

EMITTANCE SCANNER OPTIMIZATION FOR LOW-ENERGY ION BEAMS

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Abstract

Ion beam emittances are normally measured as two-dimensional distributions of the beam current fraction within a narrow window Δx centered at position coordinate x and a narrow window $\Delta x'$ centered at trajectory angle x' . The small fraction of the beam current found within both of these windows causes the measured emittance signals to be sensitive to noise, bias, and other unwanted signals. One example of unwanted signals is slit scattering that is discussed in detail for low-energy ion beams.

INTRODUCTION

The emittance is the key parameter to calculate the transport and losses of particle beams. It describes the six-dimensional distribution of all position coordinates along the three configuration space directions and the associate velocity coordinates. It is normally reduced into three subsets by projecting it into the two-dimensional planes $\{x, x'\}$, $\{y, y'\}$, and $\{z, z'\}$.

The experimental projection of transverse subsets, either x or y , is accomplished with a position slit placed at a number of equidistant coordinates. The slit accepts a narrow band Δx or Δy , respectively, of the beam cross section. Further downstream, a second, parallel probe samples narrow bands $\Delta x'$ or $\Delta y'$ of the corresponding trajectory angle distribution x' or y' , respectively.

Wire harps can measure each distribution in a single shot, but the accuracy is limited by the uniformity of the amplifier gain, the wires' size, the wires' straightness, and the wires' surface condition that affects the secondary electron emission rate. The wires are likely to be uniform initially, but exposure to the beam will gradually alter some of the characteristics at rates that depend on the exposure, which varies from wire to wire. Uniformity problems can be avoided with a single slit mounted on a suppressed Faraday cup that scans the trajectory angle distribution. Highly accurate and reliable results can be expected if the beam remains stable during the time-consuming scan.

Measuring the two-dimensional distribution with adequate resolution requires a narrow slit width or thin wires. Hence most of the beam is intercepted on the entrance slit, and only a tiny fraction of the beam is measured. Due to their small amplitude, the signals are sensitive to noise, bias, and signals produced by higher order processes such as slit scattering. The effect of noise

and bias can be eliminated with a self-consistent exclusion analysis as discussed in previous papers [1-3]. Data affected by higher order processes can be improved by applying model-based corrections with an accuracy limited by the model. More accurate and reliable data are normally obtained with design modifications that minimize the sensitivity to higher order processes.

Recently we have shown that data from electric sweep scanners contain signals from the beam being dumped on the electrical deflection planes. We have also shown that the amplitude of these ghost signals can be reduced by over 99% when using staircase deflection plates like the ones shown in Fig. 1 [4,5].

In this paper we discuss slit scattering and how it can be minimized for low-energy ion beams. The discussion is valid for most emittance devices scanning low-energy beams. As an example, we use the Allison scanner because it promises the most accurate emittance measurements for low-energy ion beams.

ALLISON SCANNERS

Electric sweep scanners [6] and Allison scanners [7] were introduced more than 25 years ago. Both scanners use an electric field between the two defining slits to measure the distribution of the entrance angle x' of the beamlet passing through the first slit. Allison scanners combine the electrical sweep of the entrance-angles with a mechanical position scan that probes the position distribution x . This allows for mounting both slits on a single support base, enabling relative alignment of both slits within tight tolerances, a potential source of error. Charged particles passing through both slits are collected in a Faraday cup with suppressed secondary electron emission. A grounded light-tight shield surrounds the entire assembly to block unwanted charged particles from reaching the Faraday cup.

The voltage to angle conversion is $x' = V \cdot L_{eff} / (2 \cdot g \cdot U)$, where U is the ion's kinetic energy divided by its charge, L_{eff} is the effective length of the deflection plates, g is the

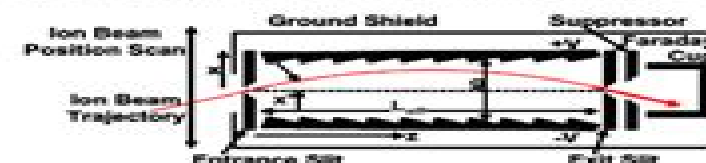


Figure 1: Schematic Allison scanner with staircase deflection plates.

