High-Energy Cosmic Neutrinos: a Personal Tour francis halzen





IceCube: a neutrino window on the Universe

- the high-energy neutrino flux from the cosmos
- the first sources
- neutrinos and multimessenger astronomy
- [a PeV beam for neutrino physics]

IceCube.wisc.edu

highest energy "radiation" from the Universe: cosmic rays, not photons



Universe beyond our Galaxy is eventually opaque to gamma rays

the opaque Universe

$\gamma + \gamma_{\rm CMB} \rightarrow e^+ + e^-$

PeV photons interact with microwave photons (411/cm³) before reaching our telescopes enter: neutrinos

Neutrinos? Perfect Messengers

- electrically neutral
- massless (in this talk)
- unabsorbed
- γ unlike γ rays, neutrinos are solely created in processes involving cosmic rays
 - ... but difficult to detect

highest energy "radiation" from the Universe: cosmic rays and neutrinos



Universe beyond our Galaxy is eventually opaque to gamma rays

highest energy radiation from the Universe: not γ -rays !

high energy high luminosity

LHC accelerator should have circumference of Mercury orbit to reach 10²⁰ eV!

Courtesy M. Unger

Fly's Eye 1991 300,000,000 TeV

cores of active galaxies as cosmic accelerators

acceleration of electrons and protons in the high field regions associated with the accretion disk and the optically thick corona of X-rays

the core is gamma-ray obscured



cores of active galaxies and jets

- some of the matter falling into a supermassive black hole is accelerated in a jet along its rotation axis
- fast spinning infalling matter comes in contact with the rotating black hole
- spacetime around spinning black hole drags on the field winding it into a tight cone around the rotation axes
- plasma from the accretion disk is then flung out along these field lines





• gamma rays are absorbed by background (EBL) photons

Ve

gamma rays accompany neutrinos

SHOCK WAVE

multimessenger astronomy $p + \gamma \Rightarrow n + \pi^{+}$ $\pi^{+} \Rightarrow [e^{+} + \bar{\nu}_{\mu} + \nu_{e}] + \nu_{\mu}$ $\Rightarrow p + \pi^{0}$ $\pi^{0} \Rightarrow \gamma + \gamma$

10,000 times too small to do neutrino astronomy...



M. Markov 1960

B. Pontecorvo

M.Markov : we propose to install detectors deep in a lake or in the sea and to determine the direction of charged particles with the help of Cherenkov radiation.

speed of light in water is
~ 3/4 of speed of light
→ shockwave

a muon neutrino produces a muon with a range of kilometers

neutrino

lattice of photomultipliers

- 3 km deep South Pole glacier
- ultra-transparent ice below 1.35 km
- absorption length: 100 ~ 250+ m

IceCube 5160 photomultipliers instrument one km³ of Antarctic ice between 1.4 and 2.4 km depth

- muon produced by
 neutrino near IceCube
- comes through the Earth
- 2,600 TeV inside detector
- not atmospheric

- muon produced by • neutrino near IceCube
- comes through the • Earth
- 2,600 TeV inside • detector
- not atmospheric •
- angular resolution: • astronomy

Signals and Backgrounds

electron and tau neutrinos (showers)

flux $\Phi = dN/dE \sim E^{-2.5}$

energy in neutrinos similar to the energy in gamma rays and cosmic rays

 gamma rays accompanying IceCube neutrinos interact with the target producing the neutrinos and with interstellar photons on their way to earth

e

e

 the gamma rays fragment into multiple lower energy gamma rays that reach Earth

• Fermi IGRB

– IceCube Cascade 4yr

► IceCube HESE 6yr

the neutrino sources are opaque to gamma rays

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- the diffuse high-energy neutrino flux
- observation of the first sources
- neutrinos and multimessenger astronomy

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138322 neutrinos in 2011

> 200 cosmic neutrinos (depending on the spectrum)
 ~12 separated from atmospheric background with E>60 TeV

neutrinos with probable cosmic origin: are they correlated to astronomical sources?

pre-trial p-value for clustering of high energy neutrinos

evidence for non-uniform sky map in 10 years of IceCube data : mostly resulting from 4 extragalactic source candidates

limits and interesting fluctuations (?)

