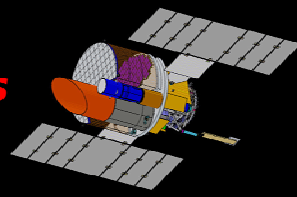


Surveying the Early Universe, Supermassive Black Hole Demographics and theTemporal Universe with *EXIST*

Josh Grindlay
Harvard/CfA

And the *EXIST* Team

Talk Outline

- Motivation and Science case for *EXIST*
  - Overview
  - Science objectives
  - Mission plan and possible schedule
- Prototype imaging *Swift*/BAT Slew Survey (*BATSS*)
  - Scanning (vs. pointing) coded aperture imaging sensitivity…
- And detector: *ProtoEXIST* balloon-borne prototype
  - First generation payload and upcoming flight
  - Evolution to full *EXIST* prototype

What is *EXIST?*
(Energetic X-ray Imaging Survey Telescope)

- A *Medium Class Mission* (~$800M) to conduct the most sensitive *full-sky* survey for ***Black Holes*** on all scales (stellar to supermassive)

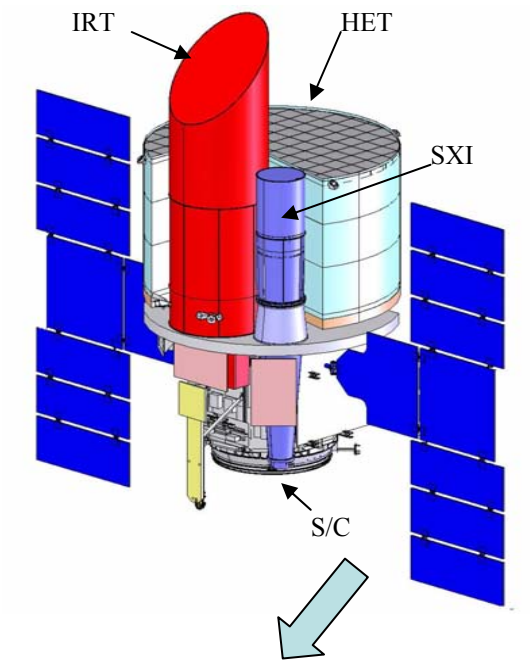
- A mission for the ***Astrophysics Strategic Mission Concept (ASMC)*** *Study* program, in preparation for the current review by the *Astronomy/Astrophysics Decadal Survey (Astro2010)*

- A wide-field (90^{o}) **hard X-ray (5-600 keV) imaging** (2 arcmin resolution, <20" source positions) telescope surveying/monitoring full sky *every 3h* with 10X higher sensitivity than any previous or planned full-sky HX imaging survey…

- *Plus* a 1.1m **optical-IR telescope** (***IRT***) and contributed (Italy) **soft X-ray imaging (0.1-10keV) telescope** (***SXI***) to obtain identifications, redshifts and diagnostics of black holes, transients & extreme objects for followup study by **Fermi, JWST, LSST, ALMA, SKA, IXO and LISA(!)**

A mission recommended by previous Decadal Survey & now considerably impoved

A Hard X-ray, full-sky imaging mission with deep IR/X-ray followup is required for the ultimate GRB & SMBH survey to *EXIST*



HET at ~zenith ***scans*** at orbital rate & ***points*** **IRT/XRT/HET** to GRBs within ~100s

HET: CZT detector arrays + mask: 5-600 keV **4.5m² tiled CZT**, **coded mask** images 90° diam. FoV, 2' resol. & <20" positions; BGO rear shield (0.2-2MeV)

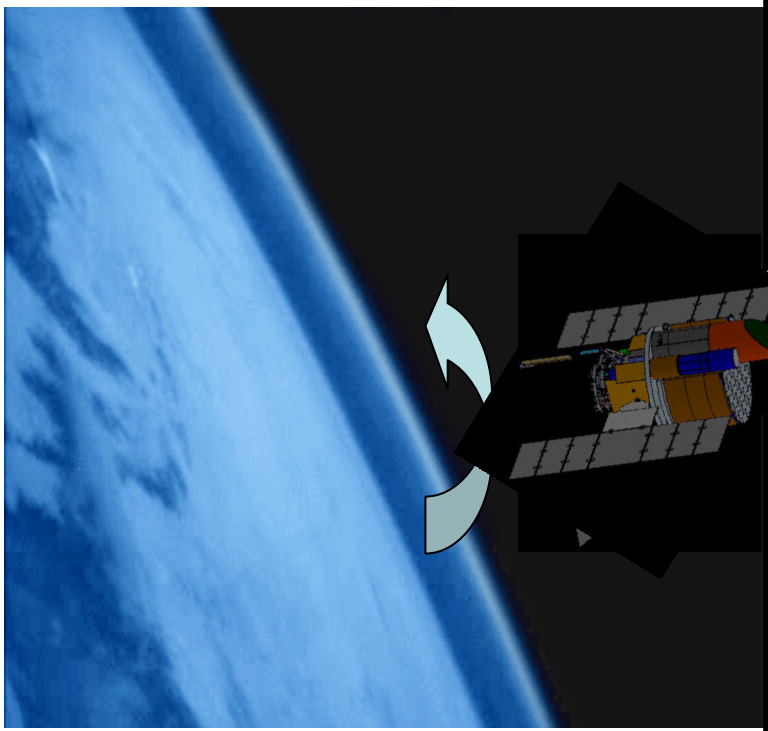
IRT: 1.1m; cooled (-30C) (dichroic: 0.3-0.9μm (HyViSI) and 0.9–2.3 μm (NIRSPEC)

SXI: 0.6m; Italy/ASI contributes upgrade of *Swift/XRT: **S**oft **X**-ray **I**mager* (0.1-10keV (CCD))

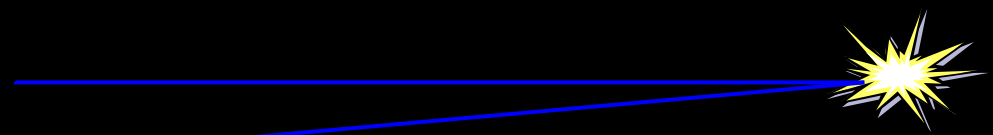
The *New EXIST* mission (600km LEO, i ≤15°):

- ***2y full sky survey:*** ±20deg *Zenith-pointed* **scanning**, 2sr FoV, *full-sky ea. 3h.*
- ***3y followup IDs:*** **IRT/XRT/HET pointings** for IDs, ***redshifts***, spectra & timing

How does ***EXIST*** operate?



1. Zenith (+/-~30^{o}) **scan** of 90^{o} FoV of HET at orbital rate to cover ~half-sky each orbit
2. Imaging in 90^{o} FoV detects Gamma-ray burst (GRB) -- or variable AGN or transient



3. EXIST slews S/C onto GRB for IRT imaging ID and spectrum (optical + IR) for redshift

4. Pointing for 1-2 orbits to measure structure in distant Universe; HET measures spectrum & variability of target *and* continues Survey
5. Resume scan (years 1 & 2) or new target

Deepest Hard X-ray *Full-Sky* Survey

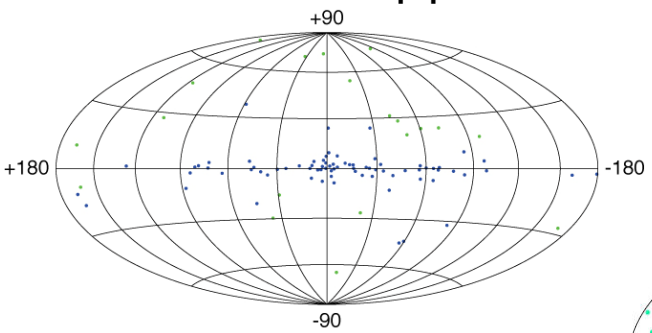
- ***EXIST***/**HET**: 5-600 keV <u>full sky mission</u> survey to Fx <u>~5 x 10^{-13} cgs, or 10X more sensitive than *Swift* or *INTEGRAL*,</u> gives ≥6 x 10^4 sources, <20″ positions

- ***EXIST***/**SXI**: 0.1-10 keV imaging & spectra to Fx <u>~5 x 10^{-14} cgs,</u> <2" positions

- ***EXIST***/***IRT***: 0.3-2.3μm imaging & spectra (AB ≤24, 19; R =30, 3000), <0.2" pos.

2000 Hard X-ray Sky

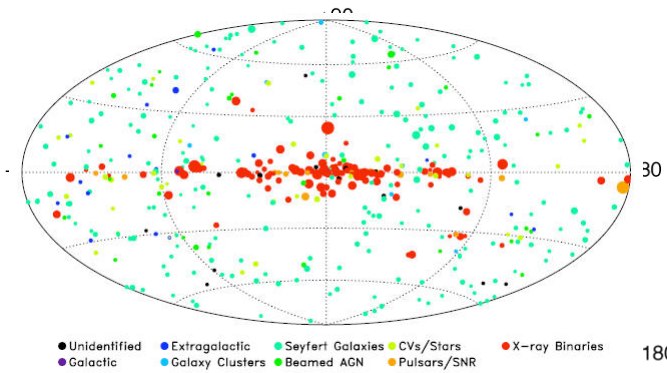
HEAO-1, BeppoSAX



~100 sources

2010 Hard X-ray Sky

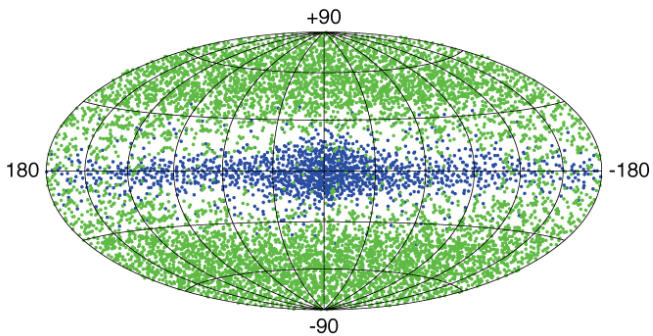
Swift (& INTEGRAL)



~600 sources

2017(?) Hard X-ray Sky

EXIST



~60,000 sources

Primary Science Objectives for *EXIST*

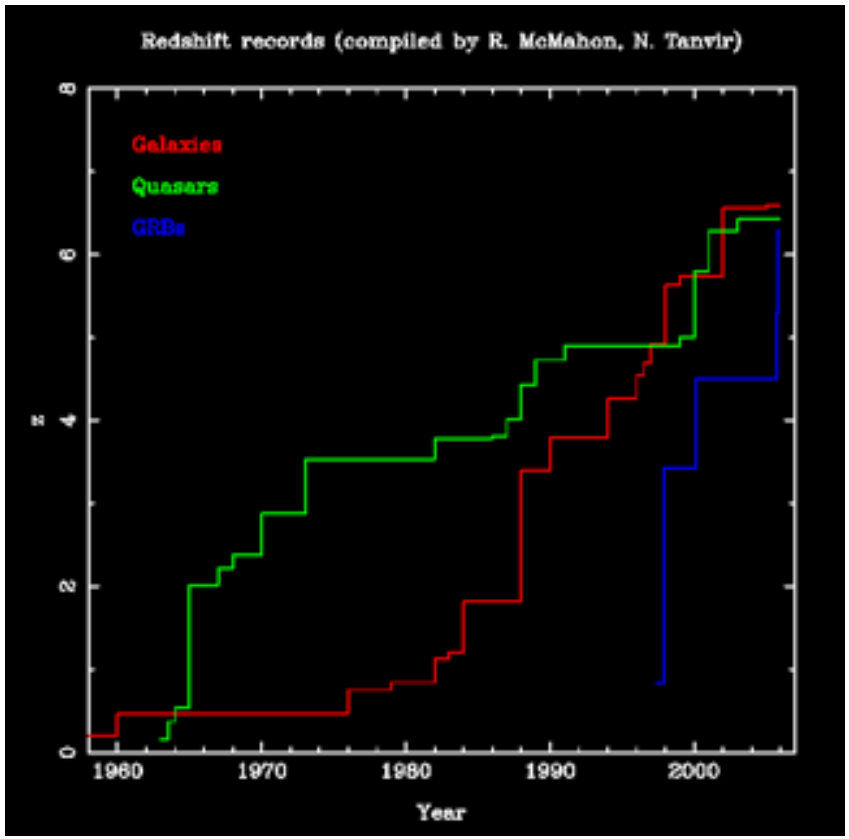
(to survey and study Black Holes on all scales: stellar to supermassive)

- **P1: Measure** cosmic gamma-ray bursts as in-situ probes of the ***Epoch of Reionization at redshifts z >7-10*** from prompt GRB redshifts and spectra

- **P2: Measure supermassive BHs in galaxies**, including *obscured* or *dormant*, to constrain SMBH demographics, growth and evolution, and ***to constrain the accretion luminosity of the universe***

- **P3: Measure the stellar and intermediate mass BH populations in the Galaxy and Local Group** by a generalized survey for Transients for which prompt IDs and X-ray/HX/IR spectra distinguish SNe, SGRs & Blazars and complement ***Fermi, JWST, LSST, Astro-H, LOFAR/SKA/ALMA*** with prompt alerts for unique objects

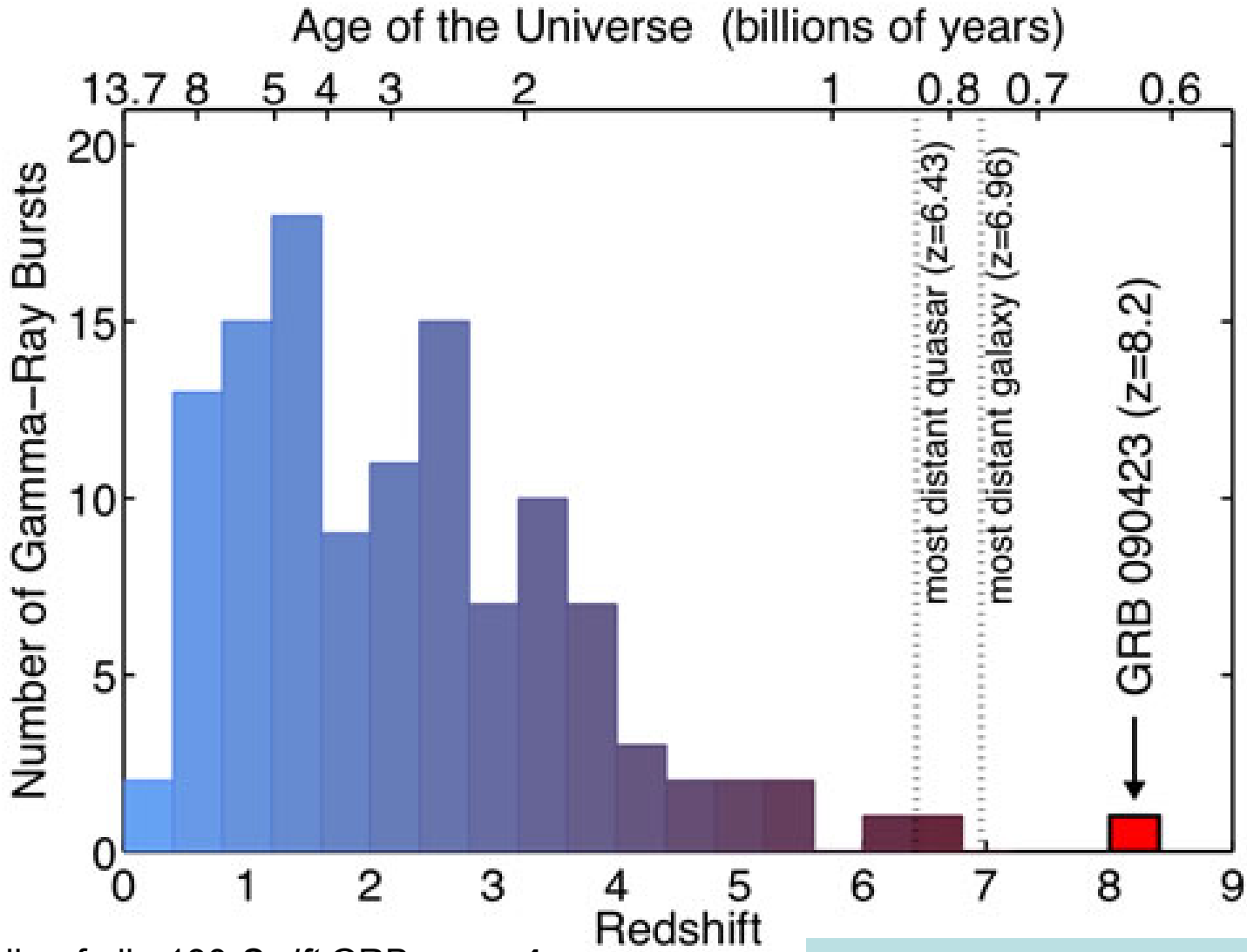
GRBs must preceed QSOs: highest-z stellar Probes



