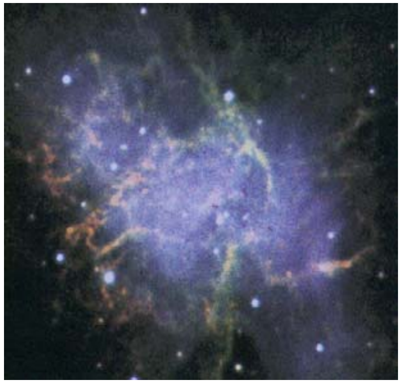
Some favorite catalogs, and some interesting blazars

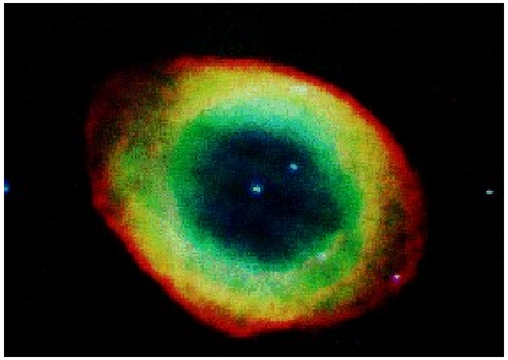


Messier 1

Messier 31

Messier 51

Messier 56



Messier 57

David Smith
SLAC, on leave from CNRS-IN2P3,
Centre d’Etudes Nucléaires de Bordeaux-Gradignan

A Quest -- where to point the instrument?

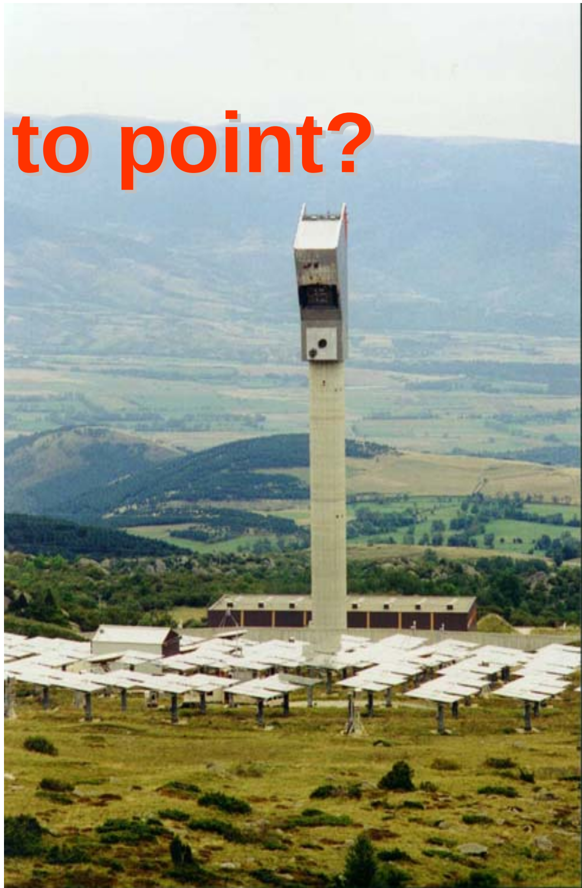
- **I'm from CELESTE: >80 GeV gammas rays with Crab/5 sensitivity, a low duty cycle (**due to clouds**), and a 1/2º field-of-view.**

- **We saw the 3 canonical objects for Cherenkov telescopes :**

  Crab, Mrk421, Mrk501

- **We wanted to see something *new* --** **where to point?**

- **I spent a lot of time perusing catalogs…**



Camp is very entertaining
And they say we'll have some fun if it stops raining.
"Camp Granada" by Alan Sherman (1963)

“But Dave, GLAST isn’t a pointing instrument”

- **GLAST expects to see *thousands* of high galactic latitude point sources, most of which will be blazars, and most of which will be difficult to identify as such.**

- **Identification will be even harder in the galactic plane, essential if you want to distinguish between e.g. an OB association and neutralino annihilation. (**“Identification” sort of means “archival multiwavelength”**)**

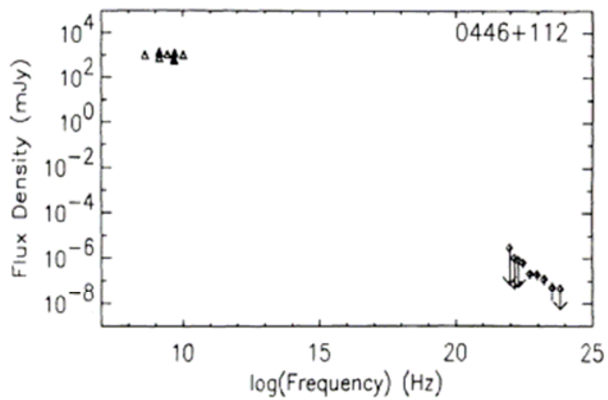
- **I believe that if you “*just wait and see what pops up*” that you will be overwhelmed.**