Nama	Class	o [dog]	A [dog]	<u><u></u></u>	â	log (m	4	1	PKS B1130+008	BLL	173.20	0.58	15.8	4.0	0.96	4.4
	ECDO			$\frac{n_s}{1.9}$	$\frac{\gamma}{2c}$	$-\log_{10}(plocal)$	$\frac{\varphi_{90\%}}{2.2}$		Mkn 421	BLL	166.12	38.21	2.1	1.9	0.38	5.3
PK5 2520-055	FSRQ	330.00	-5.29	4.0	3.0	0.45	0.0 F 1		4C + 01.28	BLL	164.61	1.56	0.0	2.9	0.26	2.4
3U 454.3	FSRQ	343.50	16.15	5.4 9.9	2.2	0.62	5.1		$1H\ 1013{+}498$	BLL	153.77	49.43	0.0	2.6	0.29	4.5
TXS 2241+406	FSRQ	341.06	40.96	3.8	3.8	0.42	5.6		4C + 55.17	FSRQ	149.42	55.38	11.9	3.3	1.02	10.6
RGB J2243+203	BLL	340.99	20.36	0.0	3.0	0.33	3.1		M 82	SBG	148.95	69.67	0.0	2.6	0.36	8.8
CTA 102	FSRQ	338.15	11.73	0.0	2.7	0.30	2.8		PMN J0948+0022	AGN	147.24	0.37	9.3	4.0	0.76	3.9
BL Lac	BLL	330.69	42.28	0.0	2.7	0.31	4.9		OJ 287	BLL	133.71	20.12	0.0	2.6	0.32	3.5
OX 169	FSRQ	325.89	17.73	2.0	1.7	0.69	5.1		PKS 0829+046	BLL	127.97	4.49	0.0	2.9	0.28	2.1
B2 $2114 + 33$	BLL	319.06	33.66	0.0	3.0	0.30	3.9		S4 0814+42	BLL	124.56	42.38	0.0	2.3	0.30	4.9
PKS 2032+107	\mathbf{FSRQ}	308.85	10.94	0.0	2.4	0.33	3.2		OJ 014	BLL	122.87	1.78	16.1	4.0	0.99	4.4
2HWC J2031+415	GAL	307.93	41.51	13.4	3.8	0.97	9.2		DVS 0726 + 01	BLL	122.40	02.31 1.69	0.0	2.8	0.31	4.7
Gamma Cygni	GAL	305.56	40.26	7.4	3.7	0.59	6.9		PKS 0730+01 PKS 0735+17	BIT	114.02 114.54	1.02 17 71	0.0	2.0	0.20	2.4
MGRO J2019+37	GAL	304.85	36.80	0.0	3.1	0.33	4.0		$AC \pm 14.23$	FSRO	114.04 111.22	14.49	8.5	$\frac{2.8}{2.0}$	0.30	3.3 4.8
MG2 J201534+3710	\mathbf{FSRQ}	303.92	37.19	4.4	4.0	0.40	5.6		40 ± 14.25 S5 0716 \pm 71	BLL	110.49	71.34	0.0	2.3 2.5	0.00	7.4
MG4 J200112+4352	BLL	300.30	43.89	6.1	2.3	0.67	7.8		PSB B0656+14	GAL	104.45	14.24	8.4	$\frac{2.0}{4.0}$	0.50	4.4
1 ES 1959 + 650	BLL	300.01	65.15	12.6	3.3	0.77	12.3		$1 \text{ES} \ 0647 \pm 250$	BLL	102.70	25.06	0.0	2.9	0.27	3.0
1RXS J194246.3+1	BLL	295.70	10.56	0.0	2.7	0.33	2.6		$B3\ 0609+413$	BLL	93.22	41.37	1.8	1.7	0.42	5.3
RX J1931.1+0937	BLL	292.78	9.63	0.0	2.9	0.29	2.8		Crab nebula	GAL	83.63	22.01	1.1	2.2	0.31	3.7
NVSS J190836-012	UNIDB	$287\ 20$	-1.53	0.0	2.9	0.22	2.3		OG + 050	FSRQ	83.18	7.55	0.0	3.2	0.28	2.9
MGBO $.11908 \pm 06$	GAL	287 17	6.18	42	$\frac{1}{2}$ 0	1 42	57		TXS 0518+211	BLL	80.44	21.21	15.7	3.8	0.92	6.6
TXS 1902 ± 556	BLL	285.80	55.68	11.7	4.0	0.85	9.9		TXS 0506+056	BLL	77.35	5.70	12.3	2.1	3.72	10.1
HESS 11857 ± 0.02	GAL	284.30	2.67	7 /	3.1	0.53	3.5		PKS 0502+049	\mathbf{FSRQ}	76.34	5.00	11.2	3.0	0.66	4.1
CPS 1285 0	UNIDB	204.30 283.15	0.60	1.4	3.1	0.33 0.27	0.0 0.2		S3 0458-02	\mathbf{FSRQ}	75.30	-1.97	5.5	4.0	0.33	2.7
UESS 1205.0	CAL	203.13	0.09	1.7	3.0 2.7	0.27	2.3		PKS 0440-00	FSRQ	70.66	-0.29	7.6	3.9	0.46	3.1
HESS J1052-000	GAL	200.00 000.00	0.00	3.3 0.0	3.7 2.0	0.30	2.0		MG2 J043337+2905	BLL	68.41	29.10	0.0	2.7	0.28	4.5
ПЕЗЗ J1049-000 ПЕЗЗ J1049-000	GAL	202.20	-0.02	0.0	- 0.0 - 0.0	0.20	2.2		PKS 0422+00	BLL	66.19	0.60	0.0	2.9	0.27	2.3
HE-55 .11643-033	(I AT L			11.0					- DIZC 0/90 01	FSRO	- 65_22_	1.92	0.0	- 1-0	0.52	3.4
	VAID		^o tria	S [°] -	\rightarrow	earch	17()	prese	lected so	LTC:	SC2	naic	1ate	2S	0.00	0.4
OT 081	VOID	$\geq_{67.0}^{267.15}$		S 2.2	→3.2S	earch	110	prese	lected so	UIRCE		naic	ate	BS	0.99	4.4
OT 081 S4 1749+70		267.15	^o trea 70.10	0.0	→3.2S		110 8.0	prese	NGC 1275	AGN	49.96			3 .1	0.99 0.41	4.4 5.5
OT 081 S4 1749+70 1H 1720+117	VOIC BLL BLL	$\geq_{61.07}^{267.15}$	⁵ t ria 70.10 11.88	0.0 0.0	→3.2S	earch 0.37 0.30	110 8.0 3.2 7.2	prese	NGC 1275 NGC 1068 PKS 0225 + 164	AGN SBG	49.96 40.67	41.51 -0.01 16.62	3.6 50.4	3.1 3.2 2.0	0.99 0.41 4.74 0.28	4.4 5.5 10.5
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177	VOIC BLL BLL BLL	267.15 267.15 261.27 259.81	70.10 11.88 17.75	0.0 0.0 19.8	→3.2S 2.5 2.7 3.6	0.37 0.30 1.32 0.21	8.0 3.2 7.3	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28 07	AGN SBG BLL ESBO	254Ca 49.96 40.67 39.67 39.48	41.51 -0.01 16.62 28.80	3.6 50.4 0.0	3.1 3.2 3.0 2.8	0.99 0.41 4.74 0.28 0.30	4.4 5.5 10.5 3.1 3.6
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501	VOIC BLL BLL BLL BLL	267.15 267.15 261.27 259.81 253.47	D 11.88 17.75 39.76	0.0 0.0 19.8 10.3	→3.2 2.5 2.7 3.6 4.0	0.37 0.30 1.32 0.61	8.0 3.2 7.3 7.3	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A	AGN SBG BLL FSRQ BLL	2 54 CA 49.96 40.67 39.67 39.48 35.67	41.51 -0.01 16.62 28.80 43.04	3.6 50.4 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8	0.99 0.41 4.74 0.28 0.30 0.30	4.4 5.5 10.5 3.1 3.6 3.9
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41	VOIC BLL BLL BLL FSRQ	267.15 267.15 261.27 259.81 253.47 248.82	D 17.10 11.88 17.75 39.76 38.14	0.0 0.0 19.8 10.3 4.2	→3.2S 2.5 2.7 3.6 4.0 2.3	0.37 0.30 1.32 0.61	8.0 3.2 7.3 7.3 7.0	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357	AGN SBG BLL FSRQ BLL FSRO	49.96 40.67 39.67 39.48 35.67 35.28	41.51 -0.01 16.62 28.80 43.04 35.94	3.6 50.4 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1	0.99 0.41 4.74 0.28 0.30 0.30 0.33	4.4 5.5 10.5 3.1 3.6 3.9 4.3
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113	VOIC BLL BLL BLL FSRQ BLL	267.15 267.15 261.27 259.81 253.47 248.82 238.93	D U (6) 70.10 11.88 17.75 39.76 38.14 11.19	S .2 0.0 19.8 10.3 4.2 0.0	→3.2S 2.5 2.7 3.6 4.0 2.3 2.8	0.37 0.30 1.32 0.61	8.0 3.2 7.3 7.3 7.0 3.2	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015	AGN SBG BLL FSRQ BLL FSRQ FSRQ FSRQ	49.96 40.67 39.67 39.48 35.67 35.28 34.46	41.51 -0.01 16.62 28.80 43.04 35.94 1.74	3.6 50.4 0.0 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\end{array}$	4.4 5.5 10.5 3.1 3.6 3.9 4.3 2.3
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129	VOIC BLL BLL BLL FSRQ BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75	D U (6 A 70.10 11.88 17.75 39.76 38.14 11.19 61.50	S 2.2 0.0 19.8 10.3 4.2 0.0 29.7	3.2 2.5 2.7 3.6 4.0 2.3 2.8 3.0	0.37 0.30 1.32 0.61 0.50 0.32 2.74	8.0 3.2 7.3 7.3 7.0 3.2 22.0	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL	40.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81	41.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86	3.6 50.4 0.0 0.0 0.0 0.0 0.0 0.0 1.6	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\end{array}$	4.4 5.5 10.5 3.1 3.6 3.9 4.3 2.3 3.5
OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31	VOIC BLL BLL BLL FSRQ BLL FSRQ FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55	70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74	S 2.2 0.0 19.8 10.3 4.2 0.0 29.7 7.1	→3.2S 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83	8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3	prese	NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL	40.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15	41.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5	0.99 0.41 4.74 0.28 0.30 0.30 0.33 0.27 0.43 0.31	4.4 5.5 10.5 3.1 3.6 3.9 4.3 2.3 3.5 3.5
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ \text{IH 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ \text{4C +38.41} \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26	70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44	S .2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0	→3.2 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28	8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9	prese	PIC CIC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL	49.96 40.67 39.67 39.67 35.28 35.67 35.28 34.46 32.81 26.15 24.14	41.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09 39.10	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	3.1 3.2 3.0 2.8 3.1 3.2 1.7 2.5 2.6	0.99 0.41 4.74 0.28 0.30 0.30 0.33 0.27 0.43 0.31 0.28	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 4.1\end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ \text{IH 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ \text{4C +38.41} \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10	P 1 (1) 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50	0.0 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0	→3.25 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0	0.37 0.30 1.32 0.61 0.61 0.32 2.74 0.83 0.28 0.33	8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6	prese	PICCLC: 0050 NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL SBG	49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52	41.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09 39.10 30.62	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99	P 1 (188) 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03	0.0 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5	 →3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 	earch 0.37 0.30 1.32 0.61 0.61 0.32 2.74 0.83 0.28 0.33 0.94	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3	prese	PICCLC: 0050 NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL SBG BLL	40.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03	11.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09 39.10 30.62 22.75	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1441+25 PKS 1424+240	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76	P 17.61 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80	0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.9 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.33 0.94 2.80	8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3	prese	PIC CIC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL SBG BLL FSRQ	b 5. C (a) 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16	11.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09 39.10 30.62 22.75 1.59	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61	P 1 (18 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56	S ² -2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 	0.37 0.30 1.32 0.61 0.60 0.32 2.74 0.83 0.28 0.33 0.94 2.80 0.25	8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL SBG BLL FSRQ SBG	b 5. C (a) 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82	$\begin{array}{c} \textbf{1.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0 0.0 11.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL BLL FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88	S .2- 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.8 	0.37 0.30 1.32 0.61 0.32 2.74 0.83 0.28 0.33 0.94 2.80 0.25 0.25	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0	prese	PIC CLC: C 0, SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL	40.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64	$\begin{array}{c} \textbf{1.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0 0.0 11.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \\ \text{S4 1250+53} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL BLL FSRQ BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02	S 2.2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 2.2	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.8 2.5 	0.37 0.30 1.32 0.61 0.60 0.32 2.74 0.83 0.28 0.33 0.94 2.80 0.25 0.39	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9	prese	PIC CTC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148	AGN SBG BLL FSRQ BLL FSRQ FSRQ BLL BLL SBG BLL FSRQ SBG BLL BLL BLL BLL	3 5.67 39.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14	A1.51 -0.01 16.62 28.80 43.04 35.94 1.74 10.86 27.09 39.10 30.62 22.75 1.59 41.24 6.14 -14.56	3.6 50.4 0.0 0.0 0.0 0.0 0.0 0.0 11.6 0.0 0.0 11.4 2.0 0.0 11.0 0.0 11.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ \end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL BLL FSRQ BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34	S 2.2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 2.2 0.0	 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 2.5 2.8 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.33 0.94 2.80 0.25 0.39 0.35	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL BLL GAL	4 9.96 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 5.3 3.6	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ \end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443	VOIC BLL BLL BLL FSRQ BLL FSRQ FSRQ FSRQ FSRQ FSRQ BLL BLL FSRQ BLL BLL FSRQ	267.15 267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73	S 2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 2.2 0.0 0.0 0.0	 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 2.5 2.8 2.6 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.35 0.25 0.35 0.28	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1837-069	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL BLL GAL GAL	2 5. C (3 9.96) 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 5.3 3.6 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ 4.0\\ \hline \end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443 M 87	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ FSRQ BLL BLL FSRQ BLL BLL FSRQ AGN	267.15 267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71	P 166a 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 31.74 31.74 31.74 31.74 31.74 31.74 325.