Outdated **record redshift vs. time: GRBs clearly outpace AGN for most effective high-z probes!**

- *Swift* GRBs at z = 6.3, 6.7 and recent record GRB090423 at z = 8.3! *GRBs **are detectable** out to at least z ~8-10 and early Pop II & possibly even PopIII?*
- Broader energy band, higher sensitivity & FoV needed for large sample at z ≥ 8-10
- IR from space needed for z ≥7 since Ly-dropout then in NIR & spectra less sensitive from ground
- GRBs provide "back-light" for IR spectroscopy of host ISM & IGM gas. *Measure galactic structure (vs. z) back to epoch of re-ionization (EOR)*

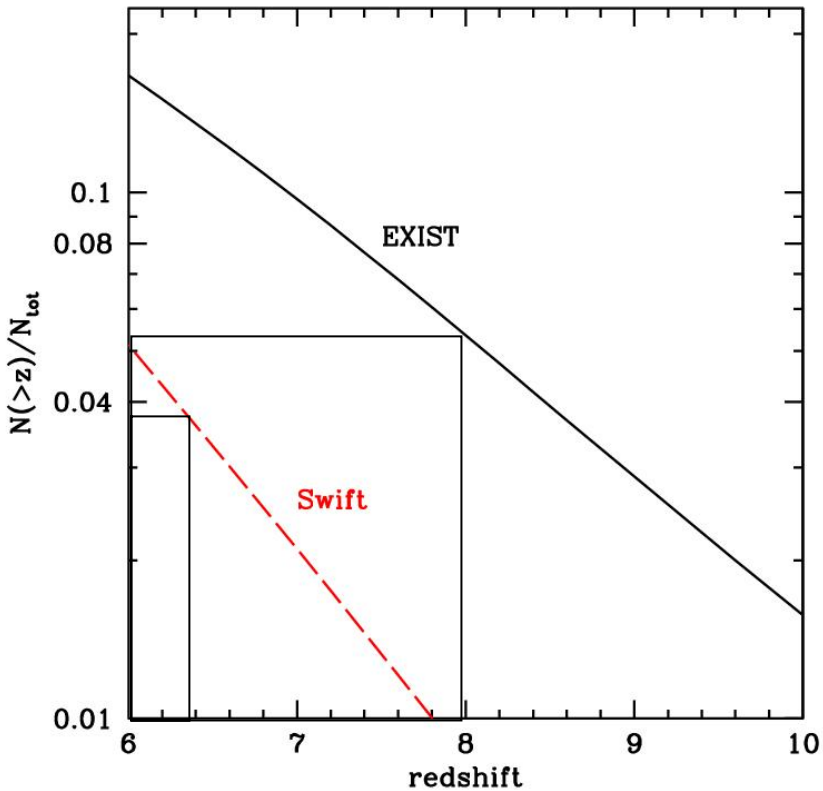
The *EXIST*ence proof… GRB090423



z-distrib. of all ~130 *Swift* GRBs over **4y**:
EXIST **would match this in ~4mo.**

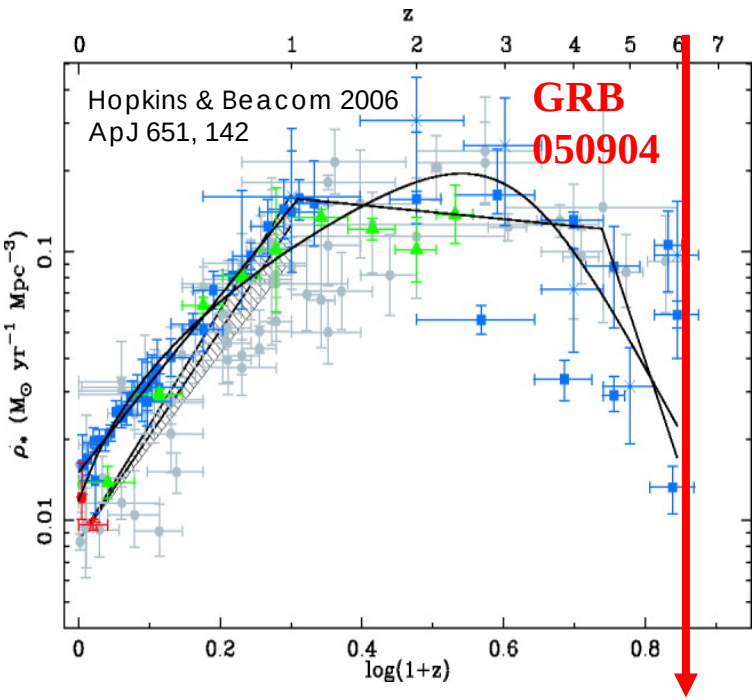
GRBs preceed AGN…

P1: *EXIST* GRBs *probe stellar universe to z ≥ 10*



Predicted *fractional* GRB rates *above* z vs. z for *EXIST* vs. Swift/BAT based on Salvaterra (2009). *EXIST will detect ~600 GRBs/y and thus ~90/y at Z > 6 and thus ~0.055 x 600 = 33 at z >8 per year!*

Swift detects ~100 GRBs/y and now ~450 GRBs. It should detect ~0.04 x 450 = 18 at z >6 and has now detected 3, suggesting most are missed.

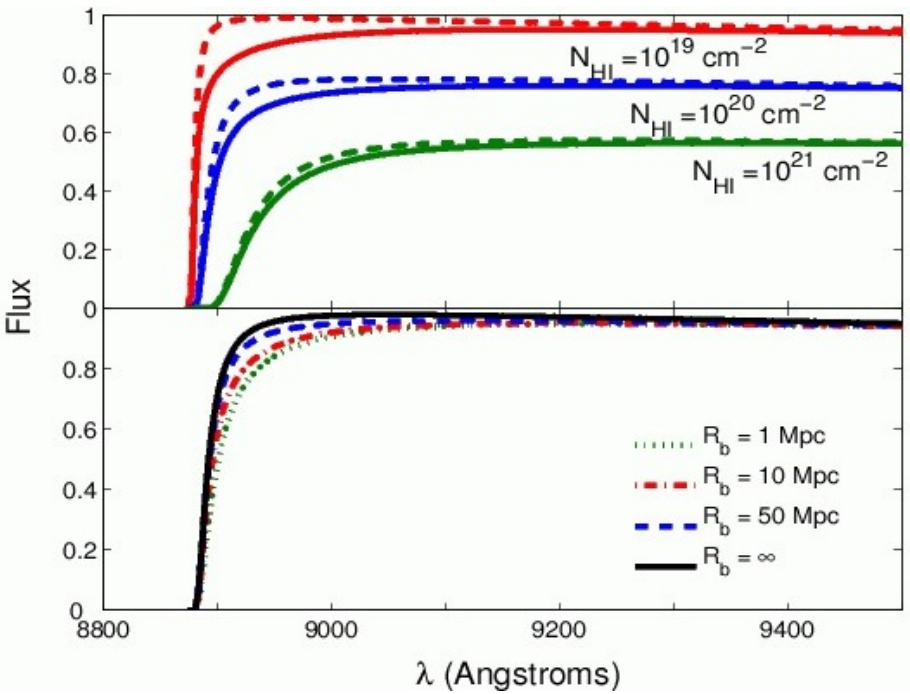


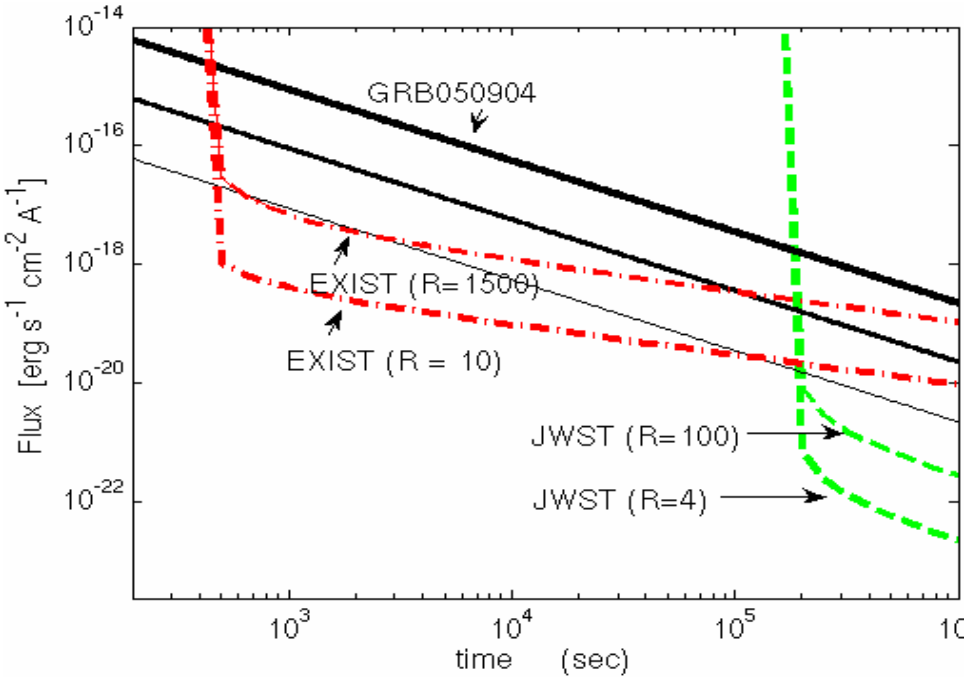
EXIST GRBs vs. z will probe the star formation rate (SFR) vs. z at highest redshifts, and constrain/measure Pop III.

EXIST will probe:

EXIST IRT spectra (R = 30) in 300-1000s: AB(H) ~23-24

2 VIS + 2 IR bands enable ***GRB redshifts*** out to z ~20(!)





Sensitivity of Ly-break *shape* to local IGM & EOR (McQuinn et al 2008)

IRT vs. JWST for GRBs 1X, 0.1X and 0.01X flux of GRB050904.

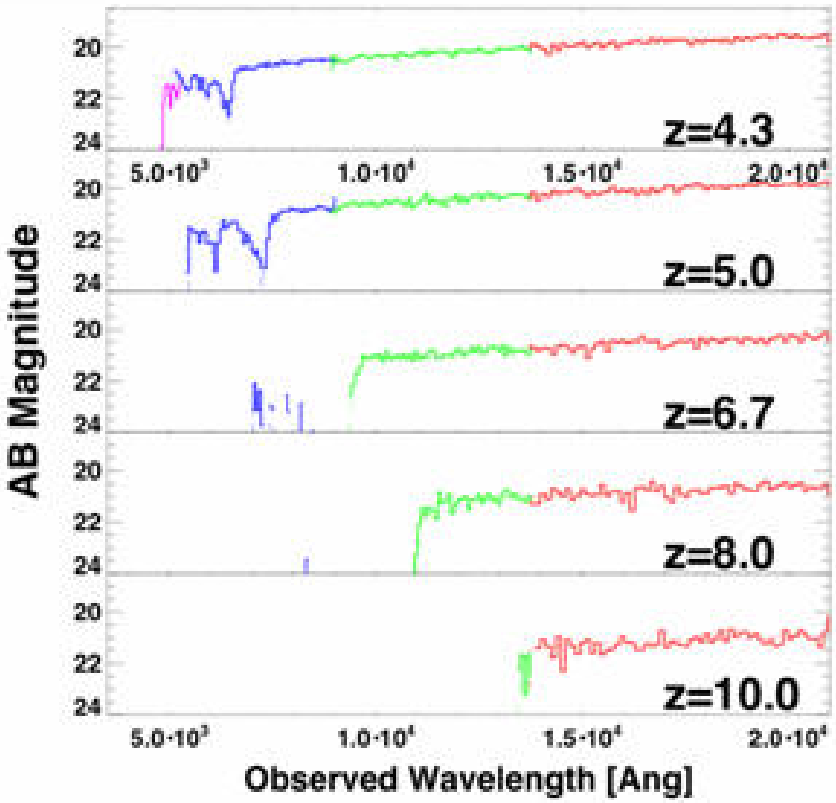
- **IRT spectra (R ~3000) for AB(H) ~18-20 in 2000sec exp. *simultaneously* for optical (0.3-0.9μm) and IR (0.9-2.1 μm): Ly profiles for EOR studies of high-z IGM**

- **Simulations: > 450 GRBs/yr *of EXIST GRBs would have z measured* ; and ~40/yr at z >7. Over 5y mission, expect N(z>8) ~ 50-100 EOR sight-lines measured.**

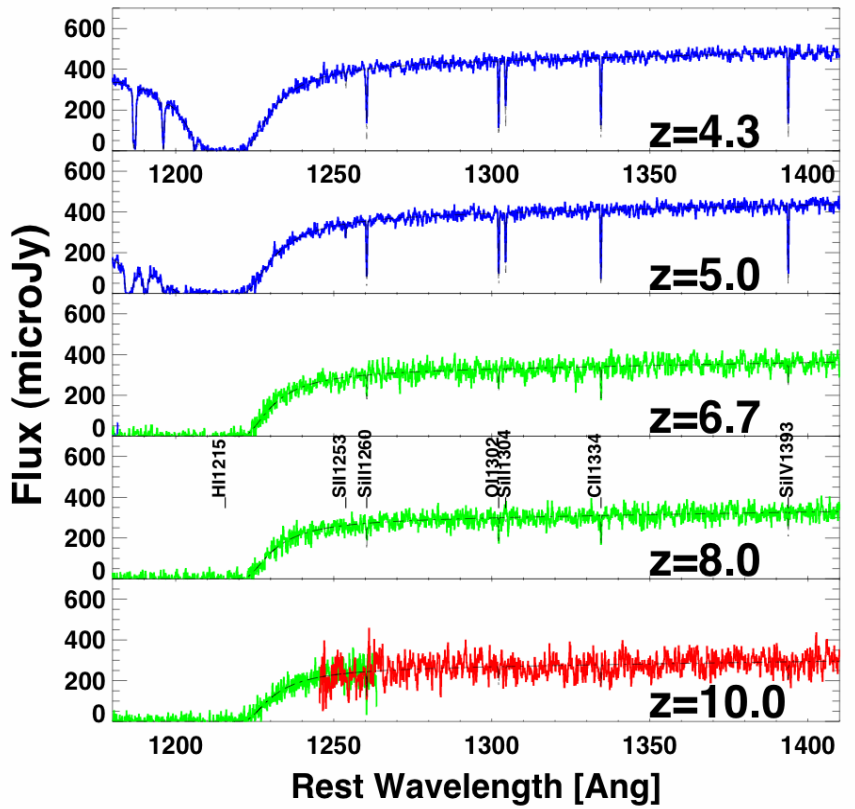
Simulated Ly-breaks for EXIST ***IRT*** vs. z (*R = 3000, T = 2000sec*)

for a GRB 3mag brighter than the anomalously faint GRB080913 (z = 6.7)

