

Dissecting the Region around *IC141209A*

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Abstract

Warning: The following results are all preliminary and will be continuously updated whenever calculations are finished. The IceCube Neutrino Observatory has recently reported the detection of a highly-energetic neutrino, *IC141209A*¹ (MJD: 57000.00), with direction $ra: 160.13^\circ$, $dec: 6.29^\circ$ in equatorial and $l: 240.77^\circ$, $b: 52.57^\circ$ in galactic coordinates. Due to the high-energy and the track-like signature the event has a good pointing and is likely of astrophysical origin. With the goal of identifying the corresponding electromagnetic counterpart we report here on the multi-wavelength dissection of the region around the event. This report was generated automatically on 2020-10-28 08:24:22.506 UTC.

1 Identifying Counterpart Candidates

The search for possible counterparts is based on the *VOU-Blazars* tool [1] and follows closely the pipeline developed in [2]. *VOU-Blazars* compares 32 multi-wavelength catalogs² to find all positions in the vicinity of the alert with a *blazar-like* emission profile in radio, optical and X-ray. Each of these matches is then additionally checked against existing catalogs to identify the associated object if possible.

In a second step a dedicated gamma-ray analysis is performed. In order to search for interesting emission features in the region we use *Fermi LAT* data around the event time and run three different analysis pipelines. Firstly, test-statistic maps are generated to search for unknown gamma-ray emitters, e.g. indication for gamma-ray emission from the previously identified *VOU-Blazars* source candidates. Subsequently SEDs and light curves are produced for each identified catalog source and interesting *VOU-Blazars* candidate. Based on these results we can finally search for specific features in flux and spectral shape around the neutrino arrival time.

The gamma-ray analyses are based on the latest version of the FSSC Tools v11r5p3 and the fermipy package [3]. We use the standard procedures as described in the *Fermi LAT* Cicerone [4]. The dataset for the analysis contains events with photon energy above 0.1 GeV in a time window between 54682.7 and 59148.7.

¹NoGCN given

²List of the 32 catalogs used in this analysis: SDSS2, 3HSP, Fermi8YR, 1BIGB, MST9Y, FIRST, SUMSS, WGACAT, IPC2E, ZWCLUSTERS, PSZ2, ABELL, SDSSWHL, CRATES, NVSS, SXPS, RASS, XMMSL, BMW, IPCSL, CHANDRA, MCXC, 5BZCat, SWXCS, PULSAR, F2PSR, 3FHL, 3FGL, 3XMM, MAXI, FermiMEV, AGILE

1.1 Catalog Sources in the Region around IC141209A

The following list gives a quick overview about the catalog blazars in the region. Sources are sorted by their angular distance to the neutrino direction.

4FGL J1040.5+0617 — Energy flux ($E \geq 100\text{MeV}$): $1.91\text{e-}11$ erg/cm²/s [Top 11.4% in 4FGL]
ra: 160.15 deg — dec: 6.28 deg — distance: 0.02 deg [ra: 0.02 deg , dec: -0.00 deg]
Associations: 3FGL J1040.4+0615, 3FHL J1040.5+0618

2 Full Multi-Wavelength Study of the Region

2.1 Description of the Analysis

In this section we present a full multi-wavelength search for possible neutrino counterparts. Starting from 32 multi-wavelength catalogs the VOU-Blazar tool [1] uses the all the available radio, optical and X-ray data in order to identify blazar-like counterparts candidates. The full output of the tool can be found in the appendix.

The analysis pipeline consists of two parts: 1) The radio and x-ray data, as well as the resulting counterpart candidates are shown and compared to the *Fermi LAT* gamma-ray emission in the region around the neutrino alert 2) For all known blazars with a angular distance of less than 1.5 degrees a multi-wavelength SED is constructed, including also a gamma-ray analysis that is started at the time of the neutrino alert. For each source we also calculated a fixed-binning light curve. For details about the analysis see the appendix.

2.2 The Multi-Wavelength SED

The multi-wavelength SED collects and visualizes all the publicly available multi-wavelength data, as well as the result of the gamma-ray analysis. The time evolution of the source is decoded in a color gradient from grey (old) to red (recent). Here the grey SEDs point and bowties represent the *Fermi-LAT* gamma-ray spectrum integrated over the entire mission while the black SED points show the gamma-ray spectrum in a time window around the neutrino arrival time. Colored bands indicate the corresponding spectral fits at different (if available) energy thresholds if the significance of the measurement is above 3σ . The green dashed and solid line show the sensitivity and discovery potential of the IceCube 7yr point-source analysis [5], respectively.

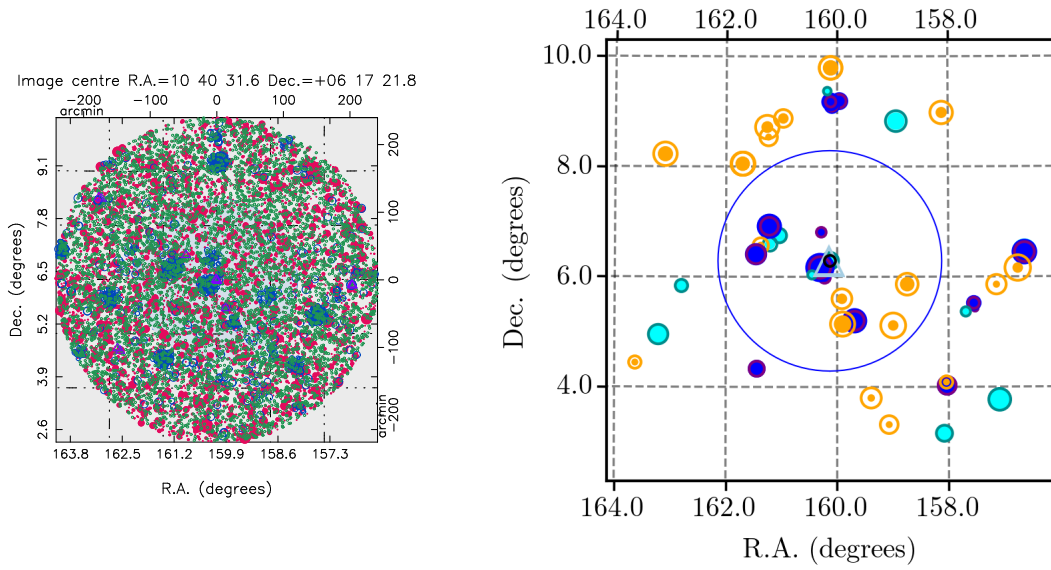


Figure 1: Left Plot: Radio and X-ray sources within 120 arc-minutes of the position of the neutrino event. Symbol diameters are proportional to source intensity. Radio sources appear as red filled circles, X-ray sources as open blue circles and gamma-ray sources as open triangles. Right Plot: Counterpart candidates in a 120 arc-minutes radius around the event direction. Dark blue circles represent LBL type candidates, that is sources with flux ratio in the range observed in the sample of LBL blazars of the latest edition of the BZCAT catalogue [6], cyan symbols are for IBL type candidates, and orange symbols are for HBL candidates. Known blazars are marked by a red diamond if they are included in the BZCAT catalogue or a star if they are part of the 2WHSP sample. The shaded area marks a circle of 90 arc-minutes around the events-best fit direction.

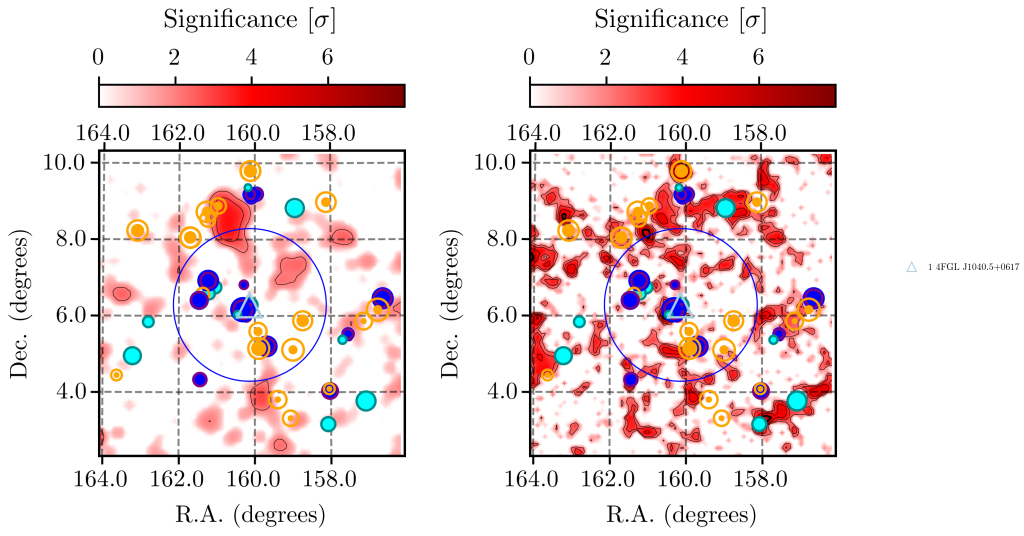


Figure 2: Test-statistic maps of the region after subtracting known sources from the 4FGL catalog. The blue and black contours show the 90% and 50% error regions, respectively. Only photons with energies above 1.0 GeV are included. The map can be used to identify additional, yet unknown gamma-ray emitters, that coincide with multi-wavelength candidates. Contour lines are shown at 2,3,4,5 σ . **Left:** The map of the region for a time window of 200 days (MJD 56900.0, 57100.0) around the neutrino arrival time. **Right:** The map of the region for the entire *Fermi-LAT* mission (MJD 54682.7 to 59148.7).