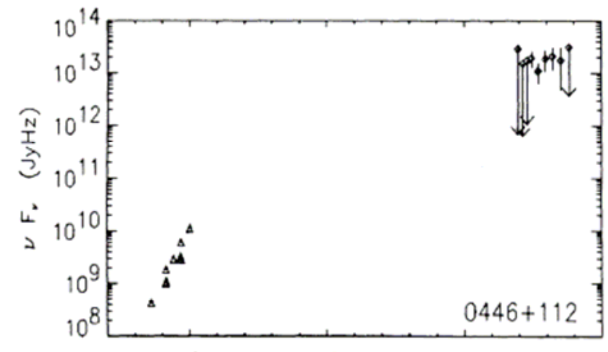
- **Personally, I think an *a priori* approach is necessary -- figure out what you want to “*point at*” long before the gammas arrive.**

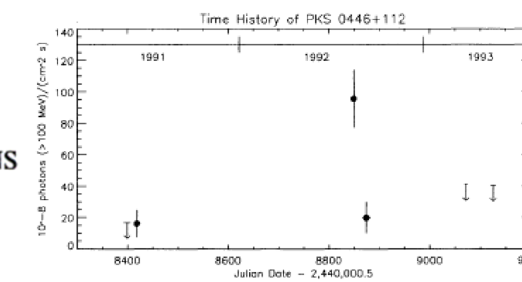
And that makes me a catalog buff!

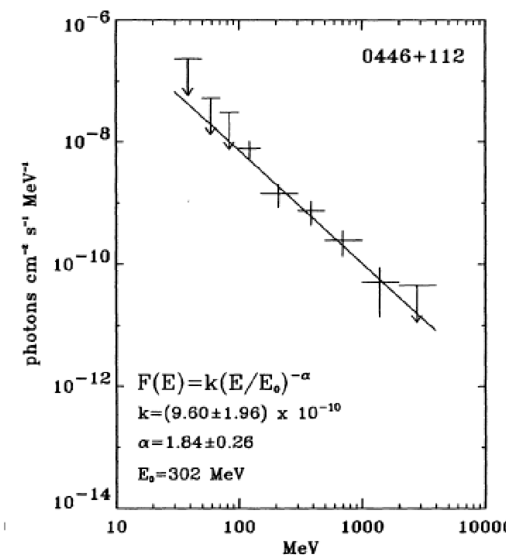
Example of “is that what that is?”

A lesser known Egret blazar. The info is often sparse…









THE ASTROPHYSICAL JOURNAL, 440:525–553, 1995 February 20

HIGH-ENERGY GAMMA-RAY EMISSION FROM ACTIVE GALAXIES: EGRET OBSERVATIONS AND THEIR IMPLICATIONS

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ABSTRACT

The energetic Gamma-Ray Experiment Telescope (EGRET) on the *Compton Gamma-Ray Observatory* has so far detected, with a high degree of certainty, 33 active galactic nuclei (AGNs) in high-energy gamma rays ($E > 100$ MeV) during Phase I (91/16/05–92/17/11) and Phase II (92/17/11–93/07/09). There are detections of 11 other active galaxies with lesser significance. Of the sources detected, the majority are quasars and six are usually classified as BL Lacertae (BL Lac) objects. They seem to be all members of the blazar class a rather well defined subclass of AGN. To aid attempts at relating the observed properties of the EGRET sources to physical models of AGNs, a summary of EGRET AGN observations is presented. This summary includes gamma-ray spectra and time-dependent gamma-ray fluxes of detected sources. For sources where the information is available in the literature, multifrequency spectra covering the range from radio to gamma rays are also included. Constraints are discussed which the EGRET observations place upon various emission models. Finally, the contribution of AGNs to the diffuse extragalactic gamma-ray emission is reexamined in light of the EGRET observations.

Subject headings: BL Lacertae objects: general — galaxies: active — gamma rays: observations — quasars: general

I especially like *older* catalogs

- I'm generally a history buff… Folklore, how wrong paths got righted, that sort of stuff.

- **Older catalogs were compiled using insensitive instruments, so you get the brightest objects.**

- **They're small enough to (**almost**) memorize.**

- **Bright objects have been known for a long time, so have been deeply studied in many ways at all wavelengths. Great for establishing confidence with GLAST.**

- **From the old, small catalogs you can grow to the huge modern ones.**

Outline

1. The catalogs of the 3 canonical sources Crab, Mrk421, Mrk501
   a) Messier
   b) Markarian

2. How Whipple went further -- the Einstein “slew” catalog

3. Two blazars I think are neat:
   a) W Com -- a testbed for electron versus proton acceleration
   b) 1ES1426+428 -- a testbed for infrared absorption

4. Things I won’t have time for
   a) Green’s supernova list
   b) Pulsar lists
   c) Whipple et cetera upper limits -- the good ideas that weren’t

(EGRET catalog goes without saying in this talk…)

Messy, Messier, Messiest

M1 = Crab = 3EG J0534+2200 = G184.6-5.8 = 3C144 = SN1054

the **canonical source.**

Charles Messier (1730 - 1817), French astronomer, catalogued ~100 diffuse objects, to avoid mistaking them for comets.

