GROWTH

Global Relay of Observatories Watching Transients Happen

Cosmic Explosions: Young & Energetic

S. R. Kulkarni

Caltech Optical Observatories

NSF PIRE

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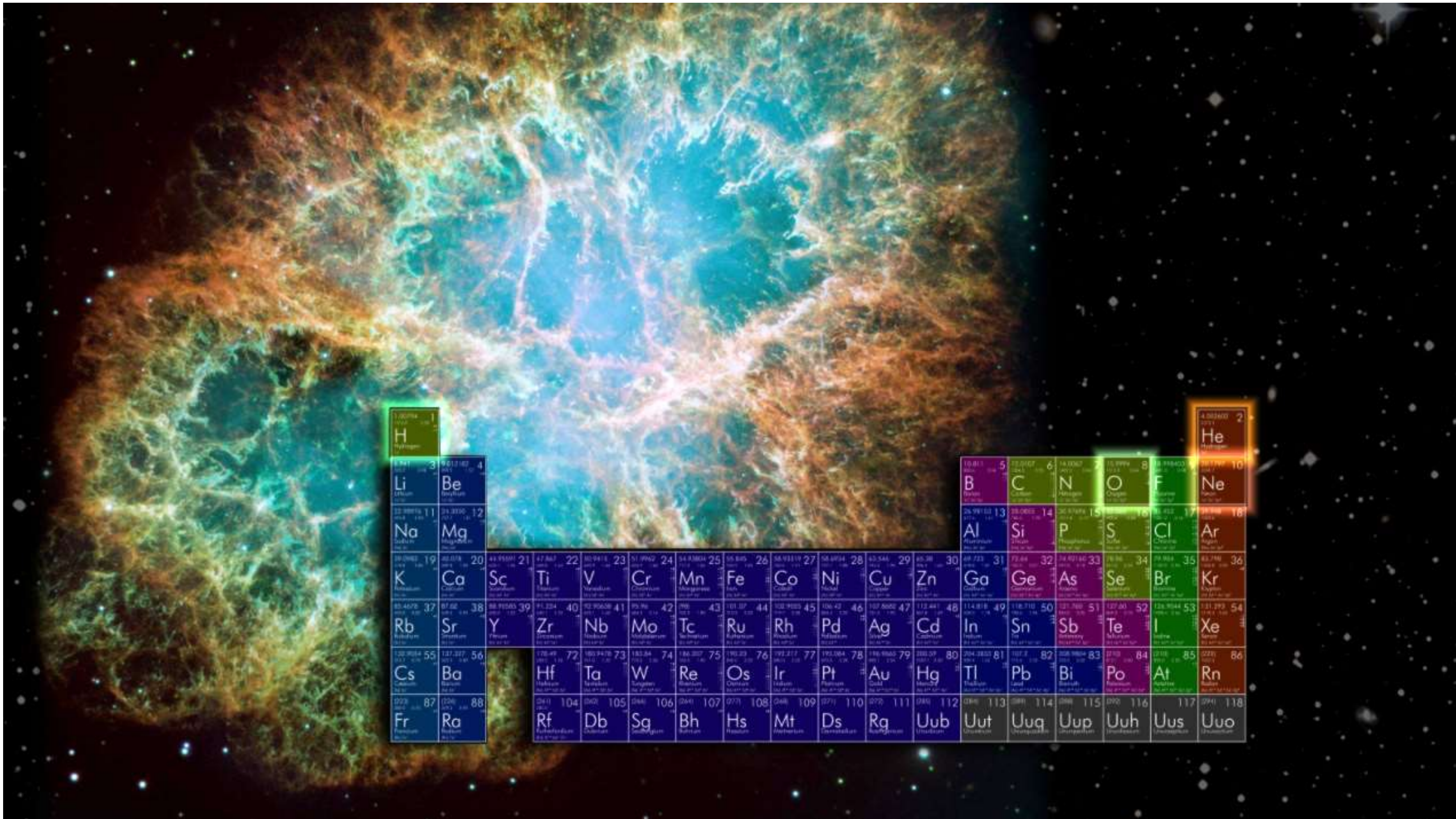
“Metals”=Stellar Ashes



Credit: NASA

Layout of the talk

- The motivations to study cosmic explosions at early times
  - Supernovae without hydrogen
  - Supernovae with hydrogen
  - Supernovae which are driven by an engine

Motivation

1. Determine what kind of stars explode as what kind of supernovae?
   – "mapping between types of supernovae and their progenitors"
2. Early studies is key
   – Early studies determine radius
   – Early studies allow us to probe circum-stellar environs (which is a clue to the state of star before it explodes)

Motivation (contd)

3. Some supernovae are note simple explosions but are driven by an "engine"

- Engines are most active at early times and easily identified by X-ray observations (early times) and radio observations (early and late)

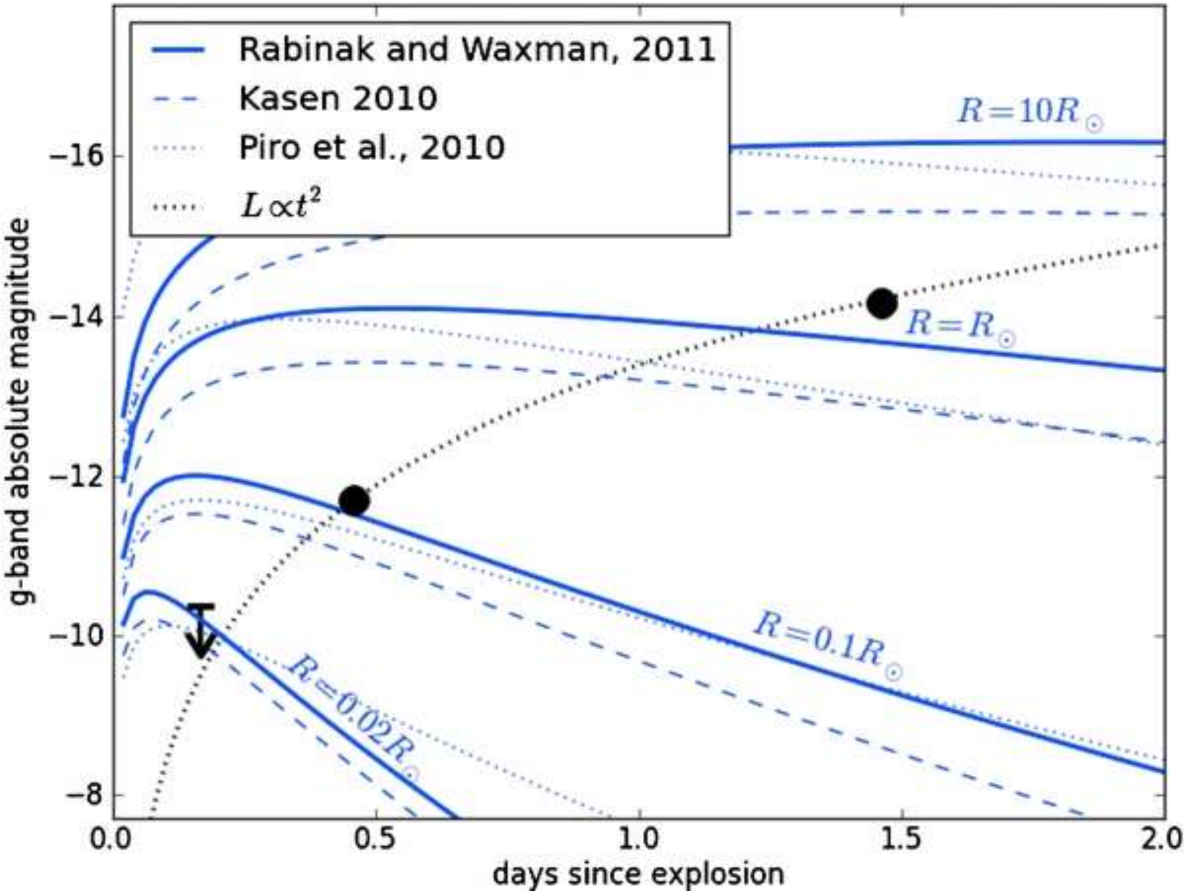
A. YOUNG SUPERNOVAE (WITHOUT HYDROGEN)

