

The Twin Questions of Authorship and the Reproducibility of Results in Large Scientific Collaborations

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Abstract

The Tevatron Collider experimental collaborations have ~ 550 ($D\bar{O}$) to ~ 800 (CDF) authors on their author list. The LHC experiments, several years from taking data, are already much more than twice that size. This phenomenon is not limited to High Energy Physics; collaboration size is growing in Astrophysics, Space Physics, and the biomedical world. But, as in the development of the Web, HEP has been a leader in these new areas of cooperation and communication. Who should be listed as an author, what is valued from collaborators, what from collaborators is rewarded, and how contributions are known, acknowledged, and archived are difficult but critical questions, especially important to the field's most important resource, young scientists. How a scientist external to the collaboration explores, understands, and if possible reproduces a published result is a question that is intertwined with the way results are published, the availability of internal documentation and the data themselves, and the custodial responsibilities and structures set up by the collaborations themselves.

1 Introduction

The intellectual achievements of High Energy Physics in the approximately last 30 years form one of the great cathedrals of science, with the discoveries of partons (quarks and gluons), the W and Z bosons, the charmed, bottom, and top quarks, direct CP violation in the kaon and B systems, neutrino masses and mixing, and the precise determination of the parameters of the Standard Model. As seen by an experimentalist, progress on the theoretical side has been equally impressive, starting with the remarkably robust Standard Model itself with its gauge theories of the electromagnetic, weak and strong interactions, and extending to a range of predicted phenomena including new extra space dimensions and structures in a wildly different geometries, a doubling of the number of elementary particles ('Supersymmetry'), new families of quarks and leptons, and new larger group structures.

During this time the size of experimental collaborations has grown enormously, with the Tevatron Collider experiments each being between 500 and 800 collaborators. So far this year CDF has published 26 physics papers and has 19 drafts in the internal review process; this pace will increase dramatically when the analysis software becomes less fluid. The current convention is that every eligible collaborator puts her or his name on every paper by default.

The Current CDF Default Author List

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(CDF Collaboration)

Authorship in Large Scientific Collaborations: Writing

Franklin was appointed by the Continental Congress to a committee charged with drafting a formal document to justify the colonies' decision of severing political ties with Britain. The other members of the committee included Thomas Jefferson, John Adams, Robert Livingston and Roger Sherman. The committee gave Jefferson the task of writing the first draft. Franklin, although a talented writer, took a back seat in drafting the document, blaming his lack of participation on poor health.

Jefferson sent his finished draft to Franklin for review. Franklin put on his editor's hat, but made only a few slight changes to Jefferson's prose. When the draft was submitted to Congress, however, sentence after sentence was either deleted or changed, much to the dismay of Jefferson.

Later, Jefferson recalled a story that Franklin told him as members of Congress picked away at the draft.

"I have made a rule, whenever in my power, to avoid becoming the draughtsman of papers to be reviewed by a public body. I took my lesson from an incident which I will relate to you. When I was a journeyman printer, one of my companions, an apprentice hatter, having served out his time, was about to open shop for himself. His first concern was to have a handsome signboard, with a proper inscription. He composed it in these words, 'John Thompson, Hatter, makes and sells hats for ready money,' with a figure of a hat subjoined. But thought he would submit it to his friends for their amendments. The first he showed it to thought the word 'Hatter' tautologous, because followed by the words 'makes hats,' which showed he was a hatter. It was struck out. The next observed that the word 'makes' might as well be omitted, because his customers would not care who made the hats. If good and to their mind, they would buy them, by whomsoever made. He struck it out. A third said he thought the words 'for ready money' were useless, as it was not the custom of the place to sell on credit. Every one who purchased expected to pay. They were parted with, and the inscription now stood, 'John Thompson sells hats.' 'Sells hats!' says the next friend. 'Why, nobody will expect you to give them away. What then is the use of that word?' It was stricken out, and 'hats' followed it, the rather as there was one painted on the board. So the inscription was reduced ultimately to 'John Thompson,' with the figure of a hat subjoined."

