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# AGS to RHIC Beam Line: Application Codes

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Collider Accelerator Department Brookhaven National Laboratory

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USDOE Office of Science (SC)

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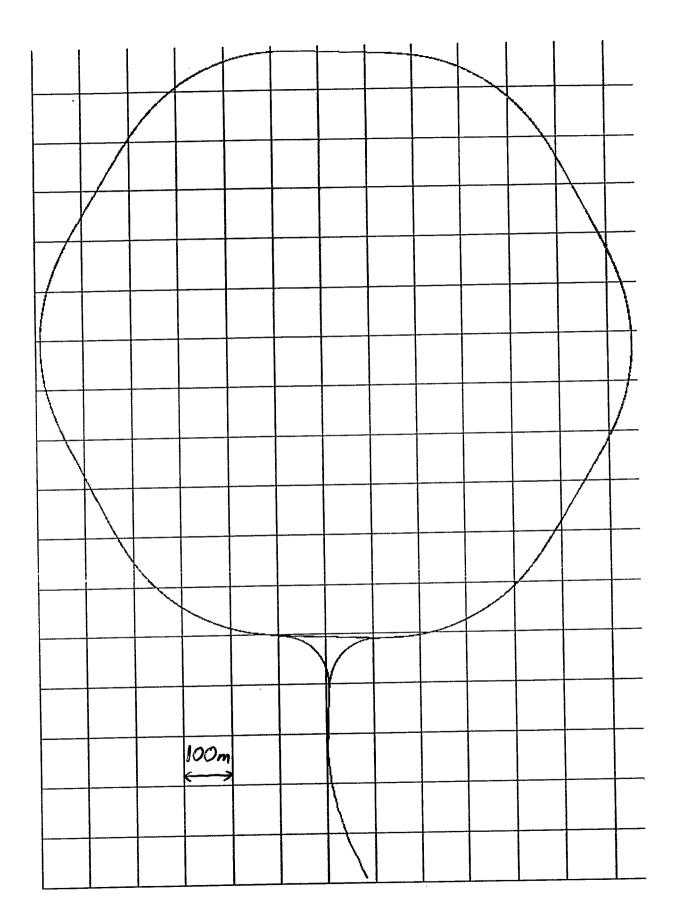
## AGS to RHIC Beam Line: Application Codes Waldo MacKay and Todd Satogata

### Waldo

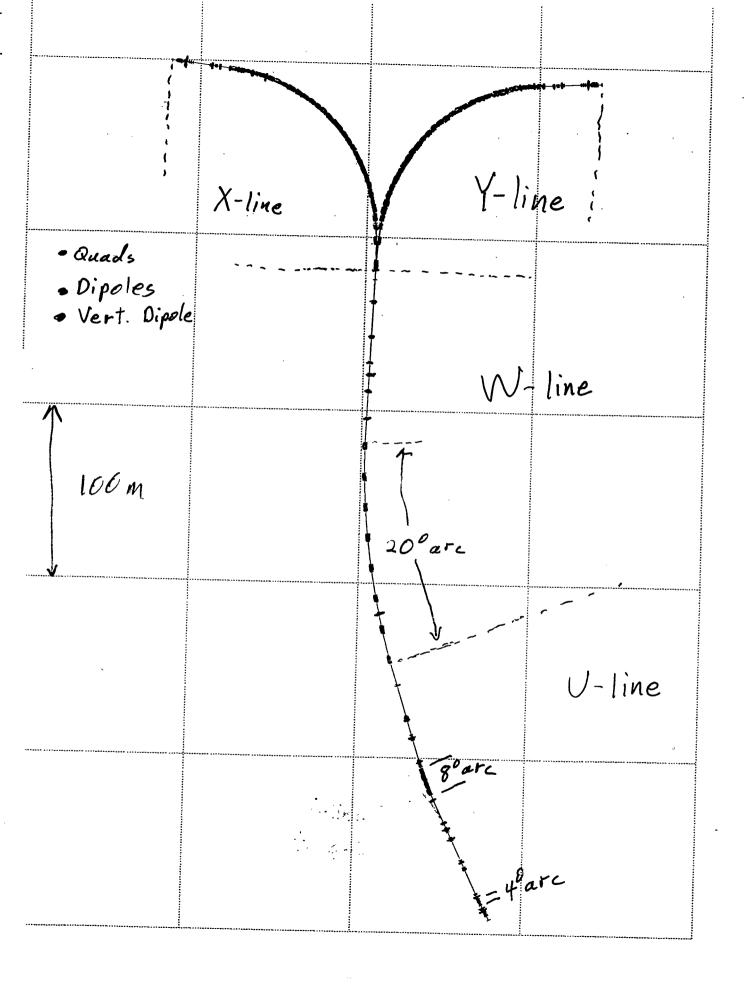
- Description of the ATR beamline (AGS to RHIC)
- Commissioning strategy
- General philosophy of application design (SDS and Glish)
- What applications do we need?
- General conclusions (Waldo's)

