The ICRANet Brazilian Science Data Center (BSDC) and Multi-frequency selection and studies of blazars

1 Topics

- Definition and set up of the technical infrastructure for the ICRANet Science Data Center in Pescara and Rio de Janeiro
- Development of a VO interface to the MAGIC and VERITAS published results repository and integration within the BSDC tools.
- Implementation of VO + Web interfaces to catalogs of astronomical sources published as part of ICRANet research.
- Installation, adaptation and testing of software suitable for the generation of Fermi adaptive bin γ-ray light curves and construction of a database of blazar γ-ray light curves to be interfaced to BSDC and Open Universe systems.
- Implementation, adaptation and testing of software for cross-correlation analysis of time series and light curves.
- Selection of large samples of high energy peaked(HSP)/high energy γ-ray emitting blazars (1WHSP, 2WHSP and 3HSP samples)
- Detection of γ-ray emission in HSP blazars (150 new Fermi of γ-ray detection of 2WHSP blazars: the 1BIGB sample)
- Search for possible spatial correlation between HSP blazars and astrophysical neutrinos
- Modelling of the variable SED of blazars using large multi-frequency/multi-temporal data sets
- Generation of high level multi-frequency data products of blazars (e.g. Fermi adaptive bin light curves, Swift spectra and X-ray light curves, optical polarization)

2 Participants

2.1 ICRANet participants

- Paolo Giommi
- Ulisses Barres de Almeida
- Narek Sahakyan
- Benno Bodmann

2.2 Ongoing collaborations

- Paolo Padovani (ESO)
- Elisa Resconi (TUM)
- MAGIC Collaboration
- VERITAS Collaboration
- SSDC

2.3 Past collaborations

- ASI-ASDC
- CESUP

2.4 Students/Postdocs

- Yu-Ling Chang
- Bruno Sversut Arsioli
- Bernardo Machado Fraga
- Carlos Enrique Brandt

3 Brief description

The activity includes two main components:

- the construction and consolidation of an ICRANet distributed science data center based in Pescara, Rio de Janeiro (this component is named BSDC, Brazilian Science Data Center), Yerevan, and other sites; discussions are ongoing for a possible expansion of these activities within the BRICS network. Concerning database expansion, the complete incorporation of VHE MAGIC and VERITAS datasets for AGNs within the BSDC/Open Universe framework, is undergoing, with future expansion to other VHE collaborations being sough.
- a scientific part, based on the data coming from the ICRANet data center, dedicated to the identification of samples of high energy emitting blazars (1 WHSP, 2 WHSP and 3HSP) and to the theoretical interpretation of the radio to γ-ray emission of selected bright blazars. The latter includes, for the first time, a detailed look and consideration of multiband light curve cross-correlations within the SED analysis.

3.1 Implementation of the ICRANet Brazilian Science Data Center (BSDC)

Following the preparatory work carried out in the past year, the establishment of the ICRANet - Brazilian Science Data Center (BSDC) on the premises of ICRANet-Rio is ready to start the implementation phase. The BSDC will host a mirror copy of the ASDC (ASI Science Data Center) public data, catalogs and of all the data reduction and analysis software that is publicly available. Specific software for archive data access at BSDC will be developed as part of this project. It will also host public data from several projects in which the Brazilian community, and in particular the Brazilian centres participating in the BSDC, are involved. Three major steps are foreseen: 1) start up phase (concluded in 2016), 2) BSDC archive and team building (January to June 2017), 3) establishment of a fully functional BSDC and related science teams at CBPF/Rio (by the end of 2017).

When fully operation, but he end of next year, in its first phase of scientific operations, the BSDC will focus on very high energy data and polarised radiation. In parallel, the novel Yerevan component of the collaboration will focus in the production of Fermi high level data products, such as adaptive-binning γ-ray light curves of selected bright blazars. The BSDC is built in collaboration with the ASI Science Data Center (ASDC) and contributes to the development of the recently approved United Nations initiative named Open Universe.

3.2 High energy emitting blazars

3.2.1 The VHE 1WHSP, 2WHSP and 3HSP blazar catalogs

Blazars are a class of radio-loud active galactic nuclei (AGN) hosting a jet oriented at a small angle with respect to the line of sight (Blandford and Rees, 1978; Antonucci, 1993; Urry and Padovani, 1995; Padovani et al. , 2017). The emission of these objects is non-thermal over most or the entire electromagnetic spectrum, from radio frequencies to hard γ-rays. HSP blazars, those where the first SED peak is located at high energy ($\nu_{peak} > 10^{15}$ Hz), play a crucial role in very high energy (VHE) astronomy. Observations have shown that HSPs are bright and variable sources of high energy γ-ray photons (TeVCat)[1] and that they are likely the dominant component of the extragalactic VHE background (Padovani et al., 1993; Giommi et al., 2006; Di Mauro et al., 2014; Giommi and Padovani, 2015; Ajello et al., 2015). In fact, most of the extragalactic objects detected so far above a few GeV are HSPs (Giommi et al., 2009; Padovani and Giommi, 2015; Arsioli et al., 2015; Ackermann et al., 2016, see also TeVCat). However, only a few hundred HSP blazars are above the sensitivity limits of currently available γ-ray surveys. Significantly enlarging the number of high energy blazars is crucial to better understand their role within the AGN phenomenon, and shed light on their cosmological evolution, which is still a matter of debate.

Arsioli et al. (2015) built a catalog of HSP blazars named 1WHSP, based on WISE color-color diagram with the sources inside the *S*edentary WISE

[1] http://tevcat.uchicago.edu

color region(SWCD), extended from WISE blazar strip (Massaro et al., 2011; D'Abrusco et al., 2012; Massaro et al., 2012) to include all the sources from the Sedentary survey blazars (Giommi et al., 1999, 2005; Piranomonte et al., 2007).

They cross-matched the AllWISE sources (Cutri et al., 2013) in SWCD with different radio and X-ray catalogs using TOPCAT[2], applied spectrum slope criteria, and selected the source with Synchrotron peak $\nu_{peak} > 10^{15}$ Hz (Padovani and Giommi, 1995; Abdo et al., 2010) and Galactic latitude $b > |20°|$. Note that there are three slope criteria in Arsioli et al. (2015) , which are radio to IR slope, IR to X-ray slope, and the AllWISE W1 to W3 slope; the criteria are obtained from normalized and rescaled the SEDs of three well-known HSP blazars.

About one year ago, Chang et al. (2017) assembled what is still the most complete and largest HSP catalog, 2WHSP, an extension of 1WHSP catalog to $b > |20°|$. Similarly to Arsioli et al. (2015), the 2WHSP catalog was built starting from cross-matching three radio catalogs (NVSS, FIRST, and SUMSS: Condon et al., 1998; White et al., 1997; Manch et al., 2003) with AllWISE IR catalog and then with various X-ray catalogs (RASS BSC and FSC, 1SWXRT and deep XRT GRB, 3XMM, XMM slew, Einstein IPC, IPC slew, WGACAT, Chandra, and BMW: Voges et al., 1999, 2000; D'Elia et al., 2013; Puccetti et al., 2011; Rosen et al., 2016; Saxton et al., 2008; Harris et al., 1993; Elvis et al., 1992; White et al., 2000; Evans et al., 2010; Panzera et al., 2003). However, 2WHSP is not subjected to WISE color-color diagram and the AllWISE W1-W3 slope criterion when selecting the sources. Therefore, the 2WHSP sample does not miss a number of good (host galaxy dominated) HSPs. We used ASDC SED tool[3] to examine and fit the Synchrotron component with a third degree polynomial to get the Synchrotron peak position (ν_{peak}) and Synchrotron peak flux ($\nu_{peak} f_{\nu_{peak}}$) for each WHSP pre-selection candidate.

The 2WHSP catalog totally includes 1,691 sources with 540 known HSPs, 288 new HSPs, and 814 HSP candidates. The name "WHSP" stands for WISE high Synchrotron peaked blazars since except for one source, 2WHSP J135340.2−663958.0, all the other sources in 2WHSP have WISE counterparts. For each 2WHSP source, we adopted as best coordinates those taken from the WISE catalog. The average ν_{peak} for our catalog is $\langle \log \nu_{peak} \rangle = 16.22 \pm 0.02$ Hz and the average redshift is $\langle z \rangle = 0.331 \pm 0.008$. We have shown that the SWCD region

[2]http://www.star.bris.ac.uk/ mbt/topcat/
[3]http://tools.asdc.asi.it/SED

needs to be extended to include HSPs in which the host galaxy is dominant. The 2WHSP radio logN-logS shows that the number of HSP blazars over the whole sky is $> 2,000$ and that HBL make up $\sim 10\%$ of all BL Lacs. A new, enhanced version of the 2WHSP catalog, called 3HSP, is currently being finalized. It includes nearly 2,000 objects and will be published in early 2018. This new sample does not rely on Wise infrared data and therefore is not subject to limitations due to the presence of the host galaxy. In addition the 3HSP list will include several new sources discovered at low Galactic latitudes, and will provide more accurate estimates of the SED parameters, based on all the available multi-frequency archival data and new software tools developed in the framework of the United Nations "Open Universe" initiative.

