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Authors	Aleksic, J., Ansoldi, S., ANTONELLI, Lucio Angelo, Antoranz, P., Babic, A., Bangale, P., de Almeida, U. Barres, Barrio, J. A., Gonzalez, J. Becerra, Bednarek, W., Bernardini, E., Paiano, S., Palatiello, M., Paneque, D., Paoletti, R., Paredes, J. M., Paredes-Fortuny, X., Persic, M., Prada Moroni, P. G., PRANDINI, ELISA, Puljak, I., Biasuzzi, B., Reinthal, R., Rhode, W., Ribo, M., Rico, J., Rodriguez Garcia, J., Rugamer, S., Saito, T., Saito, K., Satalecka, K., Scalzotto, V., Biland, A., Scapin, V., Schultz, C., Schweizer, T., Sun, S., Shore, S. N., Sillanpaa, A., Sitarek, J., Snidaric, I., Sobczynska, D., Spanier, F., Blanch, O., Stamatescu, V., STAMERRA, Antonio, Steinbring, T., Steinke, B., Storz, J., Strzys, M., Takalo, L., Takami, H., TAVECCHIO, Fabrizio, Temnikov, P., Boller, A., Terzic, T., Tescaro, D., Teshima, M., Thaele, J., Tibolla, O., Torres, D. F., Toyama, T., Treves, A., Uellenbeck, M., Vogler, P., Bonnefoy, S., Zanin, R., MAGIC Collaboration, Archambault, S., Archer, A., Beilicke, M., Benbow, W., Berger, K., Bird, R., Biteau, J., Buckley, J. H., Bonnoli, G., Bugaev, V., Cerruti, M., Chen, X., Ciupik, L., Collins-Hughes, E., Cui, W., Eisch, J. D., Falcone, A., Feng, Q., Finley, J. P., Borracci, F., Fortin, P., Fortson, L., Furniss, A., Galante, N., Gillanders, G. H., Griffin, S., Gyuk, G., Hakansson, N., Holder, J., Johnson, C. A., Bretz, T., Kaaret, P., Kar, P., Kertzman, M., Kieda, D., Lang, M. J., McArthur, S., McCann, A., Meagher, K., Millis, J., Moriarty, P., Carmona, E., Ong, R. A., Otte, A. N., Perkins, J. S., Pichel, A., Pohl, M., Popkow, A., Prokoph, H., Pueschel, E., Ragan, K., Reyes, L. C., Carosi, A., Reynolds, P. T., Richards, G. T., Roache, E., Rovero, A. C., Sembroski, G. H., Shahinyan, K., Staszak, D., Telezhinsky, I., Tucci, J. V., Tyler, J., Colin, P., Varlotta, A., Wakely, S. P., Welsing, R., Wilhelm, A., Williams, D. A., Colombo, E., Contreras, J. L., Cortina, J., COVINO, Stefano, da Vela, P., DAZZI, Francesco, de Angelis, A., de Caneva, G., de Lotto, B., de Ona Wilhelmi, E., Delgado Mendez, C., Dominis Prester, D., Dorner, D., Doro, M., Einecke, S., Eisenacher, D., Elsaesser, D., Fonseca, M. V., Font, L., Frantzen, K., Fruck, C., Galindo, D., Garcia Lopez, R. J., Garczarczyk, M., Garrido Terrats, D., Gaug, M., Godinovic, N., Gonzalez Munoz, A., Gozzini, S. R., Hadasch, D., Hanabata, Y., Hayashida, M., Herrera, J., Hildebrand, D., Hose, J., Hrupec, D., Hughes, G., Idec, W., Kadenius, V., Kellermann, H., Knoetig, M. L., Kodani, K., Konno, Y., Krause, J., Kubo, H., Kushida, J., LA BARBERA, ANTONINO, Lelas, D., Lewandowska, N., Lindfors, E., LOMBARDI, Saverio, Lopez, M., Lopez-Coto, R., Lopez-Oramas, A., Lorenz, E., Lozano, I., Makariev, M., Mallot, K., Maneva, G., Mankuzhiyil, N., Mannheim, K., Maraschi, L., Marcote, B., Mariotti, M., Martinez, M., Mazin, D., Menzel, U., Miranda, J. M., Mirzoyan, R., Moralejo, A., Munar-Adrover, P., Nakajima, D., Niedzwiecki, A., Nilsson, K., Nishijima, K., Noda, K., Orito, R., Overkemping, A.

