ATLAS e-News

14 June 2010

NEWS

Trigger time!

Getting selective in the face of increasing luminosity

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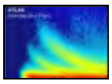
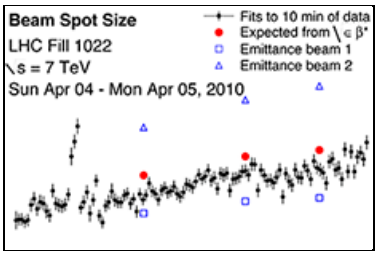
First round of ATLAS results under the spotlight

Summarising the detector performance



This was only possible thanks to the contribution of so many physicists

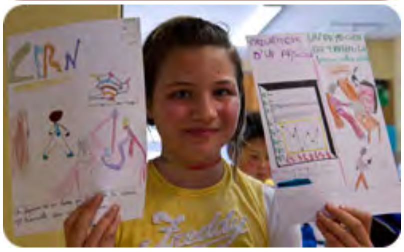
FEATURES



Where the "needles" collide

Finding out the exact beam spot position and size inside the comparatively vast beam pipe is no small task

PHOTO GALLERY



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PROFILE

"[It's] a sort of linear combination between a professorship and a Peace Corps assignment," says Trevor Vickey

EVENTS

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Trigger time!

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Racks of XPUs (Interchangeable Processing Units) which run the HLT trigger algorithms

Even though the LHC is currently delivering five orders of magnitude below its design luminosity, peaking so far at 2 x 10^{29} cm^{-2} s^{-1} in ATLAS, already the collision rate that this provides the experiment is too high to be able to store it all. With the most recent jumps in luminosity, the time has come for the High Level Trigger system to step up and get seriously involved…

"There are several stages of turning on the trigger," explains Wojtek Fedorko, who is involved with trigger operations, and affectionately describes the system as "a somewhat complicated beast."

The Level 1 Trigger – the hardware system that bases its snap decisions on the characteristics of energy clusters and energy sums in the calorimeter, or hits in the muon trigger system – has been active since the very first collisions at 900 GeV last year. It also has a number of direct inputs, including the MBTS and the forward detectors. Essentially every proton-proton collision is flagged by these detectors when charged particles from collisions hit them, and up until just a few weeks ago, every such 'minimum bias' trigger was accepted by the Level 1. At that time the calorimeter and muon triggers were a small subset of events being recorded.

As instantaneous luminosity increased, higher event rates made it impossible to write out each and every one to disk, so the minimum bias triggers were 'prescaled' such that only a known fraction of each type of event is now kept.

The prescale values are calculated for a given luminosity, based on known trigger rates from previous runs; each event type is accepted just once per n occurrences. The more common the event type, the greater the value of n. The prescales are tuned so that ATLAS is writing out data at just below the available bandwidth (a measure of how much data can be stored per second) and this scaling is then taken into account at the analysis stage.

The High Level Trigger (HLT) –which uses software at the Level 2 and Event Filter stages to wheedle out the more interesting events – has actually been running since day one of high-energy collisions, March 30th. But it wasn't run in 'physics rejection mode' until recently, and instead simply piped all events straight from Level 1 to the disk.

Overnight on Monday May 24th, the peak luminosity recorded by ATLAS almost tripled, and the HLT began rejecting electron triggers for the first time.

“The [electromagnetic trigger] thresholds at Level 1 are pretty low – we can accept at around 300 Hertz,” explains Wojtek, “but now that the triggers are firing above this frequency, we need to reject a fraction of them using more sophisticated algorithms at Level 2.”

“Of course the game becomes more complicated once you have more triggers in this regime,” he cautions. After the electromagnetic trigger rates rise, so too do other triggers, and distributing bandwidth gets trickier. “Essentially, it's solving a big equation, but an additional complication is that triggers are correlated.”

Here, the trigger team faces a choice: either prescale at Level 2 or activate the HLT algorithms. The former would guarantee that the HLT was not biasing the sample, but the latter would avoid throwing away interesting data.

