X-ray properties of Hyperluminous Infrared Galaxies

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What is all the fuss about?

- BH in centers of most local gals
  (Kormendy & Gebhardt, 2001)
- Correlation between mass of central BH and spheroid (Magorrian et al. 1998, McLure & Dunlop 2002)
- Similar evolution of X-ray AGN and optical galaxies (Silvermann et al. 2004)

→ Connected growth of central BH through accretion, and spheroid through star formation

How to observe AGN-galaxy co-evolution

- Star formation takes place in heavily obscured environments: need penetrating radiation
  - X-rays (of course!): thermal bremstrahlung, binaries
  - MIR-FIR-submm: radiation absorbed and re-emited
  - Radio
- BH growth through accretion produces AGN activity:
  - X-rays (of course!) are "smoking gun", but:
    - Most accretion power in Universe absorbed (Fabian & Iwasawa 1999)
    - X-ray background synthesis model require most AGN in Universe absorbed (Gilli et al. 1999)
  - "Warm" MIR-FIR colours: direct emission absorbed and re-emited
  - Radio

(Happy?) Marriage of X-ray and MIR-FIR Astronomy: coincidence in time of CXO, XMM, Suzaku, Spitzer, Akari, Herschel...

Why HLIRGs?

•HLIRGs:
- Strong star formation: >1000 $M_\odot$/y
- High AGN fraction

Good laboratories to investigate star formation and BH growth:
- •Young galaxies experiencing burst of star formation?
- •Transient phase in AGN evolution?

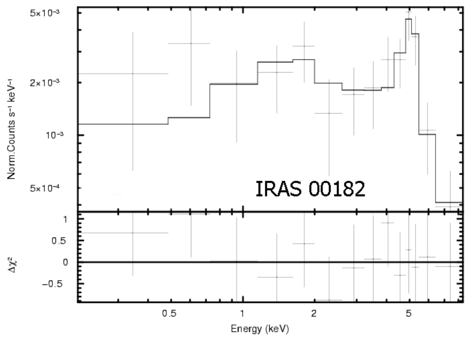
- $L_{8-1000\mu m} > 10^{13} L_\odot$: HLIRGs (Rowan-Robinson 2000 RR00)
  - Most with AGN contribution (Verma et al. 2002, ...)
  - Only some interacting (~30%) (Farrah et al. 2002)
    - Not trivially high luminosity end of ULIRGs
  - A few in X-rays: heavy obscuration, even Compton Thick (CT) (Iwasawa et al. 2005, Wilman et al. 2003)

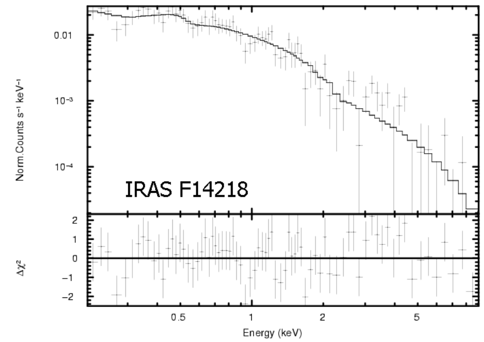
An XMM-Newton study of HLIRGs: Sample

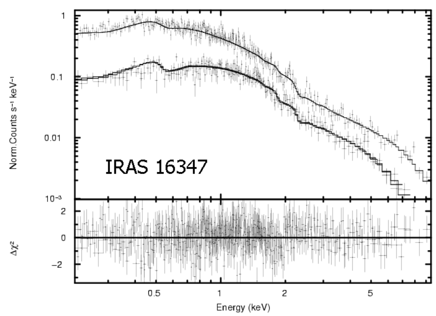
- Out of the 45 HLIRGs in RR00 sample, those with:
  - Public XMM-Newton data as of Dec. 2004
  - Own XMM-Newton AO-5 data
  - z<~2: avoid strong biasing towards high z QSOs
- 14 objects in final sample:
  - All SED fitting in MIR/FIR (RR00, Farrah et al., Verma et al.)