Comets were *the* astronomical (and astrological) topic of interest.

"Nebula": latin for cloud (diffuse, blurry).

Not astronomer royale for Louis XIV who died in 1715

Also “canonical”: Mrk421 & Mrk501

Beniamin Egishevich Markarian (1913-1985)
Active at Byurakan Observatory,
Mt. Aragat, Armenia, through 1984

“The Markarian survey contains 1500 objects selected for their excess of blue and UV emission among which about 1100 are galaxies. The catalog of Markarian galaxies is the largest sample of active galaxies known so far. The excess of blue luminosity and UV emission is the signature of either a high star formation rate or the presence of an Active Galactic Nucleus (AGN) in the central region of the galaxies. We extracted our sample …..”

(from Google “I feel lucky”)

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, **62**:751–819, 1986 December

Mt. Aragat, Armenia
(Noah's Ark landed on nearby Mt. Ararat.)

A CATALOG OF MARKARIAN GALAXIES

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Received 1986 April 25; accepted 1986 June 9

a) Active Galaxies and the Markarian Sample

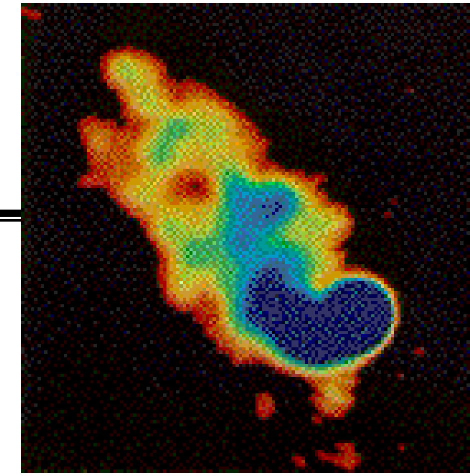
Markarian (1967, 1969), Markarian and Lipovetskii (1969, 1971, 1972, 1973, 1974, 1976*a*, *b*), and Markarian, Lipovetskii, and Stepanian (1977*a*, *b*, 1979*a*, *b*, *c*, 1981), hereafter respectively Lists I–XV, have published 15 lists of objects with blue excess and strong ultraviolet continuum radiation that were discovered on low-dispersion objective-prism plates. The observations were made using the 40–52 inch (1.0–1.3 m) Schmidt telescope of the Byurakan Astrophysical Observatory. The 1500 objects contained in the lists have provided the principal base from which the major types of non–QSO active

[1]Staff member of the Space Telescope Science Institute.

sified, and studied in detail by numerous workers. Emission-line galaxies with all degrees of activity discovered in the survey have become known collectively as Markarian galaxies.

The Markarian sample has played a central role in the task of distinguishing between the astrophysically different types of phenomena that occur in AGNs. For example, the original stratification of Seyfert galaxies into two types by Khachikian and Weedman (1971*b*) was based largely on measurements of emission-line widths in a small number of galaxies discovered very early in the Markarian survey. Seyfert 1 galaxies were determined to have broad H I emission lines and narrow forbidden lines, while Seyfert 2 galaxies have relatively narrow H I lines and narrow forbidden lines. Later, a spectral survey of AGNs chosen primarily from the Markarian lists began at Lick Observatory (Osterbrock 1976), and a number

(Mrk 501 radio image)



The purpose of this discussion is not to review the characteristics of the currently known types of AGNs (see J. S. Miller 1985, and references therein), but to emphasize the important role that Markarian galaxies are playing in studies of active galaxies. The survey currently provides the largest uniformly selected sample of AGNs to date, and, although there is much work to be done, the existing data on many Markarian objects are extensive. For example, over 30% of the 554 AGNs in Table 2 of Véron-Cetty and Véron (1984) are from the Markarian lists. As the data compiled here

With these goals
redshifts, spectral a
tudes, IR and radio
to Markarian galaxy
ture search of publis
Extensive notes inc
catalogs, the presenc
emission-line variab
In § II we briefly di
survey, and the ca

If ‘421 is good is ‘422 better? (no.)

Remarkable Markarian galaxies:

- **Mrk 231 -- the closest ULIG, BAL QSO, and the most luminous ULIG in the Local Universe**
- **Mrk 116 -- the most metal-deficient BCDG (=IZw18)**
- **Mrk 421,501 -- are among the highest known energy sources**
- **Mrk 938 -- the first dynamical merger discovered observationally**
- **Mrk 273 -- a wonderful double-double nuclei galaxy**
- **Mrk 6 -- variations of spectral lines typical of different types of objects and very high column density of H in X-rays**
- **Mrk 926 -- one of the rare Sy1 galaxies having LINER properties**
- **Mrk 266 -- has a multiple structure nuclear region**
- **Mrk 766 -- one of the most important NLS1 galaxies**
- **Mrk 110 -- crucial for understanding differences between NLS1s and BLS1s**
- **Mrk 231,507-- among the 5 known superstrongest FeII emitters**
- **Mrk 530,993,1018 -- change their spectra from Sy2 to Sy1, important for the unified scheme of AGN**
- **Mrk 180 -- frequent “also ran” in TeV candidate lists.**

