TRANSVERSE PROFILING AND ARCHIVING OF ION BEAMS AT ATLAS

By

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled **"Transverse Profiling and Archiving of Ion Beams at ATLAS"** by **Eric Lindert** in partial fulfillment of the requirements for the degree of **Master of Science**.

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Abstract

ATLAS is the first superconducting accelerator for particles heavier than the electron. Ion beams ranging from hydrogen to uranium, can be accelerated to energies as high as 17 MeV per nucleon and delivered to one of six target areas. For example, in 2003, 36 individual ion beams were used, and repeats of these runs were used on 25 more occasions. Tuning requirements include passing a beam through, nominally a 2 mm aperture, without touching it. Efficiency dictates appropriate size and position of the beam at critical points, especially entrances to accelerator sections. Though wire scanners have been in place since 1983, only qualitative approaches have been employed to utilize the scans, which are seen as a trace on an oscilloscope. Tuning beam from one of the sources has primarily been through experimentation with steerers and quadrupoles, with some caveats from similar runs, such as scaled beam/energy magnet and solenoid settings. As unique set-ups are rare, most experimental runs are replicas or hybrids of previous, and magnets are scaled from prior runs. The preponderance of runs has 15 or more scanners in the beam path. It is the premise here that better transmission can be attained, and references documented by systematic analysis of the scan traces throughout the beam path and conversion to a visual representation of beam size and position.

Chapter 1

Introduction

ATLAS (the Argonne Tandem Linac Accelerator System) is the world's first superconducting accelerator for projectiles heavier than the electron. This unique system is a DOE National Collaborative Research Facility open to scientists from all over the world. ATLAS consists of a sequence of machines where each accelerates charged atoms and then feeds the beam into the next section for additional energy gain. The beams are provided by one of three "injector" accelerators, either a 9 million volt (MV) electrostatic tandem Van de Graff, or one of two cyclotron resonance (ECR) ion sources and the Positive Ion Injector. The beam from one of these injectors is sent on to the 20-MV Booster Linac, and then finally into the 20-MV ATLAS Linac section. High precision heavy-ion beams ranging over all possible elements, from hydrogen to uranium, can be accelerated to energies as high as 17 MeV per nucleon and delivered to one of six target areas.

Magnetic fields are used throughout ATLAS to steer and focus these beams of charged particles and force them to go in the desired direction. In the Linac these magnetic focusing fields are provided by superconducting solenoids interspersed between the resonators. The PII section is composed of 3 separate cryostats, each with 6 resonators. The first cryostat has five solenoids, the next two have three. The Booster is made up of four cryostats, a total of 24 resonators, and 12 solenoids. The ATLAS Linac has 3 cryostats, 6 resonators and 3 solenoids to each cryostat, totalling

18 and 9 respectively. The beam from ATLAS can go into three different experimental areas which are well equipped with the instruments required for precision nuclear and atomic physics research. In the original Area II, these instruments include a 65" scattering chamber, a 30-ton magnetic spectrograph which feeds into the Canadian Penning Trap, an 18" scattering chamber, and a general purpose beam line. The experimental Areas III and IV contain similar but more advanced apparatus, including the gamma-ray facility with a bismuth germanate (BGO) scintillator array and Compton-suppressed germanium spectrometers, a large scattering chamber facility capable of supporting large area particle detectors and of providing long particle flight paths, a second large magnetic spectrograph, a 10-meter long mass separator called the Fragment Mass Analyzer (FMA), an atomic physics beam line, and two general purpose beam lines.

2003 marked the return of Gammasphere to the ATLAS facility. First used here in 1998, the Gammasphere can detect extremely weak gamma rays given off by nuclei when ATLAS beams strike a chosen target.

Since the first successful acceleration of an ion beam by the prototype ATLAS facility in 1978, ATLAS has been growing and expanding its capability to provide unique and powerful beams for the world-wide nuclear and atomic physics research program. The construction of ATLAS has continued until recently in parallel with the operation of the facility for research. As a national users facility, ATLAS has provided over 55,000 hours of beam to the research community. Physicists from 94 institutions in the United States and 18 foreign countries have participated in experiments at the ATLAS during that time. The most recent improvement to ATLAS was the development of the Positive Ion Injector (PII). The PII project was completed in 1992 and allowed ATLAS to provide beams including the heavier atoms, including uranium, with substantial increases in available beam currents of the lighter ions. Though beam profile scanners have been in place since 1983, only qualitative approaches have been employed to utilize the scan profiles. The most critical look at beam representation has historically been at the scanner in place at the Booster entrance, as it is immediately seen that poor transmission results from other than narrow peaks near the fiducial marks. No complete replication of prior runs has been attempted, as there has been no archiving of waveforms to date. It has been seen that transmission factor through the PII is usually .66 and as low as .45, without in-depth knowledge as to the cause. Tuning beam from one of the sources has primarily been through experimentation with steerers and quadrupoles, with some caveats from prior runs, such as similar beam/energy magnet and solenoid settings. The solenoids here are those incorporated between each resonator, and are designed to maintain focus after each pass through a section. Ideally, these solenoids would give pure focussing, but slight steering is often seen when a solenoid's field is high. Magnets settings are scaled from prior runs, absolutely new set-ups are rare, and many experimental runs are replicas of previous. An attempt at creating reference tunes through the Positive Ion Injector has recently been made, but cannot now be re-created due to phase changes within PII. It is the premise here that better transmission can be attained and documented by systematic analysis of the actual profiles throughout the beams path. From eight to 20 scanners are available for any run, depending on the source and target area. The preponderance of runs has 15 or more scanners in its path.

