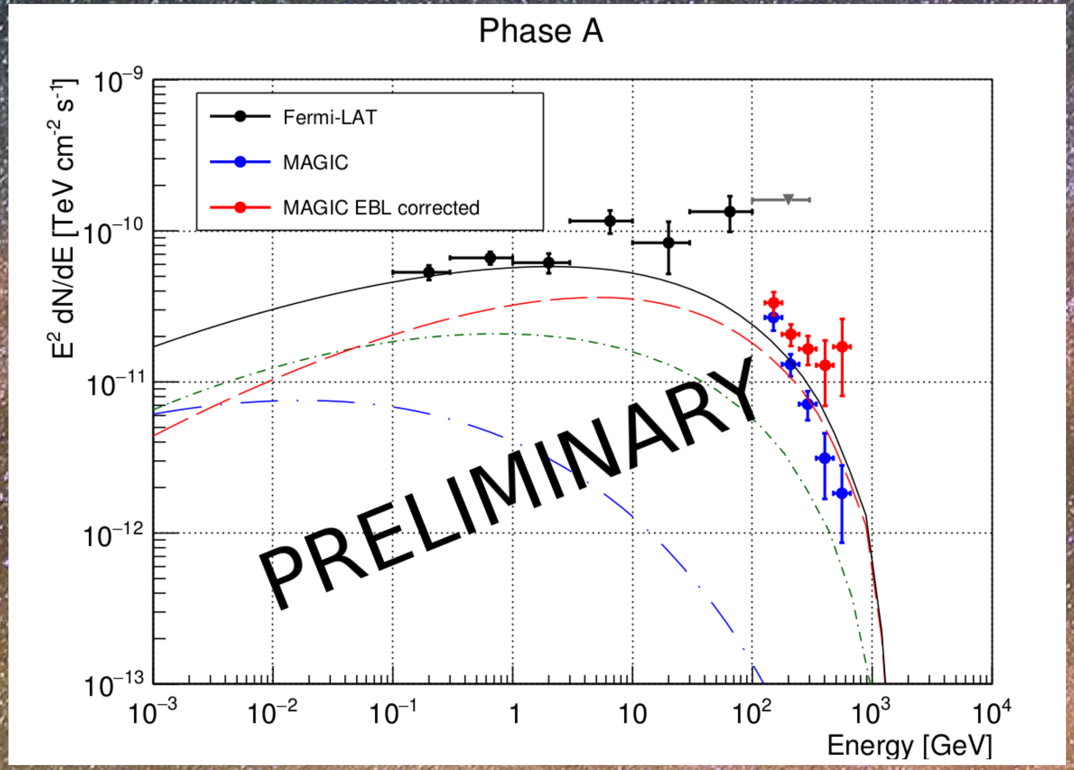
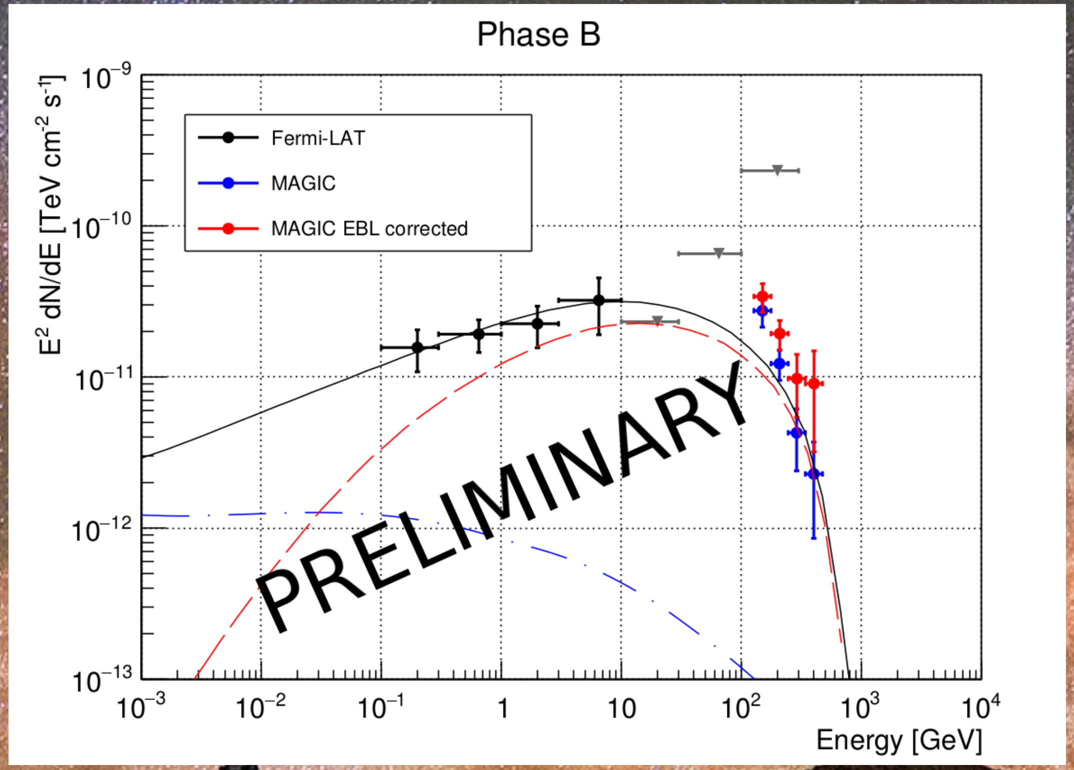
Probing high-energy acceleration processes in S5 0716+714 using combined *Fermi*-LAT and MAGIC observations

