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ELUCIDATION:

Due to the Covid-19 the Art.51 applies to this deliverable. The original aim of this deliverable was to report on a specialised training event planned for 2020, such North European Astronomy School, CSERA2020 Summer School or LOFAR data processing school. Due to the restrictions caused by pandemic, planned training events are postponed to 2021. Thus a report on the European Radio Interferometry School (ERIS) hosted by RadioNet beneficiary Onsala Space Observatory at Chalmers University of Technology in Gothenburg on October 7-11, 2019 is the actual deliverable D3.6.

1. Introduction

The training activity of RadioNet is devoted to equipping radio astronomers and engineers with the skills, which are essential to take full advantage of the present and future radio astronomical infrastructures by offering a focussed set of schools and forums.

The European Radio Interferometry School (ERIS) is a bi-annual graduate level school that forms a fundamental part of the training and development of early-career radio astronomers (and those coming to radio from other research areas), primarily from Europe, but also from users of RadioNet infrastructures throughout the world. Beside the facilities themselves, the human capital of European radio astronomy is also a crucial factor of its success. Training in such skills, as observation, data analysis and software are needed to fully exploit the potential of RadioNet facilities including, the e-Multi-Element Remotely Linked Interferometry Network (e-MERLIN), the European VLBI Network (EVN), the Low Frequency Array (LOFAR) and the Northern Extended Millimetre Array (NOEMA). These skills are not only directly applicable to data from other major telescopes such as the Atacama Large Millimetre/sub-millimetre Array (ALMA) or the Very Large Array (VLA) but are transferable to any career involving processing of large data volumes, imaging, and technical problem solving. Although most attendees stay in an astronomy-related occupation, medical science, teaching and earth-sensing for monitoring of food security trends are among the other areas which have benefited from radio astronomy training.

Previous ERIS (with attendance in some cases exceeding 100) have been extremely successful in delivering the training needed to prepare participants to write their own proposals, reduce interferometry data and interpret their results. In alternate years, general and mm-wave focussed events are held, and have been since near the start of RadioNet cooperation back to 2004.

2. ERIS 2019

ERIS2019 was hosted by Onsala Space Observatory at Chalmers University of Technology in Gothenburg October 7-11, 2019:

https://www.chalmers.se/en/researchinfrastructure/oso/events/ERIS2019/Pages/default.aspx

The Scientific Organising Committee (SOC) consisted of Michael Lindqvist (OSO/SE; Chair), Arancha Castro-Carrizo (IRAM/FR), Liz Humphreys (ESO/DE), Katharine Johnston (University of Leeds/UK), Robert Laing (SKA/UK), Matthias Maercker (OSO/SE), John McKean (ASTRON/NL), Monica Orienti (INAF/IT), Anita Richards (UMAN/UK), Eduardo Ros (MPIfR/DE), Ilse van Bemmel (JIV-ERIC/NL), Wouter Vlemmings (OSO/SE).

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The Local Organising Committee (LOC) were from OSO and consisted of Michael Lindqvist (Chair), Stephen Bourke, Matthias Maercker, Magnus Thomasson, Carmen Toribio.

The topics covered by the lectures/tutorials included:

1. Calibration and imaging of continuum, spectral line, and polarization data;
2. observing techniques for low frequencies (e.g. LOFAR), intermediate frequencies (e.g. VLA and e-MERLIN), high frequencies (e.g. ALMA and NOEMA), and VLBI (e.g. EVN);
3. extracting the information from astronomical data and interpreting the results;
4. choosing the most suitable array and observing plan for your project.

The ERIS has become an important part in the training of young radio astronomers in Europe and beyond. It covers the theoretical concepts of interferometry, gives hands-on experience of using standard analysis software (CASA), develops critical thinking in the preparation and execution of interferometry observations, and facilitates the networking of early stage researchers. Furthermore, the school gives the opportunity for experienced researchers (postdocs) to develop their teaching skills through the delivery of lectures and tutorials. As it is the primary training event of RadioNet for basic interferometry techniques, its impact for the RadioNet community is highly significant.

The ERIS 2019 presentations, including the lecture notes, tutorial guides and datasets used for the school are archived on the school website,

https://www.chalmers.se/en/researchinfrastructure/oso/events/ERIS2019/Pages/default.aspx

It provides an additional route for the transfer of knowledge to students that were unable to attend the school and will form the basis for the material used at future ERIS. It should be noted that the oversubscription was larger than 2, see section 3.

