Study of accretion and ejection processes in variable back hole systems with SVOM

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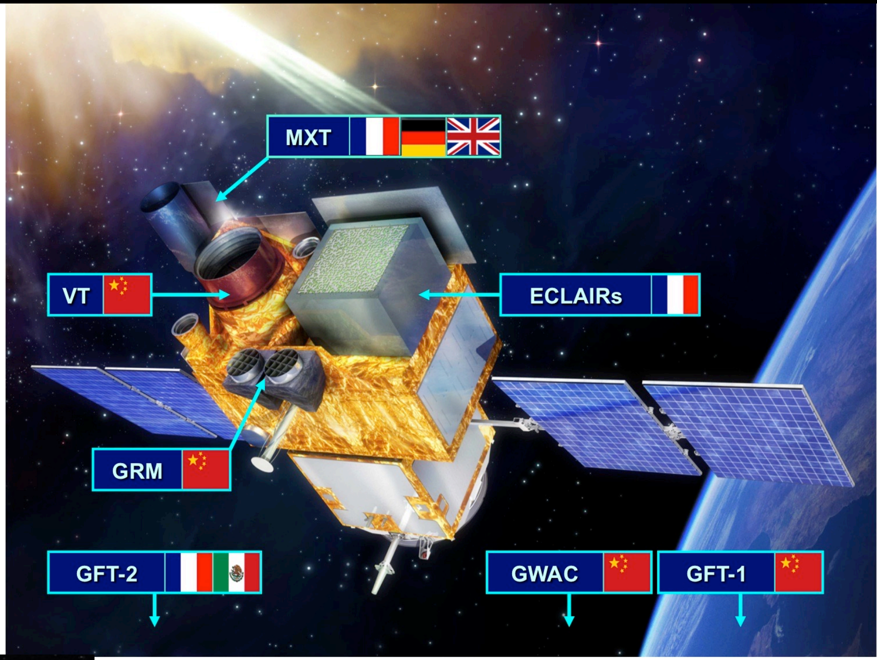
X-ray missions : INTEGRAL, Einstein Probes, SVOM

INTEGRAL : hard X-ray / Gamma ray survey

Einstein Probes : soft X-ray survey and soft X-ray accurate follow up



SVOM : hard X-ray/ Gamma ray survey, soft X-ray and visible follow up

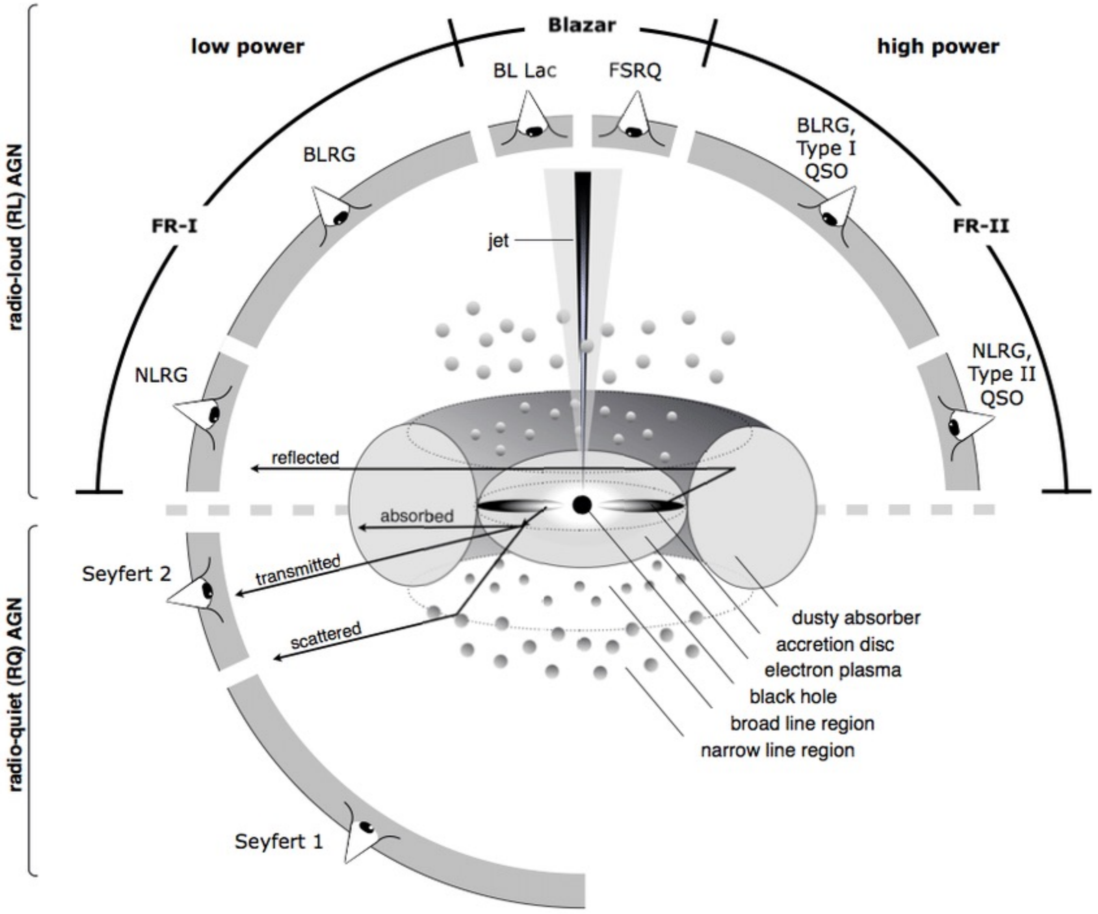
AGNs : unified model

<u>**Active Galactic Nuclei :**</u> Galaxy where the **emission** is **dominated** by the **nuclei** with a **non thermal emission**.

<u>Structure :</u>

- **SMBH** at the center with accretion disk
- Dusty torus around
- 2 regions BLR and NLR → dust ionised by the photons of the disk and emitting in visible and UV
- **Jets** in the direction of the rotation axis of the galaxy

➔ AGNs are divided in subclasses related to the direction of the jet with the line of sight



Beckmann et al. 2012.

