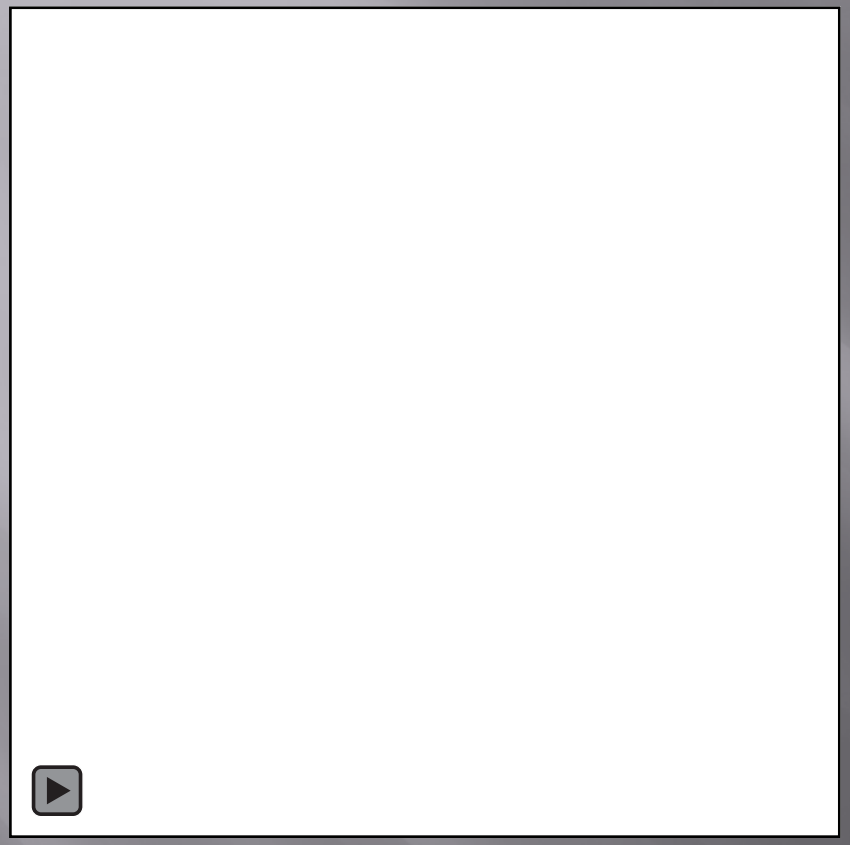
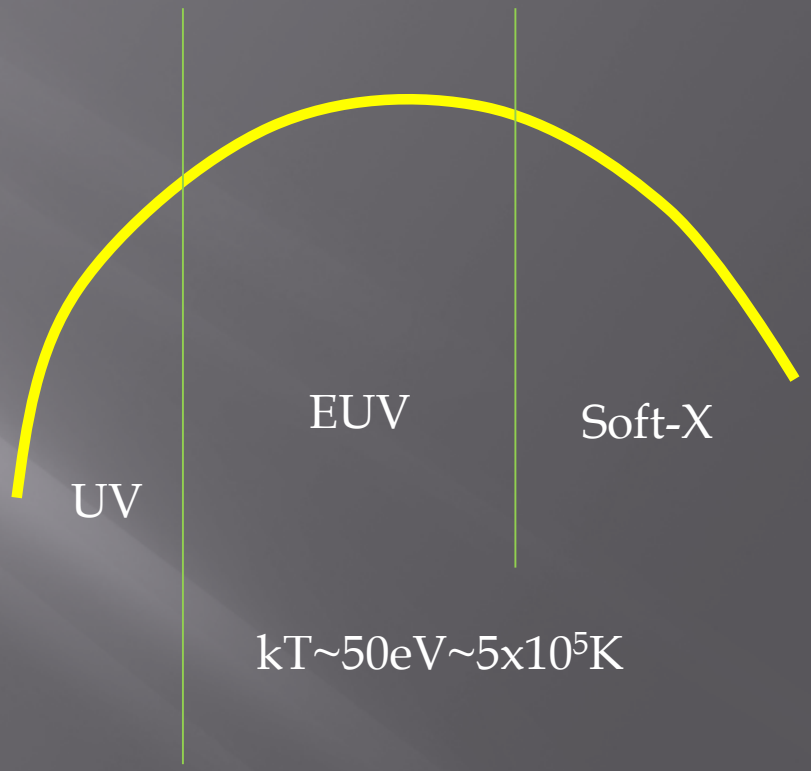
TDE past, present and future

Richard Saxton, S. Komossa, Andy Read, Kate Alexander, Paulina Lira, Iain Steele, Pedro Rodriguez, Cristian Motch, Miguel Descalzo

Overview

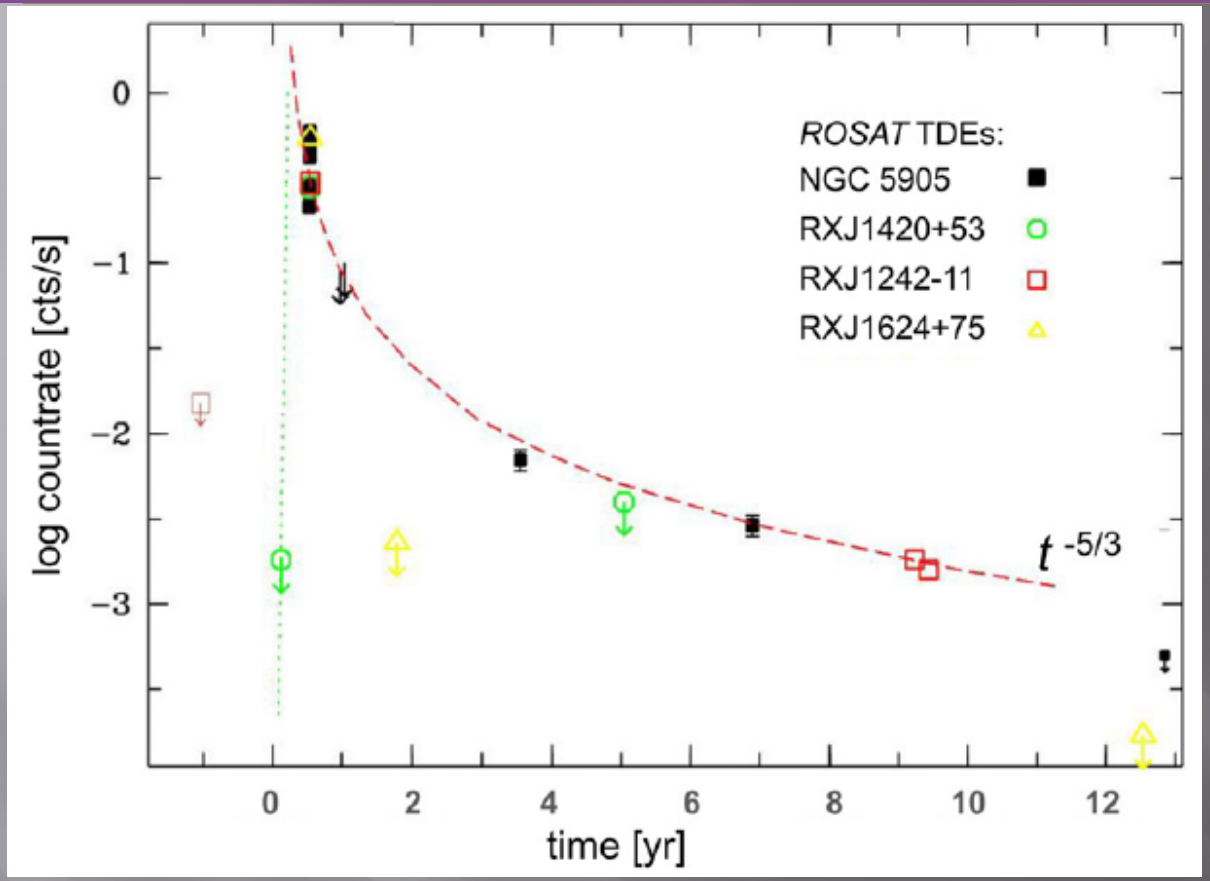


Bonnerot et al. 2015



Rees 1988
Ulmer 1999

ROSAT TDE



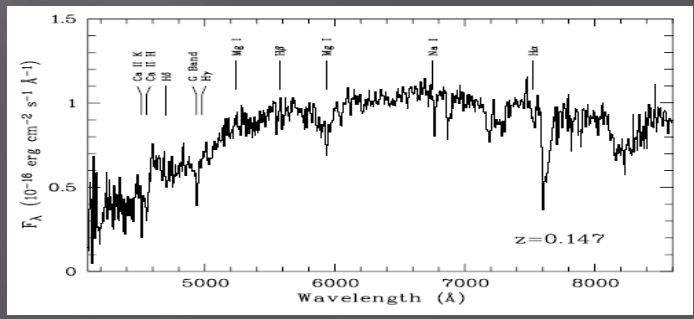
Komossa 2012

RXJ 1242.6-1119
Komossa &
Greiner 1999

RXJ 1420.4+5534
Greiner+ 2000

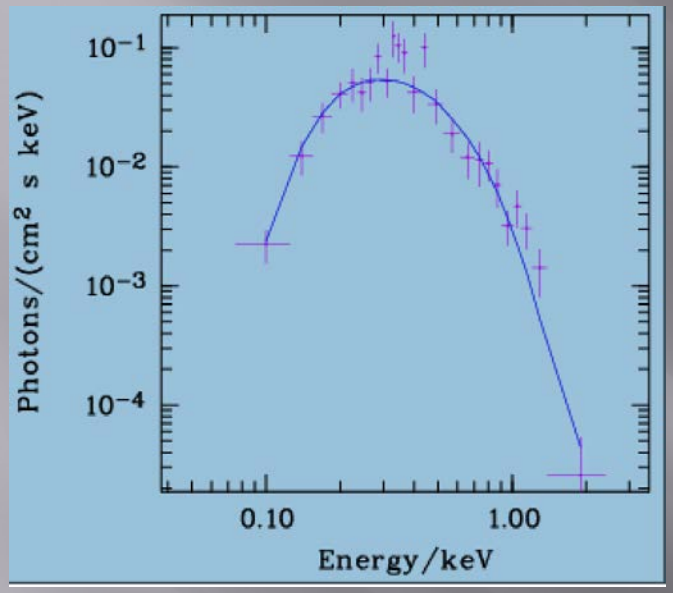
RXJ 1624.9+7554
Grupe, Thomas &
Leighly 1999