2.1 Agenda

ERIS 2019 was carried out over a week containing both lectures and plenary tutorials were well as a day of in-depth advanced tutorials on ALMA, LOFAR and VLBI. In 2019, the SOC revised the format in response to feedback in previous years, to increase the proportion of time devoted to practical training, by integrating more background material into hands-on sessions. There were 15 lecturers / tutorial leads, of which 7 were female. The science programme was the following:

Monday 7 October 2019

08:15		Registration	
08:40		Opening/Welcome	
09:00	L1	Introduction to interferometry, part 1	Marti-Vidal (M)
09:45	L2	Introduction to interferometry, part 2	Marti-Vidal (M)
10:30		Tea/Coffee	
11:00	T1	Fun with interferometers	Laing (M)
12:15	T2	Introduction to writing a proposal, short presentation	Laing (M)
12:30		Lunch	
13:30	L3+T3	Getting started with real data, interactive, part 1	Bourke (M), König (F)

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14:15	L3+T3	Getting started with real data, interactive, part 2	Bourke (M), König (F)
		Dinner	

Tuesday 8 October 2019

08:50		LOC announcements	
09:00	L4	Millimetre/low frequency interferometry: differences and similarities	Piétu (M), Williams (F)
09:45	L5+T4	Calibration, interactive, part 1	Richards (F), Muller (M), Laing (M)
10:30		Tea/Coffee	
11:00	L5+T4	Calibration, interactive, part 2	Richards (F), Muller (M), Laing (M)
11:45	L5+T4	Calibration, interactive, part 3	Richards (F), Muller (M), Laing (M)
12:30		Lunch	
13:30	L6+T5	Introduction to imaging, interactive, part 1	Tafoya (M), Johnston (F), Spingola (F)
14:15	L6+T5	Introduction to imaging, interactive, part 2	Tafoya (M), Johnston (F), Spingola (F)
15:00		Tea/Coffee	
15:30	L6+T5	Introduction to imaging, interactive, part 3	Tafoya (M), Johnston (F), Spingola (F)
16:15	L6+T5	Introduction to imaging, interactive, part 4	Tafoya (M), Johnston (F), Spingola (F)
17:00		End	

Wednesday 9 October 2019

Note that presentations, datasets etc. can be found on https://www.chalmers.se/en/researchinfrastructure/oso/events/ERIS2019/Pages/Software-packages-and-datasets.aspx

08:50		LOC announcements	
09:00	L7+T6	Proposals and observing planning, interactive, part 1	Laing (M) + all
09:45	L7+T6	Proposals and observing planning, interactive, part 2	Laing (M) + all
10:30		Tea/Coffee	
11:00	T7	Self-calibration, part 1	Radcliffe (M), Richards (F)
11:45	T7	Self-calibration, part 2	Radcliffe (M), Richards (F)
12:30		Lunch	
13:30	L8	Polarisation	Marti-Vidal (M)
14:15	L9	Spectral line interferometry	Johnston (F)
15:00		Tea/Coffee	
15:30	L10+T8	Very long baseline interferometry, interactive, part 1	van Bemmel (F), Janssen (M), Marti-Vidal (M), Spingola (F)
16:15	L10+T8	Very long baseline interferometry, interactive, part 2	van Bemmel (F), Janssen (M), Marti-Vidal (M), Spingola (F)
17:00	L10+T8	Very long baseline interferometry, interactive, part 3	van Bemmel (F), Janssen (M), Marti-Vidal (M), Spingola (F)
17:45		End	

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18:30		Mingle with snacks
19:00		Zooming-in on Massive Star Birth

Thursday 10 October 2019

08:50		LOC announcements	
09:00	T9	Advanced tutorials	See below
09:45	T9	Advanced tutorials	See below
10:30		Tea/Coffee	
11:00	T9	Advanced tutorials	See below
11:45	T9	Advanced tutorials	See below
12:30		Lunch	
13:30	T9	Advanced tutorials	See below
14:15	T9	Advanced tutorials	See below
15:00		Tea/Coffee	
15:30	T9	Advanced tutorials	See below
16:15	T9	Advanced tutorials	See below
17:00		End	

Friday 11 October 2019

08:50		LOC announcements	
09:00	L11	Useful python tools	Bourke(M)
09:45	T10	Proposal presentations	Laing (M) + all
10:30		Tea/Coffee	
11:00	T10	Proposal presentations	Laing (M) + all
11:45	T10	Proposal presentations	Laing (M) + all
12:30		Lunch	
13:30		End of school	
14:15		End	

Advanced tutorials

Note that presentations, datasets etc. can be found on this page.

