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An update of the multiwavelength campaign on OJ 287

Stefano Ciprini
Perugia INFN & University

GLAST Collaboration Meeting
Blazars and Other AGNs
Science Group Meeting
Monday, August 28, 2006
Stockholm, Sweden

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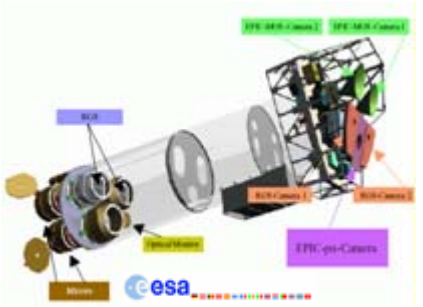
Some news about OJ 287 projects/campaigns

- Optical photometry and polarimetry monitoring program on OJ 287 ongoing (Heidt-Nilsson).
- 2 XMM-Newton observations of OJ 287 (Cycle AO-4: PI S. Ciprini) and coordinated multiwavelength (MW) campaign by the WEBT consortium (CM: S. Ciprini) performed (April & November 2005).
- A 3rd XMM-Newton observation of OJ 287 granted (Cycle AO-5: PI S. Ciprini) and scheduled on next November 2006.
- MAGIC ToO observations of OJ 287 performed in Nov. 2005 (no detection).
- Effelsberg radio IDV observations (Apr.12 and Nov. 8-9-10, 2005, Fuhrmann).
- VLBA and global 3mm-VLBI radio-structure/polarization observations performed (April 2005, Agudo). More VLBA & Global 3mm-VLBI observations ongoing (period 2005-2007).



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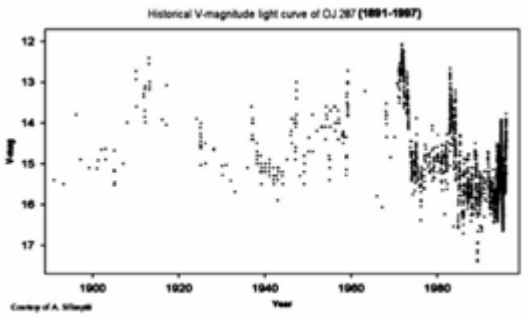
XMM-Newton observations and coordinated MW campaign on OJ 287



Goals:

- ❑ Study the spectral-temporal behaviour of OJ 287 on both short and long time scales, and in different brightness states (before and during the possible pseudo-cyclic outbursts).
- ❑ X-ray data likely provide information on the high-energy (inverse Compton, IC) spectral component, while radio-to-optical observations map the behaviour of the synchrotron bump.
- ❑ Possibly to clarify underlying physics, and relevance of geometrical and energetic models.
- ❑ Search for multifrequency correlations.
- ❑ To challenge a satellite-triggered coordinated MW campaign on a single object (in view of the next GLAST MW campaigns).

OJ 287

European Network for the Investigation of Galactic nuclei through Multifrequency Analysis
ENIGMA

WEBT

http://www.astro.utu.fi/OJ287MMVI/XMMcampaign.html

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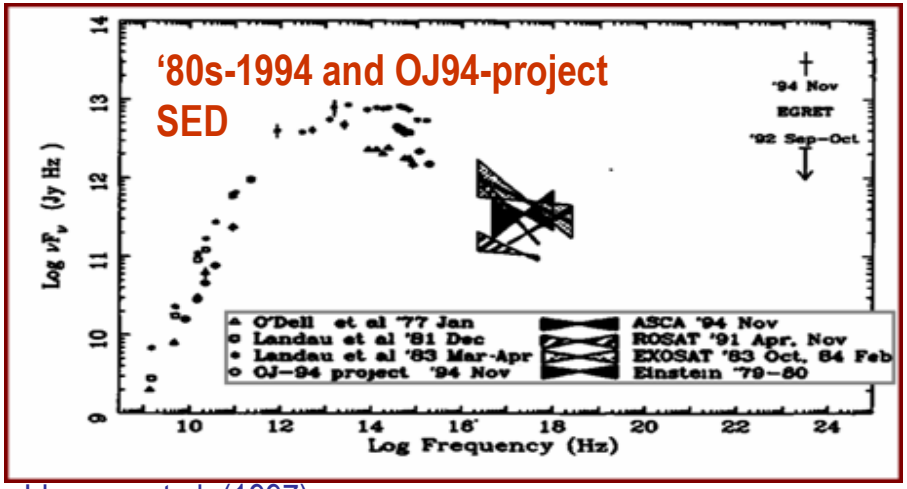
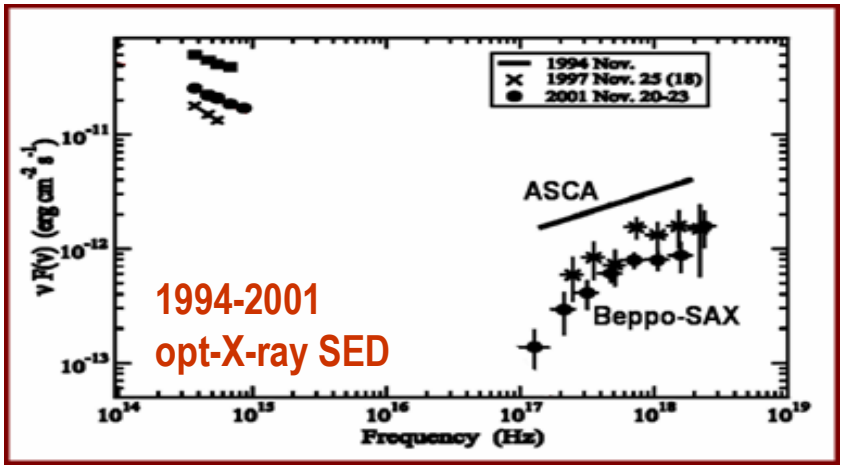
OJ 287: previous broadband SEDs



Idesawa et al. (1997)



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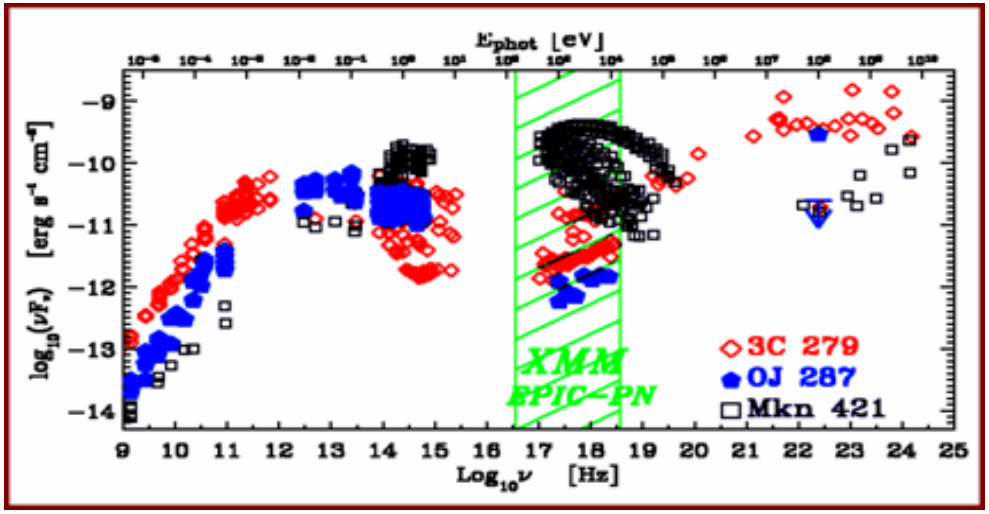

Comparison among the SED of OJ 287 SED, with the SED of a HBL (TeV blazar) and a FSRQ prototype (Mkn 421 and 3C 279).

