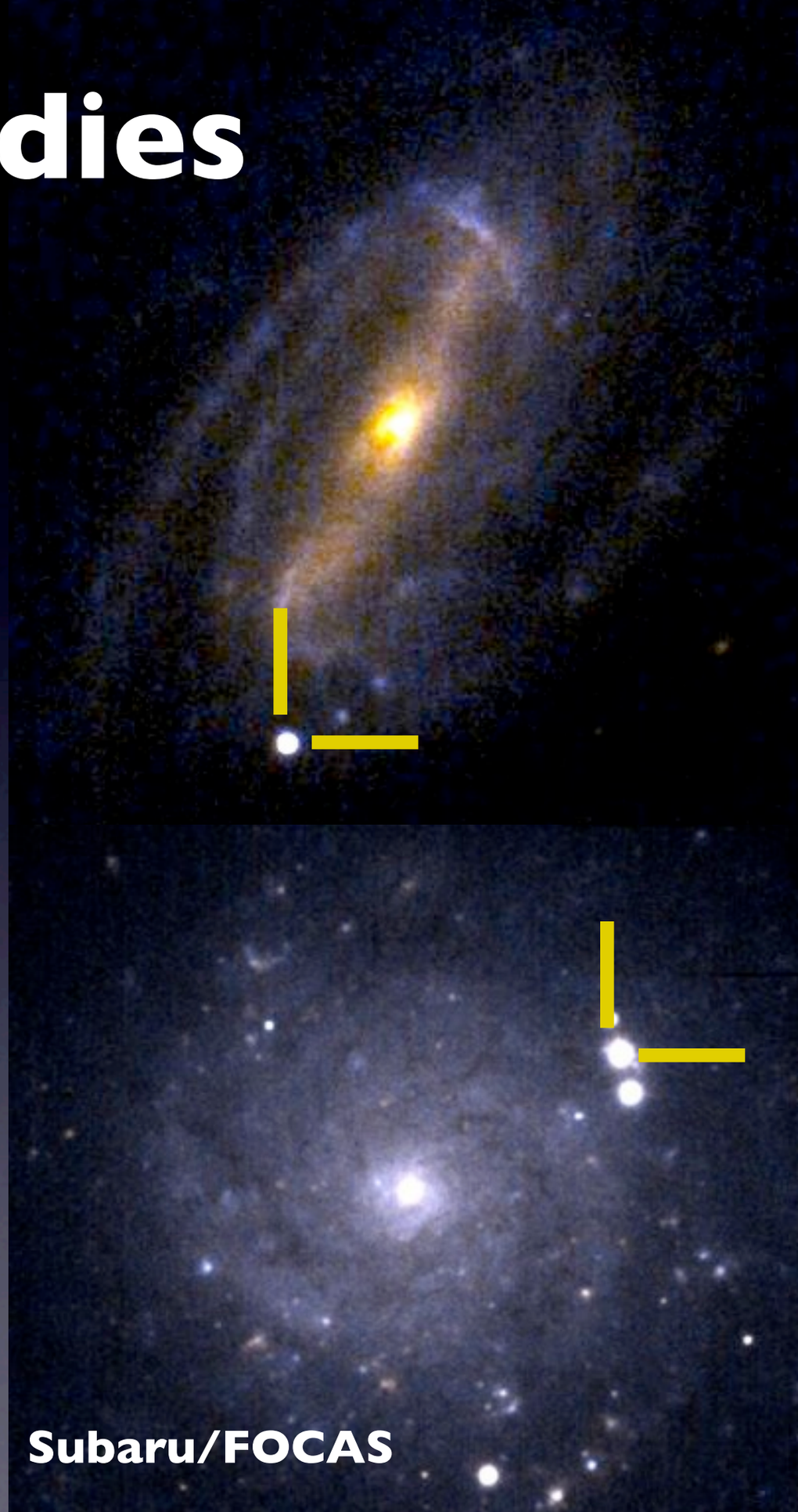
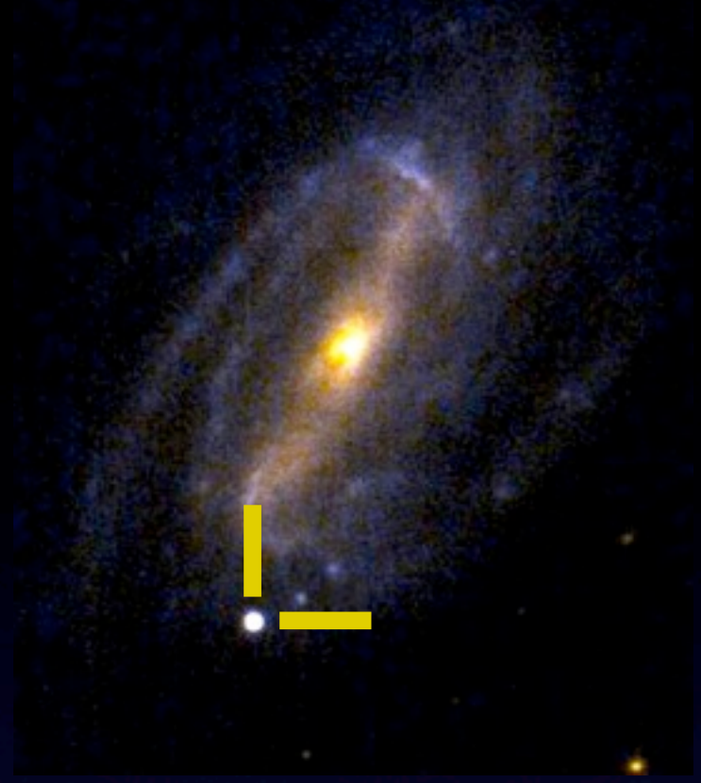
Observational Studies of Supernovae with Subaru

Masaomi Tanaka
(NAOJ)



Supernovae



- Origin of heavy elements
- Kinetic energy to ISM
- Probe of massive stars (at high-z)

Explosion mechanism?

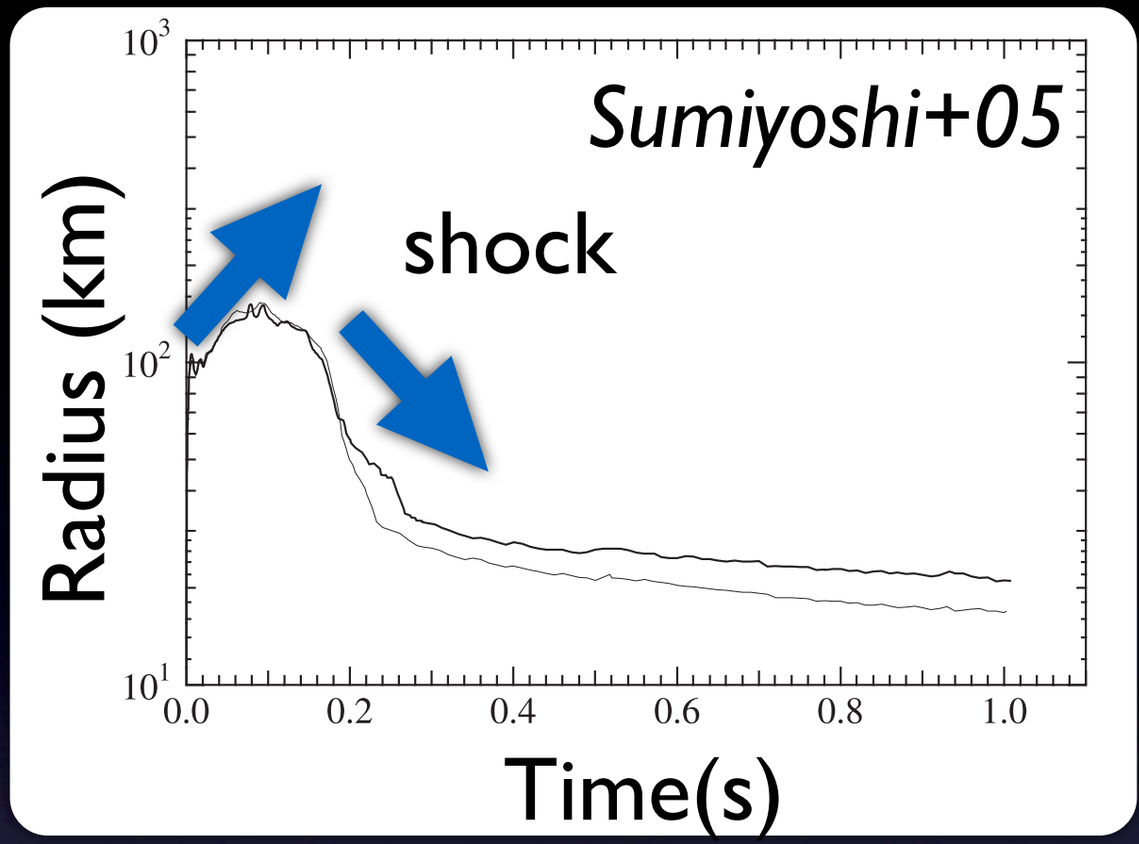
core-collapse => bounce => ??

