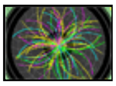
ATLAS e-News

27 July 2010

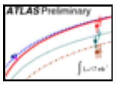
NEWS

Picking pile-up to pieces



How ATLAS is coping with concurrent collisions

W/Z latest



ATLAS takes first high p_T data to ICHEP

South Africa joins ATLAS!

Latest country joins while vuvuzelas cheer!

ATLAS at ICHEP

From preparation to presentation, sharing the ICHEP experience

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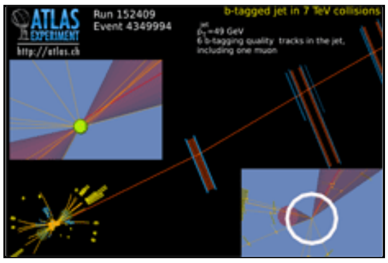

Ready for flavour tagging

Several b-taggers have been tested with first data, showing good agreement with simulation and opening the way to new physics

PHOTO GALLERY

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"We don't know what nature is like for us. We're having to find out," says swing dancer Bengt Lund-Jensen

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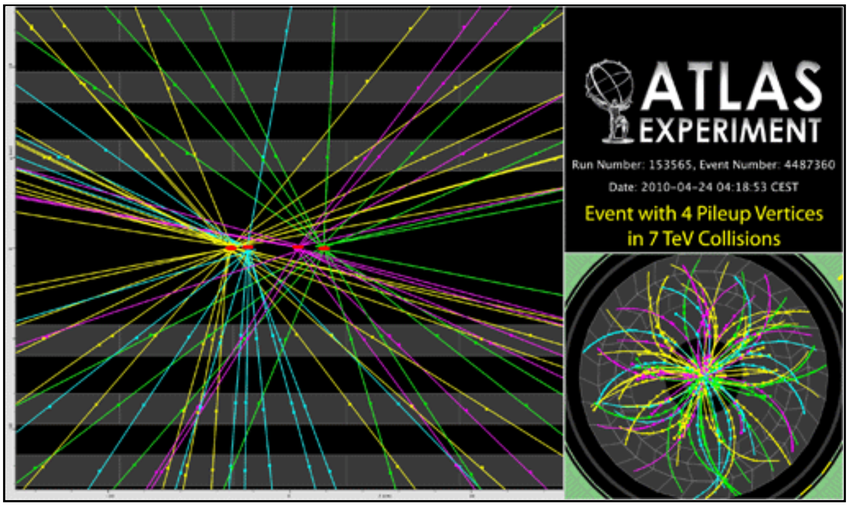

An event with with four reconstructed vertices (four overlaid minimum bias events)

In an ideal world, the LHC would smash protons together in ATLAS, and beautiful events would unfold, one at a time, under the watchful gaze of the experiment's electronics and software. Things are never that simple though, and with the thrill of increasing luminosity comes the pressure to catch events which start to arrive thick, fast, and concurrently.

'Pile-up' is distinct from 'underlying events' in that it describes events coming from additional proton-proton interactions, rather than additional interactions originating from the same proton collision.

The chances of producing more than one full-on proton-proton collision (a hard scattering event) per bunch crossing are pretty low. But as the instantaneous luminosity per bunch crossing – effectively the density of protons in the interaction region where the beams overlap – goes up, the likelihood of ' soft' interaction between the constituent quarks and gluons of additional proton-proton pairs increases. The challenge for ATLAS then is working out which tracks and energy deposits to attribute to which interaction.

On top of this so-called 'in-time pile-up' comes concern about 'out-of-time pile-up', which refers to events from successive bunch crossings. Eventually, the LHC will carry 2808 proton bunches per orbit, making them exceptionally close in space and time: just 25 nanoseconds apart. This is faster than the read-out response of many of the ATLAS sub-detectors, so being able to identify which bunch crossing each particle originated from will be crucial.

"If you look at the detector in the transverse plane [a slice, staring right down the beam pipe], and look at how far a particle will travel, even at the speed of light, it has barely reached the outer side of the ATLAS detector before the next bunches of protons will already interact," explains pile-up expert Giacinto Piacquadio.

Every sub-detector has worked hard to try to deal with overlapping energy deposits from successive bunch crossings at intervals of 25 nanoseconds. But for now at least, with only a few tens of well-spaced bunches in the machine, out-of-time pile up is not a concern. In any case, says Giacinto, "In-time pile-up will typically be much more dangerous. That is more difficult to disentangle from the event of interest because it happens at the same time."