Source name	Other names	EGRET detection	X-rays past observations	X-rays integral flux [erg cm^{-2} s^{-1}]
OJ 287	PKS 0851+202	YES	Einstein,EXOSAT,ROSAT	1.35-5.0 $\times 10^{-12}$ (2-10 keV)
$z = 0.306$	PG 0851+202		ASCA,*Beppo*SAX	(ASCA, SAX)

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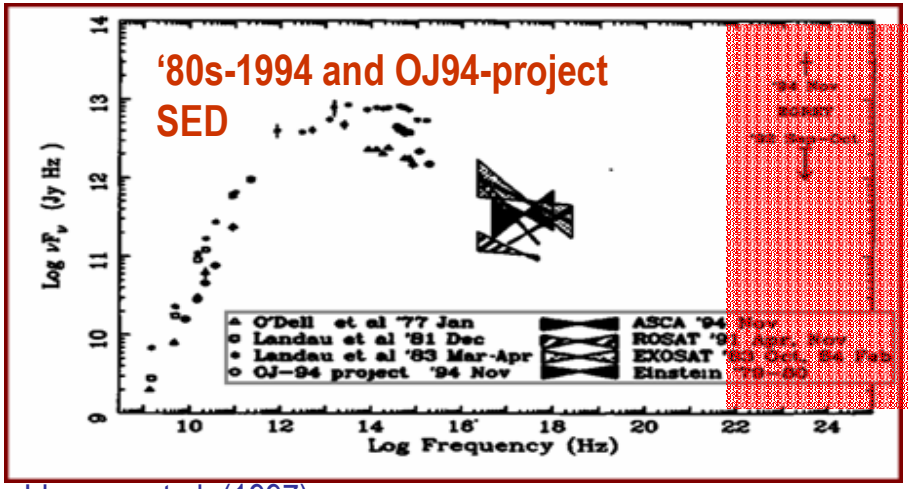
OJ 287: previous broadband SEDs



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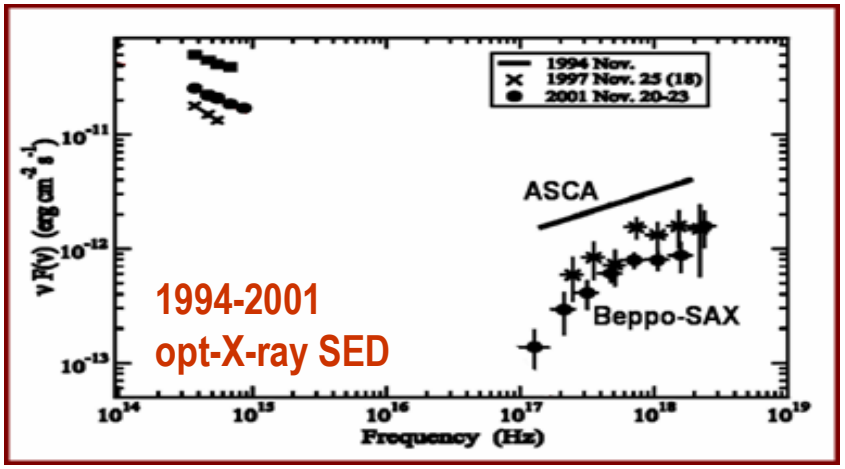

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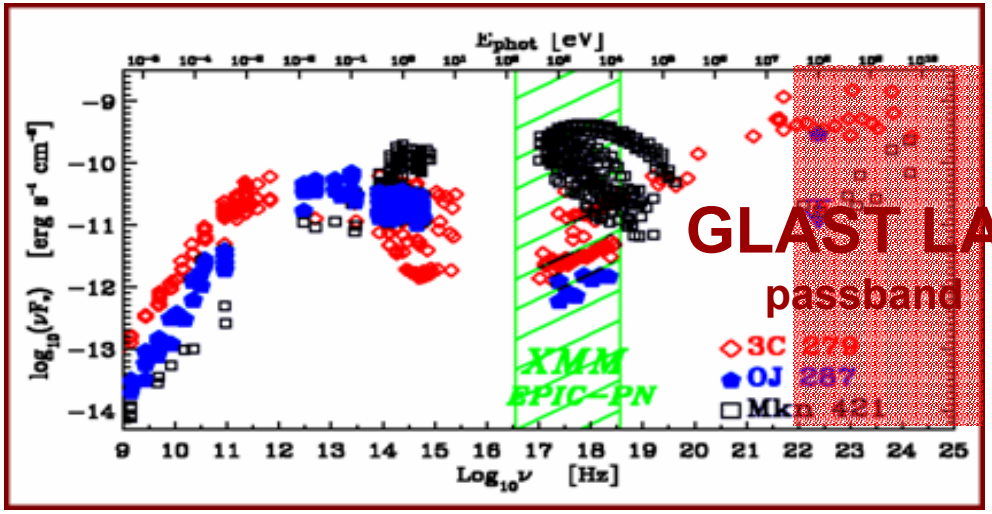

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$z = 0.306$	PG 0851+202		ASCA,*Beppo*SAX	(ASCA, SAX)

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Coord. MW campaign participants 1

Institutes/Observatories participating in the MW coordinated campaign (part-1 list):

Optical Observatories:

- ❑Osaka Kyoiku University Observatory - Kashiwara, Osaka, Japan (K. Sadakane)
- ❑Lulin Observatory - Lulin, Taiwan (W. P. Chen)
- ❑Xinglong Station of NAOC - Yanshan Mountains, China, (J.-H. Wu)
- ❑ARIES Sampurnanand Telescope - Naini Tal, Uttaranchal, India (R. Sagar, G. Krishna)
- ❑Abastumani Astrophysical Observatory - Mt. Kanobil, Georgia, (O. Kurtanidze)
- ❑Crimean Astrophysical Observatory - Nauchny, Crimea, Ukraine (Y. Efimov, V. Larionov)
- ❑Çanakkale Onsekiz Mart University Observatory - Çanakkale, Turkey (A. Erdem)
- ❑Jakokoski Observatory - Jakokoski, Finland (P. Pääkkönen)
- ❑Nyrölä Observatory - Nyrölä, Finland (A. Oksanen, K. Nilsson)
- ❑Tuorla Observatory - Piikkio, Finland (L. Takalo, A. Sillanpää)
- ❑Catania Observatory - Catania, Italy (A. Frasca)
- ❑Campo Imperatore Observatory - L'Aquila, Italy (V. Larionov)
- ❑Armenzano Observatory - Armenzano, Assisi, Italy (D. Carosati)
- ❑Perugia Observatory - Perugia, Italy (G. Tosti, S. Ciprini)
- ❑Torino Observatory - Torino, Italy (C. Raiteri, M. Villata)

Optical (cont.):

- ❑Heidelberg Observatory - Heidelberg, Germany (J. Heidt)
- ❑Michael Adrian Observatory- Trebur, Germany (J . Ohlert)
- ❑Agrupacio Astronomica de Sabadell - Sabadell, Spain (J. A. Ros)
- ❑KVA Telescope - La Palma, Canary Islands, Spain (L. Takalo, A. Sillanpää)
- ❑Nordic Optical Telescope - La Palma, Canary Islands, Spain (T. Pursimo)
- ❑Mt. Lemmon KASI Observatory - Mount Lemmon, Arizona, USA (L. Chung-Uk)
- ❑Kitt Peak SARA Observatory - Kitt Peak, Arizona, USA (J. Webb)
- ❑Tenagra Observatories - Sonoran desert, Arizona, USA (A. Sadun)
- ❑Coyote Hill Observatory - Wilton, California, USA (C. Pullen)

❑Radio-mm:

- ❑RATAN-600 (Special Astrophys. Obs.) (576 m) - Zelenchukskaya, Russia (Y. Kovalev)
- ❑Metsähovi Radio Telescope (14 m) - Metsähovi, Finland (M. Tornikoski, A. Lahteenmaki)
- ❑Noto Radio Observatory - Noto, Siracusa, Italy (C. Raiteri, P. Leto)
- ❑Effelsberg Radio Telescope (100 m) - Effelsberg, Germany (T. Krichbaum, L. Fuhrmann)
- ❑IRAM Millimeter Telescope (30 m) - Pico Veleta, Spain (T. Krichbaum, H. Ungerechts)
- ❑Univ. of Michigan Radio Astron. Obs. (UMRAO) (26 m) - Dexter, Michigan, USA (M. Aller)

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Coord. MW campaign participants 2

