

Effelsberg Newsletter

May 2012

Science Highlights

Active Galactic Nuclei as high-energy particle accelerators: Probing the physical processes in the vicinity of Black Holes with the F-GAMMA program

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Call for Proposals:

Deadline June 6, 2012, 13.00 UT

Observing proposals are invited for the Effelsberg 100-meter Radio Telescope of the Max Planck Institute for Radio Astronomy (MPIfR).

The Effelsberg telescope is one of the World's largest fully steerable instruments. This extreme-precision antenna is used exclusively for research in radio astronomy, both as a stand-alone instrument as well as for Very Long Baseline Interferometry (VLBI) experiments.

Access to the telescope is open to all qualified astronomers. Use of the instrument by scientists from outside the MPIfR is strongly encouraged. The institute can provide support and advice on project preparation, observation, and data analysis.

The directors of the institute make observing time available to applicants based on the recommendations of the Program Committee for Effelsberg (PKE), which judges the scientific merit (and technical feasibility) of the observing requests.

Information about the telescope, its receivers and backends and the Program Committee can be found at

<http://www.mpifr-bonn.mpg.de/english/radiotelescope/index.html>

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Observing modes

Possible observing modes include spectral line, continuum, pulsar, and VLBI. Available backends are a FFT spectrometer (with 32768 channels), a digital continuum backend, a pulsar system (coherent and incoherent dedispersion), and two VLBI terminals (MK4/5 and VLBA/RDBE type).

Receiving systems cover the frequency range from 0.3 to 96 GHz. The actual availability of the receivers depends on technical circumstances and proposal pressure. For a description of the receivers see the web pages.

How to submit

Applicants should use the new NorthStar proposal tool for preparation and submission of their observing requests. North Star is reachable at

<https://northstar.mpifr-bonn.mpg.de/>

For VLBI proposals special rules apply. For proposals which request Effelsberg as part of the European VLBI Network (EVN) see:

<http://www.evlbi.org/proposals/proposals.html>

Information on proposals for the Global mm-VLBI network can be found at

<http://www.mpifr-bonn.mpg.de/div/vlbi/globalmm/index.html>

Other proposals which ask for Effelsberg plus (an)other antenna(s) should be submitted twice, one to the MPIfR and a second to the institute(s) operating the other telescope(s) (eg. to NRAO for the VLBA).

After June, the next deadline will be on October 9, 2012, 13.00 UT.

by Alex Kraus

RadioNet Transnational Access Programme

RadioNet (see <http://www.radionet-eu.org>) includes a coherent set of Transnational Access programmes aimed at significantly improving the access of European astronomers to the major radio astronomical infrastructures that exist in, or are owned and run by, European organizations. Observing time at Effelsberg is available to astronomers from EU Member States (except Germany) and Associated States that meet certain criteria of eligibility. For more information:

<http://www.radionet-eu.org/transnational-access>

Time on these facilities is awarded following standard selection procedures for each TNA site, mainly based on scientific merits and feasibility. New users, young researchers and users from countries with no similar research infrastructure, are specially encouraged to apply. User groups who are awarded observing time under this contract, following the selection procedures and meeting the criteria of eligibility, will gain free access to the awarded facility, including infrastructure and logistical support, scientific and technical support usually provided to internal users and travel and subsistence grants for one of the members of the research team.

by Alex Kraus



Technical News

A New Fast Fourier Transform Spectrometer for the 100-Meter Telescope

Benjamin Winkel & Alex Kraus

Since December 2011, a new FFT spectrometer, the “XFFTS” is available for spectroscopic observations at the 100-meter telescope. It provides 32768 (32k) spectral channels and usable bandwidths of 100 and 500 MHz in each of the two intermediate frequency (IF) inputs. For the 1.3-cm and 1.0-cm prime focus receivers, even a broadband mode with 2 GHz instantaneous bandwidth is available.

With its high number of spectral channels, the XFFTS is well suited for high resolution spectroscopy. Furthermore, the broadband mode strongly increases the observing efficiency of spectral line surveys.