T9A	Metre/wide-field (LOFAR)	Williams (F), Toribio (F), Bourke (M)
T9B	Centimetre/polarisation	Richards (F), Johnston (F), Laing (M)
T9C	Centimetre/VLBI	van Bemmel (F), Radcliffe (M), Spingola (F)
T9D	Millimetre/spectral line (ALMA/NOEMA)	Johnston (F), König (F), Muller (M), Tafoya (M)
T9E	mm/VLBI	Janssen (M), Marti-Vidal (M)

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2.2 Attendance

The ERIS 2019 was open to all regardless of their ethnicity, gender and academic position. All attendees had to agree to a Code of Conduct during registration, which ensured a harassment-free school experience for everyone, regardless of gender, sexual orientation, disability, physical appearance, race, age, political opinion or religion.

Due to size of the venue we had to limit the number of students to 72. The number of applications received were more than 150. The following process was used to select students: Gender and country were weighted to achieve a balance. Career level was given the following weight after normalising: PhD student: 0.75, Postdoc or above: 0.15, Masters student: 0.08, Other: 0.02. An "Other information" field was provided on the application form. Some applicants wrote a motivation in there. This information was scored manually and included in the process. As this information was not requested it was given a small weight in the overall process. A random process was then used to rank the applicants using the above weightings.

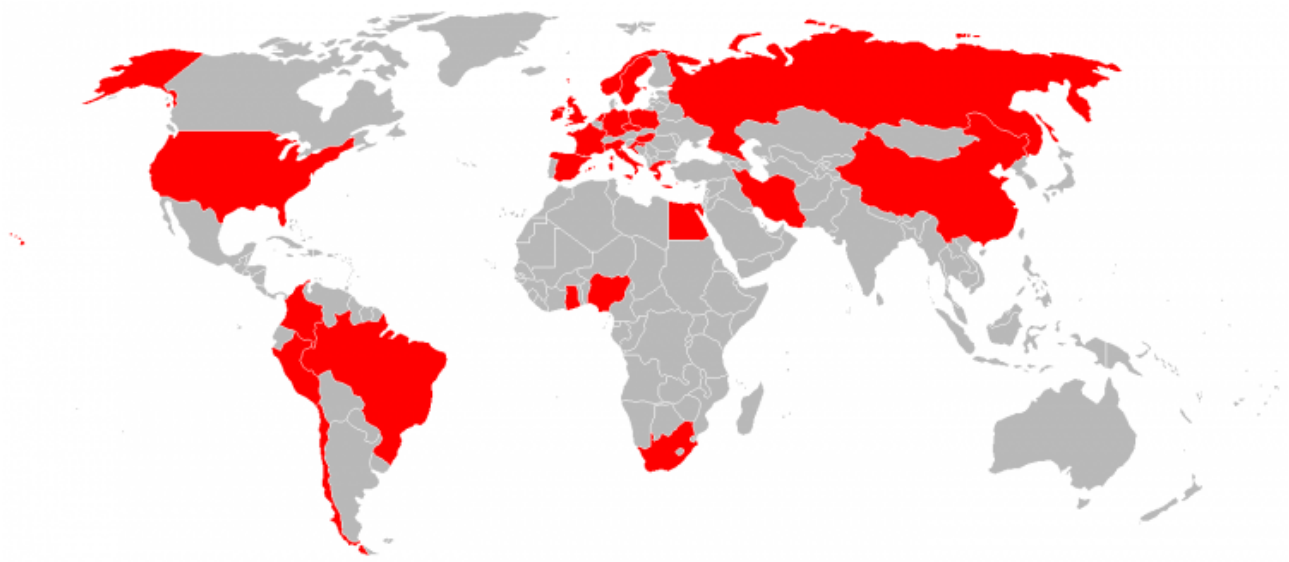

Figure 1. Map of the world showing the distribution of the participants of ERIS 2019.

The 72 students came from 26 countries, Fig. 1 and 2. The vast majority of the participants were at graduate level (Masters/PhD). The gender ratio (men vs women) for both students and lectures/ tutors were close to 50:50. In addition to the participants, there were 15 lecturers / tutorial leads (10 external, 5 internal from Chalmers).

