

## TIME TAGGING FOR THE AUGER OBSERVATORY

F. Meyer, P. Tuckey, F. Vernotte

Laboratoire d'Astrophysique de l'Observatoire de Besançon - UMR CNRS 6091  
41 bis avenue de l'observatoire, BP 1615, 25010 Besançon Cedex, FRANCE  
E-mail: francois@obs-besancon.fr

The Pierre Auger Observatory<sup>1</sup> is designed to detect and study cosmic rays at energies exceeding  $10^{19}$  eV, with an unprecedented quality and precision. When higher energy cosmic rays hit the upper atmosphere (about 20 km up) they lose about half of their energy by creating a jet of particles which carries on travelling in almost the same direction as the cosmic ray. The particles in the jet can themselves create more particles as they hit other nuclei of oxygen or nitrogen in the air. This jet is called an extensive air shower. The particles in these showers can be detected directly from the ground with particle detectors. The detectors are arranged in a grid formation on the ground (1600 detectors covering 3000 km<sup>2</sup>) allowing measurements of each shower to be made at several points. Information from the detectors tell us how many particles struck the detector and the time that they hit. This time is used to measure the direction the cosmic ray was travelling when it hit the Earth's atmosphere. The timing of the particle detection is then a key problem since it is directly connected to the precision of the estimated direction of the shower: a 15 ns time resolution is nec-

essary for determining the direction within 1 degree. The Observatory of Besançon was given the responsibility of the timing system, called the time tagging card. This device is based upon a low cost 100 MHz quartz oscillator and a commercial GPS receiver. The event dates are measured from the number of 100 MHz cycles between the event and the GPS 1 pps. At each second, the oscillator frequency is calibrated by the 1 pps. Therefore, a quartz oscillator with a stability of a few  $10^{-9}$  over 1 second is sufficient to ensure a timing accuracy of a few ns. After a detailed description of time tagging card, we will present the measurement obtained in our laboratory by simulating the events with a 1 pps from a cesium clock. Results from the first installed detectors of the Auger Observatory will be also commented.

Finally, examples of use of this system for other purposes will be given.

<sup>1</sup> The southern site, located in Argentina, is currently under construction and should be fully operational in 2003. The northern site will be build in the USA.