3.2.2 The 1BIGB catalog

The 2WHSP sources has been used as seeds of HE and VHE searches to discover new VHE detections or to find the counterparts of VHE catalogs. So far, 439 of 2WHSP sources have counterparts within the error circles from the 3FGL catalog; there is still a large number of 2WHSP HSPs which does not have γ-ray detections yet. Therefore, Arsioli and Chang (2016) analyzed bright 2WHSP sources using archival Fermi-LAT data integrated over 7.2 years observations, Pass 8 data release. By using the position of 2WHSP sources as seeds for the likelihood analysis, we found 150 previously unreported γ-ray detections.

The 150 new γ-ray sources are named with the acronym 1BIGB (first version of the Brazil ICRANet Gamma-ray Blazar catalog). Clearly, the subsample of 2WHSP blazars that have not yet been detected by Fermi-LAT is a key representative population of faint γ-ray emitters, and we show how the new detections down to TS > 10 level can probe the faint-end of the flux-distribution.

The new detections also unveil a fraction of the γ-ray sky. Our current work enabled us to associate a relevant fraction of the IGRB to a population of faint γ-ray emitters that had been previously unresolved. Moreover, we show the increasing relevance of faint-HSPs for the IGRB composition with respect to energy, specially for E > 10 GeV, reaching 6-8% in the $100 - 200$ GeV band.

Motivated by this first assessment, we plan to perform a complete γ-ray analysis of the 2WHSP sample, down to the lowest fluxes, and probably extend the search to other blazar families with potential to improve the γ-ray description of lower-significance γ-ray blazars, also helping to constrain the origins of the extragalactic diffuse -ray background.

3.2.3 γ-ray spectrum characterization of 1BIGB sources

Currently, we have an ongoing effort focus on the characterization of the γ-ray spectral energy distribution 1-100 GeV for whole population of 150 bright high-synchrotron-peaked blazars recently detected with Fermi-LAT as part of the 1BIGB catalog. Most of the 1BIGB sources do not appear in previous Fermi-LAT catalogues, and their γ-ray spectral properties will be properly described for the first time. We derive a flux estimate for energy channels between 1 and 100 GeV, considering PASS8 data, and integrating over 9 years of observations with Fermi-LAT.

Since our sample was originally selected from an excess signal in the 0.3 - 500 GeV band, they stand out as promising TeV blazar candidates, which might be in reach of the forthcoming very-high-energy (VHE) gamma-ray observatory, CTA. We also evaluate the importance of these sources in the context of future VHE population studies with CTA. For many individual sources, we might compare the derived source spectra to the published CTA sensitivity curve to estimate detectability by CTA.

All γ-ray SEDs presented in this work will be publicly available via the Brazilian Science Data Center (BSDC). This is a research effort involving B. Arsioli (Unicamp - IFGW, Campinas, Brazil), U. Barres & B. Fraga (CBPF, Rio de Janeiro, Brazil), E. Prandini & L. Foffano (University of Padova, INFN, Italy), P. Giommi (SSDC - ASI, Rome, Italy). Currently, all are CTA members.

3.2.4 The 2BIGB Catalog

The Second Brazilian ICRANet Gamma-ray Catalog (2BIGB) is a large scale likelihood analysis integrating over 9 yrs of Fermi-LAT data at E>10 GeV for ~8.000 blazars and blazar-candidates. Most of our $\gamma - ray$ candidates are placed out of the galactic plane, avoiding the galactic diffuse background. Also, working at such high-energy help to avoid spurious detections since the point spread function (PSF) is greatly improved with respect to the lower energy band (100 MeV - 1 GeV) probed by Fermi-LAT. Following previous work (Arsioli and Chang, 2016) we apply a multifrequency approach which allow us to relax the detection criteria dow to TS 9 level, since we are only probing specific regions in the sky which are associated at least with a radio + X-ray detection, with slope characteristic of blazars.

Our sample with seeds for the γ-ray analysis come from previous catalogs: WHSP, 5BZcat, Maselli and WIBR. All resulting γ-ray detections with statistical significance larger than 3σ ($\equiv$TS>9) at E>10 GeV were listed. We report on the statistical significance associated to each source for E>10 GeV, showing the fitting parameter of a power law model adjusting to the observed flux along the entire energy range from 10 GeV up to 800 GeV. The integral flux is also listed. Differential flux at specific energies are also reported: 3 GeV, 10 GeV, 30 GeV, 50 GeV and 100 GeV, providing a γ-ray SED with five data points which turn to be very useful when inspecting the SED from individual sources. The γ-ray SED allow for quick inspection of the hardness of a source close to the VHE window, important for the selection of new CTA targets. Also, going to lower significance allow us to evaluate the contribution from faint γ-ray sources to the overall background at 10 GeV energy level.

3.2.5 New γ-ray detections of radio-selected blazars with Fermi-LAT

Following Arsioli and Chang (2016) and motivated by the possibility of detecting new γ-ray sources associated to LSP blazars, we study broad-band SED properties of a complete sample of 104 bright, radio-selected northern extragalactic sources with flux density at 37 GHz larger than 1 Jy. The majority of those objects are bright Low-Synchrotron Peaked (LSP) blazars, with Spectral Energy Distributions (SEDs) well characterised from radio to X-rays. Most of them have already been detected in the γ-ray band by Fermi-LAT, however almost 20% have no counterpart in any of the Fermi catalogs published so far.

Using the Fermi Science Tools, we look for γ-ray emission for those objects not yet reported in any Fermi-LAT catalog, searching for new detections and associations. We perform a binned likelihood analysis in the 0.3-500 GeV energy band with Fermi Pass 8 data, integrating over 7.5 years of observations. We study γ-ray light curves and TS maps to validate new-detections/associations, building a better picture on the high-energy activity in radio selected LSP blazars.

We then study the multi-frequency SED for all sources in the target sample, fitting their synchrotron (Syn) and inverse Compton (IC) components.

We fit the IC component for the new detections using all data at our disposal from X-rays to GeV γ-rays, enhancing the amount of information available to study the Syn. to IC peak-power correlations. With a well characterised sample of LSP blazars at hand, we derive the distribution of the Compton Dominance parameter, as well as basic population properties like the distribution of synchrotron peak power and frequency.

We show that three previously unidentified 3FGL sources can be associated to as many objects in the sample using improved γ-ray positions obtained from TS maps. Six previously unreported γ-ray sources are detected at TS > 20 level, while three additional objects show TS values between 10-20. We evaluate two cases where source confusion is likely present. In four cases there is no significant γ-ray signature when integrating over 7.5 years. However, short-lived flares, at $\sim$1 month scale, have been detected in these sources, which we could identify from light curves. Finally, we measure the Compton dominance for this radio sample, which has a Gaussian-like distribution with median Log(Compton Dominance) of 0.1, implying that on average the peak-power output for the synchrotron and IC components are similar.

This work is a result of cooperation between B. Arsioli (Unicamp - IFGW, Campinas, Brazil), G. Polenta and P. Giommi (SSDC - ASI, Rome, Italy), and has been just recently submitted to A&,A.

3.2.6 Testing Self Synchrotron Compton (SSC) & External Compton (EC) scenarios for hints on the γ-ray emitting region in Low Synchrotron Peaked Blazars

Based on the complete sample of 104 radio-selected Low-Synchrotron Peaked (LSP) blazars (as described in sec. 3.2.5) we study broadband population properties associated to the non-thermal jet emission process, testing the capability/viability of Synchrotron Self Compton (SSC) & External Compton (EC) scenarios to explain the overall SED features. As main novelty, we incorporate 16 new γ-ray detections/associations (sec. 3.2.5) in addition to the 83 source previously detected by Fermi-LAT, therefore $\sim$95% of the objects have available information about the Inverse Compton (IC) non-thermal jet component.

We test the Synchrotron Self Compton (SSC) and the External Compton (EC) scenarios looking for hints that might help us localize the γ-ray emission site, given that the IC process is driven by the abundance of UV to X-rays photons coming from the accretion disc region (close to the jet base), or infrared (IR) dust-torus photons (far from jet base). Studying population properties, we show that SSC alone is not enough to account for the observed SEDs. Our analysis favours an EC scenario under Thomson scattering regime, with a dominant IR external photon field, probably the most favourable to account for the population properties of bright LSP blazars. This work is about to be subimited to A A and is the result of cooperation between B. Arsioli (Unicamp - IFGW, Campinas, Brasil) and Y-L. Chang (SSDC - ASI, Rome, Italy).

