MeV Emission From Galactic Binaries and RQ AGN

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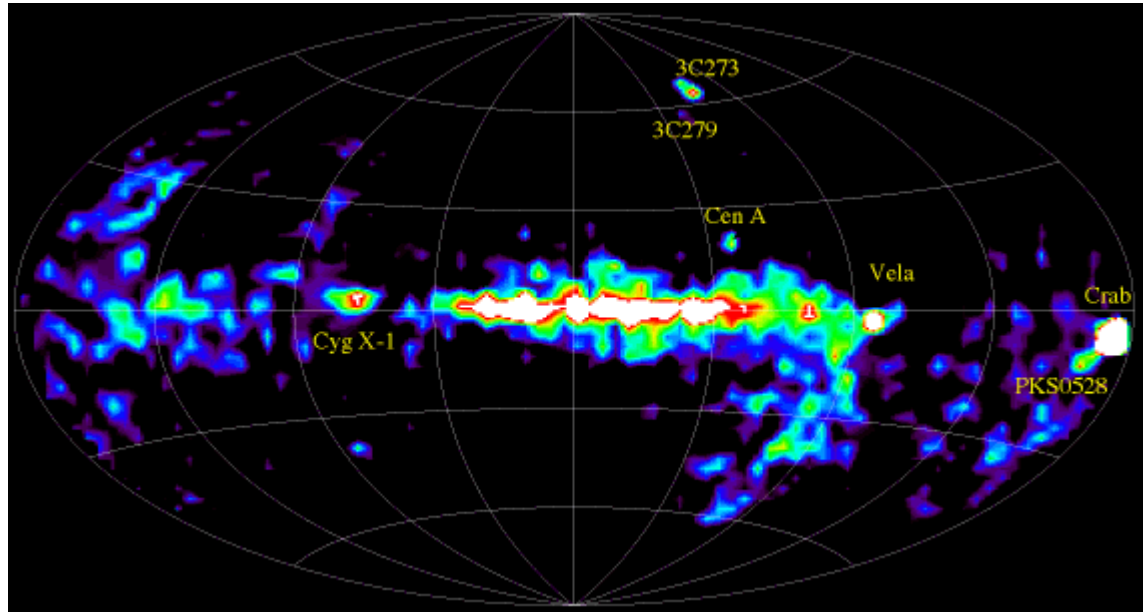
- Results from the CGRO era are limited. No RL AGN @ E<~ MeV, but several galactic BHs above at least a few MeV
  - Note that INTEGRAL "PiCsIT" failed, and SPI is optimized for narrow lines, so OSSE & COMPTEL arguably best for >~1 MeV continua
- Requires non-thermal emission components for ~MeV γ's
  - → particle acceleration → radio emission
- The BHs and RQ AGN have some striking similarities
  - →suggests common physics
- Other issues (not discussed in detail):
  - BH XRBs have anomalous Lithium abundance: hadronic induced nuclear reactions? →2.2-MeV capture or other lines?
  - Luminous 511-keV event reported in Nova Mus 1991, but enormously bright, "redshifted", and never seen since – may be erroneous
- Other object classes: massive star and WR binaries, classical novae

MeV sky as seen by CGRO/COMPTEL

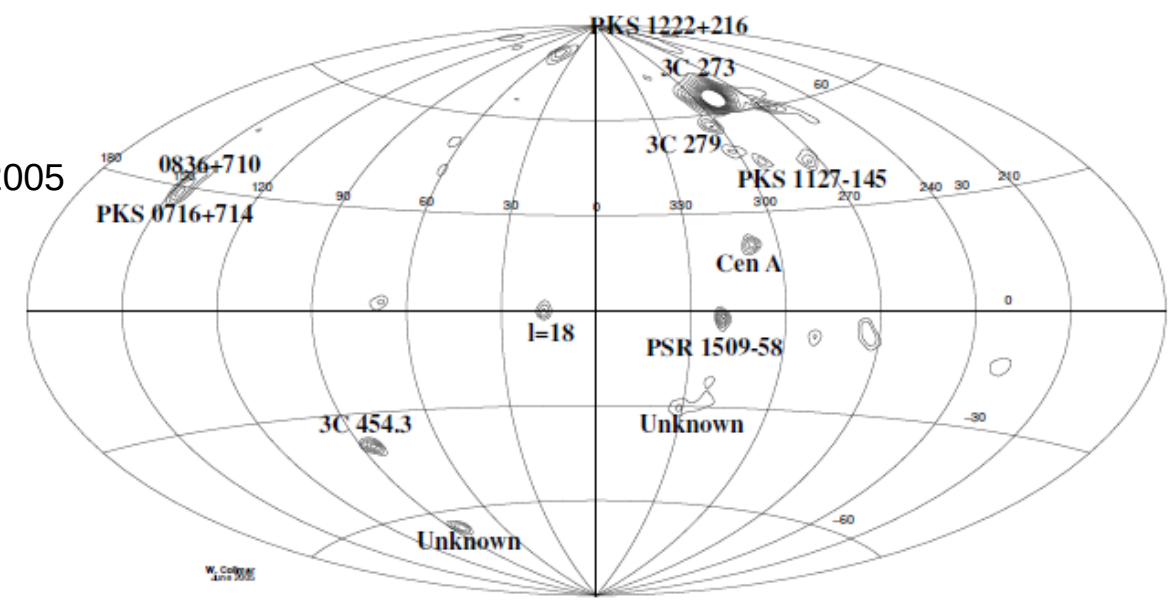
Among galactic BHXRBs only 2 >5σ MeV sources: Cyg X-1 (well known BH HMXB), GRO J0422+32 (1992 LMXB transient). Sub-5σ only for others including prolific jetted sources, GRS 1915+105 & GRO J1655-40.

COMPTEL AGN catalog includes 6-15 to AGN are included at differing levels of significance (Collmar+ 2006). All are RL. Some of the SEDs would seem to pose a challenge to the SSC or SSC/EC models.



