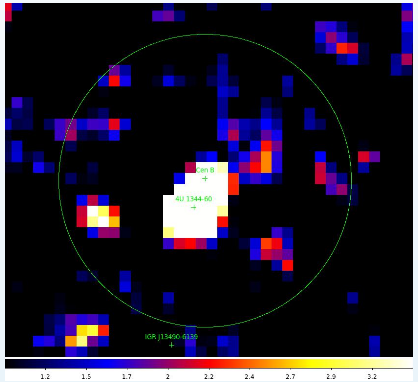
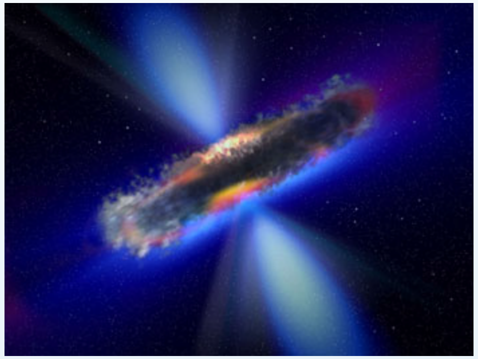
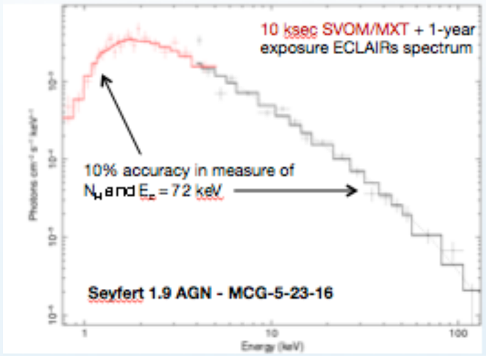
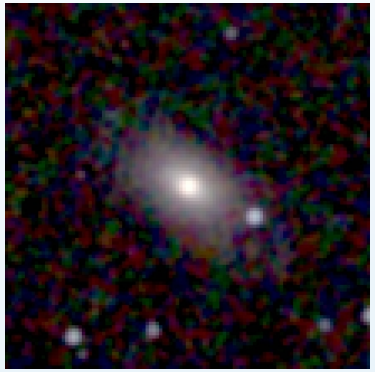
SVOM Advances on Observatory Science:

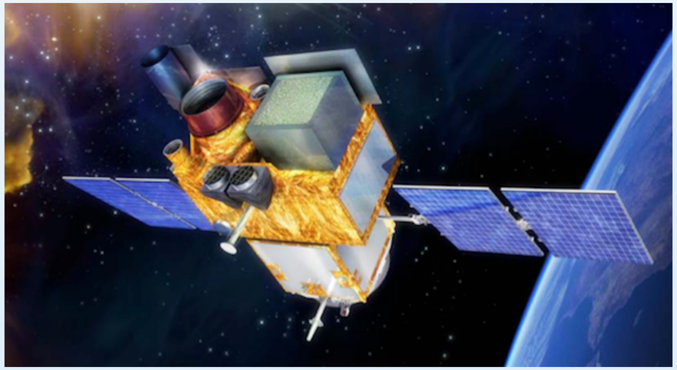
Active Galactic Nuclei

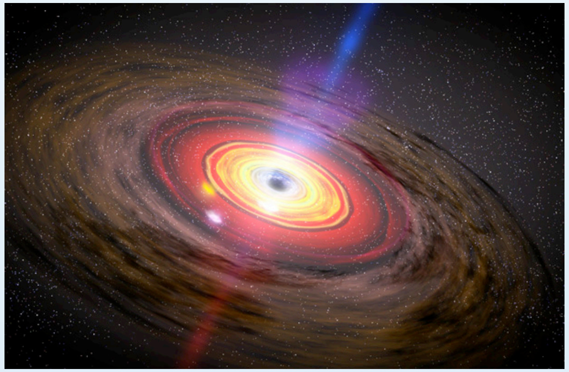










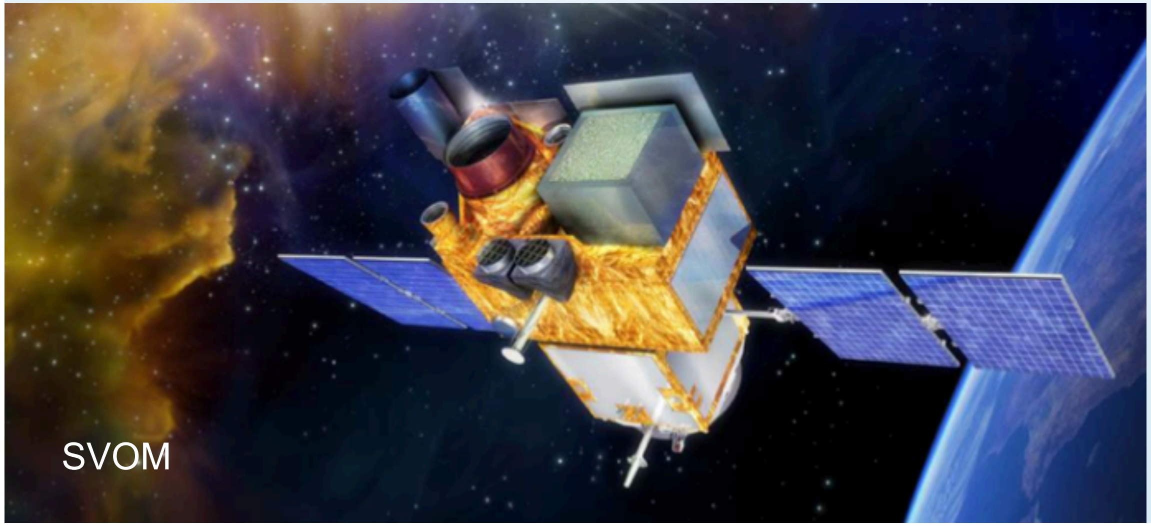


Volker Beckmann, Jin Zhang, Xin-Lin Zhou
CNRS / IN2P3 & NAOC

AGN science with SVOM

- Active Galactic Nuclei (AGN) – open questions
- SVOM perspective on AGN science
- Summary

Animations removed from these slides!



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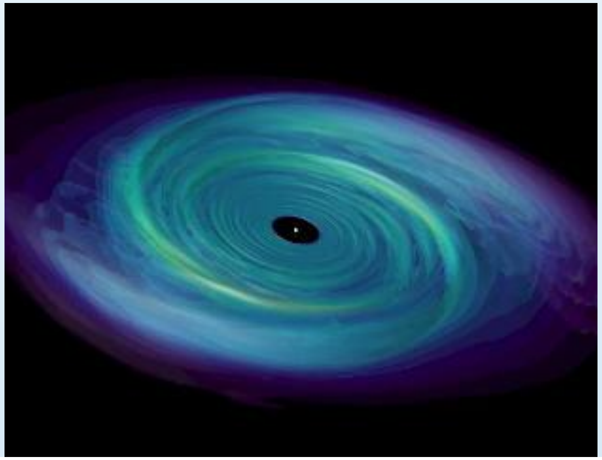
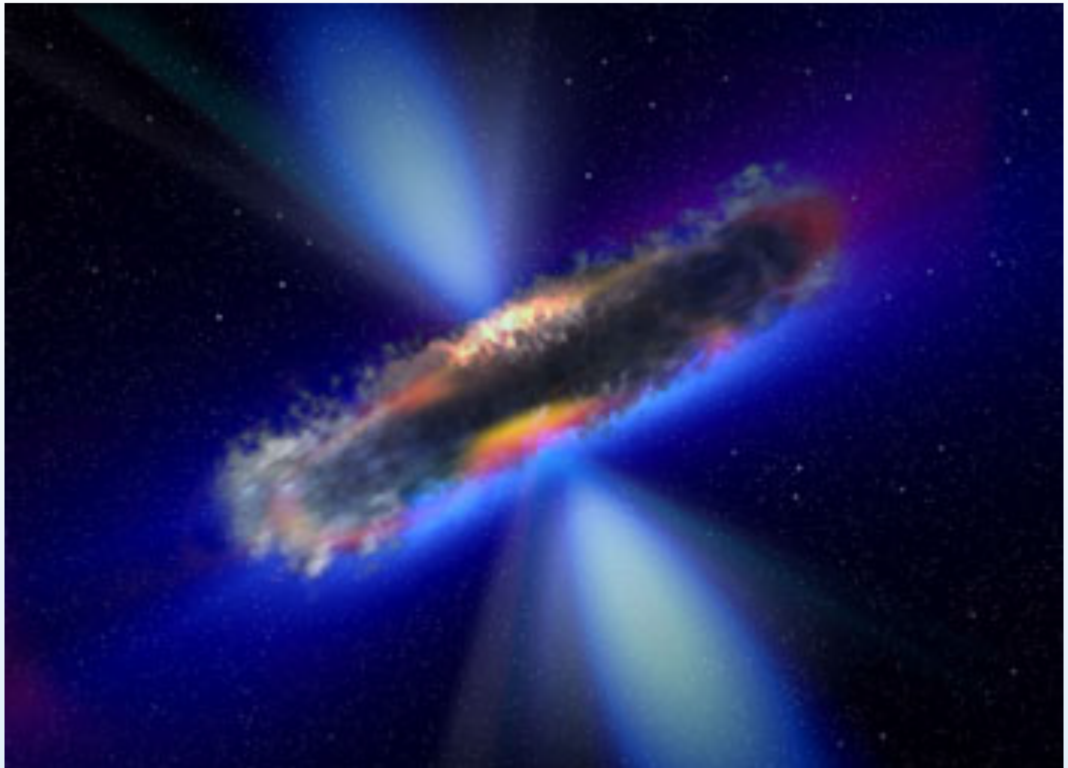
Central Engine

- AGN are bright (10^{41} - 10^{48} erg/sec), point-like (<< 100 pc; Woltjer 1959) and persistent
- No stellar emission, nor supernova, etc.
- Accretion onto a super massive black hole
- Masses (from reverberation mapping) in the range of 10^4 (NGC 4395) up to 10^{10} M_o (3C 273)
- Accretion
- Angular momentum → accretion disk → viscosity → heating → thermal emission



