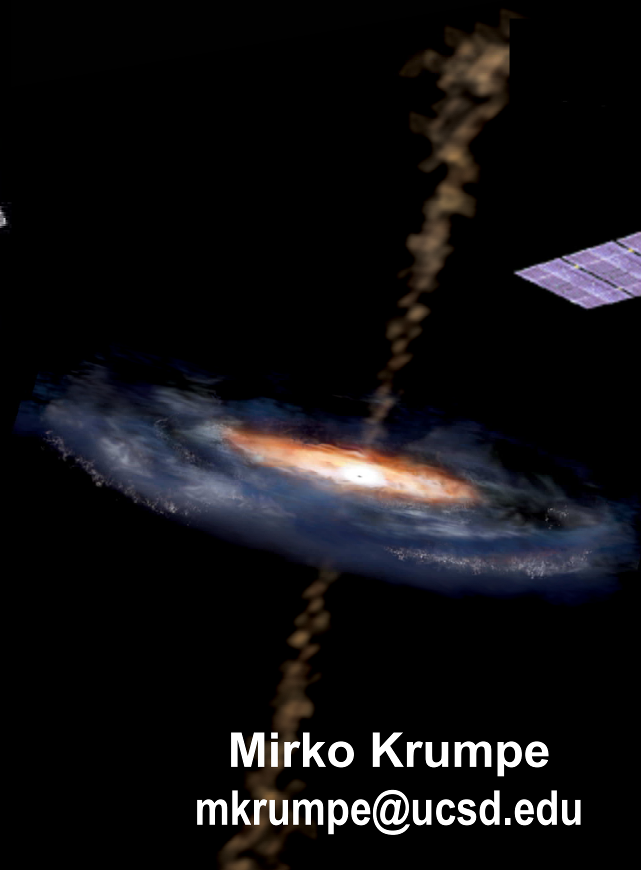
First Results from Chandra/Akari NEP Survey: Search from Compton-thick Accretion

Akari



Chandra

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Outline

Motivation

- Compton-thick AGNs
- Uniqueness of Akari

Chandra/Akari NEP survey

- Akari NEP survey
- Infra-Red AGN candidate selection
- Chandra survey

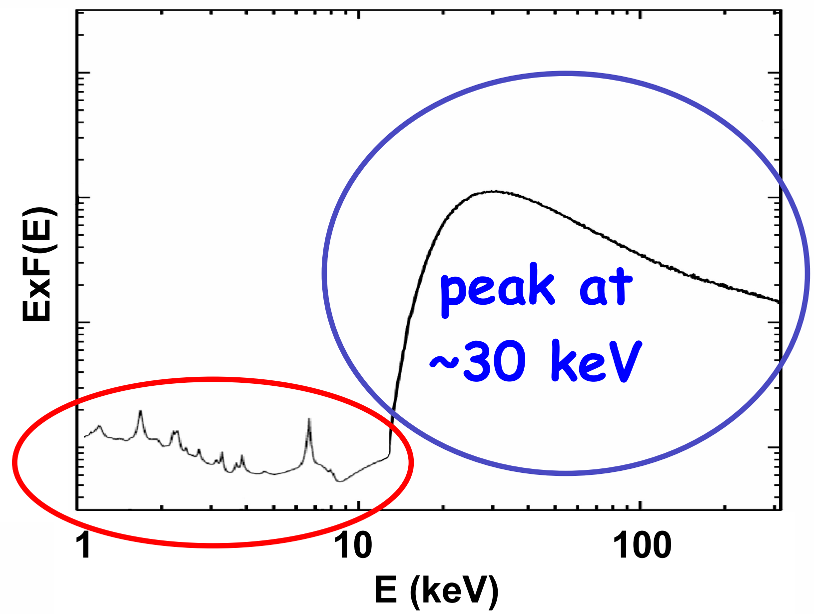
First Results & Scientific goals

Compton-thick Accretion

- XMM-Newton & Chandra most efficient in detecting unabsorbed or Compton-thin absorbed AGNs

- Compton-thick (CT) AGNs
  - ⇨ $N_H > 10^{24}$ cm^{-2}
  - ⇨ reflection features below 10 keV

- f(CT/total) SMBH accretion ?



Why should CT-AGN exist?

