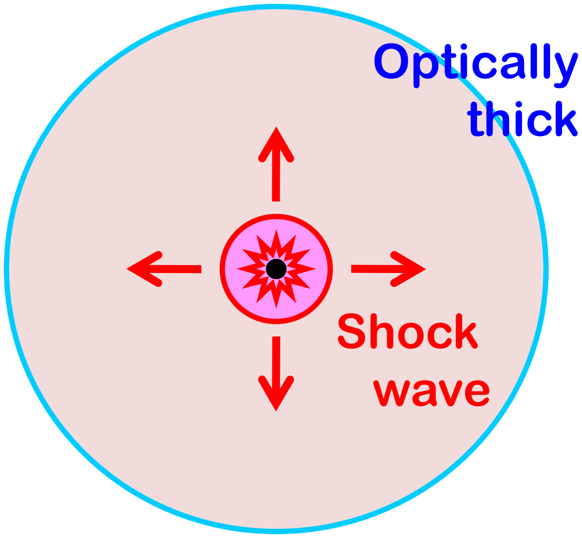
Survey of High-z Core-Collapse Supernovae with Shock Breakouts

Nozomu Tominaga
(Konan Univ., IPMU)

Collaborators:
T. Morokuma (NAOJ), S. Blinnikov (ITEP,IPMU)
P. Baklanov (ITEP), K. Nomoto (IPMU), T. Suzuki (Univ.Tokyo)

CCSNe & Shock breakout



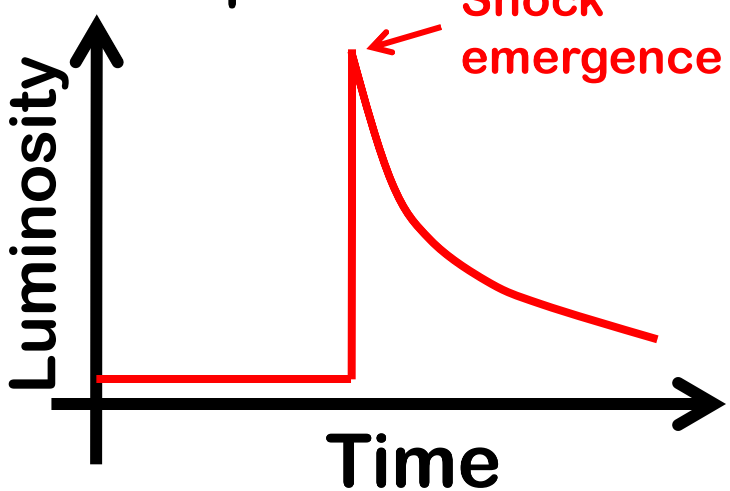
Massive Star (>10$M_\odot$)

e^--capture SNe (8-10$M_\odot$)

Core collapse
Energy deposition
Shock formation

At the shock emergence, a stored energy is released as radiation.

Core collapse



Spectra are quasi-blackbody

$$T \sim R^{-3/4}E^{1/4}$$

The first observations are reported in 2008.

