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**Scientific report from of the workshop**

**Supernova from GAIA and PESSTO Workshop**

Queen's University Belfast

5-7 February 2014

**Application reference number : 5065**

## Summary

### Organisers:

#### Scientific Organising Committee :

Stephen Smartt: Queen's University Belfast, UK

Michel Dennefeld: IAP, Paris, France

Wolfgang Hillebrandt: MPA, Garching, Germany

Xavier Luri: University of Barcelona, Barcelona, Spain

Seppo Mattila: Tuorla Observatory, Turku, Finland

Ferdinando Patat: ESO, Germany

Nancy Elias de la Rosa: IEEC, Barcelona, Spain

Mark Sullivan: University of Southampton, UK

Massimo Turatto: Observatory of Trieste, INAF, Trieste, Italy

Nicholas Walton: IoA, Cambridge, UK

All the SOC attended the meeting except Hillebrandt and Patat who had prior commitments.

#### Local Organising Committee :

S. Smartt (Chair), K. Smith, D. Young, T.W. Chen, D. Wright, J. Kennedy (secretarial support)

### Participants

42 Participants attended the workshop including 7 invited speakers and 9 ECR funded researchers.

Participants came from 10 countries outside of the UK, mostly European ESF institutes Netherlands, Spain, France, Finland Italy and Germany and also from Chile and Australia.

### Invited and Contributed talks

6 invited speakers gave 30-minute talks at the meeting. We also invited Prof. Gerry Gilmore to deliver a public lecture on the topic of the workshop, as a public outreach activity. This was very well attended (over 200 members of the public registered for the lecture) and Prof. Gilmore delivered a excellent and engaging science talk which highlighted this ESF meeting amongst the wider local population.

There were 22 early career researchers taking part in the workshop and 9 of them gave presentations.

The programme and attendees are given at the end of this report.

### Session topics covered by the talks

The 3-day workshop was divided into 5 sessions:

- 1) Gaia and the Transient Sky: The promise of Gaia & PESSTO for SNe
- 2) The Gaia Transient system
- 3) The Gaia SN Science Yield
- 4) The Gaia-SN classification challenge
- 5) The Gaia Supernova Roadmap

## Webpage

The general workshop page is:

<http://wiki.pessto.org/pessto-wiki/pessto-meetings/gaia---pessto-great-esf-workshop>  
Where the PDF files of the talks can be found.

## Location

The GAIA-PESSTO Workshop took place at Queen's University Belfast from 5-7 February 2014.

## Description of the content

### **Goals of the meeting (from the Proposal)**

This workshop will bring together the key European groups investigating Supernovae, both in understanding the physics of the objects, and their use as probes of the nearby Universe and for cosmology. The meeting will focus on the significant impact that Gaia will shortly have in revealing a significant yield of thousands of newly discovered SN – generating statistically significant samples of hitherto rare events, such as ultra-luminous SN. The workshop will be a key milestone in the organisation of the follow-up and exploitation of the Gaia SN – where scientific and operational priorities will be agreed. The meeting, to be organised early 2014, is timely with the upcoming first SN candidates from Gaia by autumn 2014. The workshop will lead to the development of a specific 'Gaia SN roadmap' defining the follow-up campaign to ensure maximal scientific return from the Gaia SN sample.

### **Content of the meeting to address the goals**

A major theme of the meeting was how PESSTO could interact with the GAIA mission to maximize science for the European community. PESSTO is the Public ESO Survey of Transient Objects and began in April 2012 as one of two ESO public spectroscopic surveys. It uses the EFOSC2 and SOFI instruments on the NTT during 10 nights a month and runs nine months of the year. PESSTO has strategically partnered with LSQ, SkyMapper, Pan-STARRS1 and OGLE-VI to get a live and continuous feed of optical transients from these surveys and to provide rapid spectroscopic follow-up together with publicly releasing the classification data and information of on these transients within 24hrs. The combination of these wide field surveys and dedicated spectroscopic follow-up has uncovered a surprising and remarkable diversity in stellar explosions. Given the success of PESSTO thus far, and the scientific promise of GAIA the meeting focused on how the two could be combined in the most productive way.

