Optical identifications of celestial high energy sources with the Telescopio Nazionale Galileo

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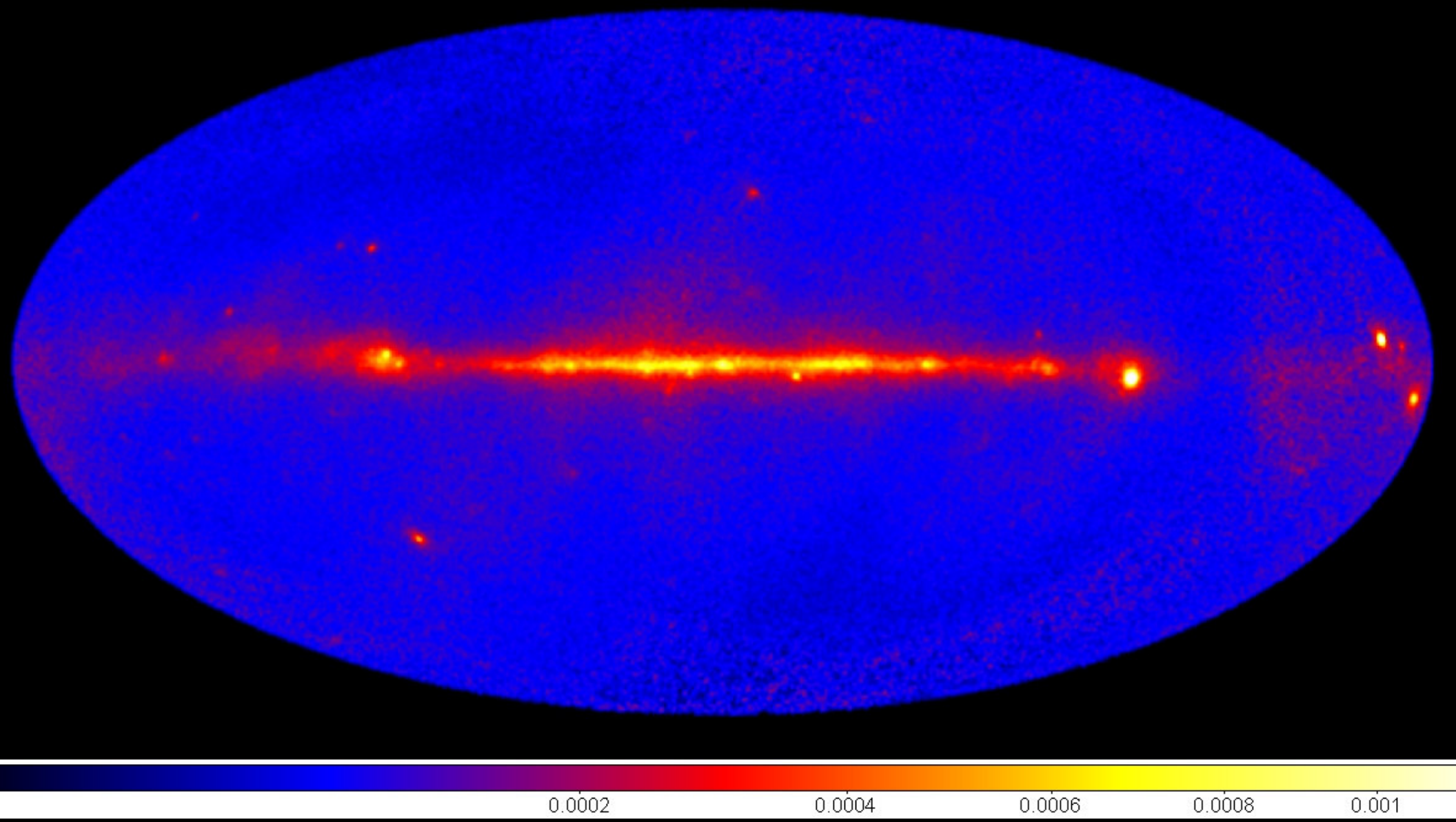
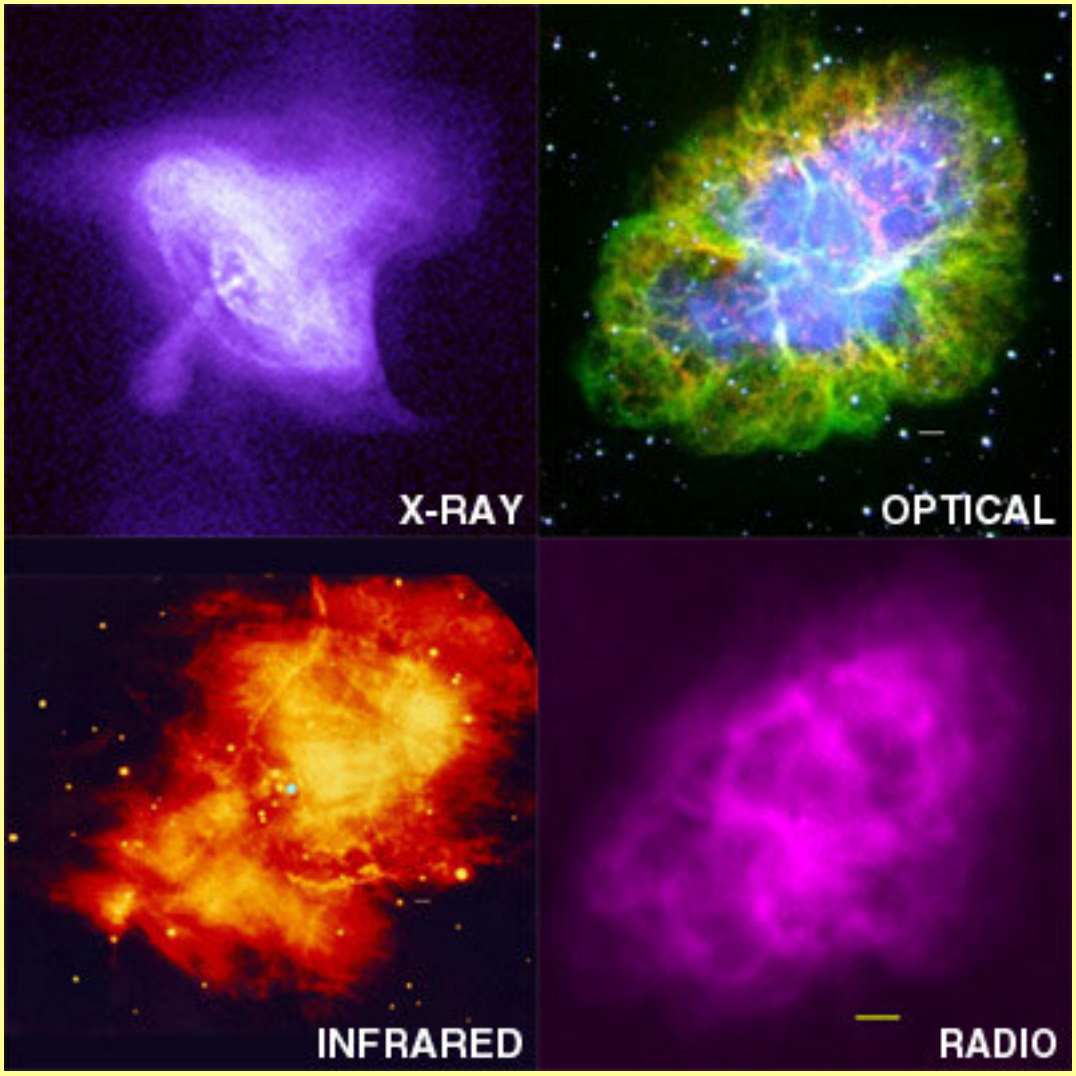
optical band sky

gamma-ray band (E>100 MeV)



CRAB NEBULA



Cen A

@ Different Wavelengths → Different emission mechanisms at work

"The problem of optical identification of high energy (X- and γ-ray) sources is a classic in modern astronomy. It is only through the optical studies that one can gain complete understanding of objects"

(G. F. Bignami, 1991)

Matter of interest

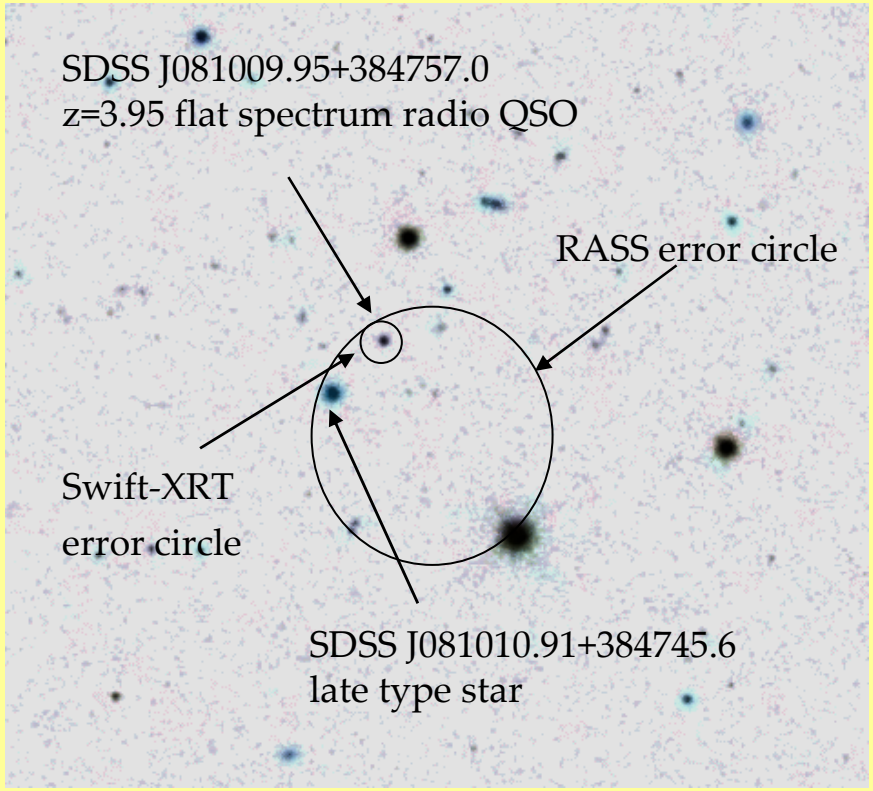
Known Issues

Currently available astronomical public optical databases do not provide an adequate support for a systematic high energy sources identification work:

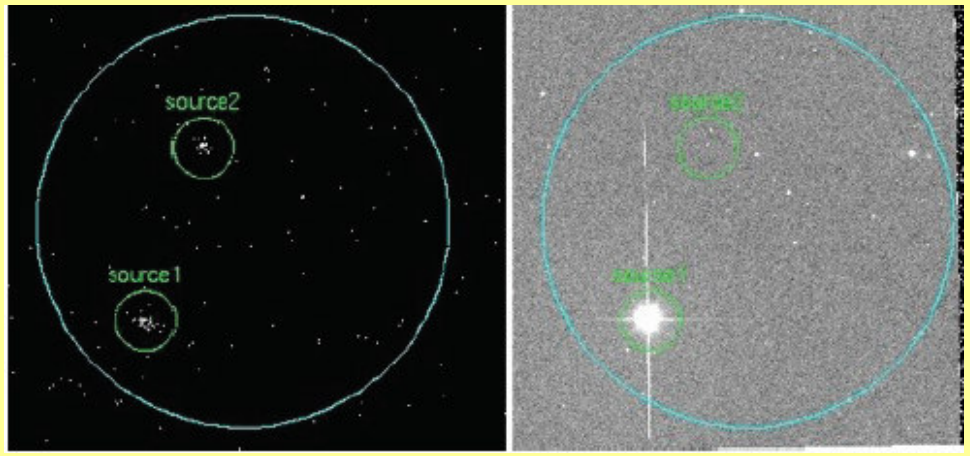
i. *poorly positioned high energy sources*

ii. *the optical limiting magnitude represents a severe limitation*

i. "poorly" positioned high energy sources



1FGL1254.4+2209



Swift/XRT *Optical (r)*

ii. the optical limiting magnitude limitation: the deepest flux limits reached by X-ray surveys require of course similarly deeper optical catalogs to homogeneously sample the available parameter space.

Telescopio Nazionale Galileo (TNG)

- **3.58m telescope, equipped with an active optics system**
- **@ Island of San Miguel de La Palma, Canary Islands**
- **5 instruments permanently mounted and operating**

DOLORES (Device Optimized for the LOw RESolution) allows imaging and spectroscopic observations

***Long-Slit Spectroscopy*: technique used to obtain both spatial and spectral information at the same time.**

Matter of interest

Rapid variability in the X-ray band is recognized as a hallmark of all AGN.

It plays a key role in constraining the size of the AGN central engine.

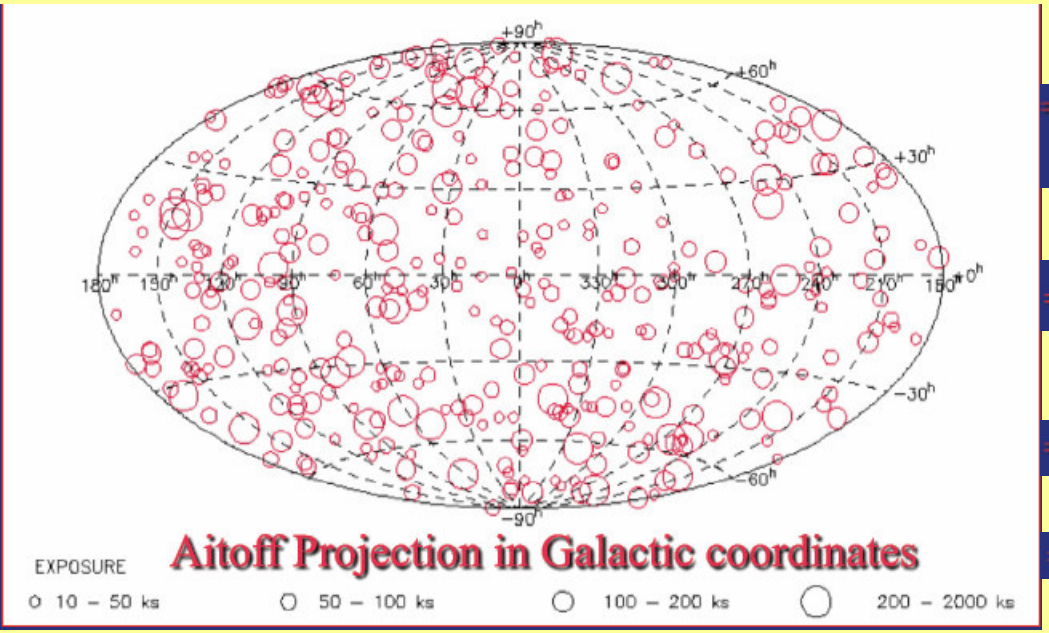
Open Questions

How does the X-ray variability depend on luminosity, redshift, wavelength and time delay?

IDEA: Ensemble Structure Function analysis as done in the optical band

The SwiftFT Survey

Puccetti et al. 2011, A&A, 528, 122



Aitoff Projection in Galactic coordinates

=> long exposure times + low background = DEEP Survey!

Flux limit (0.5-2 kev)~ 7X10^{-16}erg cm^{-2}s^{-1})

=> a rather uniform sky sensitivity.

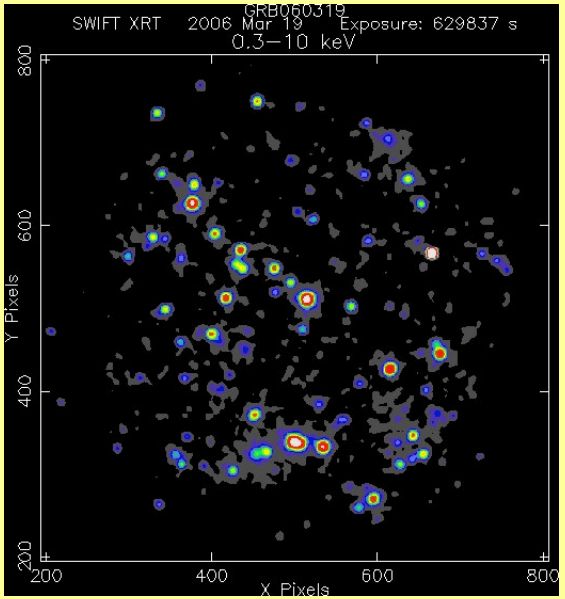
=> rare objects!

=> unbiased investigation of the properties of the X-ray sources!

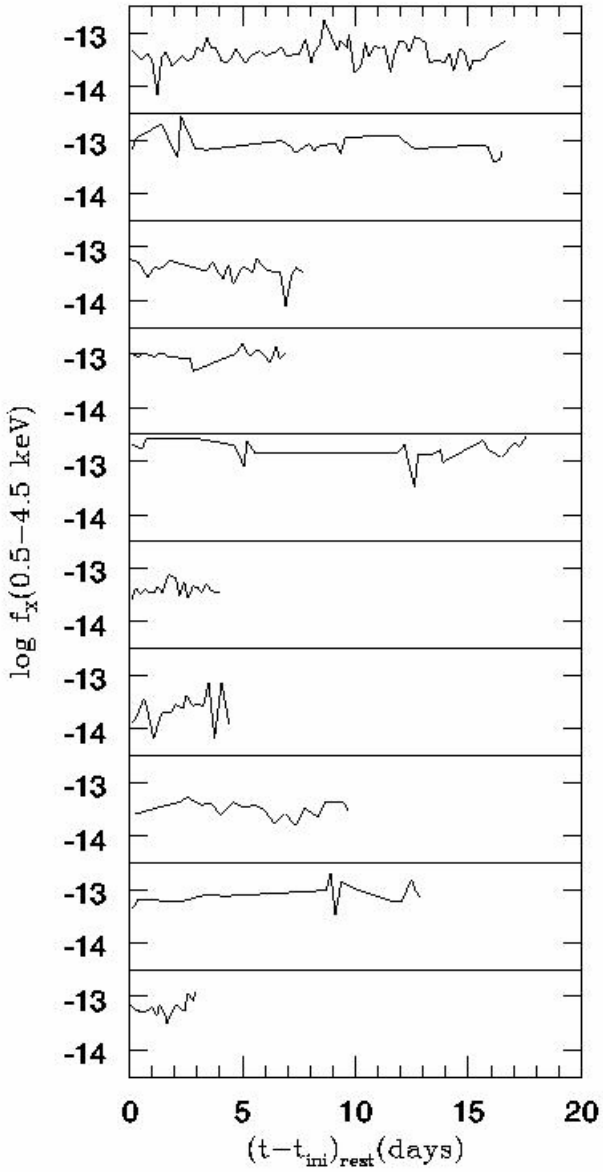
X-ray serendipitous point-like sources detected in the fields of Gamma Ray Burst **followed by XRT from January 2005 to December 2008 with exposure time >= 10 ks: 374 fields (~32.55 deg^2), 254 fields (~22.15 deg^2) at high Galactic latitude, i.e. |b|>=20°**

9387 sources (7071 at |b|>20) ,0.5-2 keV flux limit ~ 7X10^{-16}erg cm^{-2}s^{-1}, 2-10 keV flux limit ~ 4X10^{-15}erg cm^{-2}s^{-1}

The GRBs explode randomly in the sky, with isotropic distribution (Briggs 1996) and SwiftFT does not suffer of possible biases towards already known bright X-ray sources, as the large serendipitous surveys based on X-ray archival data, like Einstein, ROSAT, Chandra and XMM-Newton data.