Focus on blazars potentially related to neutrinos

Origin of the Ultra High Energy Cosmic Rays (UHECRs) → Hard to follow → deflected by $\vec{B}$

ν ?

2017 association at 3σ with TXS 0506+056

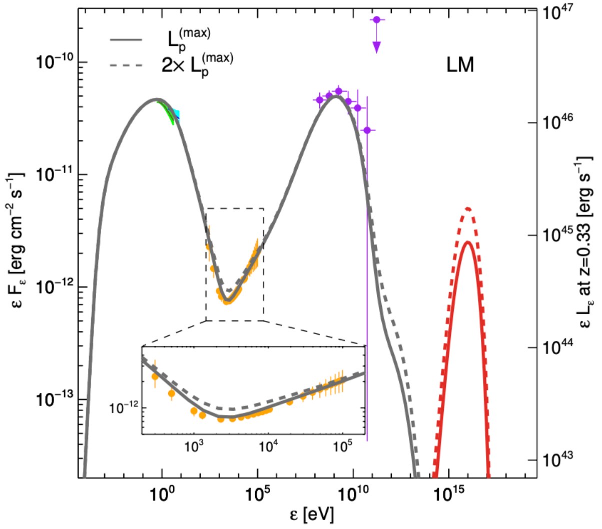
$p + \gamma \rightarrow \pi^{\pm} \rightarrow \nu$
$p + p \rightarrow \pi^{\pm} \rightarrow \nu$

→ ν detected by IceCube → Need to observe other potential associations → ToO

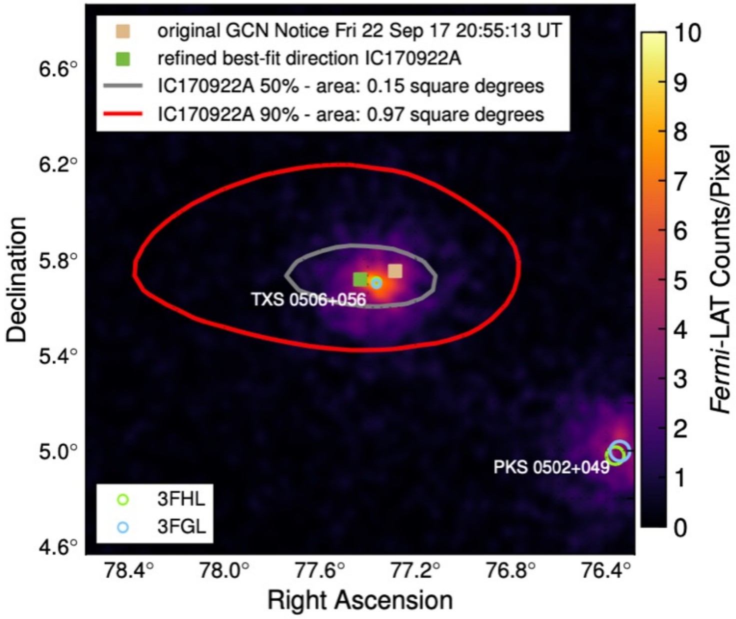
→ Need multi-wavelength data to understand the emission of the blazars → GP

Composition ?

→ p or light nucleous (max is Fe)



Keivani et al. Science. 2018



IceCube collaboration et al. APJ. 2018

Preparing the General Program observations

- Set up a list of source (list of blazars)

- Selection criteria :

- Check if the source is in the B1 law (attitude law) → pointing direction of the instruments
- Estimate the exposure time needed with MXT and ECLAIRs
- Check if the source will be enough time in ECLAIRs' f.o.v to be observed

- Difficulties :

- Finding the interesting sources
- Estimate $\boldsymbol{t_{exp}}$ ➔ 2 methods !

Blazars potentially related to neutrinos

Blazars a priori not related to neutrinos → Open Universe catalog

Selection and analysis

1 – Finding blazars to study :

- Crossmatch between IceCube alerts catalog and RFC or 5BZCAT (Plavin et al. 2020 and Buson et al. 2022)
- OR references mentioning potential associations between blazars and neutrinos