Giacinto is involved in developing primary vertexing algorithms in ATLAS, which try to reconstruct the vertices that charged particle tracks originate from, and are "one of the main ingredients" for dealing with the in-time pile-up problem.

Distinguishing overlapped vertices in the plane perpendicular to the beam, where the beam spot spans just 25 microns, however, is “extremely difficult”, considering that a typical pile-up vertex resolution is around 100 microns. They are much easier to pick out in the direction parallel to the beam, however, since their resolution is significantly better than their typical separation in this direction (here the interaction region spans 100 millimetres or so).

Picking out the ‘signal event’ – the genuine proton-proton collision that caused the trigger to fire – requires detective work. Generally, particles originating from this vertex will have much higher transverse momentum. The vertex reconstruction algorithms first try to find one single vertex, and throw away all the tracks that are incompatible with it. Then they go back to those discarded tracks and hunt for further vertices, repeating this process until, hopefully, all vertices have been found. This ‘signal vertex’ is selected as the one with the highest momenta tracks associated with it.

This is not fail-safe though. On the one hand, too many vertices can be reconstructed in cases where there are a high number of tracks, explains Giacinto: “Since even the track measurement is not perfect, at a certain point some of the tracks may be incompatible with the vertex. So the algorithm will create a new vertex nearby.”

To combat this, the algorithms have been designed to be conservative – to assign close tracks to the same vertex – which means that, on the other hand, genuinely separate vertices in close proximity are likely to get merged into one by the software.

“Of course, we'd never tested the vertex fitting algorithms on real data in the conditions we're facing now, which is more than one interaction per bunch crossing; up to six or even seven vertices per event,” Giacinto smiles.

Crunch time came on June 25th, when the LHC started running with nominal bunches containing 1.15×10^{11} protons. The average number of interactions per bunch crossing has leapt from around 0.1 to around 1.5, close to the maximum pile-up expected for this year's run, and so far the algorithms are looking good. Eventually, when the beams are fully squeezed, upping the chances of proton-proton interactions, this is expected to rise to 23.

Understanding how the number of vertices reconstructed relates to the real number of vertices – and whether the algorithms have been made too conservative or not conservative enough – is the next challenge. A dedicated vertexing group is already in place, studying how well the algorithms perform with data and comparing results with Monte Carlo expectations.

“The optimal compromise is for sure something that will have to be tuned in data,” says Giacinto. “This is something which is still ahead of us.”

Ceri Perkins
ATLAS e-News

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W/Z latest

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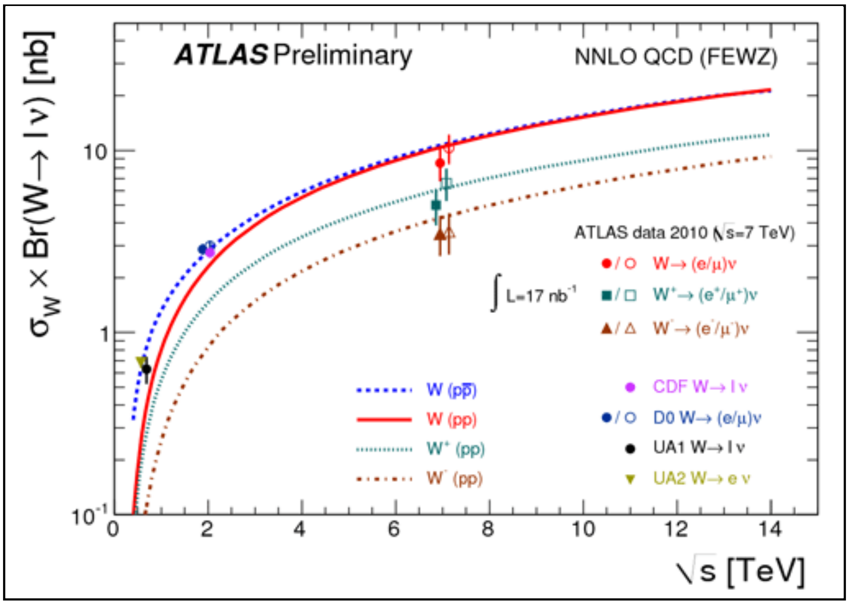


Comparison of W cross-section measurements with theoretical predictions, for UA1 and UA2 (cluster 1), the Tevatron (cluster 2) and ATLAS (cluster 3). The ATLAS measurements include W^+, W^- and the sum of these, with closed datapoints denoting electrons and open datapoints denoting muons. Datapoints within clusters are staggered to improve readability.