3.2.7 Correlation between blazars and astrophysical neutrinos

Padovani et al. (2016) cross-matched the 2WHSP with IceCube neutrino events. Their results suggest that, among the blazar family, HSPs blazars are the most likely counterparts of astrophysical neutrinos. Resconi et al. (2017) have recently presented new evidence for a direct connection between 2FHL HBLs, very high energy neutrinos, and ultra high energy cosmic rays (UHECRs) when cross-matching 2FHL HBL subsample with UHECRs from the Pierre Auger Observatory and the Telescope Array. In a nutshell, HSPs catalogs are important and timely for HE and VHE astronomy.

The most convincing association of an astrophysical neutrino with an extragalactic object reported so far is that connected with the event occurred on September 22, 2017 (Kopper & Blaufuss, 2017), where a very bright ($\approx$ 1Jy in the radio band) IBL/HBL BL Lac was found within the small ($\sim$ 0.1 sqdeg) uncertainty region of the IceCube track neutrino IC170922. A number of papers from the ICeCube, Fermi, and other teams are in preparation and are expected to be published in the early months of 2018. Our collaboration is actively participating to this research and a paper is in preparation (Giommi et al. 2018).

3.2.8 Temporal study of the spectral energy distribution of blazars

Many of the studies on blazars are focused on their spectral energy distribution (SED). These provide a photographic view of the source state, which in turn gives an overview of the emission energy balance. Despite we can get some limits on models, the approach not able to satisfactorily explain the dynamics of the physical emission processes, because they evolve in time in a complex way, as can be seen by the emission's variability and multi-band correlations. In particular, there is evidence for the existence of delays between emissions at different frequencies, a feature not accounted for in traditional SSC models of the SED. To try and get around these problems, other models have been proposed, such as those with contribution from radiation fields external to the jets for the inverse-Compton emission, or models where an emission zone is not homogeneous and multiple emitting blobs are considered to build up simultaneously the SED. However promising, these studies remain incipient and require further analysis. Key to the success of more in-depth studies is the availability of a large amount of multi-band data, for a detailed and combined view of the spectral properties and temporal evolution of the sources.

Usually, when dealing with the temporal evolution of blazar emission, the most commonly used method is to consider strictly simultaneous observations in multi-wavelength campaigns, and try to impose limits on different models. However, as previously mentioned, the emission at different frequencies may be correlated. Correlations between different bands are useful for determining the emission mechanism and constrain emitting region. In addition, if a correlation is discovered between two frequencies, it can be used to predict the emission of sources not yet detected. Some studies have found correlations in flare emission between, for example, radio and gamma rays and between optical and gamma rays. These multi-band correlations, if real, imply a delay in the variation of the emission at different frequencies. It is then clear, in these cases, that strictly simultaneous observations are not exploiting the same state of a source, since the lags are not taken into account. In order to analyze the time evolution of the emission, it is necessary to first analyse the multi-band correlations and to determine the lags between them, and then to collect the data of simultaneous observations, that is, separated by a period of time similar to the lag. This allows for a more rigorous study of emission models and the imposition of limits on their parameters. Although there are codes to calculate correlations and lags, a tool that would automate the whole process, from data selection and lag calculation to the construction of simultaneous SEDs, would be of immense value to the scientific community and could be integrated to the ASDC, making it available in a fast, easy and effective way for everyone. This is one of the technical goals and legacies of this work.

At first we intend to use a specific source, Mkn421, as a prototype for our study. We plan to publish a paper about the analysis of the temporal evolution of this source and its modeling by the end of the first year of research. At the same time, we have a preliminary version of the lags calculation tool and light curve construction already ready to be tested for a greater number of sources and deployment in ASDC.

With this study, we hope to be able to shed some light on the cause of variable emission in blazars. The lags estimation will allow us to determine how the emission at different frequencies are related and which physical mechanisms may be responsible for such a relationship. The construction of simultaneous SEDs will serve to discriminate between the different emission models already proposed, as well as to find out whether or not there is periodicity in a range of time scales. Today we have a large amount of data at hand, making it possible to create large catalogs of blazars (such as BZCAT and 1WHSP), making statistical studies more rigorous and precise. In order to work with a large number of sources it is necessary that the selection of simultaneous data be, to a great extent, automated. ASDC, being a great integrated platform for data analysis and visualization, is a perfect option to implement this procedure, making the determination of correlations, lags and the subsequent construction of simultaneous SEDs easier, faster and more accessible to the community at large. The beginning of the implementation of the Brazilian Science Data Center (BSDC) in CBPF, an integrated data platform analogous to ASDC, focusing on collecting data from missions to which Brazil is a partner, will be another opportunity for the implementation of the automated analysis of the time evolution of blazars.

4 Publications

- Barres de Almeida, U.; Bodmann, B.; Giommi, P.; Brandt, C.
  The Brazilian Science Data Center (BSDC)
  2017, International Journal of Modern Physics Conference Series, 45.

- Chang, Y.L.; Arsioli, B.; Giommi, P.; Padovani, P. 2WHSP: A multi-frequency selected catalog of VHE gamma-ray blazars and blazar candidates
  2017, A&A, 598, 17

- Arsioli, B.; Chang, Y.L. Searching for γ-ray signature in WHSP blazars: Fermi-LAT detection of 150 excess signal in the 0.3-500 GeV band (1BIGB sample)
  2017, A&A, 598, 134.

- Padovani P., Resconi E., Giommi P., Arsioli B., Chang Y.L.
  Extreme blazars as counterparts of IceCube astrophysical neutrinos
  2016 MNRAS 457, 3582

- Resconi E., Coenders S., Padovani P., Giommi P. , and Caccianiga L.
  Connecting blazars with ultra high energy cosmic rays and astrophysical neutrinos
  2017, MNRAS, 468, 597

- Padovani P., Alexander D. M., Assef R. J., De Marco B., Giommi P., Hickox R. C., Richards G. T., Smolčić V., Hatziminaoglou E., Mainieri V., and Salvato, M.
  Active galactic nuclei: what's in a name?
  A&ARv, 25, 2, 2017

Bibliography

A.~A. Abdo, M Ackermann, I Agudo, M Ajello, H.~D. Aller, M.~F. Aller, E Angelakis, A.~A. Arkharov, M Axelsson, U Bach, and Et al.
The Spectral Energy Distribution of Fermi Bright Blazars.
ApJ, 716:30–70, 2010.
doi: 10.1088/0004-637X/716/1/30.

M. Ackermann, M. Ajello, W. B. Atwood, L. Baldini, J. Ballet, G. Barbiellini, D. Bastieri, J. Becerra Gonzalez, R. Bellazzini, E. Bissaldi, R. D. Blandford, E. D. Bloom, R. Bonino, E. Bottacini, T. J. Brandt, J. Bregeon, P. Bruel, R. Buehler, S. Buson, G. A. Caliandro, R. A. Cameron, R. Caputo, M. Caragiulo, P. A. Caraveo, E. Cavazzuti, C. Cecchi, E. Charles, A. Chekhtman, C. C. Cheung, J. Chiang, G. Chiaro, S. Ciprini, J. M. Cohen, J. Cohen-Tanugi, L. R. Cominsky, J. Conrad, A. Cuoco, S. Cutini, F. D'Ammando, A. de Angelis, F. de Palma, R. Desiante, M. Di Mauro, L. Di Venere, A. Domínguez, P. S. Drell, C. Favuzzi, S. J. Fegan, E. C. Ferrara, W. B. Focke, P. Fortin, A. Franckowiak, Y. Fukazawa, S. Funk, A. K. Furniss, P. Fusco, F. Gargano, D. Gasparrini, N. Giglietto, P. Giommi, F. Giordano, M. Giroletti, T. Glanzman, G. Godfrey, I. A. Grenier, M.-H. Grondin, L. Guillemot, S. Guiriec, A. K. Harding, E. Hays, J. W. Hewitt, A. B. Hill, D. Horan, G. Iafrate, Dieter Hartmann, T. Jogler, G. Jóhannesson, A. S. Johnson, T. Kamae, J. Kataoka, J. Knödlseder, M. Kuss, G. La Mura, S. Larsson, L. Latronico, M. Lemoine-Goumard, J. Li, L. Li, F. Longo, F. Loparco, B. Lott, M. N. Lovellette, P. Lubrano, G. M. Madejski, S. Maldera, A. Manfreda, M. Mayer, M. N. Mazziotta, P. F. Michelson, N. Mirabal, W. Mitthumsiri, T. Mizuno, A. A. Moiseev, M. E. Monzani, A. Morselli, I. V. Moskalenko, S. Murgia, E. Nuss, T. Ohsugi, N. Omodei, M. Orienti, E. Orlando, J. F. Ormes, D. Paneque, J. S. Perkins, M. Pesce-Rollins, V. Petrosian, F. Piron, G. Pivato, T. A. Porter, S. Rainò, R. Rando, M. Razzano, S. Razzaque, A. Reimer, O. Reimer, T. Reposeur, R. W. Romani, M. Sánchez-Conde, P. M. Saz Parkinson, J. Schmid, A. Schulz, C. Sgrò, E. J. Siskind, F. Spada, G. Spandre, P. Spinelli, D. J. Suson, H. Tajima, H. Takahashi, M. Takahashi, T. Takahashi, J. B. Thayer, D. J.