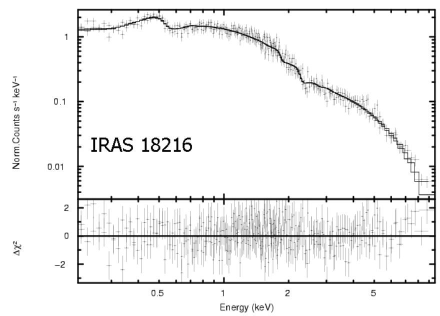
	Source	*Type (opt)*	*z*	*AGN/STB (IR SED fitting)*	*CT?*
2	**IRAS F00235+1024**	**Starburst**	**0.575**	**0.5/0.5**	✓
	IRAS 07380-2342	**Starburst**	**0.292**	**0.6/0.4**	**X**
4	**IRAS 00182-7112**	**QSO 2**	**0.327**	**0.35/0.65**	✓
	IRAS 09104+4109	**QSO 2**	**0.442**	**1/0**	✓
	IRAS 12514+1027	**Seyfert 2**	**0.3**	**0.4/0.6**	✓
	IRAS F15307+3252	**Seyfert 2**	**0.926**	**0.7/0.3**	✓
8	**PG 1206+459**	**QSO**	**1.158**	**1/0**	**X**
	PG 1247+267	**QSO**	**2.038**	**1/0**	**X**
	IRAS F12509+3122	**QSO**	**0.780**	**0.6/0.4**	**X**
	IRAS 13279+3401	**QSO**	**0.36**	**0.7/0.3**	**X**
	IRAS 14026+4341	**QSO 1.5**	**0.323**	**0.6/0.4**	**X**
	IRAS F14218+3845	**QSO**	**1.21**	**0.2/0.8**	**X**
	IRAS 16347+7037	**QSO**	**1.334**	**0.8/0.2**	**X**
	IRAS 18216+6418	**QSO**	**0.297**	**0.6/0.4**	**X**

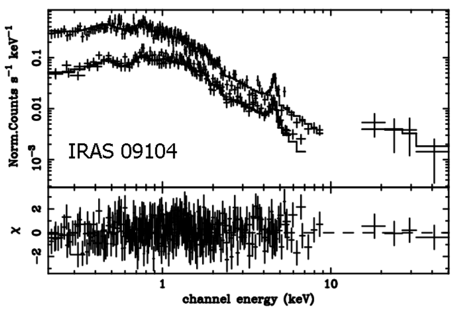
XMM-Newton spectra

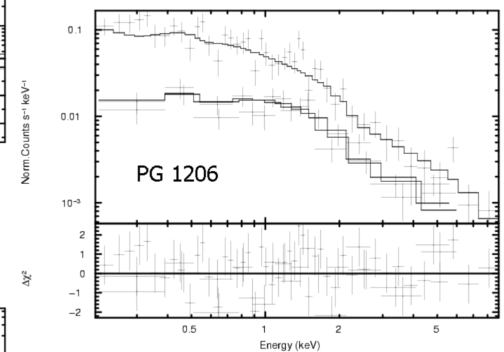


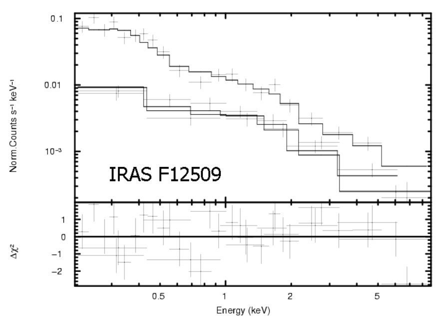


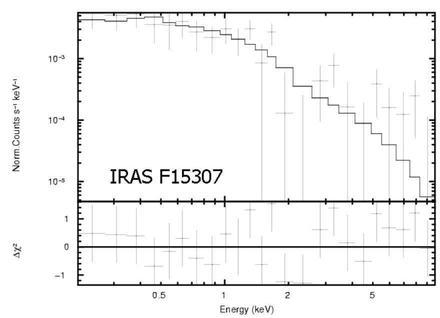


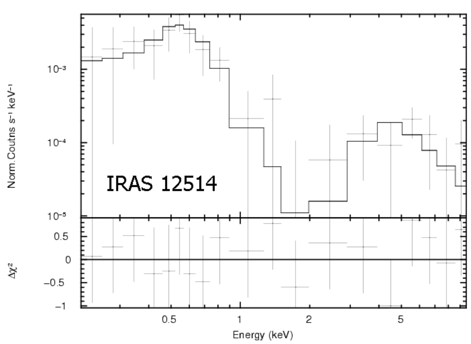


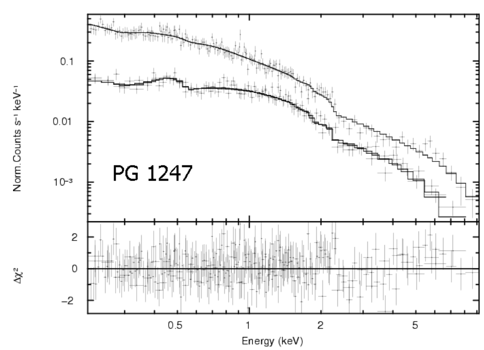












Not detected with XMM-Newton

Source	Model	$\log L_{0.5-2}$	$\log L_{2-10}$	CT?
IRAS F00235+1024	3σ upper limit	-	<42.4	✓
IRAS 07380-2342	3σ upper limit	-	<42.5	X
IRAS 00182-7112	reflected+narrow line (0.8keV)	<41.9	44.8	✓
IRAS 09104+4109	"thermal"+reflected+narrow line	44.2	45.3	✓
IRAS 12514+1027	thermal+absorbed direct (4×10^{23})	42.2	43.3	✓
IRAS F15307+3252	direct	<43.1	43.7→45.5	✓
PG 1206+459	direct	<44.0	45.1	X
PG 1247+267	"thermal"+direct	45.5	45.9	X
IRAS F12509+3122	"thermal"+direct	43.8	44.3	X
IRAS 13279+3401	3σ upper limit	-	<42.2	X
IRAS 14026+4341	3σ upper limit	-	<42.6	X
IRAS F14218+3845	direct	<43.8	44.6	X
IRAS 16347+7037	"thermal"+direct	45.7	46.0	X
IRAS 18216+6418	"thermal"+direct	45.1	45.6	X