"Right now, this is the 'flagship' analysis, if you like," smiles Joao Guimaraes da Costa, co-Leader of the W/Z muon working group. The note in his hand, destined for the ICHEP conference, details W- and Z- boson observations and cross-section measurements at ATLAS so far, and represents the first high momentum (high p_T) physics seen by the experiment.

These well-defined Standard Model particles were first seen at CERN's proton-antiproton collider in 1982 and 1983, but "rediscovering" them with the LHC allows the experiments to gauge how well they're performing in these early days.

After the W and Z, the next big physics object on the list is the top quark. When one shows up at the LHC (several candidates have already been identified), it will be the first time it has been seen at a European accelerator. Understanding the experiment's response to W and Z particles is a crucial step in picking the top quark out, Joao explains:

"It decays into a W. And many of the other new physics processes will often involve Ws and Zs, so these signatures are very common and will end up contributing to top [physics] and many others."

The ICHEP note focuses mainly on Ws, which are more plentiful in data, with their production rate a factor of 10 higher than that of Zs. Although calculated from Standard Model physics, the production rates of both bosons at the previously un-explored energy scale of the LHC have not been measured until now.

The cross-section of the W – the probability of it being produced – was already calculated and included in the first draft of the paper. By the time the machine went into a technical stop last week, ATLAS had collected 338 nb^{-1}, of which enough could be analysed in time to allow a decent Z cross-section measurement to be built into the note too.

"We'll try to include as much of that data as possible by the 21st, to take to ICHEP," was Joao's summary of the plan, during an interview on July 14th. The W cross-section measurement method was approved by July 16th, based on 17 nb^{-1} of data. The Z cross-section, which requires more data due to its lower production rate, but is speedier to calculate since it doesn't require missing energy measurements, was slipped in at the last minute with 225 nb^{-1} of data behind it.

The paper, which compares data to theoretical predictions, is an update of what was taken to the **PLHC conference** in June, where cross-sections weren't yet extracted from the data. With over ten times more data at hand now, all the other plots in the paper have been brought right up-to-date. As well as refining the calculations of the transverse mass of the W and the mass of the Z, anomalies from the previous paper have been ironed out:

"The major thing [in June] was that we had some expectation from the Standard Model, but we saw more muons than expected and fewer electrons than expected," says Joao, referring to the two different channels in which a W boson might decay (to a neutrino with either an electron or a muon).

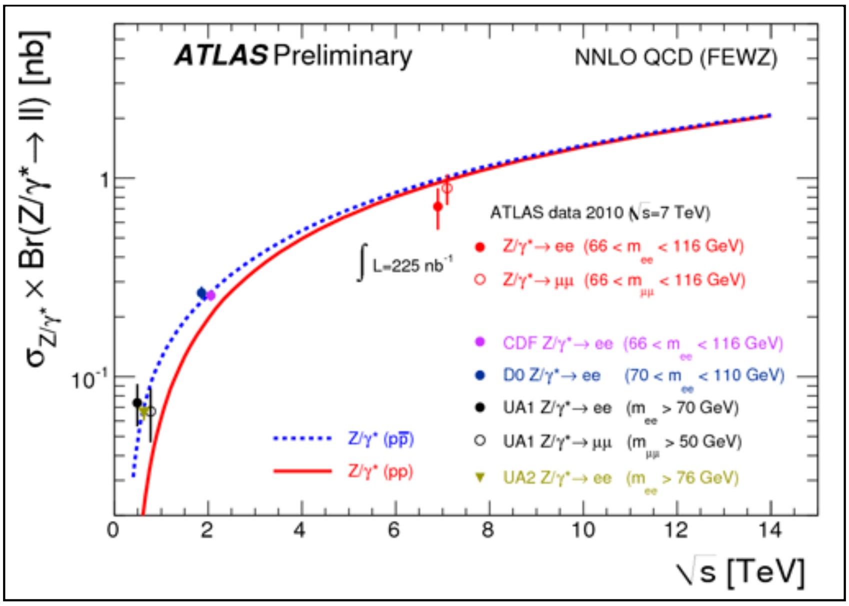
With the enlarged dataset, this was a trend that didn't persist; it completely disappeared with the increase in statistics. "Without changing the analysis, the numbers are now totally consistent with the Standard Model."

