BURLE
ELECTRO-OPTICS

Ion Beam Profiling Using a Novel Electronic Imaging Detector

*Bruce N Laprade and Richard A Prunier
BURLE Electro-Optics
Sturbridge MA

Paper 1700-2400 Presented at The 2004 Pittsburgh Conference
March 7, 2004

*Presenter

Introduction

BURLE
ELECTRO-OPTICS

- In the rapidly evolving analytical instrument market, new applications are constantly being developed. Twenty five years ago mass spectrometers were primarily research tools. Today, mass spectrometers are used in medical diagnostics, semiconductor manufacturing, environmental monitoring, drug discovery and food processing. Virtually everyone has benefited by the existence of these instruments.

Introduction Cont.

BURLE
ELECTRO-OPTICS

- Rapidly emerging new applications for Mass Spectrometers have forced instrument manufacturers to substantially reduce product development cycle time.

Discussion

BURLE
ELECTRO-OPTICS

- A number of new materials and tools including modeling software have been developed in order to facilitate rapid product development.
- Ion optics modeling software is used to design and predict the ion path within the mass spectrometer. However, ion trajectories can be influenced by many factors which are not considered in the model. Efficiently transporting ions from the source through the mass filter is critical for maximizing instrument sensitivity.

Discussion Cont.

BURLE
ELECTRO-OPTICS

- The conventional method for aligning an ion beam consists of scanning the beam over a Faraday cup or electron multiplier, integrating the current, and finding the settings which produce the highest signal.
- A new imaging tool has been developed which can be used to visualize the location of any charged particle (Ion, Electron), UV photon or soft x-ray beam. Imaging the beam enables the instrument designer to ensure all available signal ions are collected.

Typical Applications

BURLE
ELECTRO-OPTICS

- Ion Beam Profiling
- Ion Optic Model Verification
- Imaging TOF
- VUV Spectroscopy
- High Energy Physics

Apparatus

BURLE
ELECTRO-OPTICS

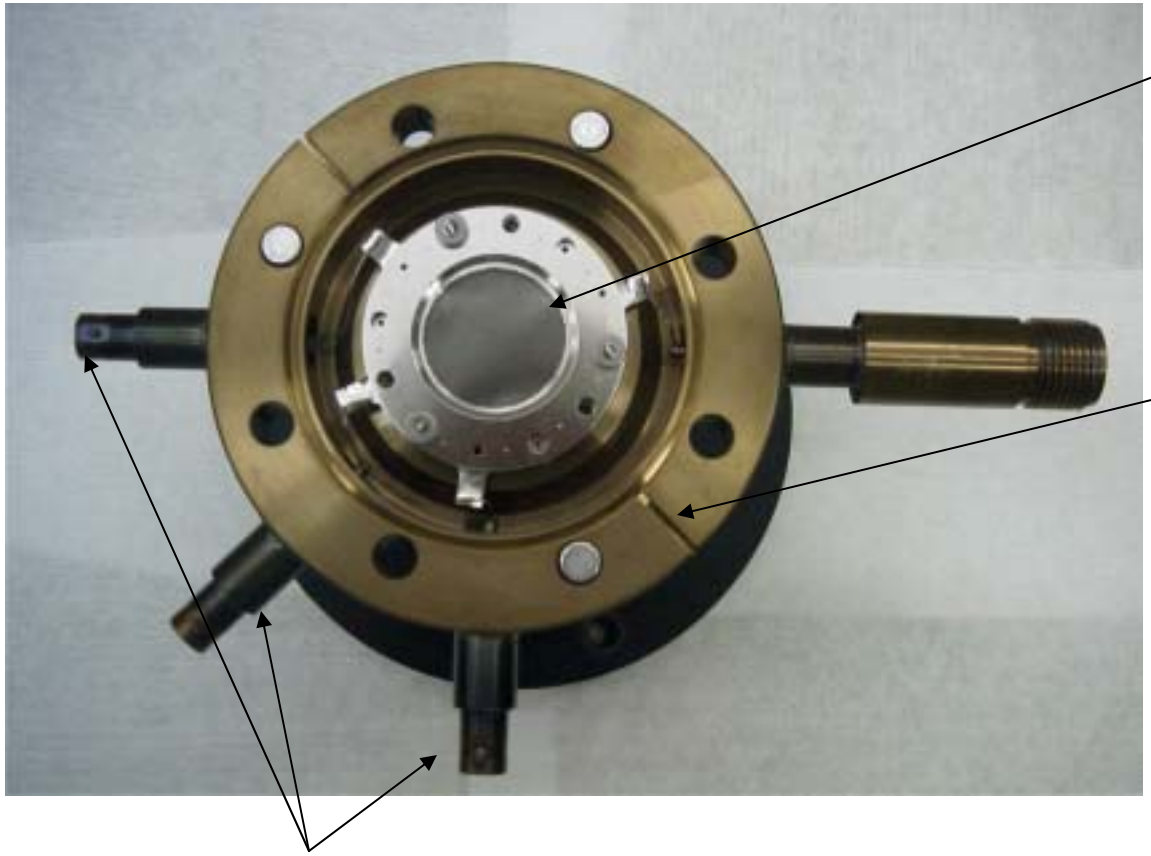
- The Electronic Imaging Detector is a microchannel plate phosphor screen based detector coupled to a CCD camera with a frame grabber card and software for a personal computer.

- This device was designed to enable the user to capture images from the phosphor screen at a rate of up to 30 frames/sec and store them in a variety of formats suitable for enhancement or manipulation. TTL inputs enable event and strobe triggers to be utilized to synchronize the camera to an event.

- The internet capability of the system enables experimenters to share real time images.

