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)
- Quads
- Dipoles
- Vert. Dipole

\[100 \text{ m}\]

\[20^\circ \text{arc}\]

\[8^\circ \text{arc}\] = \[4^\circ \text{arc}\]
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

Diagram showing plots of $\beta [m]$ and $\eta [m]$ against $s [m]$.
U-line

YTransfer

$\beta [m]$ vs $s [m]$

$H \quad V$

$\eta [m]$ vs $s [m]$

range: 0.0 to 164.6
Y-line

\[ \beta \text{[m]} \]

\[ \eta \text{[m]} \]

\[ s \text{[m]} \]

H — V —
$U, W + X$-lines

\[ \beta [m] \]

\[ \eta [m] \]

\[ s [m] \]
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.
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 (~ 10^{10} charges of some species, 1 pulse/30 sec)
   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 UTU1 by a small amount and remeasure the trajectory.
      3 Reset UTU1 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 interrupts
  - 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 editor–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 ...
| Name Lookup[144] | lattice_index | 473 |
| | atom_index | 313 |
| | fid_index | -1 |
| | network_index | -1 |
| | type | 8 |
| | orientation | 1 |
| | InOut[2] |  |  
| | Section[3] | Y |
| | DeviceName[8] | d |
| | DevNo | 23 |
| | SiteWideName[20] | yd23 |
| | SurveyName[16] | YD23 |
| | SerialName[20] | ATRCB16 |
| | LatticeName[20] | yd23 |
| | GenericName[20] | B-focus |
| | CoordinateType[4] | IP |
| | Scoord | 511.071287 |
| | Sequiv | 511.071287 |
| | Ncoord | 31681.053034 |
| | Wcoord | 4.723158e-02 |
| | Ecoord | 0.3264.959942 |
| | theta | 0.413932 |
| | phi | 4.376867e-05 |
| | psi | 9.087410e-05 |
Profile Monitor Programs

Diagram:

- **WS**
  - **pvwave**
  - **Image File**
  - **PmUi**
    - **PM sds**
    - **PmManager**
      - **PM ADO Software in FEC**
      - **Simulator**
  - **kaspar, sid, ...**
**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)

<table>
<thead>
<tr>
<th></th>
<th>U line</th>
<th>W line</th>
<th>X,Y lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal BPMs</td>
<td>6</td>
<td>5 (1)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>Vertical BPMs</td>
<td>4</td>
<td>5 (1)</td>
<td>8 (1)</td>
</tr>
<tr>
<td>Horizontal Correctors</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Vertical Correctors</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>BLM Channels</td>
<td>12</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>Profile Flags</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

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

Shared Memory

User Interface

Correction Data

Orbit Correction

Glish

BLM Manager

BPM Manager

PS Manager

Controls

Networking

Front-End Crate Computers

Data

Event / Data Flow

Process
# Start up clients, or processes to manage
NQ := client("Namequery")  # Client to look up names of things
UI := client("BeamThreadUT")  # 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/ETransfer/Namespace")

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

whenever NQ->Put do
  UI->Put($Value)

whenever UI->Corrector do
  shell("clorbit -x -y")

...
Orbit Correction Algorithm for Beam Threading

Three-Bumps

Correctors

1 2 3

Beamline

BPMs

BLMs

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.

Vertical closed orbit sigma, 20 seeds, after correction

Directory BeamThreading on 05/05/94

Physical Aperture

1σ orbit (corrected) - vertical

Corrected orbit σ(Yco) (mm)

Path length s (meters)

Corrector
BPM
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.