(Quoted at: http://www.pbs.org/benfranklin/l3_citizen_founding.html)

The APS Guidelines: Conventional Wisdom on Authorship

From the present (Nov. 2004) APS web page on Professional Conduct [2]

“APS Ethics & Values Statements

02.2 APS GUIDELINES FOR PROFESSIONAL CONDUCT

*Authorship should be limited to those who have made a significant contribution to the concept, design, execution **or** interpretation of the research study. All those who have made significant contributions should be offered the opportunity to be listed as authors. Other individuals who have contributed to the study should be acknowledged, but not identified as authors. “*

(http://www.aps.org/statements/02_2.cfm)

(Note: I am fairly sure that before 2002 the ‘or’ in the list of requirements for an author used to be ‘and’, an interesting and important evolution in meaning, but have not been able to verify this to my complete satisfaction).

Further:

“SUPPLEMENTARY GUIDELINES ON RESPONSIBILITIES OF COAUTHORS AND COLLABORATORS

(Adopted by Council on November 10, 2002) [2]

All collaborators share some degree of responsibility¹ for any paper they coauthor. Some coauthors have responsibility for the entire paper as an accurate, verifiable, report of the research. These include, for example, coauthors who are accountable for the integrity of the critical data reported in the paper, carry out the analysis, write the manuscript, present major findings at conferences, or provide scientific leadership for junior colleagues.

Coauthors who make specific, limited, contributions to a paper are responsible for them, but may have only limited responsibility for other results. While not all coauthors may be familiar with all aspects of the research presented in their paper, all collaborations should have in place an appropriate process for reviewing and ensuring the accuracy and validity of the reported results, and all coauthors should be aware of this process. ...”

¹Emphasis added by HJF. I wonder what Darwin would make of this.

Authorship: Status Quo in HEP: CDF e.g.

The large collaborations take authorship very seriously, with a tight control of the author list, a grueling internal review process, and mechanisms to ensure collaborators read the papers. However due to the rapid pace of publication and the breadth of physics topics and personal interests most papers are ever read by a small fraction of authors.

The CDF bylaws read [4]:

0.) Definitions:

- i) "List of Authors" means the names of people to be listed on a paper submitted by the CDF Collaboration for publication in a scientific journal.
- ii) "Standard Author list" represents a default group of people who are to be included in all papers for publication with the exception listed below.

1.) Members of the CDF Collaboration become part of the Standard Author list after they have completed a minimum of 1 FTE-year of service work in the CDF Collaboration.

2)...

3.) Any person on the List of Authors for a specific publication may request that their name be removed.....

Note: I refer to this as 'Opt Out'- You are an author unless you ask not.)

4)...

5.) The List of Authors for all publications shall be listed alphabetically, sorted by the last name, first name, regardless of institutional affiliation.

6.)....

7.)....

8.) A person who ceases to be a CDF Member will have his/her name included on publications for one year after their membership has ended,

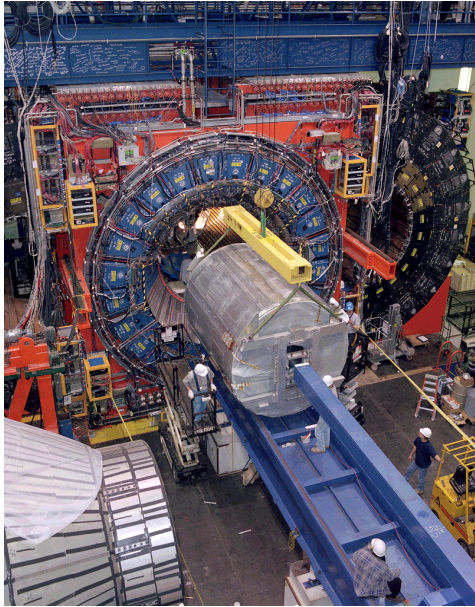
Authorship: Why It's This Way

These issues have been debated inside most big collaborations, and I can give a sample of the arguments that are made in the favor of the present policy over one that emphasizes writing the paper:

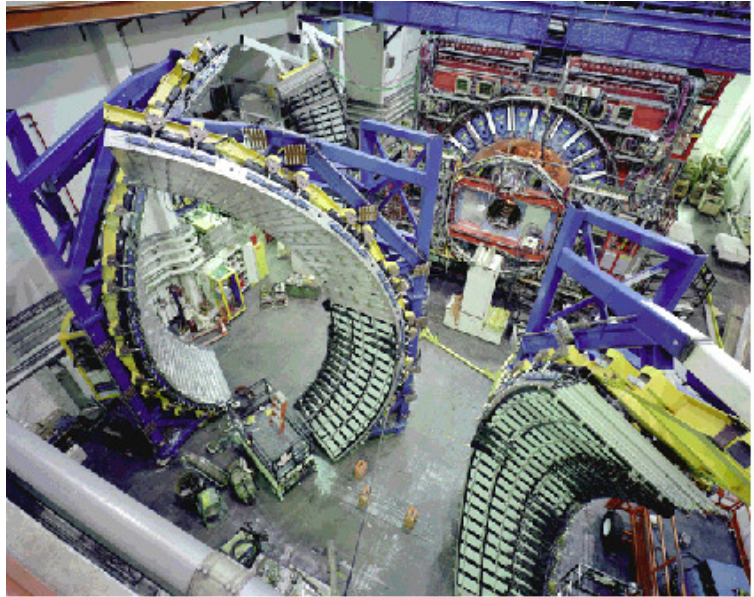
- Young physicists working hard on the nitty-gritty detector details (often hardware, in the parlance of the field, but lately increasingly complex software) will get no credit, while more aggressive and less principled folk will 'skim the cream' by preparing the analyses while waiting for the detector to be built and commissioned so that they can jump on the data.
- There is a type of physicist who understands the care and planning that it takes to get first-rate data. These are often 'instrument-builders'; people without whom the experiment would not happen. Often they are the originators of crucial ideas (for example, the silicon vertex detector at CDF was critical to our discovering the top quark), and have followed those ideas through to fruition. They are often by nature self-effacing and independent, and would not put their names on papers written by others, even those that depend critically on their work.
- It is difficult and painful to decide who among 500+ authors is deserving and who isn't; spokespeople have too much to do as it is, and it could occupy a large number of people arbitrating disputes for priority and credit. It is much easier to have a uniform policy, with clearly defined rather mechanical guidelines.

There is a great deal of truth in all these arguments.

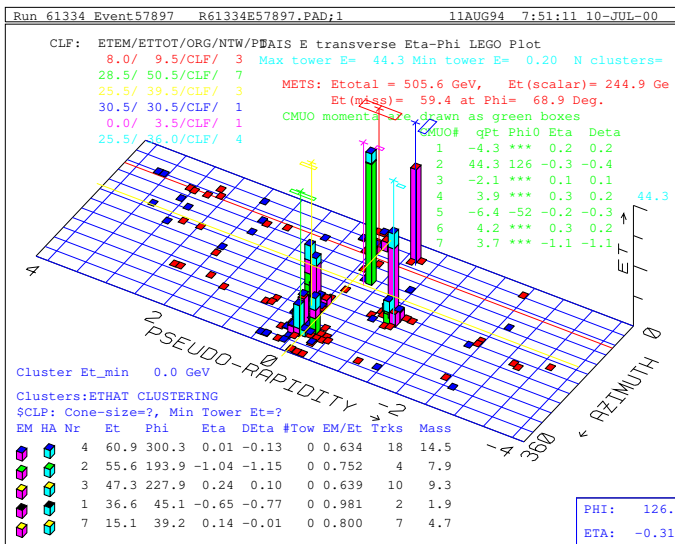
It's Hard to Convey the Complexity of A Big Detector