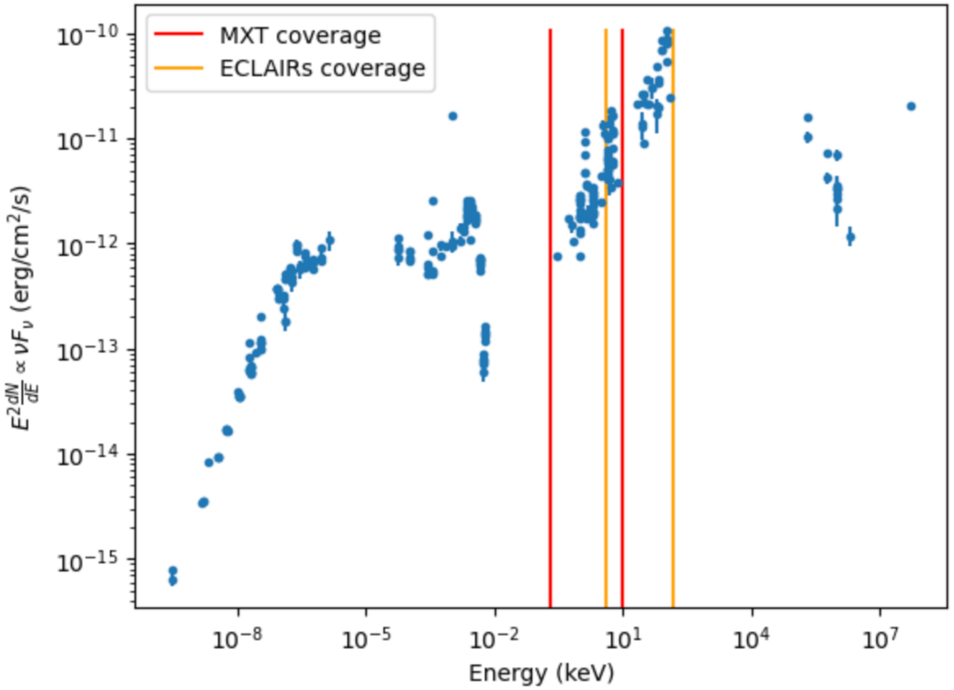
2 – Check for B1 law

3 – Fit of the SED with a **powerlaw** model

4 – Estimation of $\boldsymbol{t_{expo}}$ for **MXT** and **ECLAIRs**

➔ **Simulate Source and CXB count rates** at **SNR = 10**

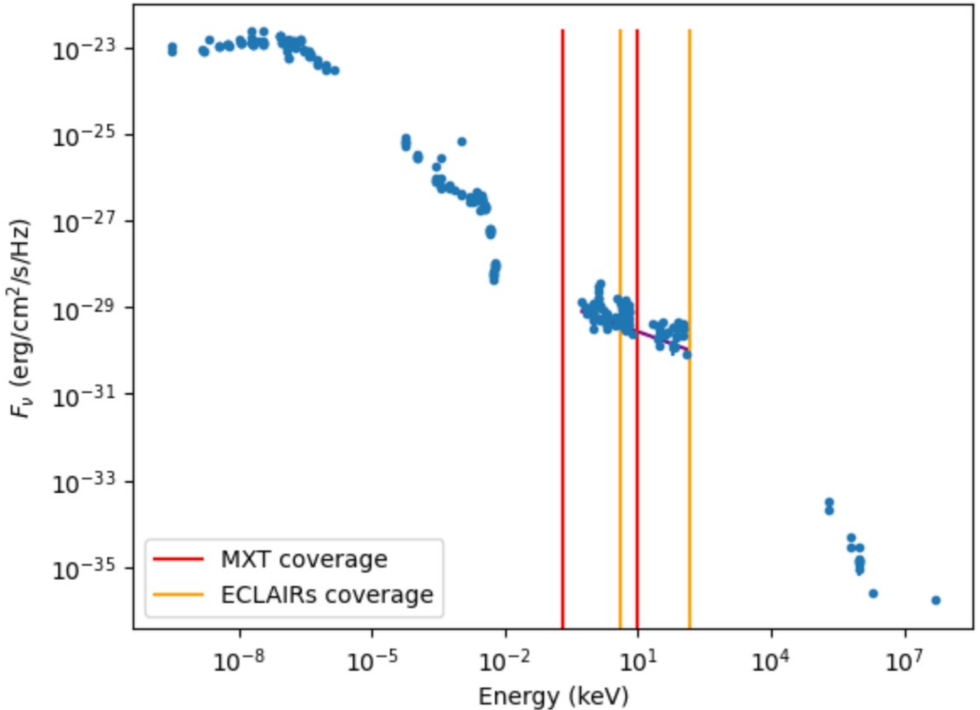
➔ **XSPEC simulations**



PKS 2149-306

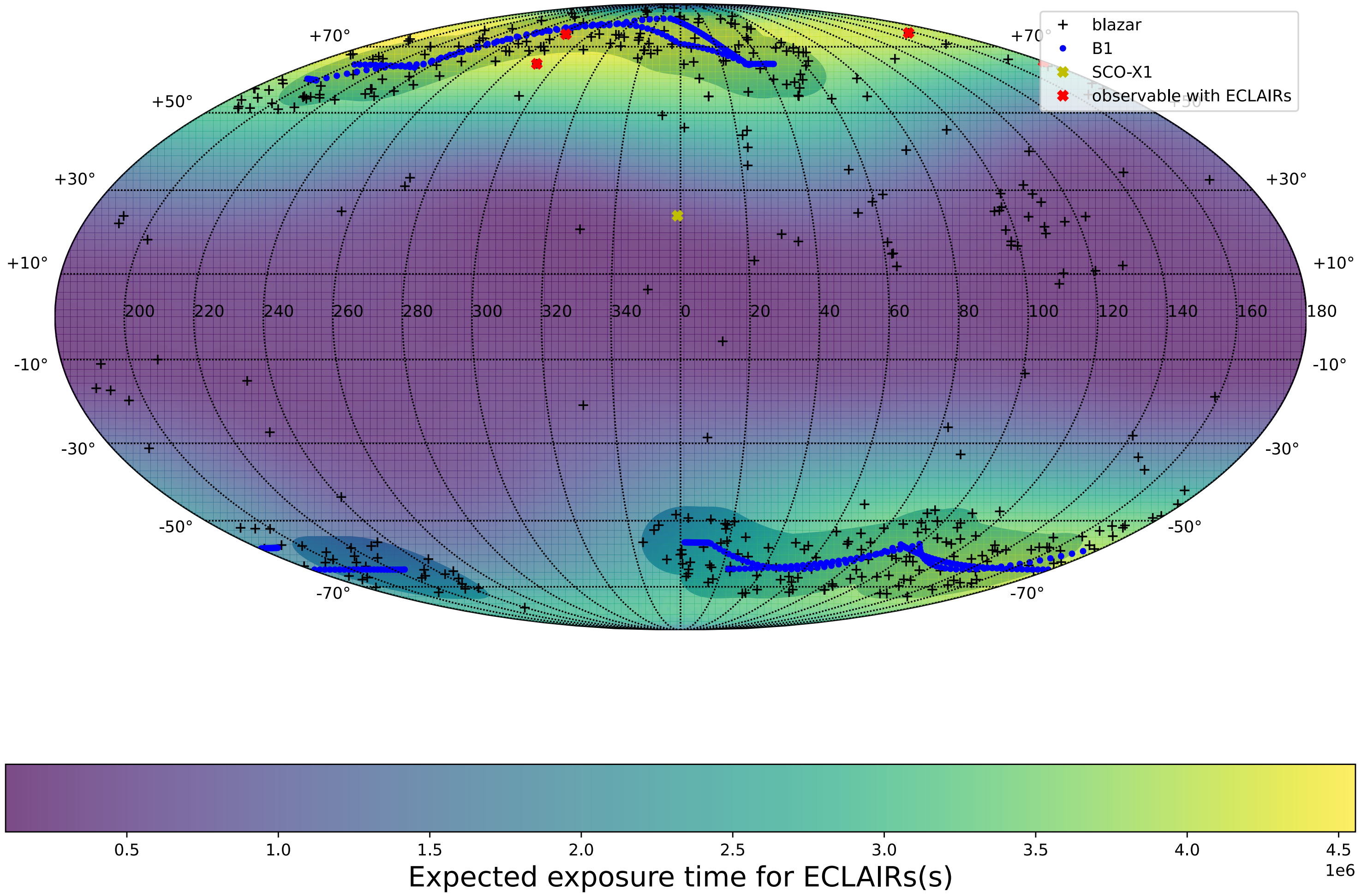
$$F_\nu = 6.62 \times 10^{-27}\, K \left(\frac{E}{E_0}\right)^{-\Gamma+1}$$