Collmar 2005

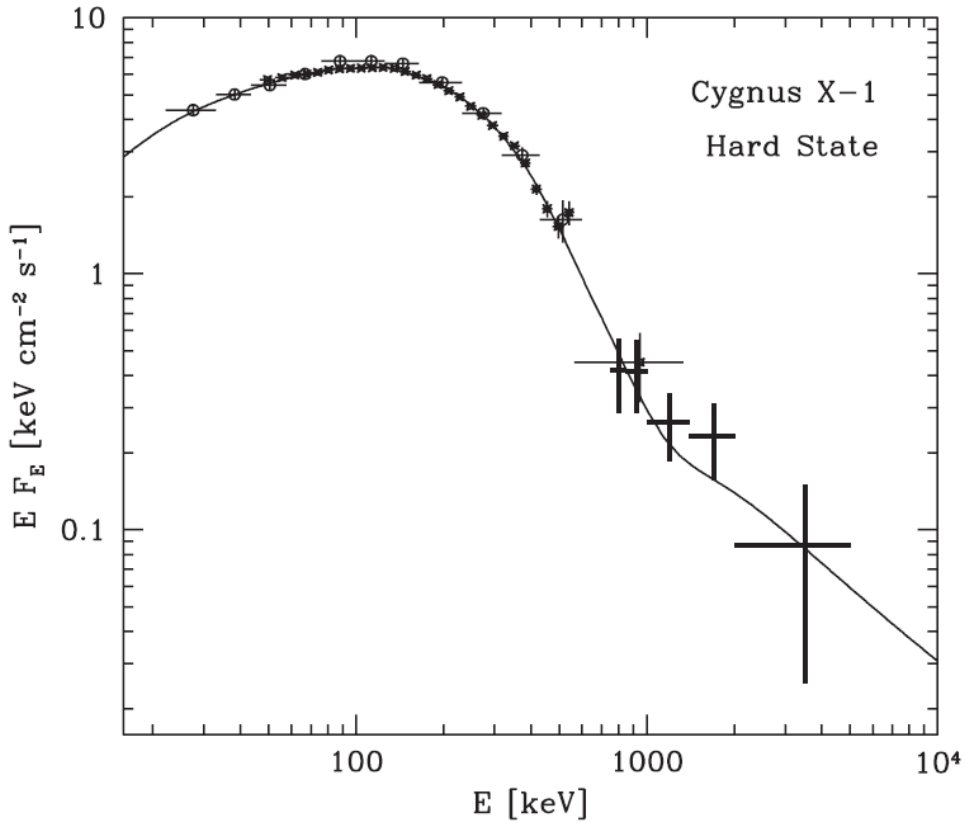
Source	Redshift	AGN Type	Significance
Cen A	0.0007	radio galaxy	high
Mkn 421	0.031	BL Lac object	low
3C 273	0.158	quasar	high
PKS 1222+216	0.435	quasar	medium
3C 279	0.538	quasar	high
PKS 1622-297	0.815	quasar	high
3C 454.3	0.859	quasar	high
PKS 0208-512	1.003	quasar	high
CTA 102	1.037	quasar	low
GRO J0516-609	1.09	quasar	medium
PKS 1127-145	1.187	quasar	medium
PKS 0528+134	2.06	quasar	high
PKS 0716+714	?	BL Lac object	low
0836+710	2.17	quasar	medium
PKS 1830-210	2.06	quasar	medium



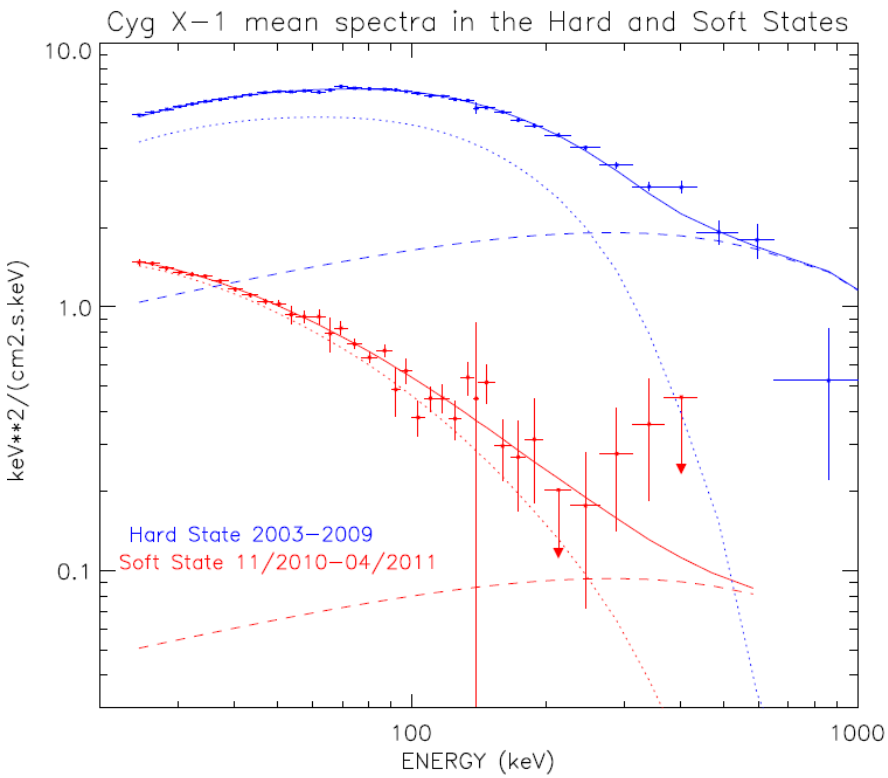
Likelihood Ratios: 12 Step 4

For at least Cyg X-1 there are definitive MeV measurements. Some skepticism may be warranted regarding the high-energy extent. In any case these two composites (CGRO, rhs) and INTEGRAL (below) illustrate the observational state of the art.

