Subaru UM FY2020

2021.03. 04

Initial results from Subaru/HSC-eROSITA AGN collaboration

Toba et al. 2021b, A&A, submitted

Brusa, Urrutia, YT, et al. A&A to be submitted

Toba et al. 2021c, A&A, in prep.

Yoshiki TOBA (Kyoto Univ.)

On behalf of the eROSITA-HSC AGN collaboration

※ This work is supposed by Subaru Archive Science Proposal FY2020 toward the Subaru international partnership (国際共同研究によるすばる成果創出サポートプログラム)

Introduction of eROSITA

- eROSITA
- eROSITA Final Equatorial Depth Survey (eFEDS)
- HSC-eROSITA AGN collaboration

Our deepest view of the X-ray sky

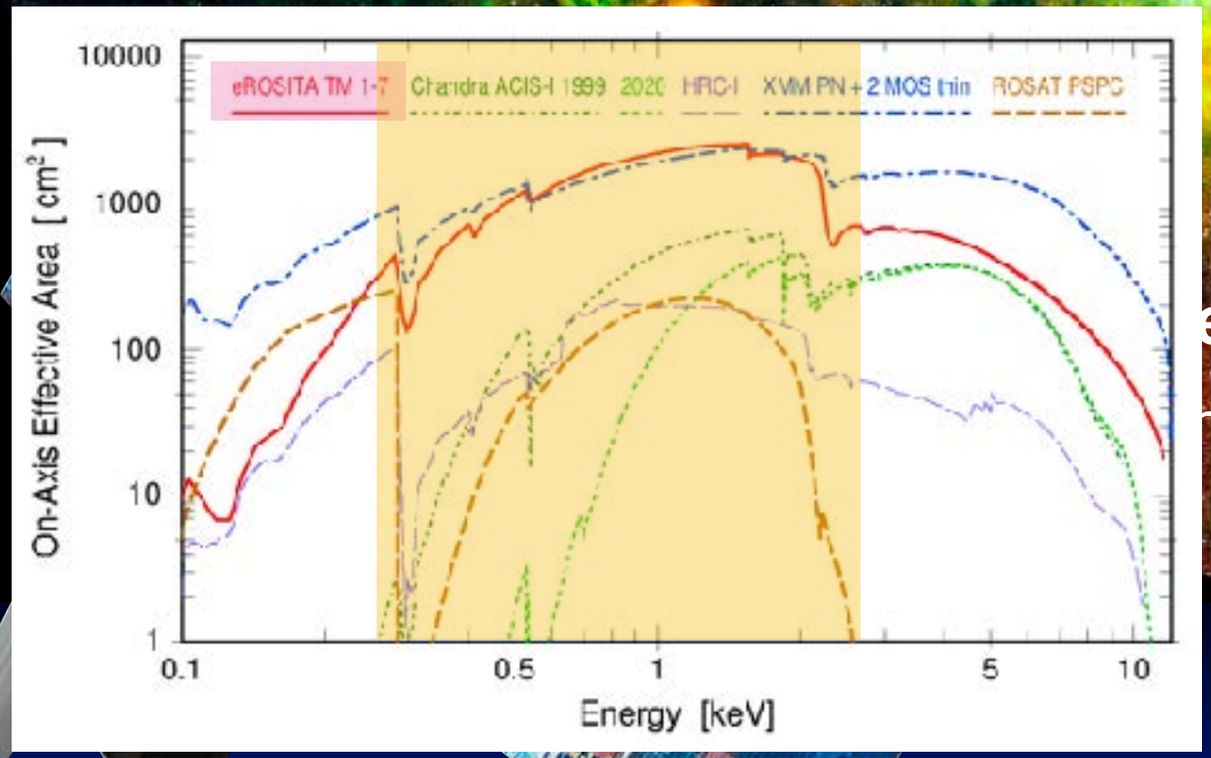
SRG/eROSITA

0.3-2.3 keV - RGB

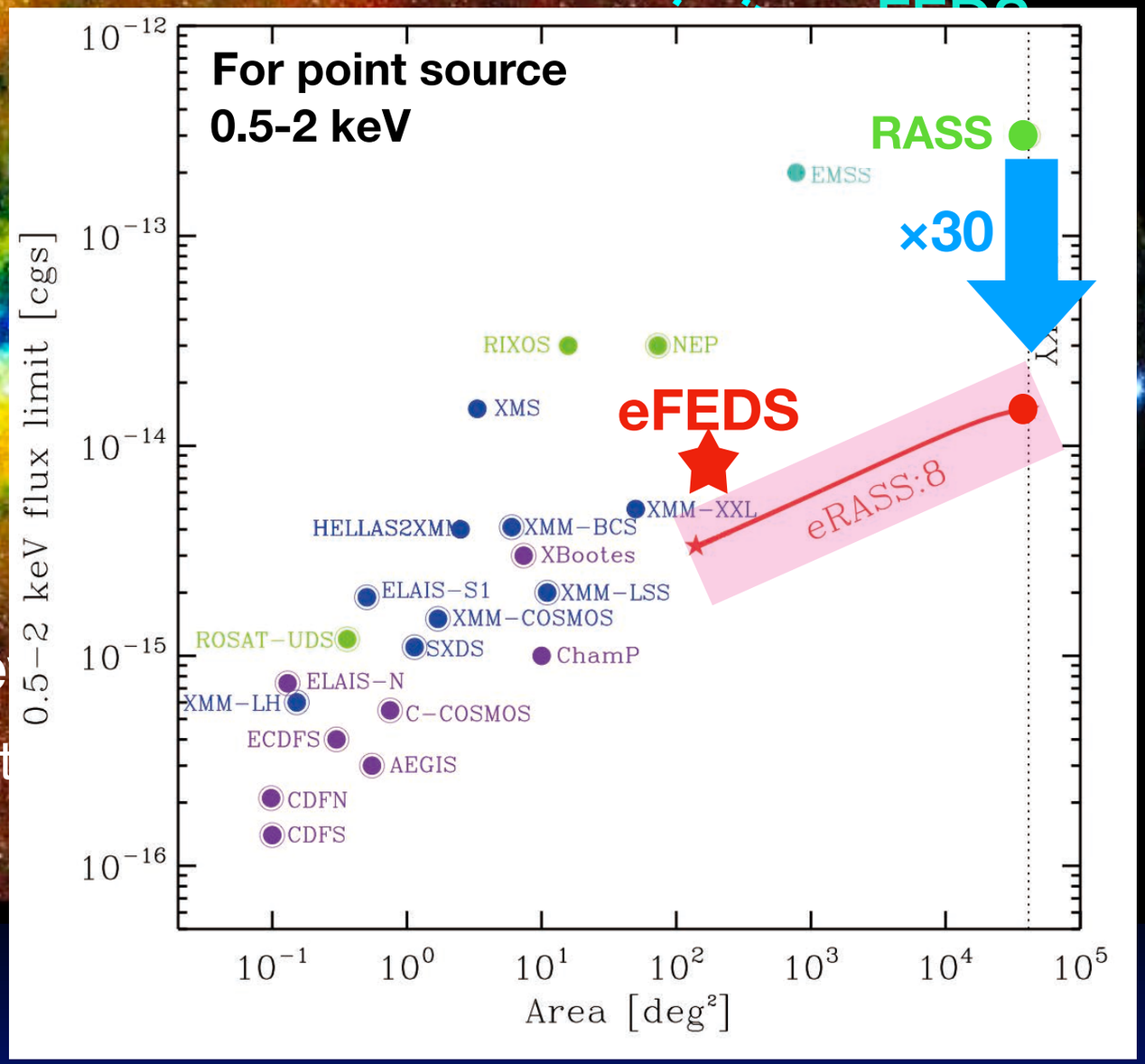
- **~1.1 million X-ray sources (~80%: AGN).**

  (c.f. ROSAT bright source catalog (|b| >30°): 2072)

- 20,000 galaxy clusters up to z ~ 1.



