News

LHC Update: Luminosity Milestones

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Abstract

This article contains LHC updates for the period of May 26, 2010 to August 7, 2010 which appeared in my blog at http://blog.vixra.org .

Key Words: LHC, Update, luminosity, milestones, LHC collisions.

June 11, 2010: LHC Latest Plan

In my previous LHC report I wrote about how the LHC was then running with a beam configuration of 13 bunches each holding 20 billion protons squeezed to 2m, providing a luminosity of 2 x 10^{29} Hz/cm^2. This took them up to the limit of what is regarded as safe levels for the LHC. As they move towards more total energy stored in the beam, the risk of damaging sensitive parts of the collider if the beam goes astray gets higher. As it happens, it is possible to get higher luminosity without increasing the stored energy by putting more protons in each bunch but having less bunches. A couple of weeks ago the plan was to carry out tests to get these high intensity bunches stabilised. These tests would be interspersed with physics runs using the 13 bunch setup.

As this got underway the LHC was hit by a power cut that knocked loads of its systems out. If you have ever had trouble getting your PC back up after a power failure you can imagine what it must have been like for the LHC engineers with multiple components to get back into working order. The hardest of all were the cryogenic systems and in the end it took over a week before beams were again circulating.

Last week there was a conference in Hamburg to report "Physics at the LHC" (pLHC). Of course there is nothing revolutionary to report yet but it was a chance for the detector collaborations to report on

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the data they had taken so far and look forward to what they may see soon as luminosity goes up. A few of the physicists were not too shy to use the opportunity to plead with Steve Meyers for more physics runs before the next big conference so that they have more exciting material to present. That conference will be ICHEP 2010 which kicks off on 22 July so there is not long to prepare.

This makes quite a dilemma for Meyers and his team who control the running of the LHC. They could spend a month running with the working 13 bunch configuration, but that would be time wasted in the long run because once the LHC is up to full luminosities the same data will be provided in a run of a few minutes. It is much better to concentrate on getting to higher luminosities sooner but currently the higher intensity beams are not sufficiently stable. As well as The Hump which I wrote about last time, the beams are suffering from instabilities of a type previously seen at the HERA accelerator in Hamburg and dubbed "batman Instabilities". Luckily, experience from HERA was taken into account when building the LHC and it has better systems including octupole magnets that can be used to cure these problems.

On Wednesday a new plan was formed to meet the challenge. There it was decided to abandon the 13 bunch config for physics and concentrate on commissioning the higher intensity bunches. This is because the process of switching between the two operation modes was causing too many delays. With some optimism they hope to have the higher intensity bunches in good shape within two weeks so that physics runs can restart at higher luminosities. If they succeed the lost time will be quickly made up and there will be plenty of physics runs in time for ICHEP 2010. If they fall behind schedule the physicists may turn up at ICHEP with little more than they had at pLHC. In truth there was no contest, the long-term goals take priority. If they miss out at ICHEP there are other conferences to follow. Patience will eventually pay-off.

So according to this new plan they will be able to restart physics runs by the end of June with nominal bunch intensities of about 110 billion protons, thus providing plenty of collisions just in time for ICHEP. The lower intensity bunches were being squeezed to beta=2m, but this process is harder at higher intensities and they had planned to aim for just 5m. After much scribbling on white boards (no doubt) they have now decided that they can get to beta=3.5m, which is better. From that point they aim to step up the number of bunches again and are hoping to be circulating 20 to 40 bunches per beam by August. They will then stick at that configuration to provide a month of physics runs. Obviously this plan allows for the fact that the French all go on holiday during the whole month of August so everything will have to run on autopilot during that time anyway. When everyone gets back they can continue stepping up the luminosity with more bunches.

What news then of the mysterious and malignant Hump? They did some further tests last week to see if The Hump was being caused by the cryogenic systems. The result was: no it isn't. I think the hope now is that as they bring better stability systems into play (such as the transverse damper), The Hump will then be less of a problem even if the source for it is never found. We shall see.

June 24, 2010: LHC Starts Its High Intensity Physics Run

For the past month there have been no physics runs at the Large Hadron Collider while the beam team prepare the systems necessary to start using higher intensity bunches of protons. The commissioning process is now deemed sufficiently complete and this evening they are making their first attempts to produce stable beams for physics runs with the new settings.

The current run has 3 bunches in each beam with about 90 billion protons per beam compared to just 20 billion the last time they did physics. With the new parameters they could achieve the highest luminosity yet seen at the LHC, but only if they can get everything perfectly tuned first time. More likely it will take a few shots to get there.

Getting to this point is an important milestone in the gradual buildup of the LHC's power. From this point on further increases in luminosity this year will be gained mostly by adding more bunches into the beam. That is an easier process in principle, but they still have to take it slowly because the more energy there is in the beams, the more risk there is that components of the machine can be damaged if they lose control of them. By the end of the year there should be 240 bunches circulating in each beam, well on the way to the design limit of 2808.

Update: They did indeed reach stable beams with high intensity bunches for the first time. Luminosities of 2.5 x 10^{29} Hz/cm^2 were reported which is about 20% up on the previous LHC record

Further Update: On a subsequent run over Saturday night they doubled the luminosity to 5 x 10^{29} Hz/cm^2 The run lasted 14 hours and the integrated luminosity should be about 15 inverse nano-barns, enough to just about double the accumulated luminosity up to this point in one run (again!) To put this in perspective, the planned-for luminosity up to end of 2011 is 1,000,000 inverse nano-barns and that may still not be enough to find the Higgs boson. There is a long way to go, but this step up to nominal intensity bunches was one of the hardest challenges in the process of building up the power of the LHC.

June 25, 2010: LHC Recap & Plans

As reported yesterday, the Large Hadron Collider has now collided nominal intensity proton bunches for the first time. This is an important turning point in the commissioning of the collider and today Oliver Bruning gave a useful talk explaining why that is. This then, could be a good moment to review the progress so far and look at the future plans for the gradual build up of energy and luminosity.

First of all, here is a table showing how the collider has gradually worked up to this point since its restart at the end of 2009:

date	**E/proton**	**n_b**	**n_c**	**β**	**I_b**	**luminosity (L)**
23/11/2009	0.45 TeV	1				
06/12/2009	0.45 TeV	4				
09/12/2009	1.18 TeV	2				
15/12/2009	1.18 TeV	16				
30/03/2010	3.5 TeV	2	1	11m	10 Gp	0.001 MHz/b
24/04/2010	3.5 TeV	3	2	2m	12 Gp	0.01 MHz/b
14/05/2010	3.5 TeV	4	2	2m	20 Gp	0.035 MHz/b
15/05/2010	3.5 TeV	6	3	2m	20 Gp	0.077 MHz/b
24/05/2010	3.5 TeV	13	8	2m	20 Gp	0.21 MHz/b
25/06/2010	3.5 TeV	3	1	3.5m	90 Gp	0.25 MHz/b

E/proton is the energy per proton. The centre of mass energy which is important for the physics is twice this number because two protons collide head-on.

