



Report from the event supported by RadioNet

TITLE *THE 3C EXTRAGALACTIC RADIO SKY: LEGACY OF THE THIRD
CAMBRIDGE CATALOGUE*

DATE: *16-20 SEPTEMBER 2019*

LOCATION: *TURIN, ITALY*

MEETING WEBPAGE: <https://agenda.infn.it/e/3csky>

HOST INSTITUTE: *DEPARTMENT OF PHYSICS AT UNIVERSITY OF TURIN (UNITO)*

**RADIONET
BENEFICIARY / NO:** *OSO / 07*

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Report:

1 SCIENTIFIC SUMMARY

Supermassive black holes hosted in active galaxies have a crucial impact on their environment at all scales. The radiatively cooling hot gas in the cores of massive elliptical galaxies is reheated by relativistic jets from the central AGN. This heating could balance radiative losses of the cluster gas which is continuously emitting X-rays. This is only one of the many facets of the feedback process, occurring in radio-loud active galaxies. In the last decades, significant efforts in observational campaigns, theory, and simulations have been dedicated to unraveling the different aspects of feedback processes. Radio surveys play an instrumental role in investigating the effects of feedback in radio galaxies and their large-scale environments, studying the origin of shocks, relics and halos.

Many of the major discoveries carried out to date have one common denominator: they were made thanks to the study of radio sources belonging to the Third Cambridge (3C) Catalogue, that since 1959 has had a tremendous influence on our view of the extragalactic radio sky. It pointed out first quasars and radio galaxies, whose early studies ushered in many fields now recognized to be fundamental in high-energy astrophysics. Thus we organized this conference to commemorate 60 years since the first release of the Third Cambridge Catalogue (3C).

The 3C catalog of radio galaxies has a long history as the fundamental sample used to understand the nature and evolution of powerful radio galaxies and the relationship to their host galaxies and environments. While other samples have emerged over time, the 3CR remains the best studied extragalactic radio source sample also being a key catalog for statistical analyses of radio source properties.

The main scientific aims of the conference are to discuss major advances in studies of interactions between radio sources and their large-scale environments (i.e., feedback processes) in the context of past and anticipated future radio surveys, with special attention devoted to the legacy of the 3C radio sources. Both observational and theoretical points of view have been covered and we focused on the legacy value of the 3C catalogue, on what we learned during the past six decades and what we could expect to improve our knowledge in the forthcoming decade.

We offered participants the opportunity to propose special topical sessions that will be more interactive and three of them have been organized as reported below.

Here below we report a brief overview of the sessions organized and a few details on them.

- SESSION 1. A historical perspective of the Third Cambridge catalogue. Here the talks gave an interesting historical overview of how the 3C radio survey was carried out in the late 50s to 1960's, including Malcolm Longair and Bruce McAdam (co-author of the 1959 paper on the 3C catalog). A historical overview of the circumstances surrounding the 1963 publication in Nature of the discovery of the first Quasar and the first extragalactic radio jet, detected in 3C 273 was also detailed. Modern perspectives of the implication of the 3C catalog for jet physics, the Fanaroff-Riley vision, and future large radio galaxy samples were also discussed. On the Fanaroff-Riley division, the LOFAR observations provided a prominent role, with exquisitely detailed low-frequency arcsecond-resolution maps of a large sample of optically-identified sources giving a fresh perspective on this long-standing observational feature of radio galaxies.

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- SESSION 2. A panchromatic view of past and future radio surveys. Talks in this session highlighted the main results achieved at other frequencies outside the radio domain for the 3C survey and on the possibility of using multifrequency observations currently crucial to get a better understanding of the feedback process. In particular, the power of the HST in probing the optical morphology of the host galaxies (indicating a prevalence of mergers) and even an offset found in a quasar with respect to its host galaxy attributed to a kick due to a gravitational wave kick after the merger of the binary supermassive black hole. The Chandra observations probe the extended thermal gas environments around the radio sources, as well as non-thermal features related to the radio jets and hotspots.

- SESSION 3. Radio-loud active galaxies and their environments: feedback mechanisms - intracluster medium - mergers, shocks and cavities - role of BCGs - non-thermal processes. During this session both invited and contributed talks focused more on the large scale environments up to Mpc scale surrounding radio sources at different redshifts. We had the opportunity to listen also an overview of the LOFAR results on galaxy cluster.

- SESSION 4. The most famous 3C sources. This session was dedicated to famous 3C sources as Cygnus A (3C 405), M87 (3C 274), and Perseus A (3C 84) that have been studied in immense detail due to their proximity to Earth and brightness. These observations demonstrated most, if not all, of the many expected features in extragalactic radio sources, including radio lobes and halos, jet collimation, the direct imaging of the torus in the case of Cyg A, as well as the recent event horizon shadow detection in M87 from the Event Horizon Telescope.

