HIGH RESOLUTION POSITION SENSITIVE DETECTORS FOR DIFFERENTIAL CROSS SECTION MEASUREMENTS OF RELATIVISTIC HEAVY IONS*

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Position measurements of high accuracy are required for ray tracing of relativistic heavy ions in various nuclear structure experiments planned at GSI. Position resolutions down to 0.1mm are required to allow for a transverse momentum measurement from which differential cross-sections for peripheral heavy ion collisions can be determined. We have explored the capability of two types of detectors, silicon-microstrip and scintillation-fiber detectors, prototypes of which were tested using an ^{238}U beam of 600 A·MeV and an ^{40}Ar beam of 200 A·MeV energy.

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The electromagnetic excitation of the double isovector giant dipole resonance was observed in recent experiments at GSI [1–3]. The experimental technique applied by our collaboration [1] relies on projectile excitation and a kinematically complete measurement of the decay products (heavy

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fragment, neutrons, γ-rays), allowing for a reconstruction of the primary excitation energy. So far, we were only able to measure impact parameter integrated cross sections.

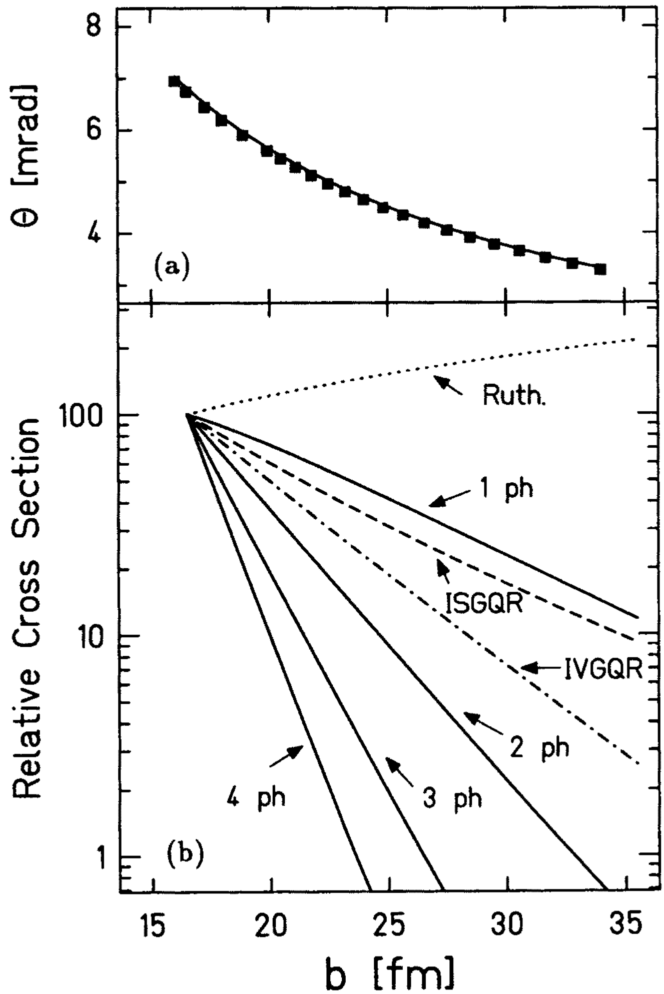

Fig. 1. (a) Deflection function for electromagnetic scattering in the system ^{208}Pb $+^{208}$ Pb at 0.5 AGeV obtained from the full relativistic treatment in Ref. [5] (dots) and the approximation of Ref. [4] (line). Θ denotes the ^{208}Pb (projectile) laboratory scattering angle and b the impact parameter. (b) Differential cross sections for the Rutherford scattering (dotted line) [5] and excitation of multi-phonon giant dipole resonances (solid lines), the isovector giant quadrupole resonance (dashed-dotted line), and the isoscalar giant quadrupole resonance (dashed line) in the same system. The values are normalized to unity at $b = 16$fm.

As illustrated in Fig. 1b, a measurement of differential cross sections is rather sensitive to the multipolarity of the inelastic excitation and the number of excitation steps involved. The deflection function (Fig. 1a) infers that a resolution in scattering angle of about 0.5 mrad is required. Therefore, our experimental setup needs position sensitive detectors with positional resolution in the order of 100 μm. The detectors and the target have to be very thin and the whole setup has to be operated in vacuum to minimize multiple scattering.

Silicon-Microstrip Detectors deliver a position resolution down to about 10μm in applications with minimum ionizing particles (MIP). It was an open question if this resolution can be maintained with relativistic heavy ions, depositing up to 10^4 times more energy than a MIP. Our prototype with an active area of $1 \times 3\text{cm}^2$ and a thickness of 150μm is subdivided into 100 strips with a pitch of 100μm in one dimension. Eighty strips were read out by means of two separate delay lines in such a way, that every second strip was connected to the same delay line with 8ns delay per strip. Single readout was performed for the remaining 20 strips to allow for a study of cross-talk effects. Fig. 2 shows for ^{238}U the correlated delay time in both delay lines for cases in which both of them have complete time information (delay line sum check). Only neighbouring strips contribute.