R = 30 Grism, imaging or slit, for AB(H) > 20



R = 3000 long slit (4"), for AB(H) <20



Assumed model (which *IRT* tests!):

AB(H) = 15.5 at T =200s, then GRB lightcurve decays: $F \sim T^{-1}\ \nu^{-1}$ Log(NH) = 20 in GRB host

Metallicity vs. z: z < 6, [Fe/H] = -2 6 < z < 7, [Fe/H] = - Z > 7, [Fe/H] = -4

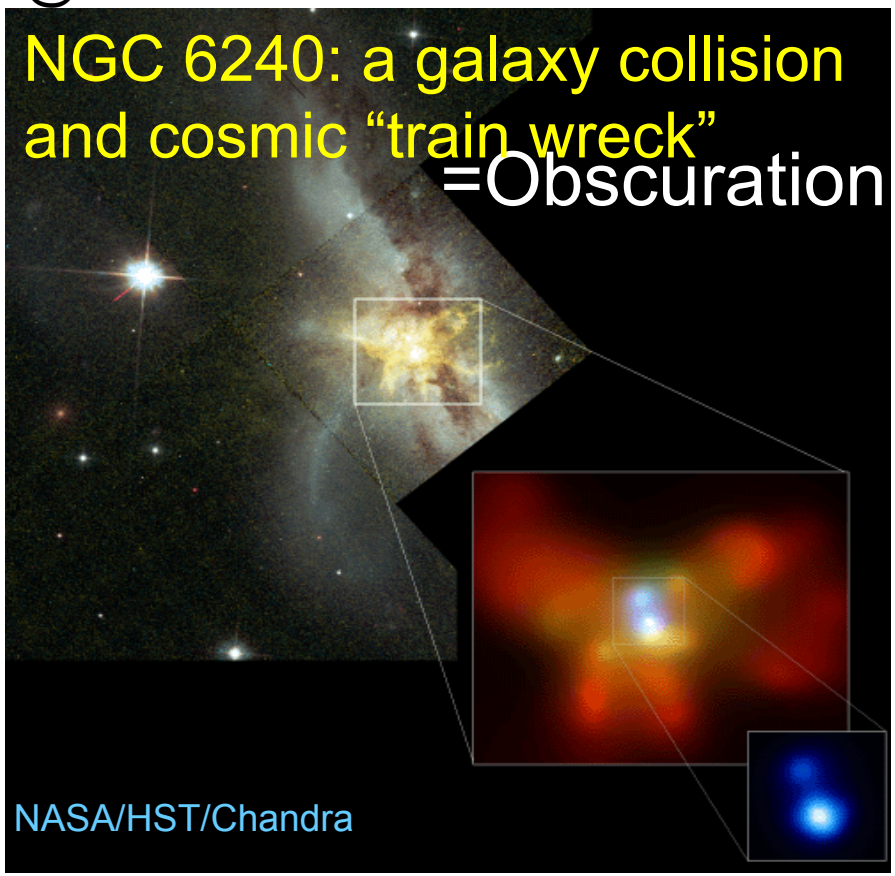
Simultaneous spectra obtained in 4 IRT bands: **0.3 – 0.9μm, 0.52 – 0.9μm, 0.9 – 1.38μm, 1.38 – 2.1μm**

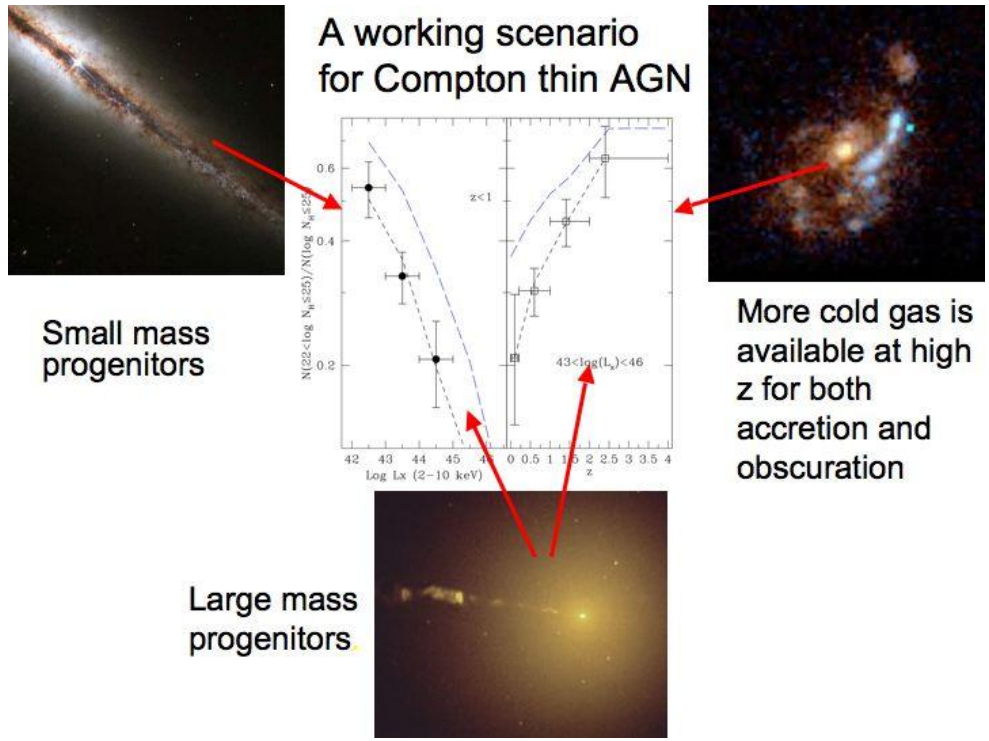
EOR & Fe/H can be measured vs. z!

P2: Obscured or Dormant AGN (all types) & Blazars vs. z?

• ***EXIST*** discovers: 1) ***obscured AGN*** over a broad range of Lx and absorption column NH *to constrain NH vs. z and growth of SMBHs*, and 2) ***Dormant SMBHs*** (like SgrA*) *revealed by HX flares from Tidal Disruption of field stars* → ***LISA triggers***

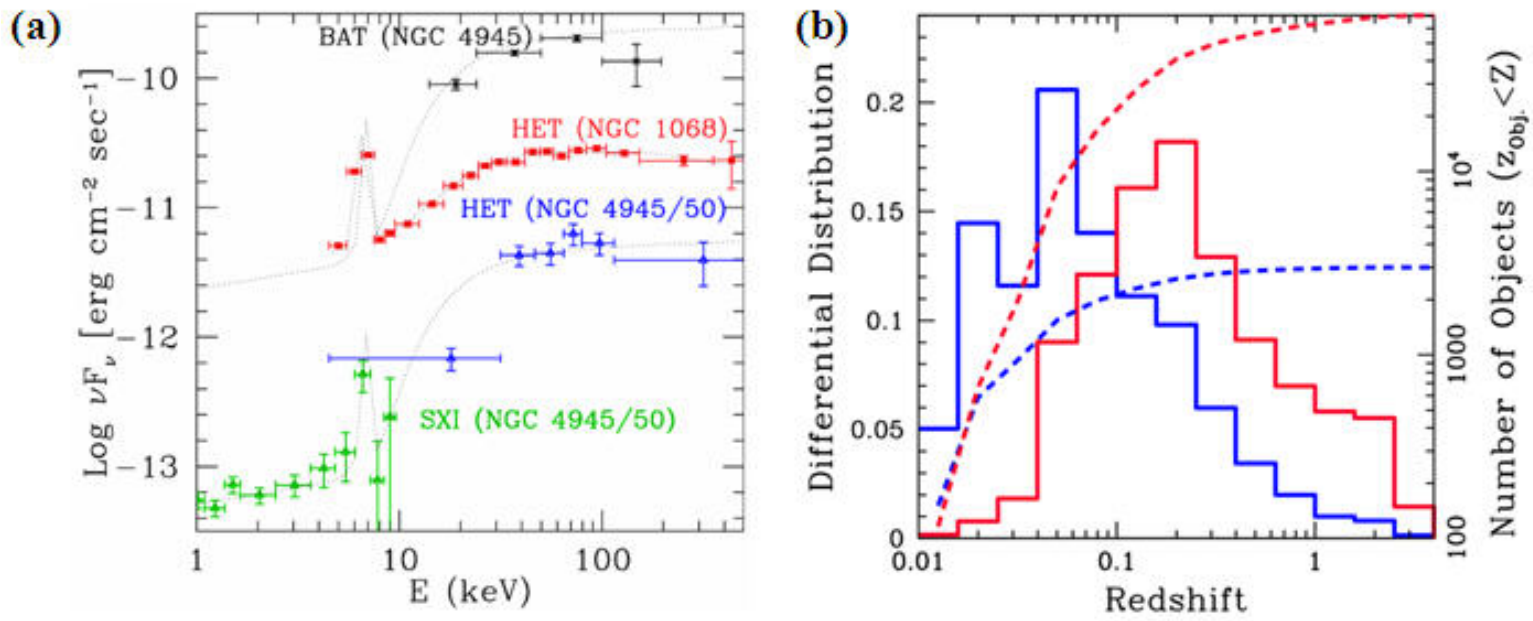
• ***EXIST*** best suited to discover rare ***Type 2 QSOs*** at z ≤3 and study Type 2s vs. SFGs @z~1





EXIST **survey will explore the evidence (e.g. La Franca et al 2005 and Treister & Urry (2006) that obscured AGN are *increasing as* $(1+z)^{0.4}$**

EXIST detects the missing *Compton Thick AGN*

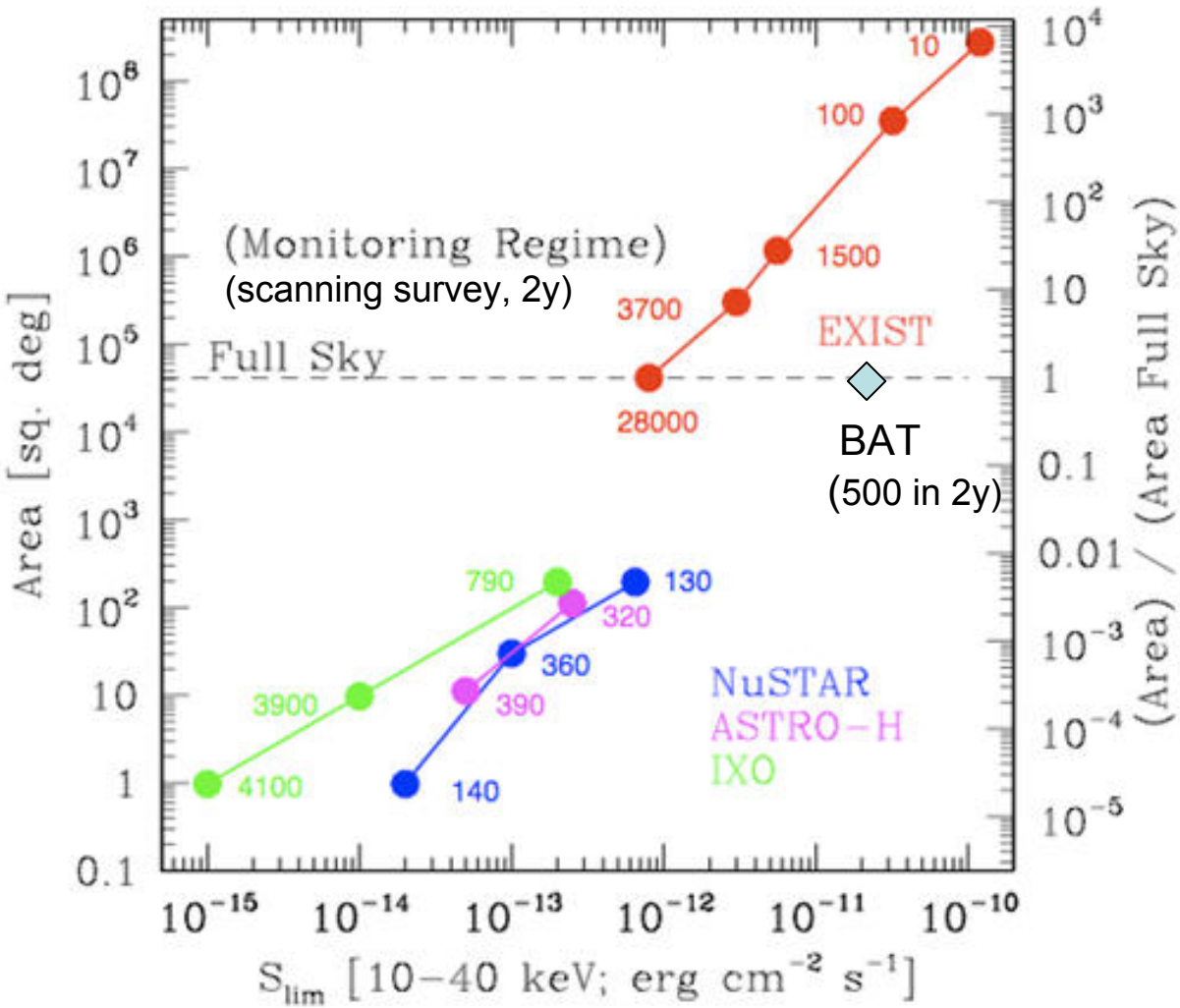


- Less than 20 Compton-thick AGN measured at >10 keV (e.g. NGC4945 & NGC1068). ***EXIST*** would detect objects 50X fainter than N4945(Fig. (a))