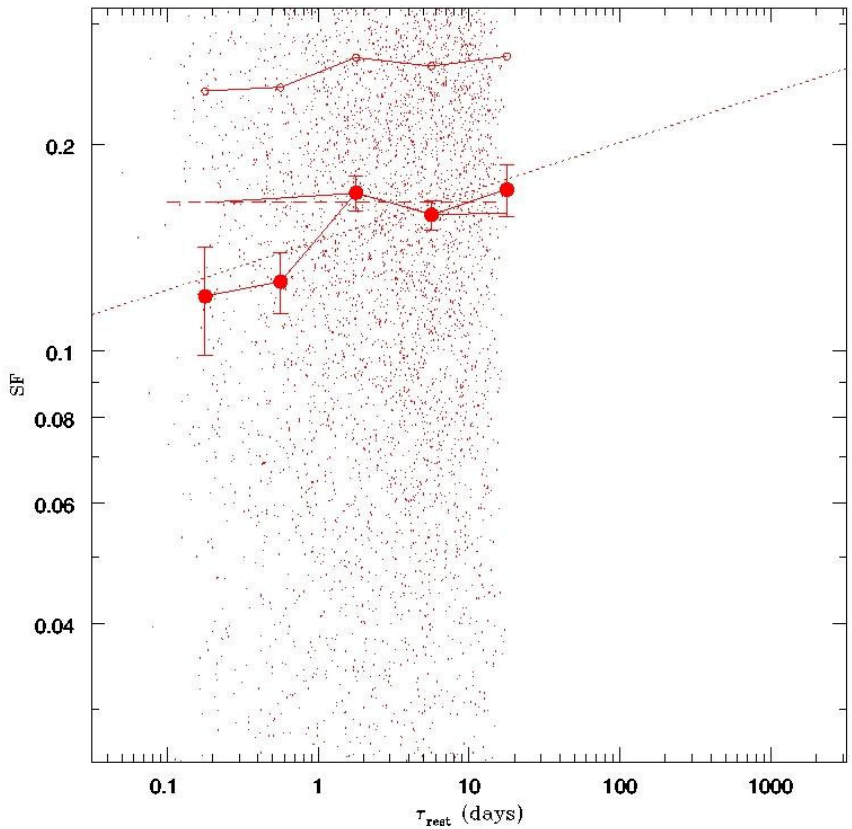


$$SF(\tau) = \sqrt{\frac{\pi}{2}\langle|logF(t+\tau) - logF(t)|\rangle^2 - \sigma_n^2} \sim \tau^{\beta}$$



Some well sampled lightcurves

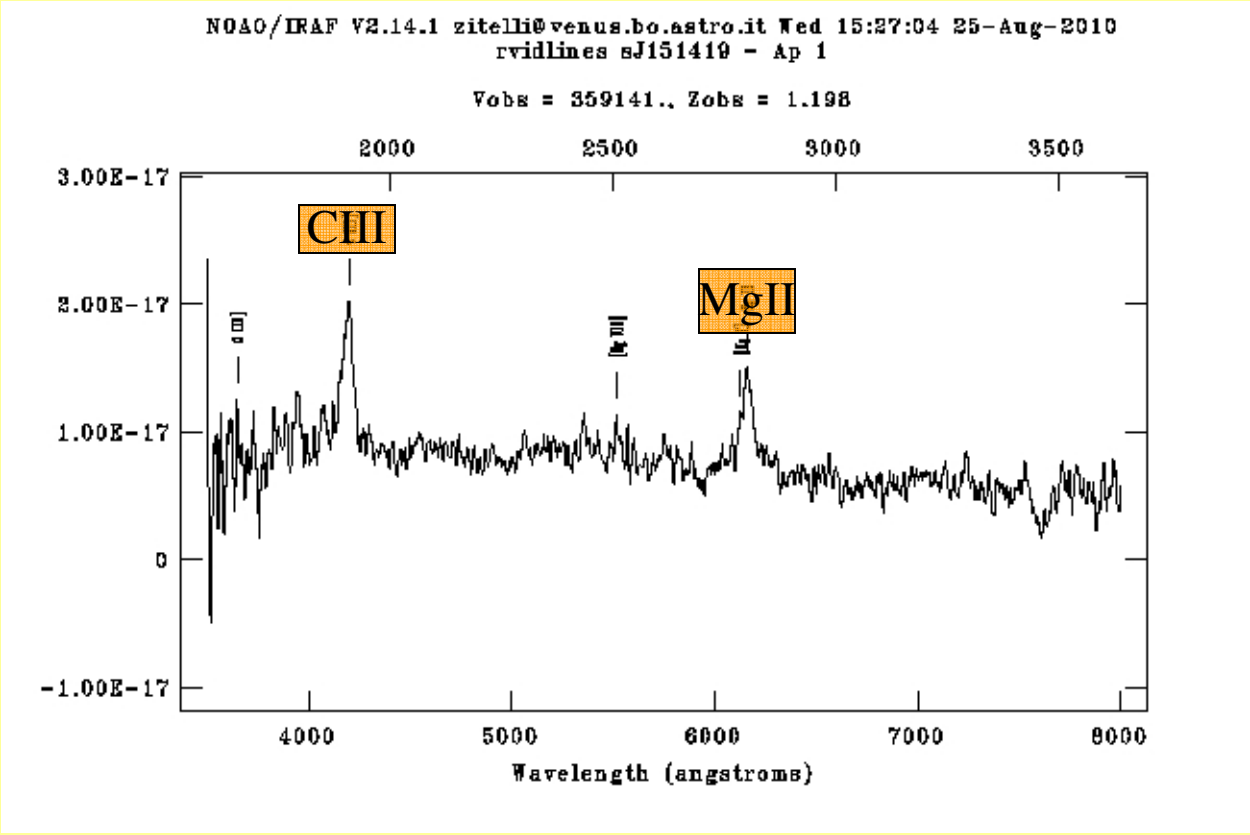
β=0.07±0.04



***SwiftFT*--- SDSS DR7 (27 obj)**

Vagnetti, Turriziani, Trevese, 2011, A&A, 536, A84

A spectroscopic campaign to identify *Swift* serendipitous sources with the TNG



<u>TNG proposal</u> (PI: *Turriziani*)
IDEA: estimate redshifts for 34 sources in 5 GRB fields observed by *Swift* selected to have:

- long exposures ($t_{expo} \geq 3 \times 10^5$ s) → **Better SF sampling at long τ**

- at least 100 photons in the X-ray lc

- an optical counterpart in the SDSS brighter than g=21.5

15 sources observed
(IRAF spectral analysis –-> *z*)

→

11 AGN (~ 80%)
2 stars
1 CV candidate
1 normal galaxy

The Observed Sample

NAME	Ra(J2000)	Dec(J2000)	r	g	Bmag	TARGET_NAME	zobs
J114557+600204	11 45 57.8	60 02 04.8	17.2	18.0	18.55	GRB060319	star
J114604+600043	11 46 04.3	60 00 43.2	18.5	18.8	19.11	GRB060319	2.8563
J123325+210606	12 33 25.2	21 06 06.2	20.8	20.7	20.82	GRB050416A	1.8526
J133053+350050	13 30 53.5	35 00 50.8	20.8	20.8	20.97	GRB060206	1.881
J133108+345742	13 31 08.5	34 57 42.8	21.0	20.8	20.88	GRB060206	1.7328
J133201+350407	13 32 01.6	35 04 07.6	20.4	20.7	21.01	GRB060206	1.32
J133207+350928	13 32 07.0	35 09 28.1	19.3	19.1	19.18	GRB060206	0.59
J151319+304612	15 13 19.8	30 46 12.4	20.1	20.2	20.42	GRB051117A	1.5031
J151335+304711	15 13 35.7	30 47 11.2	20.7	21.0	21.31	GRB051117A	0.871
J151409+305544	15 14 09.1	30 55 44.7	20.5	20.7	20.96	GRB051117A	2.6576
J151419+305847	15 14 19.7	30 58 47.2	20.7	21.0	21.31	GRB051117A	1.1978
J200001+091041	20 00 01.0	09 10 41.3	19.4	19.7	20.01	GRB050607	1.501
J200018+091330	20 00 18.8	09 13 30.5	14.3	15.1	15.65	GRB050607	star
J200025+085846	20 00 25.1	08 58 46.9	18.5	18.8	19.11	GRB050607	CV candidate
J200031+085903	20 00 31.6	08 59 03.7	14.3	14.8	15.20	GRB050607	0.023