Predehl et al. (2020)



Merloni et al. (2012)

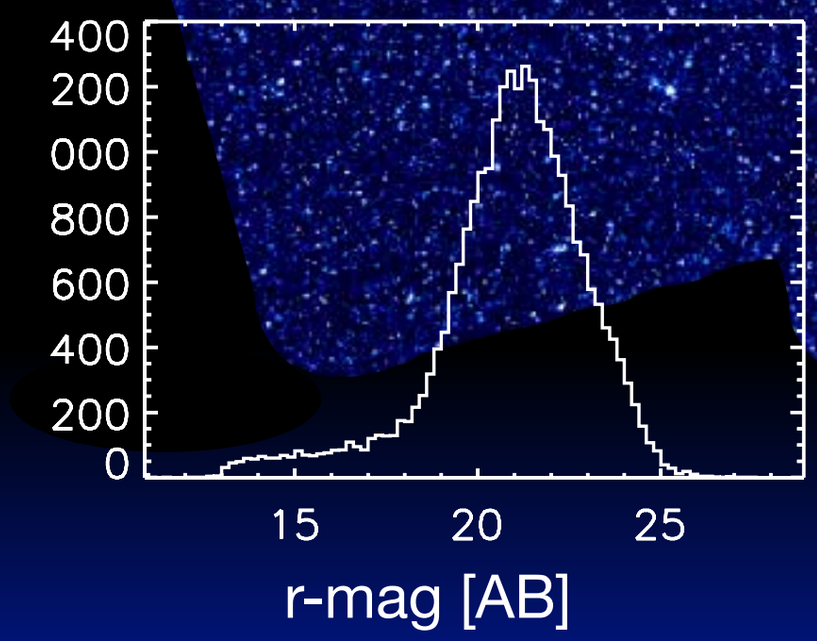
eROSITA Final Equatorial Depth Survey (eFEDS)

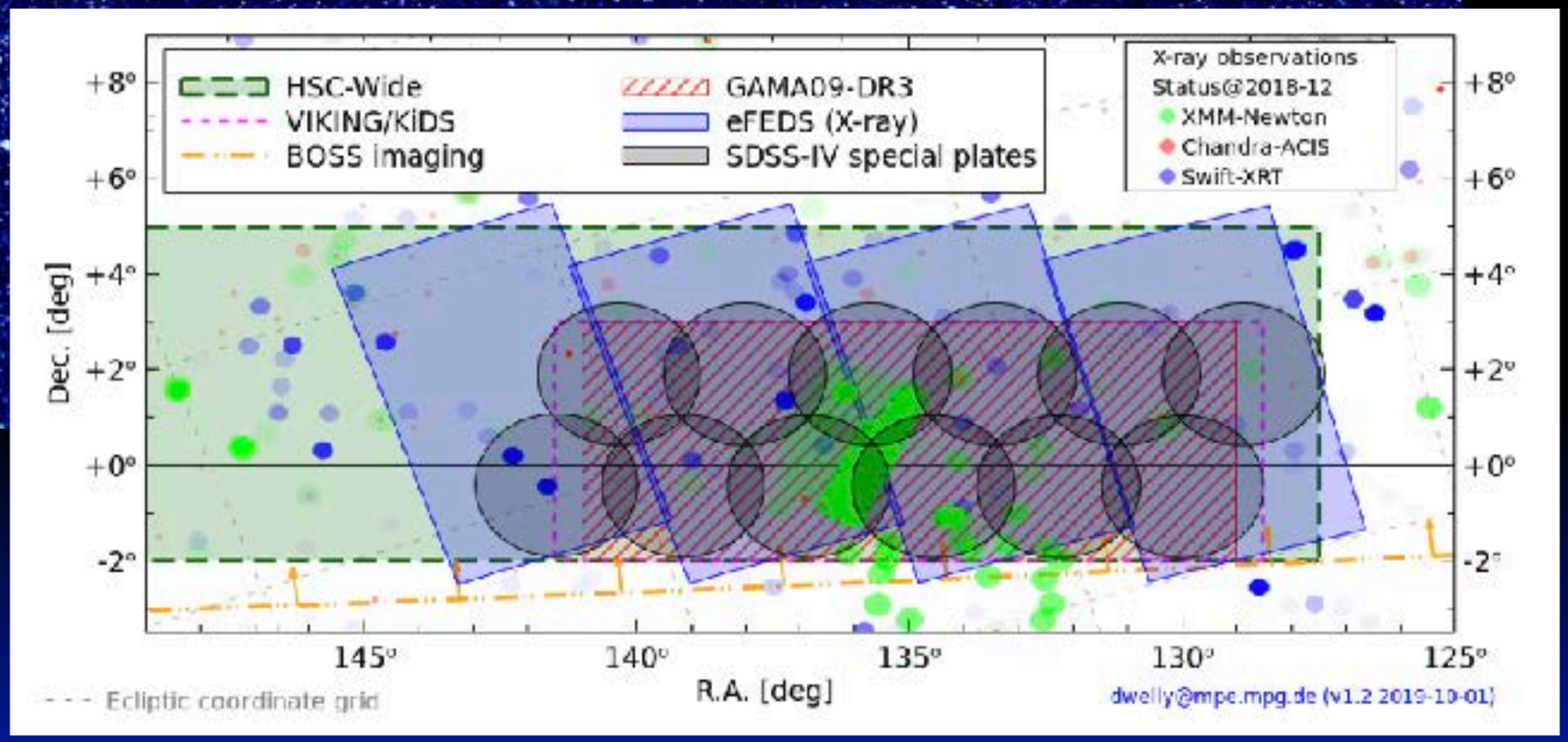
2 deg

140 deg² exposures for ~2.5 ks.

Brunner et al. in prep., Salvato et al. in prep.

- **~28,000** X-ray point sources were detected (~85%: AGN).
- ~99% sources have the optical counterparts of the Legacy Survey DR8 (LS8) and Subaru Hyper Suprime-Cam (HSC).
- ~20% sources have spectroscopic redshifts (the number of spec-z sources will be increased through the SDSS IV collaboration).





HSC-eROSITA AGN Working Group

HSC-SSP

- Optical catalogs and images
- Morphology
- Photo-z

HSC

MoU

eROSITA-DE

- X-ray catalogs
- X-ray images
- X-ray spectra

eROSITA


Mara Salvato

A1


Yoshiki Toba

A2


Tohru Nagao

A3


Johan Comparat

A4

Our HSC-eROSITA collaboration enables us to investigate AGN and host properties.

A1	A2	A3	A4
J.Silverman A.Merloni	K.Iwasawa T.Liu T.Boller K.Ichikawa A.Merloni M.Oguri G.Lamer T.Kawamuro A.Rau U.Kobayashi A.Merloni	Y.Ueda K.Nandra	

~50 colleagues from eROSITA-DE and HSC belong to some sub-projects and working together.

※Cluster WG has a similar structure facilitated by E.Bulbul, T.Schrabback, M.Oguri, and N.Okabe.

