# THE RASNIK/CCD 3-DIMENSIONAL ALIGNMENT SYSTEM

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**Abstract**
By means of an illuminated coded mask, a lens and a CCD with video readout, the relative alignment of three objects can be monitored. The spatial resolution is better than 2 microns in terms of the displacement of the middle object in the directions perpendicular to the optical axis, and 370 microns in the direction of the optial axis.

**Principle**
For the relative alignment of the L3 muon chambers the RASNIK system [1] has shown to be reliable and precise. The limited range and the limited linearity Can be improved at the cost of expensive large four-quad photodiodes and sophisticated homogeneous light sources. The replacement of the four-quad diodes by CPS is obvious given the price development of the last decade. Moreover, the CCD images can carry detailed image information about the light source. Both the range and linearity are improved dramatically in respect to the former RASNTK system. The principle of the RASNIK/CCD system is shown in fig.1. A photographic transparency with a coded pattern is illuminated from behind by means of an infra-red light-emitting diode and a field lens. By means of a lens a one-to-one image of the mask is projected onto the surface a CCD (Philips VCM 3250/00/CCIR). The CCD is read out using consumer video electronics in a personal computer (frame grabber Datatranslation ‘QuickCapture’ DT 2855-50 Hz, videomultiplexer DT 2859). Images can be stored on disk by means of the light amplitudes of individual pixels.
Fig. 2 shows the mask used Only a small section of the mask is seen by the CCD. The width of the dark and light bands is 352.7 microns. By means of fitting the contours of the dark and light fields the circle centre coordinates can be calculated. By calculating the radii of the circles, the magnification of the image can be obtained and thus the relative position of the lens in the direction along the optical axis.

**Results**
The illuminated mask in fig. 1 could be moved by means of two micron dial gauges in both the X and Y directions perpendicular to the optical axis. In fig. 3a the mask positions, measured by the CCD, are plotted against the mechanical mask position. In fig. 3b the differences from a straight line fit are plotted. The RMS precision over the range of 10 mm is 1.9 microns, and was probably limited by thermal instability of the air between the CCD and the mask.
In fig.4a the position of the lens in Z is plotted against the image scale (= ratio image size/mask size). The deviations from a straight line fit have an RMS error of 360 microns.
This offers the possibility to use the RASNIK/CCD system as a 3D space point monitor.

**Conclusions**

The RASNIK/CCD system consists of components which can be widely commercially obtained. Its precision for both the X and Y coordinates is better than 2 microns. The third coordinate can be measured better than 370 microns. Video multiplexing allows a low-cost read out of many systems. The system could be well applied in the ATLAS and GEM experiments.

The relative alignment of more than three objects can be realised by fixing a CCD on one outer object and a coded mask on the other outer object. A lens is fixed on each object between the outer two; by illuminating different sections of the mask, only light through one particular lens is projected on the CCD. This can be realised giving all lenses a different shift away from the optical axis.

**References**

[1] P. Duinker etal.: Nucl. Instr. & Methods A273 (1988) 814 - 819

Figure captions

fig.1 The principle of the RASNK/CCD alignment system. By means of a lens a coded mask image is projected on a CCD.

fig.2 Enlarged view of the coded mask

fig.3a The measured displacement of the mask plotted versus the mechanical displacement.

fig. 3b Differential plot of the data of fig.3a.

fig.4a The Z coordinate of the lens (with arbitrary offset) plotted versus the measured image size scaling.

