BNL-102138-2014-TECH
RHIC/AP/27;BNL-102138-2013-IR

AGS to RHIC Beam Line: Application Codes

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May 1994

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U.S. Department of Energy
USDOE Office of Science (SC)

DISCLAIMER

AGS to RHIC Beam Line: Application Codes

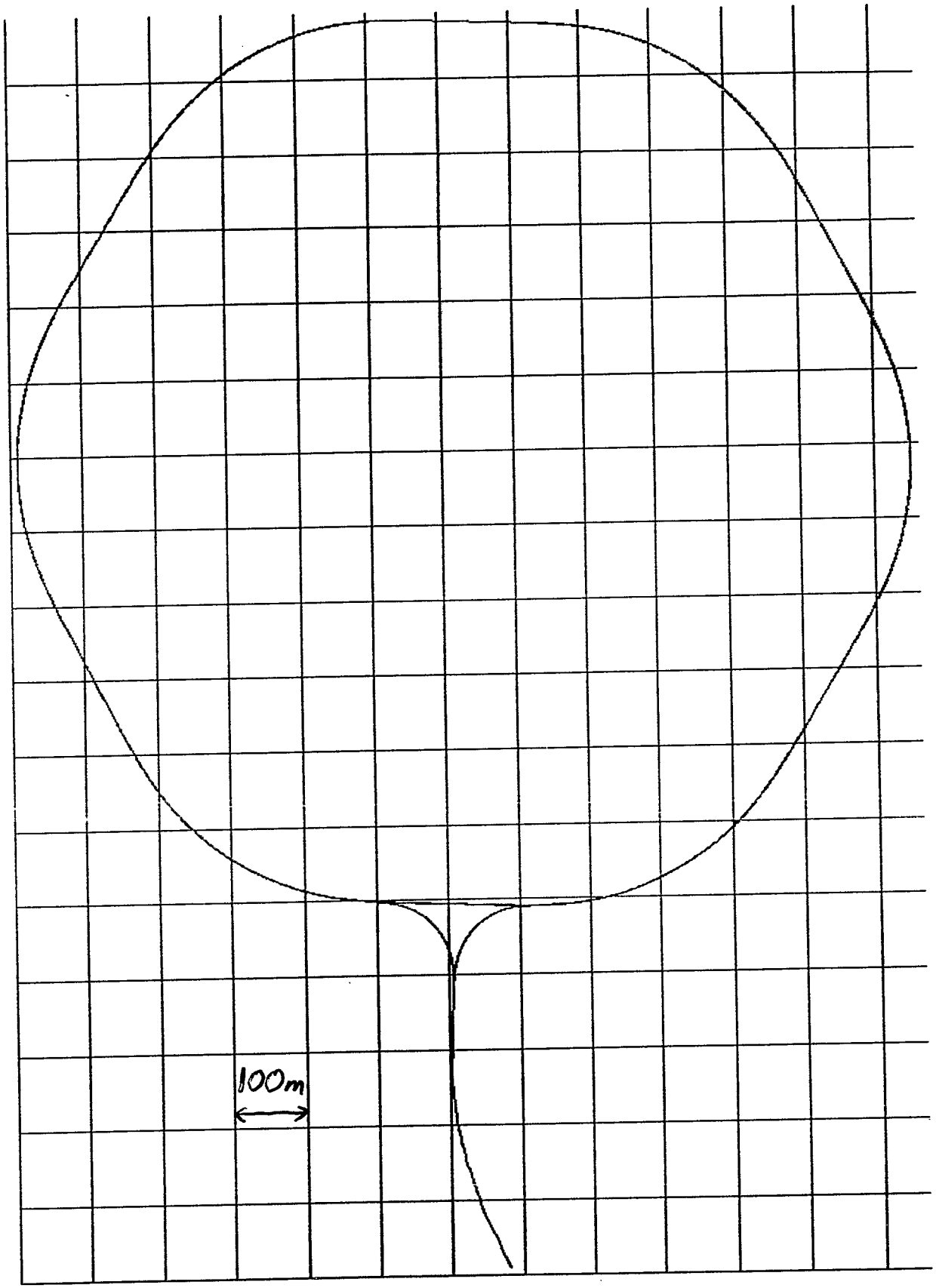
Waldo MacKay and Todd Satogata

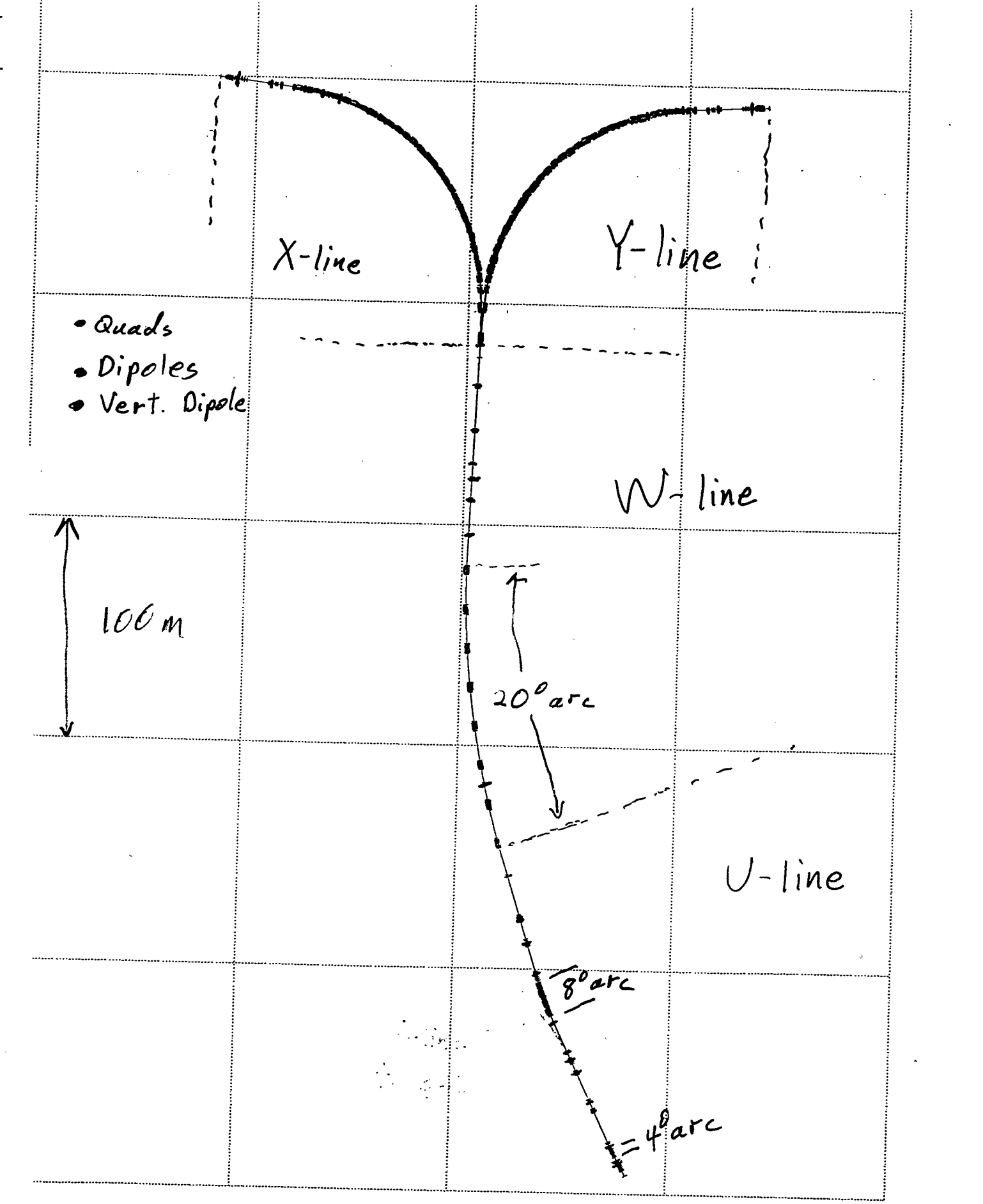
Waldo

- Description of the ATR beamline (AGS to RHIC)
- Commissioning strategy
- General philosophy of application design (SDS and Glish)
- What applications do we need?
- General conclusions (Waldo's)

Todd

- Application tools and environment (SDS, Glish, C and C++)
- Design philosophy revisited
- Beam threading for the ATR
- More conclusions (Todd's)


100m


X-line
Y-line
• Quads
• Dipoles
• Vert. Dipole
W-line
100 m
20° arc
U-line
8° arc
4° arc

ATR Injection line summary

I U-line:
- A Match beam from AGS into W-line
- B Stripping foil: $Au^{+77} \Rightarrow Au^{+79}$