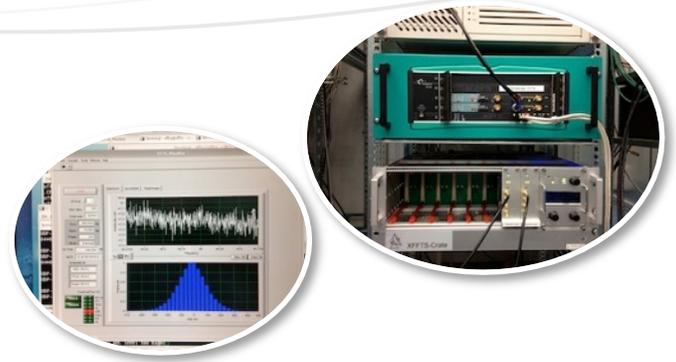
Available modes:

Bandwidth ^s [MHz]	Spectral Channels	Effective Resolution [kHz]	IF
2000	32768	70.8	Broad-band-IF (only with the 1.3cm and 1.0cm prime focus receivers)
500	32768	17.7	VLBA-IF
100	32768	3.5	VLBA-IF / Narrow-band-IF

^sNote: the usable bandwidth is about 10% smaller.

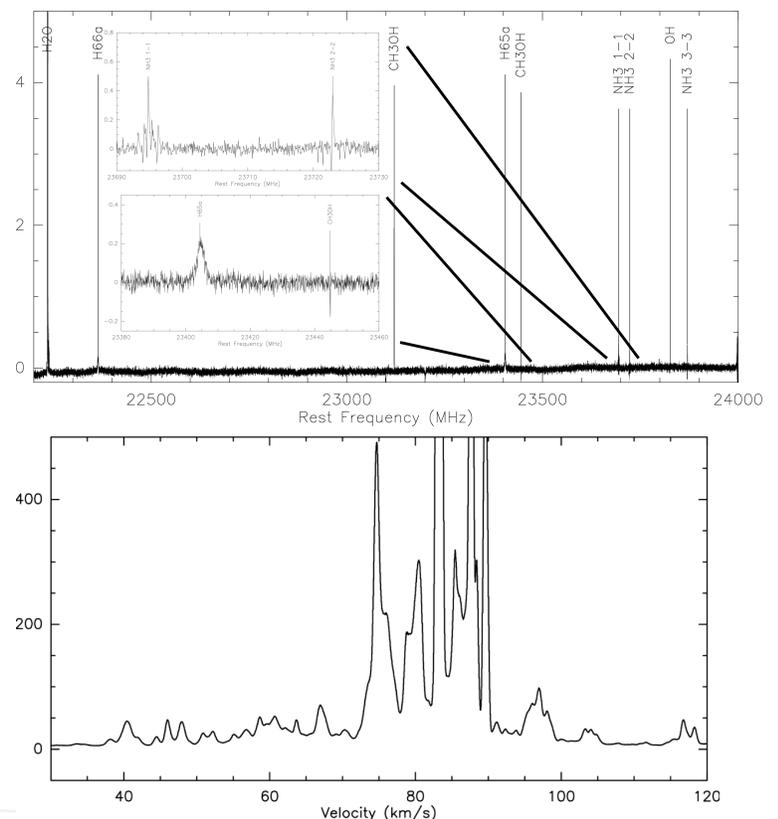
Detailed information about the FFT spectrometer developed at the MPIfR can be found in a recent paper of Bernd Klein et al. 2012 (A&A Vol. 523, L3).

And the development is not yet finished: we expect to have a FFT spectrometer with 64k channels to become usable in the near future.



Also, a 50 MHz bandwidth core is in preparation, which would boost the spectral resolution by another factor of 4 to be better than 1 kHz.

As example, two spectra observed during the system tests are shown: The first one covers a 2 GHz wide spectral range, centered at 23.0 GHz, toward W3OH. Apart from the strong water maser, a number of emission and absorption lines can be seen. The second plot shows the water vapor maser emission in W51D – the high resolution provided by the 100 MHz bandwidth mode allows to see the numerous features of the maser emission.