fig.4b Differential plot of the data of fig.4a

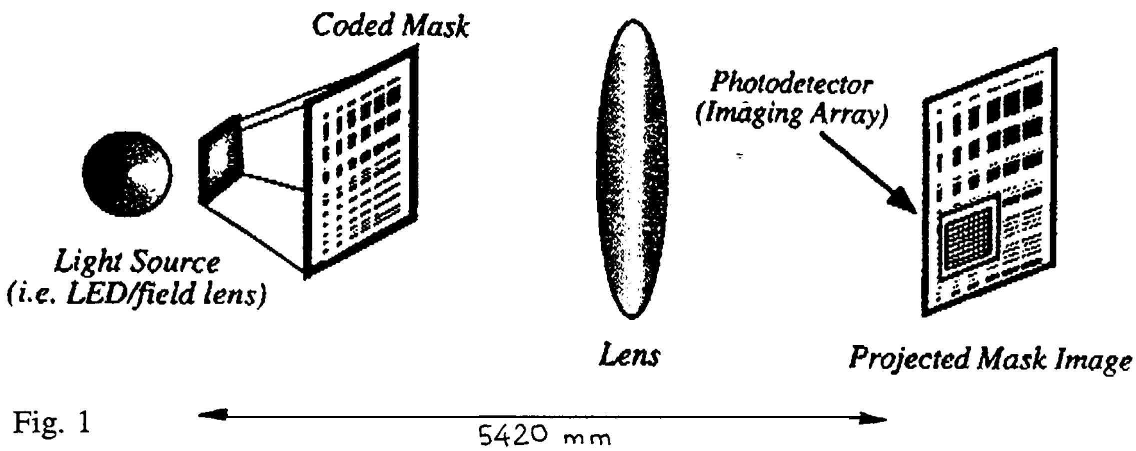