The protons in the beam are concentrated in bunches and $\mathbf{n_b}$ is the number of bunches circulating in each direction round the collider ring. The number of collisions per turn $\mathbf{n_c}$ is what counts towards luminosity and for small numbers of bunches this can be less than n_b . It depends on how the bunches are distributed in order to collide at the different intersection points where the experiments live.

β is a parameter that measures how much the beams are squeezed at the collision points. Squeezing them causes more protons to collide so the luminosity increases. Finally $\mathbf{I_b}$ is the number of protons in each bunch (1 Gp = 1 billion protons). The **luminosity L** (units are given as MegaHertz per barn which is 10^{30} cm^{-2} s^{-1} because this is the unit used on some of the LHC luminosity displays) determines the rate at which collision events can take place and it is roughly proportional to $n_c \times I_b^2/\beta$, so increasing the number of protons per bunch is the most effective way to increase luminosity.

So that is why the goal for the last few weeks has been to increase I_b to its nominal value of 110 Gp. Going beyond this number may be possible later but it is very difficult because as the protons get closer together they start to interact and form instabilities in the beam. The controllers of the LHC beams have a number of tools at their disposal to fix these problems but with the lower intensities used until now these were not needed. To bring on the higher intensities they had to test and calibrate the tools and that takes time. That is why it has now been nearly four weeks without any real physics runs in the collider, a frustrating time for the experimenters.

In his talk today Bruning explained in basic terms a little about the methods they use to control the instabilities. These are things that have been worked out in the past at other colliders so they are the results of many years of research. It is because of this experience that it is possible to get the LHC working in such a relatively short space of time. In case you are curious about the details and don't have the time to sit through the video of the talk, I'll give a quick summary. The primary way to keep the beam under control is by tuning it so that its chromaticity is positive but not too large. if chromaticity still goes negative it is possible to keep the beam stable using transverse dampers. The instability is measured on one side of the collider ring and then a signal is sent across the diameter of the ring to control magnets at the opposite point. The signal must go at nearly the speed of light to arrive in time before the beam gets there leaving enough time to adjust the magnets and correct the beam.

Another trick for making the bunches less prone to instabilities is to stretch them out. This lowers the density of protons without much loss of luminosity. When the beam is accelerated to higher energies the length of the bunches shrinks due to Lorentz contraction at the highly relativistic speeds. The LHC has controls to spread them back out. Finally, there is one other system that helps control the stability which is Landau damping using octopole magnets.

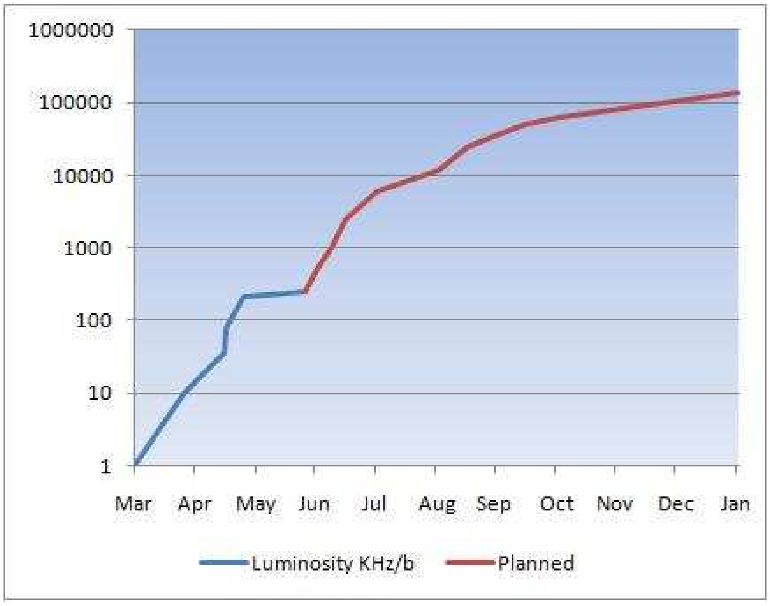
All these systems have now been commissioned or nearly commissioned over the last few weeks, so running the collider with nominal intensity bunches is now possible. The other thing they needed to do was set up the collimators. These are solid blocks that can be positioned near the beam to strip out any protons that move away from the centre. There are no less than 76 of these and each one has to be placed in the optimal position by trail and error. At lower intensities this is a relatively quick setup process, but at higher intensities it is a more delicate process. The energy in the bunches is higher and passes a safe limit for the collider. At lower intensities it is OK to disable some of the colliders built-in protection systems but above 30 billion protons per bunch that would be a very unwise risk. This means that the beams are likely to be dumped during the process of setting up the collimators. For example, if the number of protons drops suddenly by just 0.1% because a collimator isd moved in too far, or if it drops by 50% overall, then the whole beam is dumped and further collimator setup has to wait until they can be reinjected.

Because this process can take so long it is important to fix the beam parameters now with values that can be used for the rest of this year. Increasing the number of bunches is the one thing they can do to increase luminosity further without having to redo the collimation. As the number of bunches is increased the bunches will come closer together and at some point later this year this could lead to unwanted "parasitic" collisions between bunches away from the intersection points. The way to avoid this is to introduce a cross angle between the beams so they only meet at the desired point, but if the crossing angle is too large it becomes more difficult to squeeze the beams to lower β. One of the smaller experiments LHCf needs a crossing angle to be able to function. In fact the LHCf collaboration would like quite a large crossing angle but the loss of luminosity would not be acceptable to the other experiments. This would not matter so much if they could have different collimation setups ready for different parameters but to save time they have selected one compromise setting with β at 3.5m and a crossing angle of 100 micro-radians.