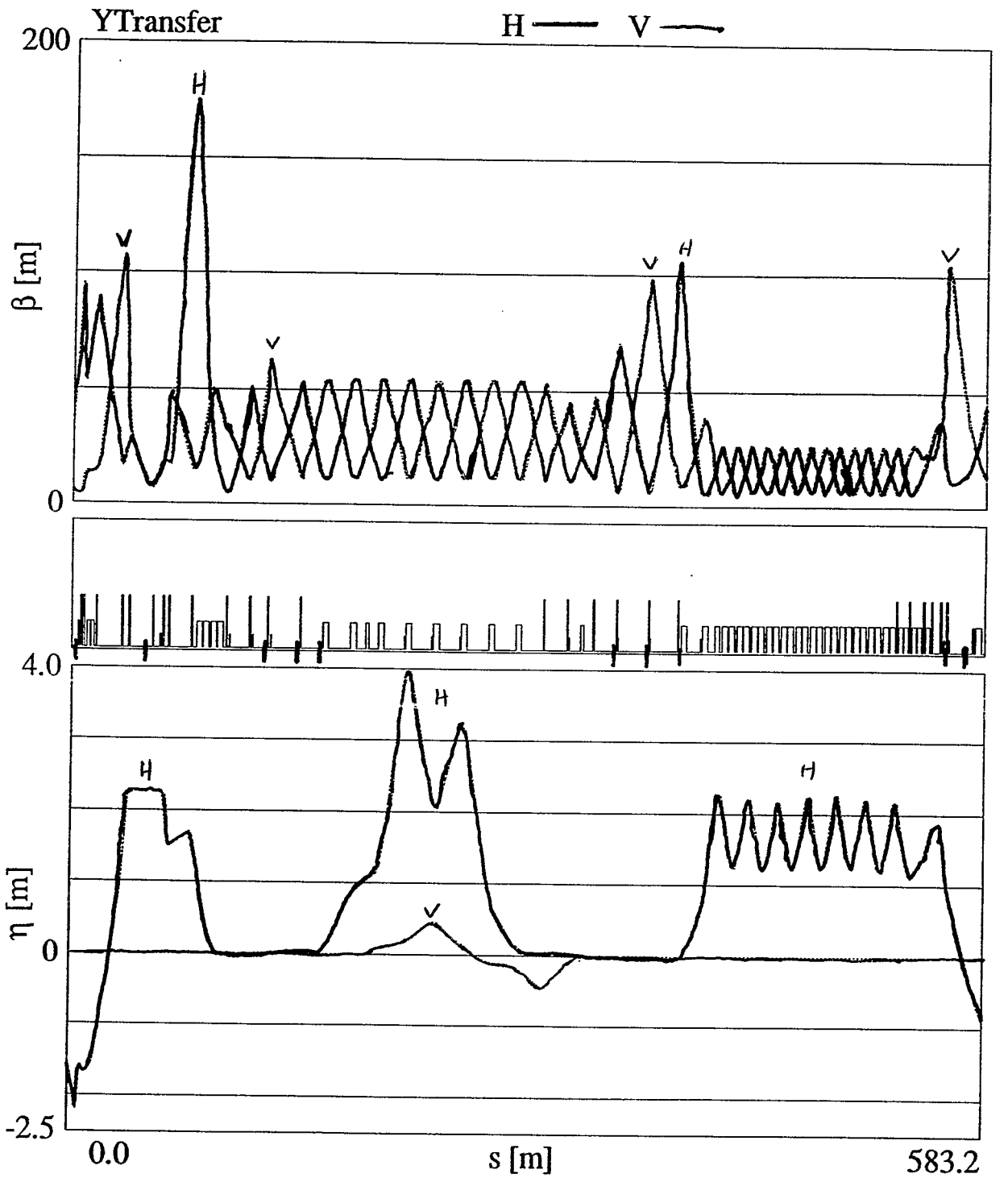
II W-line:
- A Vertical drop of 1.7m
- B 20° bend to reach 6–12 o'clock symmetry line (Requires zero dispersion upstream and downstream of the 20° arc.)
- C 6 Quads at end of W-line match into the 90° arcs.

III Y-line:
- A Bend almost 90° into the Yellow (ccw) ring.
- B 6 Quads at end of Y-line match into RHIC.
- C Vertical injection into RHIC with lambertson.

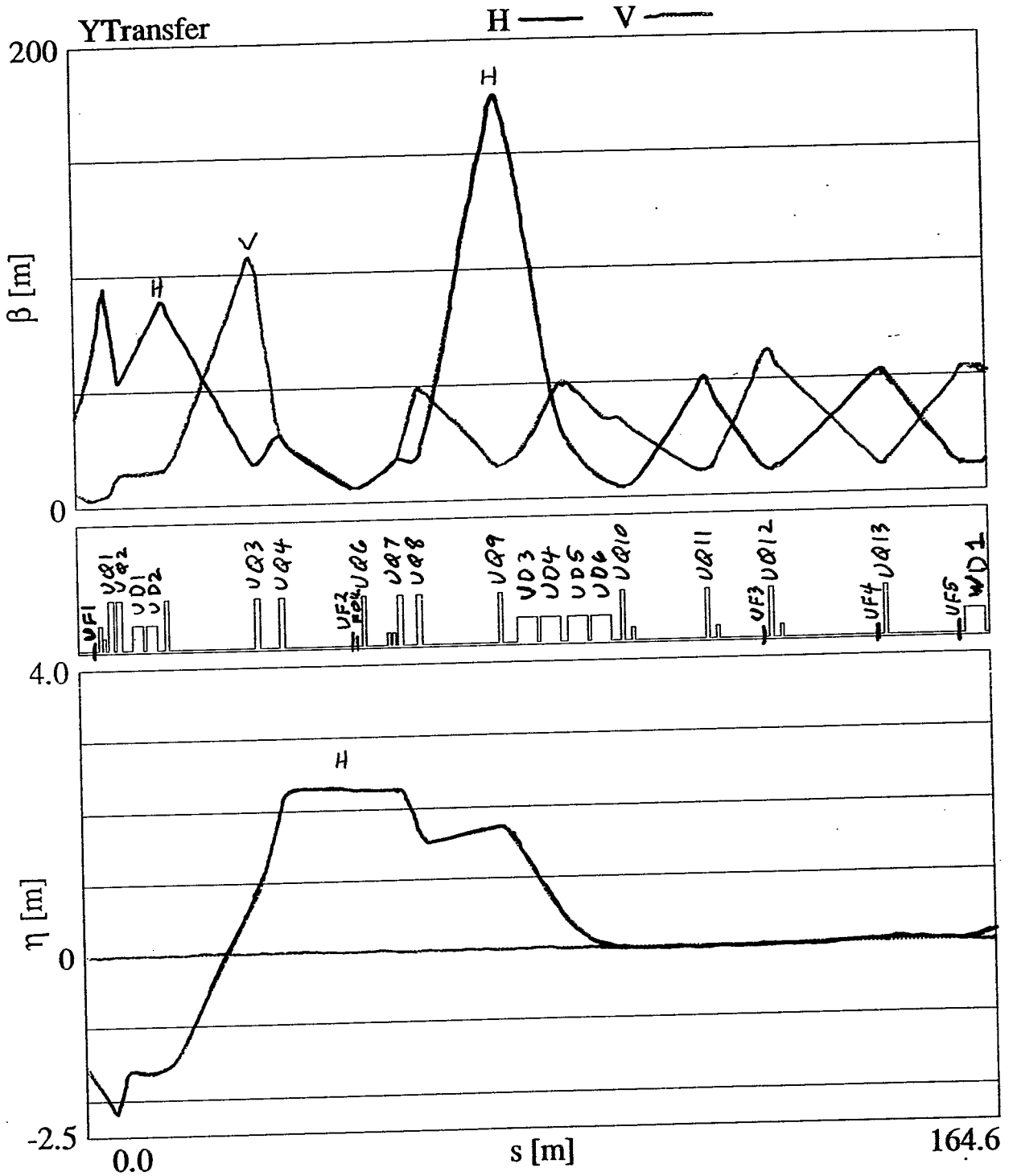
IV X-line:
- A Bend almost 90° into the Blue (cw) ring.
- B 6 Quads at end of X-line match into RHIC.
- C Vertical injection into RHIC with lambertson.

V Injection kickers inside each ring.

