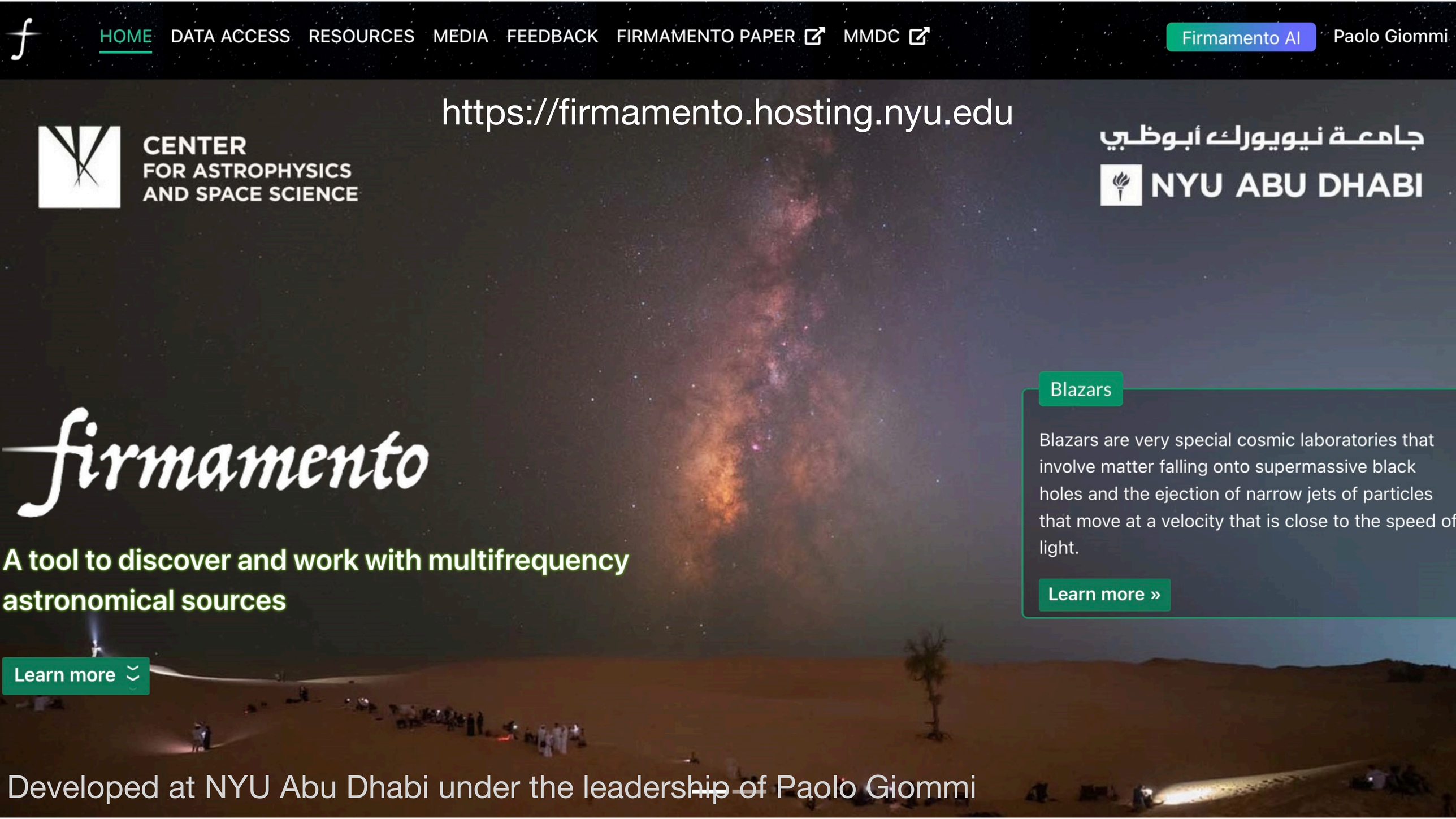
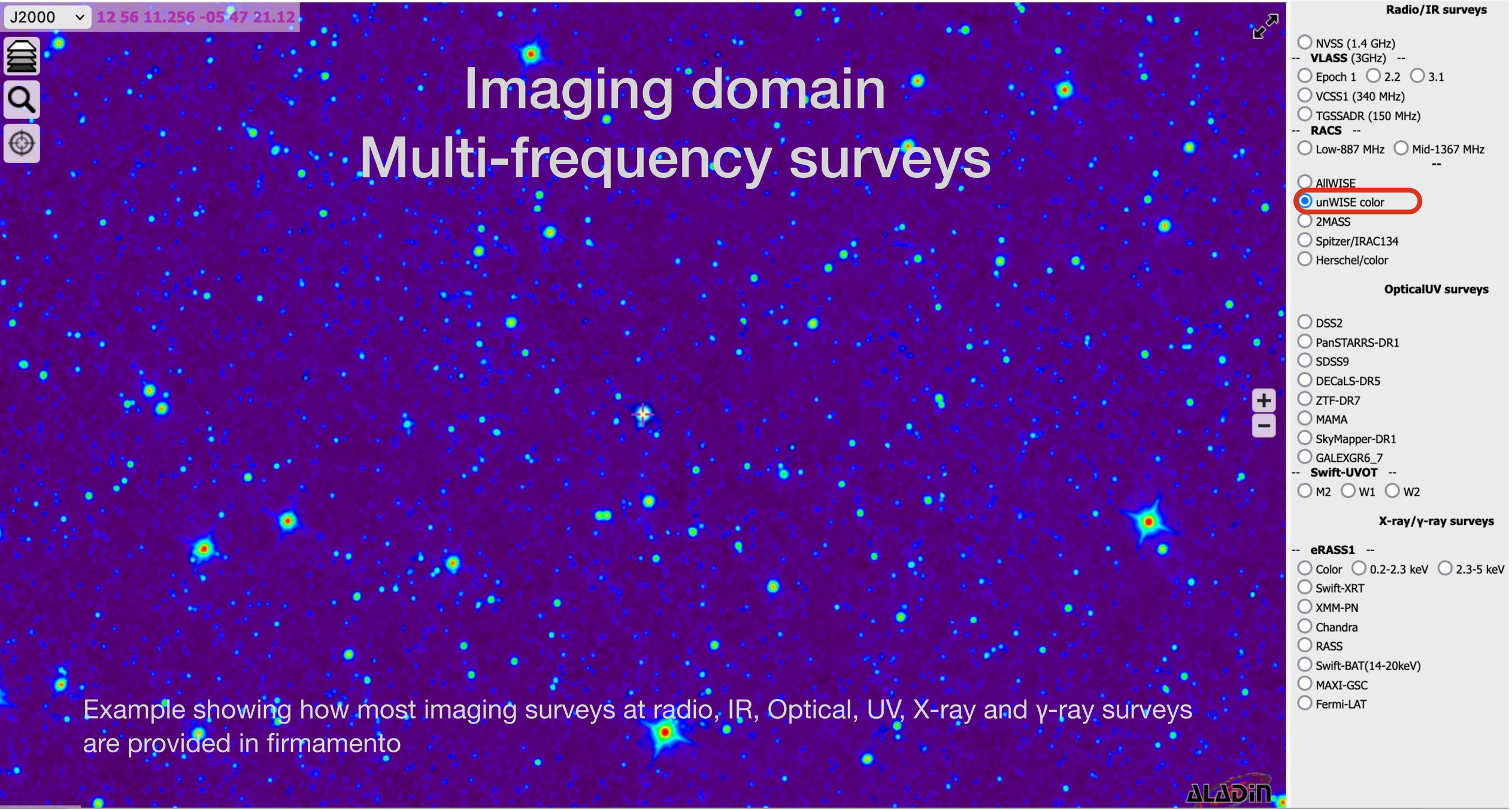
firmamento

Paolo Giommi

A new-concept platform to discover and analyse
multi-frequency/multi-messengers astrophysical sources
with discovery algorithms, machine learning tools, and AI.

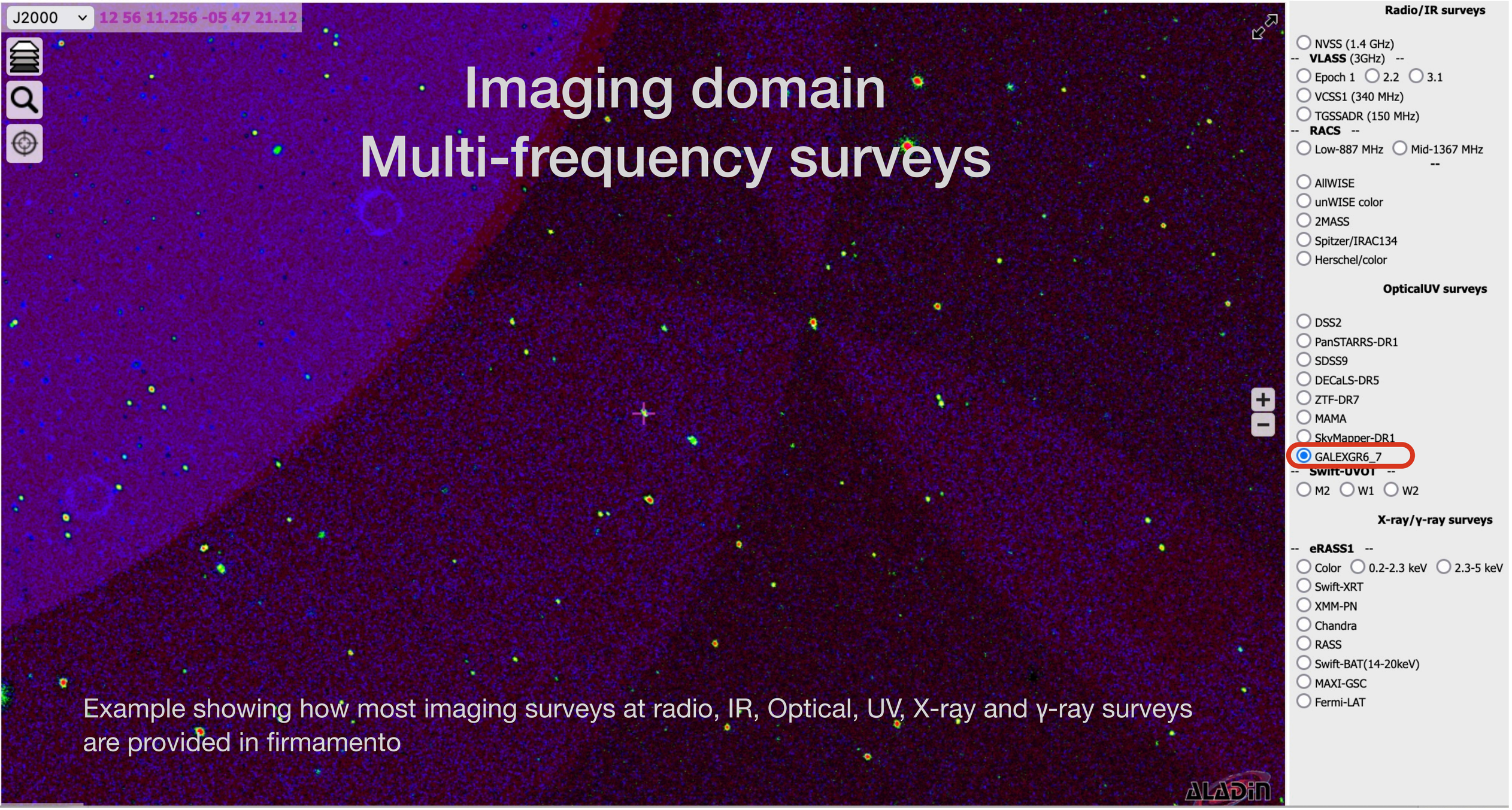

HOME
DATA ACCESS
RESOURCES
MEDIA
FEEDBACK
FIRMAMENTO PAPER
MMDC
Firmamento AI
Paolo Giommi
https://firmamento.hosting.nyu.edu
CENTER
FOR ASTROPHYSICS
AND SPACE SCIENCE
جامعة نيويورك أبوظبي
NYU ABU DHABI
firmamento
A tool to discover and work with multifrequency astronomical sources
Learn more
Blazars
Blazars are very special cosmic laboratories that involve matter falling onto supermassive black holes and the ejection of narrow jets of particles that move at a velocity that is close to the speed of light.
Learn more »
Developed at NYU Abu Dhabi under the leadership of Paolo Giommi

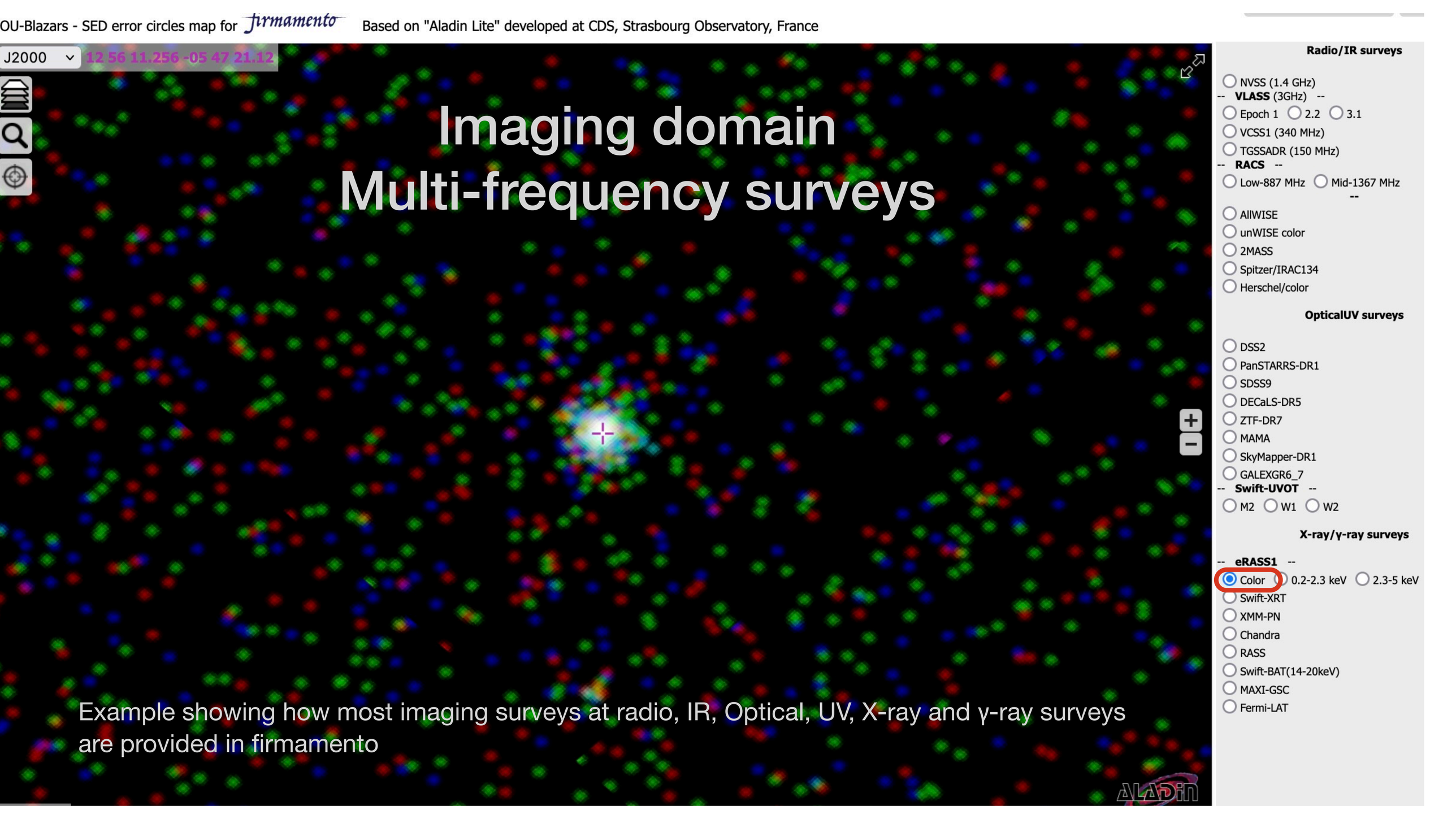
VOU-Blazars - SED error circles map for firmamento Based on "Aladin Lite" developed at CDS, Strasbourg Observatory, France