At the LHC, W and Z bosons are being produced in proton-proton collisions (as opposed to proton-antiproton or electron-positron collisions) for the first time, and as such Ws are produced with a bias towards W^+ particles. As well as ATLAS observations falling close to theoretical predictions for the W^+ and W^- cross-sections, this characteristic asymmetry is also tentatively geometrically visible – with more W^+s being observed in the barrel region and more W^-s showing up in the forward regions – a feature which is also explored in the paper.

"In terms of the Standard Model, there is nothing new to see here, but it will be interesting to see what CMS comes up with," Joao smiles, looking ahead to the reaction of the wider physics community at ICHEP. "It tells you whether the experiments are in good shape."

"Eventually, we will have millions of these particles and we will be able to study them in detail at the new energy scale," he adds. "With more statistics, the measurements we are doing will provide unprecedentedly detailed studies of the proton structure, which will be important for the understanding of all other physics at the LHC, and tests of Quantum Chromodynamics calculations."

A total of 118 W candidates and 125 Z candidates were used for the cross-section measurements. In a message to the Collaboration last Wednesday, Physics Coordinators Tom Le Compte and Aleandro Nisati expressed everyone's appreciation of the quick turn-around time on the Z cross-section: "Congratulations to all of ATLAS for producing such a nice result so quickly!"



Comparison of Z cross-section measurements with theoretical predictions, for UA1 and UA2 (cluster 1), the Tevatron (cluster 2) and ATLAS (cluster 3), with closed datapoints denoting electrons and open datapoints denoting muons. Datapoints within clusters are staggered to improve readability.

Ceri Perkins
ATLAS e-News

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South Africa joins ATLAS!

27 July 2010

ATLAS presence around the world now spreads out to include South Africa.

Vuvuzelas loudly cheered at the ATLAS Collaboration Board meeting on July 2nd when South Africa officially became part of ATLAS! Two Institutes, University of Johannesburg (UJ) and University of the Witwatersrand (WITS), form the new cluster. The South African Cluster was unanimously admitted by the Collaboration Board with strong support from the ATLAS management, bringing the total number of ATLAS institutions to 174.

Since both universities are located in Johannesburg, the WITS and UJ groups will naturally collaborate. According to Fabiola Gianotti, they have already demonstrated their ability to work closely together as evidenced by their coherent presentation of their Expression of Interest (EoI) to the ATLAS Collaboration Board.

Both groups are enjoying not only a hugely supported endeavor, but auspicious beginnings as well. Each Institute has already attained half of the funding for the member fee from their respective universities, and the other half has been promised to them by the South African Department of Science and Technology. Furthermore, there "… has been an increase in the formation of large-scale collaborations within South Africa which have attracted substantial group funding," Simon Connell and Trevor Vickey stated in their EoI letter. Simon and Trevor are respectively the heads of the UJ and WITS groups.

Within the new South African Cluster several university positions have either been recently opened or recently filled, in accordance with their ample growth needs. The cluster will focus on attracting post docs and graduate students, "... with a view to excellence in science, human capacity development and innovation," wrote Simon and Trevor in their EoI. The University of Cape Town has already shown interest in joining the South African Cluster as well, and will once Andrew Hamilton takes up his appointment there next year. Peter Jenni will continue to further this collaboration when he travels to Cape Town, Johannesburg and Pretoria in August to help finalise and consolidate the cluster plans.

ATLAS's presence is a significant step along a scientific path that South Africans have been paving for quite some time. South Africa's contributions to the scientific community are many and range from the first successful heart transplant to the discovery of the first neutrino in nature (in the South African mine-based laboratory EPRM).

CERN first signed a Cooperation Agreement with South Africa in 1992. Following investigations of radiation from lepton incidence on crystals with participation in the NA43, NA59 and NA63 experiments, a South African team joined the ALICE experiment in early 2000. Areas of particular interest to the new ATLAS cluster include GRID development, research in semiconductor tracking, hadronic tau identification, and searches for the Higgs boson and exotic particles.

