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

Pietro Ubertini
on behalf of the IBIS survey/AGN team

INTEGRAL USER GROUP
ESTEC, 21 Aprile 2009

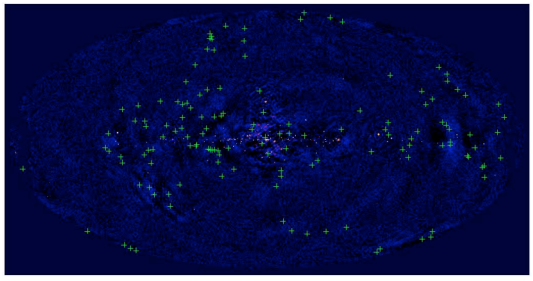
Istituto di Astrofisica Spaziale e Fisica Cosmica - Rome
INAF

The sky according to IBIS

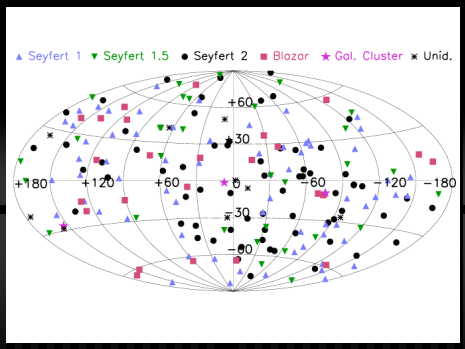
★ During its first year of observations *INTEGRAL* provided a small sample of 10 gamma-ray selected AGN *(Bassani et al. 2004)…*
★ The 2nd IBIS survey (*Bird et al. 2006)* enlarged the sample to 32 AGN…
★ The *INTEGRAL*/IBIS extragalactic survey *(Bassani et al. 2006)* increased the number of gamma-ray selected AGN to 62 objects…
★ 3rd IBIS catalogue (*Bird et al. 2007)*: 421 high energy emitting sources, [illegible] 140 are firmly identified with AGN.
★ 4th IBIS catalogue (Bird et al. in preparation): many more AGN!

WoW!

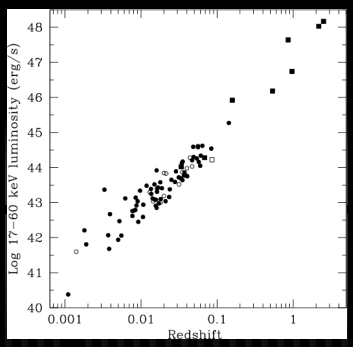
AGN distribution (140 sources)



Many other IBIS Surveys/Samples



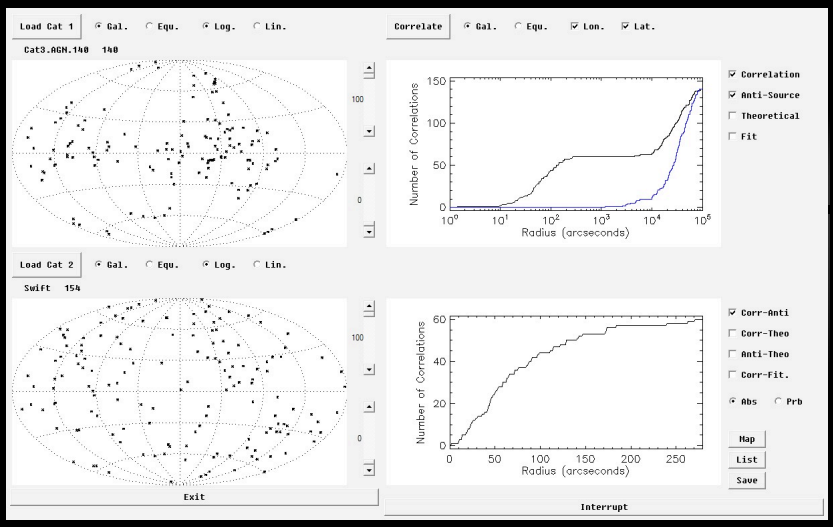
Beckmann et al. 2006
Beckmann et al. 2009