“So what the electron trigger group decided to do was trust. They were reasonably confident in their triggers,” says Wojtek. To check whether or not that trust is well-placed, a small fraction of events are accepted without applying the triggers, so that bias studies can be pushed further.

“Based on data which have been taken during the last couple of months we were able to estimate the performance of our low energy electromagnetic triggers,” explains Rainer Stamen, deputy coordinator of the egamma signature group. “ So we were confident in the system before going into the rejection mode. Once we went into rejection everything behaved as expected. The fraction of rejected events followed our predictions and the data did not show any problem.”

On top of this, there is a continuous effort to monitor the quality of the triggers. “Every run, we take a small portion of events and re-run them offline,” says Wojtek. “There we look and see if the baseline performance is ok – do the algorithms take too much time, do they crash? And also, do they make sense?”

From an operational point of view, things have been working very well thus far. Which is good news, because it's only going to get more complicated for the Trigger from here on in.

“I would say this is a big boundary, but there are going to be a lot of smaller boundaries where we have to move up in thresholds,” Wojtek summarises. “It's very exciting and it's going to be getting more and more complicated and exciting as the luminosity goes up.”

Ceri Perkins
ATLAS e-News

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Summer conferences kick off

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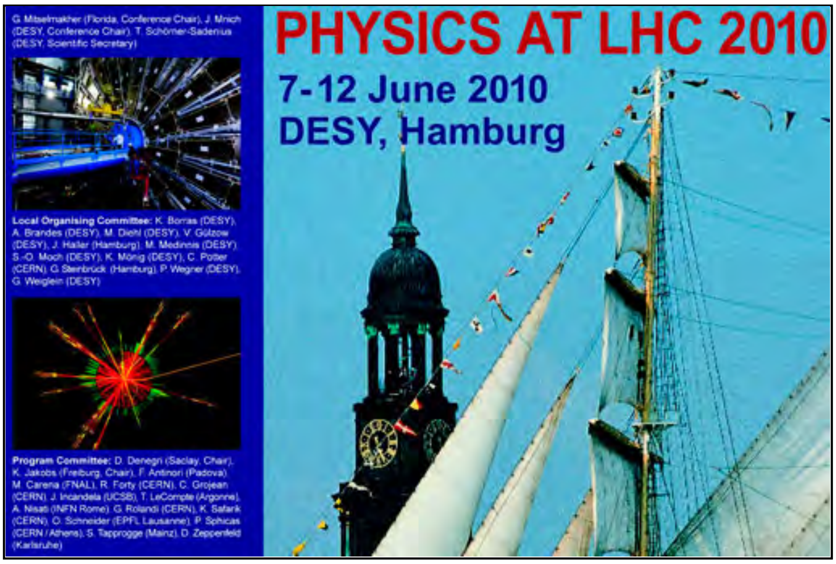

Part of the poster for the Physics at LHC meeting

Last week, the first of the big 'summer conferences', Physics at the LHC (PLHC) took place at DESY in Hamburg, representing an important opportunity for ATLAS to present LHC data to the world. The weeks leading up to the conference were a flurry of frenzied activity, sleepless nights, corridor discussions, and double espressos. ATLAS e-News caught up with Deputy Physics Coordinator, Aleandro Nisati, in the week before the conference....

When asked what it took to be ready in time for PLHC, Aleandro's response is an emphatic: “A lot of effort.” ATLAS presented a total of 16 conference notes in Hamburg, broadly covering the whole physics spectrum that can be looked at so far, as well as detector performance studies.

“It's difficult to quantify how many persons we have per note,” Aleandro considers, “but if you count just for the notes preparation, without counting the work which has been involved for the infrastructure, it's maybe of the order of 20 persons per note.”