McConnell+2002

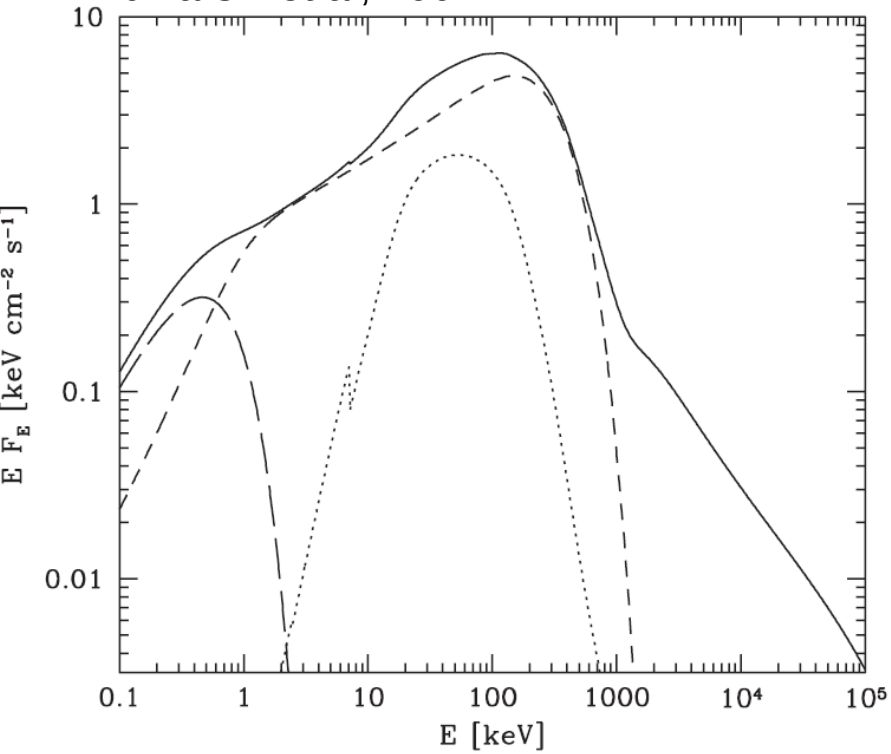


Jourdain+ 2013

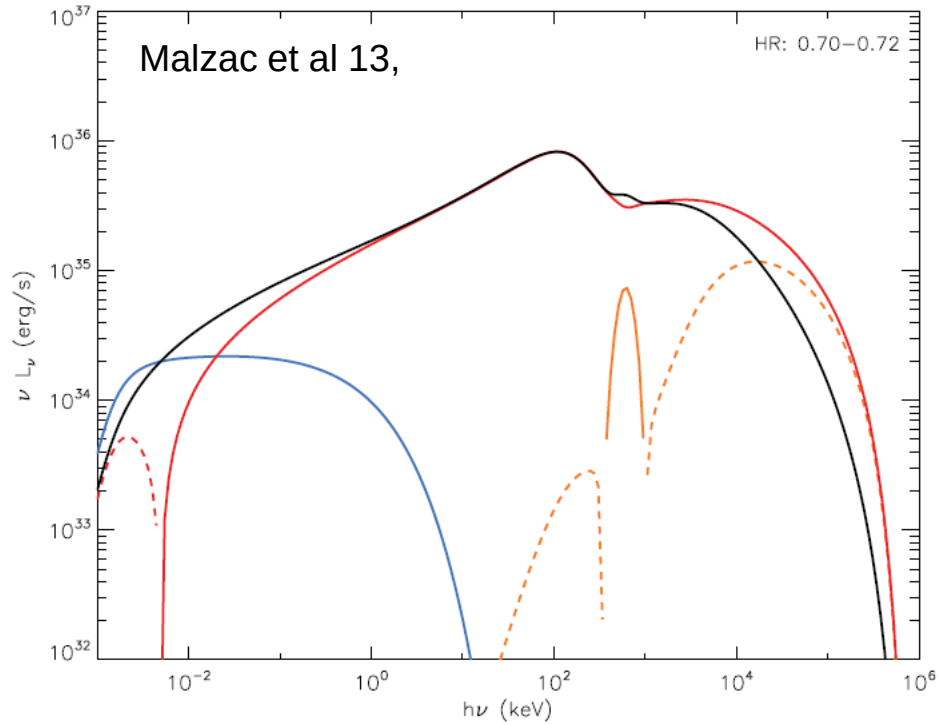


Models

Zdziarski et al, 2002



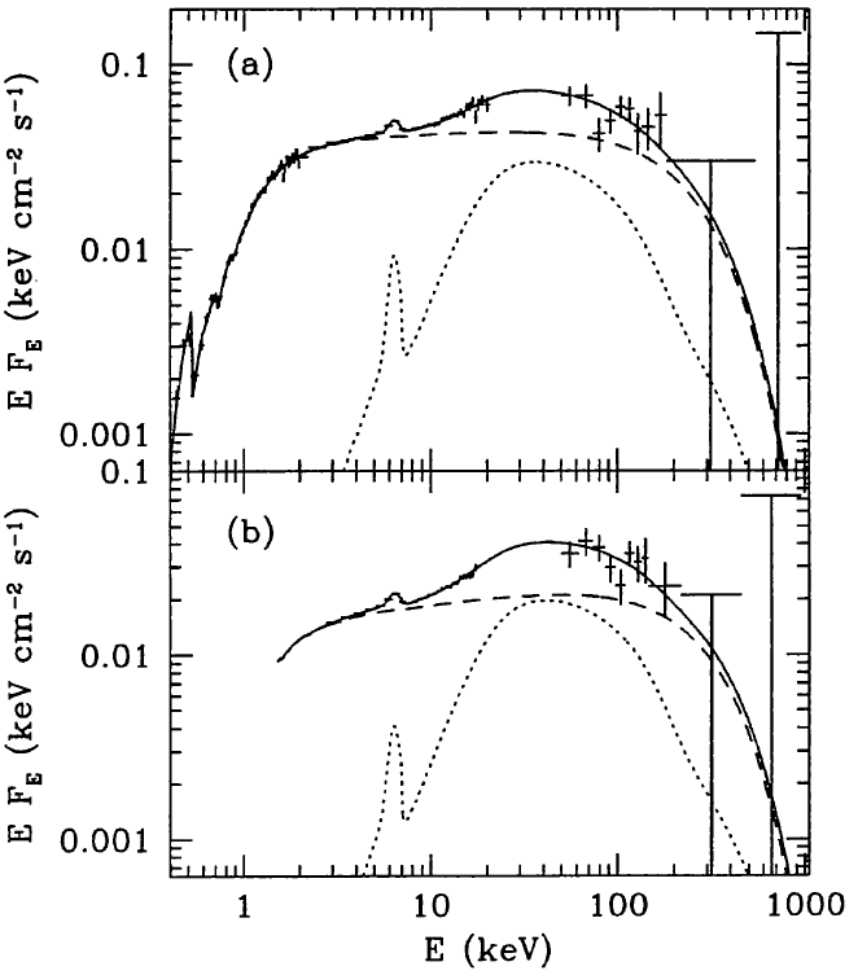
Models which include non-thermal components – synchrotron, SSC and pair plasmas -, plus thermal Comptonization components at lower energies predict high-energy emission that could extends >MeV energies.