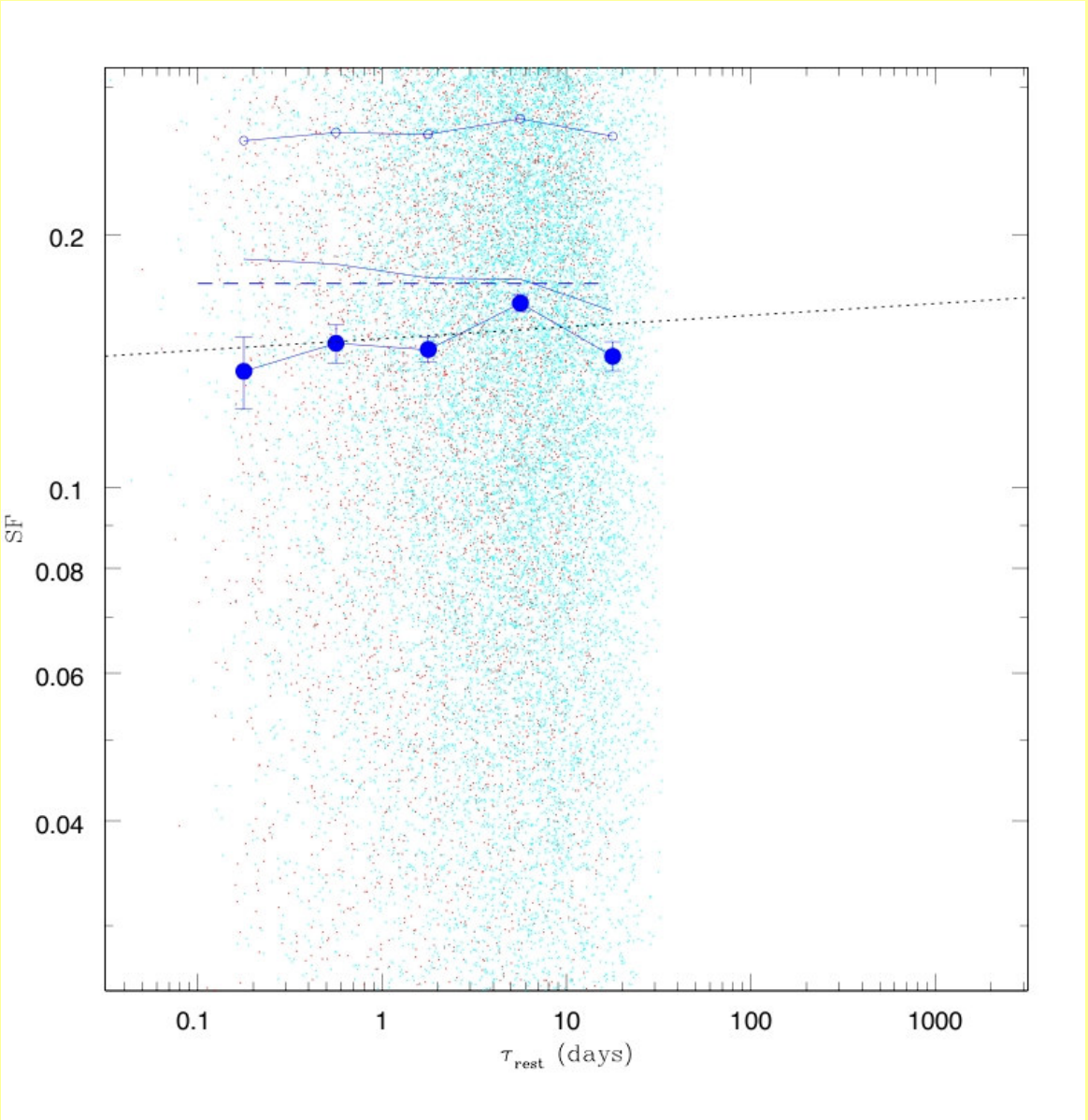
AGN

As expected, ~ 80% of extragalactic X-ray sources are AGN

***Turriziani* et al., in preparation** **In collaboration with: V. Zitelli, F. Vagnetti, D. Trevese**

The New (Preliminary) Structure Function

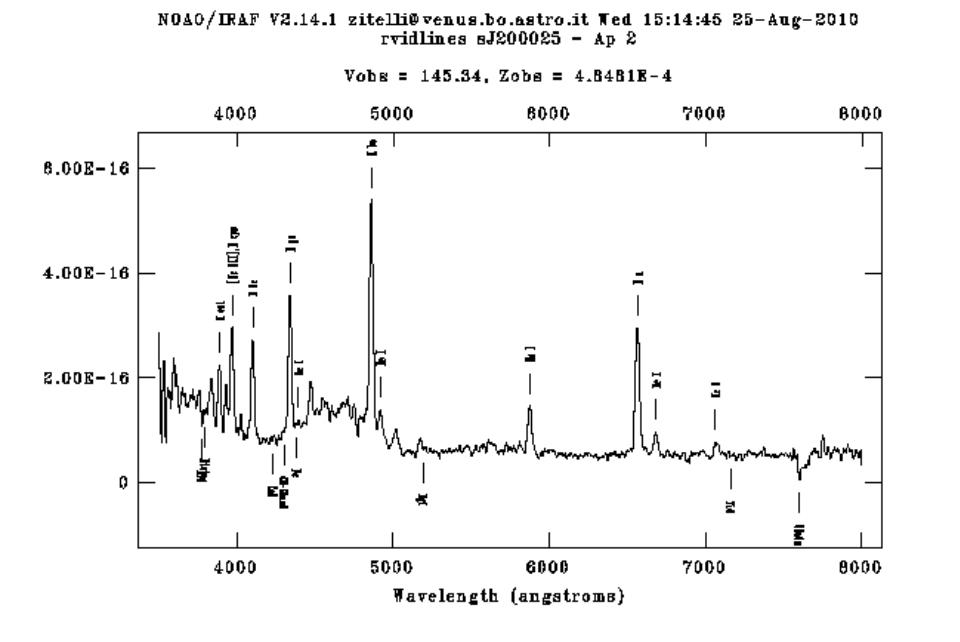
SF extended up to τ_{rest}~40 d

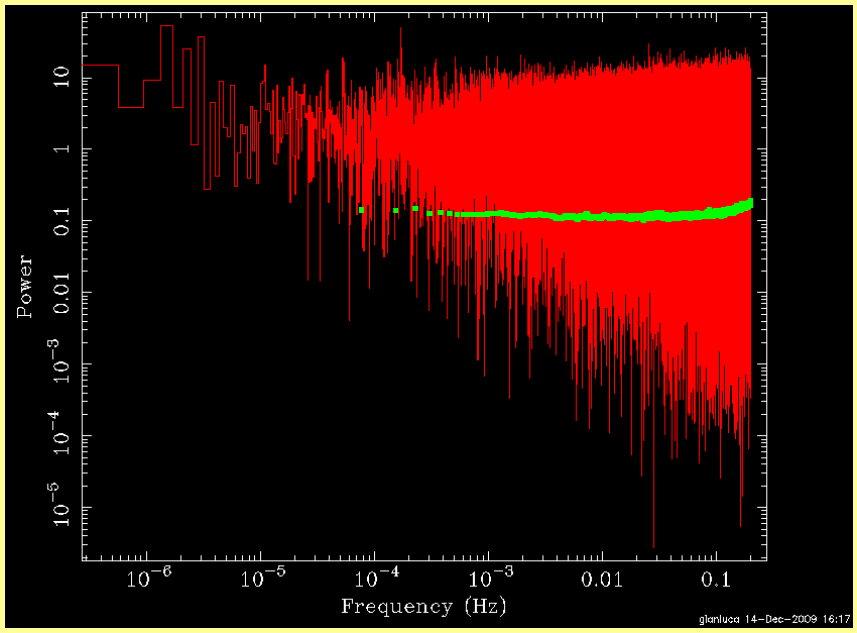


Turriziani et al., **in preparation**

In collaboration with: V. Zitelli, F. Vagnetti, D. Trevese

Not only AGN… just a taste of binaries: A candidate CV





Accretion disc dominated spectrum
Absence of HeII λ4686 Å
F_X/F_V ~ 3-4

No (X-ray) periodicities found

Hints for a non-magnetic CV

Analysis of UVOT lighcurves: on-going (to detect the orbital period)

