# The (Sci-GaIA) Open Science Vision


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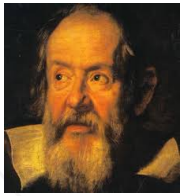
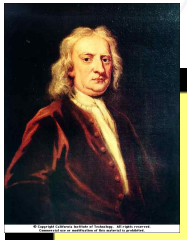
## Outline

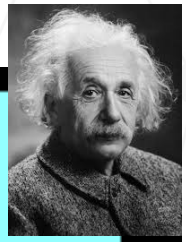
- Introductory concepts, definitions and driving considerations
- The Sci-GaIA Open Science Platform
- Summary and conclusions

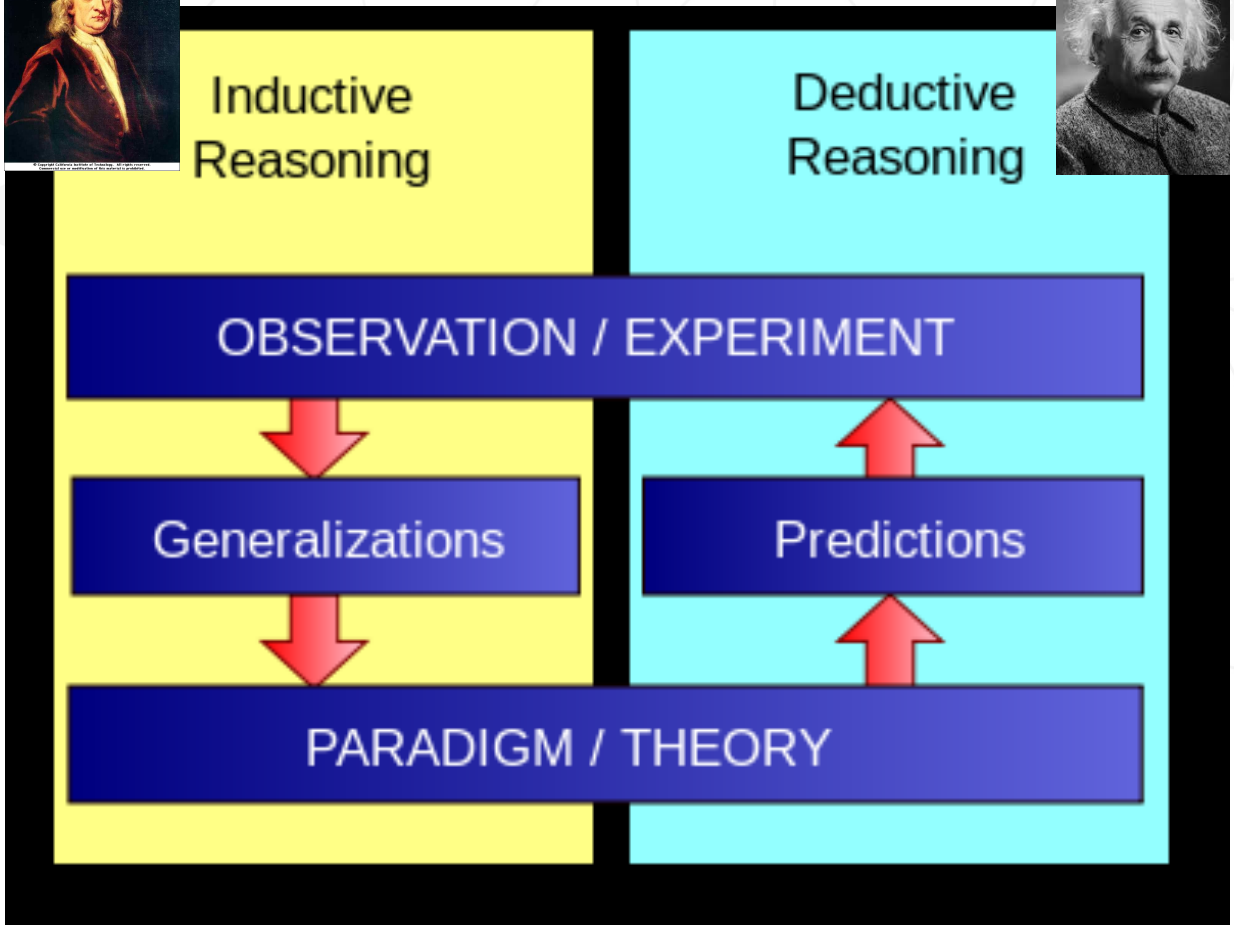
# The Scientific Method



G. Galilei








- **Examples of IR:**
  - Classical Mechanics
  - Newton's Gravitation Theory
- **Examples of DR:**
  - General Relativity
  - Standard Model of Particle Physics



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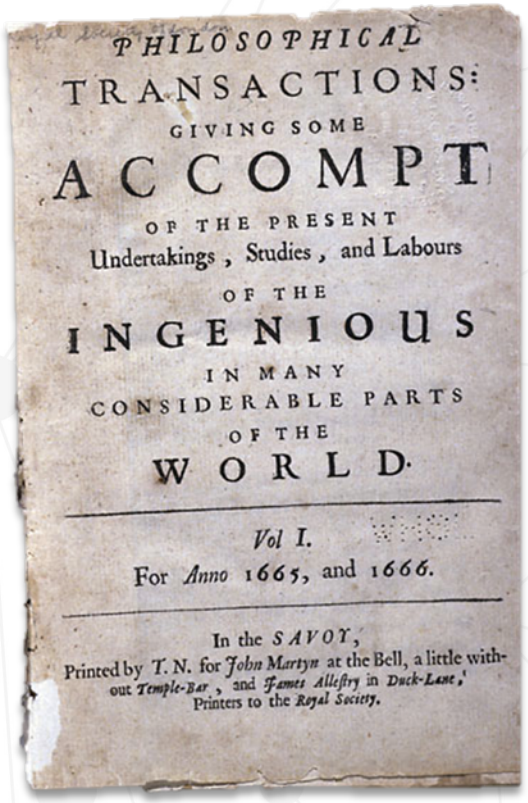
# The “output” of the Scientific Method: papers and publications



PHILOSOPHICAL
TRANSACTIONS:
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ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For Anno 1665, and 1666.