Science Highlights

Active Galactic Nuclei as high-energy particle accelerators: Probing the physical processes in the vicinity of Black Holes with the F-GAMMA program

*L. Fuhrmann and E. Angelakis on behalf of the F-GAMMA team,
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Introduction: AGN and γ -ray blazars

Contrary to “normal” galaxies, where the total emission is attributed to the superposition of stellar light, there exists a class of galaxies where the circumnuclear region alone outputs more energy than all the stars in the galaxy put together defining the class of Active Galactic Nuclei (AGN). We now know that extreme physical processes take place there, as a result of the presence of a central supermassive black hole (SMBH). Specifically potential energy of accreted material is transformed into radiation through magnetic field channeling of plasma into jets and consequent acceleration of it often up to relativistic speeds and out to distances of a few hundred of thousand light years. The produced radiation covers the entire electro-magnetic spectrum from radio bands to GeV and even TeV energies.

Depending on the angle of the observer relative to the line of site (as well as other parameters), the same underlying system gives rise to different phenomenologies creating an entire zoo of AGN “flavors” or subclasses such as quasars, radio galaxies, Seyfert galaxies, BL Lacertae objects etc. In the case of blazars, the line of sight is only a few degrees away from the jet axis. Consequently, relativistic effects such as Doppler boosting become dominant resulting in a series of unique characteristics and lead to a strong enhancement of the AGN broad-band emission. Dramatic intensity outbursts occur frequently due to newly injected jet material or relativistic shock evolution resulting in highly variable AGN emission on time scales of weeks up to years.

Their observed spectral energy distributions consist of two distinct components: (i) a low energy one (radio, optical, X-rays) due to synchrotron emission of the relativistic jet electrons and (ii) a high energy one (X-ray, GeV, TeV) attributed to Inverse-Compton up-scattering of photons by the relativistic electrons. The origin of the “seed-photons” is debated to be either the jet synchrotron photons themselves or “external



Figure 1: Artist's impression of an Active Galactic Nucleus. Credit: NASA/CXC/M. Weiss

photons” originating at the accretion disc or at structures such as clouds or the torus further out. Alternatively, in hadronic jet models, the high-energy component is explained through the interaction of relativistic protons with surrounding material and photon fields, proton-induced cascades or even proton synchrotron emission.

Despite the great deal of insight gained over the last decades a fundamental number of questions persist on details of the production and acceleration of jets, production and location of the high energy γ -ray emission, the exact emission processes and the origin of the observed variability and many more.

A new γ -ray observatory and the F-GAMMA program of the MPIfR

Given the broad-band and highly variable nature of AGN emission it is evident that deeper insight can be gained only through truly simultaneous observations across the whole electromagnetic spectrum. The *Fermi* Gamma-Ray Space Telescope (*Fermi*-GST) with the unmatched specifications of its Large Area Telescope (LAT) detector and the all-sky survey observing mode, allows for the first time to observe the variability of the high-energy AGN emission (20 MeV - 300 GeV) with unprecedented sensitivity, spectral and time resolution. Combined with earth-bound and space-borne observatories operating at other spectral bands (radio, optical, X-rays, TeV etc), detailed studies of the broad-band AGN emission and variability processes become possible.



Figure 2: Some of the collaborating telescopes.

The MPIfR initiated in 2007 a large collaboration of observatories and scientific groups – the F-GAMMA program (*Fermi*-GST AGN Multi-frequency Monitoring Alliance) – to explore the potential of such coordinated operation of observing facilities. The consortium includes the IRAM (Spain), Caltech (USA) and the *Fermi*-GST AGN group and combines state-of-the-art facilities to monthly monitor the AGN variability and spectral evolution of about 60 *Fermi*-GST γ -ray blazars over a, so far, unprecedented wavelength range: from cm to short-mm and sub-mm bands. This alliance includes the Effelsberg 100-m using its full multi-frequency capabilities (8 bands between 11 cm and 7 mm), the IRAM 30-m (two bands at 3 and 2 mm) and the APEX telescopes (0.8 mm) together with other collaborating observatories like the OVRO 40-m, the Planck satellite and optical telescopes. This long-term monitoring program addresses many of the scientific questions mentioned earlier, in particular the origin of the rapid blazar variability as well as the origin and location of the γ -ray emission.

F-GAMMA program: some results

The F-GAMMA program is being ran since January 2007 and has produced a wealth of high quality data. The light curves and the continuum spectra are publicly available in a compressed format (images) at

www.mpifr.de/div/vlbi/fgamma

The measurement accuracy is kept to below one percent at low frequencies and below a few percent at higher ones. The coherency time between Effelsberg and the IRAM 30-m telescope is better than 10 days. The first release of *Fermi* data was followed by a serious revision of the source sample to exclusively include *Fermi* sources. For this reason along with occasional targeting targets of opportunity or global campaigns, there is a total of about 100 multi-frequency light curves with at least a few data points.