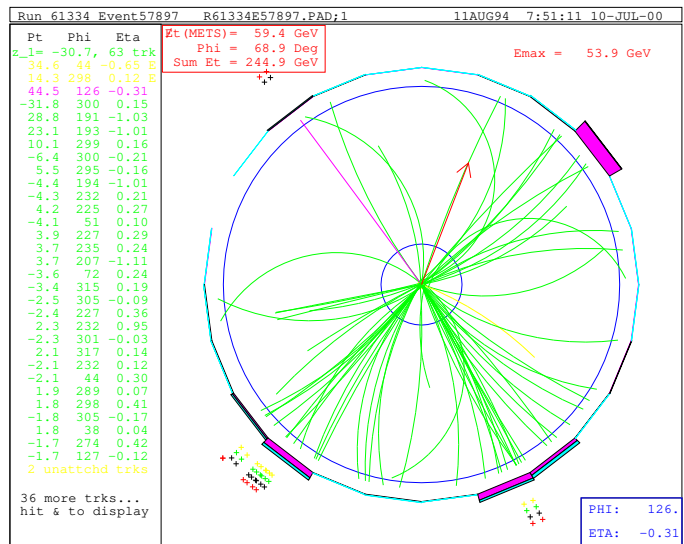
(a) The Central Detector Alone



(b) Central Detector and Some CMX



(c) A(n A)typical Event ($t\bar{t}\gamma$?): Lego



(d) A(n A)typical Event ($t\bar{t}\gamma$?): CTC

Figure 1: The CDF detector, and what may be a lovely $t\bar{t} + \gamma$ event.

Authorship: The Other Side to the Arguments

However, I believe that these arguments are based on some unwritten assumptions:

- Having one's name listed on a paper with hundreds of authors has an impact on getting a job in a university physics department.
- Physicists can do sophisticated analyses without understanding the detector.
- Getting credit for what you actually do will carry less weight than assigning equal credit to everybody for everything.
- The 'instrument-builders' benefit from credit they get from being authors on all papers from the collaboration.

Each of these assumptions I believe to be flawed. Taking them in order:

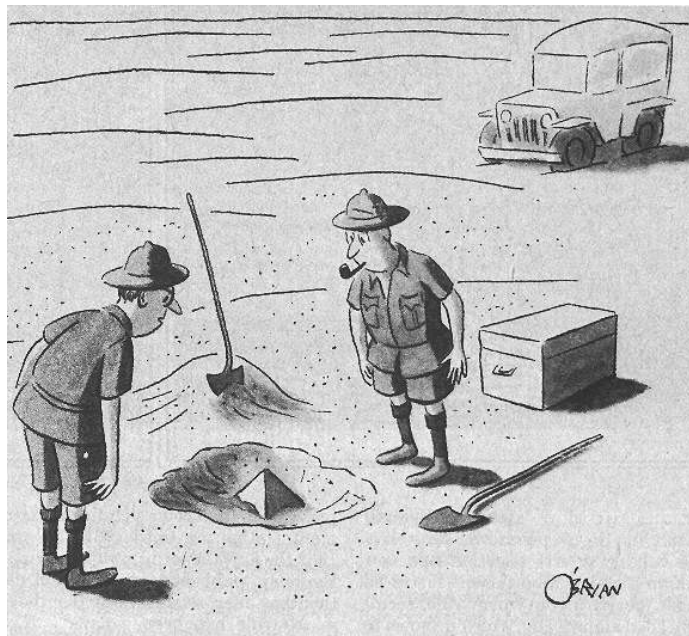
A short list of papers that one has actually written carries much more weight in a faculty meeting than 5 pages of titles all attributed to A. Aardvark et al.

Those who try to 'skim' have a huge disadvantage compared to someone intimate with the detector and the data.

And 'instrument-builders' can and should be recognized for what they do, give talks, and write papers on their contributions. Those who do are internationally known and are highly respected. Adding their names to papers they know nothing about does not increase this respect.

Reproducibility of Results in Science

This question of authorship is related, I believe, to a fundamental tenet of science: scientific results should be reproducible by others. This concept also has evolved with the advent of big unique facilities: one cannot oneself replicate results from a Mars Lander, or even from CDF. High Energy Physics has met this change by having several competing collaborations: 4 experiments at LEP, 2 at the Tevatron, Belle and Babar, as well as Cornell, in e^+e^- B-factories. Beyond that, a certain transparency is necessary to establish the credibility of results: one should have enough details to explore, understand, and discuss the methods, including access to broader documentation, contacting the authors, and, possibly access to data. There is a responsibility and custodial role for the data and the analysis framework so that results from unique data can be revisited and reproduced.