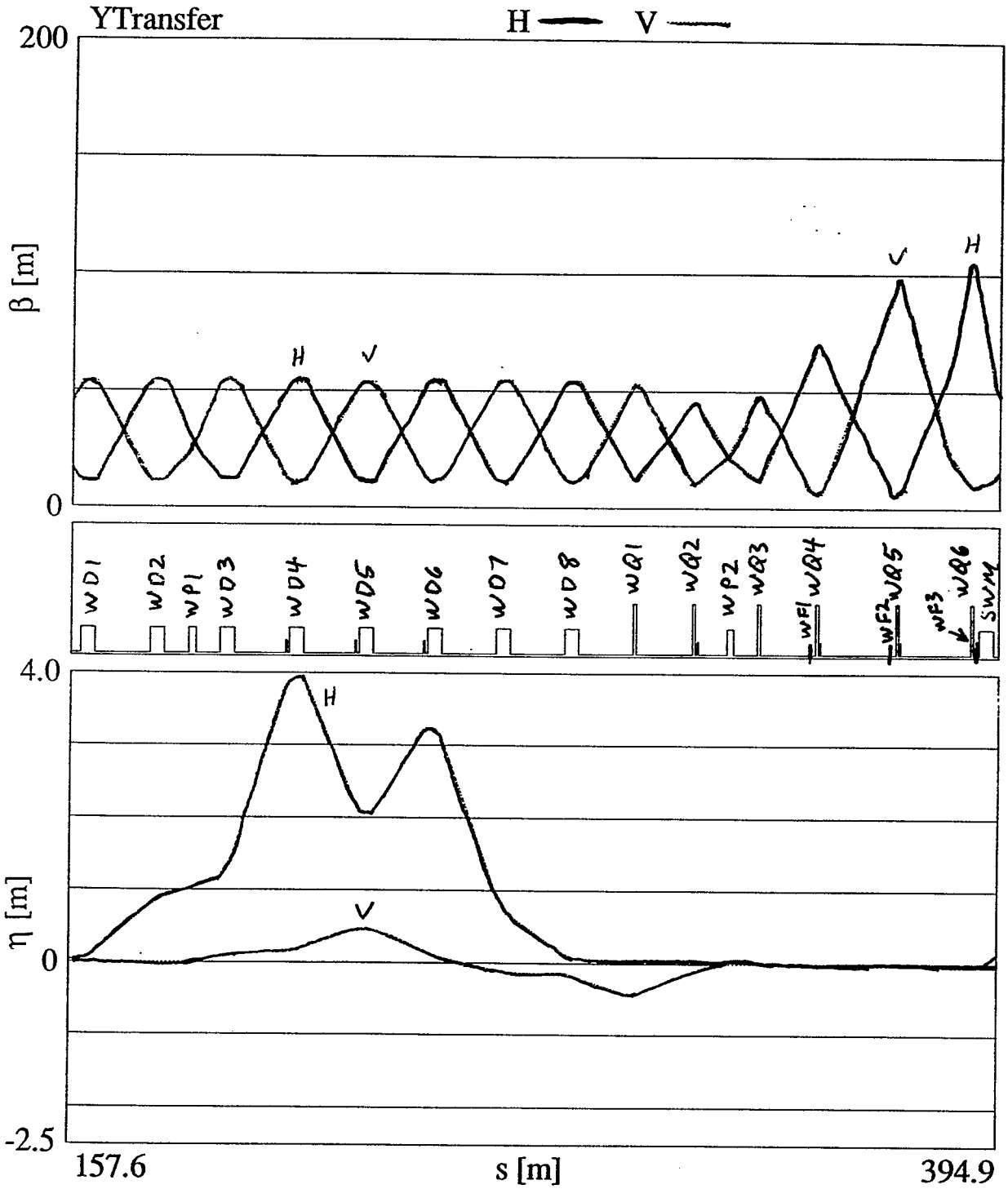
U, W, + Y - lines



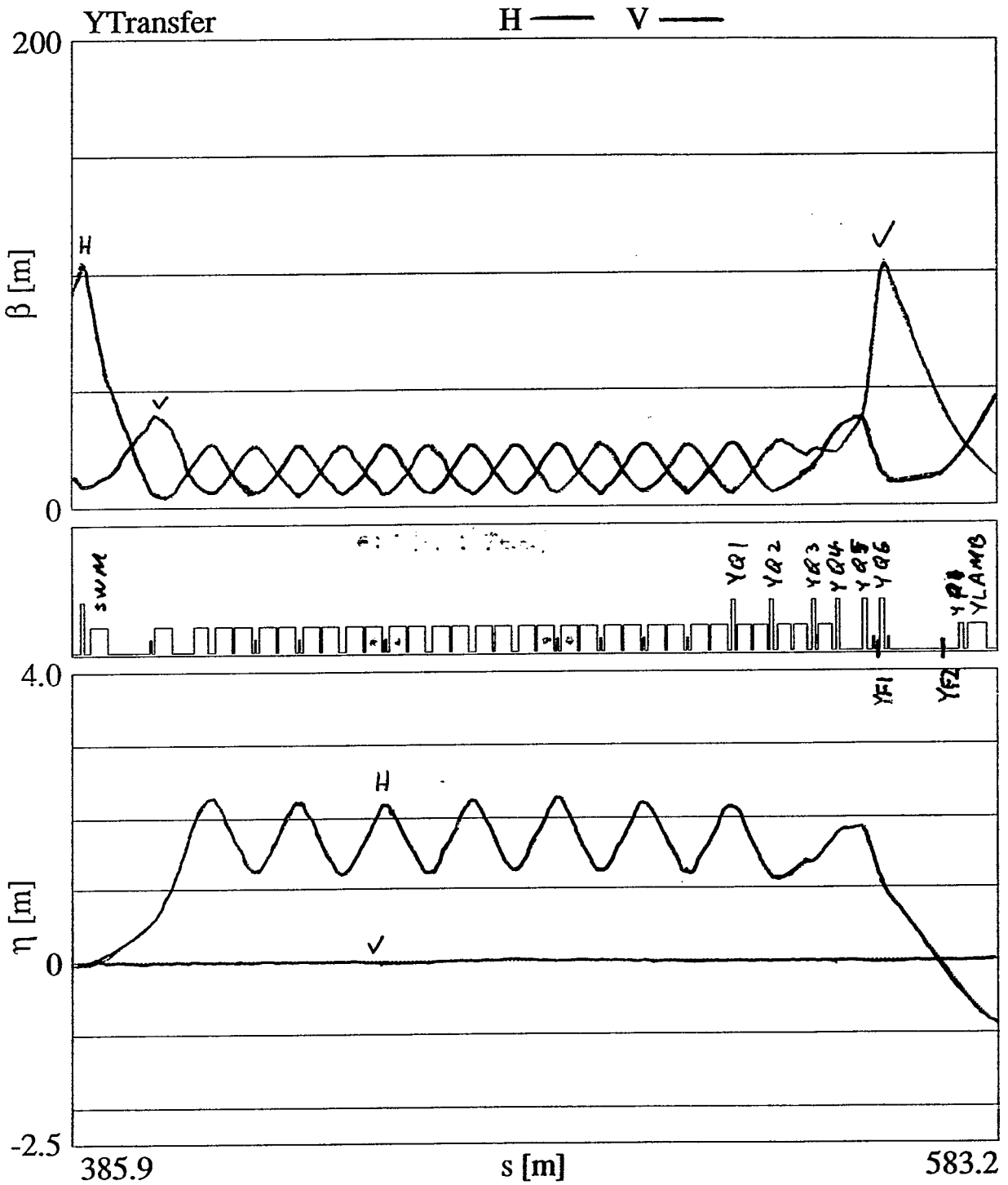
U-line


YTransfer
H —— V ——
200
β [m]
0
H
V
H
UF1
UQ1
UQ2
UD1
UD2
UQ3
UQ4
UF2
UQ6
UQ7
UQ8
UQ9
UD3
UD4
UD5
UD6
UQ10
UQ11
UF3
UQ12
UF4
UQ13
UF5
WD1
4.0
η [m]
0
-2.5
H
0.0
s [m]
164.6