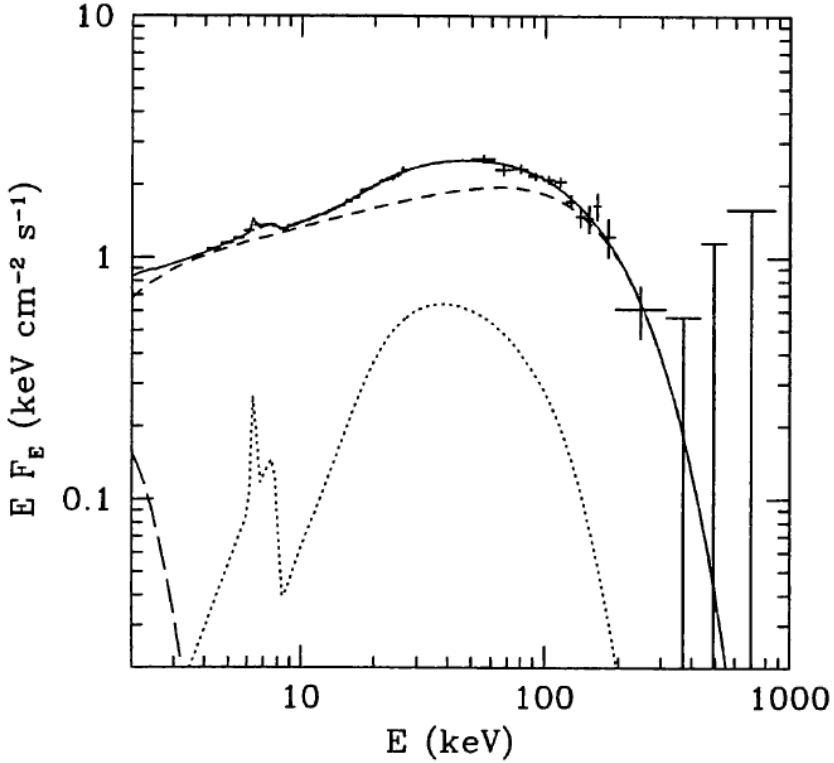
Clearly the limited nature of the current observational data cannot meaningfully constrain the details of these approaches.

The broad-band γ-ray spectra of RQ AGN and galactic BHs bear notable similarity, although the latter are ~10-100X brighter. This is somewhat surprising since the accretion disk temperatures drastically different. I

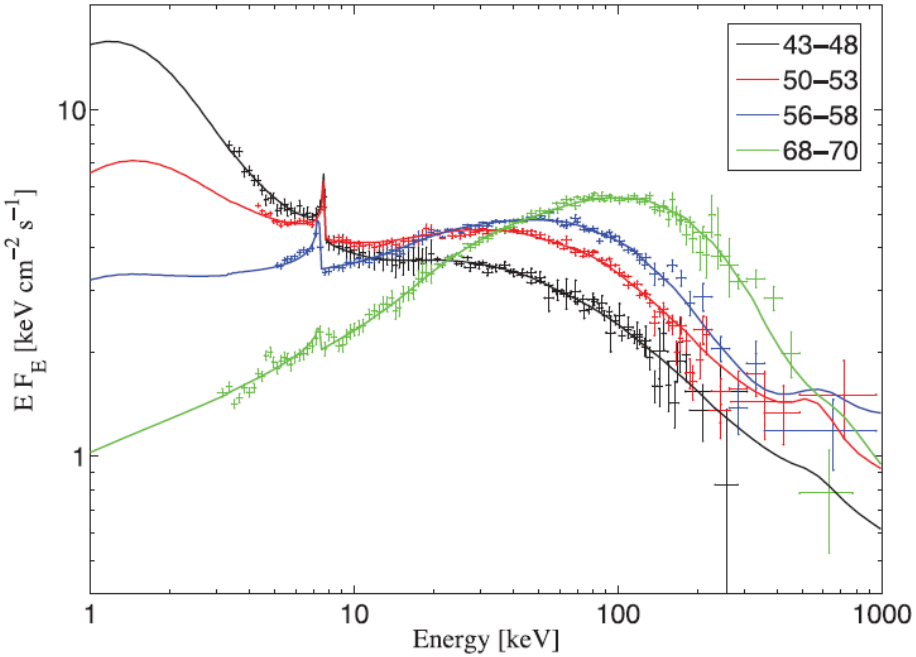
IC4329A (Madejski+ 1995)