"This could be the discovery of the century. Depending, of course, on how far down it goes."

Figure 2: Reconstructing a CDF analysis from Run 1

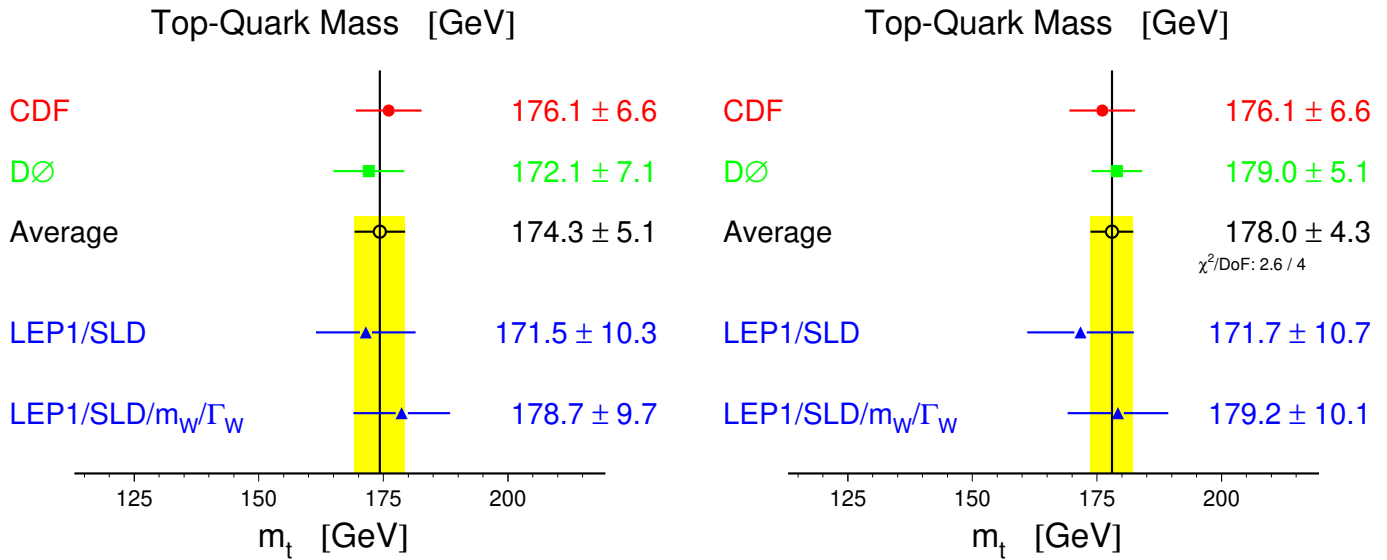
Reproducibility of Results in Science

However in a big collaboration only a few people know the details. The code has gotten exceptionally complex, so that reproducibility at a later time is difficult. And often the work has been done by a grad student or postdoc who has then moved on.

The upshot is that it is getting very hard to explore and understand an older result, much less reproduce it. As long as new and better data supercede the old this isn't a problem. It can be, however, a problem in precision measurements, where numbers are averaged.

