

# Dissecting the Region around *IC201021A*

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November 13, 2020

## Abstract

The IceCube Neutrino Observatory has recently reported the detection of a highly-energetic neutrino, *IC201021A*<sup>1</sup> (MJD: 59143.28), with direction ra:  $260.81^\circ$ , dec:  $14.35^\circ$  in equatorial and l:  $36.42^\circ$ , b:  $25.89^\circ$  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 2020-11-12 23:51:19.297 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 catalogs<sup>2</sup> 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 59165.1.

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<sup>1</sup>NoGCNgiven

<sup>2</sup>List 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

## 1.1 Catalog Sources in the Region around IC201021A

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.

**VOUJ260.8089114.3498**

ra: 260.81 deg — dec: 14.35 deg — distance: 0.00 deg [ra: 0.00 deg , dec: 0.00 deg]

## 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 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 an 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  $3\sigma$ . The green dashed and solid line show the sensitivity and discovery potential of the IceCube 7yr point-source analysis [5], respectively.

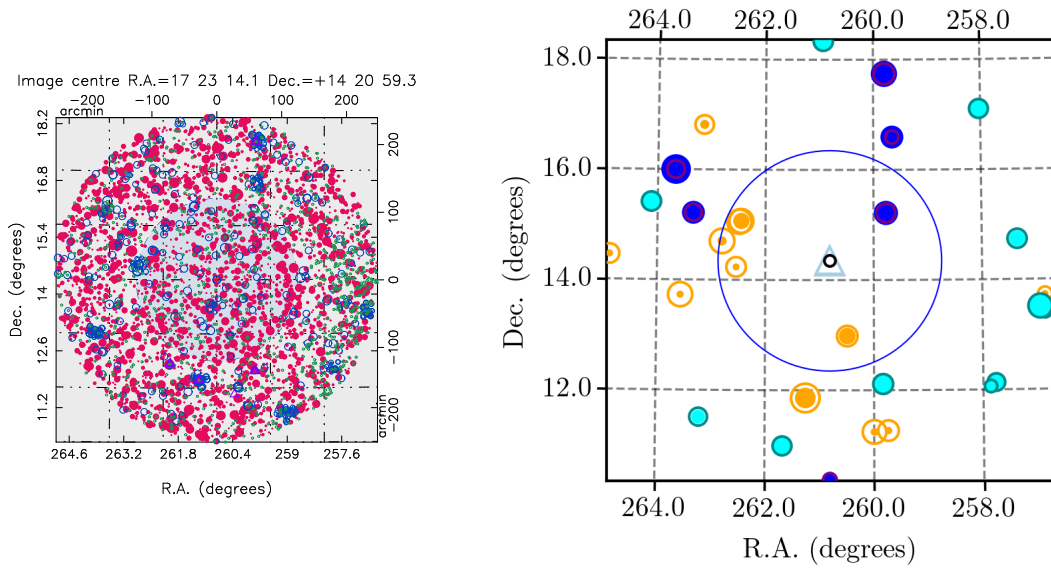


Figure 1: Left Plot: Radio and X-ray sources within 120 arc-minutes of the position of the neutrino event. Symbol diameters are proportional to source intensity. Radio sources appear as red filled circles, X-ray sources as open blue circles and gamma-ray sources as open triangles. Right Plot: Counterpart 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 arcmins around the events-best fit direction.