- **K :** Normalisation (ph/cm²/s/keV)
- ***Γ*** **:** Photon index



Mapping the blazars' sample

Total number of blazars	404	---
Blazars (neutrinos) located in B1 law (± 10°)	15	2.6 Ms = 30 d MXT for SNR =10
Blazars with enough exposure time to be detected with ECLAIRs without repointing (stacking)	4	1.5 Ms = 17.5 d For SNR = 10



XSPEC simulated spectrum

Simulate the MXT spectrum via XSPEC (using the spectral parameters of the « real » SED)

Fit the simulated spectrum with a powerlaw model

$$E^2 \frac{dN}{dE} = K \times E^{-\Gamma+2} \times e^{-0.286733\frac{n_H}{E^3}}$$

Estimate t_{expo} : $\delta_\Gamma < 10\%$ and $\delta_K < 10\%$

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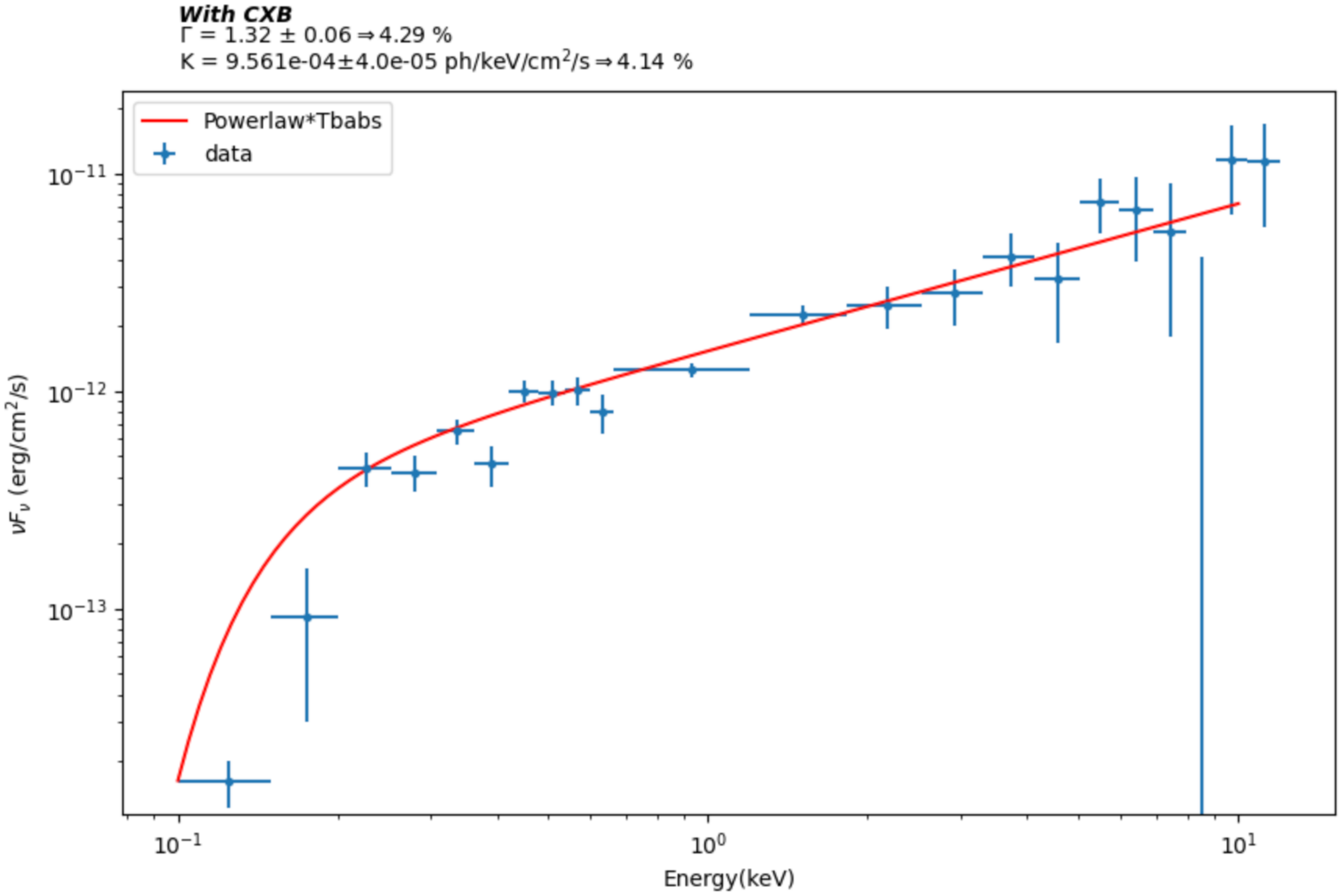
Simulated for $\boldsymbol{t_{exp}}$ = 100 ks