1.1 ATLAS facility

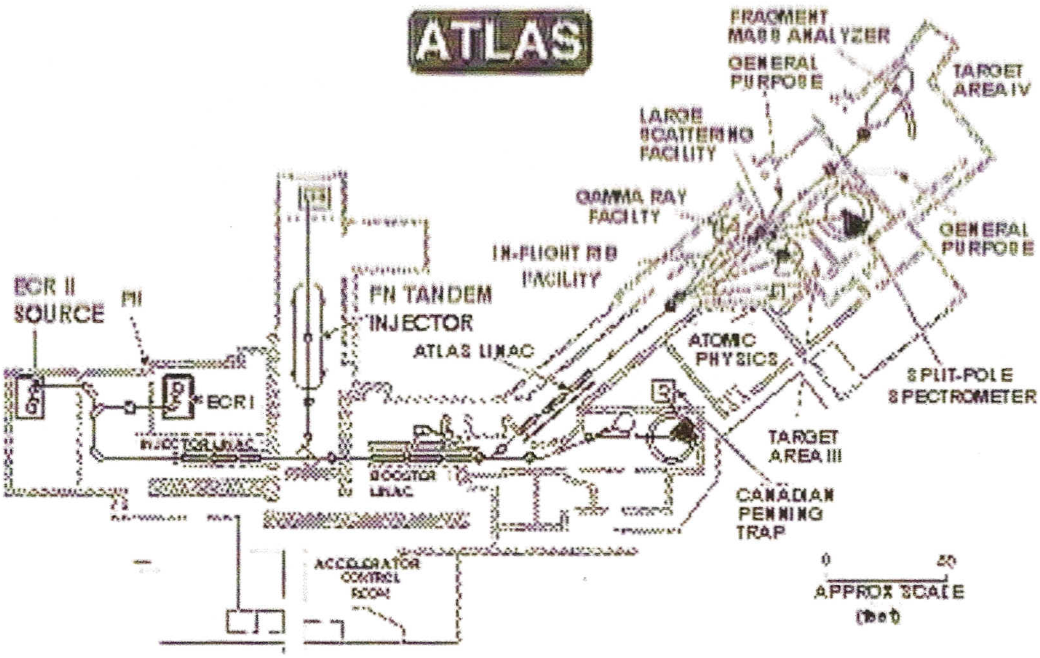


Figure 1.1: ATLAS Layout

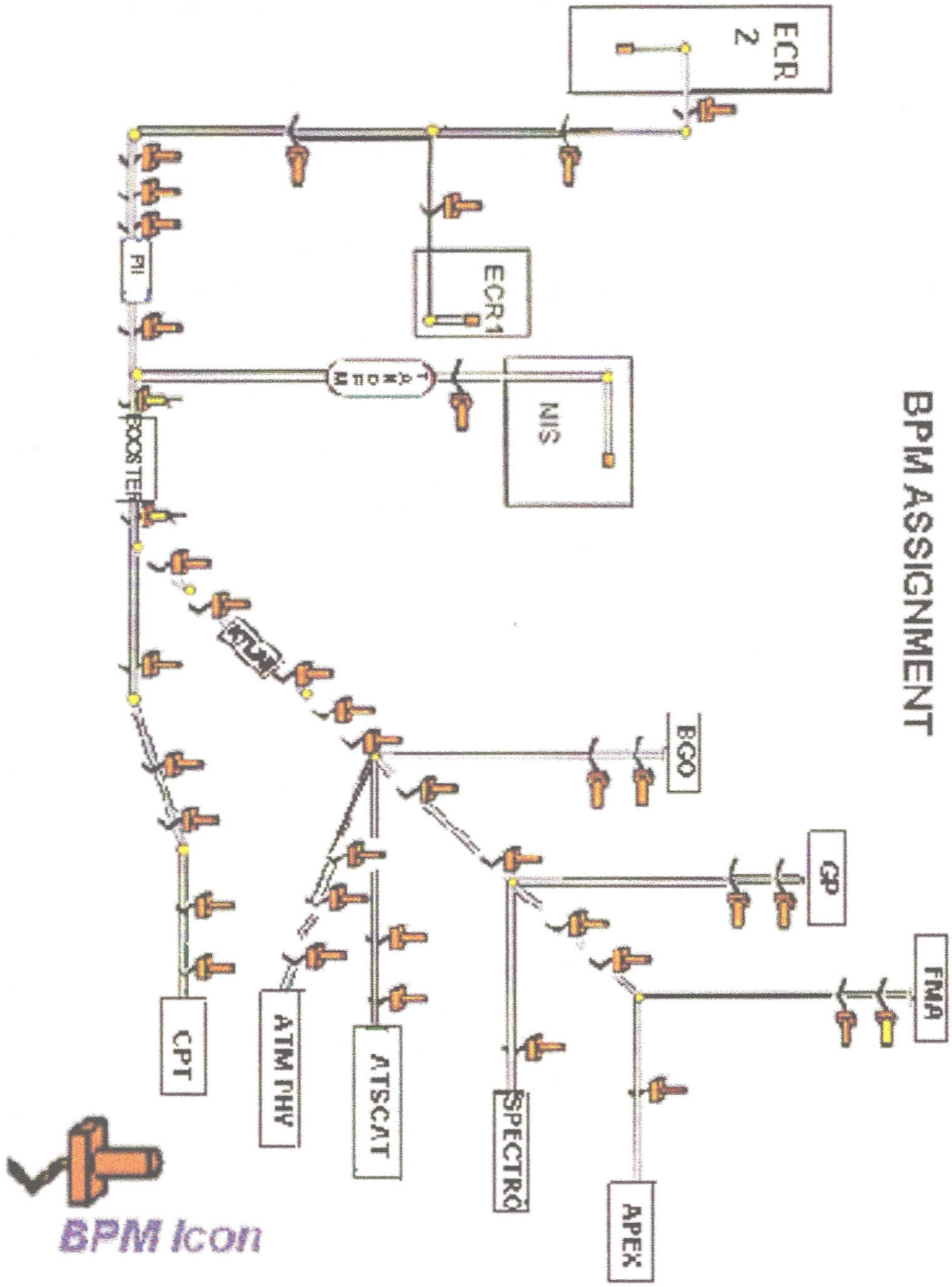


Figure 1.2: BPM Placement in ATLAS

1.2 On Beamline Alignment

Until March 2004, no effective beam line alignment had been performed. Some beamline devices, such as several quadrupoles and steerers, are absolutely known not to be "true" with respect to linear alignment, as they had merely been installed without regard to true centers of devices in conjuntion with center of beamline. As it has become increasingly evident that there were obvious discrepancies at several critical points in the beams path, laser alignment was ordered and performed at devices when scheduling permitted. As of this writing, no overall alignment has yet to be scheduled, as a sizable down-time need be utilized for such procedures. For the time being, we must use the zeroes of fiducials as the reference, and prior archives of best transmission of beam from which to base subsequent tunes.

Chapter 2

NEC Scanners

2.1 Introduction

National Electrostatics Corporation beam profile monitors (BPMs) provide a continuous scope display of the beam in both X and Y coordinates. They can monitor beams of electrons, ions, and energetic neutral particles. BPMs in the ATLAS facility beamlines are placed at an angle of $\pi/4$ radians in quadrant I as seen looking downstream. A helical .5 mm tantalum wire on a rotary drive crosses the beam vertically and then horizontally during each revolution. A cylindrical collector around the grounded wire collects beam-induced secondary electrons from the wire to provide a signal proportional to the intercepted beam intensity at every instant. By eliminating rotating electrical contact noise, the NEC BPM gives profile displays for beams down to 1 nanoamp. The drive is magnetically-coupled and eliminates rotating vacuum seals. The scanner rotates at 19 Hz, and the helical pick-up wire sweeps with a radius of 2.70 cm at an angle of $\pi/4$ w.r.t. horizontal.