In the SAVOY,
Printed by T. N. for John Martyn at the Bell, a little without Temple-Bar, and James Allestry in Duck-Lane,
Printers to the Royal Society.

[1207.7214] Observation
arxiv.org/abs/arXiv:1207.7214

Cornell University Library

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arXiv.org > hep-ex > arXiv:1207.7214

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High Energy Physics – Experiment

**Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC**

The ATLAS Collaboration

(Submitted on 31 Jul 2012 (v1), last revised 31 Aug 2012 (this version, v2))

A search for the Standard Model Higgs boson in proton-proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb^-1 collected at sqrt(s) = 7 TeV in 2011 and 5.8 fb^-1 at sqrt(s) = 8 TeV in 2012. Individual searches in the channels H->ZZ^(*)->llll, H->gamma gamma and H->WW->e nu mu nu in the 8 TeV data are combined with previously published results of searches for H->ZZ^(*), WW^(*), bbbar and tau^+tau^- in the 7 TeV data and results from improved analyses of the H->ZZ^(*)->llll and H->gamma gamma channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of 126.0 +/- 0.4(stat) +/- 0.4(sys) GeV is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of 1.7x10^-9, is compatible with the production and decay of the Standard Model Higgs boson.

Comments: 24 pages plus author list (38 pages total), 12 figures, 7 tables, revised author list, matches version to appear in Physics Letters B
Subjects: High Energy Physics – Experiment (hep-ex)
Journal reference: Phys.Lett. B716 (2012) 1-29
DOI: 10.1016/j.physletb.2012.08.020
Report number: CERN-PH-EP-2012-218
Cite as: arXiv:1207.7214 [hep-ex]
(or arXiv:1207.7214v2 [hep-ex] for this version)

**Submission history**
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Physics Letters B 716 (2012) 1–29

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Physics Letters B

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ELSEVIER

**Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC** ☆

ATLAS Collaboration *

This paper is dedicated to the memory of our ATLAS colleagues who did not live to see the full impact and significance of their contributions to the experiment.

ARTICLE INFO

ABSTRACT

A search for the Standard Model Higgs boson in proton–proton collisions with the ATLAS detector at the LHC is presented. The datasets used correspond to integrated luminosities of approximately 4.8 fb$^{-1}$ collected at $\sqrt{s} = 7$ TeV in 2011 and 5.8 fb$^{-1}$ at $\sqrt{s} = 8$ TeV in 2012. Individual searches in the channels $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ in the 8 TeV data are combined with previously published results of searches for $H \to ZZ^{(*)}$, $WW^{(*)}$, $b\bar{b}$ and $\tau^+\tau^-$ in the 7 TeV data and results from improved analyses of the $H \to ZZ^{(*)} \to 4\ell$ and $H \to \gamma\gamma$ channels in the 7 TeV data. Clear evidence for the production of a neutral boson with a measured mass of $126.0 \pm 0.4\,(\text{stat}) \pm 0.4\,(\text{sys})$ GeV is presented. This observation, which has a significance of 5.9 standard deviations, corresponding to a background fluctuation probability of $1.7 \times 10^{-9}$, is compatible with the production and decay of the Standard Model Higgs boson.

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**1. Introduction**

The Standard Model (SM) of particle physics [1–4] has been tested by many experiments over the last four decades and has been shown to successfully describe high energy particle interactions. However, the mechanism that breaks electroweak symmetry in the SM has not been verified experimentally. This mechanism [5–10], which gives mass to massive elementary particles, implies the existence of a scalar particle, the SM Higgs boson. The search for the Higgs boson, the only elementary particle in the SM that has not yet been observed, is one of the highlights of the Large Hadron Collider [11] (LHC) physics programme.

Indirect limits on the SM Higgs boson mass of $m_H < 158$ GeV at 95% confidence level (CL) have been set using global fits to precision electroweak results [12]. Direct searches at LEP [13], the Tevatron [14–16] and the LHC [17,18] have previously excluded, at 95% CL, a SM Higgs boson with mass below 600 GeV, apart from some mass regions between 116 GeV and 127 GeV.

Both the ATLAS and CMS Collaborations reported excesses of events in their 2011 datasets of proton–proton ($pp$) collisions at centre-of-mass energy $\sqrt{s} = 7$ TeV at the LHC, which were compatible with SM Higgs boson production and decay in the mass region 124–126 GeV, with significances of 2.9 and 3.1 standard deviations ($\sigma$), respectively [17,18]. The CDF and DØ experiments at the Tevatron have also recently reported a broad excess in the mass region 120–135 GeV; using the existing LHC constraints, the observed local significances for $m_H = 125$ GeV are $2.7\sigma$ for CDF [14], $1.1\sigma$ for DØ [15] and $2.8\sigma$ for their combination [16].

The previous ATLAS searches in 4.6–4.8 fb$^{-1}$ of data at $\sqrt{s} = 7$ TeV are combined here with new searches for $H \to ZZ^{(*)} \to 4\ell$, $H \to \gamma\gamma$ and $H \to WW^{(*)} \to e\nu\mu\nu$ in the 5.8–5.9 fb$^{-1}$ of $pp$ collision data taken at $\sqrt{s} = 8$ TeV between April and June 2012.