***Turriziani* et al., in preparation**

In collaboration with: G. Israel, F. Verrecchia, and others

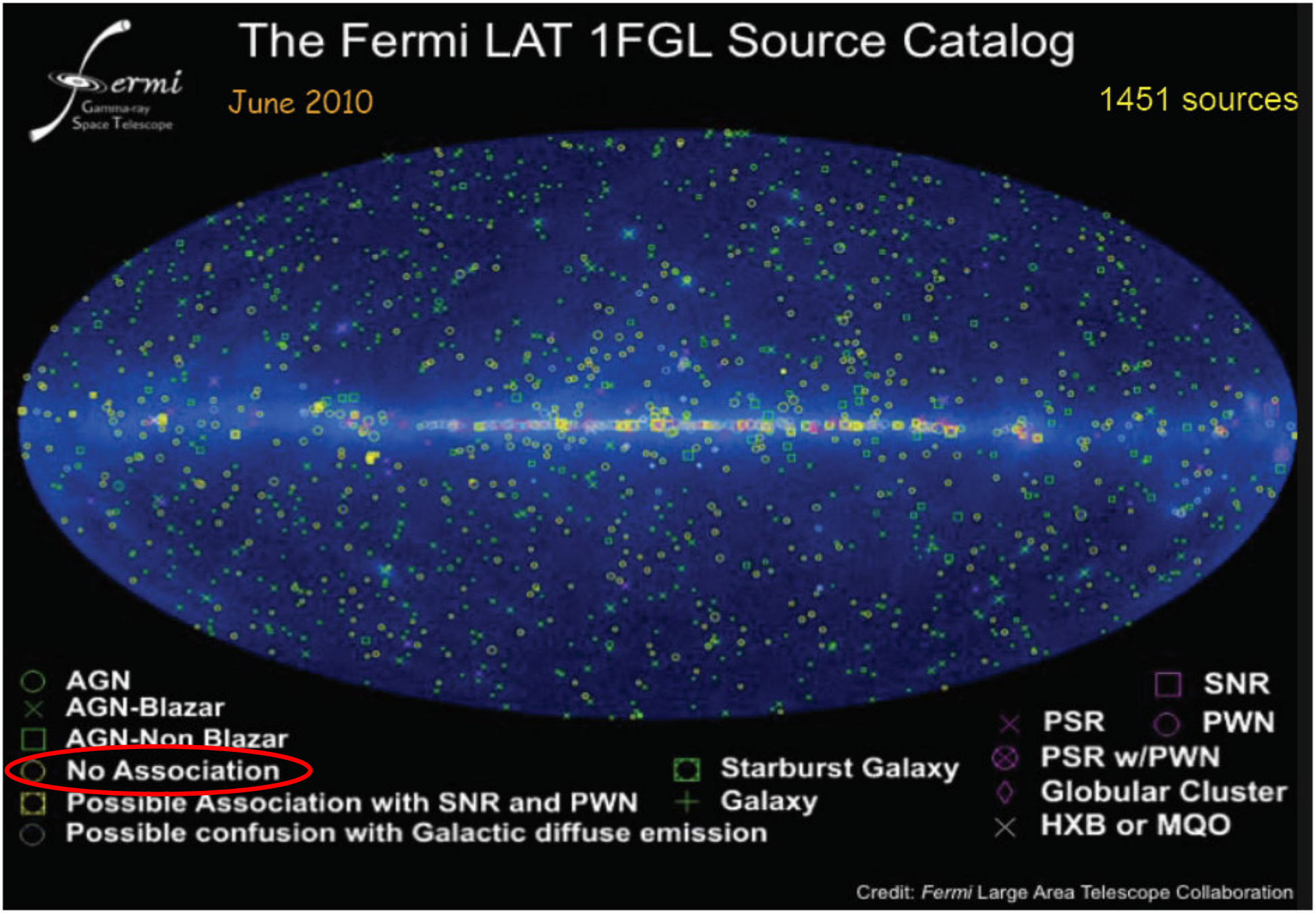
Matter of interest

The fully operational Fermi Gamma-Ray Space Telescope is providing an unprecedented view of the γ–ray sky. This is producing large and homogeneous sample of γ–ray sources, a large fraction of which are being associated to blazars.

Open Questions

i. *Lots of Un-ID γ–ray sources!!!!*

ii. *Classifications necessary to properly investigate the statistical properties of the population of blazars such as their LogN-LogS, luminosity function and evolution, and to study the differences between FSRQs and BL Lacs.*


Fermi
Gamma-ray
Space Telescope
The Fermi LAT 1FGL Source Catalog
June 2010
1451 sources
AGN
AGN-Blazar
AGN-Non Blazar
No Association
Possible Association with SNR and PWN
Possible confusion with Galactic diffuse emission
Starburst Galaxy
Galaxy
SNR
PSR
PWN
PSR w/PWN
Globular Cluster
HXB or MQO
Credit: Fermi Large Area Telescope Collaboration

OPTICAL TNG SPECTROSCOPY OF 64 FERMI LAT BLAZARS

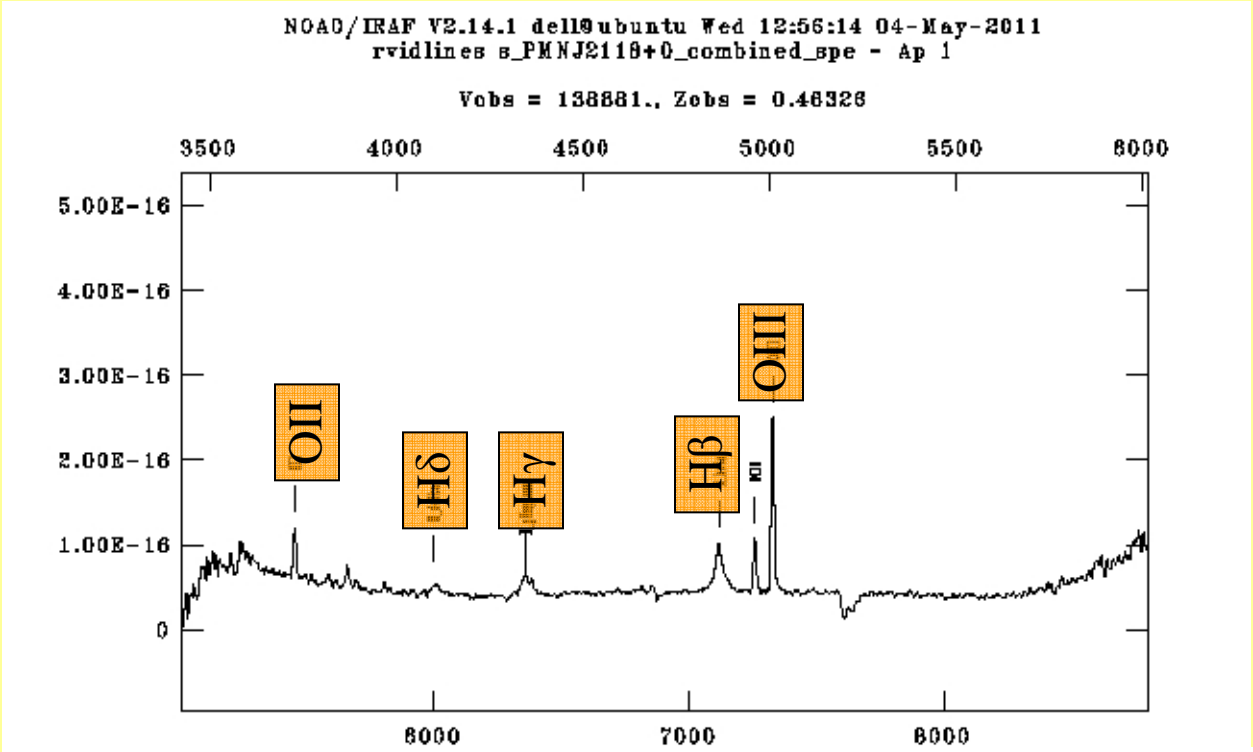
Piranomonte S., Turriziani S., D'Elia V., Sbarufatti B. to be submitted to A&A

54 unclassified extragalactic LAT sources observed at TNG between 2009-2010:

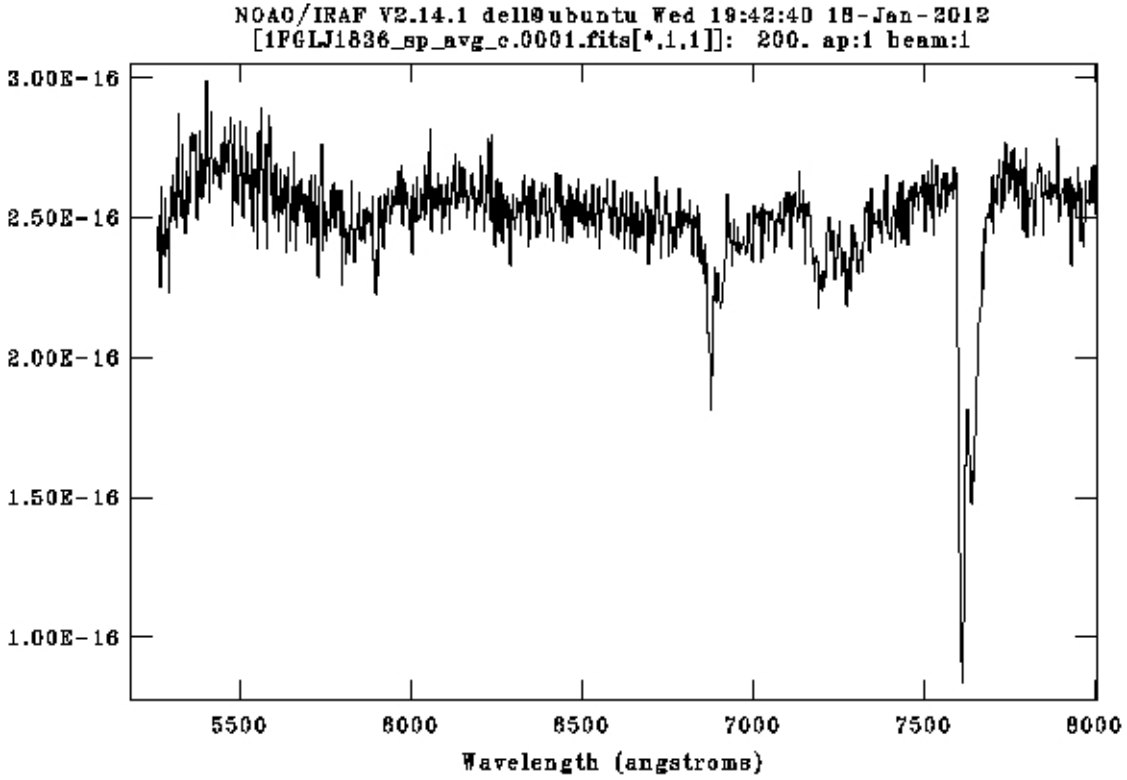
→ 16 already updated in 1LAC
→ 21 new redshifts (7 in 1LAC, 14 new)
+
10 unclassified LAT sources observed by the end of march 2011

✓ **~85 % BL Lac objects (~20% redshift)**
✓ **Others: all FSRQs with redshift**

All Confirmed Blazars!!



