The extra-galactic hard X-ray sky as painted by INTEGRAL

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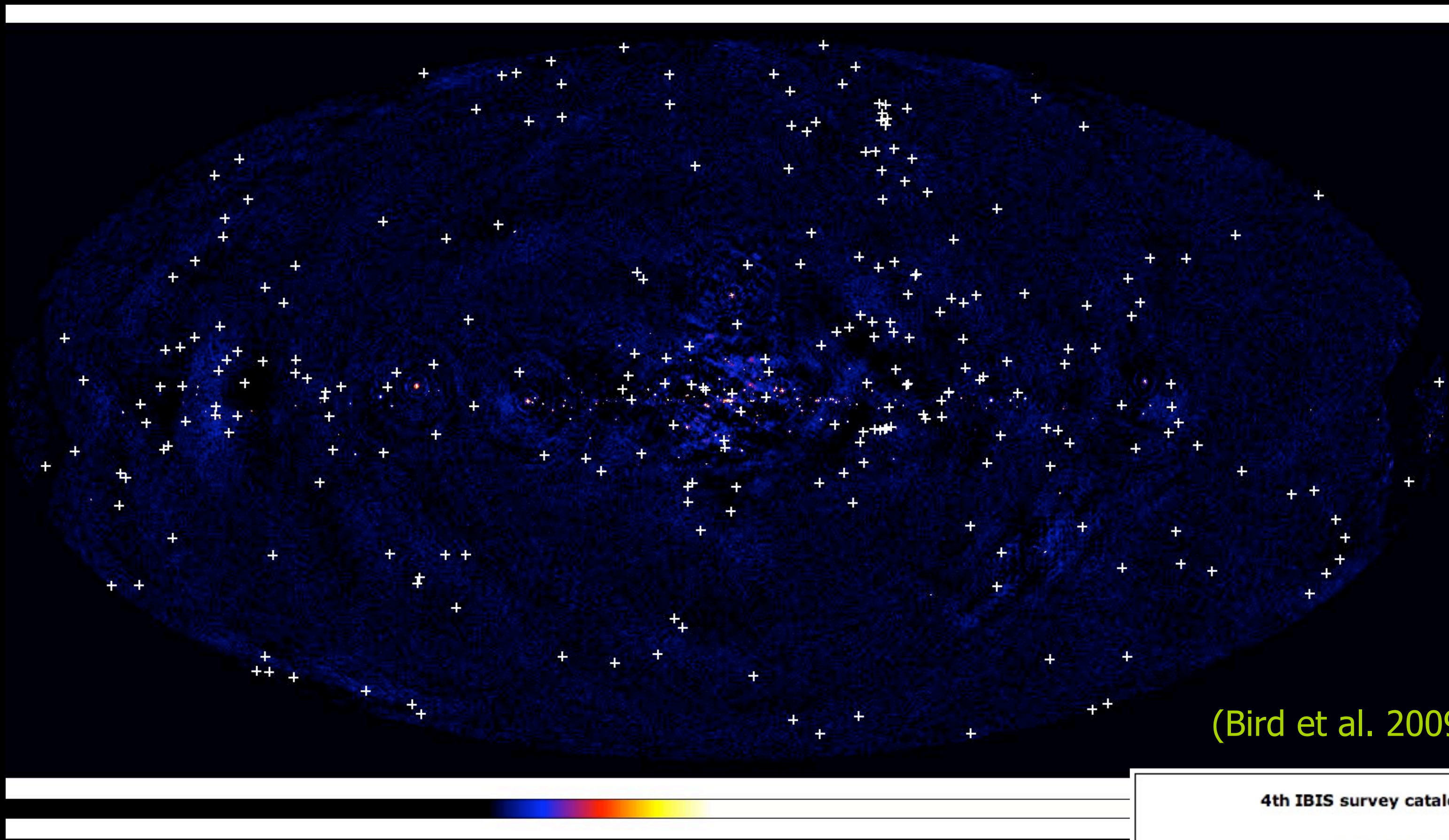
on behalf of the IBIS survey/AGN team

INTEGRAL USER GROUP
ESTEC, 10-11 December 2009

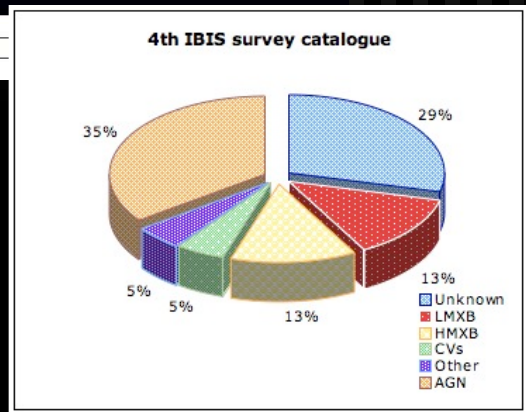
Istituto di Astrofisica Spaziale e Fisica Cosmica - Roma

INAF

The extragalactic sky in the 4th IBIS catalogue



(Bird et al. 2009)



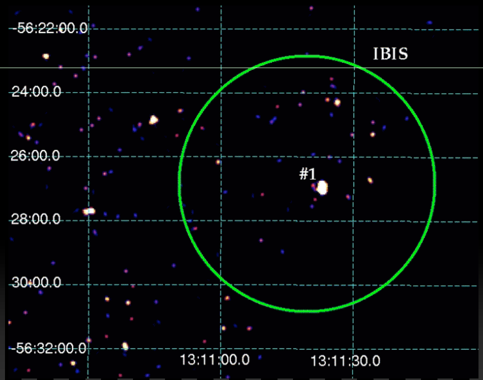
AGN distribution

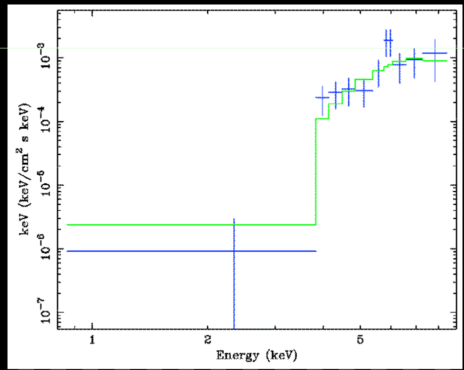
more than 250 sources, ~10% z>0.1

(more objects to be included as follow-up work progresses)

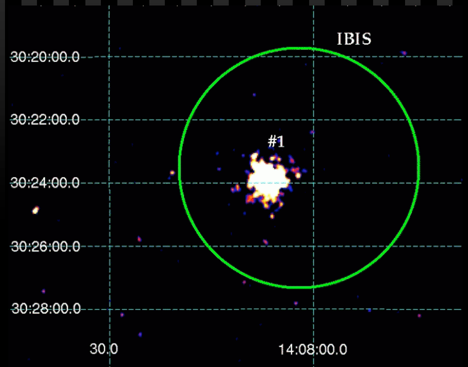
Cat 4 X-ray follow-up already started

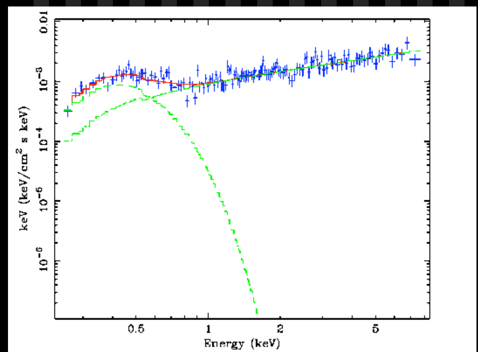
IGR J13107-5626





IGR J14080-3023





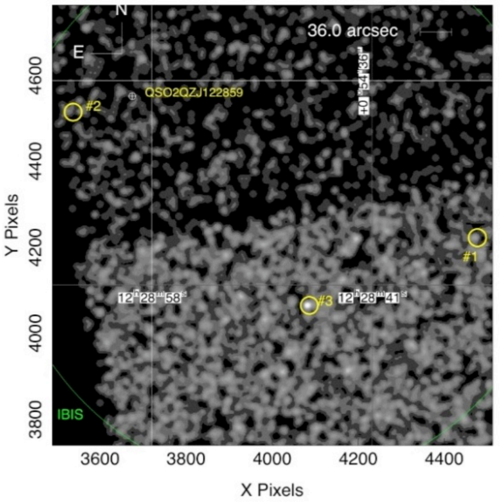
Results of *Swift*/XRT follow-up

IBIS Source	Classification
IGR J00465-4005	AGN, absorbed
LEDA 96373	AGN, Seyfert 2
IGR J08262+4051	AGN candidate
MCG+04-26-006	AGN, LINER
PKS 1143-696	AGN candidate, QSO ?
IGR J1248.2-5828	AGN, absorbed ?
NGC 4748	AGN, NLS1
IGR J13107-5626	AGN, absorbed ?
IGR J14080-3023	AGN, Seyfert 1.5
1RXS J213944.3+595016	AGN, unabsorbed
IGR J22234-4116	AGN candidate

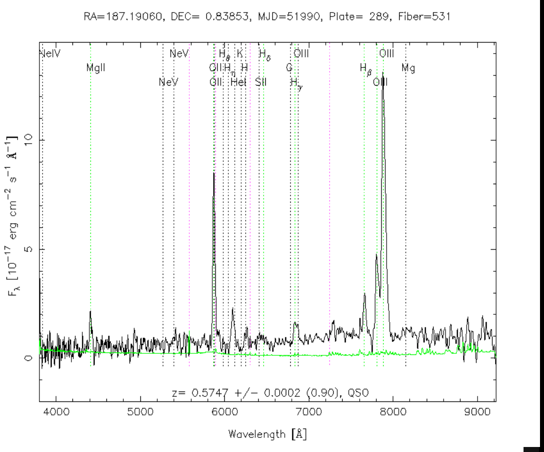
(Landi et al. 2009)