Adding to the GRID capacity is a definite focus of the South African Cluster. Tests will be conducted soon that are expected to lead to ATLAS Tier-3 status. A formal collaboration agreement is being drafted between UJ and WITS to co-develop a much larger computing cluster to eventually establish a Tier-2 site in South Africa.

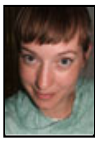
The addition of the South African Cluster to the ATLAS Collaboration resulted from substantial efforts made by Simon and Trevor, of course, but also many ATLAS members: Kétévi Assamagan, Peter Jenni, Jonathan Butterworth, Fabiola Gianotti, Howard Gordon, Michael Tuts, and Anthony Weidberg.

Simon initiated the successful forming of the ATLAS activities for the Department of Physics at UJ, the broader South African physics community and the South African Government. With Kétévi's support, they have worked diligently to create the ATLAS group, and to obtain substantial support from the university. Trevor has played a crucial role in the build-up of the new LHC activities for the School of Physics at WITS. In January 2010, Trevor started a Senior Lecturer position there inclusive of the special privilege and substantial provision for such an effort to be made.

Since the official South Africa-CERN collaboration launch event in Cape Town and Johannesburg in December 2008, Peter Jenni has been representing ATLAS in discussions with the Department of Science and Technology and in meetings with both universities' officials.

ATLAS is pleased to welcome South Africa and wishes the best to the two new groups.

Sarah McGovern
ATLAS e-News



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ATLAS at ICHEP

27 July 2010

The **ICHEP** meeting was held in Paris from 22-28 July.

It was a whole new ballgame at the International Conference of High Energy Physics (ICHEP) this year. From the excitement of new Higgs limits from the Tetravon, to the introduction of Monday's plenary session by French President Nicolas Sarkozy, the conference was obviously very exciting. The conference began as the HEP community waited eagerly to hear what had been accomplished with the brand new LHC data so far. The four LHC experiments showed their results in plenary talks given on Monday by their spokespersons. And Fabiola Gianotti did a great job for ATLAS!

Countless people from ATLAS worked around the clock recording, processing and checking the latest data to get everything ready for presentation. The fact that 228 nb^{-1} of the total 338 nb^{-1} of data was collected in the last full week before the conference surely made the job a Herculean effort. Results were flung onto graphs at breakneck speeds, papers were flying around and presenters were stressed to the limit. A new era of high energy physics had been born and ATLAS was, in part, responsible for presenting it to the world.

Of the 1000+ attendees, many just wanted to witness who the ultimate winner of this “World Cup” for particle physics would be. In all, there were 196 parallel sessions, 28 invited speakers and 28 poster sessions. (See **the list** of all ATLAS presentations and posters.) With so much going on, let's take a look at how some of the ATLAS speakers felt ahead of time, the feedback they got and the overall conference atmosphere.

Expectations were high for Fabrizio Salvatore, who presented the ATLAS results on searches for exotic long-lived particles using early data. Fab rightly expected that ICHEP would be extremely exciting this year. Stemming from the novelty of the LHC results, he said that he was, “… sure the atmosphere [would] be thrilling.” Fab was most looking forward to seeing the physics results, to experiencing the atmosphere at the conference, and, though nervous, he was very much looking forward to presenting this paper.

Jan Kretzschmar, who gave one of the two ATLAS W and Z cross-section measurement talks, looked forward to meeting old and new colleagues, as well as getting to see the CMS results. Last week, Jan commented on the intensity of preparation saying, “The W [and] Z results are constantly being updated as the new data comes in. ” There was little time yet to do in-depth analysis. This sentiment was echoed by many as a result of the fortunate, yet last-minute data increase.

Fab felt an intense mix of nervousness and exhilaration when anticipating his presentation. He said, “Presenting the results of the experiment one is working on is one of the most rewarding experiences for a physicist and, clearly, being able to present for ATLAS at ICHEP is one of the highest points of my career.”

The paper came from the SUSY group about whom Fab spoke very highly. “This is clearly one of the best parts of working in the field of particle physics: people from different countries, and very different cultures, work together toward the same result.” He emphasized how helpful everyone had been with result preparation and feedback about his presentation until the final hour before he presented.

Both Jan and Fab said they felt confident with their performances. Although they were both nervous, each got positive feedback from the HEP community. Jan noted how packed the room was where he spoke and said that many people were interested in the first results from ATLAS and CMS. According to Jan, several of the most frequent questions were related to the, "… level of data-MC understanding we have achieved so far."