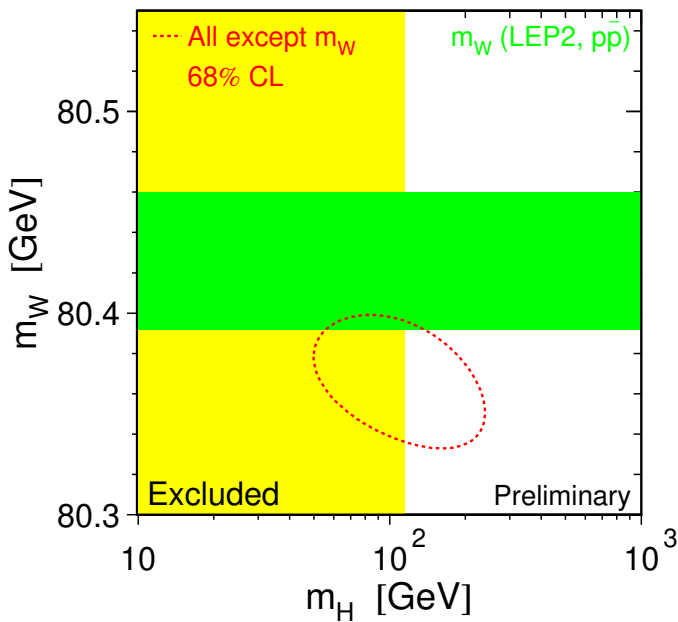
In the next page I discuss a recent example, the re-measurement by the D0 collaboration of the top quark mass using Run I data and a much more sophisticated method². The data are the same in both the old and the new analyses, and, in my understanding, all the calibrations are the same. The new method produces a result for the top mass of $180.1 \pm 3.6(stat) \pm 3.9 \text{ GeV}/c^2$, versus the older measurement [6] of $173.3 \pm 5.6(stat) \pm 5.5 \text{ GeV}/c^2$. The new paper says [5] “we expect the difference between the original and the new mass measurement to be on the order of 4 GeV/c^2 . Thus, the two results differ by less than two standard deviations.” The new measurement is an important result, as shown on the next page; moreover understanding how a change in analysis technique with the same data can significantly change a precision measurement may be important for the field. Can it be understood event-by-event?

²I see similar cases in CDF; I do this not to point fingers, but because it's such a good example of a growing problem.

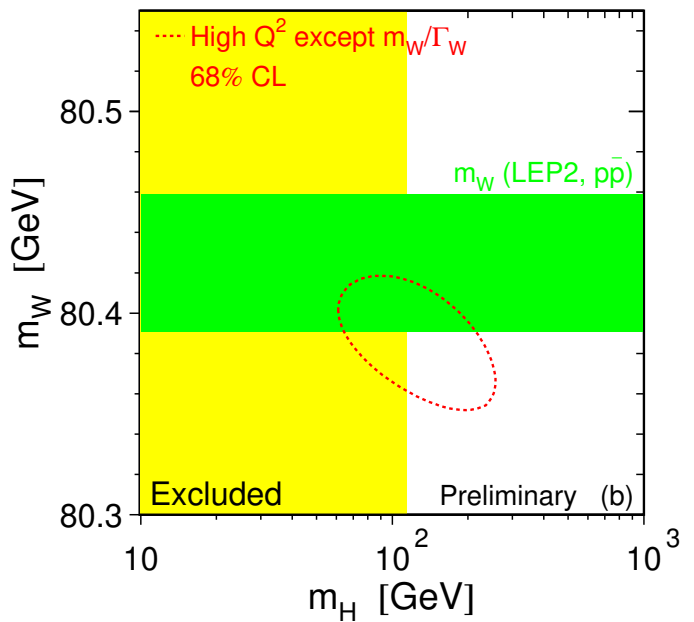


(a) Top Quark mass, Summer 2003

(b) Top Quark mass, Winter 2004



(c) Higgs/W mass plane, Summer 2003



(d) Higgs/W mass plane, Winter 2004

Figure 3: The measured and fitted values of the mass of the top quark, summer 2003 (top left) and winter 2004 (top right). The constraints on the higgs mass (red dotted oval) in the W-mass- Higgs plane from precision measurements of the SM, especially the mass of the top quark. The plots from winter 2004 (right hand plots), include the D0 top mass reanalysis of the Run I data. Plots from the LEP EWK Working Group [3].

What Should be the Goals of an Authorship Policy?

1. To allow scientific results to have as open and complete a scrutiny as possible over an extended time ('reproducibility', in short-hand, but sometimes translated as 'transparency' by necessity.), by identifying those who will carry that responsibility.
2. To give credit for the creativity and hard work of those to whom it is due, including those whose work may be critical to, but not obvious from, the work described in the paper.
3. To allow those outside the field to judge the contributions of young scientists who may be applying for jobs, promotions, or awards.
4. To encourage the publication of technological advances, possibly including software, as a means of documentation and as intellectual work in its own right.
5. To encourage more members of a large Collaboration to read widely of 'their own' work in subfields outside their own specific areas.

