LHAASO-WCDA deep Observations around 4278 Region

A joint analysis of NGC 4278, 1ES 1218+304 and 1ES 1215+303

B. R. Liu[1], H. C. Li[1], D. X. Xiao[1], S. C. Hu[1] and M. Zha[1]

[1]Institute of High Energy Physics, Chinese Academy of Sciences

Temporal observations of a low-luminosity AGN and two neighbouring BL Lac objects.

Joint time-averaged spectra and 32-day light curves around the NGC 4278 region.

01 Motivation and analysis sample

A low-luminosity AGN and two neighbouring blazars

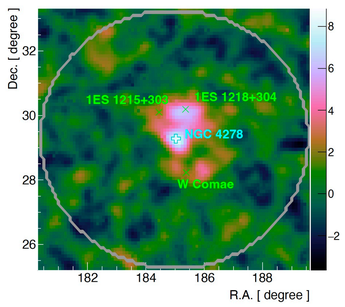
LHAASO identified TeV emission associated with NGC 4278 and reported an active period in 2021–2022 [1]. The nearby BL Lac objects 1ES 1218+304 and 1ES 1215+303 share the field. Their overlapping angular responses motivate a joint spatial and spectral analysis.

Time-averaged analysis

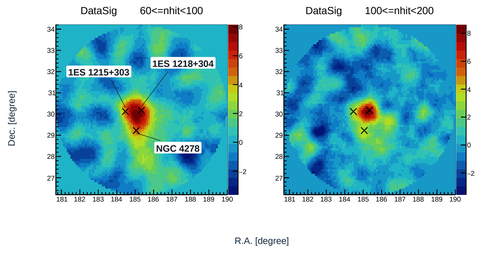
- Data period: **8 March 2021–31 July 2025**; zenith angle $\theta_z \leq 50°$.
- **Seven** $N_{\rm hit}$ bins, with edges $30, 60, 100, 200, 300, 500, 800, 2000$. $N_{\rm hit}$ is an energy proxy.
- Three point sources at fixed positions; spectral normalizations and indices fitted simultaneously with the WCDA data and response.

All three sources use an intrinsic PL with Saldaña-López EBL attenuation [2]. For NGC 4278 we adopt $D_L = 16.4$ Mpc and a linear low-redshift extension anchored at $\tau(E, 0) = 0$.

02 Region maps and source geometry



Source	Separation from 1ES 1218+304	Role
1ES 1218+304	$0°$	Target
1ES 1215+303	$\sim 0.75°$	blazar
NGC 4278	$\sim 0.99°$	LLAGN



Region context: smoothed *data-significance* maps from the earlier analysis of the same event sample. Crosses mark the fixed source positions; these are distinct from likelihood TS maps.

03 Mean source results

The observed spectra are fitted with EBL-attenuated power-law models, while the intrinsic spectra are power-law models:

$$\frac{\mathrm{d}N}{\mathrm{d}E} = F_0 \left(\frac{E}{E_{\rm piv}}\right)^{-\alpha} e^{-\tau(E)}$$

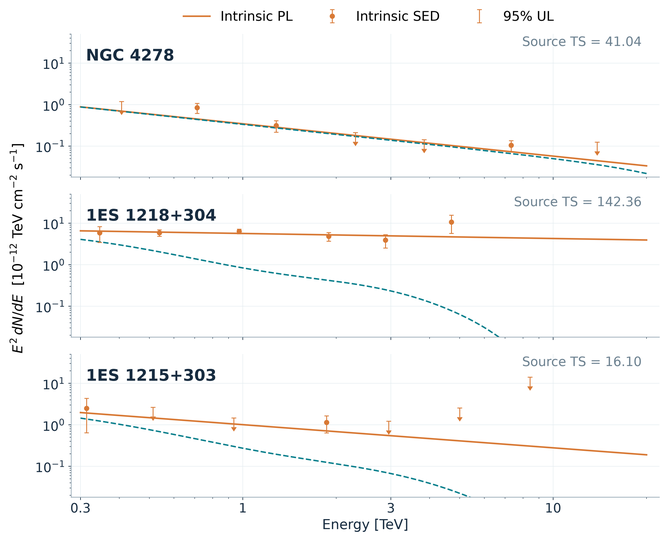
Source	Source TS	$\Gamma_{\rm int}$	$E_{\rm piv}$ [TeV]	F_0
NGC 4278	41.04	2.78 ± 0.21	3	0.0163 ± 0.0028
1ES 1218+304	142.36	2.12 ± 0.13	1	5.66 ± 0.51
1ES 1215+303	16.10	2.56 ± 0.37	1	1.01 ± 0.29