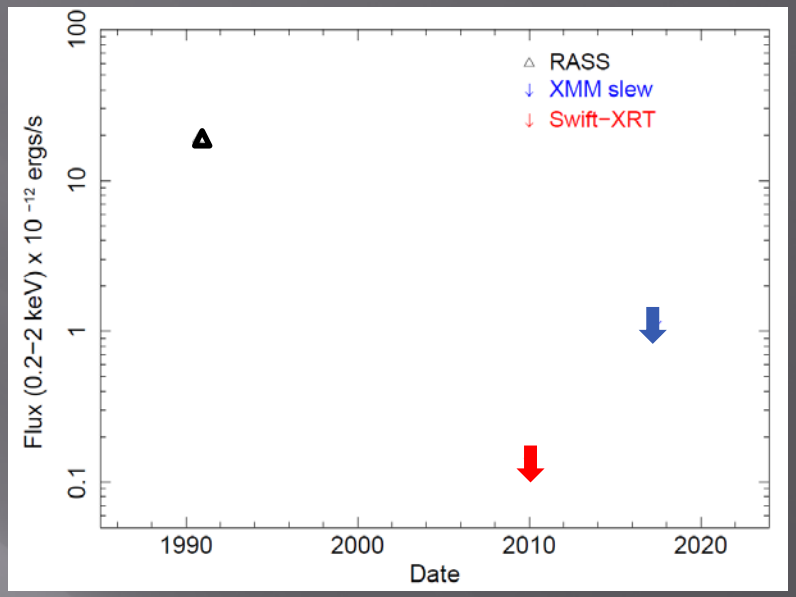
NGC 5905
Bade, Komossa &
Dahlem 1996;

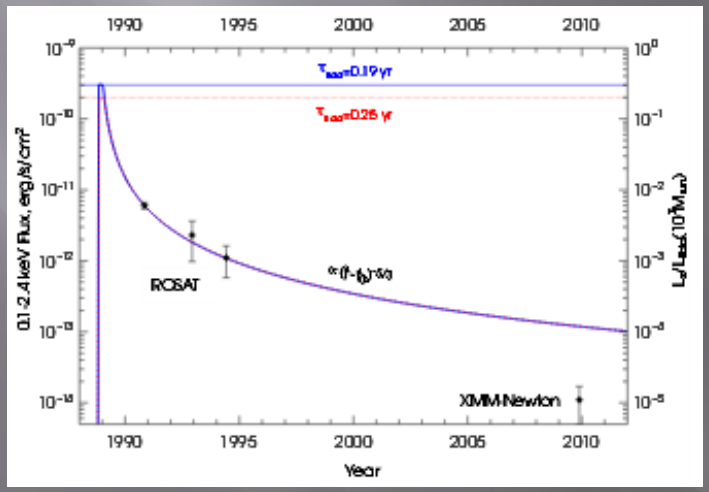


Rosat discovered several ***quiescent*** galaxies with soft X-ray flux variations > 100. Light curve decay roughly compatible with $t^{-5/3}$. Dropping by factors of 1000s in some cases.

Many TDE waiting to be discovered in RASS





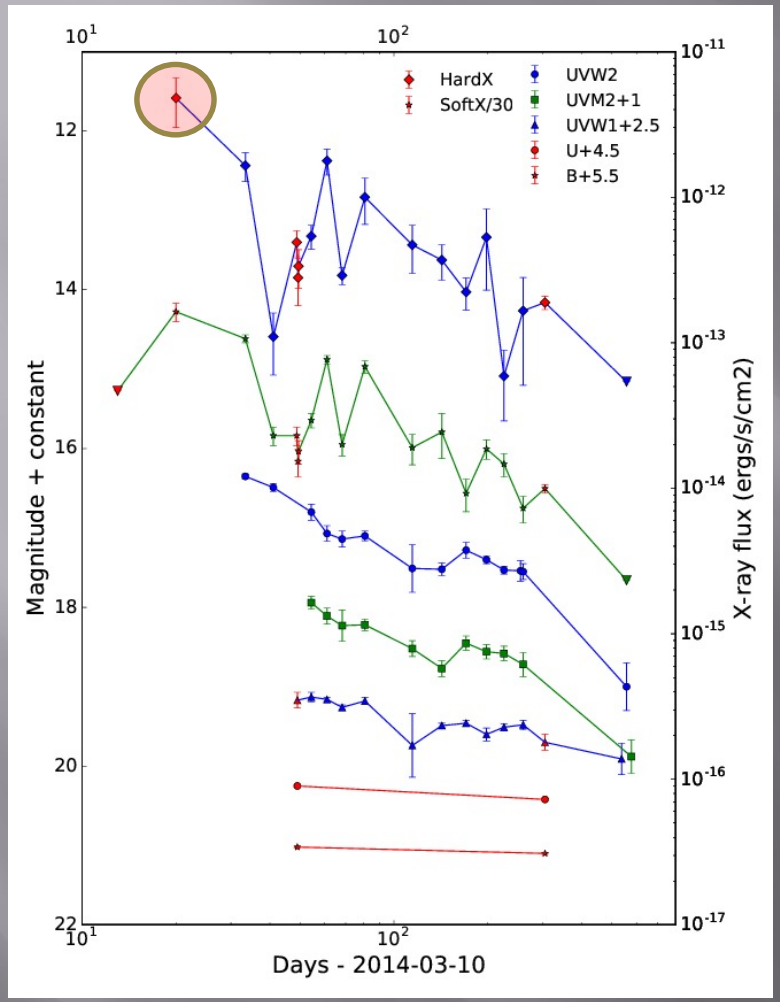


RXJ 0759 – galaxy with soft X-ray spectrum and large variability in RASS and subsequent obs.

RBS 1032

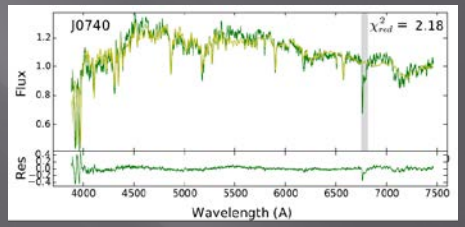
Maksym, Lin & Irwin 2014
Khabibullin & Sazonov2014

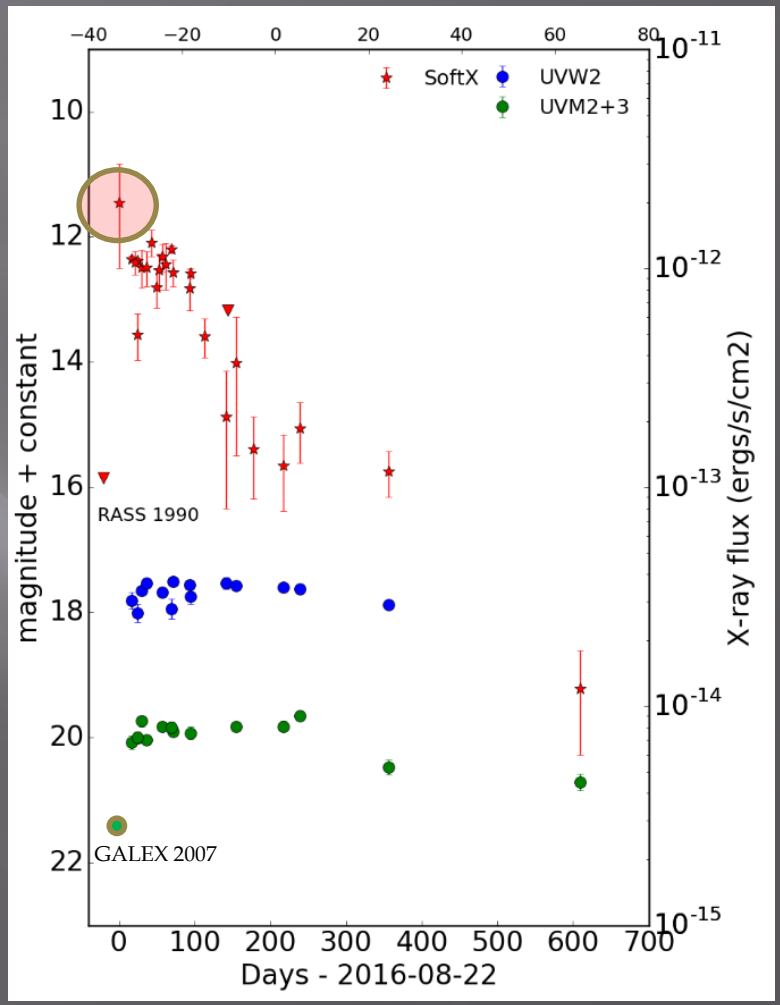
Real-time TDE discovery: XMM slew survey