How Whipple moved ahead

- **Whipple quickly found the EGRET catalog to be disappointing**

  A.D. Kerrick et al ApJ 452 588 (1995)
- **Breakthrough: 1ES 2344+514** (Christmas, then nothing for years…)

  M. Catanese et al ApJ 501 616 (1998)
- **They found it from Perlman's 1ES blazar list.**

  E. Perlman et al ApJ Supp 104 251 (1996)

- **"1ES" -- 1st catalog of Einstein X-ray sources obtained while the instrument was slewing from one target to another.**

TABLE 2

THE SLEW SURVEY BL LAC OBJECTS

(1) Name	(2) α (J2000)	(3) δ (J2000)	(4) m_O	(5) Source	(6) S(2 keV) (μJy)	(7) S(5 GHz) (mJy)	(8) Source	(9) z	(10) R	(11) α_{OX}	(12) α_{RO}	(13) Other Names	(14) Comments
1ES0033+595	00 35 52.7	+59 50 04	19.5	4	2.222	66.01	2	?		0.45	0.61		
1ES0120+340	01 23 08.7	+34 20 49	15.19	3	1.857	33.60	2	.272	4.22	1.06	0.28		1
1ES0145+138	01 48 29.7	+14 02 18	17.9	1	2.023	5.67	2	.125	5.09	0.71	0.30		2,3
1ES0158+003	02 01 16.2	+00 34 01	17.96	11	0.667	11.3	11	.299		0.88	0.36	MS0158.5+0019	3
1ES0219+428	02 22 39.6	+43 02 08	15.5	7	0.616	806	9	.444		1.27	0.57	3C66A	3
1ES0229+200	02 32 48.6	+20 17 17	14.68	3	1.130	49.09	2	.139	7.03	1.22	0.27		3
1ES0235+164	02 38 38.9	+16 37 00	15.5	7	0.0880	1934	9	.940		1.58	0.60	OD160	3
1ES0323+022	03 26 13.9	+02 25 15	17.4	7	1.760	42.0	9	.147		0.81	0.42	1H0323−022	3
1ES0347−121	03 49 23.2	−11 59 27	18.2	10	2.319	9.00	11	.188	4.87	0.64	0.36		2,3
1ES0414+009	04 16 52.4	+01 05 24	17.5	7	3.643	70	9	.287		0.67	0.47	1H0414−009	3
1ES0446+449	04 50 07.2	+45 03 12	18.5	4	0.630	139.41	2	.203:	3.77	0.81	0.60		
1ES0502+675	05 07 56.2	+67 37 24	17.0	1	1.361	32.65	2	?		0.92	0.37		3
1ES0507−040	05 09 38.1	−04 00 46	19.0	6	0.786	27	6			0.70	0.51	1H0506−039	3,4
1ES0525+713	05 31 41.7	+71 22 17	19.0	4	0.798	8.96	2	.249		0.69	0.42		1
1ES0548−322	05 50 41.9	−32 16 11	15.5	7	2.932	170	11	.069		1.02	0.39	1H0548−322	3
1ES0647+250	06 50 46.5	+25 03 00	15.8	1	2.356	73.40	2	?		1.01	0.35		
1ES0715−259	07 18 04.9	−26 08 11	18.0	4	0.477	165.03	2	?		0.94	0.58		
1ES0735+178	07 38 07.4	+17 42 19	15.1	7	0.0696	2166	9	≥ .424		1.64	0.57	PKS0735+178	3
1ES0737+746	07 44 05.5	+74 33 58	16.9	11	0.464	24.0	11	.315		1.10	0.40	MS0737.9+7441	3
1ES0806+524	08 09 49.2	+52 18 58	15.0	1	1.379	171.9	2			1.22	0.36		1
1ES0851+203	08 54 48.9	+20 06 30	14.0	7	0.667	2689	9	.306		1.49	0.51	OJ287	3
1ES0927+500	09 30 37.6	+49 50 26	17.2	1	0.674	18.34	2	.188	6.05	1.00	0.34		3
1ES0950+495	09 54 09.9	+49 14 59	19.3	11	0.207	3.3	11	> .5		0.88	0.36	MS0950.9+4929	3,5
1ES1011+496	10 15 04.2	+49 26 00	16.1	7	0.542	286	9			1.21	0.48	1H1013+498	3,4
1ES1028+511	10 31 18.5	+50 53 36	16.6	1	1.883	44.19	2	.239:		0.92	0.37		3
1ES1101−232	11 03 37.7	−23 29 31	16.1	7	[illegible]	[illegible]	9			0.89	0.36	1H1100−230	3
1ES1101+384	11 04 27.3	+38 12 32	14.4	7	3.917	722	9	.031		1.14	0.42	Mkn 421	3
1ES1106+244	11 09 16.2	+24 11 20	18.7	1	[illegible]	[illegible]	2	?		0.80	0.45		1
1ES1118+424	11 20 47.0	+42 12 25	17.0	1	1.409	35	6	.124:		0.91	0.38	EXO1118.0+4228	3
1ES1133+704	11 36 26.4	+70 09 28	14.4	7	1.789	274	9	.046		1.27	0.35	Mkn 180	3
1ES1212+078	12 15 11.0	+07 32 04	16.05	3	0.269	94.0	9	.136	8.18	1.25	0.43		3,6,7
1ES1215+303	12 17 52.1	+30 07 00	15.7	7	0.249	445	9			1.40	0.48	ON325	3
1ES1218+304	12 21 22.1	+30 10 37	16.4	7	[illegible]	[illegible]	9			0.90	0.37	1H1219+305	3
1ES1218+285	12 21 31.7	+28 13 58	16.5	7	0.268	981	9	.102		1.27	[illegible]	ON231	[illegible]
1ES1239+069	12 41 48.3	+06 36 01	19.41	3	[illegible]	[illegible]	2	.150	3.10	0.73	0.49		3
1ES1248−296	12 51 34.8	−29 58 43	19.0	9	0.794	5.78	2	.487:		0.69	0.38		[illegible]
1ES1255+244	12 57 31.9	+24 12 40	15.40	3	3.661	7.39	2	.141	6.16	1.30	0.17		3
1ES1308+326	13 10 28.7	+32 20 43	19.0	7	0.152	1131	9	.997		0.98	0.80	OP313	3,8
1ES1312−423	13 15 03.3	−42 36 01	16.6	11	0.734	18.5	11	.105		1.08	0.29	MS1312.1−4221	
1ES1320+084N	13 22 54.9	+08 10 10	18.64	1	1.749	11.89	2	?		0.55	0.44		3,6,9
1ES1332−295	13 35 29.7	−29 50 38	19.1	11	0.268	11.7	11	.513	5.64	0.87	0.44	MS1332.6−2935	3
1ES1402+042	14 04 50.9	+04 02 02	17.1	11	0.101	20.8	11	.344:		1.33	0.34	MS1402.3+0416	3
1ES1421+582	14 22 38.9	+58 01 55	18.4	1	0.468	7.27	2	?		0.88	0.35		3
1ES1426+428	14 28 32.5	+42 40 24	16.4	7	2.678	38	9			0.90	0.34	H1426+427	1
1ES1440+122	14 42 48.3	+12 00 40	17.0	1	0.577	41.26	2	.162		1.06	0.39		3