Strongly absorbed

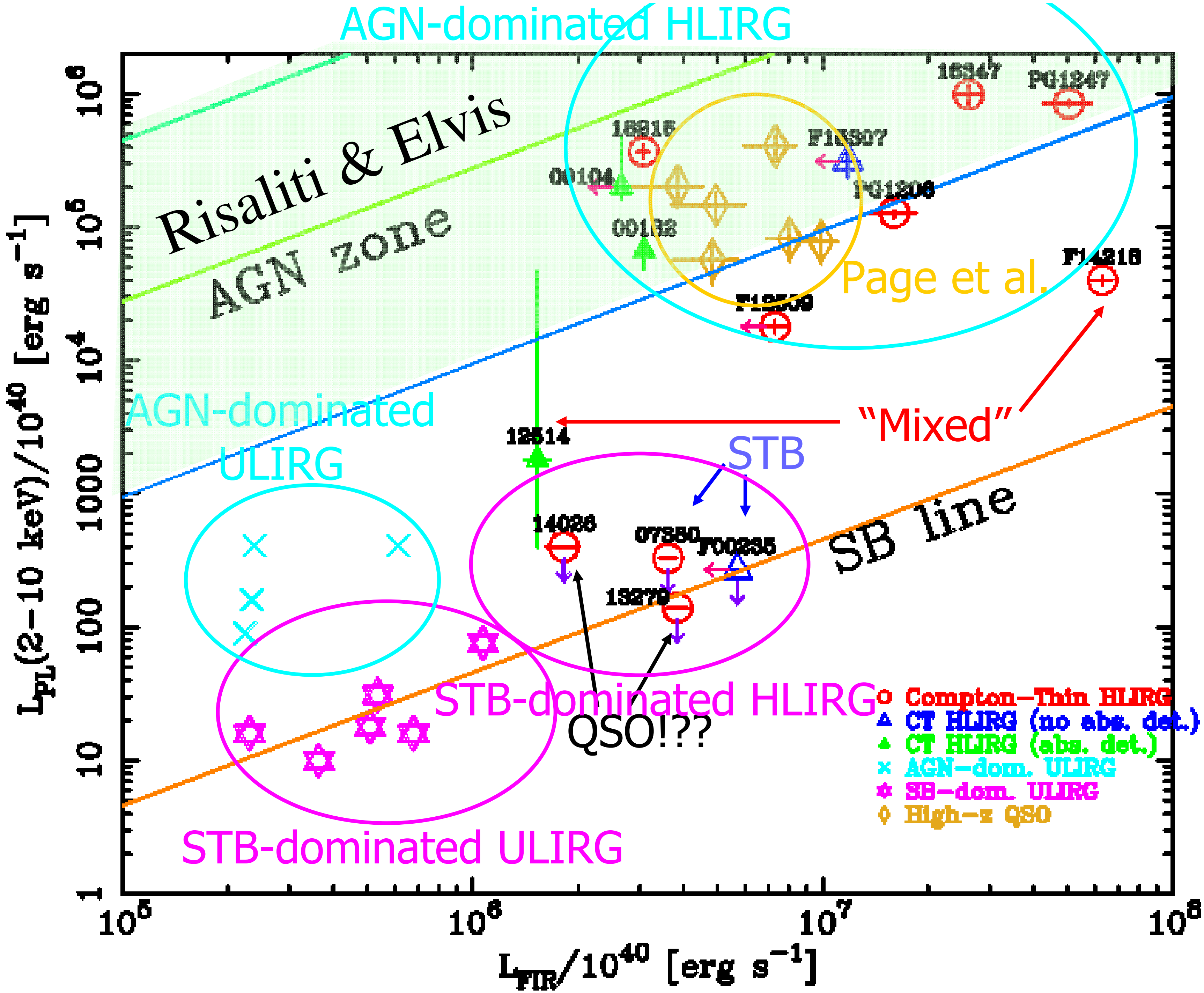
Source	*Model*	log $L_{0.5-2}$	log L_{2-10}	*CT?*
IRAS F00235+1024	3σ upper limit	-	<42.4	✓
IRAS 07380-2342	3σ upper limit	-	<42.5	X
IRAS 00182-7112	reflected+narrow line (0.8keV)	<41.9	44.8	✓
IRAS 09104+4109	"thermal"+reflected+narrow line	44.2	45.3	✓
IRAS 12514+1027	thermal+absorbed direct (4×10^{23})	42.2	43.3	✓
IRAS F15307+3252	direct	<43.1	43.7→45.5	✓
PG 1206+459	direct	<44.0	45.1	X
PG 1247+267	"thermal"+direct	45.5	45.9	X
IRAS F12509+3122	"thermal"+direct	43.8	44.3	X
IRAS 13279+3401	3σ upper limit	-	<42.2	X
IRAS 14026+4341	3σ upper limit	-	<42.6	X
IRAS F14218+3845	direct	<43.8	44.6	X
IRAS 16347+7037	"thermal"+direct	45.7	46.0	X
IRAS 18216+6418	"thermal"+direct	45.1	45.6	X

