The High Resolution Array

The High Resolution Array is a detector designed to detect and identify light charged particles like protons, deuterium, triton, alpha's and the different isotopes of nuclei with Z<10. These are particles that are produced in nuclear reactions, and by obtaining an accurate measurement of their direction and energy we can learn much about the dynamics of nuclear reactions and the structure of nuclei.

This project is a collaboration between the National Superconducting Cyclotron Laboratory, Michigan State University, Chemistry department, Indiana University, Washington University, St. Louis (MO) and INFN, Milan, Italy.

[Click anywhere in the slides to continue the slideshow]
Some of the Physics Addressed with HiRA

HiRA was designed with radioactive beam facilities like the Coupled Cyclotron Facility at NSCL/MSU in mind.

- Multifragmentation
- Transfer reactions (p,d), (d,p), (α,t), …
- Resonance spectroscopy
- Inverse Kinematics Measurements
- Radiative Capture via Coulomb dissociation.
- Elastic and Inelastic Scattering in reverse kinematics (p,p’), (α,α), …

This defines performance goals
\[\delta \theta < 0.3^\circ, \ \delta E < 50 \text{ keV} \ (E < 20 \text{ MeV})\]
With 20 Identical detectors HiRA is highly configurable for different physics experiments.
HiRA Telescope Design

- 20 Telescopes
- 62.3 x 62.3 mm² Active Area
- strip pitch 1.8 mm
- 1024 Pixels per telescope

Si-\(\Delta E\) 65 \(\mu\)m

32 strips v. (front)
32 strips h. (back)
32 strips v. (front)

Si-E 1.5 mm

Beam

4x CsI(Tl) 4cm

HiRA High Resolution Array
Energy Resolution for 1.5 mm thick double sided silicon strip detectors

- Bulk material is n type
- Interstrip on junction side is 25 μm
- Interstrip on ohmic side is 40 μm
  - P+ implant for better interstrip isolation
- Depletion voltage for 1.5 mm detector < 500 V
- 10 guard ring structure on periphery (2mm dead area region)
CsI(Tl) Crystals

55 AMeV $\alpha$ Beam Incident on crystal

Each crystal is scanned for uniformity of light output!
Particle ID by DE vs E using thick Silicon and CsI.

Particle ID by E vs TOF using thick Silicon and target MCP.

Particle ID by DE vs E using thick Silicon and CsI. Particle ID by DE vs E using thin and thick Silicon.
Electronic Readout

*Developed at Washington University (St. Louis) and Southern Illinois University,*

With 2000 channels to readout, cost of “traditional” readout is prohibitive.

**Application Specific Integrated Circuit**

**Design Includes:**
- Multiple Preamps
- Shapers
- Discriminator
- Time to amplitude converters

This chip board + one VME module replaces 64 pre-amp’s, 32 Shapers, 32 TDCs and 32 ADCs

4 Ch prototype

16 Ch Production Chip
ASIC Chip

ULM for control of ASIC

ADC module, used for ALL 20 telescopes

XLM72 Universal Logic Module
The Signals go from the ASIC chip to a differential amp and then to a sampling ADC.

Sample time

Differential Signals

α spectrum $^{228}$Th source
\rightarrow SIS 14 Bit Sampling ADC
HiRA electronics setup behind detectors in tower configuration
The HiRA collaboration (as of 2005)

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Laser Based Alignment System

- Designed for precision measurement of detector positions relative to target.
- Adaptable to various configurations and other devices.
- Computer controlled.

Resolution:
- 0.005 for angular stages.
- 100 microns for distance.

Edge Scanning Example

Distance (mm)

Angle $\varphi$ (Degrees)