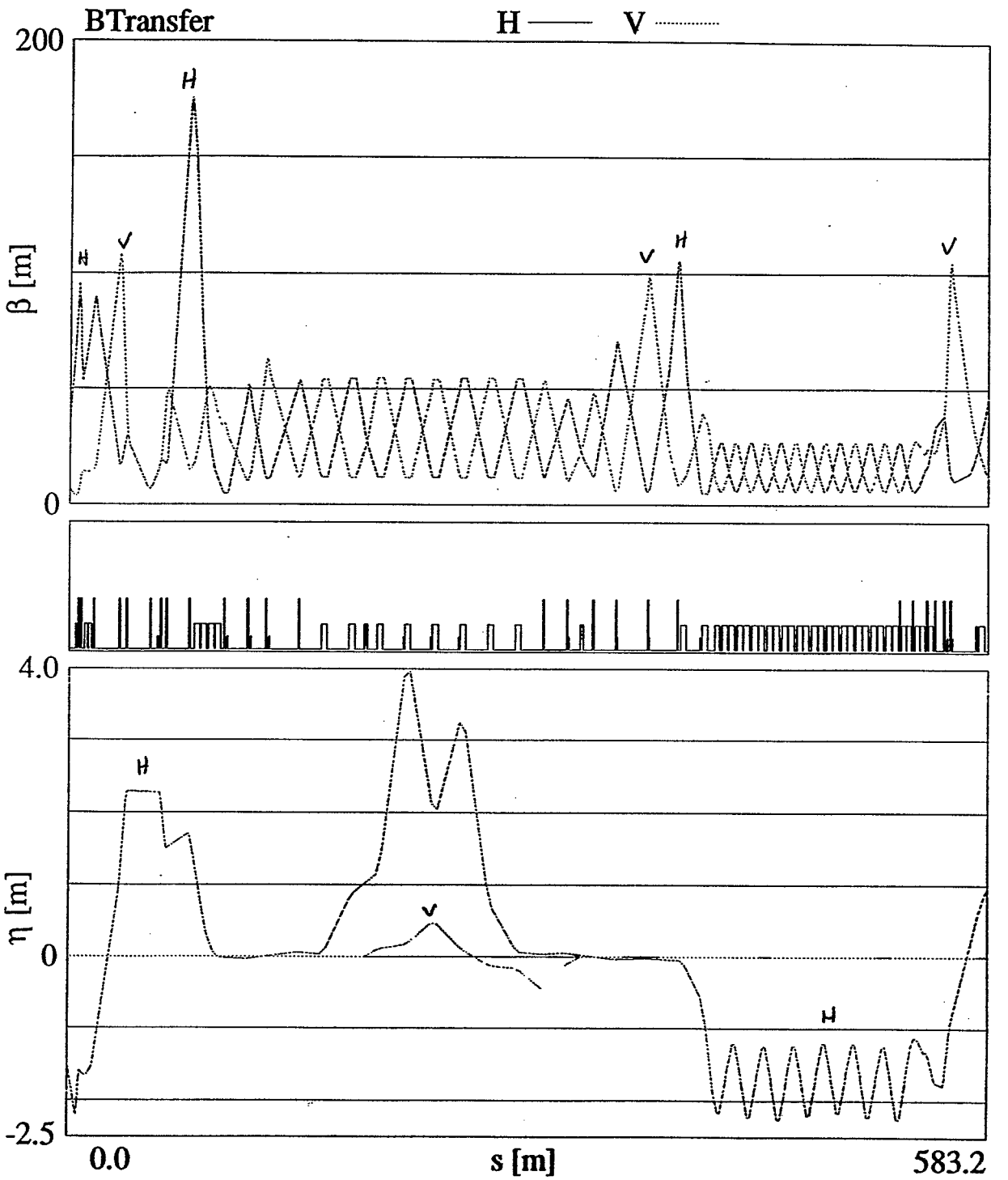
W-line


YTransfer
H
V
200
β [m]
0
H
V
H
V
WD1
WD2
WP1
WD3
WD4
WD5
WD6
WD7
WD8
WQ1
WQ2
WP2
WQ3
WF1
WQ4
WF2
WQ5
WF3
WQ6
SWM
4.0
η [m]
0
-2.5
H
V
157.6
s [m]
394.9

Y-line


YTransfer
H
V
200
β [m]
0
H
V
SWM
YQ1
YQ2
YQ3
YQ4
YQ5
YQ6
YLAMB
4.0
η [m]
0
-2.5
H
V
YF1
YF2
385.9
s [m]
583.2

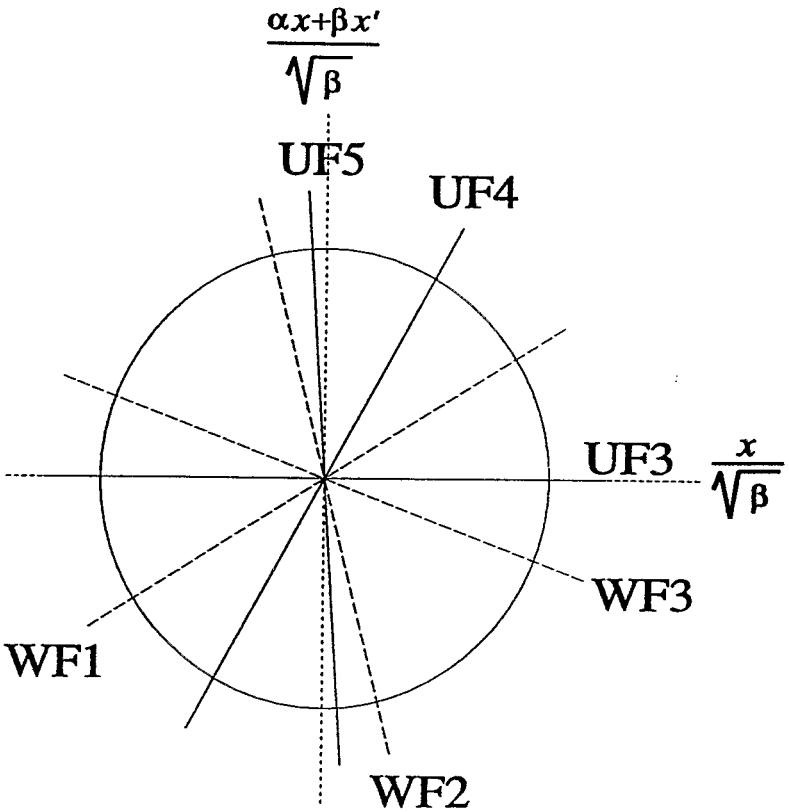
U, W + X - lines

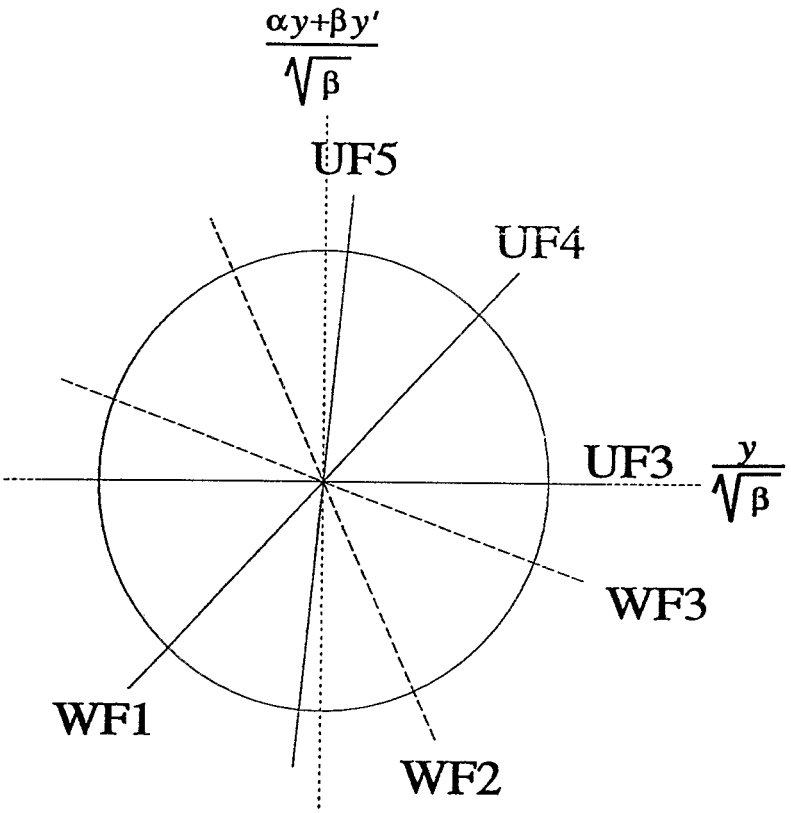


Changes

- 5 new planes of BPM's for better steering.
- Moved 2 flags and added 2 new ones.
  (Better emittance measurements.)
- BLM's allocated.

- Magnets about 50% complete.
- At least 8 dipoles have been installed in the tunnel.
- Field quality of magnets seems good.