Soft excess: too bright to come from STB

Source	*Model*	$\log L_{0.5-2}$	$\log L_{2-10}$	*CT?*
IRAS F00235+1024	3σ upper limit	-	<42.4	✓
IRAS 07380-2342	3σ upper limit	-	<42.5	X
IRAS 00182-7112	reflected+narrow line (0.8keV)	<41.9	44.8	✓
IRAS 09104+4109	"thermal"+reflected+narrow line	44.2	45.3	✓
IRAS 12514+1027	thermal+absorbed direct (4×10^{23})	42.2	43.3	✓
IRAS F15307+3252	direct	<43.1	43.7→45.5	✓
PG 1206+459	direct	<44.0	45.1	X
PG 1247+267	"thermal"+direct	45.5	45.9	X
IRAS F12509+3122	"thermal"+direct	43.8	44.3	X
IRAS 13279+3401	3σ upper limit	-	<42.2	X
IRAS 14026+4341	3σ upper limit	-	<42.6	X
IRAS F14218+3845	direct	<43.8	44.6	X
IRAS 16347+7037	"thermal"+direct	45.7	46.0	X
IRAS 18216+6418	"thermal"+direct	45.1	45.6	X

Only one detection of thermal emission from STB

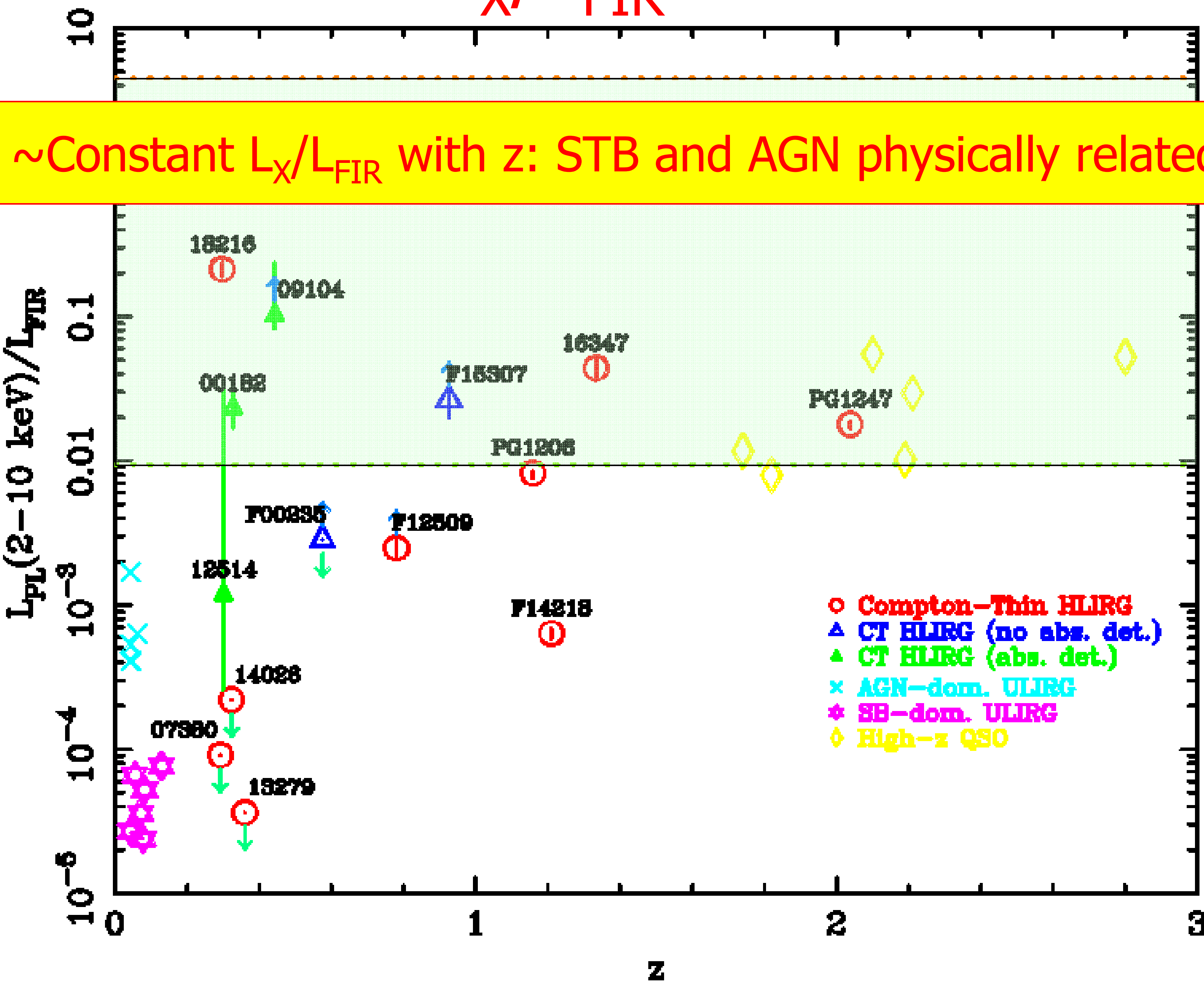
Source	*Model*	log $L_{0.5-2}$	log L_{2-10}	*CT?*
IRAS F00235+1024	3σ upper limit	-	<42.4	✓
IRAS 07380-2342	3σ upper limit	-	<42.5	X
IRAS 00182-7112	reflected+narrow line (0.8keV)	<41.9	44.8	✓
IRAS 09104+4109	"thermal"+reflected+narrow line	44.2	45.3	✓
IRAS 12514+1027	thermal+absorbed direct ($4x10^{23}$)	42.2	43.3	✓
IRAS F15307+3252	direct	<43.1	43.7→45.5	✓
PG 1206+459	direct	<44.0	45.1	X
PG 1247+267	"thermal"+direct	45.5	45.9	X
IRAS F12509+3122	"thermal"+direct	43.8	44.3	X
IRAS 13279+3401	3σ upper limit	-	<42.2	X
IRAS 14026+4341	3σ upper limit	-	<42.6	X
IRAS F14218+3845	direct	<43.8	44.6	X
IRAS 16347+7037	"thermal"+direct	45.7	46.0	X
IRAS 18216+6418	"thermal"+direct	45.1	45.6	X



