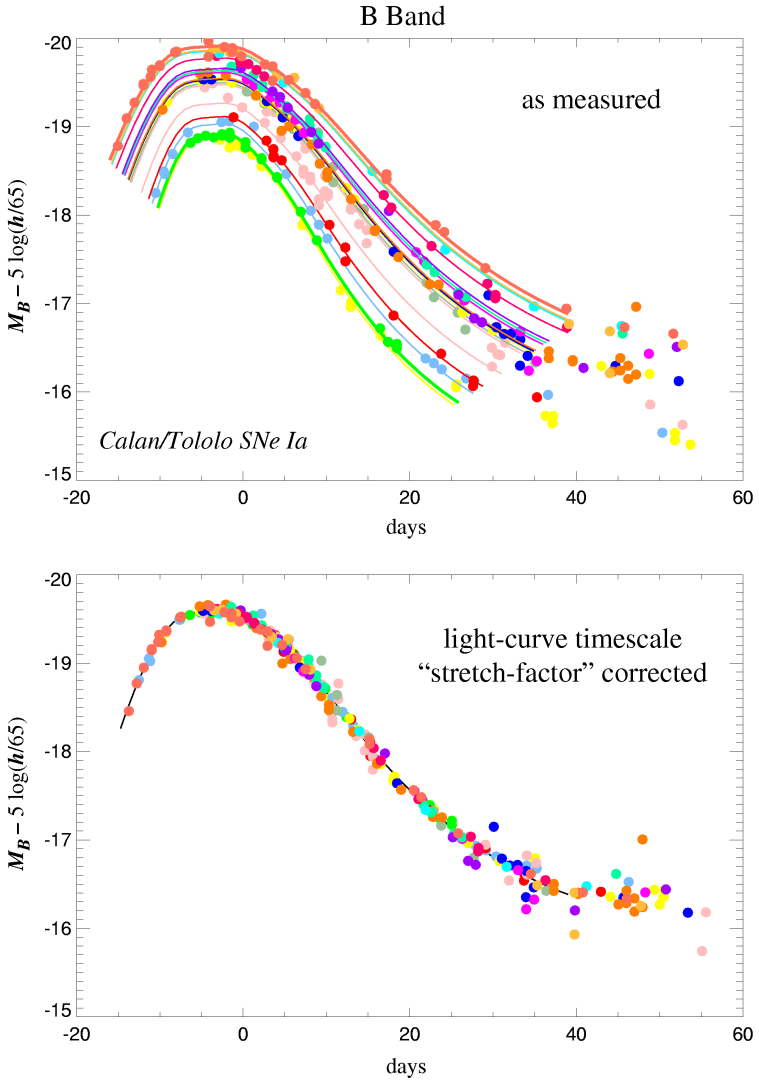


AMEGO for SN Ia

- More gamma-ray SN Ia:
  - SN Ia sample;
  - Precise and accurate measurement of m_{56Ni} →"standard model" (cosmology)
- Early stage observation:
  - Probe the progenitor type
  - Explore the ejecta structure (nucleosynthesis)
  - Search for optical obscured SN Ia in MW/starbursts →test scaling of SFR/SNR
- More to explore with AMEGO:
  - Long-lived ^{44}Ti, ^{27}Al, ^{60}Fe nuclear lines;
  - 511 keV line from electron-positron annihilation

- Backup slides

Phillips relation



Kim, *et al.* (1997)

Gamma-rays from SN Ia

- MW is optically thin to gamma-rays.