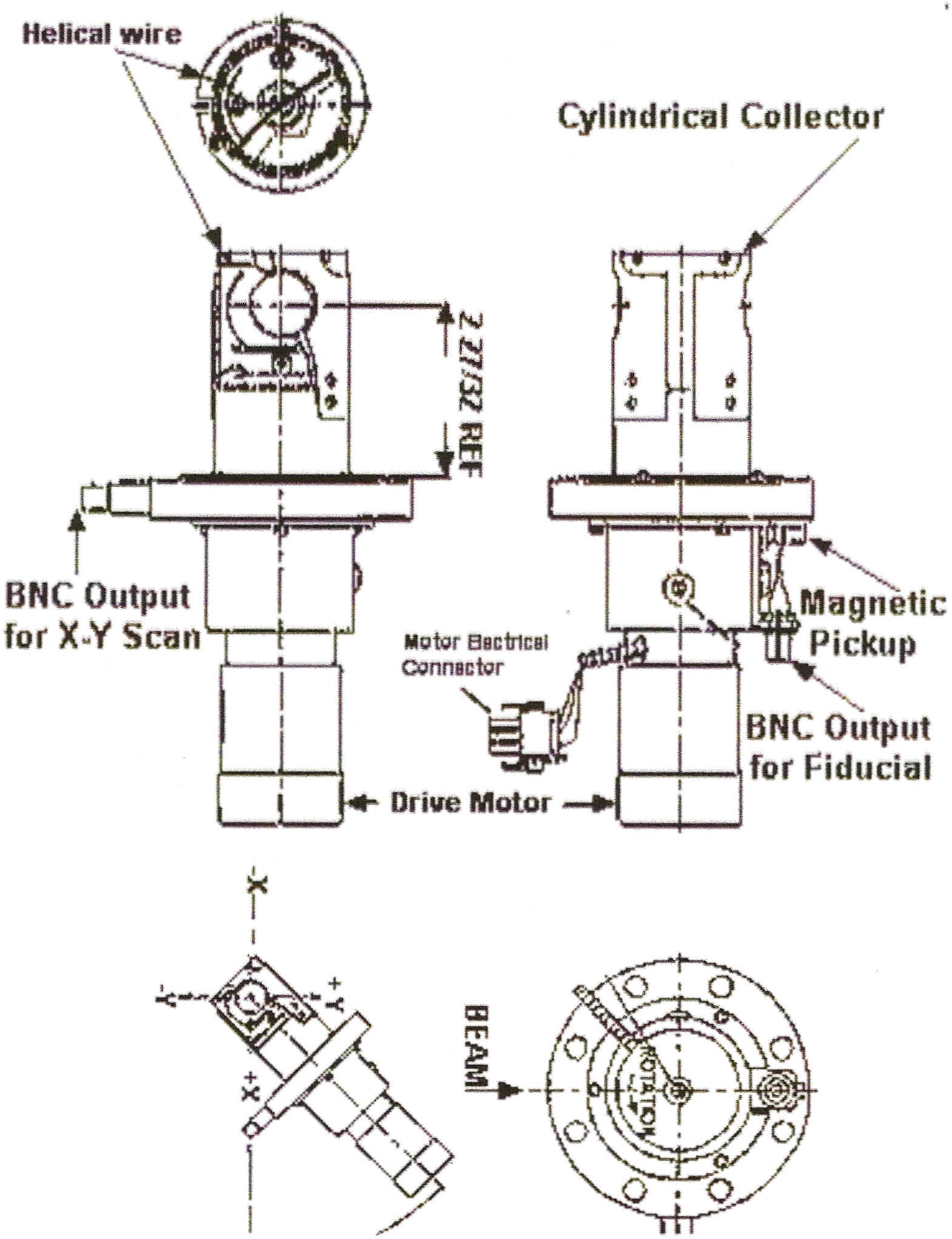


Figure 2.1: NEC BPM

One rotation of the helical wire gives a scan of both planes in s/19 = 52.6316 ms. In the Tektronix archiving scheme, 1000 position points (-.0499 to + .0500 as indicated by Tektronix storage to EXCEL files) are digitized by the Tektronix 360 for a scan. Of these 1000, the first and last 250 are repetitive, as seen in Figure 2.1, thus using the region of interest on the oscilloscope, X may be considered to begin at the -.0249 data point (leftmost point of the oscilloscope's time axis,) and Y end at .0250. Then for each plane, half of the 52.6316 ms, 26.32 ms can be attributed to 250 increments attributed to the Tektronix acquisition, or 105.263μs per acquired data point. In the Tektronix scheme, this correlates to the positions -.249 to 0 for X, and 0 to + .250 for Y.

Beam Size: For each plane, the distance (width) measured can be derived by $\pi \cdot r \cdot /(2^{1/2}/2)$, $\pi \cdot 2.70$ cm$\cdot 2/2^{1/2} = 120$ mm, then each successive point of the 250 points correspond to 480 microns i.e.120mm/250 = .48mm.

Fiducials: Four set screws (three of which are magnetized, one for balance) are mounted on a disk, orthogonal to the coaxial drive. They are mounted 90 degrees apart. The three magnetic pickup signals are detected via a magnetic pick-up, conveyed via a BNC connection output, and provide for position marking and oscilloscope triggering. The X and Y magnets provide nominally 20 mV signals, and the magnet used for triggering yields about 50 mV.

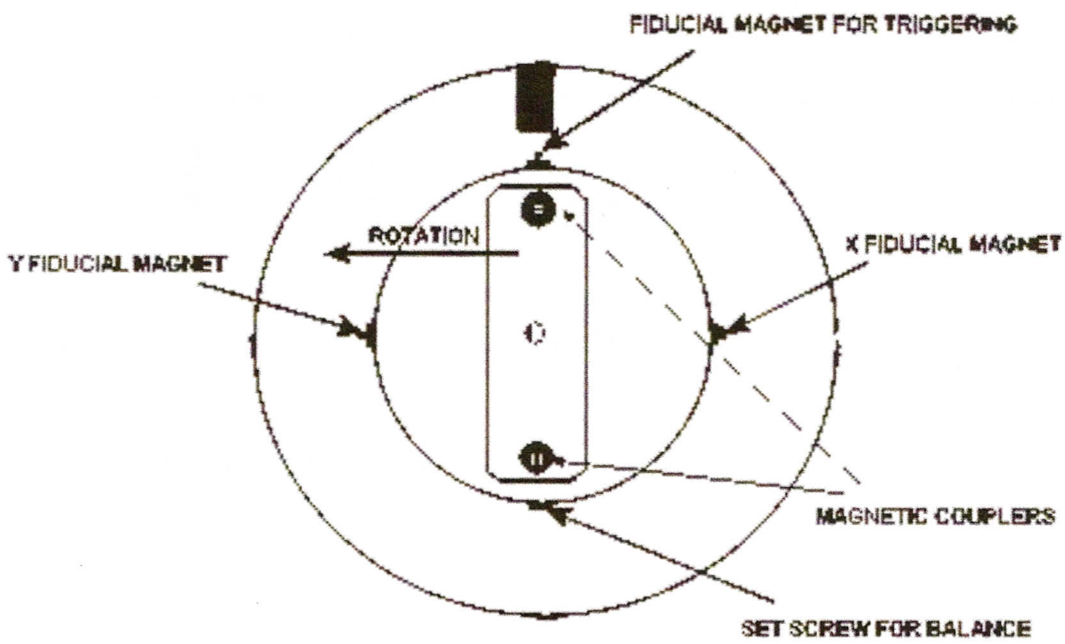


Figure 2.2: Fiducial Magnet Arrangement

The fiducial wave forms generated are shown in figure 2.3.

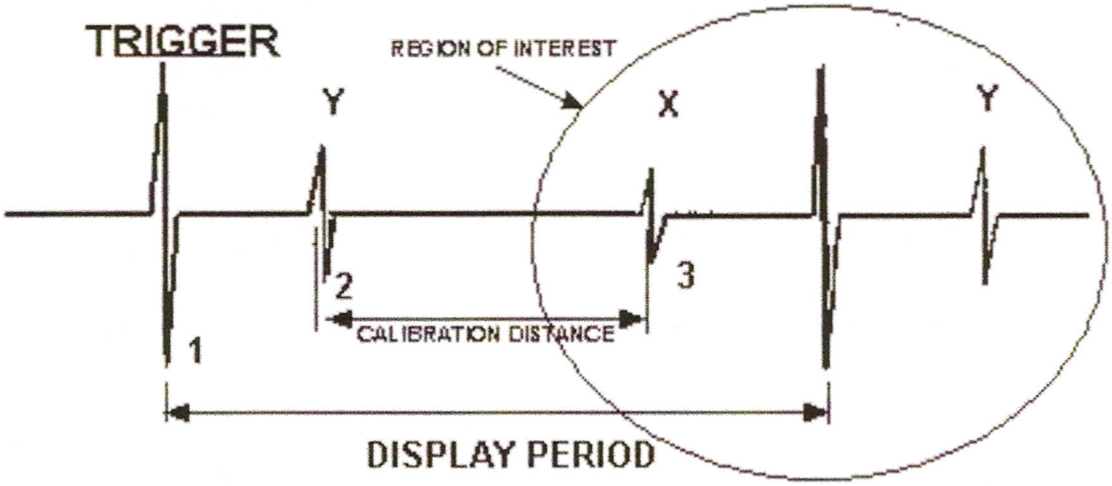


Figure 2.3: Oscilloscope trace of fiducial signal

For oscilloscope standardization, we use the latter half of the trace, so that X related fiducial is the leftmost scan, Y related the right, with their planes separated by the largest amplitude fiducial:

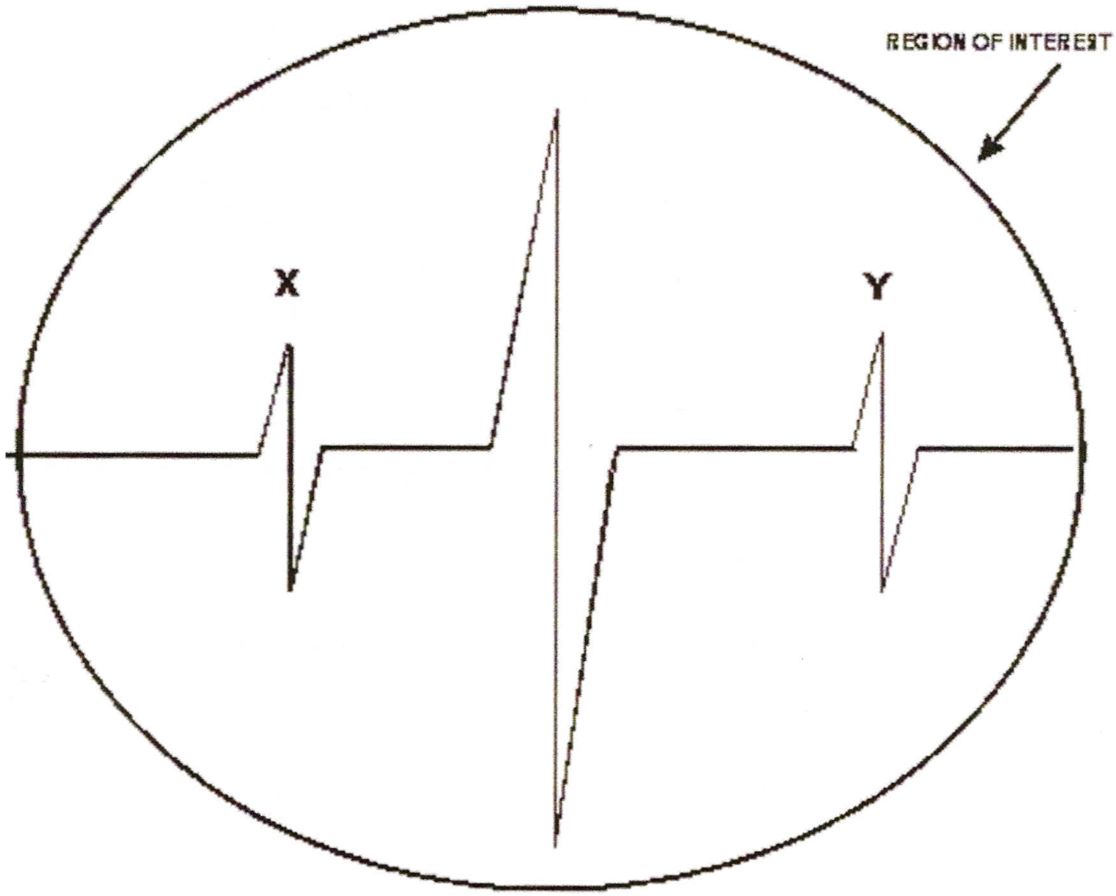


Figure 2.4: Fiducial Trace Portion Used for Oscilloscope Viewing

Composite Beams:

Occasionally, more than one isotope is present, especially when the ion beam is from one of the ECR sources. If this is the case, multiple peaks can be seen in the scans prior to the Positive Ion Injector (PII.) By the time a beam gets to the

PII entrance, it has been sent past two 90 degree dipoles which effectively reduce other charge to mass ratio ions. Identical or greatly similar q/m particles will still be present, either by volition or default. Due to choice of source materials, e.g. enriched samples, undesirable particles are usually greatly diminished compared to the particles of interest.

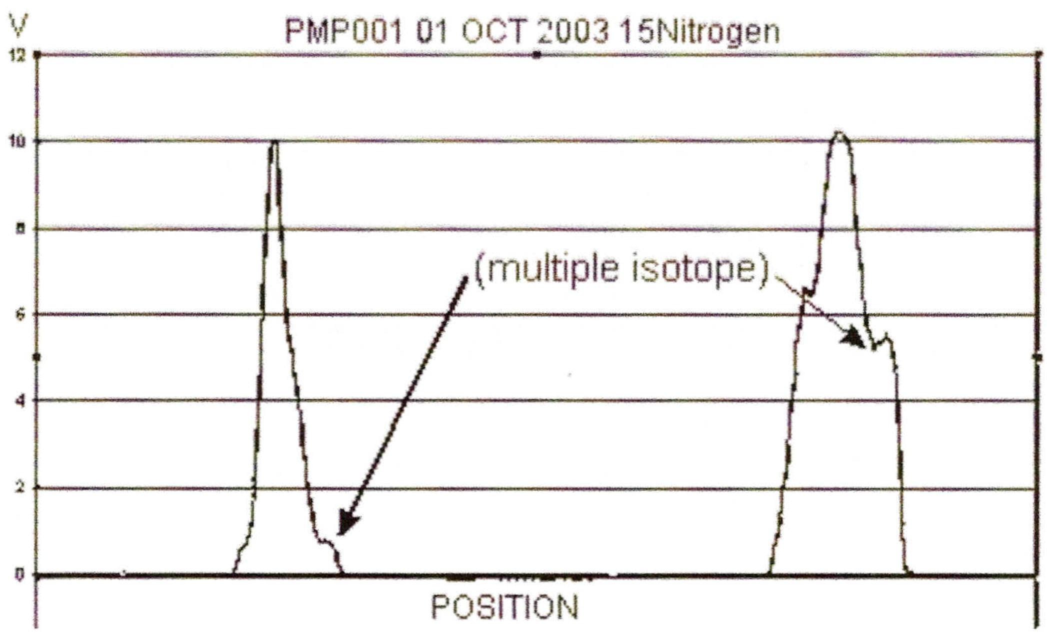


Figure 2.5: Example of Composite Beam from Source

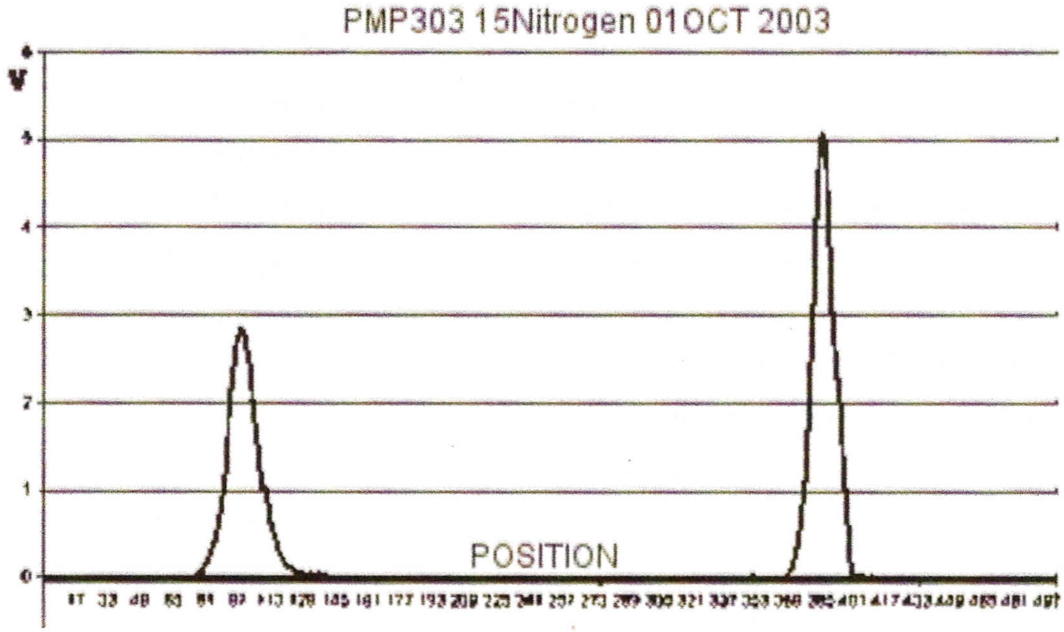


Figure 2.6: Example of Same Composite Beam after PII

2.2 Assumptions:

Beams are elliptical: As the scanners indicate relative intensity at each point, we can either plot relative intensities for each X and Y component, and color code points, or, as we are concerned primarily with size and position, consider beams to be elliptical and work accordingly. Here, we consider beams to be elliptical in nature for the following reasons: By Liouville's Theorem we theoretically preserve phase space. In practice we repeatedly pass the beam through round apertures with restrictive acceptance, such as successive accelerator sections and finally through a 2 mm collimator immediately in front of targets, this seems to be a valid assumption for each section and especially the end result. The ATLAS entrance waist is, by design, nominally .63 mm radius, for both X and Y. Magnetic devices affecting transverse aspects of beams in beam line are dipoles, steerers, quadrupoles, and solenoids. Quadrupoles are designed to accommodate up to 8.7 by 6.3 mm ellipses. Solenoids within cryostat sections are designed to focus after the adjacent resonators have defocussed the beam. Save for an occasion with multiple beams prior to PII, magnets in the beam line should not contribute to the beams aspect other than deflection, focusing, and de-focussing. On the occasions that experimenters have employed scintillators, video displays of the beam on the scintillators has always proven beams to be elliptical. In November 2003, a modified beamline was created to perform experiments in a hitherto defunct area. In the new set-up, a set of mechanical four-jaw slits was installed immediately (4 inches center of scan to slits.) These slits are used in this new experimental set-up to ascertain beam size prior to target, just as collimators are used in conventional target areas. In the first use of this area, it was required to limit beam size in order to pass through the slits when they were set to 11 mm each from center. This resulted in a square aperture 22 mm per side. Final adjustments in beamline elements had been made by watching the profile width corresponding to 22 mm in each plane, while reading current induced by beam on the slits. When current was zero, beam was considered to clear the slits, and at that time, the plot of the scanner data using this topic's software reflected a beam nearly perfectly circular, centered at the fiducial zeroes. **Fiducial Zeroes are considered center of beamline:** Actual scanner fiducial is here considered as the reference. Though alignment of each scanner need ultimately be checked with respect to the scanners positioning, each scanners fiducial zero varies less than 480 microns (one data point)from norm. Alignment or offset calculation may be performed subsequent to initial implementation of profiling process. Ideally, an alignment should be done, both for the beamline, and of the scanners. No check of either has been done since commissioning, so at this time we use fiducial zeroes as the reference. All BPM fiducials give the same zeroes when viewed on oscilloscopes, and when alignment is totally done, the beamline zeroes need coincide with fiducials anyway. Until such time as alignment of the beamline is done, we may note any obvious offset if required.