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39	S 2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 2.2 0.0 0.0 0.0 0.0	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.8 2.5 2.8 2.6 2.8 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.35 0.28 0.29	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1837-069 PKS 1510-089	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL GAL GAL FSRQ	$\begin{array}{c} \textbf{5.Ca} \\ \textbf{49.96} \\ \textbf{40.67} \\ \textbf{39.67} \\ \textbf{39.67} \\ \textbf{39.48} \\ \textbf{35.67} \\ \textbf{35.28} \\ \textbf{34.46} \\ \textbf{32.81} \\ \textbf{26.15} \\ \textbf{24.14} \\ \textbf{23.52} \\ \textbf{18.03} \\ \textbf{17.16} \\ \textbf{10.82} \\ \textbf{5.64} \\ \hline \\ \textbf{339.14} \\ \textbf{280.23} \\ \textbf{279.43} \\ \textbf{228.21} \\ \end{array}$	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.0 0.0 11.0 0.0 11.0 0.0 0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8 1.7	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ 4.0\\ 7.1\\ \end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443 M 87 ON 246	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL BLL FSRQ BLL BLL FSRQ AGN BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56	P 166a 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30	S 2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.8 2.6 2.8 1.7 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.35 0.28 0.29 0.37	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1837-069 PKS 1510-089 PKS 1329-049	AGN SBG BLL FSRQ BLL FSRQ FSRQ FSRQ BLL BLL SBG BLL SBG BLL SBG BLL BLL GAL GAL GAL FSRQ FSRQ FSRQ	$\begin{array}{c} \textbf{5.Ca} \\ \textbf{49.96} \\ \textbf{40.67} \\ \textbf{39.67} \\ \textbf{39.67} \\ \textbf{39.48} \\ \textbf{35.67} \\ \textbf{35.28} \\ \textbf{34.46} \\ \textbf{32.81} \\ \textbf{26.15} \\ \textbf{24.14} \\ \textbf{23.52} \\ \textbf{18.03} \\ \textbf{17.16} \\ \textbf{10.82} \\ \textbf{5.64} \\ \hline \\ \textbf{339.14} \\ \textbf{280.23} \\ \textbf{279.43} \\ \textbf{228.21} \\ \textbf{203.02} \\ \end{array}$	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.0 0.0 11.0 0.0 11.0 0.0 11.0 0.0 0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8 1.7 2.7	$\begin{array}{c} 0.99\\ 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ \end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \\ \text{S4 1250+53} \\ \text{PG 1246+586} \\ \text{MG1 J123931+0443} \\ \text{M 87} \\ \text{ON 246} \\ \text{3C 273} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL FSRQ BLL FSRQ AGN BLL FSRQ AGN BLL FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04	$\begin{bmatrix} \mathbf{S}_{2.2} \\ 0.0 \\ 0.0 \\ 19.8 \\ 10.3 \\ 4.2 \\ 0.0 \\ 29.7 \\ 7.1 \\ 0.0 \\ 0.0 \\ 7.5 \\ 41.5 \\ 0.0 \\ 0.0 \\ 0.2 \\ 0.0$	 3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.8 2.5 2.8 2.6 2.8 1.7 3.0 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9	prese	PIECTES 0, SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1841-055 HESS J1837-069 PKS 1510-089 PKS 1329-049 NGC 4945	AGN SBG BLL FSRQ BLL FSRQ FSRQ FSRQ BLL BLL SBG BLL SBG BLL FSRQ SBG BLL GAL GAL GAL FSRQ FSRQ SBG	5. C (a) 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 5.3 3.6 0.0 0.1 6.1 0.3	 3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 1.7 2.6 	$\begin{array}{c} 0.99\\ 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ \hline \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ \end{array}$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ \text{IH 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ \text{4C +38.41} \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \\ \text{S4 1250+53} \\ \text{PG 1246+586} \\ \text{MG1 J123931+0443} \\ \text{M 87} \\ \text{ON 246} \\ \text{3C 273} \\ \text{4C +21 35} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL FSRQ BLL FSRQ AGN BLL FSRQ AGN BLL FSRQ FSRQ FSRQ	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186 23	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38	$\begin{bmatrix} \mathbf{S}_{2.2} \\ 0.0 \\ 0.0 \\ 19.8 \\ 10.3 \\ 4.2 \\ 0.0 \\ 29.7 \\ 7.1 \\ 0.0 \\ 0.0 \\ 7.5 \\ 41.5 \\ 0.0$	7 3.3 S 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.9 3.0 2.8 2.5 2.8 2.5 2.8 2.6 2.8 1.7 3.0 2.6	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.32	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5	prese	PIC CIC: CO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1841-055 HESS J1837-069 PKS 1329-049 NGC 4945 3C 279	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL BLL SBG BLL BLL GAL GAL FSRQ FSRQ FSRQ SBG	5.62 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36 194.04 190.04 19	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \\ \textbf{-5.79} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 11.0 0.0 11.4 2.0 0.0 11.6 0.0 0.0 11.4 2.0 0.0 0.0 1.6 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	 3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8 1.7 2.6 2.8 1.7 2.6 2.4 	$\begin{array}{c} 0.99\\ 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.21\\ \hline \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 1.5\\ 1.5\\ 1.5\\ 1.5\\ 1.5\\ 1.5\\ 1.5\\ 1.5$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443 M 87 ON 246 3C 273 4C +21.35 W Comae	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL FSRQ BLL FSRQ BLL FSRQ AGN BLL FSRQ BLL FSRQ FSRQ BLL FSRQ FSRQ BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186.23 185.38	P 17.64 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38 28.24	$\begin{bmatrix} \mathbf{S}_{2.2} \\ 0.0 \\ 0.0 \\ 19.8 \\ 10.3 \\ 4.2 \\ 0.0 \\ 29.7 \\ 7.1 \\ 0.0 \\ 0.0 \\ 7.5 \\ 41.5 \\ 0.0$	3.25 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.9 3.0 2.8 2.5 2.8 2.5 2.8 2.6 2.8 1.7 3.0 2.6 3.0	earch 0.37 0.30 1.32 0.61 0.61 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.32 0.39 0.35 0.28 0.29 0.37 0.28 0.32 0.32 0.32 0.32 0.32 0.32 0.35 0.32 0.35 0.32 0.35 0.35 0.32 0.35 0.37 0.37 0.37 0.37 0.39 0.37 0.37 0.37 0.37 0.37 0.38 0.39 0.37 0.37 0.38 0.37 0.38 0.39 0.37 0.38 0.39 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.37 0.38 0.37 0.38 0.37 0.38 0.37 0.38 0.32 0.37 0.38 0.32 0.37 0.38 0.32 0.37 0.38 0.32 0.37 0.38 0.32 0.39 0.37 0.38 0.32 0.39 0.37 0.38 0.32 0.39 0.37 0.38 0.32 0.39 0.37 0.38 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39 