The nature of most of the scientific objectives of the F-GAMMA program imposes the need for long data trains before reliable conclusions can be reached. Here are listed some highlights which are already or about to be published:

Radio/ γ -ray correlations: Among the most interesting questions in AGN science is the quest of possible correlations between the radio and γ -ray bands; a problem, directly related to the connection of the two emitting regions and the origin of the high-energy emission (close to the SMBH or in the radio shocks further out). Such studies include e.g. flux/flux correlation analysis as well as direct radio/ γ -ray light curve cross-correlations.

The former are very sensitive to numerous biases like artificial correlations caused by common distance effects in small samples of limited dynamic range. We have investigated such correlations between F-GAMMA and

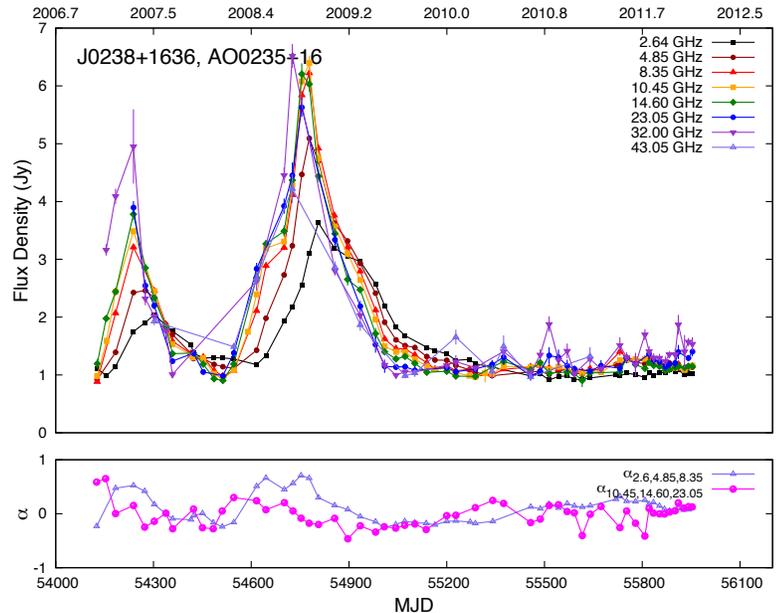


Figure 3: One of the multi-frequency F-GAMMA light curves indicating the intense activity our targets show as well as the quality of the acquired data.

Fermi/LAT 1 GeV flux densities, calculated at concurrent time intervals and, for the first time, at a large radio frequency range up to the short-mm bands. A newly developed method has been introduced for assessing the significance of these correlations and accounting for such biases. Our study shows at wavelengths below 7 mm the radio flux densities correlate with 1 GeV fluxes at significance always better than 2 sigma, while longer wavelengths do not show significant correlations. This hints towards the γ -ray emission originating close to the mm-band emission region; a view which is further supported by the fact that at 3 mm, fluxes averaged over a few months correlate with higher significance than with fluxes averaged over longer timescales.

Radio/ γ -ray light curve cross-correlations: Cross-correlating the F-GAMMA and *Fermi*/LAT three year light curves supports the above findings. While often individual sources do not yet show statistical significant correlations due to the limited time coverage, a stacking analysis reveals radio lagging corresponding γ -ray flares with lags strongly

decreasing towards short mm-bands. For instance at 3 mm the averaged lag is about 35 days, demonstrating that the emission regions are very close (< 1 pc) and coming from inside the “3 mm core region”.