3 SEDs and Light Curves

3.1 4FGL J1040.5+0617 | $ra = 160.15^\circ$, $dec = 6.28^\circ$, $\Sigma = -1.0 \sigma$, $\Delta\psi = 0.02^\circ$

Associations: 3FGL J1040.4+0615, 3FHL J1040.5+0618

MJD	Probability [%]	Energy[GeV]
58740.06	94.68	33.89
56036.73	98.87	25.02
56776.07	95.19	24.98
56381.39	99.59	22.96
55483.71	90.84	18.41

Table 1: $\geq 5\text{GeV}$ photons with highest probability ($p \geq 90\%$) to be associated with the source

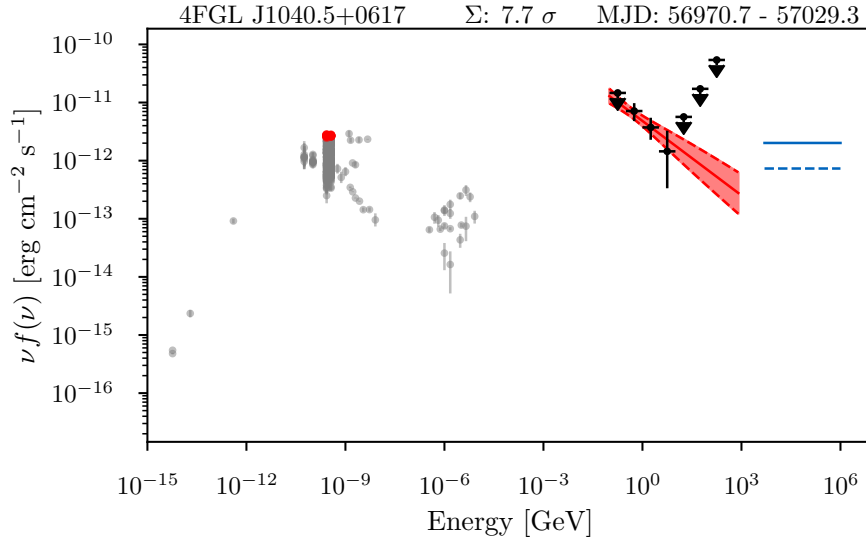


Figure 3: SED for 4FGL J1040.5+0617. See the description in section 2.2 for more details.

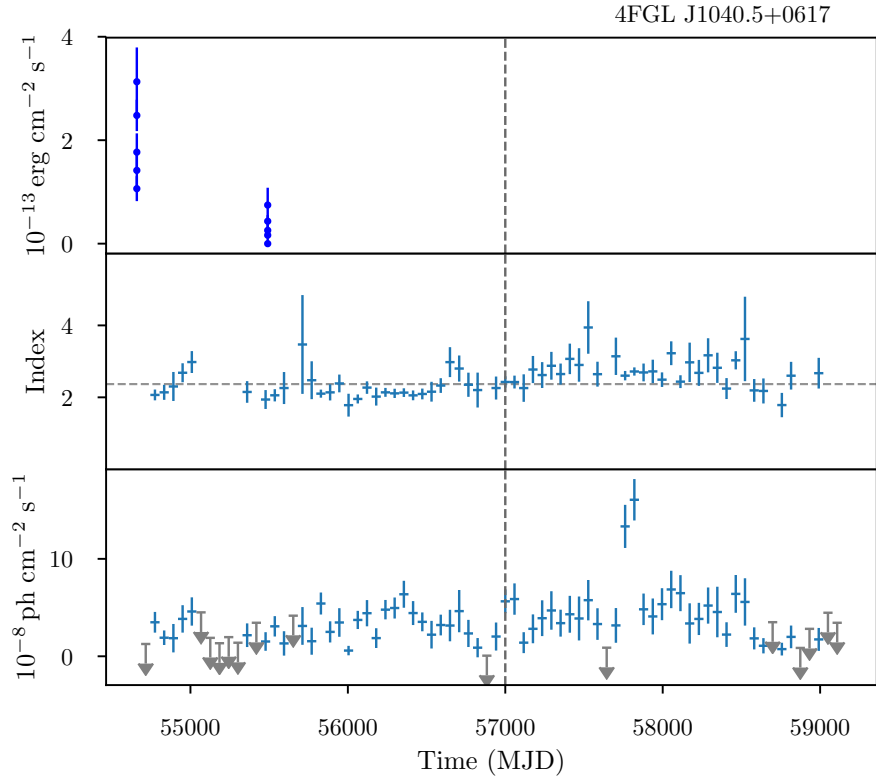


Figure 4: Light curve for 4FGL J1040.5+0617

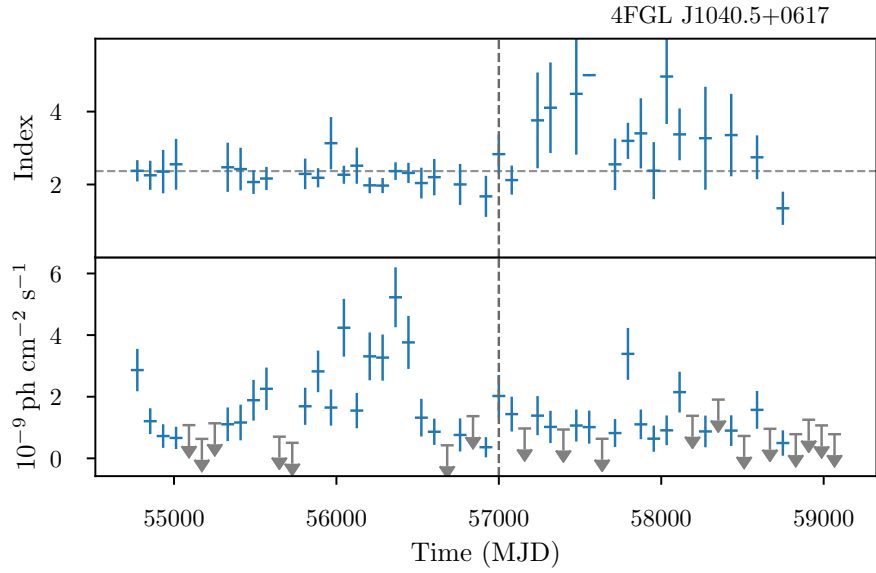


Figure 5: 1GeV light curve for 4FGL J1040.5+0617

Image centre R.A.=10 40 35.9 Dec.=+06 17 5.3

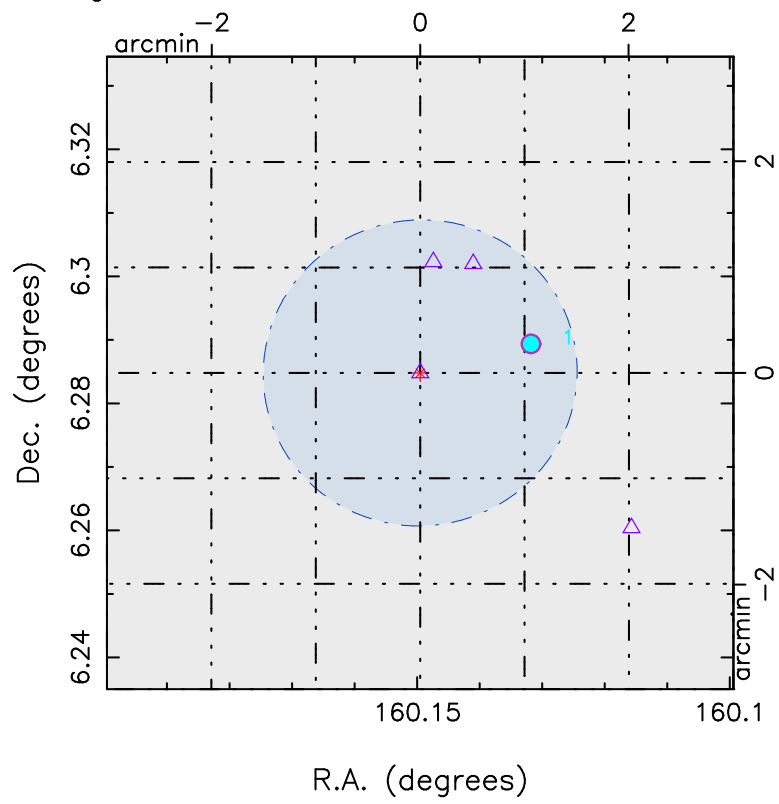


Figure 6: Possible counterparts for 4FGL J1040.5+0617

4 Appendix

4.1 Analysis Details - Light Curve

4.1.1 Light Curve Binning

Since we want to avoid running an extremely time consuming adaptive binning algorithm for all sources we try to estimate reasonable time windows for each source based on the following criteria:

- a) If possible we want to have a significant detection in each time bin
- b) IceCube needs on an order of $\mathcal{O}(100 \text{ days})$ integration time to detect a significant neutrino signal in a point-source analysis
- c) following from b) we don't care too much about extremely short time-windows, since they are experimental hard to access
- d) unknown gamma-ray emitters are not expected to have a large time-integrated signal, but can still have gamma-ray outburst/flares

As a result of this we adapt the following procedure:

- For unknown gamma-ray emitters we built a light curve with time windows of 100 days, starting from the time of the neutrino alert. In case of subsequent measurements close to the detection threshold, an adaptive binning light curve can be run as a follow-up
- For known gamma-ray emitters, i.e. sources listed in the 4FGL catalog, we calculate the time window need for a 5σ (3σ) detection assuming a constant emission. This value is then used as time window, with the only limitation that we limit it to maximal 200 days in order to avoid missing interesting fluctuations around the neutrino arrival time.

The calculation of the time-windows for known-gamma ray emitters is based on the asymptotic behaviour of counting experiments combined with the information given in the 4FGL catalog. For a counting experiments with χ^2 background test-statistic distribution in the asymptotic limit the median test statistic value of a signal behaves as [7]

$$\mathcal{TS} = 2 \times \left[(s + b) \ln \left(1 + \frac{s}{b} \right) - s \right]. \quad (1)$$

As Fermi-LAT has only limited background we consider this equation in the limit of $s \gg b \gg 1$ and $s + b \rightarrow \infty$, hence we can simplify to

$$\mathcal{TS} \rightarrow 2 \times s \left[\ln \left(\frac{s}{b} \right) \right] \quad (2)$$

rewriting $s = s_0 t$ and $b = b_0 t$ we finally get

$$\mathcal{TS} \rightarrow 2 \times s_0 t \left[\ln \left(\frac{s_0}{b_0} \right) \right] \quad (3)$$

which scales linearly in time. The 4FGL catalog provides the 8 year time-integrated test-statistic values for each source in 7 energy bands. In order to calculate the total test-statistic value for our selection we sum up all the test-statistic values with energies larger than the minimum (threshold) energy of this analysis. Finally we can calculate the integration time needed for 5σ ($\mathcal{TS} = 25$) and 3σ ($\mathcal{TS} = 9$) detection using equation (3)

$$t(5\sigma) = \frac{25}{\mathcal{TS}_{8years}} \cdot 2920 [\text{days}] \quad (4)$$

4.2 Analysis Details - SED

The construction of the SED of the counterpart candidates is based on the *VOU-Blazars* tool [1]. For a given source position it identifies all the corresponding measurements based on likelihood ratios test taking into account the specific point spread functions of the 32 respective experiments/catalogs taken into account in our analysis ³. This procedure works stable for multi-wavelength catalogs, as well as single band measurements except for gamma-ray catalogs where the point-spread function is comparably large. For the construction of the SED of Fermi-LAT counterparts the procedure is hence two-step. 1) We run a counterpart search in the given 95% confidence region of the source position. In most cases there is only one (or no) possible multi-wavelength counterpart candidate, in all other cases we assume the strongest source to be the counterpart. 2) We construct the SED using the location of the identified counterpart. In all of these cases the skymap in the vicinity with all the possible multi-wavelength counterparts is additionally shown in the source summary in section 3. Finally the IceCube point source sensitivity and discovery potential are taken from [5] and shown for reference.

³List of the 32 catalogs used in this analysis: SDS82 , 3HSP , Fermi8YR ,1BIGB, MST9Y, FIRST, SUMSS, WGACAT, IPC2E, ZWCLUSTERS, PSZ2, ABELL , SDSSWHL, CRATES, NVSS, SXPS, RASS, XMMSL, BMW , IPCSL, CHANDRA, MCXC, 5BZCat, SWXCS, PULSAR, F2PSR, 3FHL, 3FGL, 3XMM, MAXI, FermiMEV, AGILE

4.3 Full VOU Output

XMMSLEW/FIRST ra dec 10 26 31.7, 06 27 39.0 radio flux d. 376.560 X-ray/radio flux-ratio 68.
arx 0.777 Log(nu peak) 13.3+/- 1 possible IBL **Dist. 208.929 arcmin**

Match nr. 1 ra dec: 156.63223, 6.46084

.....Cataloged sources.....

MQ 3C 243

XMMSLEW/NVSS ra dec 10 26 32.0, 06 27 32.7 radio flux d. 851.500 flux-ratio 30. arx 0.820
possible LBL **Dist. 208.868 arcmin**

SXPS/NVSS ra dec 10 26 32.0, 06 27 32.7 radio flux d. 851.500 flux-ratio 17. arx 0.850 possible
LBL **Dist. 208.868 arcmin**

Match nr. 2 ra dec: 156.63317, 6.45908

.....Cataloged sources.....

XMMSLEW/FIRST ra dec 10 26 32.2, 06 27 28.4 radio flux d. 457.890 flux-ratio 56. arx 0.788
possible LBL **Dist. 208.817 arcmin**

!!!Warning, check X-ray counterpart!

Repeated radio counterpart, 5.142 arcsec away from the matched nr. 2

XMMSLEW/NVSS ra dec 10 27 3.3, 06 09 34.3 radio flux d. 10.100 X-ray/radio flux-ratio 16022.
arx 0.489 Log(nu peak) 19.0+/- 1 possible HBL **Dist. 201.041 arcmin**

RASS/NVSS ra dec 10 27 3.3, 06 09 34.3 radio flux d. 10.100 X-ray/radio flux-ratio 20042. arx
0.478 Log(nu peak) 19.2+/- 1 possible HBL **Dist. 201.041 arcmin**

Match nr. 3 ra dec: 156.76379, 6.15953

.....Cataloged sources.....

3HSPJ102703.0+060933

5BZB J1027+0609

MQ SDSS J102703.39+060933.9

XMMSLEW/FIRST ra dec 10 27 3.4, 06 09 33.7 radio flux d. 6.910 X-ray/radio flux-ratio 23418.
arx 0.469 Log(nu peak) 19.4+/- 1 possible HBL **Dist. 201.027 arcmin**

RASS/FIRST ra dec 10 27 3.4, 06 09 33.7 radio flux d. 6.910 X-ray/radio flux-ratio 29295. arx
0.458 Log(nu peak) 19.6+/- 1 possible HBL **Dist. 201.027 arcmin**

Repeated radio counterpart, 1.048 arcsec away from the matched nr. 3

RASS/NVSS ra dec 10 28 23.6, 03 45 36.2 radio flux d. 305.700 X-ray/radio flux-ratio 146.
arx 0.737 Log(nu peak) 14.1+/- 1 possible IBL **Dist. 236.420 arcmin**

Match nr. 4 ra dec: 157.09854, 3.76006

.....Cataloged sources.....

mcxcJ1028.3+0346

whl J102823.5+034531

zw 10527

RASS/NVSS ra dec 10 28 33.1, 05 51 49.7 radio flux d. 2.900 X-ray/radio flux-ratio 6113. arx
0.540 Log(nu peak) 18.0+/- 1 possible HBL **Dist. 180.445 arcmin**

Match nr. 5 ra dec: 157.13783, 5.86381

.....Cataloged sources.....

4XMM/NVSS ra dec 10 30 5.7, 05 25 50.1 radio flux d. 3.300 flux-ratio 23. arx 0.835 possible LBL **Dist. 163.971 arcmin**
Match nr. 6 ra dec: 157.52375, 5.43058
.....Cataloged sources.....
MQ SDSS J103005.78+052543.8

4XMM/FIRST ra dec 10 30 5.8, 05 25 44.1 radio flux d. 3.970 flux-ratio 19. arx 0.844 possible LBL **Dist. 163.978 arcmin**
Match nr. 7 ra dec: 157.52418, 5.42893
.....Cataloged sources.....

4XMM/FIRST ra dec 10 30 10.6, 05 29 41.2 radio flux d. 5.990 flux-ratio 43. arx 0.801 possible LBL **Dist. 161.635 arcmin**
Match nr. 8 ra dec: 157.54406, 5.49479
.....Cataloged sources.....

4XMM/FIRST ra dec 10 30 12.6, 05 31 50.3 radio flux d. 27.800 flux-ratio 23. arx 0.835 possible LBL **Dist. 160.531 arcmin**
Match nr. 9 ra dec: 157.55241, 5.53063
.....Cataloged sources.....