2MASS 0740-85

Saxton et al. 2017

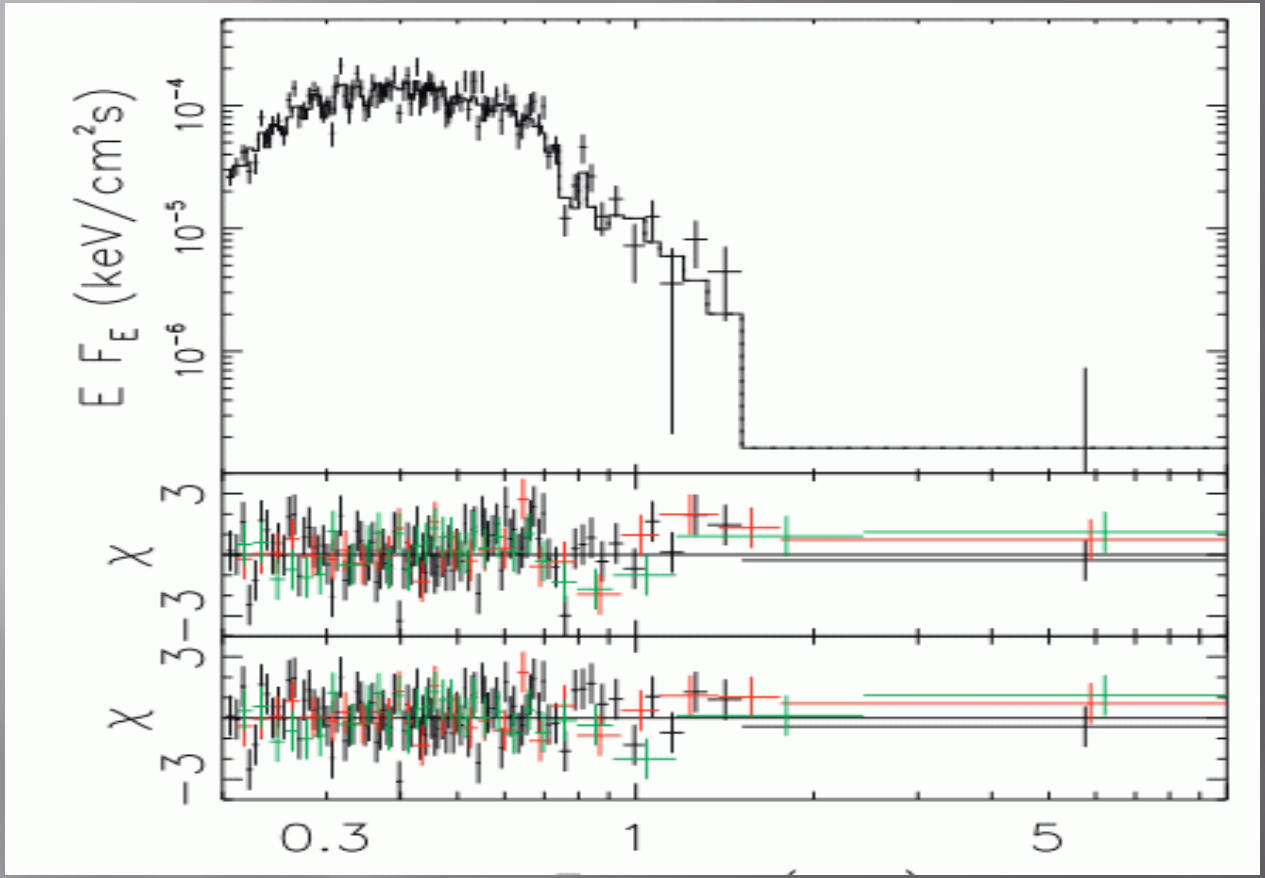




XMMSL1 1446+68

Saxton et al. in prep.