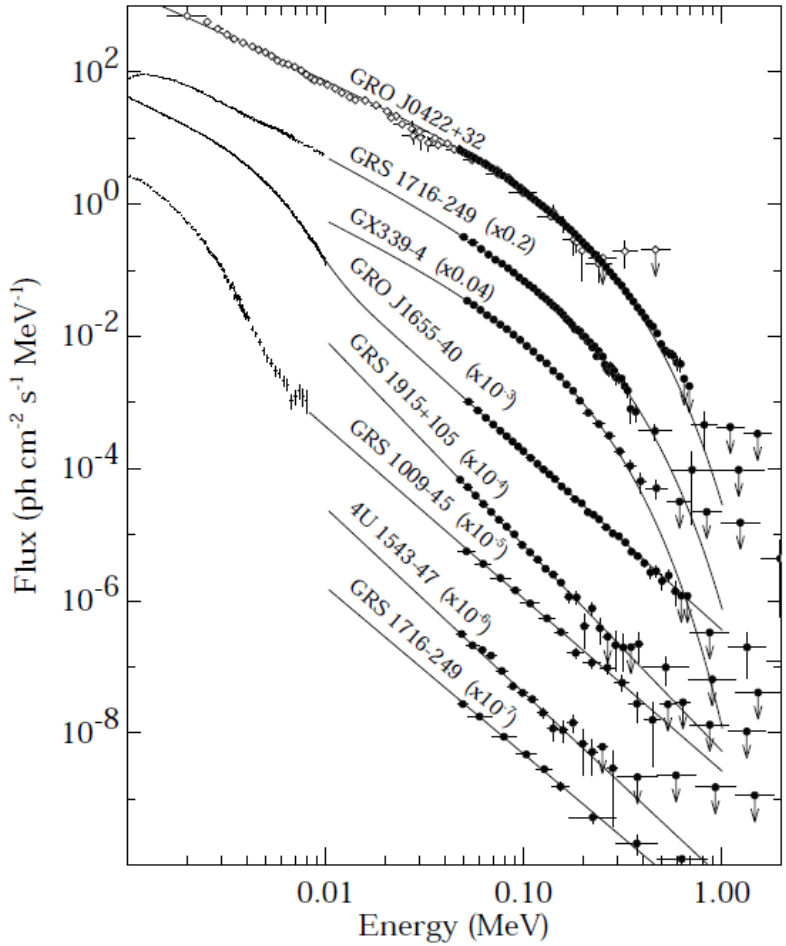
GX 339-4 (Zdziarski+ 98)



Cyg X-1, INTEGRAL (Del Santo et al 2013)



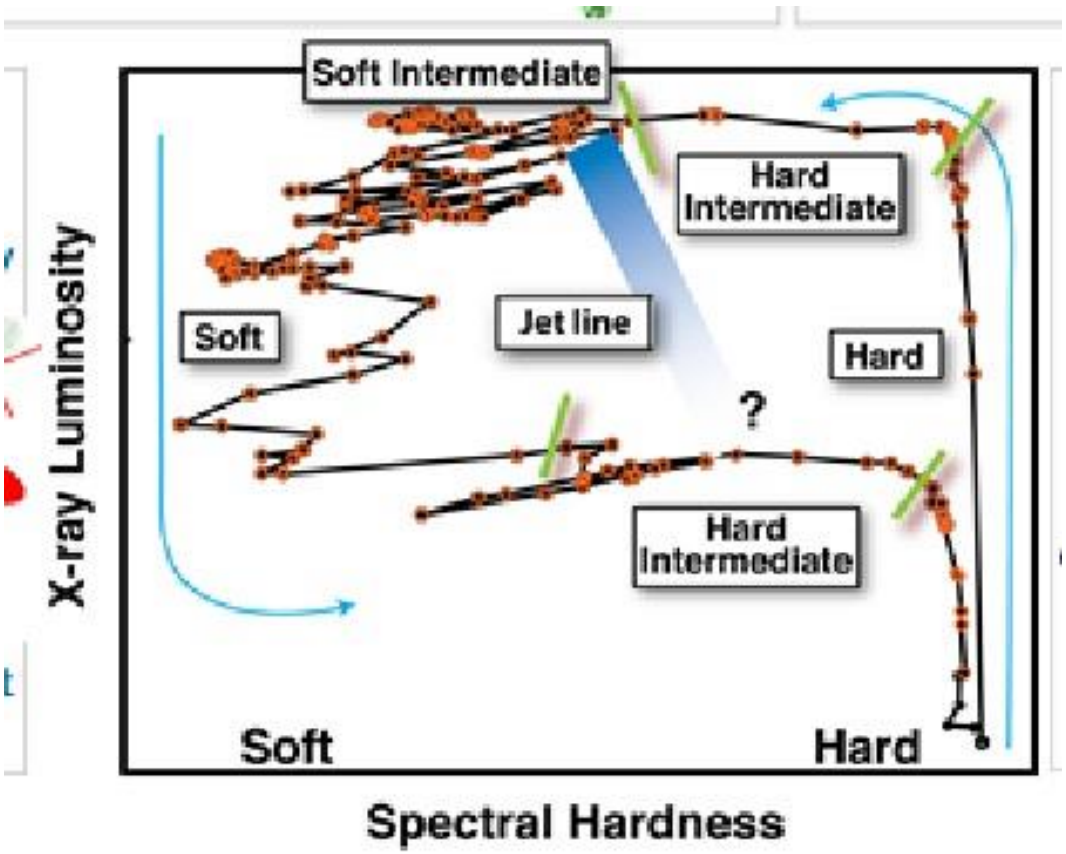
OSSE Sample, Grove+ 98



The BH binaries undergo spectral state transitions (from X-ray studies this bimodal behavior is now known to be more detailed, but is reasonably well understood in an empirical sense).