4XMM/NVSS ra dec 10 30 48.5, 05 22 12.5 radio flux d. 2.600 X-ray/radio flux-ratio 120. arx 0.748 Log(nu peak) 13.8+/- 1 possible IBL **Dist. 155.155 arcmin**
Match nr. 10 ra dec: 157.70221, 5.37014
.....Cataloged sources.....

SXPS/NVSS ra dec 10 32 8.3, 04 01 55.8 radio flux d. 165.800 flux-ratio 53. arx 0.791 possible LBL **Dist. 184.511 arcmin**
Match nr. 11 ra dec: 158.03471, 4.03217
.....Cataloged sources.....
5BZB J1032+0401
MQ TEX 1029+042

SXPS/FIRST ra dec 10 32 8.4, 04 01 56.5 radio flux d. 112.660 X-ray/radio flux-ratio 78. arx 0.770 Log(nu peak) 13.4+/- 1 possible IBL **Dist. 184.495 arcmin**
Repeated radio counterpart, 0.944 arcsec away from the matched nr. 11

SXPS/FIRST ra dec 10 32 11.1, 04 05 39.1 radio flux d. 1.090 X-ray/radio flux-ratio 981. arx 0.637 Log(nu peak) 16.1+/- 1 possible HBL **Dist. 181.314 arcmin**
Match nr. 12 ra dec: 158.04637, 4.09419
.....Cataloged sources.....

OUSXB/FIRST ra dec 10 32 20.3, 03 09 49.2 radio flux d. 31.080 X-ray/radio flux-ratio 123. arx 0.746 Log(nu peak) 13.9+/- 1 possible IBL **Dist. 223.957 arcmin**
SXPS/FIRST ra dec 10 32 20.3, 03 09 49.2 radio flux d. 31.080 X-ray/radio flux-ratio 139. arx 0.740 Log(nu peak) 14.0+/- 1 possible IBL **Dist. 223.957 arcmin**

Match nr. 13 ra dec: 158.08445, 3.16366

.....Cataloged sources.....

5BZB J1032+0309

MQ SDSS J103220.28+030949.2

OUSXB/NVSS ra dec 10 32 20.3, 03 09 47.5 radio flux d. 32.900 X-ray/radio flux-ratio 116.
arx 0.749 Log(nu peak) 13.8+/- 1 possible IBL **Dist. 223.971 arcmin**

!!!Warning, check X-ray counterpart!

Repeated radio counterpart, 2.006 arcsec away from the matched nr. 13

SXPS/FIRST ra dec 10 32 28.9, 08 59 7.5 radio flux d. 8.480 X-ray/radio flux-ratio 6641. arx
0.536 Log(nu peak) 18.1+/- 1 possible HBL **Dist. 201.176 arcmin**

Match nr. 14 ra dec: 158.12037, 8.98541

.....Cataloged sources.....

MQ SDSS J103228.89+085907.3

SXPS/NVSS ra dec 10 32 28.9, 08 59 7.0 radio flux d. 16.600 X-ray/radio flux-ratio 3392. arx
0.571 Log(nu peak) 17.4+/- 1 possible HBL **Dist. 201.169 arcmin**

Repeated radio counterpart, 0.469 arcsec away from the matched nr. 14

4XMM/FIRST ra dec 10 34 58.4, 05 52 32.0 radio flux d. 21.160 X-ray/radio flux-ratio 1435.
arx 0.617 Log(nu peak) 16.5+/- 1 possible HBL **Dist. 86.490 arcmin**

XMMMSLEW/FIRST ra dec 10 34 58.4, 05 52 32.0 radio flux d. 21.160 X-ray/radio flux-ratio 3460.
arx 0.570 Log(nu peak) 17.4+/- 1 possible HBL **Dist. 86.490 arcmin**

SXPS/FIRST ra dec 10 34 58.4, 05 52 32.0 radio flux d. 21.160 X-ray/radio flux-ratio 909. arx
0.641 Log(nu peak) 16.0+/- 1 possible HBL **Dist. 86.490 arcmin**

Match nr. 15 ra dec: 158.74317, 5.87556

.....Cataloged sources.....

MQ SDSS J103458.35+055231.8

4XMM/NVSS ra dec 10 34 58.4, 05 52 27.8 radio flux d. 25.400 X-ray/radio flux-ratio 1195.
arx 0.626 Log(nu peak) 16.3+/- 1 possible HBL **Dist. 86.491 arcmin**

XMMMSLEW/NVSS ra dec 10 34 58.4, 05 52 27.8 radio flux d. 25.400 X-ray/radio flux-ratio 2882.
arx 0.580 Log(nu peak) 17.2+/- 1 possible HBL **Dist. 86.491 arcmin**

SXPS/NVSS ra dec 10 34 58.4, 05 52 27.8 radio flux d. 25.400 X-ray/radio flux-ratio 758. arx
0.650 Log(nu peak) 15.8+/- 1 possible HBL **Dist. 86.491 arcmin**

Repeated radio counterpart, 4.375 arcsec away from the matched nr. 15

XMMMSLEW/NVSS ra dec 10 35 46.8, 08 49 40.7 radio flux d. 52.300 X-ray/radio flux-ratio
545. arx 0.668 Log(nu peak) 15.4+/- 1 possible IBL **Dist. 167.872 arcmin**

Match nr. 16 ra dec: 158.94508, 8.82797

.....Cataloged sources.....

BROS J1035.7+0849

MQ SDSS J103546.84+084939.4

XMMMSLEW/FIRST ra dec 10 35 46.9, 08 49 39.4 radio flux d. 50.210 X-ray/radio flux-ratio
567. arx 0.666 Log(nu peak) 15.5+/- 1 possible IBL **Dist. 167.850 arcmin**

Repeated radio counterpart, 1.342 arcsec away from the matched nr. 16

WGA/NVSS ra dec 10 36 1.3, 05 07 14.2 radio flux d. 7.000 X-ray/radio flux-ratio 20030. arx 0.478 Log(ν peak) 19.2+/- 1 possible HBL **Dist. 97.165 arcmin**
Match nr. 17 ra dec: 159.00529, 5.12061
.....Cataloged sources.....

WGA/FIRST ra dec 10 36 16.9, 03 19 17.7 radio flux d. 1.060 X-ray/radio flux-ratio 8185. arx 0.525 Log(ν peak) 18.3+/- 1 possible HBL **Dist. 189.035 arcmin**
Match nr. 18 ra dec: 159.07045, 3.32159
.....Cataloged sources.....

WGA/FIRST ra dec 10 37 36.0, 03 48 34.9 radio flux d. 2.970 X-ray/radio flux-ratio 7277. arx 0.531 Log(ν peak) 18.2+/- 1 possible HBL **Dist. 155.075 arcmin**
Match nr. 19 ra dec: 159.40015, 3.80969
.....Cataloged sources.....
MQ SDSS J103736.02+034835.2

OUSXB/FIRST ra dec 10 38 46.8, 05 12 30.0 radio flux d. 430.380 flux-ratio 35. arx 0.812 possible LBL **Dist. 69.909 arcmin**
SXPS/FIRST ra dec 10 38 46.8, 05 12 30.0 radio flux d. 430.380 flux-ratio 39. arx 0.807 possible LBL **Dist. 69.909 arcmin**
Match nr. 20 ra dec: 159.69507, 5.20832
.....Cataloged sources.....
5BZQ J1038+0512
BROS J1038.7+0512
CRATES J103846+051229
MQ PKS 1036+054

OUSXB/NVSS ra dec 10 38 46.8, 05 12 29.6 radio flux d. 639.900 flux-ratio 24. arx 0.833 possible LBL **Dist. 69.912 arcmin**
SXPS/NVSS ra dec 10 38 46.8, 05 12 29.6 radio flux d. 639.900 flux-ratio 26. arx 0.828 possible LBL **Dist. 69.912 arcmin**
Repeated radio counterpart, 0.508 arcsec away from the matched nr. 20

RASS/NVSS ra dec 10 39 33.2, 05 09 28.4 radio flux d. 51.900 X-ray/radio flux-ratio 2101. arx 0.597 Log(ν peak) 16.9+/- 1 possible HBL **Dist. 69.427 arcmin**
Match nr. 21 ra dec: 159.88850, 5.15789
.....Cataloged sources.....
MQ SDSS J103937.35+050933.9

SXPS/FIRST ra dec 10 39 40.7, 05 36 9.1 radio flux d. 7.180 X-ray/radio flux-ratio 2659. arx 0.584 Log(ν peak) 17.1+/- 1 possible HBL **Dist. 43.114 arcmin**
Match nr. 22 ra dec: 159.91955, 5.60254
.....Cataloged sources.....
3HSPJ103940.7+053609
MQ SDSS J103940.70+053609.2

4XMM/FIRST ra dec 10 39 51.9, 09 11 41.7 radio flux d. 55.510 flux-ratio 36. arx 0.811 possible
LBL **Dist. 174.609 arcmin**
SXPS/FIRST ra dec 10 39 51.9, 09 11 41.7 radio flux d. 55.510 flux-ratio 30. arx 0.821 possible
LBL **Dist. 174.609 arcmin**
Match nr. 23 ra dec: 159.96609, 9.19492
.....Cataloged sources.....