- SESSION 5. Frontiers of MHD simulations at all scales: jets, outflows, and intracluster medium. This entire session is devoted to numerical codes developed to compare results obtained from observations carried out over the whole electromagnetic spectrum and those of MHD simulations. Discussion between theoreticians and “observational” participants have been extremely interesting to see their different perspectives of the same problems. In particular, numerical simulations were presented that tried to replicate several key observational puzzles, including the observed change in sign of the circular polarization with time in some jetted sources and the rapidly rotation polarization position angles (over 180 degrees) observed optically in some Blazars.

- SESSION 6. Extragalactic jets at all scales: from the central supermassive black hole to their interaction with the large scale environments. Emphasized multi-wavelength observations of the large-scale environments of radio galaxies, including the relationship between the feedback mechanisms due to the large scale radio lobes and extended gas. Of particular relevance to RadioNET were exquisite observations provided by LOFAR, demonstrating its power in detecting low-frequency, very extended lobe emission due to very old relativistic particles, and deriving lobe spectral ages, as well as Faraday rotation measure analyses.

- SESSION 7. Quasars and Blazars: the heritage of 3C273, 3C279, and 3C454.3. Focused on the highest-resolution (VLBI-scale) observations of the most compact regions of the handful of blazars contained in the 3C sample. Much emphasis was given to 3C 279, with extensive multi-scale and multi-wavelengths observations considered in modeling results, arguing for emission mechanism and emission site of the high-energy, gamma-ray emission. Novel cross-correlation analyses were also presented between polarization and total intensity data. A wider discussion of proper motion results on large samples of blazars were also considered.

- Special Sessions. Three special sessions were held in parallel, giving participants the opportunity to focus discussions on three complementary conference topics, namely:

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- A. Radio Galaxy Classification - Larry RUDNICK (convener)
- B. Multi-wavelength data - Barbara BALMAVERDE and Isabella Prandoni (co-conveners)
- C. Polarimetry - Eric PERLMAN (in absentia) and Margo ALLER (co-conveners); summary given by Alan MARSCHER.

Conveners were empowered to run each sessions as they saw fit, resulting in sessions that had varying combinations of scheduled talks, discussions involving sub-panels, and open and panel discussions. Summaries of each session were given as plenary talks on the last day of the conference.

Most of the radio facilities involved in the RadioNET have been widely represented, as ALMA, EVN, e-MERLIN and overall a lot of results from the LOFAR observations caught the attention of all our participants.

2 AGENDA OF THE EVENT

You may find it attached to this report.

3 PARTICIPANTS

Our conference had 99 participants coming to attend the meeting from different countries over all continents. In particular, 1 participant from South Africa, 2 colleagues from Australia, 6 from South America (Brazil, Chile and Mexico), 23 from USA and Canada, 11 from Asia (Russia, Israel, Japan, China, India) and 57 from Europe where 30 came from Italy (host country). Women were well represented being 36% of the total number of participants.



Attendance list including name, affiliation and country is attached to this report signed by the chair of the LOC/SOC, Prof. F. Massaro.

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4 RADIO NET FINANCIAL CONTRIBUTION

The financial contribution of 3000€ was used to waive the registration fee for 8 students/active participants/speakers.

5 PUBLICATIONS

We do not plan to have any conference proceedings and/or any publication related to the conference organization.

6 CONFIRMATION:

Following the Regulation (EU) 2016/679 - General Data Protection Regulation-, I confirm that RadioNet is allowed to publish this report, incl. participants lists, statistic's details, pictures, etc.