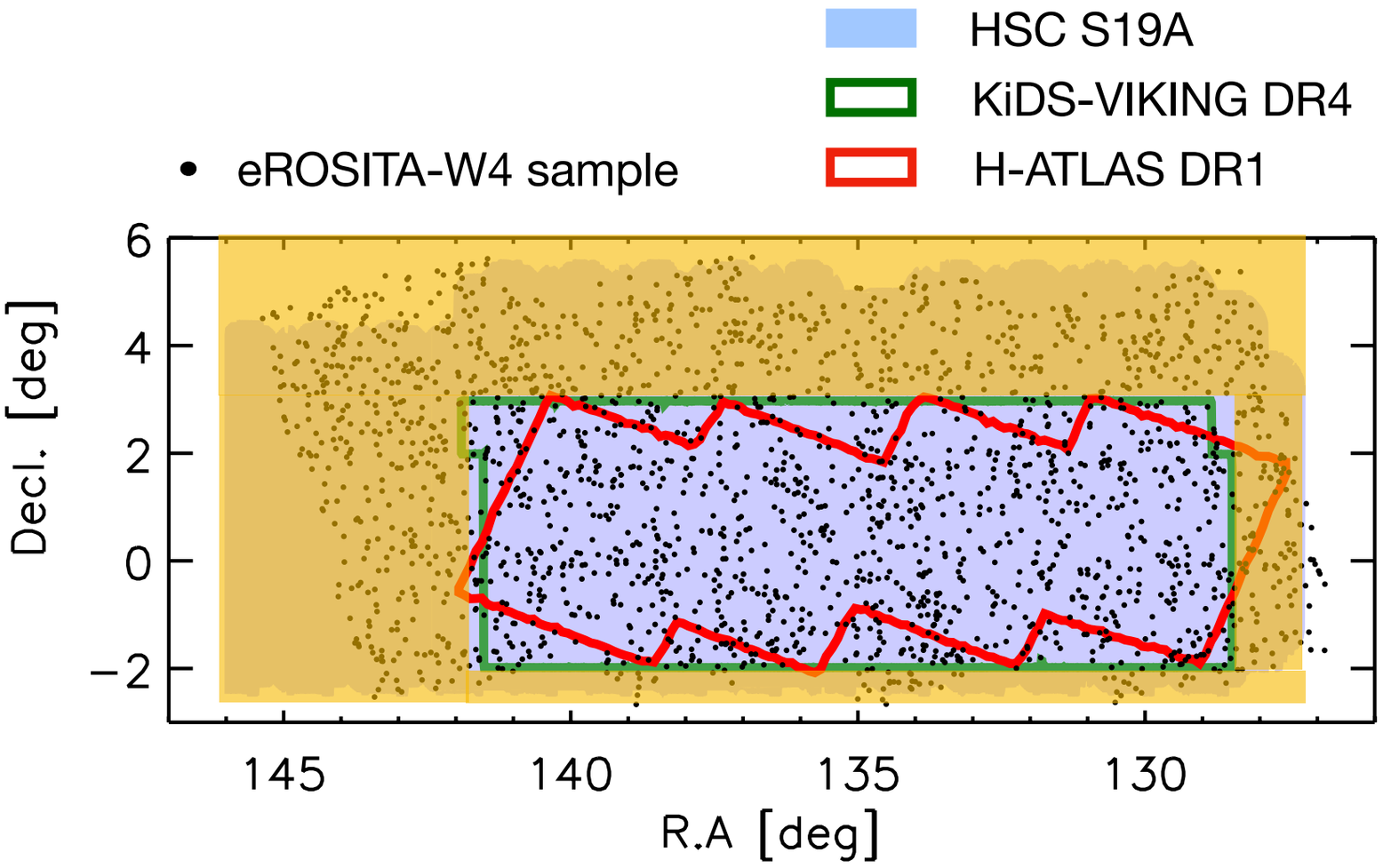
Initial results from a dusty AGN point of view

Toba et al. 2021b, submitted,
Brusa, Urrutia, YT, et al. 2021, to be submitted
Toba et al. 2021c, in prep.

- WISE 22 μm-selected sample
- Multi-wavelength approach
- Preliminary results

WISE mid-IR galaxies/AGNs

- eROSITA-W4 sample



Outside of KiDS-VIKING-HATLAS region

・u-band: SDSS ・NIR: UKIDSS ・FIR: AKARI

Legacy Survey DR8 (LS8) catalog in the eFEDS

SN (22 μm) ≥ 5.0
fracflux_w4 < 1
brightblob ≠ 3

eFEDS W4 sample

※ W4 = 22 μm

eROSITA detection?

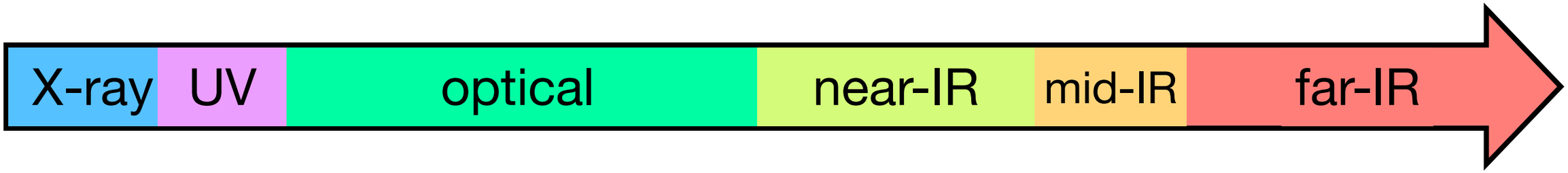
NO — **4441**

YES — **1660**

eROSITA-undetected W4 sample

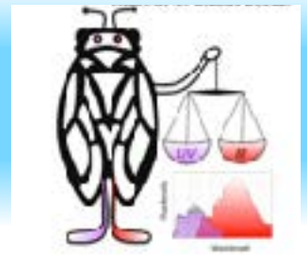
eROSITA-detected W4 sample

Multi-wavelength dataset for SED fitting



Survey	eROSITA	GALEX	SDSS	KiDS	DeCAM	HSC	UKIDSS	VIKING	WISE	AKARI	H-ATLAS
band	0.5-2 keV 2-10 KeV	FUV NUV	u,g,r,i,z	u,g,r,i,z	g,r,z	g,r,i,z,y	Y,J,H,Ks	Y,J,H,Ks	3.4, 4.6, 12, 22	65, 90, 140, 160	100, 160, 250, 350, 500
DR	eFEDS	DR5	DR16	DR4	LS8	S19A	LAS DR10	DR4	LS8 (unWISE)	FIR BSC ver.2	DR1
sensitivity	$F_{0.5\text{-}2\ keV}$ ~ 10^{-14} erg/s	NUV~21 AB mag	u ~22 AB mag	u~24.2 AB mag	g ~24 AB mag	g ~ 26.5 AB mag	Ks ~ 20.4 AB mag	Ks ~ 20.4 AB mag	f_{22} ~ 6 mJy	f_{90} ~ 0.55 Jy	f_{250} ~22 mJy

SED fitting with X-CIGALE



Code **I**nvestigating **GAL**axy **E**mission

- New version of the SED fitting code that newly implements AGN clumpy torus and X-ray module
- Considering the energy balance between UV/optical and IR.