# Todd

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



.



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:

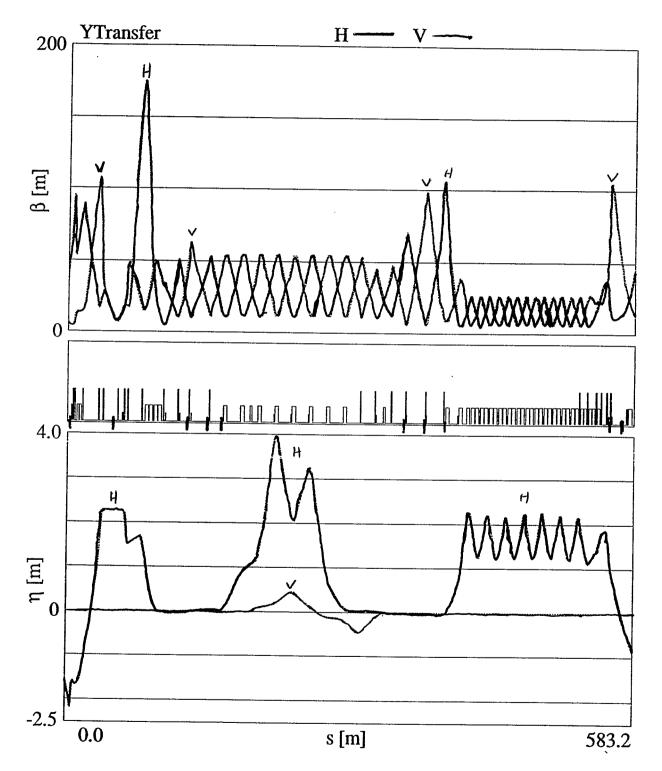
A Bend almost 90° into the Blue (cw) ring.

B 6 Quads at end of X-line match into RHIC.

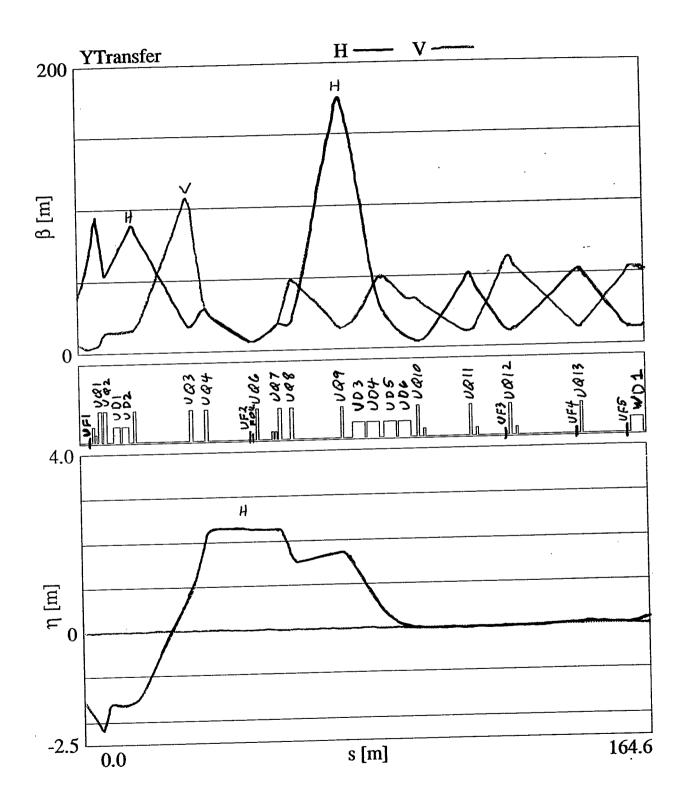
C Vertical injection into RHIC with lambertson.