Long-lasting problem!

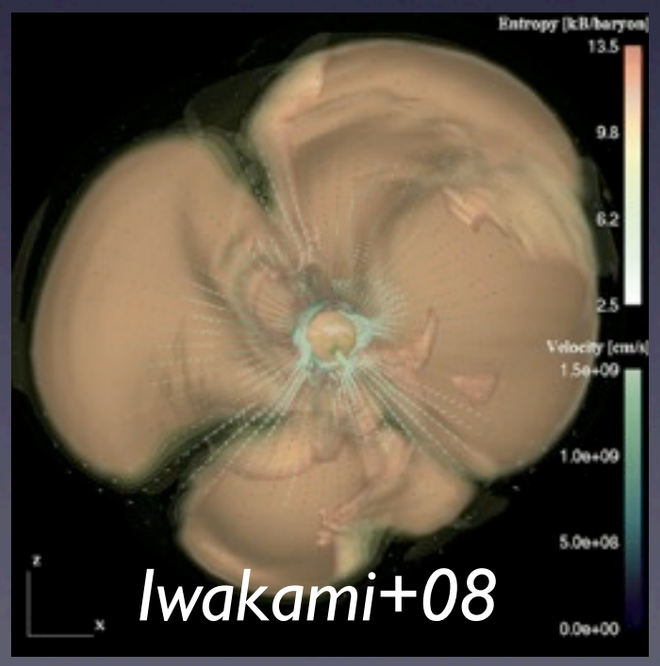
(B2FH 1957, Hoyle & Fowler 1960)

The Biggest Problem

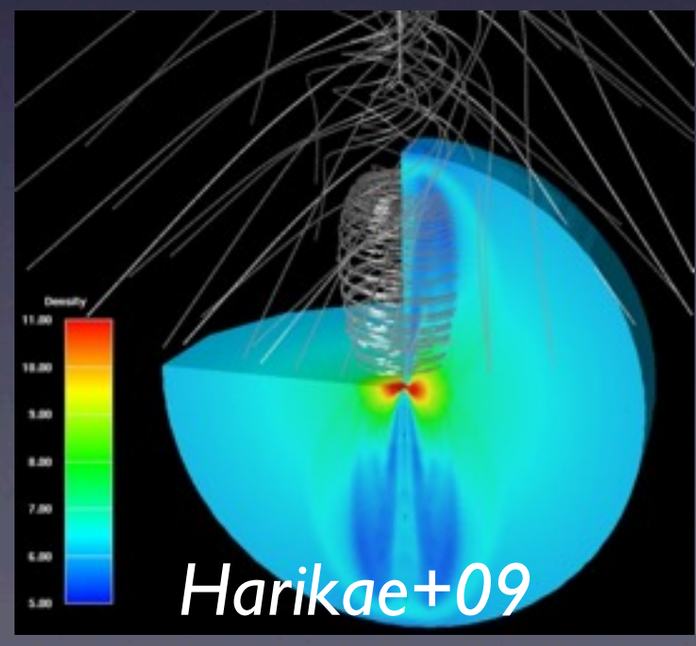
- Spherical explosion would not succeed
- ***Aspherical explosion***