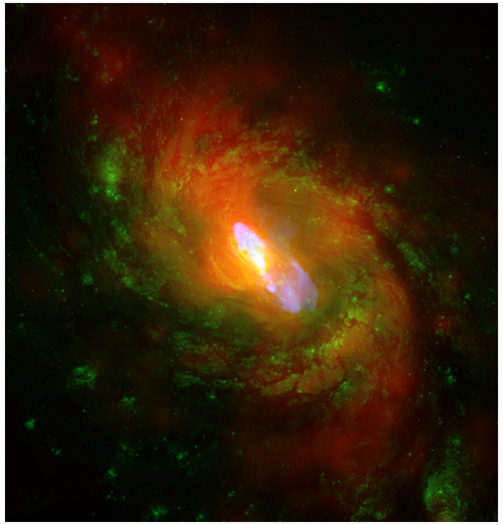


INTEGRAL data analysis of interesting AGN

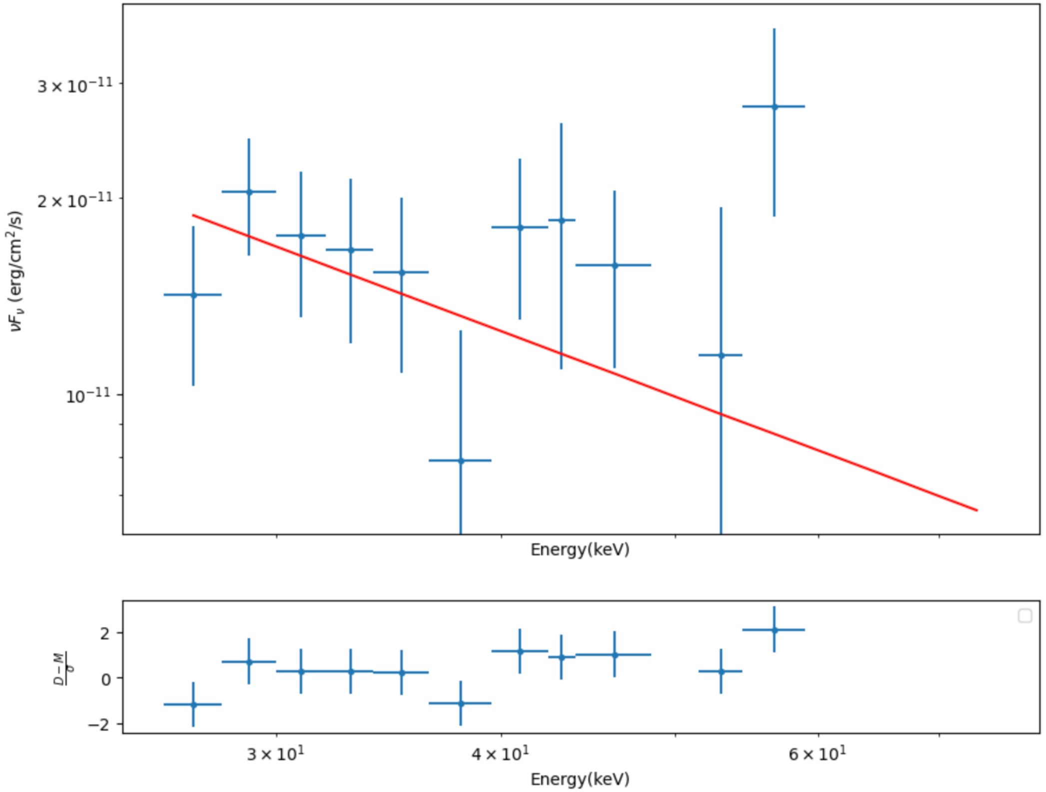
WHY ? ➔ related to high energy neutrinos

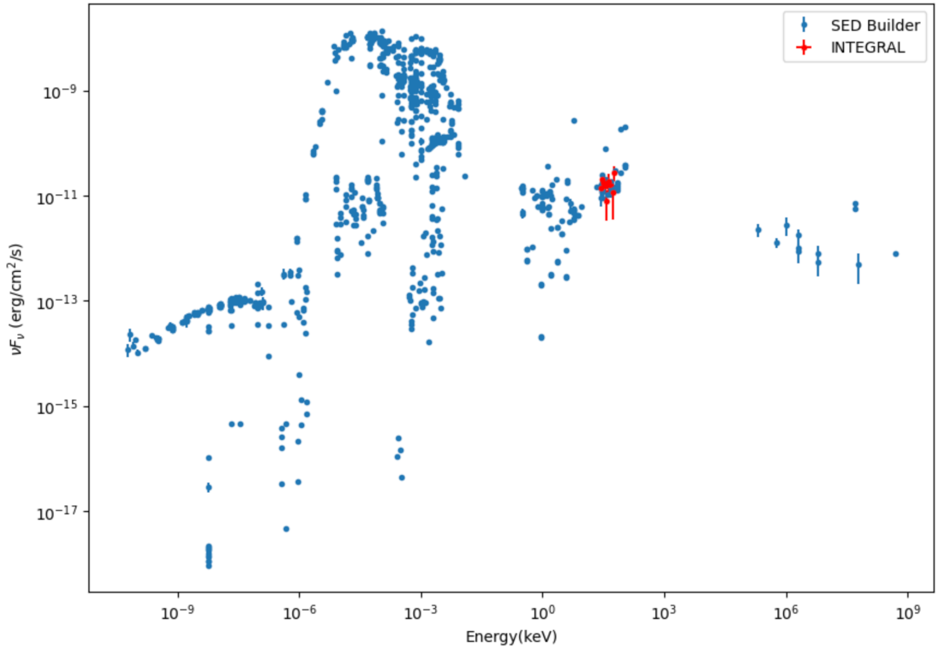
NGC 1068 : association at 4.2σ level → IceCube Collaboration et al, Science 2022

TXS 0506+056 : association at 3σ level in 2017 → Keivani et al, Science 2018 / IceCube Collaboration et al, APJ 2018



Composite image of NGC 1068 : X-ray (Chandra) + optical (HST) + radio (VLA).





Conclusion

Prepare the GP : list of blazar

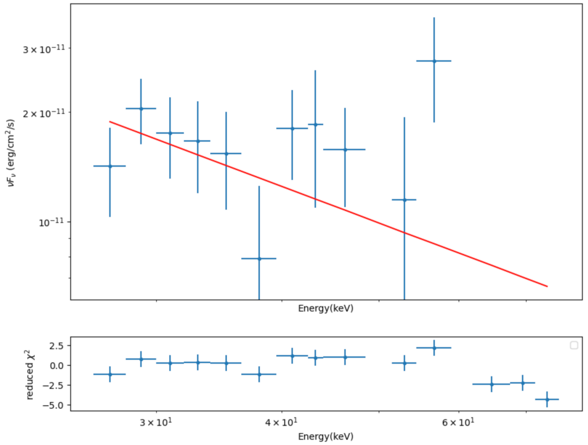
Why ?