0.32 0.39	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5 3.7	prese	PIC CIC: CO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1840 HESS J18400 HESS J18400 HESS J18400 HESS J18400 HESS J18400 HESS	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL BLL SBG BLL FSRQ SBG BLL BLL GAL GAL FSRQ SBG FSRQ SBG FSRQ SBG	5.64 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36 194.04 122.07	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \\ \textbf{-5.79} \\ \textbf{-7.86} $	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 5.3 3.6 0.0 0.1 6.1 0.3 0.3 0.0 0.2 0.1 0.1 0.1 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.9 2.8 4.0 3.1 3.0 4.0 2.9 2.8 4.0 3.1 3.0 4.0 2.9 2.8 4.0 3.1 3.0 4.0 2.9 2.8 4.0 3.1 3.0 4.0 2.9 2.8 4.0 3.1 3.0 4.0 2.8 4.0 3.1 3.0 4.0 2.8 4.0 3.1 3.0 4.0 2.8 4.0 3.1 3.0 4.0 2.8 4.0 3.1 3.0 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 1.7 2.6 2.6 4.0 2.8 4.0 2.8 4.0 2.8 1.7 2.7 2.6 2.6 2.6 4.0 2.8 4.0 2.8 1.7 2.7 2.6 2.6 2.7 2.6 2.7 2.6 2.7 2.6 2.7 2.6 2.7 2.6 2.7 2.6 2.7 2.7 2.6 2.4 2.7 2.7 2.6 2.4 2.7 2.7 2.6 2.4 2.7 2.7 2.6 2.4 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.6 2.7 2.7 2.7 2.6 2.7 2.7 2.7 2.6 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3.7 3	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.31\\ 0.20\\ 0.31\\ 0.50\\ \hline \end{array}$	4.4 5.5 10.5 3.1 3.6 3.9 4.3 2.3 3.5 3.5 4.1 6.3 3.7 2.4 9.6 2.4 21.4 4.8 4.0 7.1 5.1 50.2 2.7 4.7
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \\ \text{S4 1250+53} \\ \text{PG 1246+586} \\ \text{MG1 J123931+0443} \\ \text{M 87} \\ \text{ON 246} \\ \text{3C 273} \\ 4\text{C} + 21.35 \\ \text{W Comae} \\ \text{PG 1218+304} \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL BLL FSRQ BLL FSRQ AGN BLL FSRQ FSRQ FSRQ BLL FSRQ FSRQ BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186.23 185.38 185.38	P 17.64 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38 28.24 30.17	S .2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 2.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.25 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.4 2.7 3.0 2.4 3.9 3.0 2.8 2.5 2.8 2.5 2.8 2.6 2.8 2.5 2.8 2.6 2.8 3.0 2.5 3.0 2.3 3.0 2.4 3.0 2.3 3.0 2.4 3.0 2.3 3.0 2.4 3.0 2.3 3.0 2.4 3.0 2.3 3.0 2.4 3.0 2.5 3.0 2.4 3.0 2.5 3.0 2.5 3.0 2.5 3.0 2.5 3.0 2.5 3.0 2.5 3.0 2.5 3.0 3.0 2.5 3.0 3.0 2.5 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0	earch 0.37 0.30 1.32 0.61 0.61 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.32 0.32 0.70	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5 3.7 6.7	prese	PIC CIC: CO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1841-055 HESS J1841-055 HESS J1837-069 PKS 1329-049 NGC 4945 3C 279 PKS 0805-07 PKS 0727-11 UXC	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL BLL GAL GAL FSRQ FSRQ FSRQ FSRQ SBG FSRQ SBG SBG SBG SBG SBG SBG SBG SBG	5.623 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36 194.04 122.07 112.58 80.23	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \\ \textbf{-5.79} \\ \textbf{-7.86} \\ \textbf{-11.69 \\ \textbf{-7.86} \\ \textbf{-11.69 \\ \textbf{-7.86} \\ \textbf{-11.69 \\ \textbf{-7.86} \\ \textbf{-11.69 \\ \textbf{-7.86} \\ -7.86 \\ \textbf{-7.86 \\ \textbf{-7.8$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 3.1 3.0 2.9 2.6 4.0 3.1 3.0 2.9 2.8 2.9 3.1 3.0 2.9 2.9 2.9 2.7 2.5 2.6 4.0 2.9 2.7 2.5 2.6 4.0 2.9 2.7 2.5 2.6 4.0 2.9 2.7 2.5 2.6 2.7 2.5 2.6 2.7 2.7 2.5 2.6 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7 2.7	$\begin{array}{c} 0.99\\ 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.31\\ 0.20\\ 0.31\\ 0.59\\ 0.26\\ \hline \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 1.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 1.1\\ 50.2\\ 2.7\\ 11.4\\ 1.1\\ 1.1\\ 1.1\\ 1.1\\ 1.1\\ 1.1\\ 1.$
$\begin{array}{c} \text{OT 081} \\ \text{OT 081} \\ \text{S4 1749+70} \\ 1\text{H 1720+117} \\ \text{PKS 1717+177} \\ \text{Mkn 501} \\ 4\text{C} + 38.41 \\ \text{PG 1553+113} \\ \textbf{GB6 J1542+6129} \\ \text{B2 1520+31} \\ \text{PKS 1502+036} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1502+106} \\ \text{PKS 1441+25} \\ \textbf{PKS 1441+25} \\ \textbf{PKS 1441+25} \\ \textbf{PKS 1424+240} \\ \text{NVSS J141826-023} \\ \text{B3 1343+451} \\ \text{S4 1250+53} \\ \text{PG 1246+586} \\ \text{MG1 J123931+0443} \\ \text{M 87} \\ \text{ON 246} \\ \text{3C 273} \\ 4\text{C} + 21.35 \\ \text{W Comae} \\ \text{PG 1218+304} \\ \text{PKS 1216 010} \\ \end{array}$	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL BLL FSRQ BLL FSRQ BLL FSRQ BLL FSRQ BLL FSRQ BLL BLL BLL BLL BLL BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186.23 185.38 185.34 184.64	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38 28.24 30.17 -1.33	S .2- 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 7.5 41.5 0.0 0.0 2.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.25 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.4 2.7 3.0 2.4 3.9 3.0 2.8 2.5 2.8 2.5 2.8 2.6 2.8 1.7 3.0 2.6 2.8 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.8 3.0 2.4 2.8 3.0 2.8 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 2.8 3.0 2.8 2.8 2.8 2.8 3.0 2.8 2.8 3.0 2.8 2.8 3.0 2.8 2.8 3.0 2.8 2.8 3.0 2.6 3.0 2.8 3.0 2.8 3.0 2.8 2.8 3.0 2.9 3.0 2.9 3.0 2.8 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.9 3.0 2.8 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 2.9 3.0 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 3.0 2.9 2.9 3.0 2.9 2.9 2.9 2.9 2.9 2.9 2.9 2.9 2.9 2.9	0.37 0.30 1.32 0.61 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.32 0.32 0.70 0.45	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5 3.7 6.7 3.1	prese	PIC CLC: CO 0 SO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1837-069 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1529-049 NGC 4945 3C 279 PKS 0805-07 PKS 0727-11 LMC SMC	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL BLL SBG BLL FSRQ SBG BLL GAL FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ SBG SBG SBG SBG SBG SBG SBG SBG	5.623 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 200.23 279.43 228.21 203.02 196.36 194.04 122.07 112.58 80.00 14.50	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \\ \textbf{-5.79} \\ \textbf{-7.86} \\ \textbf{-11.69} \\ \textbf{-7.86} \\ \textbf{-11.69} \\ \textbf{-68.75} \\ \textbf{-7.75} \\ -7.7$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 