$\frac{\alpha x+\beta x'}{\sqrt{\beta}}$
UF5
UF4
UF3
$\frac{x}{\sqrt{\beta}}$
WF3
WF1
WF2


$\frac{\alpha y+\beta y'}{\sqrt{\beta}}$
UF5
UF4
UF3
$\frac{y}{\sqrt{\beta}}$
WF3
WF1
WF2

I Things to do before beam tests
- A check cooling water on magnets
- B ramp magnets
- C check polarities of magnets
- D pump down line and check vacuum
- E check interlocks
- F check other hardware
  - 1 BPM's: cables and electronics
  - 2 BLM's (with a radioactive source)
  - 3 Flags: read back pictures with calibration lights
  - 4 Scrapers: check motor control and location readbacks.
  - 5 Current transformers and electronics
  - 6 Timing system: check signals
    - a to transformers
    - b to BPM's
    - c eventually to injection kicker system
- G Test connection to RHIC abort system

II With beam ($\sim 10^{10}$ charges of some species, 1pulse/30sec)
- A Thread beam down the U and W-lines.
  - 1 Steer the beam onto the flags.
  - 2 Measure the location with the BPM's.
  - 3 After reaching a flag with a reasonable trajectory, remove the flag and go on to the next one.
- B Measure the pulse stability from the AGS.
  - 1 Current
  - 2 Position
  - 3 Profile on flags
- C Measure the transverse matrix elements (C, S, C', S') for both x and y.
  - 1 Measure the beam location at all BPM's.
  - 2 Change UTV1 by a small amount and remeasure the trajectory.
  - 3 Reset UTV1 to previous value and remeasure the trajectory.
  - 4 Change UTH2 by a small amount and remeasure the trajectory.
  - 5 Calculate the expected deviations and compare with data.
- D Measure the dispersion elements of the beamline (D, D').
  - 1 Measure the trajectory.
  - 2 Change the momentum of the AGS extracted beam.
  - 3 Remeasure the trajectory.
  - 4 Calculate the values of D and D' at the BPM locations.
  - 5 Compare with the expected values.
- E Attempt to measure momentum spread with collimator UC1.
- F Measure the beam shape (hyperellipsoid)
  - 1 Measure the profile at flags UF3, UF4, and UF5
  - 2 Measure the profile at flags WF1, WF2, and WF3
  - 3 Calculate emittances, betas, and alphas (horiz and vert) at the flag locations.
- G Tune the U-line quads to best match the desired values going into the W-line.
  - 1 Note that the dispersion should be zero at the entrance to the W-line (20° arc).
- H Tune the W-line quads to best match the desired values just upstream of SWM (switch magnet).
- I Scan aperture

III Fault studies.
- A Check for radiation leaks when the beam hits certain key elements. Of particular interest are:
  - 1 Access doors, particularly in the split region.
  - 2 Penetrations for cables and ventilation shafts.
  - 3 Thin shielding areas.
  - 4 The top of the berm where Thompson road crosses the beamline.

General Philosophy

- Use Sybase database server
  - archive data
  - define configuration.
- Use shared memory.
  - shares data between processes.
- Glish sequencing language
  - Connects programs
  - Event interupts
  - Data passing
  - Communication across network
- SDS data format: Selfdescribing data structures
  - Hardware independent binary format
  - Header contains structure info, e.g., variable names.
- Graphical interfaces should be separate programs.
  - Should run under X-windows.
  - Should generate and receive Glish events.
  - Should be able to be replaced by a Glish script in order to automate an established sequence.

Possible Application Codes

I Basic applications
- A Parameter and Status Pages
  - 1 Power supply status, settings and limits
  - 2 Vacuum status
  - 3 Interlocks
  - 4 Alarms
  - 5 Lamberson elevation control?
  - 6 Scraper control
    - a Position control
    - b Position readback
  - 7 Current transformers
    - a Readings
    - b Gain settings
    - c Timing
  - 8 BPM's
    - a Gain settings
    - b Timing
  - 9 BLM status, readings, gain settings
- B Injection pulse control
  - 1 AGS extraction kicker
    - a status, voltage, timing
  - 2 RHIC injection kicker
    - a status, voltage, timing
  - 3 RF
    - a status, voltage, timing
  - 4 RHIC abort status (go–no go)
    - a vacuum, cryogenics, ...
- C Magnet ramp control

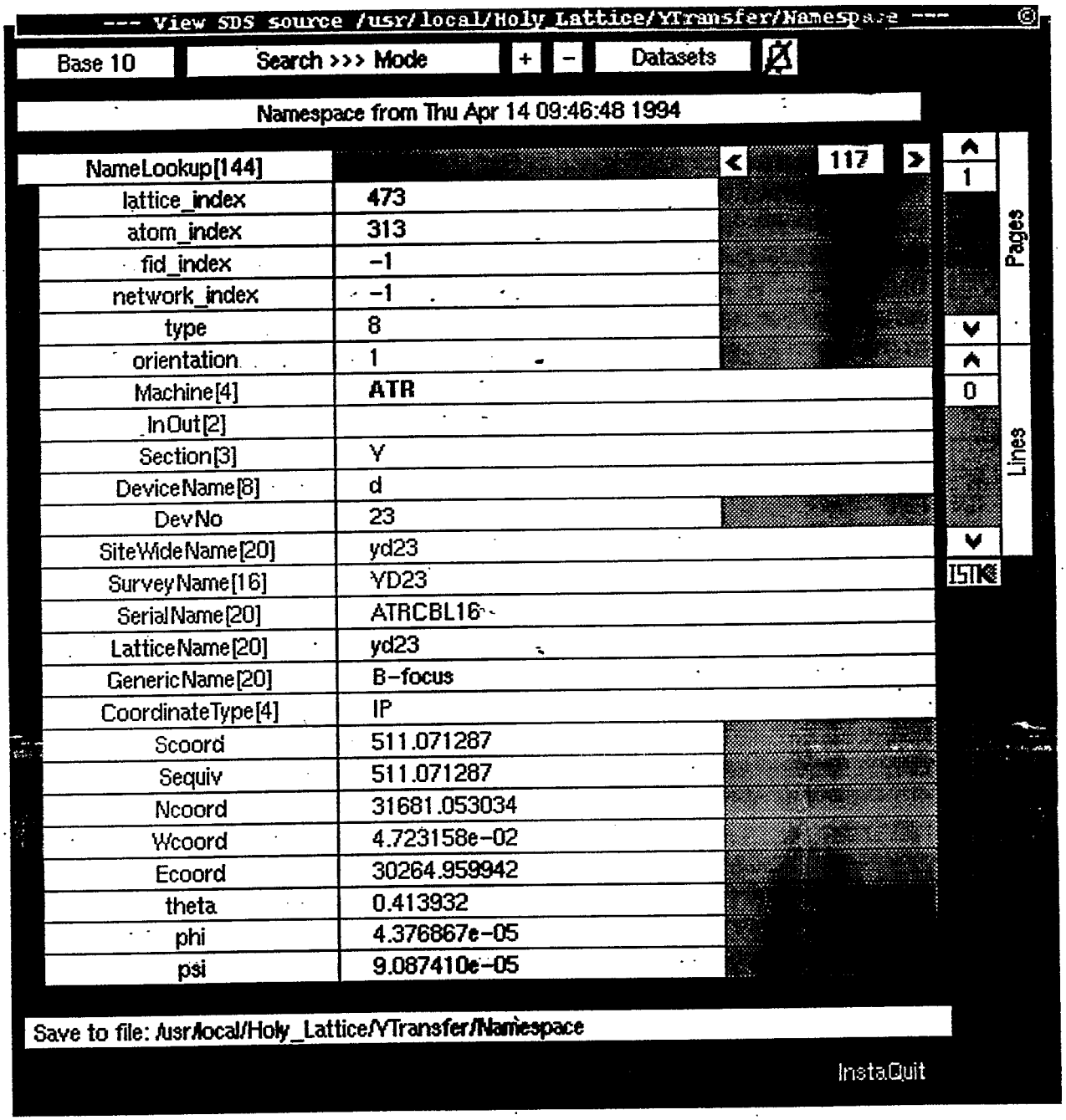
II Utilities
- A Namespace server ("phonebook")
- B Logging server
- C Conversion: $\vec{I} \Leftrightarrow \vec{B}$
- D SID: an SDS data editer–viewer
- E KASPAR: an SDS data plotter

III Beam threading
- A Beam steering display (horiz and vert)
  - 1 Aperture display
    - a beam pipe
    - b collimators (variable)
    - c lambertsons (variable)
  - 2 Predicted trajectory
  - 3 Predicted beam envelope
  - 4 BPM measurements
  - 5 Locations and sizes information from flags
  - 6 Show locations
    - a Magnets
    - b BPM's
    - c Flags
    - d Scrapers
    - e Stripping foil, if there
    - f BLM's