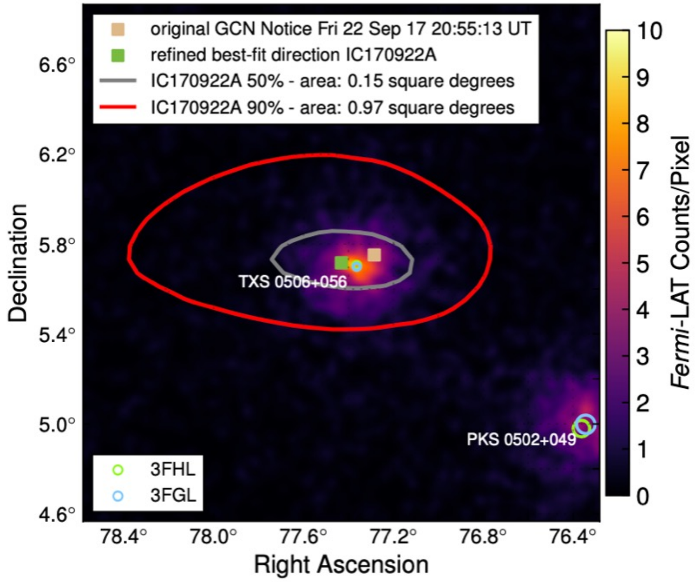
Possible accelerator of UHECRs
Association at 3σ level with TXS 0506+056 and IC-170922A

404 blazar studied
15 in B1 → 2.6 Ms
4 observable with ECLAIRs → 1.5 Ms

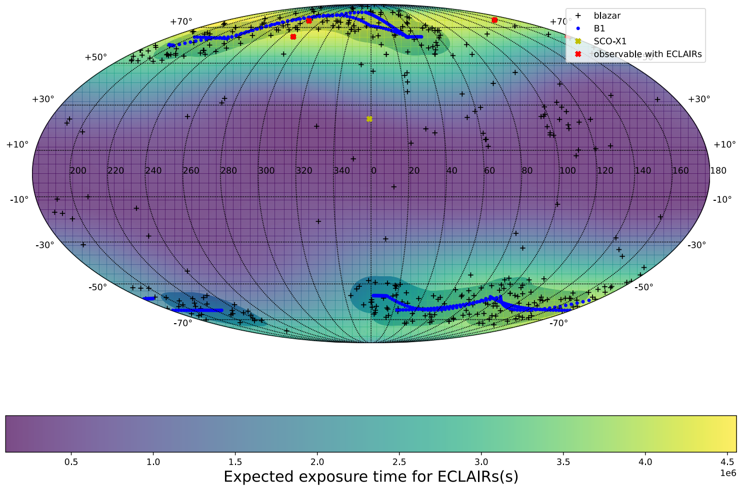
In the same time

Analysis of INTEGRAL data



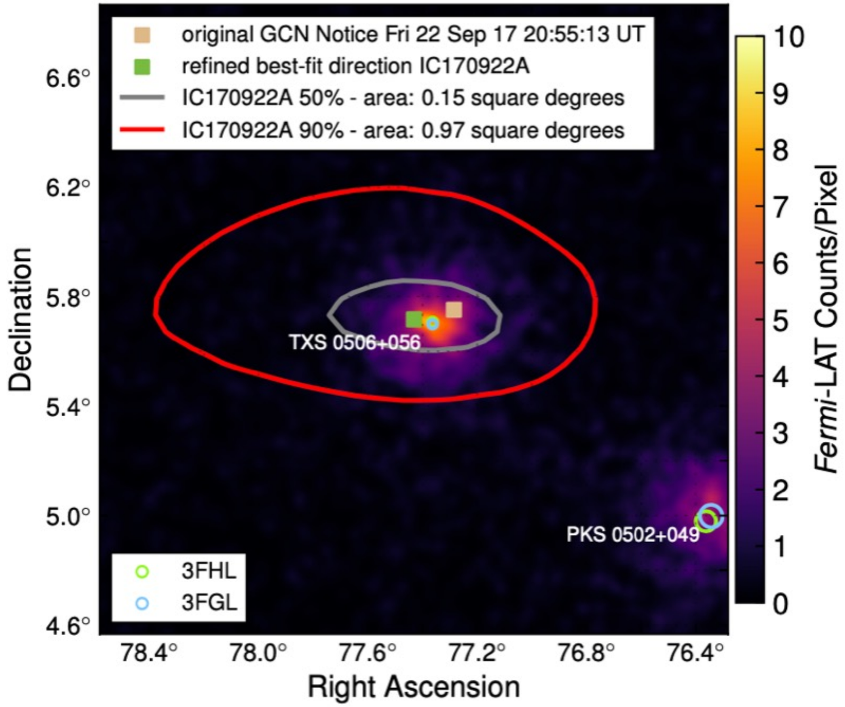


Crédit : IceCube collaboration et al. APJ. 2018



➔ And then with SVOM data ?