Example showing how most imaging surveys at radio, IR, Optical, UV, X-ray and γ-ray surveys are provided in firmamento

VOU-Blazars - SED error circles map for *firmamento* Based on "Aladin Lite" developed at CDS, Strasbourg Observatory, France




OU-Blazars - SED error circles map for firmamento
Based on "Aladin Lite" developed at CDS, Strasbourg Observatory, France
J2000
12 56 11.256 -05 47 21.12
Imaging domain
Multi-frequency surveys
Radio/IR surveys
NVSS (1.4 GHz)
-- VLASS (3GHz) --
Epoch 1
2.2
3.1
VCSS1 (340 MHz)
TGSSADR (150 MHz)
-- RACS --
Low-887 MHz
Mid-1367 MHz
--
AllWISE
unWISE color
2MASS
Spitzer/IRAC134
Herschel/color
OpticalUV surveys
DSS2
PanSTARRS-DR1
SDSS9
DECaLS-DR5
ZTF-DR7
MAMA
SkyMapper-DR1
GALEXGR6_7
-- Swift-UVOT --
M2
W1
W2
X-ray/γ-ray surveys
-- eRASS1 --
Color
0.2-2.3 keV
2.3-5 keV
Swift-XRT
XMM-PN
Chandra
RASS
Swift-BAT(14-20keV)
MAXI-GSC
Fermi-LAT
Example showing how most imaging surveys at radio, IR, Optical, UV, X-ray and γ-ray surveys are provided in firmamento
ALADIN

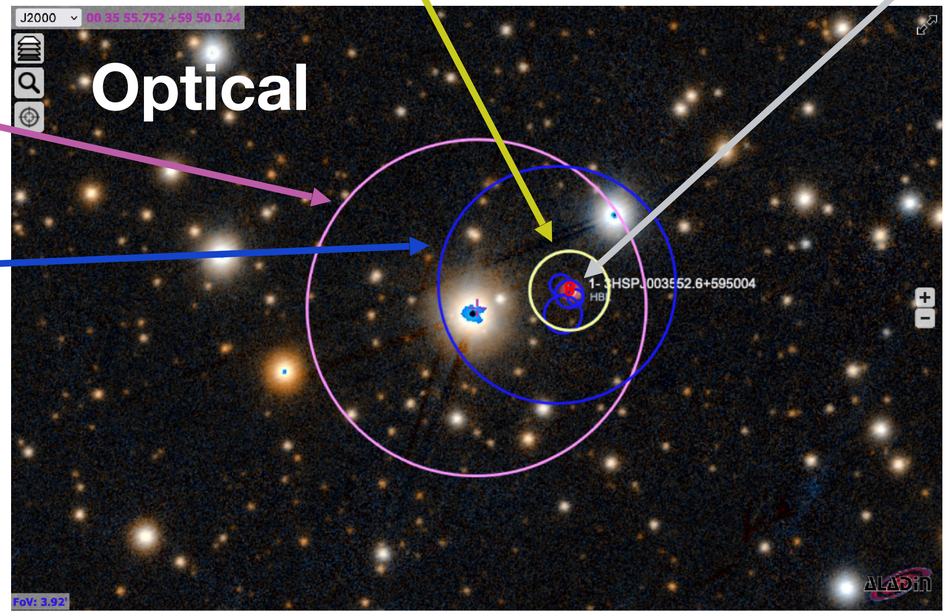
Source in 4LAC catalog

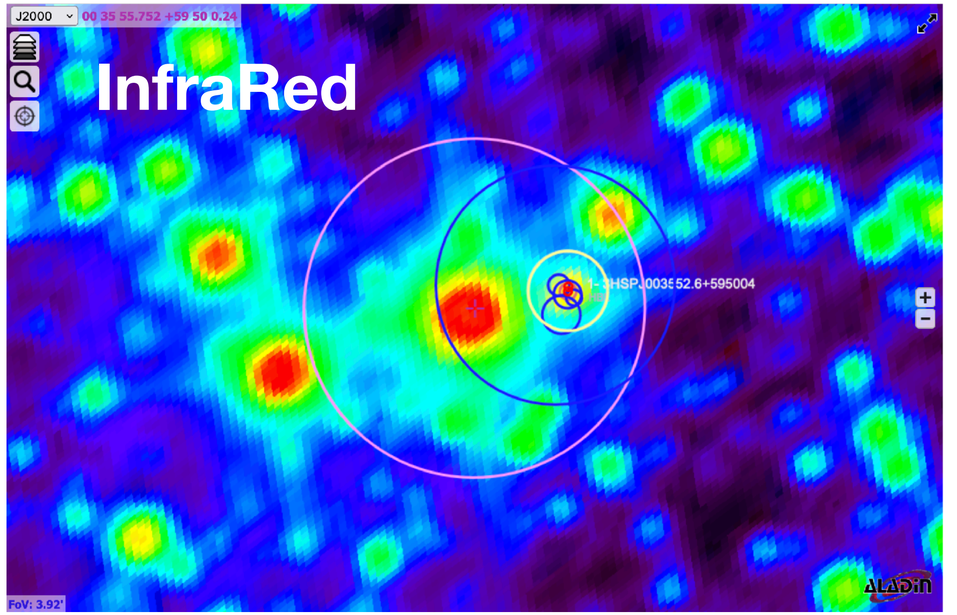
Counterpart proposed by Firmamento

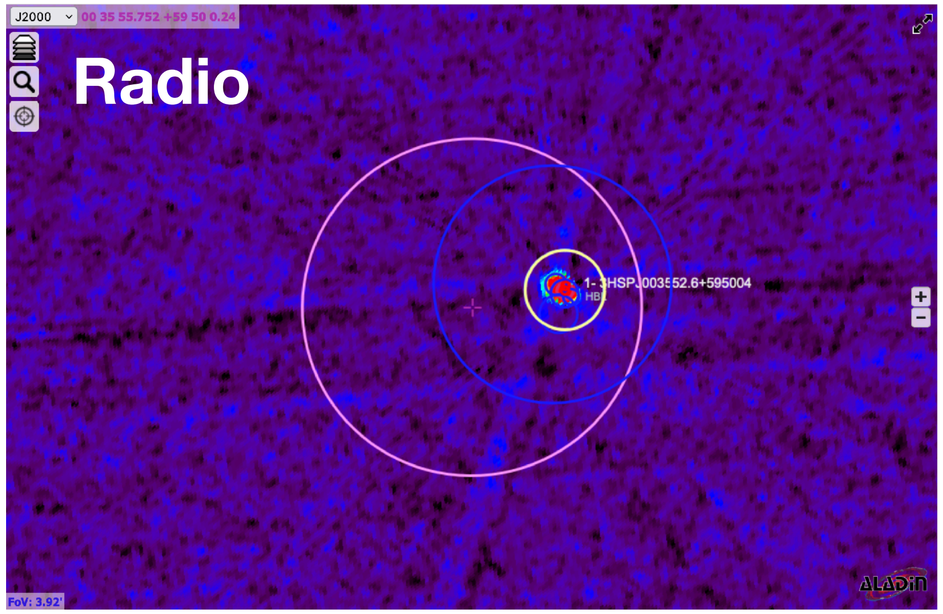
γ-ray error-ellipse

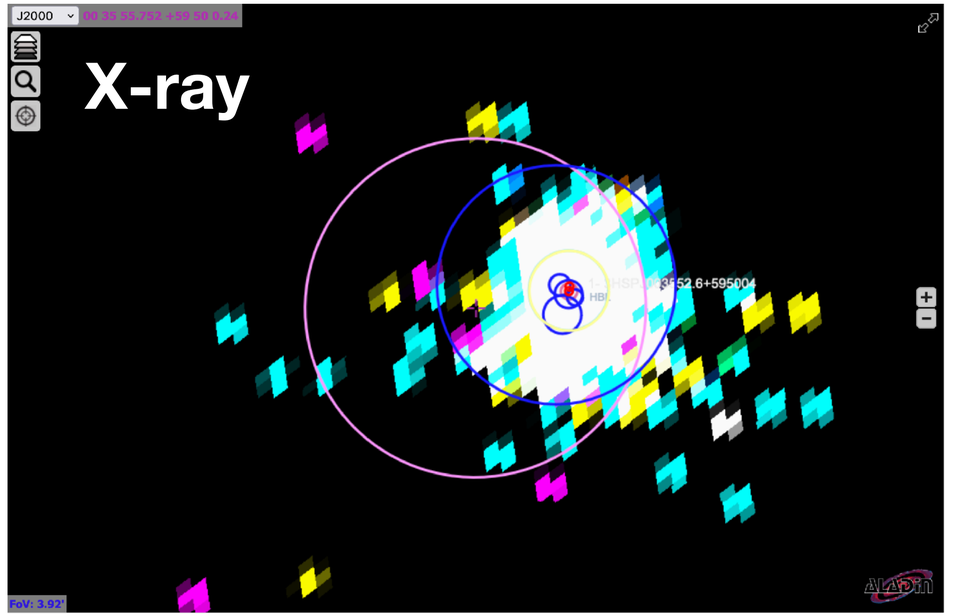
X-ray error-circle

Error regions of all types can be plotted on multi-frequency images.







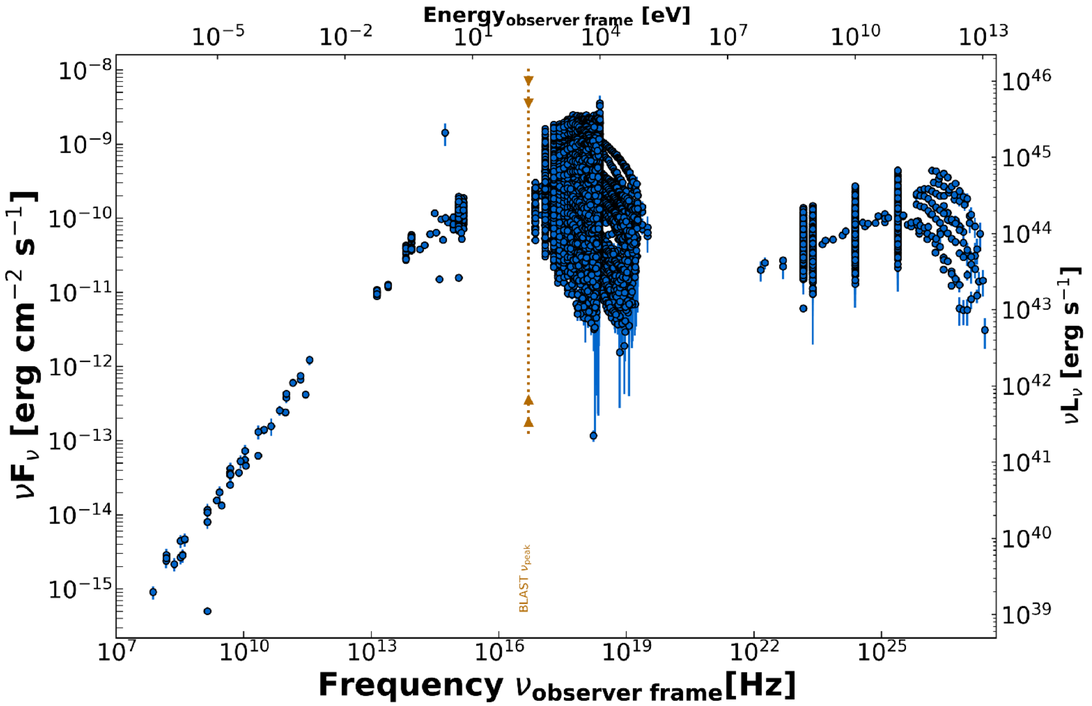


The energy domain

The energy domain is crucial for astrophysical data interpretation.
The firmamento multi-frequency data engine is VOU_BlazarsV2.24: an improved version of VOU_BLazars (Chang et al 2020 A&C, 30, 100350) specifically developed for Firmamento

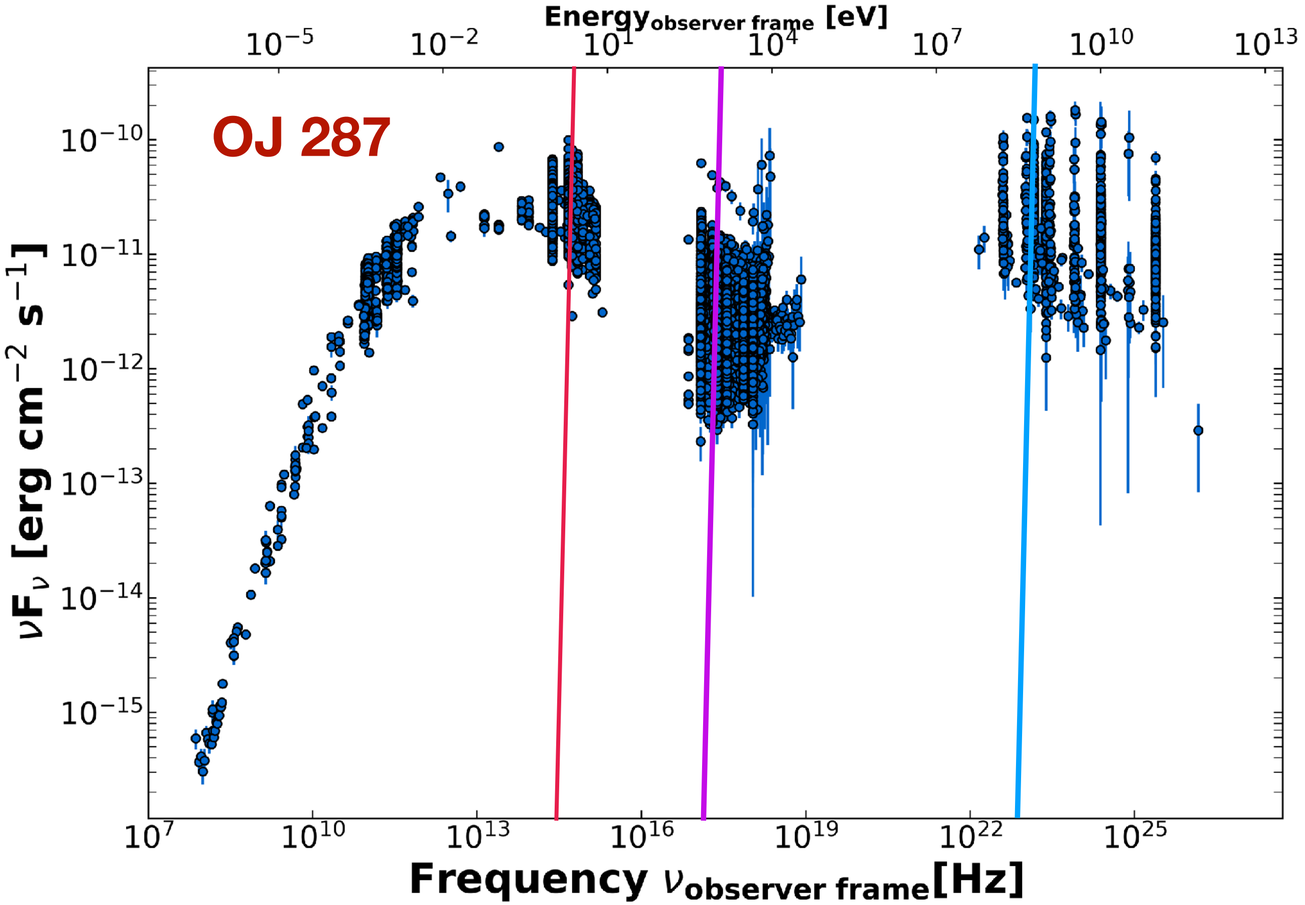
```
Searching 66 catalogs
( 1 / 66 ) WISH352 : NO SOURCES FOUND
( 2 / 66 ) LoTSS : NO SOURCES FOUND
( 3 / 66 ) VLSSR : SUCCESS -- Lane et al. 2014, MNRAS, 440,327
( 4 / 66 ) GB87 : NO SOURCES FOUND
( 5 / 66 ) AT20G : SUCCESS -- Murphy et al. 2010, MNRAS, 402, 2403
( 6 / 66 ) NORTH20 : SUCCESS -- White and Becker, 1992, ApJS, 79, 331
( 7 / 66 ) PCCS30 : SUCCESS -- The Planck Collaboration 2018, A&A, 619, A94
( 8 / 66 ) PCCS545 : SUCCESS --
( 9 / 66 ) PCCS857 : SUCCESS --
( 10 / 66 ) PCNT : SUCCESS -- The Planck Collaboration 2018, A&A, 619, A94
( 11 / 66 ) UNWISE : SUCCESS -- Schlafly et al. 2019, ApJS, 240, 30
( 12 / 66 ) H-ATLAS-DR1 : NO SOURCES FOUND
( 13 / 66 ) H-ATLAS-DR2NGP : NO SOURCES FOUND
( 14 / 66 ) H-ATLAS-DR2SGP : NO SOURCES FOUND
( 15 / 66 ) ALMA : SUCCESS -- Bonato et al. 2019, MNRAS, 485, 1188
( 16 / 66 ) 2MASS : SUCCESS -- Skrutskie et al. 2006, AJ, 131, 1163
( 17 / 66 ) AKARIBSC : SUCCESS -- Yamamura et al. 2010, VizieR, II, 298
( 18 / 66 ) TGSS150 : SUCCESS -- Intema et al. 2017, A&A, 598, A781
```