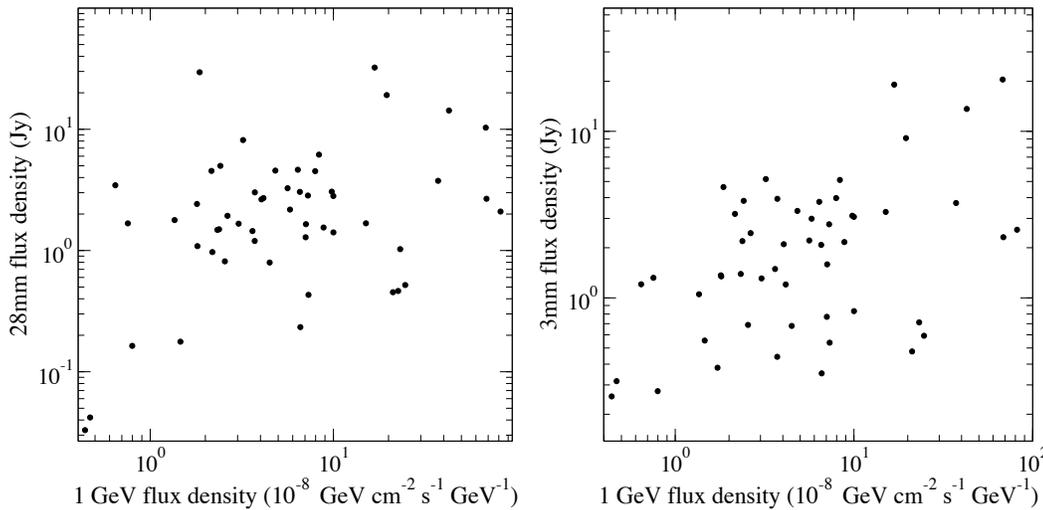


Figure 4: Radio fluxes against Fermi γ -ray flux at 28 mm (left), 3 mm (right) for the sources in our sample with known redshifts.

Variability characteristics vs γ -ray loudness: Using the three-month/one-year *Fermi* results, we have searched for possible correlations of radio characteristics with γ -ray loudness. We find that the LAT-detected sources show larger radio variability amplitudes than non-detected ones at cm to short-mm bands. However, the clear increase of the separation between flux standard deviation averages with increasing frequency is further supporting a closer correlation between γ -ray and the short-mm bands.

Origin of the radio variability and spectral evolution of flaring events: The mechanism producing the intense variability observed at radio bands has been one of the prime objectives of the F-GAMMA program. Detailed testing of e.g. shock models (time and spectral domain) becomes possible for the first time due to the simultaneous and broad F-GAMMA frequency coverage.

After collecting long enough data sets, it became clear that all the broad band continuum spectra made of Effelsberg and IRAM measurements can be classified in those changing self-similarly and those dominated by spectral evolution. Subsequent calculations showed that, in the latter case, the shock-in-jet model could easily reproduce all the observed phenomenologies with only a minor survey of the source parameter space (e.g. redshift, source power and low-frequency cut-off). In the former case, a completely different mechanism must be sought possibly in the direction of changing jet geometries. Our modeling however can be used reversely to calculate the physical conditions (magnetic fields, particle densities etc.) at the source. Furthermore, we are currently attempting a model-free study of the evolution of flares which could probably point towards an alternative evolutionary path. A first study of the multi-frequency light curves (variability amplitudes & flare time lags vs. frequency) provides further support for the shock origin of the variability in most cases.

The comparison between FSRQs (Flat Spectrum Radio Quasars and BL Lacs in our sample, however, showed that BL Lac objects exhibit systematically lower variability amplitudes at lower frequencies. Despite the similar variability time scales, the variability brightness temperatures and Doppler factors are significantly lower at lower frequencies for BL Lacs.