In Geneva and across the world, these 300-plus people worked with data taken between April 30th and May 17th 2010, although most notes were well underway before the end of that period. “It's a question of time optimisation,” Aleandro explains. “While you are collecting data, you have to start to do the analysis, to see how the results look like, and compare against Monte Carlo predictions, to understand your detector… then you can adjust and optimise your analysis.”

The Editorial Boards for each note were responsible for ensuring that the collaboration's comments were heard and implemented. “They have really to scrutinise very deeply the note. It's the systematic work that you cannot expect from anyone else,” explains Aleandro, concluding: “The success of the note is closely related to how the Editorial Board acts.”

As for the conference itself, the aim in Aleandro's eyes is twofold: Challenging discussion between the LHC experiments, as they try to understand one another's' results – “A good sign of health in our community”; and interaction with people from the wider, non-LHC community – theorists, members of other experiments, members of past experiments – whose perspectives may significantly contribute to the discussion of current observations at ATLAS.

The aim is that the conference notes converge and become journal-published physics papers. Exposing the work to the wider physics community at this stage, and gauging their reactions, is an interesting step along the way – almost like an early peer-review process. Of course physics papers are some way off yet, but for now, progress is pleasing:

“ATLAS is proving that we can well face the situation. There is a lot of work. Not much more than expected, but the moment you try your skills in reality, then the situation is different,” says Aleandro. “But I'm satisfied, very satisfied. There are areas we need to improve, this is clear. But this is exactly what we need to learn how to make it better, because at the next step, ICHEP, we expect many more results.”

ICHEP, the **International Conference of High Energy Physics**, will take things up a notch. As well as there being more to present, to a more diverse audience, the material will need to be further developed, and build on what has just been shown at PLHC.

It may be tempting to think that the public stage of ICHEP will be a place for ATLAS to assert itself over 'the competition' in the eyes of the wider world. But in fact, Aleandro's aims are quite the opposite: establishing ATLAS as a flourishing experiment is of the utmost importance, but presenting a united front on the part of the LHC and all its experiments takes precedence..

“I see, and I hope this is an approach shared by the competition, it is important that we show not only how [our individual experiments are] doing well, but how the LHC project – the machine and all the experiments – is behaving,” he explains “Finally this project, that is built around the strongest machine we've ever had, is producing results in a completely new energy domain, and that in the near future can bring our knowledge into a completely new world.”

Ceri Perkins
ATLAS e-News

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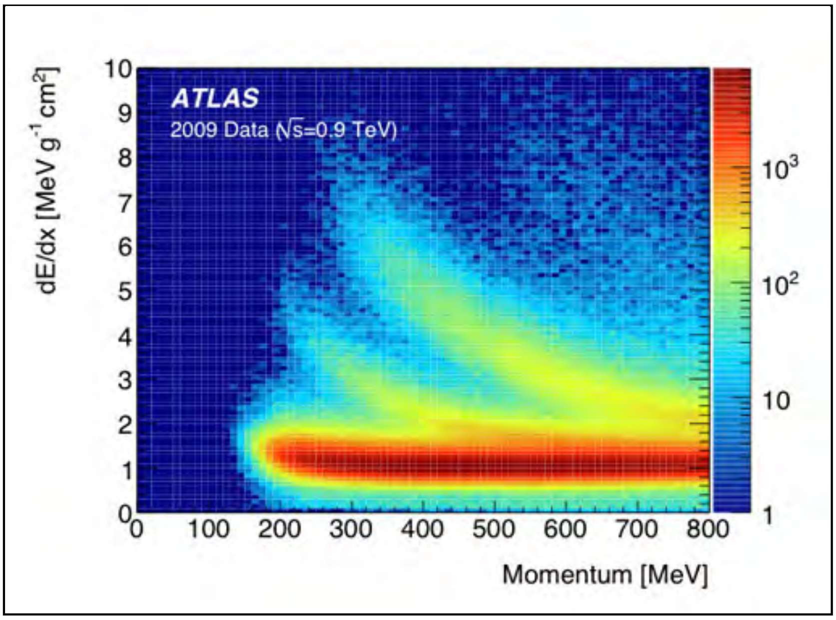
Summarising the detector performance

