Brookhaven National Laboratory

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)

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May 1994

AGS to RHIC Beam Line: Application Codes

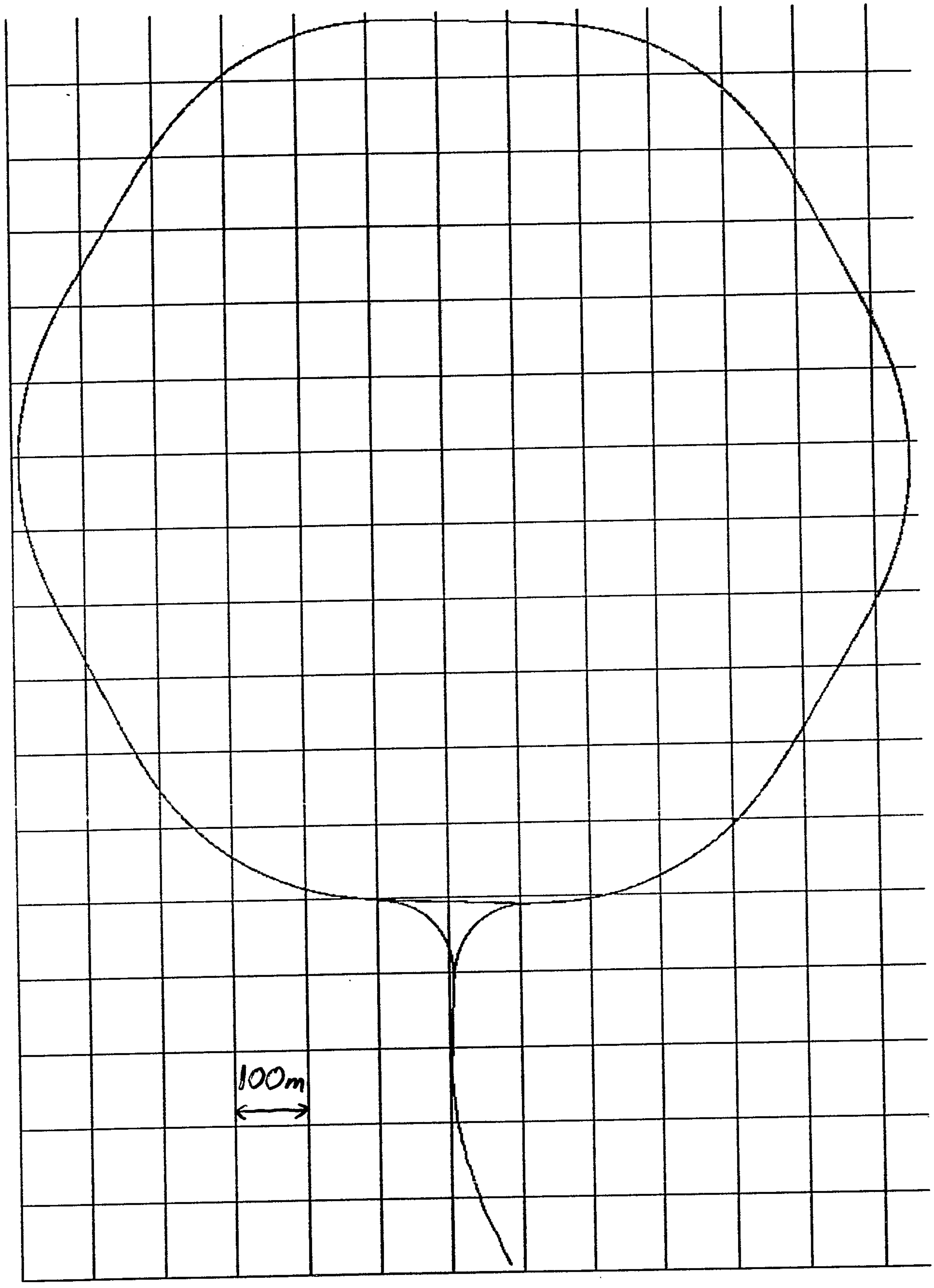
Waldo MacKay and Todd Satogata

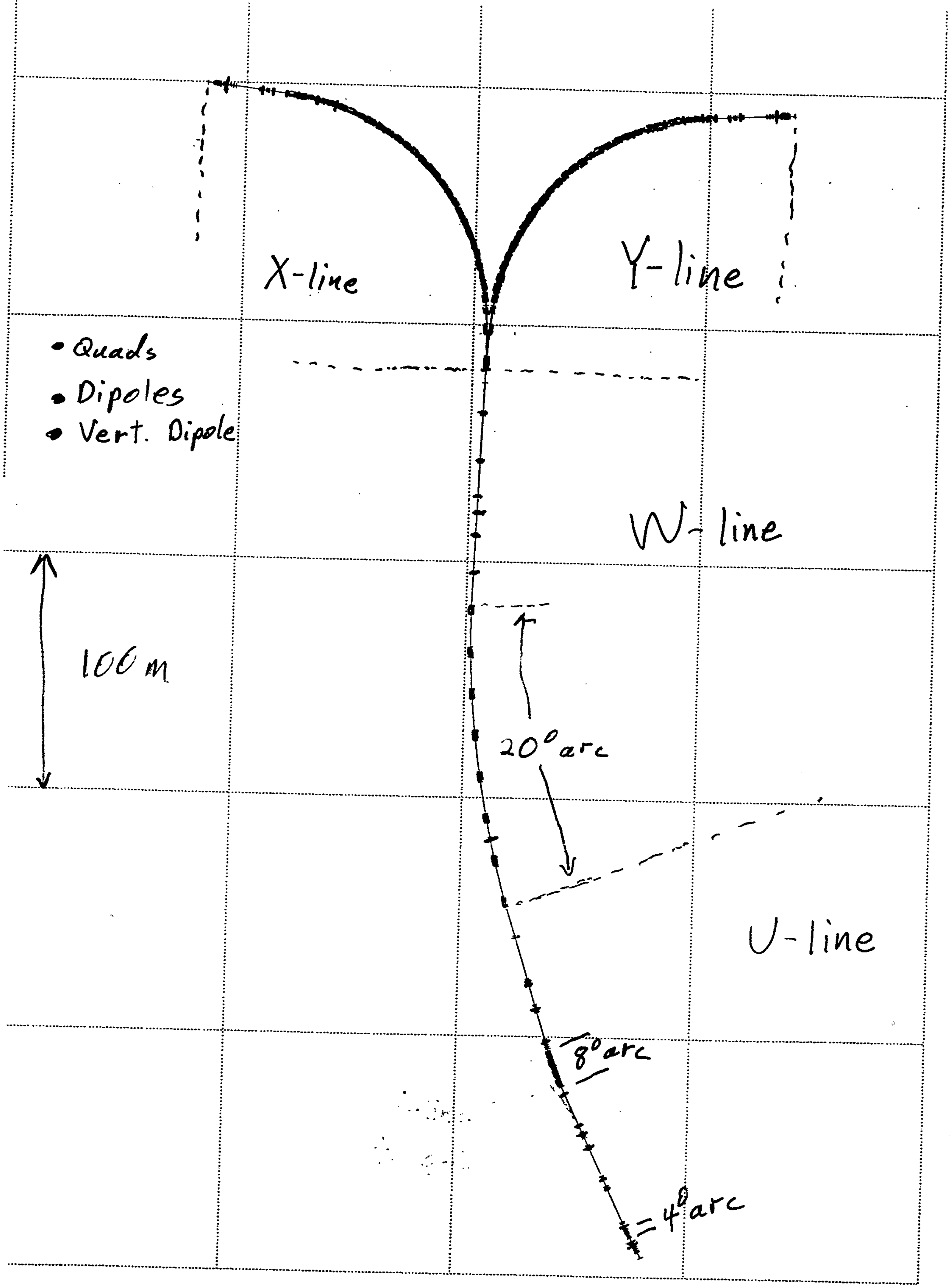
Waldo

- 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: $Au^{+77} \Rightarrow Au^{+79}$

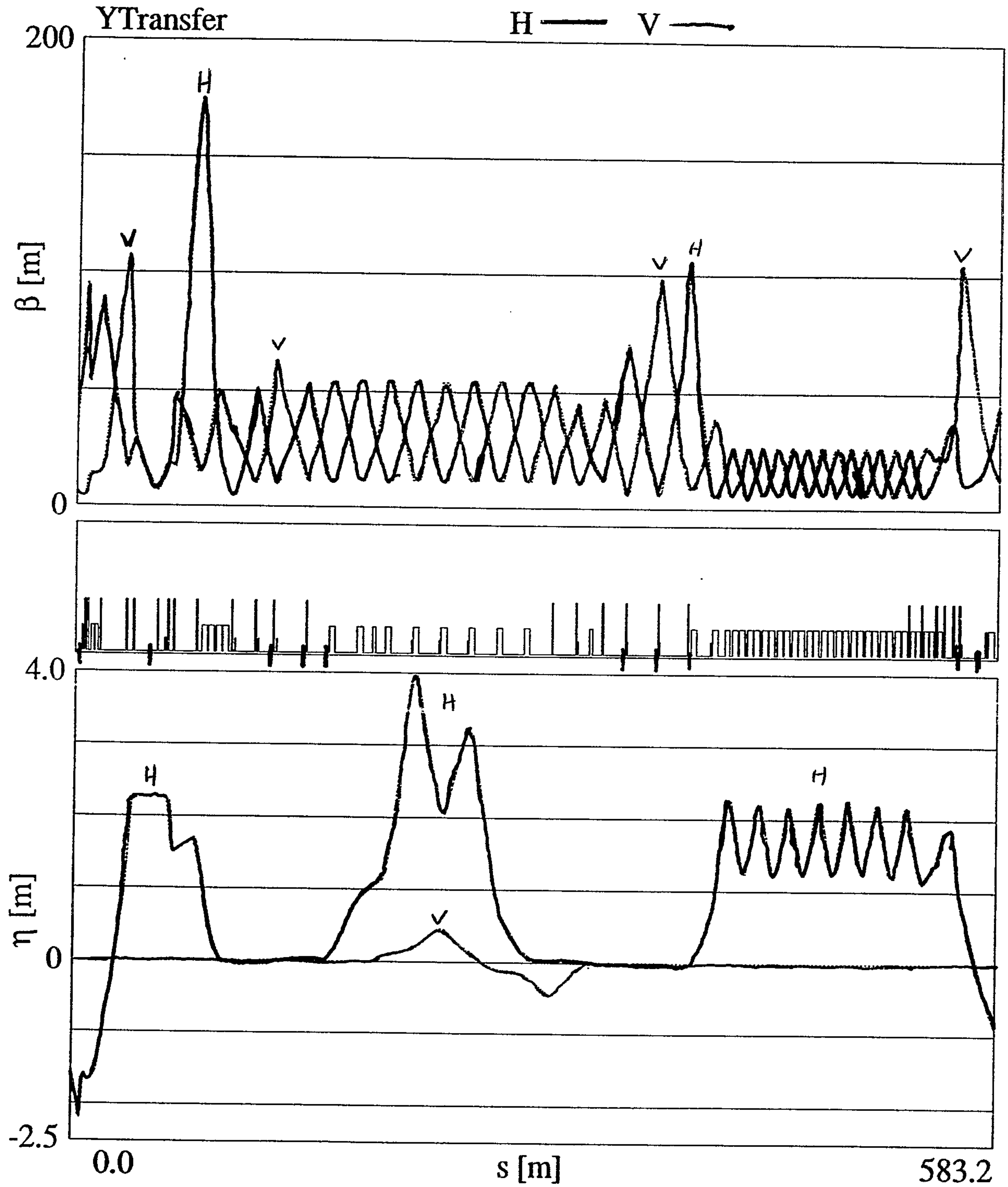
II W-line:
- A Vertical drop of 1.7m
- B 20° bend to reach 6–12 o'clock symmetry line (Requires zero dispersion upstream and downstream of the 20° arc.)
- C 6 Quads at end of W-line match into the 90° arcs.

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.

