Highlights

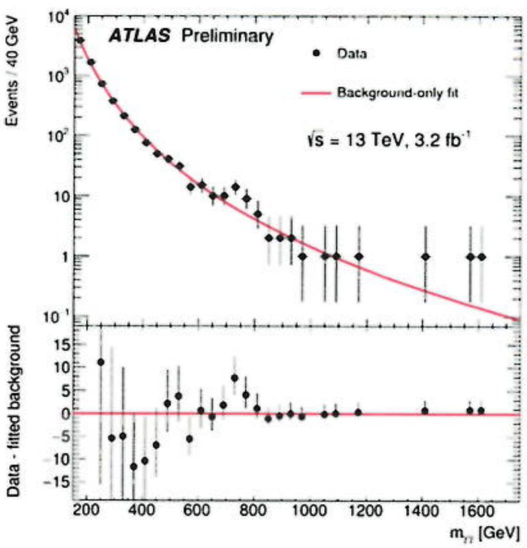
The past year was the first year in the extension of the centre. The visions for the work in the coming years were presented at a centre retreat in Elsinore in May 2015 and these visions took solid shape as the year passed.

Starting at the largest of scales, the scale of the Universe, I mentioned last year that our Planck satellite team, in collaboration with Niels Bohr Professor Subir Sarkar, was able to dismantle a claim from the BICEP II experiment of having seen primordial gravity waves, a relic of the inflation era, in the polarization pattern of the Cosmic Microwave Background (CMB). It was demonstrated that the signal most likely is caused by foregrounds (microwaves of astrophysical origin) that had not been taken into account. However, signatures of primordial gravity waves remain a holy grail for cosmology, and in 2015 the Discovery centre joined a new project called DeepSpace at the Summit site in the middle of the Greenland. This project will exactly address the problem of the imperfectly understood foregrounds to gravitational wave detection in the CMB. It is mainly financed by the US, but has now, thanks to the Villum foundation and the Discovery centre, also an important Danish component led by professor Pavel Naselsky.

The announcement by the LIGO experiment in early 2016 of the first direct observation of gravitational waves marks a giant advance in physics and astronomy and has also removed one important "risk" from the DeepSpace project, namely the risk of gravitational waves simply being non-existent. Furthermore, gravitational waves open up a completely new way for looking into the depths of the universe.

Another "new beginning" was the start-up of LHC with13 TeV proton-proton collision energy, the highest energy ever provided by mankind. The commissioning of the beams was very challenging, but in September the machine ran full blast with only 25 ns spacing between proton bunches. There was one result that attracted formidable interest, namely a possible "bump" seen by the ATLAS experiment in the two-photon mass spectrum at about 750 GeV.

The overall significance of the "signal", shown below, is about 3 sigma. So it could easily be just a statistical fluctuation. But hundreds of theory papers from all over the world ticked in shortly after the announcement, each with their own possible explanation of such a signal, all assuming a scenario beyond the Standard Model.



The best of these papers, in our view, was that from the Discovery center which showed the consistency of the signal with other data in the context of models with an extended Higgs sector. It will be enormously exiting to see if the signal holds up when LHC restarts in a few weeks. If it does, the Discovery phenomenology group is very well armed with new effective field theory methods to narrow in on the possible "new physics" scenarios.

The center also consolidated its leading international role in quantum amplitude calculations with several ground-breaking publications and an ERC starting grant rewarded to assistant professor Guido Festuccia.

LHC did not only collide protons. From November 25 and December out, Pb ions were propelled to the monstrous collision energy of 1000 TeV. The first results were published by the ALICE experiment with record speed just after a few days of running reporting that up to 24000 particles were created in such collisions. Another fast-track paper showed that the "fireball" still has collective properties and that its viscosity increases with energy even at the extreme temperatures and pressures created in these collisions. These seminal papers were lead by members of the Discovery ALICE team.

The IceCube activities at the South Pole were formally included in the centre activities in 2015. We were extremely proud to host the IceCube collaboration meeting in October with 250 people assembled in the Lundbeck Auditorium for a full week. Jason Koskinen won a Villum foundation grant to a project using the unique IceCube capabilities to constrain the conservation of probability in neutrino oscillations (the changing identities a neutrino takes while propagating though space), the possible violation of which would require "new physics". Other advances by the IceCube team include new searches for dark matter annihilation in the galaxy, significant progress towards a technical proposal for the PINGU extension of the IceCube detector and even a visit to the South Pole by one of the PhD students!

A strong reinforcement of the phenomenology activities happened when Oleg Rychaisky joined the NBI permanent staff in order to consolidate the unique collaboration between theory and experiment in the centre. He is in particular pursuing the possibility of a right-handed neutrino being responsible for Dark Matter, perhaps also baryogenesis, and has even found a hint in the sky of a possible 7 keV mass (Dark Matter) particle decay into two X-rays. It will be enormously exiting to see if this signal is upheld in future satellite observations.
He is also, together with colleagues from the Discovery center, among the proposers of a new CERN experiment, SHIP, to expand the search for "hidden sector" particles.