Neutrino + convection* VS. *Rotation + magnetic field



Observational Test

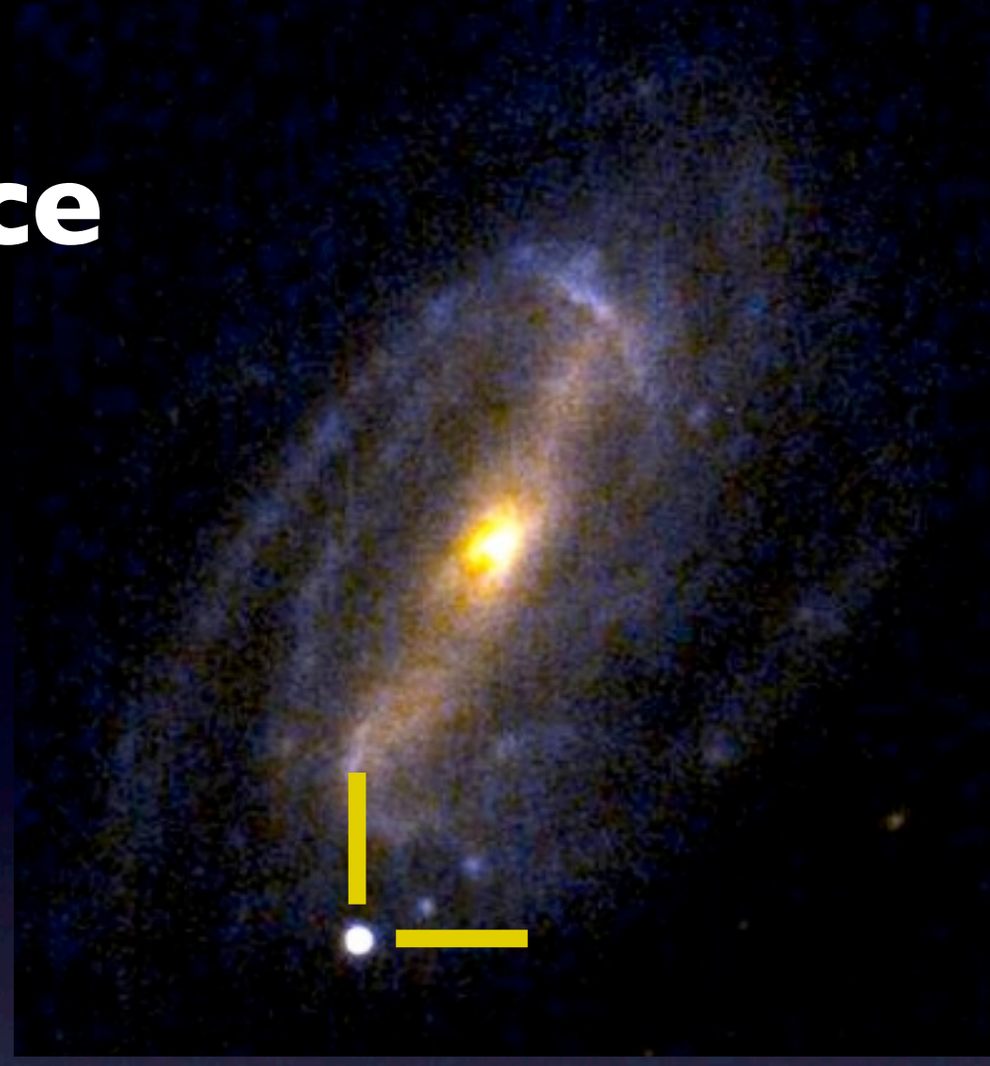


Supernova = Point Source

V ~ 5,000- 10,000 km s^{-1}

R ~ 2 x 10^{15} cm ~ 0.001pc

θ ~ 10^{-6} arcsec @ 30 Mpc



Resolve the "shape" by <u>Polarization</u>

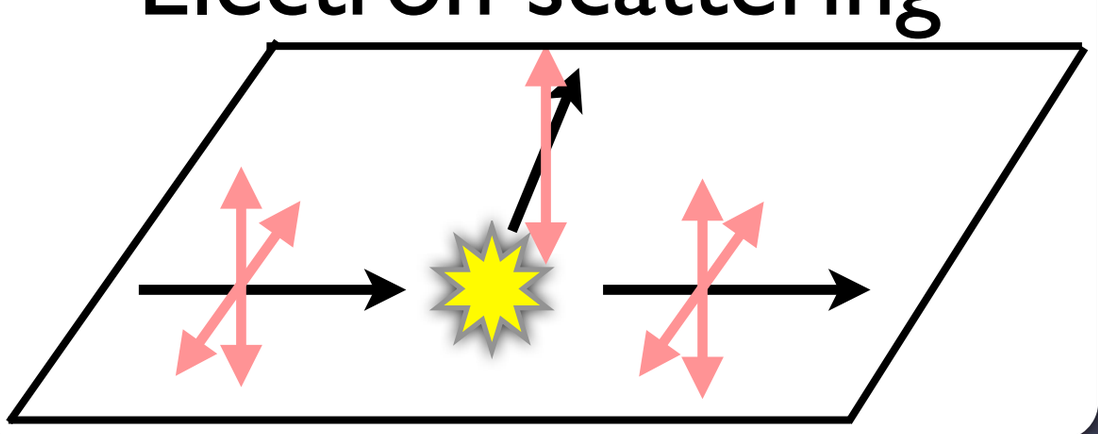
From the side

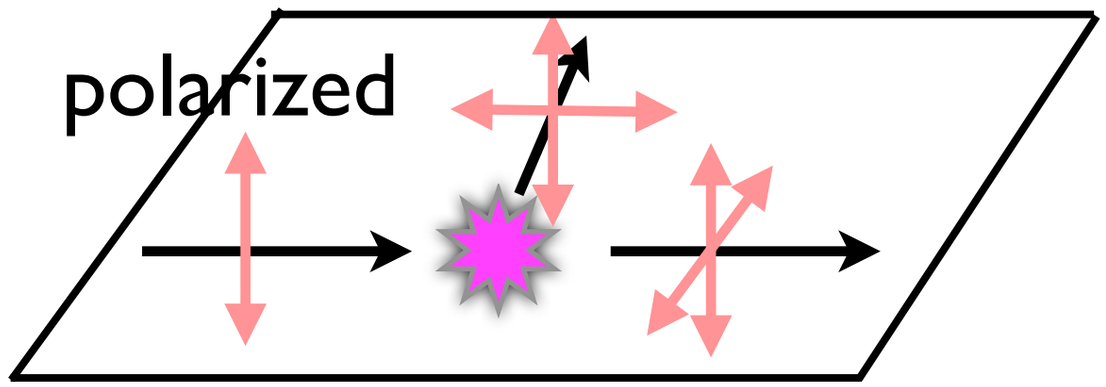
On the sky

Observer

Optically thick

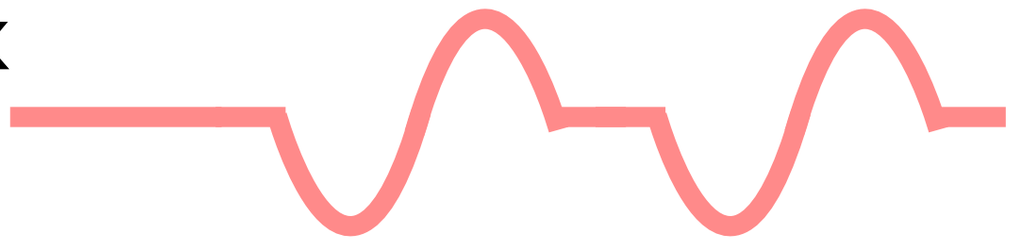
Electron scattering





Line scattering

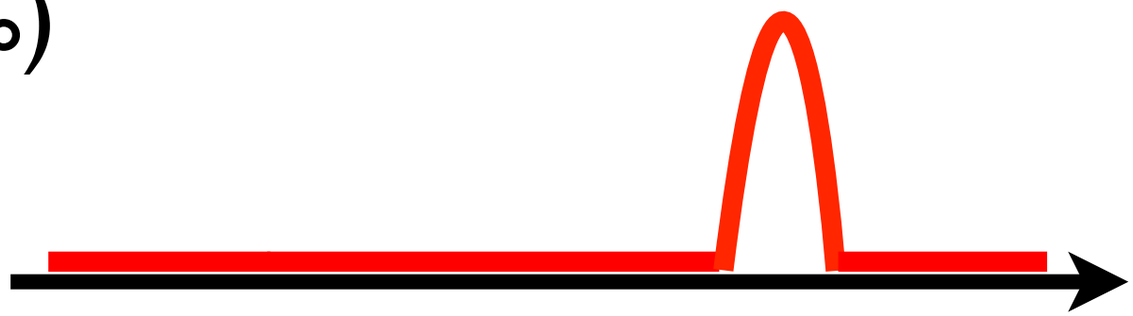
Flux



continuum aspherical

spherical

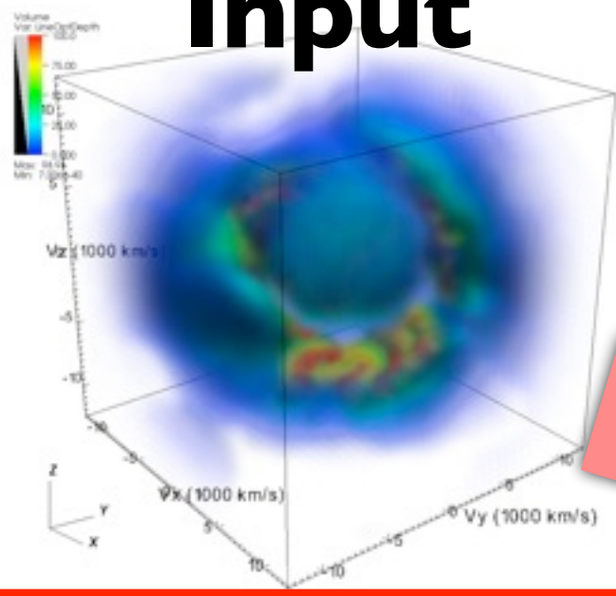
P(%)