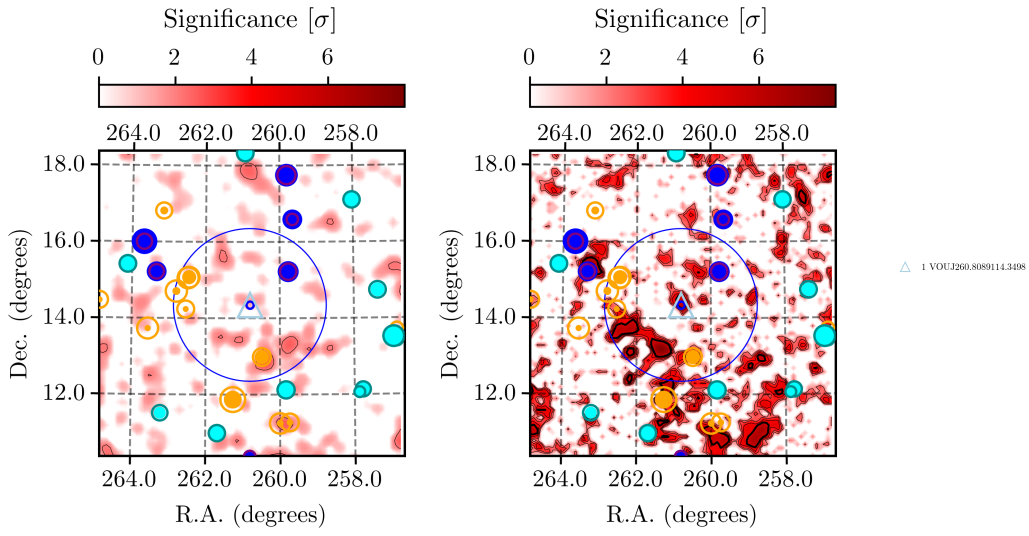


Figure 2: Test-statistic maps of the region after subtracting known sources from the 4FGL catalog. The blue and black contours show the 90% and 50% error regions, respectively. Only photons with energies above 1.0 GeV are included. The map can be used to identify additional, yet unknown gamma-ray emitters, that coincide with multi-wavelength candidates. Contour lines are shown at 2,3,4,5  $\sigma$ . **Left:** The map of the region for a time window of 200 days (MJD 59043.3, 59243.3) around the neutrino arrival time. **Right:** The map of the region for the entire *Fermi-LAT* mission (MJD 54682.7 to 59165.1).

### 3 SEDs and Light Curves

#### 3.1 VOIJ260.8089114.3498 | $ra = 260.81^\circ$ , $dec = 14.35^\circ$ , $\Sigma = 4.1 \sigma$ , $\Delta\psi = 0.00^\circ$

Associations:

MJD	Probability [%]	Energy[GeV]
55155.12	99.48	51.99
58009.54	93.96	19.71
57680.47	96.90	10.44
57984.40	96.58	6.01

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

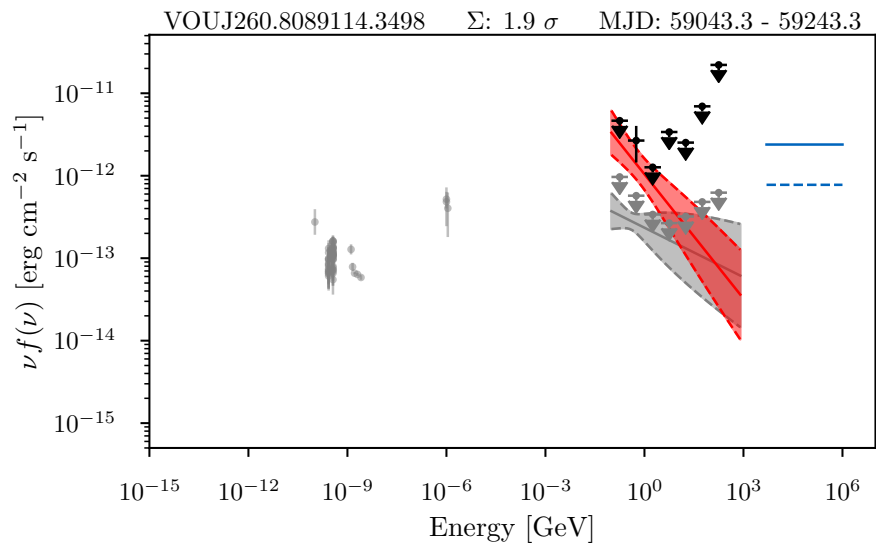


Figure 3: SED for VOIJ260.8089114.3498. See the description in section 2.2 for more details.