14 June 2010



One of the many plots found in the paper, this one on the Pixel dE/dx deposition showing the contributions from different types of particles

More than half a million minimum-bias events of LHC collision data were collected by the ATLAS experiment in December 2009 at centre-of-mass energies of 0.9 TeV and 2.36 TeV. The data went into many individual commissioning results, performance studies and notes from the various performance groups. The paper "Performance of the ATLAS Detector using First Collision Data" reports on studies of the initial performance of the ATLAS detector from these data.

The main editors (Bruno Mansoulié, Bill Murray and Hans-Christian Schulz-Coulon) put together all this information from notes and other sources and shrunk them to an intense 40 page document. "A summary of the different studies with the first collisions is that ATLAS works very well. The agreement between data and expectation (from simulations) was impressive. In the few cases where a discrepancy was found, the source was quickly identified and corrections were made to the detector description or to the software, which has been very useful for the 7 TeV collisions." explains Bruno Mansoulié. "This would not have been possible without the work and contribution of so many physicists. All performance groups of Tracking, e/gamma, Jet/EtMiss, Muon, were very active and extremely helpful," says Bruno. "We not only chose among the existing, but we also triggered some complementary studies in order to have an homogeneous presentation of all important features (to our view)."

One of the physicists who was involved in the making of one of the contributing papers was Sky French: "My role really began at the beginning of the year (before Christmas I'd been one of many people looking at the first 900 GeV electron candidates) when in mid-January, the e/gamma conveners, Laurent Serin and Mauro Donega, asked Marc Escalier and me if we would be willing to co-edit a note - which would become '*Electron and photon reconstruction and identification in ATLAS: expected performance at high energy and results at 900 GeV*'. This note was to contain ATLAS' understanding and studies of the 900 GeV electron and photon candidates - their kinematics, shower shapes, composition - and had to be completed within a timescale of a couple of weeks. "A challenge indeed!" adds Sky.

"The first step was to gather together everyone who had already started to, or wished to become involved in the endeavor. This fantastic team of people then stuck with

Marc and me throughout the adventure, working tirelessly alongside us to develop our understanding of the data into that which can be seen in the note, and now the performance paper. With each weekly meeting came more and more progress, and it wasn't long before the first draft began to crystallize" remembers Sky. Once this (first) milestone had been reached, everyone continued to work hard, with many evenings, nights and weekends sacrificed, to make sure that, by the deadline, the draft grew into a complete note which would meet everyone's expectations and leave everyone satisfied that they'd done a thorough job. "It was a bit frenetic at times to say the least - 3am phone calls, late night changes of selections - but we all made it to the finish line in the end!" she adds. Shortly after the note was approved and was integrated into the performance paper, their role as editors switched to being a role of assistance to the editors of the ATLAS performance paper - to be on hand to clarify and answer any questions they had about our note.

The decision to create the performance paper came from Fabiola Gianotti – it all started with an EB discussion on January 22nd. The whole process took four months, until the final draft was submitted to the journal on May 28th. "After each draft we had many comments from the collaboration and a few lively debates. We would like to thank these who took the time to read the paper and write comments. Then we (Bill, Hans-Christian and I) had to implement changes trying to accommodate the views of all the communities, without losing the homogeneity of the paper. Bill has many times taken the role of main editor, centralising corrections, providing new versions, answering all the comments on CDS one by one sometimes over whole nights! And Hans-Christian struggled with the plots… Also Karl Jakobs was a very active editorial board chair, even sometimes writing or correcting the paper himself." explains Bruno. In the intense process of reviewing the draft was not deeply changed but the corrections brought a lot of clarification and improved the reading.