The data were recorded with instantaneous luminosities up to $6.8 \times 10^{33}$ cm$^{-2}$ s$^{-1}$; they are therefore affected by multiple $pp$ collisions occurring in the same or neighbouring bunch crossings (pile-up). In the 7 TeV data, the average number of interactions per bunch crossing was approximately 10; the average increased to approximately 20 in the 8 TeV data. The reconstruction, identification and isolation criteria used for electrons and photons in the 8 TeV data are improved, making the $H \to ZZ^{(*)} \to 4\ell$ and $H \to \gamma\gamma$ searches more robust against the increased pile-up. These analyses were re-optimised with simulation and frozen before looking at the 8 TeV data.

In the $H \to WW^{(*)} \to \ell\nu\ell\nu$ channel, the increased pile-up deteriorates the event missing transverse momentum, $E_{\mathrm{T}}^{\mathrm{miss}}$, resolution, which results in significantly larger Drell–Yan background in the same-flavour final states. Since the $e\mu$ channel provides most of the sensitivity of the search, only this final state is used in the analysis of the 8 TeV data. The kinematic region in which a SM Higgs boson with a mass between 110 GeV and 140 GeV is

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* E-mail address: atlas.publications@cern.ch.

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http://dx.doi.org/10.1016/j.physletb.2012.08.020

☆ The symbol $\ell$ stands for electron or muon.

Marked a real Scientific Revolution in the 17th century
but… it is almost the same since then



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## The Pillars of the Scientific Method

- **Repeatability**
  - The closeness of agreement between independent results obtained with the same method on identical test material, under the same conditions (same [illegible] same apparatus, same laboratory [illegible] intervals of time)
  - Affected by *rando[illegible]*
- **Rep[illegible]**
  - [illegible]eness of agreement between independent results obtained with the same method on identical test material but under different conditions (different operators, different apparatus, different laboratories and/or after different intervals of time)
  - Affected by *systematic errors*

**Is science really reproducible?**

# Challenges in irreproducible research

(http://www.nature.com/nature/focus/reproducibility/index.html)





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## CHALLENGES IN IRREPRODUCIBLE RESEARCH

No research paper can ever be considered to be the final word, and the replication and corroboration of research results is key to the scientific process. In studying complex entities, especially animals and human beings, the complexity of the system and of the techniques can all too easily lead to results that seem robust in the lab, and valid to editors and referees of journals, but which do not stand the test of further studies. *Nature* has published a series of articles about the worrying extent to which research results have been found wanting in this respect. The editors of *Nature* and the *Nature* life sciences research journals have also taken substantive steps to put our own houses in order, in improving the transparency and robustness of what we publish. Journals, research laboratories and institutions and funders all have an interest in tackling issues of irreproducibility. We hope that the articles contained in this collection will help.

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EDITORIAL

**Journals unite for reproducibility**
Consensus on reporting principles aims to improve biomedical research.
*Nature* **515**, 7 ( 6 November 2014 )

**Code share**
Papers in Nature journals should make computer code accessible where possible.
*Nature* **514**, 536 ( 29 October 2014 )

**Reducing our irreproducibility**
*Nature* **496**, 398 ( 25 April 2013 )

**Further confirmation needed**
A new mechanism for independently replicating research findings is one of several changes required to improve the quality of the biomedical literature.
*Nature Biotechnology* **30**, 806 ( 10 September 2012 )

**Error prone**
Biologists must realize the pitfalls of work on massive amounts of data.
*Nature* **487**, 406 ( 26 July 2012 )

**Must try harder**
Too many sloppy mistakes are creeping into scientific papers. Lab heads must look more rigorously at the data — and at themselves.
*Nature* **483**, 509 ( 29 March 2012 )