4.0 2.8 3.1 3.7 2.6 2.4 2.4 3.1 3.5 3.1 3.5 3.1 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.31\\ 0.59\\ 0.36\\ 0.27\\ \hline \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 4.1\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.1\\ 1.4\\ 1.4$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443 M 87 ON 246 3C 273 4C +21.35 W Comae PG 1218+304 PKS 1216-010 B2 1215+20	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL BLL FSRQ BLL FSRQ AGN BLL FSRQ BLL FSRQ BLL FSRQ BLL BLL BLL BLL BLL BLL BLL	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186.23 185.38 185.34 185.34	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38 28.24 30.17 -1.33 30 12	S .2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.9 3.0 2.4 3.9 3.0 2.8 2.5 2.8 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0	0.37 0.30 1.32 0.61 0.61 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.32 0.39 0.35 0.28 0.32 0.37 0.28 0.32 0.39 0.35 0.28 0.32 0.37 0.28 0.32 0.37 0.28 0.32 0.37 0.28 0.32 0.37 0.28 0.32 0.37 0.28 0.32 0.45 1.00	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5 3.7 6.7 3.1 85	prese	PIC CIC: CO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1837-069 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 150-049 NGC 4945 3C 279 PKS 0805-07 PKS 0727-11 LMC SMC PKS 0049 00	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL GAL FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ	5.C (a) 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36 194.04 122.07 112.58 80.00 14.50 12.68	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.16} \\ \textbf{-49.47} \\ \textbf{-5.79} \\ \textbf{-7.86} \\ \textbf{-11.69} \\ \textbf{-68.75} \\ \textbf{-72.75} \\ \textbf{-9.40} \\ \textbf{-49.40} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.0 0.0 11.0 0.0 0.0 11.4 2.0 0.0 11.0 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 3.1 3.2 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 3.1 3.2 2.5 3.1 3.2 3.2 3.2 3.1 3.2 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.2 3.1 3.0 4.0 2.9 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.5 3.1 3.7 3.5 3.1 3.2 3.1 3.1 3.2 3.1 3.1 3.2 3.1 3.1 3.2 3.1 3.1 3.2 3.1 3.1 3.1 3.1 3.1 3.1 3.1 3.1	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.31\\ 0.59\\ 0.36\\ 0.37\\ 0.87\\ 0.87\\ \hline 0.87\\ 0.87\\ \hline 0.87\\ 0.87\\ \hline 0.97\\ \hline 0$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline \\ 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 41.1\\ 10.0\\ \hline \end{array}$
OT 081 OT 081 S4 1749+70 1H 1720+117 PKS 1717+177 Mkn 501 4C +38.41 PG 1553+113 GB6 J1542+6129 B2 1520+31 PKS 1502+036 PKS 1502+106 PKS 1502+106 PKS 1441+25 PKS 1424+240 NVSS J141826-023 B3 1343+451 S4 1250+53 PG 1246+586 MG1 J123931+0443 M 87 ON 246 3C 273 4C +21.35 W Comae PG 1218+304 PKS 1216-010 B2 1215+30 Top 500	VOIC BLL BLL BLL FSRQ BLL FSRQ AGN FSRQ FSRQ BLL BLL FSRQ BLL BLL FSRQ AGN BLL FSRQ FSRQ BLL BLL BLL BLL BLL BLL BLL BLL ESPO	267.15 261.27 259.81 253.47 248.82 238.93 235.75 230.55 226.26 226.10 220.99 216.76 214.61 206.40 193.31 192.08 189.89 187.71 187.56 187.27 186.23 185.38 185.38 185.34 184.48 184.48	P 1662 70.10 11.88 17.75 39.76 38.14 11.19 61.50 31.74 3.44 10.50 25.03 23.80 -2.56 44.88 53.02 58.34 4.73 12.39 25.30 2.04 21.38 28.24 30.17 -1.33 30.12 20.24	S .2 0.0 19.8 10.3 4.2 0.0 29.7 7.1 0.0 29.7 7.1 0.0 0.0 7.5 41.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	3.25 2.5 2.7 3.6 4.0 2.3 2.8 3.0 2.4 2.7 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.4 3.0 2.8 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.4 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 3.0 2.8 2.8 3.0 2.8 2.8 3.0 2.8 2.8 2.8 2.8 2.8 2.8 2.8 2.6 2.8 1.7 3.0 2.6 3.0 3.0 2.6 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 	0.37 0.30 1.32 0.61 0.50 0.32 2.74 0.83 0.28 0.25 0.39 0.35 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.29 0.37 0.28 0.32 0.37 0.28 0.32 0.70 0.45 1.09 0.20	11.0 8.0 3.2 7.3 7.3 7.0 3.2 22.0 7.3 2.9 2.6 7.3 12.3 2.0 5.0 5.9 6.4 2.4 3.1 4.2 1.9 3.5 3.7 6.7 3.1 8.5 4.5	prese	PIC CIC: CO NGC 1275 NGC 1068 PKS 0235+164 4C +28.07 3C 66A B2 0218+357 PKS 0215+015 MG1 J021114+1051 TXS 0141+268 B3 0133+388 NGC 598 S2 0109+22 4C +01.02 M 31 PKS 0019+058 PKS 2233-148 HESS J1841-055 HESS J1837-069 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 1510-089 PKS 0805-07 PKS 0805-07 PKS 0727-11 LMC SMC PKS 0048-09 NGC 252	AGN SBG BLL FSRQ BLL FSRQ BLL BLL BLL SBG BLL FSRQ SBG BLL GAL FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ FSRQ SBG SBG SBG SBG SBG SBG SBG	5.623 49.96 40.67 39.67 39.48 35.67 35.28 34.46 32.81 26.15 24.14 23.52 18.03 17.16 10.82 5.64 339.14 280.23 279.43 228.21 203.02 196.36 194.04 122.07 112.58 80.00 14.50 12.68 11.90	$\begin{array}{c} \textbf{11.51} \\ \textbf{-0.01} \\ 16.62 \\ 28.80 \\ 43.04 \\ 35.94 \\ 1.74 \\ 10.86 \\ 27.09 \\ 39.10 \\ 30.62 \\ 22.75 \\ 1.59 \\ 41.24 \\ 6.14 \\ \hline \textbf{-14.56} \\ \textbf{-5.55} \\ \textbf{-6.93} \\ \textbf{-9.10} \\ \textbf{-5.79} \\ \textbf{-7.86} \\ \textbf{-11.69} \\ \textbf{-68.75} \\ \textbf{-72.75} \\ \textbf{-9.49} \\ \textbf{-25.20} \end{array}$	3.6 50.4 0.0 0.0 0.0 0.0 0.0 1.6 0.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 0.0 11.4 2.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	3.1 3.2 3.0 2.8 2.8 3.1 3.2 1.7 2.5 2.6 4.0 3.1 3.0 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 4.0 2.9 2.8 3.1 3.2 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.5 2.6 4.0 3.1 3.0 2.9 2.8 3.1 3.2 2.5 2.6 4.0 3.1 3.0 2.9 2.8 3.1 3.2 2.5 2.6 4.0 3.1 3.0 2.9 2.8 4.0 2.9 2.8 4.0 2.8 3.1 3.0 4.0 2.9 2.8 3.1 3.0 4.0 2.9 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 4.0 2.8 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.0 3.1 3.5 3.1 3.1 3.5 3.1 3.4 3.1 3.5 3.1 3.4 3.4 3.5 3.1 3.4 3.4 3.4 3.4 3.5 3.1 3.4 3.4 3.4 3.4 3.4 3.4 3.4 3.4	$\begin{array}{c} 0.99\\ 0.41\\ 4.74\\ 0.28\\ 0.30\\ 0.30\\ 0.33\\ 0.27\\ 0.43\\ 0.31\\ 0.28\\ 0.63\\ 0.31\\ 0.28\\ 0.63\\ 0.30\\ 0.26\\ 1.09\\ 0.29\\ \hline 1.26\\ 0.55\\ 0.30\\ 0.41\\ 0.77\\ 0.31\\ 0.20\\ 0.31\\ 0.59\\ 0.36\\ 0.37\\ 0.87\\ 0.75\\ \hline \end{array}$	$\begin{array}{c} 3.4\\ 4.4\\ 5.5\\ 10.5\\ 3.1\\ 3.6\\ 3.9\\ 4.3\\ 2.3\\ 3.5\\ 3.5\\ 3.5\\ 4.1\\ 6.3\\ 3.7\\ 2.4\\ 9.6\\ 2.4\\ \hline \\ 21.4\\ 4.8\\ 4.0\\ 7.1\\ 5.1\\ 50.2\\ 2.7\\ 4.7\\ 11.4\\ 41.1\\ 10.0\\ 0.7\\ 7\\ 7\end{array}$