Physics of Shock Breakouts

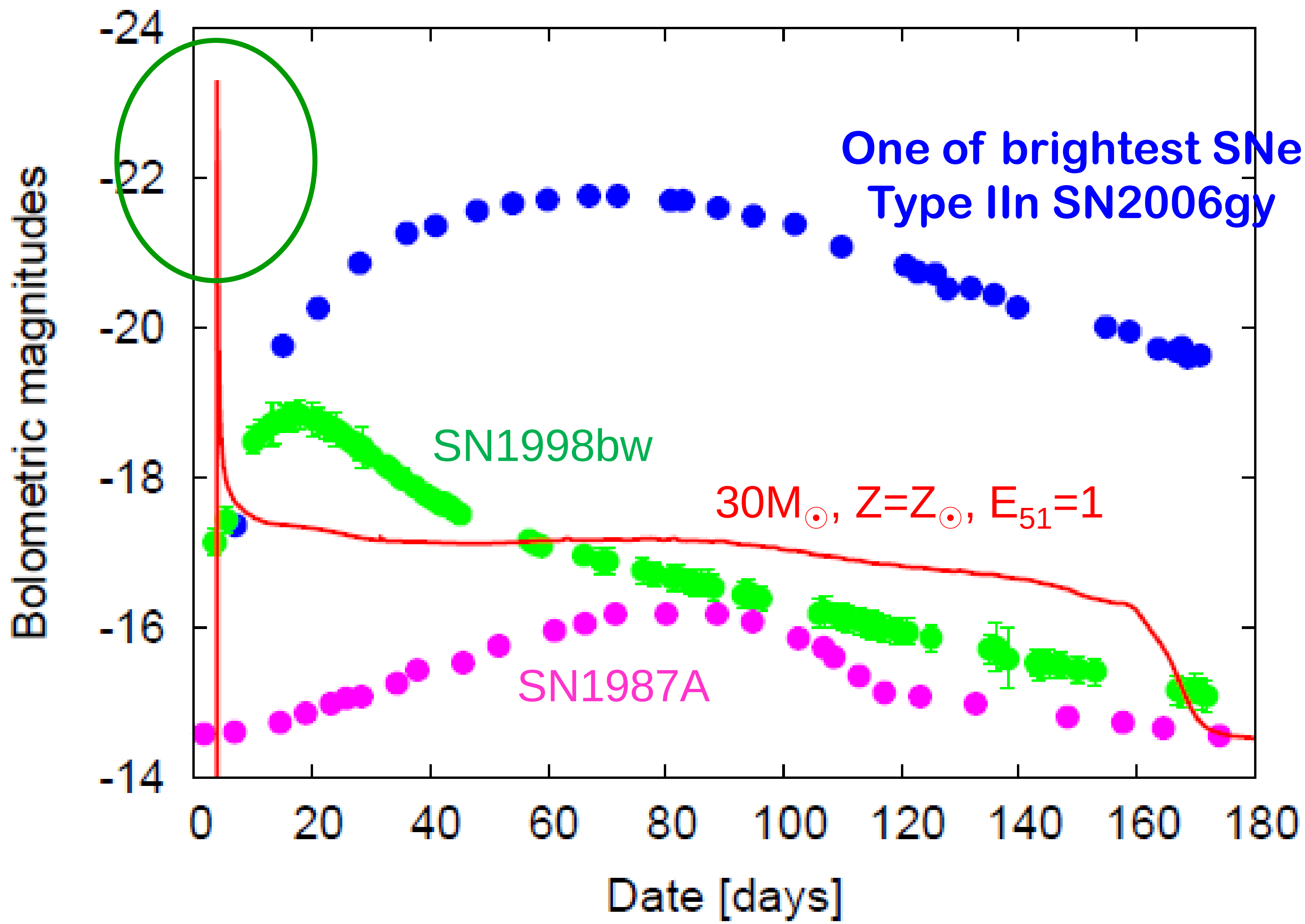
<u>Theoretically predicted in 1960s (Klein & Chevalier 78)</u>

- Phenomenon in <1-2 days
- Phenomenon at t<10
- Radiation hydrodynamics
  - Coupled hydrodynamics and radiative transfer
- Gas and radiation are being decoupled
  - Radiative hydrodynamics with at least 2 (gas and radiation) temperatures

<u>STELLA (Blinnikov + 98)</u>

Multigroup radiation hydrodynamics

Why shock breakouts?