Type Ia supernovae

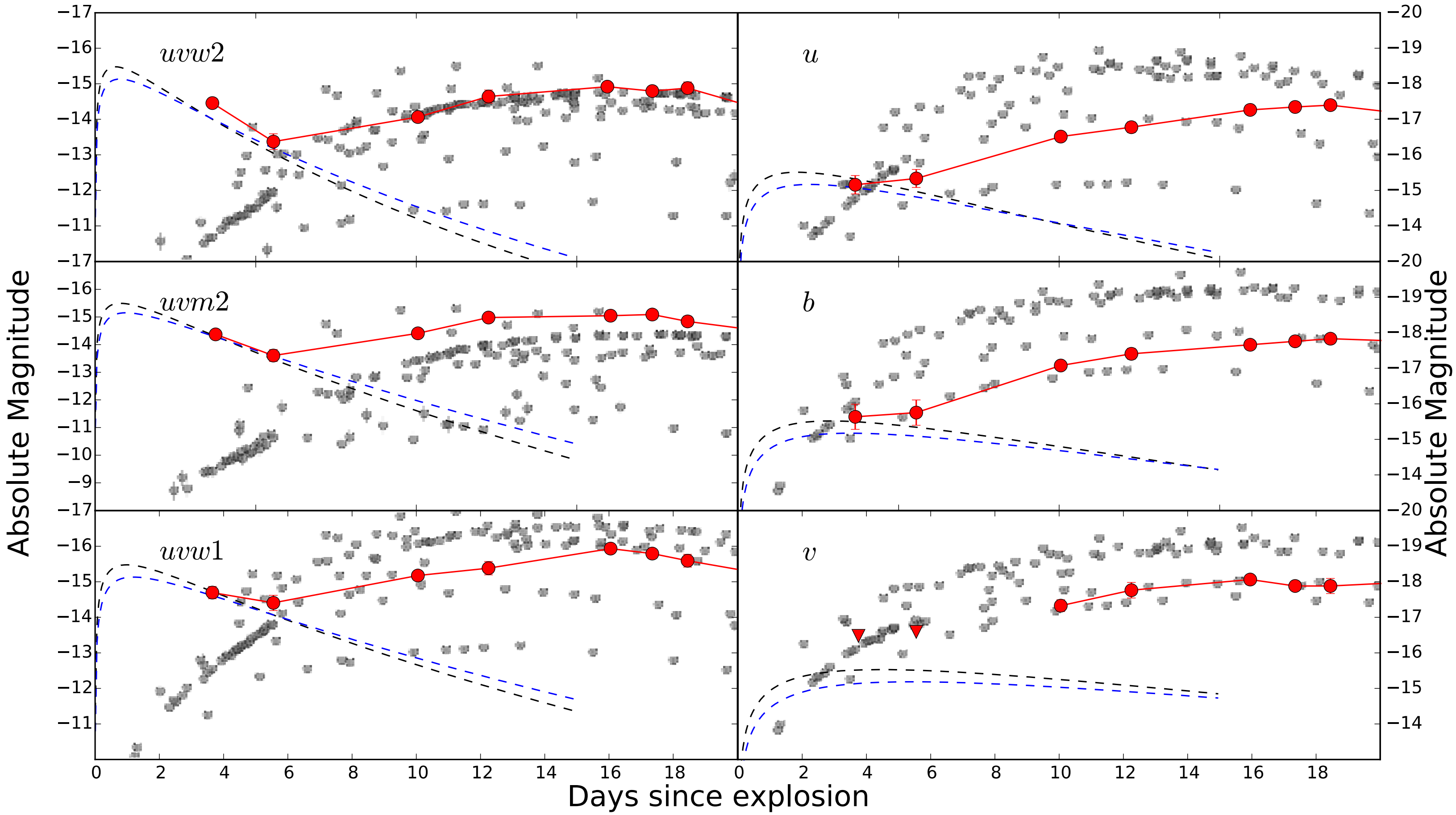
1. Two white dwarfs merge and the resulting merger explodes
    1. These are are old systems and so no expectation of rich circum-stellar medium
2. One white dwarf is fed matter by a normal star, increases in mass and then explodes
    1. This is a “dirty” system and one expects lots of circum-stellar matter
    2. Blast wave interacts with the companion star!

PTF11kly – 10 hours p.e.

Progenitor is small!

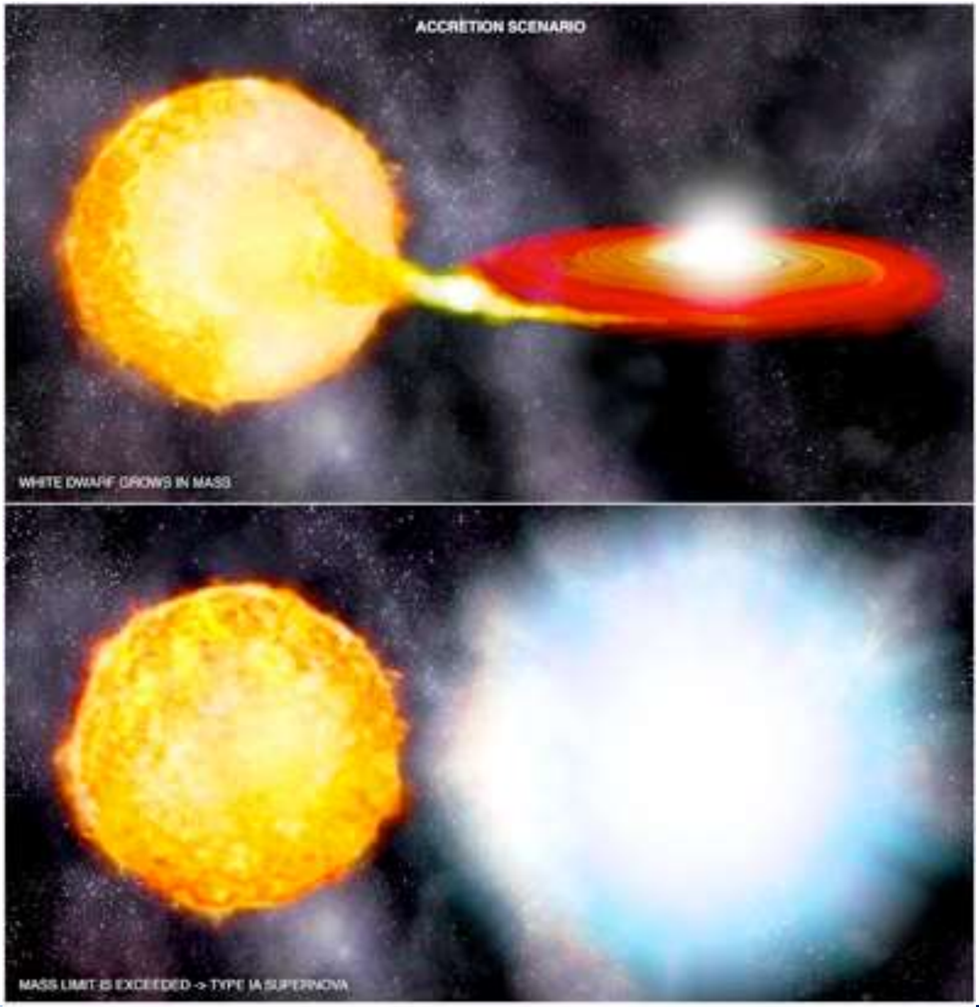


In contrast, iPTF14atg …



Yi Cao (PhD thesis)