Sazonov et al. 2007

See also Paltani et al. 2008

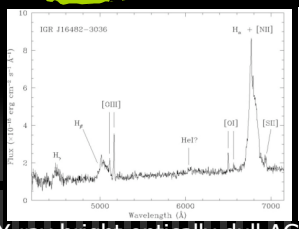
Cross-correlation of new BAT/SWIFT AGNs (148) versus IBIS/INTEGRAL CAT 3 AGNs (154):60 sources
new IBIS data indicates ~ 200 AGNs



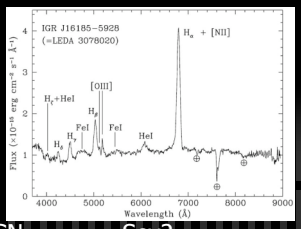
Optical spectroscopy fundamental to identify AGN

Telescopes used : Loiano-Bologna Italy, South Africa, CTIO-Chile, La Silla Chile, CASLEO Argentina

Sey1



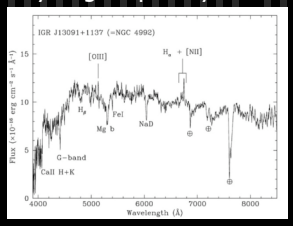
Narrow-Line Sey1



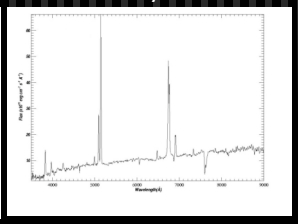
Masetti et al. 2004, 2006, 2008a, 2008b, 2009

- So far 130 identifications obtained of which ~70 are of AGN
- In our catalogue of 140 AGN, almoast 90% are Seyfert galaxies with a ratio Sey2/Sey1=1

X-ray bright optically dull AGN



Sey2



See also Bikmaev et al. 2006,2008, Burenin et al. 2008

To search for optical identifications of Integral AGN look here:
http://www.iasfbo.inaf.it/extras/IGR/main.html

Why high energy AGN surveys are important ?

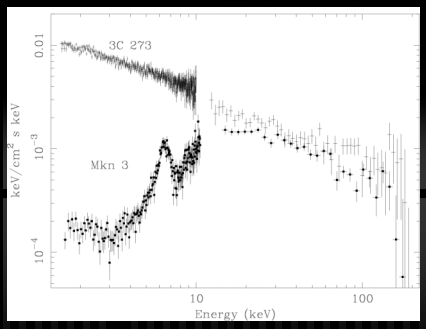
High energy coverage

Spectral information on Ec, R and constrain on Γ

Less biased samples in terms of absorption

Best definition of Nh distribution for various AGN class

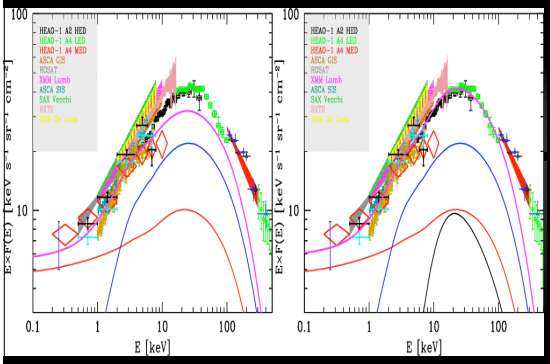
Absorbed AGN could be missed in X-ray surveys



- AGN modelling
- Unified theory, torus studies, etc
- X-ray Background (XRB) studies

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

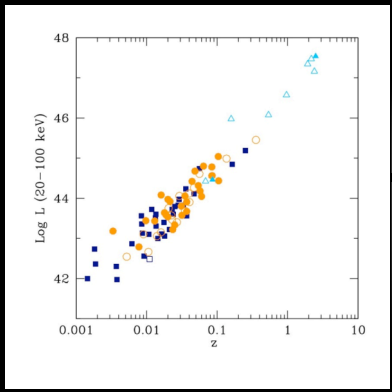
Input needed are:

- Nh 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

Third IBIS survey: a complete sample of 88 AGN

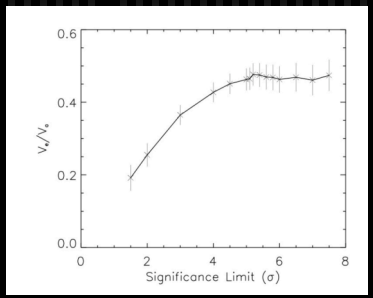
Malizia et al. 2009 MNRAS submitted



Complete sample in 20-40 keV

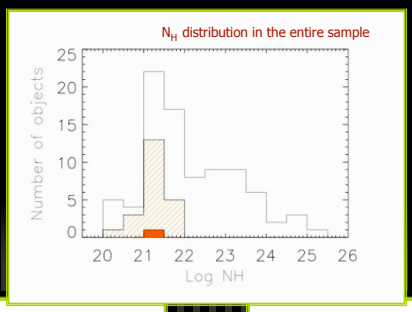
The IBIS AGN complete sample ➔ 88 objects