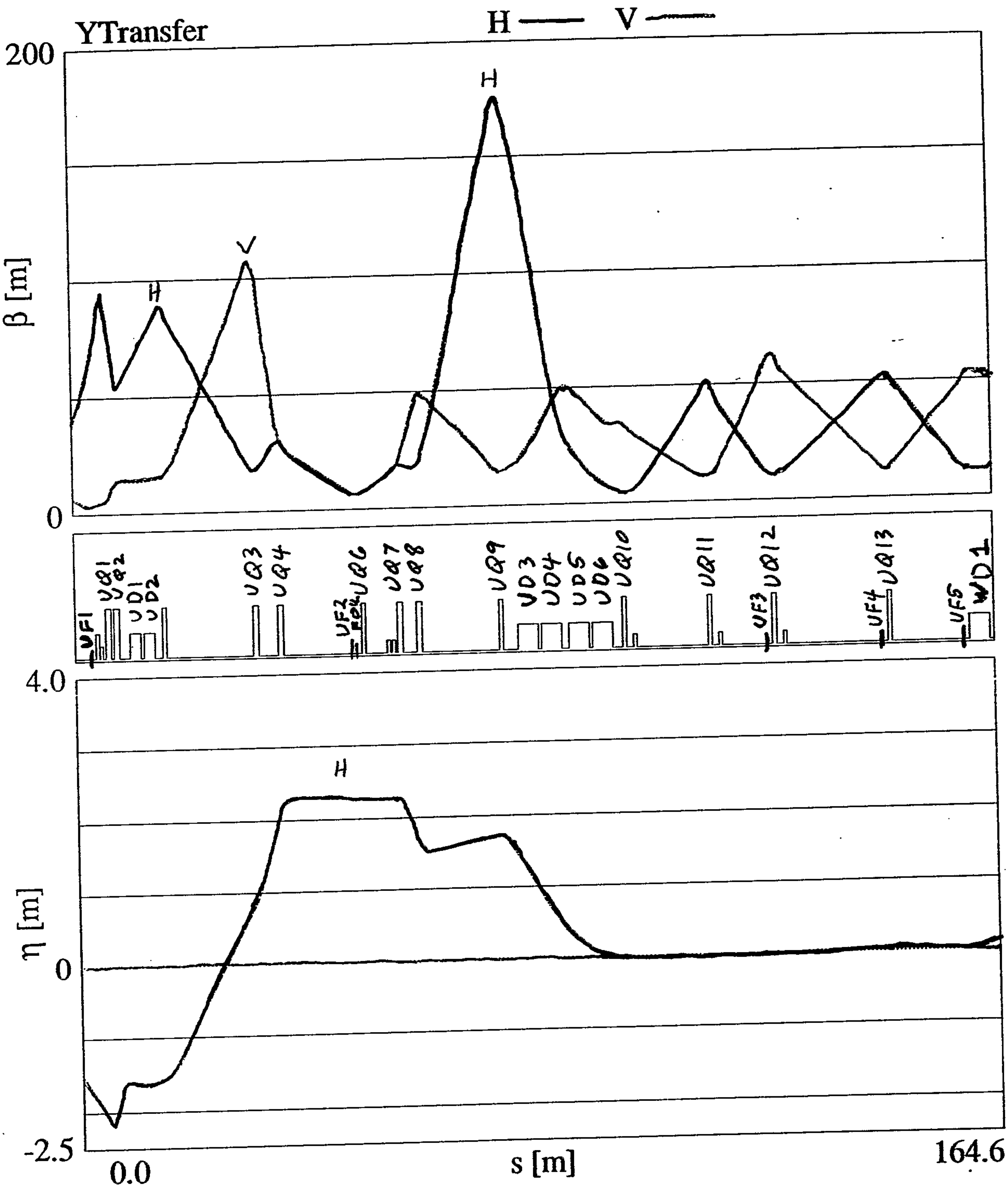
IV X-line:
- A Bend almost 90° into the Blue (cw) ring.
- B 6 Quads at end of X-line match into RHIC.
- C Vertical injection into RHIC with lambertson.

V Injection kickers inside each ring.

