What Can We Learn From MeV Observations of AGN?

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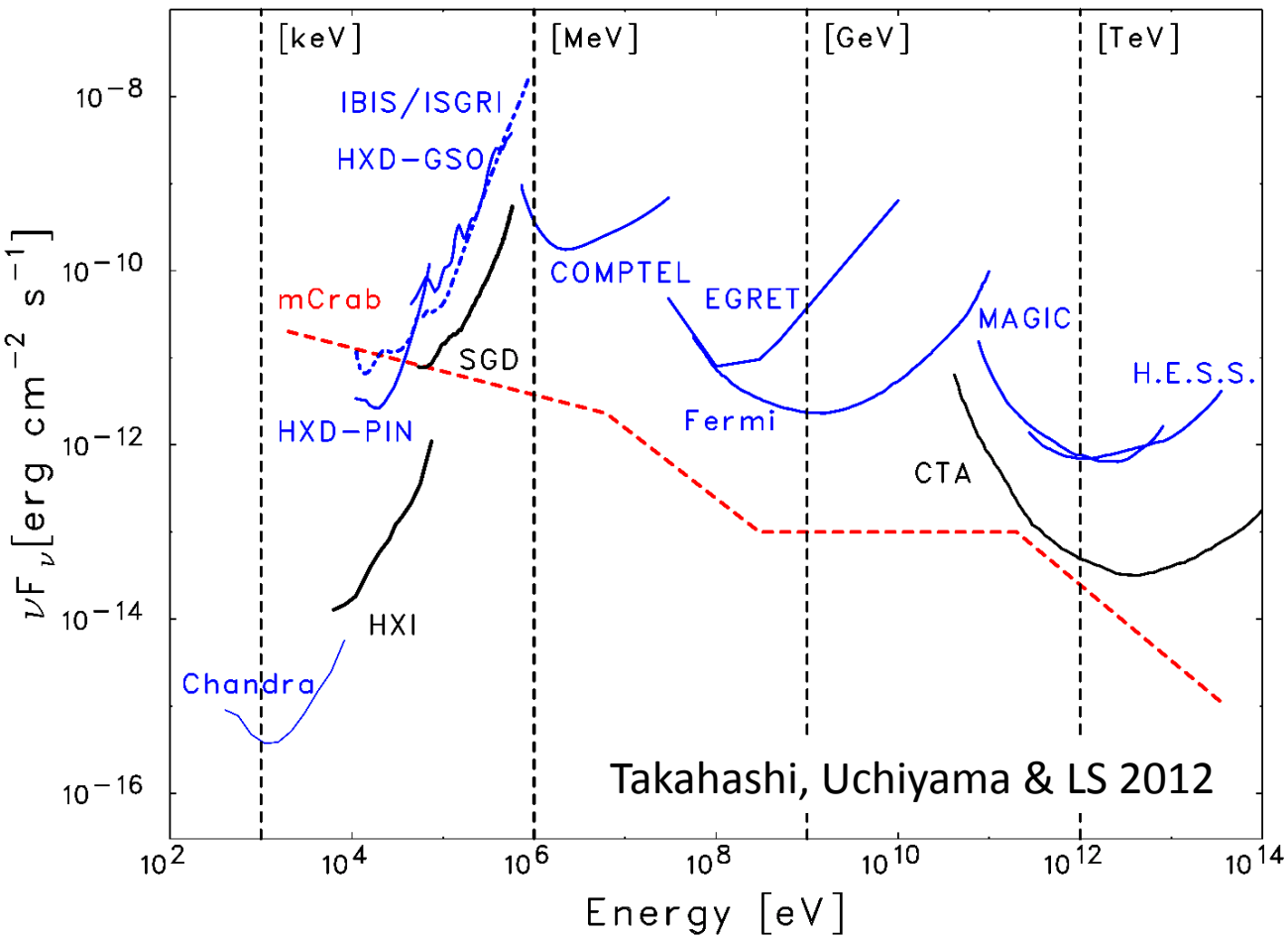
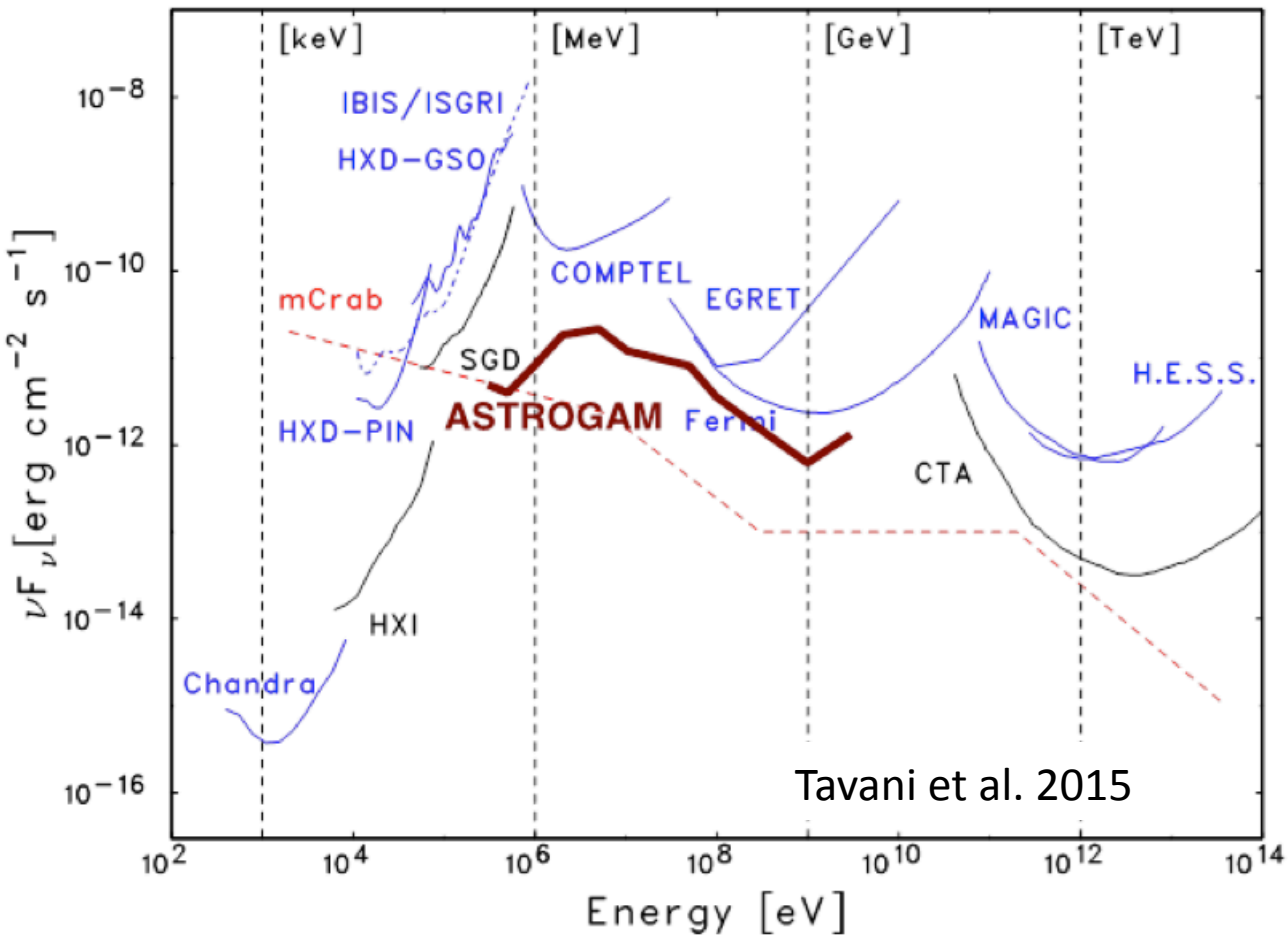
Future Space Gamma-ray Observatories

Goddard Space Flight Center, 5-6 February 2015

Hard X-rays/Soft Gamma-rays



Hard X-rays/Soft Gamma-rays



Tavani et al. 2015

MeV Observations of AGN

In this talk:

- I will *not* show the Urry & Padovani's AGN unification diagram
- I will only briefly mention some selected open problems which can be addressed by means of detailed MeV studies of AGN
- I will try to emphasize a space for potential new exciting discoveries regarding AGN physics in the MeV range

So, What Can We Learn?

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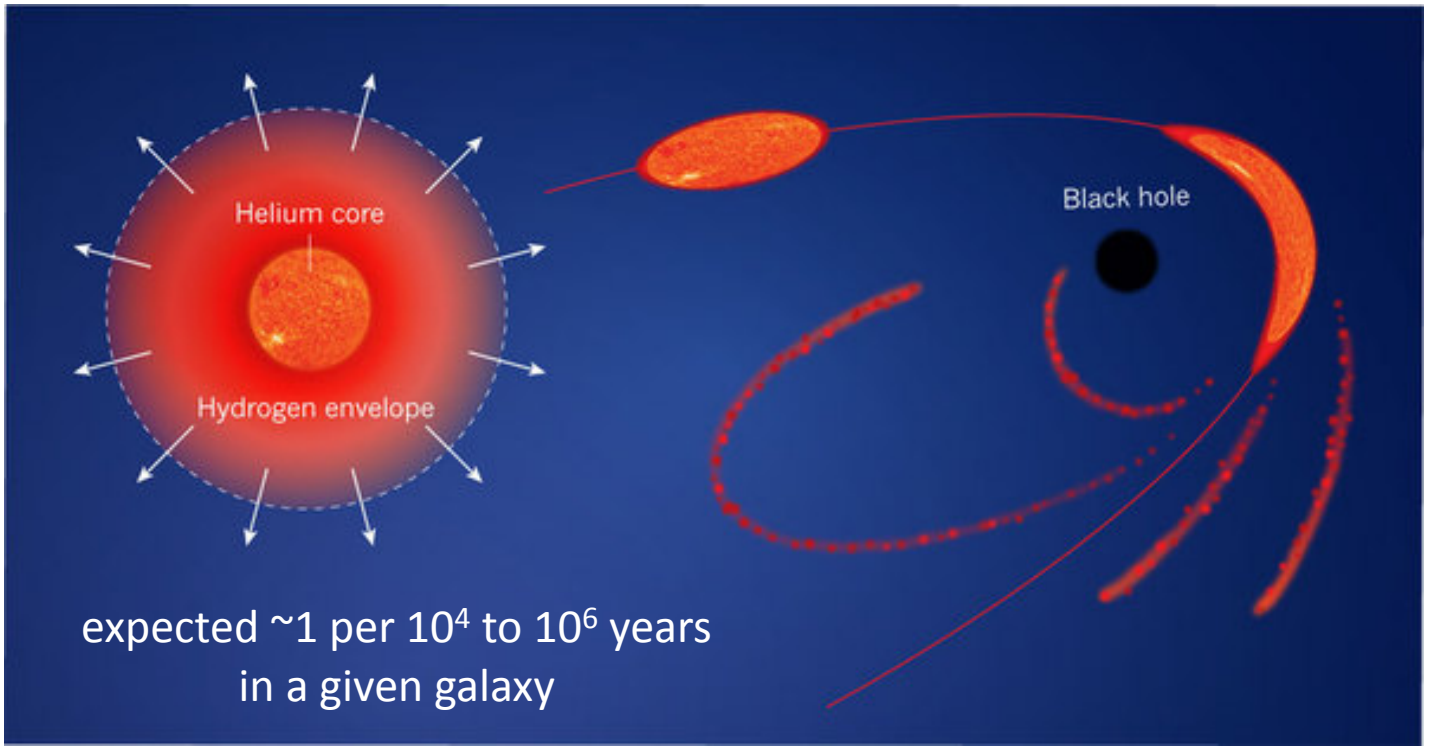
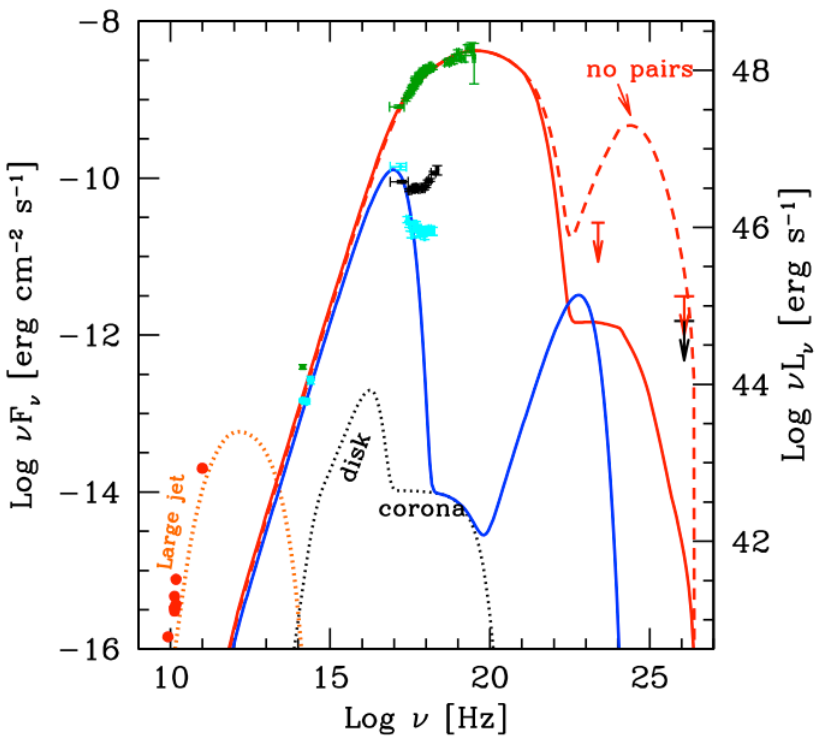
Tidal Disruption Events:



