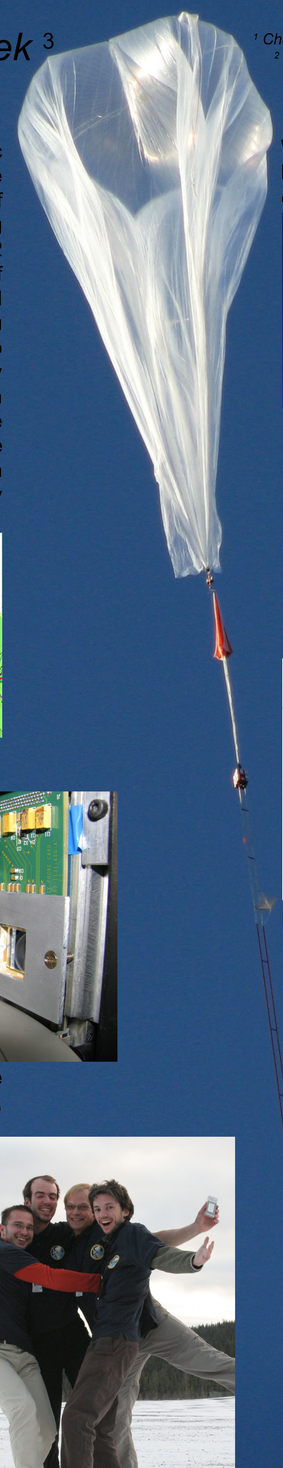
MEDIPIX cosmic ray tracking device flown on BEXUS stratospheric balloon: Atmospheric measurements by Ionizing Radiation Imaging Detectors

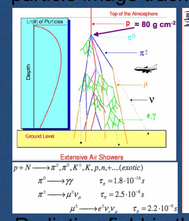
J. Urbář [1], J. Scheirich [2], J. Jakůbek [3]*

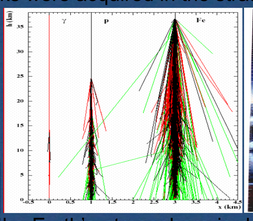
[1] *Charles University, Faculty of Mathematics and Physics, Dept. of Surface and Plasma Science, V Holešovičkách 2, 180 00 Prague, Czech Republic*
[2] *Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Microelectronics, 16627, Prague Czech Republic*
[3] *Czech Technical University in Prague, Institute of experimental and applied physics, Horská 3a/22, 12800, Prague Czech Republic*

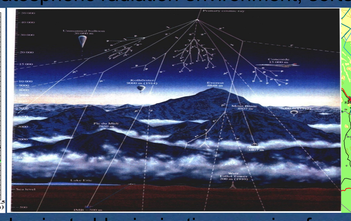


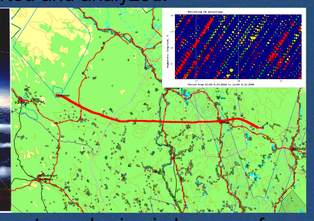
Introduction:

Results of the first two experiments using the semiconductor pixel detectors of the Medipix family for energetic particle imaging in the stratospheric environment are presented. The original detecting device was based on the hybrid pixel detectors of Medipix-2 and Timepix developed at CERN with USB interface developed at Institute of Experimental and Applied Physics of Czech Technical University in Prague. The detectors were used in tracking mode allowing them to operate as an "active nuclear emulsion". The actual flight time of BEXUS-7 with Medipix-2 on 8th October 2008 was over 4 hours, with 2 hours at stable floating altitude of 26km. BEXUS-9 measurements of 3.5 hour duration by Timepix, Medipix-2 and ST-6 Geiger telescope instruments took place in arctic atmosphere till ceiling altitude of 24km in 2009. Stratospheric balloon platform is the optimal realization for such in-situ measurements of atmospheric ionization. Optimal not only because of the high altitudes reached, but also due to its slow ascent velocity for statistically relevant sampling of the ambient environment for improving cosmic ray induced ionisation rate model inputs. The flight opportunity for BEXUS student projects was provided by Education department of the European Space Agency (ESA) and Eurolaunch - Collaboration of Swedish National Space Board (SNSB) and German Space Agency (DLR). The scientific goal was to check energetic particle type altitudinal dependencies, simultaneously testing proper detector calibration by detecting fluxes of ionizing radiation while evaluating instrumentation endurance and performance. Extensive dataset of different types of cosmic ray particle image tracks were acquired in the stratospheric radiation environment, sorted and analyzed.