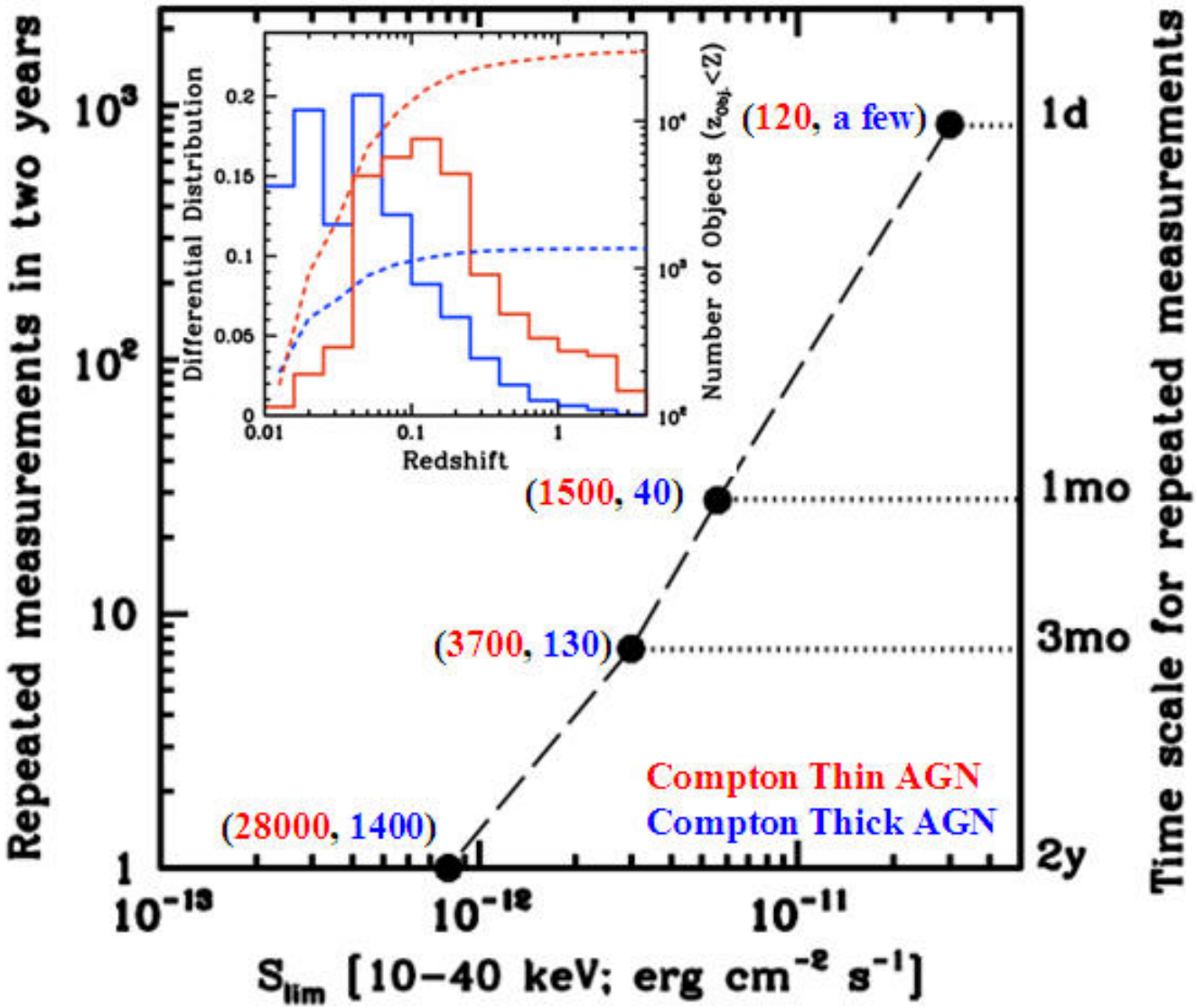
- Large sample of Compton **THICK** (~10,000?) vs. **THIN AGN** (~40,000) in Fig. (b) will also be *only method to find RARE Type 2 QSOs out z ~3*

EXIST AGN survey (10-40 keV) vs. IXO, Astro-H and NuSTAR

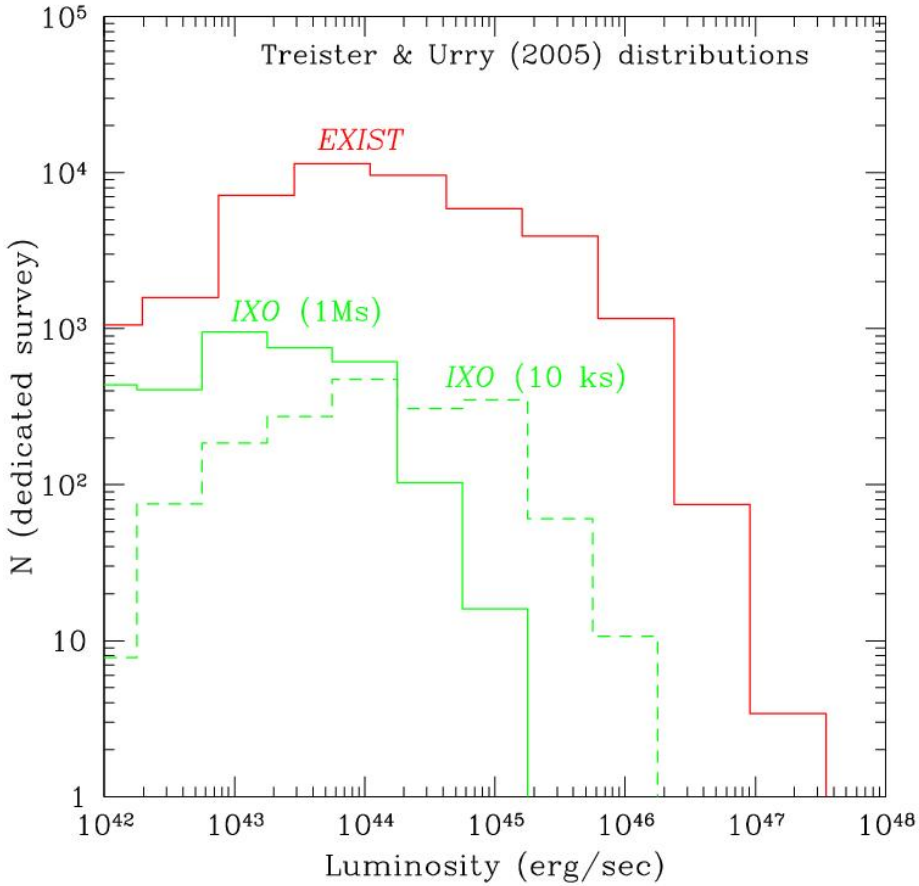
- Compare *hypothetical* pure 2yr pointing survey (2/3 of time) for IXO, NuSTAR, & Astro-H for T_{exp} ≥10ksec vs ***EXIST*** scanning survey
- ***EXIST*** complements HX focusing (deeper) missions with *much larger samples*
- ***EXIST*** alone detects rare classes of objects (Type 2 QSOs; extreme Blazars
- ***EXIST 5y mission survey*** reaches S_{lim} ~4 x 10^{-13} cgs ***full sky*** for ~60,000 sources

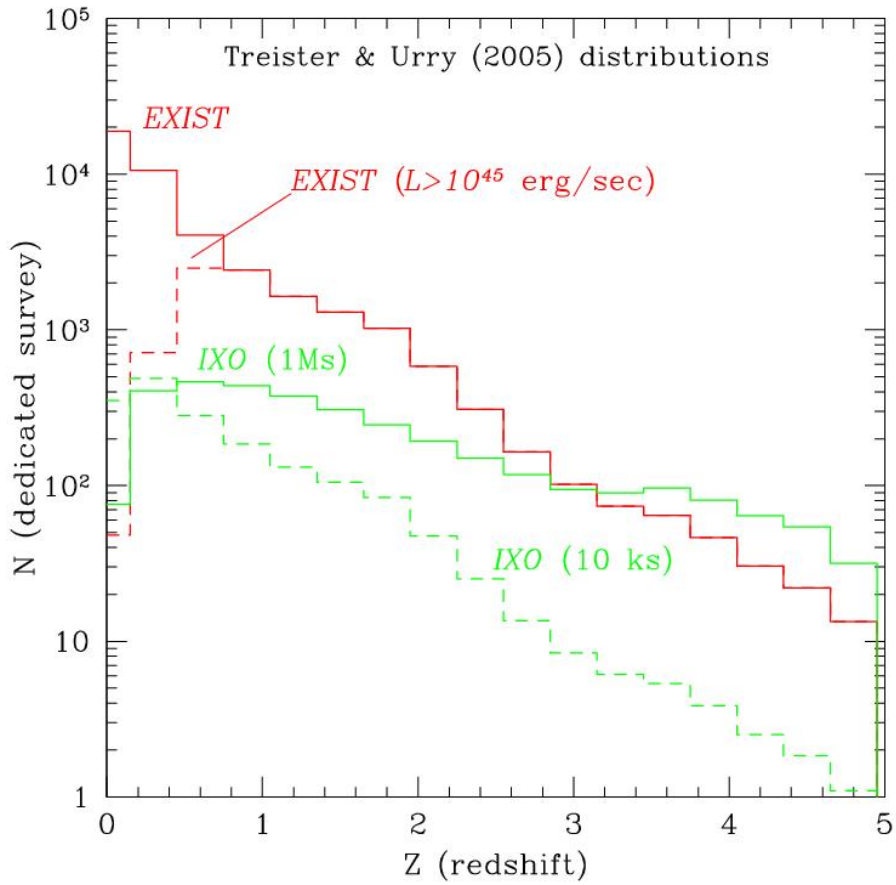


EXIST provides temporal monitoring: SMBH mass constraints



EXIST survey probes Lx, z distributions

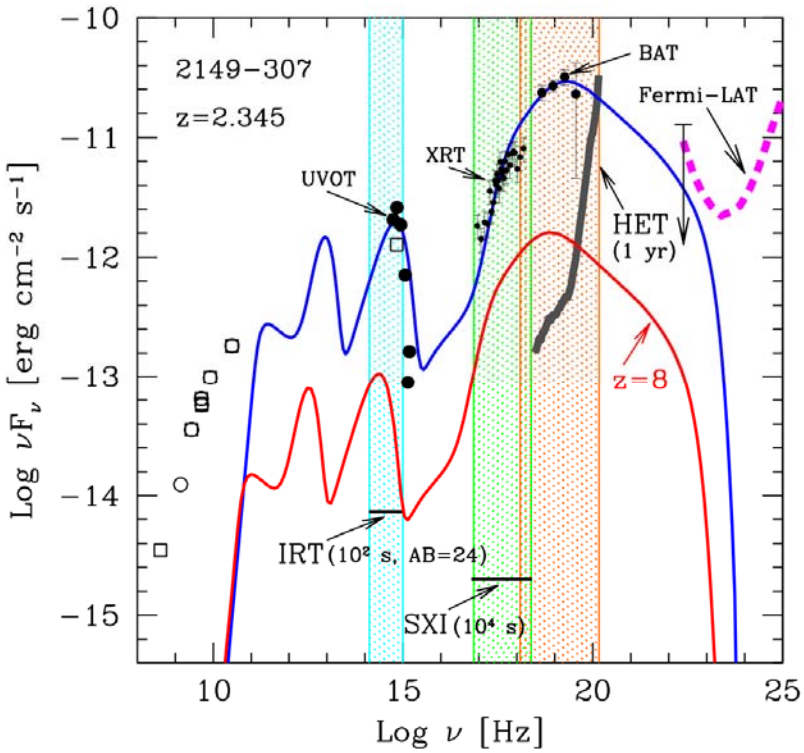




For Lx ≥10^{43} and z ≤3, the 2y scanning survey at 10-40 keV with ***EXIST*** achieves better ***AGN statistics*** in the Lx, z distribution than focusing missions (10-40 keV)

EXIST could extend Blazar surveys to z ≥8 ! (should they *EXIST*…)

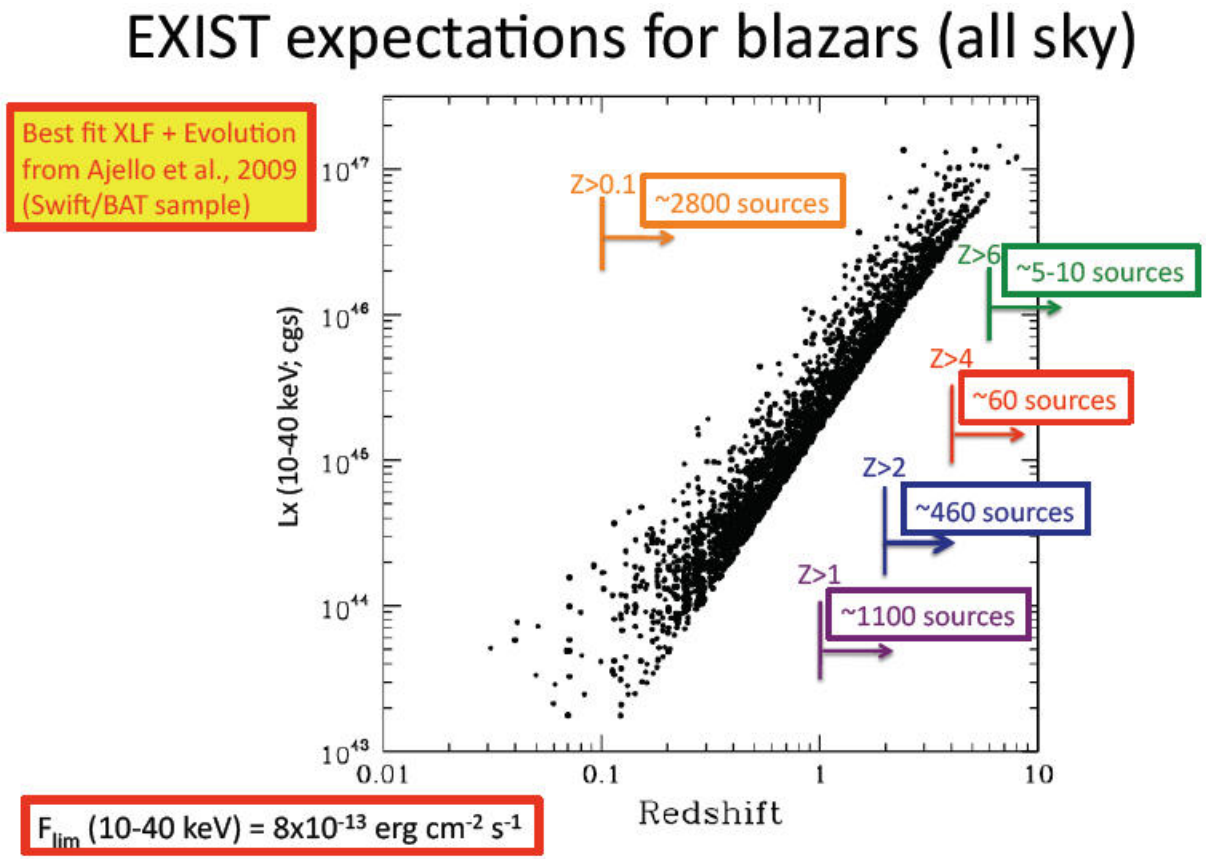
- Blazars are the AGN analog of GRBs: persistent, extreme-beamed and exceptionally luminous and variable
- Understanding their formation and evolution requires deep full sky samples with sensitivity to rapid variability
- ***EXIST*** could detect the Blazar 2129-307 detected by Swift/BAT, XRT, UVOT out to z ~8. Blazars might best probe SMBH growth?!
- Sensitivity for detection and variability study with ***EXIST***/HET exceeds Fermi/LAT



IRT and **SXI** sensitivities allow short observations during **HET** survey or pointings. ***IRT*** measures redshifts directly for Blazar survey

EXIST will detect *large* Blazar samples:
(to "beam in" to the first SMBHs?)