W Com,
3EG J1222+2841

TABLE 2—*Continued*

(1) Name	(2) α (J2000)	(3) δ (J2000)	(4) m_O	(5) Source	(6) S(2 keV) (μJy)	(7) S(5 GHz) (mJy)	(8) Source	(9) z	(10) R	(11) α_{OX}	(12) α_{RO}	(13) Other Names	(14) Comments
1ES1517+656	15 17 47.5	+65 25 23	15.91	5	1.189	39	9			1.11	0.30	H1517+656	3,4,10
1ES1533+535	15 35 00.8	+53 20 37	17.6	1	0.508	9.84	2	?		0.99	0.32		3
1ES1544+820	15 40 15.7	+81 55 06	16.9	1	0.905	42.66	2	?		1.00	0.38		3
1ES1553+113	15 55 43.2	+11 11 21	15.0	7	2.566	636	9	.360		1.11	0.47	PG1553+113	3
1ES1652+398	16 53 52.1	+39 45 37	14.4	7	3.702	1371	9	.034		1.15	0.48	Mkn 501	3
1ES1727+502	17 28 18.5	+50 13 11	16.7	7	1.072	159	9	.055		1.01	0.47	I Zw 187	3
1ES1741+196	17 43 57.5	+19 35 10	16.6	1	1.130	222.6	2	.083	4.36	1.01	0.49		3
1ES1807+698	18 06 50.5	+69 49 21	14.2	7	0.145	2189	9	.051		1.72	0.50	3C371.0	3
1ES1853+671	18 53 52.1	+67 13 55	16.41	3	0.281	12.07	2	.212	6.35	1.19	0.28		3
1ES1959+650	19 59 59.9	+65 08 55	13.67	3	3.645	251.6	2	.048	6.88	1.19	0.32		3,11
1ES2005−489	20 09 25.3	−48 49 53	15.3	7	2.128	1102	9	.071		1.11	0.53	PKS2005−489	4
1ES2155−304	21 58 51.9	−30 13 31	13.5	7	5.746	310	9	.117		1.22	0.29	PKS2155−304	3
1ES2200+420	22 02 43.2	+42 16 40	15.1	7	0.749	3593	9	.070		1.31	0.61	BL Lac	
1ES2321+419	23 23 52.0	+42 11 00	17.0	3	0.271	19	8	.059:		1.19	0.32	H2321+419	3
1ES2320+174	23 29 03.3	+17 43 30	16.82	1	0.558	18.41	2	.213	8.43	1.02	0.35		1
1ES2343−151	23 45 38.4	−14 49 29	19.2(J)	10	0.298	8.18	2	.226	8.32	0.83	0.42		3
1ES2344+514	23 47 04.8	+51 42 18	15.5	3	1.142	215.18	11	.044	9.85	1.18	0.41		