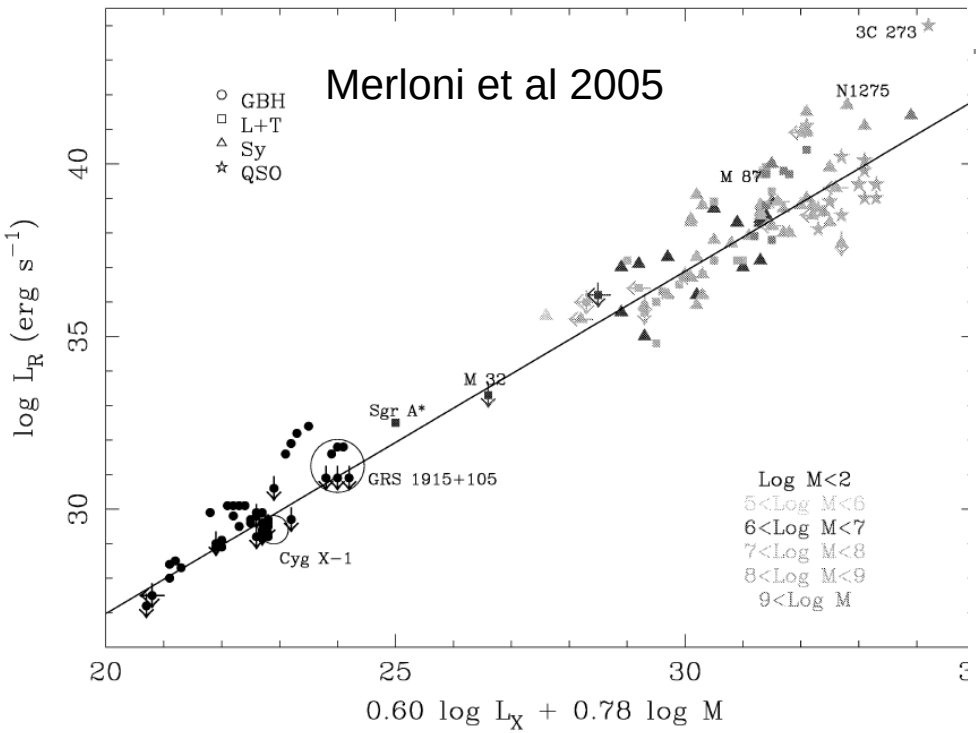
This is further illustrated by the OSSE sample, which included numerous objects extending to 100's of keV, but sub MeV.

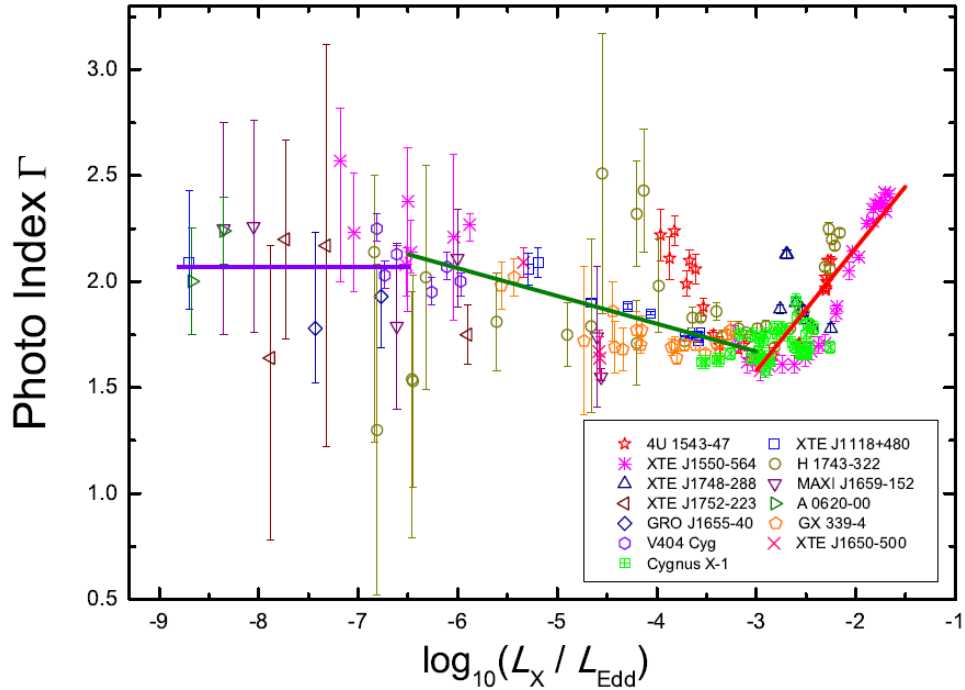
Hardness-Intensity “Q” diagram for BHXRBs. This provides an empirical framework the relating the spectral configuration of the system to other behaviors such as QPOs and jet formation. The latter are clearly of interest wrt to γ-ray production.