- required by population synthesis models of the CXB

(e.g., Ueda et al. 2003, Gilli et al. 2007, Treister et al. 2009)

- 50% of CXB above 8 keV unresolved ⇨ missing fraction has spectral signature of highly absorbed AGNs (Worsley et al. 2005)

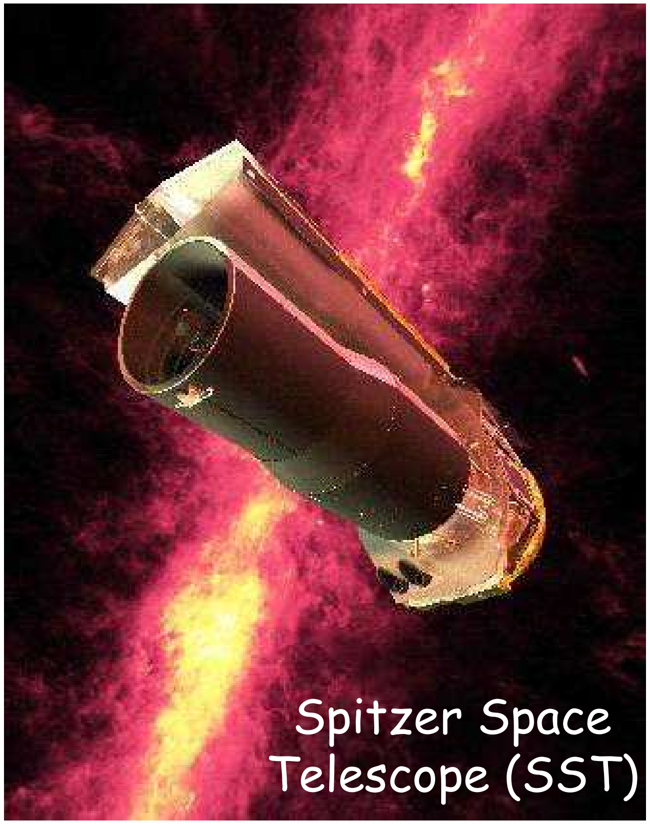
How to find CT AGNs?

- Infra-red (IR) emission of AGN is relatively unaffected by absorption from dust/gas and almost isotropic
- IR radiation is dominated by stars and warm dust associated with star formation
- AGN radiation heats dust particles to higher temperatures than star-forming activities

  ⇨ **3-8 μm** power-law like continuum

Basic idea:

Select AGN candidates based on IR color diagnostics or IR SEDs



Credit: NASA/JPL-Caltech

Uniqueness of Akari

The Akari Mission

- Japanese-led infrared satellite; launch date: February 2006
- 68.5 cm telescope; 2 instruments: 2-180 μm