Chapter 3

Use of MS EXCEL in Analysis.

Prior to digitization, the scanner signal is positioned vertically on the oscilloscope so that the majority of the signal is above the horizontal 0 (voltage) reticle. This will reduce any noise recorded in order to record signal purely above 0V and aid in analysis by not requiring normalization later. Wave forms are digitized via a Tektronix TDS360 oscilloscope and put in comma separated value format for use with a spreadsheet calculation process. A macro in a Microsoft Excel spreadsheet retrieves scans for archiving and printing, and another enters the profile information for profile analysis. Area under each trace is calculated, then the axis of rotation for equal areas computed. From the axes of rotation of equal areas, an offset from the origin is computed, and from the width, a radius. The area per point is taken as the differential area, used to approximate rotation. The elliptical parameters x, y, h, k, a, and b are calculated with a spreadsheet macro and utilized to replicate the beam ellipse. Graphic representation will be that of downstream, i.e. riding with the beam.

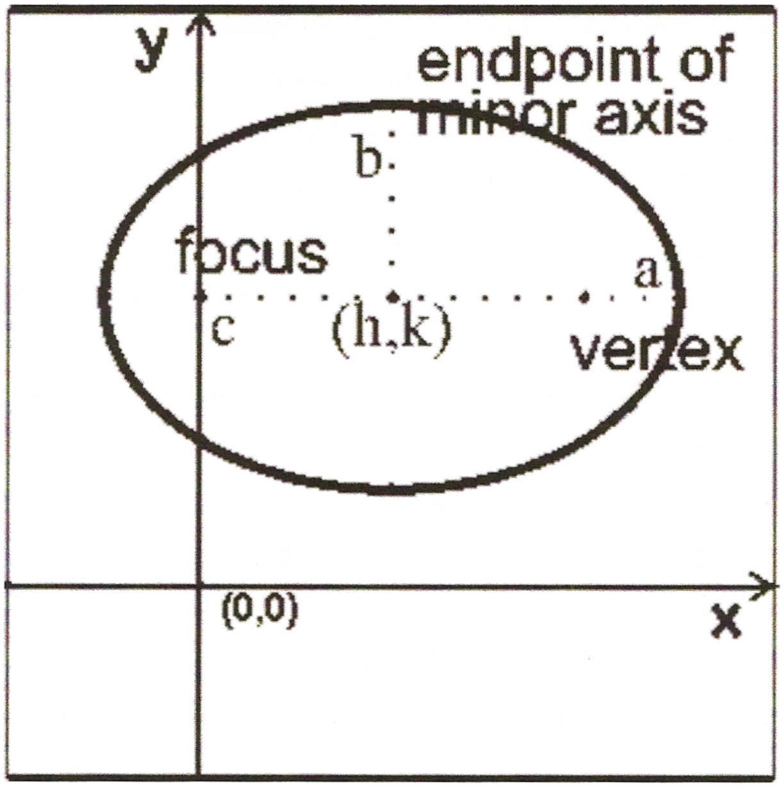


Figure 3.1: Ellipse Aspects

Trapezoidal method: This method proves to be most expedient. As the lions share of beam profiles mimic a triangular form, the trapezoidal method is easy and should be of very small error. **Area:** For each Δ abscissa, here, .0001(correlating to 480 microns,) an ordinate point is plotted. Then, for each two pairs of point sets, a differential area is computed

$$dA = [X_{i+1} X_i][Y_i + Y_{i+1}]/2 \tag{3.1}$$

Centroid: To determine the offset (if any) from the ideal (0, 0) origin of the beam, the centroid (here, actually the position of axis of rotation about the vertical axis) of each X or Y trace is considered to be representative of actual beam origin.

Determination of the centroid is done by finding the point along the horizontal axis which equally divides the plot into two separately equal areas. This is accomplished by summing the differential areas with each increment of .0001 and locating the point which corresponds with the total summation divided by two. Offset

Displacement from the ideal origin is evaluated by determining the distance between the fiducial and the centroid. The calculated offsets are used as the h, k values for the axes translation. Per NEC, signal read from the right of the fiducial (for both X and Y) is in the positive direction.

.

Zeroes of fiducial: Tektronix produced record data assigns our region of interest for X and Y from -.0249 to +.0250. This correlates on the oscilloscope with the full width, 10 divisions at 5 ms per division. With channel 119 as zero of fiducial for X, this equates accordingly with position: 119 * .0001 + (-).0249 = -.013 w.r.t horizontal axis. Similarly, the oscilloscope origin matches with fiducial 0, 249*.0001 + (-).0249 = 0, and the fiducial zero of the Y plot is 379* .0001 -.0249 = .013. Radius Profiles cannot be considered to be Gaussian distributions, as actual intercepts of the beam with the wire are the method of data gathering, and finite zeroes and peaks are accordingly obtained. Base width can here be equated with diameter, whereas with Gaussian distributions, one tends to want to use the full width half maximum treatment.

Ellipse Using the standard formula for an ellipse,

$$x^2/a^2 + y^2/b^2 = 1 \tag{3.2}$$

The prime frame ellipse is calculated via the following: a is given the attribute of half the base width for the X scan, b that of half of the Y scan. In EXCEL, 2000 equidistant incremental points are calculated from values ranging from x′ to +x′ (here, the calculated radius of X scan.) The y′ values are then easily derived from x′, a, and b.

$$(x-h)^2/a^2 + (y-k)^2/b^2 = 1 \tag{3.3}$$

$$x' = x - h \tag{3.4}$$

$$y' = y - k \tag{3.5}$$

$$(x')^2/a^2 + (y')^2/b^2 = 1 \tag{3.6}$$

$$(y')^2 = b^2[1 - (x')^2/a^2] \tag{3.7}$$

$$y' = \pm b[1 - (x')^2/a^2]^{1/2} \tag{3.8}$$

Translation of axes: As the reference Cartesian axes are accepted as centered at (0, 0), the profiled co-ordinate system will be offset by the traditional (h, k) method, where h and k are the X and Y offsets determined.

$$x = x' + hy = y' + k = \pm b[1 - (x')^2/a^2]^{1/2} + k \tag{3.9}$$

Rotation of axes We do not consider here rotation of axes, as it is not probable to ascertain such from this simple scan. It has been considered that there may be a relationship between the voltage amplitudes and proximity of beam to the scanner wire, but correlation would be presumptuous. Would that be the case, however it would be simple to incorporate rotation of the ellipse into calculations: if τ = angle of rotation, then

with representing X= rcosϕ and Y = rsinϕ

the prime frame values, x and y are thus: x = r cos($\phi - \tau$) = rcos(ϕ)cos(τ) + rsin(ϕ)sin(τ)

y = sin($\phi - \tau$) = rsin(ϕ)cos(τ) - rcos(ϕ)sin(τ)

or equivalently, x = x cos(τ) + y sin(τ) y = y cos(τ) - x sin(τ)

Then, to plot in our reference frame, x = x cos(τ) y sin(τ) + h y = y cos(τ) + x sin(τ) + k

Error

Largest error in data arises from the uncertainty in determination of the edges of the scans. This uncertainty is due to noise at the 2 millivolt level. In a worse case scenario, allowing two data points (correlating to 960 microns) on either edge of a scan profile yields an uncertainty maximum of .96 millimeter to the radius of each elliptical constituent. This is roughly four percent of a typical scan. We must keep in mind that position of the center of each plane's oscilloscope trace is the primary concern, then width.