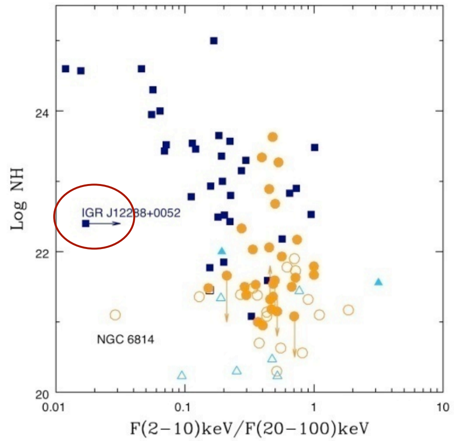
Some interesting sources

IGR J12288+0052



5-10 keV Chandra image



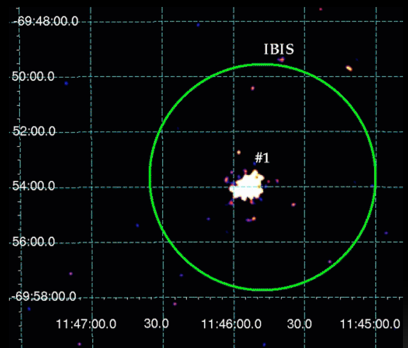


- Source #3 is the only object detected above 5 keV
- It coincides with SDSS122845.74+005018.7, a type 2 AGN at z = 0.57 from Sloan Digital Sky Survey

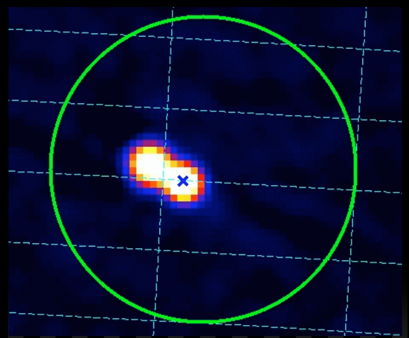
↓

First type 2 Compton thick QSO detected by *INTEGRAL* ?
(Fiocchi et al. 2009)

IGR J13107-5626



0.3-10 keV XRT image



MGPS-1 (843 MHz)

- QSO in NED
- Radio spectrum ($S \propto \nu^{\alpha}$) flat α=-0.2

↓

A new Flat Spectrum Radio QSO ?
(Landi et al. 2009)

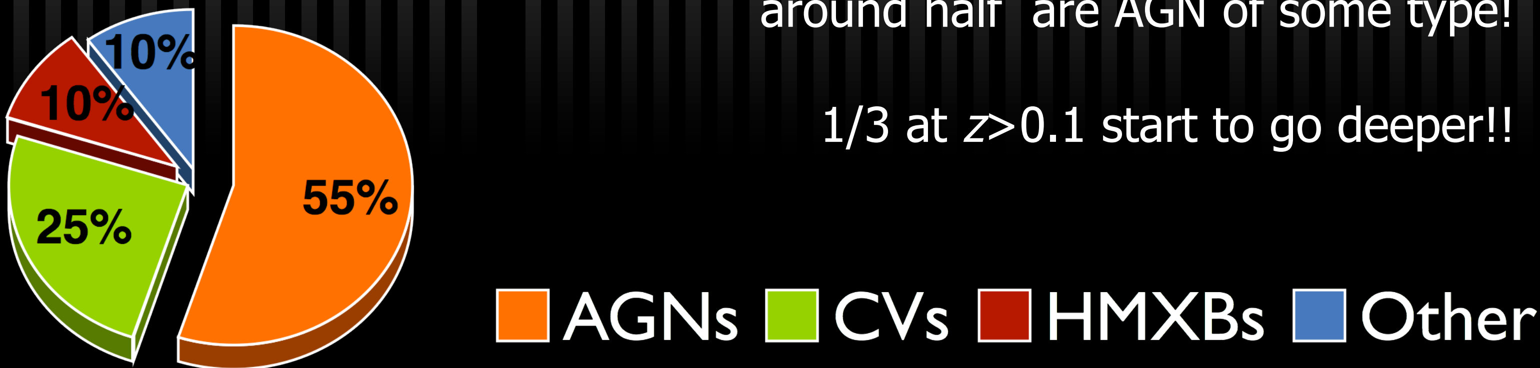
Cat 4 optical follow-up also started

(Parisi et al. 2009, Masetti et al. 2009)

✓ 4th IBIS catalogue

- We have started to find optical counterparts for the 4th IBIS survey catalogue
- We already found 23 optical counterparts reducing the number of unidentified sources by ~10%

Identified sources



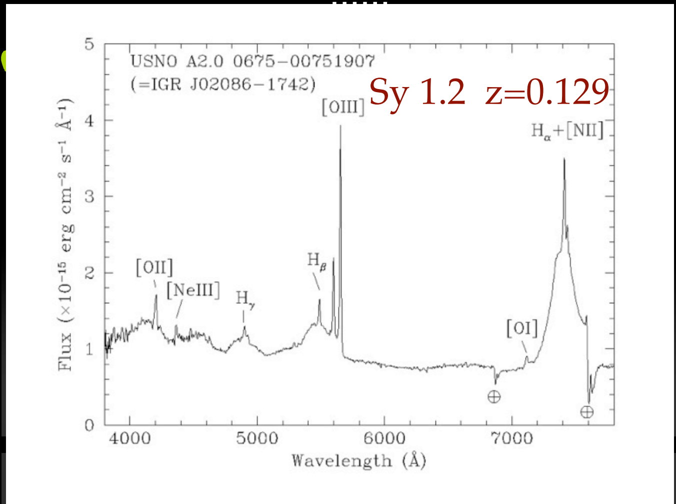
around half are AGN of some type!

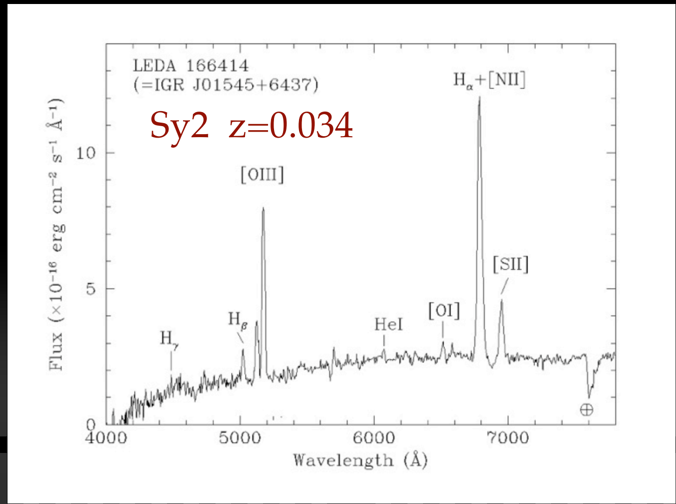
1/3 at z>0.1 start to go deeper!!

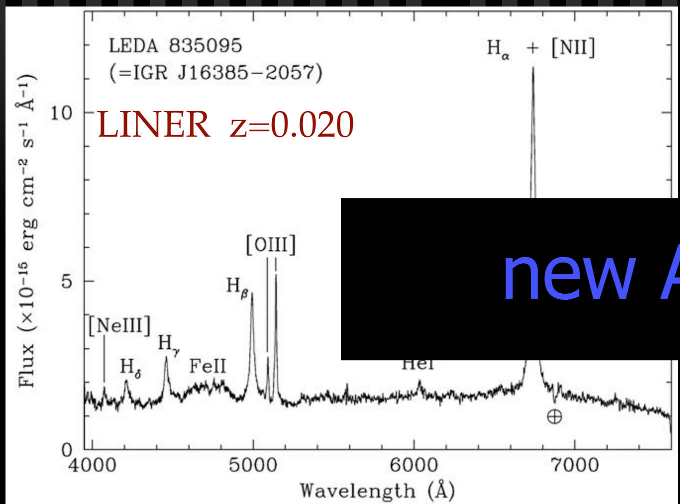
New AGN classifications

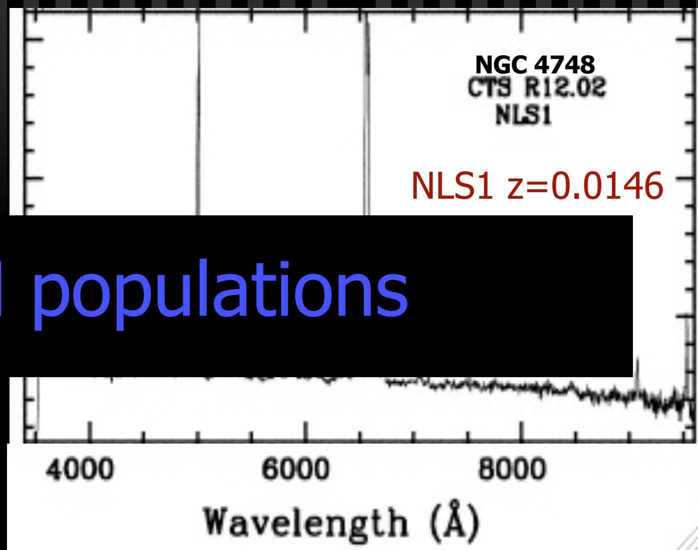
(Parisi et al. 2009, Masetti et al. 2009)

Optical follow up finds classical Seyferts but also ……









new AGN populations

Why high energy AGN surveys are important ?