UV Pulse


ACCRETION SCENARIO
WHITE DWARF GROWS IN MASS
MASS LIMIT IS EXCEEDED -> TYPE IA SUPERNOVA

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iPTF 13bv (Type Ib)

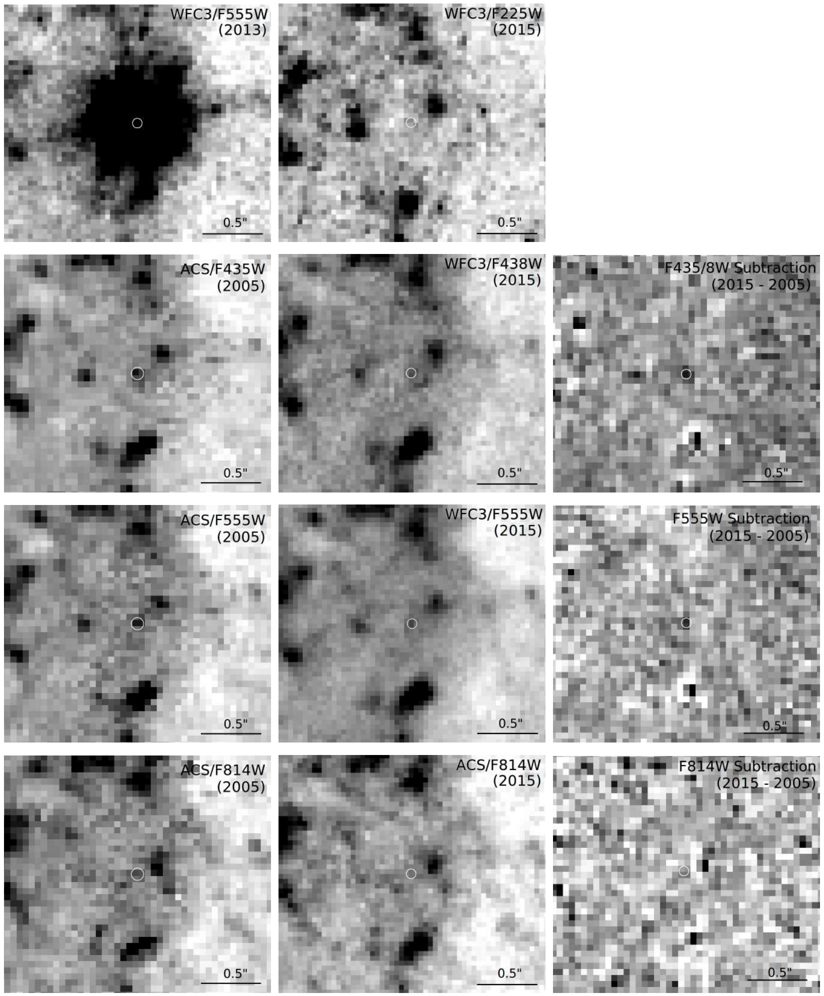

FIG. 1.— *HST* images of the site of iPTF13bvn at different epochs. *Top left:* An image near maximum light to locate the SN. *Rest of left column:* Pre-SN images obtained in 2005. *Middle column:* New images obtained in 2015. *Right column:* Pre-SN minus post-SN images. The SN location is shown with a white circle of 3σ radius. The image scale is indicated. North is up and east to the left.

Folatelli et al. 2016

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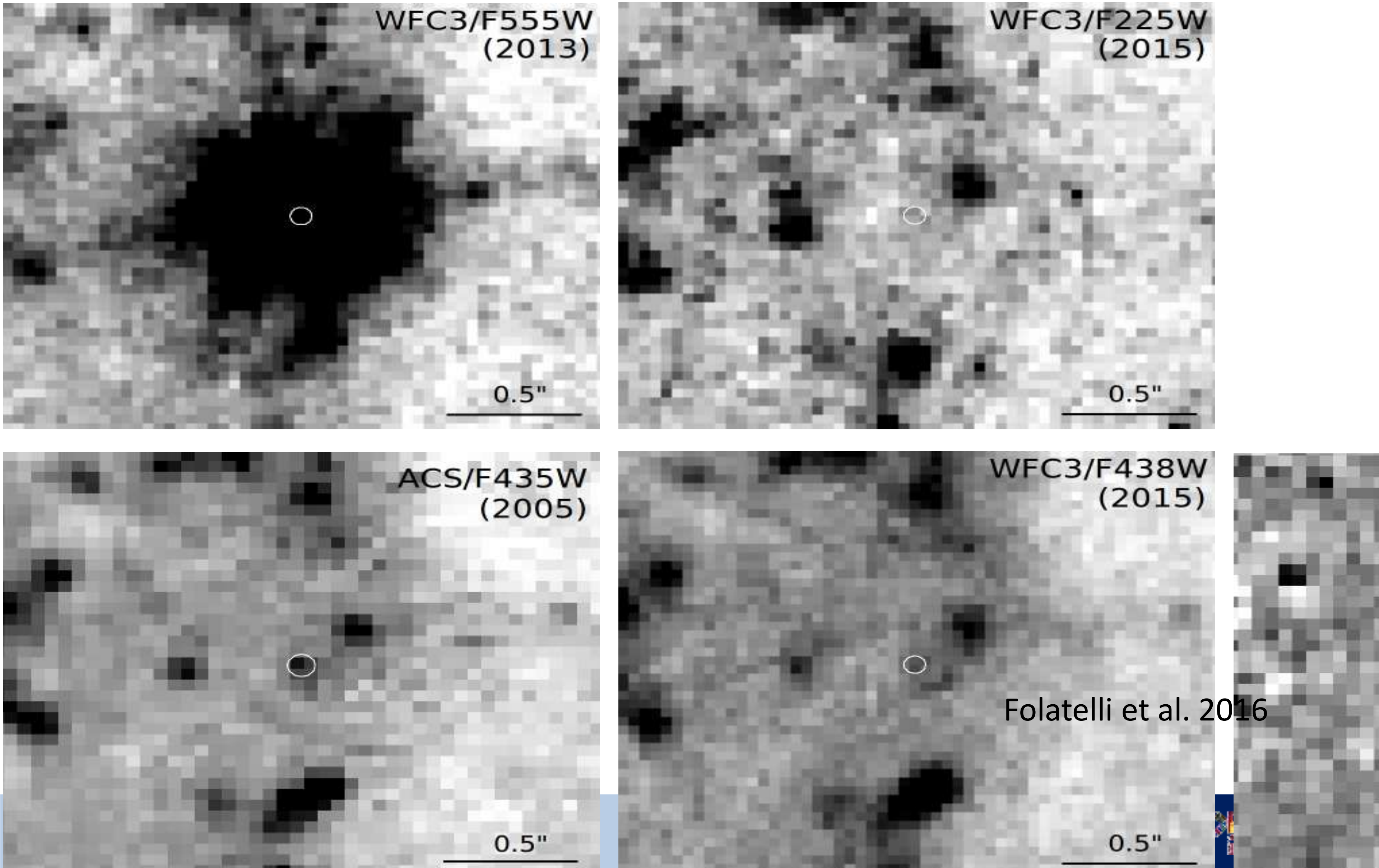
iPTF 13bv (Type Ib)