Survey	CIGALE	X-CIGALE
AGN torus module	Smooth (Fritz+06)	Clumpy (Stalevski+16)
X-ray module	✕	○
Polar dust	✕	○
Reference	Boquien+19	Yang+20

Parameter	Value
Delayed SFH with recent starburst (Ciesla et al. 2017)	
τ_{main} [Gyr]	1.0, 4.0, 8.0, 12
Nebular emission (Inoue 2011)	
log U	**−3.0**, −2.0, −1.0
line width [km s^{-1}]	300
Dust attenuation (Calzetti et al. 2000; Leitherer et al. 2002)	
R_{max}/R_{min}	30
θ [°]	0, 10, 20
f_{AGN}	**0.4**, 0.5, 0.6, 0.7, 0.8, 0.9
Dust Emission (Draine et al. 2014)	
$\lvert\Delta\alpha_{OX}\rvert_{max}$	0.2
LMXB photon index	1.56
HMXB photon index	2.0

Stellar mass

SFR

IR luminosity

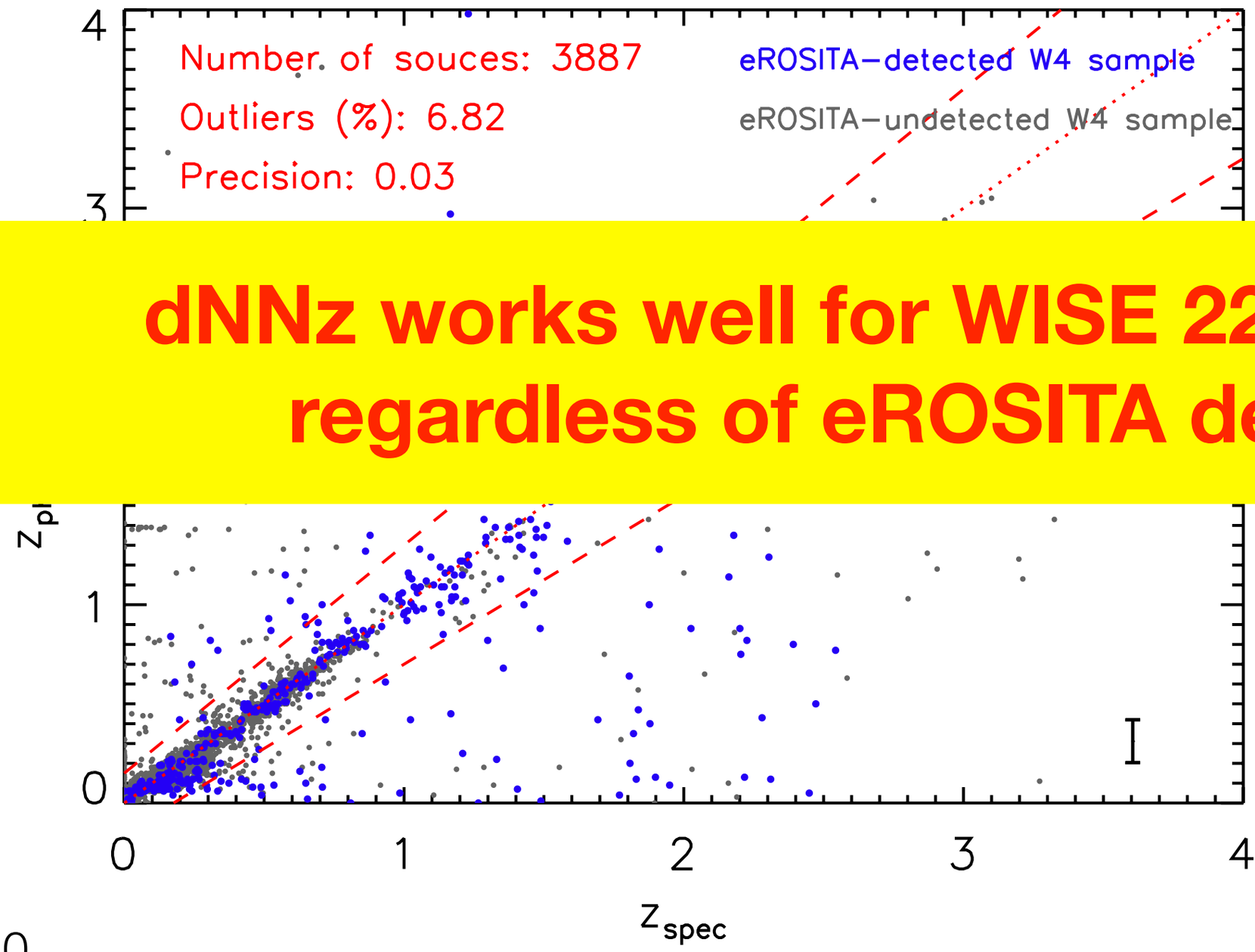
Toba+21b

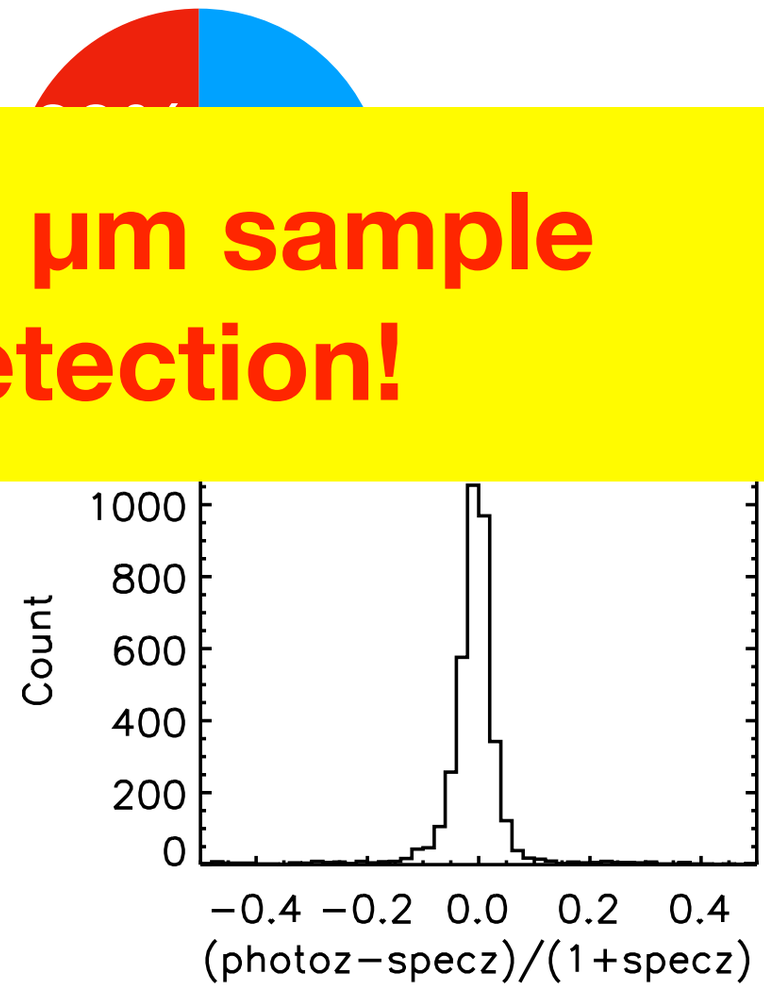
Photometric redshift

Atsushi Nishizawa
(Nagoya Univ.)