AGN-dominated HLIRG
Risaliti & Elvis
AGN zone
16347
PG1247
18216
F15307
00104
PG1206
00182
F14218
Page et al.
F12509
AGN-dominated
ULIRG
"Mixed"
12514
STB
SB line
14026
07380
F00235
15279
STB-dominated HLIRG
QSO!??
Compton-Thin HLIRG
CT HLIRG (no abs. det.)
CT HLIRG (abs. det.)
AGN-dom. ULIRG
SB-dom. ULIRG
High-z QSO
STB-dominated ULIRG
$L_{PL}(2-10\ keV)/10^{40}$ [erg s^{-1}]
$L_{FIR}/10^{40}$ [erg s^{-1}]

L_X/L_{FIR} vs. z

~Constant L_X/L_{FIR} with z: STB and AGN physically related?

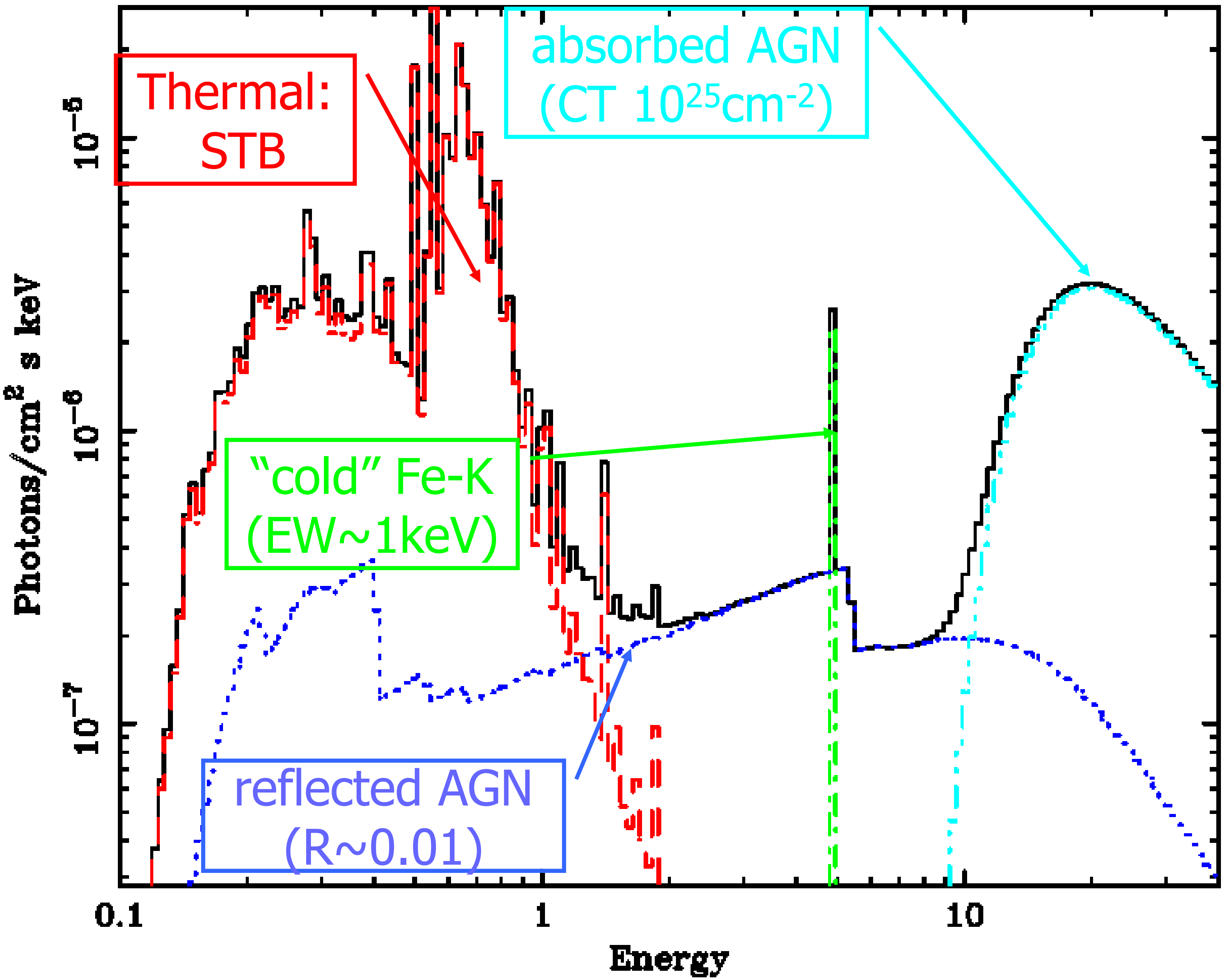


What else can we learn using XEUS?

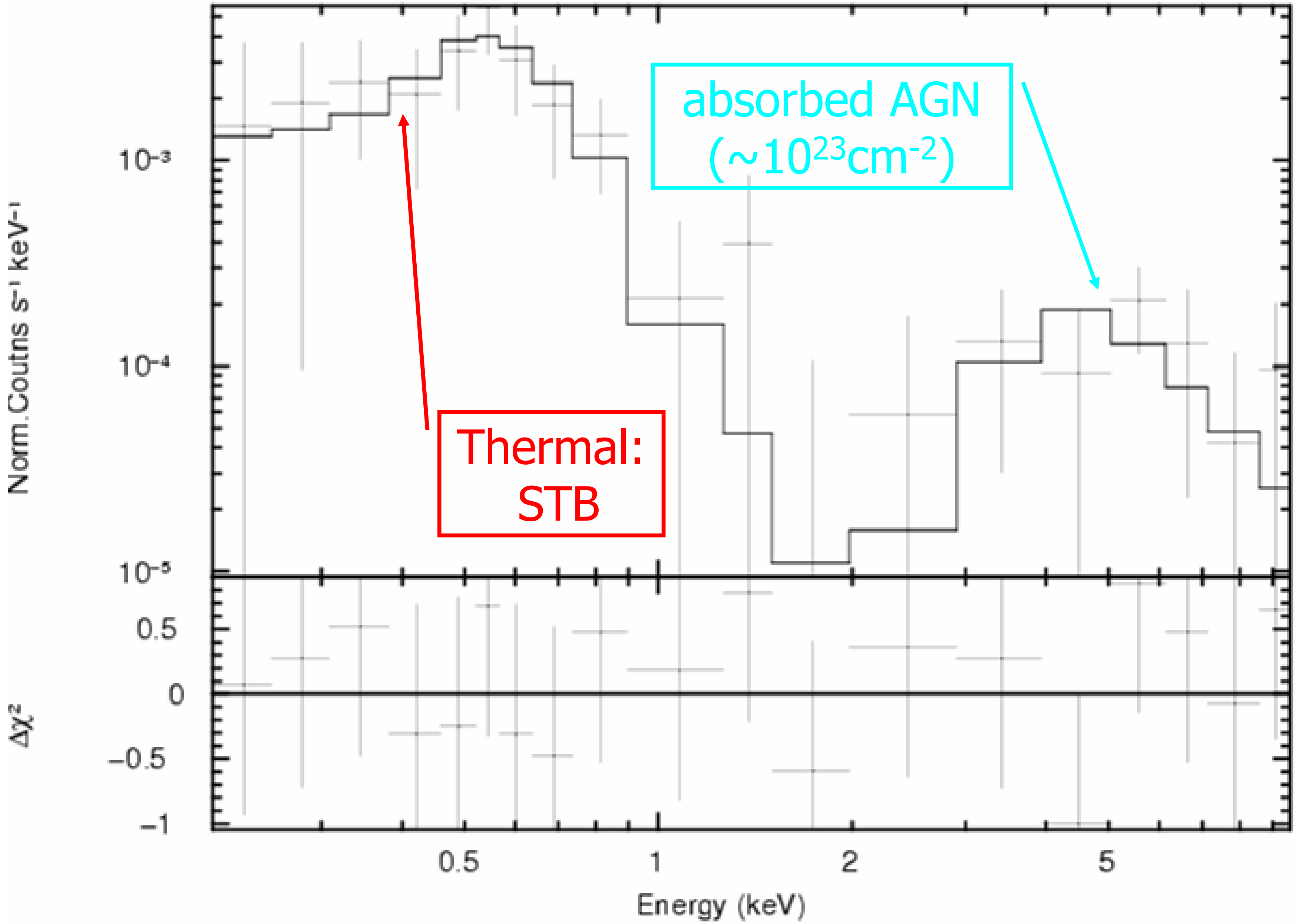
- Actually quite a lot!
- With XMM-Newton we haven't:
  - detected STB emission (only 1 source)
  - discriminated shape (origin) of >2keV continuum
    - in particular between CT and/or absorption (column density)
  - discriminated physical origin of "soft excess"
  - detected Fe K line (only 2)