The only difficulty to the end of the process was indeed a small one, but did cost a lot of work: the reformatting of the many plots in all the notes that did not have exactly the same appearance. "Our biggest role ended up being to reformat, or coordinate the reformatting of, the many plots in our note into an appearance appropriate for the performance paper (not much fun for anyone - but necessary to unite the CONF notes!)," remembers Sky. "We hope that this contributed to better defining the ATLAS standard style for plots in future papers.", says Bruno.

"Finally, it's been really nice to sit and watch the hard work of the many different groups of people in ATLAS who worked on a CONF note combine together to make the 900 GeV performance paper," summarises Sky. So it is no big surprise that the feedback of the referee of the JINST (journal of instrumentation) was "It (the paper) will certainly be acceptable for publication in JINST" with, as Bruno adds "just one page of minor editorial comments."

Birgit Ewert
ATLAS e-News

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Where the "needles" collide

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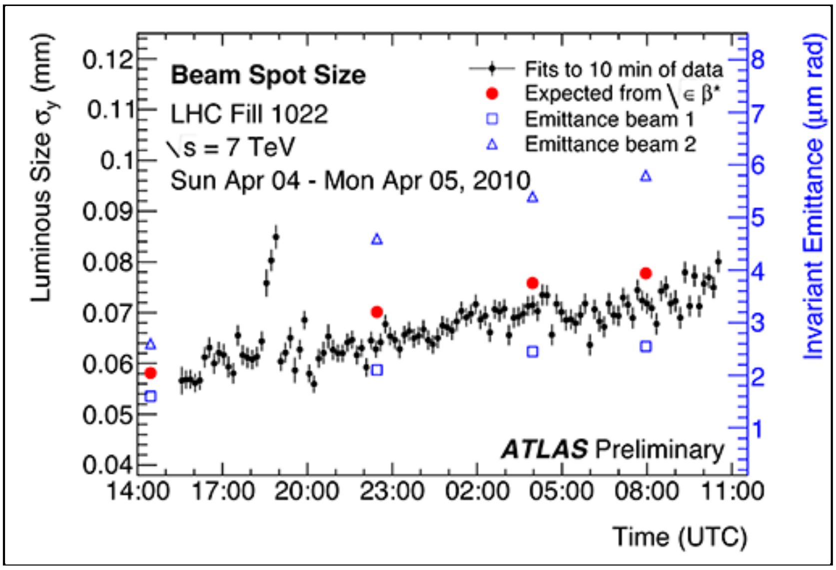

Evolution of the measured beam spot size during a fill and comparison to the size expected from machine parameters

On March 30, in a widely quoted remark, Steve Myers likened colliding the particle beams in the LHC to shooting needles across the Atlantic and getting them to collide halfway. So where exactly do these collisions take place inside the comparatively vast beam pipe? Finding this out is the task of beam spot determination. Both beam spot position and size can change quite a bit even during a single fill. Because almost every physics analysis in ATLAS uses the beam spot either directly or indirectly (as a constraint for primary vertex finding), it must be measured continually as precisely as possible.

Actually, the term beam 'spot' is a bit of a misnomer, since the luminous region, i.e. the spatial region where collisions take place, has rather the dimensions of a thin hair: along the beam direction it is a few centimeters long, while in the transverse direction the size has varied from initially about 200 μm at √s = 900 GeV to about 30 μm (1000 times smaller than its length) at the beginning of recent runs at 7 TeV. Ultimately the transverse luminous size (or beam spot size) will be even smaller: at 14 TeV with a β* of 0.55 m it will be only 12 μm, thus providing an even better constraint on the spatial origin of primary particles.

Where does this large variation of the luminous size come from, and what's the β* that's always quoted in this context? Obviously, the luminous region is defined by the volume where the proton bunches of the two beams cross through each other. The shape of the particle bunches in the LHC beams can be described by a 3-dimensional Gaussian distribution whose width in the transverse direction is given by the square root of the product of the transverse emittance and the amplitude function β. While emittance is a measure of the intrinsic spread of the particles within a bunch that scales inversely with the beam energy E_{beam}, β describes the beam optics and is determined by the accelerator magnet configuration. The value of the β function at the interaction point is called β*. For two Gaussian beams with equal transverse size, the transverse size of the luminous region is simply the beam size divided by √2. Thus the beam spot size should scale with $\sqrt{\beta^*}/\sqrt{E_{beam}}$. Indeed, from the increase in beam energy and the change of β* from 11m to 2m we expect the observed decrease of the beam spot size from 200 μm to 30 μm.