U, W, + Y - lines

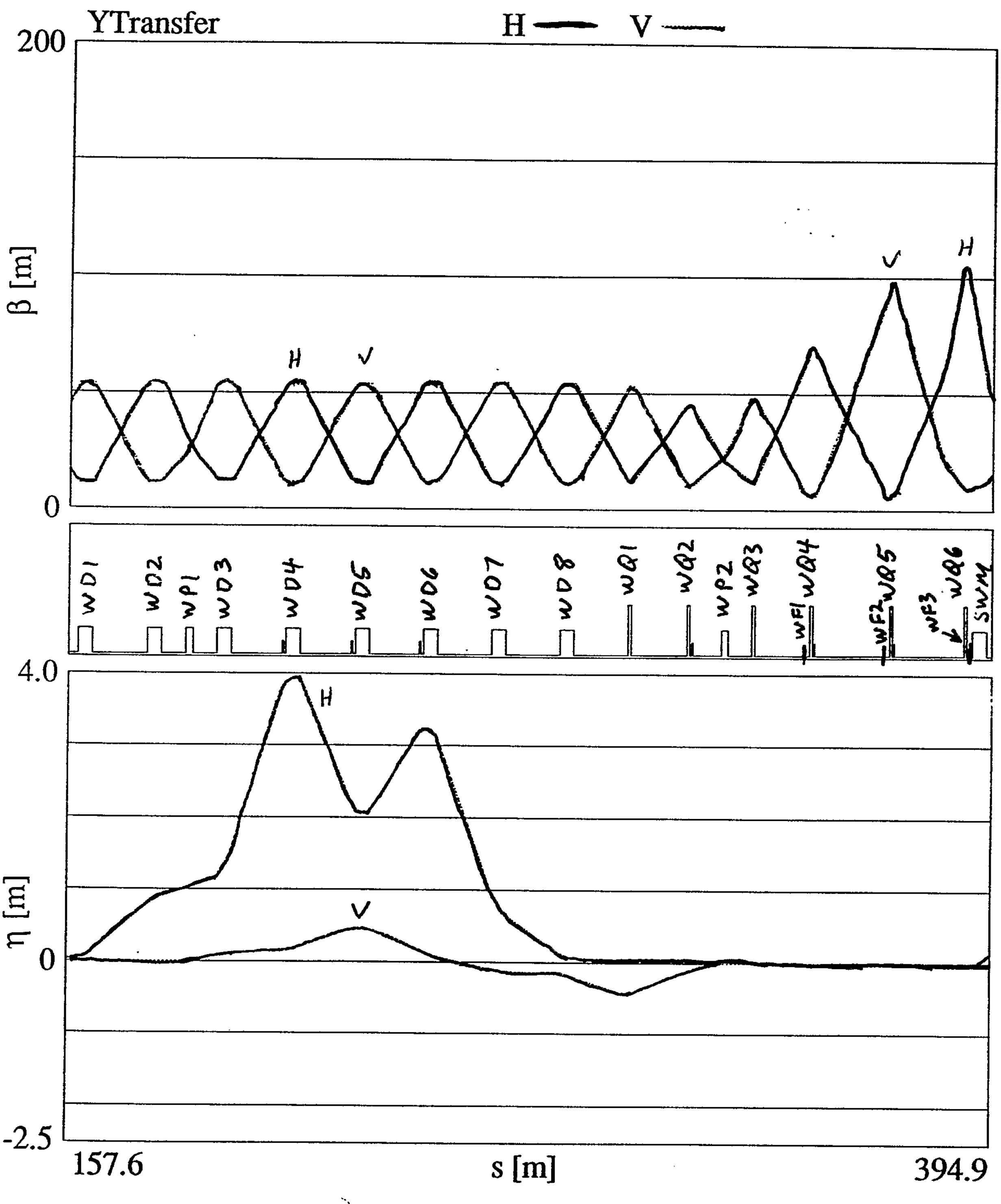


U-line

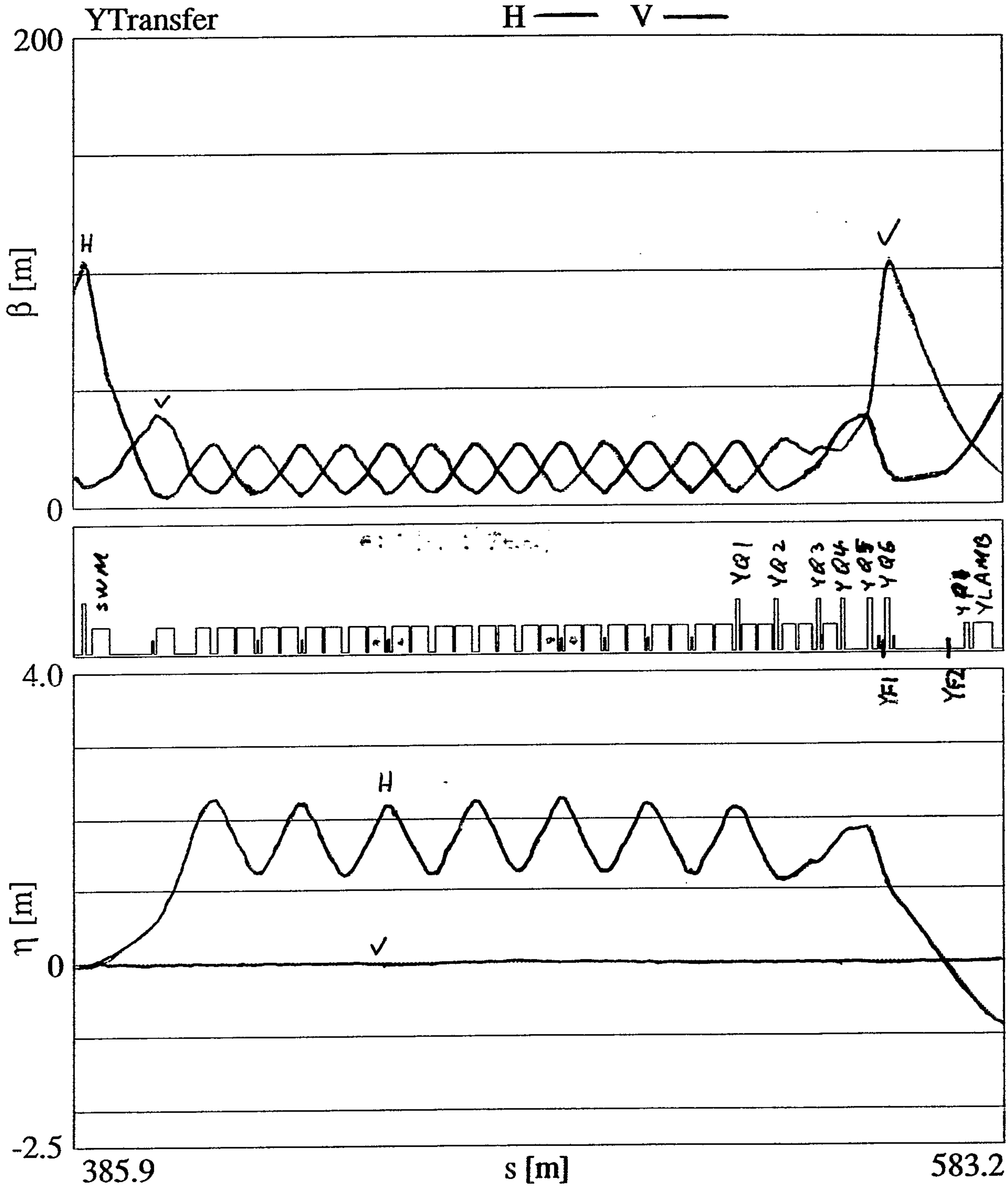


YTransfer
H
V
200
β [m]
0
UF1
UQ1
UQ2
UD1
UD2
UQ3
UQ4
UF2
UQ6
UQ7
UQ8
UQ9
UD3
UD4
UD5
UD6
UQ10
UQ11
UF3
UQ12
UF4
UQ13
UF5
WD1
4.0
η [m]
0
-2.5
0.0
s [m]
164.6