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All days

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Mon 16/9

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| 09:00 | <p>The 3CR Radio Sources - personal reflections <i>Prof. Malcom Longair</i></p> <p><i>Aula Darwin, Torino - Italy</i> 09:05 - 09:40</p> |
| | <p>3CR, 3CRR and Jet Physics <i>Dr Robert Laing</i></p> <p><i>Aula Darwin, Torino - Italy</i> 09:40 - 10:10</p> |
| 10:00 | <p>Revisiting the Fanaroff-Riley dichotomy with the LOFAR Two-Metre Sky Survey (LoTSS) <i>Dr Beatriz Mingo</i></p> <p><i>Aula Darwin, Torino - Italy</i> 10:10 - 10:30</p> |
| | <p>Coffee Break</p> <p><i>Aula Darwin, Torino - Italy</i> 10:30 - 11:00</p> |
| 11:00 | <p>Observing the 3C Survey of Radio Sources <i>Bruce McAdam</i></p> <p><i>Aula Darwin, Torino - Italy</i> 11:00 - 11:30</p> |
| | <p>The sequence of events that led to the 1963 publication in Nature of 3C273, the first Quasar and the first extragalactic radio jet <i>Dr David Jauncey</i></p> |
| 12:00 | <p>Catalogue with visual morphological classification of 32,616 radio galaxies with optical hosts <i>Natalia Zywucka</i></p> <p><i>Aula Darwin, Torino - Italy</i> 11:50 - 12:10</p> |
| | <p>Nature vs nurture: what shapes the hybrid jet morphology of radio galaxies? <i>Anna Kapinska</i></p> <p><i>Aula Darwin, Torino - Italy</i> 12:10 - 12:30</p> |
| 13:00 | <p>Lunch</p> <p><i>Aula Darwin, Torino - Italy</i> 12:30 - 14:00</p> |
| 14:00 | <p>The HST view of extragalactic 3C radio sources: from the central supermassive black holes to galaxy clusters <i>Dr Marco Chiaberge</i></p> <p><i>Aula Darwin, Torino - Italy</i> 14:00 - 14:30</p> |
| | <p>The promise of next-generation RC surveys: Revealing the physics and evolution of galaxies and AGN in the SKA era <i>Dr Isabella Prandoni</i></p> <p><i>Aula Darwin, Torino - Italy</i> 14:30 - 15:00</p> |
| 15:00 | |

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| | Radio bimodality of Swift/BAT AGNs and SDSS quasars <i>Aula Darwin, Torino - Italy</i> | <i>Katarzyna Rusinek</i> 15:00 - 15:20 |
| | Coffee break | |
| | <i>Aula Darwin, Torino - Italy</i> | 15:20 - 16:00 |
| 16:00 | X-ray and multi-wavelength observations of $z>0.5$ 3CRR radio galaxies. | <i>Dr Belinda Wilkes</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:00 - 16:30 |
| | Unravelling the origin of extended X-ray emission surrounding FR II radio galaxies | <i>Ana Jimenez-Gallardo</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:30 - 16:50 |
| 17:00 | Radio morphology-accretion mode link in FR II low-excitation radio galaxies | <i>Duccio Macconi</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:50 - 17:10 |
| | The composite X-ray spectrum and pc-scale radio structure of 3C RR radio sources | <i>Prof. Minfeng Gu</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 17:10 - 17:30 |
| | Aperitive | |
| | <i>Aula Darwin, Torino - Italy</i> | 17:30 - 18:00 |
| 18:00 | | |

Tue 17/9

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|-------|--|--------------------------------------|
| 09:00 | The case for AGN feedback in clusters of galaxies | <i>Prof. Julie Hlavacek-Larrondo</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 09:00 - 09:30 |
| | A multi-scale low radio frequency view of the Perseus cluster | <i>Marie-Lou Gendron-Marsolais</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 09:30 - 09:50 |
| 10:00 | NuSTAR observations of 3C84 in the Perseus Cluster | <i>Grzegorz Madejski</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 09:50 - 10:10 |
| | The Slow Heartbeat of Supermassive Black Hole Fuelling | <i>Alastair Edge</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 10:10 - 10:30 |
| | Coffee Break | |
| | <i>Aula Darwin, Torino - Italy</i> | 10:30 - 11:00 |
| 11:00 | Galaxy clusters at low radio frequencies | <i>Prof. Reinout Van Weeren</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 11:00 - 11:30 |


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| | Is AGN activity necessary to power diffuse emission in galaxy clusters? | <i>Chiara Stuardi</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 11:30 - 11:50 |
| 12:00 | Stormy weather in 3C 196.1: Nuclear Outbursts and Merger Events Shape the Environment of the Hybrid Radio Galaxy 3C 196.1 | <i>Dr Federica Ricci</i> |
| | Group photo | |
| | <i>Aula Darwin, Torino - Italy</i> | 12:10 - 12:30 |
| 13:00 | Lunch | |
| | <i>Aula Darwin, Torino - Italy</i> | 12:30 - 14:00 |
| 14:00 | Recent results from JVLA Observations of Cygnus A | <i>Dr Rick Perley</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:00 - 14:30 |
| | X-ray Observations of Cygnus A: a Powerful Radio Galaxy in a Dense Environment | <i>Paul Nulsen</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:30 - 14:50 |
| 15:00 | Feeding and feedback in radio galaxies: an X-ray perspective | <i>Francesco Tombesi</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:50 - 15:10 |
| | The Quasi-Quasar 3C 120 | <i>Alan Marscher</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 15:10 - 15:30 |
| | Coffee break | |
| | <i>Aula Darwin, Torino - Italy</i> | 15:30 - 16:00 |
| 16:00 | M87 (aka 3C274; Virgo A): The interaction between M87's black hole and its environment | <i>Dr William Forman</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:00 - 16:30 |
| | Detection of Proper Motions in the Knots of the M87 (3C 274) Jet with the Chandra X-ray Observatory | <i>Dr Ralph Kraft</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:30 - 16:50 |
| 17:00 | Exploring new data and imaging frontiers with the Event Horizon Telescope | <i>Dr Sara Issaoun</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:50 - 17:10 |
| | M87 black hole mass from observations of a jet shape break | <i>Elena Nokhrina</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 17:10 - 17:30 |