The method used in ATLAS for measuring the beam spot parameters is based on the distribution of the position of reconstructed primary vertices collected from many events. The High-Level Trigger gets a first stab at this by collecting histograms of the position of vertices reconstructed by a fast tracking and vertexing algorithm. The final beam spot reconstruction using an unbinned maximum-likelihood fit to primary vertices reconstructed using the full ATLAS reconstruction chain takes place shortly afterwards during the Tier-0 processing of the express stream as part of the prompt calibration loop.

Even with the relatively small statistics (compared to the level 2 trigger) available on the express stream, the precision of the measured beam spot parameters is in most cases already limited by systematic errors and not by the available statistics. This is particularly true for the measurement of the transverse luminous size, which requires the subtraction of the primary vertex resolution from the observed distribution of vertices. With the selection made for beam spot reconstruction, the most probable transverse vertex error is about 25 μm in recent 7 TeV runs (due to the asymmetric distribution of vertex errors the mean error is about twice as high). Thus the vertex resolution is similar to the beam spot size and contributes significantly to the observed distribution of primary vertices. As the beam spot size will become smaller, the extraction of the transverse size will become increasingly difficult since the vertex resolution must be known more and more precisely.

In order to cross-check the beam spot size determined by the maximum likelihood fit, a vertex-splitting method is used to determine the vertex resolution independently. In this method tracks are randomly assigned to two half-vertices instead of a single primary vertex. Since the two half-vertices represent two independent measures of the position of the same primary vertex, their average distance should depend only on the vertex resolution.

Following our earlier discussion on how the beam spot size depends on LHC machine parameters, we can compare the measured beam spot size to the size expected from measurements of emittance and β*. Such a comparison is shown in the figure above. No error bars are shown on the luminous size inferred from emittance and β* since the corresponding systematic effects have not yet been fully analyzed (they are expected to be about 10% each on emittance and β*). The agreement between the two very different methods of determining the beam spot size is excellent, particularly at this early stage (the outliers between 18:00 and 19:00 UTC are an artifact of luminosity scans carried out at that time). The figure also shows an increase of the luminous size over the course of the fill due to an emittance increase (see blue open symbols). While some growth of the transverse emittance over the course of a fill is expected, the observed growth rate appears larger than expected. These kinds of comparisons and other feedback from the ATLAS Beam Spot Group have been highly appreciated by our colleagues from LHC.

The need to continuously determine and monitor the beam spot makes it necessary to automatically run a large number of jobs. In order to keep track of these jobs and to give immediate and convenient access to the fit results and various history and validation plots even before the final beam spot results are uploaded into COOL, a **web-based monitoring system** was developed. It allows beam spot experts and shifters alike to easily spot any problems and gives detailed access to job parameters, log files and results of each beam spot job. Even earlier, beam spot and primary vertex monitoring displays from ATLAS Global Monitoring in the ATLAS Control Room give a first glimpse at the results from the offline primary vertex reconstruction. Eventually, a summary of the beam spot results can be obtained from **Run Query** or the **ATLAS Data Summary** pages.

Since the early beginnings of offline beam spot reconstruction in ATLAS at the time of the Ringberg workshop in 2008, beam spot determination has become a mature and indispensable part of the ATLAS data processing chain that has worked very well since the exciting moments when the very first collisions arrived in ATLAS. Last fall the beam spot effort became an official ATLAS working group under Data Preparation. If this article made you curious to learn more about the beam spot, please join us at one of our next Beam Spot Group meetings!