- *Swift*/BAT sample of >20 blazars out to z ~3 implies large nos. for ***EXIST***
- Highest m-dot when SMBHs growing at z >7 ⇨ ***jets*** & thus blazars as larger fraction of AGN than in local Universe
- All-sky req. for rare objects; redshifts from IRT "easy" from Ly-α breaks in cont. spectra (like GRBs!)

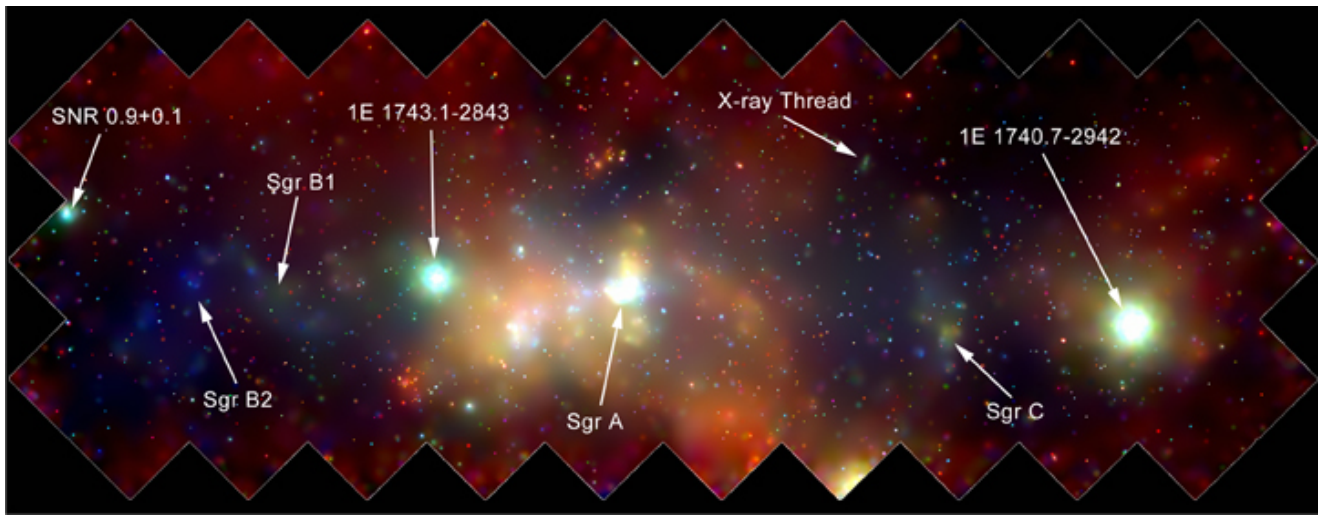


P3: *EXIST measures* stellar BHs & IMBHs as *Transients* in Galaxy, Local Group

- ***EXIST*** detects ***all*** bright stellar BHs in transients (Lx(>10 keV) ~$10^{36\text{-}38}$ erg/s) throughout Galaxy, LMC/SMC and M31. ***Reveal population of obscured HX sources. QPO monitoring of bright BH-LMXBs; ULX's in Local Group***

- ***Isolated* stellar BHs in Galaxy and IMBHs** in Local Group accreting via Bondi-Hoyle (with ~10^{-4} efficiency) from GMCs nearly Compton thick

- **Faint BH transients in *Central Galactic Bulge*?**: BHs in nuclear cusp (Alexander & Livio 2004) detected (~10d) as VFXTs if Lx(>10 keV) ~$10^{34.5}$ erg/s
  BH vs. NS or WD binaries around *SgrA** distinguished by Type I bursts & novae



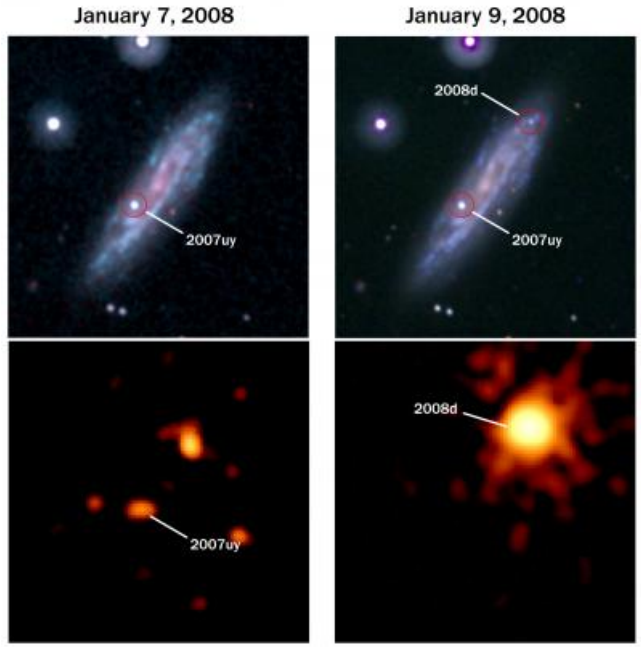
Chandra view of central Bulge (~ 2° x 1°)

And more High Energy Transients…

- **Supernovae *breakout shocks*** like NGC 2770/SN2008d discovered with Swift/BAT: ***EXIST*** HET sensitive down to ~5keV can image these on the fly and **trigger Neutrino and Gravitational Wave telescopes**

- **Soft Gamma-ray Repeaters** (SGRs): ***Magnetar survey out to ~300Mpc*** can **provide triggers for LIGOII**

- **Blazar flares**: “contamination” of high-l modes of CMB by flaring flat-spectrum radio sources; evidence for significant flaring hard X-ray Blazars from Swift BATSS (Grindlay et al 2009, in prep.)



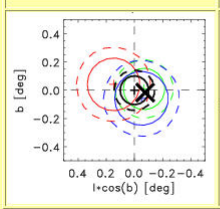
Scientists had planned on studying Supernova 2007uy in the galaxy NGC2770, which was already several weeks old when seen in this visual, ultraviolet image (upper left) taken on Jan. 7, 2008, by NASA's Swift satellite. A close-up, X-ray image of that supernova is beneath.

Seemingly out of nowhere, Supernova 2008D burst onto the scene on Jan. 9, 2008, as seen in ultraviolet images (upper right) and X-ray images (beneath) taken by NASA's Swift satellite, giving scientists the unique opportunity to witness the birth of a supernova.

Candidate source: BATSS_J1425+363

Coordinates:
RA, Dec (J2000) = 14h 24m 44s, +36d 19' 38"
l,b = 63d 41' 50", +68d 12' 37"
Radius (90.0%) = 6.1 arcmin

Candidate criteria satisfied:
Index 6: Non-simultaneous coincidence (S/N>4.0) over more than 2 spacecraft orbits

Local plot	Transient Catalog Matches	Blazar Catalog Matches			
		Avg. position (90%rad)		Ind. slews (99%rad)	
		real	random	real	random
	None	Multi-freq BZBJ1424+3615	0.008±0.089	Multi-freq BZBJ1424+3615	0.048±0.214

EXIST scanning demonstrated with BAT Slew Survey (BATSS)…

- Swift conducts ~4 slews per orbit (to/from targets and Earth limb avoidance) at ~45arcmin/sec, moving BAT FoV by ~2-3 diameters. Aspect file gives S/C pointing direction each 0.2sec (~9' ~BAT res/2)

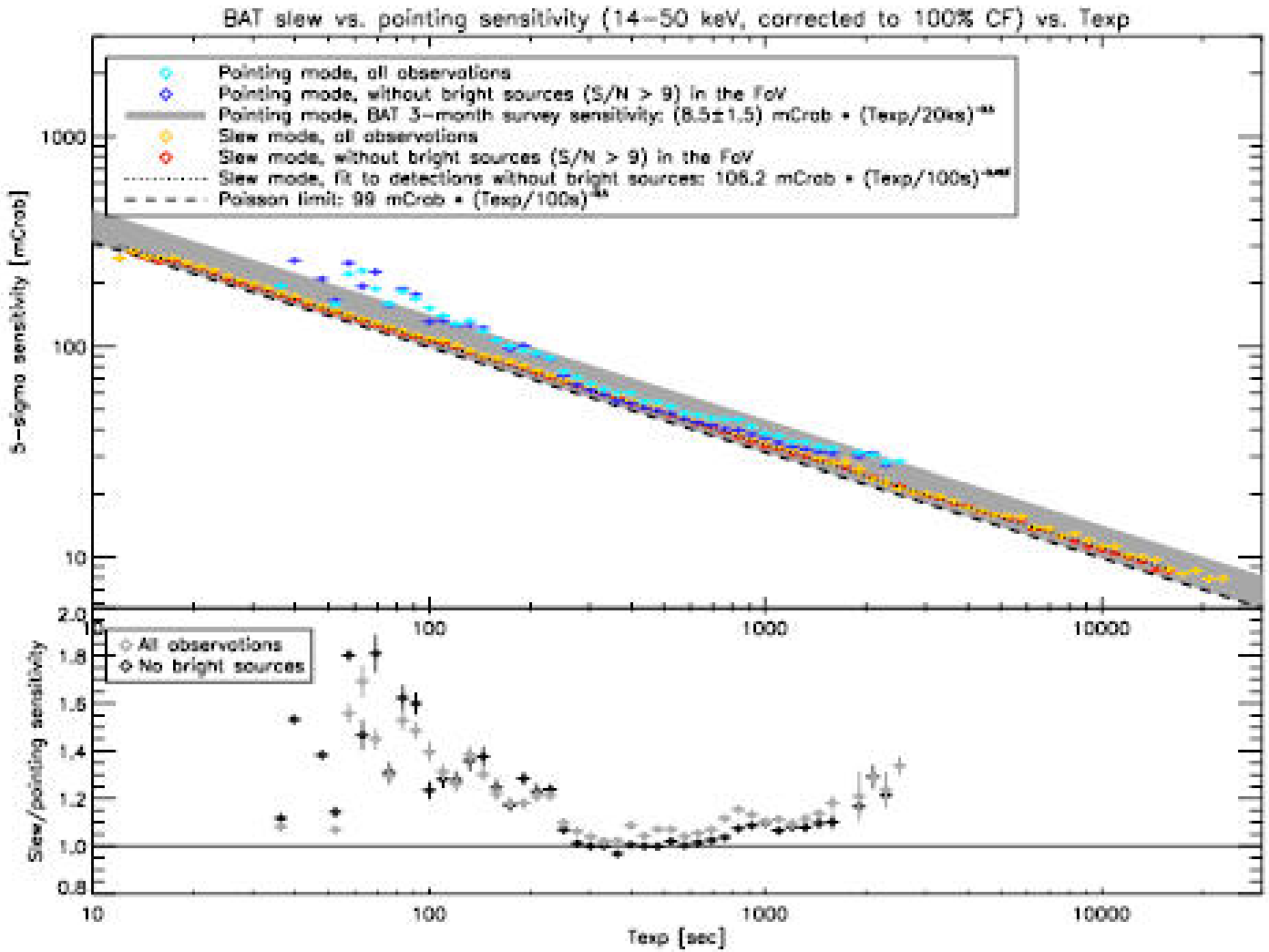
- By turning "event mode" data on during a slew, and sending it down on next TM pass, BAT imaging tools can be run on each 0.2sec data segment to make 500 images in given band for a 100sec slew and then co-add for sky image (not trivial…). *BATSS provides the only high-time res. Data from Swift/BAT; all other data (except GRBs) comes down as **5min** integrations!*

- BATSS images formed in 2 bands (S= 15-50keV and H= 50-150keV) and BAT detect run on each separately as well as on co-added broad band image (B = 15-150keV)

- **Full BATSS data release and catalogs coming *SOON* on CfA website**

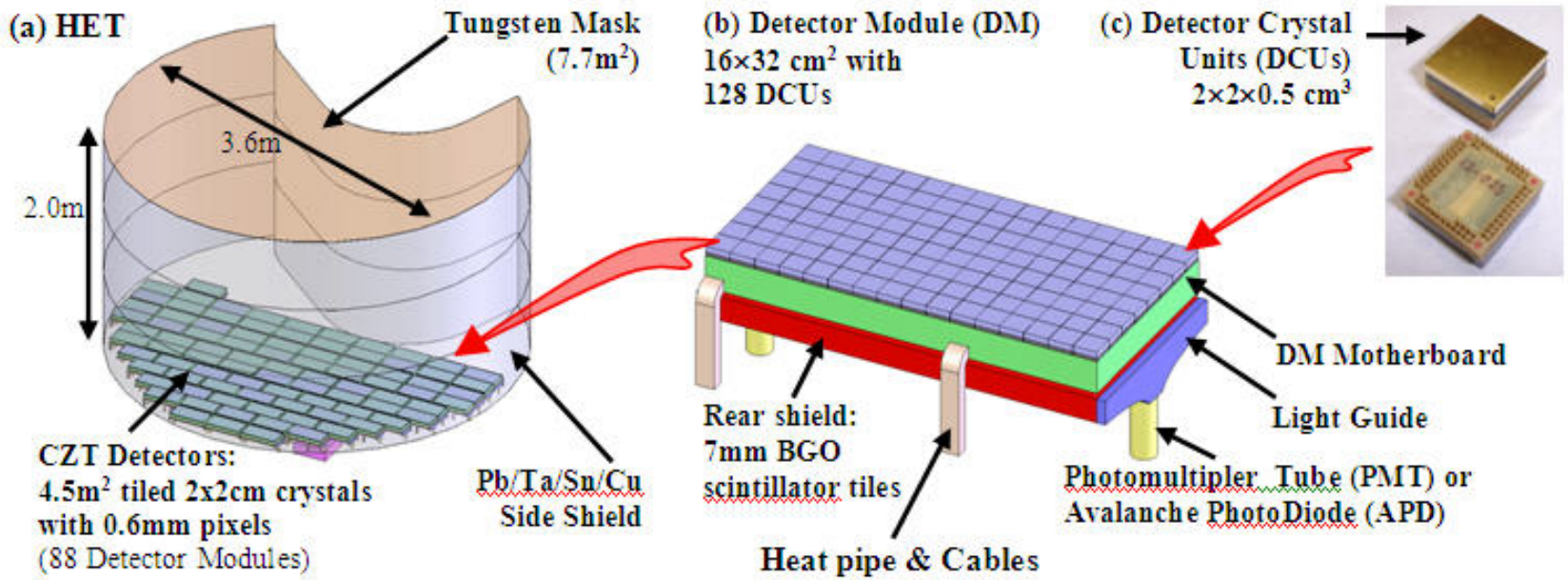
See Copete + 2009a,b for full description of BATSS processing; Copete + 2009c for GRB results and Grindlay + 2009 for Blazars

BATSS has demonstrated enhanced Scanning sensitivity vs. Normal BAT (or INTEGRAL) pointings



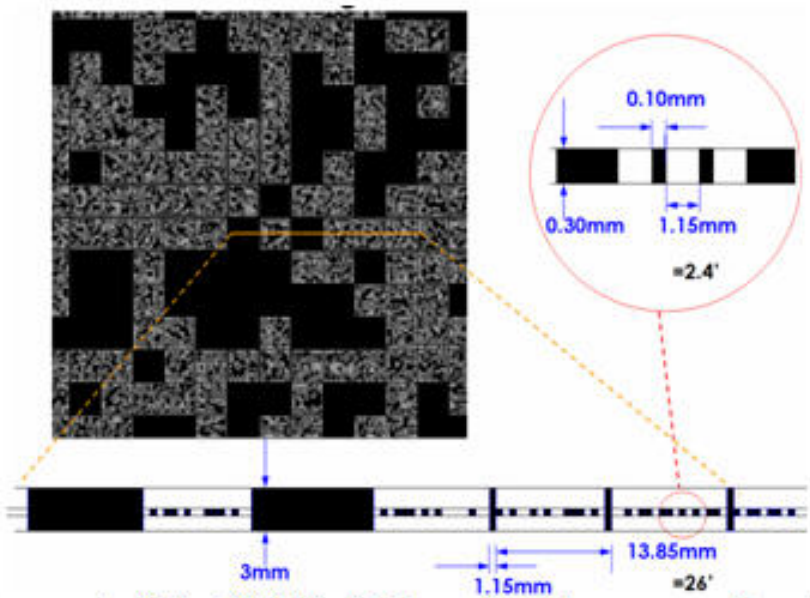
Factor of ~1.6 enhanced sens. For Texp <200sec; factor ~1.3 for Texp >2ksec

Design of the Mission…
High Energy Telescope (**HET**) Detector Design



(a) The HET design overview and the CZT detector plane consisting of (b) Detector Modules (DMs), which in turn consist of (c) Detector Crystal Units (DCUs).