Institutes/Observatories participating in the MW coordinated campaign (part-2 list):

Optical/NIR Observatories:

- ❑Osaka University - Osaka, Japan (K. Torii)
- ❑Sobaeksan KASI Optic. Astr.Obs. - Sobaeksan, Korea (C.-U. Lee)
- ❑Lulin Observatory - Lulin, Taiwan (W.-P. Chen)
- ❑Tsinghua University - Beijing, China (J. Li)
- ❑Xinglong Station of NAOC - Yanshan Mountains, China, (J.-H. Wu)
- ❑ARIES Sampurnanand Tel. - Naini Tal, Uttaranchal, India (R. Sagar, G. Krishna)
- ❑Mount Maidanak Observatory, Ulugh Beg Astronomical Institute - Mount Maidanak, Uzbekistan (M. A. Ibrahimov)
- ❑Abastumani Astrophysical Observatory - Mt. Kanobil, Georgia, (O. Kurtanidze)
- ❑Crimean Astrophysical Obs. - Nauchny, Crimea, Ukraine (Y. Efimov, V. Larionov)
- ❑Çanakkale Onsekiz Mart University Obse. - Çanakkale, Turkey (A. Erdem)
- ❑Saint Petersburg State Univ. Obs. - St. Petersburg, Russia (V. M. Larionov)
- ❑Bulgaria National Astron. Obs. - Rozhen, Bulgaria (E. Ovcharov, A. Kostov)
- ❑Jakokoski Observatory - Jakokoski, Finland (P. Pääkkönen)
- ❑Tuorla Observatory - Piikkio, Finland (L. Takalo, A. Sillanpää)
- ❑MonteBoo Obs., Masaryk University - Brno, Czech Republic (F. Hroch)
- ❑Catania Observatory - Catania, Italy (A. Frasca)
- ❑Campo Imperatore Obs. - Assergi, L'Aquila, Italy (A. Arkharov)
- ❑Armenzano Observatory - Armenzano, Assisi, Italy (D. Carosati)
- ❑Porziano Observatory - Porziano, Assisi, Italy (D. Capezzali)
- ❑Perugia Observatory - Perugia, Italy (G. Tosti, S. Ciprini)

Optical (cont.):

- ❑Torino Observatory - Torino, Italy (C. Raiteri, M. Villata)
- ❑Heidelberg Lander. - Heidelberg, Germany (L. Ostorero, D. Emmanoulopoulos)
- ❑Michael Adrian Observatory- Trebur, Germany (J . Ohlert)
- ❑KVA Telescope - La Palma, Canary Islands, Spain (L. Takalo, A. Sillanpää)
- ❑Nordic Optical Telescope - La Palma, Canary Islands, Spain (T. Pursimo)
- ❑INAOE Tonantzintla Obs. - Tonantzintla, Puebla, Mexico (O. Lopez-Cruz)
- ❑Mt. Lemmon KASI Obs. - Mount Lemmon, Arizona, USA (C.-U. Lee)
- ❑Ohio University MDM Obs. - Kitt Peak , Arizona, USA (M. Boettcher)
- ❑Kitt Peak SARA Obs. - Kitt Peak, Arizona, USA (J. Webb)
- ❑Tenagra Observatories - Sonoran desert, Arizona, USA (A. Sadun)
- ❑National Astr. Obs. of San Pedro Mártir - Baja California Peninsula, Mexico (E. Benitez, D. Dultzin-Hacyan.)
- ❑Coyote Hill Observatory - Wilton, Sacramento, California, USA (C. Pullen)

Radio-mm:

- ❑RATAN-600 (Special Astr. Obs.) (576 m) Zelenchukskaya, Russia (Y. Kovalev)
- ❑RT-22 Crimean Astr.I Obs. (22m) - Simeiz, Crimea, Ukraine (A. Volvach)
- ❑Metsähovi Radio Tel. (14 m) - Metsähovi, Finland (M. Tornikoski, A. Lahteenmaki)
- ❑Noto Radio Obs. (32m) - Noto, Siracusa, Italy (P. Leto, C. Raiteri)
- ❑Effelsberg Radio Tel. (100 m) - Effelsberg, Germany (T. Krichbaum, L. Fuhrmann)
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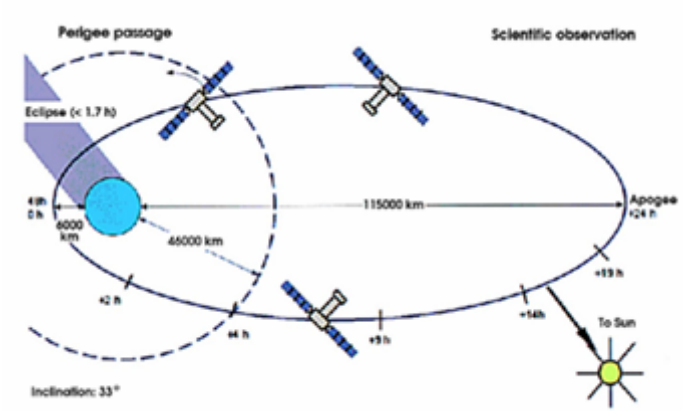
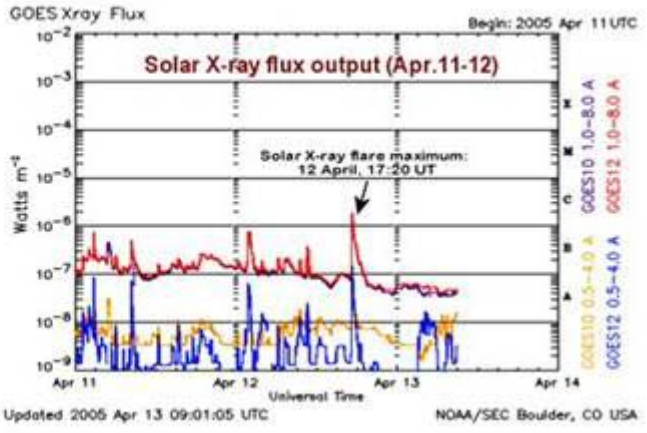
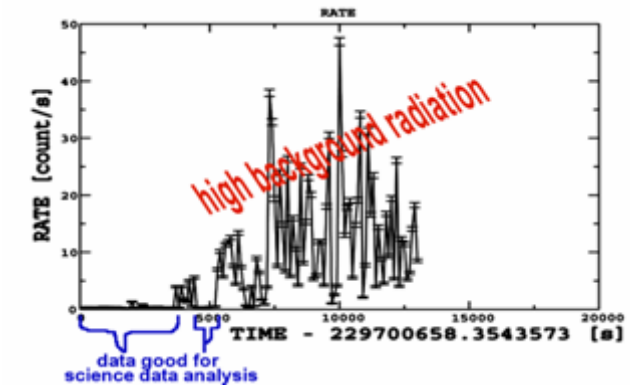
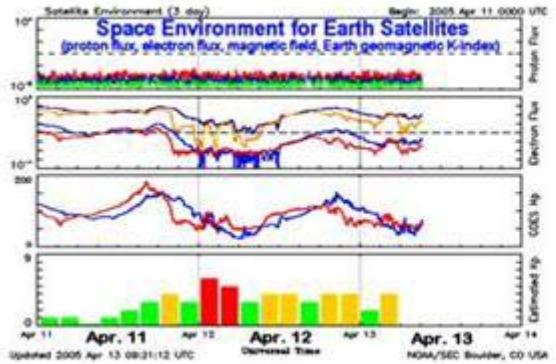
The weather conspiracy 1

Bad space weather: 1st XMM obs. (April 12, 2005) affected by high background radiation and stopped. *EPIC pn*: the excellent camera collected enough photons to construct a spectra. *RGS*: no detection. *OM*: UV-opt. observations performed. Time lost added to the 2nd pointing.









