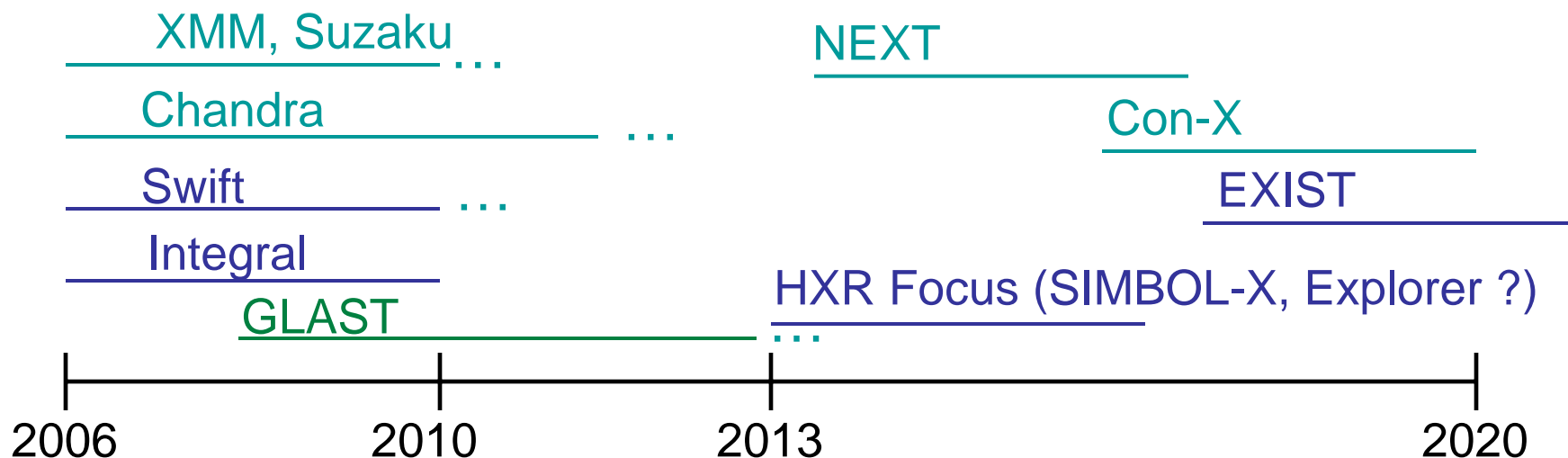


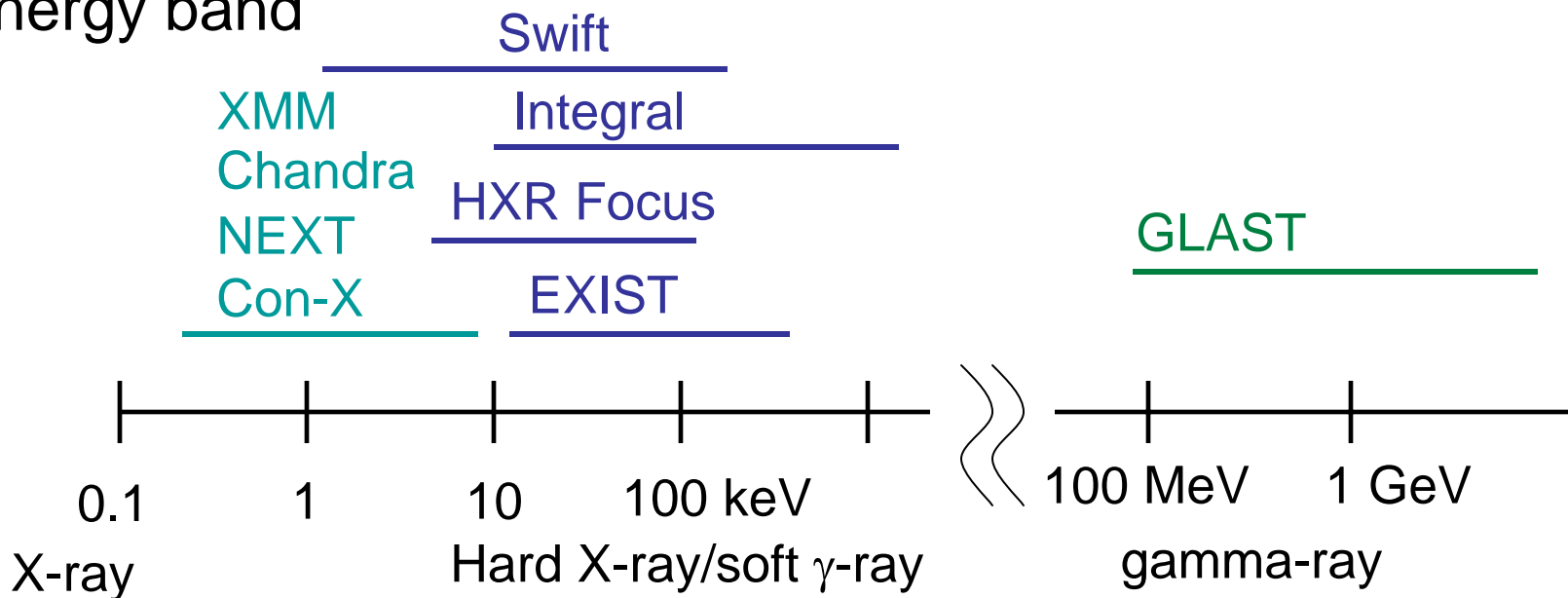
New Opportunities 2010 and  
Beyond: The High-Energy/Radio  
Connection