Deep Neural Network based photometric redshift (dNNz)

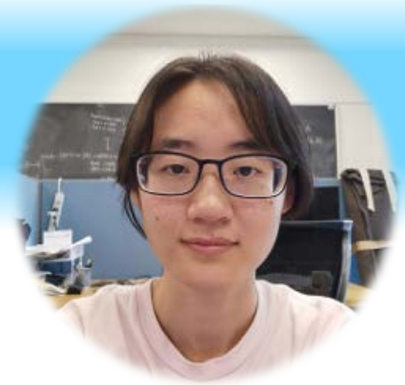
(dNNz uses HSC 5-band (at maximum) data)



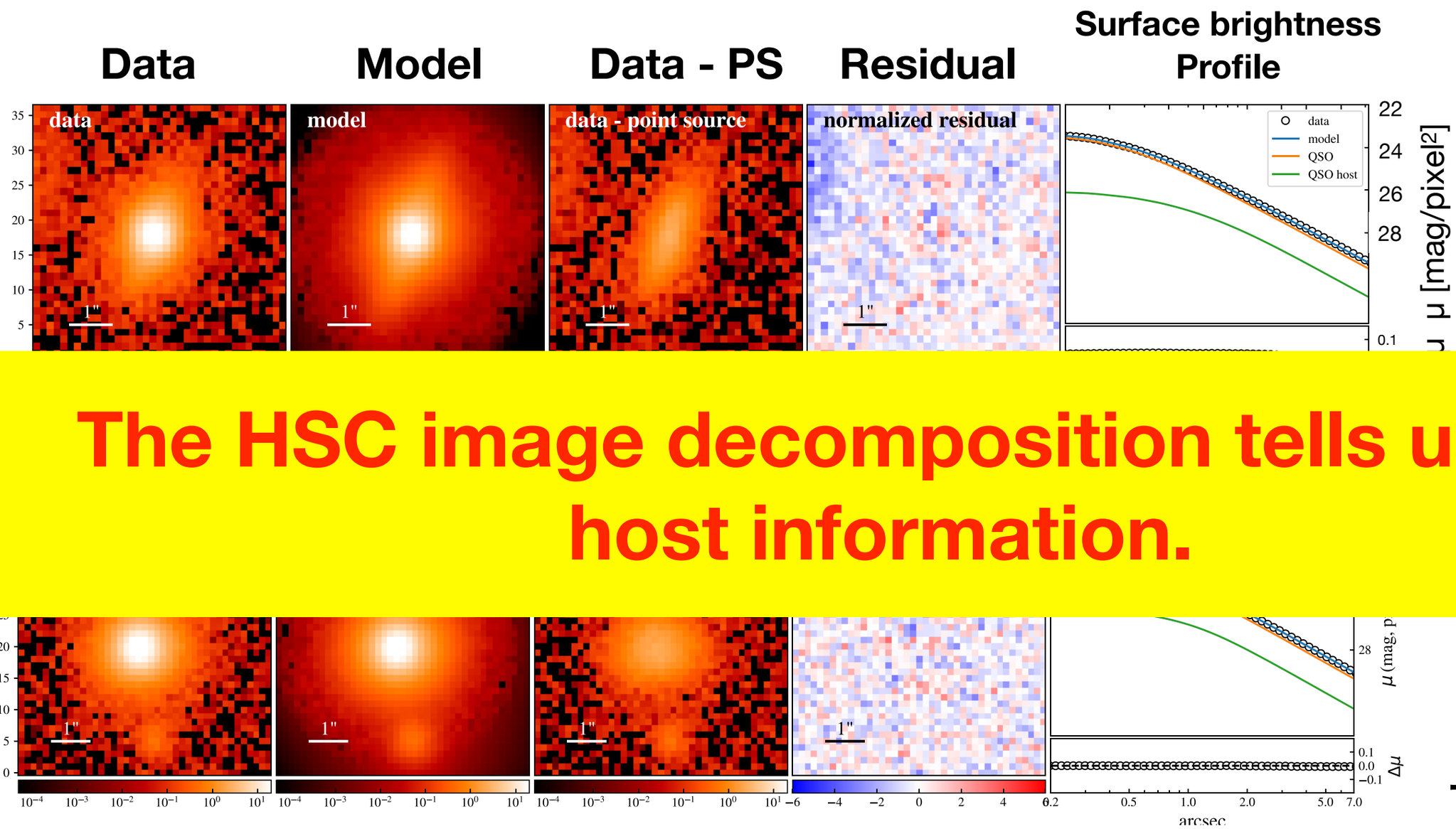


dNNz works well for WISE 22 μm sample regardless of eROSITA detection!

HSC 2D image decomposition



Junyao Li
(USTC/IPMU)



Toba+21c

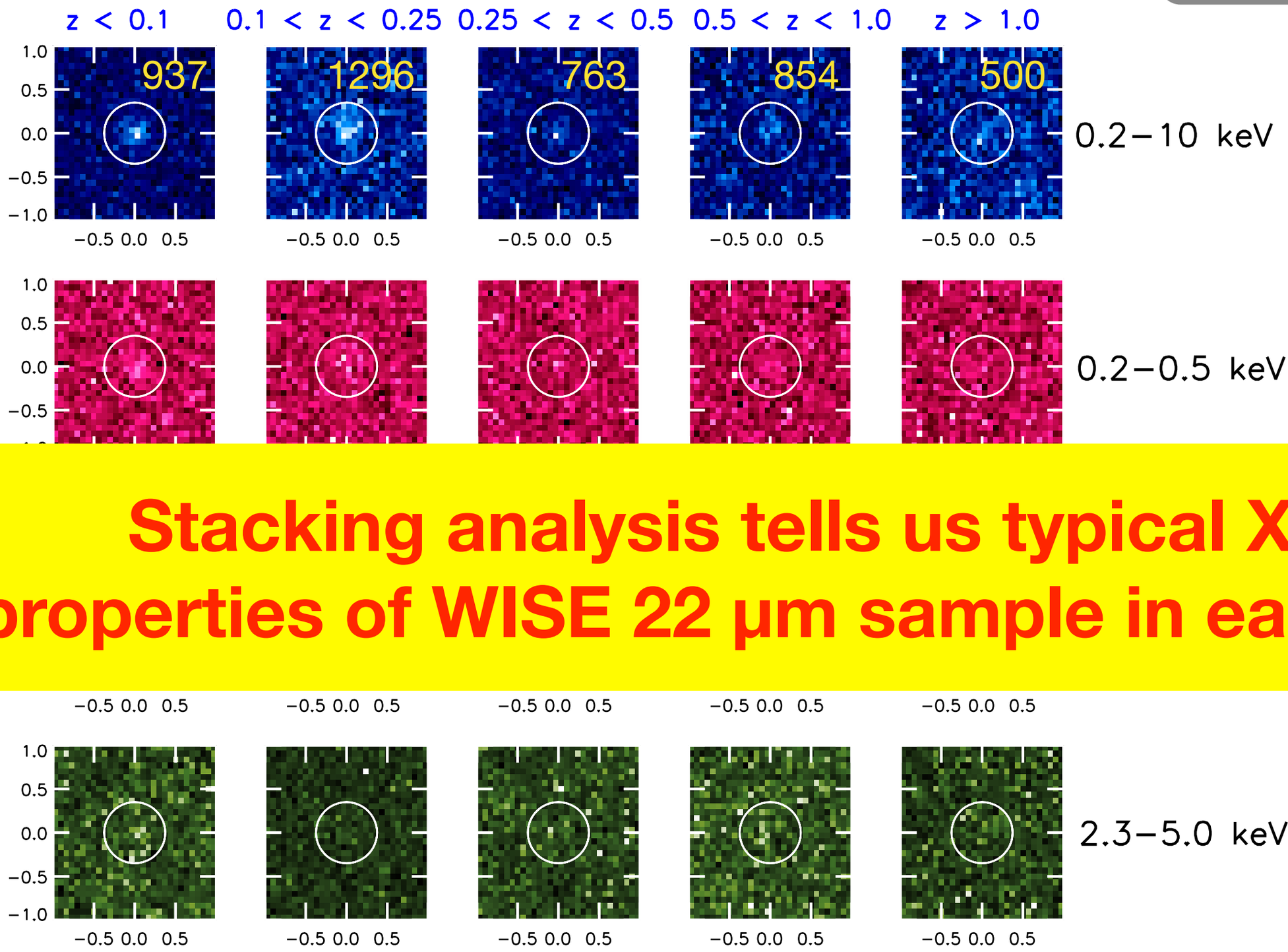
The HSC image decomposition tells us AGN host information.