We were successful in getting the key personnel from both GAIA and PESSTO to the meeting to present talks and have lively and extended discussion sessions. We had overview talks about GAIA Alters and PESSTO, covering their current status and what the leaders of these surveys thought about maximising their joint potential. In this regard we had presentations

from Smartt (PESSTO PI and Survey Director) and Young (PESSTO senior software developer) and from Walton, Luri and Hodgkin (major figures in the GAIA alerts and science archiving systems).

The meeting had two major threads – one to discuss recent science results and one to discuss logistically how we can work with GAIA, PESSTO and the other European teams in the future. Concerning the science, we had talks highlighting important new results, mostly from early career researchers (ECRs), many of whom we supported to attend the meeting with the GREAT ESF funds. This gave the younger scientists a chance to present their results and how it would impact the future direction of the GAIA – PESSTO (and broader collaborations).

The science talks covered thermonuclear type Ia supernovae and core-collapse supernovae, the two theoretical paradigms that have stood for the previous two decades. There were also presentations and discussions on supernovae that currently do not have a clear physical explanation and what the future GAIA – PESSTO synergy could bring to the understanding of those (talks by Fraser, Campbell, Maguire, Kotak, Inserra, Jerkstrand, Kangas and Rigault).

As well as PESSTO, there are also several other optical spectroscopic follow-up surveys ongoing that can further enhance the supernova science exploitation of GAIA. The meeting had presentations (and discussions) on the following projects. The ASIAGO supernova follow-up project was presented (Tomasella), along with the view from the major Australian follow-up campaign (Childress). An overview of the broad European perspective was given, along with significant discussion.

Finally, we invited some of the key personnel from European observatories that are likely to play an important role in the GAIA alerts follow-up in order that coordination and synergy between these and the PESSTO project at ESO could be optimised. These included personnel from the Liverpool Telescope, the Isaac Newton Telescope and the Polish lead OGLE-IV transient search (Steele, Benn, Wyrzykowski)

The agenda was organised for extensive discussion time and allowed us to come to important decisions about how to move forward with our joint projects. The outcomes are described below.

### **Outcomes of the meeting**

The meeting was successful in reaching its original goals of ensuring that both the GAIA and PESSTO communities talked to each other made a plan for synergy. In addition we made definite plans which focused and directed the range of telescope proposals that were submitted for the European April deadlines. The meeting was placed at a perfect time, as it allowed these ideas to be discussed in this open forum, for the PIs of the telescope proposals to take on feedback and to focus the proposals on the top science goals together with optimizing coordination.

In particular we came to the following conclusions and outcomes

1. PESSTO would work with the GAIA alerts team to help them create the software infrastructure that allows distributed teams to communicate on transient object science follow-up. PESSTO has developed this successful software project over the last few years, after building on the Palomar Transient Factory and Pan-STARRS1

work. This “Marshall” allows research collaboration and communication in interactive webpage format, backed up by an underlying database to record all information in searchable format.

2. The structure and focus of the UK proposals to the ING, LT and the International Time Project on La Palma were discussed and planned. The GAIA project PIs were endorsed (mostly science driven ECRs) and supported and advice was given to enhance the science exploitation and goals.
3. The key GAIA strengths were that it was space mission with a guaranteed and well understood observing pattern. We highlighted that this would have the following advantages over ground based surveys : astrometry, resolution, spectra/colours immediately provided, whole sky, uniform observing conditions, (well understood biases), able to tie together north and south in a uniform photometric system. These points came out of the science and logistic sessions and were used to focus the upcoming proposals.
4. We decided to aim at getting complete spectroscopic coverage of all transients (SN candidates) brighter than 18<sup>th</sup> magnitude. This was endorsed as a common goal for the broad SN projects. This would lead to a science goal of estimating rates versus subtype and galaxy hosts, providing 1000 objects in the local volume. (c.f the current state-of-the-art, which was KAIT 100-200 objects 60 MPc)
5. We estimated there would be 300 18th mag SN per year, Which implied 300 hours of spectroscopy time on 2-4m telescopes (includes multiple epochs. . However this would need supplemented with photometry. plus host classification. We aimed at a mixed INT+IDS and Liverpool+SPRAT strategy, and estimated 50n per year would be requested (5n per month / hemisphere). This could be interleaved with PESSTO to cover the south.