Conclusion : constrain emission models of blazar



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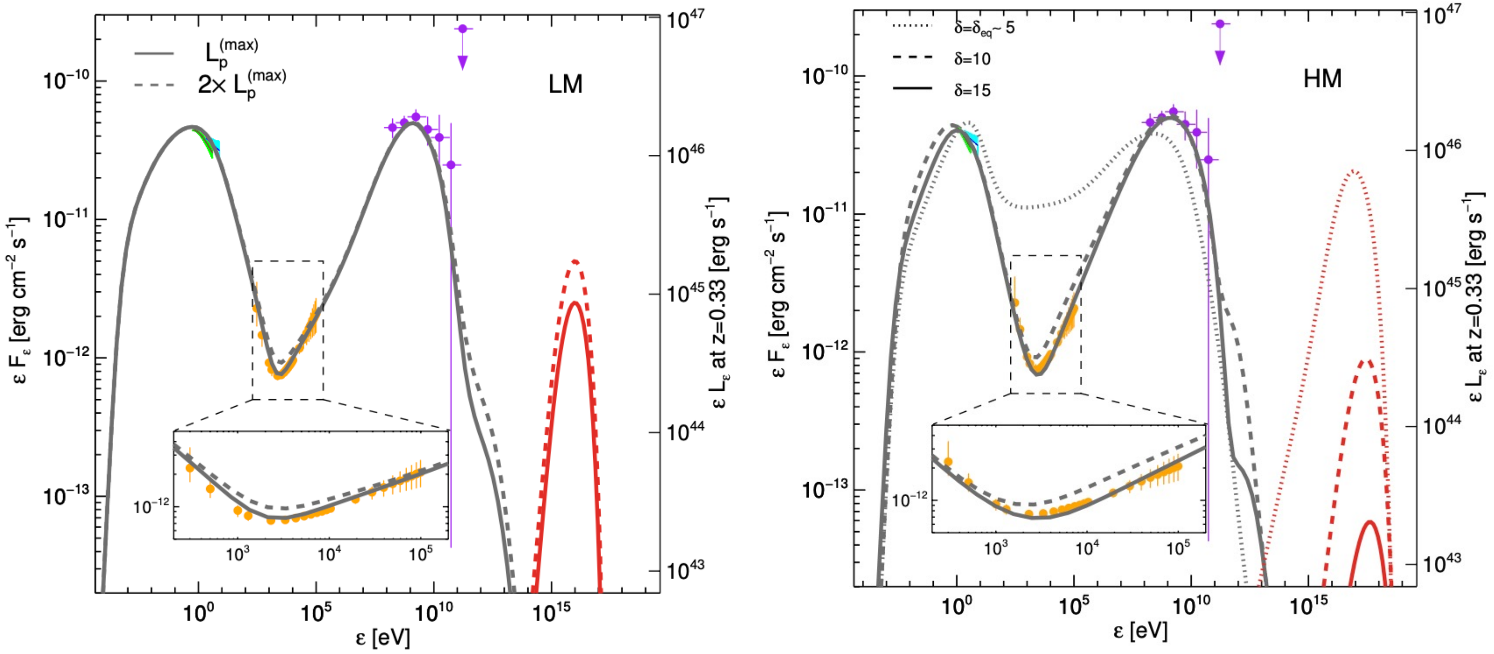
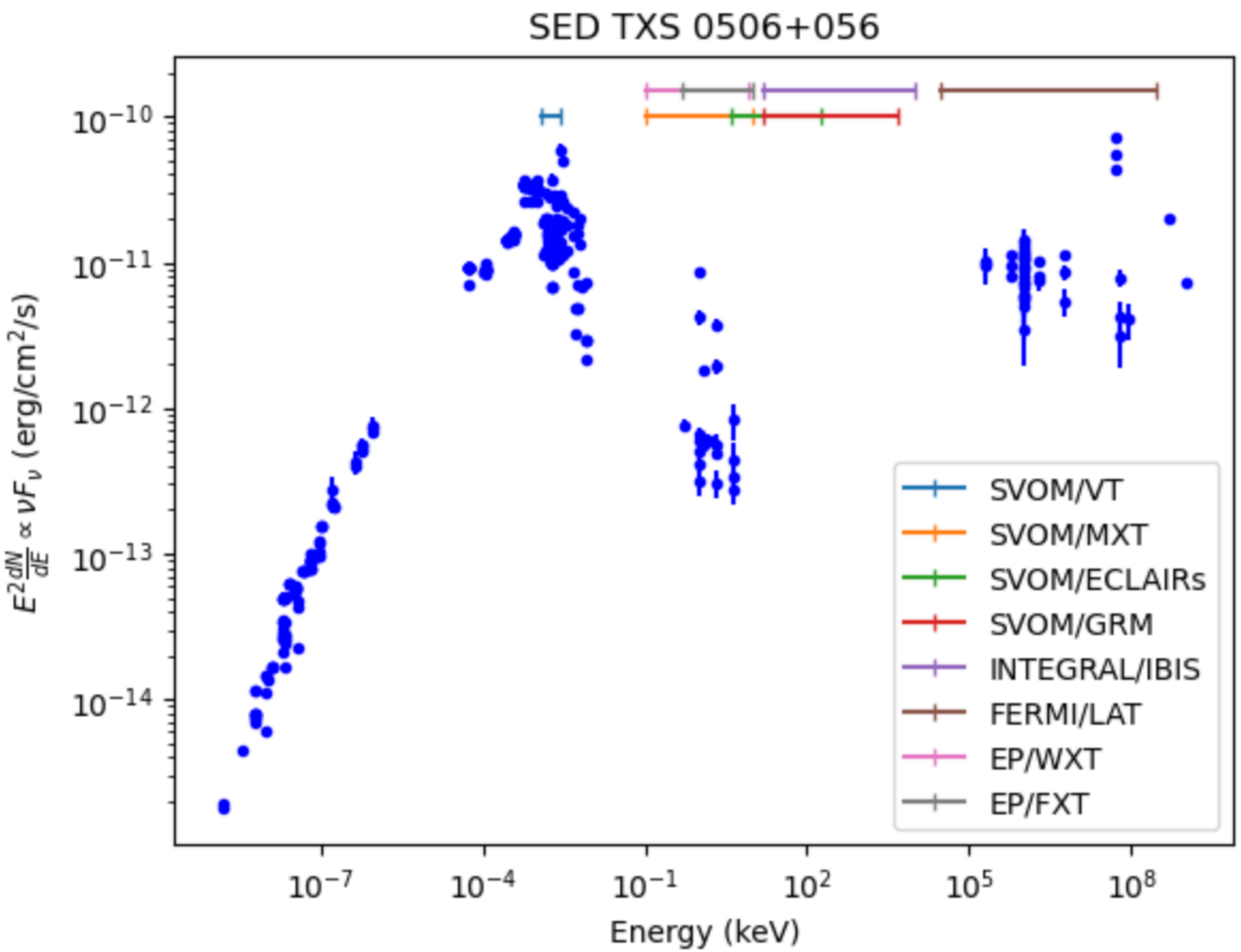


Left : leptonic model. Right : hadronic model

Keivani et al. Science. 2018

Conclusion : Multi-wavelength data from SVOM / INTEGRAL / EP / FERMI



Count rates simulations for source (S) and CXB (B)

- MXT count rates for S and B :

$$S = \int ARF \times K \left(\frac{E}{E_0}\right)^{-\Gamma} \times e^{-0.286733\frac{n_H}{E^3}}\, dE$$

$$B = \int ARF \times 3.67{\times}10^{-3} \times PSF \times \left(\frac{E}{E_0}\right)^{-1.47} \times e^{-0.286733\frac{n_H}{E^3}}\, dE$$

- ECLAIRs count rates for S and B :

$$S = \int ARF \times K \left(\frac{E}{E_0}\right)^{-\Gamma} \times e^{-0.286733\frac{n_H}{E^3}}\, dE$$

$$B = \int ARF \times PSF \times \frac{0.109}{\left(\frac{E}{E_B}\right)^{1.4} + \left(\frac{E}{E_B}\right)^{2.88}} \times e^{-0.286733\frac{n_H}{E^3}}\, dE$$

K, Γ : spectral parameter determined by the fit of the SED

E_B = 0.29 keV

Note : We use Moretti et al. 2009 for the CXB model.