- Concentrated on WFI with multilayers (+bgd, 20ks):
  - good energy range and resolution
  - HXC would improve discrimination of >10keV continuum

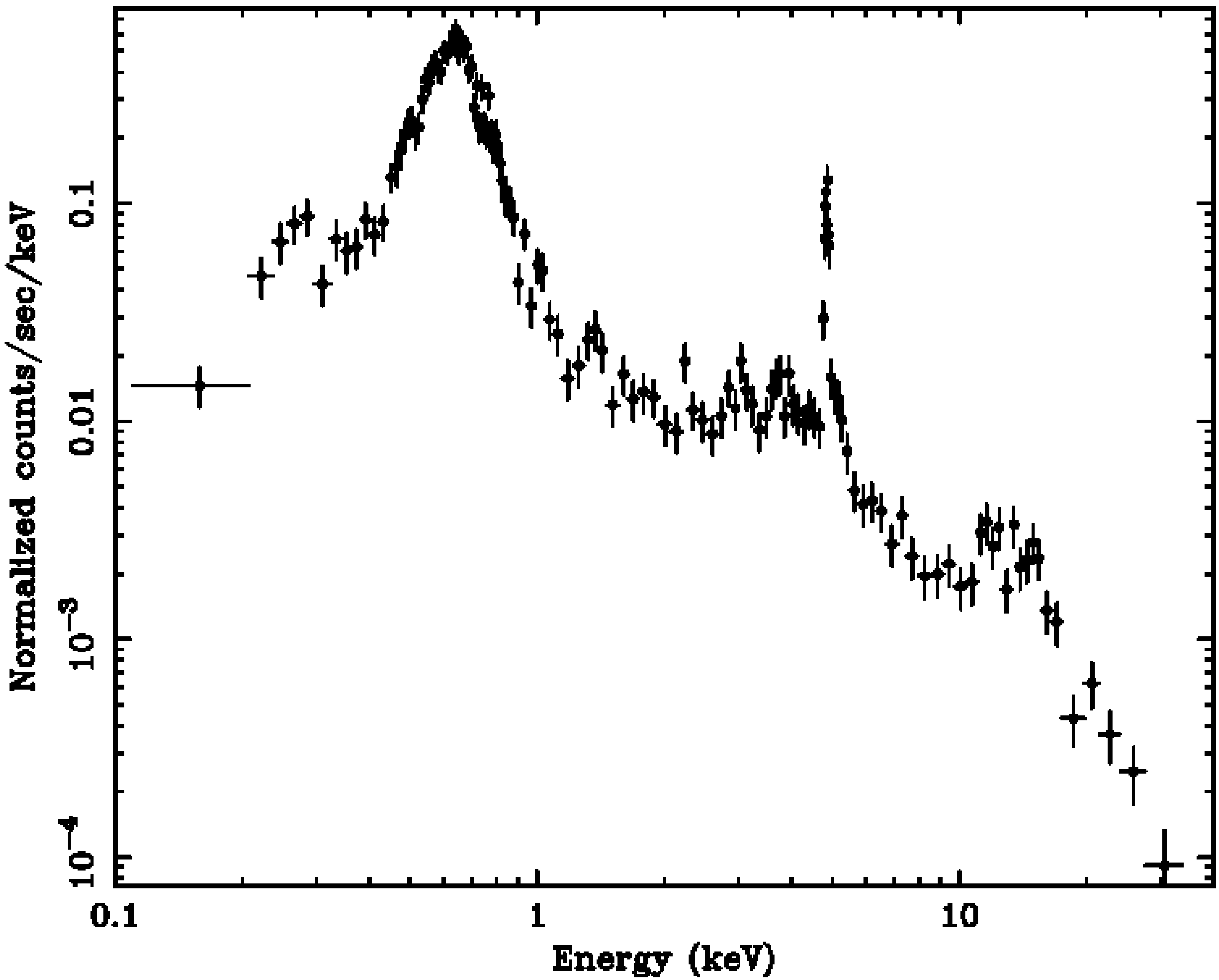
Model for XEUS sims: “standard” UM



A faint CT Sy2 (IRAS12514, XMM ~40ks)