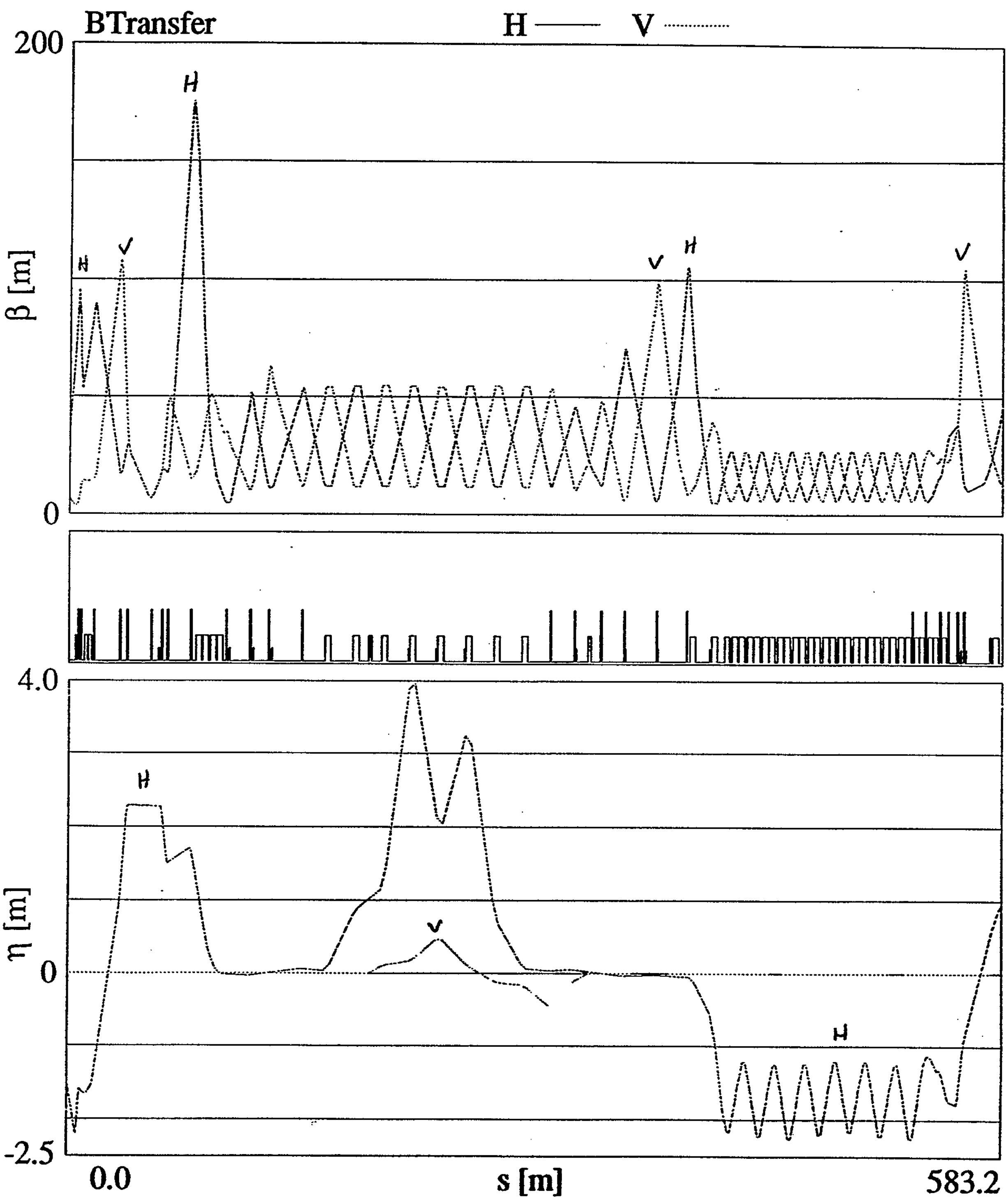
W-line


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

Y-line


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

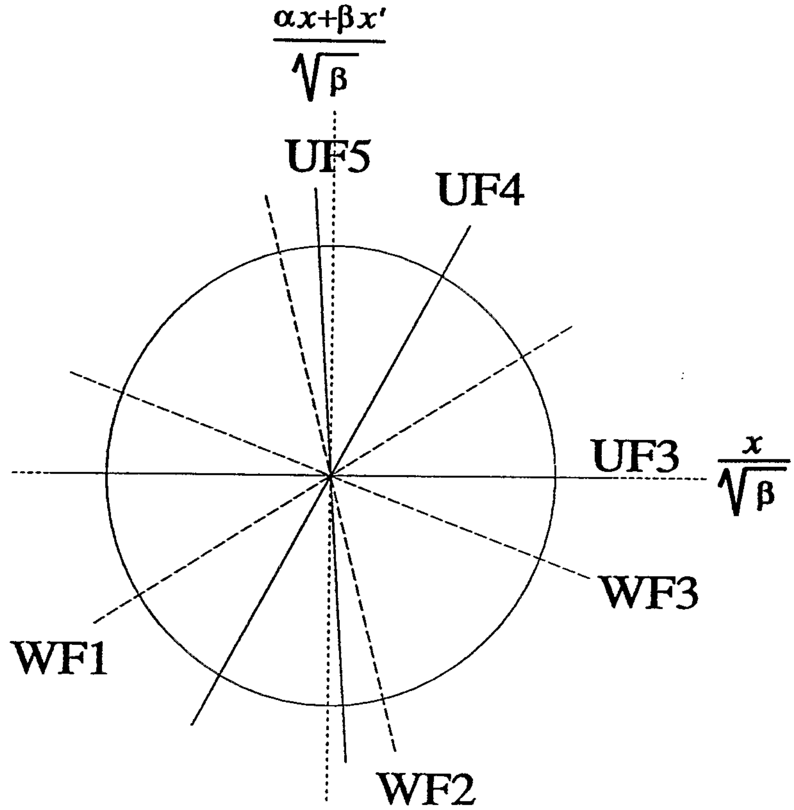
U, W + X - lines



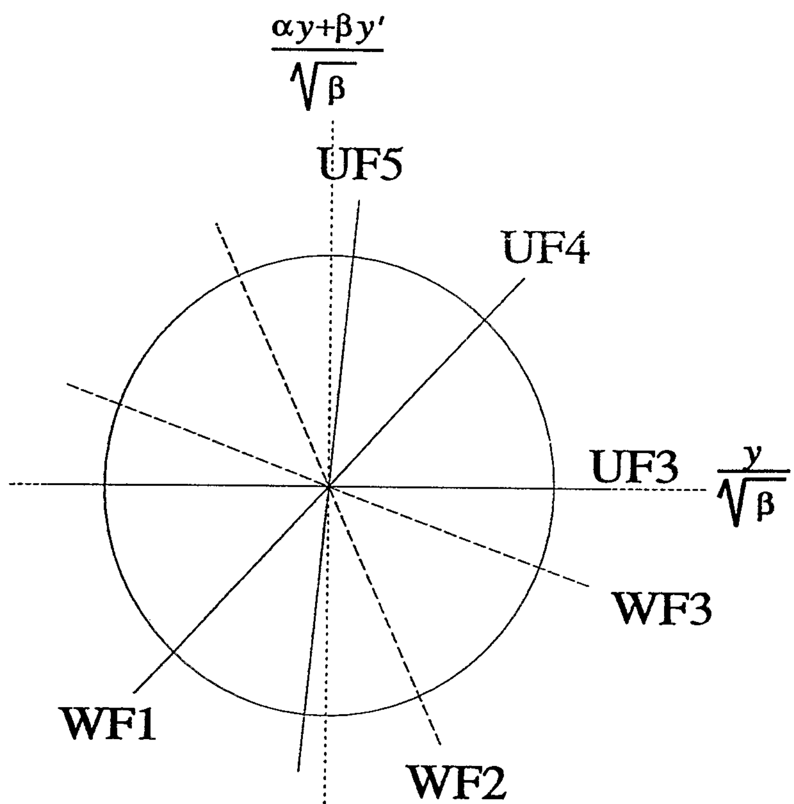
Changes

- 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

Commissioning Strategy

- 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