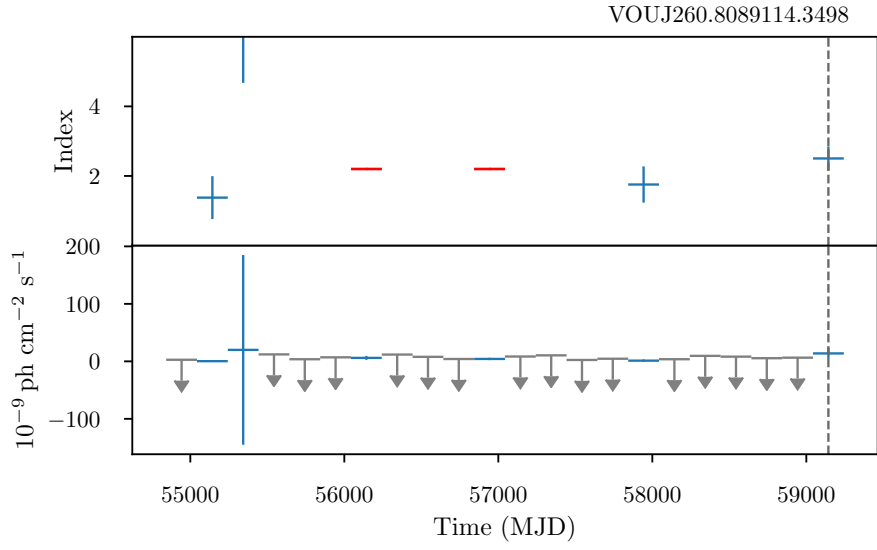


Figure 4: Light curve for VOUJ260.8089114.3498

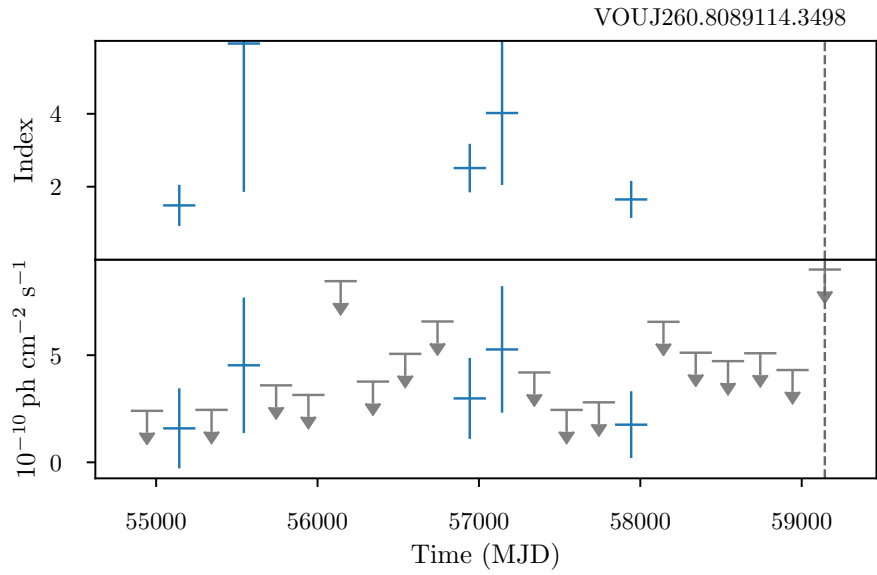


Figure 5: 1GeV light curve for VOUJ260.8089114.3498

## 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  $5\sigma$  ( $3\sigma$ ) 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  $\chi^2$  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  $5\sigma$  ( $\mathcal{TS} = 25$ ) and  $3\sigma$  ( $\mathcal{TS} = 9$ ) 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 <sup>3</sup>. 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.

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<sup>3</sup>List 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

OUSXB/NVSS ra dec 17 07 24.1, 13 43 45.5 radio flux d. 2.600 X-ray/radio flux-ratio 737. arx 0.652 Log(nu peak) 15.8+/- 1 possible HBL **Dist. 233.404 arcmin**  
SXPS/NVSS ra dec 17 07 24.1, 13 43 45.5 radio flux d. 2.600 X-ray/radio flux-ratio 812. arx 0.647 Log(nu peak) 15.9+/- 1 possible HBL **Dist. 233.404 arcmin**  
**Match nr. 1 ra dec: 256.85033, 13.72931**  
.....Cataloged sources.....  
MQ SDSS J170724.00+134330.6

OUSXB/NVSS ra dec 17 07 26.8, 13 25 23.9 radio flux d. 15.800 X-ray/radio flux-ratio 166. arx 0.730 Log(nu peak) 14.2+/- 1 possible IBL **Dist. 236.534 arcmin**  
SXPS/NVSS ra dec 17 07 26.8, 13 25 23.9 radio flux d. 15.800 X-ray/radio flux-ratio 121. arx 0.747 Log(nu peak) 13.9+/- 1 possible IBL **Dist. 236.534 arcmin**  
**Match nr. 2 ra dec: 256.86162, 13.42331**  
.....Cataloged sources.....  
BROS J1707.4+1325

XMMSLEW/NVSS ra dec 17 07 45.7, 13 31 5.7 radio flux d. 301.500 X-ray/radio flux-ratio 524. arx 0.670 Log(nu peak) 15.4+/- 1 possible IBL **Dist. 230.740 arcmin**  
RASS/NVSS ra dec 17 07 45.7, 13 31 5.7 radio flux d. 301.500 X-ray/radio flux-ratio 232. arx 0.713 Log(nu peak) 14.5+/- 1 possible IBL **Dist. 230.740 arcmin**  
OUSXB/NVSS ra dec 17 07 45.7, 13 31 5.7 radio flux d. 301.500 X-ray/radio flux-ratio 247. arx 0.710 Log(nu peak) 14.6+/- 1 possible IBL **Dist. 230.740 arcmin**  
SXPS/NVSS ra dec 17 07 45.7, 13 31 5.7 radio flux d. 301.500 X-ray/radio flux-ratio 301. arx 0.699 Log(nu peak) 14.8+/- 1 possible IBL **Dist. 230.740 arcmin**  
**Match nr. 3 ra dec: 256.94029, 13.51825**  
.....Cataloged sources.....  
5BZQ J1707+1331  
CRATES J170745+133117  
MQ TEX 1705+135

RASS/NVSS ra dec 17 09 25.5, 14 44 10.3 radio flux d. 31.400 X-ray/radio flux-ratio 468. arx 0.676 Log(nu peak) 15.3+/- 1 possible IBL **Dist. 201.853 arcmin**  
**Match nr. 4 ra dec: 257.35629, 14.73619**  
.....Cataloged sources.....