4XMM/NVSS ra dec 10 39 51.9, 09 11 41.3 radio flux d. 63.700 flux-ratio 32. arx 0.818 possible
LBL **Dist. 174.602 arcmin**
SXPS/NVSS ra dec 10 39 51.9, 09 11 41.3 radio flux d. 63.700 flux-ratio 26. arx 0.829 possible
LBL **Dist. 174.602 arcmin**
Repeated radio counterpart, 0.693 arcsec away from the matched nr. 23

4XMM/NVSS ra dec 10 40 23.3, 09 06 26.2 radio flux d. 33.300 flux-ratio 15. arx 0.857 possible
LBL **Dist. 169.086 arcmin**
Match nr. 24 ra dec: 160.09692, 9.10728
.....Cataloged sources.....
MQ SDSS J104023.41+090628.9

4XMM/NVSS ra dec 10 40 28.3, 09 10 57.2 radio flux d. 68.300 flux-ratio 7. arx 0.894 possible
LBL **Dist. 173.592 arcmin**
Match nr. 25 ra dec: 160.11804, 9.18256
.....Cataloged sources.....
BROS J1040.4+0910
zw 10880

4XMM/FIRST ra dec 10 40 28.4, 09 10 57.3 radio flux d. 64.670 flux-ratio 8. arx 0.891 possible
LBL **Dist. 173.593 arcmin**
Repeated radio counterpart, 0.714 arcsec away from the matched nr. 25

XMMSLEW/NVSS ra dec 10 40 28.6, 09 47 54.9 radio flux d. 27.900 X-ray/radio flux-ratio 2820. arx 0.581 Log(nu peak) 17.2+/- 1 possible HBL **Dist. 210.552 arcmin**
OUSXB/NVSS ra dec 10 40 28.6, 09 47 54.9 radio flux d. 27.900 X-ray/radio flux-ratio 832. arx 0.645 Log(nu peak) 15.9+/- 1 possible HBL **Dist. 210.552 arcmin**
Match nr. 26 ra dec: 160.11908, 9.79858
.....Cataloged sources.....
3HSPJ104029.0+094753
5BZB J1040+0947
MQ SDSS J104029.01+094754.2

XMMSLEW/FIRST ra dec 10 40 29.0, 09 47 54.0 radio flux d. 18.480 X-ray/radio flux-ratio 4257. arx 0.559 Log(nu peak) 17.6+/- 1 possible HBL **Dist. 210.537 arcmin**
OUSXB/FIRST ra dec 10 40 29.0, 09 47 54.0 radio flux d. 18.480 X-ray/radio flux-ratio 1257. arx 0.624 Log(nu peak) 16.3+/- 1 possible HBL **Dist. 210.537 arcmin**
SXPS/FIRST ra dec 10 40 29.0, 09 47 54.0 radio flux d. 18.480 X-ray/radio flux-ratio 3650. arx 0.567 Log(nu peak) 17.5+/- 1 possible HBL **Dist. 210.537 arcmin**
Match nr. 27 ra dec: 160.12090, 9.79833
.....Cataloged sources.....

4XMM/FIRST ra dec 10 40 31.6, 06 17 21.7 radio flux d. 39.020 X-ray/radio flux-ratio 138. arx 0.740 Log(nu peak) 14.0+/- 1 possible IBL **Dist. 0.002 arcmin**
OUSXB/FIRST ra dec 10 40 31.6, 06 17 21.7 radio flux d. 39.020 X-ray/radio flux-ratio 259. arx 0.707 Log(nu peak) 14.7+/- 1 possible IBL **Dist. 0.002 arcmin**
SXPS/FIRST ra dec 10 40 31.6, 06 17 21.7 radio flux d. 39.020 X-ray/radio flux-ratio 252. arx 0.708 Log(nu peak) 14.6+/- 1 possible IBL **Dist. 0.002 arcmin**
Match nr. 28 ra dec: 160.13182, 6.28936
.....Cataloged sources.....

4XMM/NVSS ra dec 10 40 31.7, 06 17 22.2 radio flux d. 34.200 X-ray/radio flux-ratio 158. arx 0.733 Log(nu peak) 14.1+/- 1 possible IBL **Dist. 0.009 arcmin**
OUSXB/NVSS ra dec 10 40 31.7, 06 17 22.2 radio flux d. 34.200 X-ray/radio flux-ratio 296. arx 0.700 Log(nu peak) 14.8+/- 1 possible IBL **Dist. 0.009 arcmin**
SXPS/NVSS ra dec 10 40 31.7, 06 17 22.2 radio flux d. 34.200 X-ray/radio flux-ratio 288. arx 0.701 Log(nu peak) 14.8+/- 1 possible IBL **Dist. 0.009 arcmin**
Repeated radio counterpart, 0.618 arcsec away from the matched nr. 28

4XMM/NVSS ra dec 10 40 45.3, 09 22 14.2 radio flux d. 2.300 X-ray/radio flux-ratio 70. arx 0.776 Log(nu peak) 13.3+/- 1 possible IBL **Dist. 184.904 arcmin**
Match nr. 29 ra dec: 160.18879, 9.37061
.....Cataloged sources.....

4XMM/FIRST ra dec 10 40 54.9, 05 59 30.4 radio flux d. 14.330 flux-ratio 47. arx 0.797 possible LBL **Dist. 18.772 arcmin**
Match nr. 30 ra dec: 160.22881, 5.99177
.....Cataloged sources.....
zw 10887

4XMM/NVSS ra dec 10 40 55.0, 05 59 31.0 radio flux d. 16.200 flux-ratio 42. arx 0.803 possible LBL **Dist. 18.766 arcmin**
Repeated radio counterpart, 0.915 arcsec away from the matched nr. 30

4XMM/NVSS ra dec 10 41 9.5, 06 49 12.5 radio flux d. 7.100 flux-ratio 52. arx 0.792 possible LBL **Dist. 33.206 arcmin**
Match nr. 31 ra dec: 160.28971, 6.82014
.....Cataloged sources.....

4XMM/FIRST ra dec 10 41 9.7, 06 49 12.3 radio flux d. 5.030 X-ray/radio flux-ratio 73. arx 0.774 Log(nu peak) 13.3+/- 1 possible IBL **Dist. 33.218 arcmin**
Repeated radio counterpart, 3.079 arcsec away from the matched nr. 31

4XMM/NVSS ra dec 10 41 17.2, 06 10 16.5 radio flux d. 1405.200 flux-ratio 36. arx 0.811 possible LBL **Dist. 13.352 arcmin**
OUSXB/NVSS ra dec 10 41 17.2, 06 10 16.5 radio flux d. 1405.200 flux-ratio 14. arx 0.860 possible LBL **Dist. 13.352 arcmin**
SXPS/NVSS ra dec 10 41 17.2, 06 10 16.5 radio flux d. 1405.200 flux-ratio 30. arx 0.821 possible LBL **Dist. 13.352 arcmin**

IPC/NVSS ra dec 10 41 17.2, 06 10 16.5 radio flux d. 1405.200 flux-ratio 50. arx 0.793 possible
LBL **Dist. 13.352 arcmin**

Match nr. 32 ra dec: 160.32150, 6.17125

.....Cataloged sources.....

5BZQ J1041+0610

BROS J1041.2+0610

CRATES J104118+061022

MQ 4C 06.41

4XMM/FIRST ra dec 10 41 17.2, 06 10 16.6 radio flux d. 1329.000 flux-ratio 38. arx 0.808
possible LBL **Dist. 13.354 arcmin**

OUSXB/FIRST ra dec 10 41 17.2, 06 10 16.6 radio flux d. 1329.000 flux-ratio 15. arx 0.857
possible LBL **Dist. 13.354 arcmin**

SXPS/FIRST ra dec 10 41 17.2, 06 10 16.6 radio flux d. 1329.000 flux-ratio 32. arx 0.818 possible
LBL **Dist. 13.354 arcmin**

IPC/FIRST ra dec 10 41 17.2, 06 10 16.6 radio flux d. 1329.000 flux-ratio 53. arx 0.790 possible
LBL **Dist. 13.354 arcmin**

Repeated radio counterpart, 0.227 arcsec away from the matched nr. 32

4XMM/NVSS ra dec 10 41 51.8, 06 02 36.8 radio flux d. 2.100 X-ray/radio flux-ratio 102. arx
0.756 Log(nu peak) 13.7+/- 1 possible IBL **Dist. 24.783 arcmin**

Match nr. 33 ra dec: 160.46567, 6.04356

.....Cataloged sources.....

IPC/FIRST ra dec 10 43 54.6, 08 53 4.1 radio flux d. 7.300 X-ray/radio flux-ratio 1121. arx
0.630 Log(nu peak) 16.2+/- 1 possible HBL **Dist. 163.622 arcmin**

Match nr. 34 ra dec: 160.97731, 8.88447

.....Cataloged sources.....