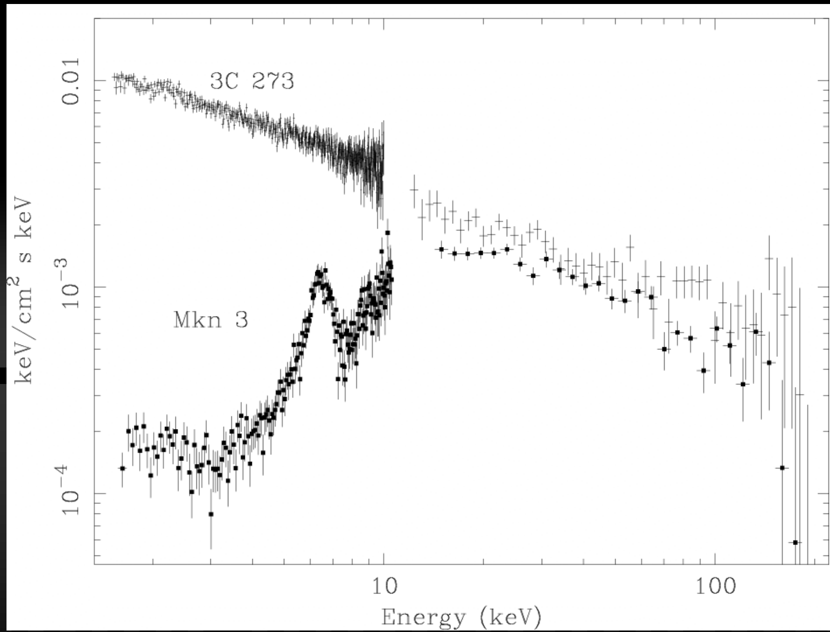
A new window to discover the heavily obscured sources and new bright AGNs

Best definition of Nh distribution for various AGN class

High energy coverage

Spectral information on Ec, R and constrain on Γ

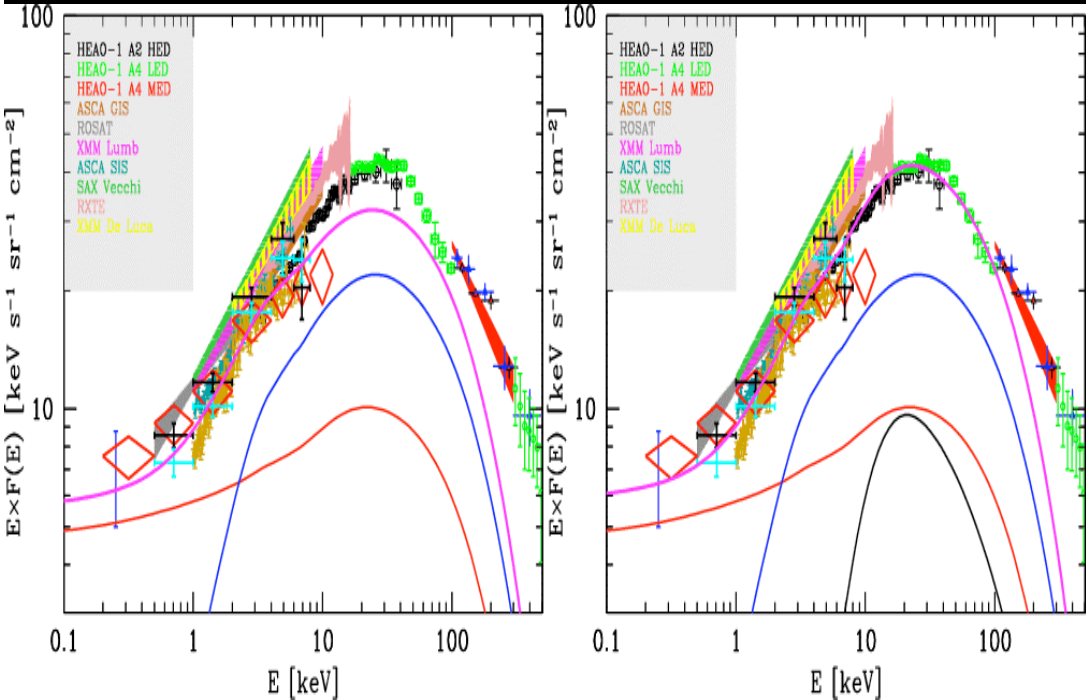
Absorbed AGN could be missed in X-ray surveys



With X-ray follow-up
- AGN modeling
- Unified theory, torus studies, etc
- X-ray Background (XRB) studies

CXB-XRB studies

With a proper mixture of absorbed, unabsorbed and Compton thick AGN it is possible to reproduce the XRB



Red -> unobscured,
Blue -> Compton Thin,
Black -> Compton Thick
(Gilli, Comastri & Hasinger, 2007)

BUT…
Tuning of all parameters very delicate

Input needed are:

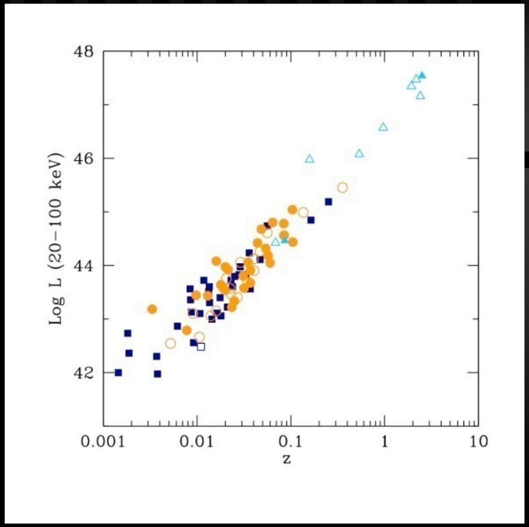
- N_H distribution
- Number of Compton thick AGN
- Spectral shape of each AGN class (Γ , R, Ec and their dispersions)

Complete AGN sample can provide all these information

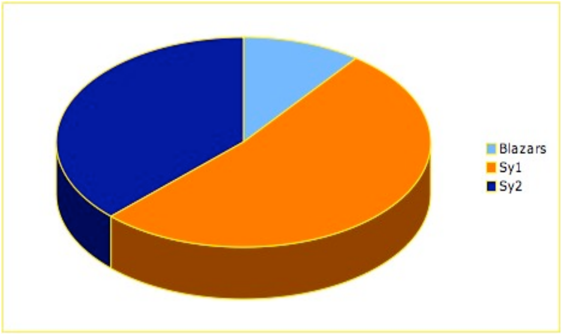
Some Results from the Third IBIS survey:

Complete sample of 88 AGN (Malizia et al. 2009)

88 objects detected in the 20-40 keV band with significance greater than 5.2σ:
46 type 1 (Seyfert 1 - 1.5 included 5 NLS1), 33 type 2 (Seyfert 1.8-2),
9 Blazars (QSO-BL Lac)

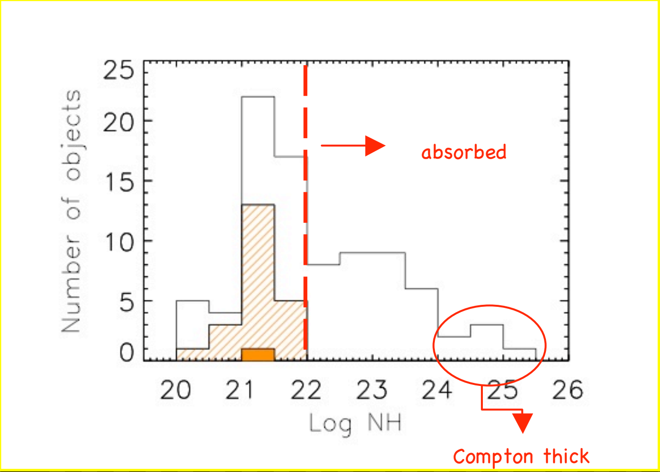


Hard X-ray luminosity versus redshift.
Circles: type 1 objects
Squares: type 2 objects
Triangles: Blazars



class and z (Parisi 2009)
N_H and $F_{2\text{-}10\ keV}$ collected

for ALL sample sources



absorption distribution in the sample

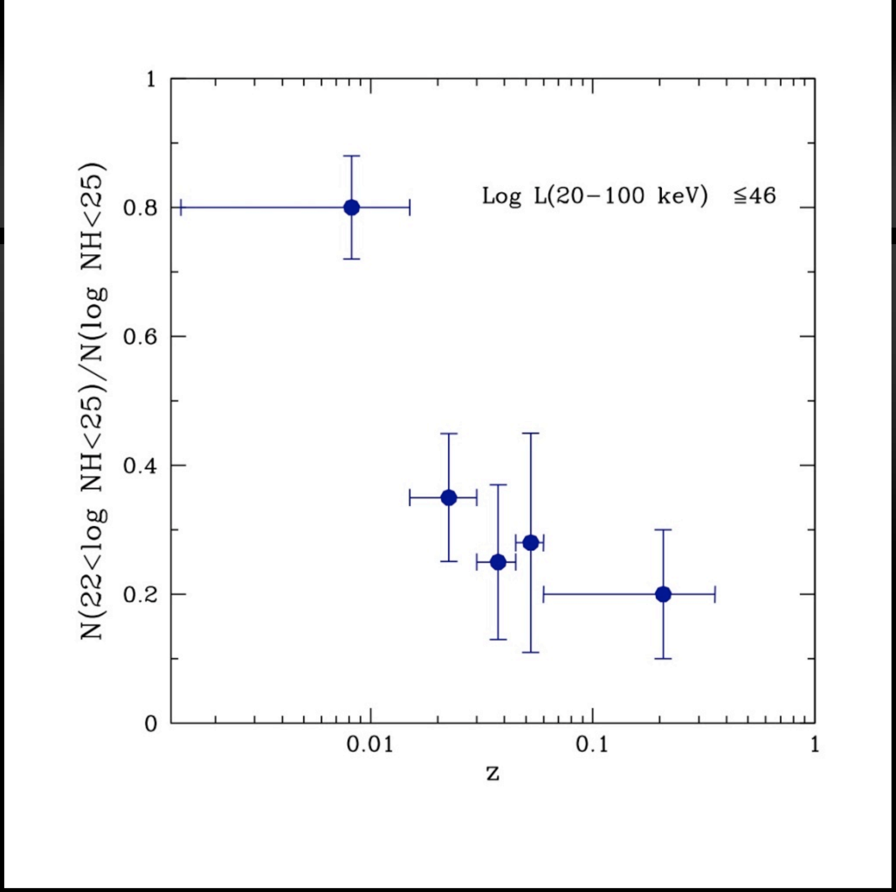
absorption in 43% of the sample

6 Compton thick i.e. 7% of the sample

The 'missing' Compton thick sources

Reduction of flux as a function of N_H i.e.