These parameters are likely to remain fixed for the rest of this year with just a gradual increase in the number of bunches. In another report at the pLHC conference a couple of weeks ago. Mike Lamont described the schedule for this in the "short to medium term", where medium term means the next ten years! The long-term plan is to upgrade the LHC to provide higher luminosities after 2020, but even before then there may be scope to increase bunch intensities from the nominal value of 110 Gp to as high as 170 Gp. Taking this into account the tentative plan for the next ten years is shown in this table:

date	**E/prot**	**n_b**	**n_c**	**β**	**I_b**	**luminosity**
25/06/2010	3.5 TeV	3	1	3.5m	90 Gp	0.25 MHz/b
01/07/2010	3.5 TeV	4	2	3.5m	100 Gp	0.51 MHz/b
08/07/2010	3.5 TeV	8	4	3.5m	100 Gp	1.0 MHz/b
15/07/2010	3.5 TeV	20	10	3.5m	100 Gp	2.5 MHz/b
01/08/2010	3.5 TeV	24	24	3.5m	100 Gp	6.1 MHz/b
01/09/2010	3.5 TeV	48	48	3.5m	100 Gp	12 MHz/b
15/09/2010	3.5 TeV	96	96	3.5m	100 Gp	24 MHz/b
01/10/2010	3.5 TeV	144	144	3.5m	100 Gp	36 MHz/b
15/10/2010	3.5 TeV	192	192	3.5m	100 Gp	49 MHz/b
01/11/2010	3.5 TeV	240	240	3.5m	100 Gp	61 MHz/b
01/02/2011	3.5 TeV	796	796	2.5m	70 Gp	140 MHz/b
01/05/2013	6.5 TeV	720	720	1m	110 Gp	1.3 GHz/b
01/03/2014	7 TeV	796	796	0.55m	110 Gp	2.9 GHz/b
01/04/2016	7 TeV	2808	2808	0.55m	110 Gp	10 GHz/b
01/07/2018	7 TeV	2808	2808	0.55m	170 Gp	24 GHz/b

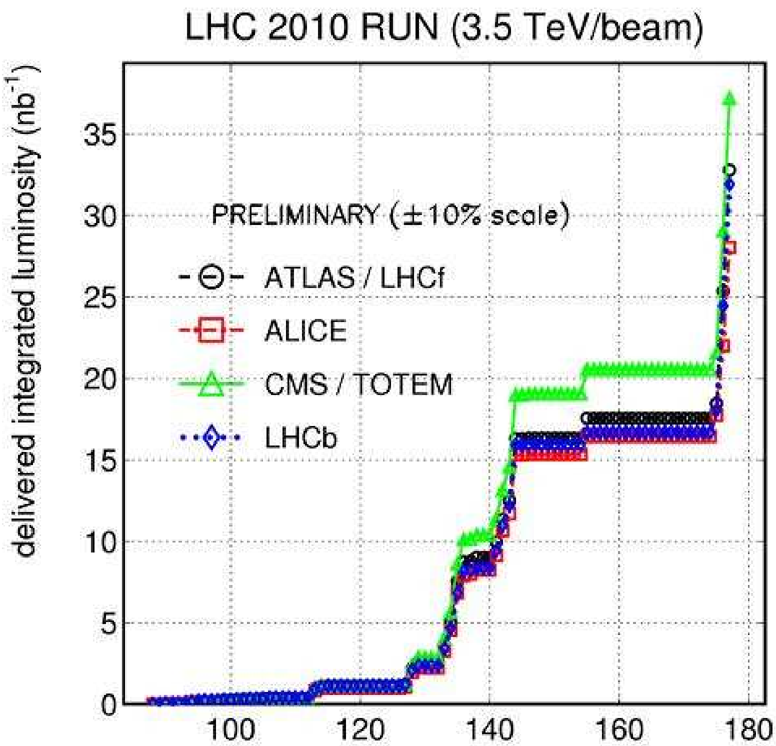
Steve Meyers who directs the beams has shown that his plans can be very flexible depending on how well the process goes, but we expect the plan for the rest of this year at least to be not unlike the first part of the above. As to when interesting new physics will emerge, that depends on what nature has in store for us.



July 1, 2010: LHC Attempts Another Luminosity Milestone Despite Problem

The Large Hadron Collider may not be producing any new physics yet, but they still keep us interested by setting new luminosity records every now and again. Now that they have high intensity bunches working, the goal for this week is to surpass a peak luminosity of 1 inverse micro barn per second. That's 10^{30} cm^{-2} s^{-1} if you prefer such units. To do this they just need to increase the number of bunches and have just made a first attempt to inject 7 per beam. Sadly the beams were dumped as the energy ramp started due to a collimator problem. They will try again shortly so keep an eye on the "Page 1" status screen if you want to follow the excitement, unless you are reading this after the event.

A report from yesterday summarises the latest events and plans. The good news is that they expect to reach an integrated luminosity of 100 inverse nano barns ahead of schedule. Currently they have about 30 inverse nano barns. However, progress has not been without its problems. All the runs with high intensity bunches so far have seen sudden heavy losses of protons due to beam instabilities. This is leading to the luminosity falling off quicker than desired. The beam lifetimes should be around 330 hours based on measurements when they are stable, but the instabilities are reducing that to 10 hours. One theory for the losses is loss of Landau damping, perhaps they are still sensitive to The Hump whose mysterious cause has not yet been uncovered. In any case, the losses are all on the collimators so they are considered safe for now. Even with so much instability they can increase luminosities by a factor of 25 before the situation becomes a concern. This gives them time to try to understand the problem and correct it.



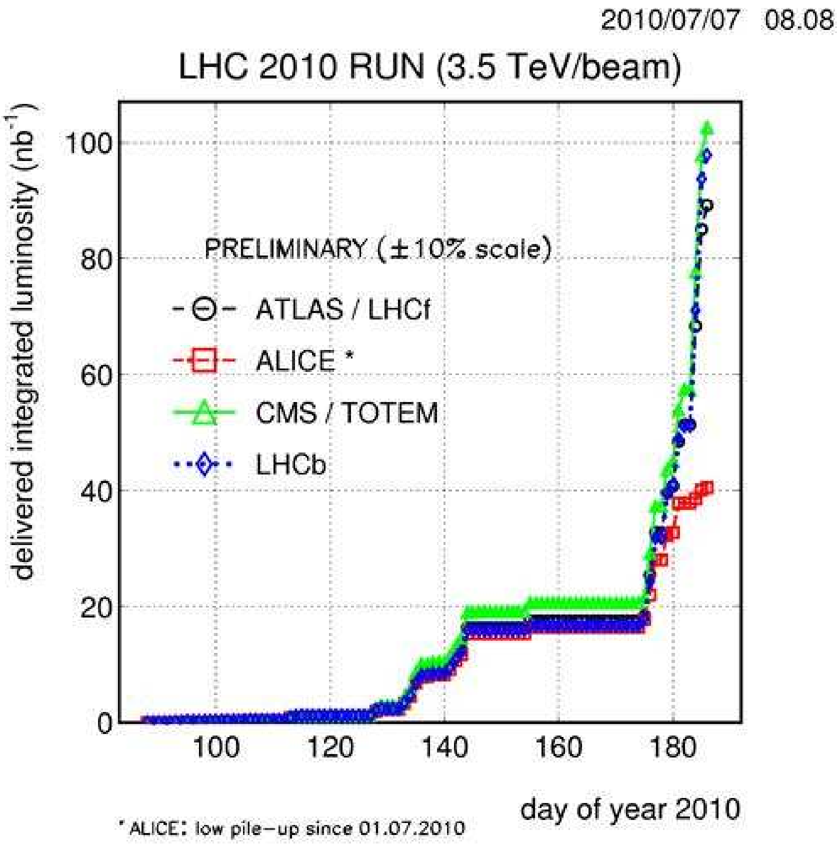
During the next week they also plan to start testing multi-bunch injections. That means they will circulate several bunches in the SPS and inject them all at once into the main collider ring. This is an important step towards running with much larger numbers of bunches in the LHC, firstly because it speeds up the injection process, but also because it is the only way they can inject bunches closely enough to pack them in.