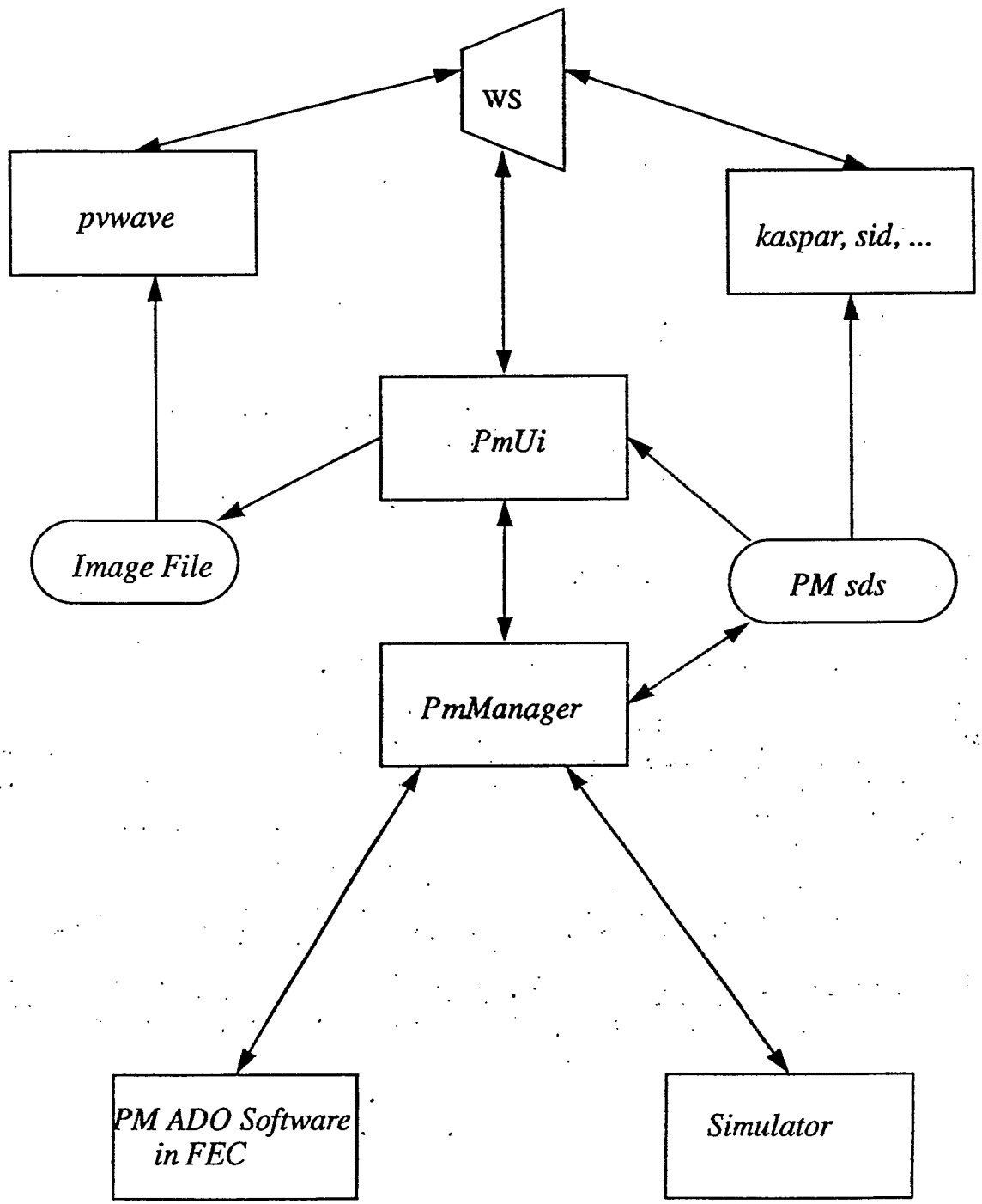
- g collimators
- 7 Indicate beam loss in BLM's
- B Beam threading code (computations)

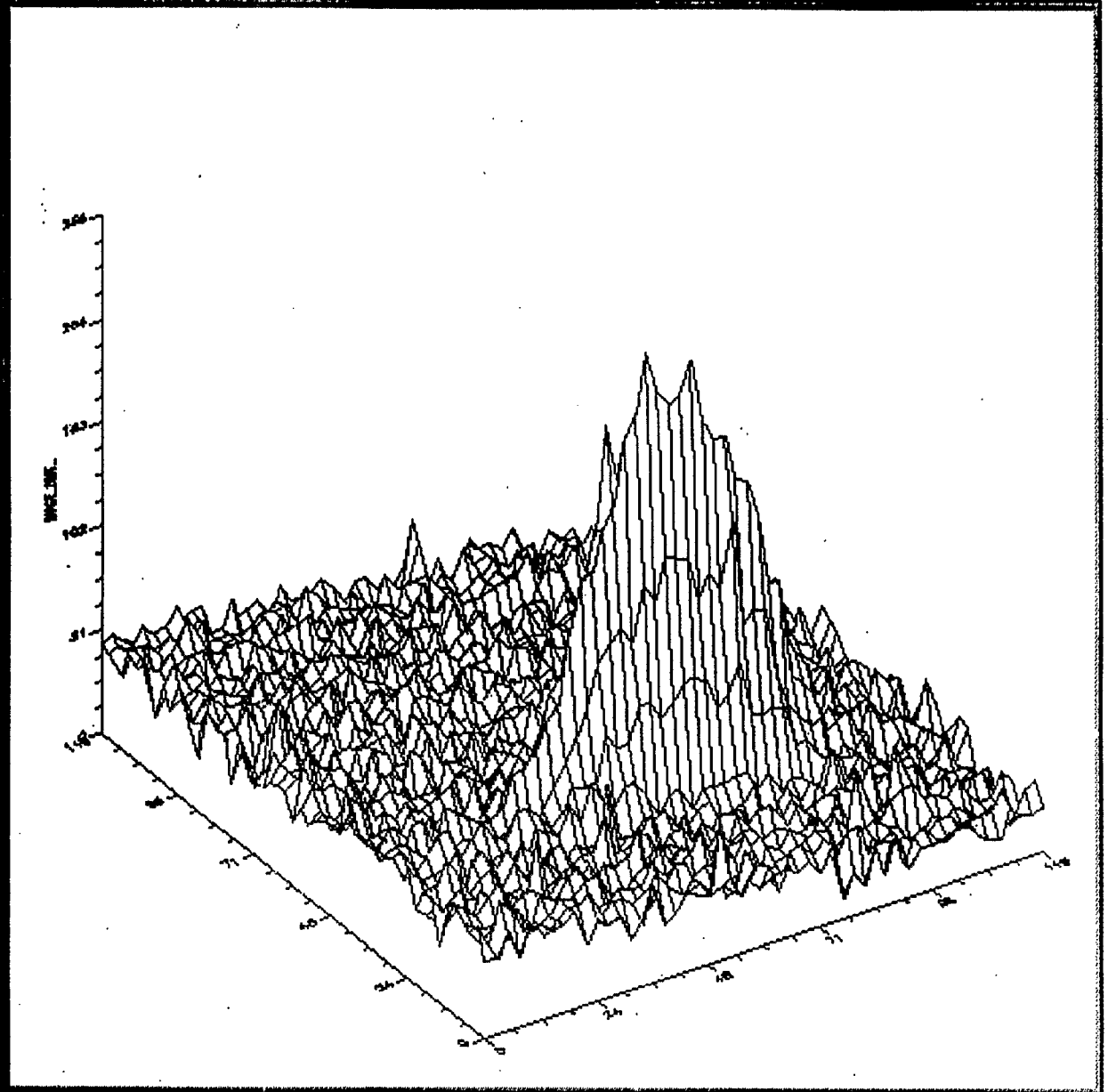
IV Profile measurements
- A Single Flag profiles
  - 1 Multiplexing
  - 2 Calibration
  - 3 Views of flag
    - a 2d intensity plot
    - b 1d projections
- B Beam Hyperellipsoid measurement
- C display of correlated flag measurements