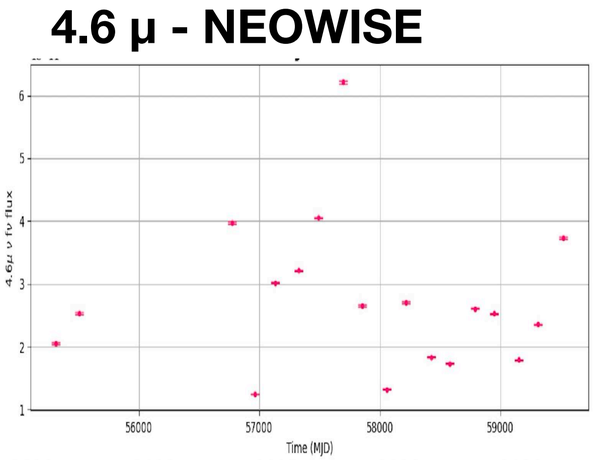
VOU_BlazarV2.24 downloads, homogenises, de-reddens, and combines multi-frequency data from about 100 remote and local catalogues and databases.

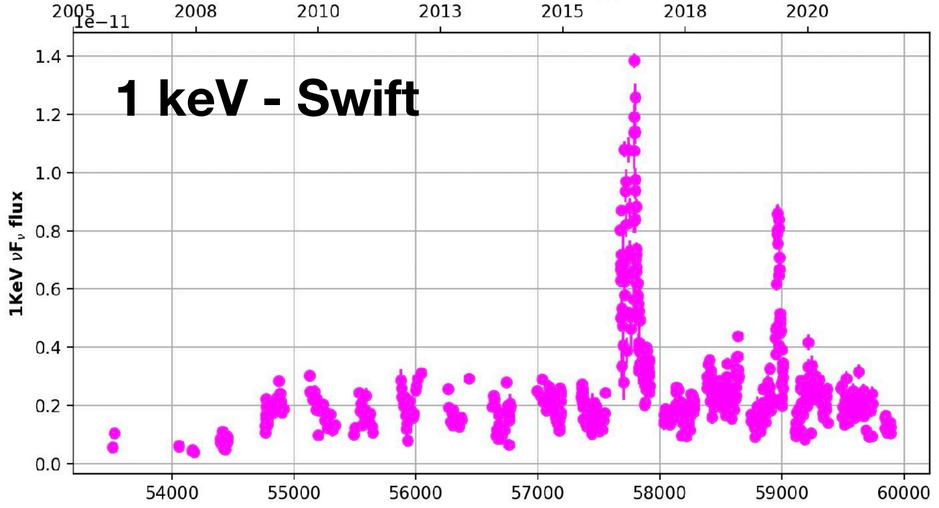


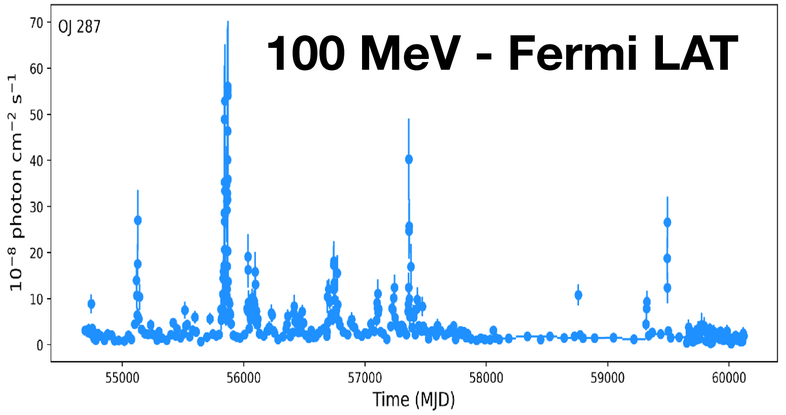
VOU_BlazarsV2.24 generates likely the best sampled and richest SEDs on the WEB

Time-domain



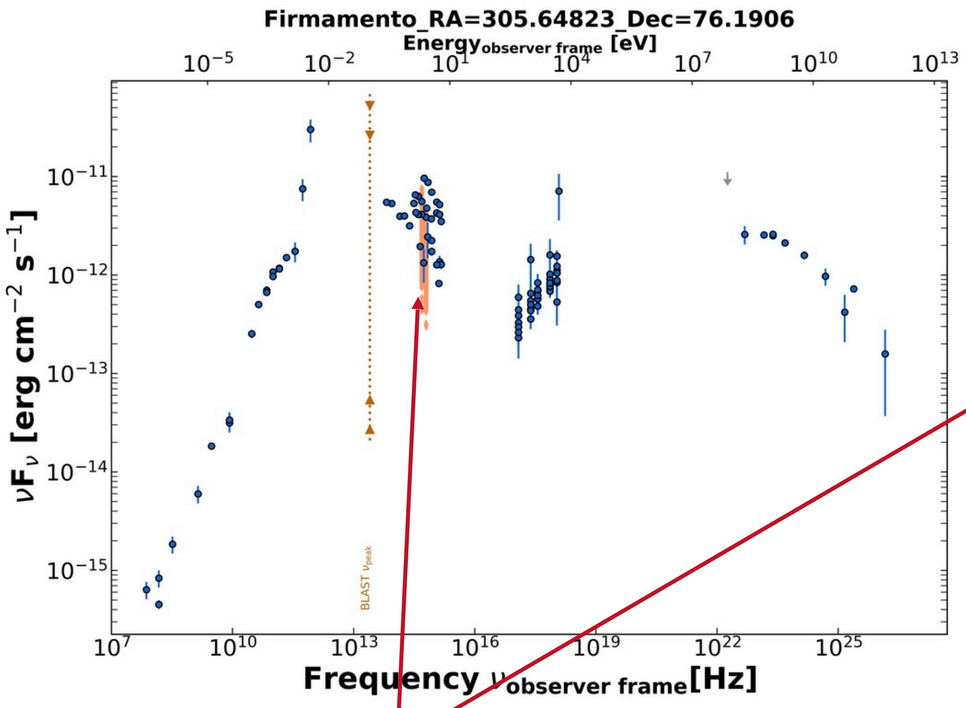






Firmamento provides light-curves in several energy bands. These are a few examples

All domains in the same page



Last run date: 2024-08-04

Add luminosity axis | Add ZTF data | Add CTAO Sensitivity

Templates

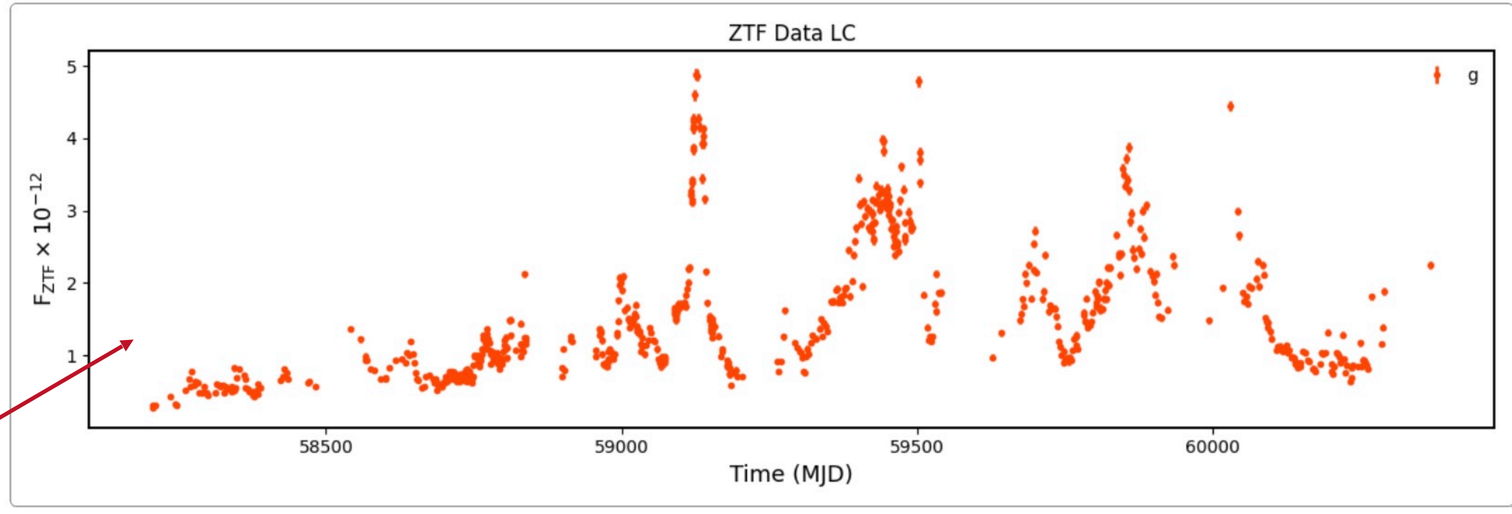
Blue Bump | Giant elliptical | 3C279 | MKN501 | TXS0505+056

Refresh

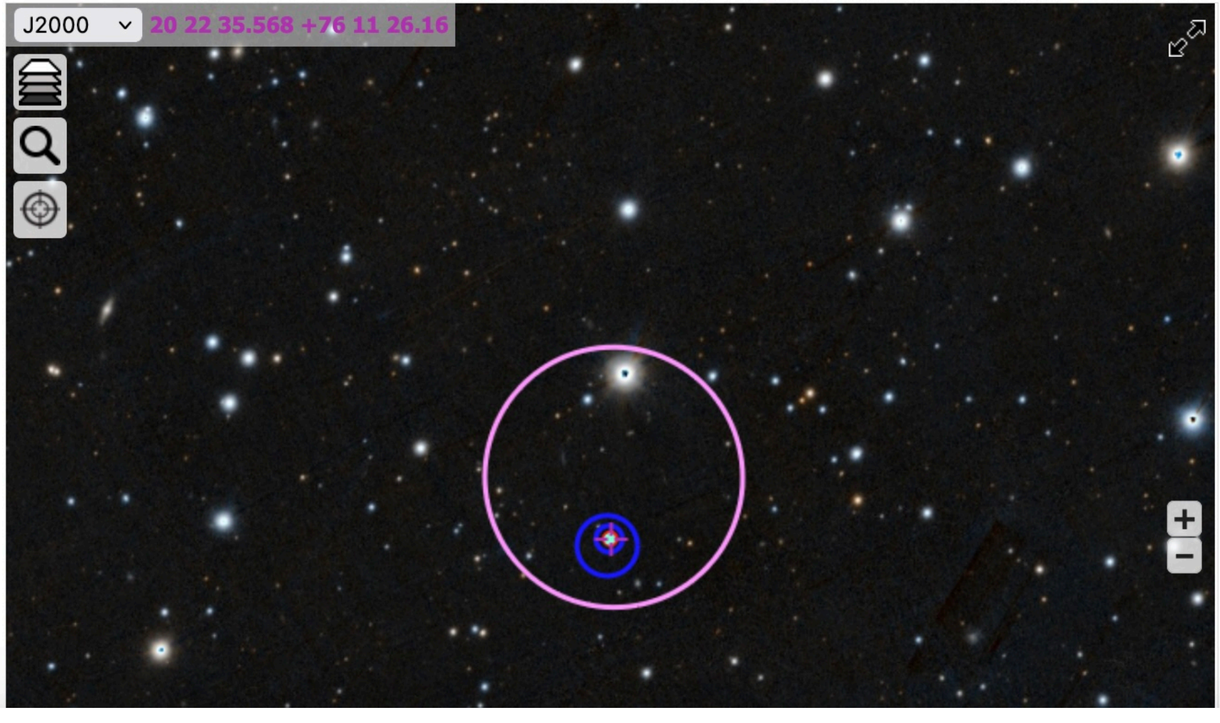
Results from BLAST Log(nu_peak): **13.4 ± 0.5** *(1 sigma)*
Log(nuFnu_peak): **-11.3 ± 0.2** *(1 sigma)*