The Electronic Imaging Detector

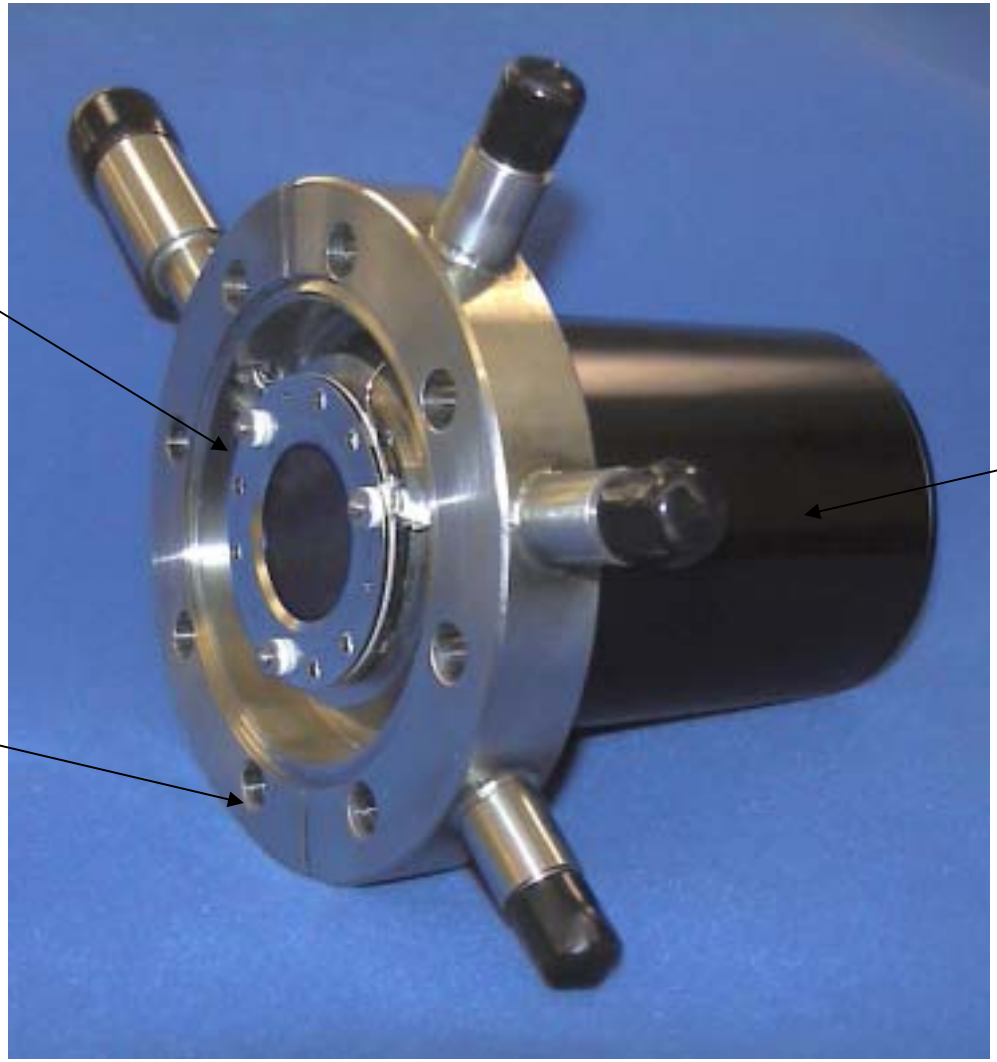
BURLE
ELECTRO-OPTICS



HV Feedthroughs for the Chevron and Phosphor screen

The Electronic Imaging Detector

BURLE
ELECTRO-OPTICS



The Electronic Imaging Detector

BURLE ELECTRO-OPTICS

Phosphor Screen High Voltage

Video Out

Chevron Out

Chevron In

Grid

Power

Vacuum Flange

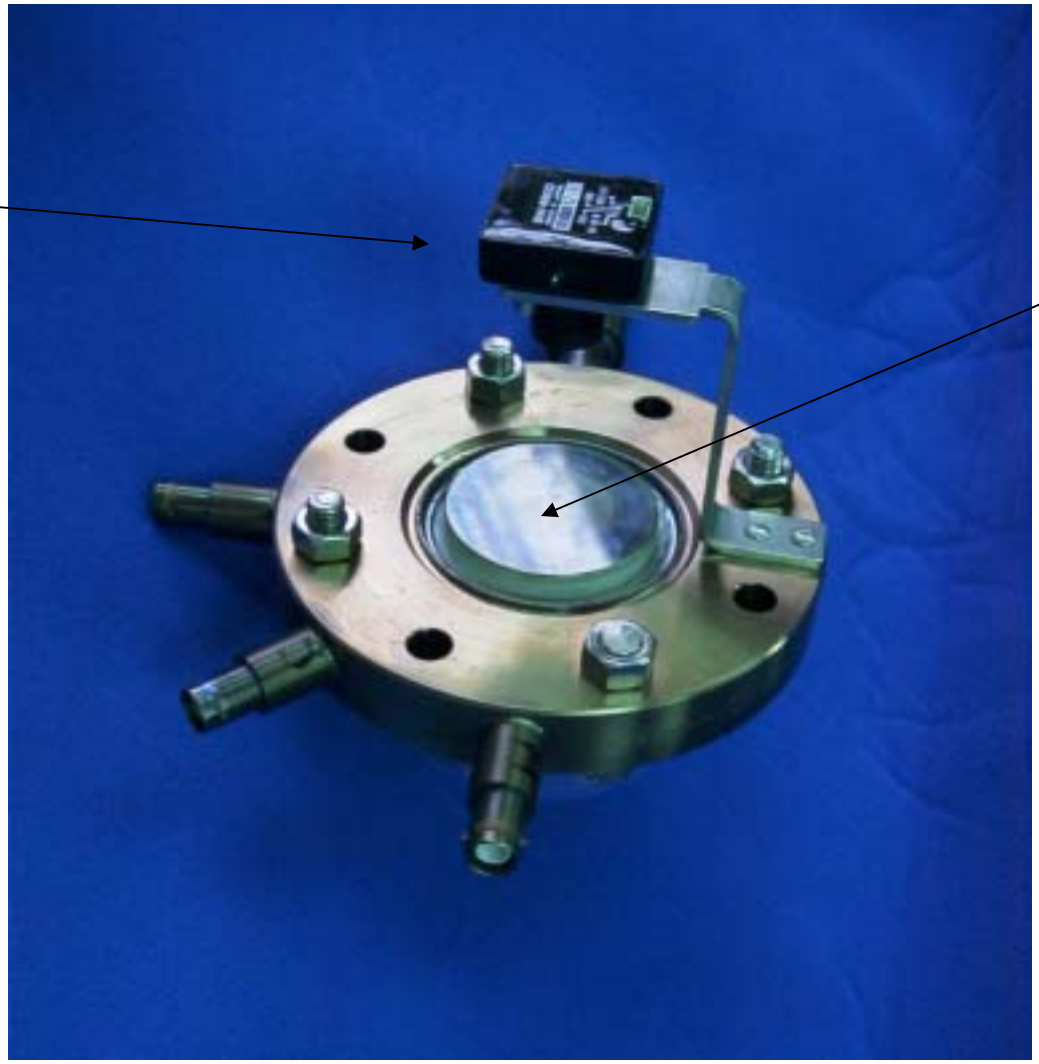
CCD Camera inside Light Shroud

+ 9 volt in

The Electronic Imaging Detector

BURLE
ELECTRO-OPTICS

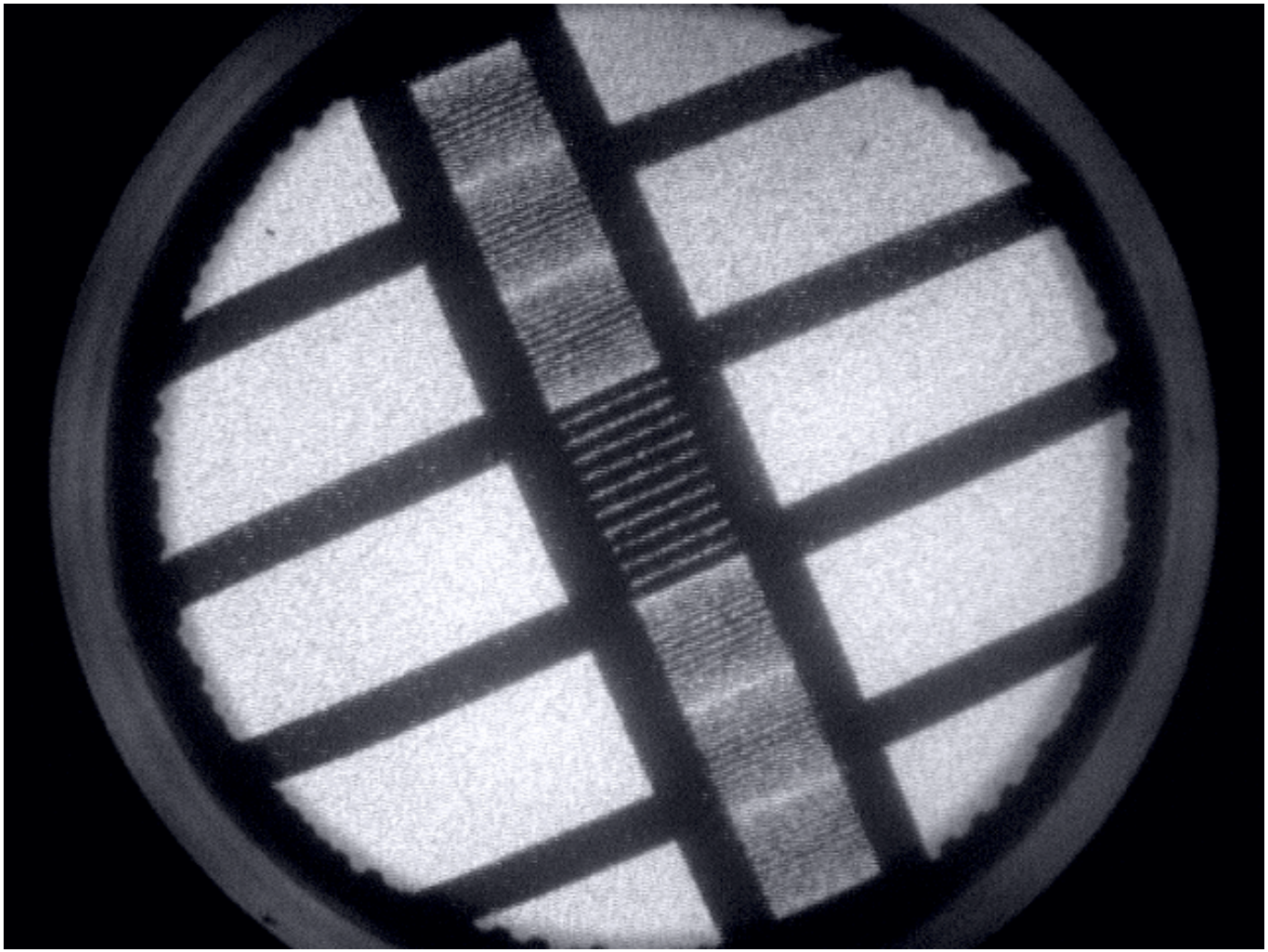
CCD
Camera



Fiber Optic
Phosphor
Screen

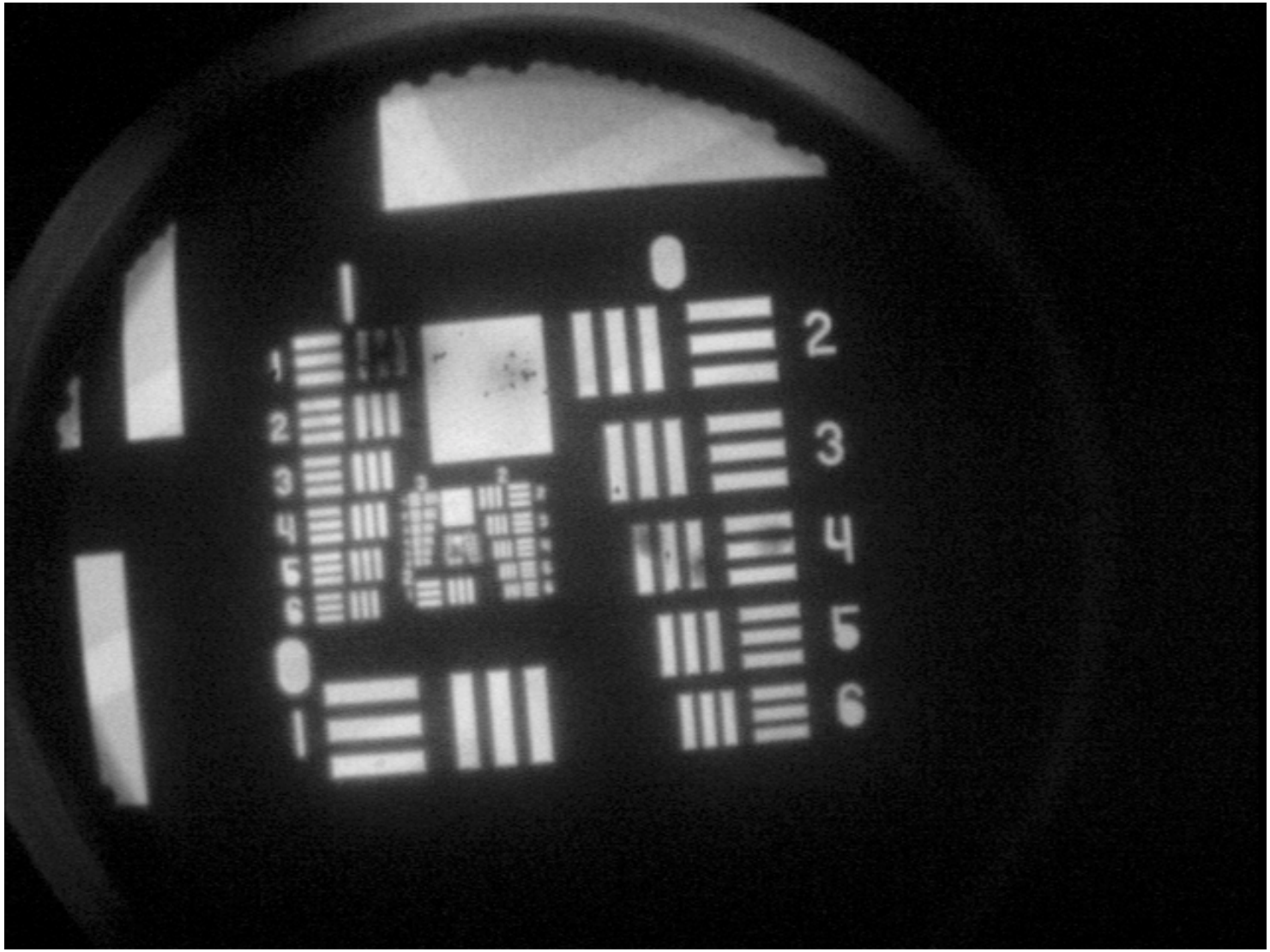