Juerg Beringer
Lawrence Berkeley National Laboratory

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Trevor Vickey

Nationality: American

Trevor Vickey

Going into his new position with Johannesburg's University of the Witwatersrand ('Wits' for short), Trevor Vickey sees his brief as "a sort of linear combination between a professorship and a Peace Corps assignment". The tenure-track Senior Lecturer post will take him to a brand new continent, but, he says, he made the original application "on a whim" after five years as an ATLAS postdoc.

"I thought South Africa would be a cool place to live," he smiles. "And I liked that there was a lot of young blood in the department, people were very friendly, and there have been some very good students there, like **Stanley Mandelstam** and **Saul Teukolsky**."

Trevor is hoping to be instrumental in bringing about change at his new institute, and the first step – getting Wits officially onto ATLAS as part of a South African cluster with the University of Johannesburg – is already in progress. He started his new job in January, and in February, he co-wrote the cluster's formal Expression of Interest letter to join ATLAS. The Collaboration is due to vote on whether to accept South Africa at ATLAS Week in Copenhagen later this month.

On the ground, when he moves to Johannesburg in early July, he expects to be doing a lot of intensive one-on-one work with disadvantaged students who aren't quite prepared for calculus-based physics courses.

"I think that you can really change some of the students' lives," he says. "It's pretty obvious, the gap between the rich and the poor. You fly in and you see people living in these tin shacks and then you see people driving Ferraris around. It's still a developing country, so even on the campus you can make changes very fast. Anything that you do, you will see have an impact."

The move also brings he and his wife Oana together on the same experiment for the first time, although they are already responsible for what he terms "the first combined result from ATLAS and CMS" – their son, Alex, now aged two.

Before their five-year postdoc stints at CERN, he and Oana – who met at the SLAC Summer Institute in 2001 – were based on CDF and OPAL respectively during their PhDs. He was studying in his home state of Illinois (at the University of Illinois), and she was studying in Freiburg, until she moved to Chicago for experimental work on D0. When he found out that there were some retirements coming up in his new department at Wits, Trevor says, in classic physicist speak, “I saw a possibility of solving this complicated two-body problem.”

His excitement at this new horizon is evident, and not just from an academic point of view. “We’ve talked about going from Johannesburg, up the coast of Africa to Egypt. I like to go camping, hiking, mountaineering, that sort of thing. It'd be great to go to Madagascar, Namibia, Botswana, Mozambique … and I'm looking forward to going to the National Parks.”

One of the first of those visits will take place in December, when he is s co-organising the “Discovery Physics at the LHC” workshop on the border of Kruger National Park. “It's one of the largest in the world actually,” he grins, “it's like the size of Israel.”

At ATLAS, Trevor busies himself with the SCT and Higgs searches.“Mostly stuff to taus,” he ponders. “Anything to taus!” Originally he focussed on Standard Model Higgs to tau-tau, but with the expected lower centre-of-mass energy and smaller datasets for the next couple of years, he has begun looking further afield to more exotic models.

“Now I think that my research will focus on alternate theories – like those where you have five Higgses and the decay mode to taus could be enhanced over the Standard Model”

While South Africa is not (yet) a part of the ATLAS Collaboration, Trevor is affiliated with Oxford University, where he holds a Visiting Lecturer position. Hopefully, the ATLAS week will bring good news for him and his South African colleagues, and the new phase of his life will begin.

But he doesn't intend to stray from Geneva for too long. He and Oana will keep hold of their house in France, and he plans to be back for ATLAS Weeks and shifter duties, as well as routinely spending the whole of the Southern Hemisphere summer (December to February) at CERN.

“I can shift my teaching duties around too,” he smiles. “so I think that with this early data-taking period, I'll definitely try to be here quite a bit.”

Ceri Perkins
ATLAS e-News

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ATLAS e-News

"Dessine-moi un Physicien" - "Draw-me a physicist"

Ecole d'Ornex - drawings before and after visiting CERN








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