北極域での気球による相対論的電子降下ガンマ線観測

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Observation of Gamma-Rays from relativistic electron precipitation with Balloon Experiment around the Northern Polar Cap

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Cosmic ray group of Kyoto University develops the SMILE-II balloon-borne low-energy gamma ray detector, an Electron Tracking Compton Camera (ETCC). The Kyoto group already observed in 2006 celestial sub-MeV gamma rays using small balloon-borne ETCC called SMILE (Sub-MeV gamma ray Imaging Loaded-on-balloon Experiment), and successfully diffuse cosmic and atmosphere gamma rays from 0.1 to 1MeV in 3 hours observation. Now the goal is to construct a larger ETCC with a size of 30x30x30cm: the main purpose is a long-duration experiment to catch gamma-rays from celestial targets such as the Crab Nebula. The Electron Tracking Compton Camera (ETCC) consists of a gaseous Time Projection Chamber (TPC) and Scintillator pixels. By measuring the 3D-track of a recoil electron in TPC, ETCC can measure the direction of incident gamma-rays photon by photon with 3 str wide field of view (FoV), and provides both a good background rejection and an angular resolution of a few degrees at 1MeV. The energy range and wide FoV of the SMILE-II are suitable for observing Bremsstrahlung from relativistic electrons precipitating (REP) into atmosphere. By measuring the energy and the depth of gamma rays in the atmosphere from observed gamma-ray image, the position of the precipitation is determined. Thus a quantitative estimate of the flux of the precipitating electrons is possible. We proceed a ground-based measurement campaign, including the EISCAT radars, all-sky cameras and photometers, as well as suitably located VLF receivers in support of the SMILE-II balloon campaign. In addition ERG satellite project now goes on to aim 2015 launching. Cooperative observation with ERG and SMILE-II would measure both plasma parameters on equator of the radiation belt where electrons are accelerated up to MeV region and its precipitation at the Polar cap simultaneously.

Already Nine REP events (18days observation) have been observed by MAXIS balloon experiment at Antarctica in 2000, which used Ge detector for measuring spectra of REP with 1str FoV. This result seems quite promising for the future observation of REP at the polar cap. SMILE-II will cover 3 str FoV and also provide an imaging observation which enables us to detect weaker REP gamma rays than the atmospheric background generated by cosmic rays. Considering those merits of SMIEL-II detector, our experiment is expected to detect about 10 times more REP events.

In addition, SMILE-II can detect the direction of fast neutron simultaneously. Solar proton precipitation at the Polar region is also considered to dissociate the atmosphere similar to REP. Solar protons with its energy > ~MeV generates secondary fast neutrons which penetrate to the stratosphere. Thus, our experiment will observe both REP and Solar proton precipitation simultaneously.

We shcedule to launch SMILE-II from Kiruna, Esrange in 2013 with one day test flight and in 2014 with a long duration flight around the Northern polar cap, corresponding to the solar maximum activity. Now, we are constructing the SMILE-II Flight Model and will complete it until the end of this year.

Here we will present the improved performance of SMILE-II for gamma-ray and fast neutron detections and expected scientific products.