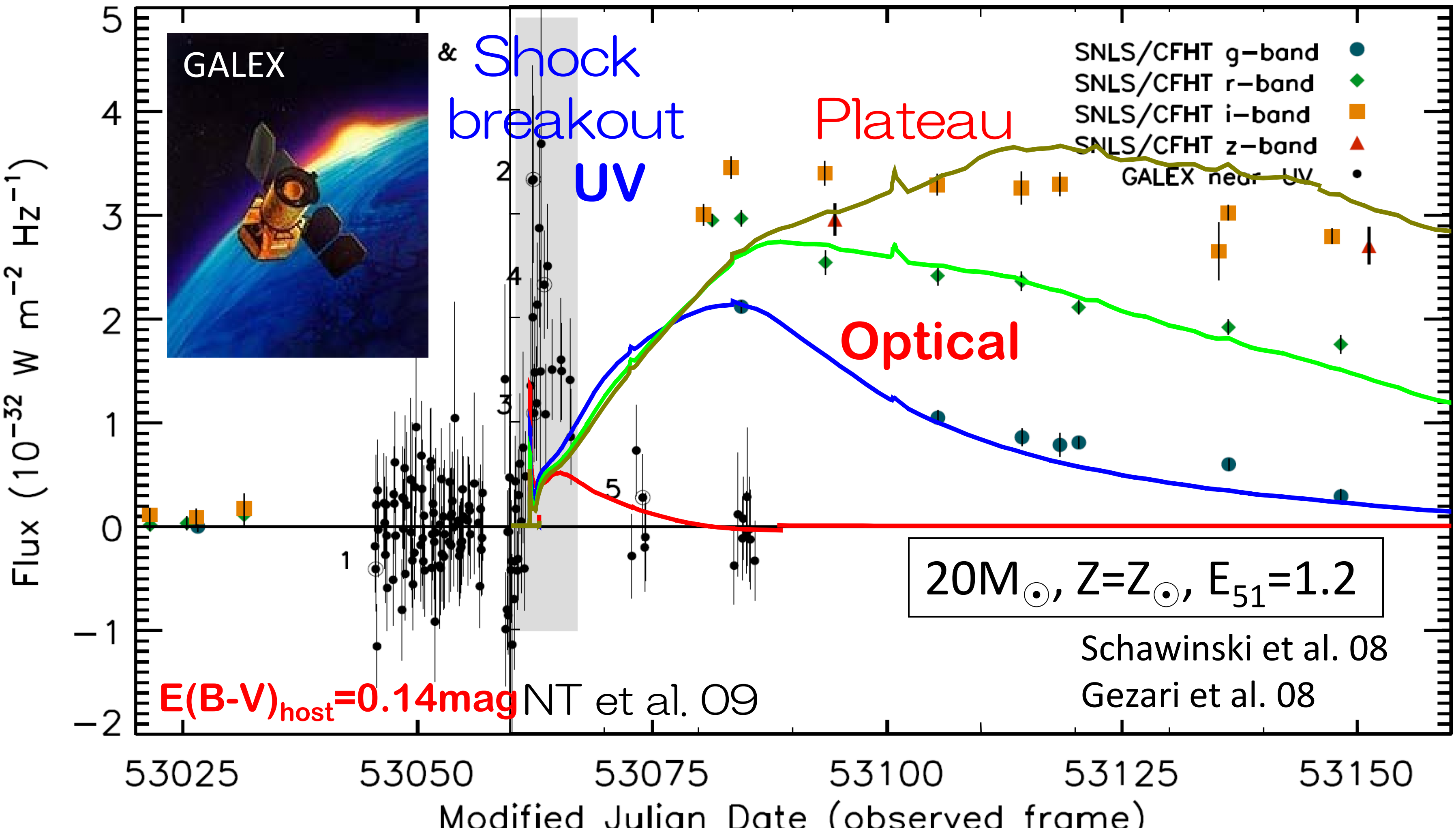
Shock breakouts of "normal" SNe are BRIGHTER than peculiar SNe!!

→We can detect them even at distant universe.