gamma-ray obscured cores of active galaxies as cosmic accelerators

acceleration of electrons and protons in the high field regions associated with the accretion disk, the optically thick corona of X-rays, and the base of the jet.



neutrinos produced in the gamma-ray obscured core of NGC 1068



point spread function consistent with simulationinsensitive to systematics



- ▶ Rayleigh (1D-projection of 2D Gauss) doesn't describe our Monte Carlo accurately → Tails are suppressed
- The distribution depends on the spectral index!
- Effect mainly visible at < 10 TeV energies where the kinematic angle between neutrino and muon matters
- Solution: Obtain a numerical representation of the V-dependent spatial term from MC simulation (for example using KDEs)

$$\frac{1}{2\pi\sigma^2}e^{-\frac{\psi^2}{2\sigma^2}} \to \mathcal{S}\left(\psi \,|\, \sigma, \, E_{\mu}, \, \gamma\right)$$

Virtual Collaboration Meeting, 2020-09-22

very soon!

High-Energy Cosmic Neutrinos: a Personal Tour francis halzen



IceCube: a neutrino window on the Universe

- the high-energy neutrino flux from the cosmos
 - the first sources
- neutrinos and multimessenger astronomy

IceCube.wisc.edu



v

HIGH-ENERGY EVENTS NOW PUBLIC ALERTS!

We send our high-energy events in real-time as public GCN alerts now!

t]

TITLE:	GCN/AMON NOTICE
NOTICE_DATE:	Wed 27 Apr 16 23:24:24 UT GCN
NOTICE_TYPE:	AMON ICECUBE HESE
RUN_NUM:	127853
EVENT_NUM:	67093193
SRC_RA:	240.5683d {+16h 02m 16s} (J2000),
	240.7644d {+16h 03m 03s} (current),
	239.9678d {+15h 59m 52s} (1950)
SRC_DEC:	+9.3417d {+09d 20' 30"} (J2000),
	+9.2972d {+09d 17' 50"} (current),
	+9.4798d {+09d 28' 47"} (1950)
SRC_ERROR:	35.99 [arcmin radius, stat+sys, 90% containmer
SRC_ERROR50:	0.00 [arcmin radius, stat+sys, 50% containment
DISCOVERY_DATE:	17505 TJD; 118 DOY; 16/04/27 (yy/mm/dd)
DISCOVERY_TIME:	21152 SOD {05:52:32.00} UT
REVISION:	2
N_EVENTS:	1 [number of neutrinos]
STREAM:	1
DELTA_T:	0.0000 [sec]
SIGMA_T:	0.0000 [sec]
FALSE_POS:	0.0000e+00 [s^-1 sr^-1]
PVALUE:	0.0000e+00 [dn]
CHARGE :	18883.62 [pe]
SIGNAL_TRACKNESS:	0.92 [dn]
SUN_POSTN:	35.75d {+02h 23m 00s} +14.21d {+14d 12' 45"

GCN notice for starting track sent Apr 27

We send **rough reconstructions first** and then **update them**.

47



from light in the ice to astronomer in less than one minute



MAGIC detects emission of > 100 GeV gammas

IceCube 170922 290 TeV Fermi detects a flaring blazar within 0.06°



NEUTRINO ASTROPHYSICS

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube Collaboration, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S, *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverpool Telescope, Subaru, *Swift/NuSTAR*, VERITAS, and VLA/17B-403 teams*†

RESEARCH ARTICLE

NEUTRINO ASTROPHYSICS

Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert

IceCube Collaboration*†



- multimessenger observations in the time domain
- change of flux 2 hours after 170922 neutrino
- source is quiet 10 previous and 3 following years

global robotic network of optical telescopes connects TXS 0506+056 to IC170922A in the time domain



"MASTER found the blazar in the off-state *after one minute* and then switched to on-state two hours after the event. The effect is observed at a 50-sigma significance level"

Optical Observations Reveal Strong Evidence for High Energy Neutrino Progenitor

V.M. Lipunov^{1,2}, V.G. Kornilov^{1,2}, K.Zhirkov¹, E. Gorbovskoy², N.M. Budnev⁴, D.A.H.Buckley³, R. Rebolo⁵, M. Serra-Ricart⁵, R. Podesta^{9,10}, N. Tyurina², O. Gress^{4,2}, Yu.Sergienko⁸, V. Yurkov⁸, A. Gabovich⁸, P.Balanutsa², I.Gorbunov², D.Vlasenko^{1,2}, F.Balakin^{1,2}, V.Topolev¹, A.Pozdnyakov¹, A.Kuznetsov², V.Vladimirov², A. Chasovnikov¹, D. Kuvshinov^{1,2}, V.Grinshpun^{1,2}, E.Minkina^{1,2}, V.B.Petkov⁷, S.I.Svertilov^{2,6}, C. Lopez⁹, F. Podesta⁹, H.Levato¹⁰, A. Tlatov¹¹ B. Van Soelen¹², S. Razzaque¹³, M. Böttcher¹⁴

NEUTRINO BEAMS



multimessenger astronomy

- → a target efficient at converting protons into neutrinos is unlikely to be transparent to high energy photons.
- → examples: diffuse flux below 100 TeV, TXS 2014-15 burst, NGC 1068 and even IC170922
- → the energy in pionic photons is absorbed in the target and likely to appear at MeV energies or below.