All of these outcomes fed into concrete proposals that were submitted to the various telescopes available to our European consortium in March and April 2014, hence representing a definite outcome of the meeting.

Finally, we would highlight that we added a public understanding of science aspect to the meeting. Prof. Gerry Gilmore of the University of Cambridge and one of GAIA’s main European proponents gave a public lecture entitled “The GAIA mission and the origin of the Milky Way” on the Wednesday evening. We held this lecture in conjunction with the local astronomy society in order to offer the chance of hearing one of the world leaders talk about this ESA mission in Belfast. We had over 200 people, members of the public, register and attend the meeting to hear an excellent lecture by Prof. Gilmore. We highlighted the GREAT ESF science meeting that made this possible and highlighted the ESF on all public lecture materials – posters, flyers, webpages etc.

## Agenda

# GAIA-PESSTO Workshop 5-7<sup>th</sup> February 2014

   <p><b>Queen's University Belfast</b></p>	<p>The GAIA Research for European Astronomy Training (GREAT) network has generously funded this meeting to facilitate discussion between the PESSTO and GAIA alert science teams. The goal of the meeting is to maximise the science potential for supernovae studies with PESSTO and GAIA. The GREAT programme is funding the lunches, coffee breaks and invited speakers and some early career researchers.</p> <p>The meeting is being hosted by Queen's University Belfast, in the School of Maths and Physics. All talks will be in the Physics Seminar room in the Physics and Astronomy Building.</p> <p>Further information will be linked from <a href="http://www.pessto.org">www.pessto.org</a></p>
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*All talks are 20 min, plus 10 min discussion unless otherwise noted*

<b>Wednesday 5<sup>th</sup> Feb 2014 (Chair: M. Sullivan)</b>	
<i>12.30 – 14.00 : Registration in the Physics and Astronomy Building</i>	
<i>Session 1: Gaia and the Transient Sky: The promise of Gaia &amp; PESSTO for SNe</i>	
14.00-14.30	Gaia: Overview and status (N. Walton)
14.30-15.00	Gaia as a supernova discovery machine (M. Fraser)
15.00-15.30	Overview of PESSTO (S. Smartt)
<b>Tea / Coffee (top floor, Physics and Astronomy Building)</b>	
<i>Session 2: The Gaia Transient system</i>	
16.00-16.30	The Gaia archive and data access system in the context of supernova and transients (X. Luri)
16.30-17.00	The PESSTO Marshall: Harvesting Gaia's Transient Detections (D. Young)
17.00-17.30	<i>Discussion:</i> Practical details of inputting/interpreting Gaia alerts into the PESSTO (and other) follow-up queues. Led by S. Hodgkin

***Public lecture in conjunction with the Irish Astronomical Association. To be held in the Larmor Lecture theatre. Workshop participants are welcome to attend but need to register.***

19.00 – 20.00	The Michael West Lecture by Prof. Gerry Gilmore (University of Cambridge) “The GAIA mission and the origin of the Milky Way”
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<b>Thursday 6<sup>th</sup> Feb</b>	
<i>Session 3: The Gaia SN Science Yield (Chair : J. Maund)</i>	
09.00-09.30	Type Ia supernova in Gaia (H. Campbell)
09.30-09.50 15+5	Thermonuclear SNe in remote locations with PESSTO and Gaia (K. Maguire)
09.50-10.20	Core collapse supernovae in Gaia (R. Kotak)
Tea / Coffee (Workshop photograph)	
11.00-11.20 15+5	SL-SNe Ic: a red transient with PESSTO and GAIA prospects (C. Inerra)
11.20-11.40 15+5	Nebular phase spectral modeling as a tool to diagnose supernova nucleosynthesis (A. Jerkstrand)
11.40-12.00 15+5	Progenitor star and host galaxy properties through spatial distributions of core-collapse supernovae (T. Kangas)
12.00-12.30	<i>Discussion:</i> The key science requirements for Gaia SNe and follow-up
Lunch (top floor, Physics and Astronomy building)	
<i>Session 4: The Gaia-SN classification challenge (Chair: S. Mattila)</i>	
13.45-14.15	BANGST: Bayesian Analysis of Nearby Gaia Supernova Transients (N. Blagorodnova)
14.15-14.35 15+5	The OGLE-IV transient search and the link to Gaia/PESSTO (L. Wyrzykowski)
14.35-15.05	Supernovae and transients with the Liverpool Telescope and robotic facilities (I. Steele)
15.05-15.35	Gaia SN/transient follow-up with the ING facilities (C. Benn)
Tea / Coffee	
16.00-16.30	Gaia SN/transient follow-up at Asiago (L. Tomasella)
16.30-17.00	Gaia follow-up from the European perspective (M. Turatto)