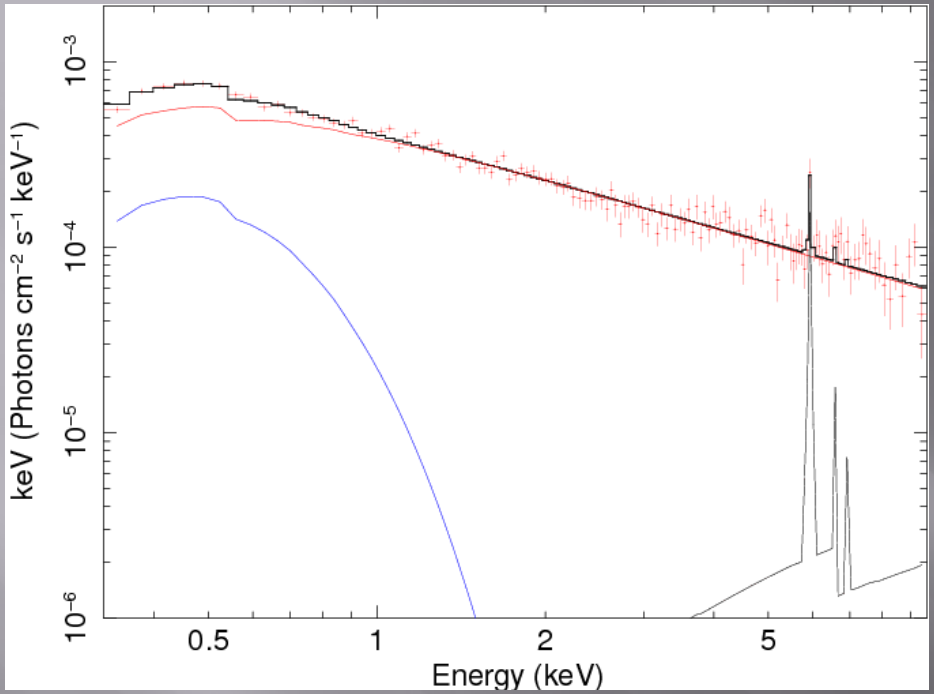
TDE: X-ray spectra

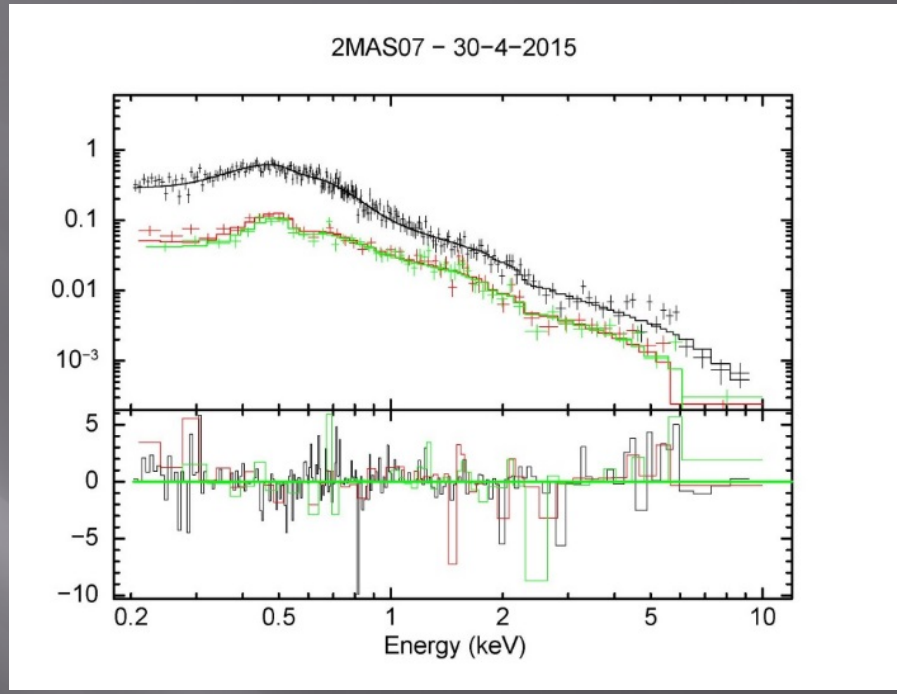


3XMM J 152130.7+074916,
Lin et al. 2015

X-ray spectra are generally very soft

TDE: X-ray spectra





NGC 4845 –
Nikolajok & Walter 2013

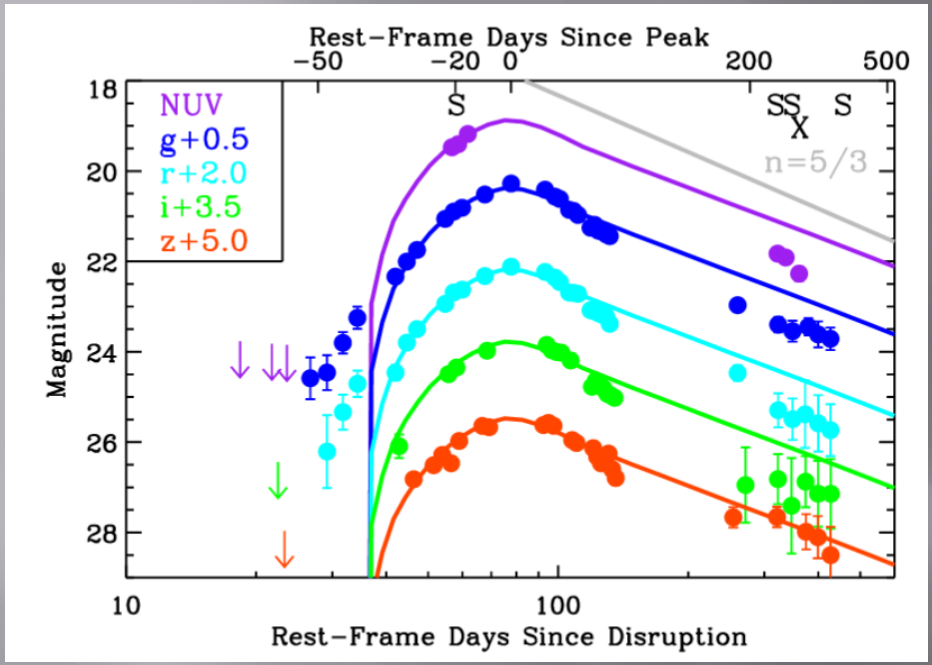
2MASX 0740-85

Γ=2, kT=87 eV - Saxton et al. 2017

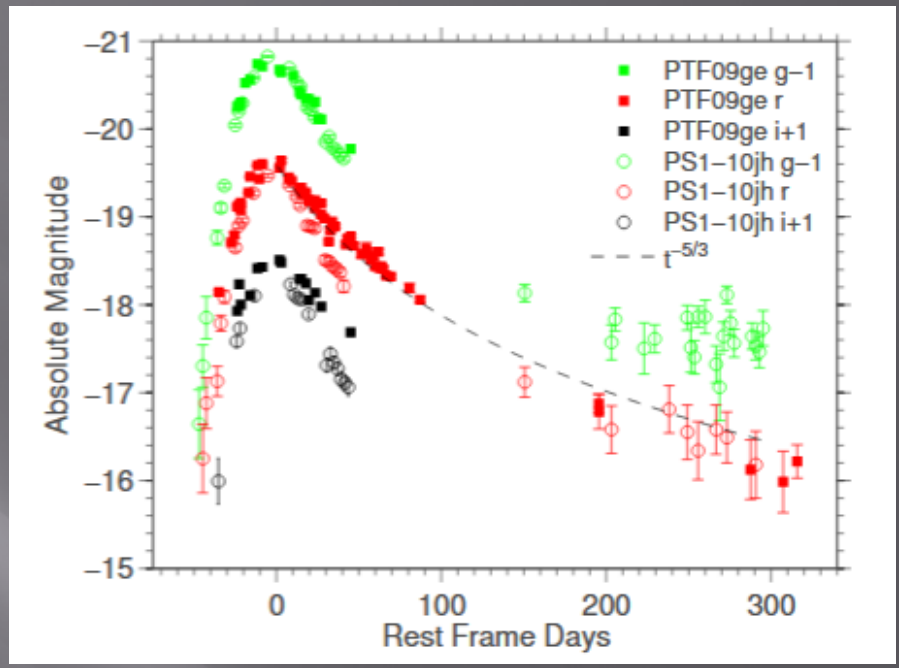
But may be a bias towards detecting soft TDE in current surveys.

TDE with harder spectra do exist.

