Transients near the centers of the galaxies

Rupak Roy

Inter-University Center for Astronomy and Astrophysics
Pune, India

ASASSN-15lh (artist impression)

Stockholm University

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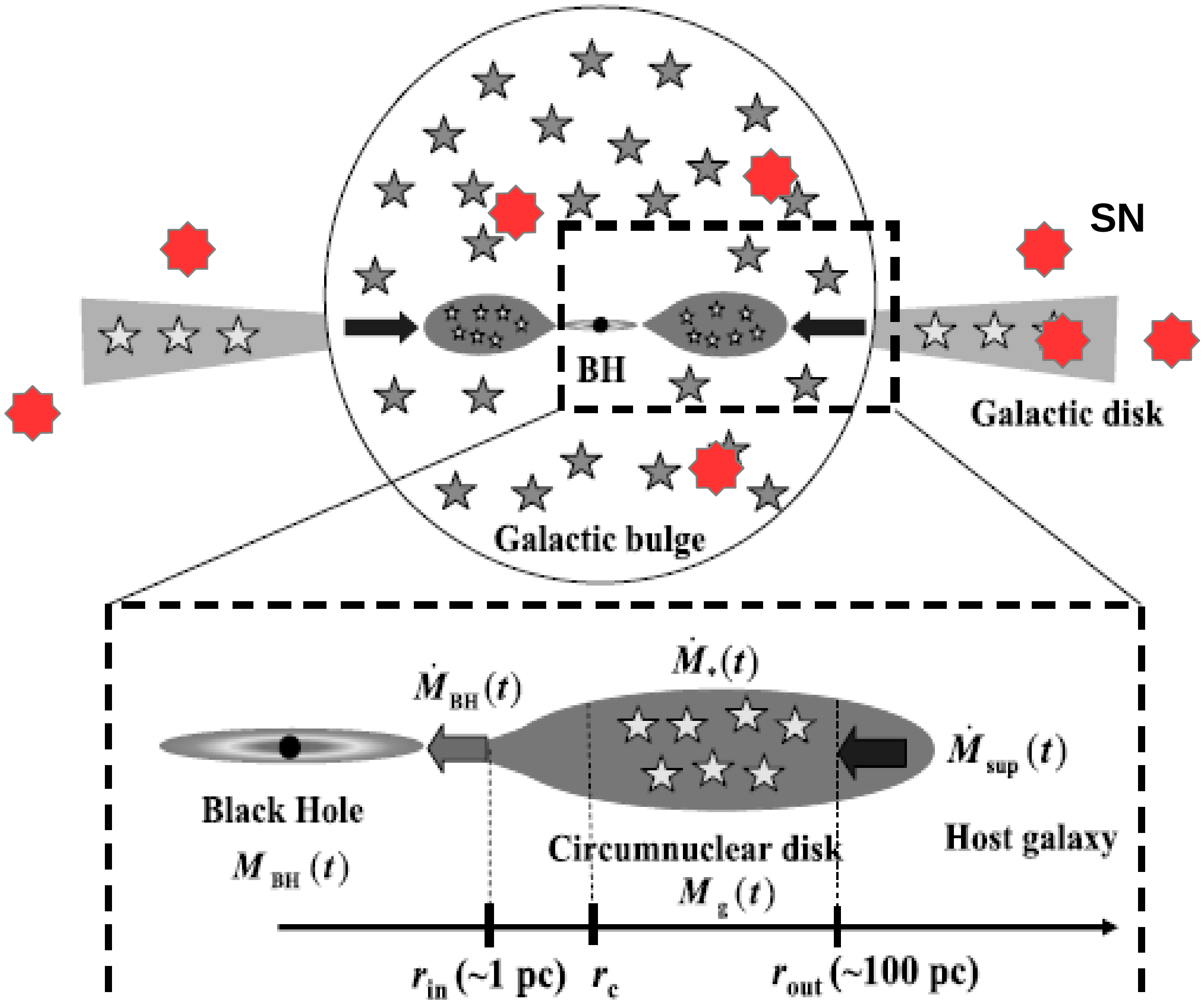
Univ. of Warsaw

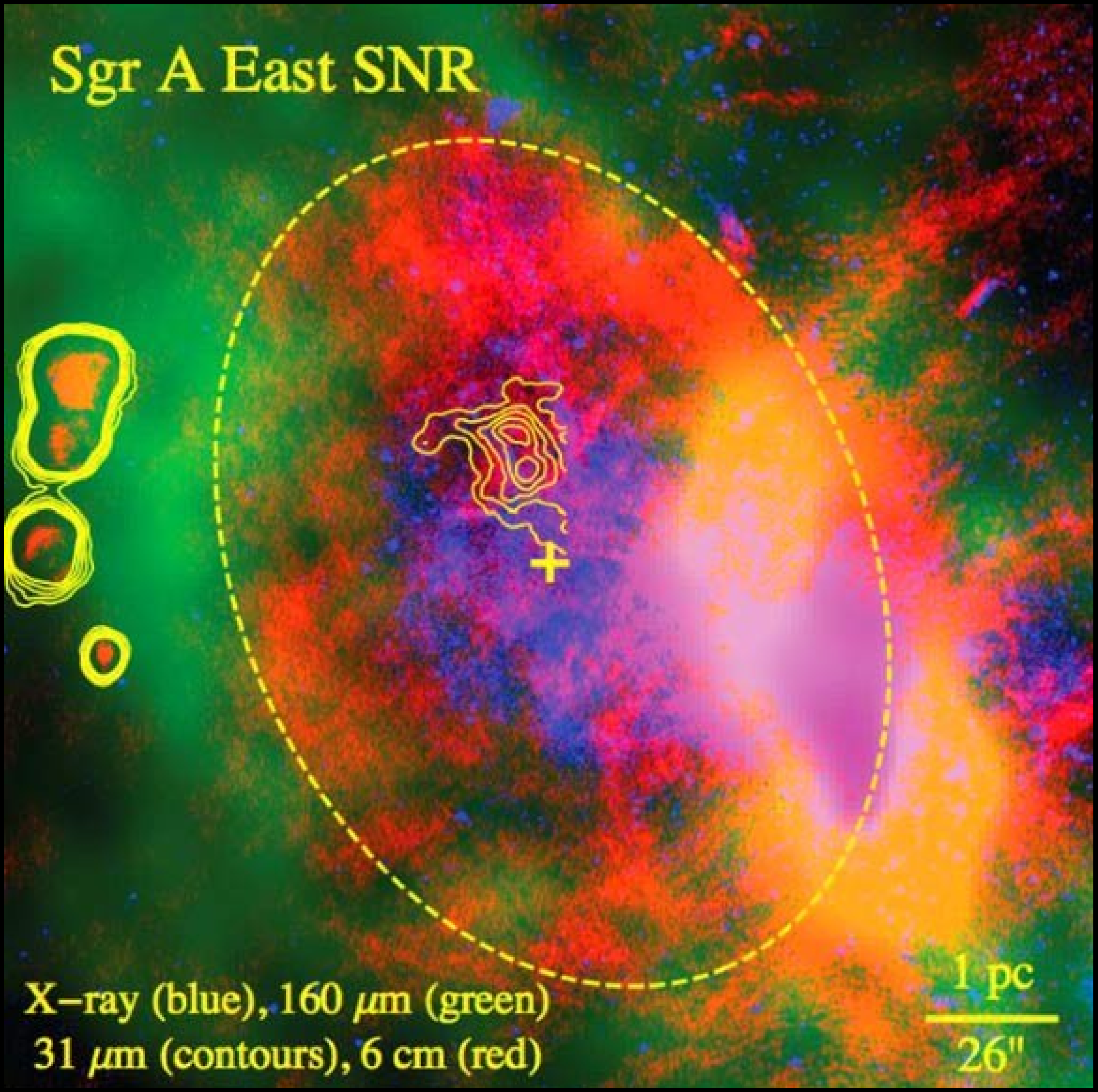
IUCAA

Star formation (& SN) near the center of galaxies



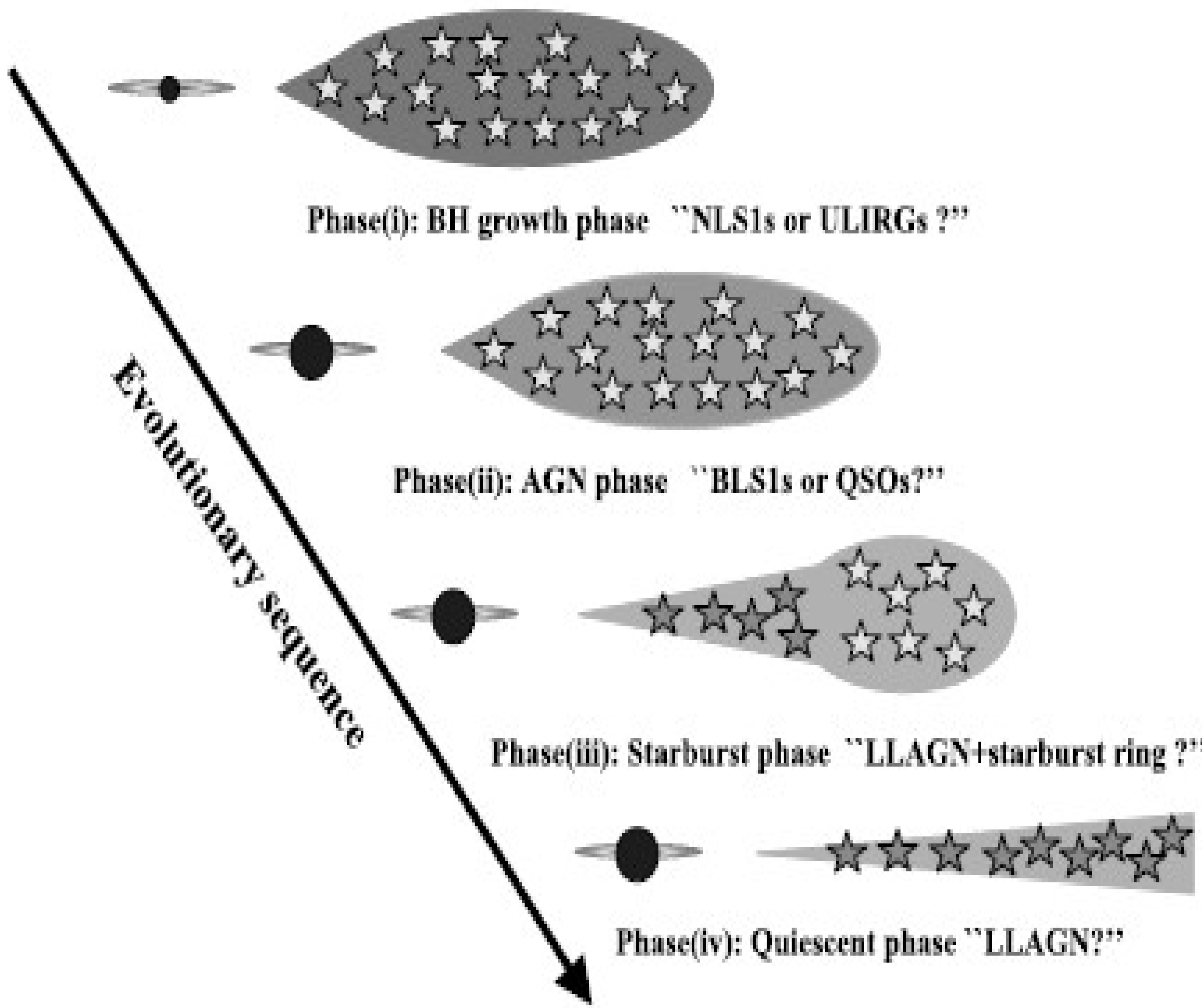
Kawakatu and Wada, ApJ, 2008

Example : SNR at Milky-way center



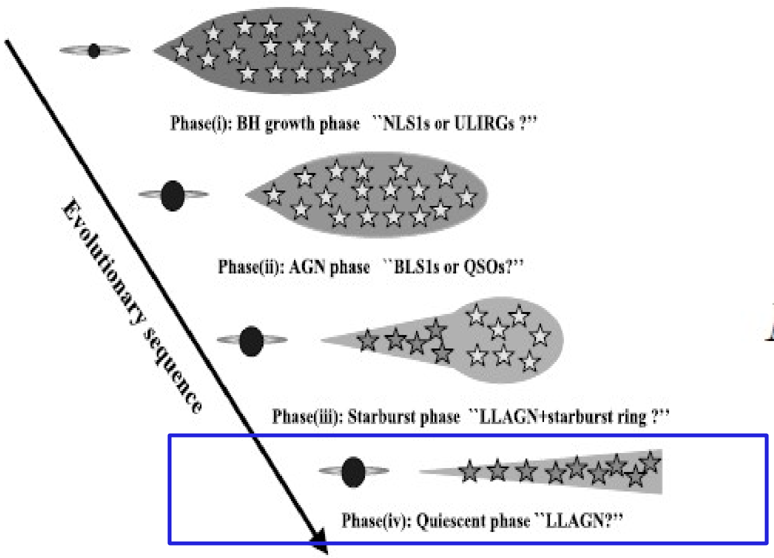
Lau, R. M. et al. 2015

Other possibilities : TDE ?