the fraction of absorbed sources as a function of redshift



The AGN of the complete sample
Has been divided into 5 bins of redshift
(up to z=0.335 i.e. excluding the sources
with Log ($L_{20\text{-}100keV}$) > 46) chosen in order
to have a reasonable
number of sources in each bin.

A clear tend of
decreasing fraction of
absorbed objects as the
redshift increases
is evident !!

The Local Universe ($z<0.015$)

This evidence indicates that to come closer to the true picture it is incorrect to consider the whole AGN sample to estimate the role of the absorption.

In the entire sample we lose the heavily absorbed *counterparts* of distant and therefore dim sources with little or no absorption.

Therefore only in the first bin (at low redshift) we are seeing almost the entire population of AGN: from unabsorbed to at least mildly Compton thick sources ($Log(N_H) \approx 24$)

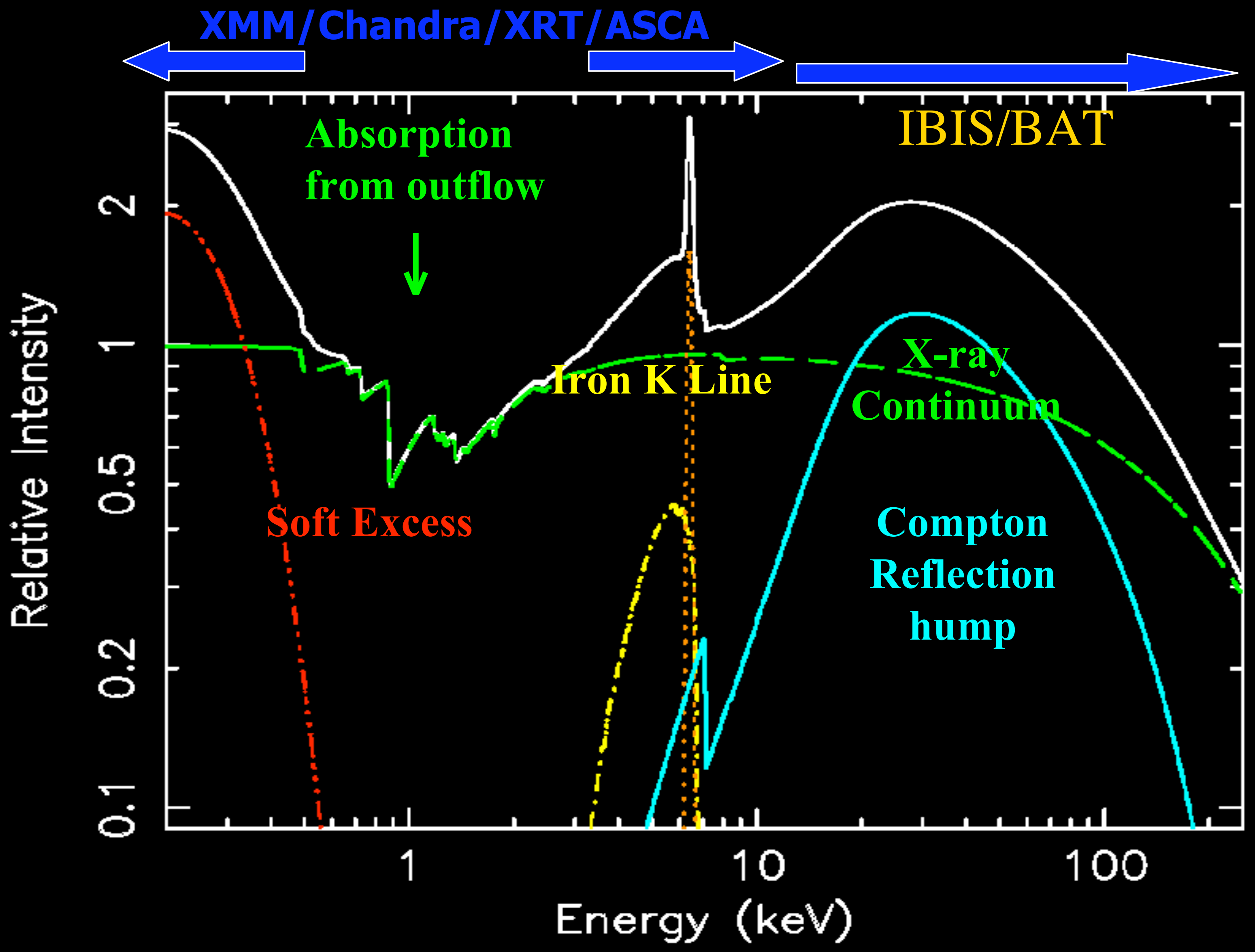
In the INTEGRAL AGN complete sample there are 25 sources with $z \leq 0.015$

20 AGN have $Log(NH) \geq 22$: 80% are absorbed

6 AGN have $Log\ (NH) \geq 24$: 24% are Compton thick

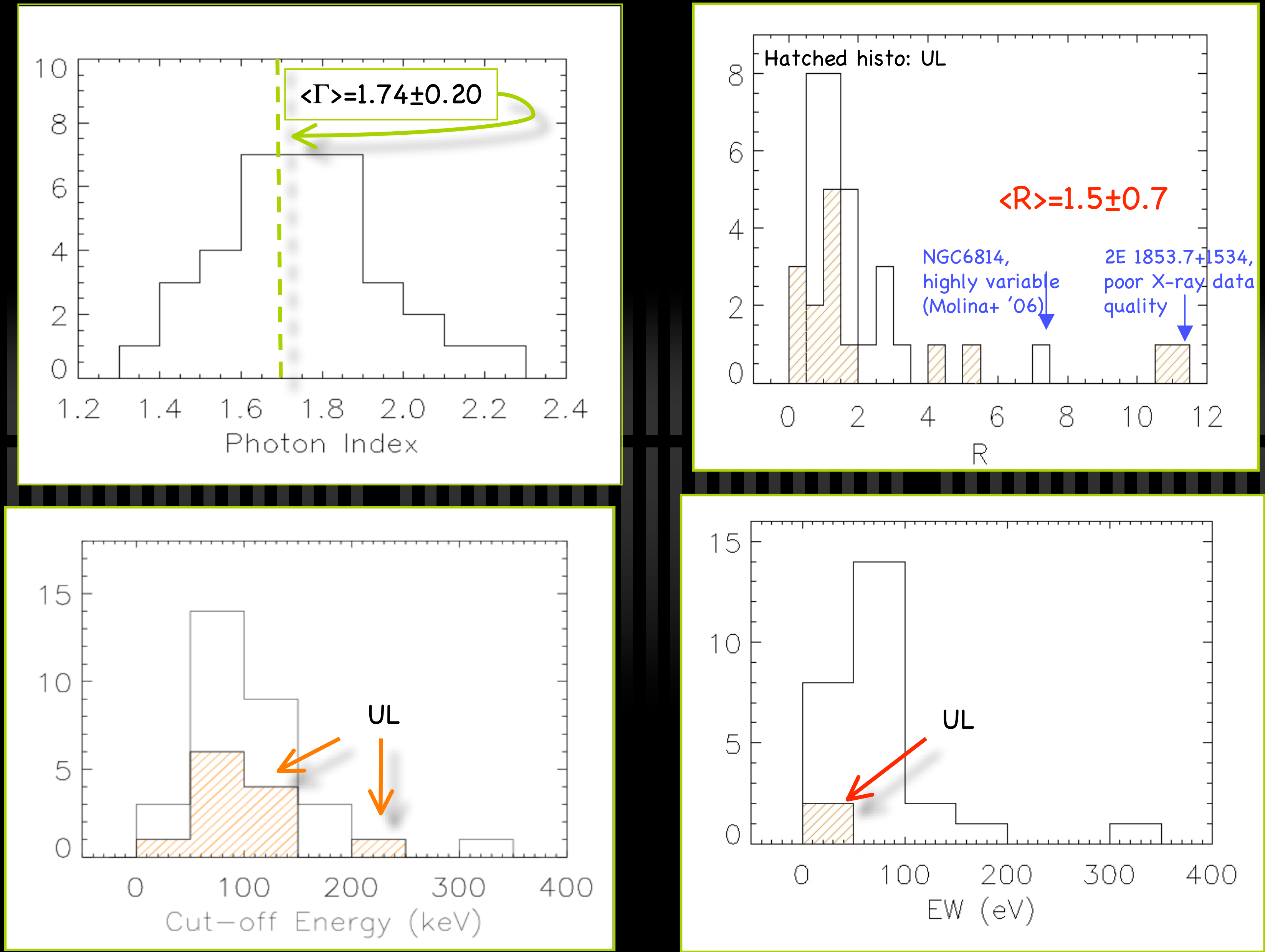
i.e. 1 out of 4 AGNs in the Local Universe is Compton Thick