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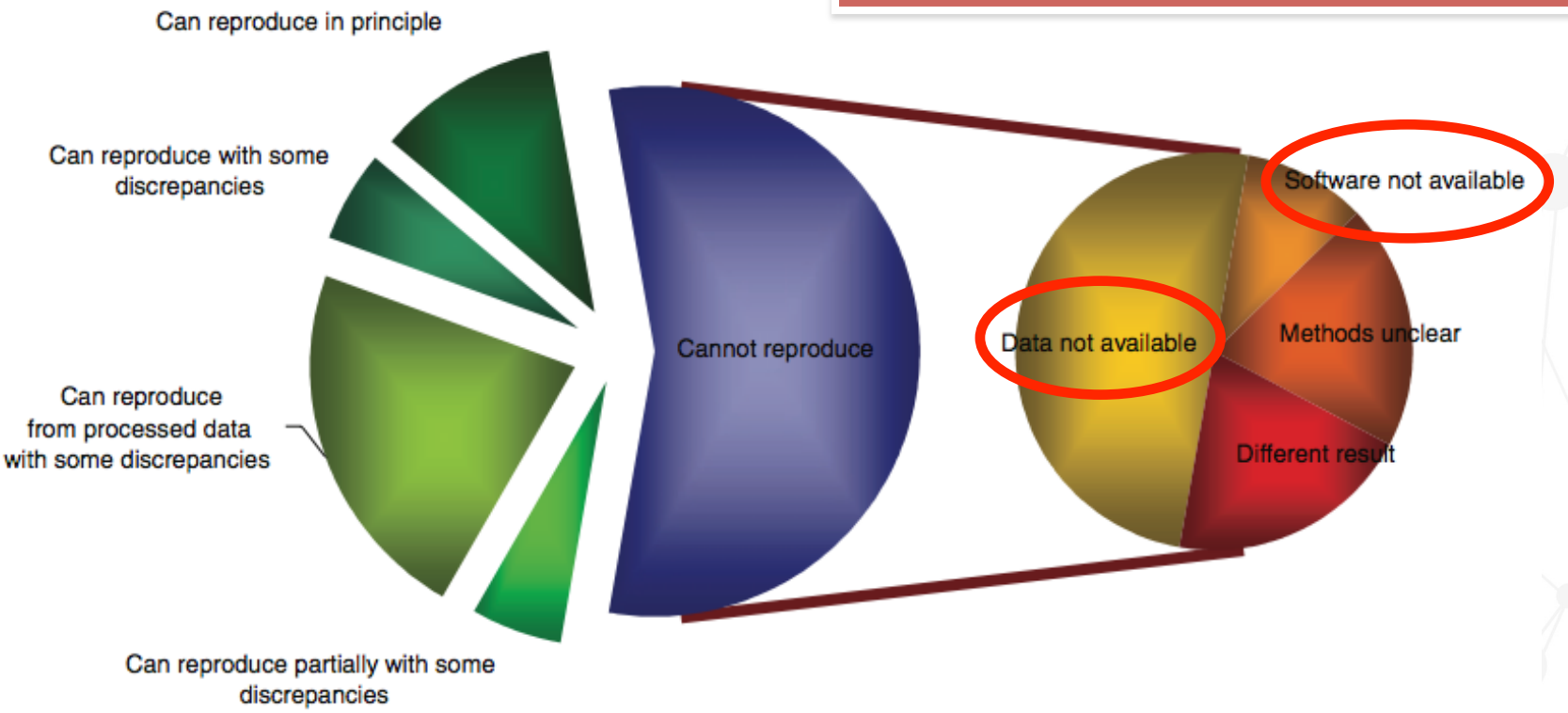
# The “reproducibility crisis”

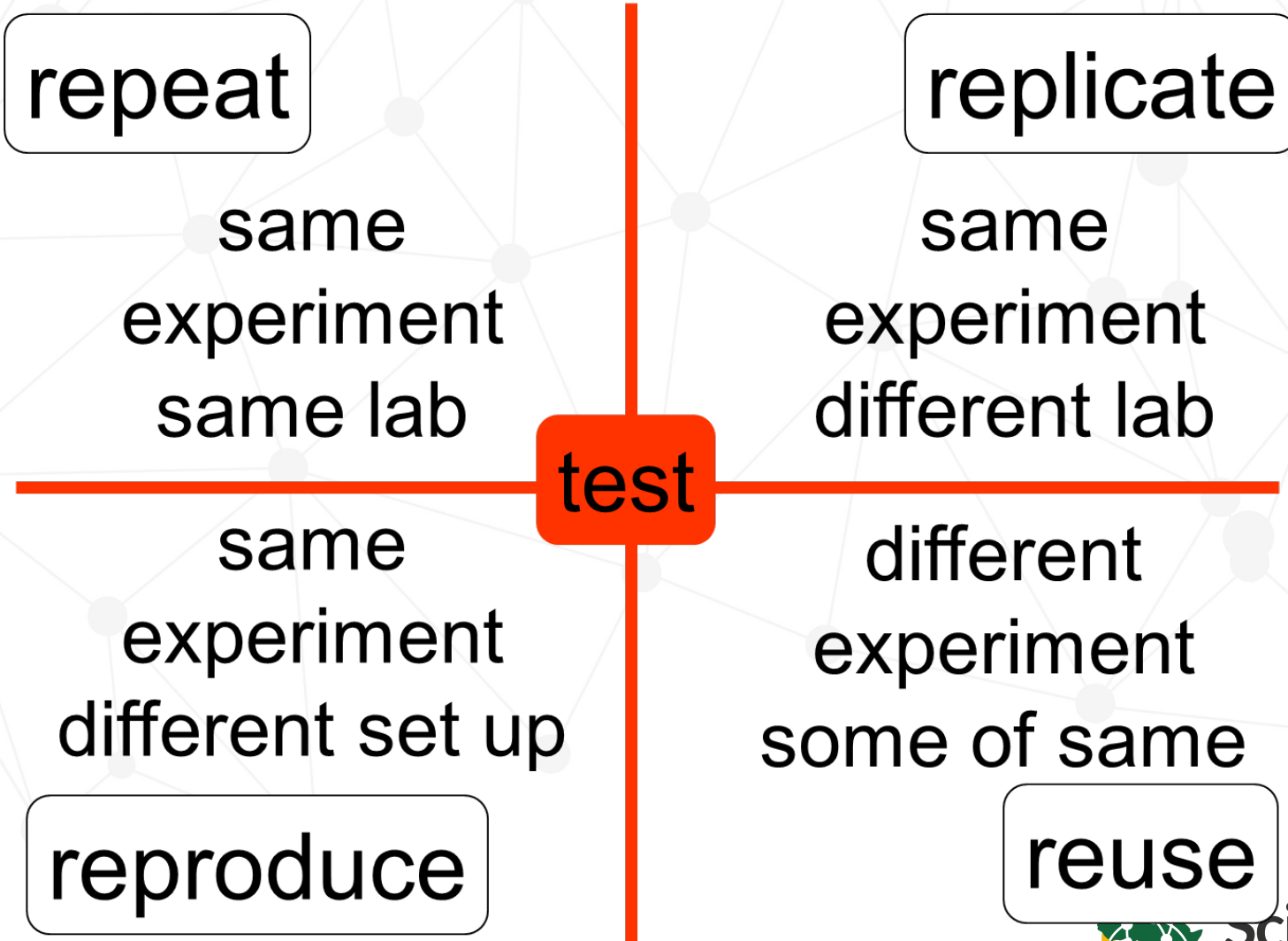
Out of 18 microarray papers, results from 10 could not be reproduced