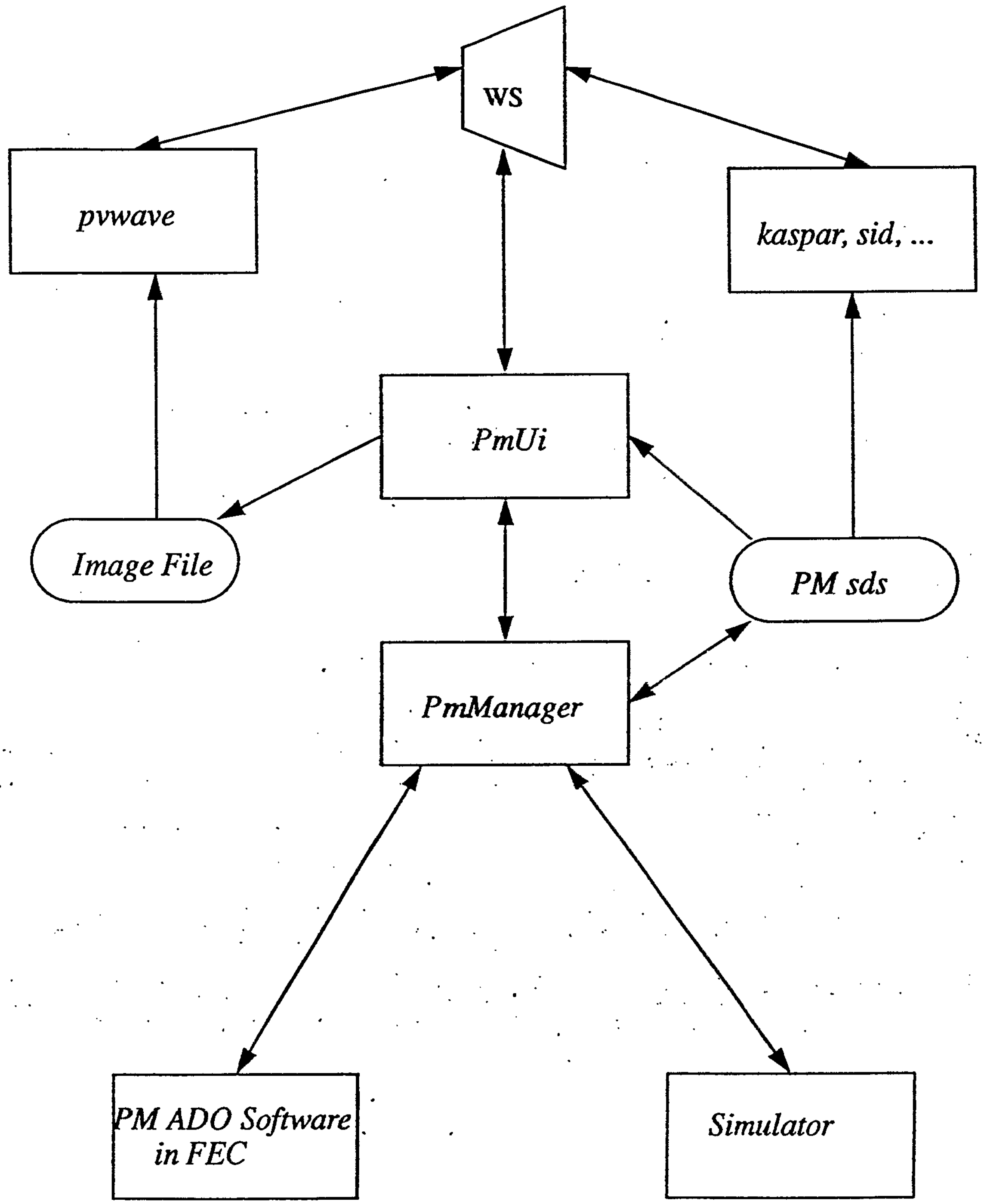
NameLookup[144]	117
lattice_index	473
atom_index	313
fid_index	−1
network_index	−1
type	8
orientation	1
Machine[4]	ATR
InOut[2]	
Section[3]	Y
DeviceName[8]	d
DevNo	23
SiteWideName[20]	yd23
SurveyName[16]	YD23
SerialName[20]	ATRCBL16
LatticeName[20]	yd23
GenericName[20]	B-focus
CoordinateType[4]	IP
Scoord	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