RASS/NVSS ra dec 17 11 5.9, 12 08 12.9 radio flux d. 37.700 X-ray/radio flux-ratio 428. arx 0.680 Log(nu peak) 15.2+/- 1 possible IBL **Dist. 221.428 arcmin**  
OUSXB/NVSS ra dec 17 11 5.9, 12 08 12.9 radio flux d. 37.700 X-ray/radio flux-ratio 95. arx 0.760 Log(nu peak) 13.6+/- 1 possible IBL **Dist. 221.428 arcmin**  
SXPS/NVSS ra dec 17 11 5.9, 12 08 12.9 radio flux d. 37.700 flux-ratio 51. arx 0.793 possible LBL **Dist. 221.428 arcmin**  
**Match nr. 5 ra dec: 257.77454, 12.13692**  
.....Cataloged sources.....  
3HSPJ171105.9+120813  
MQ J171105.89+120812.8

SXPS/NVSS ra dec 17 11 28.9, 12 03 46.9 radio flux d. 8.300 X-ray/radio flux-ratio 131. arx 0.743 Log(nu peak) 13.9+/- 1 possible IBL **Dist. 219.725 arcmin**

**Match nr. 6 ra dec: 257.87062, 12.06303**

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

RASS/NVSS ra dec 17 12 8.3, 17 06 3.6 radio flux d. 49.400 X-ray/radio flux-ratio 256. arx 0.708 Log(nu peak) 14.6+/- 1 possible IBL **Dist. 230.027 arcmin**

**Match nr. 7 ra dec: 258.03475, 17.10100**

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

OUSXG/NVSS ra dec 17 18 36.6, 16 35 38.3 radio flux d. 217.600 flux-ratio 5. arx 0.913 possible LBL **Dist. 150.334 arcmin**

SXPS/NVSS ra dec 17 18 36.6, 16 35 38.3 radio flux d. 217.600 flux-ratio 7. arx 0.899 possible LBL **Dist. 150.334 arcmin**

**Match nr. 8 ra dec: 259.65267, 16.59397**

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

RASS/NVSS ra dec 17 18 59.0, 11 16 22.4 radio flux d. 3.000 X-ray/radio flux-ratio 8106. arx 0.525 Log(nu peak) 18.3+/- 1 possible HBL **Dist. 194.806 arcmin**

**Match nr. 9 ra dec: 259.74588, 11.27289**

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

RASS/NVSS ra dec 17 19 6.8, 15 13 25.5 radio flux d. 310.800 flux-ratio 39. arx 0.806 possible LBL **Dist. 79.518 arcmin**

**Match nr. 10 ra dec: 259.77846, 15.22375**

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

XMMMSLEW/NVSS ra dec 17 19 13.1, 17 45 6.7 radio flux d. 542.500 X-ray/radio flux-ratio 74. arx 0.773 Log(nu peak) 13.3+/- 1 possible IBL **Dist. 212.179 arcmin**

RASS/NVSS ra dec 17 19 13.1, 17 45 6.7 radio flux d. 542.500 flux-ratio 36. arx 0.811 possible LBL **Dist. 212.179 arcmin**

OUSXB/NVSS ra dec 17 19 13.1, 17 45 6.7 radio flux d. 542.500 flux-ratio 38. arx 0.809 possible LBL **Dist. 212.179 arcmin**

SXPS/NVSS ra dec 17 19 13.1, 17 45 6.7 radio flux d. 542.500 flux-ratio 53. arx 0.791 possible LBL **Dist. 212.179 arcmin**

IPC/NVSS ra dec 17 19 13.1, 17 45 6.7 radio flux d. 542.500 flux-ratio 53. arx 0.791 possible LBL **Dist. 212.179 arcmin**

**Match nr. 11 ra dec: 259.80438, 17.75186**

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

5BZB J1719+1745

BROS J1719.2+1745

CRATES J171913+174506

MQ PKS 1717+177

RASS/NVSS ra dec 17 19 21.5, 12 07 22.3 radio flux d. 57.000 X-ray/radio flux-ratio 314. arx 0.697 Log(nu peak) 14.9+/- 1 possible IBL **Dist. 145.116 arcmin**