Real-time TDE discovery: optical surveys



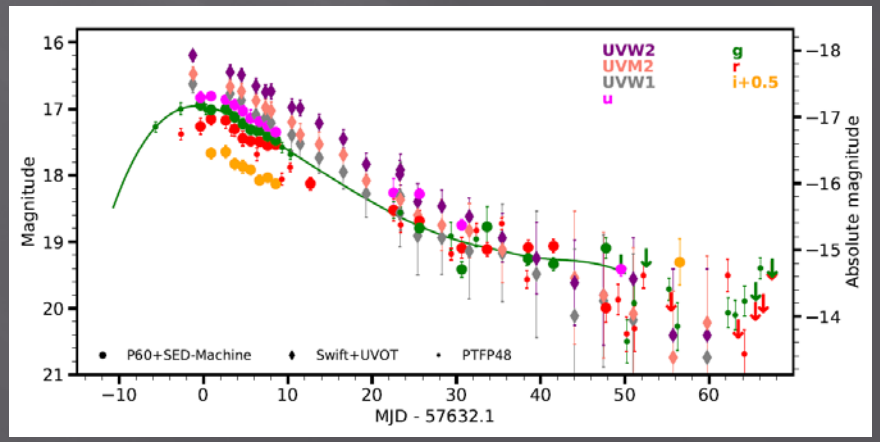
PS1-10jh
Gezari et al. 2012



Arrcavi+ 2014

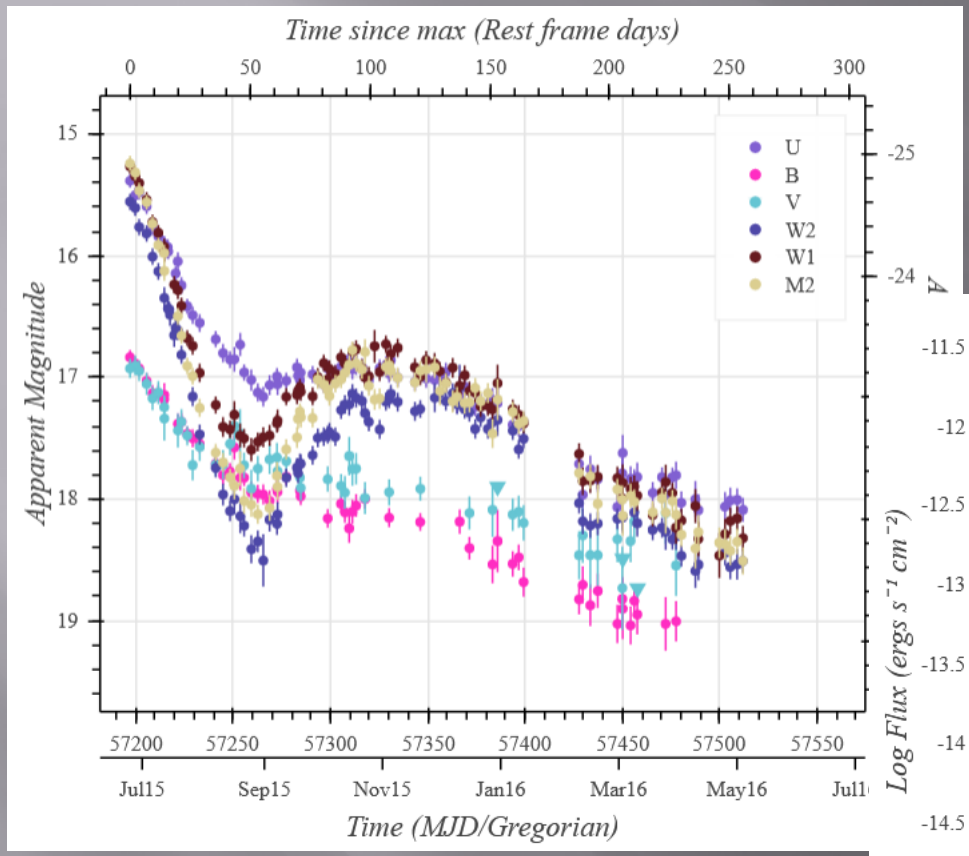
Only X-ray upper limits

$kT \sim 2 \times 10^4$ K



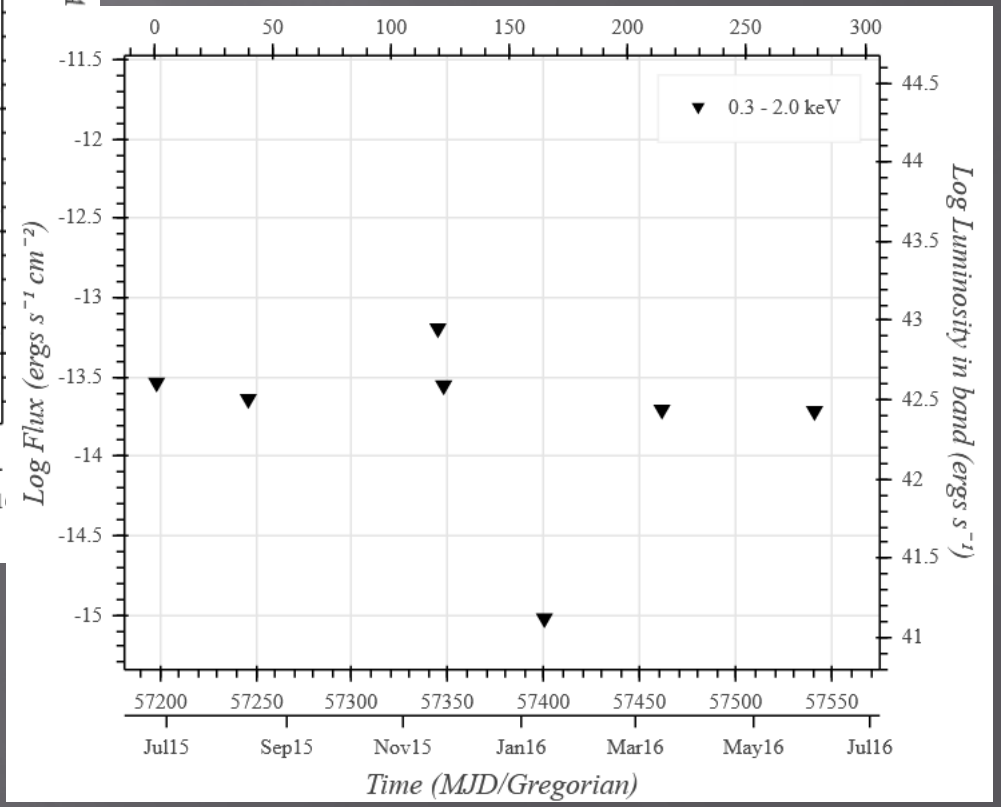
iPTF16fnl
Blagorodnova et al. 17

Real-time TDE discovery: optical surveys



ASASSN-15lh

LeLoudas et al. 2016



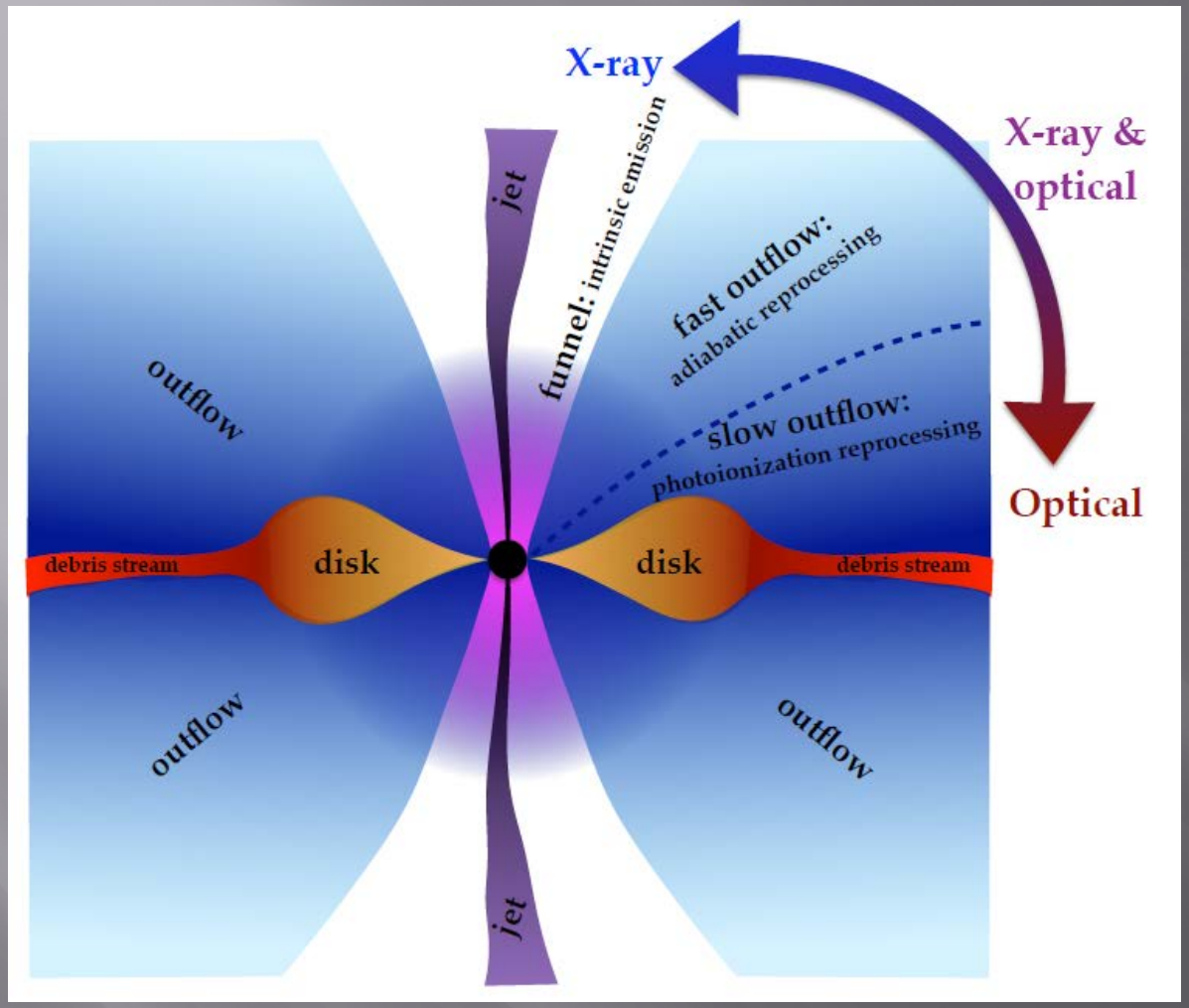
See Open TDE catalogue – https://tde.space

Table of X, UV, O TDE flares (non-relativistic)

NAME	X	UV	Opt	Radio
XMMSL1 0740-85				
2MASS 0619-65				
2MASS 1446+68				
2MASS 1404-29				
SDSS 1201+30				
ASASSN-14li				
ASASSN-15oi				
PS1-10jh				
ASASSN-14ae				
iPTF-16fnl				
iPTF16axa				

- Are X-ray and optical TDE the same phenomenon ?
- Different aspects of same phenomenon, observational bias?
- Different animals ?

Unified TDE model



Dai et al. 2018

Reprocessing models
Strubbe&Murray 2011
Guillochon+ 2014
Metzger&Stone 2016
Roth+ 2016

All TDE are same.

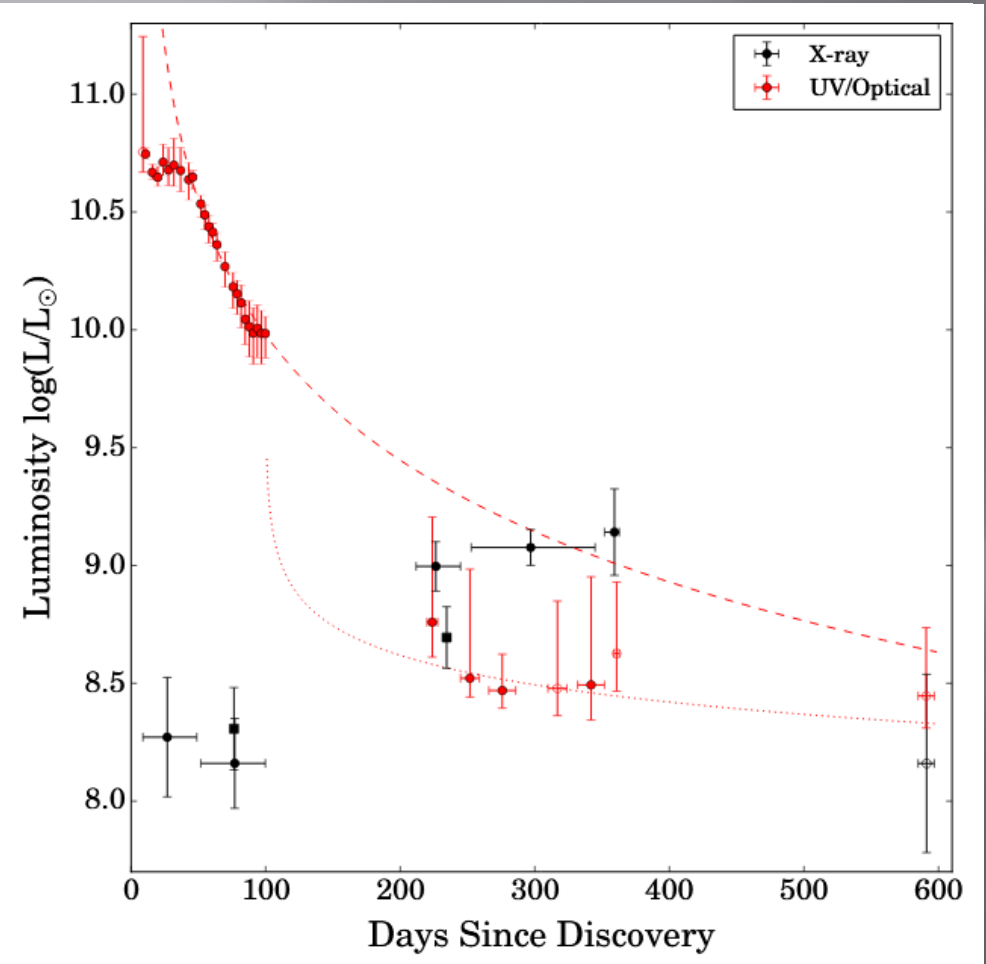
Characteristics due to viewing angle.

Predictions:

- Some X-ray TDE with high absorption

- X-rays visible when debris screen clears

ASASSN-15oi



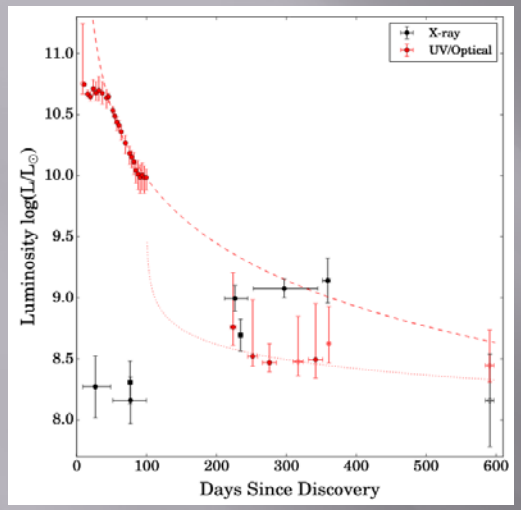
Holoien et al. 2018

First and only evidence for a delayed X-ray "flare" from a TDE

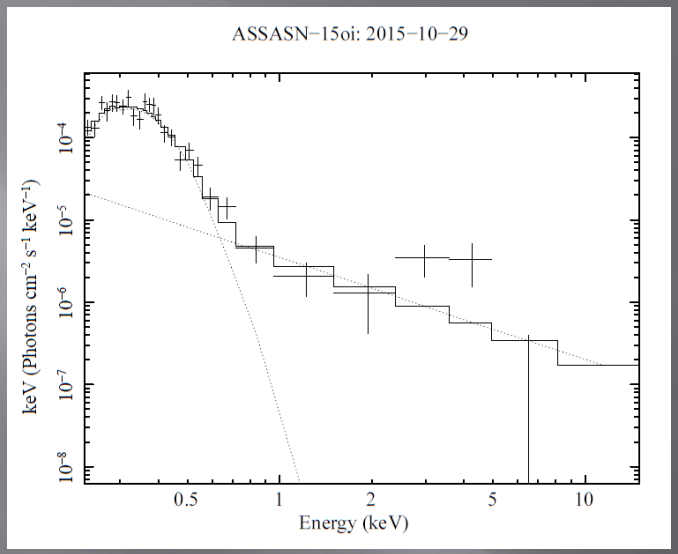
$L_X=10^{42}$ (high-state)

$L_X=10^{41}$ (low-state)