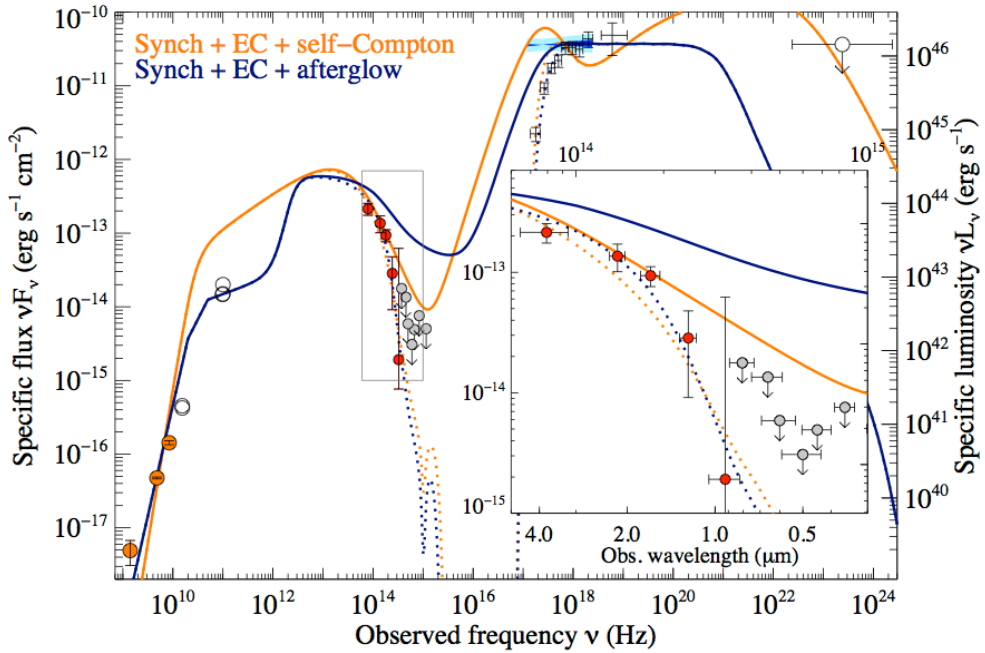
Launching of relativistic jets in AGN

TDEs: Unexpected MeV Emission!



Burrows et al. 2011

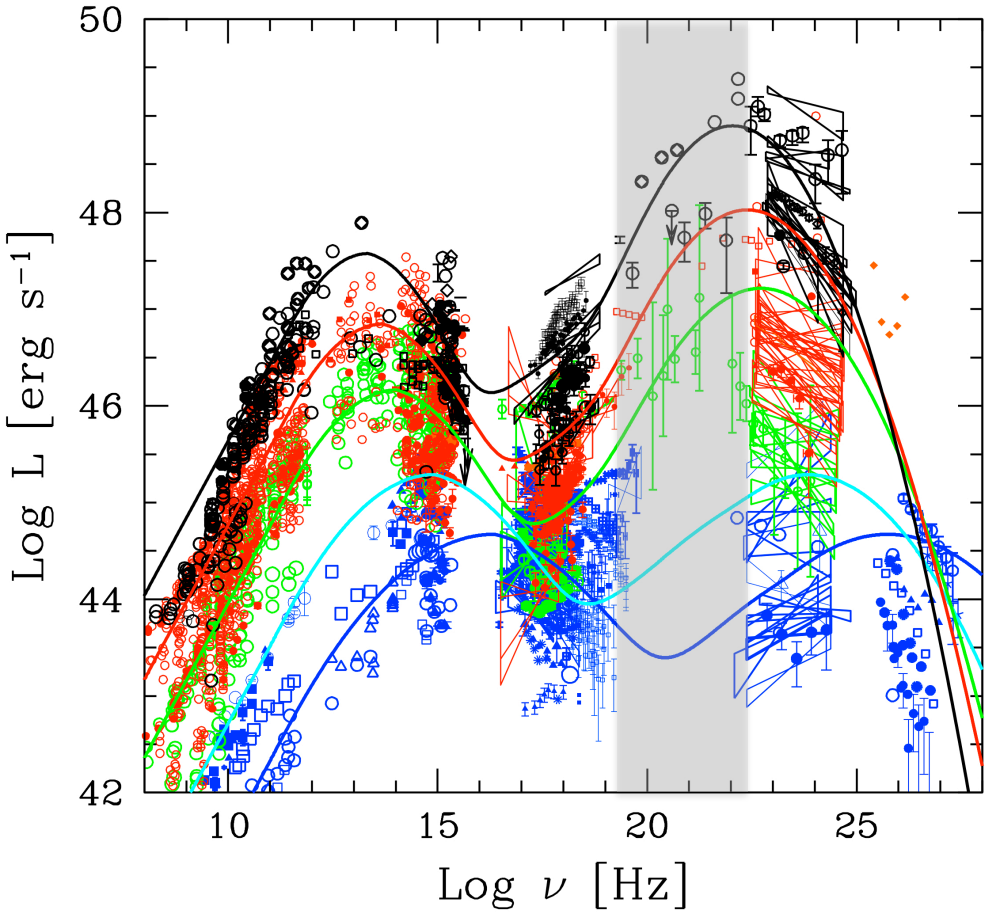
SWIFT J164449.3+573451:
originally discovered as a gamma-ray burst
("high-energy TDE")



Bloom et al. 2011

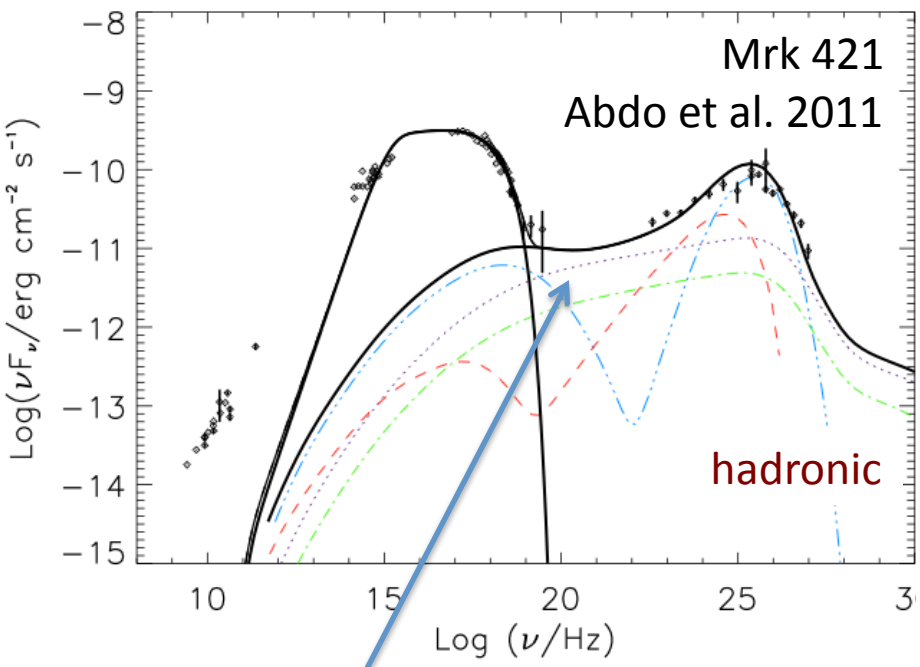
What Else Can We Learn?