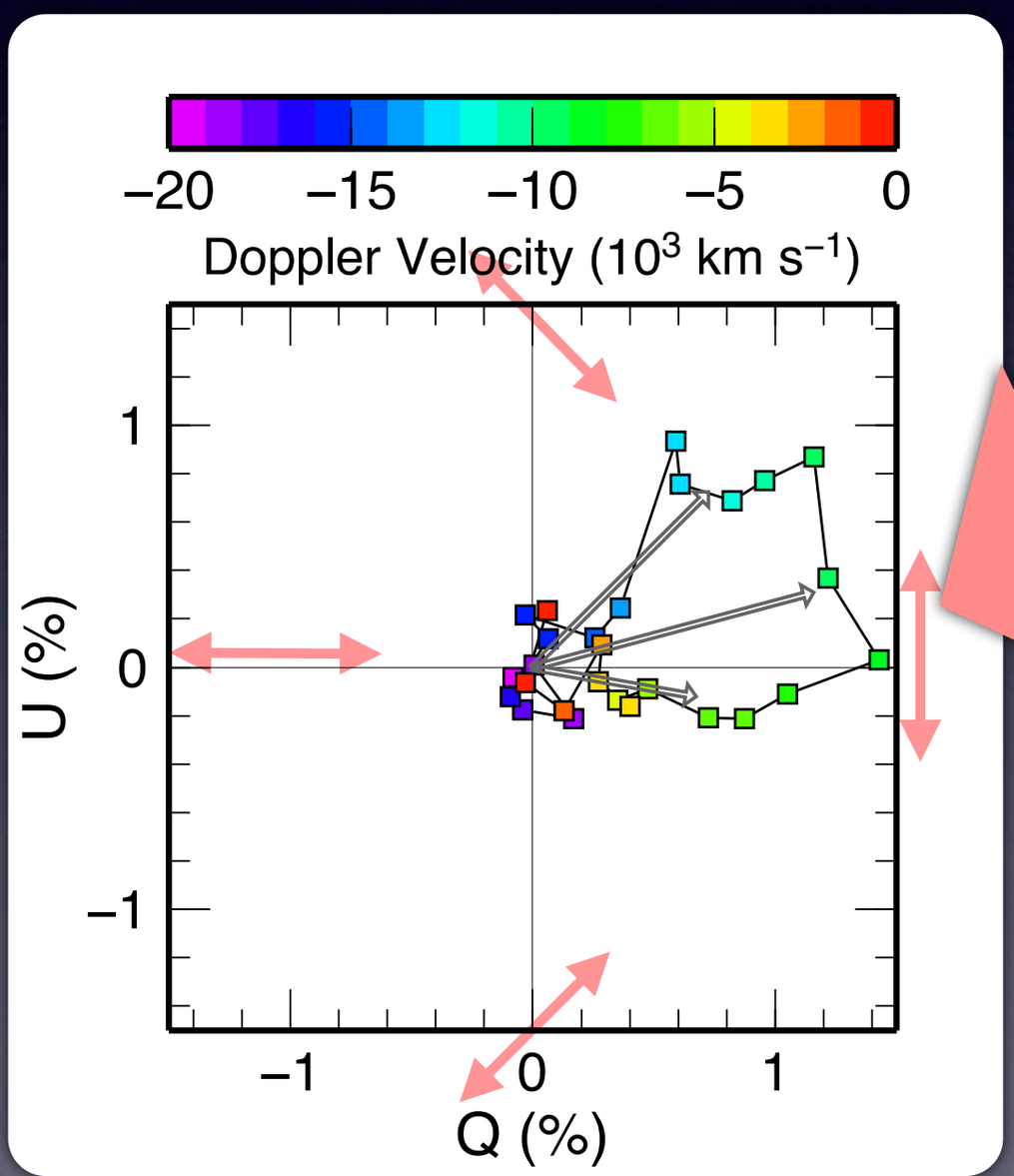


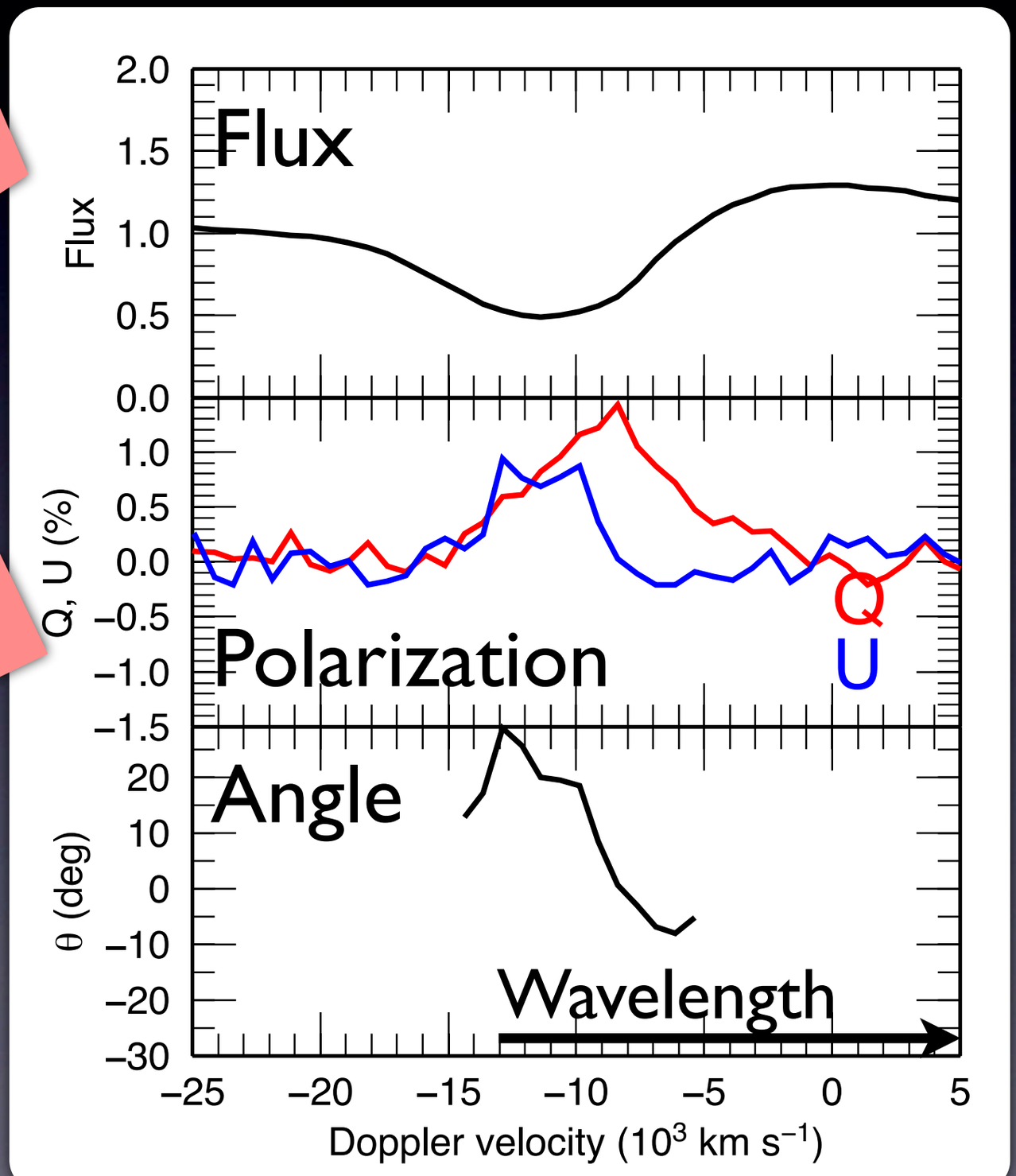
3D Radiative Transfer Simulation

MT+ in prep.