Artist's impression of an accretion disk
Credits: Owen/Blondin/NCSU

Active Galactic Nuclei



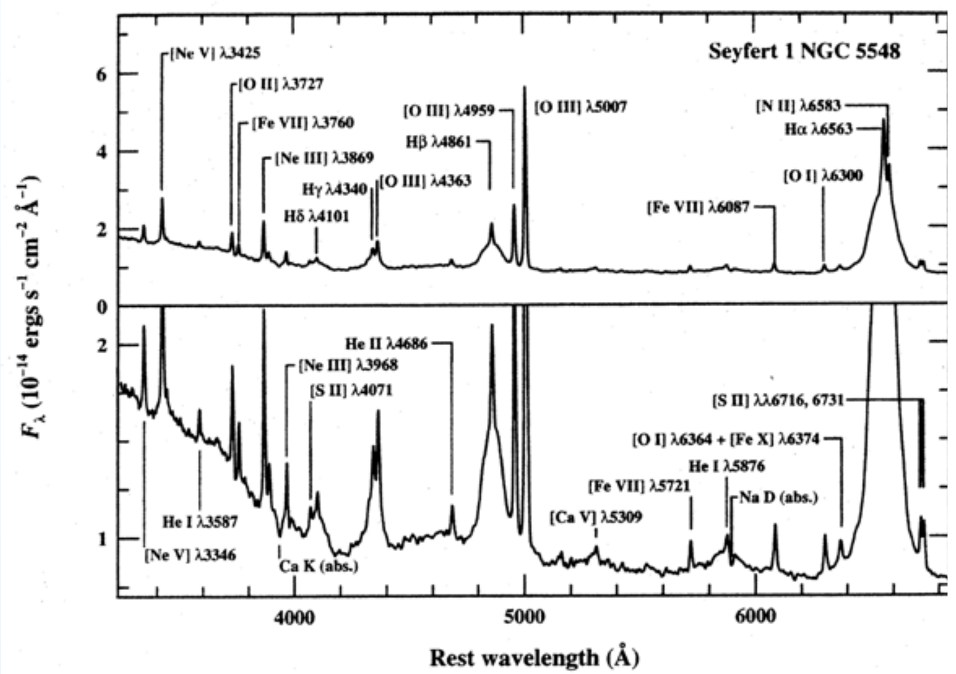
Absorbed AGN; Credit: ESA / V. Beckmann / NASA/ GSFC

- AGN are powered by supermassive Black Holes at the center of galaxies
- Unified Picture: types (QSO, Seyfert, Blazars etc.) due to viewing angle

Unification

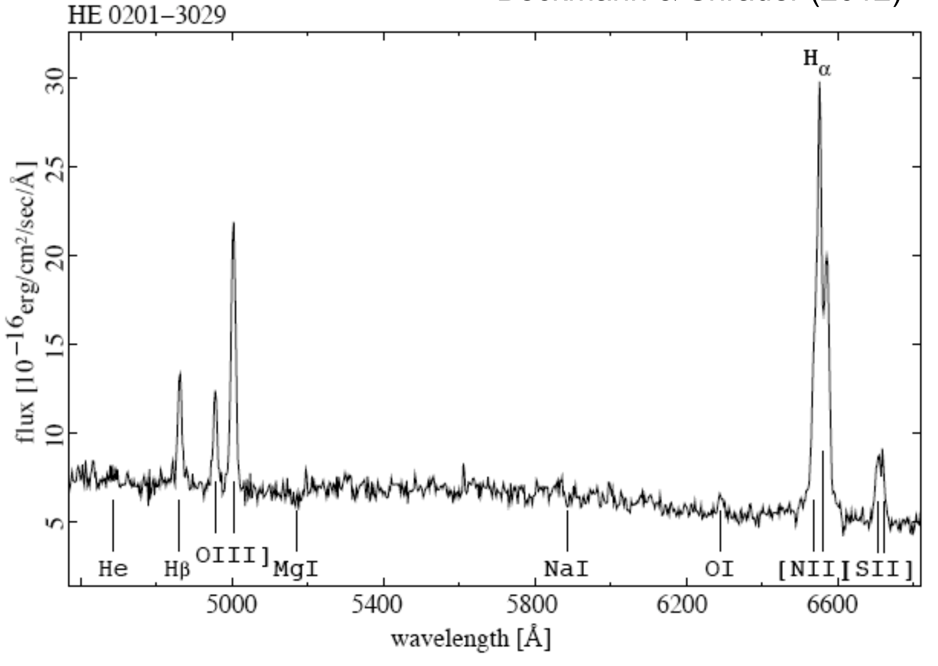
Task: find a model with the smallest number of parameters which explains all AGN.

Peterson (1997)

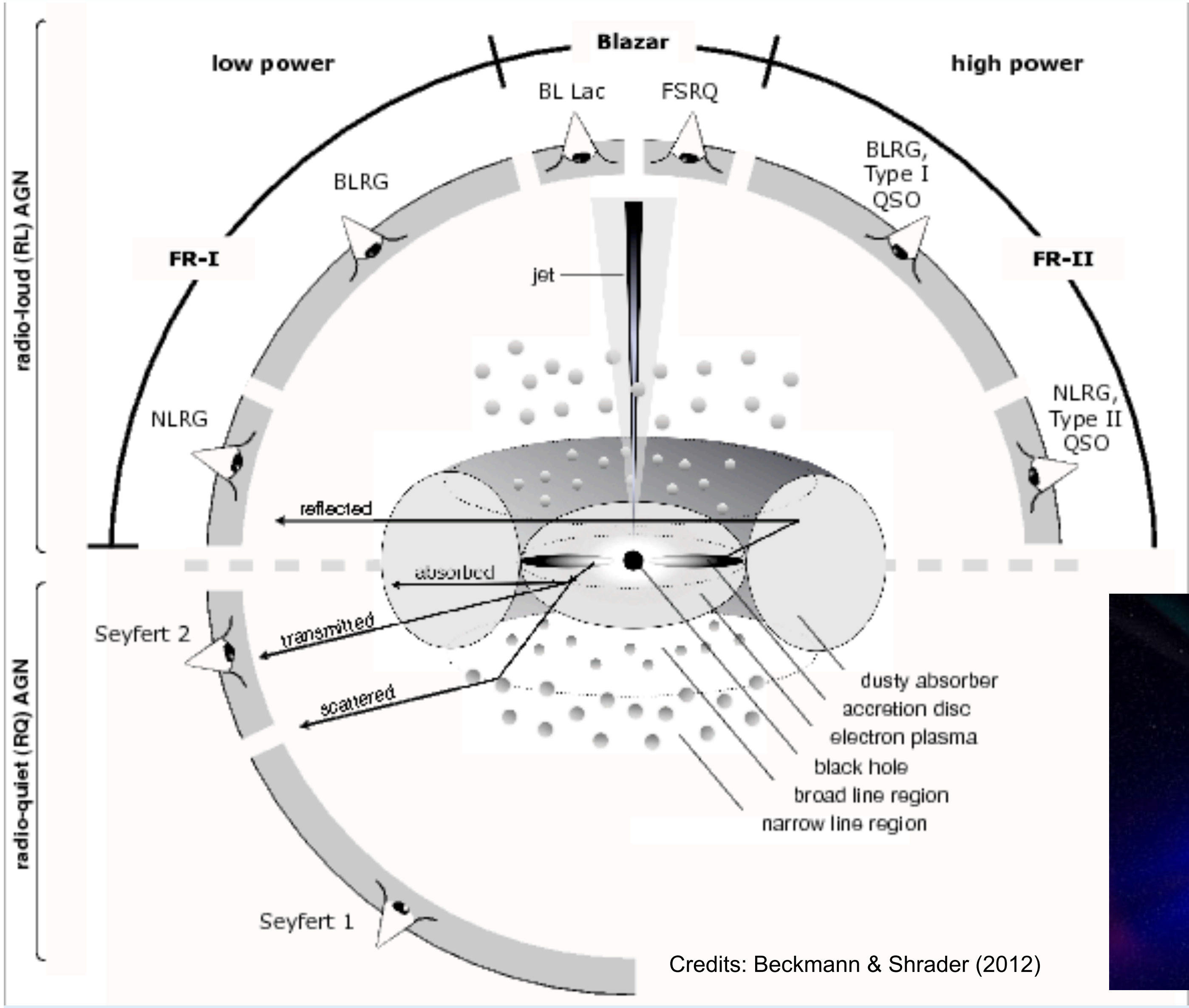


Seyfert 1 spectrum of NGC 5548

Beckmann & Shrader (2012)