# High Energy Missions

## Timeline



## Energy band



# New Opportunities

X-ray (0.1 - 10 keV) - *Constellation-X*

Thermal ( $10^6$  K) plasmas

accretion disks, galaxy clusters

large-area high-resolution spectroscopy

Hard X-ray/soft gamma-ray (10 - 1000 keV) - *EXIST, HXR Focuser*

non-thermal processes (synchrotron, IC, nuclear lines)

Relativistic jets in GRBs, microquasars, binaries; SNe, obscured AGN

GeV Gamma-ray - *GLAST*

Relativistic jets in blazars, GRB

# Hard X-ray Sky

**Hard X-ray (~3-600 keV) all-sky imaging *each orbit* to measure:**

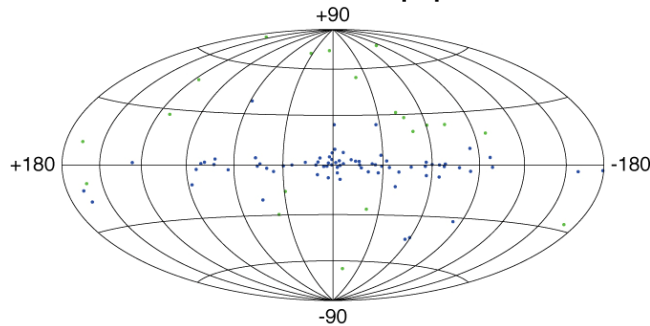
Highly variable sources, short-lived transients

GRBs out to  $z \sim 20$  and first stellar Black Holes ( $\sim 5-20\times$  *Swift* sensitivity)