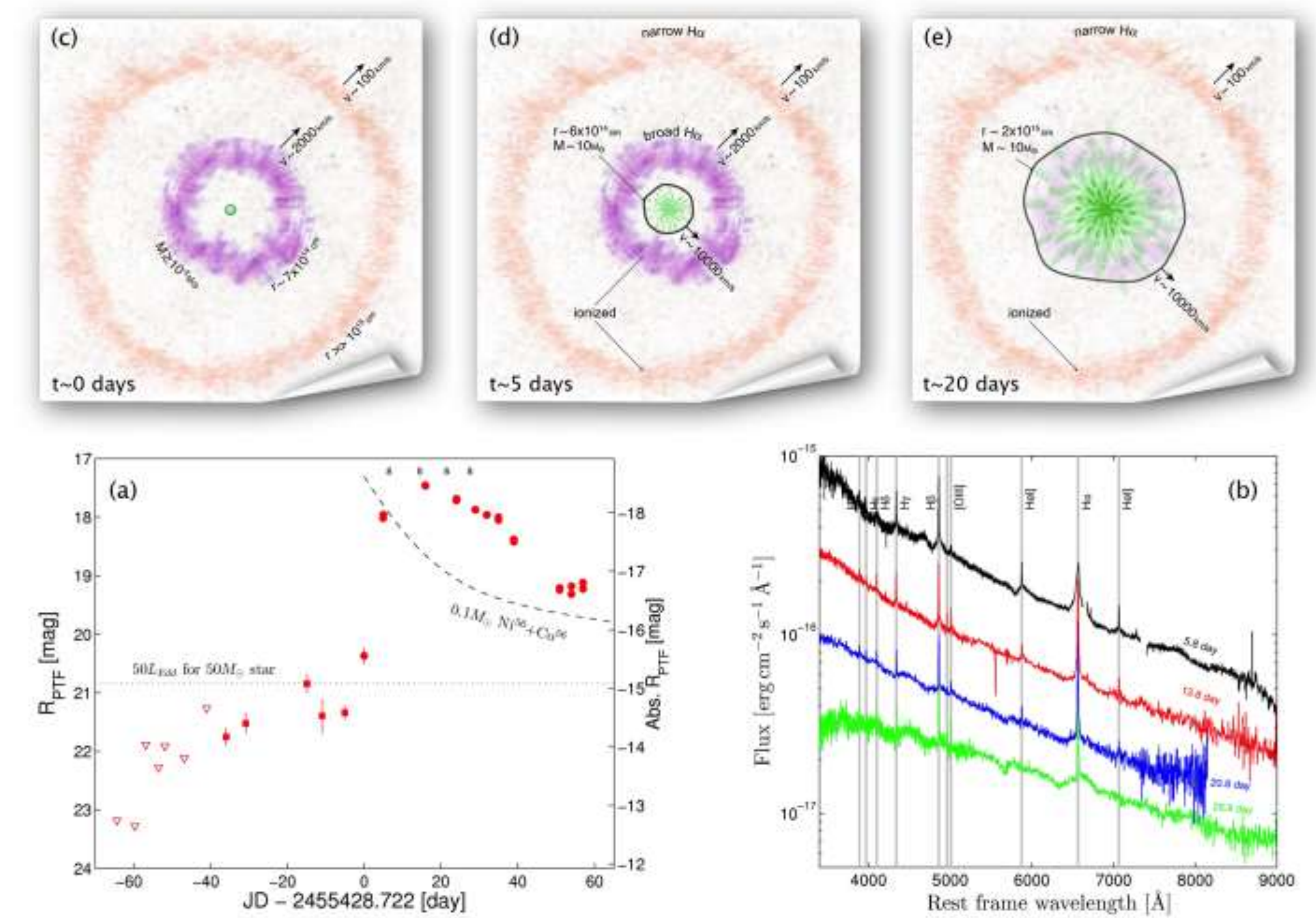
Disappearance of the Progenitor of iPTF13bvn



Folatelli et al. 2016

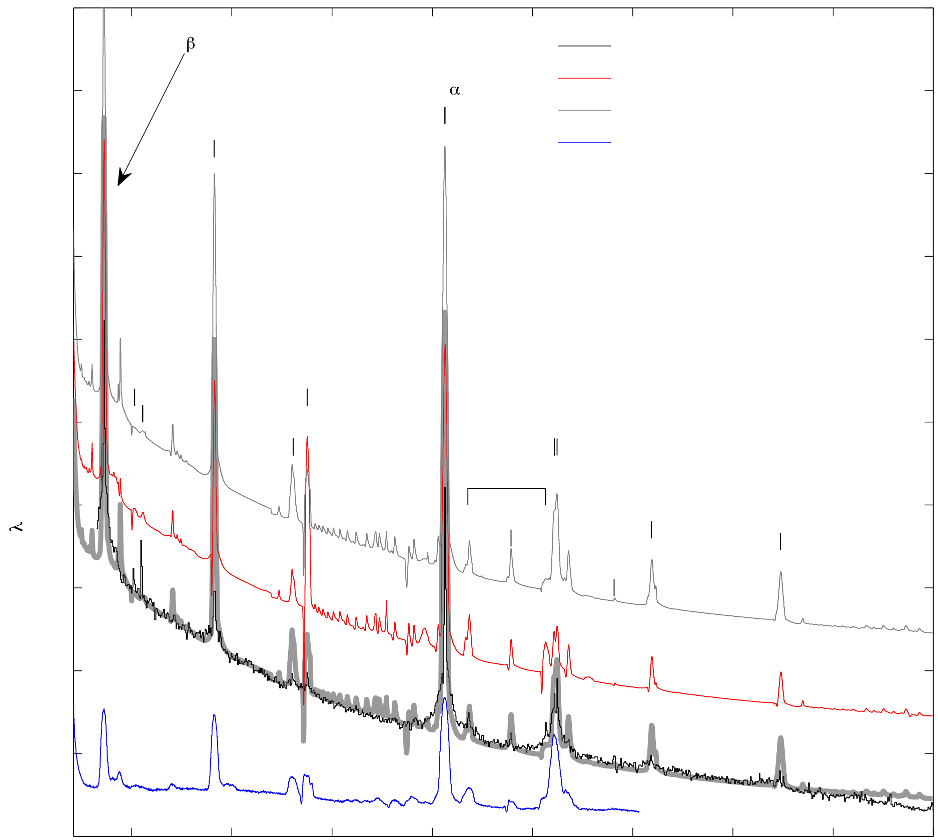
B. YOUNG SUPERNOVAE (WITH HYDROGEN)

Death Omen!