Update: Beams with 7 bunches each were successfully ramped overnight. One of the bunches in each beam does not collide and is there only to help isolate the cause of instabilities. The other bunches provide 4 collisions per turn in each experiment. Stable beams were reached but apparently a beam dump was triggered before good luminosities were reached.

Update: On Friday evening a record luminosity of 1.1 x 10^{30} cm^{-2} s^{-1} was recorded, however it was not possible to sustain stable beams for very long. In fact there have now been five attempts to run with 7×7 bunches and so far none of them have lasted well before the beams dumped. It looks like they will continue trying over the weekend.

July 7, 2010: Large Hadron Collider Passes 100 Inverse Nanobarns

Thanks to a few healthy runs over the last week, the Large Hadron Collider has surpassed an integrated luminosity of 100 inverse nano-barns for the CMS detector with the other experiments not far behind. That is one ten thousandth of the way to the inverse femtobarn that they hope to collect by the end of 2011. It may not sound much but this milestone has been reached a little ahead of schedule so the build up is progressing well.



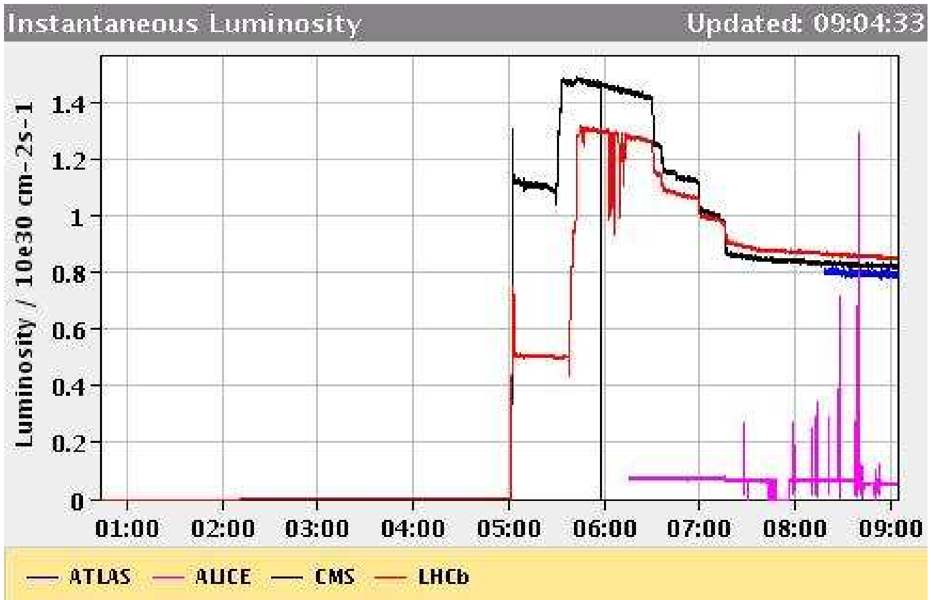
They have now switched from a 7 bunch filling scheme to 10 bunches per beam. The number of collisions per turn is still four so the luminosity will not improve, but this new scheme should have less problems with interactions between bunches. This will mean better stability and longer runs if they can avoid other hitches.

The experimenters are now preparing their results to present at the ICHEP conference that opens in two weeks time. They will probably not be able to include data taken in the July runs because it takes time to approve the results for public viewing, but they should have a bit more data in use than they did at the previous Physics at LHC meeting.

July 13, 2010: A Trillion Protons

Yesterday the LHC passed another milstone when they ramped a trillion protons per beam up to the current running energy of 3.5 TeV. The number of bunches in use is now 12 per beam with a filling scheme giving 8 collisions per turn to each experiment.

The first run at this new intensity was dumped before stable beams could be declared for physics. The reason given was problems with orbit feedback. A second run this morning has been much more successful with stable beams declared and a new record for peak luminosity of about 1.5 x 10^{30} $cm^{-2}s^{-1}$. That's 1.5 inverse micro barns per second. This follows a healthy run the previous night with 9 bunches that provided about 25 inverse nanobarns of integrated luminosity to add to the totals of around 100 inverse nanobarns so far.



It has not been all plain sailing. An uncomfortable proportion of attempts to reach stable beams have failed for a variety of reasons that caused the beams to be dumped prematurely. Typical sources of problems include glitches in the electricity network, problems with hardware and software components or just human errors. Even more worrying is the heavy losses from the beams once they are circulating. This is partly due to the electromagnetic interactions between the protons when the bunches collide and this has been mitigated by reducing the intensity of each bunch to about 90 billion protons rather than the 115 billion nominal value. It also seems likely that The Hump continues to dog operations causing the beams to disperse vertically and hit the collimators.

Despite these problems progress continues to just about keep up with the ambitious plans laid out in June. Although the multitude of problems can be frustrating, the rate of progress overall is very good compared with accelerators of the past. The collider beam teams are continually learning how to avoid failures and improve stability.

The next step is to use multi-bunch injection to push towards even higher intensities. They have already carried out tests with four bunches being fed from the SPS into the LHC ring in one go. Now they plan to use this technique on the next physics runs. The aim is to get intensities as high as possible by the end of July then run without further changes during August when some of the technical experts will be on leave.