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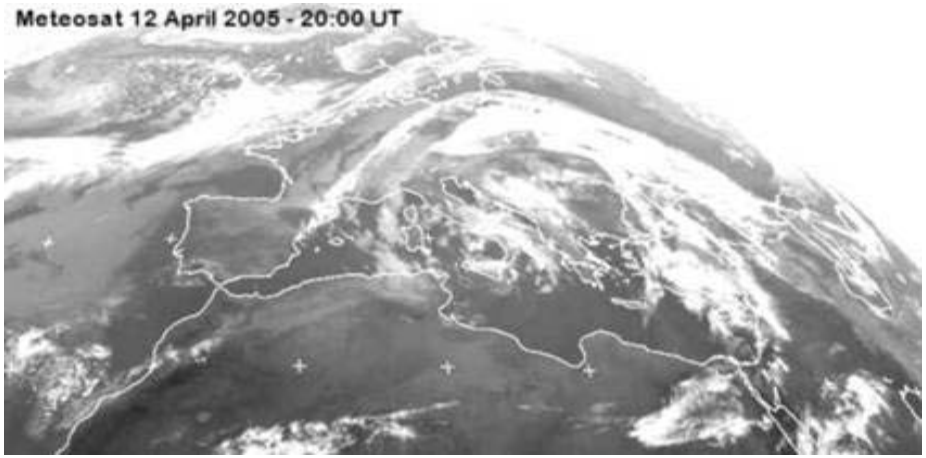
The weather conspiracy 2

Bad Earth weather: Optical ground-based observations obstructed by bad weather in Europe during the 1st XMM-Newton pointing.



5 Optical observatories in center Italy (2 amateur, 3 professional) alerted/involved personally for April 12… but bad luck with weather!

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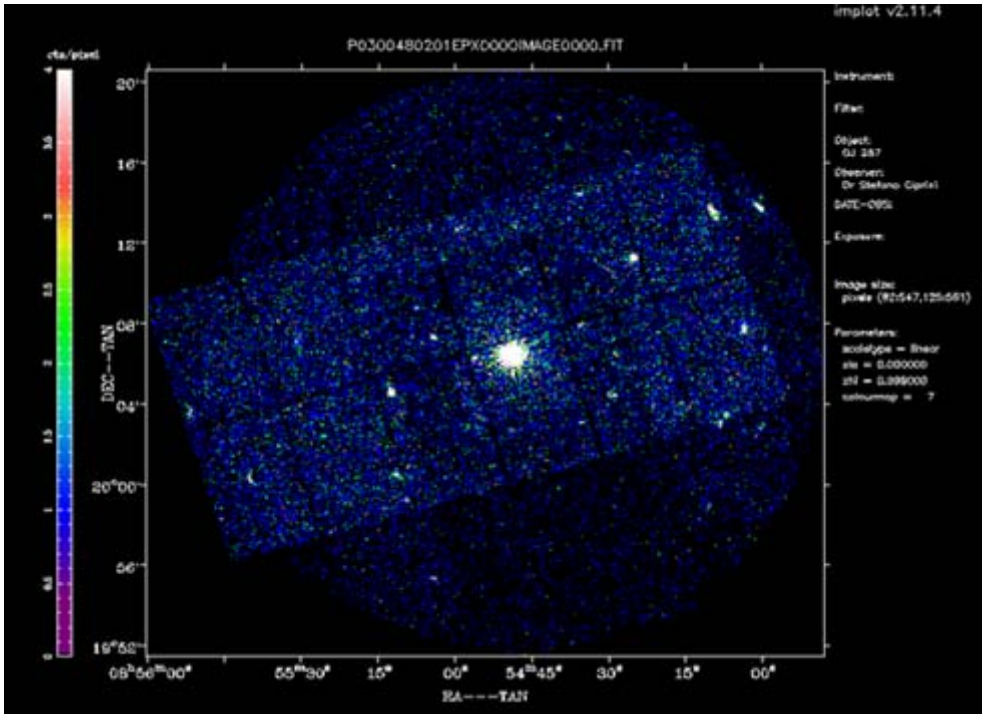
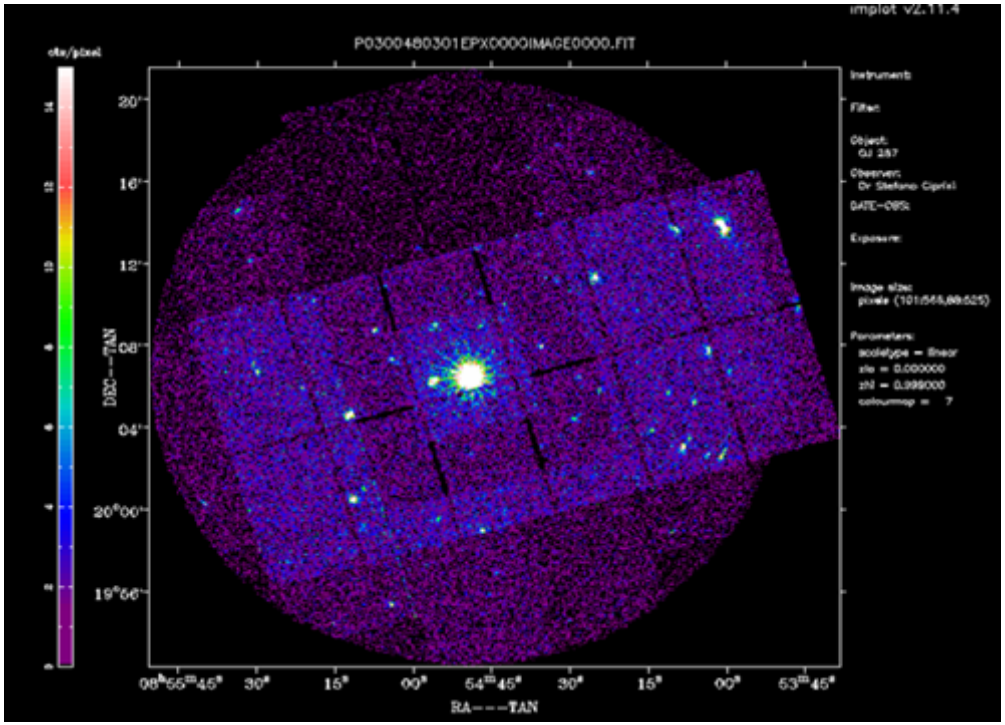
OJ 287 XMM-Newton: EPIC images

EPIC: large frame + medium filter used. Data processed with XMM-SAS v. 6.5.
Intervals of high background filtered. Spectral analysis of PN + MOS1+MOS2 data with XSPEC.

April 12, 2005



Nov. 3-4, 2005



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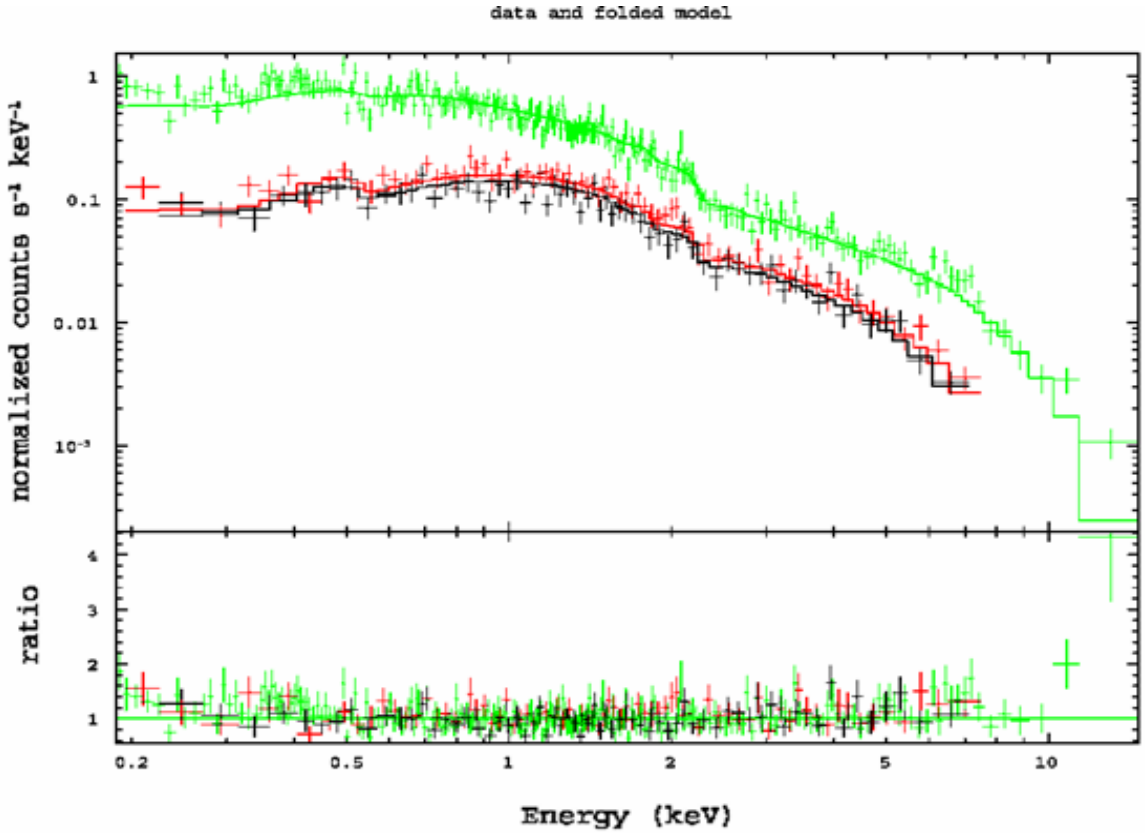
OJ 287 XMM-Newton: EPIC spectrum Apr. 12, 2005