All indices and normalizations are intrinsic, conditional on the adopted EBL model. F_0 in $10^{-12}\,\mathrm{TeV^{-1}cm^{-2}s^{-1}}$ at each pivot. Errors are statistical; source TS values are from the updated joint fit.

Relative constraints: 1ES 1218+304 is strongly detected in the mean analysis; NGC 4278 contributes independently. The 1ES 1215+303 component is weaker and its spectral constraints are less precise.

04 Time-averaged spectra

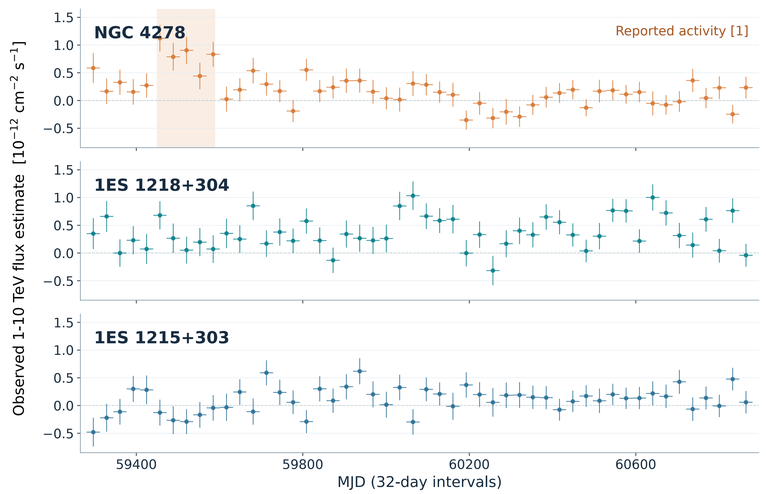
Intrinsic SEDs and best-fit models for all three sources



Orange solid: intrinsic PL; teal dashed: attenuated model. Points: intrinsic SED with statistical errors; arrows: nominal 95% upper limits (TS < 4). Intrinsic points depend on the adopted EBL correction. BL Lac redshifts: 0.182 and 0.1305. For NGC 4278, $D_L = 16.4$ Mpc corresponds to model $z_{\rm eff} = 0.003818$, not a measured redshift.

05 Long-term light curves

Three sources from the same 32-day joint fits



Fifty joint fits with $60 \leq N_{\rm hit} < 2000$; all three normalizations are free, with intrinsic indices and EBL fixed to the mean solution. Fluxes are model-dependent 1–10 TeV integrals at Earth. Points are signed estimates, including negative statistical fluctuations; bars are local 1σ Hessian errors. Shading: reported NGC 4278 activity [1]. No upper limits or calibrated variability significance are shown.

LC coverage: MJD 59280.67–60880.67 (ends 25 July 2025, Beijing time). Mean spectra additionally include $30 \leq N_{\rm hit} < 60$ and extend to 31 July.

06 Conclusions and next step

Current results

- Joint modelling yields mean spectra for the NGC 4278 region; the 1ES 1215+303 component remains the least constrained.
- With distance-based EBL attenuation, NGC 4278 has $\Gamma_{\rm int} = 2.78 \pm 0.21$ and source TS = 41.04 in the mean analysis.
- 1ES 1218+304 is strongly detected in the mean analysis and has $\Gamma_{\rm int} = 2.12 \pm 0.13$ under the adopted EBL model.
- The 32-day light curves trace all three sources; NGC 4278 has higher fitted fluxes around its previously reported active period.

Next step

- Further Refinement of the Light Curve;
- Simultaneously multi-wavelength data collection;
- SED modelling.

References [1] LHAASO Collaboration (2024), *Discovery of VHE Gamma-ray Emissions from NGC 4278*, arXiv:2405.07691.
[2] Saldaña-López et al. (2021), MNRAS 507, 5144; arXiv:2012.03035.

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