46 type 1 (circles)
33 type 2 (squares)
9 blazars (triangles)



The value of $\langle V_e/V_a \rangle$ as a function of limiting significance

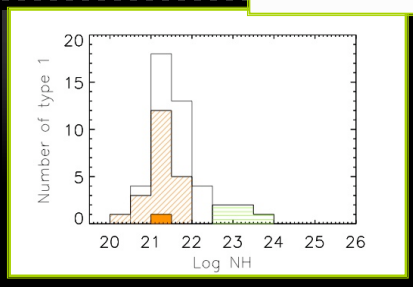
N_H distribution

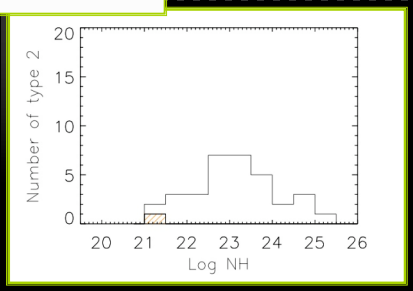


43% with $N_H > 10^{22}$ cm^{-2} compared to 50-60% of previous samples

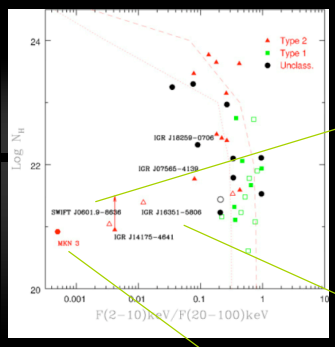
7% Compton thick in agreement with previous studies

Very few Compton thick AGN found



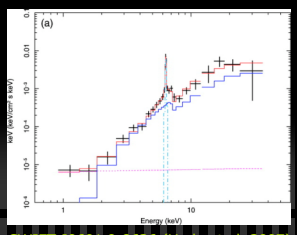


Compton thick sources: a new diagnostic diagram

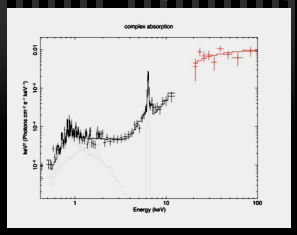


(Malizia et al. 2007)

MKN 3 known Compton thick AGN

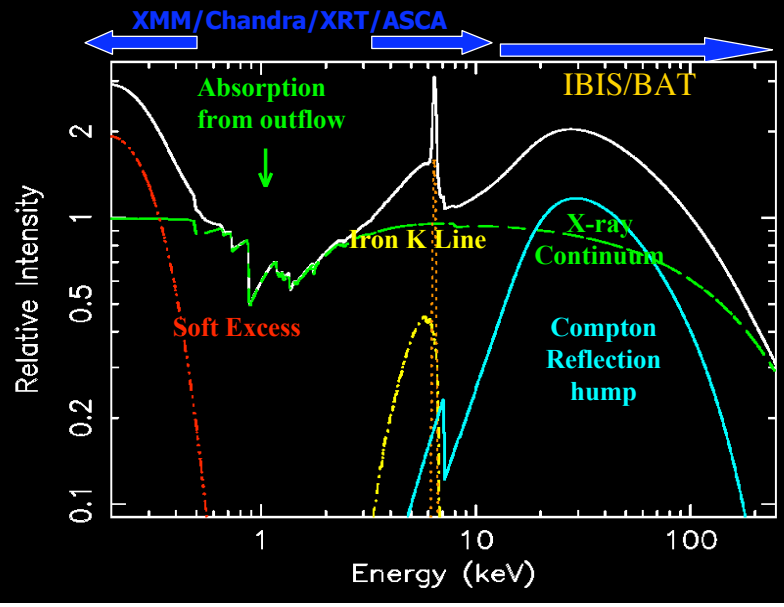


SWIFT J0601.9-8636 (Ueda et al. 2007)



