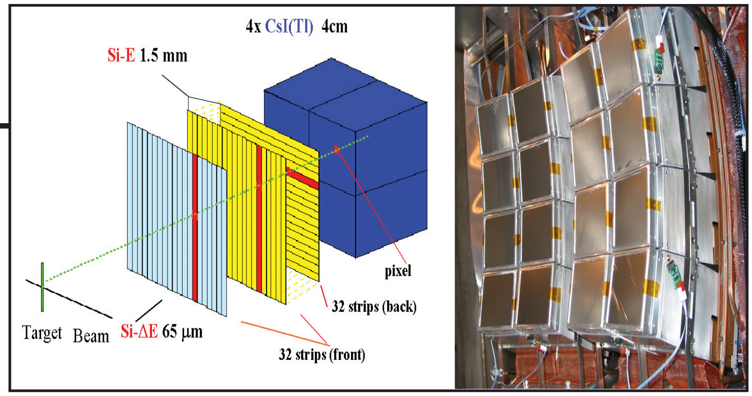
The HiRA Strip Detector Array

The High Resolution Array (HiRA) is a state-of-the-art detection array capable of detecting charged particles produced in nuclear collisions. In addition to measuring their energy and identifying their mass and charge, the array provides the precise positions of detected particles. To allow flexibility to configure the arrays in different geometries, HiRA consists of 20 modules, called "telescopes," that have individual active surface areas of 64 mm x 64 mm. Further information can be found at http://groups.nscl.msu.edu/hira

Each telescope has three layers of detector material. The first two layers are made from high-purity silicon. Charged particles that enter these detectors create a short-lived pulse of current, which is collected on electrodes on the front and back surfaces of the detectors. These electrodes are subdivided into 2 mm wide strips; each electronic pulse in a strip indicates that a charged particle has passed through it. By arranging the front strips vertically and the back strips horizontally, the front and back strips can be correlated to localize the trajectory of the particle to a point (called a pixel) on the detector 2 mm x 2 mm in area.

Lower energy particles typically penetrate the first silicon detector and stop in the second. Higher energy particles penetrate both and stop in a Cesium iodide (Thallium doped) (CsI (Tl)) crystal that emits light when hit by a charged particle. The charge detected in the silicon detectors and, if availiable, the light in the CsI (Tl) are analyzed to obtain the energy, charge, and mass of the particle.

One technological advance in the HiRA detector is the Application Specific Integrated Circuit (ASIC), developed at Washington University, to process the signals produced in the first two layers of the silicon detectors by the passage of charged particles. Compared to the electronic modules used in previous nuclear physics experiments, ASIC decreased the size of the electronics needed from that of a small suitcase to that of a postage stamp. It also reduced the cost by approximately a factor of ten.



The photo shows one arrangement of 16 HiRA telescopes in an actual experimental setup. Each element in the array is a compactly packaged HiRA telescope. The schematic diagram on the left shows the layout of one HiRA telescope, which consists of 3 detectors—a very thin silicon wafer divided into 32 vertical strips, a thicker silicon wafer with the front side divided into 32 vertical strips, and a back side divided into 32 horizontal strips backed by four CsI (Tl) scintillator detectors. Each telescope requires 100 channels of electronics to process the detected signals. During the experiment, the front of each HiRA telescope is covered by a very thin mylar foil to protect the detector from light. The compact design requires that all the electronics be channeled to the back of the detectors beyond the view of the photograph.

HiRA was commissioned in the summer of 2005. In its first year of operation, it was used in four experiments to study the structure of unstable nuclei and the reaction mechanisms that produce them. Other experiments have been performed to measure the masses of nuclei that may be important to rapid hydrogen burning on the surfaces of neutron stars. Such burning processes are believed to be the likely source of astronomical X-ray bursts. Future experiments will expand the scientific agenda for HiRA.

HiRA was built by a collaboration of scientists at NSCL, Washington University in St. Louis, Indiana University, Western Michigan University, Southern Illinois University at Edwardville, and INFN in Milan, Italy.

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