1. Ioannidis et al., 2009. Repeatability of published microarray gene expression analyses. *Nature Genetics* 41: 14
2. Science publishing: The trouble with retractions http://www.nature.com/news/2011/111005/full/478026a.html
3. Bjorn Brembs: Open Access and the looming crisis in science https://theconversation.com/open-access-and-the-looming-crisis-in-science-14950

## Repeatability and Reproducibility are not all…






Drummond C Replicability is not Reproducibility: Nor is it Good Science, online
Peng RD, Reproducible Research in Computational Science *Science 2 Dec 2011: 1226-1227.*

# Open Science (definitions)

- *"**Open science** is a means and not an end in itself and it is much more than just open access to publications or data; it includes many aspects and stages of research processes thus enabling full reproducibility and re-usability of scientific results"*
  - OECD (2015), "Making Open Science a Reality", OECD Science Technology and Industry Policy Papers, No. 25, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jrs2f963zs1-en


- *"**Open Science** refers to a scientific culture that is characterized by its openness. Scientists share results almost immediately and with a very wide audience"*
  - http://book.openingscience.org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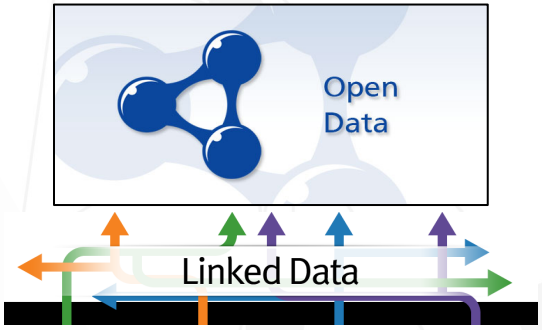
# Open Science (enablers)



open science



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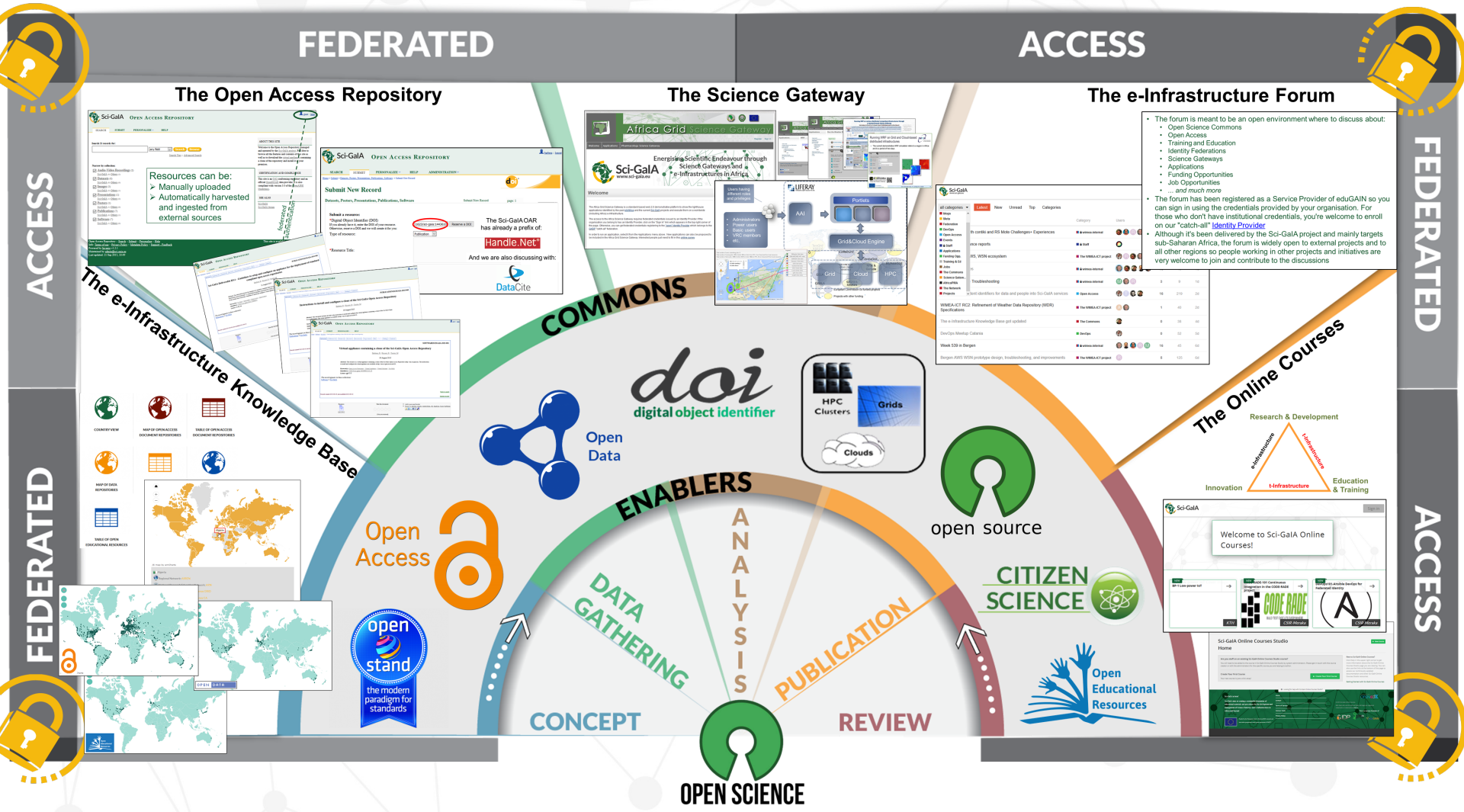
# The Sci-GaIA Federated Platform for an Open Science Commons in Africa




www.sci-gaia.eu/osp/



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“Who’s this science of?”

