Highlights from the MAGIC paper "Multi-wavelength characterization of the blazar S5~0716+714 during an unprecedented outburst phase"

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Major Atmospheric Gamma-Ray Imaging Cherenkov Telescopes
MAGIC

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Introduction

- The BL Lac object S5 0716+714, a highly variable blazar, underwent an impressive outburst in January 2015 (Phase A), followed by minor activity in February (Phase B).
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- The MAGIC observations were triggered by the optical flux observed in Phase A, corresponding to the brightest ever reported state of the source in the R-band.In the present work, we report the results of a MWL campaign organised to follow an unprecedented outburst phase of the blazar S5 0716+714 during January 2015.
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- The source was detected at its historic highest brightness at optical and IR bands. On January 11, 2015 the NIR photometry reported an increase of its flux by a factor of 2.5 in the NIR band in a rather short lapse of 12 days (Atel #6902 and #6962). During the night of 18 January 2015 (MJD 57040), the source was detected at its historic high brightness, with R band magnitude~11.71 (Atel #6975).
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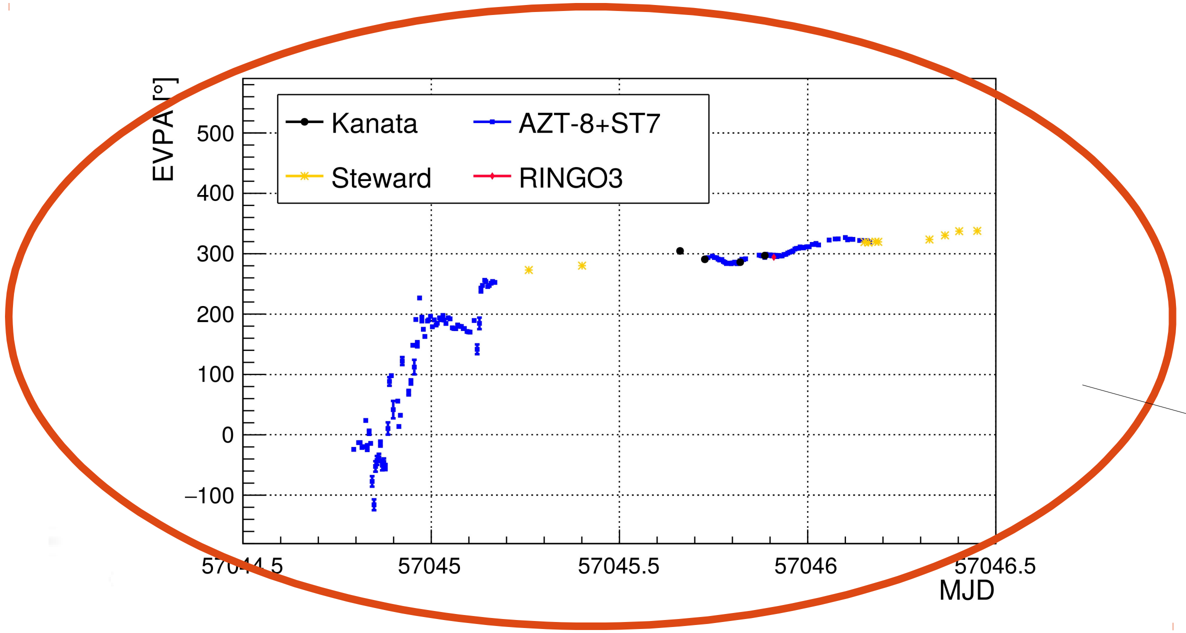
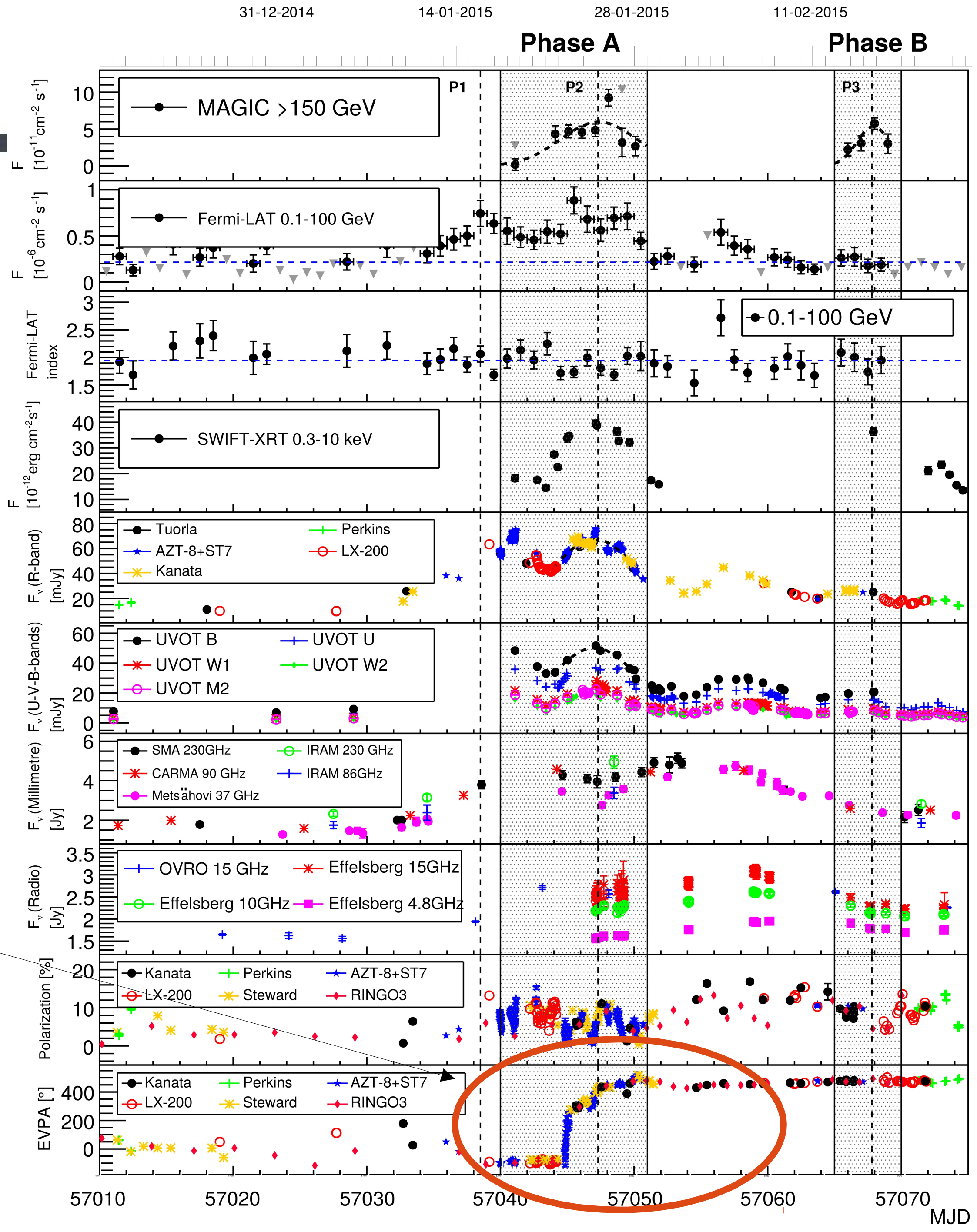
- The TeV observations triggered to follow the exceptionally high optical state detected the source at energies above 150 GeV (Atel #6999) and went on until the flaring activity faded away.