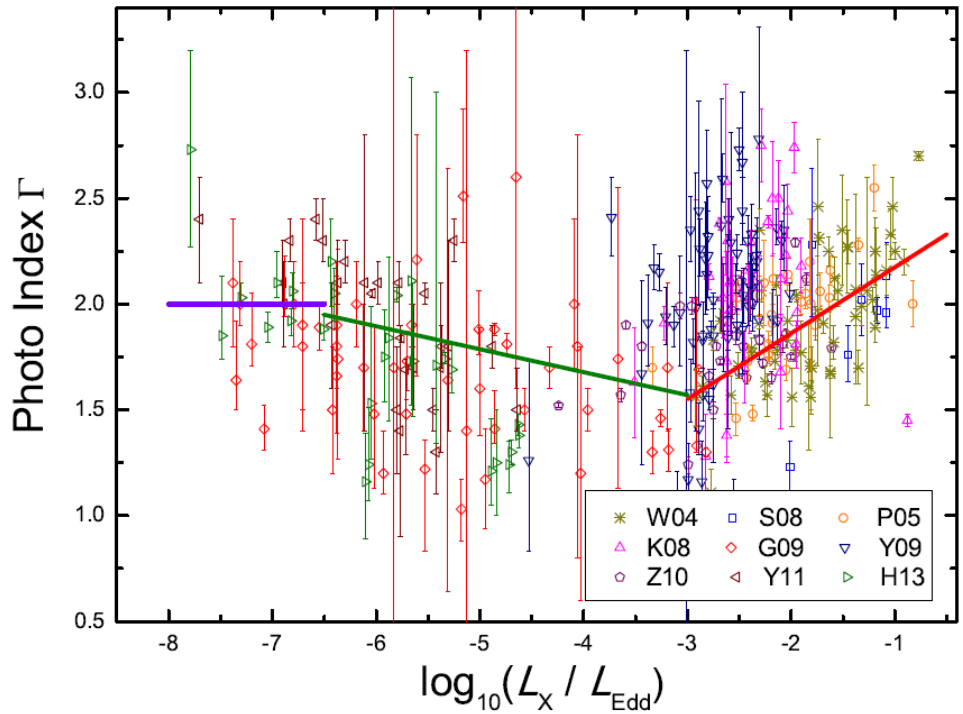


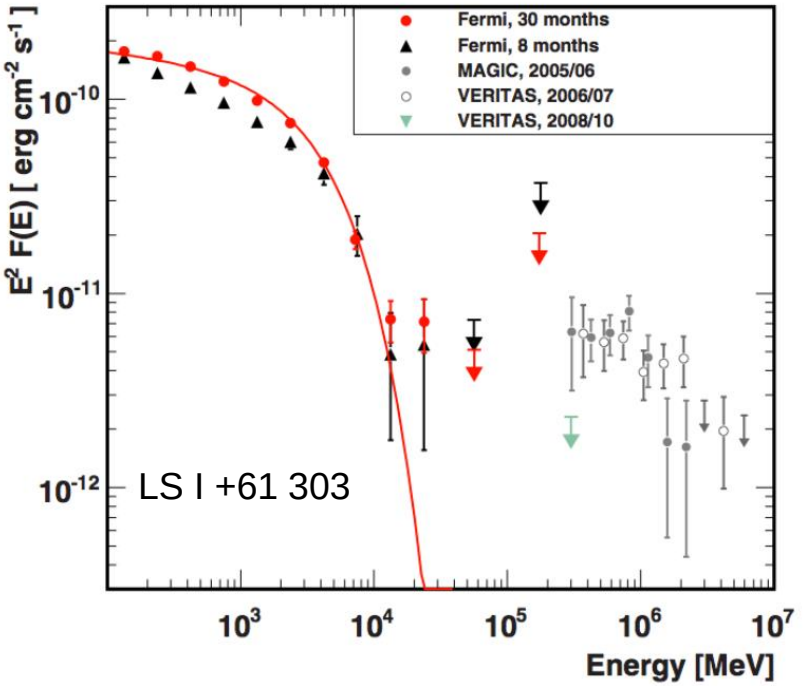
Compact radio source appears in rise (hard) state w/ $L_R \propto L_X^{0.7}$ Jet formation follows: γ-ray production most prolific?

Other observational trends support the notion of a common physics underlying the BHXRBs and RQ AGN.