Seyfert 2 spectrum of HE 0201-3029

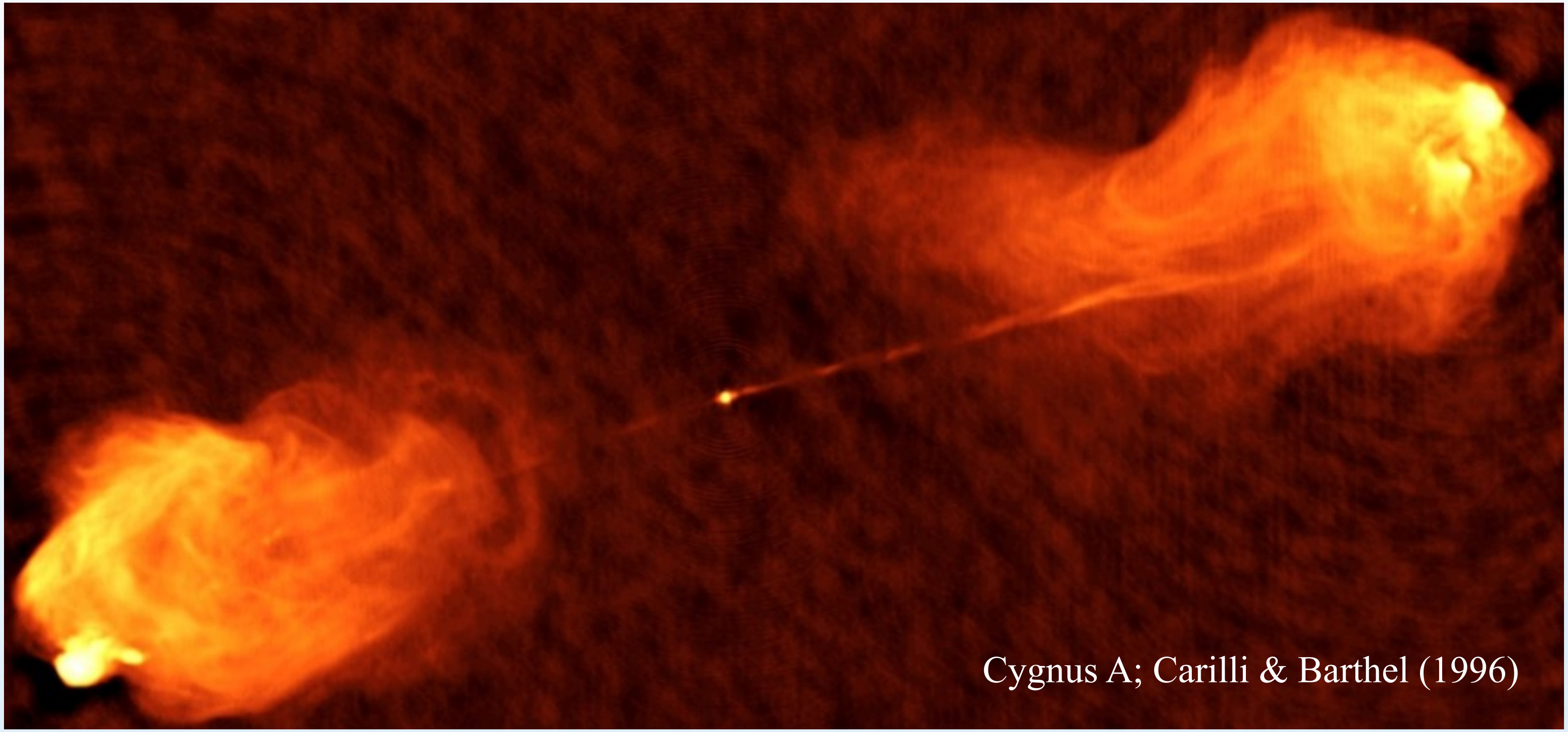


Credits: Beckmann & Shrader (2012)

- Unified Picture: types (QSO, Seyfert, Blazars etc.) due to viewing angle
- Accretion/ejection physics => properties of the BH (spin!)
- But also feedback, BH/Galax growth, Gal. Cluster, eventually …Cosmology

Jets in AGN

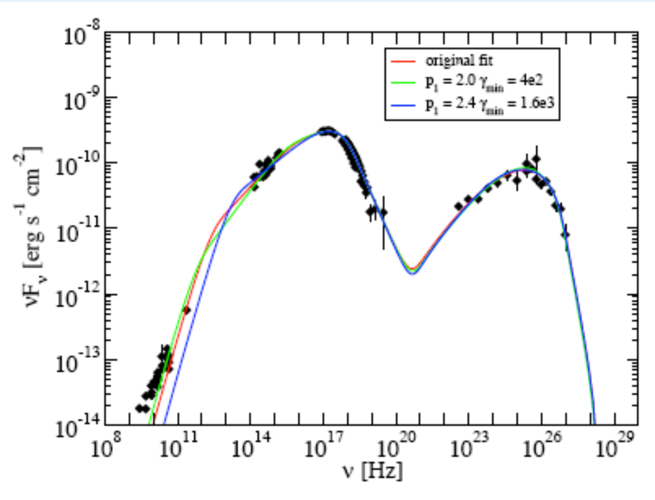
Jets manage to stay confined for >50 kpc



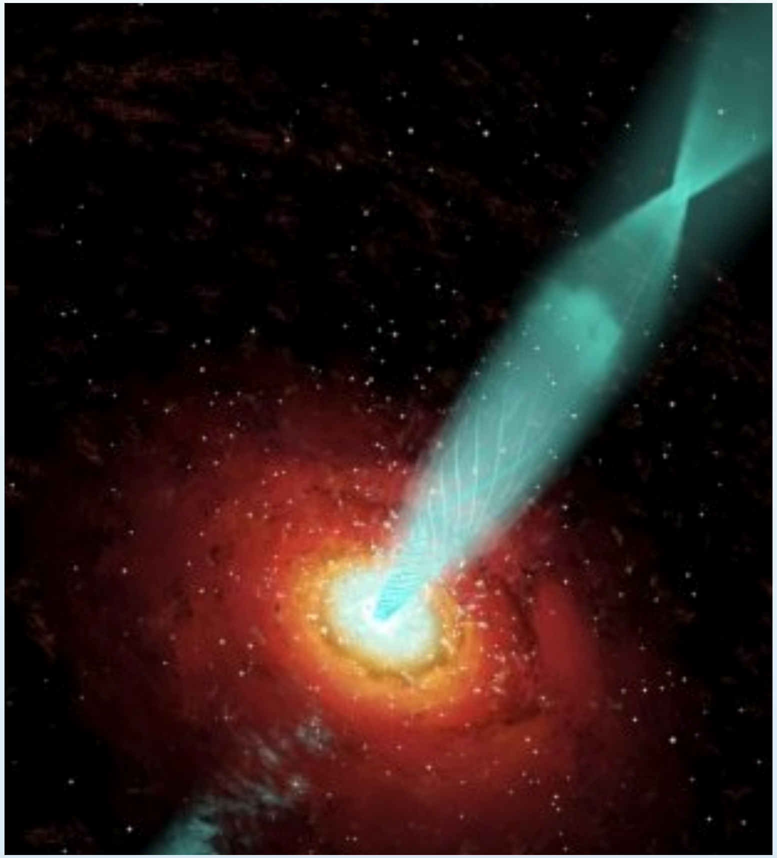
Protons take more energy for acceleration, but could explain better the confinement over long distances and times (>10^6 yrs)

Jets in AGN

- Radio galaxies to study morphology of jets
- Blazars show jet physics
- Spectral energy distribution (SED) and variability give:
- Size and density
- Magnetic field
- Doppler factor
- Particle energy distribution

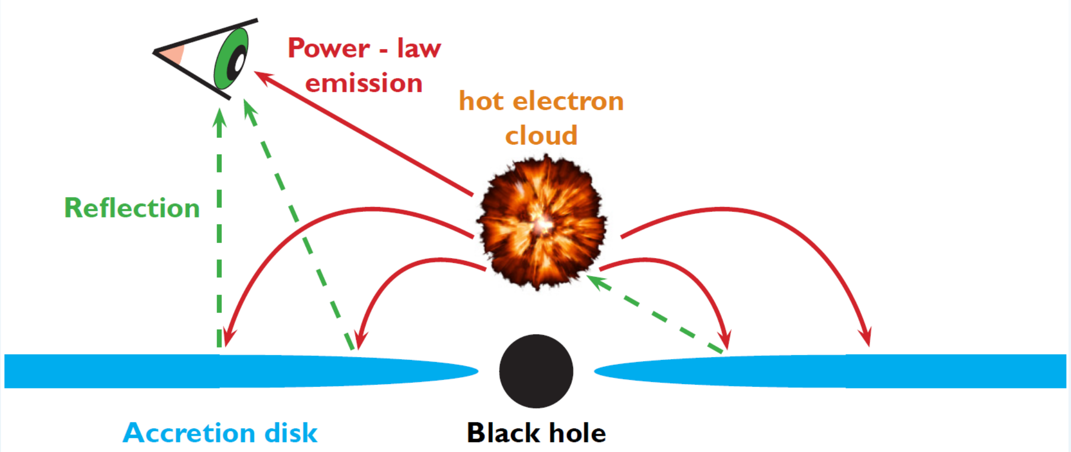


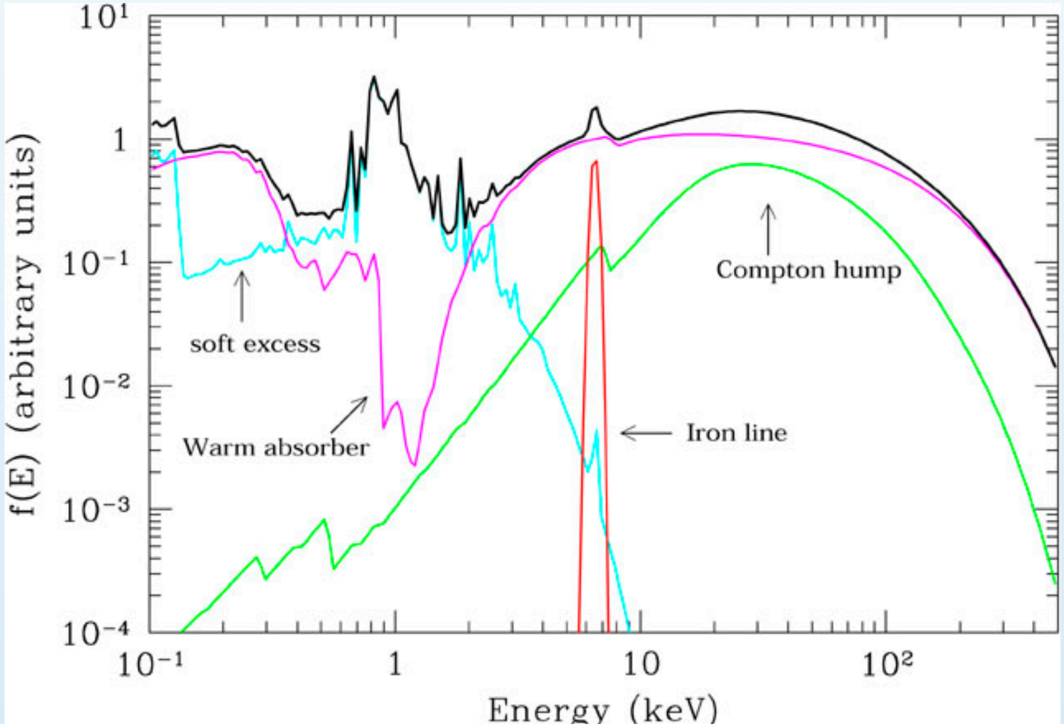
SED of Mrk 421 (Abdo et al. 2011)