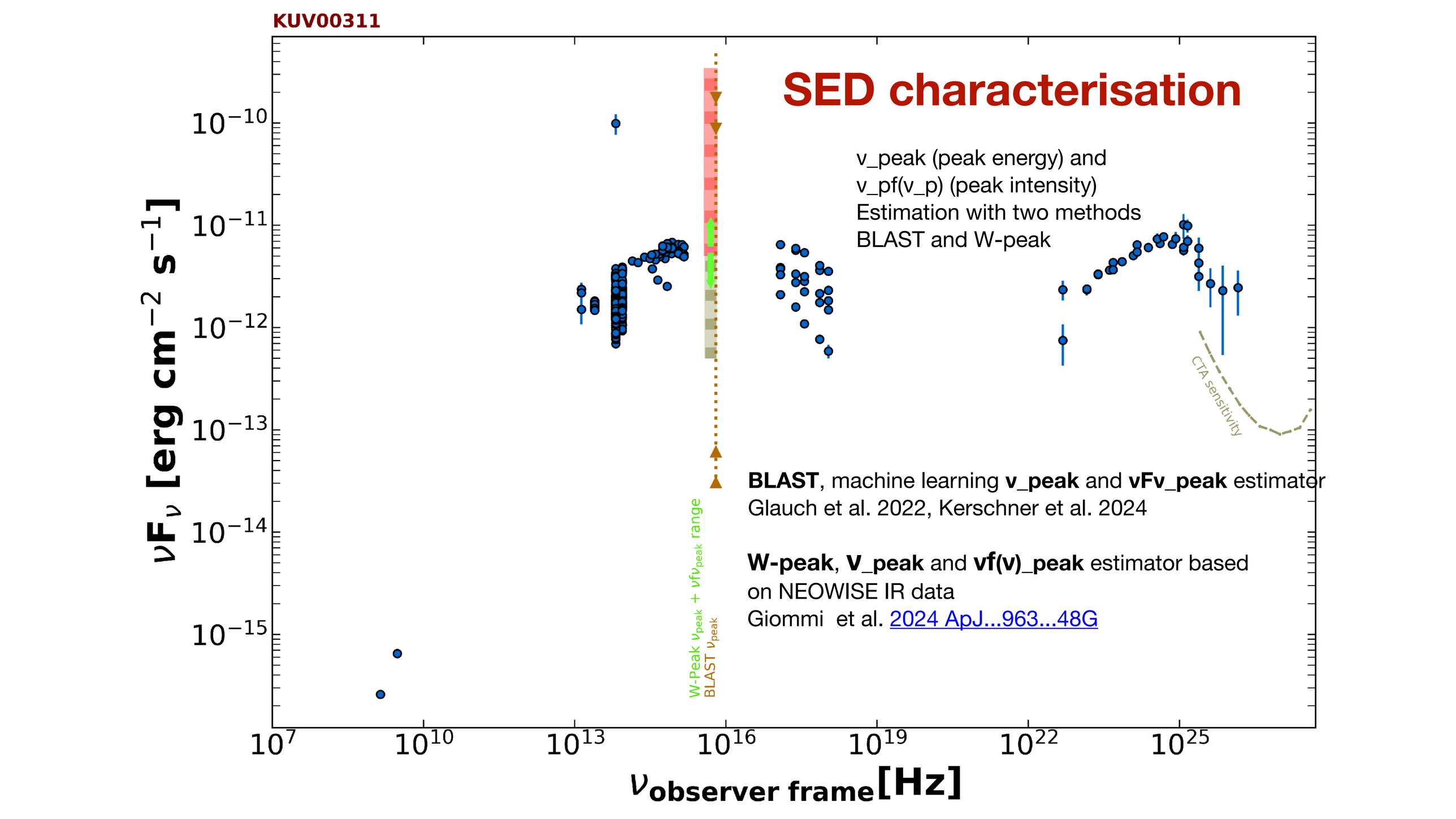
Results from wpeak See warning

SED data *(preview:)* ASCII | CSV | SSDC SED input file

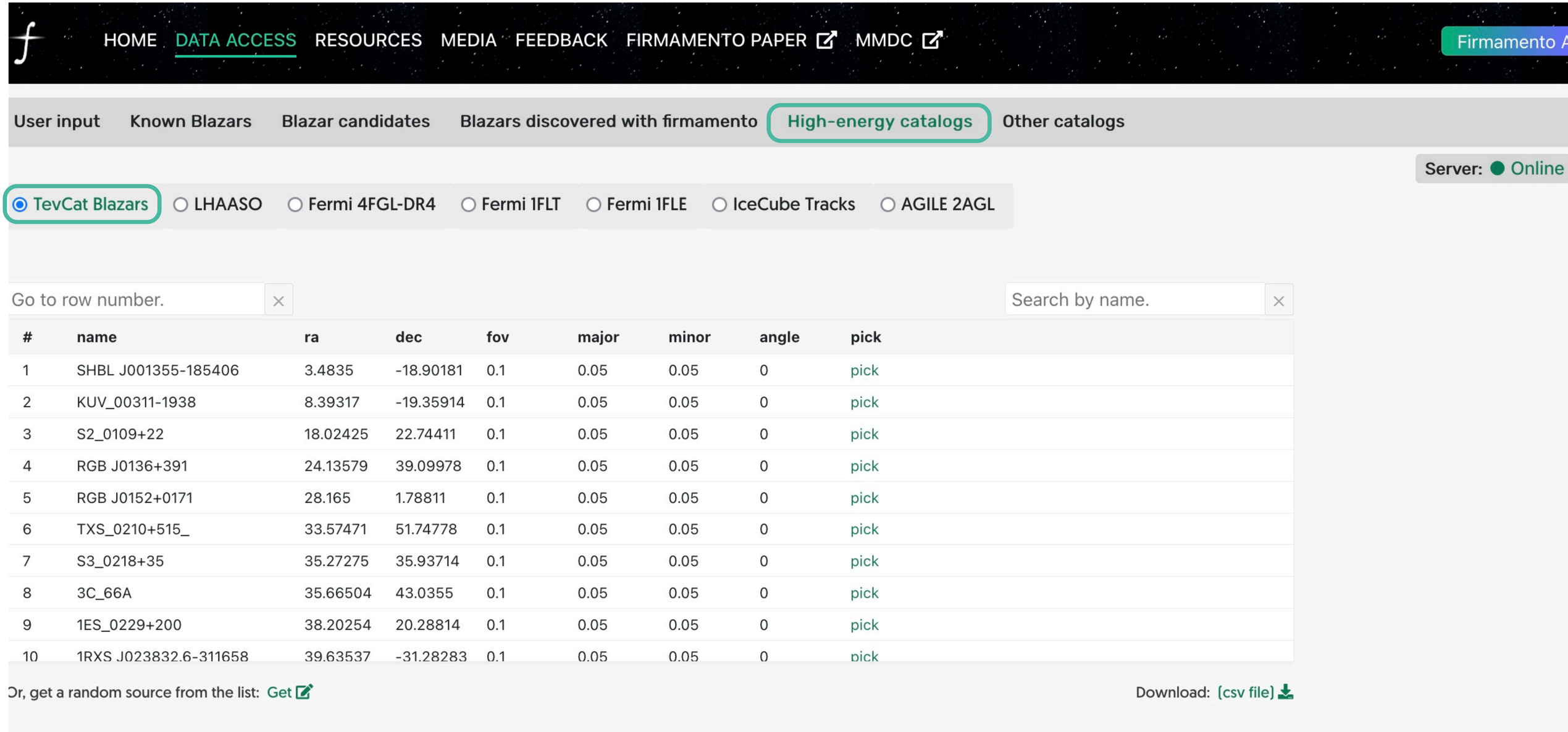


VOU-Blazars - SED error circles map for *firmamento* Based on "Aladin Lite" developed at CDS, Strasbourg Observatory, France




KUV00311
SED characterisation
v_peak (peak energy) and
v_pf(v_p) (peak intensity)
Estimation with two methods
BLAST and W-peak
CTA sensitivity
BLAST, machine learning v_peak and vFv_peak estimator
Glauch et al. 2022, Kerschner et al. 2024
W-peak, v_peak and vf(v)_peak estimator based
on NEOWISE IR data
Giommi et al. 2024 ApJ...963...48G
W-Peak νpeak + νfνpeak range
BLAST νpeak
νF_ν [erg cm^-2 s^-1]
ν observer frame [Hz]

Tables and samples



Firmamento provides many tables of astronomical objects. Users can also upload tables

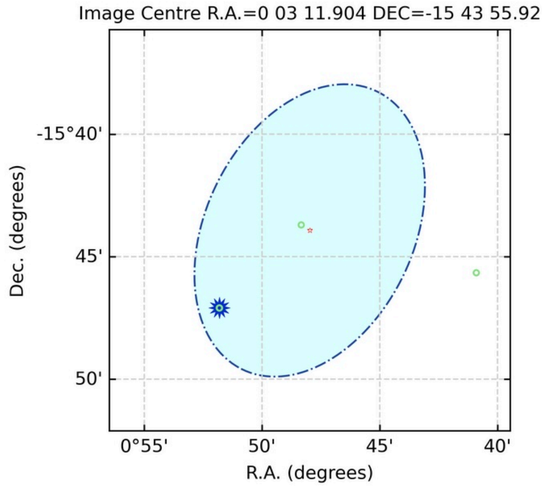
The error region identifier

Firmamento tool to identify counterparts in the error region of X-ray, γ-ray and neutrino sources

Based on the following parameters
aox,airx,airo,aro,arx,aw1w2,arg,nu_peak,x_en_slope,gamma_sp_index,host_galaxy_sed,host_galaxy_image,blue_bump,Xray_extended

15. Souce name: 4FGL J0003.1-1543

Candidates Image from voublazar



Last run date:
2024-06-12

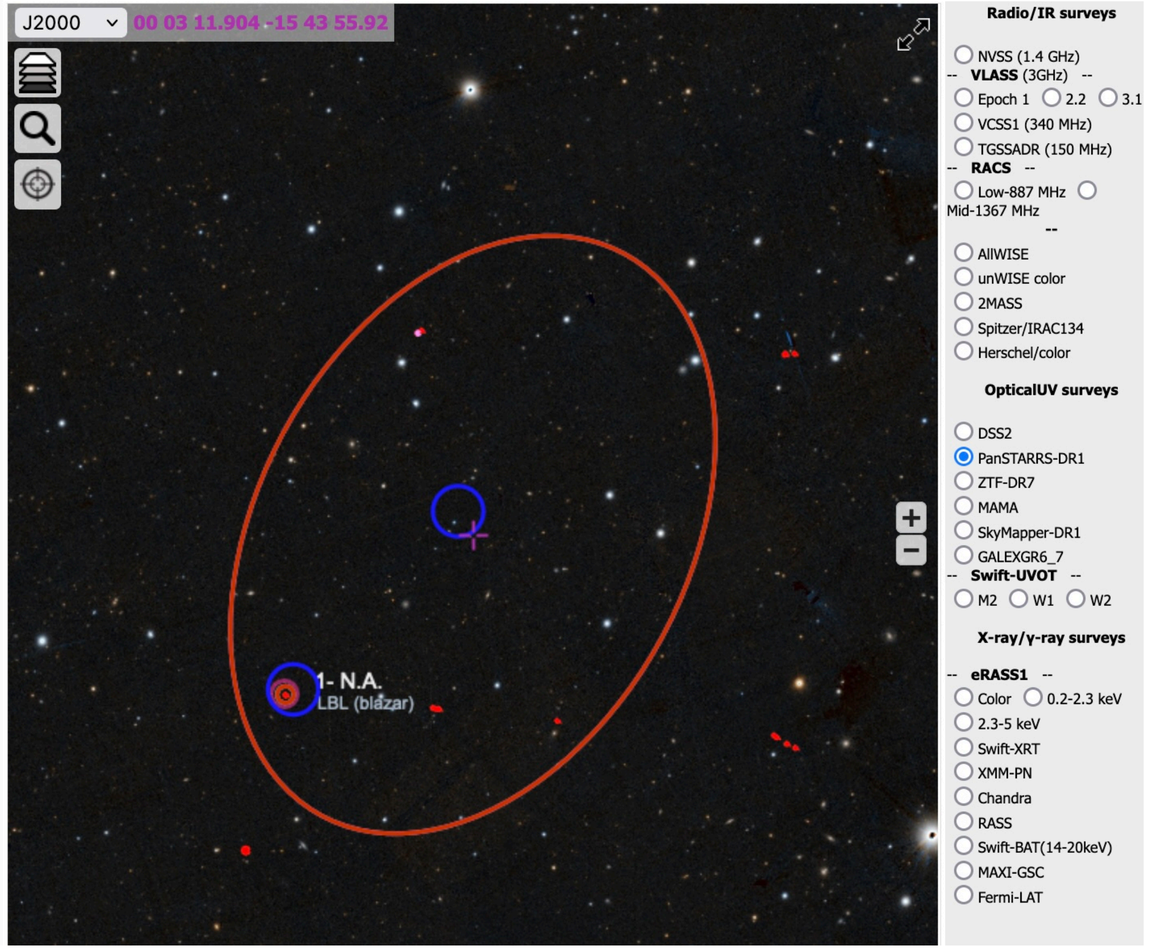
Candidate legend »

Aladin error region legend »

List of candidates found. Please pick one.

#	name	ra	dec	possible SED type	redshift	pick
1	N.A.	0.86360	-15.78486	LBL (blazar)	0.508	pick

VOU-Blazars - SED error circles map for *firmamento* Based on "Aladin Lite" developed at CDS, Strasbourg Observatory, France



This slide illustrates the case of the identification of the counterpart of a γ-ray error region of a few arc-minutes size.

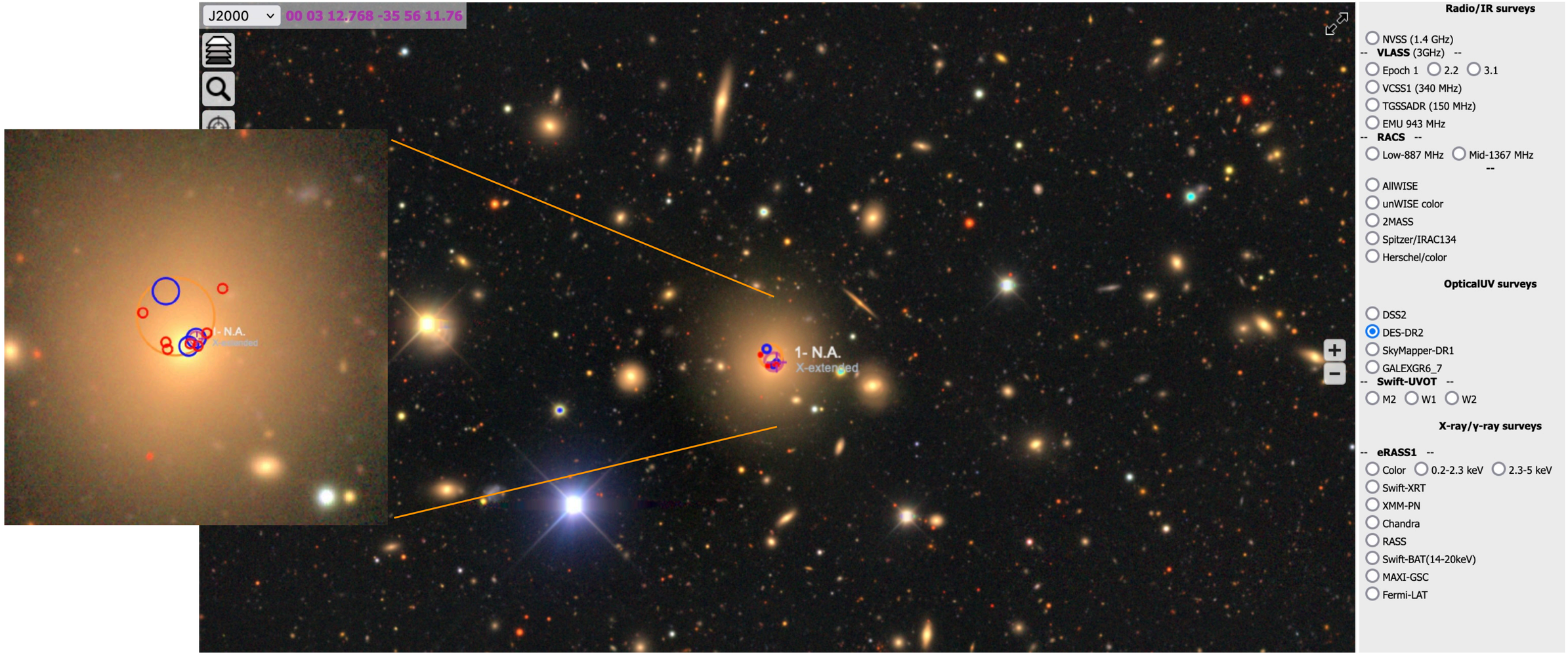
The error region identifier

Firmamento tool to identify counterparts in the error region of X-ray, γ-ray and neutrino sources

Based on the following parameters
aox,airx,airo,aro,arx,aw1w2,arg,nu_peak,x_en_slope,gamma_sp_index,host_galaxy_sed,host_galaxy_image,blue_bump,Xray_extended