NOTES.—(1) Priority (4) source (see § 2.3.1). (2) Companion at same redshift. (3) Member of the northern, High-latitude sample (§ 4). (4) Position from Kollgaard et al. 1996. (5) $z > 0.6$ based on being unresolved in optical, radio, and X-ray images (Perlman et al. 1995). (6) Probable BL Lac object; further observations are required to confirm this classification. (7) Originally identified as an SAO star in Elvis et al. 1992, but corrected in this paper and in Schachter et al. 1995. (8) Possible "blazar." See Antonucci 1993. (9) Possible complex X-ray source. (10) Listed as a confirmed BL Lac object in Elvis et al. 1992 with credit to Remillard et al. 1996. (11) Also in the 200 mJy radio-selected sample identified by Marcha 1994, but with $m_v = 16$.

SOURCES.—(1) Approximate *V* magnitudes obtained via CCD photometry taken by J. F. S. and P. K. at the FLWO 1.2 m. (2) This work, from 5 GHz, CnD array map. (3) Approximate POSS O magnitudes obtained from Cambridge APM measurements. (4) Approximate *V* magnitudes obtained by E. S. P. and J. T. S. by eye from Quick *V*. (5) Brissenden 1989. (6) Giommi et al. 1991. (7) Hewitt & Burbidge 1993. (8) S. A. Laurent-Muehleisen (private communication). (9) NASA Extragalactic Database (NED). (10) Schachter et al. 1993. (11) Stocke et al. 1991.

Warning: *z* not always reliable…

Why I like W Comae

A common conversation at cocktail parties and church socials:

Q: “What and where are the accelerators that push cosmic rays to such high energies?”

A: ”Above the knee at 10^{15} eV, acceleration may occur outside of our galaxy, by the Fermi mechanism, in shocks in the jets we observe for some galaxies.”

Q: “Oh really. How interesting. Electron or proton accelerators?”

A: “Well there’s this one called Wcom that might answer that.”

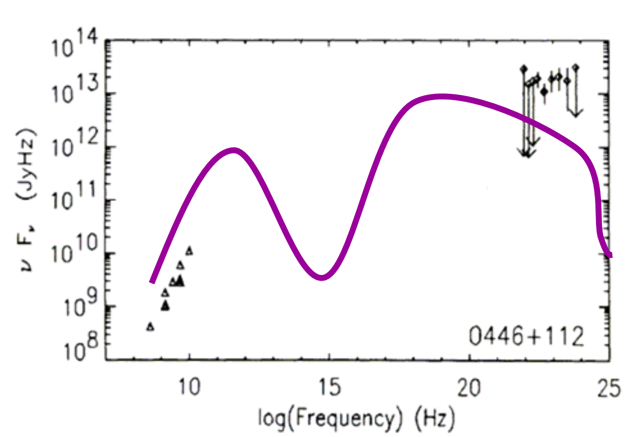
Q: “You don’t say… how do you find strange galaxies to look at?”

A: ”Well, we scientists have catalogs of things in space.”

A great Xray measurement constrains "SSC"

- Remember this garden-variety Egret blazar?

(curve is a doodle)



- For W Comae, BeppoSAX caught

the "V" between synchrotron and I.C.

Tagliaferri, G., et al. 2000, A&A, 354, 431

- Not easily compatible

With EGRET spectrum

THE ASTROPHYSICAL JOURNAL, 581:143–154, 2002 December 10

PREDICTIONS OF THE HIGH-ENERGY EMISSION FROM BL LACERTAE OBJECTS: THE CASE OF W COMAE

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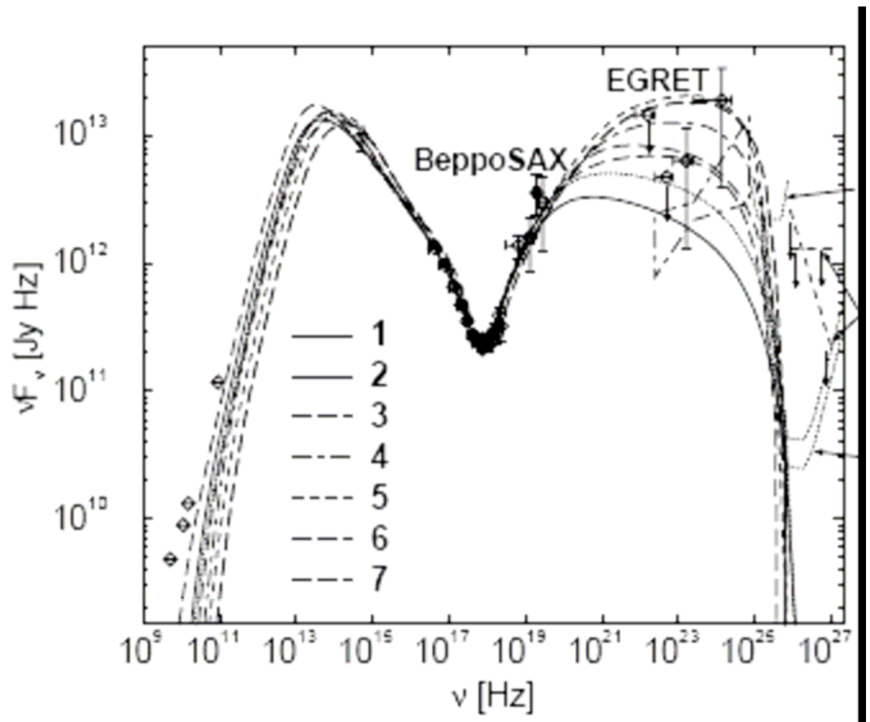