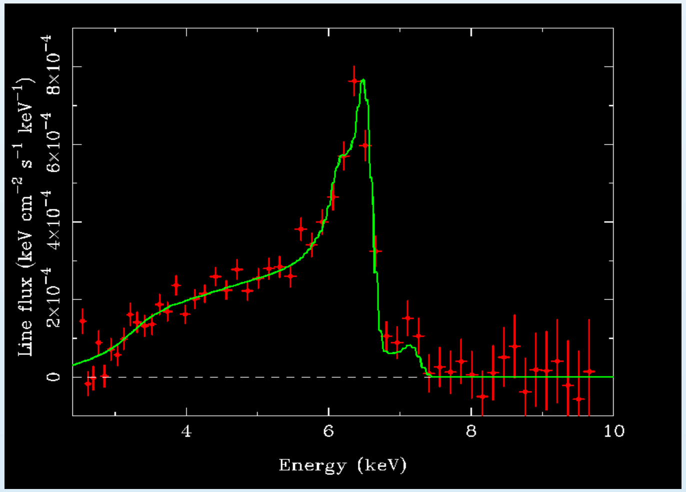
Courtesy: Alan Marscher (Boston Univ.)

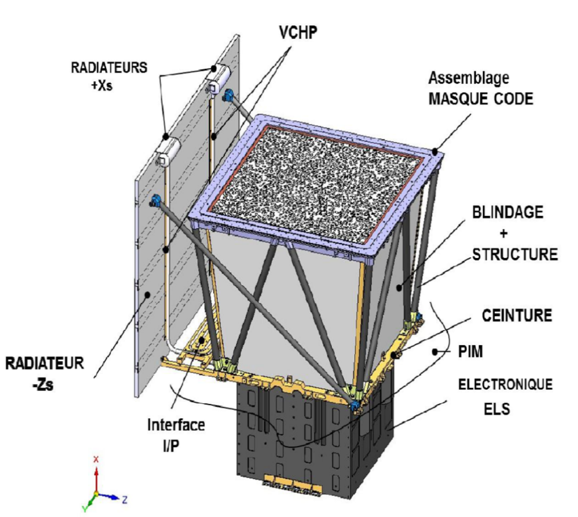
AGN X-ray Spectra

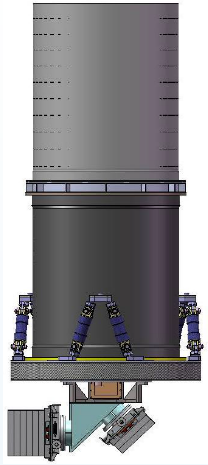




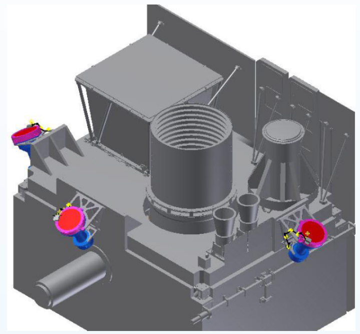
- Soft excess (Disk ?)
- Corona emission
- Absorption
- Reflection component with fluorescence lines (skewed and redshifted by Rel. eff.)
- Warm absorber
- Jet emission (sync + IC) in Blazars

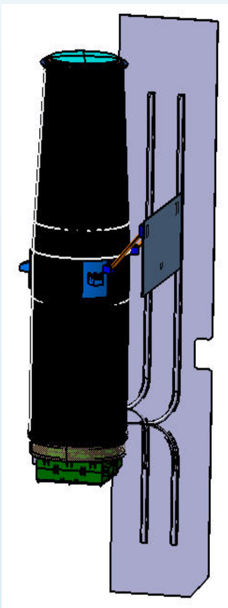






SVOM Instruments





	FOV	Angular Res. localization	Energy range	Sensitivity
ECLAIRs	**90° × 90°**	**1.5° loc < 16′**	**4-150 keV**	**22 mCrab (1000 sec)**
MXT	**1° × 1°**	**4.5′ loc < 1′**	**0.5-10 keV**	**0.1 mCrab (1000 sec)**
VT	26′ × 26′	loc < 2″	400-950 nm	V=23 (300 sec)
GRM	~ 2 π sr	15° × 15° loc	15 keV - 5 MeV	?
GFTs (1F + 1C)	30′ x 30′	~ 1″	400 – 900/1700	R=21.5 (100 sec)
GWACs (36 cam)	5000 s.d.	~ 1″	500-800 nm	V=16 (10 s)

General Comments

- SVOM is a GRB mission but Observatory Science will contribute to the success of the mission

- SVOM Core Program (GRB science Obs.) will totally amount to < 25 % of the mission observation time => More than 70 % for non-GRB science

- Observatory science planned observations will be performed within the **General Program**, unplanned ones in **Target of Opportunity Obs**.
- They shall not impact on the Core Program => GP, ToOs are subject to a several constraints (B1 attitude law, interruption by GRB detections).

- However Swift shows that science other than GRB becomes important for a GRB mission in the extension phase and in the long run (> few years) => need to prepare the mission to relax constraints for a fraction of the observing program and particularly in the extension phase.

Strengths as an Observatory

- Rapid and flexible High-Energy Observatory: catching transient and variable events of the violent universe

- Broad-Band Multi-wavelength Observatory

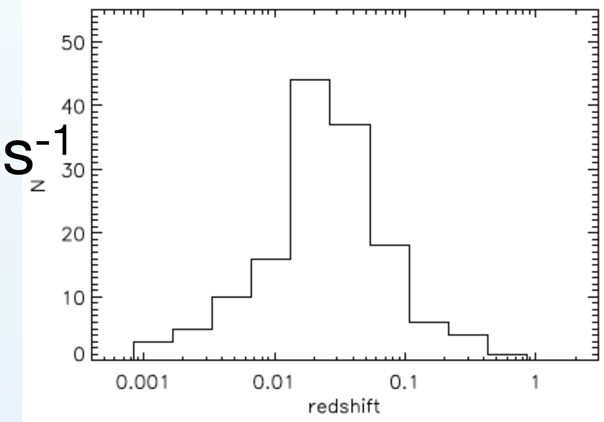
- Dedicated and flexible optical/IR ground based follow-up facilities

- THE after-Swift-era high-energy sky monitor, during operation of CTA, JWST, Euclid, LSST, SKA photon experiments, and advanced multi-messanger observatories (GW, ν)

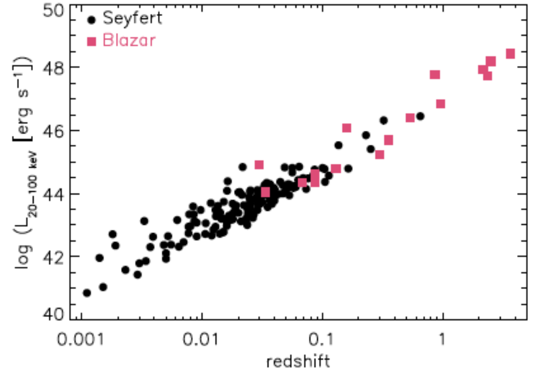
What AGN to expect

INTEGRAL AGN results

Beckmann et al. 2006, 2009; Bassani et al. 2006; Sazonov et al. 2007



- Near-by: $z = 0.03$
- Low luminosity: $L_{20\text{-}100\ keV} = 4\ 10^{43}$ erg s^{-1}
- Absorbed: $N_H = 8\ 10^{21}$ cm^{-2}
- 66 unabsorbed, 44 absorbed Seyferts
- 55 Sy1, 20 Sy1.5, 44 Sy2, 16 blazars
- Moderate black hole mass: $M_{BH} = 4\ 10^7$ Mo
- Low Eddington ratio: $L_{bol} = 0.03\ L_{Eddington}$



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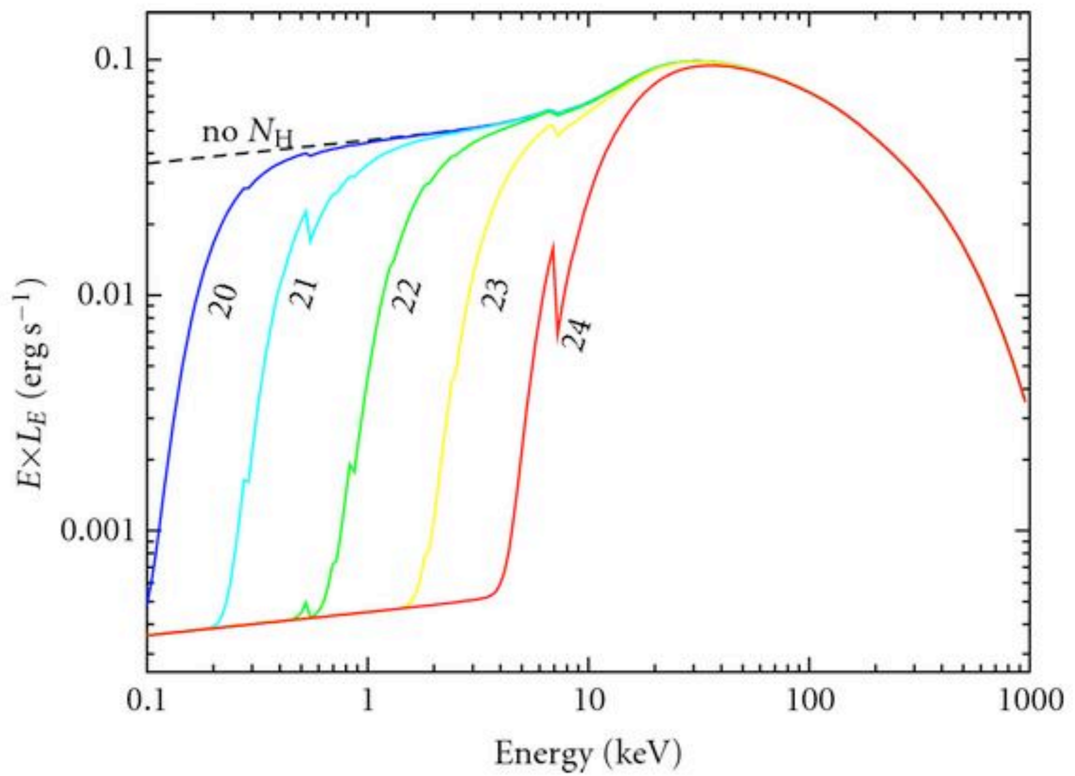
Seyfert galaxies with SVOM