**Match nr. 12 ra dec: 259.83950, 12.12286**

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

3HSPJ171921.5+120721

BROS J1719.3+1207

XMM/LEW/NVSS ra dec 17 20 1.1, 11 15 3.3 radio flux d. 3.300 X-ray/radio flux-ratio 34924. arx 0.448 Log(nu peak) 19.8+/- 1 possible HBL **Dist. 191.796 arcmin**  
RASS/NVSS ra dec 17 20 1.1, 11 15 3.3 radio flux d. 3.300 X-ray/radio flux-ratio 22865. arx 0.471 Log(nu peak) 19.4+/- 1 possible HBL **Dist. 191.796 arcmin**  
**Match nr. 13 ra dec: 260.00442, 11.25092**  
.....Cataloged sources.....  
MQ WISEA J172001.13+111500.6

RASS/NVSS ra dec 17 21 57.5, 12 59 17.6 radio flux d. 39.600 X-ray/radio flux-ratio 595. arx 0.663 Log(nu peak) 15.5+/- 1 possible HBL **Dist. 83.788 arcmin**  
**Match nr. 14 ra dec: 260.48967, 12.98822**  
.....Cataloged sources.....

SXPS/NVSS ra dec 17 23 16.1, 10 22 40.3 radio flux d. 31.900 flux-ratio 51. arx 0.793 possible LBL **Dist. 238.317 arcmin**  
**Match nr. 15 ra dec: 260.81696, 10.37786**  
.....Cataloged sources.....

RASS/NVSS ra dec 17 23 46.1, 18 20 15.9 radio flux d. 66.900 X-ray/radio flux-ratio 217. arx 0.716 Log(nu peak) 14.5+/- 1 possible IBL **Dist. 239.399 arcmin**  
**Match nr. 16 ra dec: 260.94188, 18.33775**  
.....Cataloged sources.....  
MQ WISEA J172346.02+182016.3

XMM/LEW/NVSS ra dec 17 25 4.3, 11 52 15.5 radio flux d. 120.400 X-ray/radio flux-ratio 7743. arx 0.528 Log(nu peak) 18.2+/- 1 possible HBL **Dist. 151.130 arcmin**  
RASS/NVSS ra dec 17 25 4.3, 11 52 15.5 radio flux d. 120.400 X-ray/radio flux-ratio 5989. arx 0.541 Log(nu peak) 18.0+/- 1 possible HBL **Dist. 151.130 arcmin**  
OUSXB/NVSS ra dec 17 25 4.3, 11 52 15.5 radio flux d. 120.400 X-ray/radio flux-ratio 1720. arx 0.607 Log(nu peak) 16.7+/- 1 possible HBL **Dist. 151.130 arcmin**  
SXPS/NVSS ra dec 17 25 4.3, 11 52 15.5 radio flux d. 120.400 X-ray/radio flux-ratio 3400. arx 0.571 Log(nu peak) 17.4+/- 1 possible HBL **Dist. 151.130 arcmin**  
**Match nr. 17 ra dec: 261.26804, 11.87097**  
.....Cataloged sources.....  
3HSPJ172504.3+115215  
5BZB J1725+1152  
BROS J1725.0+1152  
CRATES J172504+115227  
MQ H 1722+119

RASS/NVSS ra dec 17 26 44.1, 10 59 26.2 radio flux d. 116.500 X-ray/radio flux-ratio 113. arx 0.751 Log(nu peak) 13.8+/- 1 possible IBL **Dist. 207.955 arcmin**  
**Match nr. 18 ra dec: 261.68383, 10.99061**  
.....Cataloged sources.....

XMM/LEW/NVSS ra dec 17 29 48.9, 15 04 46.0 radio flux d. 35.700 X-ray/radio flux-ratio 3028. arx 0.577 Log(nu peak) 17.3+/- 1 possible HBL **Dist. 105.018 arcmin**  
RASS/NVSS ra dec 17 29 48.9, 15 04 46.0 radio flux d. 35.700 X-ray/radio flux-ratio 2035. arx

0.598 Log( $\nu$  peak) 16.8 $\pm$  1 possible HBL **Dist. 105.018 arcmin**

**Match nr. 19 ra dec: 262.45383, 15.07944**

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

XMMSLEW/NVSS ra dec 17 29 57.3, 15 03 25.2 radio flux d. 4.500 X-ray/radio flux-ratio 24019.

arx 0.468 Log( $\nu$  peak) 19.4 $\pm$  1 possible HBL **Dist. 106.319 arcmin**

**Match nr. 20 ra dec: 262.48867, 15.05700**

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

RASS/NVSS ra dec 17 30 11.1, 14 14 13.3 radio flux d. 2.600 X-ray/radio flux-ratio 6498. arx

0.537 Log( $\nu$  peak) 18.1 $\pm$  1 possible HBL **Dist. 101.236 arcmin**

**Match nr. 21 ra dec: 262.54617, 14.23703**

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

RASS/NVSS ra dec 17 31 13.5, 14 42 51.6 radio flux d. 5.000 X-ray/radio flux-ratio 26364.