Date: April 12, 2005 - OJ 287, z=0.306.

XMM-Newton *EPIC: PN* + *MOS1* + *MOS2* spectra

Model: single power law + galactic absorption in the 0.2-10 KeV range



H column density:

$N_H = 3.09 \times 10^{20}$ cm^{-2}

Power-law photon index:

$\Gamma = 1.628 \pm 0.023$

Reduced chi-squared:

$\chi_r^2 = 1.035$, d.o.f.=367

Flux density (2-10 KeV):

$F_{2-10keV} = (2.47 \pm 0.8) \times 10^{-12}$ erg s^{-1} cm^{-2}

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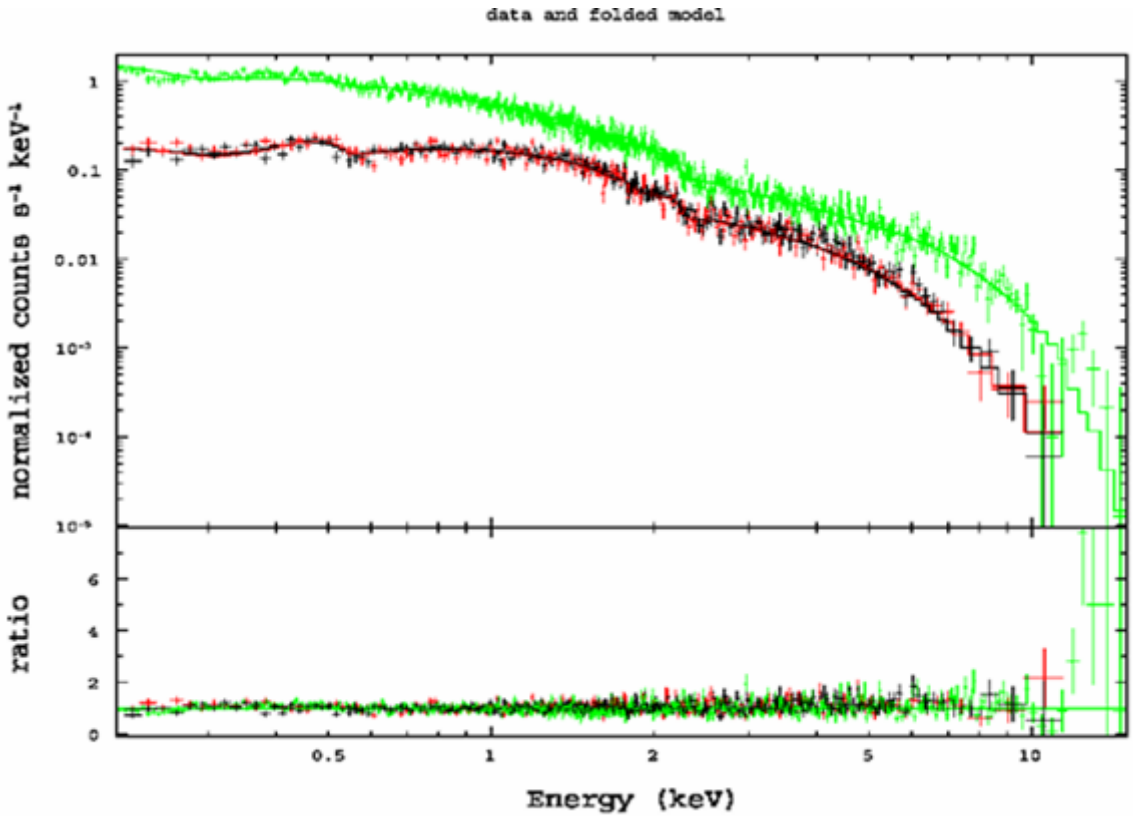
OJ 287 XMM-Newton: EPIC spectrum Nov. 3-4, 2005

Date: November 3-4, 2005 - OJ 287, z=0.306.

XMM-Newton *EPIC: PN* + *MOS1* + *MOS2* spectra

Model: broken power law + galactic absorption in the 0.2-10 KeV range



H column density:

$N_H = 3.09 \times 10^{20}$ cm^{-2}

Broken power-law photon indexes:

$\Gamma_1 = 2.65\,(-0.07/+0.12)$

$\Gamma_2 = 1.79 \pm 0.02$

break energy: 0.69 KeV

Reduced chi-squared:

$\chi_r^2 = 1.030$, d.o.f.=927

Flux density (2-10 KeV):

$F_{2-10keV} = (1.82 \pm 0.07) \times 10^{-12}$ erg s^{-1} cm^{-2}

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Preliminary summary on the X-ray observations

- Apr.12 (XMM 1st obs.): Best fit: simple single power law component (IC?).
- Nov.3-4 (XMM 2nd obs.): Best fit: broken power law component (break ~0.7 keV), (Synch.tail+IC ? Break signature between the synchrotron and IC components ?)
- X-ray observations provided information on the high-energy (IC) spectral component.
- Different brightness states, flux variations: $F_{2-10keV}=2.47\times10^{-12}$(1st), and $F_{2-10keV}=1.82\times10^{-12}$(2nd), erg s^{-1} cm^{-2} (previous obs.: fluxes in the range $1.35-5.0\times10^{-12}$ erg s^{-1} cm^{-2}).
- Spectral variability: single/broken power law, slope variation.

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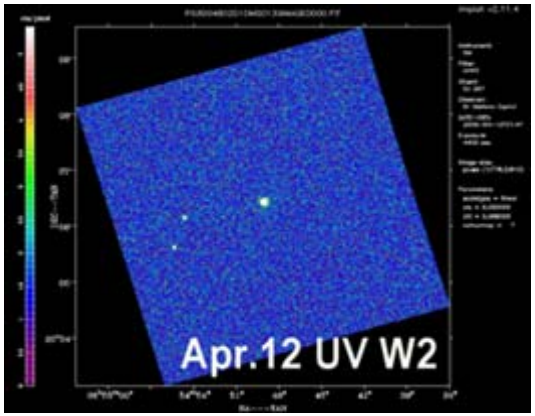
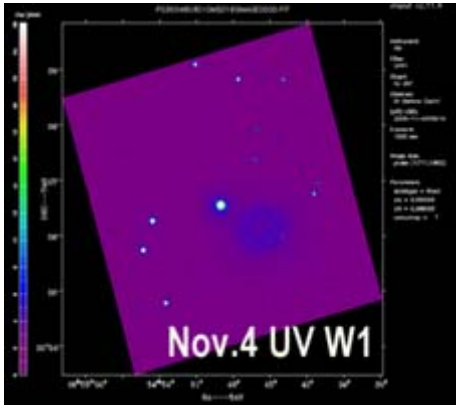
OJ 287 XMM-Newton: OM opt-UV observations