IPC/NVSS ra dec 10 43 54.7, 08 53 4.9 radio flux d. 8.200 X-ray/radio flux-ratio 998. arx
0.636 Log(nu peak) 16.1+/- 1 possible HBL **Dist. 163.645 arcmin**

Repeated radio counterpart, 2.177 arcsec away from the matched nr. 34

4XMM/FIRST ra dec 10 44 12.4, 06 45 32.2 radio flux d. 13.220 X-ray/radio flux-ratio 305.
arx 0.698 Log(nu peak) 14.8+/- 1 possible IBL **Dist. 61.642 arcmin**

Match nr. 35 ra dec: 161.05156, 6.75894

.....Cataloged sources.....

zw 10994

4XMM/FIRST ra dec 10 44 51.7, 06 35 48.7 radio flux d. 6.670 X-ray/radio flux-ratio 273. arx
0.704 Log(nu peak) 14.7+/- 1 possible IBL **Dist. 67.193 arcmin**

Match nr. 36 ra dec: 161.21551, 6.59685

.....Cataloged sources.....

MQ NGC 3362

zw 11017

SXPS/FIRST ra dec 10 44 55.9, 06 55 38.0 radio flux d. 409.640 flux-ratio 21. arx 0.840 possible
LBL **Dist. 75.975 arcmin**

Match nr. 37 ra dec: 161.23301, 6.92721

.....Cataloged sources.....

BROS J1044.9+0655

CRATES J104456+065528

MQ PKS 1042+071

SXPS/NVSS ra dec 10 44 55.9, 06 55 37.9 radio flux d. 489.600 flux-ratio 17. arx 0.850 possible LBL **Dist. 75.975 arcmin**

Repeated radio counterpart, 0.129 arcsec away from the matched nr. 37

IPC/FIRST ra dec 10 44 59.7, 08 32 30.1 radio flux d. 1.020 X-ray/radio flux-ratio 7575. arx 0.529 Log(ν peak) 18.2+/- 1 possible HBL **Dist. 150.591 arcmin**

Match nr. 38 ra dec: 161.24873, 8.54169

.....Cataloged sources.....

SXPS/FIRST ra dec 10 45 5.2, 08 43 38.7 radio flux d. 10.390 X-ray/radio flux-ratio 8025. arx 0.526 Log(ν peak) 18.3+/- 1 possible HBL **Dist. 161.226 arcmin**

Match nr. 39 ra dec: 161.27150, 8.72743

.....Cataloged sources.....

MQ 2MASX J10450515+0843387

SXPS/NVSS ra dec 10 45 5.5, 08 43 40.8 radio flux d. 17.600 X-ray/radio flux-ratio 4737. arx 0.554 Log(ν peak) 17.7+/- 1 possible HBL **Dist. 161.292 arcmin**

Repeated radio counterpart, 5.454 arcsec away from the matched nr. 39

4XMM/NVSS ra dec 10 45 30.8, 06 34 3.6 radio flux d. 3.300 X-ray/radio flux-ratio 1018. arx 0.635 Log(ν peak) 16.1+/- 1 possible HBL **Dist. 76.171 arcmin**

Match nr. 40 ra dec: 161.37829, 6.56767

.....Cataloged sources.....

MQ SDSS J104530.38+063351.1

4XMM/FIRST ra dec 10 45 46.7, 04 20 28.9 radio flux d. 55.730 flux-ratio 51. arx 0.792 possible LBL **Dist. 140.761 arcmin**

Match nr. 41 ra dec: 161.44478, 4.34136

.....Cataloged sources.....

RASS/FIRST ra dec 10 45 52.7, 06 24 36.4 radio flux d. 179.590 X-ray/radio flux-ratio 140. arx 0.739 Log(ν peak) 14.0+/- 1 possible IBL **Dist. 80.111 arcmin**

OUSXB/FIRST ra dec 10 45 52.7, 06 24 36.4 radio flux d. 179.590 flux-ratio 32. arx 0.817 possible LBL **Dist. 80.111 arcmin**

SXPS/FIRST ra dec 10 45 52.7, 06 24 36.4 radio flux d. 179.590 flux-ratio 35. arx 0.813 possible LBL **Dist. 80.111 arcmin**

Match nr. 42 ra dec: 161.46974, 6.41010

.....Cataloged sources.....

5BZQ J1045+0624

BROS J1045.8+0624

CRATES J104552+062437

MQ Q 1043+066A

RASS/NVSS ra dec 10 45 52.7, 06 24 36.3 radio flux d. 156.800 X-ray/radio flux-ratio 160. arx 0.732 Log(nu peak) 14.2+/- 1 possible IBL **Dist. 80.112 arcmin**
OUSXB/NVSS ra dec 10 45 52.7, 06 24 36.3 radio flux d. 156.800 flux-ratio 37. arx 0.810 possible
LBL **Dist. 80.112 arcmin**
SXPS/NVSS ra dec 10 45 52.7, 06 24 36.3 radio flux d. 156.800 flux-ratio 40. arx 0.806 possible
LBL **Dist. 80.112 arcmin**
Repeated radio counterpart, 0.080 arcsec away from the matched nr. 42

RASS/FIRST ra dec 10 46 48.8, 08 03 18.6 radio flux d. 2.610 X-ray/radio flux-ratio 27488. arx 0.461 Log(nu peak) 19.6+/- 1 possible HBL **Dist. 141.331 arcmin**
Match nr. 43 ra dec: 161.70320, 8.05516
.....Cataloged sources.....

RASS/NVSS ra dec 10 46 50.2, 08 03 30.0 radio flux d. 21.200 X-ray/radio flux-ratio 3384. arx 0.571 Log(nu peak) 17.4+/- 1 possible HBL **Dist. 141.715 arcmin**
Match nr. 44 ra dec: 161.70933, 8.05833
.....Cataloged sources.....

RASS/FIRST ra dec 10 46 50.6, 08 03 33.3 radio flux d. 15.590 X-ray/radio flux-ratio 4602. arx 0.555 Log(nu peak) 17.7+/- 1 possible HBL **Dist. 141.822 arcmin**
Match nr. 45 ra dec: 161.71097, 8.05926
.....Cataloged sources.....

4XMM/NVSS ra dec 10 51 13.7, 05 50 42.1 radio flux d. 19.600 X-ray/radio flux-ratio 133. arx 0.742 Log(nu peak) 14.0+/- 1 possible IBL **Dist. 161.838 arcmin**
Match nr. 46 ra dec: 162.80725, 5.84503
.....Cataloged sources.....
zw 11261

XMMSLEW/NVSS ra dec 10 52 24.5, 08 14 9.0 radio flux d. 34.900 X-ray/radio flux-ratio 4716. arx 0.554 Log(nu peak) 17.7+/- 1 possible HBL **Dist. 211.861 arcmin**
RASS/NVSS ra dec 10 52 24.5, 08 14 9.0 radio flux d. 34.900 X-ray/radio flux-ratio 2410. arx 0.589 Log(nu peak) 17.0+/- 1 possible HBL **Dist. 211.861 arcmin**
OUSXB/NVSS ra dec 10 52 24.5, 08 14 9.0 radio flux d. 34.900 X-ray/radio flux-ratio 1764. arx 0.606 Log(nu peak) 16.7+/- 1 possible HBL **Dist. 211.861 arcmin**
SXPS/NVSS ra dec 10 52 24.5, 08 14 9.0 radio flux d. 34.900 X-ray/radio flux-ratio 2072. arx 0.597 Log(nu peak) 16.9+/- 1 possible HBL **Dist. 211.861 arcmin**
Match nr. 47 ra dec: 163.10188, 8.23583
.....Cataloged sources.....
3HSPJ105224.5+081409
BROS J1052.4+0814

XMMSLEW/FIRST ra dec 10 52 24.5, 08 14 9.5 radio flux d. 25.460 X-ray/radio flux-ratio 6464. arx 0.537 Log(nu peak) 18.1+/- 1 possible HBL **Dist. 211.880 arcmin**
RASS/FIRST ra dec 10 52 24.5, 08 14 9.5 radio flux d. 25.460 X-ray/radio flux-ratio 3303. arx 0.573 Log(nu peak) 17.3+/- 1 possible HBL **Dist. 211.880 arcmin**
OUSXB/FIRST ra dec 10 52 24.5, 08 14 9.5 radio flux d. 25.460 X-ray/radio flux-ratio 2418. arx

0.589 Log(nu peak) 17.0+/- 1 possible HBL **Dist. 211.880 arcmin**
SXPS/FIRST ra dec 10 52 24.5, 08 14 9.5 radio flux d. 25.460 X-ray/radio flux-ratio 2840. arx
0.581 Log(nu peak) 17.2+/- 1 possible HBL **Dist. 211.880 arcmin**
Repeated radio counterpart, 1.198 arcsec away from the matched nr. 47

RASS/FIRST ra dec 10 52 53.0, 04 57 35.0 radio flux d. 72.710 X-ray/radio flux-ratio 223. arx
0.715 Log(nu peak) 14.5+/- 1 possible IBL **Dist. 200.966 arcmin**
Match nr. 48 ra dec: 163.22096, 4.95973
.....Cataloged sources.....
BROS J1052.8+0457
CRATES J105253+045730
MQ WISEA J105253.08+045734.7

RASS/NVSS ra dec 10 52 53.0, 04 57 35.3 radio flux d. 82.100 X-ray/radio flux-ratio 197. arx
0.721 Log(nu peak) 14.4+/- 1 possible IBL **Dist. 200.969 arcmin**
Repeated radio counterpart, 0.407 arcsec away from the matched nr. 48

SXPS/FIRST ra dec 10 54 33.2, 04 26 33.6 radio flux d. 1.530 X-ray/radio flux-ratio 637. arx
0.660 Log(nu peak) 15.6+/- 1 possible HBL **Dist. 236.957 arcmin**
Match nr. 49 ra dec: 163.63825, 4.44268
.....Cataloged sources.....