**How to provide authorship to research products?**



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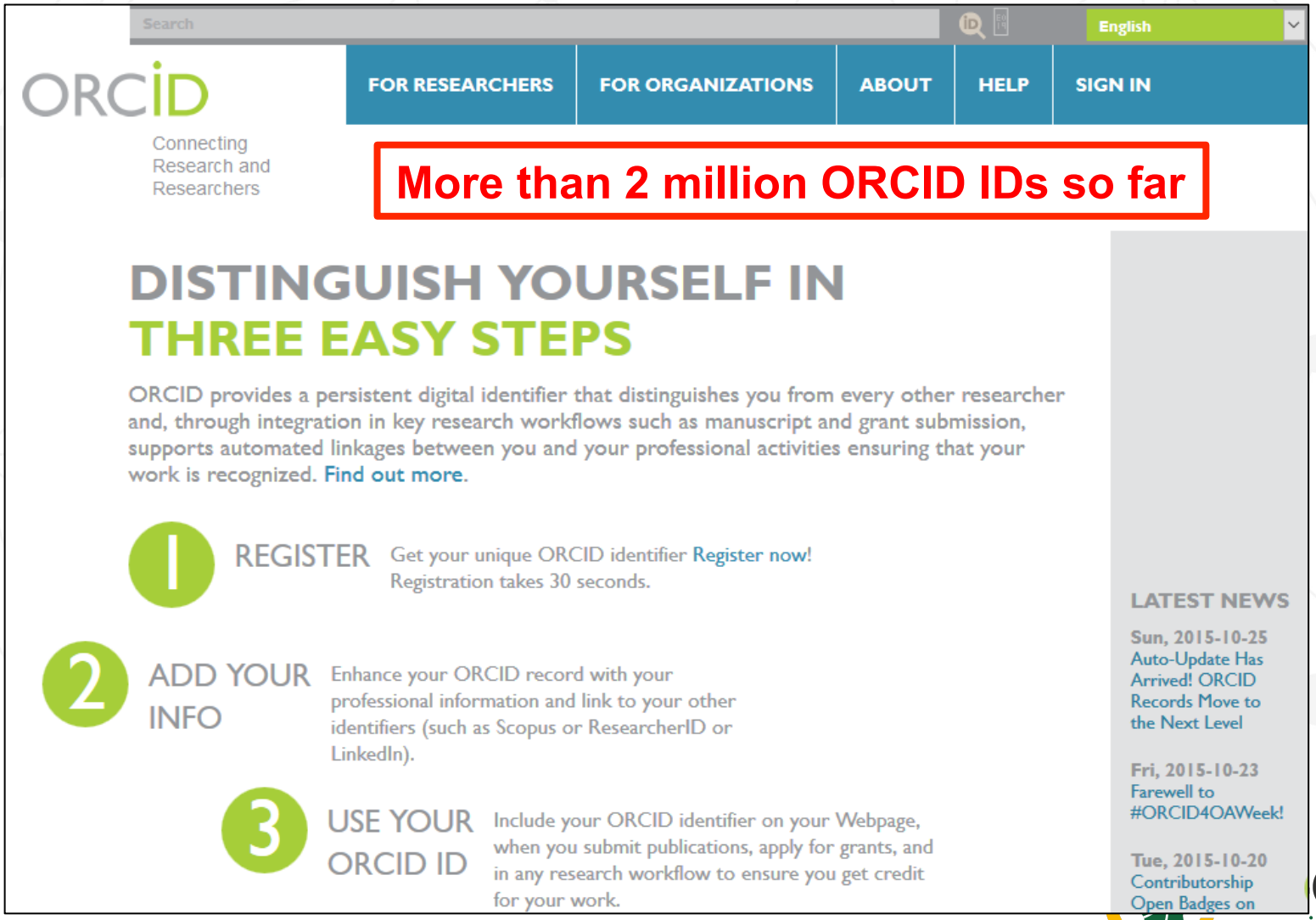
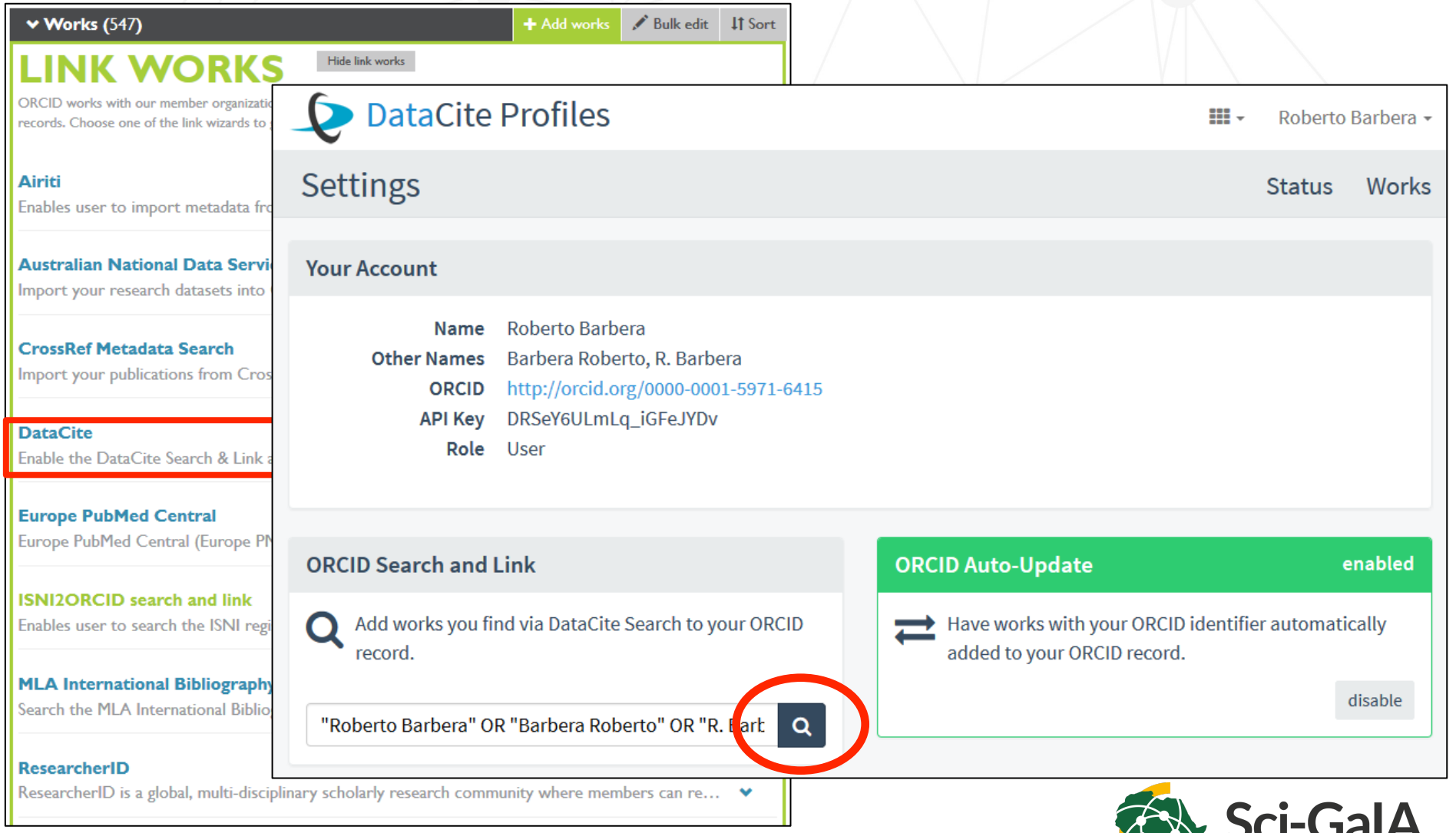
# ORCID
## (www.orcid.org – becoming a “de facto” standard)