⇨ AGN host flux, Sérsic index, and half-light radius

※ A full description of the above method is given by Li+21, submitted.

Impact of stacking analysis

eROSITA-undetected W4 sample



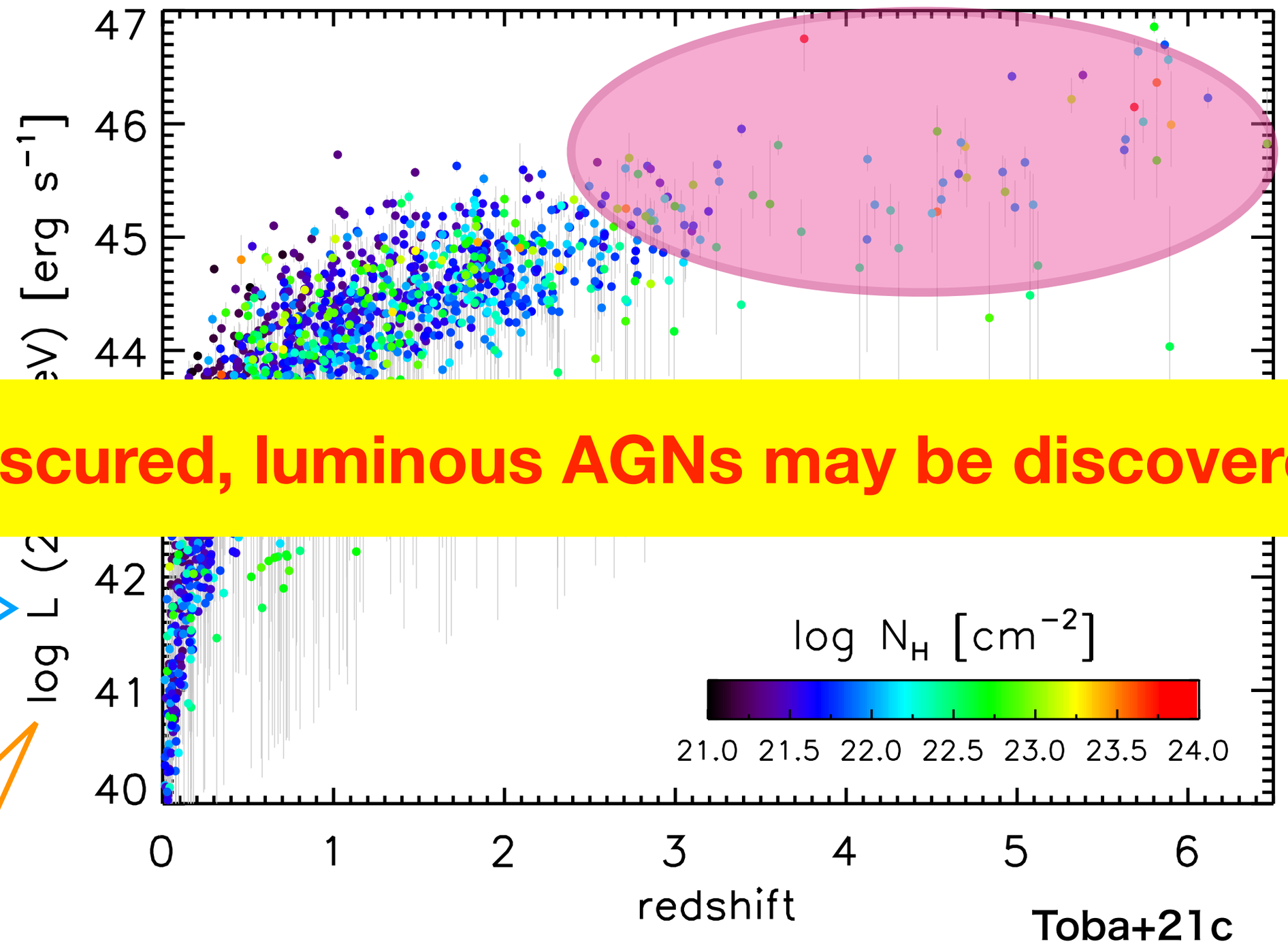
Tanya Urrutia
(AIP)

Stacking analysis tells us typical X-ray properties of WISE 22 μm sample in each z-bin.

Toba+21c

z vs. hard X-ray luminosity (L_X)

Teng Liu
(MPE)



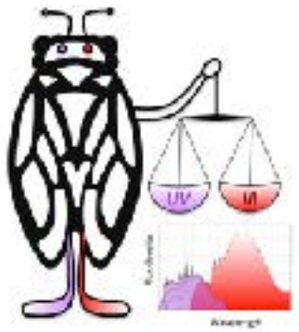
X-ray obscured, luminous AGNs may be discovered.