<b>Friday 7<sup>th</sup> Feb (Chair M. Dennefeld)</b>	
09.00-09.30	Supernova science from Australia (M. Childress)
09.30-10.00	The nearby SN factory (M. Rigault)
<i>Session 5: The Gaia Supernova Roadmap</i>	
10.00-10.30	Organising Gaia SN follow-up (S. Hodgkin)
Tea / Coffee	
11.00-12.30	<i>Discussion:</i> Generation of specific planning for science characterisation and follow-up of Gaia SN candidates
12.30-13.00	Summary and meeting close
Lunch (top floor, Physics and Astronomy building)	

## Participants

### Attendees

Dr Chris Benn	Isaac Newton Group	Speaker
Dr Cosimo Inserra	Queen's University Belfast	Speaker
Dr David Young	Queen's University Belfast	Speaker
Dr Gerry Gilmore	University of Cambridge	Speaker
Dr Heather Campbell	University of Cambridge	Speaker
Dr Iain Steele	Liverpool JMU	Speaker
Dr Kate Maguire	ESO	Speaker
Dr Lina Tomasella	Asiago	Speaker
Dr Lukasz Wyrzykowski	University of Cambridge	Speaker
Dr Massimo Turatto	INAF Padova	Speaker
Dr Michael Childress	Australian National University	Speaker
Dr Mickael Rigault	Physikalisches Institut	Speaker
Dr Morgan Fraser	University of Cambridge	Speaker
Miss Nadejda Blagorodnova	Institute of Astronomy	Speaker
Dr Nicholas Walton	University of Cambridge	Speaker
Dr Rubina Kotak	Queen's University Belfast	Speaker
Dr Simon Hodgkin	University of Cambridge	Speaker
Dr Stephen Smartt	Queen's University Belfast	Speaker
Mr Tuomas Kangas	University of Turku	Speaker
Dr Xavier Luri	Universitat de Barcelona	Speaker
Dr. Anders Jerkstrand	Queen's University Belfast	Speaker
Mr Christopher Frohmaier	University of Southampton	Participant
Dr Cristina Romera-Canizales	Institute of Astrophysics, Chile	Participant
Mr Darryl Wright	Queen's University Belfast	Participant
Miss Emma Reilly	Queen's University Belfast	Participant
Dr Erkki Kankare	University of Turku	Participant
Mr Giorgos Dimitriadis	University of Southampton	Participant
Miss Janet Chen	Queen's University Belfast	Participant
Mr Joe Polshaw	Queen's University Belfast	Participant
Dr Justyn Maund	Queen's University Belfast	Participant
Dr Ken Smith	Queen's University Belfast	Participant
Dr Laurent Le Guillou	LPNHE/UPMC	Participant
Dr Mark Sullivan	University of Southampton	Participant
Mr Matt Nicholl	Queen's University Belfast	Participant
Mr Mattia Bulla	Queen's University Belfast	Participant
Dr Michael Dennefield	IAP - Paris	Participant
Dr Philipp Podsiadlowski	University of Oxford	Participant
Mr Robert Firth	University of Southampton	Participant
Dr Seppo Mattila	University of Turku	Participant
Dr Stuart Sim	Queen's University Belfast	Participant
Miss Susanna Spiro	University of Oxford	Participant
Mr Thomas Wevers	RU Nijmegen	Participant



