RADIATION SURVEY VEHICLE FOR THE NAL MAIN RING

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Summary

We have instrumented a battery-powered golf cart for making routine radioactivity surveys of the NAL Main Accelerator. The purpose of the surveys is to provide complete and reproducible plots of induced radioactivity for radiation safety, extrapolation to higher intensity operation, and accelerator diagnostics. We discuss the design of the vehicle and present some results of surveys.

Design

Design criteria for the Main Ring Radioactivity Survey Vehicle (Rover) were:

a. to provide $\pm 20\%$ radioactivity measurements over a 5 decade dynamic range with a ± 1m position accuracy for the 6283 m circumference Main Accelerator,

b. to provide a permanent record in an easily interpretable and reproducible form (e.g., independent of vehicle speed),

c. to allow a complete survey to be made by one man in as short a time as possible.

A block diagram of Rover is shown in figure 1. A strip chart recorder was chosen over other digital recording methods as being the simplest to instrument and operate. 110V ac power is derived from the 12 volt golf cart battery by a 60 cycle inverter circuit. All of the electronics interfacing the detector to the chart recorder are modular plug-in printed-circuit cards used extensively in other Radiation Physics instruments.

The radiation detector and associated circuitry were selected so that counting rates and signal averaging time constants were consistent with expected radiation levels and vehicle speeds. The basic limitations were to minimize statistical fluctuations but not to have time constants so long that high speed scans would affect the resolution. At present we are using two GM probe assemblies, but the system was designed so that other types of probes such as NaI(tl) could be used.

The y axis data is processed in a integrated circuit discriminator-multivibrator and fed into a solid state 5 decade logarithmic ratemeter. The z axis information (the horizontal position axis) is derived from a small bicycle wheel pulled behind the vehicle.

An event marker on the chart recorder is used to indicate the location of quadrupoles in the Main Ring, hence, providing z axis calibration information. A typical Rover plot of the 6283 m circumference Main Accelerator is about 1.4m long (and 25cm high). The horizontal demagnification is easily changed by altering the number of magnets on the bicycle wheel.

Figure 2 shows a photograph of Rover in the Main Ring tunnel. The detector probe is on a pivot which allows positioning it directly over the magnet structure. We find that the positioning of the probe is not critical and need not even be over the magnet structure.

Results

Figures 3, 4, and 5 show Rover plots of the NAL Main Ring and Booster. Note the characteristic tails on the "point" beam losses in the Main Ring. The tails are due to multiple scattering of protons out of the beam and the creation of a hadron cascade. In the Main Ring the slopes of the tails range from $\simeq$15m/decade to nearly 50m/decade, depending on such factors as the beam loss mechanism, the physical size of the vacuum chamber, the magnet lattice structure, and the beam energy.

A detailed study of cascade development may be able to explain these differences in tail slopes. One such calculation has been carried out by Ranft.[1]

Rover has now been in service for about 8 months, and is now being used for periodic surveys of both the Booster and Switchyard (external beam lines), as well as Main Ring. It is quite reliable, and has essentially completely replaced surveys by hand-held portable instruments except for critical areas such as the 200 GeV extraction magnets.