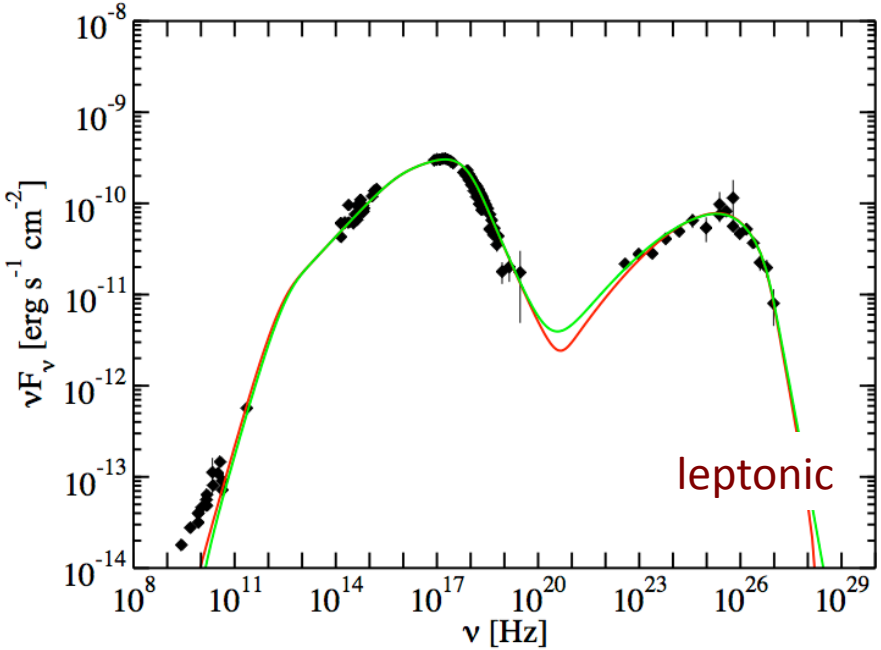
Blazars:



Jet Content and Energetics

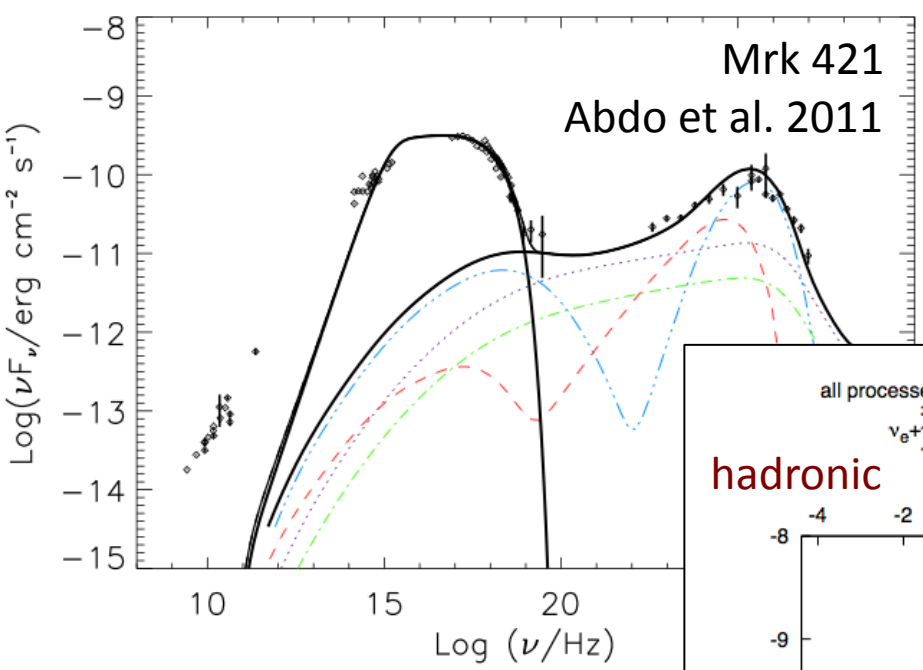
BL Lacs: Hadronic or Leptonic?

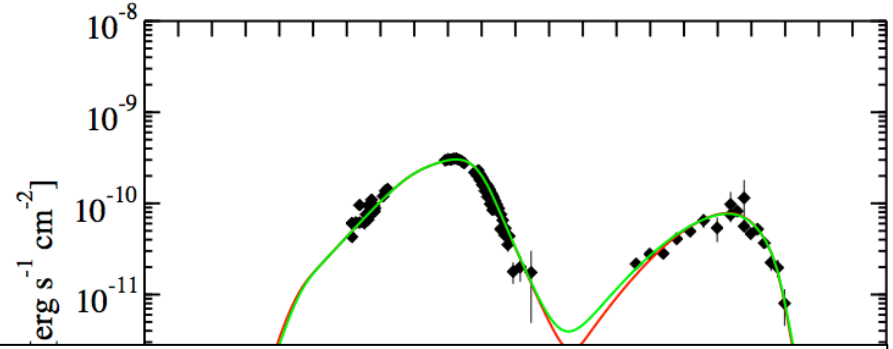


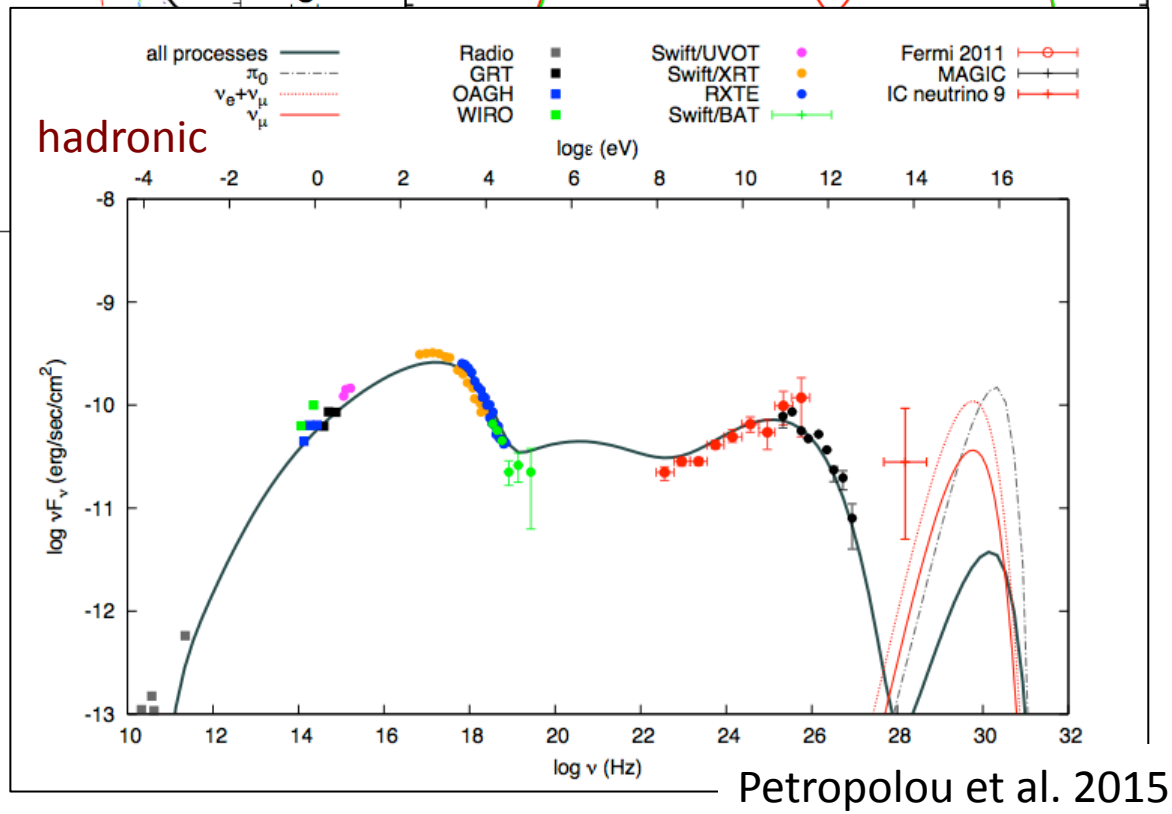


hard X-rays/soft γ-rays:
secondaries from
pion production (pγ)
and proton-synchrotron

BL Lacs: IceCube Neutrinos?







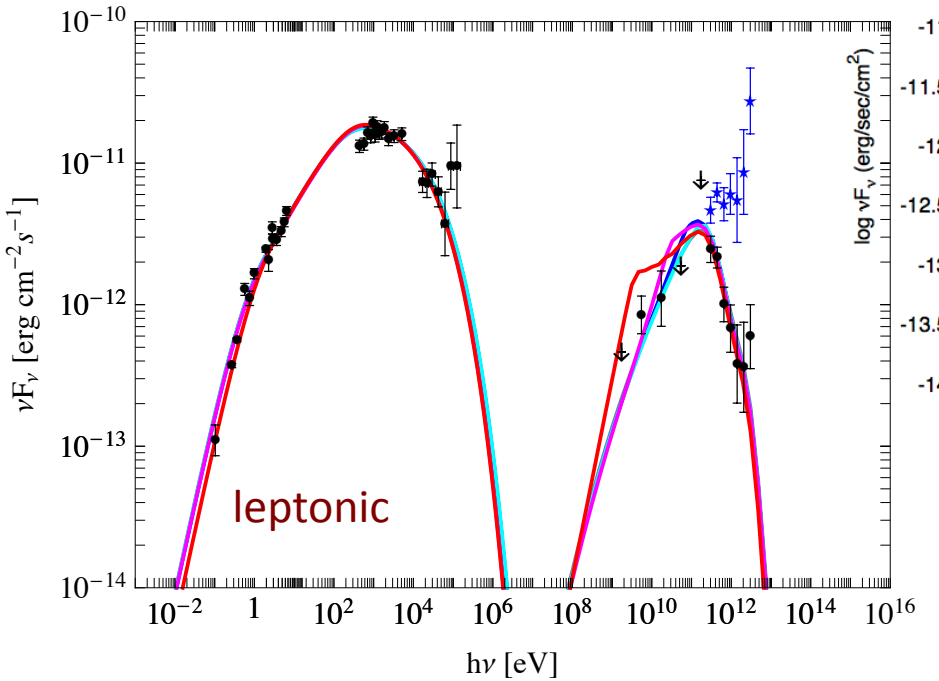
hard X-rays/soft γ-rays:
secondaries from
pion production (pγ)
and proton-synchrotron

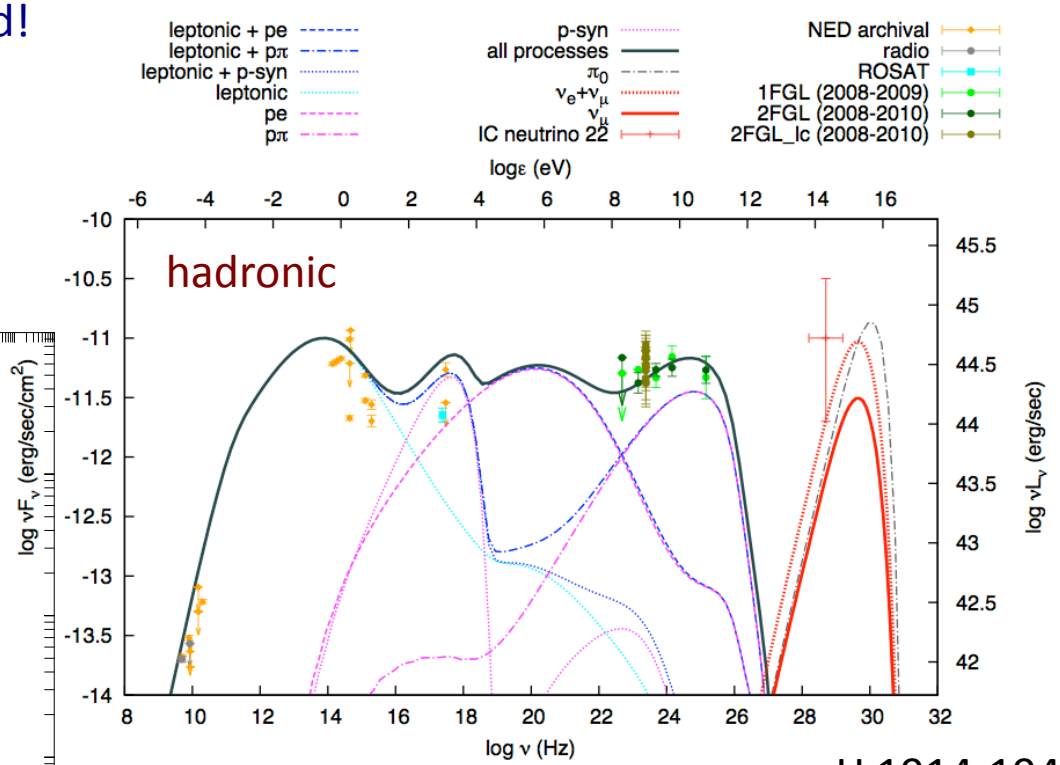
Petropolou et al. 2015

BL Lacs: Crucial MeV Range!

dramatic differences
in the MeV range expected!