IGR J16351-5806 (Malizia et al. 2009)

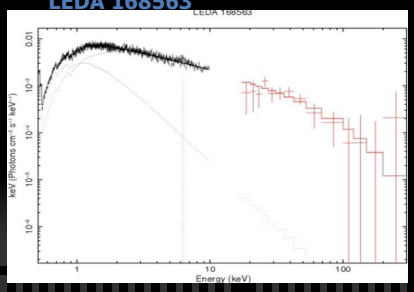
Broad band spectral information on a complete set of 36 Seyfert 1-1.5
(all with > 5.5 sigma detection in ISGRI)



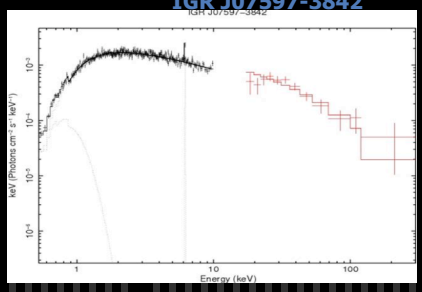
Some examples of broad band spectra

(*Panessa et al. 2008; Molina et al. 2008, 2009*)

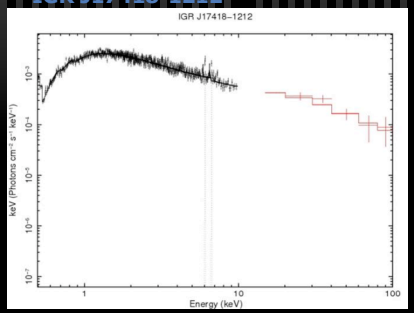
LEDA 168563



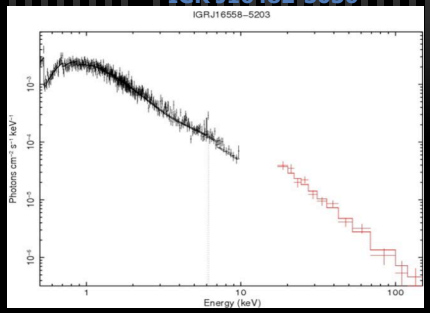
IGR J07597-3842



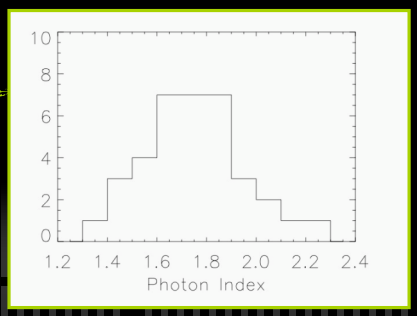
IGR J17418-1212



IGR J16482-3036



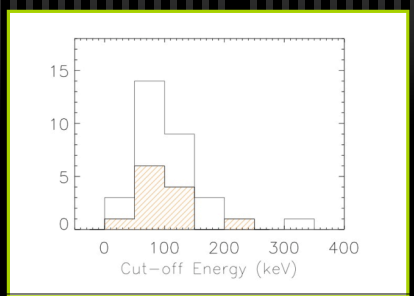
Determine Γ, Ec, R distribution

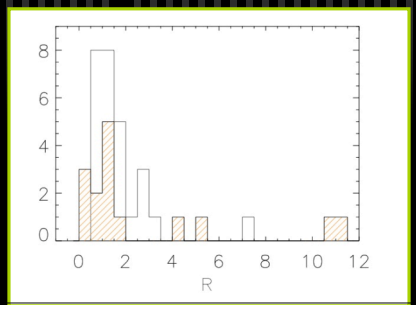


Γ= 1.74±0.03, σ=0.19
Ec=109±58 keV, σ=60 keV
R=1.52±0.2, σ=0.7

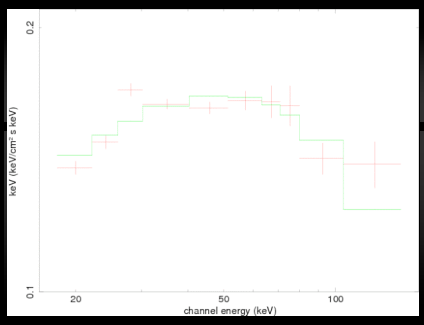
No correlation found between Γ, Ec, R , i.e. no strong interplay between parameters