References

1. J. Ranft, Particle Accelerator 3 129 (1972).

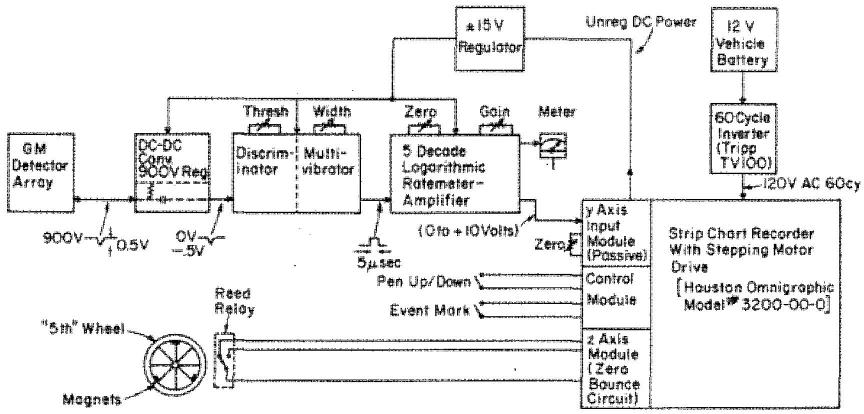

Fig. 1. Rover electronics block diagram. All electrical power is derived from golf cart storage battery. The strip chart is advanced digitally from a reed relay pickup on a wheel pulled behind the vehicle. Two interchangeable detectors are used, covering the range from 10 μrad/hr to 5 rad/hr.

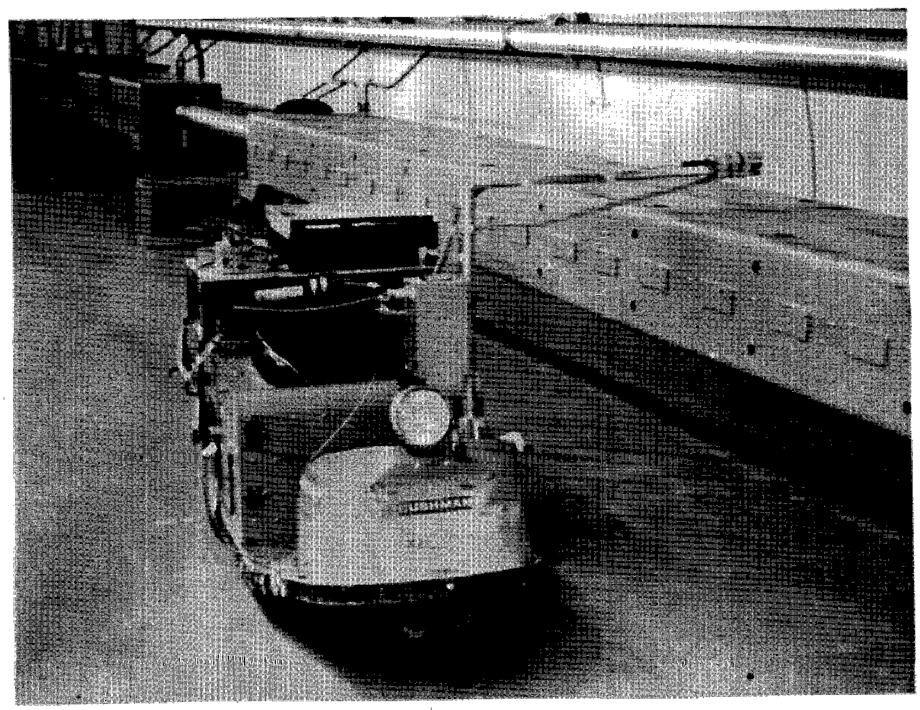

Fig. 2. Photograph of Rover in Main Ring. The detector probe and electronics are mounted on pivot in front, and the strip chart recorder in back of the driver. The wheel for advancing the strip chart is mounted on a pivot behind the vehicle. Typical speeds for surveys are about 10 km/hr.