Candidate nr. 50, Known blazar with no radio/X-ray match: 3HSPJ102827.1+055515 found at a distance of 181.332 arcmin

5BZG J1028+0555, repeated with candidate nr. 50 3HSPJ102827.1+055515

Candidate nr. 51, Known blazar with no radio/X-ray match: 5BZU J1033+0711 found at a distance of 116.933 arcmin

Candidate nr. 52, Known blazar with no radio/X-ray match: 5BZB J1035+0723 found at a distance of 104.214 arcmin

Candidate nr. 53, Known blazar with no radio/X-ray match: 5BZQ J1037+0424 found at a distance of 121.178 arcmin

Candidate nr. 54, Known blazar with no radio/X-ray match: 5BZB J1043+0653 found at a distance of 55.784 arcmin

Candidate nr. 55, Known blazar with no radio/X-ray match: 5BZQ J1050+0432 found at a distance of 177.913 arcmin

Candidate nr. 56, Known flat spectrum radio source with no radio/X-ray match: BROS J1032.9+0307 found at a distance of 220.964 arcmin

Candidate nr. 57, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.5+0311 found at a distance of 194.438 arcmin

Candidate nr. 58, Known flat spectrum radio source with no radio/X-ray match: BROS J1030.6+0334 found at a distance of 219.769 arcmin

Candidate nr. 59, Known flat spectrum radio source with no radio/X-ray match: BROS J1030.7+0349 found at a distance of 208.535 arcmin

Candidate nr. 60, Known flat spectrum radio source with no radio/X-ray match: BROS J1031.4+0401 found at a distance of 191.837 arcmin

Candidate nr. 61, Known flat spectrum radio source with no radio/X-ray match: BROS J1026.6+0424 found at a distance of 235.488 arcmin

Candidate nr. 62, Known flat spectrum radio source with no radio/X-ray match: BROS J1032.7+0359 found at a distance of 179.686 arcmin

Candidate nr. 63, Known flat spectrum radio source with no radio/X-ray match: BROS J1034.4+0400 found at a distance of 164.013 arcmin

BROS J1037.6+0424, repeated with candidate nr. 53 5BZQ J1037+0424
 Candidate nr. 64, Known flat spectrum radio source with no radio/X-ray match: BROS J1035.0+0454
 found at a distance of 116.125 arcmin
 Candidate nr. 65, Known flat spectrum radio source with no radio/X-ray match: BROS J1027.8+0520
 found at a distance of 197.349 arcmin
 Candidate nr. 66, Known flat spectrum radio source with no radio/X-ray match: BROS J1029.3+0519
 found at a distance of 176.304 arcmin
 Candidate nr. 67, Known flat spectrum radio source with no radio/X-ray match: BROS J1031.5+0528
 found at a distance of 143.276 arcmin
 Candidate nr. 68, Known flat spectrum radio source with no radio/X-ray match: BROS J1035.5+0502
 found at a distance of 105.425 arcmin
 Candidate nr. 69, Known flat spectrum radio source with no radio/X-ray match: BROS J1037.4+0550
 found at a distance of 52.856 arcmin
 Candidate nr. 70, Known flat spectrum radio source with no radio/X-ray match: BROS J1037.6+0553
 found at a distance of 49.151 arcmin
 Candidate nr. 71, Known flat spectrum radio source with no radio/X-ray match: BROS J1038.2+0227
 found at a distance of 232.823 arcmin
 Candidate nr. 72, Known flat spectrum radio source with no radio/X-ray match: BROS J1043.5+0305
 found at a distance of 196.960 arcmin
 Candidate nr. 73, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.5+0312
 found at a distance of 187.822 arcmin
 Candidate nr. 74, Known flat spectrum radio source with no radio/X-ray match: BROS J1047.7+0259
 found at a distance of 225.738 arcmin
 Candidate nr. 75, Known flat spectrum radio source with no radio/X-ray match: BROS J1039.5+0336
 found at a distance of 161.091 arcmin
 Candidate nr. 76, Known flat spectrum radio source with no radio/X-ray match: BROS J1038.2+0452
 found at a distance of 91.345 arcmin
 Candidate nr. 77, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.1+0421
 found at a distance of 118.775 arcmin
 Candidate nr. 78, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.3+0443
 found at a distance of 97.968 arcmin
 Candidate nr. 79, Known flat spectrum radio source with no radio/X-ray match: BROS J1046.7+0349
 found at a distance of 174.653 arcmin
 Candidate nr. 80, Known flat spectrum radio source with no radio/X-ray match: BROS J1050.2+0343
 found at a distance of 211.847 arcmin
 Candidate nr. 81, Known flat spectrum radio source with no radio/X-ray match: BROS J1044.5+0438
 found at a distance of 115.690 arcmin
 Candidate nr. 82, Known flat spectrum radio source with no radio/X-ray match: BROS J1046.2+0428
 found at a distance of 138.877 arcmin
 Candidate nr. 83, Known flat spectrum radio source with no radio/X-ray match: BROS J1045.4+0451
 found at a distance of 113.186 arcmin
 Candidate nr. 84, Known flat spectrum radio source with no radio/X-ray match: BROS J1039.0+0536
 found at a distance of 46.696 arcmin
 Candidate nr. 85, Known flat spectrum radio source with no radio/X-ray match: BROS J1044.0+0642
 found at a distance of 58.518 arcmin
 Candidate nr. 86, Known flat spectrum radio source with no radio/X-ray match: BROS J1049.0+0548
 found at a distance of 130.364 arcmin
 Candidate nr. 87, Known flat spectrum radio source with no radio/X-ray match: BROS J1048.5+0606
 found at a distance of 120.807 arcmin
 Candidate nr. 88, Known flat spectrum radio source with no radio/X-ray match: BROS J1047.6+0610
 found at a distance of 106.316 arcmin
 Candidate nr. 89, Known flat spectrum radio source with no radio/X-ray match: BROS J1047.4+0628
 found at a distance of 103.109 arcmin
 Candidate nr. 90, Known flat spectrum radio source with no radio/X-ray match: BROS J1052.1+0455
 found at a distance of 191.895 arcmin

Candidate nr. 91, Known flat spectrum radio source with no radio/X-ray match: BROS J1051.9+0501 found at a distance of 186.115 arcmin

Candidate nr. 92, Known flat spectrum radio source with no radio/X-ray match: BROS J1054.2+0448 found at a distance of 223.522 arcmin

Candidate nr. 93, Known flat spectrum radio source with no radio/X-ray match: BROS J1053.9+0544 found at a distance of 202.333 arcmin

Candidate nr. 94, Known flat spectrum radio source with no radio/X-ray match: BROS J1052.8+0643 found at a distance of 185.660 arcmin

Candidate nr. 95, Known flat spectrum radio source with no radio/X-ray match: BROS J1029.3+0657 found at a distance of 170.811 arcmin

Candidate nr. 96, Known flat spectrum radio source with no radio/X-ray match: BROS J1027.9+0803 found at a distance of 215.499 arcmin

Candidate nr. 97, Known flat spectrum radio source with no radio/X-ray match: BROS J1031.6+0642 found at a distance of 135.112 arcmin

Candidate nr. 98, Known flat spectrum radio source with no radio/X-ray match: BROS J1034.0+0701 found at a distance of 105.723 arcmin

Candidate nr. 99, Known flat spectrum radio source with no radio/X-ray match: BROS J1033.5+0704 found at a distance of 114.499 arcmin

BROS J1033.5+0711, repeated with candidate nr. 51 5BZU J1033+0711

Candidate nr. 100, Known flat spectrum radio source with no radio/X-ray match: BROS J1034.2+0712 found at a distance of 108.723 arcmin

Candidate nr. 101, Known flat spectrum radio source with no radio/X-ray match: BROS J1035.1+0646 found at a distance of 85.412 arcmin

Candidate nr. 102, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.2+0718 found at a distance of 88.516 arcmin