Discussion: Looking Forward

Some Suggestions

1. Separate the list of Collaboration Members as a separate entity from the paper author lists. Refer to the Collaboration list in the author list in each paper as well as to the authors listed by name (see next item).
2. Change the default from ‘Opt Out’ to ‘Opt In’. ‘Opt In’ starts with only those who have taken part in the specific analysis as authors on the draft. All eligible authors who acknowledge having read the paper are welcome to put their names on it. The Belle collaboration has done this using a web form; it is easily and cleanly implemented.
3. Have senior managers put more emphasis on a continuing publication of the technical (instrumentation and software developments by those physicists who work primarily on them. These papers have traditionally have only the primary authors on them. This documentation is beneficial both inside and outside the collaborations.
4. Encourage physicists in ‘support roles’ to adopt a physics topic and to study and vet the papers in that area [8].
5. Make public access to the internal notes associated with each paper. This gives a paper trail and allows a detailed understanding of what was done.
6. Identify in the author list those to whom questions should be addressed. This (short) list should start with the graduate student whose thesis this is (this is the usual case), and include up to several others.

Summary

I believe that having clarifying authorship will help rather than hurt young folk. The related problem of what I call ‘reproducibility’, but which often means exploring and understanding a result that cannot be directly reproduced, will also benefit from a clarified authorship. These are very hard problems: high energy physics has evolved rapidly into these huge collaborations of immensely talented driven young physicists, with a benign management structure of the scientific output itself (as opposed to fiscal management, which is tightly run). I hope physicists in other fields aren’t too critical; the problems are different, and inside the field the conventions are understood. But I think the present policy isn’t serving well the very people it was intended to protect.



Figure 4: Too many CDF papers to read!

Acknowledgments

I would like to thank Kent Staley for the opportunity to talk about these issues in a broader context. I benefited from conversations in 2002 with Steve Mrenna, Jack Sandweiss, and George Trilling, and more recently several extended conversations with Vera Luth, Chair of the C11 Commission of IUPAP. I thank Martin Blume for historical information on the evolution of the APS guidelines. My wife Priscilla found the cartoons [9].

The opinions are my own, however, and slings and arrows should come at me alone. I have no special wisdom in these matters, but the dilution of the meaning of authorship, particularly with respect to the questions of reproducibility and responsibility, has troubled me for a long time.

References

- [1] The pre-2002 APS guidelines were found on the APS pages at <http://www.aps.org/conduct.html>. The link now seems to be broken. My original essay on this topic quoted from this page with the 'and' in the place of the present 'or'.
- [2] The 2004 web site of the APS under Professional Conduct: (http://www.aps.org/statements/02_2.cfm).
- [3] The LEP EWK Working Group <http://lepewwg.web.cern.ch/LEPEWWG/plots>.
- [4] From the CDF bylaws: on an (internal) page at: <http://www-cdf.fnal.gov/internal/spokes/Laws.html>. I can probably smuggle out the full text on request.
- [5] New Measurement of the Top Quark Mass in lepton + jets t anti-t Events at DØ. By DØ Collaboration (V.M. Abazov et al.). FERMILAB-PUB-04-102-E, July 2004. e-Print Archive: hep-ex/0407005
- [6] DØ Collaboration, S. Abachi *et al.*, Phys. Ref. D58, 052001 (1998).
- [7] This solution may not be workable in the huge international collaborations at the LHC where national issues also intrude (I thank George Trilling for pointing this out).
- [8] I thank Vera Luth for this idea.
- [9] Figure 1 was on <http://www.homepages.dsu.edu/Mukhopai/cart0479.jpg> (Dakota State University, Madison S. Dakota); Figure 3 is from: http://www.skyrootuni.com/forum_main.htm. The credits at this URL are: "Original cartoon by Jack Corbett from American Scientist, Jan.-Feb. 2001, vol.89, #1, p.45.