 \rightarrow one more example



highest energy alert so far





[Previous | Next]

Neutrino candidate source FSRQ PKS 1502+106 at highest flux density at 15 GHz

ATel #12996; S. Kiehlmann (IoA FORTH, OVRO), T. Hovatta (FINCA), M. Kadler (Univ. W¼rzburg), W. Max-Moerbeck (Univ. de Chile), A. C.S. Readhead (OVRO) on 7 Aug 2019; 12:31 UT

Credential Certification: Sebastian Kiehlmann (skiehlmann@mail.de)

Subjects: Radio, Neutrinos, AGN, Blazar, Quasar

У Tweet

On 2019/07/30.86853 UT IceCube detected a high-energy astrophysical neutrino candidate (Atel #12967). The FSRQ PKS 1502+106 is located within the 50% uncertainty region of the event. We report that the flux density at 15 GHz measured with the OVRO 40m Telescope shows a long-term outburst that started in 2014, which is currently reaching an all-time high of about 4 Jy, since the beginning of the OVRO measurements in 2008. A similar 15 GHz long-term outburst was seen in TXS 0506+056 during the neutrino event IceCube-170922A.

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- 12926 VLA observations reveal increasing brightness of 1WHSP J104516.2+275133, a potential source of IC190704A

IC 190730: 300 TeV

- coincident with PKS 1502+106
- radio burst



2009.09792 [astro-ph.HE]





138322 neutrinos in 2011

> 200 cosmic neutrinos (depending on the spectrum)
~12 separated from atmospheric background with E>60 TeV



the earth diameter is 1 absorption length at 70 TeV



partially contained event with energy 6.3 PeV



- energy measurement understood
- shower consistent with the hadronic decay of a weak intermediate boson W
- identification of anti-electron neutrino



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# oscillations of PeV neutrinos over cosmic distances to 1:1:1



oscillating PeV neutrinos [7.5 years starting events]

# tau neutrino production and decay

tau decay length:  $\gamma c \tau = 50 m per PeV$ 



## a cosmic tau neutrino with 17m lifetime

light from nutau interaction and tau decay



# oscillations of PeV neutrinos over cosmic distances to 1:1:1



oscillating PeV neutrinos (7.5 years starting events)





### imminent unblinding:

- analysis with a sample of 210,000 atmospheric neutrinos
- 9,600 tau neutrinos

[9.3 years and 97.3% purity with energies of 5~55 GeV]





next attraction: gravitational waves + neutrinos?

(August 17, 2017 neutron star merger: jet not aligned ⊗)







# neutrino astronomy 2022

- it exists
- more neutrinos, better neutrinos, more telescopes
- closing in on cosmic ray sources
- [are active galaxies with obscured cores the sources of cosmic rays?]

icecube.wisc.edu

# THE ICECUBE COLLABORATION




- the extreme Universe is opaque to the EM spectrum
- non-thermal Universe powered by cosmic accelerators
- probed by gravitational waves and neutrinos

# standing on the shoulder of giants

1987: DUMAND test string





.. success with Baikal and Antares

#### neutrinos produced in the gamma-ray obscured core of NGC 1068





#### selection:

- X-ray catalogues 2RXS + XMMSL2
- IR WISE catalogue: X-rays associated with the core produce infrared light on dust at the center of the galaxy

TABLE I. Properties of the AGN samples created for the analysis. The surveys used for the cross-match to derive each sample, the final number of selected sources, cumulative X-ray flux in the 0.5-2 keV energy range from the selected sources and the completeness (fraction of total X-ray flux from all AGN in the universe contained in the sample) are listed.

| Radio–selected AGN                                                                      |                      | IR–selected AGN         | LLAGN              |
|-----------------------------------------------------------------------------------------|----------------------|-------------------------|--------------------|
| Matched catalogues                                                                      | NVSS + 2RXS + XMMSL2 | ALLWISE + 2RXS + XMMSL2 | ALLWISE + 2RXS     |
| Nr. of sources                                                                          | 9749                 | 32249                   | 15887              |
| Cumulative X-ray flux [erg cm <sup><math>-2</math></sup> s <sup><math>-1</math></sup> ] | $7.71	imes10^{-9}$   | $1.43 \times 10^{-8}$   | $7.26	imes10^{-9}$ |
| Completeness                                                                            | $5^{+5}_{-3}\%$      | $11^{+12}_{-7}\%$       | $6^{+7}_{-4}\%$    |

# multimessenger astronomy $p + \gamma \Rightarrow n + \pi^{+}$ $\pi^{+} \Rightarrow [e^{+} + \overline{\nu}_{\mu} + \nu_{e}] + \nu_{\mu}$ $\Rightarrow p + \pi^{0}$ $\pi^{0} \Rightarrow \gamma + \gamma$ $\gamma + \gamma_{EBL} \Rightarrow \text{cascade}$

 efficient neutrino production sites are likely to be optically thick to gamma rays

IOCK WAVE

- expect no correlation between gamma-ray and neutrino activity
- gamma rays lose energy on the target that produces neutrinos even before reaching the EBL



muon neutrino flux filtered by the Earth: atmos. vs astrophysical



### RADIO INTERFEROMETRY

- core brightening observed in a radio burst that started 5 years ago
- beyond 5 milliarcseconds the jet loses its tight collimation





- obscures the gamma rays
- obscured core: accretion disk, X-ray cocoon, base of the jet, BLR clouds..., we need higher resolution ...



# **NEUTRINO BEAMS**



# the $p\gamma$ efficiency dilemma

 efficiency for producing the neutrinos in the photon target:

 $\tau_{p\gamma} = \mathbf{R}_{\text{escape}} \, \sigma_{\mathbf{p}\gamma} \, \mathbf{n}_{\text{photons}}$ 

 likelihood of the multimessenger photons to be absorbed in target

 $\tau_{\gamma\gamma} = R_{\text{target}} \, \sigma_{\gamma\gamma} \, n_{\text{photons}}$ 

- → therefore, with  $R_{escape} \sim R_{target}$  $\tau_{\gamma\gamma} = 300 \ \frac{R_{target}}{R_{escape}} \tau_{p\gamma}$
- → do not expect high energy gamma rays to accompany cosmic neutrinos

 $\rightarrow$  blazar jets are out

#### gamma rays in 2017 at the time the neutrino is produced? a few ~10 GeV photons and not much else, consistent with an obscured source, not a blazar



- MAGIC, HESS and VERITAS: no TeV gamma rays at the time the neutrino was produced
- MAGIC: onset of the TeV flux 5 days after IC170922
- confirmed by MASTER: the blazar switches from the "off" to "on" state 2 hours after the neutrino



### IceCube dark matter targets



dark matter annihilation in the sun: a smoking gun

world-best limits on spin-dependent cross sections





velocity-independent limits by combining IceCube (sensitive to low velocity) and PICO (sensitive to high velocity) data