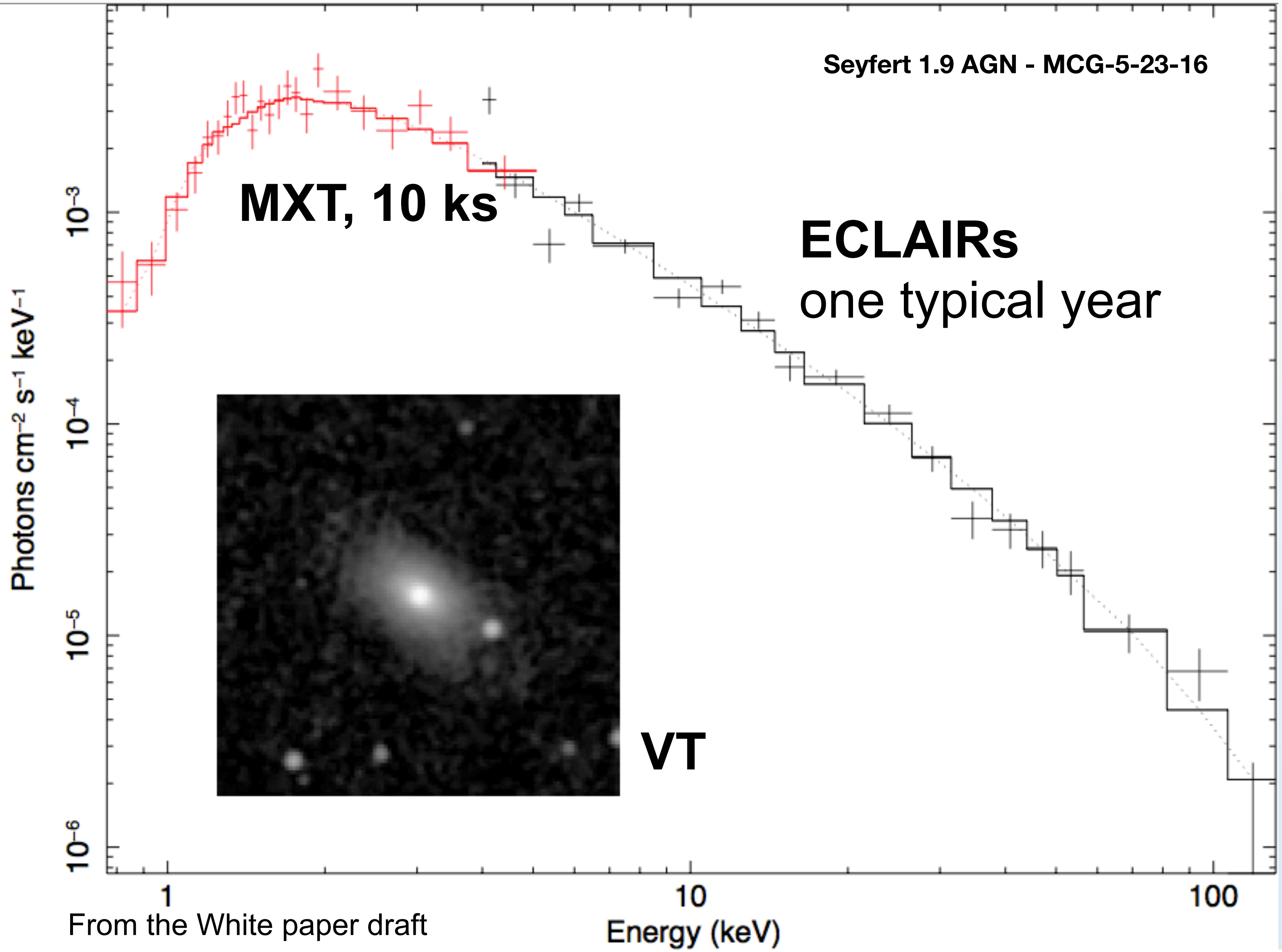
Studies of individual sources

- Broad band coverage
- Measurement of Compton reflection (important for CXB)



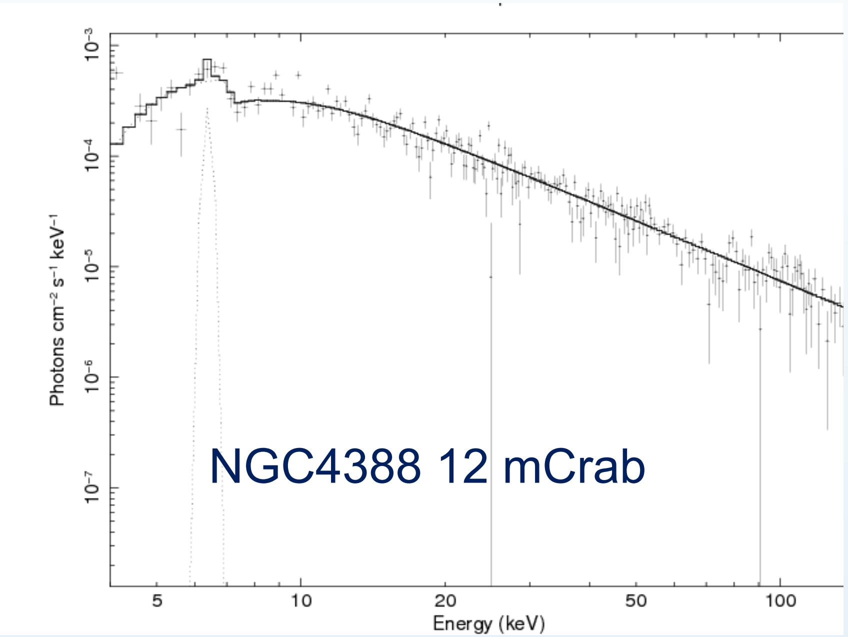
Treister & Urry (2012)

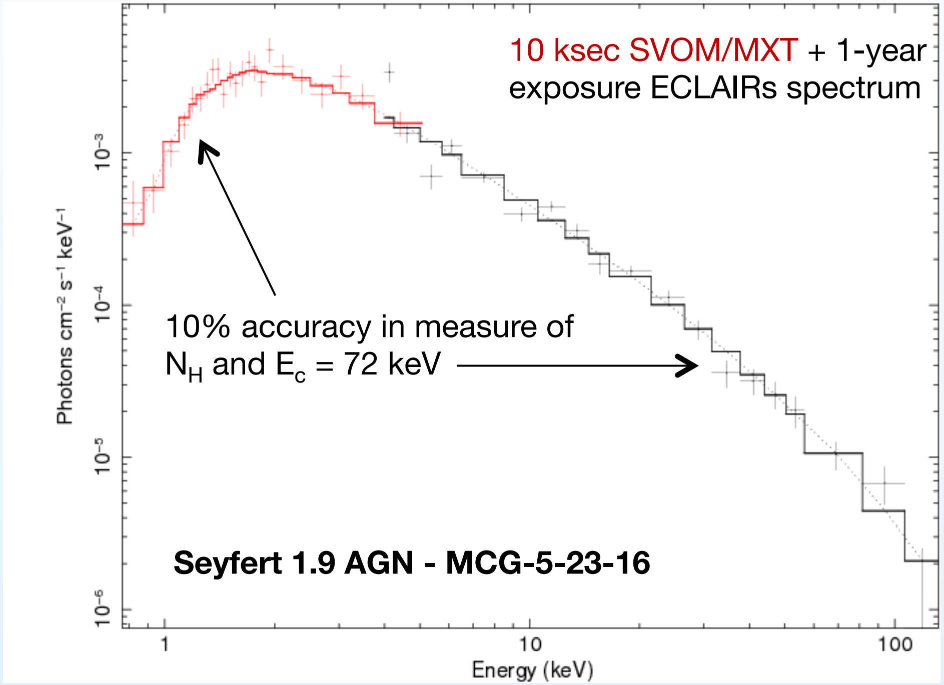
SVOM AGN potential



From the White paper draft

Observations of Seyfert type AGN





AGN are priority targets for the SVOM GP since easily compliant with CP constraints:

- 10 mCrab AGNs: measure reflection, Compton hump, absorption in MXT (10 ks)
- 1 mCrab AGNs: measure photon index, absorption in MXT in 10 ks
- > 250 AGN with ECLAIRs in the first year ~700 at end of mission (for ~ 4 Ms /yr)
- No Iron line detection with ECLAIRs, and difficult with MXT
- Strongly variable AGN: Seyfert 2 Fairall 272, NGC 5252 and from radio G Cen A Pic A