V Injection kickers inside each ring.

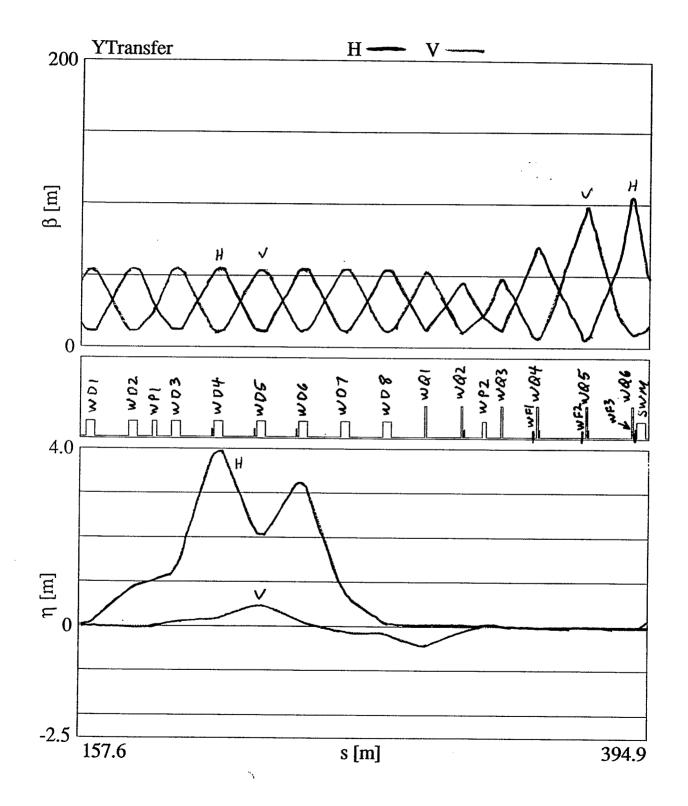
U, W, + Y -lines



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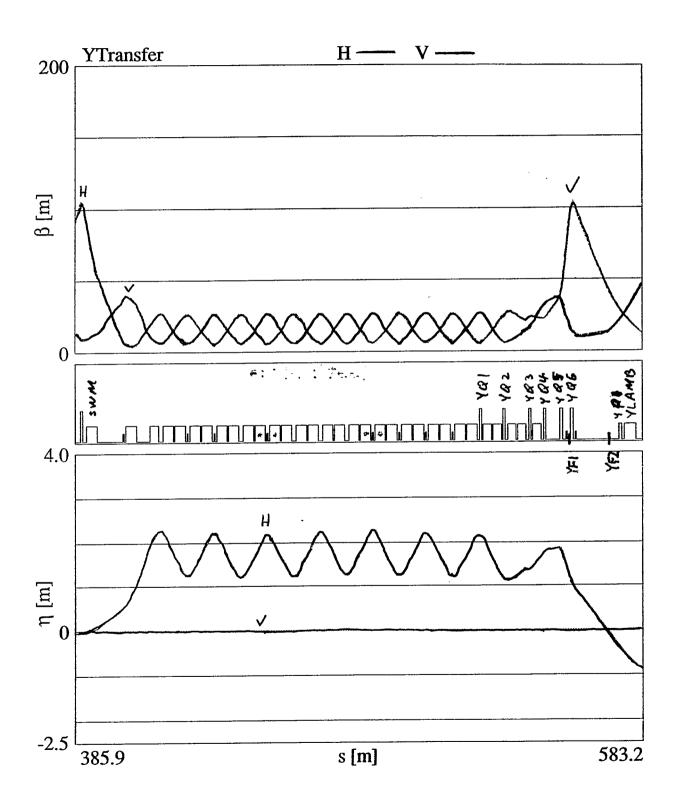




