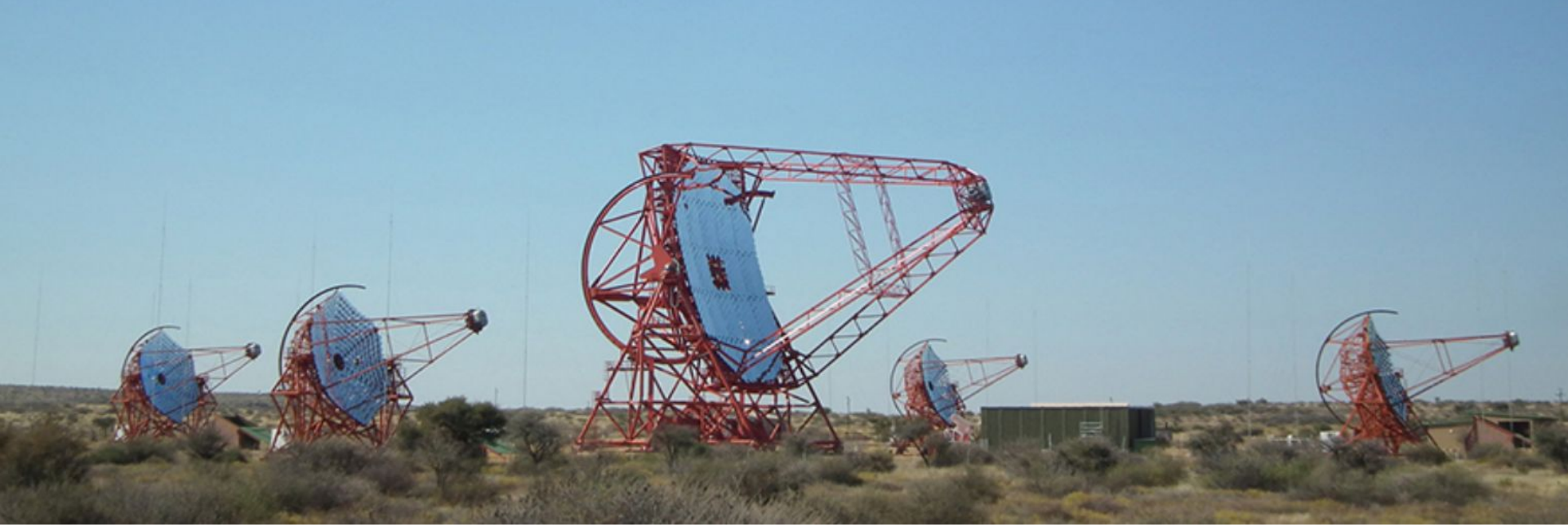

Detection of new Extreme BL Lac objects with H.E.S.S. and *Swift*-XRT

MRC 0910-208 and 1RXS J195815.6-301119

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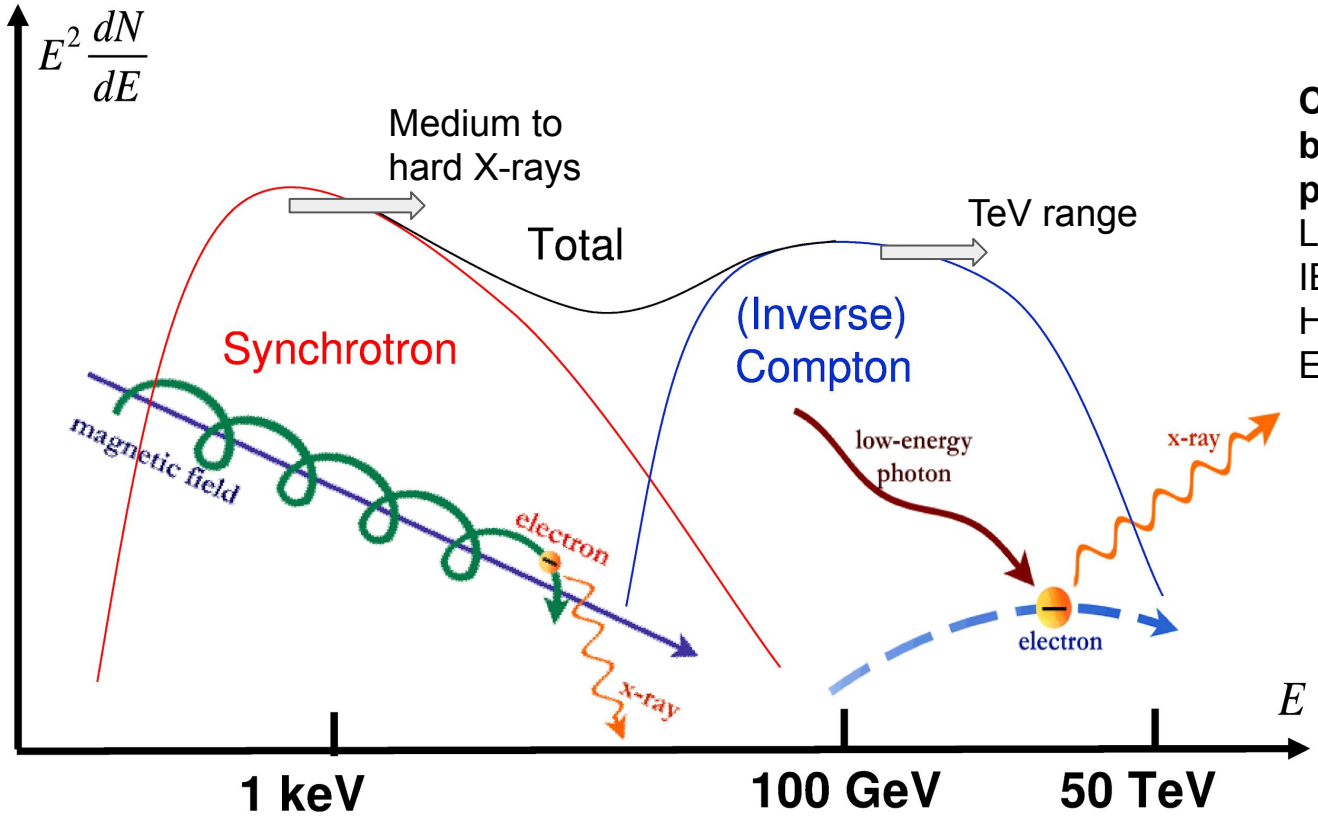
On behalf of the H.E.S.S. and Fermi-LAT collaborations