❑ Optical Monitoring instrument (OM). Summary of the observations obtained:

	UVW2	UVM2	UVW1	U	B	V
lambda (A)	2120	2310	2910	3440	4500	5430
Num. of images (Apr.12):	1	2	2	1	1	1
Num. of images (Nov.3-4):	0	0	8	1	1	1

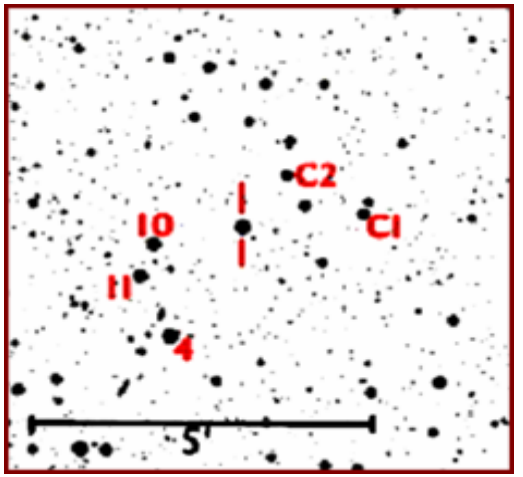
❑ High brightness of OJ 287 in UV bands during both the pointings (synch. peak in UV, or UV thermal bump, or…).





Example of 2 UV images

The optical finding chart



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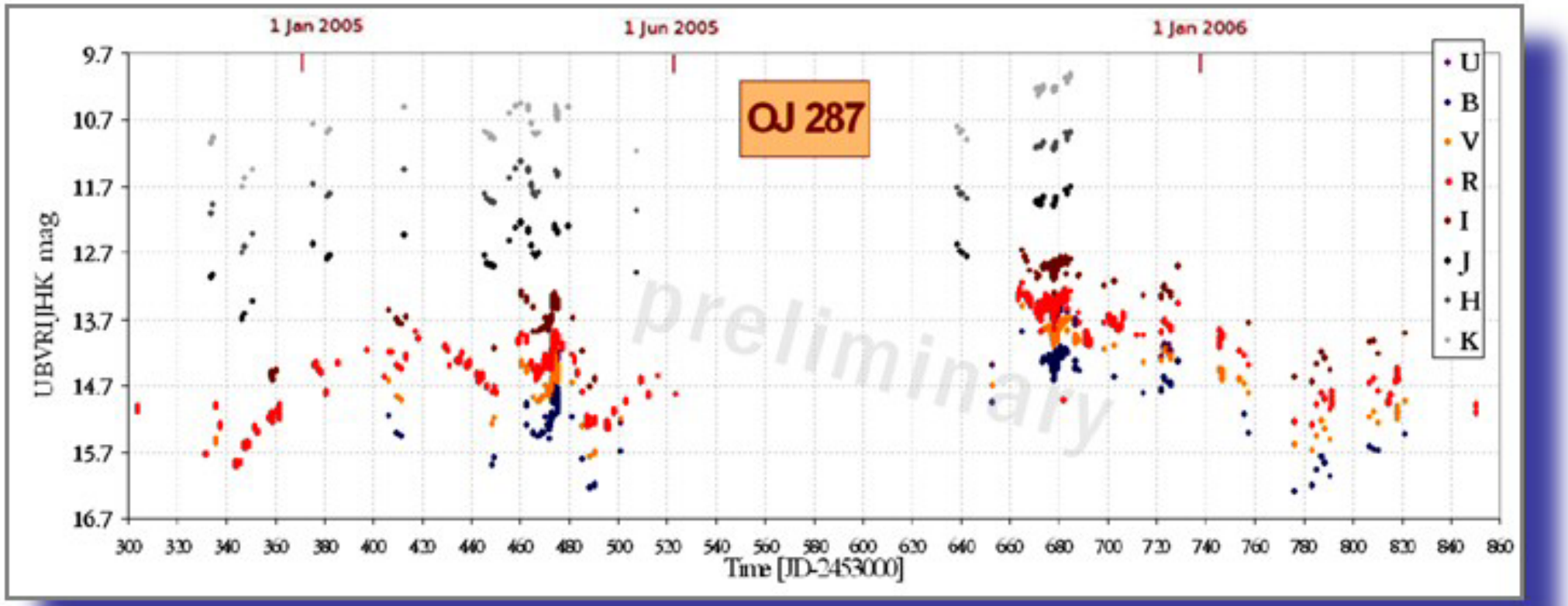
OJ 287: optical/NIR coordinated campaing data

Extended-campaign/monitoring: some month around the 2 XMM pointing dates. 2 observing (night-time visibility) seasons. Total period: Oct. 2004 – April 2006.



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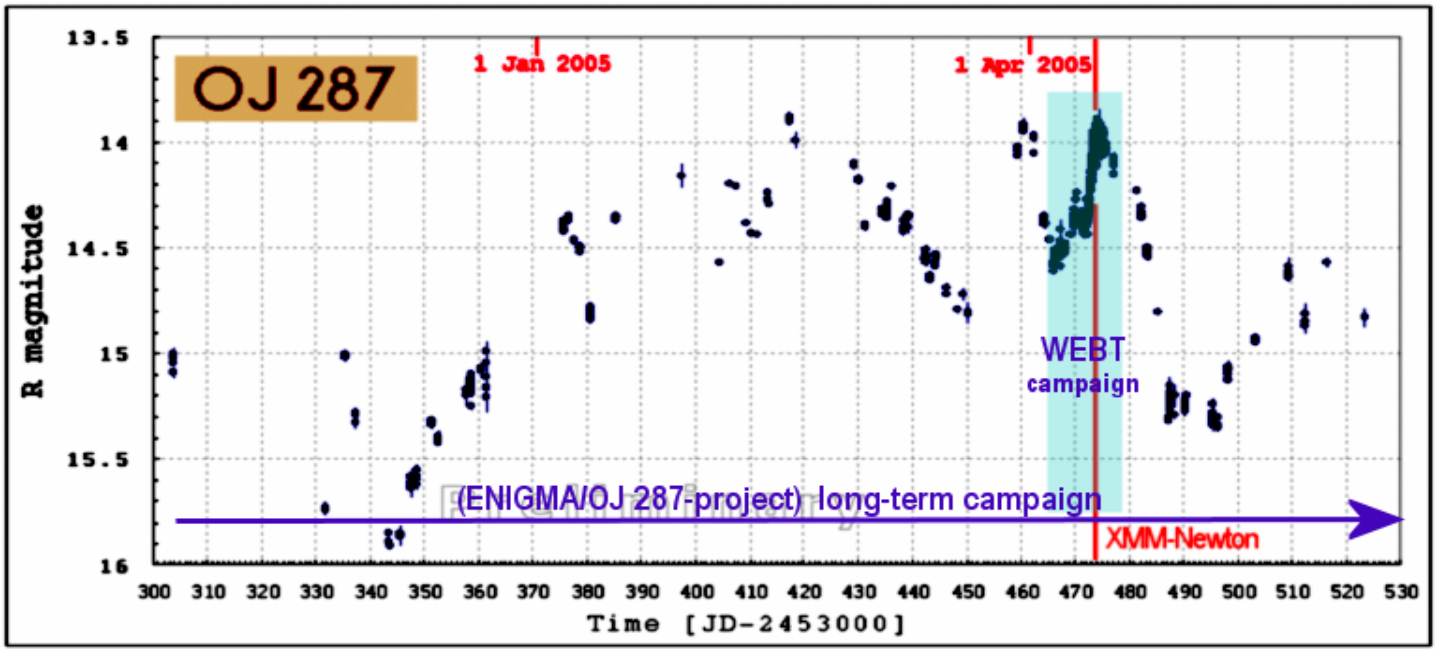
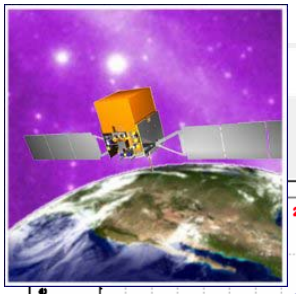
Coord. Campaign, part 1: optical light-curve