3.1 Waveform Storage

Earlier attempts to analyze and store/retrieve waveforms have been made by other ATLAS personnel in the last several years, but no progress was made past the initial digitization process, and further work abandoned. The ability of the TEKTRONIX TDS 360 to digitize and record waveforms lends itself to the process of archiving profiles. For each possible source to target area configuration, 1.44 MB disks with filenames of the relevant scanners, e.g., PMR001....PMC202 are written to by the TEKTRONIX TDS 360. Prints of the wave forms and fiducials are then available via Excel charts, and created for each ATLAS run.

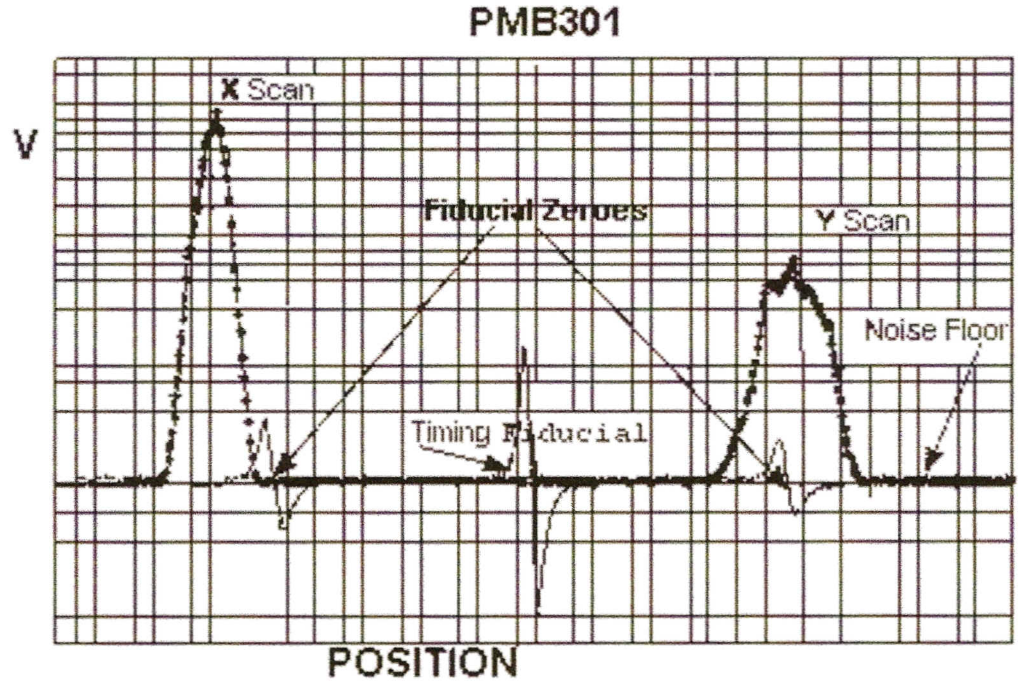


Figure 3.2: Scanner Profile Analysis Points

3.2 Archiving with Excel

For each ATLAS run, waveforms for each scanner are stored to a single 1.44 MB PC disk in spreadsheet format. A macro for each source to target area, e.g. ECR2 to FMA is utilized to glean each successive scan and write it as an individual, accessible chart within the run's spreadsheet , with fiducials as references. Each run's waveforms are then printed and stored in hard copy for reference.

3.3 Beam profile portrayal as EXCEL Chart

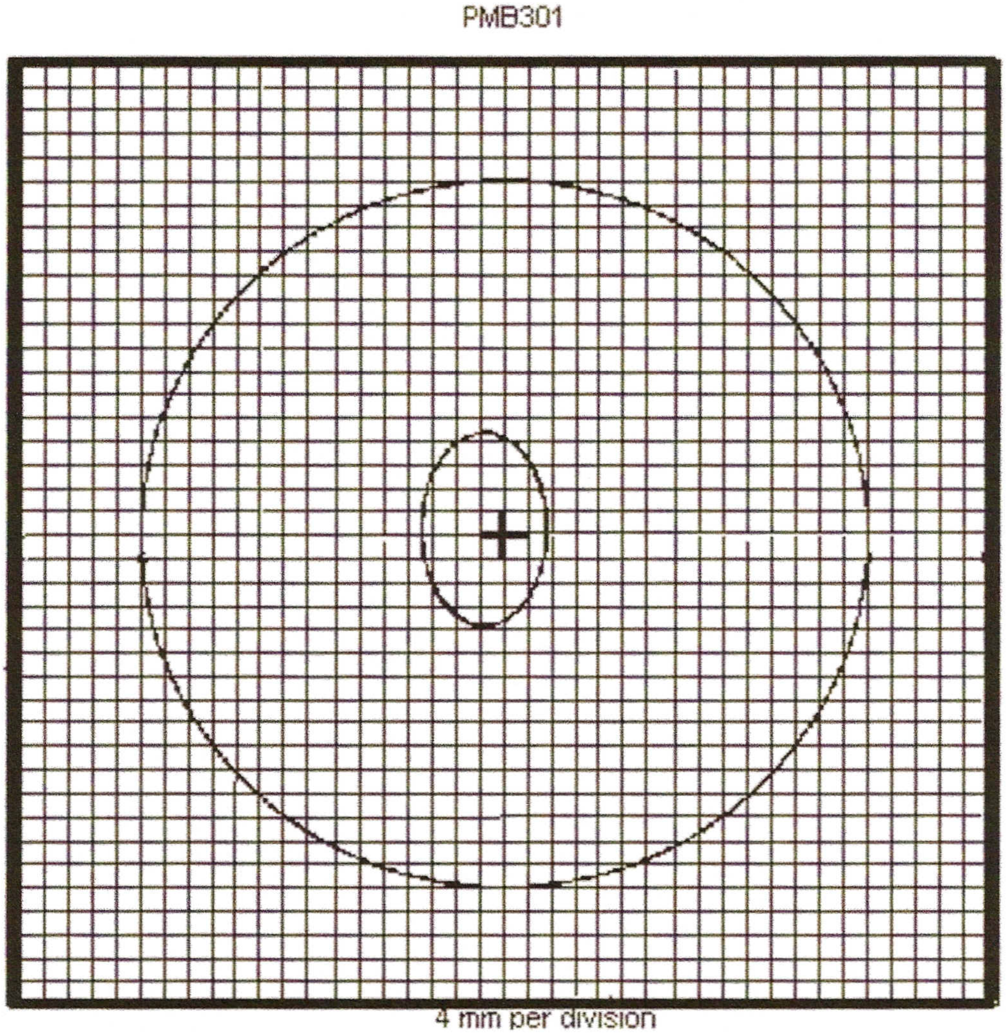
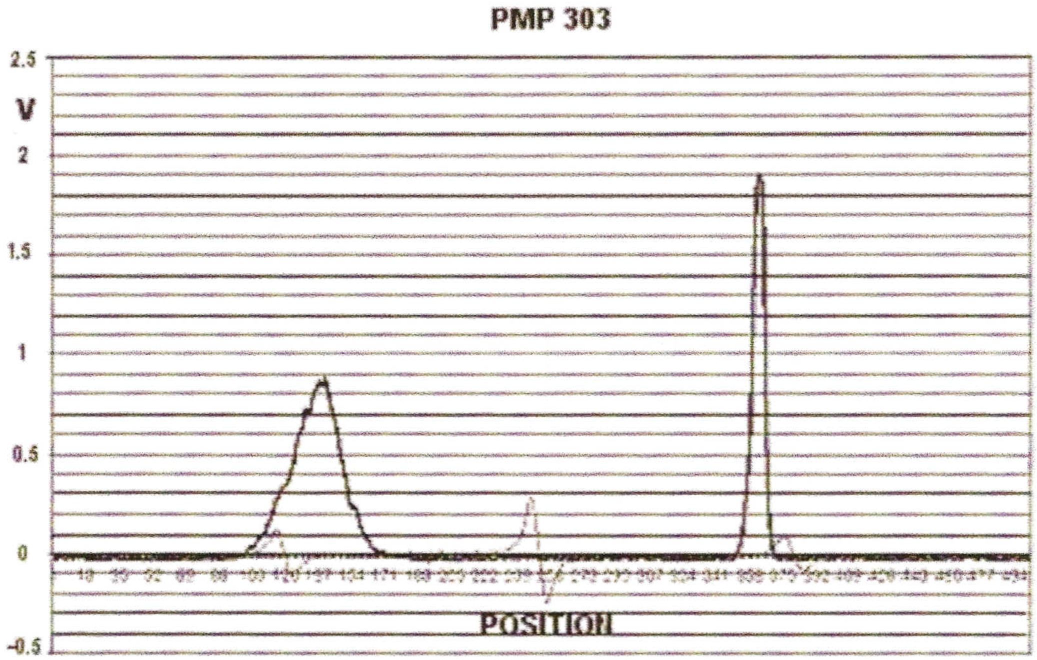
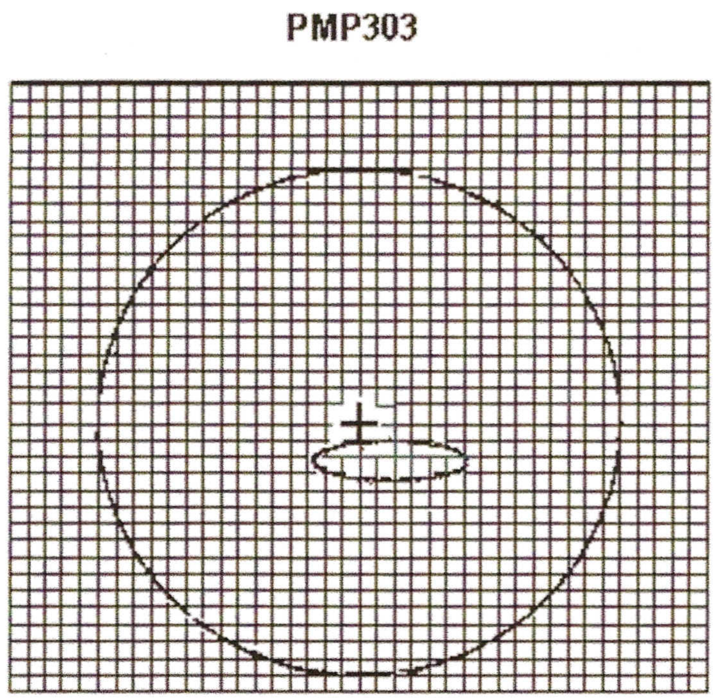