Thompson, L. Tibaldo, D. F. Torres, G. Tosti, E. Troja, G. Vianello, K. S. Wood, M. Wood, M. Yassine, G. Zaharijas, and S. Zimmer.
2FHL: The Second Catalog of Hard Fermi-LAT Sources.
ApJS, 222:5, 2016.
URL `http://arxiv.org/abs/1508.00444`.

M. Ajello, D. Gasparrini, M. Sanchez-Conde, G. Zaharijas, M. Gustafsson, J. Cohen-Tanugi, C. D. Dermer, Y. Inoue, D. Hartmann, M. Ackermann, K. Bechtol, A. Franckowiak, A. Reimer, R. W. Romani, and A. W. Strong.
The Origin of the Extragalactic Gamma-Ray Background and Implications for Dark-Matter Annihilation.
ApJ, 800(2):L27, 2015.
doi: 10.1088/2041-8205/800/2/L27.
URL `http://arxiv.org/abs/1501.05301http://dx.doi.org/10.1088/2041-8205/800/2/L27`.

R. Antonucci.
Unified Models for Active Galactic Nuclei and Quasars.
ARA&A, 31(1):473–521, 1993.
ISSN 00664146.
doi: 10.1146/annurev.astro.31.1.473.

B. Arsioli, B. Fraga, P. Giommi, P. Padovani, and P. M. Marrese.
1WHSP: an IR-based sample of ~1,000 VHE gamma-ray blazar candidates.
A&A, 579:A34, 2015.
doi: 10.1051/0004-6361/201424148.
URL `http://arxiv.org/abs/1504.02801`.

Bruno Arsioli and Yu-Ling Chang.
Searching for $/gamma$-ray signature in WHSP blazars: Fermi-LAT detection of 150 excess signal in the 0.3-500 GeV band.
A&A, in press, 2016.

R. Blandford and M. Rees.
Some comments on radiation mechanisms in Lacertids.
In A. M. Wolfe, editor, *Pittsburgh Conf. BL Lac Objects*, pages 341–347, Pittsburgh, 1978. University of Pittsburgh press.

Yu-Ling Chang, Bruno Arsioli, Paolo Giommi, and Paolo Padovani.

2WHSP: A catalog of HE and VHE $/gamma$-ray blazars and blazar candidates.
A&A, 598, 17, 2017.

J.~J. Condon, W.~D. Cotton, E.~W. Greisen, Q.~F. Yin, R.~A. Perley, G.~B. Taylor, and J.~J. Broderick.
The NRAO VLA Sky Survey.
AJ, 115:1693–1716, 1998.
doi: 10.1086/300337.

R. M. Cutri, E. L. Wright, T. Conrow, J. W. Fowler, P. R. M. Eisenhardt, C. Grillmair, J. D. Kirkpatrick, F. Masci, H. L. McCallon, S. L. Wheelock, S. Fajardo-Acosta, L. Yan, D. Benford, M. Harbut, T. Jarrett, S. Lake, D. Leisawitz, M. E. Ressler, S. A. Stanford, C. W. Tsai, F. Liu, G. Helou, A. Mainzer, D. Gettings, A. Gonzalez, D. Hoffman, K. A. Marsh, D. Padgett, M. F. Skrutskie, R. P. Beck, M. Papin, and M. Wittman.
Explanatory Supplement to the AllWISE Data Release Products.
Technical report, November 2013.

R D'Abrusco, F Massaro, M Ajello, J.~E. Grindlay, H.~A. Smith, and G Tosti.
Infrared Colors of the Gamma-Ray-detected Blazars.
ApJ, 748:68, 2012.
doi: 10.1088/0004-637X/748/1/68.

V. D'Elia, M. Perri, S. Puccetti, M. Capalbi, P. Giommi, D. N. Burrows, S. Campana, G. Tagliaferri, G. Cusumano, P. Evans, N. Gehrels, J. Kennea, A. Moretti, J. A. Nousek, J. P. Osborne, P. Romano, and G. Stratta.
The seven year Swift -XRT point source catalog (1SWXRT).
A&A, 551:A142, 2013.
ISSN 0004-6361.
doi: 10.1051/0004-6361/201220863.
URL `http://adsabs.harvard.edu/abs/2013A{&}A...551A.142D`.

M. Di Mauro, F. Donato, G. Lamanna, D. A. Sanchez, and P. D. Serpico.
Diffuse Γ-Ray Emission From Unresolved Bl Lac Objects.
ApJ, 786(2):129, 2014.
ISSN 0004-637X.
doi: 10.1088/0004-637X/786/2/129.
URL `http://adsabs.harvard.edu/abs/2014ApJ...786..129D`.

Martin Elvis, David Plummer, Jonathan Schachter, and G. Fabbiano.
The Einstein Slew Survey.
ApJS, 80:257–303, 1992.
ISSN 0717-6163.
doi: 10.1007/s13398-014-0173-7.2.
URL `http://www.ncbi.nlm.nih.gov/pubmed/15003161http://cid.oxfordjournals.org/lookup/doi/10.1093/cid/cir991http://www.scielo.cl/pdf/udecada/v15n26/art06.pdfhttp://www.scopus.com/inward/record.url?eid=2-s2.0-84861150233{&}partnerID=tZOtx3y1`.

Ian N. Evans, Francis A. Primini, Kenny J. Glotfelty, Craig S. Anderson, Nina R. Bonaventura, Judy C. Chen, John E. Davis, Stephen M. Doe, Janet D. Evans, Giuseppina Fabbiano, Elizabeth C. Galle, Danny G. Gibbs, John D. Grier, Roger M. Hain, Diane M. Hall, Peter N. Harbo, Xiangqun (Helen) He, John C. Houck, Margarita Karovska, Vinay L. Kashyap, Jennifer Lauer, Michael L. McCollough, Jonathan C. McDowell, Joseph B. Miller, Arik W. Mitschang, Douglas L. Morgan, Amy E. Mossman, Joy S. Nichols, Michael A. Nowak, David A. Plummer, Brian L. Refsdal, Arnold H. Rots, Aneta Siemiginowska, Beth A. Sundheim, Michael S. Tibbetts, David W. Van Stone, Sherry L. Winkelman, and Panagoula Zografou.
THE <i>CHANDRA</i> SOURCE CATALOG.
ApJS, 189(1):37–82, 2010.
ISSN 0067-0049.
doi: 10.1088/0067-0049/189/1/37.
URL `http://stacks.iop.org/0067-0049/189/i=1/a=37?key=crossref.42a9a7044ff77f3df9aa9f5aa3c7d167`.

P Giommi, M T Menna, and P Padovani.
The Sedentary Multi-Frequency Survey . I . arXiv : astro-ph / 9907014v1 1 Jul 1999.
MNRAS, 310:465–475, 1999.

P Giommi, S Piranomonte, M Perri, and P Padovani.
The Sedentary Survey of Extreme High Energy Peaked BL Lacs. II. The Catalog and Spectral Properties.
A&A, 434(1):385–396, 2005.
URL `http://www.aanda.org/articles/aa/pdf/2005/16/aa1789.pdf`.

P Giommi, S Colafrancesco, E Cavazzuti, M Perri, and C Pittori.
Non-thermal Cosmic Backgrounds from Blazars: the contribution to the CMB, X-ray and gamma-ray Backgrounds.
A&A, 445:843–855, 2006.
ISSN 0004-6361.
doi: 10.1051/0004-6361:20053402.
URL `http://arxiv.org/abs/astro-ph/0508034`.

Paolo Giommi and Paolo Padovani.
A simplified view of blazars: contribution to the X-ray and gamma-ray cosmic backgrounds.
MNRAS, 450:2404–2409, 2015.
doi: 10.1093/mnras/stv793.
URL `http://arxiv.org/abs/1504.01978http://dx.doi.org/10.1093/mnras/stv793`.