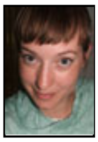
Rick Van Kooten, who was presenting a recent result from the D0 experiment, commented on how ATLAS and CMS compared. "Regarding performance and 'being ready for data', CMS and ATLAS really are running neck-to-neck and are quite similar. There are a lot of exciting first results, and the level of understanding of the detectors is very impressive. This is true for jets, E_T, missing E_T, lepton ID, b-tagging, etc."

Fab perceived a general understanding that data collected so far was not enough for any of the experiments to show discoveries of new physics beyond the Standard Model. This limitation didn't seem to matter though because a, "…first look at the LHC data was enough to get people intrigued..."

Fab cautioned that, "As time goes on there will be more and more expectations of new results from the LHC experiment, so pressure will build up." In order for a presenter not to feel overwhelmed by pressure, he said they should keep in mind the extensive help they have available. He found the review process by experts, conveners of his group and ATLAS collaboration to be very thorough. Consequently, his advice was that a presenter should guard against excessive worry by accessing their ample support system. But whatever you do, Fab says above all, remember to simply "Enjoy it!"

For those interested, all ATLAS results presented at ICHEP are available **here**.

Sarah McGovern
ATLAS e-News



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Ready for flavour physics

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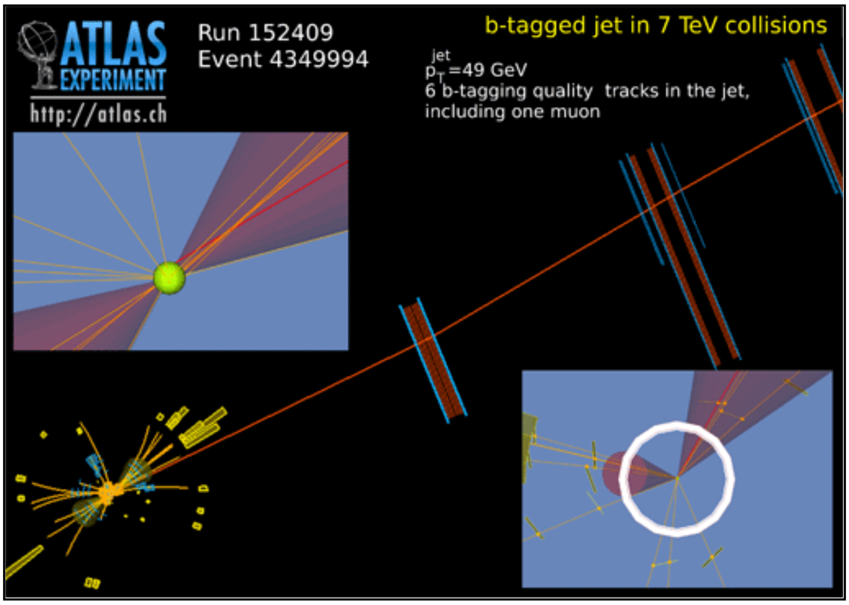


Event Display: "Event display of an ATLAS event with a b-tagged jet on the right."

As we are approaching the first pb^{-1} of integrated luminosity, it is time to pave the road to new discoveries. Many ingredients are needed to build a solid foundation that we can use for our higher luminosity physics analyses. An important one is the ability of our detector to tag the flavour of the hadrons we detect. Let's take a look at how this is done and how the taggers are prepared for action…

Flavour tagging is a general term but it mostly means the identification of jets that stem from decays of b-hadrons, which are of special interest to many types of physics measurements. On short term, it will be crucial to have this identification power for finding top quarks and the first-time measurement of the top production cross-section at 7 TeV centre of mass energy. On a longer scope, it will be important for certain channels of the Higgs boson search and a valuable tool in many searches for supersymmetry.

There are a lot of different flavour taggers conceived to be used for physics analyses, too many in fact to describe them in a short article like this. However, only a handful of the taggers are being commissioned for the early physics phase and they are an interesting subset since they demonstrate the different techniques used and we can already show how surprisingly well they work.

To build a flavour tagger, we need to carefully exploit characteristics of bottom quarks to spot them in a jungle of the light quark background. We know that many b-hadrons have mean lifetimes that allow them to travel a measurable distance from the primary interaction before they decay. This is already the main idea used by most of the taggers and it illustrates how important our fine granularity and high precision tracking devices are.