Figure 3.3: Same Profile as Previous, Analyzed



For comparison, this Booster entrance scan shows a greater eccentricity



PMP303 analyzed

Chapter 4

LabView as User Interface

4.1 Introduction

As LabView is becoming more prevalent in laboratory environments, it was chosen as the interface of choice for this, and many other applications at ATLAS. Lately, Lab-view applications have been modified to interface with EXCEL applications, thus the feasibility of real-time updating of synthesized beam profile displays became higher, without purchase or installation of any new equipment. This fact(no capital outlay or downtime) is a driving rationale.

4.2 Interfacing to LabView

Using the same signals that input to the Tektronix 360, where averaging of the signal is usually done, we now input first to a digitizer. Basic controls of an oscilloscope are recreated and displayed on an IBM compatible PC monitor, utilizing a 2.4GHz Pentium processor. This display provides the familiar initial oscilloscope trace before analysis, and provides a simple method to choose the threshold above the noise floor. Here, the waveform is now normalized from -1.00 to + 1.00, based upon the largest peak, to facilitate in uniform analysis. Amplitudes of the oscilloscope traces vary from 1 to 12 V, depending on the scanner's proximity to the source, and the gain setting of its own current to voltage amplifier. The width of the X and Y segments of the trace remain constant, as they are results of the time aspect of the oscilloscope portrayal. This is conducive in the subsequent analysis.

4.3 Importing Excel data

Once the triggering and noise threshold levels are chosen, we start to read the normalized waveform into an array, namely "dat.xls." Within the Excel program, "XYBPM-BETA8," "dat.xls", which is overwriting itself constantly, is copied as often, to "DAT-BUFFER.xls." "dat.xls," thus "DATBUFFER.xls," have written to them the value of the chosen threshold via the GUI interface, and 500 array entries representing the waveform.

4.4 Labview Set-up

In Labview, then we have the oscilloscope controls, and normalize the standard trace in its own window. That display has the user interface control to determine visually, where the threshold (above noise) should be for data acquisition. The value of the threshold is written, along with the digitization of the normalized trace, to a 2-D file, 'dat.xls.) Within the Excel application, 'XYBPMBETA8.xls,' the macro 'GETDAT' copies 'dat.xls' to 'DATBUFFER.xls,' which is used to refresh data in the main application. 'dat.xls' is overwritten constantly by Labview, and each iteration copied to a newer DATBUFFER, then updates the main application, XYBPMBETA8. Within XYBPMBETA8, where the profile calculations are done, h,k,a, and b offset and ellipse aspects are ascertained, and written to the file, 'HKABBUFFER.xls.' This file is read next by Labview, via another OPEN, READ iteration of Excel, and the values are plotted to the graph on the LabView front panel.

Chapter 5

Conclusion

5.1 Improved Efficiency

Use of Excel within Labview enables the user to interface with the process and optimize thresholds. Careful attention to beam profiles has made tuning at ATLAS a more efficient process. As the Positive Ion Injector accelerator has had a traditional transmission efficiency of at best .66, a transmission factor of .90 has been attained on several occasions.

5.2 Reproducible Results

Records of tuning in the past has shown that upwards of 8 hours has been used consistently for tuning to target after beamline devices had been loaded. Re-creation of previous runs can be and have recently been done many times in less than an hour by matching archived waveforms to present. This is accomplished by first matching all resonator and beamline devices to prior records (as is the norm,) then matching archived waveforms.

5.3 Diagnostic Tool

Occasionally, beamline elements fail during runs (this is when they are noticed most.) Use of the archived profiles enable Operations Group to quickly identify troubled areas by finding the last good section between scans. Prior to using this method, frantic searches have been done, looking at everything from possible quenched solenoids to every quadrupole and steerer in an accelerator. By comparing before and after scans, one can now determine not only the section, but most probably the choice of steerer or quadrupole, for instance.

5.4 Present Plans

As of April 2004, archiving of waveforms will have been been done at ATLAS for one full year. Study of this, combined with repeated notice of seemingly aberrant centers in beamlines, have resulted in survey and alignment of two beamline sections. More alignment is planned now for the first time since construction, in most cases. This alignment will take place during scheduled maintenance periods. Checks with National Electrostatics Corporation as well as several users of their scanners reveal that no one else has, to date, packaged an analysis of NEC scanner data (other than indication of peak position.) A stand-alone processor with separate display running this LabView application is now is about to be acquired for ATLAS Operations. It is considered by ATLAS staff to be a valuable tool at this time, and would be definitive upon completion of alignment.