Broad band spectral information on all AGN in complete sample



Determine Γ, Ec, R distribution in 36 type 1 AGN

(Molina et al. 2009)

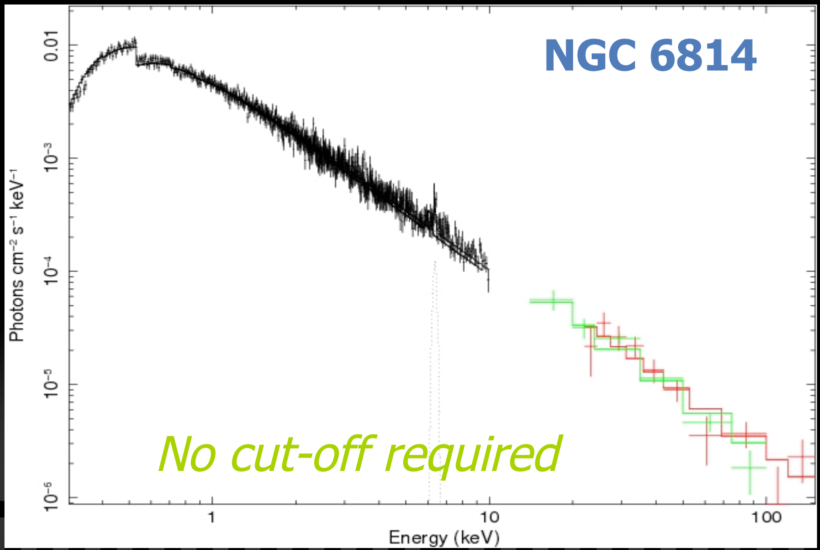


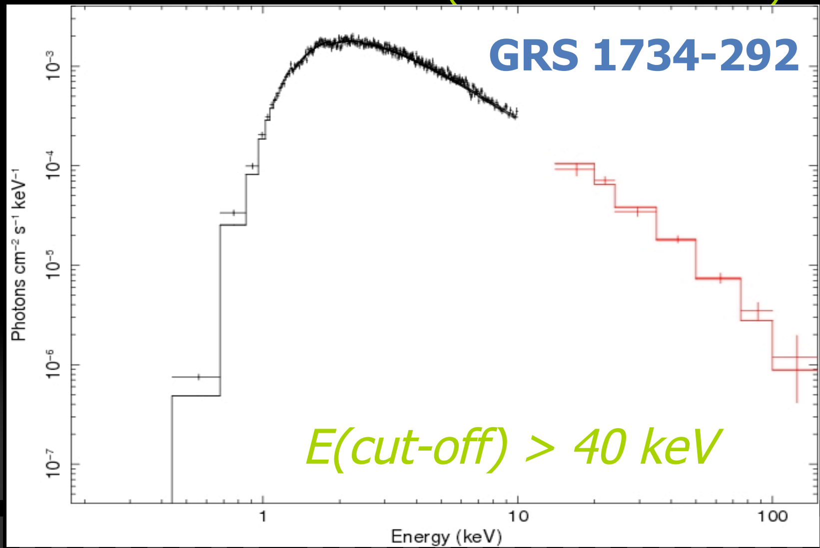
Conclusions on Type 1 objects

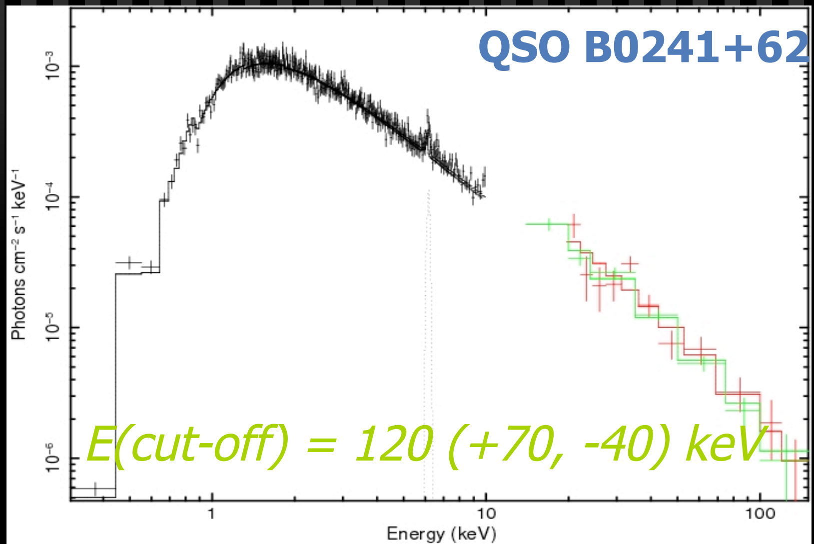
- First broad-band spectral analysis of a *COMPLETE SAMPLE* of type 1 detected in the 20-40 keV band by INTEGRAL.
- N_H generally small or absent, but some examples of complex absorption.
- $<\Gamma>=1.7\pm0.2$, flatter than canonical value of 1.9.
- $<E_{cut}>=110$ keV, with small spread. Most objects have E_{cut} in the range 50-150 keV.
- $<R>\sim1.5\pm0.7$, slightly higher than in previous results and in CXB modelling.
- Narrow Fe Kα, except in 15% of the cases.
- EW generally below 100 eV
- No correlations found in the parameter space, except a weak one between R and EW.
- Estimate of plasma temperature in the range 20-80 keV (2-9×10^9K), with optical depth in the range 1 to 4.
- New self-consistent set of parameters for synthesis models of CXB.

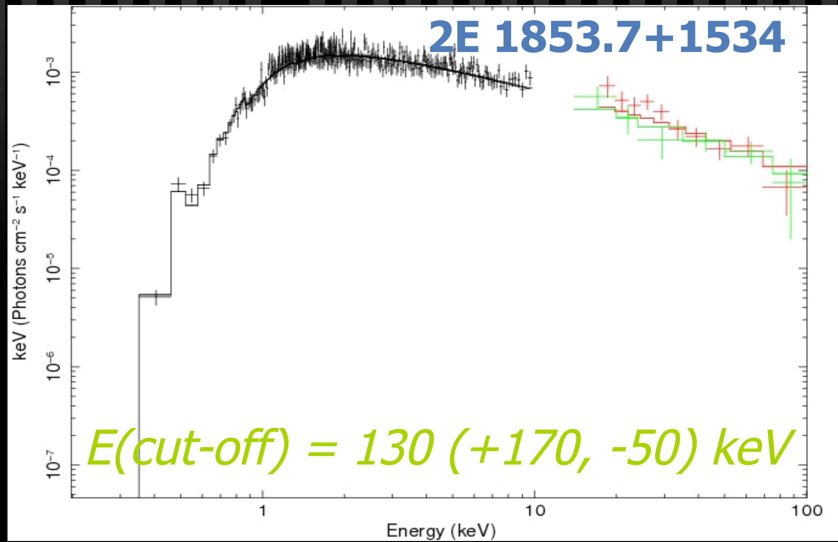
First results of broad band observations
with NEW XMM-Newton data obtained in AO7 - AO8 for 7 sources
and IBIS +BAT spectra

(Panessa et al 2009)