Unprecedented study of the broadband emission of Mrk 421 during flaring activity in March 2010.

Aleksic J., Ansoldi S., Antonelli L.A., Antoranz P., Babic A., Bangale P., de Almeida U.Barres , Barrio J.A., Gonzalez J.Becerra , Bednarek W., Bernardini E., Biasuzzi B., Biland A., Blanch O., Boller A., Bonnefoy S., Bonnoli G., Borracci F., Bretz T., Carmona E., Carosi A., Colin P., Colombo E., Contreras J.L., Cortina J., Covino S., Da Vela P., Dazzi F., De Angelis A., De Caneva G., De Lotto B., de Ona Wilhelmi E., Delgado Mendez C., Dominis Prester D., Dorner D., Doro M., Einecke S., Eisenacher D., Elsaesser D., Fonseca M.V., Font L., Frantzen K., Fruck C., Galindo D., Garcia Lopez R.J., Garczarczyk M., Garrido Terrats D., Gaug M., Godinovic N., Gonzalez Munoz A., Gozzini S.R., Hadasch D., Hanabata Y., Hayashida M., Herrera J., Hildebrand D., Hose J., Hrupec D., Hughes G., Idec W., Kadenius V., Kellermann H., Knoetig M.L., Kodani K., Konno Y., Krause J., Kubo H., Kushida J., La Barbera A., Lelas D., Lewandowska N., Lindfors E., Lombardi S., Lopez M., Lopez-Coto R., Lopez-Oramas A., Lorenz E., Lozano I., Makariev M., Mallot K., Maneva G., Mankuzhiyil N., Mannheim K., Maraschi L., Marcote B., Mariotti M., Martinez M., Mazin D., Menzel U., Miranda J.M., Mirzoyan R., Moralejo A., Munar-Adrover P., Nakajima D., Niedzwiecki A., Nilsson K., Nishijima K., Noda K., Orito R., Overkemping A., Paiano S., Palatiello M., Paneque D., Paoletti R., Paredes J.M., Paredes-Fortuny X., Persic M., Prada Moroni P.G., Prandini E., Puljak I., Reinthal R., Rhode W., Ribo M., Rico J., Rodriguez Garcia J., Rugamer S., Saito T., Saito K., Satalecka K., Scalzotto V., Scapin V., Schultz C., Schweizer T., Sun S., Shore S.N., Sillanpaa A., Sitarek J., Snidaric I., Sobczynska D., Spanier F., Stamatescu V., Stamerra A., Steinbring T., Steinke B., Storz J., Strzys M., Takalo L., Takami H., Tavecchio F., Temnikov P., Terzic T., Tescaro D., Teshima M., Thaele J., Tibolla O., Torres D.F., Toyama T., Treves A., Uellenbeck M., Vogler P., Zanin R., (The MAGIC Collaboration),
Archambault S., Archer A., Beilicke M., Benbow W., Berger K., Bird R., Biteau J., Buckley J.H., Bugaev V., Cerruti M., Chen X., Ciupik L., Collins-Hughes E., Cui W., Eisch J.D., Falcone A., Feng Q., Finley J.P., Fortin P., Fortson L., Furniss A., Galante N., Gillanders G.H., Griffin S., Gyuk G., Hakansson N., Holder J., Johnson C.A., Kaaret P., Kar P., Kertzman M., Kieda D., Lang M.J., McArthur S., McCann A., Meagher K., Millis J., Moriarty P., Ong R.A., Otte A.N., Perkins J.S., Pichel A., Pohl M., Popkow A., Prokoph H., Pueschel E., Ragan K., Reyes L.C., Reynolds P.T., Richards G.T., Roache E., Rovero A.C., Sembroski G.H., Shahinyan K., Staszak D., Telezhinsky I., Tucci J.V., Tyler J., Varlotta A., Wakely S.P., Welsing R., Wilhelm A., Williams D.A.,
(The VERITAS Collaboration),
Buson S., Finke J., Villata M., Raiteri C., Aller H.D., Aller M.F., Cesarini A., Chen W.P., Gurwell M.A., Jorstad S.G., Koptelova E., Kurtanidze O.M., Laehteenmaeki A., Larionov V.M., Larionova E.G., Lin H.C., Moody J.W., Morozova D.A., Marscher A.P., Max-Moerbeck W., Nikolashvili M.G., Perri M., Readhead A.C.S., Richards J.L., Ros J.A., Sadun A.C., Sakamoto T., Smith P.S., Tornikoski M., Troitsky I.S., Wehrle A.E., (External Collaborators)