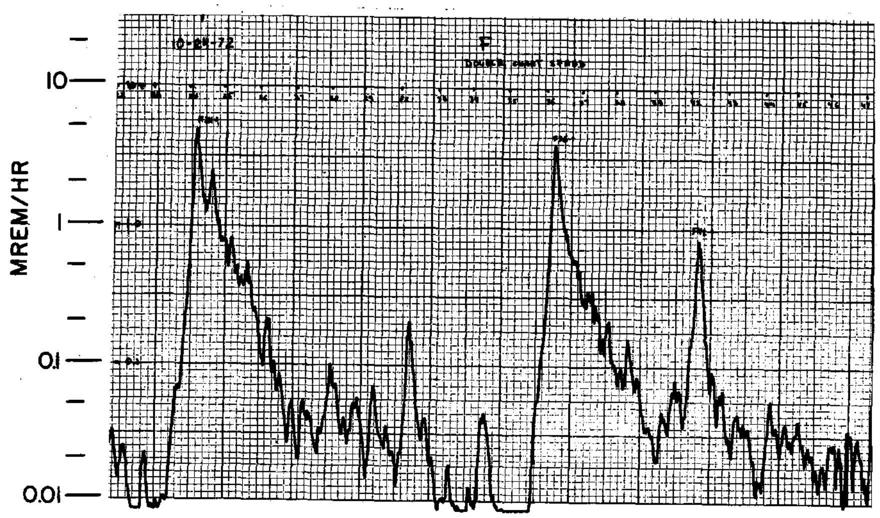

Fig. 3. Rover survey of portion of F Sector in Main Ring. The two large peaks are separated by 297 m (roughly one betatron wave length). A slight vertical displacement of the beam caused it to scrape against a restricted aperture (beam dump magnets) at these points, producing beam losses. These peaks are 2.5 orders of magnitude greater than losses in adjacent areas, and show the long tails characteristic of hadron cascade development. Their tail slopes are roughly 45 m/decade, which contrasts to the smaller peak at the right (15 m/decade).

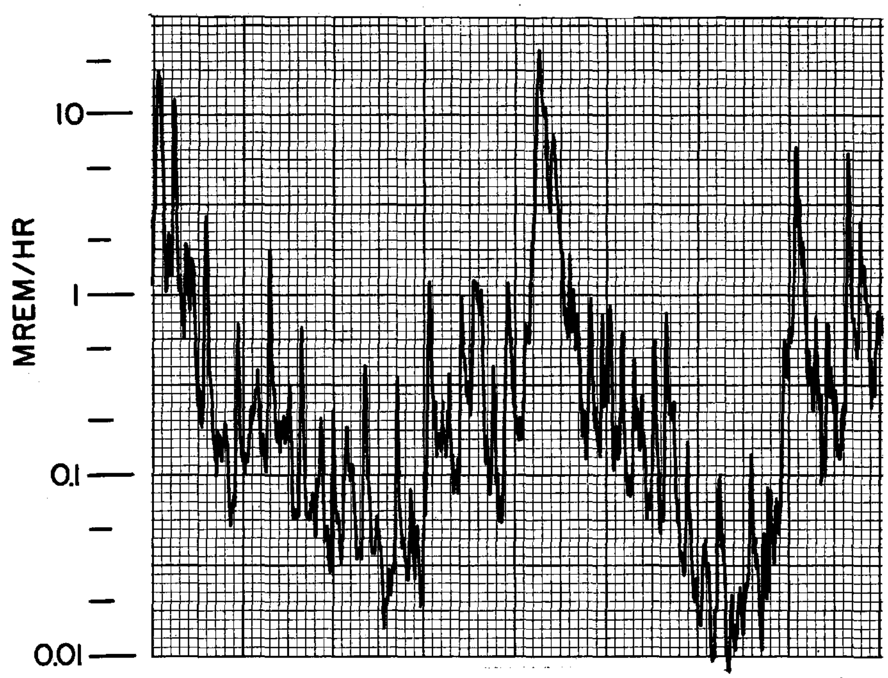

Fig. 4. Rover survey of entire Booster ring (474 m circumference). The central peak represents the injection region, and the peaks at the ends represent the extraction area. Note especially the fine structure here, which is generally not seen in Main-Ring surveys.