Part 1 period: Oct. 2004 - May 2005. Monitoring observations + intensive WEBT campaign around the 1st XMM-pointing date:

- ❑ **Intermediate/high brightness level. Brightness increased of 2 mag in about 2.5 months.**
- ❑ **Optical flare during the 1st XMM-Newton pointing (April 12): increase of ~ 0.8 mag in 8 days, large drop of ~ 1.4 mag in 13 days.**





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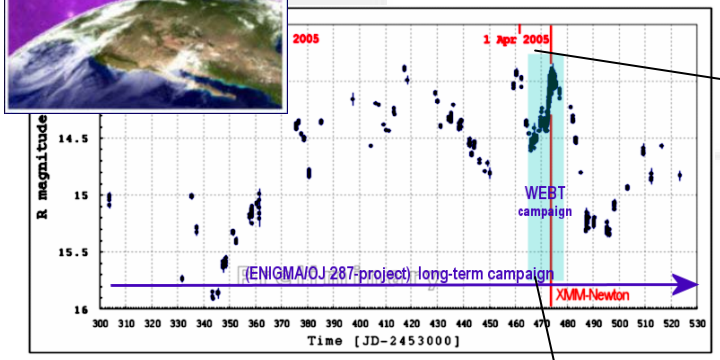

Coord. Campaign: 5-days optical WEBT light-curve

Date: April 10-14
(XMM-Newton 1st pointing: April 12)

- **Almost 0.3 mag brightness increase in less than 9 hours!**

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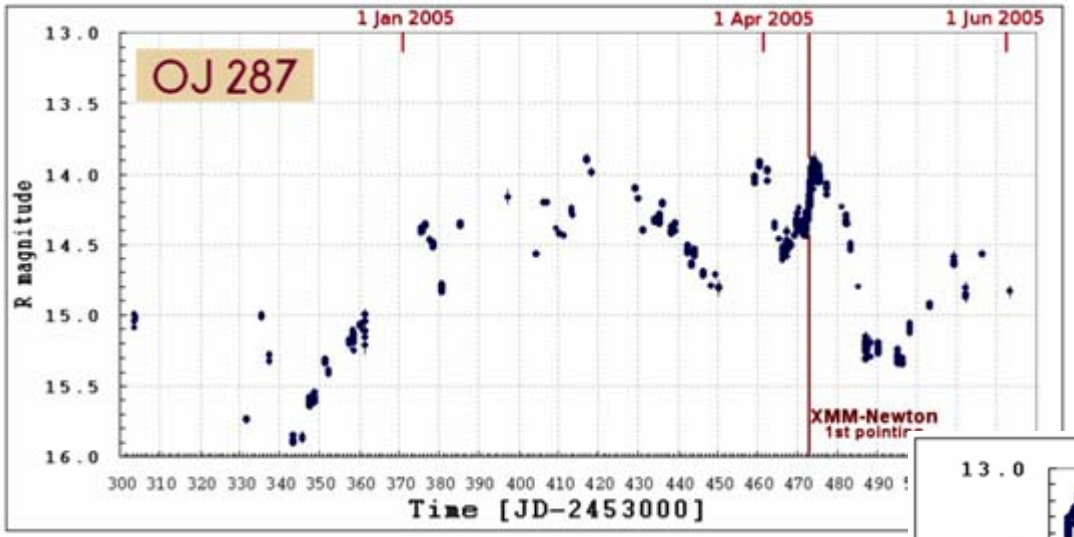
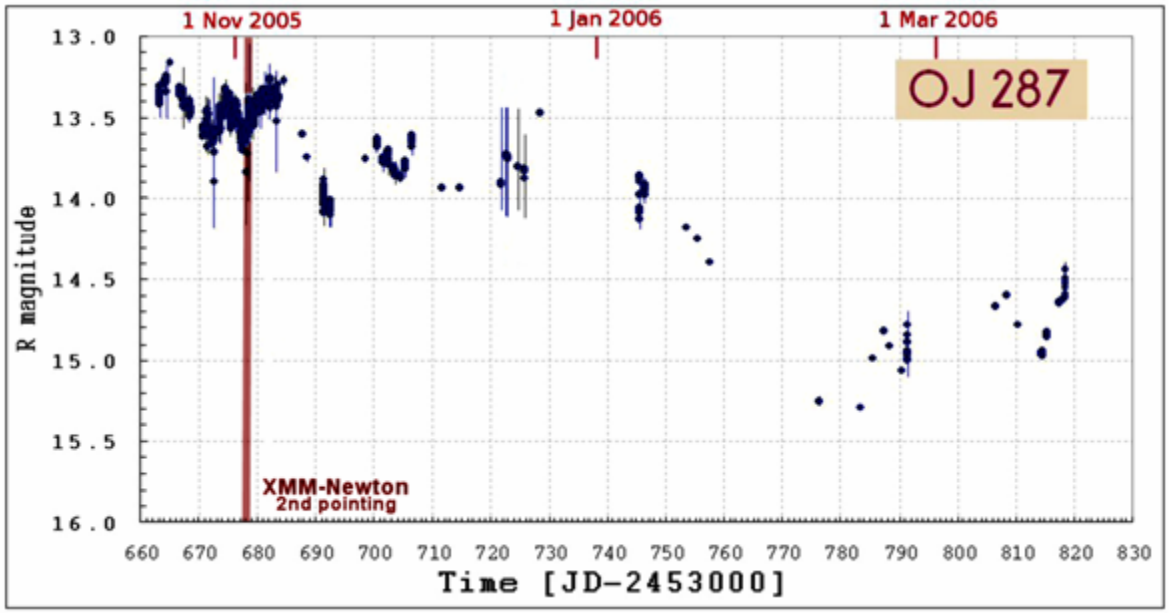
Coord. Campaign, part 1-part 2: optical light-curves



During the 2 GO scheduled XMM observations OJ 287 was flaring in the optical bands. …*The source was not shy!*



Part 2 period: Oct. 2005 – April 2006. Monitoring observations + intensive WEBT campaign around the 1st XMM-pointing date:

- ❑ Optical outburst and high brightness during the 2nd XMM pointing.

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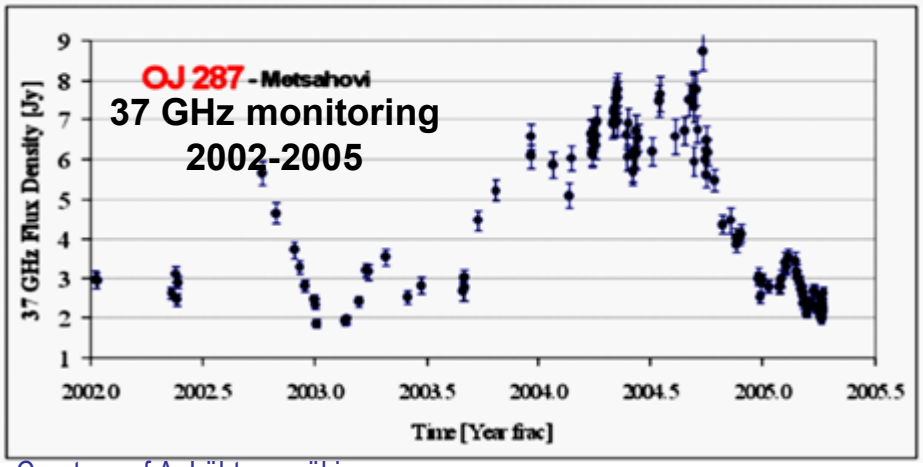
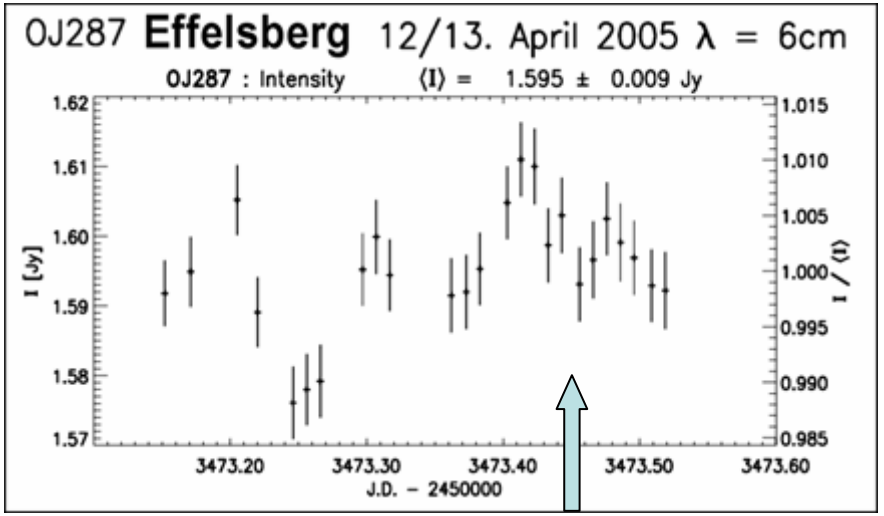
Coord. Campaign: radio observations