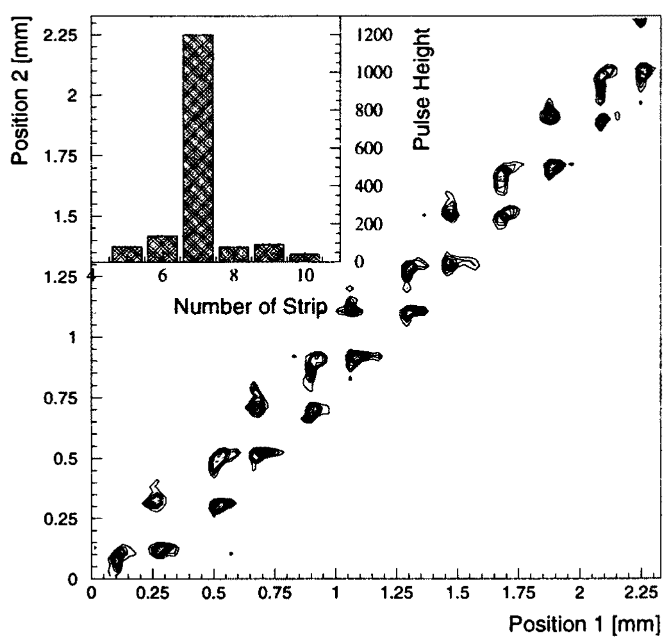

Fig. 2. Position information from delay line 1 versus delay line 2. Inset: charge distribution measured in single strips (see text).

The cross-talk between strips was checked by gating on events where strip 7 was hit centrally. The coincident pulse height distribution over neighbouring strips is shown in the inset of Fig. 2. Essentially only one or two neighbouring strips are fired. Within a 3% error we observed a detection efficiency of 100%.

The **Scintillation-Fiber Detector** prototype consists of 200 parallel fibers of BCF-10 (Bicron) material spanning an active area of 18 × 5cm^2. Each fiber has a quadratical cross section of 250μm×250μm and is covered by thin cladding and absorber material. The 200 fibers are coupled to one position-sensitive phototube (Hamamatsu, R2486) with a photocathode diameter of 6cm, a linear dynode structure and a mesh-type anode consisting of 16 wires in each dimension (x, y), spaced by 3.75mm. Single readout for the pulse height from the 32 wires was performed. The position is reconstructed by calculating the center of gravity of the 16 x- and 16 y-energy signals. Each fiber was centered at a crossing point of the mesh. Fig. 3 shows the image of the fibers coupled to the position-sensitive phototube measured with ^{238}U. Obviously, the observed spots (FWHM 0.5mm) can be identified with individual fibers, although slight non-linearities in the positional phototube response are recognized. In future experiments a much larger number of

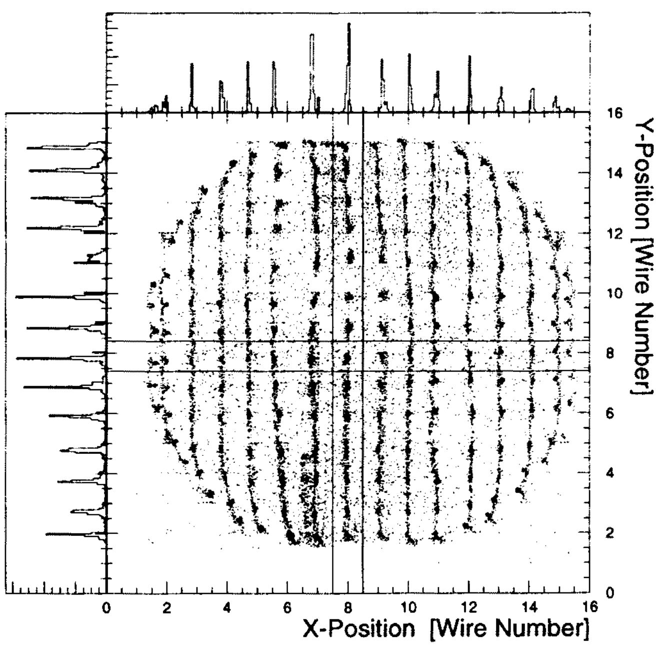

Fig. 3. Fiber image measured with the position sensitive phototube, labels correspond to the 16 anode wires in x- and y-direction. Projections as indicated in the twodimensional plot are also shown.

fibers will be readout with one phototube. An efficiency of 85% was determined, representing the geometrical efficiency for the detector because of the inactive coating of the fibers.

Conclusion

For both U and Ar beam particles the tested detectors fulfill our requests concerning position resolution and for both types of these high granularity detectors we have found an easy readout concept allowing for a single hit recognition.

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