Ion Beam Profile on a Test Pattern

BURLE
ELECTRO-OPTICS



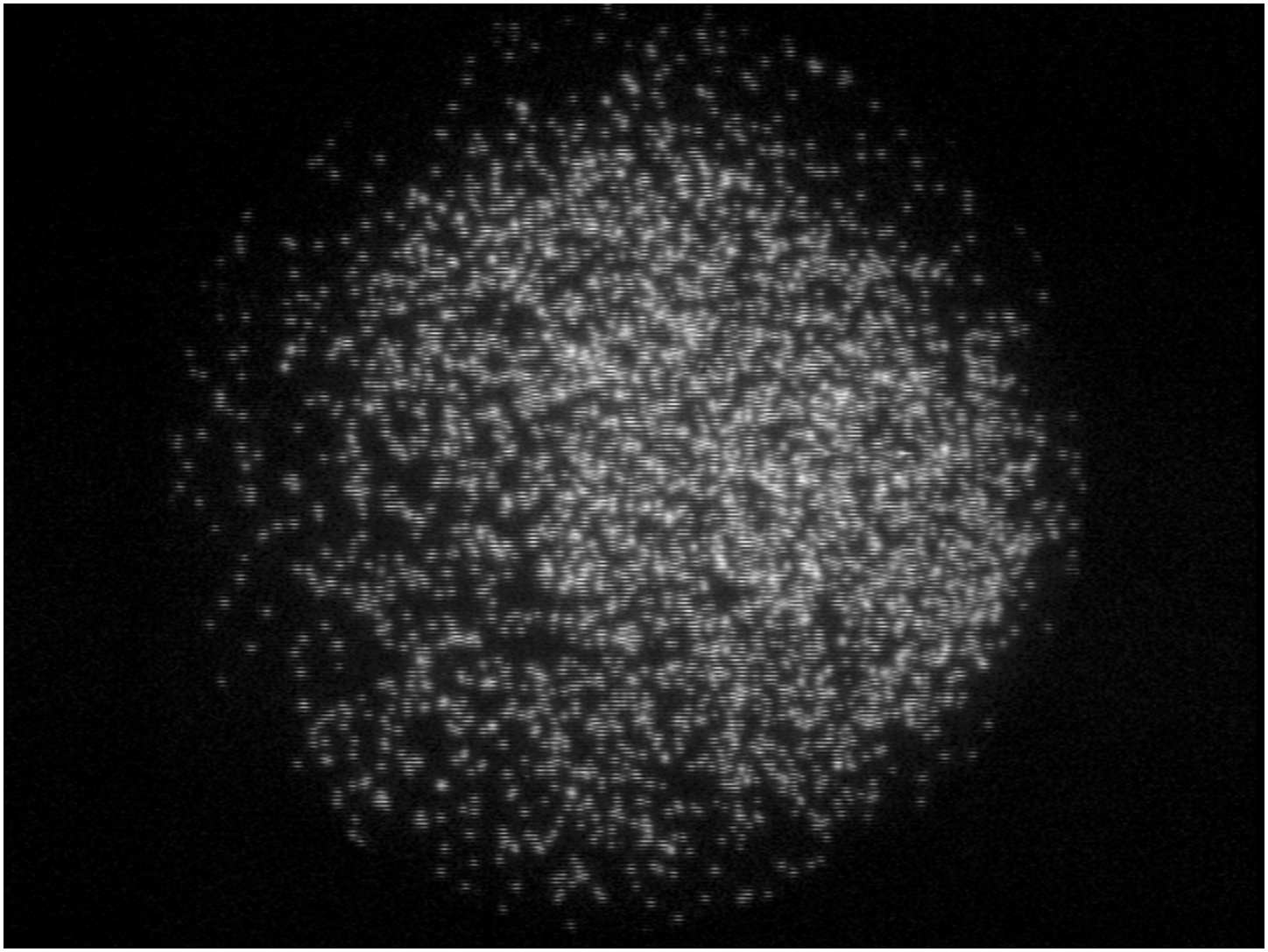
Chevron Resolution Test

BURLE
ELECTRO-OPTICS

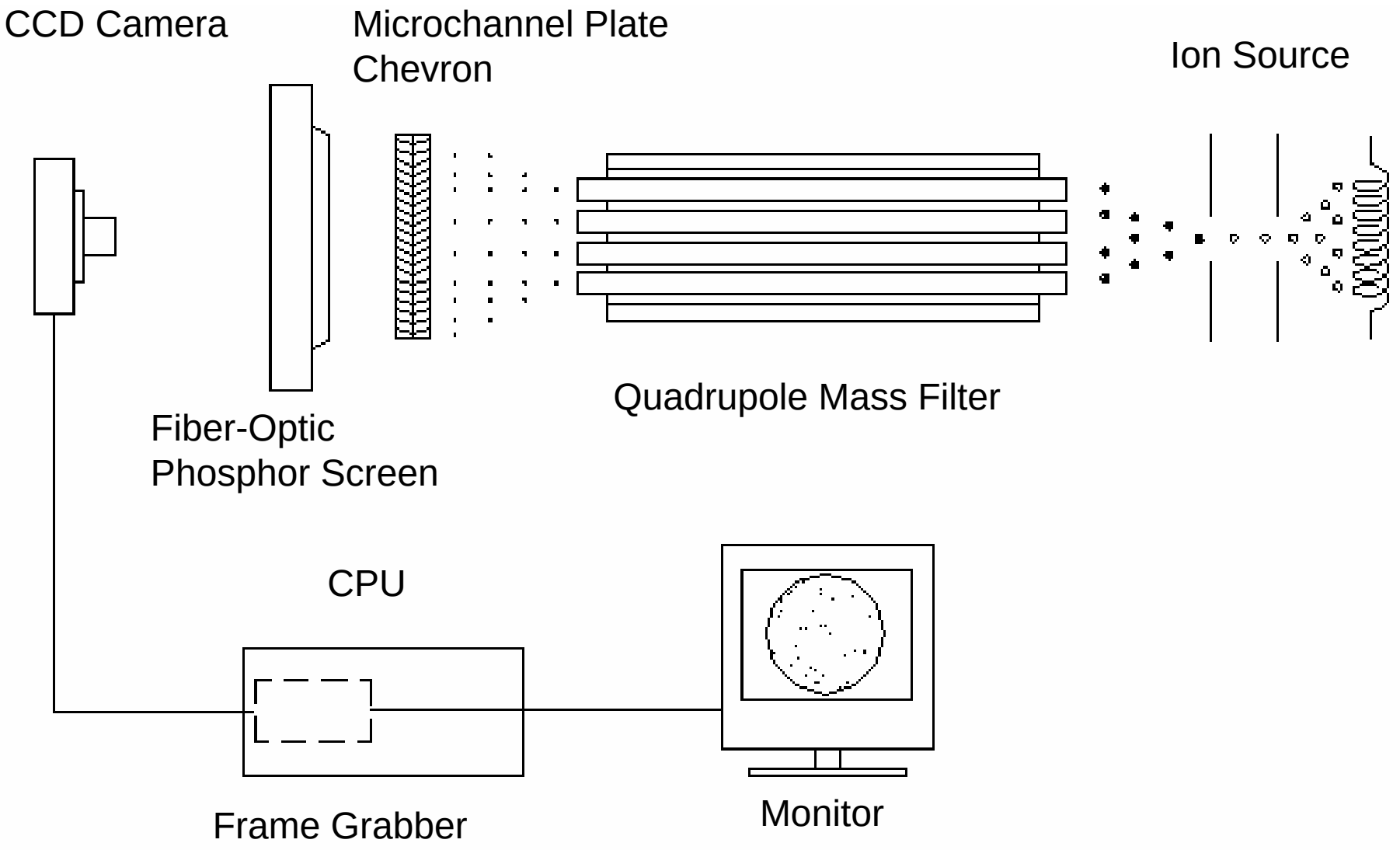


Random Ion Pattern

BURLE
ELECTRO-OPTICS

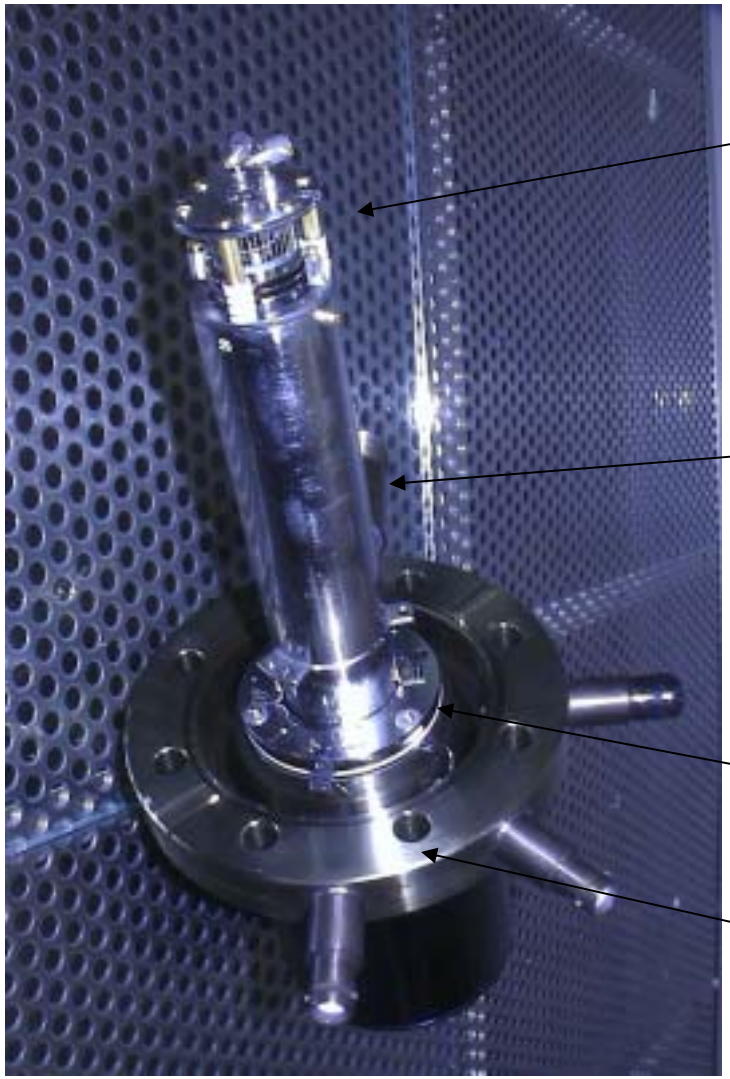


Test Configuration for Imaging an Ion Beam From a Quadrupole Mass Filter

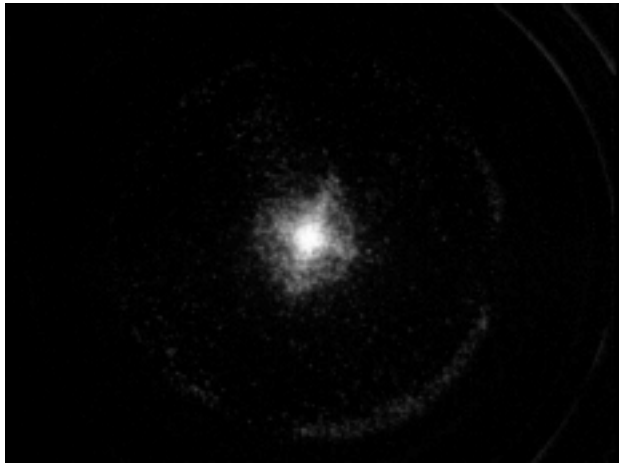


Experimental Test Set-Up

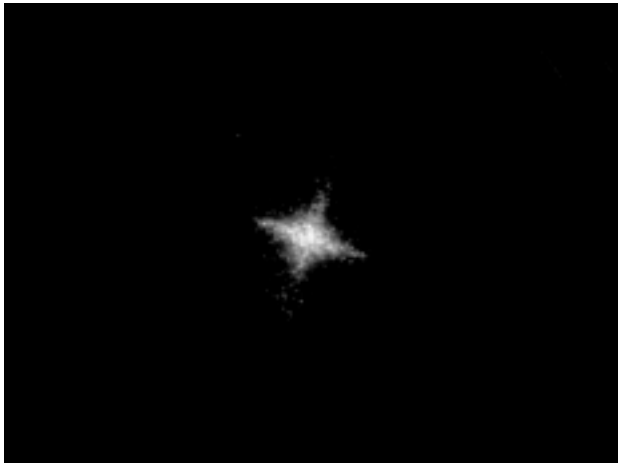
BURLE
ELECTRO-OPTICS



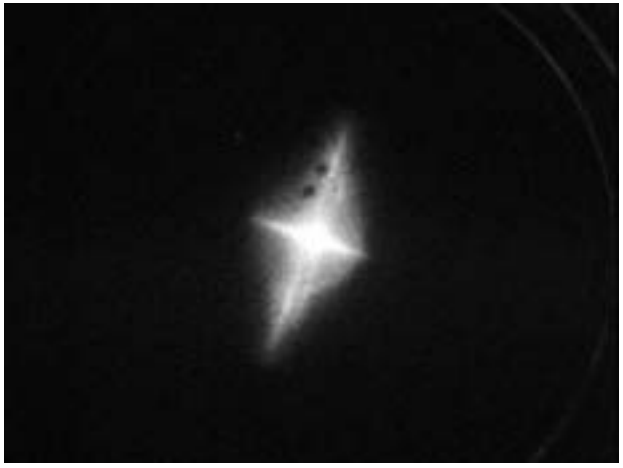
Ion Beam from a Quadrupole Mass Filter