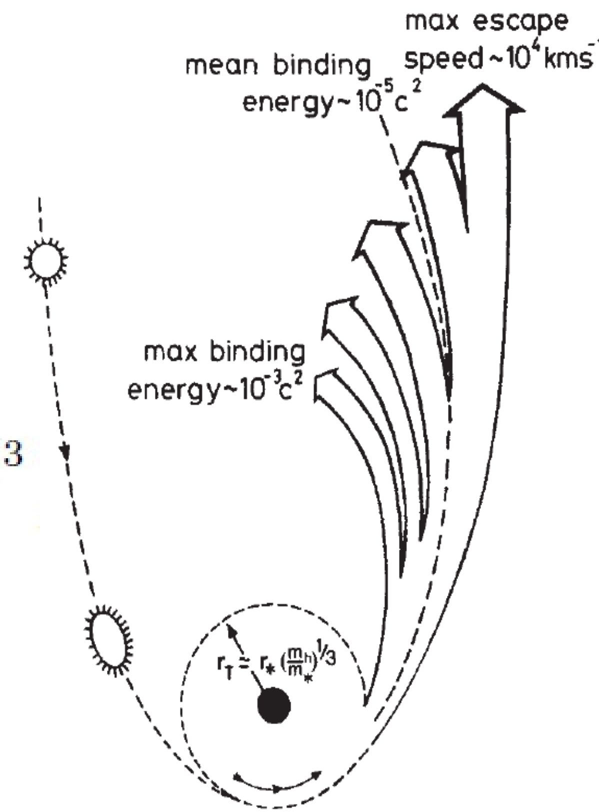


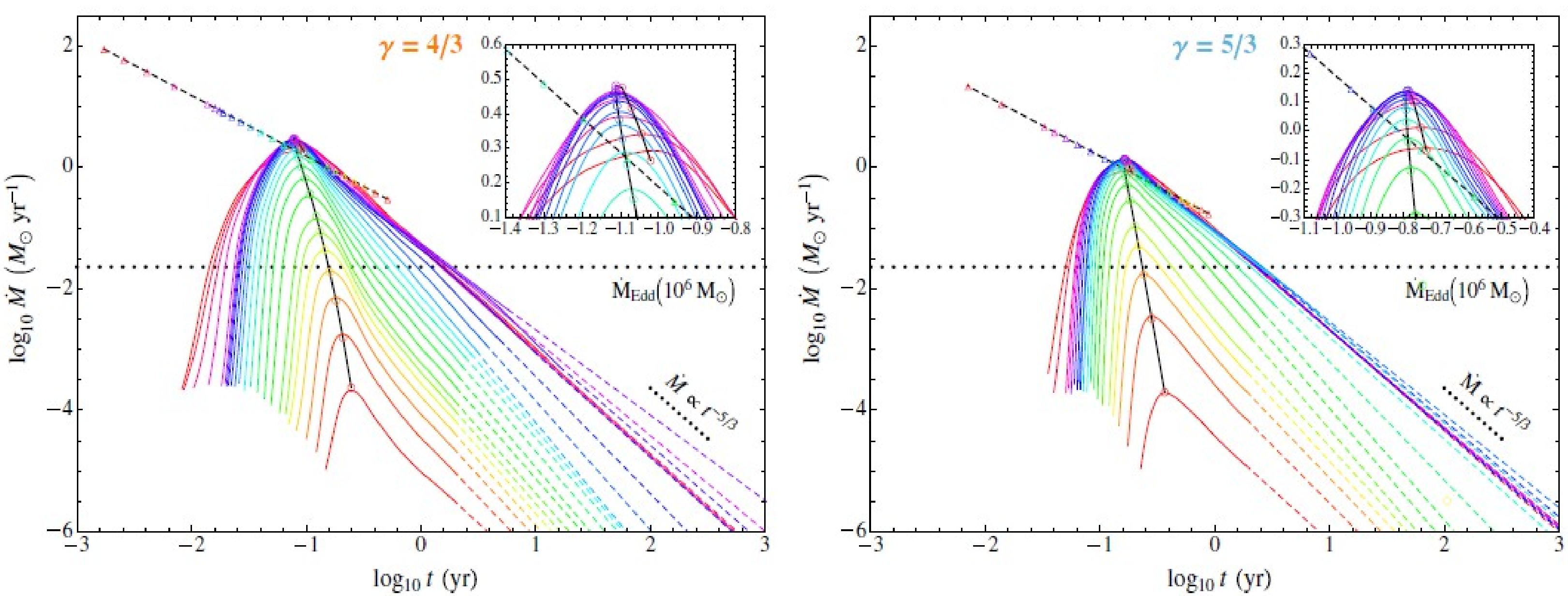
Kawakatu and Wada, ApJ, 2008

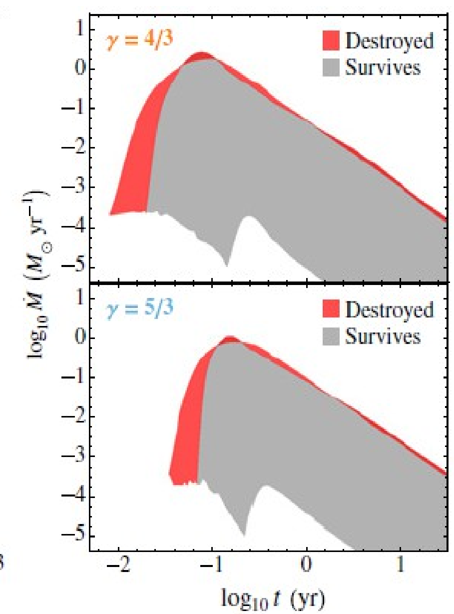
TDEs and their hosts



$$\dot{M}(t) \propto L(t) \propto \left(\frac{t - t_D}{t_0 - t_D}\right)^{-5/3}$$

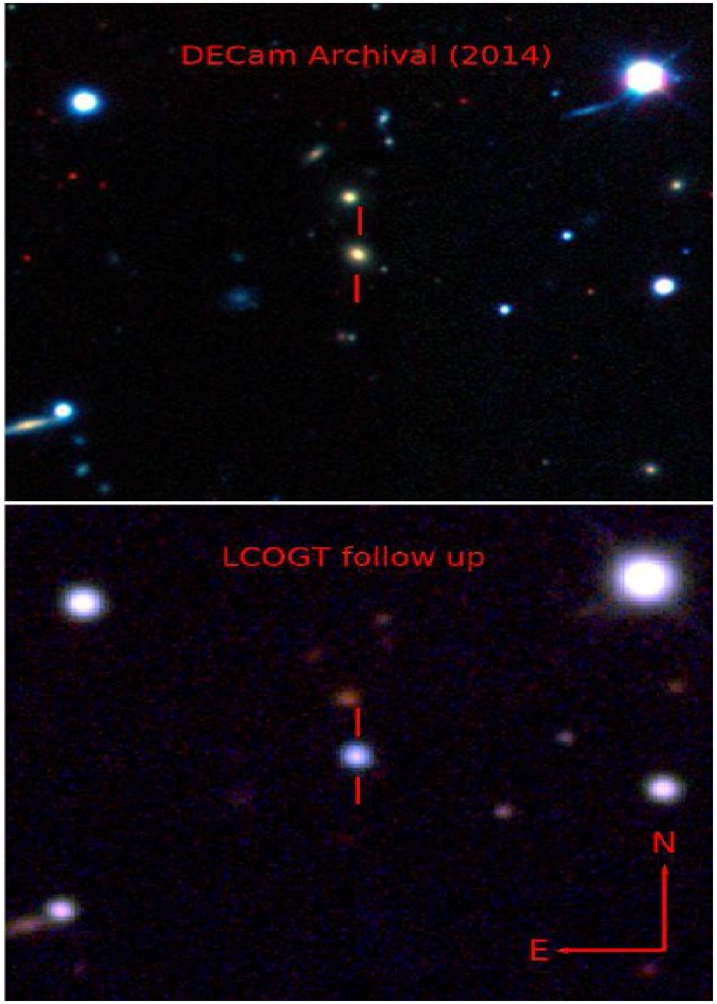






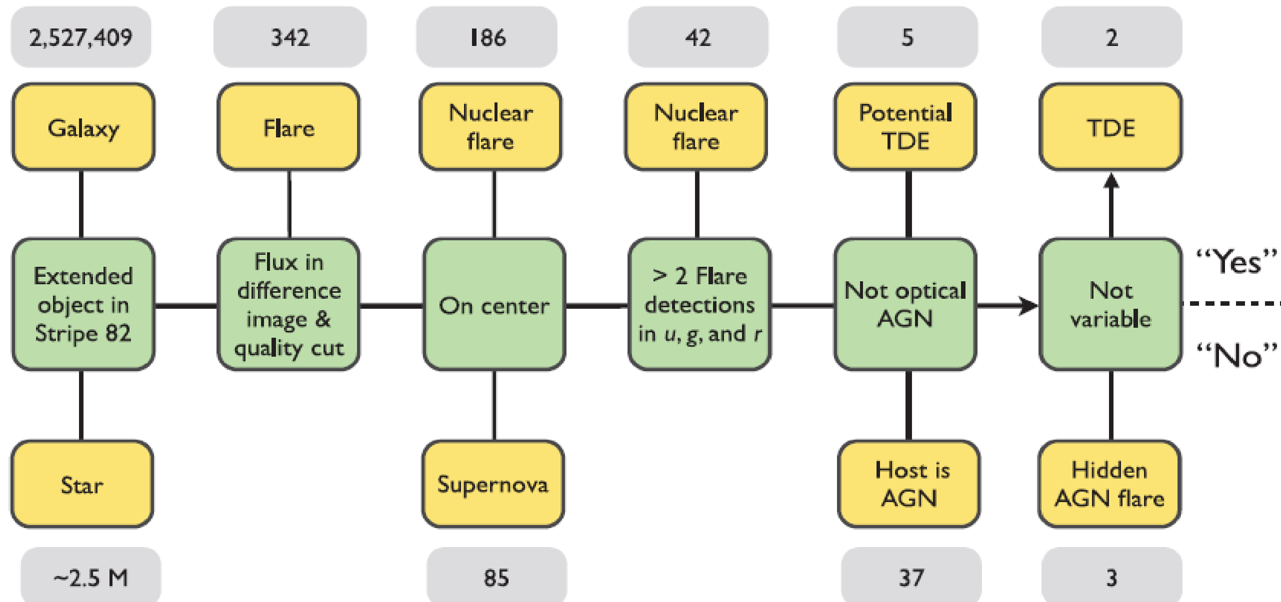
Hills 1975; Rees 1988; Mageshwaran & Mangalam 2015; Guillochon et al. 2013, 2014

Confusion in determining the nature of nuclear transients



ASAS-SN 15lh :

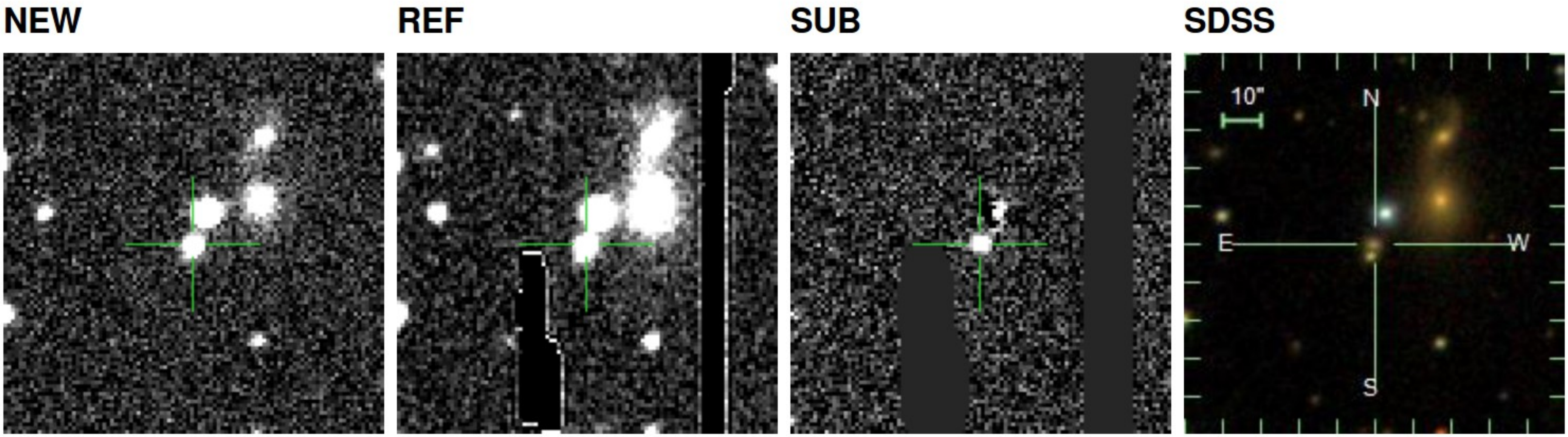
SLSN - Dong et al. Science, 2016
TDE - Leloudas et al. Nature, 2016



van Velzen et al. (2011)