Paolo Giommi, Sergio Colafrancesco, Paolo Padovani, Dario Gasparrini, Elisabetta Cavazzuti, and Sara Cutini.
The number counts, luminosity functions and evolution of microwave-selected (WMAP) blazars and radio galaxies.
A&A, 508:107–115, 2009.
ISSN 0004-6361.
doi: 10.1051/0004-6361/20078905.
URL `http://arxiv.org/abs/0908.0652`.

D. E. Harris, W. Forman, I. M. Gioia, J. A. Hale, Jr. Harnden, F. R., C. Jones, T. Karakashian, T. Maccacaro, J. D. McSweeney, and F. A. Primini.
The Einstein Observatory catalog of IPC X ray sources. Volume 1E: Documentation, 1993.

Kopper C., Blaufuss E., 2017, GCN.2, 21916, 1

T. Manch, T. Murphy, H. J. Buttery, J. Curran, R. W. Hunstead, B. Piestrzynski, J. G. Robertson, and E. M. Sadler.
SUMSS: A wide-field radio imaging survey of the southern sky - II. The source catalogue.
MNRAS, 342(4):1117–1130, 2003.
ISSN 00358711.
doi: 10.1046/j.1365-8711.2003.06605.x.

Enrico Massaro, Roberto Nesci, and Silvia Piranomonte.
The colours of BL Lac objects: a new approach to their classification.
MNRAS, 422(3):2322–2331, 2012.
ISSN 00358711.
doi: 10.1111/j.1365-2966.2012.20782.x.
URL `http://adsabs.harvard.edu/abs/2012MNRAS.422.2322M`.

F Massaro, R D'Abrusco, M Ajello, J.~E. Grindlay, and H.~A. Smith.
Identification of the Infrared Non-thermal Emission in Blazars.
ApJ, 740:L48, 2011.
doi: 10.1088/2041-8205/740/2/L48.

P. Padovani and P. Giommi.
A simplified view of blazars: the very high energy -ray vision.
MNRAS, 446(1):L41–L45, 2015.
ISSN 1745-3925.
doi: 10.1093/mnrasl/slu164.
URL `http://adsabs.harvard.edu/abs/2015MNRAS.446L..41P`.

P. Padovani, G. Ghisellini, A. C. Fabian, and A. Celotti.
Radio-loud AGN and the extragalactic gamma-ray background.
MNRAS, 260(2):L21–L24, 1993.
ISSN 0717-6163.
doi: 10.1007/s13398-014-0173-7.2.
URL `http://www.ncbi.nlm.nih.gov/pubmed/15003161http://cid.oxfordjournals.org/lookup/doi/10.1093/cid/cir991http://www.scielo.cl/pdf/udecada/v15n26/art06.pdfhttp://www.scopus.com/inward/record.url?eid=2-s2.0-84861150233{&}partnerID=tZOtx3y1`.

Paolo Padovani and Paolo Giommi.
The connection between x-ray- and radio-selected BL Lacertae objects.
ApJ, 444:567–581, 1995.

Paolo Padovani, E Resconi, P Giommi, B Arsioli, and Y L Chang.
Extreme blazars as counterparts of IceCube astrophysical neutrinos.
MNRAS, 457:3582–3592, 2016.

Padovani, P., Alexander, D. M., Assef, R. J., De Marco, B., Giommi, P., Hickox, R. C., Richards, G. T., Smolčić, V., Hatziminaoglou, E., Mainieri, V., and Salvato, M.

Active galactic nuclei: what's in a name?.
A&ARv,25, 2, 2017

M R Panzera, S Campana, S Covino, D Lazzati, R P Mignani, A Moretti, and G Tagliaferri.
Astrophysics The Brera Multi-scale Wavelet ROSAT HRI source catalogue.
Astron. Astrophys., 399:351–364, 2003.
doi: 10.1051/0004-6361.

S. Piranomonte, M. Perri, P. Giommi, H. Landt, and P. Padovani.
The sedentary survey of extreme high-energy peaked BL Lacs.
A&A, 470(2):787–809, 2007.
ISSN 0004-6361.
doi: 10.1051/0004-6361:20077086.
URL `http://adsabs.harvard.edu/abs/2007A{&}A...470..787P`.

S Puccetti, M Capalbi, P Giommi, M Perri, G Stratta, L Angelini, D.~N. Burrows, S Campana, G Chincarini, G Cusumano, N Gehrels, A Moretti, J Nousek, J.~P. Osborne, and G Tagliaferri.
The Swift serendipitous survey in deep XRT GRB fields (SwiftFT). I. The X-ray catalog and number counts.
A&A, 528:A122, 2011.
doi: 10.1051/0004-6361/201015560.

E. Resconi, S. Coenders, P. Padovani, P. Giommi, and L. Caccianiga.
Connecting blazars with ultra high energy cosmic rays and astrophysical neutrinos.
MNRAS, 468, 597, 2017.

S. R. Rosen, N. A. Webb, M. G. Watson, J. Ballet, D. Barret, V. Braito, F. J. Carrera, M. T. Ceballos, M. Coriat, R. Della Ceca, G. Denkinson, P. Esquej, S. A. Farrell, M. Freyberg, F. Grisé, P. Guillout, L. Heil, D. Law-Green, G. Lamer, D. Lin, R. Martino, L. Michel, C. Motch, A. Nebot Gomez-Moran, C. G. Page, K. Page, M. Page, M. W. Pakull, J. Pye, A. Read, P. Rodriguez, M. Sakano, R. Saxton, A. Schwope, A. E. Scott, R. Sturm, I. Traulsen, V. Yershov, and I. Zolotukhin.
The XMM-Newton serendipitous survey. VII. The third XMM-Newton serendipitous source catalogue.
A&A, 590(3):A1, 2016.
URL `http://arxiv.org/abs/1504.07051`.

R. D. Saxton, a. M. Read, P. Esquej, M. J. Freyberg, B. Altieri, and D. Bermejo.
The first XMM-Newton slew survey catalogue: XMMSL1.
A&A, 480(2):611–622, 2008.
ISSN 0004-6361.
doi: 10.1051/0004-6361:20079193.
URL `http://www.aanda.org/10.1051/0004-6361:20079193`.

C Megan Urry and Paolo Padovani.
Unified Schemes for Radio-Loud Active Galactic Nuclei.
PASP, 107:803–845, 1995.

W. Voges, B. Aschenbach, Th. Boller, H. Bräuninger, U. Briel, W. Burkert, K. Dennerl, J. Englhauser, R. Gruber, F. Haberl, G. Hartner, G. Hasinger, M. Kürster, E. Pfeffermann, W. Pietsch, P. Predehl, C. Rosso, J. H. M. M. Schmitt, J. Trümper, and H. U. Zimmermann.
The ROSAT all-sky survey bright source catalogue.
A&A, 349:389–405, 1999.
ISSN 0004-6361.
URL `http://adsabs.harvard.edu/abs/1999A{&}A...349..389V`.

W. Voges, B. Aschenbach, T. Boller, H. Brauninger, U. Briel, W. Burkert, K. Dennerl, J. Englhauser, R. Gruber, F. Haberl, G. Hartner, G. Hasinger, E. Pfeffermann, W. Pietsch, P. Predehl, J. Schmitt, J. Trumper, and U. Zimmermann.
ROSAT all-sky survey faint source catalogue.
In *IAU Circ.*, 2000.

N.E. White, P Giommi, and L. Angelini.
The WGACAT version of the ROSAT PSPC Catalogue, Rev. 1.
VizieR Online Data Cat., 2000.

Richard L. White, Robert H. Becker, David J. Helfand, and Michael D. Gregg.
A Catalog of 1.4 GHz Radio Sources from the FIRST Survey.
ApJ, 475(2):479–493, 1997.
ISSN 0004-637X.
doi: 10.1086/303564.

The ICRANet activities on the Brazilian Science Data Center

ICRANet – BSDC

January 15th, 2018

SUMMARY

Introduction to ICRANet Activities

The signature of the Agreements of collaboration between ICRANet and Brazilian (see fig. 1), as well as international Universities and Research Centers has allowed the first step towards the definition of an organic program of collaboration between ICRANet and Brazil.

The activities of ICRANet in Brasil do present a coordinate action which develops on three major directives:

a) The Academic and Outreach program;

b) The Space Science, with endorsement of collaboration with ASI (see Fig.6);

c) The Brazilian Space Data Center.