Three of the early taggers use the following principle described. The first one is the JetProb tagger, which uses the displacement from the primary interaction of tracks in a jet. These are then compared to templates. This yields the track probability of being a prompt track from a W or Z decay, and therefore not from a b-hadron decay. The second tagger is TrackCounting. It also looks at tracks associated to a jet and requires them to be significantly displaced. And last but not least, we commissioned a secondary vertex based tagger, the SV0 tagger. It tries to directly reconstruct the decay vertex of the b-hadron and judge on its flavour by using the displacement of this vertex from the primary interaction.

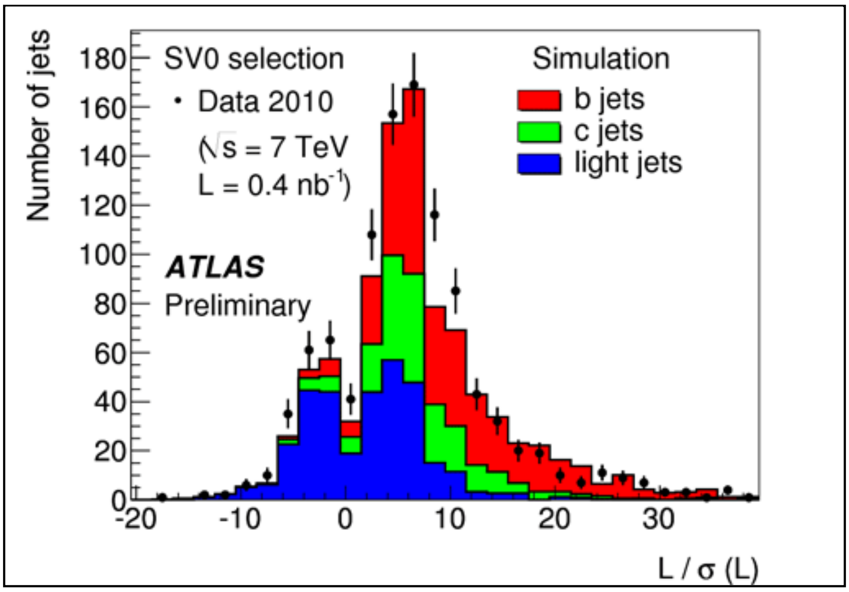
These taggers rely strongly on a good understanding of our tracking devices since position and resolution of objects like tracks and vertices are input quantities. It is due to the hard work of many people in the performance groups that we actually do have this understanding. Therefore we were able to already show at the **ICHEP conference** that these taggers indeed work. More results based on the latest data are in the pipeline for upcoming conferences.

Taking plots out of conference notes and putting them here puts them out of context a bit so I'd rather show you only two selected images: First a comparison of one of the tagger weights between data and simulation. The agreement is decent and it's clear that a cut on a high tagger weight enriches the sample with b-jets. Additionally there is an event display with a displaced reconstructed decay vertex that illustrates the taggers principle. In the top right jet, you can see that the tracks in the jet can be used to form a displaced secondary vertex. The jet also contains a muon, which leads to the fourth tagger being commissioned.

This tagger looks at a different quirk of bottom quarks: A fraction of them decays to leptons. The high initial quark mass (higher than the light quark mass that is) pushes the lepton away from the direction of flight of the initial hadron. By comparing the jet direction of flight with its associated leptons direction, we can “soft lepton tag” this jet. Not only is this an interesting way of using the decay kinematics, but it also is a complementary method to the ones described before. Therefore it allows us to measure the taggers performance!

Performance measurements are among the main current projects in the flavour-tagging group. We use complementary taggers like the soft lepton tagger and physics processes like di-jet events with tagged back-to-back jets to measure the efficiencies and make assumptions about the impact parameter distributions and estimate the fake-rates. Eventually, events containing top quarks will be used for performance measurements that will give better results, but this will only happen in several months.

We have already found out that the early taggers work more or less the way we expect them to work. Now the amount of integrated luminosity is getting to the realm where we can make quantitative statements about the performance of the taggers. This is the “pavement” we need: what would a physics analysis be without good knowledge of the efficiencies and fake-rates of the used techniques?



Distribution: "Secondary vertex tagger weight. A cut on high weights enriches the fraction of b-jets."