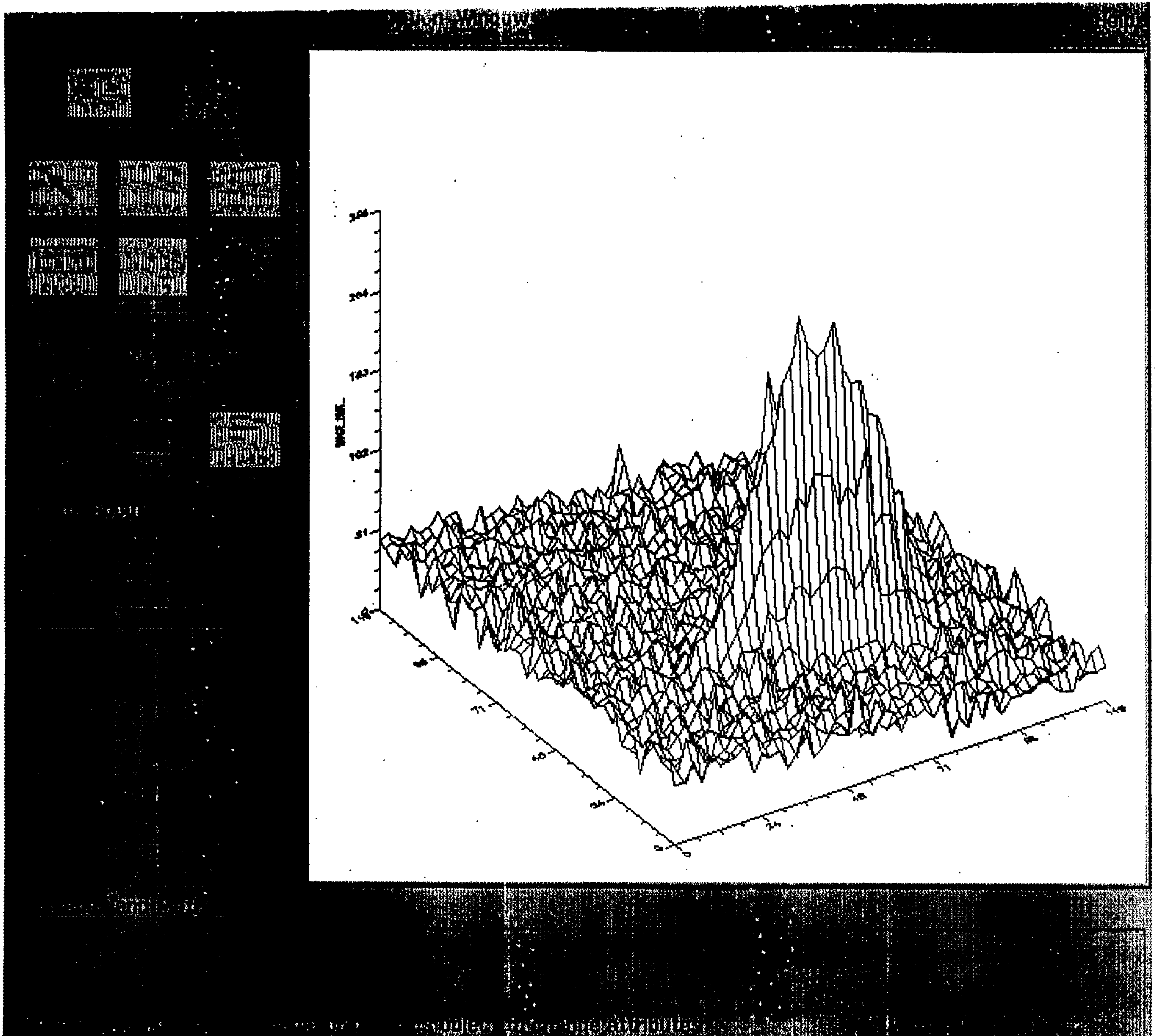
Pages 1 | Lines 0 | ISTK

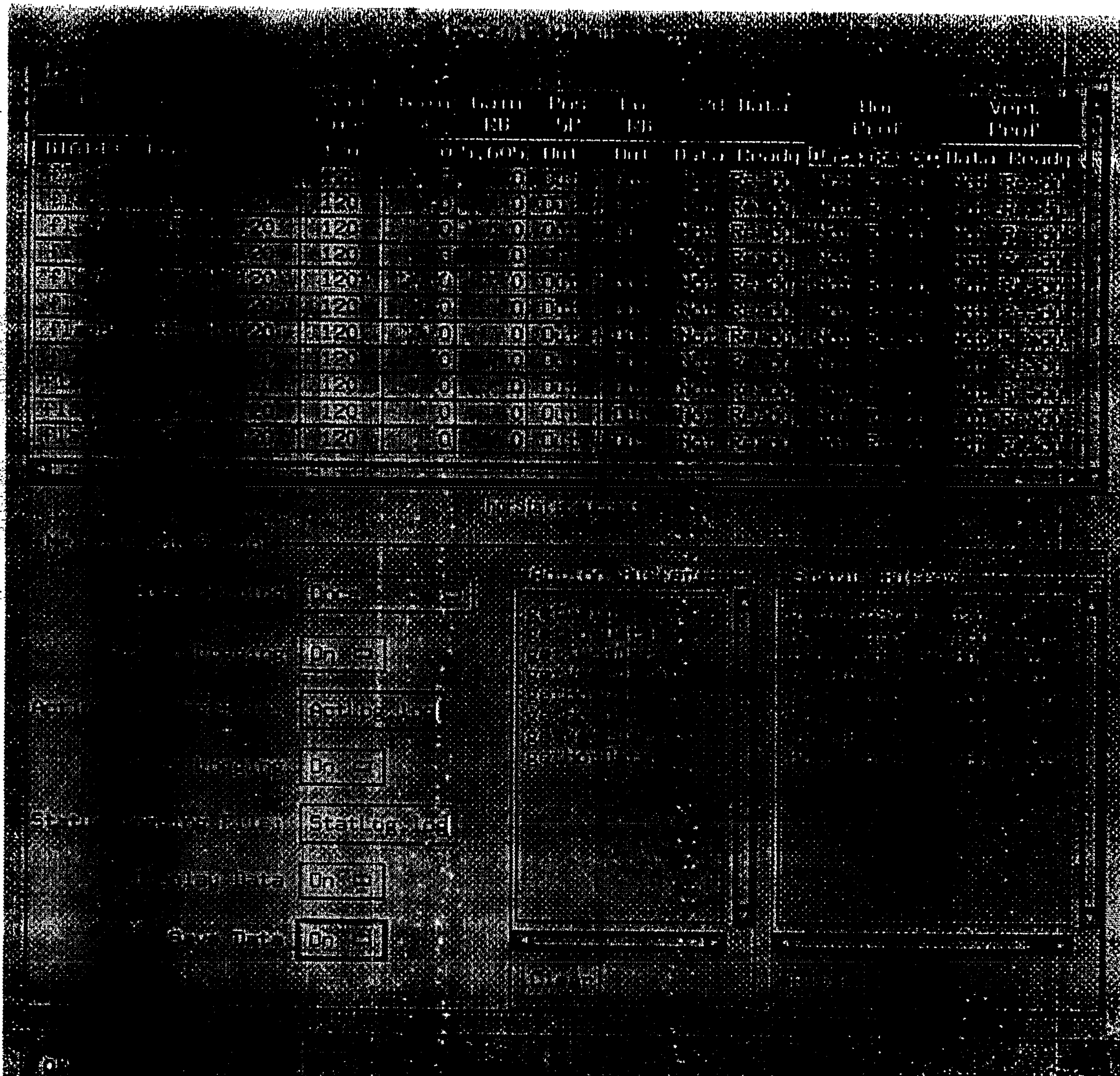
Save to file: /usr/local/Holy_Lattice/YTransfer/Namespace

InstaQuit

Profile Monitor Programs






Gain FB
Pos SP
Data Ready
Hor Prof
Vert. Prof
120
On

