Report on the session "PS and non accelerator physics" at the New Opportunities on the Physics Landscape at CERN.

Convenor: T. Sloan

1. Comments from the Convenor

All abstracts represented important physics. They outlined plans which stretch well into the next decade.

1.1 Non accelerator Physics

The abstracts describing non-accelerator experiments all address burning questions in the SM with an overlap with Astroparticle Physics. These abstracts involved dark matter searches, axion searches, a search for proton decay and Astroparticle Physics searches for e.g. energetic neutrinos. All these proposals are well motivated and represent the frontiers of physics described in Ed Witten's talk. Many of the proposals are outgrowths of CERN recognised experiments. Some new proposals particularly in Astroparticle Physics request a symbolic connection with CERN in a similar manner to the existing recognised experiments. These are the use of CERN as a centre for meetings, use of CERN as an executive financial institution, use of test beams and as a centre for R and D and assembly and testing of detectors.
An interesting suggestion, which came up in the discussion, is that it may be advantageous for CERN to set up an Astroparticle Physics department similar to the one at FNAL. This would act as an umbrella for the experiments with astrophysical connections in both the new proposals and existing recognised experiments. In addition it could house a theory group (as proposed in abstract 40).

1.2 Accelerator experiments.

Two further abstracts each required access to particle beams.
One abstract, of outstanding merit, proposed a search for the electric dipole moment (EDM) of the proton and deuteron. This would improve the sensitivity over the current neutron EDM limit by 3-4 orders of magnitude. This experiment would require the acceleration of polarised protons in LEIR and a beam transfer system to a 50 m diameter ring in an experimental hall. The experiment has been proposed at BNL. However, the proposers believe that it would be done much faster at CERN.

The second abstract was the CLOUD experiment which described its plans for the coming years. While few people believe that there is a strong link between global warming and cosmic rays, nevertheless it is interesting from the point of view of both meteorology and climatology to establish whether or not ionization from cosmic rays plays a part in cloud formation. A similar experiment is being performed by a Danish group. However, to obtain credible results it is necessary to have data from both groups.

All abstracts are summarized below and more details are given in the speakers' slides which are available on the workshop web site.

2. Summary of the Talks and Abstracts.

2.1 Astroparticle Physics. (abstracts 22,30,36 and 40)

Christian Spiering gave an overview over the field and its relations to CERN physics. Astroparticle physics in Europe has been coordinated under the ApPEC and ASPERA programmes. He further reviewed 3 submitted abstracts. The first, abstract 30, was AMS-02 (a CERN recognized experiment). This is a spectrometer to search for antimatter in cosmic rays to be place on the International Space Station (launch date June 2010). The Science Operation Centre (SOC) and the Payload Operation Control Centre (POCC) will be located at CERN, as well as the raw data processing. KM3NeT (abstract number 22) is a proposed cubic kilometre instrumented underwater neutrino detector. It is approaching the end of its EU funded design phase, having entered an FP7 preparatory phase. It looks forward to closer connection to CERN. Finally, there is a proposal (abstract 56) to establish a European Astroparticle Theory "centre" for which CERN would be the natural host given the synergy between LHC physics and Astroparticle Physics.

2.2 Searches for Dark Matter (DM) (abstracts 13,23,72,73)

Laura Baudis reviewed these abstracts of which 4 concerned DM detection and one included also a search for neutrinoless double beta decay. Such searches were highlighted in Ed Witten's first overview talk and represent frontier research topics in our field. The proposed experiments all aimed to make larger and larger detectors (ton scale) which are needed to achieve the improved sensitivity over current detectors. This will lead to more stringent limits and hopefully in the long term to positive detection of DM

The submitted abstracts were

1. EURECA (abstract 23) which is a joint effort of ~110 physicists and is part of the ILIAS/ASPERA/ApPEC strategy which aims to achieve sensitivity 2-3 orders of magnitude greater than existing searches.

The group wishes to have CERN involvement in order to have access to the Technology and Engineering Departments to assist it with design studies for large scale shielding against backgrounds, for the planning and manufacturing of its cryogenic infrastructure and for R and D into radio-pure cryogenic scintillator. It also wishes to use CERN support facilities such as the finance office and administration and its meeting facilities. It also would like closer collaboration with the Theory Division on the interpretation of its experimental data in the context of SUSY models and the LHC results.

2. ArDM, (which is one of the CERN recognized experiments) submitted an abstract for the continuation of its program. This is clearly needed for it to begin to take data and to

capitalise on its R and D program. The same is applicable to WARP (another CERN recognized experiment).