Fig. 1

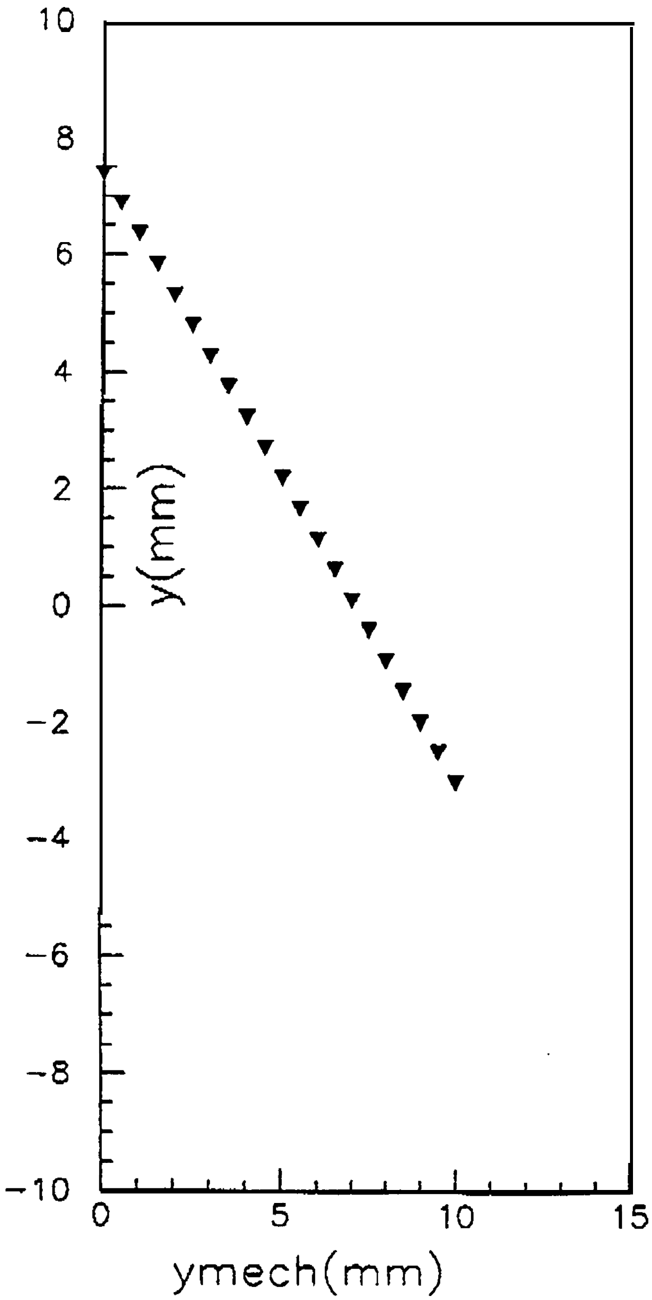


Fig. 3 a

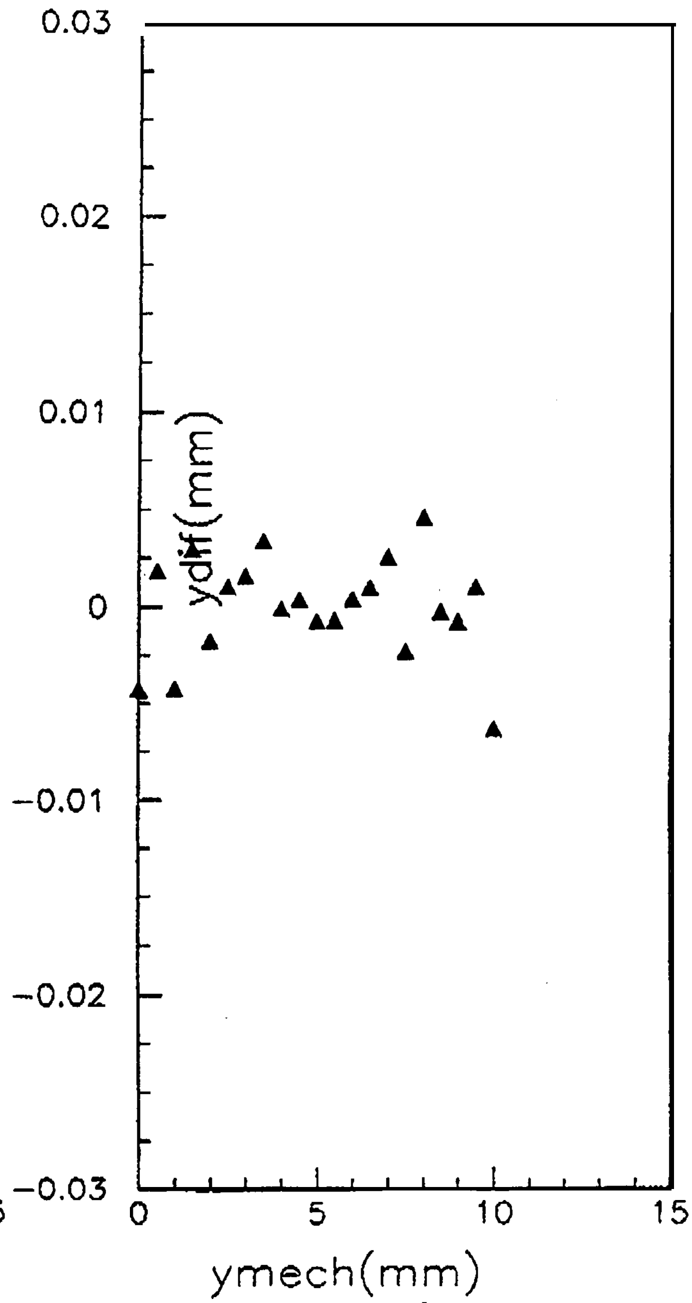