Apples with apples

Electromagnetic vs Proton afficionados can use this source as a testbench to distinguish the two paradigms.

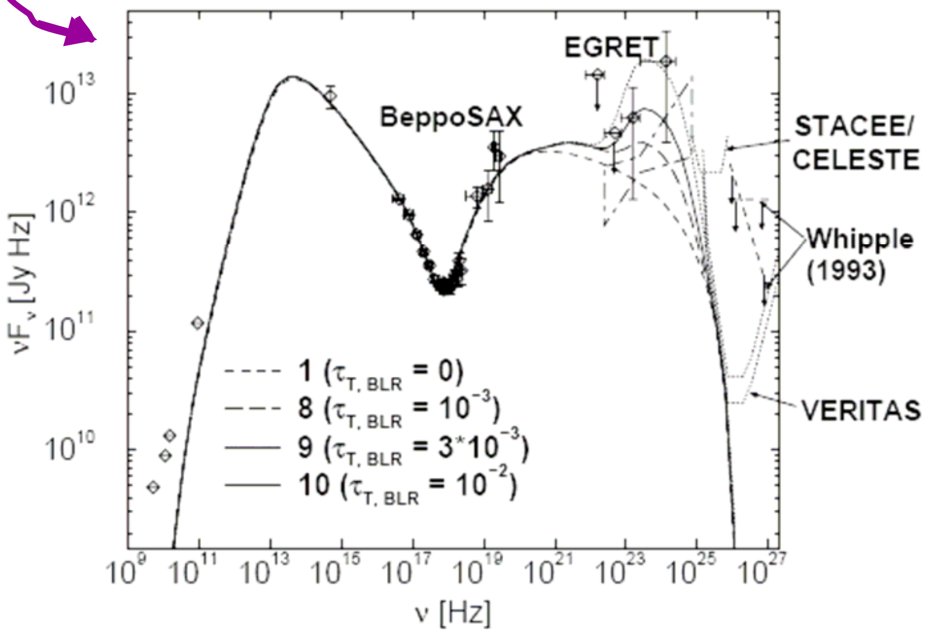


FIG. 4.—Various model fits to the optical–X-ray spectrum of W Comae in 1998, using an SSC+ERC model. The choice of parameters is based on fit 1 in Fig. 3, but accounting, in addition, for an increasing amount of reprocessed accretion disk radiation in a broad-line region of radial Thomson depth $\tau_{BLR} = 0$ to 10^{-2}. For the complete list of parameters, see Table 2.

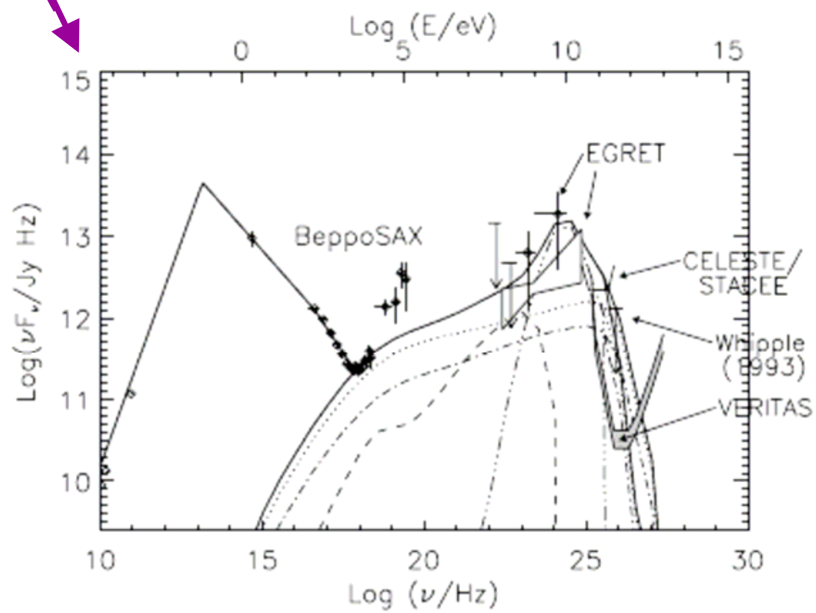


FIG. 11.—Emerging cascade spectra for SPB model 1: *p* synchrotron cascade (*dashed line*), μ synchrotron cascade (*triple-dot–dashed line*), π^0 cascade (*dotted line*), $\pi^{\pm}$-cascade (*dash-dotted line*), and total (*solid line*). All model fluxes are corrected for absorption in the cosmic photon background as described in Fig. 8.