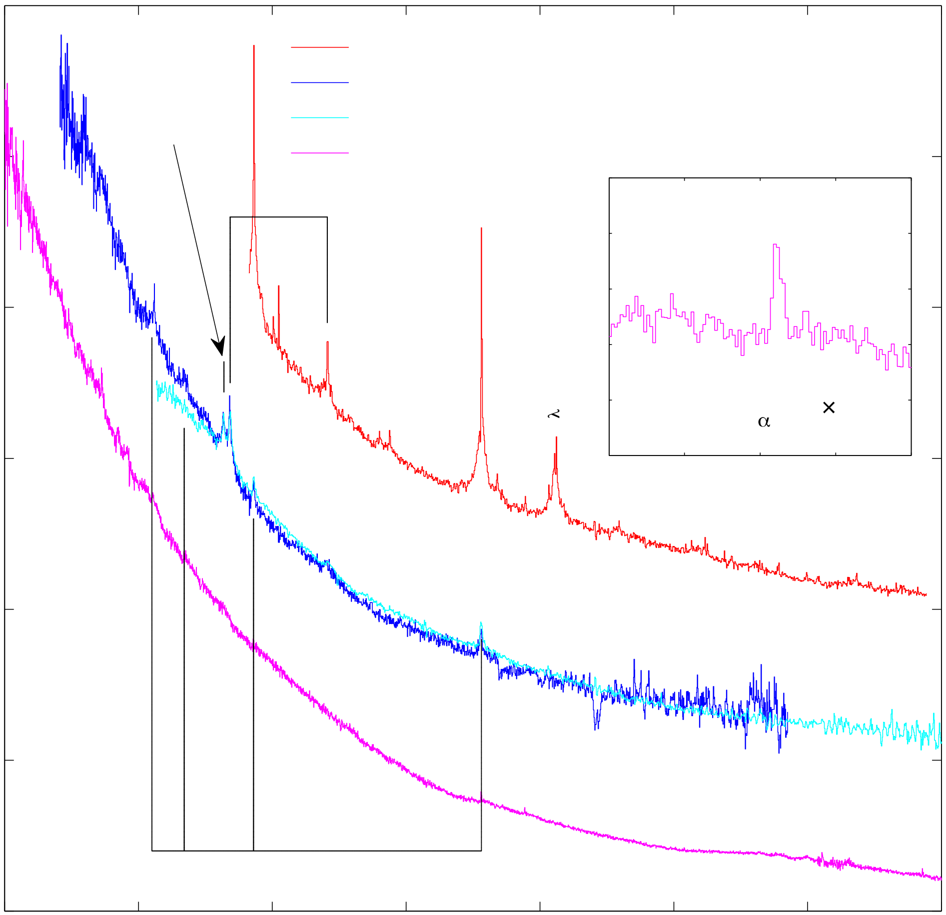
Ofek et al.

iPTF13ast (type IIb)



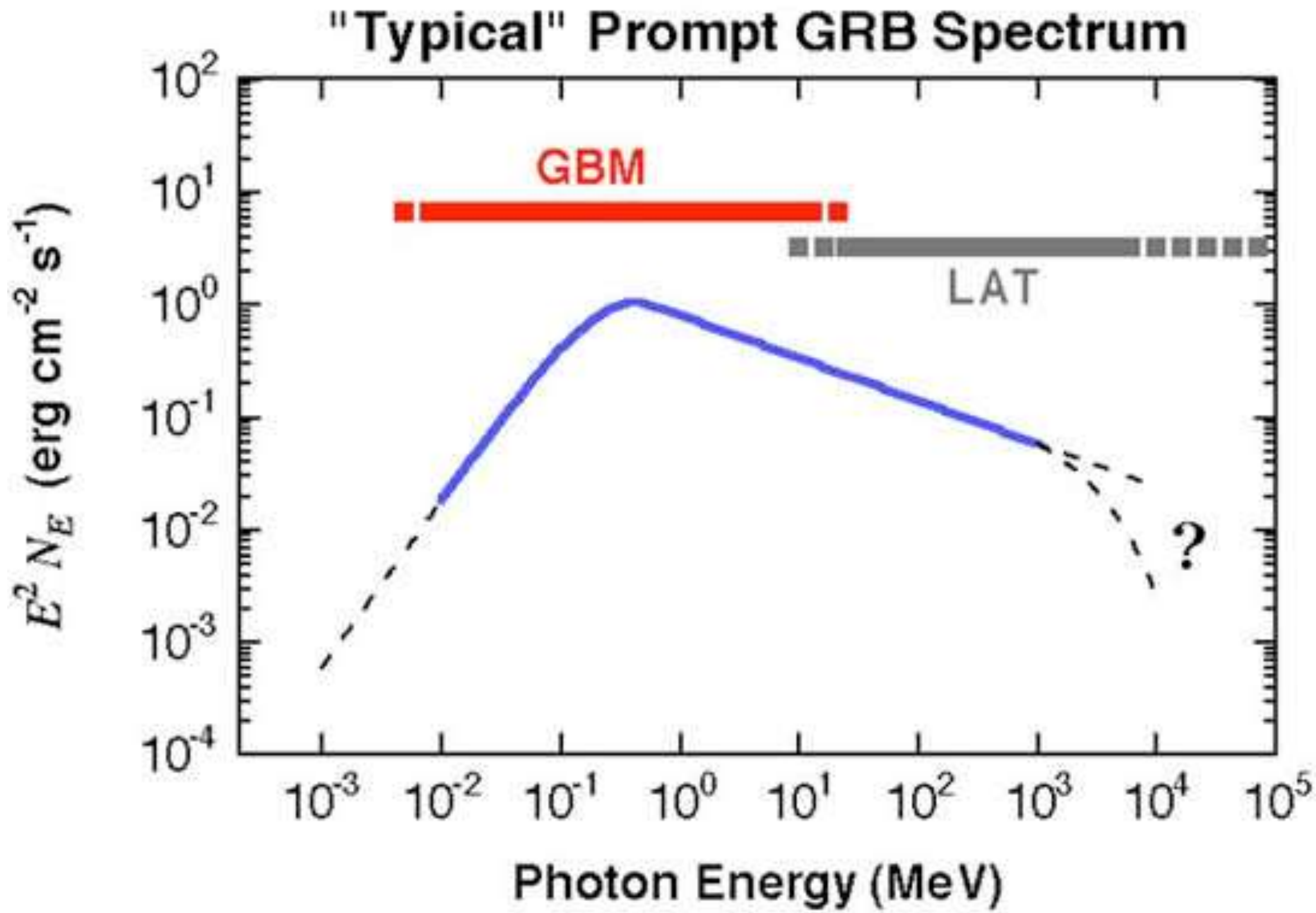
Gal-yam+

iPTF13ast (type IIb)