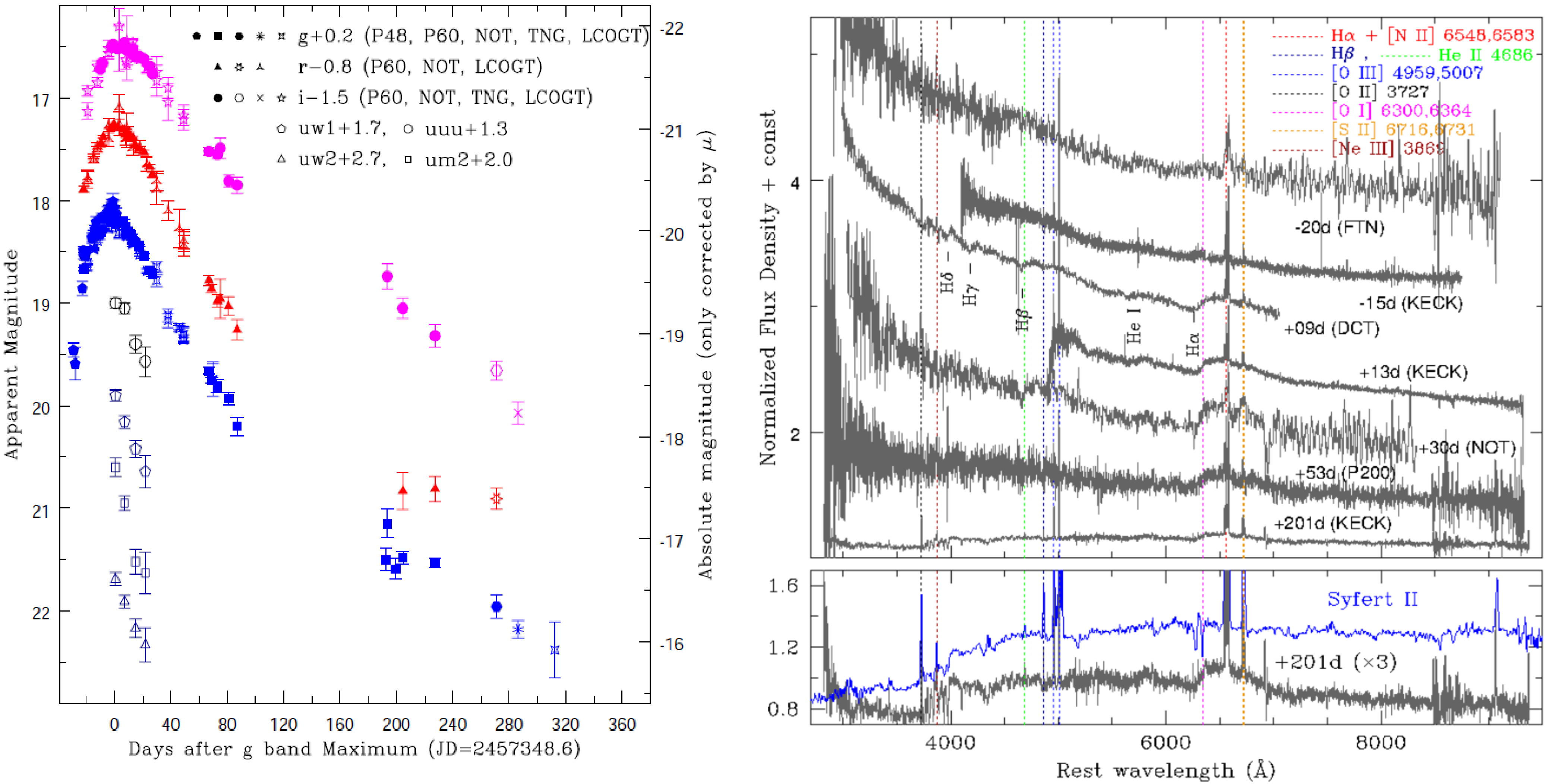
- SDSS multi-epoch imaging data (Stripe 82)
- 2 TDEs were found searching 2.5 M galaxies randomly.
- 37 On-center objects where host is an AGN.
  At least 10% of these AGN will be Seyfert galaxies and hence a potential site to get nuclear-SNe.
- Thus probability of getting SNe and TDEs in galaxy center is comparable to each other !

An iPTF nuclear transient at z = 0.098



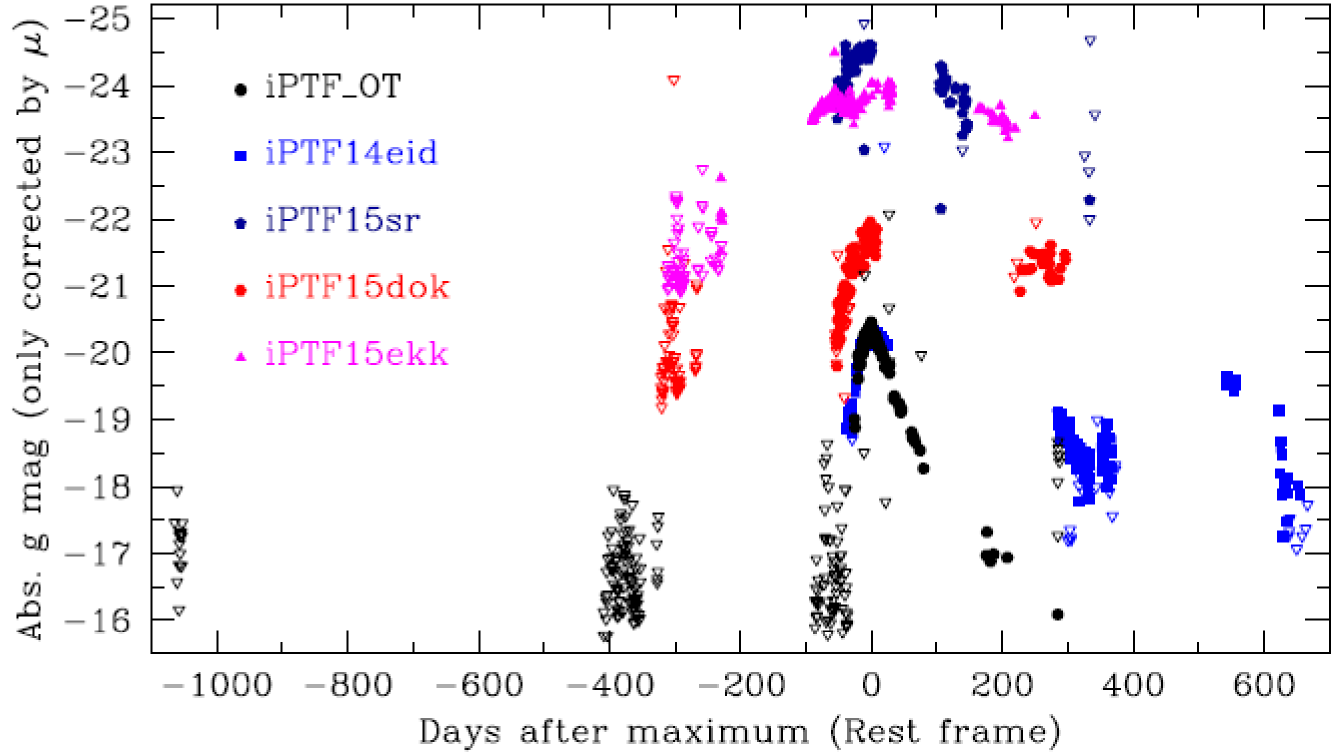
Is it - AGN ? TDE ? SN ?

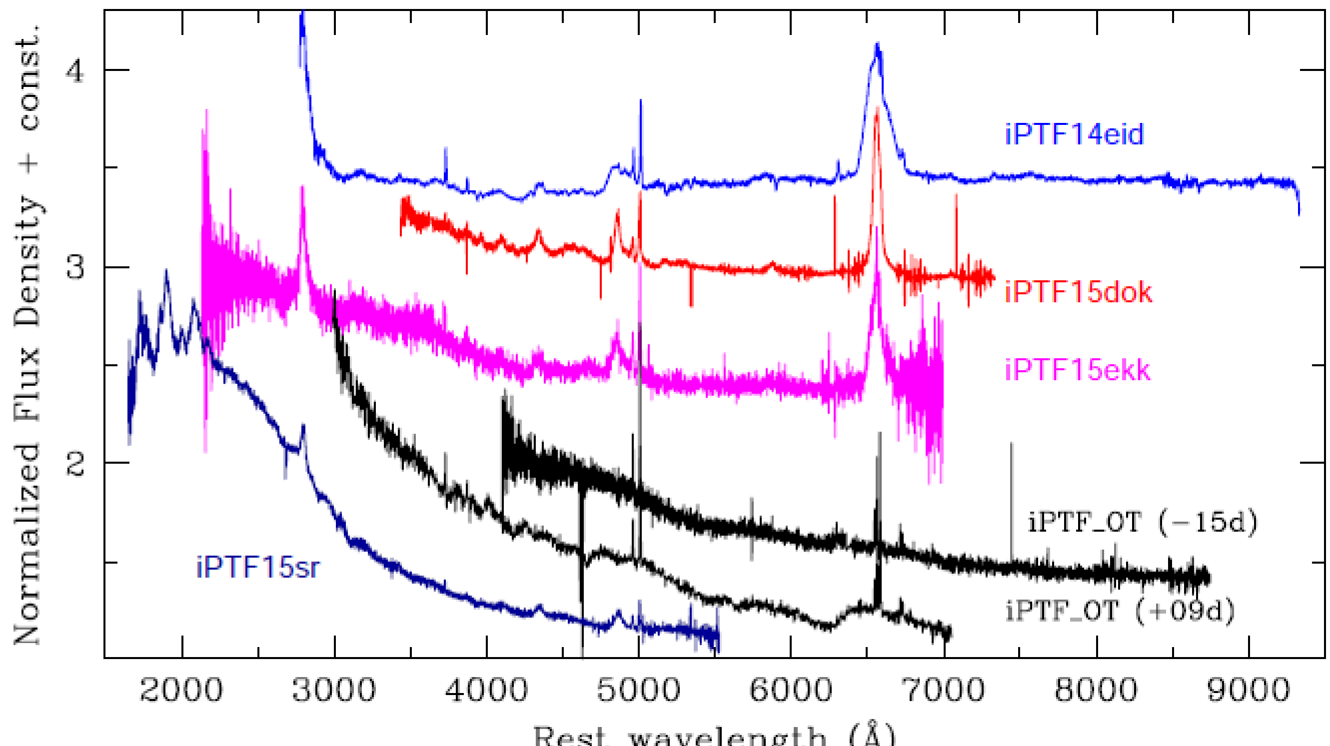
Optical properties :



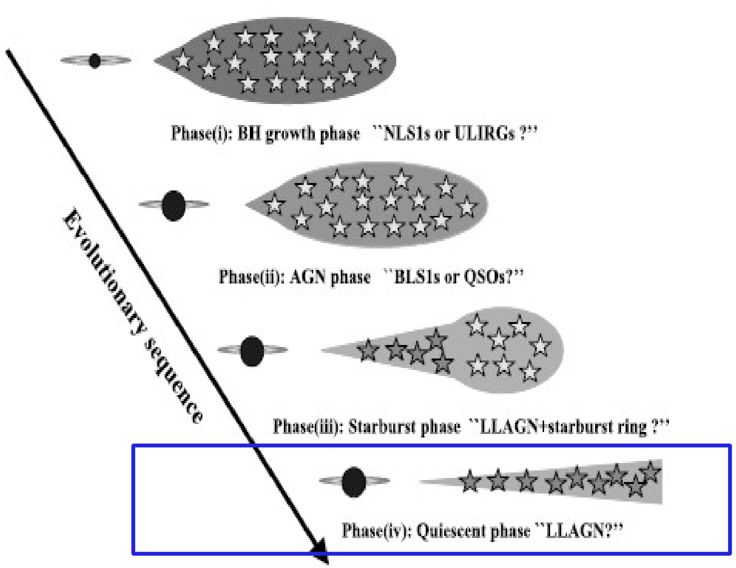
Is it an AGN ?

- Probably not !