all-sky survey in 6 bands + deep imaging & spectroscopy

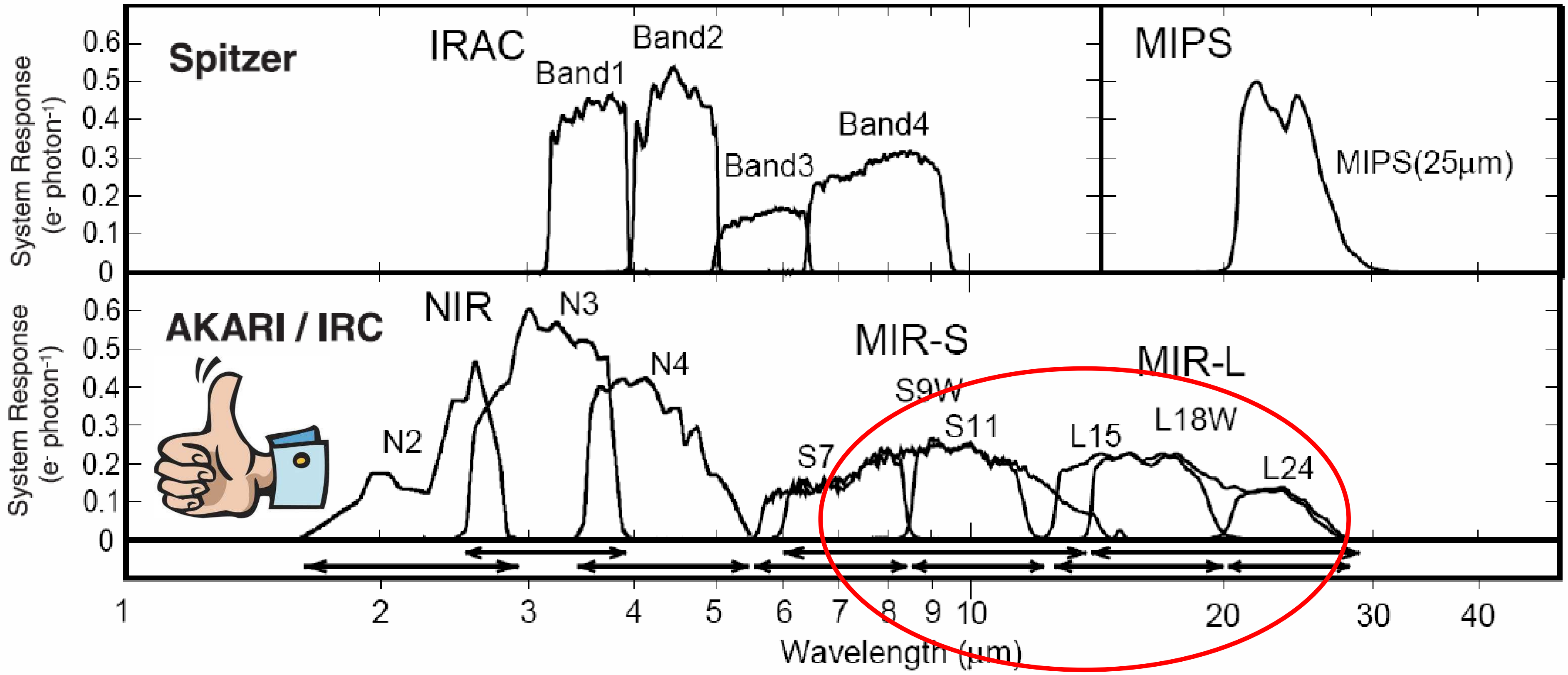
Matsuhara et al. 2006

Why the North Ecliptic Pole?

- attitude control constraints
  ⇨ ecliptic polar regions preferred for deep surveys
- bright star (K ≤ 12 mag) density at NEP is 2x smaller than at SEP
- another large-area Akari survey (LMC) is close to SEP

Credit: JAXA artist's concept

Uniqueness of Akari



Continuous wavelength coverage from 2-25 µm (9 filters)
⇨ filling the 9-20 µm Spitzer gap

Akari North Ecliptic Pole (NEP) survey

- Akari selects IR AGN candidates **more effectively** than Spitzer in $0.4 < z < 1.5$

- Akari NEP survey is **one of the deepest** 15 µm surveys achieved and by far **the widest** among those with similar depth

- Akari NEP survey is **5x larger in area** than Spitzer IRS 16 µm and has additional filters at 9, 11, and 18 µm

- **extensive multi-wavelength** Akari NEP follow-up data sets are already available