Stellar Black Holes in Galaxy & IMBHs in Local Group

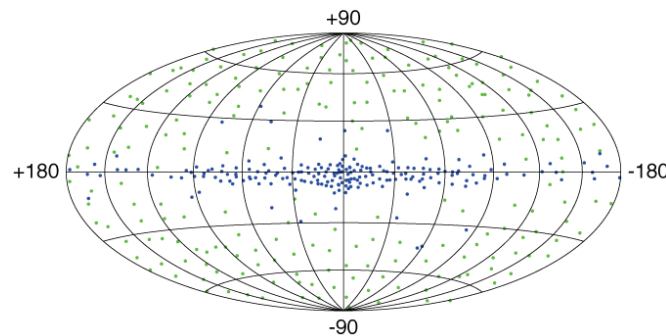
## Previous Hard X-ray Sky

HEAO-1, BeppoSAX



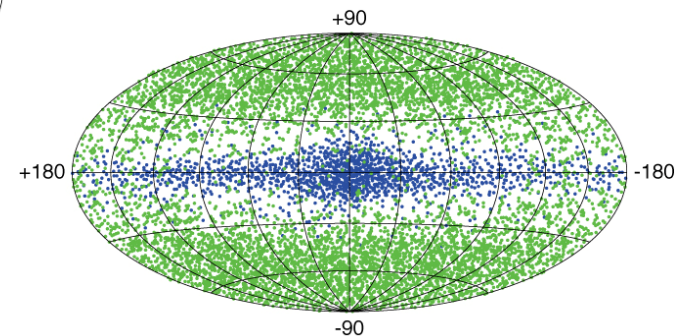
## $\leq 2010$ Hard X-ray Sky

Swift & INTEGRAL



## 2017(?) Hard X-ray Sky

EXIST

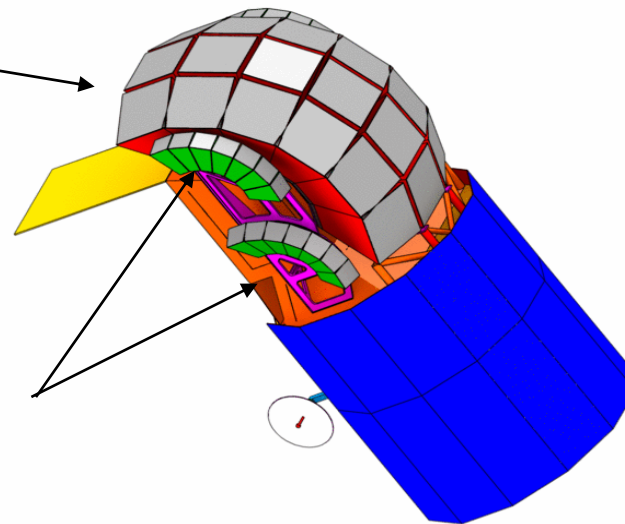


# Wide-Field Hard X-ray Imaging: EXIST

- ~20X more sensitive than *Swift* or *INTEGRAL* and cover full sky
- Detect  $\sim 10^4$  sources,  $\leq 10''$  positions, 3-600 keV spectra
- unique temporal survey: *full sky imaging each orbit*

*High Energy Telescope*  
*HET (10-600keV)*

(6 x 3 coded  
aperture telescopes;  
131° x 65° FoV)



*Low Energy Telescope*  
*LET (3-30 keV)*

(4 arrays of 7 x 1 coded  
aperture telescopes;  
116° x 64° FoV)

# Radio Connections

Gamma-ray bursts (Kulkarni)

Stellar mass black holes(&NS) in Galactic binaries

'low/hard states' now believed to be jet-powered down to  $10^{-6} L_{\text{Eddington}}$  (through radio observations)

High states dominated by accretion disk

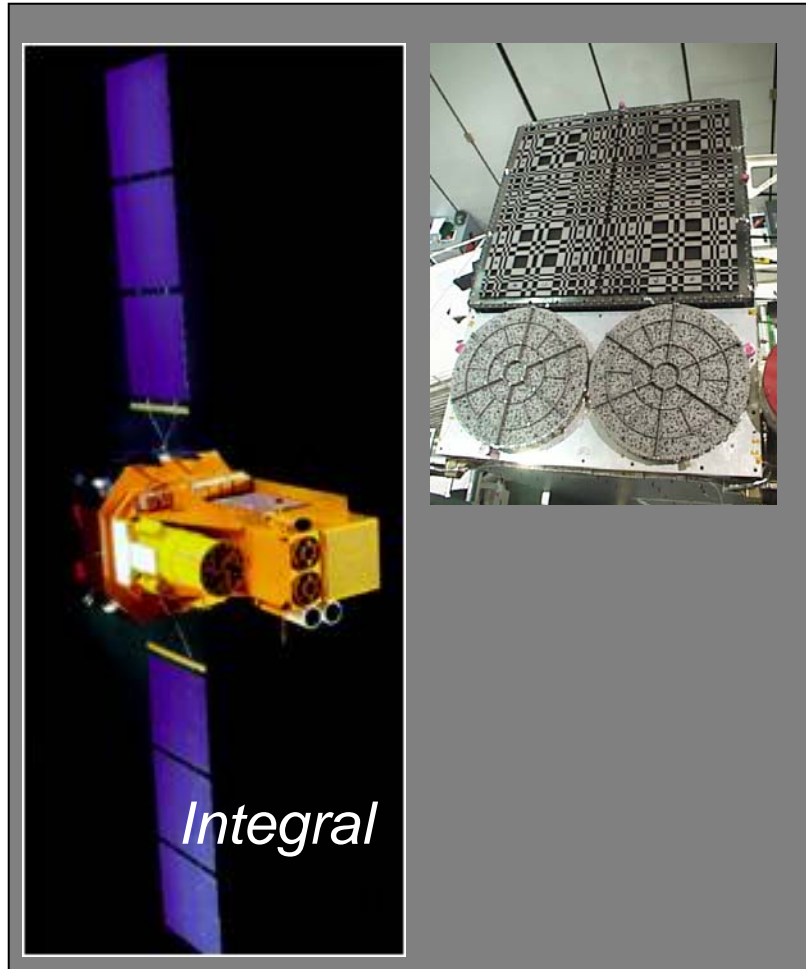
Jet studies; physical timescales associated with jet formation set by size (mass); days to decades probes jet-accretion disk coupling