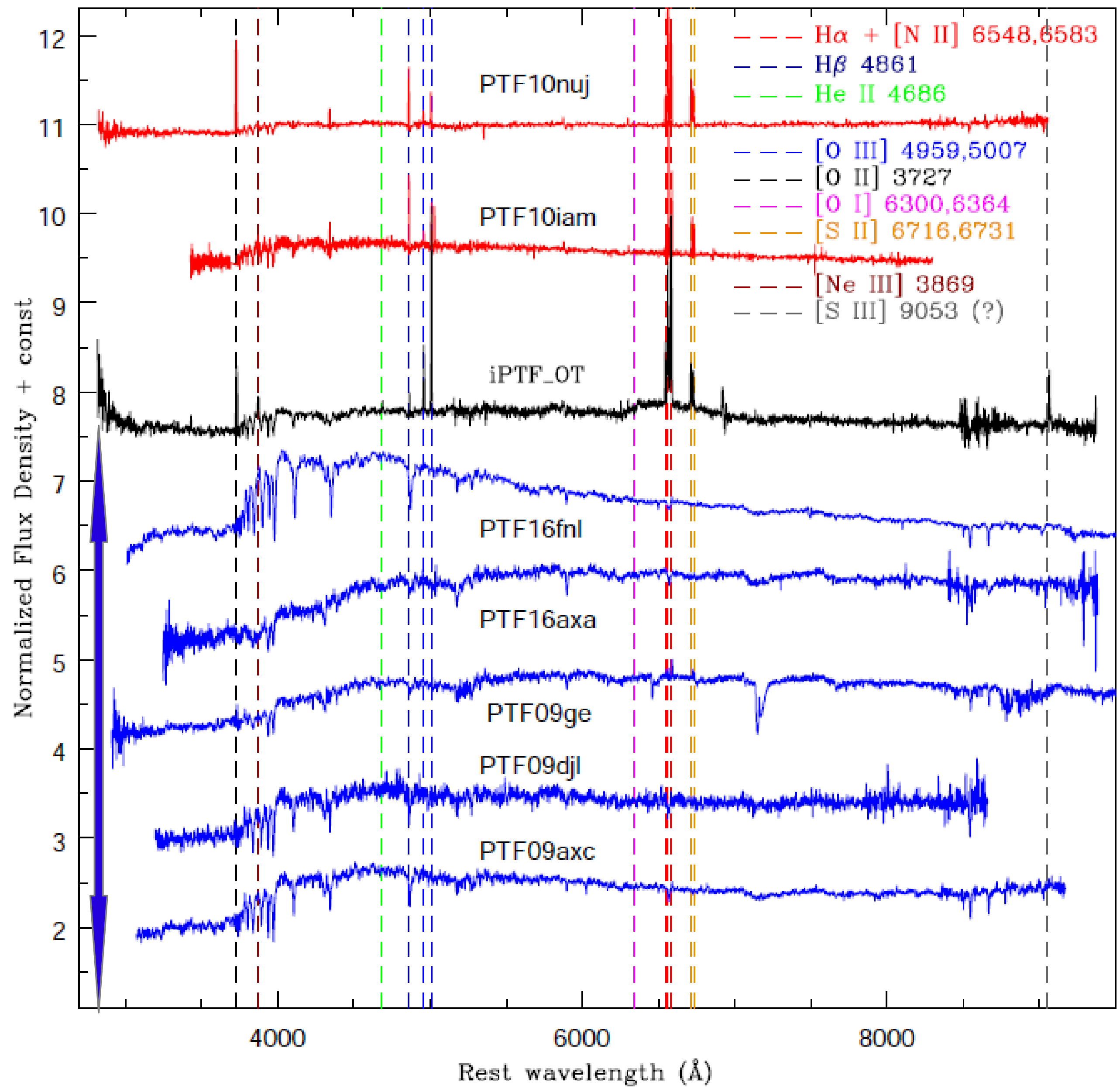




TDE host

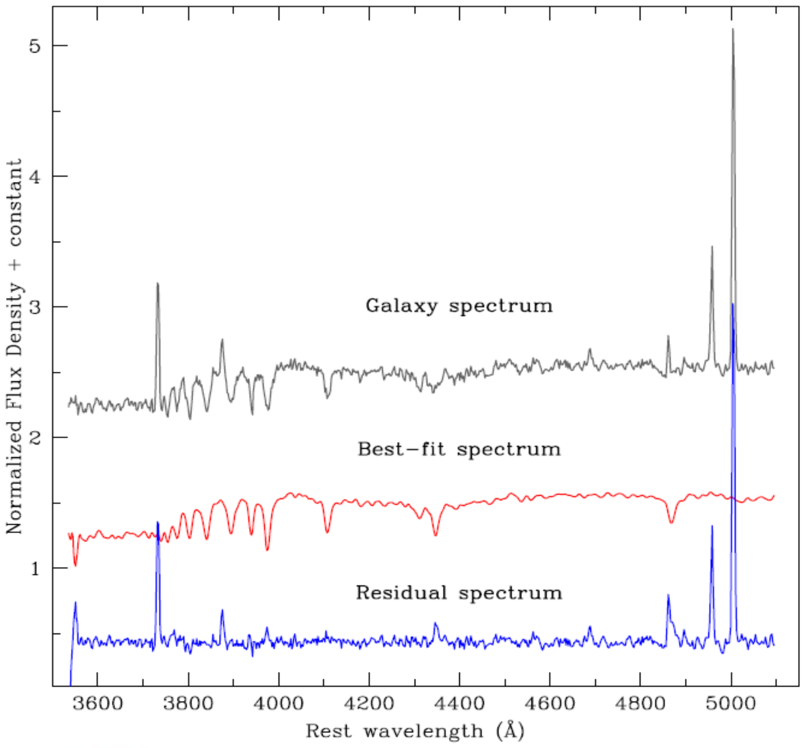


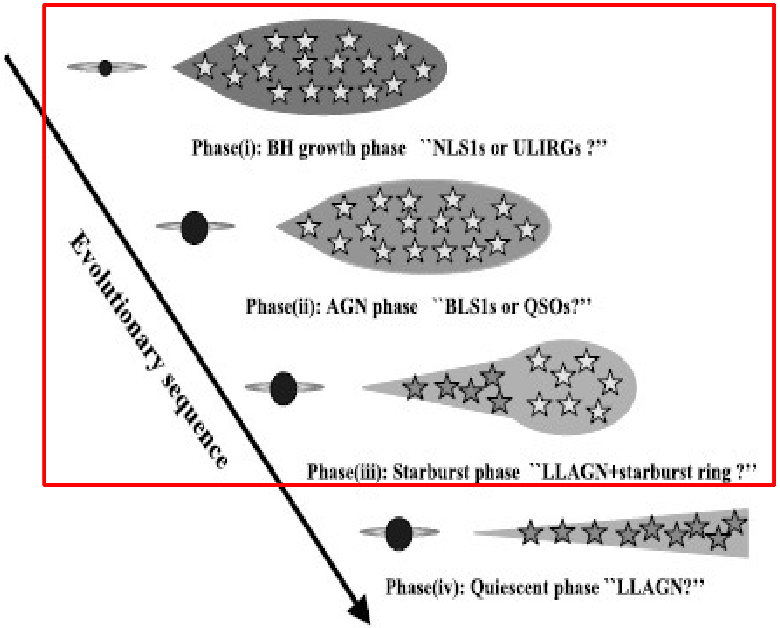
Phase(i): BH growth phase ``NLS1s or ULIRGs ?''
Phase(ii): AGN phase ``BLS1s or QSOs?''
Phase(iii): Starburst phase ``LLAGN+starburst ring ?''
Phase(iv): Quiescent phase ``LLAGN?''
Evolutionary sequence

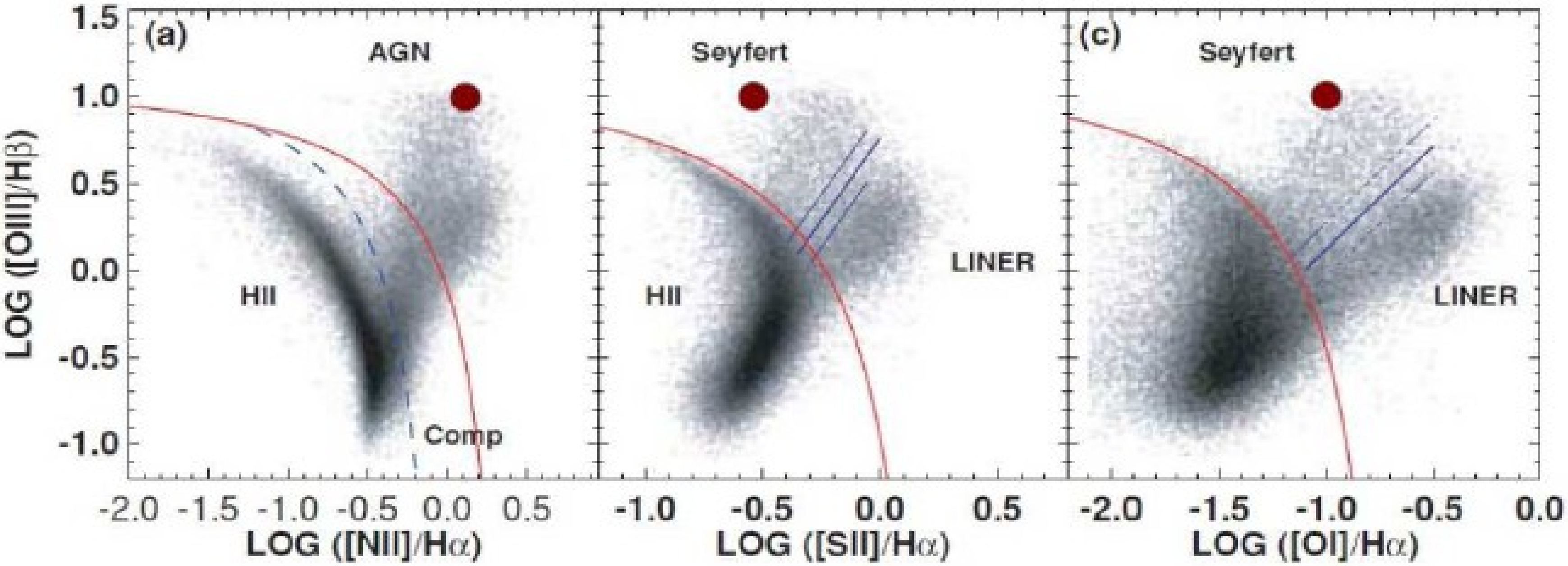


Hα + [N II] 6548,6583
Hβ 4861
He II 4686
[O III] 4959,5007
[O II] 3727
[O I] 6300,6364
[S II] 6716,6731
[Ne III] 3869
[S III] 9053 (?)
PTF10nuj
PTF10iam
iPTF_OT
PTF16fnl
PTF16axa
PTF09ge
PTF09djl
PTF09axc
Normalized Flux Density + const
Rest wavelength (Å)
4000
6000
8000
2
3
4
5
6
7
8
9
10
11
12