ASASSN-15oi – X-ray spectra



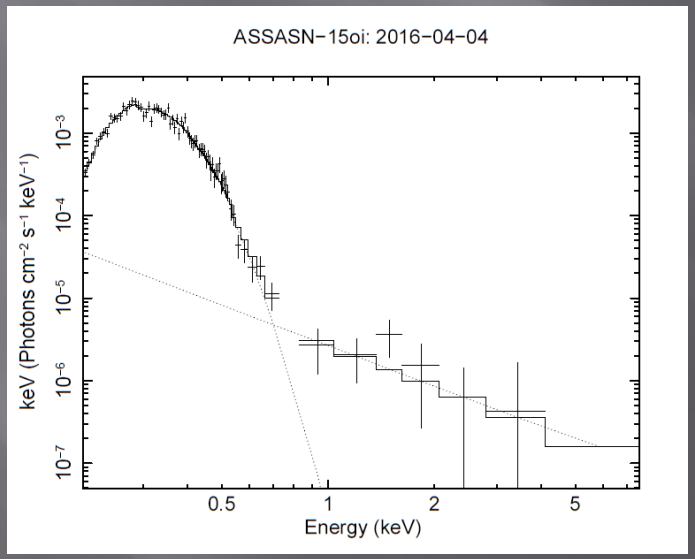
Holoien et al. 2018



Low-state

kT=47eV + Plaw

Gezari et al. 2017



Higher-state

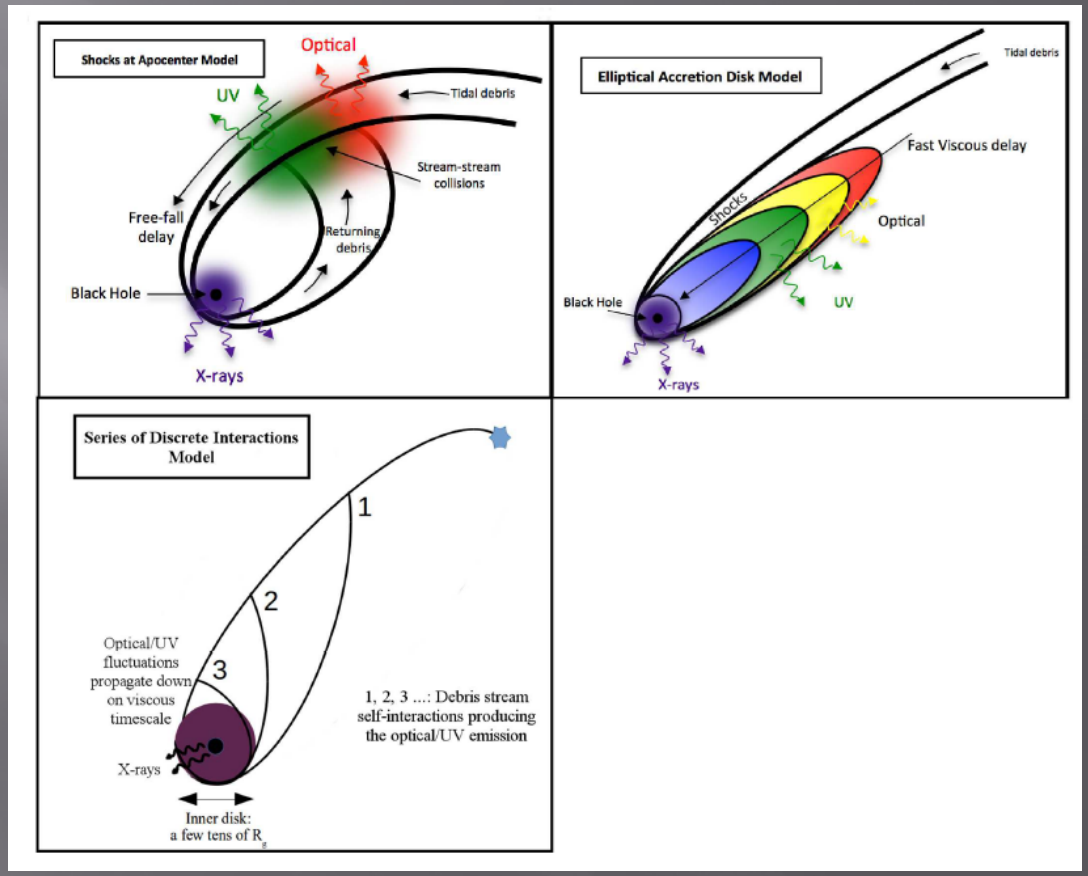
kT=42eV + Plaw

Little spectral evolution ??

Jerusalem Bagel model

Piran et al. 2015

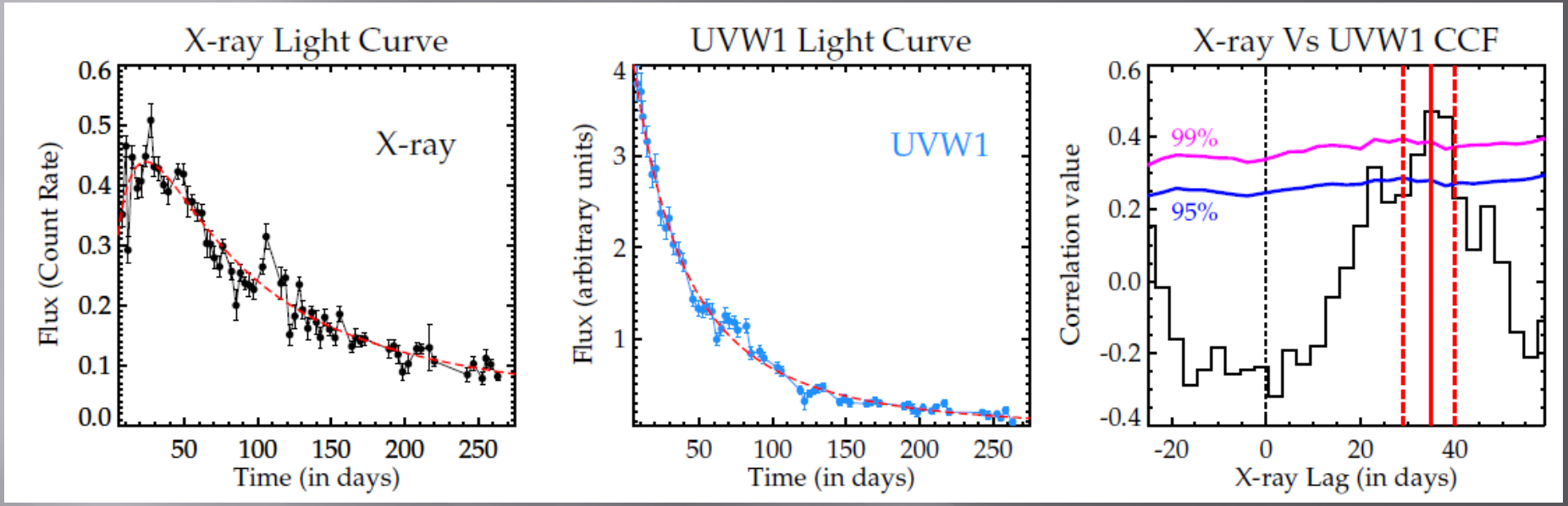
No accretion disk, optical/UV radiation generated by shocks. X-rays by subsequent accretion.



Pasham et al. 2017

Predicts a delay between UV/opt flare and X-ray flare

ASASSN-14li – UV/X delay ?

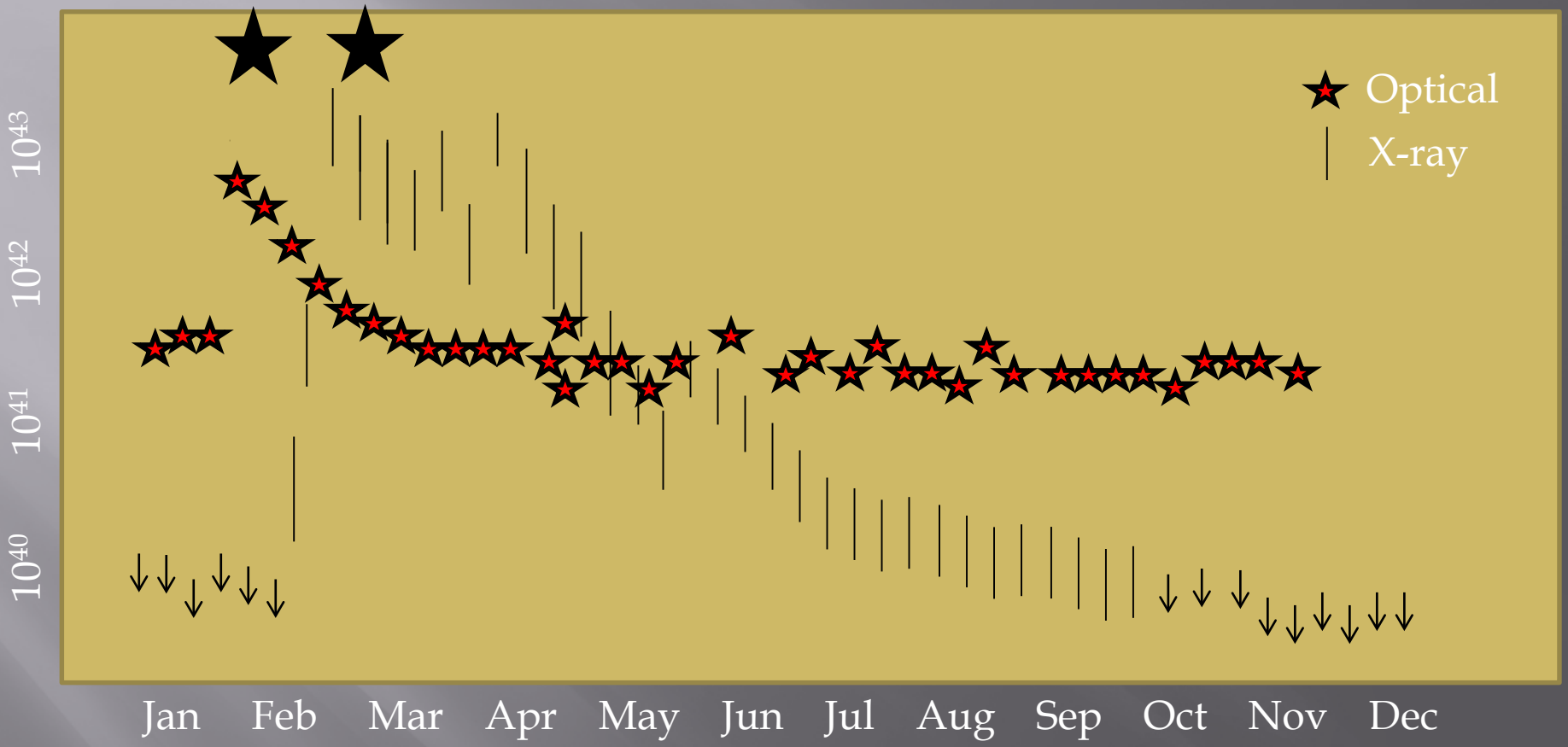


Pasham et al. 2017

~30 day delay lag of X with respect to UV

Future prospects - ideal

Need good coverage of X-ray and optical LCs.