Radio - indicates jet component

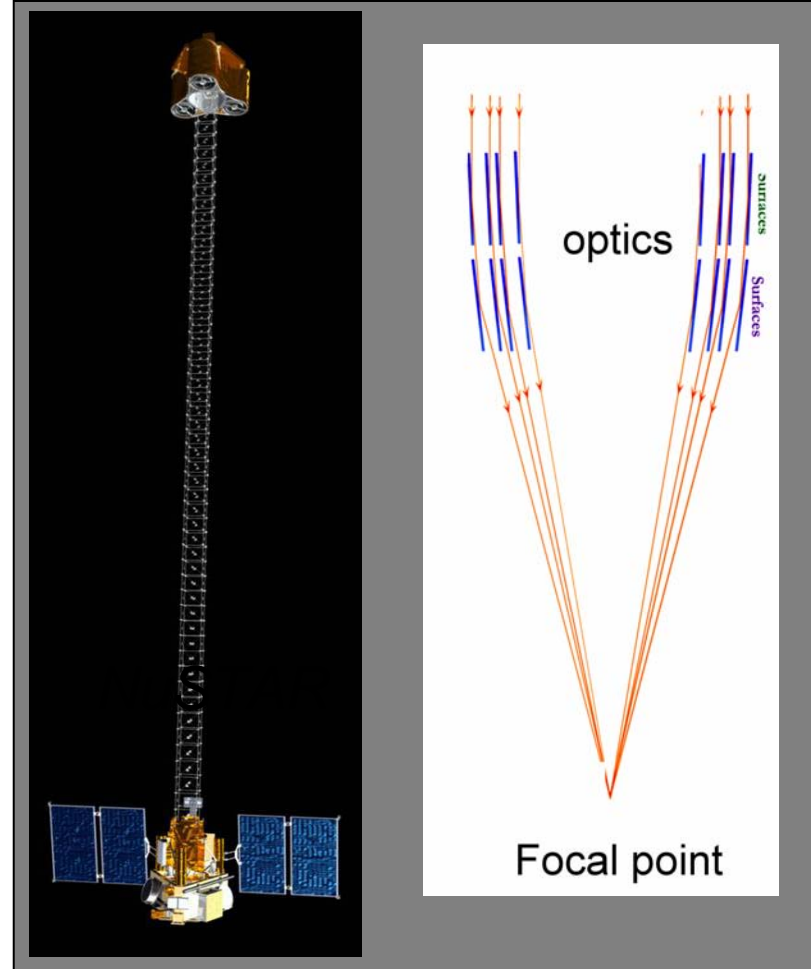
Radio nebulae - calorimeters for jet kinetic power