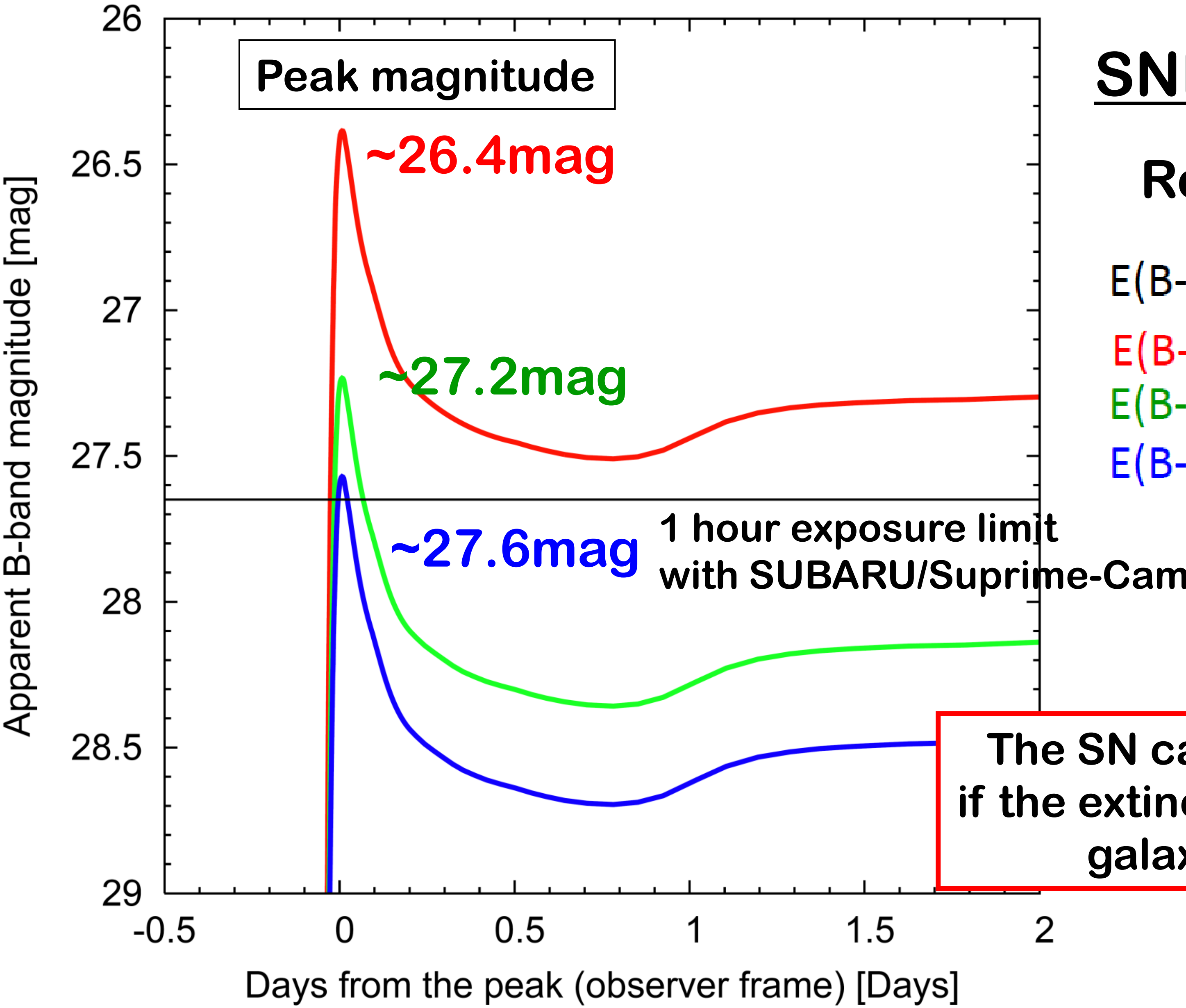
Shock breakouts of Type IIP SNe
—Observations and model—

SNLS-04D2dc

SNLS SuperNova Legacy Survey



When the same SN takes place at high z,



SNLS-04D2dc

Redshift z=1

$E(B-V)_{Gal}$=0.02mag.

$E(B-V)_{host}$=0

$E(B-V)_{host}$=0.1mag.

$E(B-V)_{host}$=0.14mag.

The SN can be detected, if the extinction of the host galaxy is small.

Summary

- SN shock breakout
  - Observations begin to be reported.
- UV-optical LCs of SNLS-04D2dc
  - A theoretical model can reproduce them.
- Models predict detections at z>~1.
- HSC :~6detections in 1 FoV with 5 nights
- Direct observations of normal CCSNe at z>0.5 become possible.
  - They can be compared with theoretical models and derive M_{ms}, R_{preSN}, E at z>0.5
- It will be another clue of the distant universe.