Appendix A

EXCEL Visual Basic Code

```
Private Sub WorkbookWindowActivateByValWn
AsExcel.Window
Wn.WindowState = xlMinimized
End Sub
Private Sub  BIGWindowActivate ByVal Wn As Excel.Window
Wn.WindowState=xlMaximized EndSub
Sub auto_open   EXECUTES UPON OPENING
'Macro recorded  by ERIC  ' 'OPEN HKABBUFFER FIRST NOT REQUIRED
Call GETDAT2 End Sub Sub GETDAT2
On Error GoTo handleCancel
MOVE DATBUFFER SECTION* Dim SourceFile, DestinationFile SourceFile = C:\
\Eric\dat.xls'sourceDestinationFile =
C:\Eric\DATBUFFER.xls FileCopySourceFile,
DestinationFile ' Copy renewing dat.xls to DATBUFFER.xls.
Dim DATObject As Object
Set DATObject=GetObject C:\ \Eric\DATBUFFER.xls
Workbooks.Open Filename:=
C:\Eric\DATBUFFER.xls
Windows DATBUFFER.xls .Activate
Application.Visible = True Range  A1:B500  .Select
**********VISIBLE DATBUFFER
Application.Visible = True Selection.Copy
'END DATBUFFER SECTION* Windows XYBPMBETA8.xls .Activate
Sheets Sheet1 .Select
Application.Visible = True
Range B2 .Select ActiveSheet.Paste
'Shrink MAIN SHEET Workbook_WindowActivate
Windows XYBPMBETA8.xls  Windows DATBUFFER.xls.Activate
```

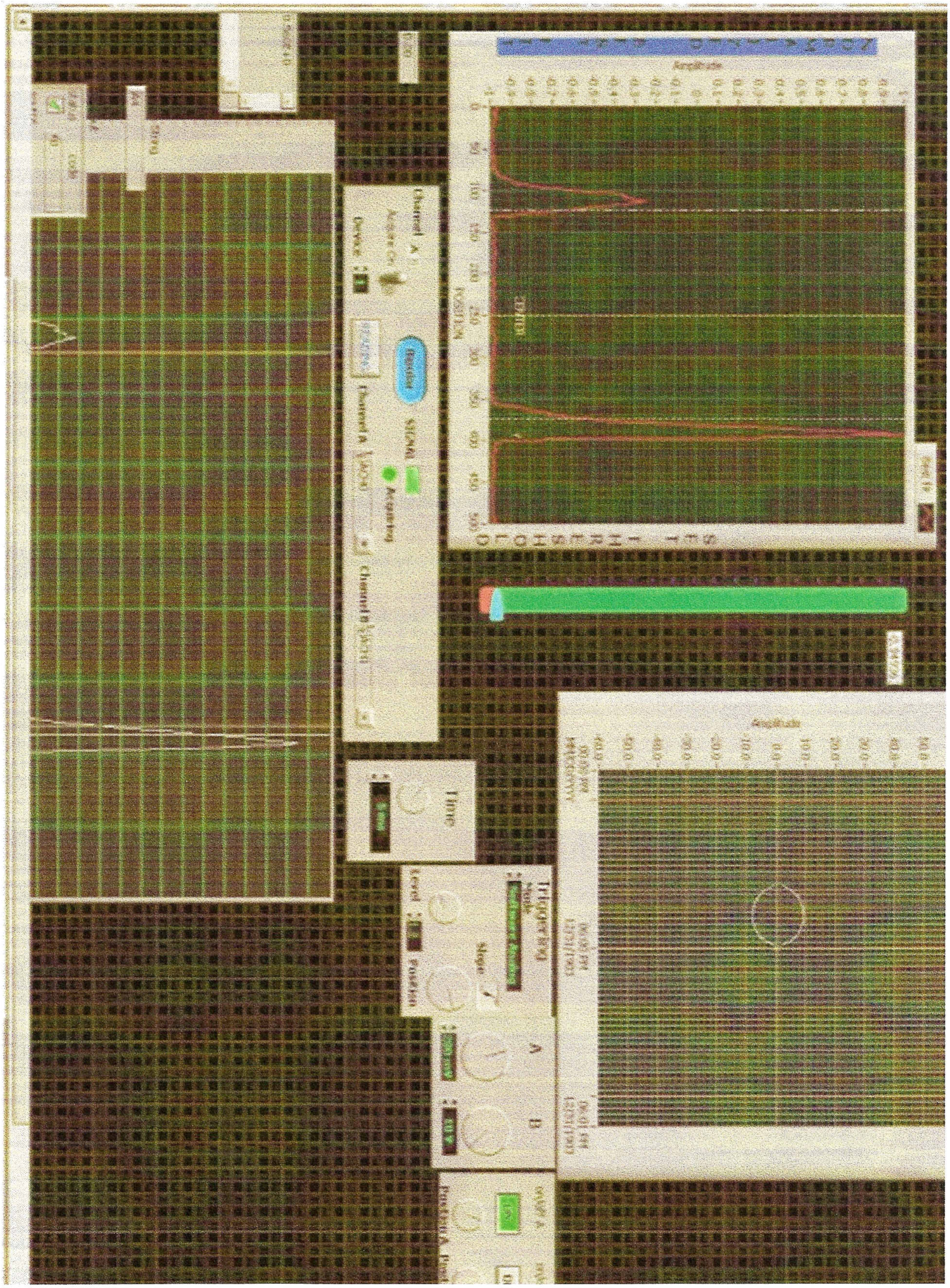
```
Application.Visible = True  Application.DisplayAlerts = FalseHKABUFFER"
Save DATBUFFER
ActiveWorkbook.Save
'Close DATBUFFER ActiveWindow.CloseWorkbook_WindowActivate
'*ACTIVATE XYBPMBETA8, THEN save Windows XYBPMBETA8.xls .Activate
'Save XYBPMBETA8 ActiveWorkbook.Save '***next2
Application.Visible = True RangeA2:B251 .Select '***next
Application.Visible = True Selection.Copy ***********2
Application.Visible = True
Range D2 .Select ActiveSheet.Paste
'Next disappears until refresh Application.Visible
Range A252:B501 .Select Application.CutCopyMode =
False Selection.Copy
Range M2" .Select" ActiveSheet.Paste
Application.EnableCancelKey = xlErrorHandler.Activate"
*****HKABBUFFER FOR EXPORT OF h, k, a, and b in AY2 through AY5.Activate"
'OPEN HKABUFFER
Workbooks.Open Filename:= C:\Eric\HKABBUFFER.xls
Windows XYBPMBETA8.xls .Activate
Range AY2:AY5 .Select Selection.Copy Windows HKABBUFFER.xls .Activate
Range A1 .Select
Selection.PasteSpecial Paste:=xlValues,
Operation:=xlNone, SkipBlanks:= False,
Transpose:=False ActiveWindow.WindowState = xlMinimized
'ActiveWindow.WindowState = xlMinimized
Windows  HKABBUFFER.xls  .Activate Application.DisplayAlerts = False
***HKABBUFFER************** ActiveWorkbook.Save ActiveWindow.Close
ActiveWorkbook.Save
Windows HKABBUFFER.xls .Close 'Workbooks HKABBUFFER.xls .Close
```

```
----ERROR HANDLING
handleCancel: If Err = 18 Then Application.DisplayAlerts = False
MsgBox User cancelled 'EscapeKey is exit
ActiveWindow.Close
Else If Err Then
MsgBox ERROR
Windows(XYBPMBETA8.xls).Activate
Sheets(CONTROL).Select Go to CONTROL page on exit
Exit Sub
End If 'Other error if End If" Escape key if
Call GETDAT2
End Sub  GETDAT2
```

Appendix B

LabView Front Panel In Operation

Voltage scale for the oscilloscope display ensures that the full scale of the primary trace is used, then triggering is set accordingly. The normalized waveform is derived then from the primary, and is used for the EXCEL portion of analysis. Ellipse plotted is one computational cycle, 10 milliseconds, after display of normalized waveform. The display and analysis process repeats until stopped by the user.



Bibliography

[1] **Manual for Model BPM81 Integral Collector** *National Electrostatics Corporation* **1985**

[2] **Manual for Labview 2000** *National Instruments* **2000**

[3] **Manual for Excel 2000** *Microsoft* **1999**

[4] **Manual for Microsoft Visual Basic** *Microsoft* **1999**

[5] **Calculus with Analytical Geometry** *Mounem-Foulis* **1986**

[6] **A Proposal for A Precision Heavy Ion Accelerator at Argonne National Laboratory** *Bollinger* **1978**

[7] **Beam Control and Manipulation** *Minty* **1999**

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Research Assistant University of Wisconsin-Milwaukee 1996-1997
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Technician, Laser Artistry, Oak Creek, WI 1987-1997
Proprietor, Allegheny Audio, Shorewood, WI 1983-Present
Recording Engineer, AudioTrak, Rockford, IL 1982-1983
Recording Engineer/Instructor , Kennedy Recording, Milwaukee, WI 1980-1982
Engineering Technician, Giles Engineering, Waukesha, WI 1979-1980

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Army Commendation Medal

Additional Information

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Three years as Computer Systems and Network Administrator, United States Particle Accelerator School (2000-2003)
Additional majors at University of Wisconsin were Electrical Engineering and Mathematics.
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10 years experience fabricating and designing electronic and electromechanical devices for commercial laser display systems.