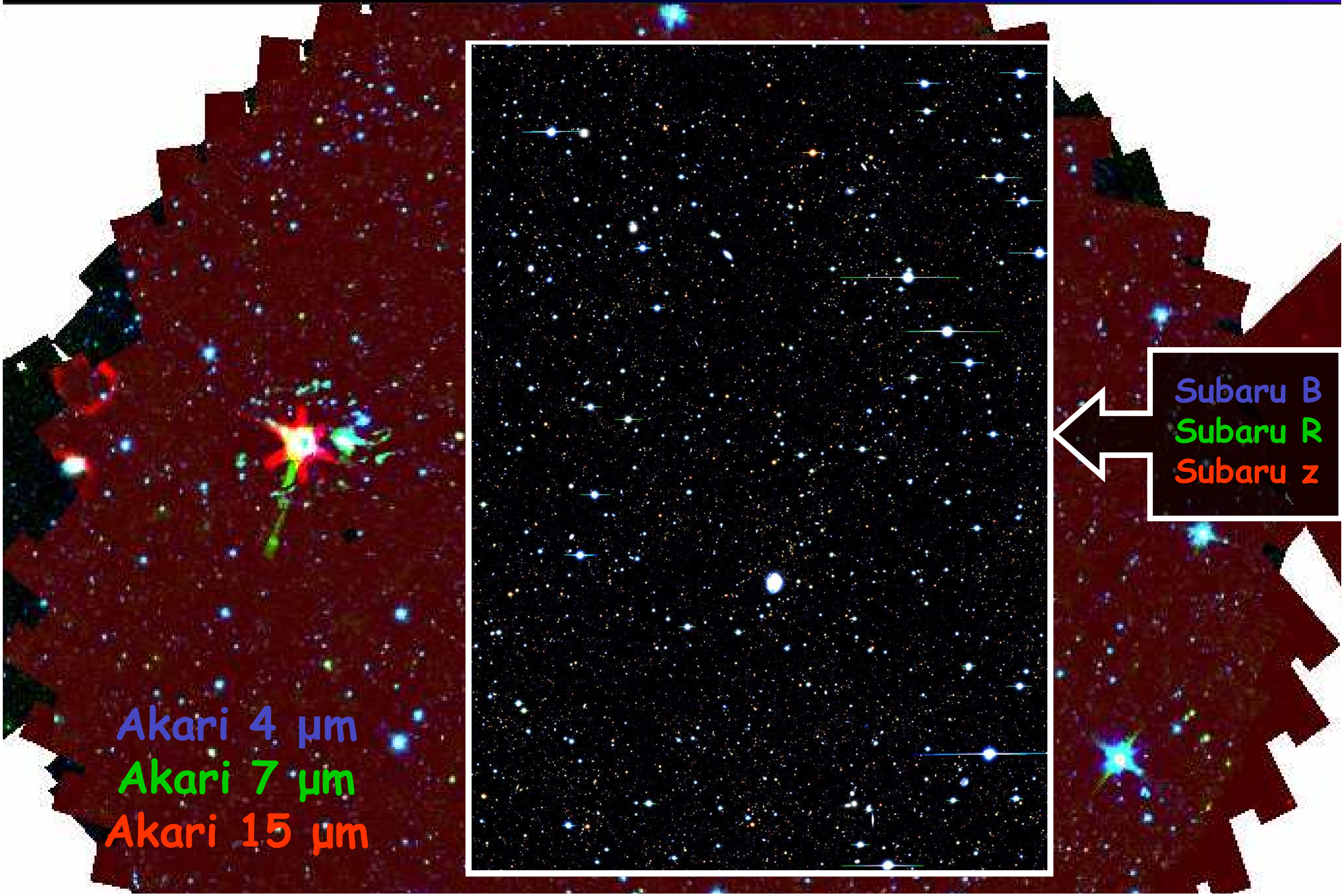
Multi-wavelength data in the Akari NEP

based on Wada et al. 2008

Observatory	Band/Filter	Area/Sources	Sensitivity
Subaru/SuprimeCam	B,V,R,i,z	27'x34'	B=28 AB
Subaru/FOCAS	opt. spectr.	57	R~24 AB
Keck/DEIMOS	opt. spectr.	420	R~24 AB
CFHT/WIRCam	YJK	0.5 deg^2	YJK~24 AB
GALEX	NUV, FUH	0.6°φ	NUV=26
WSRT	1.5 GHz/20cm	1.7 deg^2	0.5 mJy
Herschel/SCUBA-2	proposal accepted	waiting for data	