All these actions are complementary and essential in creating in the field of Relativistic Astrophysics a coordinate approach which will a) form the scientists by their participation to the joint Ph.D. program, the IRAP PhD; b) will develop selected topics of research with the participation of post-doctoral fellows, sabbatical scientists, senior visiting scientists in all participating institution in Brazil and in the Network with the support of CAPES; and c) will create a totally new data repository the BSDC. It will create in Brazil a new reality in research, building infrastructure and training personal which is specialized in high level relativistic astrophysics with academic, scientific research, data analysis. The ICRANet activities in Brasil will be creating a program very rich from the technical development and human resources point of view with new management and analysis infrastructure in the country. The skills that people working on such structure will learn can then be transferred to many other fields of science and applied elsewhere in society.

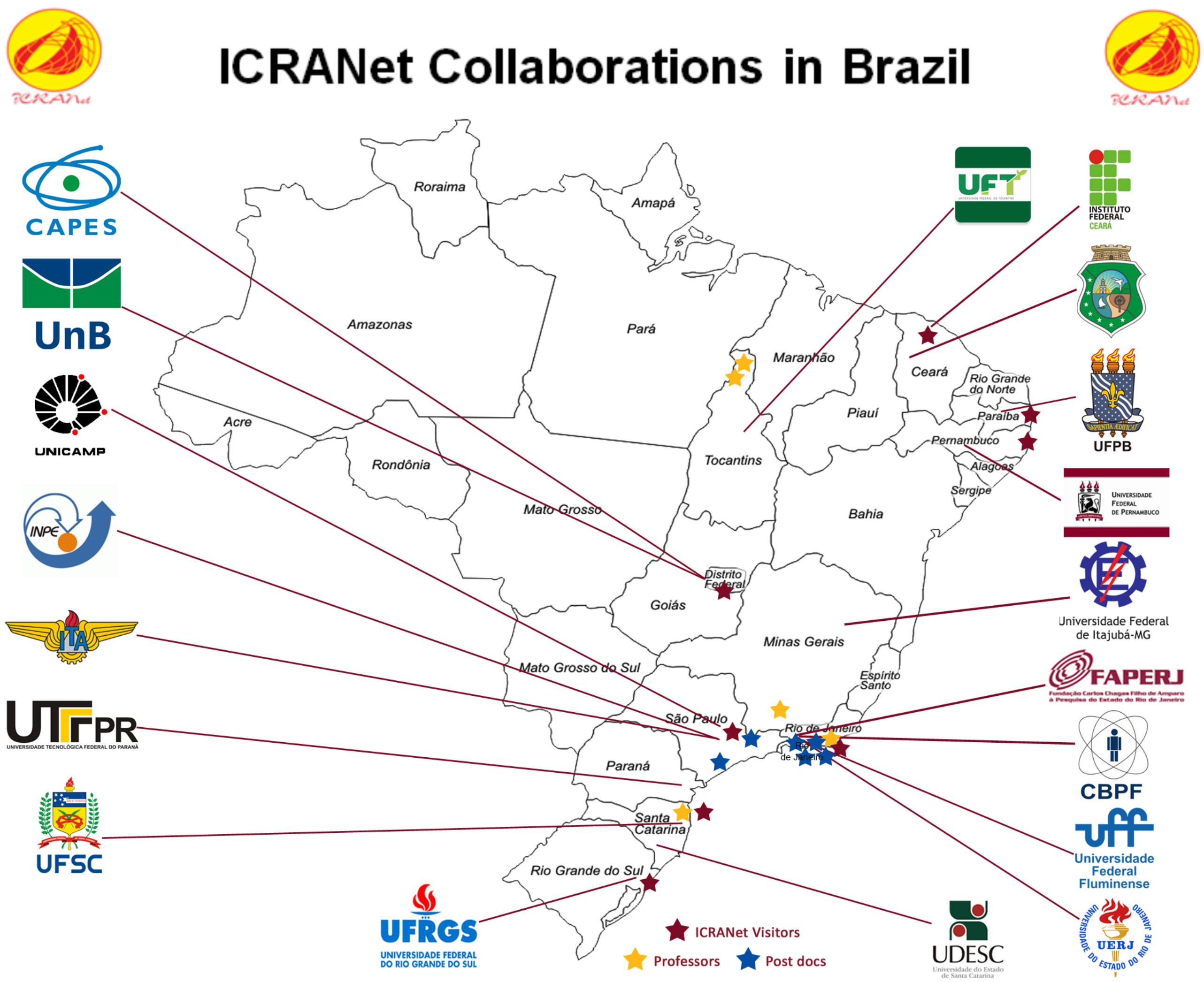


Fig. 1. ICRANet Collaborations in Brazil

asi - Agenzia Spaziale Italiana
AOO_ASI_2 - Agenzia Spaziale Italiana
REGISTRO UFFICIALE
Prot. n. **0007568** - 08/09/2014 - USCITA

agenzia spaziale italiana

Il Presidente

Prot/Prz/CE/2014/150

Rome, 8th September 2014

Subject: ASI endorsement to the Letter of Request for support to BSDC

Dear Sirs,

With regard to the Letter of Request for support to the ICRANET Brazilian Science Data Center (BSDC), that is being presented to the Brazilian Ministry of Science Technology and Innovation, I am pleased to inform you that the Italian Space Agency (ASI) fully supports this initiative.

I look forward to a very fruitful cooperation between our institutions within the framework defined in the ASI-ICRANet agreement (2013-048-A.0) signed on 26 June 2013.

Sincerely yours,

Roberto Battiston

Via del Politecnico, s.n.c. 00133 ROMA - Tel 068567821 - 068567829 - Fax 068567468

Fig. 2. Letter of endorsement of ASI, Prof. Roberto Battiston.

PROJECT OF BRAZILIAN SCIENCE DATA CENTER

1. Introduction

The development of scientific research in the fields of astrophysics, cosmology and space research has been limited in Brazil, due to the lack of a Data Center able to receive, file, process and make available to the Brazilian scientists the information coming from the stations and laboratories connected to satellites, telescopes and radio-telescopes, as well as to other space stations and other centers producing scientific data. For this reason Brazilian scientists and technicians had access to important data with more difficulty and often late. This has limited their competitiveness with respect to their colleagues from other Countries, who on the contrary have efficient services, which allow them to have the necessary expertise for an optimal interpretation of data. Modern data centers also consent to do researches based on large quantity of data, coming from many instruments, a very efficient type of research, which could not be possible by individual researcher. It is a problem then, whose solution cannot be postponed.

2. Early Implementation Plan

ICRANet, in addition to bringing together theoretical and observational astrophysicists who work on the most important researches, have the collaboration of high qualified technicians who are able to plan and install the Brazilian Data Center and provide assistance during its implementation. Moreover, it avails itself of the support and cooperation of ASI Science Data Center (ASDC), a branch of the Italian Space Agency (ASI) equipped to provide support to the space missions in the fields of astronomy, astrophysics, cosmology, solar system exploration, and astro-particle physics.

The cooperation of ASDC in the project of BSDC started in the phase of the requests for the elaboration of the project BSDC and is currently ongoing. Among the preliminary activities for the installation of BSDC a series of meetings have been held in Italy with ASDC and in Brazil, at Centro Brasileiro de Pesquisas Físicas (CBPF in Rio), with Brazilian specialists. The BSDC will consist in offering technical support, provide public data of several scientific missions, promote the development and exchange of software packages and offer scientific cooperation.

BSDC will not only represent a source of data and astrophysics information, in cosmology and astro-particles, which Brazil needs in order to develop as a pole of attraction for scientists working in these fields. BSDC will represent a tool for a Latin-American integration once its strategic information and its expertise will be made available to the scientists from South America.

BSDC, since the beginning of its activities, benefits of the participation to international collaborations of high level, which have already started by the ASDC in the field of Virtual Observatory. An example is the current Open Universe Initiative, carried out under guidance of the United Nations, including the realization of advanced tools for the management and scientific analysis of multi-frequency data (radio, infrared, optical, X-ray and gamma ray) and multi-temporal data of extragalactic sources.

3. OBJECTIVES OF BSDC

The main objective of BSDC is to provide data of all international space missions existing on the wavelength of X and gamma rays, and later on the whole electromagnetic spectrum, for all the galactic and extragalactic sources of the Universe. A special attention will be paid to the achievement and the complete respect of the levels defined by the International Virtual Observatory Alliance (IVOA). In addition to these specific objectives, BSDC will promote technical seminars, annual workshops and it will assure a plan of scientific divulgation and popularization of science with the aim of the understanding of the universe. The realisation of BSDC will take place in three steps: the first one is already ongoing at CBPF and consists in the installation of a minimum research infrastructure for an early implementation of the project and scientific exploitation of the facility. The second, which consists in the proper installation of the Data Center, will take place simultaneously at CBPF, in conjunction with the United Nations Open Universe Initiative, in Viena and ASI. The third and final phase consists in the expansion towards a larger scale data center and will be of long-term implementation.