18:00

19:00

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| 20:00 | The 3C Survey - A personal perspective <i>Dr Alastair Edge</i> <i>Aula Darwin, Torino - Italy</i> 20:00 - 20:30 |
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Wed 18/9

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| 09:00 | Frontiers in Computational Plasma Astrophysics: connecting small and large scales <i>Prof. Andrea Mignone</i> <i>Aula Darwin, Torino - Italy</i> 09:00 - 09:30 |
| | How relativistic jets from AGNs affect the host galaxy and its environment <i>Dr Dipanjan Mukherjee</i> <i>Aula Darwin, Torino - Italy</i> 09:30 - 09:50 |
| 10:00 | Jets, Blobs, and Circular Polarization: Using PLUTO to Model Time Domain Variability in Blazars <i>Nicholas MacDonald</i> <i>Aula Darwin, Torino - Italy</i> 09:50 - 10:10 |
| | Self-consistent modeling of particle acceleration and evolution of spectral distribution in blazars. <i>Andrea Tramacere</i>  <i>Aula Darwin, Torino - Italy</i> 10:10 - 10:30 |
| | Coffee break <i>Aula Darwin, Torino - Italy</i> 10:30 - 11:00 |
| 11:00 | What makes a good jet? <i>Prof. Alexander Tchekhovskoy</i> <i>Aula Darwin, Torino - Italy</i> 11:00 - 11:30 |
| | Hot Relativistic Jets <i>Marek Sikora</i> <i>Aula Darwin, Torino - Italy</i> 11:30 - 11:50 |
| 12:00 | Theory vs. observations: Unraveling black hole accretion physics with the Event Horizon Telescope <i>Mr Michael Janssen</i> <i>Aula Darwin, Torino - Italy</i> 11:50 - 12:10 |
| | Reconnection and Associated Flares in Global Relativistic Jets Containing Helical Magnetic Fields with PIC Simulations <i>Prof. Kenichi Nishikawa</i> |

13:00

14:00

Tour Buses Departure from Conference Venue*Aula Darwin, Torino - Italy*

14:00 - 14:10

Thu 19/9

09:00

Powerful Radio Galaxies: The Heavy Lifters of the Universe*Prof. Brian McNamara**Aula Darwin, Torino - Italy*

09:00 - 09:30

The cool ISM reservoirs of powerful radio galaxies: a new window on fuelling and triggering*Clive Tadhunter**Aula Darwin, Torino - Italy*

09:30 - 09:50

10:00

The MURALES survey: a MUse RAdio Loud Emission lines Snapshot*Barbara Balmaverde**Aula Darwin, Torino - Italy*

09:50 - 10:10

Feedback in local radio galaxies using optical IFS*Guilherme Couto**Aula Darwin, Torino - Italy*