Spectrum of 1FGL2117.8+0016 FSRQ @ z = 0.463



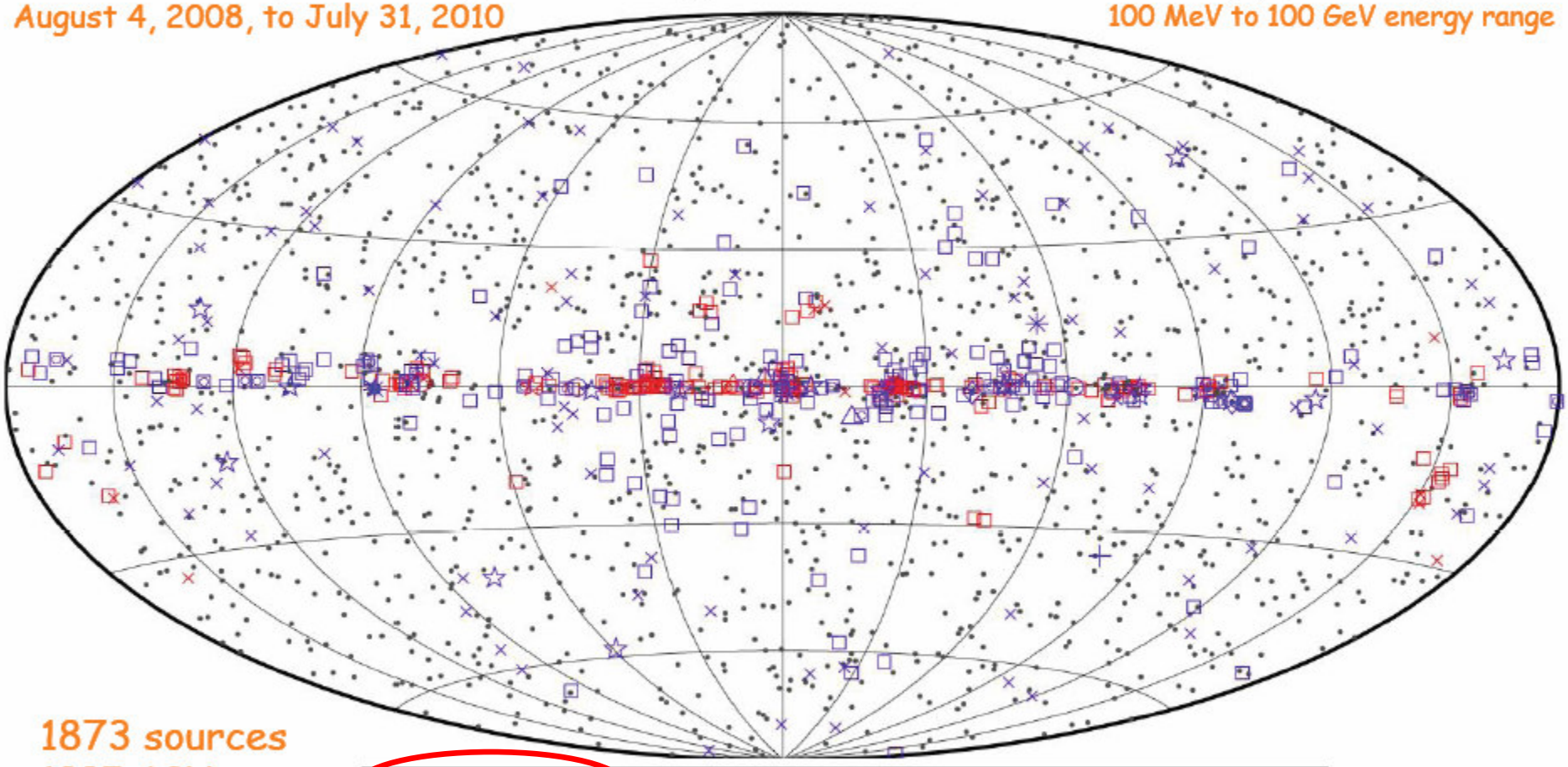
Featureless spectrum of 2FGL1836.2+3137 BL Lac object – no z

The Fermi LAT 2FGL Source Catalog

http://fermi.gsfc.nasa.gov/ssc/data/access/lat/2yr_catalog/

August 4, 2008, to July 31, 2010

100 MeV to 100 GeV energy range



1873 sources
1095 AGN
589 unidentified

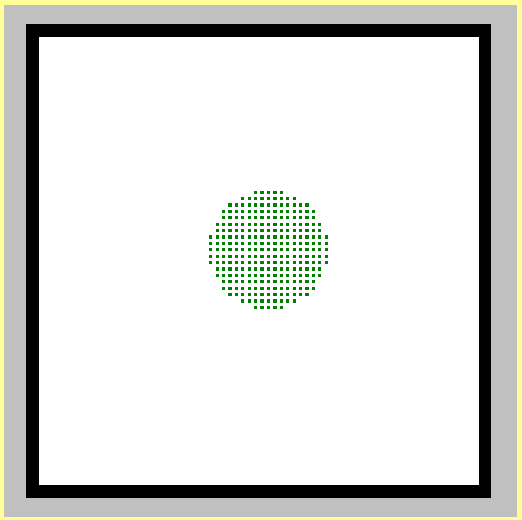
~31%

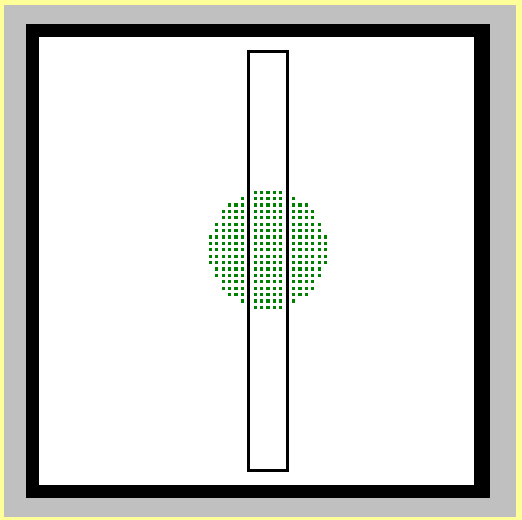
□ No association	▣ Possible association with SNR or PWN	
× AGN	☆ Pulsar	△ Globular cluster
✳ Starburst Gal	◈ PWN	⊠ HMB
+ Galaxy	○ SNR	✷ Nova


Thank you!
©1998 Giovanni Tessicini

Long-Slit Spectroscopy I.

Long-slit spectrometers get their name from a long slit which blocks most of the field, allowing only a narrow strip to pass through.

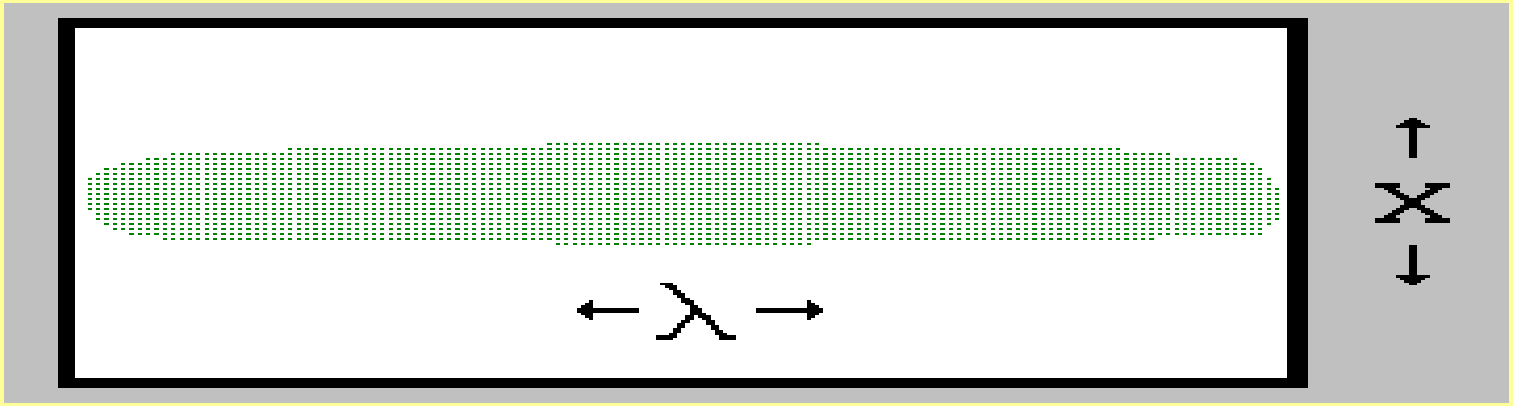




This radiation then passes through a dispersive device such as a prism or diffraction grating which breaks it into its component wavelengths.