arx 0.463 Log( $\nu$  peak) 19.5 $\pm$  1 possible HBL **Dist. 118.041 arcmin**

SXPS/NVSS ra dec 17 31 13.5, 14 42 51.6 radio flux d. 5.000 X-ray/radio flux-ratio 24000. arx

0.468 Log( $\nu$  peak) 19.4 $\pm$  1 possible HBL **Dist. 118.041 arcmin**

**Match nr. 22 ra dec: 262.80608, 14.71433**

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

MQ 2MRS J17311341+1442561

RASS/NVSS ra dec 17 32 35.6, 16 49 5.1 radio flux d. 5.000 X-ray/radio flux-ratio 2379. arx

0.590 Log( $\nu$  peak) 17.0 $\pm$  1 possible HBL **Dist. 200.523 arcmin**

**Match nr. 23 ra dec: 263.14833, 16.81808**

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

RASS/NVSS ra dec 17 32 52.1, 11 30 56.2 radio flux d. 18.500 X-ray/radio flux-ratio 491. arx

0.673 Log( $\nu$  peak) 15.3 $\pm$  1 possible IBL **Dist. 220.774 arcmin**

**Match nr. 24 ra dec: 263.21688, 11.51561**

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

SXPS/NVSS ra dec 17 33 22.6, 15 13 21.8 radio flux d. 227.600 flux-ratio 26. arx 0.828 pos-

sible LBL **Dist. 156.132 arcmin**

**Match nr. 25 ra dec: 263.34433, 15.22272**

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

BROS J1733.3+1513

CRATES J173322+151313

RASS/NVSS ra dec 17 34 16.0, 13 43 52.6 radio flux d. 2.700 X-ray/radio flux-ratio 38805.

arx 0.443 Log( $\nu$  peak) 19.9 $\pm$  1 possible HBL **Dist. 164.748 arcmin**

**Match nr. 26 ra dec: 263.56654, 13.73128**

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

BMW/NVSS ra dec 17 34 42.6, 16 00 33.0 radio flux d. 1455.800 flux-ratio 5. arx 0.916 pos-

sible LBL **Dist. 193.648 arcmin**

**Match nr. 27 ra dec: 263.67733, 16.00917**

.....Cataloged sources.....  
MQ PKS 1732+16

RASS/NVSS ra dec 17 36 29.0, 15 25 27.4 radio flux d. 125.200 X-ray/radio flux-ratio 113.  
arx 0.751 Log(nu peak) 13.8+/- 1 possible IBL **Dist. 202.576 arcmin**  
**Match nr. 28 ra dec: 264.12088, 15.42428**  
.....Cataloged sources.....  
CRATES J173629+152531

RASS/NVSS ra dec 17 39 30.6, 14 28 0.4 radio flux d. 2.800 X-ray/radio flux-ratio 6169. arx  
0.540 Log(nu peak) 18.0+/- 1 possible HBL **Dist. 236.532 arcmin**  
**Match nr. 29 ra dec: 264.87738, 14.46678**  
.....Cataloged sources.....

Candidate nr. 30, Known blazar with no radio/X-ray match: 5BZQ J1728+1215 found at a  
distance of 144.171 arcmin  
Candidate nr. 31, Known flat spectrum radio source with no radio/X-ray match: BROS J1726.0+1027  
found at a distance of 237.463 arcmin  
Candidate nr. 32, Known flat spectrum radio source with no radio/X-ray match: BROS J1713.0+1117  
found at a distance of 236.727 arcmin  
Candidate nr. 33, Known flat spectrum radio source with no radio/X-ray match: BROS J1716.1+1131  
found at a distance of 198.212 arcmin  
Candidate nr. 34, Known flat spectrum radio source with no radio/X-ray match: BROS J1708.7+1254  
found at a distance of 227.848 arcmin  
Candidate nr. 35, Known flat spectrum radio source with no radio/X-ray match: BROS J1708.5+1306  
found at a distance of 226.749 arcmin  
Candidate nr. 36, Known flat spectrum radio source with no radio/X-ray match: BROS J1715.7+1317  
found at a distance of 126.693 arcmin  
Candidate nr. 37, Known flat spectrum radio source with no radio/X-ray match: BROS J1714.9+1329  
found at a distance of 130.758 arcmin  
Candidate nr. 38, Known flat spectrum radio source with no radio/X-ray match: BROS J1719.0+1113  
found at a distance of 197.722 arcmin  
Candidate nr. 39, Known flat spectrum radio source with no radio/X-ray match: BROS J1726.4+1048  
found at a distance of 217.387 arcmin  
Candidate nr. 40, Known flat spectrum radio source with no radio/X-ray match: BROS J1720.8+1211  
found at a distance of 133.741 arcmin  
Candidate nr. 41, Known flat spectrum radio source with no radio/X-ray match: BROS J1720.4+1219  
found at a distance of 127.608 arcmin  
Candidate nr. 42, Known flat spectrum radio source with no radio/X-ray match: BROS J1718.2+1316  
found at a distance of 97.576 arcmin  
Candidate nr. 43, Known flat spectrum radio source with no radio/X-ray match: BROS J1719.5+1321  
found at a distance of 79.896 arcmin  
Candidate nr. 44, Known flat spectrum radio source with no radio/X-ray match: BROS J1722.8+1307  
found at a distance of 74.113 arcmin  
Candidate nr. 45, Known flat spectrum radio source with no radio/X-ray match: BROS J1723.9+1346  
found at a distance of 36.200 arcmin  
Candidate nr. 46, Known flat spectrum radio source with no radio/X-ray match: BROS J1726.2+1227  
found at a distance of 121.876 arcmin  
BROS J1728.1+1215, repeated with candidate nr. 30 5BZQ J1728+1215  
Candidate nr. 47, Known flat spectrum radio source with no radio/X-ray match: BROS J1725.1+1312  
found at a distance of 73.510 arcmin  
Candidate nr. 48, Known flat spectrum radio source with no radio/X-ray match: BROS J1725.3+1318

