Observing Black Holes at High Energies

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Black Holes in the X-Ray Sky

Optical: Hubble Deep Field

X-ray: Chandra Deep Field

Credit: NASA/Penn State; NASA/PSU/G.Garmire, N.Brandt, et al.
800ksec XMM-Newton View of the Lockman Hole

Hasinger 2003
Current X-Ray Observatories

- **Specialists in orbit:**
  - Imaging: *Chandra*
  - Spectroscopy: *XMM, Suzaku, Chandra*
  - Hard X-Rays: *INTEGRAL, Suzaku, RXTE*
  - Monitoring: *RXTE*
  - Rapid Response: *Swift*
  - Broadband Spectra: *Swift, Suzaku*

Images: NASA/ESA/JAXA
Pictor A

Contours: Radio (VLA); Color: X-Ray (XMM)

Perley et al. 1997; Grandi et al., 2003
Pictor A

XMM Newton

Grandi et al. 2003

Chandra

NASA/UMD/A.Wilson et al.
Black Hole X-Ray Spectra

de Kool et al., 1994; Maisack 1993
AGN X-Ray Spectra

- Comptonization of soft X-rays from accretion disk in hot corona (T~10^8K): power law continuum

J. Wilms
AGN Broad Iron Line Emission

Dauser et al., in prep.
Broad Iron Lines Probe BH Accretion Disks

Miniutti et al. 2007

MCG-6-30-15
Spectral Energy Distribution (SED) in Blazars

Blazars: Extragalactic jets pointing from supermassive BHs towards earth

Broadband SEDs: Radio to Gamma (Double-Hump Structure)

1. Synchrotron! 2. leptonic (inv. Compton) or hadronic?
The Fermi γ-Ray Observatory

- Launch from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT
- Two instruments:
  - Gamma-ray Burst Monitor (GBM)
  - Large Area Telescope (LAT): 20MeV to >300GeV
- Continuous all-sky monitoring
Radio-Gamma Jets

LAT & MOJAVE Collaborations; M. Kadler
The variable Gamma-Sky
Multiwavelength BH Observations

VLBI (Radio)

Fermi-LAT (Gamma)

Chandra (X-Ray)

Swift

XMM-Newton
Summary

- Many different high-energy observatories available
- Each mission with unique strengths and characteristics
- X-ray spectroscopy probes BH accretion disks, disk coronae, and jets
- γ-ray all-sky monitoring with Fermi/LAT