Flatter spectra and lower cut-off energies than typically used in XRB modeling
Molina et al. 2009,MNRAS submitted



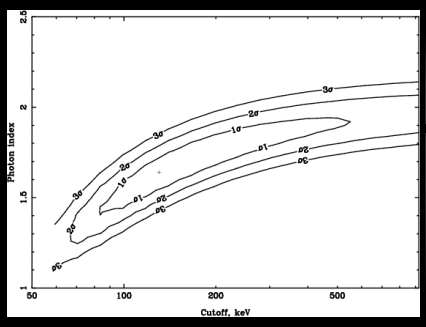


Similar results in other samples



Γ= 1.5±0.1
Ec=$99\pm^{64}_{24}$ keV

Beckmann et al. 2009



Γ ~1.7
Ec ~100-200 keV

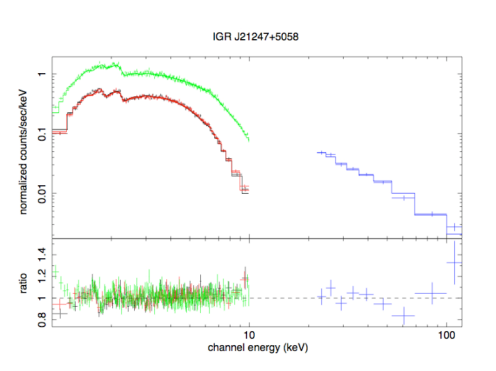
Sazonov et al. 2008

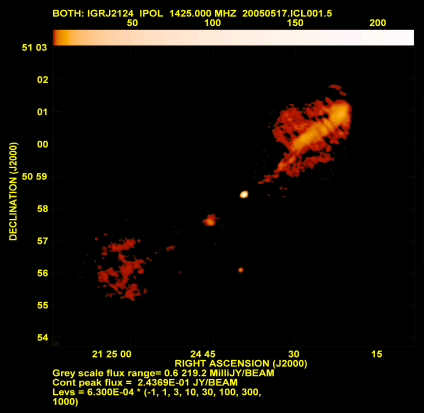
No significant differences between radio loud and radio quiet objects in the Seyfert 1 sample

But some interesting objects between radio loud AGN

IGR J21247+5058: FRII BLRG with Complex and variable absorption

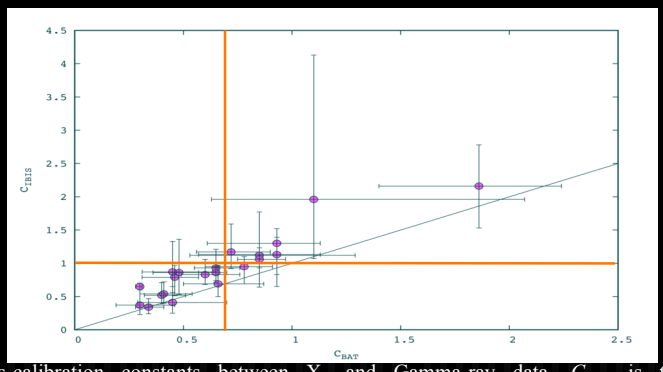
However… Complex absorption is NOT a characteristic of classical BLRG and so far has been observed only in another BLRG, i.e. 3C 445 (*Sambruna et al. 2007*).





(Molina et al. 2007)

Interesting comparison: cross calibration constant bewteen X-ray data and IBIS(C_{IBIS}) or BAT (C_{BAT})



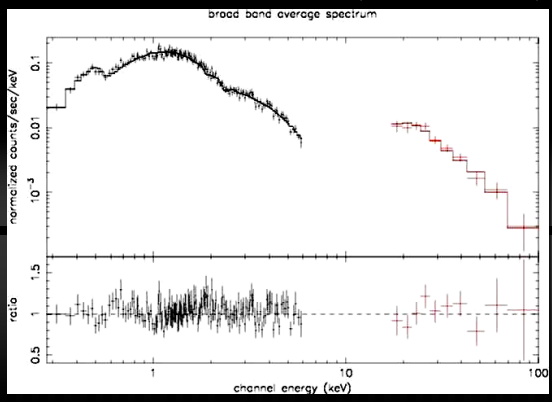
Plot of the cross-calibration constants between X- and Gamma-ray data. C_{BAT} is the *XMM/ASCA/XRT* and *BAT* cross-calibration constant and C_{IBIS} is the *XMM/ASCA/XRT* and *INTEGRAL* one. The 1 to 1 (C_{BAT}=C_{IBIS}) line for the constants is also shown. C_{IBIS} clusters around 1, a sign that the spectral match between X-ray and ISGRI data is quite good, while C_{BAT} clusters around 0.6/0.7, an indication that *BAT* spectra may have some systematics when compared to low energy data.