Long-Slit Spectroscopy II.

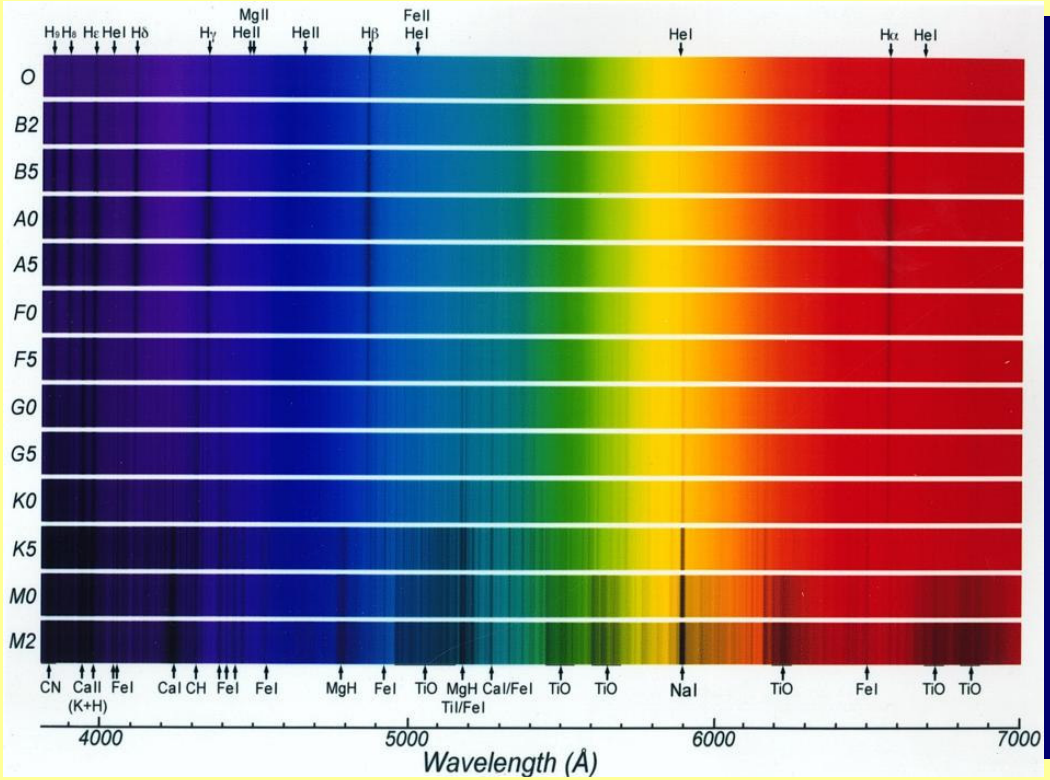
In a long-slit spectral image, the orizontal axis no longer corresponds to a spatial direction in the sky – it now represents wavelenght.

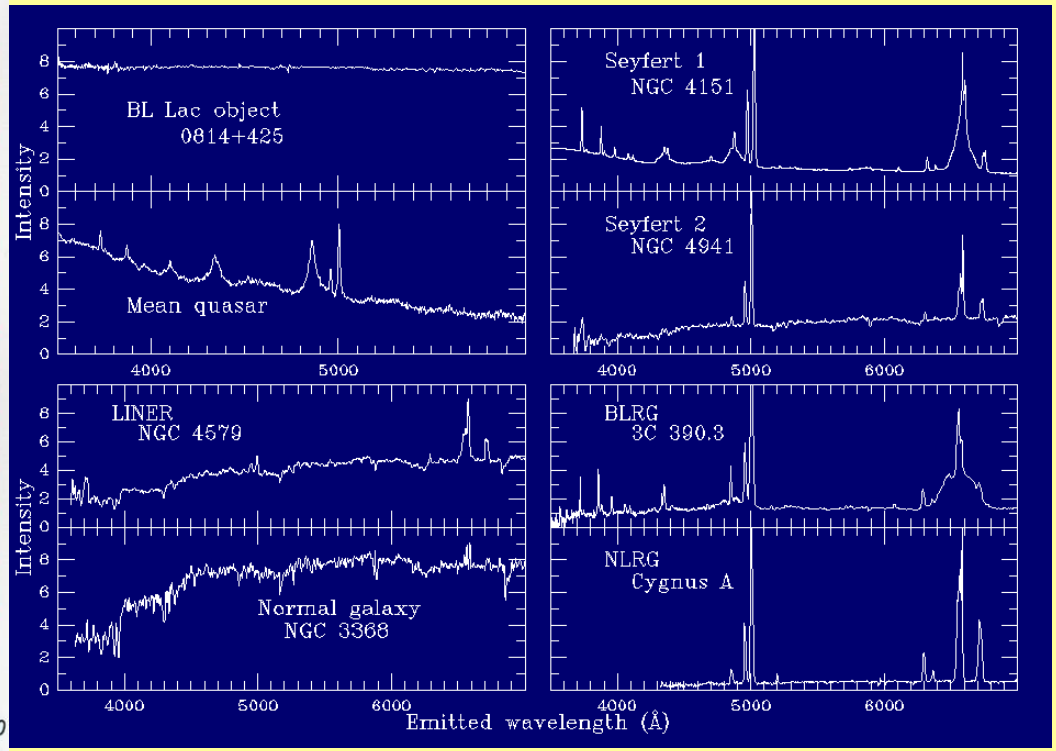


The vertical axis is still spatial, so that for an extended source, a long-slit spectral image contains several spectra, each corresponding to a different position in the slit, or more precisely, a different part of the source along the slit.

Why optical spectroscopy?

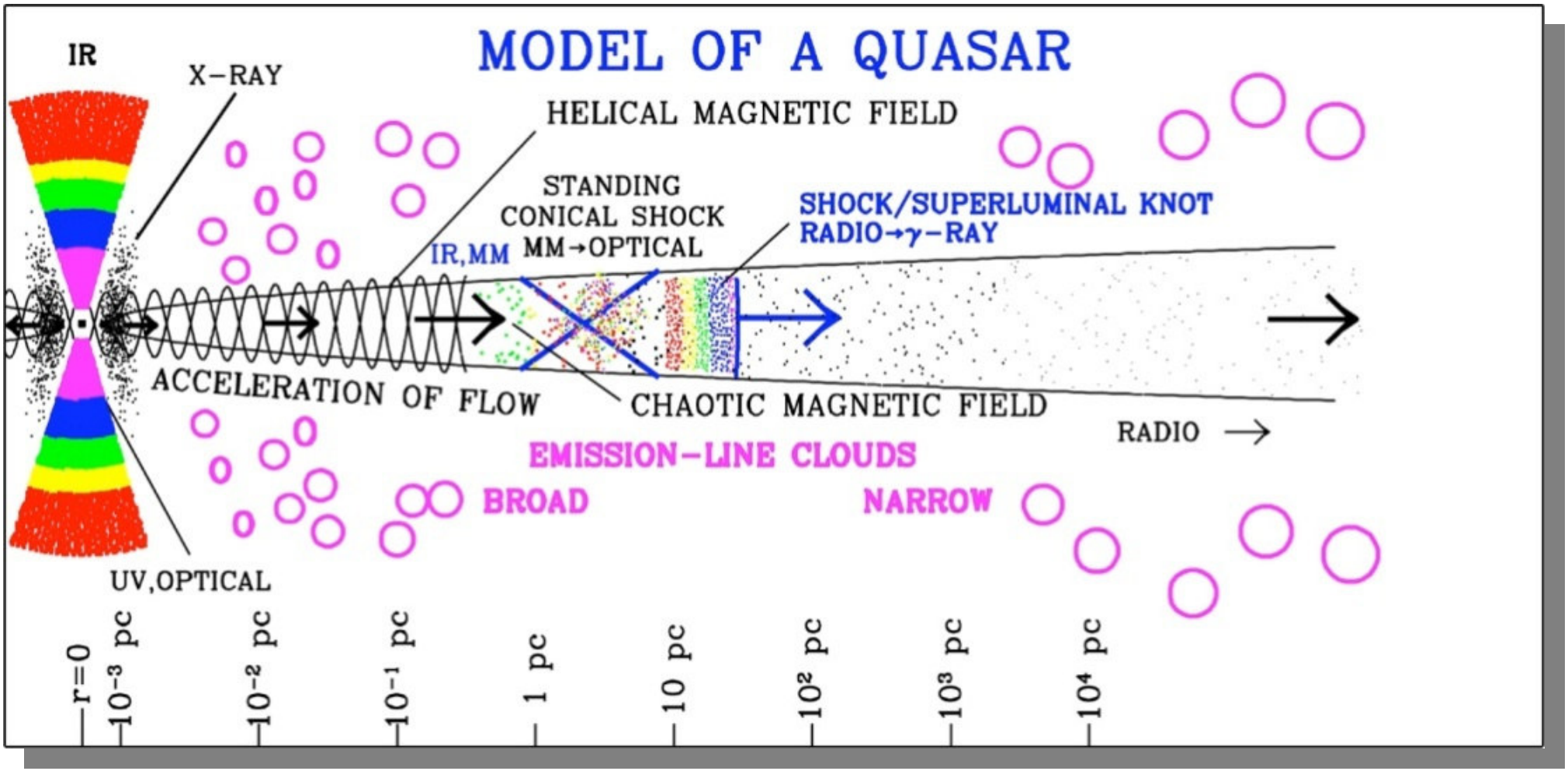
Classification and characterization of different astronomical sources