Souce name: 1eRASSJ000313.1-355607

X-ray error region of a few arc seconds size

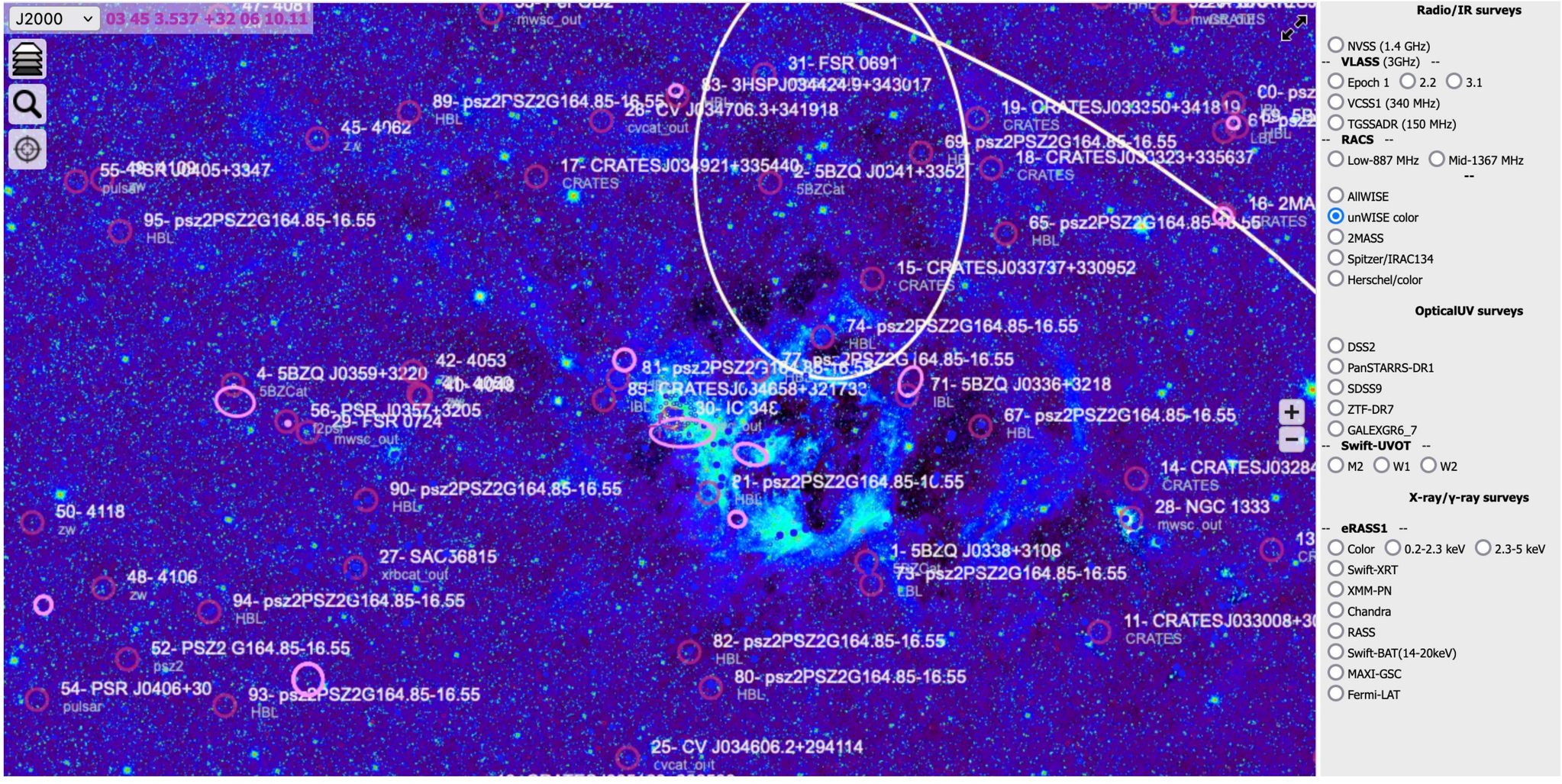


The error region identifier

Firmamento tool to identify counterparts in the error region of X-ray, γ-ray and neutrino sources

Based on the following parameters
aox,airx,airo,aro,arx,aw1w2,arg,nu_peak,x_en_slope,gamma_sp_index,host_galaxy_sed,host_galaxy_image,blue_bump,Xray_extended

A IceCube neutrino track error region with size larger than one degree



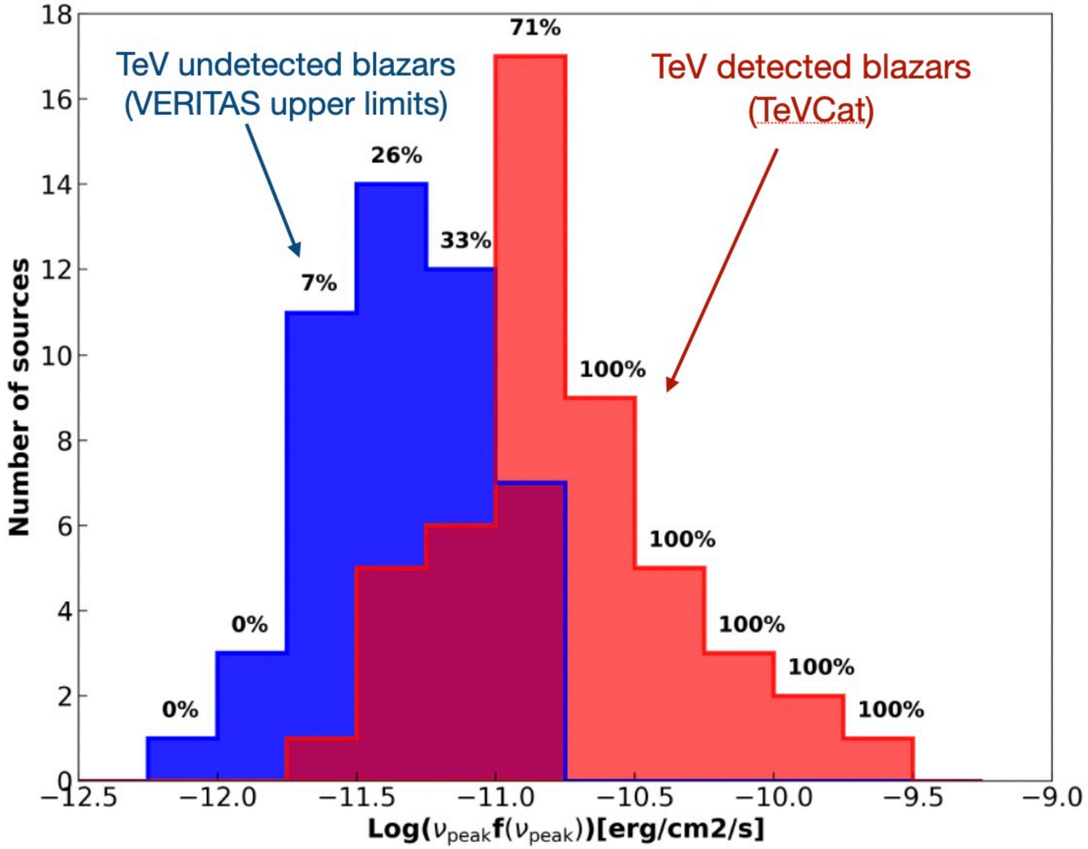
VHE detectability estimation

TeV detectability script

Python **tev_detectability.py** Log(v_peak) Log(vFv_peak) redshift

Python **tev_detectability.py** 16.0 -11.18 0.22

Probability of detection with current IACTs : 33%
Probability of detection in a CTAO medium exposure : > 95%
Probability of detection in a CTAO exposure : > 95%



Giommi et al. 2024 ApJ...963...48G

Firmamento can estimate the probability of detection of a IBL or HBL blazar at VHE energies (E > 200 GeV) based on vFv_peak, v_peak and redshift.
The method is explained in Giommi et al. 2024

Two on-going *Firmamento* projects

- A reanalysis of the Fermi 4FGL-DR4/4LAC catalogues
- The BlazaR eRASS1 (BReRASS) survey of X-ray selected blazars

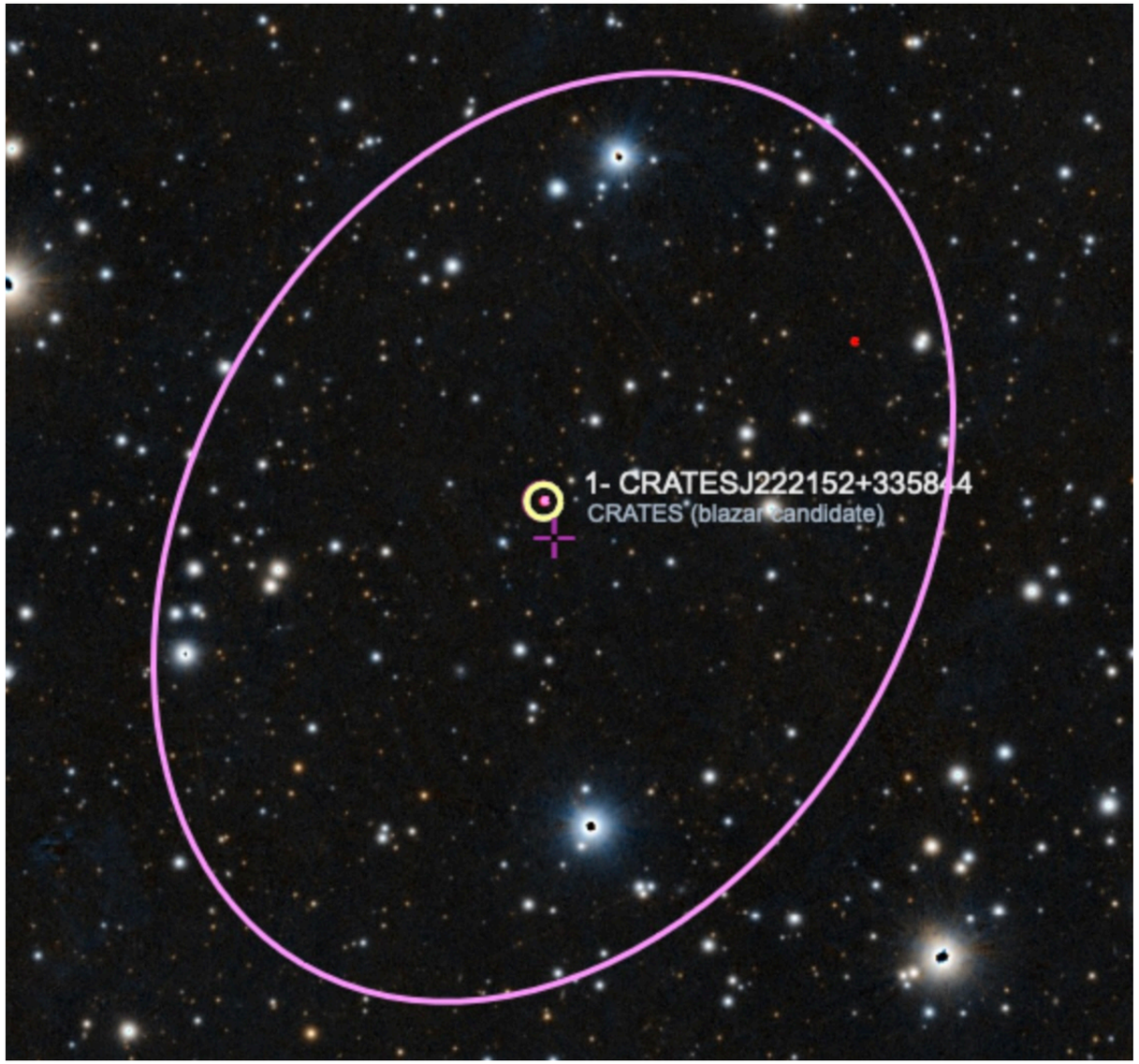
The Firmamento error region identifier tool was run on

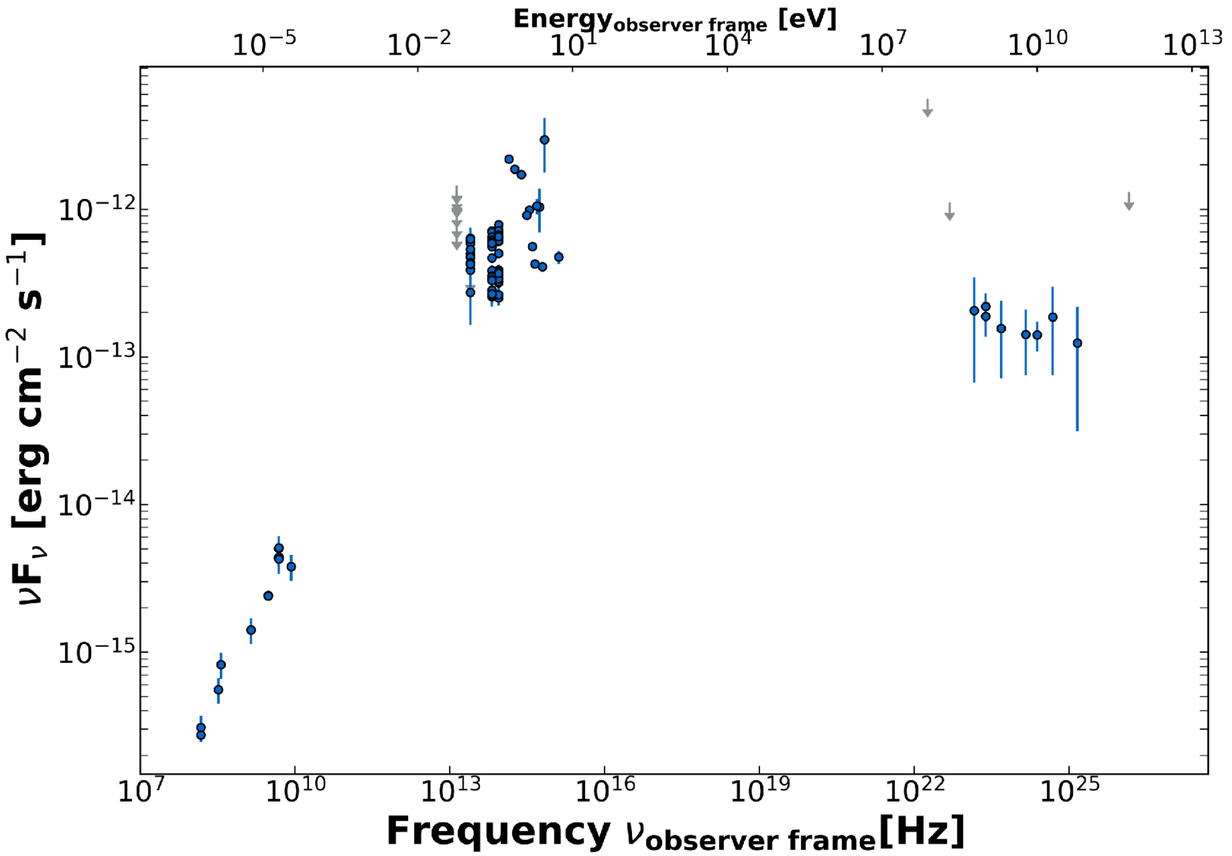
- all the 5,060 Fermi 4FGL-DR4 γ-ray sources with |b| > 10
- >1,500 eRASS1 radio matching X-ray sources (in selected areas) + eFEDS

The output was loaded to Firmamento as tables and all sources were individually checked using Firmamento by some collaborators (including an international team of students)

Parameters like nu_peak and nu_Fnu peak were calculated using BLAST and W-Peak.
These parameters, together with redshift were used to estimate the expected VHE detectability

