⟨S|P|S⟩ swiss physical society

Science Culture

A particle physicists view

let's live science culture

«We Scientists Shape Science»

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Science Culture

Science Culture, i.e. the **way science is advancing** and the **way scientists pursue their tasks is specific** to every field and every domain.

In many fields, **small teams** with **a professor**, **a post doc** and **one or few PhD students** are the prevailing and established way to advance science:

- Finding problems worth attacking / solving
- Developing the corresponding tools and methods
- Taking data
- Analyzing data
- Concluding and publishing

Often, fast turn around is possible, and a full cycle can be envisaged within a short period in time. **An idealistic model**, for PhD students, to be active over the entirety of such a cycle within a normal SNF PhD grant of three years.

Small teams can be in fierce competition with each other

adding to the competiveness

adding to redundancy and robustness to the results produced

Too much competition can lead to a climate of mistrust.
Too much redundancy is a waist of resources (Human capital and monetary funding).

Science Culture

Science Culture, i.e. the **way science is advancing** and the **way scientists pursue their tasks is specific** to every field and every domain.

In some fields, **large teams** with **hundreds of university teams across the globe** are working together to advance science, **the cycle is the same**:

- Finding problems worth attacking / solving
- Developing the corresponding tools and methods
- Taking data
- Analyzing data
- Concluding and publishing

Big teams are required where **developing tools and methods** is so **complex** and **resources intense**, that no single team can consider to get even started. Only by **joining resources** (Human capital and monetary funding), tools and methods can be developed. Often, this **takes many years** or even **decades**!
Data taking is often a lengthy process, taking **years** or even **decades**.
Analyzing data is an ongoing process, where new results come out with every significant chunk of data collected.

Team members in large teams need to be **competitive**, to gain visibility, and **collaborative**, as members depend on each other, simultaneously.
Social skills evolve with this required **coopetiveness**.

Science Culture

In **Big Science**, an **individual PhD student** has no chance to live through an entire cycle, and will be exposed to a specific phase of the project.

In the beginning of any Big Science project, **R&D efforts prevail** that will not lead to physics results. Although, engineering efforts can be published and analysis based on simulated data can be pursued.

In the start-up phase, lots of **commissioning and teething problems are normal** and will take all the time of the team members.
The first few physics results can be published, but these are early glimpses, and lots and lots needs to be learned about the new tools and the new methods developed before.

In the data-taking phase, data is collected, and idealistically, data comes in abundantly, leading to **many results that are published** with the **entire collaboration listed as co-authors** in alphabetical order.

The record holder today is a joint paper written by ATLAS and CMS, two large collaborations at CERN, with a total of 5154 co-authors, published in Physical Review Letters, PRL **114**, 191803 (2015)

Example: My career in Big Science

In the **first decade** working on the ATLAS experiment at the Large Hadron Collider at CERN, I had **only a handful of published articles** between 1997-2010, during pre-data-taking period.