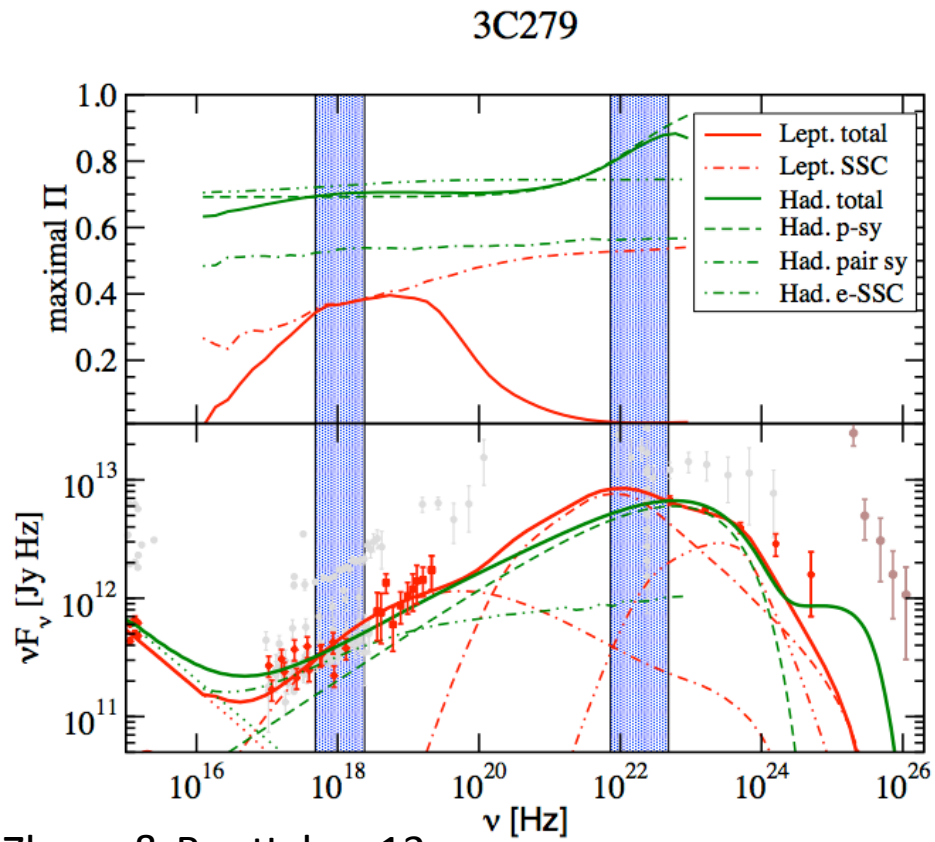
1ES 0347−121
Tanaka, LS et al. 2014





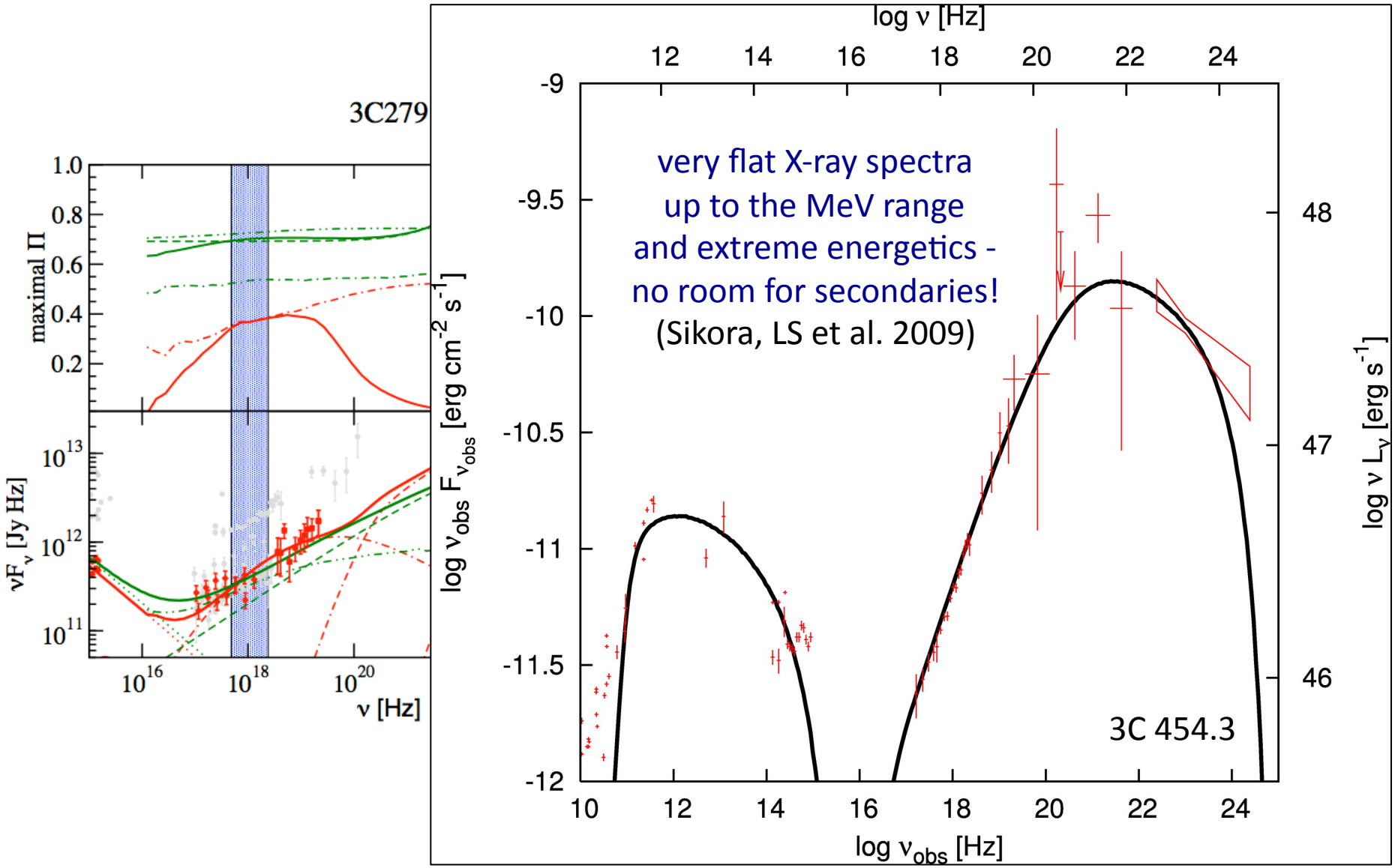
H 1914-194
Petropolou et al. 2015

FSRQs: Hadronic or Leptonic?

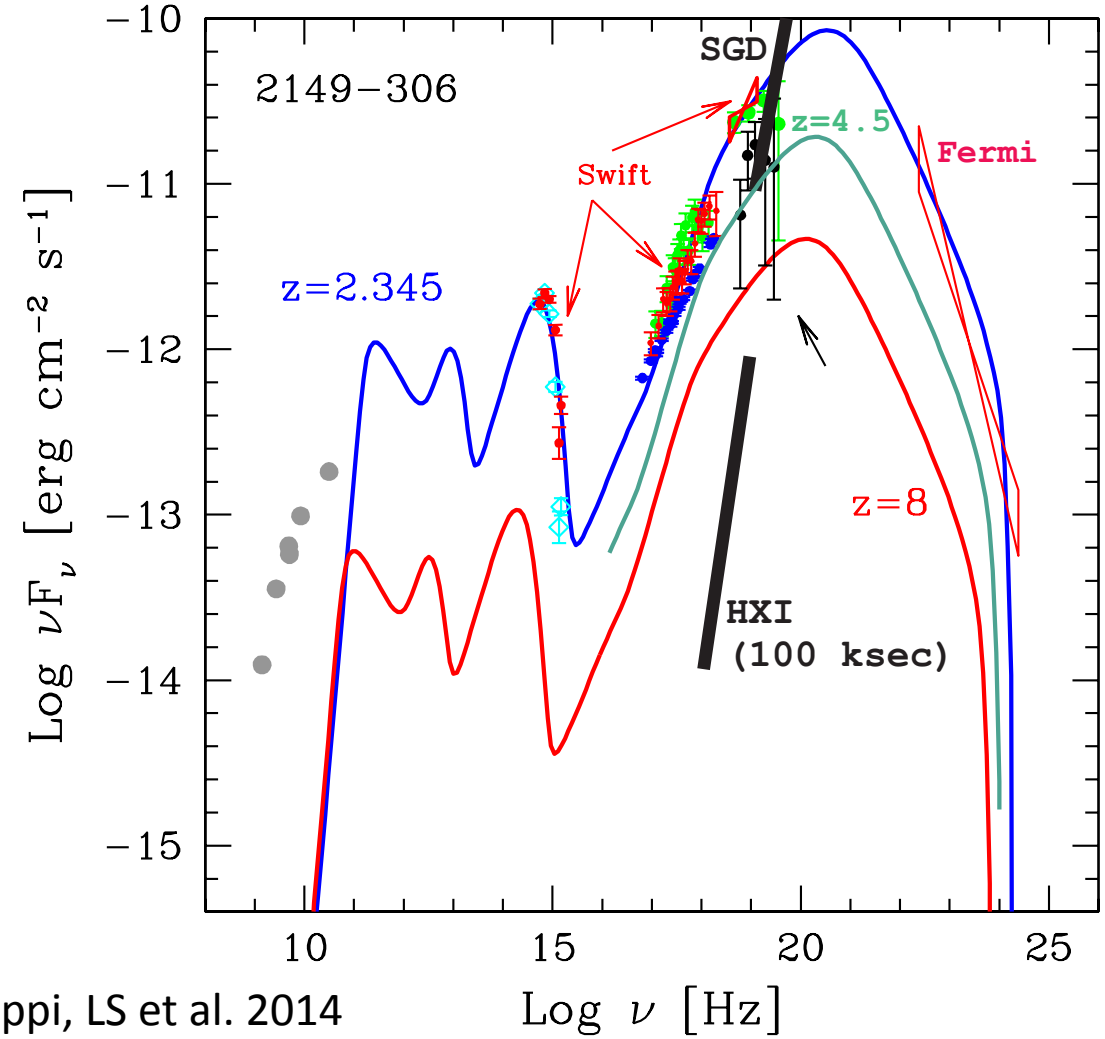


Zhang & Boettcher 13

FSRQs: ~~Hadronic or~~ Leptonic!