M. Manganaro, B. Rani *, G. Pedaletti, E. Lindfors for the Fermi-LAT and MAGIC Collaborations

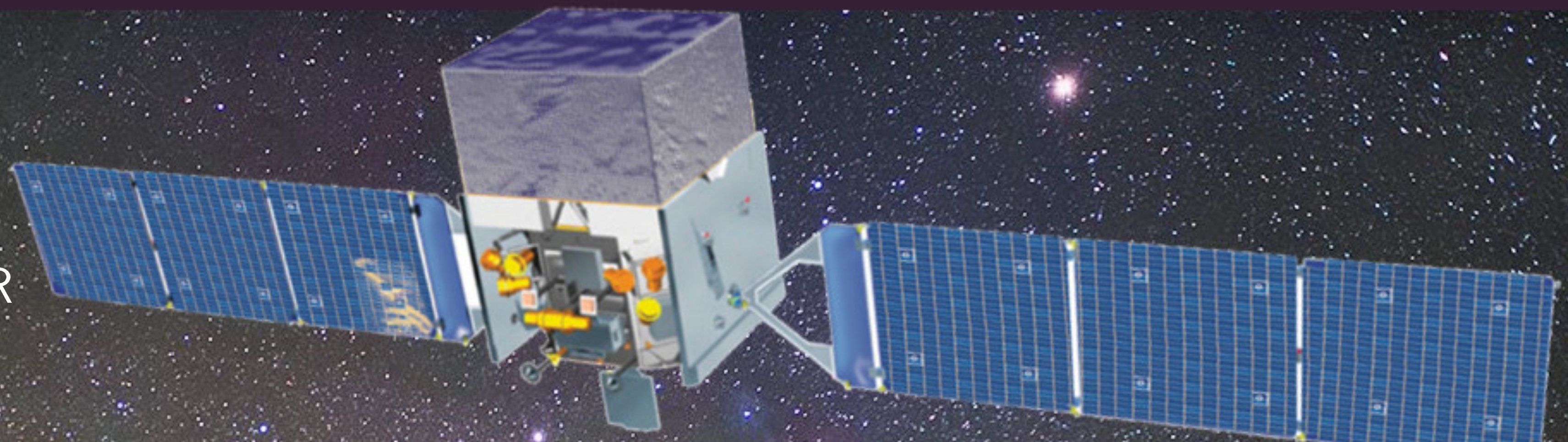




The BL Lac object S5 0716+714 underwent an impressive outburst in January/February 2015, being detected by many instruments spanning from radio to very high energy gamma-rays (VHE, $E > 100$ GeV). For the first time for this source, the high energy (HE, $0.1\ \text{GeV} < E < 100\ \text{GeV}$) and VHE gamma-ray data have been collected simultaneously, from Fermi-LAT and MAGIC respectively, allowing the possibility to study the whole high energy part of the broadband SED in an unprecedented high state. In the pictures, the combined spectrum of Fermi-LAT (black full circles) and MAGIC (red full circles) observations of S5 0716+714 in the two Phases A(from 18 to 27 January 2015 MJD 57040 to MJD 57050) and Phase B (from 13 to 17 February 2015 MJD 57066 to MJD 57070). The preliminary two-zone modeling is shown by the black line (sum of the components).

* NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

Introduction



The preliminary results here presented have been obtained during a multi-wavelength campaign organised to follow an unprecedented outburst phase of the blazar S5 0716+714 during January 2015. The source was detected at its historic high brightness at optical and IR bands. On January 11, 2015, (MJD 57033) 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 (Carrasco et al., 2015; Chandra et al., 2015b). During the night of 18 January 2015 (MJD 57040), the source was detected at its historic high brightness, R band magnitude ~ 11.71 (Bachev et al., 2015). The TeV observations triggered to follow the exceptionally high optical state, detected the source >150 GeV (Mirzoyan et al., 2015) and went on until the flaring activity faded away.