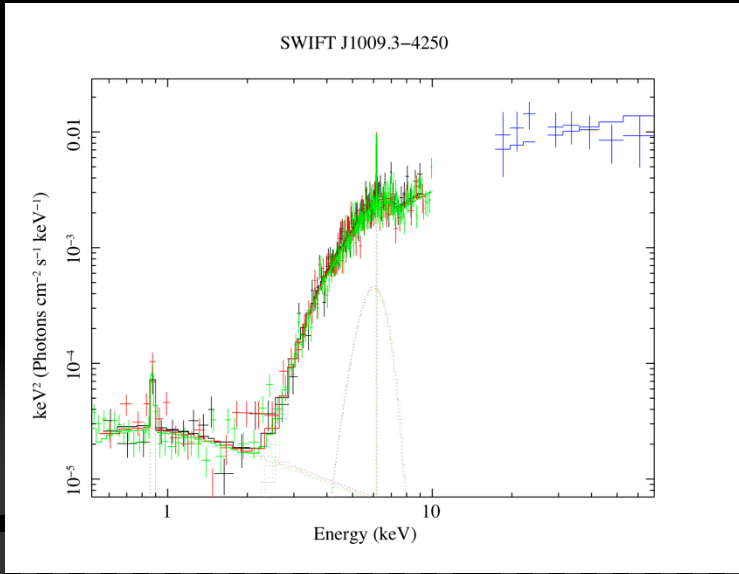


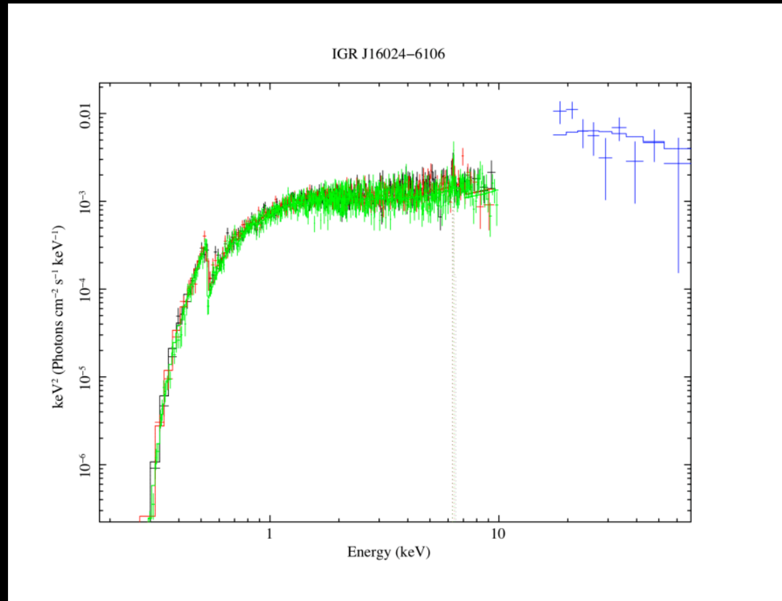




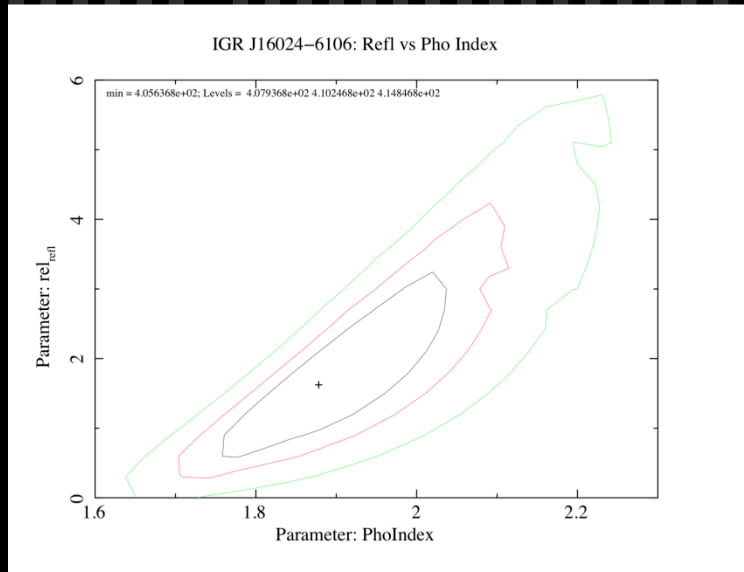


Some preliminary results on broad band analysis on Seyfert 2 galaxies





- Heavily and moderately absorption gas
- Compton reflection features definition: reflection hump & iron line

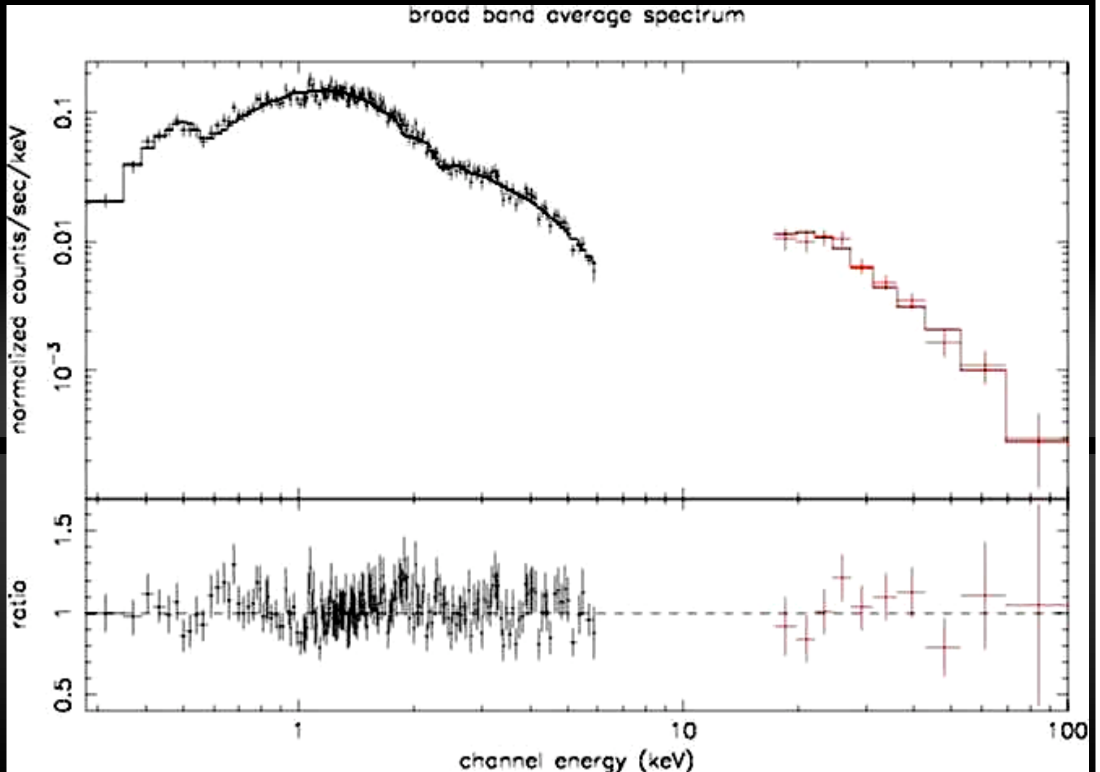


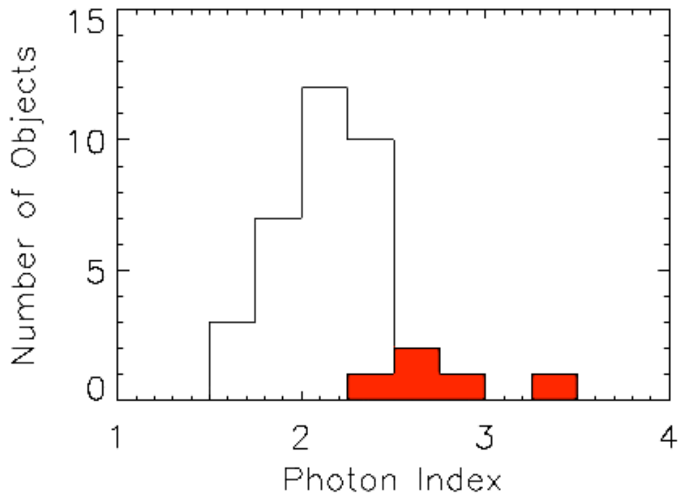
High energy observations of Narrow Line Seyfert 1s

(Malizia et al. 2008)

Five Hard X-ray selected NLSy1s:

Analysis of their IBIS spectra combined with Swift/XRT

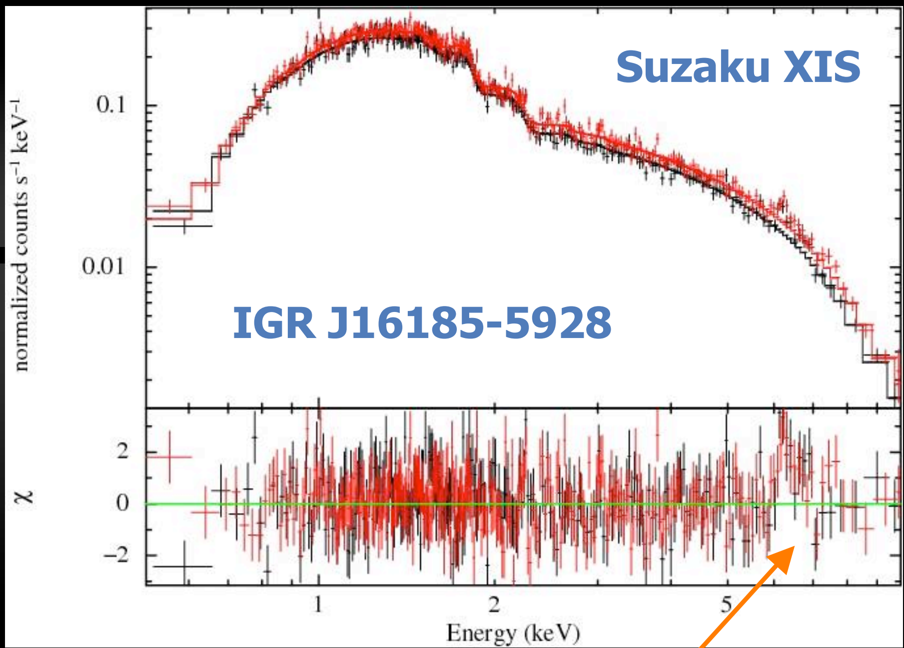


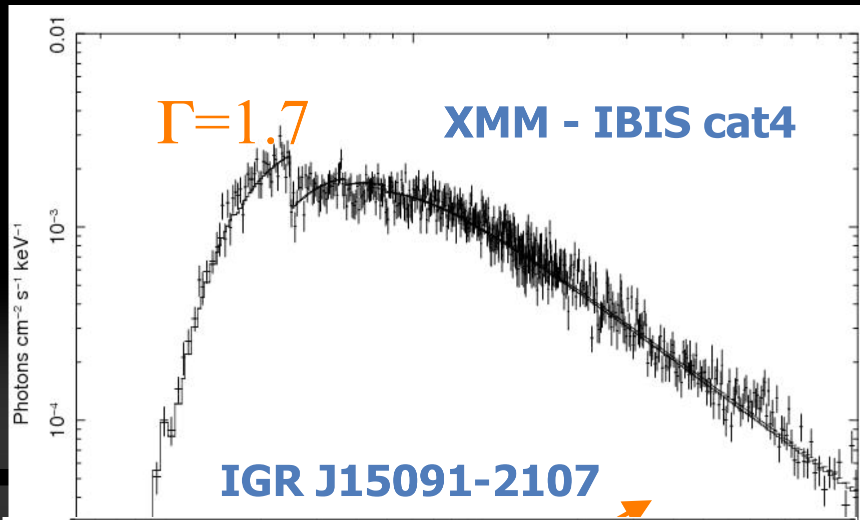


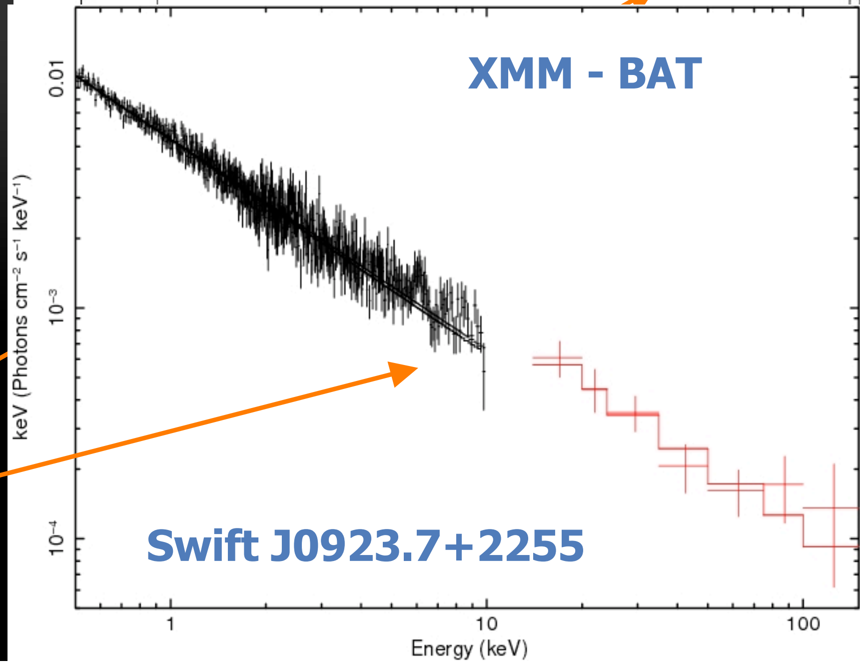
- Steep power law spectrum above 10 keV
- Absent or absorbed soft excess
- Low high energy cut-off (3/5: 30-50 keV)

New XMM and Suzaku observations of hard X-ray selected/discovered NLSy1

(Panessa et al. 2009)



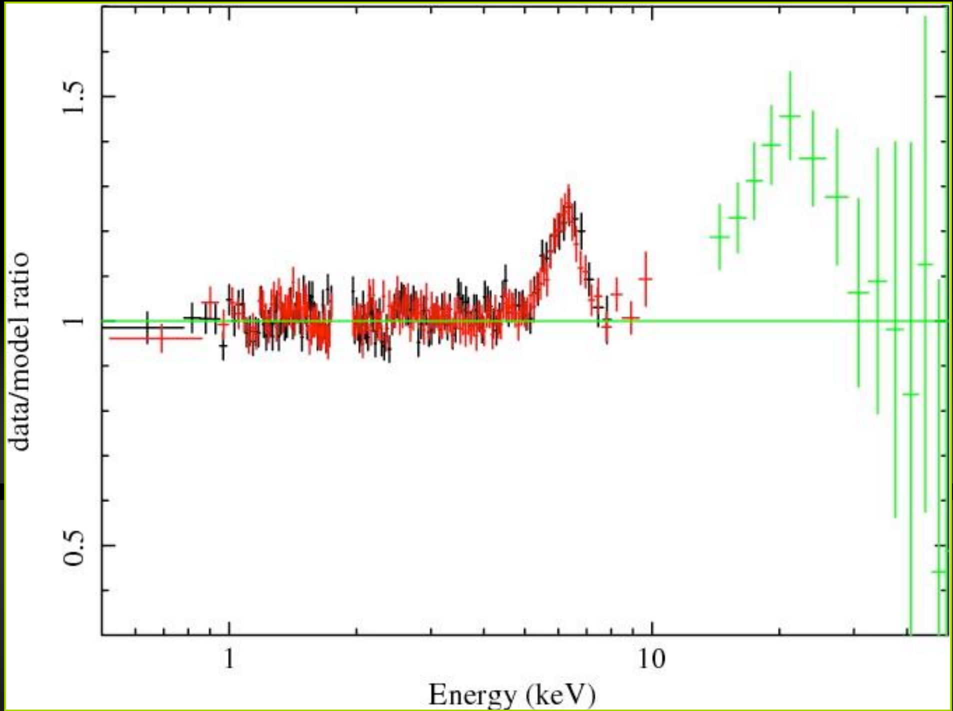




Strong FeK

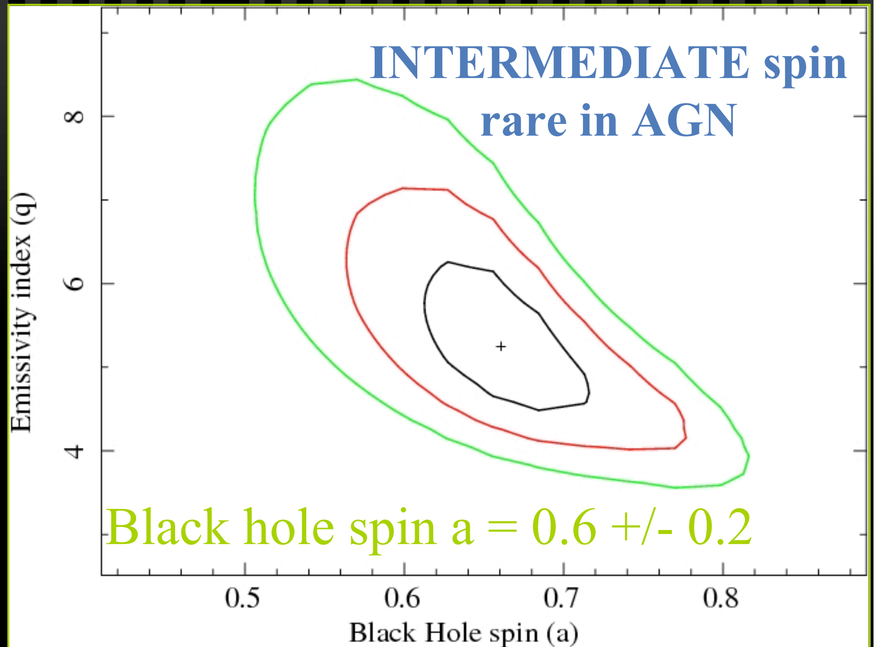
A nice example: SWIFT J2127.4+5654

(Miniutti et al 2009 MNRAS)



• **IBIS cut-off confirmed > 35 keV**

→ Broad relativistic iron emission line (originating in reflection from the innermost region of the AD)



→ **recent merger**

→ **chaotic accretion episodes**

→ **rotational energy extraction via magnetic fields**

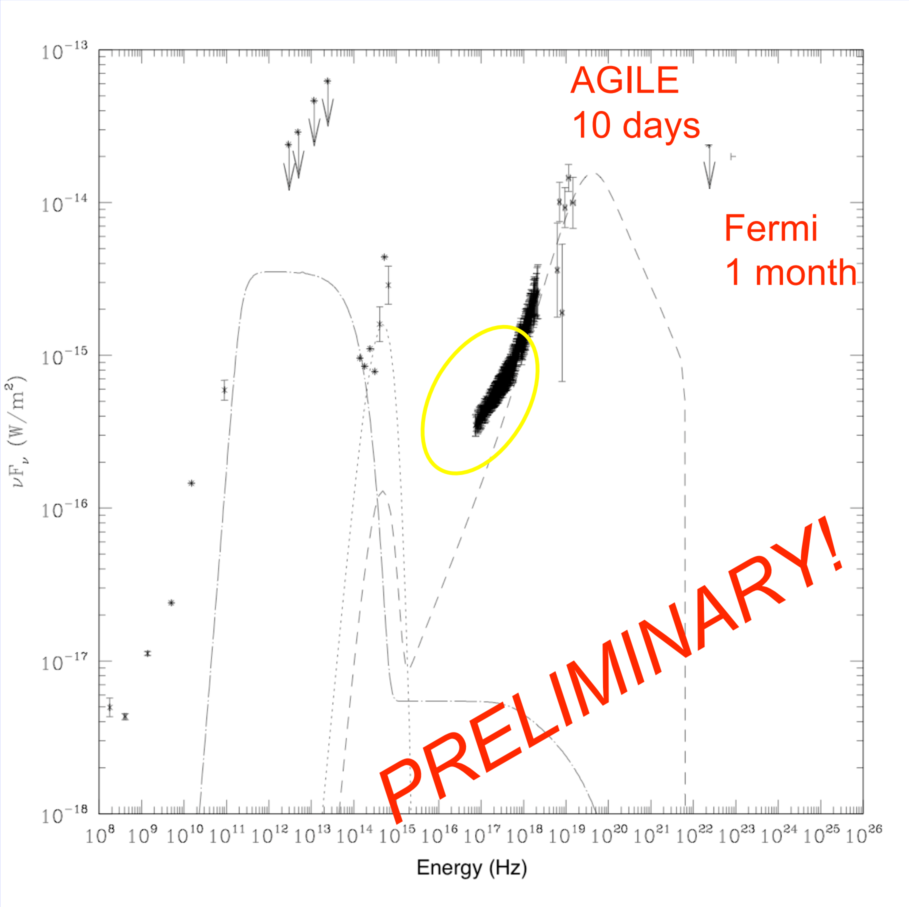
Blazars in CAT4 under study

(De Rosa et al. 2009)