Expected ECLAIRs 1-yr Exposure

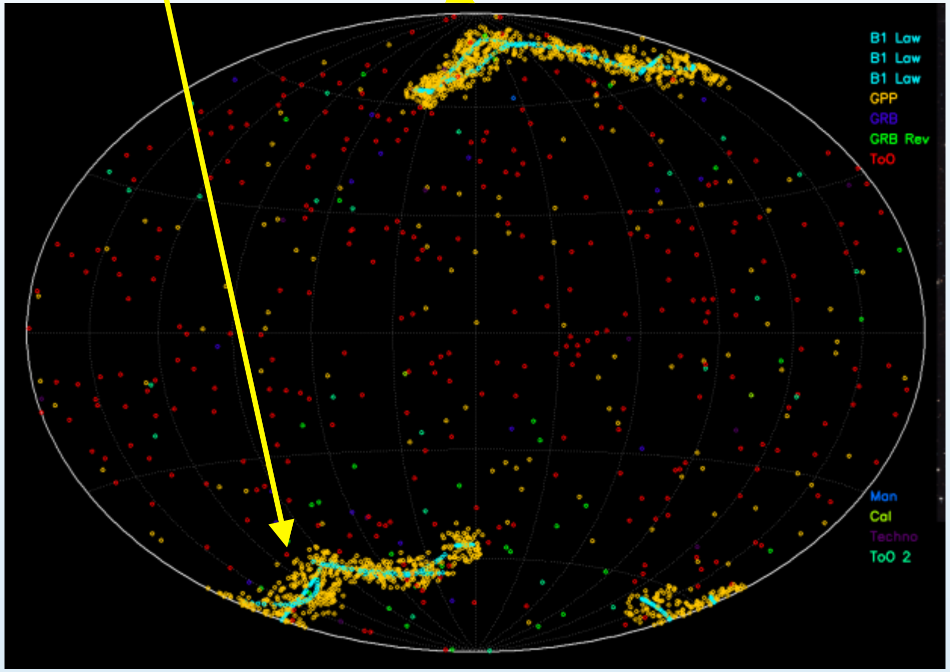
Simulation of 1 year SVOM Observing Program

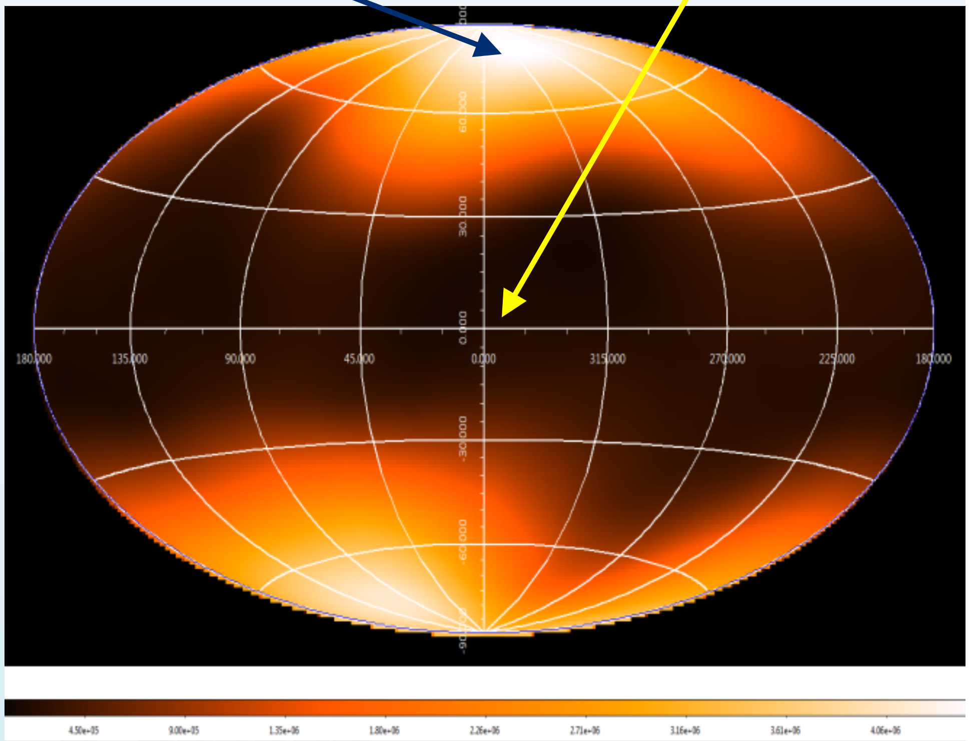
(GP fully within 5°B1 law, GRB follow-up/rev. ToOs randomly distr.)

B1 Attitude law

Max Expo: 4.5 Ms

Galactic Center: 200 ks





Aitoff proj., Gal. coo., 18% SAA 30% Earth Occ. loss

Source Name	Type	ECLAIRs exposure in one year [Ms]	Significance [σ]	Comments
NGC 4151	Seyfert 1.5	3.3	130	Variable plasma temperature; Lubinski et al. 2010
3C 273	Blazar	3.4	109	X-ray reference source ; gamma-ray bright
NGC 4388	Seyfert 2	4.2	76	Strongly absorbed : N_H=4 10^{23} cm^{-2} (Beckmann et al. 2004)
Centaurus A	Radio galaxy	0.2	74	Thermal or non-thermal dominated hard X-rays ? Beckmann et al. 2011
NGC 5506	NLSeyfert 1	2.3	49	Brightest known NLS1 (Soldi et al. 2011)
NGC 7172	Seyfert 2	2.2	34	strongly variable source (Beckmann et al. 2007)
Mrk 421	BL Lac	2.5	34	gamma-ray bright blazar
NGC 5252	Seyfert 2	3.5	29	Strongly variable (Soldi et al. 2014)
Mrk 926	Seyfert 1	3.4	28	not much studied in X-rays so far
MR 2251-178	BL Lac	3.3	25	Complex X-ray spectrum (Nardini et al. 2014)
NGC 3227	Seyfert 1.5	2.7	24	Complex X-ray spectrum (Noda et al. 2014)
3C 454.3	Blazar	1.8	23	The « crazy diamond »
NGC 2110	Seyfert 2	0.3	21	Borderline between Seyfert and blazar (Beckmann et al. 2010)
Mrk 348	Seyfert 2	0.9	20	
NGC 5548	Seyfert 1.5	3.7	20	
NGC 788	Seyfert 2	3.5	20	
NGC 1142	Seyfert 2	2.5	18	
NGC 4593	Seyfert 1	2.5	18	
Circinus galaxy	Seyfert 2	0.2	17	Compton thick source
IC 4329A	Seyfert 2	0.2	17	Strongly absorbed, N_H=6 10^{23} cm^{-2}
PKS 2149-306	FSRQ	2.2	16	
MCG -05-23-016	Seyfert 2	0.3	16	See Figure 2
NGC 4945	Seyfert 2	0.2	16	Compton thick source
NGC 7582	Seyfert 2	2.1	16	

NGC 4151

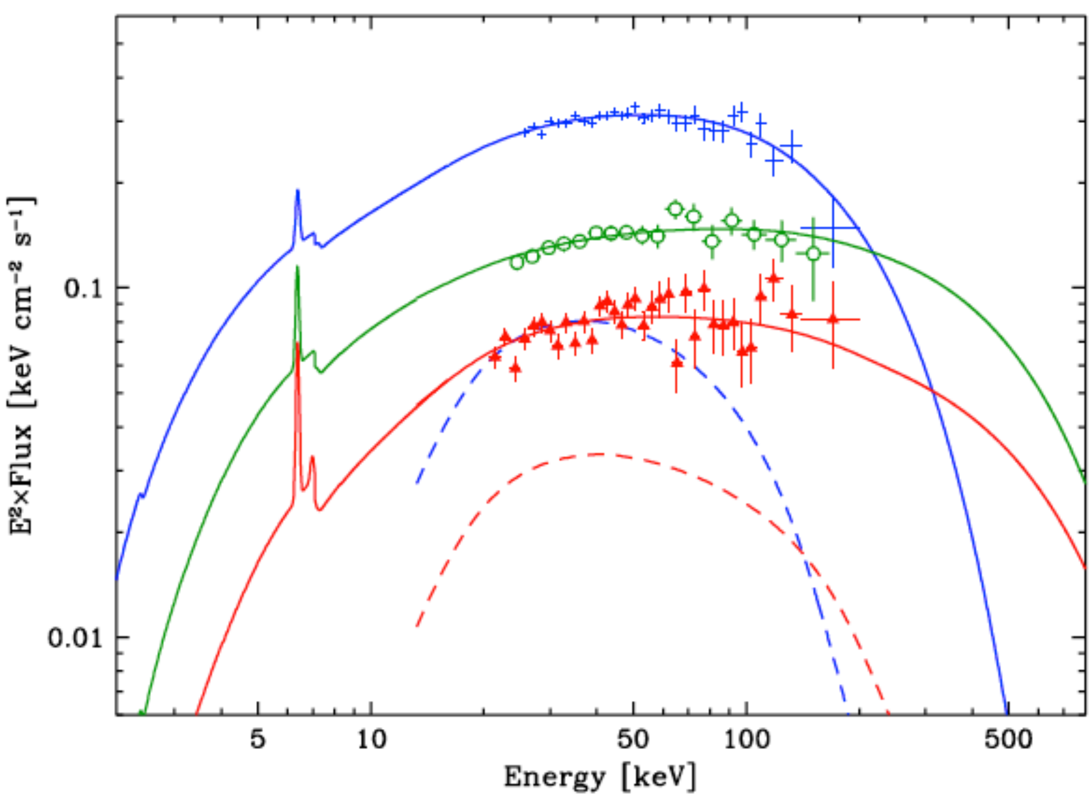


Figure 6. The Comptonization model spectra (solid curves; the geometry parameter = 0) of the three states of the NGC 4151, shown together with ISGRI spectra. The bright, medium and dim spectra are shown by the blue crosses, green circles and red triangles, respectively. The dashed curves show the reflection model components for the bright (upper) and dim state. The fitted JEM-X, *RXTE*, *XMM-Newton* and *Suzaku* spectra are not shown for clarity.

