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# FRANCESCA CAPEL

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## EDUCATION

01/09/2015 - present

### Doctor of Philosophy (Ph. D.)

KTH Royal Institute of Technology

- Supervised by Prof. Christer Fuglesang, Prof. Mark Pearce and Prof. Daniel J. Mortlock.
- Thesis title: *Identifying the origin of ultra-high-energy cosmic rays: novel instrumentation and analysis aspects.*
- Planned graduation in June 2020

01/09/2012 - 31/08/2013

### Master thesis (Erasmus Program)

École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

- Supervised by Prof. Ivo Furno and Prof. Benoit Labit
- Thesis title: *Characterization of scrape-off layer plasma using Langmuir probes in the TCV tokamak.*
- Awarded the *European Master Certificate in Fusion Science and Engineering* by the FuseNet Association.

01/09/2010 - 01/08/2014

### Msci. (Hons.) Degree in Physics

Imperial College London, United Kingdom

- Graduated with First Class Honours.
- Specialized in Astrophysics, Plasma Physics, Space Physics and Cosmology.

## RESEARCH POSITIONS

01/09/2014 - 31/08/2015

### Young Graduate Trainee

ESTEC, European Space Agency (ESA), The Netherlands

- Testing and calibration of a novel, highly miniaturized radiation monitor for space applications.

01/06/2009 - 31/08/2009

### Nuffield Science Bursary holder

Cardiff University, United Kingdom

- Based in the Electrical engineering department.
- Design and testing of a near-field microwave microscope.
- Received Gold CREST award.

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## PUBLICATIONS

I have a total of **8** publications in refereed academic journals, including papers with the full JEM-EUSO Collaboration author list. In this section I list only publications that I have lead and/or made substantial contributions to. I also list relevant conference proceedings to highlight my contributions as part of the JEM-EUSO Collaboration.

Link to full publication list on Google Scholar: <https://scholar.google.com/citations?user=jKM43oUAAAAJ>.

### Selected publications

1. **Capel, F.** & Mortlock, D. J., 2019, Impact of using the ultra-high-energy cosmic ray arrival energies to constrain source associations. *Monthly Notices of the Royal Astronomical Society*, 484, 2324, 10.1093/mnras/stz081. Cited by 3.
2. **Capel, F.** et al., 2018, Mini-EUSO: A high resolution detector for the study of terrestrial and cosmic UV emission from the International Space Station. *Advances in Space Research*, 62, 2954, 10.1016/j.asr.2017.08.030. Cited by 21.
3. Belov, A., Bertaina, M. **Capel, F.\*** et al., 2018, The integration and testing of the Mini-EUSO multi-level trigger system. *Advances in Space research*, 62, 2966, 10.1016/j.asr.2017.10.044. Cited by 12.  
\* **Capel, F.** is corresponding author, but author list is alphabetically ordered.

### Under review

4. **Capel, F.** et al., Mini-EUSO (Extreme Universe Space Observatory) data acquisition and control software. Under review with the *Journal of Astronomical Telescopes and Instrumentation*. Submitted in July 2019.

### Selected conference proceedings

5. **Capel, F.** et al., 2017, Mini-EUSO flight software and operations on ISS. *Proceedings of the 35th International Cosmic Ray Conference (ICRC 2017)*, PoS, 454. Cited by 3.
6. **Capel, F.** et al., 2017, The Mini-EUSO multi-level trigger algorithm and its performance. *Proceedings of the 35th International Cosmic Ray Conference (ICRC 2017)*, PoS, 453. Cited by 1.

## AWARDS

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|------------|---|
| 15/01/2019 | Shortlisted as one of four finalists for the American Statistical Association's <i>Best Astrostatistics Student Paper Award</i> . |
| 31/08/2018 | TeVPA award for <i>Excellent Young Scientists</i> , 500 EUR.  |
| 01/12/2014 | FuseNet Association <i>European Master Certificate in Fusion Science and Engineering</i> .  |
| 30/09/2009 | Gold CREST award ( <a href="https://www.crestawards.org/crest-gold">https://www.crestawards.org/crest-gold</a> ).                 |

## GRANTS

Grants awarded for conferences, short research visits and equipment.

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|------------|---|
| 26/06/2019 | <b>9 800 SEK</b> from Jubileumsanslaget for travel to the JSM conference, main applicant .  |
| 08/05/2019 | <b>15 000 SEK</b> from Gållöstiftelsen for travel to the EPS-HEP conference, main applicant.  |
| 28/06/2018 | <b>18 900 SEK</b> from Signeuls Stiftelsen for travel to the TeVPA conference, main applicant.  |
| 23/11/2017 | <b>50 000 SEK</b> from Alexandra och Bertil Gyllings Stiftelsen for research visits and equipment related to the Mini-EUSO project, co-applicant with Christer Fuglesang. |
| 22/02/2017 | <b>2 700 SEK</b> from the Swedish National Space Board for travel to the SRS meeting.   |

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## SCIENTIFIC SERVICES

- Referee for the *Monthly Notices of the Royal Astronomical Society* journal.
- Advocate for reproducible, open-source research and programming, active on GitHub ([www.github.com/cescalara](http://www.github.com/cescalara)).
- Organizer of the 18<sup>th</sup> JEM-EUSO Collaboration Meeting, Stockholm 7<sup>th</sup>-11<sup>th</sup> December 2015.