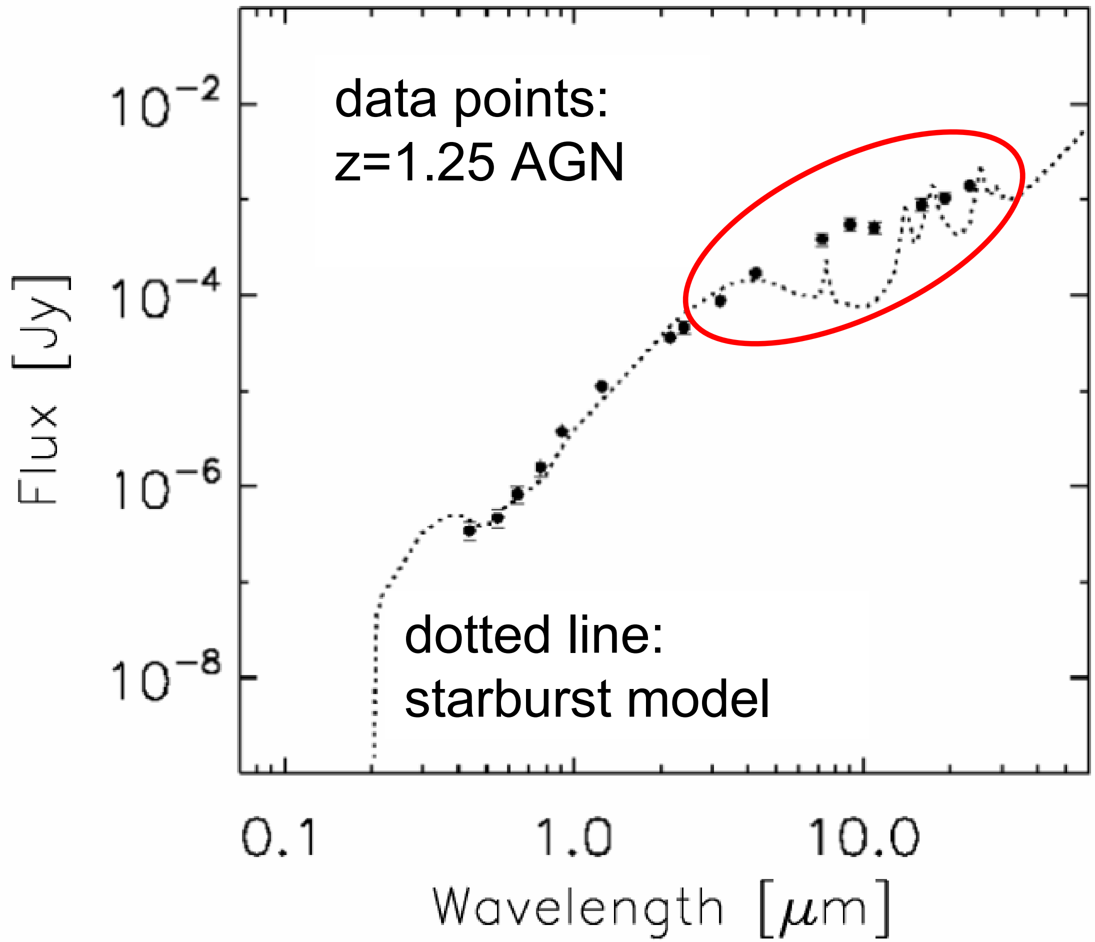
...and even more!

Akari North Ecliptic Pole (NEP) survey



Identifying IR AGN candidates

use full SED fits (rather than color-color diagnostics)



starburst differs from AGN model in the 3-8 μm (rest-frame)

Two IR AGN candidate selection methods

Takagi et al., in prep.

- requires all-band Akari detection
- SED starburst models (SBURT)

+ very reliable IR AGN candidates

− very shallow sample

$n_{AGN} = 76$

Hanami et al., submitted

- at least 3 detections in 7, 9, 11, 15, 18, 24 µm bands & $z_{photo} > 0.4$
- SED starburst model and dusty torus component (Siebenmorgen & Krügel 2007)

+ allows for mixture of AGN+SB

+ extends to lower fluxes

− more fit parameter, z_{photo}

$n_{AGN} = 91$, $n_{AGN+SB} = 177$

~2/3 of Takagi et al. IR AGN candidates are in Hanami et al. sample

Chandra/Akari NEP Survey

Chandra data ⇨ classify the IR AGN candidates into:

1) unabsorbed (type I) AGNs

2) Compton-thin absorbed (type II) AGNs

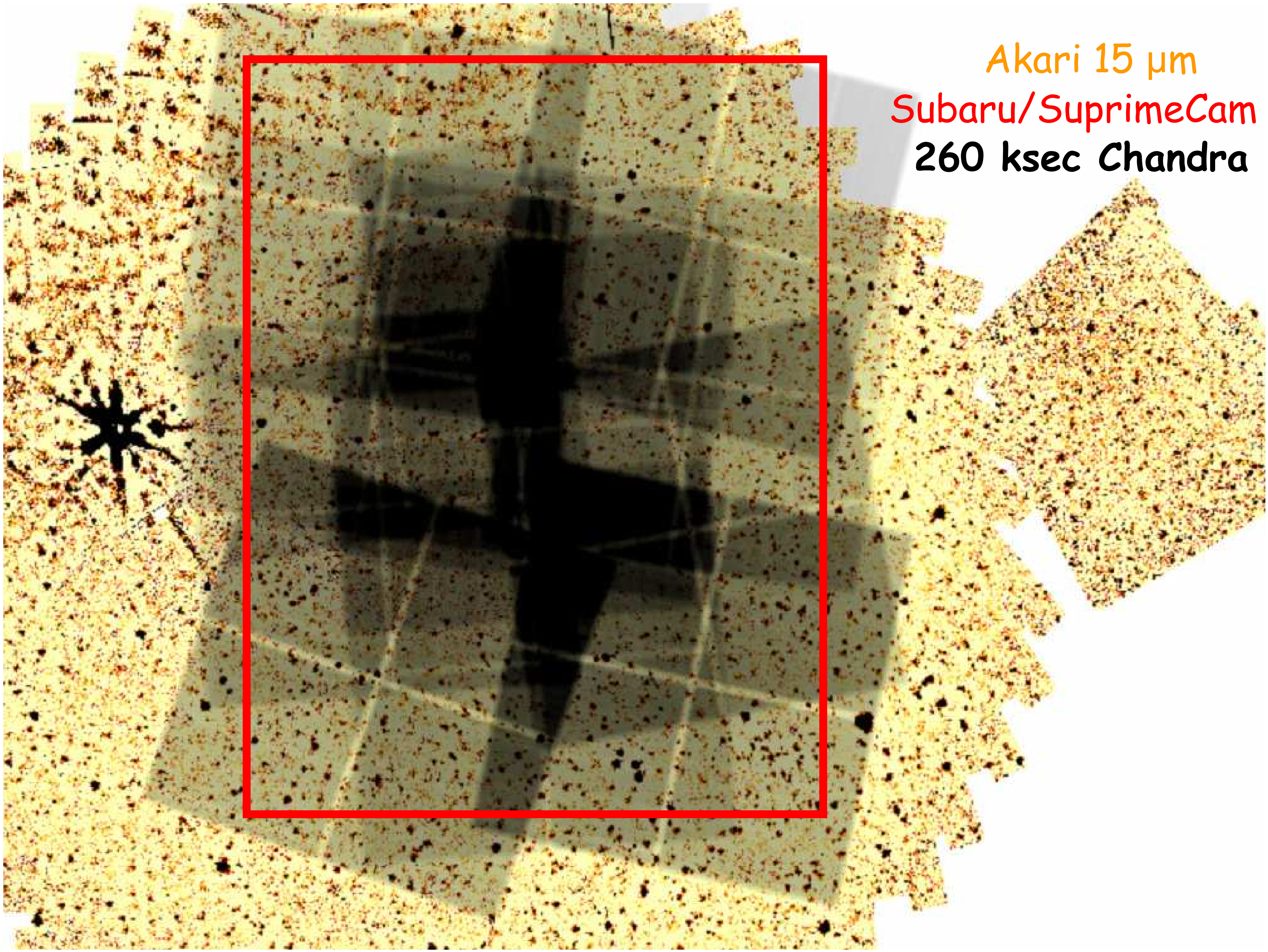
3) Compton-thick (CT) AGNs

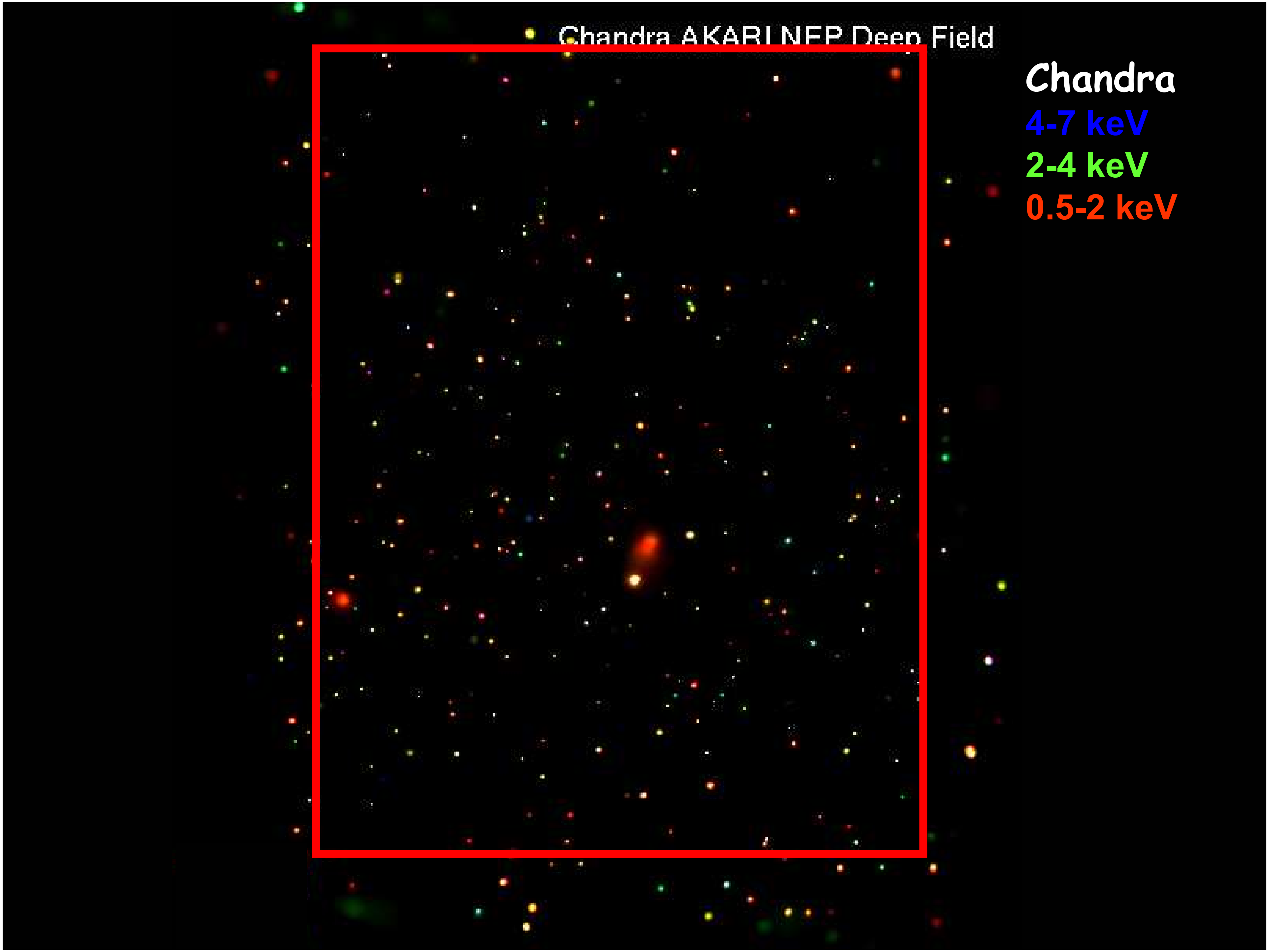
Chandra survey requirements:

- restrict to Subaru/SuprimeCam (0.26 deg^2)
- utilize sharp PSF to ensure unambiguous identification

  ⇨ 3x4 ACIS-I pointing
- aim for $L_{limit,0.5-2\ keV} = 10^{43}$ erg s^{-1} at z~1

  ⇨ ~50 ksec (typically)


Akari 15 μm
Subaru/SuprimeCam
260 ksec Chandra


Chandra AKARI NEP Deep Field
Chandra
4-7 keV
2-4 keV
0.5-2 keV

Chandra/Akari NEP Survey – First Results

Source detection:

- 399 X-ray (likelihood ≥ 10 ⇨ ≥ 5 counts)

Detections/Non-detections of IR AGN candidates:

Takagi et al. sample
(shallow sample, all bands, n=76)

- 32% clear X-ray detections
- 14% weak/marginal X-ray det.
- **54% non-X-ray detections**

Hanami et al. sample
(fainter sample, z_{photo}>0.4, ≥3 bands,
n_{AGN}=91 / n_{AGN+SB}=177)

- 42% / 12% clear X-ray detections
- 9% / 3% weak/marginal X-ray det.
- **49% / 85% non-X-ray detections**

preliminary

~ 50% of all IR AGNs are not detected in X-rays
⇨ are they Compton-thick absorbed AGNs?

Testing for Compton-thick absorbed accretion

First of all: **spectra** ⇨ classification & redshift

⇨ Keck/Deimos run beginning of July 2011 ($mag_Z < 23$, $mag_R > 21.5$)

⇨ WIYN spectroscopy 2011 ($mag_R < 21.5$)

⇨ further Keck/Deimos proposals

⇨ extensive multi-wavelength data ⇨ z_{photo}

L_X/L_{IR} ⇨ calculate expected L_X based on L_{IR} from Akari for unabsorbed, Compton-thin, and CT absorbed

stacking techniques ⇨ imaging stacking

⇨ spectral stacking

http://cstack.ucsd.edu **by T. Miyaji**

Do we detect excess emission around the fluorescent Fe line?