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Figure 2. Participants in the ERIS 2019. Photo taken during a visit to Onsala Space Observatory. © Magnus Thomasson, OSO.

	Name	Affiliation	Country
1	Marta Frias Castillo	Leiden University	NL
2	Maria Moutzouri	Dublin Institute for Advanced Studies	IE
3	Joshua Lovell	University of Cambridge	UK
4	Ann Njeri	The University of Manchester	UK
5	Galina Motorina	Astronomical Institute ASCR	CZ
6	Aurora Aguayo	Universidad de Valparaís	CL
7	Jael Rojas Miguel	Pontificia Universidad Católica del Perú	PE
8	Victoria Cabedo Soto	CEA-Saclay	FR
9	Chiara D'eugenio	CEA-Saclay	FR
10	Christian Binggeli	Uppsala Universitet	SE
11	Tim Sprenger	Max-Planck-Institut für Radioastronomie	DE
12	Hugo Méndez-Hernández	CEA-Saclay	CL
13	Ivan Delvecchio	CEA-Saclay	FR
14	Asnakew Bewketu Belete	Federal University of Rio Grande do Norte	BR
15	Thomas Rose	Durham University	UK
16	Alexandra Le Reste	Stockholm University	SE
17	Ciara Maguire	Trinity College Dublin	IE
18	Aleksandr Popkov	Moscow Institute of Physics and Technology	RU
19	Ana Jimenez Gallardo	Università degli Studi di Torino	IT
20	Aoife Maria Ryan	Trinity College Dublin	IE

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	Name	Affiliation	Country
21	Jenny Kim	Universität Heidelberg	DE
22	Miriam Mumbua Nyamai	University Of Cape Town	ZA
23	Sambatriniaina Hagiriche Aycha Rajohnson	University of Cape Town	ZA
24	Farrah Zainol	UNIVERSITY OF BIRMINGHAM	UK
25	Rebeka Bőgner	Eötvös Loránd University	HU
26	Felix Pötzl	Max-Planck-Institut für Radioastronomie	DE
27	Maria Edvige Ravasio	University of Milano-Bicocca & INAF	IT
28	Rozeena Ebrahim	University of the Witwatersrand	ZA
29	Bonny Barkus	The Open University	UK
30	Rosemary Coogan	University of Sussex	UK
31	Mohamed Said Darwish	National Research Institute of Astronomy and Geophysics	EG
32	Ana Erceg	Ruđer Bošković Institute	HR
33	Henrik Eklund	University of Oslo	NO
34	Juan Camilo Guevara Gomez	University of Oslo	NO
35	Alba Covelo Paz	Universidad Complutense de Madrid	ES
36	Aleksandra Leśniewska	Adam Mickiewicz University	PL
37	Daria Zobnina	Russian Academy of Sciences	RU
38	Felipe P. Mosquera	University of Leed	UK
39	Mohammad Javad Shahhoseini	Shahid Beheshti University	IR
40	Tímea Orsolya Kovács	Max Planck Institue for Radio Astronomy	DE
41	Dongjin Kim	Max Planck Institute for Radioastronomy	DE
42	Albert Kuntu Forson	Ghana Space Science and Technology Institute	GH
43	Silvia Belladitta	Università degli Studi dell'Insubria & INAF - OA Brera	IT
44	Jun Liu	Max-Planck-Institut für Radioastronomie	DE
45	María Teresa Valdivia Mena	Universidad de Chile	CL
46	Isabella Lamperti	University College London	UK
47	Magda Kulczak-Jastrzębska	Jagiellonian University	PL
48	Lauren Rhodes	University of Oxford	UK
49	Boris Sindhu Kalita	CEA - Saclay	FR
50	Palaskos Achilleas	Aristotle University of Thessaloniki	GR
51	Tracy Garratt	University of Hertfordshire	UK
52	Ugochukwu Christian Elejere	University of Nigeria	NG
53	Pedro Mafa	University of South Africa	ZA
54	Luka Turić	Ruđer Bošković Institute	HR
55	Chiara Ceccobello	Chalmers	SE
56	Timur Mufakharov	Chinese Academy of Sciences	CN
57	Juan Sebastian Hincapie Tarquino	Universidad Nacional de Colombia	CO
58	Christian Sahlholdt	Lund Observatory, Sweden	SE
59	Alexander Bartilsson	Stockholm University	SE
60	Johannes Allotey	University of Bristol	Uk
61	Paz Alonso Arias	Instituto de Astrofísica de Canarias	ES
62	Ilin Lazar	Max Planck Institute for Astronomy	DE
63	Nasiru Aliyu	University of Nigeria Nsukka	NG