OUTLINE

- Brief introduction about extreme BL Lac objects
- TeV detection with H.E.S.S.
- *Fermi*-LAT analysis
- X-ray analysis
- SED modeling
- Summary & Conclusions

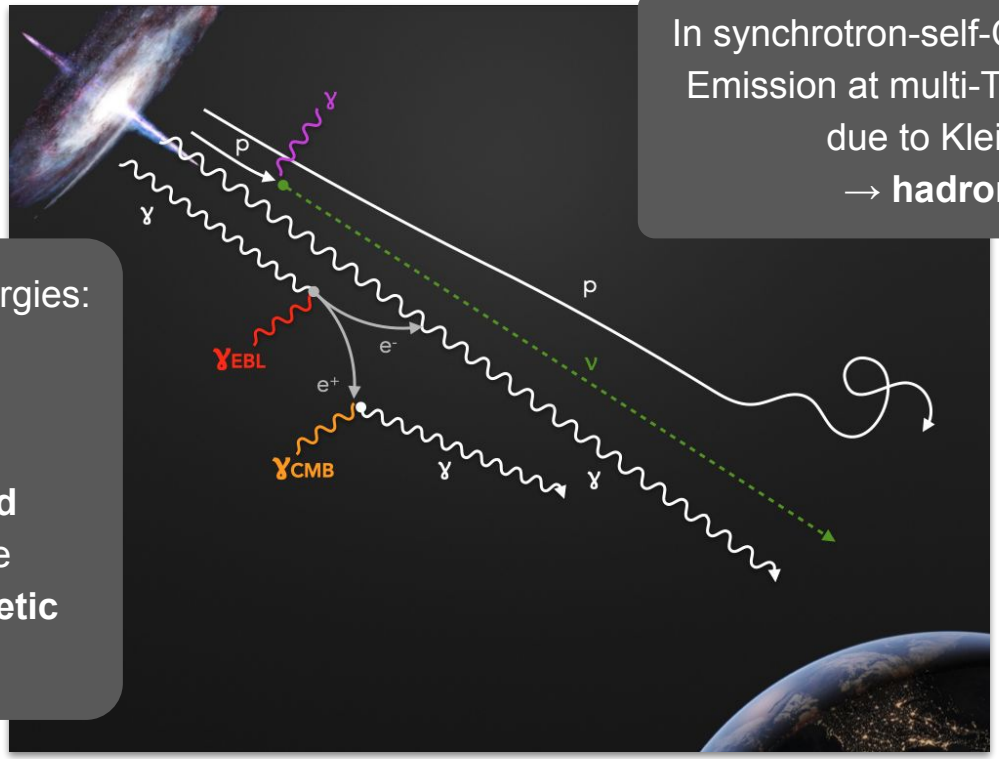
Extreme BL Lac objects (EHBL) - synchrotron and inverse Compton peak shifts to higher energies



