Geneva, April 15

It is a stormy day in the "old town" section of Geneva. The Russian orthodox Easter has brought a number of regular parishioners and visitors to Vespers on this hilltop of a town which, surprisingly for its international status, has only some 200,000 citizens. In the US it is tax day. Today also marks 1 month since the physics community put to rest a puzzling result involving two major European laboratories - CERN, the European Organization for Nuclear Research, in Geneva, and Gran Sasso National Laboratory, which is 0.9 miles below the surface in central Italy's largest Massif.

On March 15th, a day after what would have been Albert Einstein's 133rd birthday, the ICARUS collaboration posted on the web a paper with the title "Measurement of the neutrino velocity with the ICARUS detector at the CNGS beam". CNGS is an acronym for the particle beam (containing, so far as anyone knows, only neutrinos) from CERN to Gran Sasso. The papers submitted to this website only appear around 9PM Eastern time so, when I ran into Carlo Rubbia, the spokesperson for ICARUS, at lunchtime on the 15th in the CERN cafeteria few people would have been aware of this paper's existence.

Rubbia was sitting at lunch with two colleagues in his typical uniform of rumpled blazer and open collared white shirt in a sun-filled breezeway connecting the original 50 year old dining area with the new addition of the cafeteria, completed a year ago. I had been trying to catch up with Rubbia about a topic unrelated to neutrinos and he seemed to be in a cheerful mood so we talked for a while. I asked when we could finish our topic and he said, with characteristic irony, "Well, you younger people have to work very hard and try to make discoveries whereas I, since I am now retired, can afford to travel the world and enjoy the finer things in life." But he suggested I drop him an email reminder and we could schedule something.

People familiar with Rubbia would have guessed he was up to something. In fact, he had probably been orchestrating the release of his new result with the Directorate all day.

At CERN, in the early 80's Rubbia had completed work on a very risky transformation of the Super Proton Synchrotron into a machine that collided beams of protons with antiprotons. For this, he worked with a team led by the Dutch accelerator physicist, Simon van der Meer. He then went on, as spokesperson of the "UA1" experiment, to discover two long sought elementary particles (the Z and W Bosons) which mediate one of the four elementary forces in physics. In 1984 Rubbia and van der Meer won the Nobel Prize in Physics for their work.

I was a starting postdoc representing one of the other experiments at the daily planning meetings in '83 when Rubbia was starting to leak out their evidence for the Z. It was hilarious.

In 1987 the CERN Council appointed Rubbia as Director General for a 5 year mandate, effective 1989. This brought to an end an 18 year career as professor at Harvard, where his students, who were all Humphrey Bogart fans, compared him affectionately to characters played by Sydney Greenstreet, for example.

So it is easy to imagine the nervousness of the OPERA team, which had

reported evidence for neutrinos moving faster than light between CERN and Gran Sasso, when Rubbia showed up in their neighboring counting room and asked if ICARUS could share their high quality GPS satellite timing signal to check their result.

What followed was certainly an interesting adventure in particle physics.

But this is really only half of the story. The earlier evidence from OPERA for faster-than-light neutrinos had already been "suspended" on the 15th by their collaboration after a process that is fundamental to progress in science- the peer review.

When on Sept. 23rd, 2011 the CERN Director General, Rolf-Dieter Heuer, invited the OPERA experiment to make a major presentation at the laboratory (after months of internal discussion about a puzzling result that wasn't going away) it was with a clear purpose. This was announced first to the CERN staff and then to the press:

" When a collaboration makes a surprising observation such as this and is unable to account for it, the ethics of Science demand that the results be made available to a wider community, to seek scrutiny and to encourage independent experiments."

A few of us have tried, unsuccessfully, to view this announcement from the perspective of a lab Director with a primary responsibility to get the maximum public interest and support for the work at CERN and guarantee the lab's future. It's not clear that any of us have had the training to do this in an informed way, given the International, multi-cultural setting of the lab, the lack of public understanding of what science is all about and our lack of understanding of what the press is all about.

There were many circumstances complicating this release of information. The OPERA result wasn't really from a CERN experiment, since the main role of CERN was to provide a beam of neutrinos to an experiment in Gran Sasso, 454 miles away. CERN had little direct involvement in either experiment.