MWL lightcurves

Multi-wavelength flux and index curves of S5 0716+714. The shadowed areas indicate Phase A and Phase B high states in the VHE range and the corresponding activity in the other bands. P1, P2 and P3 (vertical dashed lines) indicate peaks in the HE and VHE emission.



The very fast EVPA rotation



MWL lightcurves in a wider time-range

Since radio activity showed a different behavior respect to other bands, we studied possible delays and responses in a wider time-range. The delay in the radio emission from the optical/gamma ones is supporting a scenario in which the gamma-ray emission is produced upstream of the core while the radio one has its origin in a shock in the jet, first appearing and evolving in the innermost, ultracompact VLBI core region and subsequently moving downstream the jet at parsec scales with apparent superluminal speeds. (See VLBI section of the paper).

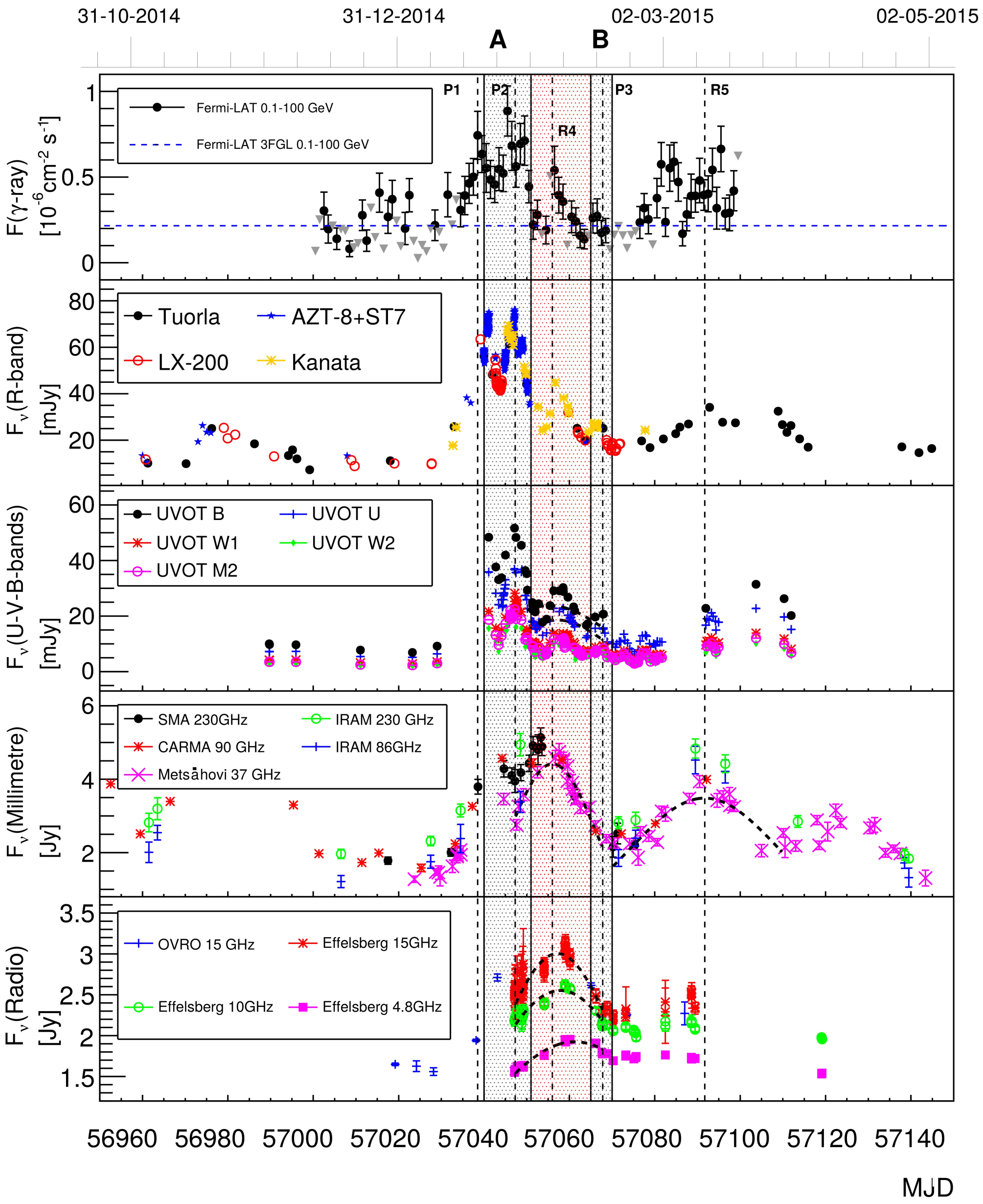
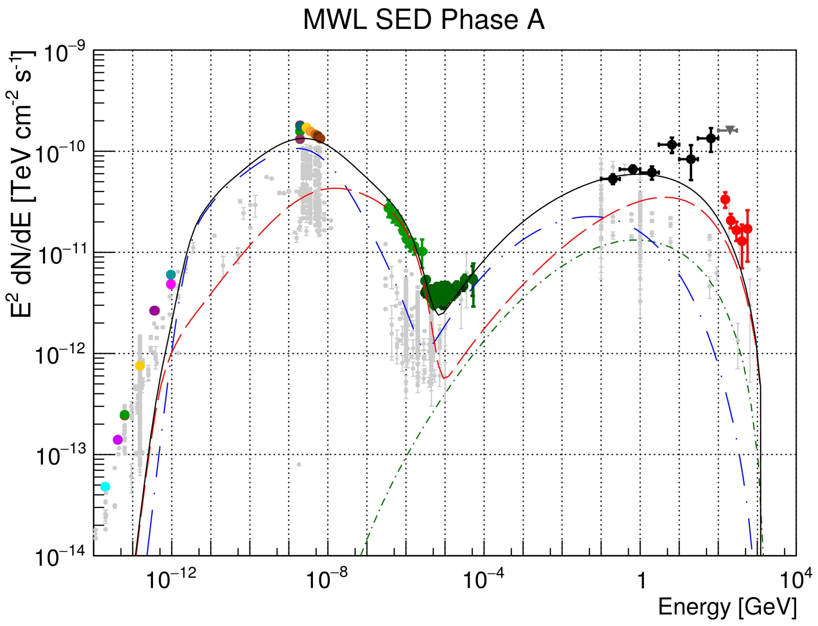