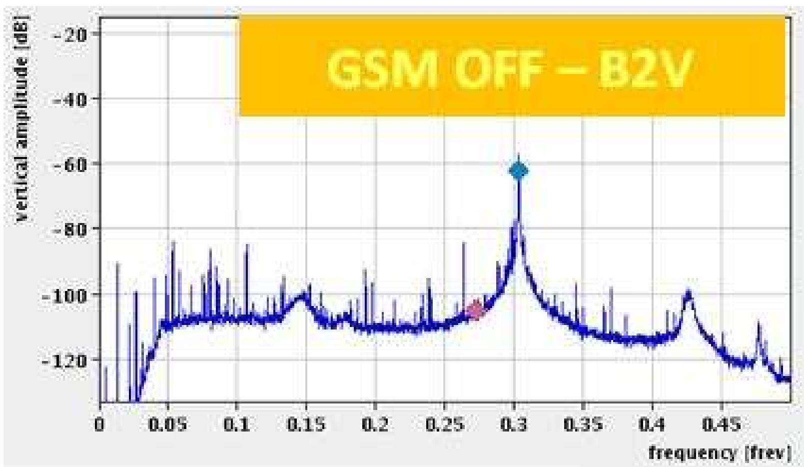
The focus of excitement is now turning towards the ICHEP conference starting in one weeks time. Tommaso Dorigo has been mischievously pumping up the tension with rumours of an observation of a low mass Higgs at the Tevatron. Lobos Motl has prepared an excellent discussion of what that would mean for physics if it is true. Let's hope his effort is not wasted! At ICHEP we might also expect further clarification of recent reports on neutrino physics, and perhaps some other new surprises.

Update: They followed the first 12 bunch run with another that is still ongoing after 12 hours with luminosity still above 1 inverse microbarn per second. Combining the three runs of the last three days provides about 100 inverse nanobarns of integrated luminosity. That doubles the total to date.

After so many failed runs over the previous couple of weeks the LHC is suddenly looking on great form. The target for the end of 2011 is 100 inverse picobarns. If they can increase the luminosity by another factor of 10 to 20 that should be easily achievable.

July 16, 2010: The Hump at the LHC Is Not GSM Interference

If you have been following our LHC news features for a little while you will know that the Large Hadron Collider has been dogged by a particularly annoying form of interference that the beam engineers have dubbed "The Hump". Yesterday they ran some tests to see if the source could be the GSM phone network that they run throughout CERN. By switching off the GSM transmitters while a 450 GeV beam circulated in the collider ring they were able to show that the interference did not go away. Something else must be to blame.



The Hump takes the form of a hump in the spectrum of beam oscillations that drifts up and down the frequency range. The beam is normally given a tune frequency away from any interference to keep it stable, but because the hump frequency keeps changing it is difficult to avoid whatever tune frequency is chosen.

When the hump drifts over the beam frequency it destabilised the beam causing it to spread out vertically. The first effect of this is to decrease luminosity because as the protons spread out they are less likely to collide, then as the beam spreads out further the protons hit the collimator causing losses that reduce the lifetime of the beams. In the worst case the losses can trigger an unwanted dump of the beams.

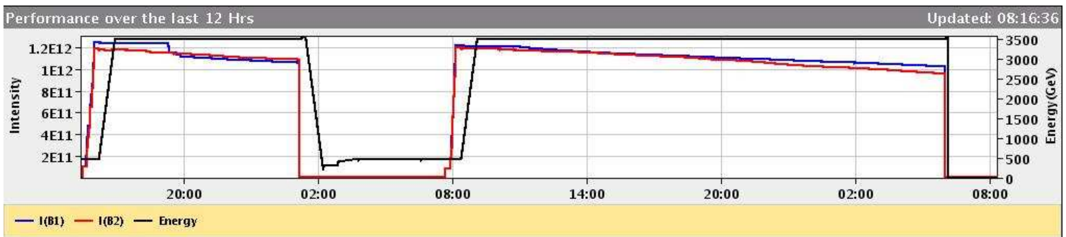
The LHC has a number of inbuilt dampers and other features that help to stabilise the beams by steering wayward protons back into the centre of the beam, but at high intensities these don't seem to be quite enough to avoid the effects of The Hump. It has been around since the LHC was restarted at the end of the year and has thwarted all attempts to track down its cause.

The history of collider building provides several stories of interference that was hard to track down in the past. When LEP was running at CERN another nasty problem was finally diagnosed when the French rail workers went on strike and the interference disappeared. It had been caused by a nearby TGV line. For the last few months the LHC beam teams have been looking for causes of The Hump and yesterday's GSM test is the latest in a series that have eliminated many possible causes such as vacuum pumps, and Cryogenic coolers, bur whatever they do the hump remains.

Meanwhile we can look forward to the LHC engineers testing for even less likely sources for The Hump and hope it does not have too bad an effect on the continuing build-up of luminosity.

July 19, 2010: LHC Best Run Yet

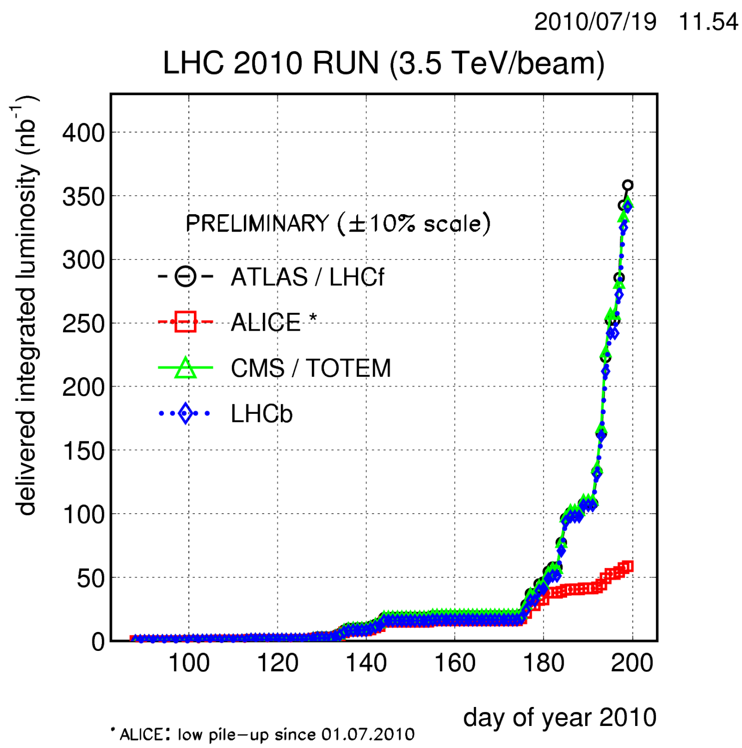
The Large Hadron Collider has just finished its best run yet with 19 hours of stable beams providing an integrated luminosity of about 75 inverse nanobarns. This takes the total luminosity accumulated to about 350 inverse nanobarns. The run with 13 on 13 bunches and 8 collisions per turn began with a new record peak luminosity of 1.6 mHz/barn for ATLAS and CMS.