Classification on the basis of synchrotron peak energy
LBL: Infrared
IBL: Optical/UV range
HBL: X-ray
EHBL: > 1 keV

EHBLs: laboratories for particle acceleration and gamma-ray propagation

In synchrotron-self-Compton (SSC) scenario:
Emission at multi-TeV energies suppressed due to Klein-Nishina effect
→ **hadronic emission?**



Emission beyond TeV energies:

- Ideal to probe **EBL absorption**
- Ideal to search for **gamma-ray initiated cascades** and probe **intergalactic magnetic fields**

About the sources-
MRC 0910-208 and 1RXS J195815.6-301119

- Sources selected due to their hard spectral index in Fermi point source catalog (from 2FGL onward)
- Sources also listed in Fermi catalog of extreme high synchrotron peaked blazars (3HSP)

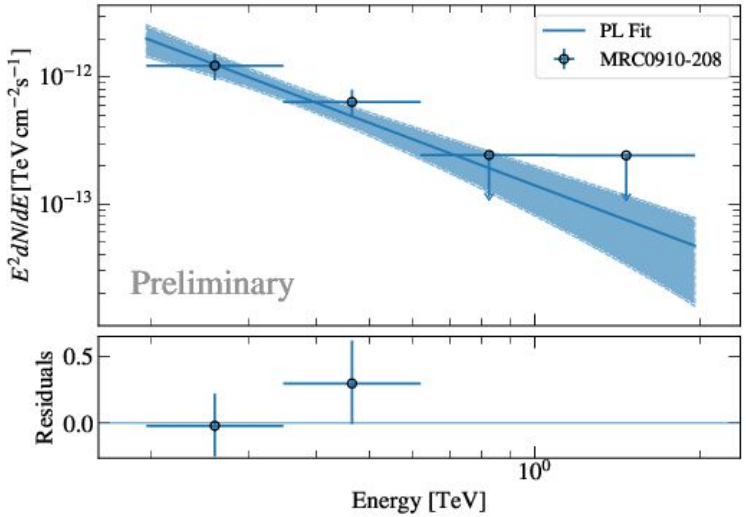
Source name	Redshift	RA [J2000]	Dec [J2000]
MRC 0910-208	0.19802	9h 13m 0.24s	-21d 3' 20.9"
1RXS J195815.6-301119	0.119	19h 58m 15.6s	-30d 11' 19.3'

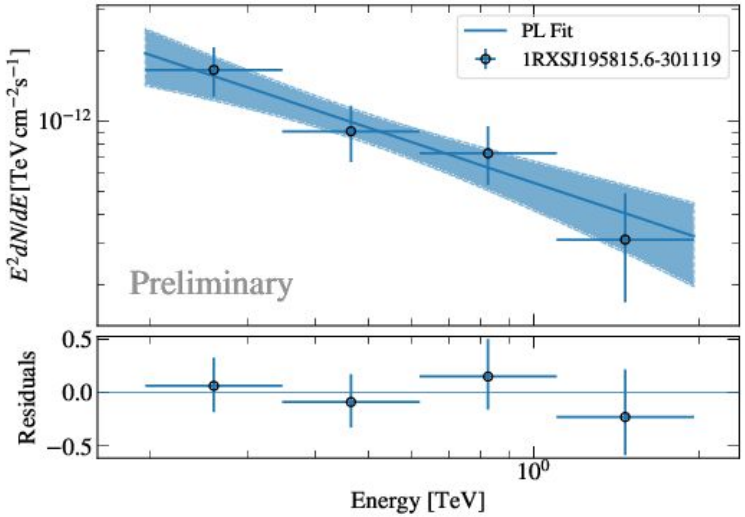
Very-high energy gamma-ray detection with H.E.S.S.

