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FLASH-TW experiment status report

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FLASH-TW is an experiment to measure the shower lateral and longitudinal profiles. We perform the shower profile measurement by shooting the 1.5 GeV electron beams in NSRRC on targets made of 15 aluminum blocks, each with a thickness of 2.9 cm. A scintillator (Al_2O_3: Cr)) is placed behind the targets, converting the secondary shower particles into light. The light from the central region of the shower is recorded by a CCD camera while the light from the outer region is monitored by PMTs. The CCD system is successfully implemented in the run 2 and run 3 of experiment FLASH at SLAC. A test run of the current experiment has been conducted in NSRRC in the past June to study the scintillator spectrum. Two more runs are planned from now to the year 2006 to measure the shower lateral and longitudinal profiles.

1. Introduction

Ultra-high energy cosmic rays (UHECR) have been observed for some time. However, the existence of GZK cutoff [1] is still a debating issue among UHECR experiments. Fluorescence detectors (Fly's Eye/HiRes) measure the shower longitudinal profile by observing the nitrogen fluorescence light. Ground charged-particle detector array, such as AGASA, measures the shower lateral profile, which is one slice of the longitudinal profile. The disagreement between two types of experiments raises many questions about their systematic errors. Two major weak points potentially responsible for such a disagreement are the fluorescence light yield and the shower developments.

The main goal of FLASH-TW experiment is to study both longitudinal and lateral profiles in the same experimental setup to eliminate any bias in the shower development. FLASH-TW experiment is conducted at the National Synchrotron Radiation Research Center (NSRRC) in Taiwan. Although the beam energy is only 1.5 GeV, the beam current is large enough to produce total energy of the order 0.1 to 1 EeV. The shower can be simulated with electrons beams shot into various thickness of the aluminum target.

The main instrument is a platform of two chambers and 15 movable aluminum blocks of size 10cm×10cm×2.9cm. Each block can be moved in or out of the beam path. Therefore, it is possible to study shower longitudinal profile in 15 steps, with an increment of 1/3 radiation length (R.L.) per step. Figure 1 shows the top view of the experimental platform. Left chamber contains a 6-hole wheel, which can accommodate several different materials or calibration light sources for the experiment. One can perform the spectrometer experiment by placing the scintillator in the wheel, to be hit by the electron beam, and measures the light outside the chamber. The central part of the platform consists of 15 movable aluminum blocks. Finally, the right chamber is for measuring the lateral profile. Electron beam is shot into the left chamber, which then showers in the aluminum blocks. The resulting secondary electrons travel through the right chamber and hit the scintillator. The light reflected from the scintillator is subsequently detected. Because of the large dynamic range of the electron density in the lateral profile, two types of detectors are used. A CCD camera takes the image in the high electron density region, while a PMT system works for the low electron density region. The CCD system provides coverage with a fine resolution over a large area. It was tested in NSRRC and then used in the FLASH experiments at SLAC [2, 3].