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	Name	Affiliation	Country
64	Romain A. Meyer	University College London	UK
65	Aleksei Nikonov	Lebedev Physical Institute	RU
66	Valentina Missaglia	Center for Astrophysics, Harvard & Smithsonian	USA
67	Anastasiia Girdiuk	Bundesamt für Kartographie und Geodäsie (BKG)	DE
68	Dennis Alp	KTH Royal Institute of Technology	SE
69	Nikita Kosogorov	Moscow Institute of Physics and Technology	RU
70	Giacomo Principe	IRA - INAF	IT
71	Chi Yan Law	Chalmers	SE
72	Niklas Falstad	Chalmers	SE
73	Sara Piras	Chalmers	SE

3. Impact

Over the period of a week, ERIS provided the participants with theoretical understanding of complex concepts of interferometry, gave hands-on experience on using standard analysis software (CASA, AIPS), developed critical thinking in the preparation and execution of interferometry observations. ERIS also facilitates the networking of early stage researchers. For example, a subgroup interested in Solar physics contained students working on extremely low and very high radio frequencies. Despite a scarcity of detailed comparisons in the literature, they devised a hypothetical observing project to exploit this range, with the intention of future collaboration. In addition, the school gave opportunities to experienced researchers (postdocs) to develop their teaching skills through the delivery of lectures and tutorials. As part of the review of the school, the students completed a short questionnaire (~30% response), in which 100% of the respondents considered the school to be “useful”. Additional comments and suggestions (mainly about the limited time allotted for tutorials) from the participants will be incorporated into future ERIS.

In many cases, students/researchers came from institutes with only a few or even no experienced radio astronomers, or from countries just developing their capacity. Thanks to ongoing contact with a number of attendees, we know that they are already preparing specific plans for exploitation of radio interferometry and RadioNet facilities. They also encourage their colleagues to participate in other RadioNet activities such as Short Term Missioins and the Spectrum Management school.

At the other extreme, we 'exploited' attendees with some previous experience as demonstrators. In a typical tutorial, the tutor would provide a skeleton script or an example, and explain the purpose of each step, whilst the students filled in the details and discovered how to check whether they had optimised the inputs. The demonstrators performed this on a large screen, both to ensure that the tutor did not go too fast, and (once the class had had time to experiment) to show the required inputs and results. This gave confidence to the demonstrators and made the topics more approachable for all.

Many of the current staff at RadioNet facilities are 'graduates' of previous ERIS, and many more continue to exploit RadioNet instruments for research. In the 6 months since ERIS 2019, there are at least two dozen papers listed on ADS with trainees who attended on the author list and 'Radio' in the abstract, e.g. 2020A&A...633A..56M (LOFAR), 2020MNRAS.495.1188M and 2020MNRAS.493.4442D (e-MERLIN), 2020arXiv200104576G (EVN).

The RadioNet contribution was vital in keeping the costs low enough to enable radio astronomers from all over Europe to attend, especially from institutes without long tradition and depth of

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expertise in this field, as well as providing expert lecturers and enough tutors to ensure that the hands-on sessions went smoothly and participants could focus on radio astronomical problem solving.

Software packages, datasets and presentations are available on-line: https://www.chalmers.se/en/researchinfrastructure/oso/events/ERIS2019/Pages/Software-packages-and-datasets.aspx . Lessons from ERIS including the selection procedure have been added to the ERIS Organisers' Manual https://radiowiki.mpifr-bonn.mpg.de/lib/exe/fetch.php?media=na:training:eris-manual_radionet-2019aug_amsr.pdf.

4. RadioNet financial support

The RadioNet contribution was used to cover the accommodation for the students (18000 €). The registration fee for each student was 1680 SEK (excluding VAT), which was used to cover the lunches. Onsala Space Observatory, Chalmers, covered the rest of cost for the school.

5. Acronyms

CASA	Common Astronomy Software Application
ALMA	Atacama Large Millimetre/sub-millimetre Array
e-MERLIN	UK radio interferometry array
ERIS	European Radio Interferometry School
EVN	European VLBI Network
LOC	Local Organising Committee
LOFAR	Low Frequency Array
NOEMA	NOrthern Extended Millimetre Array
SOC	Scientific Organising Committee
VLA	Very Large Array
VLBI	Very Long Baseline Interferometry

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