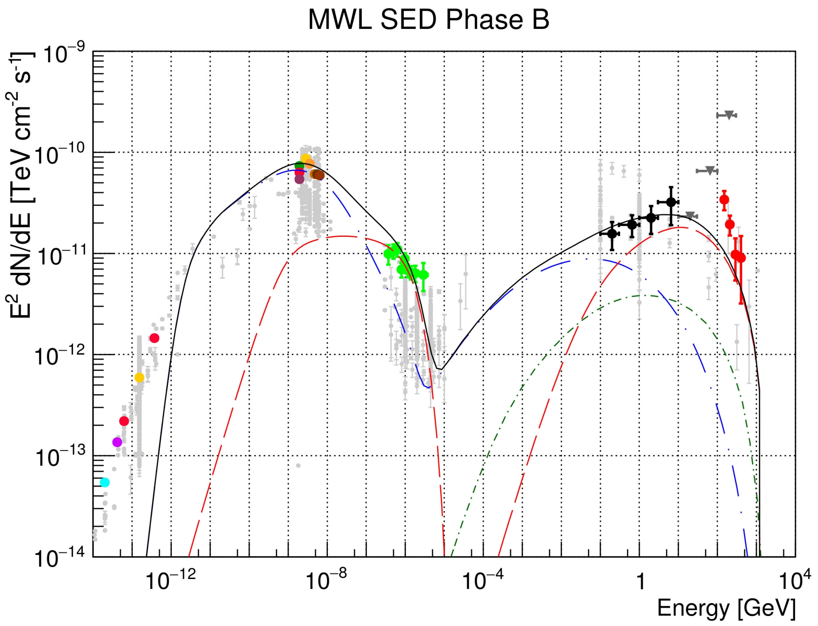
Table 1: Summary of important dates

MJD	Calendar date	Description
57038.5	16 January 2015	P1: first peak of the HE emission → trigger VHE observations
57040	18 January 2015	start of Phase A
57044/45	22/23 January 2015	1day EVPA rotation of ~360°
57047.3 ± 0.53	25 January 2015	P2: Gaussian fit peak of the VHE emission in PHASE A
57050	28 January 2015	end of Phase A
57050 ± 3	28 January 2015	K14b passage through A1
57056	03 February 2015	R4: Gaussian fit peak of radio emission in the intermediate phase
57065	12 February 2015	start of Phase B
57067.8 ± 0.23	14 February 2015	P3: Gaussian fit peak of the VHE emission in Phase B
57070	16 February 2015	end of Phase B
57092	11 March 2015	R5: Gaussian fit peak of radio emission

MWL SEDs

MWL Spectral Energy distributions for Phase A and Phase B. Archival data form ASDC are shown in grey. The two components (blobs representing a moving emission feature and a recollimation shock, see text) are shown with blue and red dashed lines.
The green line is the emission that is a result of interaction between these two blobs and the black solid line the sum of these three components. The red full circles represent the intrinsic (EBL deabsorbed according to (Domınguez et al., 2011)) MAGIC SED used in the model. For data taken in the radio and optical band the error bars are smaller than the size of the marker.





Conclusions

- The broadband flaring activity period of Phase A coincides with the passage of a moving feature through a stationary feature. We have found a very fast change in the electric vector position angle during Phase A. The > 400 degree swing in the optical EVPA is explained here as the passage of a superluminal knot through a stationary feature near the radio core.

- The VHE emission is then found originating in the entrance and exit of a superluminal knot in and out a recollimation shock in the inner jet. This suggests that shock-shock interaction in the jet seems to be responsible for the observed flares and EVPA swing.

- The jet behaviour, studied with VLBA-BU-BLAZAR data, is in agreement with the scenario described in Rani et al. (2015), suggesting a connection between jet kinematics and the observed broadband flaring activity. More precisely, the gamma-ray emission in the HE and VHE bands is attributed to a shock in the helical jet downstream of the core, closely followed by an optical and X-ray outburst in the core. The presence of low radio activity, observed during Phase A, was not reported in April 2008, when MAGIC observed the source in the VHE range for the first time (Anderhub et al., 2009), but it could be a delayed response of a previous less intense flare, as observed in the past in the same source, when between optical/gamma flares lagged the radio counterparts almost two months (Rani et al., 2013, 2014).

- The first peak in the VHE gamma-ray emission takes place ~2 days after the very fast EVPA rotation and the second~18 days after the new knot has been emerged from the VLBA core. This is a strong indication that the VHE gamma-ray emission is associated to a component entering and exiting the core region.

- The broadband SEDs, for the first time including MAGIC and Fermi-LAT simultaneous data and the quasi-simultaneous NuStar data, could not be described by a simple one-zone model. Instead we used a two-zone model, where two spherical blobs are co-spatial and provide seed photons to each other. This modelling setup provides an acceptable description of the spectral energy distributions in Phase A and B, even if it is certainly an over-simplified presentation of the true physical processes taking in place when superluminal knots enter and exit the recollimation shock region.

The paper is on A&A 619, A45 (2018) and also on ArXiv: https://arxiv.org/pdf/1807.00413.pdf
ADS link: http://adsabs.harvard.edu/abs/2018A%26A...619A..45M