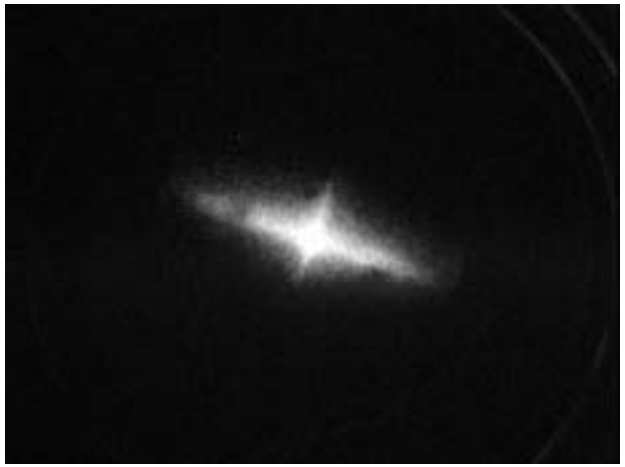
Poorly Focused Beam



Well Focused Beam

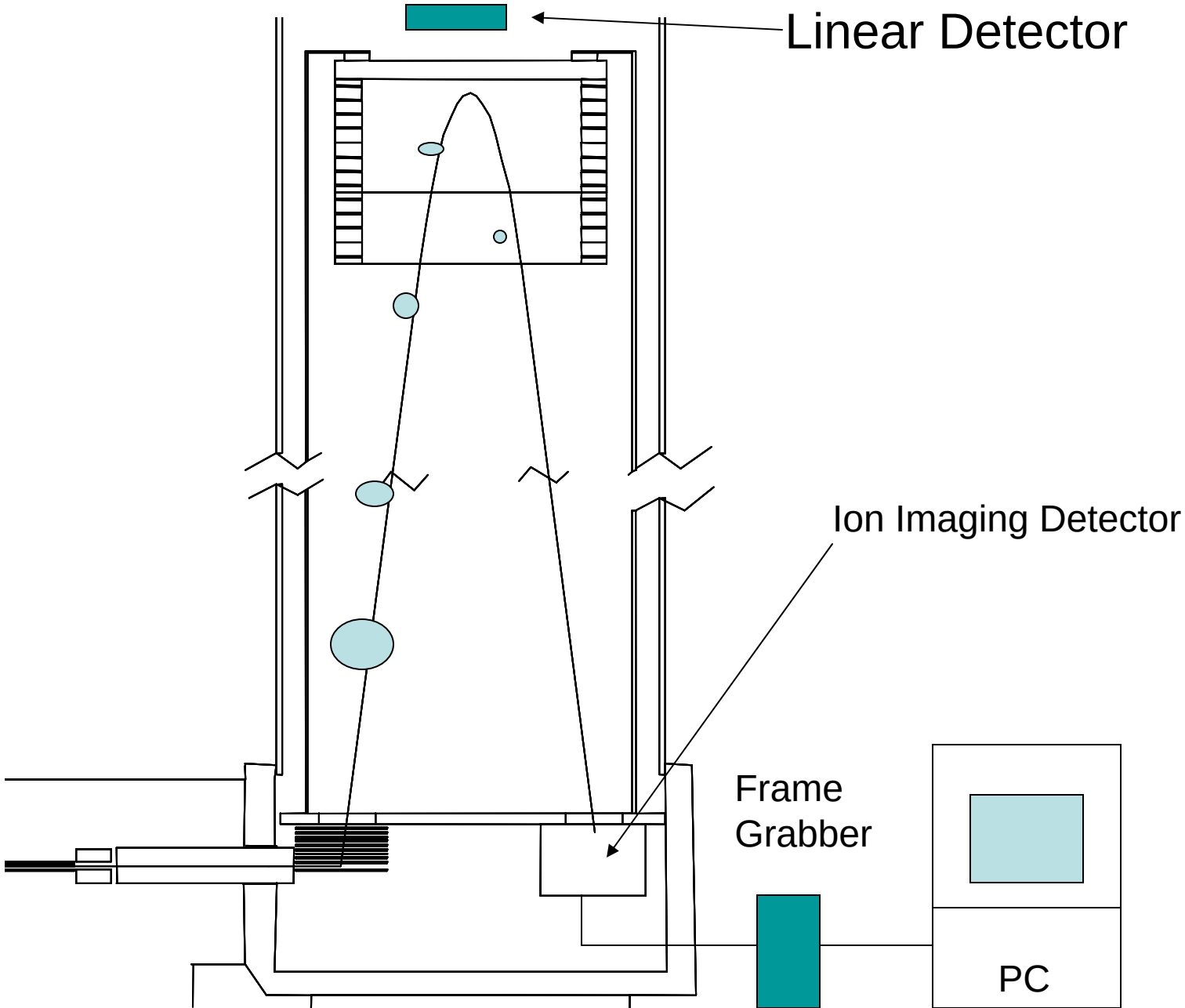


Quad Rods in Positive Mode



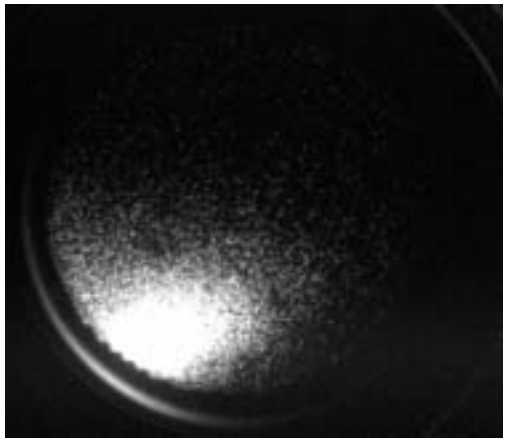
Quad Rods in the Negative Mode

Typical Reflectron Instrument Geometry

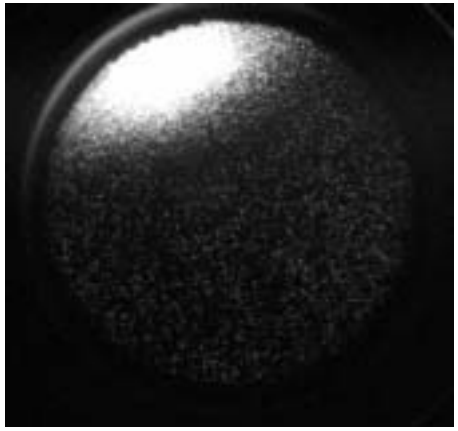


Ion Beam Images

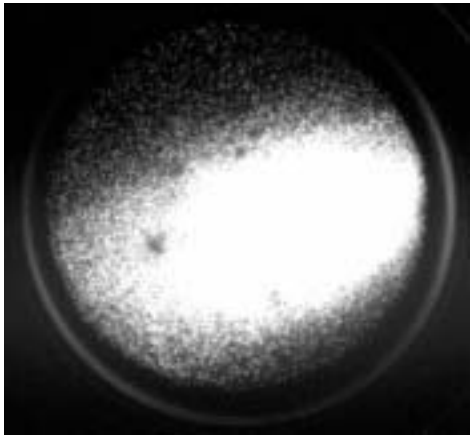
BURLE
ELECTRO-OPTICS



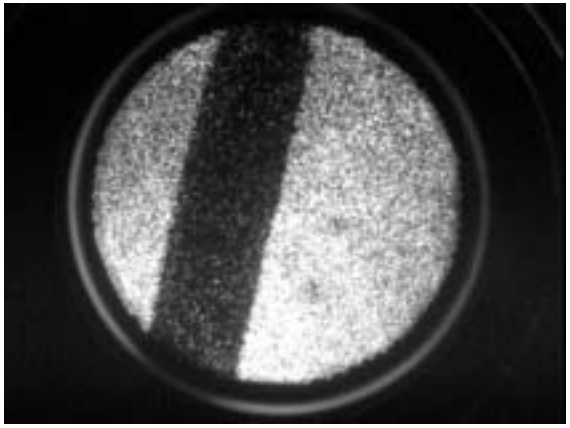
Beam off the detector Left Side



Beam off the Detector Top Left



Beam Centered, But not Focused



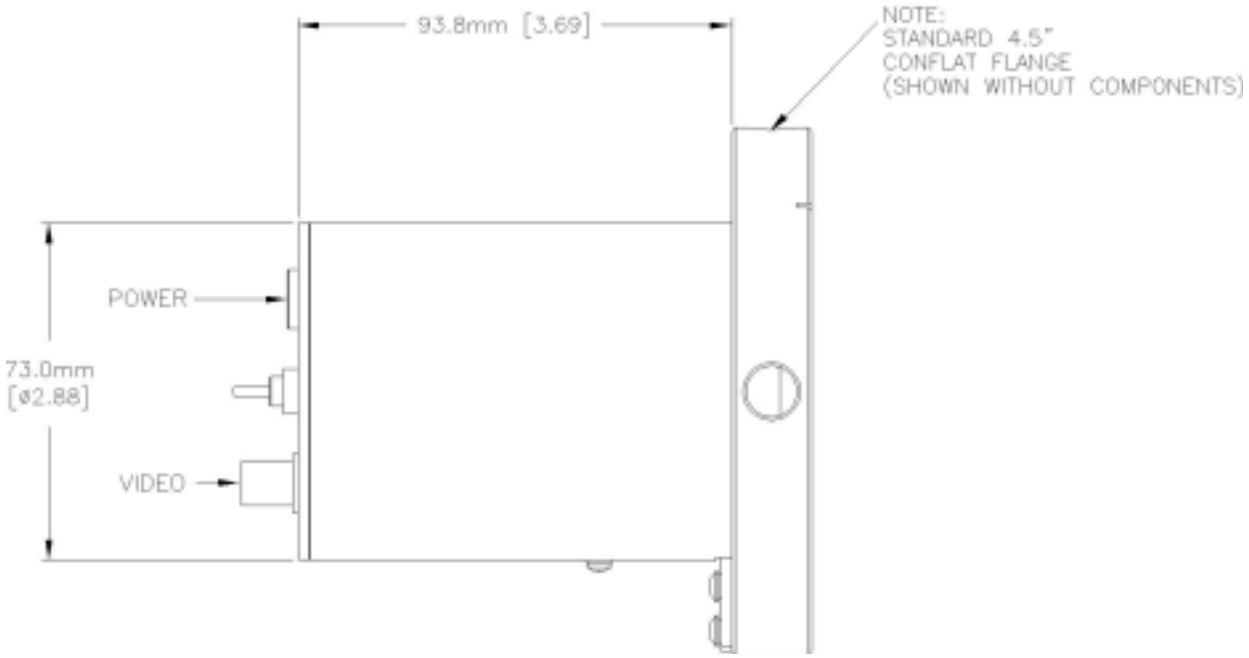
Loose wire found obstructing the beam