- Both sources observed during observation campaign in 2018
- Observations carried out in wobble mode, with the ON region offset 0.5º from the camera centre
- Events detected with at least three of the small-sized telescopes are considered
- Event energies reconstructed with `ImPACT` method and standard selection cuts.

Source name	Live time	Significance	Avg. Zenith angle
MRC 0910-208	17.2	7.0 σ	24º
1RXS J195815.6-301119	7.3	8.8 σ	17º

H.E.S.S. spectra





Spectra well described with simple **power law**

$$\frac{dN}{dE} = N\left(\frac{E}{E_0}\right)^{-\Gamma}$$

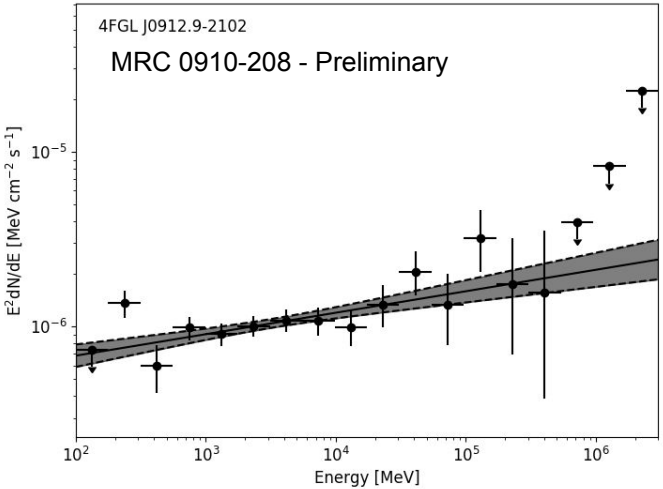
	MRC 0910-208	1RXS J195815.6-301119
Γ	3.63 ± 0.38	2.78 ± 0.26
Γ (including EBL absorption, model of Dominguez et al. 2011)	2.35 ± 0.42	2.00 ± 0.27

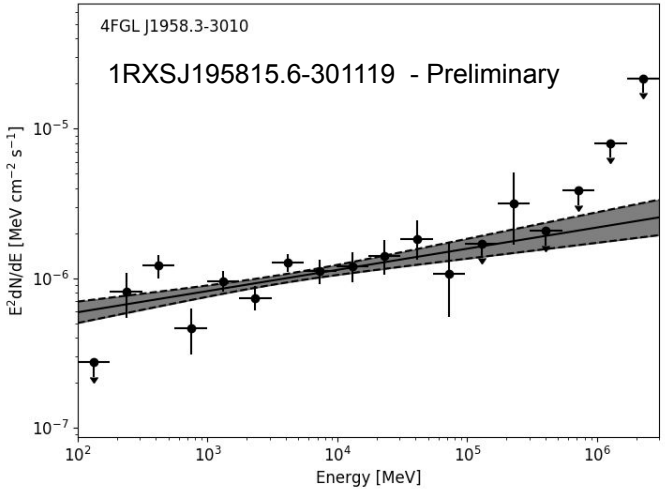
Fermi-LAT Analysis

Data selection

Time range	11.5 years
Energy Range	100 MeV - 3 TeV
ROI size	10º x 10º
Max. Zenith angle	90º
Filter	DATA_QUAL>0 && LAT_CONFIG==1
Spatial binning	0.1º / pixel
Energy binning	8 bins per decade
Event Class / IRFs	P8R3_SOURCE_V3
Catalog	4FGL DR2

Spectral fitting of *Fermi*-LAT data





Spectra well described with simple **power law**

	MRC 0910-208	1RXS J195815.6-301119
Γ	1.87 ± 0.04	1.83 ± 0.05
Γ (including EBL absorption, model of Dominguez et al. 2011)	1.84 ± 0.05	1.82 ± 0.05