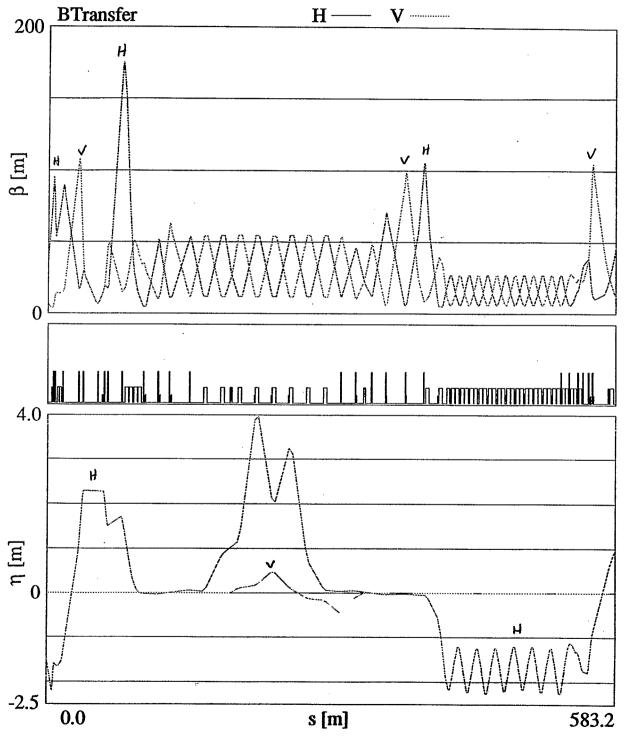


Y-line

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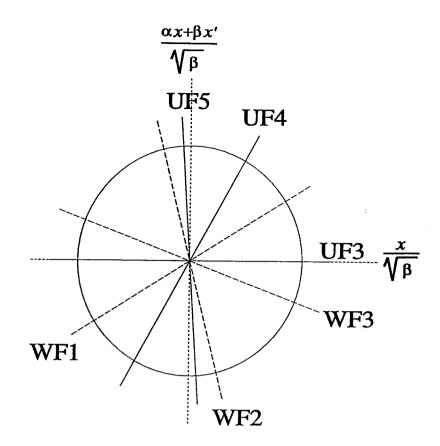


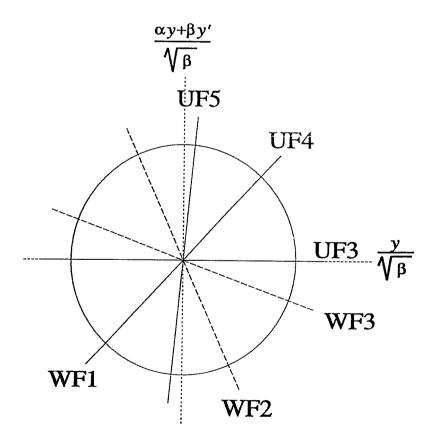
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### Changes

- 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.





- 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 (~  $10^{10}$  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.

- Use Sybase database server
  - $\circ$  archive data
  - define configuration.
- Use shared memory.
  - o 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

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- 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