# ORCID:
## search & link your works having DataCite DOIs



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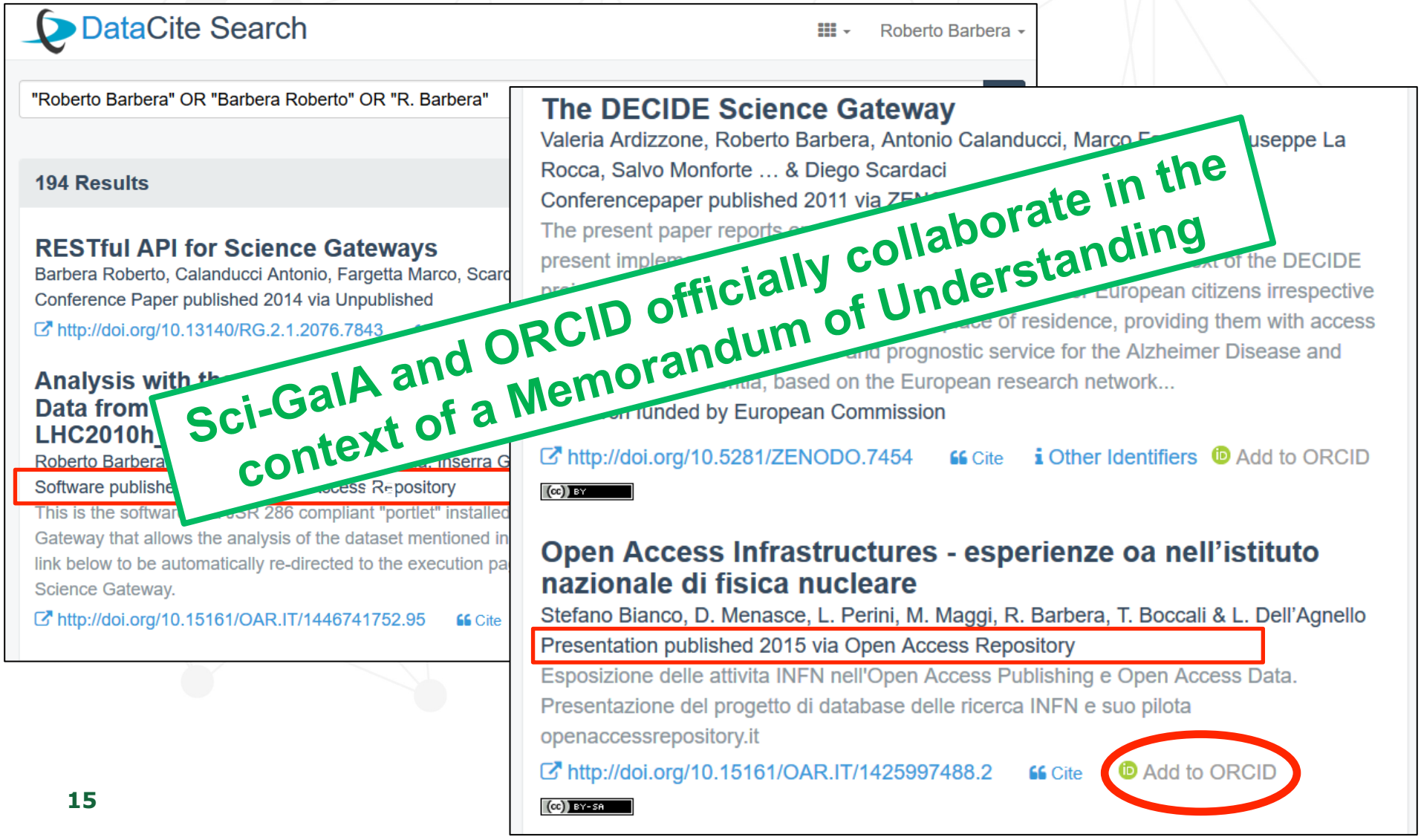
# ORCID:
## add your research products to your ORCID profile