## INVITED TALKS

- 30/07/2019 **American Statistical Association - Joint Statistical Meetings, Denver**  
Impact of using the ultra-high-energy cosmic ray arrival energies to constrain source associations.
- 13/07/2019 **European Physical Society - High Energy Physics, Ghent**  
Multi-messenger astroparticle physics through hierarchical modelling.
- 16/11/2018 **Bayes Forum, Max Planck Institute for Astrophysics, Munich**  
A hierarchical model for the energies and arrival directions of ultra-high-energy cosmic rays.
- 28/02/2018 **Research Seminar, University of Turin**  
Scientific goals of the Mini-EUSO mission.
- 09/06/2017 **Science Coffee, ESTEC, European Space Agency, Noordwijk**  
The Mini-EUSO instrument.

## OTHER TALKS

- 04/04/2019 **IMAGINE Consortium workshop, Nijmegen**  
Connecting UHECR theory to data via hierarchical modelling.
- 15/11/2018 **CRC 1258 working group, Max Planck Institute for Extraterrestrial Physics, Munich**  
Impact of using the ultra-high-energy cosmic ray arrival energies to constrain source associations.
- 25/10/2019 **Extreme objects working group, Oskar Klein Center, Stockholm**  
A hierarchical model for the sources of ultra-high-energy cosmic rays.
- 31/08/2018 **TeV Particle Astrophysics, Berlin**  
Connecting UHECR theory to data with Bayesian hierarchical models.
- 01/12/2015 **Partikeldagarna, Uppsala**  
Towards a space-based cosmic ray observatory.

## SCHOOLS & COURSES

60 ECTS of graduate-level courses at KTH and Stockholm University in *Advanced Astrophysics*, *Frequentist Statistical Methods*, *Bayesian Statistics for Astronomers and Physicists*, *Quantum Field Theory* and *General Relativity*.

Other courses

- Proposal writing workshop, Technische Universität München, 11-14/08/2019.
- CERN School of Computing, Universidad Politécnica de Madrid, 27/08/2017 - 09/09/2017.
- Robust Chip Inc. TCAD sensor simulation workshop, ESA/ESTEC, 15-16/04/2015.
- Space Systems Engineering course organized by Southampton University, ESA/ESTEC, 14-16/10/2014.
- Geant4-DNA radiation simulation workshop, ESA/ESTEC, 07/11/2014.

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## TEACHING & SUPERVISION

Teaching assistant for the *Radiation, Protection, Dosimetry and Detectors* and *Modern Physics* courses at KTH Royal Institute of Technology during the autumn semester of 2015 and 2016.

Erasmus student theses from the University of Turin

- D. D'Ago, *Simulations of UHECR induced air showers in ESAF*, 31/08/2017.
- S. Durando, *Data analysis for the EUSO-SPB mission*, 31/08/2017.
- A. Liberatore, *Optimization of the L2 trigger algorithm for Mini-EUSO*, 31/08/2016.

Bachelor student theses as part of the MIST student CubeSat project

- C. Eriksson & V. Minoz, *Development of a Helmholtz coil for the MIST satellite*, 27/05/2019.
- M. Al-Janabi & L. Fischer, *A subsystem simulator for the MIST satellite*, 27/05/2019.

Bachelor student theses at the KTH Department of Physics

- F. Hülphers, *Identification of UHE cosmic rays using neural networks*, 31/05/2018.
- P. Bühlmann & J. Sigvant, *Simulation study of meteors for Mini-EUSO*, 31/05/2017.

## OUTREACH

- 20/08/2019 Press release on the KTH website (in Swedish) for the launch of the Mini-EUSO experiment on-board the Soyuz MS-14 rocket to the International Space Station.  
link: <https://www.kth.se/forskning/artiklar/svensk-mjukvara-skickas-till-rymden-1.919615>.
- 30/11/2018 *Gravitational waves*, popular science seminar for undergraduate students at KTH as part of the *Modern Physics* course.
- 12/09/2018 *Exploring the universe with ultra-high-energy cosmic rays*, KTH Library public seminar series, filmed and published online.  
link: <https://www.youtube.com/watch?v=HK0hus6qBXQ>, **675 views**.
- 02/02/2018 Interview with *Rymdstyreslen* (Swedish National Space Agency) space blog (in Swedish), filmed and published online.  
link: <https://www.youtube.com/watch?v=-vEmMWaM5cU>, **471 views**.
- 24/10/2017 *Gravitational waves*, invited popular science talk at the KTH Ph. D. Conference, Helsinki.
- 05/10/2014 Volunteer at the European Space Agency's open day at ESTEC. Gave short talks and answered questions from the public.

