(cntn'd from p. 1)

AMK – *Yesterday, at the Cracow Epiphany Conference you said that, if everything goes well, in 2010 you would be running the LHC at 3.5 TeV each ring.*

RDH – 3.5 TeV x 2 means the proton collision at 7 TeV in the CM system. We'll get there this year. Then we'll have some work to do on the magnets. After that, we'll gradually ramp the energy up to 7 TeV x 2. I will be very cautious in doing that. Further, in the next few months we'll be brainstorming on how we could improve the luminosity of the LHC. With a new machine it will be easier than for a mature machine to improve the luminosity steadily.

AMK – *Please, let us talk a little bit about physics at the LHC. 7 TeV CM is one-half of the energy the LHC is designed for and expected to yield. So far, no one went significantly beyond the Tevatron energy (~2 TeV CM), but from theoretical predictions – is there much new physics up to 7 TeV CM?*

RDH – First of all, for the discovery of the Higgs boson the energy 7 TeV CM should be enough, but it will take time.

Higgs boson is the signature of the Higgs field, which is a scalar field, a field without any direction preference, i.e. everywhere in space. In the Standard Model the particles acquire their masses through an interaction with this field. The prime candidate for the mass acquiring mechanism is the Higgs boson; unfortunately it is not produced very often, and it decays because it is very short-lived. It may decay in different channels, depending on its mass. If it does exist, it will be found at the LHC. If it does not exist then something else has to be happening in the same energy range, which introduces the mass. And that something else would also be found at the LHC.

AMK – *In 2008 Peter Higgs said he believed the Higgs boson had been already detected at FermiLab but it's remained buried in the experimental data. If so, it would come down to algorithms and computing power to find it.*

RDH – Well, it might be true. But, you know, it's not only the question of computing power or algorithms. You have to find the needle in the haystack, many haystacks. And if the needle is very similar to the hay, it is very difficult to distinguish for it is in background and the background is large.

AMK – *And the physics – at the LHC – beyond the Standard Model?*

RDH – There must be such physics, another model that encompasses the Standard Model. The question is: Is it at the energy accessible to us with the LHC? And I believe it is.

If there exists a supersymmetric particle of the mass ~300 GeV/c^2, 7 TeV CM should also be enough. If we're lucky and Nature has supersymmetry in her pocket, we shall find it. It depends on the model; there may be a whole spectrum of supersymmetric particles. If I'm not mistaken, the mass of a supersymmetric particle of about 300 GeV/c^2 would explain dark matter.

The beam energy 3.5 TeV, i.e. 7 TeV CM, should open the window for discoveries. With the LHC energies we can look at the Universe 10^{-12} second after the Big Bang; we begin to look at the microcosm at the one hand and at the Early Universe at the other. This intrinsically means we can look at the connection between particle physics and the Early Universe. Extremely high energy density in the collisions makes the similarity to the Early Universe.

For example, the LHCb detector will study the origin of the matter–antimatter asymmetry. At the beginning of the Universe, matter and antimatter were created in equal quantity. If it would have stayed this way, we wouldn't be here. Shortly into the life of the Universe, a small asymmetry of matter and antimatter was introduced: one part in ten billion. This one part in ten billion is us.

AMK – *Dark matter and dark energy await explaning too…*

RDH – Ha! We are ready to enter the Dark Universe too. The future space telescopes can tell us more about dark matter in the Universe, its fraction, and how it is distributed, etc. However, only a particle accelerator can produce the dark matter in the laboratory to study it and tell what it is. The LHC might be the perfect machine to study dark matter.

The favoured candidate is the lightest supersymmetric particle (LSP). If supersymmetric particles do exist, the LHC will find their signature through the "missing energy" after they will have escaped the detector. But we have to understand our detector very well in order to prove the missing energy. It may take some time. With the LHC, and possibly a linear collider in later years, we can also measure the mass of the supersymmetric particle. Should this mass measurement correspond to the measurements of the dark matter fraction by space telescopes, then this particle would be responsible for the dark matter. If it wouldn't correspond, this supersymmetric particle would only be part of the dark matter and it would mean we have several species of dark matter particles. One way or another, particle physics and astrophysics together will explain the nature of the dark matter.

But this will explain only 25 percent of the missing mass of the Universe. Dark energy is supposed to inflate the Universe and be the cause of the expansion of the Universe in all directions. No direction is preferred. This is a scalar being 75 percent of the mass of the Universe.

There is a field predicted that is scalar: the Higgs field. It would be the first fundamental scalar ever detected. If we could measure this scalar, it might give us some hint also on dark energy. I'm not saying the Higgs is the dark energy. The question is: could the Higgs give us some handle on dark energy?

AMK – *Let's sidetrack a little bit. You've mentioned the LHCb detector. There are three more detectors at the LHC: ATLAS, CMS, ALICE.*

RDH – These are the most complex detectors existing today. They are indeed an engineering art. We will have 40 million collisions and 10^9 interactions within a second. Approximately 10^3 particles are produced per collision. This is an enormous challenge for the detectors and for data processing. Trough the Grid we are connected to 200 computing centres over the world, where the data will be distributed and stored.

It is not enough to find a new particle. In order to prove that the Higgs mechanism alone is responsible for the mass we have to measure its properties very precisely. Only then we could understand for the first time properties of a fundamental scalar. And if supersymmetry exists then there exist more than one Higgs boson. So, there is a whole plentitude of measurements awaiting to be done.

AMK – *However, one of the applications of the three detectors will be different than others, i.e. heavy ion collisions. Are you ready for the heavy ion beam too?*

(cntn'd in p. 3)