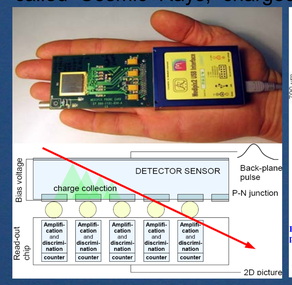


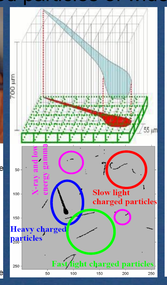


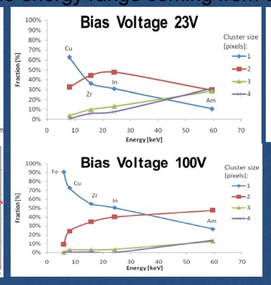


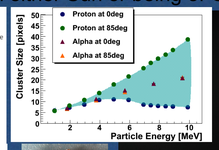


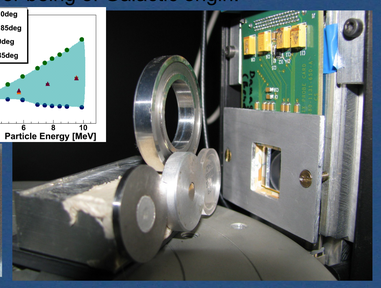
Radiation field in the Earth's atmosphere is dominated by ionization coming from atmospheric airshowers of so-called Cosmic Rays, charged particles of wide energy range coming from either Sun or being of Galactic origin.



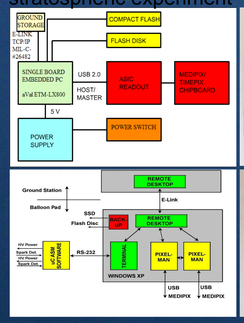


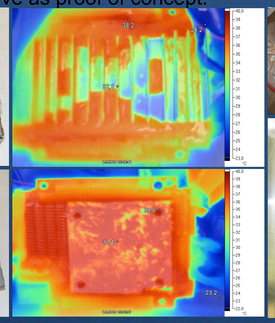


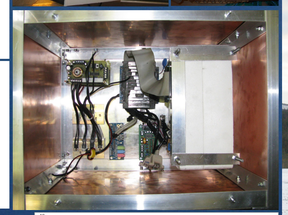


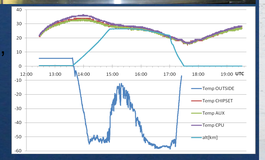


Capabilities of hybrid imaging detector Medipix2 allow precise in-situ measurements , enabling sorting the detections into pre-defined particle type categories, not thus just fluxes as is done routinely. Therefore, stratospheric experiment was undertaken to serve as proof of concept.







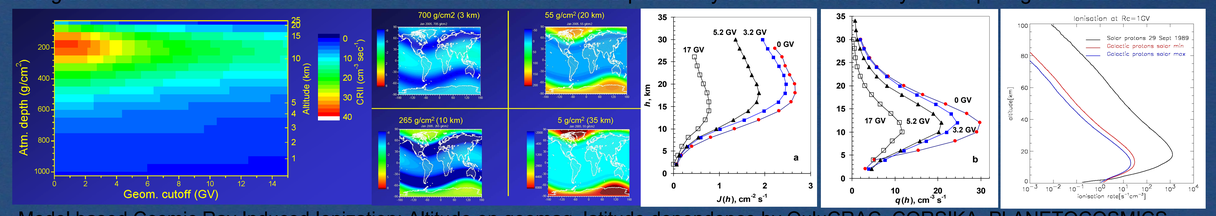


Both systems have shown good performance and stability in near-space thermal vacuum operating environment. Control device was custom developed, based on PC/104 platform. Envisaged improvements:

- Proper representation of track patterns of mixed radiation components
- How far can we get in precision of our analysis
- How does different shileding attenuate the specific components