10:10 - 10:30

Coffee break*Aula Darwin, Torino - Italy*

10:30 - 11:00

11:00

Special Session A,B,C

12:00

Aula Darwin, Torino - Italy

11:00 - 12:30

Lunch

13:00

Aula Darwin, Torino - Italy

12:30 - 14:00

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|-------|--|--|
| 14:00 | Dynamical modelling of powerful radio galaxies and their environmental impact <i>Aula Darwin, Torino - Italy</i> | <i>Martin Hardcastle</i> 14:00 - 14:30 |
| | Life-cycle of radio galaxies seen by LOFAR <i>Aula Darwin, Torino - Italy</i> | <i>Raffaella Morganti</i> 14:30 - 14:50 |
| 15:00 | Resolved spectral studies in the SKA era: radio galaxies and the AGES-XL survey <i>Aula Darwin, Torino - Italy</i> | <i>Jeremy Harwood</i> 14:50 - 15:10 |
| | Resolved spectral ageing in 3C320 and 3C444 <i>Aula Darwin, Torino - Italy</i> | <i>Vijay Mahatma</i> 15:10 - 15:30 |
| | A study of different orientation of jet axes in DDRGs <i>Aula Darwin, Torino - Italy</i> | <i>Sumana Nandi</i> 15:30 - 15:50 |
| 16:00 | Coffee break <i>Aula Darwin, Torino - Italy</i> | 15:50 - 16:20 |
| | A new class of radio structures: hybrid ICM/radio tails <i>Aula Darwin, Torino - Italy</i> | <i>Prof. Lawrence Rudnick</i> 16:20 - 16:40 |
| | A low frequency view on the restarted radio galaxy 3C388 <i>Aula Darwin, Torino - Italy</i> | <i>Marisa Brienza</i> 16:40 - 17:00 |
| 17:00 | A correlation between supermassive black holes and the hot atmospheres of host galaxies <i>Aula Darwin, Torino - Italy</i> | <i>Prof. Norbert Werner</i> 17:00 - 17:20 |
| | POSTER HAIKUS <i>Aula Darwin, Torino - Italy</i> | 17:20 - 17:45 |
| 18:00 | Aperitive and Poster session <i>Aula Darwin, Torino - Italy</i> | 17:45 - 19:00 |
| 19:00 | | |

Fri 20/9

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| 09:00 | Legacy of Monitoring Parsec-Scale Jets of the Quasars 3C279, 3C273, and 3C454.3 <i>Aula Darwin, Torino - Italy</i> | <i>Dr Svetlana Jorstad</i> 09:00 - 09:30 |
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| | <i>Aula Darwin, Torino - Italy</i> | 09:30 - 09:50 |
| | Centimeter-band Variability in 3C 273, 3C 279, and 3C 345 as a Probe of Jet Evolution | <i>Margo Aller</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 09:30 - 09:50 |
| 10:00 | Multiwavelength behaviour of the blazar 3C 279: decade-long studies from γ-rays to radio. | <i>Valeri Larionov</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 09:50 - 10:10 |
| | Exploring the Dominant Gamma-Ray Emission Mechanism using Multiwavelength Variability Analysis. Case Study: 3C 279 | <i>Dr Victor Manuel Patiño Alvarez</i> |
| | Coffee Break | |
| | <i>Aula Darwin, Torino - Italy</i> | 10:30 - 11:00 |
| 11:00 | Analysis of 3C 279 Orphan Gamma-Ray Flare | <i>Dr Tiffany Lewis</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 11:00 - 11:20 |
| | Acceleration of AGN jets on parsec-to-kiloparsec scales. | <i>Alexander Kutkin</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 11:20 - 11:40 |
| | The radio properties of FR0 radio galaxies | <i>Dr Ranieri Diego Baldi</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 11:40 - 12:00 |
| 12:00 | UNVEILING THE PARTICLE ACCELERATION REGIONS IN 3C HOT SPOTS | <i>Giulia Migliori</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 12:00 - 12:20 |
| | Peering Into the Extended X-ray Emission on Megaparsec Scale in 3C 187 | <i>Alessandro Paggi</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 12:20 - 12:40 |
| | Lunch | |
| 13:00 | | |
| | <i>Aula Darwin, Torino - Italy</i> | 12:40 - 14:00 |
| 14:00 | Special Session Summary: Radio Galaxy Classification | <i>Prof. Lawrence Rudnick</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:00 - 14:20 |
| | Special Session Summary: Multi-wavelength perspective of the 3C radio sources | <i>Barbara Balmaverde</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:20 - 14:50 |
| 15:00 | Special Session Summary: Polarimetry | <i>Prof. Alan Marscher</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 14:50 - 15:20 |
| | Coffee break | |
| | <i>Aula Darwin, Torino - Italy</i> | 15:20 - 15:50 |
| 16:00 | Radio galaxies in gamma rays | <i>Marcello Giroletti</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 15:50 - 16:10 |
| | Gamma-emission and variability: Beaming in Radiogalaxies | <i>Stefan Wagner</i> |
| | <i>Aula Darwin, Torino - Italy</i> | 16:10 - 16:30 |
| | Closing lecture | <i>Prof. Diana Worrall</i> |

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| 17:00 | <i>Aula Darwin, Torino - Italy</i> 16:30 - 17:05 |
| | Concluding remarks <i>Prof. Francesco Massaro</i> <i>Aula Darwin, Torino - Italy</i> 17:05 - 17:10 |

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| 18:00 | Farewell |
| 19:00 | <i>Aula Darwin, Torino - Italy</i> 17:30 - 19:00 |