Nature of the host

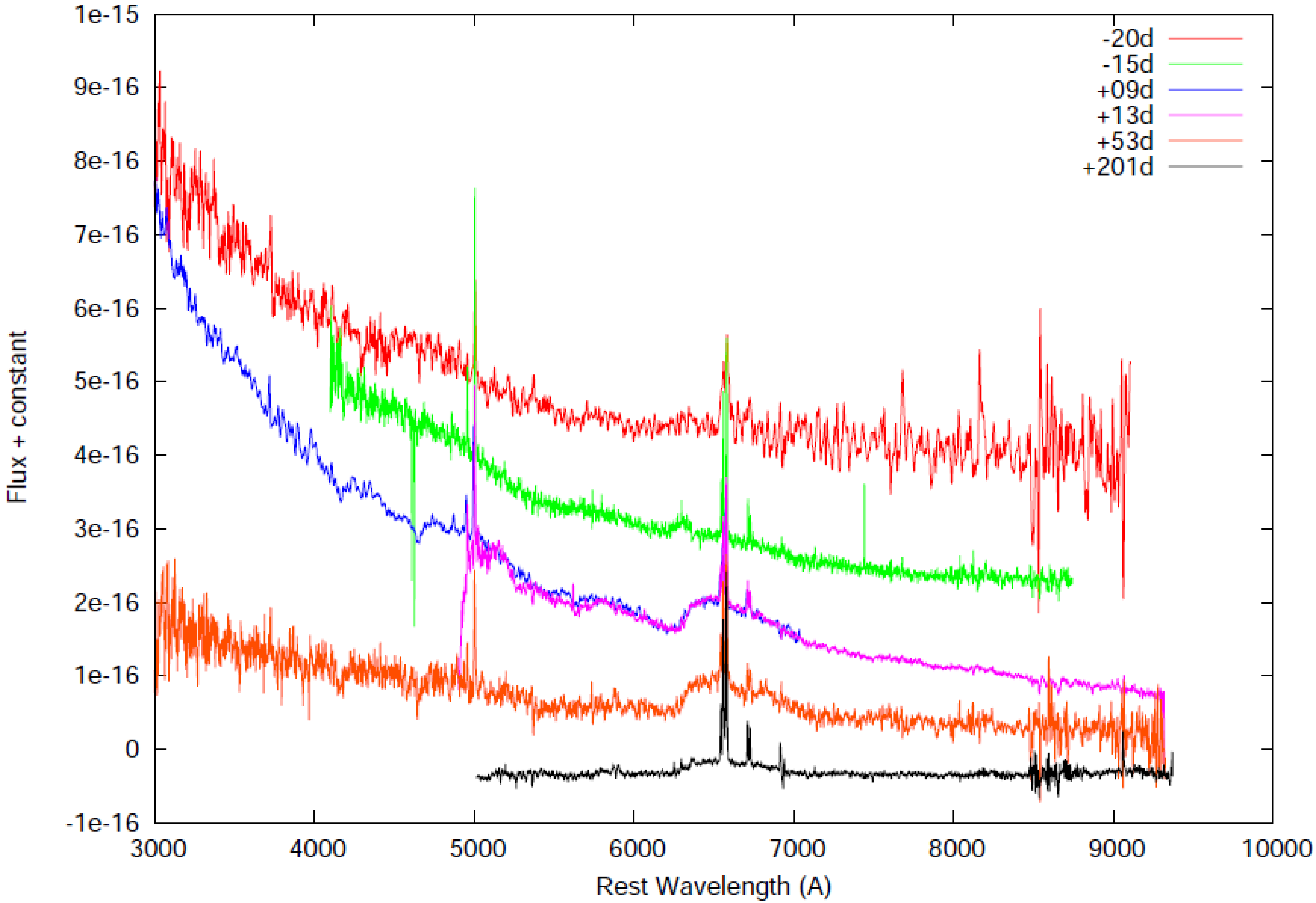




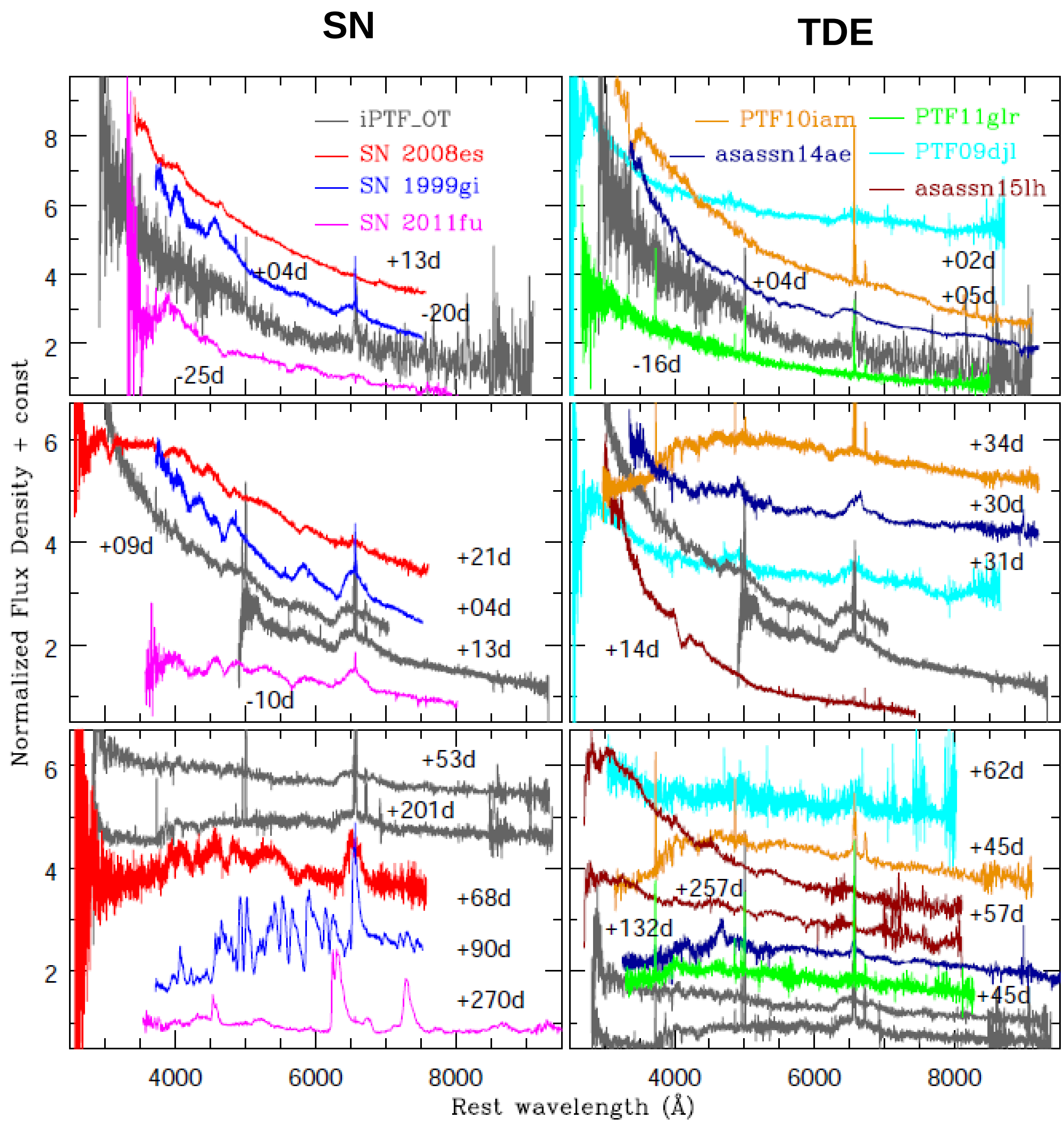


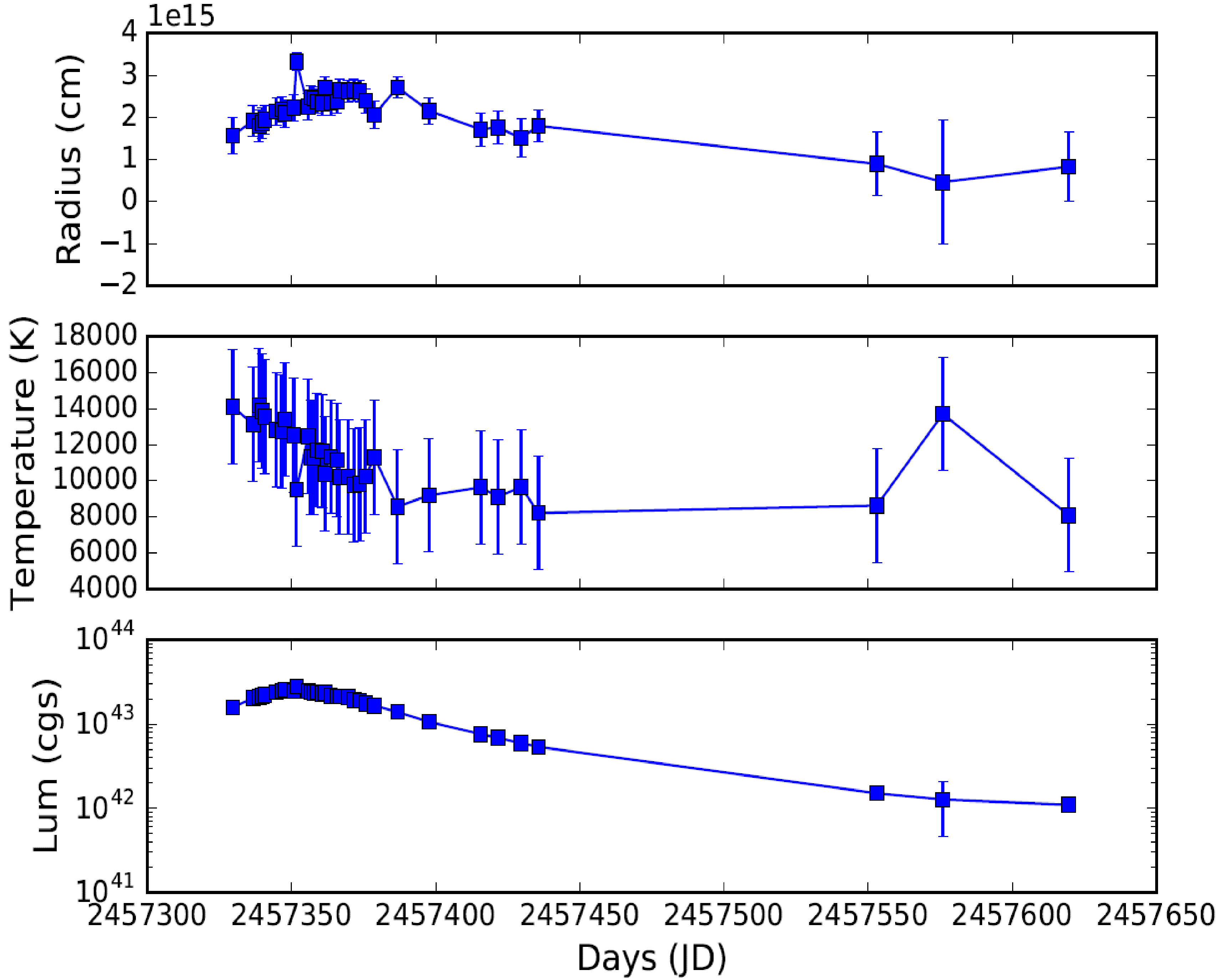
BPT diagram

Transient Spectra (with AGN emission lines)



Compare - spectra with SN & TDE

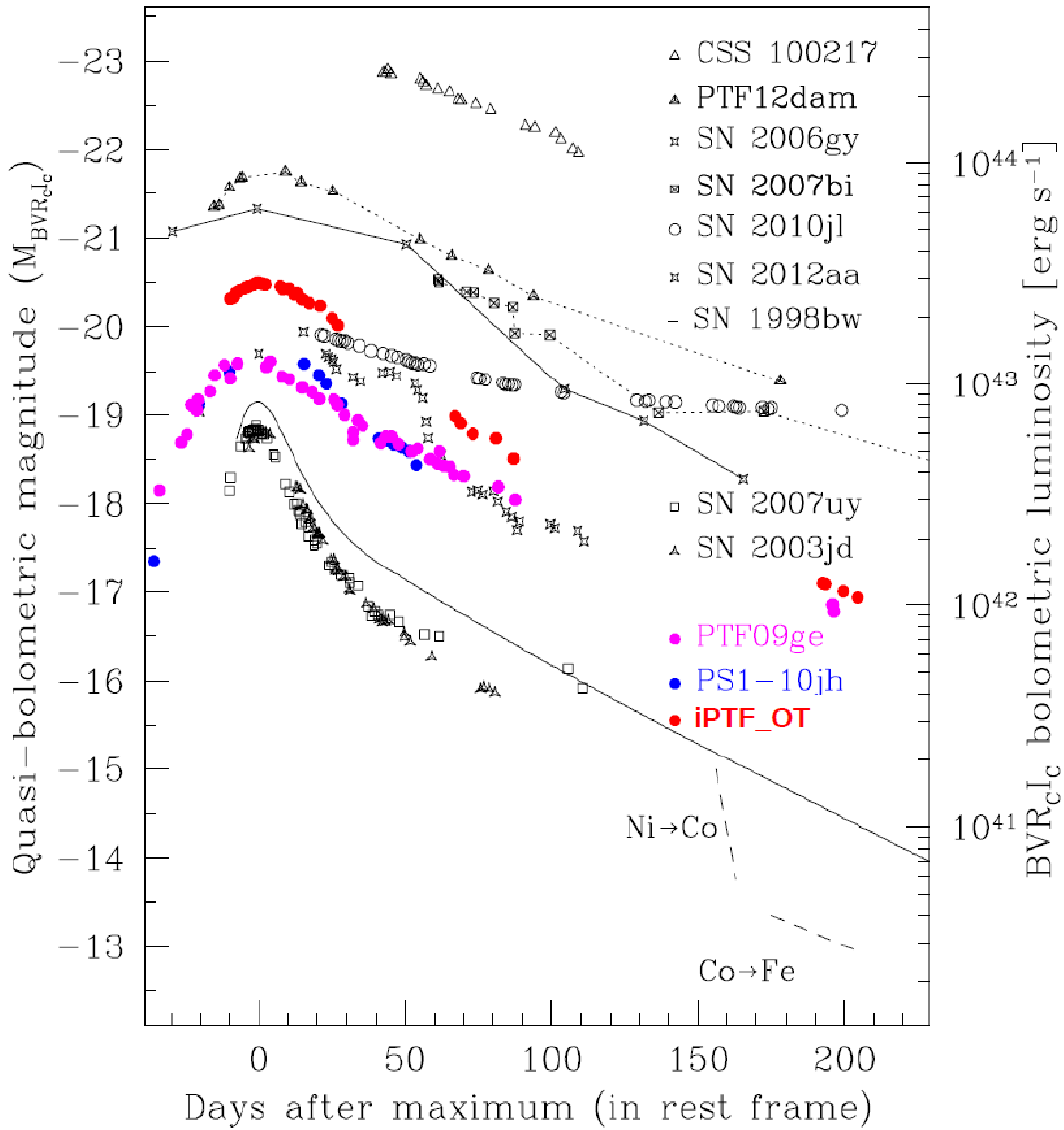




Radius and Temperature profiles are more similar to SLSNe rather than canonical TDEs

Bolometric LC

(SN and TDE)



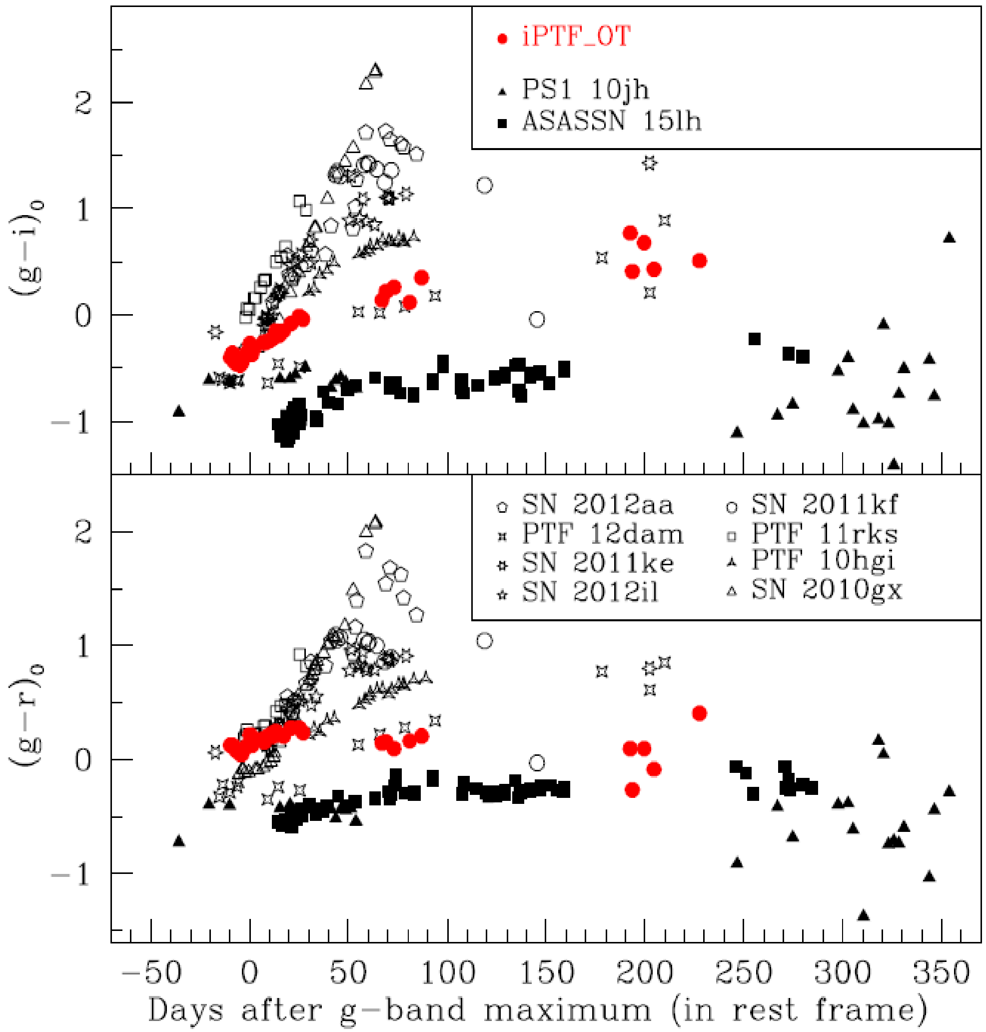
- If only powered by Ni :