Time-constrained (simultaneous w/ X-ray) observations over wide flux range

# Focusing in the Hard X-ray Band

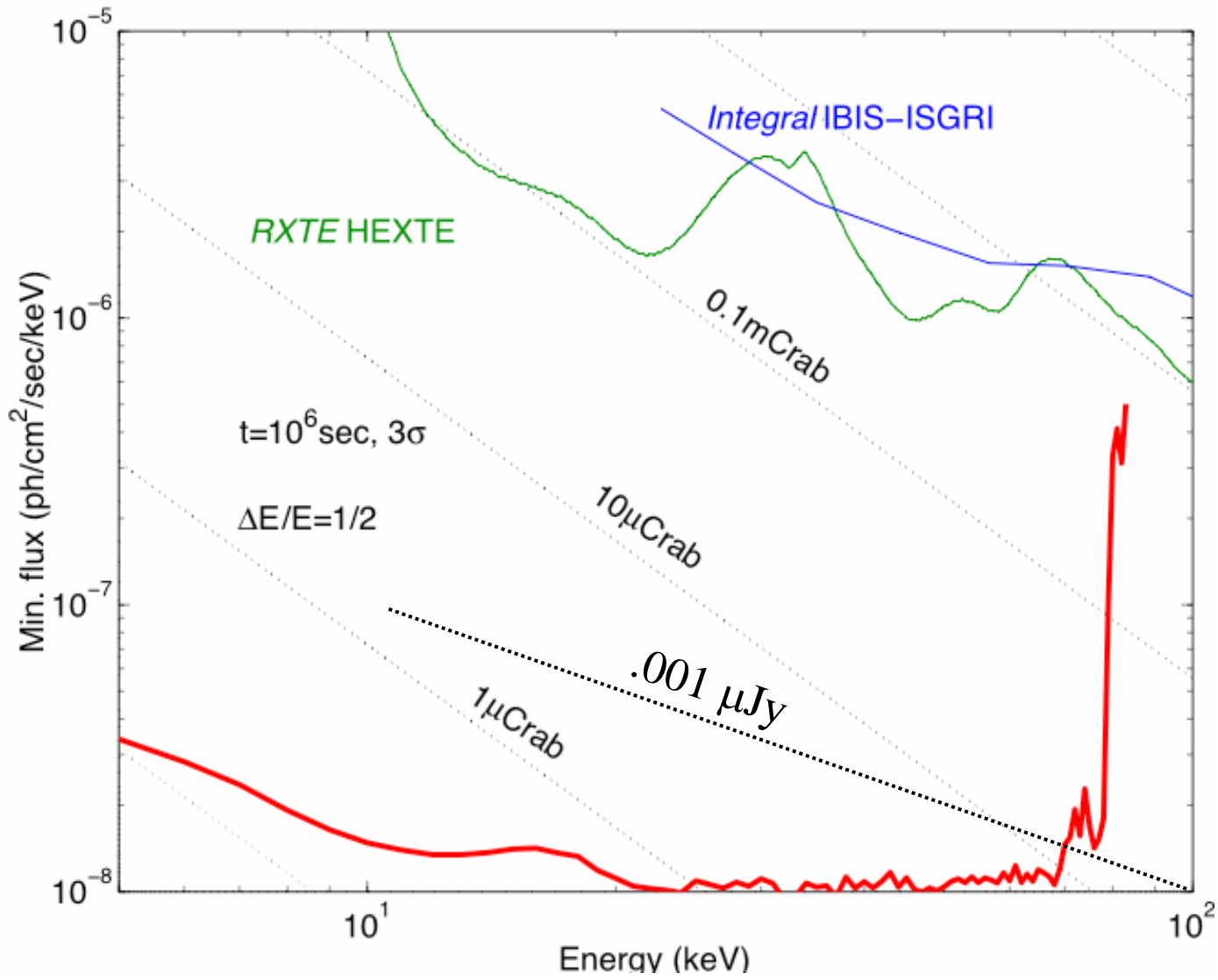


Pinhole camera  
High background, large  
detector, low resolution



Focusing telescope  
Low background, compact detector,  
high resolution