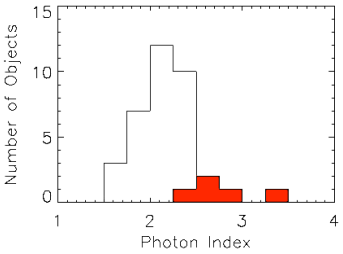
High energy observations of Narrow Line Seyfert 1s

(Malizia et al. 2008)

Five NLSy1s:

- Steep power law spectrum above 10 keV
- Absent or absorbed soft excess
- Low high energy cut-off (60 keV),



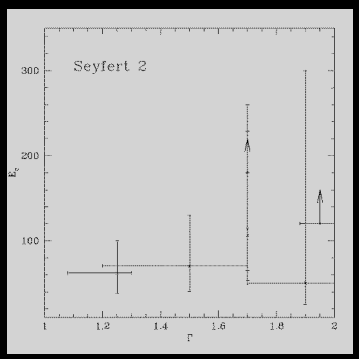


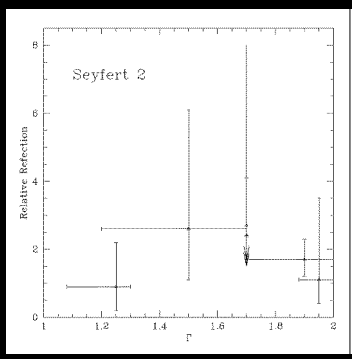
Work also started on Seyfert 2 in complete sample

Only few sources analysed

Chandra and/or XMM-Newton data + INTEGRAL data

- Compton thin absorption (no reflection dominated sources, confirmed also by low EWs and low OIII/F(X) fluxes)
- Low energy cut-off constrained (also by lower limits found below 200 keV)
- Flatter spectra

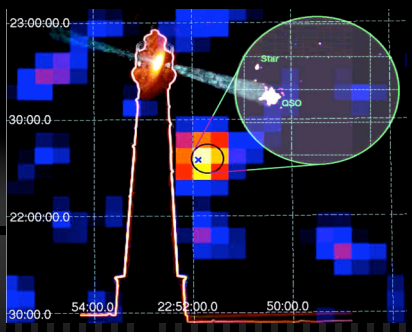


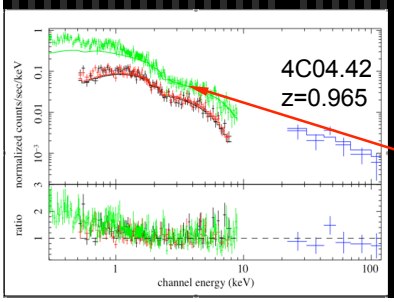


(De Rosa et al. 2008)

Also a few High-z QSOs detected

A gamma-ray lighthouse:
IGR J22517+2218
(z=3.668)
(Bassani et al. ApJL 2007)
L(2-10 keV)=0.3x10^{48} erg/s
L(20-100 keV)= 5x10^{48} erg/s





The FSRQ 4C04.42, z=0.965

Excess of emission
below 2 keV obs frame
EVIDENCE of Bulk Compton?

(De Rosa et al. MNRAS Letter 2008)

Future prospects

- ✓ Collect XMM data for all AGN in complete sample : already 17 observed with XMM
- ✓ Complete analysis of Seyfert 2 galaxies
- ✓ Use cat4 data (≈200 AGNs) for a more in depth analysis of absorption
- ✓ Study Blazars in more detail (Correlation with Fermi sources)
- ✓ Multiwaveband studies (radio, Infrared etc..)
- ✓ Variability studies, we have now new "AGNs all sky monitors": FERMI and AGILE
- ✓ Observe , observe, observe !……

Extragalactic gamma ray astronomy has only just started.....