Florian Hirsch,
Universitaet Dortmund

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Bengt Lund-Jensen

Nationality: Swedish

Bengt Lund-Jensen

"In Sweden you can go out dancing in the summertime, where they play popular music but adapted for dancing," says Stockholm native Bengt Lund-Jensen. Nine years ago, he decided to re-visit the dances of his undergrad days in pursuit of fitness, and now he spends his summers stepping out with other Scandinavians in the midnight twilight.

"It's a kind of swing dance, but it's not done in more than Sweden, Finland, and Norway," he explains. "Most swing dance is six or eight counts, but this is four counts to the basic step."

Already a master of Boogie Woogie and Lindy Hop, two years ago Bengt added this new dance, Balboa, to his repertoire. "It's danced to the same music as Jitterbug," he says of the fast dance, which originated in the crowded ballrooms of 1930s west coast America. "It was forgotten for a long time, but some people have been taking it up again and now there's a Balboa community all over the world."

This dancing community that Bengt can count himself a part of is not trivial. After a reception at the recent ATLAS Week in Copenhagen, he wandered to a local park on the off-chance and ended up dancing the night away with familiar faces, a fact which, while staggering to an outsider, leaves him absolutely un-phased: "I expected that some would be there," he smiles. "Though I recognised more dancers than I thought."

Some of these, he knew from the **Herräng summer dance camp**, a five-week long party which attracts dancers from all over the world to a tiny Swedish village. This year, he made his third trip to the camp, meandering down the coast on his IF sailing boat, Spinaway, to spend a week dancing with 1000 others who simply can't sit still.

Boats, too, are a way of life for Bengt, who lives just outside the city of Stockholm, in the stunning archipelago. "I absolutely love it as a place," he beams. "If I bike for five minutes, I can take a boat into central Stockholm to go to work."

The boats run from April to Christmas – until the water freezes and becomes impassable, forcing people into their cars – and the same motley crew of ten or fifteen regulars can be found there each morning and evening. "We sit and chat. You can drink a coffee. And they have Internet on the boat, so working is a possibility. You can finish off work in the evening, send the last few emails on the way home." It was a chance encounter on the boat that eventually led to Bengt's 17-year-old son, Malcolm, taking up the bagpipes six years ago.

The trade-off for these lovely social summers, of course, is the Scandinavian winters: “the worst time of the year”. The sun shows its face reluctantly between the hours of 9:00 a.m and 3:00 p.m. but once the snow falls in December, things start to turn magical. “Without any snow, it's dark, just plain dark. But with the snow,” Bengt considers, slowly, contemplatively, “it's… different. The tiny bit of light there is reflects back.”

Bengt's life is and always has been blissfully Stockholm-centric, but he tries hard to “jigsaw” family life, working in the tiny ATLAS group at the Royal Institute of Technology, Stockholm, and visits to CERN for meetings, discussions, and to fulfil his shift-duty to his detector.

“I spent a lot of my scientific life building this fantastic detector, and now we really need to make the very best of the data that we can,” he explains. “It's not just about doing your own analysis. That's the collaborative spirit.”

He has been involved with ATLAS since the very beginning, joining to work on preparations for LHC experiments as a post-doc with the Royal Institute of Technology in 1989, following a stint at CERN as an Uppsala University engineering physics PhD student from 1980 to 1985. Here, he fell in love with the place, the attitude of the people, the international style, and the scientific possibilities.

“It's a fantastic place for a PhD student to be,” he says. “There're so many people, a lot of scientific knowledge, and most are willing to give PhD students part of their time answering questions.”

On the subject of the 20-year LHC journey, he laughs: “If someone had told me in 1989 that we'd get data in 2010, I might have done something else in the meantime! But I think we learned a lot along the way about making a large experiment. And it was a very, very nice feeling to know that, after all these years, we've got data.”

Up until this point in his career, Bengt has been solely involved in detector design, preparation, construction, and testing (contributing to the ATLAS barrel presampler and optical read-out fibres for the Liquid Argon calorimeter). For the first time now, his attentions are turning to physics analysis. His eye is on Supersymmetry, and what it might tell us about Dark Matter and Dark Energy, but his mind is open.

“We don't know what nature is like for us. We're having to find out. I believe we'll find something, but what this something is, I don't know.”

In the meanwhile, expect Bengt to continue dancing to his own beat.

Ceri Perkins
ATLAS e-News

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Impressions of the Hardronic Festival









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