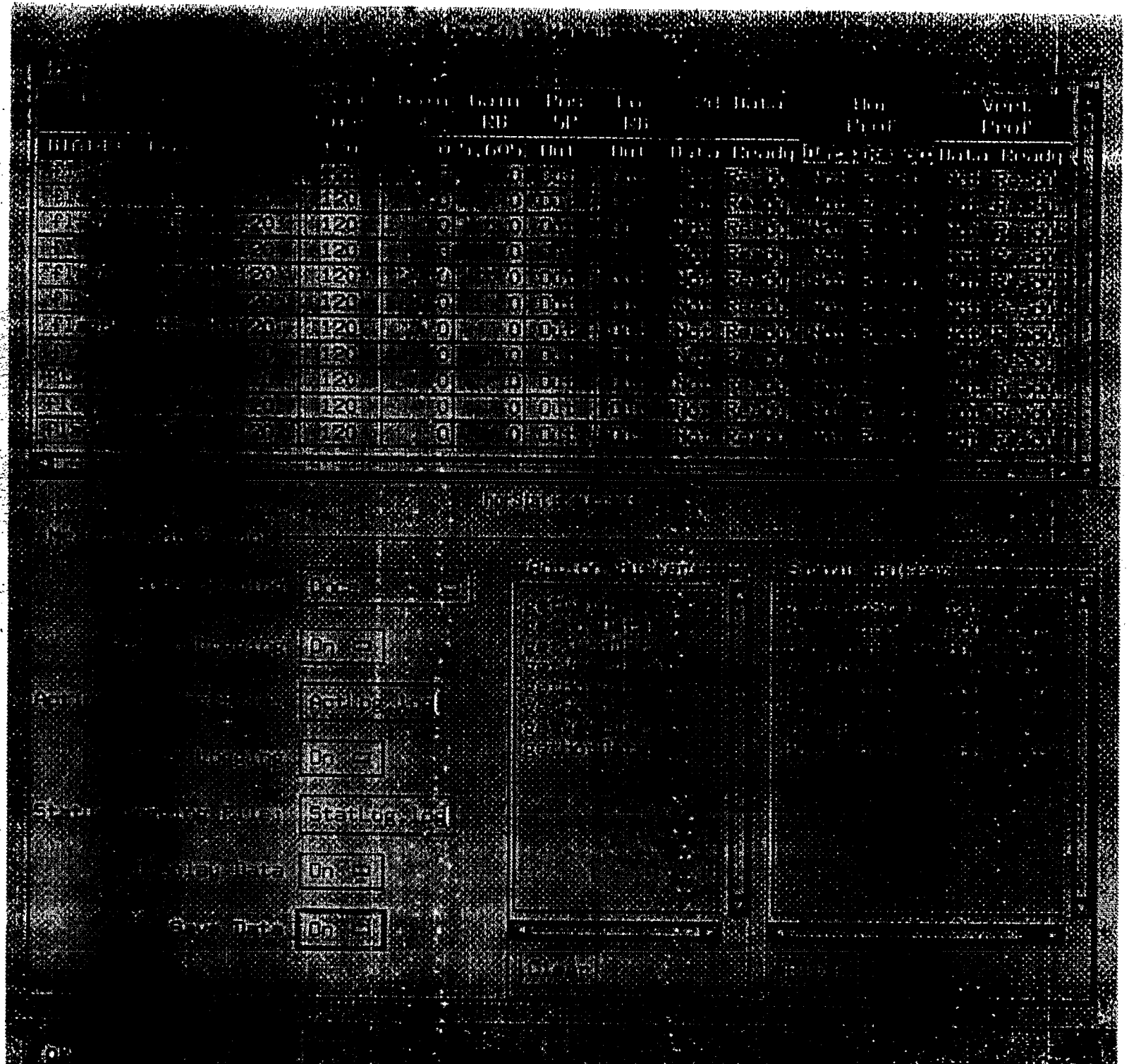
V Injection sequence (possibly just a Glish script)
- A Species and momentum
- B set magnet currents
- C Number of bunches
- D Bunch timing
- E ...


--- View SDS source /usr/local/Holy_Lattice/YTransfer/Namespace ---
Base 10
Search >>> Mode
+
-
Datasets
Namespace from Thu Apr 14 09:46:48 1994
NameLookup[144]
117
Pages
1
Lines
0
lattice_index 473
atom_index 313
fid_index -1
network_index -1
type 8
orientation 1
Machine[4] ATR
InOut[2]
Section[3] Y
DeviceName[8] d
DevNo 23
SiteWideName[20] yd23
SurveyName[16] YD23
SerialName[20] ATRCBL16
LatticeName[20] yd23
GenericName[20] B-focus
CoordinateType[4] IP
Scoord 511.071287
Sequiv 511.071287
Ncoord 31681.053034
Wcoord 4.723158e-02
Ecoord 30264.959942
theta 0.413932
phi 4.376867e-05
psi 9.087410e-05
Save to file: /usr/local/Holy_Lattice/YTransfer/Namespace
InstaQuit

Profile Monitor Programs







Development Environment

1) Data structures and transfer
   * SDS / shared memory at high level
   * Communication protocols are well-established
   * Data structures are shared and jointly developed between Instrumentation, Controls and Physics

2) High level process communication
   * Glish is used for both low-level and high-level sequencing.

3) Sybase database
   * Front-end configuration data
   * Lattice/simulation information
   * Data archiving and logging

4) General development environment
   * C/C++ and unix, although not exclusively
   * Interfaces are X/Motif

Beam Threading Objectives

Primary (required for AtR Commissioning in '95)

* Measure/Archive orbit data, shot-by-shot
* Correct global orbit in each plane
* Use BLMs/BPMs for correction information
* Interface with optics database for simulation

2) Secondary (not required for commissioning)

* Control individual 3- and 4-bumps
* Allow (x,x') specification at any point in beamline
* Minimize corrector strengths
* Use profile monitors as accessory BPMs
* Correct orbit downstream of last 3-bump

Beam Threading Hardware in AGS to RHIC Transfer Lines (5/5/94)

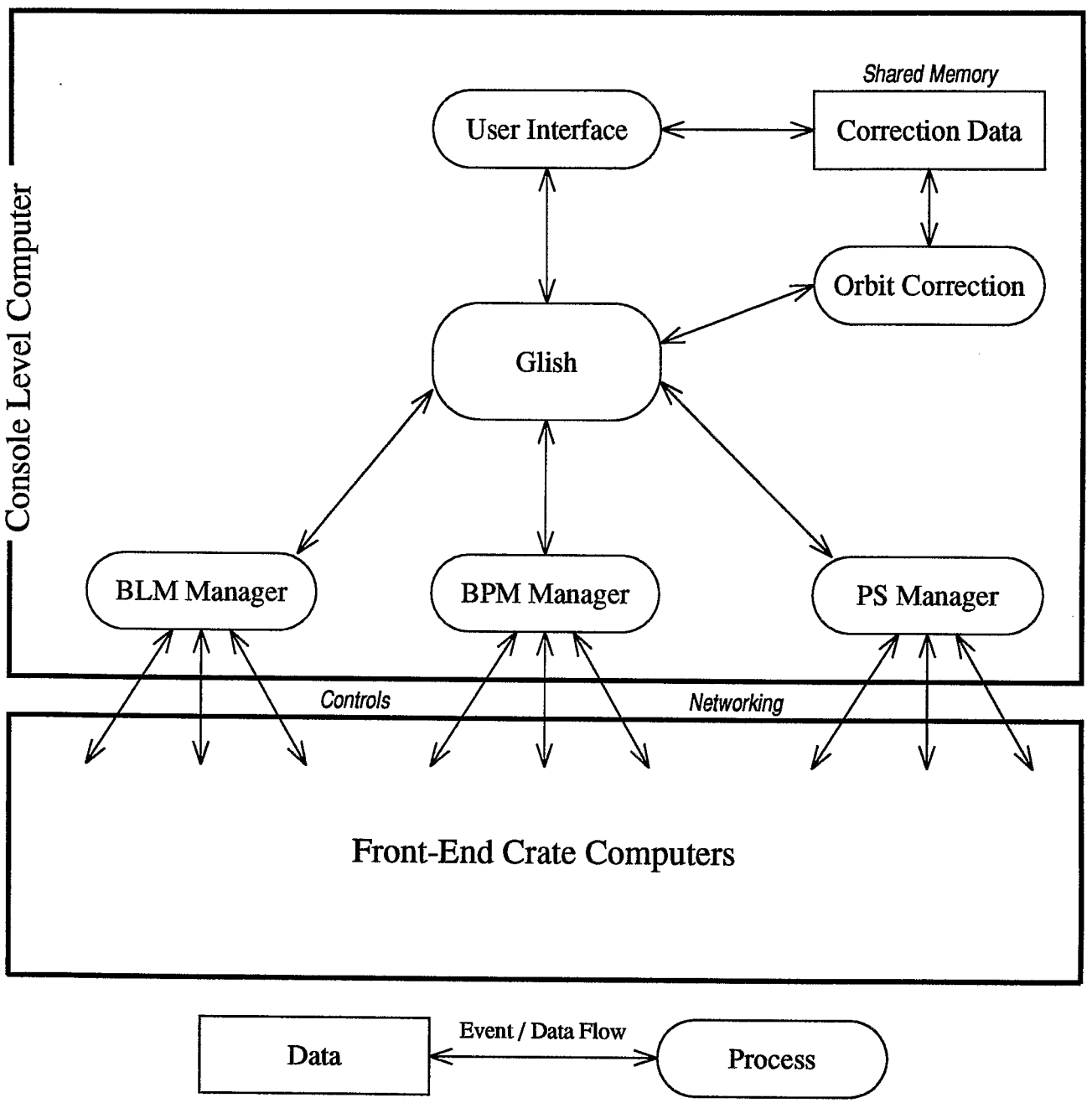
	U line	W line	X,Y lines
Horizontal BPMs	6	5 (1)	6 (1)
Vertical BPMs	4	5 (1)	8 (1)
Horizontal Correctors	3	4	7
Vertical Correctors	4	4	6
BLM Channels	12	8	16
Profile Flags	5	3	2

Parenthesized BPM planes added 12/93

BLMs are used to diagnose aperture losses and alter correction weights.