PHYSICAL CHARACTERISTICS of MCPS	**SPECIFICATION**
Quality Diameter:	25mm Minimum
Center-to-Center Spacing:	12µm Nominal
Pore Size:	10µm Nominal
Bias Angle:	12° ± 1°
Open Area Ratio:	55% Minimum
Quality Level:	Imaging
ELECTRICAL CHARACTERISTICS of DETECTOR	**SPECIFICATION**
Electron Gain @ 2400 Volts: Maximum	1×10^7 Minimum
Bias Current Range @ 2400 Volts:	4-29 Microamps
Resistance:	83-600 Megohms Reference
Dark Count (measured at gain voltage):	5 (cts/sec/cm^2) Maximum
Pulse Height Distribution (measured at gain voltage)	100% Maximum
Linear Output Current Density: (Microamps/cm^2)	Typically 10% of Bias Current Density

CCD CAMERA AND FRAME GRABBER	**SPECIFICATIONS**
CCD Camera:	Monochrome
Pixel Size: (H X V)	7.15 X 5.55 microns
Pixels (H X V)	537 X 550
Horizontal Resolution:	380 TV Lines
Signal Format:	EIA
Features:	AGC and Auto Electronic Iris
Electronic Shutter Speed:	1/60 – 1/10,000 sec
Gamma	0.45
Minimum Sensitivity:	0.5 lux
Frame Rate:	30 FPS
Power Consumption:	0.9 watts
Image Coupling to the Phosphor Screen:	Lens
Frame Grabber:	
Operating System Requirements:	Windows 98, 2000, NT and XP
Hardware Installation Requirements:	Half Size PCI Slot
Installation:	True Plug and Play

Software Installation:	CD
Bus Interface:	PCI Bus Rev. 2.1 Compliant
Max. read/write speed:	130 MBytes/sec.
Data Format:	YUV 4:2:2, RGB 565, RGB 888, XRGB and 8 bit Monochrome.
Video Input:	4 composite video, software switchable
Connector:	DB-15HD High Density Connector or RCA Connector
Frame File Type Choices:	TIFF, Bitmap and TARGA
Event Strobe and Trigger:	Two channels of TTL

The Chevron™ Model 3025FM detector assembly contains two Imaging Quality Advanced Performance Long-Life™ Microchannel Plates and a fiberoptic phosphor screen with P20 phosphor mounted to a 4.5" vacuum flange and CCD camera.



System Features

BURLE
ELECTRO-OPTICS

- An ion imaging tool has been successfully developed and has been demonstrated to produce high quality images of various beam profiles.
- The microchannel plate detector provides signal amplification up to 10 million, enabling single ion or electron events to be imaged and stored.
- Automatic brightness control (ABC) and variable electronic shutter speed prevents blooming.
- The CCD camera, frame grabber and software facilitates efficient image capture, storage and manipulation.
- TTL event trigger and strobe ensures frames are collected during relevant timeframes.