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)

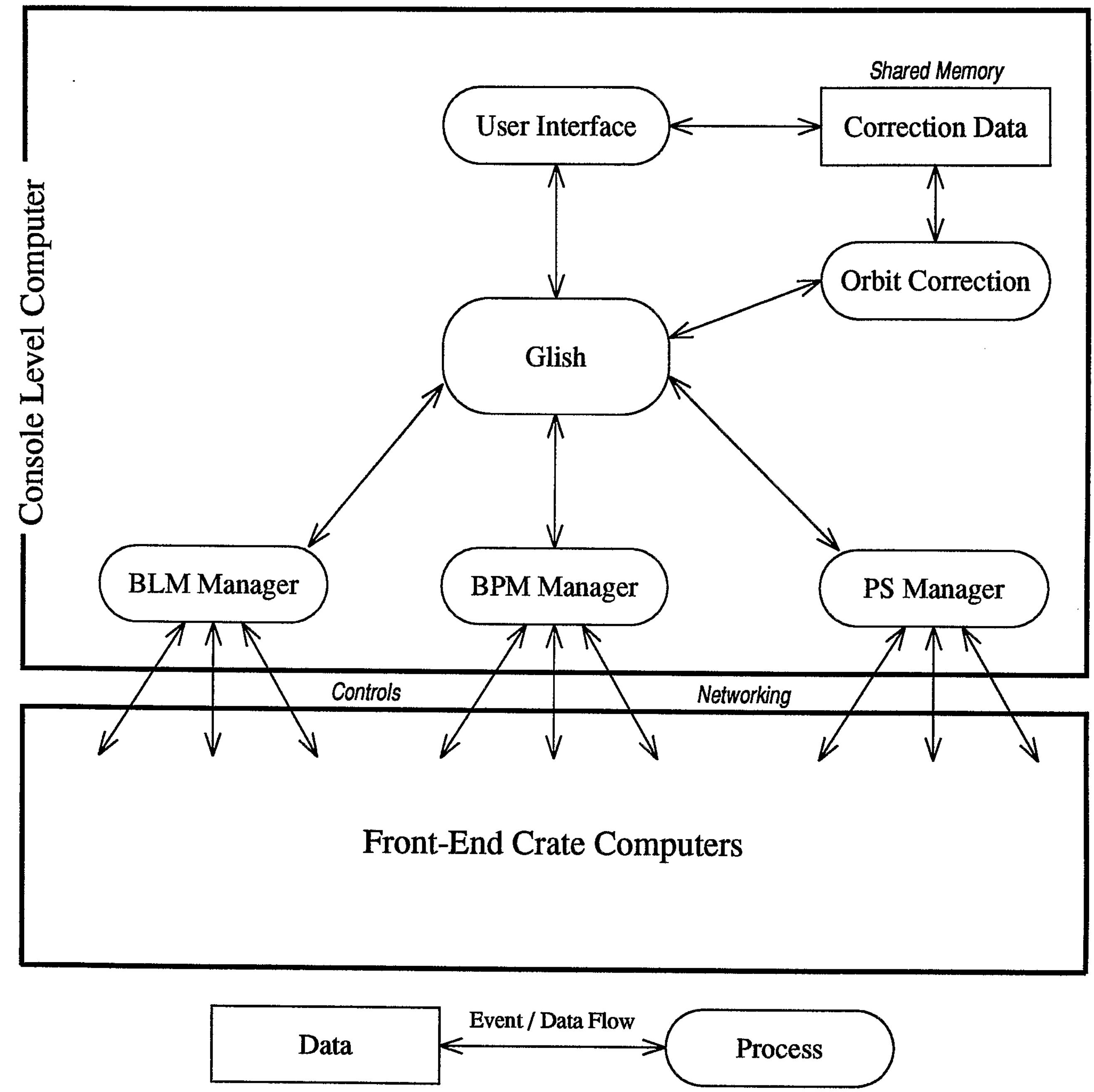
	U line	W line	X,Y lines
Horizontal BPMs	6	5 (1)	6 (1)
Vertical BPMs	4	5 (1)	8 (1)
Horizontal Correctors	3	4	7
Vertical Correctors	4	4	6
BLM Channels	12	8	16
Profile Flags	5	3	2