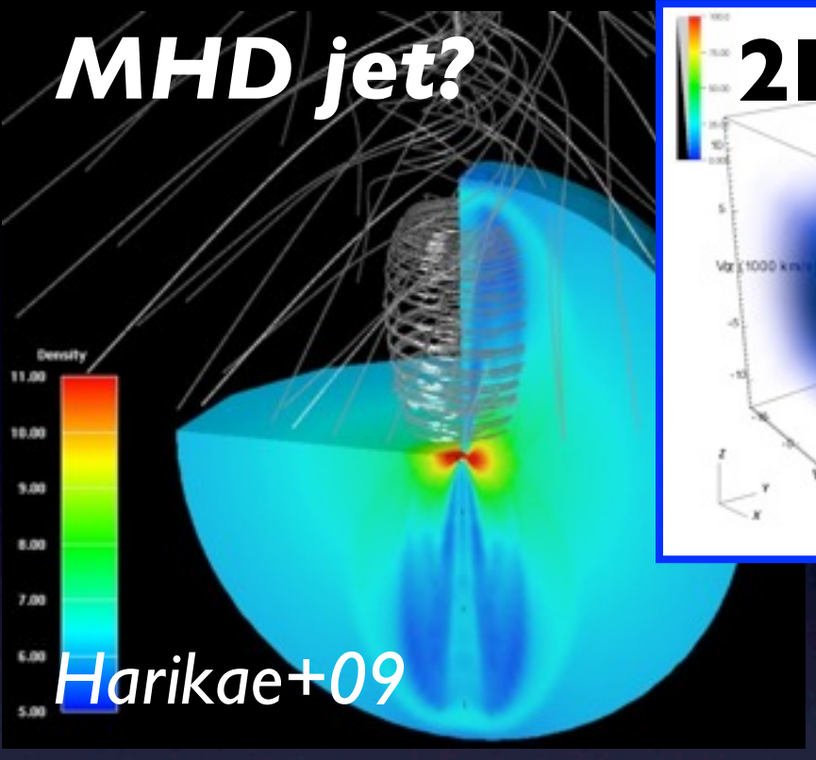
Input

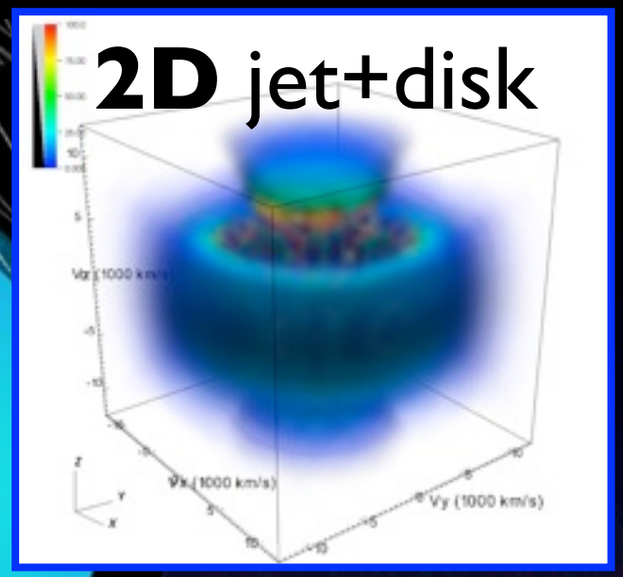


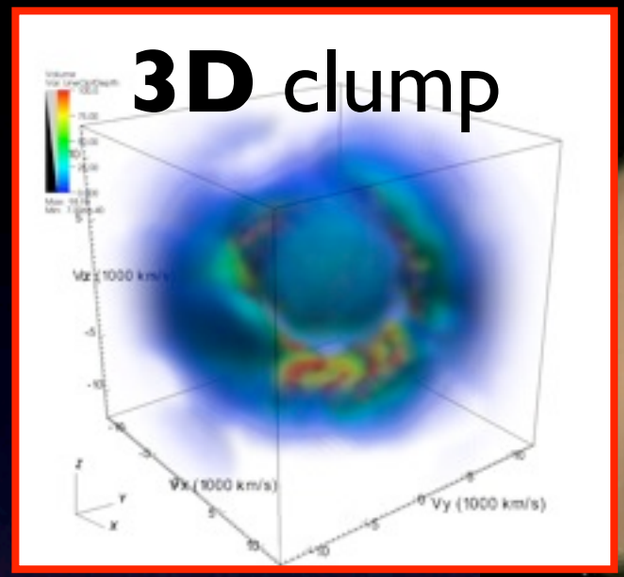


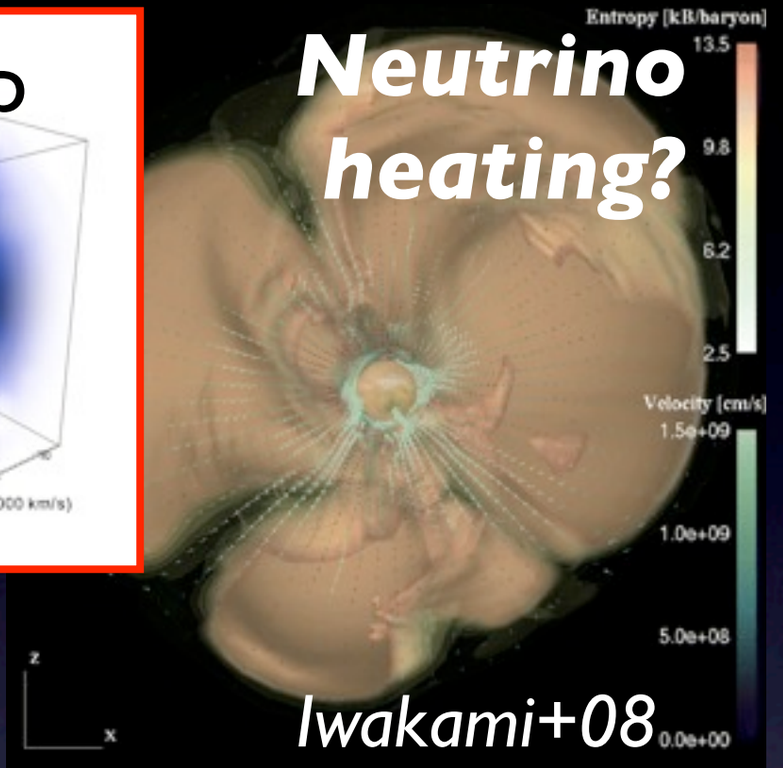


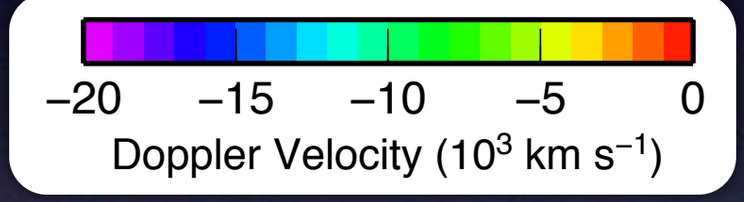
Diagnostic of the Geometry

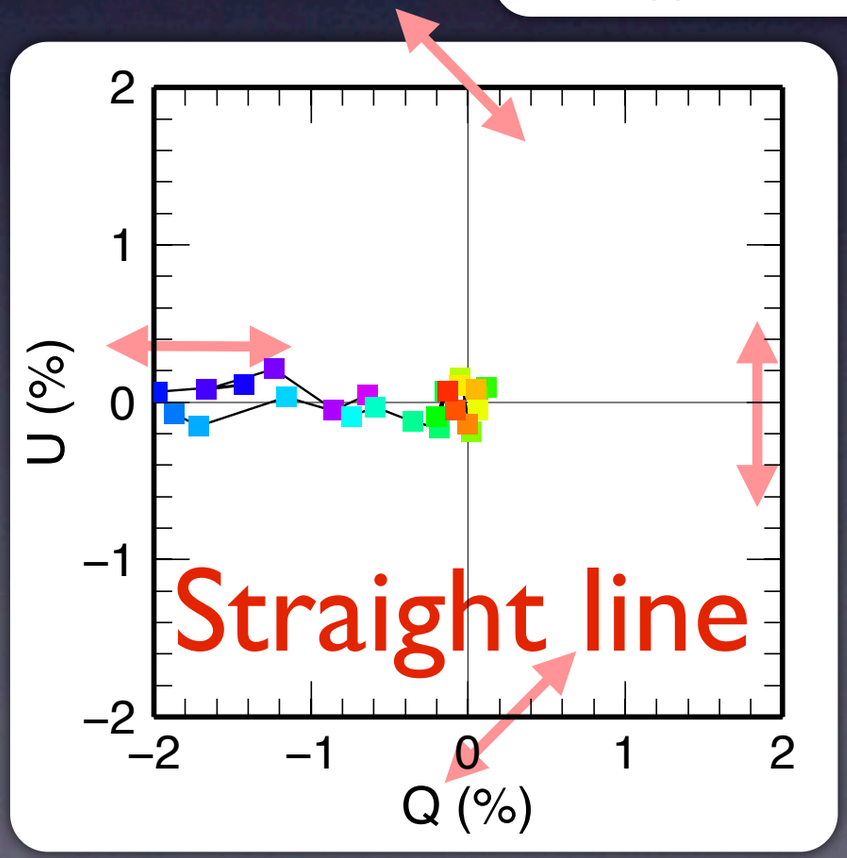


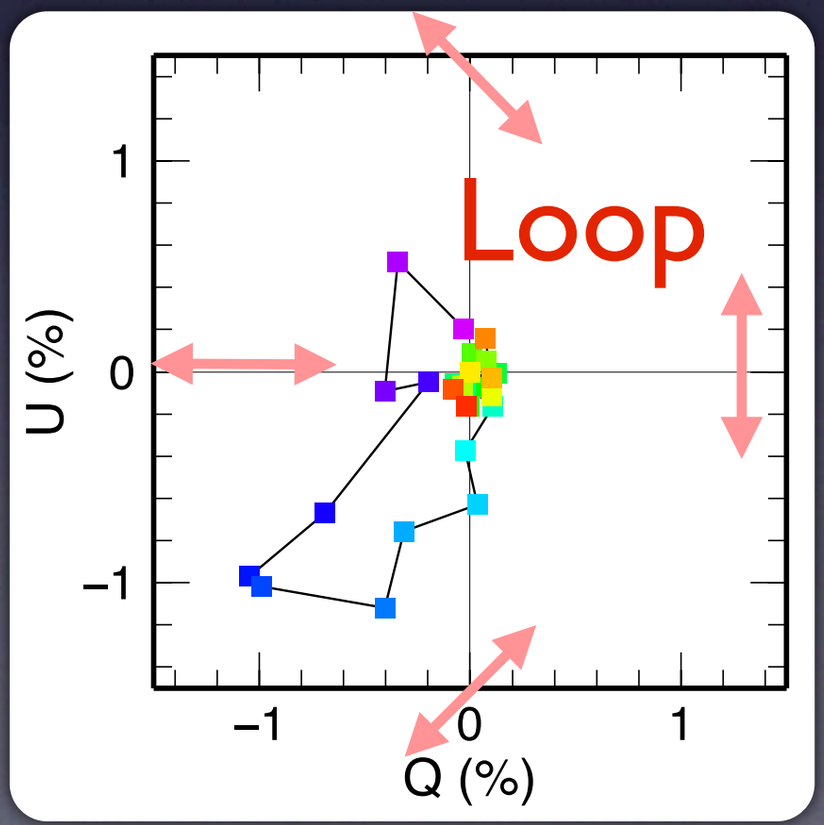










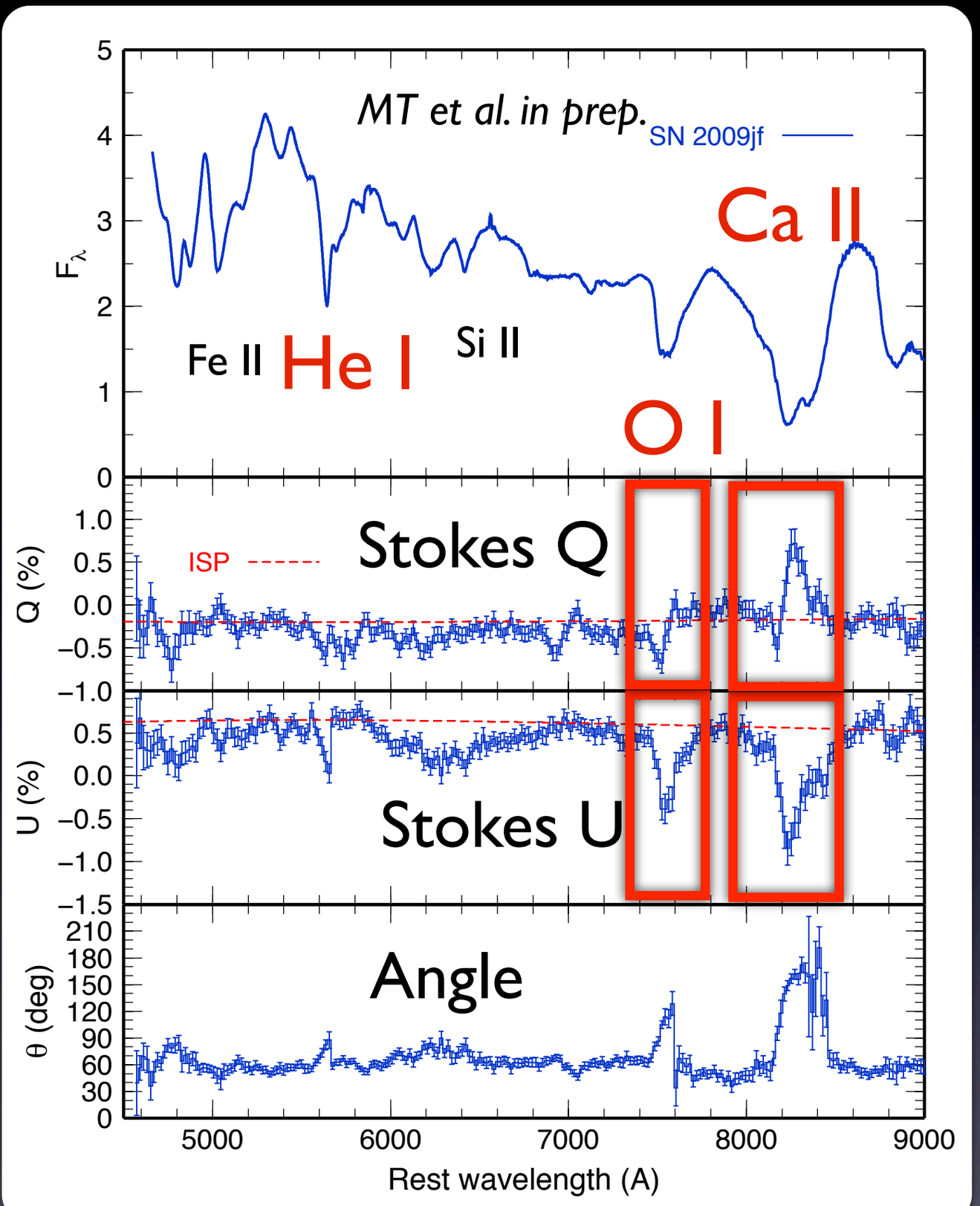


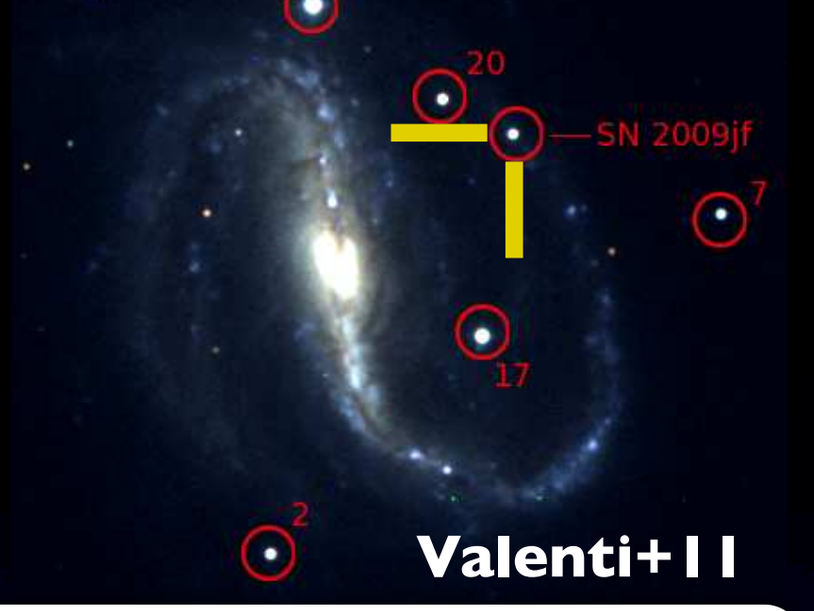
ToO spectropolarimetry for SNe with Subaru/FOCAS

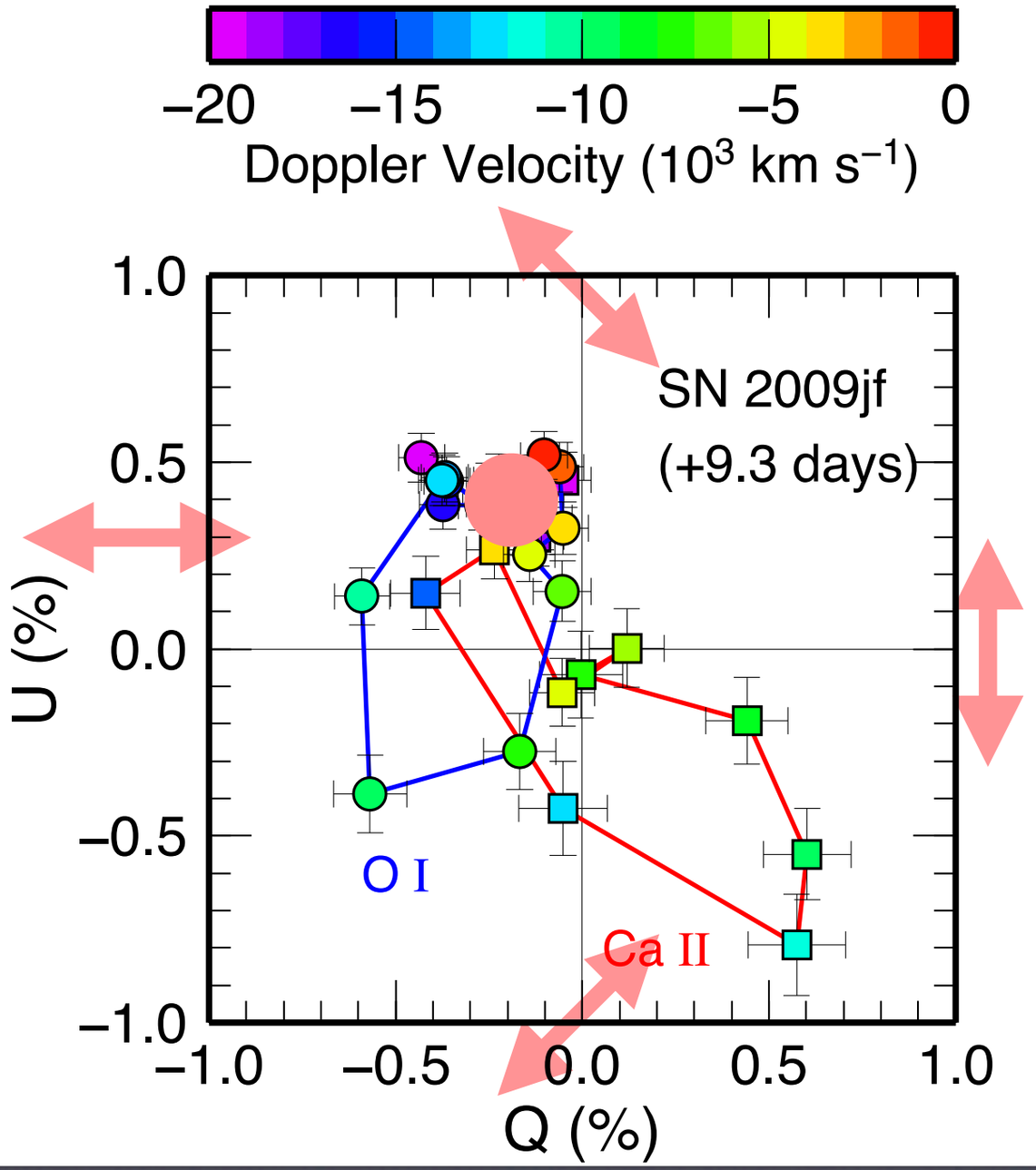
PI: M. Tanaka,
Co-I: K. S. Kawabata, T. Hattori.
E. Pian, K. Maeda, M. Yamanaka, K. Nomoto,