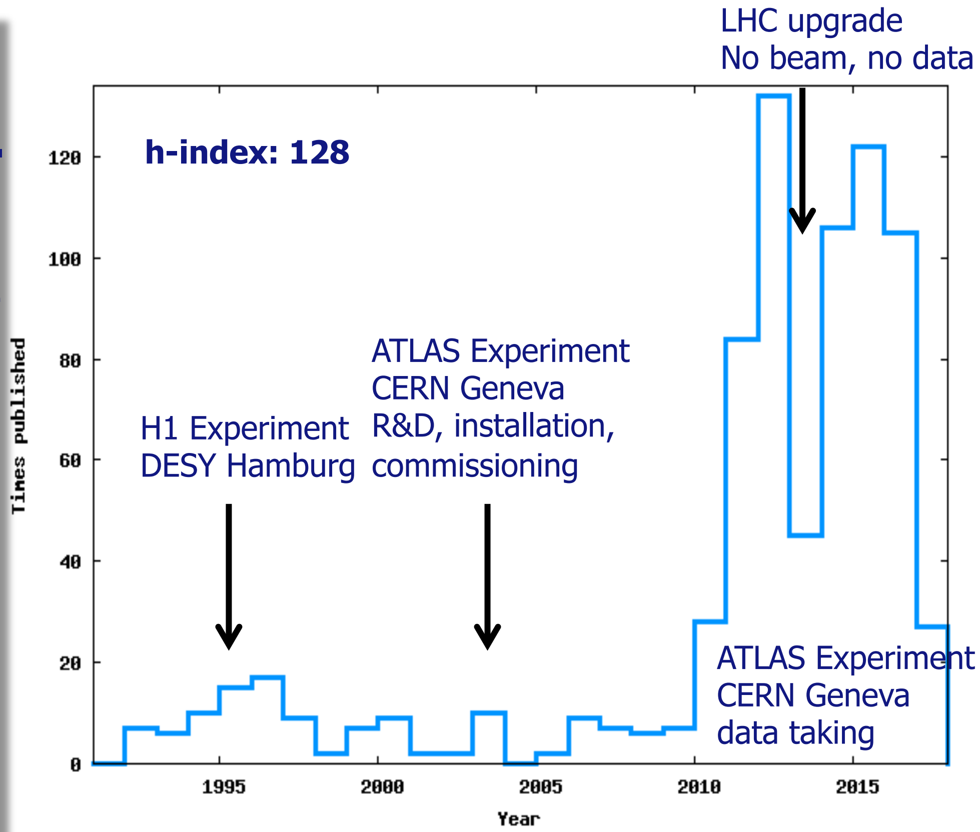
From 2010 onwards, with ATLAS taking data, my **h-index** is sky-rocketing with an average of over 100 peer-reviewed articles per year, which showcases that this is **a pure nonsense qualifier**.

The publication record does not reflect whether a person is excellent, good, mediocre, or under preforming.

PhD students and postdocs can still advance, because of **assessments made inside the collaboration**.
However - this means basing decisions on insider knowledge !

Getting a faculty positions is tricky:
Selection boards are more than often hinging on metrices that don't really make sense.

There is a **dilemma** between transparent metrices that don't make sense, and non-transparency when basing decisions on insider knowledge.



Published articles per year [HPB]

A 2nd Example: Peter W. Higgs

For Nobel-prize laureate Peter Higgs, his publication record looks entirely different.

A Nobel prize doesn't require many papers - sometimes, only a few, or just one is enough to mark a decisive development. But how to asses this ?

Peter Higgs: I wouldn't be productive enough for today's academic system

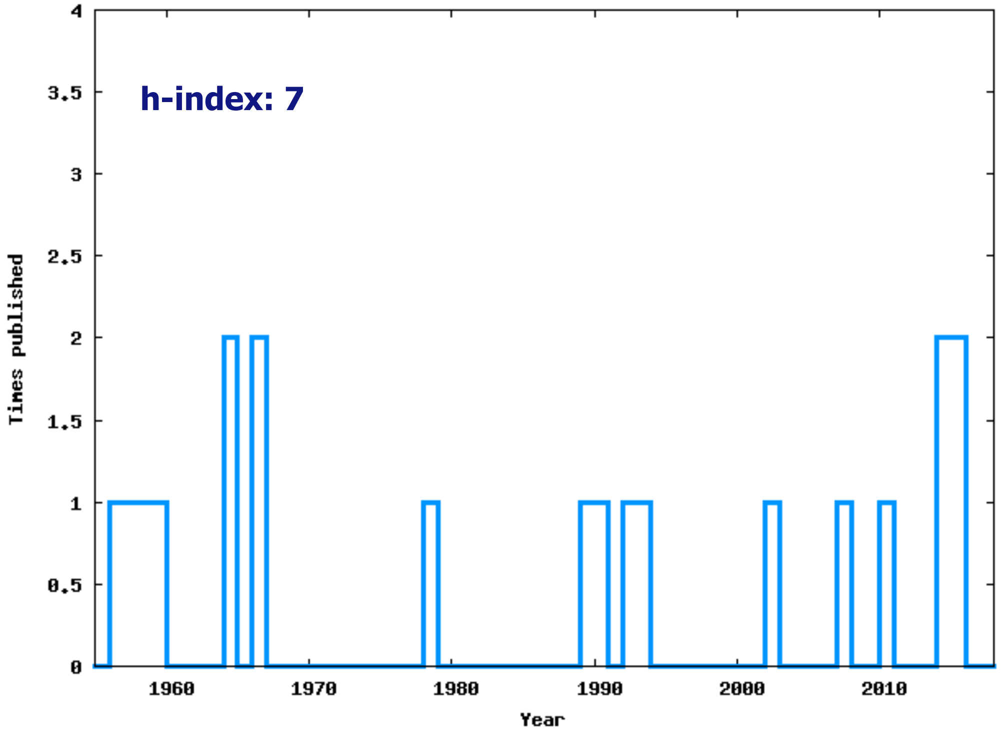
Physicist doubts work like Higgs boson identification achievable now as academics are expected to 'keep churning out papers'