Swift-XRT Analysis

- Both the sources observed with *Swift* XRT
- Table on the right: fitting parameters for the XRT data.
- Tested spectral models: power law (PL) and log parabola (LP)
- Both models corrected for Galactic absorption and redshift
- Hydrogen column density fixed to the values of the LAB survey
- For both sources, slight preference for log parabola using difference in Cash statistics
- Log parabola model used to estimate peak energy

Power law vs **Log Parabola**

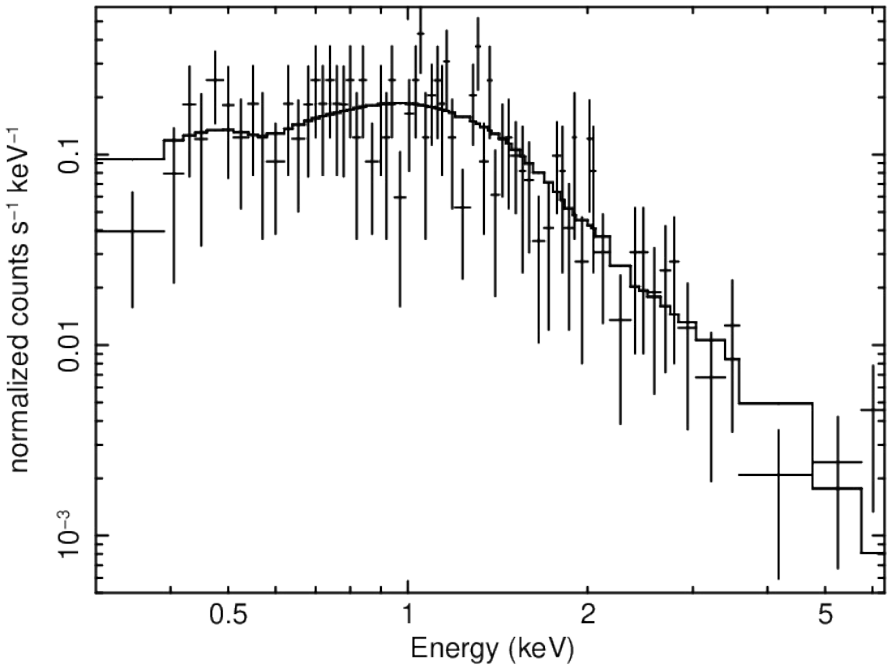
$$\frac{dN}{dE} = N\left(\frac{E}{E_0}\right)^{-\Gamma}$$

$$\frac{dN}{dE} = N\left(\frac{E}{E_0}\right)^{-\alpha-\beta\ln(E/E_0)}$$

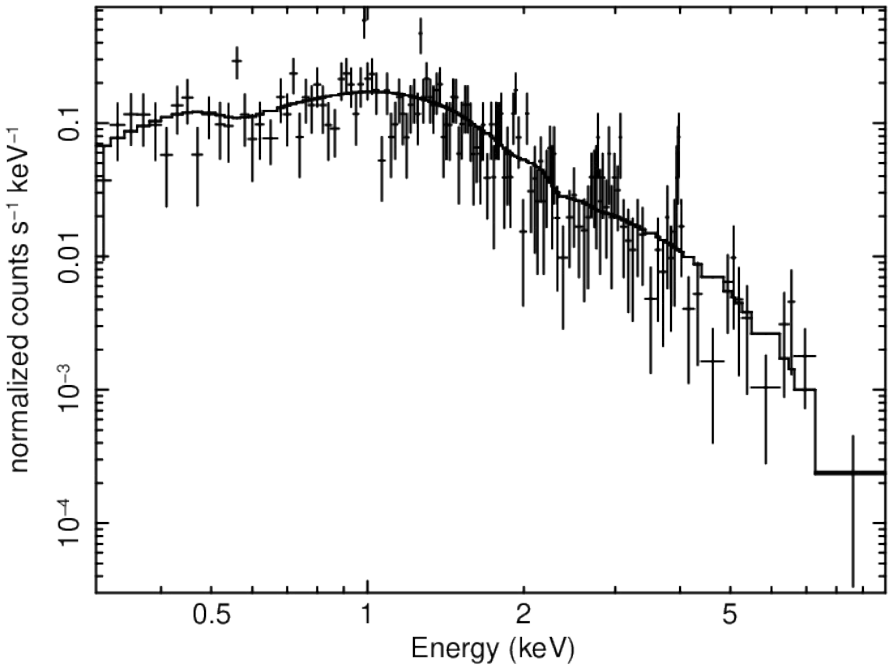
	MRC 0910-208	1RXSJ195815.6-301119
T (ks)	6.4	11.6
N_{PL} (10^3 keV^{-1} cm^{-2} s^{-1})	2.55 ± 0.19	2.59 ± 0.11
Γ	2.26 ± 0.134	1.96 ± 0.063
Cash statistic PL	106.53	326.89
N_{LP} (10^3 keV^{-1} cm^{-2} s^{-1})	2.90 ± 0.25	2.76 ± 0.13
α	2.07 ± 0.16	1.79 ± 0.086
β	0.97 ± 0.39	0.53 ± 0.18
Cash Statistic LP	100.15	318.01
E_{peak}(keV)	2.91 ± 1.55	5.41 ± 1.78