« Extreme flux states of NGC 4151 observed with INTEGRAL », Lubinski et al. 2010

High state: kT~60 keV, τ=1.3-2.6

Low state: 200 keV

τ=0.3-0.7

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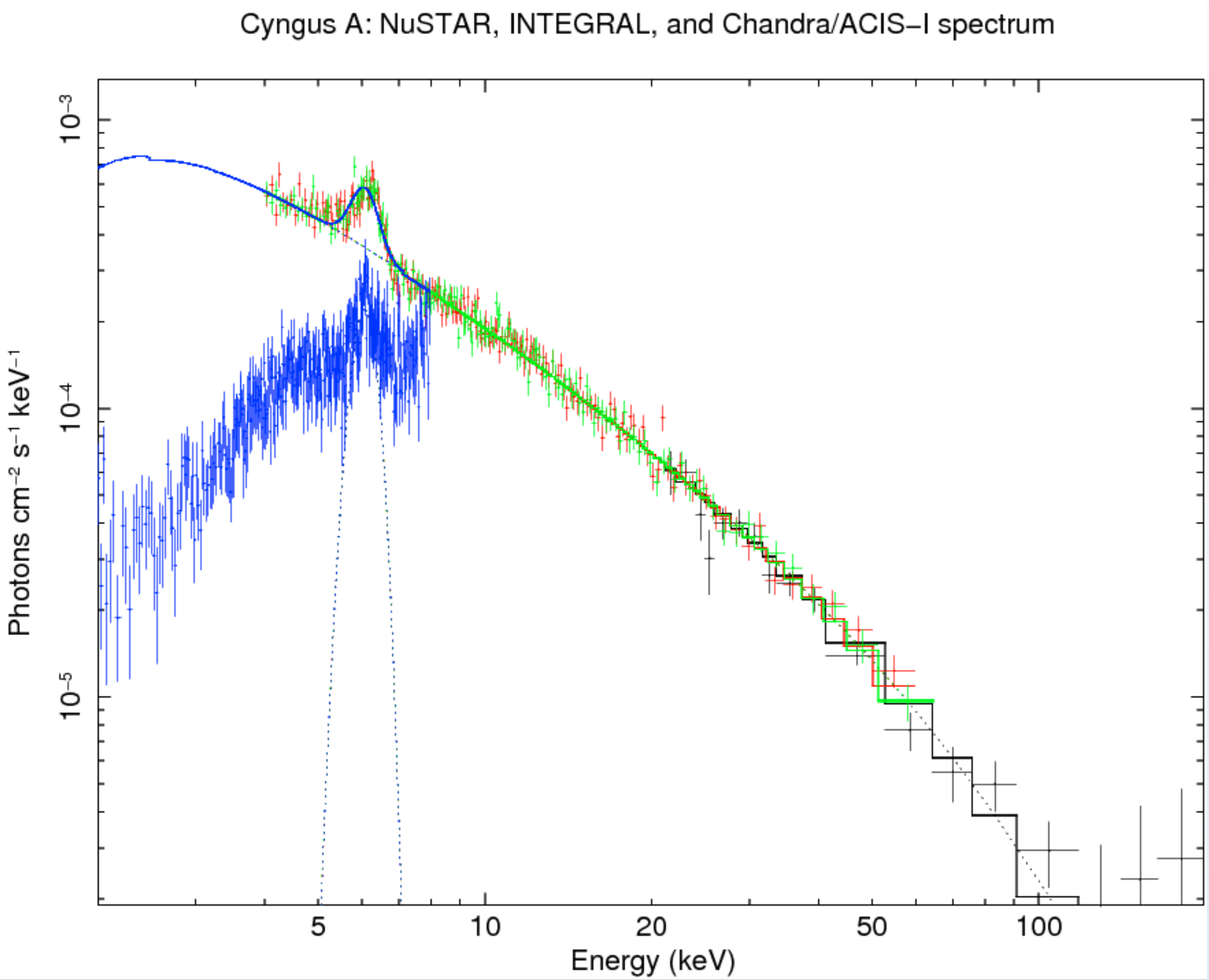
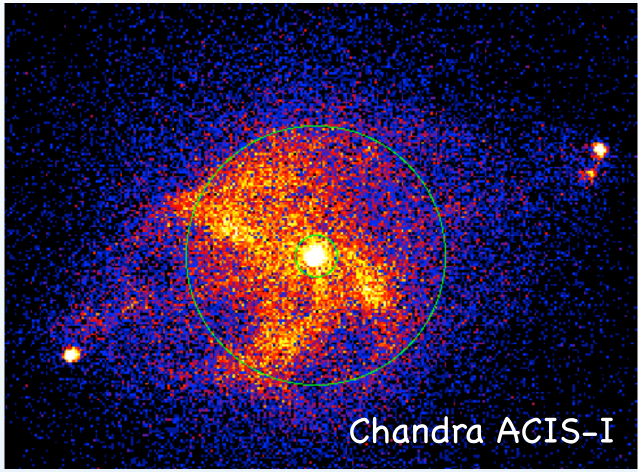
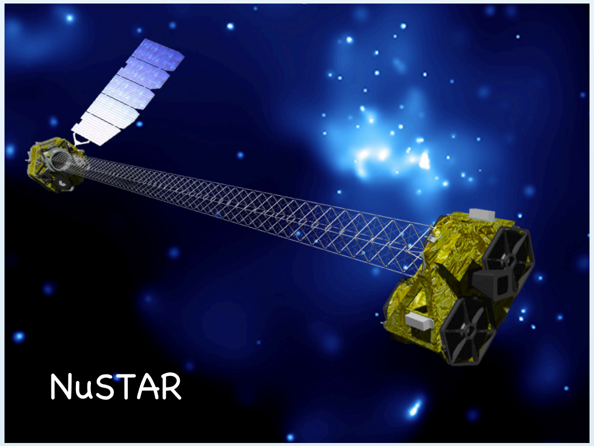
Cygnus A







Chandra (blue) + NuSTAR + INTEGRAL

The core is stronger absorbed (but the hard X-rays come from the core)