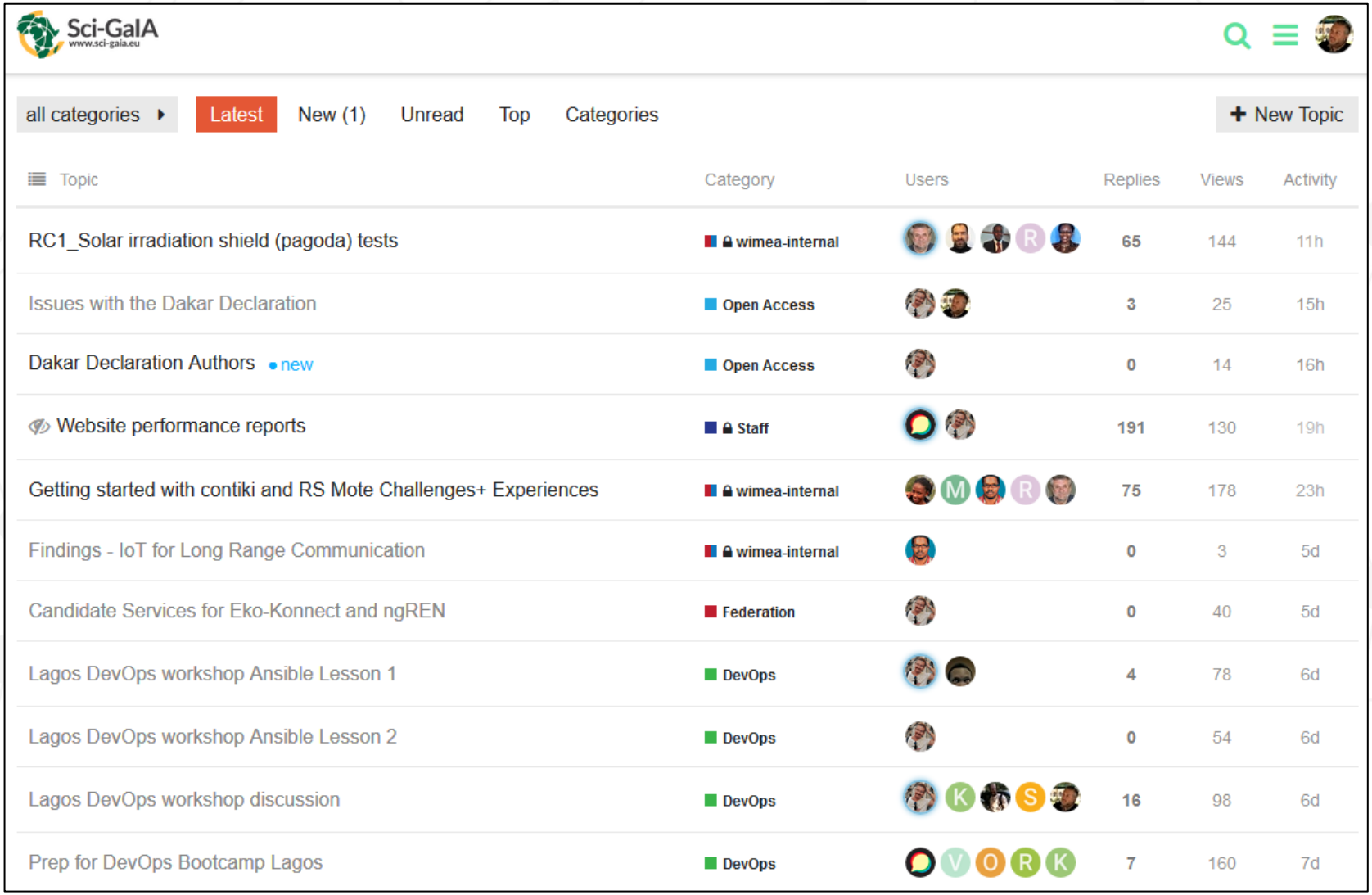



**Sci-GaIA and ORCID officially collaborate in the context of a Memorandum of Understanding**

## Summary and conclusions

- The Open Science vision can be implemented only if the "openness" paradigm becomes pervasive in day-by-day research
- Science outputs' reproducibility, but also re-usability and extensibility, are key to walk through the "knowledge path" in both directions
- The Sci-GaIA project is strongly committed to promote the uptake of the Open Science paradigm and it's building a viable federated platform for Open Science Commons across Europe and Africa
- A novel approach connects Open Access Repositories to Science Gateways and exploit e-Infrastructures worldwide to easily reproduce/extend scientific analyses and provide full authorship to researchers
- The connection with DataCite and ORCID will provide full authorship (and hence credit, reputation and visibility) for all products of a scientist → this is key for a correct evaluation of research

# Join us on the e-Infrastructure forum: http://discourse.sci-gaia.eu



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# Thank you!

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