Swift-XRT Spectra

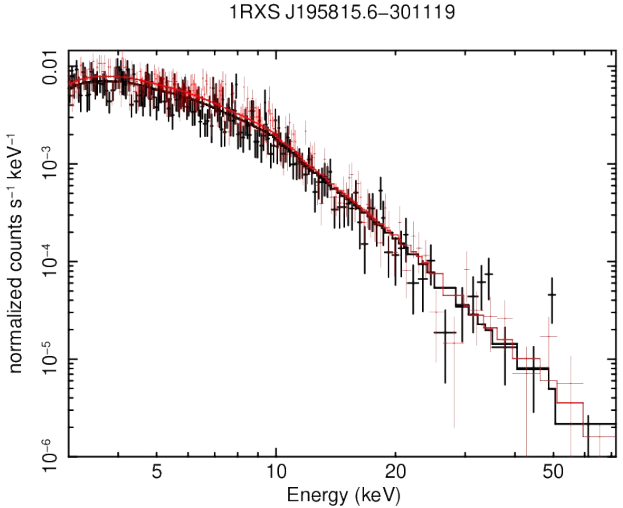
MRC 0910−208



1RXS J195815.6−301119



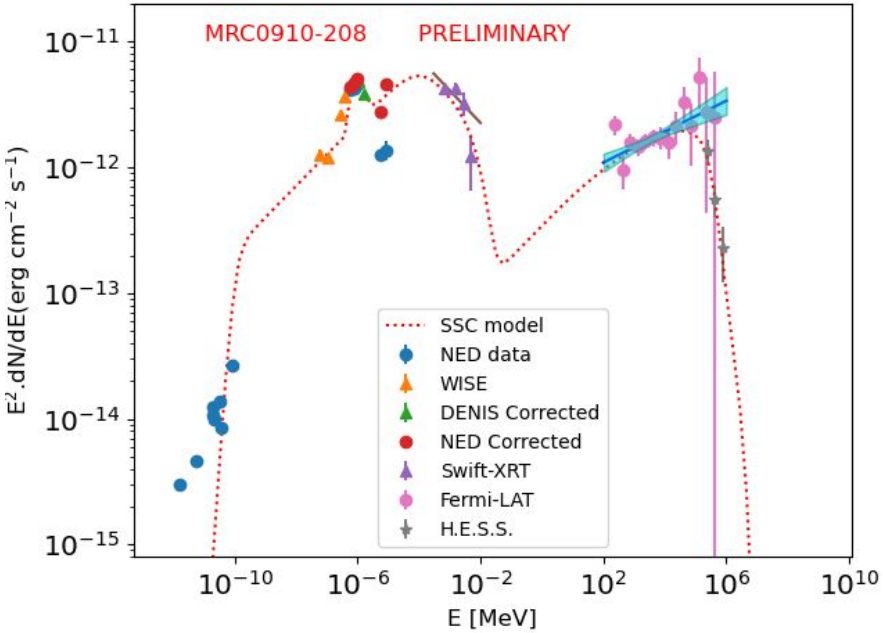
NuSTAR Analysis

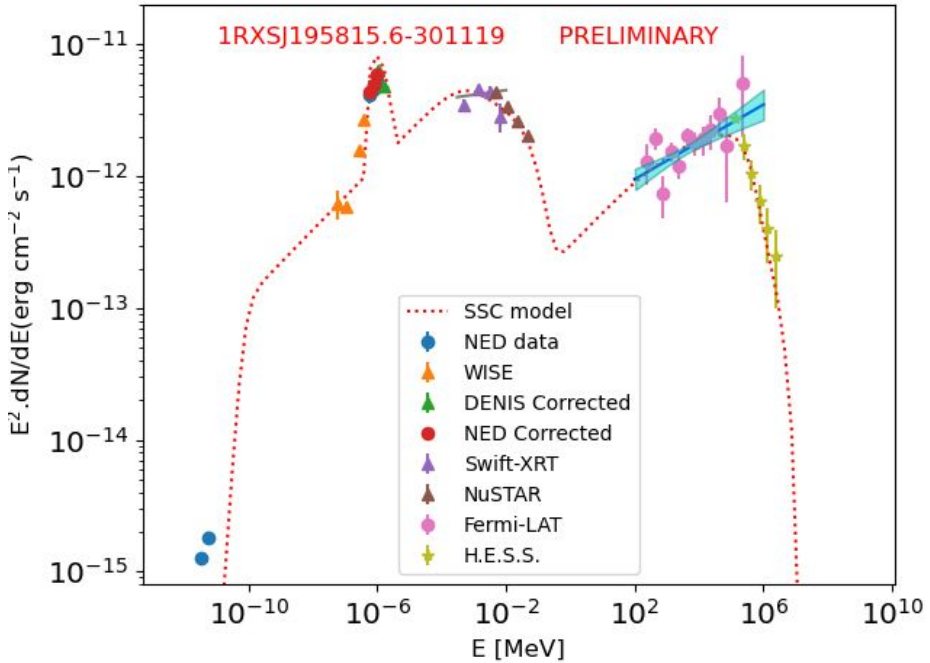


	1RXS J195815.6-301119
T (ks)	52.8
N_{PL} (10^3 keV^{-1} cm^{-2} s^{-1})	4.82±0.30
Γ	2.35±0.03
C_{PL}	756.82
dof_{PL}	818

- 1RXS J195815.6-301119 also observed with NuSTAR satellite
- The spectra from NuSTAR has been fitted with power law corrected for Galactic absorption (fixed to the value in LAB survey) and redshift

Spectral Energy Distribution (SED)





- SEDs fitted with simple one-zone SSC model + giant elliptical galaxy template for host galaxy emission
- Archival data extracted from NED for WISE, GALEX, and DENIS surveys
- SSC model describes data well

Summary & Conclusions

- MRC 0910-208 and 1RXS J195815.6-301119 have been detected as VHE sources
- The synchrotron peak energy was found above 1 keV, i.e. above 2.4×10^{17} Hz → Confirms the EHBL nature of the sources.
- Both sources exhibit hard intrinsic γ-ray spectra which is well described by photon index of around 2