Candidate nr. 103, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.4+0726 found at a distance of 91.499 arcmin

Candidate nr. 104, Known flat spectrum radio source with no radio/X-ray match: BROS J1032.1+0752 found at a distance of 157.590 arcmin

Candidate nr. 105, Known flat spectrum radio source with no radio/X-ray match: BROS J1034.9+0738 found at a distance of 115.682 arcmin

Candidate nr. 106, Known flat spectrum radio source with no radio/X-ray match: BROS J1027.9+0824 found at a distance of 225.708 arcmin

Candidate nr. 107, Known flat spectrum radio source with no radio/X-ray match: BROS J1030.6+0853 found at a distance of 214.378 arcmin

Candidate nr. 108, Known flat spectrum radio source with no radio/X-ray match: BROS J1031.3+0930 found at a distance of 235.782 arcmin

Candidate nr. 109, Known flat spectrum radio source with no radio/X-ray match: BROS J1033.7+0857 found at a distance of 189.375 arcmin

Candidate nr. 110, Known flat spectrum radio source with no radio/X-ray match: BROS J1034.9+0833 found at a distance of 159.046 arcmin

Candidate nr. 111, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.8+0821 found at a distance of 135.531 arcmin

Candidate nr. 112, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.0+0926 found at a distance of 200.209 arcmin

Candidate nr. 113, Known flat spectrum radio source with no radio/X-ray match: BROS J1036.0+1007 found at a distance of 239.685 arcmin

Candidate nr. 114, Known flat spectrum radio source with no radio/X-ray match: BROS J1041.6+0720 found at a distance of 65.034 arcmin

Candidate nr. 115, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.3+0721 found at a distance of 69.581 arcmin

Candidate nr. 116, Known flat spectrum radio source with no radio/X-ray match: BROS J1037.8+0814 found at a distance of 123.691 arcmin

Candidate nr. 117, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.9+0748 found at a distance of 98.384 arcmin

Candidate nr. 118, Known flat spectrum radio source with no radio/X-ray match: BROS J1043.9+0755 found at a distance of 110.351 arcmin
Candidate nr. 119, Known flat spectrum radio source with no radio/X-ray match: BROS J1043.9+0759 found at a distance of 114.055 arcmin
Candidate nr. 120, Known flat spectrum radio source with no radio/X-ray match: BROS J1041.9+0802 found at a distance of 107.545 arcmin
Candidate nr. 121, Known flat spectrum radio source with no radio/X-ray match: BROS J1043.3+0808 found at a distance of 118.769 arcmin
Candidate nr. 122, Known flat spectrum radio source with no radio/X-ray match: BROS J1044.7+0711 found at a distance of 83.403 arcmin
Candidate nr. 123, Known flat spectrum radio source with no radio/X-ray match: BROS J1044.9+0750 found at a distance of 113.529 arcmin
Candidate nr. 124, Known flat spectrum radio source with no radio/X-ray match: BROS J1045.4+0805 found at a distance of 129.918 arcmin
Candidate nr. 125, Known flat spectrum radio source with no radio/X-ray match: BROS J1048.5+0747 found at a distance of 149.463 arcmin
Candidate nr. 126, Known flat spectrum radio source with no radio/X-ray match: BROS J1047.9+0758 found at a distance of 149.364 arcmin
Candidate nr. 127, Known flat spectrum radio source with no radio/X-ray match: BROS J1039.8+0833 found at a distance of 136.217 arcmin
Candidate nr. 128, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.4+0825 found at a distance of 131.315 arcmin
Candidate nr. 129, Known flat spectrum radio source with no radio/X-ray match: BROS J1043.3+0840 found at a distance of 149.234 arcmin
Candidate nr. 130, Known flat spectrum radio source with no radio/X-ray match: BROS J1041.3+0859 found at a distance of 162.619 arcmin
Candidate nr. 131, Known flat spectrum radio source with no radio/X-ray match: BROS J1040.1+0916 found at a distance of 179.637 arcmin
Candidate nr. 132, Known flat spectrum radio source with no radio/X-ray match: BROS J1042.2+0933 found at a distance of 198.234 arcmin
Candidate nr. 133, Known flat spectrum radio source with no radio/X-ray match: BROS J1046.4+0833 found at a distance of 161.982 arcmin
Candidate nr. 134, Known flat spectrum radio source with no radio/X-ray match: BROS J1046.7+0904 found at a distance of 191.213 arcmin
Candidate nr. 135, Known flat spectrum radio source with no radio/X-ray match: BROS J1047.0+0911 found at a distance of 199.250 arcmin
Candidate nr. 136, Known flat spectrum radio source with no radio/X-ray match: BROS J1049.9+0931 found at a distance of 239.347 arcmin
Candidate nr. 137, Known flat spectrum radio source with no radio/X-ray match: BROS J1050.7+0718 found at a distance of 163.996 arcmin
Candidate nr. 138, Known flat spectrum radio source with no radio/X-ray match: BROS J1051.6+0718 found at a distance of 176.116 arcmin
Candidate nr. 139, Known flat spectrum radio source with no radio/X-ray match: BROS J1050.8+0756 found at a distance of 183.070 arcmin
Candidate nr. 140, Known flat spectrum radio source with no radio/X-ray match: BROS J1052.0+0831 found at a distance of 217.629 arcmin
Candidate nr. 141, Known flat spectrum radio source with no radio/X-ray match: BROS J1052.1+0903 found at a distance of 239.940 arcmin
Candidate nr. 142, Known flat spectrum radio source with no radio/X-ray match: CRATES J104234+032145 found at a distance of 178.231 arcmin
CRATES J103037+033430, repeated with candidate nr. 58 BROS J1030.6+0334
Candidate nr. 143, Known flat spectrum radio source with no radio/X-ray match: CRATES J104937+033611 found at a distance of 210.794 arcmin
Candidate nr. 144, Known flat spectrum radio source with no radio/X-ray match: CRATES J104037+034157 found at a distance of 155.374 arcmin

CRATES J104209+042053, repeated with candidate nr. 77 BROS J1042.1+0421
 CRATES J103738+042401, repeated with candidate nr. 53 5BZQ J1037+0424
 CRATES J105008+043237, repeated with candidate nr. 55 5BZQ J1050+0432
 Candidate nr. 145, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J105531+050152 found at a distance of 236.265 arcmin
 CRATES J102921+051938, repeated with candidate nr. 66 BROS J1029.3+0519
 Candidate nr. 146, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J105239+052502 found at a distance of 188.376 arcmin
 Candidate nr. 147, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J104340+053718 found at a distance of 61.772 arcmin
 Candidate nr. 148, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J104830+060446 found at a distance of 119.496 arcmin
 CRATES J103333+071135, repeated with candidate nr. 51 5BZU J1033+0711
 Candidate nr. 149, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J105050+075635 found at a distance of 182.687 arcmin
 CRATES J103458+083306, repeated with candidate nr. 110 BROS J1034.9+0833
 CRATES J103038+085340, repeated with candidate nr. 107 BROS J1030.6+0853
 Candidate nr. 150, Known flat spectrum radio source with no radio/X-ray match: CRATES
 J103736+100024 found at a distance of 226.956 arcmin
 Pulsar PSR J1046+0304 214.280 arcmin away

GRB141207A 141.758 arcmin away
 GRB140219A 128.992 arcmin away

References

- [1] Chang Yu Ling. Vou blazars. https://github.com/ecylchang/VOU_Blazars, 2018.
- [2] P. Padovani, P. Giommi, E. Resconi, T. Glauch, B. Arsioli, N. Sahakyan, and M. Huber. Dissecting the region around IceCube-170922A: the blazar TXS 0506+056 as the first cosmic neutrino source. *Mon. Not. Roy. Astron. Soc.*, 480:192, 2018.
- [3] M. Wood, R. Caputo, E. Charles, M. Di Mauro, J. Magill, J. S. Perkins, and Fermi-LAT Collaboration. Fermipy: An open-source Python package for analysis of Fermi-LAT Data. *International Cosmic Ray Conference*, 35:824, January 2017.
- [4] Fermi-LAT Collaboration. Fermi science tools: Cicerone, 2018.
- [5] M. G. Aartsen et al. All-sky Search for Time-integrated Neutrino Emission from Astrophysical Sources with 7 yr of IceCube Data. *Astrophys. J.*, 835(2):151, 2017.
- [6] Enrico Massaro, Alessandro Maselli, Cristina Leto, Paolo Marchegiani, Matteo Perri, Paolo Giommi, and Silvia Piranomonte. The 5th edition of the Roma-BZCAT. A short presentation. *Astrophys. Space Sci.*, 357(1):75, 2015.
- [7] Glen Cowan, Kyle Cranmer, Eilam Gross, and Ofer Vitells. Asymptotic formulae for likelihood-based tests of new physics. *Eur. Phys. J.*, C71:1554, 2011. [Erratum: *Eur. Phys. J.* C73,2501(2013)].