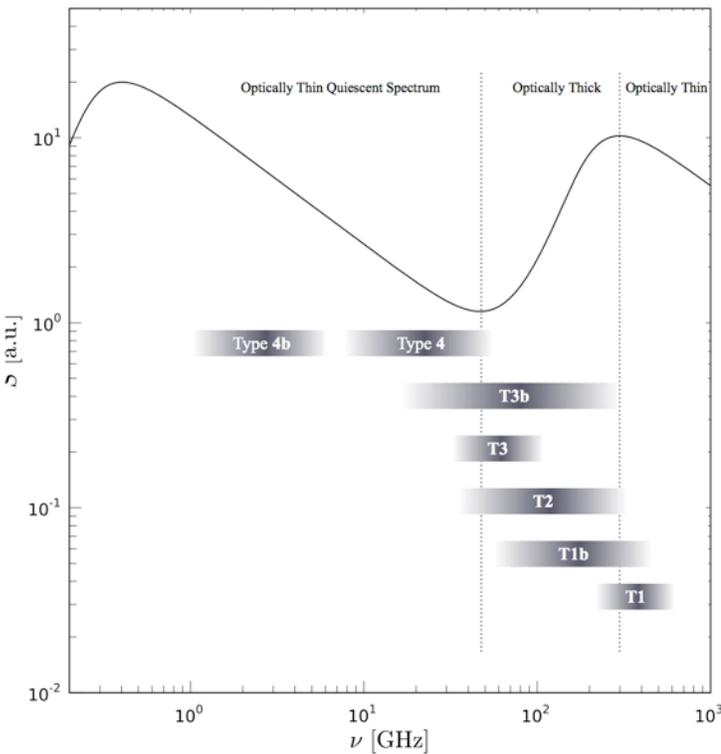


Figure 5: The simple model that seems to be describing the observed phenomenologies of all the sources dominated by spectral evolution.

Jet emission from NLSy1s: The early *Fermi* discovery of γ -ray emission from a small number of Narrow Line Seyfert 1 galaxies (NLSy1s) came as surprise; until then the only γ -ray bright classes of AGNs were thought to be blazars and radio galaxies. This discovery revolutionized the belief that jets are associated (chiefly) with large elliptical galaxies. To understand the poorly known radio

behavior of this class of AGNs, we have been studying three such sources since their *Fermi* discovery. Our study shows that the three monitored NLSy1s show a typical blazar-like behavior. That is, highly variable spectra caused by the presence of prominent evolving high frequency spectral components. The variability happens at

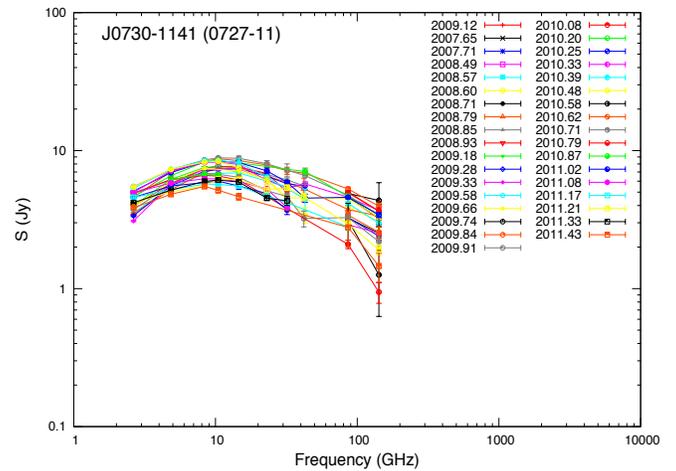


Figure 6: A source showing achromatic variability pattern

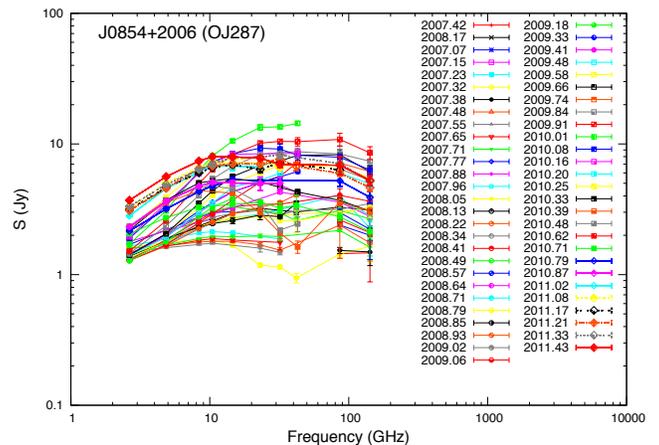


Figure 7: A source showing a pattern heavily dominated by spectral evolution.

interestingly fast pace with the mean number of events per unit time being clearly larger than that of the rest of the F-GAMMA targets.

Part of these data and studies has already been published in more than 40 refereed journal publications and more than 30 conference proceedings.