P. A. Mazzali, K. Aoki, T. Sasaki, and M. Iye

- <u>High precision</u>
  - ΔP = 0.1-0.2%
    (for R = λ/Δλ~600 => Δv ~500 km/s)
    Need for 8m-class telescopes
- <u>Immediate observations</u>
  - Need for ToO observation
    within ~2 weeks after the discovery

MT+2008, ApJ, 689, 1191
MT+2009, ApJ, 699, 1119
MT+2010, ApJ, 714, 1209
MT+ in prep.


MT et al. in prep.
SN 2009jf
Ca II
Fe II
He I
Si II
O I
Stokes Q
ISP
Stokes U
Angle
F_λ
Q (%)
U (%)
θ (deg)
Rest wavelength (A)


20
SN 2009jf
7
17
2
Valenti+11


Doppler Velocity (10^3 km s^−1)
SN 2009jf
(+9.3 days)
O I
Ca II
U (%)
Q (%)

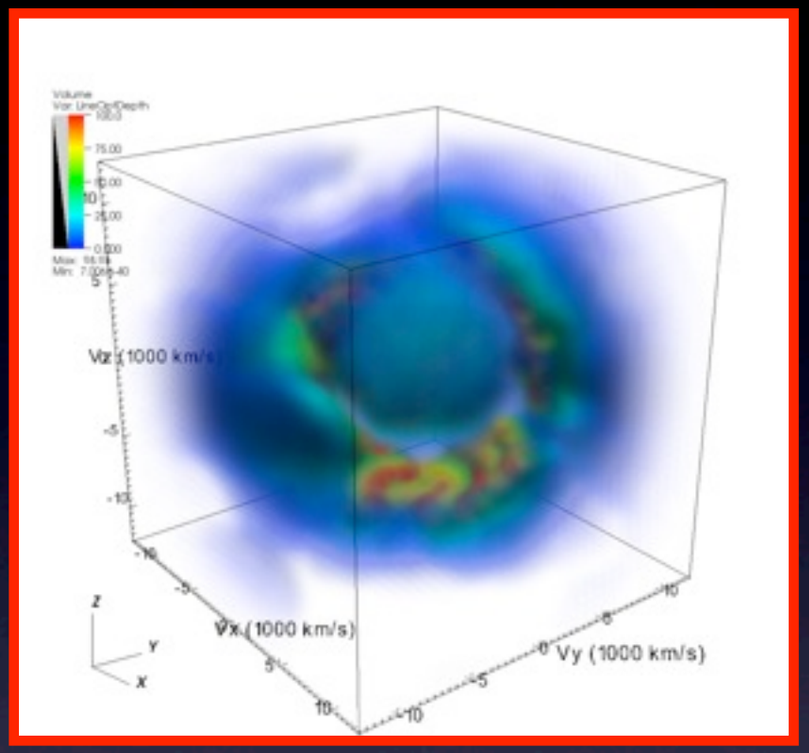
3D geometry!