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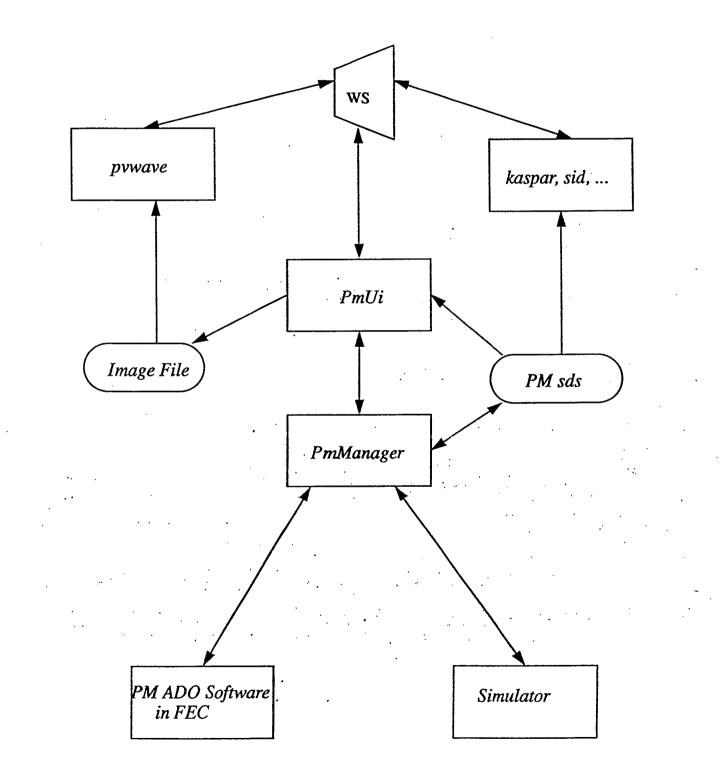
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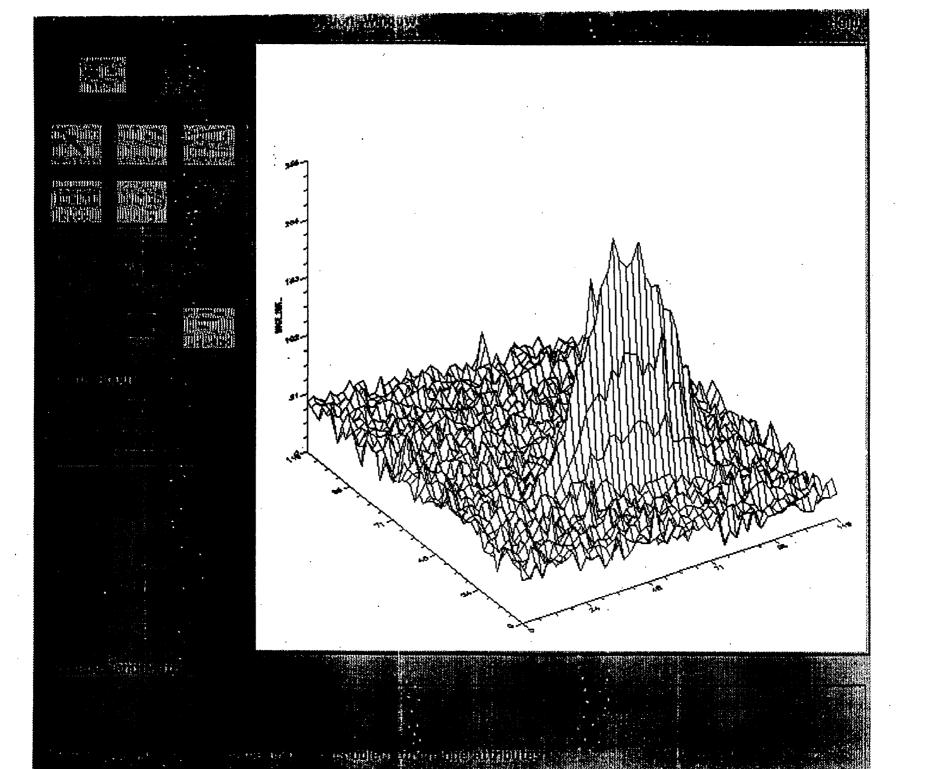
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# Development Environment

- 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)

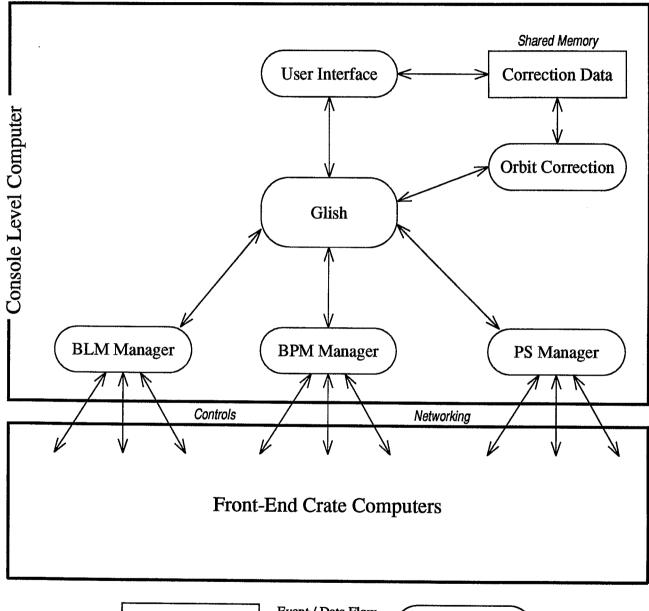
|                       | Uline | W line | X,Y lines |
|-----------------------|-------|--------|-----------|
| Horizontal BPMs       | 6     | 5 (1)  | 6 (1)     |
| Vertical BPMs         | 4     | 5 (1)  | 8 (1)     |
| Horizontal Correctors | 3     | 4      | 7         |
| Vertical Correctors   |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