found at a distance of 69.244 arcmin  
Candidate nr. 49, Known flat spectrum radio source with no radio/X-ray match: BROS J1728.2+1336  
found at a distance of 85.117 arcmin  
Candidate nr. 50, Known flat spectrum radio source with no radio/X-ray match: BROS J1731.7+1151  
found at a distance of 194.980 arcmin  
Candidate nr. 51, Known flat spectrum radio source with no radio/X-ray match: BROS J1735.8+1330  
found at a distance of 189.827 arcmin  
Candidate nr. 52, Known flat spectrum radio source with no radio/X-ray match: BROS J1708.0+1402  
found at a distance of 221.911 arcmin  
Candidate nr. 53, Known flat spectrum radio source with no radio/X-ray match: BROS J1709.7+1416  
found at a distance of 196.138 arcmin  
Candidate nr. 54, Known flat spectrum radio source with no radio/X-ray match: BROS J1707.9+1510  
found at a distance of 227.779 arcmin  
Candidate nr. 55, Known flat spectrum radio source with no radio/X-ray match: BROS J1710.5+1457  
found at a distance of 187.785 arcmin  
Candidate nr. 56, Known flat spectrum radio source with no radio/X-ray match: BROS J1711.0+1348  
found at a distance of 180.939 arcmin  
Candidate nr. 57, Known flat spectrum radio source with no radio/X-ray match: BROS J1715.9+1425  
found at a distance of 105.520 arcmin  
Candidate nr. 58, Known flat spectrum radio source with no radio/X-ray match: BROS J1712.7+1511  
found at a distance of 160.766 arcmin  
Candidate nr. 59, Known flat spectrum radio source with no radio/X-ray match: BROS J1715.9+1511  
found at a distance of 117.326 arcmin  
Candidate nr. 60, Known flat spectrum radio source with no radio/X-ray match: BROS J1712.4+1536  
found at a distance of 173.429 arcmin  
Candidate nr. 61, Known flat spectrum radio source with no radio/X-ray match: BROS J1712.9+1551  
found at a distance of 173.692 arcmin  
Candidate nr. 62, Known flat spectrum radio source with no radio/X-ray match: BROS J1715.4+1528  
found at a distance of 130.851 arcmin  
Candidate nr. 63, Known flat spectrum radio source with no radio/X-ray match: BROS J1713.1+1655  
found at a distance of 212.438 arcmin  
Candidate nr. 64, Known flat spectrum radio source with no radio/X-ray match: BROS J1716.2+1622  
found at a distance of 157.737 arcmin  
Candidate nr. 65, Known flat spectrum radio source with no radio/X-ray match: BROS J1721.3+1405  
found at a distance of 30.874 arcmin  
Candidate nr. 66, Known flat spectrum radio source with no radio/X-ray match: BROS J1722.3+1524  
found at a distance of 64.313 arcmin  
Candidate nr. 67, Known flat spectrum radio source with no radio/X-ray match: BROS J1724.9+1425  
found at a distance of 25.487 arcmin  
Candidate nr. 68, Known flat spectrum radio source with no radio/X-ray match: BROS J1728.1+1438  
found at a distance of 73.011 arcmin  
Candidate nr. 69, Known flat spectrum radio source with no radio/X-ray match: BROS J1729.4+1441  
found at a distance of 92.193 arcmin  
Candidate nr. 70, Known flat spectrum radio source with no radio/X-ray match: BROS J1725.3+1506  
found at a distance of 54.298 arcmin  
Candidate nr. 71, Known flat spectrum radio source with no radio/X-ray match: BROS J1719.2+1543  
found at a distance of 100.522 arcmin  
Candidate nr. 72, Known flat spectrum radio source with no radio/X-ray match: BROS J1721.8+1541  
found at a distance of 82.613 arcmin  
Candidate nr. 73, Known flat spectrum radio source with no radio/X-ray match: BROS J1721.8+1559  
found at a distance of 100.617 arcmin  
Candidate nr. 74, Known flat spectrum radio source with no radio/X-ray match: BROS J1718.5+1619  
found at a distance of 136.114 arcmin  
Candidate nr. 75, Known flat spectrum radio source with no radio/X-ray match: BROS J1721.0+1626  
found at a distance of 129.580 arcmin