FSRQs: High-z Universe



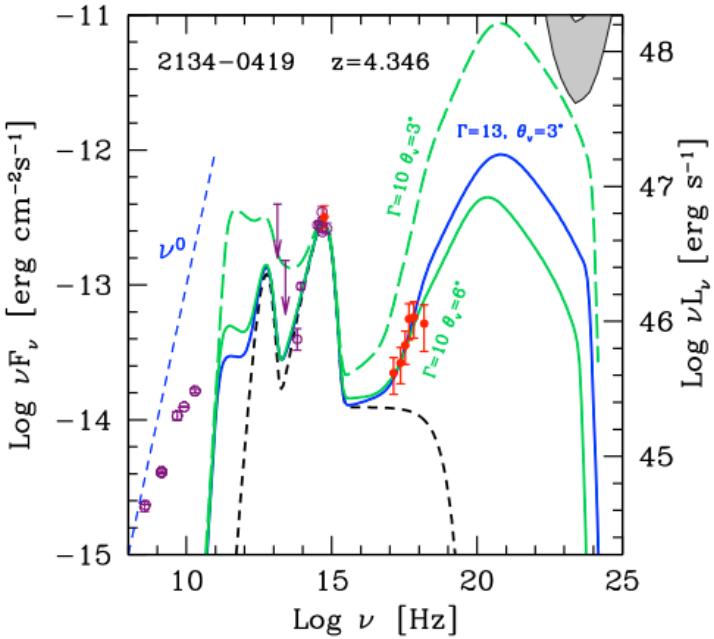
Coppi, LS et al. 2014
(adopted from Ghisellini et al. 2010)

the bulk of the radiative power of FSRQs (comparable to the available accretion power) released in the MeV range

FSRQs: Evolving SMBHs

extremely powerful, but at really high redshifts (z>3) rather weak GeV emitters…
MeV range much more relevant!

Sbarrato et al. 2015



two extrapolations of blazar LF from Swift/BAT (Ajello et al. 2009)

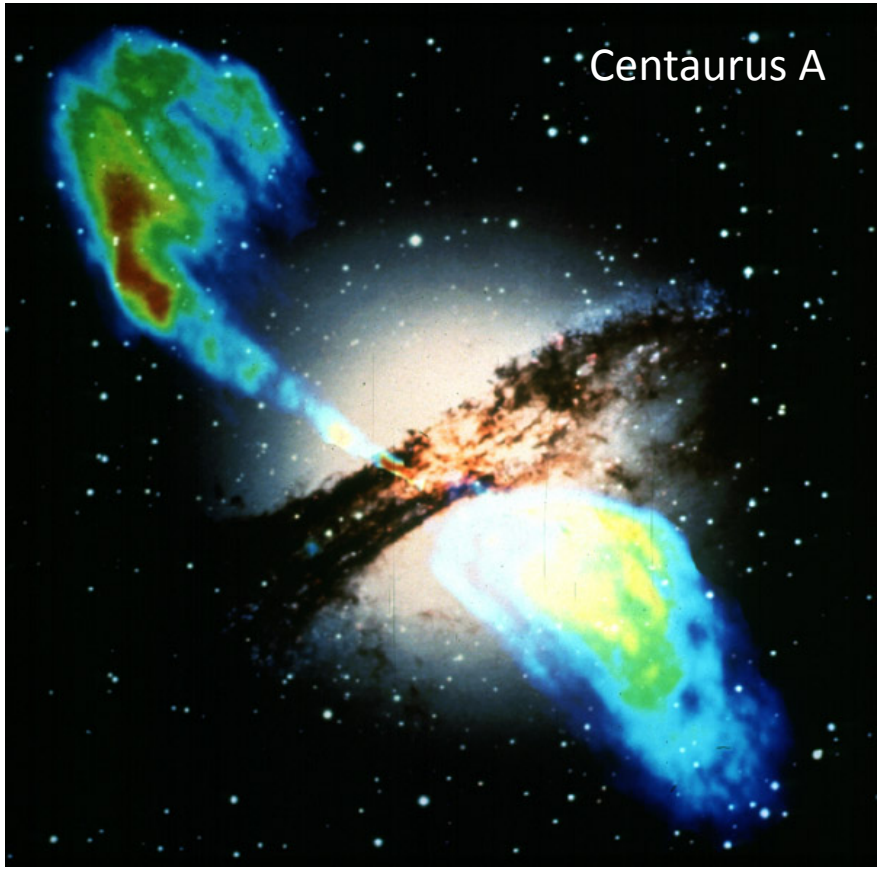
z	N(>z)	N(>z)
3	199	102
4	154	57
5	76	5
6	24	0
7	9	0
8	3	0

PLE Evolution (A09) up to high *z*.

PLE Evolution (A09) to *z*~4 + high *z* exponential cut-off at *z*>4.

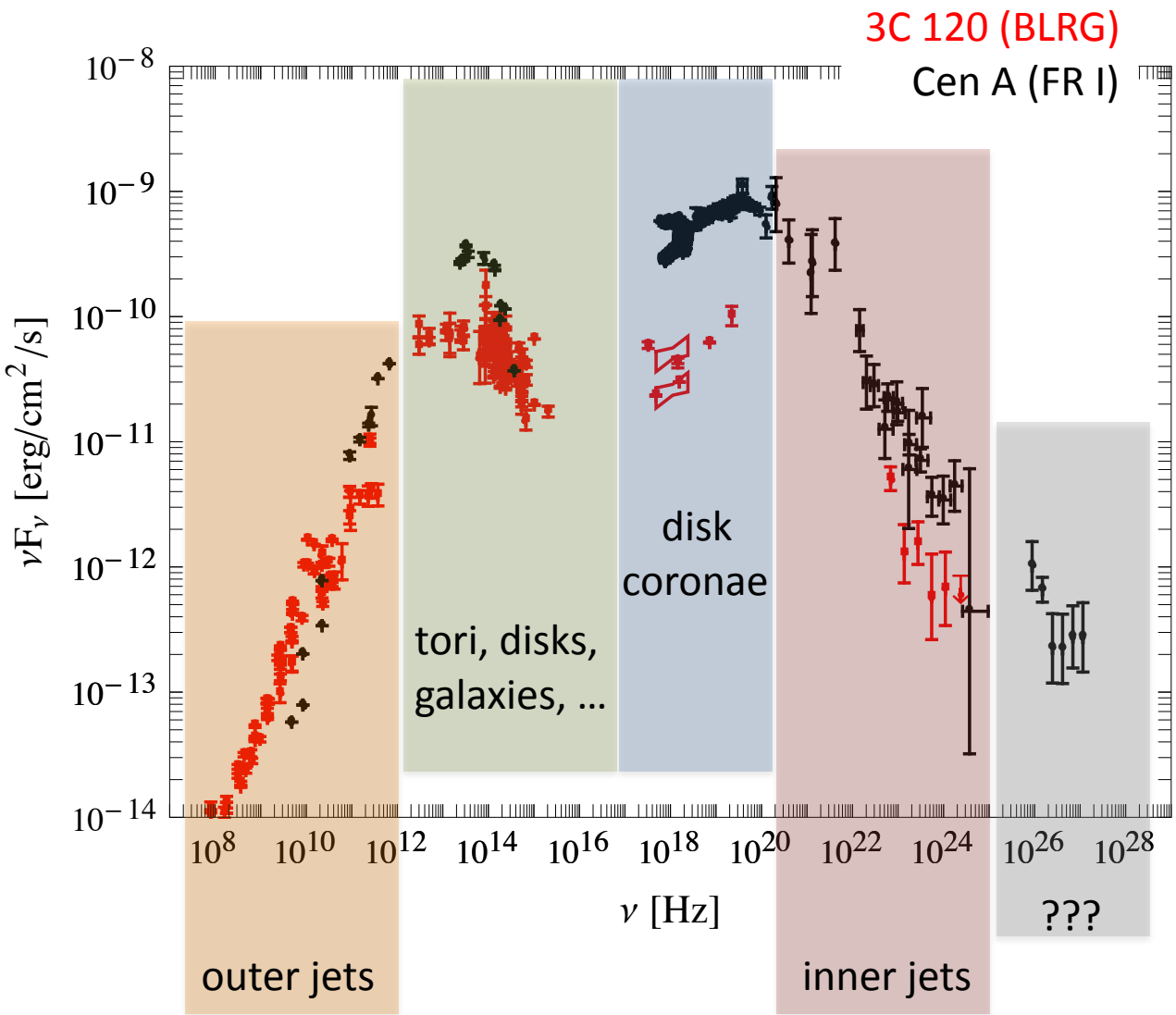
What Else Can We Learn?

Radio galaxies:

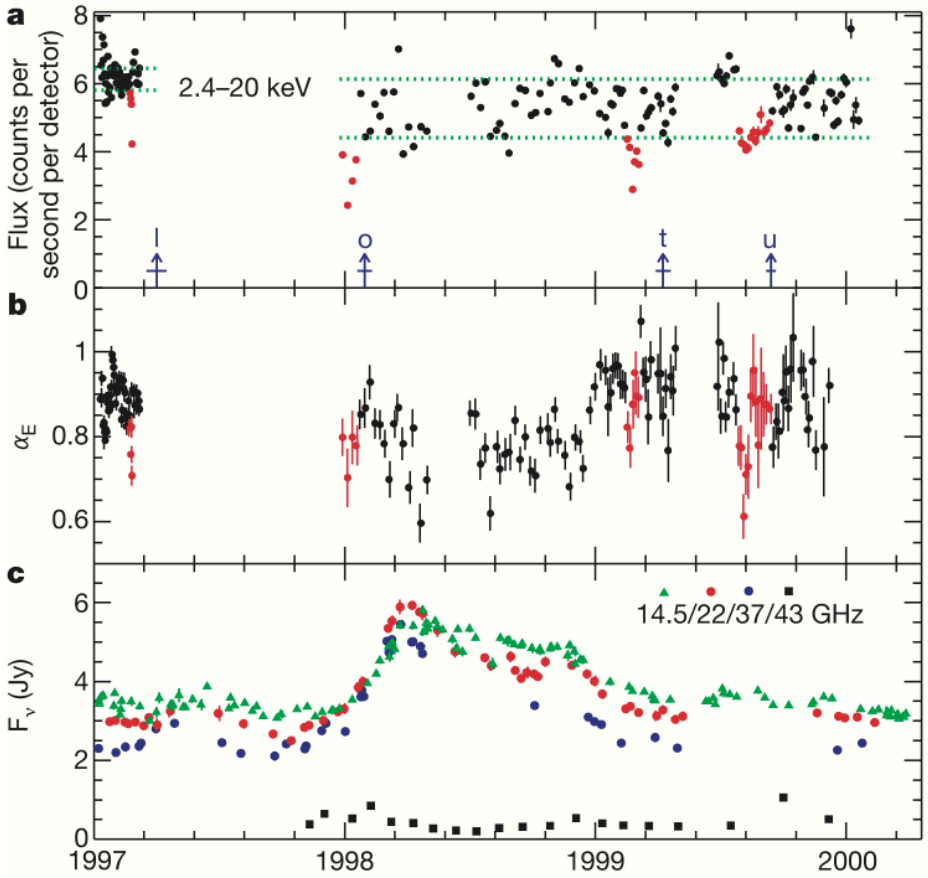


Disk-Jet Coupling

RGs: Complex Spectra

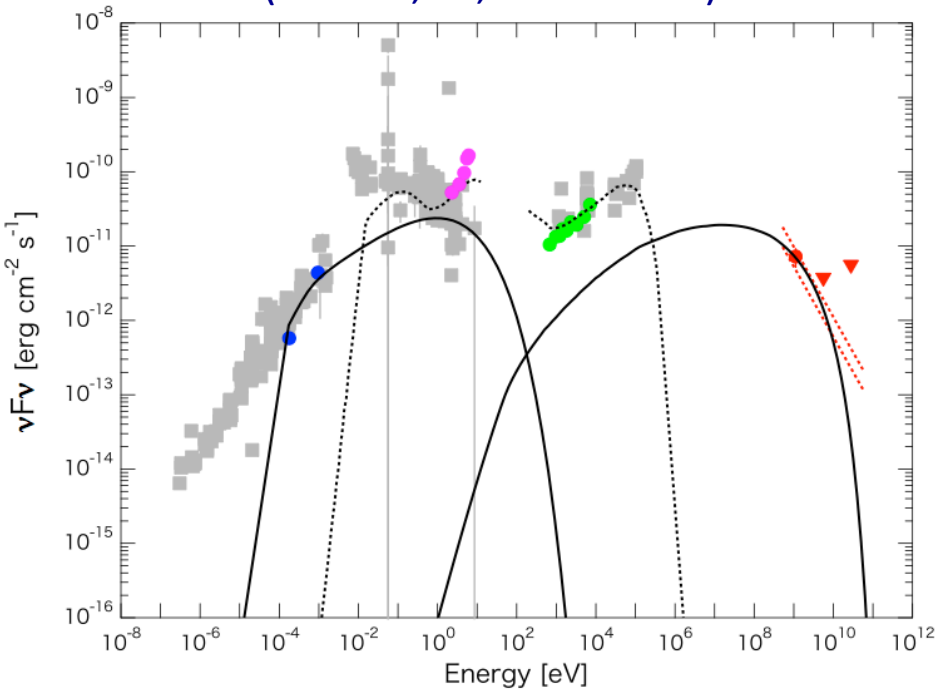


RGs: Disks & Jets



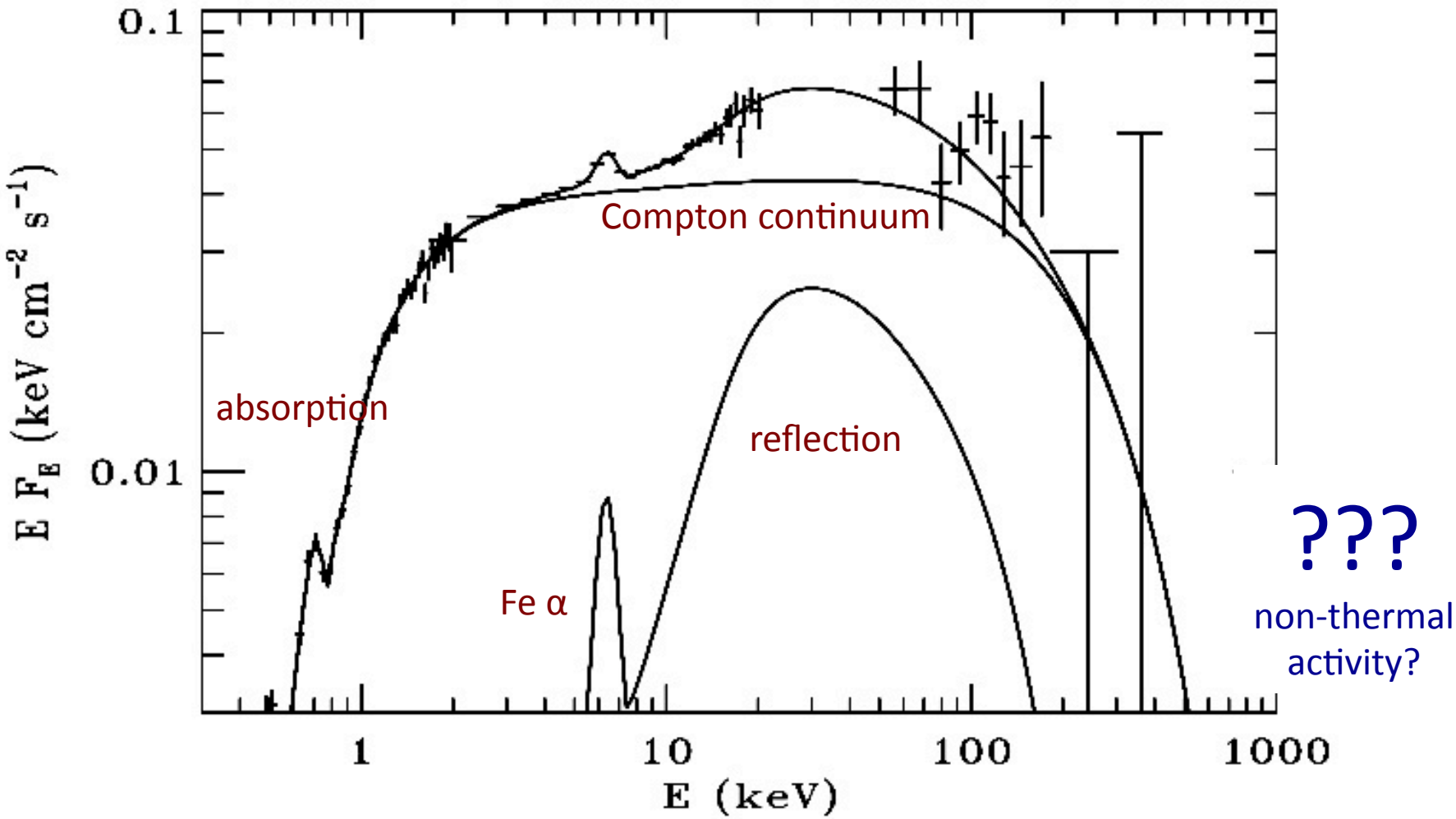
dips in the X-ray (disk) emission in 3C 120 followed by ejections of bright superluminal knots in the radio jet (Marscher et al. 2002, Chatterjee et al. 2009, 2011, Lohfink et al. 2013)

… and also by GeV flares?
(Tanaka, LS, et al. 2015)

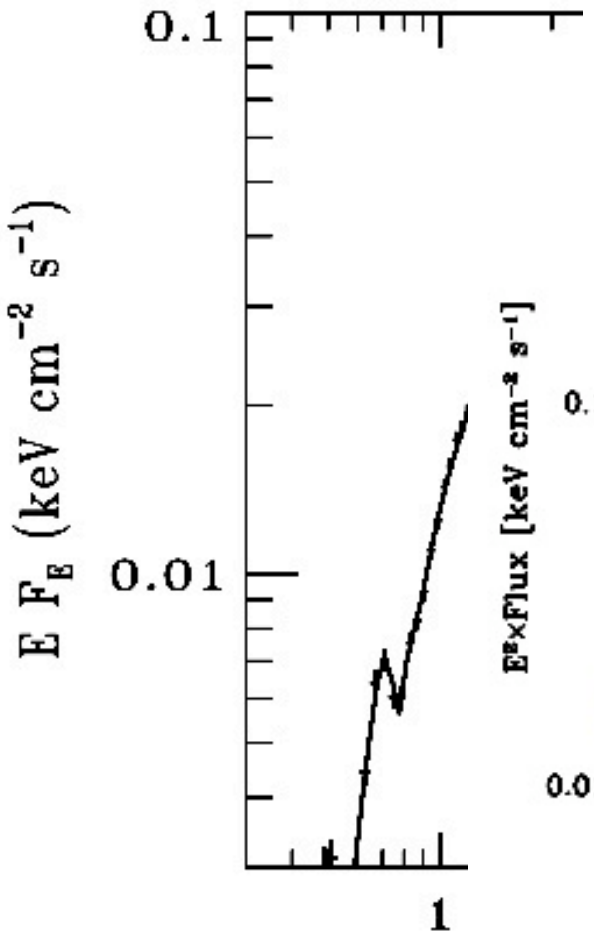


close analogy to XRBs?

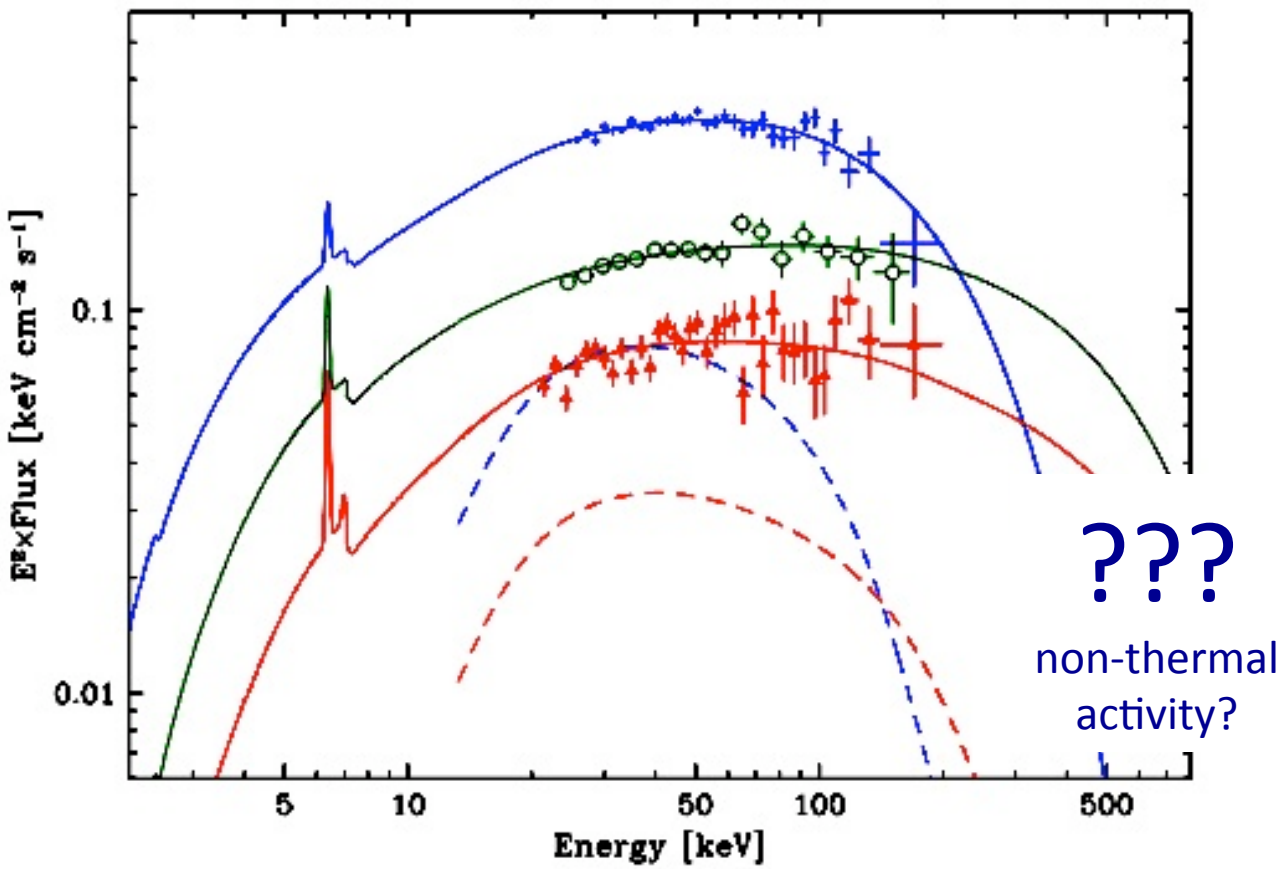
AGN: Disk Coronae



AGN: Disk Coronae

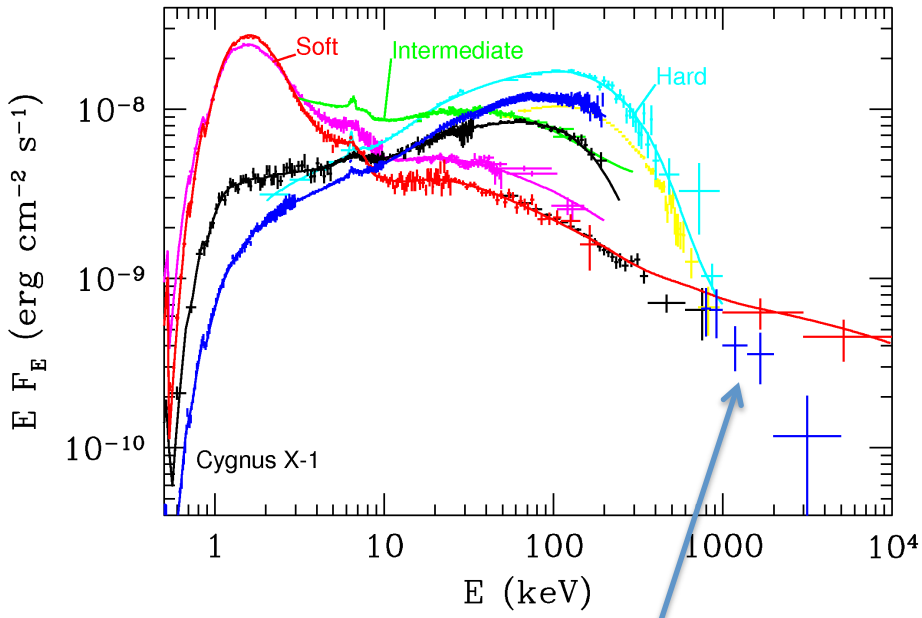


the X-ray brightest Seyfert: NGC 4151 (Lubinski et al. 2010)