Fig. 3 b

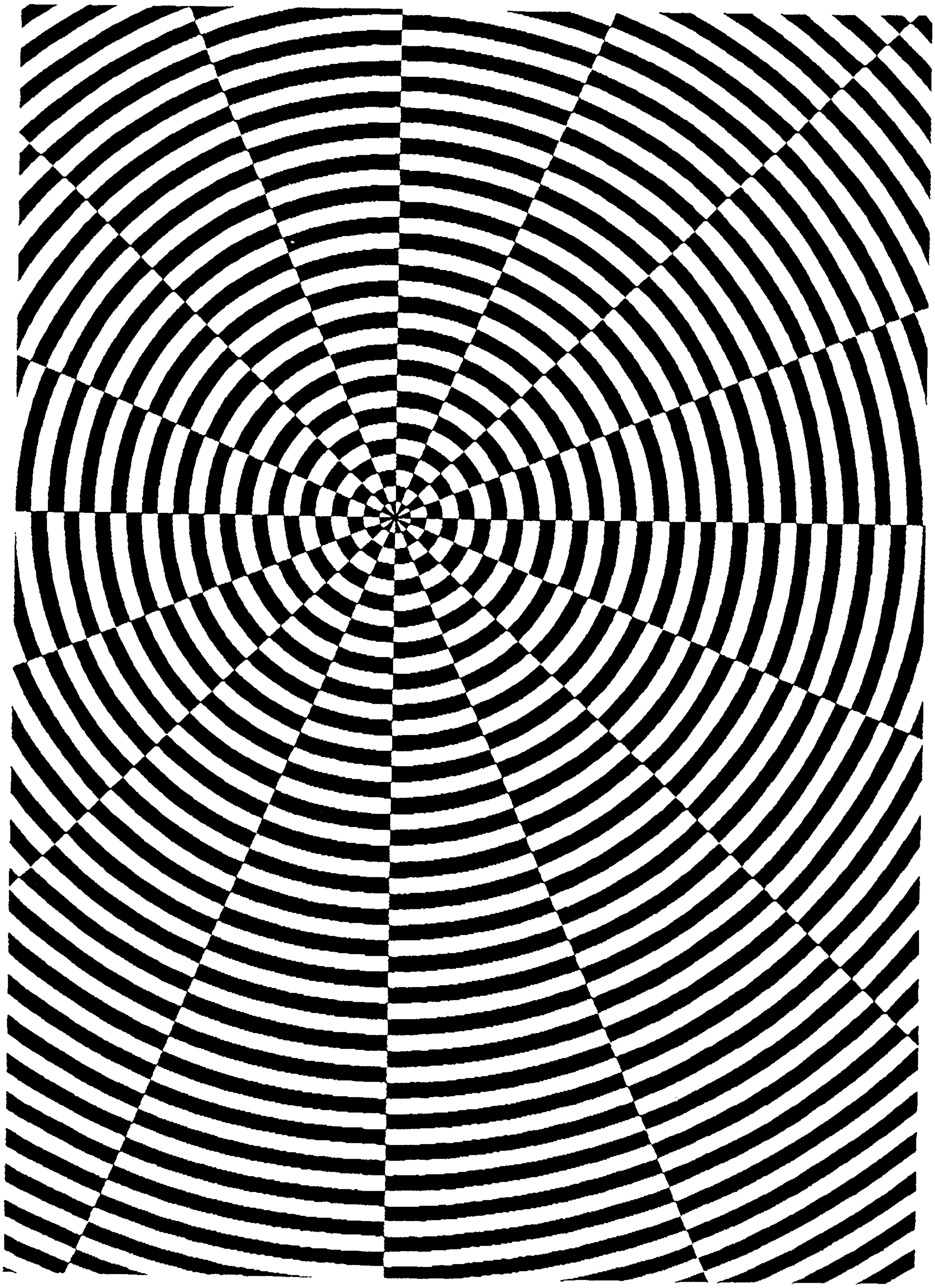

Fig. 2

r.m.s. 0.3641 mm.