# Sensitivity Advance



# Science Goals

Census of accreting supermassive black holes in the Universe

Evolution of SMBH over cosmic time

Current Chandra/XMM surveys do not reach  $\nu F_\nu$  peak in XRB

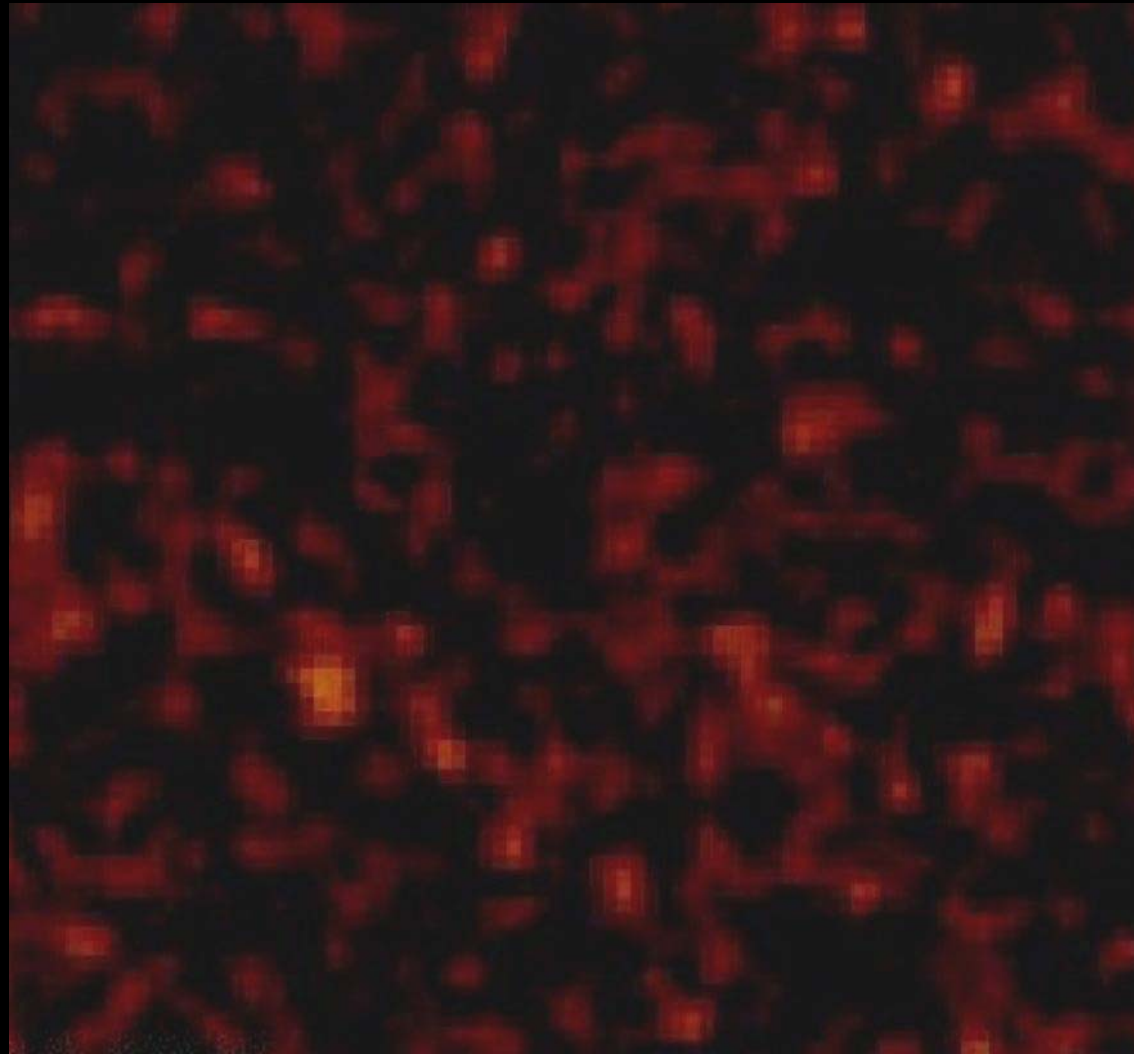
Nature of obscured Galactic binary population