The LHC has now entered a planned technical stop that will last two or three days before restarting for the last push to increase luminosity before a period of steady physics runs during August. According to the medium term plan set a few weeks back they should be aiming to double the number of bunches up to 24 over the next two weeks. However the luminosities have been a bit lower than expected because they have settled for bunch intensities below nominal in order to improve stability. A Physics Programme Meeting this afternoon will tells us what they plan to do next.

As we've said before, optimising the filling schemes for the LHC is difficult because the collision point of the LHCb experiment is 11 meters away from its ideal position exactly one eighth of the way round the collider ring. This is because the experiment has an asymmetric design and had to be placed in an old cavern used by a more symmetric experiment for LEP, the previous collider in the tunnel. If it were not for this they could place the 4N proton bunches equally spaced around ring and get 4N collisions per turn in all the experiments. Because of the asymmetry this is not possible. Up to now they have used mostly a filling pattern that provides 2 collisions per turn for every three bunches in each beam (see my previous post for a video of how that works). That is just 67% efficient compared to the optimum.

That was a democratic solution because it gave the same potential luminosity in each experiment which was great for the calibration stage. Now as they move into a more serious phase where potential new physics becomes possible it is more important to give the maximum luminosity to CMS and ATLAS. ALICE can take a back seat because its real role is for heavy ion collisions and that will not be tried until much later. LHCb can also do with less but not too much less.



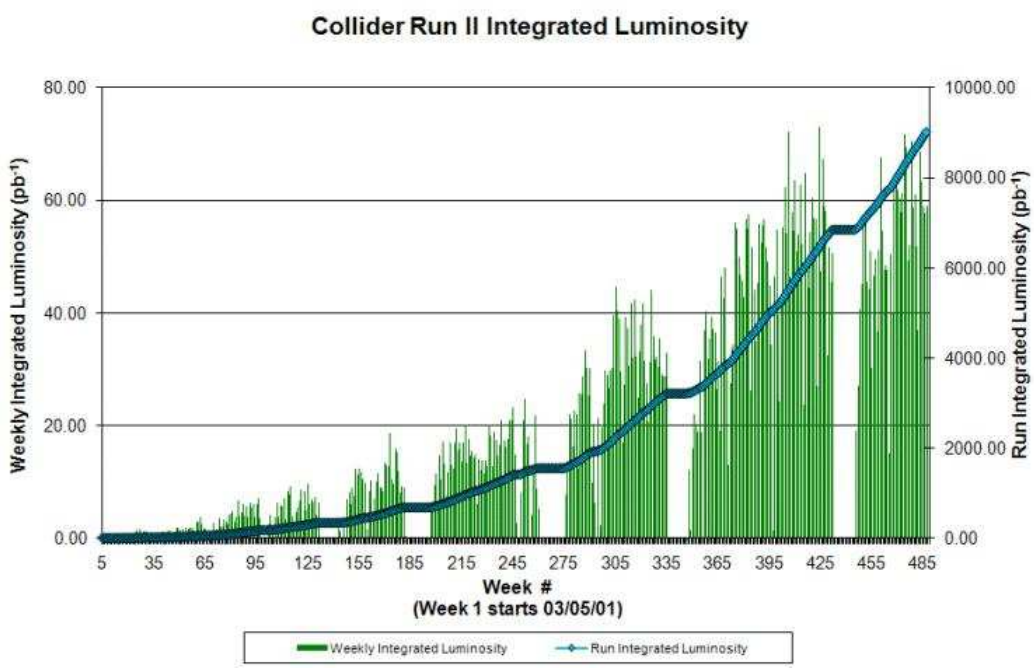
Another filling scheme with offsets the positions in such a way that ATLAS and CMS get the optimum number of N collisions per turn with N bunches, while LHCb gets just half the number and ALICE gets none. This is described as scheme 1 in the presentation of this afternoon. Then there is also scheme 2 that gives two collisions per turn for every three in LHCb. By alternating between these two schemes and possibly the current one, they can get a good mix of luminosities.

Update: The technical stop is due to end on Thursday. The plan now is to attempt ramping the energy up with 24 bunches on Friday.

July 20, 2010: LHC, Tevatron, Higgs, Neutrinos, Rumours and Much More all at ICHEP

If you stand in the middle of Place de la Porte Maillot in Paris you can see L'Arc de Triomphe to the East, La Défense to the West and Palais des Congrès to the North. This is where the ICHEP conference will begin on Thursday. The International Conference on High Energy Physics is a biennial conference that has been held since 1950 as the largest gathering of experimenters and theorists in particle physics. This year it is billed as a special event because it is the first time that results from the Large Hadron Collider can be presented.

Of course, that is not quite true, some results were already presented a few weeks ago at the "Physics at the LHC" conference in Hamburg. In any case, we do not expect too much from the LHC just yet. It has only gathered 350 inverse nano barns worth of data whereas its rival the Tevatron has 9 inverse femtobarns. That's 25000 times as much. Also, most of the LHC data comes from the last few weeks and it will be hard to get results ready fast enough for the conference using such recent data. Even [the most optimistic studies]() suggest that about 30 times more data is needed before there is a possibility of seeing something new at energies beyond the reach of the Tevatron. Luckily there are other experiments that may report some new physics.



The conference starts with three days of parallel sessions from Thursday until Saturday. With seven talks going on at any one time it will be hard to follow everything. After a break on Sunday there will be three more days of plenary session talks. Counting all the talks and posters there will be an incredible 1247 presentations at the conference. For those of us who can't make it in person there will be live webcasts. They only have one video stream so only a limited number of the parallel sessions will be shown. To find out in advance which ones can be seen you should consult this timetable . For other talks we will have to just look at the slides.

Following the rumours of the last week, there will be a lot of attention focused on the Tevatron Higgs searches. The individual CDF and DZero collaborations have already given us a preview of what they intend to present, and they took the opportunity to pour scorn on our favorite ICHEP blogger Tomasso Dorigo for blogging about the rumours, but who will have the last laugh? According to Fermilab Today they have kept back one presentation in which they will tell us the result of combining their data from the two experiments. This sounds like a desperate attempt to get a signal that would encourage their sponsors to keep them going a bit longer. Will it correspond to the three sigma observation the Tommaso suggested? If it does then some Fermilab people are going to look a little silly over what they said about the rumour, but it will still be a mouth-watering result to announce. Even if there is no signal there remains a good chance that they will exclude a larger mass range for a possible Higgs and that should be very interesting too. All will be revealed on Monday at 16:00 European Time.