Candidate nr. 76, Known flat spectrum radio source with no radio/X-ray match: BROS J1723.7+1634 found at a distance of 133.970 arcmin  
Candidate nr. 77, Known flat spectrum radio source with no radio/X-ray match: BROS J1722.6+1703 found at a distance of 162.264 arcmin  
Candidate nr. 78, Known flat spectrum radio source with no radio/X-ray match: BROS J1724.3+1648 found at a distance of 148.211 arcmin  
Candidate nr. 79, Known flat spectrum radio source with no radio/X-ray match: BROS J1727.9+1536 found at a distance of 101.808 arcmin  
Candidate nr. 80, Known flat spectrum radio source with no radio/X-ray match: BROS J1728.5+1545 found at a distance of 114.207 arcmin  
Candidate nr. 81, Known flat spectrum radio source with no radio/X-ray match: BROS J1726.0+1639 found at a distance of 144.462 arcmin  
Candidate nr. 82, Known flat spectrum radio source with no radio/X-ray match: BROS J1711.3+1700 found at a distance of 234.939 arcmin  
Candidate nr. 83, Known flat spectrum radio source with no radio/X-ray match: BROS J1720.0+1718 found at a distance of 183.970 arcmin  
Candidate nr. 84, Known flat spectrum radio source with no radio/X-ray match: BROS J1733.7+1440 found at a distance of 154.075 arcmin  
Candidate nr. 85, Known flat spectrum radio source with no radio/X-ray match: BROS J1736.8+1434 found at a distance of 198.626 arcmin  
Candidate nr. 86, Known flat spectrum radio source with no radio/X-ray match: BROS J1736.6+1512 found at a distance of 201.260 arcmin  
Candidate nr. 87, Known flat spectrum radio source with no radio/X-ray match: BROS J1738.0+1551 found at a distance of 233.002 arcmin  
Candidate nr. 88, Known flat spectrum radio source with no radio/X-ray match: BROS J1735.6+1603 found at a distance of 206.457 arcmin  
Candidate nr. 89, Known flat spectrum radio source with no radio/X-ray match: BROS J1733.0+1635 found at a distance of 195.518 arcmin  
Candidate nr. 90, Known flat spectrum radio source with no radio/X-ray match: BROS J1735.6+1645 found at a distance of 230.628 arcmin  
Candidate nr. 91, Known flat spectrum radio source with no radio/X-ray match: BROS J1736.0+1646 found at a distance of 235.822 arcmin  
Candidate nr. 92, Known flat spectrum radio source with no radio/X-ray match: BROS J1732.6+1725 found at a distance of 228.880 arcmin  
CRATES J172626+104833, repeated with candidate nr. 39 BROS J1726.4+1048  
Candidate nr. 93, Known flat spectrum radio source with no radio/X-ray match: CRATES J173143+111509 found at a distance of 223.532 arcmin  
CRATES J171302+111716, repeated with candidate nr. 32 BROS J1713.0+1117  
CRATES J172807+121541, repeated with candidate nr. 30 5BZQ J1728+1215  
CRATES J170801+140246, repeated with candidate nr. 52 BROS J1708.0+1402  
CRATES J173345+144031, repeated with candidate nr. 84 BROS J1733.7+1440  
Candidate nr. 94, Known flat spectrum radio source with no radio/X-ray match: CRATES J171913+154310 found at a distance of 100.578 arcmin  
CRATES J172830+154553, repeated with candidate nr. 80 BROS J1728.5+1545  
CRATES J173300+163542, repeated with candidate nr. 89 BROS J1733.0+1635  
CRATES J173603+164650, repeated with candidate nr. 91 BROS J1736.0+1646  
CRATES J172421+164826, repeated with candidate nr. 78 BROS J1724.3+1648  
Candidate nr. 95, Known flat spectrum radio source with no radio/X-ray match: CRATES J173215+170550 found at a distance of 210.305 arcmin  
Candidate nr. 96, Known flat spectrum radio source with no radio/X-ray match: CRATES J173142+172517 found at a distance of 221.393 arcmin

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