HET coded mask design and Instrument Summary



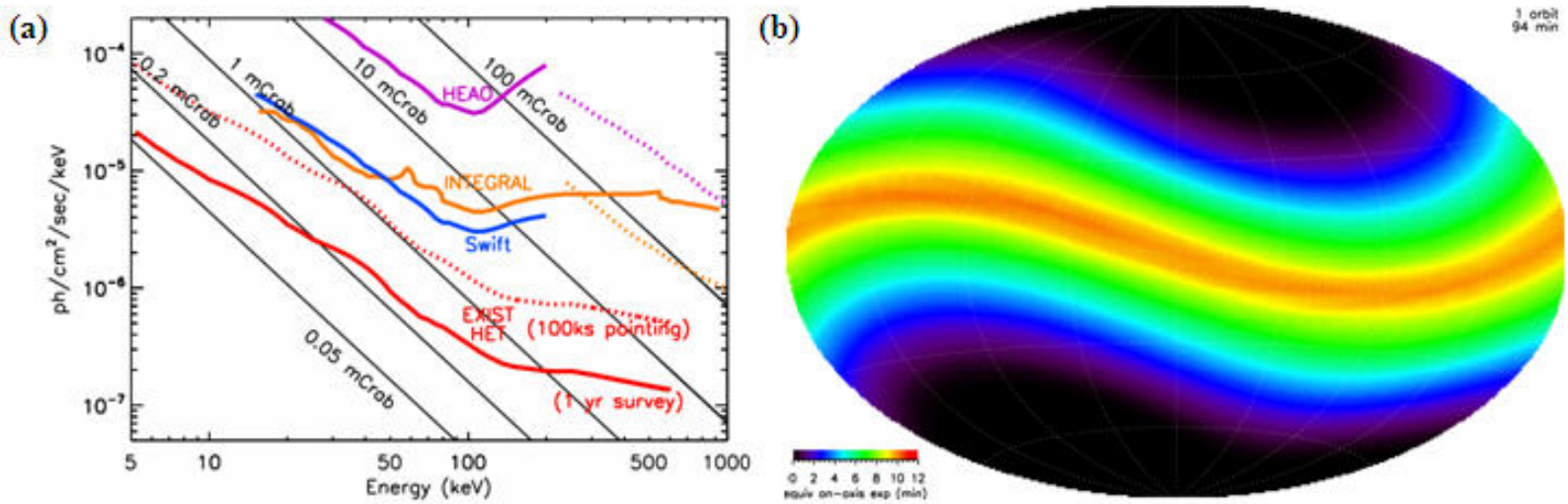
Segment of the HET hybrid mask with cross sectional view: coarse (15mm pitch, 3mm thick) and fine (1.25mm pitch, 0.3mm thick).

EXIST/HET parameters.

Parameters	Values
Telescope (coded-aperture)	4.5m² CZT (0.6mm pix, 11.5Mpix) 7.7m² Tungsten mask
Energy Range	5 – 600 keV (imaging CZT) 200 – 2000 keV (BGO for GRBs)
Sensitivity (5σ) (~1y survey)	0.08– 0.4mCrab (<150keV) 0.5–1.5mCrab (>200keV)
(10s on-axis)	~24mCrab (<150keV)
Field of View	90° × 70° (out to 10% coding)
Angular Res. Centroiding	2.4′ resolution <20″ for >5σ source (90% conf. rad.)
Sky Coverage	Full sky every two orbits
Spectral Res.	2–4 keV (3% at 60 keV, 0.5% at 511 keV)
Time Res.	10 μsec
Heritage	*Swift*/BAT, *INTEGRAL*/IBIS, *Fermi*/LAT

EXIST sky survey coverage and sensitivity

(5σ survey threshold, 1year of mission ops., **full-sky**; 15° orbit incl.)



EXIST*-*HET survey vs. pointing sensitivity **(a)** and sky coverage over 1 orbit **(b)**

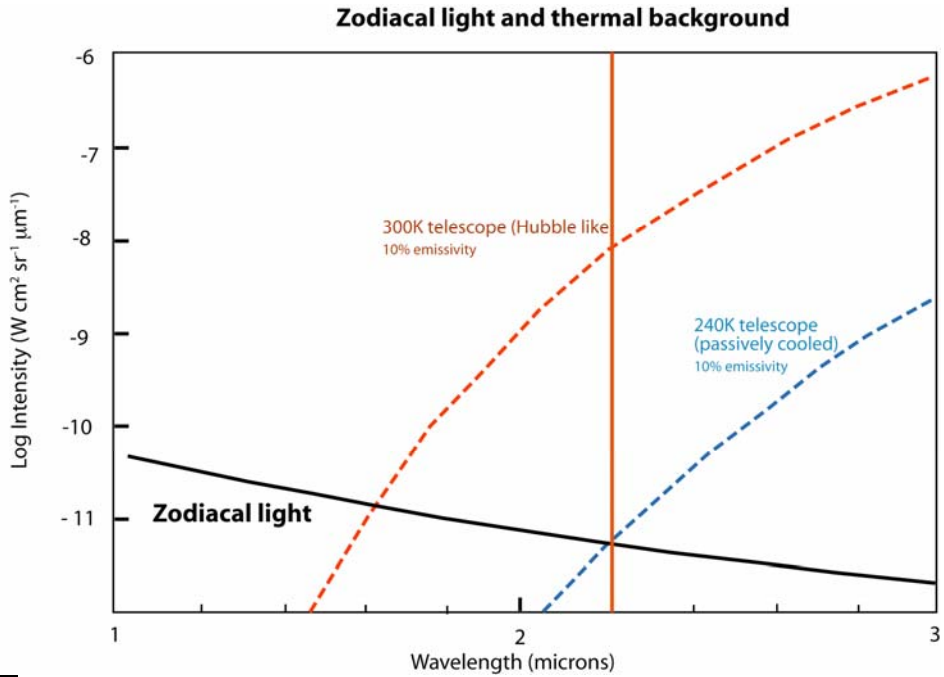
5σ in *1 yr sky survey* flux sens. over band ΔE=E , with image psf 2' & pos. <20"

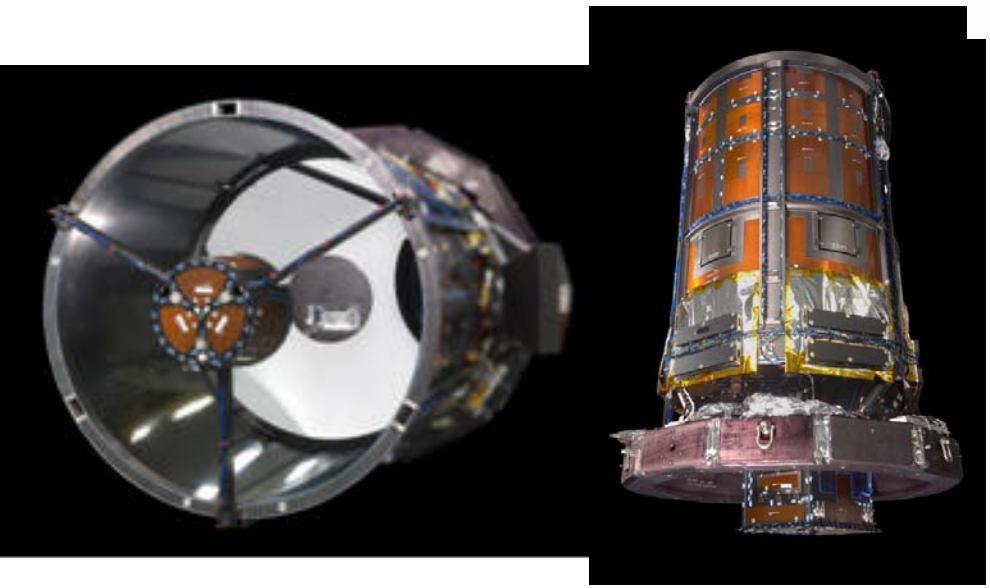
- **0.08mCrab = 7 x 10^{-13} cgs, *(~5-10X below Swift/BAT)* for HET (5-100 keV)**
- **~0.5mCrab = 1 x 10^{-11} cgs (*~20X below INTEGRAL/IBIS)* for HET (100-600 keV)**
- ***~600 GRBs/yr (~6X Swift/BAT rate) and ~30,000 AGN: IRT redshifts for most!***
- ***unique* ~15% duty cycle coverage on any source, ~90% *full-sky every 3 hours!***

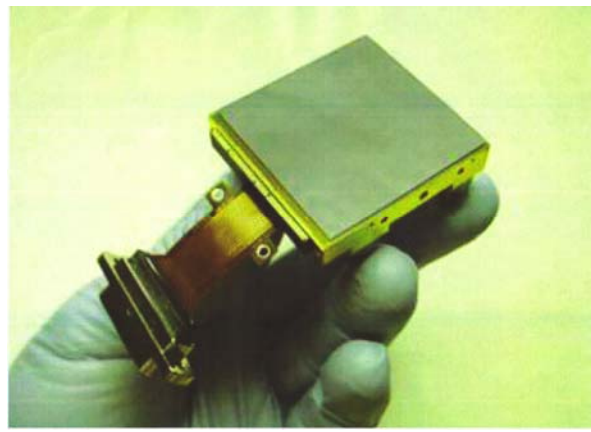
EXIST IRT: 0.3-2.3μm imaging & spectroscopy

- IRT mirror (primary and secondary) passively cooled to -30C (radiator) give zodiacal light limited backgrounds: *IRT could be* ***~10X faster than Keck*** *at 2μm!*

- IRT based on space-qualified 1.1m telescope (ITT-*GeoEye*) and H2RG IR arrays with readout ASIC (developed for JWST-NIRSPEC/NIRCAM)



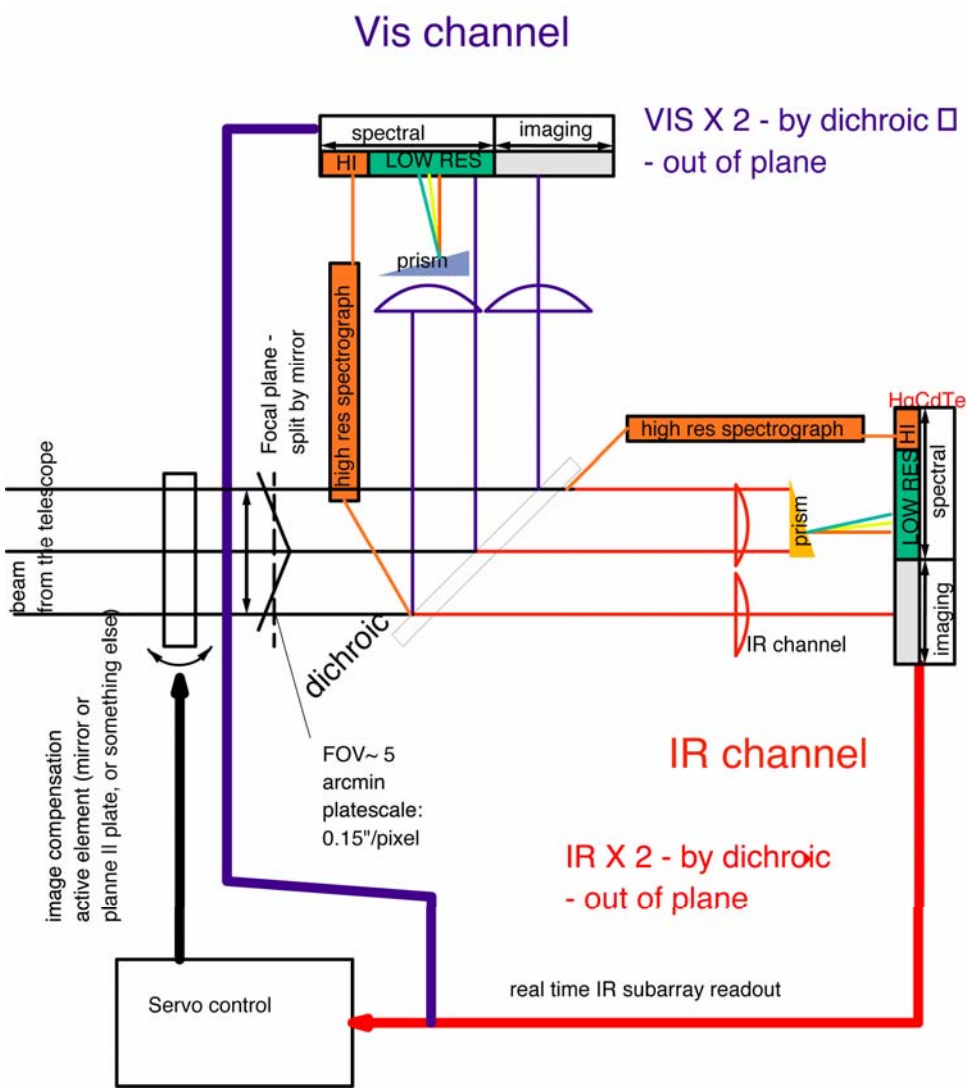


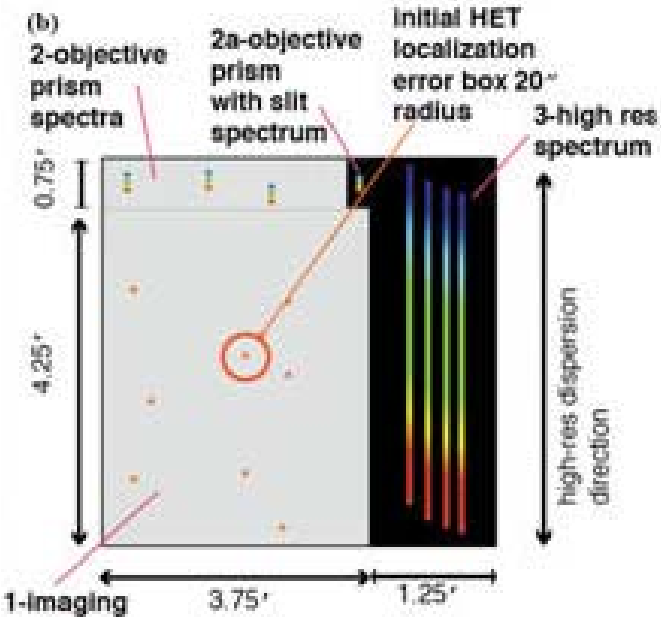


IR: HgCdTe +H2RG detectors (2K x 2K)
Vis: CMOS+H2RG (2K x 2K); pix size 0.15”