The first phase of the project is to demonstrate its technical feasibility, ahead of full implementation and support. Initially, a first prototype of the WEB software and portal are being installed and a part of the data archives of optical polarisation, VHE gamma-ray astronomy and Swift are being installed in one of the computers located at CBPF in Rio de Janeiro~~.~~ The site of BSDC is actually reachable at the address www.bsdc.cbpf.br.

In 2017, a high-capacity front-end machine has been acquired and was installed at CBPF to function as a server for external users interface, and the technical specifications of two other machines are being derived for acquisition: a storage center with capacity for about 10 TB of data, and a medium-to-high performance computing machine, for processing data and running simulations for data analysis.

Once this minimal infrastructure is now established, there are some immediate actions that will be taken in order to incite the science exploitation of the facility:

(a) A BSDC/VERITAS agreement for the publication of the complete VHE Gamma-ray Astronomy database of the VERITAS Collaboration, which will constitute the first public data repository of TeV Gamma-ray data ever built in the world.

(b) Once this is accomplished, we will seek to extend similar agreements with the H.E.S.S. and MAGIC collaborations, thus turning the BSDC at CBPF the very first complete TeV Gamma-ray Data center in the world, giving it immediately visibility and putting from the start at a central position in the international high-energy astrophysics scenario.

(c) Expansion of the Data enter to include a portal for optical polarimetric data, align with the spectral and timing tools, following along with the production of original scientific research at CBPF and formation of human resources.

(d) Development, in 2018, of a complete Swift legacy database at the BSDC at CBPF

ICRANet-BSDC Server Infrastructure

Report of setup activities

Centro Brasileiro de Pesquisas Físicas
Rio de Janeiro, June 2017

Damiano Verzulli
ICRANet
damiano.verzulli@icranet.org

Benno Bodmann
CBPF
benno.bodmann@gmx.de

Content

Summary

Following the implementation plan of the **Brazilian Science Data Center – BSDC**, **ICRANet** started the required actions on June 2017.

Based on agreements with the **Centro Brasileiro de Pesquisas Físicas - CBPF** – two servers and related storage were acquired and installed within CBPF datacenter, in Rio de Janeiro

Field activities were executed by:

- Damiano Verzulli, senior System and Network Administrator in ICRANet;
- Benno Bodmann, Computer Scientist at CBPF

in collaboration with technical resources of the CBPF **Coordenação de Atividades Técnicas - CAT** department.

Activities lasted for three days (Jun 6th, 7th and 8th 2017).

This document briefly present the architecture implemented so far.

1. Introduction

On Jun 6th, 7th and 8th 2017, the server infrastructure acquired to serve the initial BSDC needs, have been put “on production”.

Activities have been conducted directly in CBPF, by:

- Benno Bodmann (benno.bodmann@gmx.de)
- Damiano Verzulli (damiano@verzulli.it)

in collaboration with technicians of the BSDC's CAT department.

This document briefly present the architecture implemented so far.

2. The servers

Infrastructure is provided by two SuperMicro servers:

- BSDC-S01:
  - **Model**: SuperMicro SYS-1028U-TR4+
  - **CPU**: n. 2 x E5-2620 v4 CPU;
  - **RAM**: 32GB RAM;
  - **Disks**: 1 x 120GB SSD + 1 x 1TB SATA Disk + 8 free 2.5” bay for further expansions;
  - **Ethernet**: 4 x 1Gbps NIC;
  - **Management**: 1 x IPMI dedicated NIC;
  - **Power-supply**: redundant;

- BSDC-S02:
  - **Model**: SuperMicro SSG-2028R-E1CR24N
  - **CPU**: n. 2 x E5-2620 v4 CPU;
  - **RAM**: 16GB RAM;
  - **Disks**: 1 x 120GB SSD + 2 x 2TB SATA Disk + 22 free 2.5” bay for further expansions;
  - **Ethernet**: 4 x 10Gbps NIC;
  - **Management**: 1 x IPMI dedicated NIC;
  - **Power-supply**: redundant

Physical network connection of the two servers are ensured by an Extreme X450e-48p switch, kindly provided by CBPF.

As can be seen from picture below, the two servers are properly placed inside a rack.

Each server is connected, in addition to two power-supply plug/cable, with 4 network connections (see below for details):

BSDC-S01 (1RU top) and BSDC-S02 (2RU bottom)

BSDC-S01 (1RU top) and BSDC-S02 (2RU bottom)

3. The network infrastructure

The two servers have been configured to implement a virtual infrastructure on top of which several virtual machines (VMs) will be hosted.

To properly reach such goal, in collaboration with CBPF CAT-team, three distinct networks have been created within CBPF network infrastructure:

- **Public / NET**: this is the network directly connected to the Internet, without any kind of filtering implemented by BSDC equipments.
  It should be noted that such a network still sits behind CBPF firewalling layers and, as such, it's not directly connected to the "wild Internet", in a strict formal sense. Nevertheless, as for BSDC concerns, such a network is out of BSDC control and, as such, it will be considered publicly exposed to the Internet;
- **Public / DMZ**: this is the "demilitirized" network, where BSDC VMs will be connected to "serve" content and services toward the Internet. Inbound traffic from the main Internet (Public/Net) to such VMs will be filtered by an ad-hoc firewall, created and mantained by BSDC.
  Due to aforementioned filtering applied by CBPF, it will be required –as for BSDC point of view-- to ask CPBF/CAT for opening related "protocols/ports";
- **Management**: this is the "management" network, completely disconnected from the main Internet, as its purpose is to connect critical services (low-level access to physical servers and software components) that have no need to be exposed to the Internet.

Furthermore, CBPF/CAT team has kindly reserved the **"Public Subnet" 152.84.124.0/24** for BSDC needs. Such a network have been cutted in two halves:

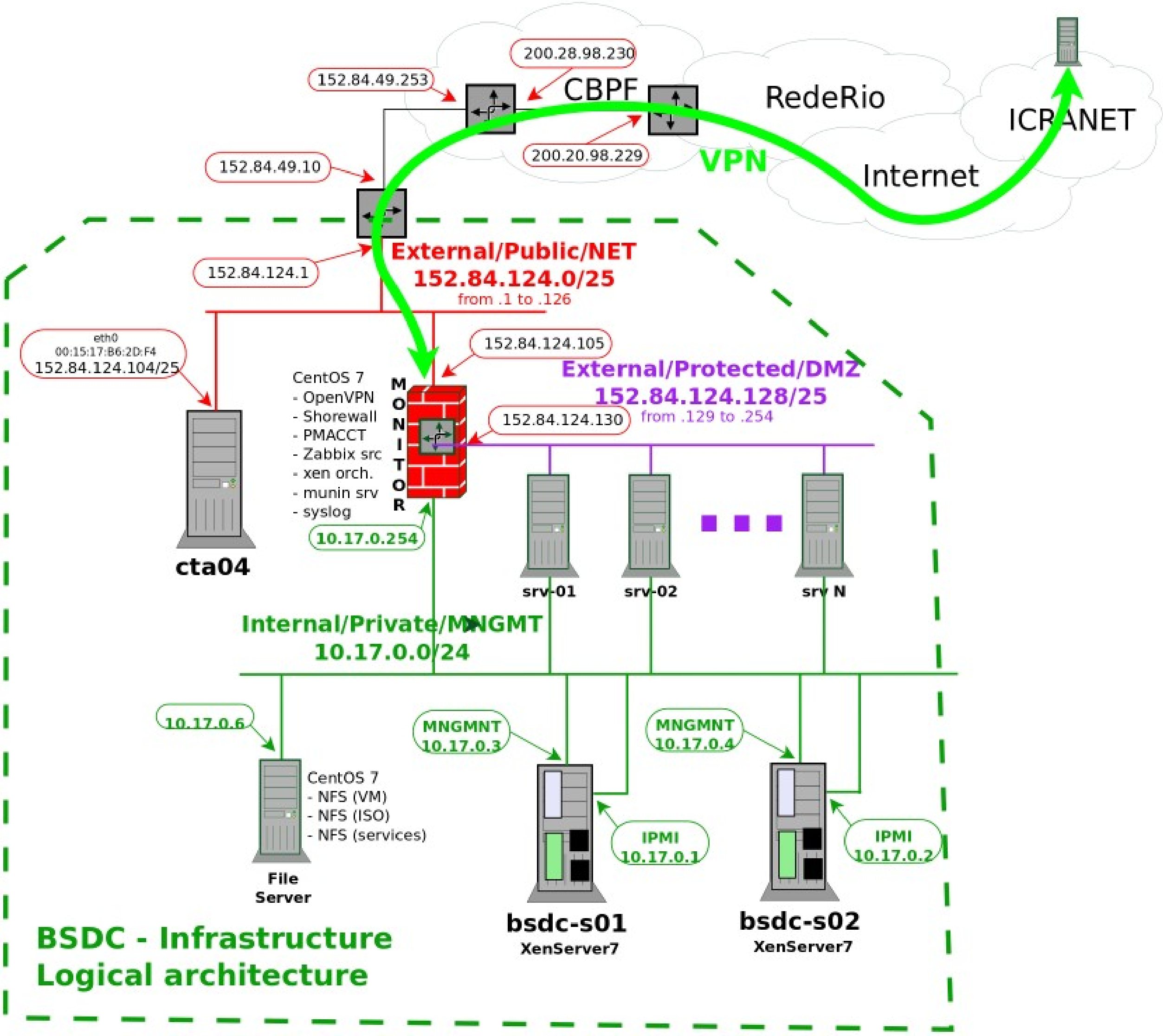
- 152.84.124.0/25: to be used as for the Public / NET network;
- 152.84.124.128/25: to be used as for the Public / DMZ network.