Object	Type	3D?	Ref.
SN 2002ap	Ic broad	YES	Kawabata+02, Leonard+02, Wang+03
SN 2005bf	Ib	YES	Maund+07, MT+09
SN 2007gr	Ic	No	MT+08
SN 2008D	Ib	YES	Maund+09
SN 2009jf	Ib	YES	MT+ in prep.
SN 2009mi	Ic	YES	MT+ in prep.

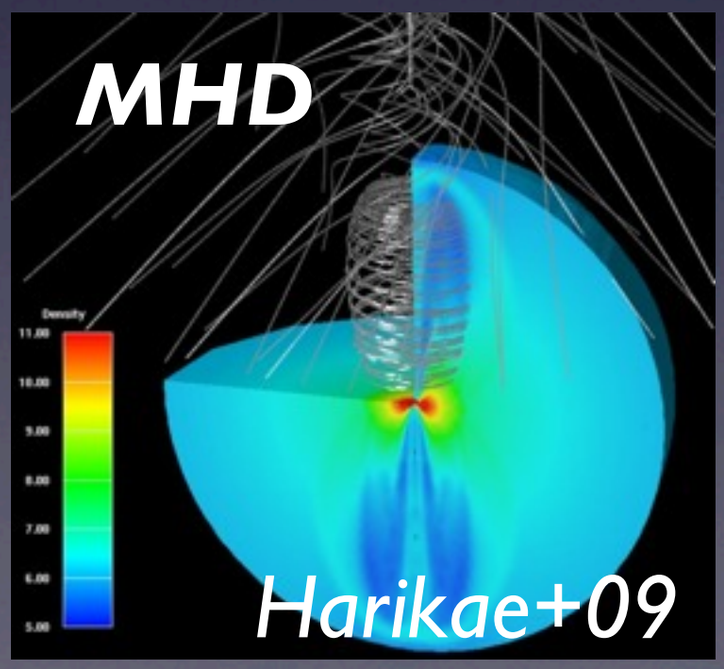
3D signature is quite common

(5 of 6 are Subaru data)

Summary: Explosion mechanism



- Explosion has a 3D geometry
- 3D signature is common
- Convection seems to play an important role



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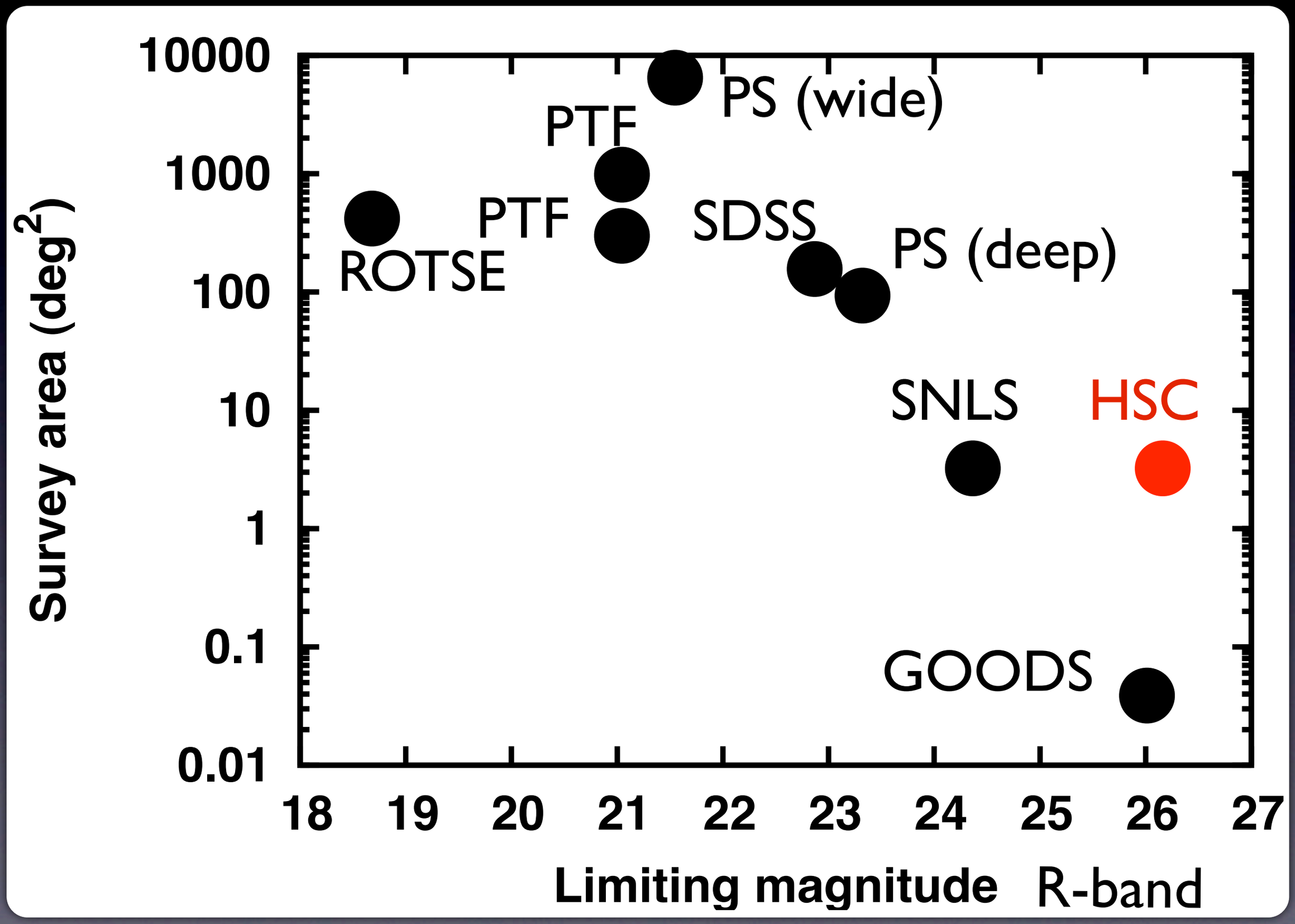
Subaru - Supernovae in the Future

Supernova Survey with HSC

Transient Surveys



HSC Transient Survey

Day	g	r	i	z	y
-6		30		81	81
-3	30		60		81
0	30	30		81	
+3		30	60		81
+6	30		60	81	

Exposure time (min) by N. Yasuda

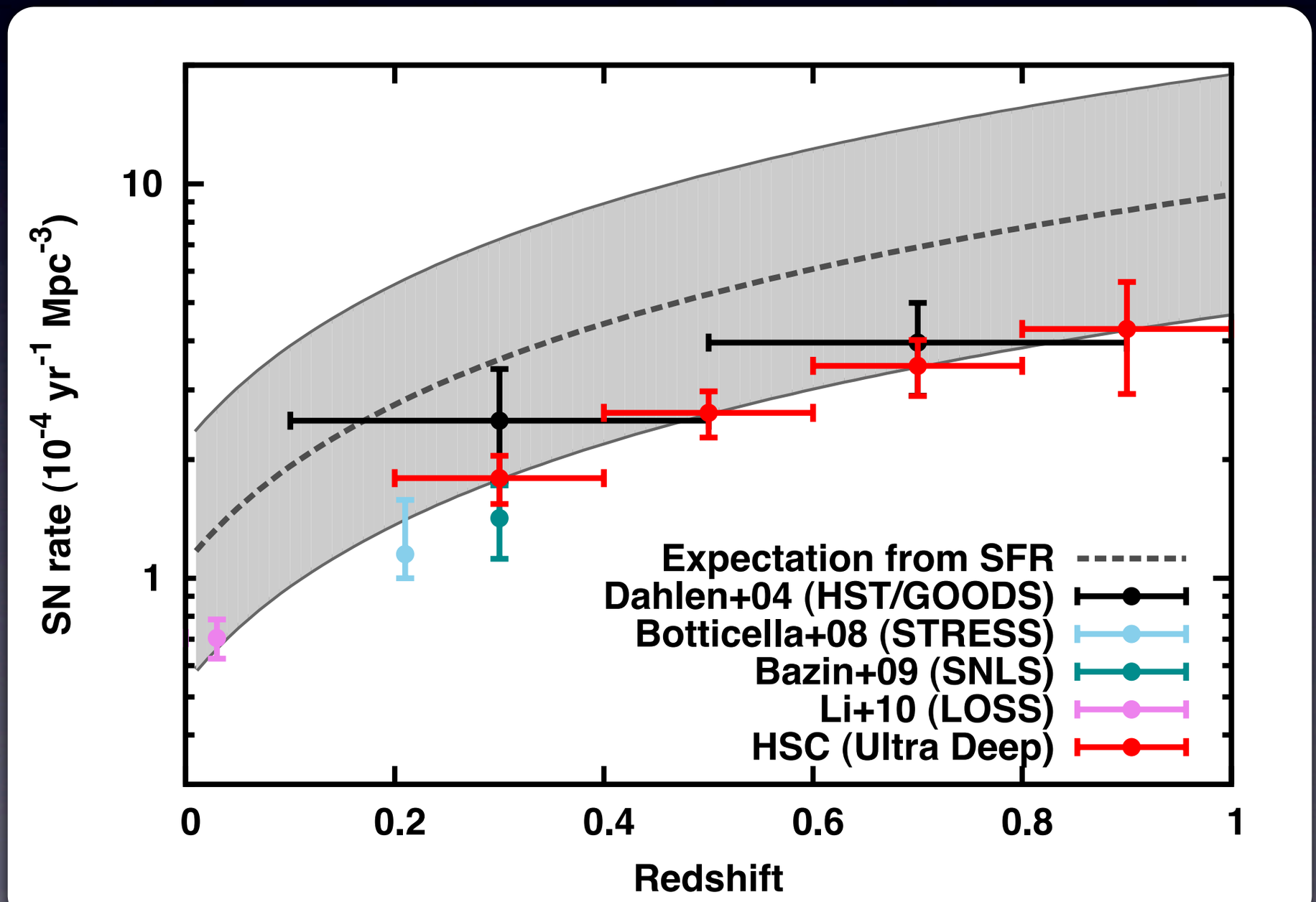
- Type Ia supernovae cosmology
- By-products
- **Core-collapse supernova rate**
  => cosmic star formation rate, host galaxies
- **Superluminous supernovae**
- Orphan GRBs