Parenthesized BPM planes added 12/93

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

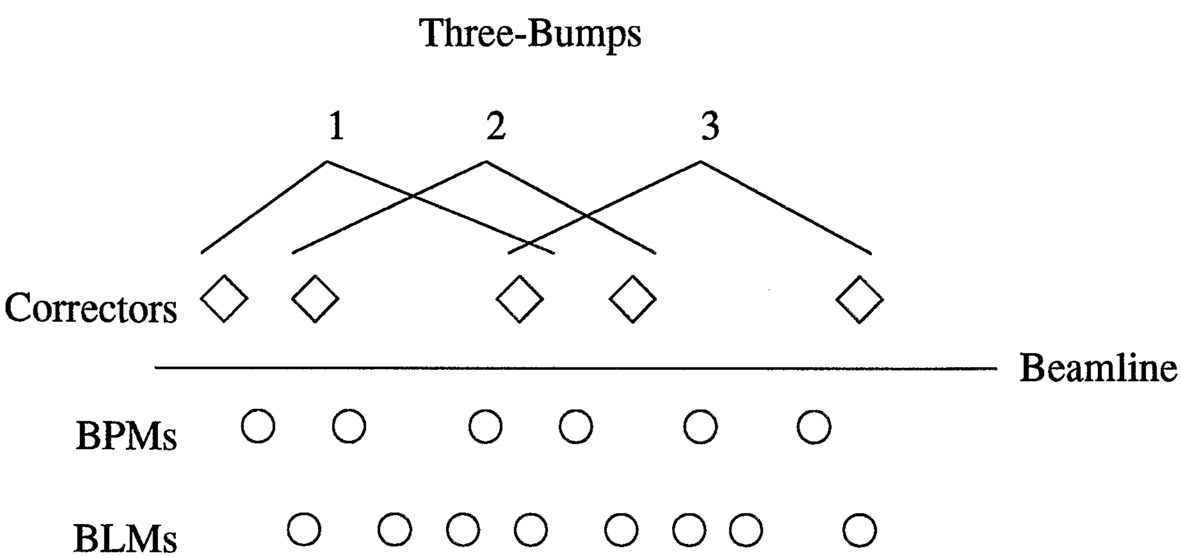
Flags can be used as dual-plane BPMs during commissioning.

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



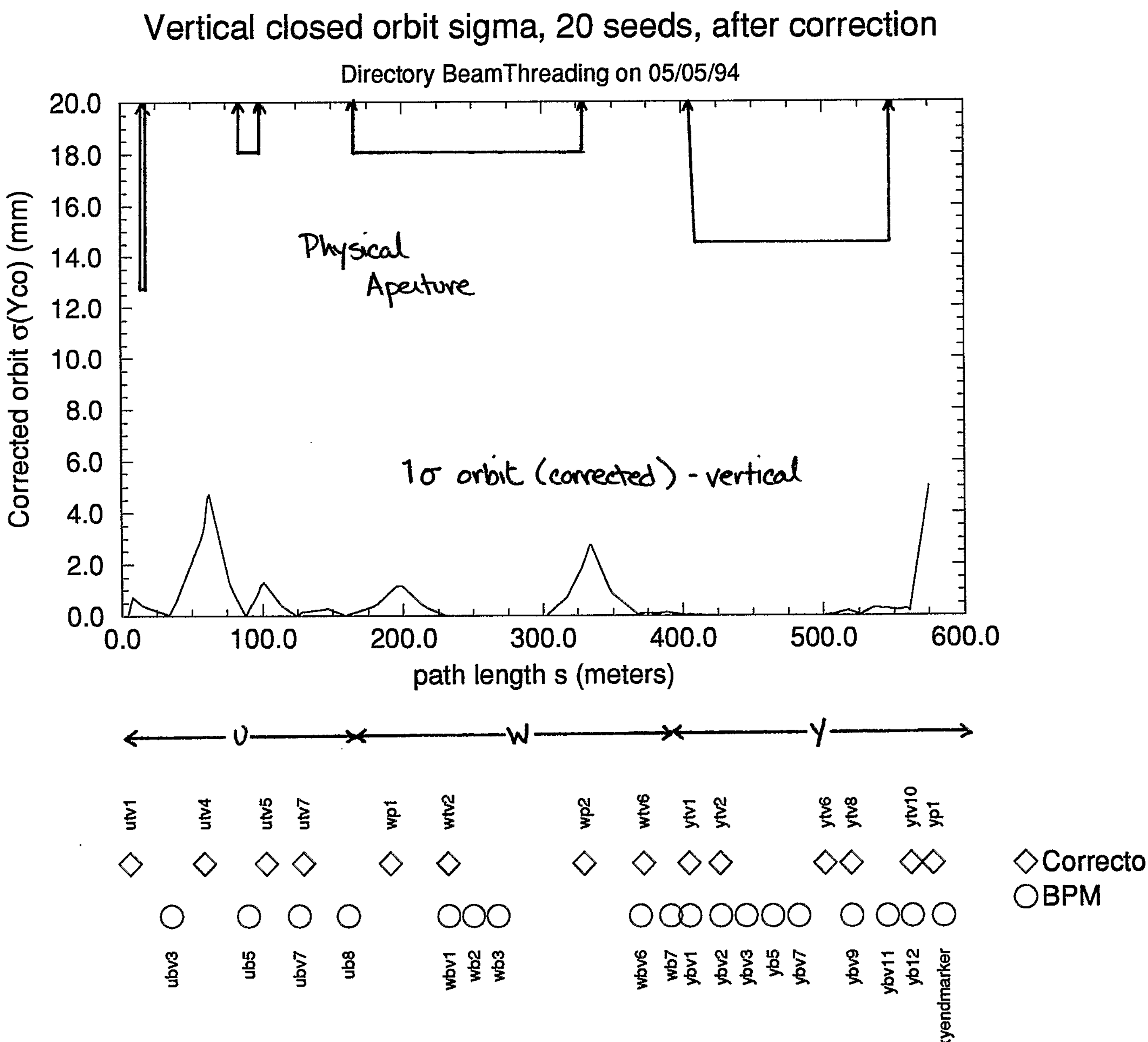
Successively and iteratively corrects overlapping three-bumps down beamline

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.