4FGL J2221.8+3358



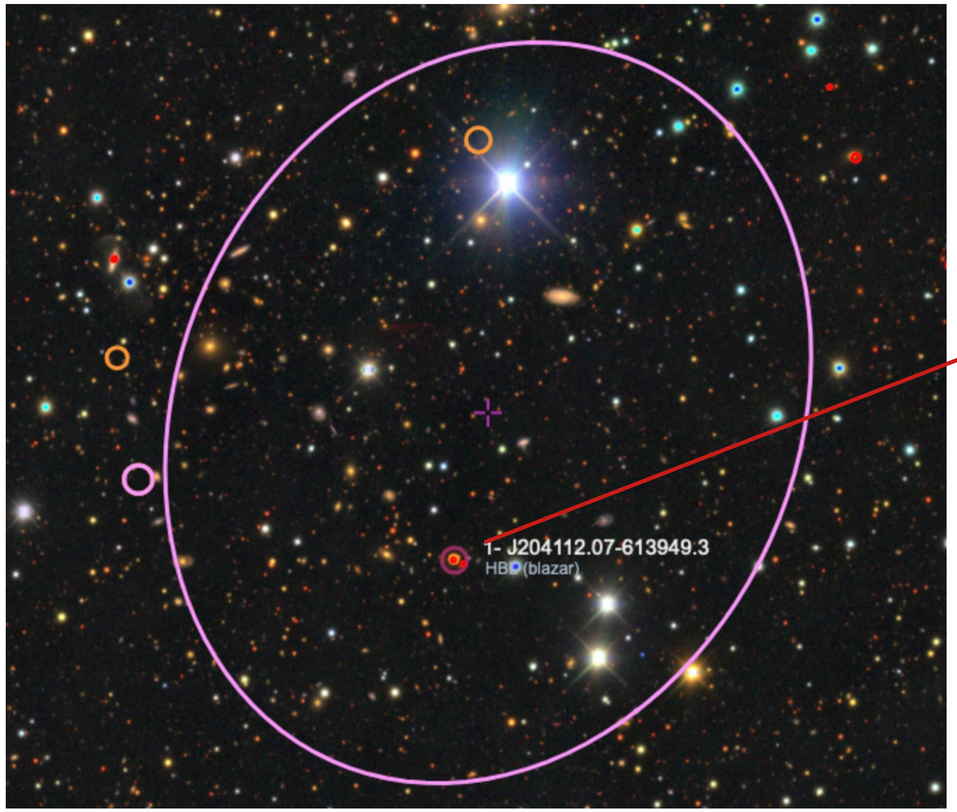


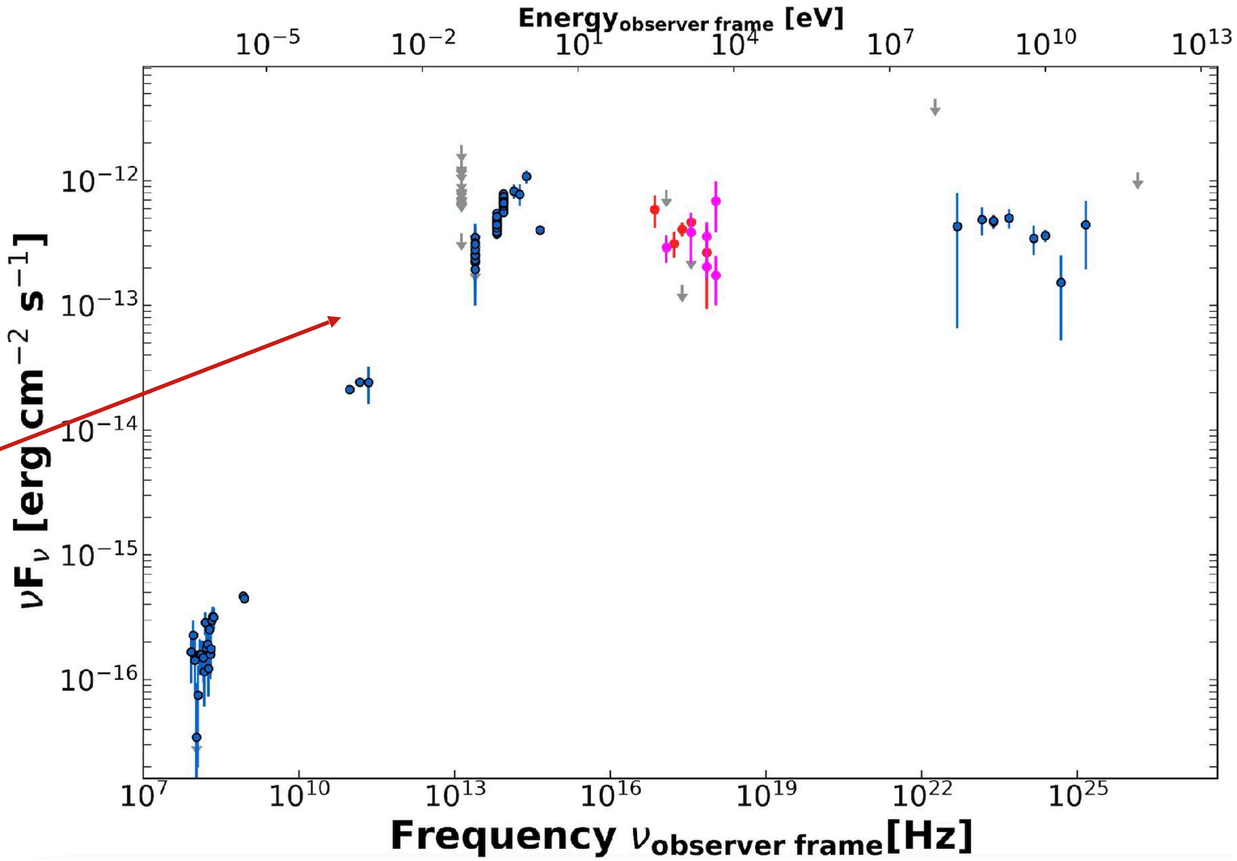
Blast: Log(nu_peak) = 14.4

Log(nu_f(nu)_peak = -12.1

The most common case: our proposed counterpart (source 1 CRATES..) coincides with the 4FGL-DR4 counterpart, represented by the yellow circle

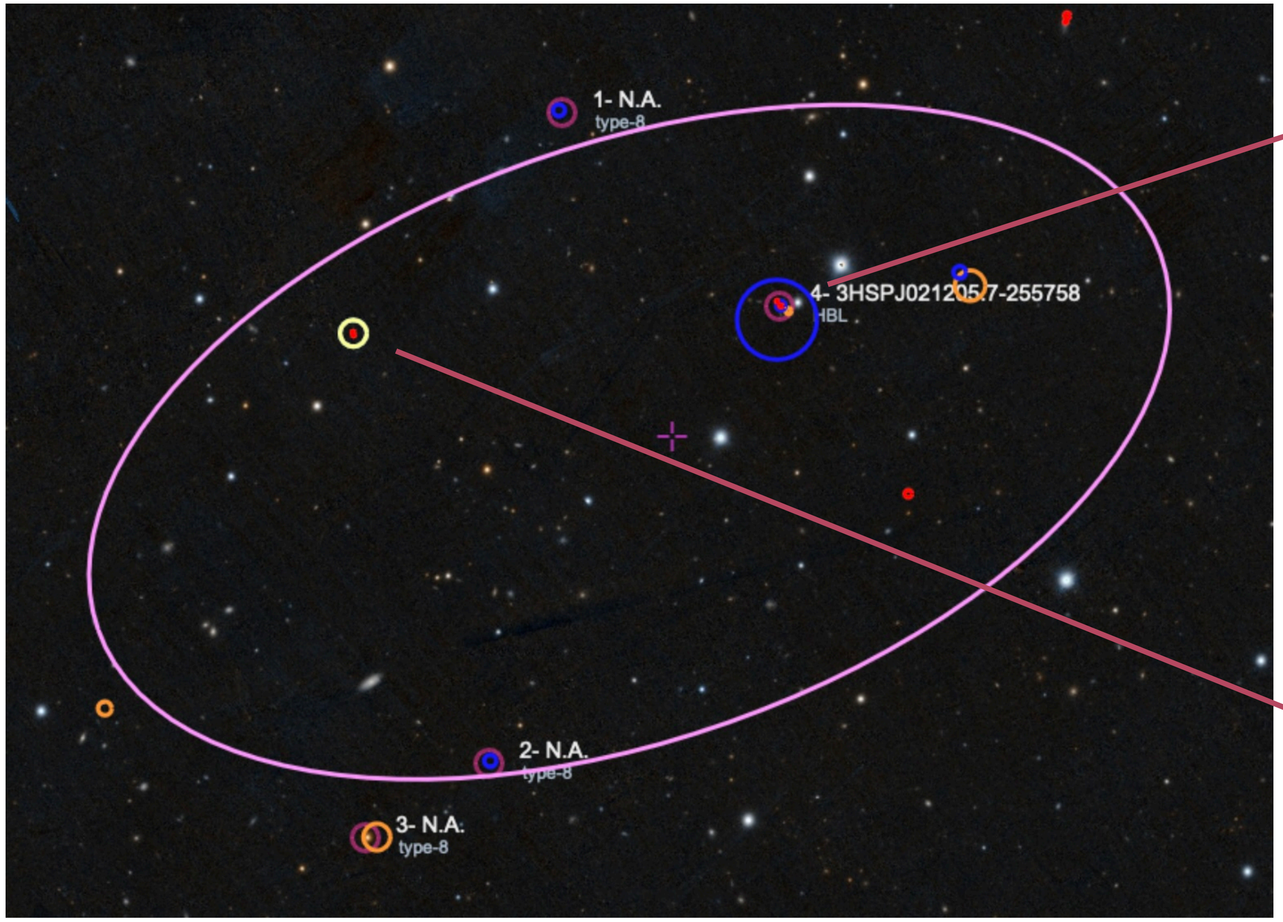
4FGL J2041.1-6138

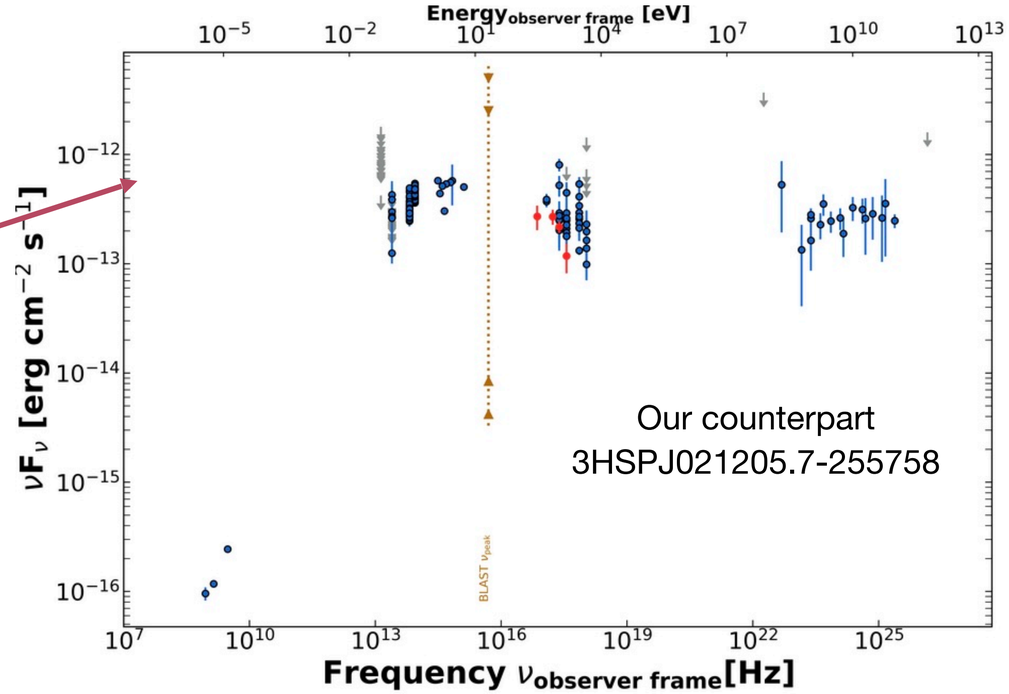


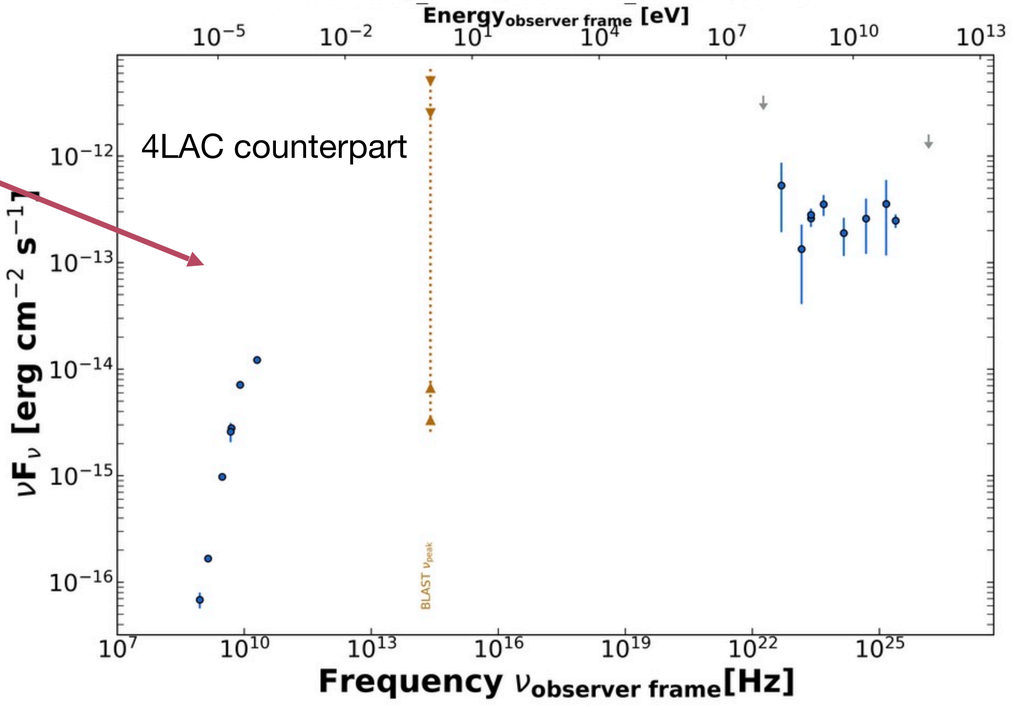


Case where the γ-ray source is unassociated in 4FGL-DR4/4LAC and Firmamento finds a reliable counterpart