The OPERA result hadn't been submitted for publication in a scientific journal, let alone accepted and published in September. It was simply a puzzling, not yet understood, effect.

Once OPERA submitted their paper, the editors of the scientific journal passed it on to some of the smartest experimentalists around, for comment. Those comments went back to the collaboration on January 10 and, after a long silence, the collaboration made a press release in which they announced, on February 22nd, that they had discovered an error in their timing system and would need to conduct further tests in order to re-measure their effect.

CERN is a very exciting place to be working today. During the period I have described there were constant discussions between technical people, experimental physicists, accelerator physicists, GPS specialists, etc. about what could have led to the OPERA anomaly.

Measuring the speed of neutrinos had essentially nothing to do with the experimental program of ICARUS or OPERA. But putting a time stamp on events has a long tradition in physics. One of Galileo Galilei's last inventions was a higher quality clock. He felt that all astronomical observations should be recorded with their time of occurrence. The inventor of the first tool to record subatomic particle

interactions, C.T.R. Wilson, insisted that a clock should always appear in the image.

This principle paid off in 1987 when physics experiments around the world were recording the time of neutrino events that arrived simultaneously with the light signal from a supernova explosion that occurred about 1,000 quadrillion miles away from earth (a 160,00 year journey rather than the milliseconds from Geneva to Italy). There were many good reasons for physicists' skepticism about the OPERA anomaly.

As an experimental physicist, I found the emphasis of the world press on far-fetched, speculative theories that might claim to allow the breakdown of special relativity disappointing. One may find in small universities all over the world people willing to talk to the press about interesting academic exercises. Why is that news?

It is possible that there will never again be a place like CERN where, through a major success of international politics, so many resources and so many people whose primary interest is fundamental research could have come together. In the year ahead, where there is much optimism about finding the Higgs Boson but also trepidation about the technical difficulties, interest will continue in the challenging work that goes on here daily. There will be plenty of time later to hear people's speculative theories about what it all means.

There has been a lot of discussion about the impact this 5 month saga would have had on public perception of work at CERN and of "big science".

Through this period the same website (arxiv.org) that posted the ICARUS paper had been carrying as many as half a dozen papers a night dealing with the OPERA anomaly. Almost every one of those papers addressed potential flaws in the conclusions based on the available information about their measurement. Some dealt with rigorous theoretical analysis of the consequence of faster-than-light neutrinos, which were either already falsified or could be tested with other measurements.

This other side of the story may sound like a lot of energy focused on one small puzzle but this approach has been key to the enormous progress in science over the past 100 years.

Take, for example, this past year's 2011 Nobel Prize in Physics. It was awarded half to Saul Perlmutter (a physicist at Berkeley) and half to Brian P. Schmidt and Adam G. Ross (who are astronomers).

They were recognized for an obsessive project to test Hubble's law for the recession of the galaxies to a new level of precision during the 1990's. What they found surprised everyone. The consequences are certainly fundamental to physics:
-does Newton's law of gravity change behavior beyond where it is now well tested?
-does Einstein's cosmological constant (which he later considered his biggest blunder) exist after all?

Since theoretical cosmology is derived from these basic laws of physics, more sexy questions, which get more press, (ie: how will the Universe end?) immediately follow.

This approach has been so successful over the past century that few doubt that it will be fruitful in the next decades. It has a long tradition in the US. Ben Franklin, who spoke good French and was elected (as a physicist) to the Royal Society of London, would have had a great time at CERN and in Geneva.

On the lighter side, the OPERA anomaly gave rise to a number of good jokes which got people asking themselves what neutrinos are, for example.

One of Saul Perlmutter's colleagues wrote to an Italian physicist in September:

" We are all very confused here about the neutrino result recently announced at CERN. How can neutrinos leave Switzerland and arrive ***early*** in Italia? It is well known that they will pass Brig at exactly the correct time, but when they reach Domodossola they will be an hour behind schedule. Please explain?"

to which Francesco answered "the OPERA physicists took this hour into account and corrected for it."

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