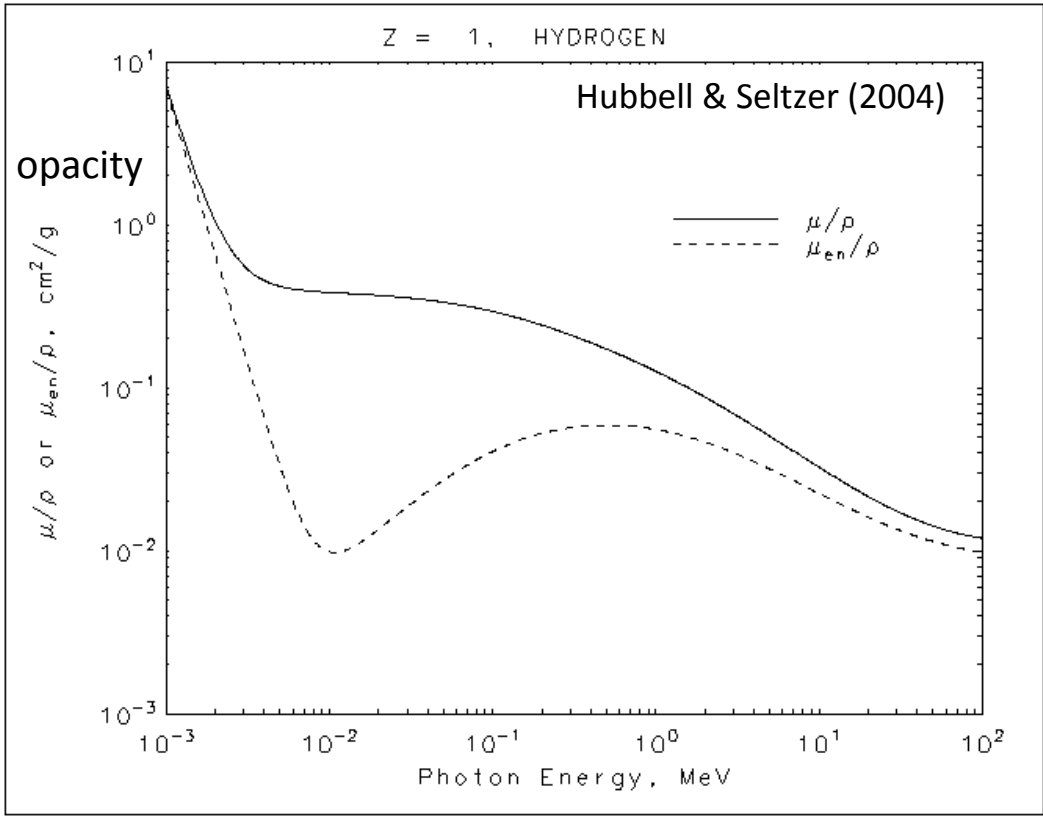
Optical depth of photons in MW:

$$\tau = \int n_H \sigma \, ds \sim \mathrm{N}_H \sigma = \mathrm{N}_H \frac{\mu}{\rho} m$$

$$\frac{A_V}{N_H} = \frac{3.1}{5.8 \times 10^{21} Hcm^{-2} mag^{-1}}$$

$$A_V \sim 30, \text{ for } \mathrm{E}_\gamma > 10^{-1} MeV,$$

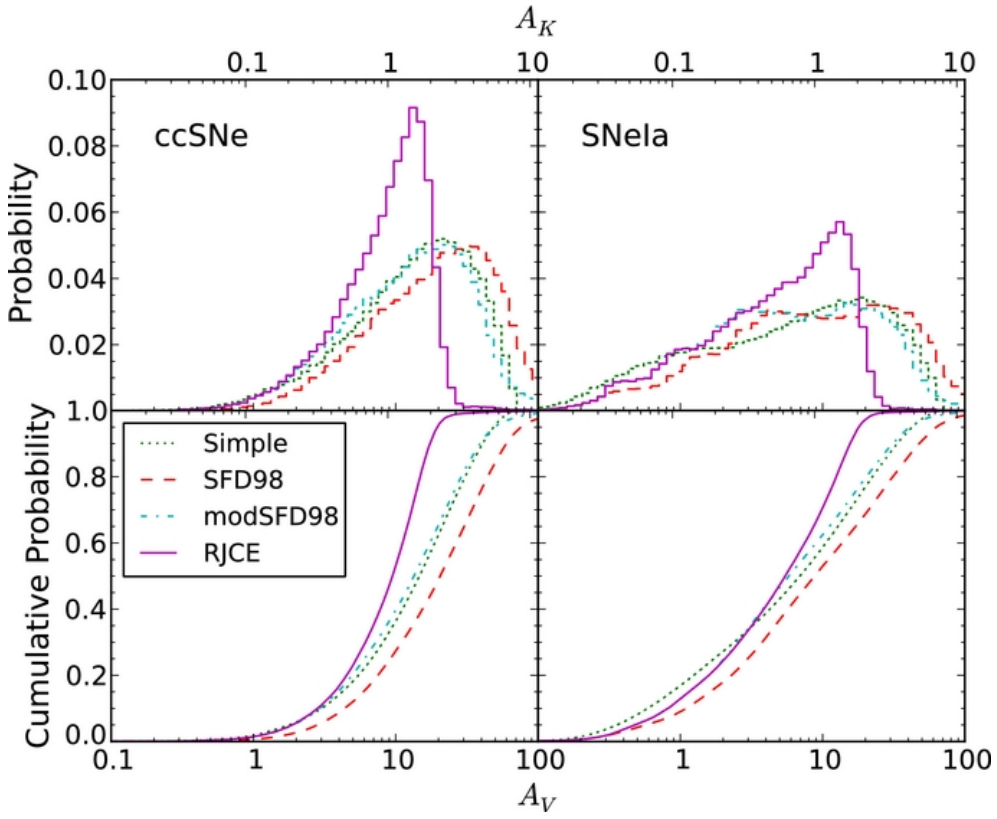
$$\frac{\mu}{\rho} < 1 \Rightarrow \tau < 1 \text{ optical thin}$$