HSC transient working group
T. Morokuma, N. Yasuda, Y. Urata, L. Huang, N. Tominaga, T. Moriya, M. Tanaka, J. Okumura, R. Quimby, A. Kong, N. Yoshida, C-H Tang, M-F Wang, C-H Shen, M-F Tsai,

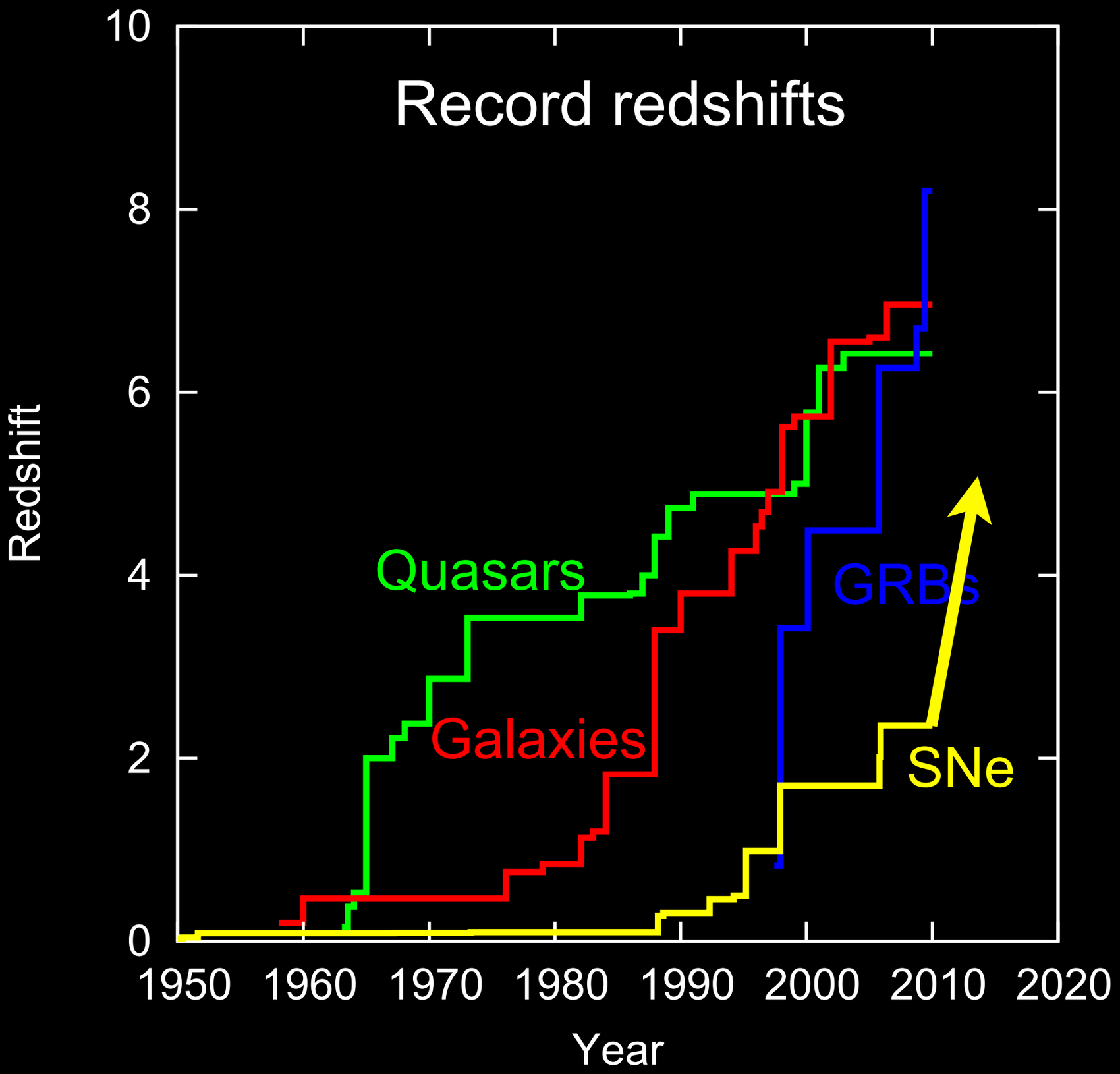
~100 SNe in 4 months

=> Best SN rate up to z~1

=> Cosmic star formation rate

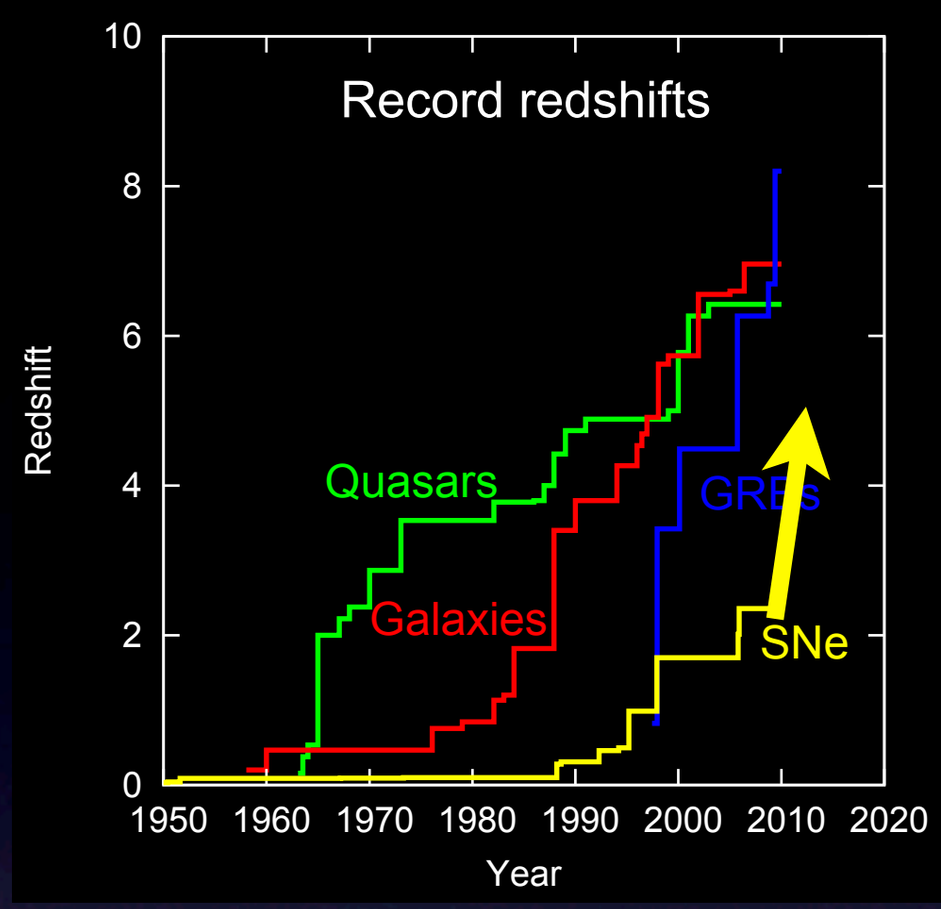


Breaking the Record



MT, T. Moriya, N. Yoshida, K. Nomoto 2012

Subaru - Supernovae in the Future



- **Transient survey with HSC**
  - Best transient survey at pre-LSST era
- **Core-collapse supernova rate up to z~1**
  - Cosmic star formation rate by counting massive star
- **Supernova studies up to z~5**
  - Constraints on IMF by counting massive stars