Peter Higgs: 'Today I wouldn't get an academic job. It's as simple as that'. Photograph: David Levene for the Guardian

Peter Higgs, the British physicist who gave his name to the Higgs boson, believes no university would employ him in today's academic system because he would not be considered "productive" enough.

https://www.theguardian.com/science/2013/dec/06/peter-higgs-boson-academic-system

Simply by reading and understanding the paper to assess its quality but not by statistical counting. Sometimes, it can take years until a new idea is understood well enough such its merit can be assessed!



Published articles per year [Peter Higgs]

Assessing Big Science

Physics and Society

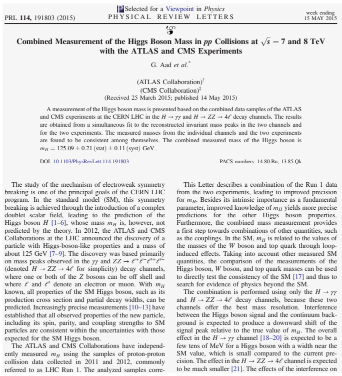
Big Science – Assessing Collaborative and Individual Merits

Hans Peter Beck, Uni Bern

Scientific progress in fundamental research has been made by individuals, by small groups, and in the recent decades also by ever-larger growing collaborations, nowadays involving thousands of scientists from hundreds of institutions across the globe. Complex, expensive infrastructure especially designed, developed and built by the collaborations over years, sometimes even over decades, only exists because of the hard work of many, concentrating small funds from many sources, and creating together the shear impossible. A success story but not without problems.