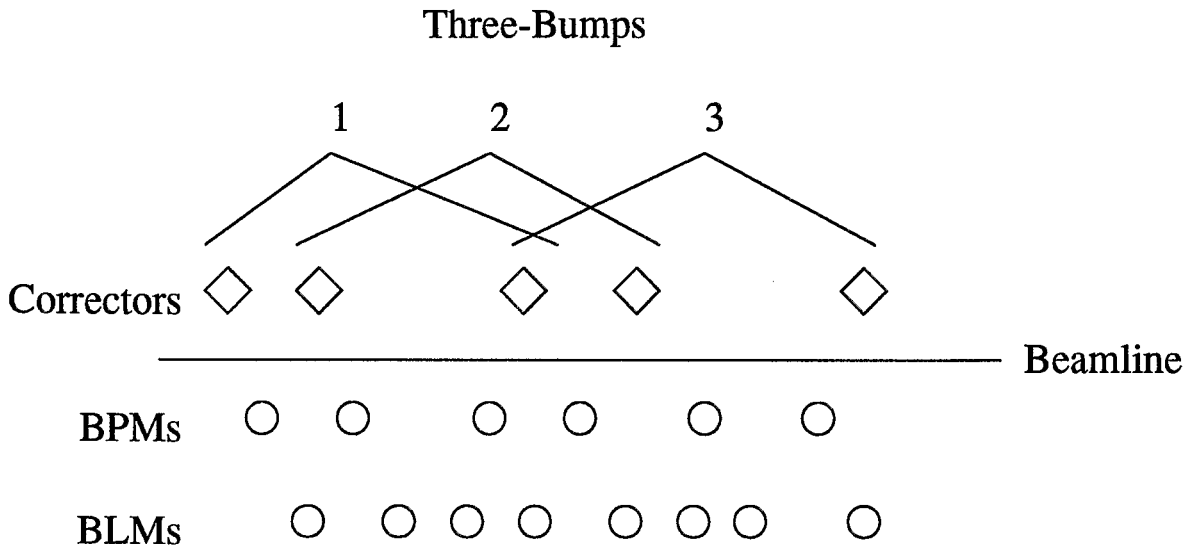
Flags can be used as dual-plane BPMs during commissioning.

AGS to RHIC Beam Threading Processes and Data



```
#################################################################
# Start up clients, or processes to manage
#################################################################
NQ  := client("Namequery")       # Client to look up names of things
UI  := client("BeamThreadUI")    # Client to act as user interface
BLM := client("BLM_Manager")     # Client to manage BLM data/interface
BPM := client("BPM_Manager")     # Client to manage BPM data/interface
PSM := client("PS_Manager")      # Client to manage PS  data/interface

#################################################################
# Whenever the user requests a list of BPM names, go to
# the NameQuery process and ask it for such a list.
#################################################################
whenever UI->GetBpmNames do
{
  # Set which namespace to use
  NQ->Display("/usr2/local/Holy_Lattice/BTransfer/Namespace")

  # Send search query, listing field to match and field to return
  NQ->Search(Dataset = "Namespace",
             Dataname = "NameLookup.DeviceName",
             Pattern = "b",
             Return = "NameLookup.SiteWideName",
             Start = SearchStart,
             SearchType = "inexact")
}

#################################################################
# Whenever Namequery finds something, sent it off to the
# user interface
#################################################################
whenever NQ->Found do
{
  UI->Found($value)
}

#################################################################
# Whenever the user requests an orbit correction, start a
# SYNCHRONOUS process to generate suggested corrector settings
# for a corrected orbit.
#################################################################
whenever UI->CorrectOrbit do
{
  shell("clorbit -x -y")
}

...
```

Orbit Correction Algorithm for Beam Threading



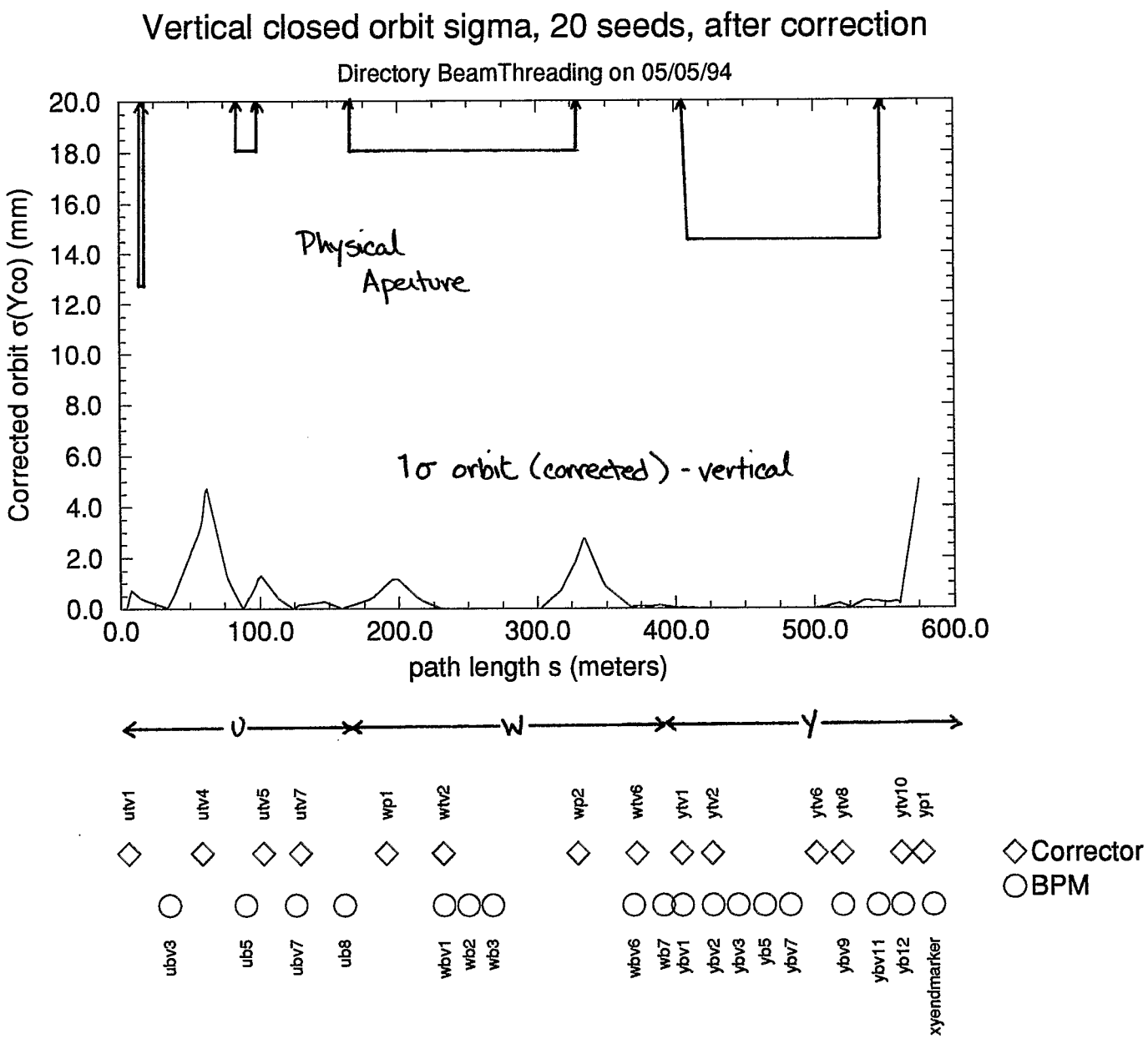
Successively and iteratively corrects overlapping three-bumps down beamline

Uses easily modifiable weighting schemes

Requires linear optics model of beamline, but is strongly robust due to iterative corrections.

Transfer line orbit correction simulation -

- 0.5 mm random quad displacements
- 1.0 mrad random dipole rolls
- Uses correction algorithm that will be applied in AtR commissioning.
- See RHIC AP note #24 for additional details.



Conclusions

1) Development environment is adequate for application design
   * SDS / shared memory for data transfer
   * Glish for low/high level sequencing
   * Interfaces to low-level controls under development
   * Environment is C/C++ with X graphics

2) Beam threading and hyperellipse applications are on schedule for ATR commissioning.

3) Other applications are well-defined, with tools available for their development on schedule with commissioning. Of highest priority is a parameter page application.

4) True vertical integration has been accomplished with profile monitor measurements in the BTA line; this remains to be done with beam threading.