Lessons From XRBs

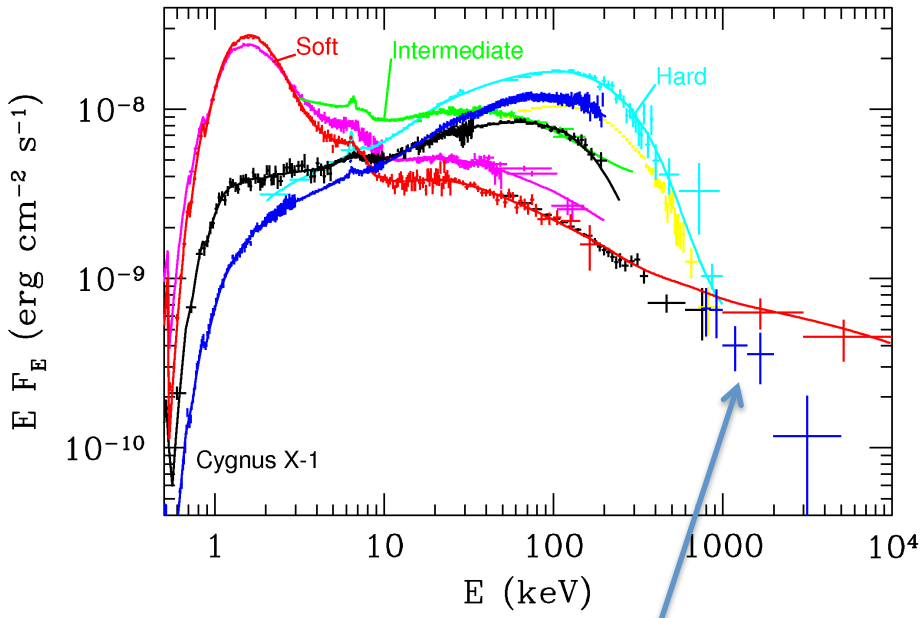
Galactic binary Cygnus X-1



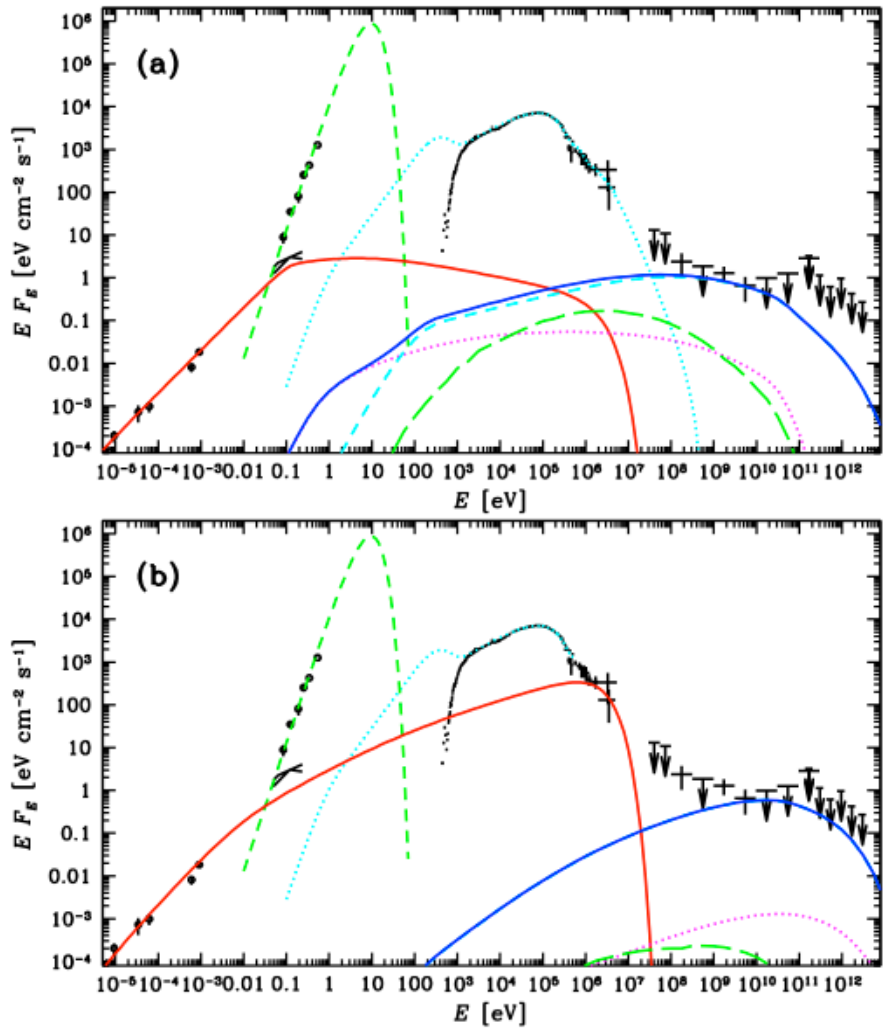
disk corona OR
a jet component?

Lessons From XRBs

Galactic binary Cygnus X-1



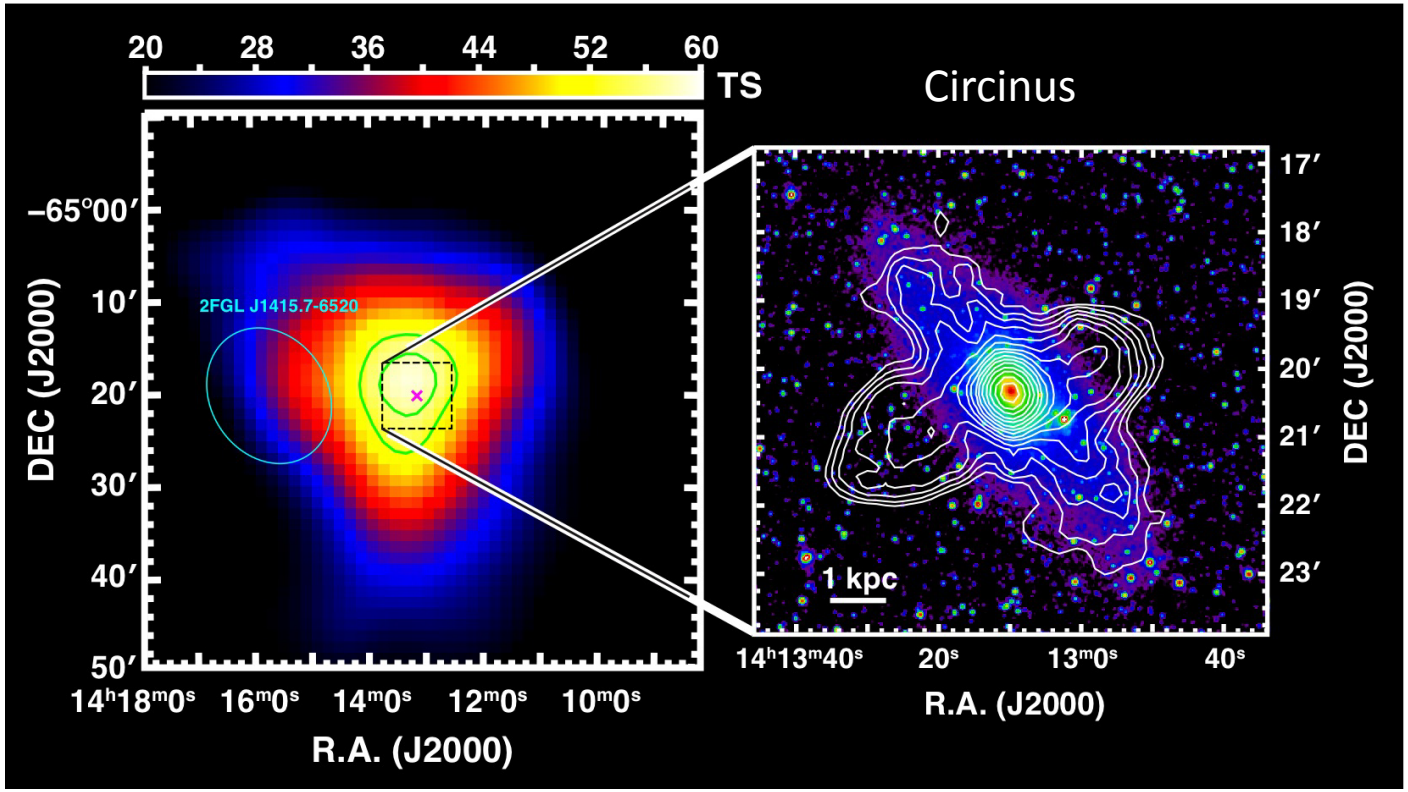
disk corona OR
a jet component?
(polarization!)