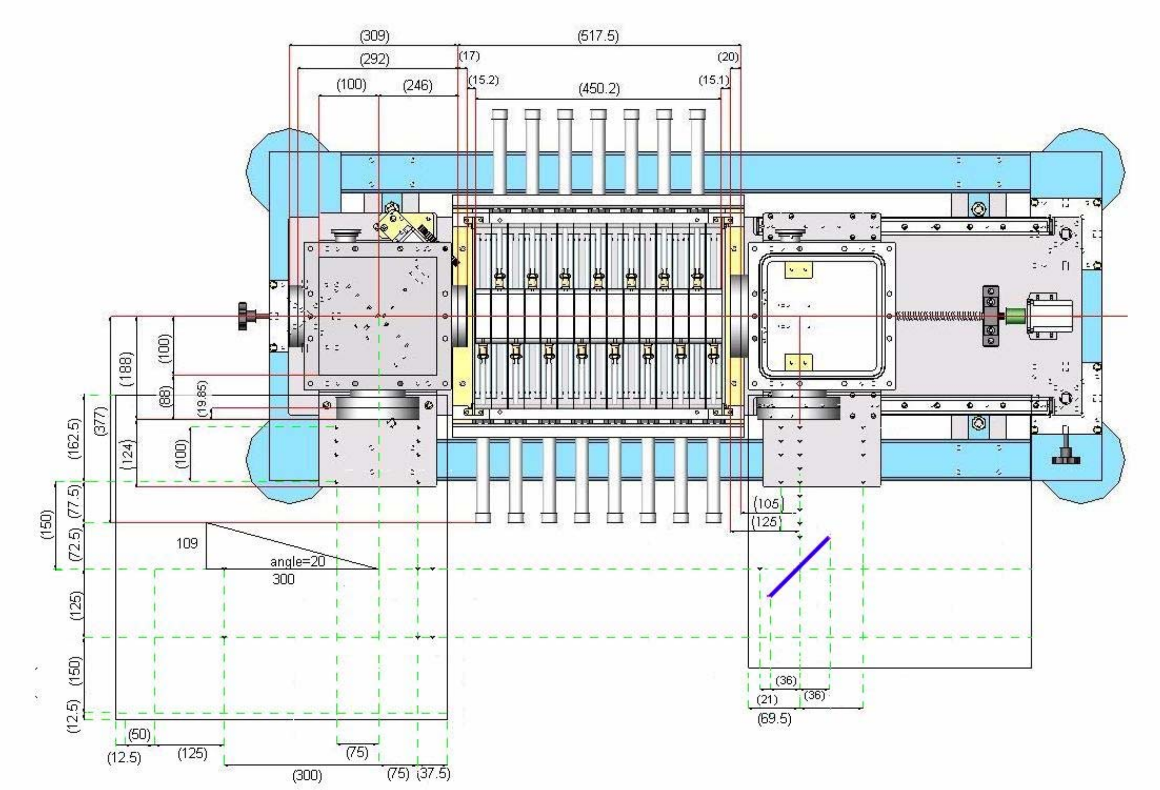

Figure 1. Top view of FLASH-TW experimental platform..

2. Preliminary results

Scintillator (AF995r ; Al_2O_3 :Cr^{3+}) is widely used for monitoring the beam. It is a radiation hard, high photon yield, and reliable material. Ref. [4] shows a spectrum of fluorescence photons with only one decay time 3.4 ms listed.

To prepare for the future FLASH-TW experiments, we had a test run to measure the wavelength and decay time of the scintillator spectrum. This experiment began in late June 2005. Figure 2 shows a decay time measurement using a photo-diode and digital multi-meter. Electron beams are shot to the scintillator in a 10 Hz frequency. Photons produced by scintillator Al_2O_3:Cr^{3+} are detected by a photo-diode. Their signals show a rise in first few ms, believed to be the electronic response time. It is then followed by an exponential decay. Two distinct decay patterns are observed, one has a 5 ms decay time, the other has a decay time roughly 20 ms. Figure 3 show the fluorescence spectrum of the scintillator. It contains two close peaks located at 694.0 nm and 692.8 nm respectively.

The main experiment uses a scintillator of 1.5 inch radius as well as PMTs as sensors for detecting the shower lateral profile. It is expected that the shower lateral profile will grow up larger than the size of the the scintillator as one increases the target radiation length. In this case, the PMTs will be applied to catch the low electron density far from the shower central region.

Figure 4 shows a comparison of the preliminary data on the shower longitudinal profile with the FLUKA simulation. In this plot, we have normalized the data to the simulation at the 2.5 radiation length, the location of the shower maximum. In fact we have observed that the experimental data also peaks at 2.5 radiation length prior to the above normalization, which is consistent with the simulation result. The discrepancy between the data and simulations at the lower radiation length could be due to the Cherenkov contamination. This issue is currently under investigation.

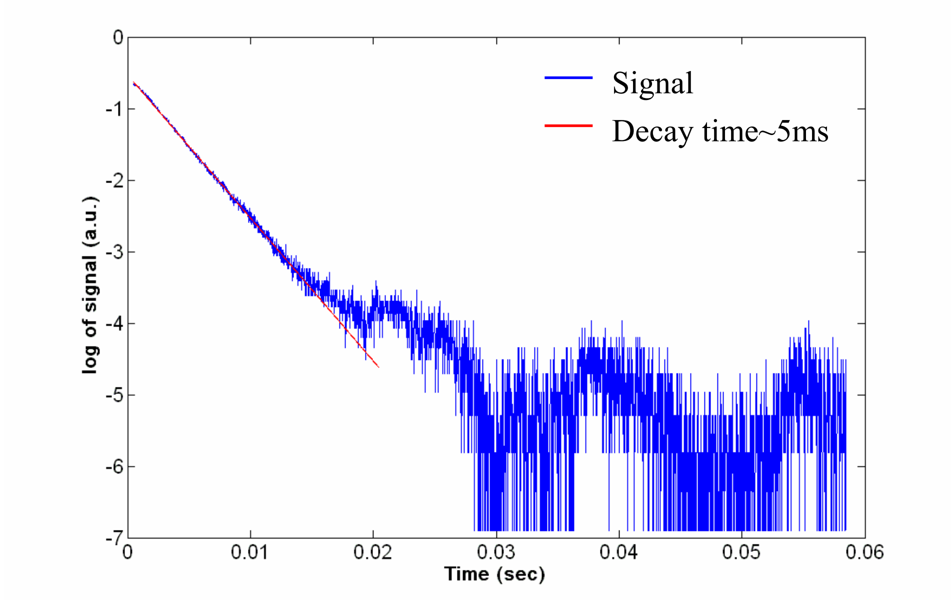

Figure 2. Preliminary results from decay time measurement.