3. The XENON100 Experiment at LNGS (abstract 72). This is an already funded experiment and data taking is planned for 2009-2010 with 65 kg of fiducial target volume (total volume 170 kg). The proposal is to upgrade to 100 kg fiducial (260 kg total mass) of liquid Xenon and then on up to ton scale in the longer term. It would ask CERN to assist with the liquid Xenon purification system, the HV system, shielding and use of test beams to study the rate of production of radioisotopes in the Xenon.

4. DM Detection with bubble chambers (abstract 13) – The GEYSER project.
This is to develop a 1 ton bubble chamber using a scintillation liquid to help eliminate backgrounds from radioactivity. Small scale prototypes have been constructed and these are being used to investigate the scintillation properties. The requests from CERN would include support for use of scintillation liquids, collaboration with experts on the construction of the bubble chamber and some small laboratory space.

5. The GERDA (abstract 72) experiment to search for neutrinoless double beta decay in enriched ^{76}Ge aiming at an exposure of 150 kg-years. The request from CERN is for R and D to achieve this and the use of test beams to investigate the production of radioisotopes in the detector.

2.3 Axion Searches (abstract 73)

Axions were highlighted in the opening talk by Ed Witten. They have been postulated to prevent the neutron having too large an electric dipole moment in the Standard Model. They are also predicted in string theories and they might be a window to them. They are a candidate for the dark matter of the Universe, being connected also to the dark energy.

Thomas Papaevangelou described the plans of the CAST collaboration, which is the leading experiment in the field of solar axions. They request support at the same level as in previous years for their anticipated data taking with upgraded detectors also in 2011-12 with improved sensitivity. They then look to increasing the magnetic field strength with further detector and X-ray optics upgrades with plans starting in 2013 and continuing beyond 2016. This should lead to a large part of the QCD favoured model region being investigated including the otherwise non-accessible sub-keV range.

2.4 OSQAR (abstracts 48 and 71)

Krzysztof Meissner gave an overview of the OSCAR experiments looking for the changes in polarisation of the light from a laser passing through a magnetic fields provided by LHC dipoles. Such an effect is predicted from QED but has not yet been directly observed. The group believe that they will be able to measure this subtle effect. However, a similar, but distinguishable, effect could be observed if axions exist and are sufficiently strongly coupled to photons. Data taking is expected with the current set up in 2009-2010. Upgrades and further data taking are proposed in 2011-2014. A further possible proposed experiment to shine a laser beam through a wall via 8 LHC dipole

magnets was described, again to detect the presence of axions. A further idea was proposed (abstract 71) to use an LHC quadrupole magnet as an axion detector. The motivation for this is that new theoretical ideas suggest that the coupling of axions to photons in magnetic fields could be stronger in the presence of a field gradient.

Clearly the hunt for axions represents frontier particle physics research.

2.5 EDM of the Proton and Deuteron (abstract 4)

A beautiful idea to measure the electric dipole moment (EDM) of the proton and deuteron was presented by Yannis Semertzidis. The aim would be to be sensitive to EDMs down to 10^{-29} e-cm. i.e. 3-4 orders of magnitude lower than the current limit on that of the neutron. The idea comes from the same group as that which has completed the measurement of g-2 of the muon at BNL. This is physics of the highest quality. A 50m diameter proton storage ring is proposed using radial electric fields to store a polarized proton beam (without a magnetic field). In such an electric field, in the absence of an EDM, the spin precesses to lie along the momentum vector at a proton momentum of 0.7 GeV/c. A finite EDM along the spin direction would cause the spin direction to deviate from the momentum vector in the vertical direction. Such a deviation is used to look for the EDM.

The experiment is proposed for BNL. However, the experiment could be done much more quickly at CERN if polarised protons could be accelerated in LEIR.

2.6 CLOUD (abstract 16).

Jasper Kirkby reviewed the progress of the CLOUD experiment, showing some of the data taken in 2006 with a pilot experiment. This demonstrates a possible link between ionization and aerosol concentration in the air, the precursor of cloud forming particles.
Following the technical lessons learnt from the pilot run, a new chamber has been constructed and will be commissioned at CERN later this year, with data taking foreseen during 2010-2013. This experiment is being undertaken by a multidisciplinary team using a beam from the PS.

Changing solar activity causes changes to the cosmic ray rate. The level of scientific understanding of the contribution of such changes to the radiative forcing which produces global warming is labelled as very low by the IPCC (International Panel on Climate Change). Although many studies conclude that the contribution of cosmic rays can only play a minor part in the present global warming, there remain numerous observations of solar-climate variability in the palaeoclimate record, for which there is no established mechanism. Hopefully CLOUD will allow this understanding to be improved.

Acknowledgement
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