4FGL J0212.2-2559

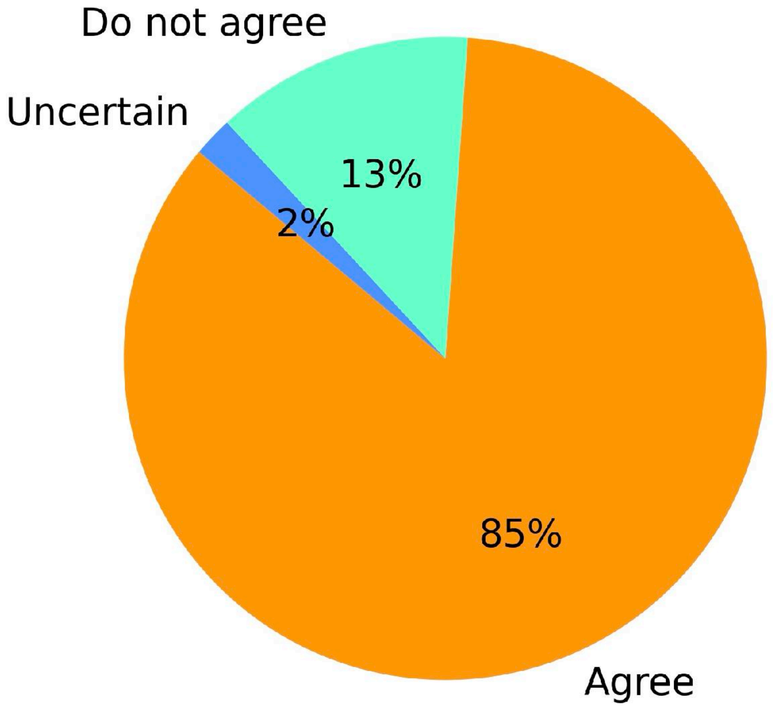


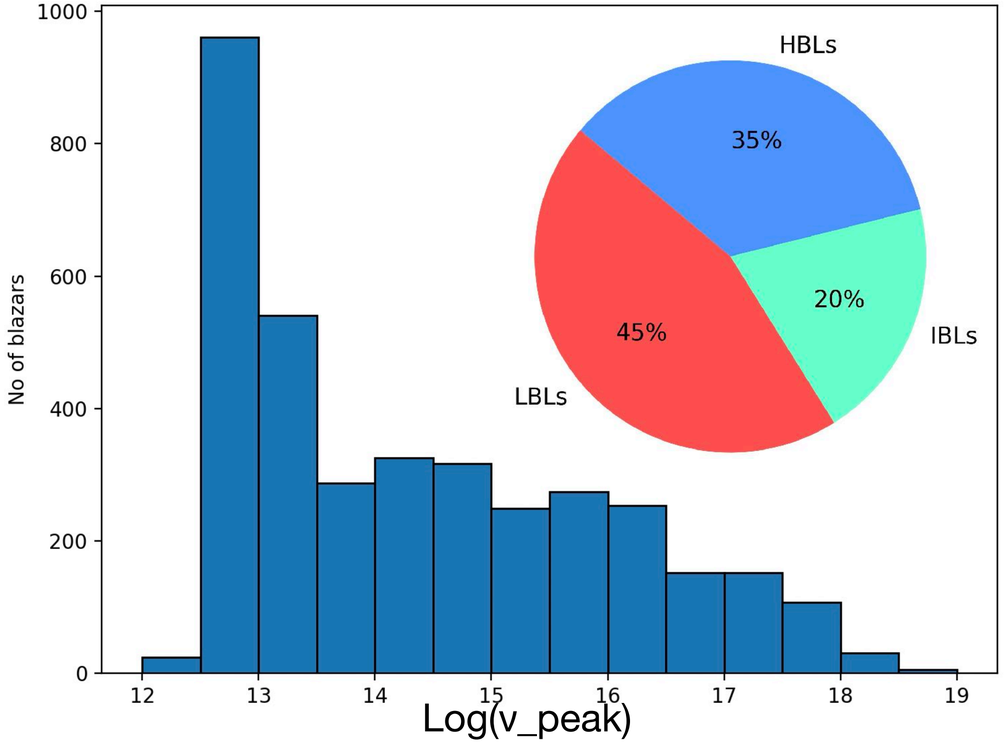


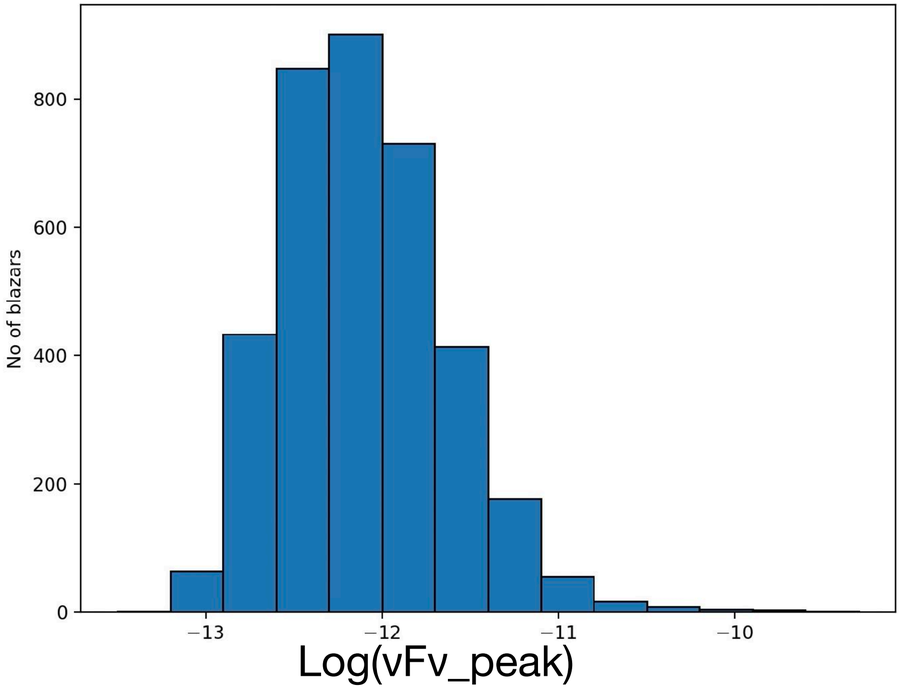


Case where the 4FGL-DR4 source is associated. with a counterpart (yellow circle) that firmamento does not confirm as it finds an alternative counterpart with a better SED

Preliminary results







Main enhancements over 4FGL-DR4/4LAC

- 430 new identifications of previously unassociated sources
- v_peak and vFv_peak machine estimation for > 3,730 blazars
- Predictions for VHE detection of **IBL and HBL blazars**

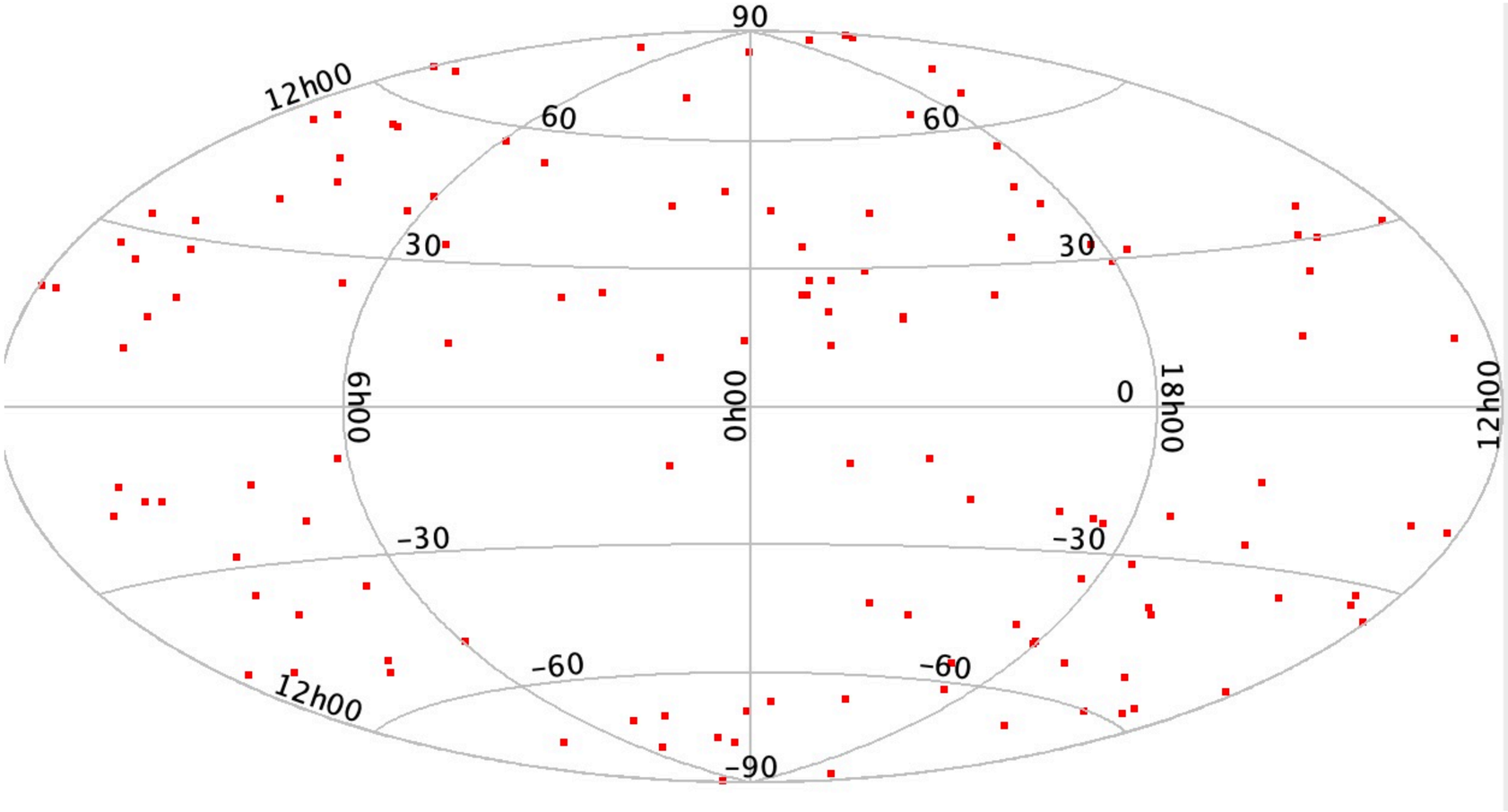
Current generation of IACTS	175.1 sources
CTAO medium exposure	523.5 sources
CTAO deep exposure	1102.8 sources

The table with the results will be published on Firmamento

# Name	Counterpart name	ra	dec	nu_peak	nu_Fnu_peak	VHE detectability Expectations (%) p current IACTS	p CTAO medium exp.	p CTAO deep exp.	Monte Carlo Survey Detected current IACTS	Detected CTAO med. exp.	Detected CTAO deep exp.
4FGL J0541.1−4854	3HSPJ054106.9−485410	85.2788	−48.9029	16.2	−12.5	0.0	0.0	7.0	no	no	no
4FGL J0541.4−7334	PKS 0542−735	85.4595	−73.5373	12.4	−12.2	–	–	–	–	–	–
4FGL J0541.6−0541	5BZQ J0541−0541	85.4094	−5.6971	12.6	−12.0	–	–	–	–	–	–
4FGL J0542.8−3458	WISEAJ054254.31−3459	85.7263	−34.9985	14.3	−12.5	0.0	0.0	7.0	no	no	no
4FGL J0542.9−0913	N.A.	85.7332	−9.2232	12.6	−12.0	–	–	–	–	–	–
4FGL J0543.2+8238	S5 0532+82	85.9143	82.6417	12.5	−12.6	–	–	–	–	–	–
4FGL J0543.9−5531	3HSPJ054357.0−553207	85.989	−55.5361	16.4	−10.9	95.0	95.0	95.0	yes	yes	yes
4FGL J0545.0+0613c	J054340.10+062553	85.9208	6.4315	−99.0	−99.0	–	–	–	–	–	–
4FGL J0546.9−2206	3HSPJ054656.8−220457	86.7366	−22.0826	16.1	−12.3	0.0	7.0	33.0	no	no	yes
4FGL J0548.5−5218	CRATESJ054828−521829	87.1253	−52.308	14.1	−12.4	0.0	0.0	7.0	no	no	no
4FGL J0550.3−5733	5BZQ_J0550−5732	87.5399	−57.5401	12.9	−11.5	–	–	–	–	–	–
4FGL J0550.5−3216	3HSPJ055040.6−321616	87.669	−32.2713	17.6	−10.9	95.0	95.0	95.0	yes	yes	yes
4FGL J0551.0−1622	CRATESJ055050−162127	87.7136	−16.3639	12.8	−12.6	–	–	–	–	–	–
4FGL J0553.5−2034	3HSPJ055333.1−203418	88.388	−20.5719	16.2	−11.7	7.0	33.0	95.0	no	no	yes

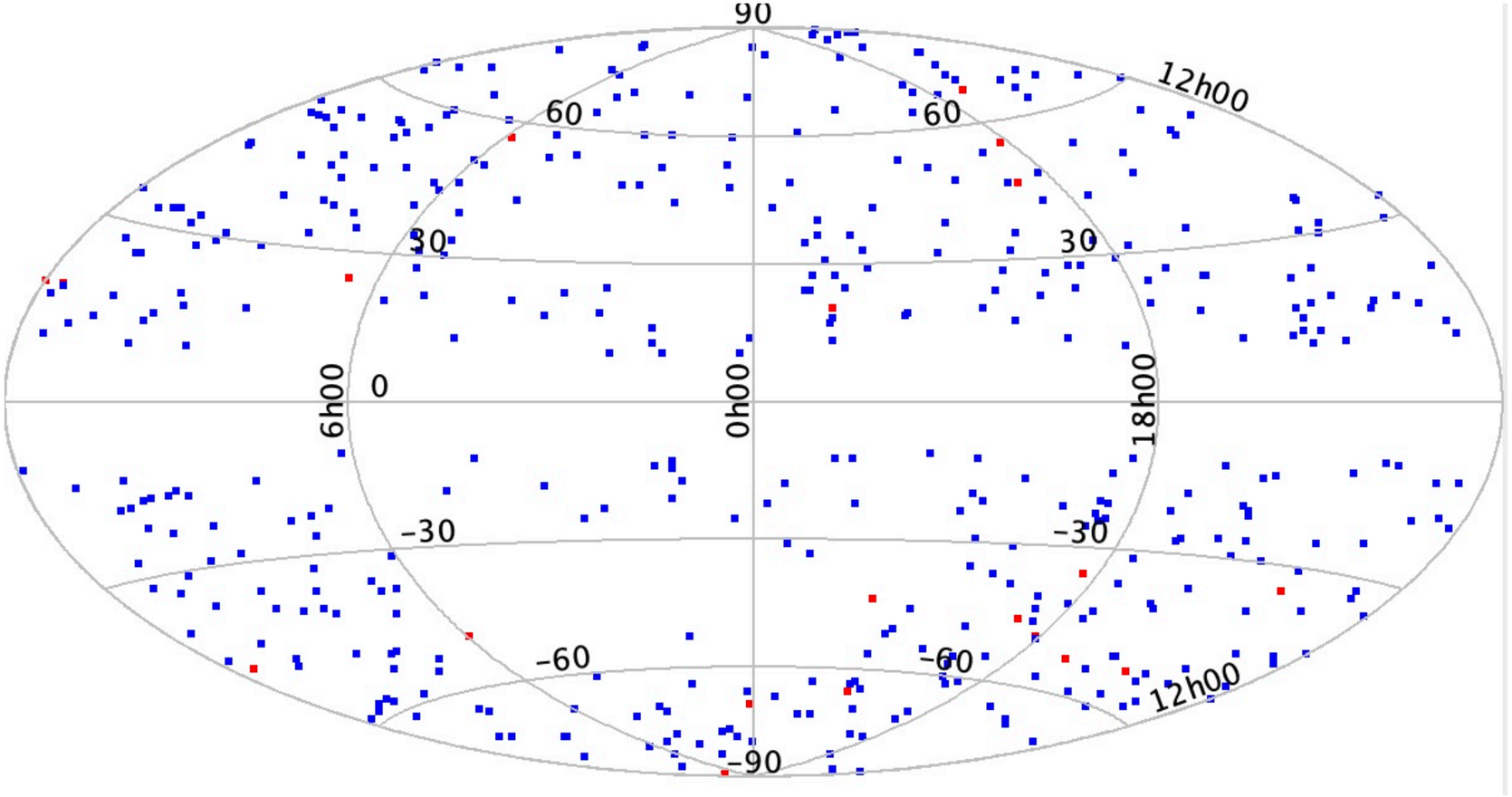
Example of a section of the table displaying Firmamento results, including various parameters and the estimated probability of detection at VHE energies.(E>=200 GeV) with current IACTS, a medium CTAO exposure (factor 3 better than current IACTS) and a deep CTAO exposure (factor 10 better than current IACTS). The last three columns give the detection (as “yes” or “no”) in a simulated survey based on the probabilities of the previous three columns.
A “-“ means that the source has Log(v_peak) lower than 13.5