Estimation of t_{exp}

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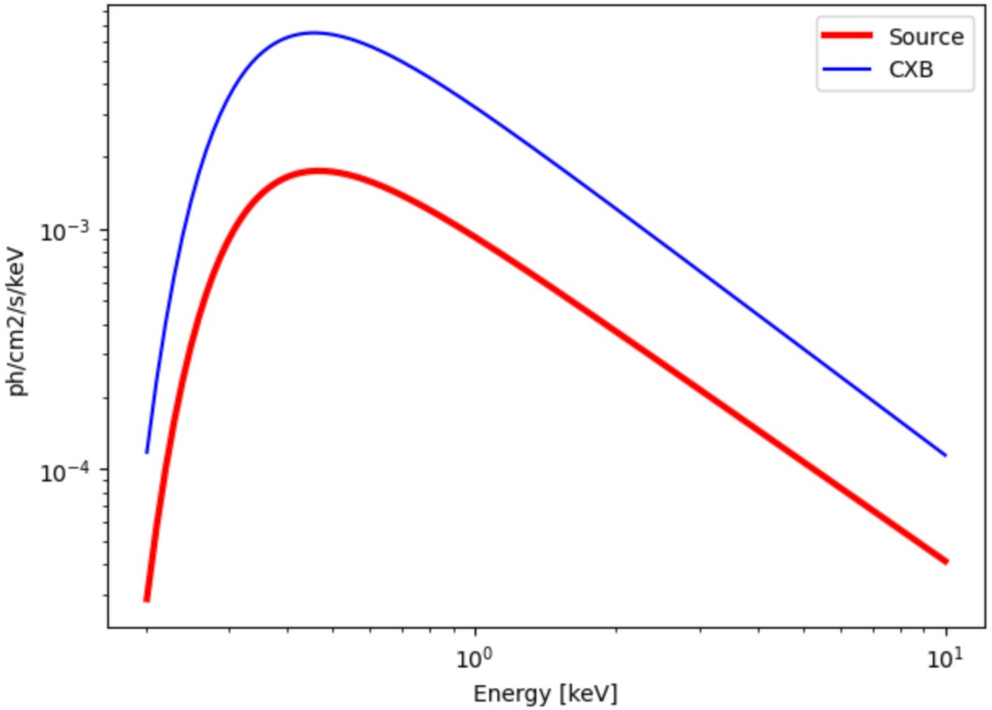
***t_{exp}* MXT :**

$$t_{exp} = \left(\frac{SNR}{S}\sqrt{S+B}\right)^2$$

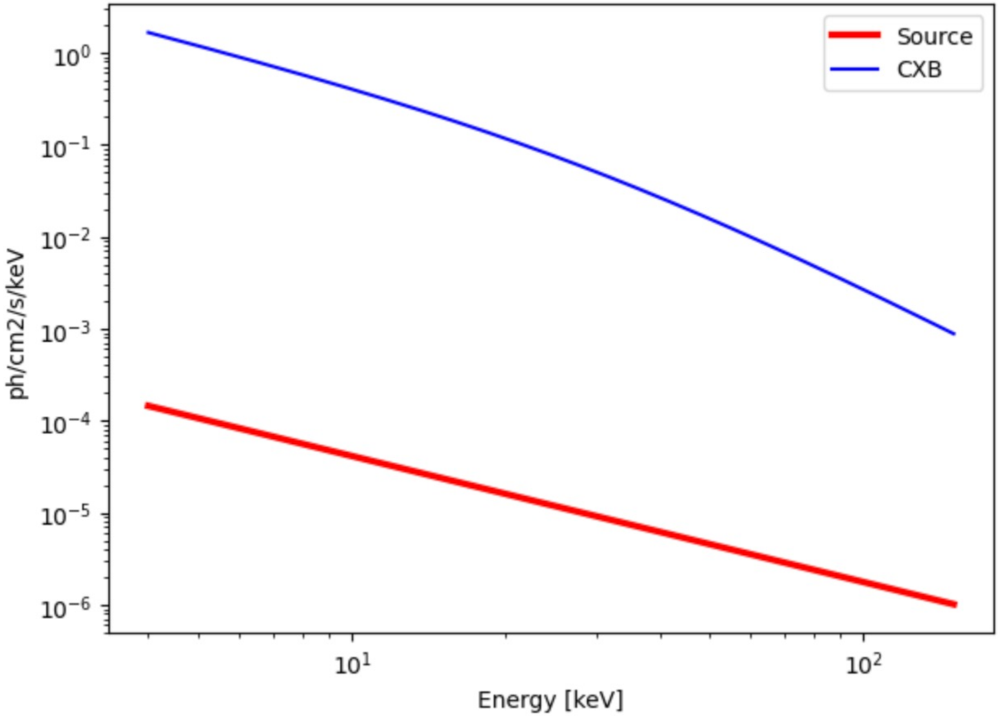
MXT



***t_{exp}* ECLAIRs :**

$$t_{exp} = \left(\frac{SNR}{S}\sqrt{\frac{S}{0.4}+B}\right)^2$$

ECLAIRs



SNR = Signal to noise ratio = 10

S, B = count rates for source and background (CXB)

Note : We followed Skinner et al. 2008 to compute t_{exp} for ECLAIRs

XSPEC simulations

$T_{PKS\ 2149\text{-}306} \simeq$ **25,08 ± 0,24 ks**