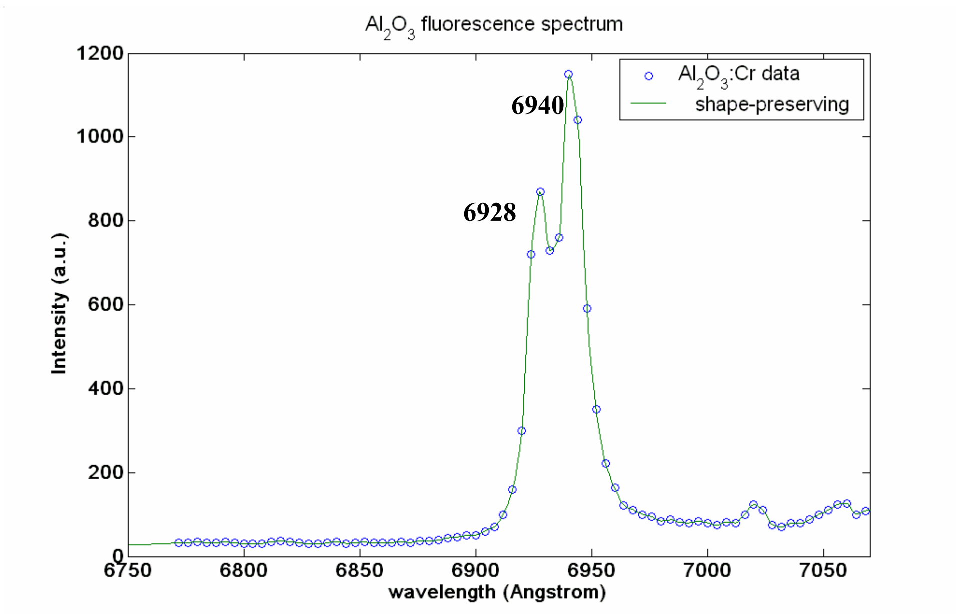

Figure 3. The fluorescence spectrum of Al_2O_3:Cr scintillator.

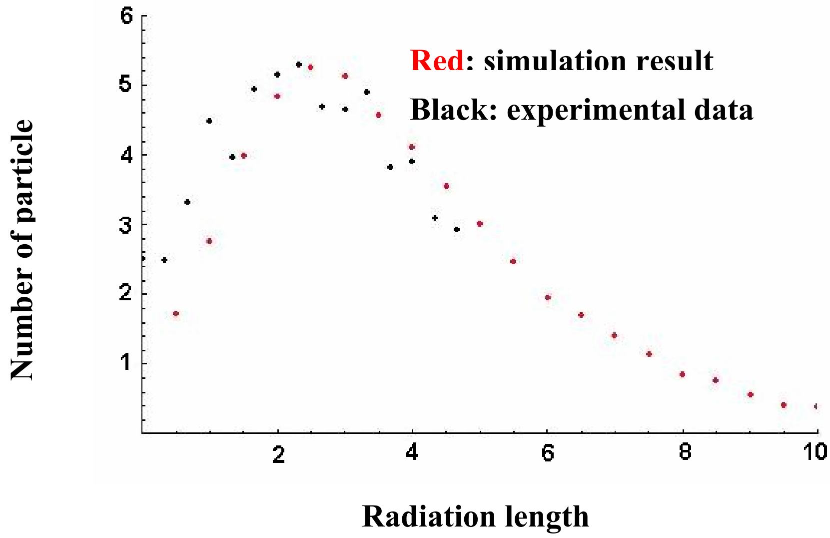

Figure 4. Red points are the simulated shower longitudinal profile generated by shooting 1.5 GeV electrons into aluminum targets. The simulations are done by FLUKA with 10^6 events. Black points are the experimental data normalized to the simulation result at the shower maximum. The shower maximum occurs at 2.5 radiation lengths.

3. Acknowledgements

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References

[1] K. Griesen Phys. Rev. Lett. 16, 748 (1966); G.T. Zatsepin and V.A. Kuzmin, JETP. Lett. 4, 78 (1966).
[2] K. Reil *et al.* Presented at 22nd Texas Symposium on Relativistic Astrophysics at Stanford University, Stanford, California, 13-17 Dec 2004; published in **eConf C041213:2417, 2004**.
[3] See also proceedings of FLASH collaboration in this conference.
[4] K.J. McCarthy, et al., J. of Applied Phys., 92, 6541 (2002).
[5] J.Belz et al., 29th ICRC, Pune (2005) ,usa-belz-J-abs3-he15-oral;P.Huentemeyer et al., 29th ICRC, Pune (2005) ,usa-huentemeyer-P-abs2-he15-oral.