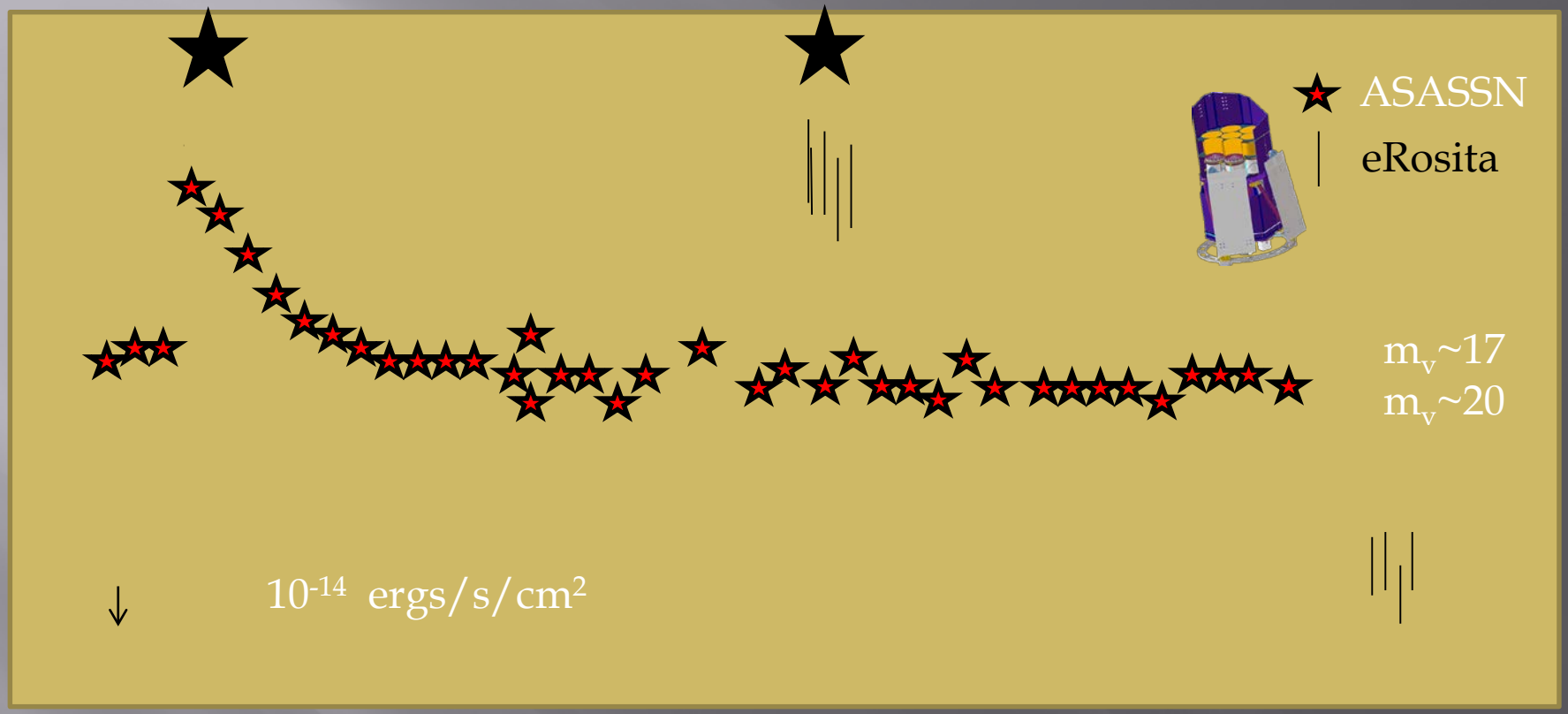
IDEAL:

Weekly coverage of large sky area in X-ray and optical bands

Deep, high spectral resolution X-ray and UV observations to measure absorbers

Future prospects – next year

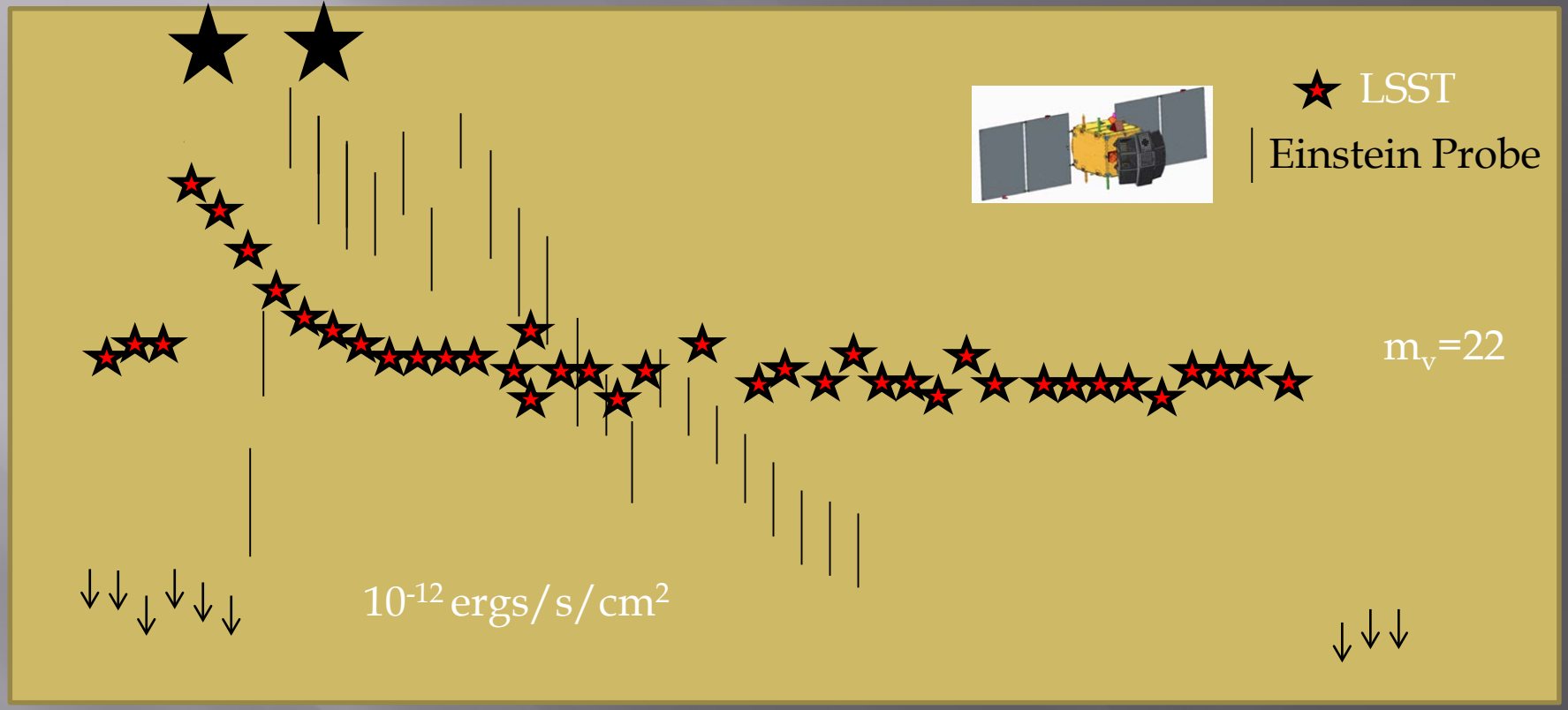
eRosita + ASASSN or ZTF



Weekly coverage of large sky area in optical band, 6-monthly returns in X-rays

RGS if bright enough and soft enough. HST for UV?