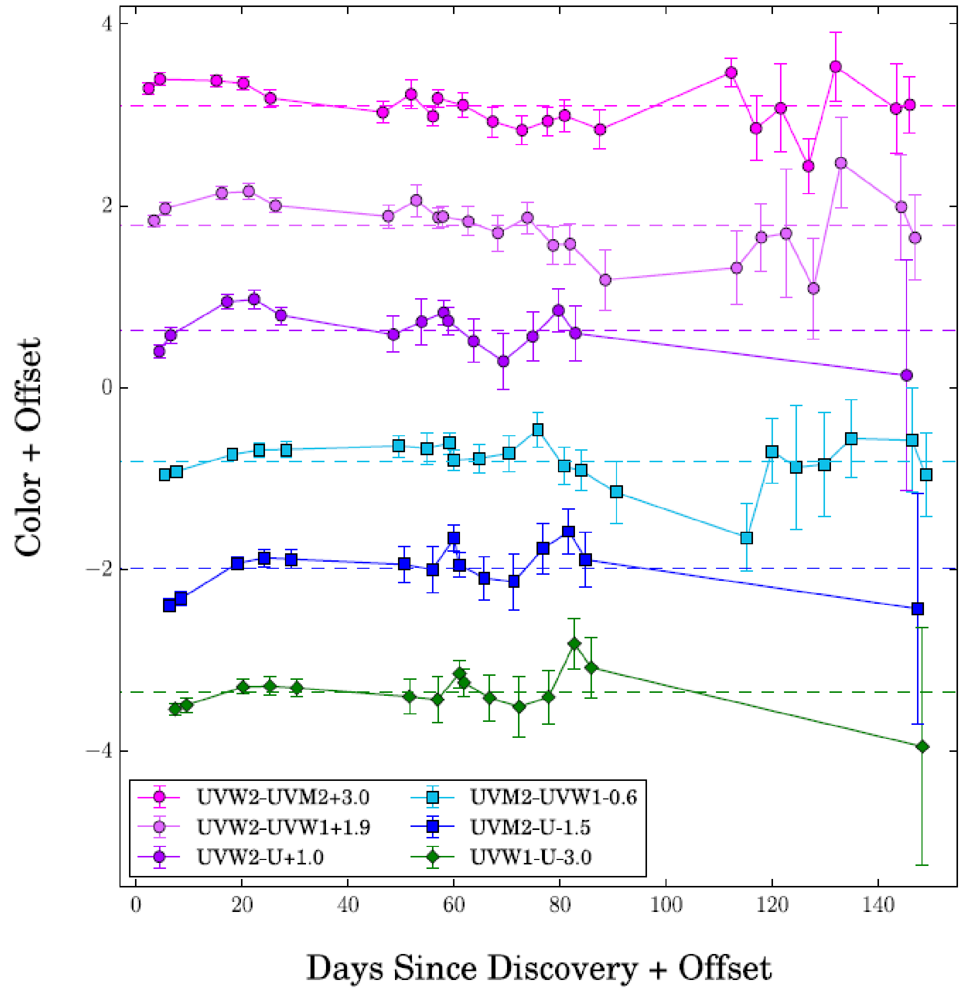
M_Ni ~ 1 M_sun
M_ej ~ 40 M_sun

- If powered by interaction :

M_csm ~ 5 - 10 M_sun

Compare - colour

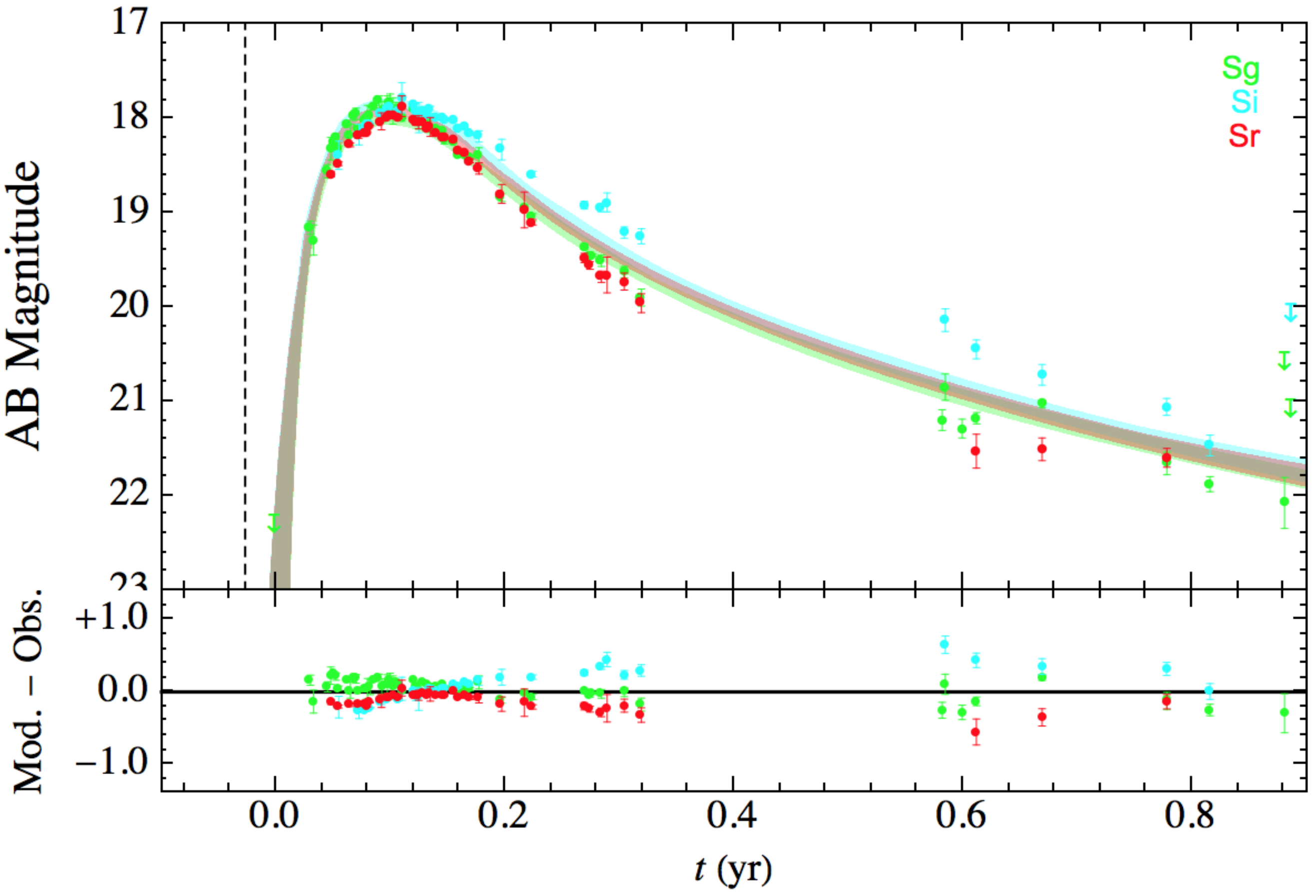


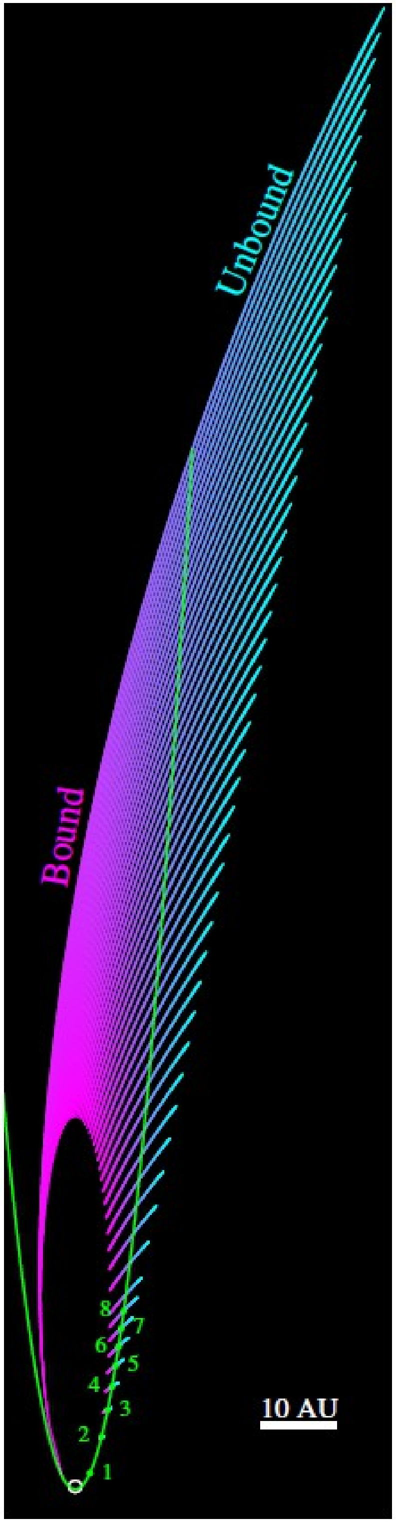


ASASSN 14ae : a TDE
(Holoien et al. 2014)

It is redder than other TDE

As a TDE [TDEFit]





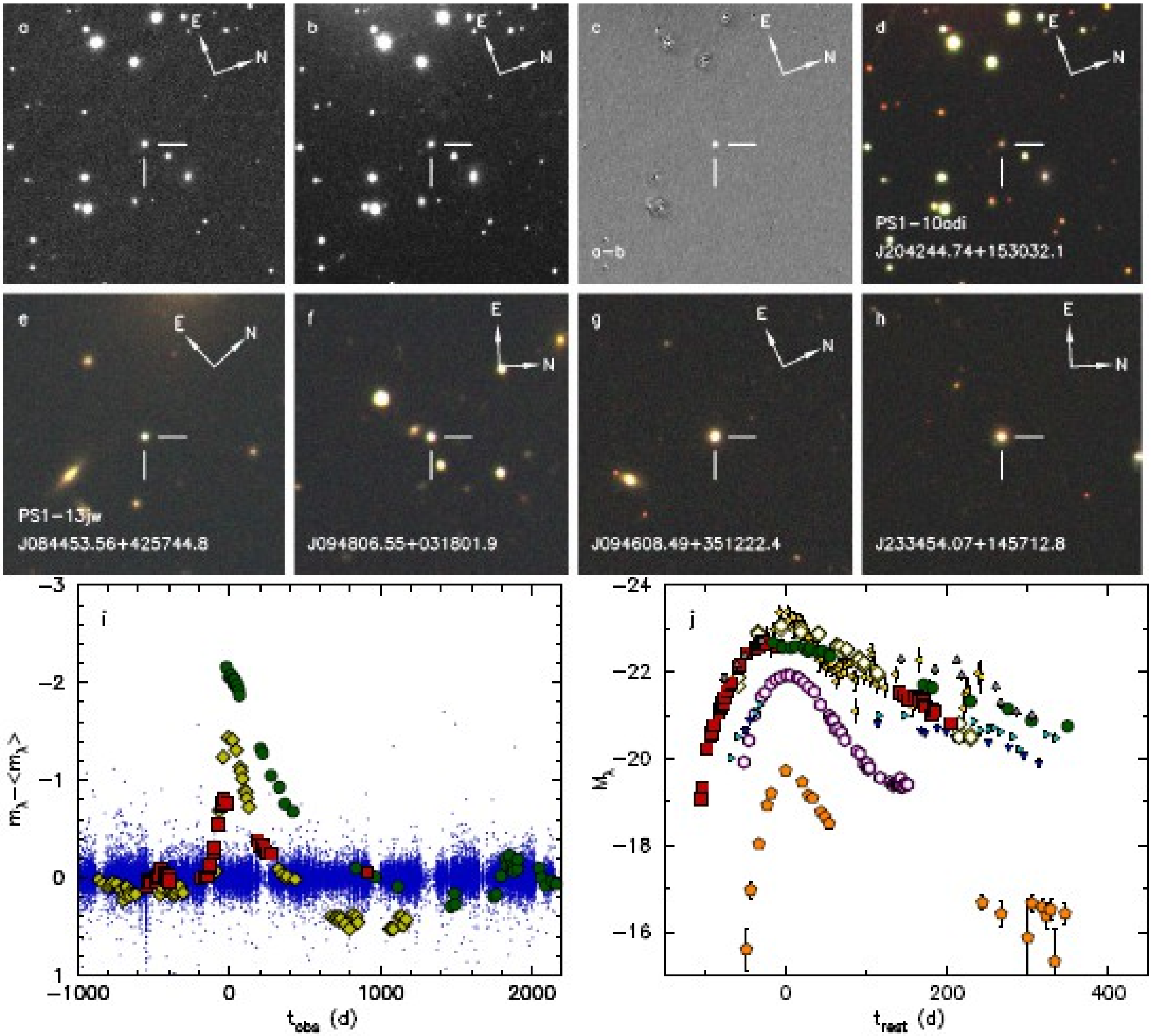
- **16 Free parameters !**

M_smbh > 10^6 M_sun ; Spin > 0.9 ; M_star ~ 0.08 M_sun

TDEFit (Guillochon et al. 2013, 2014)