IRT telescope and instrument **layout**

(H. Moseley & A. Kutyrev design)

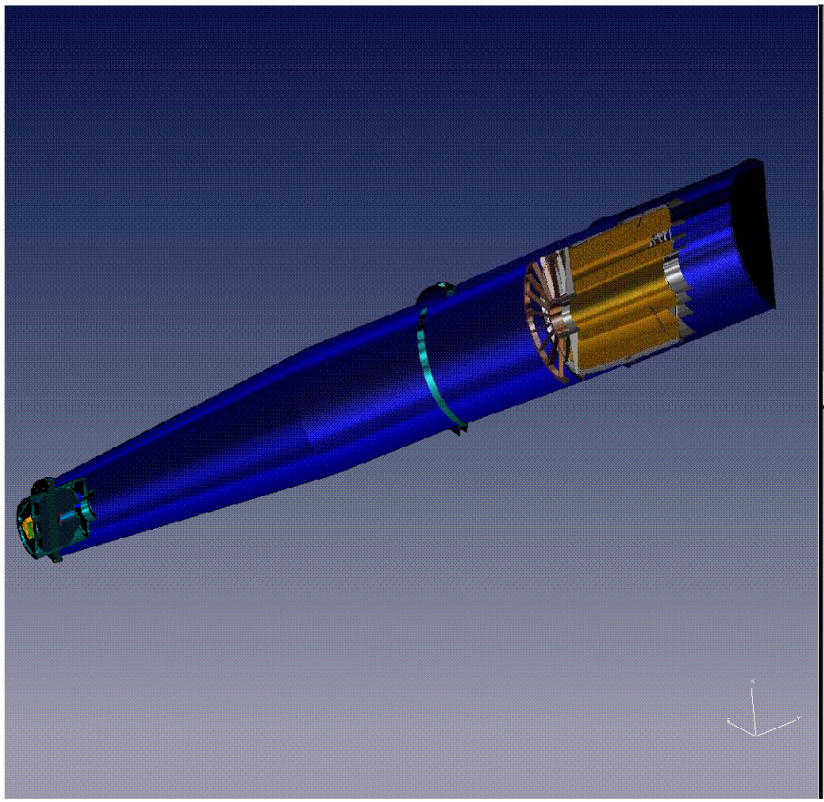


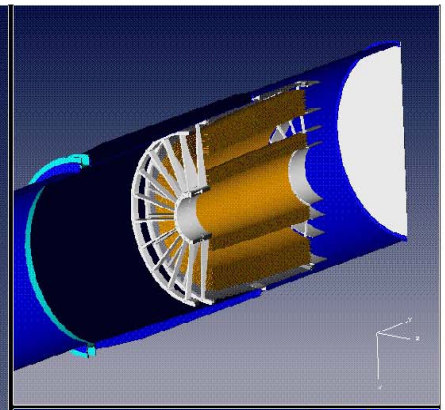


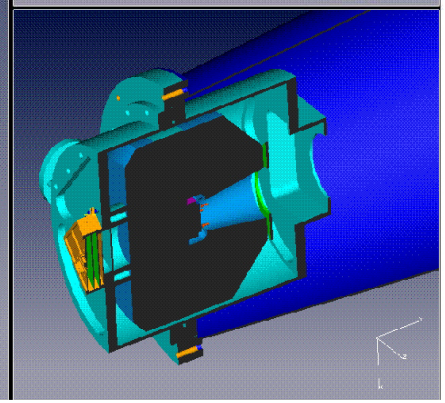
EXIST IRT parameters.

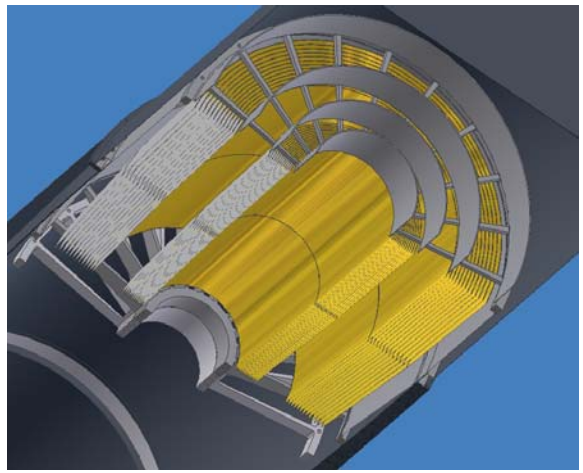
Telescope	1.1m aperture Cassegrain		
Ang. Res.	≤0.3″ PSF (0.15″/pixel pl. scale)		
Spectral Bands (4)	0.3 – 0.52, 0.52 – 0.9μm (*HyViSi*) 0.9 – 1.38, 1.38 – 2.2μm (*H2RG*)		
Mode	**Field of view**	**Spec. Res.**	**AB (S/N≥5σ) @ int. time t_{int}**
Imaging	3.75′×4.25′ (16arcmin^2)	~3	24 (100 sec)
Low Res. Obj. Prism	3.75′×0.75′ (1.8arcmin^2)	~30	22 (300 sec)
Low Res. Single Slit	20″ long slit	~30	23 (300 sec)
High Res. Single Slit	4″ long slit	3000	18 (1 ksec)

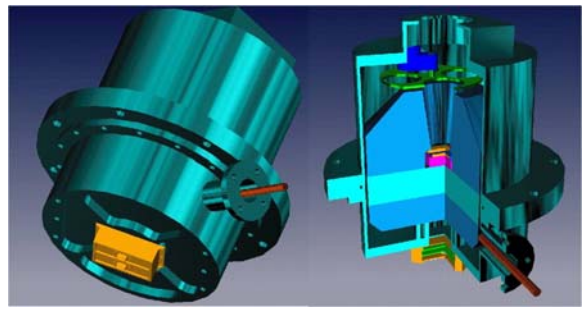
SXI: proposed from Italy/ASI (OAB, Milan, Rome)







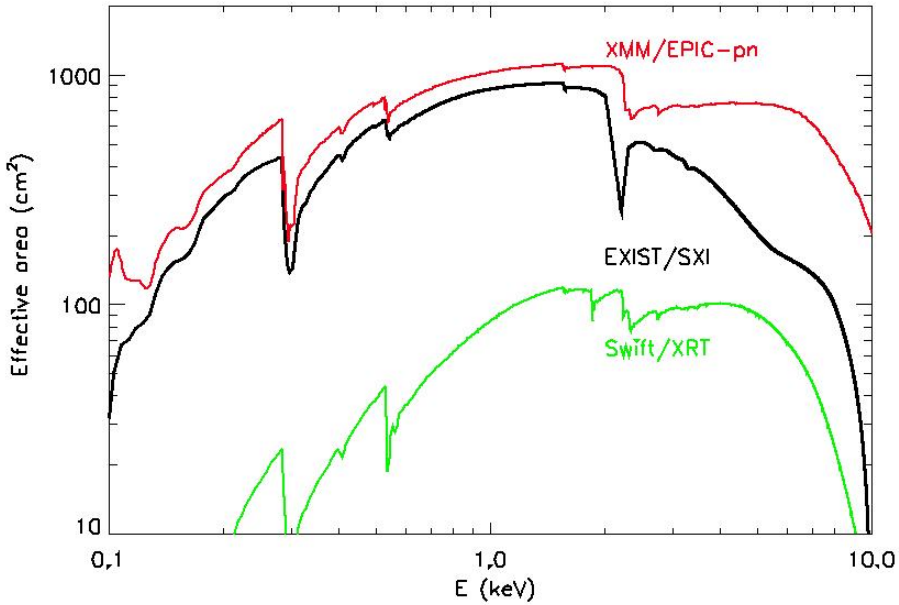


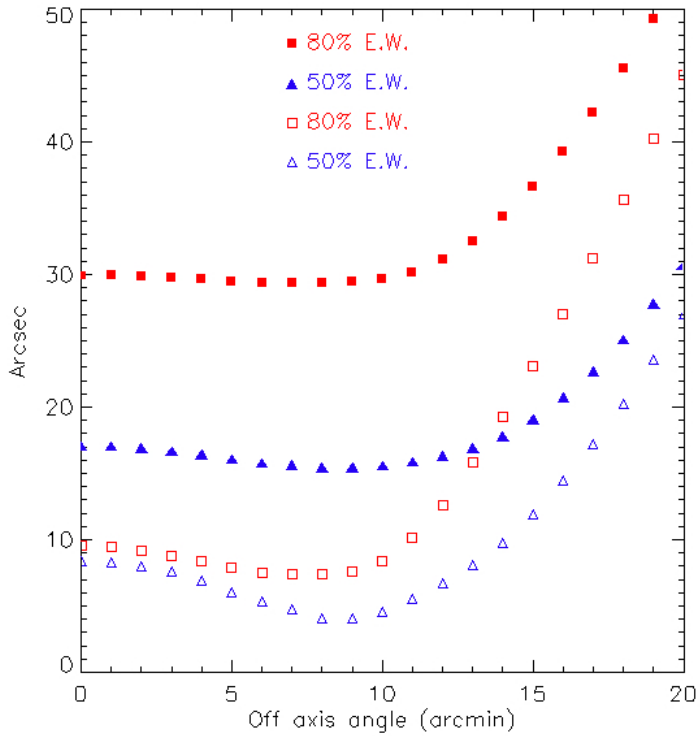


- Wolter I telescope: 26 Ni shells, 3.5m focal length, 60cm max. diam. shell
- 950 cm^2 at 2 keV & 120 cm^2 at 8 keV; 20' FoV; ≤15" PSF (HEW, on axis)
- 4 x 4 cm^2 CCD (1K x 1K; 2.3" pixels); *Sens.: 2 x 10^{-15} erg /(cm^2 s) in 10 ks*
- 40 kbs telemetry; 1msec temporal resol. (timing mode); -110C op. temp.

SXI effective area & Resolution and Parameters

- EXIST-SXI comparable to XMM-pn (single telescope). Can match 5-10 keV sens. with addtl. low-mass shells.
- 30arcmin FoV; ~15" HEW resolution
- **SXI** ***scanning survey (2y): Half-sky, 5 x 10^{-14} cgs, or comparable to eROSITA***





Parameter	Baseline (Goal)
Mirror	26 (38) shells
Angular Res.	20″ (15″) @ 1 keV
Energy range	0.1 – 10 keV
Dia. of mirrors	60 cm
Focal length .	3.5m
Detector type	PN-type CCD (APS DEPFET)
FOV, Detector	20×20 arcmin^2, 3×3 cm^2
Energy Res.	E/ΔE = 47 at 6 keV
Readout speed	5 – 10 ms (1 ms)
Instrument effective area	950 cm^2 (1200 cm^2) at 1.5 keV, >100 cm^2 at 8 keV
Sensitivity (10^{4}s)	2×10^{-15} (1.5×10^{-15}) erg cm^{-2} s^{-1}

.

EXIST mission operations: Simple; autonomous

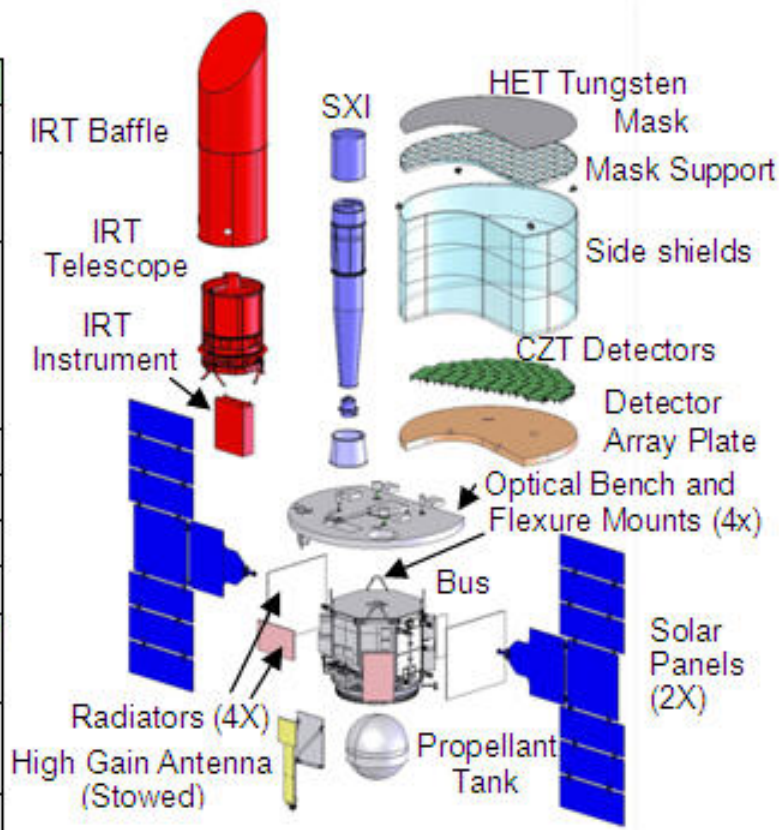
- *Very simple operations*: nominal continuous scan+IRT sun angle constraints → *~90% full-sky coverage every 2 orbits*
- ~100 sec slew to GRB positions (~2-3/day) for IRT spectra and *redshifts on board*. On board photometry and acquisition with tip/tilt mirror in focal plane (maintain 0.1" pointing with only ~2" S/C pointing)
- Full-sky **scanning** survey for 2y and ~1200 GRB redshifts; then 3y HET/IRT **pointings** on ~40,000 survey AGN for redshifts and timing while continuing GRB survey and followup IRT spectra on additional ~1900 GRBs/hosts and continuing survey for transients (LSST)
- 5y mission life required to accumulate large samples of *high-z GRBs, rare survey objects (e.g. Type 2 QSOs) and rare transients (e.g. TDEs)*
- *GI program similar to Fermi (Survey) and Swift, Chandra (pointings)*

EXIST mission concept: Summary after ASMC Eng. Study (carried out at GSFC's IDL and MDL in Oct. – Dec. 2008)