Nucleosynthesis and dynamics in supernovae

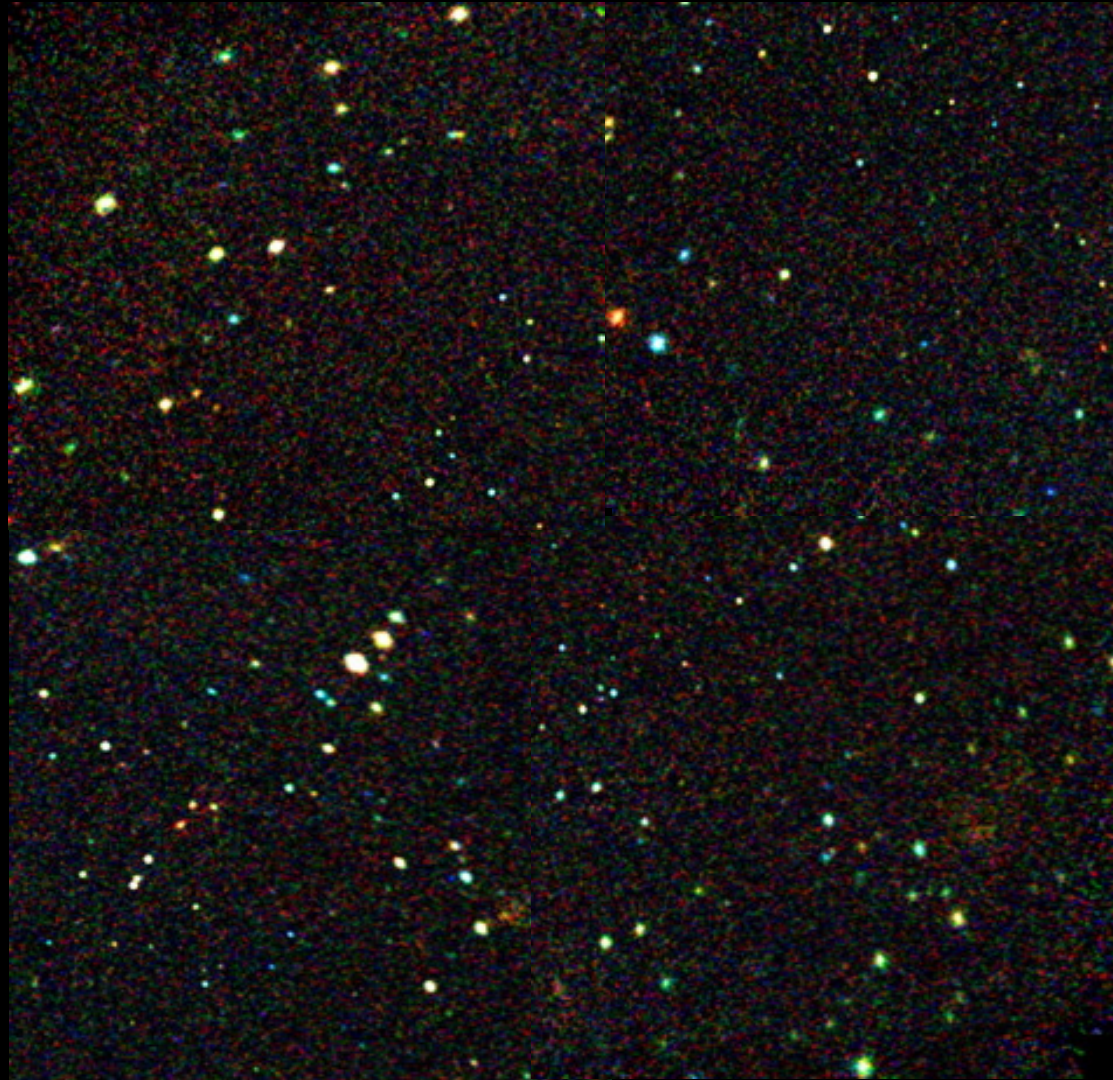
Resolve origin of diffuse Galactic emission

Mapping non-thermal components in galaxy clusters, radio galaxies

30 keV X-ray sky with Integral (2 sq degrees)



2 x 2 degrees at 30 keV with focusing HXR telescope



# Radio Connection

## BH Census

Deep radio surveys (and mid IR) required to identify Compton thick component

Deep imaging observations of selected survey fields

## Diffuse non-thermal emission

Hard X-ray maps IC scattering off CMB, radio maps synchrotron emission - combined can map magnetic field strength in galaxy clusters, relic radio galaxies

Low-frequency radio maps

# Summary

One of the new frontiers in high energy astrophysics  
2010-2020 will be hard X-ray (10 - 1000 keV)