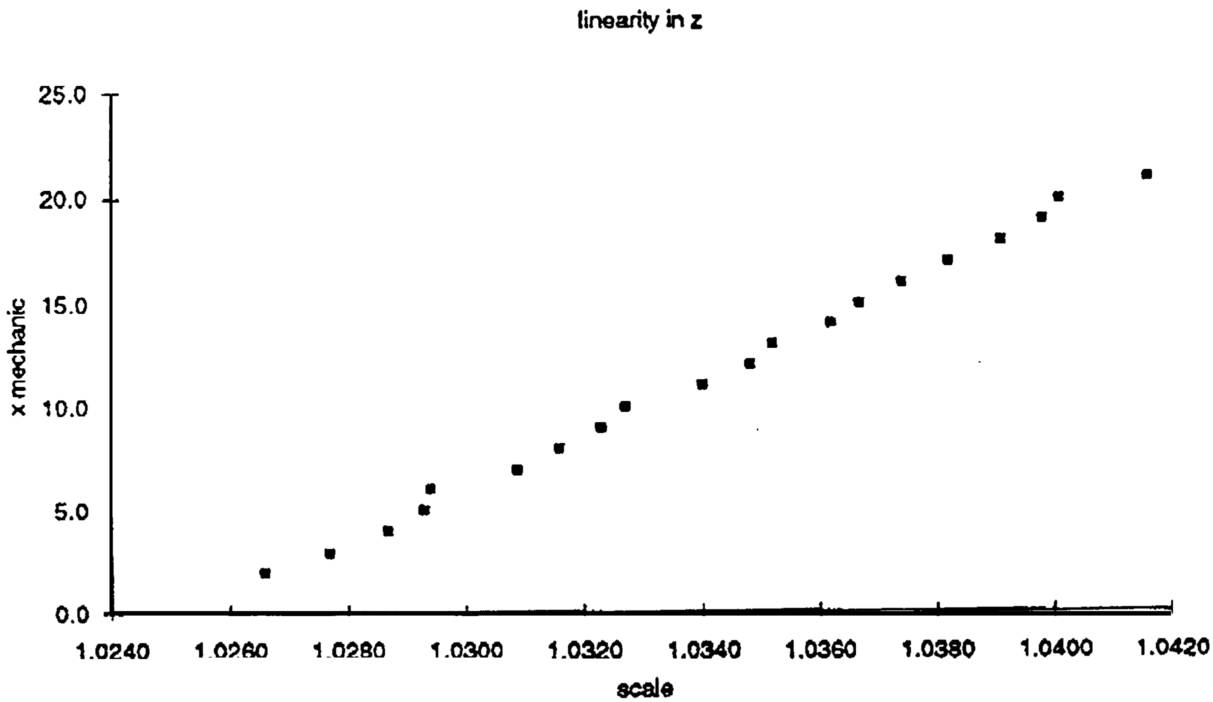


Fig. 4 a

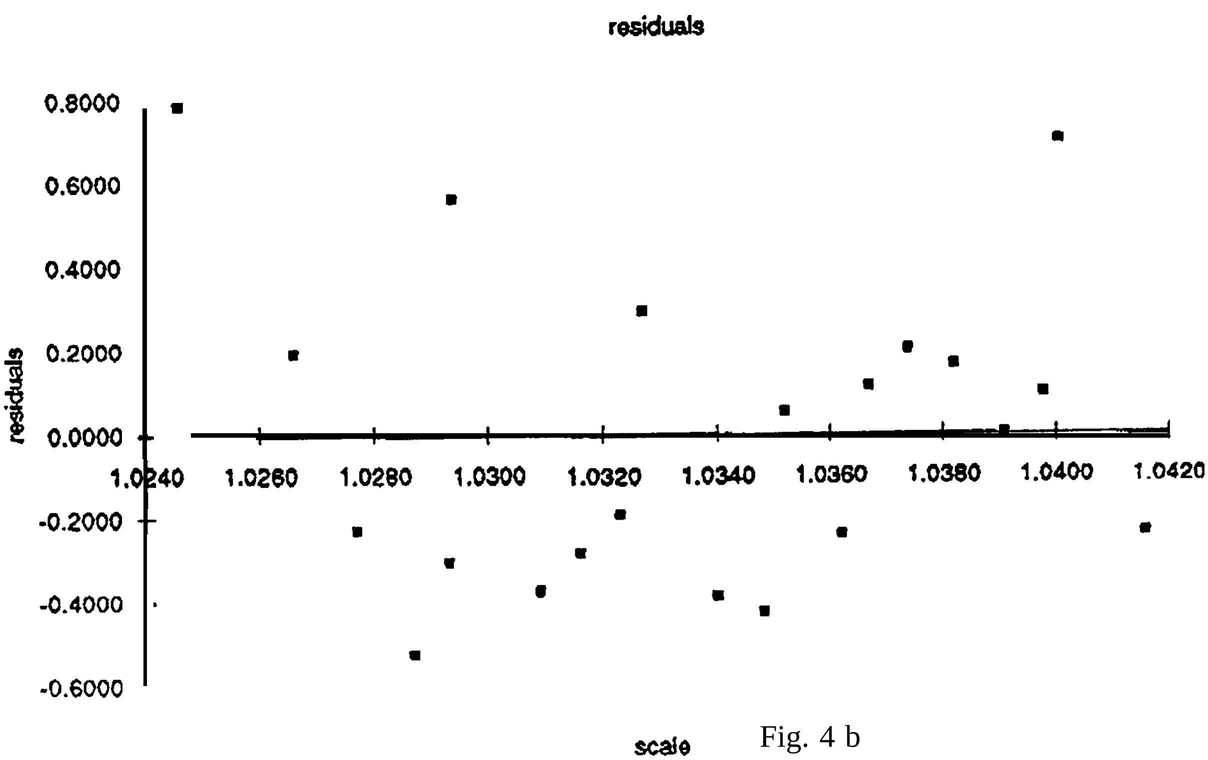


Fig. 4 b