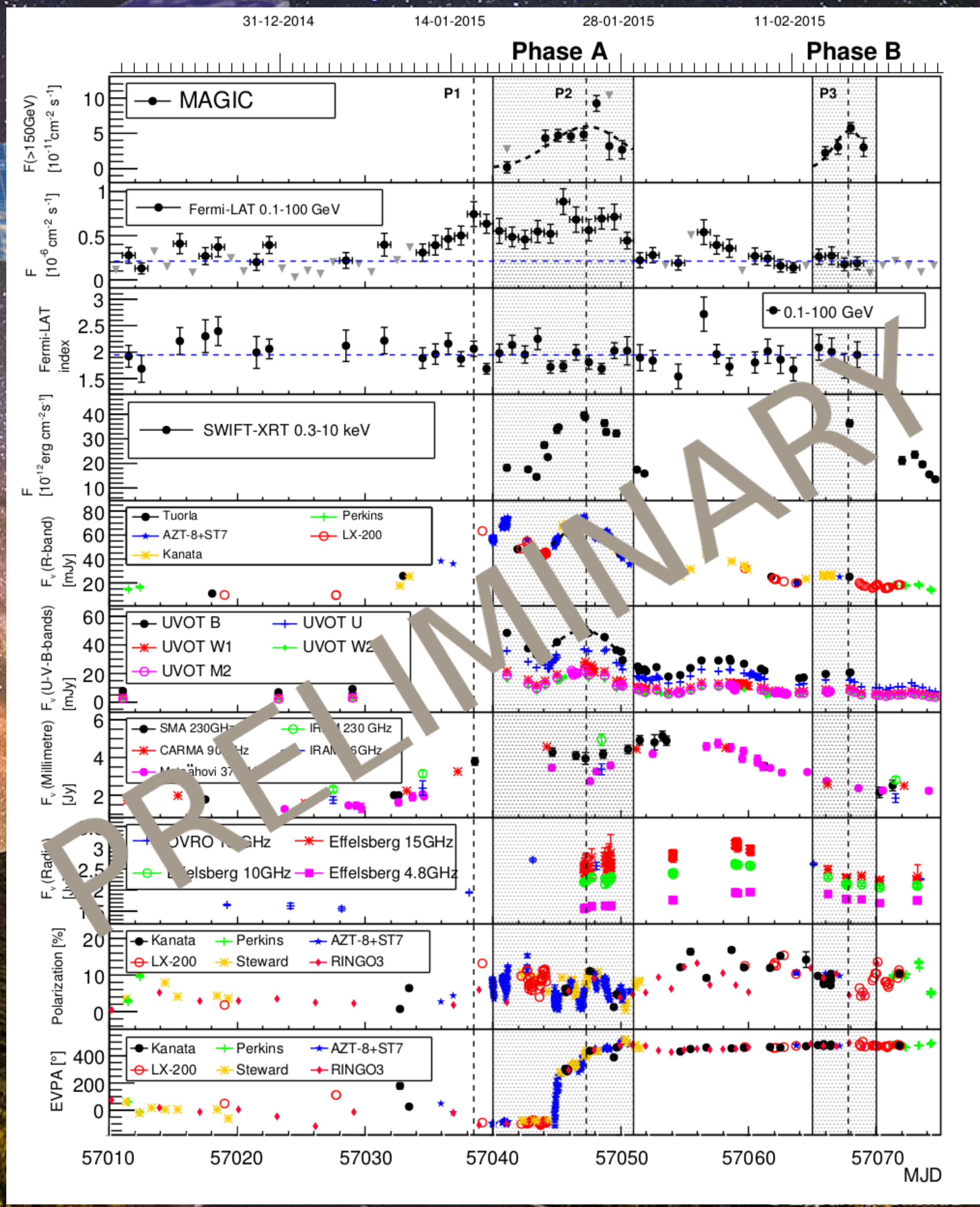
S5 0716+714 was first detected in the VHE range by MAGIC with 5.8σ significance level in November 2007 and in April 2008 (Anderhub et al., 2009) during an optical flare. At that time MAGIC was working with a single telescope and the energy threshold of the telescope for such and high zenith range ($47^\circ < zd < 55^\circ$) was 400 GeV. The analysis of multi-wavelength data suggested a correlation between the VHE γ-ray and optical emission. A structured jet model, considering the jet composed by a fast spine surrounded by a slower moving layer (Ghisellini et al., 2005; Tavecchio & Ghisellini, 2009) was better describing the data **in respect to** a simple one zone SSC model. This source is also among the bright blazars in the *Fermi*/LAT (Large Area Telescope) Bright AGN Sample (LBAS) (Abdo et al., 2010) and in the Fermi third catalog (Acero et al., 2015) among the ones with the highest indexes of variability. The combined GeV – TeV spectrum of the source displays intrinsic absorption-like features in 10 – 100 GeV energy range (Senturk et al., 2013).

Multi-wavelength context

The multiwavelength dataset collected made possible a deep study of the broadband Spectral Energy Distribution (SED), which in blazars is described by two components. The low-energy component, in case of S5 0716+714 peaked between 10^{14} -10^{15} Hz, is generated by synchrotron emission from relativistic electrons in the jet, while the high-energy one is in general attributed to inverse-Compton (IC) up-scattering of soft synchrotron photons off the same electrons that have undergone synchrotron cooling. The light curves are presented in the picture and the most important dates are reported in the table below.