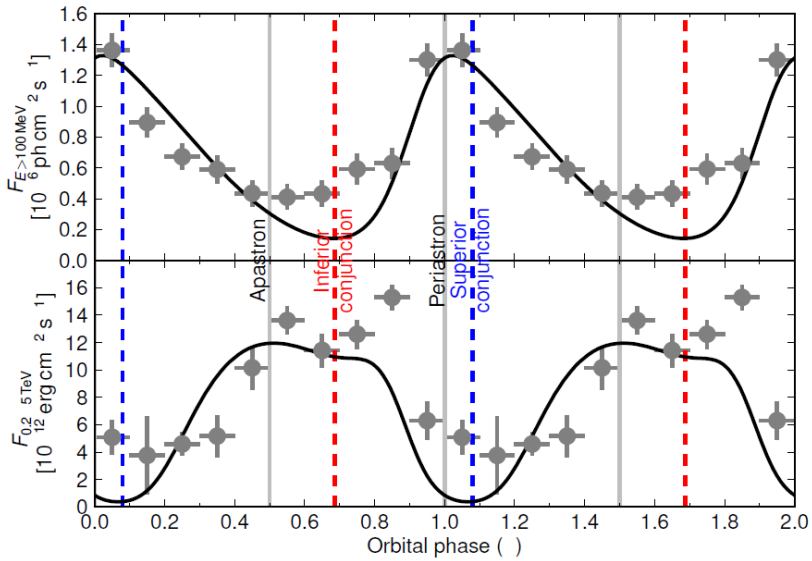


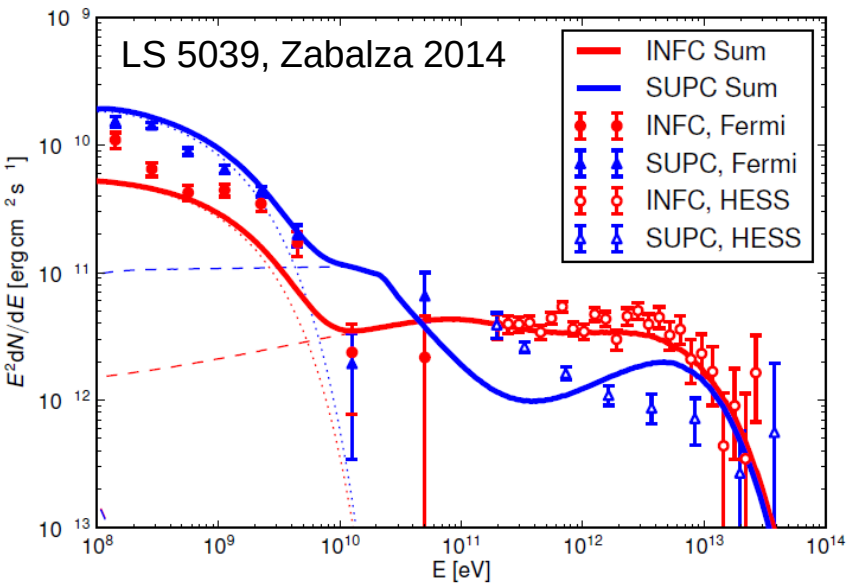


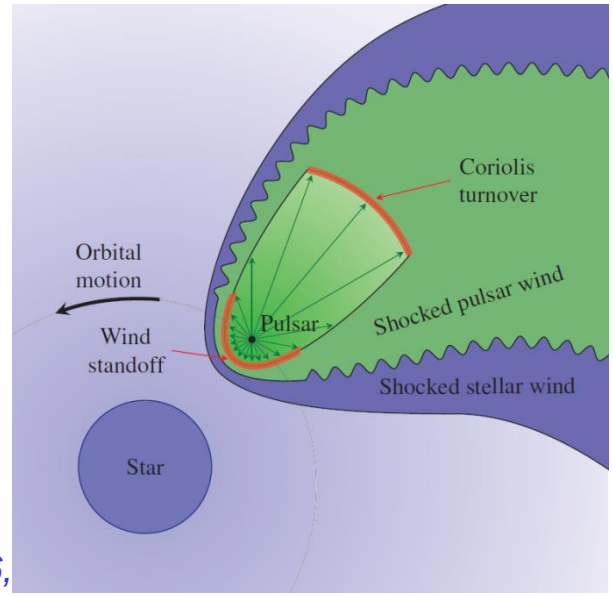




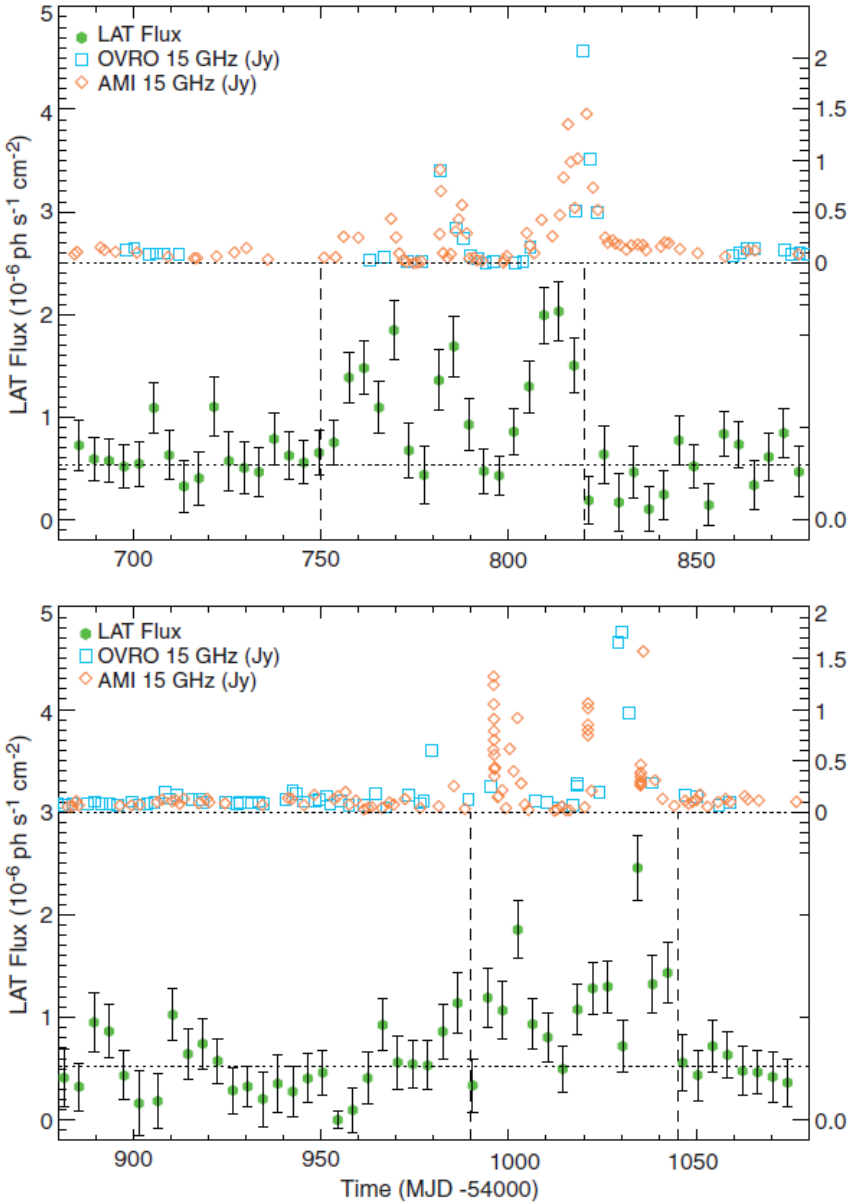
The Fermi γ-ray binaries seem be distinct from the known MeV binaries (except perhaps for Cyg X-3).







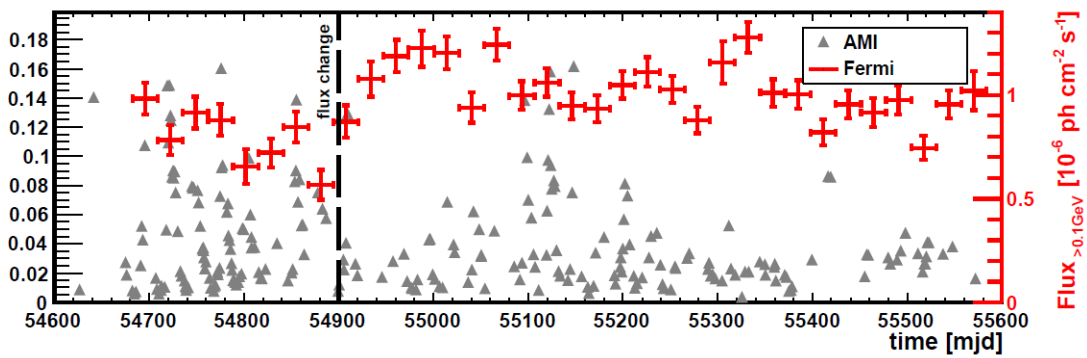
Cyg X-3 Abdo+2009



Cyg X-3 is an outlier in L_R among XRBs and probably consists of a BH-WR binary. Rough correlations appear to exist between the radio, X- and γ-ray behavior.

LSI +61 303 seems to exhibit a more random, uncorrelated radio - γ-ray variability. Also, L_X is modest and consistent with wind accretion.

LSI +61 303: Hadasch+2012



Summary

- To date MeV there is good evidence that BHXRBs are MeV emitters
  - Tip of the iceberg?
  - Models exist but unsubstantiated
- RQ AGN have not been established as MeV sources but have strikingly similar sub-MeV spectra
  - Suggestive of a common underlying physics
  - Other patterns in observational data support this
- Fermi γ-ray binaries may be a distinct phenomena
  - PWN embedded in OB wind?
  - Except for Cyg X-3, which could be extreme manifestation of the micro quasar scenario
- Other issues:
  - Evidence (albeit marginal) for nuclear physics in BHXRBs
  - Was luminous 511-keV event in Nova Mus1991 real?