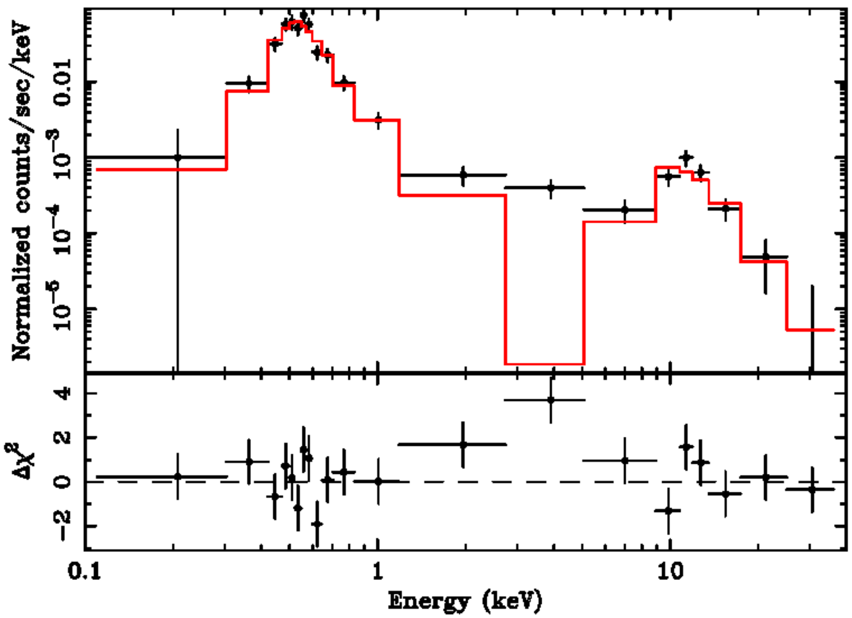
A faint CT Sy2 (IRAS12514, XEUS ~20ks)



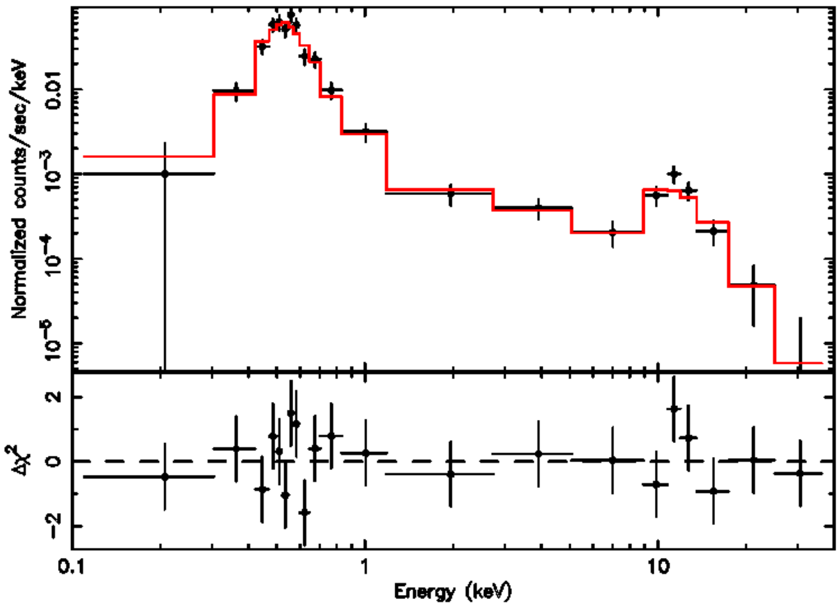
A CT STB: IRAS F00235

- Undetected with XMM-Newton in 15ks
- With XEUS in 20ks:
  - Significant detection of thermal STB, absorbed AGN and reflected AGN
  - Partial covering strongly rejected

XEUS: Best fit without reflection



XEUS: Best fit with reflection



Conclusions

- HLIRGs have strong star formation and high fraction of AGN activity: good testbed for AGN-gal. growth
- XMM-Newton-selected sample of 14 HLIRGs:
  - 10/14 detected and AGN-dominated in X-rays:
    - 8 pure AGN, 2 mixed
    - Thermal STB emission only 1
  - Under luminous in X-rays with respect to local QSO SED:
    - X-ray absorption
    - Departure from standard local QSO SED
  - X-ray-to-IR lum. ratio ~constant with z: STB and AGN physically related?
- XEUS WFI+multilayers would detect in X-rays:
  - Direct emission from CT objects ⇒ bolometric AGN luminosity
  - Column density, reflected emission and Fe line ⇒ orientation and/or covering factor (~geometry of BH environment!)
  - Emission from STB ⇒ thermal vs. binaries