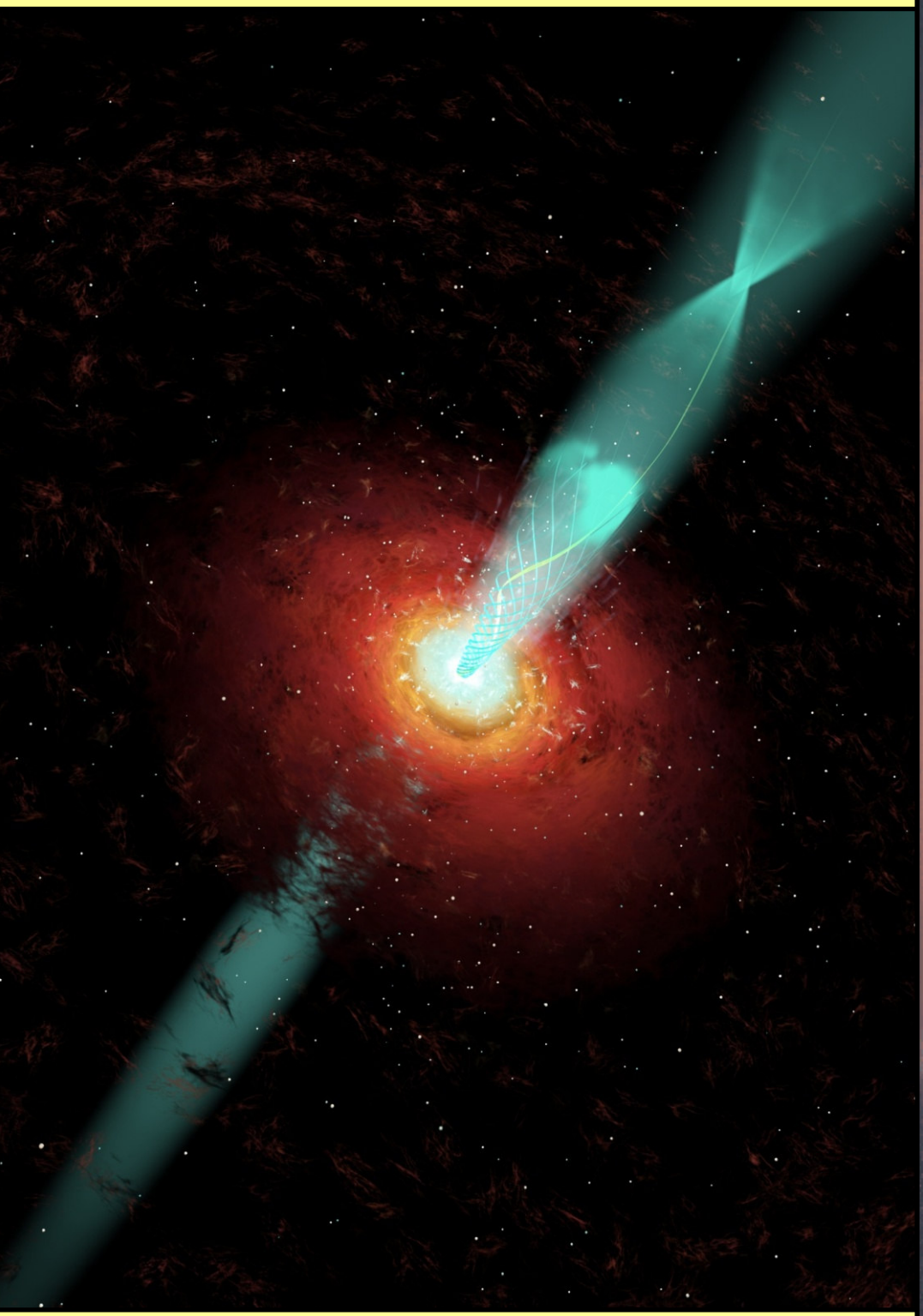


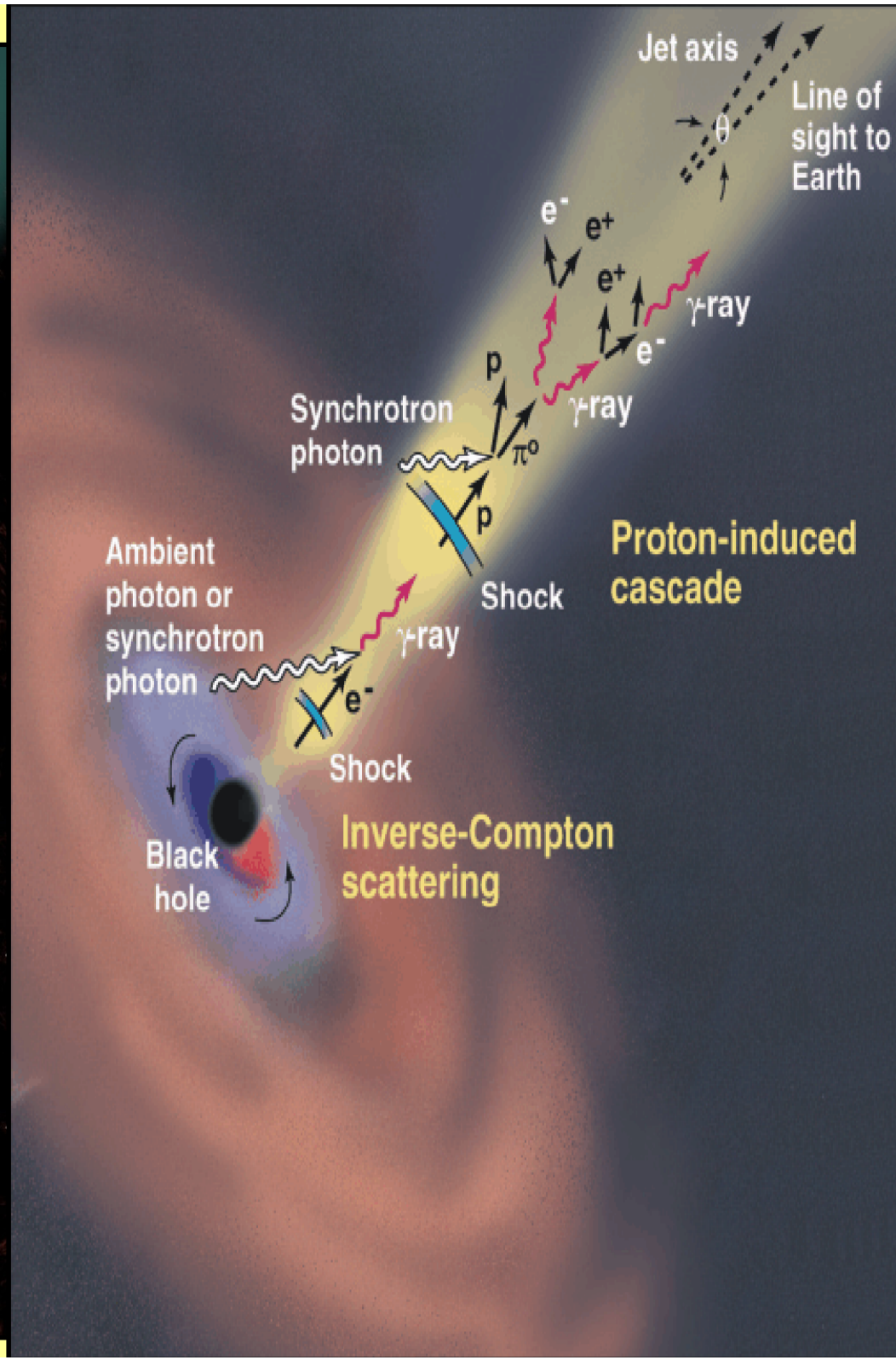


STARS

EXTRAGALACTIC OBJECTS


MODEL OF A QUASAR
IR
X-RAY
HELICAL MAGNETIC FIELD
STANDING
CONICAL SHOCK
MM→OPTICAL
IR,MM
SHOCK/SUPERLUMINAL KNOT
RADIO→γ-RAY
ACCELERATION OF FLOW
CHAOTIC MAGNETIC FIELD
RADIO
EMISSION-LINE CLOUDS
BROAD
NARROW
UV,OPTICAL
r=0
10⁻³ pc
10⁻² pc
10⁻¹ pc
1 pc
10 pc
10² pc
10³ pc
10⁴ pc




Jet axis
Line of sight to Earth
θ
e-
e+
e+
e-
γ-ray
γ-ray
p
Synchrotron photon
π0
p
Shock
Proton-induced cascade
Ambient photon or synchrotron photon
γ-ray
e-
Shock
Black hole
Inverse-Compton scattering