Collaborative efforts in the quest for fundamental knowledge

Despite of the scientific success in the quest of deeper and deeper understanding of the structure of matter and the buildup of the Universe, the ever-growing size of scientific collaborations has been criticized ever since groups started working together. Scientific collaborative efforts started in the 1950's (or even earlier), when small teams involving two to three groups of geographically not too far-away universities were joining, up to these days, where groups involving 200 university teams across the globe are spanning together and focusing their efforts towards a common research goal that otherwise would be unthinkable to achieve. Recent examples are the direct observation of gravitational waves, this February, and published jointly by the LIGO and the VIRGO scientific collaborations, signed by 1011 co-authors from 133 institutes [1], or the discovery of the Higgs boson at CERN's Large Hadron Collider by the ATLAS and CMS collaborations in summer 2012. Here, ATLAS and CMS are competing collaborations both selecting, measuring and analyzing proton-proton collisions at the Large Hadron Collider independently and at opposite collision points of the ring. In order to prevent possible scientific bias from one experiment to the other, the two groups develop their tools and methods independently, and minimize premature exchange of know-how and preliminary results to an absolute minimum. Still, the observation of a new particle in summer 2012 (at that time, it was not yet established, whether this new resonance was indeed the sought after Higgs boson, or something completely new) was announced jointly in two seminar talks in a single session at CERN, and was submitted to the same journal a few weeks later on a beforehand agreed day and journal editor [2, 3]. The count of authors of these two papers is impressive, with 2932 signing the ATLAS paper, and 2900 signing the CMS paper. This is not the limit, which today, at least to my knowledge, occurs for common publications between the ATLAS and the CMS collaborations, as happened recently, when ATLAS and CMS data were statistically combined resulting in a measurement of the mass of the Higgs boson to be 125.09 ± 0.21$^{(stat)}$ ± 0.11$^{(sys)}$ GeVc^{-2} i.e. with 2‰ precision [4] and 5154 signing authors. Another example where an important and crucial scientific result is obtained through a collaboration of two otherwise distinct collaboration is the observation of a rare decay of a *B* meson into a muon pair with a measured branching ratio $\mathcal{B}(B_s^0 \to \mu^+\mu^-) = 2.8^{+0.7}_{-0.6} \times 10^{-9}$ [5], compatible with the Standard Model prediction. This very stringent test of the Standard Model is signed by 2830 authors, and as an exception in the field of particle physics, is published in Nature, where open access under the Creative Commons



Selected for a Viewpoint in *Physics*

PRL **114**, 191803 (2015) PHYSICAL REVIEW LETTERS week ending 15 MAY 2015

Combined Measurement of the Higgs Boson Mass in pp Collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS and CMS Experiments

G. Aad *et al.**

(ATLAS Collaboration)†
(CMS Collaboration)‡
(Received 25 March 2015; published 14 May 2015)

A measurement of the Higgs boson mass is presented based on the combined data samples of the ATLAS and CMS experiments at the CERN LHC in the $H \to \gamma\gamma$ and $H \to ZZ \to 4\ell$ decay channels. The results are obtained from a simultaneous fit to the reconstructed invariant mass peaks in the two channels and for the two experiments. The measured masses from the individual channels and the two experiments are found to be consistent among themselves. The combined measured mass of the Higgs boson is $m_H = 125.09 \pm 0.21\,(\mathrm{stat}) \pm 0.11\,(\mathrm{syst})$ GeV.

DOI: 10.1103/PhysRevLett.114.191803 PACS numbers: 14.80.Bn, 13.85.Qk

As an example from [4]: While the first 7 pages of the publication describe the scientific method and result, the following 26 pages list the 5154 authors and their affiliations.

PRL **114**, 191803 (2015) PHYSICAL REVIEW LETTERS week ending 15 MAY 2015

Big Science
– Assessing Collaborative and Individual Merits
HP Beck, SPS Communications **49**, June 2016

http://www.sps.ch/fileadmin/articles-pdf/2016/Mitteilungen_BigScience.pdf

Conclusions: A Particle Physicist's View

- Science culture is specific in every field and domain
- Science conducted in **small teams** and science conducted in **Big Science Collaborations** is **complementary** in the scientific topics pursued and in the science culture defining how the specific research is conducted.
- Both, small and big science are needed to advance knowledge and insight.
- **Fierce competition** and **applying of metrices blindly** that try to measure quality transparently, have shown to **lead to biases** in the **scientific topics** being addressed, lead to biased (i.e. wrong) **assessments of scientists**, **despises good people** out of their field of choice, favours those that **obey the rules** of a (flawed) game, and therefore, **propagates mediocrity in the best case**.
- The **San Francisco Declaration on Research Assessment DORA** addresses some of the problems and is pointing out correctly that our scientific culture needs to evolve. **DORA is definitely a right step into the right direction.**
- **I am glad that SNF, and many Swiss institutes have signed the DORA declaration.** The way to implement DORA, however, requires change in style.
- As long as metrices stay the prevailing tool to **rank Universities**, **Collaborations**, and **individuals**, we are **leaving out the creative minds** and **pushing hard for promoting only those who are good playing a flawed game**.