source	$F_{20\text{-}40KeV}$	$F_{40\text{-}100keV}$	z	type
1ES 0033+59.5	*1.3*	*0.9*	*0.086*	*HBL*
RX J0137.7+5814	0.4	<0.4		
SWIFT j0218.0+7348	1.2	1.9	2.367	BLlac
IGR J03532-6820	1.3	<0.8	0.09	BLLac
QSO B0836+710	2.4	4.2	2.172	FSRQ
MKN 421	*25.6*	*19.4*	*0.03*	*HBL*
4C 04.42	*0.8*	*1.8*	*0.965*	*FSRQ*
3C 273	*10.4*	*12.3*	*0.158*	*FSRQ*
3C 279	*1.1*	*1.4*	*0.5362*	*FSRQ*
H 1426+428	1.0	1.1	0.129	HBL
MKN 501	*3.1*	*2.1*	*0.03366*	*HBL*
SWIFT 1656.3-3302	1.4	2.1	2.40	FSRQ
PKS J1830-211	*2.4*	*3.2*	*2.705*	*FSRQ*
1RXS J192450.8-291437	0.9	0.8	0.352	FSRQ
QSO B1933-400	0.5	1.0	0.965	FSRQ?
PKS 2149-306	1.2	1.7	2.345	FSRQ
Bl Lac	*1.3*	*1.5*	*0.0686*	*BLLac*
IGR J22517+2218	1.3	2.3	3.668	FSRQ
3C 454.3	*9.4*	*12.8*	*0.859*	*FSRQ*

4C 04.42 a key study

(De Rosa et al. 2008)



Energy Budget

$\nu_{BC} = \Gamma^2 \nu_{BLR}/(1+z) \sim 1$ keV

$L_{BC} = 4/3 \sigma c \delta^4 U_{BLR} \Gamma^2 N_{cold}$

$\sim 10^{46} N_{cold}/N_{rel},$

$L_{BC} \sim 10^{45}$ erg/s

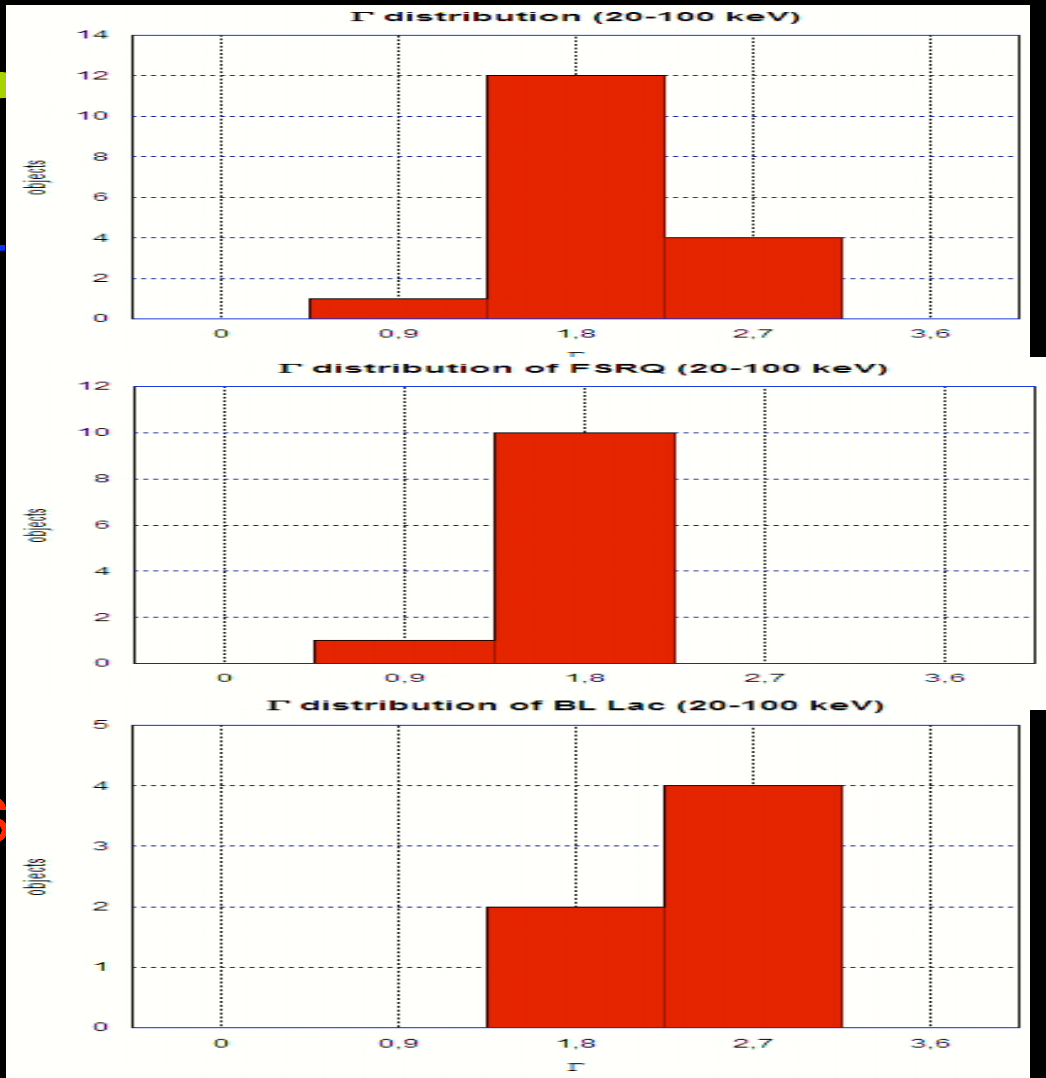
$\Rightarrow N_{cold}/N_{rel} \sim 0.1$

Multifrequency program: INTEGRAL & AGILE (quick look courtesy of L. Pacciani)+ public Fermi

X and Gamma-rays photon index distribution IBIS *vs* FERMI

BL

FS



Following the spectral sequence, gamma and X-ray spectral ranges match different emission processes in blue and red blazars

Future prospects

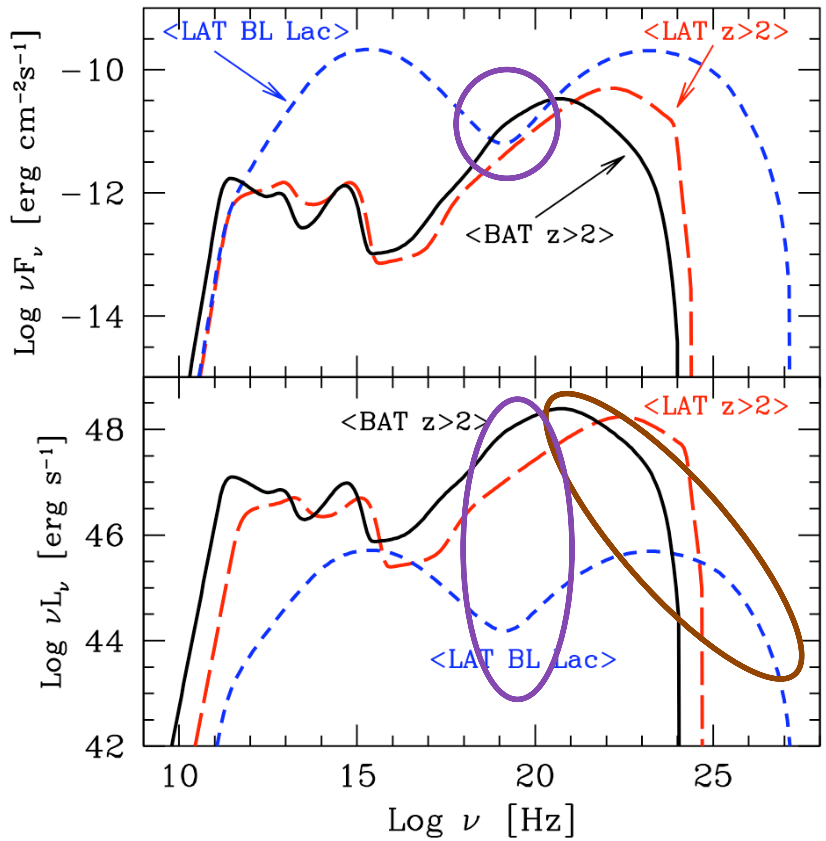
- ✓ Study of absorption in combined IBIS/BAT AGN samples
- ✓ Update broad band analysis of Seyfert 1s in complete sample
- ✓ Finish broad band analysis of Seyfert 2s in complete sample
- ✓ Study in detail all Narrow Line Seyfert in CAT4
- ✓ Analyse SED of Blazars in more detail including Fermi/Agile data
- ✓ Multiwaveband studies (radio, Infrared etc..)
- ✓ Keep working on CAT4 AGN data
- ✓ Work … work … work..

- ✓ and FERMI is doing something for INTEGRAL: trigger TOO on giant flares from BLLac and FSRQ →
  3C454.3 was 13 mCrab yesterday ..was 50 before!!

Extragalactic gamma ray astronomy has only just started………

Inportance of hard X-ray blazar selection

- LAT BL Lacs and high-z FSRQs have the same average flux in hard X–rays
- High-z FSRQs are brighter in hard-X rays wrt gamma rays
- LAT BL Lacs are the least luminous
- Comparing high–z BAT and LAT FSRQs, in the entire X–ray band **, we see that BAT blazars are more powerful than LAT blazars**



Ghisellini et al. 2009