Goals of the Project

• quantifying the contribution of CT AGNs to the total accretion onto SMBH at $0.4<z<1.5$

IR SED of X-ray confirmed AGNs

• multi-wavelength data (X-ray-to-radio)

⇨ determine host galaxy/AGN properties

(e.g., star-formation rate, stellar mass, SMBH mass, accretion ratio relative to Eddington, etc.)

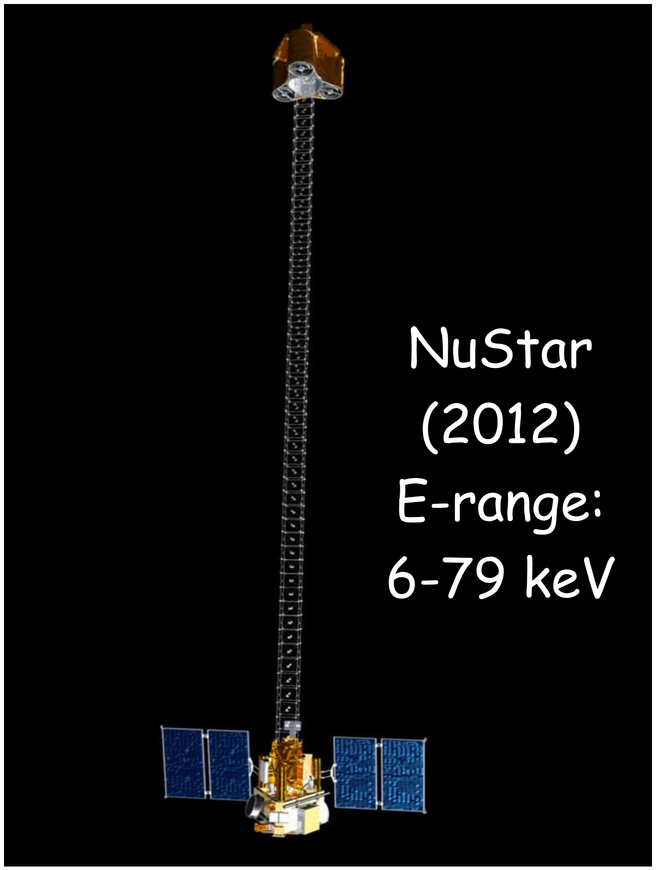
⇩

• compare to unabsorbed/Compton-thin AGNs

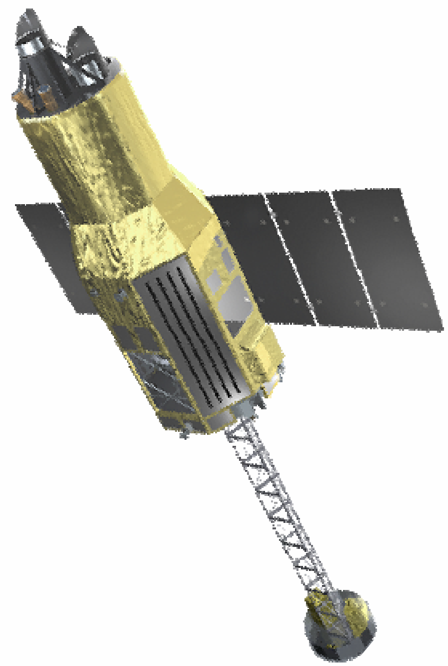
• how/where do CT AGN fit into the general AGN/galaxy evolution?

Future

Upcoming telescopes with imaging capability in hard X-rays



⇨ see talk by Fiona Harrison (Thursday)



ASTRO-H (2013)
0.3-80 keV, Calorimeter (7 eV)

⇨ see talk by Tadayuki Takahashi (Thursday)

Summary

Akari fills the 9-20 μm Spitzer gap

Akari NEP survey one of the deepest and the widest at 15 μm
⇨ search for **Compton-thick AGNs ($0.5<z<1.5$)**

IR AGN candidates selected ✔
260 ksec Chandra observation ✔
extensive multi-wavelength data ✔

~50% of IR AGN candidates are not detected in X-ray
⇨ Compton-thick AGNs?

• estimate expected $L_X(L_{IR})$
verify the CT nature by stacking analysis?

Goals: • constrain average f_X and contribution to CXB
• study galaxy/AGN properties – What makes them CT?

Stay tuned!