Gal-Yam+

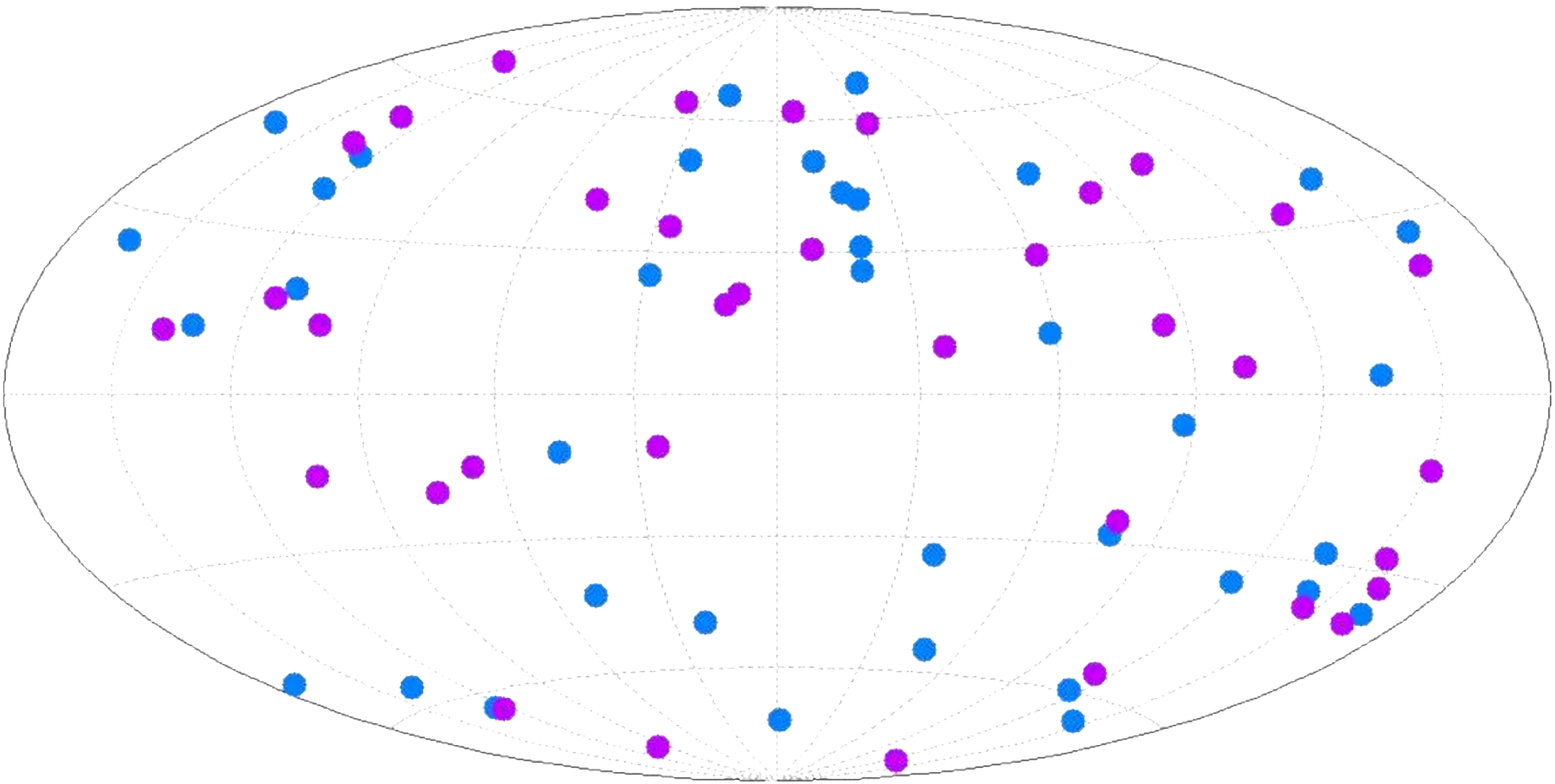
C. X-RAY FLASHES (XRF)


"Typical" Prompt GRB Spectrum
GBM
LAT
?
$E^2 N_E$ (erg cm^{-2} s^{-1})
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
10^4
10^5
Photon Energy (MeV)

MAXI on ISS


全天X線監視装置
(MAXI)
超伝導サブミリ波リム放射サウンダ
(SMILES)
宇宙環境計測ミッション装置
(SEDA-AP)

GRBs & transients



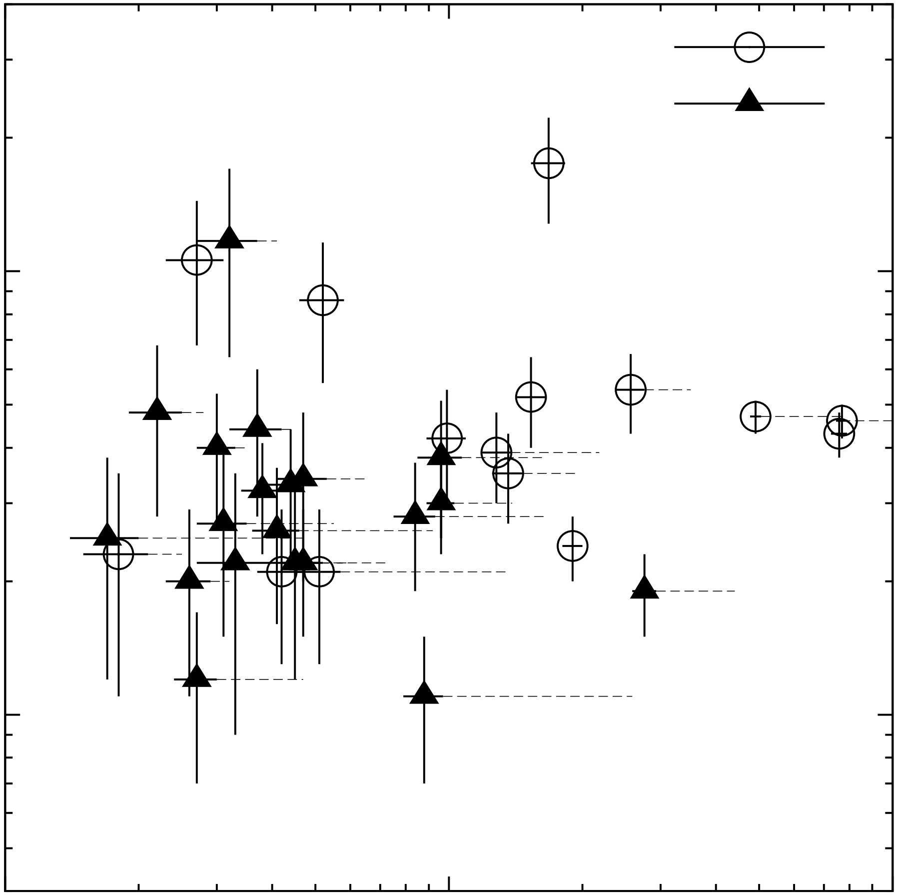
Serino et al. (2014)

http://maxi.riken.jp/grbs/

●: only MAXI (43)

●: MAXI + other (39 prompt + 7 afterglows)