In case you haven't given up hope of something unexpected from the LHC, the plenary sessions will open with a talk by Steve Meyers to say how many bunches he can now spin at once, followed by updates from the LHC experiments, ATLAS, CMS, and LHCb. The more savvy people will probably be looking beyond the accelerators to what is being seen in the multitude of static detectors for neutrinos, cosmic rays, dark matter and the like. In addition there will be some theory talks and finally some discussion on the future of particle physics. I'm not sure what that will cover but it has to be worth watching.

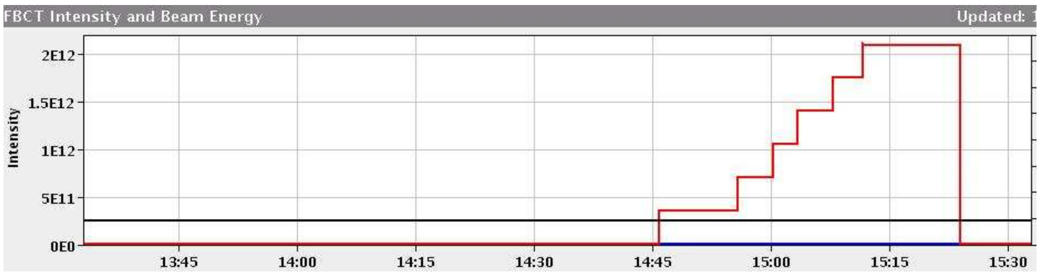
What about the gravitational wave detectors? When they started building LIGO in the 1990s the blurb that came with them made it sound like they should have detected gravitational waves by about 2003. Now they are looking towards an upgrade that will give a factor of ten improvement in sensitivity by 2015. The problem with such detectors seems to be that they are not too good at frequencies below something like 100Hz due to thermal noise and environmental vibrations. Cosmic events that are likely to give off gravitational waves tend to work at lower frequencies just because of their size. Hopefully this talk will tell us what we want to hear about future prospects.

If neutrino physics is your thing you will want to pay attention to the Status Update for the MINERvA Experiment, Latest results from the MINOS experiment, Results from the first T2K physics run, The ANTARES neutrino telescope and The ArgoNeuT Experiment. For cosmic rays there's Results from the Telescope Array Experiment, Recent Results from the Pierre Auger Observatory and Recent Results From VERITAS.

Of course there is much more but for the rest you should look at the timetable yourselves.

July 27, 2010: 24 Bunches in LHC

The Large Hadron Collider has demonstrated multi-bunch injection for the first time by injecting 24 bunches, arriving in batches of 4 at a time from the SPS. In the previous runs up to 13 bunches were used in each beam, but they need to inject more bunches to reach higher intensities. They have a target to collide 24 bunches throughout the month of August.



After a technical stop last week the LHC had been slow to get restarted properly but this latest test puts them back on track. Now they have to repeat the injection for both beams at the same time and ramp them to high energies for collisions. They will be hoping to do that in the next few days ready for August.

Eventually the LHC will circulate 2808 bunches in each beam and to do that they will have to be able to inject 72 bunches at a time from the SPS.

July 29, 2010: Record Luminosity at LHC with 25 Bunches

The Large Hadron Collider has today reached new record luminosities of about 2.8 Megahertz per barn using 25 bunches per beam. Each experiment now sees 16 collisions per turn which is twice the number in the previous scheme that used 13 bunches per beam. With some tuning slightly higher luminosities will be possible.

The current plan confirmed by Steve Meyers at ICHEP is to run with this scheme constantly during August. This will give the collider control teams the opportunity to perfect their operations and improve stability so that they can get the maximum amount of stable beam time.

It should now be possible to sustain average luminosities of about 2 MegaHertz per barn with this scheme. If they can produce enough hours of stable beam per day during August the experiments could collect about ten times the integrated luminosity seen so far. From results presented at ICHEP - especially the dijet and dimuon observations – there is some hope that new physics at above 1 TeV could already become evident with such a data sample.

After August they will once again start to step up the number of bunches ready to collect the much higher target of 1 inverse femtobarns by the end of 2011.

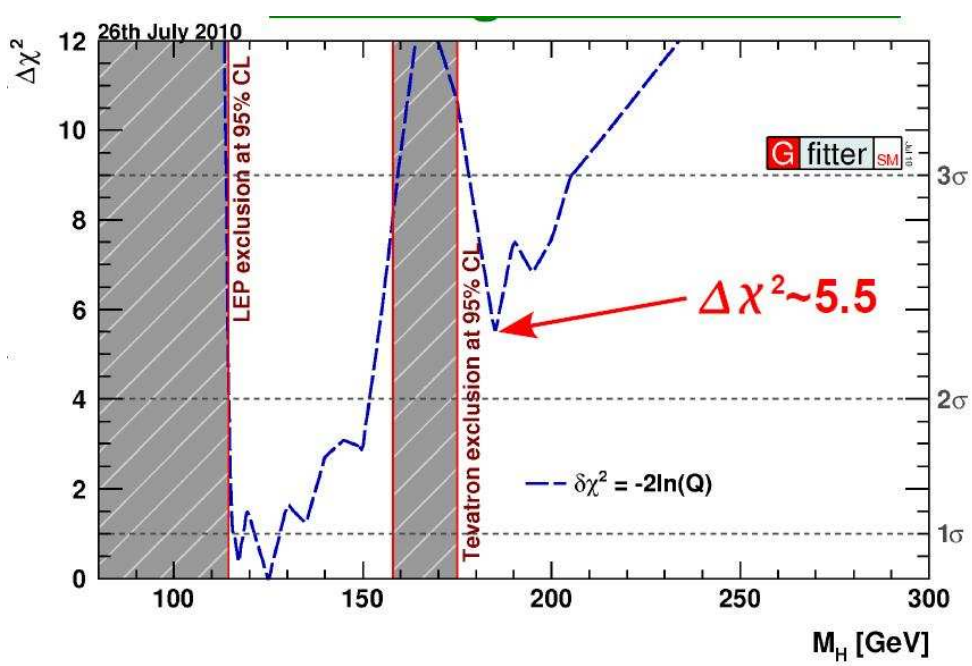
August 5, 2010: How Long until New Physics?

The LHC is nearing the end of a long overnight run that started with a record luminosity of 3/ub/s. It is already the first run to collect over 100/nb (100 inverse nanobarns) in one go and it has another hour to run before they plan to terminate it. With luck they will be able to repeat this most days throughout August enabling them to collect 3/pb (3000 inverse nanobarns) this month which is about 10 times the data used for the ICHEP talks. After that they will start a rapid exponential growth of luminosity until the end of this year that should enable them to collect 1/fb (a million inverse nonabarns) by the end of 2011 when the LHC will shut down for further maintenance. Meanwhile the Tevatron continues to steadily collect data at a higher rate but lower energy and waits to hear how long it can continue.