Future prospects - 2023

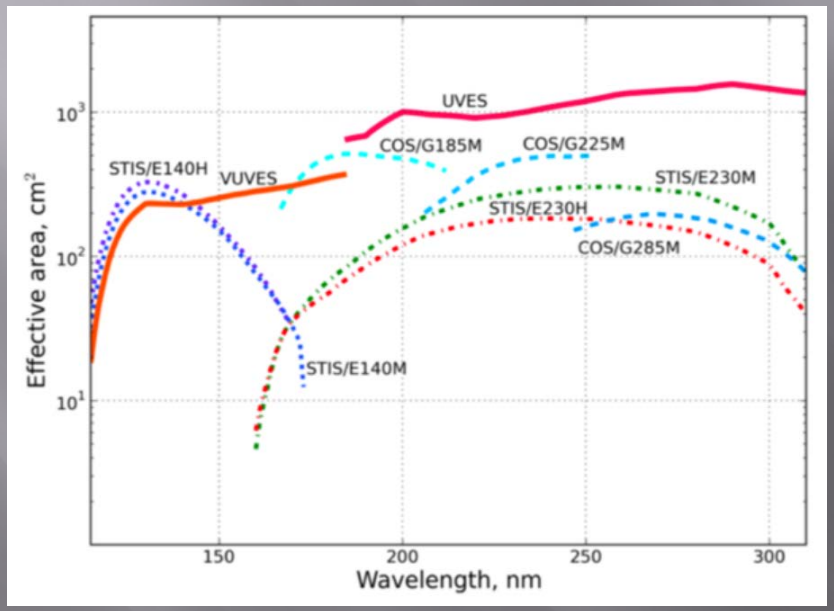


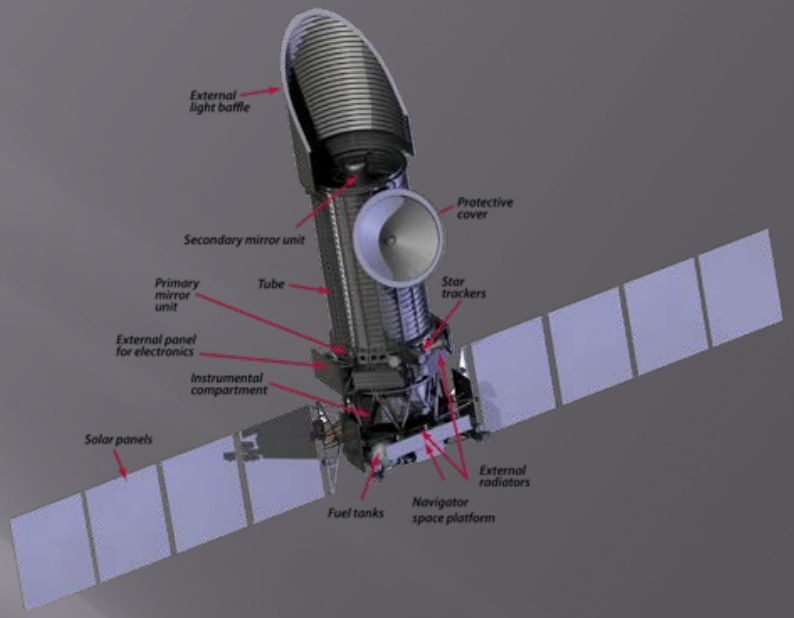
Weekly (daily) coverage of large sky area in X-ray and optical bands

★ RGS if bright enough and soft enough. WSOUV for UV?

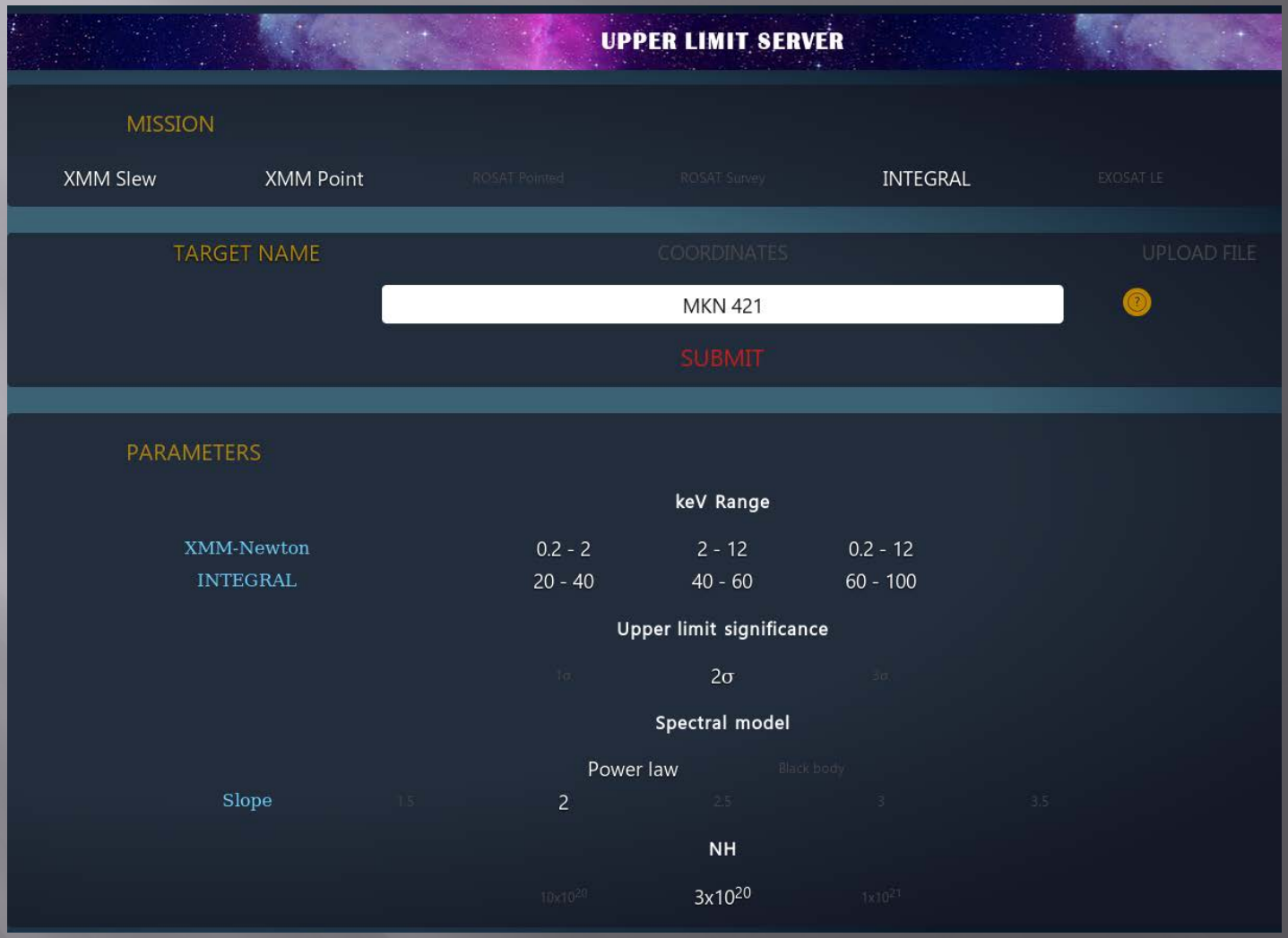
Future prospects - WSOUV

R=55000
D=1.7m
Launch slated for 2023
Russian-Spanish mission





Long-term lightcurve server : HILIGT - input



Long-term lightcurve server : HILIGT - output

UPPER LIMIT SERVER RESULTS

ADVANCED SETTINGS

XMM-NEWTON SLEW

115.0341 . -85.6575

Observation Date	Count rate 0.2 - 2	Count rate 2 - 12	Count rate 0.2 - 12	Exp. time(s)	Flux 0.2 - 2	Flux 2 - 12	Flux 0.2 - 12
2012/08/21 18:13:14	<0.7624	<1.3971	<1.2935	4.7811	<1.0947e-12	<1.2775e-11	<4.0863e-12
2014/03/24 06:05:21	<1.8313	<2.9561	<2.9183	1.9903	<2.6297e-12	<2.7031e-11	<9.2189e-12
2014/04/01 20:42:53	4.2512 ± 0.6330	0.7832 ± 0.2960	5.2278 ± 0.7355	10.7037	(6.1047 ± 0.9090) e-12	(7.1623 ± 2.7071) e-12	(1.6514 ± 0.2324) e-11
2015/01/12 05:54:47	<0.6102	<1.3111	<1.3224	10.0212	<8.7621e-13	<1.1988e-11	<4.1776e-12

XMM-NEWTON POINTED

Observation Date	Count rate 0.2 - 2	Count rate 2 - 12	Count rate 0.2 - 12	Exp. time(s)	Flux 0.2 - 2	Flux 2 - 12	Flux 0.2 - 12
2014/04/29 19:24:29	0.5911 ± 0.0136	0.0662 ± 0.0046	0.6573 ± 0.0143	3917	(8.4876 ± 0.1950) e-13	(6.0624 ± 0.4270) e-13	(2.0766 ± 0.0454) e-12
2014/04/30 06:00:00	0.4546 ± 0.0062	0.0442 ± 0.0020	0.4988 ± 0.0065	14466	(6.5276 ± 0.0893) e-13	(4.0444 ± 0.1852) e-13	(1.5757 ± 0.0207) e-12
2014/04/30 10:33:11	0.3729 ± 0.0047	0.0362 ± 0.0015	0.4091 ± 0.0049	28281	(5.3552 ± 0.0678) e-13	(3.3113 ± 0.1402) e-13	(1.2924 ± 0.0157) e-12
2015/01/11 18:44:30	0.2357 ± 0.0049	0.0279 ± 0.0017	0.2636 ± 0.0052	35259	(3.3843 ± 0.0701) e-13	(2.5593 ± 0.1644) e-13	(8.3293 ± 0.1643) e-13

INTEGRAL

Observation Date	Count rate 20 - 40	Count rate 40 - 60	Count rate 60 - 100	Exp. time(s)	Flux 20 - 40	Flux 40 - 60	Flux 60 - 100
2003/08/07 02:45:23	<0.1950	<0.2440	<0.1940	66000.0	<3.5958e-12	<3.1476e-12	<3.1505e-12

HILIGT – example light curve

Summary

- Currently, optical surveys + Swift can analyse optical TDE.
- XMM slew + monitoring for X-ray TDE
- Next year: eRosita + ASASSN/PanSTaRRS… can attack X-ray TDE in large numbers
- 2023: EP + LSST + WSOUV can find X-ray and optical TDE *at peak* in large numbers. First good chance to solve the X/opt exclusivity problem unless we get lucky beforehand.
- 2031: Athena can follow-up TDE with high sensitivity and high spectral resolution.
- HILIGT: a web-based client for a set of X-ray flux and upper limit servers