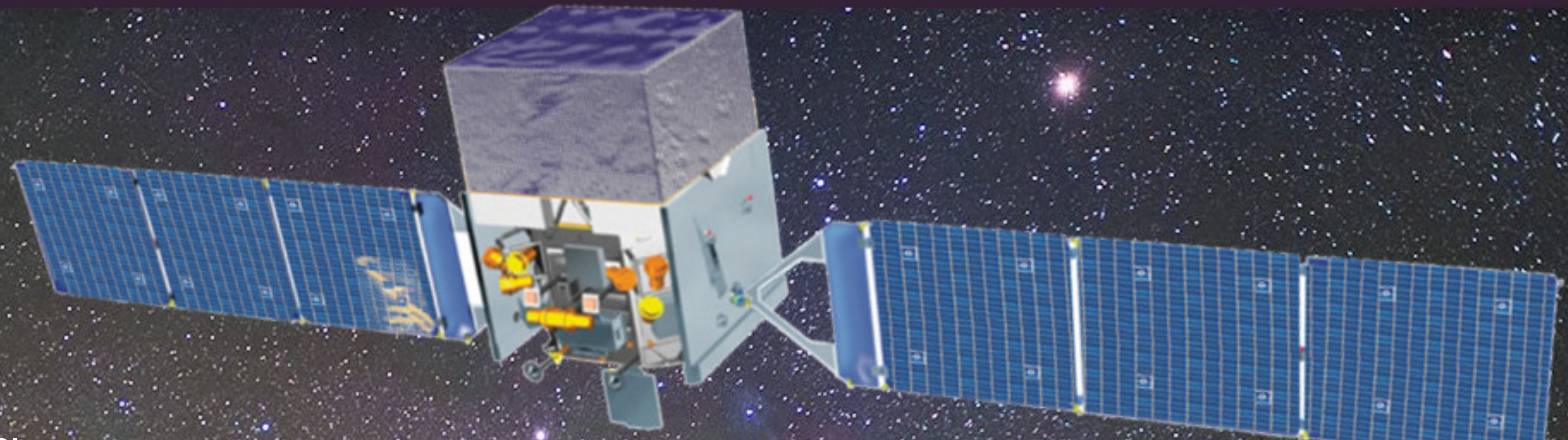
Table: Summary of important dates

MJD	Calendar date	Description
57040	18 January 2015	start of PHASE A
57038.5	16 January 2015	P1: first peak of the HE emission → trigger VHE obervations
57044/45	22/23 January 2015	1 day EVPA rotation of ∼360°
57047.3 ± 0.53	25 January 2015	P2: gaussian fitted 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	P3: gaussian fitted peak of radio emission in the intermediate phase
57066	13 February 2015	start of PHASE B
57067.8 ± 0.23	14 February 2015	P4: gaussian fitted peak of the VHE emission in PHASE B
57070	16 February 2015	end of PHASE B



Conclusions and references

The BL Lac object S5 0716+714 has been studied in a multi-wavelength frame for the first time from radio to VHE γ-ray band. In January 2015 an unprecedented outburst of S5 0716+714 was registered in all the energy bands, from low radio to the VHE. The broadband SEDs, for the first time including MAGIC and *Fermi*-LAT simultaneous data, could not be described by a simple one-zone SSC model: instead a two-zone modelling following the model presented for flat-spectrum radio quasar PKS 1222+216 in Tavecchio et al. (2011) and modified for the case of no external seed photons as in Aleksić et al. (2014) for PKS 1424+240 has been found optimal in describing the data. The two emission regions are considered to be co-spatial and an interaction between them is also taken into account.



References:

Abdo, A. A., Ackermann, M., Ajello, M., et al. 2010, ApJ,710,1271

Acero, F., Ackermann, M., Ajello, M. et al. 2015, ApJS,218,23

Ahnen M. L., Ansoldi S., Antonelli L. A., et al. 2017, in preparation

Aleksić, J., Ansoldi, S., Antonelli, L. A., et al. 2014, A&A,567,A135

Anderhub, H., Antonelli, L. A., Antoranz, P., et al. 2009, ApJL,704,L129

Bachev, R., et al. 2015, ATel 6957

Carrasco, L., et al. 2005, ATel 6902

Chandra, S., et al. 2015b, ATel 6962

Ghisellini, G., Tavecchio F., & Chiaberge, M., et al. 2005, A&A,432,401

Mirzoyan, R., et al. 2015, ATel 6999

Rani, B., Krichbaum, T. P., Marscher, A. P., et al. 2014, A&A,571,L2

Rani, B., Krichbaum, T. P., Marscher, A. P., et al. 2015, A&A,578,A123

Senturk, G. D., Errando, M., Boettcher, M., et al. 2013, ApJ, 764, 119

Tavecchio, F., & Ghisellini, G., 2009, MNRAS, 394, 13

Tavecchio, F., Becerra-Gonzalez, J., Ghisellini, G., et al. 2011, A&A, 534, A86