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Astroparticle Physics Experiments

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Outline:

- Cosmic rays in balloon and from space
- Very High Energy Gamma-ray Astronomy
- Ultra High Energy Cosmic Rays
- High Energy Neutrino Astronomy
- Direct Dark Matter Searches
- Gravitational Waves

Since their discovery by Victor HESS in 1912, the origin of Cosmic Rays that are constantly bombarding the earth remains mysterious. The spectrum of cosmic rays is one of the most regular feature of Nature, extending over more than 12 decades in energy up to $\sim 10^{21}$ eV and 32 orders of magnitude in flux. Supernova Remnants have been proposed as soon as in the early 1930's as the most probable objects able to accelerate particles up to the so called knee (around 10^{15} eV), but are not energetic enough to reach the highest observed energies. Extragalactic accelerators such as Active Galactic Nuclei are believed, in the bottom-up models, to be able to provided the necessary acceleration to protons and ions, whereas decay of very heavy particles (possible supersymmetric particles) are invoked in the so-called top-down models.

The connection between Particle Physics and Astroparticle, very deep during the 1930's-1940's (with the discover of positrons, pions, and strange particles in high energy cosmic rays), is now experiencing a new birth with the wealth of new data that Astroparticle Physics experiments are currently producing. Astroparticle experiments are now shedding the light on Particle Physics are energies well beyond the LHC, particle acceleration mechanisms at play in the Universe, cosmic ray propagation in our Galaxy, and give valuable constraints on the nature of Dark Matter as well as on long term evolution of the Universe. Exciting times are still ahead of us with experiments tracking down gravitational waves from binary systems or trying to detect relic dark matter particles.

This lecture will make a panorama of past, current and future experiments in astroparticle physics. After a brief introduction on the general problematic, special emphasis will be given to the most successful domains of the last decade: cosmic ray experiments in space and from balloons, high energy and very high energy gamma-ray astronomy, and ultra high energy cosmic ray experiments. In a second part, an outlook of major challenges for the near future will be given: radio and acoustic detection of cosmic rays, high energy neutrino experiments, direct dark matter searches and the quest for gravitational waves.