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Keywords: radiation mechanisms: non-thermal - galaxies: active - BL Lacertae objects: individual: Mrk 421 - gamma rays: galaxies

Abstract:

A flare from the TeV blazar Mrk 421, occurring in March 2010, was observed for 13 consecutive days from radio to very high energy (VHE; E>100GeV) gamma-rays with MAGIC, VERITAS, Whipple, FermiLAT, MAXI, RXTE, Swift, GASP-WEBT, and several optical and radio telescopes. We model the day-scale SEDs with one-zone and two-zone synchrotron

self-Compton (SSC) models, investigate the physical parameters, and evaluate whether the observed broadband SED variability can be associated to variations in the relativistic particle population. Flux variability was remarkable in the X-ray and VHE bands while it was minor or not significant in the other bands. The one-zone SSC model can describe reasonably well the SED of each day for the 13 consecutive days. This flaring activity is also very well described by a two-zone SSC model, where one zone is responsible for the quiescent emission while the other smaller zone, which is spatially separated from the first one, contributes to the daily-variable emission occurring in X-rays and VHE gamma-rays. Both the one-zone SSC and the two-zone SSC models can describe the daily SEDs via the variation of only four or five model parameters, under the hypothesis that the variability is associated mostly to the underlying particle population. This shows that the particle acceleration and cooling mechanism producing the radiating particles could be the main one responsible for the broadband SED variations during the flaring episodes in blazars. The two-zone SSC model provides a better agreement to the observed SED at the narrow peaks of the low- and high-energy bumps during the highest activity, although the reported one-zone SSC model could be further improved by the variation of the parameters related to the emitting region itself (δ, B and R), in addition to the parameters related to the particle population.

Description:

I. The multi-wavelength light curves (LCs) of Mrk 421 between MJD 55264 and 55278, from VHE to radio (the data in Fig. 1) are given in 32 files (INSTRUMENT_BAND.dat)

II. The day-by-day broadband spectral energy distributions (SEDs) between MJD 55264 and 55278 (the data in Figs. 7,8a-9f,12a-13f) are given in 13 files (55265-55277.dat)

Objects:

RA (2000)	DE	Designation(s)
11 04 27.31	+38 12 31.8	Mrk 421 = LEDA 33452

File Summary:

FileName	Lrecl	Records	Explanations
ReadMe	80	.	This file
asm.dat	54	14	Light Curve from RXTE-ASM 2-10keV
fluxes.dat	73	101	Light Curve from MAGIC, VERITAS, Whipple, Fermi-LAT, Swift-BAT, MAXI, Swift-XRT and RXTE-PCA
fdens1.dat	70	121	Light Curve from Swift-UVOT, Bradford, ROVOR, NMSkies, GASP and GRT
evpa.dat	68	11	Light Curve from Steward, St Petersburg and Crimean (EVPA)
pol.dat	68	11	Light Curve from Steward, St Petersburg and Crimean (polarization degree)
fdens2.dat	70	7	Light Curve from SMA, Metsahovi, OVRO and UMRAO
55265.dat	74	58	SED on MJD 55265
55266.dat	74	52	SED on MJD 55266
55267.dat	74	53	SED on MJD 55267
55268.dat	74	56	SED on MJD 55268

55269.dat	74	58	SED on MJD 55269
55270.dat	74	57	SED on MJD 55270
55271.dat	74	40	SED on MJD 55271
55272.dat	74	50	SED on MJD 55272
55273.dat	74	45	SED on MJD 55273
55274.dat	74	53	SED on MJD 55274
55275.dat	74	43	SED on MJD 55275
55276.dat	74	46	SED on MJD 55276
55277.dat	74	49	SED on MJD 55277

See also:
J/A+A/545/A117 : Monitoring of Mrk 421 at 15 and 24 GHz (Lico+, 2012)
J/A+A/559/A75 : 43GHz observation of the blazar Mrk 421 (Blasi+, 2013)