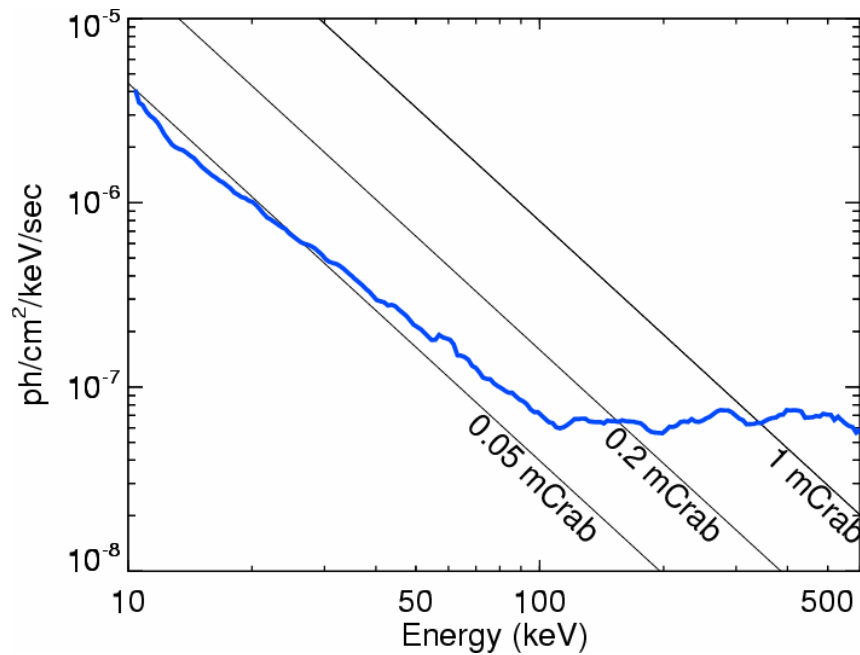
time domain

sensitivity

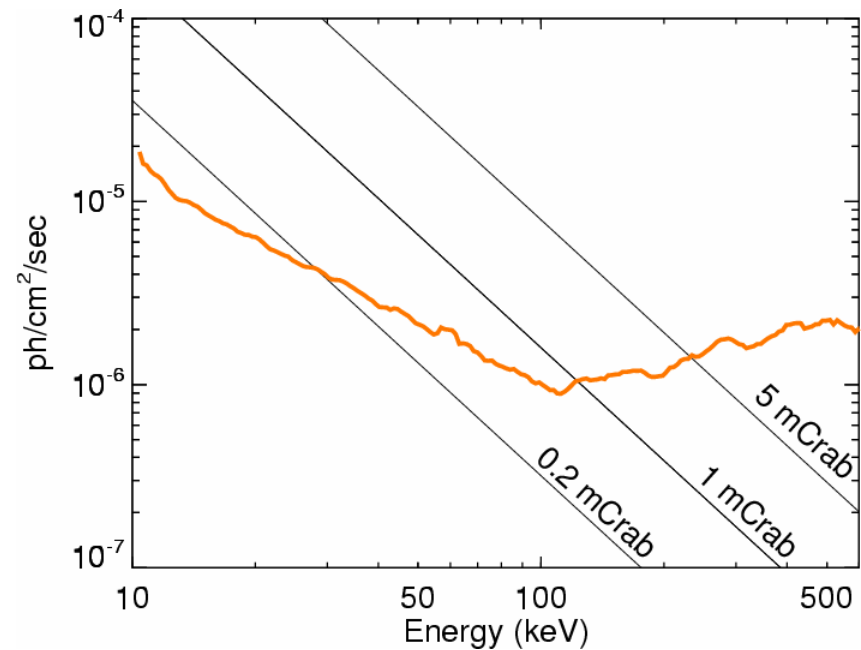
For fast transients, jets in BH on all scales, evolution of  
accreting black holes, strong connection to radio  
observations

# Expected EXIST Survey Sensitivity

## Continuum



## Narrow Line



LET 3-30 keV; HET 10-600 keV

0.05mCrab =  $5 \times 10^{-13}$  cgs, (over any  
band  $E_{\text{low}} \rightarrow 2E_{\text{low}}$ )

$5\sigma$ , ~1yr, 20-40% duty cycle any source