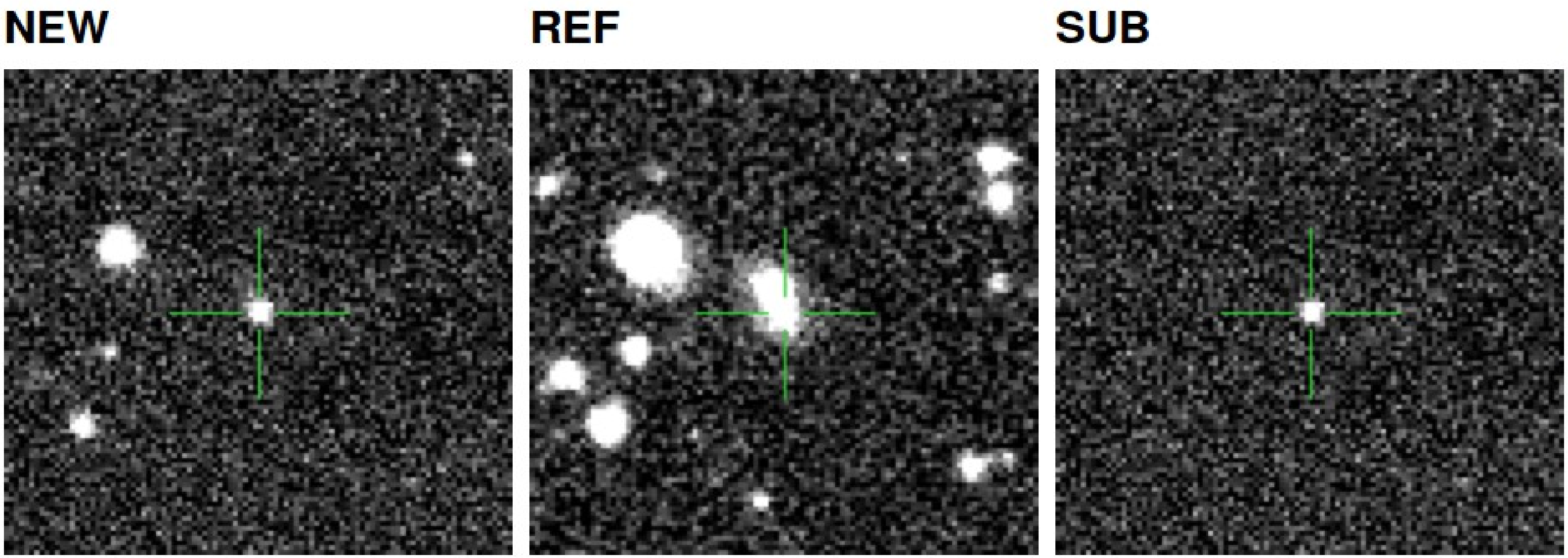
**There are nuclear objects which show properties similar to TDE and CCSNe.
We should find better technique to segregate them.**

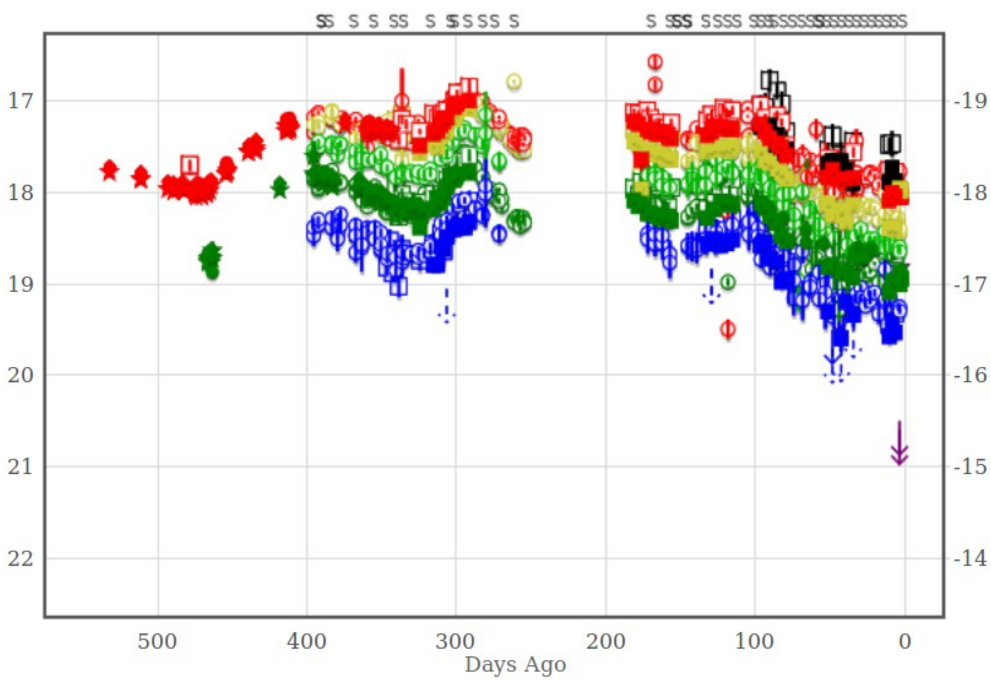
A new class of nuclear transients at the centers of active galaxies

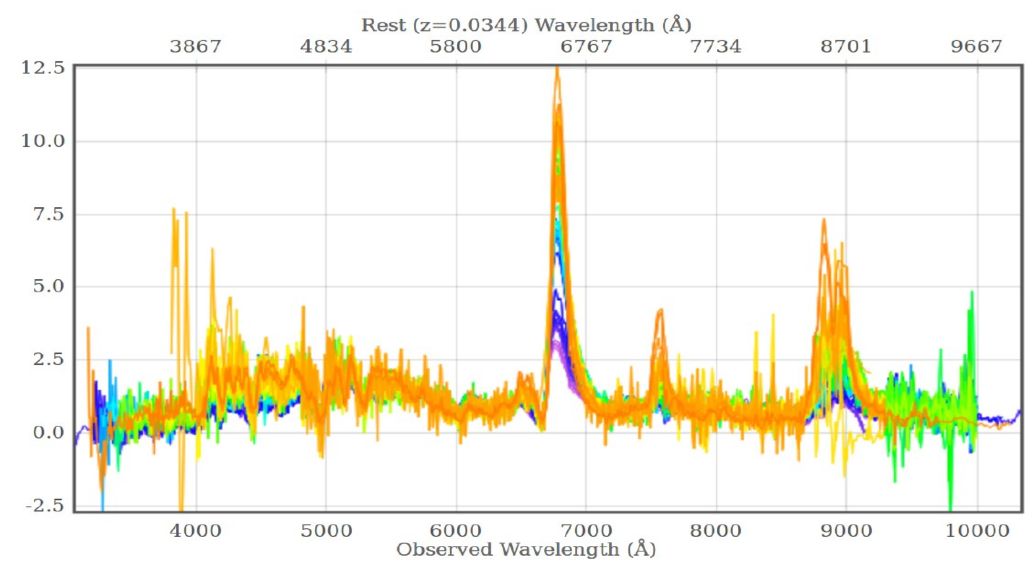


Kankare et al., Nature, 2017

iPTF 14hls : an example of slowly evolving SN !



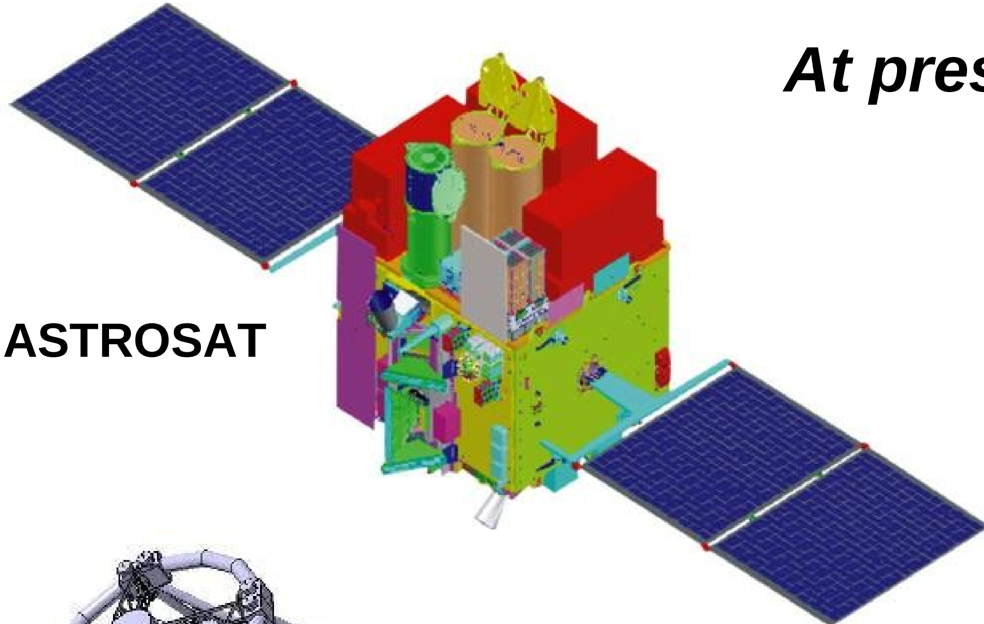


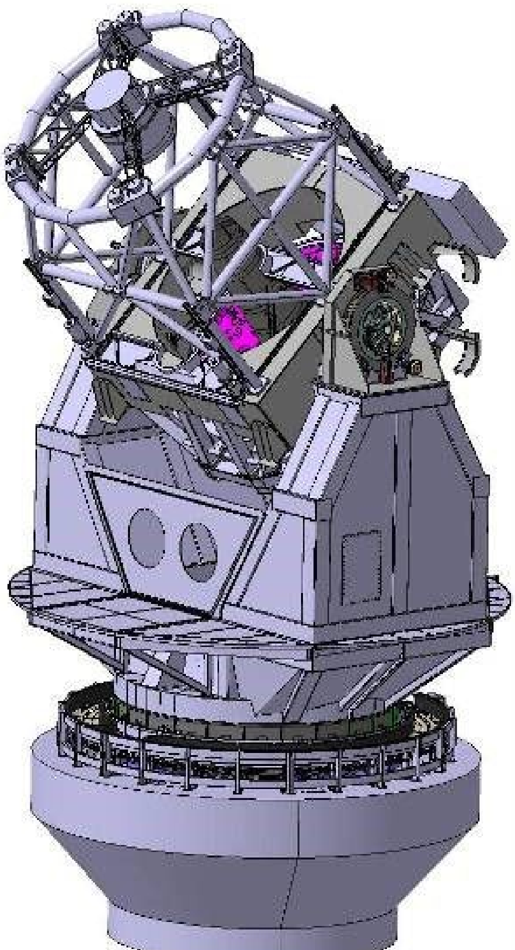


Archavi et al., Nature, 2017

At present where India can contribute ....