MAXI-only events

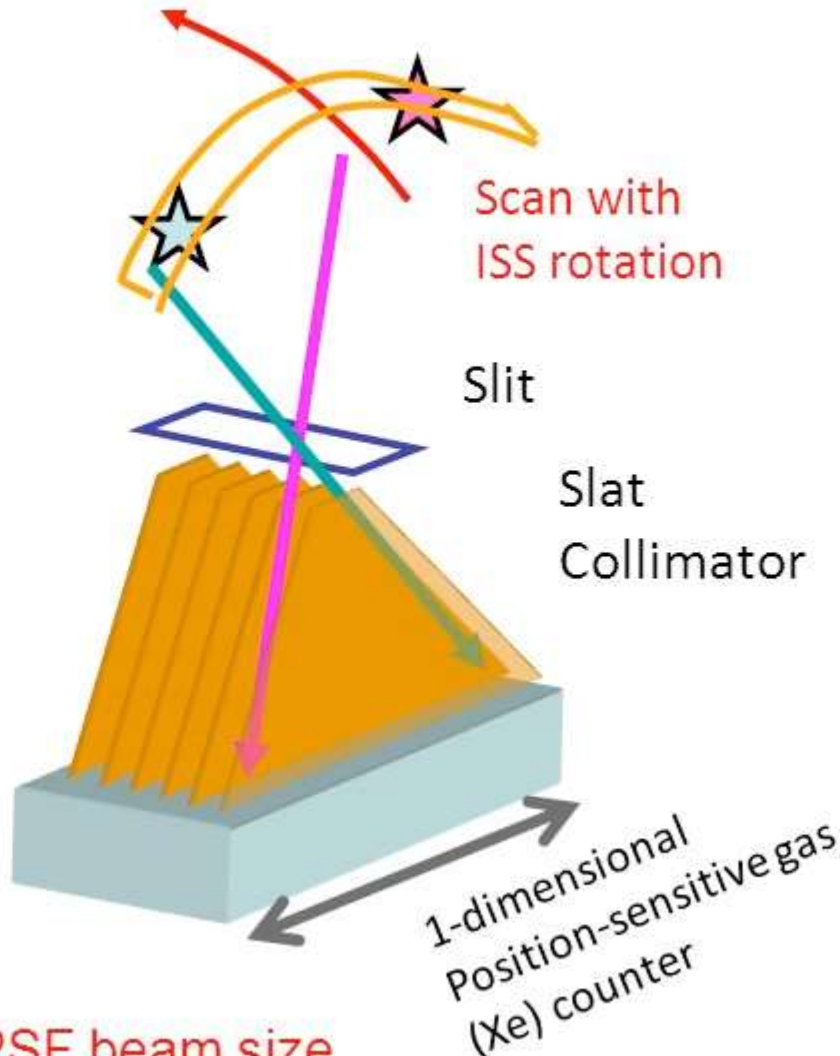


Serino+ 2014

Engine Driven SNe?

1. Rich in X-rays, so XRF
2. log(n)-log(S) and peak flux suggests a closer distance than GRBs
   – Low luminosity GRBs?
   – A class of supernovae driven by underlying relativistic engine (GRB980425/SN1998bw)?
3. SN1998bw was particularly bright in radio
   – Search for radio and thence optical counterparts

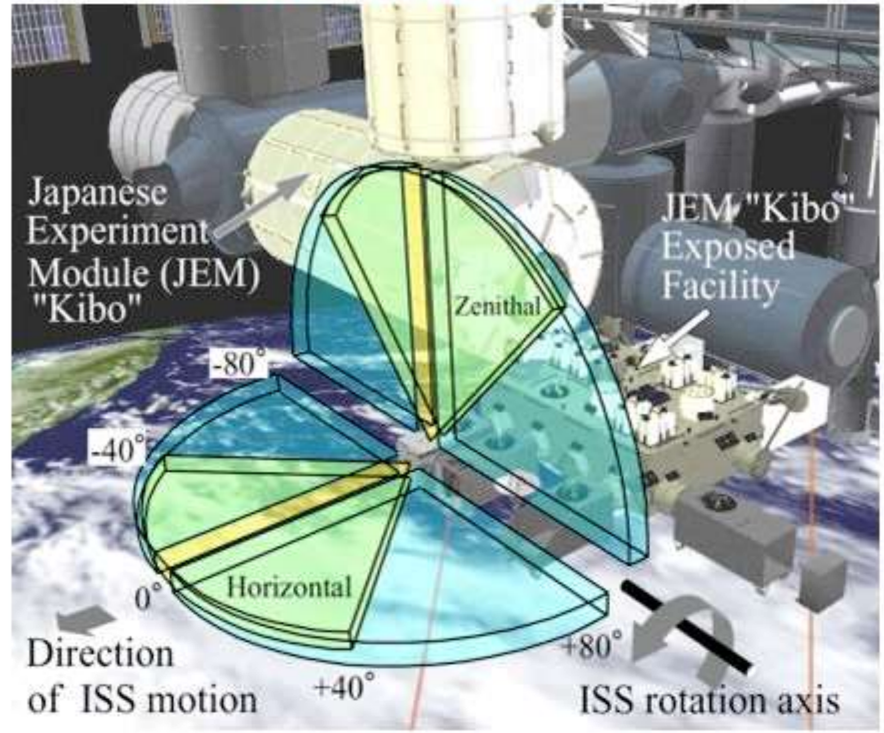
Gas Slit Camera (GSC) on MAXI

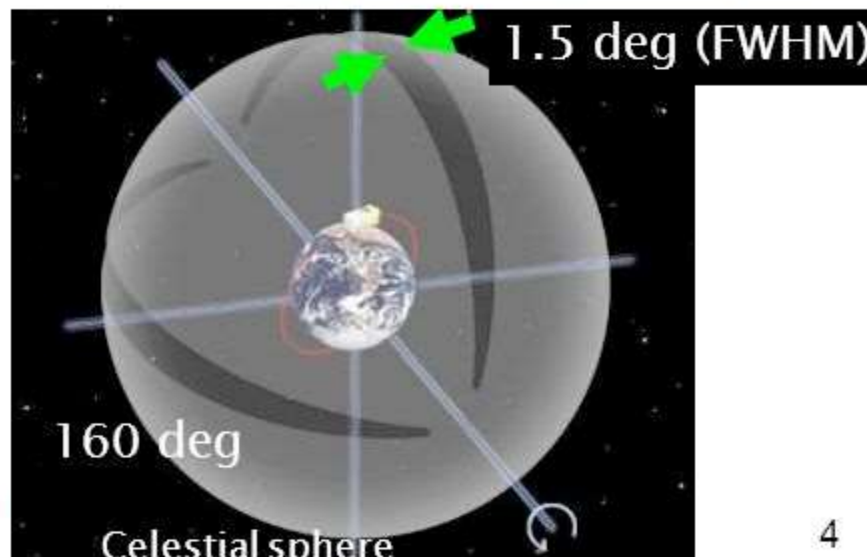


PSF beam size ~ 1.5x1.5 deg.