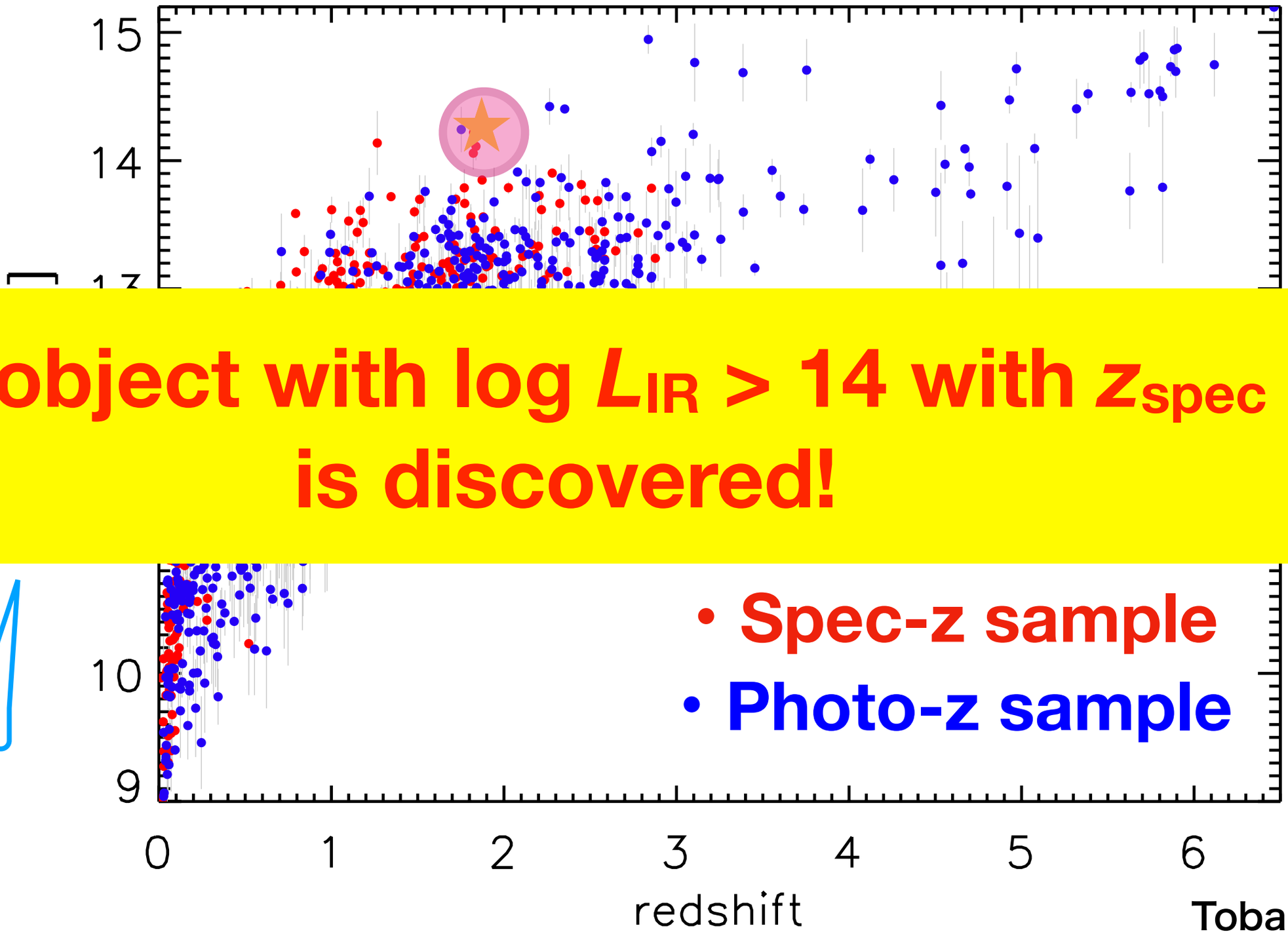
X-ray spectral analysis

Absorption-corrected

※ A full description of the X-ray spectral analysis is given in Liu+21 in prep.

z vs. IR luminosity (L_{IR})



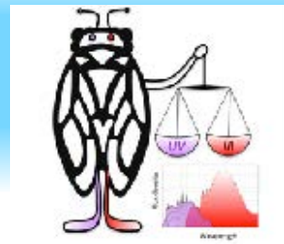


An object with log L_{IR} > 14 with z_{spec} is discovered!

SED fitting

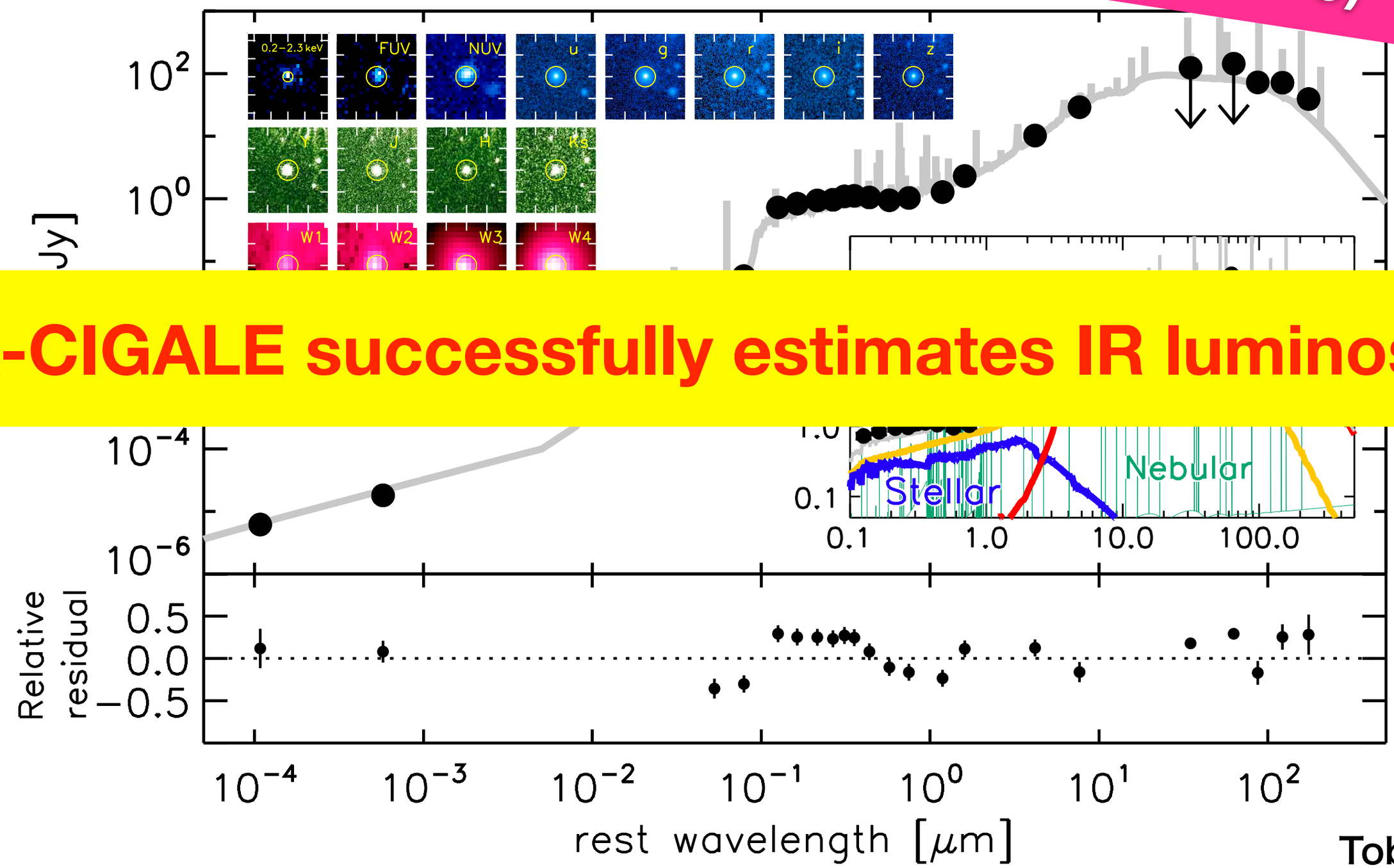
※ We need to check the reliability of photo-z especially for objects at z > 5.

Best-fit SED of the Extremely-Luminous IR Galaxy



z_{spec} = 1.87 (SDSS)