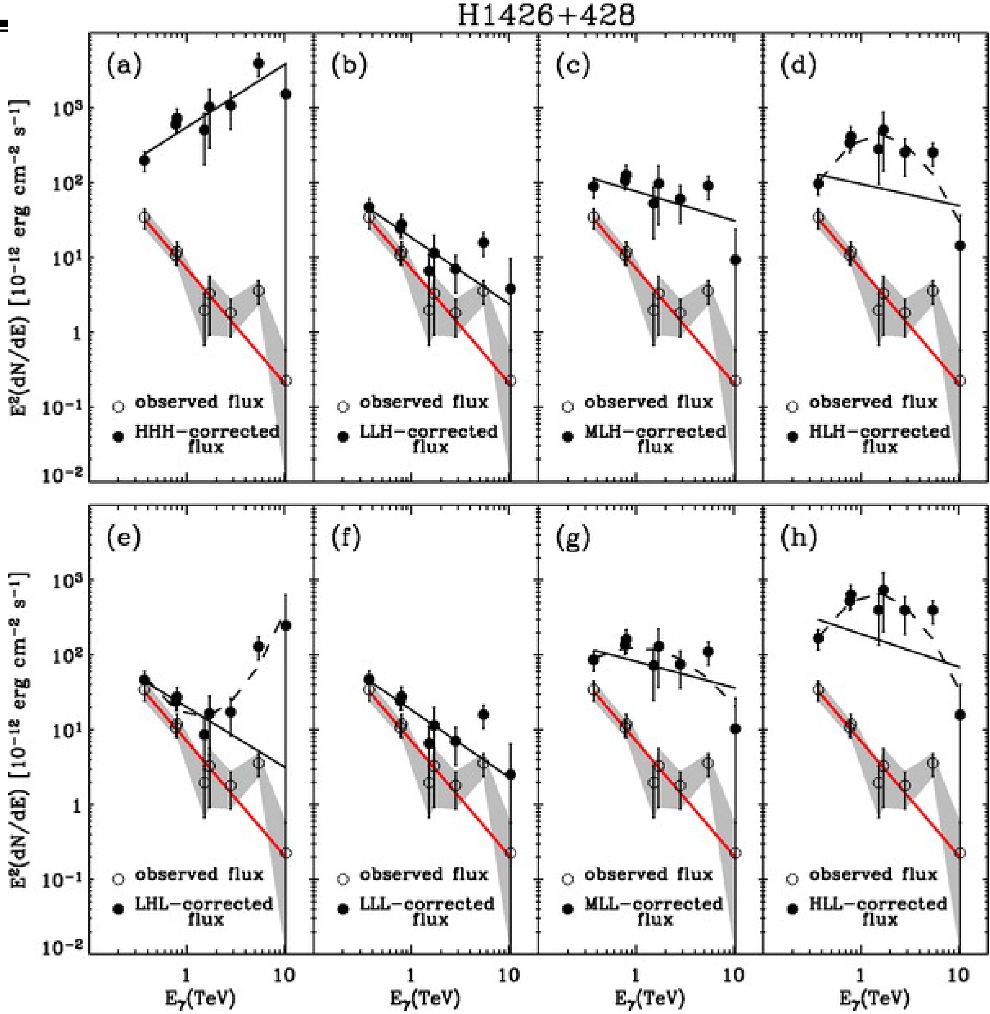
Why I like 1ES 1426+428 (z = 0.129)

- **multi-TeV (Whipple, CAT, Hegra).**
- **CELESTE limit.**

- **Infrared de-absorption leads to intensity >1 Crab for <0.1 TeV, in some scenarios.**

(Crab ~ 100 in these units)

- **Identify others for GLAST…**



Dwek & Krennerich, ApJ *<u>618</u>, 657-674 (2005)* "Simultaneous constraints on the spectrum of the extragalactic background light and the intrinsic TeV spectra of Markarian 421, Markarian 501, and H1426+428 "

Some other catalogs

- **"A Catalogue of Galactic Supernova Remnants" D.A.Green http://www.mrao.cam.ac.uk/surveys/snrs/**

- ***Didja know?*** 3EG J0222+4253 **is both**
  - **a blazar 1ES 0219+428 = 3C66A, and**
  - **a pulsar PSR J0218+4232,**
  - **but without a known SNR counterpart** (17° from galactic plane)

- **Someday I'd like to tell you the story of how CTB 80 = G69.0+2.7 was deduced to have a neutron star, leading to the discovery of PSR 1951+32, which later became an EGRET pulsar.**

- **Other good stories -- how the strange "stars" W Comae and BL Lacertae wound up not being stars at all (**learn your star catalogs, and check out the AAVSO's web site**).**

- **CONCLUSION: Folklore pays!**