## SKILLS

Programming (<https://github.com/cescalara>)

- Advanced: C/C++, python, Stan
- Competent: VHDL and high-level synthesis, ROOT, Geant4.
- Familiar: R, MATLAB, Fortran.

Software

- Engineering: Xilinx Vivado Design Suite, AutoCAD, Accuro TCAD.
- Tensorflow, LaTeX.

Languages

- Mother tongue: English.
- Fluent: Swedish, French.
- Basic knowledge: German, Dutch.

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## RESEARCH EXPERIENCE

My research has focused on the development of instrumentation, software and data analysis techniques which I have applied to a range of important problems in high energy astrophysics, space physics, plasma physics and electrical engineering. I enjoy drawing on my varied experience to synthesise new ideas and solve problems creatively.

### **Astrophysical neutrino source population constraints**

Using the IceCube observations of an astrophysical neutrino flux, but no significant point sources to place constraints on the properties of the unknown source population. I have independently proposed a novel approach that goes beyond the standard “multiplet limit” by improving the physical model, including a luminosity function, realistic cosmological evolution and uncertainties. In this way, the various results can be brought together in a single analysis to coherently show constraints on the source population. This can be useful in sensibly choosing the catalogs of astrophysical sources for an association analysis. The work is ongoing in collaboration with Prof. Daniel J. Mortlock and Prof. Chad Finley. *An associated publication is currently in preparation.*

### **Association analysis of ultra-high-energy cosmic rays and astronomical source catalogs**

Independently proposed successful work on the application of advanced statistical techniques to key questions in ultra-high-energy cosmic ray (UHECR) physics and multi-messenger astronomy. The initial proposal was reviewed and accepted by the doctoral supervisors (Prof. Christer Fuglesang and Prof. Mark Pearce). These projects then became the focus for the Ph. D. work after the halfway point of 2.5 years, and new collaborator Prof. Daniel J. Mortlock was added as an external co-supervisor. The work concerned on the development of a hierarchical model for the UHECR energies and arrival directions. This was then used to analyse the association of cosmic rays with astronomical source catalogs, resulting in *publication 1*.

### **Instrument data analysis and control software**

Responsible for the Mini-EUSO instrument software and author of greater than 10k lines of code. The software is an asynchronous, object-oriented design implemented in C/C++ and released as open source with integrated documentation. Also responsible for the design and implementation of the level 2 trigger algorithm for Mini-EUSO, implemented in the FPGA of the front-end electronics. This software will be used by other instruments as part of the JEM-EUSO collaboration work. The work has resulted in *publications 4 and 5*.

**Development of a space-based ultra-high-energy cosmic ray detector** Lead contributor to the integration and testing of the Mini-EUSO instrument, which was successfully launched to the International Space Station on the 22nd August 2019. Also contributed to the characterization of PMTs and front-end electronics for the EUSO-SPB NASA Balloon project, and completed shift work at the Telescope Array site in Utah for the observation of UHECR air showers with the EUSO-TA instrument. These detectors have laid essential groundwork for future large-scale projects like K-EUSO and POEMMA. This work has lead to *publications 2, 3 and 6*.

**Development of a novel miniaturized radiation monitor** Testing and calibration of a highly miniaturized radiation monitor for the European Space Agency, based in the TEC-EES section for the study of the space environment and its effects on satellites. The monitor was designed to be small and lightweight in order to be easily mounted on a wide range of satellites. This would allow us test models of the Earth orbit space environment with direct measurements of charged particles, as well as provide a monitor for scientific instruments which can be affected by the charged particle background.

**Characterization of plasmas for nuclear fusion research** Analysis of measurements from Langmuir probes inserted into magnetically confined plasmas at the TCV Tokamak in Switzerland. By studying the plasma behavior at the edge of confinement, the energy loss mechanisms can be understood, and the energy losses to the container walls can be calculated. The work focused on a comparison of energy loss predictions from magnetohydrodynamic simulations and theory to the experimental measurements. The results have important implications for scaling up the size of fusion reactors, relevant for the design of the ITER project.

**Development of a near-field scanning microwave microscope** Design and testing of a near-field scanning microwave microscope for non-destructive measurement of small-scale variations in surface topology. Motivated by the need for a non-destructive alternative to atomic force microscopy commonly used for such applications. Based in the electrical engineering department of Cardiff University under the supervision of Prof. Adrian Porch.