Monte Carlo simulation of hypothetical VHE surveys



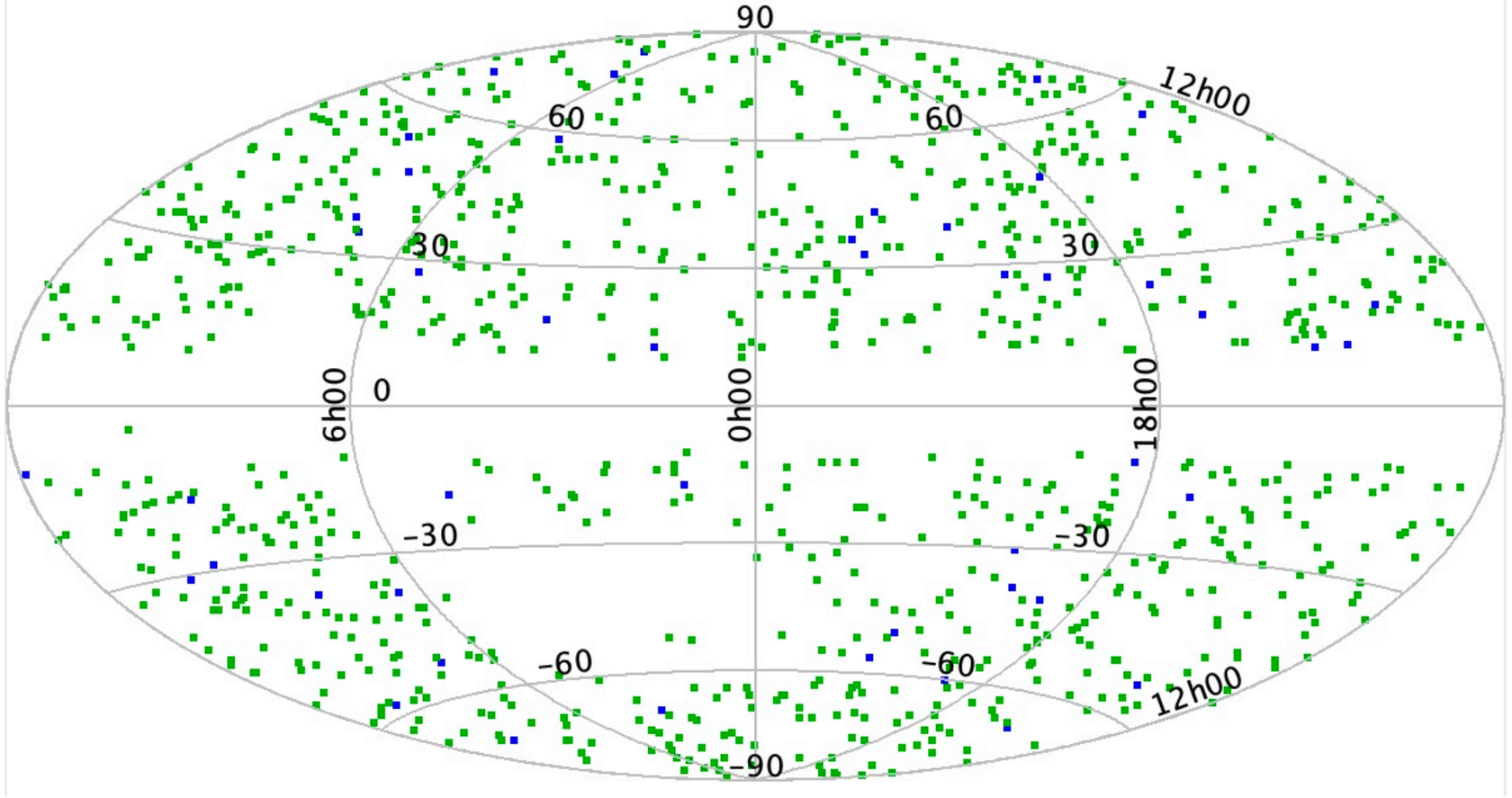
Hammer-Aitoff plot in Galactic coordinates plotting the sources detectable by current IATCS (red)

Monte Carlo simulation of hypothetical VHE surveys

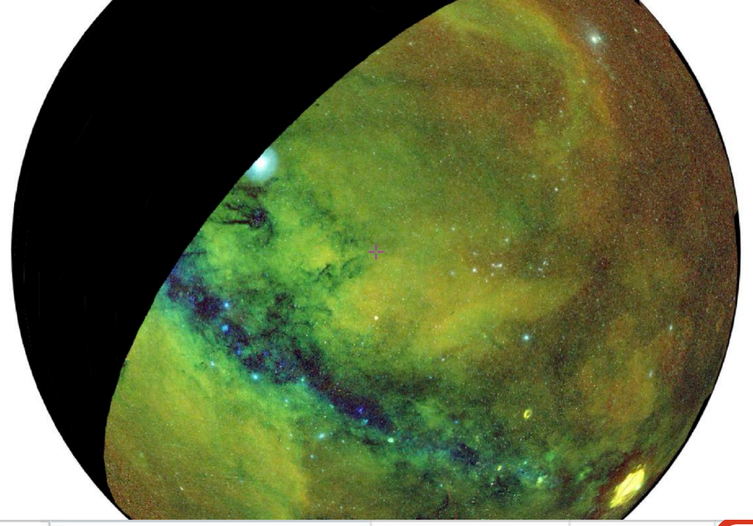


Hammer-Aitoff plot in Galactic coordinates plotting the sources detectable in a medium CTAO extragalactic survey (blue)

Monte Carlo simulation of hypothetical VHE surveys



Hammer-Aitoff plot in Galactic coordinates plotting the sources detectable in a hypothetical deep full-sky (|b| > 10) CTAO survey (green)

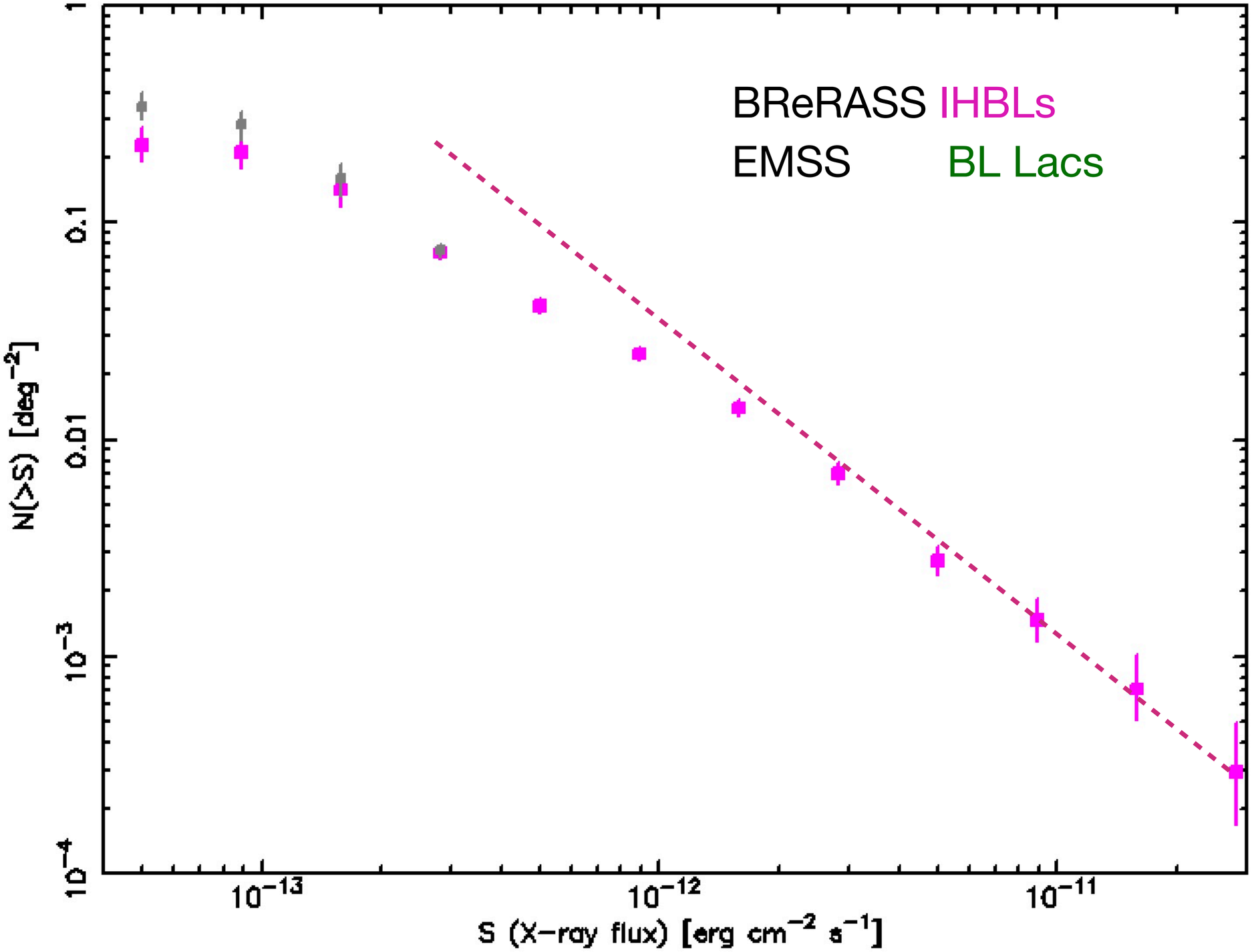


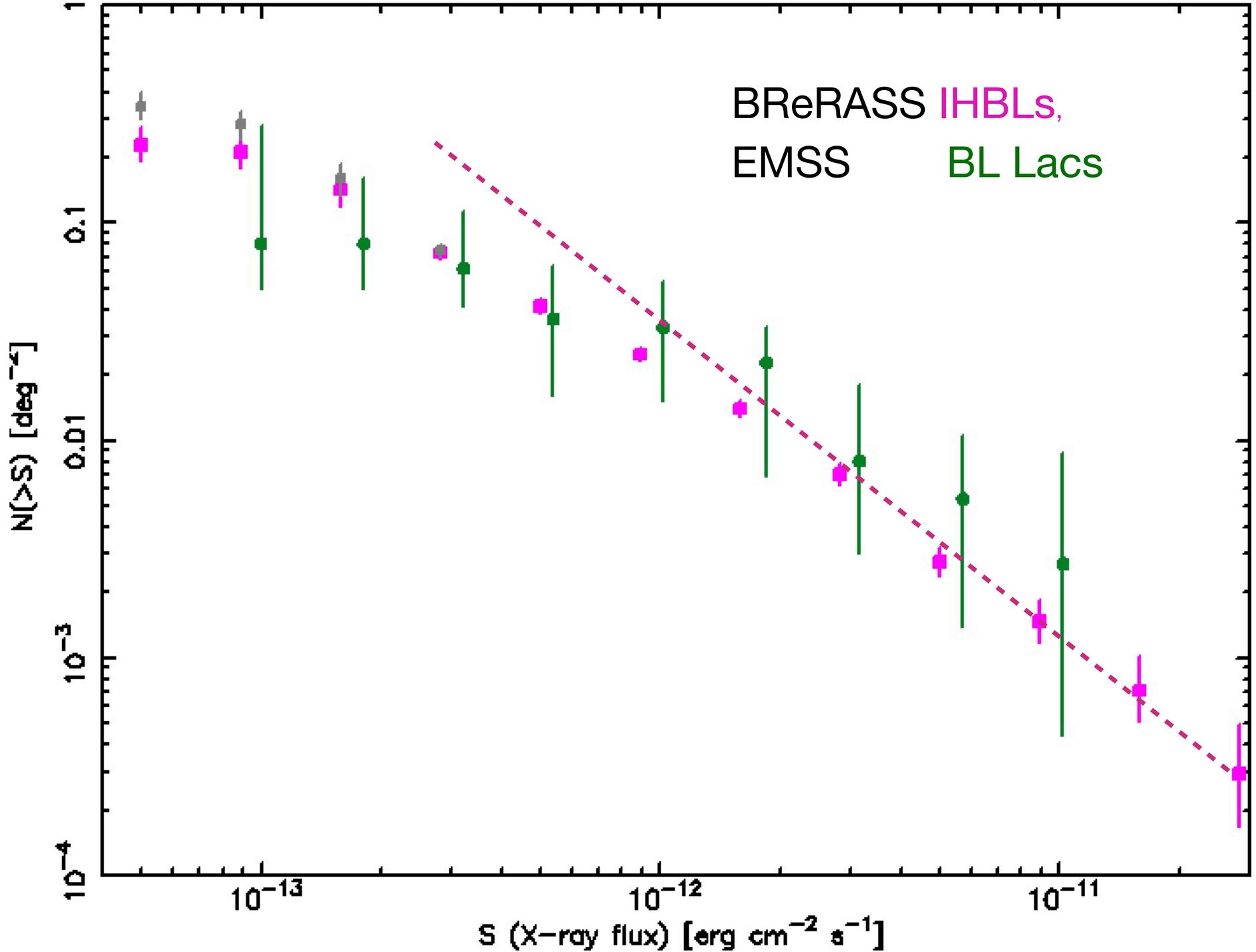
The BReRASS survey

Led by a team based at the Brera Observatory, Milan

	Name	ra	dec	Type	CatalogName	redshift	Spect/phot	nu_peak	last nu_/-peak	nu_	nu_p	Accepted	PG	AW
7	1eRASSJ010402.1-72020	16.00175	-72.03503	HBL	J010401-720206									no
8	1eRASSJ010516.9-58261	16.32031	-58.43757	Seyfert	N.A.	0.026							no	
9	J010750.4-364317	16.95959	-36.72254	cluster?	J010750-364321								no	
10	1eRASSJ011109.6-47273(	17.79062	-47.46286	Seyfert	N.A.								no	
11	J011501.5-340026	18.75717	-34.00756	HBL	3HSPJ011501.7-34002	0.482	spec		17.5	--	-11.8		yes	
12	J011555.4-274431	18.98124	-27.74304	HBL	3HSPJ011555.5-274431			18	16.9	--	-12		yes	
13	J011811.2-265805	19.54657	-26.96943	Seyfert	J011811-265813								no	
14	J012031.5-270126	20.13192	-27.02353	IBL	5BZB J0120-2701	0		13.9	14.4	--	-11.1		yes	
15	J012237.4-264646	20.65603	-26.77909	QSO/Seyfert	RXSJ01226-2646	0.417							no	
16	J012338.1-231059	20.90975	-23.18294	HBL	3HSPJ012338.3-23105	0.404		18	17.1	--	-11.5	yes	yes	
17	1eRASSJ012345.7-58481	20.94068	-58.80578	radio-AGN	N.A.	0.046							no	
18	J012354.2-350356	20.97654	-35.06546	Xray-UNCL	N.A.	0.019							no	
19	J012910.8-214156	22.29421	-21.69944	Seyfert	IRAS01267-2157	0.047			16.1	--	-11.5		no	

A wide range of astronomical objects can be counterpart of eRASS1 X-ray sources.
Firmamento provides preliminary identifications that can be studied in full detail
for confirmation or rejection. BReRASS is the subsample of confirmed blazars of all types.


BReRASS IHBLs
EMSS BL Lacs
N(>S) [deg^{-2}]
S (X-ray flux) [erg cm^{-2} s^{-1}]
1
0.1
0.01
10^{-3}
10^{-4}
10^{-13}
10^{-12}
10^{-11}


BReRASS IHBLs,
EMSS BL Lacs
N(>S) [deg^{-2}]
S (X-ray flux) [erg cm^{-2} s^{-1}]
1
0.1
0.01
10^{-3}
10^{-4}
10^{-13}
10^{-12}
10^{-11}

la Nuova di Venezia e Mestre

CONTENUTO PER GLI ABBONATI PREMIUM

Quattro ragazzi del liceo Morin di Mestre scoprono le nuove “sorgenti dell’universo”

Brando Mazzon, Laura Fronte, Francesco Metruccio e Nicolò Munaretto

Instagram

Mi piace: 78

zaiaufficiale 🦁 BRAVISSIMI I NOSTRI VENETI!

🔭🌌 Brando Mazzon, Niccolò Munaretto, Francesco Metruccio e Laura Fronte, quattro studenti del Liceo scientifico Morin di Venezia che nel 2022 hanno fatto un percorso con il Dipartimento di Fisica dell'Università di Padova, sono volati alla New York University of Abu Dhabi per presentare il loro studio sullo spazio, le onde e l'energia.