Byte-by-byte Description of file: asm.dat

Bytes	Format	Units	Label	Explanations
1- 12	E12.7	d	Time	Time in MJD
17- 25	E9.4	ct/s	CR	Count rate
30- 41	E12.7	d	e_Time	[0.5] Error of time
46- 54	E9.4	ct/s	e_CR	Error of count rate

Byte-by-byte Description of file: fluxes.dat

Bytes	Format	Units	Label	Explanations
1- 9	A9	---	Inst	Instrument (1)
11- 18	A8	---	Band	Observed band (1)
20- 31	E12.7	d	Time	Time in MJD
35- 44	E10.4	cm-2/s	Flux	Observed flux
49- 60	E12.7	d	e_Time	[0/1] Error of time
65- 73	E9.4	cm-2/s	e_Flux	Error of flux

Note (1): MAGIC (>200GeV), VERITAS (>200GeV), Whipple (>200GeV), Fermi-LAT (>300GeV), Swift-BAT (15-50keV), MAXI (4-10keV), Swift-XRT (2-10keV and 0.3-2keV) and RXTE-PCA (2-10keV).

Byte-by-byte Description of file: fdens1.dat

Bytes	Format	Units	Label	Explanations
1- 10	A10	---	Inst	Instrument (1)
12- 15	A4	---	Band	Observed band (1)
17- 28	E12.7	d	Time	Time in MJD
33- 41	E9.4	mJy	FluxD	[8/22] Flux density
46- 57	E12.7	d	e_Time	[0/0.005] Error of time
62- 70	E9.4	mJy	e_FluxD	[0.1/3.2] Error of flux density

Note (1): Swift-UVOT (UVM2, UVW1 and UVW2), Bradford (B), ROVOR (BVRI), NMSkies (VR), GASP (R) and GRT (R)

Byte-by-byte Description of file: evpa.dat

Bytes	Format	Units	Label	Explanations
1- 13	A13	---	Obs	Observatory (1)
15- 26	E12.7	d	Time	Time in MJD
31- 39	E9.4	deg	EVPA	[110/132] Electric vector polarization angle
44- 55	E12.7	d	e_Time	[0] Error of time
60- 68	E9.4	deg	e_EVPA	[0.1/2.5] Error of EVPA

Note (1): Crimean, St Petersburg and Steward.

Byte-by-byte Description of file: pol.dat

Bytes	Format	Units	Label	Explanations
1- 13	A13	---	Obs	Observatory (1)
15- 26	E12.7	d	Time	Time in MJD
31- 39	E9.4	%	Pol	[3/7] Polarization degree
44- 55	E12.7	d	e_Time	[0] Error of time
60- 68	E9.4	%	e_Pol	[0.02/0.42] Error of polarization degree

Note (1): Crimean, St Petersburg and Steward.

Byte-by-byte Description of file: fdens2.dat

Bytes	Format	Units	Label	Explanations
1- 9	A9	---	Obs	Observatory (1)
11- 15	F5.1	GHz	Freq	[14.5/225] Observed frequency (1)
17- 28	E12.7	d	Time	Time in MJD
33- 41	E9.4	Jy	FluxD	[0.2/0.5] Flux density at Freq
46- 57	E12.7	d	e_Time	[0/0] Error of time
62- 70	E9.4	Jy	e_FluxD	[0.01/0.07] Error of flux density

Note (1): SMA (225GHz), Metsahovi (37GHz), OVRO (15GHz) and UMRAO (14.5GHz)

Byte-by-byte Description of file: 552*.dat

Bytes	Format	Units	Label	Explanations
1- 9	E9.4	Hz	Freq	[1.4e+10/1.e+27] Frequency
14- 22	E9.4	Hz	e_Freq	Low error of frequency
27- 35	E9.4	Hz	E_Freq	High error of frequency
40- 48	E9.4	mW/m2	EFlux	Energy flux
53- 61	E9.4	mW/m2	e_EFlux	Low error of energy flux
66- 74	E9.4	mW/m2	E_EFlux	High error of energy flux

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Shangyu Sun, shangyu.sun.khh(at)googlemail.com
Max-Planck-Institut fur Physik, Germany

(End) Shangyu Sun [Max-Planck-Inst. Physik], Patricia Vannier [CDS] 23-Jan-2015