Parenthesized BPM planes added 12/93

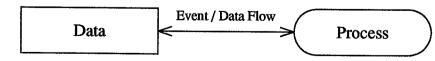
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BLMs are used to diagnose aperture losses and alter correction weights.

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



AGS to RHIC Beam Threading Processes and Data



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Mon May 9 10:17:13 1994
```

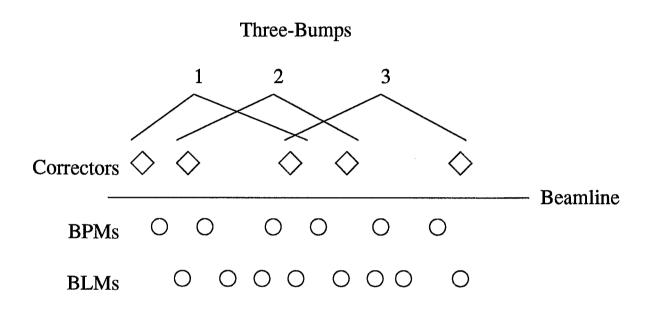
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```
Sample Gilsh script
```

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

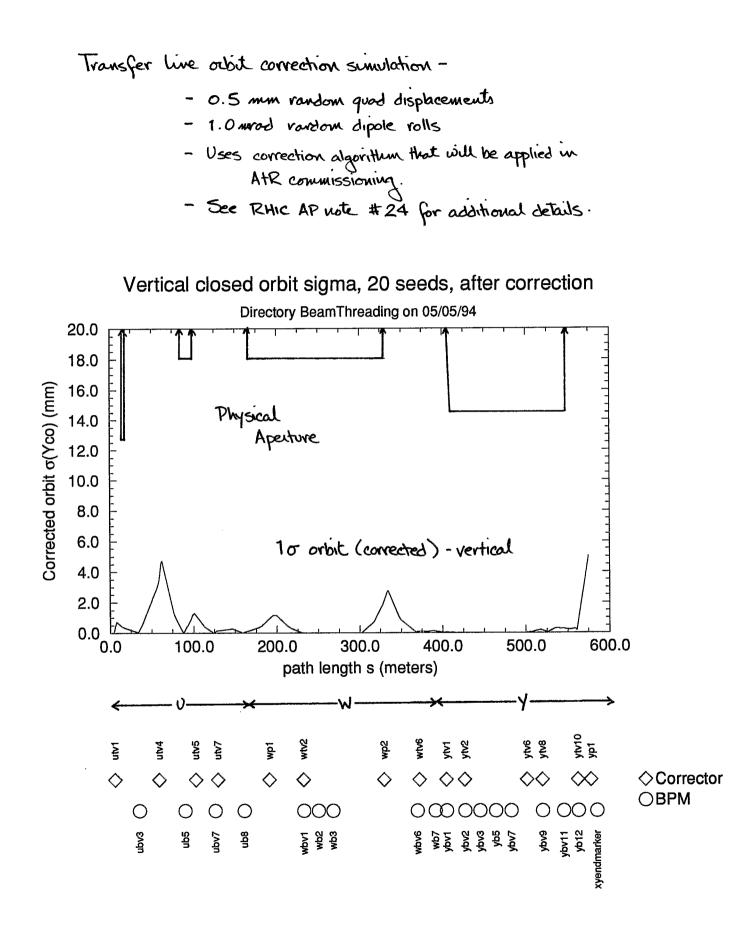
### **Orbit Correction Algorithm for Beam Threading**



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.



### 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.