That makes this a great time to play the game of guessing what will be discovered when and where. It is a game that anyone can play whether they are a humble independent blogger like myself or a full-time phenomenologist guru like John Ellis. Those who are insider members of one of the experimental collaborations will have to be careful not to reveal unpublished results but for the rest of us it is harmless fun.

Tommaso Dorigo looks to a 4th generation quark as the next discovery based on excesses above background for high mass events, now seen in both CDF and DZero at the Tevatron. In the end he cops out and says the signal is too weak and he thinks it will be a while before new physics is seen.

Lubos Motl has been excited about supersymmetry with the likelihood of a light Higgs and some excesses in channels where supersymmetry is supposed to live. The mass likelihoods for Higgs are represented by this plot from this presentation. Remember there could be more than one Higgs if supersymmetry is right.



Peter Woit reports a claim that early results from the LHC have already ruled out parts of the parameter space of supersymmetry and asks how long it will be before supersymmetry is ruled out. Nobody was expecting a high chance of seeing supersymmetry with so little data from the LHC so the impact on its parameter space so far must be very small. There is a small chance that evidence for new physics including supersymmetry could be seen this year in dijet or dimuon events at high mass if the right sort of particle exists. It is also even possible that Fermilab already have the evidence for a supersymmetry style Higgs and are going through a careful process of review and approval that could take several months.

To rule out supersymmetry if it is not there would take a little longer. Eliminating supersymmetry at the electroweak scale would require the full Higgs sector to be explored. If the Higgs is light as supersymmetry favours then it will take about 16 inverse femtobarns to cover the whole mass range looking for a 3-sigma signal. Fermilab could reach that point around 2013 if they are allowed to continue and their detectors withstand the potential radiation damage.

To convincingly rule out supersymmetry will however require the full force of the LHC. Taking Steve Meyers predictions for LHC luminosities as shown in this table, we can see that it should be around 2014 before they have enough data to rule out electroweak scale supersymmetry. Of course there may be another form of supersymmetry at much higher energies but that would be something very different that could not easily account for the effects that supersymmetry is meant to explain in the Higgs sector.

Preliminary Luminosity Predictions

Very preliminary with large error bars

Year	TeV	OEF	β*	Nb	Ib	Itot	MJ	Peak luminosity	Pile up	[illegible]	[illegible]	Integrated (fb-1/year)	Total Int (fb-1)
2010	3.50	0.20	2.00	796	8.0E+10	6.4E+13	36.0	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0.07
2011	3.50	0.25	2.00	796	8.0E+10	6.4E+13	36.0	[illegible]	[illegible]	[illegible]	[illegible]	0.98	1.04
2012								[illegible]	[illegible]	[illegible]	[illegible]	0.0	1.0
2013	6.50	0.20	0.55	796	1.15E+11	9.2E+13	[illegible]	[illegible]	[illegible]	[illegible]	180.0	8.2	9.2
2014	7.00	0.20	0.55	1404	1.15E+11	1.6E+14	[illegible]	[illegible]	[illegible]	[illegible]	240.0	20.7	30.0
2015	7.00	0.20	0.55	2808	1.15E+11	[illegible]	[illegible]	[illegible]	[illegible]	172.8	210.0	36.3	66.3
2016						[illegible]	[illegible]	[illegible]	[illegible]		0.0	0.0	66.3
2017	7.00	0.25	0.55	2808	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	216.0	240.0	51.8	118.1
2018	7.00	0.28	0.55	2808	[illegible]	[illegible]	[illegible]	[illegible]	32.3251	411.6	240.0	98.8	216.9
2019	7.00	0.30	0.55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41.5198	566.4	210.0	118.9	335.8
2020			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				0.0	0.0	335.8
2021	7.00	0.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.006E+34	76.1197	692.3	150.0	103.8	439.7
2022	7.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	571.3	5.390E+34	102.4060	1257.3	220.0	276.6	716.3
2023	7.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	571.3	5.390E+34	102.4060	1257.3	220.0	276.6	992.9
2024	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	1290.0
2025	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.1E+14	571.3	5.390E+34	102.4060	1350.5	220.0	297.1	1587.1

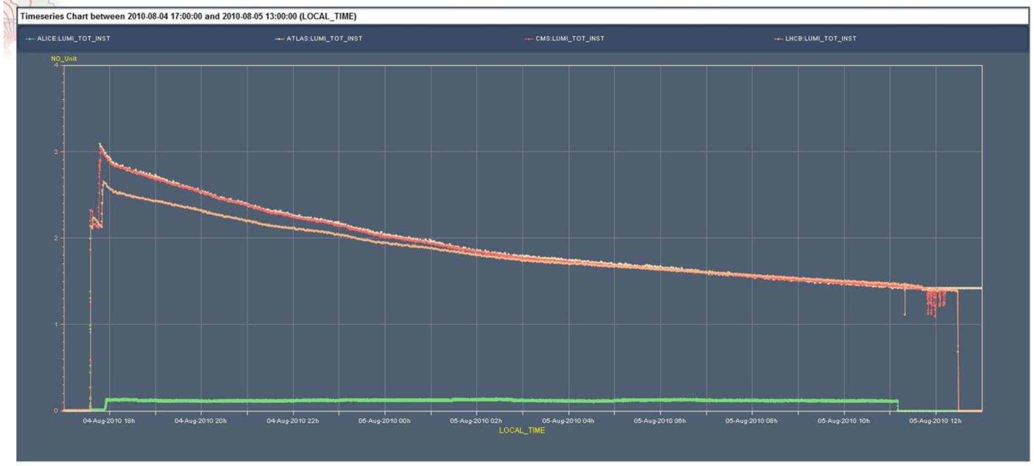
So if it is time for me to place my chips on the table I will bet on growing evidence for supersymmetry from now until end of 2011, but with the likelihood that we will have to wait until about 2014 for all the full details to emerge. If a fourth generation exists there is no reason to expect it at around this mass scale so I don't expect to see it. Tommaso is probably right that the Tevatron excesses are due to something else.

If anyone thinks something else will unfold, now is the time to say it.

August 6, 2010: Record Breaking Run at LHC

Yesterday the Large Hadron Collider completed a physics run lasting 18.5 hours that set two new records for the collider. The peak luminosity reached 3.1 MHz/b and the total luminosity collected was 120/nb, it is the first time they have collected over 100/nb in one run. This takes the accumulated luminosity to about 670/nb. Another similar run is already underway showing that they are now settling in to the routine physics runs they planned for August with 25 on 25 high intensity bunches.

- End of physics at ~11:00 after 18.5 hours



~120 nb^{-1}