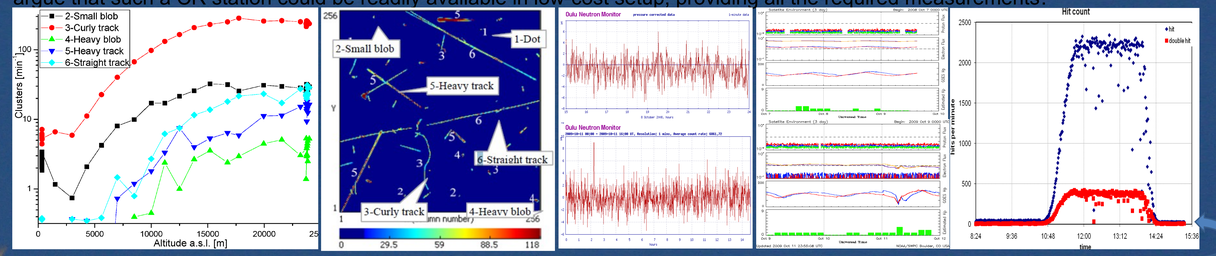
Motivation:

While the Cosmic Ray Induced Ionization is the main atmospheric ionization contributing process in altitudes of 3-35km, and we know relevant cosmic-ray fluxes well, we need more specific data on its ionization yields. Those depend on *particle types* and their *energies*. This still needs to be measured in more detail in situ as requested by scientific community – competing MODELS exist.

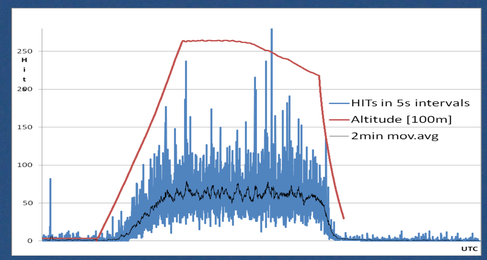


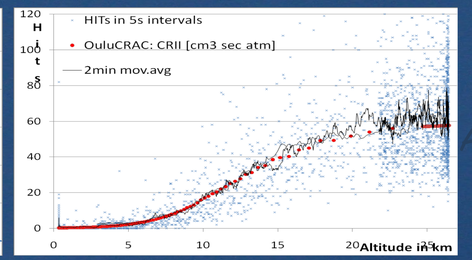
Model based Cosmic Ray Induced Ionization: Altitude on geomag. latitude dependence by OuluCRAC, CORSIKA, PLANETOCOSMICS. Ionization by GCR & SCR as simulated by Dr. Stozhkov, RAS model (LEFT) and by PLANETOCOSMICS (Uni. Bern model) based on GEANT4 (RIGHT)

Terrestrial Cosmic Ray Flux (CR) is considered by the scientific community as a possible important agent influencing various atmospheric phenomena that range from Global Atmospheric Electric Circuit, dust concentrations, to cloud properties. Therefore, better experimental data on specific atmospheric fluxes along with particle types and energies present are an important input into various models. According to many scientists it will be very important to develop fully automatic, small, and light CR stations for regular ship and aircraft lines for continuous planetary surveys. Such an extended network of both stationary and moving CR stations will be much more effective also for problems related to space situational awareness and space weather (e.g., forecasting of dangerous magnetic storms by analyzing galactic CR distribution and great radiation hazards from solar CRs). Therefore we argue that such a CR station could be readily available in low-cost setup, providing all the required measurements.



Particle track (cluster) type distribution changes during the ascent of BEXUS-9 along with radiation environment conditions (STS-6)





BEXUS-7 flight profile HITs and CRII from OuluCRAC for specified time and place [10*cm^{-3}.sec^{-1}.atm^{-1}]

Results:

We recorded data available to provide better atmospheric altitudinal spectra of particle types and energies, improving overall CRII model simulations. It has been found feasible that the Medipix-type detectors can provide required data as demonstrated during original flight campaigns. This provides helpful synthesis of experimental needs and theoretical considerations. By setting different bias voltages during the floating phase or on separate detectors, sensitivity to different types of heavily ionizing/nucleonic reactions produced/muons and electrons particles is changed and those can then be easier distinguishable.

On board the second (BEXUS-9) balloon flight campaign we have additionally undertaken in-flight comparison (based on previous on-ground intercalibration) between Timepix and Medipix-2 (equipped with neutron converter) and with STANDARD RAS STS-6 Geiger tube telescope.

Any Suggestions? Please tell us