OJ 287: April 2005, radio flux and structure:

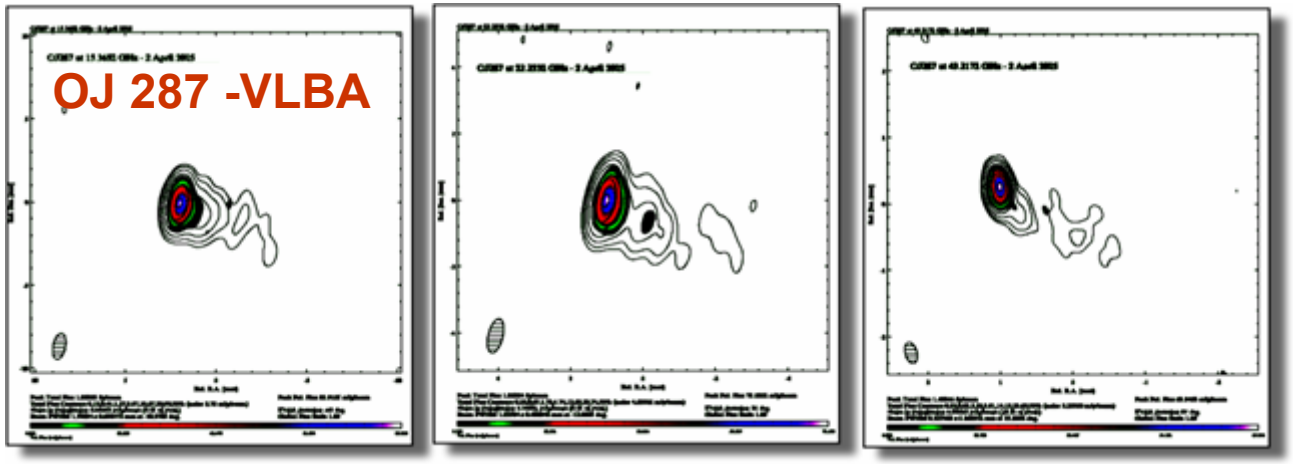


Courtesy of A. Lähteenmäki



Courtesy of L. Fuhrmann

IDV ~ 3%



Courtesy of I. Agudo

VLBA radio structure/polarization observations in 3 bands (April 2, 2005).

GLAST The Gamma Ray Large Area Space Telescope

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OJ 287 campaign: some related comments

- The OJ 287 MW campaign was really a challenge. A lot of work is needed: the XMM GO proposal (2 stages); observation requests, information support and interaction with the ground based observatories (e.g. > 200 email received); reduction of satellite and optical data; data assembling; data analysis; results publication. This could be too much to be timely handled by only 1 person.
- MW campaigns are beautiful but do not forget: - time needed; - manpower; - possible and useful funding (…a sort of GLAST MW-Legacy program could be very good).
- Reduced final radio data are easier to handle with respect to heterogeneous optical data coming from very different (professional and amateur) observatories.
- Optical data can better provide temporal information (light curves) because of the narrow spectral extension.
- A possibly constant and long-term monitoring at radio and optical bands is important to characterize the variability of blazars on different timescales. GLAST will produce long-term light curves too. Models profit of temporal variability information on several time decades.

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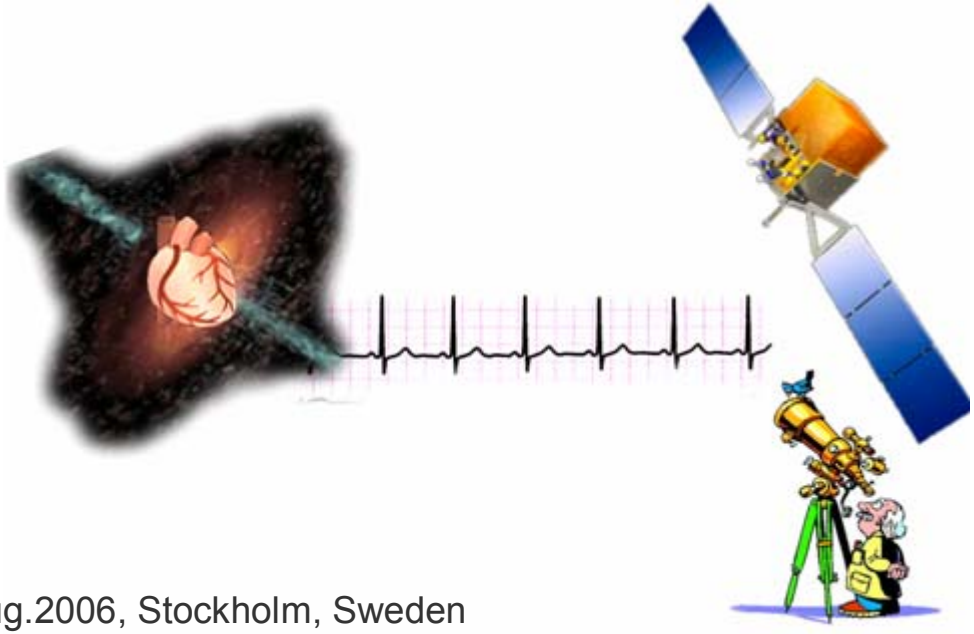
OJ 287 campaign: some related comments

- Observation of the temporal behaviour on long/intermediate timescales is important to be compared with the short-term behaviour observed during MW campaigns (~MW snapshots). Time domain (=evolution) is an important knowledge and light curve (time-series) analysis is important in many science fields (so should be important for blazars too).
- Long-term monitoring is also important from an historical point of view, being a farsighted effort (we are constructing an historical record of blazar variability on long scales, useful also for the next generation of researchers).
- Triggers and alerts for astronomical satellites and large telescopes are usually based on a regular radio-optical monitoring. Do not forget also serendipity.



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Some networks/consortiums of observatories

❑ An example of some existing telescope networks. Possible collaboration/partnership with GLAST; exchange of know-how, ideas, contacts, information, technical solutions (i.e. telescope robotization, data pipelines…); data-archives; involvement for small amateur observatories, schools/universities obs., students/teachers; public outreach; involvement of sponsors, funding agencies; promoting international collaboration, etc.

- The Whole Earth Blazar Telescope (WEBT) www.to.astro.it/blazars/webt/
- ENIGMA Network (will end next November) www.lsw.uni-heidelberg.de/projects/enigma/
- The Global Telescope Network (GTN, formerly GLAST Telescope Net.) gtn.sonoma.edu/public/
- RoboNet (1.0 = Liverpool + Faulkes telescopes) www.astro.livjm.ac.uk/RoboNet/
- Whole Earth Telescope (WET, the older network of global telescopes?) wet.physics.iastate.edu
- American Association of Variable Star Observers (AAVSO, founded in 1911) www.aavso.org
- MOA Global Network www.physics.auckland.ac.nz/moa/global_network.html
- The Whole Year Blazar Telescope (WYBT) wybt.fisica.unipg.it
- Global Network of Astronomical Telescopes (GNAT) www.darksky.org/gnat/
- Heterogeneous Telescope Networks Workshop (E-Star) ww.estar.org.uk