log ($L_{IR}/L_{\odot}$) ~ 14.3



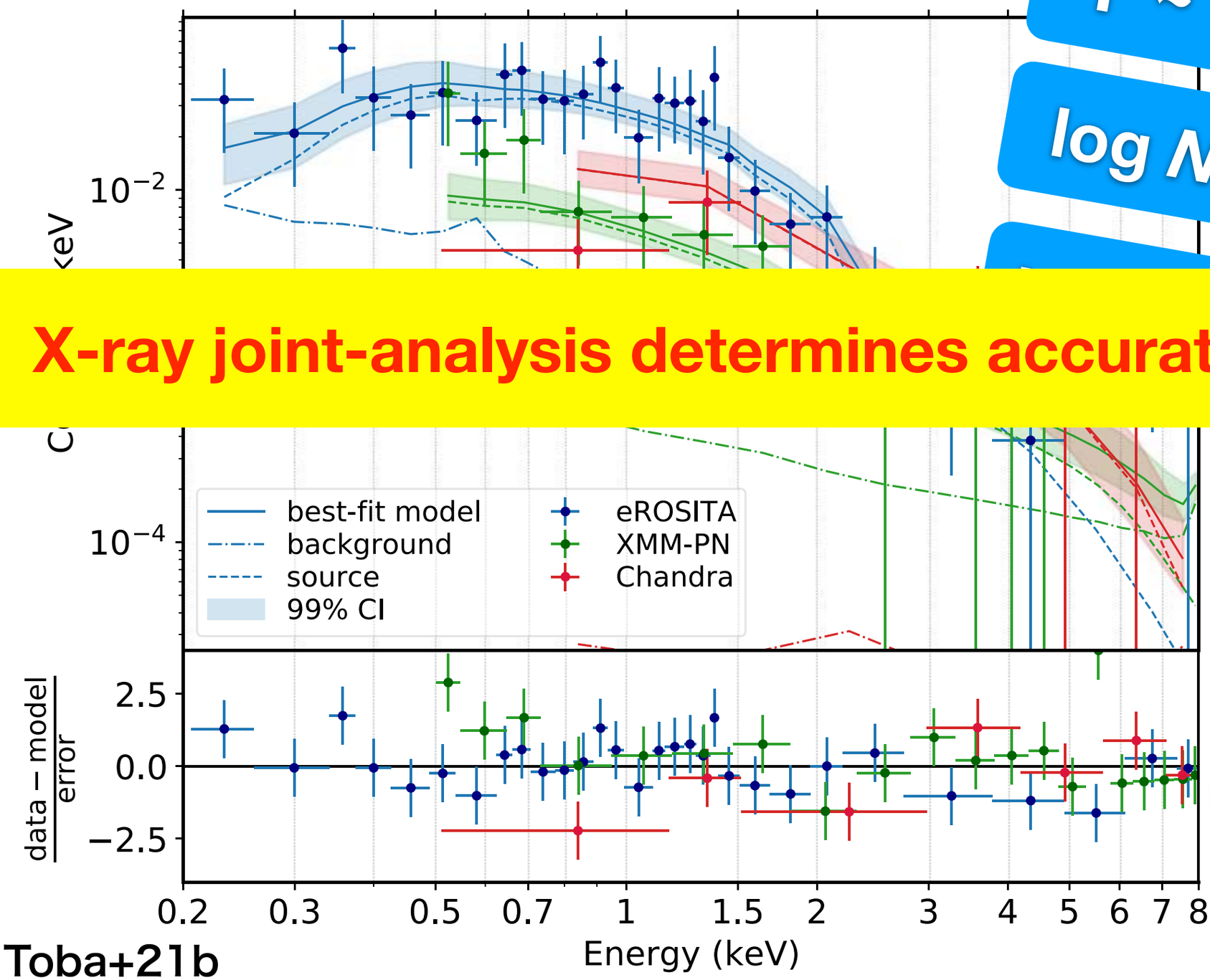
X-CIGALE successfully estimates IR luminosity.

Toba+21b

Joint analysis of eROSITA-Chandra-XMM

Teng Liu
(MPE)

Power-law model (with Γ)
with Galactic abs. and intrinsic abs (NH)



Γ ~ 1.73

log N_H < 21.0 cm^{-2}

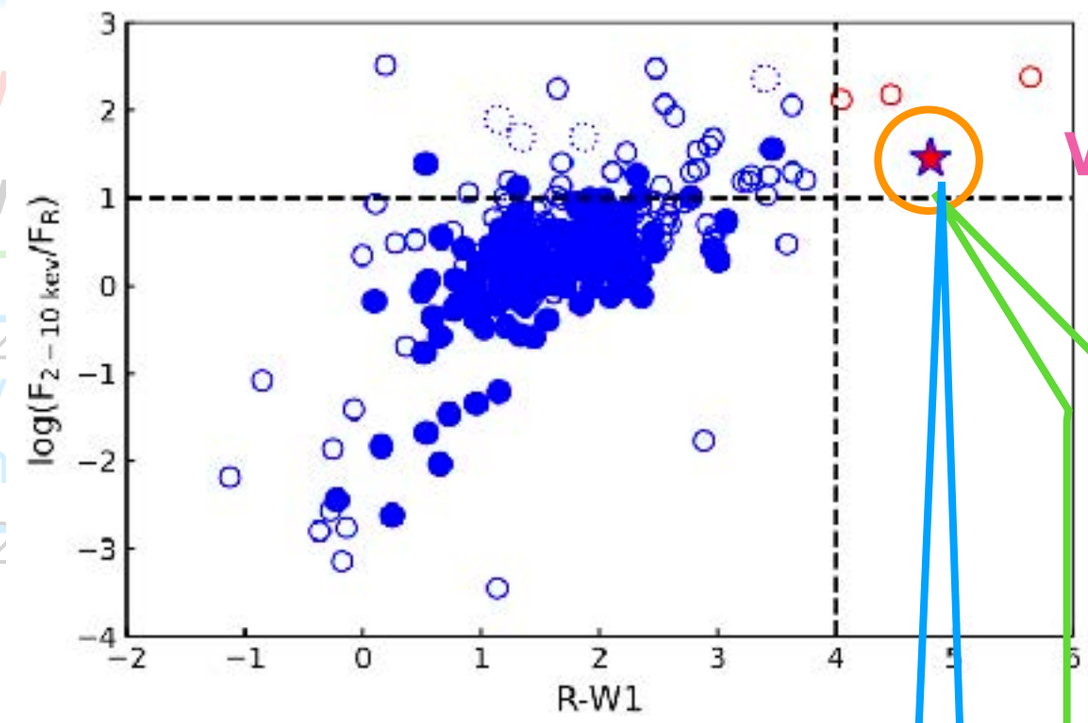
X-ray joint-analysis determines accurate X-ray properties.

Yuichi Terashima
(Ehime Univ.)

Toba+21b

XID439: A powerful quasar in the feedback phase

Marcella Brusa
(U. of Bologna)

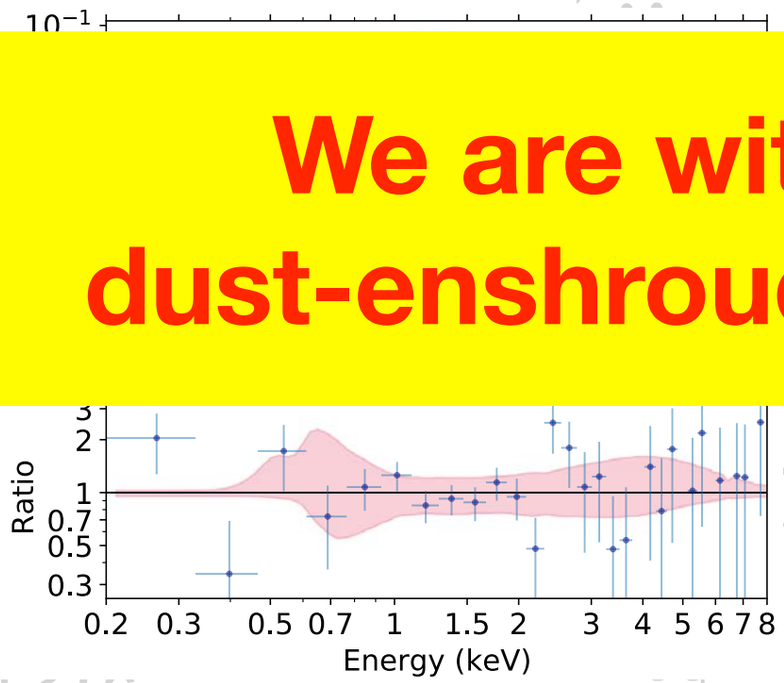


z_{spec} = 0.603 (SDSS)

Very red color

SDSS spectrum

eROSITA spectrum



We are witnessing a short-lived, dust-enshrouded, and feedback phase.

Brusa+21

MBH and Lbol are needed

2021. 03. 04

Summary

- **HSC-eROSITA collaboration will provide abundant information on AGN and its host properties.**
- **An ELIRG with log ($L_{IR}/L_\odot$) = 14.3 and log L_X = 45.3 erg s^{-1}, and log N_H < 21 cm^{-2} is founded.**
- **A powerful quasar in the feedback phase is also discovered.**
- **As a consequence of the eROSITA all-sky survey, ~2,000 such X-ray luminous IR galaxies are expected to be discovered in the entire extragalactic sky, which will be the key population to constrain the bright-end of luminosity function.**

This work is supposed by Subaru Archive Science Proposal FY2020 toward the Subaru- international partnership.

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