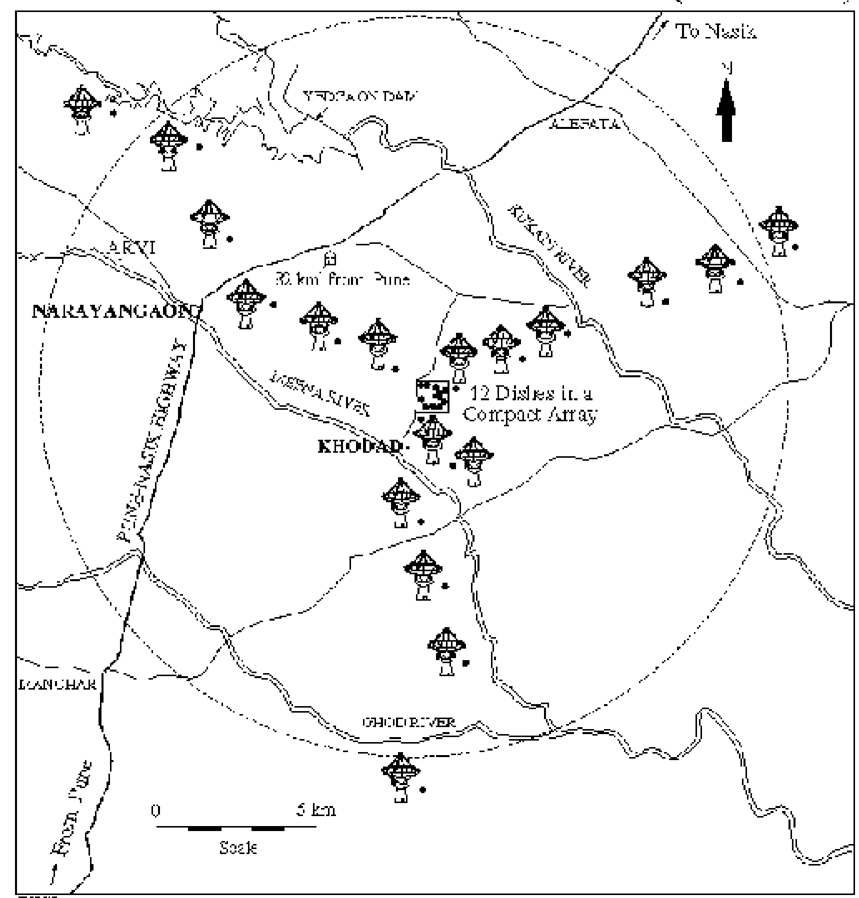
ASTROSAT





3.6m DOT

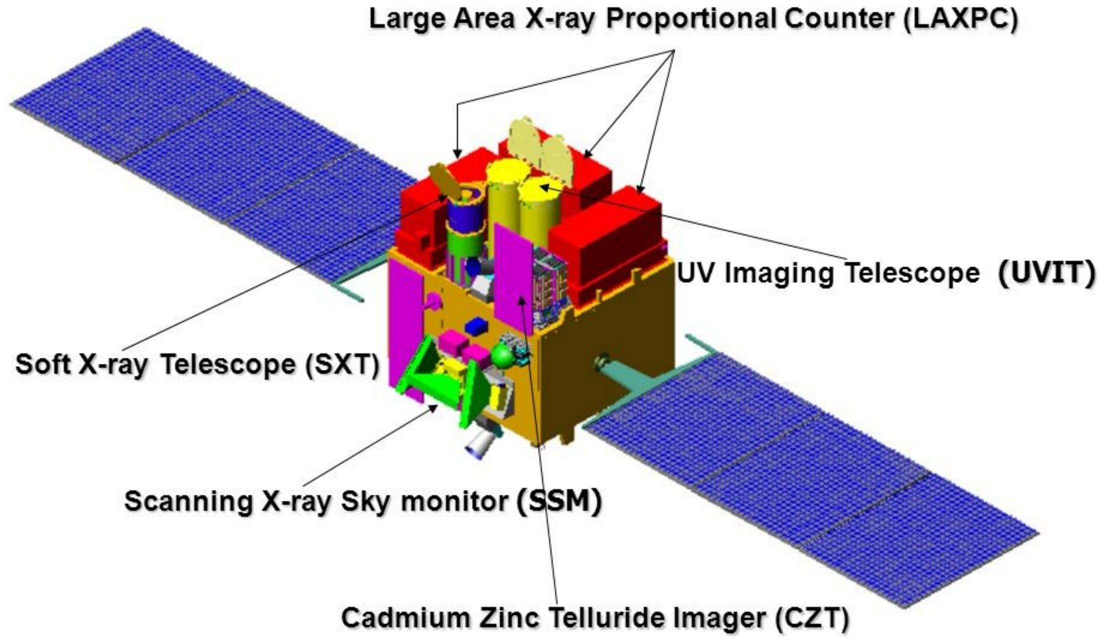
LOCATIONS OF GMRT ANTENNAS (30 dishes)



Giant Meterwave Radio Telescope

Channel	Slot	Filter	Name	Mean λ (A)	Δ λ (A)
FUV	0	Block	Block		
	1	F148W	CaF2-1	1481	500
	2	F154W	BaF2	1541	380
	3	F169M	Sapphire	1608	290
	4		Grating-1		
	5	F172M	Silica	1717	125
	6		Grating-2		
	7	F148Wa	CaF2-2	1485	500
NUV	0	Block	Block		
	1	N242W	Silica-1	2418	785
	2	N219M	NUVB15	2196	270
	3	N245M	NUVB13	2447	280
	4		Grating		
	5	N263M	NUVB4	2632	275
	6	N279N	NUVN2	2792	90
	7	N242Wa	Silica-2		
VIS	0	Block	Block		
	1	V461W	VIS3	4614	1300
	2	V391M	VIS2	3909	400
	3	V347M	VIS1	3466	400
	4	V435ND	ND1	4354	2200
	5	V420W	BK7	4200	

ASTROSAT Instrument Configuration



http://astrosat.iucaa.in/

The main characteristics of the CZT imager will be as follows:

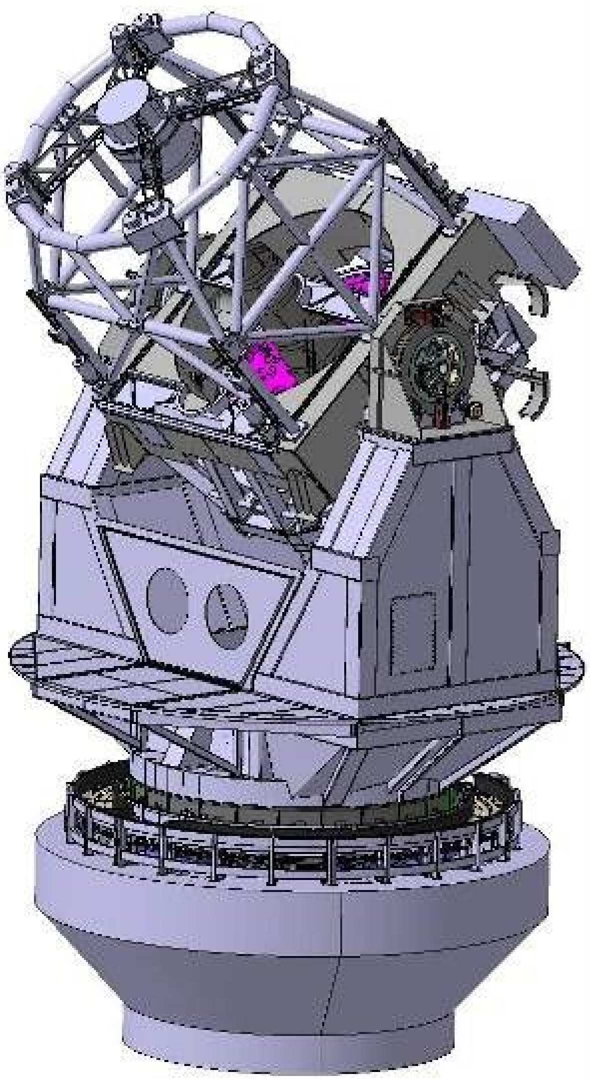
Detector	:	Cadmium-Zinc-Telluride detector array
Energy Range	:	10 - 150 keV
Pixel size	:	2.4 mm x 2.4 mm
Number of pixels	:	16384
Geometric area	:	1024 cm^2
Field of View	:	6^o x 6^o (10-100 keV) (defined by collimator) 17^o x 17^o (>100 keV) (defined by Coded Mask Housing)
Angular resolution	:	8 arc min (<100 keV)
Veto layer	:	2cm thick CsI crystal+PMT
Overall size	:	50cm x 50cm x 70cm (height) (without radiator plate)

The main characteristics of the SXT will be as follows:

Telescope length	:	2465 mm (including baffle, door and camera)
Focal Length	:	2000 mm
Telescope PSF	:	1.5 - 2.5 arcmin (rms)
Field of View	:	41.3 x 41.3 arcmin
Energy range	:	0.3-8.0 keV
Detector	:	E2V CCD-22 (Frame Store)
Detector Format	:	600x600 pixels
Pixel Scale	:	4.13 arc sec/pixel
CCD Readout modes	:	Photon Counting, Imaging, Timing
Effective Area	:	200 cm^2 @ 1.5 keV (See figure below)
Position accuracy	:	30 arc sec
Sensitivity expected	:	10 micro Crab or better

3.6m Devasthal Optical Telescope (DOT)

Detectors : Now Optical-NIR Imagers are operating
FOSC will be available from 2019



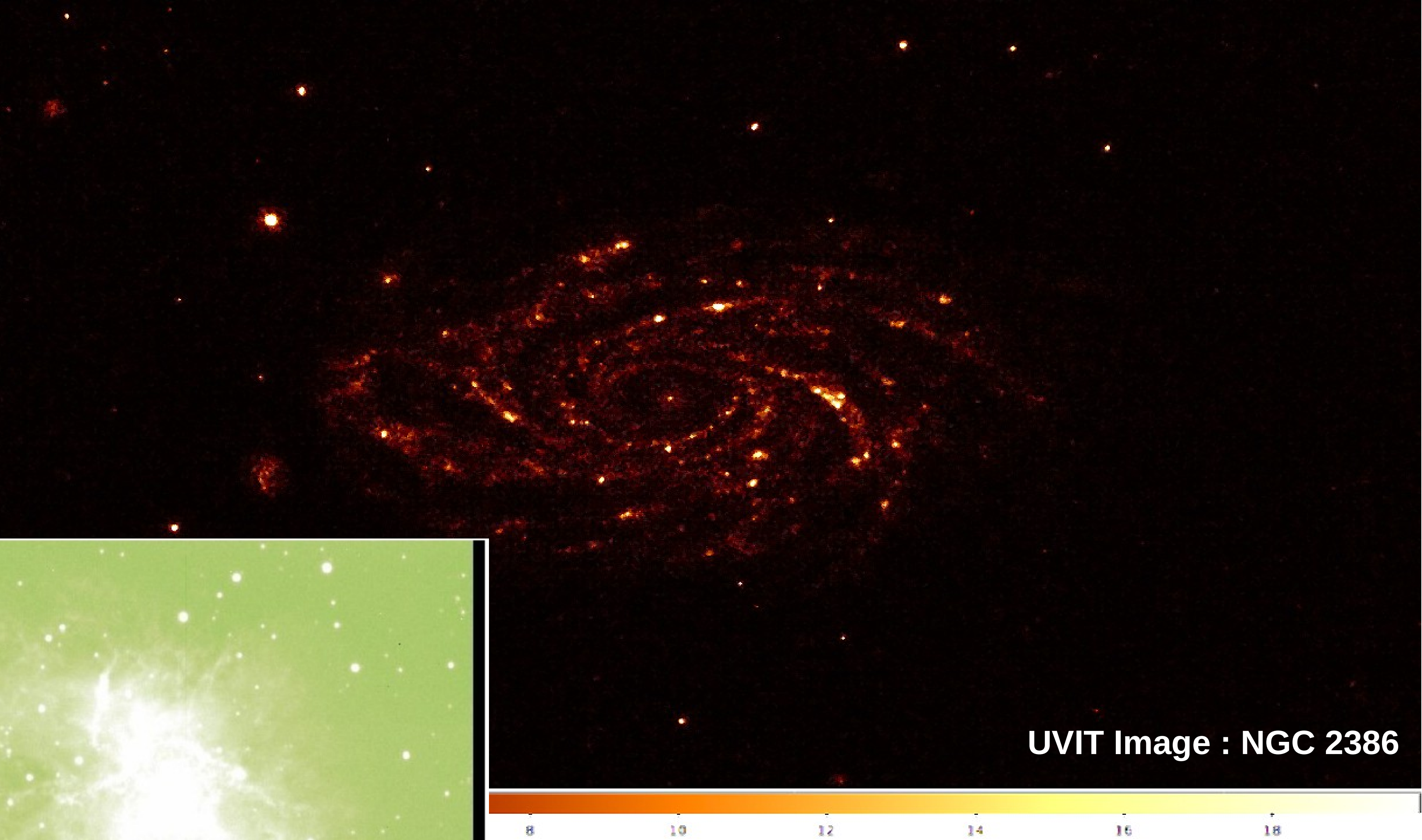
Longitude = 79.7 E
Latitude = 29.4 N
Altitude = 2450 meters above MSL
Median seeing = 1".1
Best seeing = 0".6
Humidity = nominal 30 % (Winter)

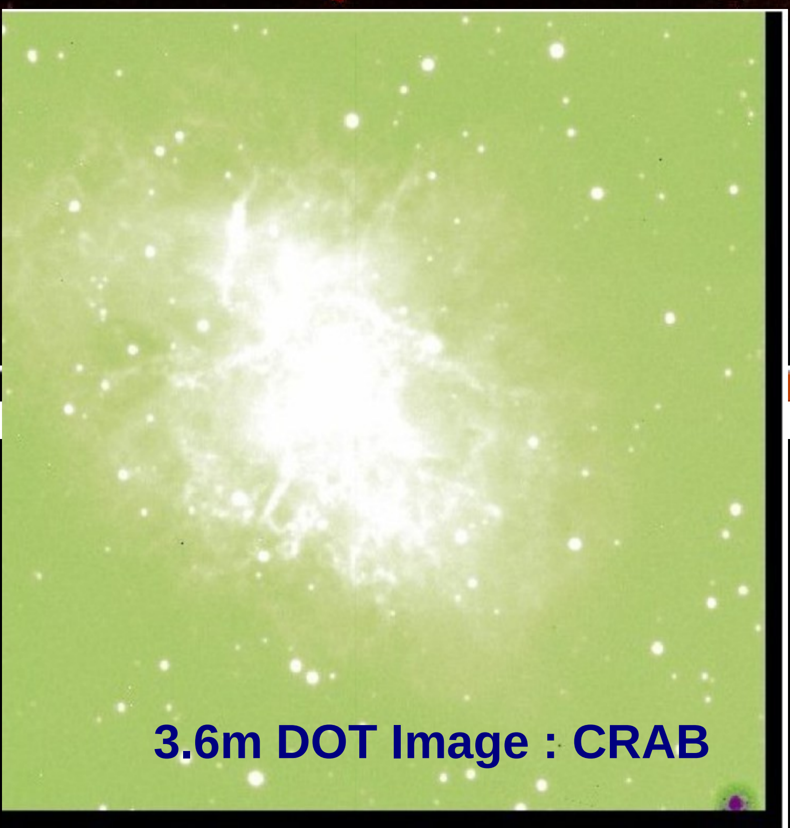
Almost 40% of the nights seeing is below 1".0

Spectroscopic Night ~ 150
Photometric Night ~ 120

Take-home messages :

- There are nuclear transients (e.g., ASASSN-15lh, PS1-10adi) which show natures similar to both SNe and TDEs. High astrometric precision of Gaia will be extremely useful.
- Theoretical predictions about the probable spectral signatures of TDEs and SNe are necessary to distinguish TDEs from SNe.
- Rapid follow-ups of the early evolutions of TDE and SNe in X-ray/UV and late radio observations are important to distinguish these objects on the basis of their observational signatures. Early discovery by Gaia and rapid follow-up by other telescopes like ASTROSAT will be extremely helpful.





Thanks