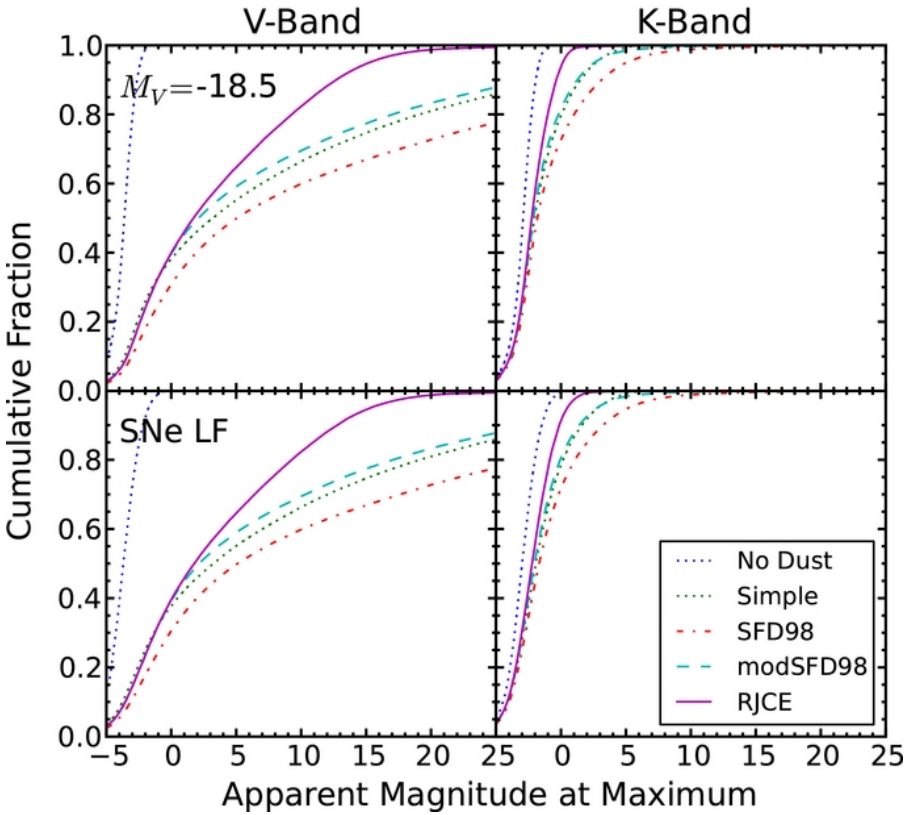


A gamma-ray detector is in need:

- ✓ sensitive to decay line energy range;
- ✓ continuously monitors the sky!

Extinction and Apparent Magnitude of A Future Galactic Supernova





Adams et. al. 2013