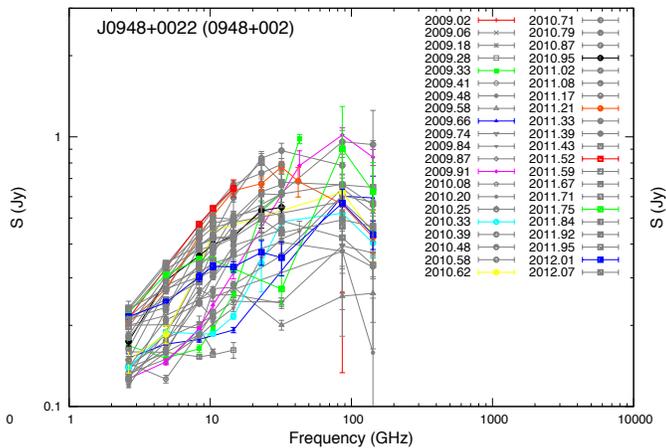


Figure 8: The F-GAMMA radio spectrum of the most famous gamma NLSY1, 0948+0022 clearly showing intense and rapid variability dominated by remarkable spectral evolution.



F-GAMMA program: the family

The F-GAMMA program was born in January 2007 and was bred in the VLBI group of the MPIfR by L. Fuhrmann, E. Angelakis, J. A. Zensus and T. P. Krichbaum. Since then it has hired four PhD students, two pre-doctoral projects and three MSc students. Currently the F-GAMMA team at MPIfR includes:

Seniors: L. Fuhrmann (P.I.), E. Angelakis (co-P.I.), T. P. Krichbaum, V. Pavlidou and J. A. Zensus

PhD Students: I. Nestoras, V. Karamanavis, I. Miserlis

MSc student: T. Breuchert

Who is Who in Effelsberg ?

Ms. Annemie Franzen and Ms. Sylvia Wilfert

Guest Administration and Public Outreach

Annemie Franzen joined the staff at the Effelsberg Observatory in 1990. Before she started at the Max-Planck-Institute she worked as a hotel manager assistant. Later on, she was employed in a cooperative bank and worked there as bank assistant until her first child was born.

Ms. Franzen is married and has three children. In her spare time she is a successful artist, and with her collie she does dog agility. She likes hiking; especially in the Dolomites.



Sylvia Wilfert studied Economics at the University of Hannover. Until the birth of her daughter she worked for the Trade Union of the chemical workers in Hannover. There, she worked as a staff member of the Press Secretary.

In 1991 Ms. Wilfert moved with her family to Bonn. She spent the following years raising her daughter and in 2006, after a long break from her career, she joined Max-Planck-Institute in Effelsberg.

In her spare time Ms. Wilfert enjoys knitting and reading criminal stories. She lives in a lovely area vis-a-vis the well-known Drachenfels mountain, close to Bonn, with her beloved old dog und two horses.

Both Ms. Franzen and Ms. Wilfert take care of administrative issues at the observatory, they support the Public Outreach and are the contact persons for lodging and transport of observers coming to Effelsberg.

Public Outreach

By Norbert Junkes

Astronomy Day 2012 at Effelsberg Radio Observatory

Once a year, amateur astronomy groups, planetariums and amateur observatories all over Germany organise a so-called “Astronomy Day”, providing a special program for visitors and astronomically interested people.

The Max-Planck-Institut für Radioastronomie participates with a program of topical talks and presentations at the visitors’ pavilion of the Effelsberg Radio Observatory.

On March 24 we presented five talks, ranging from the history of the 100m radio telescope to astrobiology, from astronomy walks in the neighbourhood of the telescope to observations of molecular lines. In a final talk, the strongest radio sources in the sky were presented to the audience:

<http://www.mpifr-bonn.mpg.de/public/pr/pr-tda12.html>

At 12:00 and at 15:00 a selection of 3D-movies was shown in the pavilion. They included a guided tour through the 100m radio telescope with Alex Kraus, the station manager, and also three astronomical movies (produced by Swinburne Centre for Astrophysics and Supercomputing) about the Sun, the astronomical distance and size scale and extreme places in the solar system. Altogether, about 400 visitors attended the talks and movie presentations in the pavilion at that day.

The presentations at the “Astronomy Day 2012” have started this year’s program for visitor groups at Effelsberg radio observatory. Public talks are offered to groups from 10 up to a maximum of 80 people. The talks are normally held in German; English talks are available on request:

http://www.mpifr-bonn.mpg.de/public/vortraege_e.html





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