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

Takahashi, Uchiyama & LS 2012
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?
So, What Can We Learn?

Tidal Disruption Events:

Launching of relativistic jets in AGN

expected \( \sim 1 \) per \( 10^4 \) to \( 10^6 \) years in a given galaxy
TDEs: Unexpected MeV Emission!

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

Burrows et al. 2011

Bloom et al. 2011
What Else Can We Learn?

Blazars:

Jet Content and Energetics
BL Lacs: Hadronic or Leptonic?

Mrk 421
Abdo et al. 2011

hard X-rays/soft γ-rays:
secondaries from
pion production (pγ)
and proton-synchrotron
BL Lacs: IceCube Neutrinos?

Mrk 421
Abdo et al. 2011

hadronic

hard X-rays/soft \( \gamma \)-rays: secondaries from pion production (\( p\pi \)) 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

10^{-2} \times 10^{16}

H 1914-194
Petropolou et al. 2015
FSRQs: Hadronic or Leptonic?

Zhang & Boettcher 13
FSRQs: Hadronic or Leptonic!

Very flat X-ray spectra up to the MeV range and extreme energetics - no room for secondaries! (Sikora, LS et al. 2009)
FSRQs: High-z Universe

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)

<table>
<thead>
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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:

Centaurus A

Disk-Jet Coupling
RGs: Complex Spectra

- Outer jets
- Tori, disks, galaxies, ...
- Disk coronae
- Inner jets
- 3C 120 (BLRG)
- Cen A (FR I)
RGs: Disks & Jets


... and also by GeV flares? (Tanaka, LS, et al. 2015)
AGN: Disk Coronae

non-thermal activity?
AGN: Disk Coronae

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

non-thermal activity?
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!)

So, What Can We Learn?

Seyfert galaxies:

Something new!
Seyferts: Gamma-ray Emitters (?)

unknown origin of the detected gamma-rays!

Hayashida, LS, et al. 2013
Seyferts: Gamma-ray Emitters (?)

Hayashida, LS, et al. 2013
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