- Hard spectra are also measured with *Fermi*-LAT with a photon index of less than 2.
- The current datasets are well described by a simple SSC model.
- Further data taking might be required to probe the emission at energies beyond 1 TeV for these sources
- Future plan:
  - Model emission with hadronic interactions
  - Include CT5 telescope in analysis to lower energy threshold
  - In particular 1RXS J195815.6-301119 appears well suited to be included in studies on EBL absorption and search for gamma-ray initiated cascade emission

H.E.S.S. spectra - best-fit parameters

	MRC 0910-208	1RXS J195815.6-301119
N (10^{-12}cm^{-2} s^{-1} TeV^{-1})	5.69 ± 0.97	4.38 ± 0.64
E_0 (TeV)	0.36	0.47
Γ	3.63 ± 0.38 ± 0.38	2.78 ± 0.26 ± 0.14
N (10^{-12}cm^{-2} s^{-1} TeV^{-1}) (including EBL absorption)	12.6 ± 2.2	8.34 ± 1.22
Γ (including EBL absorption)	2.35 ± 0.42 ± 0.38	2.00 ± 0.27 ± 0.14

SED parameters

	MRC 0910-208	1RXSJ195815.6-301119
α_1	2.5	2.5
α_2	3.5	3.3
$\log_{10}(\gamma_b)$	5.2	5.6
$\log_{10}(\gamma_{max})$	6.1	6.7
$\log_{10}(1055)$	3.06	7.71
B(G)	0.01	0.01
$\log_{10}$(R/cm)	17.0	17.13
Γ_L	30	20