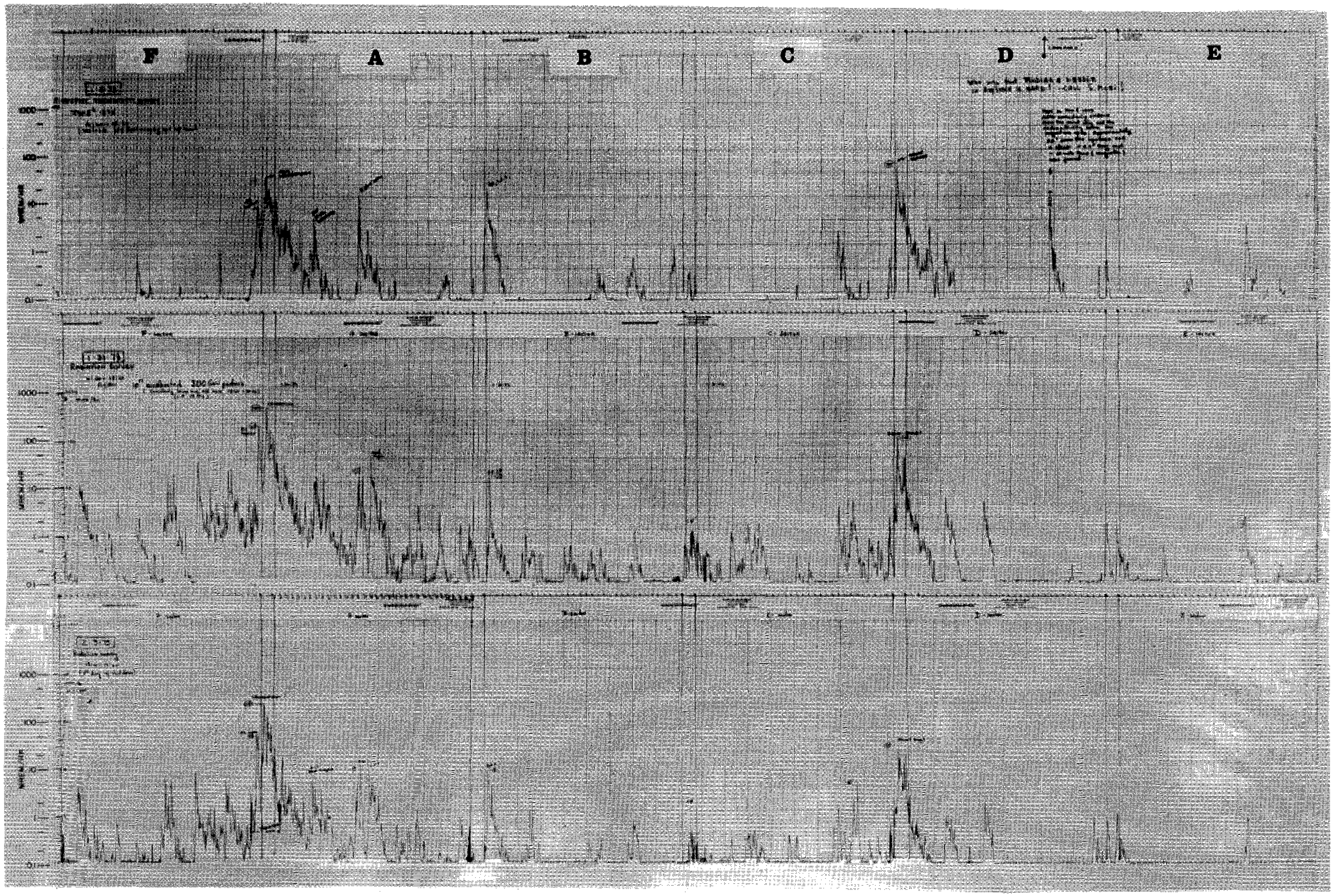

Fig. 5. Rover surveys of the entire Main Ring (6283 m circumference). Sector identification is along the top and radiation level scale is at left. Event marker at top of each chart is used to indicate location of quadrupoles (every 29.7 m) for horizontal axis calibration. These three surveys were taken over a one month period in early 1973. Prominent features include the extraction area (between F and A sectors), and the abort system (between C and D sectors). The unexpected peak in D sector (top survey) resulted from a 0.5 mm dia needle of magnetic tainless steel, which would stand on end and intercept the beam whenever the magnets were rgized.