EXIST Observatory Mission Parameters

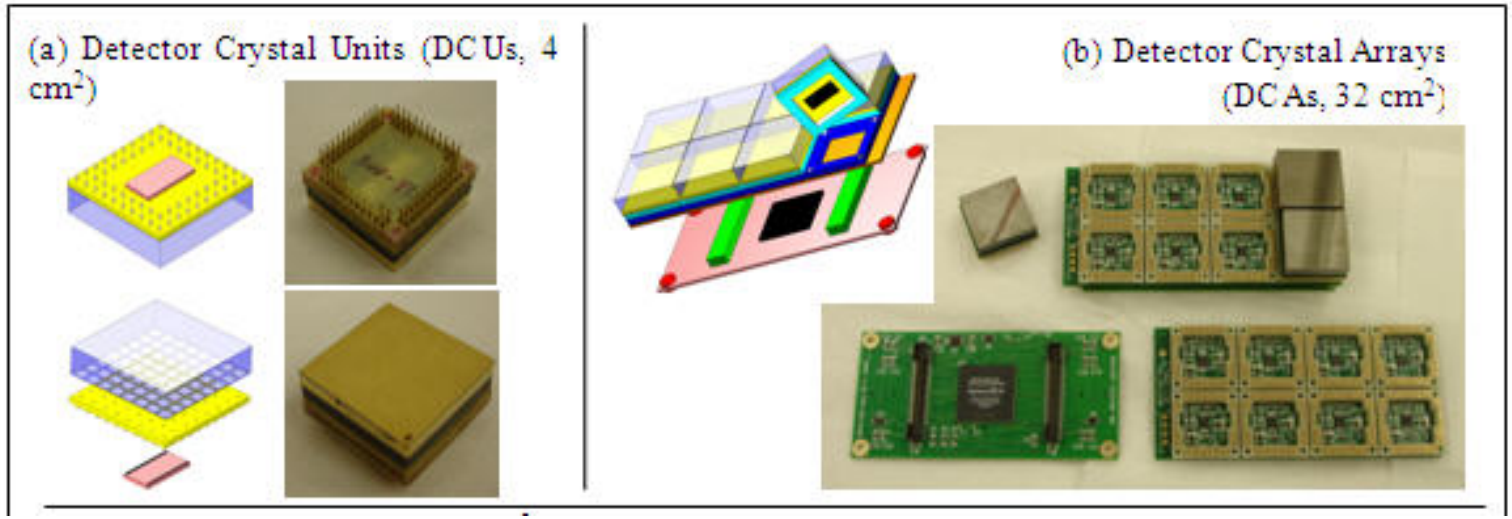
Parameter	Requirement	Capability	Margin
Orbit	600 km, ≤ 22°	Comply	N/A
Launch Mass Atlas V-401	5932kg. CBE+ Contingency	8000 kg @ 22°	35%
Pointing Control Knowledge Stability	 10″ 5″ (3σ) <2″	 5″ < 3″ (3σ) < 1″	 100% 67% >100%
Slew Time	45° in 180 s	Comply	N/A
Avg. Power	2803 W	3645 W	30%
Data Storage	180 Gbits	300 Gbits	67%
Downlink	200 Mbps	Comply, TDRS Ku	3.2 dB*
Commanding Uplink	Not defined	2kbps TDRS SSA, GN; TDRS MA	3.0, 32.0, 3.7 dB*
Propulsion	Controlled de-orbit, 160 m/s	202 m/s with full tank	26%
Lifetime	5-yr	Comply, full redundancy	N/A

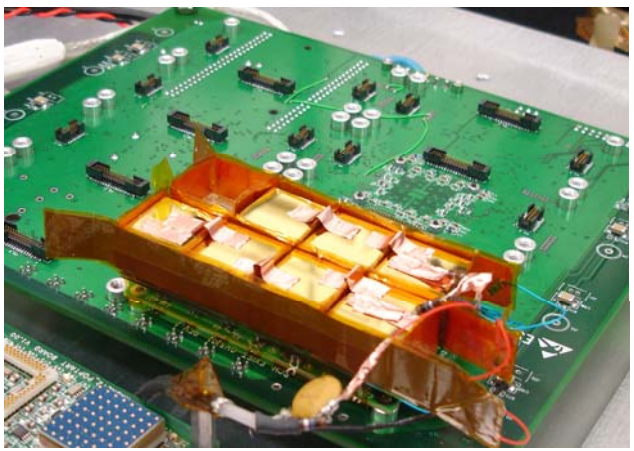
*TDRS only requires 0dB margin due to large system margins.



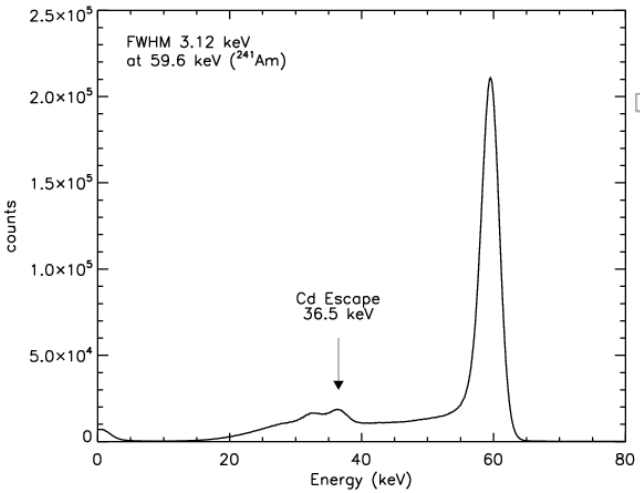
EXIST exploded view; the Observatory uses a modular instrument/bus design.

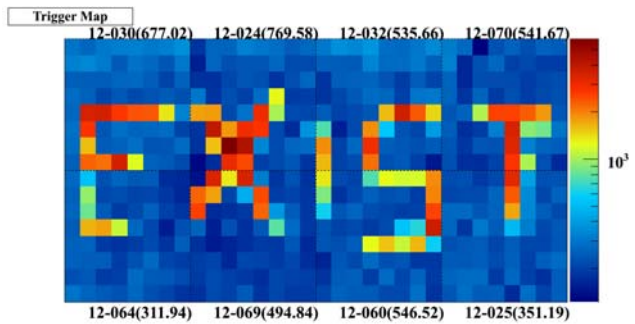
HET Detector develoment: Building a large area CZT detector/telescope prototype for balloon-borne *ProtoEXIST1*





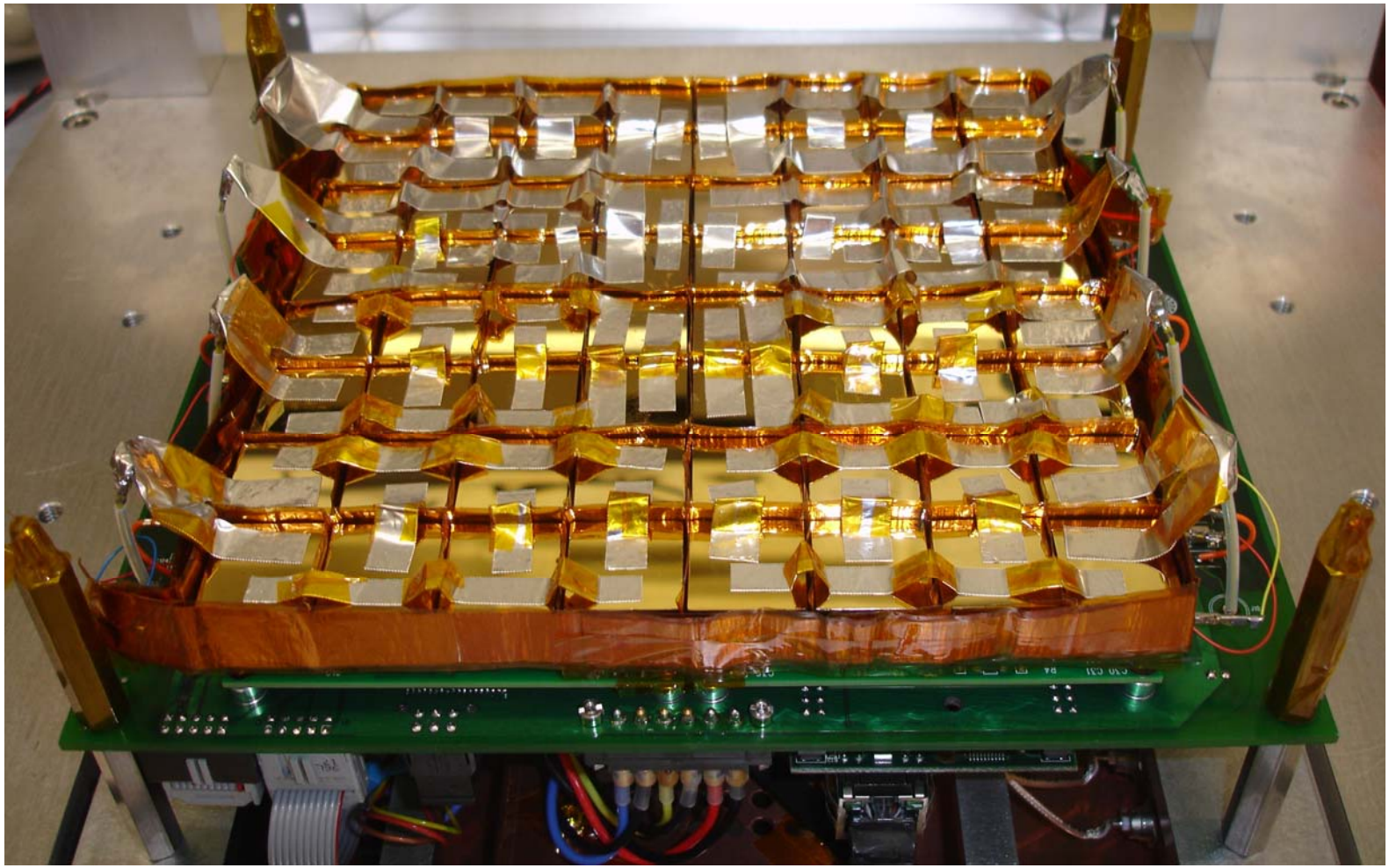
Test flight DCA board (1 of 8)





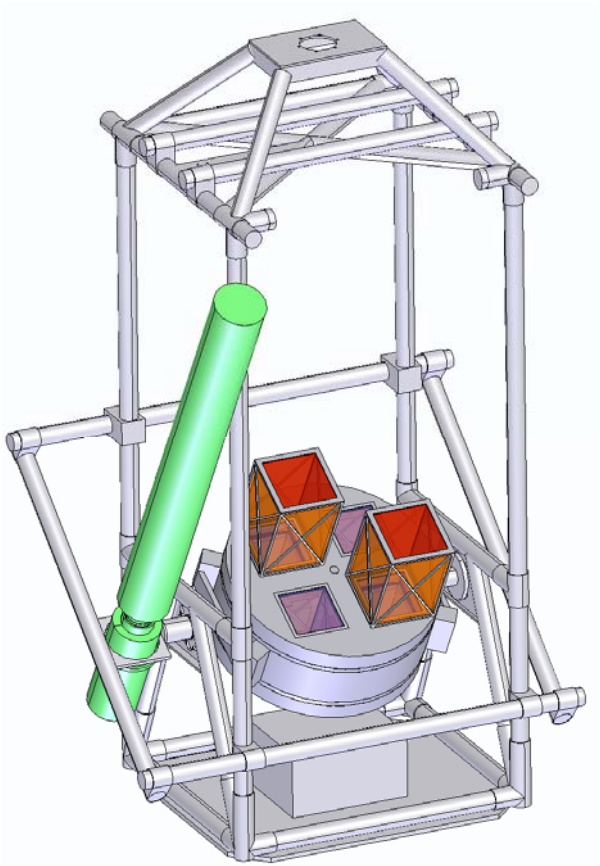
60keV spectrum & DCA image (2.5mm pixels) through Pb mask

Fully integrated first ***ProtoEXIST1*** detector array



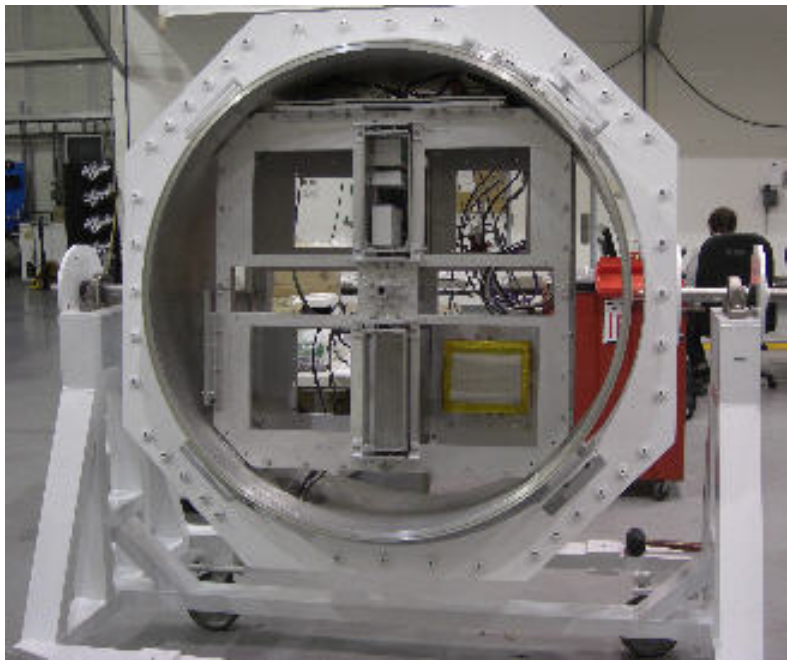
8 x 8 array of close-tiled (0.4mm gaps) CZT crystals (20 x 20 x 5mm), each with 8 x 8 pixels (2.5mm) for 256cm^2 imaging of coded mask

ProtoEXIST Gondola with 2 of 4 Telescopes



ProtoEXIST1 payload (2 telescopes: with/without active rear shield)
(only *one* telescope for first Ft. Sumner flight, Sept. 2009)

ProtoEXIST1 Payload



- **Main pressure vessel supports up to 4 separate detector planes. Only one to fly on first flight (Sept. 2009)**
- **Total Payload Mass: ~300 kg (PV, etc)**
- **900 mm focal length for ProtoEXIST1 (22arcmin resolution)**

ProtoEXIST1 in pressure vessel (in shipping dolly)

EXIST Team for *ASMC Study* & Astro2010 submission

- *Lead Institutions:* **CfA** (Grindlay, PI) and **GSFC** (Gehrels, co-PI)
- *Co-I Institutions for SWG/TWG leads:* Berkeley (Bloom, *GRBs*), GSFC (Mosely, *IRT*; Skinner, *HETimaging*), CfA (Hong, *HET;* Soderberg, *Transients*; Fabbiano, *MODA*), MSFC/GD (Fishman/Conte, *SC-Mission*), Yale (Coppi, *AGN*)
- *Industry Collaborators:* General Dynamics (*S/C*), ITT (*IRT*)
- *Co-I Institutions for Study (many members):* Caltech, Clemson, GSFC, MSFC, SAO, Santa Cruz, Washington U., more …
- *International partner Institutions:* **Italy** (Milan/Brera, Rome, Bologna); also, Greece, Israel, Japan, Netherlands, UK

See *EXIST* webpages at ***http://exist.gsfc.nasa.gov/***

EXIST Summary and Prospects

- *Highest z stellar universe only measured via GRBs*: >6X *Swift* rate; ***SXI*** essential for rapid ***IRT* IDs & redshifts & high-res spectra** for ~2500 & >1000 GRBs to constrain cosmic structure back to Pop III (!)

- Both obscured and dormant SMBHs best studied with ***HET*** imager and ***SXI*/*IRT***: *complete BH census/evolution & accretion luminosity of universe*

- Broad band (~5 – 600 keV), large area & FoV are unique for ***EXIST***: image half-sky each orbit. ALL sources observed with ≥15% continuous coverage;

- ***EXIST*** is a multi-wavelength Observatory; ***Unique IRT-SXI-HET telescope*** enables wide range of Science (stellar flares to early Universe) for GI prog.

- ***EXIST*** **needs no new technology and *could* launch** in ~2017-18 window *if* given a start in ~2012-13. Collaboration with Italy (and ESO?)

See *EXIST* website (***http://EXIST.gsfc.nasa.gov*)** for Study & **Team**