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Low-energy Ion Beams, 1980 Ian Howard Wilson, Kenneth Gilbert Stephens, 1980 **Low-energy Ion Beams, 1980** Ian Howard Wilson, Kenneth Gilbert Stephens, 1980 **Treatise on Heavy-Ion Science** D.A. Bromley, 2013-04-17 INIS Atomindex, 1982 *Energy Research Abstracts*, 1984 **Ion Implantation: Equipment and Techniques** H. Ryssel, H. Glawischnig, 2012-12-06 The Fourth International Conference on Ion Implantation Equipment and Techniques was held at the Convention Center in Berchtesgaden Bavaria Germany from September 13 to 17 1982 It was attended by more than 200 participants from over 20 different countries Several series of conferences have dealt with the application of ion implantation to semiconductors and other materials Thousand Oaks 1970 Garmisch Partenkirchen 1971 Osaka 1974 Warwick 1975 Boulder 1975 Budapest 1978 and Albany 1980 Another series of conferences has been devoted to implantation equipment and techniques S ford 1977 Trento 1978 and Kingston 1980 This conference was the fourth in the latter series Twelve invited papers and 55 contributed papers covered the areas of ion implantation equipment measuring techniques and applications of implantation to metals and semiconductors A school on ion implantation was held in connection with the conference and the lectures presented at this school were published as Vol 10 of the Springer Series in Electrophysics under the title Ion Implantation Techniques edited by H Ryssel and H Glawischnig During the conference space was also provided for presentations and demonstrations by manufacturers of ion implantation equipment Once again this conference provided a forum for free discussion among implantation specialists in industry as well as research institutions Especially effective in stimulating a free exchange of information was the daily get together over free beer at the Bier Adam Many people contributed to the success of this conference **Materials Surface Processing by Directed Energy Techniques** Yves Pauleau, 2006-04-25 The current status of the science and technology related to coatings thin films and surface modifications produced by directed energy techniques is assessed in Materials Surface Processing by Directed Energy Techniques The subject matter is divided into 20 chapters each presented at a tutorial level rich with fundamental science and experimental results New trends and new results are also evoked to give an overview of future developments and applications Provides a broad overview on modern coating and thin film deposition techniques and their applications Presents and discusses various problems of physics and chemistry involved in the production characterization and applications of coatings and thin films Each chapter includes experimental results illustrating various models mechanisms or theories Proceedings of the International Ion Engineering Congress, 1983 **National Union Catalog, 1980**, 1981

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Implantation and Ion Beam Processing of Materials G. K. Hubler, 1984 *Energy Research Abstracts* ,1984-03 Fusion Energy Update ,1979 **Effects of Radiation on Materials** N. H. Packan, 1990 Annotation Effects of Radiation on Materials Fourteenth International Symposium was presented at Andover MA June 1988 The symposium was sponsored by ASTM Committee E 10 on Nuclear Technology and Applications The papers from the first three days of the symposium appear in the two volumes of this publication Volume I encompasses radiation damage induced microstructures point defect solute and gas atom effects atomic level measurement techniques and applications of theory Volume II includes mechanical behavior all papers dealing with pressure vessel steels breeder reactor components dosimetry and nuclear fuels The fourth day of the symposium was devoted to the single topic of reduced activation materials see TK9204 The two volumes are separately sold at 127 and 128 respectively each is independently indexed Annotation copyrighted by Book News Inc Portland OR **Elemental Analysis by Particle Accelerators** Zeev Alfassi, Max Peisach, 2020-11-26 Elemental Analysis by Particle Accelerators describes the theory methodology and applications for a wide variety of sensitive non destructive methods of analysis capable of both high selectivity and multielemental determinations Specific methods discussed include radioactive methods particle backscatter analysis recoil techniques and nuclear reaction analysis The use of multielemental PIXE and PIGME analyses of real world thick samples in environmental studies trace element applications in biology and provenance studies in archaeology are also covered The book is a useful reference for practicing specialists and an essential text for students **Current Catalog** National Library of Medicine (U.S.), 1985 First multi year cumulation covers six years 1965 70 **National Library of Medicine Current Catalog** National Library of Medicine (U.S.),

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