As for the management network, IP subnet assigned to it is:

- **10.17.0.0/24**: to be used as for the Management network.

Routing and firewalling between the various networks is managed by an ad-hoc firewall that has properly created (as a VM), installed (CentOS7 box) and configured (details below)

A graphical representation of the whole network follows:



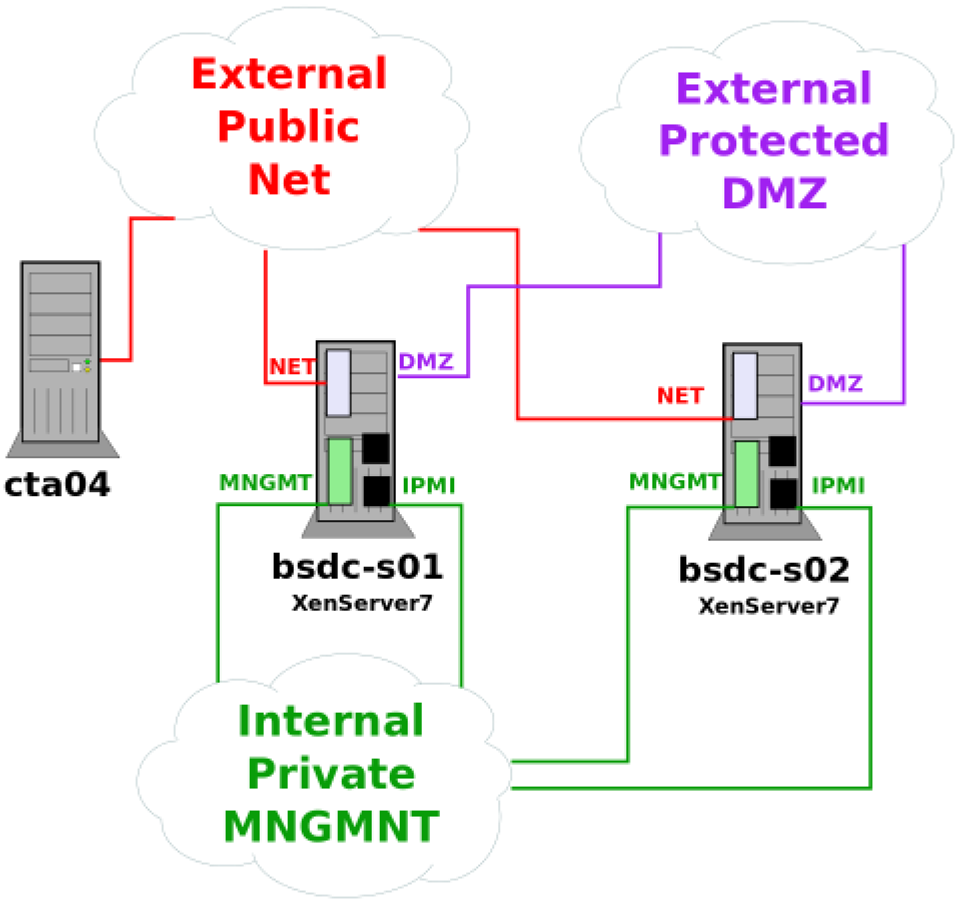
4. Physical infrastructure

From a physical point of view, the two servers are physically connected to all the three network (NET,DMZ, MNGMT).

In addition, the IPMI network interface –used to remotely access the very same server at BIOS level--, is also connected to the MNGMT network.

The four cables can clearly be recognized in the photo provided above.

A simple schema representing the connections is reported below



BSDC - Infrastructure
Physical architecture

5. Services and Application infrastructure

5.1. Hypervisor

As the hypervisor adopted to properly handle the virtualization layer, the choice has been "Xen Server 7". Even tough this might sounds "uncomfortable" with respect of other solutions (like VMware ESXi or Microsoft HyperV), such a choice has been based on following factors:

- **Open Source**: Xen Server is a completely Open Source platform (since 2013) and due to the "publicly-funded" nature of BSDC, we strongly believe that Open Source solutions should be considered as the first choice, trying to avoid – whenever possible-- the implementation of proprietary software components;
- **Feature**: Xen Server provides very advanced features, like "Xen Motion" and "Xen Storage Motion" that can greatly simplify the management of the two BSDC servers remotely and, at the same time, are not provided by the free version of VMware (here the term "free" is used as "gratis");

- **Well known**: technical people in ICRANET already rely on Xen Server to deploy mission-critical services for ICRANET. As such, the adoption of Xen Server don't require the needs to acquire other/different know-how;
- **Licensing costs**: in addition of being OpenSource –and, as such, requiring no licensing costs--, XenServer does not impose any kind of restrictions in terms of related software components (guest OS; management host; etc.). To be short: it can be adopted with zero costs.

5.2. Router/Firewall VM

Since the very beginning of the installation process, it was clear the need for a "special" VM, to be elected as the main "regulator" of the whole platform.

Such a system should fulfill, at least, following "roles":

- **router**: the system should be able to "route" IP packets to/from the three interconnected networks;
- **firewall**: the system should be able to "filter" (and "log") unwanted traffic, "enforcing" a more than reasonable "security level". This, expecially with traffic INBOUND from the "Public Internet";
- **remote access**: being BSDC remotely located, it's of paramount important to be able to access all the related component (hardware and software), remotely, while at the same time, enforcing a proper "security level";

furthermore:

- **monitoring (alarm)**: the system should take care to continuosly monitor the key component of the infrastructure, raising proper alerts in case of failure;
- **monitoring (metric)**: the system should gather relevan counters about resource utilization (CPU, Memory, Disks, Network I/O, etc.);

In order to fulfill those roles, a dedicated Linux VM has been configured and installed. Software involved by such VM is briefly described below:

Operating System.......: **Linux CentOS 7**

Routing.........................: standard routing engine provided by Linux;

Firewall.........................: **netfilter** engine, managed and configured by "**Shorewall**"

Remote access............: two **OpenVPN** instances. The first acting "as a client" towards che official OpenVPN server running in ICRANET/Italy; The second acting "as a server" available to provide secure access to both the system management team and remote BSDC users;

Monitoring...................: the monitoring infrastructure is based on **Zabbix**.

5.3. Test Web Server

In order to properly test all the architecture, a test Web Server has been create and configured within the DMZ.

Tests were successfull: after ensuring proper firewalling both at CBPF level and on BSDC firewall, the services exposed by the webserver (HTTP/HTTPS) were currectly accessible.

6. Final notes

6.1. Contact points

Technical issues and/or communications at all levels should be handled via e-mail involving at least following addresses:

- **ICRANET BSDC**: bsdcadmin@icranet.org
- **CBPF**: redes@cbpf.br

Escalation should be handled wisely, based on common-sense, involving:

- **ICRANET BSDC**:
  - Ulisses Barres: ulisses@cbpf.br
  - Carlos Brandt: carlos.brandt@icranet.org
  - Damiano Verzulli: damiano.verzulli@icranet.org
  - Benno Bodmann: benno.bodmann@gmx.de
- **CBPF**
  - Sandro: sandro@cbpf.br
  - Marcelo Albuquerque: marcelo@cbpf.br

6.2. Open issues

1. Current infrastructure is not covered by any kind of backup plan. ICRANET will provide a first layer of backup, but only regarding the system components of the router/firewall (data and configurations). When entering "serious production", a proper backup plan should be put in place;
2. In order to enter "production", a "real"workload need to be put in place, by creating related VMs, allocating proper storage and launching related computations. At the moment, such workload has not yet configured;