Localisation better than resolution

Cen B

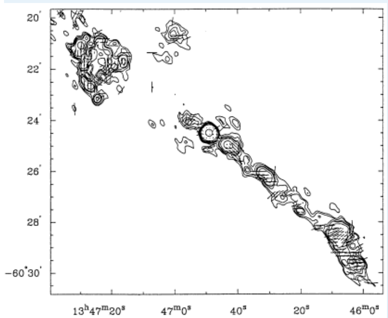
detected

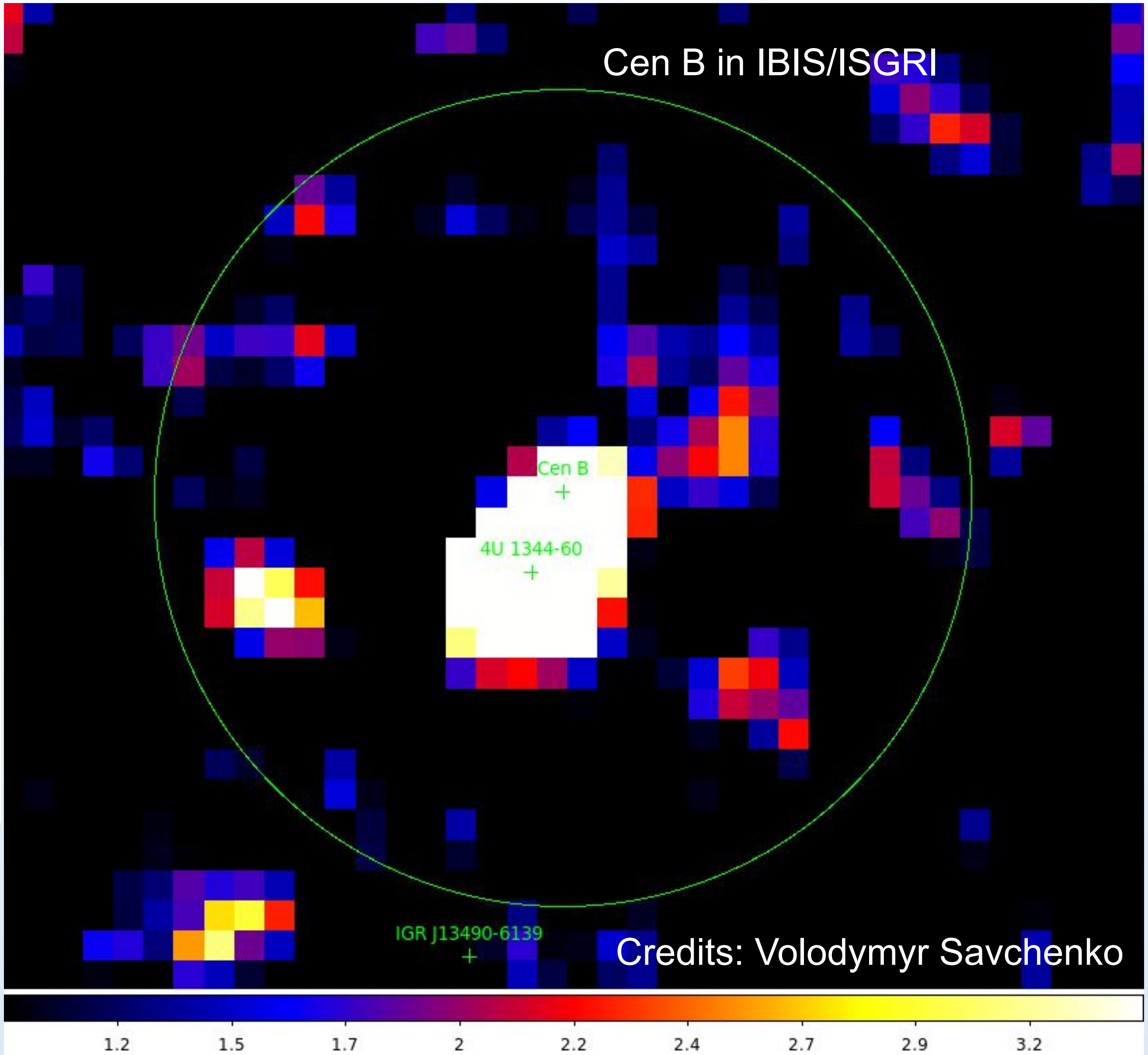
by INTEGRAL

FR I

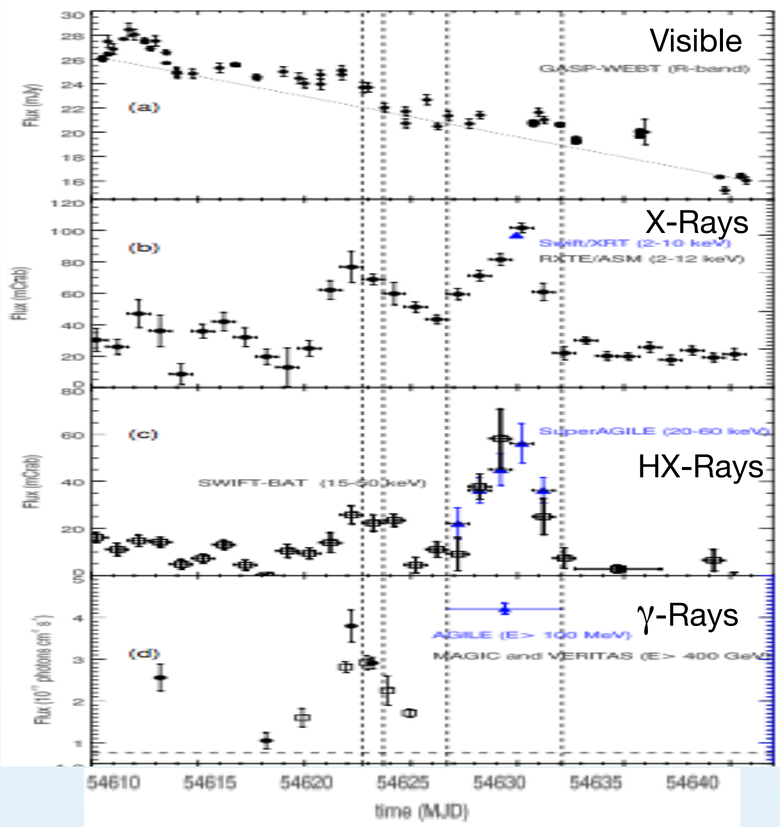
radio galaxy

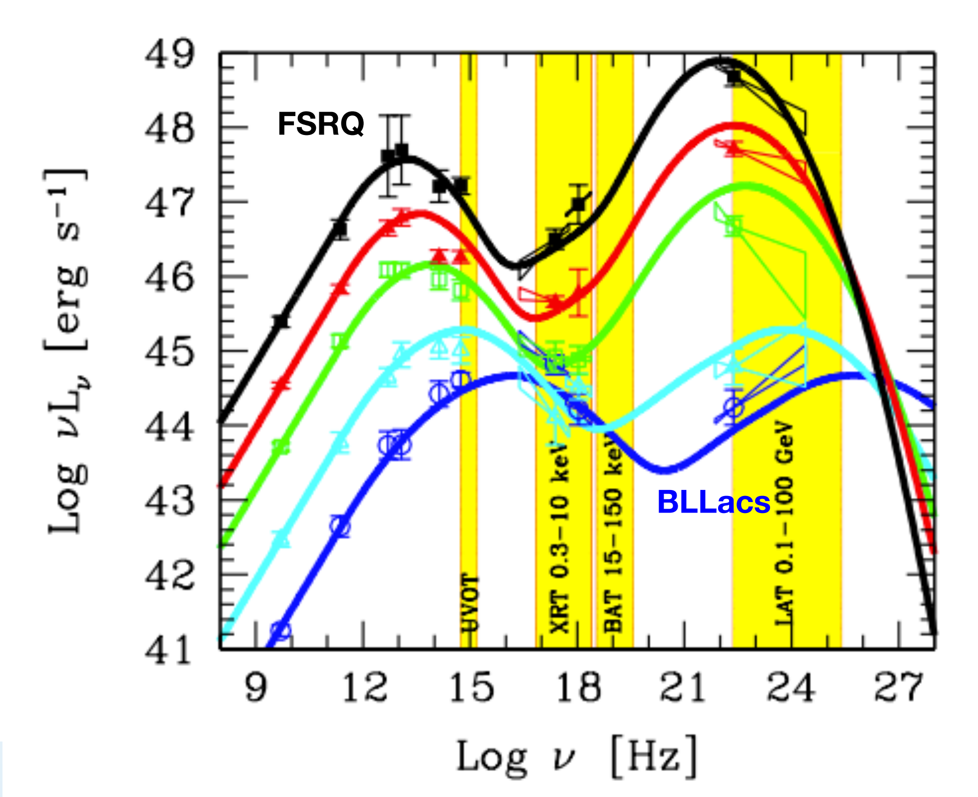
z=0.013





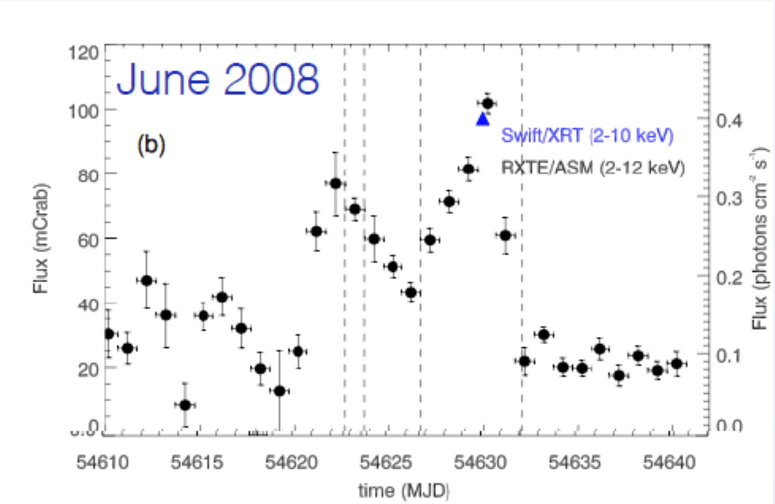
Blazar type AGN

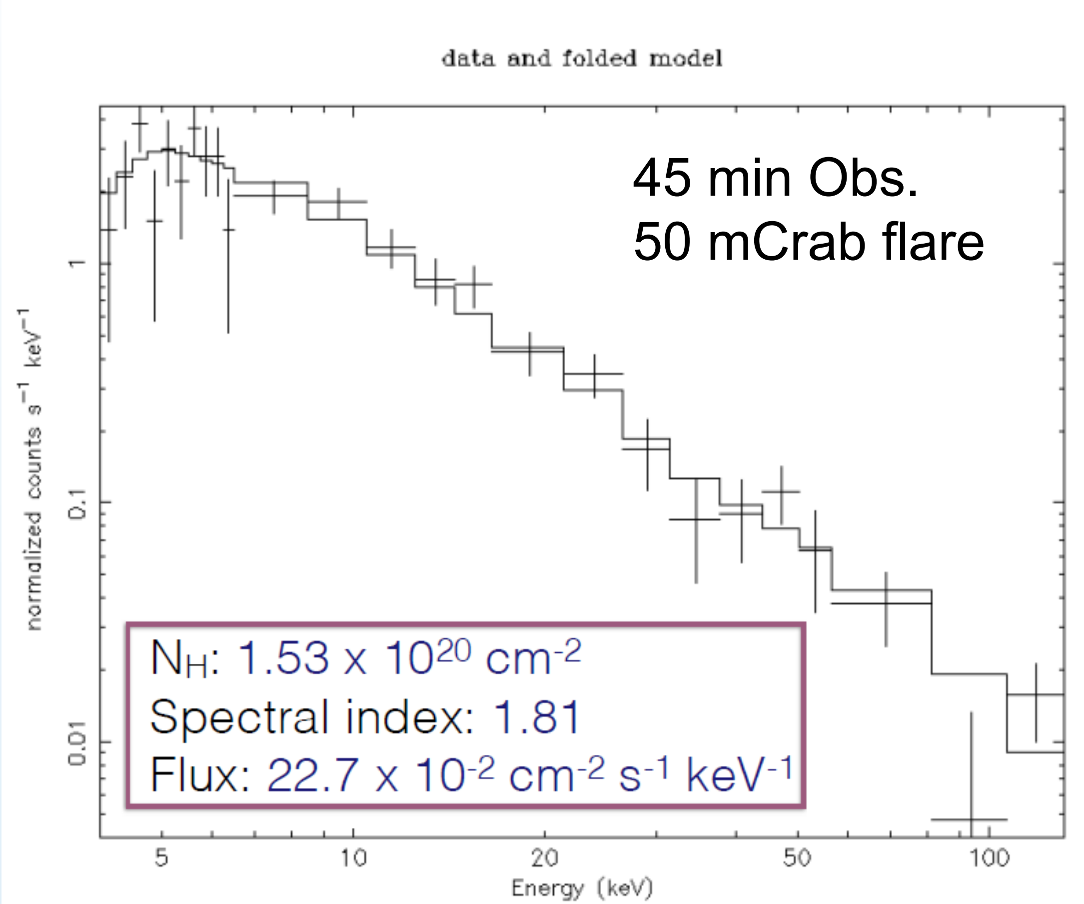




- Blazars: AGNs with jets aligned to the line of sight (BL Lacs, FSRQ)
- Extremely variable objects over the entire EM spectrum, SVOM will contribute:
  1. Alert for known Blazar entering flaring state
  2. Participate in MWL campaigns on Blazars
  3. by accumulating Blazar database available for constructing multi-epoch spectral energy distributions

Mkr 421 (vH-S) Blazar observed with SVOM





AGN with SVOM

Strengths for AGN science:

- Broad coverage: 1 – 150 keV
- Good energy resolution
- large field of view with ECLAIRs: 90° x 90°
- Simultaneous V-band imaging with VT
- MXT to study continuum down to ~1 keV and to measure intrinsic absorption

SVOM AGN Perspectives

- spectroscopic AGN catalogue
- Spectral monitoring
- Population studies, luminosity function
- Single source studies: ToOs (blazars, Seyfert in special state, simultaneous observations, tidal disruption events)
- NuSTAR: only nominal up to 80 keV, very few sources
- SVOM legacy: first broad band 4-150 keV spectroscopic sample (~100 AGN)
- only wide-angle hard X-ray telescope