Zdziarski, LS, et al. 2014

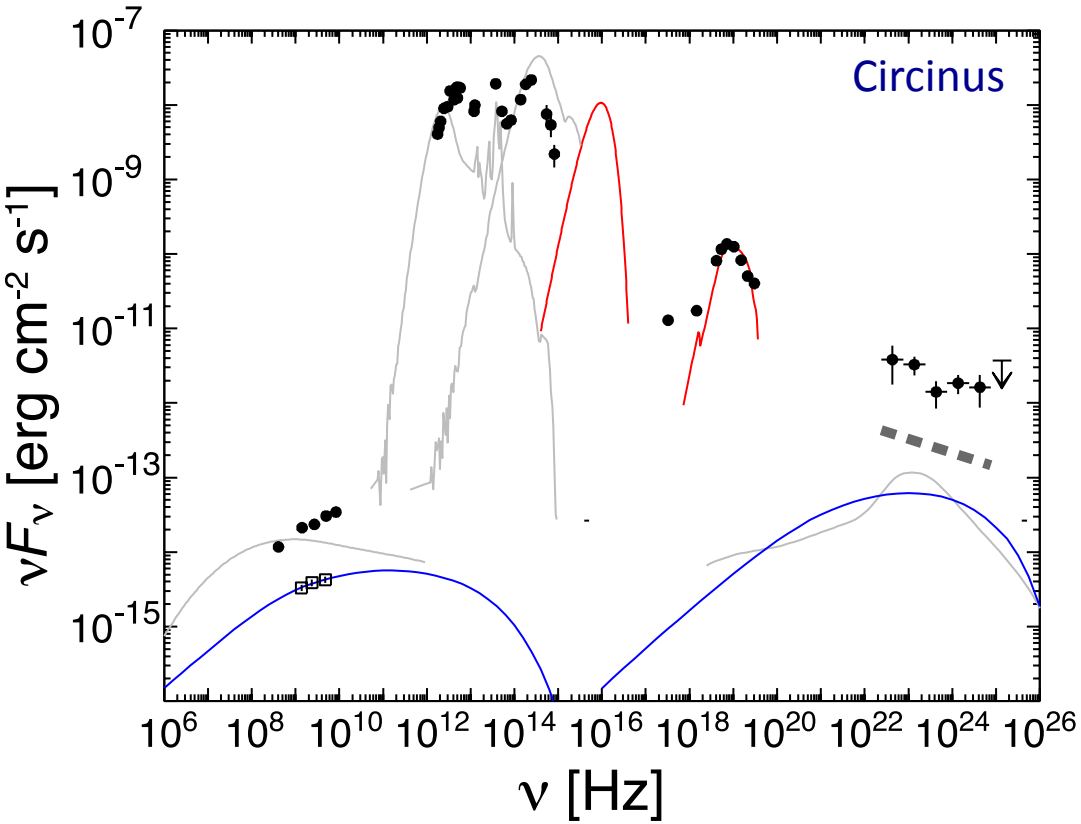
So, What Can We Learn?

Seyfert galaxies:



Something new!

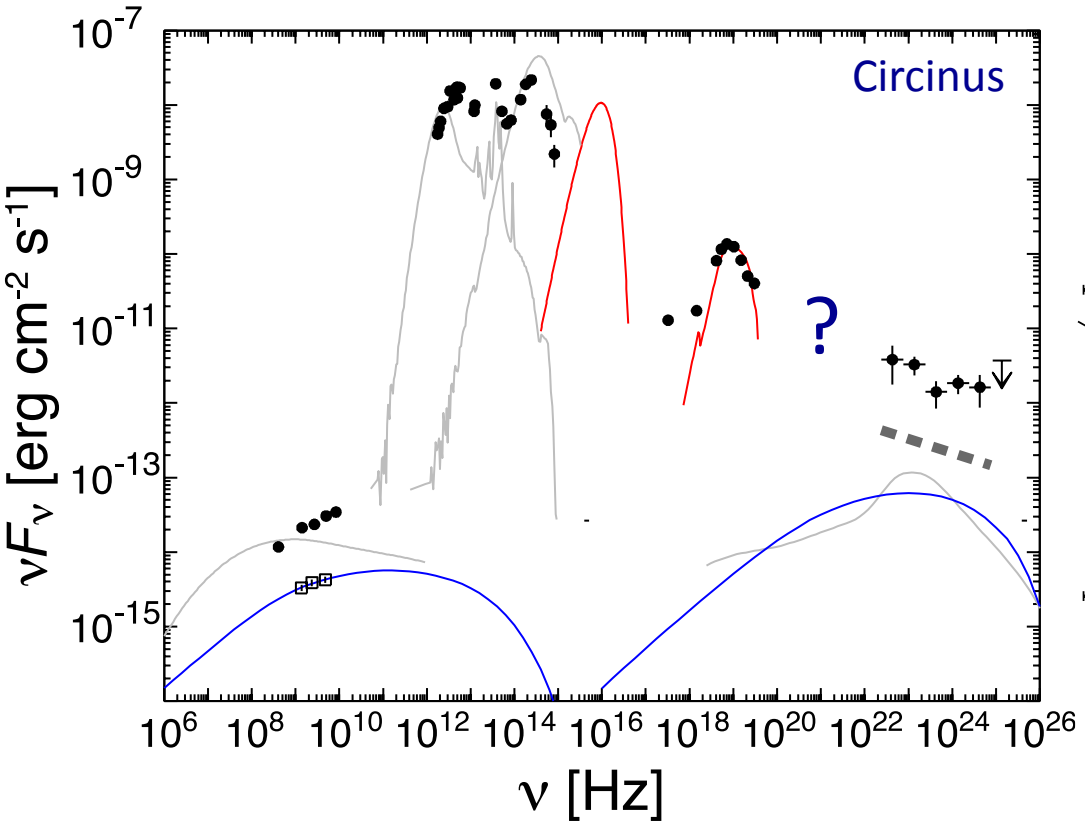
Seyferts: Gamma-ray Emitters (?)

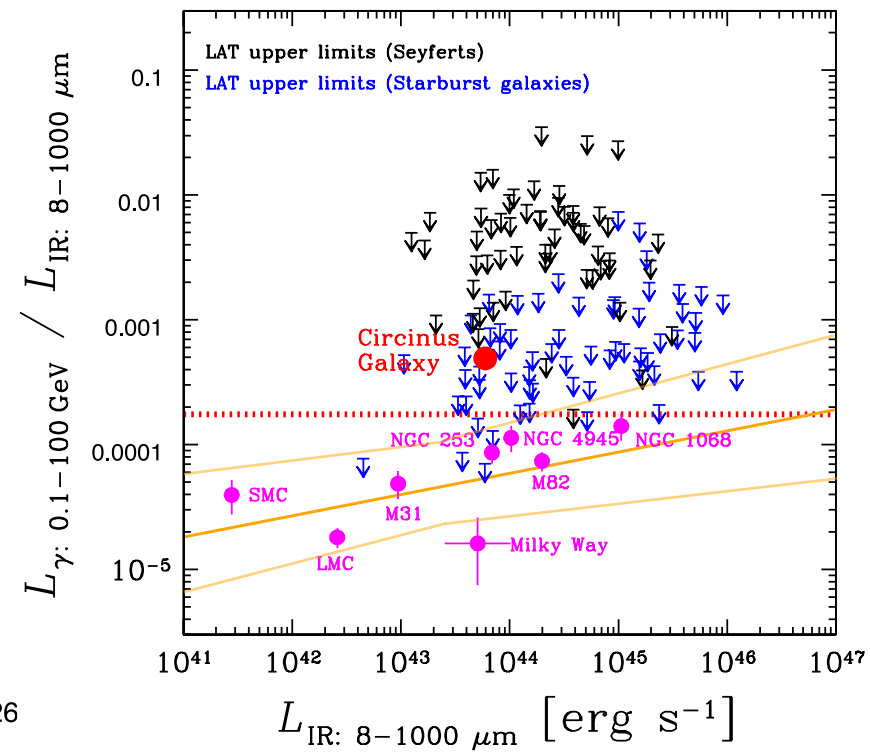


Hayashida, LS, et al. 2013

unknown origin of the detected gamma-rays!

Seyferts: Gamma-ray Emitters (?)



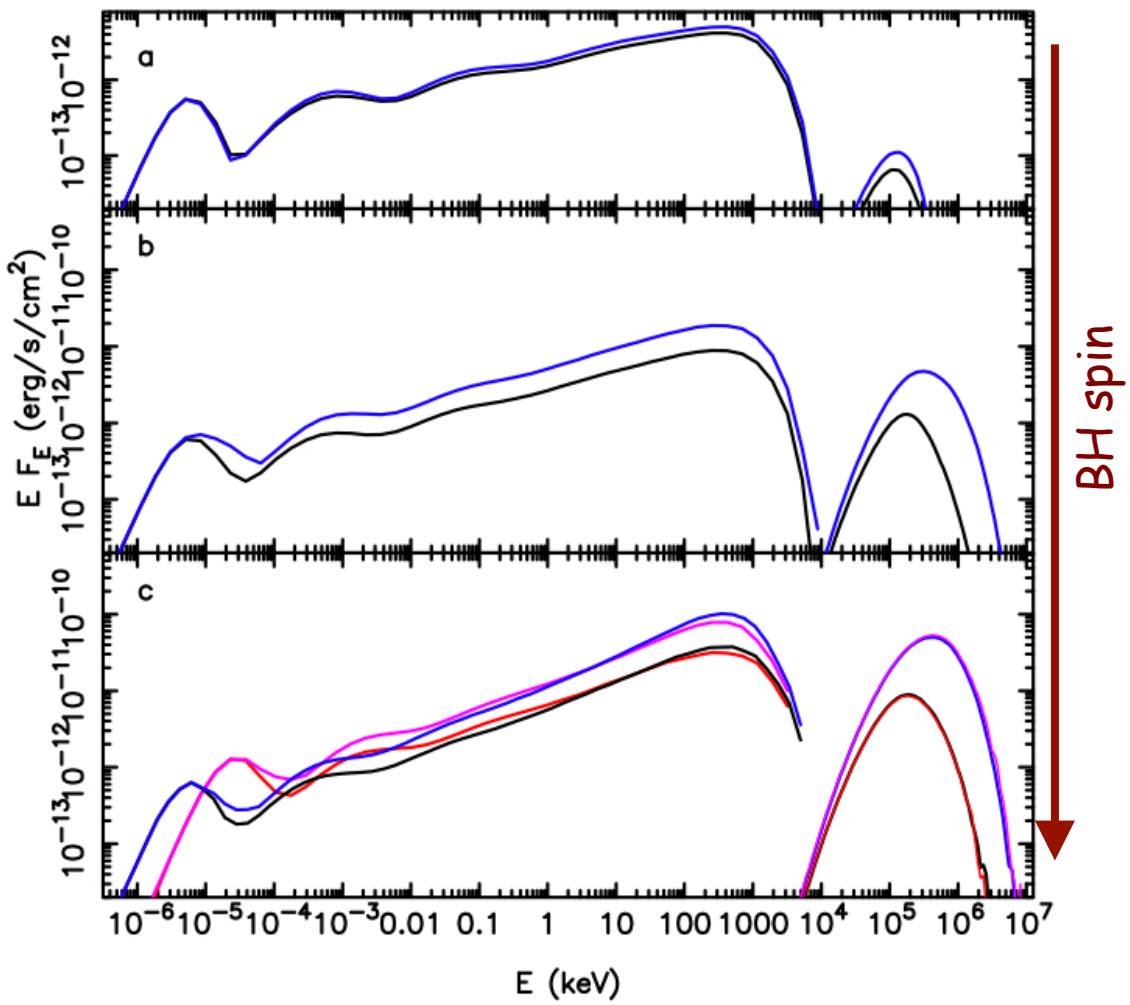


Hayashida, LS, et al. 2013

Seyferts: Something New?

For a Kerr black hole the innermost stable orbit of the accretion disk is located much closer to the event horizon, and hence the number density of the matter within the innermost parts of the accretion disk as well as the proton temperature are increased, leading to the enhanced proton-proton interactions above the threshold for the pion production.

Exciting MeV-GeV range!



Niedziwecki et al. 2009

Things We Can Learn

- TDEs: how relativistic jets are launched
- BL Lacs: sources of UHECRs and PeV neutrinos?
- FSRQs: cosmological evolution of SMBHs
- Radio Galaxies: disk-jet coupling
- Seyferts: non-thermal activity of accretion disks and coronae