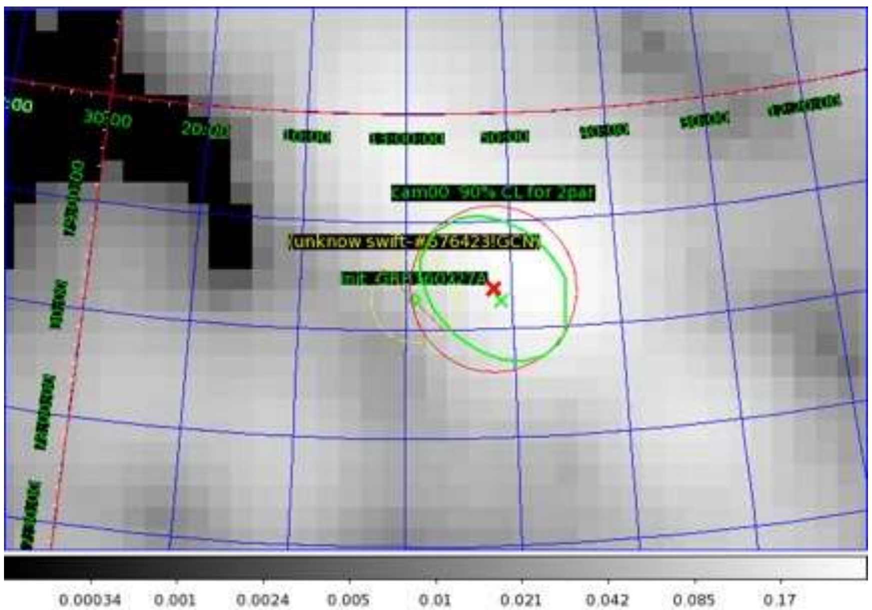
Energy band: 2-30 keV

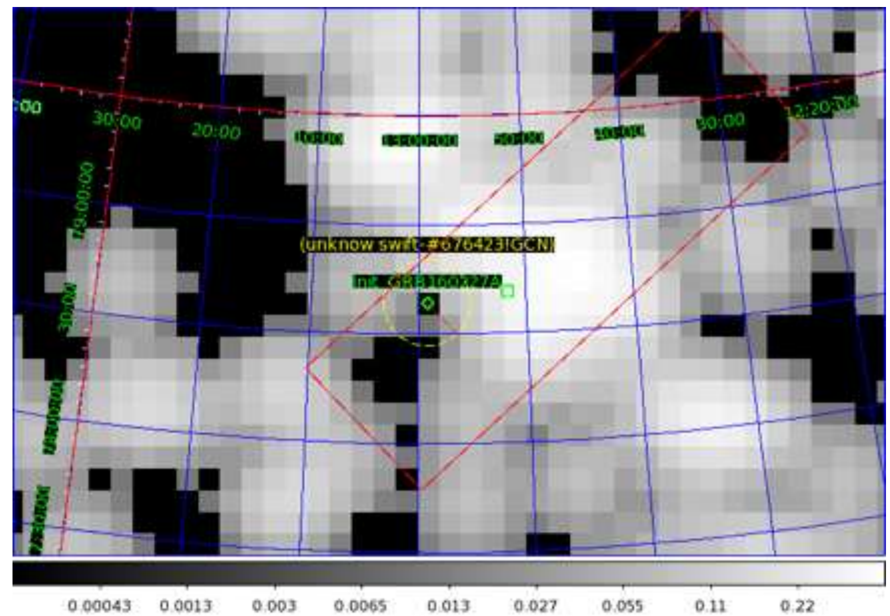
Field of Views





Localization with MAXI

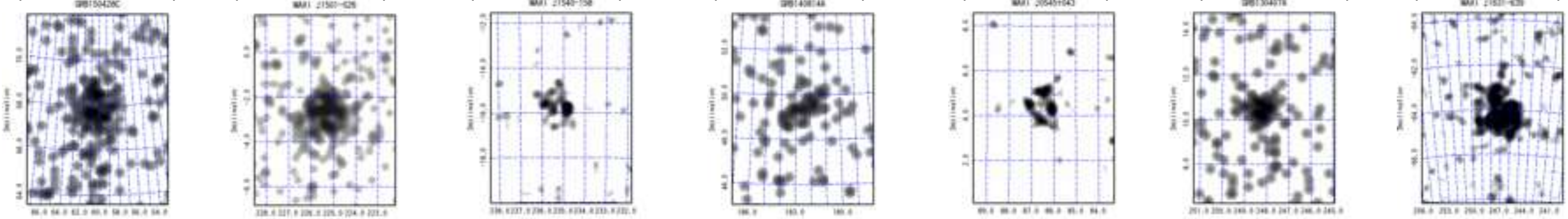




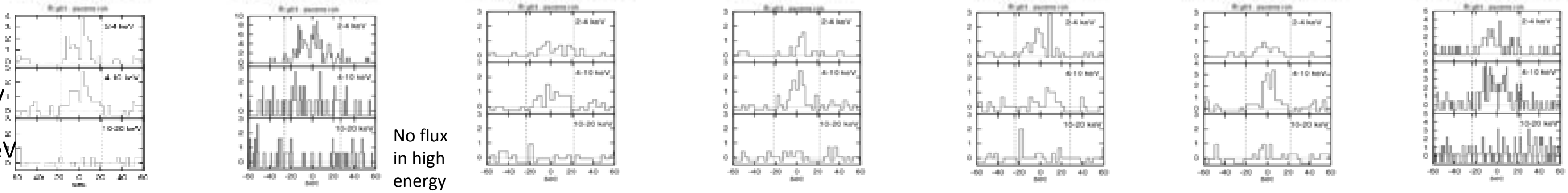
Challenge is coarse ocalization: 1/2 degree x 3 degree

Curiously no XRT counterparts

	GRB 150428C	MAXI J1501-026	MAXI J1540-158	GRB 140814A	MAXI J0545+043	GRB 130407A	MAXI J1631-639
(l, b) =	(139.1, +11.3)	(354.6, +46.8)	(351.6, +30.6)	(139.9, +66.4)	(201.1, -12.6)	(26.4, +35.6)	(324.4 -10.8)

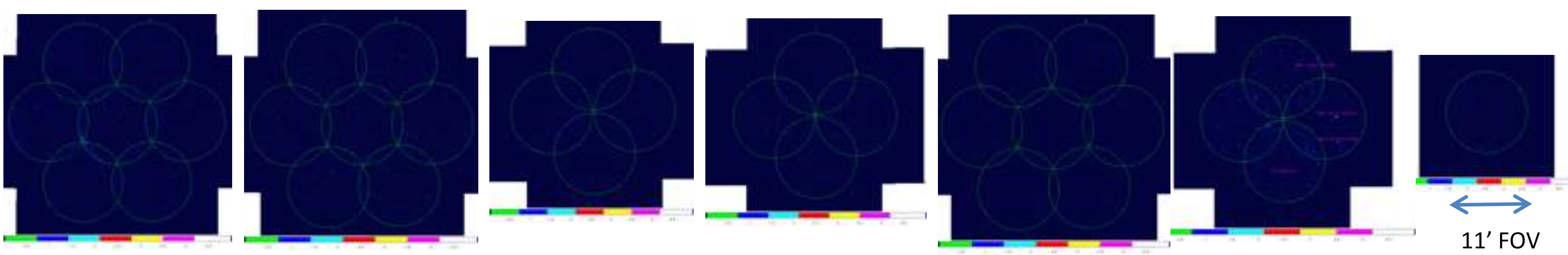


2-4 keV
4-10 keV
10-20 keV



No flux in high energy band

flux	0.16 Crab	0.44 Crab	0.1 Crab	0.23 Crab	0.2 Crab	0.17Crab	0.12 Crab
	2015-04-28	2015-08-26	2015-03-11	2014-08-14	2014-04-12	2013-04-07	2011-04-29
	GCN #17772	Atel #7954	GCN #17568	GCN #16686	ATel #6066	GCN #14359	ATel #3316



11' FOV

MAXI light curves not corrected for collimator transmission

Plan of Action

1. ZTF has the capacity to identify *one young supernovae per night* (<24 hours old)
2. Between Palomar, Keck and Liverpool we are very well set up for both ultra-low & low spectroscopy and imaging
3. The MAXI rate of XRFs is one very two months
   - VLA imaging (using OTFM), ZTF imaging
   - Follow up world wide

Grayware

1. MAXI: A collaboration between Caltech, Tokyo Tech and NRAO.
   – Good graduate student thesis project
2. Young supernovae: This constitutes two key projects within ZTF and is also a major project for the public use of ZTF. Expect considerable activity within the ZTF group and also by the US community.